Investigating Climate Trends in 14 Years of AERI Data at the ARM SGP Site

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Introduction

Ground-based measurements of downwelling infrared radiance have a rich information content: H_2O and CO_2 absorptions bands, the 8-12 μm atmospheric window and the far-infrared regions (Figure 1) provide data on profiles of atmospheric temperature, water vapor and aerosol and cloud microphysics. Furthermore, a long term time series of such observations can be used to observe trends in the climate, given that the measurements are made with demonstrable accuracy. The ARM program has collected infrared spectra from the Atmospheric Emitted Radiance Interferometer (AERI) at the SGP site since the mid 1990's. The AERI regularly views high-accuracy blackbody calibration targets that have been tested against NIST standards. Thus the accuracy of the AERI observed infrared radiance is robust over the past decades. Any statistically significant trend in the AERI data over this time can be attributed to changes in the atmospheric composition, and not to changes in the sensitivity or response of the instrument.

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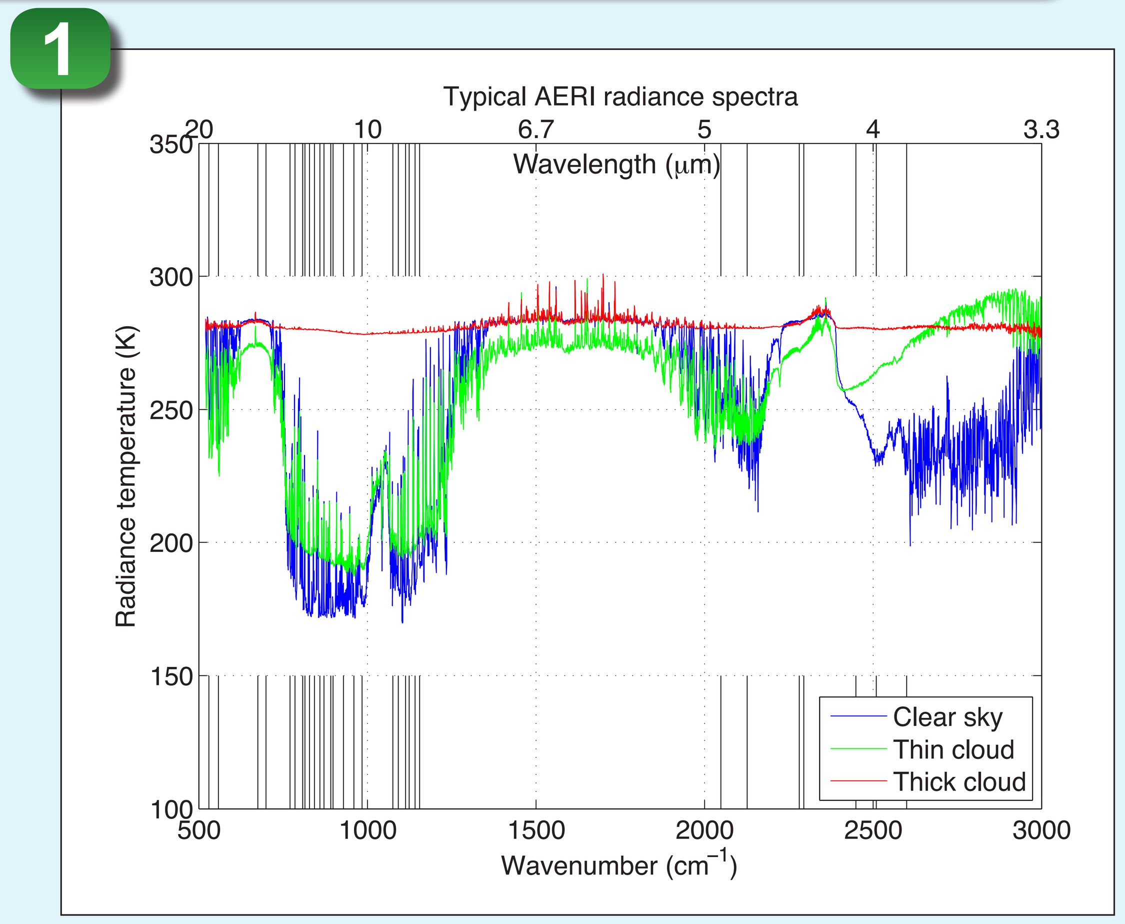

