Atmospheric Circulation of Brown Dwarfs and Directly Imaged Extrasolar Giant Planets Driven by Cloud Radiative Feedback

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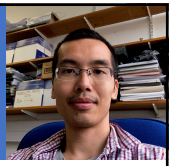
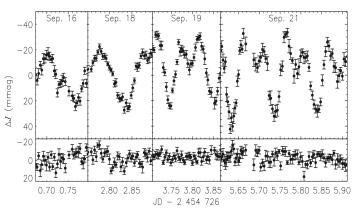
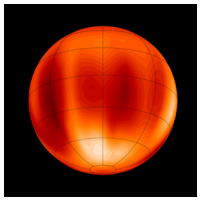


Evidence of weather on brown dwarfs:

- Photometric/Spectroscopic variability.
- Doppler imaging of surface inhomogeneity.
- Wind speed measured from radio and IR lightcurve variability.
- Measured polarization and its time variability.
- Sudden L to T dwarf transition.
- Chemical disequilibrium driven by mixing.



Artigau + (2009)



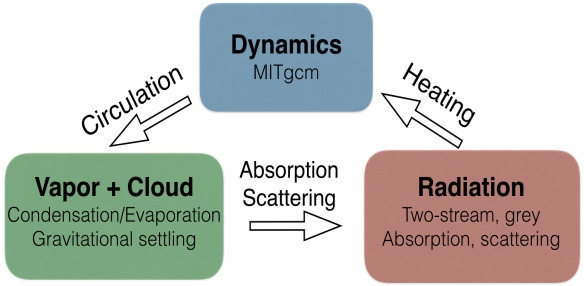
Crossfield + (2014)

Motivation:

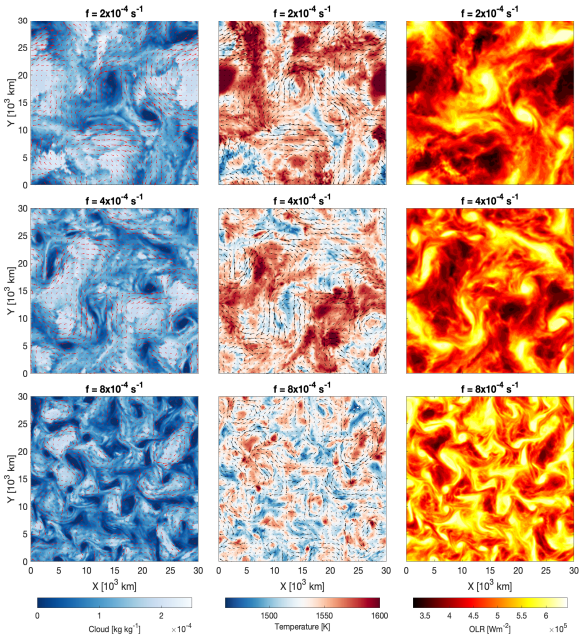
- Cloud formation and the radiative effects could be critical in driving vigorous circulation in brown dwarf atmospheres.
- We explore the properties of such circulation and implications for observations.

General circulation models:

- Dynamics – advects tracers (vapor+clouds) and generates patchy clouds.
- Radiation – generates isobaric heating due to cloud feedback, which drives the circulation.
- Vapor + clouds – condensation, evaporation, sedimentation, and are regulated by the flow.

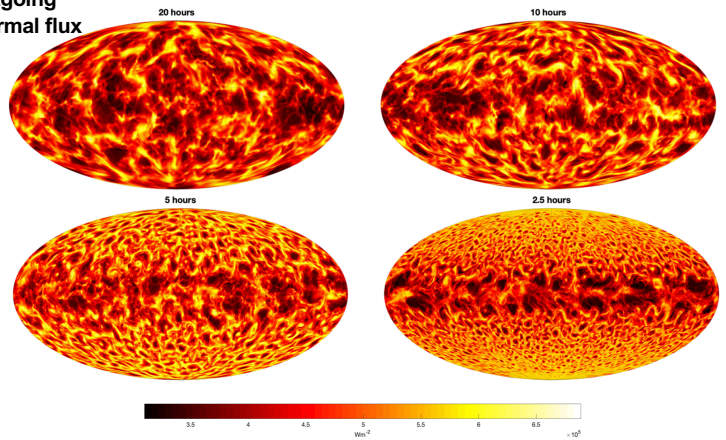


Reginal models with varying rotation:

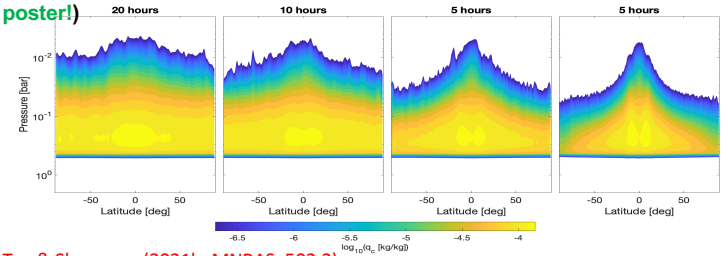


Tan & Showman (2021a, MNRAS, 502,1)

Global models with varying rotation:

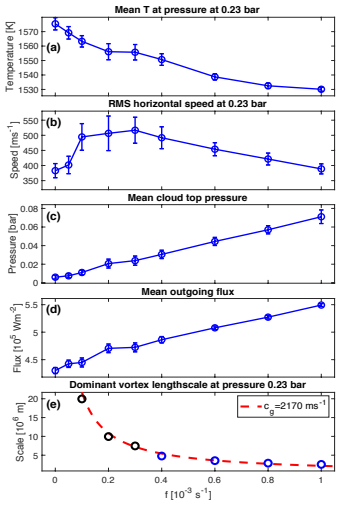


Zonal-mean cloud mixing ratio (supporting Johanna Vos's observations, see her poster!)



Tan & Showman (2021b, MNRAS, 502,2)

Atmospheric properties with varying rotation



Main Points

- Cloud radiative feedback is a natural mechanism generating vigorous atmospheric circulation, significant large-scale cloud and outgoing flux inhomogeneity on brown dwarfs.
- At mid-to-high latitudes, the characteristic size of storms is close to the Rossby deformation radius- inversely proportional to the Coriolis parameter f.
- Near the equator, large-scale waves propagating eastward and westward, mainly responsible for the irregular lightcurve variability.
- Vertical extent of clouds is the highest near the equator and decreases poleward due to effects of planetary rotation.

Lightcurve variability from global models