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1.1 LARGE AND LOCAL SCALE OROGRAPHIC EFFECTS IN RELATION TO CYCLONIC FORMATION AND PRECIPITATION DURING THE MAP-SOP EPISODE

Andrea Buzzi, Piero Malguzzi, Italy

During the Mesoscale Alpine Programme Special Observing Period (SOP), several events of heavy orographic precipitation were induced by the interaction of the Alpine (and surrounding) orography with synoptic-scale and mesoscale weather systems, taking the aspect of cyclones or vortexes originating or redeveloping in the Mediterranean area. We consider here the following question: "How are pre-existing mesoscale systems modified by the orography... and how do these modifications localise heavy and persistent precipitation?" (MAP Science Plan). The question is addressed by means of numerical experimentation on selected MAP Intensive Observing Periods (IOP), namely IOPs 14 and 15. In the first case, a depression formed south of the western Alps, in correspondence with an upper level trough, moving slowly from west to east. Intense precipitation was observed in the southerly flow directed toward the Alps. In the second case, rapid and intense cyclogenesis took place in association with an upper trough deepening from the north, and with a cold front passing quickly over the Alps. The heaviest precipitation was associated in this case with a strong north-easterly flow impinging over the northern Apennines. The MAP dataset is used to validate model results in high resolution simulations. The large scale effect of the orography is studied in both cases by contrasting experiments in which the orography itself is modified in the model domain. The role of the different scales of the orography in modifying mesoscale features and in producing local enhancement of precipitation is studied by filtering out small scale details of the orography itself and by performing experiments with different horizontal resolution.

1.2 VERIFICATION OF BOLAM-99 DURING MAP-SOP: SOME RESULTS

N. Arena, A. Buzzi, G. Contri, M. Corazza, R. Cresta, S. Gallino, F. Pasi,
D. Sacchetti, N. Tescaro, E. Trovatore, Italy

Some results about the performance and forecast skill of BOLAM-99 during the Special Observation Period (SOP, Autumn 1999) of the Mesoscale Alpine Programme (MAP) are presented.

BOLAM-99 is the most recent version of the model developed at ISAO-CNR in Bologna. This verification applies to the model runs performed on a daily basis during MAP-SOP at the Physics Department of the University of Genoa. This particular implementation of BOLAM-99 involves two different runs: a 21 km resolution version, using the ECMWF analysis/forecast as initial/boundary conditions on the original hybrid levels, and a self nested, 6.5 km resolution version on the MAP area.

Thanks to the availability of intensive observations during SOP, detailed information about the capability of the model of reproducing mesoscale structures is obtained. Particular attention on surface parameters and precipitation field is paid.

1.3 VERIFICATON OF THE PERFORMANCES IN PRECIPITATION FORECASTS DURING MAP SOP EPISODES FOR AN OPERATIONAL HYDROSTATIC MODEL (MEPHYSTO) AND A NON-HYDROSTATIC ONE (RAMS)

P. Faggian, S. Finardi, D. Ronzio, Italy

To improve the understanding of orographically influenced precipitation events and related flooding episodes, the performances of two meteorological models have been evaluated. One of these is MEPHYSTO, an hydrostatic model, and the other is RAMS, a non-hydrostatic one.

In particular, MEPHYSTO is a limited area model used at CESI for electric energy management application. It is an eta-model, similar the code used operatively at NCEP of Washington. It is a finite difference grid point model, whose prognostic fields are defined by the Arakawa E-grid (from 1 W to 2 E degrees in longitude and from 33 N to 55 N degrees in latitude) with a horizontal resolution of 0.125 degrees.

RAMS is a non-hydrostatic model developed by Colorado State University.

The simulations have been based on a test case (20-21 October 1999), characterized by heavy precipitation over the Alpine Region. For the validation of the models at the finest achievable scale in precipitation forecasts, MAP SOP data base have been used.

Extensive tests have been performed using MEPHYSTO with an increasing number of vertical levels and with soil and surface properties described at different degree of approximation to investigate the possible improvement in the numerical rain intensity prediction connected to a better specification of the surface budgets.

To test the improvement of simulating the orographic circulations and their interaction with the synoptic-scale flow, RAMS has been applied at high-resolution (few kilometres). To enhance the accuracy of the heat and moisture budgets, RAMS has been applied with a land-use representation. Increasing the spatial resolution, through the nesting technique allowed by the non-hydrostatic model, we tested the convective precipitation development in response to mesoscale circulations and local surface heating. At last, a numerical experiment has been made applying the non-hydrostatic model with a more accurate initial boundary condition through a data assimilation of detailed data observed during MAP SOP campaign.

The accuracy of the models have been verified analysing both the precipitation patterns (spatial and temporal distributions) and by the calculation of the statistical indexes defined for objective evaluation of quantitative precipitation forecasts.

1.5 PROJECT ROM: THE VERTICAL STRUCTURE OF THE BOUNDARY LAYER IN THE AUSTRIAN RHINE VALLEY DURING MAP IOP'S

Martin Piringer, Kathrin Baumann, Ulrike Pechinger, Austria

Within the MAP field programme, ZAMG investigated meteorological conditions and ozone patterns of the boundary layer during south foehn events by making use of vertical sounding devices like a sodar, a multi-sonde tethered balloon system and a cable car sonde besides an ultrasonic anemometer at the sodar site and a meteorological weather station at the tethersonde launching site. The area of investigation comprised a part of the Austrian Rhine valley just south of Lake Constance. The presentation will focus on a variety of boundary layer features observed during MAP IOPs in this area. In particular, it was observed that, below the foehn flow, a pool of relatively cool air is often present in this area, giving rise to enhanced wind shear, a persistent elevated inversion and significantly different ozone levels of the air masses involved. Different kinds of foehn breakdown could be observed and will be shown. Special attention will be given to the new kind of observation provided by the multi-sonde tethered balloon system and the cable car sonde used for the first time by ZAMG during a field experiment

1.6 COMPARISON OF AIRCRAFT DATA (STAAARTE 99) AND GROUNDBASED MEASUREMENTS OF OZONE (PROJECT ROM) BEFORE THE ONSET OF SOUTH FOEHN

Gabriele Rau, Kathrin Baumann, Austria

Within STAAARTE - FOEHN 99 aircraft measurements with the french aircraft ARAT - Fokker 27 were carried out in the lower Rhine Valley and above the Lake of Constance. The measurements took place in close cooperation with the MAP-activities in the same area, especially with project ROM.

The aircraft data are compared with ground based measurements that were carried out in the lower Rhine Valley during the same time, for example acoustic radar, ozone measurements with a cable car sonde, data from air quality network.

A flight under pre-Foehn conditions was performed on October 19 1999. Airborne measurements were carried out during this flight across the Alps and along the Rhine Valley at a height of 4400 meters. The LIDAR measurements reveal the existence of two inversions at 2600 meters and 1300 meters, the lower inversion was characterised by a thick layer of clouds. Over the Lake of Constance two Cross-Sections at a height of 4400 meters and close above the lower of the two observed inversions were examined.

The ozone data measured during the flight show a quite uniform distribution over the Rhine Valley and the Lake at the higher flight level, except for one area with higher ozone values over the Lake in the layer between the two inversions. Below the cloud cover the ozone concentrations were very low. Tethersonde soundings, that were performed near the lake the next day, show that the ozone from this upper-level reservoir was mixed downward rapidly when Foehn set on (October 20).

1.7 **MAP SOP SEVERE ADRIATIC BORA EVENT**

Branka Ivancan-Picek, Drazen Glasnovic, Vlasta Tutis, Croatia

MAP SOP severe Adriatic bora event on 07-09 November 1999 (identified as IOP15) based on the enhanced radiosounding observations, detailed surface data analysis and numerical results of HRID and ALADIN/LACE is presented. The radiosonde measurements in Zagreb gave us an opportunity to get more information on the capability of the model to predict locally the upstream bora vertical atmospheric structure and its changes. The detailed surface wind analysis is conducted to resolve the possible vertical structure indicated by model results and aircraft measurements.

1.8 KINEMATIC STRUCTURE OF CONVECTIVE STORMS OBSERVED DURING IOP 14 (3 NOVEMBER 1999) OVER THE APENNINE MOUNTAINS USING AIRBORNE DOPPLER RADAR

David Jorgensen, U.S.A.

One of the principal scientific objectives of "Wet MAP" is to investigate the mechanism of orographically generated heavy precipitation events with special emphasis on their dynamics, microphysics and hydrological consequences (especially flooding). Specifically, the SOP was to provide data sets to distinguish the relative roles of orographic, baroclinic, and convective dynamics in the airflow producing precipitation over complex terrain (mountains).

During IOP 14 of the MAP SOP, the NOAA P-3 and NCAR Electra aircraft conducted flight patterns in and around strong convective storms located over the Apennine terrain along the western coast of Italy. Airborne Doppler radar from the NOAA P-3 has been processed to provide three-dimensional wind fields that illustrate the kinematic structure of the convection located over the seaward facing slopes of the Apennine mountains. The aircraft flew "box" patterns surrounding the storms as well as a 1000 ft altitude pass along the coast to sample the character of the inflowing air. These storms produced heavy rain and the mesoscale convective system that contained the individual storms was relatively stationary during the period of aircraft investigation.

The Doppler radar derived winds and reflectivity fields indicate a complex structure of airflow within the storms. Specifically, storms tended to generate over the coastal regions in response to a strong convergence region produced by shallow downslope winds (presumably) produced as part of the storm outflow with the prevailing onshore environmental winds. Storms thus generated then moved slowly up the slope in response to the prevailing steering flow, and dissipated near the crest of the Apennines.

The presentation will illustrate this conceptual model of storm behavior through reflectivity and wind cross sections.

1.9 RADAR OBSERVATION OF A MESOSCALE CONVECTIVE SYSTEM OVER NORTH EASTERN ITALY ON 4TH OCTOBER DURING MAP

Stéphanie Pradier, Frank Roux, France

During MAP, "Project P1 *Orographic precipitation mechanisms*" was aimed at addressing the basic mechanisms of creation or enhancement of precipitation by special configurations of topography in complex terrain. On 4 October 1999, the US National Center for Atmopsheric Research Electra and the National Oceanic and Atmospheric Administration P3 aircraft carrying meteorological Doppler radars and other instruments have been used to investigate the dynamic, thermodynamic and microphysical properties of a convective system that occured near the border between Italy and Slovenia, in a transition region between the flat Adriatic coast and the Julian Alps. Complementary observations are provided by the Italian operational Doppler radar aat Fossalon di Grado. This precipitating system started on the Italian side as a 100 km long and 10-20 km wide line of very intense convective cells at 0730 UTC and it propagated southeastwards. After 0900 UTC, a region of stratiform precipitation developed on its northern side and the system dissipated by about 1200 UTC as it moved toward Croatia. In both convective and stratiform regions, the radar, microphysical and flight level measurements suggested strong influence of the underlying topography. Preliminary analyses of these data will be discussed at the 26th Int. Conf. on Alpine Meteorology.

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FOREWORD AND INTRODUCTORY REMARKS

This volume comprises the abstracts of all contributions of ICAM 2000 which took place in Innsbruck, 11-15 September 2000. Almost fifty years have elapsed since the First International Conference on Alpine Meteorology. During this period these conferences had always a tradition in providing a platform for interdisciplinary exchange of information on meteorology, climatology and hydrology between the researchers and the experts in these fields as well as students and the user community not only from Alpine countries but from virtually all mountainous regions of the world. The 26th ICAM 2000 will continue with this tradition and shall be a common ground for encouraging the initiation and the progress of international research projects. Initiatives like the Mesoscale Alpine Programme, which has put a lot of additional momentum to the research in the scientific disciplines of Alpine meteorology, climatology and hydrology give evidence how fruitful international synergistic collaborations can be.

The conference, however, gives clear evidence that several questions in the field of Alpine meteorology are not yet fully answered and the wide variety of themes is still growing. On behalf of the Scientific Organising and Programme-Committee of ICAM 2000 I would like to thank all of the authors for submitting a large number of high quality contributions. I think we have an exceptional programme and several keynote contributions that highlight the increasing width and importance of the field of Alpine Meteorology.

Reinhold Steinacker
(Chairman of the Scientific Programme Committee)

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In the present abstract volume the short abstracts of all contributions are published. The extended proceedings of the conference are published on a CD-ROM. This electronic form gives many advantages to the publisher and the user. The production is much cheaper especially using colour pages and the format and the length of the abstracts are not so limited than in a printed version. The CD-ROM will enable users to conduct more efficient and timely searches than the printed issues. One can search the tables of contents electronically and display the preprint pages on the screen or just print them.

Most of all I want to thank Karl Gabl helping me as local organizer and several other colleagues of the ZAMG who had taken care of all the difficulties and the program planning from beginning to the end of the conference.

Ernest Rudel

(Head of Local Organising Committee)

ORAL PRESENTATIONS

SESSION 1 Mesoscale Alpine Programme (MAP)

SESSION 2 Alpine Synoptic

SESSION 4 Alpine Climatology

SESSION 5 Hydrology

SESSION 6 Snow and Ice

POSTER PRESENTATIONS

SESSION 1 Mesoscale Alpine Programme (MAP)

SESSION 2 Alpine Synoptic

SESSION 7 Biometeorology and Environmental Meteorology

1.10 SPACE-TIME ANALYSIS OF RAINFALL IN RELATION TO TOPOGRAPHY FOR HEAVY PRECIPITATION EVENTS OBSERVED DURING MAP

Matthias Steiner, James A. Smith, Mary Lynn Baeck, Yu Zhang, Robert A. Houze, U.S.A.

Several heavy rainfall events were observed on the Mediterranean side of the Alps during the Special Observing Period (SOP) of the Mesoscale Alpine Program (MAP). The hydrologic response at the land surface to the intense rainfall was significant, resulting in local flooding, debris flows, and at least one fatality. The events earlier in the SOP, especially the Intensive Observation Periods (IOPs) 2, (September 17-21), 3 (September 24-27), and 5 (October 2-5), were characterized by moist, potentially unstable air being lifted at the Alpine barrier, triggering convection that resulted in short-term rainfall accumulations with local maxima in excess of 200 mm. Smaller-scale topographic features appear to have played an important role in the generation (or intensification) of convective cells, as revealed by inspection of radar data.

Particular attention is given to the spatial and temporal distribution of rainfall relative to the topography. To explain the observed spatial rainfall distribution, objective tracking analyses are performed based on Monte Lema and/or S-Pol radar data to document formation, evolution, and decay of radar-echo cells and their motion relative to the larger precipitation system and the terrain. Time-series analyses of cell characteristics (including maximum intensity and height of echo centroid), together with storm-microphysical information based on S-Pol multiple polarization radar and lightning data, shed light on the importance of warm-rain processes for heavy rainfall events. Rainfall amounts will be estimated based on radar and rain gauge information.

1.11 SUMMARY OF THE MEASUREMENTS OF GAP FLOW IN THE BRENNER TARGET AREA OF MAP SOP

Georg Mayr, Austria

An overview of the instrumental setup provided by European and US research groups will be given to show how it was supposed to answer the scientific questions.

A short climatological review will show the above-average occurrence of south foehn during the 10 weeks of the SOP and classify the cases into deep/shallow.

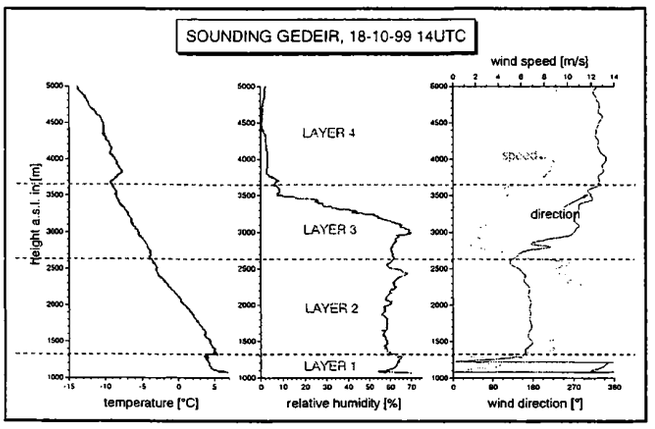
Finally, highlights from the intensive observation periods when the ground-based measurements were supplemented with aircraft missions will be presented.

1.12 CASE STUDY OF THE MAP-IOP "SANDWICH" FOEHN ON 18TH OCTOBER 1999

Johannes Vergeiner, Georg Mayr, Austria

A shallow south foehn event is defined by a decoupled westerly or even northwesterly flow above a pressure-driven south flow. Quite often a stable cold air surface pool beneath a marked inversion can not be removed by the southerly flow above it because of the highly stable stratification. This three layer structure is here referred to as "Sandwich" foehn.

But on the 18th of October a very rare event was recorded in the Wipp valley target area: Not only a stagnant cold pool hinders the south flow to reach the ground, but a northerly surface flow into the Wipp valley with a vertical extent of approximately 300m is present! The south foehn in a 1300m thick layer above it is topped by a transition zone with winds turning from south over west to north accompanied by strong drying. A pronounced inversion marks the beginning of the very dry and strong NNW flow above 3600m a.s.l.



The vertical structure will be studied in detail using the radiosoundings of Verona and Sterzing upstream of the main Alpine crest and of Gedeir in the Wipp valley (see figure above) and of Innsbruck. Additionally the NOAA-lidar, also placed at Gedeir in the middle of the Wipp valley, gives superb information on the structure of the flow along the valley up to a height of more than 2km. Pseudo-vertical temperature profiles of stations up along the valley sides, a very dense network of surface stations in the Wipp valley as well as in the main tributary the Stubai valley and in the Inn valley, a Sodar placed at the Brenner pass and a Mini-Sodar in Innsbruck and car-based measurements between Innsbruck and Sterzing complement the data set.

The focus of the talk will be on the synoptic and meso-scale driving forces for the opposite flows in the different layers. Furthermore the difference in the stratification, the vertical extent and the strength of the flow upstream and downstream of the main Alpine crest will be analysed.

It will be shown *how and why* the south flow managed to reach the ground around noon of the same day in the upper part of the Wipp valley with the transition zone between southerly and northerly flow on the valley ground slowly progressing northward. Hence the time evolution of the inflow eroded by the southerly flow will also be under consideration.

2.1 **HASELGRABENWIND - AN UNUSUAL BEHAVIOR OF A MOUNTAIN WIND**

Wolfgang Gepp, Austria

The Haselgraben wind is a well known mountain wind in the city of Linz (Austria). Under favourite conditions, the strength of this mountain wind is unusually high for a small valley like the Haselgraben with a jet maximum of app. 7 m/s in 50 m above ground just outside the mouth of the valley. The time of the maximum mass flux is around 10 pm. After midnight the Haselgraben wind dies suddenly and is not measureable during the second half of the night. This strange behaviour will be shown and its driving forces as well as consequences for the urban area will be discussed.

2.2. A MODEL FOR THE CONVECTIVE BOUNDARY LAYER DEVELOPMENT IN AN ALPINE VALLEY

Dino Zardi, Italy

Valley wind systems display very peculiar features: the way they typically affects local microclimate and transport processes, like diffusion and dispersion of passive tracers, motivated a deeper investigations of the dynamics involved in their development.

In the present work we shall consider a few case studies of well known valley winds which develop in the Eeastern Italian Alps.

One of them - the so called 'Ora del Garda' - develops in the northern part of Garda Lake under fair weather conditions. It usually arises in the late morning as a typical lake breeze along the shore, thence it channels in the Sarca Valley and in the Lakes Valley nearby, and finally, after reaching a maximum height of about 650 m a.s.l., it blows out, through an elevated saddle, in the River Adige Valley, just North of Trento (200 m a.s.l.), where it appears as a strong gusty wind.

Another typical wind flows along the whole Adige Valley, displaying specific features in single tracts. Time series of surface data have been analyzed in order to gain an overall quantitative description of the wind: a few episodes are reported, for which special observations have been carried out in specific sites. Ground based measurements included both conventional meteorological instruments and advanced sensors, namely an ultrasonic anemometer and a doppler sodar. In addition airborne measurement have been obtained at differnet day hours with an equipped motor-glider. The measurement flights allowed the determination of both potential temperature vertical profiles and potential temperature anomalies within the valley atmosphere. Data obtained from the analysis allow a finer tuning of the parameterisation of models which will be used to simulate boundary layer development in the valley and pollutants dispersion, with particular emphasis on the effects due to complex terrain.

2.3 **NUMERICAL SIMULATIONS OF SHALLOW FOEHN**

Guenther Zängl, Germany

Numerical simulations related to shallow foehn in the Wipptal have been performed using the nonhydrostatic PSU/NCAR MM5 model. Both idealized and high-resolution realistic orography is used. Idealized orographies comprise differently-shaped east-west oriented mountain ridges with a gap representing the Wipptal. The mountain shapes are an elliptical mountain (EL), a quasi-twodimensional mountain ridge (Q2D), i.e. a mountain ridge with constant north-south width but finite east-west extension, and an arc-shaped mountain similar to the Alps (ALP). The mountain height is set to 3 km, and the gap depth is either 1.5 km or 3 km, the latter corresponding to a level gap. As large-scale conditions, uniform westerly wind (u = 10 m/s) and a constant Brunt-Vaisala frequency (N = 10^{-2} 1/s) are prescribed. The wind field is geostrophically balanced, the Coriolis parameter being 10^{-4} 1/s. In sensitivity experiments, the geostrophic wind is specified to turn from W to WSW between 700 hPa and the surface and/or a cold pool on the southern side of the model Alps is prescribed as initial condition. Both free-slip lower boundary conditions and surface friction with a roughness length of 50 cm are used.

With purely westerly wind and free-slip conditions, none of the orographies considered in this study exhibits southerly gap flow (shallow foehn). This is in marked contrast to a recent study of Sprenger and Schaer (QJRMS, accepted), who considered an infinite mountain ridge with a gap and found quite strong gap flow in this case. It appears that the anticyclonic flow around the isolated mountain is the primary reason for this discrepancy. The anticyclonic flow is connected with a light northerly wind component on the northern side of the model Alps which piles up some air there and largely compensates the geostrophic pressure gradient across the Alps. If surface friction is added, the southerly wind component in the boundary layer reinforces the geostrophic pressure gradient across the Alps, and strong gap flow (~ 15 m/s) occurs if the gap is level. If the gap has a height of 1500 m, light gap flow is found in the EL and Q2D cases. However, there is still no gap flow in the ALP case. This appears to be because a weak lee cyclone is established over the Po valley. The same result is found with realistic orography. In the two latter cases, gap flow occurs only if the geostrophic wind has a southerly component below 700 hPa or if a cold pool is prescribed over the Po valley.

