

Observing the Earth's Atmosphere and Surface using Satellite-based Hyperspectral Observation

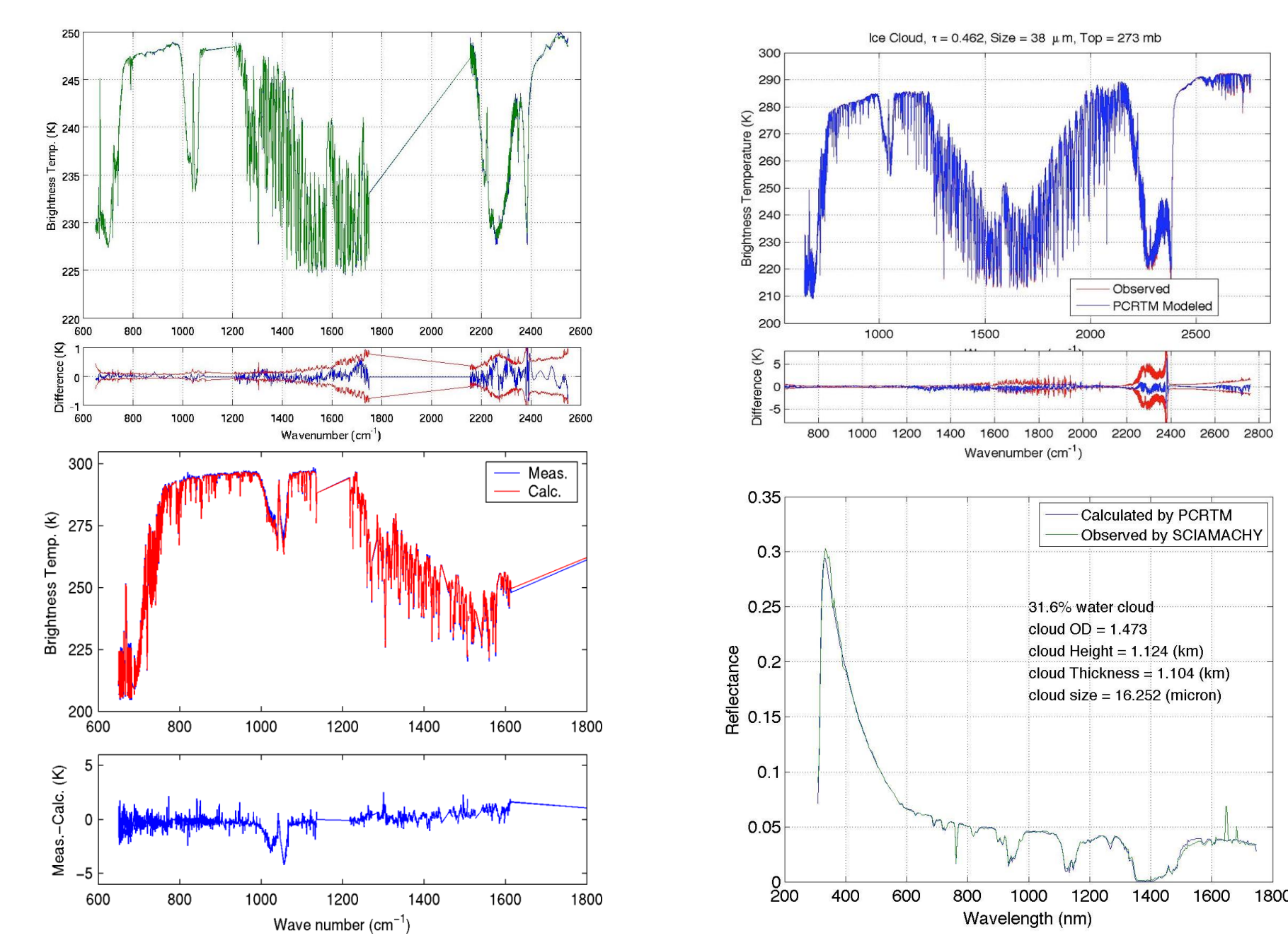


X. Liu¹, D. K. Zhou¹, A. Larar, Wan Wu², and Q. Yang²,
¹ NASA Langley Research Center, Hampton, VA 23681, USA
² Science Systems Applications Inc., Hampton, VA 23666 USA

