

Exploring the ocean's role in climate asymmetries

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University of Washington, Seattle

In collaboration with:

Andrew Shao

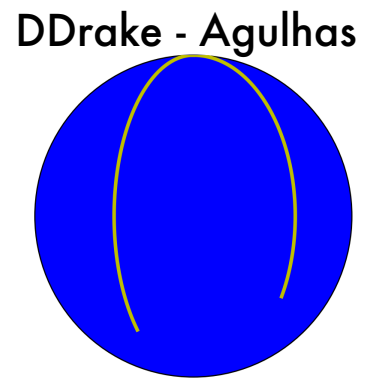
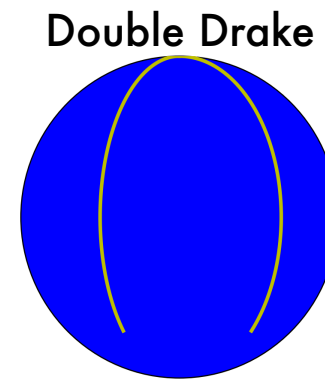
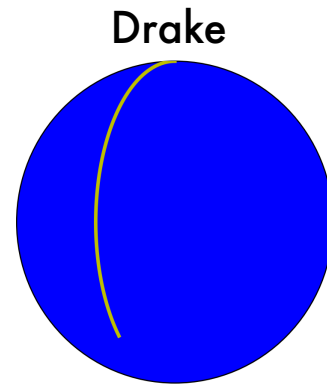
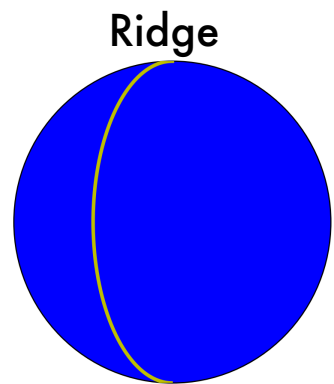
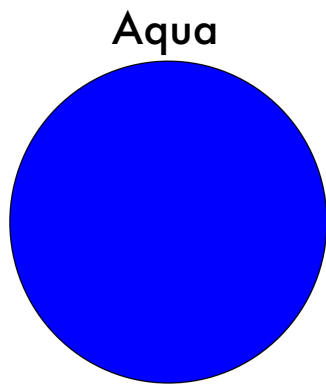
Elizabeth Maroon

OMWG Meeting

April 5, 2019

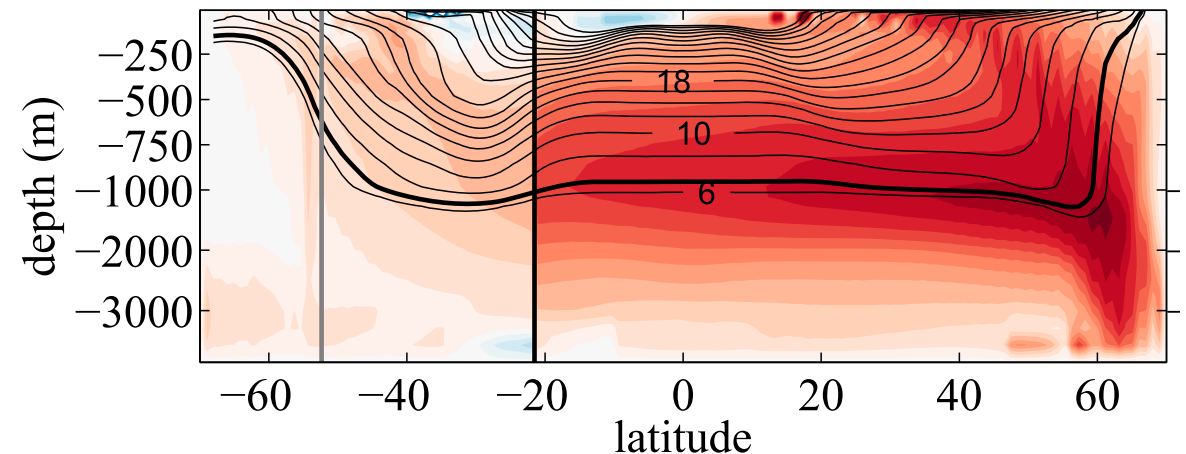
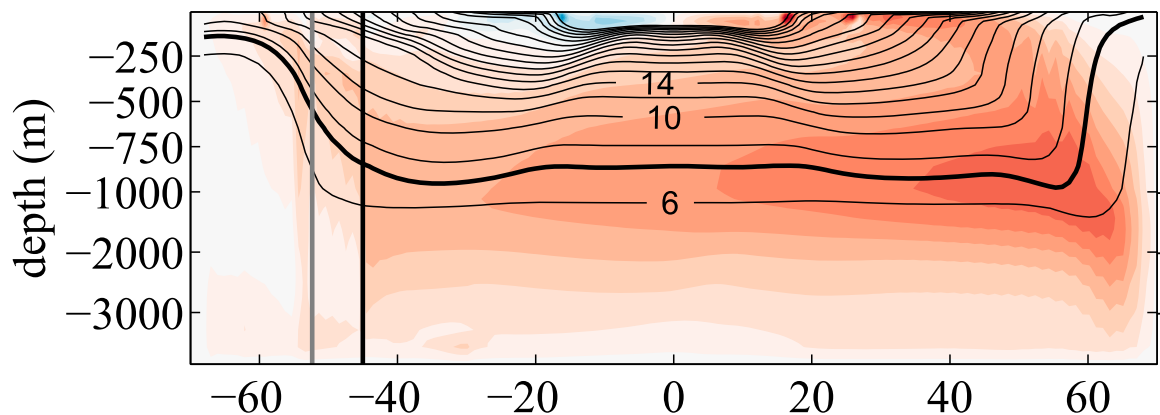
Idealized geometry coupled model studies

- MITgcm ocean coupled to either SPEEDY or a Gray Radiation atmosphere
 - Role of continents in heat transport (Enderton & Marshall 2009)
 - Localization of deep sinking and overturning in narrow basin (Ferreira et al. 2010; Nilsson et al. 2013)
 - Role of continents in freshwater transport (Ferreira and Marshall 2015)
 - AMOC's role in ITCZ location (Marshall et al. 2014)
 - Role of subtropical cells in ITCZ sensitivity to interhemispheric forcing (Green and Marshall 2017)



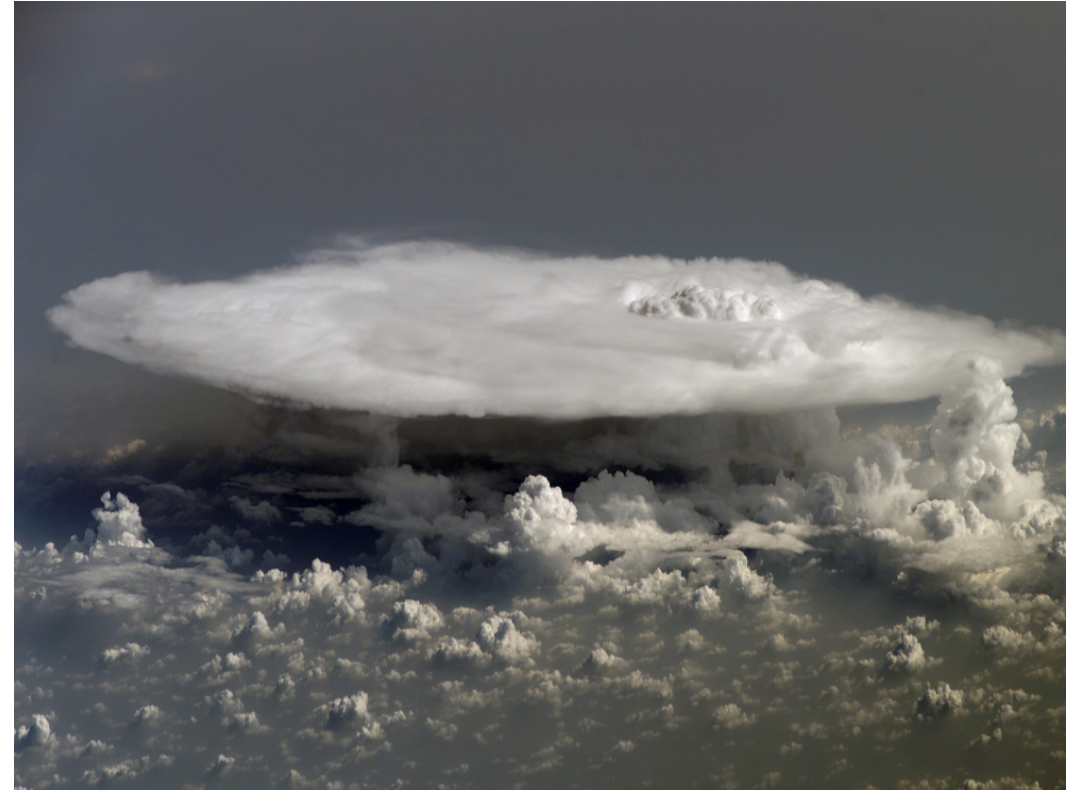
Idealized geometry ocean-only model studies