This result agrees well with observations which show that shallow foehn is generally associated with a stable layer over the Po valley and with a large pressure gradient across the Alps (e.g. between Innsbruck and Bozen). Purely westerly flow without a cold pool over the Po valley has never been found to be a favourable condition for shallow foehn.

2.4 SENSITIVITY ANALYSIS OF RAMS IN WESTERN MEDITERRANEAN SEA TO THE REPRESENTATION OF THE LOWER SURFACE

M. Pasqui, B. Gozzini, D. Grifoni, F. Meneguzzo, G. Messeri, M. Rossi, Italy

Several meteorological situations are examined using the three dimensional non-hydrostatic mesoscale model RAMS with different representations of the lower surface in order to analyse the effects of the detail of such representations, the accuracy of the surface fluxes on the low level circulation and the quantitative precipitation forecasts.

The basic RAMS equations are the standard non-hydrostatic Reynolds-averaged primitive equations, thus the prognostic and the other variables represent grid-volume averaged quantities. The vertical structure of the model grid is built according to the "terrain-following" scheme: the upper part of the domain is flat and the lower one follows the terrain. To achieve a high spatial resolution, needed to represent all relevant atmospheric structures (such as deep convection), RAMS offers very advanced nesting capabilities.

In the case studies analysed in this paper, up to three different grids are nested one into another: each grid interacts with the following nested in a two-way mode. Coarser grid feeds the boundary values to the finer from which it gives back computed values, at higher resolution, to updated atmospheric fields.

Different averaging methods of elevation height are tested in order to provide the best description of complex terrain areas in conjunction with land surface representation, both as a homogeneous domain and with heterogeneous land cover coming from the U.S.G.S. land - use database. The sea surface temperature is assumed both climatological and really observed and their impacts are assessed for model performances. The horizontal differences developed in the PBL (Planetary Boundary Layer) and the vertical motion at the top of the PBL are heavily affected by the land cover and sea surface characterisations in the complex orography test area.

The major differences appeared both when low level circulation is driven by local breezes and when a strong synoptic forcing pass through mountain chains generating turbulence behind the ridge. The quantitative precipitation forecast performances and local low-level circulation simulations are also studied in detail and compared with recorded data, for a general assessment of a specific model configuration for forecasting purpose in areas prone to hydrological hazards.

A distinct improvement of forecast capabilities for both meteorological and hydrometeorological purposes are reached at the most detailed surface representation which is able to trigger properly and enhance the starting energy fluxes near ground. These induced changes may significantly affect low-level circulation patterns and vertical stratification in the atmospheric boundary layer. Temperature inversion and turbulence field, coming from the different RAMS configurations are also compared with observed SODAR and RASS profile.

2.5 **EXTENDED RANGE PREDICTABILITY IN THE CARPATHIAN REGION**

Roxana Bojariu, D. Paliu, Romania

Extended range predictability in the Carpathians mountains is studied using linear and non linear predictive models for monthly and seasonal precipitation amounts and temperature means. The linear models are based on canonical correlation pairs which link local climate anomalies with large scale variability. Monthly and seasonal geopotential height anomalies at 500 mb have been chosen as a parameter representative for large scale climate processes. Data from 19 mountains stations are used in this study. Geopotential height data used in the paper span the Atlantic-European sector. The linear model is trained in the interval 1961-1975 and hindcasts experiments are performed for the interval 1976-1990. The data are seasonally stratified.

The nonlinear predictive models, based on the multifield analog technique developed by Barnett and Preisendorfer (1978), have been adapted for seasonal forecasting in the Carpathians regions. Two climate state vectors have been built to represent the large scale features and the more local characteristics. For this purpose, anomalies of the geopotential height at the 500 mb level over the Atlantic-European region and sea surface temperature (SST) anomalies from Atlantic have been used together with air surface temperature and rainfall anomalies. The local climate state vector is defined by thermal and rainfall anomalies computed at 19 mountain stations. The selection of the analogs takes into account both large scale and local characteristics. The training interval for the analog model is 1960-1975 and the hindcast interval is 1976-1990.

Areas and time scales with the highest predictability are identified by assessing the spatial and temporal variability of predictive model skills.

2.6 **DIAGNOSIS OF ALPINE LEE CYCLOGENESIS - THE COMPLETE PICTURE**

Manfred Kurz, Germany

After the investigation of some cyclonic developments in the lee of the Alps, Mc Ginley (1982) proposed a conceptual model of lee cyclogenesis which is strongly related to a frontogenetic effect caused by the Alps and the transverse circulation connected with it. In case of a northerly or northwesterly air flow directed towards the Alps there is always a strong tendency for a splitting of the flow into two branches passing the mountain barrier at its flanks. A cold front approaching the Alps experiences a strong frontogenetic effect in this diffluent stream field leading to an increase of the temperature gradient. Due to the frontogenesis a solenoidally direct circulation across the Alps is released with ascent of the warm air over northern Italy and descent of the cold air north of the mountain barrier, when the frontal zone crosses it. Since the ascent of the circulation is working above the orographically forced descending motion at the lee flank, the resulting vertical stretching leads to horizontal convergence and corresponding production of cyclonic vorticity below the level of the strongest upward motion.

A diagnosis of these effects can be made with the aid of the Q vector. Its component transverse to the isotherms indicates frontogenesis in the geostrophic flow when pointing towards the warmer air, and the divergence of this component describes the forcing of the vertical motions belonging to the transverse circulation.

Case studies of cyclonic developments south of the Alps connected with front passages from the north have demonstrated the correctness of this argumentation. They also have shown, however, that the scheme proposed by Mc Ginley does not reflect the complete picture of the development. According to Q vector diagnostics, there are also divergences of the vector component along the isotherms effective leading to a succession of descent and ascent along the frontal zone with a forcing of descent over southern France and southern Germany including the eastern Alps and a forcing of ascent over northern Italy and the western Alps as well as east of the Alps. This is also due to the flow splitting forced by the Alps since through that not only the temperature gradient is increased, but also the direction of the isotherms is changed and that differently along the frontal zone. The isotherms are deformed in a way that cold bulges develop at the flanks of the Alps whereas along it the isotherms assume an anticyclonic (or at least less cyclonic) curvature. Connected with these changes there is a forcing of descent in the cold bulges and of ascent in between covering the relatively warm air.

The contributions from both Q-vector components to the total forcing partly compensate, but also reinforce each other at some places. The latter is true for northern Italy where both contribute to an ascending motion leading to the described cyclogenetic effect.

2.7 TRANSFER OF HIGHER PREDICTABILITY FROM A LARGE SCALE NWP-MODEL TO SMALLER SCALES BY STOCHASTIC DOWNSCALING

F. Huber-Pock, Ch. Kress, G. Skoda, A. Tiesner, Austria

NWP-Models with high resolution (LAMs) unfortunately produce insufficient results on short range predictability. Using as basical method of 'stochastic downscaling', a special variant of 'inverse' optimum interpolation, the authors discovered that it was possible to transfer higher predictability from a large-scale NWP-Model with better predictability over longer lead-times into smaller scales. Predictability tests for 2m-temperature, surface pressure and relative humidity over the Austrian Alps computed by help of the anomaly correlation coefficient (ACC) and the reduction of variance (RV) demonstrate the possibility mentioned above.

In nearly all cases the loss of predictability in the considered small scales is only marginally higher than the loss in the ECMWF-parent model.

2.8 **PREDICTION OF MOUNTAIN CUMULUS IN THE COLORADO ROCKIES**

Thomas Haiden, U.S.A.

The onset of cumulus clouds in the Rocky Mountains of Colorado is modelled using a high-resolution (dx=1km) simplified mesoscale model. The model has been designed to predict the daytime evolution of the convective boundary layer (CBL) under the combined action of a large-scale flow and thermally induced up-valley and upslope flows. Cumulus cloud formation is modelled by releasing buoyant parcels from the surface layer, simulating their ascent using entraining parcel equations, and checking whether they are able to reach their lifting condensation level and level of free convection. The purpose of these simulations is twofold:

First, the interplay of various forcing mechanisms in mountain cumulus formation is studied. For example, it is shown how the timing of cumulus initiation upwind from a ridge is controlled by the growth of the CBL. Moisture ist transported upwards by CBL turbulence and then dynamically lifted by flow over the ridge. On the downstream side, the convergence of thermally-induced upslope flow with the large-scale flow is shown to be essential for cumulus initiation. This confirms the results of earlier studies of the 'lee-side convergence' mechanism.

Second, the performance of the model as a real-time forecasting tool is evaluated. Initial and boundary conditions are taken from MAPS (Mesoscale Analysis and Prediction System) analyses and forecasts. Predicted mountain cumulus cloud patterns and onset times are compared to GOES data and visual observations.

2.9 **THUNDERSTORMS IN THE KHUMBU HIMAL**

Yolanda N. Rosoff, E. E. Hindman, U.S.A., Kedar Koirala, Nepal

In light of the fact that during the pre-monsoon period in the Northeast of the Indian subcontinent, thunderstorms are almost a daily occurrence, this study attempts to show how convective activity is initiated in the Khumbu Himal by relating the daytime up-valley flow to synoptic conditions. At the higher - over 5000 m - elevations in the Khumbu, the up-valley flow that delivers humid, warm air from the Terai by mid to late afternoon has been observed to combine with the prevailing upper air westerly flow, resulting in an orographically lifted field of convergence. This convective activity sometimes supports the formation of thunderstorms, and sometimes not. This behaviour appears to be dependent on upper air temperatures. Northerly flow at the surface and at the 6000 m level in the Khumbu have suppressed thunderstorm activity, even though conditions at Kathmandu further south were ideal. In addition, at elevations above 5000 m in the Khumbu, high daytime surface temperatures and dewpoints are not essential for thunderstorm formation, because convective activity is initiated above the surface where the core of the fast, moist valley flow appears to be located. At the surface above 5000 m, the up-valley wind has been observed to cease for long periods at midday. The goal of this research is to develop procedures for forecasting severe thunderstorm activity in the Khumbu Himal of eastern Nepal.

2.10 THE MEAN VERTICAL CIRCULATION FEATURES OVER THE TIBETAN PLATEAU AND ITS NEIGHBORHOOD

Zheng-An Qian, China

In order to obtain the clear picture of the mean 3-dimension vertical circulation over the Tibetan Plateau and its neighbourhood (TPN) and better to understand the precipitation climate over the TPN, the 30 year mean vertical motion fields and the mean meridional and zonal cells in summer and winter have already been computed and drawn in this paper, utilizing the NCEP/NCAR reanalysis gridded data for the ¦Ø,u, v, and z values from 1961 to 1990. The features of yearly variations of both the mean vertical motion and meridional and zonal circulation cells over the TPN and the likely reasons for them have been analyzed as well.

The main conclusions are as follows:

1. There is very clear yearly change of the mean vertical motion over the TPN. The downward motion over the TPN is dominant in winter half year but the upward motion in summer half year.
2. Following the yearly change of the mean vertical motion over the TPN, there are obvious yearly changes of the mean meridional and zonal cells. In winter half year, there exist three giant Hadley meridional cells in low latitudes of the Plateau, East Asia, and Central Asia meridians, respectively. There exists an indirectly Ferrel cell on the north side of the Plateau. But in summer half year, there are three giant monsoon cells in the low latitudes of the Plateau, East Asia, and Central Asia meridans (especially for the former two). There are the secondary Northwest Chinese drought meridional cell over the Northwest China which ascends from the north edge of the Plateau and descends on the its north side and causes the drought climate over the Northwest China and the North China semi-drought meridional cell over North China which causes the North China semi-drought Climate. In the Meanwhile, there is a giant westward zonal cell in the south of 32.5oN of the Plateau meridians.
3. It is possible that the yearly change of atmospheric heat source over the Plateau causes the yearly changes of mean vertical motion and meridional and zonal cells over the TPN.
4. The features of mean vertical motion and circulation over the TPN can well comprehend the precipitation climate over it.

3.1 ON THE REPRESENTATIVITY OF PRECIPITATION MEASUREMENTS BY RADAR AND GAUGES

Urs Germann, Juerg Joss, Switzerland

The representativity of point measurements can be estimated from the variogram (or, alternatively, the spatial autocovariance). We propose to use high-resolution reflectivity data of operational weather radars to determine the range of precipitation variograms in Alpine climates. The expected difference between point measurements, or point measurements and areal averages, is then calculated from the obtained variograms.

Because of the direct influence of the orography on precipitation physics we expect a complex picture of variograms in the Alps. In fact, the variogram significantly varies in time and space, and so does the representativity. The error of a gauge-estimate for the average hourly rainfall in a drainage basin may be negligible in stratiform rain but serious in a meso-scale convective system.

For 96 hours of heavy precipitation in the Southern Alps (MAP SOP, September 1999) we found, for example, that reflectivity variation is much weaker close to the crest of the Alps than in upslope regions. In regions with weak variation point values are representative for larger areas. These findings must be considered when interpreting point measurements, as e.g. in radar-gauge adjustment, or when correcting radar reflectivity seen aloft to obtain precipitation rates at ground level.

Keywords: Precipitation estimation, Representativity of measurements, Geostatistics, Variogram

3.2 **REMOTE SENSING OF PBL STRUCTURE IN ALPINE VALLEYS BY SODAR**

Stefan Emeis, Germany

The boundary-layer structure in mountainous terrain is much more complicated than over level terrain. The knowledge of this structure is important for air quality measures, and for the assessment of vertical exchange of heat, water, momentum, and trace gases over mountainous terrain. One possibility to learn about the vertical structure of the atmosphere in valleys is to operate a SODAR. Acoustic remote sounding gives data on wind and turbulence from the atmosphere's first kilometer. Both, 3-antenna sodars and phased-array sodars have been used.

This talk gives examples from field experiments made on both sides of the Alps. The data show the valley and mountain winds on a pass, in valleys and in the forelands near the orifices of major valleys, in winter and in summer. From this data we learned about the height of the boundary layer, about the height of nocturnal drainage flows, about the turbulence intensity, and about local secondary circulations. Near Innsbruck, two alternating modes could be observed in which a foehn flow entered the Inn valley.

Together with near surface meteorological and chemical observations especially the vertial mixing and the horizontal advection of pollutants can be assessed. Together with other meteorological observations (lidar, ultralight aircraft) the observations indicate a three-fold structure of the atmosphere over mountains like the Alps (valley boundary layer – mountain boundary layer – free troposphere). In the valleys we find a thermally and dynamically driven "valley boundary layer" which has much in common with the boundary layer over level terrain. In the height of the crests and summits we find a "mountain boundary layer" which covers larger parts of the Alps. This intermediate layer is mostly mechanically driven, although it is definitely influenced and modified by dry and moist convection over crests and summits. Stronger convection penetrates through this layer into the lower free troposphere above. In summer the boundary between the mountain boundary layer and the free troposphere can be found in heights around 4000 m.

3.3 OBSERVATIONS FROM THE FRENCH ST-RADAR NETWORK DURING MAP: CASE STUDIES OF PV STREAMER PASSAGES AND RHONE VALLEY WINDS (MISTRAL)

J.L. Caccia, B. Campistron, P. Currier, F. Girard-Ardhuin, V. Klaus, Y. Pointin and E. Richard, France

The Mesoscale Alpine Program (MAP) international cooperative campaign took place over and around the Alps between 99/09/07 and 99/11/15 and was devoted to the study of the interactions between large scale processes and the mesoscale flow over a complex mountainous terrain. The scientific objectives can be summarized as follows: (1) orographic precipitation mechanisms, (2) incident upper-tropospheric PV anomalies, (3) hydrological measurements for flood forecasting, (4) dynamics of gap flow, (5) unstationary aspects of foehn in a large valley, (6) three-dimensional gravity wave breaking, (7) potential vorticity banners, and (8) structure of the planetary boundary layer over steep orography. Numerous airborne and ground based instrumental systems and mesoscale numerical models were involved in the campaign, as well as radiosoundings and satellite observations.

During MAP the French ST radar research-network consisted of five VHF and three UHF profilers. Four VHF's (institutes: OMP/LA/CRA, LaMP/OPGC, SA/CNRS and LSEET) and two UHF's (institutes: EDF/LA/CRA and Degréane) were installed in southern France and one VHF and one UHF (institute: Météo-France/CNRM) were in Italy, in the Lago Maggiore target area. The VHF's provided 15-min time-resolution vertical-profiles of wind and vertical-SNR from the low troposphere up to high tropospheric or low stratospheric levels, depending on the instrument and/or the atmospheric conditions. The same kind of data were obtained by the UHF's, but from a few hundreds of meters up to about 3 km. All these instruments are therefore appropriate to experimentally document the time evolution and the vertical structure of mesoscale dynamic processes in their respective altitude ranges. VHF observations made during upper-level PV-anomaly passages (PV streamers) above southern France (IOP8/9/10/11 and IOP15) and Lago Maggiore area (IOP15), including jet-stream passages and tropopause variations, will be presented. IOP 8/9/10/11, i.e. the 10/22 to 10/26-days, is a typical period of incident upper-tropospheric PV-anomalies arriving to the Alps from the Atlantic ocean (study related to MAP objective (2)). Though meteorologically more complex, the same kind of processes occurred during IOP15, i.e. the 11/05 to 11/09-days. In addition, in this particular case the processes led to intense precipitations in and around the Alps (study related to MAP objective (1)). UHF observations of wind speed made at the exit of low-tropospheric Rhône-valley winds, also called Mistral (second part of IOP4 and first part of IOP15), will be also presented. The second part of IOP4, 10/01, and the first part of IOP15, 11/06-11/07, correspond to moderate and strong Mistral situations (study related to MAP objective (7)), respectively. Preliminary results have shown that our observations are consistent both between themselves and with synoptic-scale ECMWF-model analyses. Cross-comparisons with mesoscale model simulations should be made to allow the mesoscale aspects of the atmospheric dynamics to be really investigated.

3.4 **BOUNDARY-LAYER FEINSTRUCTURE DURING PRE-FOEHN**

Erich Mursch-Radlgruber, J. Vergeiner, Austria

During the intensive observation periode of MAP for Föhn cases a high resolution mini-Sodar was operate at the roof of the University building in Innsbruck. Profiles of wind and turbulence with a vertical resolution of 10m up to 150m above surface are analysed. The behaviour of the boundary layer structure during pre-Föhn situations will be discussed.

3.5 10 YEARS AFTER THE INTRODUCTION OF THE NEW SWISS RADIOSONDE SRS 400 - A SCIENTIFIC AND OPERATIONAL ASSESSMENT

H. Richner, J. Joss, B. Hoegger, D. Ruffieux, P. Ruppert, P. Viatte, G. Levrat,
Switzerland

In the late eighties, MeteoSwiss, industry, and scientists developed in a joint effort a modern, state-of-the-art radiosonde. The aim was to create an instrument that does not require calibration, neither of the individual sensors nor as a system. In a first version this goal was partially achieved: Air temperature is measured by a thermocouple. Pressure is determined by boiling 1 ccm of water, the boiling temperature being measured by another thermocouple. Subsequently, pressure is calculated using the Goff-Gratch equation for the saturation water vapor pressure. Thus, pressure and temperature observations are based entirely on basic physical constants (thermoelectric force and saturation water vapor pressure). For humidity observations, a commercially available carbon hygristor was employed in the original version of the sonde.

Since April 1, 1990, i.e., for over ten years, this sonde is operationally used at the aerological station Payerne (06610) and by the Swiss Air Force weather service. In total, more than 11'000 ascents were made. Reliability and accuracy of the data was continuously improved by statistical and scientific evaluations, identifying previously unknown or underestimated sources of errors.

A recent effort was made to determine and compensate the "radiation error", i.e., the heating of the air temperature sensor by the absorption of sunlight. By combining statistical analyses, laboratory experiments, and theoretical investigations, a best estimate was made. This value still leaves a difference in the stratosphere of a few tens of a degree between the day and night temperatures, which is believed to be caused by atmospherics tides.

Currently, the carbon hygristor is being replaced with a miniaturized dew point mirror. Since dew point temperature is simply measured with a third thermocouple, the original goal of a truly "physical" sonde has been reached. In addition, the dew point mirror allows reliable and highly resolved humidity measurements well into the stratosphere.

3.6 STATISTICAL TEST OF GEOGRAPHIC PARAMETERS DESCRIBING THE SPATIAL DISTRIBUTION OF TEMPERATURE AND RAINFALL IN THREE SECTORS OF THE ITALIAN EASTERN ALPS

C. Bisci, F. Dramis, M. Fazzini, M. Gaddo, Italy

The research aims at defining the geographic parameters which describe at best the spatial distribution of rainfall and temperature. To this end, thermo-pluviometric features desumed from historical records have been statistically described basing upon a rather large set of geographic and topographic parameters, trying to highlight the influence of each of them.

Three valleys located in the Italian Eastern Alps have been investigated, which were chosen for the relative abundance of recording stations located at varying altitudes, both inside them and in the neighbouring. The study areas are the Cismon Valley (Southern Dolomites), the Venosta Valley (Rethic Alps) and the Fella Valley (Carnic and Julian Alps). The above areas differ for both orientation and geographic position, thus allowing to analyse different micro- and meso-climatic conditions.

Geographic and topographic parameters taken into account:

Longitude	Elevation of the divide E	Distance from the valley head
Latitude	Elevation of the divide S	Sin of the valley head aspect
Elevation a.s.l.	Elevation of the divide W	Cos of the valley head aspect
Distance from the divide N	Distance from the outer Prealps	Sin of the slope aspect
Distance from the divide E	Distance from the main divide	Cos of the slope aspect
Distance from the divide S	Elevation of the main divide	Sin of the valley trend
Distance from the divide W	Elevation above the valley bottom	Cos of the valley trend
Elevation of the divide N	Width of the valley bottom	

The Cismon Valley trends ca. N-S. Even though both the Vicentine Prealps (Grappa Mt.) and the Vette Feltrine (Pavione Mt.) separate it from the Adriatic area, its climate is strongly influenced by Mediterranean humid and warm air-masses, which result in heavy precipitation rates (1'600-1'800 mm/y). Temperatures are influenced by the relatively small distance from the sea. In fact, annual averages are higher than it can be figured out basing upon altitude and latitude. The Venosta Valley trends ca. W-E and is completely bordered by high mountain ranges. As a consequence, precipitations are particularly reduced (locally less than 500 mm/y) and the thermal regime is typically continental, with relevant daily amplitudes, particularly along the valley bottoms. The Fella valley, which is articulated into different orthogonal sectors, receives more southern currents. Therefore, precipitations are abundant, exceeding 2'000 mm/y in the hilly area to slowly decrease moving mountainwards. In parallel, thermal regime passes from sub-littoral Adriatic to continental with very cold winter. For all the recording stations located in the above study areas (ca. 30 for temperatures plus some 50 for pluviometric data), climatic features desumed from the available records for the 1960-1990 time span have been compared with a set of geographic and topographic parameters, the most relevant of which are listed in the table. Statistical analyses allowed to connect climatic characteristics with local geographic features through equations which explain a fair amount of variance. Adopting these equations it is possible to improve both interpolation and extrapolation of recorded data, and, subsequently, to draft good climatic maps. To do this, an accurate DEM is needed for the semi-automatic production of the various data layers (one for each of the geographic parameters which are considered). Basing upon the latter it is then possible to reconstruct for the whole territory the distribution of all the above parameters and, consequently, of climatic features. For each of the study areas, stations have been individuated which are representative for the local average climate. For the latter, climatic trends have been studied for a time span of ca. 70 years, aiming to point out variations which could possibly be connected with global change.

