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Tropical-extratropical teleconnections on subseasonal time scale

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Environment and Climate Change Canada

Pan-WCRP Modelling meeting, Met Office, Exeter, Oct 9-13,2017

Outline

- Introduction
- MJO influence on the extratropics
- Impact on S2S predictions
- YTMIT

Introduction

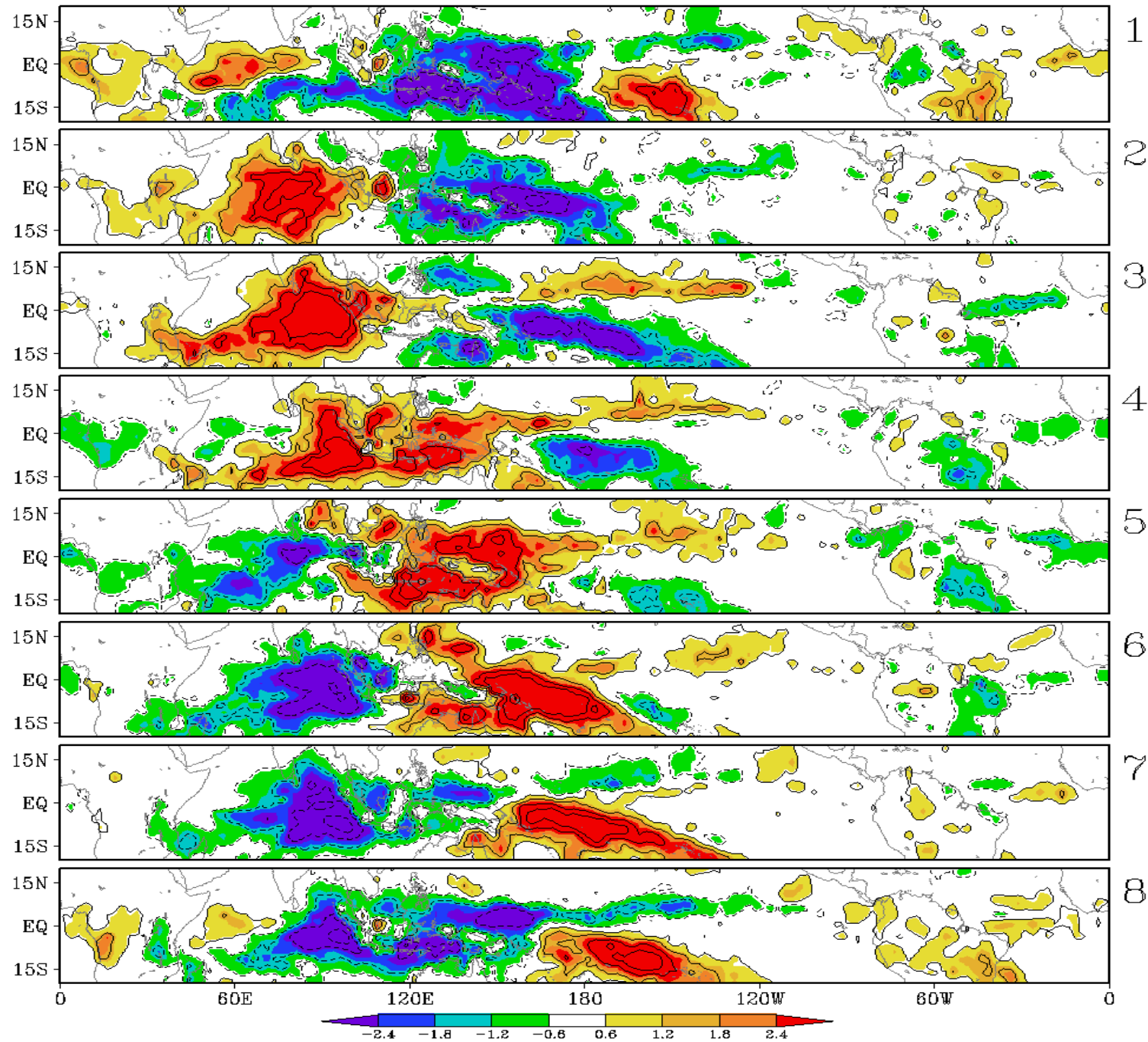
- Long history (e.g., *Riehl* 1950, *Bjerknes* 1966, 1969)
- Teleconnections on different time scales (subseasonal, interannual and decadal)

Response to tropical thermal forcing (classical dynamics)

- Rossby wave source (Sardeshmukh and Hoskins 1998)
- Wave propagation (e.g., Hoskins and Karoly 1981)
- Instability (Simmons et al, 1983; Frederiksen 1982)
 preferred locations
- Feedback from transient eddies

Composites of tropical
precipitation rate for 8 MJO
phases, according to Wheeler
& Hendon index.

and Arkin pentad data,
1979-2003



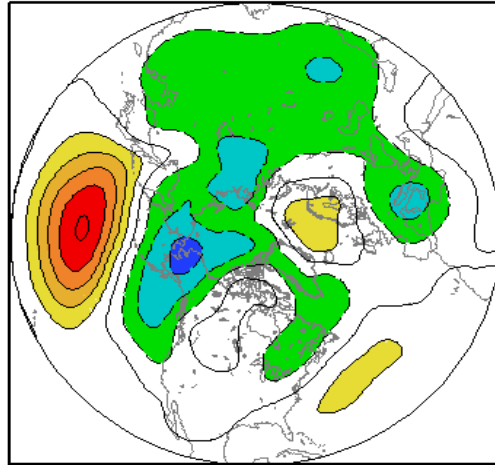
Lagged probability of the NAO index

Positive: upper tercile; Negative: low tercile

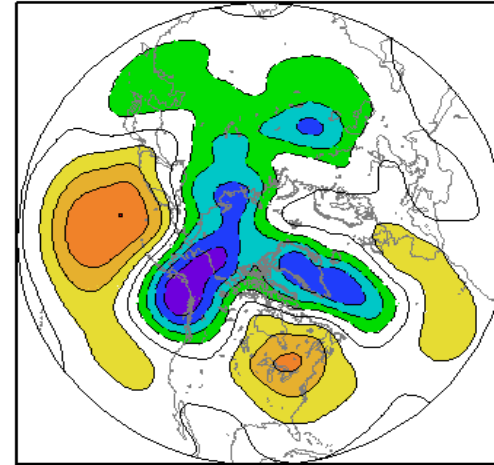
Phase	1	2	3	4	5	6	7	8
Lag 0				+45%				-42%
Lag +1			+47%	+45%				-46%
Lag +2		+47%	+50%	+42%		-41%	-41%	-42%
Lag +3		+48%				-41%	-48%	
Lag +4						-39%	-48%	
Lag +5				-41%				

