Report of the NEWS Science Team Meeting

University of California Irvine
13-14 June 2011

NEWS background

The overarching long-term challenge of NEWS is documenting and enabling improved, observation-based predictions of the water and energy cycle consequences of Earth system variability and change. This requires assessing the variability of the global energy and water cycle on time scales ranging from seasonal to decadal, and space scales ranging from regional to continental to global, and will enable supporting the application of climate prediction capabilities for estimating the societal impact of climate variability and climate changes on water resources over a variety of spatial and temporal scales.

The scientific framework for the *Water and Energy Cycle focus area* was outlined in the NASA Earth Science Enterprise Strategy document, issued in October 2003. It is one of six focus areas that define the scientific content of the NASA Earth Science Program, and includes both research and technology components. The scientific priorities adopted by NEWS reflect the issues outlined in the Strategic Plan for the U.S. Climate Change Science Program (July 2003). These are:

- To understand the mechanisms and processes responsible for the maintenance and variability of the energy and water cycle, including the extent of human interaction

- To determine how feedback processes control the interactions between the global energy and water cycle and other components of the climate system, and how these feedbacks are changing over time

- To assess the key uncertainties in seasonal-to-annual and longer term predictions of energy and water cycle variables, and to outline improvements needed in global and regional models to reduce these uncertainties

- To evaluate the consequences, over a range of space and time scales, of energy and water cycle variability and change to human societies and ecosystems, and their affect on nutrient and biogeochemical cycles

- To provide a scientific basis for supporting informed decision processes in the context of changing water resource conditions and policies

When fully implemented, the NEWS research program will yield significant advances and breakthroughs in hydrological cycle climate science. Progress in achieving its objectives will be measured against its success in identifying gaps and making significant advances in:

Promoting the development and deployment of an experimental energy and water cycle global observing system

Assessing the global energy and water cycle through an observational record of all associated geophysical parameters

Building a fully interactive experimental global climate model that encompasses the process-level forcings on and feedbacks within the global energy and water cycle

Creating a global land and atmosphere data assimilation system for energy and water variables.

Second-tier NEWS research questions adopted were:

How are global precipitation, evaporation and the cycling of water changing?

What are the effects of clouds and surface hydrologic processes on Earth's climate?

How are variations in local weather, precipitation and water resources related to global climate variation?

What are the consequences of land cover and land use change for human societies and the sustainability of ecosystems?

What are the consequences of climate change and increased human activities for coastal regions?

How can weather forecast duration and reliability be improved?

How can predictions of climate variability and change be improved?

How will water cycle dynamics change in the future?

Over the past three years, the project has been working on how to refine a NEWS team approach to tackling integration. NEWS is attempting to create a structure that allows for consistency from existing NEWS activities, (i.e., conservation of scientific momentum), and at the same time welcomes new NEWS PIs and their projects. To these ends, the project created four NEWS working groups that identify integration needs and make the needed connections to partner and coordinate with water & energy cycle research and application activities going on at other organizations within NASA, nationally, and internationally. The four groups established in 2009 are:

- Drought & Flood Extremes- including water and energy aspects of abrupt climate change
- Evaporation & Latent Heating - including both land and ocean
- Water and Energy Cycle Climatology - to exploit and influence evolving observing systems
- Modeling & Water Cycle Prediction – to foster interaction with the global modeling community

The working groups are charged with coordinating and integrating NEWS PI science investigations; liaise with relevant flight missions and NASA R&A Programs; implement annual assessment of progress in meeting NEWS scientific requirements; and contribute to periodic Implementation Plan (IP) updates. A principal goal of the working groups is to promote the development of scientific papers that integrate various NEWS research within the working group topic area.

