The consistency between measured radiance and retrieved profiles at climate scales – a study in uncertainty propagation

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Accuracy requirements for Climate Measurements:

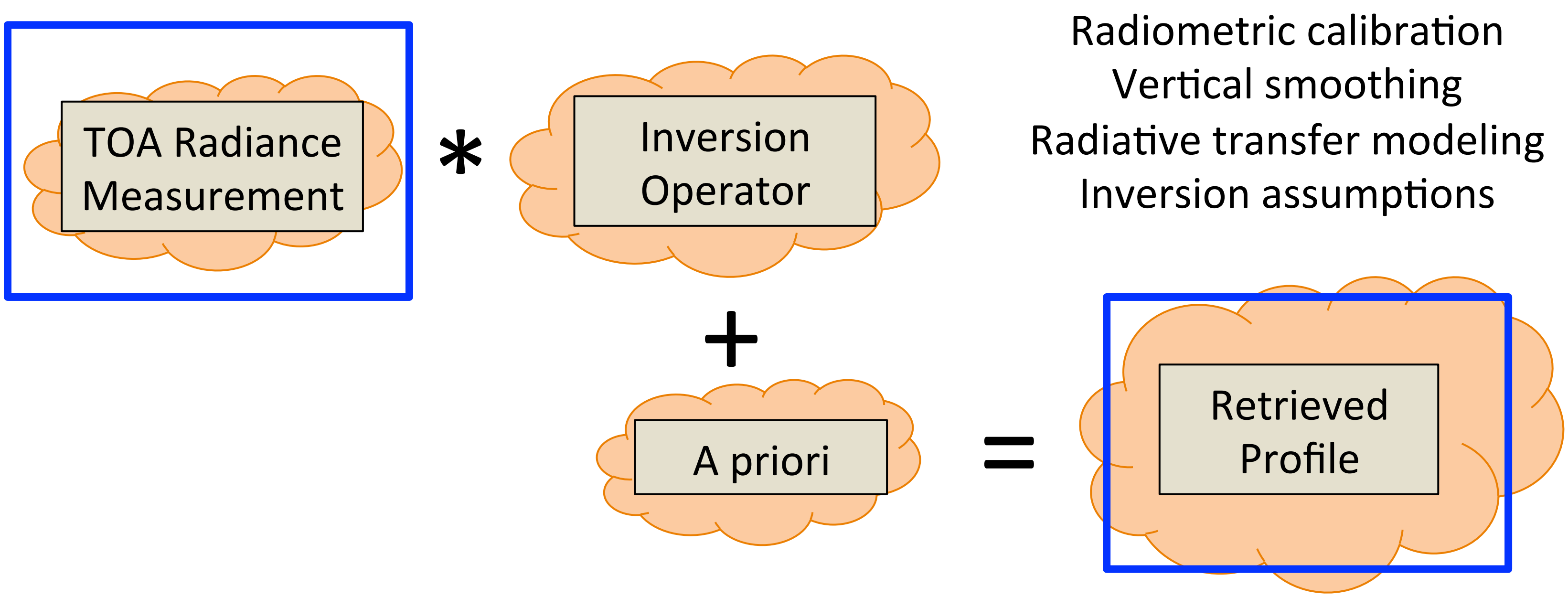
- Reflected solar irradiance; 0.3% accuracy
- Emitted infrared radiance; <0.1K accuracy
- Radio occultation; 0.06% accuracy

AIRS, IASI and CrIS; 1K accuracy

Wielicki et al. 2013: *Achieving climate change absolute accuracy in orbit*. BAMS

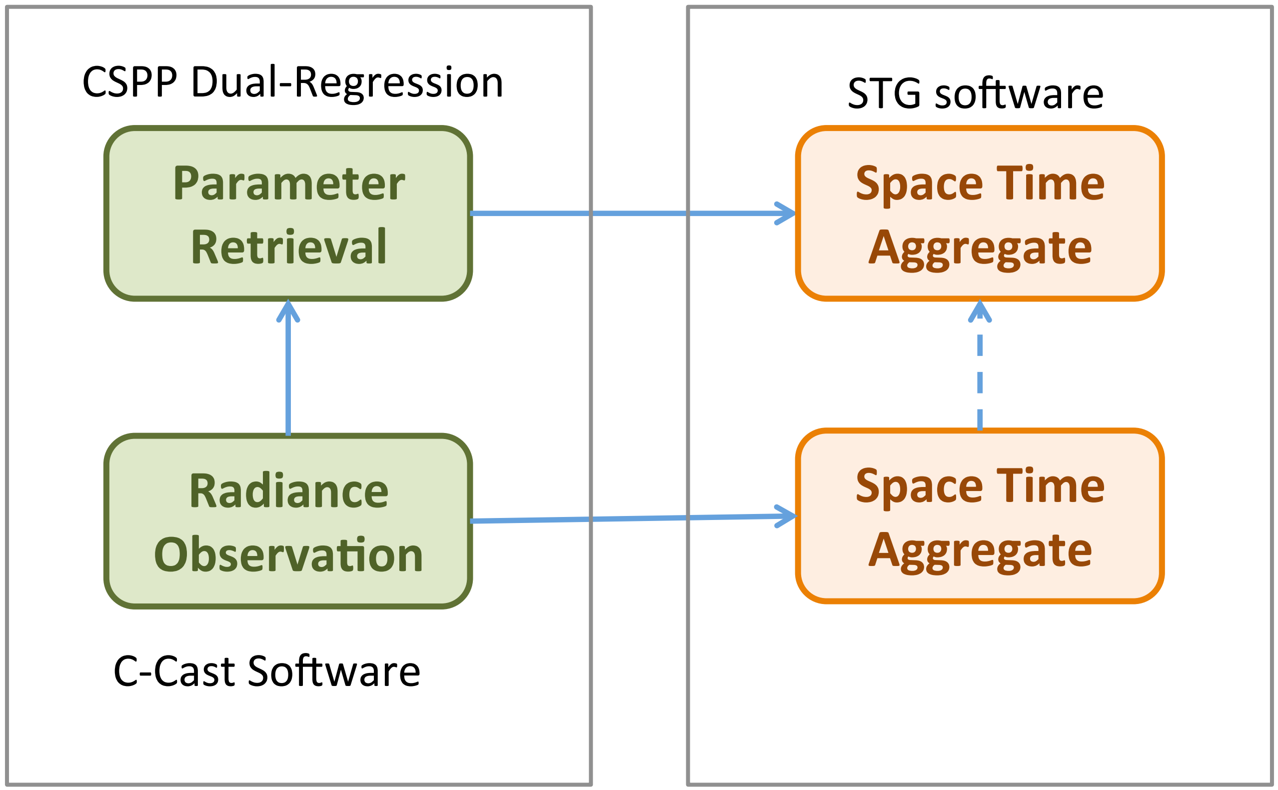
Can we use weather measurements to calculate climate observations?