Tropical influence

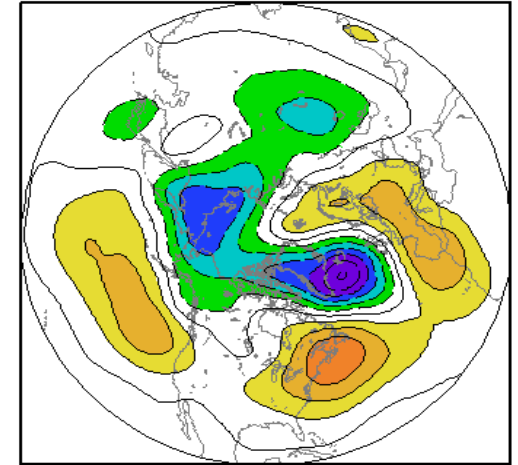
a) PHASE 3 lag=0



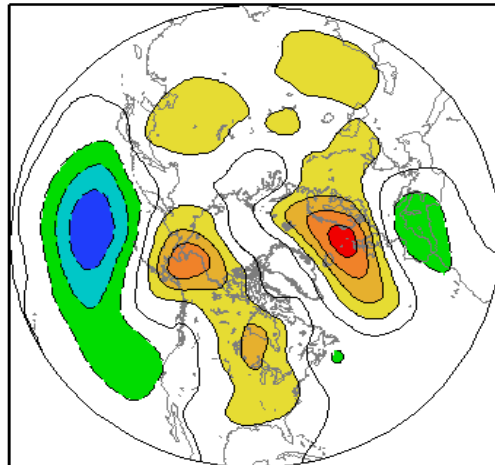
b) PHASE 3 lag=1



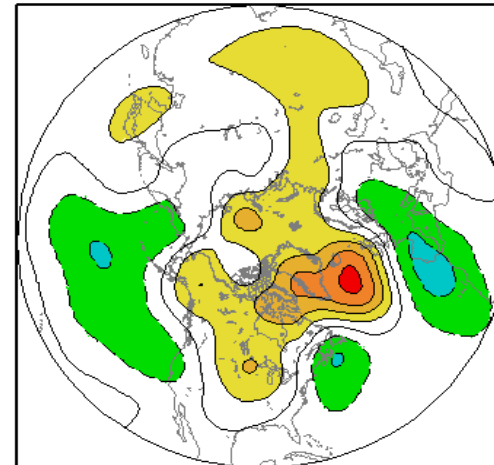
c) PHASE 3 lag=2



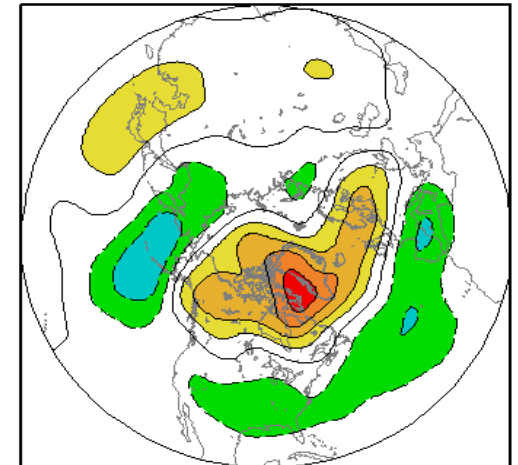
d) PHASE 7 lag=0



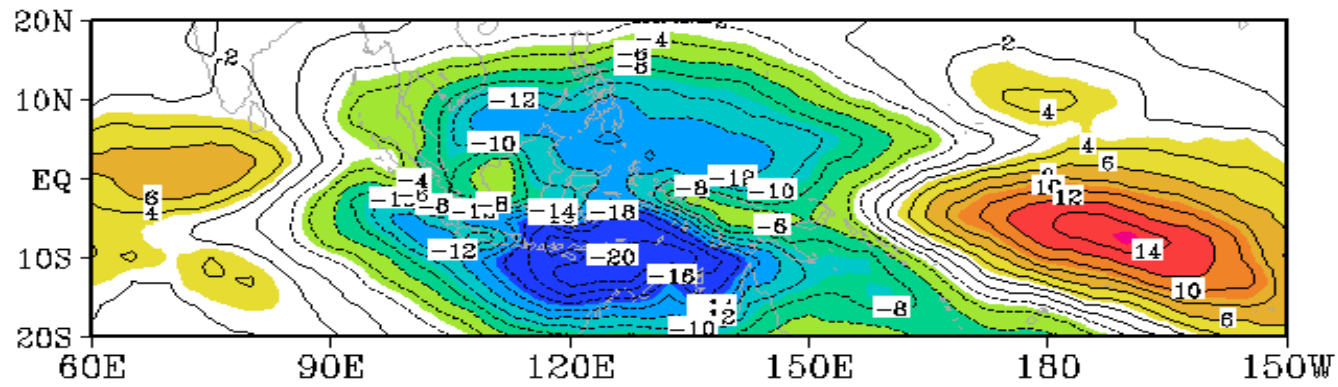
e) PHASE 7 lag=1



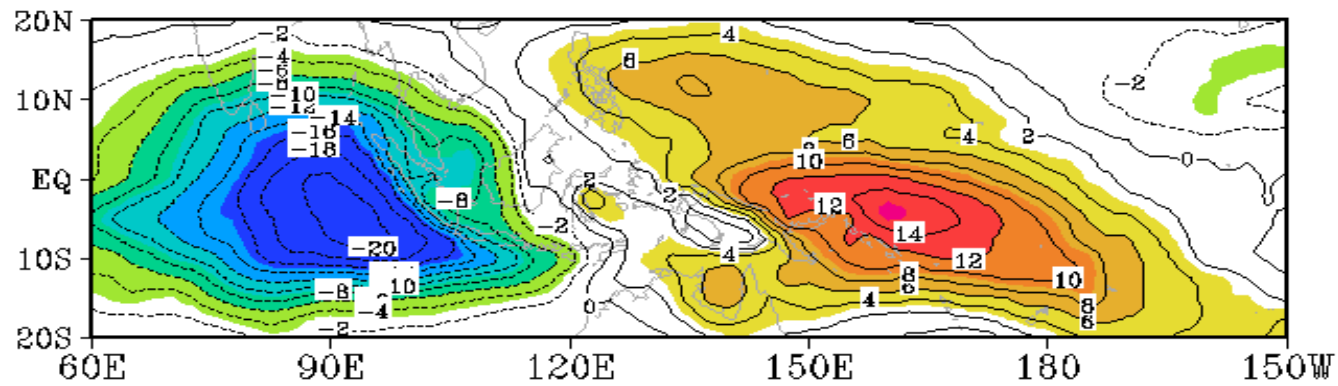
f) PHASE 7 lag=2



a) OLR EOF1 11%

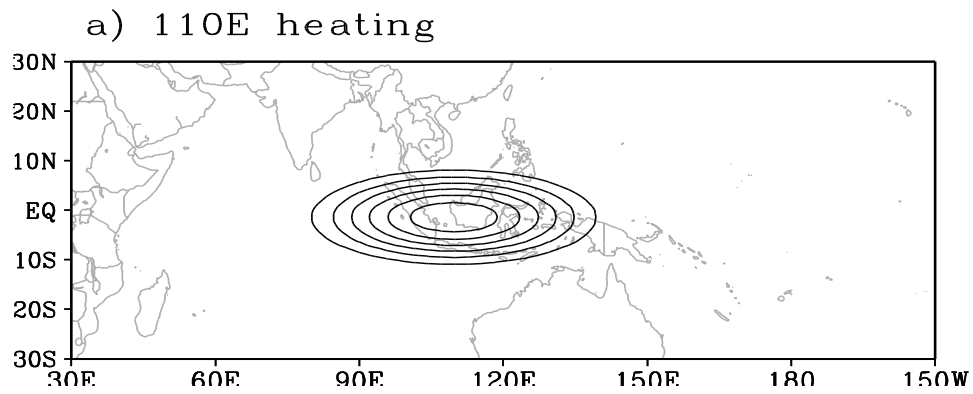


