Clouds & Precipitation: Observation error characterization

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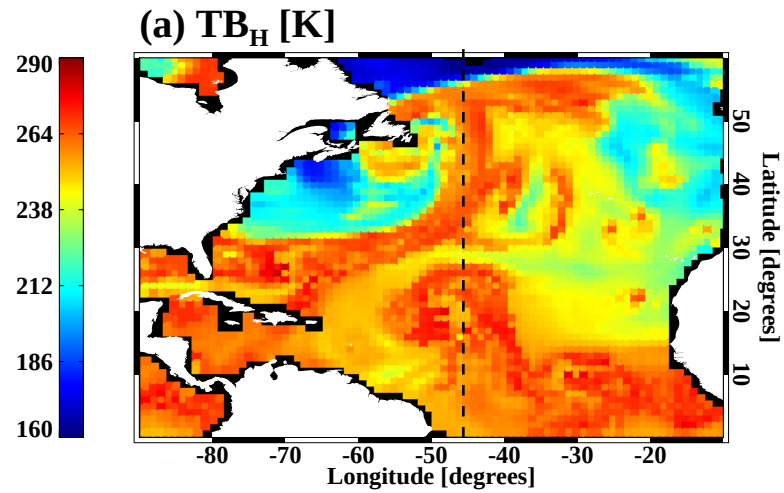
Outline

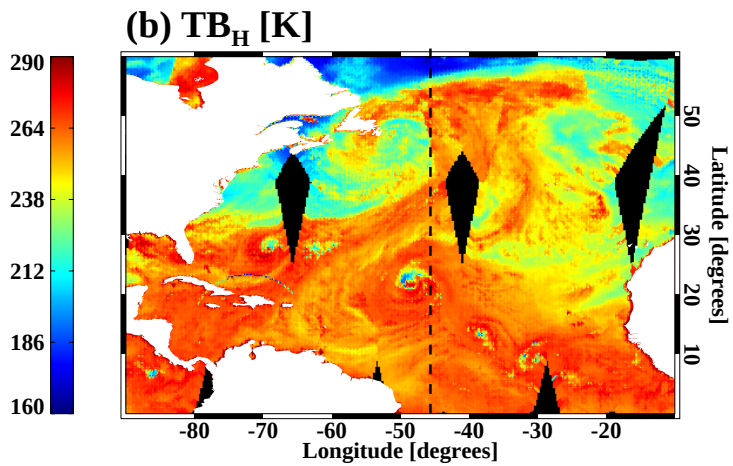
- Introduction
- Modeling environment
- Old and new results
  - Radiative transfer solver errors MW and IR
  - Cloud/precipitation overlap
  - Cloud microphysics
  - 3D errors
- Future plans

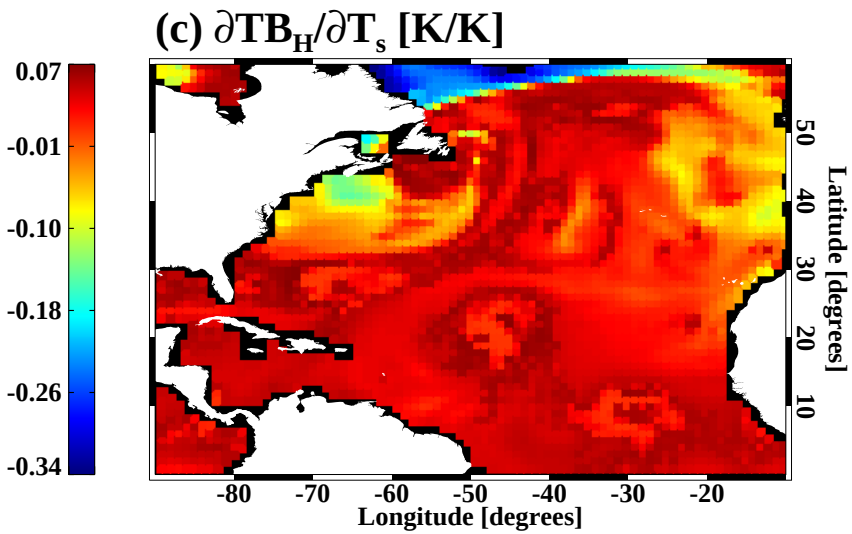
Assessing error characteristics: What are the challenges?

