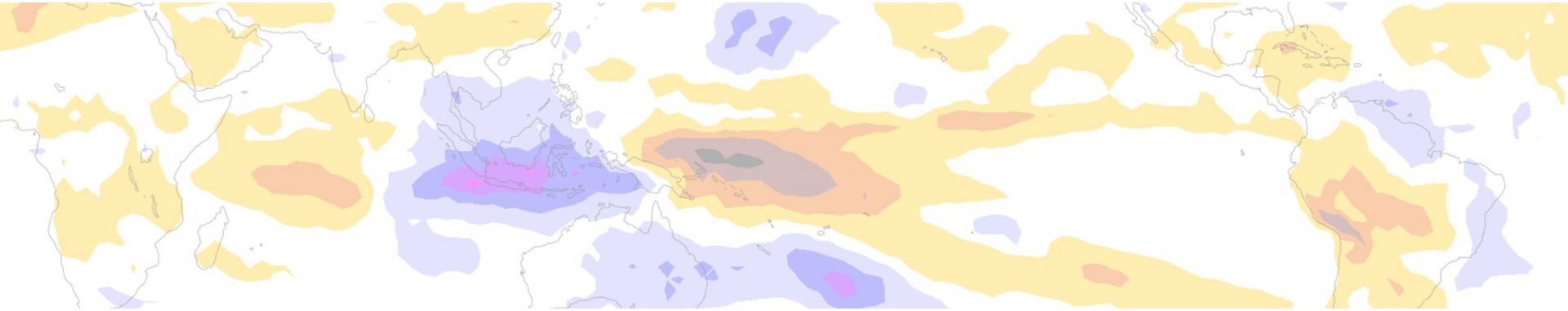
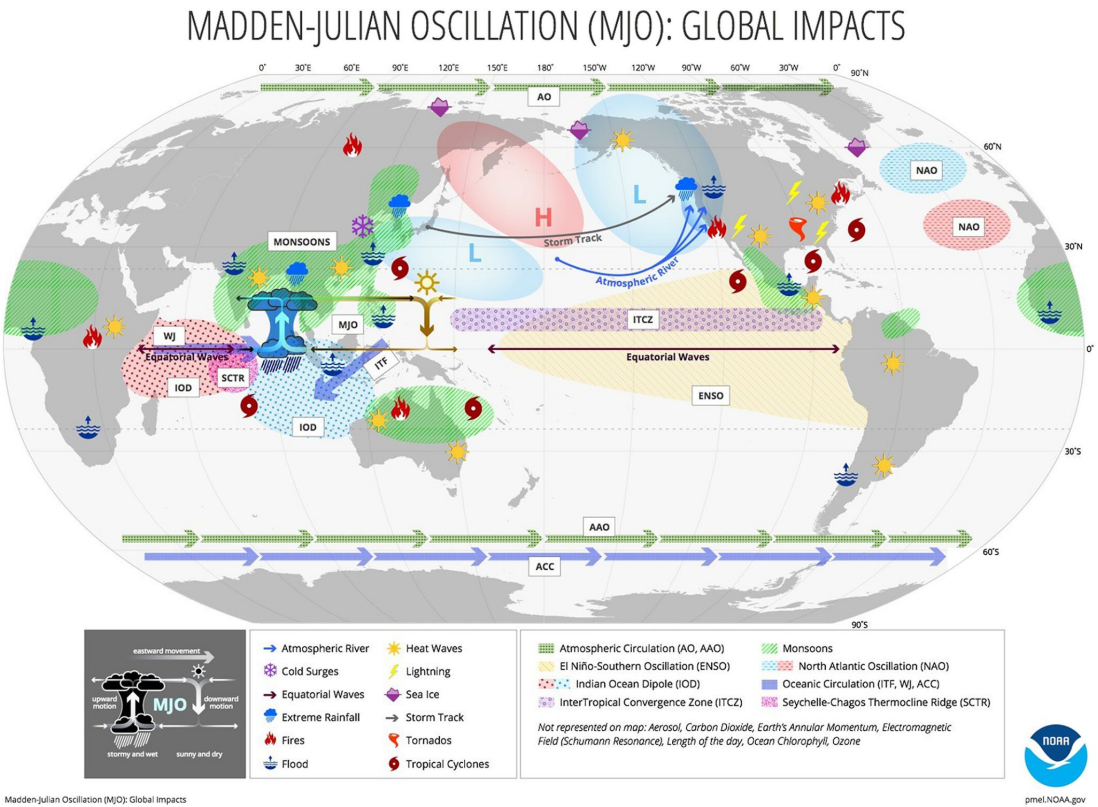


Development of an MJO testbed to support UFS global applications

Juliana Dias[1], Maria Gehne[2], Lisa Bengtsson[1] and Cristiana Stan[3]

1: Physical Sciences Laboratory, 2: CIRES University of Colorado, 3: George Mason University

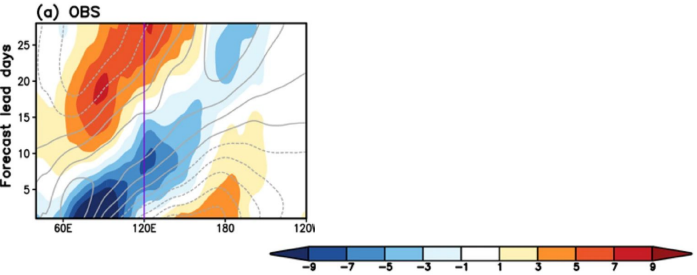
What is the MJO and why is it important?



