The Effects of VIIRS Detector-Level and Band-Averaged Relative Spectral Response Differences on the Thermal Emissive Bands

Lin Lin[1], Changyong Cao[2], and Satya Kalluri[2]

[1] ESSIC/University of Maryland, College Park, MD, U.S.A.

[2] NOAA/NESDIS/Center for Satellite Application and Research, College Park, Maryland, U.S.A.

Introduction

The Joint Polar Satellite System-1 (JPSS-1, renamed NOAA-20 after reaching the polar orbit) was successfully launched on 18 November 2017 into an afternoon orbit with a local equator crossing time of ~1:30 p.m., in the same orbital plane as the Suomi National Polar-orbiting Partnership (S-NPP) but with a time separation of 50 min. The NOAA-20 Visible Infrared Imaging Radiometer Suite (VIIRS) will become the primary operational imager succeeding the VIIRS onboard S-NPP, which has been in orbit for more than six years. Although the VIIRS onboard S-NPP and NOAA-20 have identical designs, there are small differences in the relative spectral response (RSR) in most bands. Previous studies have shown that minor differences in the S-NPP RSRs at Thermal Emissive Bands (TEBs) can lead to several effects at the detector level, such as striping in Sensor Data Record (SDR) products. Such differences may explain the striping pattern found in S-NPP VIIRS sea surface temperature (SST) products. The present study analyzes the detector-level and operational band-averaged RSRs for NOAA-20 VIIRS TEBs and examines the radiometric response to them using the Line-By-Line Radiative Transfer Model (LBLRTM) at a very high spectral resolution for convolving with the RSRs. We also evaluate the impact of RSR differences between S-NPP and NOAA-20 for radiometric biases and potential striping in VIIRS TEB SDR brightness temperature. This study will contribute toward measurement consistency for long-term observations in the thermal infrared bands and ensure the quality of retrieval data produced by VIIRS such as SST, fire, and other retrievals.

Assessment of RSR on VIIRS TEBs from LBLRTM Simulation

Model: LBLRTM V12.8

Inputs: six representative atmospheric conditions

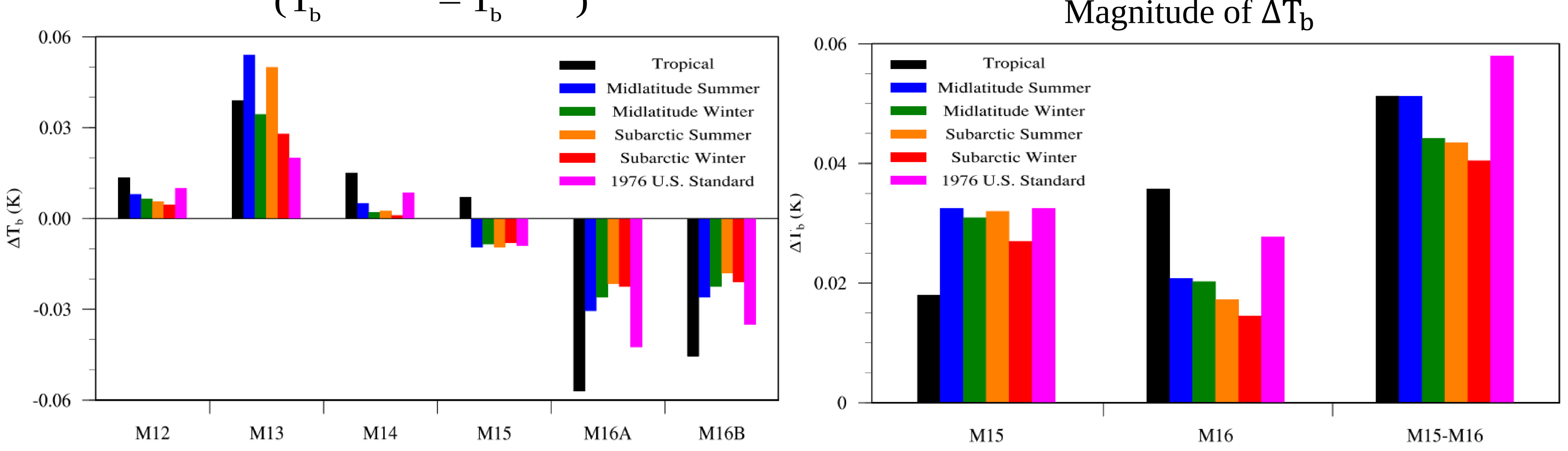
The in-band mean effective radiance ($\overline{R}$):

