Outline

• Sponsor’s motivation
• Roadmap for Research to Operations
• Science objectives
• Approach
• Summary
Sponsor’s vision

- NASA's vision is "to improve life here" and our mission is "to understand and protect our home planet". Applications extend the NASA vision and mission by enabling and facilitating the assimilation of Earth observations and prediction outputs into decision support tools. The purpose is to enhance the performance of the decision support resources to serve society through Earth exploration from space.

[Emphasis is speaker's]
Research to Operations

Concept | Basic Research | Applied Research | Operations
Research to Operations

Enabling *applications* for societal benefits

1. provides critical information to support *drought monitoring* and mitigation
2. provides essential information for *predicting droughts* based on weather and climate predictions
3. supports *irrigation water management*
4. supports *fire risk assessment*
5. supports *water supply forecasting* and NWS *flood forecasting*
6. supplies a critical missing component to assist with snow, climate and associated *hydrometeorological data applications*
7. supports *climate change assessment*
8. enables *water quality monitoring*
9. supports a wide variety of *natural resource management* & research activities such as NASA remote sensing activities of soil moisture and ARS watershed studies.
RPC Evaluations: Motivation and Activities
Motivation

• Precipitation is the main forcing for hydrological and land surface models
• Precipitation events that result in flooding often evolve over short space and time scales, where properly instrumented surface networks may not be available
• Satellite data often provides the only source of timely precipitation data over many of the world’s remote watersheds
• Hydrological modeling is a key focus of the future NASA/JAXA Global Precipitation Measurement Mission (GPM) in 2013; however
• The members of the GPM constellation will change owing to launch schedules before and during the mission; therefore
• How can we leverage today’s existing environmental satellite constellation to examine the impact of (existing and future) satellites and orbits on hydrological applications?
Purpose of our RPC experiments

- Evaluate usefulness of potential (future) GPM data for decision support in water resources management and other cross-cutting applications.
  
  Test, characterize, and evaluate GPM data in conjunction with other precipitation products in the context of land surface and hydrological modeling for earth science applications.
Experimental objectives of RPC precipitation evaluation

- Evaluate space-based precipitation estimation using ground-based radar and rain gauge data for different cases representing different synoptic condition and surface types.
- Run land surface model experiments to produce water and energy fluxes at 1-10 km resolutions in selected domains, for use in precipitation product evaluation, and subsequent science and application use.
- Identify water resources applications and metrics to characterize and evaluate for.
- Define basic standards for error analyses and data quality control by cross correlating the various inputs to the hydrological and land surface models.
Tasks to achieve objectives

• Precipitation Data Processing
  ▪ Satellite precipitation products
  ▪ Gage analysis, NEXRAD, other satellite estimates

• Precipitation Evaluation
  ▪ Technique development
  ▪ Statistical analysis

• Intra-satellite Sensitivity Analysis

• Hydrological Modeling
  ▪ Control runs (gage and NEXRAD)
  ▪ Model sensitivity to different precipitation forcings.

• Analyze results and publish
Land Surface and Hydrological Modeling Applications
Identified Decision Support Needs

• Routine analysis *land surface state* (soil moisture, evaporation, land surface temperature) over the continental involves:

- **Observations**
  - water
  - soils
  - sun
  - weather
  - climate
  - vegetation
  - terrain

- **Analysis / Modeling**
  - observe, model, assimilate

- **Information**

![Soil Moisture Anomaly (mm) Last day of APR, 2006](image)
Land Data Assimilation

- Energy and moisture fluxes, at different spatial and temporal scales, at the land-atmosphere interface is modulated by the land surface conditions
- Hence, accurate initialization is critical
- Remotely sensed and in-situ data provide key initial conditions
- Land models provide information about land-surface state, essential for improving environmental assessment, prediction and decision support
An Integrated Framework for Land Data Assimilation System

**Inputs**
- Topography, Soils
- Land Cover and Vegetation
- Meteorology (air temperature, precipitation, ...)
- Observed Land States (snow, ET, soil moisture, etc.)

**Physics**
- Land Surface Models (LSM)
  - Physical Process Models
    - Noah, CLM, VIC, SiB2, Mosaic, Catchment, etc.

**Data Assimilation Modules**
- (EnKF, EKF)
- Rule-based

**Outputs**
- Energy Fluxes: Le & H
- Biogeochemistry: Carbon, Nitrogen, etc.
- Water Fluxes: Runoff
- Surface States: Moisture, Carbon, Ts

**Applications**
- Water Supply & Demand
- Agriculture, Hydro-Electric Power, Ecological Forecasting
- Water Quality
- Improved Short Term & Long Term Predictions

[Christa Peters-Lidard]
Study Area
Arkansas Red River Basin
Precipitation Observations in ABRFC Domain
Arkansas-Red River Basins

The Arkansas River is the longest tributary in the Mississippi-Missouri system. From its source near Leadville, Colorado, the river travels through Kansas and northeastern Oklahoma. There it is joined by the Canadian, Cimarron, Neosho-Grand, and Verdigris Rivers, crosses the state of Arkansas where it empties into the Mississippi River.

