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Characterisation of Atmospheric Turbulence with Space-Geodetic Observation Techniques

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For more than 25 years, space-geodetic observation techniques such as Very Long Baseline Interferometry (VLBI) and the Global Positioning System (GPS) have been used to determine precise station coordinates, Earth orientation parameters and other geophysical parameters. Both techniques use microwaves in the X/S- and the L-band of the electromagnetic spectrum, respectively. Thus, these observations are affected by atmospheric refraction, scintillation, ray bending, and attenuation. In the beginning, atmospheric effects (especially the tropospheric signal path delay) have been treated as error sources when determining station coordinates. But soon, these effects have been considered as valuable 'signal' and are now intensively used for remote sensing of the atmosphere.

Both VLBI and GPS are not only sensitive to long-periodic diurnal variations of the tropospheric delay but also to high-frequency variations of the refractivity which yield e.g. fluctuations of the phase measurements. For both microwave techniques these fluctuations are mainly caused by water vapor variations within the atmospheric boundary layer. The integral effect of atmospheric turbulence can thus be determined by various methods and on different levels of the data analysis: Temporal and spatial structure functions are used to characterise the underlying power-law processes in GPS double-differences or estimated zenith delay parameter time series (Vennebusch et al., 2010). Furthermore the shape of these functions depends on the prevailing wind direction and velocity. From the point of view of observation analyses, turbulence theory provides a useful theoretical framework to describe the (physical) correlations between phase observations (Schön/Brunner, 2008). This information is mandatory to improve the estimation of tropospheric delays and to adequately evaluate the quality and significance of the estimated parameters.

This poster provides a short overview of the measurement principles of both space-geodetic techniques, shows the principles of space-geodetic determination of atmospheric turbulence as well as results of GPS-derived turbulence parameters. Using results from specially designed test networks, the applied methodology for studying atmospheric turbulence is explained and open issues are addressed.