NEWS Challenge: Document and enable improved, observationally-based, predictions of water and energy cycle consequences of Earth system variability and change.

Outline:
- Define water and energy cycle
- Why water & energy cycle?
- Outstanding issues
- NEWS Strategy & Plan
- Partnerships
The global water and energy cycle encompasses the movements, transformations, and reservoirs of water, energy, and water-borne materials throughout the Earth system and their interactions with ecosystems and the global water system. The global water and energy cycle operates on the full continuum of space and time scales and involves phase changes and energy exchanges.
The Water and Energy Cycle

Water in the climate system functions on all time scales: From hours to centuries.

- Water exists in all three phases in the climate system and the phase transitions are a significant factor in the regulation of the global and regional energy balances.

- Water vapor in the atmosphere is the principal greenhouse gas and clouds at various levels and composition in the atmosphere represent both positive and negative feedback in climate system response.

- Water is the ultimate solvent and global biogeochemical and element cycles are mediated by the dynamics of the water cycle.

- Water is the element of the Earth system that most directly impacts and constraint human society and its well-being.

The Energy and Water Cycles are *tightly intertwined* – Solar radiation drives and feedbacks with the water cycle, and energy is transferred through water movement and phase change.
Why study the water and energy cycle?

Variations in greenhouse gases, aerosols, and solar activity force changes in climate...

...but, **consequences** of climate change are **realized through the water cycle**.

Thus, we must **characterize**, **understand**, and **predict** variations in the global water cycle.

*Water and Energy* is linked to all 12 Science Application Themes.
A generally accepted hypothesis regarding global water cycle changes:

“According to model predictions, the most significant manifestation of climate change would be an acceleration of the global water cycle, leading to … a general exacerbation of extreme hydrologic regimes, floods and droughts” (NASA-GWEC, 2000).

“There is evidence that suggests that the global hydrologic cycle may be intensifying, leading to an increase in the frequency of extremes” (USGCRP water cycle science plan)

Climate models generally project an acceleration in the rate of global water cycling and an increase in global precipitation … (Morel, GEWEX News, 2001)
Current Knowledge and Major Uncertainties

**What we know**
- global atmospheric and surface temperature distributions
- top-of-the-atmosphere radiation fluxes
- point processes

**What we need to know**
- global precipitation and water vapor distributions
- cloud radiation absorption and scattering properties
- global soil moisture, snow cover/depth distributions
- surface runoff
- evaporation
- land surface/atmosphere feedbacks
- uncertainties in integrated E&WC processes
What are the causes of water cycle variations?

Are variations in the global and regional water cycle predictable?

How are water and nutrient cycles linked?

NASA Earth Science Program Water & Energy Cycle Science Questions (7 of 24 questions):
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 climate variation?
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?

**NASA Water and Energy cycle Study (NEWS) Challenge:**
Document and enable improved, observationally-based, predictions of water and energy cycle consequences of Earth system variability and change.
The NEWS challenge is **global** in scale and requires the integration of NASA **system components** to **make decisive progress toward the NEWS challenge** in an **end-to-end program**.

**Product-driven NEWS investigations** directly cooperate with NASA to produce a coordinated cross-discipline comprehensive solution.

**Discovery-driven NEWS investigations** carried out by individuals or small groups of scientists to make advances in our understanding of key Earth-science processes.

**NEWS is an interdisciplinary program:** Discipline-based research will be performed by existing NASA disciplinary programs.

**NEWS Science Integration Team:** Support NEWS investigations and integrate their research results to address NASA-ESE science questions. The NEWS integration group will work with NEWS investigations to implement their results into a larger coordinated product, such as a NASA model, data system, etc.
**NASA Energy and Water cycle Study Road Map**

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**Address the ESE vision; deliver and evaluate system**

Phase 3 Deliverables:
- Dataset gaps filled and extended
- Intensive prediction system testing
- Prediction system delivery

**APPLICATION:**
- Improved water & energy cycle forecasts for use in decision support systems

**ANALYSIS & PREDICTION:**
- Understand variability in stores and fluxes
- Accurate cloud prediction
- Improve latent heating & convection models

**OBSERVATION:**
- Quantify mean state, variability, and extremes of the water & energy cycles
- Flux, transport, and storage rate quantification

**Exploiting current capabilities and preparing for the future**

**Phase 1 Deliverables:**
- First coordinated global W&E description
- Current prediction system evaluation
- Identify required system improvements

**Phase 2 Deliverables:**
- Fix model problems with new observations
- New measurement approaches developed
- End-to-end prediction system developed

**Phase 3 Deliverables:**
- Dataset gaps filled and extended
- New measurement approaches developed
- End-to-end prediction system developed

**Focus Area Linkages**

= Carbon  
 rightly  
= Climate variability  
= Atmospheric composition  
= Weather  
= Surface & interior

= Technology development  
= Field campaign

= Funded  
= Unfunded

**Application**

- Observations used in planning
- Test prediction of extremes
- Develop application metrics

