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Measuring long-term ground deformations using GNSS: Experiences from the EPN

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Measuring long-term ground deformations using GNSS is typically performed by computing over several years the daily positions of continuously observing GNSS sites. The obtained movement can then be separated in a linear site motion and non-linear signals. Ideally, the linear motion is due to the combined effect of the tectonic plate motion and intra-plate deformations and the non-linear signals can be due to geophysical processes e.g. loading effects or displacements linked to the seismic cycle. In reality, these motions can also be due to e.g. monument instability, unexpected local effects or analysis-related artefacts.

The EUREF Permanent Network (EPN) offers almost 250 permanent GNSS tracking stations installed throughout the European continent. Originally installed to maintain and provide access to the European Terrestrial Reference System, the data and products of the EPN are used today to learn more about the geodynamics of the western part of the Eurasian plate. However, due to the small amplitude of the intra-plate deformations in the stable part of Europe (<1 mm/yr), GNSS-based deformation monitoring is reaching the limits of its capabilities. So, even while the GNSS-based EPN site velocities have the potential to provide information on the geodynamics over Europe, extreme care is necessary during the interpretation in order to avoid 'false positives'. Using examples from the EPN, we will show how GNSS instrumentation can produce apparent position changes and we will demonstrate that a rigorous quality check of the GNSS tracking data is a prerequisite for the correct interpretation of position changes resulting from the data analysis. Further, we will show the sensitivity of the estimated site velocities to analysis-related issues such as the outlier rejection, introduction of the so-called discontinuity epochs and the size of the analyzed GNSS network. Also non-linear signals can be reduced by 20% depending on the analyzed network.

In conclusion, even if the GNSS networks showing up all over the world can potentially be a valuable asset for geodynamical interpretations, their installation, maintenance and data analysis should be done with extreme care if the measurement of sub-mm/yr deformations is targeted.