1. Introduction

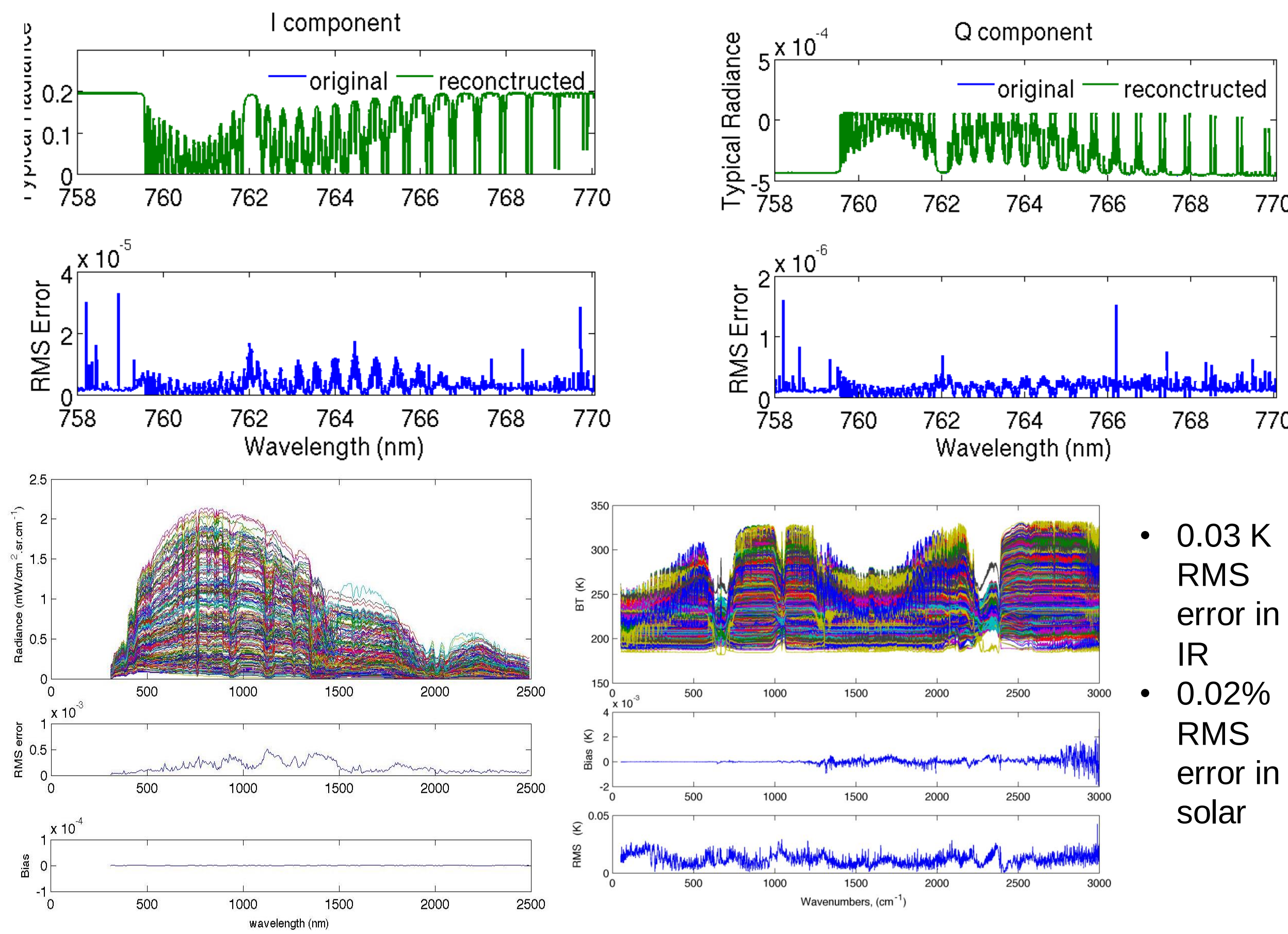
- Radiative transfer model is the key in Satellite Remote Sensing
 - Information content analysis, atmospheric and geophysical parameter retrievals, data assimilations, climate studies
- PCRTM (Principal Component-based Radiative Transfer Model)
 - Milliseconds to fraction of seconds for IR, fraction of second to seconds for solar
 - 3-4 orders of magnitude faster than LBLRTM and MODTRAN
 - 0.03 K accuracy in IR, 0.02% in solar
 - Spectral converge from 310 nm to 200000 nm (50 cm⁻¹)
 - Provide Jacobian needed for retrievals
 - Cloud and aerosol multiple scatterings included
- Efficient retrieval algorithm needed
 - PCRTM-based retrieval algorithm developed
 - Climate trend analysis
 - Weather and atmosphere related parameters retrieved

