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Climatology of free tropospheric humidity: Extension into the SEVIRI era, evaluation and exemplary analysis

Marc Schröder (1), Rémy Roca (2), Laurence Picon (3), Anke Kniffka (1), Hélène Brogniez (4), and Felix Dietzsch (1)

(1) Deutscher Wetterdienst, Offenbach, Germany, (2) OMP/LEGOS/CNRS, Toulouse, France, (3) Université Sorbonne, CNRS/INSU; ENS; École Polytechnique; LMD–IPSL, Paris, France, (4) Université Versailles St Quentin; Université Sorbonne, CNRS/INSU; LATMOS–IPSL, Guyancourt, France

Water vapour has an amplifying role in a warming environment through a strong positive climate feedback loop as evident in climate predictions, and this water vapour feedback loop is dominated by water vapour in the tropical free troposphere (Held and Soden, 2000). The importance of humidity in the free troposphere originates from the non-linear interaction between humidity and long-wave radiation. The outgoing longwave radiation (OLR) is much more sensitive to perturbations at the dry end than at the moist part of the distribution (Spencer and Braswell, 1997; Roca et al., 2011). Sherwood et al. (2010a) recently reviewed the processes that determine the humidity distribution in the intertropical region. They emphasize the strong connection between the large scale dynamics and water vapour and the roles of eddies (mesoscale convection, circulation transients) in establishing these links pointing out to a broad range of scale implied in the humidity distribution. They further indicate that there is a need to better constrain the available theory. Satellites that observe the humidity of the free troposphere, and particularly, geostationary platforms are very well suited to contribute to this constraint by providing observations at kilometres and hours scale resolution over a 30 years long period.

A new free tropospheric humidity (FTH) data record is presented. It is based on observations of Meteosat-2 - 5 and Meteosat-7 Meteosat Visible and Infrared Imager (MVIRI) and Meteosat-8 and -9 Spinning Enhanced Visible and Infrared Imager (SEVIRI) at the water absorption band at 6.3 μm. With the extension to SEVIRI observations the data record now covers the period 1983 – 2009 with a spatial and temporal resolution of 0.625° and 3 hours, respectively. The data record is freely available from http://www.cmsaf.eu/wui.

The relation between the observed brightness temperature (BT) and FTH is well established: Here, existing retrievals have been refined mainly through the consideration of relative humidity Jacobians in the training process of the statistical retrieval. The temporal coverage has been extended into the SEVIRI era, the homogenisation of the BT record has been improved and the full archive has been reprocessed using updated regression coefficients.

The FTH product is compared against FTH computed on the basis of the Analysed RadioSoundings Archive (ARSA) observations. An average relative bias and root mean square difference (RMSD) of -3.2% and 16.8%, respectively, are observed. The RMSD confirms the expectation from an analysis of the total uncertainty of the FTH product. The decadal stability is 0.5±0.45% per decade.

As exemplary applications the inter-annual standard deviation, differences on decadal scales and the linear trend in the FTH data record and the frequency of occurrence of FTH < 10% (FTHp10) are analysed per season. Maxima in inter-annual standard deviations as well as maxima in absolute differences occur in gradient areas between dry and wet regions and areas with minima in FTH and maxima in FTHp10. An analysis of the linear trends and associated uncertainty estimates has been attempted to identify possible problems with the data record. Positive trends in FTHp10 coincide with gradient areas and regions of minimum FTH, maximum FTHp10 as well as with negative differences between decadal FTHp10 averages of the 1990s and 2000s. However, they are accompanied by maximum standard deviation and are therefore hardly significant which is also valid for FTH trend estimates.