b) OLR EOF2 10%

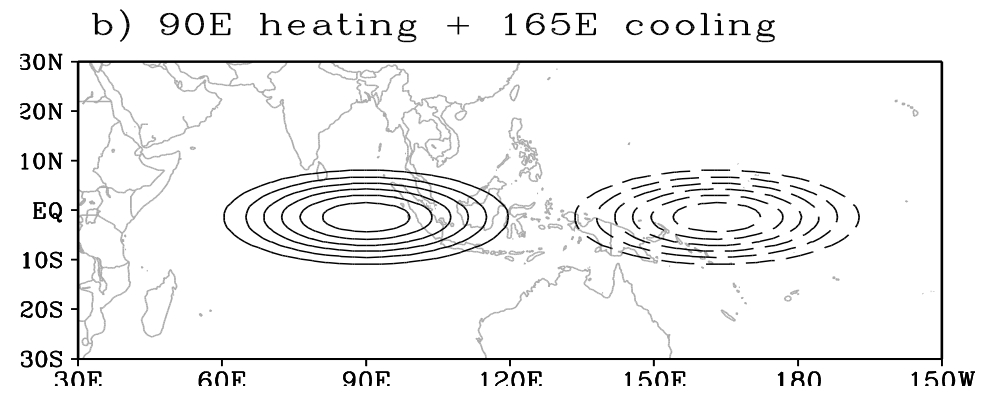


Correlation when PC2 leads PC1 by 2 pentads: 0.66

Thermal forcing



Exp1 forcing



Exp2 forcing

Z500 response

Exp1

a) Exp1: days6-10

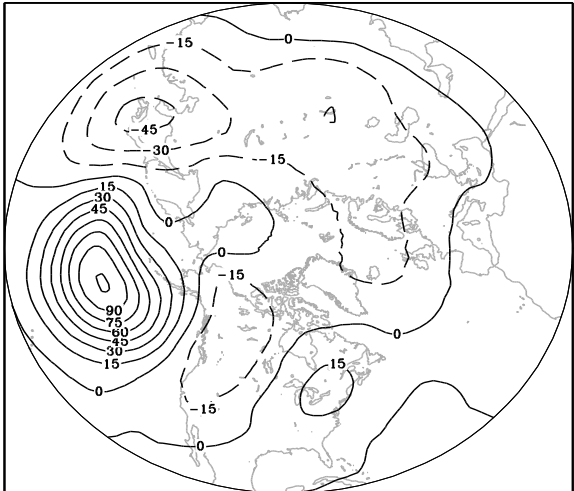


b) Exp1: days11-15

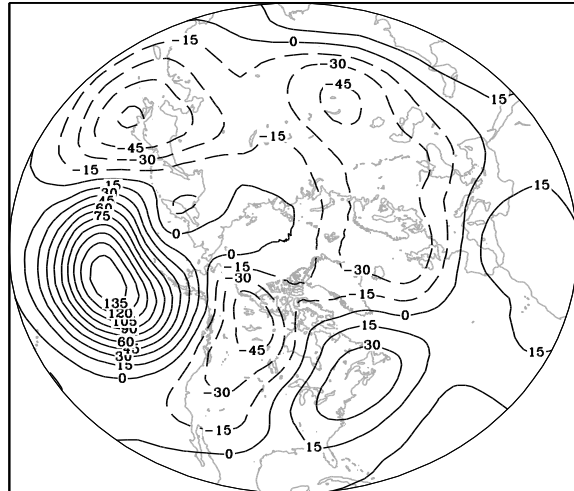


Exp2

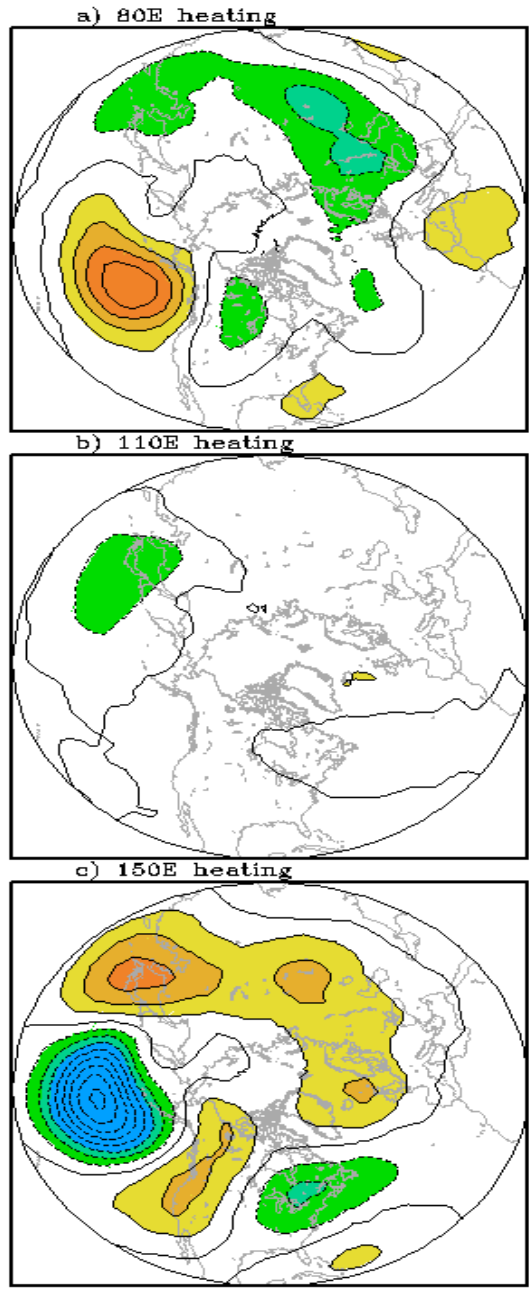
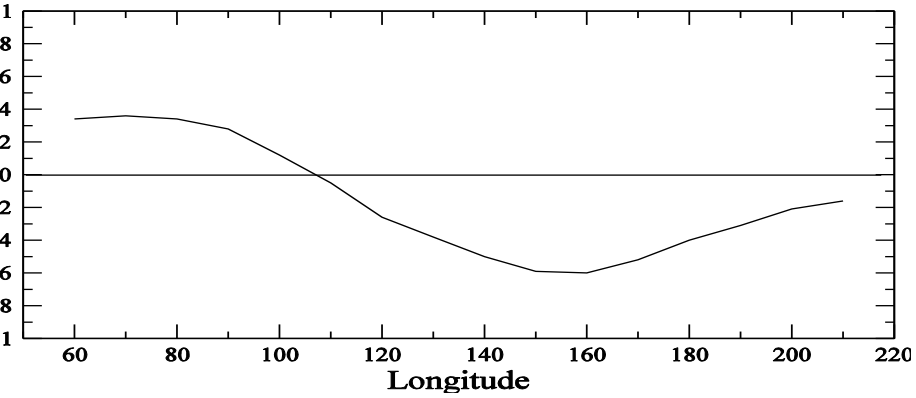
c) Exp2: days6-10