Madden-Julian Oscillation (MJO): Global Impacts

- The MJO is a prominent element of intraseasonal (30- to 90-day) variability in the tropical atmosphere that interacts with faster (weather) and slow (climate) atmospheric processes.
- The MJO is a precursor of weather events around the world, and a main source of subseasonal predictability (Weeks 2-4)

MJO and MJO-teleconnections in UFS global applications



Phase 2 & 3 OLR and U850 composites

Figure from Wang et al. (2025)

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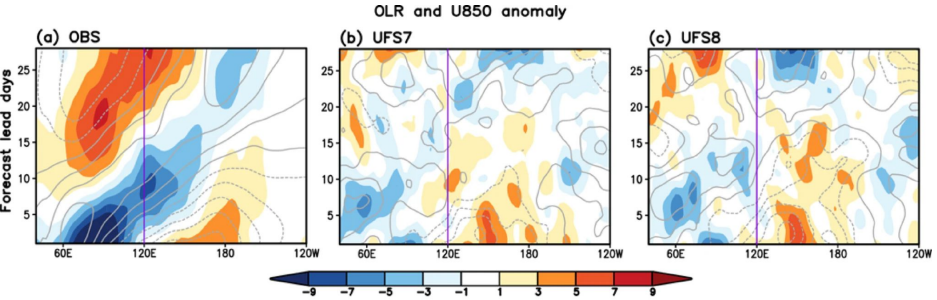

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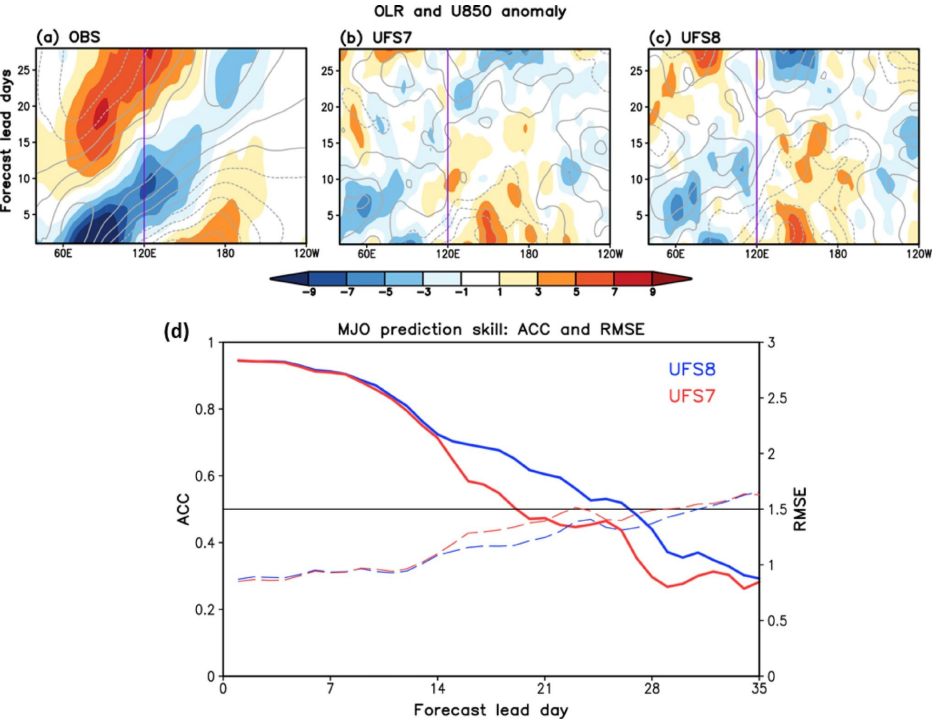

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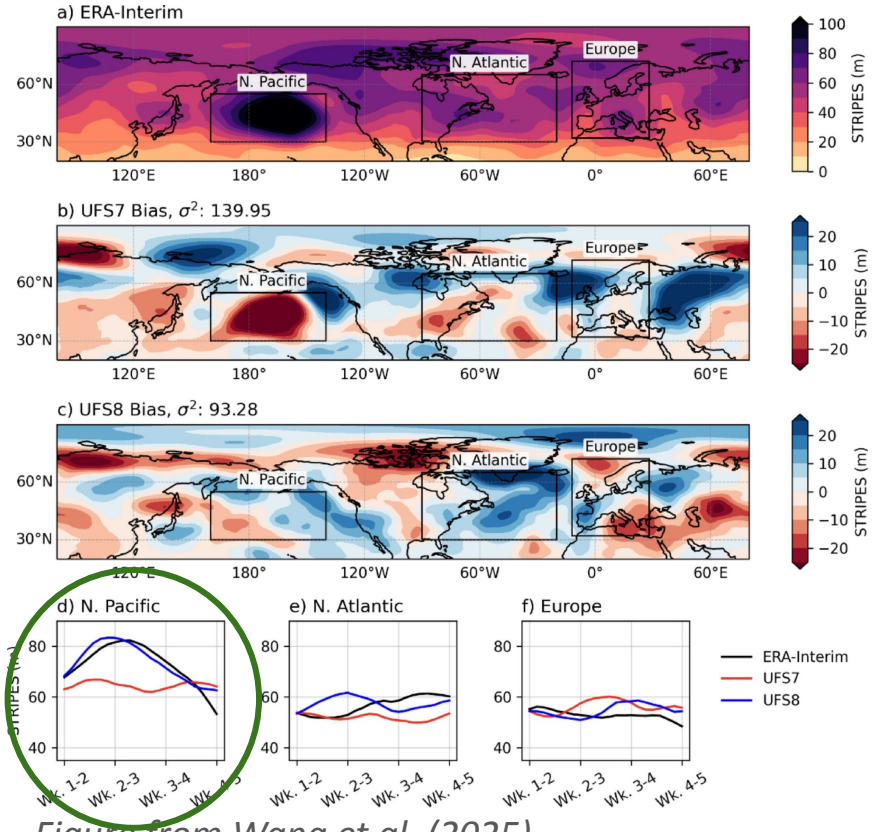

