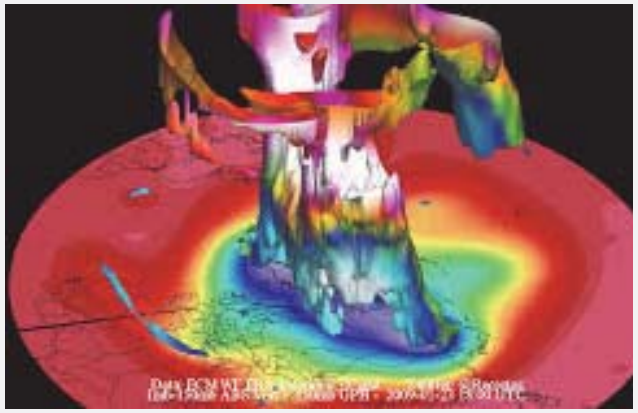
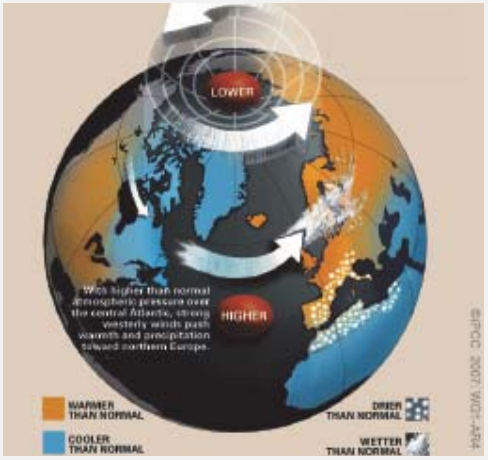
PREDICTABILITY OF THE TROPOSPHERIC NAM AND SSWS IN THE NMME PHASE-2 MODELS





Jason C. Furtado, ***School of Meteorology, University of Oklahoma***
Judah Cohen, *Atmospheric and Environmental Research*
Emily Becker, *NOAA CPC*
Dan Collins, *NOAA CPC*

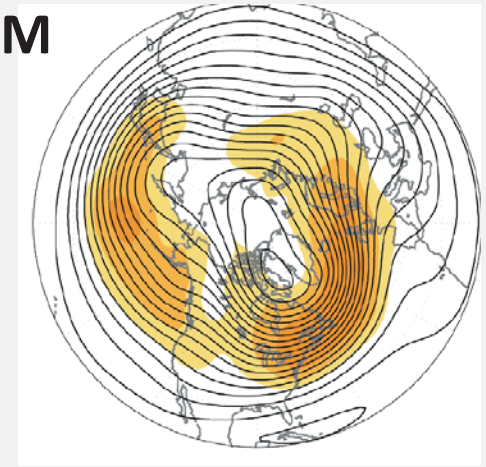
NOAA MAPP Webinar – 28 February 2017

#NA15OAR4310077

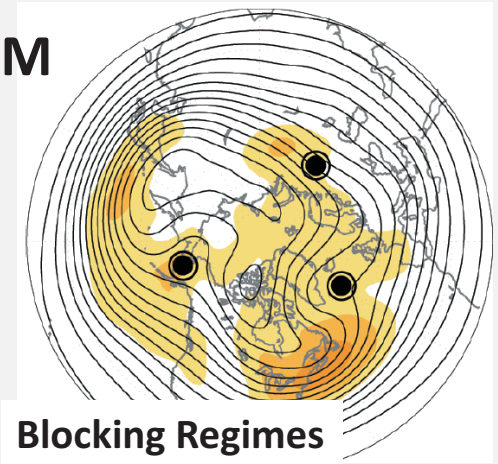
MAPP Modeling, Analysis, Predictions, and Projections

MOTIVATION

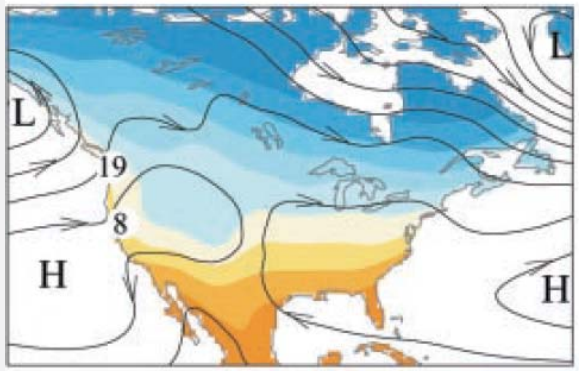
+NAM

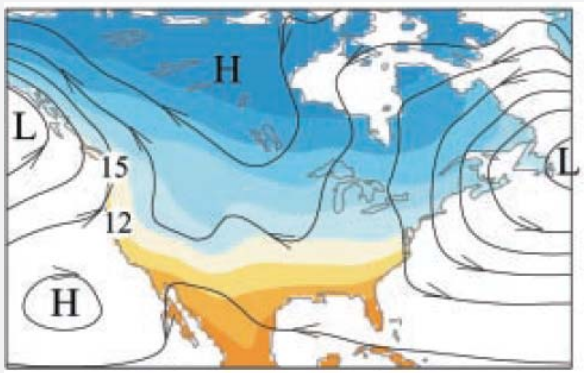


-NAM



Blocking Regimes



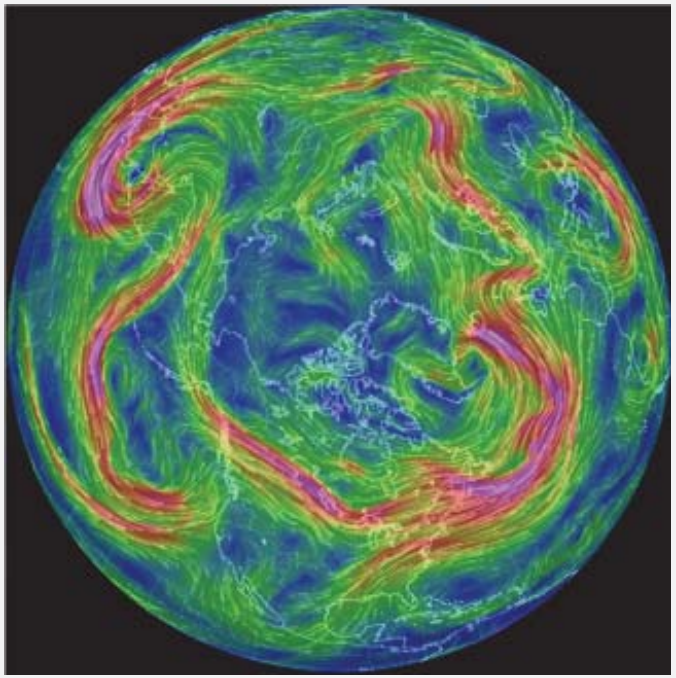


- Skillful subseasonal weather predictions of NH cold season extratropical weather and extreme weather events / blocking linked to the **Northern Annular Mode (NAM).**

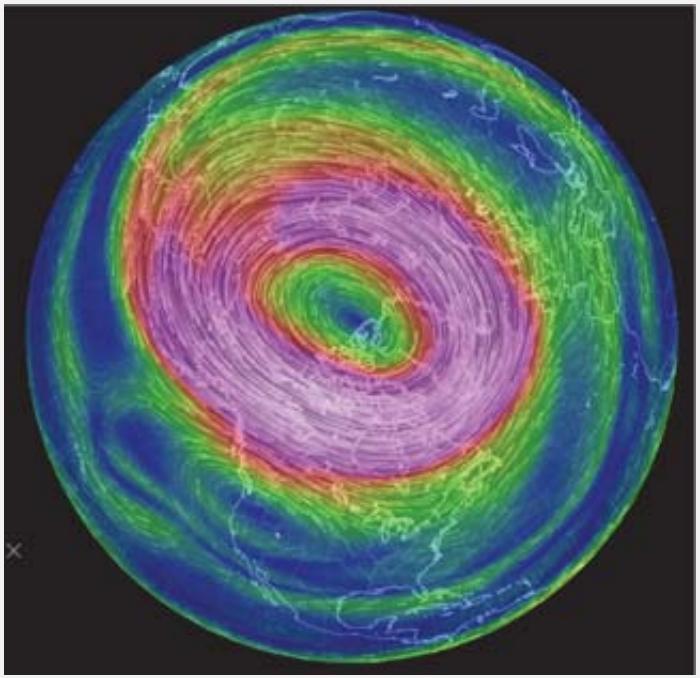
Thompson and Wallace [2001]

