

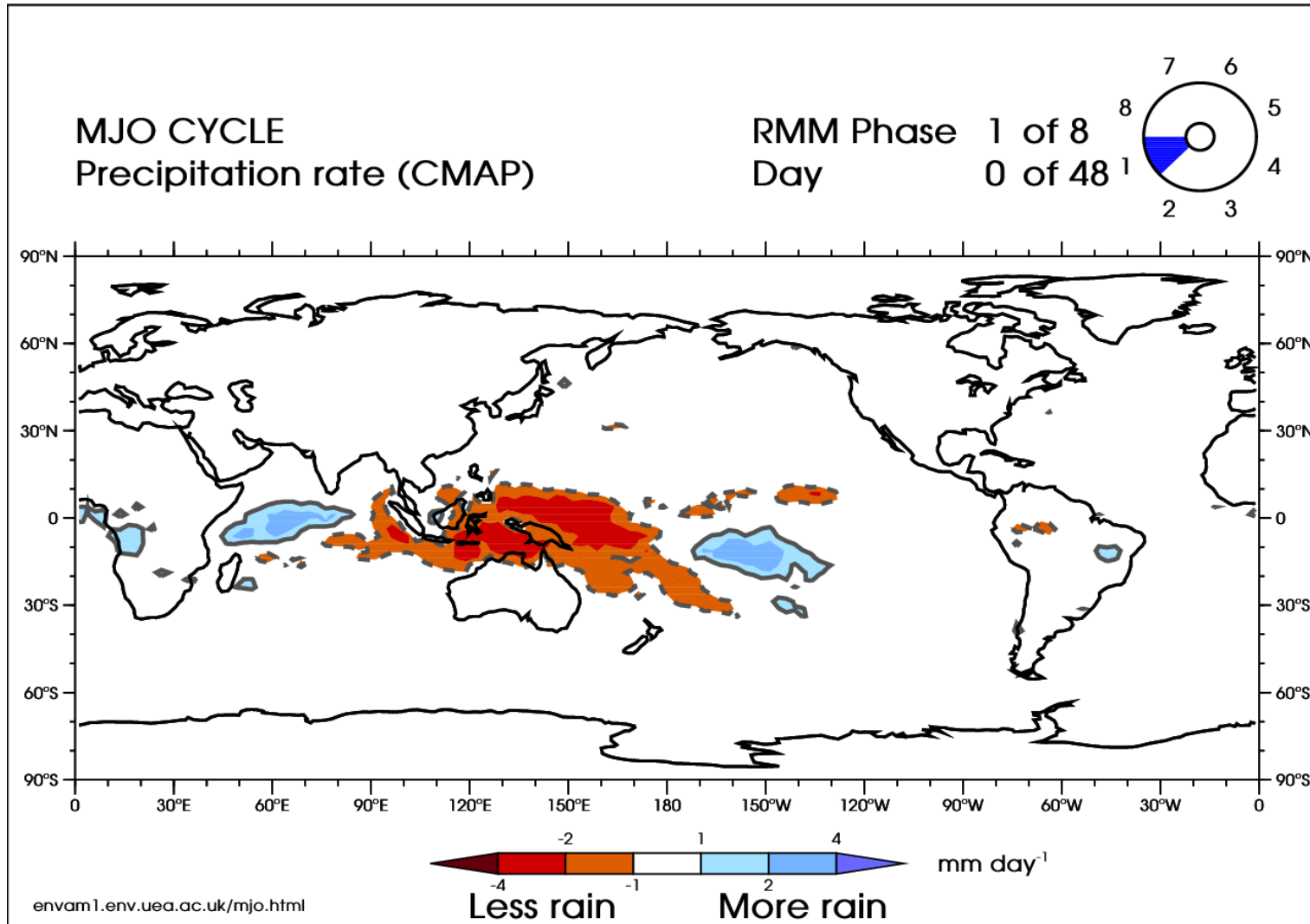
Understanding the Madden-Julian oscillation in a future warming climate

Hien Bui (hien.bui@monash.edu)