d) Exp2: days11-15



Day 10 Z500 linear response



80E

Similar pattern for heating 60-100E

110E

150E

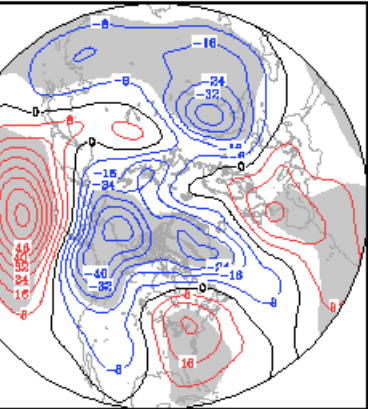
Similar pattern for heating 120-150W

Nonlinearity

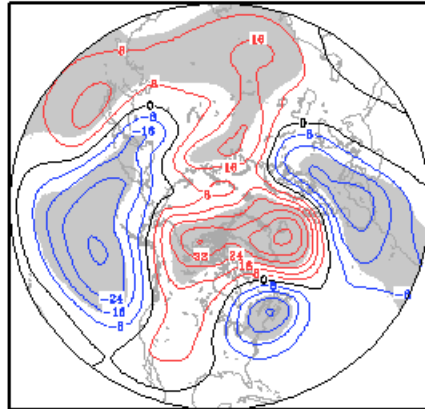
Observation

Simple model simulation

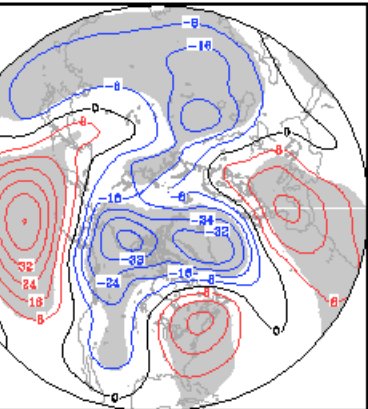
PHASE 2 lag2



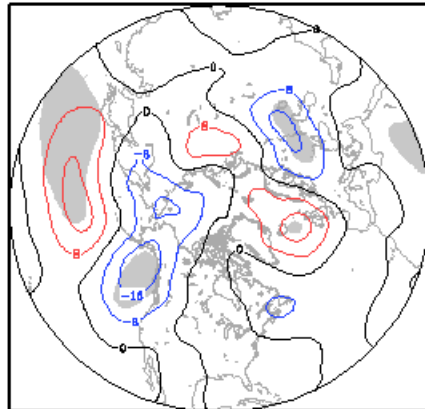
b) PHASE 6 lag2



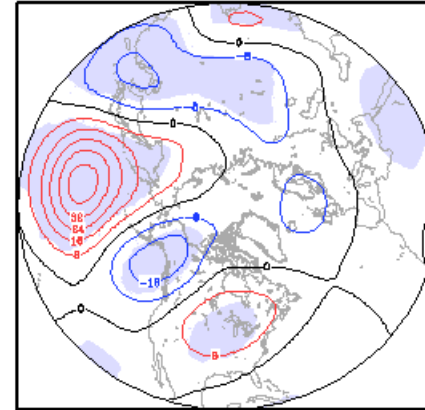
Linear Component



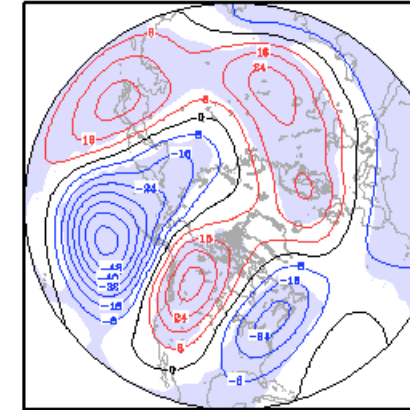
d) Nonlinear Component



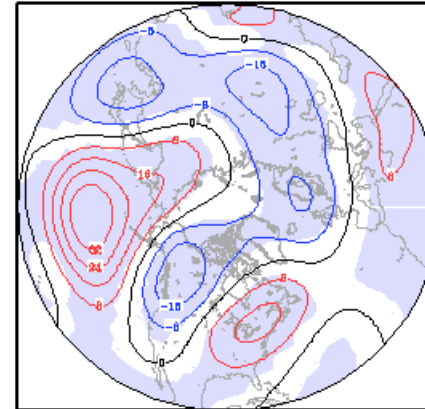
a) +MJO Day11-15



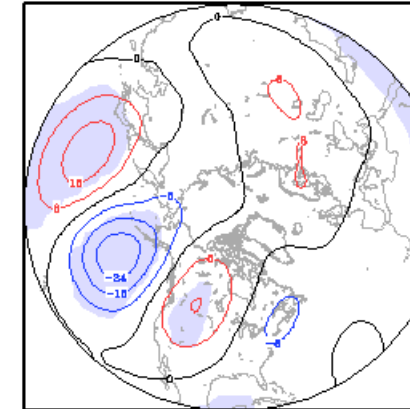
b) -MJO Day11-15



c) Linear Component

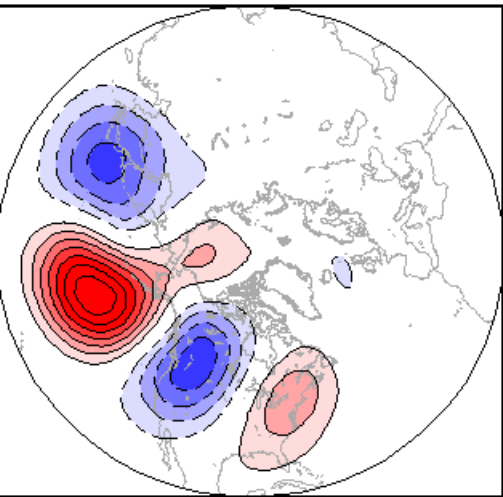


d) Nonlinear Component



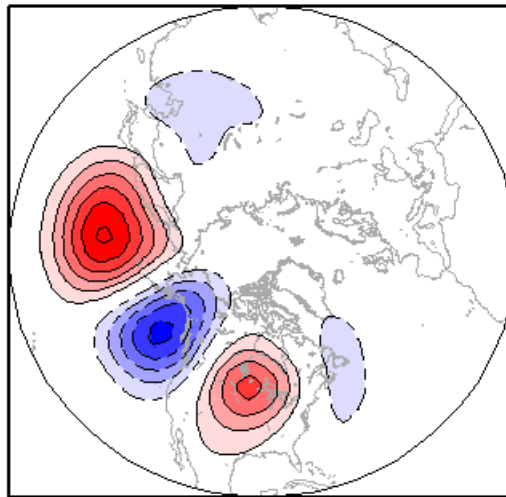
Sensitivity to initial state

a) EOF 1 23%



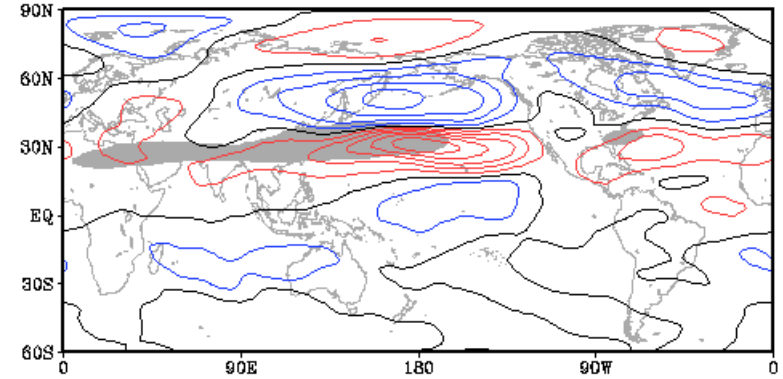
Eastward phase shift

b) EOF 2 14%

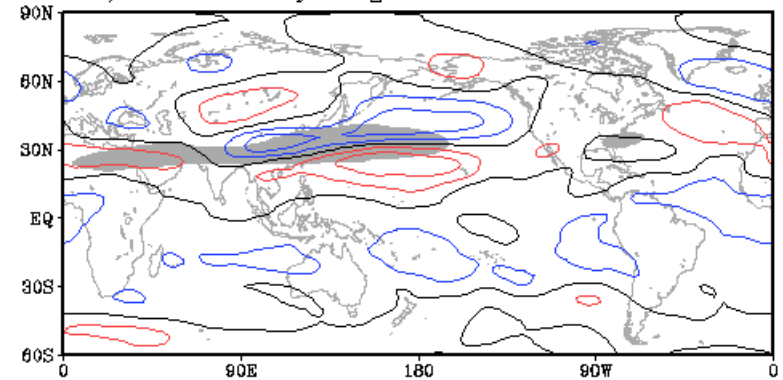


Similar to mean response

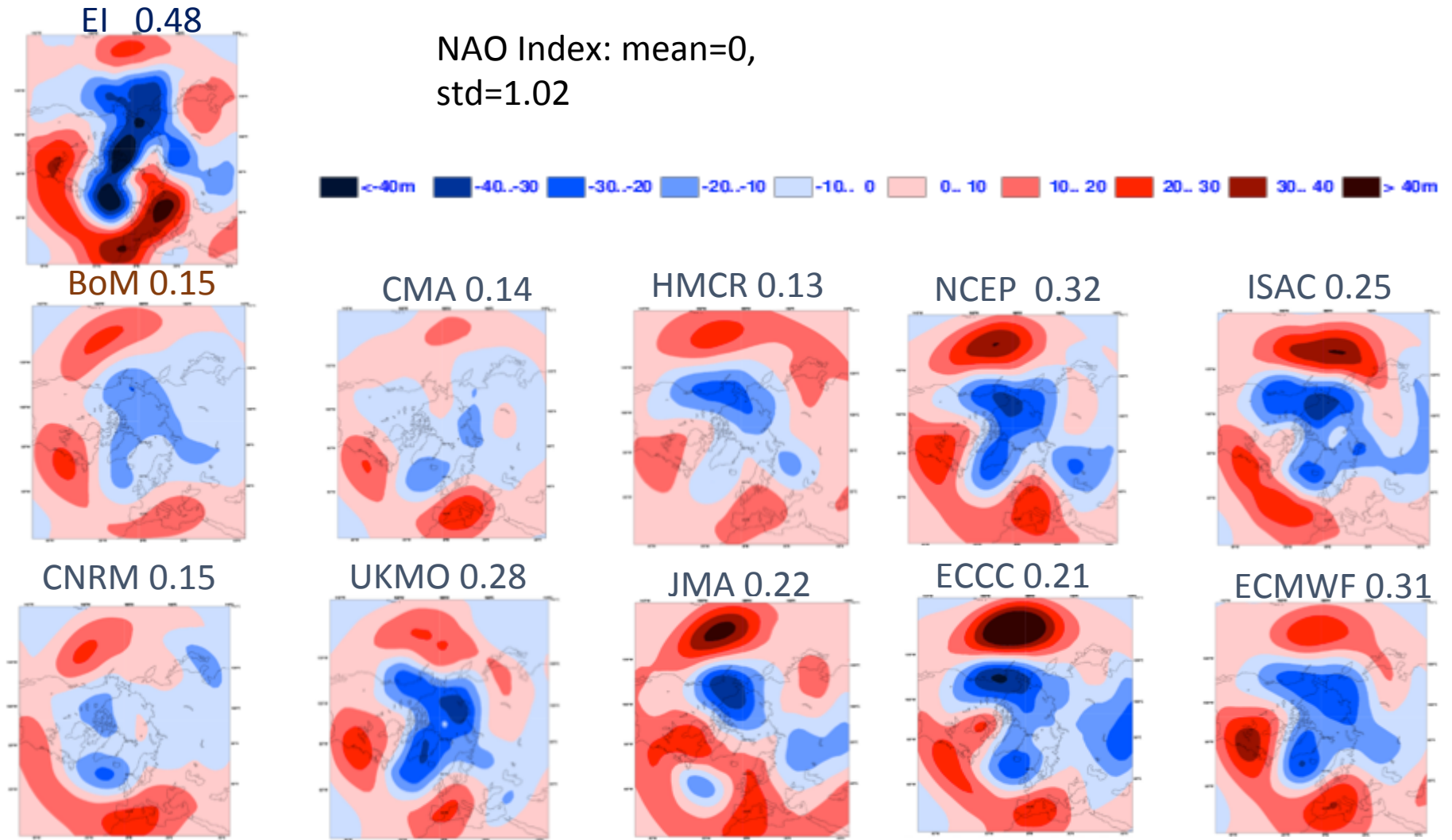
a) U200-IC5days reg to PC1



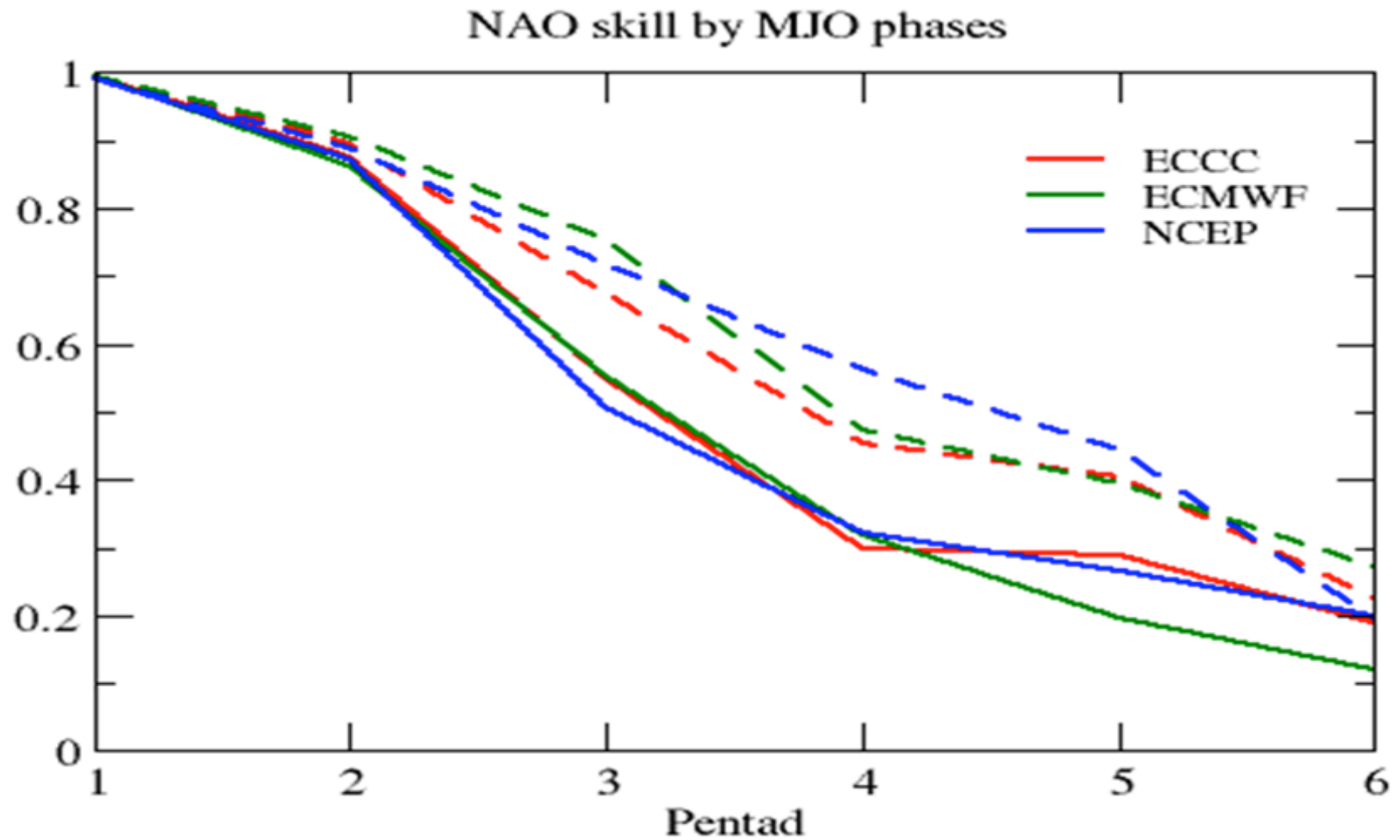
b) U200-IC5days reg to PC2



Composites of Z500 3rd pentads after an MJO in Phase 3 NDJFM



