EVALUATION OF AN OPTIMAL SPECTRAL SAMPLING RETRIEVAL ALGORITHM FOR THERMAL EMISSION SPECTROMETER RADIANCES

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Introduction:

We compare Mars Global Surveyor (MGS) Thermal Emission Spectrometer (TES) retrievals from the Planetary Data System (PDS; Smith et al., 2000) with new retrievals based the Optimal Spectral Sampling (OSS) radiative transfer (forward) model. The OSS method produces retrievals that show significant differences from the PDS retrievals. Both the PDS and OSS retrievals are compared to independent Radio Science (RS) occultation temperature retrievals following the methodology of Hinson et al. (2004). In addition to comparing with the coincident RS occultation profiles, both the PDS and OSS retrievals are assimilated into the GFDL Mars GCM using an ensemble Kalman filter.

Optimal Spectral Sampling:

OSS is a radiative transfer model specifically designed for the modeling of radiances as part of the retrieval process from operational sounders (Moncet et al., 2008). OSS is a monochromatic method that requires only a few spectral points to produce accurate radiances, as compared with the rigorous (but computationally intensive) line-by-line calculations.

An OSS-based retrieval algorithm model has been implemented for the TES instrument (Eluszkiewicz et al., 2008), accompanied by scripts that allow batch processing of TES radiances from the PDS. For the comparison, we focus on single-scan radiances measured by the TES Detector 2 during two time periods. The first is between Ls≈180° and Ls≈198° of Mars year (MY) 24 and the second is between Ls≈46° and Ls≈140° of MY 25. The MY 25 period is one of the largest periods of time when there are RS occultation profiles that are nearly coincident with TES observations and was one of the periods studied by Hinson et al. (2004).

During the MY 24 period, the OSS retrievals show overall qualitative agreement with the PDS profiles (Fig. 1). However, there are also significant differences, of up to 10 K in some regions (Fig. 2). The largest areas of disagreement are in the equatorial upper atmosphere and the polar regions (Eluszkiewicz et al., 2008). The causes of these differences are under investigation, as is the sensitivity of the OSS retrievals to various implementation options. The OSS retrievals also exhibit difference day and night behavior, with cooler night surface temperatures and reduced anomalies in the upper atmosphere (Fig. 3).

Comparison with Radio Science Occultation Profiles:

For validation of the OSS retrievals and as an independent comparison for evaluating OSS vs. PDS retrievals, as well as the results from assimilating both data sets, we use temperature profiles derived from Radio Science occultation experiments. RS profiles have higher resolution than TES profiles and can therefore pick up vertical structure that is missed by TES. While RS and TES zonally averaged temperature profiles are relatively similar, there are differences seen of up to 8 K (Hinson et al., 2004).

Comparison of Assimilation Products:

Coincident RS profiles with TES are only available above 65°N latitude, offering only limited opportunities for a direct comparison between the two retrieval methods. To further compare the OSS and PDS retrievals, we assimilate both products into a Mars GCM using an advanced data assimilation system. This allows the comparison of the full three-dimensional fields with the full RS occultation record.

GFDL Mars GCM. The GFDL Mars GCM (MGCM) was originally based on the GFDL SKYHI terrestrial GCM and has been used extensively in Mars studies (e.g. Wilson and Hamilton, 1996; Richardson and Wilson, 2002). The model configuration here is the finite volume dynamical core with 5x6 degree horizontal resolution and 28 hybrid vertical levels extending to roughly 85 km.

Local Ensemble Transform Kalman Filter. The retrievals are assimilated into the MGCM using the local ensemble Kalman filter (LETKF). The LETKF is an advanced data assimilation system that has been used in a range of terrestrial atmospheric and oceanic applications. The code is efficient, parallel, and highly modular and has been coupled to the MGCM and tested in identical twin experiments (Hoffman et al., 2010). In addition, the LETKF-MGCM system has been used to assimilate real retrievals from both the MGS TES instrument and the Mars Reconnaissance Orbiter Mars Climate Sounder (Greybush et al., 2010; Greybush et al., 2011).