- MITgcm ocean-only
 - Interbasin transport and overturning with one wide and one narrow basin (Jones and Cessi 2016)
 - Cold route versus warm route inter-basin exchange dependence on continental length (Cessi and Jones, 2017)
 - Effect of Southern Ocean buoyancy loss on abyssal circulation and stratification (Jansen and Nadeau 2016; Jansen 2017)
 - Transient and equilibrium response of overturning circulation (Jansen et al. 2018)

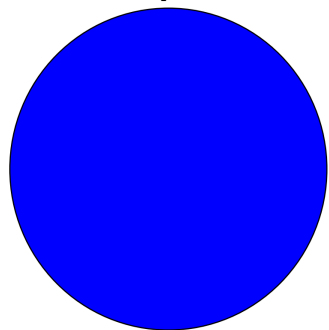


Time for an update!

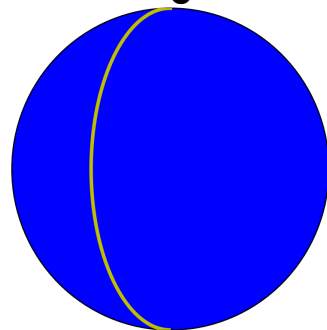
- The community would benefit from the ability to perform similarly idealized oceans and climate studies (with configurable continents and bathymetry), but with:
 - A state-of-the-art ocean (MOM6)
 - Realistic clouds and cloud feedbacks (AM2.1, CAM4, etc)
 - Continuity within a climate model hierarchy



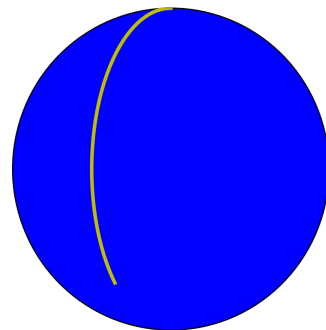
Aqua



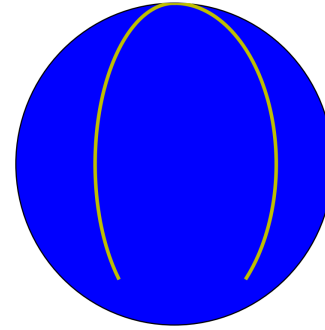
Ridge



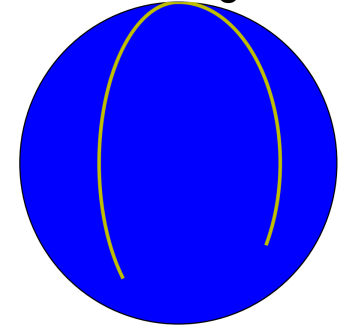
Drake



Double Drake

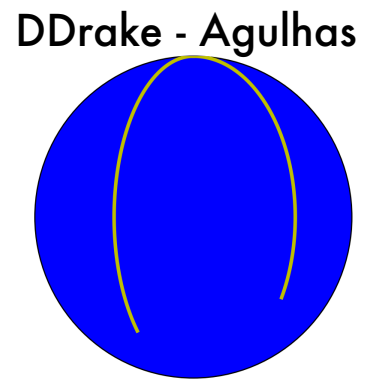
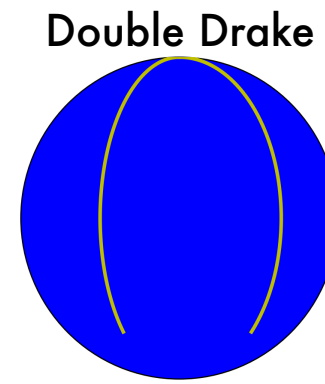
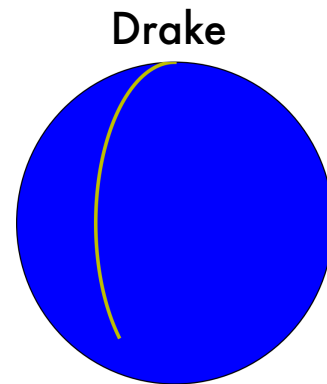
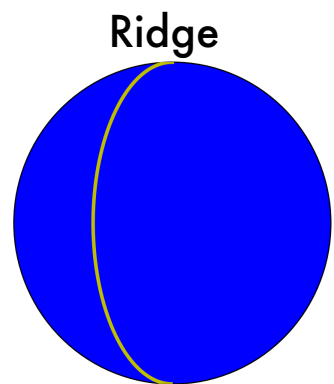
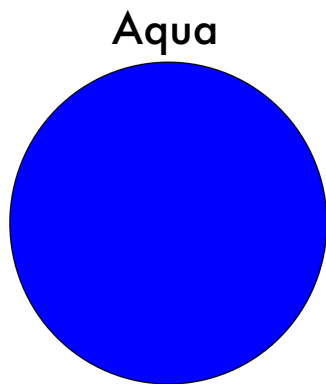


DDrake - Agulhas



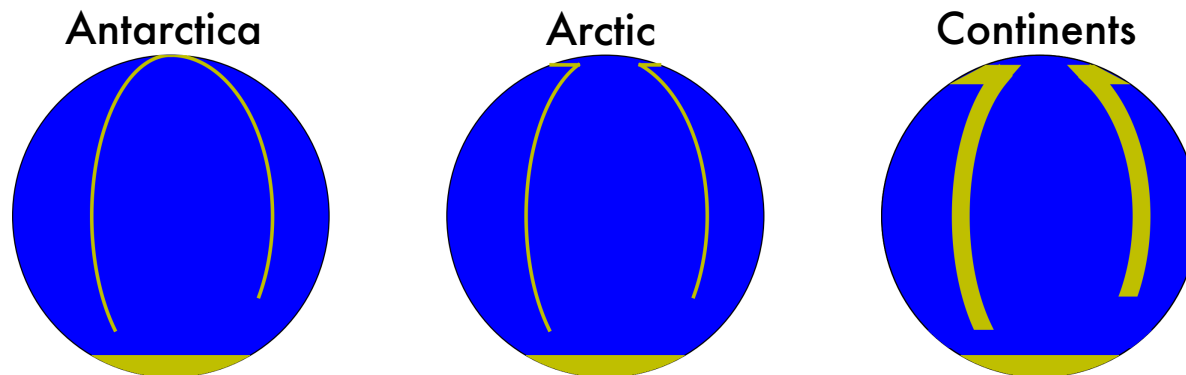
Open science questions

- How do clouds and cloud feedbacks change our understanding of
 - Role of continents in meridional heat transport and ocean overturning
 - Relative roles of ocean and atmosphere in meridional heat transport under different rotation rates
 - Role of ocean circulation in setting ITCZ location