hindcast data



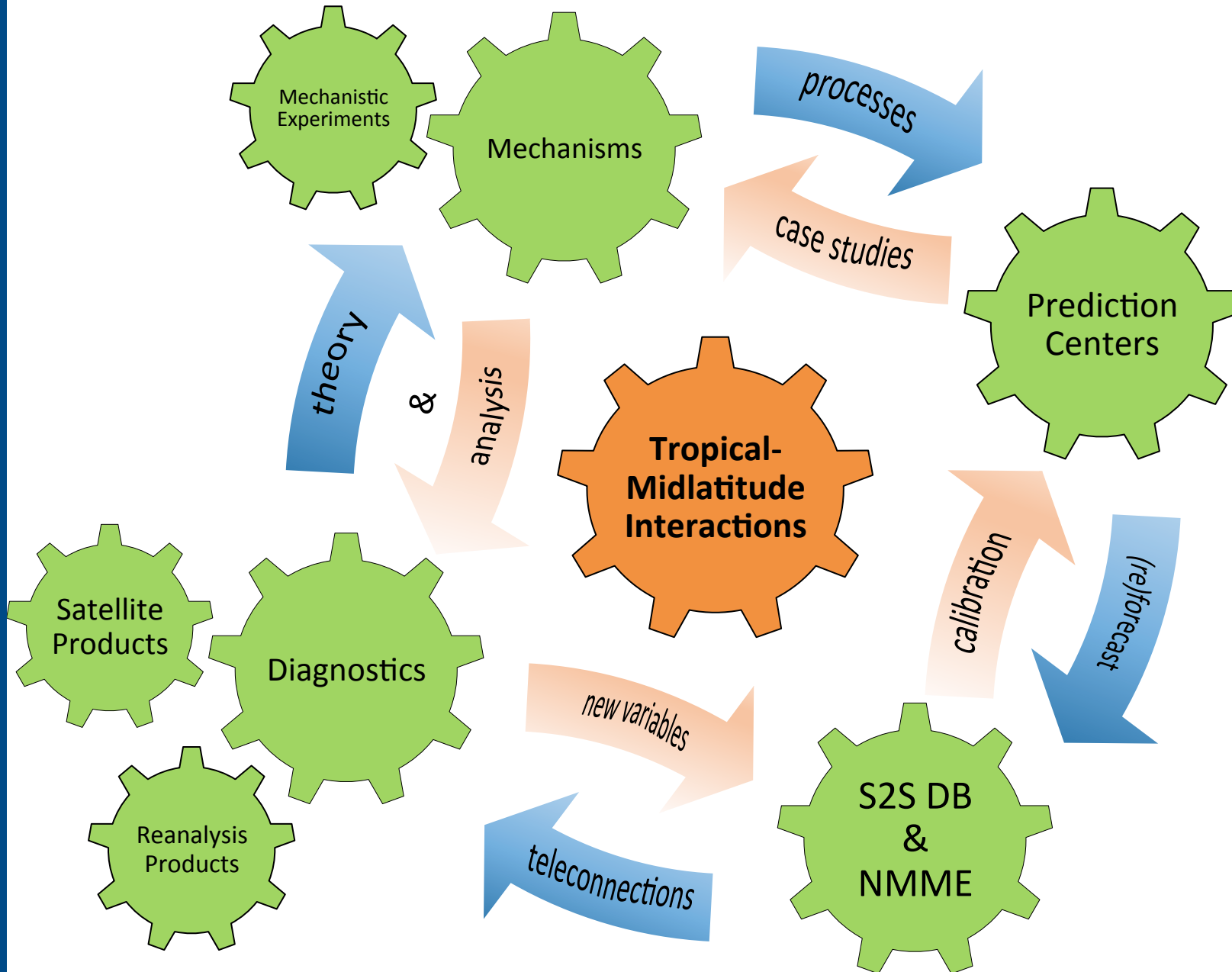
NAO forecast skill when the initial condition is in MJO phase 2367 (dashed) compared with MJO phases 1458 (solid).



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understand
predict
seasonal
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action
ways



Year of Tropics-Midlatitude Interactions and Teleconnections



YTM
mid 2017-m

Virtual

Field

Campaign





Year of Tropics-Midlatitude
Interactions & Teleconnections

YTMIT

Scientific Steering Committee

Co-Chairs: Cristiana Stan (GMU), Hai Lin (EC Canada),

Members: Jorgen Frederiksen (CSIRO), Eric Maloney (CSU), Courtney Schumacher (TAMU), David Straus (GMU)





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Year of Tropics-Midlatitude Interactions and Teleconnections

Description

- Intense coordinated effort involving existing observational data, forecasts and applications, diagnostics, theory and modeling experiments

Mission

- Foster relationship between research, forecasting, and stakeholder communities, and facilitate the sharing of common interests to explore the links between the tropics and midlatitudes for a better prediction skill at intraseasonal time scales

