IBS Center
for Climate Physics


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Earth System Predictability

Subseasonal to Interdecadal Variability and Long-term Changes

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Research Topics

I. Subseasonal Variability and Their Changes

- Madden Julian Oscillation (MJO)
- Boreal Summer Intraseasonal Oscillation (BSISO)

II. Variability and Changes in Atmosphere and Land

- Stationary wave and wildfire
- Atmospheric river
- Dust

III. Variability and Changes in Atmosphere, Ocean, and Sea Level

- ENSO and its teleconnection
- SST seasonal cycle
- Sea level rise
- Ocean mixing and current

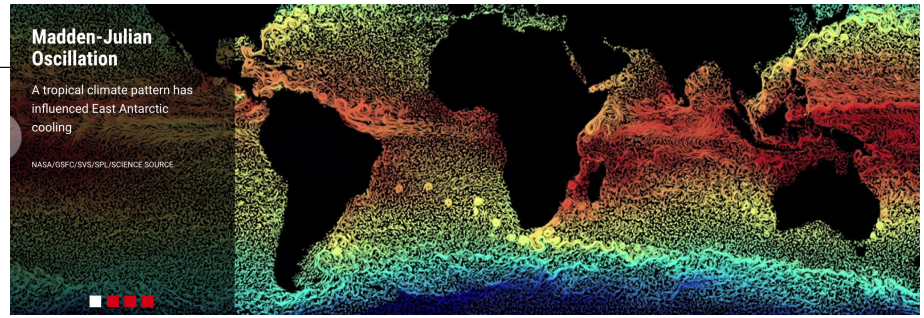
DJF East Antarctic Cooling by MJO Decadal Changes

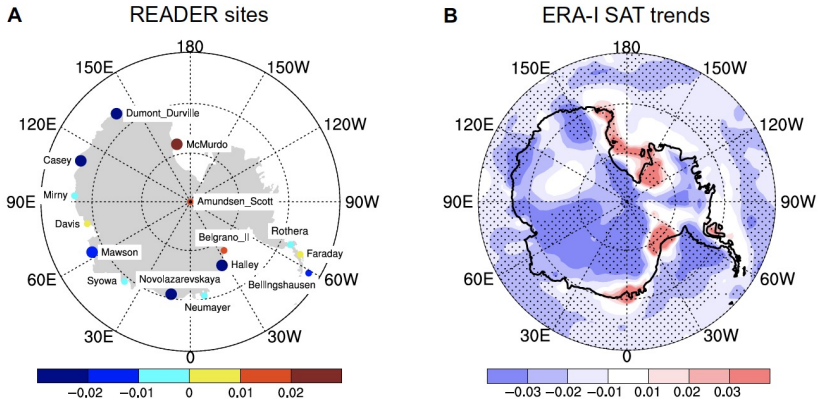
SCIENCE ADVANCES | RESEARCH ARTICLE

ATMOSPHERIC SCIENCE

East Antarctic cooling induced by decadal changes in Madden-Julian oscillation during austral summer

Pang-Chi Hsu[1], Zhen Fu[1], Hiroyuki Murakami[2,3], June-Yi Lee[4,5]*, Changhyun Yoo[6], Nathaniel C. Johnson[2], Chueh-Hsin Chang[7,8], Yu Liu[1,9]

