A Library of Whole Earth Spectra with AIRS

Thomas Hearty

Jet Propulsion Laboratory/California Institute of Technology, Pasadena, CA 91109

Thomas.J.Hearty@jpl.nasa.gov

Inseok Song and Sam Kim

Gemini Observatory, Hilo, Hawaii, 96720

Giovanna Tinetti

Institut d'Astrophysique de Paris, 98bis, bld Arago,75014 Paris, France

Abstract

We have investigated mid-IR spectra of Earth obtained by the Atmospheric Infrared Sounder (AIRS) instrument on-board the AQUA spacecraft to explore the characteristics that may someday be observed in extrasolar terrestrial planets. We have used the AIRS infrared (R $\sim$ 1200; 3.75-15.4 microns) spectra to construct directly-observed high-resolution spectra of the only known life bearing planet, Earth. The AIRS spectra are the first such spectra that span the seasons. We also used the 4 Visible/Near-Infrared Channels of AIRS to investigate the vegetation signatures that might be observed in the visible. Additionally, we investigated the diurnal and seasonal variations as well as spectral variations that would arise due to varying cloud amount and viewing geometry.

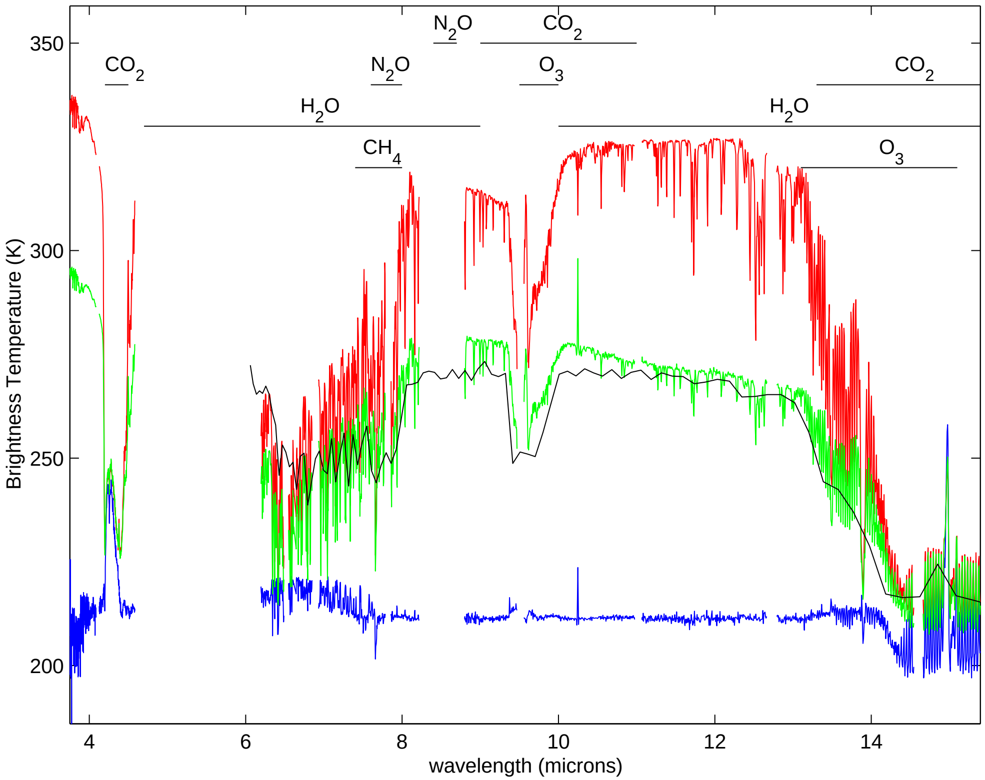


Figure 1: Three AIRS spectra from September 6th, 2002 are displayed to illustrate the diversity of Earth spectra. The warmest spectrum (red) is of the daytime Sahara, the next cooler spectrum (green) is the daytime pacific near the equator, and the coldest spectrum (blue) is of Antarctica. The lower resolution spectrum (black) is a spectrum of Earth obtained with the TES instrument on MGS in 1997. The TES spectrum which was of the daytime pacific is very similar to the AIRS spectrum over the pacific.

