

Exploring hemispheric tectonics on tidally locked super-Earths

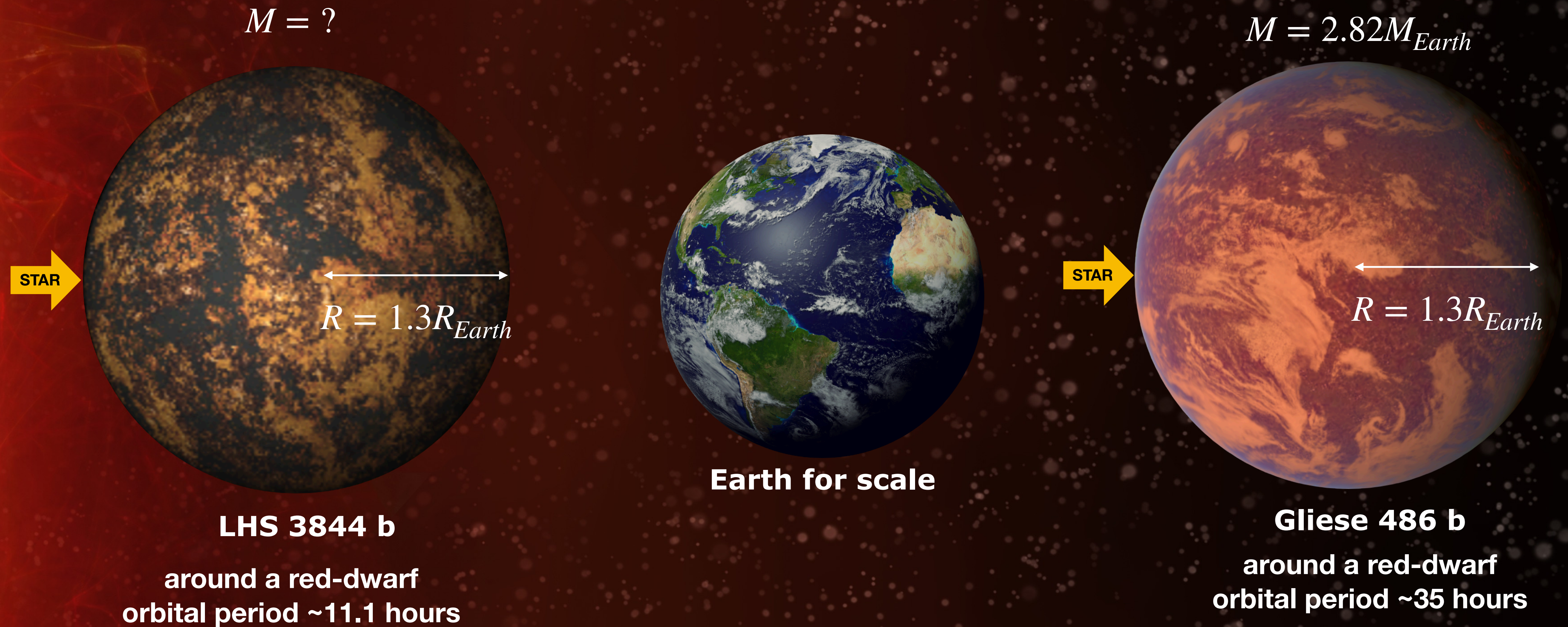
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Display Material**

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Brice-Olivier Demory**



Illustration: Thibaut Roger - Universität Bern

Tectonic regimes on super-Earths?



Goal

Use observational data to constrain the interior dynamics of rocky exoplanets

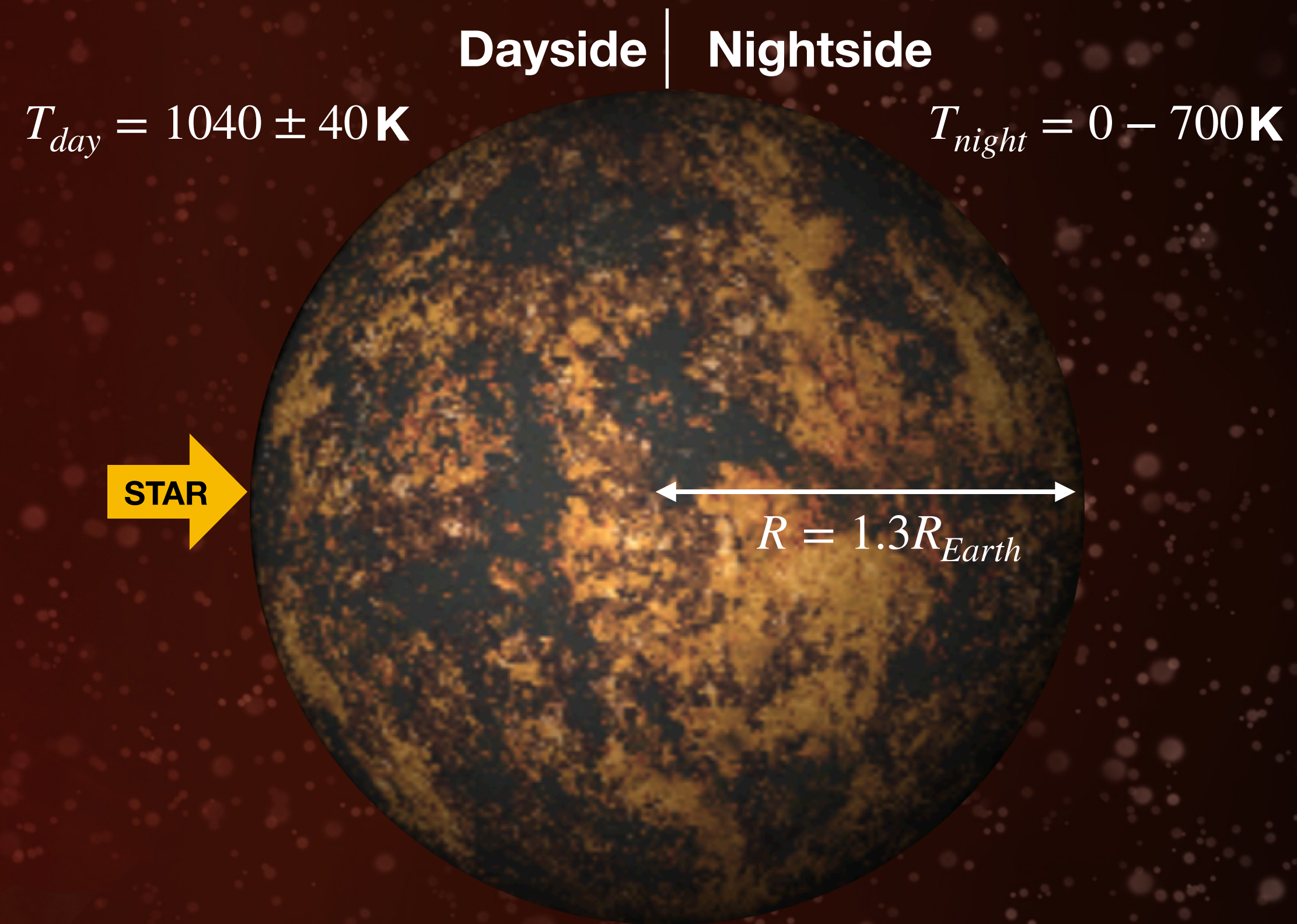


How?

