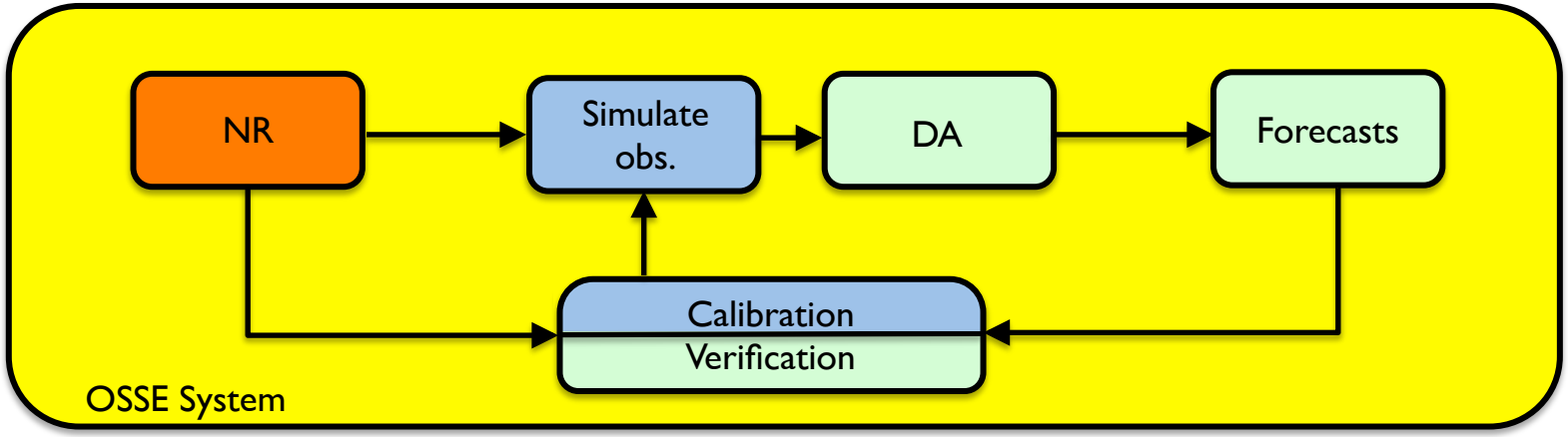
Future Advances in OSSEs



Ross N Hoffman (CIMAS)
Robert Atlas (AOML)