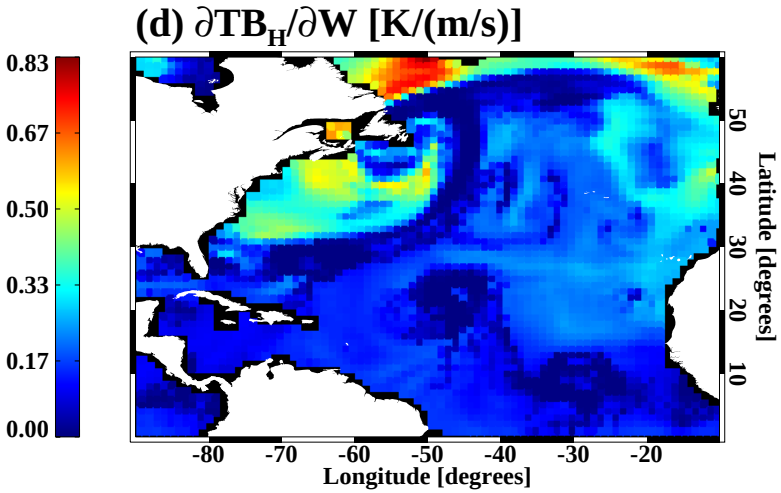
- Representativeness of forecast model
- Scale of forecast model
- Gas absorption models
- Representation of particle scattering
- Surface emissivity models
- Radiative transfer solver
- Instrument characteristics
- Various components need to go together

