

MEGA-MIP: M-EARTH GLOBAL ATMOSPHERES MODEL INTERCOMPARISON PROJECT

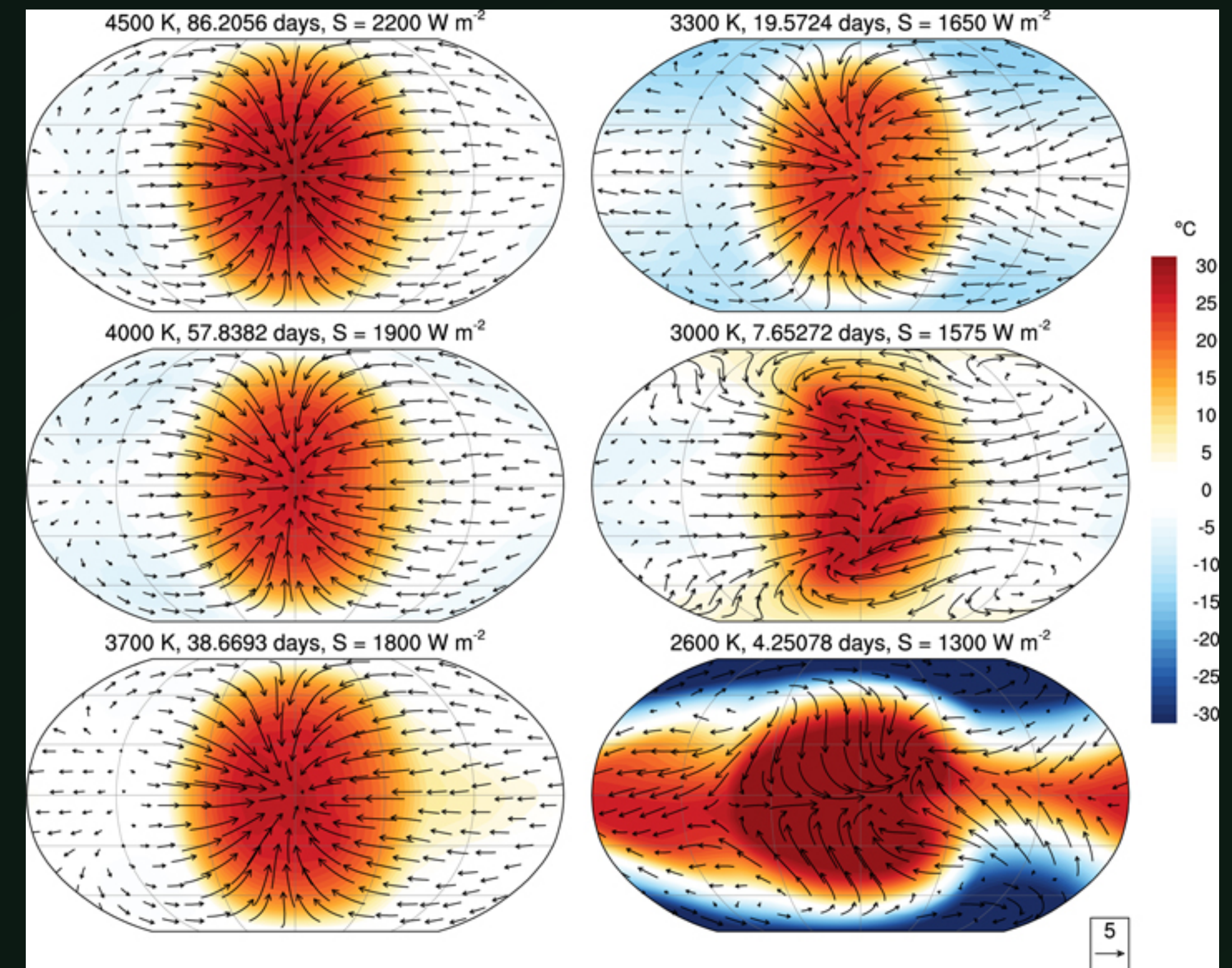
EGU – 29th April 2025

Hannah Woodward, Birkbeck, University of London (hannah.woodward@bbk.ac.uk)