**Prediction**

- Select demonstrations
- Climatology baselines
- Establish requirements

**Observation**

- First Coordinated W&E Obs
- TRMM TERRA AQUA GRACE ICESAT
- AURA CloudSAT CALIPSO

**Knowledge Base**

**Focus Area Linkages**

- Carbon
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NEWS Constraints

- Focus on water and energy processes and dynamics in the climate system.
- The NEWS challenge is a **global scale** objective.
- Integrate water and energy cycle system components (observations and predictions).
- NEWS elements: **Observation, Understanding, Models, Prediction and Consequences**
- Make **decisive progress** toward NEWS challenge.
- NASA administers the water and energy cycle focus area as an **end-to-end program**.
- DSS development is not supported by NEWS.

NEWS Objectives:

- Develop and deploy experimental **E&WC global observing system**.
- **Document the global E&WC** by obtaining complete observational record of all associated relevant geophysical properties.
- Build **fully interactive global climate model** that encompasses process-level E&WC forcings and feedbacks – *Climate models that can predict weather-scale extremes*.
- Create global surface and atmosphere **data assimilation system for E&WC variables**.
- **Assess variability of the global E&WC** on time scales ranging from seasonal to decadal, and space scales ranging from regional to continental to global.
- Support the **application of climate prediction capabilities** for estimating the impact of climate variability and change on water resources.
NEWS Linkages

**Interdisciplinary Research**

- **Atmosphere Science**
  - **Terrestrial Bio/Geo/Chemo Hydrology**
  - **Ocean Science**

**Understanding**

- **UNDERSTANDING**
  - NSF, NASA, DOE

**Prediction**

- **PREDICTION**
  - NOAA, DOE, NASA

**Applications**

- **APPLICATIONS**
  - USDA
  - USGS
  - EPA
  - BoR
  - USACE

**Observations**

- **OBSERVATIONS**
  - NASA, NOAA (DOE, USGS, USDA)

**Formal – CCSP**
- Water Cycle sub-group
  - Basic research (NSF, NOAA, DOE)
  - Applied research (EPA, BoR, USDA, USGS)
- Climate Variability and Change group
- Others (Atm. Comp., International, Human Dimensions, etc.)

**Informal**
- NCAR - explicit water cycle program
- GFDL
- GAPP – small scale end to end / focused on prediction
- CUASHI – land observation inspired research

**World Climate Research Program (WCRP)**
- Global Energy and Water Experiment (GEWEX)
- Climate Variability (CLIVAR)
- Climate and Cryosphere (CLIC)

**IGOS-Partners Water Cycle Theme**
- Global Observing system (GCOS)
- Global Earth Observation (GEO and IWGEO)
- International Geosphere-Biosphere Programme (IGBP)
- Hydrology for Environment, Life, and Policy (HELP)
- Global Water System Project (GWSP)
- And many more.....!
We must define an integrated water & energy observation system that can not only detect global mean trends but also local variation of extremes.

Input - Output = Storage Change

Transport + Evaporation - Precipitation – Runoff - P
= \Delta \text{Land Storage} + \Delta \text{Water Vapor}
Useful prediction is critical – it is the link to stakeholders.

We must move towards a new paradigm of climate models that produce useful weather-scale, process-scale, and application-scale prediction of local extremes (not just mean states).

We must more fully constrain climate models with observations.
What is science/model/data integration (coordinate, synthesis, enhance, link, interface, etc)?

- **Quantification**: Intercomparison, geolocation, balance assessment, error assessment, validation, super-ensembles, predictability assessment
- **Unification**: Data assimilation, calibration, time/space continuity, etc.
- **Collaboration**: Encouraging groups to team towards grand-challenge solutions.
Climate models’ grid-box representation of Earth’s processes...

Each grid-box can only represent the “average” conditions of its area.

However, controlling processes of the water cycle (e.g. precipitation) vary over much smaller areas.

**How can climate models effectively represent the controlling processes of the global water cycle?**

**“Conventional” approach:** make the model grid-boxes smaller (increase resolution)
  • Slow progress: may take ~50 years to be computationally feasible

**Breakthrough approach:** *Simulate a sample* of the small-scale physics and dynamics using high resolution *process-resolving models* within each climate model grid-box
  • “Short-cut” the conventional approach (~10 years to implement)
End-to-end coordination enabling understanding and prediction of the Earth system:

**Research driven by the needs of society**

To deliver social, economic and environmental benefit to stakeholders through sustainable and appropriate use of water by directing towards improved integrated water system management

Paul R. Houser, June 24, 2005, Page 18
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Status:
- NEWS NRA: Written, Reviewed, and <almost> announced
- NEWS – NSIT: 7-member NEWS science integration team formed
- NEWS – Kick off meeting: Sept 7-9, 2005 New York (GISS)
- NEWS - ROSES: Gap-filling amendment to be released in early July