$$\overline{R} = \frac{\int_{\nu_1}^{\nu_2} r(\nu)\cdot R(\nu)d\nu}{\int_{\nu_1}^{\nu_2} r(\nu)d\nu}$$

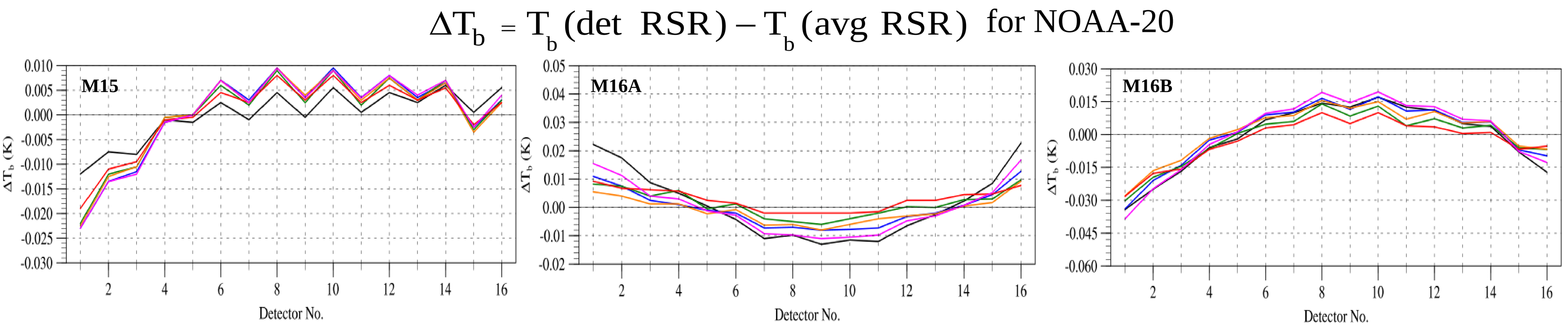
The effective brightness temperature can be converted from radiance using the VIIRS LUT based on the Planck function:

