Future Advances in OSSEs

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Introduction

- OSSEs are observing system simulation experiments
- OSSEs are used to evaluate the impact of proposed observing systems
- OSSEs were used in planning for FGGE
- OSSEs are increasingly used by decision makers to allocate resources
OSSE presentations this week

- Monday, 2:30 PM-4:00 PM in Hall D/E: Poster Session on Data Assimilation: Data Impact Experiments and OSSEs, posters 243-247
- Tuesday, 11:15 AM in Room 252/254: talk J5.2 will present an overview in the session on Ensuring the Data Continuity from the Environmental Satellite Constellation
- Tuesday, 1:30 PM-5:30 PM in Room 345: Observing System Simulation Experiments (OSSEs) I and II
- Wednesday, 9:00 AM-10:00 AM in Room 225: Observation System Simulation Experiments and Other Studies to Assess the Impact of Future Satellite Sensors
Motivation & context

• Advances in operational NWP will greatly challenge our ability to conduct realistic OSSEs and require us to add extensions and innovations to future OSSE systems
  – Use of data with more complex error characteristics
  – Use of coupled forecast and data assimilation (DA) systems
OSSE system components

- Green marks operational system components
- Blue marks the OSSE specific components
OSSE applications

• Evaluation of impact on the analysis and forecast skill
  – From observations collected from proposed or new instruments and platforms
  – From new data assimilation techniques
• Trade studies for existing and proposed sensors
• Preparation of DA systems for upcoming/new sensors
Each OSSE component must be realistic

- The nature run (NR)
- The DA and forecast systems
- The observations and their errors
The four questions

1. Will the study be completed soon enough to be useful?

2. What are the limitations of the OSSE system?
   – Do not draw conclusions that go beyond these

3. Is the difference between the NR and forecast models realistic?

4. Are the simulated errors realistic?
Future OSSEs: Outline

• Opportunities and challenges
• Future NRs
• Future DA systems
• Future obs simulation
• Looking ahead
Challenges & opportunities

• OSSE will be needed for many analysis and forecast systems

• Operational systems will assimilate
  – Obs currently rejected, including
    • All sky microwave
    • Cloud affected radiances
    • Surface affected radiances
  – With much higher resolution and
  – With coupled DA systems
Future NRs

• Will include
  – More earth system components
    • Ocean, land, ice, aerosols, ….
  – 2-way coupled high res models
    • Instead of 1-way coupled high resolution NRs, future NRs will have 2-way coupling between components
  – Different representation, resolutions, detail for different components
    • Topography, SST, land types, vegetation types

• Will save everything, more often
  – G5NR (4 PB) points the way to serve large data sets
The G5NR at 00 UTC 11 Sep 2006. Graphic created by William Putnam, NASA GMAO.
Future DA/forecast systems

- O2R process will keep the OSSE system fresh
- Coupled DA systems
  - Will result in optimal use of additional data
    “contaminated” by other earth system components
  - Spin up times for different earth system components
    (ocean, ice, ….) IRL and in the OSSE world may be long
Obs simulation

• Simple approach
  1. Determine the observation time and location
  2. Interpolate the NR to that time and location
  3. Add errors

• But it’s not so simple, if we want to be realistic…
**IRL template dangers**

- Use of PrepBUFR and other templates from IRL are an efficient shortcut, but endanger the realism of our OSSEs and will be more of a problem in the future.
- Skips most pre-processing, QC and data selection components of the DA system
  - Data selection, gross QC, O-B QC, data thinning
- Incorrect locations of obs wrt geophysical phenomena
  - Clouds :: IR radiances
  - Winds :: radiosondes, aircraft
  - Precip :: MW radiances, scatterometers, DWLs
Future obs simulation

• Much more realistic instrument simulation
  – Very realistic obs simulation is done by sensor developers

• Include everything possible affecting the observation
  – Geophysical parameters/processes, spatial/temporal scales not included in NR should be included here
    • Realistic and consistent with NR
    • Provides realistic representativeness error (r-error)
  – Include most detailed and realistic of the representations across the earth system model components
    • Topography, SST, land types, vegetation types
Realistic representativeness error (r-error)

- R-error comes from things in nature not in the obs operator
- In OSSE setting should include things in the NR not in the obs operator AND things in nature not in the NR
  - Small scale cloud variability
  - Small scale land surface variability
  - Realistic (not climatological) phenology
Graphic created by Jack Woollen, NOAA Environmental Modeling Center (EMC)
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NOAA Environmental Modeling Center (EMC)

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Simulate obs.
Atmospheric motion vectors (AMVs)

- Simulation of AMVs (includes cloud track winds) should include the operational (or near operational) systems that generate AMVs
- For this purpose realistic imagery must be simulated from the NR
  - Requires high resolution in space and time
    - Current requirements are 3-5 km and 15 minutes
Natural analogs for obs simulation

• Aircraft routes in reality depend on the jet stream
  – Find jet stream analogs in reality to a particular time and location (or route, say IAD-LHR) in the NR
    • Use flight patterns from one of the close analog days
• Radiances in reality depend on cloud field details
  – Find large scale stability and wind analogs in reality to a particular time and place in the NR
    • Use high resolution cloud imagery (MODIS, LandSat) from one of the analog matches
    • Only consider analogs in reality that have the appropriate imagery available
OSSE issues for Geo-HSS

• Current DA systems
  – Use only limited HSS channel sets
  – Greatly thin Geo data

• Geo-HSS AMVs could be of great value
  – Development of AMV generation required
  – Best DA practices to use such dense wind data are needed
OSSE issues for GPS/RO

• GPS/RO data useful
  1. As (T, RH) profiles
  2. To anchor the VarBC

• OSSE obs simulation must introduce appropriate biases for all data types including
  – Radiances: MW and IR
  – Aircraft
  – Radiosondes
Looking ahead

• Use of much more realistic obs simulators
  – Will introduce natural and realistic representativeness errors

• Coupled earth system components in the NR, in the DA system, and in the obs simulation

• Application of OSSEs to diverse domains
  – Severe Storms, Ecosystems, Air Quality, and other components of the earth system.
Infrastructure requirements

• O2R process extended to additional systems
• Computational resources to keep pace with operations
• Convert NR to model state
  – For initialization and verification
• Obs locations from satellite orbit and sensor parameters
• …
Thank you

• Article: 10.1175/BAMS-D-15-00200.1
• OSSE checklist: www.aoml.noaa.gov/qosap/osse-checklist/
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