When working with probable solutions to complex problems (e.g., Earth system change) we need to understand UNCERTAINTY



Radiances alone do not tell the full story.
We need to develop methods that allow the use of radiances with retrievals in a geophysically consistent manner at climate scales

Our Toolbox



Granular
Instrument specific
sampling

Global Uniform
equal-angle
sampling

CSPP Dual-Regression Retrieval Algorithm for AIRS, IASI and CrIS

Smith, W. L., et al. 2012, JAMC, 8:1455–1476
Weisz, E., et al. 2013, JGR, 118:6433–6443

Linear dependence on radiance spectra: Variation depends only on radiance, no first guess

All sky: Retrievals are made in clear and cloudy (0 - 100%) conditions; from top-of-atmosphere to cloud top pressure.

Independent of Field-of-View (FOV) size: Can be applied to AIRS, IASI and CrIS, on single- or aggregate-FOV

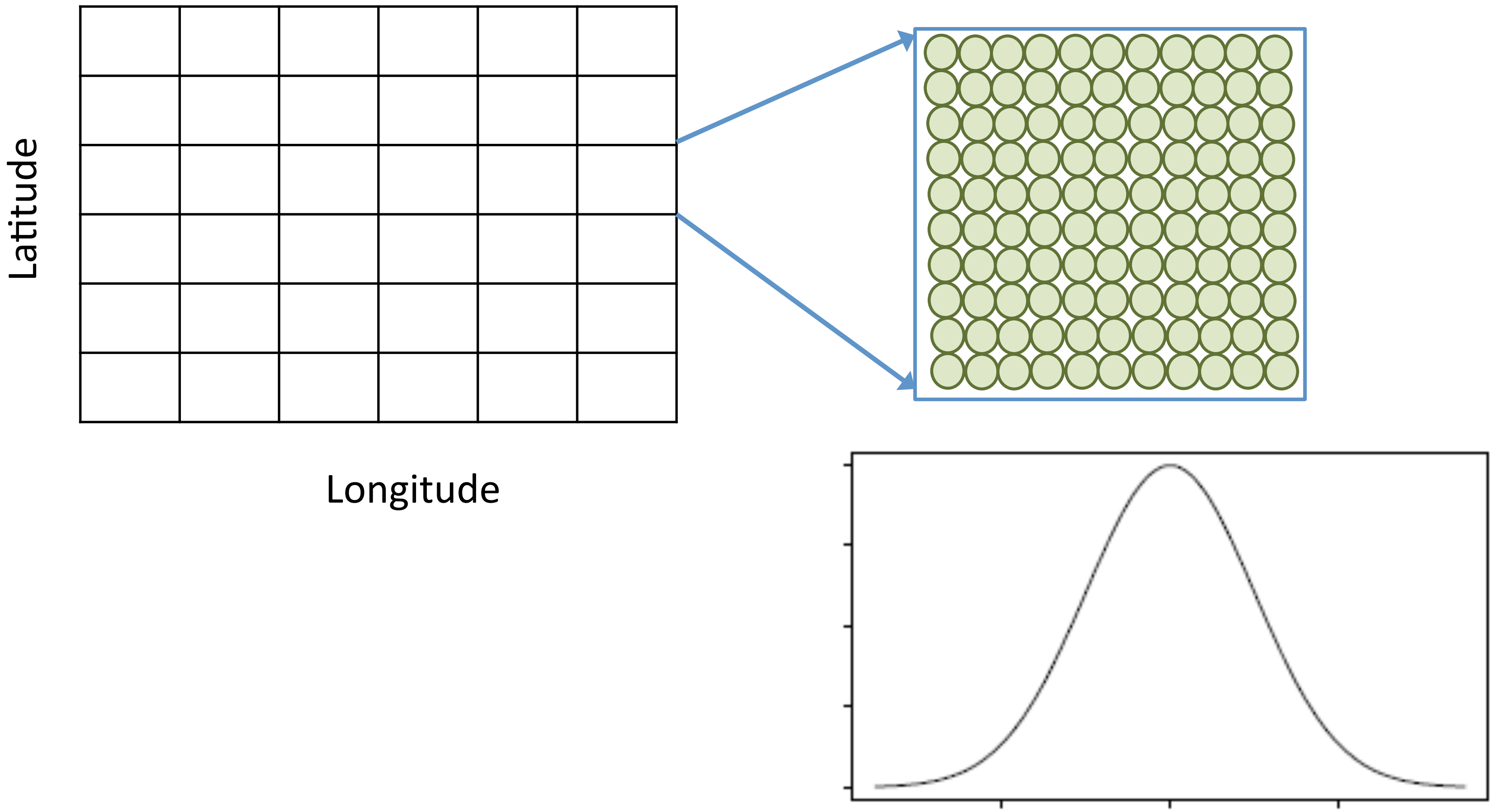
Fast: Off-line Radiative transfer calculation allows for fast inversion. Sensor archive can easily be reprocessed