Research Questions

- Are mid-latitude teleconnections from the fluctuating tropical heating fundamentally just time-lagged stationary wave responses to heating, or does time-dependent wave interface play a role?
- Why are the North Atlantic weather regimes so influenced by MJO-related heating in the distant Indian and Pacific Oceans?
- What is the role of synoptic-scale transients?
- Is the impact of extra-tropical forcing associated primarily with the initiation of tropical convection, or can it organize tropical convection of intraseasonal time scale?
- What is the role of PV streamers?

YTM
mid 2017-m

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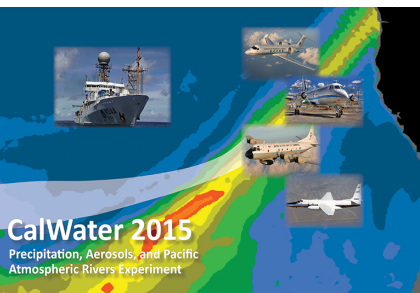
Projects



Whitepaper

YTMIT-CalWater2015

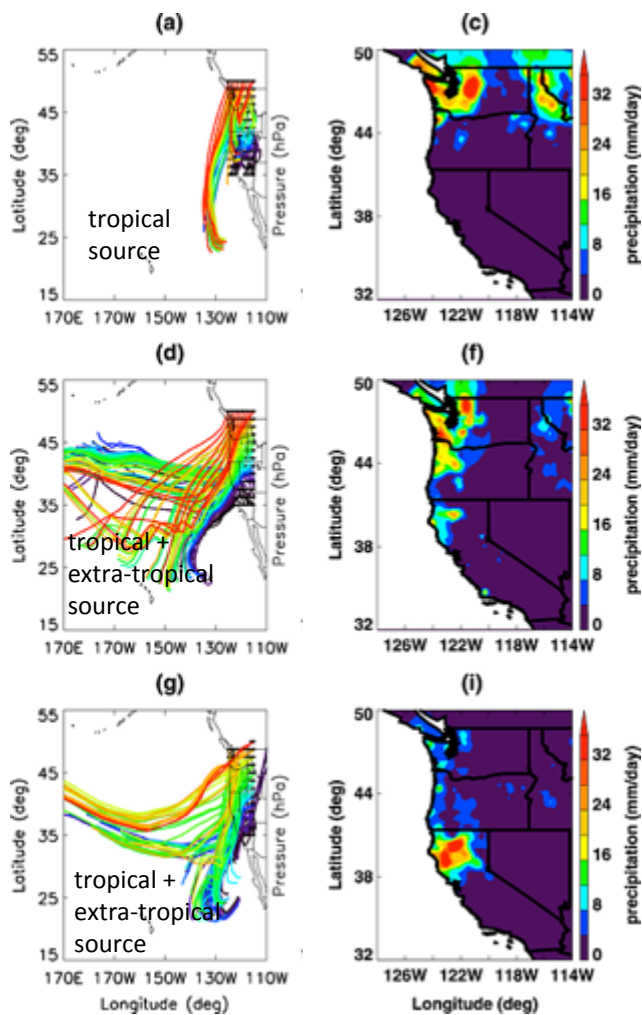
Atmospheric Rivers and their Teleconnections



L. Ruby Leung
PNNL

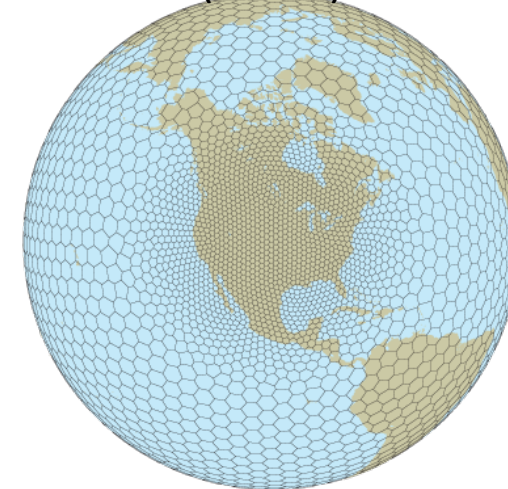
Cristiana Stan
GMU

Classification of AR events on the U.S. West Coast

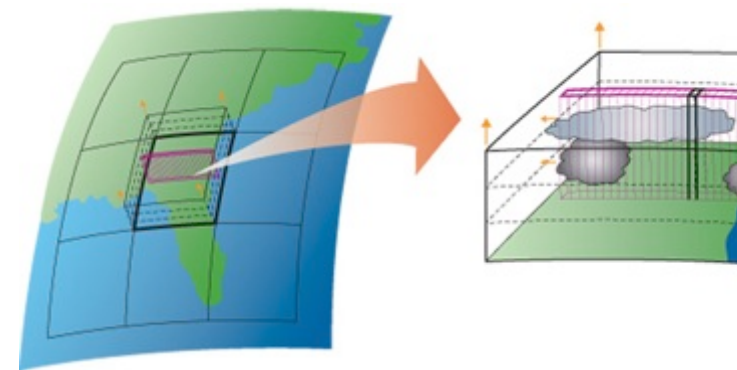


Ryoo et al. (2015)

