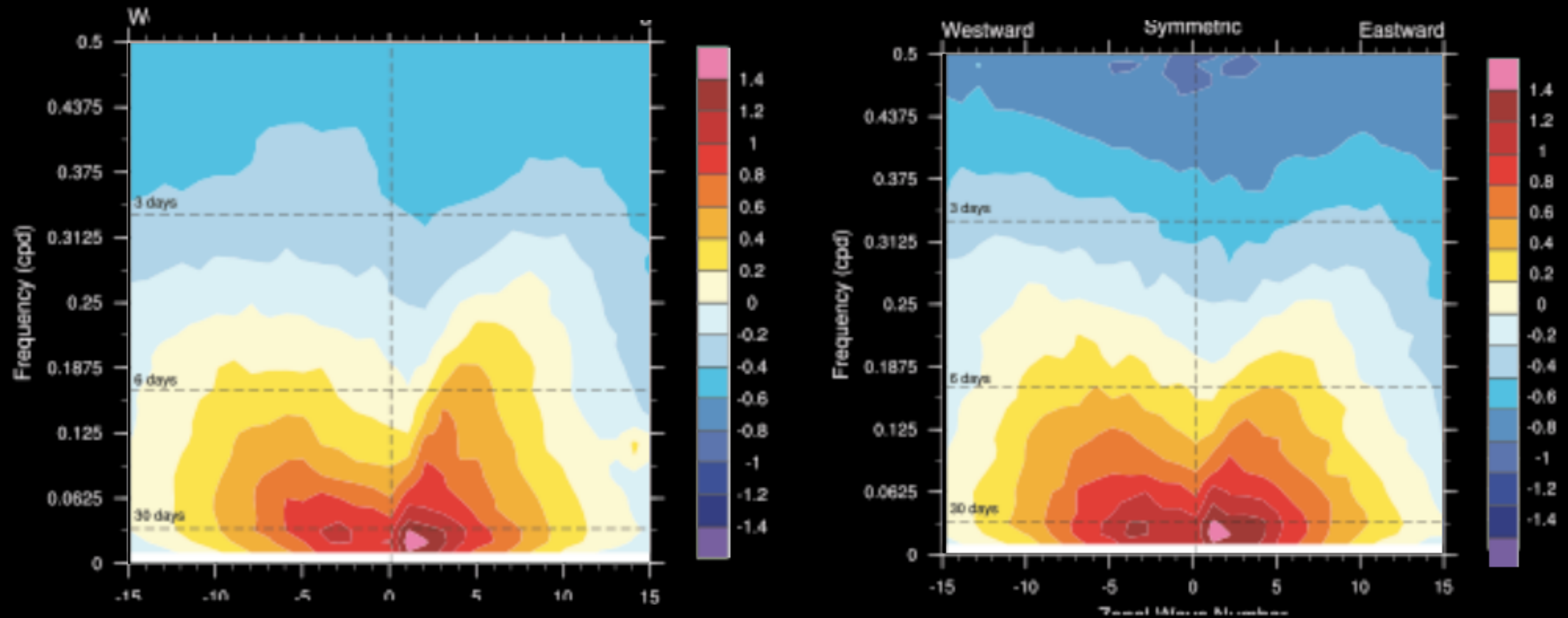# Intrinsic predictability insensitivities of the super-parameterized MJO.

Mike Pritchard
University of Washington
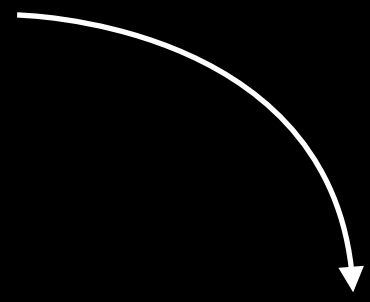
In collaboration with
Chris Bretherton, Tom Ackerman, Roj Marchand

The statistical composite signal of the MJO in multidecadal simulations of free-running SPCAM3.0 is remarkable.
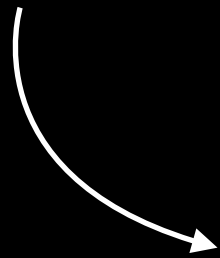
Prior:

Proven quality of SPCAM's
composite MJO.

Hypothesis:

**The SPMJO is a
valid analog to nature.**
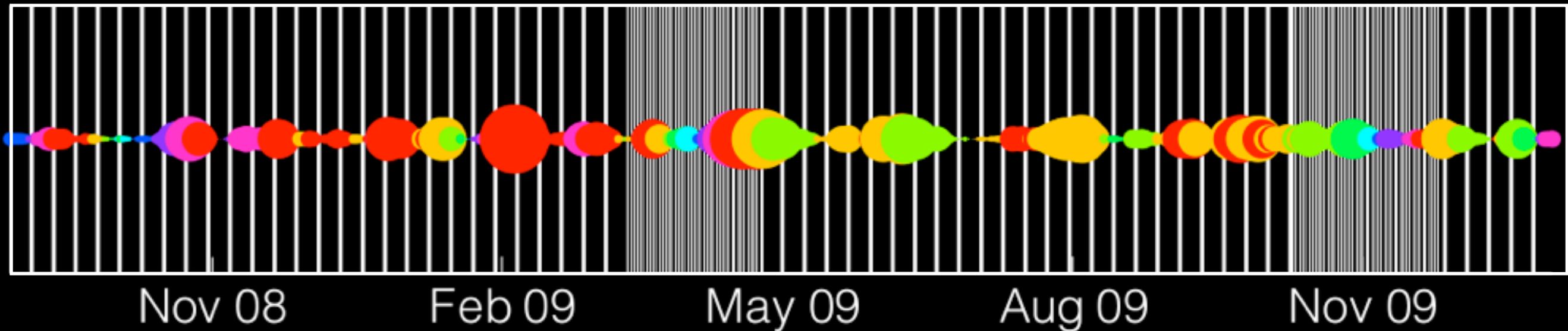
Expect:

Nontrivial forecast skill.

Last time: An event-centric forecast experiment design. (YOTC-GASS MJO Diabatic Heating Model Intercomparison.)

Case D

Case E

MJO activity during YOTC

Nov 08   Feb 09   May 09   Aug 09   Nov 09
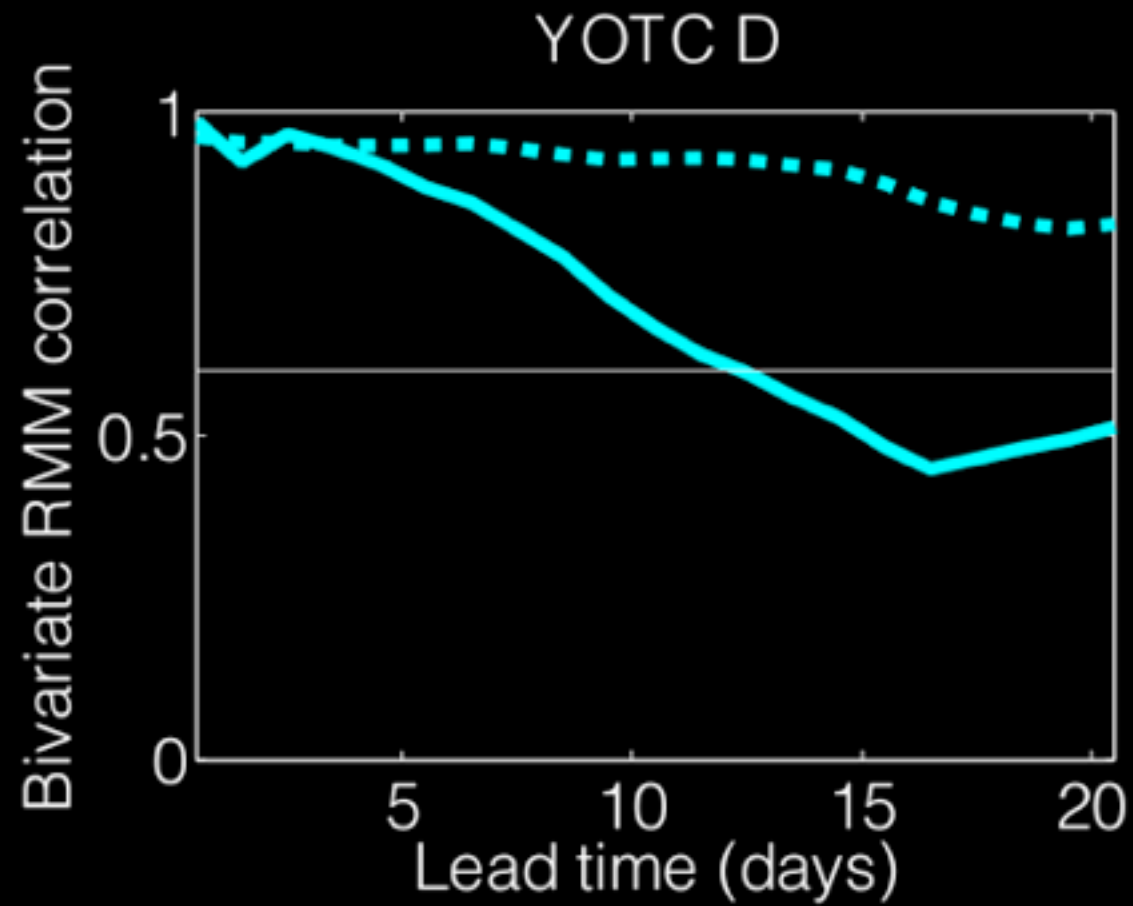
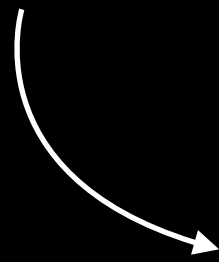1   2   3   4   5   6   7   8

MJO phase

It is tempting to infer from the event-centric ensemble that SPCAM has impressive forecast skill.

YOTC D

Hypothesis:

**The SPMJO is a
valid analog to nature.**

Expect:

Nontrivial forecast skill. ✔

Skilfull forecasts across
2 YOTC cases affirm
validity of SPMJO.

On further thought, the event-centric GASS-YOTC experiment design is prone to misinterpretation.

A new, useful, customized ensemble design.

A multi-MJO forecast ensemble aligned with NOAA OLR EOFs.

Ensemble design considerations:

1. 18 MJOs, 18 forecasts: Minimal MJO degeneracy boosts confidence in skill limit.
2. Initial phase alignment: Mean lead-time dependence can be viewed spatially.
3. Phases pinned on OLR: Allows convection, not just winds, to be clearly aligned.
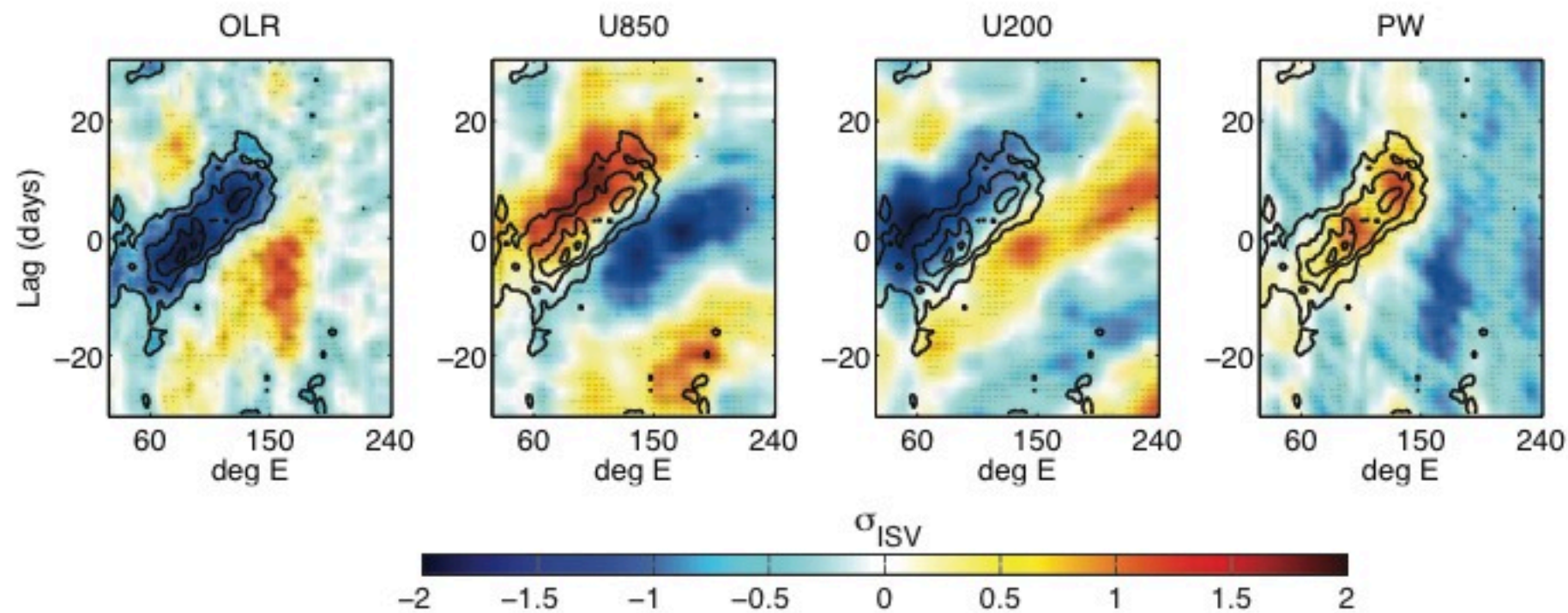
Observed composite time-longitude structure of 15S-15N anomalies across an objectively identified MJO forecast ensemble (18 events).
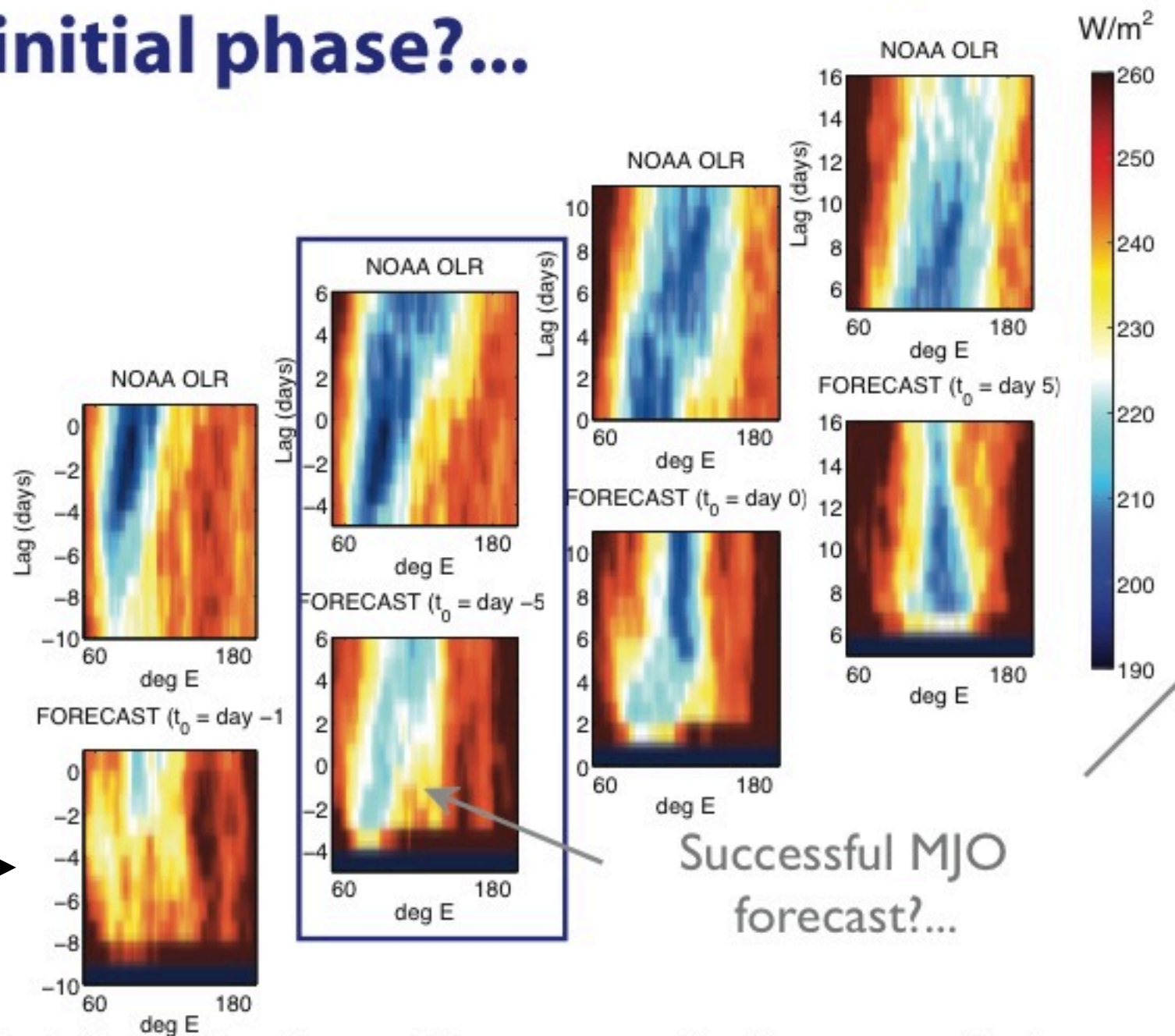
# Useful forecast skill at a specific initial phase?...

