Joint Center for Satellite Data Assimilation

Who we are... What we do... Why it matters...

Tom Auligné, Director, JCSDA
Presented by Jim Yoe, Chief Administrative Officer, JCSDA
To the National Academy of Sciences
Committee on Earth Sciences and Applications from Space (CESAS)
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Description of the JCSDA

**Vision:**
An interagency partnership working to become a world leader in applying satellite data and research to operational goals in environmental analysis and prediction.

**Mission:**...to accelerate and improve the quantitative use of research and operational satellite data in weather, ocean, climate and environmental analysis and prediction models.

**Science priorities:** Radiative Transfer Modeling (CRTM), new instruments, clouds and precipitation, land surface, ocean, atmospheric composition.
**Improve Satellite Data Assimilation**

**Socio-economic benefit of NWP forecast:** estim. $100B-$1T per year *(Riishojgaard, 2014)*

**Contributions to NWP forecast:** *Initial Conditions = Model* *(Magnusson and Källen, 2013)*

**Initial Conditions:** Satellites dominate global impact of observations

*Source: Jung (2012)*
Accelerate Satellite Data Assimilation

Depreciation

Back-of-the-envelop Estimation
Cost = $11B
Design life = 20 years
Use for NWP = estim. 50%
Depreciation = $275M/year
Introduction to Data Assimilation

Data assimilation systems usually combine together information from a set of observations, a short term forecast, and possibly other information to estimate the most probable state of a physical system.

- **Observations** provide information about “reality” but are disparate and irregular in space and time

- **Models** provide regular, physically consistent information about the system, but are prone to systematic errors

Source: ECMWF
Hypotheses: observation and model background have errors that are uncorrelated, unbiased, normally distributed, with known covariances

Method: Bayesian statistical framework, potentially combined with dynamical constraints

Outcome: “best estimate” of current state (maximum likelihood, minimum RMSE)

Main Applications:
- Initial conditions for Numerical Prediction
- Calibration and validation
- Observing system design, monitoring and assessment
- Reanalysis (for climate and reforecast)
Description of the JCSDA

• History
  – 2001: creation (NOAA, NASA)
  – 2005: DoD joining (Air Force, Navy)
  – 2008: Charter (signed by Agency Executives) and Terms of Reference

• JCSDA has enabled (multi-agency) partners to share efforts and results to accelerate, enhance, and expand use of satellite data in operational prediction systems

• Keys to Success
  – Development and adoption of common tools (e.g. CRTM)
  – R2O supported by O2R infrastructure
  – Effective communication b/w Research and Operation communities

• New: UCAR CPAESS providing structure and mechanism for JCSDA government agencies to accomplish planning and execution of common mission more effectively.
JCSDA Management Structure

**Agency Executives**
NASA, NOAA, Department of the Navy, and Department of the Air Force

**Management Oversight Board**
- NOAA / NWS / NCEP (Lapenta (Chair))
- NASA/GSFC/Earth Sciences Division (Pawson)
- NOAA / NESDIS / STAR (Cikanek)
- NOAA / OAR (Atlas)
- Dept. of the Air Force / Air Force Director of Weather (Col. Gremillion)
- Dept.of the Navy / N84 and NRL (McCarren and Hansen)

**Executive Team**
- Director (Auligné) *
- Partner Associate Directors
  (Baker, Gelaro, Cetola Benjamin, Derber, Weng)
- Chief Administrative Officer (Yoe)

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JCSDA Mode of Operation

- **Internal Research**
  - Research undertaken by partners, overlapping with JCSDA priorities

- **External Research**
  - **External Research ($1M/year)**
    - NOAA FFO
    - NASA ROSES

- **Systems Support**
  - Offers O2R environment
  - Access to HPC & operational systems in R&D

- **Coordination, Education & Outreach**
  - JCSDA Mode of Operation

- **Visiting Scientist Program**

- **Summer colloquium on satellite DA**
  - Jul-Aug. 2015: Fort Collins, CO (->3-year)

- **Annual JCSDA Science Workshop**
  - May 2016: Moss Landing, CA
  - May 2017: College Park

- **Joint Workshops with Programs and International Partners**
  - Dec. 2015: 3rd Joint JCSDA-ECMWF Workshop
  - March 2016: Joint NCAR-JCSDA Workshop
  - Jan 2017: JCSDA Symposium @AMS Annual Meeting

- **JCSDA Newsletters and active Web Site (jcsda.noaa.gov)**
  - Highlight achievements by JCSDA scientists
  - Promote collaboration
Strategic Goals

1. Expand capabilities in assimilating satellite sensors
2. Spearhead a community data assimilation initiative
3. Address scientific frontiers to optimize the use of satellite data
4. Deliver new and improved tools to support observing system impact assessments
5. Foster improved organizational management, interagency coordination and outreach strategies
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Satellites

