Project Progress Report

Award: NA10NES4400007

Title: Research in Support of Radiance Assimilation of Clouds and Precipitation

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Reporting period: 12/1/2013-5/31/2014

Proposed work:

This project addresses open issues in the Community Radiative Transfer Model (CRTM) that have a direct impact on its performance within a system that assimilates satellite radiance data in cloudy and precipitating regions. The focus of this final year of work is to further develop and test ways of optimizing microwave scattering calculations in the presence of clouds and precipitation, and extend these methods to the infrared and aerosols.

Work accomplished:

Preliminary work on applying the scattering indicator (SI) to infrared sensors in order to accelerate multiple scattering calculations in the CRTM was presented at the 12th JCSDA Technical Review Meeting & Science Workshop on Satellite Data Assimilation, in May. The same methods used for microwave sensors was applied to the HIRS (High Resolution Infrared Radiation Sounder) for longer wavelengths (6-15 µm), which involved establishing thresholds on the SI based on simulated radiances from high-resolution WRF model runs of hurricane Katrina and marine stratocumulus off the coast of Baja California. We assumed a target solution accuracy of 0.2 K.

For the hurricane Katrina case, the new approach does a better job of predicting the optimum numbers of streams than the current CRTM; particularly for the CO_2 sounding channels (see Figures 1 and 2). However, our method tends to predict too few streams more often than the current CRTM. The speed benefits of the new approach show factors of 30 speed ups in the CO_2 sounding channels and factors of about 2 for all other channels (see Table 1).

For the marine stratocumulus case, the new approach is comparable to the current CRTM for the window channels but performs far better for the CO_2 and H_2O sounding channels (see Figures 3 and 4). Table 2 shows speedups of up to a factor of 30 for the sounding channels but decreases significantly to about only 25% speedups for the window channels.

While our approach is an overall better predictor of the optimum number of streams than the current CRTM we believe there is room for improvement. The remaining time on this project will be spent enhancing the method and integrating it into the CRTM. The latter task will be much easier than before since the code infrastructure is already in place.

Table 1: Timings for the hurricane Katrina case relative to the current CRTM, which has a value of 1, for the optimum number of streams and the new method.

HIRS channel (μm)	Optimum	New
15	0.032	0.032
14.7	0.032	0.039
14.5	0.048	0.083
14.2	0.131	0.479
14	0.164	0.522
13.7	0.201	0.559
13.3	0.228	0.569
11.1	0.179	0.525
9.7	0.197	0.502
12.5	0.239	0.545
7.3	0.449	0.559
6.5	0.250	0.585

Table 2: Same as Table 1 but for the marine strato-cumulus case.

HIRS channel (μm)	Optimum	New
15	0.039	0.039
14.7	0.039	0.039
14.5	0.049	0.039
14.2	0.041	0.044
14	0.042	0.084
13.7	0.043	0.383
13.3	0.043	0.808
11.1	0.063	0.768
9.7	0.098	0.744
12.5	0.044	0.802
7.3	0.048	0.230
6.5	0.041	0.058