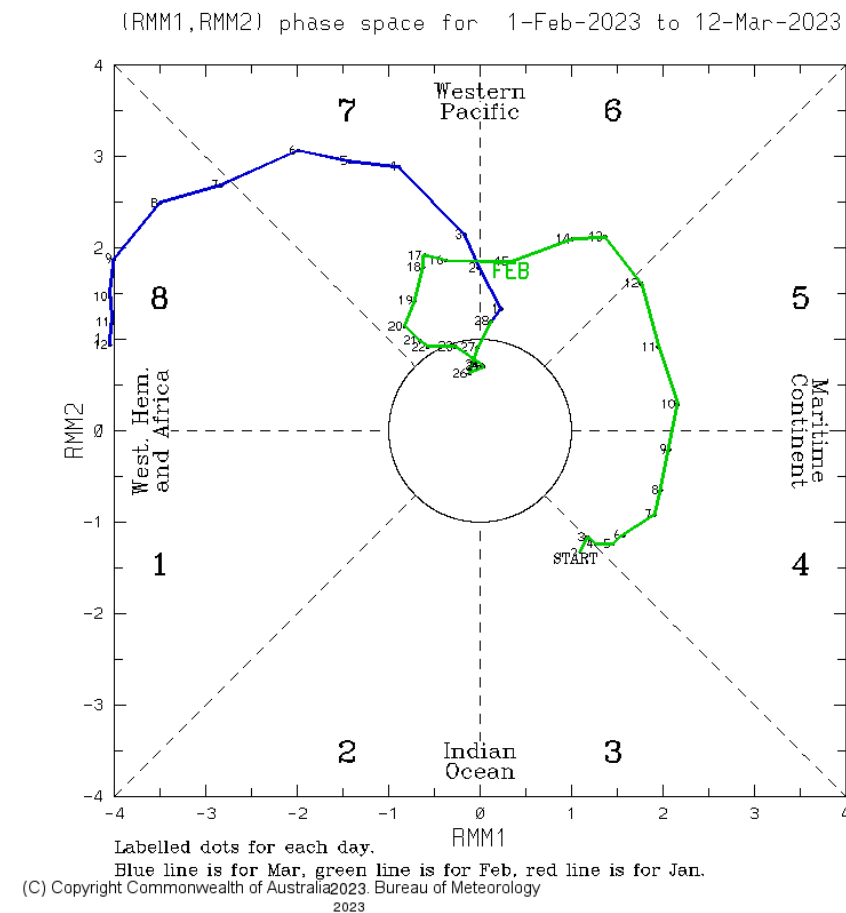
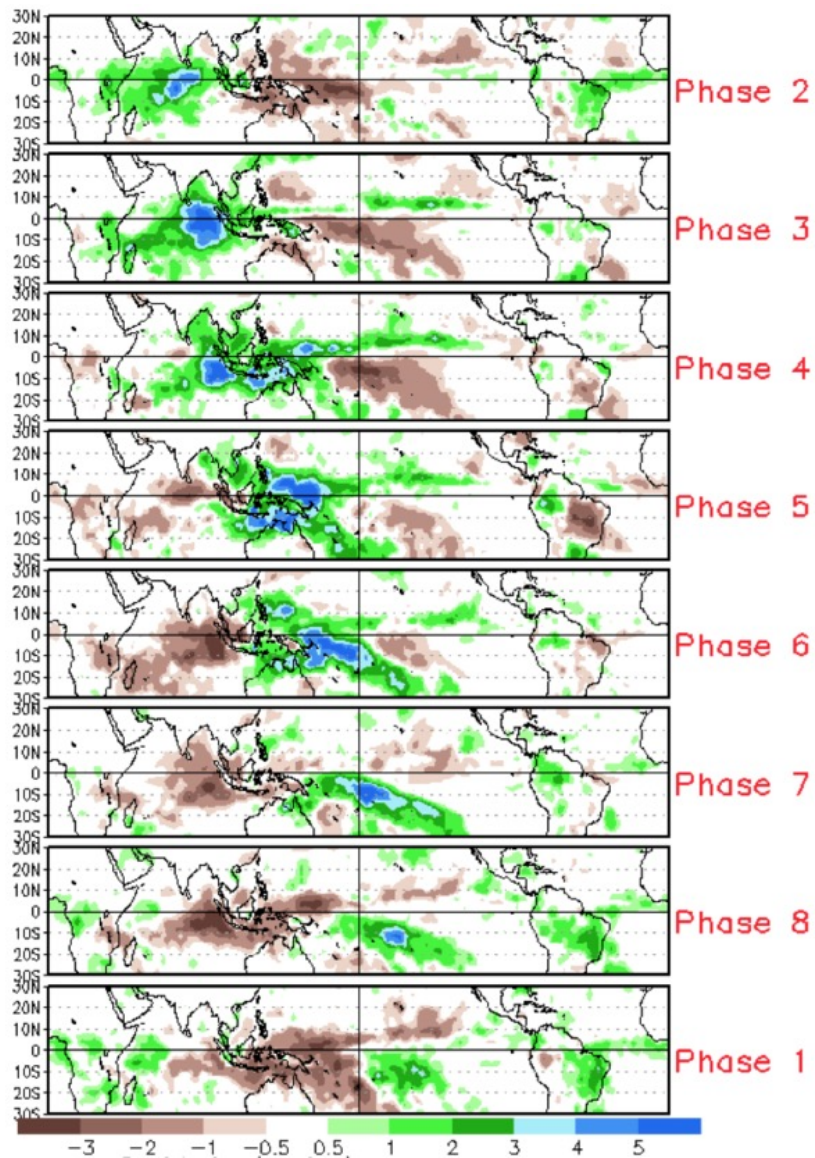
Monash University

