Poster 221

Insights on Tropical Convection from MIRS and TRMM Inter-comparisons

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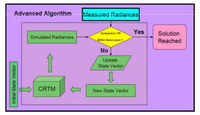
Science Motivation: Vertical structure of latent heat release in tropical convection, and the net radiative effect of tropical clouds varying in height and in liquid and ice water content remain key uncertainties central to climate variability (seasonal to interannual to decadal) and to climate change. High frequency passive microwave on the GMI and constellation satellites, when reconciled with DPR reflectivities, should enable improved discrimination of ice versus liquid hydrometeors, and more accurate tropical heating profiles.

Microwave Integrated Retrievals System (MIRS)

- NOAA NESDIS 1DVAR physical retrieval algorithm based on OI theory; assumes local linearity and gaussian pdf of state variables; [i.e. ln(hydrometeor water content, specific humidity) are retrieved].
- Heritage is Microwave Surface and Precipitation Products System (MSPPS)
- Applicable to any PMW sensor combining imaging /sounding capabilities.
- Community Radiative Transfer Model (CRTM) forward model computes radiances and adjoints needed to minimize cost function, J(x).

$$\mathbf{J(x)} = \underbrace{\left[\frac{1}{2}(\mathbf{X}-\mathbf{X_o})^T \times \mathbf{B}^{-1} \times (\mathbf{X}-\mathbf{X_o})\right]}_{\text{penalty for departing from background estimate}} + \underbrace{\left[\frac{1}{2}(\mathbf{Y^m}-\mathbf{Y(X)})^T \times \mathbf{E}^{-1} \times (\mathbf{Y^m}-\mathbf{Y(X)})\right]}_{\text{penalty for modeled radiances not matching measured/observed}}$$

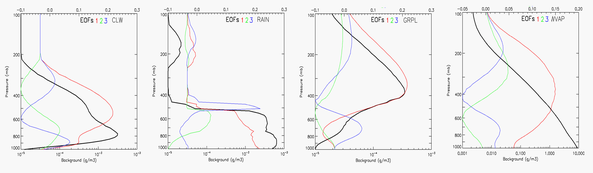
X	**: retrieved geophysical quantity (e.g. hydrometeor, atmos or sfc state)**
X_o	**: background** *a priori* **of retrieved quantity**
Y^m	**: measured channel radiances**
Y(X)	**: forward model estimates based on Xs**
B	**: background error covariance**
E	**: forward model error covariance**



Retrievals

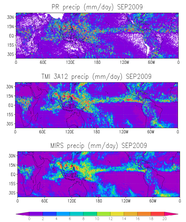
- 1st sweep: temperature, water vapor, non-precipitating liquid, skin temperature, emissivity spectrum; 2nd sweep: rain, snow, graupel.
- Hydrometeor background and covariance statistics come from a 4 km MM5 simulation of Hurricane Bonnie (1998).
- Retrievals performed in a reduced space (EOFs)→ more stable inversion.
- Convergence criteria is Chi-square from matching observed and forward modeled radiances (< 1.0 s.d. assumed channel noise)
- Surface emissivity spectrum is part of the retrieved state vector enabling more direct response to precipitation over land.
- MIRS currently employs a first generation estimate of cloud, rain and graupel profiles that serve as the background in the 1-DVar penalty function. (Moisture and temperature profile backgrounds come from a 60-level ECMWF database.)

Background Hydrometeor Profiles and EOF Structures



Project Objectives: In order to better understand the information content on hydrometeor content from polar orbiter sounders (i.e. AMSU, AMTS, SAPHIR) we are: **(1)** Analyzing similarities and differences in retrievals from the TRMM TMI and PR in contrast to those from the NESDIS Microwave Integrated Retrieval System (MIRS); **(2)** Collecting co-incident TRMM (PR, TMI) and POES (AMSU-A, AMSU-B / MHS; SSMIS) data and developing cloud / precipitation regime-stratified statistics, **(3)** Quantifying the role of *a priori* information on uncertainties and relative differences among these retrieval products.

TRMM PR, TMI, MIRS Monthly surface Precipitation Comparisons



- MIRS column integrated cloud, rain, ice water paths are used in a statistical regression algorithm to generate a rain rate *(See Iturbide-Sanchez et al., 2011. IEEE Trans GRS.)*

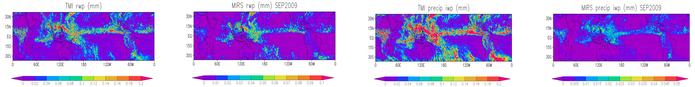
RR_{oc} = .274 + 2.202 CLWP
+5.329 RWP – 0.302 IWP

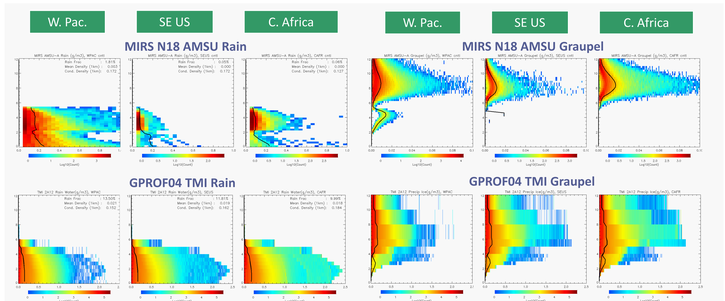
RR_{ts} = -.0264 +9.742 RWP + 12.036 IWP

- Despite different sampling strategies (cross-track vs conical; diurnal vs sun-synchronous) MIRS rain rates *on a monthly basis* are similar in structure and magnitude to those from TRMM.