2. PCRTM has been developed for numerous sensors



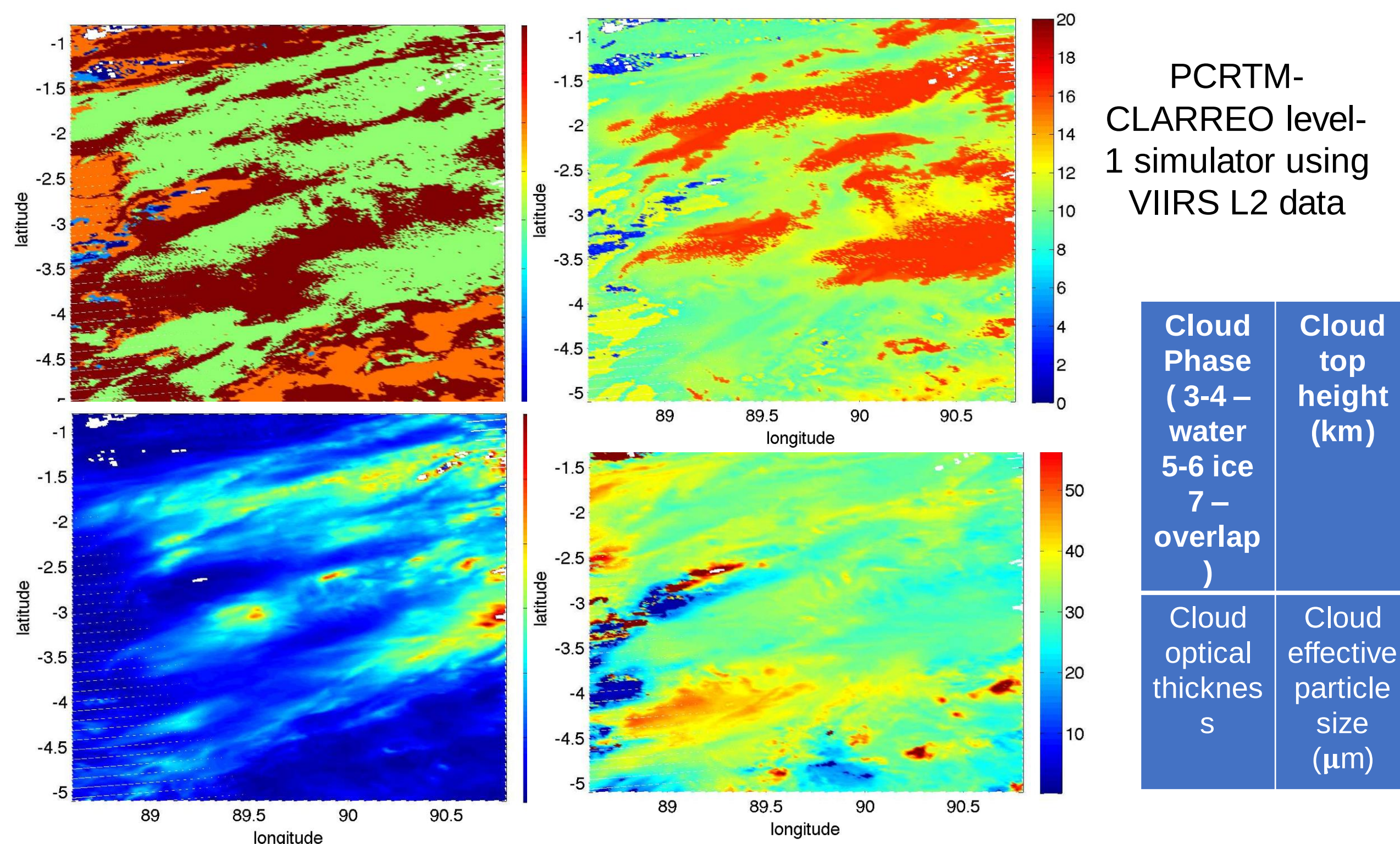
PCRTM has been developed for:

- CrIS
- CrIS full resolution
- IASI-A
- IASI-B
- AIRS
- NAST-I
- CALRREO-IR
- CLARREO-RS
- SCIAMACHY
- Handles clouds
- Aerosols
- 15 trace gases
- I,Q,U polarizations
- BRDF