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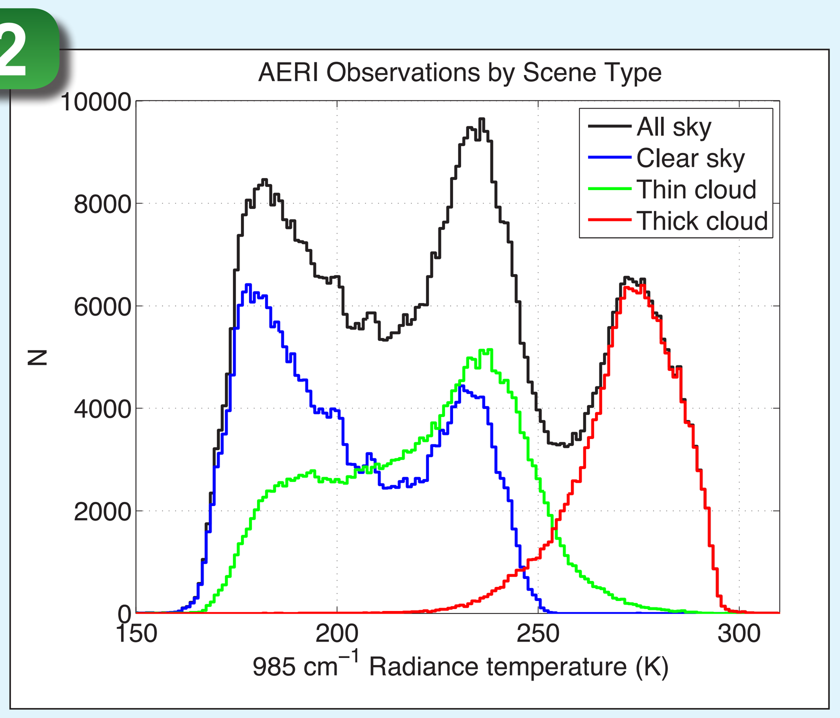

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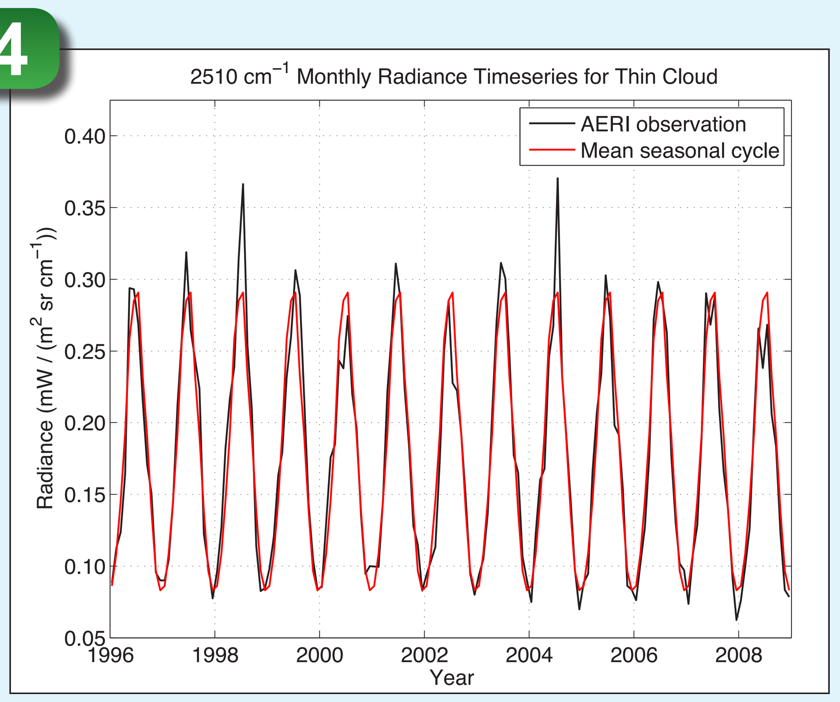