THE NAM IN THE TROPOSPHERE AND STRATOSPHERE

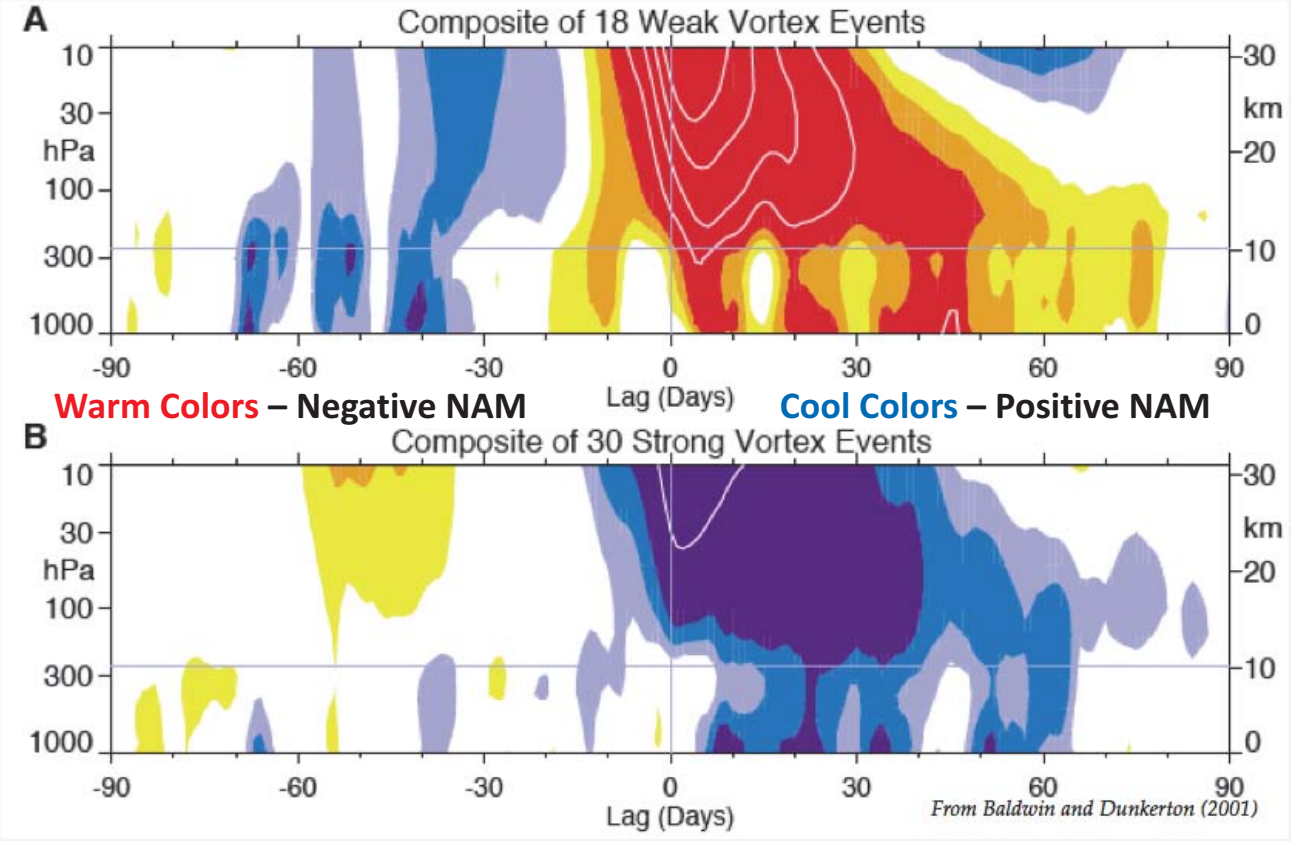
500 mb winds



10 mb winds



USING THE STRATOSPHERE TO FORECAST THE JET STREAM?



KEY POINTS

- **Predicting the state of the stratospheric polar vortex, we can predict the AO and thus surface temperature and storm track patterns out 20-40+ days into the future**
- **Break the "10-day prediction barrier."**

Model	Hindcast Period	No. of Members	Arrangement of Members	Lead (month)	Model resolution (atmos)	Model resolution (ocean)
Active						
NCEP/CFSv2	1982-2010	24 (28)	4 members (0, 6, 12, 18z) every 5th day	0-9	T126L64	MOM4L40 .25deg Eq
GFDL/CM2.1	1982-2010	10	All 1st of the month 0Z	0-11	2x2.5degL24	MOM4L50 .3deg Eq
GFDL/CM2.5 (FLOR)	1982-present	24	All 1st of the month 0Z	0-11	C18L32 (50km)	MOM5 L50 0.30 deg Eq 1degPolar1.5
CMC1-CanCM3	1981-2010	10	All 1st of the month 0Z	0-11	CanAM3 T63L31	CanOM4L40 .94deg Eq
CMC1-CanCM4	1981-2010	10	All 1st of the month 0Z	0-11	CanAM4 T63L35	CanOM4L40 .94deg Eq
NCAR/CCSM4	1982-2010	10	All 1st of the month 0Z	0-11	0.9x1.25degL26	POPL60 .25deg Eq
NASA/GEOS5	1981-2010	11	4 mems every 5 days; 7 mems on last day of last month	0-9	1x1.25 deg L72	MOM4L40 .25deg Eq
NCAR/CESM1	1982-2010	10	All 1st of the month 0Z	0-11	0.9x1.25degL30	POPL60 .25deg Eq

Kirtman et al., 2014

<u>Phase 1:</u> Seasonal Predictions (Monthly-Mean Output)

<u>Phase 2:</u> Subseasonal Forecasts (Sub-daily and Daily-Mean Output)

<u>Research Objectives:</u>

(1) Quantify fundamental NAM characteristics in the NMME-2 models and related NAM predictability.

(2) Identify model biases in the development and subsequent impacts of major **sudden stratospheric warmings**.

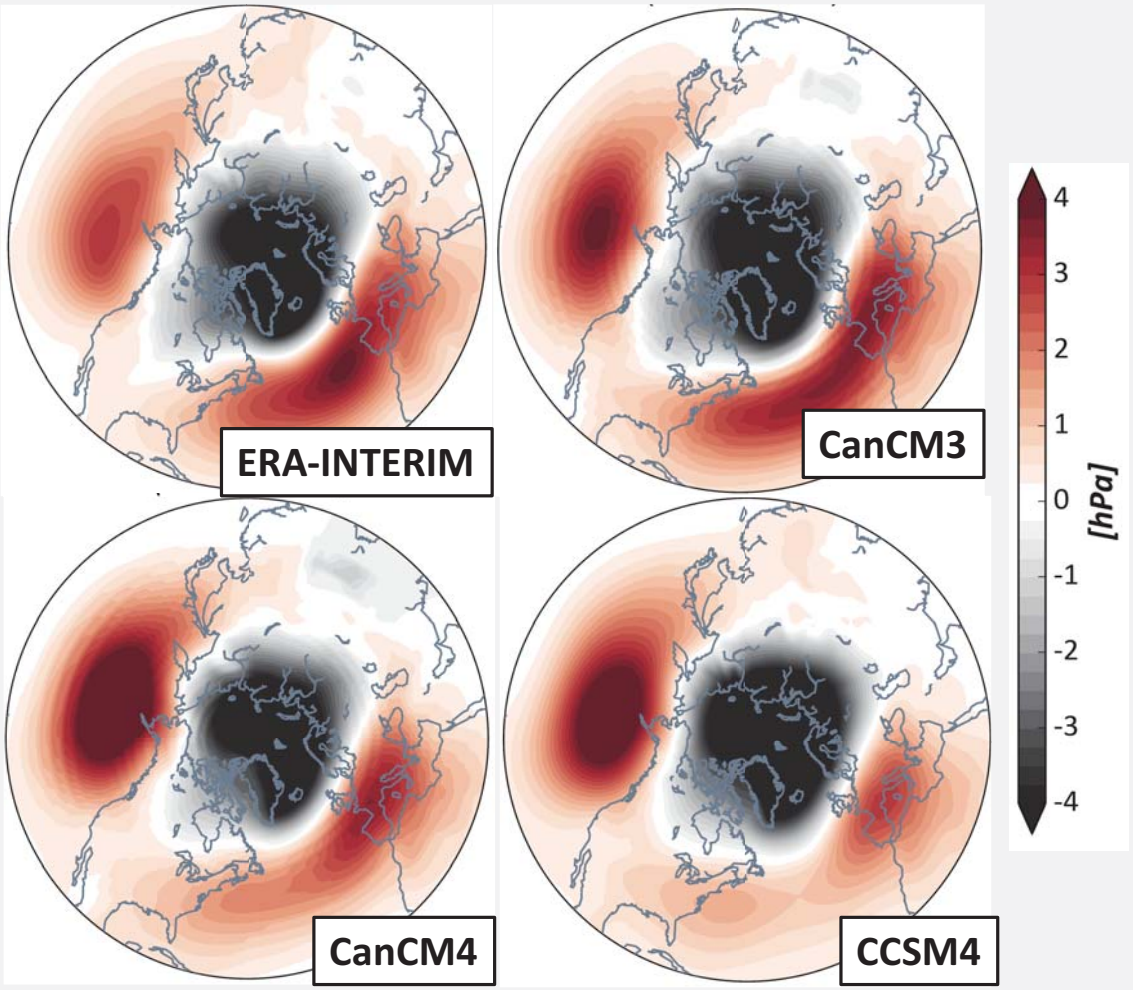
DATA & METHODOLOGY

- *ERA-Interim Reanalysis* – "Observations" (1982-2013)
- NMME-2 Models (CanCM3, CanCM4, CCSM4) (1982-2013)
  - Focus on November – March initializations.
- Daily-mean fields.
- **NAM** defined as 1st EOF of GPH at each pressure level**.** Leading PC = NAM Index.
- For NMME models, NAM calculated by projecting **model** fields onto NAM characteristic patterns from **reanalysis** (avoid model biases in modes).