contact: ross.n.hoffman@noaa.gov

Introduction

OSSE

- 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

OSSE

- 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

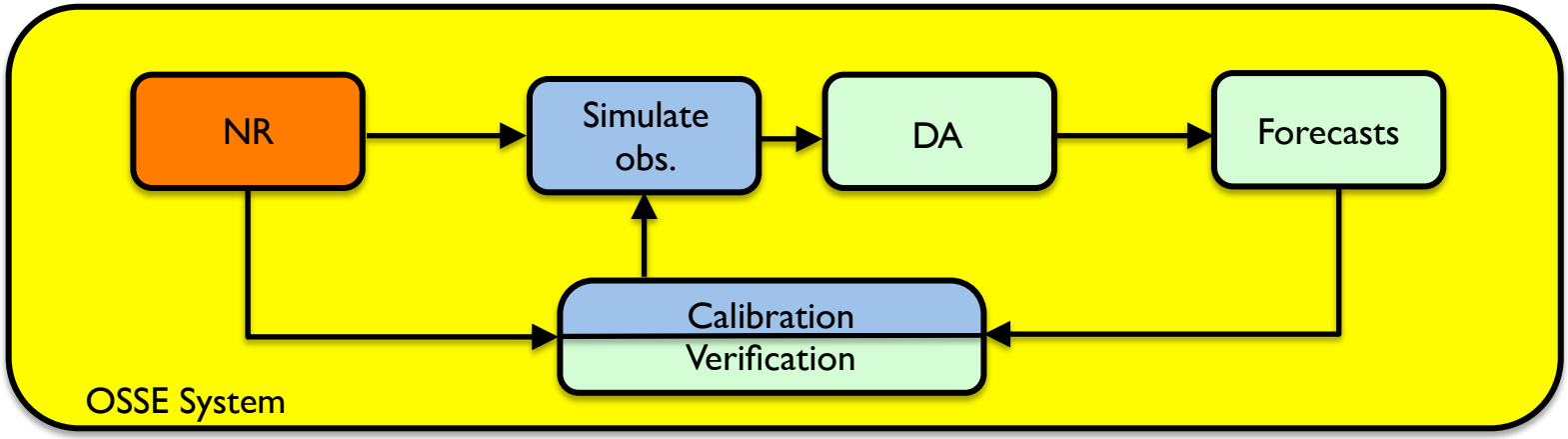
Motivation & context

OSSE

- 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

OSSE



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

OSSE applications

OSSE

- 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

OSSE requirements

OSSE

- Each OSSE component must be realistic
  - The nature run (NR)
  - The DA and forecast systems
  - The observations and their errors

The four questions

OSSE

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

OSSE

- Opportunities and challenges
- Future NRs
- Future DA systems
- Future obs simulation
- Looking ahead