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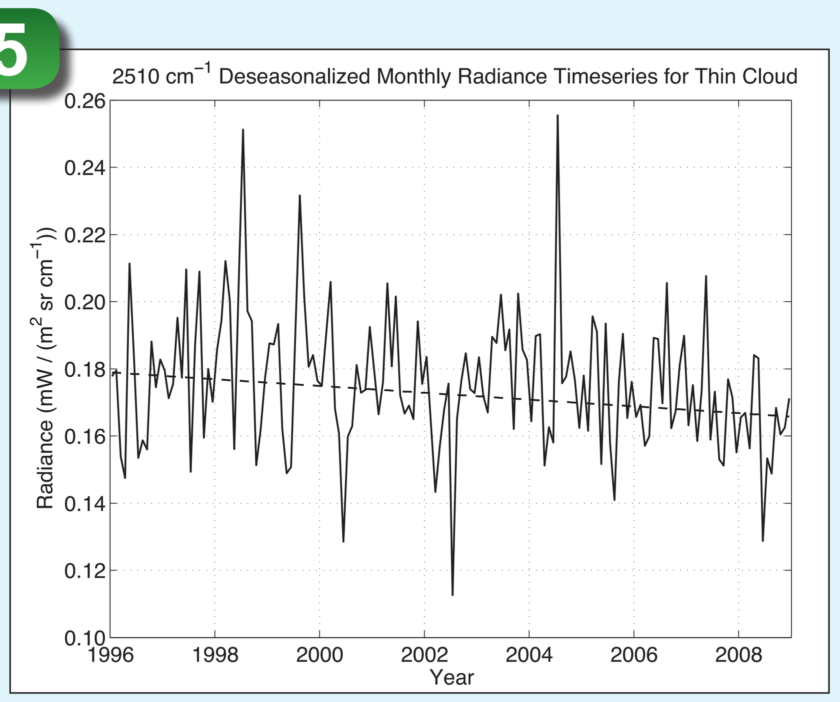

Scene Type Selection

We have analyzed the AERI time series from 1996 through 2008, which is comprised of **751,208 reliable spectra**. A histogram of the 985 cm^{-1} radiance temperature shows a trimodal distribution (Figure 2) corresponding to various cloud regimes. We have used a neural network, trained using Raman lidar observations over a 14 month period in 2007-2008, to identify clear vs. cloudy conditions in the AERI radiance data (Figure 3). We have further broken down the cloudy data into optically thin and thick classifications. Typical spectra from each classification are shown in Figure 1.

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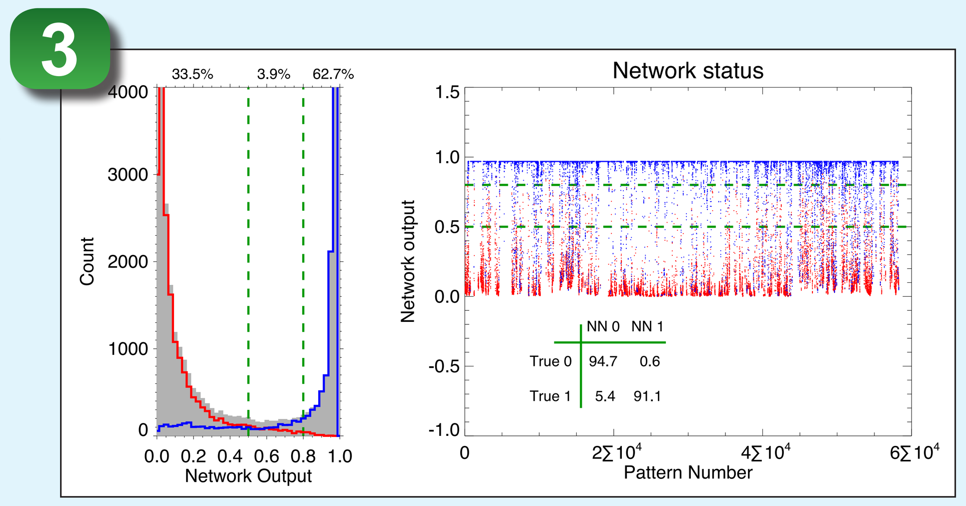

Trend Detection

We took monthly averages of the dataset. Of the 156 months of data, only 3 had less than 2500 reliable spectra (Figure 6). The data from these 3 months were not used in the trend analysis, as they did not contain sufficient synoptic variability. Specific microwindows were selected from the spectra (Figure 1, black lines). A resulting radiance time series is shown in Figure 4. The data were deseasonalized and the trend was calculated using a least squares regression weighted by the variance and number of data points (Figure 5). The 95% confidence interval for the trends was computed using the method of Weatherhead et al. (JGR 1998).