**Thermal phase curve observations &
GCMs provide surface temperature**

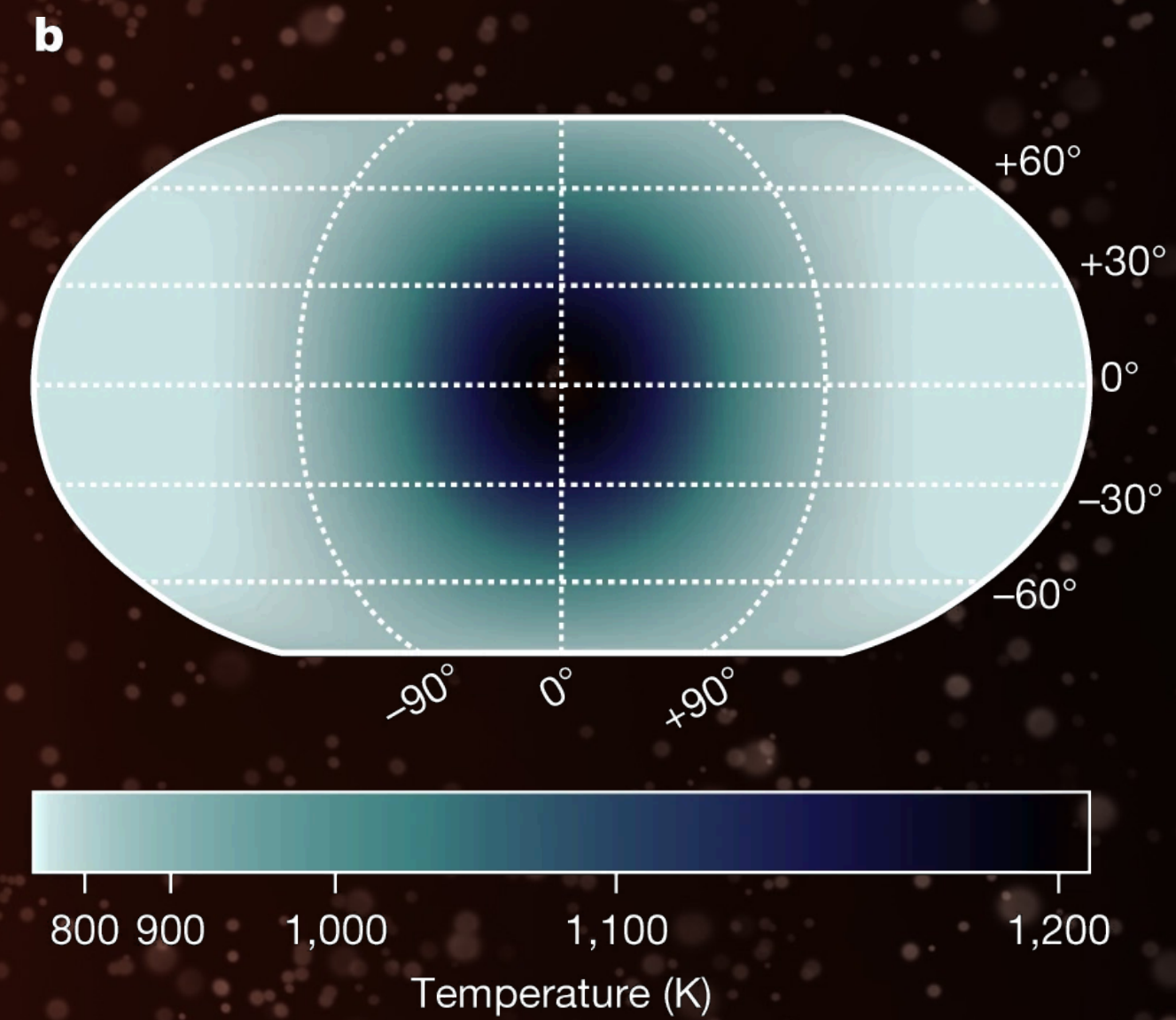
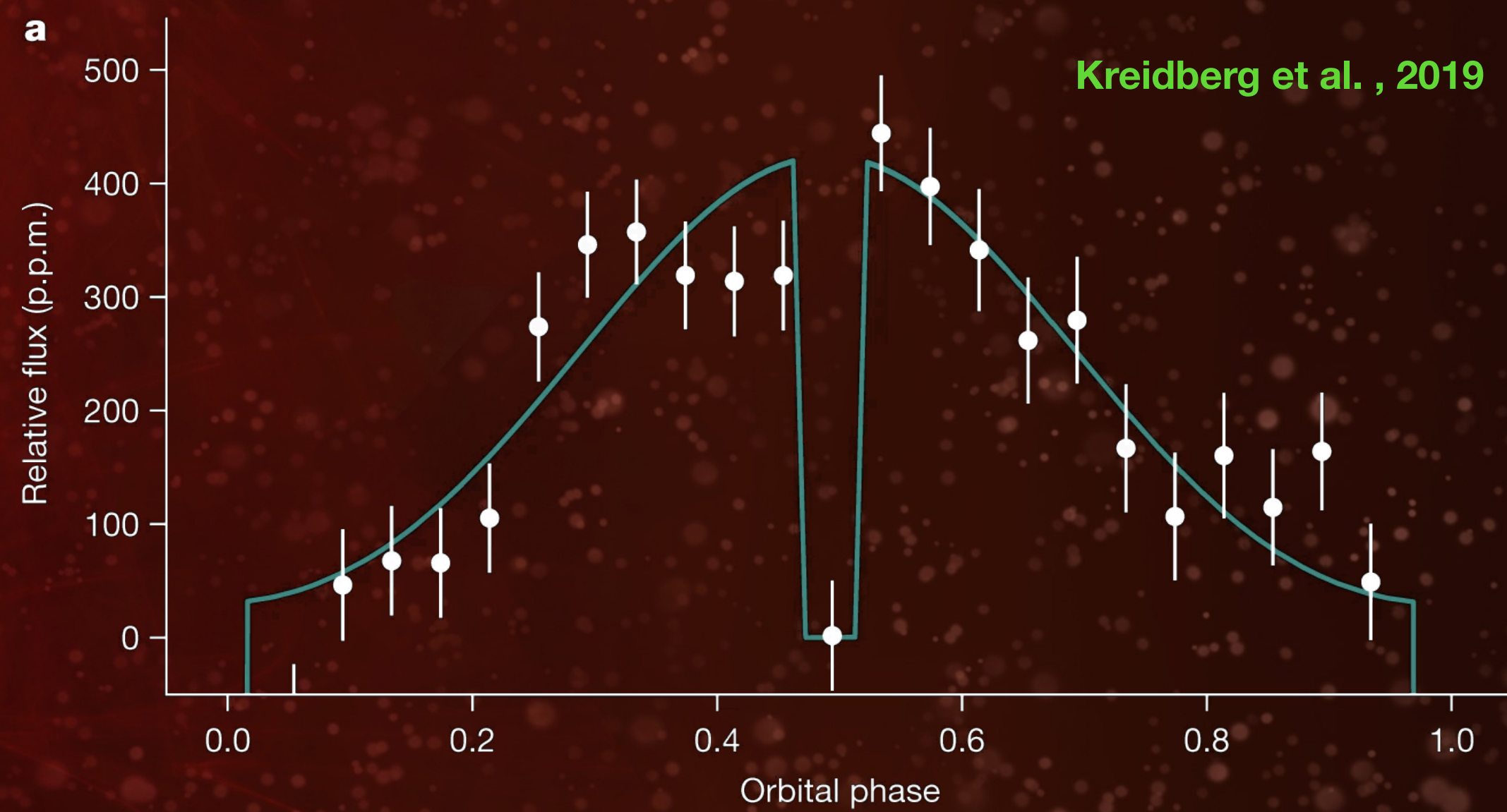
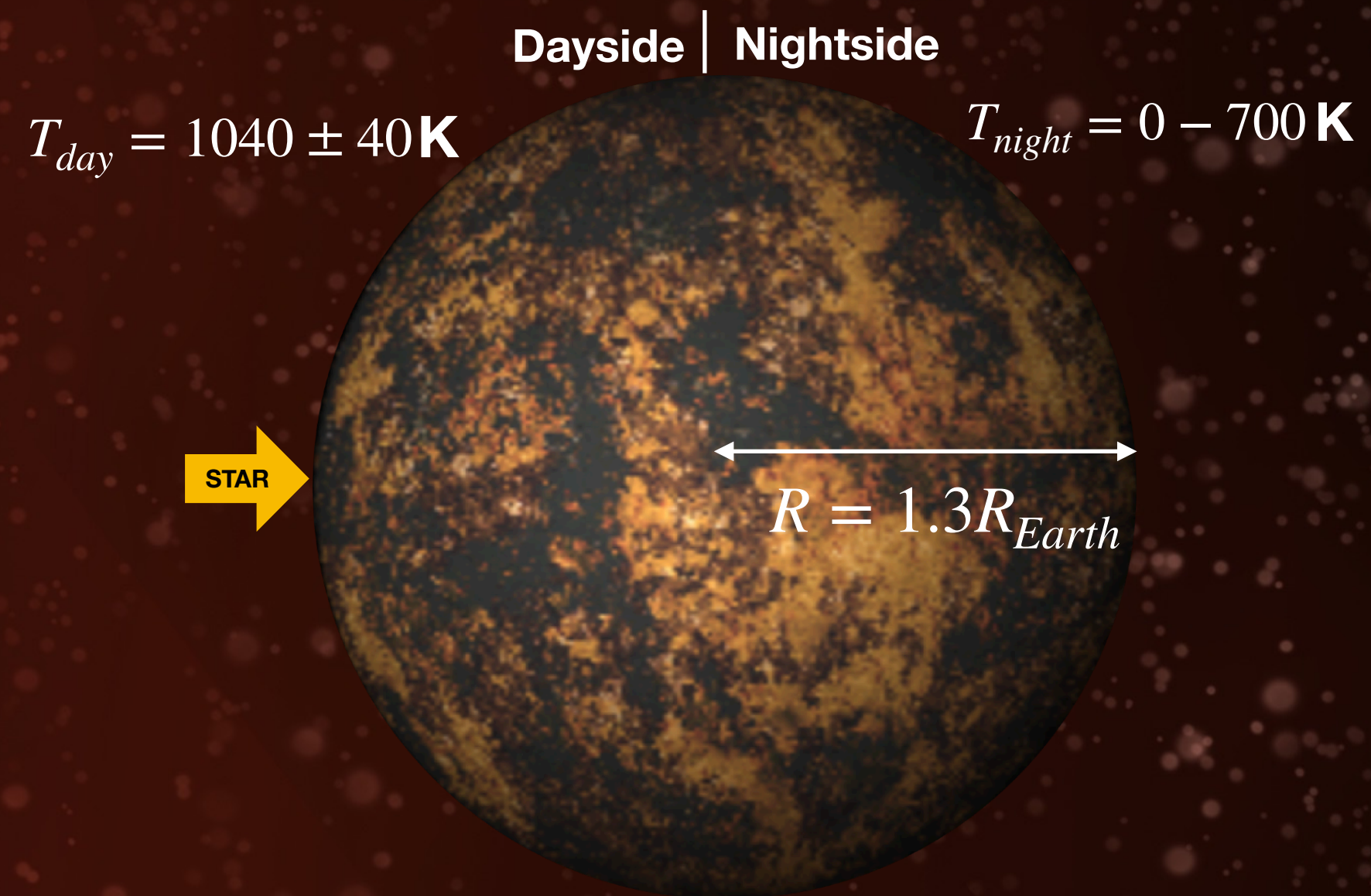