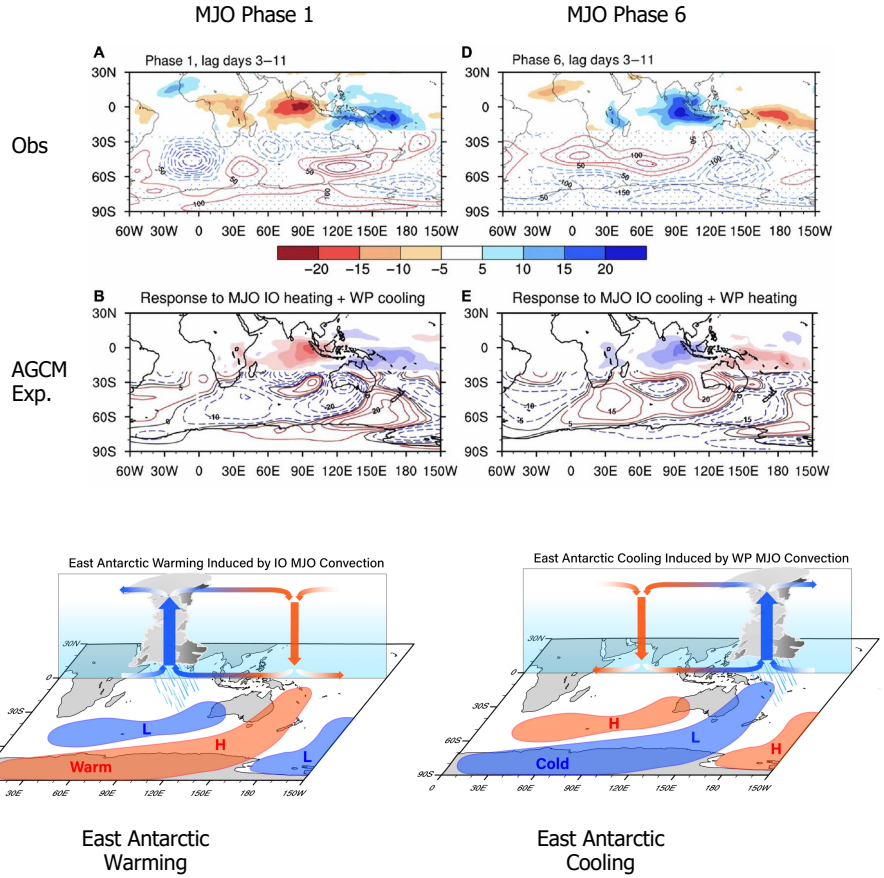


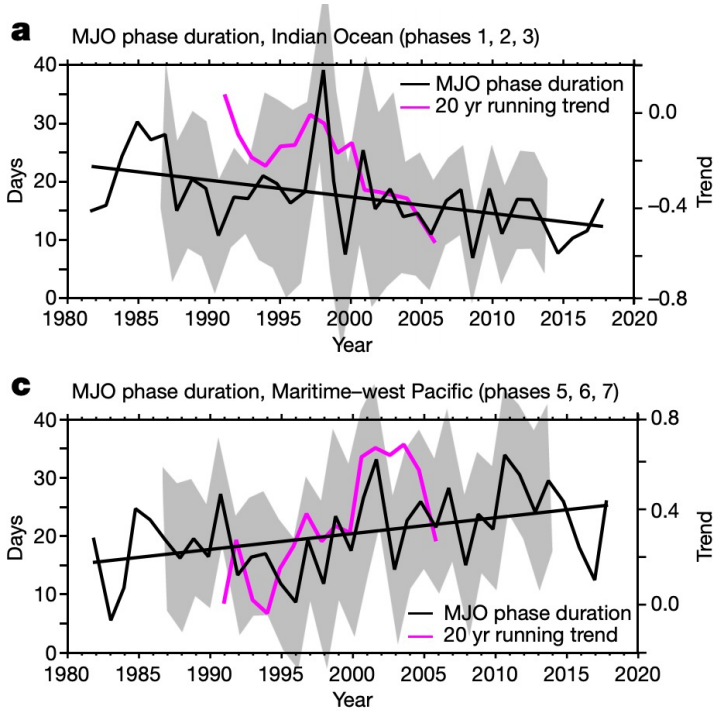


Changes in the Antarctic SAT in austral summer from 1979 to 2014

- **Atmospheric internal dynamics** at higher latitude, such as variability of the Southern Annular Mode (Marshall, 2007; Turner et al., 2020)
- Stratospheric **ozone change** (Thompson et al., 2011)
- The Antarctic terrain as an **internal effect** to determine the patterns of local climate change (Jun et al., 2020)
- Excitation of Rossby wave trains by T**ropical sea surface temperature anomaly** (Turner, 2004; Li et al., 2014; Clem et al., 2020)