OBS → vs. **SPCAM** forecast → composite

Successful MJO forecast?...

(Top) observed vs. (bottom) forecast outgoing longwave radiation across the MJO composite, at four different initialization lags. Each case involves 18 forecasts initialized from regridded ERA-I fields.

... or an artifact of climate drift.

Resampling the ensemble during non-MJO years cautions that SPCAM's mean drift from ERA-I rivals its MJO signal.
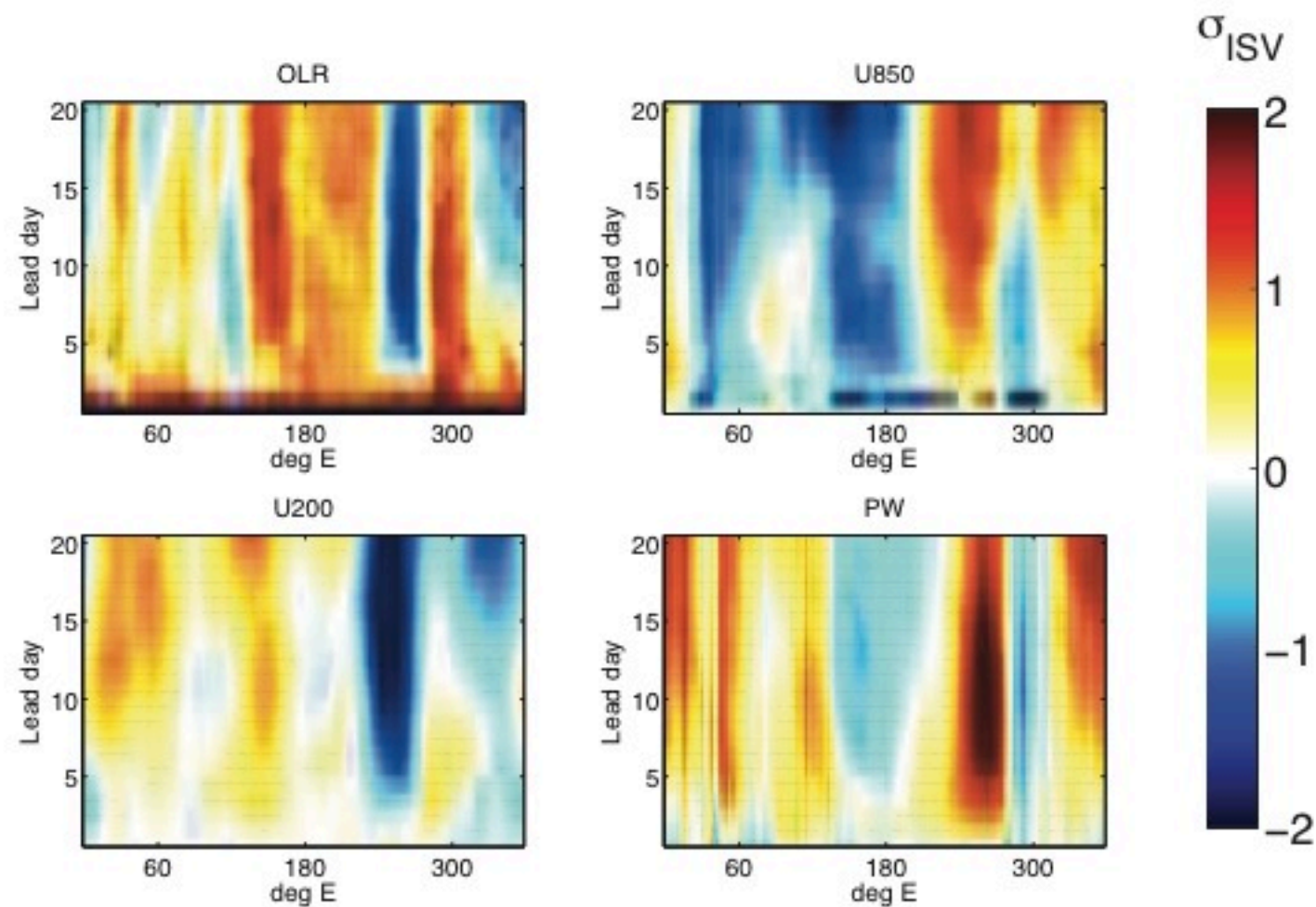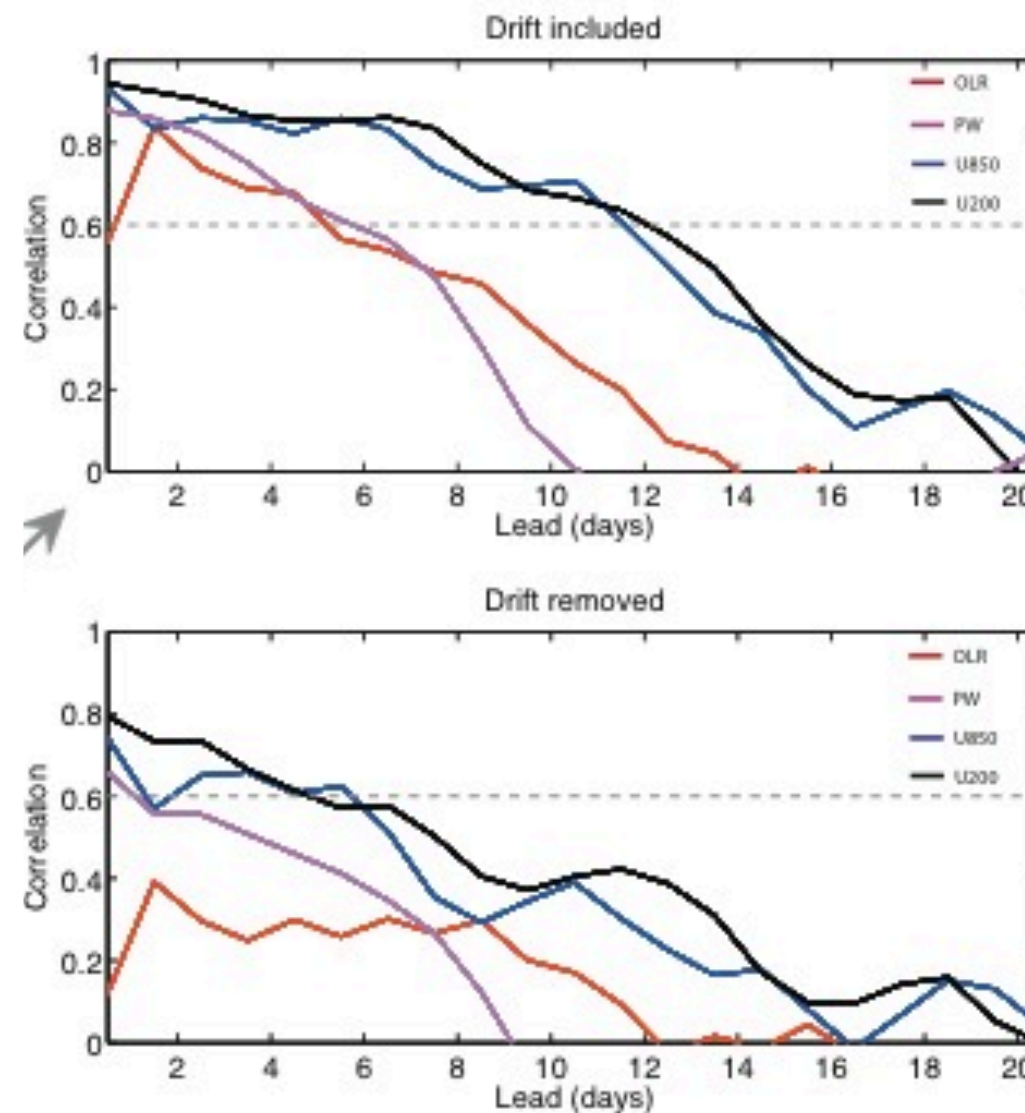

Lead time-longitude section showing the time mean 15S-15N drift structure from 5x reforecasting of the MJO ensemble calendar dates.

Drift masquerading as MJO skill. Adjusted forecast limit < 6 days.

Drift adjustment reduces SPCAM's wind anomaly forecast skill limit from 12 to 5 days for the ensemble forecast
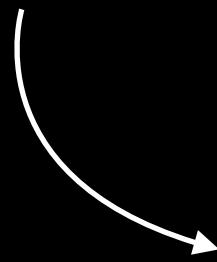

... Fluke of mean drift.

Correlation of 15S-15N anomalies in the vicinity of the Maritime continent for the MJO forecast ensemble highlighted in Fig. INSERT.

Hypothesis:

**The SPMJO is a
valid analog to nature.**

Expect:

Nontrivial forecast skill. ✔

~~Skilfull forecasts across
2 YOTC cases affirm
validity of SPMJO.~~

An unsolved initialization
problem masks the answer.

Prior:

Nature of SP

Prior:

Exceptionality of the SPMJO

Hypothesis:

**Mesoscale organization is critical
to the dynamics of the SPMJO.**

Expect:
More skill if inner cloud
model is initially spun-up

To explore skill sensitivities, avoid drift by using model ICs.

Clean SPCAM sensitivity testing means forecasting from states close to the model's internal climate. Thus forecast "validation" becomes relative to a free-running model state trajectory.