LHS 3844b



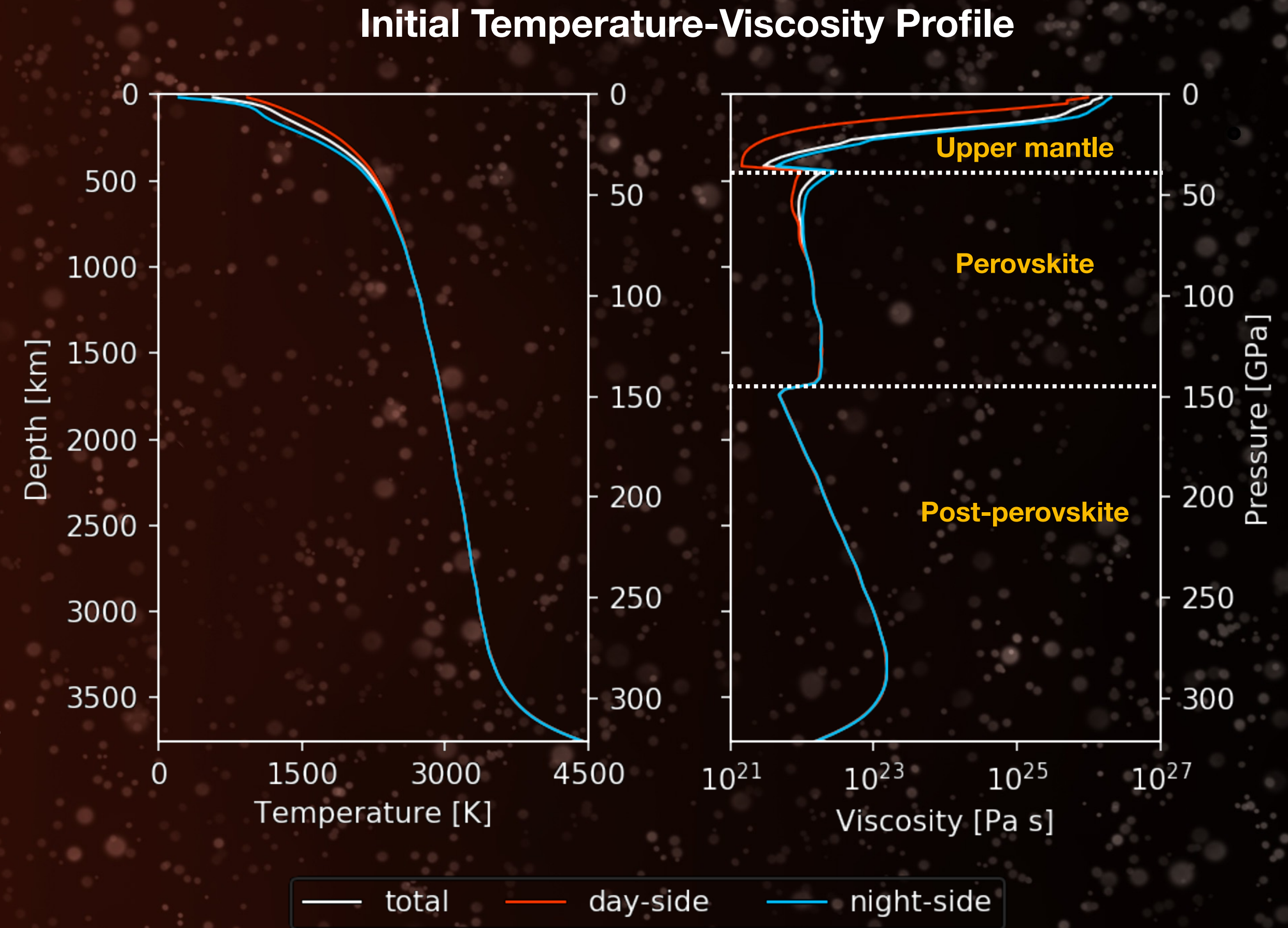
around a red-dwarf
orbital period ~11.1 hours

LHS 3844b



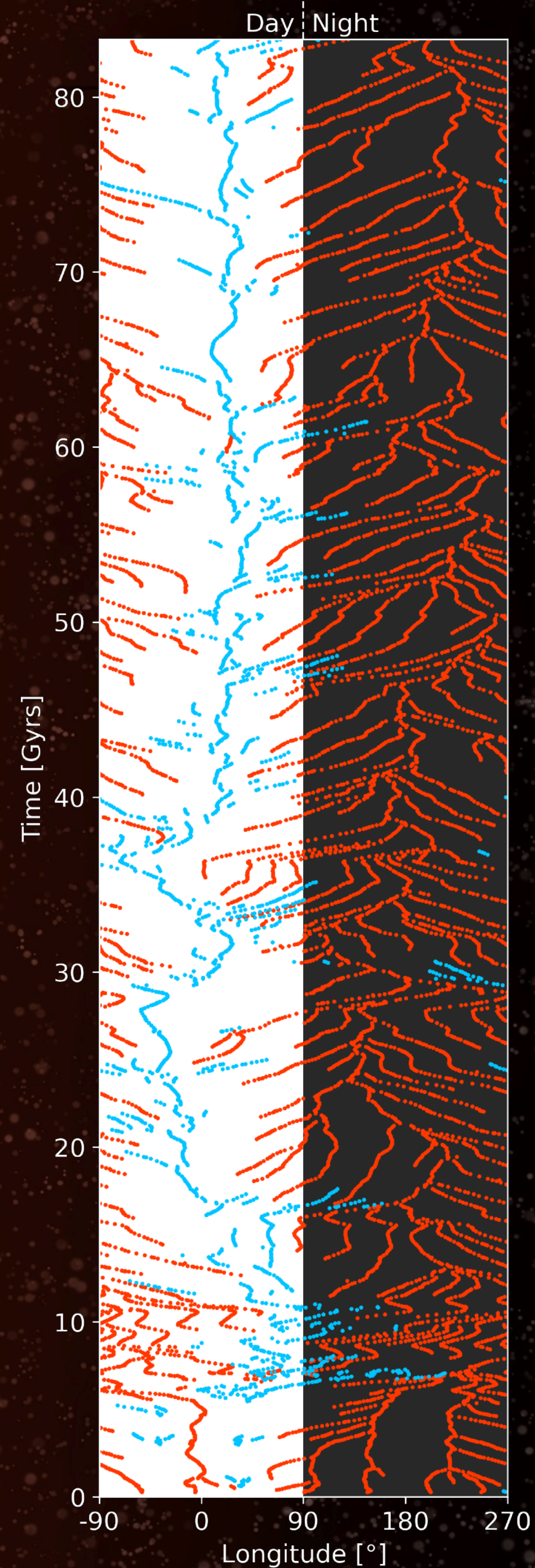
$$\eta = \eta_0 \exp \left(\frac{E_0 + pV(p)}{RT} - \frac{E_0}{RT_0} \right)$$

- 2D spherical annulus geometry, solid-state convection models (Tackley, 2008)
- CMB temperature (isothermal): 4500 K
- Substellar point temperature: 1000 K
- Nightside temperature: 10 K
- Fully compressible models with parameters from (Tackley et al., 2013)