Collaborators: Andrew Rushby, Nathan Mayne

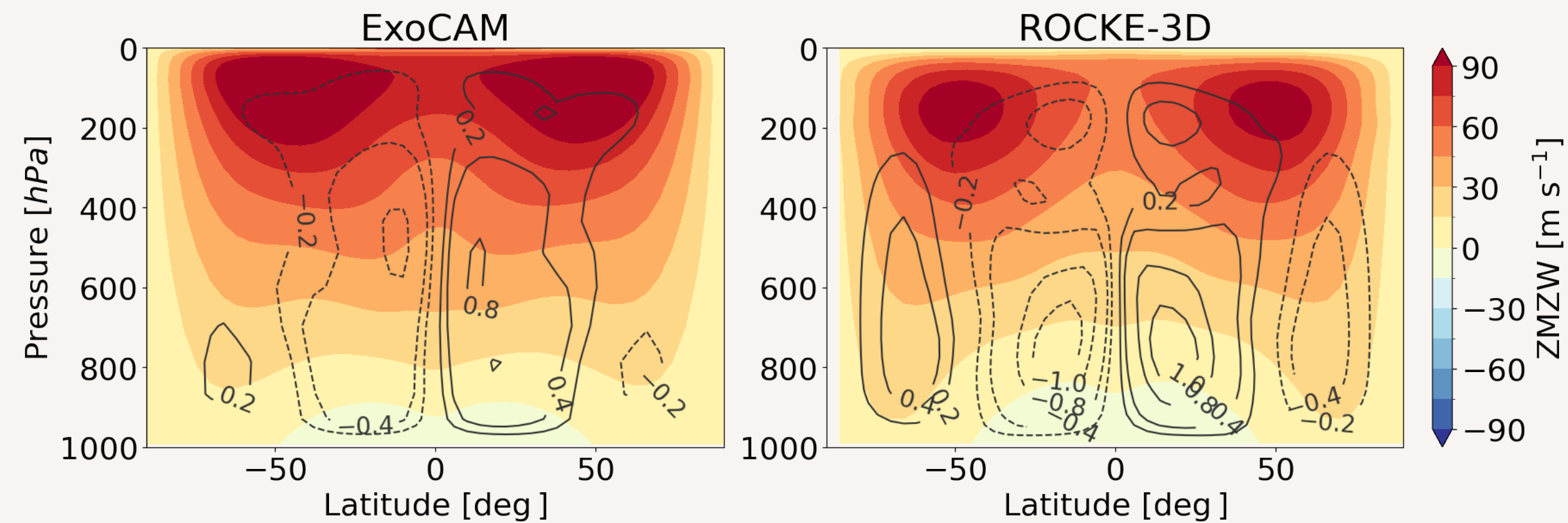
OVERVIEW

- ▶ Haqq-Misra+ (2018) introduced 3 circulation regimes for potentially habitable tidally-locked planets. For an 'Earth-like' planet (i.t.o. mass, radius, 1 bar N₂ atmosphere):
 - ▶ 'Fast rotators' ($P_{\text{rot}} < 5$ days)
 - ▶ 'Rhines rotators' ($5 \text{ days} < P_{\text{rot}} < 20$ days)
 - ▶ 'Slow rotators' ($P_{\text{rot}} > 20$ days)
- ▶ Aims:
 - ▶ How do characteristics for each regime vary across models?
 - ▶ How does global circulation affect surface climate and habitability?