3.7 **THE SPATIAL INTERPOLATION OF THE DAILY PRECIPITATION IN THE MOUNTAINOUS REGIONS IN SLOVENIA**

Damijana Kastelec, Tomaz Vrhovec, Slovenia

The universal kriging and cokriging were used for spatial interpolation of daily precipitation measured on meteorological observation stations in the North-Western mountainous part of Slovenia. Data from the Special Observation Period (SOP) in the MAP Project, especially from IOP 3rd - 4th October 1999 and 23rd - 26th October 1999 were analysed. During MAP SOP there were 25 additional precipitation stations with recording pluviographs in that region.

First, some exploratory methods were used for data control and for analyses of the relations between precipitation and some geographical variables like altitude, latitude, longitude, slope and aspect. The significant relations were taken into account when universal kriging procedure was developed.

We present results of different kriging models for spatial interpolation of daily precipitation. The importance of the data from the additionally observational stations was evaluated on the basis of the comparison of spatial distribution of precipitation: we compared the results if only data from operational network were used with the spatial distribution of precipitation using also the data form additionally observational stations. Different grid resolution (100 m, 500 m, 1km, 4 km) and the appropriate influential surroundings were studied. The cross-validation technique was used for the verification of the results.

3.8 REMOTE AND IN SITU MEASUREMENTS OF LOCAL FLOWS GENERATED BY A KNIFE-EDGE MOUNTAIN

C. G. Helmis, H. A. Flocas, J. Kalogiros, D. N. Asimakopoulos, Greece

Hymettos mountain is a 1024 m high knife edge obstacle that runs along north-south direction within the Greater Athens Area. Its western side is a complex terrain slope consisting of crests and slopes with different orientation while its eastern side is rather homogenous, non urbanised with low and sparse vegetation. University of Athens has developed its own remote and in situ instrumentation that has been used in the last five years in studies of downslope flows generated along both sides of Hymettos mountain..In particular, the instrumentation consists of: a) three-axial high resolution sodar, capable of measuring in real time the horizontal and vertical wind speed and the wind direction with a maximum range of 350 m, b) high range vertical monostatic sodar, capable of measuring in real time the vertical component of the wind and the thermal turbulent structure of the atmosphere (facsimile record) up to a height of 800 m, c) meteorological masts allowing measurements of air temperature, wind speed and direction at different heights, d) tethered balloons, capable of measuring wind speed speed and direction, temperature and humidity up to the height of 900 m. In addition, the study of katabatic flows in the western side was supported by a 84 m high meteorological tower with measurements at three different levels. The aforementioned instrumentation has been employed at the top, slope and foot of the mountain and at various distances from the feet of the mountain providing simultaneous measurements. The objective of the paper is to present an overview of the main results about the local flows that generated by Hymettos mountain, as derived from experiments being carried out in both slopes. It was found that the katabatic flow in the western side of the mountain is characterised by small depth as it is affected substantially by the westerly background flow while is usually discontinuous and develops in different successive phases that is more likely associated with the thermal mechanism responsible for the development of the phenomenon. The flow can arrive marginally at a distance of 1.5 km being substantially weakened. In the eastern (lee) side of the mountain, the katabatic flow appears similar characteristics with those in the western side. However, it is more interesting to note that strong background westerly flows may lead to the development of intense downslope winds along the lee side. Strong downdrafts of the order of 4-5 ms-1, within the first 600 m above ground, and characteristic vertical turbulent structures appeared, that persist weaker under unstable and neutral conditions in the atmospheric boundary layer. Such structures had not previously been observed in the temporal and space detail provided by modern sodars. It was also shown that these type of disturbances can reach the nearby plain area, 12 km away from the foot of the mountain.

3.9 MODELLING AND EVALUATION OF THE RIME-ICE DEPOSITION IN THE MOUNTAIN REGIONS OF BULGARIA

Emil Moralijski, Bulgaria

Because of the favourable location of the territory of the country with respect to the ways of the Mediterranean cyclones exceptionally powerful depositions of rime-ice are observed in the Bulgarian mountains. The beginning of the measurements on the process of rime-ice depositing in Bulgaria is posed in 1949 on peak Cherny (2286m above see level). Later on these measurements continue on special frames installed on five alpine peaks with altitude above 1000 m (and in a meteorological station under this level (850m) also). Because of the small number of these points, a physical-statistical model is developed for calculation the parameters of the deposited rime-ice on the basis of data from the standard meteorological observations. Empirical relationships between the rime-ice density, the water content in the fog, the size of water droplets as well as the air temperature and the fog visibility are established. A special attention is paid to the coefficient of deposition (calculated using Lengmoure' and Mazin's approach). A software (RIME) giving as output the parameters of the deposited rime-ice mass on cables with different diameters and orientation (with respect to the four cardinal points) is worked out. For the central mountain area of the country vertical profiles are drown up for the values with different integral probability of the radius and the mass of the deposition. A part of the results are applied in 'Up-dating of the cimatic conditions for mechanical determining the parameters of the air high- and middle-voltage conductors on the territory of the mountain regions in Bulgaria' for the needs of the National Electric Company.

4.1 TOWARDS AN ALPINE-WIDE DATA-SET OF TEMPERATURE AND PRECIPITATION VARIABILITY OF THE INSTRUMENTAL PERIOD

Reinhard Böhm, Ingeborg Auer, Wofgang Schöner, Austria

One of the objectives of EU-project ALPCLIM is the generation of a gridded data-set of monthly instrumental temperature and precipitaion data. The area of investigation covers the Alps and wide regions of the surroundings from 2 deg W to 18 deg E and 43 to 48 deg N. Grid distance is 2 deg longitude and 1 deg latitude. More than 120 single series have been homogeneity tested and adjusted using both meta data information and relative homogeneity tests. The average station density is 2 series per grid box. The project is not finished yet. By the time of the ICAM-conference, the temperature data-set will be ready for use already, the precipitation data-set will still be in the state of homogenising. The presentation shows results of first analyses on spatial correlation within the Alps (both horizontal and vertical) and of the Alps versus the whole of Europe. Furthermore first results can be shown, dealing with the main purpose of the generation of the instrumental data-set – to use the instrumental data to create a longer proxi-data-set based on stable isotope ice core data from high elevation sites in the Monte Rosa and Mont Blanc region. Whereas Alpine instrumental data start at 1760, the ice core proxis are supposed to be at least 500 years long. The precipitation series will be used to analyse the problem, that ice-cores in principle carry information only for precipitation days, not for all days. Analyses on daily temperature and precipitation data of 50 years series have shown already a way to construct "precipitation-mass weighted mean temperatures" for the longer series based on monthly values. The degree of correlation of those precipitation-mass-weighted temperatures with real temperatures will decide on the possibility to use stable isotope proxis from high level sites as temperature information.

4.2 TEMPERATURE DIFFERENCE BETWEEN HIGHLANDS AND PLAIN METEOROLOGICAL STATIONS: THE CASE OF SONNBLICK AND VIENNA

Raymond Sneyers, Belgium

The definition of randomness of a time-series being independent of the underlying distribution of this series, distribution free tests have to be applied for its statistical analysis. For the comparison, the most powerful tests used for the purpose are the distribution free ones derived from the equations defining the null hypothesis, and applied on the ranks of the series.

For the particular example of the two mentioned stations, statistical homogeneity being realised when the rank differences are random, the analysis reduces to the search of inhomogeneities (change-points) separating random sequences in these series of differences. In addition, results are finalised with parametric tests, after verification of the validity of the normality of the distribution for the original series of difference values.

Applied on the annual averages and on the seasonal ones, conclusions are derived for the orographic effect in continental stations.

4.3 **SENSITIVITY OF THE MOUNTAIN ZONE IN ROMANIA TO THE CLIMATE GLOBAL CHANGE**

Ileana Mares, Constantin Mares, Romania

The temperature and precipitation fields from Vf. Omu (Man Peak), the highest station from Romania in the period 1928-1998 are analyzed. The non-parametric statistical tests, estimates of the signal -to noise ratio are applied in order to emphasize trends and climate change points. Time series are fitted by AR-MEM (autoregressive, maximum entropy methods) models by means of the power spectra are constructed in order to test the statistical cvasi - periodicities.

Statistical characteristics as climate change points, cvasi-periodicities at the Vf. Omu are compared with the results obtained by others authors for the different mountain stations from Europe. The 500 hPa height over Atlantic-European region is filtered by the statistical significant EEOFs (extended empirical orthogonal functions) and by the circulation index. The link between climate behavior of the 500 hPa over Europe and response of temperature and precipitation amounts time series from mountain zone are achieved by CCA (canonical correlation analysis) application.

Also using the outputs of ECHAM 3-42 model with time-slice experiments of 2* CO^2 and 3* CO^2 concentration, the sensibility of the mountain climate to the global change due to increase of CO^2 is emphasized.

4.4 EXTREME DAILY PRECIPITATION TOTALS IN SLOVAKIA SINCE 1950 AND POSSIBLE DEVELOPMENT IN 21ST CENTURY

Pavel Fasko, Milan Lapin, Pavel Stastny, Slovakia

The area of Slovakia is about 49,000 sq. km and about one third of it can be considered as mountainous area. More than 700 precipitation stations are in the operation in Slovakia each year. 607 of these stations have sufficiently reliable time series to obtain maximum daily precipitation total for each individual month in the 1950-1999 period, but only at about half of them they are those which are complete without any interruption. This is probably sufficient database for obtaining new knowledge predominantly in areal analysis of heavy daily precipitation events. Increasing number of local floods caused by heavy rains and exceptional rain intensities occurred in Slovakia by the end of 90th. This initiated the statistical analysis of maximum daily precipitation totals. The areal distribution of heavy rains is significantly different compared to monthly precipitation totals. No regular altitudinal increase was observed at maximum daily totals. The upper Váh river catchment (7,122 sq. km) can be considered as one of the mostly loaded mountainous area by heavy rains in Slovakia. This area was selected for more complex analysis. Presented statistics of 50-year period's daily maximum precipitation elaboration for the upper Váh catchment is the most profound analysis made in Slovakia up to present. The analysis of annual course of maximum daily precipitation totals is included. The statistics of 100, 50, 10 and one year returning periods have been calculated at maximum totals by several statistical methods. The most significant two precipitation events in the 1950-1980 period and two in the 1994-1999 period have been analysed more in the details. Preliminary analysis showed a close correlation of high daily totals with high specific humidity at the 850 hPa level. Outputs of the Canadian coupled General Circulation Model indicate possible rise of specific humidity at the 850 hPa level by about 30% during the 21st century. Simple model calculation leads to the expectancy of considerable rise of the maximum daily precipitation totals in Slovakia during next 100 years. The more detail elaboration of daily totals for the Hurbanovo station (115 m a.s.l., south-western Slovakia, 1900-1999 period) is included for comparison.

4.5 EFFECTS OF LARGE SCALE PHENOMENA ON TEMPERATURE AND PRECIPITATION ANOMALIES IN THE CARPATHIANS

Daniela Paliu, R. Bojariu, Romania

This paper analyses the relationships between large scale phenomena and regional modes of climatic variability in the area of Carpathians mountains. Datasets consist of monthly precipitation amounts and temperature means from 19 stations which span the interval 1961-1990. Data used are seasonally stratified in order to eliminate the influence of annual cycle and to focus on interannual to decadal variability.

The connections between local and large scales are identified using canonical correlation modes (CCA) which relate temperature and precipitation anomalies to sea level pressure and geopotential height fluctuations.

The effects of certain dominant modes of climate variability such as North Atlantic Oscillation (NAO) and Eastern Atlantic Pattern (EA) in the Carpathians area will be also estimated using correlation coefficients between NAO, EA indicies and local climate parameters. The trends in time coefficients which modulates CCA modes will be compared with the trends exhibit by large scale indicies in order to identified statistically significant climate change signals.Non parametric tests will be used for this purpose. The results obtained in this paper will constitute a basis for regionally orientated system for diagnosis and prediction of climate variability and change of temperature anomalies and precipitation amounts in mountains area.

4.6 ON THE FEATURES AND REASONS OF THE EUROPEAN CLIMATE VARIABILITY

A. Polonsky, D. Basharin, N. Mickailova, E. Voskresenskaya, Ukraine

The goal of the presentation is to discussed the manifestations and possible reasons of the European climate interannual variability using ECMWF Re-Analyses Sample Daily Data in 1979 to 1993, monthly data on the characteristics of the Atlantic centers of action (Azores High and Iceland Low), Rossby/NAO and Southern Oscillation indexes in XX century, and Russian analogy of the COADS. Special attention is paid to the Central European Climatology including the Alpine region.

It was shown that the synoptic temperature variability prevails over the European and Mediterranean areas in summer/autumn, while in winter the interannual fluctuations are responsible for about a half of the daily temperature variance over the most of the European region. It is due to the temporal-spatial storm-tracks' variability associated with the interaction in the coupled ocean-atmosphere system. The influence of the NAO and ENSO-type variability on the location and intensity of the storm tracks over the North Atlantic and European/ Mediterranean region manifests in intensification and displacement of the storm tracks to the North/South during strong/weak phase of the NAO. As a result, there are two typical winter regimes with the storm tracks over the Northern Europe and over Mediterranean region. Significance of the ENSO signal in the European region is at a maximum March/April when the typical ENSO event begins. The most prominent anomalous conditions over the Europe coincide with the intense Pacific El/La Nina events (Table 1). In particular, climatology of the Central Europe and Alpine region is characterized by strong interannual variability associated with the phases of the NAO and SO.

Table 1. Ratio of number of the grid points with significant anomalous variance of daily winter temperature during Pacific ENSO-events to average number of the anomalous grid points (criterion of abnormality after [Polonsky et al., 1999]).

Month	Jan	Feb	Mar	Apr	Mean annual criterion
Criterion of abnormality	1.16	1.01	3.20	1.66	1.41

4.7 CIRCULATION AND CLIMATE FACTOR, DETERMINING SEVERE WINTER

Latin Latinov, Bulgaria

The purpose of the present work is to determine the factors leading to severe winters and use them in the prognostic practice. It could be useful for reducing of the losses from severe winters in Bulgaria.

Analyzing mean winter temperatures in the period 1990-1998, thirty-three cases of severe winters were found out and studied. There are comparatively warm periods during cold winters, but usually greater number of cold periods defines character of the winter.

Radiation cooling has a considerable role in formation of the negative winter temperature anomalies. In almost all-severe winters, one of determined factors for the negative anomalies was the presence of thicker and steady snow cover than in case of normal conditions. Periods with snow cover in North Bulgaria were usually very long. These conditions were optimal for fog formation, too. During the most severe winters rivers have frozen and in a certain periods freezing of the Danube was observed.

During severe winters zonal transport was strongly disturbed or the frontal zone has been situated the Northerly of its mean position and the Atlantic cyclones have rarely entered over the continent. Meridional forms of atmospheric circulation have predominated. Europe has been often under the influence of anticyclonic baric field. This, to a great extent, refers to the Balkans. Cyclones have usually moved away over the continental periphery. Mediterranean cyclones on the trajectory Southerly of Bulgaria predominate, but frequently they have lower power. Areas with high pressure in the Azorian anticyclone have usually developed in the Northeasterly to the Scandinavian Peninsula, as subsequently are expanding to the South and Southeast and connecting with the Siberian anticyclone. Anicyclones formed in this way over the continent have restored constantly and their life was 15-20 days. Connection between the Azorian and Siberian anticyclones leads to continuous pervasion of cold air over the Middle Europe and Balkans and Arctic air has frequently reached Western Europe. During particular years forming of severe winter was assisted from the high activity of Mediterranean cyclone center. In that case cyclones have passed to the South of Bulgaria. They have provoked formation of comparatively thick and durable snow blanket.

The observed synoptic situations in European – Atlantic natural synoptic region have many common elements, especially in the presence of the most severe winters. Simultaneously there are differences that could be described with three schemes of development of the atmospheric processes.

Typical peculiarity of the first is the zonal circulation in the European – Atlantic region with main frontal zone over the northern parts of the continent. Bulgaria is in the southern periphery of the belt with high atmospheric pressure as the flow near the surface is mainly weak from the east.

The processes in the development of the meridional circulation can be divided in two groups. In the first group in the region of the Balkans cold air rushes from northwest and north. The other group embraces mainly processes, blockade of cyclones in the eastern and central Mediterranean is typical and frequently restoration of a particular cyclone in the height over Scandinavian.

4.8 **TEMPERATURE-HUMIDITY CONDITIONS IN THE ALPINE ZONE ON THE TERRITORY OF BULGARIA**

Anelia Gocheva, Bulgaria

The temperature-humidity conditions are analysed on the basis of data from the available on the territory of the country meteorological stations with altitude above 1000m - the peaks Murgash, (1680m), Snejanka (1923m), Cherny (2290m), Botev (2376m) and Mussala (2925m). Statistical modelling of the air temperature, relative humidity, moisture content and enthalpy monthly distributions is accomplished. The corresponding appropriate approximating functions are established (using normal distribution, Gramm-Charlier's type A function, Pearson's system curves). A technique for approximation of distributions with different extent of asymmetry (including bimodal ones) by means of a linear combination of two Beta-type functions and using Nelder-Mid's simplex procedure is also proposed and applied. The climate variability of the examine characteristics is analysed and the probabilistic expectations for the nearest years and decades are estimated (using statistical extrapolation of the corresponding integral distribution curves approximated by Fisher-Tippet type II function). The temperature-humidity conditions in the examined alpine zone are compared with these ones typical for the territory of the country under 1000m altitude above see level.

4.9 **AIR TEMPERATURE AND RELATIVE HUMIDITY VARIABILITY AT THESSALONIKI AND OLYMPUS MOUNTAIN - GREECE**

Peter Pennas, Angeliki Arseni-Papadimitriou, Greece

The interdiurnal differences of the mean daily values of air temperature and relative humidity are calculated, at two Greek meteorological stations: the Aristotelian University of Thessaloniki (AUT, h=31m) and the Olympus Skiing Center (OSC, h=1750m). Three years (1993, 1994 and 1995) of data are used, for the months of July, August and September.

It is concluded that the higher percentage of the differences is identified into the very small classes: that is, ±2oC for the air temperature and ±5% for the relative humidity. Particular interest was focused on a certain number of extreme cases, of very low and very high differences.

5.1 REAL-TIME FINESCALE PRECIPITATION AND FLOOD FORECASTING DURING THE MESOSCALE ALPINE PROGRAMME (MAP)

R. Benoit, N. Kouwen, W. Yu, J. Innes, P. Pellerin, S. Chamberland, Canada

The primary objective of MAP is to improve the understanding and short term numerical prediction of Alpine precipitation, and particularly, heavy precipitation and flooding events. This objective requires a drastic improvement of our understanding of the flow dynamics at several scales. These features become potentially more predictable as numerical models improve in resolution and accuracy, and incorporate more advanced representations of physical processes. During the MAP Special Observing Period (SOP, September 15 to November 15, 1999), the MC2 Canadian non-hydrostatic mesoscale atmospheric model was run daily with a resolution of 3 km on a domain of 350x300x50 points. The daily forecast of precipitation and temperature was used to drive the hydrological model WATFLOOD/SPL developed at the University of Waterloo, Canada. Flow hydrographs were produced for both the Toce-Ticino watersheds as well as the Ammer river. In this way, the hydrographs provided a real-time daily feedback on the quality of the precipitation fields generated by MC2.

An evaluation of the precipitation and of the streamflows forecasts is presented with attention to the three hydrologically significant episodes that occurred during the SOP. Two were heavy rainfall events while the third was a snowfall event. The MC2/WATFLOOD combination provided a good flow forecast for the first rainfall event while the second rainfall was under estimated. The snow event was significant as MC2 properly predicted a snow event, and resulted in a non-runoff-producing event . In flood forecasting, a false positive flood forecast will reduce the confidence in future forecasts so the prediction of a non-event is a significant benefit. We can thus count two successful forecasts out of three possibles.

5.2 HYDROLOGICAL MEASUREMENTS DURING THE MAP-SOP AT THE LAGO MAGGIORE TARGET AREA

M. Menziani, S. Pugnaghi, S. Vincenzi, L. Pilan, Italy

The Ticino-Toce watershed is one of the MAP-SOP target areas, named Lago Maggiore target area, chosen because of the frequent and heavy precipitation events occurring there. Several Italian teams (Hydrology working group and Planetary Boundary Layer working group) operated jointly in this target area, during the MAP Special Observing Period (7 September-15 November), in order to study the effect of the soil moisture on floods in mountain areas and the influence of the soil characteristics on the evapotranspiration fluxes. The soil moisture measurements performed by the team of the Osservatorio Geofisico (University of Modena and Reggio E.) in the Ticino-Toce watershed will be presented. All the measurements utilise the Time Domain Reflectometry (TDR) technique.

To monitor the water content of the upper part of the soil (70 cm), 15 buriable TDR probes were set up in a wide field in the Toce River valley. Measurements were automatically collected at four hours steps, starting at the end of March 1999 up to the end of SOP (15 November 1999). Furthermore other TDR measurements were collected manually in other sites of the Toce valley, during two intensive field measurements campaigns, while a passive radiometer (in the microwaves range), on board of a helicopter, was operating. The availability of precise TDR soil volumetric water content measurements should allow validating the remotely sensed data.