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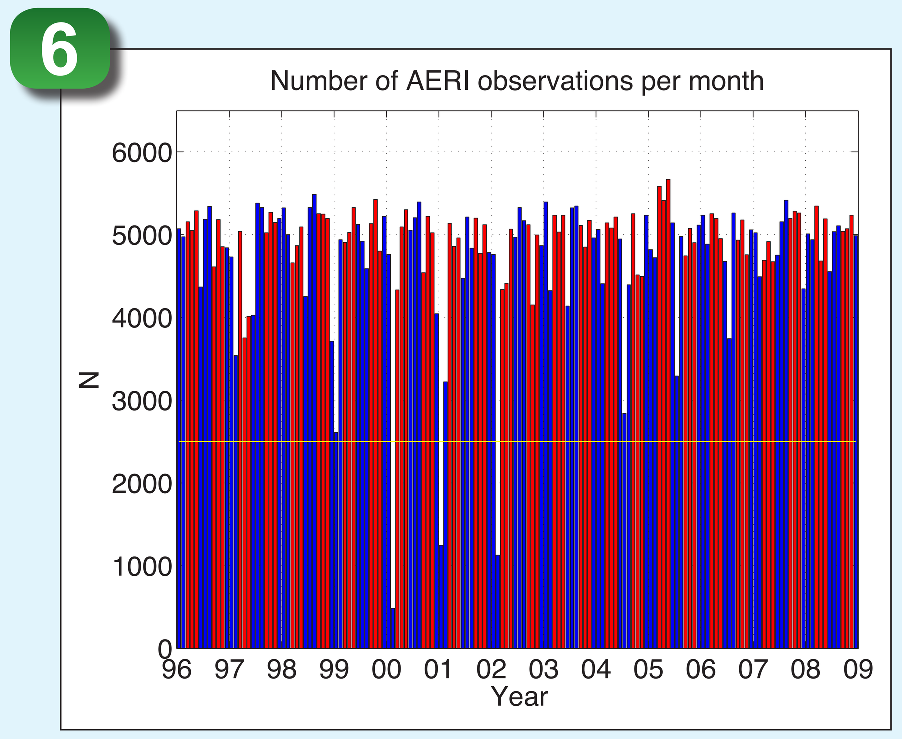

Trend Results

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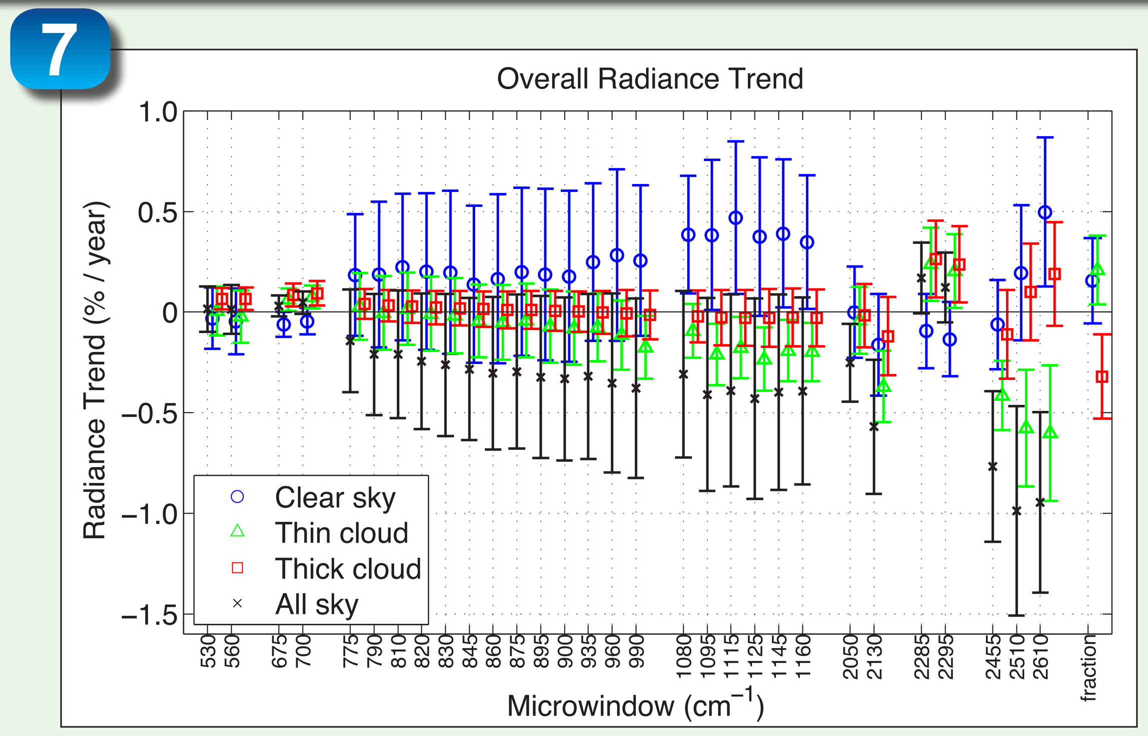