$$L(\nu, T) = \frac{c_1 \nu^3}{e^{\frac{c_2 \nu}{T}} - 1}$$

$(T_b^{NOAA-20} - T_b^{S-NPP})$ Magnitude of ΔT_b

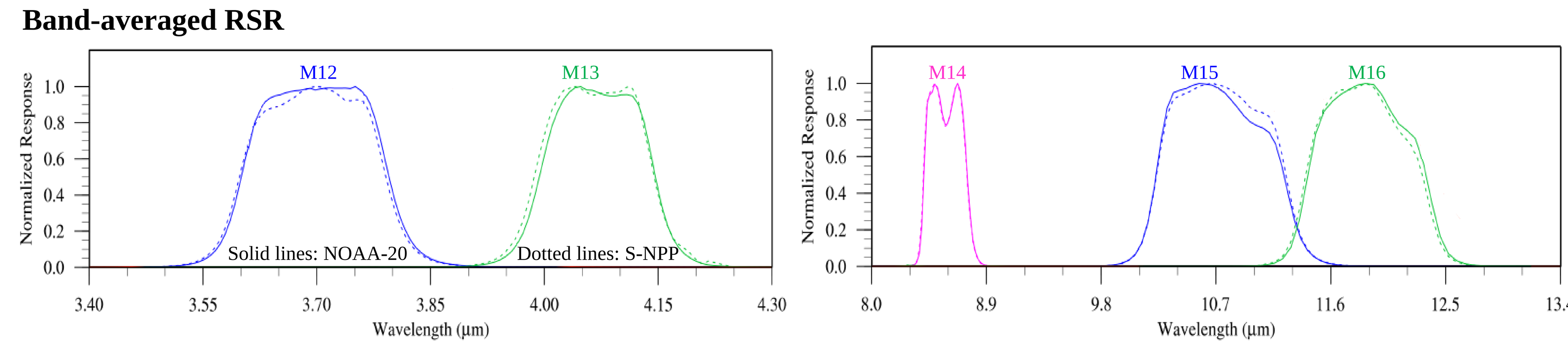


$\Delta T_b = T_b(\text{det RSR}) - T_b(\text{avg RSR})$ for NOAA-20

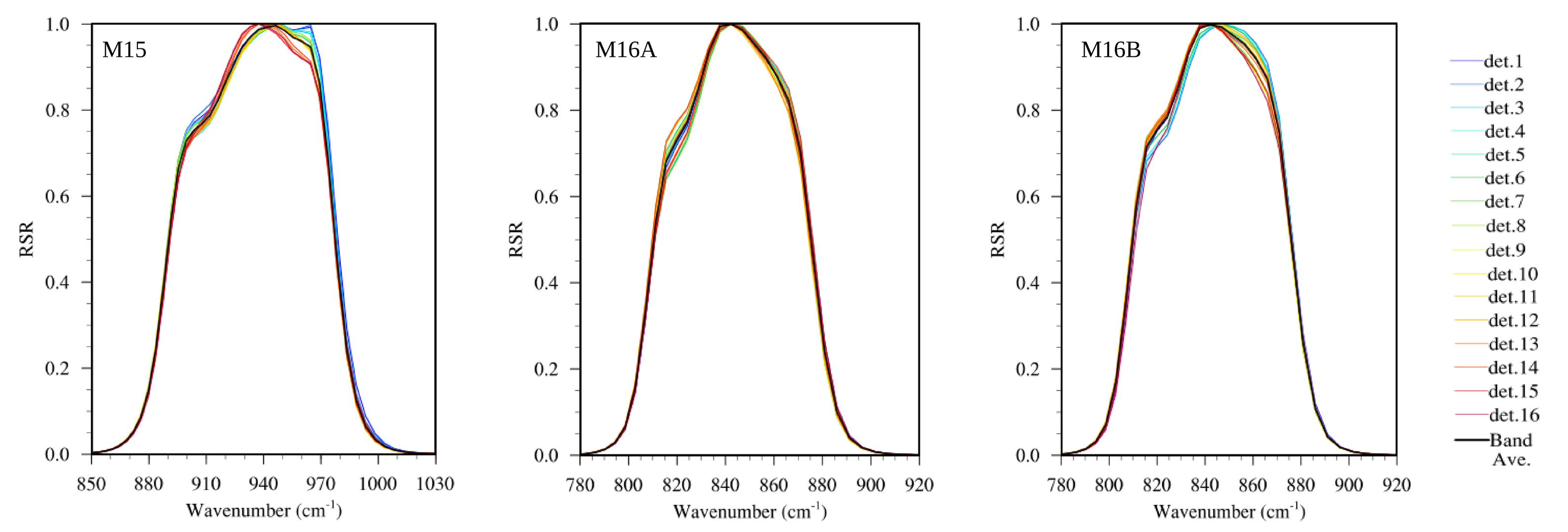


VIIRS TEBs RSR from S-NPP and NOAA-20

Band-averaged RSR

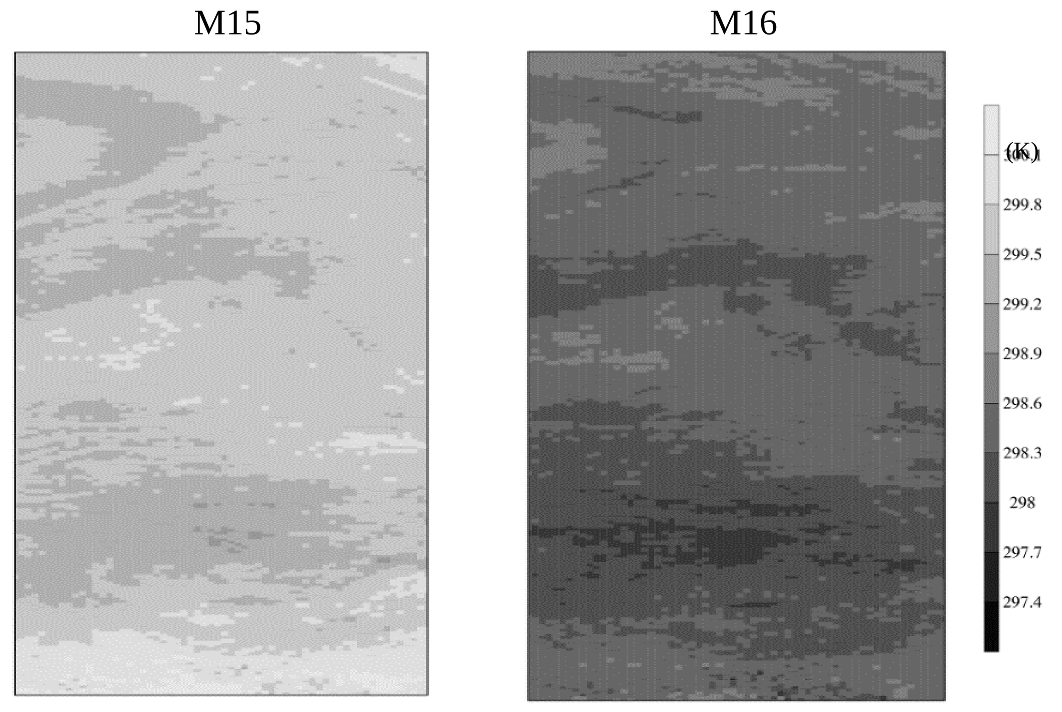


16 detector-level and band-averaged RSR for NOAA-20

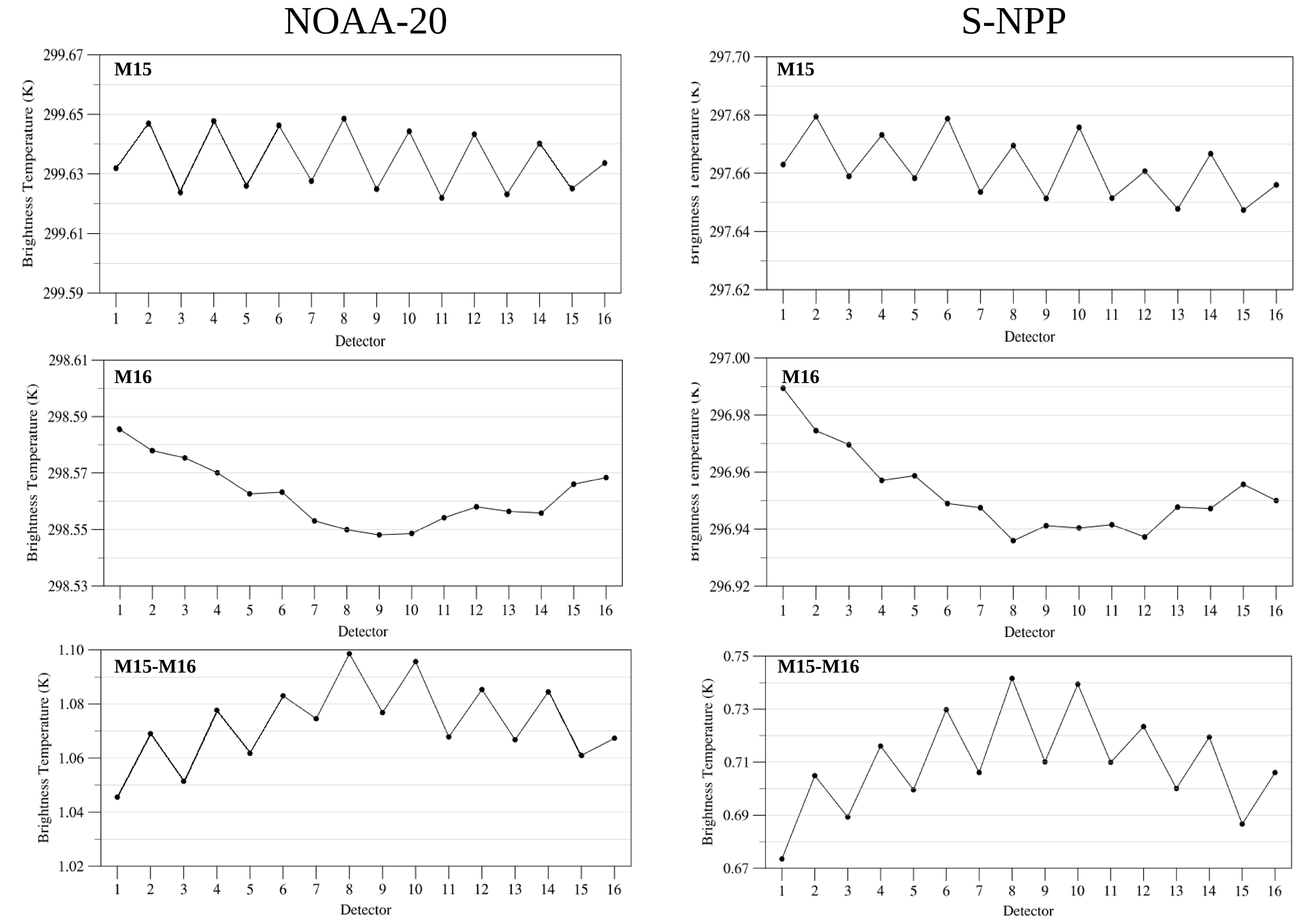


Case Study

The sample shows a clear-sky "uniform" open ocean surface near the Bay of Bengal on 21 April 2018. It has the size of 62 pixels along the scan direction and 16 scans × 16 detectors in the along-track direction.