The long file of data automatically collected over a period of about six months enables to highlight several aspects of the soil moisture dynamics. The time evolution of the soil water content daily profiles shows peculiar aspects during wet and dry periods. A daily cycle is present at all the measured depths and its possible significance will be discussed. The soil drying between heavy precipitation events is treated by means of the mass balance equation to compute the cumulative evaporation or evapotranspiration in the period. The soil moisture change after a precipitation event is obtained as a function of the precipitation itself and of the soil moisture condition before the precipitation.

5.3 SHORT-TERM STREAMFLOW FORECASTS USING GLOBAL-SCALE ATMOSPHERIC FORECAST MODELS

Lauren Hay, Martyn P. Clark, George H. Leavesley, U.S.A.

In this study, 38 years (1958-1996) of 8-day forecasted precipitation (PRCP) and maximum and minimum temperature (TMAX and TMIN) from phase one of the National Center for Environmental Prediction (NCEP) Reanalysis (horizontal grid spacing of ~210km) were used as input to a distributed hydrologic model, to forecast streamflow in the Animas River basin. The Animas is a small (1820 km2) mountainous (2000-4000m) river basin located in southwestern Colorado, United States. To assess the benefits of atmospheric forecasts in hydrologic models, the U.S. Geological Survey's Precipitation Runoff Modeling System (PRMS) was forced with three sets of PRCP, TMAX, and TMIN: (1) station data; (2) climatological values; and (3) NCEP 8-day forecasts with the systematic biases removed. PRMS output forced with station data were used as "truth" to focus attention on the hydrologic effects of errors in the atmospheric forecasts. The climatological values can be considered similar to the mean value from an extended-streamflow prediction procedure and provide a baseline for measuring the skill of hydrologic forecasts when forcing PRMS with the NCEP 8-day forecasts.

Using climatology, some skill in runoff forecasts was achieved at the beginning of the forecast cycle. This can be attributed to the lag time in PRMS and stresses the importance of accurately specifying initial conditions. Significant skill was present in the NCEP TMAX forecasts in spring and autumn and in the NCEP TMIN forecasts during winter. The reliable TMAX predictions translated into reliable estimates of snow melt and runoff with forecast errors much lower than those generated using the climatology. Skill in the NCEP PRCP forecasts was poor. Apparently useful forecasts using NCEP output occur because the Animas River basin is dominated by snow melt (which is influenced by variations in temperature), and may not hold in other river basins where the surface hydrology is predominately influenced by rainfall. The coarse horizontal resolution of the NCEP model is responsible for the large forecast errors, therefore methods that resolve subgrid scale information in the forecasted fields is needed.

5.4 IMPROVEMENTS OF RUNOFF PREDICTIONS FOR AN ALPINE BASIN BY MEANS OF METEOROLOGICAL FORECAST DATA

Hubert Holzmann, Hans Peter Nachtnebel, Martin Bachhiesl, Austria

Short term forecasts of surface runoff are an essential prerequisite for several water managemental aims like flood prevention measures or optimisation of hydro power utilisation. In a joint applied research project with meteorologists and hydrologists a rainfall runoff model was developed and calibrated for the main Austrian river catchments. The aim of the project was the provision of specific runoff predictions for a three days forecast period. This information supported the national hydro energy provider in the estimation of the capacity of hydro energy production for the next days. The paper aims a comparison of forecast performance under optimal knowledge of the real input, under utilisation of meteorological forecasts and under persistence assumptions, which means the continuation of the past values for the next day. A representative example of an alpine catchment is given.

The duration of the runoff formation process between the rainfall event and the runoff response is about one day for most alpine catchments. Thus the simple transformation of rainfall into runoff provides only a short lead time for predictions. The direct use of meteorological forecasts of precipitation and air temperature by means of meteorological models, which are available up to 96 hours, expands the potential lead time significantly.

The components of the developed hydrological rainfall runoff model consist of a snowmelt module and a multiple storage module which separates the runoff in a quick, intermediate and slow component. The snowmelt module uses an altitudinal discretisation. Snow accumulation and depletion are estimated by the temperature index method considering the specific temperature gradient. The meteorological data are based on the ALADIN (3h – 48h) and the ECMWF Model (48 – 96h). All meteorological data are provided by the meteorologists as mean areal data for each catchment. These data are estimated by spatial interpolation of the grid values.

The performance of the runoff forecast estimates are, besides others, dependent on the reliability of the meteorological predictions. The quality of these data rely on the type of the rainfall events. Local convective events are sparsely represented by the models. Thus the results are better for advective events with longer durations and uniform intensities. The snowmelt processes could be described reliably by the temperature index method. Some underestimation of the runoff exhibited for the first snowmelt event in the spring period. This is caused by some conceptual shortcoming of the hydrological model. For high altitude catchments the consideration of glacier depletion methods could improve the model performance for the summer period.

5.5 HORIZONTAL RESOLUTION IMPACT ON THE HYDROLOGICAL SIMULATION OF THE DURANCE HIGH ALPINE CATCHMENT

Pierre Etchevers, France

The high altitude Durance river catchment is located in the southern French Alps. This basin, with a 2170 km2 surface area and an average altitude of 2149 m, is the largest mountainous French basin not perturbed by a dam. It is particularly interesting for alpine hydrological studies because the Durance regime is typically snowy and that is why it has been modelled by hydrologists since 1965. In our study, the major hydrological components of the catchment are modelled from 1981 to 1994 with an explicit resolution of the diurnal cycle of evaporation and snowmelt. The meteorological parameters are obtained from observations with the meteorological analysis system SAFRAN (especially adapted for mountainous areas) and provided at a one-hour time step. Particular attention is paid to the snow cover, which is simulated with the snow evolution model CROCUS. The soil-vegetation-atmosphere interactions are treated by ISBA, the water and energy exchange model operationally used by the French Weather Forecast Service. The underground domain is modelled with MODCOU, the hydrological macroscale model of Ecole des Mines de Paris. The reference simulation uses a 8 km grid to solve the surface water and energy balances. The soil and vegetation data sets are derived from French databases and satellite measurements. The results of the simulation are validated by comparison with the daily discharge observations of 3 gauging stations located on the Durance. They show a good estimation of the snowy regime of the Durance river, but the spring flash floods generated by the snow melt are generally overestimated. A second experiment has been done in order to study the impact of the model resolution on the simulated discharge quality. A resolution of 1 km has been used and the vegetation map has been improved. The simulation of the spring discharge is significantly improved. Therefore, the error of the maximum value of the spring discharge is reduced by 50 \%. The annual Nash criterion (calculated with daily discharge) is also improved from 0.72 to 0.8. The main explanation is the better simulation of the global snow cover because of the more realistic topography. The winter accumulation is a bit weaker and the melting process is more progressive and realistic. A third simulation consists of using only a single cell for the whole catchment (of about 46 km x 46km surface area) , which approximately corresponds to the best resolution of the actual climatic simulations. It shows that the parametrisation of snow is not adapted to this scale and that the simulated discharge does not correspond very well with the observations compared to reference simulation, whereas the annual partition of precipitation between evaporation and runoff is very close to the results of the reference simulation.

5.6 SIMULATION OF DAILY DISCHARGES FOR THE UPPER DURANCE CATCHMENT (FRENCH ALPS) USING DIFFERENT RESOLUTIONS AND SUBGRID PARAMETERIZATION

U. Strasser, P. Etchevers, France

The upper Durance catchment (2170 km², mean altitude 2149 m) is the largest montainous French basin not perturbed by a dam. It is a site of particular hydrological interest because its runoff regime is mainly driven by snowmelt.

This study describes the application of the coupled models SAFRAN (meteorological parameters), ISBA (soil-vegetation-atmosphere interactions) and CROCUS (snow evolution) for the simulation of the diurnal cycle of evapotranspiration and snowmelt. The results are validated by comparison with daily discharge observations of the station La Clapiere. The spatial resolution of the reference simulation is 8 km, the considered time period 1981 - 1994.

Previous investigations have shown a remarkable overestimation of the spring flood generated by snowmelt which could be significantly improved by increasing the model resolution to 1 km and thus taking into account the spatially variable snowmelt patterns due to strongly varying topography.

This study shows the impact of a better description of the physical processes concerning snowmelt for the original resolution of 8 km: in a first step each model box is divided in three subareas of equal size to take into account the strongly varying gradients of the utilized meteorological parameters and their influence on snowmelt dynamics. Second, those parameters are modified for forest conditions in conjunction with distributed landuse information. Finally, the glacier runoff contributing to the Durance river are respected separately.

On the other hand, the sophisticated, physically based model CROCUS is replaced by the comparably much simpler model ESCIMO, which simulates the snow cover and melt runoff based on the energy balance of one single snow pack. The goal of this investigation is to quantify the loss of accuracy by neglecting the detailed description of the processes within each layer of a snow pack.

The discussion of the results shows the quantitative influence of the different subgrid parameterizations and snow model schemes on the simulation results.

6.1 **ESTONIAN SNOW COVER ATLAS**

H. Tooming, J. Kadaja, Estonia

Snow cover is a climatically very important substance. Its presence or absence determines the surface albedo which shows whether the flux of incoming radiation is absorbed in the surface or reflected back into the atmosphere and space. Years are very different as for the duration of snow cover as well as for albedo and heat regime. In Estonia, the soil may sometimes remain covered with snow until the end of April, but there may be years without any snow cover at all. The rate of heat accumulation in the surface during spring depends to some extent on the albedo of late winter and early spring.

Snow on the surface accumulates great reserves of water. After snowmelt in spring, part of water runs into the soil meeting the plant requirements for water at the beginning of the vegetation period. This is particularly important in the droughty regions - on islands and coastal areas. Part of meltwater gets into rivers as runoff, increasing the current quantities and causing floods. Consequently, snow cover depth and water equivalent are of great importance to the water budget in catchment areas.

The task of the present atlas is to provide information on snow cover duration, snow cover depth, density and water equivalent in Estonia. Data on the time variation and areal distribution of these parameters over Estonia in different months and for the whole snowy season are presented. In addition the maps of snow cover duration and maximal depth for each year in the time span 1962-1997 are included. These maps provide comparative retrospect into the snow conditions. The tables of mean values of snow cover parameters for the whole Estonian mainland are presented for different months in the period 1962-1997 with their time series statistics. To answer the question whether the fluctuations in snow cover parameters and surface albedo remain stochastic or reveal climate changes of some kind, the maps and tables with the trends of snow cover duration, depth, density, water equivalent and surface albedo are included. Our point of view is that climatic fluctuation is also expressed in the changes of statistical indicators of meteorological elements. Therefore, the standard deviations of snow cover occurrence and territorial variability as well as their trends are presented in the atlas.

6.2 **SNOW CONDITIONS IN RILA-RHODOPE REGION OF BULGARIA**

Nadejda Petkova, Ekaterina Koleva, Bulgaria

The snow cover in Bulgaria is a seasonal phenomenon. The knowledge of snow cover extension and snow depth during the winter has a great importance to economy and people. Power industry needs of this information for water supply. Nowadays, the tourist sector wants to find areas with long cover period. On the long run, snow cover and snow depth data can used an indicator for climate change. Lately a growing demand of snow cover data observed during the resent decades was experienced. This interest has been aroused by more and more frequent droughts, occurred in the region.

The aim of the study is to describe the snow conditions and its variability in the period of 1935/6 to 1997/8. The basic data consists of number of days with snow cover, the date of the first and the last day with show cover and maximum snow depth. Variability of snow cover characteristics is compared with winter temperature.

6.3 **SIMULATION OF SNOWDRIFT OVER COMPLEX TERRAIN**

Yves Durand, Laurent Mérindol, Gilbert Guyomarc'h, France

Snowdrift forecasting is one of the main research topic of our centre (CEN/ Météo-France). This phenomenon is a key factor in the formation of slab which increases the avalanche risk. To achieve this purpose, the first step was to determine different thresholds of wind velocity based on field measurements. These thresholds take into account the different types of snow (faceted crystals, fine grains, crust, ...). In a second step, we use different kinds of numerical simulations for the wind and the other relevant parameters. The last step is the merging of these both previous sources of information through a software named " Sytron ". We will discuss the results and the validation of this approach. A special emphasis is done on the application of this simulation over complex terrain like Alps, in order to better take the snowdrift events into account in the forecast of accidental avalanche hazard.

6.4 METEOROLOGICAL CONDITIONS IN CASES OF RIME-ICING IN THE MOUNTAIN REGIONS OF BULGARIA

Dimitar Nikolov, Emil Moralijski, Bulgaria

The meteorological conditions in the mountain regions of Bulgaria are exceptionally favourable for powerful rime-icing leading to heavy damages especially on the electric power system. Depositions with mass up to 50 kg per linear meter are measured on the high-voltage conductors in the mountain regions. In the present work a detailed investigation of the meteorological conditions in cases of rime-icing in the mountain regions of the country is proposed.

The cases of rime-icing in 6 mountain meteorological stations (with altitude from 850 m up to 2925 m above sea level) for the period 1980-1990 are examined. Data from the eight-term (synoptical) observations are used. As the general characteristics (period of appearance, frequency, beginning, duration and ending of the phenomenon) as well as the basic meteorological characteristics determining the process of rime-icing (air temperature, wind direction and velocity, horizontal visibility in the fog) are investigated.

A special attention is paid to the change with the altitude of the main parameters characterising the phenomenon by analysing the corresponding vertical profiles (of the mean air temperature, wind velocity and duration of the process as well as of the frequency of the rime icing). The level is established (2400 m for the central part of the country) above which the examined characteristics change essentially.

6.5 HEIGHTENDED RISK OF AVALANCHES AND ATMOSPHERIC CIRCULATION IN BULGARIAN MOUNTAINS

Nikolay Mihnevski, Teodossia Andreeva, Bulgaria

Some cases of the avalanches during the last three winter-spring seasons in Bulgarian mountains (Rila, Pirin, Rodopi, Balkan, Vitosha) are presented and analysed in this contribution. The snow cover's thickness is tightly related to the value of snowfall during a given season. Atmospheric circulation and like result meteorological conditions play a significant role in snow cover forming. Snow structure reflects weather conditions existing at the time of snow cover forming. The snow surface changes thanks to snow deposition, melting, evaporation, erosion and sublimation.

The peculiarities of some large anomalies of temperature are analysed on the base of investigations as follows:

- areas distribution of the large anomalies for the territory of Bulgaria for the months;
- relation between the types of the anomalies of the air temperatures and precipitation for the whole month and its particular avalanche-dangerous periods;
- spatial distribution of the intensity of the centres with the large anomalies of the temperatures and precipitation.

6.6 **THE EFFECT OF TIBETAN SNOW ON ASIAN MONSOON AND RAINFALL**

Tong-Wen Wu, China

The interannual variability of Tibetan snow cover has much of regional characteristic. There are four main patterns of different spatial distribution (LS, ETHS, NCTHS, and SWTHS) of the Tibetan winter/spring snow. LS is characterized by light snow in the most area of the whole Tibetan Plateau, ETHS by heavy snow in the southeastern part, NCTHS by heavy snow in the northern and central part, and SWTHS by heavy snow in the southwestern part of the Tibet.

Some observations of the effect of the four Tibetan winter/spring snow patterns on Asian summer monsoon and rainfall are explored. On the whole, more Tibetan winter/spring snow is associated with colder Tibetan tropospheric atmospheric temperature and weaker summer sea-land thermal contrast between the equator and the Tibetan latitude belt and results in weaker subsequent summer South Asian monsoon. Associated with different winter/spring Tibetan atmospheric thermal condition, each pattern of the Tibetan snow results in the different subsequent summer Asian monsoon variation, atmospheric circulation and large-scale rainfall anomaly. For LS case, it is stronger South Asian summer monsoon circulation and more rainfall. Over East Asia, there is a clear zonal more and less anomalous summer rainfall interval strips: more rainfall in South China Sea, less in Yangtse River, China and Japan, and more in the Sea of Ochotsk. For ETHS or WSTHS case, it is vice versa; For NCTHS case, the variations of Indian monsoon and Southeast Asian monsoon are out of phase. Stronger Indian monsoon and weaker Southeast Asian monsoon are coincident to more anomalous rainfall in Indian monsoon area and less anomalous rainfall in Southeast Asia and associated with the complicated Eastern Asian summer anomalous rainfall.

7.1 MOUNTAIN WEATHER AND CLIMATE INFORMATION TAKING INTO ACCOUNT CUSTOMERS NEEDS

Tanja Cegnar, Slovenia

Weather in mountains is more variable and often more severe as in the low land. Therefore special weather forecasts for the mountain region are required, taking into account variability in time and space, but also possible severe weather events. To emphasize peculiarities of the mountain weather it is necessary to include some biometeorological relevant parameters to complement the usual meteorological information. Tourists should be aware of the complex effect of weather conditions on their well being for example their thermal comfort, increased solar radiation at high altitude, especially UV radiation.

Several tools to provide biometeorological relevant information have been developed in the past. Not all of them are appropriate to be used in forecast, some of them are not suitable for mountains, and some of them are not widely used and could be misinterpreted or confusing. Applying the same indices in the whole alpine region should be the goal. A good example of internationally agreed and widely used o biometeorological parameter is UV index.

But not only for the weather forecast, also descriptions of climate in mountains should pay adequate attention to the frequency of the extreme conditions, like very strong winds, or heavy precipitation, how often we have to face their combined impact, and include at least the most important biometeorological parameters.

7.2 **ROM-PROJECT - AIR MASS ANALYSIS BASED ON PBL SOUNDINGS AND TRAJECTORIES**

Kathrin Baumann, Harald Maurer, Gabriele Rau, Martin Piringer, Ulrike Pechinger, Austria

Within the project ROM (Rhine valley Ozone study in MAP), extensive boundary layer measurements have been conducted by ZAMG in the Rhine Valley south of lake Constance during the MAP SOP. Data from high resolution tethersonde and cable car sonde soundings of ozone, temperature, humidity and wind, are used to distinguish different air masses: free tropospheric air where the PBL has been eroded by the Foehn flow, mixed air coming from low-level Foehn flow and air from the upper valley atmosphere and "old" stagnating air below an inversion (cold air pool at lake Constance). The measured ozone concentrations are used as a tracer for these air masses. During some of the MAP Foehn IOPs, a distinct increase of the ozone concentration by downward mixing from above was observed by the sounding systems, when photochemical ozone production could be excluded. These measurements give an indication of the Foehn flow penetrating into the boundary layer.

Three-dimensional backward trajectories calculated from ECMWF analysis fields are used to investigate the origin of the different air masses, esp. the region from where high ozone concentrations are advected. Based on the trajectory calculations, the Foehn events of the MAP Special Observation Period between August and November 1999 are compared.

7.3 **METEOROLOGY AND OZONE IN THE NORTHERN ITALY**

Mauro Valentini, Italy

In 1999 has been performed a campaign of meteorological measurement and monitoring of air polluttants in the area between Milan and the Prealpine zone, in the Po Valley (Northern Italy).

The periods of the campaign covered both winter (February) and summer season (July and August); the main purposes was the characterisation of atmospheric vertical structure and the meauremnts of vertical profiles of air pollutants (O3 and NOx).

During the campaign advanced meteorological instrumentation has been operated: four sonic anemometers and two SODAR-RASS stations, together with rawinsondes provided data on turbulence and atmospheric vertical structure; vertical profiles of temperature, humidity, ozone and nitrogen oxides has been performed by the use of a light aircraft.

Some of the preliminary results of the campaign will be presented.

7.4 ANALYSIS OF TRACE GAS MEASUREMENTS AT SONNBLICK OBSERVATORY - AUSTRIA'S CONTRIBUTION TO THE GLOBAL ATMOSPHERE WATCH PROGRAMME OF THE WMO

August Kaiser, Austria

In co-operation with Germany and Switzerland (measuring sites: Hohenpeißenberg / Zugspitze, Jungfraujoch, "DACH-co-operation"), the Sonnblick Observatory contributes to the Global Atmosphere Watch Programme of the World Meteorological Organization. The participants in the Austrian GAW programme are: Umweltbundesamt Wien (trace gas concentration measurements), Universität für Bodenkultur (total ozone, UV-B), Technische Universität Wien (precipitation chemistry), Bundeskanzleramt (7Be) and Zentralanstalt für Meteorologie und Geodynamik (meteorology).

Assessing and understanding climate change and changes in the global chemical composition of the atmosphere can only be achieved through high-quality, strategically orientated observations free of effects of local or - most of the time - regional pollutant sources. The high elevated Alpine stations provide unique platforms to study changes in the "background" composition of the atmosphere in Central Europe. Nevertheless, sometimes thermally or synoptically driven transport from regional pollutant sources (e.g. vertical transport of polluted boundary layer air triggered by the topography) can create episodes with strong air chemistry differences. Therefore, the aim of the DACH co-operation is to develop operational filtering techniques to separate such episodes from the remaining data, referred to as "background".

In this paper, the first results of data-filtering will be presented and an outlook to further activities - early detection of trends, including measuring sites in Italy and Slovenia - will be given.

7.5 **ANALYSIS OF AIR POLLUTION LOAD IN THE INN VALLEY**

Michaela-Maria Hirschberg, Petra Seibert, Helga Kromp-Kolb, Austria

Traffic on motorways and federal highways is an important line source for the air pollution load in the large Alpine valleys like the Inn and the Wipp valley (Tyrol). Because of topographic restrictions the exchange of air masses and dilution are reduced in comparison with the lowlands. At critical weather situations the thermal induced local wind circulation is separated from the general circulation, yielding relatively high pollutant accumulations within the valley. In this study we use exhaust gas components (NOx, CO, CH4, SO2, VOC and particles) which are derived from traffic counting with respect on the composition of motor vehicles of each year. These data were combined with air quality and meteorological measurements at different sites for the 5-year period 1993-1997. By the means of episode studies the influence of high wind velocity and in contrast of stagnation will be investigated to answer the question which processes control the distribution and dynamic of pollutants. What are the effects of higher road toll or the ban for heavy transport vehicles during the night on the Brenner motorway (A13)? We set up a statistical model to predict the dependence of air pollution load in the Inn and Wipp valley on the emission and the meteorological situation. Results will be discussed.

7.6 **PRECIPITATIONS AND CHEMICAL DEPOSITIONS OVER THE SOUTHERN SWISS ALPS**

Giovanni Kappenberger, Urs Germann, Switzerland, Alberto Barbieri, Italy

The precipitation characteristics over the southern part of the Alps are discussed, using raingauge data series, radar data and chemical compositions of weekly sampled wet depositions. The sampling sites are located along the South North axis ranging from the foothills (300 m asl) to the southern alpine region. At the highest site (Robiei, 1900 m asl) a comparison has been made between two heated raingauges, one sampling "wet only" and another collecting "bulk" depositions. Furthermore, chemical characteristics of snow layers sampled at two different altitudes (Robiei and Basodino Glacier, 2'600 m asl) are discussed.