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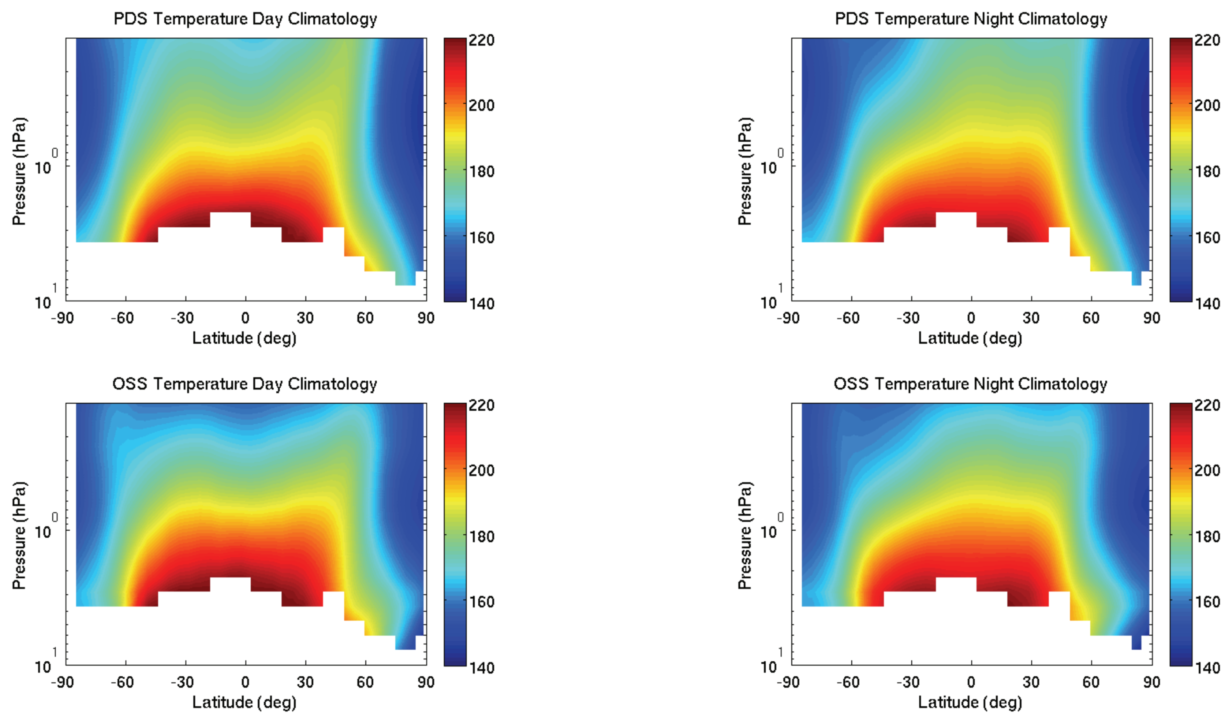

Figure 1: Zonally averaged retrievals from PDS (top) and OSS (bottom) during the day (left) and night (right).

