Dayside Land on Tidally-Locked Rocky Planets

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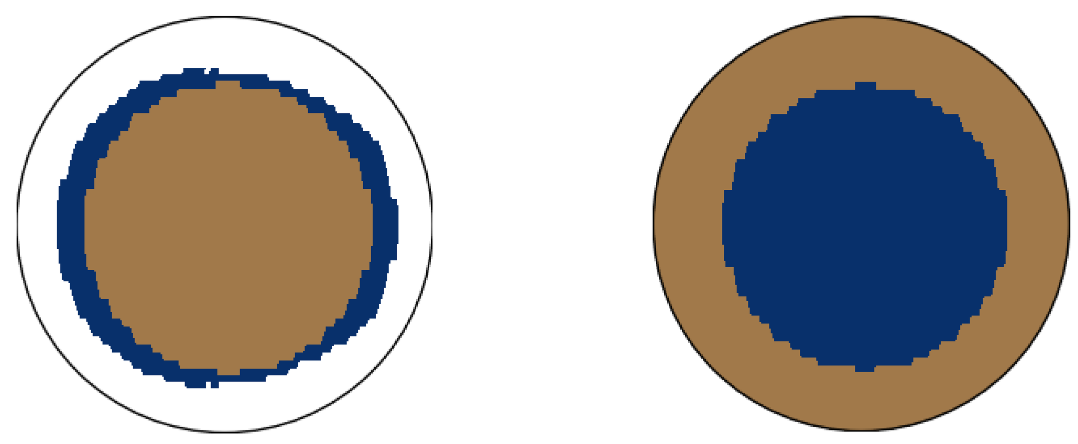
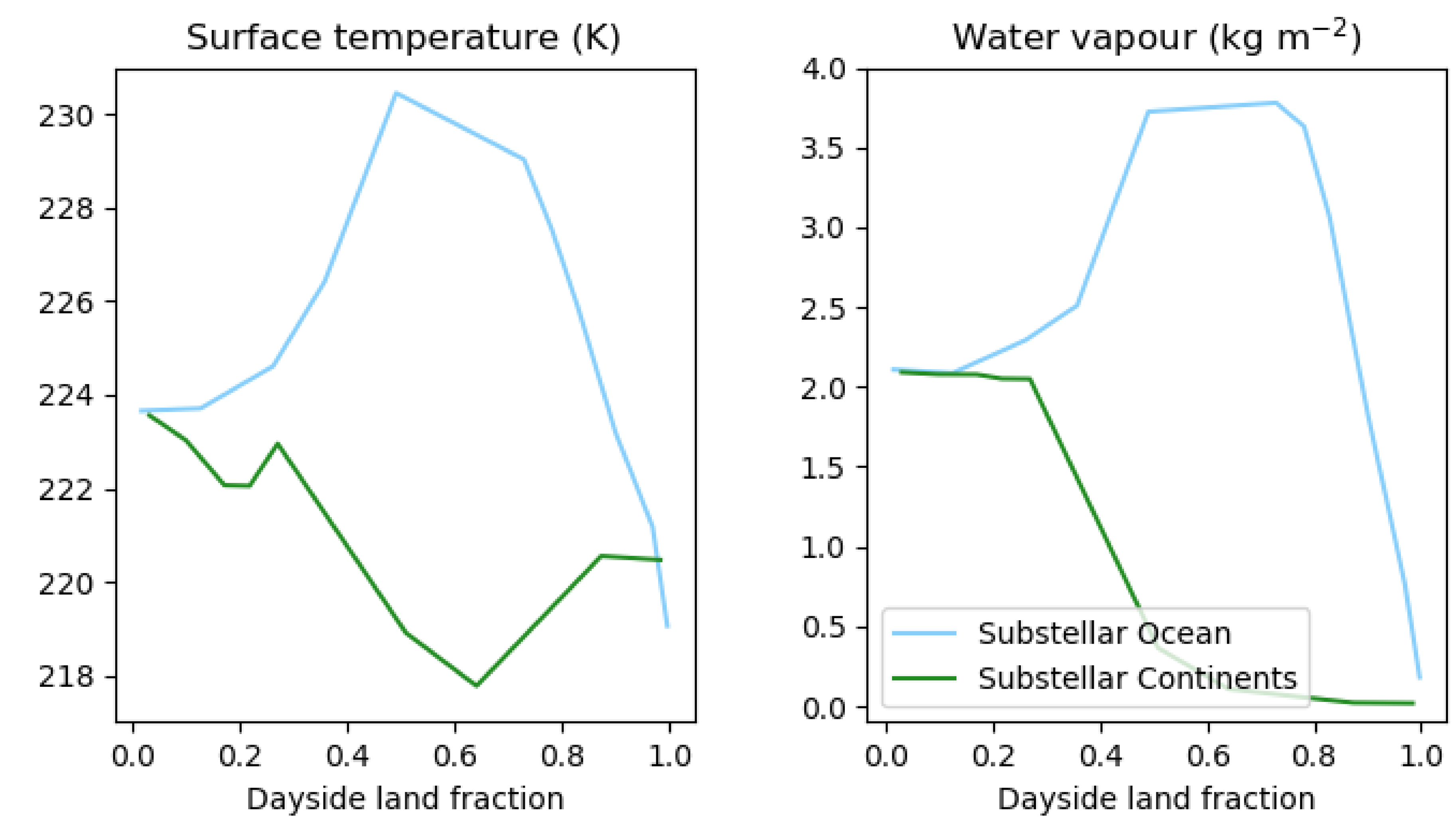
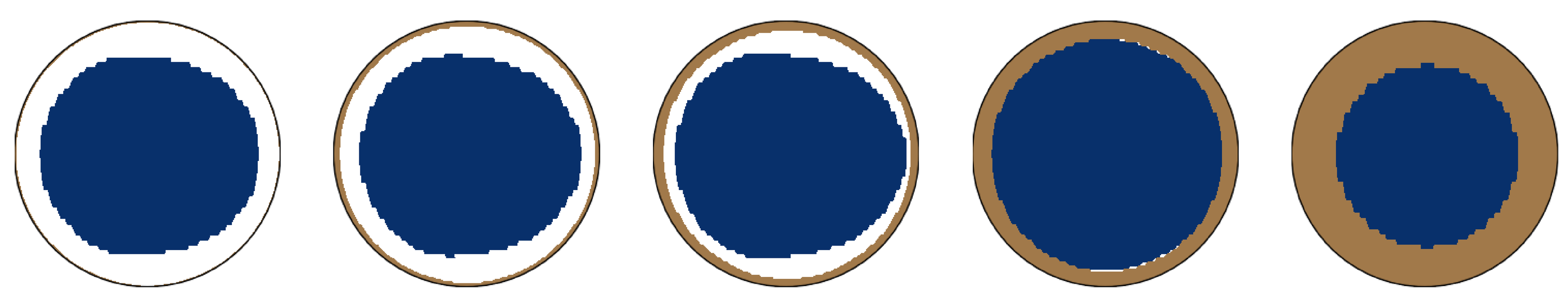
Introduction

