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The Climates of Earth's next Supercontinent:
Effects of Tectonics, Rotation rate & Insolation

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Abstract

We investigate two possible deep future Earth climate scenarios using a 3-D GCM [1], 200 and 250 million years into the future when the next supercontinent phase is expected to take place. We use knowledge of the evolution of plate tectonics, solar luminosity, and rotation rate over this time period. In one scenario, a supercontinent forms at low latitudes. In the other scenario it forms at high northerly latitudes with an Antarctic subcontinent remaining at the south pole. The climates differences between these two scenarios are dramatic, with differences in mean surface temperatures approaching 4 degrees. The fractional habitability (where mean surface temperatures are between 0<T<100C year round) on land surfaces (as opposed to the ocean) is shown to differ up to 40\% between the two simulations. We believe these demonstrate that the community needs to consider alternative boundary conditions when simulating Earth-like exoplanetary climates. This work has recently been submitted to GRL and can be accessed at the ESSOAr repository [2].

References: [1]Way et al. 2017 ApJS, 231, 12, doi: 10.3847/1538-4365/aa7a06 [2] https://doi.org/10.1002/essoar.10501348.1

Summary list of simulations and results

SIM	Sun	79% N2, 21% O2 CO2/CH4/N2O	Topography	Runtime (years)	Tsurf (C)
01	Aurica Control	285/.79/0.3ppmv	Aurica	2000	20.5
02	Aurica PD	285/.79/0.3ppmv	"	2500	20.6
03	Aurica 250f	285/.79/0.3ppmv	"	2000	20.6
04	Amasia Control	285/.79/0.3ppmv	Amasia	2567	19.7
05	Amasia PD	285/.79/0.3ppmv	"	3000	17.2
06	Amasia 200f	285/.79/0.3ppmv	"	3000	20.2
07	Modern Earth No O3 nor Aerosols	285/.79/0.3ppmv	Modern Earth	1000	14.2

Future Continent Descriptions

Aurica is a Low Latitude Supercontinent 250 million years into the future
Control= Low mean topography, land close to sea level, no mountains
PD = Higher mean topography, land close to present day (PD) topography, no mountains
250f = Low mean topography with mountains

Amasia has a northern Supercontinent and most of present day Antarctica 200 million years into the future
Control= Low mean topography, land close to sea level, no mountains
PD = Higher mean topography, land close to present day (PD) topography, no mountains
200f = Low mean topography with mountains

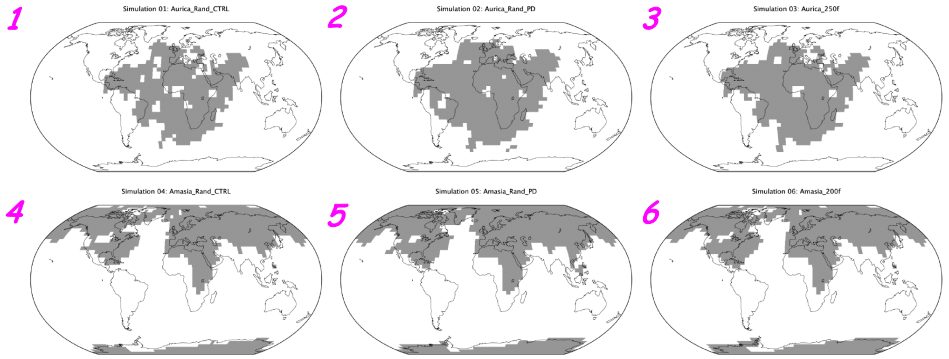
GCM Model Setup

3-D General Circulation Model : ROCKE-3D (Way et al. 2017)
Model Resolution: Atmosphere: 4° x 5° x 40 (latitude x longitude x layers), Ocean: 4° x 5° x 32 layers
Topographies: Modern Earth, Aurica & Amasia (Future Earth Supercontinents)
Land: Albedo = 0.2 At Model Start (AMS), No land ice AMS, No vegetation, 50/50 = clay/sand soil
Oceans: Fully coupled (dynamic),
Orbital Parameters: Modern Earth orbital period, day length = 24.5 hrs, **Insolation:** 1.025 x Modern
Atmospheres: 1.) N2 dominated 1 bar, O2=21%, CO2=285ppmv, CH4=0.79ppmv, N2O=0.3ppmv

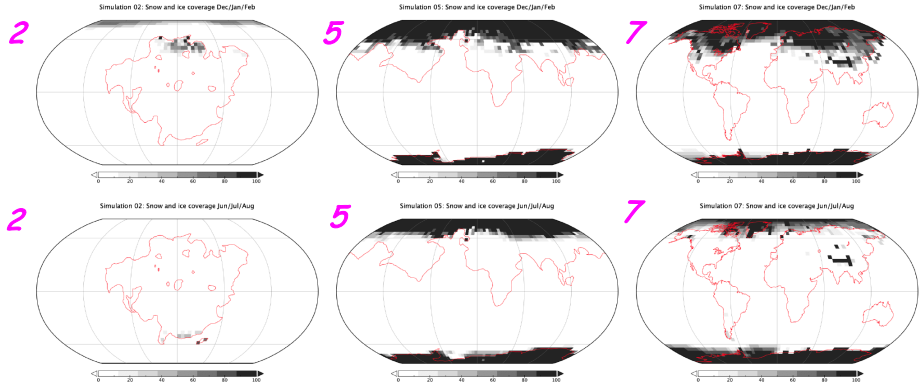
Conclusions

Aurica: Mean surface temperatures for all simulations with large low latitude supercontinent are within 0.1 C.
Amasia: Mean surface temperatures span a range of 3 degrees with lowest mean surface temperature of 17.2 C due to large contiguous ice sheets in northern hemisphere. This is because, unlike modern Earth, the oceans cannot transport sufficient heat from equatorial regions to higher northern latitudes.

Topographies (Future Supercontinents in dark gray Modern outlined black)



Results: Snow & Ice Coverage in black, Continental outlines in red



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