Error bars signify 95% (2σ) confidence intervals

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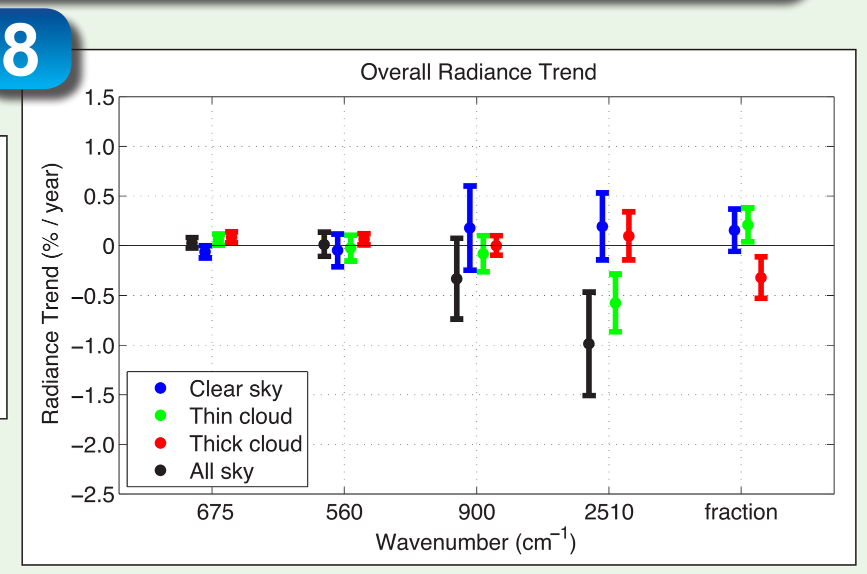

The trends for each scene type for a selection of 30 microwindows are shown in Figure 7. Few significant climactic trends emerge from the overall time series. As the data are parsed seasonally (Figures 9-12), however, significant trends become evident. For example, thick clouds in the winter have a positive trend, suggesting that the clouds may be getting warmer or lower. Clear sky scenes in the winter are getting colder, which can be attributed a decreasing trend in water vapor. The strong positive trend clear sky autumn radiance at shorter wavelengths, but not at higher ones, may be attributed to a changing aerosol layer.

Seasonal Trends

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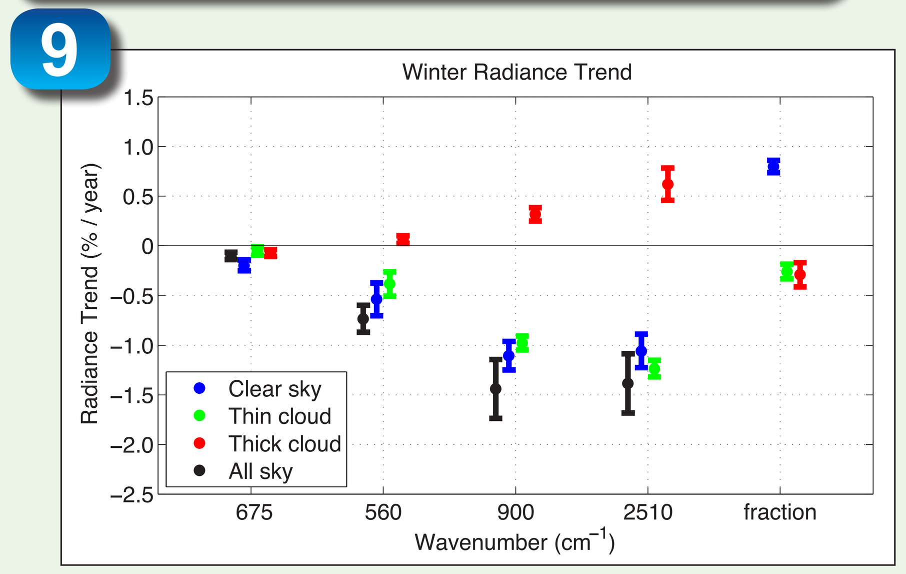

