REFAG 2022 THESSALONIKI - GREECE
17-20 October 2022

Predicting Non-tidal Loading Contributions Induced by Environmental Loading

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Abstract. Earth’s surface is elastically deformed by time-variable surface mass loads such as variations in atmospheric surface pressure, ocean bottom pressure, and terrestrial water storage. We look at the individual environmental loading contributions from the three different sub-systems (atmosphere, terrestrial water storage, ocean) as well as from sea level variations induced by the global water mass balance between land and ocean. Dividing the contributions into a set of period bands by means of a Wavelet decomposition, we show that non-tidal atmospheric surface loading (NTAL) by far dominates non-tidal ocean (NTOL) and hydrospheric loading (HYDL) for periods as long as a few months. The contribution of terrestrial water storage is continuously growing for increasingly longer periods and dominates atmospheric pressure at periods of 300 days and above. Ocean dynamics including sea level variations due to the seasonal global mass balance are only important in the immediate vicinity of the coast. In representative regions we compare environmental loading estimates (NTAL, NTOL, HYDL) from ESMGFZ based on ECMWF operational atmospheric data with station coordinate time-series from different GNSS solutions. Depending on the geographical location and considered frequency range, the different GNSS solutions (individual analysis center contributions to ITRF2020 as well as the combined solution) can exhibit large differences. To evaluate the ability of different GNSS solutions to confirm the vertical deformations predicted by the geophysical fluid models, we compared at selected sites the vertical station coordinates from six GNSS solutions (IGS' contribution to ITRF2020, IGS repro 3) with the loading model predictions. For station location where the dominant loading signal is generated from atmospheric surface pressure most GNSS solutions fit very well to the model predictions. In contrast, the GNSS derived variations and the model predictions show large deviations from each other for seasonal and annual variations.