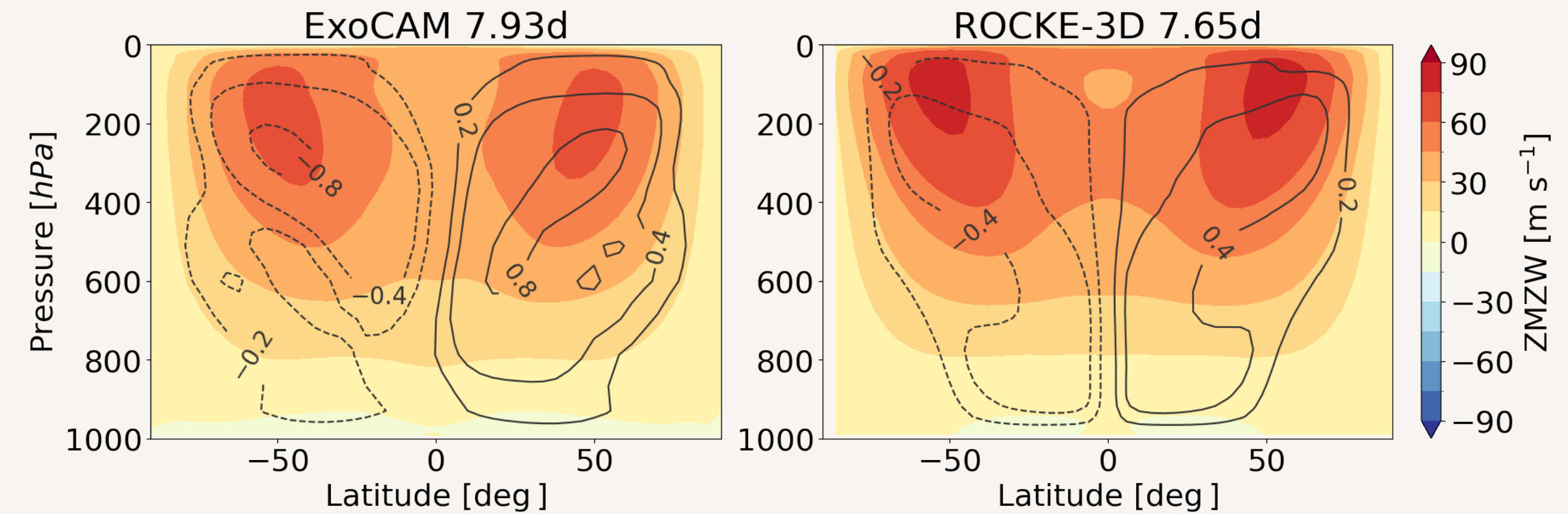


ATMOSPHERIC CIRCULATION: ZONAL MEAN ZONAL WIND + MERIDIONAL OVERTURNING

