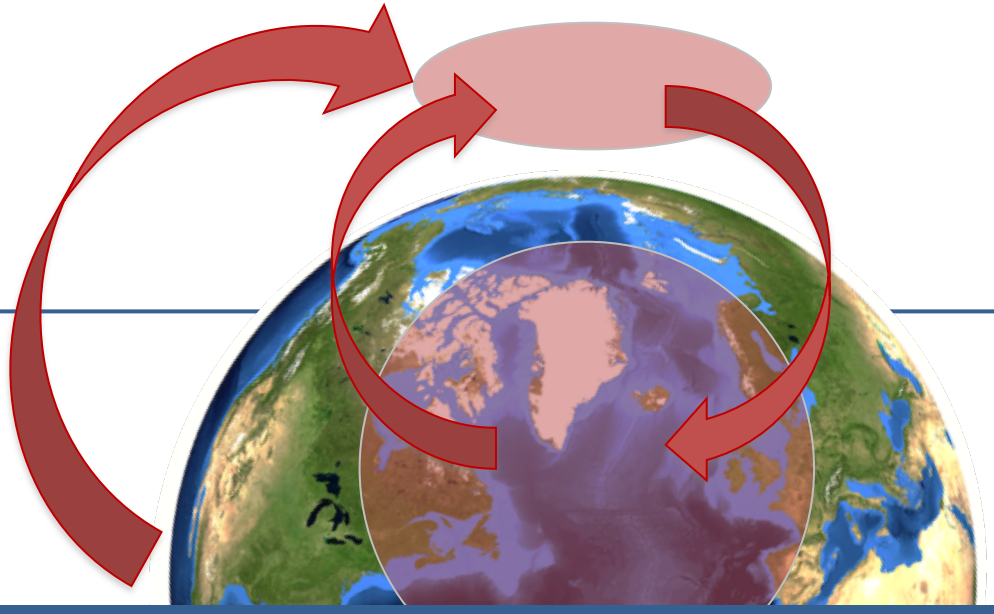

The role of the stratosphere in sub-seasonal to seasonal variability and predictability: A report from the SPARC community

Daniela Domeisen

ETH Zurich, Switzerland

with contributions from

Bernat Jiménez-Esteve, Ole Wulff, Alexander Wollert, Olivia Martius, Amy Butler, Andrew Charlton-Perez, Peter Hitchcock, Gang Chen, Lantao Sun, Gualtiero Badin, Inga Koszalka, Johanna Baehr, Mikhail Dobrynin, Wolfgang Müller, Blanca Ayarzagüena, Mark P. Baldwin, Etienne Dunn-Sigouin, Jason C. Furtado, Chaim I. Garfinkel, Peter Hitchcock, Alexey Yu. Karpechko, Hera Kim, Jeff Knight, Andrea L. Lang, Eun-Pa Lim, Andrew Marshall, Greg Roff, Chen Schwartz, Isla R. Simpson, Seok-Woo Son, Masakazu Taguchi, Scott Osprey, Susann Tegtmeier, Elisa Manzini, Edwin Gerber

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SPARC
Stratosphere-troposphere
Processes And their Role in Climate

SPARC General Assembly 2018
1 - 5 October 2018
Kyoto, Japan

Menu

- Home
- Abstract Submission
- Registration and Accommodation
- Venue and Travel Information
- Program
- Presentation
- Sponsors
- Abstract e-booklet *
- Online Abstract *

* password required

Heian-Jingu Shrine, near the venue

Home

SPARC General Assembly 2018

1 - 5 October 2018

Kyoto, Japan

What's new!!

SPARC GA 2018 Opening Ceremony on October 1st (Monday)

New version of the program for Monday - Wednesday

click here

New schedule on the opening day, Monday

We have suffered influence of another Typhoon Trami, and the following is the new schedule of the opening day, October 1 (Monday):

SPARC
Stratosphere-troposphere
Processes And their Role in Climate

SPARC:
The study of stratosphere - troposphere processes, including chemistry, transport, and dynamics on all timescales from days to centuries using a range of tools including targeted measurements, models and observations

