# *Annual Report by Work Group 2*

# Data Assimilation, Uncertainty Assessment and Environmental Model Confirmation

**Thomas Nicholson, U.S. Nuclear Regulatory Commission**

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***U.S. Nuclear Regulatory Commission***
***Rockville, MD***

# Outline

- Work Group 2 (WG2) New Objectives/ Goals
- Members and Participants
- WG2 Seminars
- Activities and Technical Projects
- Methodologies, Tools and Applications
- Forward Strategy
- Recommendations for FY2018 – 2019

# Work Group New Objectives

- Coordinate ongoing and new research conducted by U.S. Federal agencies on:

  Data Assimilation

  Uncertainty Assessment

  Environmental Model Confirmation

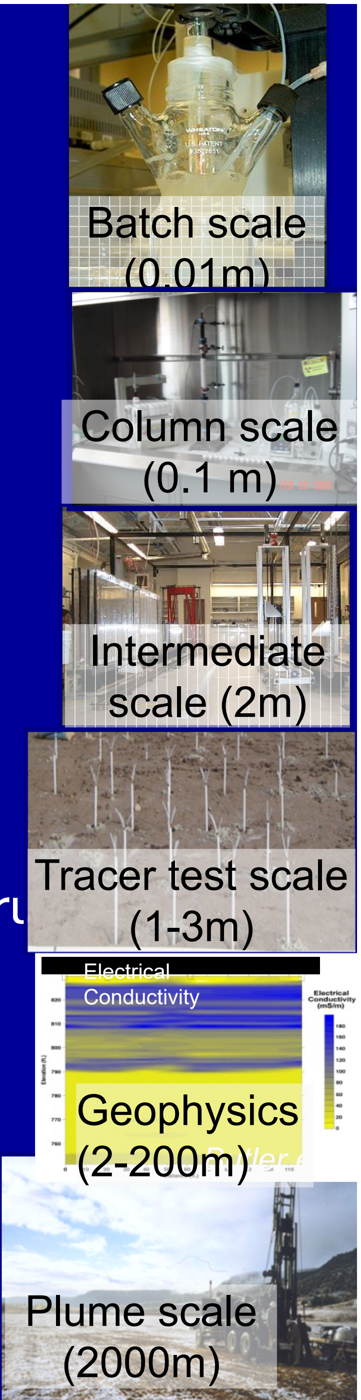
  in support of environmental modeling & monitoring
- Focus on strategies, techniques and software
- Includes sensitivity analysis

*What is needed to achieve this objective?*

Coordination of research activities thru efficient and targeted use of our limited resources.

# Work Group New Goals

- **Basics**:
  - ✓ Develop a creative, collaborative environment to advance
    - ➢ Data assimilation in the context of model development .
    - ➢ Address sources of uncertainty in the context of model predictions and risk assessment.
    - ➢ Develop guidelines for environmental model confirmation.
  - ✓ Develop a common terminology.
  - ✓ Identify innovative applications.
- **Existing Tools**: Identify, evaluate, and compare available analysis strategies, tools and software.
- **Exchange**: Facilitate exchange of techniques and ideas thru teleconferences, technical workshops, professional meetings, interaction with other WGs and ICEMM
- **Communicate**: Develop ways to better communicate uncertainty to decision makers (e.g., evaluation measures, performance indicators, visualization).



# Members and Participants

from U.S. Federal agencies, DOE national laboratories & universities

- Tom Nicholson, NRC, Chair
- Ming Ye, Florida State U
- Ming Zhu, DOE
- Brian Skahill, USACOE
- Tom Purucker, EPA-Athens
- Steve Yabusaki, PNNL
- Sanja Perica, NOAA/NWS
- Boris Faybishenko, LBNL
- Pierre Glynn, USGS
- Philip Meyer, PNNL
- You?