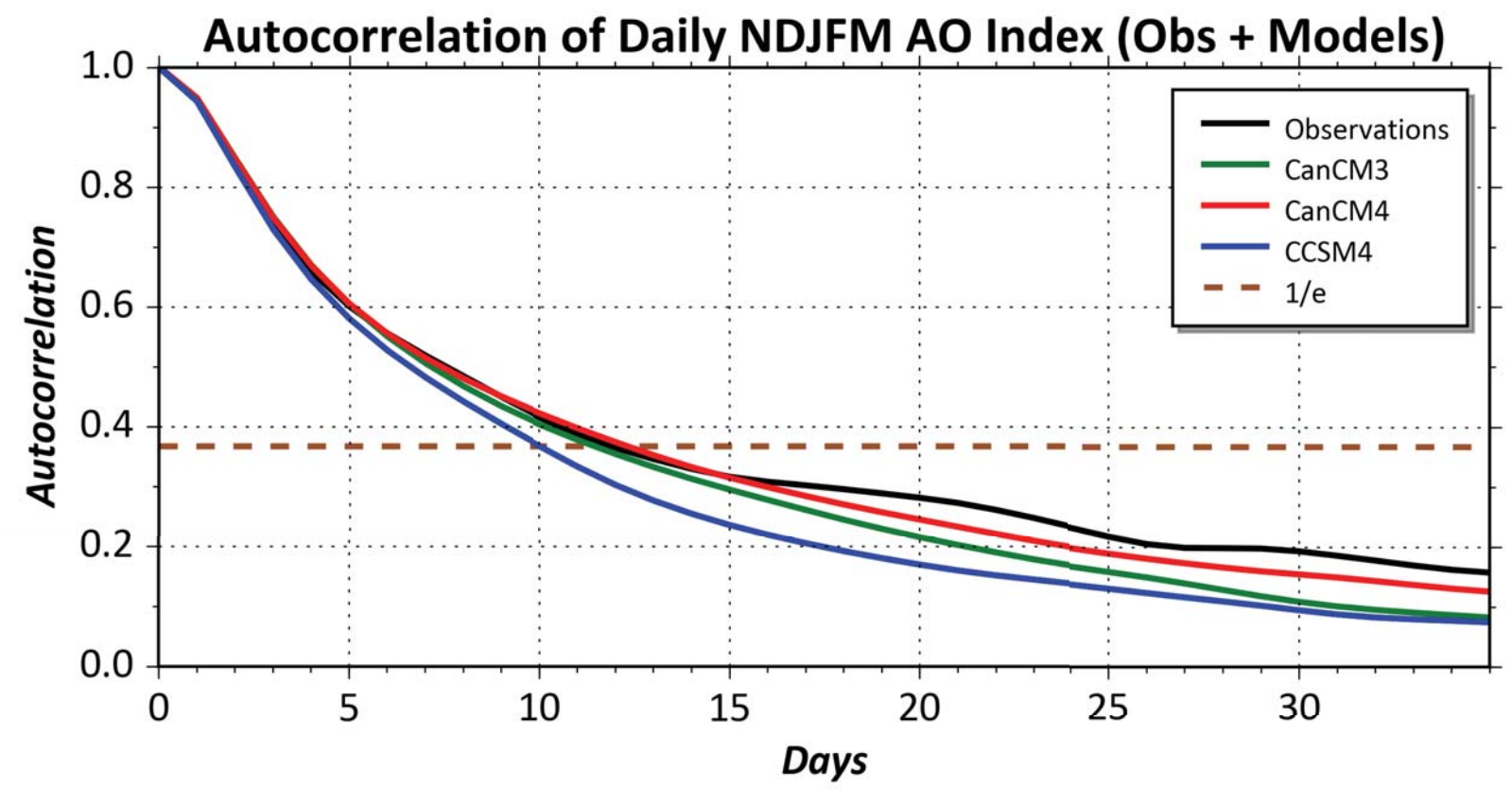
Part I: Fundamental Characteristics of the AO/NAM in the NMME-2 Models

SURFACE AO SIGNATURE (NDJFM SLP REGRESSED ONTO AO INDEX)

- Model bias toward **east-based** NAO.
- Much **stronger** Pacific loading center than obs (especially in CanCM4 and CCSM4 models.
- High spatial correlations (> 0.7).

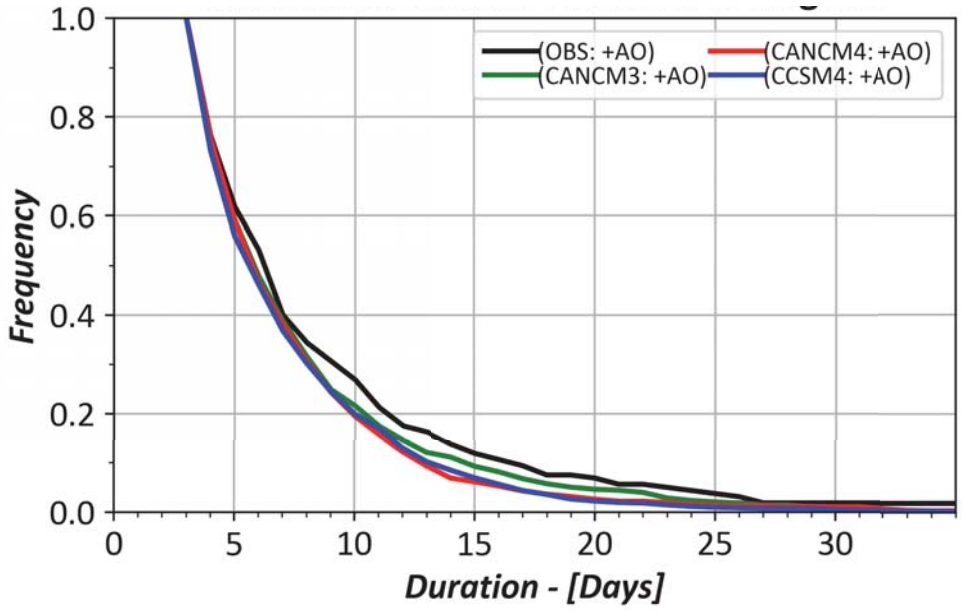


SURFACE AO AUTOCORRELATION



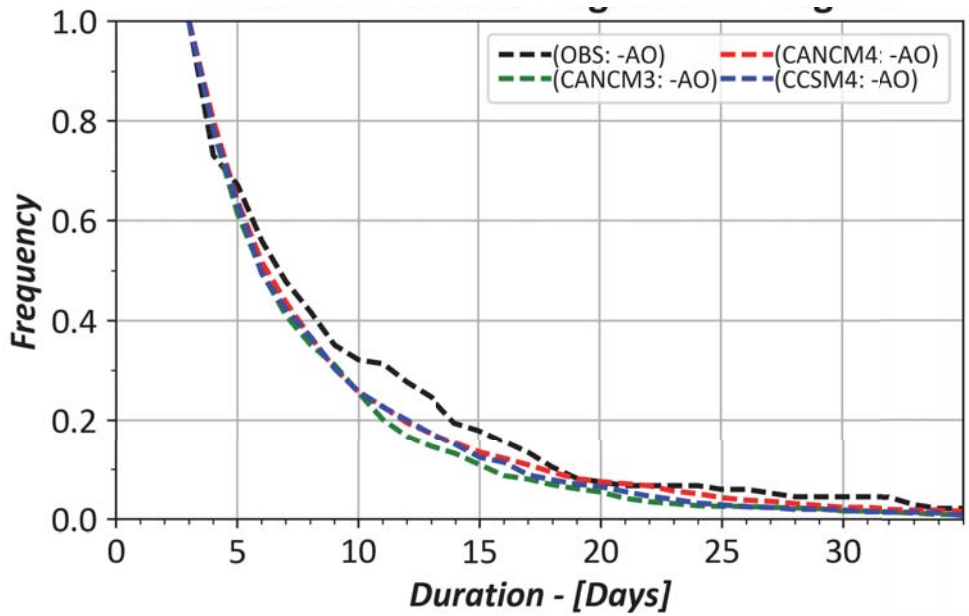
POSITIVE vs. NEGATIVE AO FREQUENCY

Positive AO Regimes



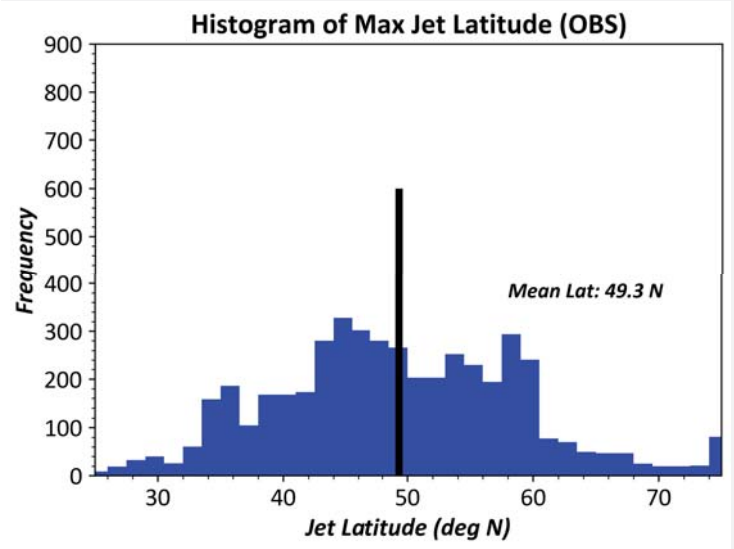
- Underestimate frequency of AO regimes past ~day 7