Wet depositions show large differences between summer and winter period in their chemical composition. To explain this seasonal variation, a meteorological model (Swiss Model) has been used in order to find out the origin of precipitation in the southern Alps.

At the foothills about 98% of the precipitation is falling out of air masses coming from the Po-valley. At Robiei, which is close to the watershed, an important part of the precipitation comes from the North, after having crossed the Alps. The Monte Lema radar station, located at 1'620 m asl, provides objective information on the precipitation and wind fields in the studied area.

The vertical wind profiles of Lema have been used to check the quality of the model trajectories.

Keywords: Wet depositions chemistry, Trajectories, Southern Swiss Alps, Radar Monte Lema.

7.7 VERTICAL POLLUTANT FLUXES AND BUDGETS ACROSS EUROPE - RESULTS OF A 6 MONTH TRACER RUN WITH SPECIAL CONSIDERATION OF THE ALPS

Gerhard Wotawa, A. Stohl, P. Seibert, Austria

Vertical transport and mixing are important processes determining pollutant concentrations in the boundary layer and the free troposphere over Europe. A correct treatment of these processes is crucial for all studies dealing with tropospheric chemistry and climate. The vertical exchange of pollutants emitted near the surface is determined by synoptic-scale ascent connected with frontal systems (warm conveyor belt mechanism), by forced ascent due to the presence of mountain ranges (and by resulting gravity wave motions) as well as by deep convection. By means of a 6-month tracer simulation of anthropogenic CO and NOx emissions all over Europe based on ECMWF analysis data, we try to quantify the importance of these processes alltogether, and we try to assess the role of the Alps on a European scale in determining vertical transport and mixing.

THE SOUTH FOEHN OF OCTOBER 30 1999 - PORTRAITS BY MC2 AND OBSERVATIONS

T. Exner , G. J. Mayr, Austria

The results of a comparison of dedicated forecasts by the MC2 model during the Special Observing Period (SOP) of the Mesoscale Alpine Programme (MAP) in fall 1999 and observational data are presented here. The south foehn along the Brenner cross section started at night of October 30, 1999, and ended in the morning of the following day with the passage of a weak cold front. The flow above the alpine crest was mainly westerly making it a case of shallow foehn. The pressure difference between Verona and Munich was about 8 hPa.

The comparison between model results and observations is confined to a swath between Verona and Munich, which includes the major, roughly north-south running valleys on both sides of the Brenner pass, the lowest gap in the Alps. The observational data set consists of the dense network of stations operating during the SOP of MAP (70 surface stations, 2 rawin soundings, lidar-, sodar- and aircraft measurements) in addition to permanent GTS and regional surface stations and the rawin soundings in Milano, Udine, Innsbruck and Munich. The model data are from the Canadian nonhydrostatic MC2 (grid distance 3 km), which is nested into the hydrostatic Swiss Model (grid distance approx. 14 km).

Cross sections of potential temperature and wind will be compared as well as surface pressure distributions on the lee side of the Brenner pass as an integral measure of the atmospheric processes aloft - even if the actual and model topographies differ greatly: 3 km grid distance is still too coarse to completely resolve the north-south valleys.

INVESTIGATION ON TWO HEAVY PRECIPITATION CASES ON EASTERN PO VALLEY DURING THE MAP-SOP

Mauro Boccolari, Paolo Frontero, Luca Lombroso, Sergio Pugnaghi,
Renato Santangelo, Alessandro Bruscagin, Italy

During the MAP Special Observing Period (SOP) the data related to two interesting heavy precipitation (HP) events in the northeast of the Emilia-Romagna region were collected.
The first was an unpredicted isolated convective system originated mainly at the border between the Province of Modena and Bologna at the end of the first MAP - Intensive Observing Period (IOP-01). The second was an early heavy snowfall, just few days after the last MAP-IOP (IOP-17).

The two quoted events show the typical synoptic pattern leading to heavy precipitation above the NE of the Po Valley. Both these cases were characterised by a well-defined minimum, at the surface level, over the Thyrrhenian Sea; than it moved eastwards with an easterly low jet while a southern flow was present in the upper levels.

The convective system (September 16th, 1999), embedded on a squall line, produced a severe local heavy precipitation: roughly 150 mm/h according to radar images. These kinds of phenomenon, always more frequent in this area, have to be studied to be better understood and predicted. Their main synoptic features are usually well forecasted but, but space and timing of the convective system triggering are very difficult to predict using the standard available LAMs; some better results can be obtained using non-hydrostatic models. [Frontero et al., 1999]

The second event (November 21, 1999) produced a heavy snowfall both on the Apennines and the Po Valley. A daily snow thickness of 25 cm was recorded at Modena; it resulted the greatest value ever measured in November in the historical time series of the meteorological data of Modena [Boccolari et. al., 1998]. The first signal of this cold advection was seen during the last MAP IOP-17 when two successive cold fronts crossed the Alps. The first was linked with a PV streamer while the second was connected with a backwards low-pressure system moving toward North Africa till on 19-20 November. Successively the low pressure came back shifting towards northern Adriatic Sea. Some interesting pattern: well defined boundary of warm advection close to the Adriatic Sea and the northern Po River area, waved streamlines and so on will be shown.

Finally, according to the described inhomogeneous behaviour, we are preliminary analysing the role played by gravity waves, triggered in the higher layers over the northern Apennines and their possible breaking in the lower layers.

FOEHN EVENTS IN THE RHINE VALLEY DURING MAP AND COMPARISON TO FORMER CASES

Patrick Haechler, Switzerland, Richard Werner, Austria

For many years a group of german, austrian and swiss scientists has analysed and documentated Foehn cases in the Rhine Valley and in the Lake of Constance aerea. The aim was to find a better understanding of Foehn processes and to work out tools for more precise forecasts. As a result we disseminate Foehn gust warnings for several years in the region around the lake.

MAP has given a perfect opportunity to learn more about Foehn, specially for shallow Foehn and for Foehn which encounters cold stable air masses in the Lake of Constance basin. New forecast tools have not yet been established so far.

But we have analysed the Foehn events and we made classifications considering synoptic and mesoscale aspects and systematic effects of windspeed, temperatures and also rain. The poster will show comparisons of our former cases and the MAP cases. Answers if the MAP Foehn cases are representative will be given, and we also try to compare these automn cases to typical spring cases. We specially compare also to the longtime Foehn case of april 1993.

MAP SOP HEAVY PRECIPITATION EVENT - DIAGNOSIS BY HRID AND ALADIN/LACE

Branka Ivancan-Picek, Drazen Glasnovic, Vlasta Tutis, Croatia

MAP SOP heavy precipitation event on 04 October 1999 (identified as IOP5) based on the enhanced radiosounding observations and numerical results of HRID and ALADIN/LACE is presented. The 3-hourly radiosonde measurements in Zagreb gave us an exceptional opportunity to get more information on the capability of the model to predict quite locally the vertical atmospheric structure and its changes. The verification against observation was done here by intercomparison of the HRID vertical time cross-sections produced on the basis of both the ALADIN/LACE pseudotemps and TEMP messages at every 3-hour.

Results show that the model was successful in forecasting heavy precipitation event over the western Slovenia and Croatia. An obvious similarity between analyses and prognostic time cross-sections can be recognized. From the forecaster point of view the intensity, local development and lifetime of the considered atmospheric system was successfully predicted, although there are minor differences and some delay in the wind structure and the moist processes in the upper and middle troposphere.

SURFACE MEASUREMENTS DURING MAP-SOP: ENERGY AND RADIATION FLUXES IN RONDISSONE (LAGO MAGGIORE TARGET AREA)

Marianna Nardino, F. Calzolari, T. Georgiadis, V. Levizzani, Italy

During MAP-SOP surface measurements of incoming and outgoing shortwave and longwave radiation were measured in Rondissone, north of Turin. Momentum flux, turbulent kinetic energy, sensible heat, and subsurface heat flux were also computed from sonic anomometer continuous measurements. A first processing of the whole data set has been done and the main aerodynamic parameters were computed.

The surface energy and radiation fluxes were associated to the meteorological conditions in order to characterize the turbulent pattern of the site.

The spectral analysis was conducted for the identification of the synoptic forcing on the atmospheric surface layer.

HANDLING OF A HETEROGENEOUS, HIGH RESOLUTION OBSERVING NETWORK DURING THE SPECIAL OBSERVATION PERIOD OF THE MESOSCALE ALPINE PROGRAMME

Christoph Pippan, Georg J. Mayr, Austria

The Mesoscale Alpine Programme (MAP) has been the most comprehensive field experiment to study orography-related weather phenomena. Two target areas were heavily instrumented for the observation of foehn in the fall of 1999. One of them was the Brenner cross section. 80 surface stations, a scanning Doppler lidar, three radiosonde stations, three Doppler sodars, a wind profiler, and four research aircraft observed the foehn flow through the lowest gap in the Alps. Instruments from several research groups made up the dense, but heteorgenous network of surface stations. This presentation describes the observational setup and the necessary steps to mold the various measurements into a homogeneous data set that can be used to answer the scientific questions posed.

To assure that the fine-scale structure of the foehn flow can be derived from so closely spaced stations, all pressure, temperature and humidity sensores were calibrated against traceable standards.

The raw data were then put into a standard format, and missing values were indicated. After a quality control the dataset was expanded by several derived parameters (e.g. various potential temperatures) The final step is the provision of visualization tools for both a quick overlook and detailed study of the data.

AIRCRAFT MEASUREMENTS (STAAARTE 99) AND CABLE CAR SOUNDINGS (PROJECT ROM) DURING A SOUTH FOEHN EVENT

Gabriele Rau, Kathrin Baumann, Austria

Within STAAARTE – FOEHN 99 aircraft measurements with the french aircraft ARAT - Fokker 27 were carried out in the lower Rhine Valley and above the Lake of Constance on two days (October 19 and November 5). The measurements took place in close cooperation with the MAP-activities in the same area, especially with project ROM. This poster presents the data of the second flight, which took place during Foehn.

On November 5 1999 the ARAT performed a high level flight (16000 ft) over the Rhine Valley. During the same time Cable Car Soundings at Bregenz were carried out.

Ozone concentrations measured at flight level show a quite uniform distribution along the flight track. Above the target area (lower Rhine Valley and the Lake) ozone values vary between 60 and 66 ppb. Cable Car soundings, that were performed at Bregenz on November 5, show increasing ozone concentrations throughout the day with a maximum of 55 ppb in the late afternoon.

A COMPARISON OF FOEHN FLOW IN A MAJOR VALLEY AND ITS TRIBUTARIES

Reinhold Steinacker, Inga Groehn, Christian Haeberli, Andreas Schmoelz, Manfred Dorninger, Manfred Spatzierer, Austria

One objective of MAP was and still is the investigation of the temporal development and the three dimensional structure of foehn flow in a large valley. Besides the issue of predictability and model validation the observational data should answer the question how the mechanism of penetration of the foehn flow down the valley and the removal of cold air pools can be understood and explained. In complex large Alpine valleys, like the Alpine Rhine valley, with segments of different valley axis orientation, valley splittings, narrow and wide portions, the role of tributary valleys has not been investigated in detail so far. The Department of Meteorology and Geophysics of the University of Vienna as part of a consortium of international research groups concentrated some of their measurements to a comparatively short and narrow, south-north oriented side valley, the Brandner Valley in Vorarlberg, some 15 km long and well known for its severe foehn wind storms. The special situation of this valley is given by a mountain chain (Raetikon) at its origin, which is oriented approximately perpendicular to the the main direction of the Rhine valley and hence acts as a secondary barrier to the foehn flow.

Fortunately the weather during MAP-SOP (Early September till mid November 1999) brought us a considerable number of foehn events, more than could be expected from climatology. Different types of foehn, summertype foehn, involving unstable airmasses, shallow and "sandwich" type, influencing only some layers of the valley atmosphere and deep, dry as well as rather moist foehn events with a variety of intensities occurred. An extremely dense surface automatic station network and upper air stations, conventional radiosoundings and remote sensing instruments together with aircraft measurements allow to analyse the temporal evolution and the spatial structure in a way, never achieved before. The paper will focus on the comparison of the evolution of the wind and mass field in the main Rhine valley and the Brandner valley.

AIRFLOW WITHIN MAJOR RIVER VALLEYS ON THE SOUTH SIDE OF THE ALPS AS OBSERVED DURING THE MAP SPECIAL OBSERVING PERIOD

Matthias Steiner, James A. Smith, Bradley Smull, Robert A. Houze, U.S.A.

The Special Observing Period (SOP) of the Mesoscale Alpine Program (MAP) documented the precipitation and airflow structure over a section of the Mediterranean side of the Alpine range and its major river valleys. This was achieved by means of a nested array of operational and research radars. In the Lago Maggiore region, the Swiss Monte Lema and several Italian operational radars, and research radars from the U.S., France, Germany, and Switzerland documented the precipitation systems as they approached and moved over the Alpine barrier. These radars either scanned above the ridges and mountain crests, and thus were not able to see what was happening within the major river valleys, or they pointed only vertically. The Doppler-on-Wheels (DOW), a mobile scanning Doppler radar platform, was thus crucial for the documentation of the precipitation and airflow within individual river valleys. The DOW was operated at different sites within the Toce and Ticino river valleys during the MAP SOP.

One of the most intriguing observations obtained with the DOW was a persistent and sometimes quite strong flow of air down and out of the valleys. This phenomenon was particularly pronounced in IOP 8 (October 20-21, 1999), when highly stable air was pushed towards the Alps and the atmospheric stability apparently prevented the air from crossing over the barrier. The air seemed to be seeking ways to escape by diving under the up-sloping air and pushing back out along the valley bottom. This down-valley flow was likely enhanced (if not initiated) by the evaporation of precipitation, cooling the air within the valley and causing subsidence.

Using the DOW data, we analyze the airflow within the major river valleys. In particular, we seek to determine connections between the flow within the valley (up- or down-valley, strength, and depth in relation to the surrounding mountain crest line) and the environmental flow (strength, direction relative to the valley orientation, and atmospheric stratification) impinging upon the Alps. Does this down-valley flow constitute an important feedback mechanism of orographic precipitation, contributing to the lift of air and subsequent condensation?

SMALL SCALE PRECIPATATION VARIABILITY IN THE JULIAN ALPS ASSESED BY SNOW COVER MEASSUREMENTS

Tomaz Vrhovec, Slovenia

Spatial distribution of precipitation in complex topography is a problem that can be studied in several ways. A large part of Mesoscale Alpine Program (MAP) was devoted to this problem and during MAP SOP a network of additional pluviographs was established in the western part of Slovenia, in the Julian Alps and in the So•a drainage basin. This network provided the precipitation data in approximately 20 km grid. As the spatial variability of topography and precipitation is considerable also at smaller scales, during the winter 1999-2000 a very dense network of stations (in approximately 1 – 2 km grid) for measuring snow depth and snow water content was established in the Southern Julian Alps at the altitudes between 1400 and 2200 m. The network consisted of 50 stations where the data were collected at regular time intervals (6 weeks apart) during winter, before the spring ablation started. The data provided were spatially and temporally analyzed and the spatial gradients of precipitation accumulation in the Southern Julian Alps were established for the mountainous region to the North of the precipitation maximum. The fine scale analysis for this special network was compared with the analysis of regular precipitation network data for the region for winter 1999-2000 and the results are discussed.

ON OROGRAPHICAL INFLUENCE OF METEOROLOGICAL FIELDS OVER BULGARIA

Teodossia Andreeva, Vasil Zahariev, Bulgaria

The meteorological fields are changed over the mountain range and massif. The mountain surface has influence by nature of locality, exposure and atmospheric radiation.

Results are given from research of the fields of: wind, temperature and dew point.

The deviation's fields over the high-mountain regions are obtained in relation with the atmospheric elements relevant on the pressure level in the free atmosphere. By the use the aerological sounding from observatory Sofia, we present in the paper the results of deviation of wind, temperature and dew point at the high-mountain station. Considered high - mountain meteorological stations are: peak Mussala (2925 m), in the Rila Mountains; peak Botev (2375 m) and peak Murgash (1687 m) in the Balkan Range; Black top (2286 m) in the Vitosha Mountains. Peak Mussala is approximately at the pressure level of 700 hPa; the other peaks - between pressure levels 700 and 850 hPa.

The orographical change of the meteorological fields over mountain regions for the territory of Bulgaria is shown. It is of significant importance for different applications, including the local weather forecast.

EVALUATING MOISTURE BUDGETS OVER THE ALPS USING FINITE ELEMENTS

Manfred Dorninger, Christoph Matulla, Leopold Haimberger, Austria

It is common practice to interpolate observation data to a regular grid using various analysis techniques before forecasts or budget calculations are performed. During this process valuable information may be lost particularly if one is interested in phenomena not much larger in scale than the spacing between observations.

We propose a method for calculating gridscale moisture budgets from quality-controlled radiosonde data without interpolation. This can be accomplished by using irregular grids and the finite element method (FEM). It has been shown that this method is superior when estimating kinematic quantities of the wind field from radiosonde data. Although quite accurate, the wind field is not suitable for budget evaluations since it does not fulfil the three-dimensional continuity equation. Thus one has to slightly modify the wind field in order to make it consistent with the continuity equation discretized on the finite element grid. This modification is weaker than the filtering that takes place during the usual analysis process at forecast centres.

Our FEM evaluations should contain less systematic errors than conventional budget evaluations since they are independent from assumptions and parameterizations in the assimilating models that affect the analysis data from forecast centres. On the other hand they may contain more noise since only consistency with the continuity equation is enforced. We therefore compare the budgets from the FEM with budgets from routine ECMWF analyses on model levels in order to study the benefits/drawbacks of the FEM method. (For the method of calculating budgets from ECMWF analyses it is referred to the paper Maurer et. al which will also be presented at the conference.)

The FEM has been already used for calculating moisture budgets on pressure levels, thereby avoiding horizontal interpolation. We are currently trying to generalise this method in order to allow irregularity also in the third dimension, in particular at the surface. This step is necessary to cope with high-resolution MAP-SOP data as well as operational data over complex terrain.

First results will be shown at the conference.

LEEWAVES IN THE ANDES REGION, MOUNTAIN WAVE PROJECT (MWP) OF OSTIV

Carsten Lindemann, Rene Heise, Wolf Dietrich Herold, Martin Just, Klaus Ohlmann, Thomas Ruhtz, Germany

A small expedition in November and December 1999 with motorgliders in the Southern Andes mountains in Argentina was used to equip one of the motorgliders, a Stemme S10, for meteorological measurements. Standard parameters have been measured such as temperature, humidity, vertical velocity and other aircraft data including navigation and at least horizontal wind. Some leewave patterns of more than six oscillations were detected. The inclination of waves upwind and momentum transport could be computed out of the data, when flying parallel to the airflow. Typical high amplitude wave patterns were found, when flying crosswind.

An analysis of leewave forecast was done.

AN OBEJECTIVE CRITERIA FOR NORTH FOEHN DETECTION OVER WESTERN ALPS

G. Balsamo, C. Cassardo, R. Cremonini, E. Minguzzi, N. Loglisci, Italy

The North foehn is a rather common phenomena that affects the Western Alpine region. Very high visibility, relatively high temperatures and low humidities, are consequences of wind flow coming from French side of Alps, and producing the so called "wall" of clouds on the top of the mountain chain. We develop a diagnostic method for the foehn episode assessment using the observations gathered from a conventional complete meteorological station. The dataset provided by Piedmont Regional Meteorological Service station network, refers to the period 1990-1999.

Considering a selection of cases and using the Synop ground based network on the upwind and downwind sides of the Alps, we investigate the seasonal pattern and the foehn depth. From the regional network is produced a statistic of the foehn event its evolution with regard to different tipology of foehn episodes.

MOISTURE AND HEAT BUDGETS DURING MAP-SOP OVER THE ALPINE AREA

Harald Maurer, Manfred Dorninger, Leopold Haimberger, Austria

The better understanding of the Alpine hydrological cycle is an important scientific target of the Mesoscale Alpine Programme (MAP). This issue will be addressed by evaluating gridscale and sub-gridscale atmospheric moisture and heat budgets components on the meso-alpha scale. The basic concept of evaluating sub-gridscale quantities indirectly from gridscale atmospheric energy budgets goes back to Yanai et al. in the early seventies. The presented approach goes beyond Yanai's concept in the sense that the vertical eddy flux of equivalent temperature is also calculated from the budget components. This quantity is a measure of the strength of the atmospheric convection and referred to as the convective flux. The proposed method is rather sensitive to input data quality. It is demonstrated with a thermodynamic diagnostic model that the convective flux can be diagnosed from routine gridscale analyses with tolerable error.

Input data are the gridscale initialized fields from the ECMWF data archive, further the surface values of latent and sensible heat flux from a SVAT-model. Surface precipitation is analysed by an objective interpolation method from SYNOP-reports.

Case studies will be concentrated on heavy precipitation events in the Alpine area and surroundings during the MAP Special Observing Period (SOP) from early September to mid of November in 1999. Characteristic vertical profiles of the budget components and of the convective flux will be presented.

However, the proposed method may suffer from systematic errors in the assimilating forecast model which can be comparatively large over mountainous terrain. Further, some information is lost due to interpolation onto the regular model grid. An alternative approach for calculating moisture budgets is proposed in the paper Dorninger et. al which will also be presented at the conference.

THE CLOUDE BASE OF PRECIPITATING CLOUDS IN THE ALPINE REGION

Gerd Ragette, Austria

Hourly objective cloud observations are conducted at several airports around the Alps. The data from the Vienna airport obtained by means of a ceilometer have been used for statistical analysis. The results indicate a diurnal and seasonal cycle. From midnight to midday the frequency of clouds occurring below 1500 m increases by as much as 35 %, between 1500 m and 3600 m a corresponding decrease is observed. As a consequence the height of the mean cloud base is in all months during the day lower than during the night, the difference being greatest in spring and fall and smallest in the winter.

During January there is a very high chance of 91 % that clouds below 300 m will accompany precipitation. During the warmer season clouds are most frequently encountered between 600 and 1400 m, the mean cloud base rising from about 770 m above ground in January to 1760 m in August.

Dividing the cloud observations into cases with warm or cold air advection shows that below 1500m cold air advection is associated with fewer cloud observations than warm air advection, above that level clouds are more often observed with cold air advection than warm air advection.