Recent progress

Since initiation of the project by NASA and publication of the Science Implementation Plan in 2007, NEWS has focused on addressing the range of its Phase 1 objectives. The first phase focuses on the first coordinated attempt to describe the complete global energy and water cycle using existing and forthcoming satellite and ground based observations, and laying the foundation for essential NEWS developments in model representations of atmospheric energy and water exchange processes. This comprehensive energy and water data analysis program must exploit crucial datasets, some still requiring complete re-processing, and new satellite measurements. These data products will then be evaluated for accuracy and consistency, in part by using them in the first diagnosis of the weather-scale (space and time) variations of the

global energy and water cycle over the past one-two decades. The primary objective is to ensure that results of this analysis effort serve as a recognized data basis to compare with corresponding climate statistics produced by existing climate models, quantify systematic deficiencies, and identify needed improvements. The data records to be produced through these efforts are mandatory for developing and validating models that meet NEWS scientific requirements.

At the same time, this implementation plan calls for the development of radically new model representations of energy and water exchange processes that resolve significant process scales and spatial variability in ground boundary conditions. Such process-resolving models may be first constructed as independent stand-alone modules that can be tested against *ad hoc* field measurements and systematic observations at selected experimental sites. At a later stage, the codes may be simplified through statistical sampling of process-scale variables or otherwise reduced to generate integrated fluxes representative of each grid-element in a climate model. Finally, the implementation plan calls for broad exploration of potential new observing techniques concerning all aspects of the energy and water cycle, and initiating relevant technical feasibility and scientific benefit studies.

Objectives for the NEWS 2011 Science Team Meeting

In contrast to earlier NEWS Science Team annual meetings, which emphasized sharing of research objectives, accomplishments and plans, the June 2011 workshop was organized to stress interaction and integration of the scientific goals and agendas of the four Working Groups through joint sessions and, as noted, to further promote journal publications emphasizing unique NEWS scientific contributions. The following reports were provided by the four Working Group co-Chairs.

Working Group Meeting Reports

• **Drought & Flood Extremes Working Group** (submitted by X. Dong and Y. Deng)

The content of this report comes from three sources: (1) Presentation by Xiquan Dong at the NEWS workshop, (2) discussions within the extreme breakout working group, and (3) the discussion with the whole NEWS team on the last day of the workshop. The following people attended the extreme working group breakout meeting: Xiquan Dong, Yi Deng, Baike Xi, Paul Houser, Adam Schlosser, Bob Adler, Kuolin Hsu, Amir AghaKouchak, Wei Chu, Bing Lin, and Jun Yin.

1) Review of ongoing or developing integration activities

A request was made to all NEWS participants to prepare powerpoint slides highlighting recent NEWS integration work; including new results, activities and or publications to share at the workshop. In response, the Extremes working group showcased the following publications where NASA NEWS Phase-1 datasets were used to study the SGP extreme events (Dong et al.), Improving satellite precipitation estimate (Z. Feng, X. Dong, and A. AghaKouchak), An integrative study of SGP extreme using WRF, NARR, and MERRA (Santanello, J. A., C. Peters-Lidard, S. Kumar, A. Kennedy, and X. Dong), Extreme rainfall events over the USA great plains (USGP) during the last decade (Amita Mehta and Eric Smith), Consistency of cloud properties observed from different times and locations (Bing Lin), Identify controls and predictability of

extreme drought persistence (J. Albertson), NASA MERRA revealed dynamical organization of the North Pacific atmospheric river activity by East Asian cold surge events (Y. Deng), A study of arctic clouds and radiation budget supported by NASA NEWS project (Dong et al.), and A 10-yr climatology of cloud fraction and vertical distribution derived from both surface and GOES observations over the DOE ARM SGP site (Xi et al.). Several PIs agreed to continue the study of the SGP extreme events and collaborate with the modeling group to focus on improving the prediction of these extreme events. Also discussed was the possibility of collaborating with the climatology working group to investigate the extreme events that occurred over the 10-yr period (2000-2009) when a substantial amount of observation is available. The extreme working group will continue to collaborate with other groups to identify the extreme events that occurred with scientifically sound metrics and thresholds, and then work with others to investigate energy and hydrological features of extreme events, which may involve other NEWS team members. A good example for us to follow is the SGP extreme events study by Dong et al. (2011).

