Environment and Climate Change Canada
Environnement et Changement climatique Canada
Canada

Tropical-extratropical teleconnections on subseasonal time scale

Hai Lin

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)

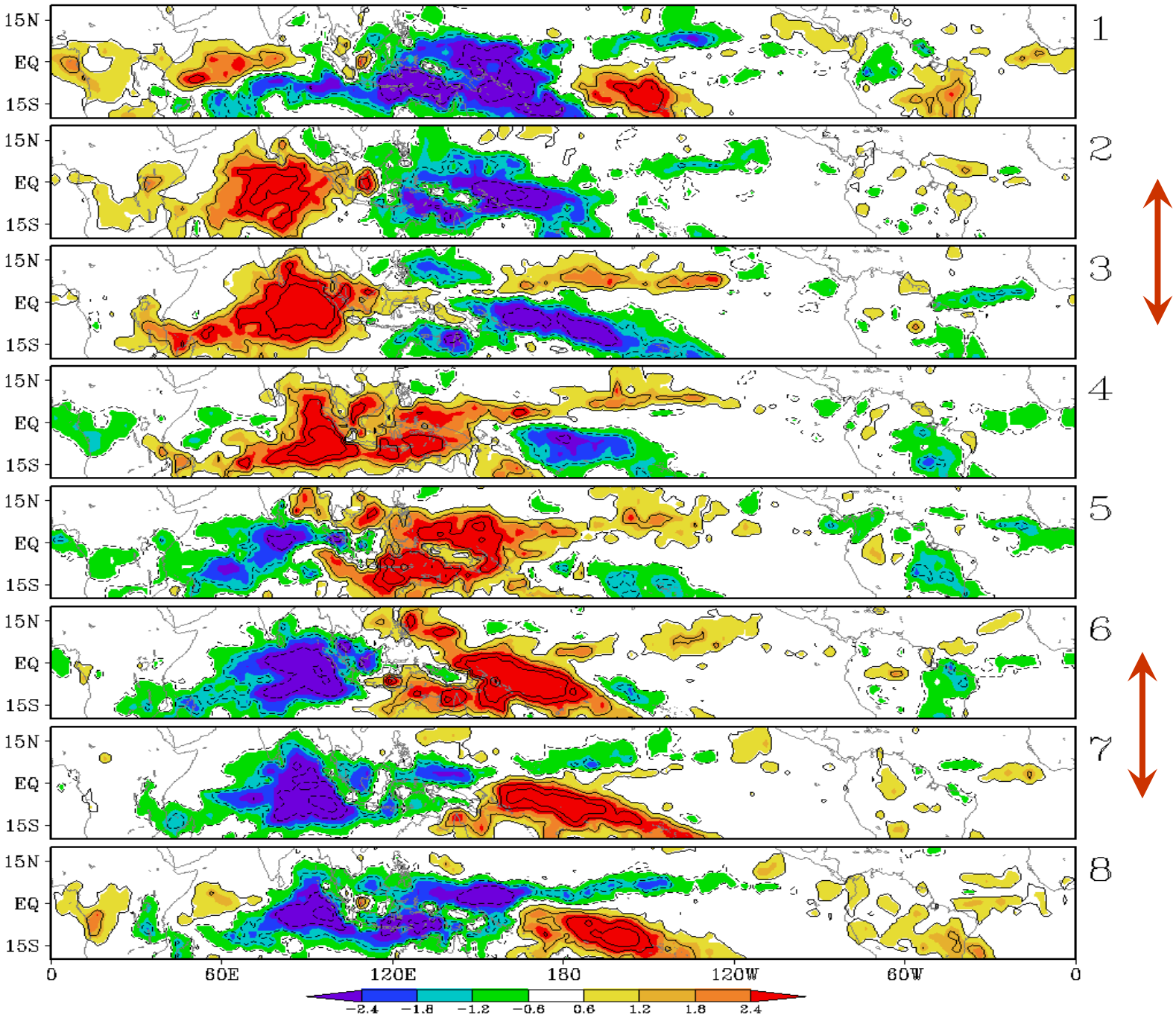
Response to tropical thermal forcing (classical dynamics)

- 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 and Hendon index.

