



Single FOV ATMS/CrIS Products Under All Sky Condition

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Acknowledgement: Y. Han, Q Liu, NOAA cal/val team, CLARREO science team...

2014 STAR JPSS Science Team Annual Meeting, May 14, 2014 dx.doi.org/10.1016/j.jstia.2014.05.001



Presentation outline

- Motivations
- Principal Component-based Radiative Transfer Model (PCRTM)
- PCRTM retrieval algorithm (PCRTM-RA) and applications
- Summary and Conclusions

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Motivations

- Need fast radiative transfer model to handle hyperspectral data
 - Modern sensors have thousands of channels and 0.1-1 million spectra per day
 - Only 4-10% of data are used in satellite data assimilations
- Need fast RT model to handle clouds explicitly
 - Most of the cloudy radiances are not used in data assimilations
 - Difficult to characterize the error in cloud-cleared radiances
- Explore optimal approach for hyperspectral retrievals
 - Retrieve all parameters that contribute to the TOA radiance
 - No need to perform retrieval on cloud-cleared radiances
 - No need to make assumptions about the inhomogeneity of the scene
 - Provide realistic error estimate on the retrieved parameters
 - More physical cloud parameters can be retrieved
- PCRTM (Principal Component-based Radiative Transfer model) was developed to satisfy the need listed above

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Introduction to PCRTM Forward Model

- Explore spectral correlation in hyperspectral data
 - No need to calculate spectrum one channel at a time
 - Compress spectra into compact form using PCA, wavelet, Fourier Series etc
 - Reduce dimension of the data
- PCA is a good approach for compressing spectra and capture information
 - Leading EOFs captures all essential information of thousands of channels
 - PCA has been used to reduce instrument noise and to compress spectra
- PCRTM parameterization is physical-based fast model

$$y_i = \hat{R}^a \times U_i = \sum_{j=1}^N \phi_j R_j^{a, \text{mean}} U_i = \sum_{j=1}^N A_j R_j^{a, \text{mean}}$$

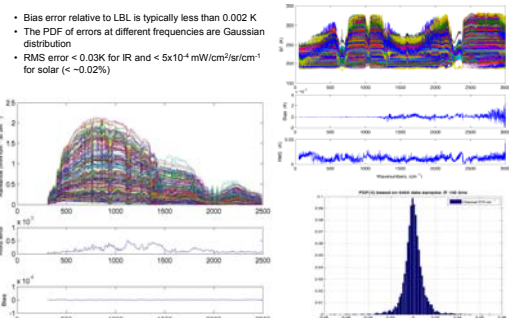
$$\hat{R}^a = \sum_{j=1}^N y_j U_j + \varepsilon$$
 - Radiative transfer done monochromatically at very few frequencies
 - Very accurate relative to line-by-line (LBL) RT model ($< 0.05\%$ or 0.05%)
 - 3-4 orders of magnitude faster than LBL RT models
 - A factor of 2-100 times faster than channel-based RT models
 - Provides Jacobian or radiative kernel needed for retrievals and climate studies
 - Includes accurate cloud RT

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Accuracy of PCRTM is very good relative to reference RT models

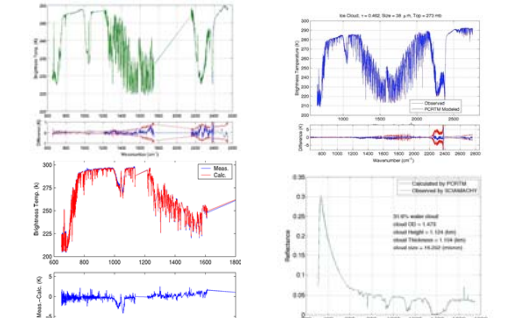
- Bias error relative to LBL is typically less than 0.002 K
- The PDF of errors at different frequencies are Gaussian distribution
- RMS error $< 0.03\text{K}$ for IR and $< 5 \times 10^{-4} \text{ mW/cm}^2/\text{sr/cm}^{-1}$ for solar ($< -0.02\%$)



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PCRTM has been validated using CrIS, IASI, AIRS, NAST-I, and SCIAMACHY real data



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