TURBULENT DISSIPATION OF THE COLD AIR POOL IN A BASIN: THE EXPERIMENTAL EVIDENCE

J. Rakovec, B. Paradiz, Slovenia, S. Jernej, Austria

Z. Petkov¹ek has published a decade ago two papers (1985, 1992) in which he postulated two basic conditions for the turbulent dissipation of the cold air lake in the basin. The first is that the wind must be strong enough to produce enough vertical turbulent gusts to start to erode the temperature inversion at the top of the cold air pool. And second: as the development of the adiabatic lapse-rate from above down into the cold air increases the strength of the inversion, the production of the turbulent energy must be stronger and stronger. This implies that the source of this energy - the speed of the upper-levels wind - must increase in time. According to our knowledge there was not yet experimental confirmation or rejection of the Petkov¹ek's conceptual model. Now we have measured with sodar (in a scope of the experiment KML: Klima Mesta Ljubljane - Climate of the Town of Ljubljana) some cases in the Ljubljana basin to illustrate and to confirm the model also experimentally.

THE VALIDATION OF MESOSCALE WEATHER PREDICTION MODELS

Andreas Schmölz, Austria

In the project VAMP (Validation of Mesoscale Atmospheric Model Products) forecasts of the Swiss model (SM) are verified with the analysis of VERA. VERA (Vienna Enhanced Resolution Analysis) is a high resolution analysis scheme for the atmosphere over complex terrain, which has been developed in the last years.

Because of its independence from first guess fields e. g. from numerical model fields, VERA can be optimally used for the validation of these models.

One of the major features of VERA is transferring information from data rich to data sparse regions. For this purpose the influence of topography on meteorological quantities can be used. There are two different features coupled to the shape of topography: The thermal structure (i.e. heat low, cold high) and the dynamic (i.e. sharp gradients along mountain ridges due to blocking or forced de- and ascent). These features ("fingerprints") of the atmosphere may be refined even at scales, not resolved by stations directly.

Fingerprints, however, can also be computed from the (artifical) topography used by the NWP models. The results on the one hand can be used to transfer (filter) the observations to the model scale, and on the other hand, a higher resolved fingerprint allows a downscaling of model fields to the resoultion of the analysis. Hence, a major innovation in this scheme is the application of the fingerprint technique to resolve mesoscale structures in the lower troposphere in mountainous regions. Both ways allow a comparison of observations with model results and vice versa on the respective scale.

EXPANSIONS OF THE WEATHERPRO SYSTEM

G. Spreitzhofer, Elmar R. Reiter, Austria

WeatherPro, formerly known as 'WELS system', is a PC-based weather prediction scheme, developed by the American WELS research corporation (now Alden Electronics Inc.). It is currently operationally employed in parts of the USA and Central Europe, mainly by avalanche centers, traffic operation centers and airport meteorologists. WeatherPro is based upon a number of unconventional concepts like that of 'hybrid modeling': An independent, grid-based mesoscale model, integrating the full set of prognostic equations is run twice daily, essentially using radiosonde and surface observations as its input. It delivers 36-hour forecasts that can be displayed, manipulated and enriched by means of a Graphical User Interface (GUI). The system is also coupled with a high-resolution geographic information system (GIS), making its application over mountain areas particularly useful.

The GUI is the core part of the system, installed at the users' end. This is a user-interactive, object-oriented tool designed for use by non-specialists. A revolutionary aspect of the GUI is that it can be utilized to improve the forecast quality by the incorporation of additional data into the prediction process as soon as observational evidence begins to indicate that the forecast is off-track.

Several expansions of the GUI are being processed, aiming at an even better coupling between sensor data and model forecast data to improve weather predictions. A first step is the concurrent screen display of observation and prediction data over a certain geographic area. Further work is done related to the display of the time history of spot forecasts. In future forecast histograms will display a mixture of observations (up to the time when the histograms are called) and prediction data. Optionally, the latter can be altered by the built-in forecast correction modules that access the most actual sensor data available.

A NEW MODEL FOR THERMALLY INDUCED AIRFLOW IN AN ALPINE VALLEY

Friedrich Wölfelmeier, Reinhold Steinacker, Austria

A new model was developed to simulate a valley wind circulation. The model consists of a thermal and a dynamic part. In the first part the heating of air in a valley is calculated, considering the reduced air volume in the valley, compared to a plain. Starting with high resolution topography data, relative air volumes of the grid elements are calculated. These volumes are averaged on a scale which is around the valley width, to gain the along valley circulations. Smaller relative air volumes result in stronger heating or cooling of a grid element. To parametrize the slope winds during the day, superadiabatic lapse rates are compensated by adjusting the temperature gradient to adiabatic. From the temperature field in the valley, the pressure tendency is calculated hydrostatically.

In the dynamic part, the valley wind is calculated using the circulation theorem. This offers a favourable way to treat very small horizontal pressure gradients and also saves computation time. The flow in the valley is considered to be balanced with no acceleration.

The model was run with different configurations to examine the sensitivity of the wind field to modifications in the model equations. Results are presented for the temperature and pressure tendency and the derived velocity field of the Mesolcina valley, which is located in the Swiss Alps. A comparison between wind measurements from the field campaign VOTALP and model runs is shown.

THUNDERSTORM TRACKS AND THEIR RELATIONSHIP TO OROGRAPHY FROM AN ALPINE LIGHTNING COMPOSITE

Andreas Frank, Manfred Dorninger, Alexander Kann,
Reinhold Steinacker, Austria

A deeper understanding of orographically influenced precipitation systems is one of the primary scientific objectives of MAP. The investigation of the electrical activity of them will complement this effort. During the 'convective season' from May to November 1999 including the period of the MAP-SOP (Special Observing Period) from early September to mid November an Alpine Lightning Location System which interconnected existing lightning sensors from 5 Alpine countries was in operation to get the best possible coverage of the entire Alpine Region.

A recently developed tracking algorithm is used to calculate the trajectories of the thunderstorms. The method uses a simple Gaussfilter and a selection procedure to define displacement vectors of the specific convective system. The change of the filter width results in a separation of the system's scale which allows to distinguish between the movement of a single convective cell and the whole cell complex. In principle the method is applicable to several data sources like satellite data, RADAR and lightning data. However, so far only results from lightning data will be presented.

In the paper the role of orography in relation to thunderstorms will be investigated in several respects. These includes: a) Connection of storm tracks to orography. Recent studies show a strong correlation between storm tracks and main Alpine valleys and the Alpine foreland. Are there differences between convective cells and cell complexes? b) Regions of initiation of thunderstorms triggered by mountains in the Alpine area. Since lightning data are continually available they are frequently the first indicator in space and time for the beginning of convection. Case studies will be presented for certain weather situations and c) possible enhancement of lightning frequency in the vicinity of mountain peaks.

DATA QUALITY CONTROL IN THE ALPINE REGION

Inga Groehn, Reinhold Steinacker, Christian Haeberli, Wolfgang Pöttschacher, Manfred Dorninger, Austria

Before using meteorological data a quality control should be carried out. A new mathematical method of quality control (variational approach close to a local thin plate spline) has been developed and improved during the last years.

The project is part of the international Mesoscale Alpine Programme (MAP) called DAQUAMAP (Data Quality Control in MAP). The aim is to assess the performance and control for the meteorological stations of all the participating institutions in order to get a more homogeneous data set for the whole Alpine region irrespective of state borders.

Covering the time period of the years 1997 - 1999 and the first half of 2000, for each of the (400 GTS) stations below 750 msl and each analysis step (usually 3 hourly synoptic terms), the parameters mean sea level pressure, potential temperature, humidity and the horizontal wind-components were checked and corrected by using this method. An extension to the non GTS stations and other parameters is under way. The results can give some hints at the percentage of gross errors, possible systematic errors (e.g. bias) and at the representativity of each station with respect to the scale which can be resolved by the regional station density. Also a statistical evaluation of type and number of errors can be given.

REGIS: REGIONAL GEOGRAPHIC INFORMATION SYSTEM FOR METEOROLOGICAL PARAMETERS

Josef Haslhofer, Erich Dumfarth, Austria

Advances in methods and techniques of meteorological model development as well as progress in information technologies are setting the framework for spatial high resolution analysis of predicted values for meteorological parameters. Predictions and analysis are however restricted to a finite numbers of points, which are objects of an idealized model space. Aim of the REGIS project is the development of tools for the meteorological scientist that allow to transfer the results derived from a finite number of points in space to a general analysis in an infinite space. Austria and selected adjecent regions are completely represented in respect to predictions, that are accessible to experts and other interested clients in map formats. REGIS was developed in cooperation of ZAMG, Salzburg, and the ICRA company, Salzburg.

The databasis of REGIS consists of ECMWF-MOS data provided by 120 stations in Austria. The inclusion of selected stations in neighboring countries of Austria made interpolation over Austria's boundaries possible. The number of interpolation points and their distribution is however not satisfactory in respect to a complete surface coverage. Further, the diversitiy of the landforms in Austria and its surrounding areas is also considered a problem. A positive and useable analysis therefore needs additonal information sources for an accurate interpolation process. Such information is provided by a digital elevation model (DEM). By combining the data of the base stations with the DEM and the derived information of the two, as well as by producing a regression analysis based on temperatures and altiudes, a succesful interpolation of the predicted air temperatures is possible. This type of interpolation equally incorperates horizontal and vertical components. As a result both locale phenomenons and supra regional effects in the spatial distribution of the air temperatures are being analysed. The combination of horizontal and vertical information is based on the following formula:

$$T = hiT + (DEM - hiS) * g$$

List of Abbreviations: T horizontal and vertically interpolated air temperature, hiT horizontal interpolated air temperature, DEM digital elevation model, hiS horizontal interpolated sea level, g vertical temperature gradient

For determining the vertical temperature gradient, there are additionally ECMWF-QFA- and virtual ALADIN vertical profile data available. Predictions of the day are also supplemented by temperature data derived from radio sondes ascents. REGIS allows the user to interactively engage in the regression analysis of the vertical gradients. The course of the gradients can be observed between one and three altitude levels. If necessary, the experienced user can manually - with the help of graphic tools - correct and adjust meterological pecularities. For the regression analysis as well as for the subsequent horizontal and vertical interpolation, the research area can be subdivided into several meterological study regions. These regions (max. 26) - defined as the smallest spatial elements - are delineated by approximately homogeneous characteristics. Depending on the various distinct conditions, REGIS combines the regions to form larger units and calculates, using a "First Guess" analysis, the vertical temperature gradient. Furthermore, a complete coverage of the temperature distribution is calculated for each region, including the above mentioned vertical and horizontal components. Finally, between regions an end result is formulated and automatically - after re-examination by experts and necessary changes - displayed in a map layout. The whole analysis is processed by REGIS within a few minutes.

Thus maps for spatially predicted temperatures are available for a time period of up to four days in advance and for daily for points in time. Meteorological phenomenons, as for instance Foehn valleys, cold air coming with cold fronts or Inversion are substantially easier to understand for experts and non experts in this visual form of representation.

UV INDEX DETERMINATION BY THE AUSTRIAN UV NETWORK - CORRECTION FOR NON-IDEAL SPECTRAL SENSITIVITY OF THE DETECTORS

Roland Silbernagl, Josef Schreder, Martin Huber, Mario Blumthaler, Austria

On behalf of the Austrian Federal Ministry of Agriculture, Forestry, Environmental and Water Management, a network of 9 Solar Light UV Biometers is in routine operation throughout Austria since 1996. The instruments are located in urban, rural and high alpine areas, covering a range of altitudes from 153 m a.s.l. (Vienna) to 3106 m a.s.l. (Sonnblick).

The instruments relative spectral sensitivity and their angular response have been regularily characterized by laboratory measurements in order to achieve comparability and to correct for temporal drifts in their specifications. Absolute sensitivity was determined by side to side intercomparisons with an absolutely calibrated spectroradiometer. Daily measurement data are homogenized using the lab characterisations and converted to UV index values. Based on additional pyranometer and topographic data, the UV index is interpolated for the whole area of Austria and a daily UV map is published on the internet.

Frequent recalibration and characterization of the instruments result in high quality measurement data, thus allowing a detailed comparison of the local UV climate at the individual sites with data from similar networks on an international scale. As biologically relevant results, daily UV totals and values for the UV index in their annual course are shown for the individual measurement sites.

ATMOSPHERIC CONDITIONS AND RADIATION REGIME AT A MOUNTANEOUS SITE IN THE TEMPERATE REGION

Moses G. Iziomon, Helmut Mayer, Germany

The upper Rhine valley region, which extends northwards to the lowlands of Karlsruhe in Germany and westwards to the uplands of the French Vosges, exhibits considerable orographical diversity. Consequently it is characterised by a climate of pronounced spatial and temporal variability resulting from an interplay of both macro-scale and local influences. In an attempt to investigate the long term regional, temporal and altitudinal variability of climatic conditions and energy balance components within the upper Rhine valley region, the Regio-Klima-Projekt (acronym REKLIP) was inaugurated in 1991. The REKLIP investigating area occupies an approximate area of about 40, 000 km2 with a perimeter greater than 250 km N-S and 160 km E-W. About 35% of the investigation area is covered with forest, most of which are located on the mountains. The elevations of the REKLIP meteorological sites ranged from 100 m a.s.l. within the lowlands of Rhine valley to 1489 m a.s.l. at Feldberg (on the peak of the Black forest). The latter which is the highest elevated REKLIP location is the focus of this report.

Based on four years REKLIP data-set of surface radiative fluxes and additional meteorological parameters, the analysis of atmospheric conditions and radiation regime for the mountainous site of Feldberg (47°52'31"N, 8°00'11"E), located 16 km south-east of Freiburg, in south-west Germany is presented. Time series and inter-annual variability of atmospheric variables including air temperature, humidity, precipitation, wind speed and direction, Linke turbidity factor, bulk atmospheric transmissivity, cloud amount and relative sunshine duration at the site are highlighted. Also presented is the surface budget analysis of shortwave-, longwave- and net radiative fluxes. The mean annual cumulative magnitude of the daily total of the net radiative flux amounted to 1255 MJm-2d-1 at this mountainous site with a summer radiation efficiency of about 0.5. Additionally, the effect of sky and surface conditions on the budget of surface radiative fluxes have been investigated. Finally empirical models for the estimation of surface radiative fluxes for this location are proposed.

MEASURING WATER FROM FOG

Marina Mileta, Croatia

The amount of fog water collected by Grunow fog collector in the mountain region close to the Adriatic sea during the past 30 years period is considered.

In the analyzed time period a collector placed at the mountain station Zavizan (1594m a.s.l.) collected 106% more precipitation than the standard Hellmann raingauge. In the continental part of Croatia this difference is much smaller, i.e. 12% as measured at the Sljeme mountain station (1007m a.s.l) near Zagreb.

Different methods of measuring and analyzing water collected from fog are presented and results discussed.

MEASUREMENT AND CHARACTERIZATION OF LOCAL ATMOSPHERIC STRUCTURES IN AN ALPINE VALLEY

Dino Zardi, Massimiliano de Franceschi, Gabriele Rampanelli, Italy

A hydrodynamic bulk flow model for the evolution of the convective boundary layer in a valley and the development of an up-valley wind is proposed. The model extends previous results on the diurnal evolution of an inversion capped convective boundary layer (Nieuwstadt and Glendening 1989, Park & Mahrt 1979, Driedonks 1982) to include the effects of a sloping valley bottom and adjacent slopes. Assuming the layer to be well mixed, suitable evolution equations are derived for the cross section-averaged horizontal wind velocity component, potential temperature and the boundary layer depth. Turbulent fluxes of momentum and sensible heat are modelled with suitable closures. Various possible solutions are found for both steady and unsteady states, under different boundary and initial conditions. The results are compared with experimental evidences from both ground and airborne measurements. In particulare the model is applied to the case study of the valley wind arising in the northern part of Garda Lake and known as 'Ora del Garda'.

A STATISTICAL-CLIMATOLOGICAL STUDY TO IMPROVE THE UNDERSTANDING OF BASIN WIND PATTERNS IN THE PIEDMONT REGION

Gian Paolo Balsamo, Barbara Cagnazzi, Giovanni Paesano, Italy

The purpose of this study was to identify common wind pattern characteristics in the Piedmont Region through a climatological analysis of Regional winds measured over full years and considered in relation to actual weather conditions. The objective was to gain a better understanding of geomorphological influences in the area can create or foster wind or calm conditions. The statistical analysis used wind data collected through the Piedmont Region monitoring network over several year (6 years, from 1990 to 1995).

The meteorological situation was analysed through a subjective assessment of the European synoptic pattern for the 1993-1995 period, according to the Borghi-Giuliacci classification method. Weather stations installed in the Piedmont Region are equipped with wind speed and direction sensors and then provided data on wind intensity and direction. Forty-one stations were included in the study. The equipment was installed at some sites during the data collection period and hence the number of days considered is not always the same. As a consequence the sampling frequencies of analysed events was included in order to ensure data consistency and allow direct data comparisons. Statistical results regarding winds measured by regional weather stations for the 1990-1995 period come from the analysis of frequencies in order to determinate basin wind patterns.

Daily European meteorological conditions for the 1993-1995 period were also analysed according to the Borghi Giuliacci criteria (1985). This led to the cataloguing of daily synoptic patterns and the subjective comparison of analyses of the 12 UTC at 850hPa isobaric level geopotential. The analysis were provided by the Deutschen Wetterdienstes European weather report with simplified basic conditions. When it was not possible to clearly assign a case to a specific class a panel of independent experts was used (to make the choice less subjective) and the final choice was made after careful comparison. During the classification process, an additional pattern (numeric code=150) was deemed necessary to complement the original 17 types identified by Borghi- Giuliacci. This code allowed for the inclusion of a very common synoptic pattern that was not present in the classification but for which the effects are quite important in Piedmont. Weather classification on a synoptic scale was applied to the 1993-1995 period, including details on flows in the Piedmont Region.Statistical results highlight several high frequency classes corresponding to prevailing wind directions. In effect these synoptic patterns essentially determine West by Northwest and Southwest wind flows. The frequency analysis of wind intensity and direction by weather type is performed by averaging wind speeds in uniform classes defined by direction of occurrence in Piedmont (based on the Borghi-Giuliacci classification). Prevailing wind directions (on a synoptic scale) were West and Southwest. For winds at 10m, this confirmed the correlation and/or influence on local flows by the synoptic pattern. On the other hand, Southeast and Northeast wind directions are more attributable to the geomorphology of the Piedmont Region - enclosed by the Alps to the west and "open" at the East to winds coming from that direction. On the synoptic scale, the strongest winds come from the Northwest and North diminishing as they move clockwise towards the Southwest. The formidable barrier represented by the Alps is generally very effective protection against prevailing winds from the Northwest, which tend to be the weakest - with one exception, the Foehn.

VARIABILITY OF CLIMATE OVER ALBANIAN ALPS

Eglantina Bruci, Liri Muçaj, Albania

The socio-economic structure and the activities of every country or region are closely depended upon climate condition. This is so because the climatic conditions impact the natural environment (soil, air, water, vegetation, etc.).

This paper aims to give a brief description only of the temperature and precipitation variability over the Albanian Alps as well as the analysis of its influence and of the expected change.

The zone under study, according to the climatic Albanian division, belongs to the Northern Mountainous Mediterranean Sub region, with cold winter and cool summer. The stations over this zone (up to 1300m above see level) register mean annual temperature between 2 - 11 °C and the mean winter temperature between -2 up to -8 °C, while the summer one varies between 15 - 20 °C. The precipitation total registers values between 2000 to 2500 mm.

The reveal of long term changes in temperature, precipitation in Alpine zone (9 stations) and the determination of their tendency and rate are performed (period 1931-1995). The anomalies and trends of filtered series are analyzed. The actual trend is discussed in relation with the expected temperature and precipitation changes scenario.

PIEDMONT DROUGHT IN WINTER 1999-2000

Barbara Cagnazzi, Daniele Gandini, Elena Turroni, Italy

Meteorological part

In winter 1999-2000 the meteorological situation was characterised by frequent and long- lasting expansions towards north-eastern and Central Europe of the Azores anticyclone. In these conditions the weather in Piedmont region, which is localised in the North-Western part of Italy, was stable, with a clear or partly cloudy sky, some episodes of fog in the plains and no precipitation. The Azores anticyclone opposed a blocking action to the advance in the Mediterranean basin of the Atlantic depressions; fronts were constrained to follow a trajectory which went from Iceland to Scandinavia and finally to the Balkans. So precipitations and cloudness affected mainly the Northern slope of the Alps, while in the Southern one strong north-westerly winds (the typical "*foehn*") flowed down the Alpine relieves determining an increase of the temperature due to adiabatic heating. In fact we registered maximum temperature values 10-15°C above climatological means in some *foehn* episodes.

Climatological part

The winter precipitations of 1999-2000 are compared with winter mean precipitation of 1951-1986 period.

Winter mean precipitation amount is less than 200 mm in Piedmont, except for Ligurian-Piedmontese Appennines chain and northern area (Toce and Sesia valleys) where the average precipitation rises up to 300 mm.

In winter 1999-2000 the measured mean precipitation was the about 25% of mean value in western relieves and only the 10% in the rest of the region.

Statistically there is a probability of 5% that it will happen again a draught like this.

Nivological part

Snow conditions of winter 1999/2000 have been analysed comparing snow data (snowfall total amount (Hn) and days number with snow precipitation (Gn) - from December to February - for six identified locations, with the mean values of period 1966-1996.

By comparing mentioned data, we calculated the snowfall rate expressed as percentage variation.

The analysis proved that in winter 1999/2000 all the stations measured lower values than the thirty-year mean value, either as snowfall total amount or as days number with snow precipitation.

CHANCES IN HEAVY DAILY RAINFALL IN MOUNTAIN AREA OF ROMANIA

Liana -Victoria Cazacioc, Andreea Cazacioc, Romania

In the paper, extreme daily time series of precipitation amounts is presented on seasonal time scale for the period 1961-1996 from 13 meteorological stations located in the mountain area of Romania. The total number of days for the time period of interest, when daily precipitation were found to be higher then a fixed limiting value, was used as an index of climatic extremes. All values greater then 95th percentiles were considered as daily extremes. The number of days with extreme precipitation was determined for the above mentioned intervals of each year over the 1961-1996 period. The time distribution of these values on different stations was analyzed by comparing with the highest annual values for successive years over the same period.

In addition, different types of trend in the number of days were calculated for each station for the period of interest.