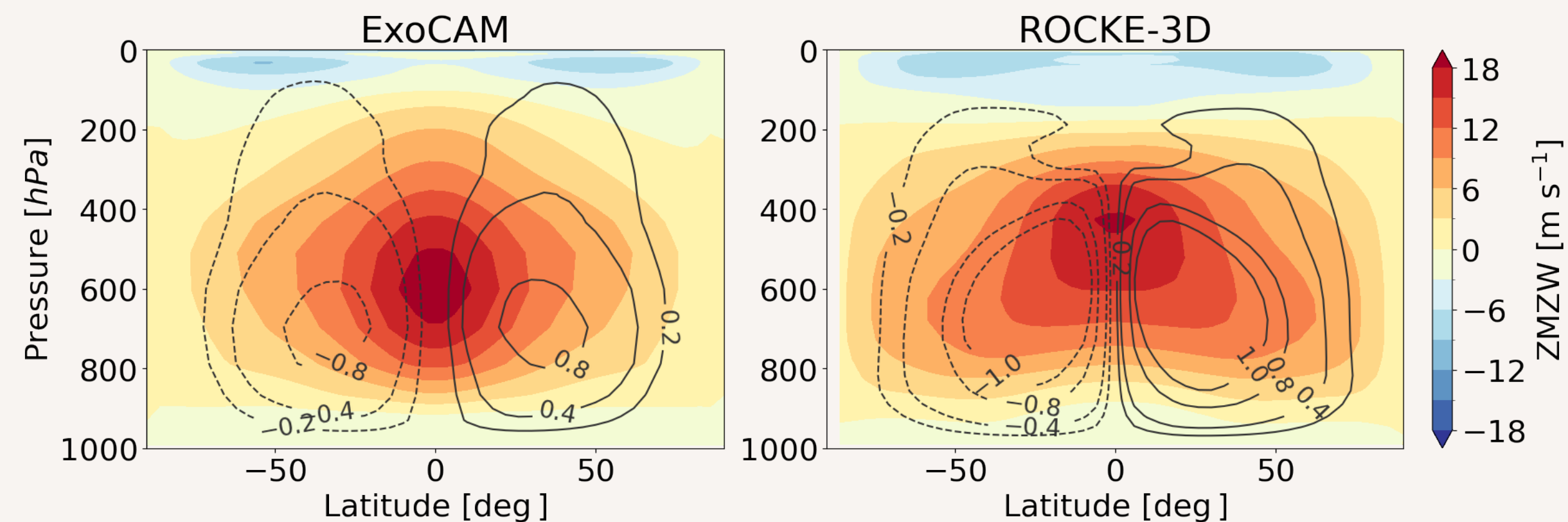
2600K 4.25D: "FAST"



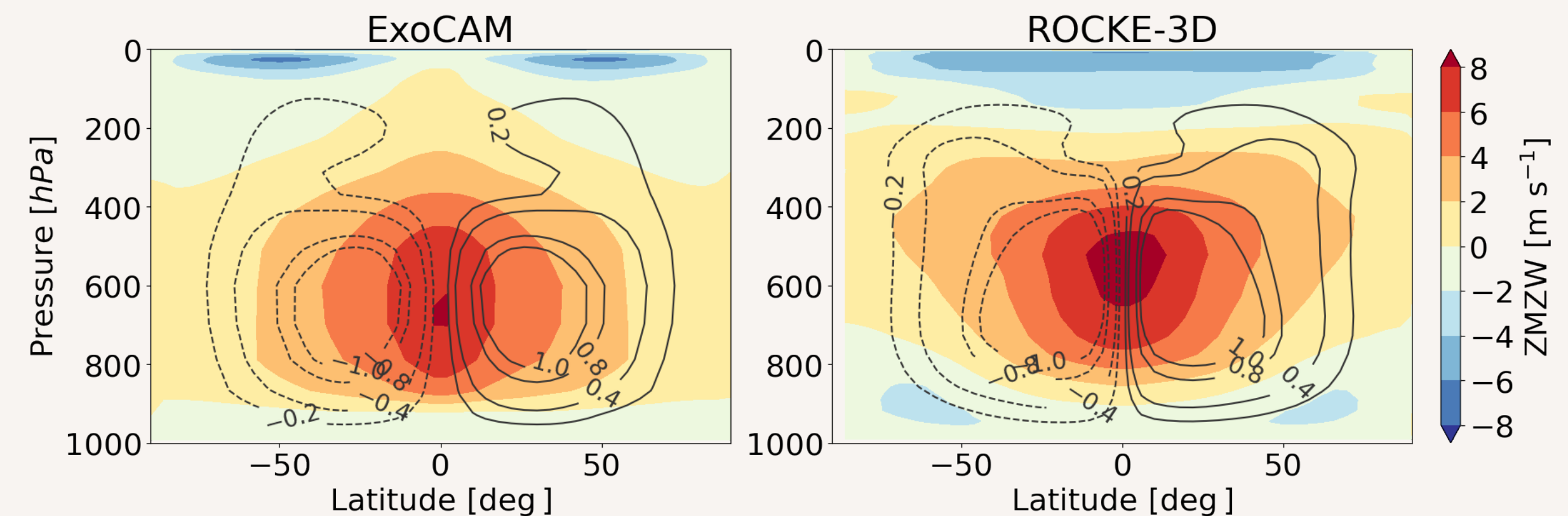
3000K 7.93D/7.65D: "RHINES"



