Use of Hyperspectral IR Data in 4D Assimilation at NRL

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Data Use: AIRS and IASI

AIRS

- AIRS-324 channel subset
- Co-located with AMSU/A sensor, *simultaneous assimilation*
- Channels with sensitivity above model top (4mb) rejected
- Ozone sensitive channels rejected
- Near-infrared channel rejected in daytime

IASI

- 616 channel subset
- AMSU/A an independent data stream, *independent assimilation*
- Channels with sensitivity above model top (4mb) rejected
- Ozone sensitive channels rejected
- Near-infrared channel rejected in daytime
- Monitor ~303 ECMWF/UK-Met compatible channels

IASI challenges

Overcome:

- data reader (3 unique platforms with 4 different compilers)
- preliminary quality control
- preliminary channel blacklist
  - based on gaseous sensitivity, and estimated height sensitivity
- NAVDAS-AR (NRL 4D-Var) assimilation tests

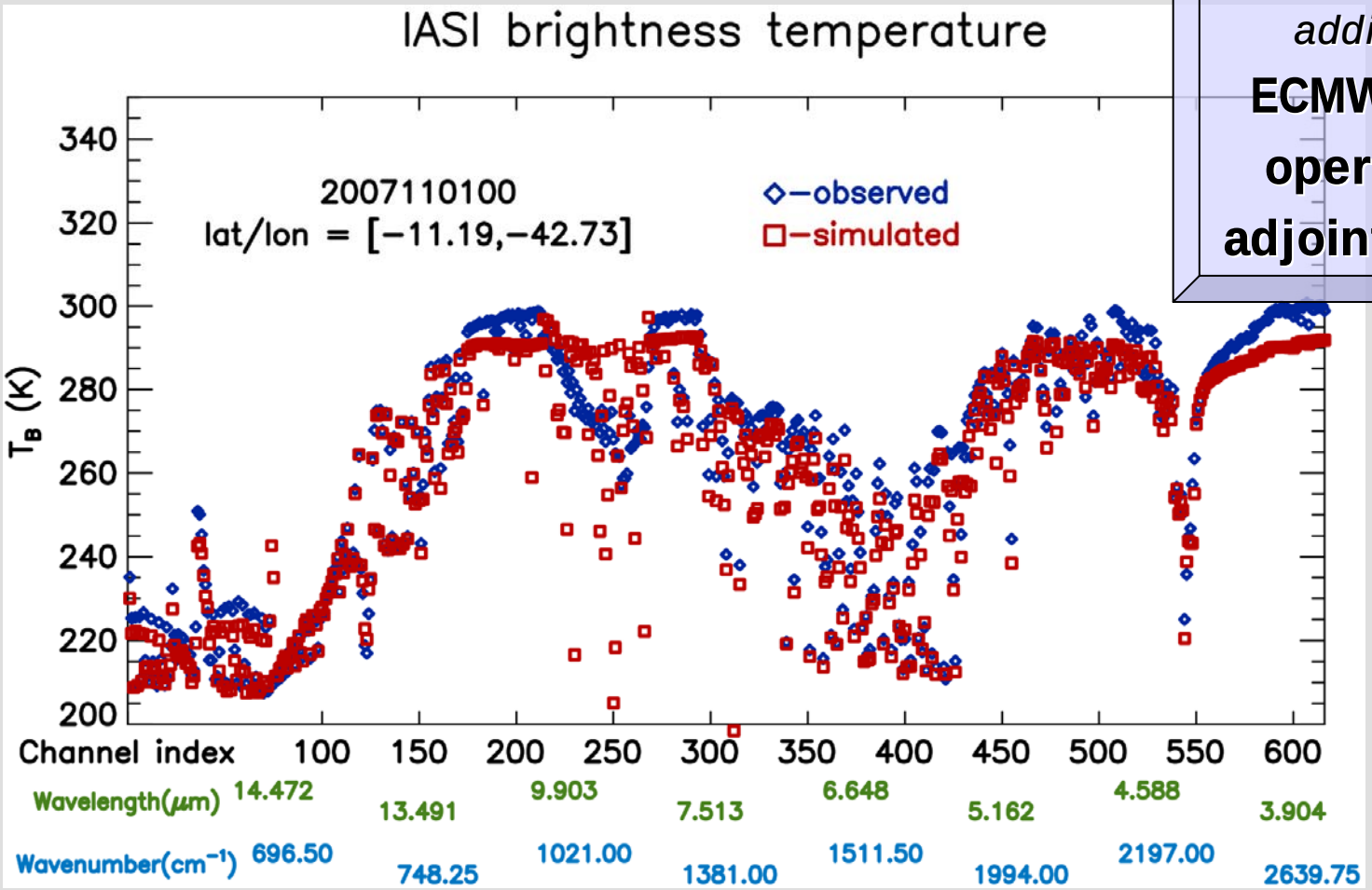
On-going:

- modify CRTM release to output upwelling radiance from each level (for cloud screening algorithm)
  - finalize quality control procedures
- observation sensitivity tests / refine channel selection
- build NAVDAS-AR tailored observation error covariances
- principle component side-by-side testing

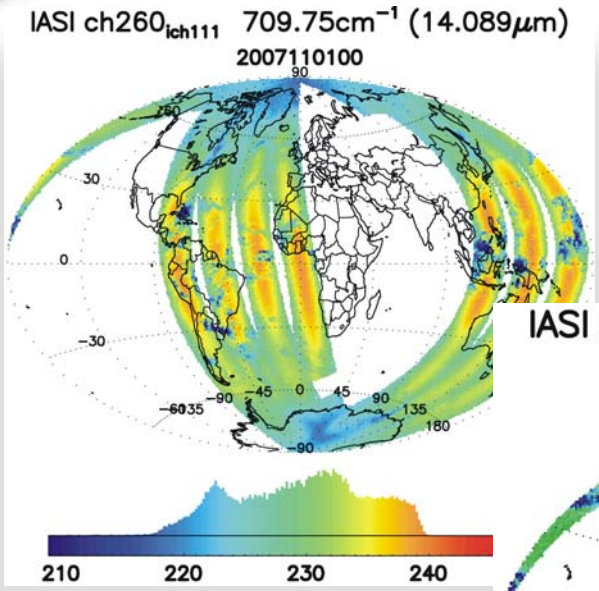
Channel Selection

NOGAPS top 4hPa
no prognostic O_3

additional tools:
ECMWF & UK-Met