# Note 4x model speedup possible using tiny CRMs – same nice MJO.

For expedience, we harvest initial conditions (ICs) from a reference run using unconventionally tiny cloud resolving model arrays (25% extent). Interestingly, shrinking SPCAM's CRMs does not impact its intrinsic MJO structure.
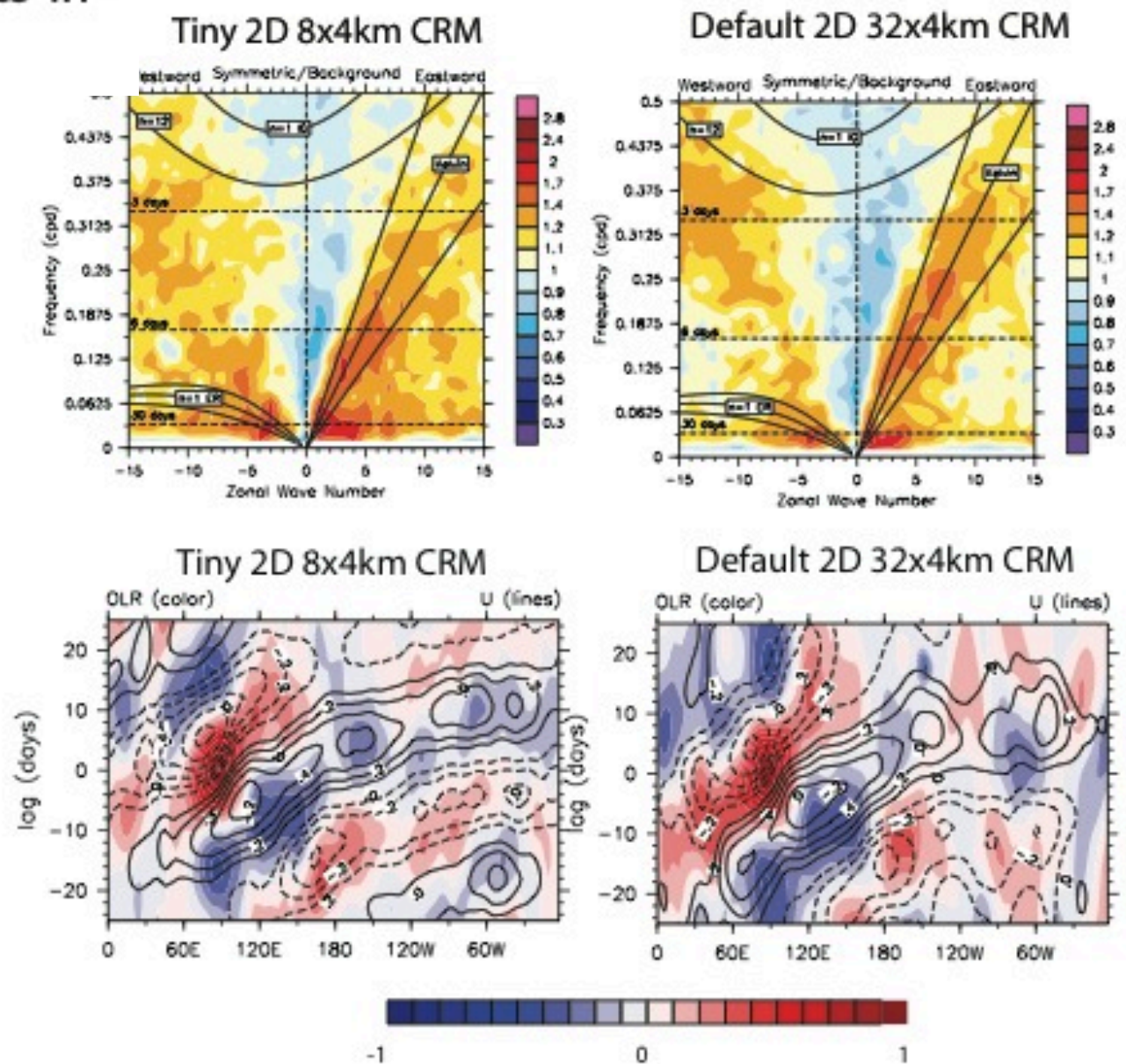
(Top) wavenumber-frequency OLR signal-to-noise spectra and (bottom) lag-correlation of 20-100 day filtered OLR (color) and 850 hPa zonal winds (contours) for 15-year runs in two configurations.
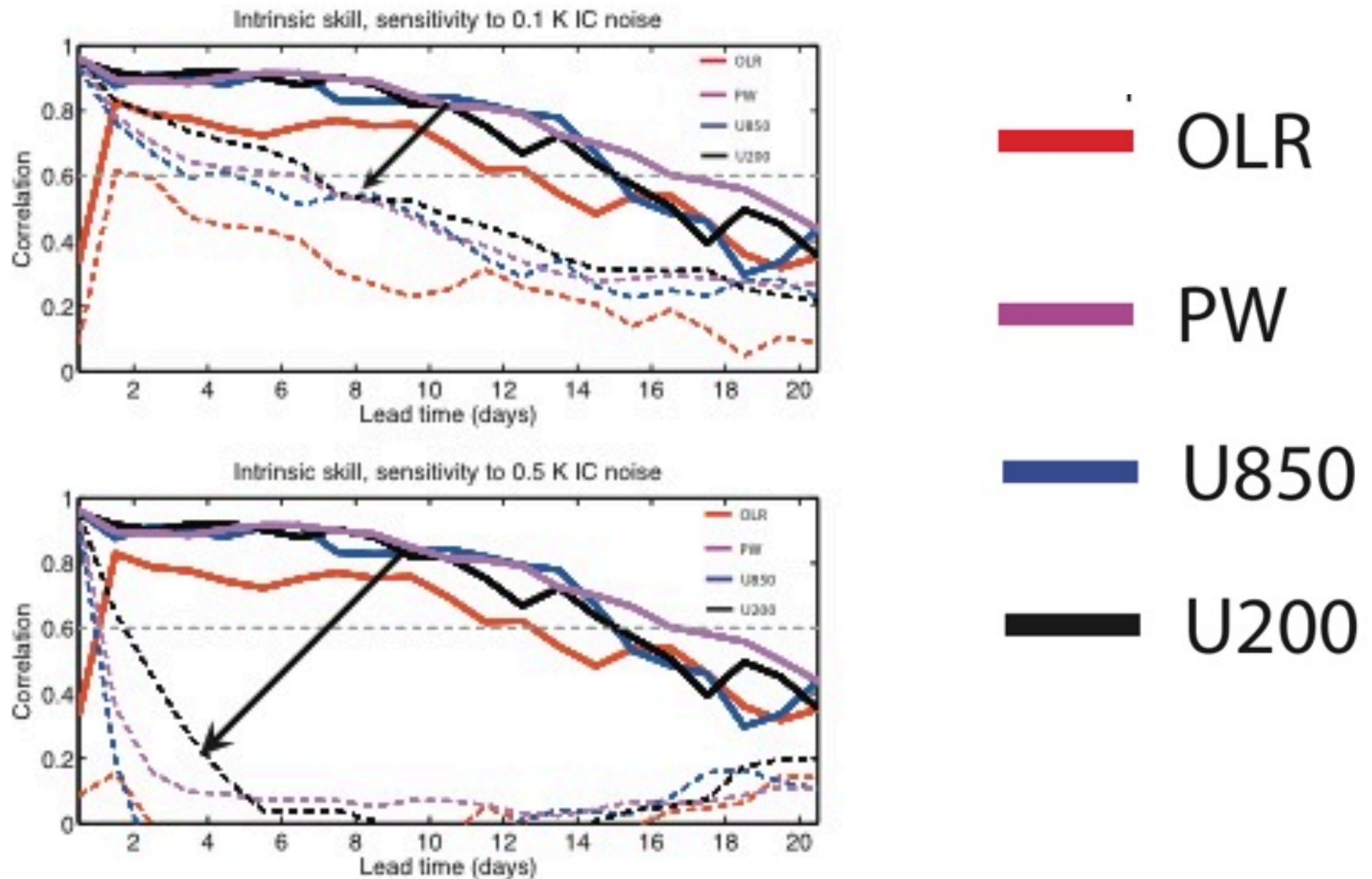
New multi-MJO ensemble, from free-running SPCAM / tiny CRM.
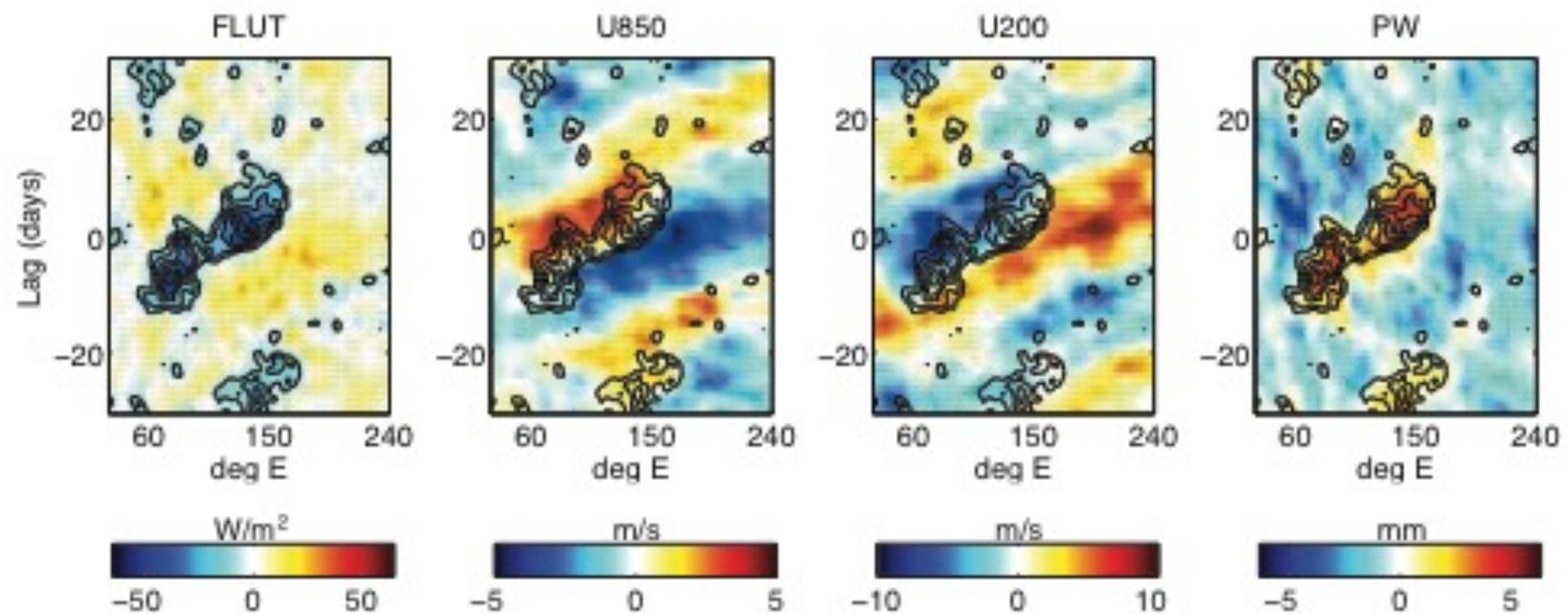
As in the first figure, but for intrinsic MJO in free-running SPCAM customized with the tiny 2D 8x4km cloud resolving arrays (11 events).
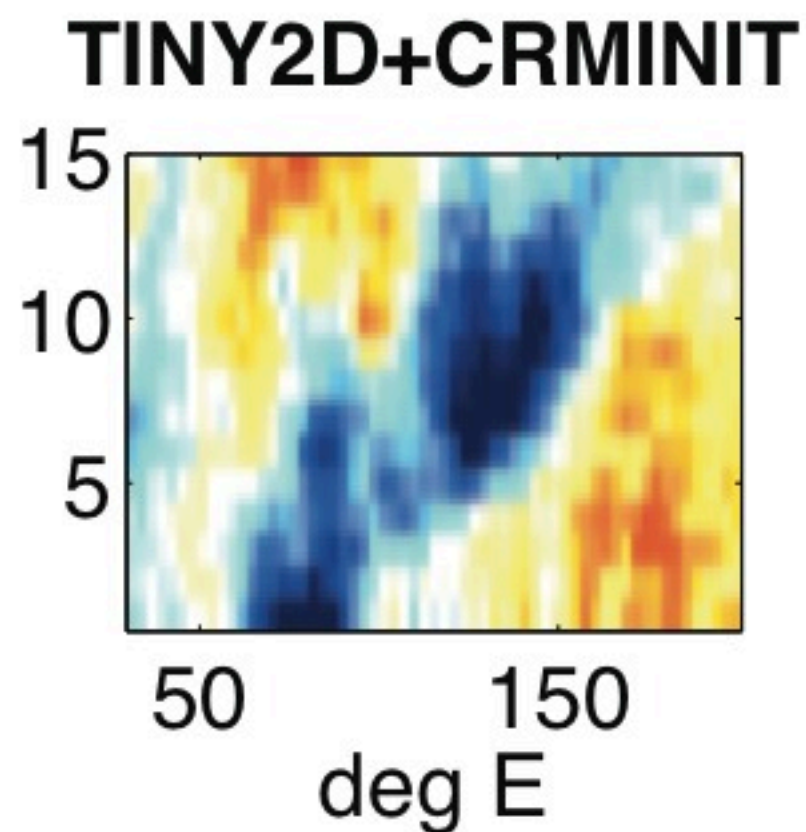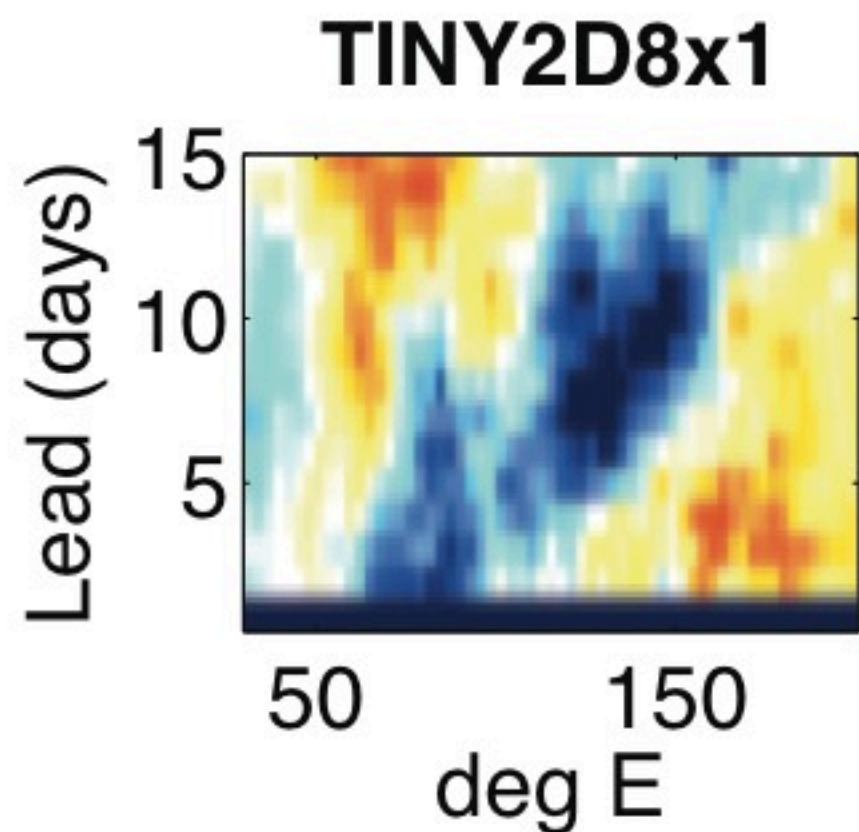
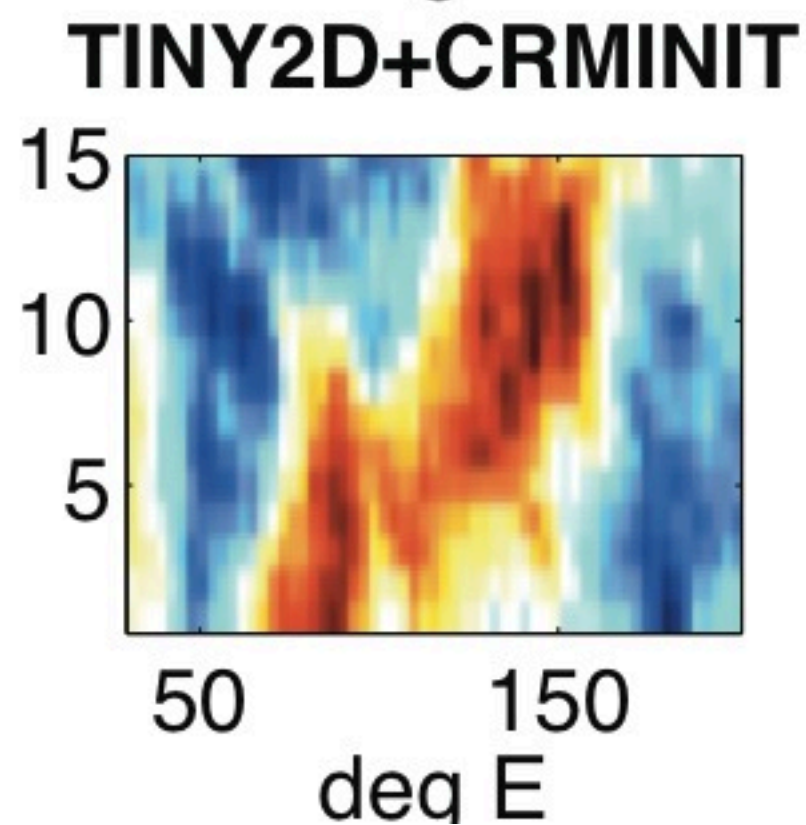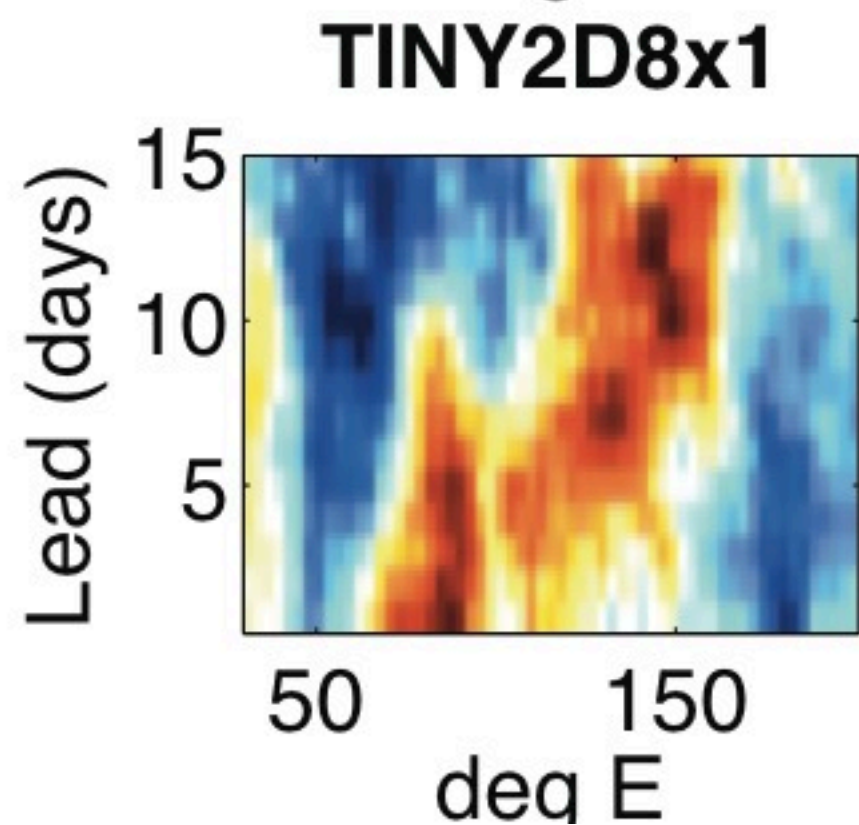# Weak initial noise disrupts MJO predictability.

