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The atmosphere- and hydrosphere-correlated signals in GPS observations

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The circulation of surface geophysical fluids (e.g. atmosphere, ocean, continental hydrology, etc.) induces global mass redistribution at the Earth's surface, and then surface deformations and gravity variations. The deformations can be reliably recorded by permanent GPS observations nowadays. The loading effects can be precisely modelled by convolving outputs from global general circulation models and Green's functions describing the Earth's response. Previously published papers showed that either surface gravity records or space-based observations can be efficiently corrected for atmospheric loading effects using surface pressure fields from atmospheric models. In a similar way, loading effects due to continental hydrology can be corrected from precise positioning observations. We evaluated 3-D displacement at the selected ITRF2008 core sites that belong to IGS (International GNSS Service) network due to atmospheric, oceanic and hydrological circulation using different models. Atmospheric and induced oceanic loading estimates were computed using the ECMWF (European Centre for Medium Range Weather Forecasts) operational and reanalysis (ERA interim) surface pressure fields, assuming an inverted barometer ocean response or a barotropic ocean model forced by air pressure and winds (MOG2D). The IB (Inverted Barometer) hypothesis was classically chosen, in which atmospheric pressure variations are fully compensated by static sea height variations. This approximation is valid for periods exceeding typically 5 to 20 days. At higher frequencies, dynamic effects cannot be neglected. Hydrological loading were provided using MERRA land (Modern-Era Retrospective Analysis for Research and Applications – NASA reanalysis for the satellite era using a major new version of the Goddard Earth Observing System Data Assimilation System Version 5 (GEOS-5)) for the different stations. After that we compared the results to the GPS-derived time series of North, East and Up components. The analysis of satellite data was performed twofold: firstly, the time series from network solution (NS) processed in Bernese 5.0 software by the Military University of Technology EPN Local Analysis Centre, secondly, the ones from PPP (Precise Point Positioning) from JPL (Jet Propulsion Laboratory) processing in Gipsy-Oasis were analyzed. Both were modelled with wavelet decomposition with Meyer orthogonal mother wavelet. Here, nine levels of decomposition were applied and eighth detail of it was interpreted as changes close to one year. In this way, both NS and PPP time series where presented as curves with annual period with amplitudes and phases changeable in time. The same analysis was performed for atmospheric (ATM) and hydrospheric (HYDR) models. All annual curves (modelled from NS, PPP, ATM and HYDR) were then compared to each other to investigate whether GPS observations contain the atmosphere and hydrosphere correlated signals and in what way the amplitudes of them may disrupt the GPS time series.