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On GPS Water Vapour estimation and related errors

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Water vapour (WV) is one of the most important constituents of the atmosphere: it plays a crucial role in the earth's radiation budget in the absorption processes both of the incoming shortwave and the outgoing longwave radiation; it is one of the main greenhouse gases of the atmosphere, by far the one with higher concentration. In addition moisture and latent heat are transported through the WV phase, which is one of the driving factor of the weather dynamics, feeding the cloud systems evolution. An accurate, dense and frequent sampling of WV at different scales, is consequently of great importance for climatology and meteorology research as well as operational weather forecasting.
Since the development of the satellite positioning systems, it has been clear that the troposphere and its WV content were a source of delay in the positioning signal, in other words a source of error in the positioning process or in turn a source of information in meteorology.
The use of the GPS (Global Positioning System) signal for WV estimation has increased in recent years, starting from measurements collected from a ground-fixed dual frequency GPS geodetic station. This technique for processing the GPS data is based on measuring the signal travel time in the satellite-receiver path and then processing such signal to filter out all delay contributions except the tropospheric one. Once the troposheric delay is computed, the wet and dry part are decoupled under some hypotheses on the tropospheric structure and/or through ancillary information on pressure and temperature. The processing chain normally aims at producing a vertical Integrated Water Vapour (IWV) value. The other non troposheric delays are due to ionospheric free electrons, relativistic effects, multipath effects, transmitter and receiver instrumental biases, signal bending. The total effect is a delay in the signal travel time with respect to the geometrical straight path.
The GPS signal has the advantage to be nearly costless and practically continuous (every second) with respect to the atmospheric dynamics. The spatial resolution is correlated to the number and spatial distance (i.e. density) of ground fixed stations and in principle can be very high (for sure it is increasing). The problem can reside in the errors made in the decoupling of the various delay components and in the approximation assumed for the computation of the IWV from the wet delay component. Such errors often are "masked" by the use of the available software packages for GPS data processing and, as a consequence, it is easier to find, associated to the final WV products, errors given from a posteriori validation processes rather than derived from rigorous error propagation analyses.
In this work we want to present a technique to compute the different components necessary to retrieve WV measurements from the GPS signal, with a critical analysis of all approximations and errors made in the processing procedure also in perspectives of the great opportunity that the European GALILEO system will bring in this field too.