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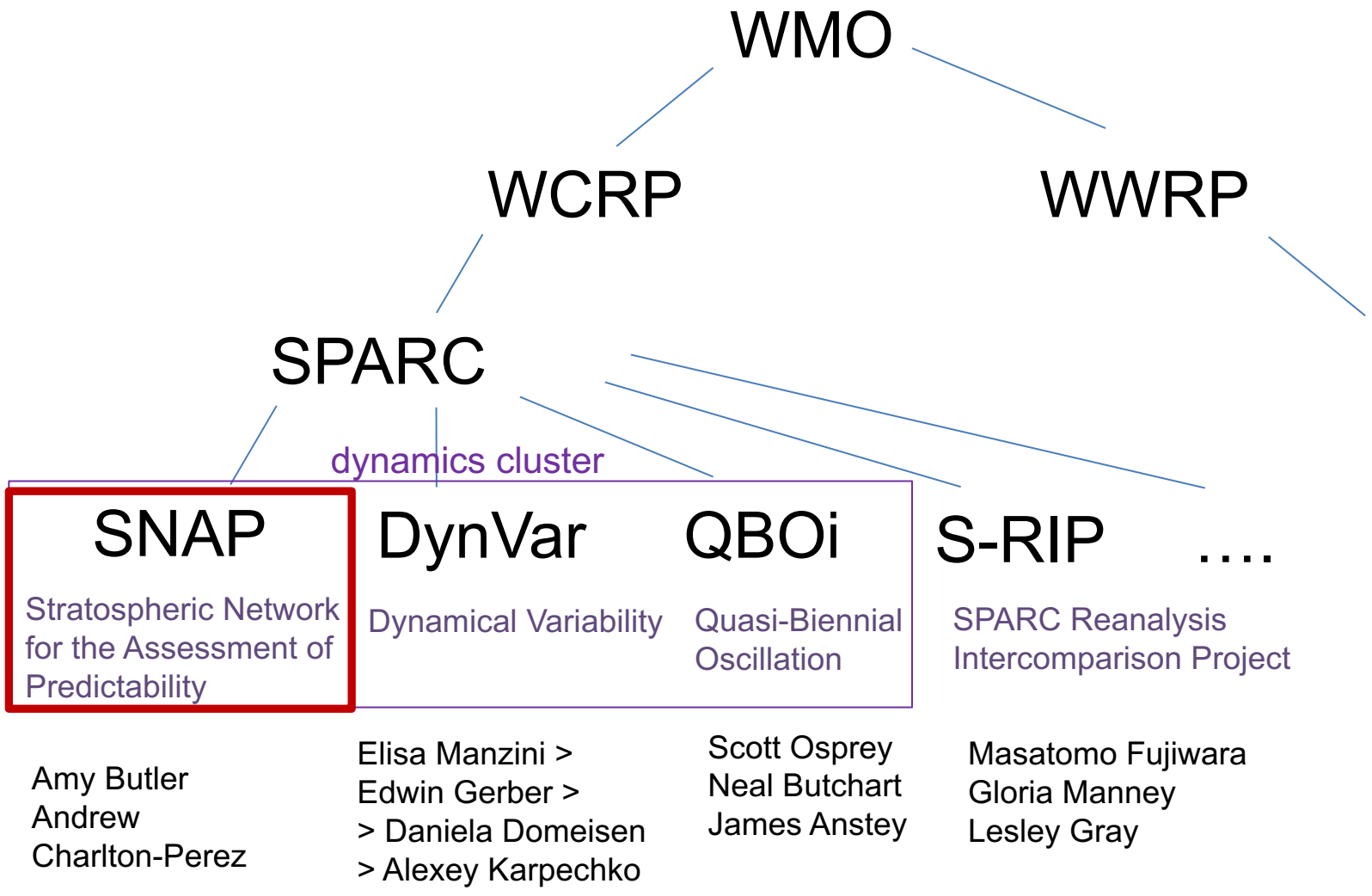
INITIATIVES WITHIN SPARC TO TACKLE PREDICTABILITY AND DYNAMICS



SNAP AND ITS CONNECTIONS TO S2S

(SNAP = STRATOSPHERIC NETWORK FOR THE ASSESSMENT OF PREDICTABILITY)

Outcome from the S2D meeting in Boulder:

- Session on the role of the stratosphere: significant interest in the S2S community about stratospheric processes.
- SNAP is now an official sub-project of the S2S project (A. Charlton-Perez & A. Butler @ Boulder S2D meeting)
- Work on getting stratospheric data for other projects, e.g. SubX, NMME, etc