CHARACTERISTICS OF THE MAXIMUM AND MINIMUM TEMPERATURES ASSOCIATED WITH THE PRESENCE OF THE SNOW COVER IN ROMANIA

Otilia Diaconu, Romania

The paper presents an analysis of the maximum and minimum air temperatures connected to the presence or absence of the snow cover in the cold season in Romania. The daily data regarding the snow cover depth and minimum and respectively minimum temperatures at 90 meteorological stations in the cold season of
the year, November - April 1961-1990 were used. They were stratified by 15-day periods and further by the presence or absence of a snow cover. The paper emphasized that for a snow cover depth that exceeded 2.5 cm. the thermal depressions for the minimum and maximum temperatures could go over 6 C. Also, these depressions present a different spatial distribution. Temporally, the depressions of the maximum temperatures are larger in the first and last part of the cold season and relatively low in the middle winter months. Potential geographic forcing mechanisms are evaluated. The results indicate that the large sensible and, in some cases, latent heat fluxes from the lower atmosphere to the snowpack account for much of the observed temperature depressions.

ENVIRONMENTAL RESEARCH STATION SCHNEEFERNERHAUS (UFS)

Gerhard Enders, Germany

In 1999 Germanys new high alpine research station 'Schneefernerhaus' was formerly opened. It serves all atmosphere-related sciences, especially atmospheric physics and chemistry. The poster describes its concept, infrastructure and main research fields, and gives information on its availability for international research.

CLIMATIC CONDITIONS ALONG THE MEDITERRANEAN COAST OF EGYPT

Abdel Aziz Abdel Baeth Hamed, Egypt

The hourly values of meteorological elements in the period from Jan. 1951 to Dec. 1998 at 5 stations along the Mediterranean Coast of Egypt are analyzed. Spectral and Harmonic analyzes of the monthly means of the meteorological elements along the Egyptian Coast of the Med. Sea are studied, coherence is determined, trends and Annual of temperature have been investigated.

Results indicated the following:

- The means over 40 years of the air temperature give lower values than that obtained over 30 years.
- The means of wind speed over 40 years are higher than those over 30 years.
- Higher values of wind speed are observed during winter season and early spring due to the Cyclonic activities over the Med. Sea during that period, while the lower ones are observed during summer and autumn seasons.
- The evaporation gives higher values at Sallum (2993 mm per year) while lower one occur at El-Arish (1569.5 mm per year).
- The rainfall gives higher values at Alex. (195 mm per year) due thermal instability, while the lower ones occurs at Port Said (75 mm per year).
- The thunderstorms over the Egyptian coast of the Med. Sea are entirely confined to the period from Oct. To May, while the sand rising and the sandstorms give highest maximum frequency of occurrence in the spring season, and the lower values occur in the autumn season.
- Downward trend is found in temperature observations.
- In the case of temperature and pressure there is a significant peak at the period of 12 months.
- The Coherence of temperature along the Med. Coast of Egypt are significant over the wide range

TRENDS OF PHENOLOGICAL SPRING PHASES IN THE SWISS AND AUSTRIAN ALPS

Elisabeth Koch, Austria

In the context of climate change phenology, the classical science which investigates the seasonal plant and animal acitvity driven by environmental factors has been revived. Phenological changes affect ecology, agriculture, forestry, human health and acts thus having a feedback mechanism to the climate system.

The phenological spring phases of perennial plants, being especially sensitive to temperature, of 22 observation sites in Austria were tested if they show a tendency to an earlier onset date during the period 1961 to 1998.

The linear trends of the phases florescence of apple (malus domesticus), lilac (syringa vulgaris) and sweet cherry (prunus avium) and the phase bud break of lark (larix decidua), covering at least 25 yeares of observations were calculated. A third of these trends are significant at the 5 % level with emphasis in the Western and Southwestern parts of the Austrian Alps.

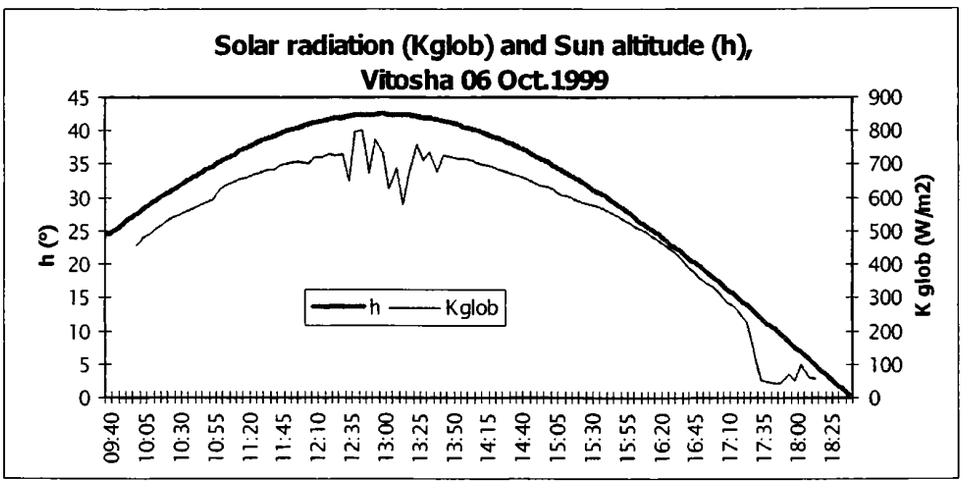
Extra alpine observation sites don't show any significant trends except of two locations and then with different signs. This result does agree at least in the Alpine regions with the warming trend especially in the last decade in Austria thus revealing a tendency to an earlier onset of plant acitvity in spring going together with an extension of the growing season.

SOME ASPECTS OF THERMAL CONDITIONS OF THE HIGH TATRAS (POLAND) AND VITOSHA (BULGARIA)

J. Baranowski, K. Blazejczyk, M. Kuchcik, Poland, Z. Mateeva, Bulgaria

Thermal and solar features of mountain areas are not only depended on their latitude, but also on local orography, land cover, exposition. They influence plant cover, the length of snow cover, etc. The aim of the paper is to define the effects of solar radiation on mountains thermal conditions on example of High Tatras (Hala Gasienicowa) and Vitosha ridge.

The studies were carried out in High Tatras, Gasienicowa Pasture (Poland), in 1997-1999 and in Vitosha massif, 20 km south to the centre of Sofia (Bulgaria), in 1999. Tatra is small mountain chain within Carpathians, with steep slopes and poor plant cover. Vitosha is also small mountain ridge with quite rich plant cover except top parts. In both, the measurement were conducted north slopes and the posts were located on the similar altitude.



Thermal conditions in the mountains depend mainly on the amount of solar radiation but also on relative and absolute altitude, the slope's inclination and exposition, horizon shading. Therefore, despite similar altitudes of Tatra and Vitosha , their thermal character are different. It is appeared in mean daily temperature as well as its extreme values. In Vitosha the high air humidity, its particular location and forestation cause that both, daily amplitudes and day to day changes of air temperature were in the studied period much higher than in Tatras.

THE CITY CLIMATE ANALYSIS OF LAIBACH

R. Lazar, S. Jernej, Austria

The impulse for a city climate analysis in Ljubljana is the revision of the utilisation plan presently carried out by the Office for Conservation and Planning in Ljubljana. Climatic aspects or rather the principle spreading conditions of air pollutants shall influence that revision.

Ljubljana (300m) has about 250.000 inhabitants. Located between the Ljubljana moor (S) and the Save valley (N), the city lies in a very clear-cut valley basin which has a relief energy of about 300 metres. Temperate and continental, its climate is typical for south-alpine regions. Climatically speaking, the city's shielding location manifests itself in a high amount of days with fog (about 130 days/year), an extreme lack of wind (especially in the winter period when average wind speeds are lower than 1m/s), a high frequency of calms and an increased readiness for inversions.

The aim of this study is to capture the heat island structures and to document the spreading conditions of selected air pollutants on the basis of the local wind systems and their layer conditions. It will evaluate the inversion structures and analyse the daily variation of the pollution content for inversion conditions. The methodology is based on the data from a special network of stations, tethersonde soundings, SODAR - campaigns, an infra-red thermal satellite scene and measuring drives. With their help a map of climatopes and a map of planning tips has already been set up as a basis for the new utilisation plan. The net of measurement was set up in May 1998 and covers eight additional stations. The registration of the data is carried out in cooperation with the Office of Hydrology in Ljubljana. Unfortunately, a useful satellite scene (Thermatic-Mapper/Landsat) is still missing as the degree of clouding has so far been too high. All the other measuring programmes have nearly been finished. It is expected that the study will be completed in summer 2000.

So far the results show that in Ljubljana the formation of a heat island very strongly depends on the fog situation. In clear nights without fog the heat island can extend to a degree between 5 and 7 K and extends even more with a covering of snow. When there is fog in the valley, its extension drops down to some few K. Very frequently the heat island is only developed in the first half of the night as the development of fog reduces the differences. The valley fog can thereby take off in the city centre and by that causes a transformation into free inversions which have a mixed layer of about 150 to 200 metres. In the end it is that rather minor mighty layer which is responsible for the fact that Ljubljana has to fight more air-hygienic problems than Graz. From time to time there can also be building up effects of inversions. This is especially true for situations with a high concentration of NOx pollution if the density of the mixed layer does not increase on the following days. The frequency of inversions is of about 70 to 80 %. Here ground inversions are more common in the surrounding areas, whereas taken-off inversions are typical in the city centre especially in the winter period.

As far as the local winds are concerned, a system of cold air flows (50 to 100m mighty) directed at the city centre could be proved for the night and morning situation. These winds can no longer be seen as purely thermally induced country breezes. During the day the Save up-valley wind is dominant. Coming from SE and heading especially to the north of the city, it increases its speed during the day and reaches its maximum in the afternoon (summer period).

EVALUATION OF THE SOLAR RADIATION PENETRATION IN THE SNOW: AN APPLICATION TO THE SNOWLAYER OF THE FITZ ROY MASSIF (ARGENTINEAN PATAGONIA)

Augusto Biancotti, Luigi Motta, Michele Motta, Italy

In the Andes of Patagonia, by the Paso of Cuadrado (Fitz Roy massif), we have carried out tests in order to obtain a procedure to measure the solar radiation that penetrates in the snowlayer. On the shady wall of a stratigraphic trench, were dug long tunnels, in which a sensor of a radiometer was inserted. The resulted values were compared with the ones collected at the same time by a sensor placed on the snow surface, and by a sensor placed at a height of 1m and downward-oriented. The main purpose of the study was to test the method application, evaluating if the considered depths were compatible with a radiation quantity sufficient for its measurement, and if the results weren't too much affected by the parameters changeability, such as snow density and moistness and solar radiation more or less filtered by clouds. The analysed late summer snow, was characterised by a metamorphic process of melting-refreezing, with only little significant facets of a previous constructive metamorphism. The snow presented also a density constant in a profile, varying from 440 and 465 kg/m^3. The water content was more variable, influenced by the local drainage conditions. Taking also these conditions into consideration, the obtained data are homogeneous; since the transmittance of the solar radiation dependent on the depth, obtained from ten-thirty series of measurements for each site, are overlapping. The radiation penetration pattern of LISTON & AL. (1993) was so applied and the value of the attenuation rate of the downward flux $\eta(z)$ for the different depths of the profile was obtained. In every of the analysed profiles, $\eta(z)$ regularly decreases with the depth. The obtained values of $\eta(z)$ have to be considered in order to diversify the snow in the different sites. In the site 1, the clustered roundshaped grains with residual facets, show reduced values of $\eta(z)$ compared with the snow in the site 2 and 3, which is characterised only by wet grains. The transformation of the snow through the metamorphic melting process, has probably resulted as a consequence in the decreasing of the value $\eta(z)$ at every heights of the profile. A simple pattern of light transmittance as a homogeneous microcrystalline mean, can't be applied for reduced depths of the snowlayer, whereas it can be possible for depths major of 5 cm.

THE INFLUENCE OF MOUNTAIN OLYMPUS ON THE CONVECTIVE CLOUDS CHARACTERISTICS

P. J. Pennas, A. N. Tournaviti, T. S. Karacostas, Greece

The main objective on this paper is to identify and study some particular characteristics of the convective clouds, which have been developed due to the presence of mountain Olympus. To meet this objective, radar and radiosonde data are used, for the warm period of 1984-1988.

The wind characteristics at the atmospheric levels of 700 and 850 hPa are taken from the radiosonde of the synoptic station of Thessaloniki. Based on this information, the areas of development of the convective clouds, due to the 3-D mountain of Olympus, are defined. Using the Thessaloniki radar records, the cells of the convective clouds are determined and some characteristics of them are considered.

Two groups of convective clouds are distinguished and their characteristics are analyzed and compared. The identified differences are depicted, and an attempt is made to explain them. The diurnal distributions of the two groups of the convective clouds are studied and their differences are pointed out.

ALPCLIM PROJECT: RECONSTRUCTION OF THE MONTLY VALUES OF SOLAR RADIATION INCIDENT OVER THE LYS GLACIER SURFACE (MONTE ROSA-WESTERN ITALIAN ALPS)

G. C. Rossi, P. Johnston , V. Maggi, Italy

The ALPCLIM Project (Environmental and Climate Records from High Elevation Alpine Glaciers) operates within the framework of the 4th EU Environment and Climate Programme (1994-1998), and its objective is to gather, interpret and validate the environmental information present in ice-cores extracted from cold alpine glaciers. The Italian site is located at Colle del Lys (4250 m a.s.l.), on the southern slope of the Monte Rosa Group, with an ice-core spanning a time period of the last 50 years. The interpretation of the environmental information uses mathematical models to describe ice-flow dynamics. The models require suitable meteorological inputs, with particular emphasis on energy constraints such solar radiation fluxes. To this end, meteorological data are collected by a weather station located at the drilling site on the Colle del Lys. In addition, time series of cloud cover observations for different neighbouring sites are also available for the period covered by the ice core.

Monthly values of incident and reflected radiation fluxes are calculated by application of statistical relations relating cloud cover values to astronomical radiation values. Calibration of the statistical parameters is carried out using the experimental data and backward simulation values are obtained using cloud cover data.

LONG-TERM VARIABILITY OF MINIMUM AND MAXIMUM DAILY TEMPERATURE AT SUBMONTANE STATION ZAKOPANE IN POLAND (1906-1998)

Joanna Wibig, Poland

Meteorological station Zakopane is located in a small city under the Tatra Mountains at the altitude of 833 m a.s.l. The measurements of minimum and maximum temperature began in May 1906. There are only some gaps in 1911, 1921 and 1922. The station is far from big cities so the temperature records should render real changes in meteorological condition at the south of Poland. There are marked trends in different parameters related to minimum temperature, e.g. in the record of annual sum of minimum temperature below -10^{0}C (fig.1). Such trends are absent in indices related to maximum temperature. In this case there are two subperiods with lower values: the first before 1927 and the second in 1970s (fig.2). The comparison of distributions of minimum temperature in warm decades 1927-1936 and 1989-1998 shows that in the latter one winter minimum temperature was evidently higher then in the first one (fig.3). The relations of minimum and maximum temperature records with circulation is also examined.

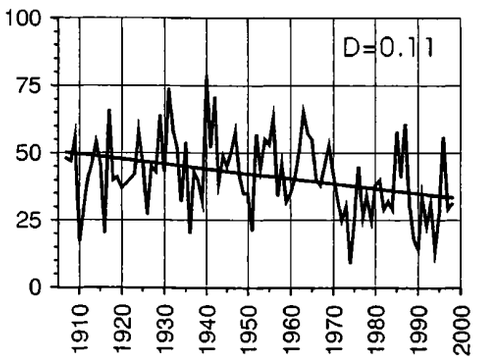


Fig.1. Annual frequency of days with minimum temperature below -10 C

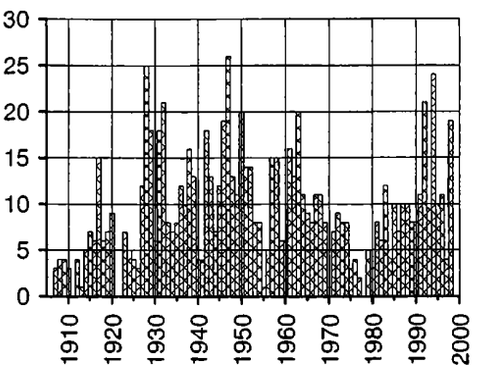


Fig.2. Annual frequency of days with maximum temperature above 25 C

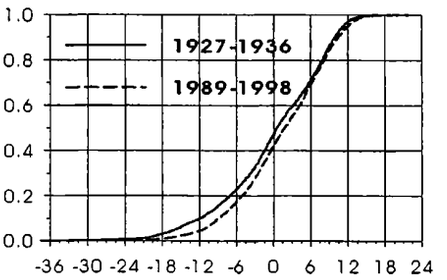


Fig. 3 Distribution of minimum temperature in Zakopane in 1927-1936 and 1989-1998

ON RAINFALL ENHANCEMENT IN MOUNTAINOUS TERRAIN

Bart Geerts, USA

Dramatic increases in rainfall rate have been noted when a tropical cyclone makes landfall over mountainous terrain. Heavy warm-season rain events resulting from relatively weak extratropical cyclones in the alpine region have also been documented. In this poster examples are given for landfalling tropical cyclones in central America and Taiwan. Detailed airborne radar and passive microwave data are examined for Hurricane Georges as it made landfall on the mountainous island of Hispaniola on 22 September 1998, leaving behind a trail of death and devastation, largely the result of excessive rainfall, not storm surge or wind. The data suggest that surface rain rates increased during landfall, both in the deep convection and in the more widespread stratiform rainfall areas over the island. The main evidence for this is the increase in radar reflectivity below the bright band down to ground-level. Such increase is strongest in the Cordillera Central, weaker over the coastal plains, and absent offshore. Radar reflectivities are well-known to underestimate surface rain rates in tropical cyclone environments, partly because of low-level growth, partly because of differences in the drop size distributions, when compared to typical midlatitude precipitating systems. This underestimation appears to be even more dramatic during Georges' landfall. The observed low-level rain enhancement must be due to the ascent of boundary-layer air over the topography.

MOUNTAIN AND SOIL FACTORS AFFECTING TIBER BASIN HYDROMETEOROLOGY

Sabino Palmieri, Pio Bersani, Anna Maria Siani, Giuseppe Casale, Italy

A medium size river basin in Central Italy (Tiber) is considered . Various scales of climatic and soil factors play a role in the river hydrometeorological behaviour. High mountains belonging to the Appennine Range in the East of the catchment do contribute to enhance convective summer rainfall and occasionally give rise to a snowmelt water increase in spring. More organised medium size mountain ranges, such as those exsisting in the southeastern part of the Basin (Simbruini), are a very active barrier for the moist Mediterranean air currents and behave as an effective rain stimulator in cases of frontal passages. The precipitated rain water percolates through the carbonatic rocks and later appears in the last section of the river. Finally in the medium section of the basin, evapotranspiration and soil moisture storage are the leading processes. The relationship among the observables and the typical parameters characterising the basin, could be analysed by means of a physically-based model capable of describing all major processes including the land phase of the hydrological cycle. Nevertheless this approach requires the provision of a large amount of parametric and input data. A preliminary "black box analysis" is applied and presented with the intent to gather possible clues to simplify the conceptualization of the considered physical system . Preliminary results along this line are discussed.

ON THE RELIABILITY OF GPCP-1DD GLOBAL SATELLITE-BASED PRECIPITATION ESTIMATES OVER THE ALPS

B. Rudolf, Germany, P. Skomorowski, F. Rubel, Austria

Quite recently a new experimental precipitation estimate of the Global Precipitation Climatology Project, the GPCP-1DD product, was introduced. The NASA provides the research community with these global 1degree (latitude/longitude gridded) daily precipitation fields combined from of different satellite-based estimates. In the 40° N-S belt 3hourly IR observations from geostationary satellites calibrated with SSM/I data are used. The mid-latitude precipitation is derived from SSM/I data only while high-latitude precipitation is estimated from TOVS data of the polar orbiting satellites NOAA-12 and NOAA-14. These two satellites, with 0130/1330 and 0730/1930 local time equator crossing times, are flying simultaneously and provide global precipitation estimates based on an empirical relationship between rain gauge observations and a function of the cloud-top pressure, fractional cloud cover and relative humidity profile (Susskind et al., 1997).

The question needs be discussed how far the SSM/I and TOVS based GPCP-1DD rain rates could be used for verification of climate model results. To do this, high resolution observations from hydrometeorological networks are used to evaluate the reliability of the GPCP-1DD product. The raingauge measurements have been analyzed on the same grid. Statisical techniques such as regression analysis, correlation and skill scores as well as exemplary case studies (discussion of difference fields) are used for comparison of the raingauge- and satellite-based estimates. Results for the European Alpine area will be presented and discussed at the ICAM 2000.

SNOW COVER DURATION IN SLOVENIA

Tadeja Ovsenik-Jeglic, Mojca Dolinar, Slovenia

Snow cover characteristics in Slovenian Alps were analysed. For turistical management and other economic branches in alpine region the information about snow cover duration is very important. A lot of winter turistical resorts reported about poor winter seasons in recent years, because of reduced snow cover duration. We tried to find out whether the change in snow cover duration in the last years is significant and whether it is related to temperature changes.

Snow cover duration, average, minimum and maximum temperature were analysed for four alpine meteorological stations with homogenical time series. Statistical significance of trends and correlation between trends of all four above-mentioned parameters were checked. With comparing charts of medians for two relatively long time series we tried to find out weather the change in the spatial pattern of snow cover duration is significant.

SELECTED SNOW COVER CHARACTERISTICS CHANGE DURING THE PERIOD 1921 - 2000 IN SLOVAKIA

S. Handzák, P. Fasko, P. Nejedlik, Slovakia

Seasonal snow cover is more frequently in the centre of interest than some other climatic phenomena. It is one of the components with the role of the terrestrial cryosphere within the climate system. Nowadays it is important to know what are the interactions and feedbacks between the terrestrial cryosphere and current climate, its variability and change.

Systematic snow cover observations are to disposal in Slovakia since 1921. The contribution contains the meteorological stations which were chosen according to their altitude, kind of place etc. They were used as the base for snow conditions analysis in the period 1921 – 2000 in Slovakia. To present areal and temporal variability of snow cover the characteristics were used as follows: number of days with snow cover, maximum of snow cover depth, sums of daily snow cover depths. More detail analysis of snow cover during winter season was performed at selected stations. The calculation of elevation dependence of snow cover characteristics (including significance test) was necessary for preparing the snow cover maps in complex geographical conditions. Air temperature and solid precipitation determine the creation of snow cover, that is why they are also presented. Temperature and precipitation conditions in Slovakia are mostly determined by the variability of the terrain which varies in between 95 to 2655 m a.s.l. (Gerlach), that is the top point of Carpathian ridge.