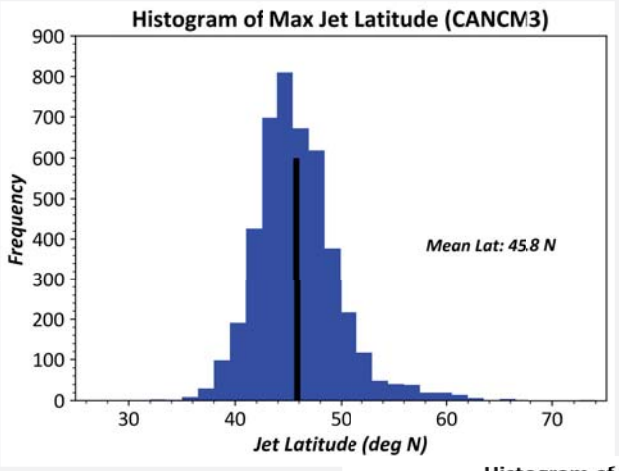
Negative AO Regimes

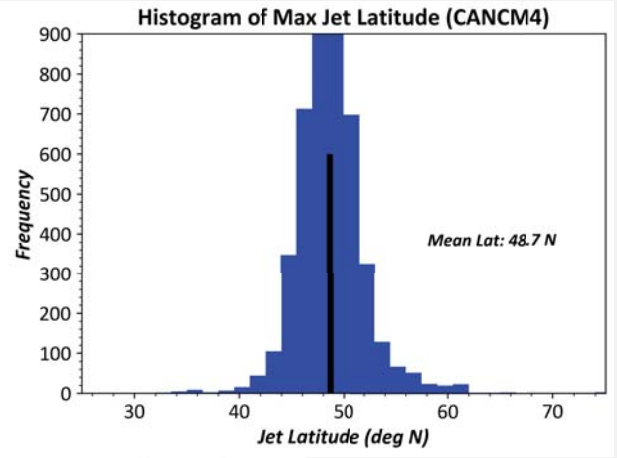


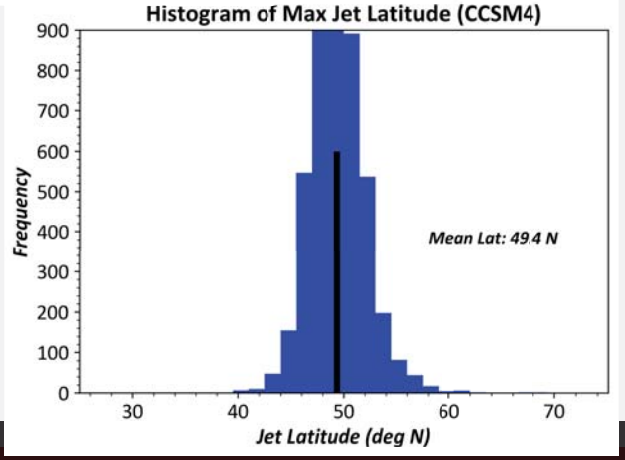
- Significant 'bump' for –AO duration Days 10-16 in observations not matched by models.