0.03 K
RMS error in IR
0.02%
RMS error in solar

3. Proxy data generation



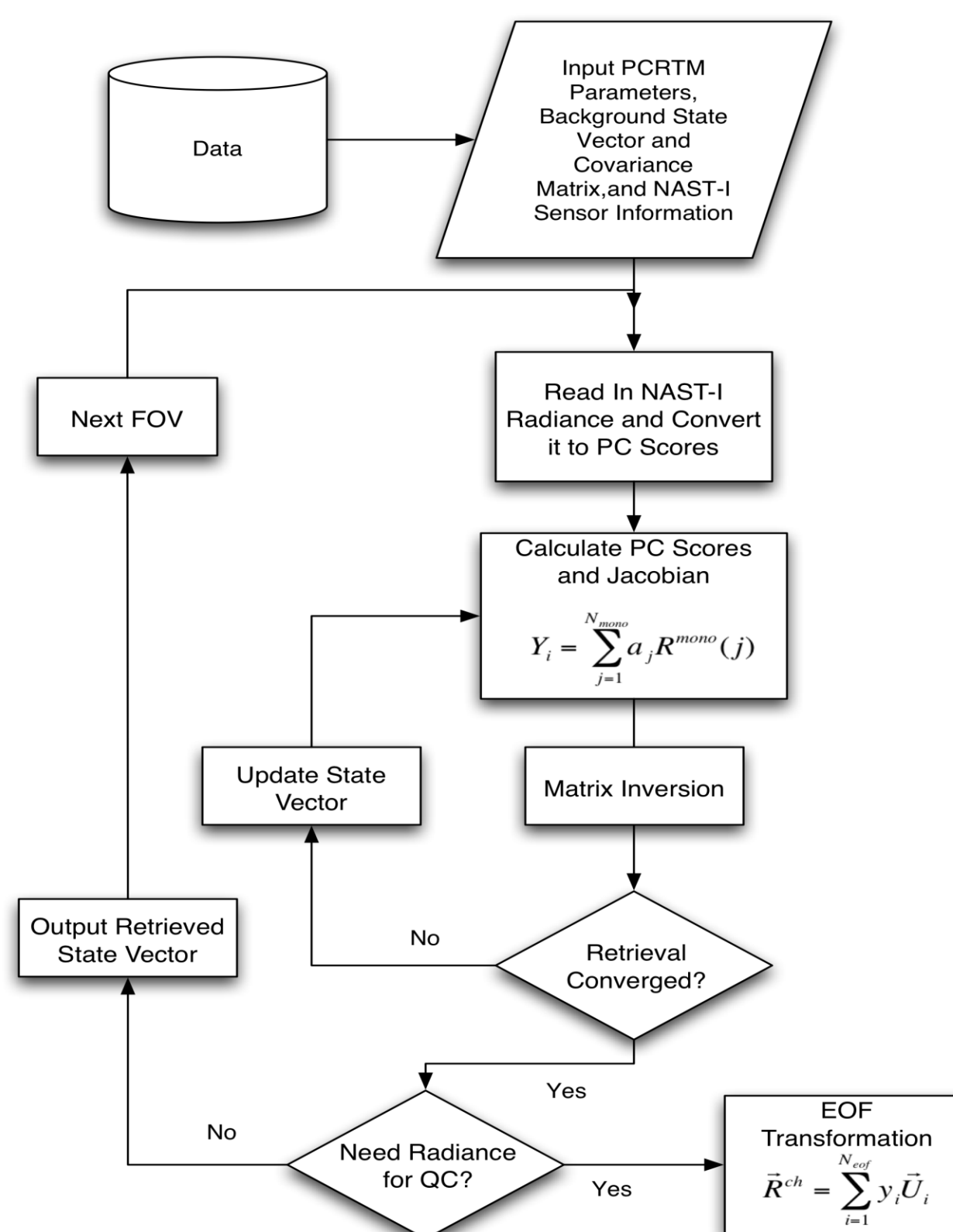
PCRTM-CLARREO level-1 simulator using VIIRS L2 data

Cloud Phase (3-4 - water, 5-6 ice, 7 - overlap)
 Cloud top height (km)
 Cloud optical thickness
 Cloud effective particle size (μm)