Detector-averaged T_b



Summary

- There is a clear difference between difference S-NPP and NOAA-20 band-averaged TEB RSRs. LBLRTM simulation shows that such differences lead to a radiometric bias of larger than 0.02 K in M13 and M16 for all six representative atmosphere cases. There is also an atmospheric dependence although the difference is less than 0.06 K.
- The slight differences between detector-level and band-averaged RSRs on NOAA-20 VIIRS TEBs lead to odd/even detector-to-detector patterns. LBLRTM simulations show slight atmospheric dependencies, i.e., the T_b difference in the tropical atmosphere case is generally larger than that in the subarctic atmosphere case.
- Because the differences in observed T_b between M15 and M16 are used in the level-2 VIIRS SST EDR retrieval, $T_{b,M15} - T_{b,M16}$ is examined. The striping in $T_{b,M15} - T_{b,M16}$ is more apparent than that in single band of M15 and M16.
- A case study chosen from a "uniform" region near the Bay of Bengal shows that VIIRS SDR T_b observations are more variable than the LBLRTM simulations. While the major characteristics are very consistent. Moreover, the striping in the NOAA-20 TEBs tends to be 20% less than that in the S-NPP TEBs.

Acknowledgment

This work was supported by NOAA grant NA14NES4320003 (Cooperative Institute for Climate and Satellites -CICS) at UMD