operational lists
adjoint sensitivities

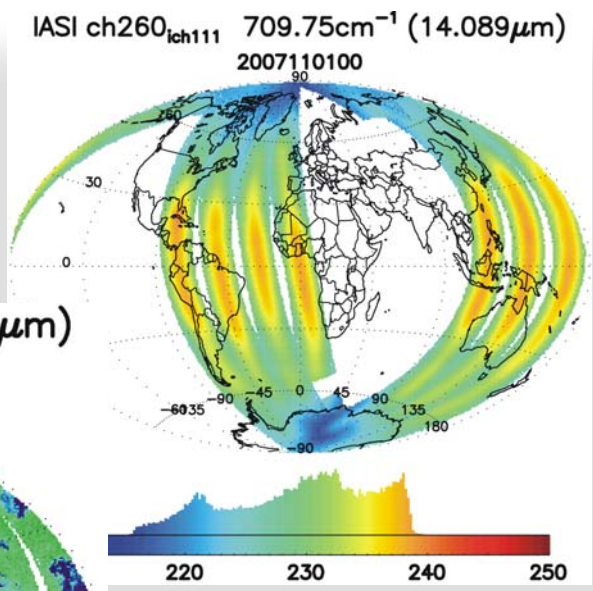


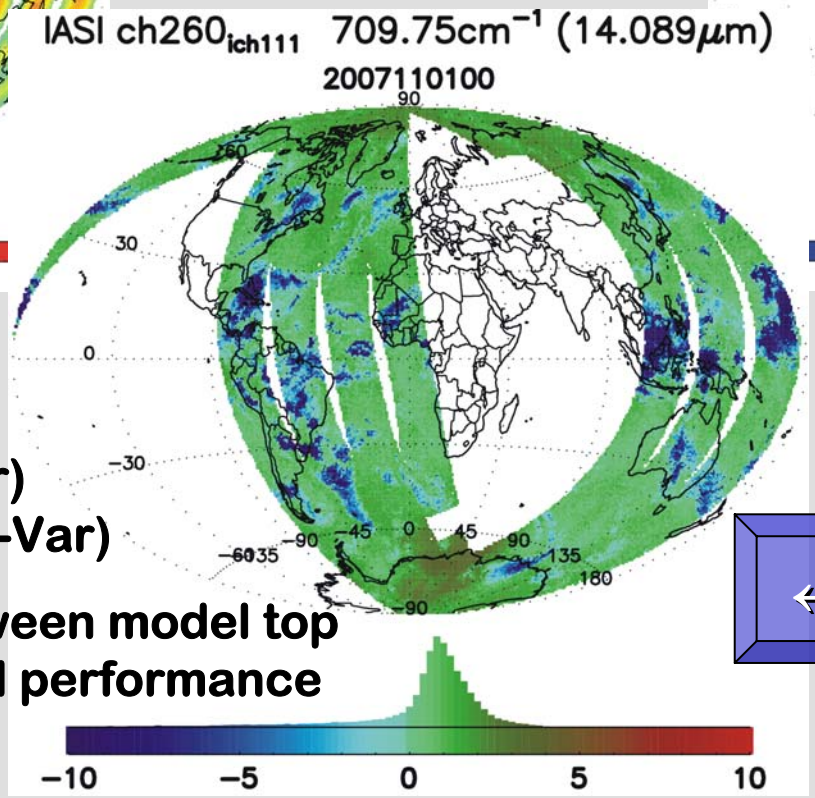
JCSDA CRTM released 200711



← observed

simulated →

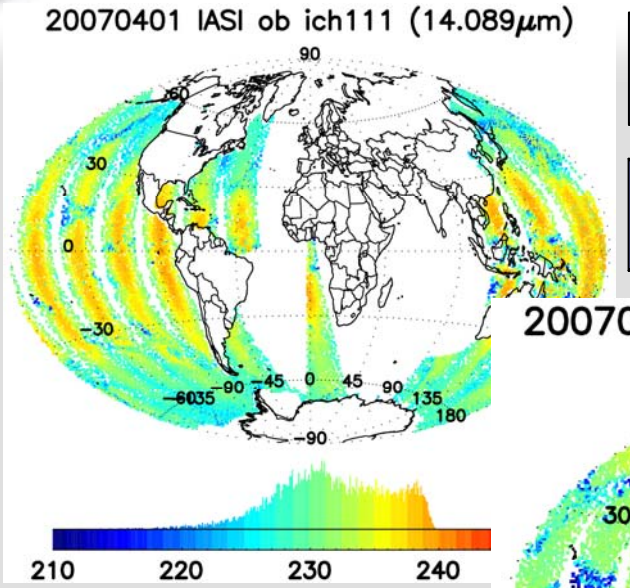




← difference

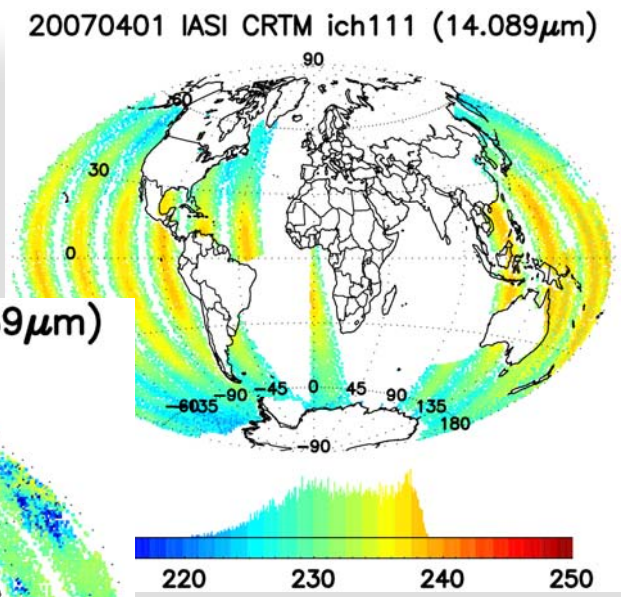
- new version Feb '08
- implemented
  - NAVDAS (3D-Var)
  - NAVDAS-AR (4D-Var)
- additional layers between model top and 'space' – improved performance