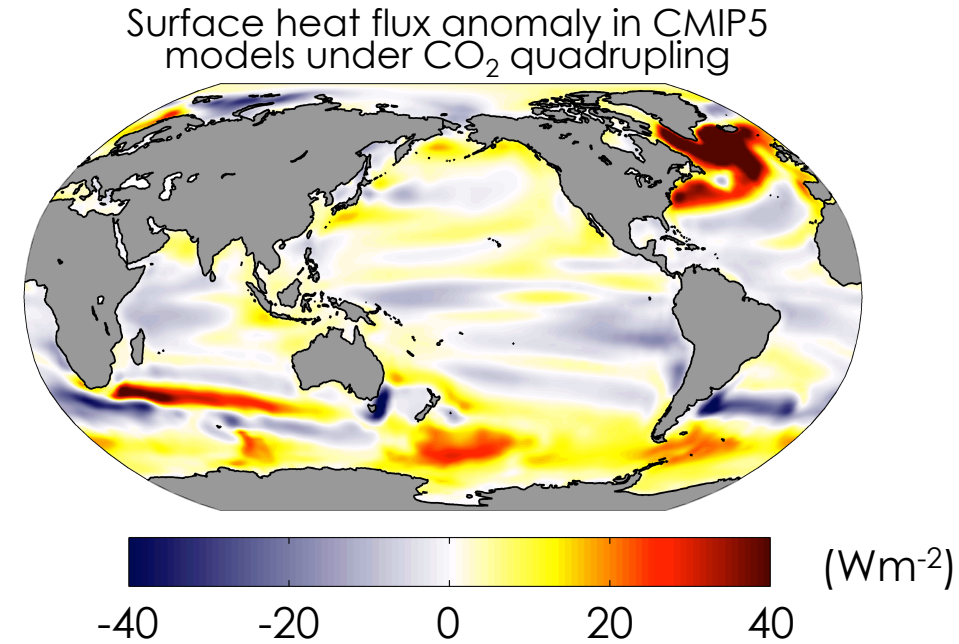
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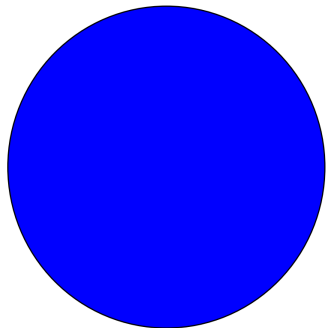


Open science questions

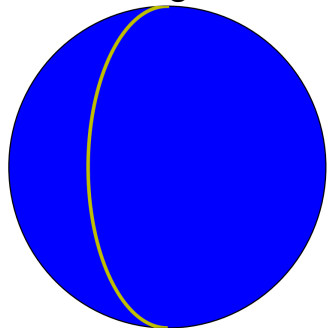
- What sets the spatial pattern and magnitude of ocean heat uptake under CO₂ forcing?



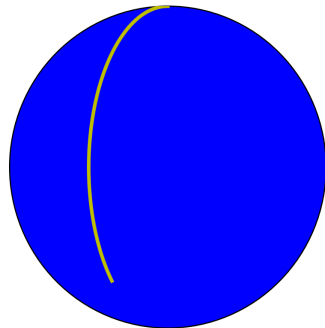
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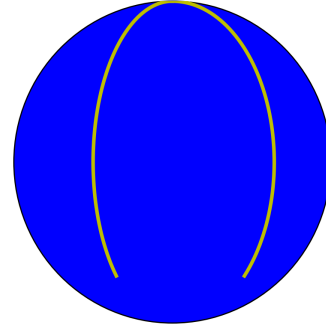
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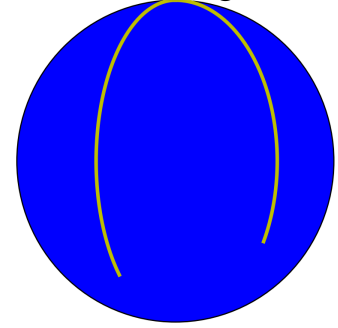
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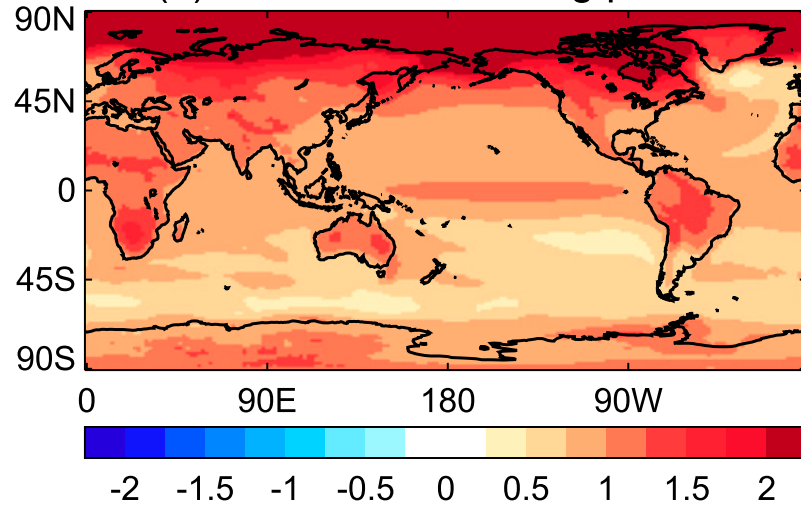
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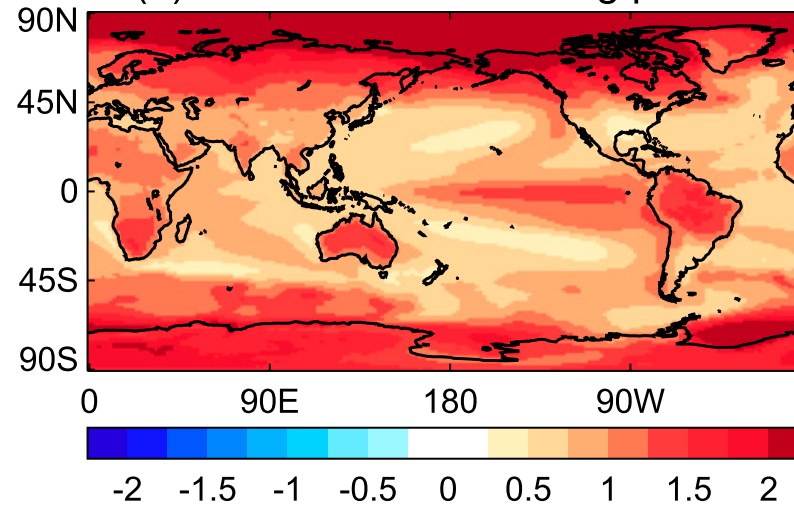
Open science questions

- What sets the spatial patterns of radiative feedbacks and sea-surface warming? And why do radiative feedbacks become more positive over time?

(a) Years 1-20 warming pattern

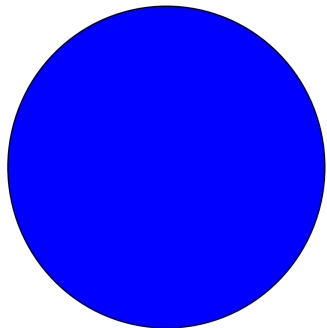


(b) Years 21-150 warming pattern

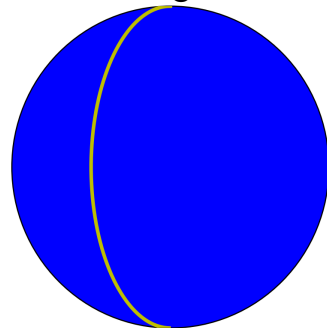


(Andrews et al. 2015)