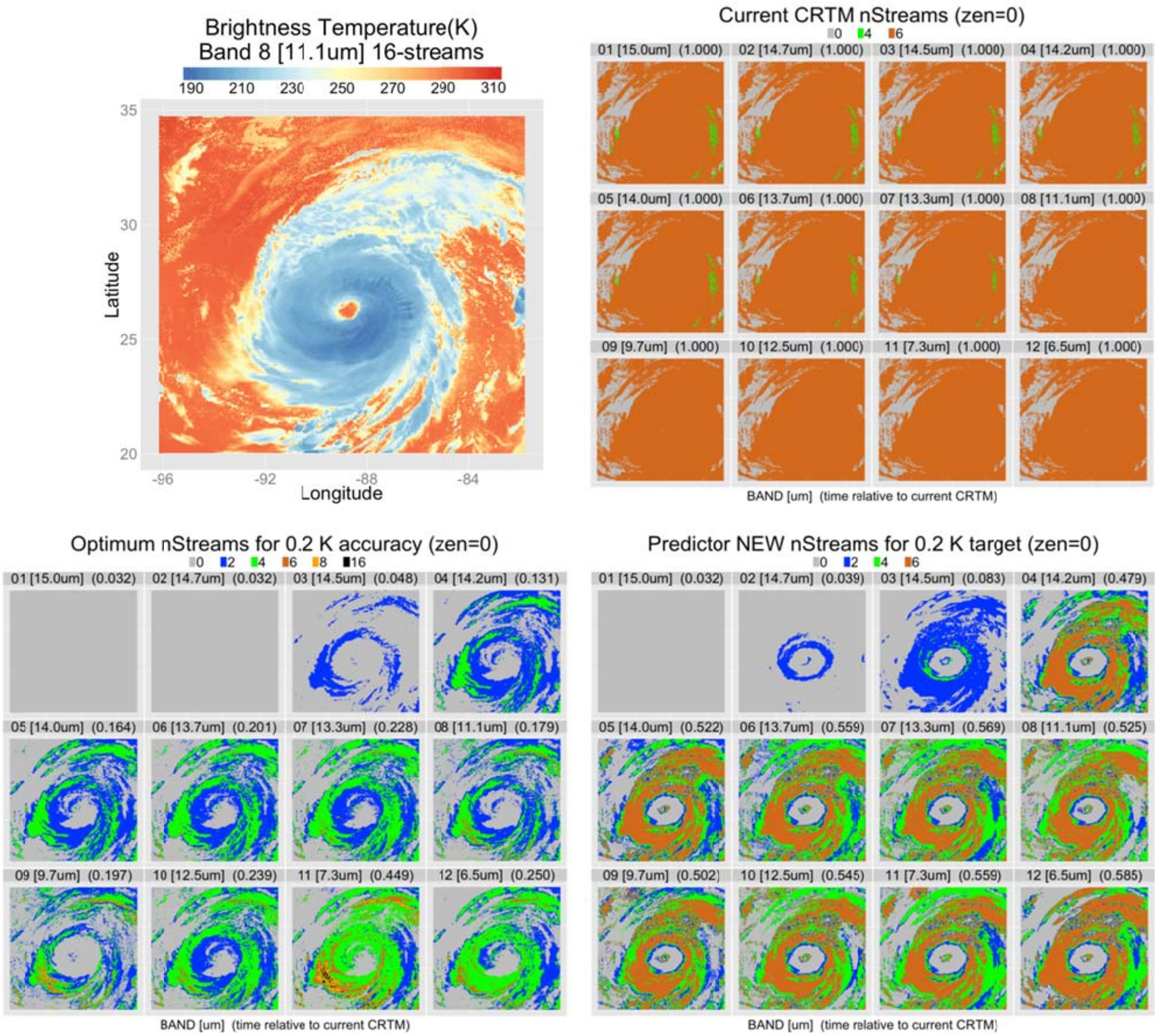

Fig. 1: Number of streams predicted by the current CRTM (upper right panels) and SI (lower right panels) for selected HIRS channels as compared to the optimum number of streams (lower left panels) based on simulated hurricane Katrina brightness temperatures. A zenith angle of 0^o was assumed.

