Annual Report by Work Group 2

Data Assimilation, Uncertainty Assessment and Environmental Model Confirmation

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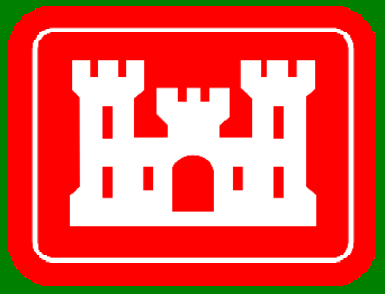


Data Assimilation

NOAA's Hurricane Research Division (HRD) defines:

Data assimilation as a technique by which numerical model data and observations are combined to obtain an analysis that best represents the state of the atmospheric phenomena of interest.

At HRD, the focus is on the **utilization of a wide range of observations** for the **state analysis of tropical systems and their near environments to study their structure and physical/dynamical processes, and to improve numerical forecasts.** (NOAA, 2014)

United Kingdom Research and Innovation - UKRI

Natural Environment Research Council – NERC is the driving force of investment in environmental science in the UK.

National Centre for Earth Observation – NCEO

Data assimilation (DA) is a powerful tool for combining the information contained in observations with models. The output can be a more accurate estimate of the earth system state than can be provided by either the observations or model alone.

NCEO EO/DA Tools – Atmosphere, Ocean, Land Surface

EMPIRE which allows for any model to be used with ensemble data assimilation techniques such as the EnKF and the particle filter.

Also included are application-specific DA tools such as those for the ocean (NEMOVar) and for the land surface (EOLDAS and CARDAMON).

Ensemble Data generated from EO datasets

Uncertainty Assessment

Refers to a lack of data or an incomplete understanding of the context of the risk assessment decision. It can be either qualitative or quantitative (U.S. EPA, 2019).

Qualitative uncertainty may be due to a lack of knowledge about the factors that affect exposure, whereas quantitative uncertainty may come from the use of non-precise measurement methods. Chemical concentrations in environmental media can be approximated using assumptions (more uncertainty) or described using measured data (less uncertainty).

Uncertainty can be introduced when defining exposure assumptions, identifying individual parameters (i.e., data), making model predictions, or formulating judgments of the risk assessment. (EPA, December 2019)

Environmental Model Confirmation

Guidance on the Development, Evaluation, and Application of Environmental Models, EPA/100/K-09/003 March 2009

Confirmation Addresses Model Framework and Data Uncertainties

- **Develop and Test Conceptual Models**
- **Develop Anticipatory Scenarios**
- **Model Complexity, Coding and Verification**
- **Model Calibration**

Best Practices for Model Evaluation

- **Scientific Peer Review**
- **Quality Assurance Planning**
- **Corroboration**
- **Sensitivity Analysis**
- **Uncertainty Analysis**

Environmental Model Confirmation

Barnett and others, ***Australian Groundwater Modeling Guidelines***, Waterlines Report, National Water Commission, Canberra, Australia, 2012. ISBN: 978-1-921853-91-3

Model Confidence – Levels, Characteristics and Indicators (Data, Calibration, Prediction and Key Indicators)

- ✓ Conceptualization of Current and Future States
- ✓ Developing and Checking Conceptual Model
- ✓ Calibration and Sensitivity Analysis
- ✓ Checking Model Results
- ✓ Sources of Uncertainty
- ✓ Relation of Model Calibration to Model Uncertainty
- ✓ Review Process and Checklists

Work Group Objectives

- Coordinate ongoing and new research conducted by U.S. Federal agencies on:
  - Data Assimilation
  - Uncertainty Assessment
  - Environmental Model Confirmation

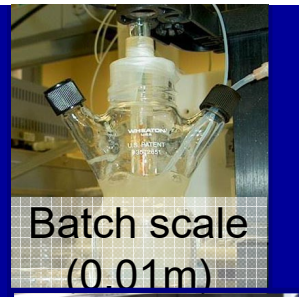
  in support of environmental modeling & monitoring
- Focus on strategies, techniques and software
- Includes sensitivity analysis

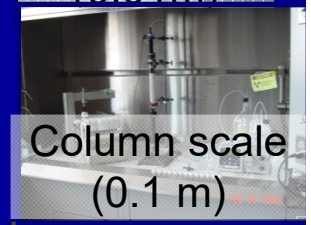
What is needed to achieve this objective?