Simulation example forward and adjoint

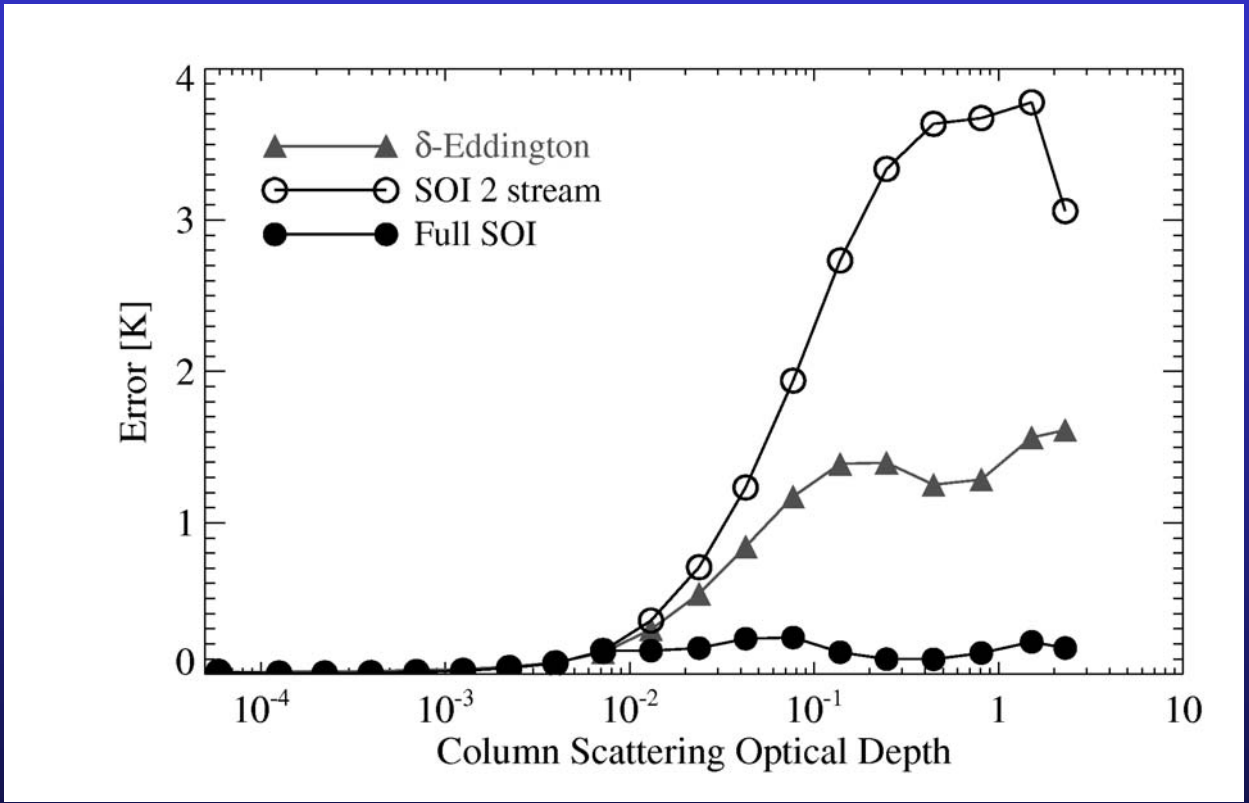






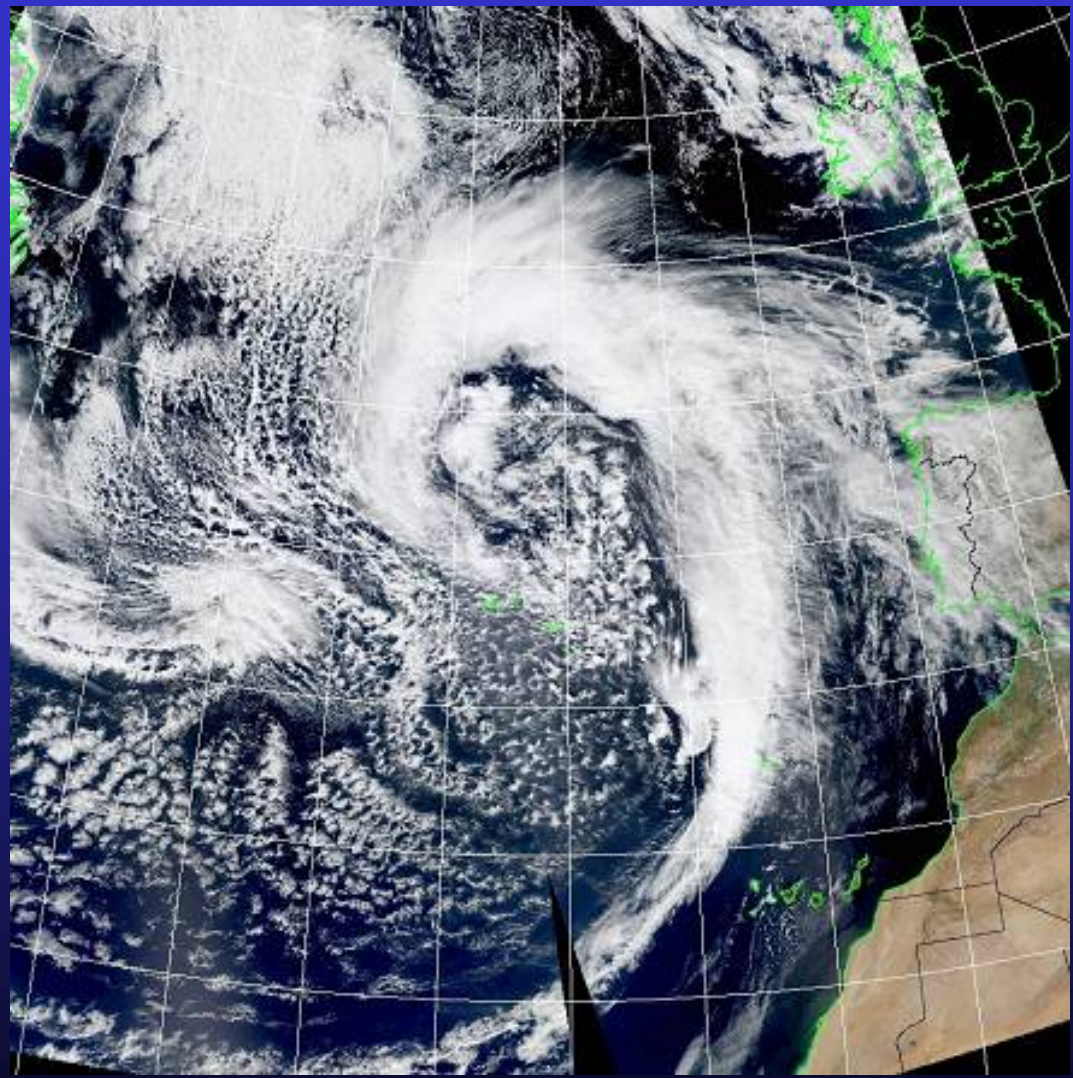


