Earth as an Extrasolar Planet

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The NASA Astrobiology Institute’s VPL 3-D spectral Earth model simulates Earth’s appearance to a distant observer (Tinetti et al. 2006, Robinson et al. 2010). Spatially-resolved, data-specific observations of key surface and atmospheric properties are taken from Earth-observing satellites and used as input. Specular reflectance from liquid water surfaces as well as scattering from liquid and ice water clouds are all realistically simulated in our model. Figure 1 shows a true-color image generated by our model as compared to an image from NASA’s EPOXI mission.

Validation

Model validation against disk-integrated, time-resolved observations of Earth include:
• visible photometric (0.3-1.0 µm) (NASA/EPOXI)
• NIR spectroscopic (1.05-4.8 µm) (NASA/EPOXI)
• MIR spectroscopic (6-15 µm) (AIRS)

Figure 2 shows a comparison of our model to EPOXI and AIRS data, and residuals are typically less than about 7%.

Clouds and continuum absorption from water vapor can prevent thermal radiation from Earth’s surface from escaping to space, obscuring direct measurements of Earth’s surface temperature from disk-integrated, MIR spectra. Figure 3 shows simulated disk-integrated brightness temperature spectra of Earth from our model both with and without clouds, demonstrating the ability of atmospheric effects to obscure measurements of surface temperature. This effect is slightly less pronounced in pole-on spectra.

Conclusions

• Our model successfully reproduces high-resolution spectral and phase-dependent photometric observations of Earth, at wavelengths from the ultraviolet to the mid-infrared.

• Glint from the Earth’s oceans can produce as much as a 100% increase in observed brightness at crescent phases and can be discriminated from a similar brightening due to forward-scattering clouds.

• Clouds and continuum absorption from water vapor prevent direct measurement of Earth’s surface temperature from disk-integrated, MIR spectral observations, and reduce the maximum observed brightness temperature by as much as 20 K.

References & Acknowledgements


Tinetti, G., Meadows, V.S., Crisp, D., Fong, W., Fishbein, E., Turnbull, M., Birg, J.P. 2006, Astrobiology, 6, 34.

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