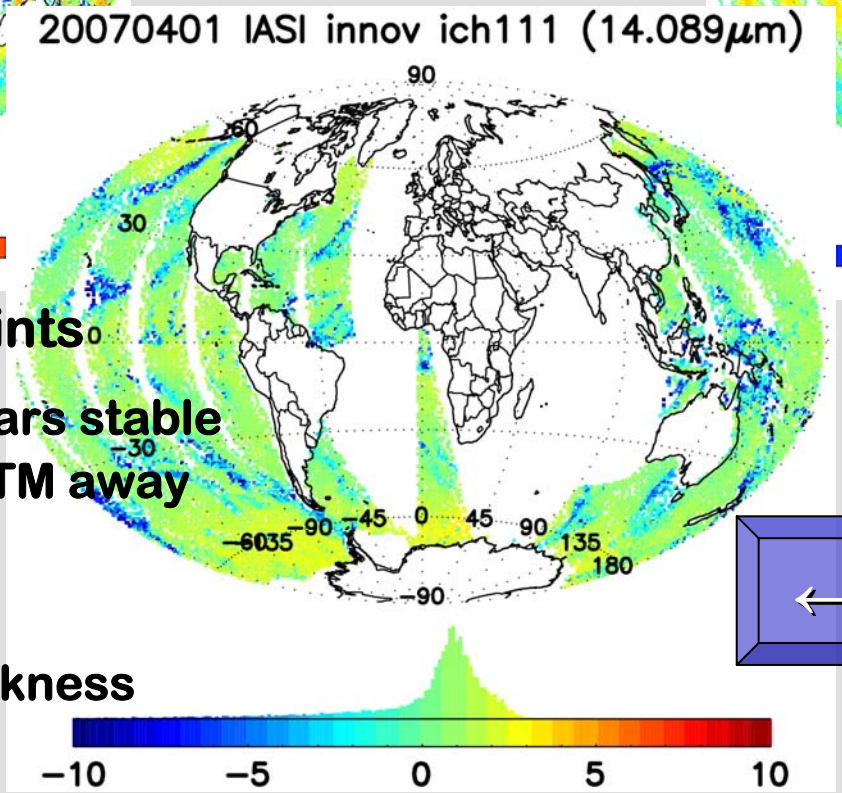
JCSDA CRTM released 200802



← observed

simulated →





← difference

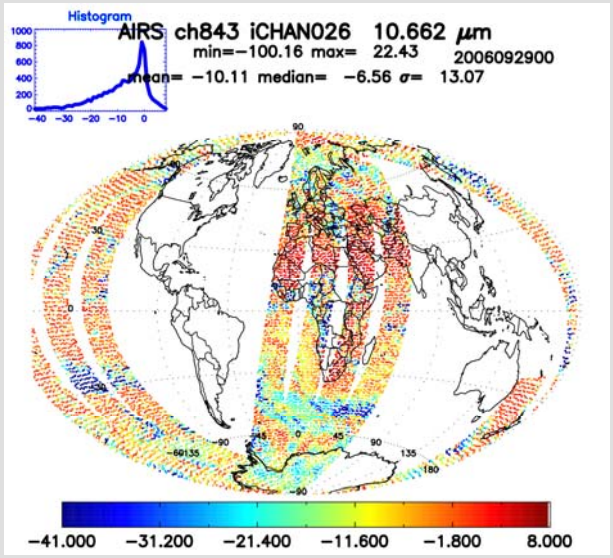
Take away points

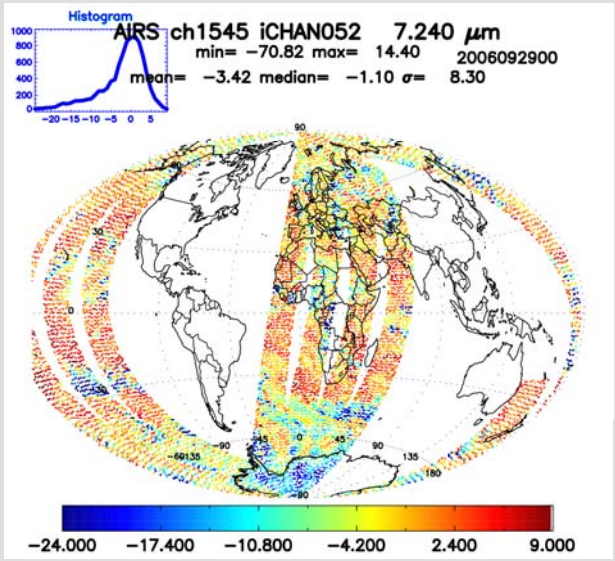
innovation bias appears stable
3 mos & different RTM away

- bias methodology
  - scan correction
  - two airmass thickness

Quality Control

- **Radiances modeled using JCSDA-CRTM**
  - **Gross error check departure window channel (H_20 likely)**
  - **Slope change in wavelength vs. (ob-background)***
  - **Individual checks for each channel based on ob error**
  - **thinned to ~300km resolution**





*A. McNally and P. Watts, 2003, *A cloud detection algorithm for high-spectral-resolution infrared sounders. Q. J. R. Meteorol. Soc.*, **209**, pp. 3411-3423.

NRL's 4D-Var system

NAVDAS-AR ("AR" stands for accelerated representer)