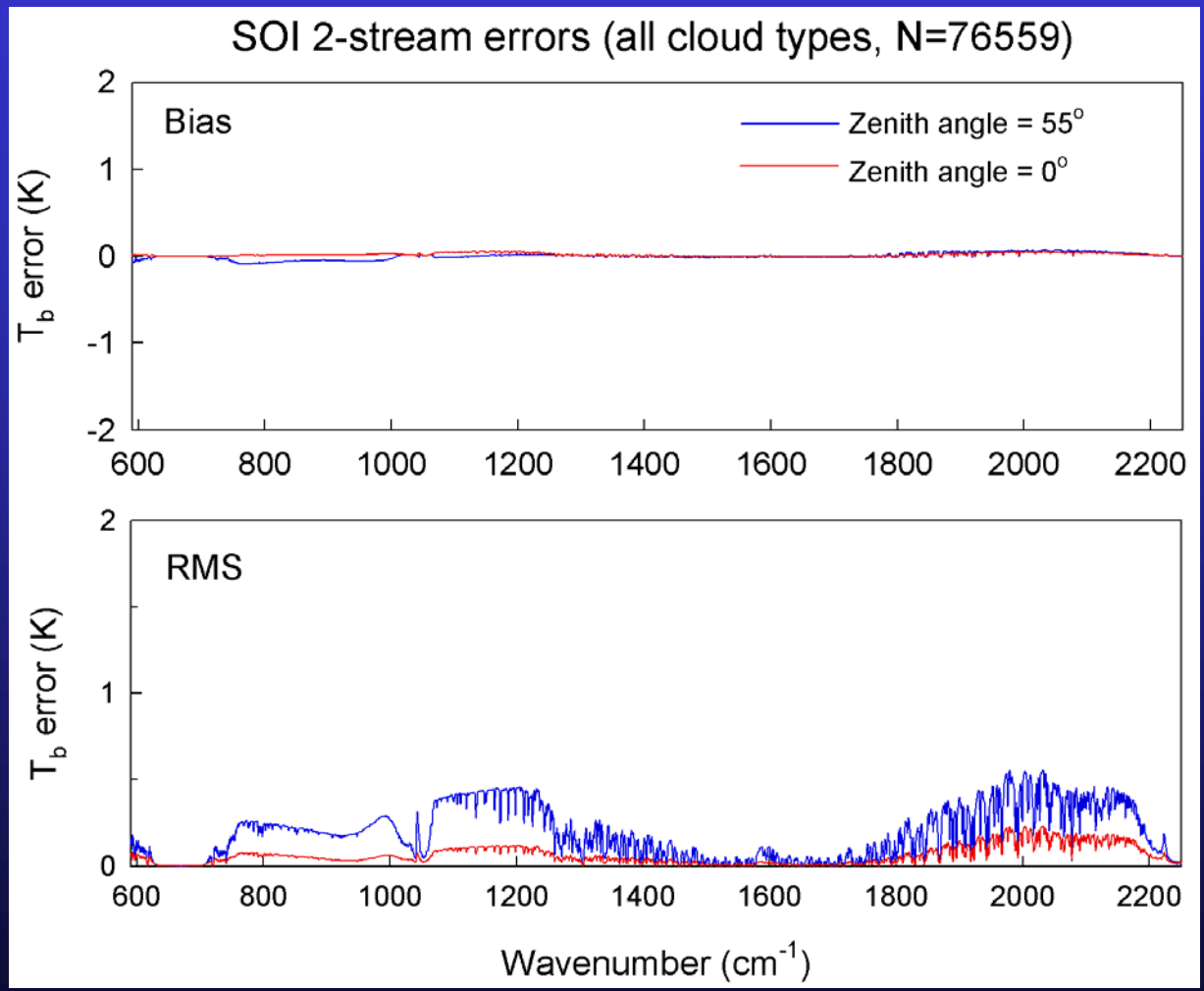
RT solver errors under scattering conditions in MW