Rain and Ice Water Path and Vertical Distributions

RWP and IWP retrievals from MIRS N18 AMSU are smaller (2-3x and 5-10x, respectively) than those from TMI 2A12. Global and even regional scale patterns are in reasonable agreement MIRS. Profiles of various quantities are much more challenging from radiometers. While the number of high frequency passive microwave sounding channels on new sensors is increasing, the weighting functions are still broad. *A priori* information from the TRMM PR and cloud models is structured by regime in GPROF10 while the MIRS *a priori* is still uniform in space / time.



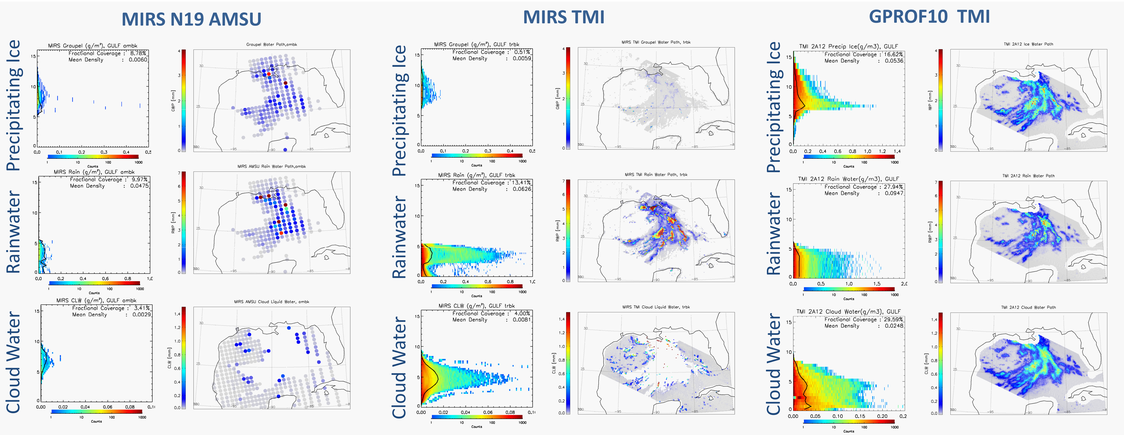


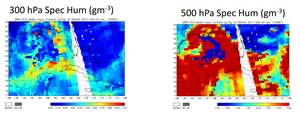
Summary: **(1)** 1st generation MIRS hydrometeor profiles are, in a physical sense, too narrowly constrained. A single *a priori* background profile for each species is derived from limited sampling of ECMWF 60L and MM5 hydrometeors. AMSU integrated rainwater and precipitating ice are underestimated relative to GPROF; but, TMI rainwater (graupel) is over-(underestimated). **(2)** Despite these artificial restrictions, MIRS is able to retrieve integrated rain and precipitating ice water paths sufficient to enable reasonable surface RR estimates via multiple regression / calibration. **(3)** Sensitivity to the initial guess is evident and suggests that multiple minima in the cost function is likely a frequent occurrence.

Next Steps: **(1)** Efforts are underway to generalize / stratify the background to build in a larger degree of "regime dependence". We are exploring possible strategies of adapting regime-dependent structure more in line with the GPROF cloud library. **(2)** Employing reanalysis as background or first guess for water vapor, temperature. **(3)** Intercomparison of MIRS on SSMIS (f18) with GPROF. **(4)** Extension to ATMS, then Megha-Tropiques.

Case Study: Tropical Storm Lee, 2 Sept 2011

MIRS retrievals are made using both TMI and N19 AMSU data and compared to TMI GPROF V7 retrievals. Separation of orbital passes is about 42 minutes. CFADS (Contoured Frequency by Altitude Distributions) of retrieved water contents (g/m^3) are constructed for each set of retrievals as a means to understand systematic vertical structure differences. AMSU CFADS have fewer counts since their footprints are 25 to 150 times larger than TMI footprints. Solid line in CFADs represents conditional mean value at each level in the vertical. MIRS precipitation is strongly affected by second EOF.





Background upper tropospheric water vapor is systematically too dry in regions of strong precipitation and is not being effectively changed. Reanalysis initial guess could likely provide an effective constraint.

Regression first guess used for graupel in TMI instead of climatological background results in much larger graupel amount but greatly reduces rainwater amounts