The Red River rises in two branches in the Texas Panhandle and flows east along the border of Texas and Oklahoma, and briefly between Texas and Arkansas. There it turns south into Louisiana to empty into the Atchafalaya and Mississippi Rivers.
Arkansas River Tributaries
Precipitation Datasets
Late June Oklahoma Heavy Rain Events and Effect on Runoff of Small Streams

Conversion: $1 \, \text{m}^3 \, \text{s}^{-1} = 35 \, \text{ft}^3 \, \text{s}^{-1}$
Examining Impact of Satellite Type for the GPM Era

Satellite Omission Experiments

Case 0: All satellites included (baseline)
Case 1: Omit all crosstrack sounders
Case 2: Omit morning crosstrack sounders
Case 3: Omit afternoon crosstrack sounders
Case 4: Omit TRMM TMI and PR and Aqua
Case 5: Omit TRMM PR only
Case 6: Omit TRMM TMI only
Case 7: Omit TRMM TMI and PR
Case 8: Omit all morning satellites
Case 9: Omit all afternoon satellites
Examining Impact of Satellite Type for the GPM Era

**Satellite Omission Experiments: Baseline**

- 24-hour accumulations ending 2007/06/29 12Z
- 12-hour accumulations ending 2007/06/29 12Z
- 6-hour accumulations ending 2007/06/29 12Z
- 3-hour accumulations ending 2007/06/29 12Z
Examining Impact of Satellite Type for the GPM Era

Satellite Omission Experiments: Case 2
3-Hour Accumulations: Omit Crosstrack Sounders

**Case 1:** Omit all crosstrack sounders

**Case 2:** Omit morning crosstrack sounders

**Case 3:** Omit afternoon crosstrack sounders
24-Hour Accumulations: Omit Crosstrack Sounders

Case 1: Omit all crosstrack sounders
Case 2: Omit morning crosstrack sounders
Case 3: Omit afternoon crosstrack sounders
3-Hour Accumulations: Omit TRMM/Aqua Imagers

Case 4: Omit TRMM TMI and PR and Aqua
Case 5: Omit TRMM PR only
Case 6: Omit TRMM TMI only
Case 7: Omit TRMM TMI and PR
24-Hour Accumulations: Omit TRMM/Aqua Imagers

**OKLAHOMA**

33N-38N 100W-94W

**AVERAGE**

- **CASE0**
- **CASE4**
- **CASE5**
- **CASE6**
- **CASE7**

**PEAK VALUE**

- **Case 4:** Omit TRMM TMI and PR and Aqua
- **Case 5:** Omit TRMM PR only
- **Case 6:** Omit TRMM TMI only
- **Case 7:** Omit TRMM TMI and PR

**TEXAS**

28N-34N 102W-95W

**AVERAGE**

- **CASE0**
- **CASE4**
- **CASE5**
- **CASE6**
- **CASE7**

**PEAK VALUE**

- **Case 4:** Omit TRMM TMI and PR and Aqua
- **Case 5:** Omit TRMM PR only
- **Case 6:** Omit TRMM TMI only
- **Case 7:** Omit TRMM TMI and PR
3-Hour Accumulations: Omit AM or PM Satellites

Case 8: Omit all morning satellites
Case 9: Omit all afternoon satellites
24-Hour Accumulations: Omit AM or PM Satellites

Case 8: Omit all morning satellites
Case 9: Omit all afternoon satellites
Summary

• An intercomparison of GPM-like satellite constellations was performed for the purpose of analyzing the impact of satellites and orbits on hydrological models.

• Compared to the “all satellites” configuration, the elimination of the morning satellites (specifically the across-track sounders) showed the largest impact.

• However this type of experiment is not a true validation, where the different satellite configurations are compared against ground truth data.

• Future means of validation (other than raingauge) are planned that use other types of hydrological and land surface observations (runoff, fluxes).
Contact Information

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Team & Collaborators

• **MSU Team**
  – Valentine Anantharaj
  – QiQi Lu
  – Nicholas Younan
  – Georgy Mostovoy
  – Louis Wasson
  – Yangrong Ling
  – Graduate students

• **External Collaborators**
  – Paul Houser (GMU CREW)
  – Joe Turk (Naval Research Laboratories, Monterey, CA)

• **Partner Agencies**
  – Garry Schaeffer (USDA NRCS)
  – Steve Hunter (United States Bureau of Reclamation)
When BASC examined the plans and capabilities for the transition of research to operations at EMC, several shortcomings were noted:

1. EMC does not possess the capability to test and evaluate new algorithms and new forecast models in parallel with the operational system or to obtain feedback from the user community. There are insufficient computational resources to allow simultaneous testing of new model versions in parallel with the operational forecast computer runs.

2. In most cases, when new sensors are developed, insufficient budget is provided to develop the algorithms necessary to introduce those sensors into the operational system. There is limited capability to address the special needs associated with assimilation of a large volume of new satellite observations.

3. No one at EMC is clearly assigned the responsibility for technology transition.

4. Human resources at EMC receive only 47 percent of their funding from the base budget. The remainder is supported by soft money (funding that is not stable from year to year). Soft money poses difficulties in the planning that is required for an operational agency and can dilute the mission's effectiveness since the source of the soft funding frequently has objectives that may diverge from the operational mission.
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Lessons from NAS Study

From Research to Operations in Weather Satellites and Numerical Weather Prediction:
Crossing the Valley of Death (2000)

• Operational agencies often do not possess the capability to test and evaluate new algorithms and new products in parallel with the operational system or to obtain feedback from the user community.

• In most cases, when new sensors are developed, insufficient budget is provided to develop the algorithms necessary to introduce those sensors into the operational system. There is limited capabilities to address the special needs associated with the incorporation of satellite precipitation products.

• No one at the operational (and/or research) agencies is clearly assigned the responsibility for technology transition.

• Human resources at operational centers receive only XX percent of their funding from the base budget. The remainder is supported by soft money. Soft money poses difficulties in the planning that is required for an operational agency and can dilute the mission's effectiveness since the source of the soft funding frequently has objectives that may diverge from the operational mission.