MAX JET LATITUDE



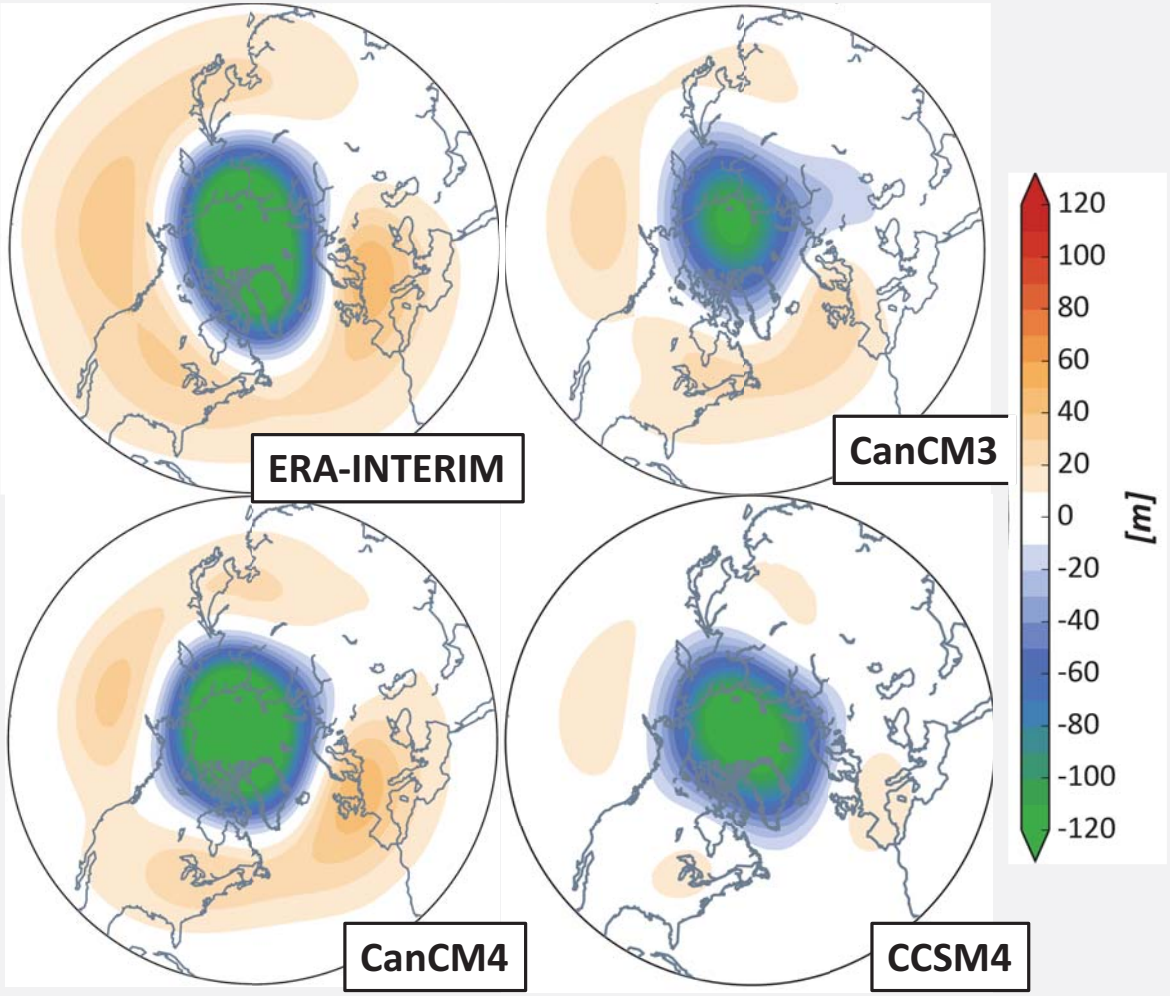




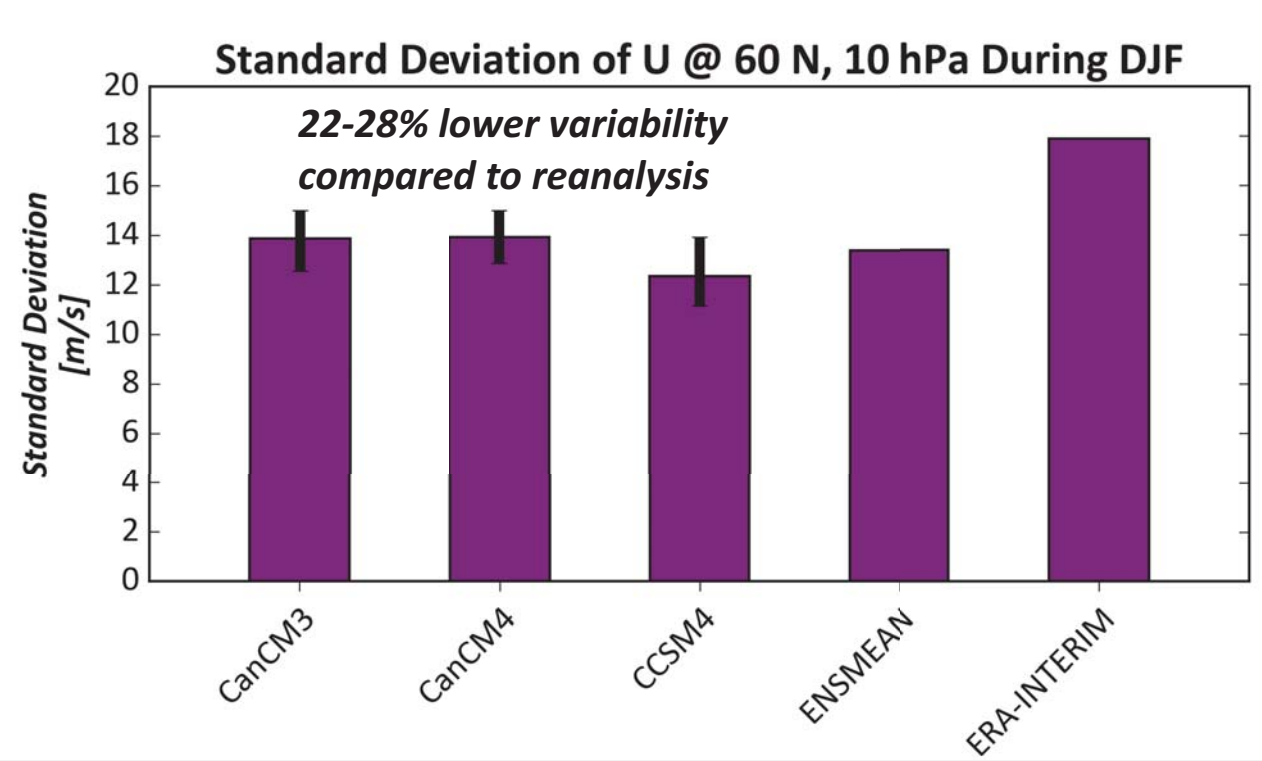


NDJFM 50 MB HEIGHTS REGRESSED ONTO AO INDEX

- Annular-like in most models (except CCSM4).
- Important symmetry and regional differences in center and structure of vortex.



STRATOSPHERIC POLAR VORTEX VARIABILITY



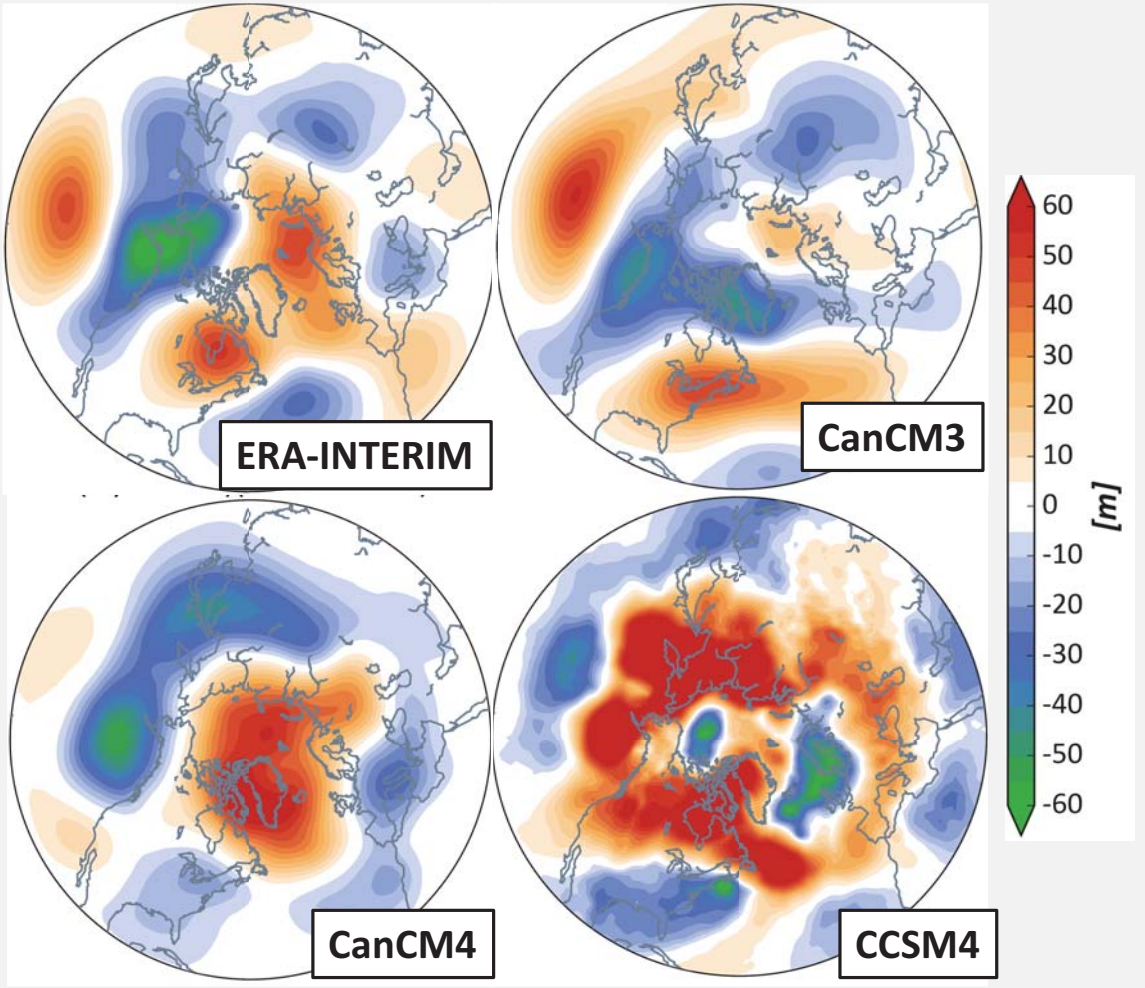
- Models underestimate variability in NH polar vortex.
- Likely due to weaker and more infrequent SSWs.
- Issue known with low-top models [e.g., *Charlton-Perez et al.* 2013; *Furtado et al.* 2015].

Part II: *Simulated* Major SSWs: Precursors and Post-SSW Impacts

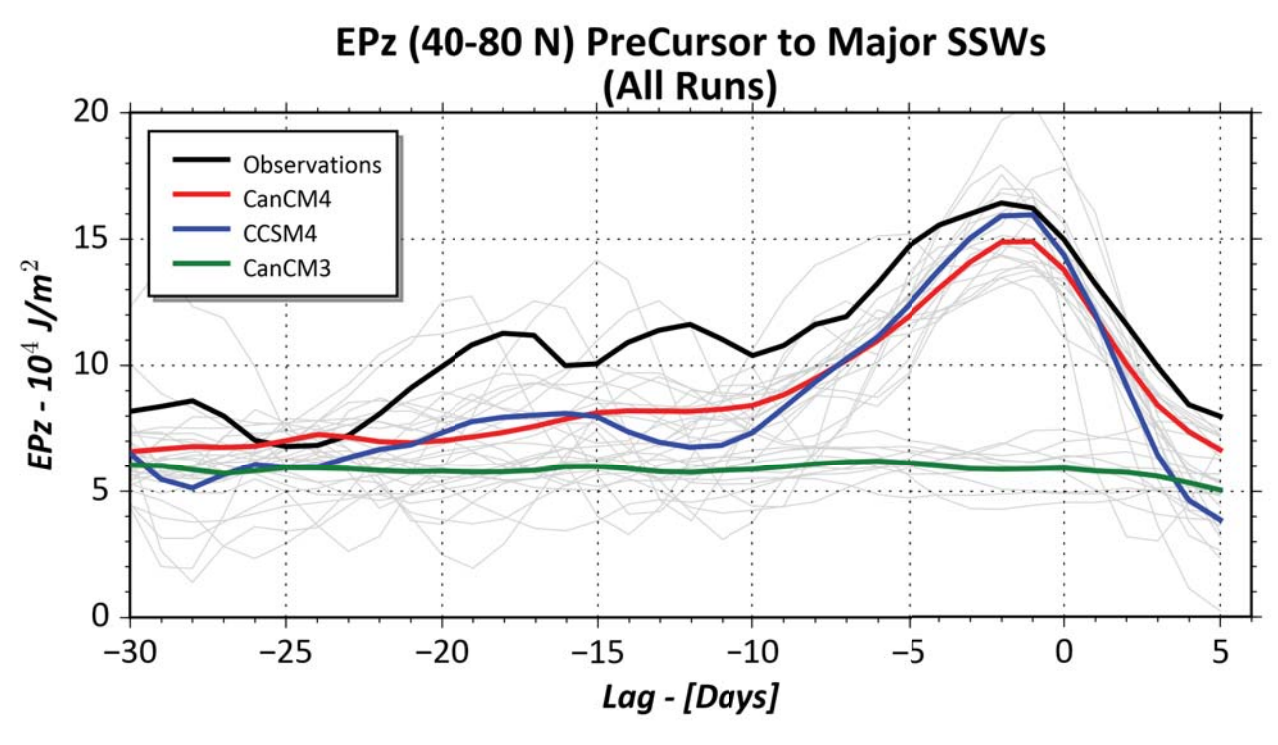
- Define a **major sudden stratospheric warming (SSW)** as done in *Charlton and Polvani* [2007] and *Butler and Polvani* [2011].
- For **ERA-Interim**, 20 events from 1982-2013.
- For **models**, apply definition per ensemble member (starting month = November). For **statistics**, randomly choose **10** simulated SSWs per run (*N* =100 – less for CCSM4 because of lack of major SSW frequency – Factor of 3 less).