Challenges & opportunities

OSSE

- 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

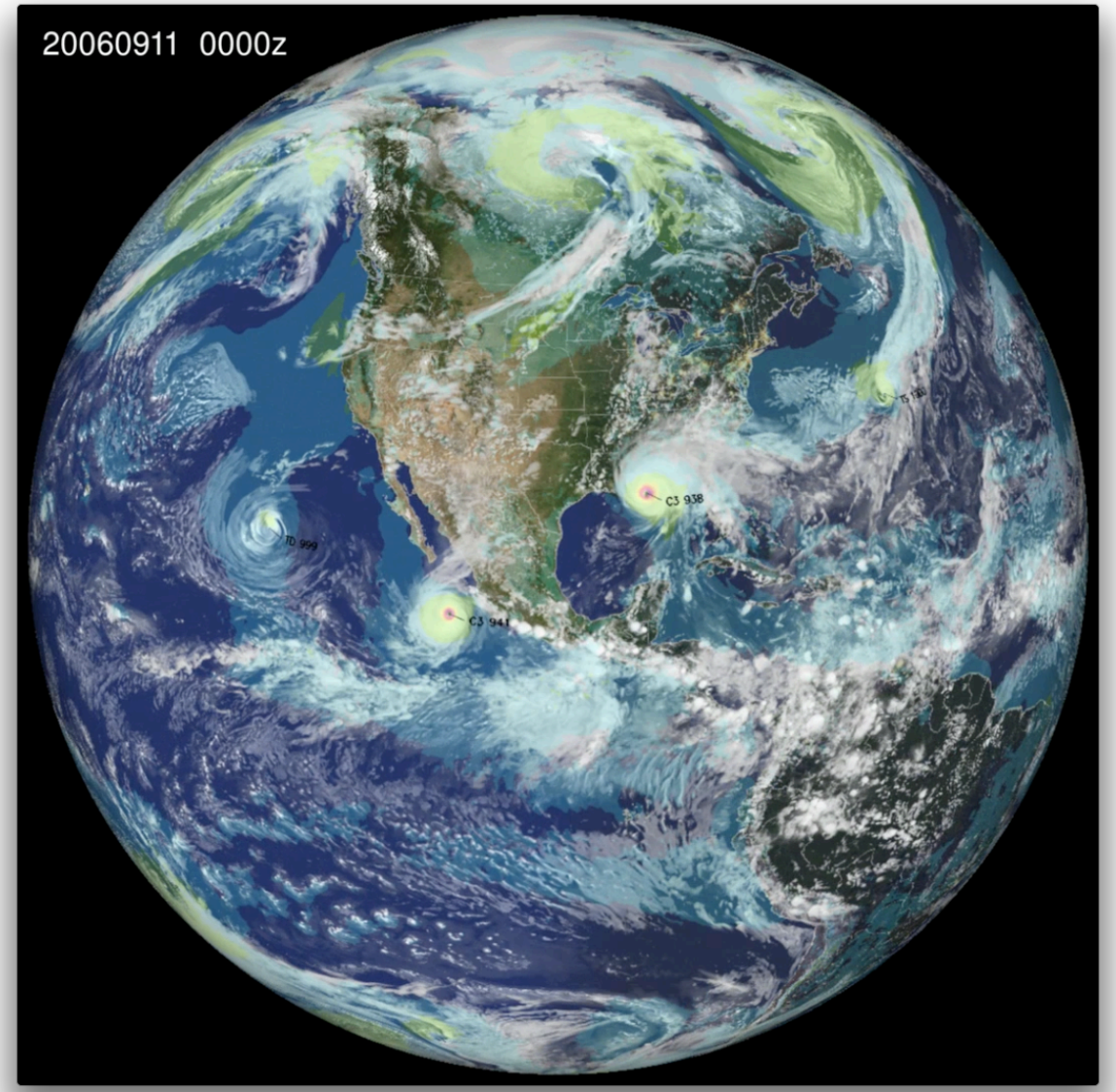
Future NRs

NR

- 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

The G5NR at 00 UTC 11 Sep 2006.
Graphic created by William Putnam, NASA GMAO.



NR

Future DA/forecast systems

DA

- 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

Simulate obs.

- 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

Simulate obs.

- 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

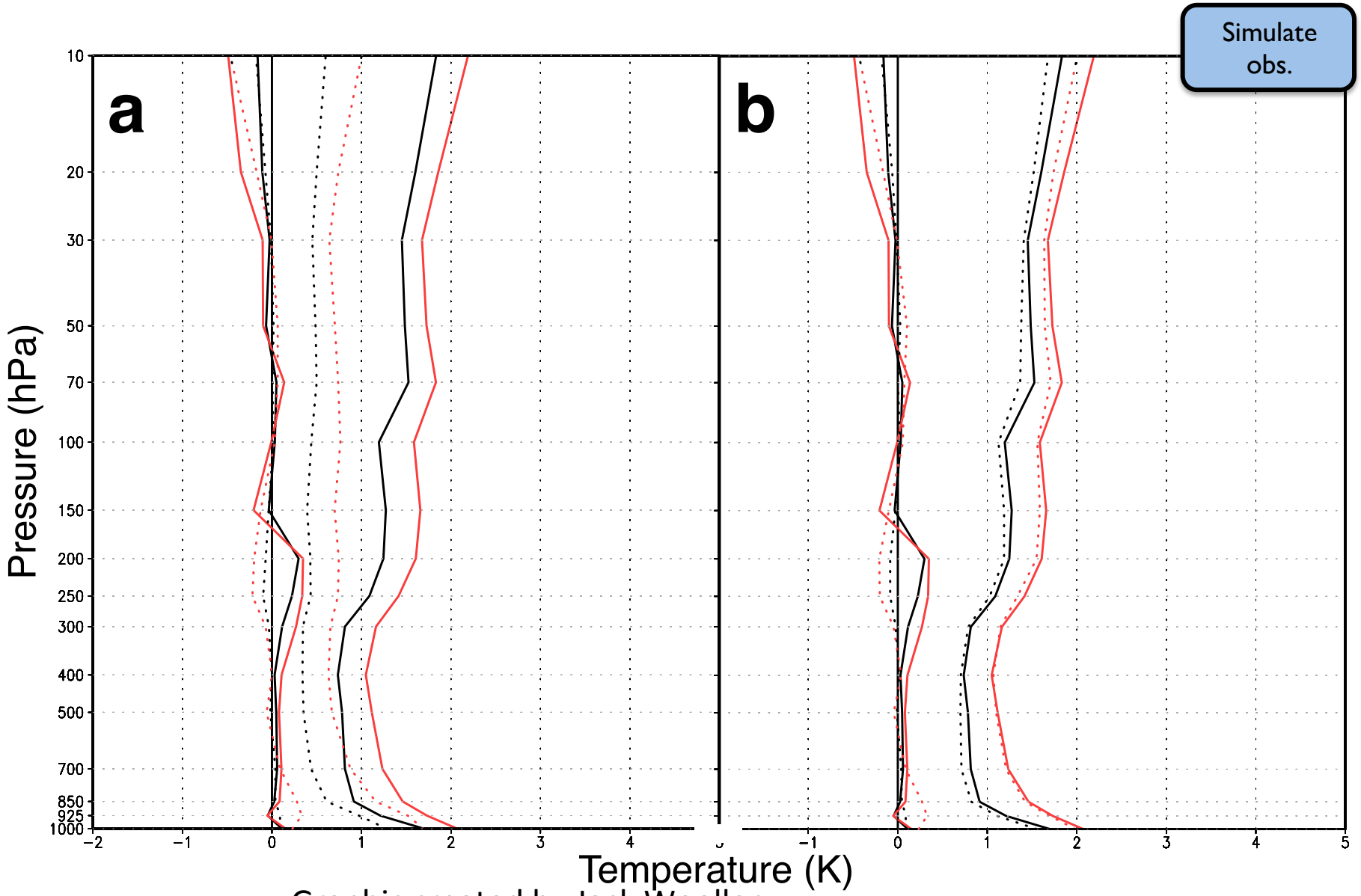
Simulate obs.