Retrieves Full Atmospheric State Retrieval
Surface : temperature & spectral emissivity
Atmosphere : T, H_2O, and O_3 profiles & CO_2 ppm
Cloud : height and optical thickness

For this project, we use DR as a diagnostic tool

Space Time Gridding

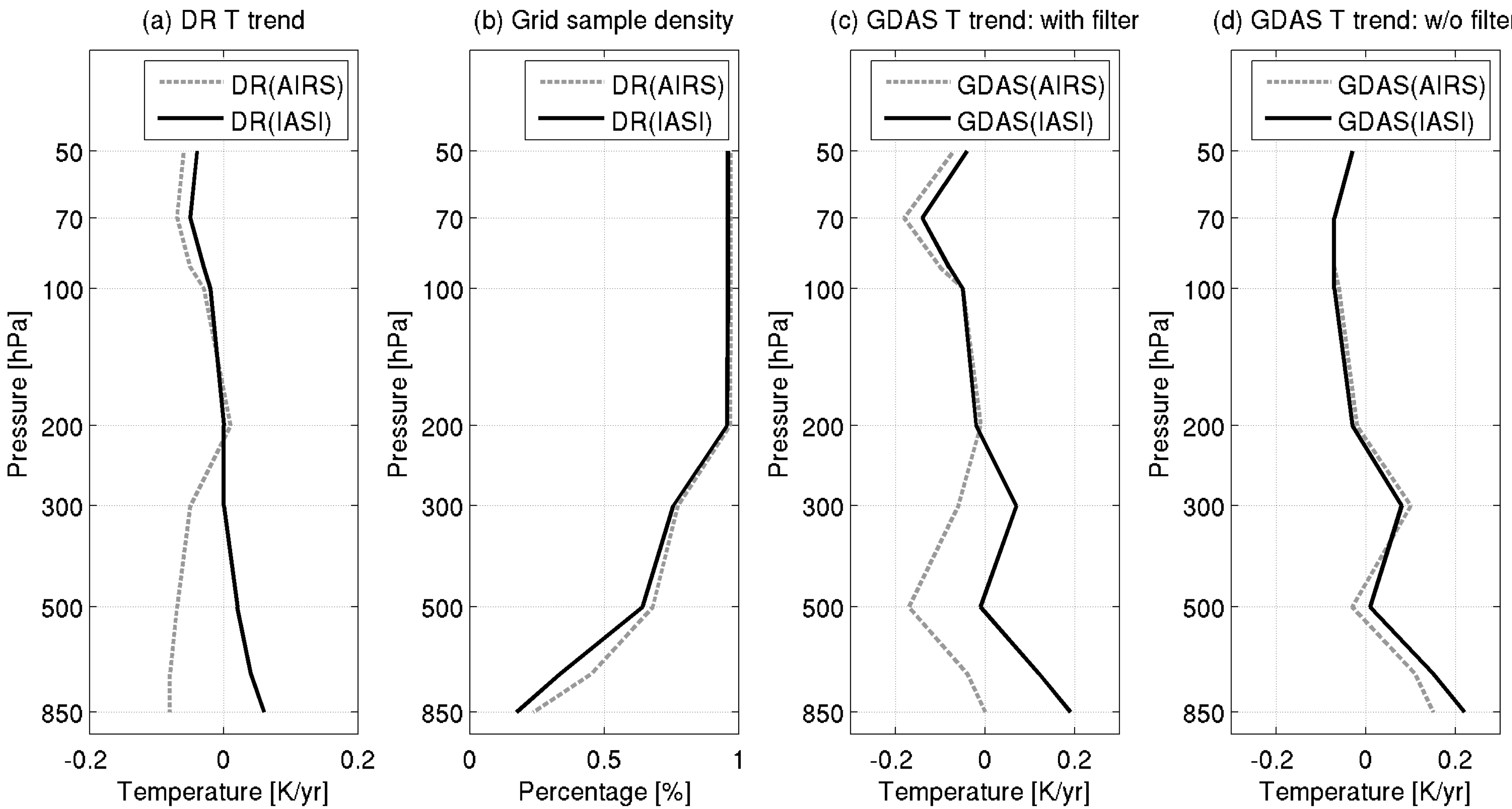
*Smith, N. et al. 2013, JAMC, 52:*255–268