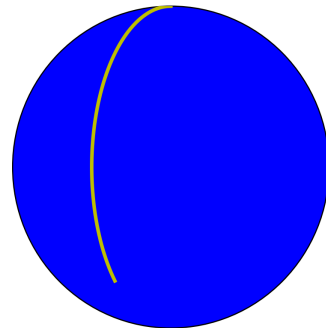
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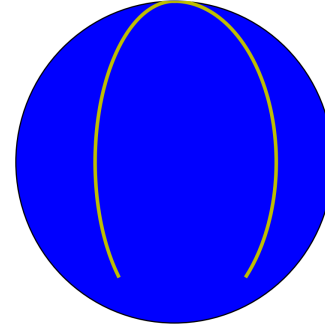
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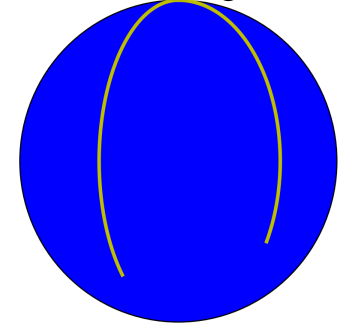
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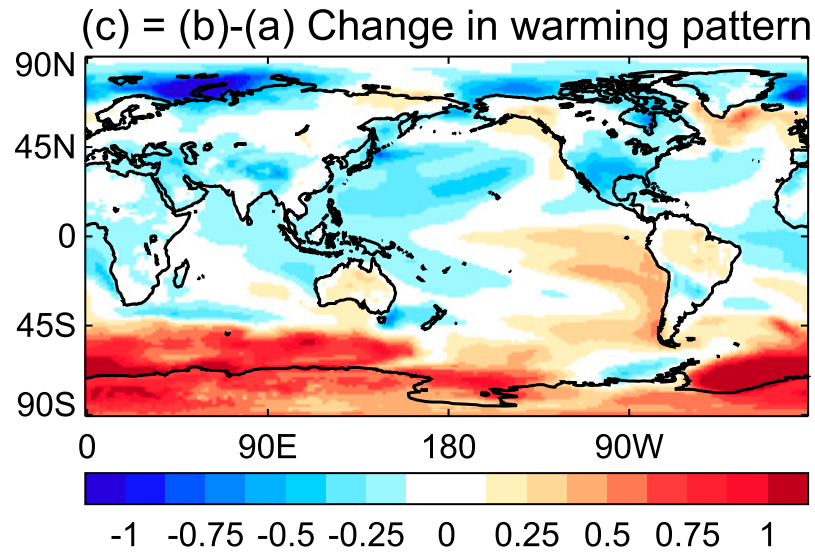


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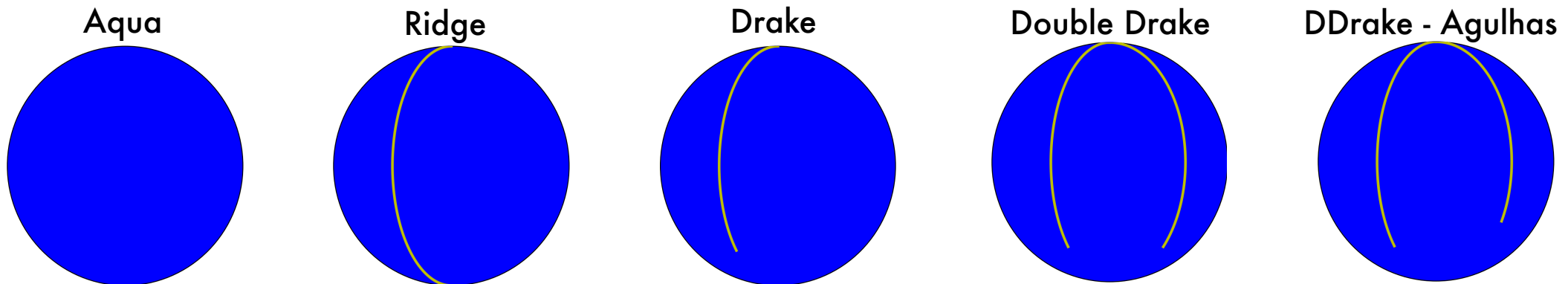


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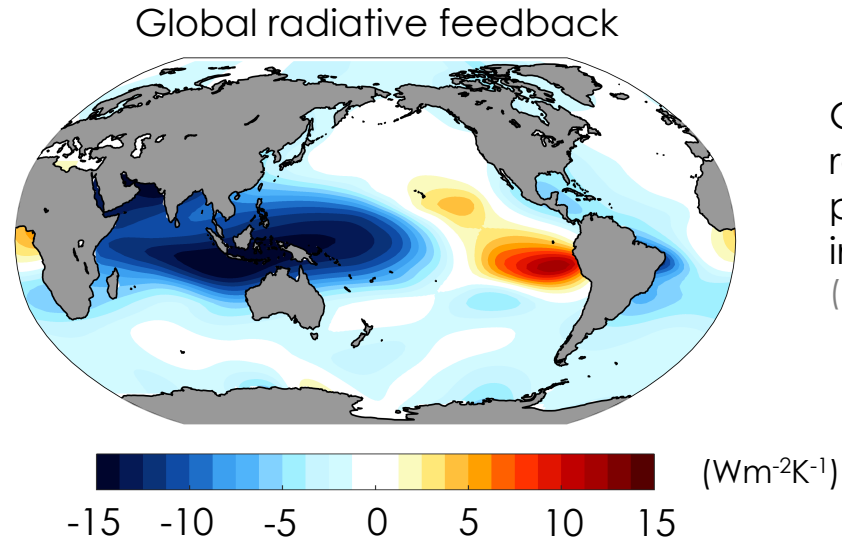
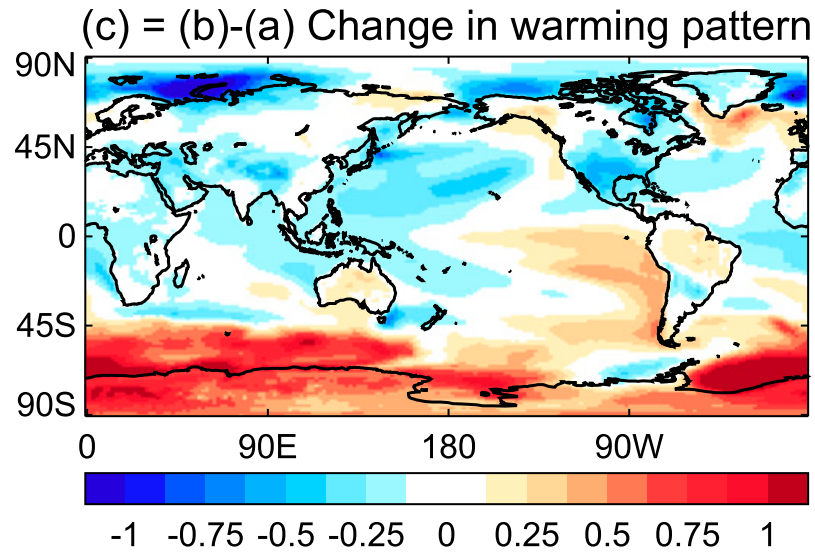


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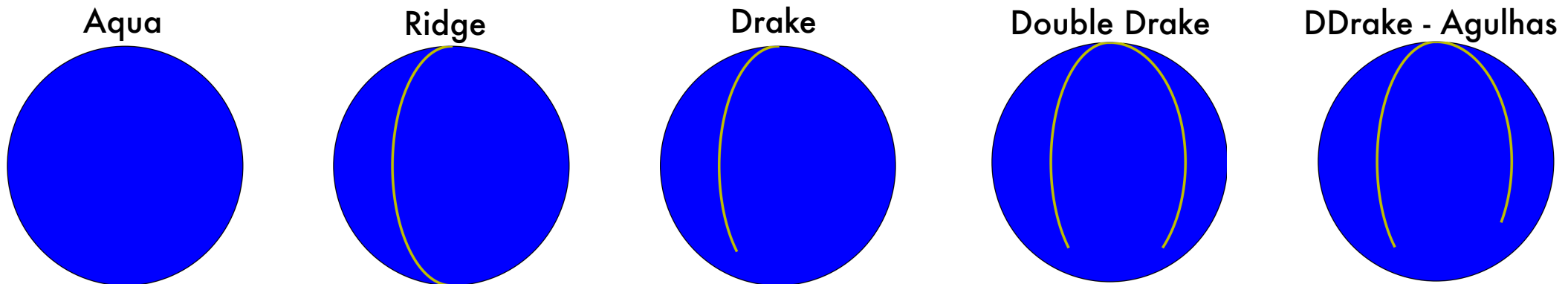