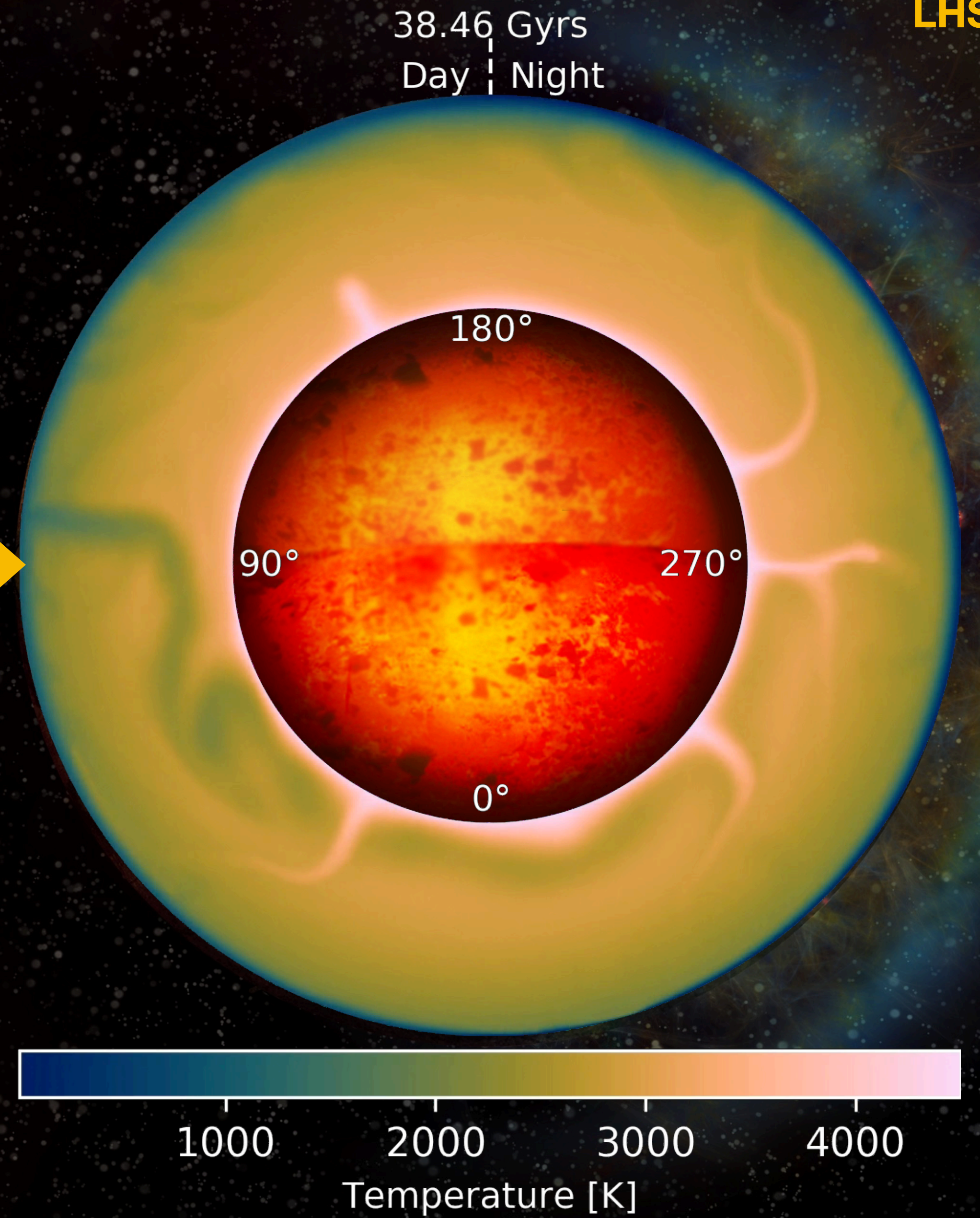


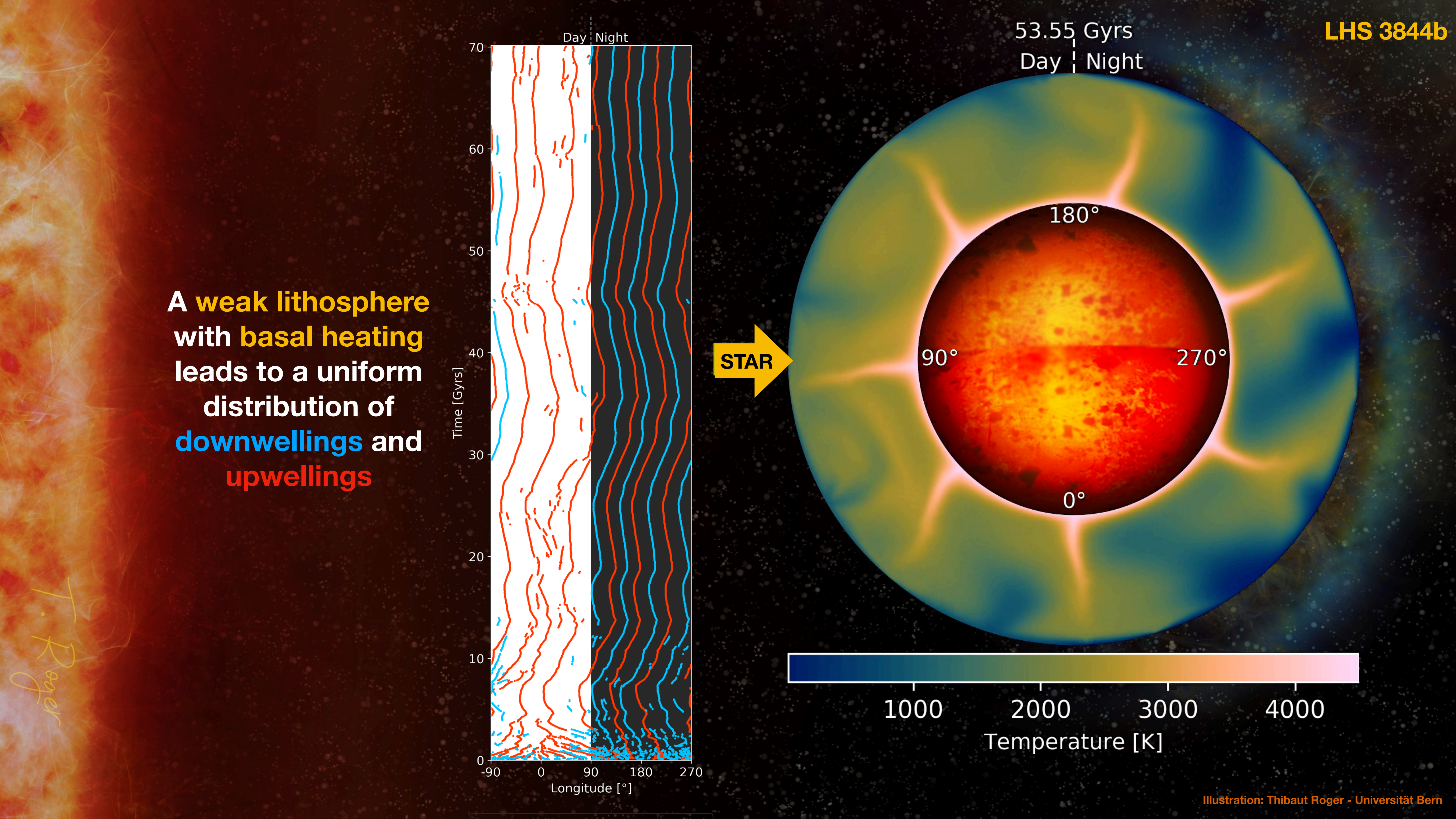
Parameters from Tackley et al. 2013

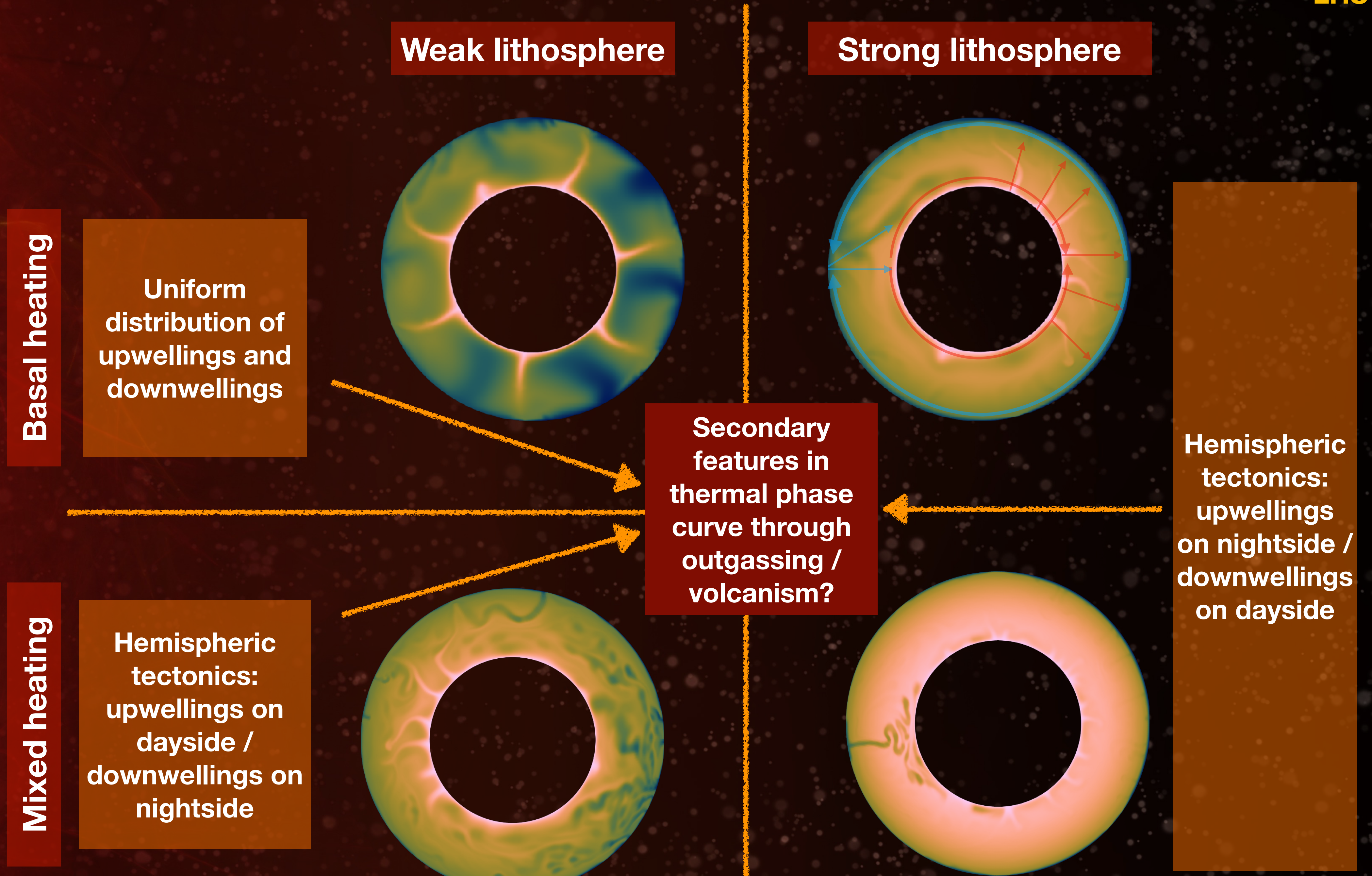
A strong lithosphere
with basal heating
leads to
downwellings on the
dayside and
upwellings on the
nightside