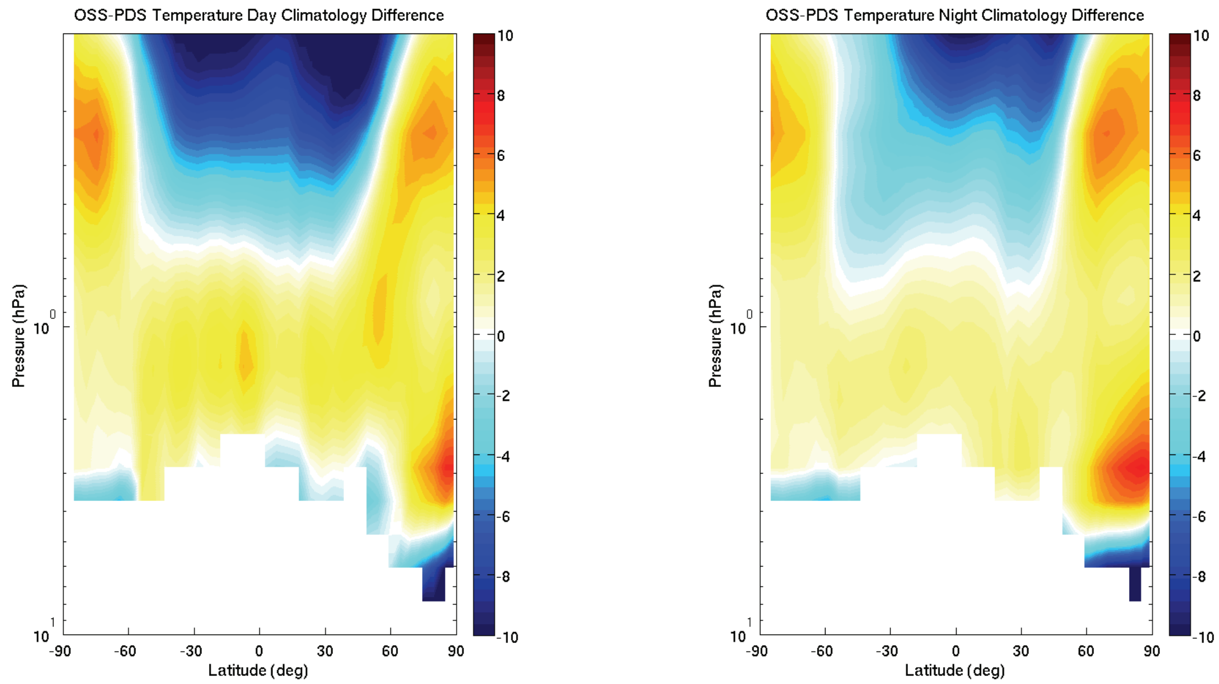

Figure 2: Day (left) and night (right) temperature differences (K) between the zonally averaged OSS temperature profiles and the PDS profiles.

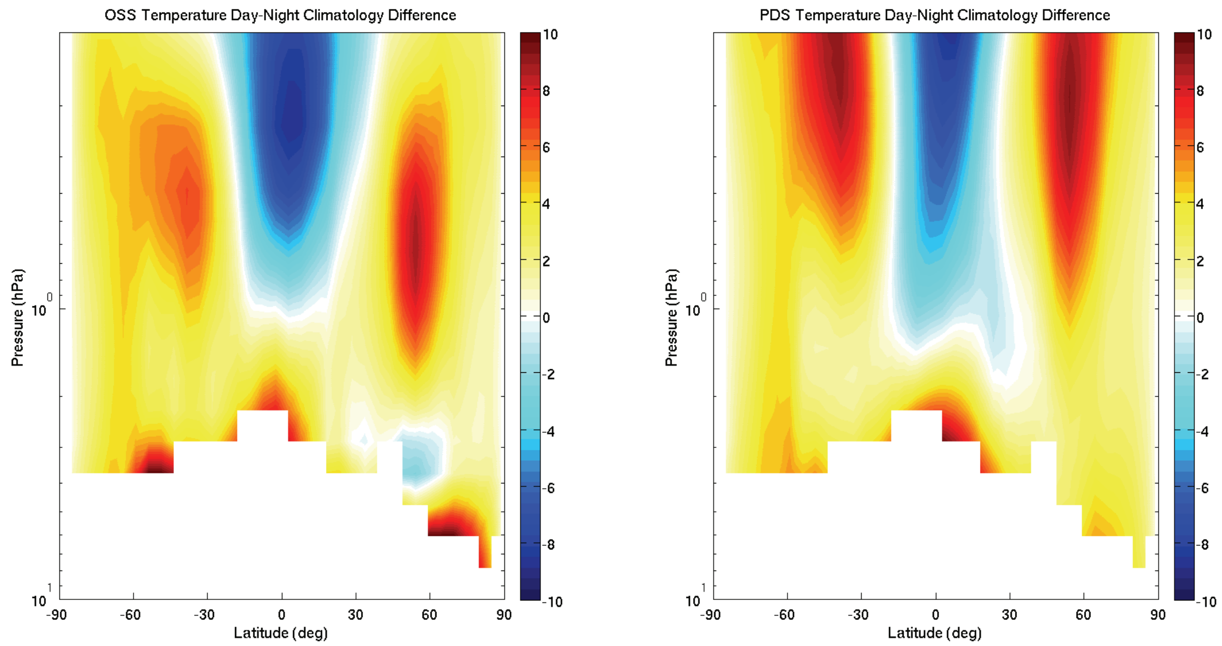

Figure 3: Day minus night temperature differences (K) for OSS (left) and PDS (right) profiles.