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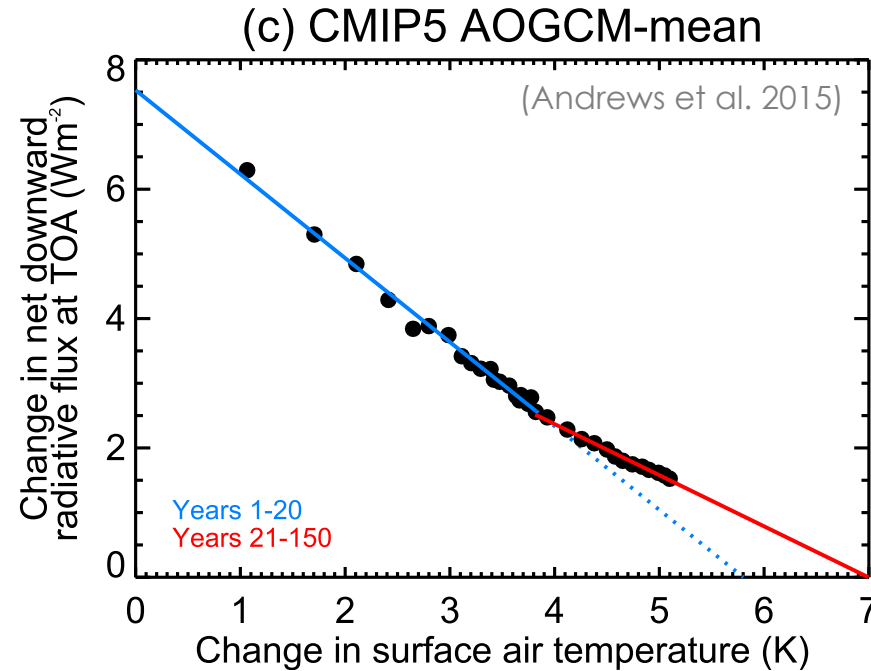


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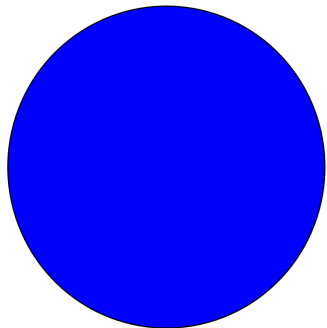
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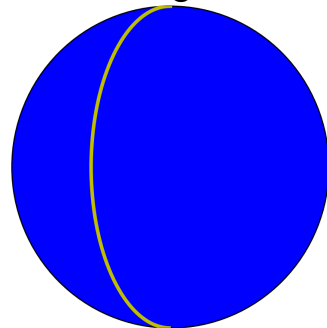


Radiative feedbacks become more positive (higher ECS) as the pattern of warming evolves

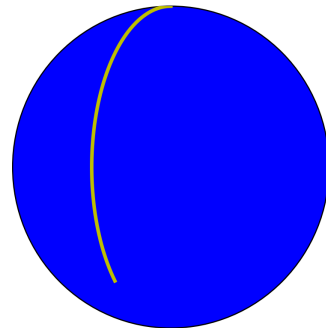
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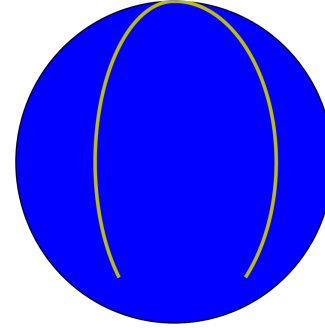
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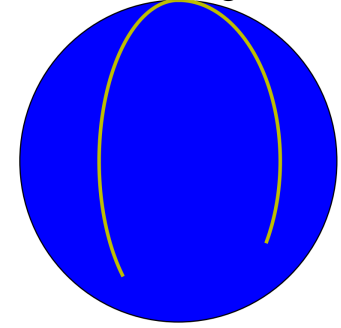
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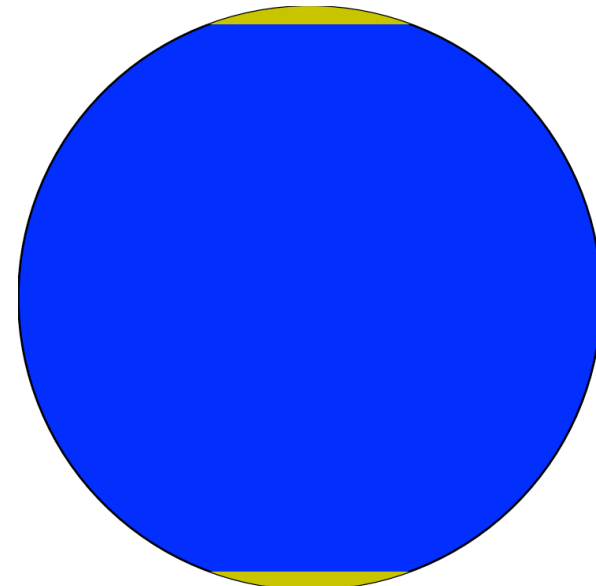
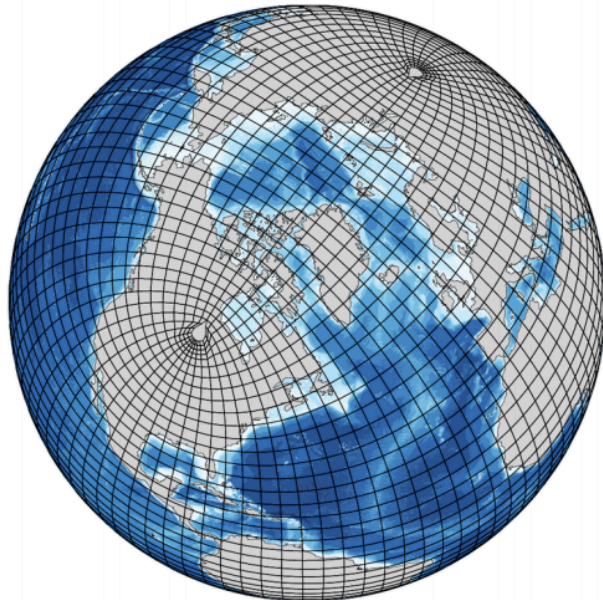


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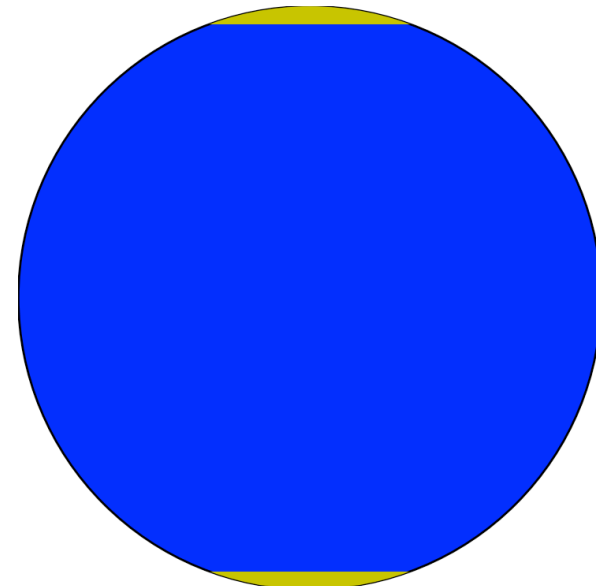
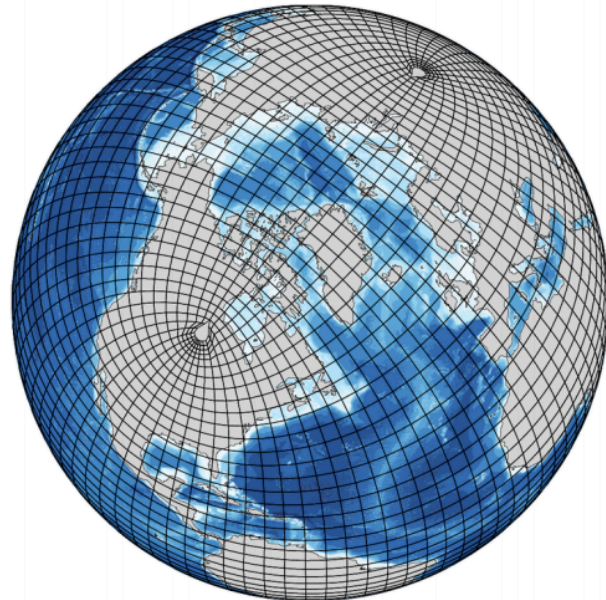
Grid customization

- Creating continents: Python script generates ocean, atmosphere, land grids
- Specify ocean depth and coordinate ranges for land (or ridges)



