Variational assimilation of GPS radio-occultation observations in rainy conditions

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Space borne radio-occultation observation from the GPS satellite constellation has been routinely assimilated at operational centers since 2002. With the coming launch of the US-Taiwan COSMIC2 constellations in 2015, the number of radio-occultation observations available for assimilation is expected to increase by a factor 10. Additionally, receivers on the COSMIC-2 mission will be able to sound down to the surface, providing refractivity profiles through low clouds and moist layers over sea.

Assimilation of GPS Radio-Occultation (GPSRO) observations typically requires the integration of the GPS phase along the ray path between the emitting GPS satellite and the low earth orbit receiving satellite. Evaluation of the atmospheric refractivity along the ray path is therefore part of any GPSRO observation operator. At GPS frequency, the atmospheric refractivity is function of pressure, temperature and water vapor. The dependence on water vapor, however, vanishes in saturated atmosphere. This introduces a switch in the GPSRO observations operator. The problem is therefore twofold:

1) Find those rainy regions along the ray path,
2) Mitigate the non-linear effects of saturation during the transition into those regions.

To address 1) and to improve the representation of the cloud field in the model, satellite radiance in cloudy regions can be jointly assimilated with GPSRO data. This approach brings additional non-linearity in the minimization due to the scattering caused by hydrometeors in the radiative transfer model calculations. Various strategies, such as adaptive variational bias correction and re-linarizations are proposed. 2) has been traditionally addressed using smoothing operators.

We describe our strategies to overcome non-linearities and present our recent efforts to jointly assimilate cloudy radiances and GPSRO observations in rainy conditions with the Gridpoint Statistical Interpolation (GSI) hybrid variational/ensemble data assimilation system