2) Revise and redefine the working group objectives

During the extreme working group and NEWS team-all meeting, we discussed working group objectives in both a broad view and narrative as follows:

Broadview Objectives:
Generate a global database about the hydrological extremes from multiple data sources; investigate these extremes and how these extremes associate with other climate/weather phenomena over the past 30 years. Global extreme conditions would be quantitatively expressed. This dataset should serve as the best starting point and provide an umbrella for our working group for the NEWS phase II in next five years.

Under the umbrella of global database, we would further investigate the regional extremes, as well as their association with different monsoon systems (i.e., Asia-Australian monsoon, West-African monsoon, North and South American monsoon). This investigation will build upon our current extreme study at the U.S. SGP region, take advantage of the multiple datasets constructed by NEWS Phase I. Studies in this area should recognize the diversity of weather/climate phenomena that lead to the occurrence of extremes over different climatic regions. This study will also provide an opportunity for us to understand the similarities and differences of regional extremes under the different climate regimes.

Studies that explore the predictability of hydrological extremes on seasonal to decadal time scales. This study will collaborate with other NEWS groups such as modeling and prediction group to reach the overarching goals of NEWS program. The knowledge gained by this study would be injected into modeling studies and used to modify models and advance predictions of extremes. Another priority of this group of studies is to project future changes in the characteristics of extreme events under global warming, focusing on the assessment of the changes in the overall “risk” of floods/droughts. These studies would enhance public awareness and reduce the impacts of these extremes.

Narrative Objectives (in details):
What is the best definition of extreme events given multiple variables used and multiple aspects (e.g., meteorological, hydrological, and agricultural) to emphasize in the definition?

What datasets should be used, or how many datasets are enough for studying the extreme events. The currently available datasets include GPCP, SPI, PDSI, NEXRAD, surface precipitation, MERRA. Also how many years of data are enough? Based on the discussion with climatology working group, we plan to use the 10-yr of GPCP data from 2000 to 2009.

• **Evaporation & Latent Heating Working Group** (submitted by J. Famiglietti)

The ELH group focused on three topics that could form the basis for further joint research and for journal articles. These included 1) the role of evaporation and latent heating in fueling extreme events; 2) the causes of differences between NEWS ELH products; and 3) the differences between ELH products as a group, vs ELH output from the IPCC models and NWP models. The latter two of these topics will form the basis for a fall 2011 AGU presentation.

Discussion of latent heating and extreme events focused on whether potential increases in extremes will result from the need for a warming Earth to redistribute its additional heating in a more turbulent manner. Will a more variable water (and energy) cycle implicitly rely on more frequent and intense bursts of energy (i.e. extreme events) to move heat poleward?

Discussion of differences between ELH products centered on differences in input datasets and variations in algorithms. Some groups agreed to self-assess, and to compare with other development groups, both within and outside of NEWS.

A key observation made at the WG meeting was that there were far bigger differences between ELH products (as a group) and the IPCC models and NWP models. The WG was surprised to see the similarity amongst NEWS ELH products relative to the climate and NWP models. The WG felt that this topic was worthy of publication, and at least two funded NEWS PIs agreed to take the lead.

• **Water and Energy Cycle Climatology Working Group** (submitted by M. Rodell)

Working Group Goals

The goal of the NEWS Water and Energy Cycle Climatology group is to harness the expertise in the NEWS team to develop "state of the global water cycle" and "state of the global energy cycle" assessments based primarily on recent, high quality ground and space based observational datasets. This is important because the NASA Water and Energy Cycle Study's (NEWS) Grand Challenge is to "document and enable improved, observation-based predictions of water and energy cycle consequences of Earth system variability and change". In order to quantify change, it is necessary to define a baseline. The Climatology group is focused on defining baselines for the water and energy cycles. Our first study focused on estimating the annual and monthly mean fluxes of the water and energy cycles at continental and ocean basin scales, as well as the global scale. Observation integrating models have been used to fill gaps in data coverage. An unique aspect of this study is that the water and energy budgets will be optimized by enforcing balance among the water budget states and fluxes and equating latent heat from the energy budget assessment with evapotranspiration from the water budget.

