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NDSA measurement simulation during a relative LEO-LEO set event and performance evaluation

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Measurement of water vapor is of primary interest for remote sensing of the atmosphere, since it is significantly present in the troposphere up to about 20 km altitude and has a significant impact on climate mechanisms and consequently on climate analysis/prediction models. Its measurement is not an easy task, since its concentration may considerably vary both with time and altitude. Radio occultation techniques, exploiting changes of phase and amplitude in the signal propagating along a satellite-to-satellite link during an occultation (rise or set) event, are promising methods for providing climatological parameters. The retrieved vertical profiles of the atmospheric bending angle, and in turn refractivity, are used to extract information about temperature, pressure and water vapor content as a function of height. Through the ACE+ mission studies carried out within the framework of the Earth Explorer Opportunity Missions, the European Space Agency has been investigating for the first time the possibility to exploit radio occultation at frequencies close to the water absorption peak at 22.235 GHz through radio links between two Low Earth Orbiting (LEO) satellites. However, propagation of radio waves at such frequencies is subject to atmospheric scintillation effects, that may have a not negligible residual impact when implementing radio occultation with standard single frequency measurements methods. In this paper, we describe a new differential measurement concept (NDSA: Normalized Differential Spectral Attenuation), which has the potential to limit all spectrally 'flat' and spectrally correlated phenomena (atmospheric scintillation among these). The NDSA method provides estimates of the total content of water vapor (IWV, Integrated Water Vapor) along the propagation path between two LEO satellites. Such estimates can then be usefully integrated with standard radio occultation data products. The approach is based on the simultaneous measurement of the total attenuation at two relatively close frequencies in the K band, and on the estimate of a “spectral sensitivity parameter” S that is highly correlated to the IWV content of the LEO-LEO link in the low troposphere. Then, accounting for ITU frequency allocations regulations, we focus on two frequencies only: 17.25 and 20.25 GHz, and describe the signaling chosen for NDSA measurements, together with the transmit-receive system used to simulate an end-to-end transmission during a complete LEO-LEO set occultation. Simulations are presented based on both atmospheric models and on real radiosonde data, which allowed us to account for the natural variability of the atmospheric conditions. The effects of thermal noise at the receiver, atmospheric scintillation, multipath and defocusing, on the IWV estimates is evaluated as a function of the carrier to noise ratio, the transmit/receive parameters as well as channel parameters, namely the statistical correlation coefficient between the two spectral lines characterizing the scintillation phenomenon.