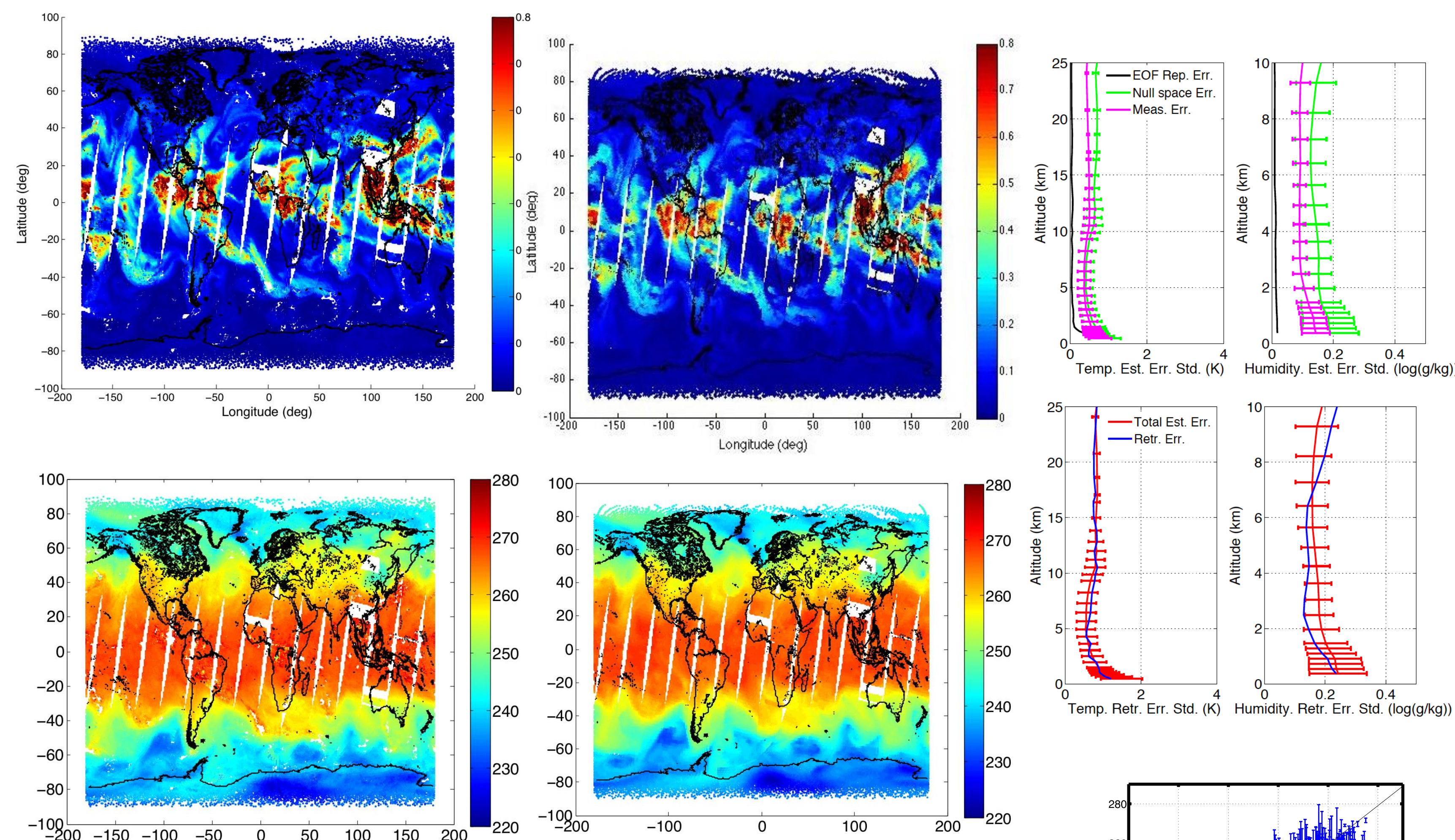
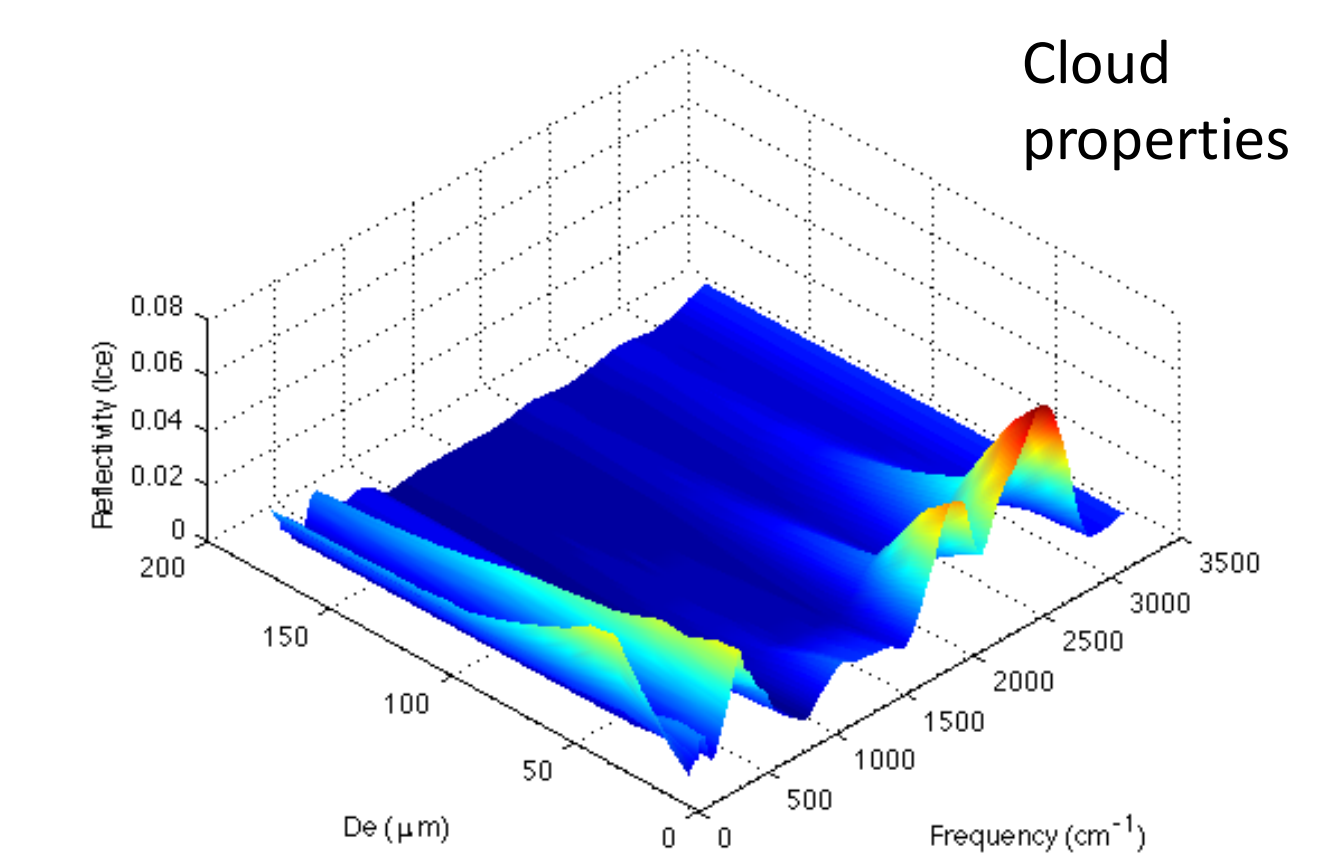
Left: VIIRS Observed
 Right: PCRTM simulated using VIIRS L2 data