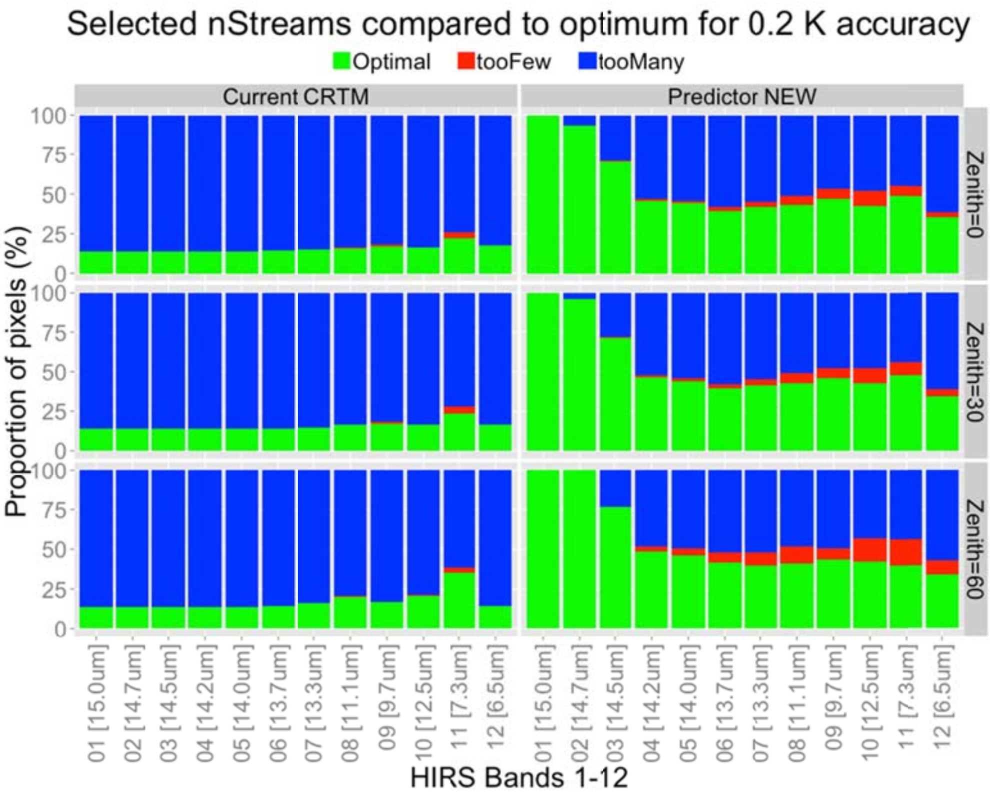

Fig. 2: Percentage of points where the optimum number of streams was predicted correctly (green bars), where too many streams were predicted (blue bars) and where too few streams were predicted (red bars) for the current CRTM (left) and new approach (right) for hurricane Katrina. Results are shown for zenith angles of 0^o, 30^o and 60^o.