Internal 15S-15N correlation decay relative to free-running trajectory for 11 forecasts initialized (solid) from standard model ICs vs (dashed) the same ICs perturbed with uncorrelated thermal noise.

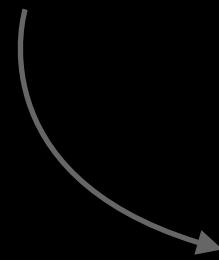A sensitivity test of the importance of CRM-scale initiation.

OLR

PW

TINY2D8x1 **TINY2D+CRMINIT**

TINY2D8x1 **TINY2D+CRMINIT**

Hypothesis:

**Mesoscale organization is critical
to the dynamics of the SPMJO.**

Expect:
More skill if inner cloud
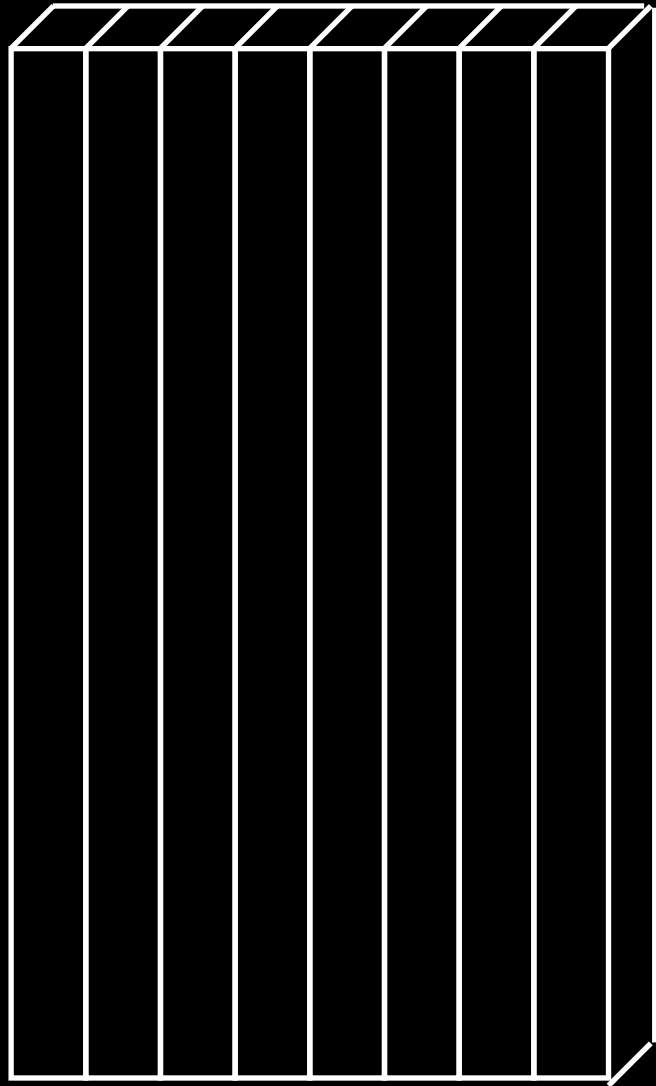model is initially spun-up

X

Expect:
Skill responds to
changing
inner model
geometry.

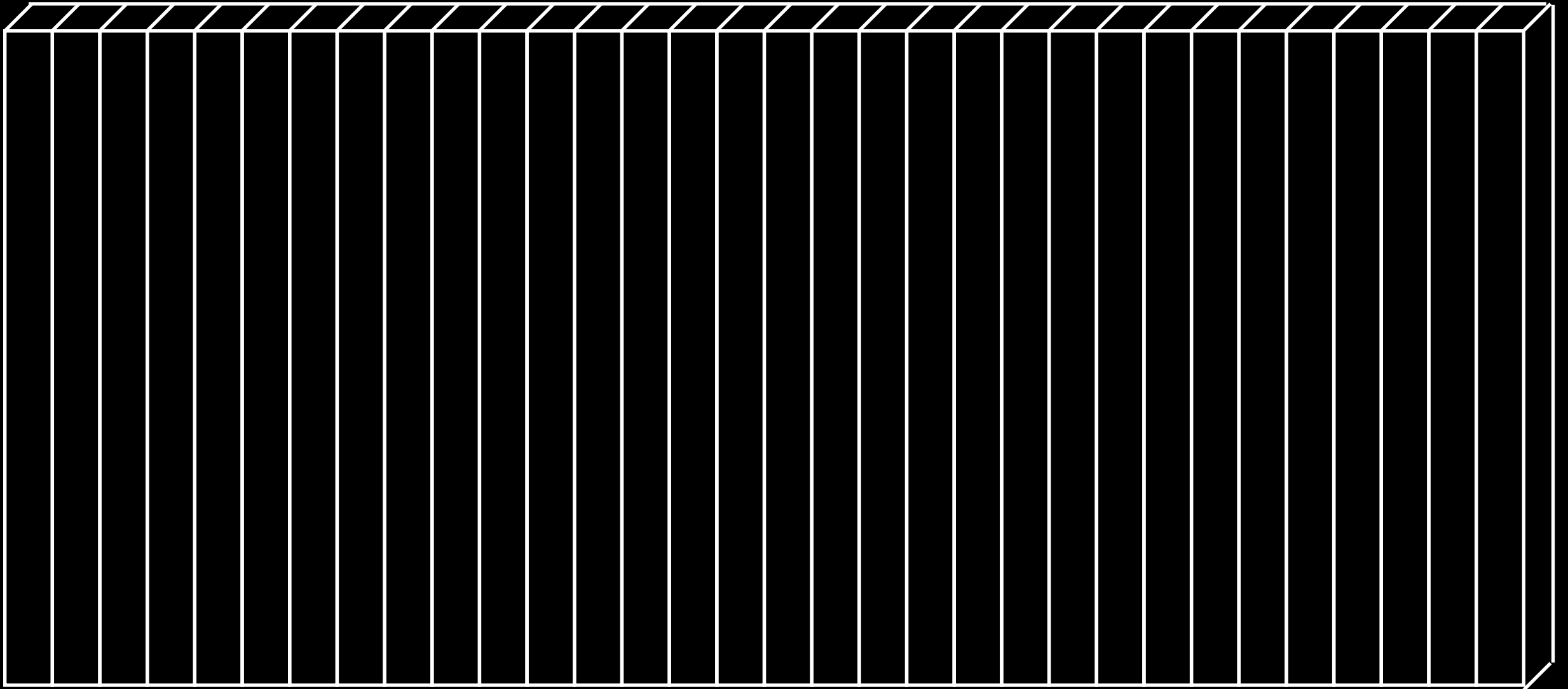A sensitivity test varying the inner cloud model's ability to organize.

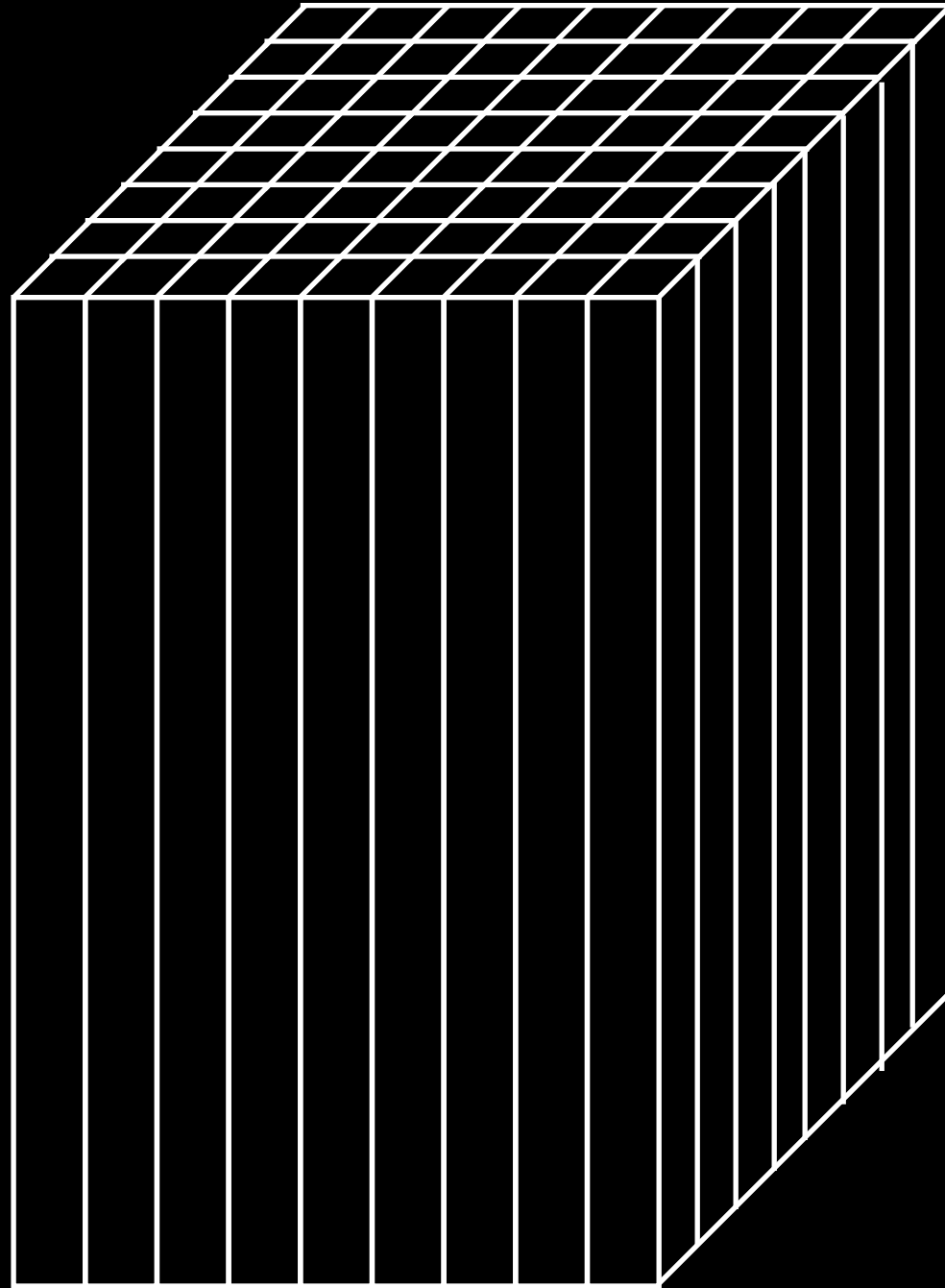So far all forecasts have used an unusually tiny 2D cloud model configuration:

8x4km

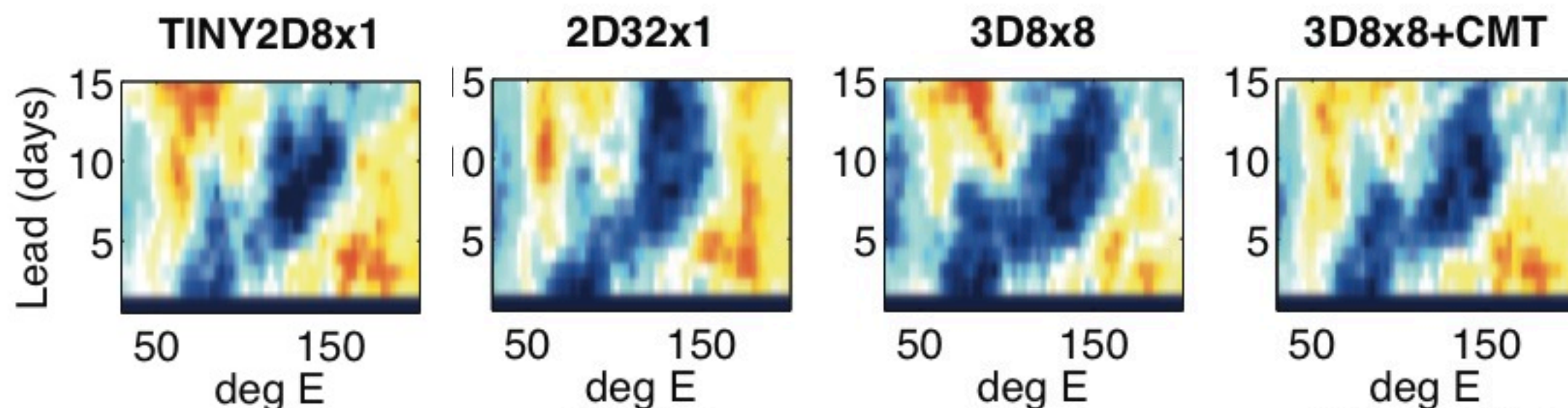# Repeat ensemble forecast using default, big 2D CRM, with much more room for storm organization.

