Vertical Mixing in Hot Jupiter Atmospheres

2D post-processing coupling general circulation and disequilibrium chemistry

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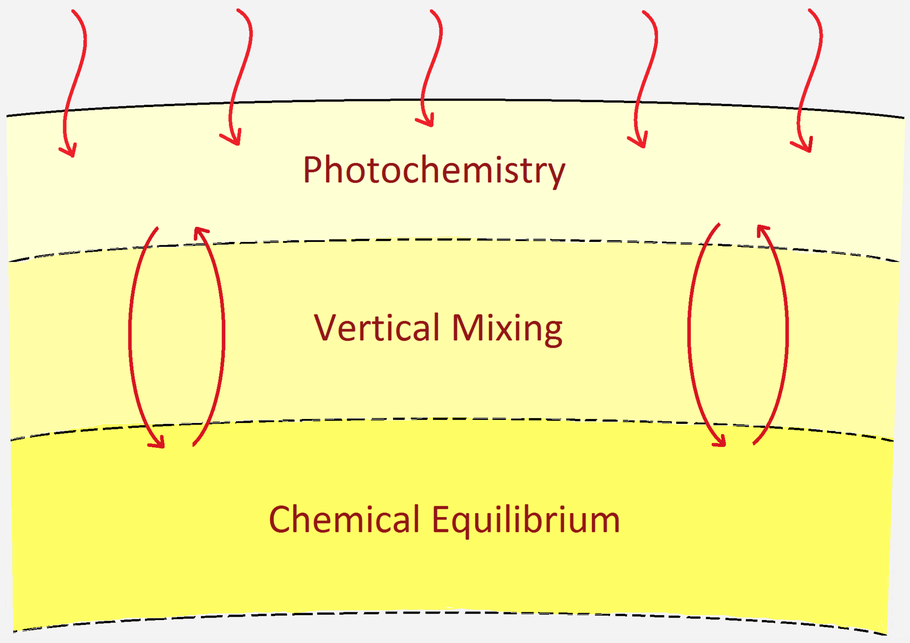
The chemical composition of an exoplanet atmosphere holds essential information about the planet's formation history and habitability. Dynamical mixing has a significant effect on this composition.

Vertical mixing is often parametrized as a 1D diffusion process. However, the atmospheres of tidally-locked hot Jupiters are inherently longitude-dependent.

To investigate this longitudinal dependence, we simulated the climate of HD 209458b using a 3D general circulation model and used the temperature and wind data as input for a 1D and pseudo-2D chemistry code.

We have identified a confined region of strong vertical mixing on the night side of the planet, which has a significant impact on the local chemical abundances.



General Circulation Model

Radiative Transfer — *petitCODE*[1]

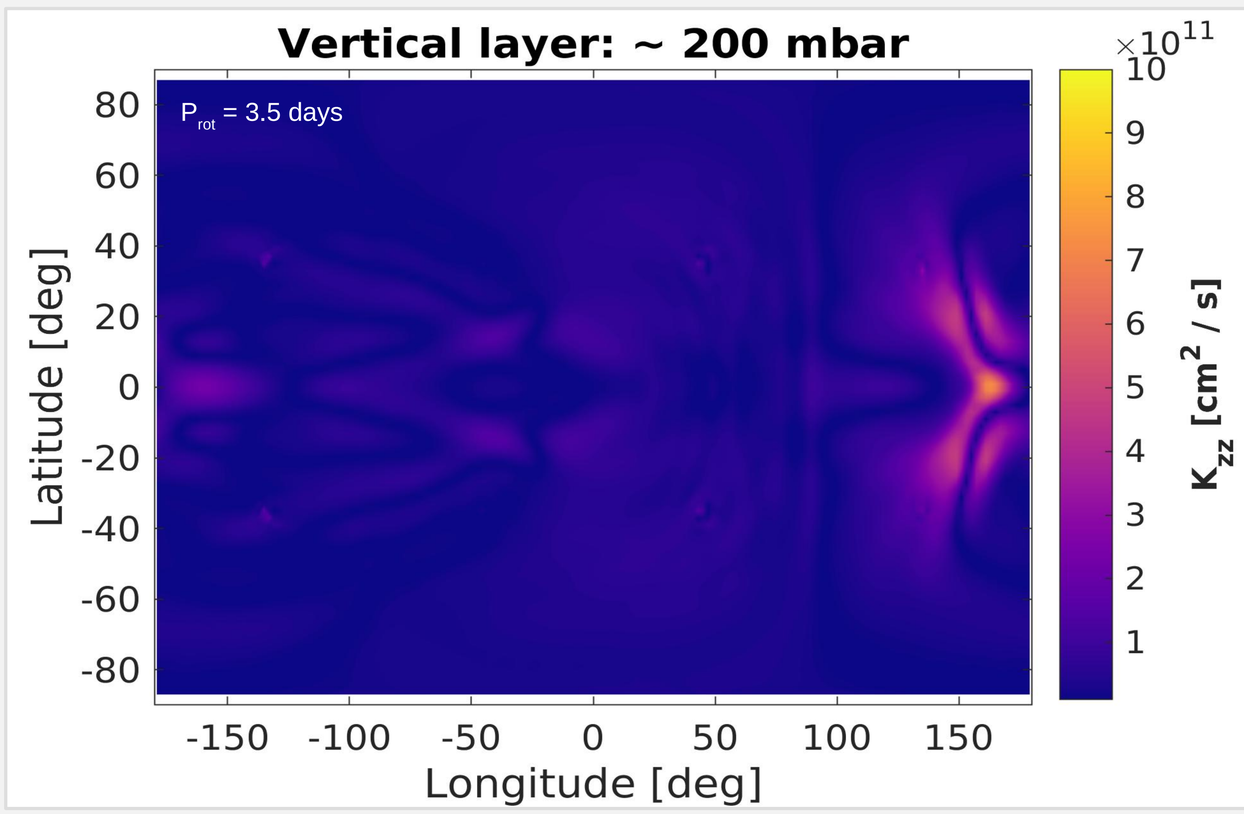
3D Hydrodynamics — *MITgcm*[2]