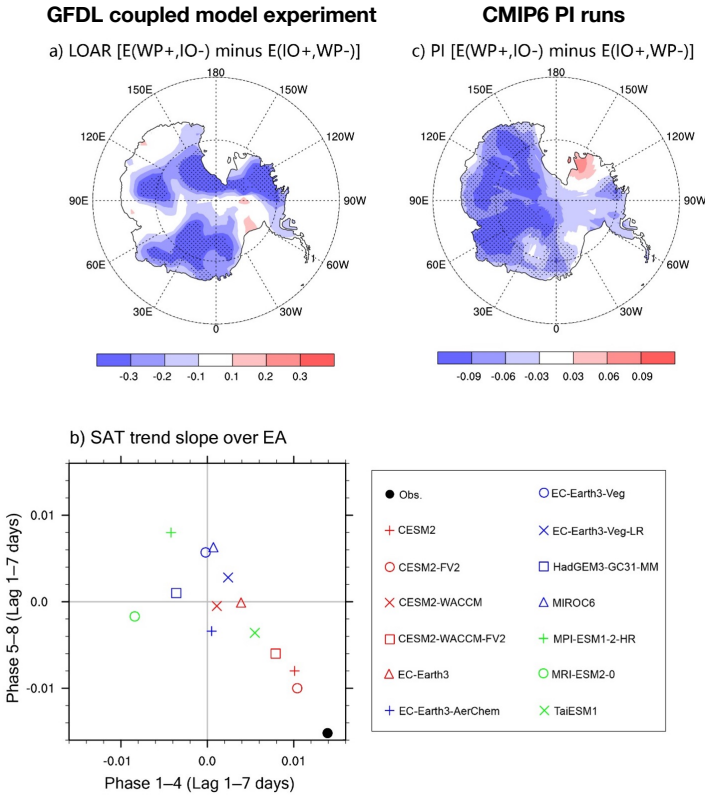
DJF East Antarctic Cooling by MJO Decadal Changes



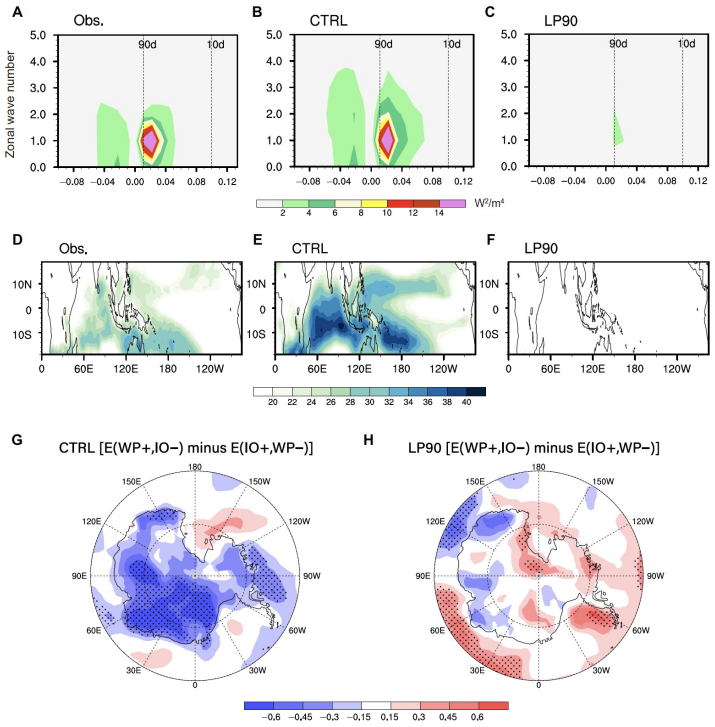


Decadal changes in MJO phases
(Roxy et al., 2019, Nature)

DJF East Antarctic Cooling by MJO Decadal Changes



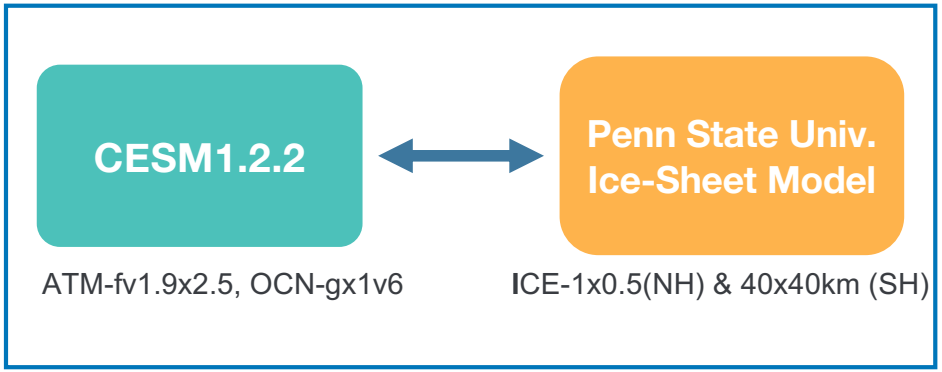
Pre-industrial-control simulations of CMIP6 models reproduce the observed MJO-East Antarctic SST relationship.