32x4km

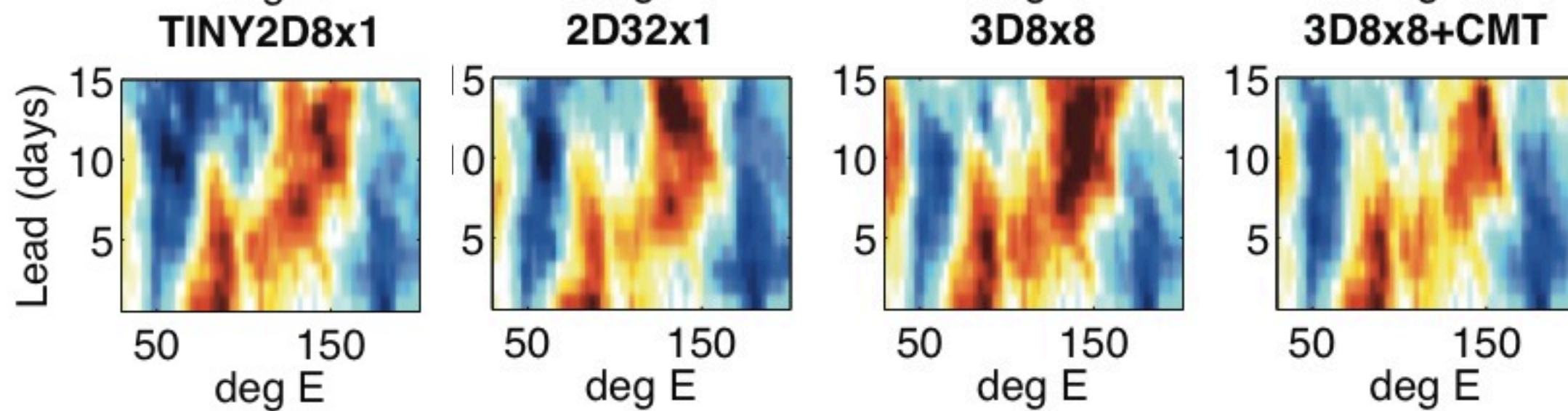# Repeat ensemble forecast using less organizable 3D domain:
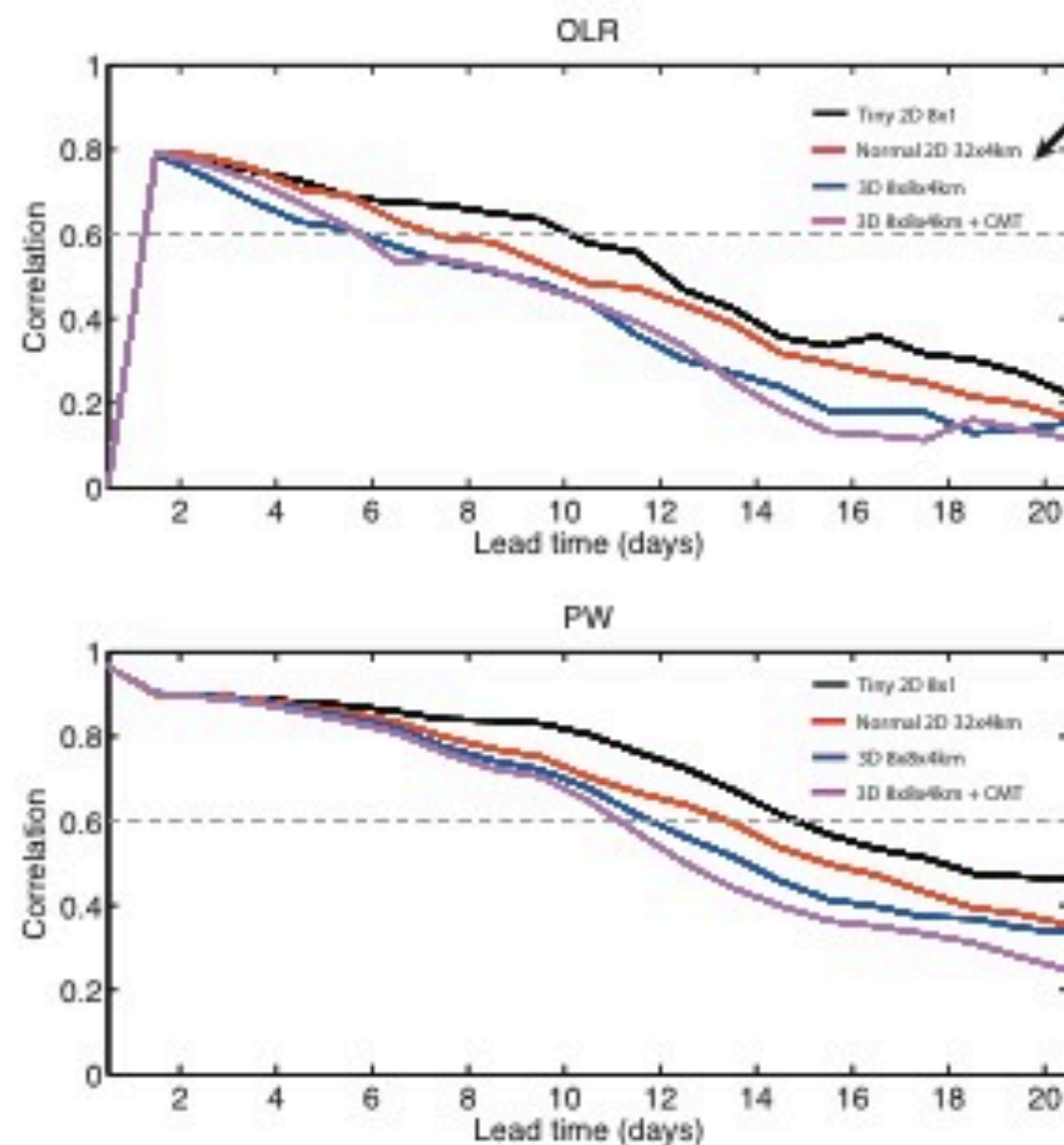
"8x8x4km"

Further test effect of adding SPCMT.

OLR

TINY2D8x1   2D32x1   3D8x8   3D8x8+CMT

PW

TINY2D8x1   2D32x1   3D8x8   3D8x8+CMT

MJO predictability robust to CRM configs with no mesoscale
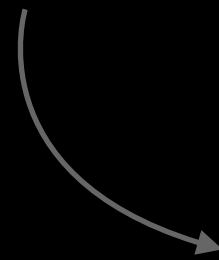

OLR

PW

Sensitivity tests altering the CRM's capacity for internal organization.

Internal 15S-15N anomaly correlation of (top) OLR and (bottom) PW relative to free-running SPCAM for three perturbed-CRM versions of SPCAM. Each test has 22 forecasts across two initial phases.

Hypothesis:

**Mesoscale organization is critical
to the dynamics of the SPMJO.**

Expect:
More skill if inner cloud
model is initially spun-up

X

Expect:
Skill responds to
changing
inner model
geometry.

X

Take-home points

- **Mesoscale organization may not be a critical link** in how SPCAM couples large scale intreasonal convection and tropical circulation.

    - Intrinsic predictability insensitive to CRM initialization, domain size, dimensionality & CMT.

- Intrinsic predictability of the **SPMJO is disrupted by weak white noise.**

⟶ - **4x MMF speedup seems possible** using tiny CRMs.

Motivates a closer look at SPCAM's MJO in new free-running tiny-CRM configurations...

Glimmers of realistic intraseasonal behavior in an 8x1 CRM configuration of SPCAM have been seen before....
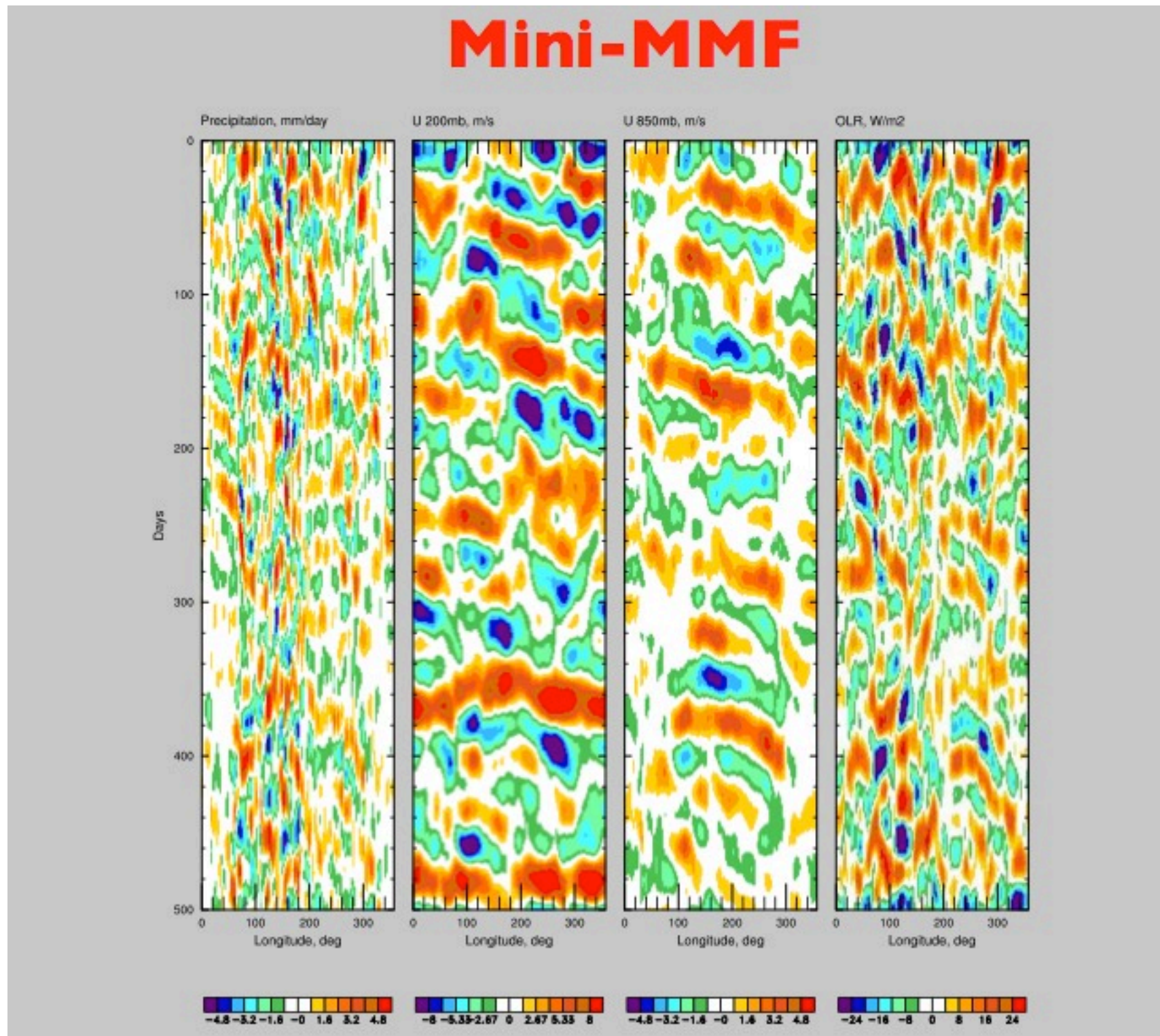
Mini-MMF

How low can you go?

