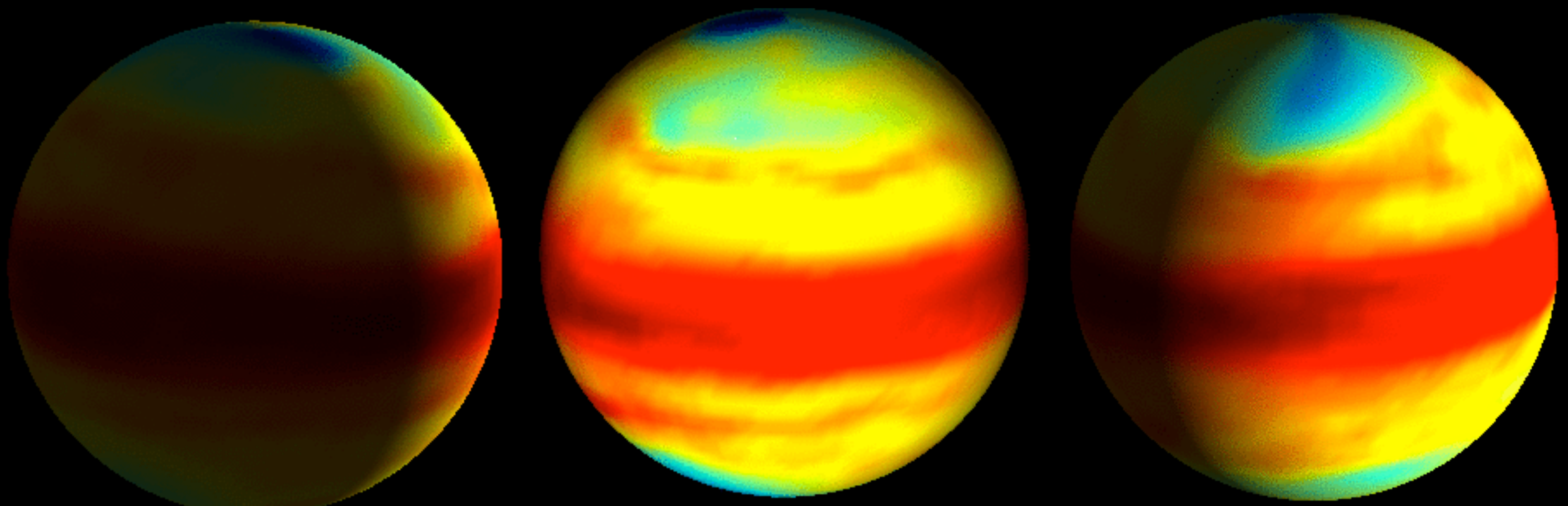
Chemistry of Exoplanet Atmospheres: Linking Three-Dimensional Chemical, Dynamical and Radiative Processes



Nikole K. Lewis

The SPARC Model

- I will provide key updates to the three-dimensional Substellar and Planetary Atmospheric Radiation and Circulation (SPARC) model to incorporate atmospheric chemical processes.

Dynamics

Calculate wind speeds and temperatures given heating rates

Radiative Transfer

Solve for heating rates given pressure, temperature, and chemical abundances

Chemistry

Determine chemical abundances given chemical and dynamical timescales and overall atmospheric composition

Disequilibrium Carbon Chemistry

- I will investigate the three-dimensional nature of disequilibrium carbon chemistry in the atmospheres of HD 209458b, HD 189733b, and GJ 436b.