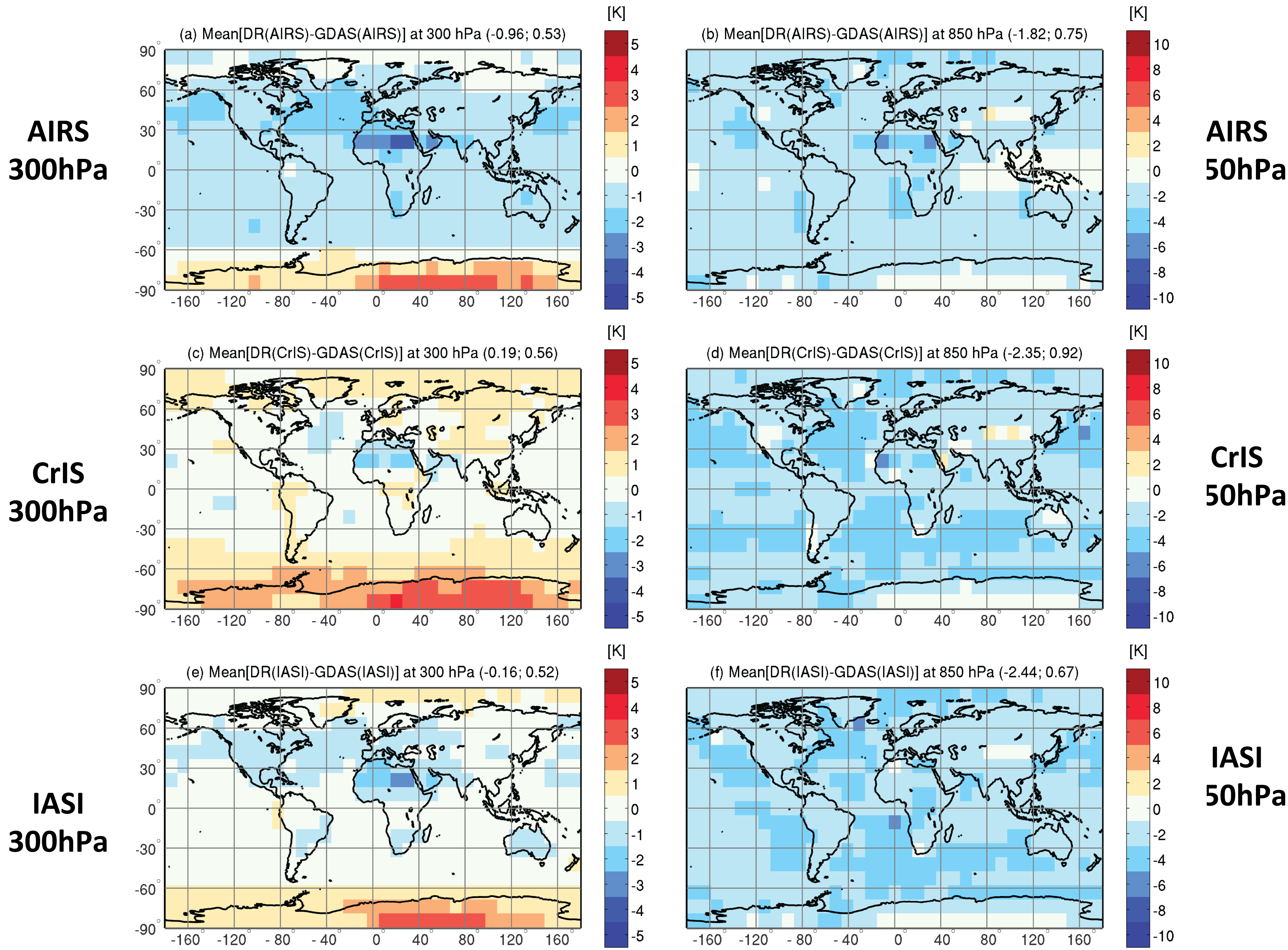
We work with **estimates** (probabilities) of the **'truth'** that we can never know exactly

The best we can do is describe probability accurately

What we know so far: There is an air mass dependence in retrieval differences between AIRS and IASI due to presence and frequency of clouds



Smith, Nadia et al. 2015: *AIRS, IASI, and CrIS retrieval records at climate scales: an investigation into the propagation of systematic uncertainty*. **JAMC.**, 54, 1465–1481



Smith et al. 2015 JAMC

How do we begin to understand these differences at large scales?

