Coastal Hazards - Subsidence Monitoring with GNSS-controlled Tide Gauges in Indonesia

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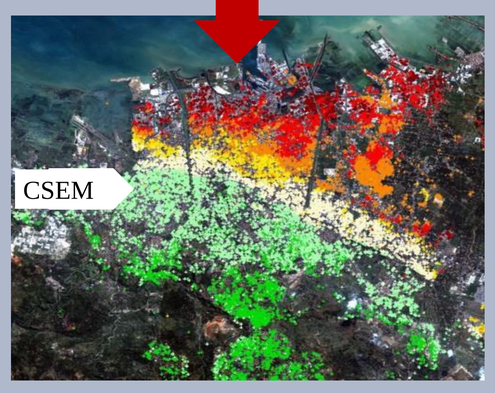
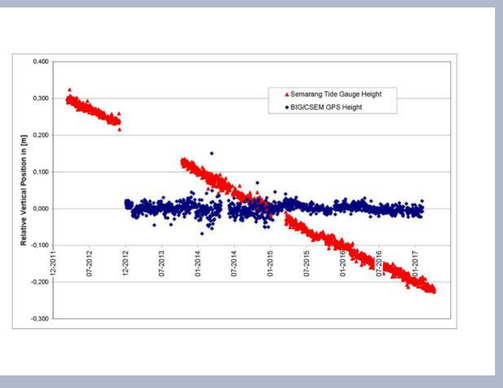
PS-points with classified annual motion rates over section of IKONOS MS satellite image of Semarang taken on May 22, 2005 © BGR, Germany (Includes material ©2002, Space Imaging LLC.)

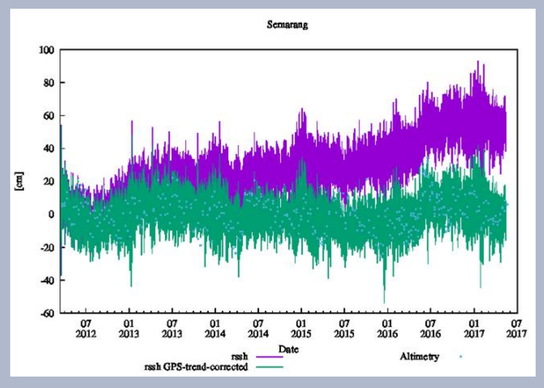


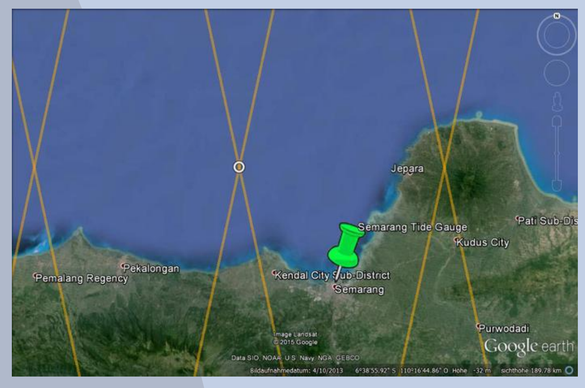
Lately major cities in Indonesia have experienced significant regional subsidence rates. Jakarta, Indonesia's capital, with 10 Million inhabitants show a complex and varying subsidence pattern along the coast, which is mainly driven by groundwater extraction and surface load. Semarang, a 2 million residence city in north-west Java show subsidence rates of several cm per year, clearly visible in the landscape. Such high rates cause major consequences for the local population as well as require actions on the political and governmental level.

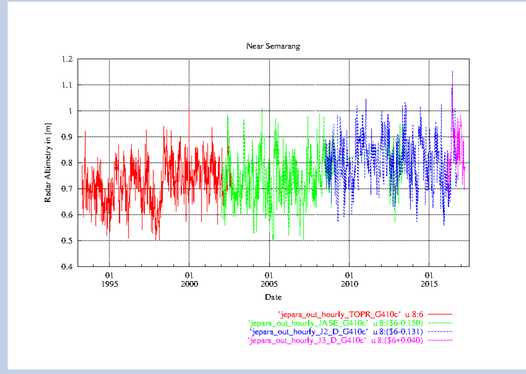
Sinking houses in Semarang due to high subsidence.