Xie and Arkin pentad data, 1979-2003



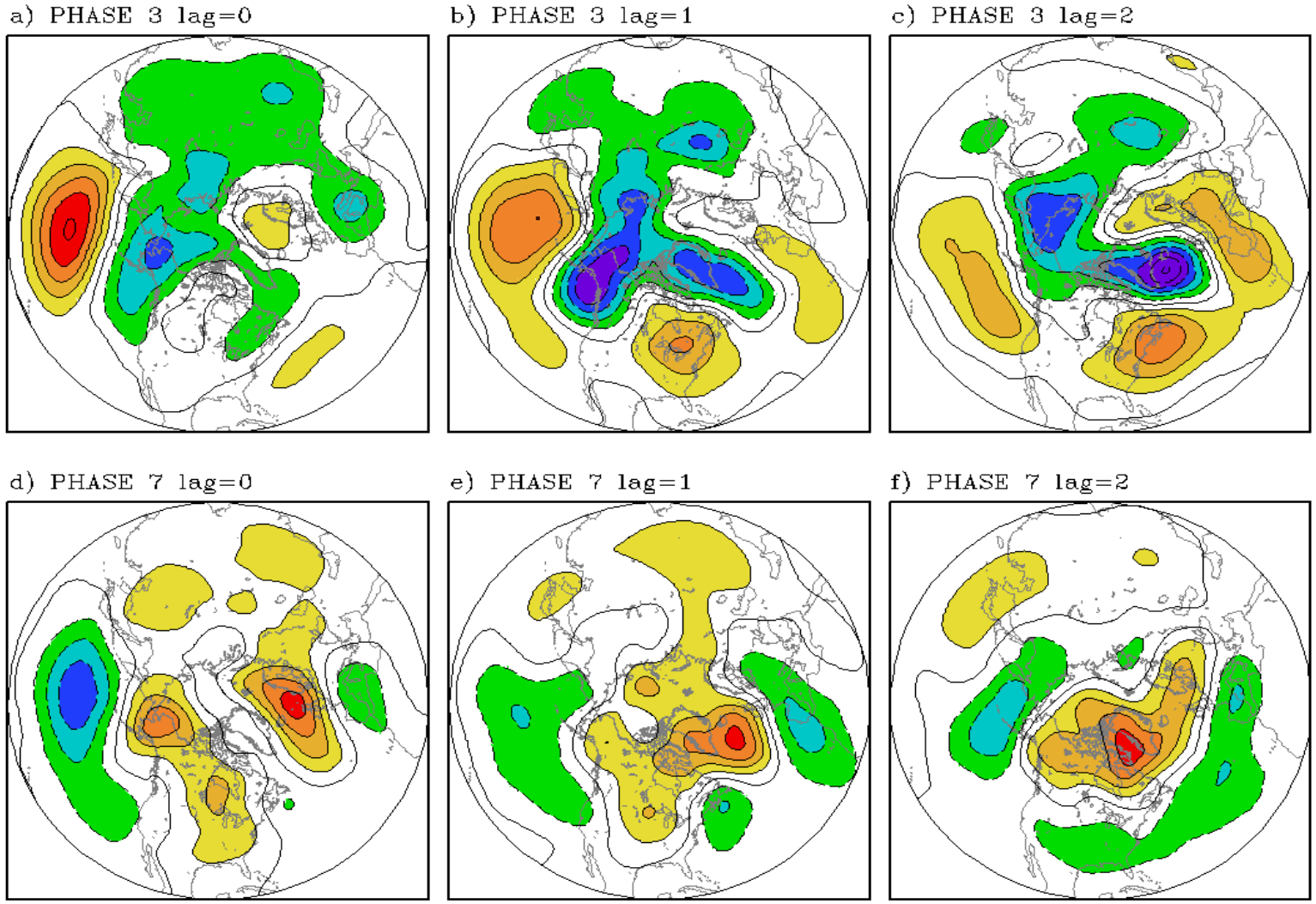
Lagged probability of the NAO index

Positive: upper tercile; Negative: low tercile

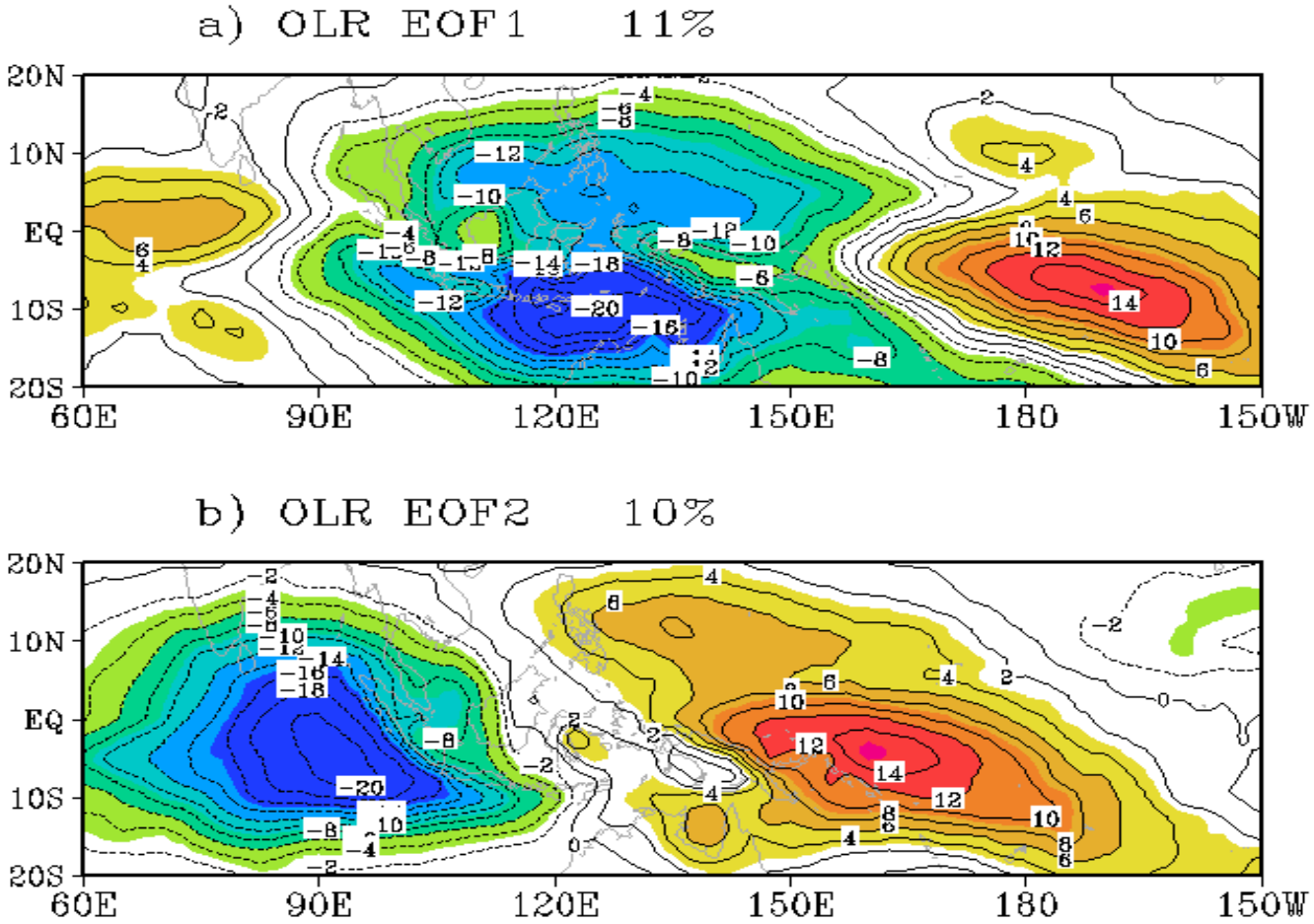
Phase	1	2	3	4	5	6	7	8
Lag 0				+45%				−42%
Lag +1			+47%	+45%				−46%
Lag +2		+47%	+50%	+42%		−41%	−41%	−42%
Lag +3		+48%				−41%	−48%	
Lag +4						−39%	−48%	
Lag +5				−41%				

(Lin et al. JCLIM, 2009)

Tropical influence

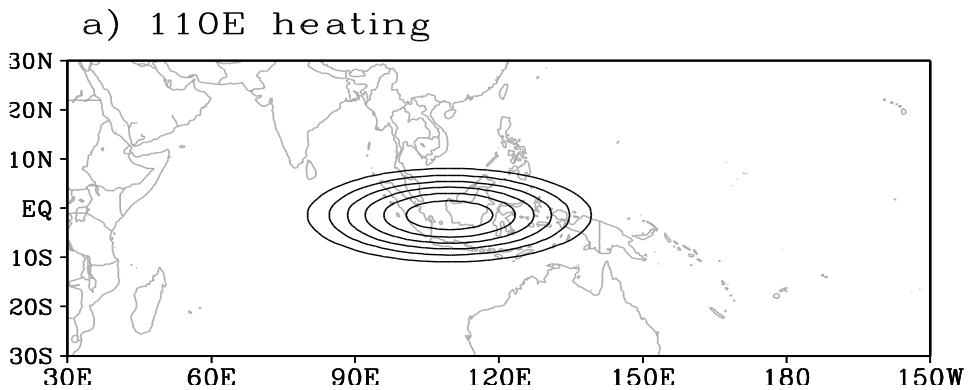


(Lin et al. JCLIM, 2009)

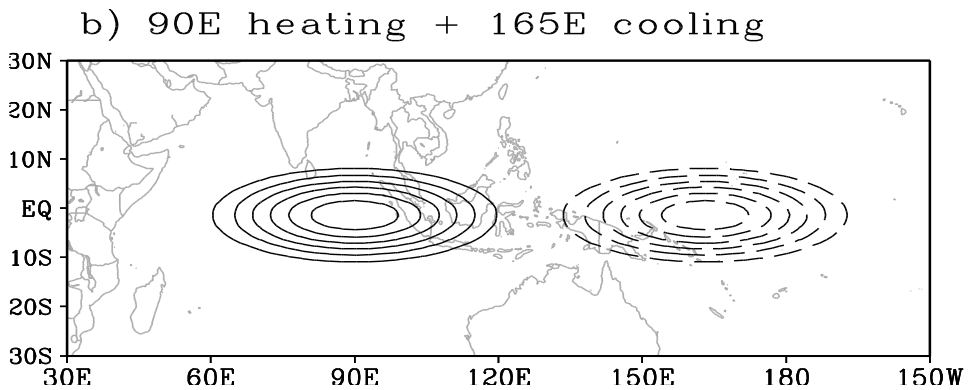


Correlation when PC2 leads PC1 by 2 pentads: 0.66

Thermal forcing



Exp1 forcing

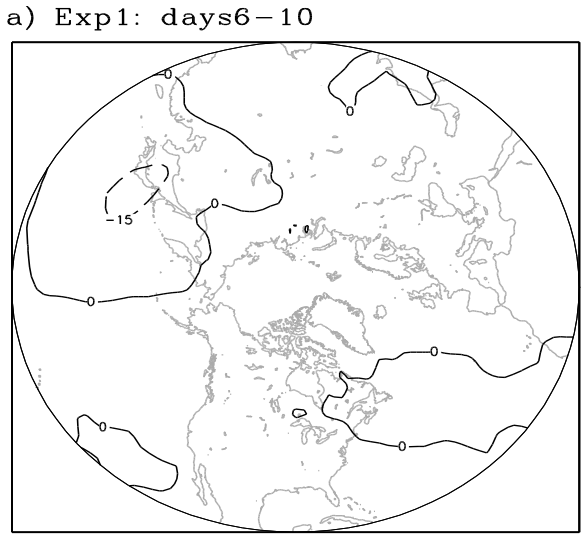


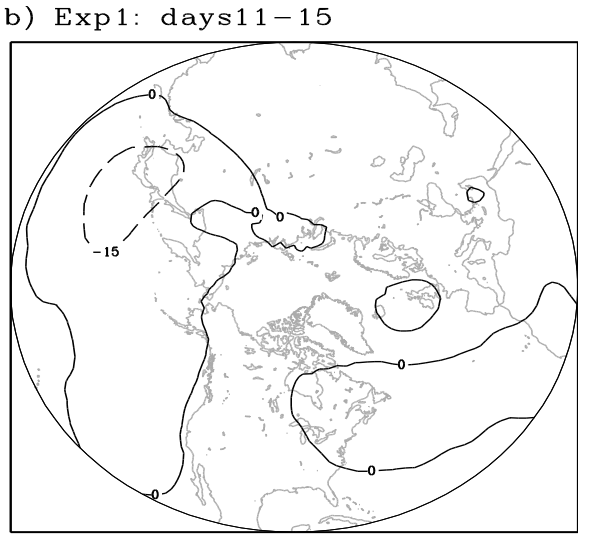
Exp2 forcing

Lin et al. (2010)