STAR

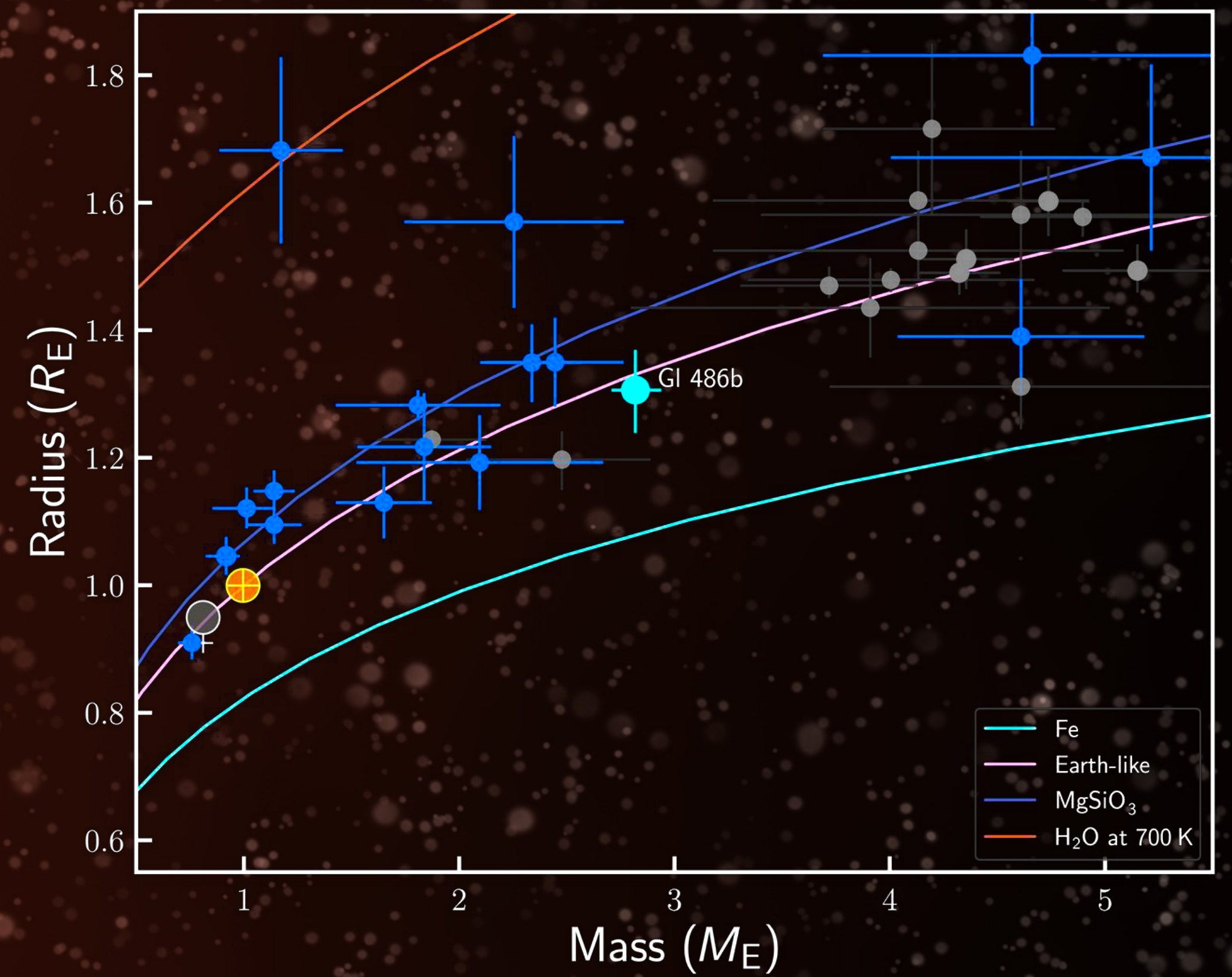
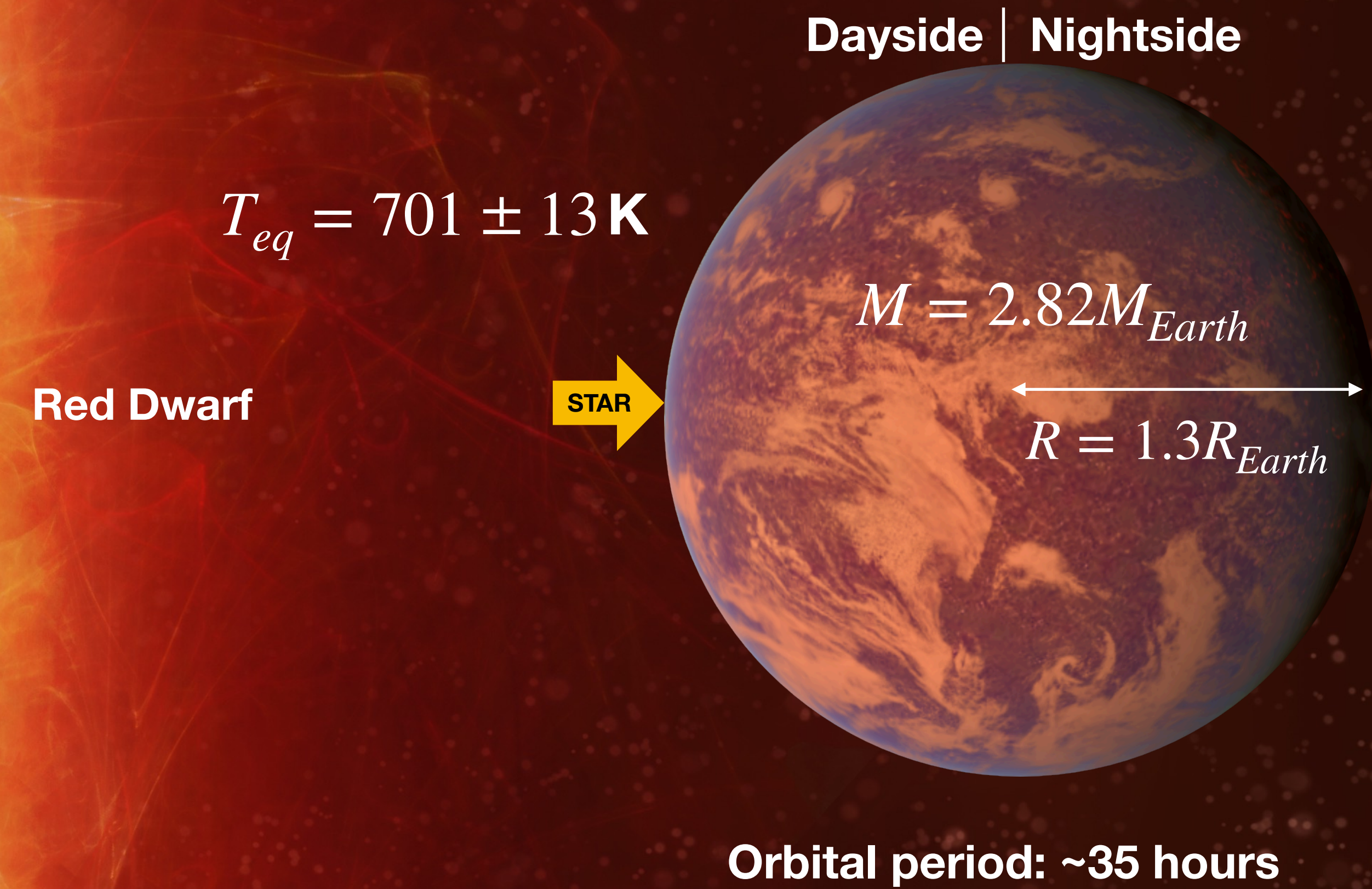




