Long-term observations at the Geodynamic Observatory Moxa: Can we identify evidence for climate change?

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Long term geophysical recordings of natural Earth’s parameters besides other signals also may contain past and ongoing temperature fluctuations, as they are occurring e.g. when groundwater moves or when climate changes. Similarly, repeated logs or continuous recordings reveal the amount of ongoing climate fluctuations. However, such thermal signals in the subsurface also may have other causes, e.g. groundwater motion or fluid infiltration after strong rainfall events. The Geodynamic Observatory Moxa of the Friedrich-Schiller University Jena, Germany, is an ideal test site for long-term monitoring of the subsurface temperature distribution in boreholes using optical fibre temperature-sensing, as it is equipped with a variety of complementary sensors.

A 100 m deep borehole on the ground of the Observatory, is equipped with an optical fibre and a water level gauge. Clearly shown in the records of the first five years of continuous recordings are seasonal temperature fluctuations. Seasonal fluctuations could be identified down to a depth of about 20 m and diurnal temperature signals down to 1.2 m. Precipitation events may influence subsurface temperature still in a depth as deep as 15 m. Besides these, temperature anomalies were detected at two depths, 20 m and 77 m below the surface. These anomalies most probably result from enhanced groundwater flow in aquifers. Recordings of deformation from laser strain meter systems installed in a gallery at Moxa, which are highly sensitive to pore pressure fluctuations, and measuring the physical properties during drilling the borehole, help to identify and quantify the causes of the observed temperature fluctuations.

For more than 20 years variations of the Earth’s gravity field have been observed at the Observatory Moxa employing the superconducting gravimeter CD-034. Besides the free oscillations of the Earth and hydrological effects, the tides of the solid Earth are the strongest signals found in the time series. Tidal analysis of the main constituents leads to obtaining the indirect effect for all tidal waves which is mainly controlled by the loading effect of the oceans. Satellite altimetry revealed a mean global sea level rise of about 3.3 mm/a which may be caused amongst others mainly by ice melting processes in the polar regions. However, more detailed analyses and resulting global maps show that the sea level rise is not uniformly distributed over all oceans. This means that actual and future tidal water mass movements could vary regionally and even locally. As a consequence, the tidal parameter controlled by the ocean loading effect could change over long-term observation periods and it should possibly be detectable as a trend or
temporal variation of the tidal gravity parameters locally. Actually, a long-term change of the tidal parameters is observed for the main tidal waves like K1 and O1 in the diurnal and for M2 and K2 in the semi-diurnal frequency band. However, it is not clear if these changes can be correlated with sea level changes as observed from satellite data. On the other hand, surface and subsurface temperature fluctuations directly reveal the size of the thermal signal inherent to climate change.