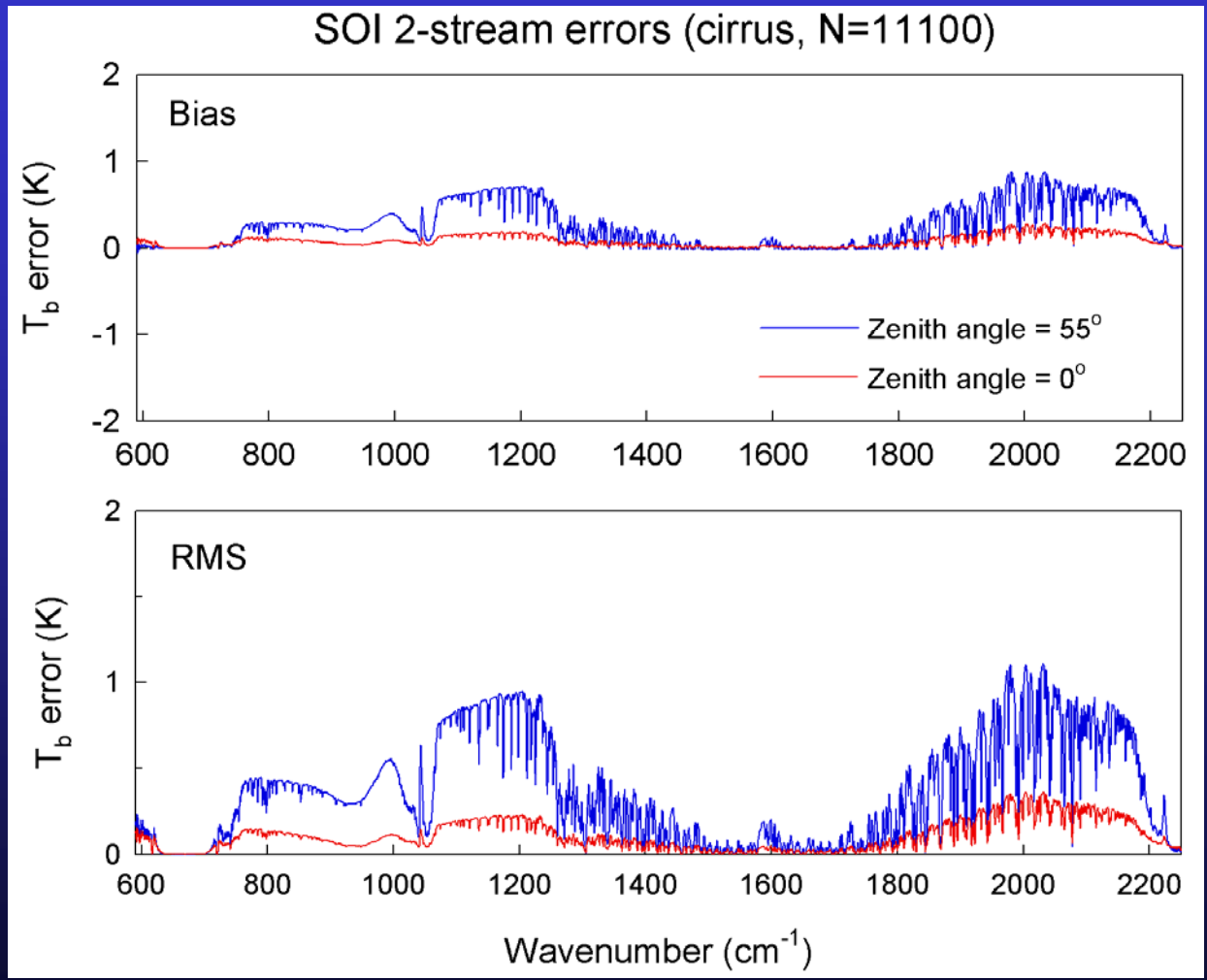


RT solver errors under scattering conditions in IR

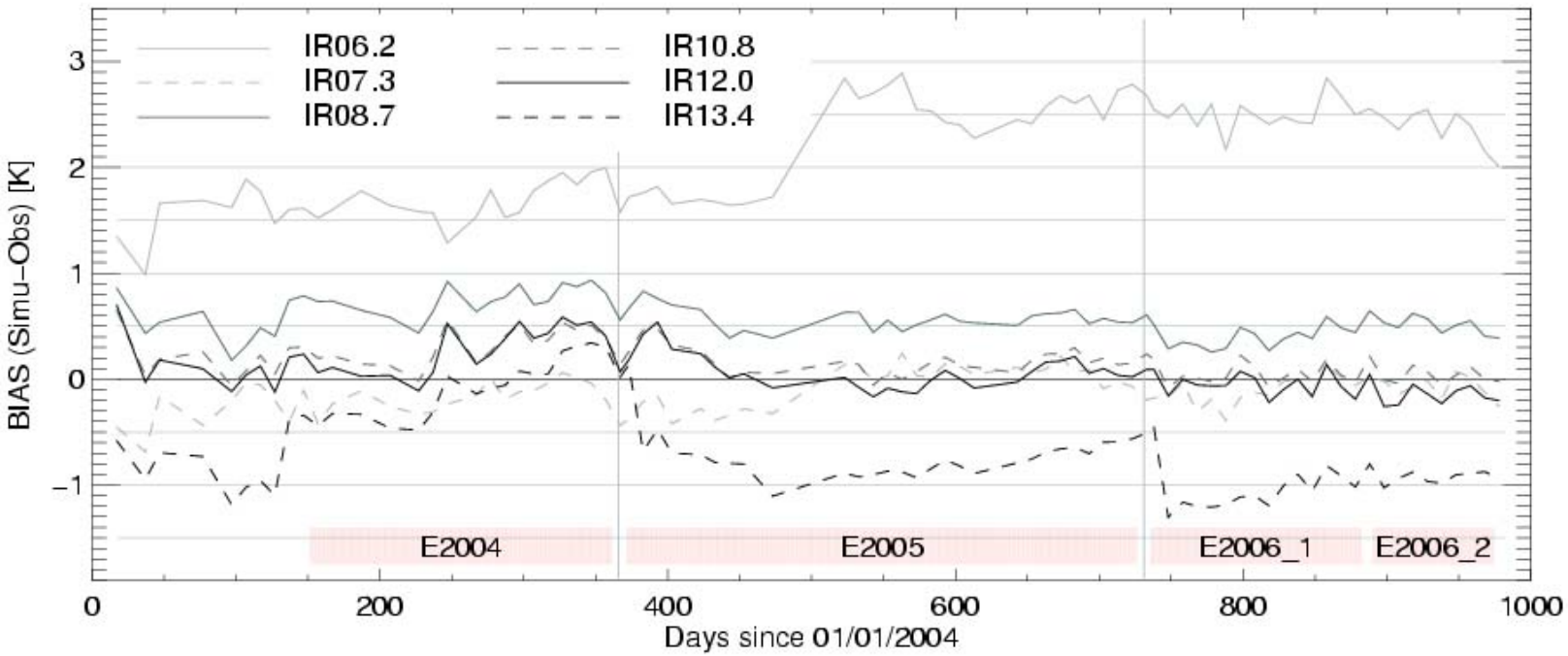
- WRF 4 km resolution run
- SOI IR 32-stream versus 2-stream
- Simulate typical high spectral resolution IR instrument (AIRS/IASI etc…)
- Ice clouds (Bryan Baum/Ping Yang)
- Liquid clouds (Mie)