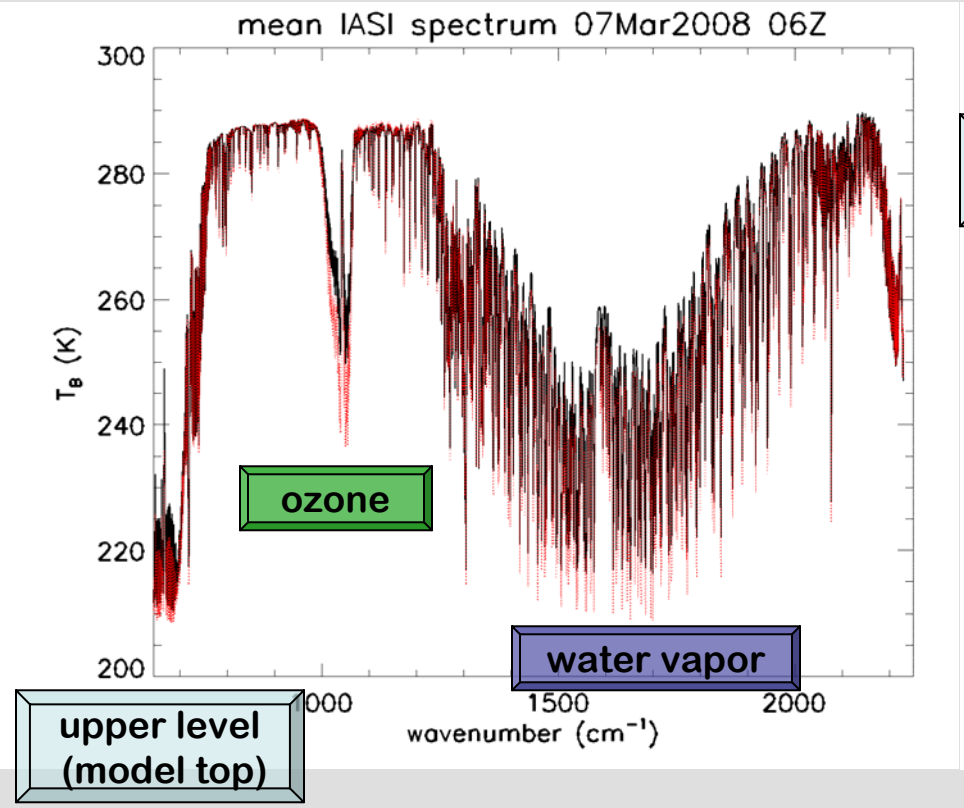
- Currently in real-time parallel testing against operational system
- Weak-constraint formulation allows for model error to be included

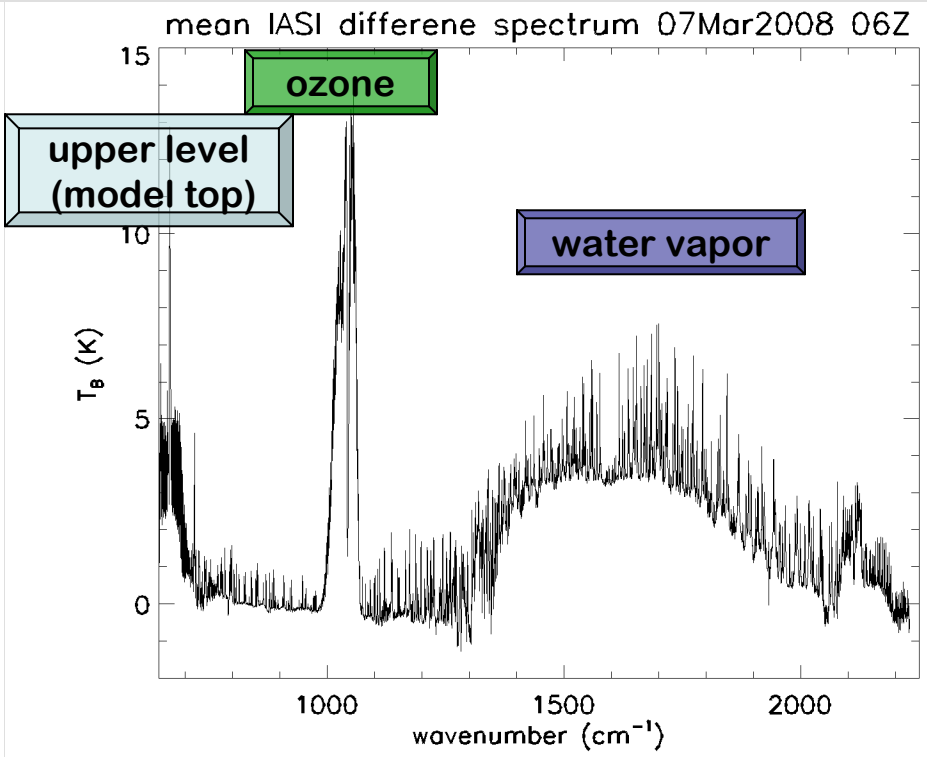
Advantages of 4D-Var over 3D-Var

- Assimilation occurs over a time window of ~ 6 hours
- Makes better use of asynoptic data
- Observations are used at the correct time
- More observations can be used
- Uses surface and other single-level observations (e.g., ships, buoys, aircraft, UAVs, satellite wind vectors,...) more effectively
- Flow dependent background and forecast model statistics