A brief look at the mean state and MJO in ludicrously tiny unexplored configurations of SPCAM.
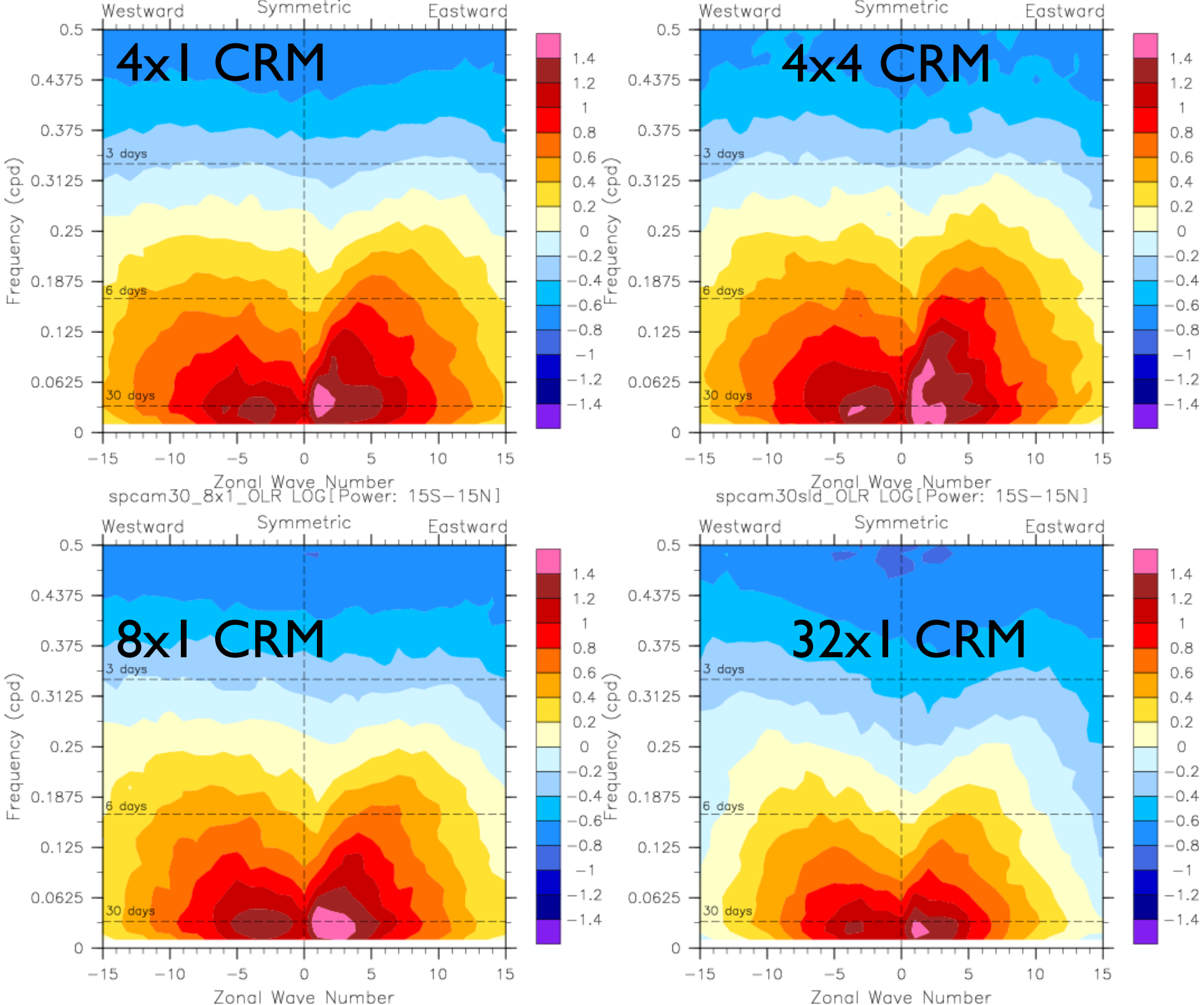
Comparing default (32x1) CRM vs. 8x1, **4x1, 4x4.**
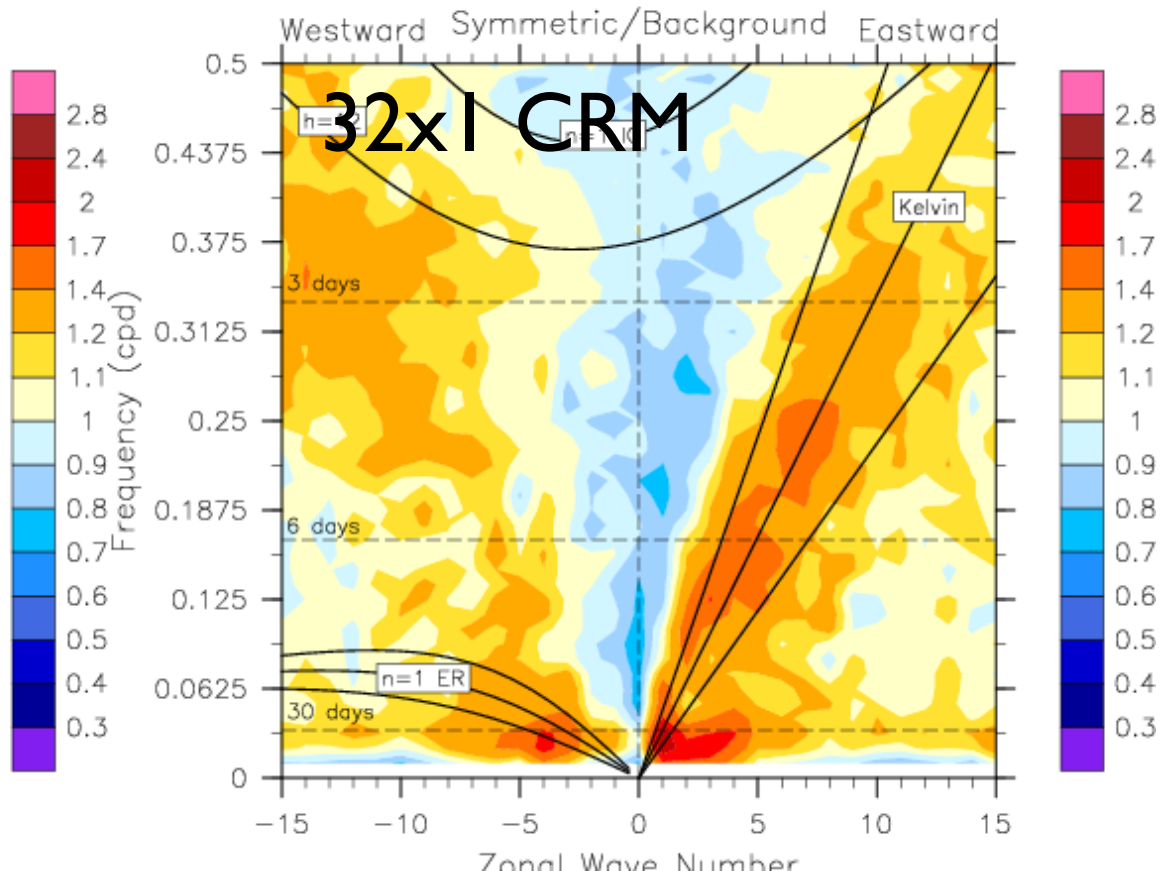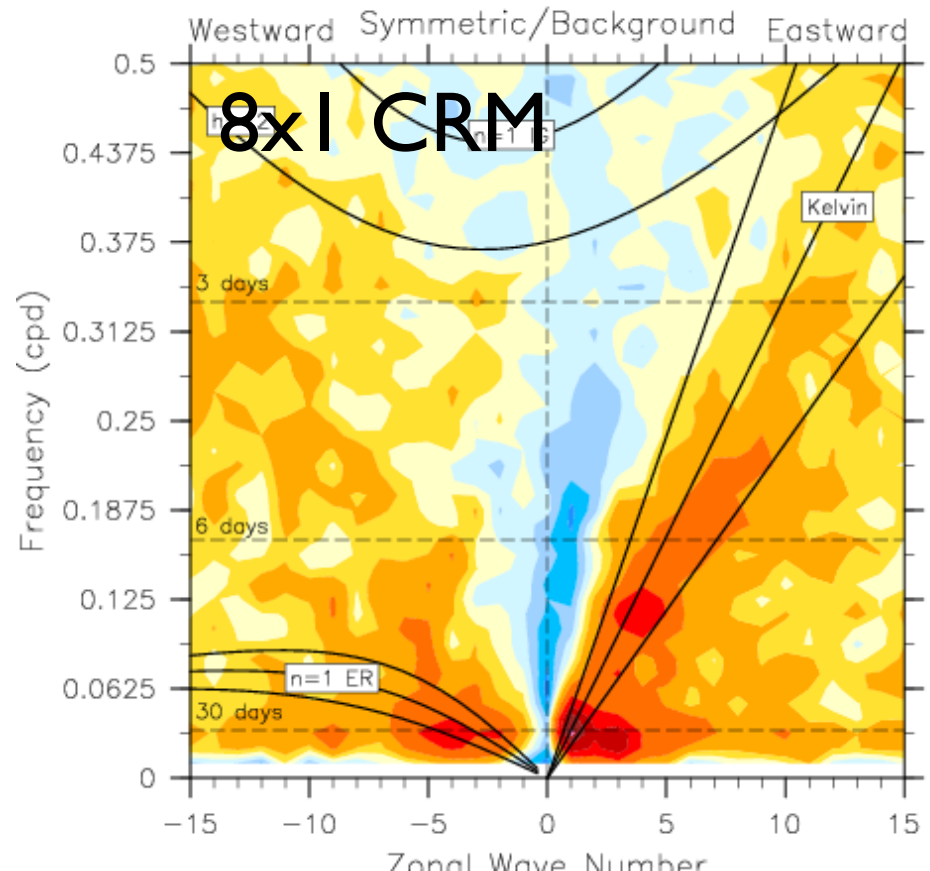
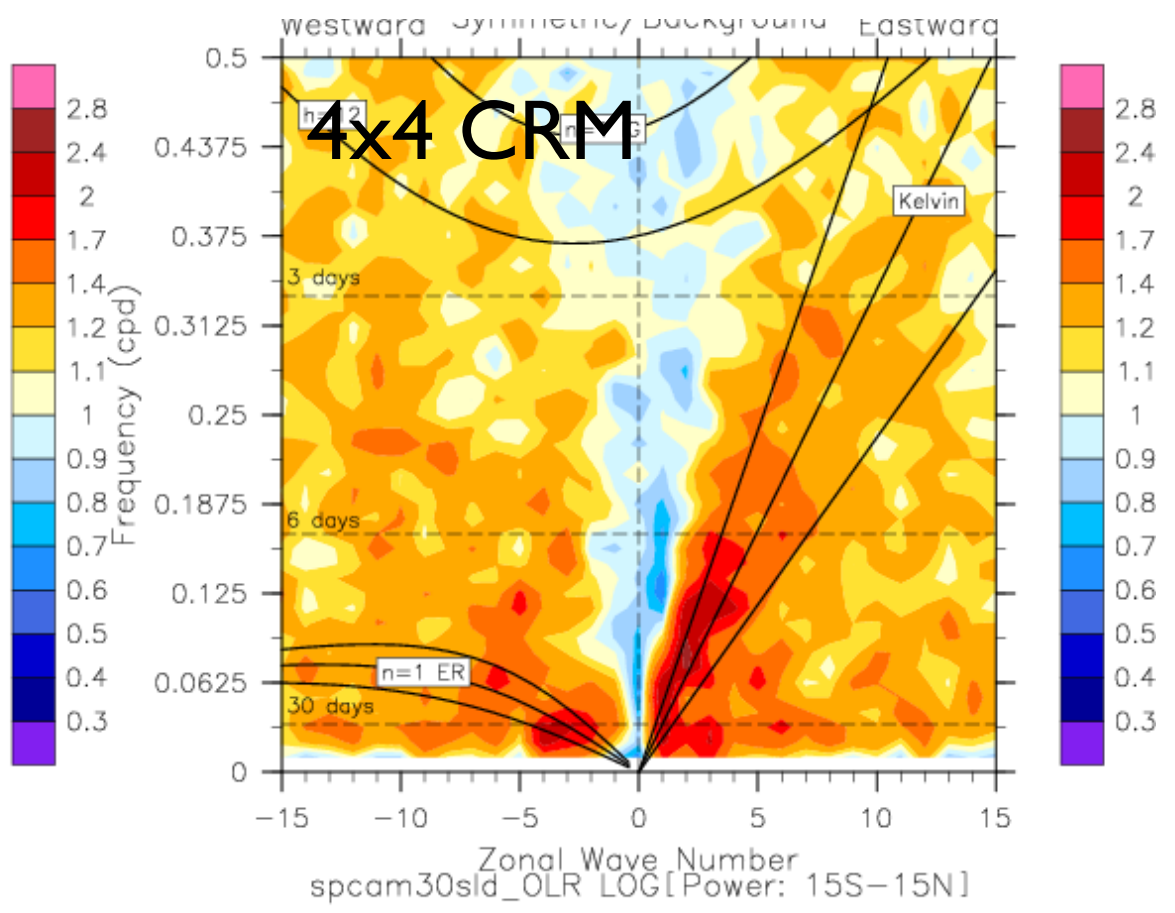# Mean DJF RMSE in three tiny-CRM versions of SPCAM.
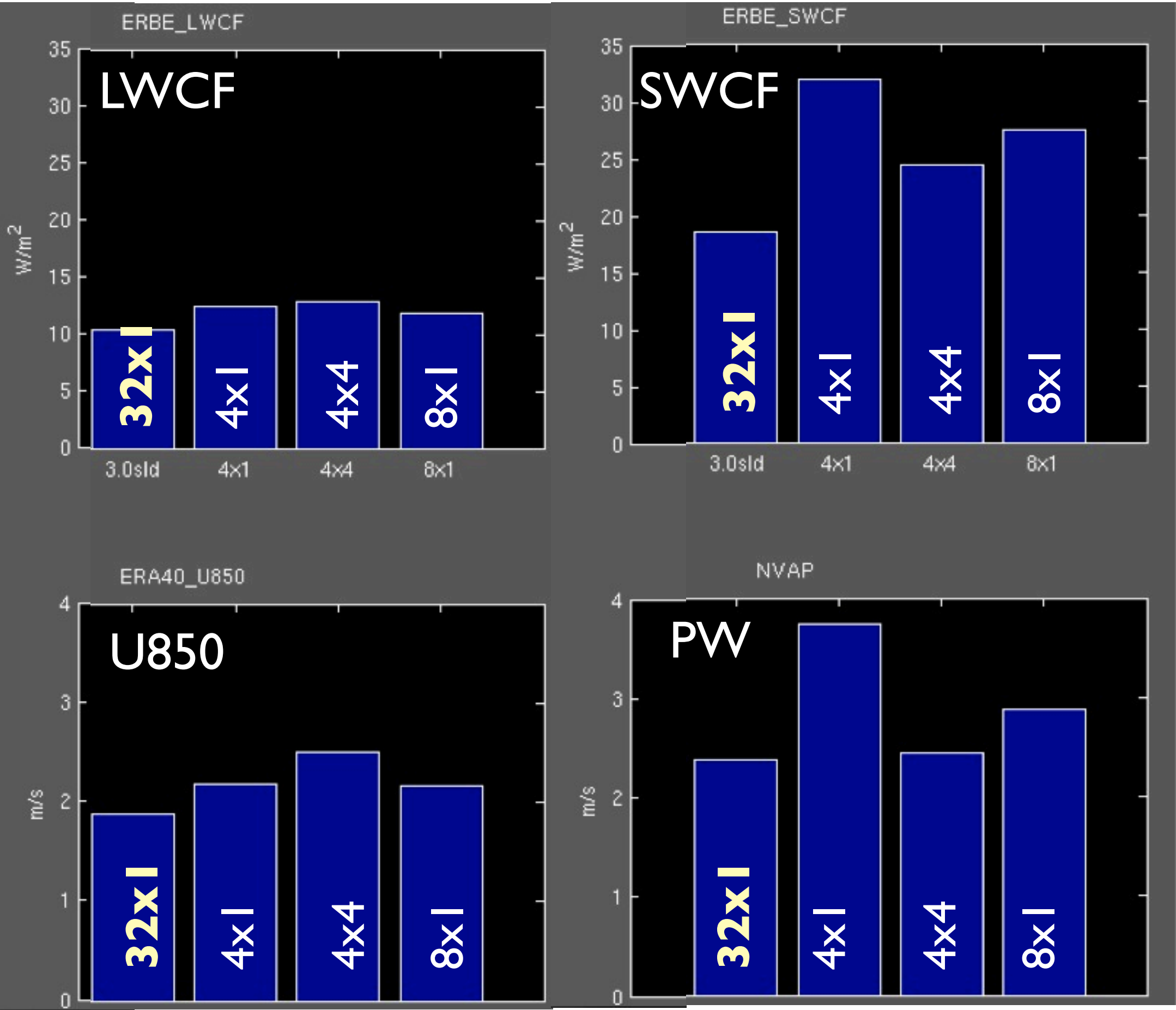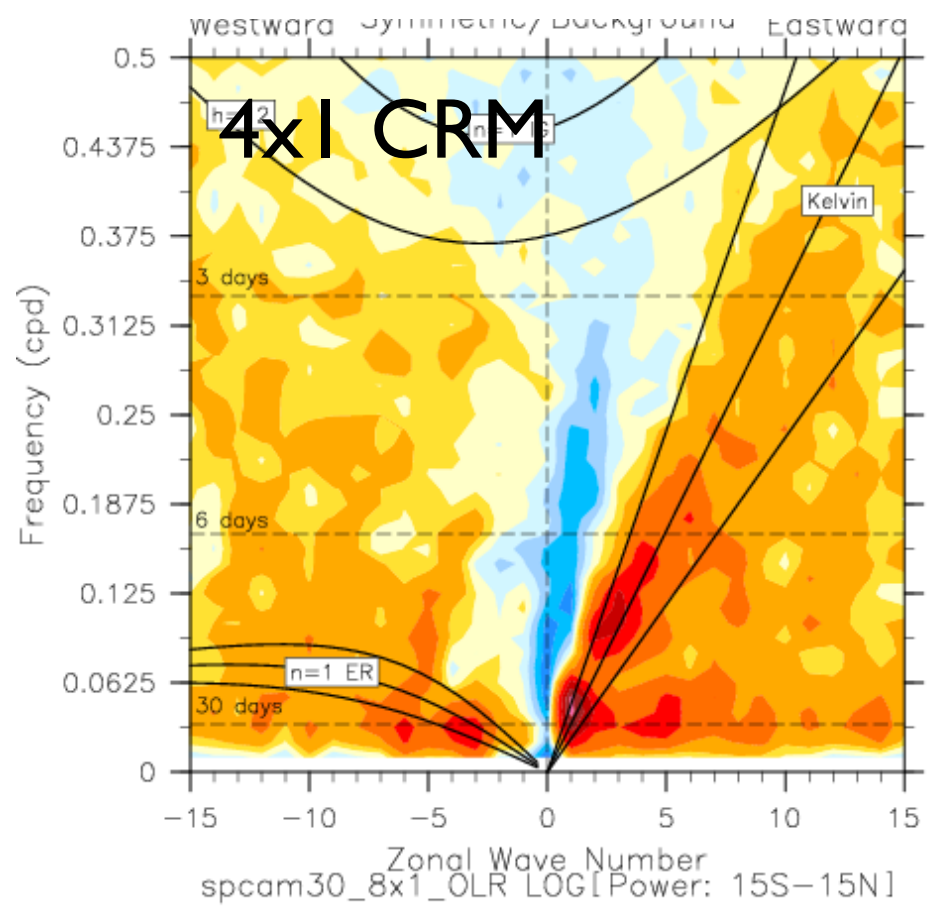

