JPSS Data Assimilation Improvements / Data Denial Experiments.

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In Collaboration With
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Outline

• Data Thinning
  • All Fields of View
  • VIIRS cloud information
  • Relaxed center of thinning box

• Detector Differences

• Channel Restrictions

• Correlation Matrix

• Ensemble Forecast Sensitivity to Observation Impacts (EFSOI)

• Data Addition Experiments
Data Thinning (All Fields-of-View)

- All fields-of-view now used in the thinning criteria.
- Scan angle now calculated for all fields of view within all fields of regard and accounts for sensor twist.
- Update to variational bias correction which has a 4th order fit for scan angle (Yanqiu Zhu).
- ~500 more profiles used from scan edges.
Data Thinning (Warmest Spot Statistics)

- Warmest field-of-view is biased toward the corners (1,3,7,9).
- Coldest field-of-view is also biased toward the corners.
- Instruments with 4 or more (>2x2) fields-of-view will have similar characteristics.
- Detector(s) with a warm bias have a greater probability of being chosen.
- Need for a more intelligent selection (thinning) criteria.
Data Thinning (Cloud Detection)

- Enterprise VIIRS cloud algorithm (A. Heidinger) mapped onto the CrIS field-of-view.
- Lowest cloud height (alt.) chosen.
- Implemented for CrIS-NPP in NESDIS Ops 4 May 2018.

- Clear fields-of-view within each field-of-regard should be about equal (~11%).
  - No detector bias
- Number of clear fields-of-view are expected to have a maximum at nadir and decrease toward the limbs.
- Chart should be symmetric around nadir?
Data Thinning

• Time series of used CrIS observation data counts.
• Each change to the thinning routine improves data counts, without exception (lines never cross).
Data Thinning

• Previous Criteria
  ➢ Field-of-view #5 only.  (may not be best field of view)
  ➢ Warmest spot. (creates false biases in the assimilation)
  ➢ Center of thinning box. (may not be clear)  (dominant criteria)

• Current Criteria
  ➢ Use all fields of view.  (7% increase in observations)
  ➢ Use cloud detection.  (11% increase in observations, cumulative)
  ➢ Use clearest field of view.  (21% increase in observations, cumulative)
Detector Differences

- Thanks to Chris Barnet, Larrabee Strow, Dave Tobin, Hank Revercomb, Paul van Delst, Joe Predina, et al.
- Bias and standard deviation must be similar between detectors.
  - Variational DA assumes non-biased and normal distribution.
- NWP Centers treat all 9 detectors as if they are identical.
  - Logic gets messy and time consuming to treat all detectors as independent instruments.
  - Reject detectors that are not “similar”
- How different are the CrIS detectors?
- What are “acceptable differences”? 
Detector Differences

RMS Error from Mean
CrIS-NPP Band 1

RMS Error from Mean
CrIS-NPP Band 2

RMS Error from Mean
CrIS-NPP band 3
Hyperspectral Sensor Channel Restrictions

• NWP Centers use a subset of channels from AIRS, IASI, and CrIS.
• Fixed and Difficult to change.
  - Required new radiative transfer coefficient files.
  - Changes to array sizes throughout the code.
  - Must edit bias correction files and spin up new bias corrections.
  - CRTM, BUFR, bias correction files and array sizes had to be consistent.

• Internal Gridpoint Statistical Interpolation (GSI) software modifications
  - Call Community Radiative Transfer Model (CRTM) subset routine (Paul van Delst).
  - Variational bias correction adjusts automatically (Yanqiu Zhu).
  - Edit a text file to add/remove channels and connect new (BUFR) data file.

• WIN – WIN for NWP Centers and Research
CrIS Correlation / Covariance Matrix

• Work in progress
• NCEP has developed a covariance matrix computation utility (Kristen Bathmann)
• Similar utility developed by NRL (Ben Ruston)
• Based on Desrosiers et al. (2005) with Hollingsworth and Lonnberg (1986) option.
• Gridpoint Statistical Interpolation (GSI) has this feature.
• Changes to improve convergence will be incorporated this week (Kristen Bathmann).
CrIS Correlation / Covariance Matrix

Desrosiers method (forecast * analysis) (analysis * analysis)

(forecast * analysis) has stronger +/- correlations
Ensemble perturbation-based Forecast Sensitivity to Observations Impact (EFSOI)

• New diagnostic and verification routine in development (Dave Groff)
• This is based on the ensembles, not the forecast model and adjoint typically know as FSOI, but results are similar.
• Used as an alternative to computing anomaly correlations.
  ➢ Tends to be sensitive to observation counts more than forecast skill.
• Experiment adds
  ➢ 12 CrIS temperature channels
  ➢ 8 CrIS water vapor channels
  ➢ Adjusted assimilation weights
• Larger negative numbers implies greater impact.
EFSOI Sensor Comparison

Adding 20 channels moves CrIS from 9th among the various sensors to 5th.
EFSOI CrIS Channel Comparison

Scales are not identical
Water vapor channels dominate impact
Data Addition Experiments

• Considerable observation redundancy in NCEP’s Global Forecast System.
  ➢ Multiple satellites in nearly same orbit.
  ➢ Conventional data denial experiments will only show impact of unique (non-redundant information).

• Use a minimum set of observations to set a baseline.
• Use all observations to define “best possible” forecast.
• Add one instrument to baseline to determine contribution to forecast skill
Data Addition Experiments

- August 2012
- 500 hPa
- Southern Hemisphere

“One AIRS is equal to one AMSU” Greamme Kelly 2003
Closing Remarks.

• All of the changes (GSI, CRTM, etc.) outlined here are in the NOAA/NWS/NCEP, NASA/GMAO and DTC Operational Suite (or soon will be).
  • Including Regional ATOVS Retransmission Service and Direct Broadcast.
• NCEP Operations (NCO) will be transitioning to CrIS-FSR and add NOAA-20 (CrIS-FSR and ATMS) in June.

• How data are thinned/selected is the foundation for future work and needs to evolve with requirements and knowledge.
Questions?

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