Subseasonal-to-Seasonal S2S Prediction Project

www.s2sprediction.net

Ongoing work:

- Contributed book chapter to “The Gap between Weather and Climate Forecasting: Sub-seasonal to Seasonal Prediction”
- Overview paper on examination of Stratosphere-Troposphere coupling in S2S database (Domeisen et al., to be submitted to JGR/GRL special issue on S2S prediction)

Sub-seasonal to Seasonal Prediction

1st Edition

The Gap Between Weather and Climate Forecasting

☆☆☆☆☆ Write a review

Editors: Andrew Robertson, Frederic Vitart

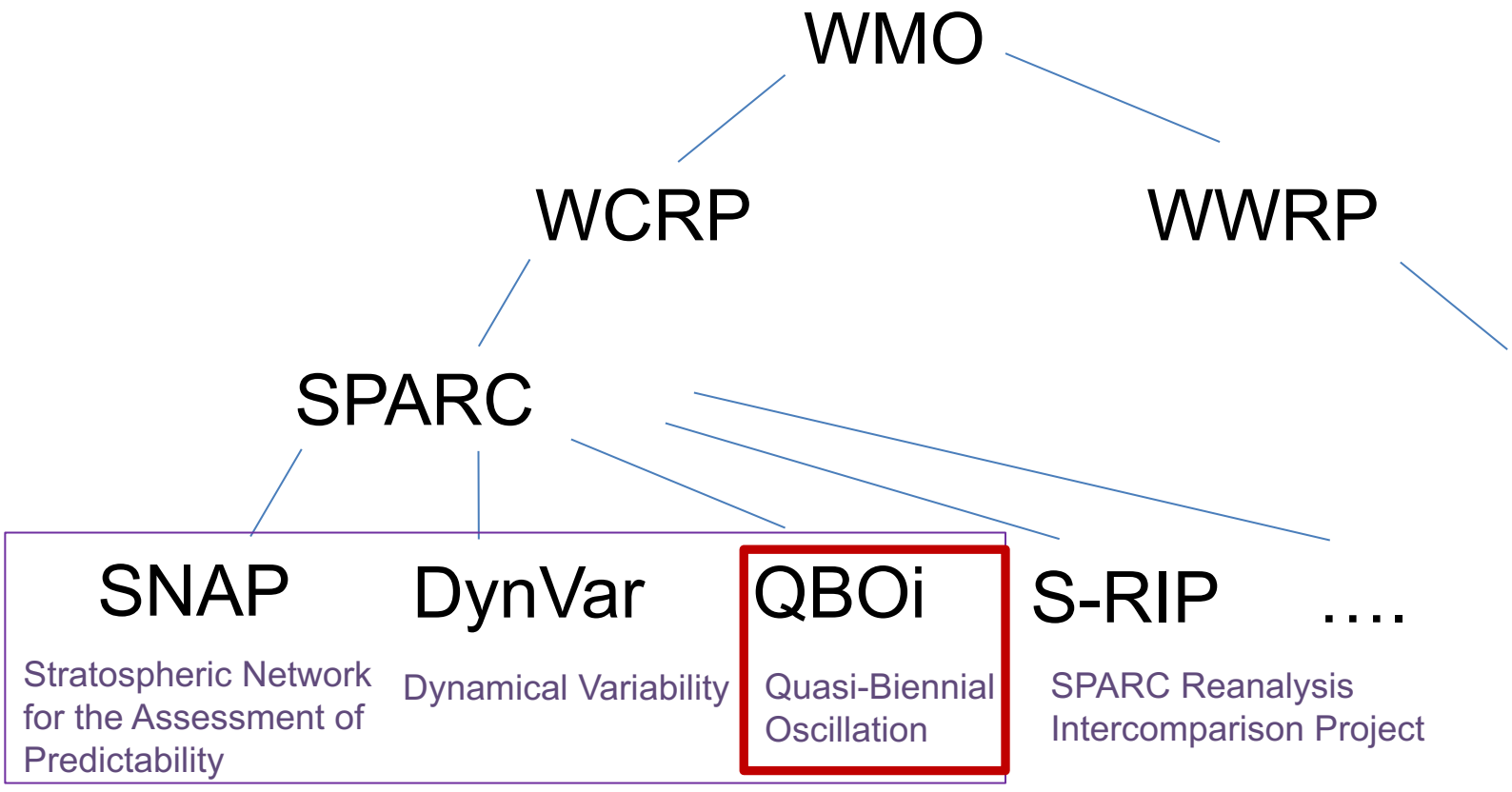
Paperback ISBN: 9780128117149

Imprint: Elsevier

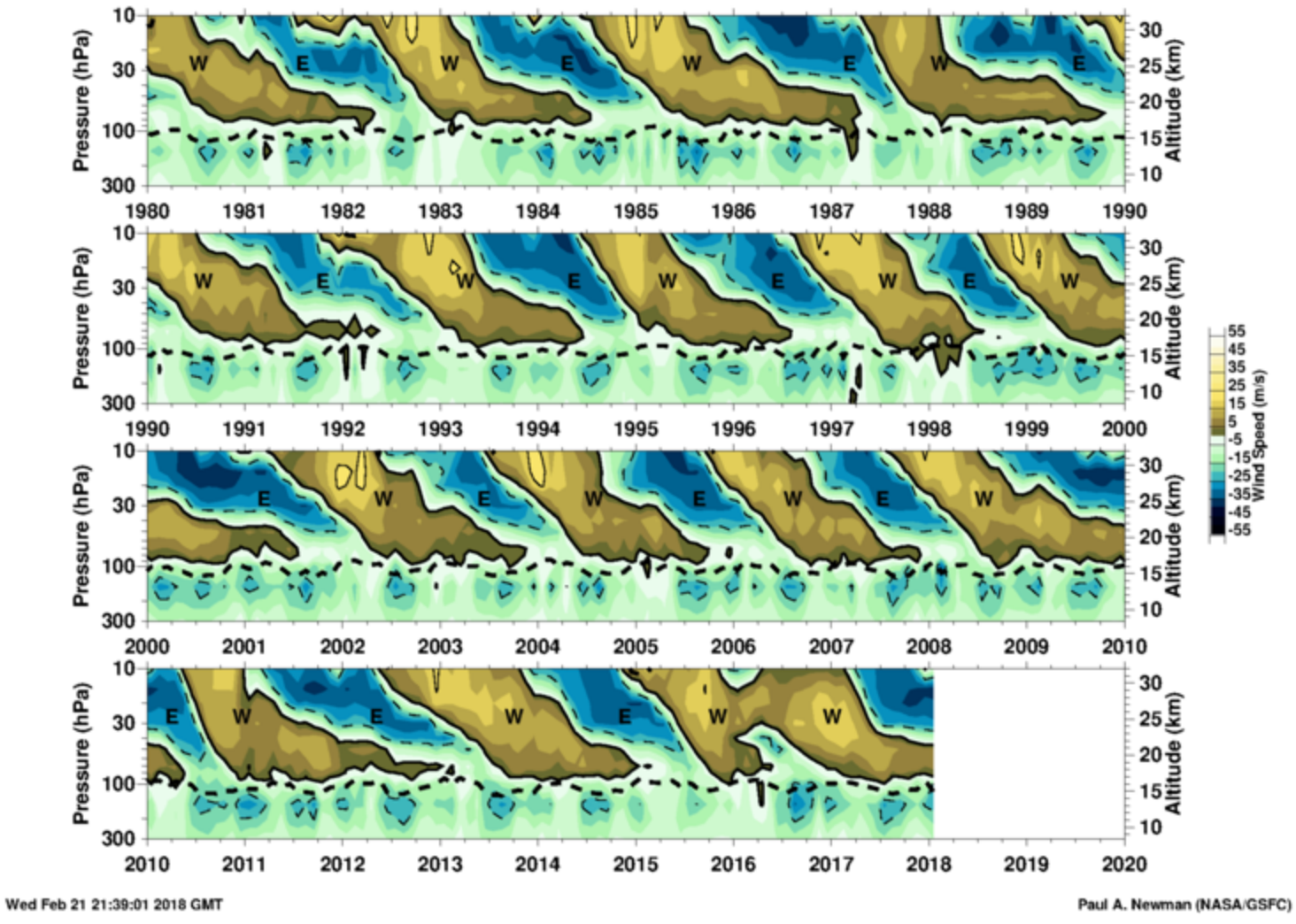
Published Date: 26th October 2018

Page Count: 570

INITIATIVES WITHIN SPARC TO TACKLE PREDICTABILITY AND DYNAMICS



THE QUASI-BIENNIAL OSCILLATION (QBO)