IASI Reconstructed Radiances

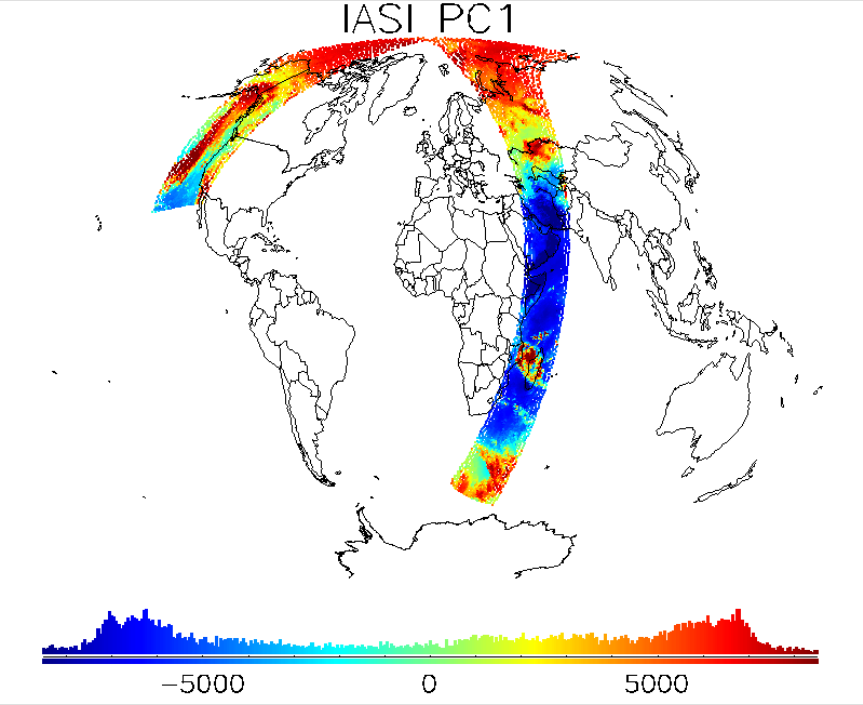
- Mean from ~2700 points 1hr window 5:30-6:30Z, 07Mar2008
- 43 RTTOV fixed level profiles
- Crude cloud screen applied
- Ocean points only

