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On the estimation of water vapor of the troposphere by using a microwave link

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Measuring water vapor (WV) in the troposphere, where almost the totality of WV is found, is a key point to understand atmospheric composition and dynamic completely. In particular, a critical problem is to perform systematic WV measurements in the lowest part of the troposphere (∼5-6 km) on a global scale, which is helpful to improve both climate modeling and numerical weather prediction (NWP) capabilities at short time scale.
Recent studies proposed an innovative approach (the Normalized Differential Spectral Attenuation (NDSA)) capable to retrieve the integrated water vapour (IWV) from attenuation measurements made in the Ku/K bands along microwave links crossing the troposphere. The NDSA is based on the estimate of a parameter (called spectral sensitivity, S) related to the differential attenuation undergone by a pair of tone signals separated by a fractional band of less than 2%. It was demonstrated that S can be directly converted into IWV by a linear relationship. Theoretical studies also proved that the NDSA can be successfully applied from space by using a couple (or more) of co-rotating or counter-rotating LEO satellites. In spite of these promising results, the NDSA has not been yet tested from both ground or space. With the purpose of overpass this limitation and achieve the first validation of the NSDA concept a project , funded by Tuscany Region, Italy recently started. In detail the aims of the project are: (i) the implementation of a NDSA demonstrator operating from ground in order to perform the first NSDA measurements; (ii) the development of retrieval techniques able to derive IWV from microwave measurements; (iii) the evaluation of the impact of the IWV information in the weather prediction chains. The two last points will be in depth discussed in this presentation. The retrieval algorithm, which allows to retrieve the WV profile from the measurements of IWV, consists of a Gauss-Newton method based on the optimal estimation approach. The algorithm allows to retrieve the vertical profiles around a vertical axis at a fixed angle with respect to the terrestrial one, by using a set of measurements of IWV at different elevation angles. In order to take into account the horizontal variability of the atmosphere, a gradient is simultaneously fitted with the profile.
Numerical prediction models in use at meteorological centers are essentially the set of partial differential equations that describe the evolution of the atmosphere starting from certain initial conditions and from the boundary conditions in case of limited area models (LAM).The mesoscale WRF - ARW model was used for performing the tests required by the project analyzing the impact of the new measures on weather prediction chain.For the data assimilation, WRF model requires Precipitable Water (PW) as input which can be obtained by the retrieved vertical IWV. The preliminary results are encouraging, showing that the assimilation of the station measurements produces benefits, which are further increased when PW measures are assimilated.