May 2023

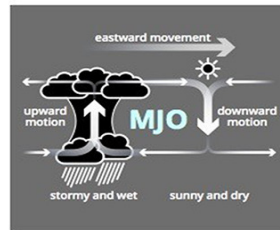
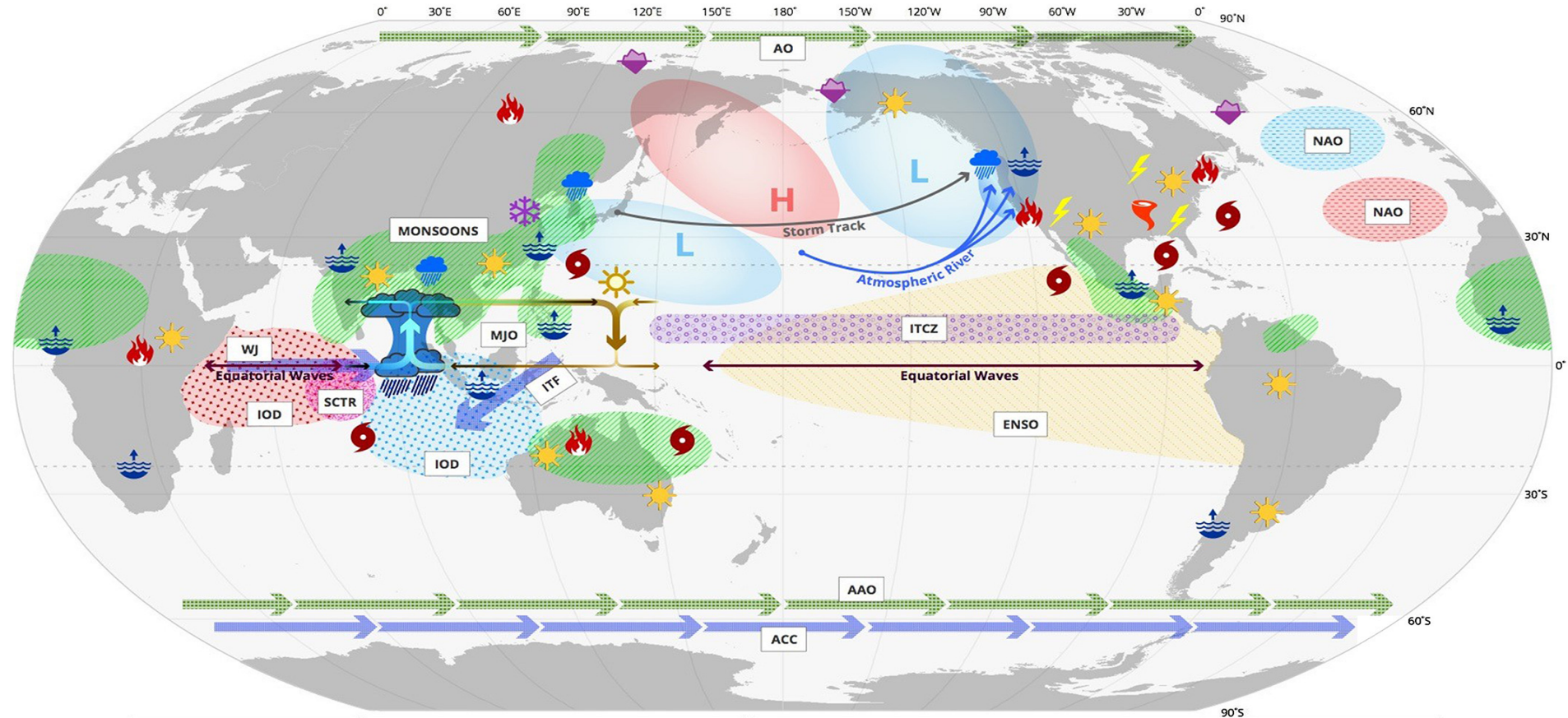
What is MJO?



Wheeler and Hendon (2004)



MADDEN-JULIAN OSCILLATION (MJO): GLOBAL IMPACTS



- | | |
|---------------------|---------------------|
| → Atmospheric River | ☀ Heat Waves |
| ❄ Cold Surges | ⚡ Lightning |
| → Equatorial Waves | ❄ Sea Ice |
| ☁ Extreme Rainfall | → Storm Track |
| 🔥 Fires | 🌀 Tornadoes |
| 🌊 Flood | 🌀 Tropical Cyclones |

- | | |
|---|---|
| → Atmospheric Circulation (AO, AAO) | ☀ Monsoons |
| ☀ El Niño-Southern Oscillation (ENSO) | ☀ North Atlantic Oscillation (NAO) |
| ☀ Indian Ocean Dipole (IOD) | ☀ Oceanic Circulation (ITF, WJ, ACC) |
| ☀ InterTropical Convergence Zone (ITCZ) | ☀ Seychelle-Chagos Thermocline Ridge (SCTR) |

Not represented on map: Aerosol, Carbon Dioxide, Earth's Annular Momentum, Electromagnetic Field (Schumann Resonance), Length of the day, Ocean Chlorophyll, Ozone

Is “global warming” really happening?

Every global indicator shows warming:

- Sea ice: retreating
- Permafrost and glacier: melting
- Species migrations: poleward
- Tree-ring derived temperature: upward
- Spring thaws: earlier
- And, underwear ...

Positive proof of global warming.