- **Motivation**: real planets' surface conditions are unknown
- **Goal**: constrain effect of land on tidally-locked climates
- **Methods**: 3D simulations with the general circulation model ExoPlaSim
  - Proxima Centauri b parameters with Earth atmosphere, 3000 K star
  - Varying dayside land fraction in two opposite configurations: either all land or all ocean is at the substellar point



Dayside maps of substellar continent (left) and substellar ocean (right) models, with land in beige, ocean in blue, and ice in white.





Dayside maps of substellar ocean climates with land fraction decreasing to the right. At low land fraction, sea ice cools the planet.

Results

- Largest disagreement at partial dayside land cover
- **Substellar continent climates:**
  - Temperature and water vapour drop sharply once all ocean is ice-covered
- **Substellar ocean climates:**
  - Temperature and water vapour are highest at partial dayside land cover
  - Large substellar oceans have sea ice, which cools the planet
  - More ice forms and ice-free ocean gets smaller as land fraction decreases in models with sea ice

Conclusions

- Fundamental climate uncertainty: globally-averaged surface temperature changes by up to 15 K just from changing the land fraction and configuration
- Water vapour varies by over an order of magnitude between discrepant models
- Realistic landmaps may be somewhere in the middle
- **Future work**: simulate transit spectra to see whether we can tell these regimes apart observationally

References

Paradise et al., 2021 (in prep)
Lewis et al., 2018
Salazar et al., 2020
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