Optimizing Radiative Transfer Calculations in the CRTM for Clouds, Precipitation and Aerosols

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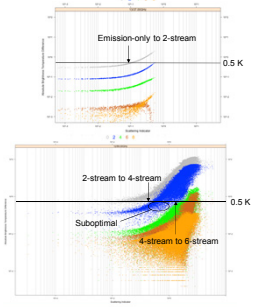
Motivation

Radiative transfer in cloudy and aerosol-laden atmospheres are the most time-consuming calculations in the Community Radiative Transfer Model (CRTM). To address speed/accuracy tradeoffs in these calculations we developed a scattering indicator to help find beforehand the fewest number of streams (i.e., angular resolution) needed to achieve a desired accuracy.

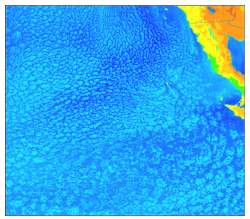
Methods

- Scattering indicator is based on successive order of scattering
- Source of cloud/precipitation profiles were three cloud-resolving WRF model simulations
- Thresholds (selection rules) to switch to higher order streams were found by visually inspecting scatterplots of simulated brightness temperature errors (using CRTM v2.1 and the 16-stream solution as a reference) vs. the scattering indicator

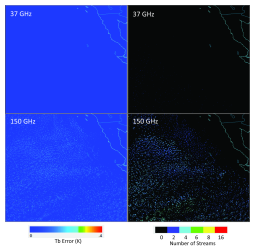


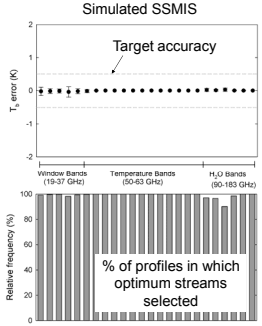
Results: Microwave wavelengths

California Marine Stratocumulus

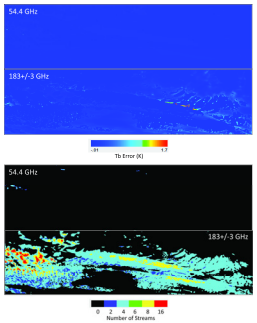


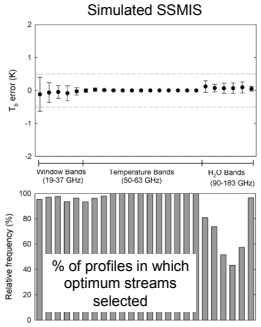
Simulated 150 GHz brightness temperature field





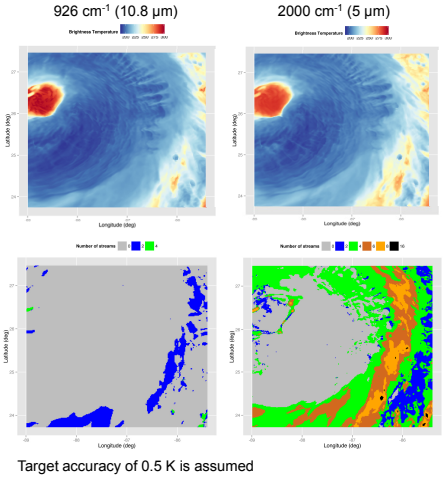
South Atlantic frontal system





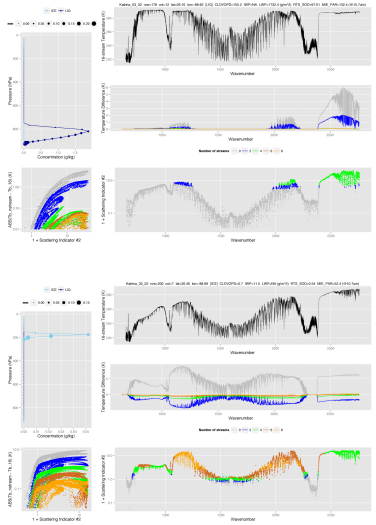
The selection rules correctly predicted the optimum number of streams over 90% of the time for all SSMIS channels (nearly 100% for temperature sounding channels) except the highest frequency channels (90-183 GHz).

Results: Infrared wavelengths

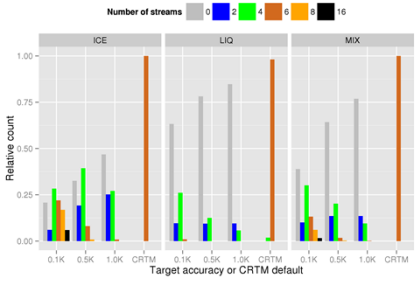


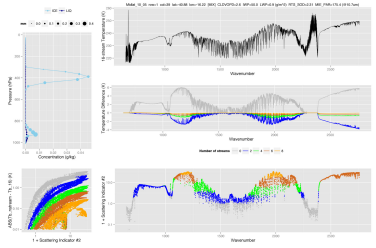
Target accuracy of 0.5 K is assumed

Selection rules have not yet been derived for the IR. Instead, we examined how the optimum number of streams relate to the scattering indicator for IASI and select profiles from the simulations.
At left is a portion of the hurricane Katrina simulation at two different IASI channels.
At right are three select profiles for the hurricane Katrina and South Atlantic frontal system simulations.

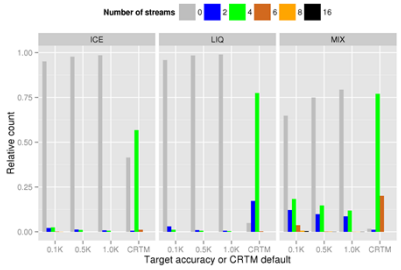


In the IR, CRTM v2.1 consistently over-estimates the number of streams needed by assigning 6 streams regardless of the conditions.





CRTM v2.1 overestimates the number of streams needed over a wide range of target accuracies.



Conclusions and future work

- In the microwave, optimum number of streams was achieved in >90% of the cases, but suboptimal in water vapor bands; 5-10X speedup expected for microwave temperature sounding channels
- In the IR, there is an opportunity for 10-fold or more speedups provided the optimum number of streams is selected often
- Consider alternative scattering indicators for certain situations (e.g., microwave water vapor bands)
- Determine selection rules for the IR
- Investigate aerosol scattering in the IR

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