# METHODOLOGY FOR ASSESSING UNCERTAINTIES

- Identify sources of uncertainty which are the major contributors to the total uncertainty for a site-specific application

- Formulate procedures for defining and later testing the model assumptions based upon site characterization and monitoring databases

- Determine the range of plausible values for each of the parameters used in the models

- Develop a probability distribution or otherwise characterize the likelihood of parameter values over the range of values for each parameter

- Use Monte Carlo simulation methods to determine the distribution of possible values, the best-estimate and uncertainty bounds and identify the likelihood of the originally adopted values within the distribution

- Test the models using real-site monitoring datasets and compare to estimated values using conventional deterministic methods

# Activities: Seminar

We conduct seminars to:

- review and discuss ongoing research studies and software development
- formulate proposals for field applications

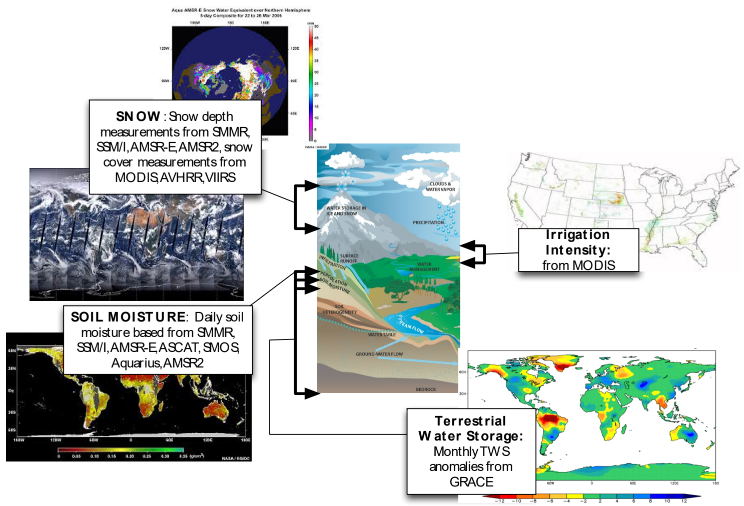
The next three slides highlight the themes from past seminars

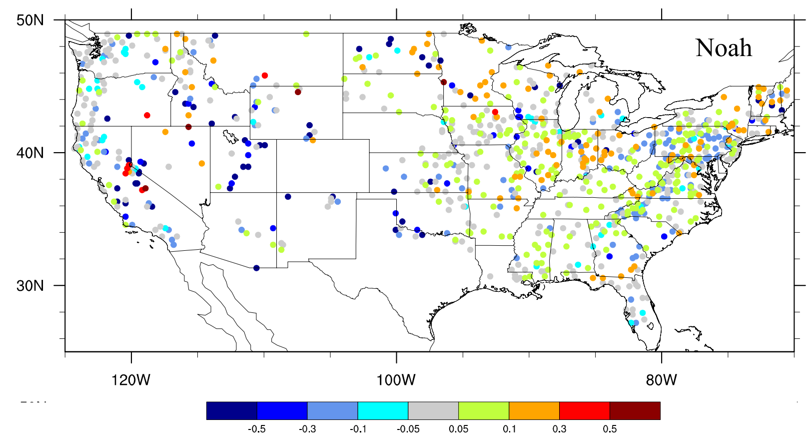
***Big Data and Data Assimilation***

**Land Surface Modeling and Data Assimilation**
Dr. Sujay Kumar, Hydrologic Sciences Laboratory,
NASA Goddard Space Flight Center

**EPA/USGS/NOAA/NASA Cyanobacteria Assessment Network Project**
Dr. Blake Schaeffer, Research Physical Scientist, EPA

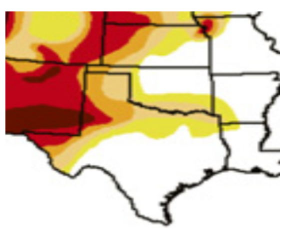
# Kumar, NASA - Multivariate assimilation of satellite-derived remote sensing datasets in the National Climate Assessment LDAS



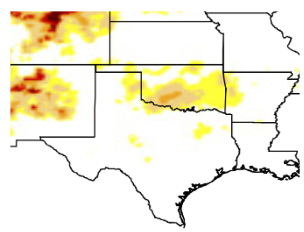




The concurrent, multivariate assimilation of various terrestrial hydrological datasets (soil moisture, snow depth, snow cover, terrestrial water storage, irrigation intensity) has been demonstrated for the NCA LDAS.