***18th
Century***

1900

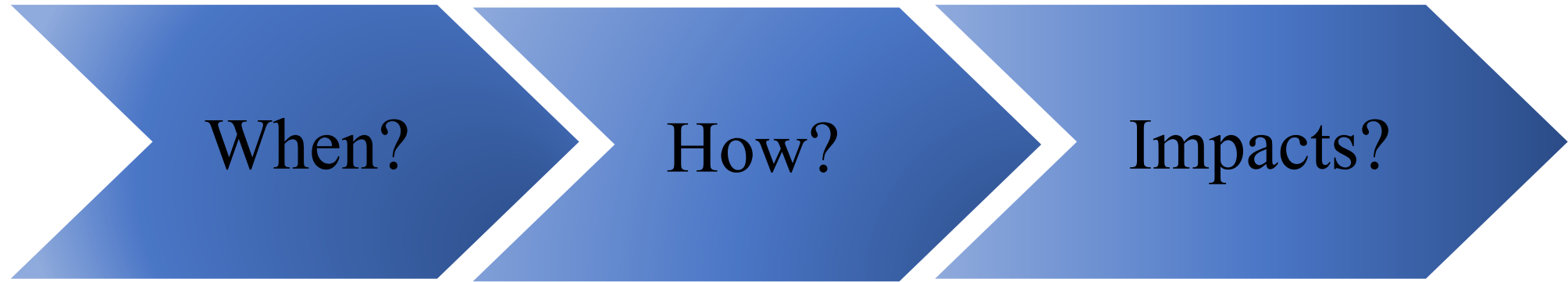
1950

1970

1980

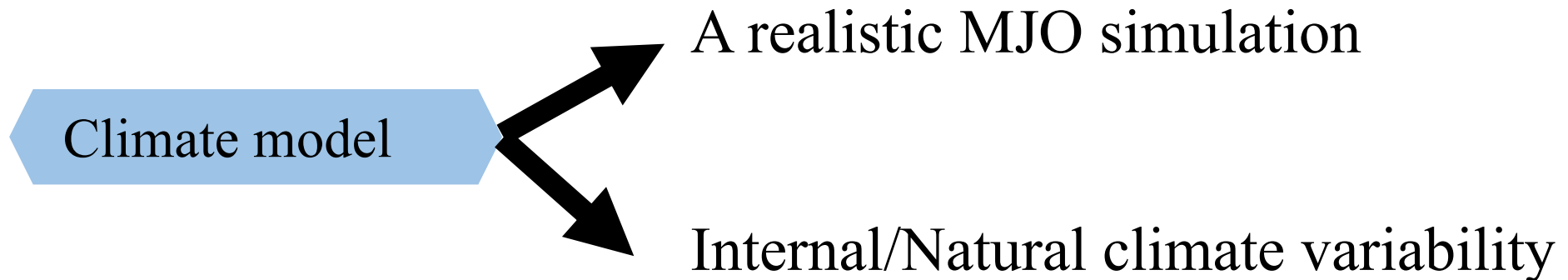
1990

MJO changes under global warming



- When the change signal is detectable?

- Precipitation
- Wind





Document version: 13 February 2019

Climate models

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World Climate Research Programme

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MIP Era

Activity

Product

Source ID

Institution ID

Source Type

Nominal Resolution

Experiment ID

Sub-Experiment

Variant Label

Grid Label

Table ID

Frequency

Realm

Variable

CF Standard Name

Data Node

WARNING: Not all models include a variant "r1i1p1f1", and across models, identical values of variant_label do not imply identical variants! To learn which forcing datasets were used in each variant, please check modeling group publications and documentation provided through ES-DOC.

CMIP6 project data downloads are unrestricted. Downloads should be performed with the -s option to a wget script without the need to login. When using this method for download, ensure you are not using additional options, eg. -s and -H should never be combined.

For more information about CMIP6 data please consult this guide: <https://pcmdi.llnl.gov/CMIP6/Guide/dataUsers.html>

Please try our updated ESGF web application (named "Metagrid"), now undergoing beta testing. For this test release we are reaching out for help from users in the community to report any issues they encounter with the application. The beta-test web application can be found at the following site: <https://aims2.llnl.gov/metagrid/>
Please see the following page for more information including a FAQ: <https://esgf.github.io/esgf-user-support/metagrid.html>

Enter Text:

Search

Reset

Display 10 results per page

[More Search Options](#)

☐ Show All Replicas ☐ Show All Versions ☐ Search Local Node Only (Including All Replicas)

The search returned 0 results.