Model for Prediction Across Scales (MPAS)



Super-Parameterization

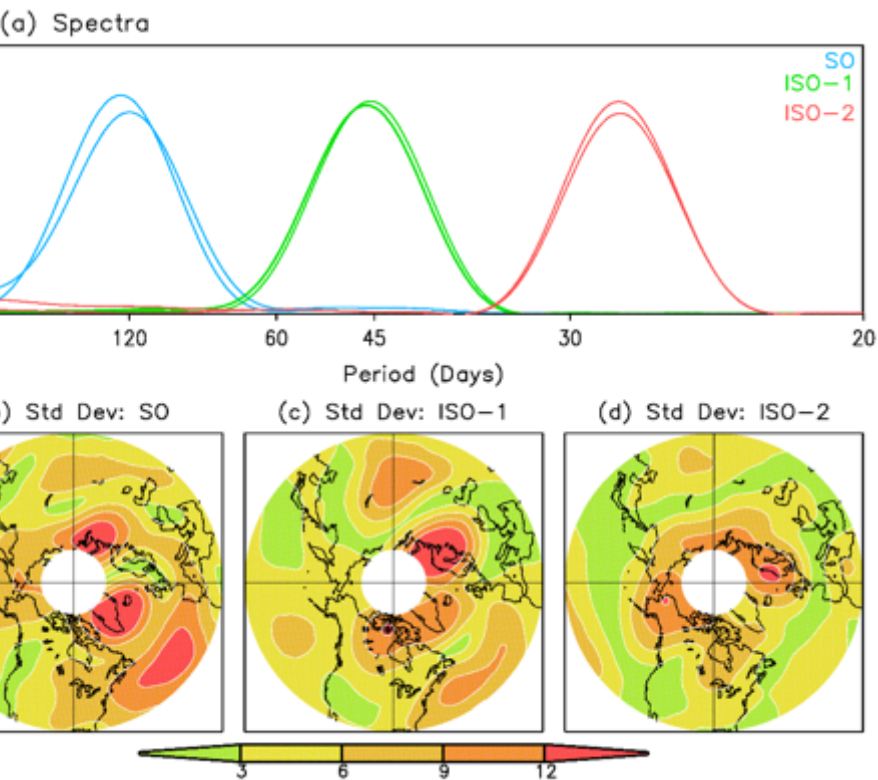


Participation from other modeling groups

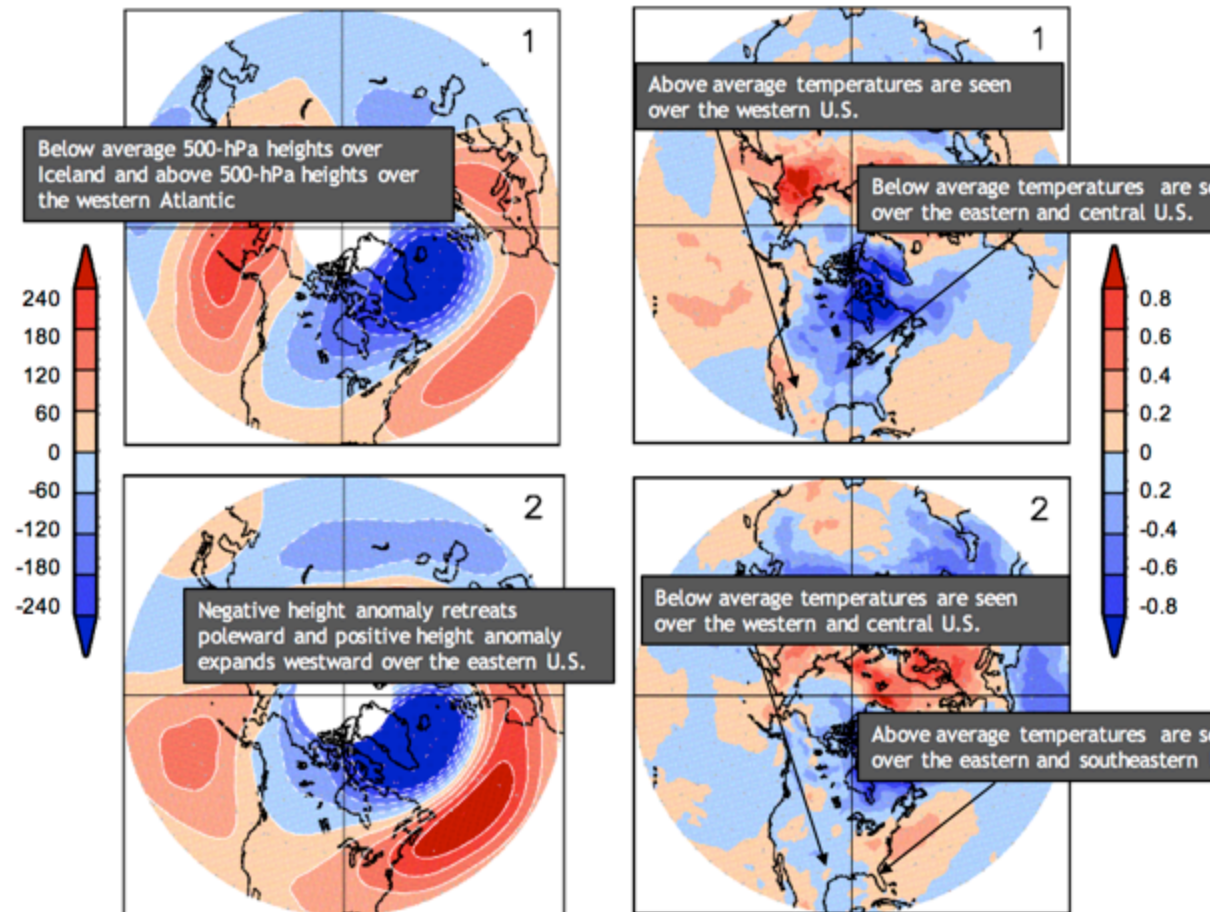


Projects

tiana Stan (GMU), Laura Ciasto (CPC), Dan Harnos (CPC), Venkat Krishnamurthy (GMU), Michelle L'Heureux (CPC), E...
oney, (CSU), David Straus (GMU)