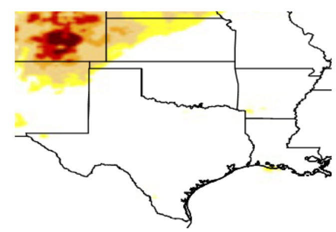
Multivariate assimilation of satellite remote sensing datasets are helpful in improving water budget components, including streamflow



US drought monitor

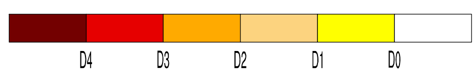


LSM based drought estimate



LSM based drought estimate with data assimilation

Impact of LDA on drought estimates (Sep, 2012).




Kumar et al. (2014):Assimilation of remotely sensed soil moisture and snow depth retrievals for drought estimation, J. Hydromet., 10.1175/JHM-D-13-0132.1

Kumar et al. (2016): Assimilation of gridded GRACE terrestrial water storage estimates in the North American Land Data Assimilation System, J. Hydromet., 10.1175/JHM-D-15-0157.1

# Summary – Kumar, NASA

- Land Data Assimilation Systems have been developed for central North America (NLDAS, NCA-LDAS), Africa (FLDAS) and the globe (GLDAS)

- The common goal of these projects is to integrate all relevant data in a physically consistent manner within sophisticated land surface models to produce optimal estimates of hydrological states (e.g. soil moisture, surface temperature) and fluxes (e.g. runoff, evapotranspiration)

- The Land Information System (LIS) is an efficient and configurable software that can be used to specify an instance of LDAS

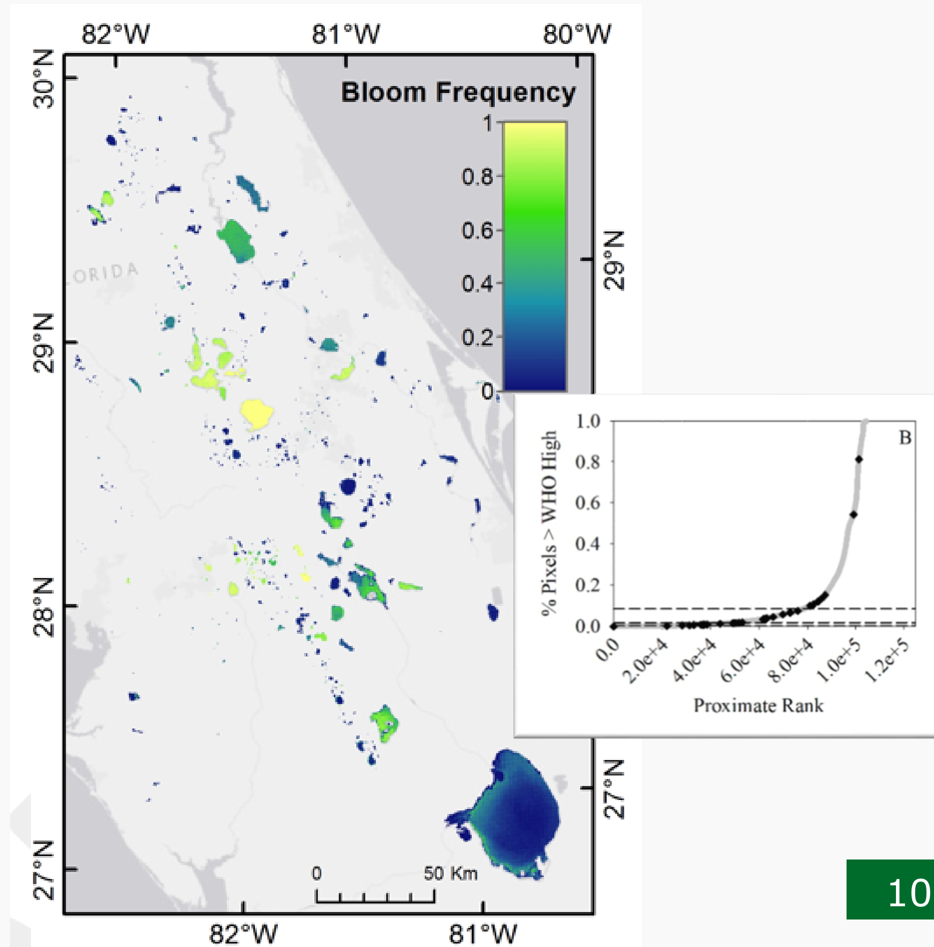
- LDASs have been used for water availability applications including drought/flood monitoring, agricultural management, weather and climate initialization.