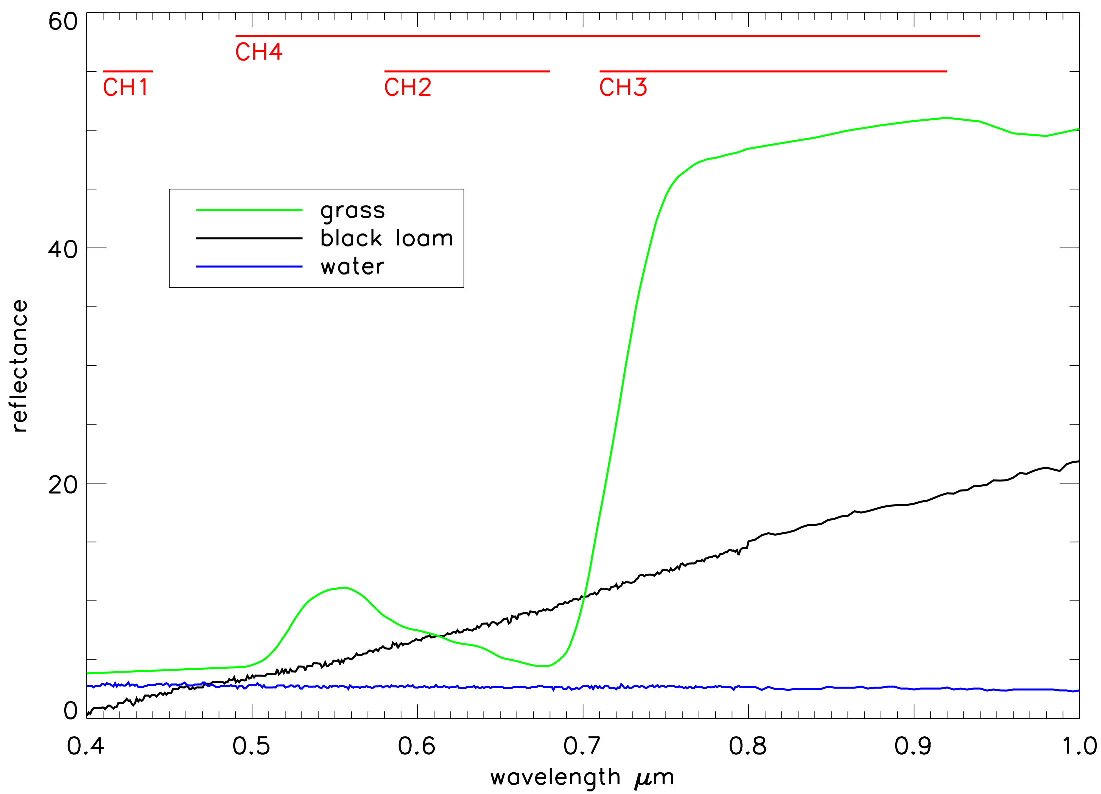


Figure 2: The band passes of the AIRS Visible Near-infrared channels are displayed in red along with reflectance spectra provided in the ASTER spectral library is displayed for grass, black loam, and water. The red edge $\sim 0.75\ \mu$m due to photosynthetic plants is a potential observable in extrasolar terrestrial planets.