- 26-28-month oscillation of descending easterly and westerly zonal winds in the tropical stratosphere
- driven by tropical tropospheric waves.
- predictable out to several months (except in 2016!)
- remote impacts on tropical troposphere and extratropical stratosphere

[e.g. Garfinkel et al., 2018, JGR]

THE QBOI SPARC INITIATIVE: IMPROVE UNDERSTANDING OF AND ABILITY TO MODEL THE QBO AND ITS IMPACTS

QBOi phase I: 17 models (12 modelling centres) contributed model runs of coordinated experiments to multi-model ensemble (~30 TB of data stored at CEDA). Details in **Butchart et al. 2017 GMD**.

Biases:

current climate:

- QBO amplitude too weak in lowermost stratosphere (~70-30 hPa).
- Teleconnections: Stratospheric polar vortex response: similar to observed, but weaker. NAO response also seen in many models.

future climate (2xCO2 & 4xCO2):

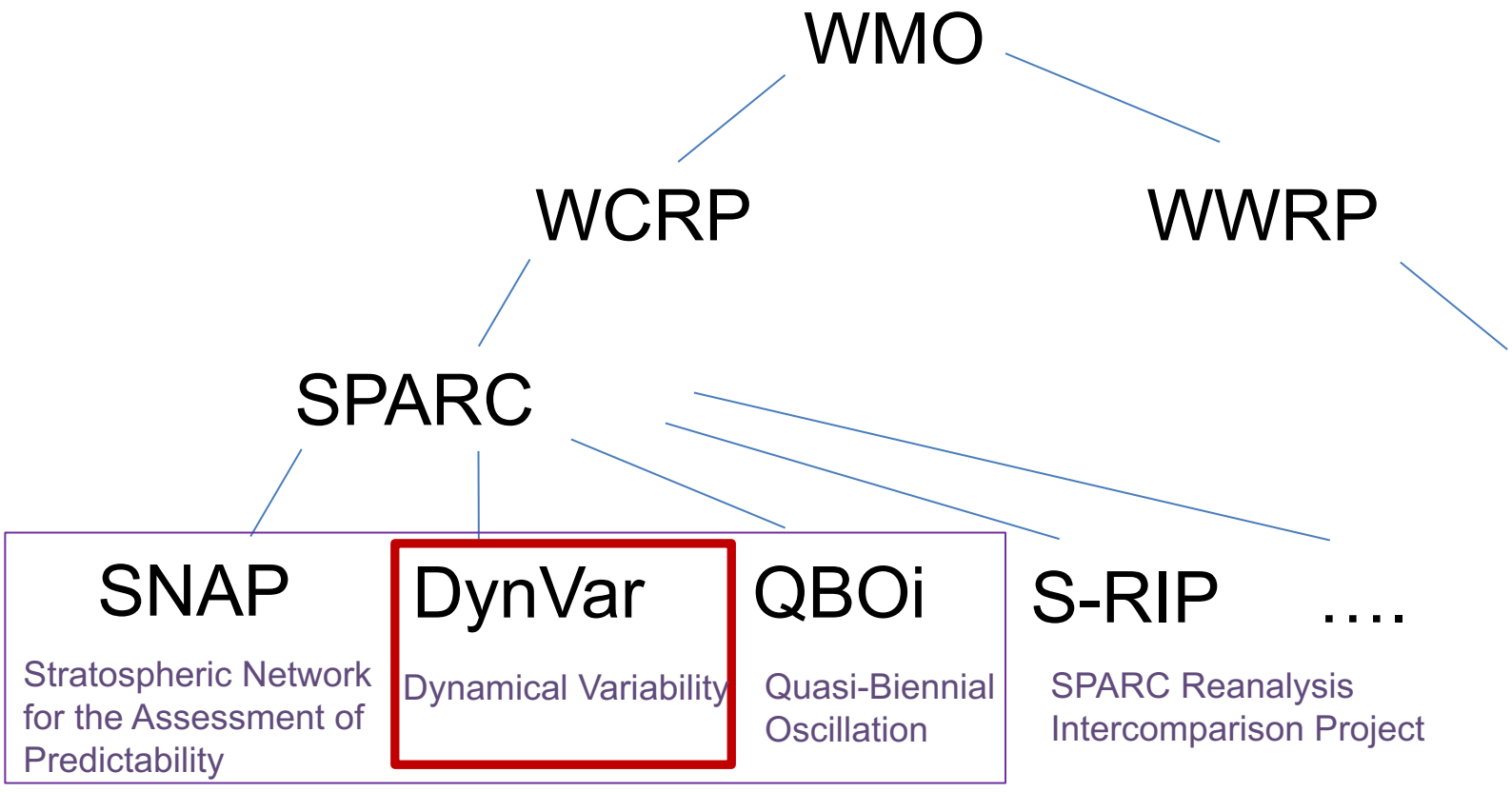
- QBO amplitude robustly decreases.
- QBO period changes, but no consistency between models.
- In many models, QBO vanishes from lowermost stratosphere.