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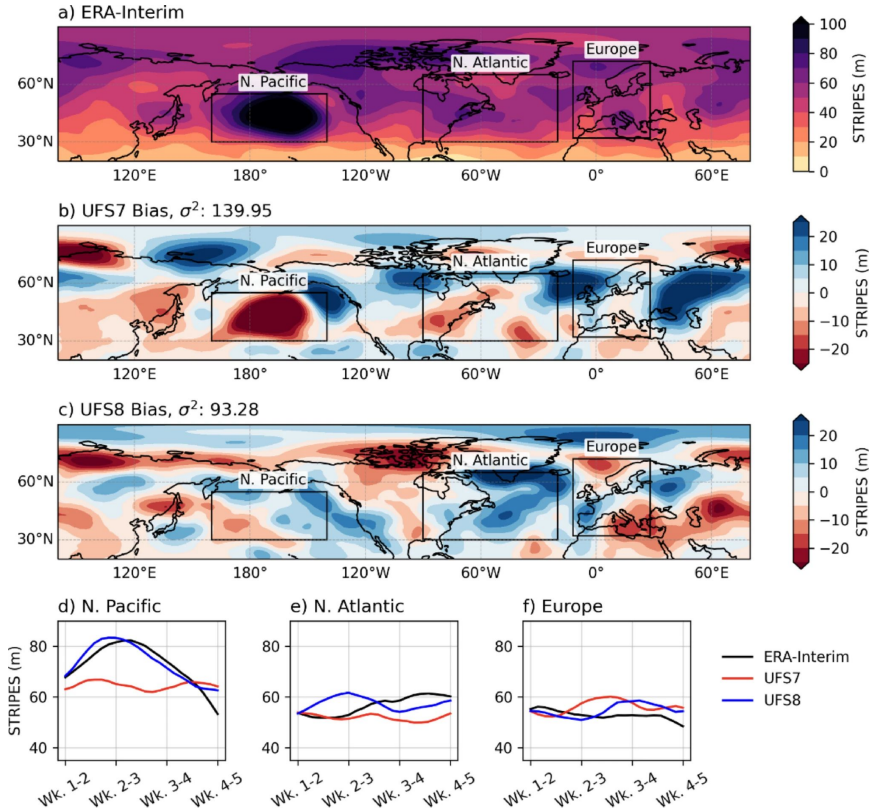

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The MJO, and tropical variability in general have improved in the UFS;

MJO teleconnections have also improved;

MJO is still too fast and both MJO amplitude at its teleconnections are too weak

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How can we accelerate MJO evaluations and integrate it with model development?

Traditional diagnostics rely on long records of MJO events;

Reforecasts take a while to become available;

MJO process level diagnostics are time consuming and they rely on both domain and model expertise to be leveraged into improved predictions.

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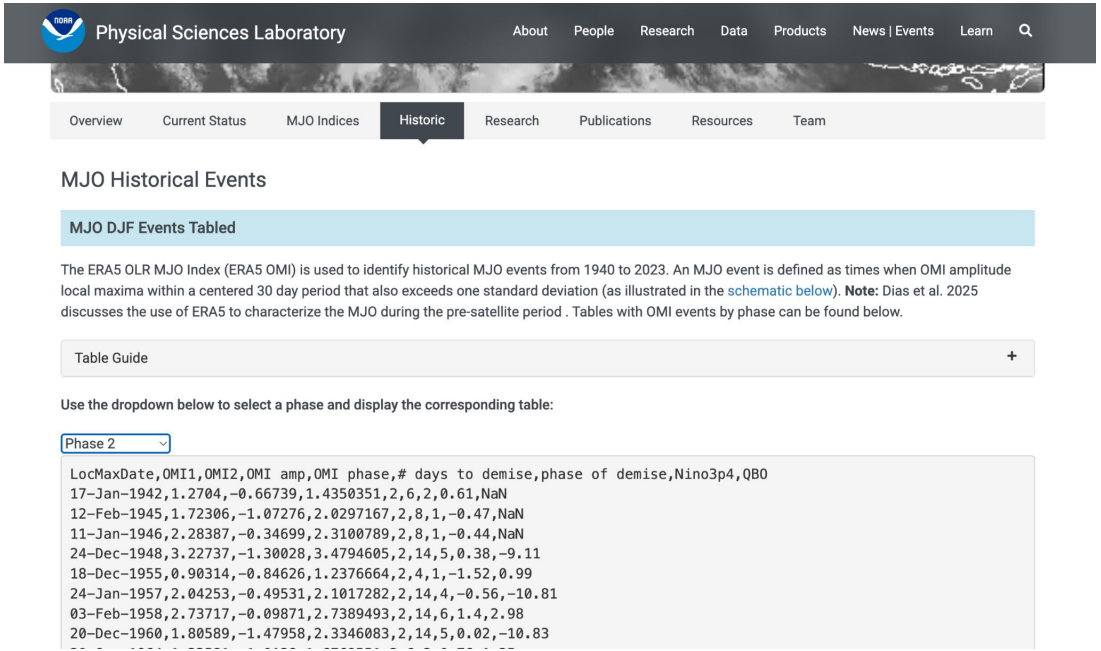
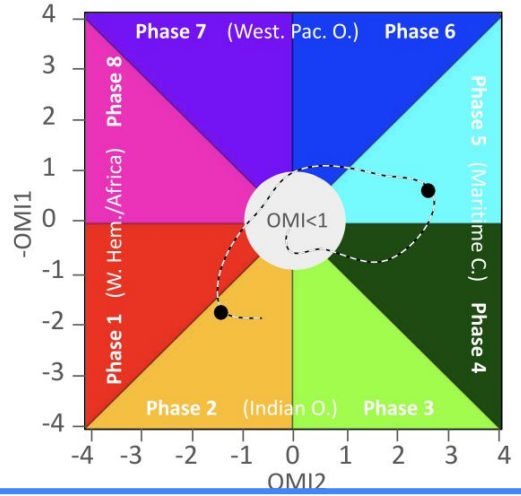
Our goal is to establish a common set of MJO events to use a testbed for accelerating MJO improvements in UFS global applications during development stages (GEFS, SFS?)