SOI 2-stream errors (all cloud types, N=76559)
Bias
Zenith angle = 55°
Zenith angle = 0°
T_b error (K)
2
1
0
-1
-2
600
800
1000
1200
1400
1600
1800
2000
2200
RMS
T_b error (K)
2
1
0
600
800
1000
1200
1400
1600
1800
2000
2200
Wavenumber (cm^-1)


SOI 2-stream errors (cirrus, N=11100)
Bias
RMS
T_b error (K)
Zenith angle = 55°
Zenith angle = 0°
Wavenumber (cm^{-1})
2
1
0
-1
-2
600
800
1000
1200
1400
1600
1800
2000
2200

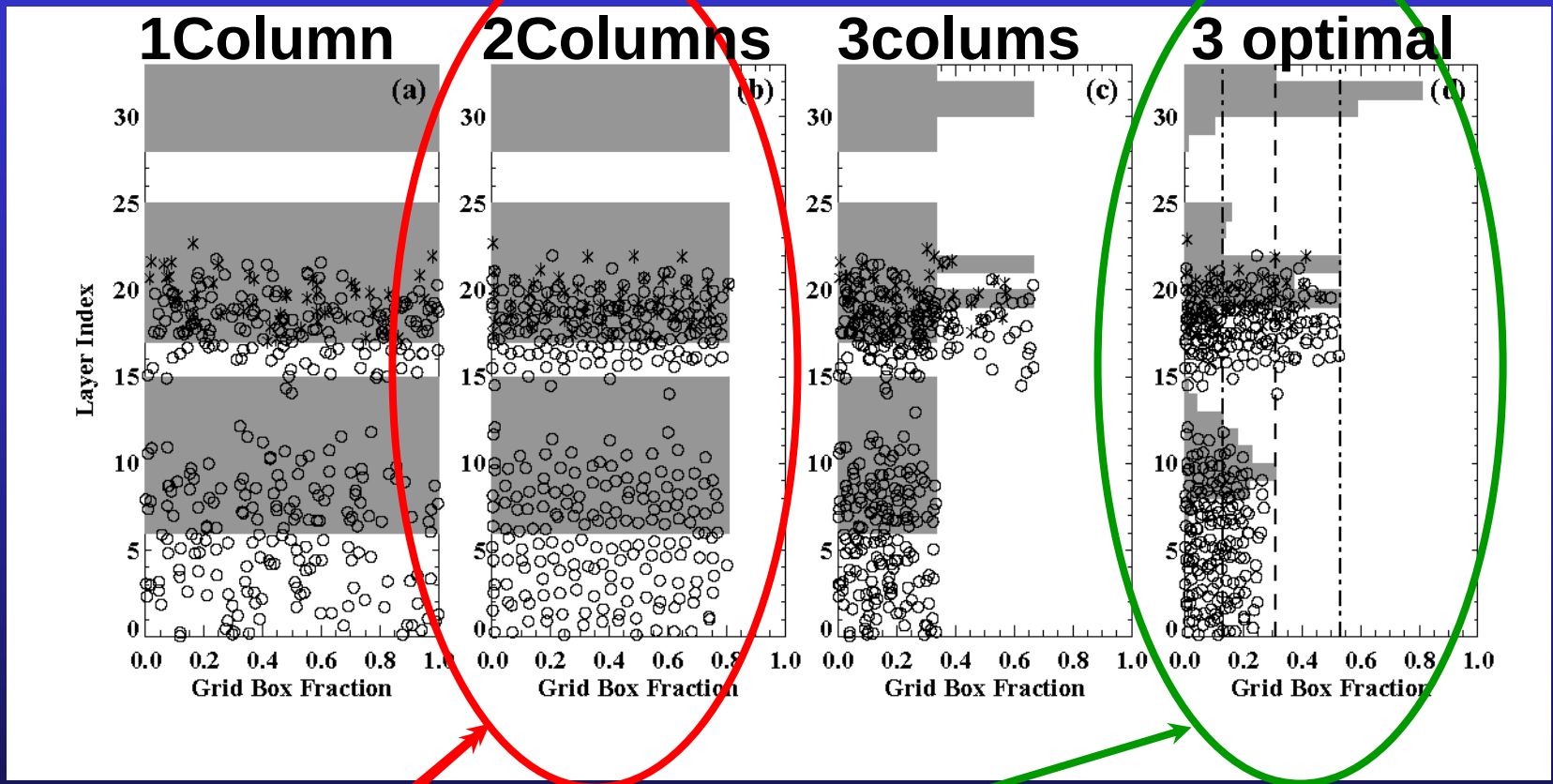
Bias monitoring infrared (cloud-free)