(9-year integrations)

Symmetric OLR spectrum in tiny-CRM versions of SPCAM.
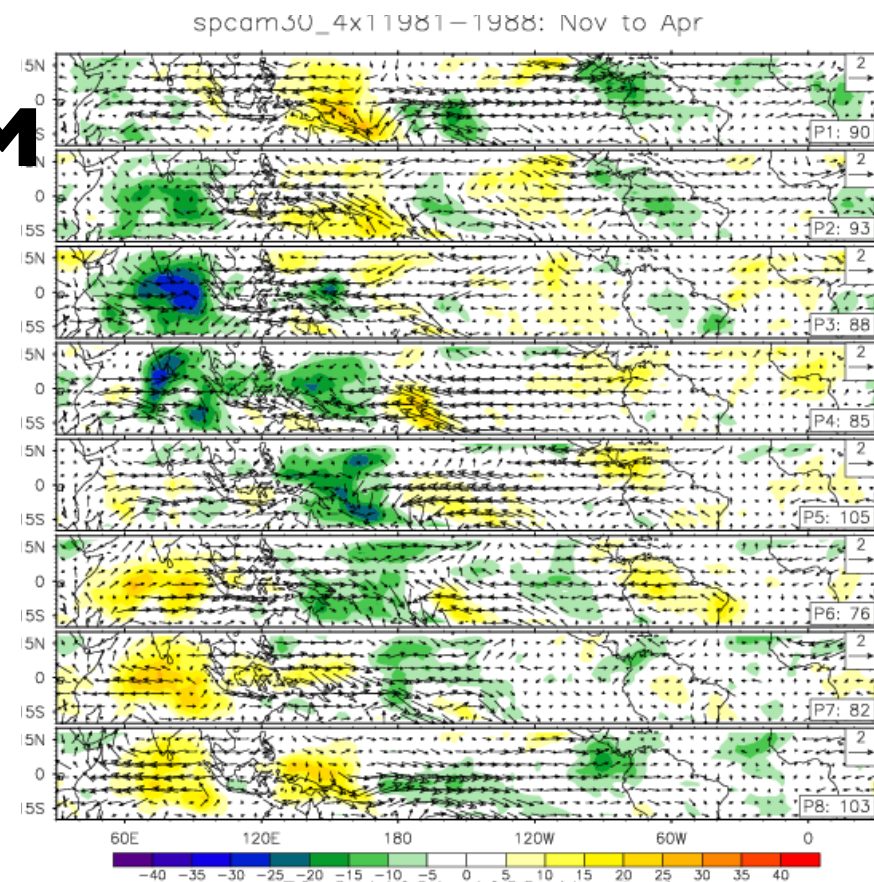
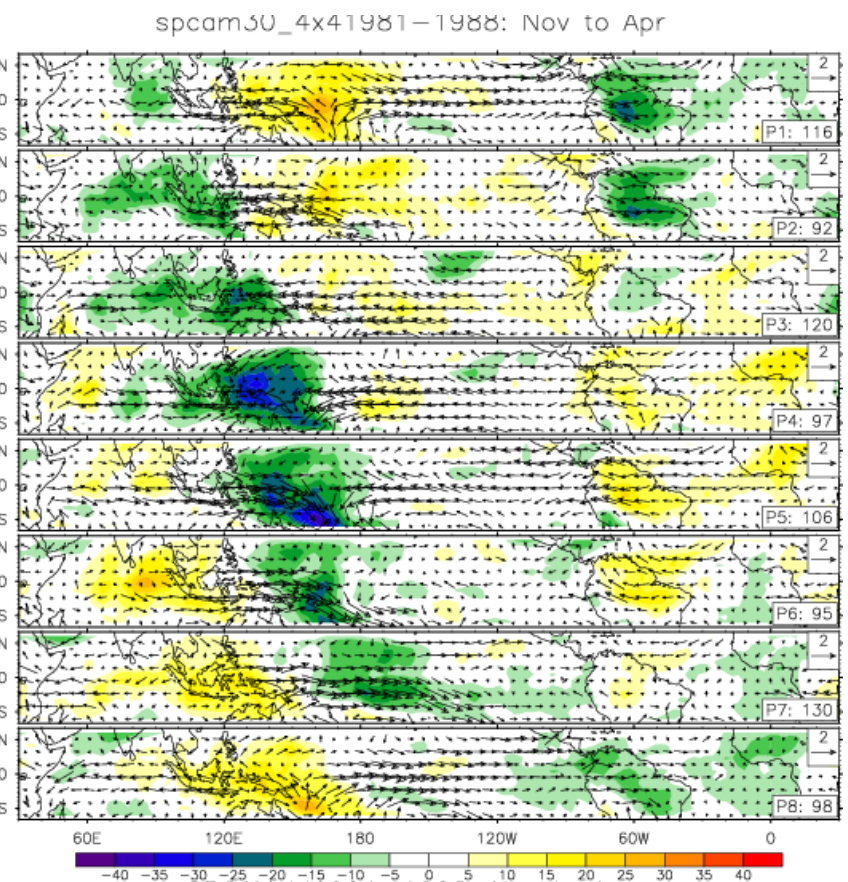# Symmetric OLR signal-to-noise in tiny-CRM versions of SPCAM.

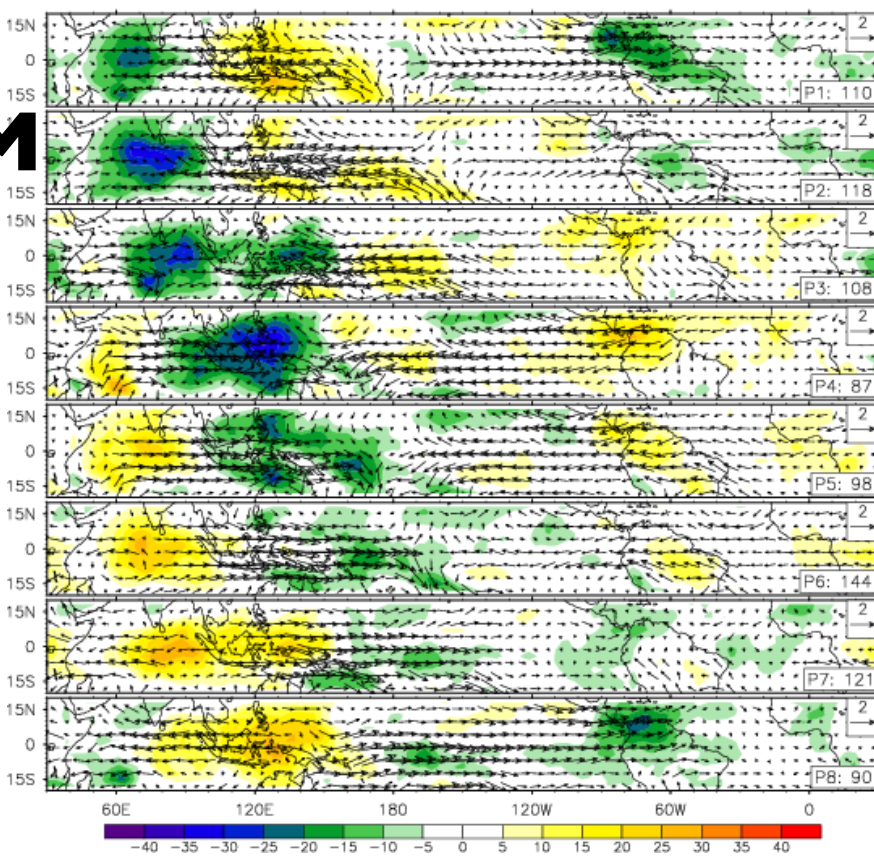# Intrinsic MJO composite in tiny-CRM versions of SPCAM.

Aside.

