**POSSIBLE CLIMATES OF PROXIMA CENTAURI B IN THE PRESENCE OF A DYNAMIC OCEAN.**
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**Introduction:** Proxima Centauri b is a potentially rocky planet lying within the habitable zone of a cool star [1]. Although it may not have retained any water or even any atmosphere that existed at formation, its history is likely to have been complex, and scenarios for its current habitability exist [2,3]. Initial simulations of the climate of Proxima Centauri b with a 1-dimensional model [4] and a 3-dimensional model coupled to a shallow thermodynamic (slab) ocean [5] indicate that an Earthlike atmosphere can sustain surface liquid water, with a surface temperature of 17°C in the 1-D model and ~28°C at the substellar point in the 3-D model for a synchronously rotating aquaplanet.

Ocean heat transport is important in ameliorating temperature extremes but has only rarely been considered in exoplanet studies [6-8]. We conduct GCM simulations of possible Proxima Centauri b climates for various ocean, land and atmosphere configurations to understand their influence on the planet's habitability.

**Simulations:** We use the Resolving Orbital and Climate Keys of Earth and Extraterrestrial Environments with Dynamics (ROCKE-3D) GCM [9] at 4°x5° latitude-longitude resolution with 40 layers, coupled to a dynamic ocean of the same resolution with 13 layers. The atmosphere has 1 bar of $N_2$ + 376 ppm $CO_2$. The planet is assumed to be in an 11.2 d orbit in synchronous rotation with zero obliquity and eccentricity, with size 1.1 x $R_E$ and mass 1.4 x $M_E$. Aquaplanet (all-ocean, 900 m depth) and Earth land-ocean (1360 m depth) configurations are simulated. The planet is irradiated by the Proxima Centauri spectrum created by the Virtual Planetary Laboratory [4] (vpl.astro.washington.edu/spectra/stellar/proxcen.htm).

**Results:** Unlike the "eyeball Earth" open ocean pattern created when synchronously rotating aquaplanets are simulated with thermodynamic oceans [5,10], Proxima Centauri b with a dynamic ocean exhibits the "lobster Earth" open ocean pattern [8] produced by atmospheric equatorial Rossby and Kelvin waves in the presence of a stationary heat source [11] and a strong equatorial westerly ocean current. The most notable features of this climate are:

(1) Although the open ocean area is more extensive (49%) than in thermodynamic ocean simulations, dayside temperatures are much cooler (maximum surface temperature of 5°C) due to ocean heat transport from the dayside to the nightside (Fig. 1, upper). A simulation with an Earth land-ocean configuration and a substellar point over the Pacific has much warmer dayside temperatures and is more like an eyeball Earth (Fig. 1, lower), because ocean heat transport is restricted.

(2) Temperatures, clouds, sea ice, etc. are asymmetric about the substellar point in the aquaplanet case, suggesting the possibility that if Proxima Centauri b is a habitable ocean planet this might be detectable in the asymmetry of phase curves.

**References:** [1] Anglada-Escudé G. et al. (2016) *Nature, 536,* 437-440. [2] Barnes R. et al. (2016) *arXiv:1608.06919*. [3] Ribas I. et al. (2016) *A&A, 596,* A111. [4] Meadows V. S. et al. (2016) *arXiv:1608.08620.* [5] Turbet M. et al. (2016) *A&A, 596,* A112. [6] Cullum J. et al. (2014) *AsBio, 14,* 645-650. [7] Cullum J. et al. (2016) *PNAS, 113,* 4278-4283. [8] Hu Y. and Yang J. (2014) *PNAS, 111,* 629-634. [9] Way M. J. et al. (2017) *arXiv:1701.02360*. [10] Pierrehumbert R. T. (2011) *Ap.J. Lett., 762*, L8. [11] Gill A. (1980) *QJRMS, 106,* 447-462.

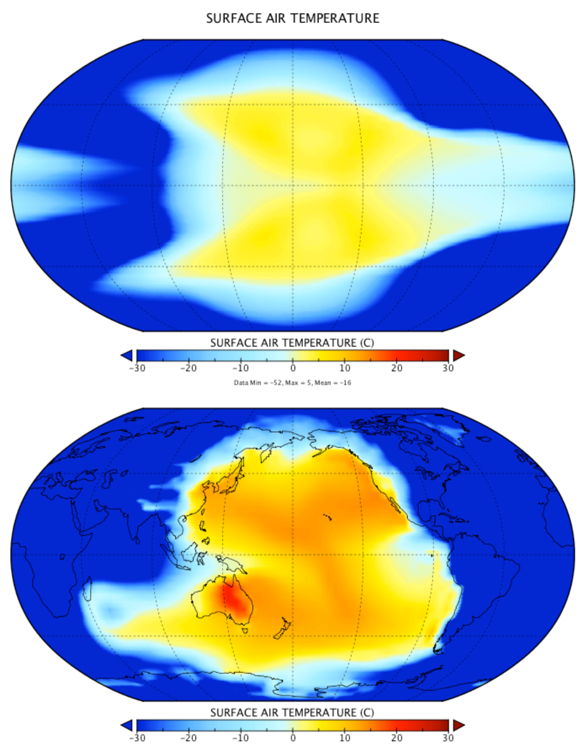


Fig. 1. Surface temperature for the simulations with an (upper) aquaplanet and (lower) Earth land-ocean configuration. The substellar point is at the center of each figure.