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CSM

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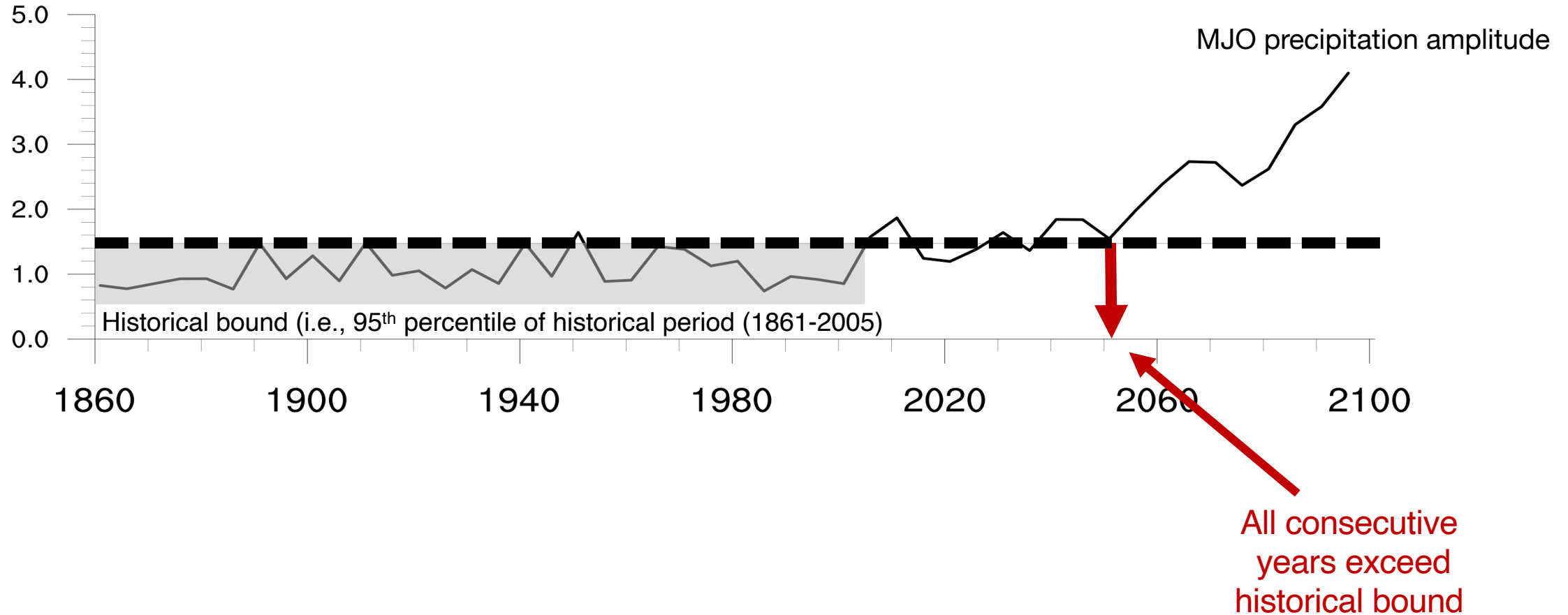
EVENTS

CESM2-LE (100 members)

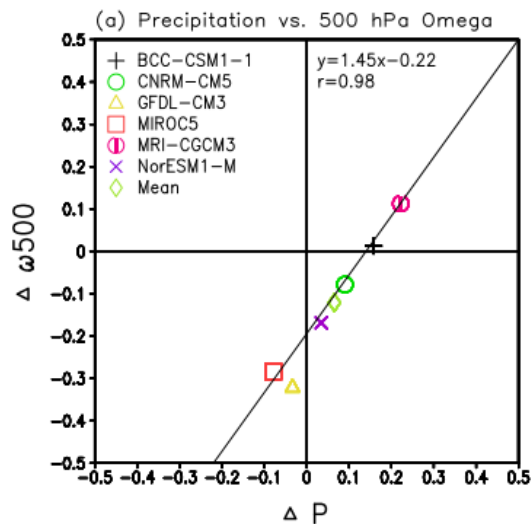
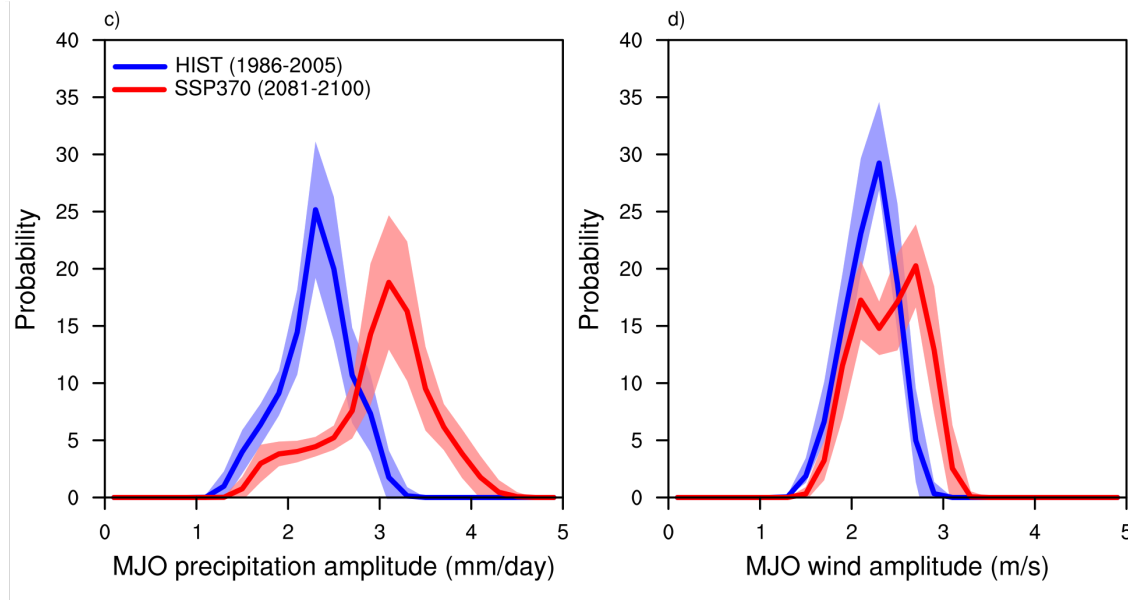
https://pcmdi.llnl.gov/pmp-preliminary-results/mjo_metrics/mjo_ewr_cmip5and6_overlap_runs_average_sorted_standalone.html
<https://esgf-node.llnl.gov/search/cmip6/>
<https://pcmdi.llnl.gov/CMIP6/>
<https://www.cesm.ucar.edu/community-projects/lens2>