Science Questions

• What is the current state of the water budget, as represented by the annual and monthly mean fluxes at continental, ocean basin, and global scales? This information is critical for future efforts to determine the ways in which the water and energy budgets are changing.

• What are the current uncertainty levels in global water and energy budget assessments?

• What observational gaps hamper our ability to monitor water and energy budget variability?

• How well do current global analysis models and climate prediction models simulate the water and energy budgets?

Near Term Integration Efforts

Mean monthly and annual, continental/ocean basin to global scale water and energy budget fluxes from multiple data providers, mostly within the NEWS team, have been compiled. After some debate, the working group agreed that it was reasonable to emphasize NEWS datasets in this analysis (as opposed to an average of several existing products) provided adequate discussion of other products is provided for completeness. The deadline for updating datasets was set to July 31, 2011. After that, optimization processes will be performed to enforce balance in the water budget and balance within a given error level in the energy budget, resulting in a final set of flux estimates. It was noted that these balanced budgets will only be as good as the uncertainty estimates used to derive them so the importance of comparing uncertainty estimates against existing references and correcting known biases in certain radiation budget estimates was emphasized.

Publication Plans

We have developed outlines for two manuscripts, on the states of the water and energy budgets. August 31, 2011 is the deadline for 1-paragraph descriptions of the datasets used in the analysis, and September 30, 2011 is the target date for completion of first drafts of the manuscripts. A significant focus in the revision of these manuscripts will be on ensuring adequate emphasis of the coupling of the energy and water cycles in this study and the rigorous assessment of uncertainties in each component.

• **Modeling & Water Cycle Prediction Working Group** (submitted by M. Bosilovich)

Present at the working group meeting: Michael Bosilovich (Co-Chair), Christa Peters-Lidard, Joe Santanello and Wei Kuo Tao. Occasional representative students from the UCI groups audited the discussion.

The agenda for the working group included:

1. Review some ongoing or developing integration activities
2. Develop ideas for integration papers
3. Revise and redefine the objectives of this working group

Items: 1 and 2. Review of Activities and Integration Papers

A request was made to NEWS participants to send in recent results or activities related to integration of NEWS projects to share at the meeting. Among those received include the LIS-WRF boundary layer diagnostics studies (Santanello and Peters-Lidard), Ocean flux comparisons of observations, models and reanalyses (Bourassa and Clayson), integrate LIS-MMF simulation results (Tao, Mohr, Peters-Lidard) and MERRA US basin scale studies (Bosilovich and Robertson, recent results for the April 2011 Ohio river flooding). (see the ppt for more details on each project)

The broader perspective of the model integration, however, seems to revolve around the use of MERRA, in different ways, among different projects. Using MERRA as a common thread, we

propose an integration paper on the water and energy cycle representation of characterized by MERRA. This effort would be open to all NEWS team members (past and present) who have used MERRA data in their NEWS project. The goal of the paper will be to characterize the MERRA water and energy cycle from the NEWS perspective. Prospective contributors should summarize their efforts in 1 page, and may include the strengths, uniqueness's and need for MERRA in the projects, the limitations and issues uncovered and the diagnostics and metrics used to support the strengths and weaknesses. Co-Chair Bosilovich will combine the contributions along with an overview of NEWS and MERRA projects, as well as the goal of the paper. The difficult part of the writing will be linking all the disparate contributions together in an estimate of the water and energy cycles. It is possible some contributions may not fit the main goal, or that some areas do not have a contributor. In the case of lacking a topic that needs covered, the NEWS PIs will be polled for information, but we may need to simply note this as a gap in the project. The components of an "integration" paper was discussed at length. The floor was open to suggestions for additional integration paper ideas, but none were proposed at that time.