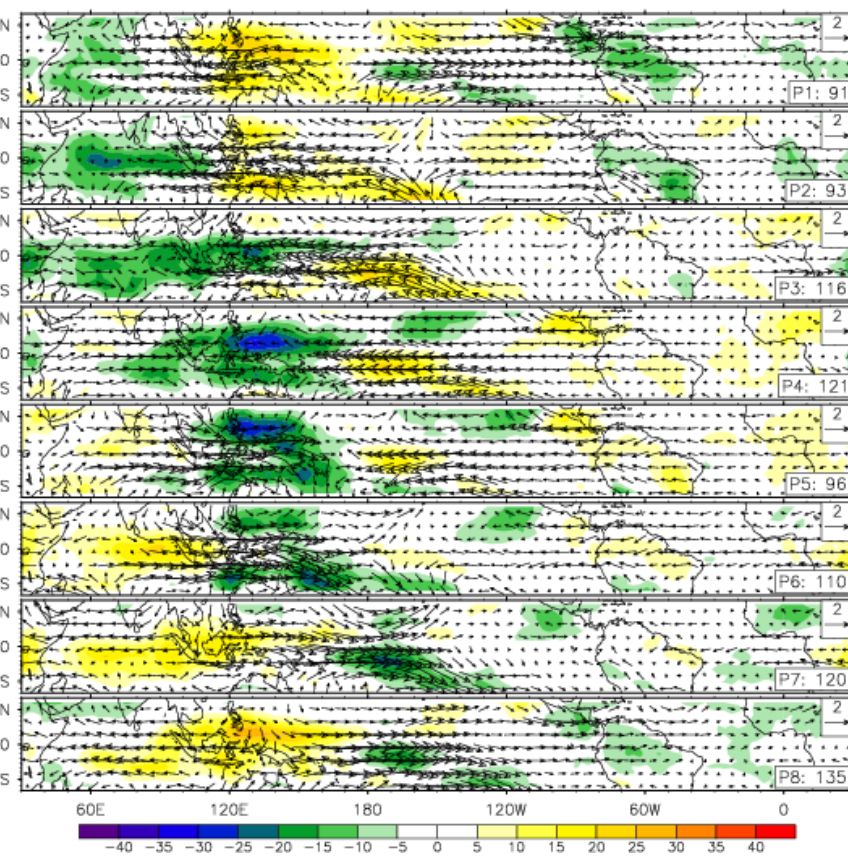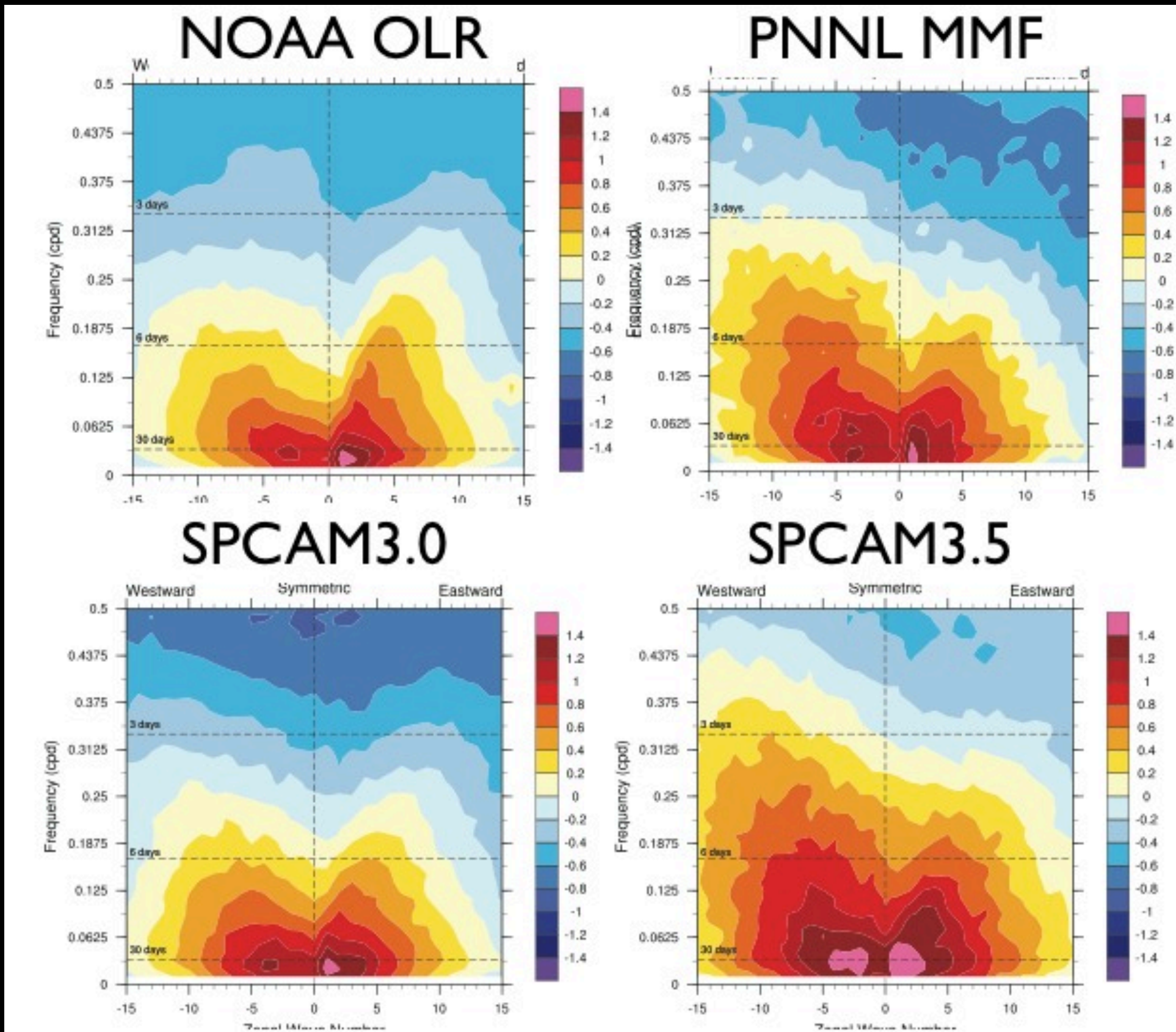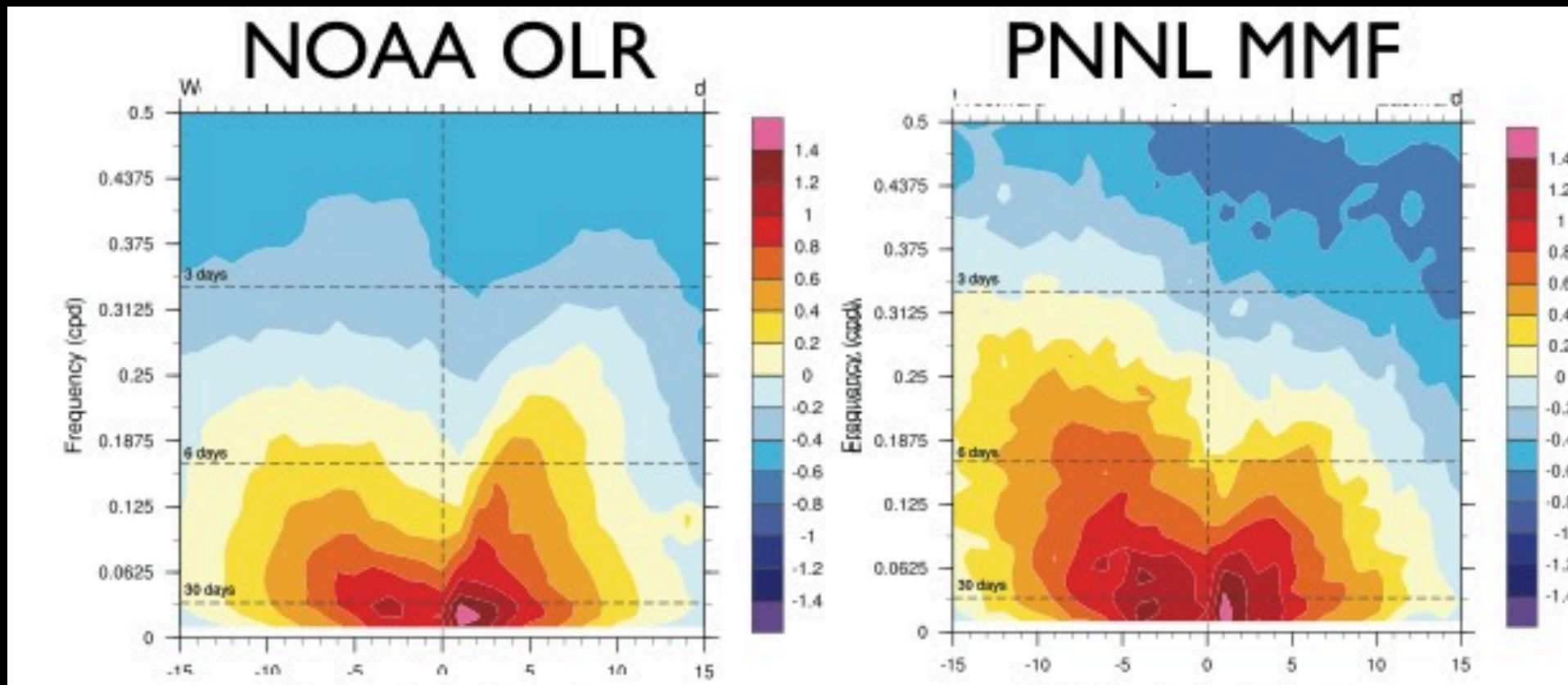An unsolved legacy-critical mystery:

"What degraded the SPMJO in versions of SPCAM since SPCAM3.0?"

Last time: New versions of SPCAM do not have a good MJO signal compared to the original model.
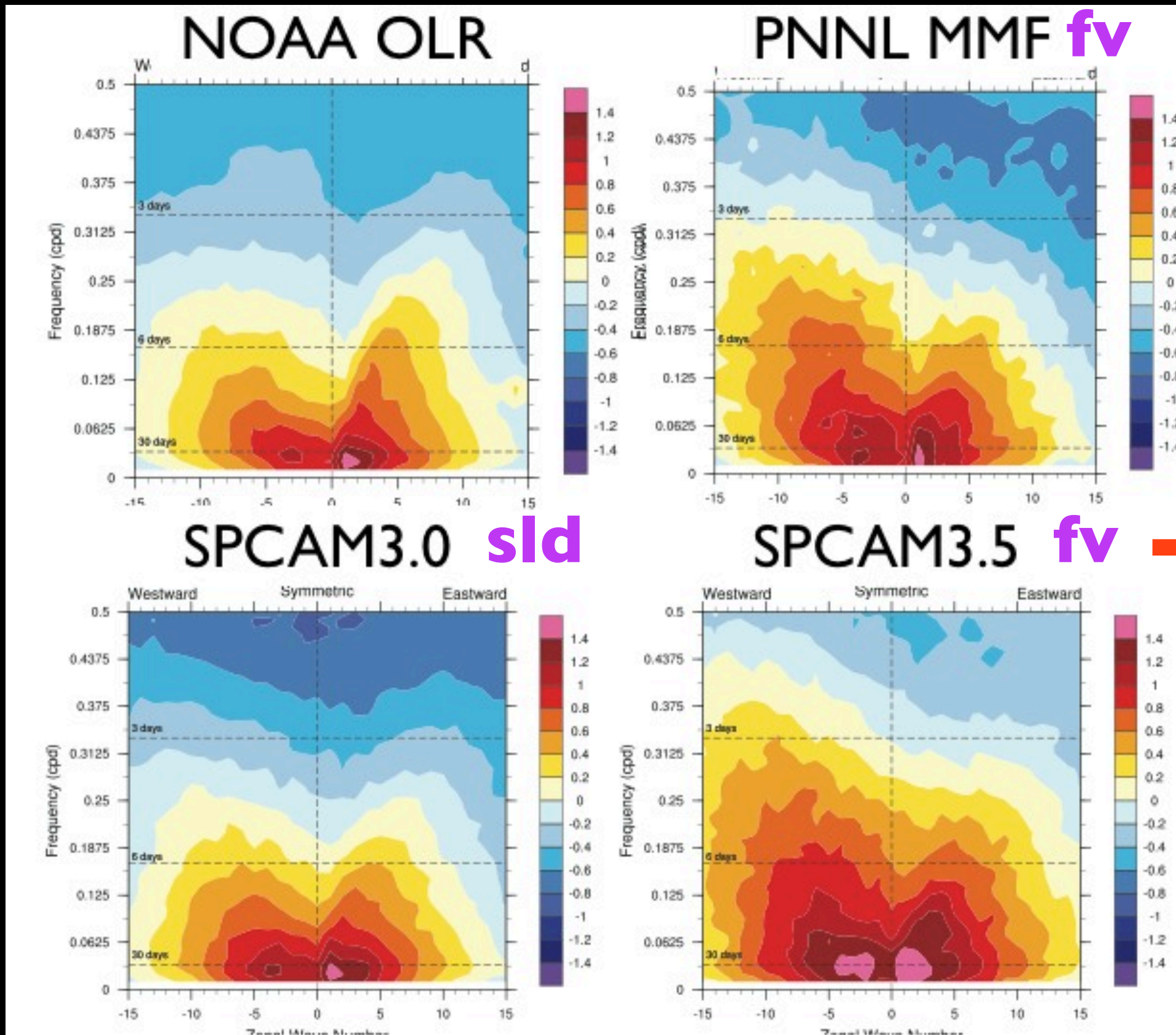
Last time: New versions of SPCAM do not have a good MJO signal compared to the original model.

A legacy-critical dilemma: This model version is being merged onto the CESM trunk.

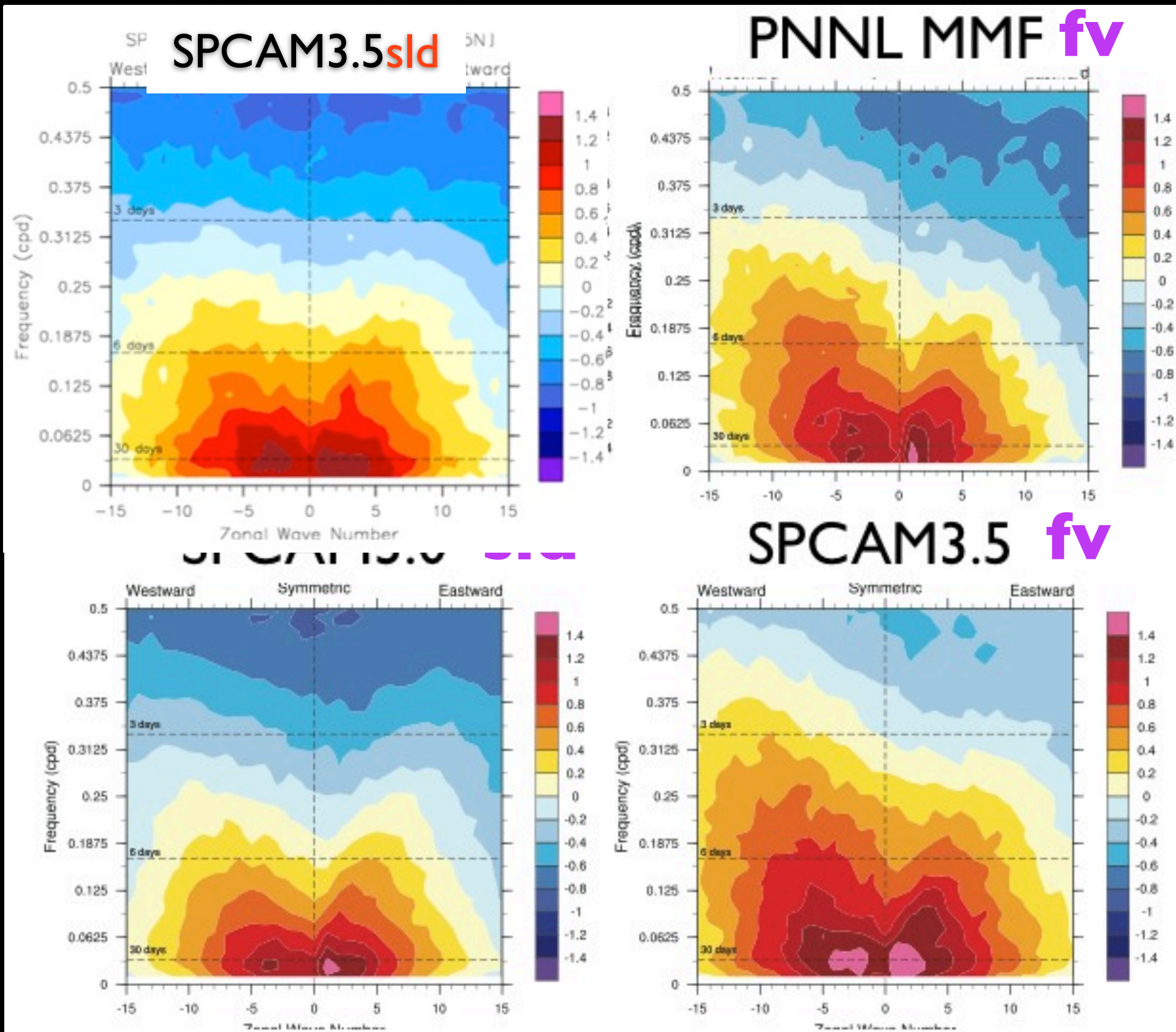**Last time:** *Is the **FV dycore** the culprit?...*

A new missing link: SPCAM3.5 sld (5 yr, clim. SSTs).

Thanks to Nathan Arnold for sharing this output.

So what hurt the SPMJO in SPCAM versions since 3.0?
Is the **FV dycore** *the culprit?...* **No.**

*Were updates to the CRM in 3.5 the culprit***? Marat: No.**

Inference: *Changes in the exterior host model are responsible.*

Logical path to understanding:
Sysematically search CAM version repo to find breaking point.

CAM tag circa.   CAM tag circa.
"SPCAM3.0"   ⟷   "SPCAM3.5"

binary revision search
re-test SP