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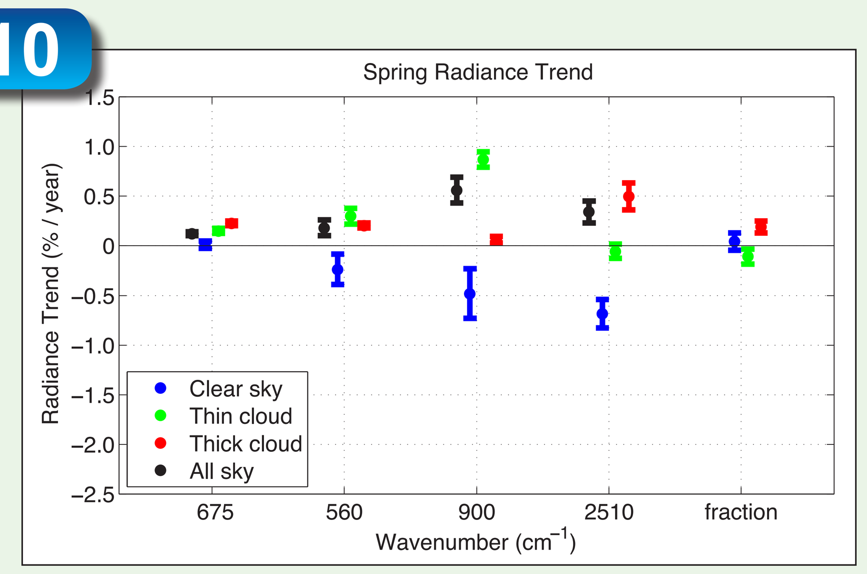

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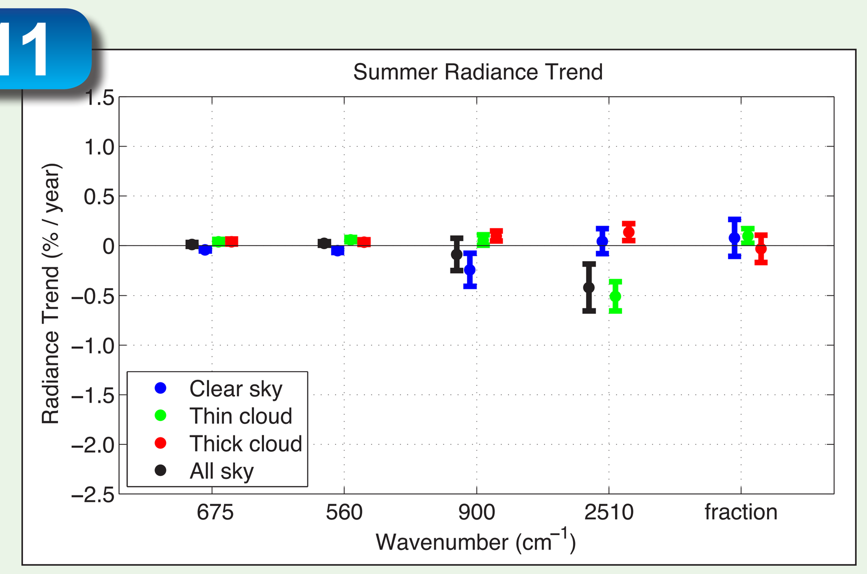