Sensitivity experiments of coupled GCM for verifying MJO effects on East Antarctic SAT changes

Future Plan for Earth System Modeling and Prediction

New experiments using the fully coupled ESM and Ice-Sheet model



Estimating future sea level rise

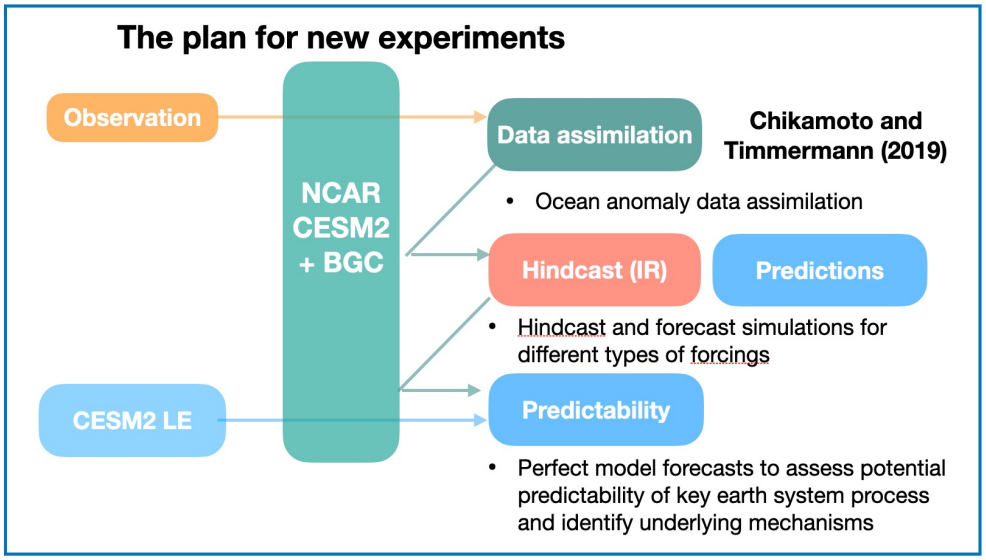
- **Research purpose:** To better estimate future change of sea level and contributions from Greenland and Antarctic ice sheet
- **Experiment type** (concentration-driven runs):
  - Spin-up: 10,000 years for the ice component and 3,000 years for CESM1.2.2
  - 20-ensemble historical simulation from 1850 to 2015
  - Each 20-ensemble simulation from 2015 to 2500 for five SSP scenarios

Estimating sea level predictability

- **Research purpose:** To estimate initial condition dependency of ice-sheet variability
- **Experiment type** (concentration-driven runs):
  - Initialized runs: 10 20-member ensembles of 500 years starting from 10 distinct dates from the spin-up simulation.

Future Plan for Earth System Modeling and Prediction

New experiments using the CESM2 including BGC




Multi-year Earth System Predictability

- **Research purpose:** To determine earth system predictability including soil moisture, wildfire, carbon cycle, marine ecosystem, etc.
- **Experiment type** (emission-driven runs):
  - Initialized runs: 50 20-member ensembles of 20 years starting from 50 distinct dates from CESM2 LE simulations from 1850-2015. Many different ocean states and volcano states can be selected for initial conditions.

Multi-year to Decadal Earth System Prediction

- **Research purpose:** To explain and predict near-term Earth System variability and change
- **Experiment type** (emission-driven runs):
  - Assimilation: 30-ensemble ocean assimilation run from 1950 to 2022
  - Hindcasts with full forcing: 30-ensemble hindcast for 10-year integration initiated every Jan 1st from 1950 to 2022
  - Hindcasts with constant forcing, constant aerosol forcing, without volcanic eruptions, with pacemaker Pacific, with pacemaker Atlantic, etc.

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Thank you for your attention!