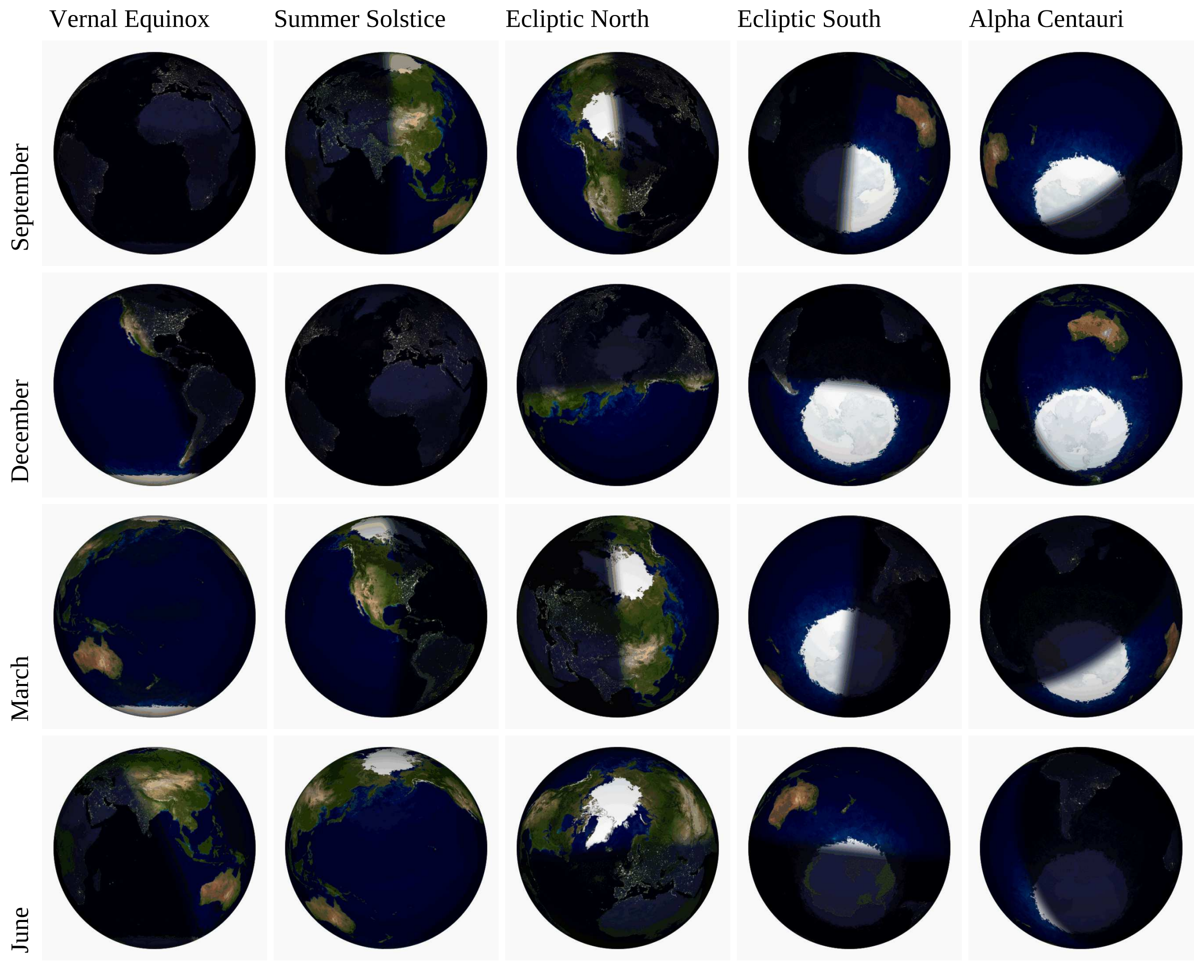


Figure 3: Views of Earth at 0 UT are displayed for the 5 views examined in this study.

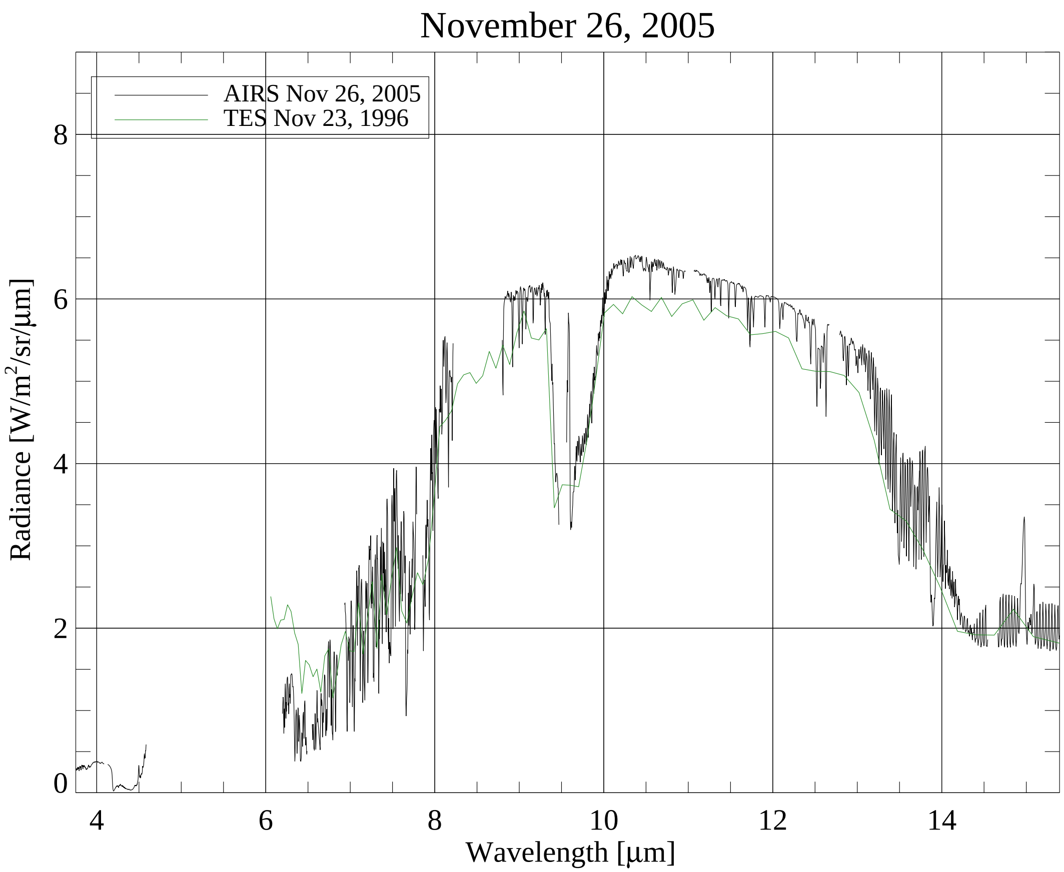


Figure 4: AIRS observations from November 26, 2005 are compared with a TES observation of Earth from November 23, 1996.