Item 3; Revise and Redefine the Working Group Objectives

In order to inspire discussion on new integration tasks for the model Working Group, we reviewed last year's Tasks and Gaps spreadsheet, especially the items pertaining to models (the full list is provided in the presented slides), While some issues are deemed important, the need for the model working group was significantly questioned on two points. First, NEWS has not funded many model development or prediction proposals, which makes sense, as the Modeling, Analysis and prediction program (MAP) generally covers that area. Secondly, while there are many PIs in NEWS familiar with models (with varying degrees of development expertise, most PIS use models to support their scientific goals. As such, these PIs choose to participate first in their scientific oriented working group and model group second.

In addition, there is a prevailing need for knowledgeable model contributions to each of the other groups. One gap brought up, which may make a good model integration topic, but also has shortcomings, is comparison of the AR5 model present day simulations with NEWS observations, specifically with a water and energy budget priority. Such a task would be an excellent use of NEWS data sets and effort, but at the same time, could encompass a project unto itself and so require an entirely new proposals submission. Such comparisons have not been included in many of the existing NEWS projects. By the end of the meeting, while this idea was positively received, there were no immediate PIs taking the lead role.

After much deliberation on these points, and discussions to identify a motivating integration topic based on the existing gaps in NEWS, no definitive and cohesive integrating project could be identified. The working group decided that the obvious and efficient path forward is to remove the Model working group as an individual identity, thereby allowing members to contribute their modeling expertise to the other groups. This notion was presented to the full plenary session, along with a request that anyone who has an idea for a model working group integration project to contact the co-chairs. There has not been a response to this request. On the other hand, there is tremendous interest in having model group representatives participate in the other different working groups.

Summary of Workshop Conclusions & Future Activities

• Drought & Flood Extremes Working Group

Dong's group developed a new index to study the extreme events. However, some PIs were questioning this new index because the advantage to adapt a new index is not clear. They suggested using other statistical methods to figure out the extremes, such as the 95th percentile of the PDF of the variable, and higher temporal resolution dataset to characterize these extreme events. For example, if we study the extreme events using the 95th percentile of GPCP data over the 10-yr period, can other datasets also reveal the same amount of (similar) global extreme events as using existing index? Do other variables correlate with these extreme events? Can models simulate these extreme events? If the answers are 'yes' for the above 3 questions, then we will use the re-analysis(es) for other decades even back 100 years to re-produce these extremes to investigate the similarities/differences compared to the 10-yr analysis.

• Evaporation & Latent Heating Working Group

Future Plans

- How do we know if the land-ocean latent heat data is consistent in quality, variability, etc?
- Work in water vapor data to the analysis
- Isotopes!
- Promote best dataset building/comparisons by providing/using well documented and compared datasets
- Reviewed NEWS IP

• Water and Energy Cycle Climatology Working Group

Future Directions and Activities

Much of the discussion in the Water and Energy Cycle Climatology breakout sessions at the NEWS Meeting in Irvine centered on future directions for the group following completion of the first study. Several ideas were deliberated, including

- Interannual variability/trends - same scale
- how does the system respond to variations?
- mechanisms
- changes in variability
- does interannual variability in the E and W cycles agree

Pros: Obvious climate change implications
Cons: Potentially perilous given the short data record
- Smaller spatial scales (e.g., gridded, climate regimes, river basins, different surface types, etc.).

Pros: Potentially more valuable in many ways
Cons: Other than river basins, difficult to close water budget; each region has its own particular characteristics, prior work, and local datasets that need to be researched in advance; Data quality may be worse at smaller scales
• Partition fluxes into components

- precip becomes liquid and solid
- ET becomes sublimation, evaporation, and transpiration
- terrestrial water storage becomes groundwater, soil moisture, snow, surface water
- heat transport
- snowfall, snowmelt
- clear-sky and cloudy sky radiative fluxes

• Evaluate representation of energy and water cycles in MERRA (and other reanalyses) and develop framework/metrics/benchmarks for AR5 model inter-comparison activities.