http://lis.gsfc.nasa.gov

CYAN CYANOBACTERIA ASSESSMENT NETWORK

# Quantifying cyanobacteria *frequency*

- **Problem**: How do we quantify bloom frequency at relevant spatial scales?
- **Action:** Determine coverage of satellite data and analyze site-specific frequencies of cyanobacterial concentration.
- **Result:** Derive relative risk profiles from frequency data, but current resolution limits applicability.
- **Impact:** Possible applications for understanding HAB risk at management-relevant sites, e.g. surface water intakes or rec. waters.




Clark et al. (*In Clearance*). Methods for monitoring cyanobacteria harmful algal blooms in recreational waters and drinking source waters with satellites. Ecological Indicators.

# WG2 Forward Strategy

Energize the science and technology thru closer linkage to decision making:

- better understand the methods being used in data assimilation and uncertainty assessments
- *establish a base set of model sensitivity analysis and uncertainty evaluation measures, in addition to the other performance measures*
- use and compare different methods in practical situations
- address environmental model confirmation

# Recommendations for FY2018 – 2019

- Transform WG 2 into a new Research Interest Team focusing on
  - Data Assimilation
  - Monitoring and Model Data Fusion
  - Uncertainty Assessments
  - Environmental Model Confirmation

✓ Act as an incubator to build support for new ideas on Data Assimilation, Uncertainty Assessments and Environmental Model Confirmation methods

- Sponsor technical workshops on endorsed studies

## Recommendations for FY2018 – 2019
## – continued –

Invite others to join ICEMM

- Work with USGS, NASA, NOAA/NCEI and USACE to obtain access to databases and uncertainty tools

- Utilize ongoing environmental modeling studies to obtain and assess uncertainty and parameter estimation tools, and address model confirmation

Work with Pierre Glynn, USGS to develop paper on Monitoring and Model Data Fusion

# References

Kumar and others, Assimilation of Remotely Sensed Soil Moisture and Snow Depth Retrievals for Drought Estimation, Journal of Hydrometeorology, 10.1175/JHM-D-13-0132.1, 2014

Kumar and others, Assimilation of Gridded GRACE Terrestrial Water Storage Estimates in the North American Land Data Assimilation System, Journal of Hydrometeorology, 10.1175/JHM-D-15-0157.1, 2016

# References
– continued –

NAS, Refining the Concept of Scientific Inference When Working with Big Data: Proceedings of a Workshop – in Brief; Committee on Applied and Theoretical Sciences: Division on Engineering and Physical Sciences, National Academies of Sciences, Engineering, and Medicine; The National Academies Press, Washington, DC, September 2016

Takemasa Miyoshi and others, "Big Data Assimilation" Revolutionizing Severe Weather Prediction, Bulletin of the American Meteorological Society, pp. 1347 – 1354, August 2016

# I C E M M

## Interagency Collaborative for Environmental Modeling and Monitoring

Thank you for your attention