newtonian temperature forcing

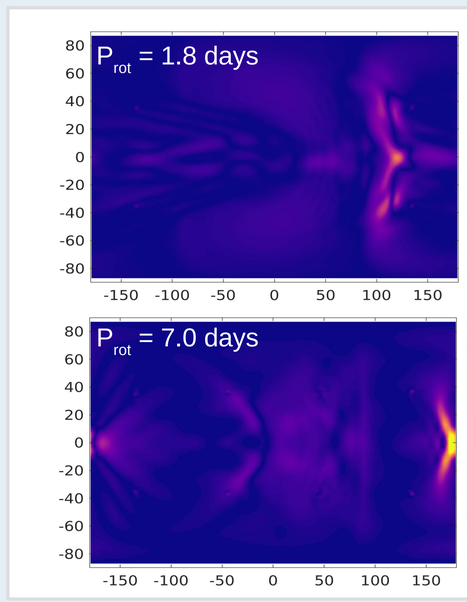
Proxy for Local Eddy Diffusion Coefficient

vertical wind speed
x
scale height

$$K_{zz}(\theta, \phi, z) = |w(\theta, \phi, z)| H(\theta, \phi, z)$$

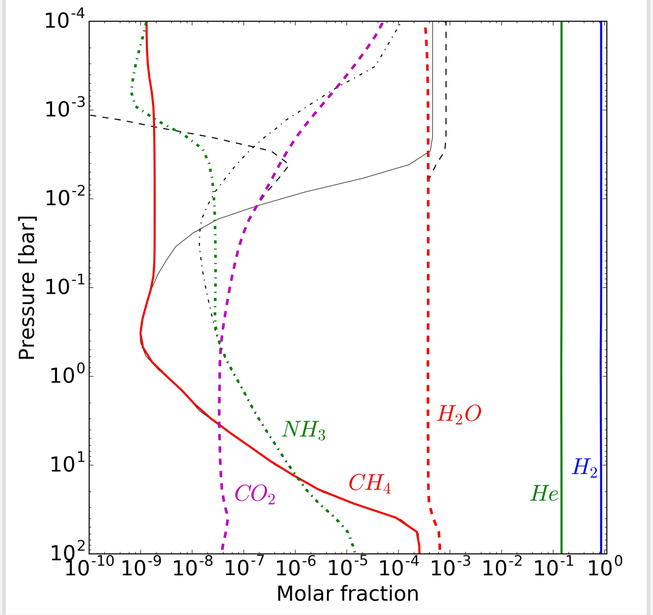


slower rotation
↓
more vertical mixing

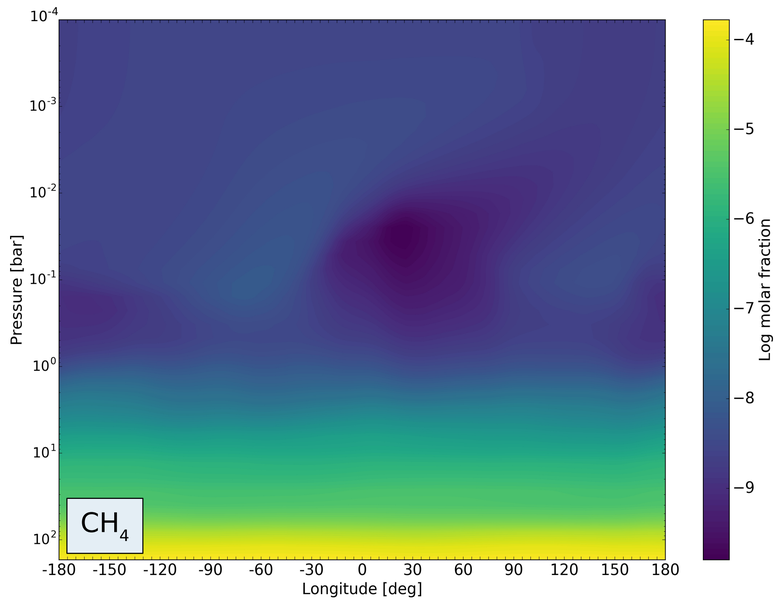


(Dis)equilibrium Chemistry Model

1D [3]



pseudo 2D [4]



Significant effect on abundances:

→ relative differences of 70% to 100%
→ lower CO_2 and CH_4 mixing ratio

compared with earlier mixing coefficients[5]

Future work

- 2D vertical mixing in chemistry model
- better quantification with passive tracers
- include cloud model

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