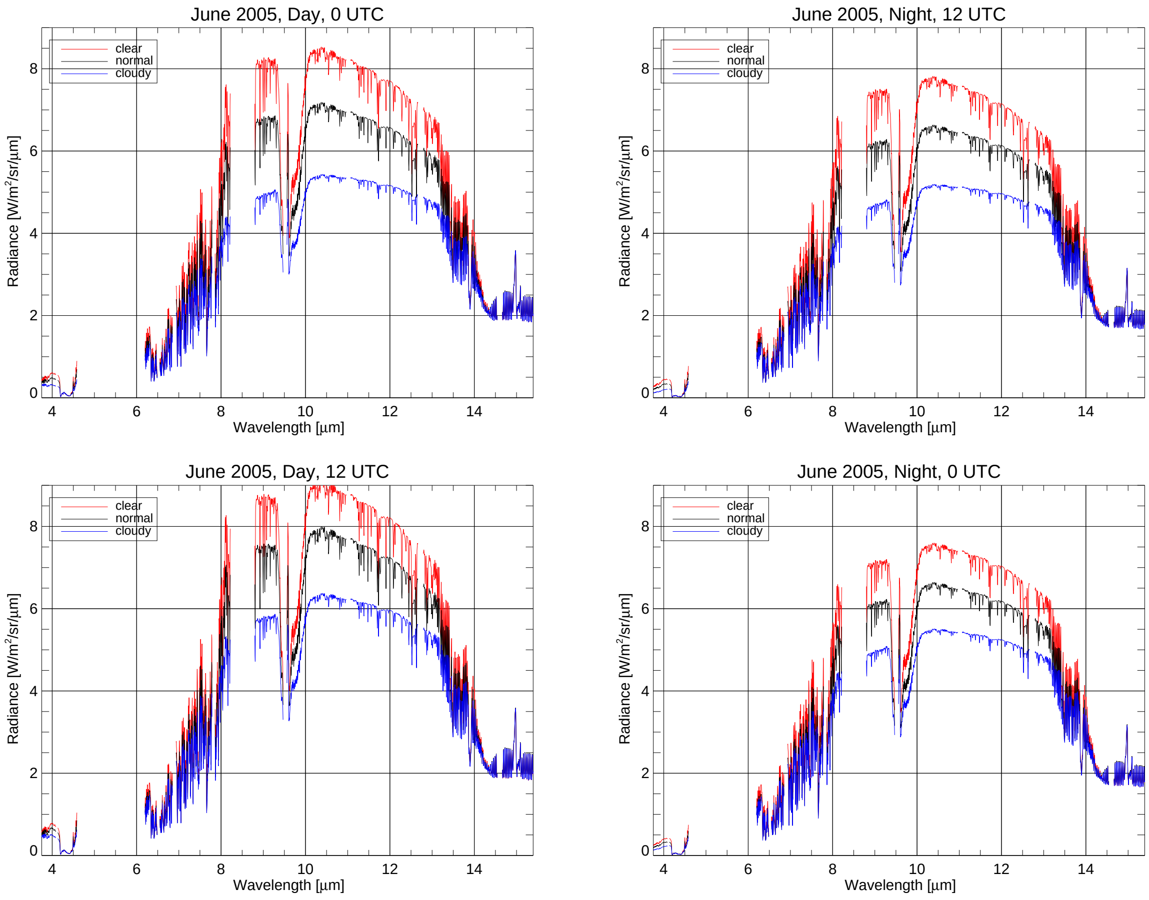


Figure 5: Clear, Normal, and cloudy whole earth spectra are displayed for a view of Earth from the summer solstice on June 26, 2005 at 0 UTC and 12 UTC and compared with a synthetic spectrum from the virtual planet laboratory. The spectral variation due to clouds is larger than the diurnal variation