What we have done so far…



https://psl.noaa.gov/mjo/

MJO events are defined by local peaks in OMI amplitude



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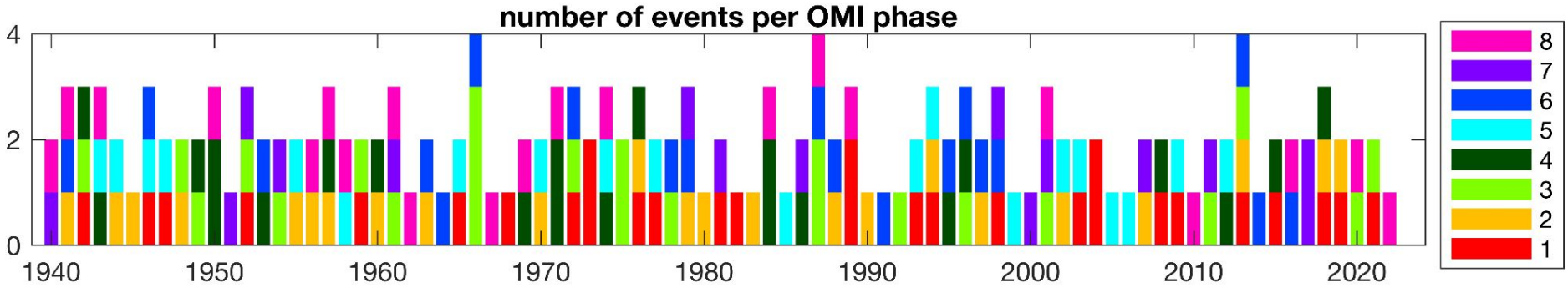

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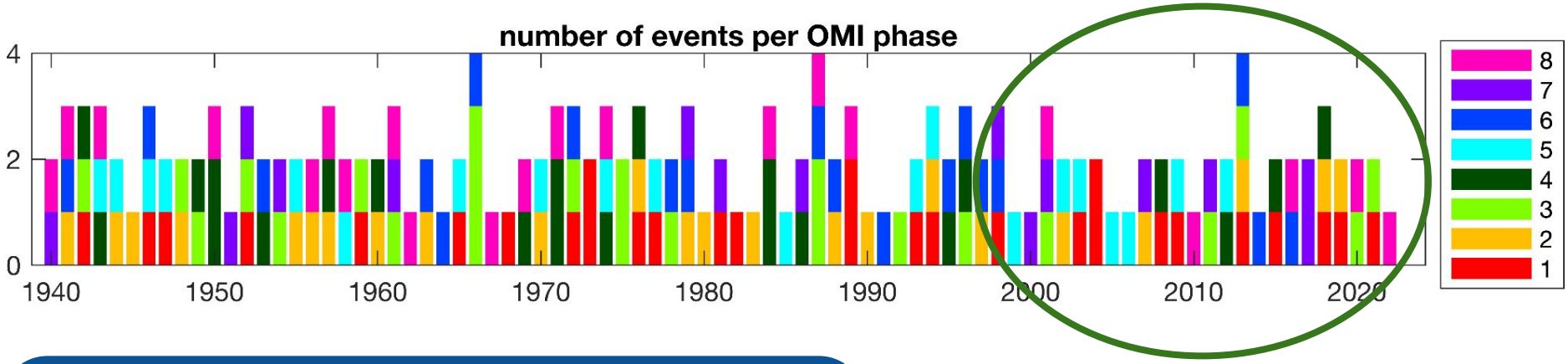

Sample sizes are small, for example, there are **12 MJO events that peak during phases 2 & 3** that also overlap with the available GEFSv13 reforecasts, if we want to compare those to GEFSv12, then there are 8 events.