- 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

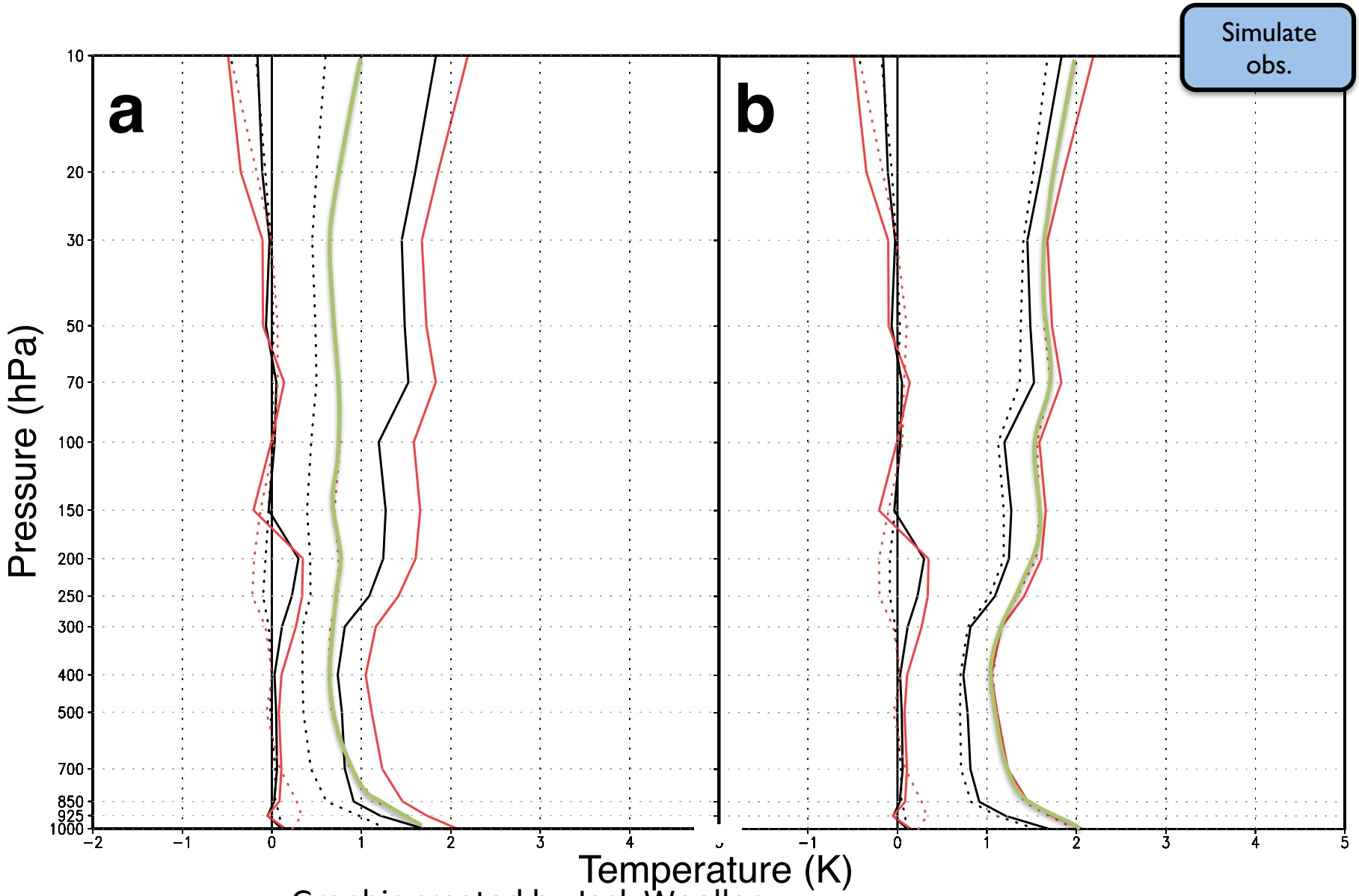
Realistic representativeness error (r-error)

