The NASA Energy and Water Cycle Study (NEWS)

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Overview

Predicting the consequences of global change is a paramount challenge. The cycling of water and energy among the atmosphere, ocean, and land determine the Earth's climate and cause much of its variability. Natural and human-induced changes to the water and energy cycle have major impacts on industry, agriculture, and other human activities. Improved monitoring and prediction of the global water and energy cycle enable improved knowledge of the Earth system that must be nurtured to proactively mitigate future adversities. Current and forthcoming projections of such impacts will remain speculative unless fundamental understanding is assimilated into effective global prediction systems and effective decision support tools.

Therefore, the NASA Earth science research program has established the NASA Energy and Water cycle Study (NEWS) that has the long-term grand challenge to *document and enable improved, observationally-based, predictions of water and energy cycle consequences of Earth system variability and change*. The broad national objectives of energy and water cycling related climate research extend well beyond the purview of any single agency or program, and call for the support of many activities that are matched to each agency's respective roles and missions. To achieve this goal, NASA will seek collaborations with other Federal agencies including NOAA, NSF, DoE, USGS, DoI, the DoA, the scientific community-at-large and private industry. NASA's water and energy cycling connection to the international science community is through the World Climate Research Programme (WCRP), especially GEWEX, but also CLIVAR and CLiC.

Implementation of the NASA Water and Energy Cycle research program is planned in three phases. The emphasis during Phase-1 is to exploit current capabilities and prepare for future developments of NEWS program elements. Phase-2 focuses on addressing deficiencies and building a viable "prediction" system. Phase-3, focuses on the delivery of an end-to-end system to address the ESE vision, namely: comprehensive observations to accurately quantify the state and variability of the global water cycle, including time series data sets with no major gaps; routine analysis of variability in storage, transports and fluxes of water and energy ; routine prediction of key water and energy cycle parameters (including clouds, precipitation, radiation interactions, energy budgets, and surface hydrological variables) and improved forecasts for use in water management and decision making.

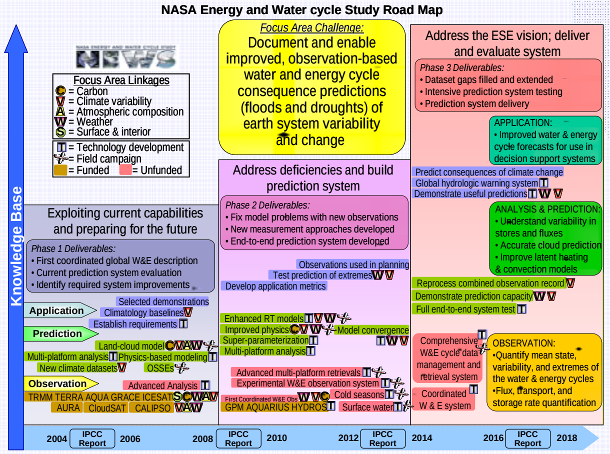
The NEWS activity will be comprised principally of product-driven investigations, discovery-driven investigations and integrative efforts studies. NEWS will include:

Product-driven investigations: Systematic research investigations intended to combine and interpret past and current observations, derive global analysis and prediction tools and products and identify technological and observational requirements to guide future NASA investments.

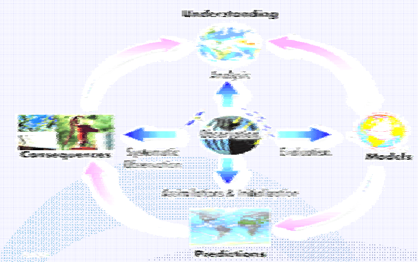
Discovery-driven investigations: Fundamental investigations to identify key missing elements and explore new scientific frontiers to improve capabilities and knowledge.

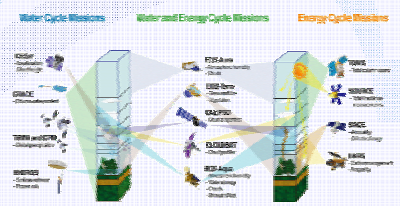
Integration studies: Integration of the science activities to serve the overall purpose of NASA by acting as an interface with other ESE research foci and activities, coordinating the execution of the NASA Water and Energy Focus Area Implementation Plan, and leading specific studies needed for integration of the results of independent product-driven or discovery-driven investigations.

NASA Energy and Water cycle Study Road Map



Program Implementation





Conclusions & Future Directions

Land surface data assimilation has been demonstrated and has great potential, but many open areas of research remain, including:

(i) better quantify and use model and observation errors;
(ii) create model independent data assimilation algorithms that can account for non-linear land models;
(iii) optimize data assimilation computational efficiency for use in large operational hydrological applications;
(iv) use forward models to enable the assimilation of remote sensing radiances directly;
(v) link model calibration and data assimilation to optimally use available observation information;
(vi) create multivariate hydrologic assimilation methods to use multiple complementary observations;
(vii) quantify the potential of data assimilation downscaling; and
(viii) create methods to extract the primary information content from redundant/overlapping observations.

Recent advances in understanding of land physical processes, satellite observing systems, and economical computing power, enables us to operationally merge model predictions and observations using data assimilation to address critical hydrologic issues. In the future, we must develop a comprehensive land data assimilation framework using a patch-based, bias-correcting, parameter-augmented local ensemble Kalman filter that is applicable for use in practical large-scale, high-resolution land-surface applications, taking the following steps:

(1) Develop the land data assimilation theory and framework to enable the multi-variate assimilation of relevant remote-sensing observations, using recently developed Kalman filter assimilation tools that allow propagation of subgrid variability in land surface models, while also practically imposing remote-sensing constraints at larger scales in an operational framework.

(2) Implement the framework in off-line setting that will provide value-added assimilated data products for use in satellite retrieval algorithms, as initial conditions to enable improved earth system model predictions, and that will enable Observing System Experiments (OSEs) and Observing System Simulation Experiments (OSSEs) to guide the development of future observing systems.

(3) Integrate this land assimilation framework into coupled Earth System Model(s). It is well known that the high-resolution time and space complexity of land surface phenomena have significant interaction with atmospheric, biogeochemical, and oceanic processes.

Literature cited

Charney, J. G., Halem, M., and Jastrow, R., 1969. Use of incomplete historical data to infer the present state of the atmosphere. J. Atmos. Sci. 26, 1160-1163.

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More information

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