https://psl.noaa.gov/mjo/

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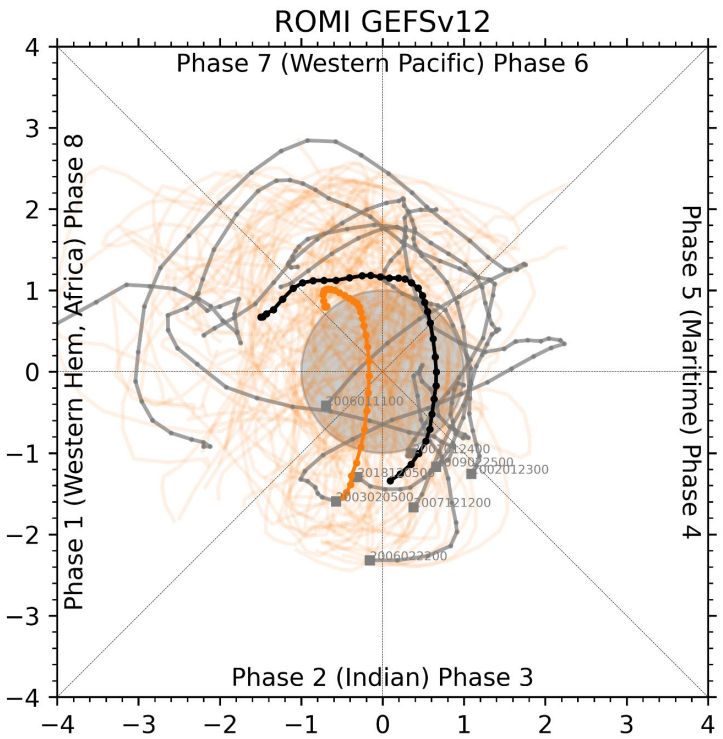
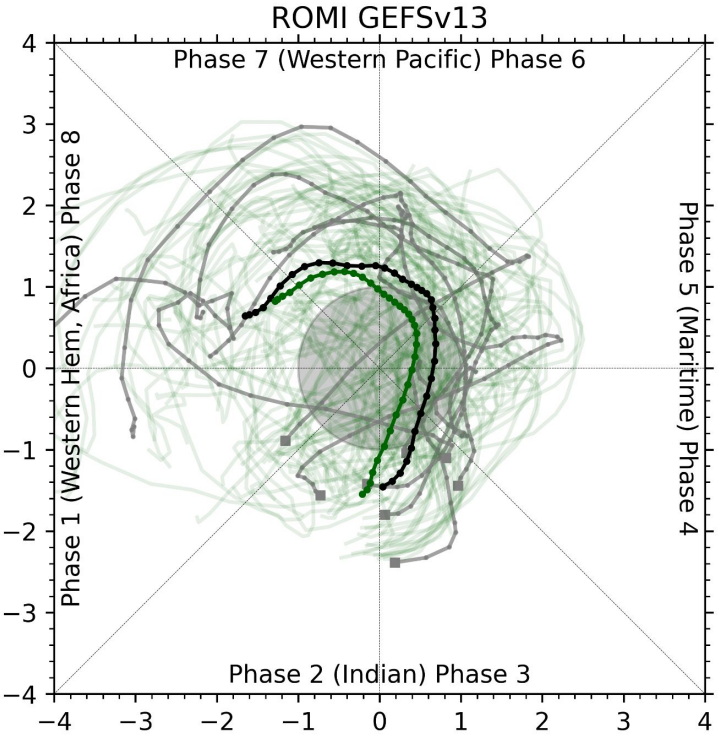
MJO performance in the GEFSv13 vs GEFSv12





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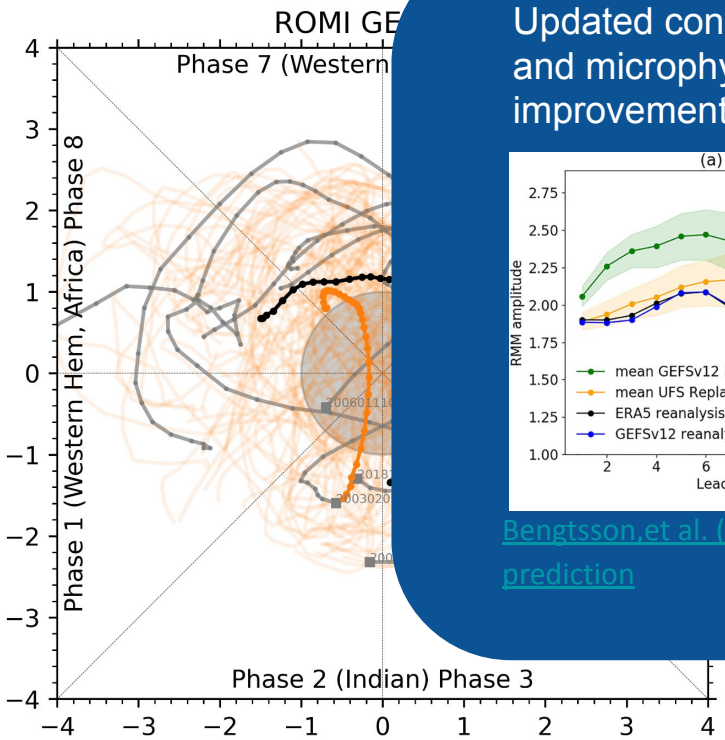
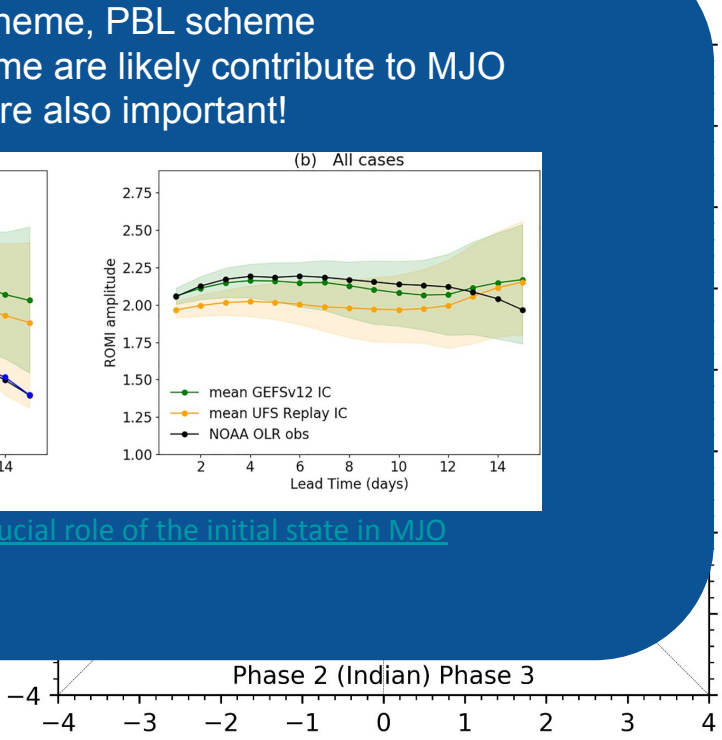