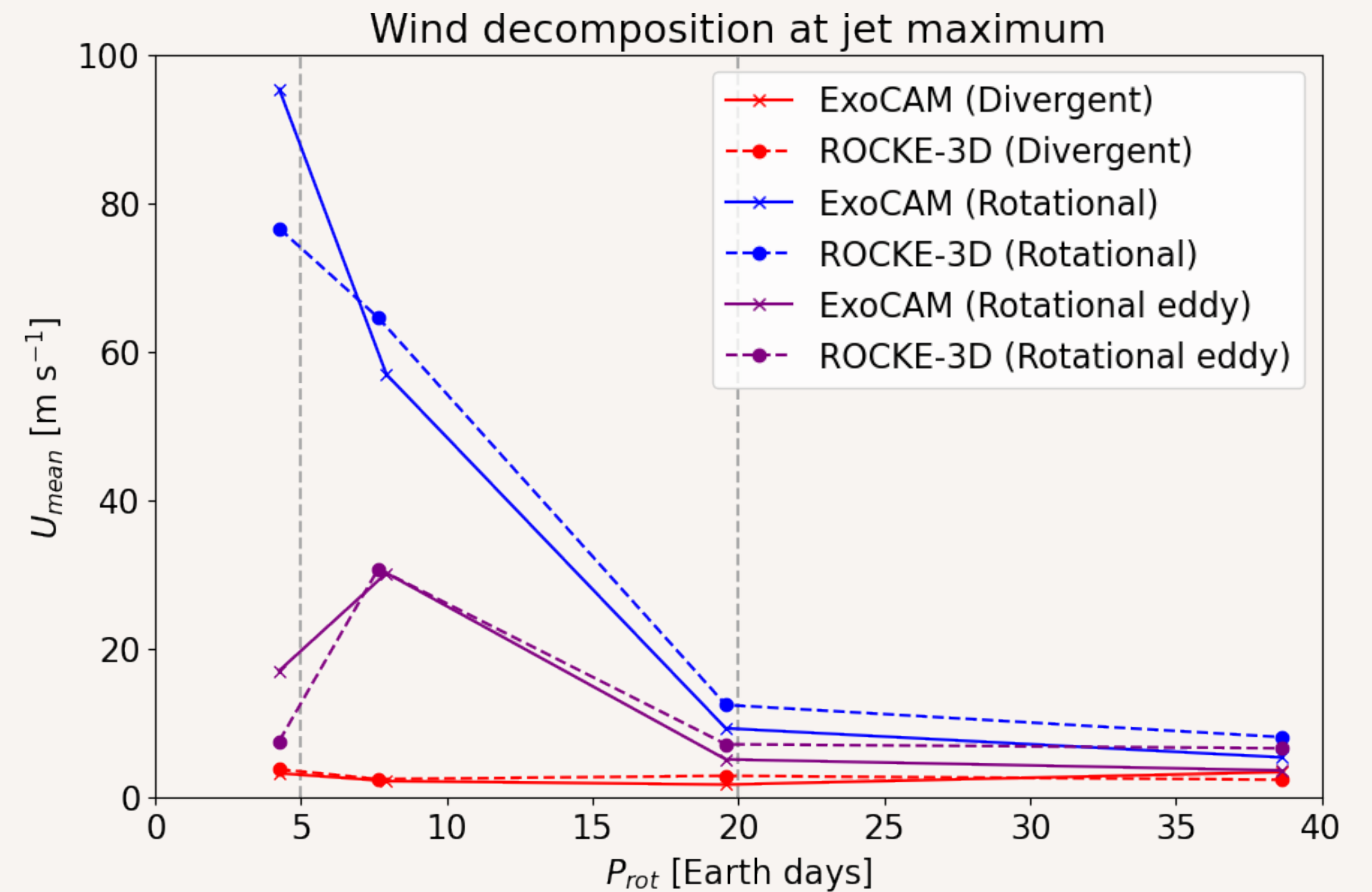
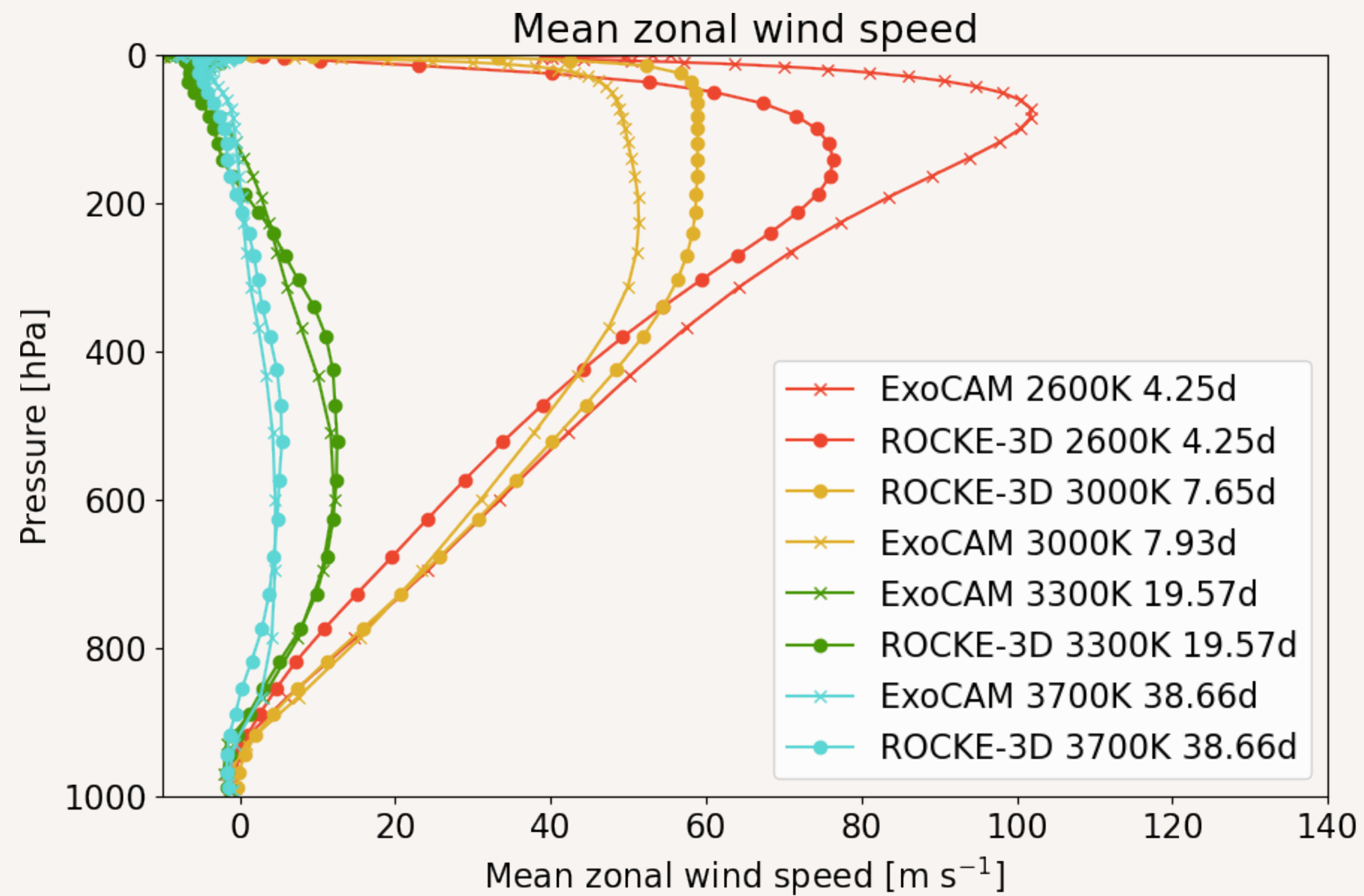
3300K 19.65D: "RHINES"