Different cloud/precipitation overlap models

- Conventional approach uses cloud cover to subdivide NWP pixel in cloudy/precipitation
- New approach derives two/three optimal columns based on subscale distribution of precipitation columns with similar optical properties
- Numerically efficient (2-3 radiative transfer calculations per NWP grid point)
- Highly accurate against independent column/MR-overlap reference
- Optimal approach reduces errors due to cloud overlap from maximum values of 5-10 K to values < 1K

Different cloud/precipitation overlap models

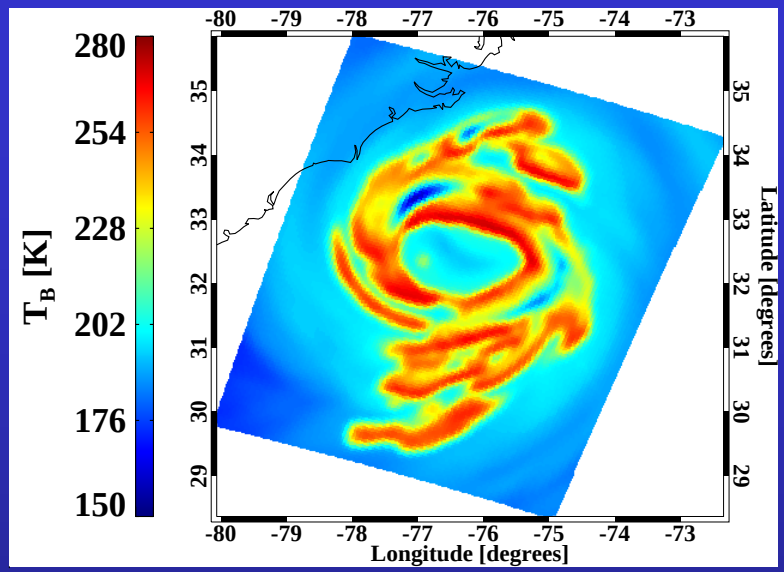


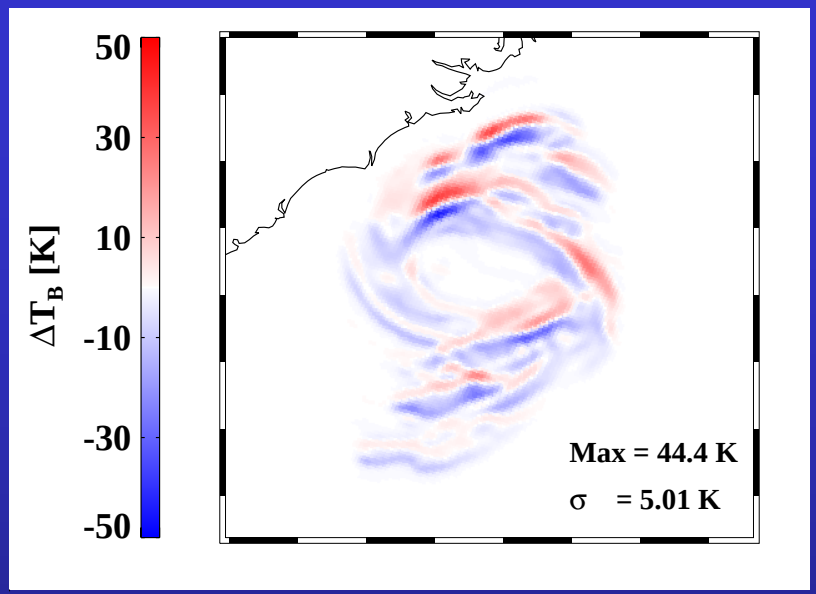
Currently operational at ECMWF

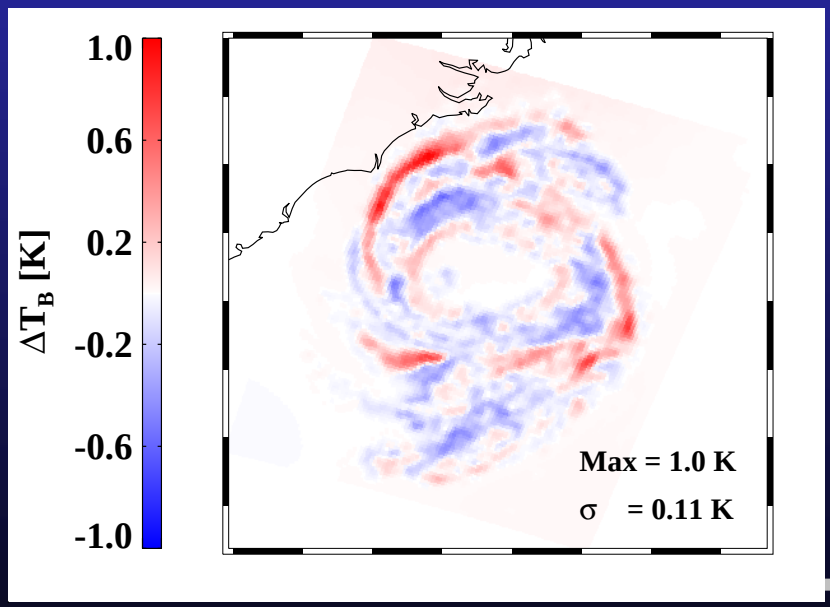
New scheme with much better error characteristics

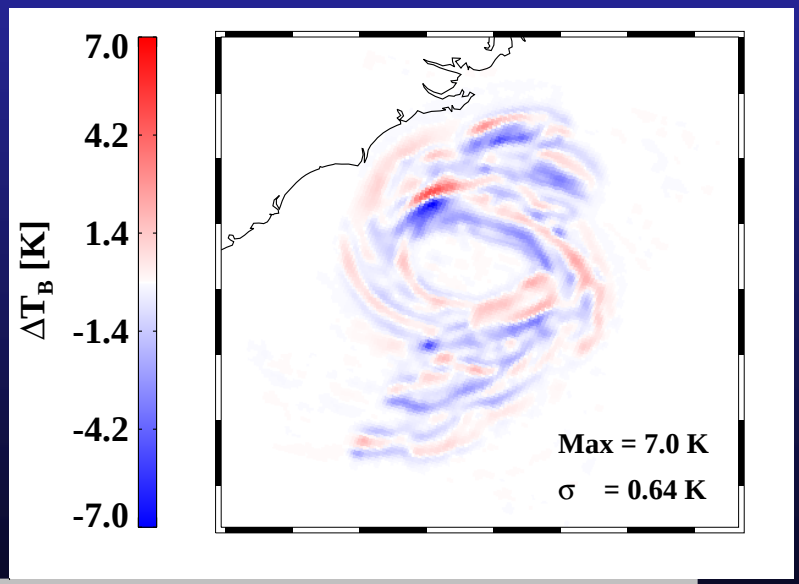
O'Dell, Bauer, Bennartz, JAS, 2006, in press

Slant path errors


280
254
228
202
176
150
T_B [K]
-80 -79 -78 -77 -76 -75 -74 -73
35 34 33 32 31 30 29
Latitude [degrees]
Longitude [degrees]


50
30
10
-10
-30
-50
ΔT_B [K]
Max = 44.4 K
σ = 5.01 K


1.0
0.6
0.2
-0.2
-0.6
-1.0
ΔT_B [K]
Max = 1.0 K
σ = 0.11 K


7.0
4.2
1.4
-1.4
-4.2
-7.0
ΔT_B [K]
Max = 7.0 K
σ = 0.64 K

Where are we?

- CRTM and integrated yet modular radiative transfer modeling approach is a big step forward.

- We got bits and pieces together, but consistent framework needs to be developed.

Future plans

- Further test and integrate SOI with other models in CRTM
- Develop formulation for observation error including all modeling errors, RT solver, ice scattering, cloud overlap, 3 D effects etc.
- Bias statistics for various sensors under cloud precipitating conditions for different cloud microphysics schemes.