AIR-SEA COUPLING SHAPES NORTH AMERICAN HYDROCLIMATE RESPONSE TO LGM ICE SHEETS

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CESM Paleoclimate Working Group Meeting
February 8, 2021
LGM precipitation difference in PMIP3 models

Proxies and models point to a wetter Southwest U.S. and drier Pacific Northwest during LGM

Proxy Reconstructions:
- Green circle: Agrees with model
- Yellow circle: Weakly disagrees with model
- Red circle: Strongly disagrees with model

Oster et al. (2015)
Modern Day Topography

LGM Topography

Storms

LGM HYDROCLIMATE

Meters Above Sea Level

-6000 -5000 -4000 -3000 -2000 -1000 0 1000 2000 3000
Research questions:
1. Mechanical (tall) vs thermodynamic (bright) influence of continental ice sheets on North American west coast hydroclimate?
   • Influence on North Pacific jet and downstream rainfall.
2. What role do air-sea interactions and/or ocean dynamics play in modulating that response?

Roberts et al. (2019)

Summer stationary waves in LGM HadCM3 single forcing runs

LGM HYDROCLIMATE
CESM1 EXPERIMENTS

Pre-industrial Control (Ctl)

Full LGM Climate (LGM-Full)

Green Mountain (GM; Mechanical forcing)

White Mountain (WM; Mech. + Therm. forcing)

Surface Height

TOA Upward SW

Surface Height

TOA Upward SW

*See DiNezio et al. (2018) Science Advances, for complete model details
CESM1 EXPERIMENTS

White Mt and Green Mt experiments across hierarchy of ocean model configurations

*All runs appropriately spun-up

AGCM-only

Forced at lower boundary by SSTs

Slab Ocean Model (SOM)

Interactive mixed layer with air-sea heat exchange

Dynamical Ocean Model (DOM)

Fully dynamical ocean circulation
GREEN MOUNTAIN

Mechanically forced shift of the N. Pacific jet, shift in west coast hydroclimate

Amaya et al. in review
Including ocean-atmosphere interactions leads to opposite result

Amaya et al. *in review*
Including ocean-atmosphere interactions leads to opposite result

Amaya et al. *in review*
Mechanical + thermodynamic ice sheet effects reproduce LGM-Full

Amaya et al. in review
Thermodynamic forcing and subsequent air-sea interactions critical

Amaya et al. *in review*
Thermodynamic forcing and subsequent air-sea interactions critical

Amaya et al. in review
Summer large-scale atmospheric circulation uncoupled from the ocean

**WHITE MOUNTAIN**

**DOM SST response**

**Summer stationary wave response**

AGCM

SOM

DOM

Shading: 850mb Contours: 200mb
Estimated Inversion Strength (EIS)

EIS > 0 = more stable

Relative Humidity at 700mb

Summertime low cloud ingredients WM-AGCM

SST anomalies implied by changes in shortwave

(a) $SST_{SW}$  
(b) $SST_{SW,Cld}$  
(c) $SST_{SW,Clr}$