To support studies on subsidence, GNSS-controlled tide gauges have been installed in Indonesia e.g. Semarang (2012), Surabaya (2014) and Kolinamil (Jakarta, 2013). The installations follow the standard of installations of the German-Indonesian Tsunami Early Warning System (GITEWS) project (Schöne et al., 2010). All stations sample sea level data and basic meteorological parameters like wind speed, wind direction and air pressure with a sampling rate of 1 min, as well as 30-second GNSS (primarily GPS) data.



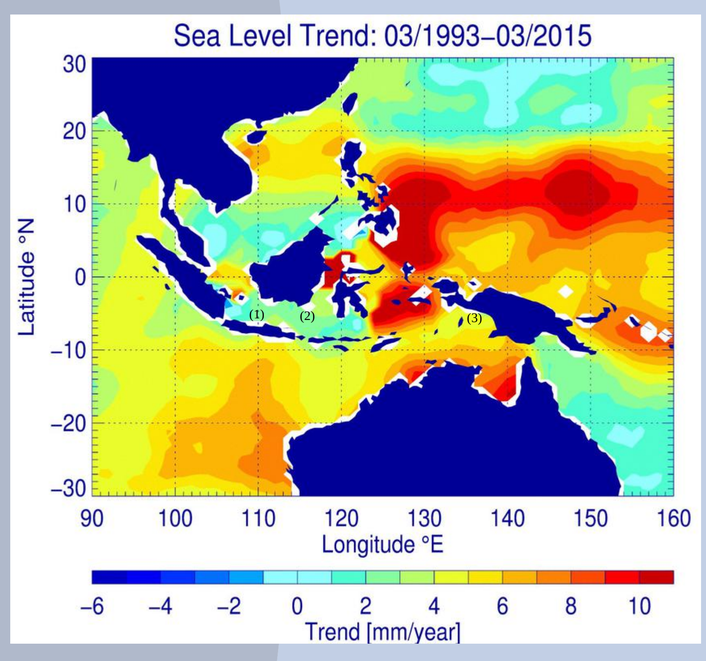


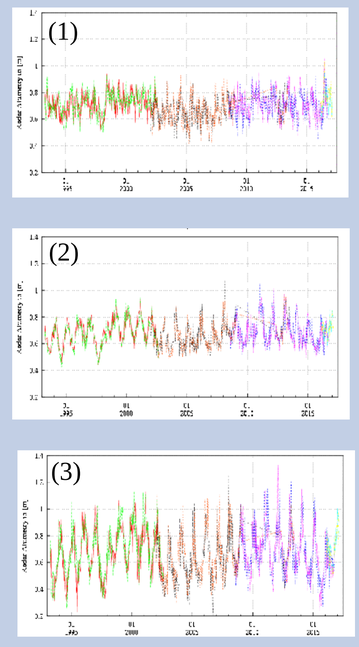




The GNSS at tide gauges (GNSS@TG) is important to separate land subsidence from sea level change. Though the "absolute" regional sea level can be derived by combining the tide gauge measurements together with GNSS data. Since the installation of the GNSS@TG-station in Semarang (2012) the measured sea level rise has accelerated to a value of ~10cm/year. But, high subsidence rates in this region leads to a negative GPS trend of also about 10 cm/a measured directly on top of the tide gauge hut. In combination, the "absolute" local sea level is approximately stable, which can be validated by altimetry as independent instrument. But, the residents still face frequent floods and a fast rising water level. The subsidence in Semarang shows a strongly divergent spatially pattern. While the tide gauge site faces high subsidence rates, the CSEM-GPS station operated by BIG in ~6 km distance shows no vertical trend.

All tide gauge stations installed in the frame of the German Indonesian Tsunami Early Warning System project donated by GFZ are equipped with GNSS, mainly to correct tidal data in case of an tsunami event for vertical displacements. But the data is also valuable for long-term sea level studies. Despite Semarang all of the installed tide gauges show vertical movements between +1,5 cm/year and -1 cm/year.





BIG developed an in-house tidal and oceanographic model, available for our research. The model is supported by a large database of tide gauge measurements derived from several stations all over Indonesia. GFZ's 'Altimetry Database and Processing System' (http://adsc.gfz-Potsdam.de/ads,ADS) delivers sea level time series which are independent from local land movement and thus a valuable tool for validation and improvement.