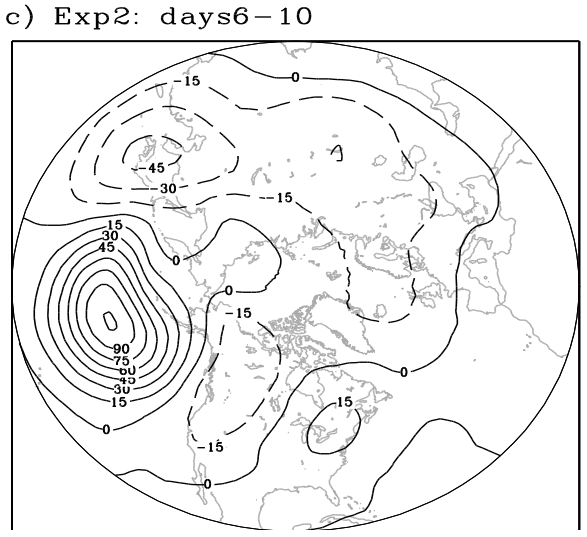
Z500 response

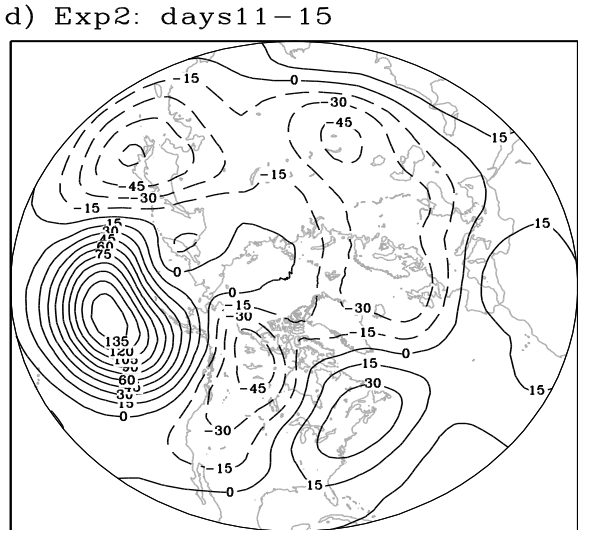
Exp1





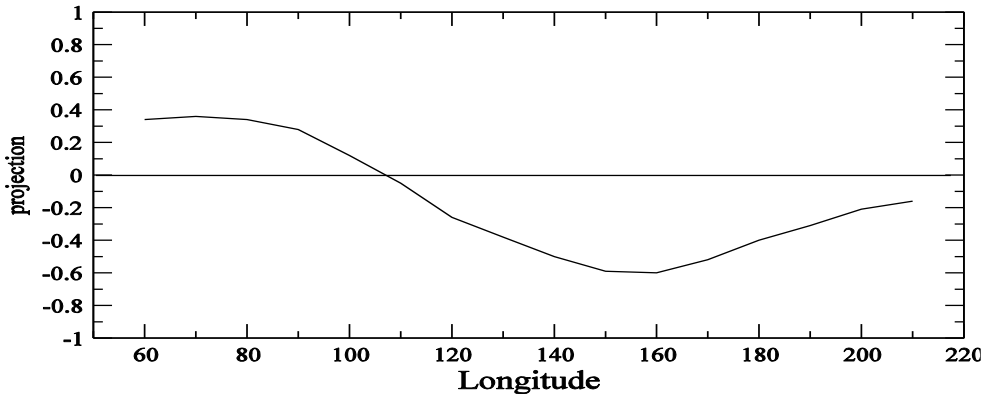
Exp2

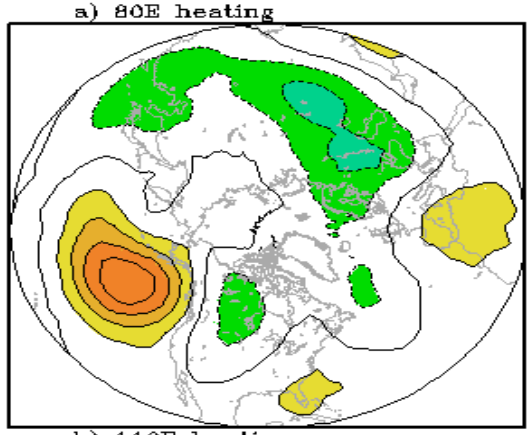




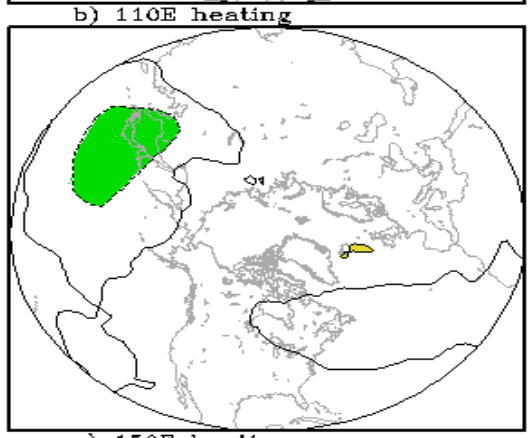
Lin et al. (2010)