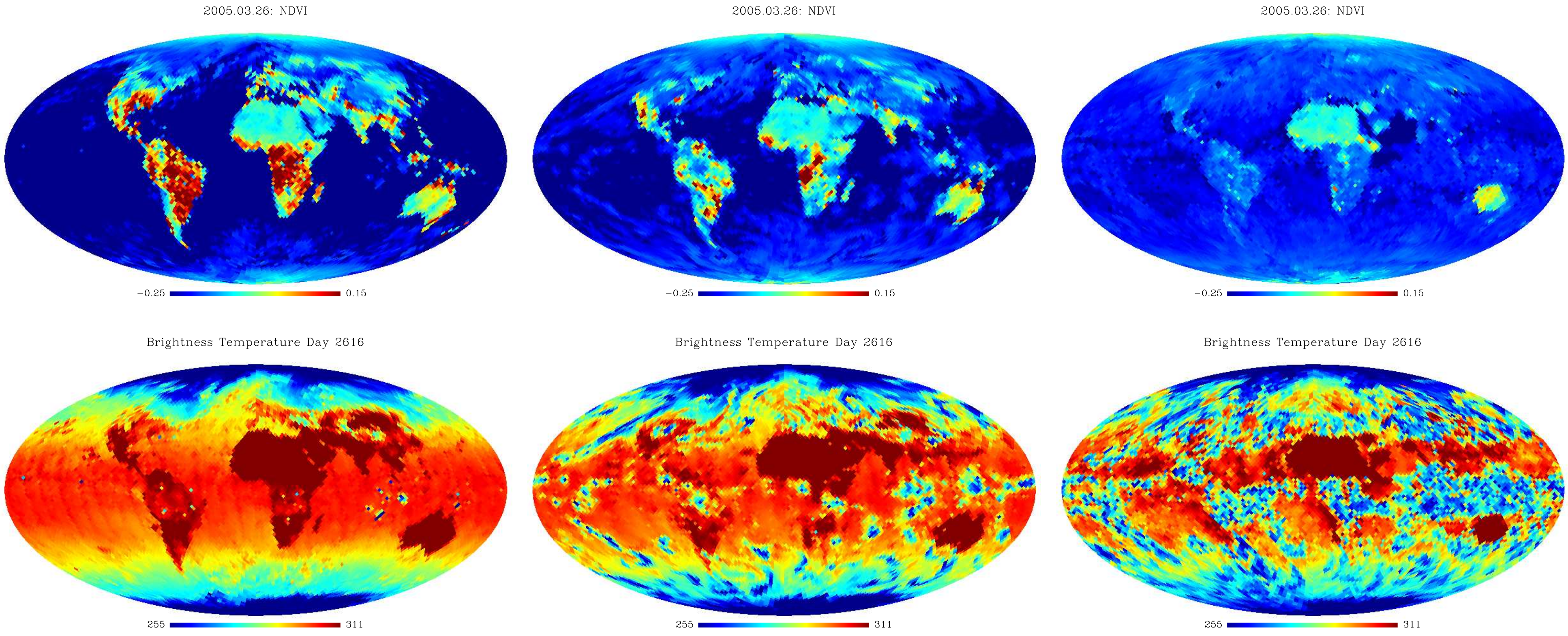


Figure 6: The three top figures are maps of NDVI for clear scenes (left), the actual earth (middle), and a cloud covered earth (right). NDVI is defined as $\frac{CH3-CH2}{CH3+CH2}$. The three bottom figures are maps of the daytime infrared brightness temperature of the Earth at 3.8 μm

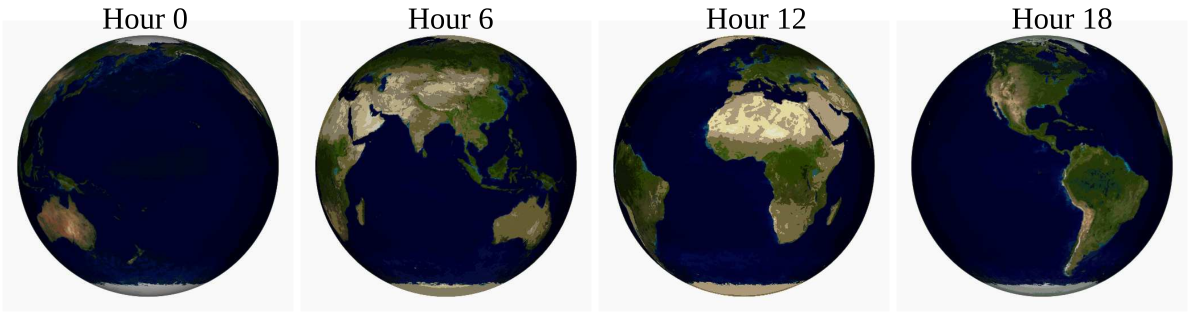


Figure 7: The view of Earth as seen from the sun at four different times on March 26, 2005.

