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Assessing Climate Trend Indicators from Radio Occultation based on Reanalyses and Global Climate Model Scenarios

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The upper troposphere-lower stratosphere (UTLS) region is reacting particularly sensitive to climate change and variations of its key parameters are promising candidates for the monitoring and diagnosis of climate change. While only several decades ago surface temperature changes were solely used as climate change records, the establishment of radiosondes in the late 1950s and spaceborne measurement systems in the late 1970s enabled the investigation of upper-air atmospheric parameters. The radio occultation (RO) method, an active limb-sounding technique, provides high quality measurements of atmospheric parameters in the UTLS comprising bending angle, refractivity, pressure, geopotential height, temperature, and—in the lower to middle troposphere—specific humidity. Because of characteristics such as long-term stability, self-calibration and a good height-resolution, RO retrieved parameters are highly qualified to investigate upper tropospheric warming and lower stratospheric cooling in a changing climate. This study aims at assessing the potential of the whole set of RO accessible parameters as climate change indicators in the UTLS region.

Due to the availability of continuous RO data only since the end of 2001, longer-term climatologies of two reanalyses and three representative global climate models for the IPCC 4^{th} Assessment Report are used for the assessment. The datasets are systematically explored to find the most robust and sensitive trend indicators, which are defined by three properties: (1) agreement between the climate model runs / the reanalyses on

the direction of the trends; (2) the goodness-of-fit; (3) the statistical significance of the trends. The trends themselves are derived by least squares fitting, accounting for lag-1 autocorrelation, and the trends' significance is determined by means of a Students t-test. The temporal characteristics of the trends are analyzed based on seasonal means. Different investigated spatial domains (6 large zonal mean bands, 30 regions following the IPCC 2007 definition) allow a mapping of regions particularly suitable for trend indicators. In addition to the focus on optimal trend indicators, differences in the results between reanalyses and the global climate models are analyzed. We found that the RO method can valuably contribute to climate monitoring by providing climate records of a set of atmospheric parameters, which differ in trend sensitivity at different heights and regions and thus allow to monitor the UTLS as a whole with high quality.