PRECURSOR PATTERNS– DAYS -30 TO -15 COMPOSITE 500 MB MAP

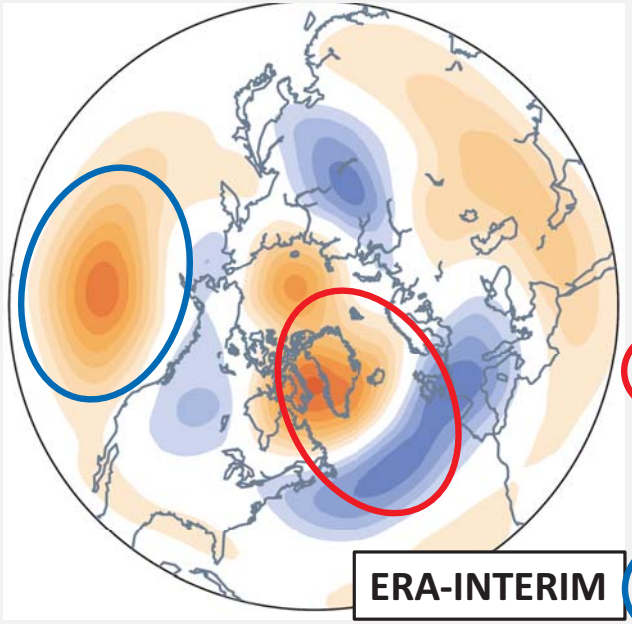
- Common features include **negative NPO/EPO** and **Northern Eurasian** ridge.
- CCSM4 has almost the complete opposite pattern.



PRECURSOR PATTERNS – VERTICAL EP FLUX (WAVE FORCING)



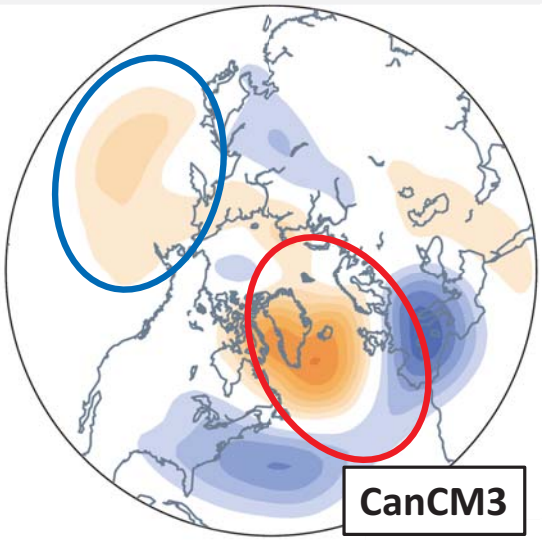
POST-SSW IMPACTS – DAYS +5 TO +60 COMPOSITE 500 MB GPH



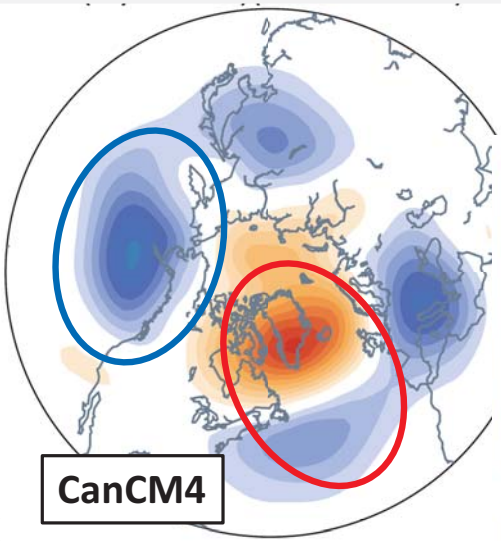
ERA-INTERIM

NAO signature present but slight-east bias in models.

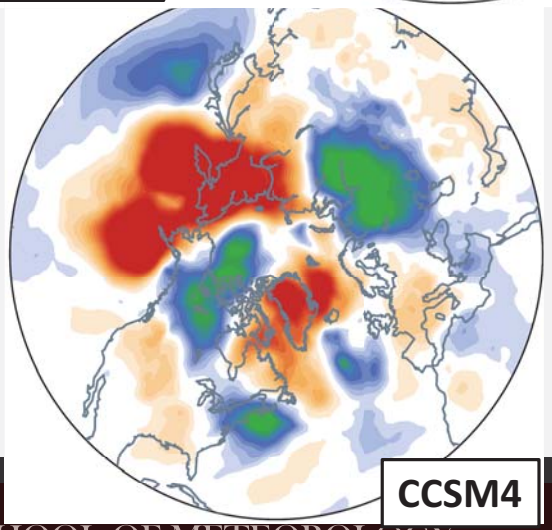
Little agreement in Pacific sector.



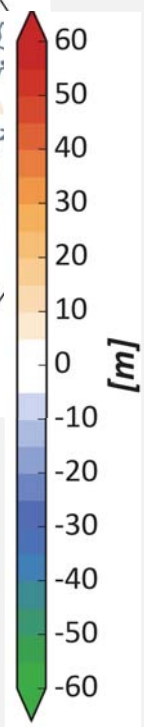
CanCM3



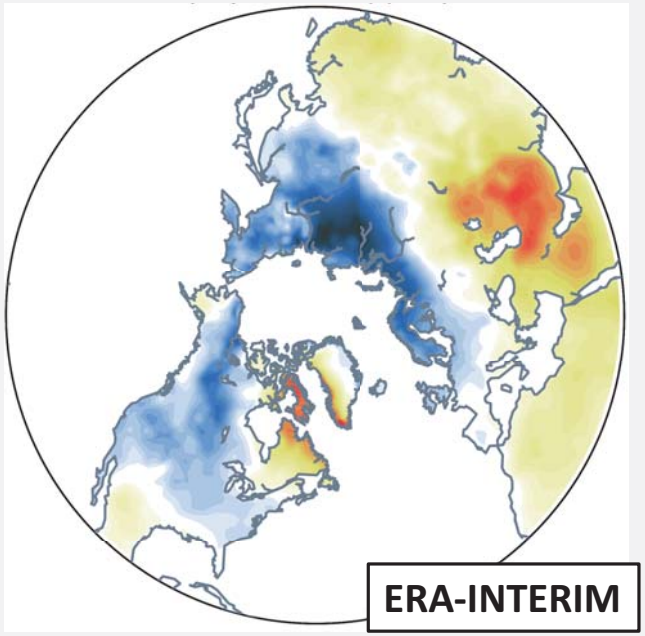
CanCM4

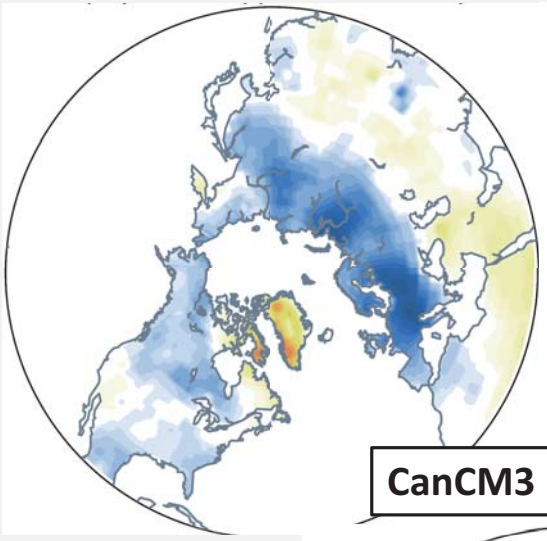


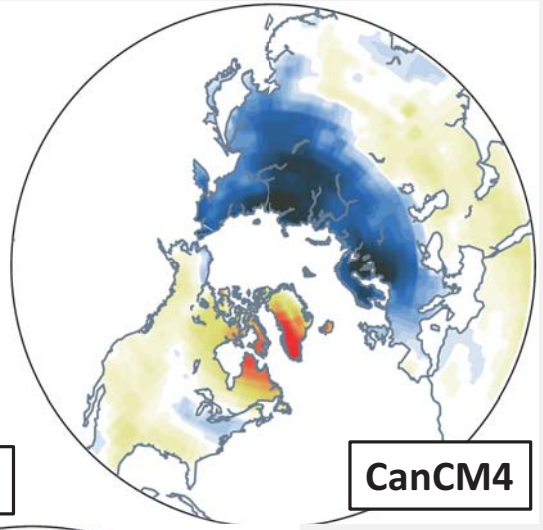
CCSM4

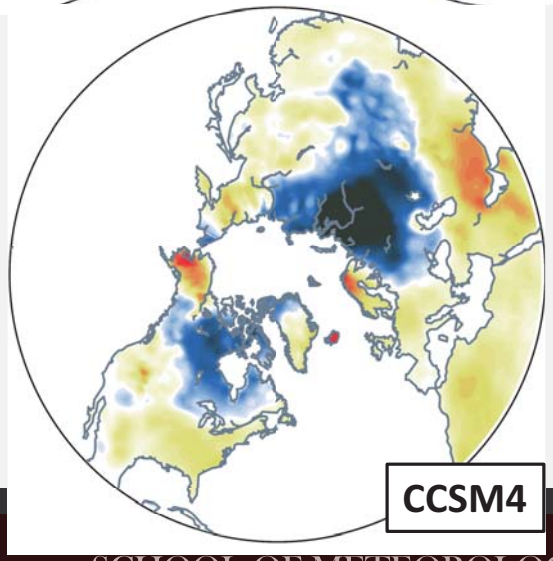


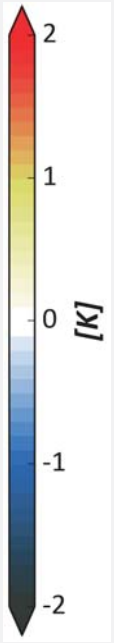
POST-SSW IMPACTS – DAYS +5 TO +60 COMPOSITE SFC T