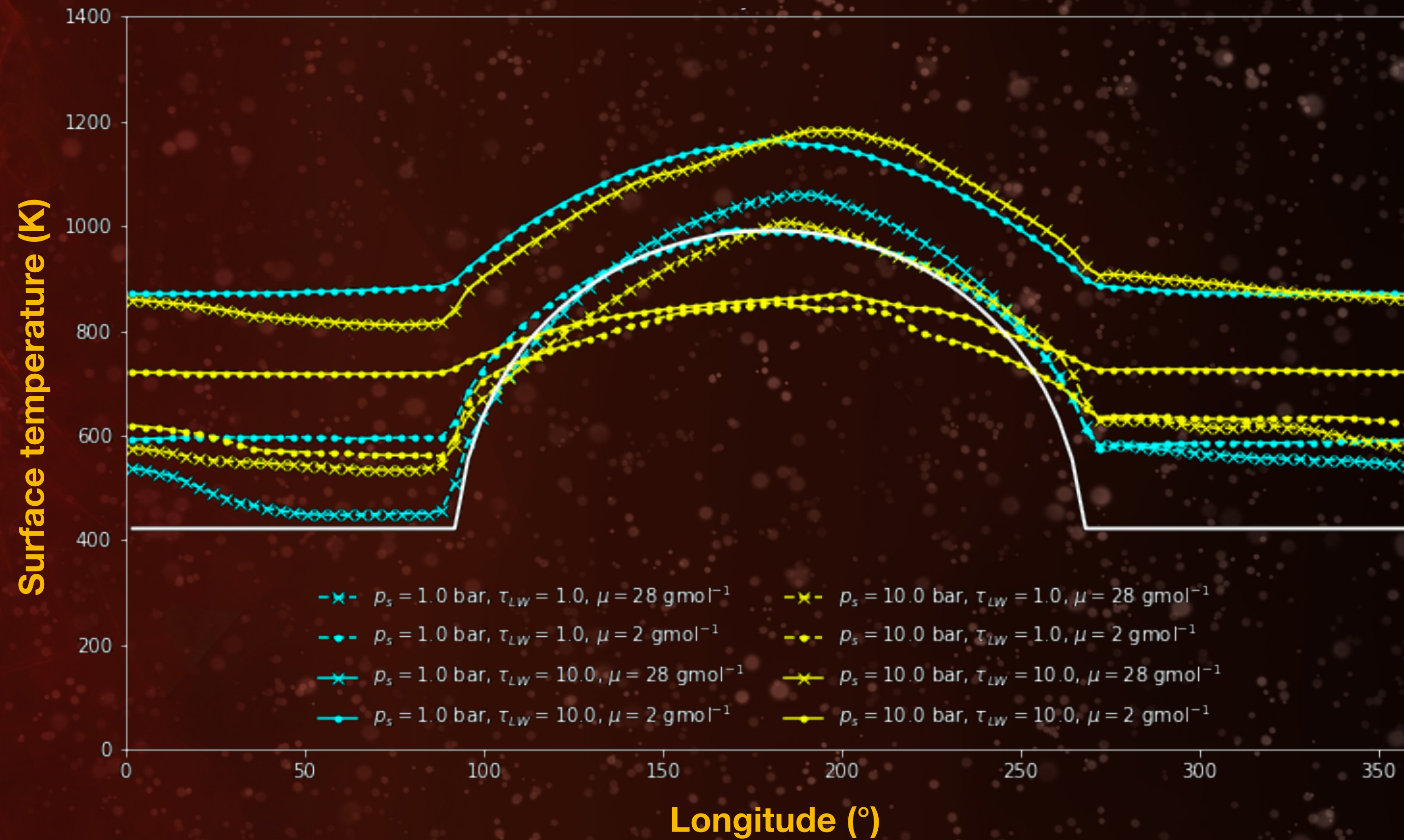


Gliese 486b

(Trifonov et al., 2021)

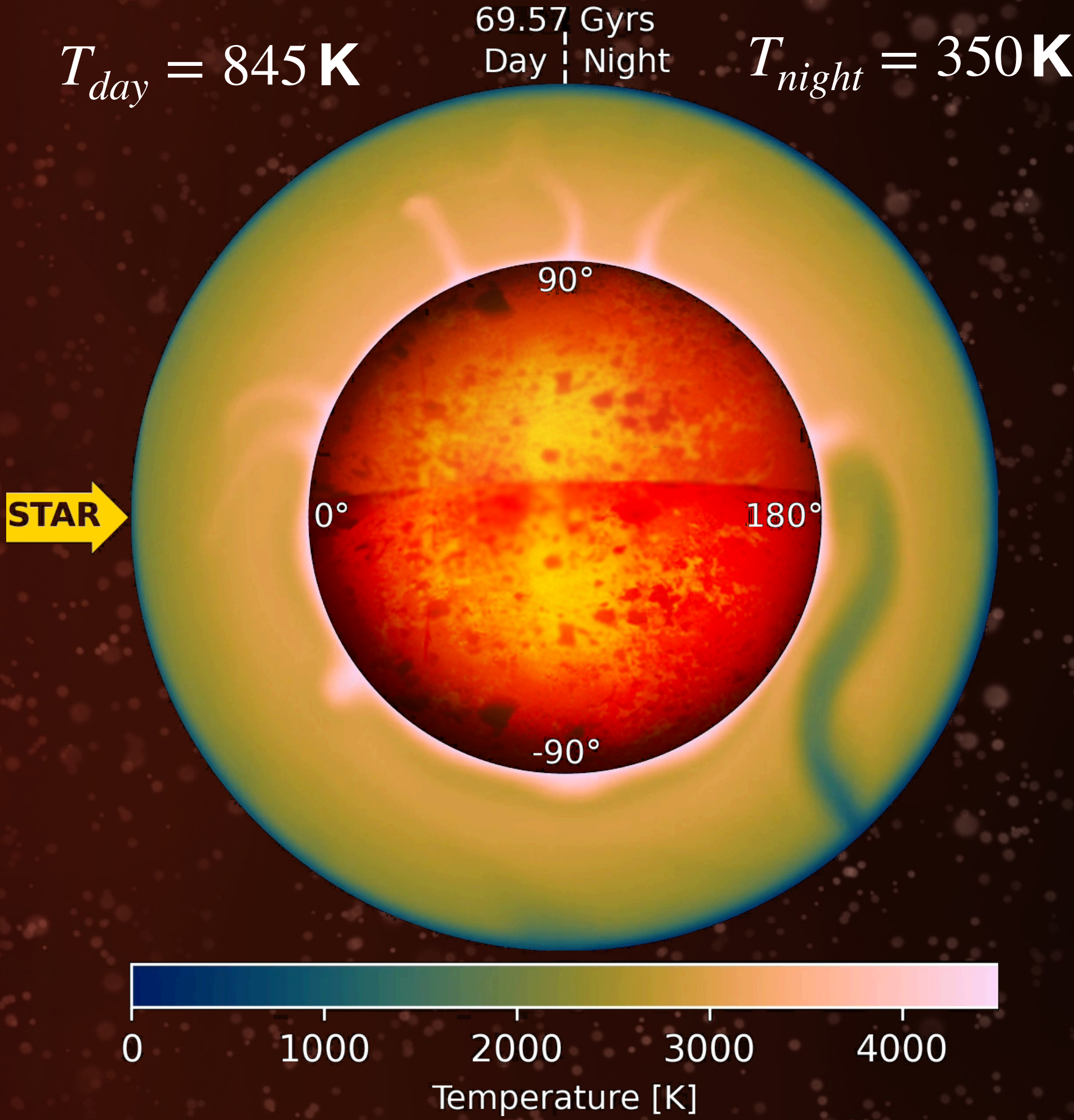
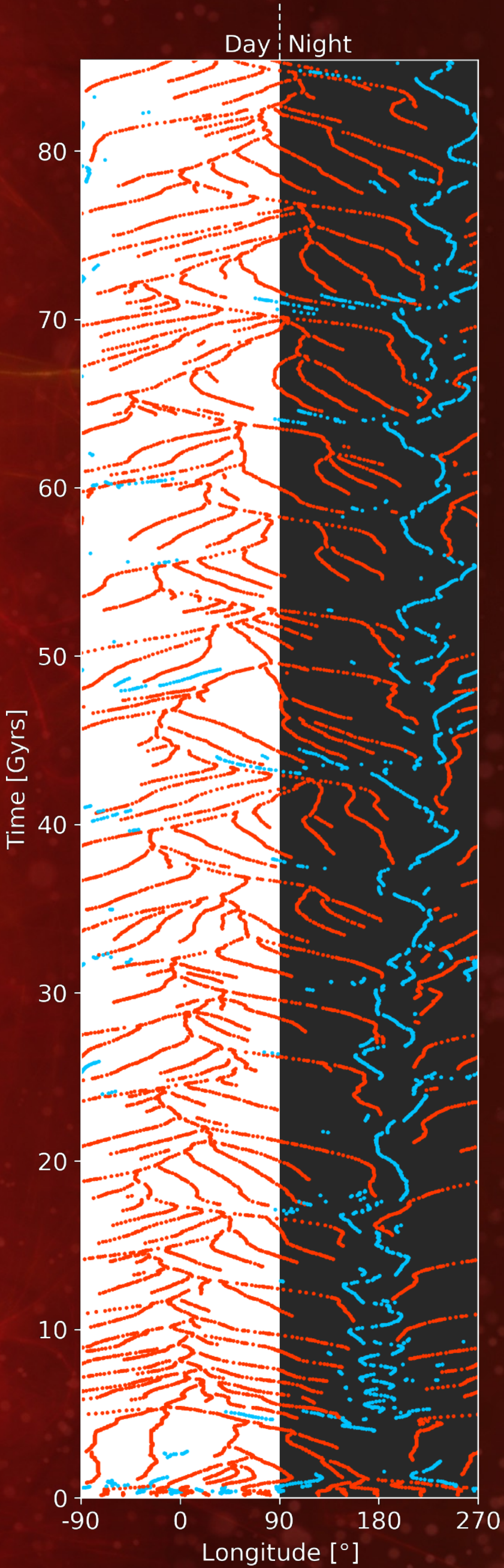