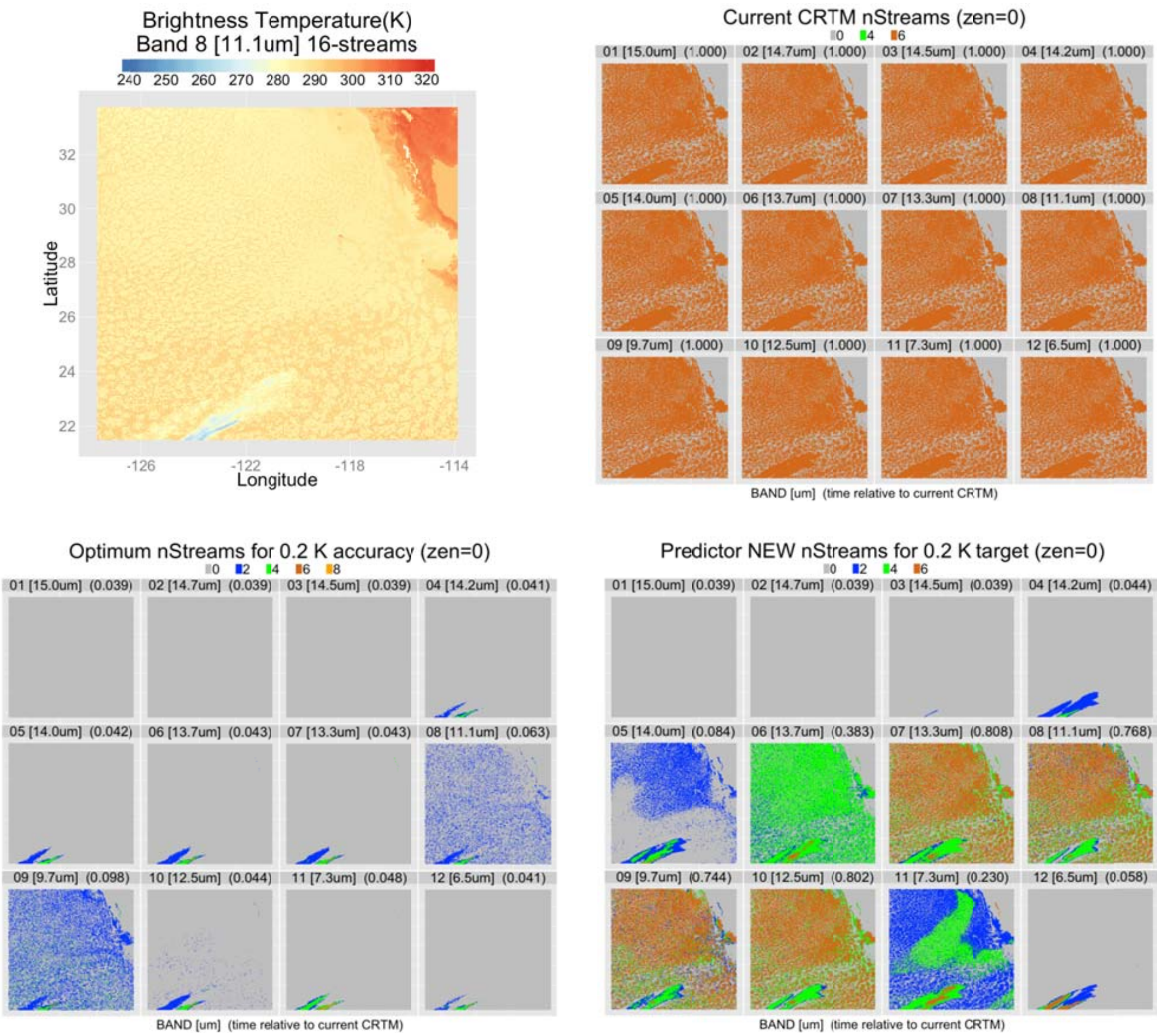

Fig 3: Same as Fig. 1 but for the marine stratocumulus case.

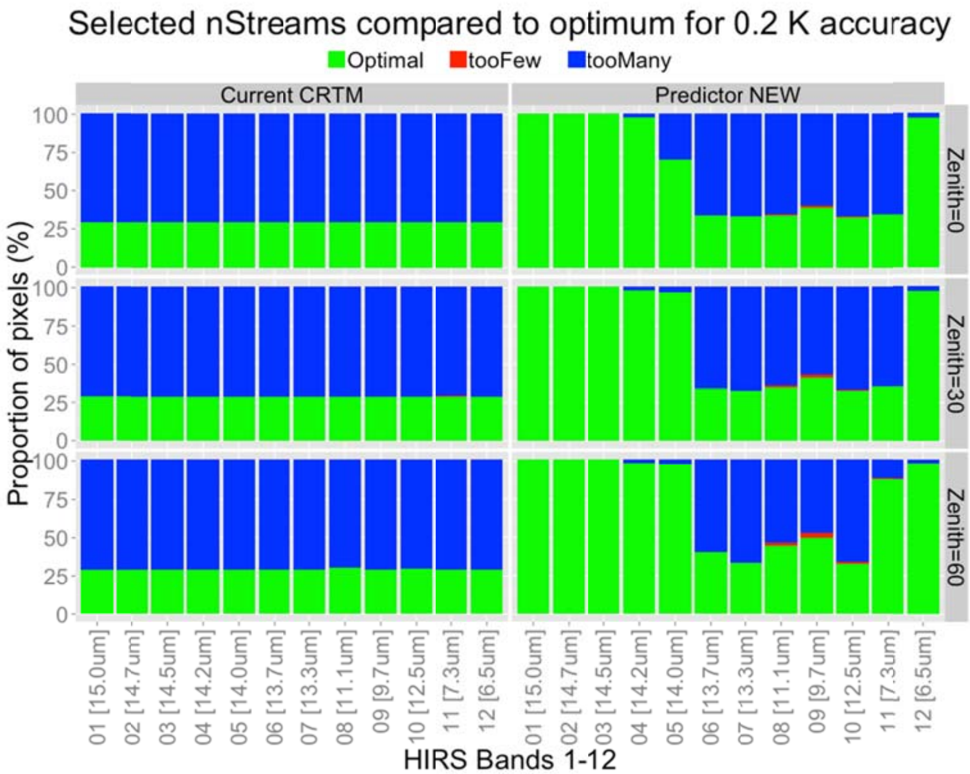

Fig 4: Same as Fig. 2 but for the marine stratocumulus case.