Geophysical Research Abstracts
Vol. 13, EGU2011-12346, 2011
EGU General Assembly 2011

A vision for an ultra-high resolution integrated water cycle observation and prediction system

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Society's welfare, progress, and sustainable economic growth—and life itself—depend on the abundance and vigorous cycling and replenishing of water throughout the global environment. The water cycle operates on a continuum of time and space scales and exchanges large amounts of energy as water undergoes phase changes and is moved from one part of the Earth system to another. We must move toward an integrated observation and prediction paradigm that addresses broad local-to-global science and application issues by realizing synergies associated with multiple, coordinated observations and prediction systems.

A central challenge of a future water and energy cycle observation strategy is to progress from single-variable water-cycle instruments to multivariable integrated instruments in electromagnetic-band families. The microwave range in the electromagnetic spectrum is ideally suited for sensing the state and abundance of water because of water's dielectric properties. Eventually, a dedicated high-resolution water-cycle microwave-based satellite mission may be possible based on large-aperture antenna technology that can harvest the synergy that would be afforded by simultaneous multichannel active and passive microwave measurements. A partial demonstration of these ideas can even be realized with existing microwave satellite observations to support advanced multivariate retrieval methods that can exploit the totality of the microwave spectral information. The simultaneous multichannel active and passive microwave retrieval would allow improved-accuracy retrievals that are not possible with isolated measurements. Furthermore, the simultaneous monitoring of several of the land, atmospheric, oceanic, and cryospheric states brings synergies that will substantially enhance understanding of the global water and energy cycle as a system. The multichannel approach also affords advantages to some constituent retrievals—for instance, simultaneous retrieval of vegetation biomass would improve soil-moisture retrieval by avoiding the need for auxiliary vegetation information.

This multivariable water-cycle observation system must be integrated with high-resolution, application-relevant prediction systems to optimize their information content and utility is addressing critical water cycle issues. One such vision is a real-time ultra-high resolution locally-moasiced global land modeling and assimilation system, that overlays regional high-fidelity information over a baseline global land prediction system. Such a system would provide the best possible local information for use in applications, while integrating and sharing information globally for diagnosing larger water cycle variability. In a sense, this would constitute a hydrologic telecommunication system, where the best local in-situ gage, Doppler radar, and weather station can be shared internationally, and integrated in a consistent manner with global observation platforms like the multivariable water cycle mission. To realize such a vision, large issues must be addressed, such as international data sharing policy, model-observation integration approaches that maintain local extremes while achieving global consistency, and methods for establishing error estimates and uncertainty.