What types of error affect satellite precipitation products?

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While satellite precipitation products are regularly evaluated against reference measurements, and numerous attempts have been made toward the systematic assessment of their uncertainty, the fundamental question of the nature of their errors is often ignored. Simple error models generally represent the error as a systematic bias, associated with an additive or multiplicative random term; and eventually, whatever the parametric representation, all the information is reduced the joint probability distribution of the true precipitation intensity and the error. Such a representation simply ignores the fact that the error is temporally and spatially correlated and shows complex patterns and structure across a wide range of scales. Without accounting for the space-time correlation of the error, one cannot for example properly assess the effect of aggregating a precipitation product at a coarser resolution on the uncertainty. Beside systematic biases and random noise, other forms of error that commonly affect precipitation products are mislocation and mistiming of the precipitation features, geometric distortions of the multidimensional space-time precipitation patterns, linear and non-linear filtering effects.

Because retrieved precipitation fields and associated errors fields are dynamical tensors, spectral representations such as Fourier, wavelet or empirical mode decompositions allow to characterize them in a much more comprehensive way than what can be done through pixel statistics and probability density functions. We performed the evaluation of IMERG and several other satellite precipitation products against gauge-radar data in the Fourier and wavelet domains and derived a spectral error model that can represent systematic space-time filtering effects as well as characterize the space-time correlation of the random errors (noise) through their power spectrum. We find that, at the native sub-hourly sub-degree resolution of the products, systematic linear filtering effects can explain up to 50% of the error variance. The relative importance of the systematic filtering term however decreases when the data is aggregated at a coarser resolution. Concerning the random errors, their power spectrum is complex, with different noise regimes at different scales. Carefully assessing the nature and the dynamical properties of the error reveals that, at high resolution, the error is not independent from the precipitation signal, and therefore errors are not independent across different products.

We extended the utilization of spectral representations into the design of a deep-learning retrieval algorithm. In machine-learning, proper understanding of the nature of retrieval errors is necessary to choose an adapted objective function. Carefully constraining the spectral properties of precipitation and error fields within the objective function allows to preserve desired dynamical characteristic of precipitation.