Day 10 Z500 linear response

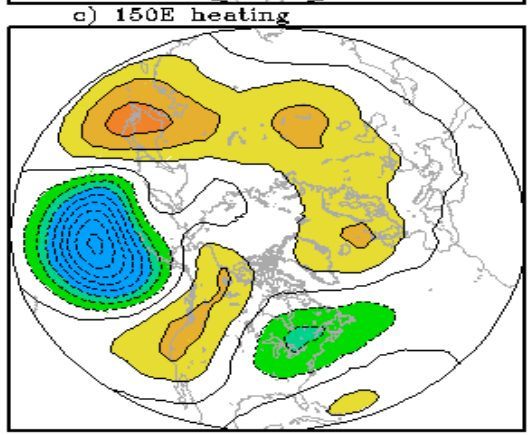




80E



110E



150E

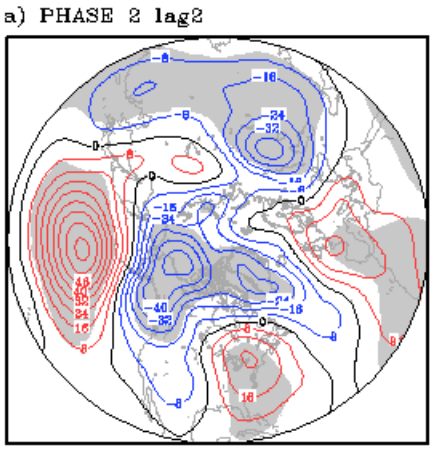
Similar pattern for heating 60-100E

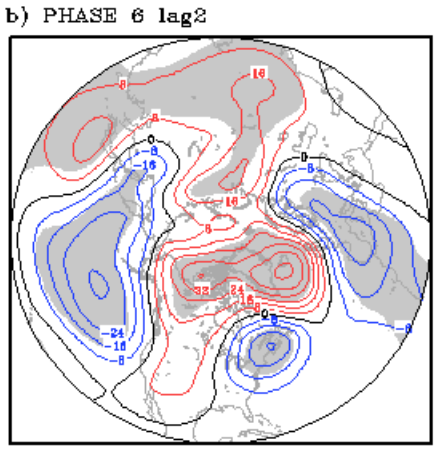
Similar pattern for heating 120-150W

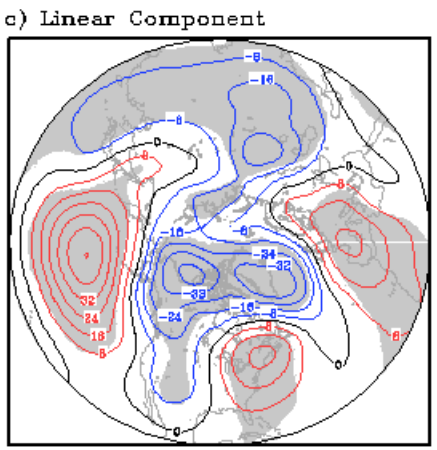
Lin et al. MWR, 2010

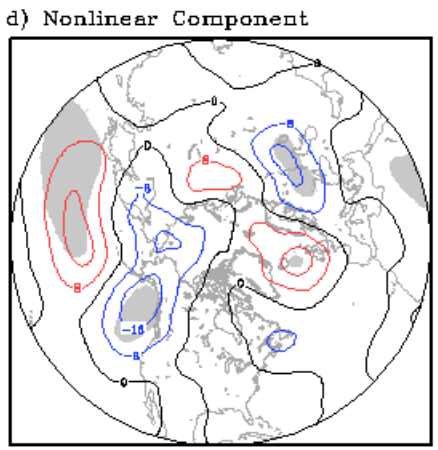
Nonlinearity

Observation

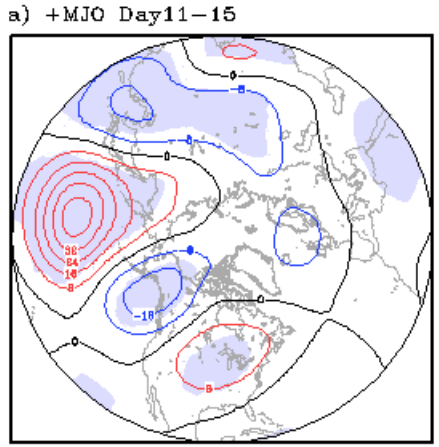


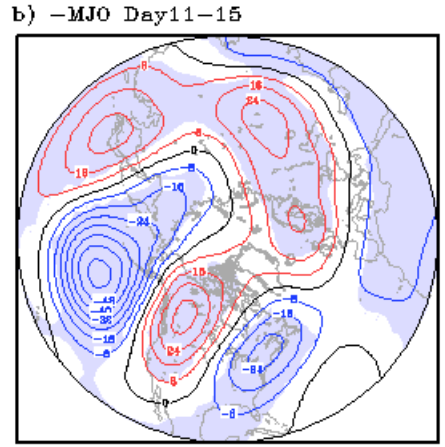


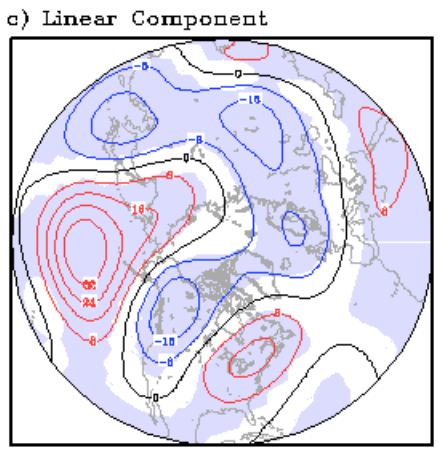


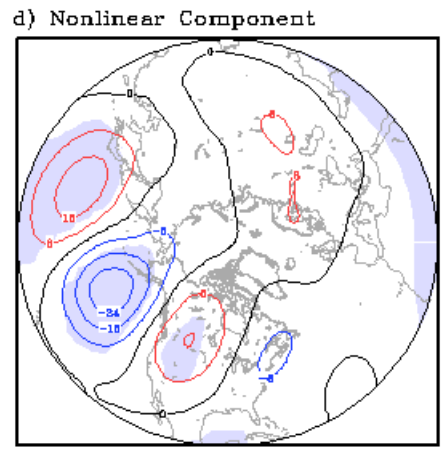


Simple model simulation



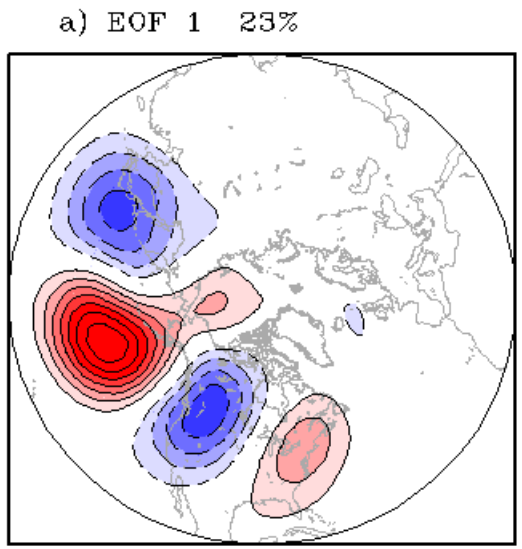


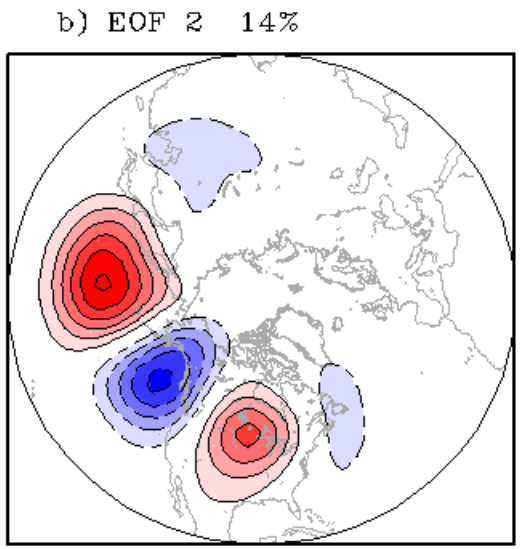




Lin and Brunet, JAS in press

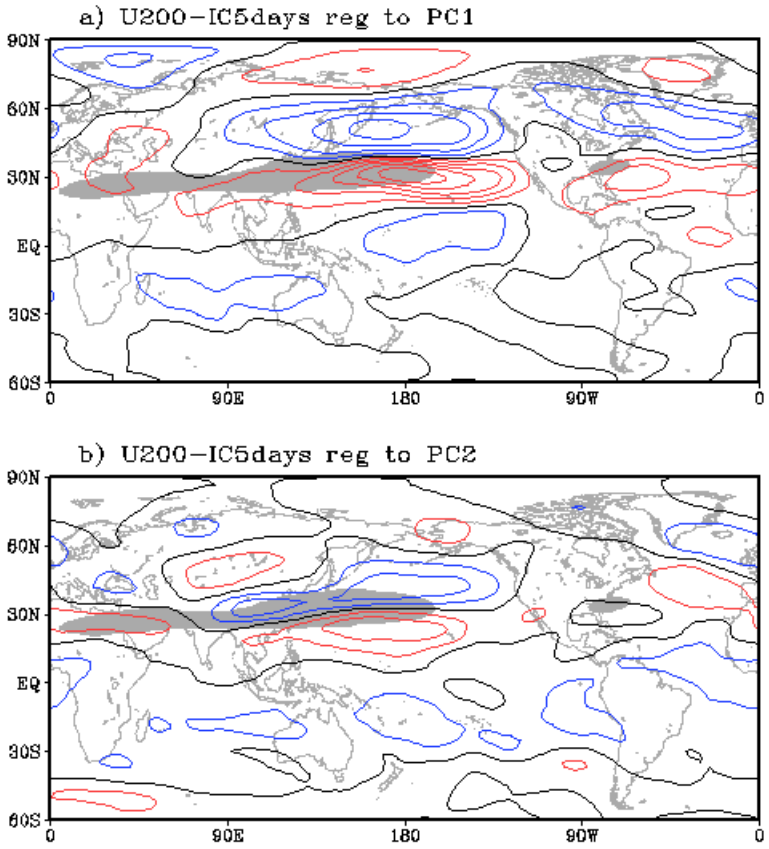
Sensitivity to initial state





Eastward phase shift

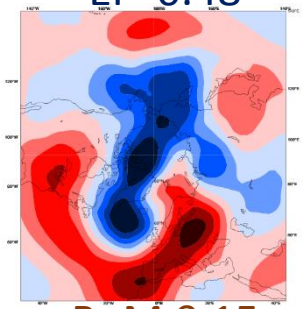
Similar to mean response



Lin and Brunet, JAS in press

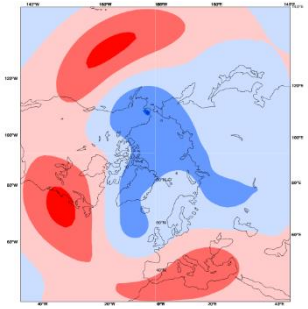
Composites of Z500 3rd pentads after an MJO in Phase 3 NDJFM