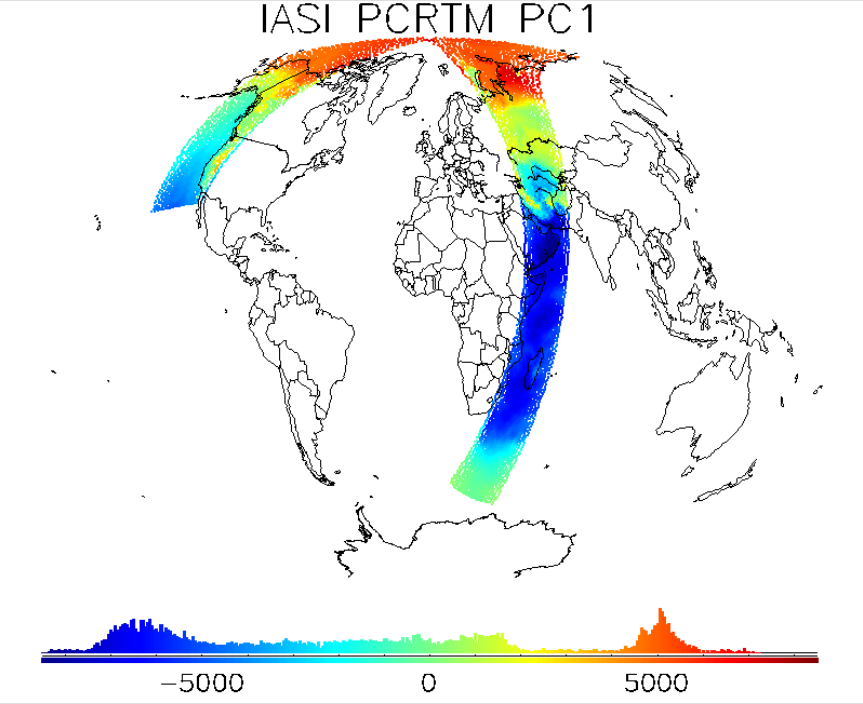




Leading IASI Principle Component

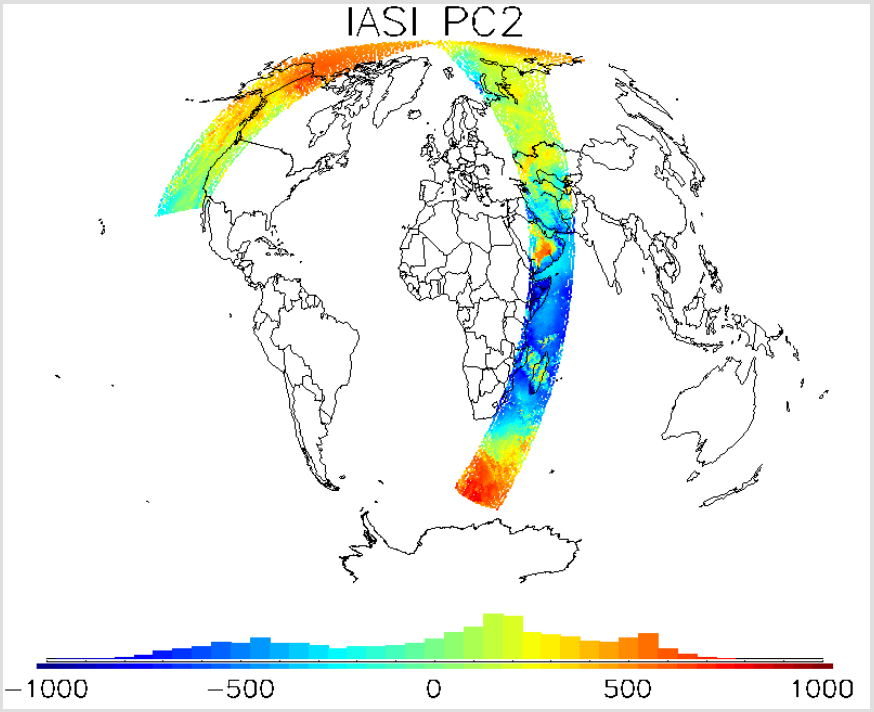
- Observed and simulated PCs for ~13500 points
- 43 RTTOV fixed level profiles
- NO cloud screen applied *(generate PC-based QC without reconstruction?)*
- ocean emissivity used for all points