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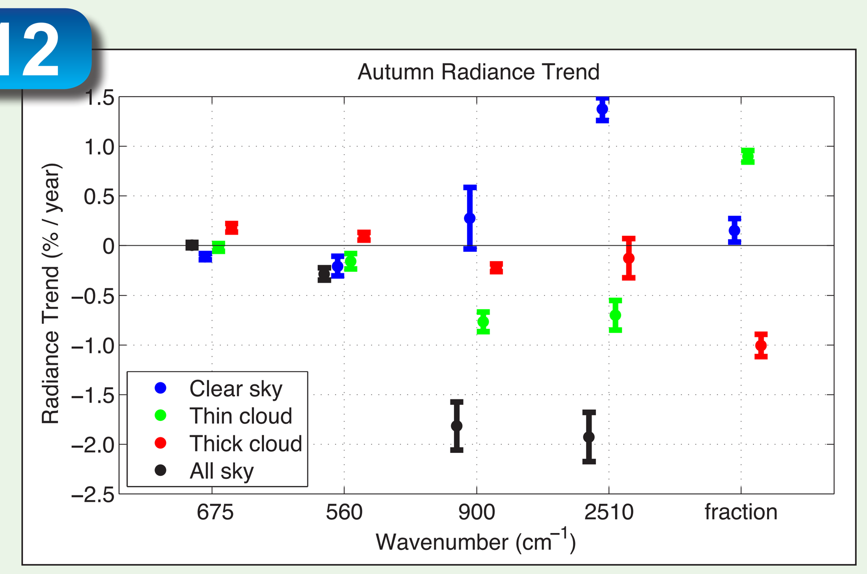

Diurnal Trends

While the trends in the summer are not large, separation of the thin cloud results (for example) into diurnal components reveals two distinct physical phenomena (Figure 13): The slope of the trends increasing towards higher wavelengths is indicative of a trend towards clouds with smaller effective radii, whereas the overall vertical shifting of the trends reveals diurnal dependence in the cloud radiance.

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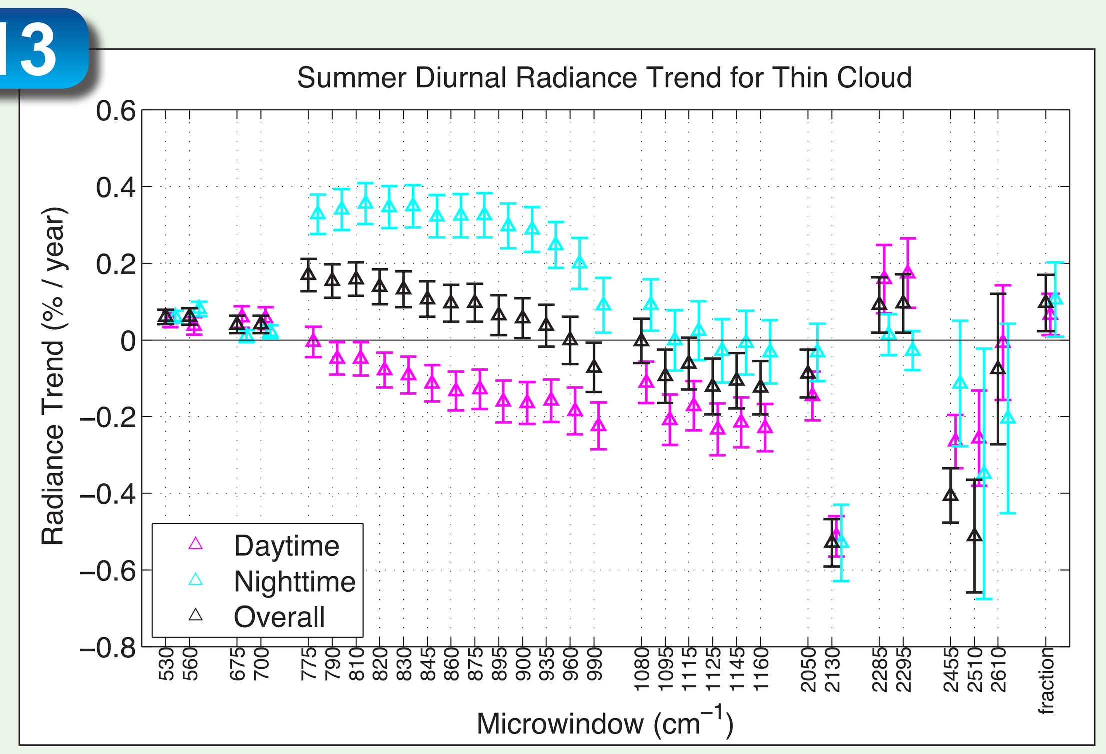

Summary

Significant climactic trends are obtained from the AERI radiance dataset when looking at the data on a seasonal or diurnal scale. Further work can be done to study and attribute physical mechanisms to the observed trends. Given the decadal timespan of the dataset, effects from natural variability should be considered when drawing broader conclusions. The high value of these accurate spectral observations reinforces the importance of maintaining the AERI time series at SGP and other sites worldwide, as its value for climate studies will appreciate as the dataset grows with time.