EI 0.48

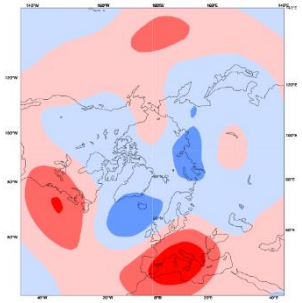


NAO Index: mean=0,
std=1.02

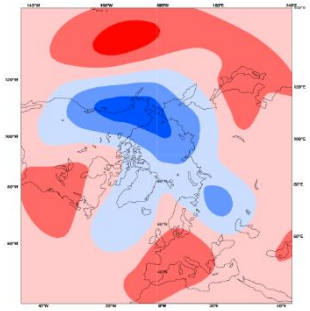
BoM 0.15



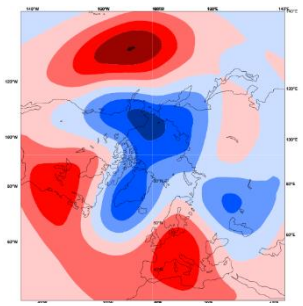
CMA 0.14



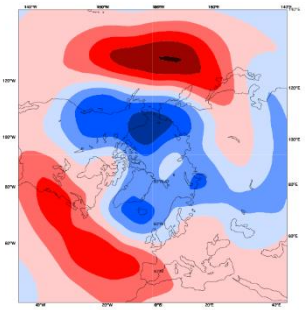
HMCR 0.13



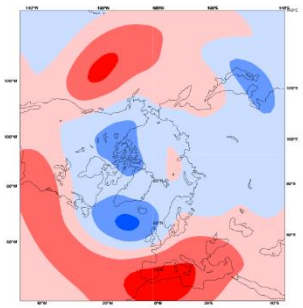
NCEP 0.32



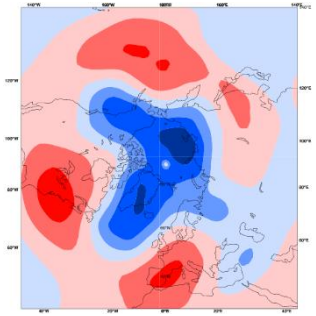
ISAC 0.25



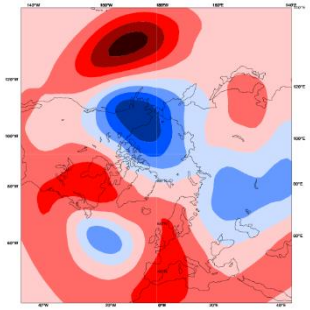
CNRM 0.15



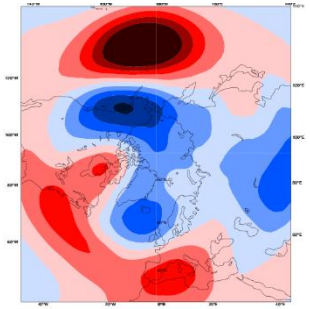
UKMO 0.28



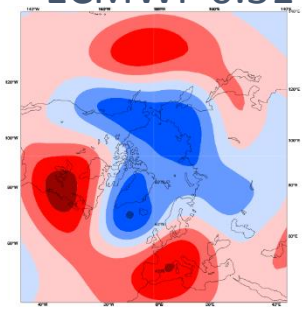
JMA 0.22



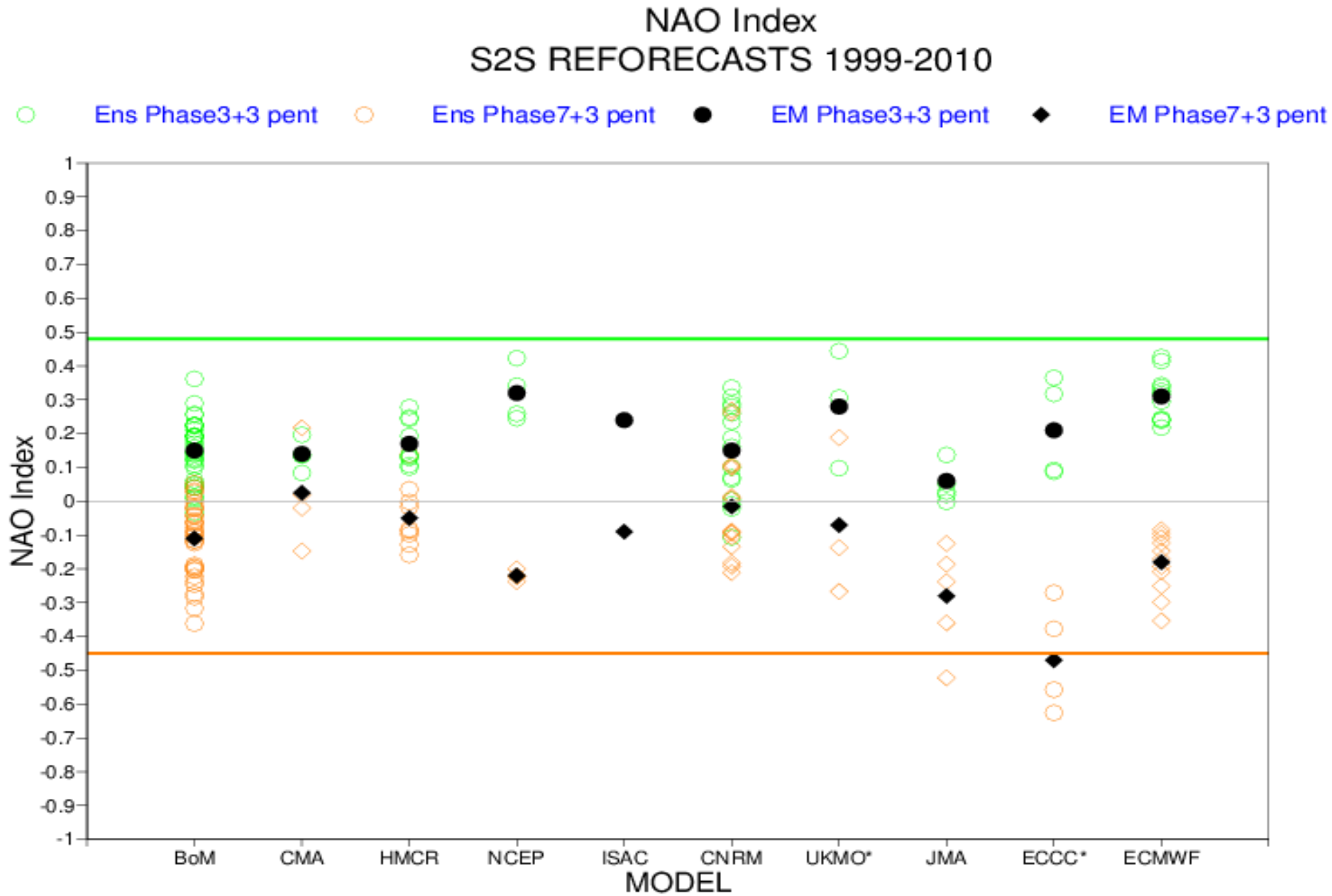
ECCC 0.21



ECMWF 0.31

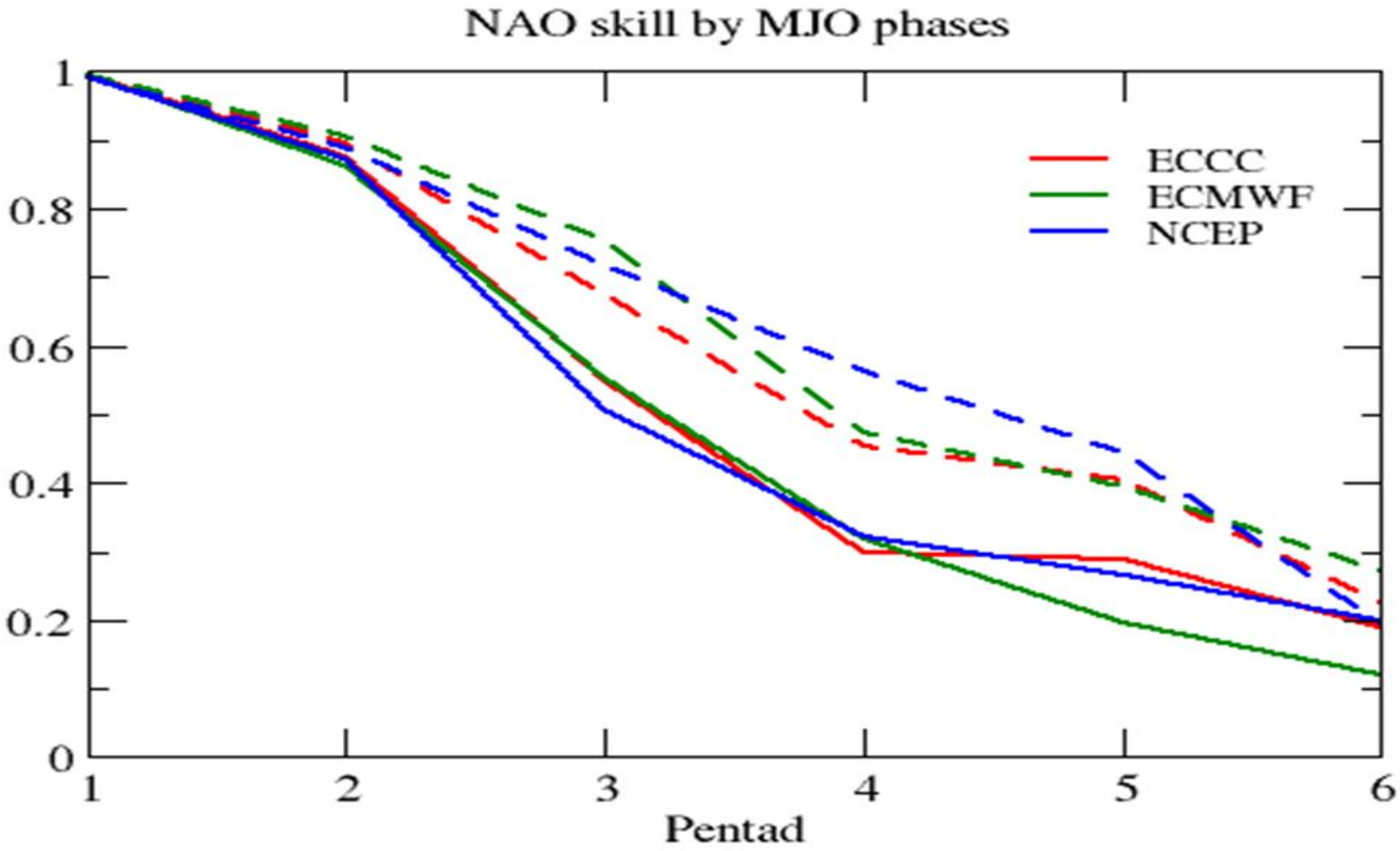


F. Vitart


NAO Index
S2S REFORECASTS 1999-2010
Ens Phase3+3 pent
Ens Phase7+3 pent
EM Phase3+3 pent
EM Phase7+3 pent
NAO Index
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
BoM
CMA
HMCR
NCEP
ISAC
CNRM
UKMO*
JMA
ECCC*
ECMWF
MODEL