3700K 38.66D: "SLOW"

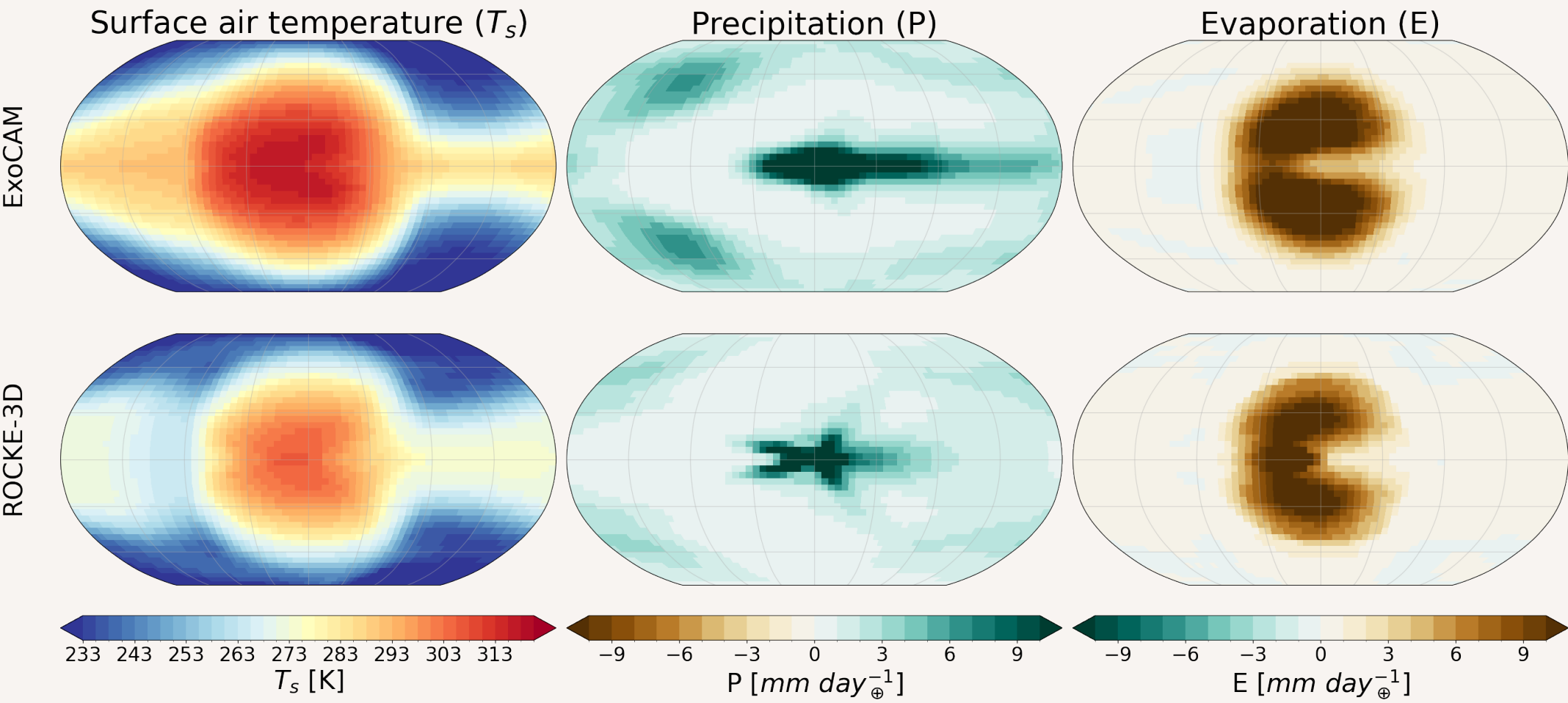


ATMOSPHERIC CIRCULATION: MEAN ZONAL WIND SPEED + WIND DECOMPOSITION