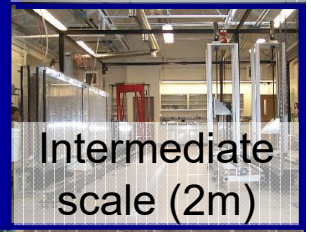
Information transfer and coordination of research thru efficient and targeted use of our limited resources.

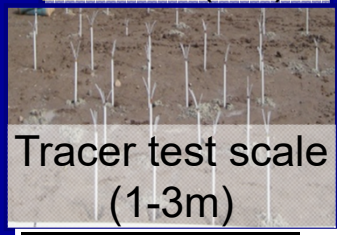
Work Group Goals

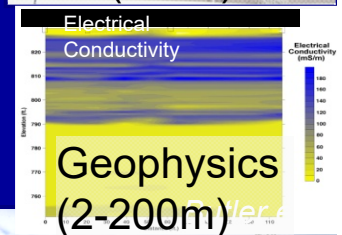
- **Basics**:
- ✓ Develop a creative, collaborative environment to advance
  - ➢ Data assimilation in the context of model development .
  - ➢ Address sources of uncertainty in the context of model predictions and risk assessment.
  - ➢ Develop guidelines for environmental model confirmation.
- ✓ Develop a common terminology.
- ✓ Identify innovative methods and applications.
- **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).

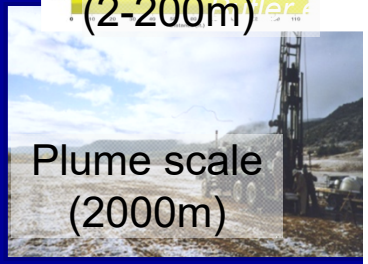












Collaborative Project Discussions

Organize Meetings to Review Environmental Modeling and Monitoring Methods and Applications by Focusing on:

- ✓ Data Assimilation Techniques
- ✓ Uncertainty Assessments to Identify Knowledge Needs
- ✓ Environmental Model Confirmation using Characterization and Monitoring Datasets to:
  - ➢ Check Conceptual Models and Future States
  - ➢ Model Input and Assumptions
  - ➢ Assess QA/QC of Model Predictions

Recommendations for FY2020 – 2021

- Develop WG 2 into a Research Interest Team focusing on U.S. and International:
  - Data Assimilation Techniques & Earth Observation Data
  - Monitoring and Model Data Fusion
  - Uncertainty Assessments
  - New Methods for Assessing Model Errors
  - Environmental Model Confirmation

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

- Sponsor technical workshops on collaborative studies

Recommendations for FY2020 – 2021
– continued –

Invite others to join ICEMM

- Work with USGS, NASA, NOAA/NCEI, ARS and USACE to obtain access to Databases, Data Assimilation 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 Integrated Monitoring and Model with Nature

Members and Participants

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

- ✓ Tom Nicholson, NRC, Chair
- ✓ Ming Ye, Florida State University
- ✓ Ming Zhu, DOE
- ✓ Tom Purucker, EPA-Athens
- ✓ George Alexander, NRC/NMSS
- ✓ **Boris Faybishenko, LBNL**
- ✓ Pierre Glynn, USGS
- ✓ **Philip Meyer, PNNL**
- ✓ You?

References

Barnett and others, ***Australian Groundwater Modeling Guidelines***, Waterlines Report, National Water Commission, Canberra, Australia, 2012. ISBN: 978-1-921853-91-3

EPA, *EPA Expo Box: Uncertainty and Variability with Tools for Assessing Uncertainty and Variability*, https://www.epa.gov/expobox/uncertainty-and-variability

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NOAA, Hurricane Research Division, Data Assimilation, 2014. https://www.aoml.noaa.gov/hrd/themes/0/

I C E M M

Interagency Collaborative for Environmental Modeling and Monitoring

Thank you for your attention