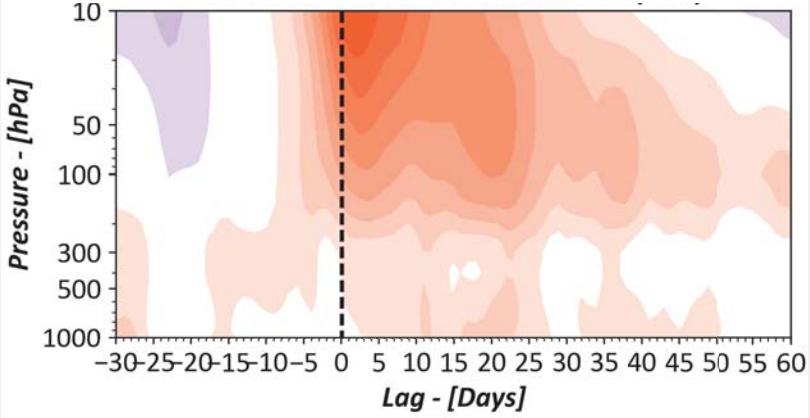




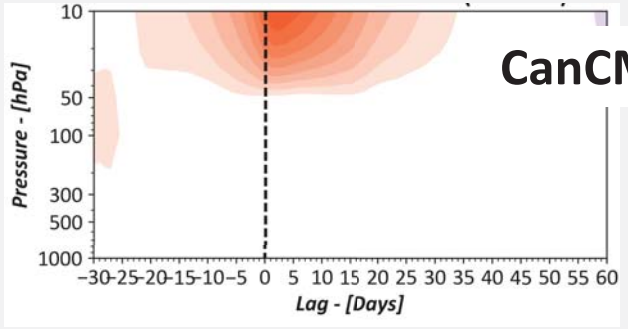
LAG NAM COMPOSITES FOR MAJOR SSWS

CanCM3 and CCSM4 plots agree with most other coupled models [*Furtado et al.*, 2015]

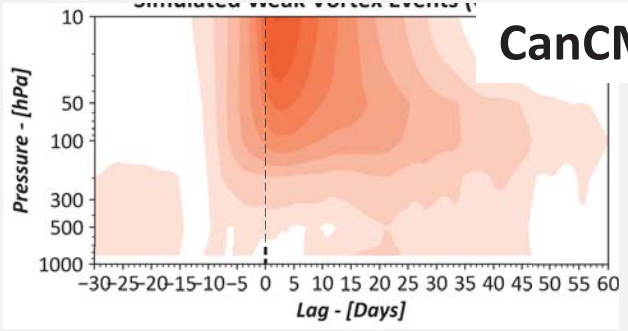
ERA-Interim



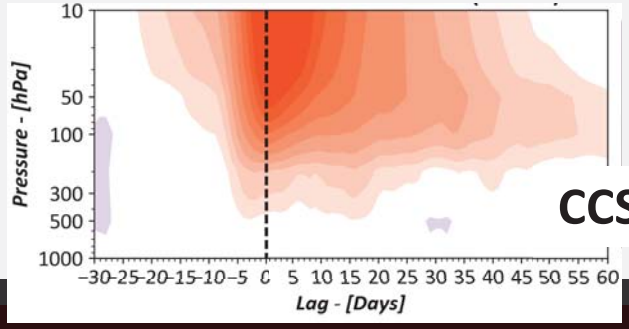
CanCM3

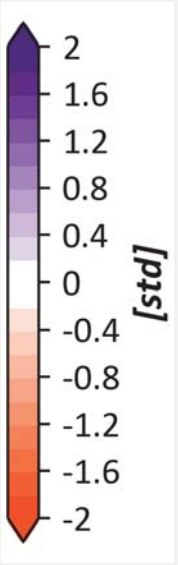


CanCM4

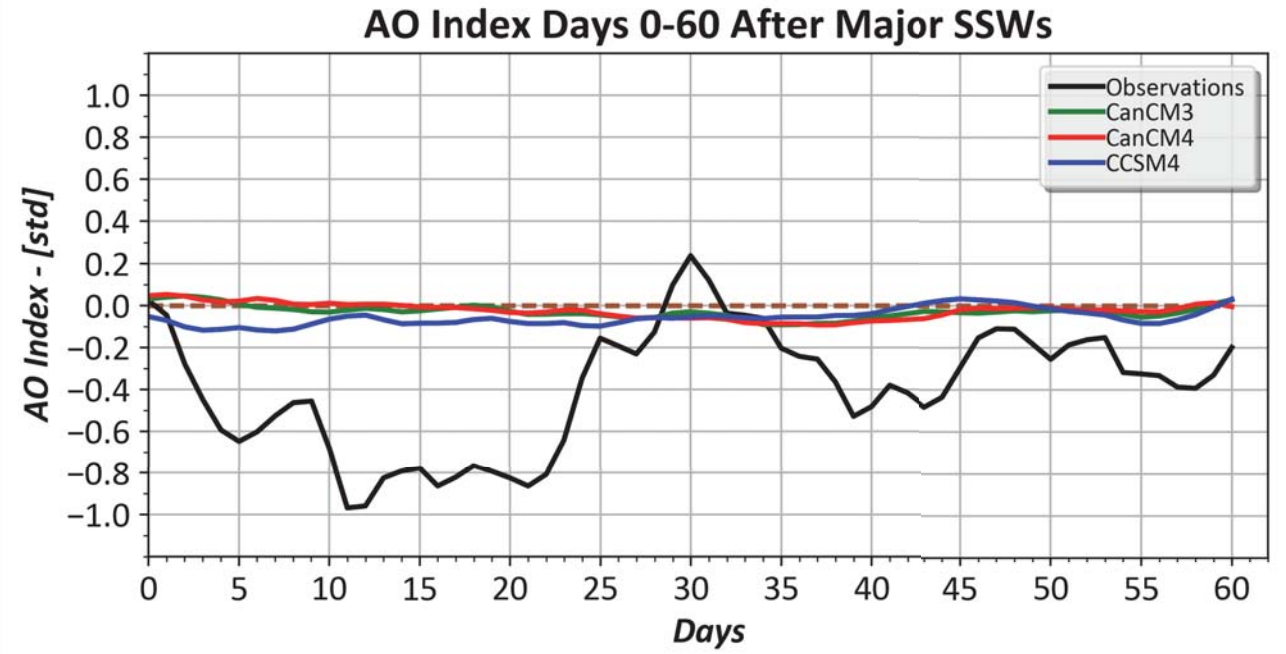


CCSM4





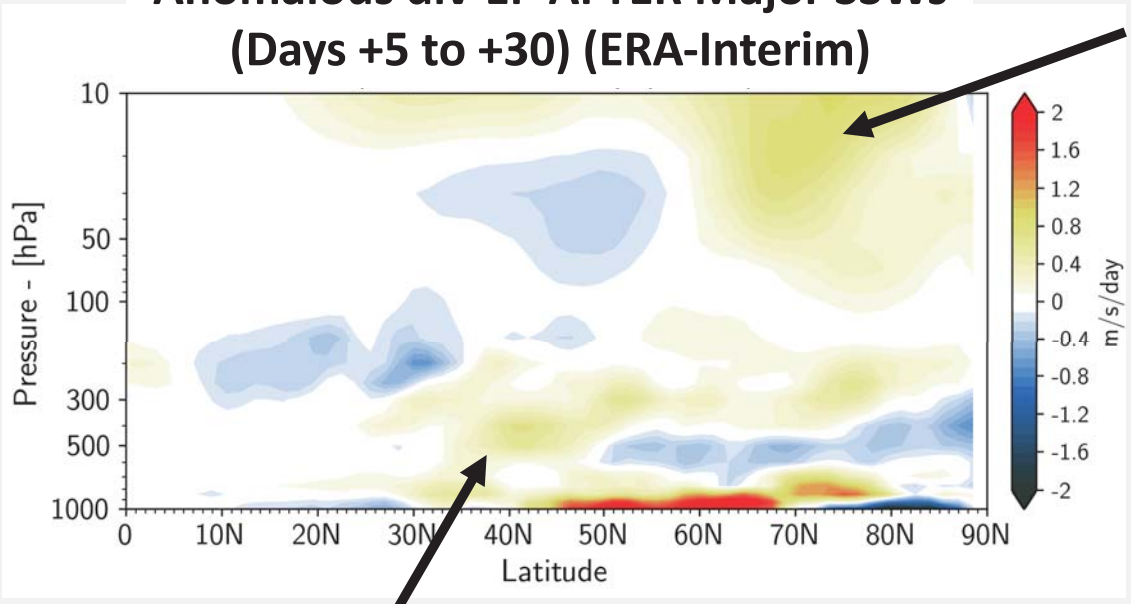
SURFACE AO RESPONSE – 0 TO 60 DAYS AFTER MAJOR SSW



- Negative tendancy clearly seen in the observations for near-surface AO.
- Models have a very weak / near neutral signal.