CESM2 Large Ensemble Community Project (LENS2)

Estimate the time of emergence



Changes in MJO amplitude

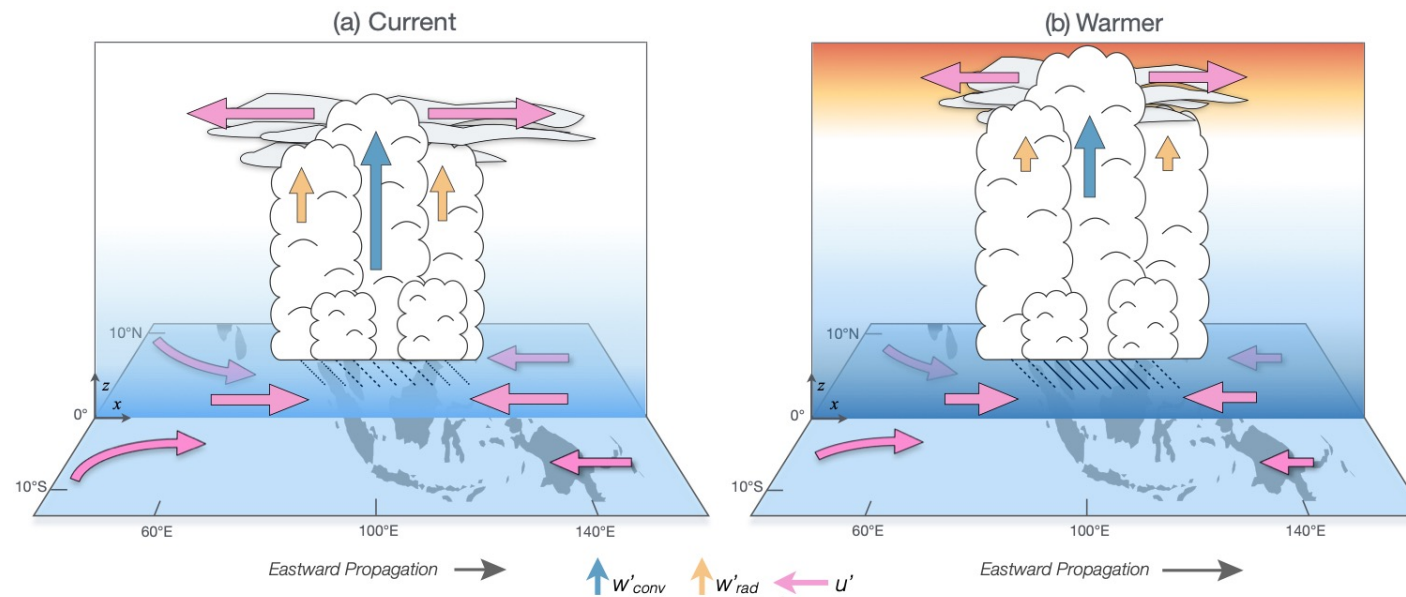
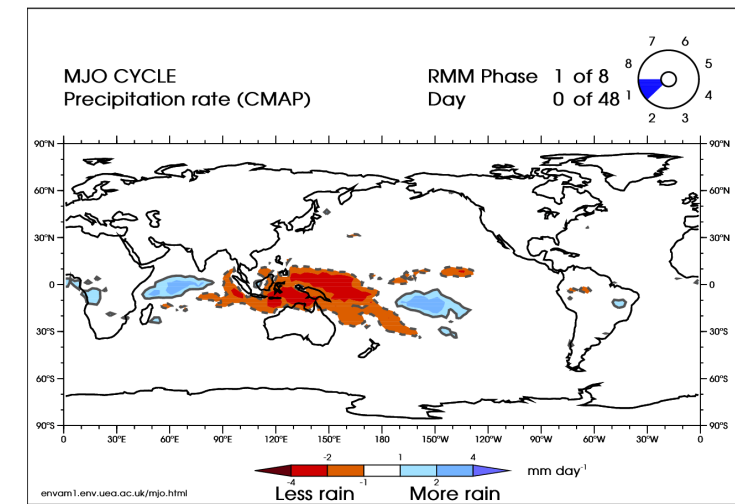


- MJO precipitation tends to **increase**
- MJO wind tends to **weaken** (or increase with a slower rate compared to precipitation)
- These differences can be explained by Weak Temperature Gradient (WTG)

