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New directions in multi-scale precipitation estimation (downscaling, fusion, assimilation, and retrieval) for hydrologic applications at the catchment scale

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We propose a new and innovative formalism for statistical estimation (data fusion, assimilation, retrieval, and resolution enhancement) of multi-sensor, multi-scale precipitation measurements for use in hydrologic applications at the catchment scale. The proposed framework draws upon: (1) recent observations that precipitation fields exhibit "sparsity" in a gradient or wavelet domain (a manifestation of the coherent multicellular structure of rainfall and the presence of sharp fronts or rainbands), and (2) new theoretical developments in the signal processing community for non-linear, non-smooth data recovery from noisy, blurred and downsampled signals. We pose the fusion problem in a nonlinear variational formulation setting and use a Maximum a Posteriori (MAP) estimation which is constrained by a sparse prior in the wavelet domain. In contrast to the widely used least-squares approaches which yield smoother estimates, the proposed approach incorporates a non-smooth term (L1 norm) and, as such, allows preservation of extremes and localized features, important for hydrologic applications. Within the same general formalism, we propose new ideas for improving the performance of precipitation retrieval and resolution enhancement of multi-sensor products using a non-linear dictionary-based inverse estimation approach with sparse priors.