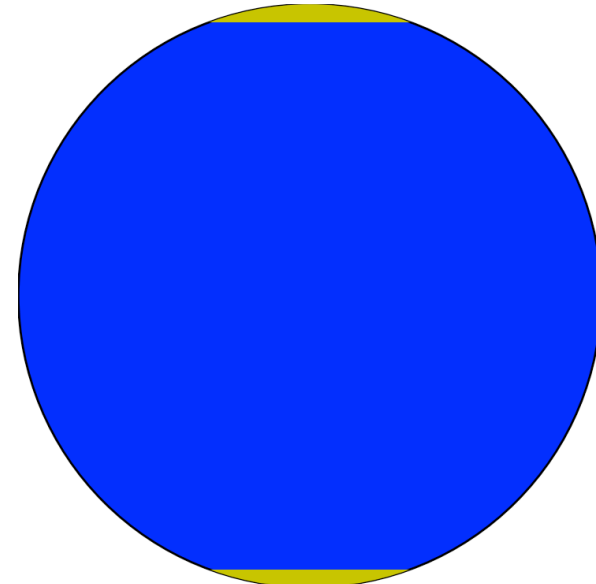
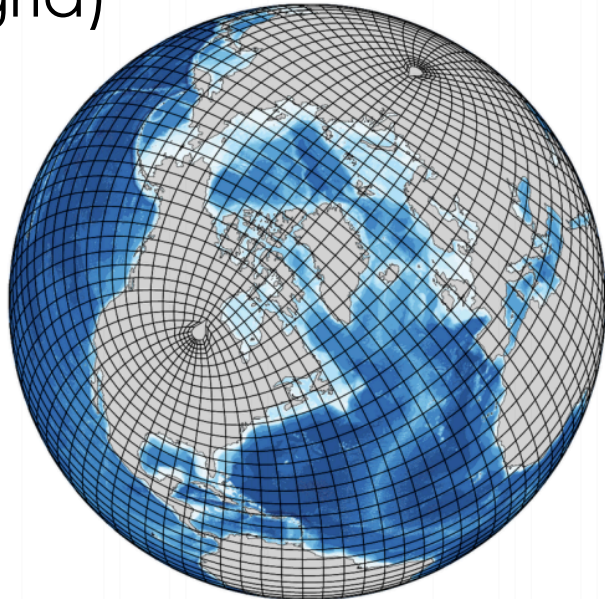
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- Bash script calls GFDL's FMS NC-Tools to create grid mosaics and coupler mosaics

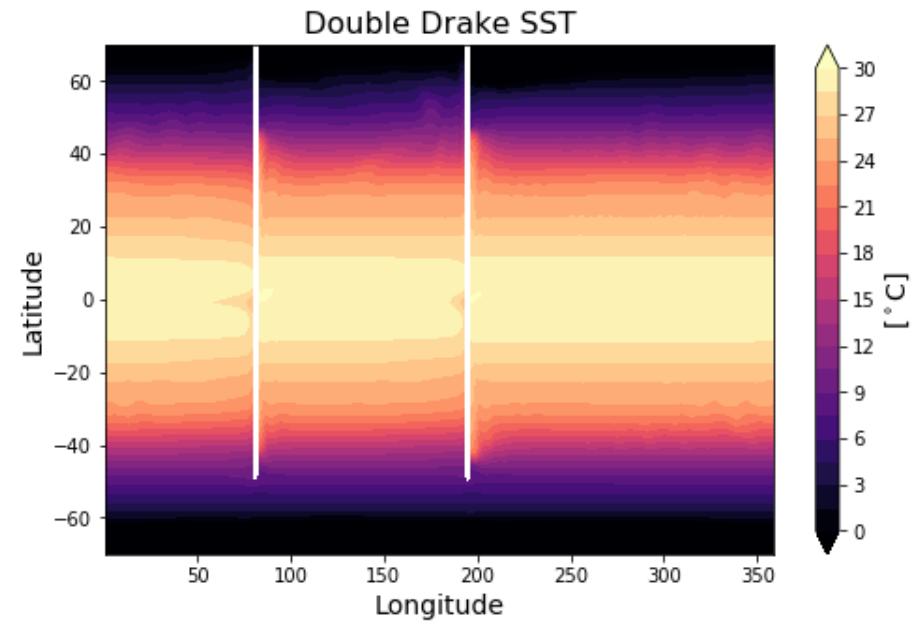
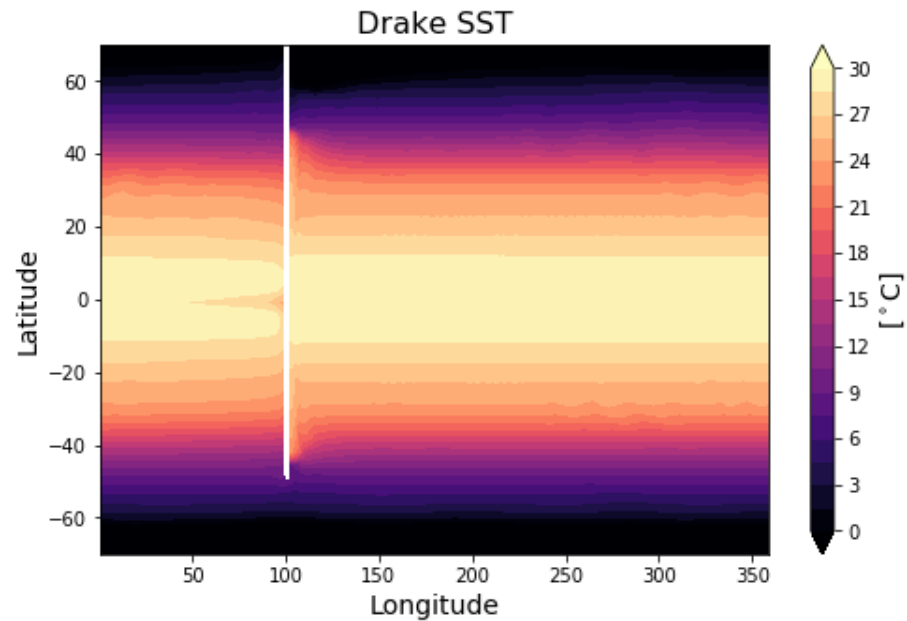
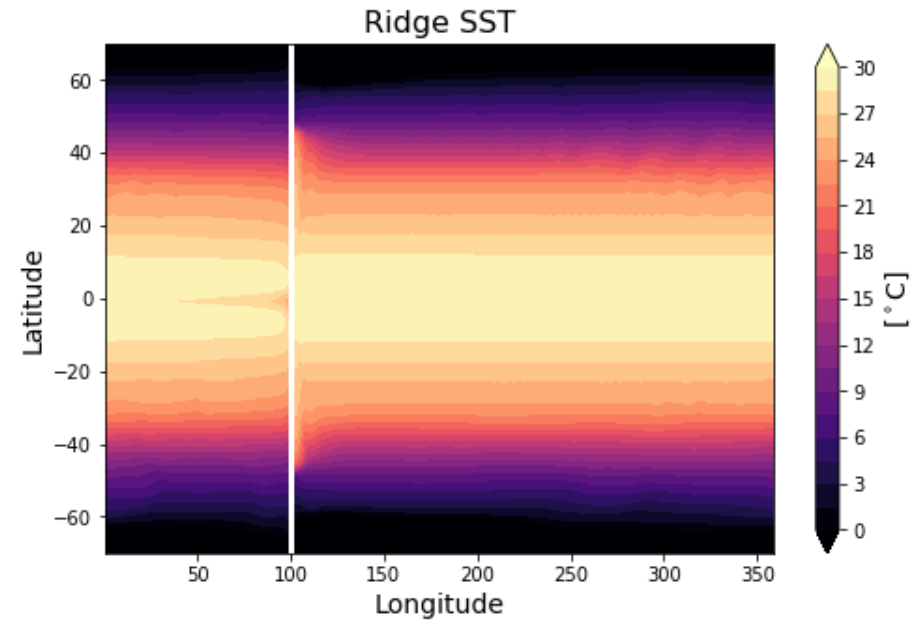
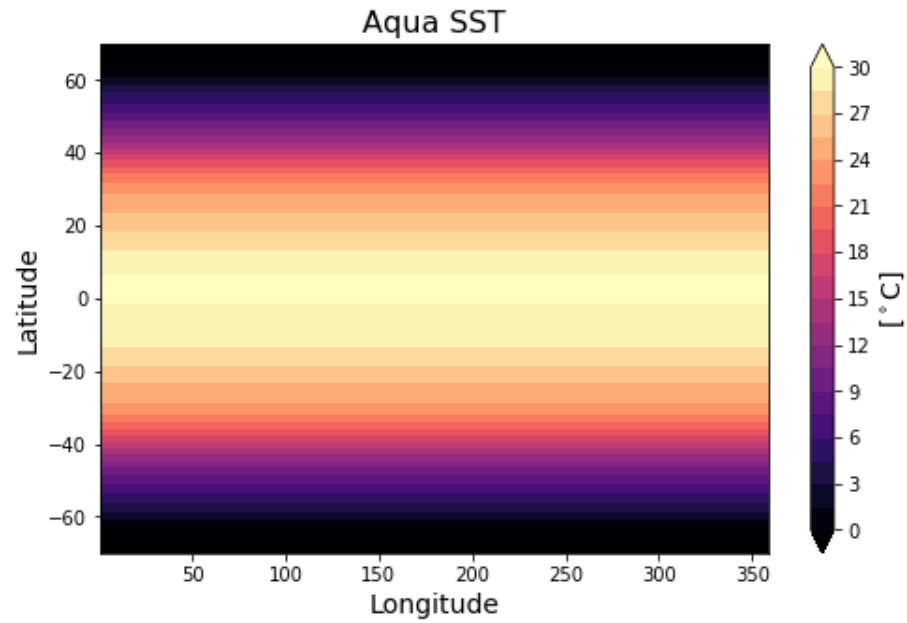