SYNOPTIC CLIMATOLOGY OF EASTERN ALPINE GLACIER BEHAVIOUR, 1966-1990

Hanns Kerschner, Austria

A weather type classification system similar to one used by the Swiss Meteorological Office (SMA) is used to compare weather type frequencies during the accumulation period and the ablation period of extremely positive and extremely negative mass balance years of Hintereisferner (Ötztal Mountains) and Stubacher Sonnblickkees (Hohe Tauern).

Results show that years with positive mass balance at Hintereisferner are characterised by a higher frequency of cyclonic southerly and southwesterly weather types and on an above-average frequency of cyclonic activity in the Mediterranean. During positive years at Stubacher Sonnblickkees, cyclonic westerly and northwesterly weather types are more frequent.

Extremely negative years at Hintereisferner show a high frequency of dry and sunny anticyclonic weather during the accumulation period and hence a significant lack of winter precipitation. At Stubacher Sonnblickkees, the weather of the accumulation period seems to be of lesser importance.

During the ablation period of negative years, weather type frequencies are about the same for both glaciers with a predominance of anticyclonic weather types. The ablation period of positive years show a weather type frequency pattern which is astonishingly similar to that of the accumulation period during those years. During the ablation period of Hintereisferner, southerly and southwesterly cyclonic types are more frequent, whereas cyclonic westerly and northwesterly weather types are more frequent during the ablation period of positive years of Stubacher Sonnblickkees.

These facts, which are intuitively well known to the researchers involved, can obviously be proven by the analysis of weather type frequencies.

CLIMATE CHANGES AND TRIGLAV'S GLACIER

Mateja Nadbath, Slovenia

Trigav's glacier lies on the north-east slope of the Triglav mountain in the Julian Alps, on the 2400 - 2500 meters above see level. Because of blue-green colour of its snow it is called also Zeleni sneg - Green snow.

At the end of 19th century Glacier's surface measured 45 ha, in the year 1946 its surface reduced to 15 ha and in the year 1994 was 4 ha. One year later (1995) the surface of the glacier measured only 3,03 ha. Researchers of the Geographical Institute on Scientific Research Centre of Slovenian Academy of Sciences and Arts observe glacier from 1946 and they find out, that glacier's surface is the smallest ever; glacier's surface is reducing constantly from the end of the 19th century.

Hydrometeorological Institute of Slovenia has its observation station on Kredarica, 2514 m above see level and 300 m far from Triglav's glacier. On this station we started regularly to observe and measure meteorological parameters in January 1955.

We will present meteorological parameters, which impact the most on glacier's reduction. These parameters are: mean air temperature, mean maximum air temperature, number of days with maximum air temperature below 0 °C, maximum snow cover, number of days with snow cover and number of days with snowing. All mentioned meteorological parameters will be shown for the period 1995 to 1999 and for the last twenty years. To emphasise the changes nine-years moving average and linear trend are used.

In the last twenty years there is a rising linear trend of the following meteorological parameters: mean air temperature, mean maximum air temperature, number of days with snow cover in the cold part of the year. On the other hand, there is a decreasing linear trend of number of days with snowing, maximum snow cover, number of days with snow cover in the whole year and in the warm part of the year and number of days with maximum air temperature below 0 °C.

SUMMER SNOWFALL IN THE INNER ÖTZTAL IN CONNECTION WITH CENTRAL EUROPEAN AND NORTH ATLANTIC WEATHER CONDITIONS

Alexander Ohms, Michael Kuhn, Austria

Newly fallen snow increases the albedo of the glacier surface strongly, whereby a majority of the global radiation is reflected. In this way, mass reduction can be brought to the deadlock temporarily. Therefore, no modelling of glacier balancs gets along without estimating summer snowfall.

Due to the uncertainty when determing snowfall events at the glacier from data of surrounding stations, the statistical analysis was limited to summer snowfall observations at the nearby station Vent (1906 m.a.s.l.). Snowfall at this station was correlated with the classification of Central European weather conditions by Hess and Brezowsky. It is shown that snow is falling in Vent with almost all classes of these weather classification in the summer months und thereby at the higher glacer areas, too. Mainly three classes of weather conditions are connected with excessive summer snowfall in the inner Oetztal: Trough over Central Europe, through over Western Europe and cyclonical Westerly flow.

Close to zero correlation coefficients show that there are no connections between the frequency of summer snowfall in the Oetztal and the North Atlantic Oscillation. However, there is a correation between the mass balances of the Hintereisferner and the NAO, espacially in the extreme budget years. The most positive mass balance happen to be during weak circulation over the North Atlantic. In these years, about twice as much snow fell in Vent compared to the years with extreme negative mass balances. The later ones are all correlated with strong circulation patterns.

In greater detail it was found that the above mentioned two trough categories are dominating the snow fall on the glacier, 70 percent of all summer snowfall cases are connected with those circulation patterns.

Great differences between the precipitation events at the tongue and the high-altitude station Hintereis (3030 m.a.s.l) occur with flow from Southerly directions. Small-scale precipitation patterns are influenced strongly by orograhic conditions.

A NEW MAP OF ACCUMULATED NEW SNOW IN AUSTRIA

Wolfgang Schöner, H. Mohnl, Austria

GIS software systems are powerful tools for climate mapping specially in complicated terrain. Today interpolation of point measurements to raster-values based maps can be done by PC-solutions of GIS software systems. The climate mapping of accumulated new snow in Austria is based on annual sums (hydrological year) of about 450 stations for the WMO normal 1961-90. The work is done within the national funded ÖKLIM project (Klimatographie von Österreich).The intensely structured terrain of Austria is captured by a digital elevation model with 500 m resolution in space. All data are checked for quality. As station networks of new snow height is not dense enough and also the distribution of stations are not homogeneous in space an area interpolation of data points alone (eg inverse distance weighting, krigging etc.) do not lead to satisfying results. Therefore as a first step of regionalisation we use a model of elevation dependency of new snow height for the entire region of Austria. In a second step still existing residuals are corrected by regional effects like windward/lee-sites, inner-alpine sites etc.. The described method results in high quality maps of accumulated new snow in Austria with low residuals to stations measurements and a transparent and reproducible procedure with a high degree of variance explained by topographic effects.

EVALUATION AND MONITORING OF SNOWCOVER WATER RESOURCES IN CARPATHIAN BASINS BY REMOTE SENSING AND GIS TECHNIQUES

Gheorghe Stancalie, Simona Catana, Romania

The surveillance and management of the water resources in Romania represent an issue of natural importance considering the fact that the natural potential of the water courses is rather reduced, altered by water consuming users and by those which redistribute the flow in time. In this respect the efficient and rational management of water resources involve also the knowledge of snowpack condition evolution and the snowcover water equivalent estimation in Carpathian basins, in different phases of the snowmelt-runoff season.

Dependent of physiographic and climatic characteristics of the Carpathian mountainous basins, the most efficient way to evaluate and monitor the snowcover and the related physical processes proved to be the remote sensing and GIS techniques.

The paper presents the technical means and the working methods developed in the Remote Sensing Lab of the National Institute of Meteorology and Hydrology in Bucharest, for operational applications in the following field of the snow hydrology.

A complex related geo-referenced database, consisting of high and medium resolution satellite data (NOAA-AVHRR, LANDSAT-TM, SPOT-XS), terrain information derived from Digital Terrain Models (DTM) and other exogenous data (maps and ground measurements) was designed and implemented on PC-based computing systems. The GIS developed for the snowcover water resources management includes information referring to the topography, land vegetation cover, land use, soil type, hydro-meteorological parameters, that could be used as separate layers or interconnected in order to extract the necessary information for a correct and accurate estimation of the snowpack conditions and snowcover water resources during the winter-spring period. The possibility of merging satellite imagery in GIS layers allows periodical up dating of spatial information for land cover, land use and other basin features, as well as for the snowmelt-runoff model parameters evaluation.

The paper describes the methods developed and analyses the obtained results for: basin snowcover areal extent and snowline elevation determination, new snowfalls identification, melting zones discrimination, snowpack water volume determination, snowcover depletion curves, etc. Based on snow accumulation and melting features, the characteristics of the runoff generated by the snow melting in some basins of the Carpathian mountains are also discussed.

MEASURING AND MODELLING THE VERNAGTFERNER ENERGY BALANCE COMPONENTS: RESULTS FROM HYMEX98 AND THE PEV MODEL

Heidi Escher-Vetter, Markus Weber, Germany

The IOP of the micrometeorological-hydrological experiment HyMEX98 was performed on Vernagtferner (Oetztal Alps, Austria) from August 9 to 11, 1998. During this fair weather period with high solar radiation input and air temperatures, all energy balance components were determined at a site which is typical for the main snow-free part of the glacier. Thus, short-wave and long-wave radiation balances were derived from records of global and reflected radiation and from incoming and outgoing long-wave radiation. The turbulent fluxes were assessed with eddy correlation methods. Additional profile measurements up to 10 m gave information on the stratification. As these data are only representative for an area of several 100 m^2 upwind, the spatial distribution of all the components is provided by the distributed energy balance model PEV. The data for this model are taken at the site of the Pegelstation Vernagtbach, which lies approximately 1 km below the glacier terminus. The comparison of the components, derived with the regionalization methods and the parameterization schemes of PEV for the HyMEX98 site with the directly determined fluxes casts a light on the shortcomings of the model as well as on the difficulties to determine turbulent surface fluxes during glacier wind situations with conventional methods. As shortwave radiation balance is the quantitatively most important component for the meltwater production, the measurements of ice albedo during HyMEX98 help to improve this part of the model considerably. The turbulent fluxes, derived with eddy correlation, differ quite markedly from those of the model, which are based on a bulk method and thus include the characteristics of a convective boundary layer. Over the glacier, the fluxes are rather small as warm air from upper layers is only induced by dynamical entrainment and not by thermal mixing in the shallow stable glacier wind layer. As turbulence is intensified by the katabatic flow of the glacier wind, a more fully developed deeper surface layer will display higher sensible heat fluxes.

ROM-PROJECT - SIMULATIONS OF THE BOUNDARY LAYER - FOEHN INTERACTION

Kathrin Baumann, Erwin Polreich, Matthias Langer, Ulrike Pechinger, Austria

Within the project ROM (Rhine valley Ozone study in MAP), the non-hydrostatic model MM5 nested to ECMWF data is applied to simulate the meteorological conditions in the Rhine Valley during a Foehn IOP. The innermost model domain has a horizontal resolution of 1 km. The spatial distribution of boundary layer properties as inversion heights, mixing heights and the energy budget at the surface is deduced from the model results.

These model results are compared to boundary layer parameters that are calculated with a meteorological pre-processor based on the analysis of meteorological surface observations and radiosoundings. For this purpose, the meteorological measurements are interpolated on a horizontal grid of 1 km resolution based on a geographical information system and parametrization formulas are applied to deduce the boundary layer parameters e.g. surface heat flux, friction velocity, Monin-Obukhov length and mixing height.

BACKGROUND OZONE VARIATIONS IN THE NOTHERN APENNINES

P. Cristofanelli, P. Bonasoni, A. Stohl, U. Bonafè, F. Calzolari,
T. Colombo, F. Evangelisti, Italy

In order to assess the behaviour of background ozone concentrations at Mt. Cimone (2165 m a.s.l.), the highest peak of Italian northern Apennines, surface ozone variation has been studied. Since 1996 an analysis on three years of ozone measurements as a function of air mass origin and path using six-day backward trajectories was carried out. We defined background ozone to occur in air masses that do not penetrate below 780 hPa for at least 48 hours before reaching Mt. Cimone, that is typically at 790 hPa.

The highest background ozone concentrations were related to air masses coming from high latitudes and from central Europe while low values were related to air masses flowing from low latitudes, in particular from the Saharan desert and Atlantic Ocean. The analysis has shown that the background ozone concentration recorded at Mt. Cimone presents a yearly mean higher than that recorded in non-background conditions. Moreover, the background ozone behaviour exhibits a principal maximum in spring and a secondary maximum in summer: the former, mainly due to transports from high latitudes, can be considered characteristic of the seasonal ozone cycles in the clean atmosphere; the latter is recorded earlier than in non-background conditions, when the site can be reached by polluted air masses coming from the lower troposphere and from the Po Basin.

Analysis of background and non background ozone concentration associated with air masses coming from north of the Alps and flowing through the Po Basin will be presented.

TRAJECTORY CLUSTER ANALYSES FOR TWO CROATIAN MOUNTAINOUS LOCATIONS

Lidija Cvitan, Croatia

The synoptic meteorological influence on the pollution transport is assessed for Risnjak (1528 m asl.) and Troglav (1913 m asl.) - locations situated at two adjacent mountainous regions close to the Adriatic sea. For both of these two regions is provided a proper "weather type climatology" based on a local weather type classification which is in application in Croatia last thirty five years (Poje, 1965). Simultaneously different atmospheric transport to the Risnjak and Troglav suggest the more or less different weather types predomination at two regions. The transport differences between these two locations are more precisely analysed applying the statistical technique of cluster analysis to isentropic trajectories arriving at each location.

For Risnjak and Troglav are calculated 366 three-dimensional 72-h backward trajectories for the period January-December 1996. The HYSPLIT4 (Hybrid Single-Particle Lagrangian Integrated Trajectory) model has been used (Draxler and Hess, 1999). The calculation started from 100 m agl. once a day beginning at 0600 UTC.

The cluster program developed by Stunder (1996), which is used for the purpose of this paper, uses Ward´s method (Ward, 1963). Clustering is applied in classification of all 366 trajectories for the whole one-year period as well as in classification of the seasonal trajectories. For each season and a year in all and for each location separately, the appropriate number of clusters is identified as well as the cluster-mean trajectories. Namely, the cluster model used offers few numbers of clusters for each period considered.

At first, this paper shows the results of the analysed significance for pollution transport of all the clusters groups of trajectories suggested by the model. Discovered are mainly the different numbers of corresponding clusters representative for the same period for Risnjak and Troglav. Finally, the comparisons of the mentioned finally accepted numbers of clusters are shown together with the appropriate cluster-mean trajectories for Risnjak and Troglav.

CASE STUDY OF A NORTH FOEHN EVENT IN SOUTH TYROL DURING THE SPECIAL OBSERVATION PERIOD OF THE MESOSCALE ALPINE PROGRAMME

Guenther Geier, Georg Mayr, Austria, Peter L. Jackson, Canada

The Brenner cross section was one of the heavily instrumented target areas for the field phase (SOP) of the Mesoscale Alpine Programme (MAP) from September 7 - November 15, 1999. The goal was to understand the combined effects of lateral constrictions and the lowest pass of the Alps on the flow and its connection to the flow aloft. Due to the much simpler topography north of the Brenner pass, south foehn was of prime interest and luckily also occurred frequently. The appearance of its counterpart, the north foehn, remained far below the climatological average. During a period of north foehn extending over several days, radio soundings on both sides of the pass, and car-based measurements were taken on November 8, 1999, in addition to the ground instrumentation deployed over the whole SOP. This included a Doppler sodar each at Brenner pass and in the narrowest section downstream of the pass.

Even though north foehn is often more extreme in terms of pressure contrast across the Alps and dryness of the air, little scientific effort has gone into understanding foehn on the southern side of the Brenner pass. This data set is by far the most extensive one so far and will be used to describe the fine-scale structure of the effects of north foehn in South Tyrol and compare it to south foehn.

OZONE MEASUREMENTS IN THE UPPER RHINE VALLEY WITH PASSIVE SAMPLERS

Helfried Scheifinger, Richard Werner, Kathrin Baumann, Austria

As an alternative to expensive continuous analyser measurements passive samplers provide a cost effective method for air quality monitoring. A network of eight passive samplers for ozone (weekly resolution) and of three for NO2 (two weekly resolution) was operated in the upper Rhine valley between Austria and Switzerland from July to November 1999.

Comparing continuously measured ozone data with data from three passive sampling sites a common variance between both time series of more than 80% was found . Data from passive sampling sites are biased by 2 to 9 ppb towards higher values. The higher bias was recorded at a mountain station. For NO2 the common variance is lower and no clear bias is evident.

The common variance between the sampling sites is well correlated with distance and height difference of the stations. In case the network should be designed as to grant a common variance between the stations not lower than 70% the horizontal distance should not exceed 35 km and the height difference should not be more than 200 m.

During the summer months temperature, relative humidity and global radiation are highly correlated with ozone (more than 80% common variance). As the atmospheric regime governing the ozone level changes from summer to autumn the common variance between ozone time series and time series of atmospheric variables drops significantly. It appears that frequent Föhn episodes (as studied with FORMIL = FOehn in the Rhine valley during MAP Immision Luftschadstoffe) in autumn do enhance the ozone level at high altitude stations even on a weekly sampling period.

STUDY OF SPECTRAL UV IRRADIANCE IN ALPINE REGIONS

S. Simic, P. Weihs, M. W. Mikielewicz, G. Rengarajan, Austria

Institute of Meteorology and Physics, BOKU, performs routine spectral UV irradiance measurements from 280 and 500 nm, at two stations: at Sonnblick observatory at 3106 m and in Grossenzensdorf, Wien at 150 m).

The measurements are performed with Bentham DM 150 spectrometers. Both are carefully calibrated to the same 1000 W NIST lamp standard. The data of both sites can be used to examine the different UV climatology at an alpine High mountain site and at a site with low altitude. At both sites the data were used to examine the influence of ground albedo, turbidity and clouds on UV irradiance at ground level. We additionaly also obtained the increase in UV irradiance with altitude.

These results can be used to refine the calculations and forecast of the UV index.

AIR POLLUTION AND LONG-RANGE TRANSPORT OF POLLUTANTS AT REMOTE ALPINE MONITORING SITES

Wolfgang Spangl, Austria

The Austrian Federal Environment Agency has built up a background air quality monitoring network since 1990 consisting of now nine monitoring sites, of which six are located in the Alps: Zöbelboden (Upper Austria), St. Koloman (Salzburg) and Sulzberg (Vorarlberg) at the northern border of the Alps, St. Sigmund (Tyrol) and Stolzalpe (Styria) in the central Alps and Vorhegg (Carinthia) in the south. These sites are located at altitudes between 900 and 1700 m some 100 m above the bottom of the nearest settled valleys. At these monitoring stations the trace gases ozone, sulphur dioxide and nitrogen oxides are measured, additionally particulate matter and carbon monoxide at St. Koloman and Vorhegg.

The purpose of the monitoring network is the measurement of pollution levels in remote areas – representative on a large scale and not influenced by near-by emissions – the observation of long-range transport of air pollutants and trend analysis. The results obtained up to now show that **ozone** levels in the Alps are mainly determined by a large-scale background concentration. Averaged over annual or monthly periods, ozone concentrations increase with altitude; in alpine valleys, annual mean values about 40 $\mu g/m^3$ are observed, at alpine background sites about 80 $\mu g/m^3$, at Sonnblick (3106 m) about 100 $\mu g/m^3$. The spatial variations of concentration levels are mainly determined by the relative amount of ozone depletion by dry deposition and exchange with the free troposphere. Regional photochemical ozone formation is of minor importance. High concentrations (up to 200 $\mu g/m^3$ as one-hour mean) observed at these sites can be attributed to regional transport from neighbouring extra-alpine regions, manly from southern Germany (Wüttemberg, Munich), the Vienna Region and northern Italy.

The pollution by **sulphur dioxide**, **nitrogen oxides** and **particulate matter** at the alpine background sites is mainly determined by local advection from the near-by valleys. Local transport usually occurs during daytime at unstable dispersion conditions, whereas at night the monitoring sites are situated above a ground-level inversion in the valleys. Annual mean values of NO_2 are 2 to 4 $\mu g/m^3$ during the last years at Vorhegg in a remote valley and 4 to 6 $\mu g/m^3$ at St. Koloman, 8 km from the Tauern highway.

The local contribution to the pollution of **sulphur dioxide** is superimposed by long-range transport from sources in eastern central Europe, the amount of which decreases from east to west and from north to south. The major sources are large stacks mainly in the Czech Republic and Poland. Long-range transport of SO_2 mainly affects sites at the northern border of the Alps, the highest concentrations are observed during episodes with cold weather and strong inversions in the plains north of the Alps. Nevertheless, SO_2 transport can also be observed across the central Alps during unstable conditions to southern alpine valleys. In the central Alps on average SO_2 is advected in a nocturnal reservoir layer and shows a similar diurnal variation like ozone. Annual mean values of SO_2 vary between 3 $\mu g/m^3$ at Zöbelboden and 1 $\mu g/m^3$ at Stolzalpe. The trend during the last years is significantly decreasing corresponding to emission reductions in eastern central Europe.

COMPARISON OF DIFFERENT METHODS FOR THE DETERMINATION OF THE AVERAGE UV ALBEDO IN A MOUNTAINOUS TERRAIN

P. Weihs, S. Simic, G. Rengarajan, W. Laube, W. Mikielewicz, Austria

One aim of the European project 'Characteristics of the UV radiation field in the Alps' (CUVRA) was to improve the modeling of the effect of inhomogeneous albedo fields on ground UV irradiance and to compare different methods for calculation of an effective surface albedo in topographically structured terrain. For the determination of the effect of heterogeneous illumination (shading effects, inclination and orientation of the facet) on the reflectivity of a facet in a mountainous region more complex approaches (than for the calculation of the reflectivity of flat surfaces) have to be chosen. We determined the 'effective' albedo for the surroundings of the Observatory Sonnblick (3106 m, 47.03 ° N, 12.57°E) by using three different methods. The first method consisted of a combination of a 3-D albedo model calculation and 1-D radiative transfer calculation. By using this method and a digital elevation map the reflectivity of the 22x24 km region surrounding Sonnblick Observatory was calculated. The second method was an inversion method using a 1-D radiative transfer model. The routine spectral UV measurements performed at Sonnblick Observatory were used to calculate the average effective albedo.The third method was entirely experimental. An albedo measuring system was used to perform reflectivity measurements of the surrounding of Sonnblick. The measurements were performed in the visible and in the UV A and an average albedo was obtained. Overall, the results showed that the average albedo of a topographically structured surface is lower than the average albedo of a corresponding (surface with same ground characteristics/ reflectivity) flat surface.

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