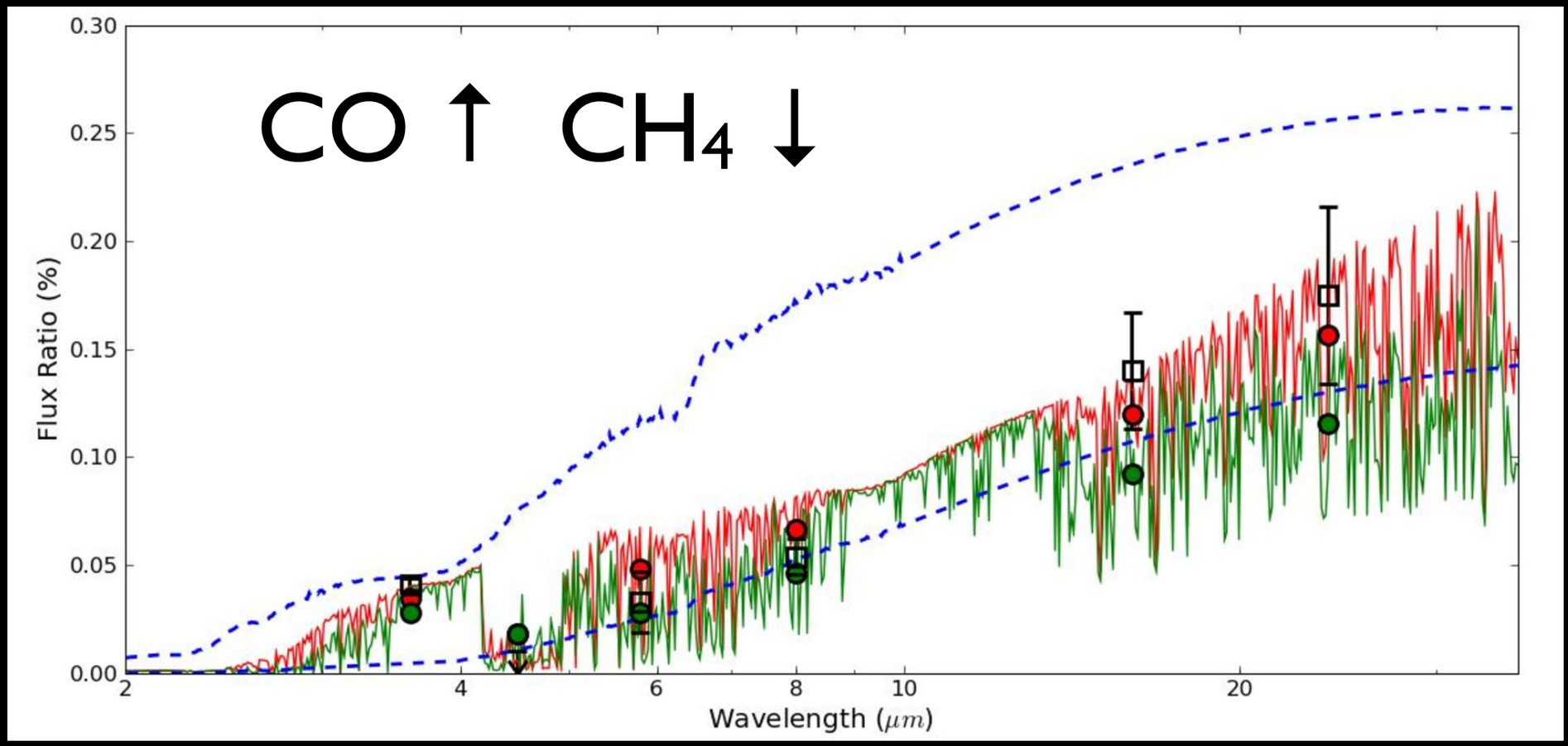
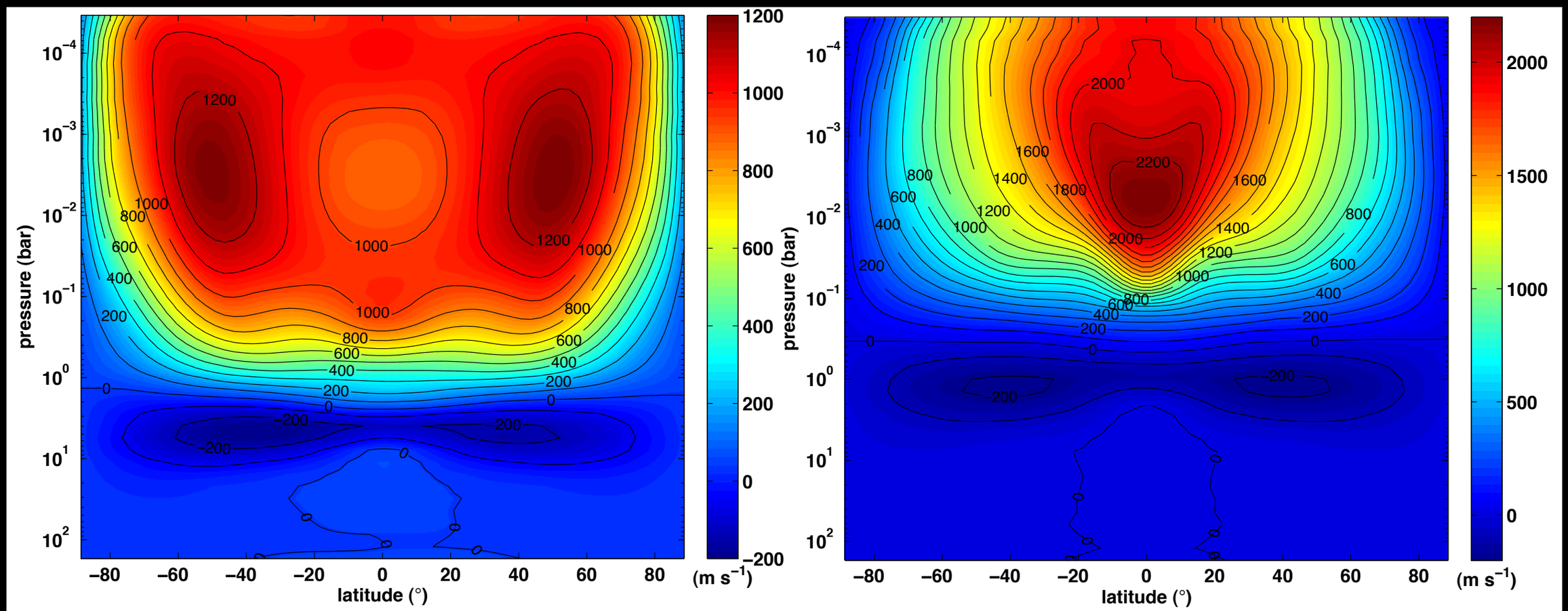