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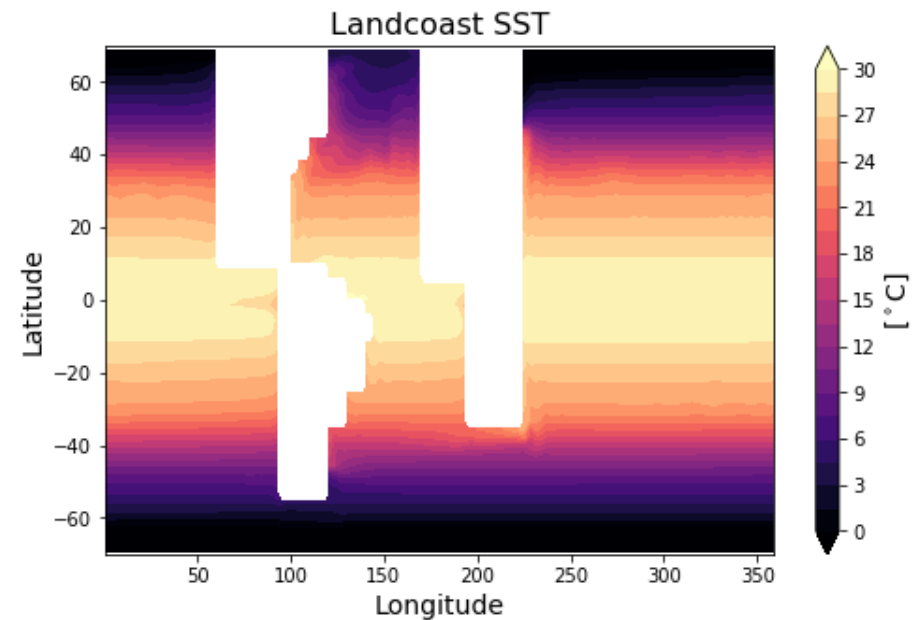
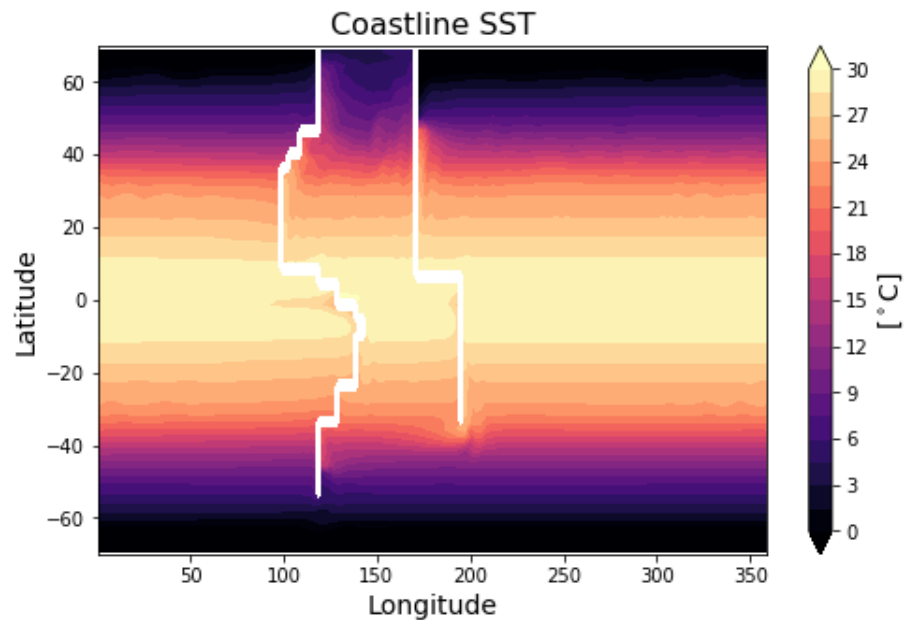
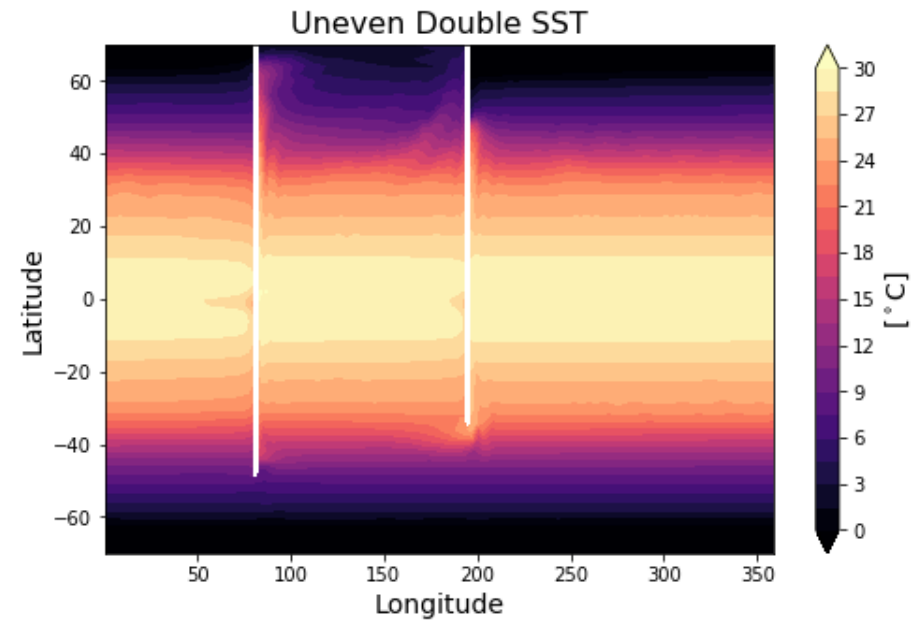
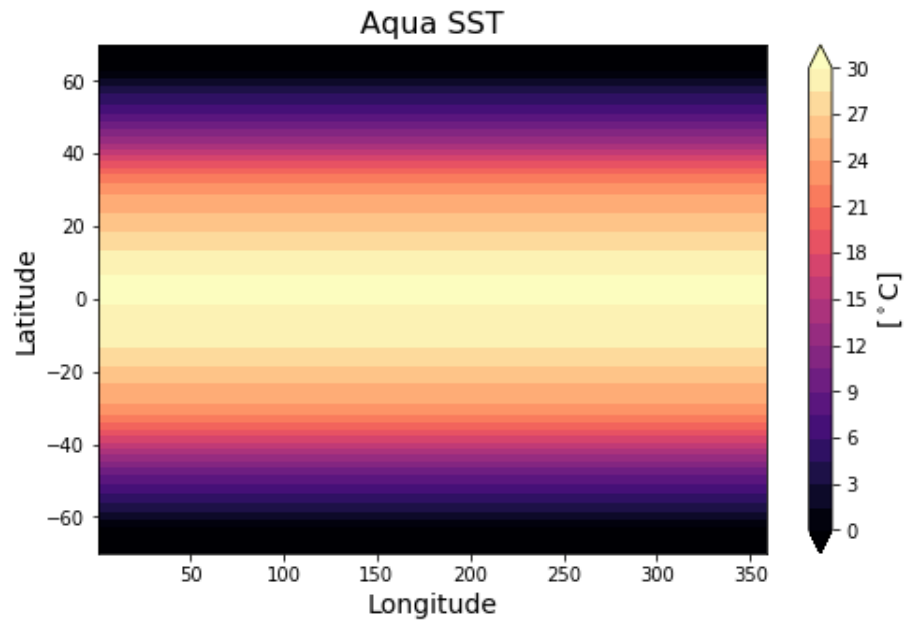
- Creating continents: Python script generates ocean, atmosphere, land grids
- Specify ocean depth and coordinate ranges for land (or ridges)
- Bash script calls GFDL's FMS NC-Tools to create grid mosaics and coupler mosaics
- Ocean grid extends from 70°S to 70°N. Currently using bipolar grid (instead of MOM6's tripolar grid)