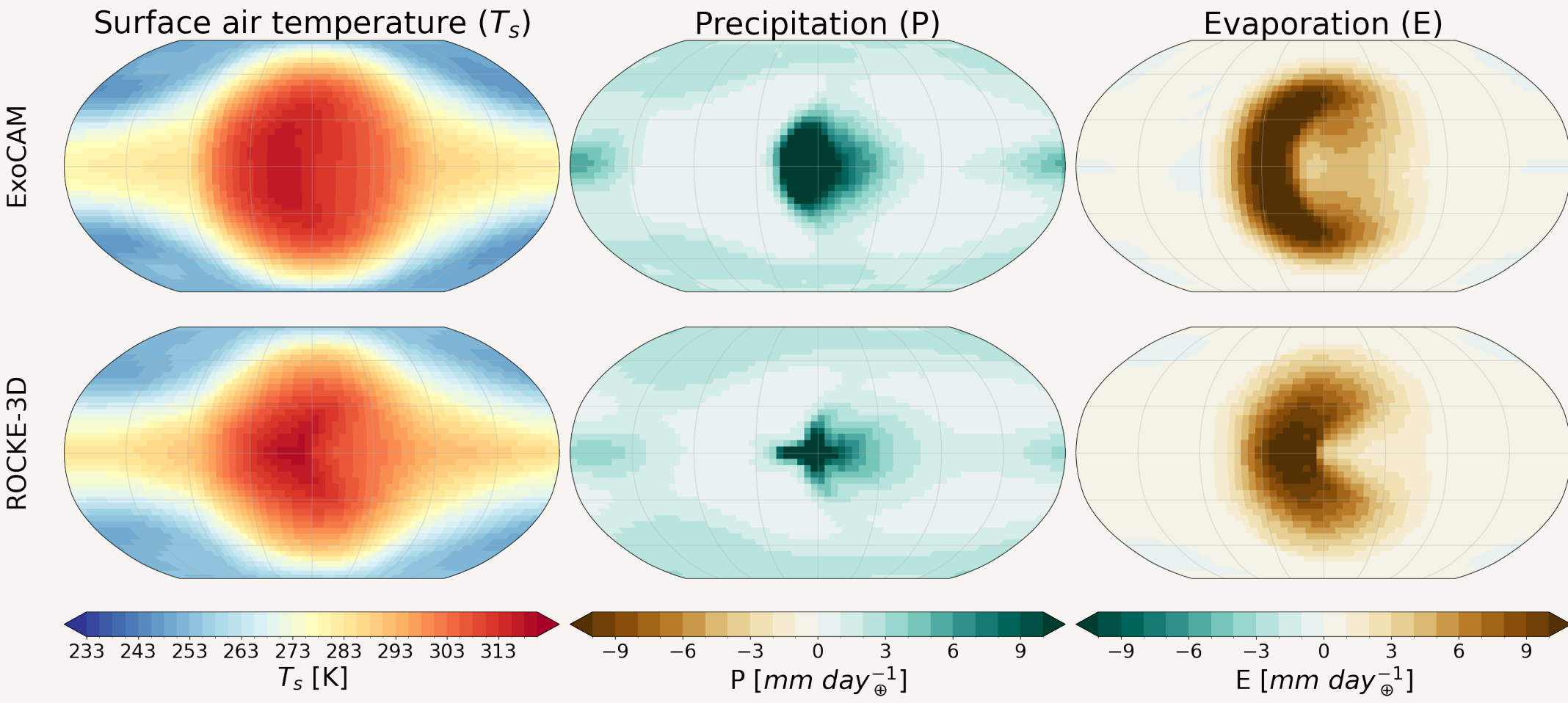


SURFACE CLIMATE

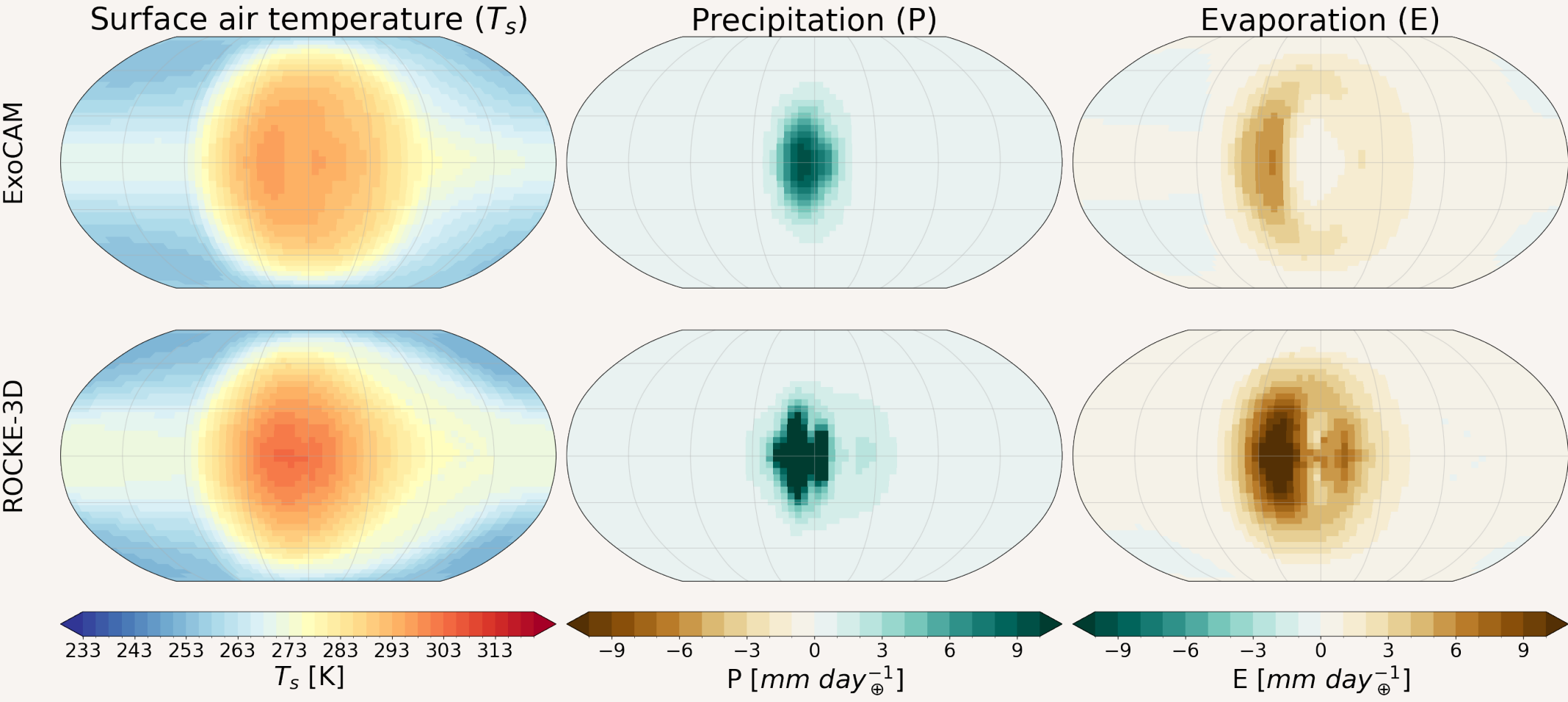
2600K 4.25D: "FAST"