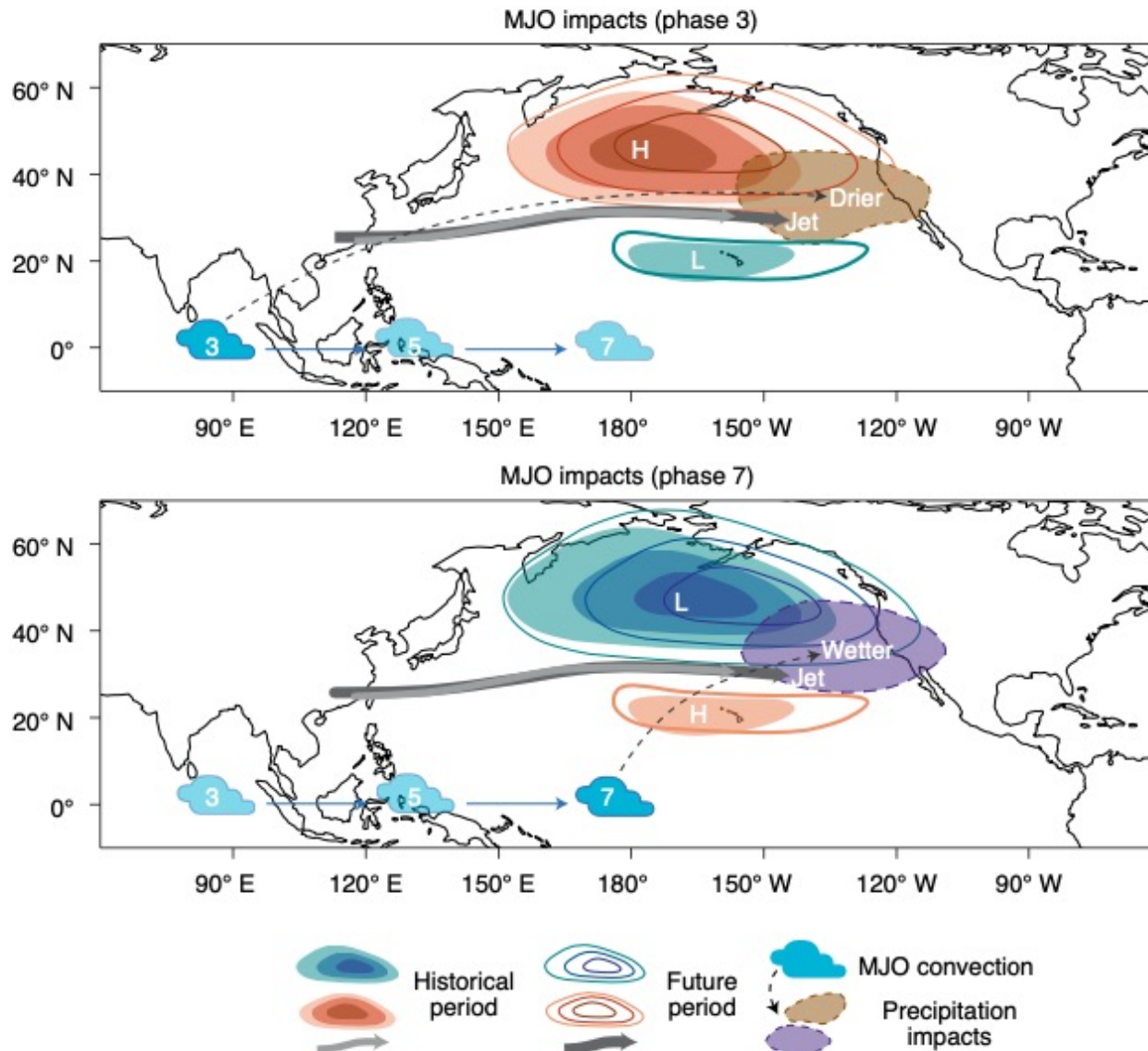
$$P \approx \omega \frac{\partial s}{\partial p}$$

Other changes

- ☐ Faster eastward propagation
- ☐ Extend further eastward
- ☐ Changes in the seasonal cycle (delay in seasonal phase)
- ☐ Depending on SST warming pattern