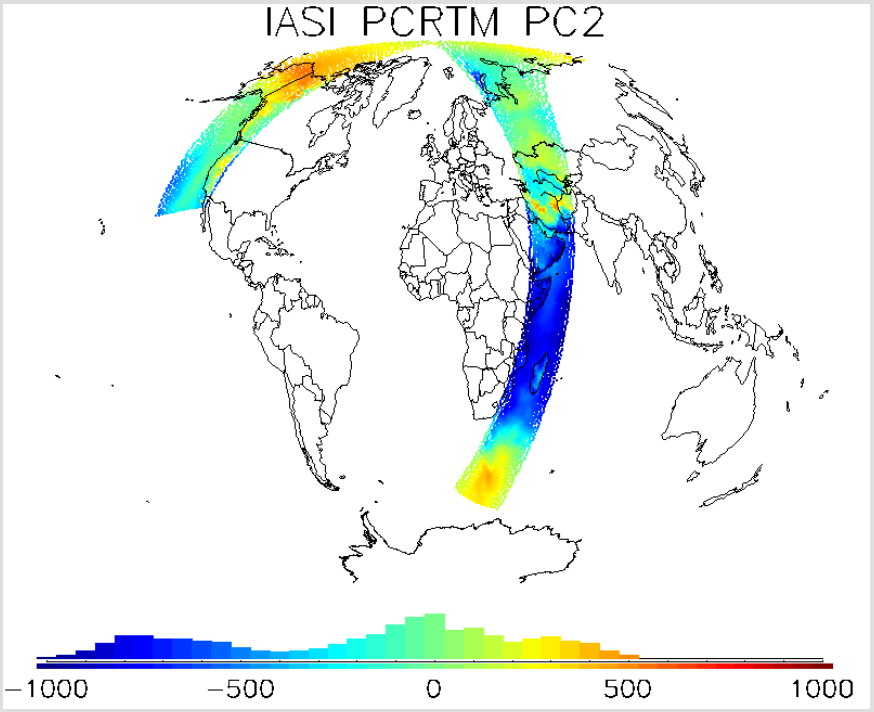




IASI 2nd Principle Component

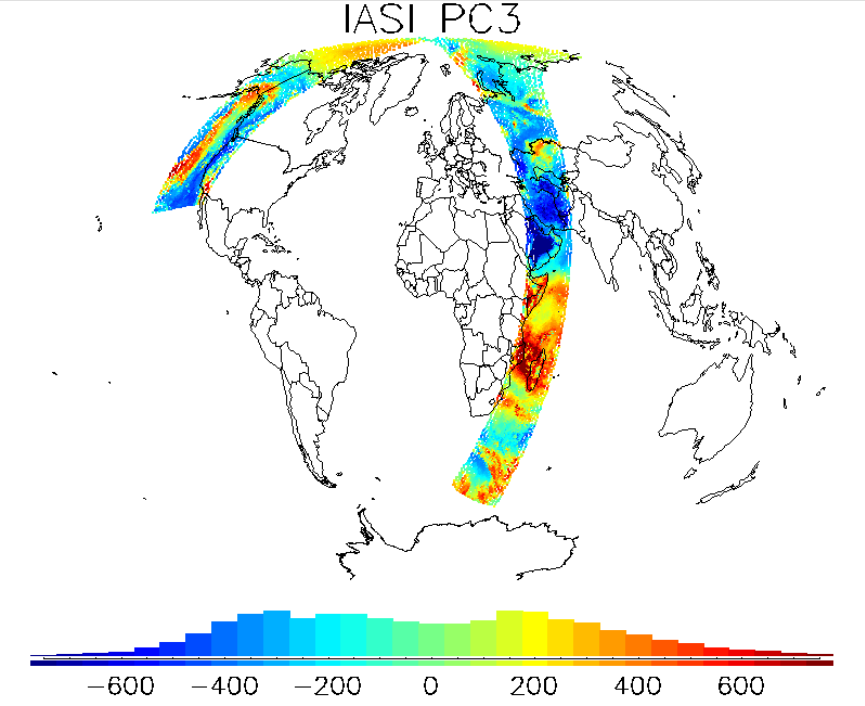
- Observed and simulated PCs for ~13500 points
- 43 RTTOV fixed level profiles
- NO cloud screen applied
- ocean emissivity used for all points

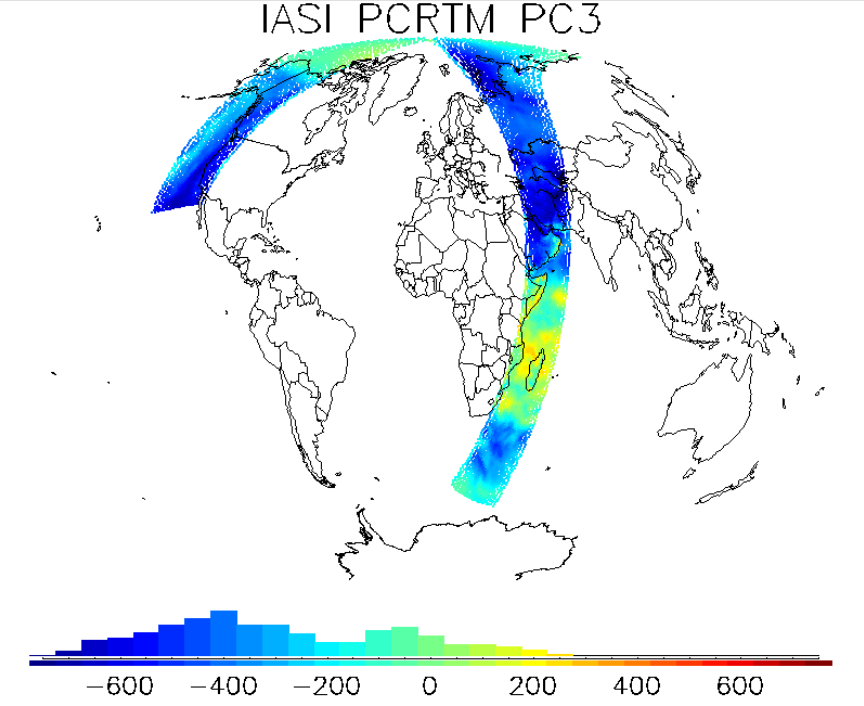




IASI 3rd Principle Component

- Observed and simulated PCs for ~13500 points
- 43 RTTOV fixed level profiles
- NO cloud screen applied
- ocean emissivity used for all points





Principle Component Assimilation

Challenges / Open Questions

- Quality control
  - will more channels be screened because the PCs correlate the window channels with the atmospheric ones
  - how does data compare to traditional channel based QC
- Error covariances
  - will traditional RMS(ob – simulated) be adequate
  - begin with errors from Xu Liu's 1D-Var
- Current PC-CRTM has an analytic Jacobian
  - will the analytic Jacobian work in the full NAVDAS-AR system
  - is an adjoint necessary

Summary

- IASI data undergoing trial assimilation in NAVDAS-AR
- Latest version of JCSDA-CRTM performing reliably
- Observation sensitivities will be used to 'refine' channel list
- Principle component assimilation offers possibility to utilize "full spectrum" at little extra computational costs

Future Work

- Fully implement rigorous QC *(MWP-SAF hosted ECMWF package)*
- Compare PC assimilation against channel subset
  - additional test: NASA 1D-Var principle component retrievals against channel subset & PC assimilation
- Collocation with Met-Op AMSU simultaneous land emissivity retrieval