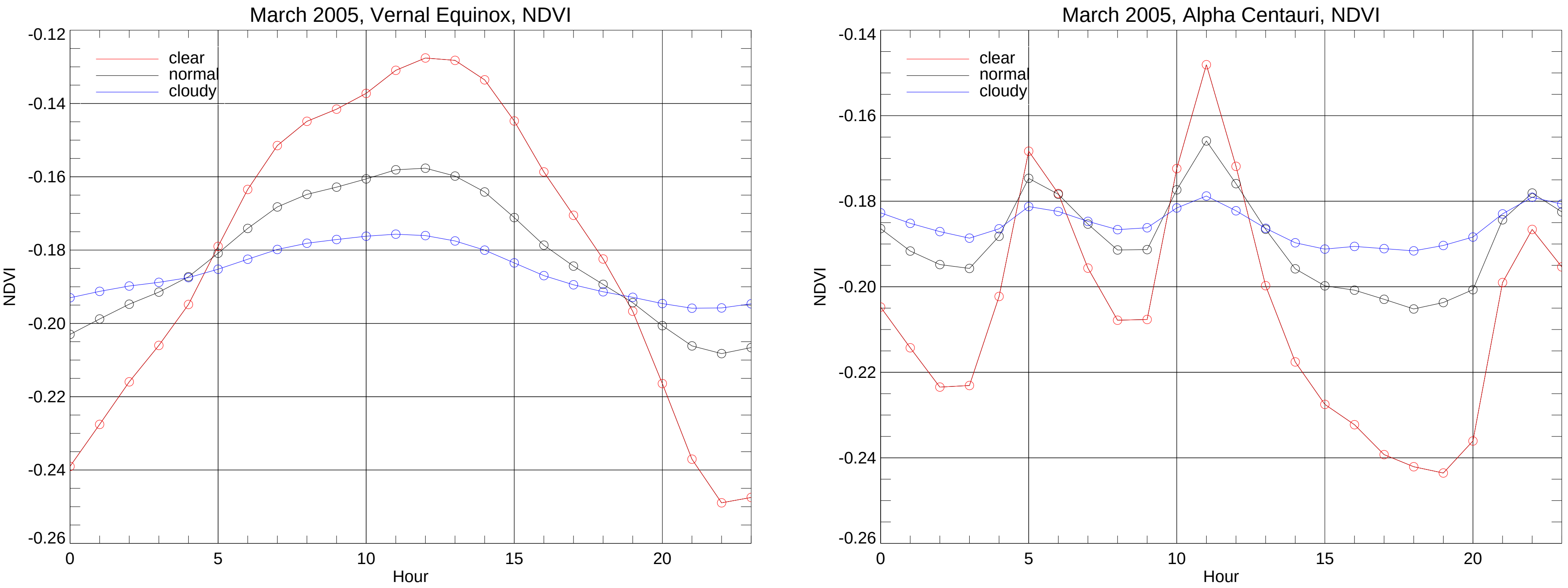
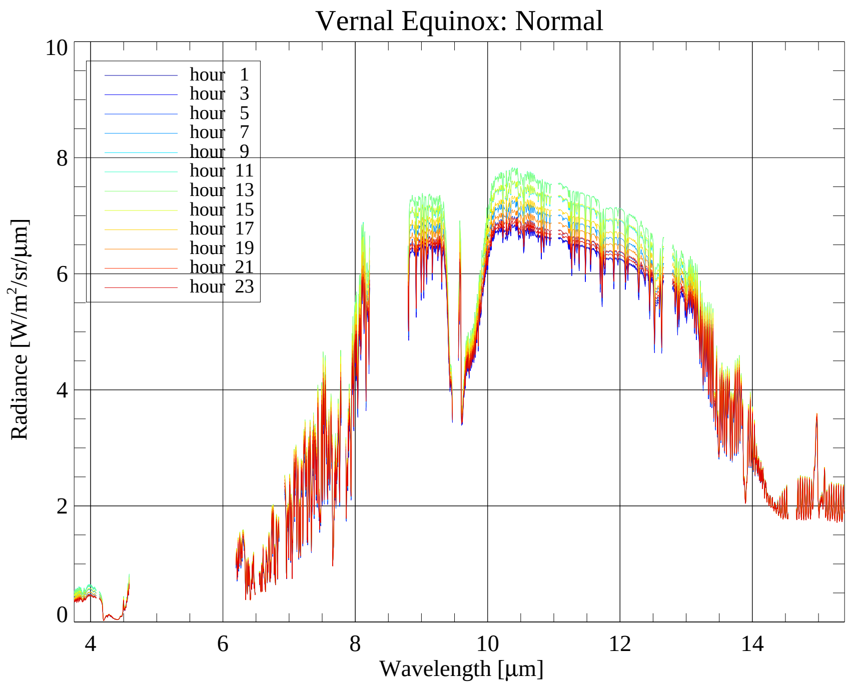


Figure 8: Lightcurves of NDVI are displayed for clear, normal, and cloudy scenes on March 26, 2005.



