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Systematic Errors in GNSS Radio Occultation Data - Part 1

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The Global Navigation Satellite System (GNSS) Radio Occultation (RO) technique has the potential to deliver climate benchmark measurements of the upper troposphere and lower stratosphere (UTLS), since RO data can be traced, in principle, to the international standard for the second. Climatologies derived from RO data from different satellites show indeed an amazing consistency of (better than 0.1 K). The value of RO data for climate monitoring is therefore increasingly recognized by the scientific community, but there is also concern about potential residual systematic errors in RO climatologies, which might be common to data from all satellites. We started to look at different error sources and present results on two of them. (1) RO data are commonly regarded as vertical reference profiles, but the RO method does not provide vertical scans through the atmosphere. The average elevation angle of the tangent point trajectory (which would be 90° for a vertical scan) is about 40° at altitudes above 70 km, decreasing to about 25° at 20 km and to less than 5° below 3 km. This leads to noticeable representativeness errors when the RO profiles are compared with vertical reference profiles. Systematic and random errors in RO data increase with increasing obliquity of the RO profiles, which in turn increases with the azimuth angle (between the orbit plane of the receiving satellite and the position of the transmitting satellite). (Apparent) errors in RO data decrease by up to a factor of 2, if the geometry of RO data is properly taken in to account. (2) All current RO retrievals use a "classic" set of (measured) constants, relating atmospheric microwave refractivity with temperature, pressure, and water vapor partial pressure. With the steadily increasing quality of RO climatologies, errors in these constants are not negligible anymore. We show how these parameters can be related to more fundamental physical quantities (fundamental constants, the molecular/atomic polarizabilities of the constituents of air, and the dipole moment of water vapor). This approach also allows to compute sensitivities to changes in atmospheric composition (e.g., CO2 increase).