Subsidence Monitoring with GNSS-controlled Tide Gauges in Indonesia

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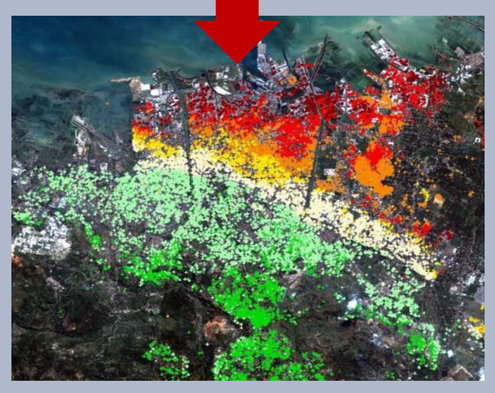
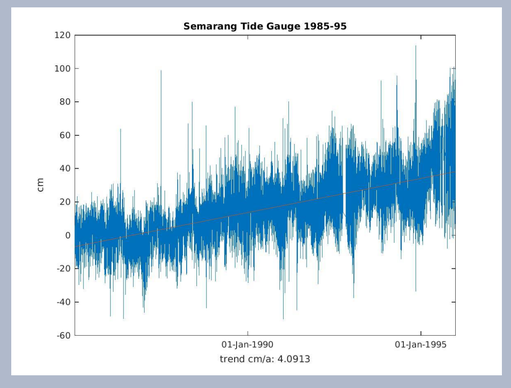
PS-points with classified annual motion rates over section of IKONOS MS satellite image of Semarang taken on May 22, 2005 © BGR, Germany (Includes material ©2002, Space Imaging LLC.)

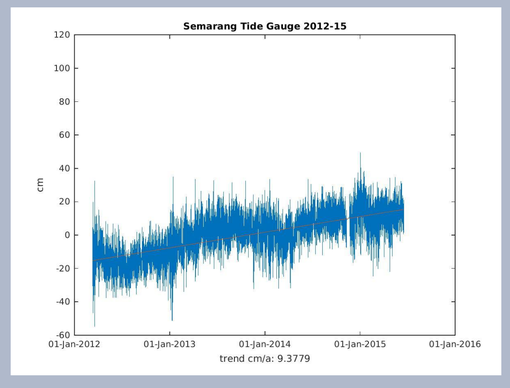


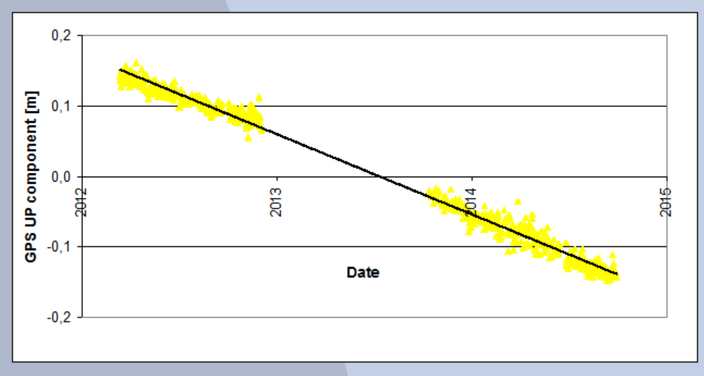
Lately major cities in Indonesia have experienced significant regional subsidence rates. Jakarta, Indonesia's capital, with 10 Million inhabitants show a complex and varying subsidence pattern along the coast, which is mainly driven by groundwater extraction and surface load. Semarang, a 2 million residence 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.

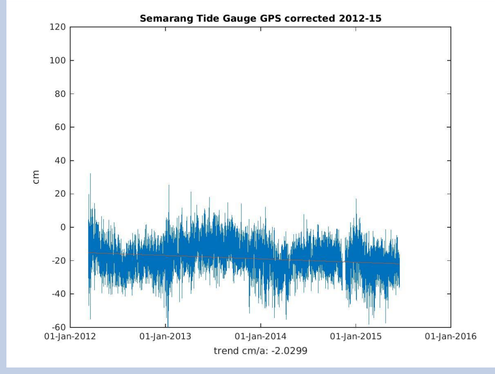
Sinking houses in Semarang due to high subsidence.

To support studies on subsidence, GNSS-controlled tide gauges have been in-stalled 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.



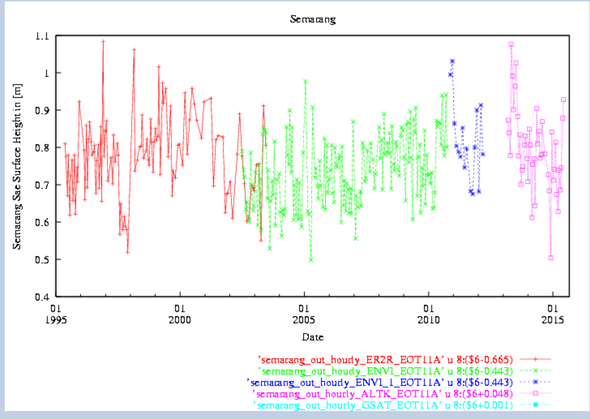






The GNSS at tide gauges (GNSS@TG) is important to separate land subsidence from sea level change. Though the "absolute" regional sea level can be derived by combining the tide gauge measurements together with GNSS data. Sea level measurements in Semarang (BIG, Badan Informasi Geospasial) from 1985 to 1995 show a sea level rise of 4cm / year. Since the installation of the GNSS@TG-station in Semarang (2012) the measured sea level rise has accelerated to a value of >9cm/year. But, high subsidence rates in this region leads to a negative GPS trend of more than 11cm/year measured directly on top of the tide gauge hut. Although the "absolute" local sea level decreases with a trend of -2 cm / year, the residents still face frequent floods and a fast rising water level.

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 (green) and -1 cm/year (yellow).



Altimetry as an independent instrument confirms a local sea level decrease over the past three years measured ~50km offshore of the tide gauge site. This partially compensates for the local disastrous increase of sea-level. However, long-term periodic movement during the past 20 years derived from several altimetry missions suggest an increase in the sea level rise as in the past years. This periodic movement is a local phenomenon, while altimetry data in e.g. Waikelo show a stable altimetry signal as well as an almost stable GPS uplift.