• Mechanisms: examine relationships between components of the energy and water cycle (joint-pdfs, time variations, etc.); move toward diagnosing processes and evaluating predictability in models.

• Supplement means with analysis of extremes or full histograms.

• Diurnal cycle or day/night differences

• Modeling & Water Cycle Prediction Working Group

While there has been good discussion and interactions facilitated by the model working group, the requests from other groups for model project PIs to participate seems to be much more convincing and also the preferred way forward by many NEWS participants. There will be one last model working group effort, specifically generating a consensus paper on MERRA's representation of water and energy cycle. This would be open to all NEWS participants who have used MERRA data. An invitational email has been sent and responses are coming in. Beyond that, the model group participants will begin contributing to integration projects organized by other working groups. Indeed, there may be integration projects sponsored by the former model working group members, but we expect those will be a much more science oriented effort.

The sense of the participants was open to some new model group effort, but it would require a few key ingredients to success. Firstly, a well formed objective is a fundamental need. The water and energy cycle group has that. The former model group objective(s) were vague, such as improving models. Also the PIs with accepted NEWS projects that generated some component of the W&ECs are quite numerous, while PIs working on model improvement are few. Therefore, any new working group should be formed considering the current activities of PIs.

For Reference: June 2010 NEWS Tasks and Gaps Excel Spreadsheet and brief summaries of model related gaps

https://spreadsheets.google.com/spreadsheet/ccc?key=0AhOeEdCvTkTBdFNBQ2h4ZERjSUVSeGJjMm9QR3JaRHc&hl=en_US#gid=0

- Resources to examine climate models and their hydrological cycle in comparison with these observed results.
- water vapor transport estimates will likely receive more attention with the start of the GPM mission as we resolve discrepancies between the annual mean and seasonal cycles of precipitation over the northern and southern hemisphere extratropics.
- Ice sheet monitoring and modeling; cold region processes are still the major gap for water and energy cycle.

- Expertise in regional/global modeling/data assimilation is needed in order to convert new knowledge of dynamical mechanisms into prediction capability, and evaluation of feedback mechanisms
- The impact of land data assimilation (e.g. soil moisture) on the coupled system during extreme events.
- Development of parameterized processes requires multi-scale observations for validation at fine to coarse resolutions
- GCM output insufficient diagnostics for certain evaluations
- Fine scale ability of reanalyses to represent extreme events
- Uncertainty of reanalyses, regarding WEC remains an issue
- Need recommended baseline data for metrics of model validation; new metrics needed in many cases, NEWS could document metrics

Workshop Agenda

Day-1
08:30 - 12:00 Plenary Session
- NASA management commentary (Entin)
- Invited presentations

10:00 - 10:30 coffee break
10:30 - 12:00 Summaries of Working Group Accomplishments/Plans (co-chairs)
- Climatology WG
- Modeling WG
- Evaporation and Latent Heating WG
- Drought and Flood Extremes WG

12:00 - 13:00 lunch
13:00 - 17:00 Individual Working Group meetings (4 parallel sessions)
Day-2
08:30 - 12:00 Working Group joint meetings (2 parallel sessions led by co-chairs)
08:30 – 10:00 • AM-1: Climatology WG (ROOM 1) / ELH WG (ROOM 2)
10:00 – 10:30 coffee break
10:30 – 12:00 • AM-2: Modeling WG (ROOM 1) / Extremes WG (ROOM 2)
12:00 - 13:30 lunch
13:30 – 17:00 Working Group joint meetings (2 parallel sessions led by co-chairs)
13:30 - 15:00 • PM-1: Climatology WG (ROOM 1)/ Extremes WG (ROOM 2)
15:00 - 15:30 coffee break
15:30 - 17:00 • PM-2: Modeling WG (ROOM 1)/ ELH WG (ROOM 2)
Day-3
08:30 – 12:00 Plenary Session
- Summary of Working Group interactions/findings (co-chairs)
- Future plans and opportunities (Entin/Houser/Schiffer/Belvedere)

12:00 adjourn

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