WHY NO DOWNWARD PROPAGATION? – WAVE FLUXES

Anomalous div-EP AFTER Major SSWs
(Days +5 to +30) (ERA-Interim)

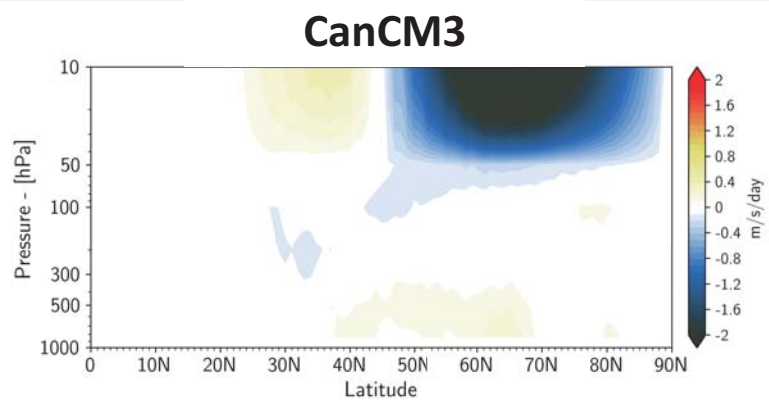


EP FLUX DIVERGENCE
STRENGTHENING PV

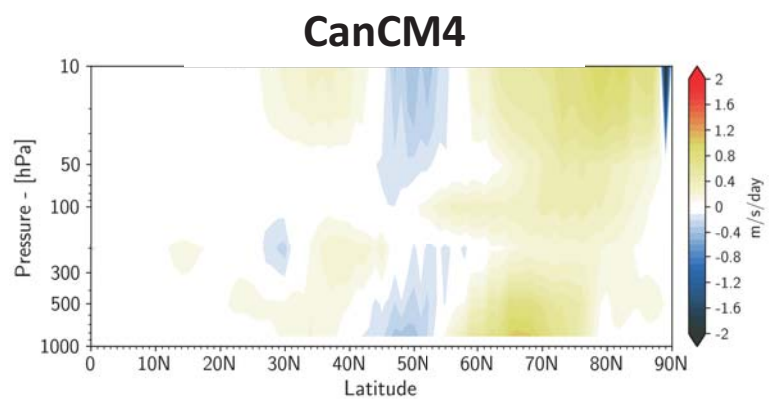
EP FLUX DIVERGENCE
JET DISPLACEMENT EQUATORWARD

WHY NO DOWNWARD PROPAGATION? – WAVE FLUXES

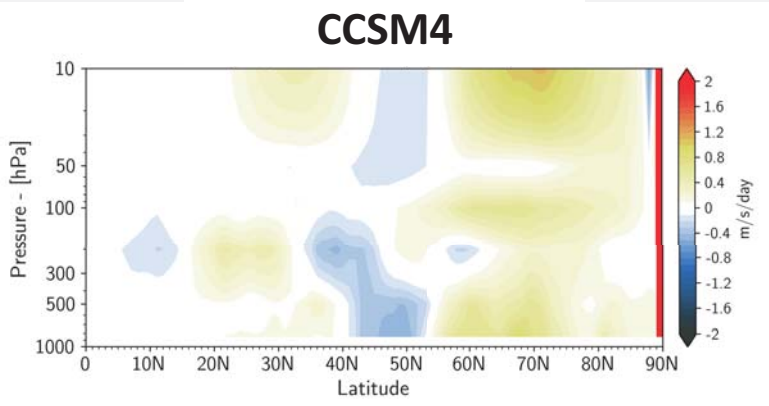
CanCM3



CanCM4

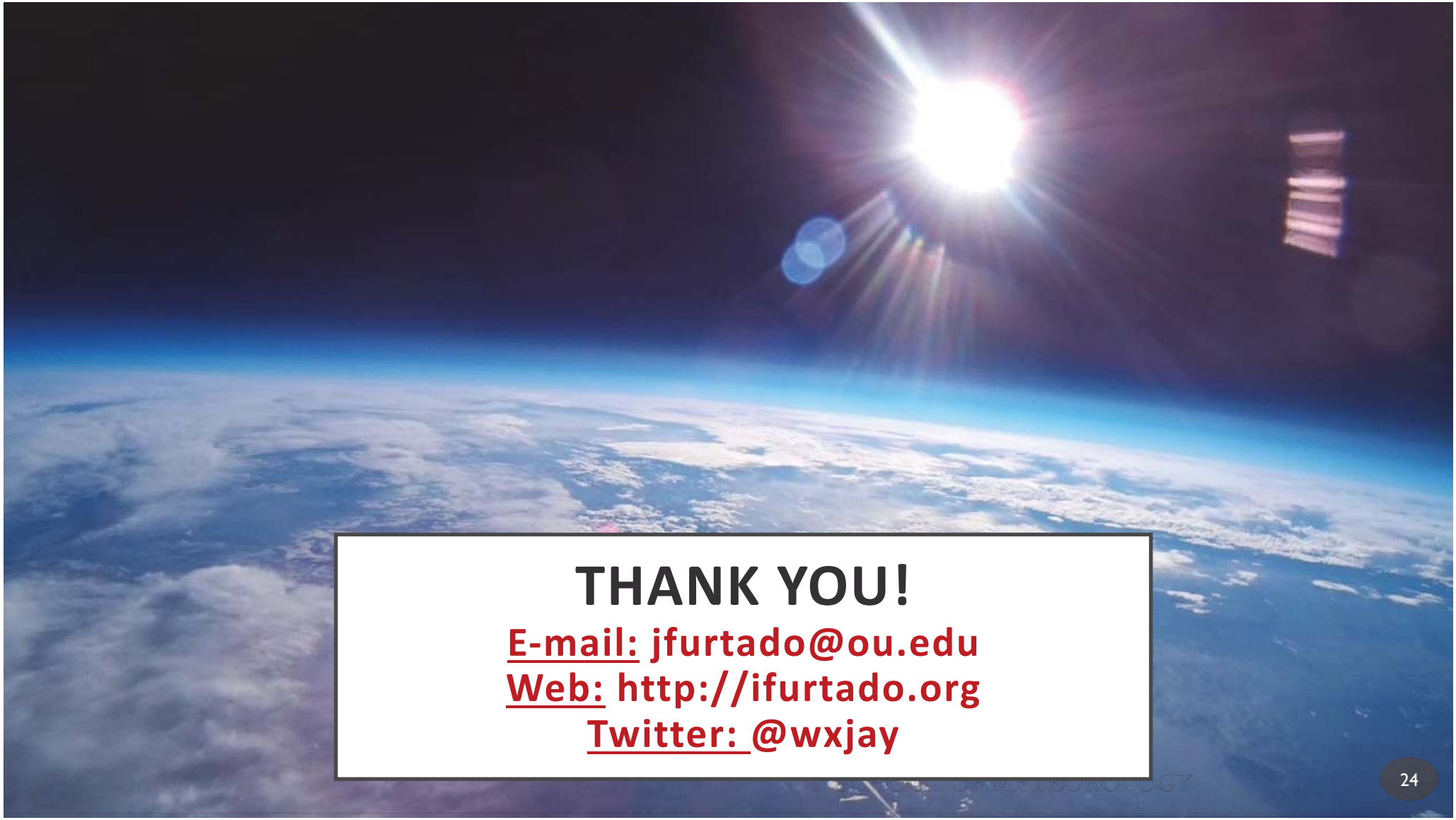


CCSM4



CONCLUSIONS

- NMME Phase-2 models have fundamental flaws in the general structure of the NAM (frequency of regimes, east-based NAO).
- Downward propagation of signal from the stratosphere → troposphere remains a problem (CanCM4 an exception).
- S/T coupling biases be tied to incorrect wave-mean flow interactions in the troposphere following major SSWs.
- **Ongoing Work:**
  - Model-skill scores for *observed* SSWs and their post-SSW impacts on lower tropospheric conditions.
  - Closer look into case studies for insight into wave propagation or other associated errors/model bias.



THANK YOU!

E-mail: jfurtado@ou.edu
Web: http://ifurtado.org
Twitter: @wxjay