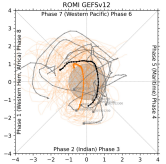


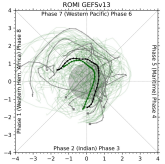
Updated convection scheme, PBL scheme and microphysics scheme are likely contribute to MJO improvements, but IC are also important!

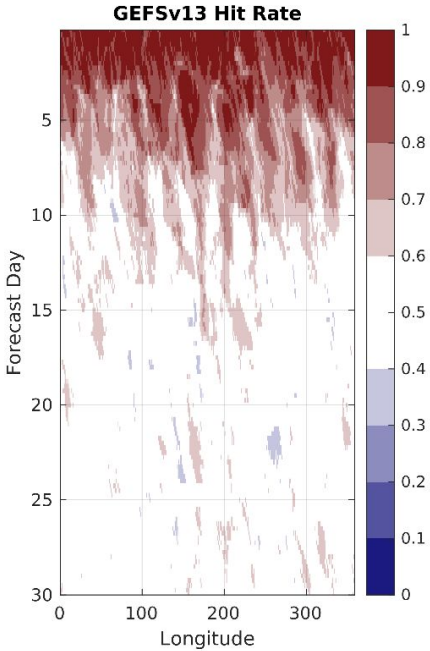
Bengtsson,et al. (2025). The crucial role of the initial state in MJO prediction

MJO teleconnections might also have improved

(average V200 hit rates between 35°N-55°N)







Hit: V200 anomalies in ERA5 and forecast match sign

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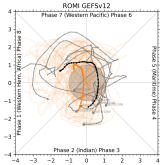