~268 Earth observation satellites
~413 instruments
Tens of millions of observations daily

(not all of them are currently used)

Processing satellite data requires an army of specialized scientists

-> incentive to mutualize efforts
Prioritized New Satellites and Sensors

- **New Sensors Data Assimilation:**
  (new QC, error optimization, impact assessment on NOAA forecast systems)
  - GOES-R – ABI (AMV winds and radiances) (Launched in Dec 2016)
  - JPSS1 – ATMS and CrIS (Launch date Q4 FY17)
  - COSMIC 2 (Launch date Q2 FY17)
    - HIMAWARI-8 AHI (Dry run for GOES-R ABI)
    - GPM /GMI
    - Megha-Tropiques SAPHIR (WV Sounder)
    - ISS-RAPIDSCAT (Scatterometer)
    - GCOMW AMSR2
    - SMAP
    - JASON 3

- **Existing Sensors optimization:**
  (QC, Surface-sensitive channels assimilation, pre-processing, dynamic emissivity, etc)
  - ATMS, SSMIS, AMSU, MHS
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Joint Effort for Data assimilation Integration (JEDI)

*Nation Unified Next-generation Data Assimilation*

**OBJECTIVES**

1. Facilitate innovative developments to address DA grand challenges
2. Increase R2O transition rate from community
3. Increase *science productivity* and *code performance*

**STRATEGY**

1. Collective path toward unification, allowing multiple levels of engagement
2. Modular, Object-Oriented code for flexibility, robustness and optimization
3. Mutualize *model-agnostic* components across
   - Applications (atmosphere, ocean, land, aerosols, strongly coupled, etc.)
   - Models & Grids (operational/research, regional/global models)
   - Observations (past, current and future)
MULTI-LEVEL COMMUNITY REPOSITORY

Scientific efforts in academia
Scientific efforts in OAR
Scientific efforts in satellite DA in Navy
JCSDA’s own DA Activities

(TRL 1-4)
(TRL 4-7)
(TRL 7-9)

Research
Community
Operational
Operations

DART
GSI

NCODA

Code Standards & Constraints

Oper (TRL 1-4)
Community (TRL 4-7)
Operational (TRL 7-9)

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Immediate priorities

- Improve the Community Radiative Transfer Model (CRTM) transmittance calculation, cloud and aerosol optical properties, software efficiency
- Assimilation of all-sky satellite radiances cloud-affected and over land
- Improve balance in analysis better use of ensemble information

Longer-term

- Multi-scale DA (spatial + temporal) global to convective scale, “seamless” DA across scales
- Coupled Earth System Model [Strongly] coupled DA for multiple domains (ocean, atmosphere, land, etc.)
- Non-linear, non-Gaussian DA Algorithms
- Representing model uncertainty & systematic errors
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Observing System Impact Assessment

- Global Forecast Dropout Tool (GFDPT)
- JCSDA Observing System Assessment Standing Capability (JOSASC)
- Forecast Sensitivity - Observation Impact (FSOI)
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Supporting External Research

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  - Highlight achievements by JCSDA scientists, and promote collaboration
  - Open positions at JCSDA, Visiting Scientist Program, projects, etc
Components of O2R/R2O Infrastructure

• What Money can Buy….
  – Supercomputer (Hardware, basic software, and IT) *(almost the easiest part!)*
  – Scientific Software Integration *(this is the hardest part: keep in sync with operational models)*
  – User Support & Documentation
  – Management of resources to allow R2O and O2R to be sustained
  – Documented Utilities to help scientists (CRTM, assessment, formatting tools)
  – Constant engagement between Research and Operations
  – Rigorous software configuration system to track changes
  – Rigorous (and independent) testing mechanism to demonstrate added value
• **What Money can NOT Buy….
  
  – And perhaps more importantly: the right culture.
    • Transparency of R2O protocols and willingness to accept research performed by researchers & work collaboratively (on the operational partner)
    
    • Willingness to work/start with operational system and follow protocols and accept constructive feedback (on the research partner)
    
    • Sense of Mutual respect between Researchers and Operational partners: respect for innovation in research and pragmatism in the operational implementation

Accept that R2O is not for everyone: careful choice of research and operations partners is important
Summary

• JCSDA = multi-agency, distributed center enabling partners to share efforts and results to accelerate, enhance, and expand use of satellite data in operational prediction systems

• Keys to success include
  – Identify community of partners with overlapping interests
  – Nurture communication and incentives b/w Research and Operational Communities
  – R2O supported by O2R infrastructure
  – Development and adoption of Common Tools (e.g. CRTM)

• Future Outlook
  – Exploring means to be more collaborative in planning and execution
Discussion...