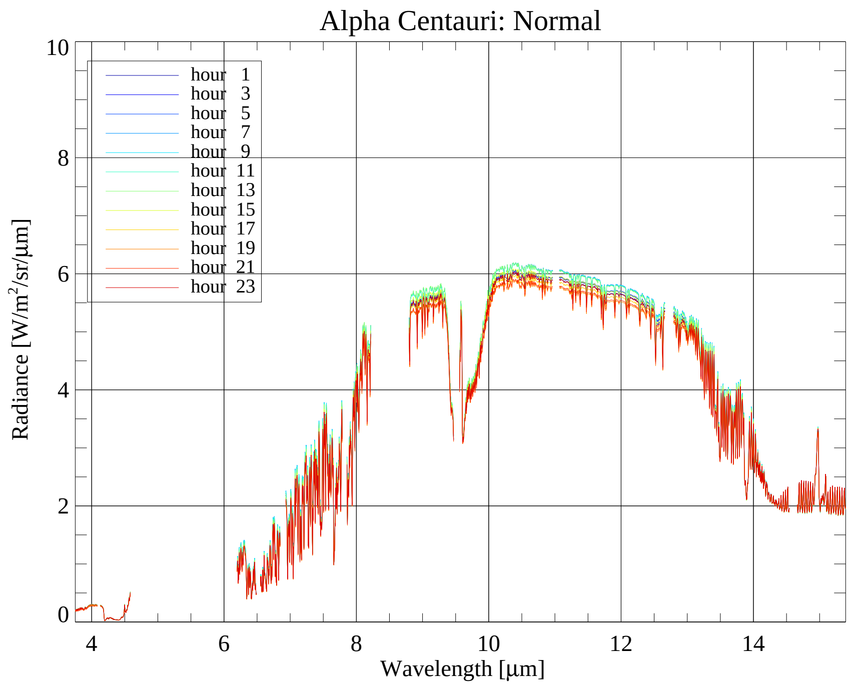


Figure 9: Infrared spectra are displayed for clear, normal, and cloudy scenes with 2 different viewing geometries on March 26, 2005.