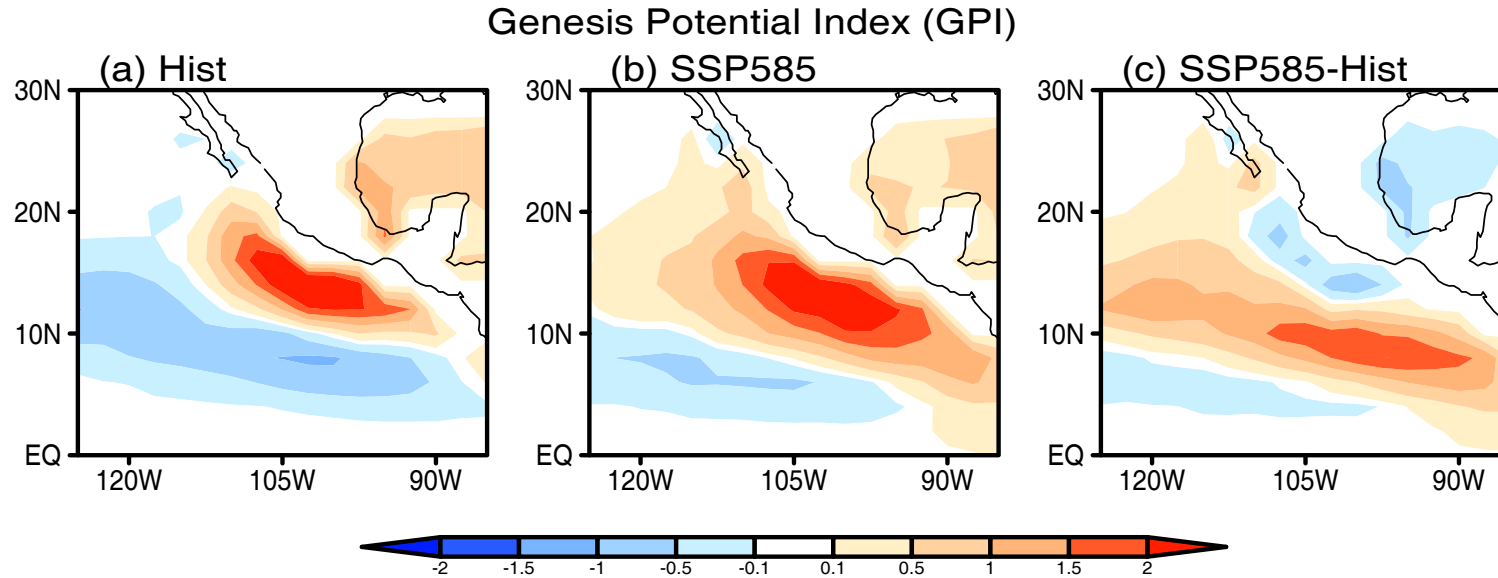
Impacts on winter rainfall variability



The Northern Hemisphere teleconnection pattern associated with the MJO tends to extend further east under global warming

→ Impact of MJO on the northeast Pacific and North American West Coast will be stronger

Impacts on tropical cyclogenesis



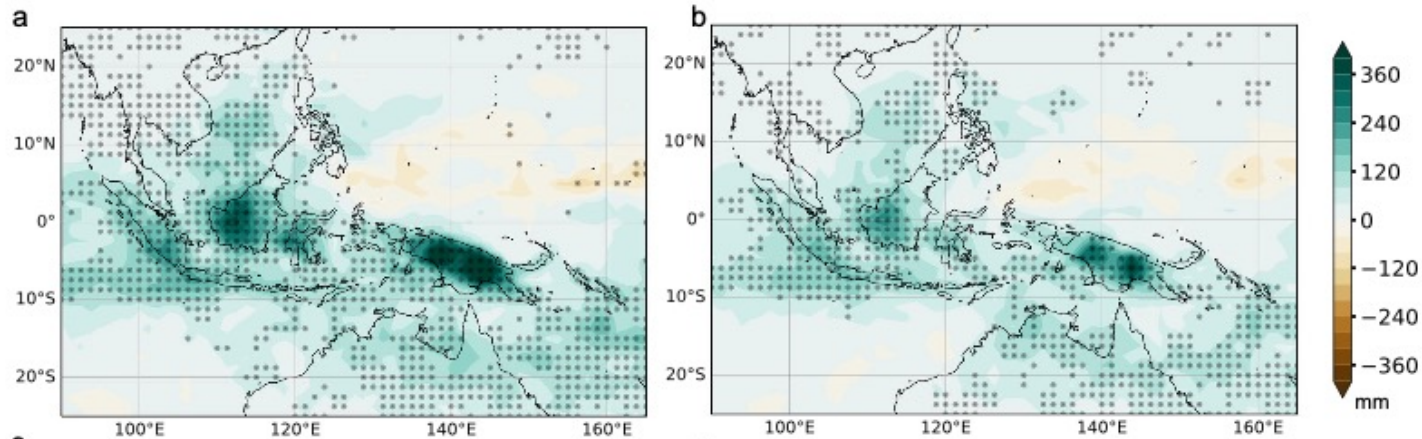
Boreal summer GPI (Tropical Cyclone Genesis Potential Index)
associated with the MJO from 8 CMIP6 models

→ The MJO's modulation of GPI weakens near the coast of Mexico and Central America with warming, associated with a southward shift of GPI anomalies

Impacts on extreme rainfall

Changes in boreal winter
extreme rainfall amount

MJO-induced extreme rainfall amount



<https://www.nature.com/articles/s41612-022-00291-1>

- Nearly 60% increase in extreme rainfall over tropical Asia and Australia by the end of the 21st century under the fossil-fueled warming scenario (SSP5-8.5)
- 84% of this change is associated with MJO-induced extreme rainfall

In summary, ...

When the changing signal detectable

Changes in MJO amplitude
and other characteristics

MJO impacts

Multi-model/ensembles
from CMIP and CESM2-LE

Thank you!