Figure from Stevenson et al (2010) shows dayside emission observations are best fit by model spectra with disequilibrium abundances of CO and CH_4. Disequilibrium chemical abundances are the result of the interplay between chemical and advective timescale and can vary with pressure, latitude, and longitude.

Carbon Rich/Poor Atmospheres

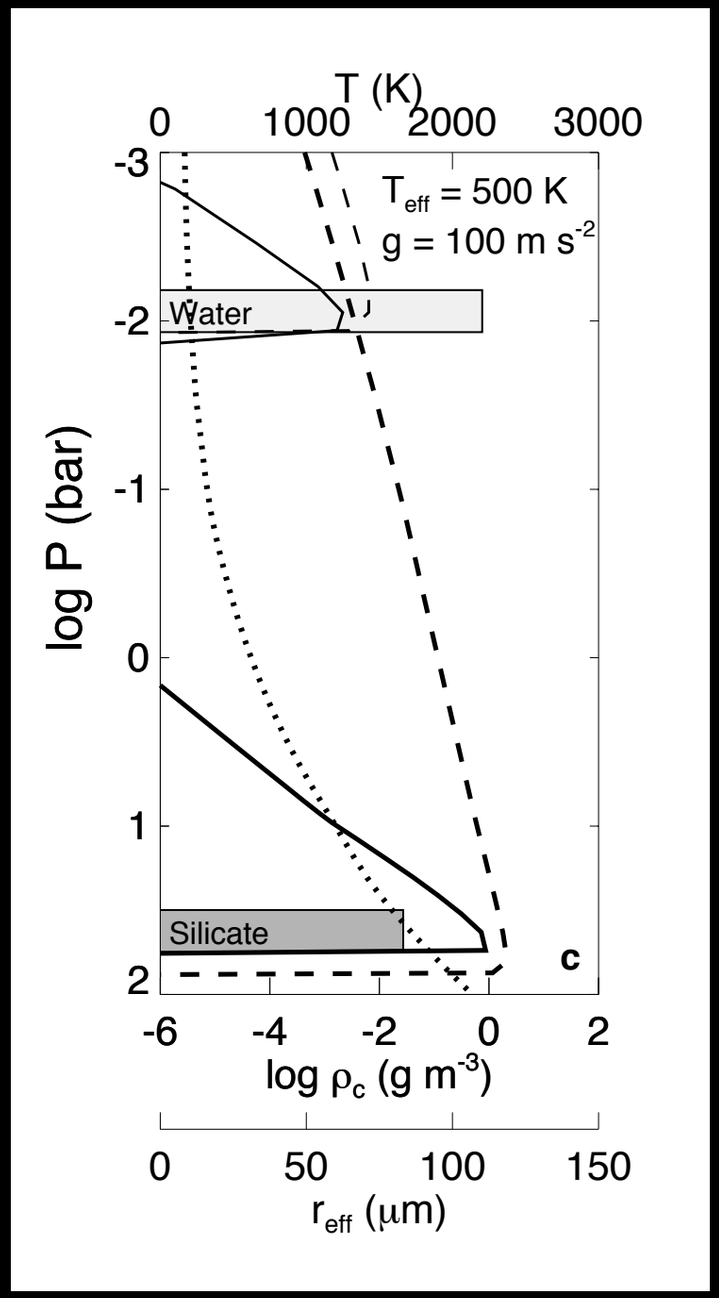
- I will integrate carbon rich and carbon poor opacity databases into the SPARC model to explore how changes in composition affect global circulation patterns.



Zonal mean-zonal wind plots for 1x (left) and 50x (right) solar metallicity atmosphere for GJ 436b. Specific changes to the C/O ratio in exoplanet atmospheres could significantly alter global wind and thermal patterns.

Cloudy Exoplanets

- I will explore three-dimensional cloud formation in the atmospheres of exoplanets and investigate the effect of atmospheric hazes on the observed flux from the planet.



Cloud condensation model from Ackerman & Marley (2001) for a generic extrasolar giant planet. Thus far the possible presence of clouds in exoplanet atmospheres has been largely ignored. The presence of clouds and the uniformity of their distribution can significantly change the predicted flux from the planet as a function of wavelength and orbital phase.