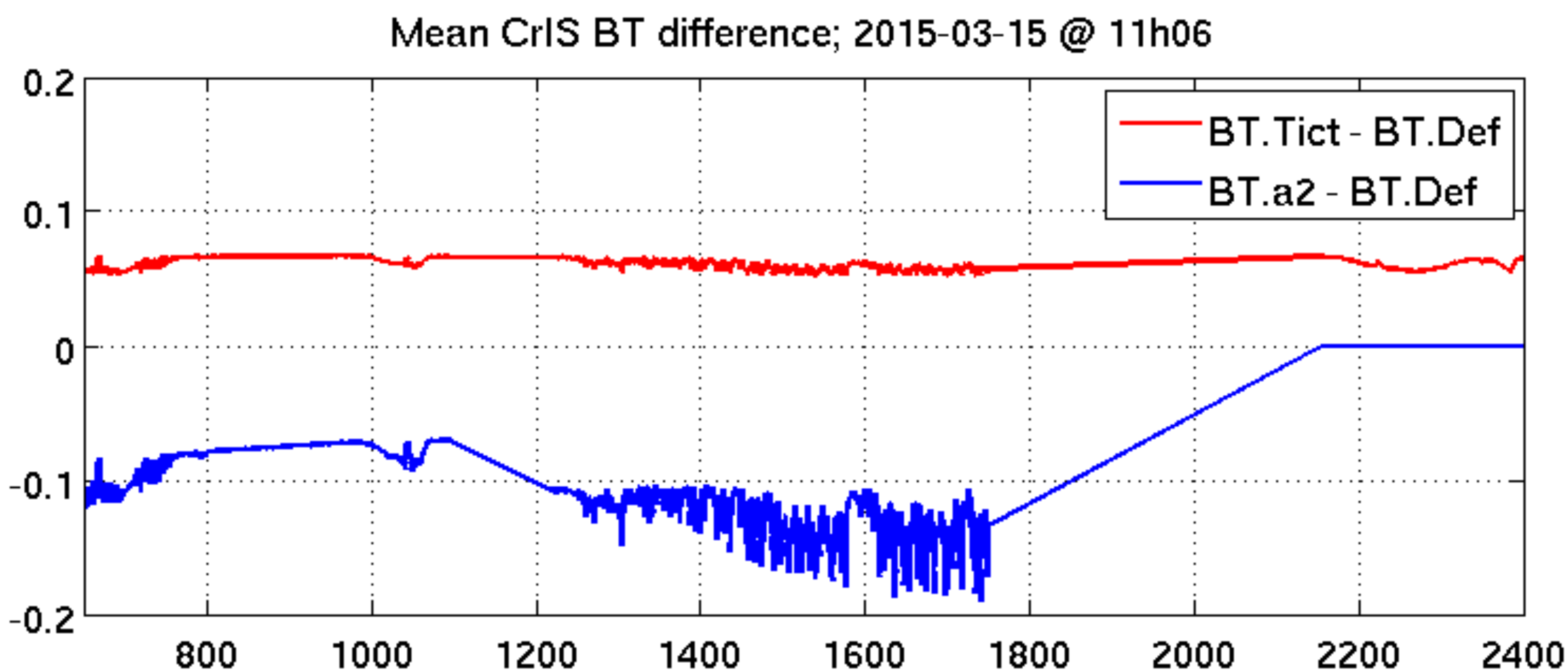
By starting with something we know very well:
CrIS radiances

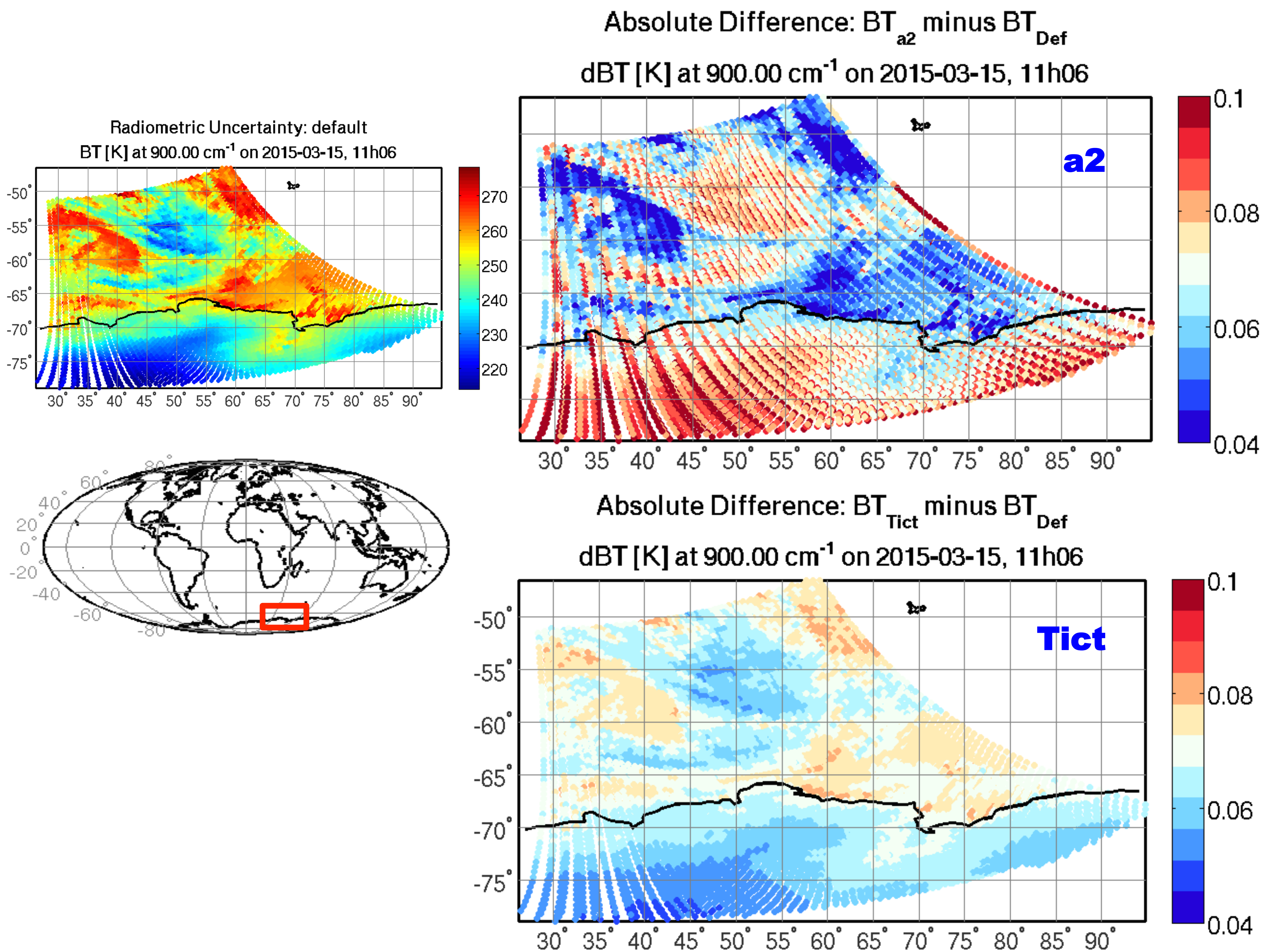
Tobin, David et al. 2013: *S-NPP CrIS radiometric calibration uncertainty*.
JGR 118, 1–12; doi:10.1002/jgrd.50809

Characterizing the spectral and air mass dependence of radiance observation uncertainties.