General Circulation models constrain the surface temperature



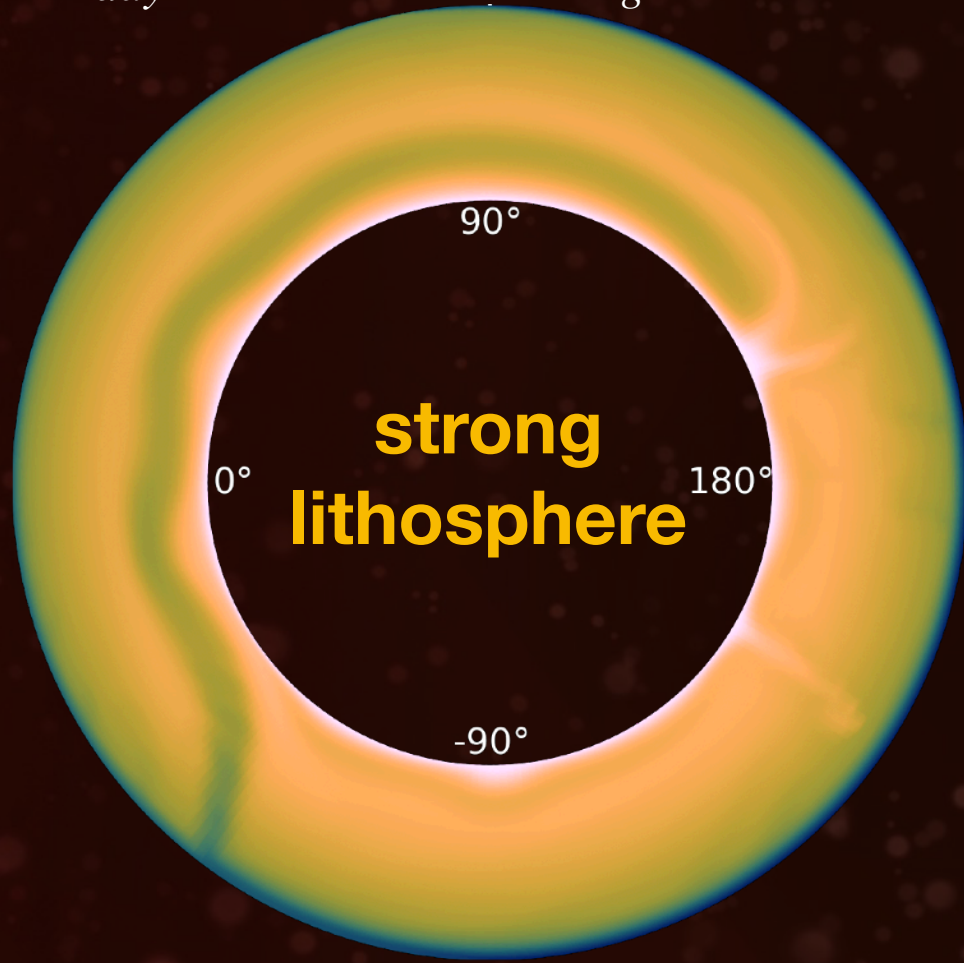
Moderate heat redistribution

Strong lithosphere ($\sigma_{yield} = 300 \text{ Mpa}$)



no heat redistribution

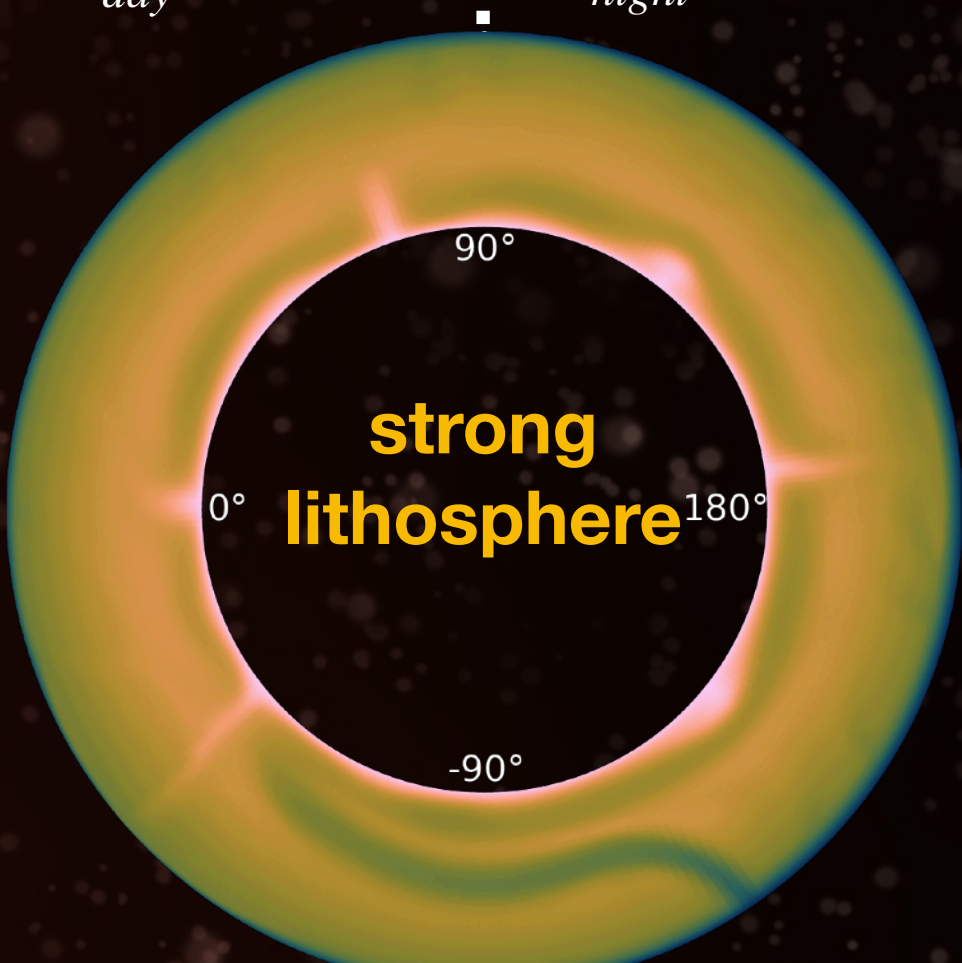
$$T_{day} = 990\text{K} \quad T_{night} = 10\text{K}$$



Hemispheric
tectonics

moderate heat redistribution

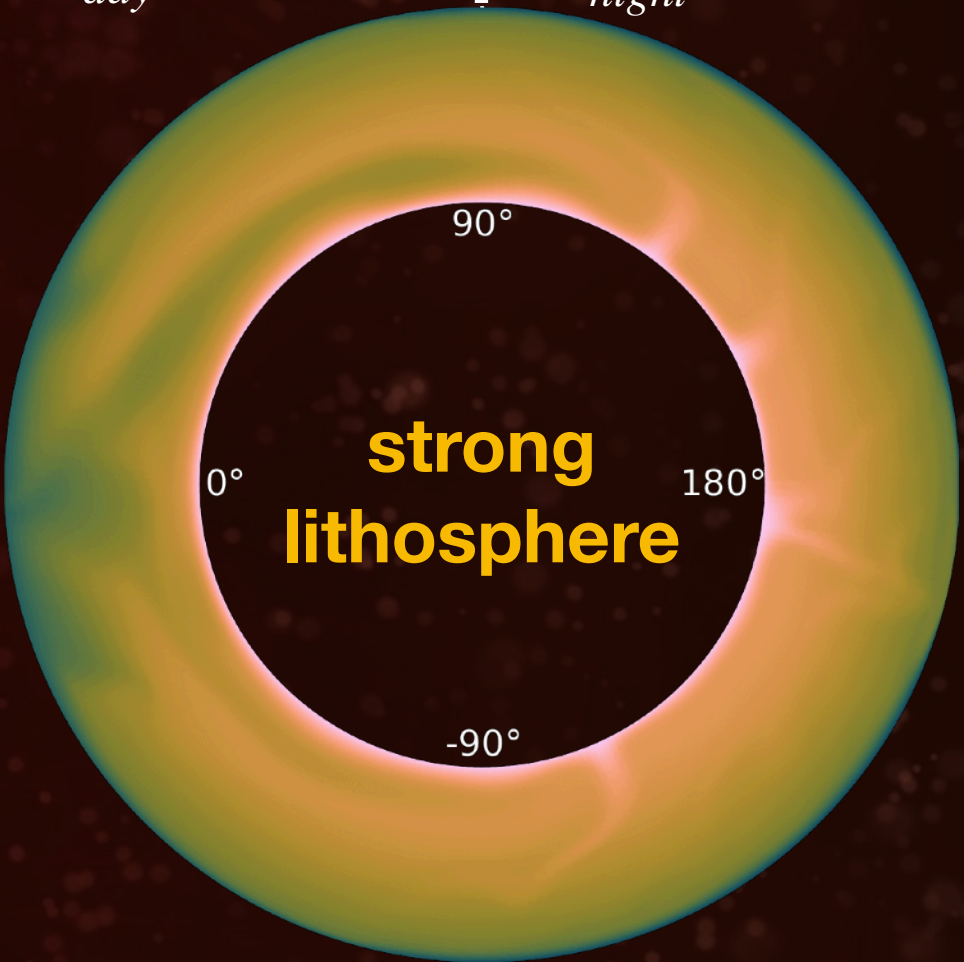
$$T_{day} = 845\text{K} \quad T_{night} = 350\text{K}$$



