Atmospheric Climate Monitoring with GNSS Radio Occultation

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While surface temperature trends are in good agreement amongst different groups, upper-air trends show larger uncertainties. Particularly in the upper troposphere and in the stratosphere, differences across conventional upper-air data sets can be substantial. This is identified as a key issue in the recent world climate report, stating the need for data with better accuracy for monitoring and detecting atmospheric climate change. Climate data records need to be homogeneous, long-term stable, and traceable to standards of the international system of units (SI). The uncertainty in observing essential climate variables (ECVs), such as temperature and water vapor, must be smaller than the signals expected from long-term change.

Radio Occultation (RO) based on Global Navigation Satellite System (GNSS) signals provides high quality observations in the upper troposphere and lower stratosphere region over the last 15 years. This is still a short record from a climate perspective, but the traceability to fundamental time standards with precise atomic clocks enables a long-term stable and consistent multi-satellite record with global coverage. Basic error characteristics are well understood and advances are ongoing towards establishing RO as a reference record of ECVs with integrated uncertainty estimation.

We review climate quality aspects and present an overview on the recent accomplishments in monitoring climate variability and change with RO. We discuss vertically resolved atmospheric change signals in the troposphere and lower stratosphere, based on the Wegener Center RO record over 2001-2016. Using a

multiple linear regression analysis we separate the different contributions to atmospheric variability, including the seasonal cycle, the Quasi-Biennial Oscillation, El Niño–Southern Oscillation, volcanic eruptions, and solar variability. We further present a comparison of RO trend results to trends from radiosondes as well as layer-average brightness temperatures of AMSU microwave soundings. Finally, current and future challenges for RO and its climate applications are briefly discussed.