Nonlinearity (a2): Quadratic nonlinearity coefficient increased by the 3-sigma uncertainties, 29% (LW) and 47% (MW)

Calibration Blackbody Temperature (Tict): Blackbody (ICT) temperature increased by 3-sigma uncertainty, 85 mK

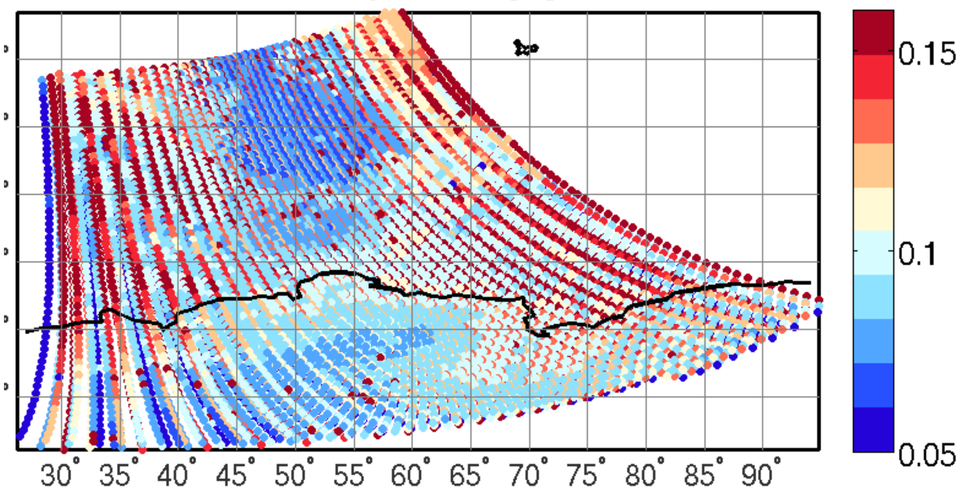




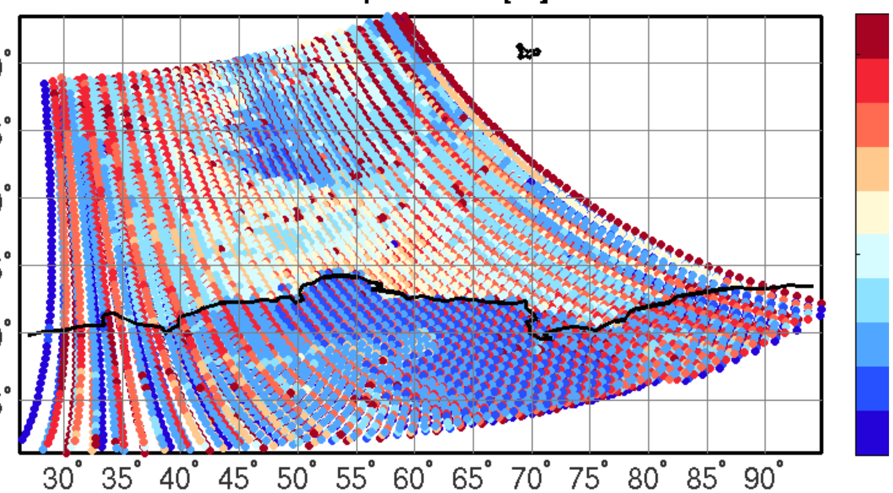
Radiometric Uncertainty: default
BT [K] at 900.00 cm-1 on 2015-03-15, 11h06
-50° -55° -60° -65° -70° -75°
30° 35° 40° 45° 50° 55° 60° 65° 70° 75° 80° 85° 90°
270 260 250 240 230 220
80° 60° 40° 20° 0° -20° -40° -60° -80°
Absolute Difference: BTa2 minus BTDef
dBT [K] at 900.00 cm-1 on 2015-03-15, 11h06
a2
0.1 0.08 0.06 0.04
30° 35° 40° 45° 50° 55° 60° 65° 70° 75° 80° 85° 90°
Absolute Difference: BTTict minus BTDef
dBT [K] at 900.00 cm-1 on 2015-03-15, 11h06
Tict
-50° -55° -60° -65° -70° -75°
0.1 0.08 0.06 0.04
30° 35° 40° 45° 50° 55° 60° 65° 70° 75° 80° 85° 90°

Temperature Retrieval Sensitivity to Nonlinearity Coefficient (a2)