Hemispheric
tectonics

higher surface temperature
moderate heat redistribution

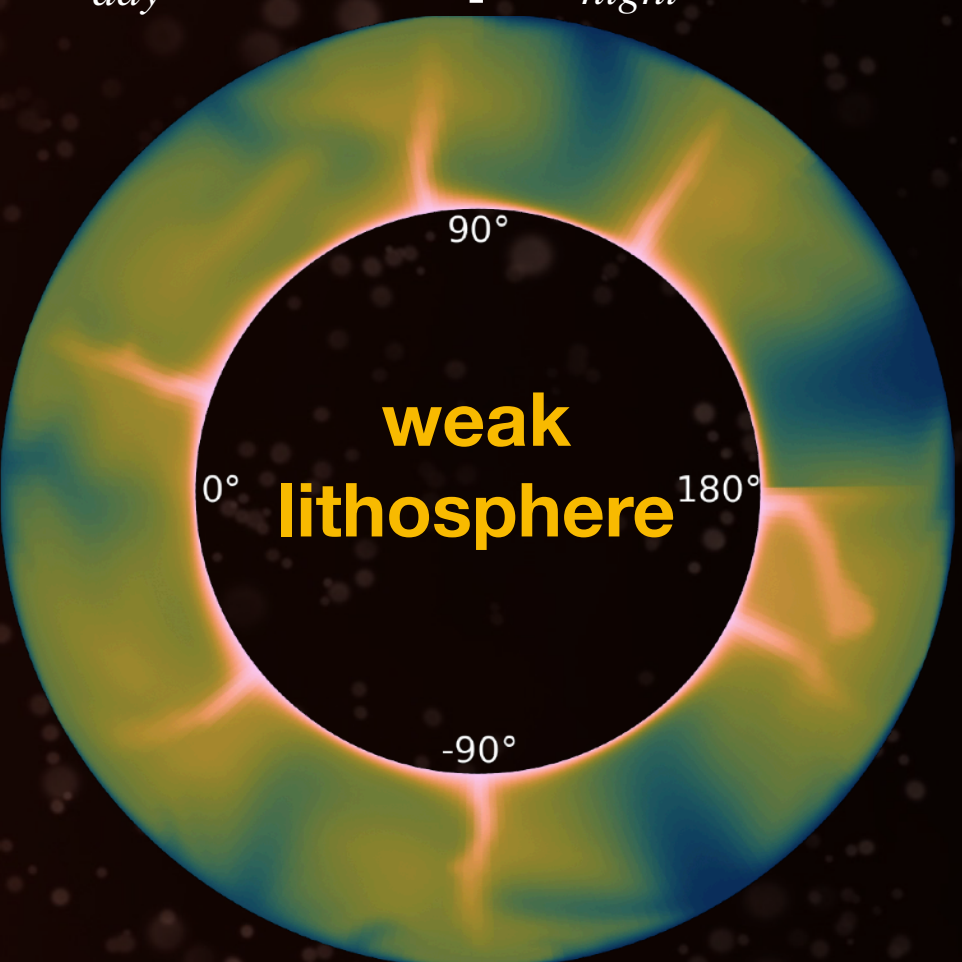
$$T_{day} = 1200\text{K} \quad T_{night} = 850\text{K}$$



Hemispheric
tectonics

moderate heat redistribution

$$T_{day} = 845\text{K} \quad T_{night} = 350\text{K}$$

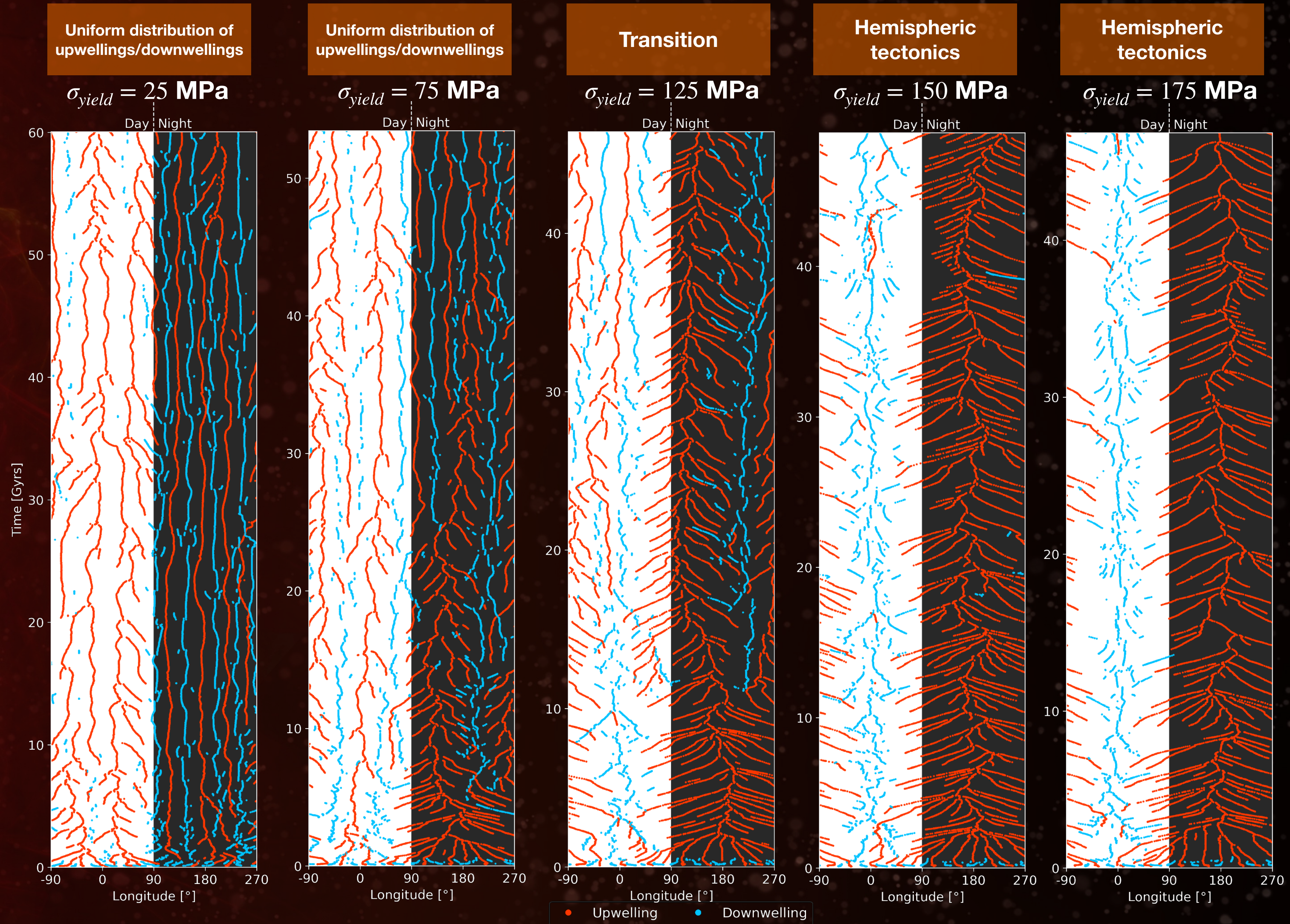


Uniform distribution
of upwellings and
downwellings

Varying the strength of the lithosphere (yield stress)

Gliese 486b

$T_{day} = 1200 \text{ K}$
 $T_{night} = 850 \text{ K}$



LHS 3844b (Meier et al., 2021)

- Inferred two different tectonic regimes
 - **Uniform distribution** of upwellings and downwellings
 - **Hemispheric tectonics**
- Such a tectonic regime is currently absent in our solar system

Gliese 486b (Meier et al., 2022, in prep.)

- GCMs regulate surface temperature
- Weak lithosphere leads to **uniform distribution of upwellings and downwellings**
- Strong lithosphere can lead to **hemispheric tectonics** even for cases with **moderate heat circulation**
- Transition from uniform to hemispheric tectonic regime depends on **yield stress** (around $\sigma_{yield} = 125$ Mpa)