Stan and Krishnamurthy, 2017



Stan and Krishnamurthy, 2017



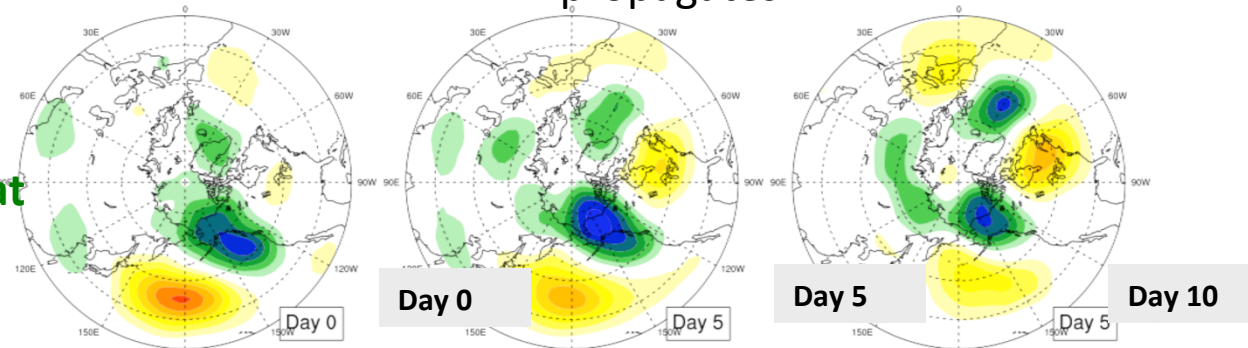
Projects

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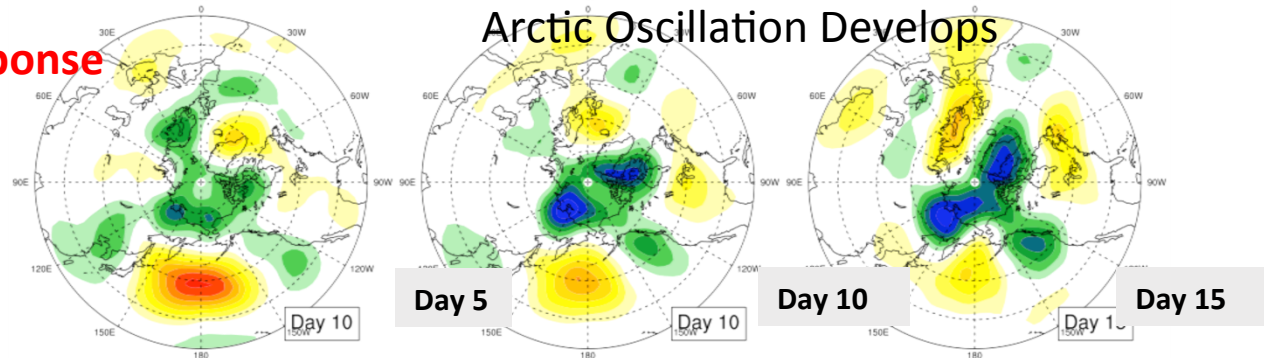
Fast MJO → propagation, development of PNA along great circle route into the Atlantic

Slow MJO → North Pacific response → Arctic Oscillation → NAO+

PNA propagates



Arctic Oscillation Develops



Results from ERA-Interim Reanalysis

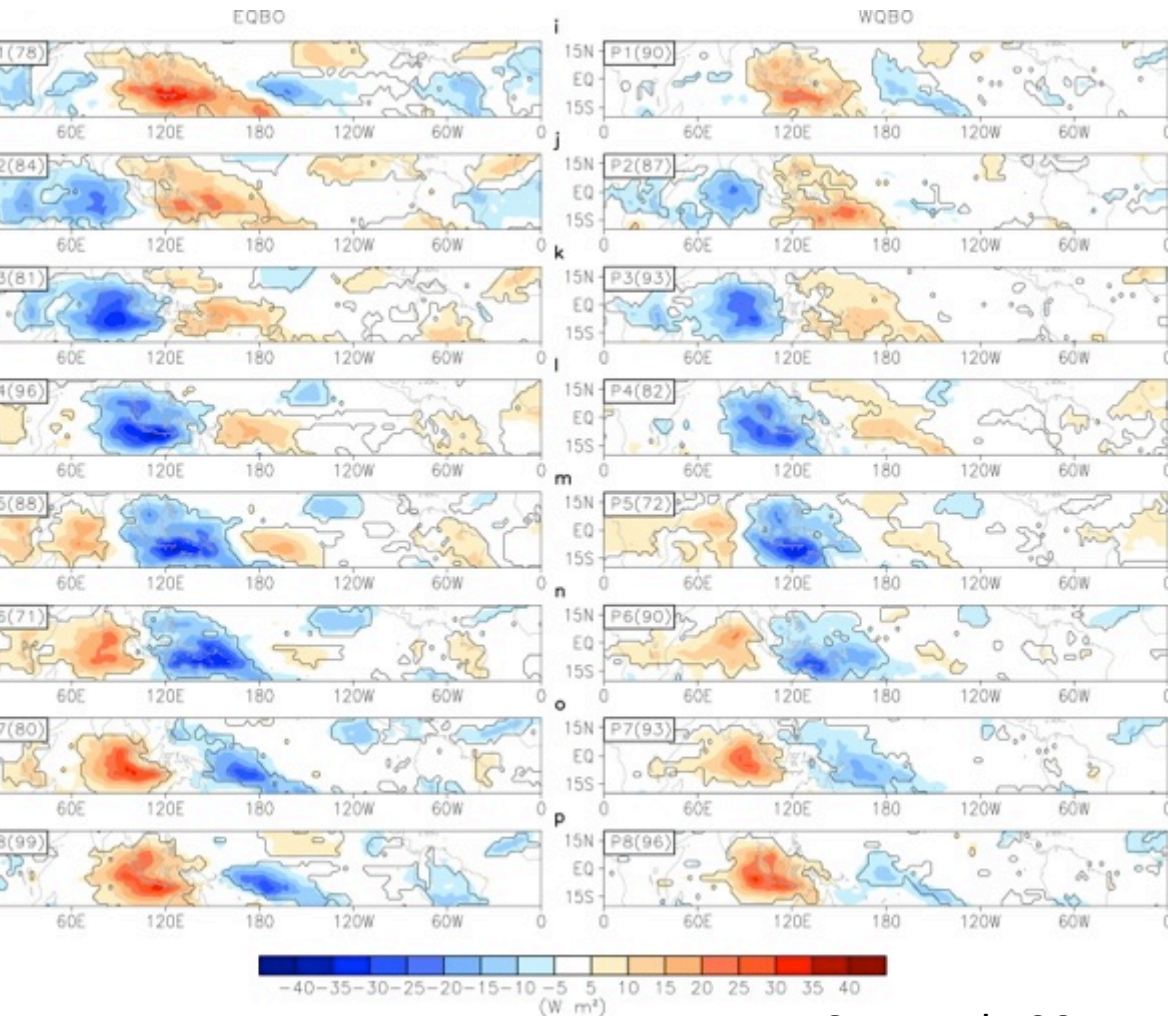
Upper panel: Fast case (<10 days); Bottom panel: Slow case (>15 days)

Yadav and Straus, 2016



Projects

The influence of stratospheric biases on the tropospheric S2S forecast skill



Son et al., 2017

Explore the potential of improved representation of stratosphere on the S2S prediction skill of an experimental version of the NAVy Global Environmental Model (NAVGEM) analysis and forecast systems.



Other Activities

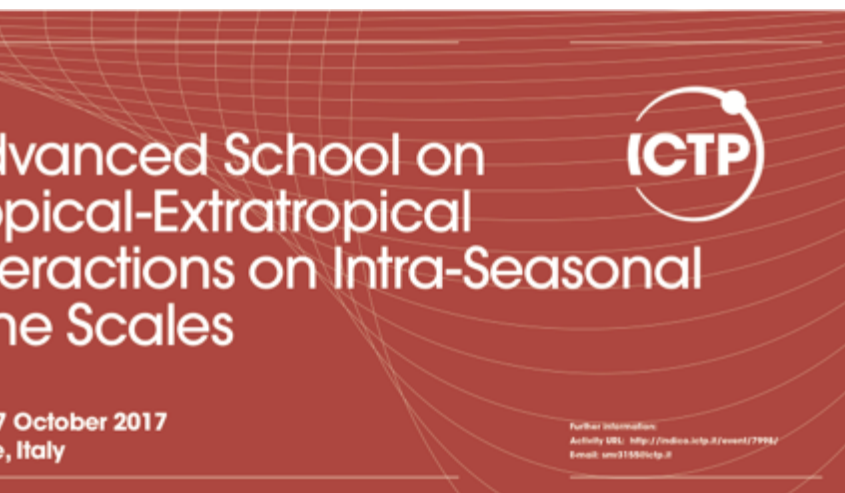
Publications



Special issue on YTMIT in the Atmosphere-Ocean, manuscripts accepted through May, 2018.

For submission instructions, please visit <http://cmos.ca/site/ao>. The special issue can be selected from the drop-down list of the submission process.

Training Activities



Practical activities on the use of S2S Database and diagnosing teleconnections in sub-seasonal forecasts using the IRI Data Library



Other Activities

Numerical Experiments

Relaxation type experiments designed to understand the upper bound of predictability given perfect tropical forcing, i. e., nudging the tropical atmosphere toward analysis

Relaxation type experiments designed to understand the role of extra-tropical mean state on the teleconnection forecast skill

Nudging experiments with idealized profiles of diabatic heating in the tropics.

If you are interested in contributing to these experiments, please contact Cristiana Stan, cstan@gmu.edu