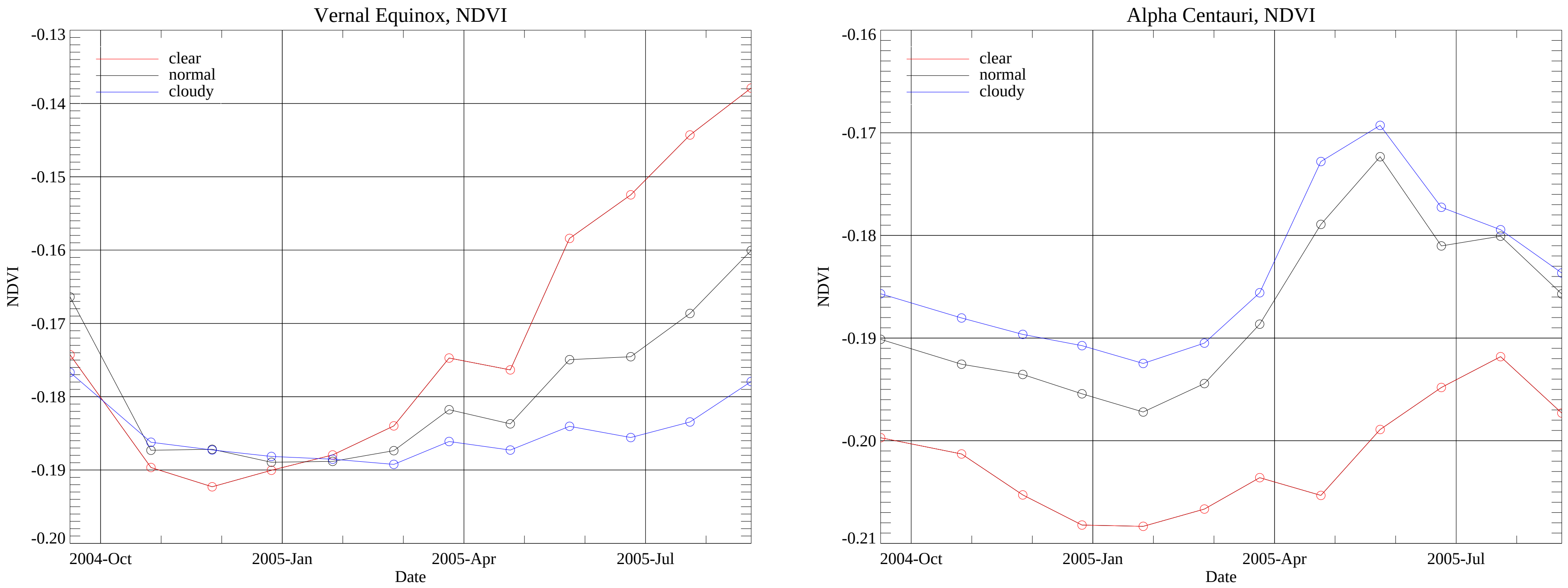


Figure 10: Lightcurves of NDVI as seen from 5 difference viewing geometries are displayed for clear, normal, and cloudy scenes for a year of observations.

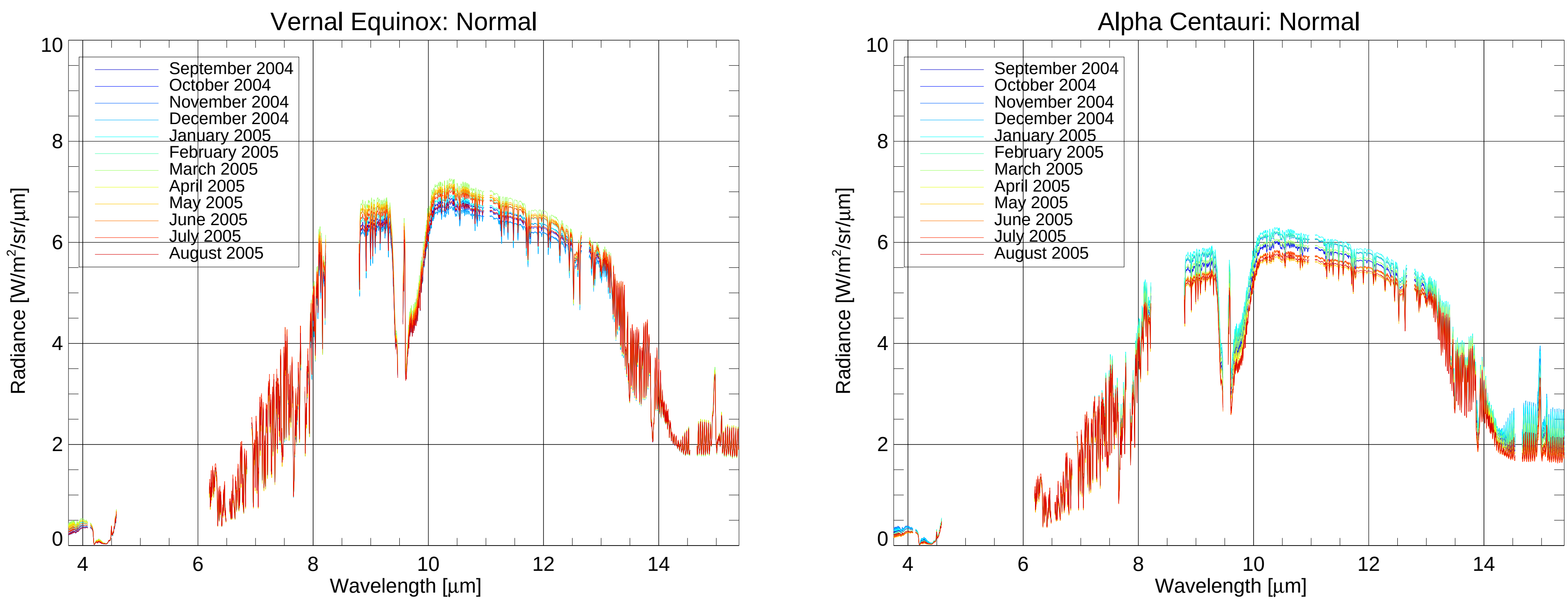


Figure 11: The Seasonal variations are displayed for 5 viewing geometries for Clear, Normal, and Cloudy cases.

Conclusion

- The Cloud amount will be the largest source of uncertainty in characterizing earth-like extrasolar planets.
- viewing geometry can also influence the interpretation of spectral features.
- NDVI can be an indicator of vegetation, but it is attenuated by clouds.