Example configurations with MOM6

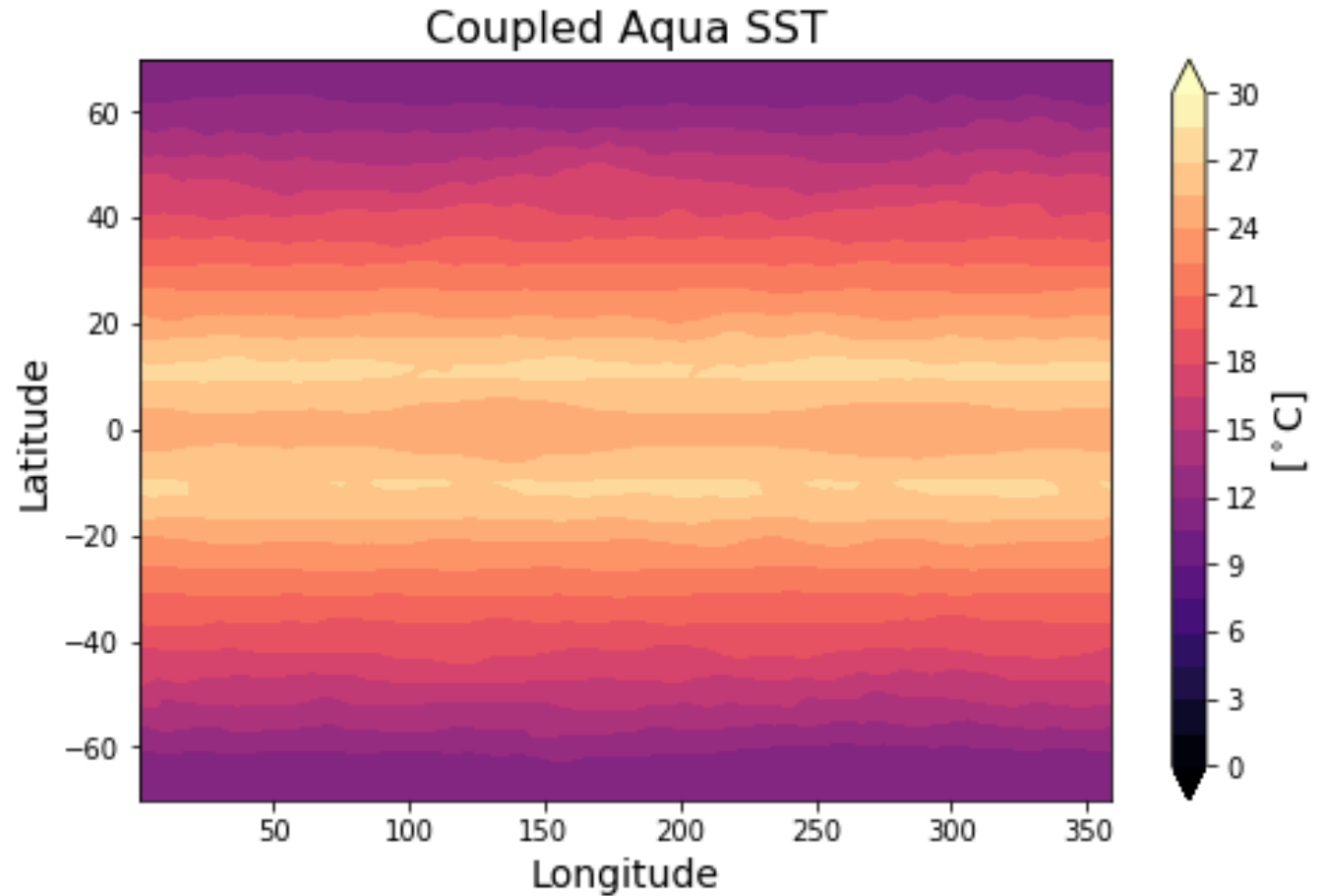
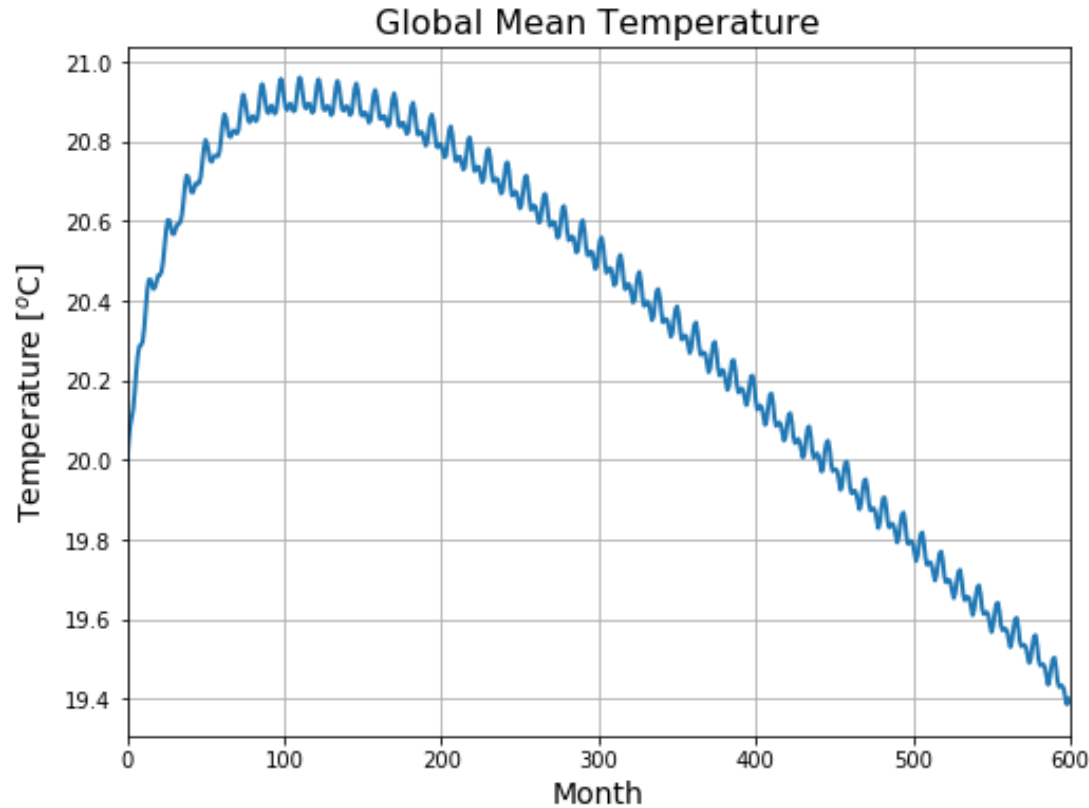


Example configurations with MOM6



Coupled model (MOM6-AM2.1)

- Not yet spun up to equilibrium – only 50 years of output shown here



Future work

- Coupled model run to equilibrium
- Additional configurations
- Greenhouse gas forcing
- Variable rotation rate experiments