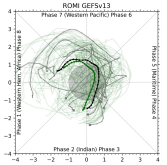

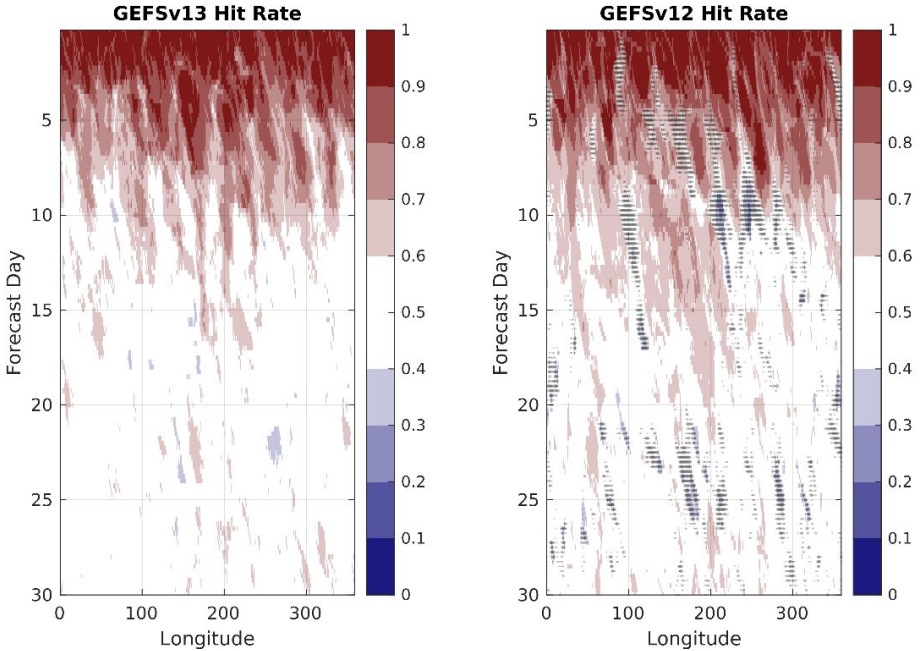

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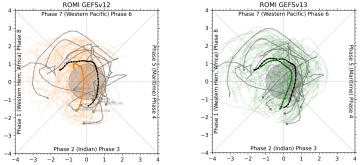
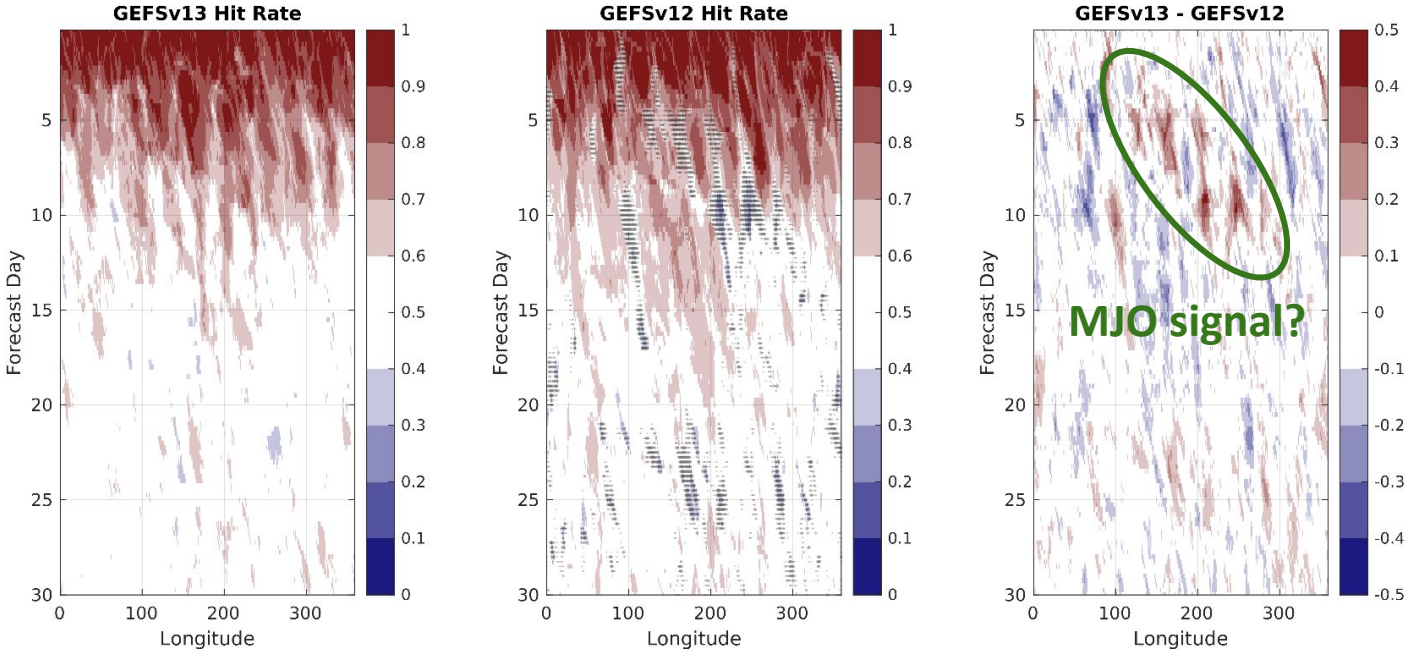


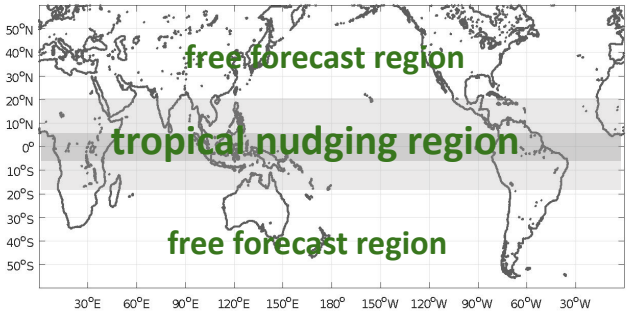


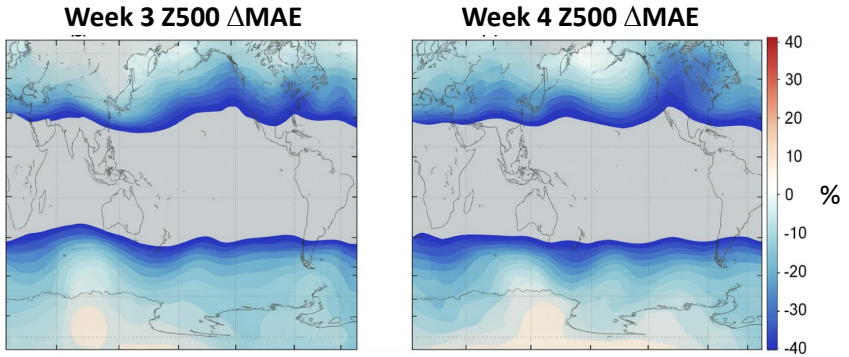
Hit rates in midlatitude upper level meridional wind anomalies (v200 35N-45N) are **improved** from **GEFSv12 to v13**, potentially following the expected **MJO teleconnection pathway.**

Hit: V200 anomalies in ERA5 and forecast match sign

Looking ahead, how much should we expect from improved MJO predictions?

Our approach is to nudge the tropics towards reanalysis allowing forecasts to freely evolve at higher latitudes ("perfect MJO scenario", and this is applied to the MJO phase 2 & 3 IC



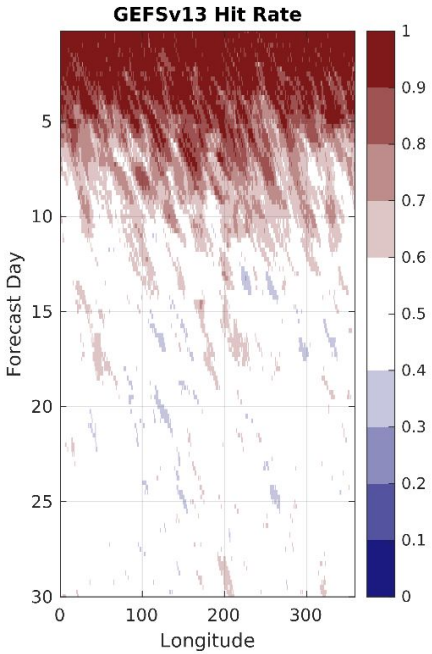


Blue shading denotes regions where Z500 MAE is reduced comparing tropical nudged and free forecasts

Dias et al., 2021: Tropical Origins of Weeks 2–4 Forecast Errors during the Northern Hemisphere Cool Season

Midlatitude hit rates improve when the tropics is nudged

(average V200 hit rates between 35°N-55°N)