F. Vitart

S2S hindcast data



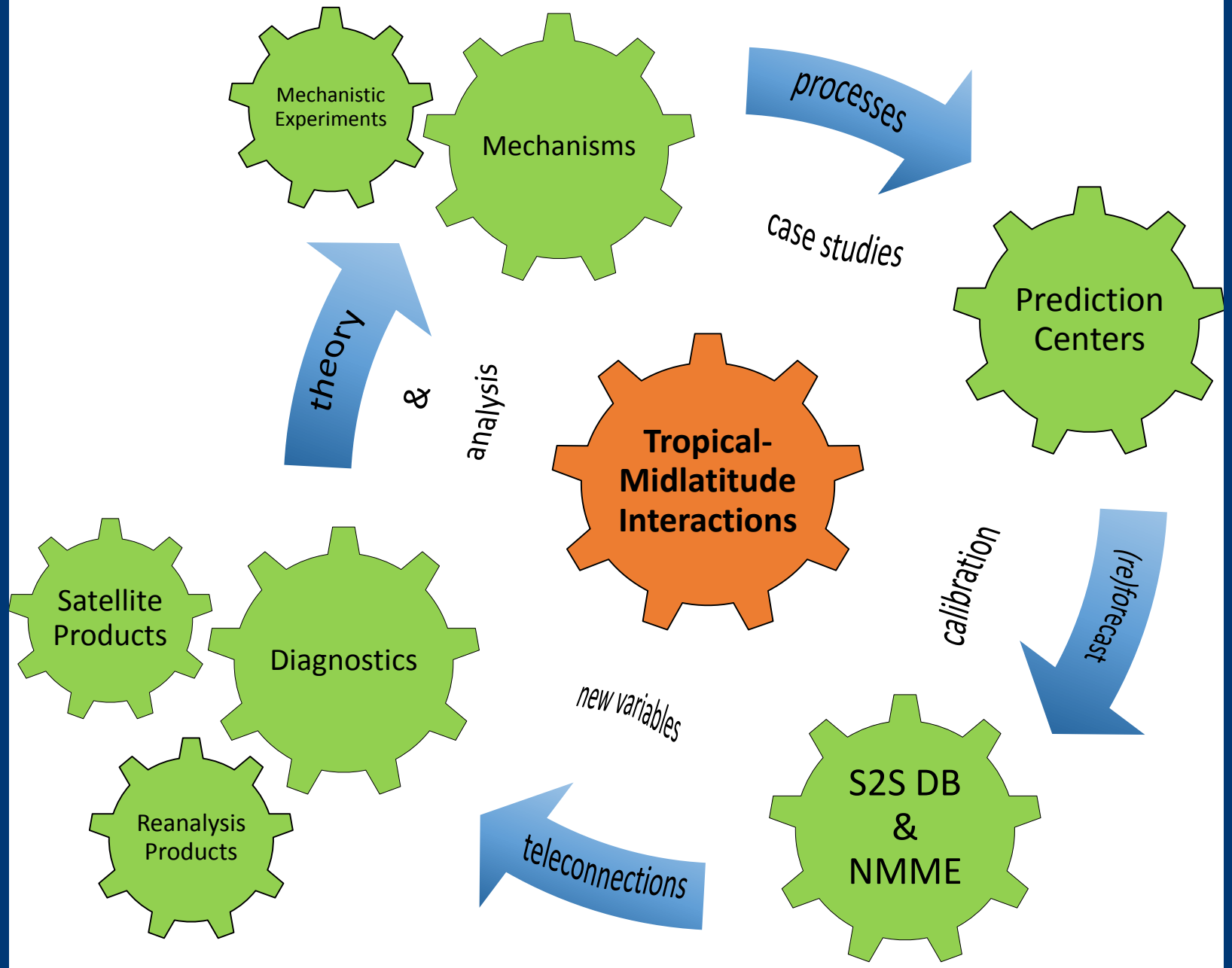
NAO forecast skill when the initial condition is in MJO phase 2367 (dashed) compared with MJO phases 1458 (solid).

Year of Tropics-Midlatitude Interactions and Teleconnections

YTMIT

mid 2017-mid 2019

Better understand and predict sub-seasonal tropical-extratropical interaction pathways



Virtual

Field

Campaign

Subseasonal-to-Season

Prediction Project

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)

Year of Tropics-Midlatitude Interactions and Teleconnections

YTMIT

mid 2017-mid 2019

Virtual

Field

Campaign

Better understand and predict sub-seasonal tropical-extratropical interaction pathways

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

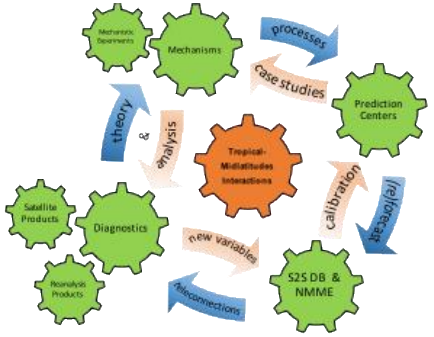
- Are mid-latitude teleconnections from the fluctuating tropical heating fundamentally just time-lagged stationary wave responses to heating, or does time-dependent wave interface play a role?
- Why are the North Atlantic weather regimes so influenced by MJO-related heating in the distant Indian and 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?