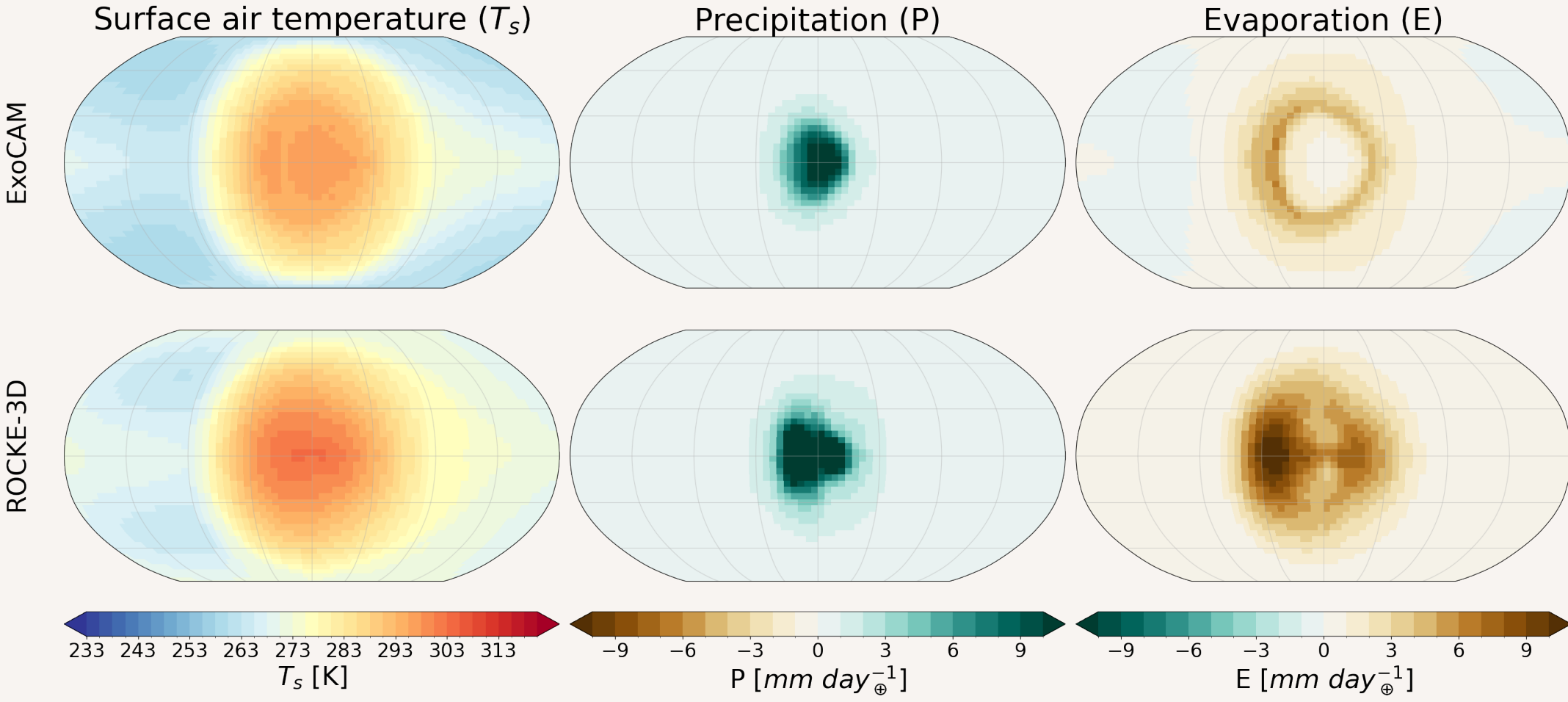
3000K 7.65/7.93D: "RHINES"



3300K 19.65D: "RHINES"



3700K 38.66D: "SLOW"



SUMMARY + NEXT STEPS

- ▶ **‘Fast rotators’:**

- ▶ Atmospheric structure similar with two jets sitting high in the atmosphere and 2 meridional cells in each hemisphere, but planetary rotation leading to faster jet in ExoCAM.
- ▶ Increased equator-pole temperature contrast. Precipitation focused around sub-stellar point but with some precipitation in mid-latitudes on night-side. ExoCAM slightly warmer overall.

- ▶ **‘Slow rotators’:**

- ▶ ExoCAM and ROCKE-3D in broad agreement, showing a single jet that sits lower in the atmosphere and one meridional cell in each hemisphere.
- ▶ Increased day-night temperature contrast, with ROCKE-3D slightly warmer. Models show slight differences in patterns of evaporation.

- ▶ **‘Rhines’** rotators more of a ‘transitory’ regime between ‘fast’ and ‘slow’ rotators?

- ▶ Finalise the rotation period for 3000K case
- ▶ Add more models to ensemble — UM + Generic PCM