Simulate obs.

- 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)



Graphic created by Jack Woollen,
NOAA Environmental Modeling Center (EMC)

Atmospheric motion vectors (AMVs)

Simulate obs.

- 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

Simulate obs.

- 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

Simulate obs.

- 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

Simulate obs.

- 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

OSSE

- 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

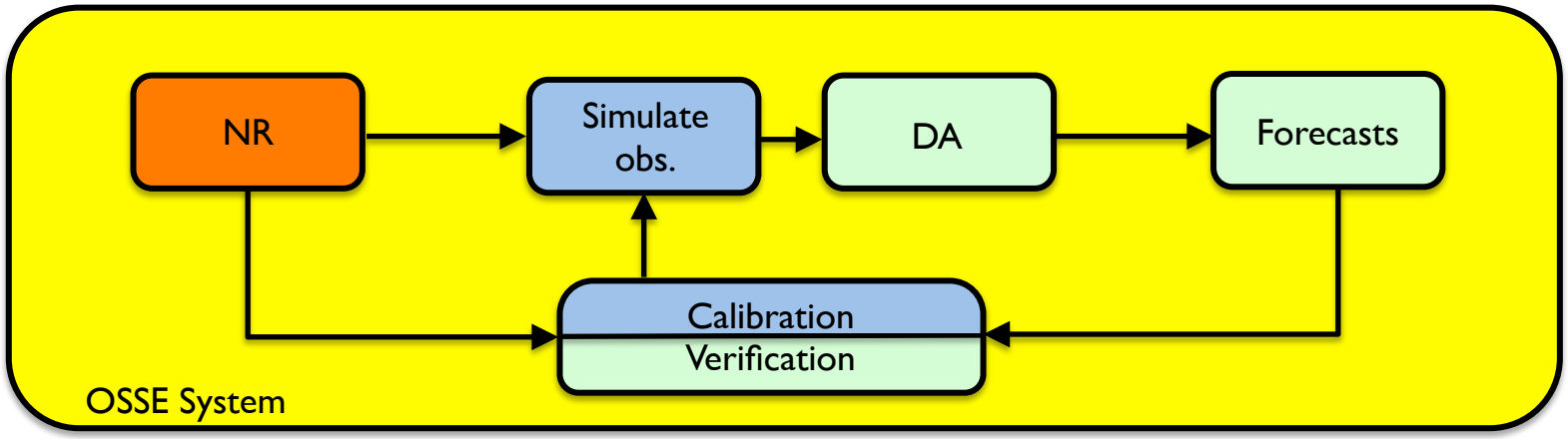
OSSE

- 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

OSSE

- Article: 10.1175/BAMS-D-15-00200.1
- OSSE checklist: www.aoml.noaa.gov/qosap/osse-checklist/
- Contact info: ross.n.hoffman@noaa.gov



OSSE presentations this week

OSSE

- 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