Subseasonal-to-Season

S2S

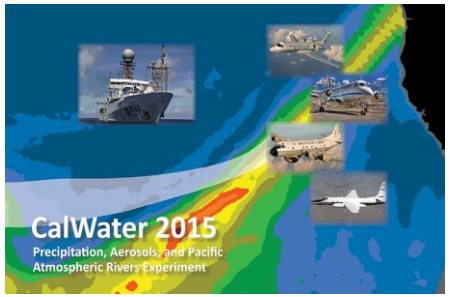
Prediction Project

Projects



YTMIT-CalWater2015

Atmospheric Rivers and their Teleconnections

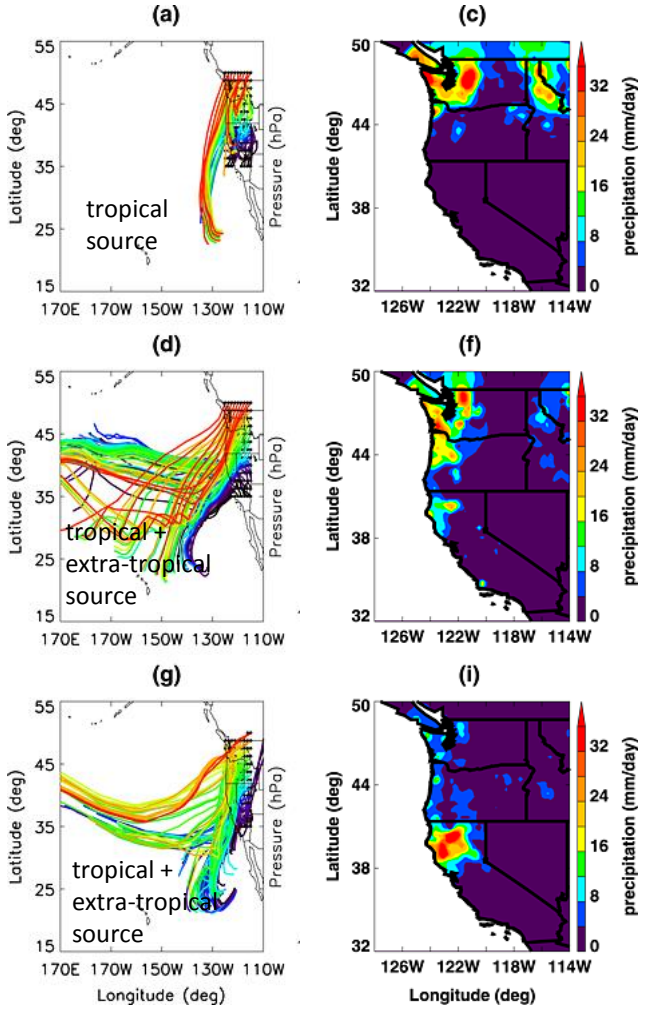


Whitepaper

L. Ruby Leung
PNNL

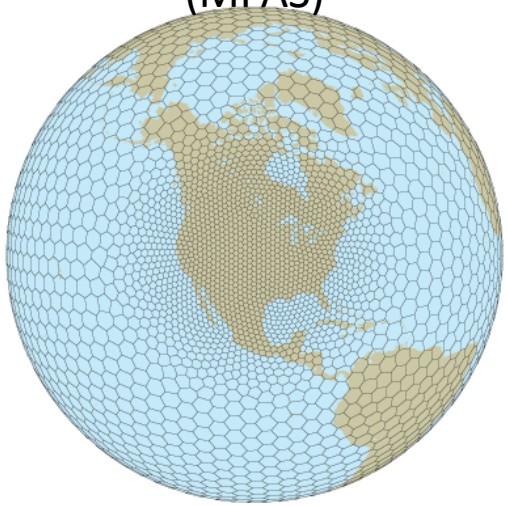
Cristiana Stan
GMU

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

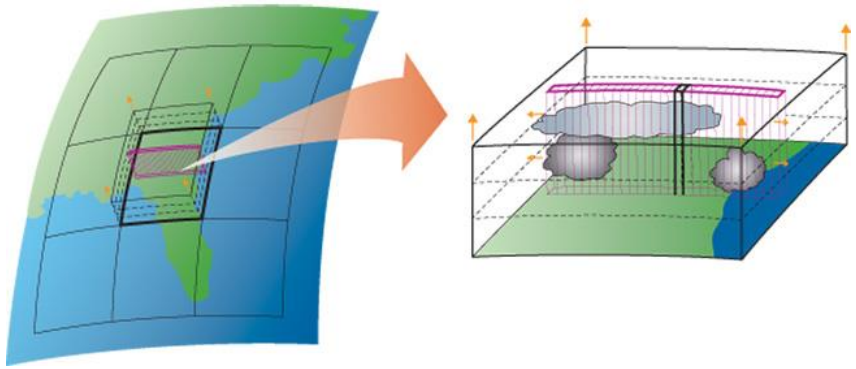


Ryoo et al. (2015)

Model for Prediction Across Scales (MPAS)



Super-Parameterization

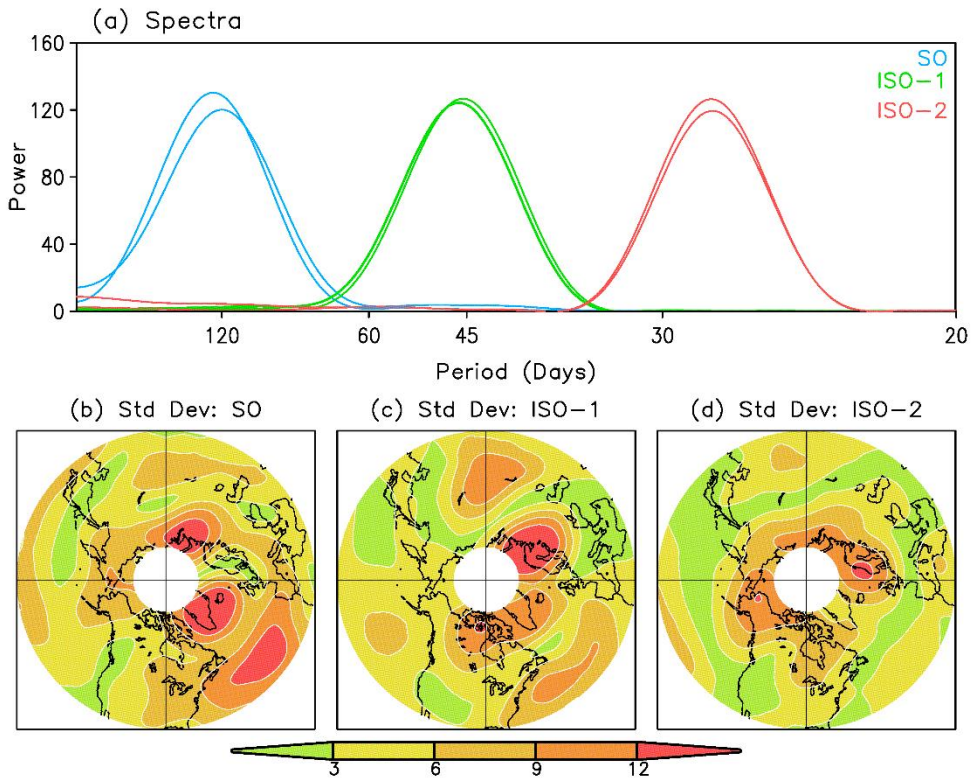


Participation from other modeling groups?

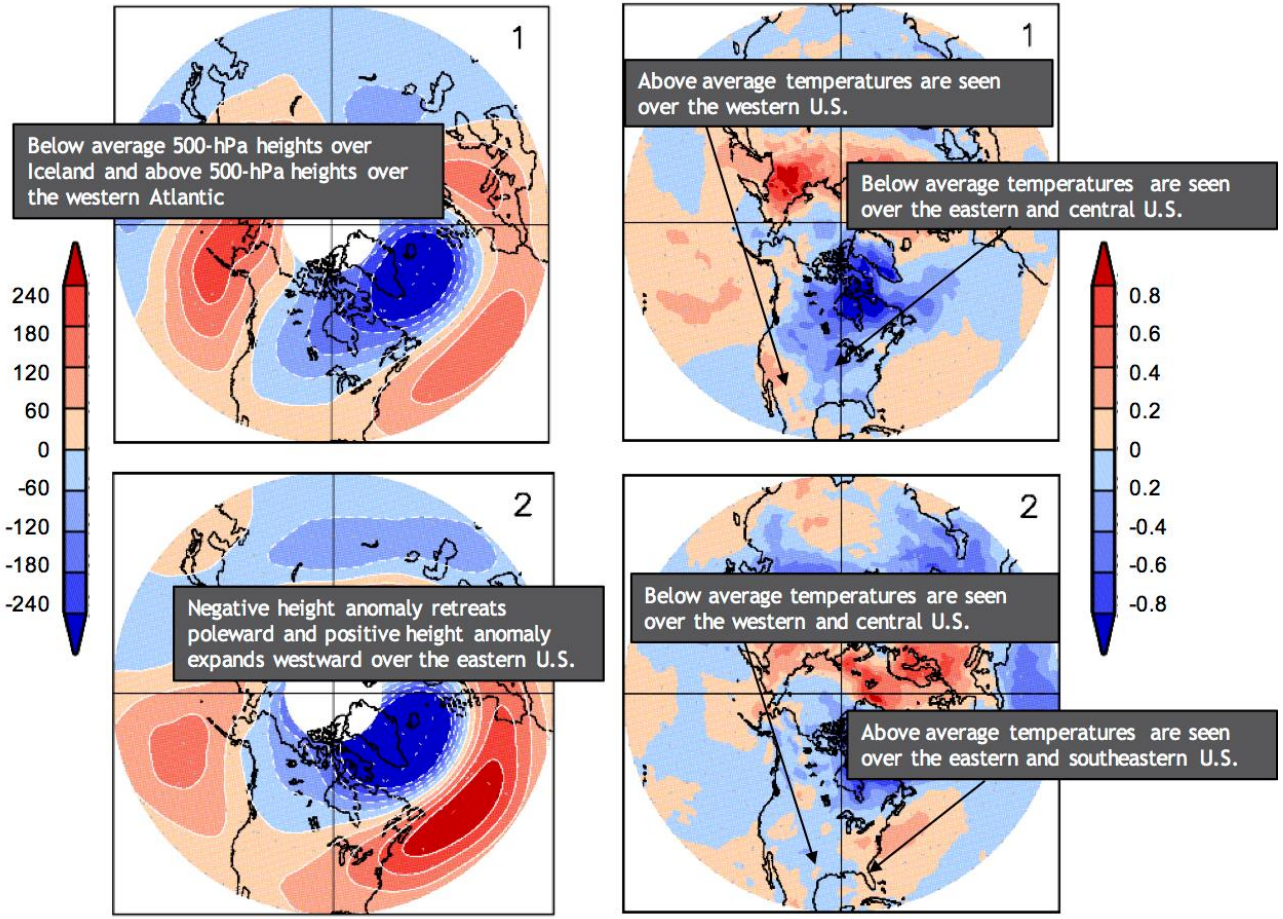
Projects

Advanced Diagnostics for Tropical-Midlatitude Interactions

Cristiana Stan (GMU), Laura Ciasto (CPC), Dan Harnos (CPC), Venkat Krishnamurthy (GMU), Michelle L'Heureux (CPC), Eric Maloney, (CSU), David Straus (GMU)