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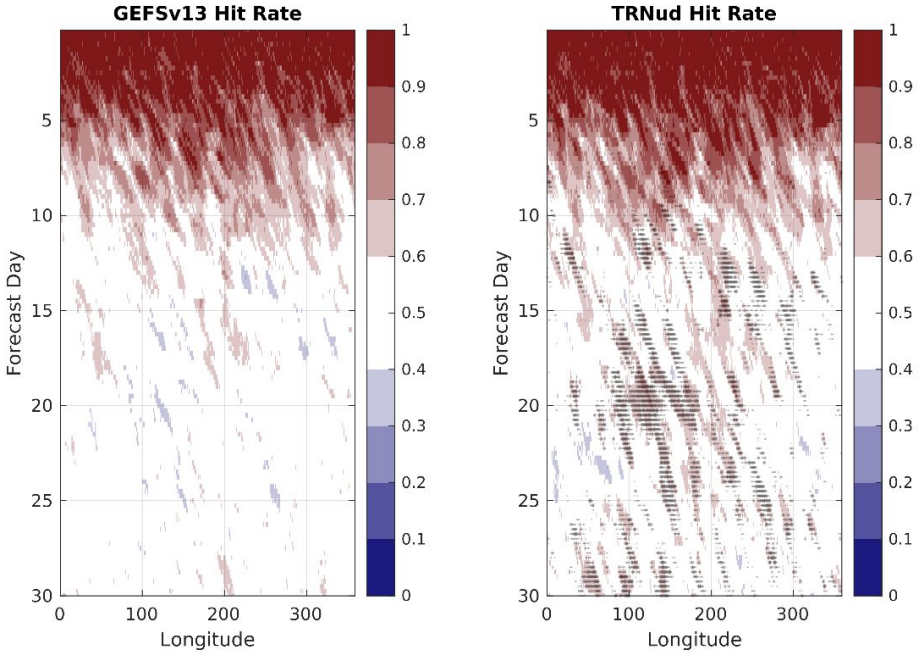

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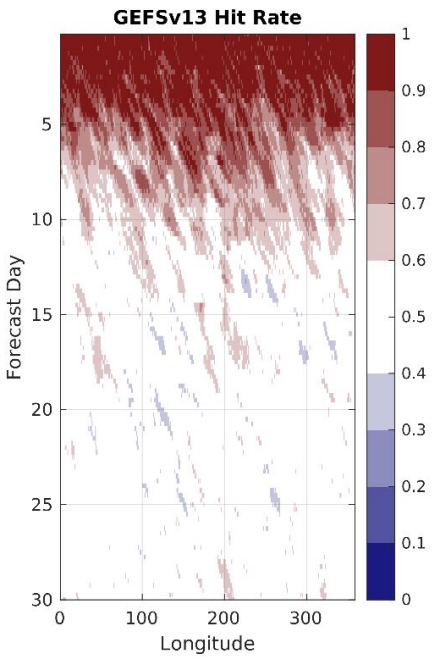

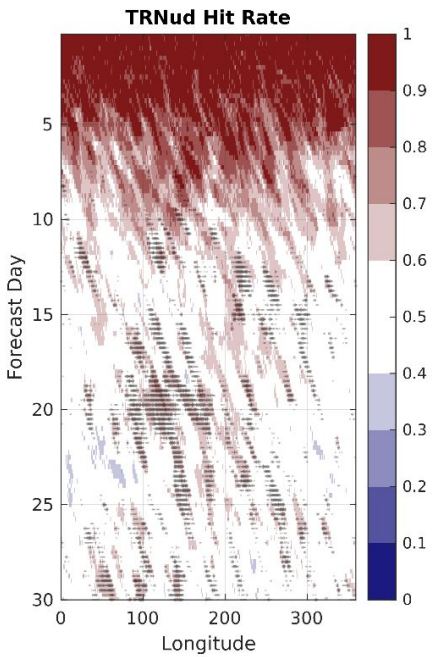

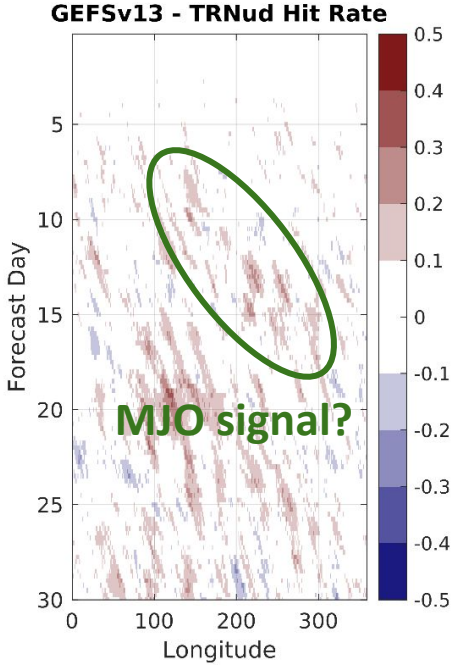

Hit rates in midlatitude upper level meridional wind anomalies (v200 35N-45N) are **improved** when **GEFSv13 is nudged in the tropics**, potentially following the expected **MJO teleconnection pathway.**

Summary:

- A list of “MJO events” can be found here: https://psl.noaa.gov/mjo/
- Eight MJO events in phases 2 & 3 that overlap with GEFSv12 and GEFSv13 initializations were sufficient to evaluate MJO improvements;
- Tropical nudging suggests that we have not reached an upper bound on how much the MJO can contribute to Weeks 2-4 NH prediction skill.