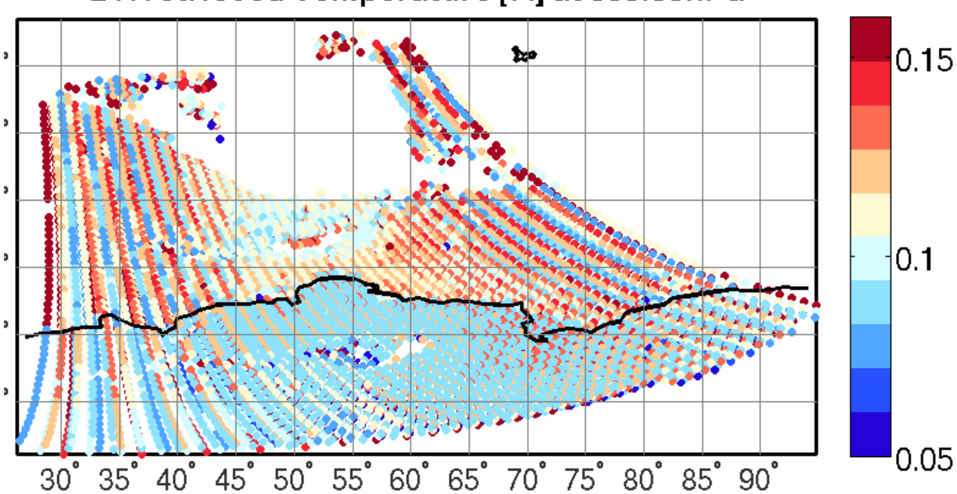
Absolute Difference: T_{a2} minus T_{Def} minus
DR retrieved Temperature [K] at 10.00hPa



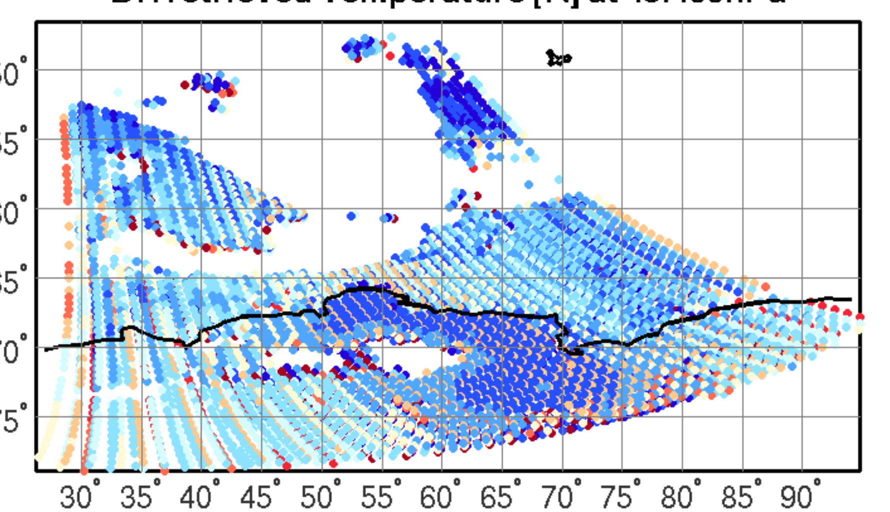
Absolute Difference: T_{a2} minus T_{Def} minus
DR retrieved Temperature [K] at 103.00hPa



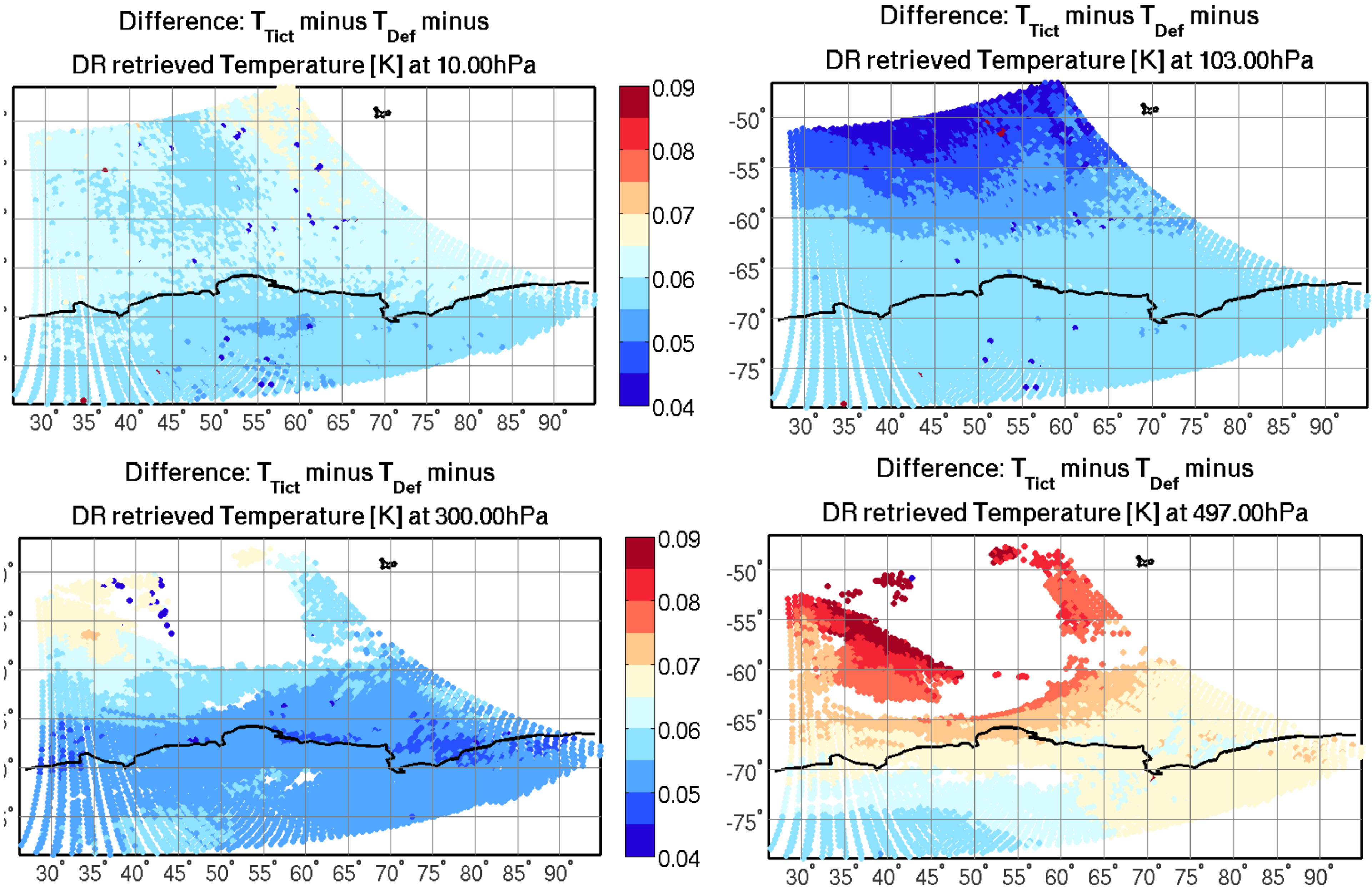
Absolute Difference: T_{a2} minus T_{Def} minus
DR retrieved Temperature [K] at 300.00hPa



