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Gravity variations at Medicina: mass movements or vertical displacements?

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Superconducting gravimeters allow the continuous monitoring of local gravity variations over extended periods of time. The longest time series span now more than 20 years and support the study of long-term non-linear processes. Residual gravity variations, after removing effects of the Earth tides, atmosphere and polar motion, can either be induced by vertical movements of the sensor or by mass redistribution in its surroundings. The separation of the two signals is, in general, a complicated task that requires the careful consideration of a number of different processes. In this study, we analyze the gravity time series recorded at the astronomical observatory of Medicina, Italy, by means of a superconducting gravimeter and of absolute gravity observations. Since the beginning of gravity measurements, the Medicina site has also hosted two GPS stations, a VLBI antenna and two piezometers, allowing the simultaneous monitoring of gravity variations, crustal deformations and environmental parameters. The considered time series cover the period 1998-2017. The study shows that the long-term behavior of the gravity dataset is mostly controlled by the local land subsidence, which is characterized by an average rate of -2 mm/year. Non-linear long-period features are also observed, correlating with large-scale variations in groundwater content. At the annual time scale, a prominent seasonal cycle is found with a peak-to-peak amplitude of about 50 nm/s2. Concerning the phase, this cycle is well synchronized with the hydrological loading. However, a proper representation of the amplitude requires to account also for local geotechnical phenomena and for the shielding effects caused by the housing of the gravimeter. In our modeling of the gravity variations, the analysis of the g-to-h ratio played a critical role for the discrimination between mass variations and height displacements.