4. Retrieval Algorithm based on PCRTM

- PCRTM-based optimal estimation algorithm retrieves the following parameters
 - Atmospheric Temperature, Water, CO₂, CO, CH₄, O₃, and N₂O profiles
 - Cloud phase, height, temperature, size, optical depth
 - Surface emissivity spectrum and skin temperature
- Advantages over existing algorithms
 - Performs retrieval for each FOV with the presence of clouds
 - 9 times high spatial resolution than operational CrIS and AIRS algorithm
 - Uses all spectral information instead of selecting only a few hundred channels
 - Fitting observed radiance spectra directly instead of cloud-cleared radiances



Retr. Config/Matrix Dimension	Radiance/Profile	Subset Radiance/Profile	Radiance PC/Profile PC
Y	~8400	300	100
X	100	100	41
K	8400x100	300x100	100x41
S _y ⁻¹	8400x8400	300x300	100x100
S _x	100x100	100x100	41x41



5. Summary and Conclusions

- PCRTM is ideal for dealing with hyperspectral data
 - Whole spectral information can be calculated efficiently
 - It has capability of handling multiple scattering calculations
 - Accurate relative to line-by-line models
 - PCRTM has been trained to work from far-IR to UV-Vis spectral region
- Multiple spectral regions provide additional information
 - MW+IR, IR+solar, MW+IR+Solar
- The current algorithm is capable of retrieving:
 - Atmospheric Temperature, Water, CO₂, CO, CH₄, O₃, and N₂O profiles
 - Cloud phase, height, temperature, size, optical depth
 - Surface emissivity spectrum and skin temperature