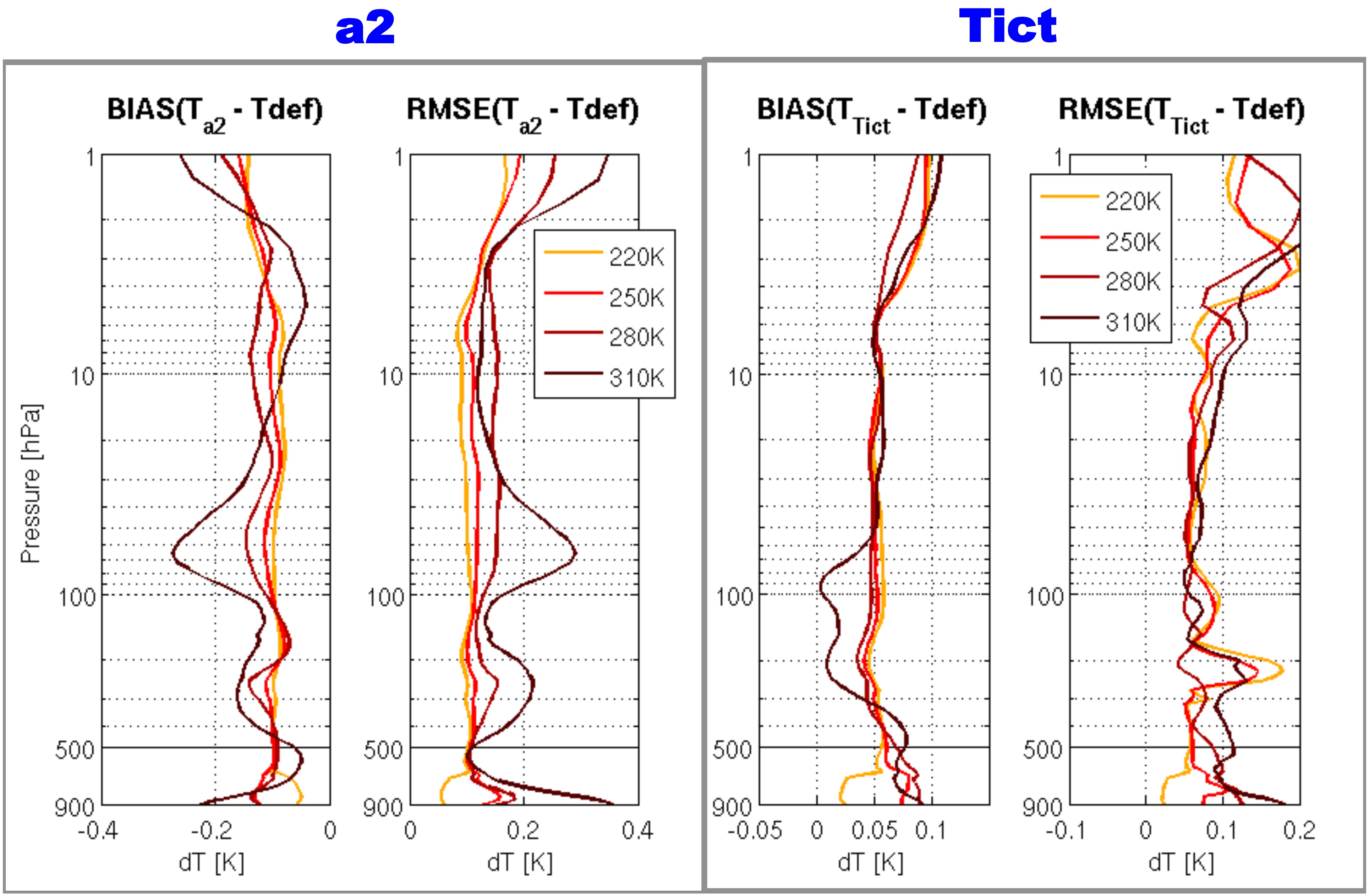
Absolute Difference: T_{a2} minus T_{Def} minus
DR retrieved Temperature [K] at 497.00hPa



Temperature Retrieval Sensitivity to Calibration BB Temperature (Tict)



Statistics for a global day of retrievals (2015-03-15) demonstrating height and scene (temperature) dependence of radiance uncertainty



The way forward

Develop covariance matrices that fully characterize the spectral and air mass dependence of radiance observation uncertainties.

Repeat this experiment, but this time isolate and estimate the other main sources of uncertainties, e.g. due to the Radiative Transfer Model, Clouds, etc.