From a disturbing influence to a desired signal: Hydrological effects in gravity observations

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Hydrological effects in an order of magnitude of up to several µGal are observed worldwide in gravity data, particularly in the high resolution recordings of superconducting gravimeters. Because they superpose other geodynamic signals, their reduction is necessary. For the development of a reduction model the understanding of the underlying hydrological processes is of central importance. Especially in areas with strong topography and/or inhomogeneous subsoil a simple reduction model based on hydrological measurements at the observatory is not sufficient. If the gravity variations in the observatory surrounding caused by hydrological variations and the hydrological parameters are observed two-dimensional it should be possible to model the influence of hydrological variations on the gravity recordings at the observatory and develop a reduction model. Because generally there is no superconducting gravimeter available for two-dimensional gravity measurements, the question raises whether by repeated gravity measurements with field gravimeters hydrological variations can be detected significantly in the µGal range. On the other hand the hydrological effects observed in the gravity data are of interest to hydrologists and hydrogeologists because they contain information about mass distributions and their changes in the subsoil, e.g. groundwater movement. Gravity measurements, in particular two-dimensional gravity measurements, detect hydrological variations integral - in contrast to the hydrological measurements which contain only information about the point of the measurement. Thus, information is also won about areas, in which hydrological measurements are not or hardly possible. That way gravity measurements can help to understand hydrological processes better. They also can be a boundary condition for hydrological modelling.

At the Geodynamic Observatory Moxa in Germany a local gravity network was established. Using excellent LCR field gravimeters the gravity differences between these observation points were measured in nine campaigns so far. The hydrological variations observed by the superconducting gravimeter as well as by water level, soil moisture and run off measurements are significantly provable as gravity changes in the range of some µGal between different observation points of the network by repeated gravity measurements using field gravimeter. In particular differences in gravity differences are observed between observation points in the valley and at the steep slope to the east of the observatory. They are bigger during dry weather and smaller during wet weather conditions. This indicates significant hydrological variations in the slope. For a better understanding of the hydrologically caused gravity changes as well as for the evaluation of hydrological models existing for the observatory surrounding 3D gravity modelling is carried out. Based on the free air anomaly a 3D gravity model of the observatory surrounding is developed. In the model the measured hydrological variations are converted to density changes of the subsoil. It is analysed in which areas and in which range hydrological variations appear, which are significant for the gravity observation points. First results indicate a good agreement in the range of the measured and modelled gravity changes.