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The effect of meteorological data on atmospheric pressure loading corrections in VLBI data analysis

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Earth's crustal deformation is a manifestation of numerous geophysical processes, which entail the atmosphere and ocean general circulation and tidal attraction, climate change, and the hydrological circle. The present study deals with the elastic deformations induced by atmospheric pressure variations. At geodetic sites, APL (Atmospheric Pressure Loading) results in displacements covering a wide range of temporal scales which is undesirable when rigorous geodetic/geophysical analysis is intended. Hence, it is of paramount importance that the APL signal are removed at the observation level in the space geodetic data analysis.

In this study, elastic non-tidal components of loading displacements were calculated in the local topocentric frame for all VLBI (Very Long Baseline Interferometry) stations with respect to the center-of-figure of the solid Earth surface and the center-of-mass of the total Earth system. The response of the Earth to the load variation at the surface was computed by convolving Farrell Green's function with the homogenized in situ surface pressure observations (in the time span 1979-2014) after the subtraction of the reference pressure and the S1, S2 and S3 thermal tidal signals. The reference pressure was calculated through a hypsometric adjustment of the absolute pressure level determined from World Meteorological Organization stations in the vicinity of each VLBI observatory. The tidal contribution was calculated following the 2010 International Earth Rotation and Reference Systems Service conventions. Afterwards, this approach was implemented into the VLBI software VieVS@GFZ and the entirety of available VLBI sessions was analyzed.

We rationalize our new approach on the basis that the potential error budget is substantially reduced, since several common errors are not applicable in our approach, e.g. those due to the finite resolution of NWM (Numerical Weather Models), the accuracy of the orography model necessary for adjusting the former as well as the inconsistencies between them, and the interpolation scheme which yields the elastic deformations.

Differences of the resulting TRF (Terrestrial Reference Frame) determinations and other products derived from VLBI analysis between the approach followed here and the one employing NWM's data for obtaining the input pressure fields, are illustrated. The providers of the atmospheric pressure loading models employed for our comparisons are GSFC/NASA, the University of Luxembourg, the University of Strasbourg, the Technical University of Vienna and GeoForschungsZentrum of Potsdam.