Stan and Krishnamurthy, 2017



Stan and Krishnamurthy, 2017

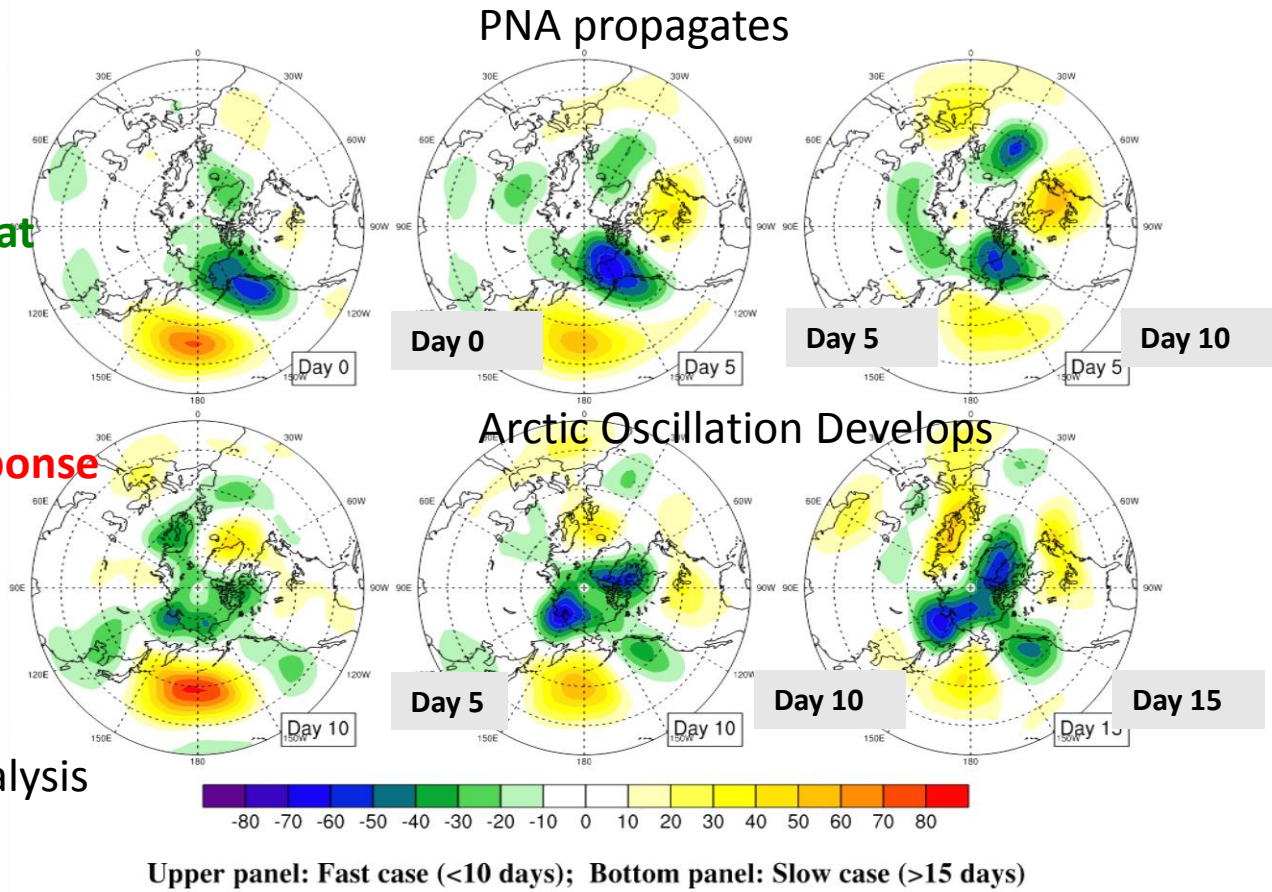
Projects

Cristiana Stan (GMU), Laura Ciasto (CPC), Dan Harnos (CPC), Venkat Krishnamurthy (GMU), Michelle L'Heureux (CPC), Eric Maloney, (CSU), David Straus (GMU)

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

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

Results from ERA-Interim Reanalysis

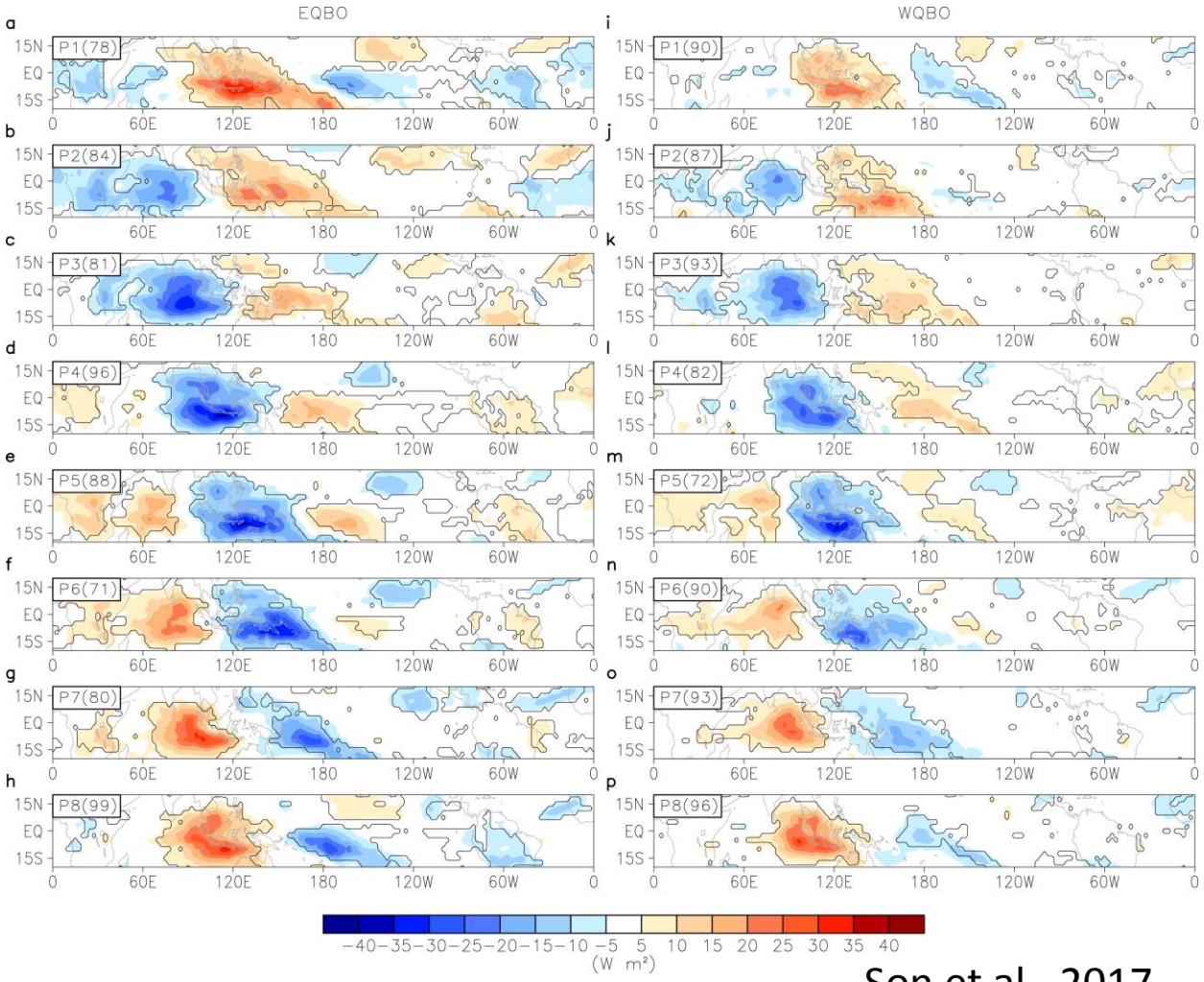


Upper panel: Fast case (<10 days); Bottom panel: Slow case (>15 days)

Yadav and Straus, 2016

Projects

The influence of stratospheric biases on the tropospheric S2S forecast skill



Son et al., 2017

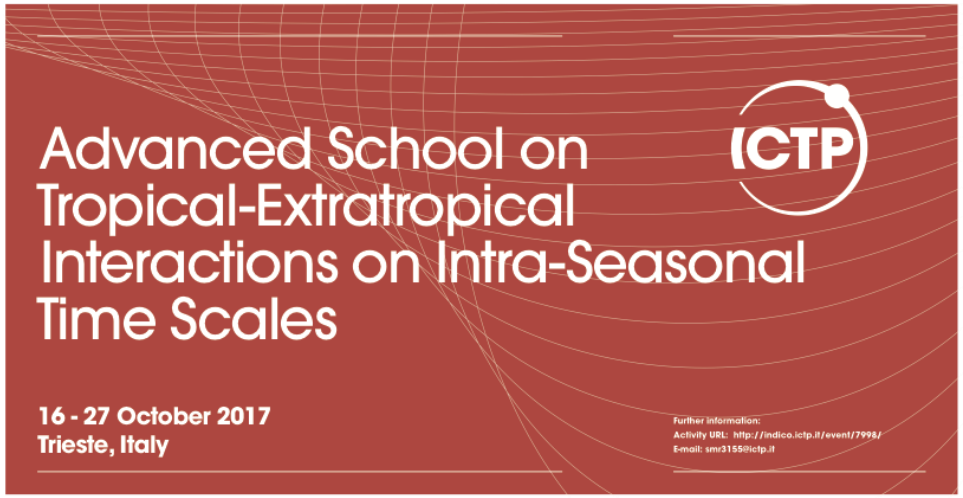
Explore the potential of improved representation of stratosphere on the S2S prediction skill of an experimental version of the NAVy Global Environmental Model (NAVGEM) analysis and forecast systems.

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