Results to be submitted to QJRMS by Nov 30.

Planned Activities 2019

- Summer School planned by GOTHAM project in Beijing autumn 2019 (QBOi partner groups involved)

INITIATIVES WITHIN SPARC TO TACKLE PREDICTABILITY AND DYNAMICS



DYNVAR
(SPARC ACTIVITY ON DYNAMIC VARIABILITY)

Bridging the SPARC activities focused on dynamics

DynVarMIP: Targeted model intercomparison experiments:
quantify resolved and parameterized momentum and heat transport with finer vertical resolution in CMIP6 models

New focus of DynVar:
dynamics, predictability and extremes across timescales

- teleconnections
- stratospheric influence
- response of the above to a changing climate

Workshop in October 2019 in Madrid (see next slide)

Workshop in 2021: jointly with storm track meeting?

Workshop Announcement!

Atmospheric Circulation in a Changing Climate

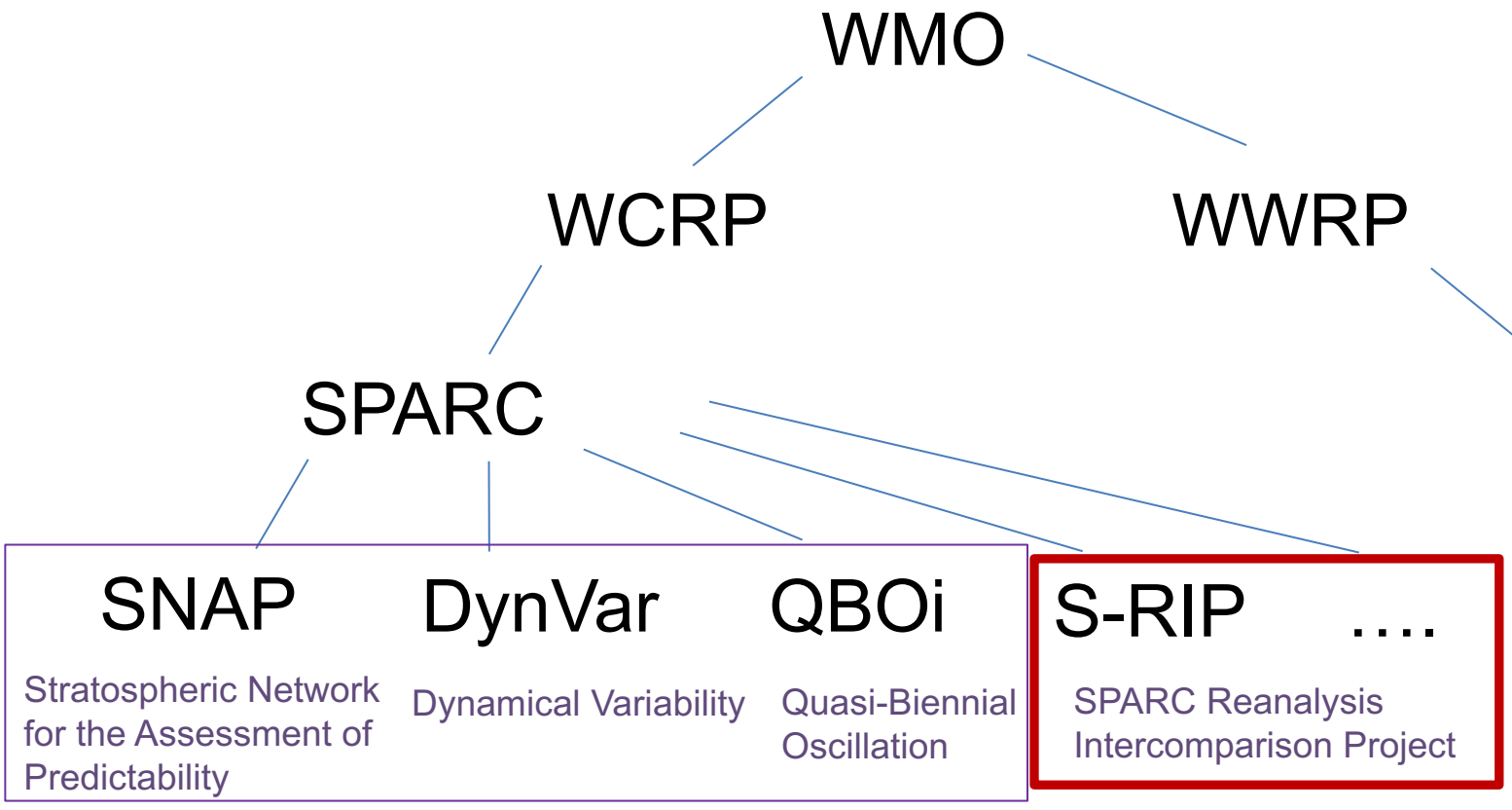
22-25 October 2019, Madrid

A joint meeting of the DynVarMIP and SPARC DynVar Activity, focused on the role of dynamics in predictability and change in our atmosphere.

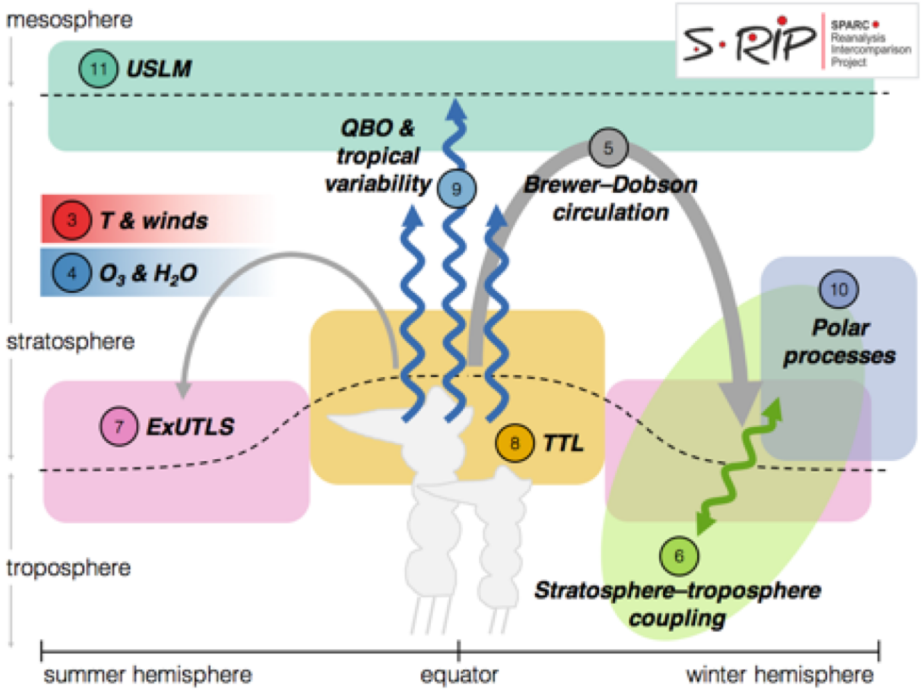
Sponsors:

- Facultad de Ciencias Fisicas, Universidad Complutense de Madrid, Spain,
- Instituto de Geociencias, a joint center of the Universidad Complutense de Madrid and the Consejo Superior de Investigaciones Científicas, Spain,
- Stratosphere-Troposphere Process and their Role in Climate Project of the World Climate Research Program (SPARC/WCRP).

INITIATIVES WITHIN SPARC TO TACKLE PREDICTABILITY AND DYNAMICS

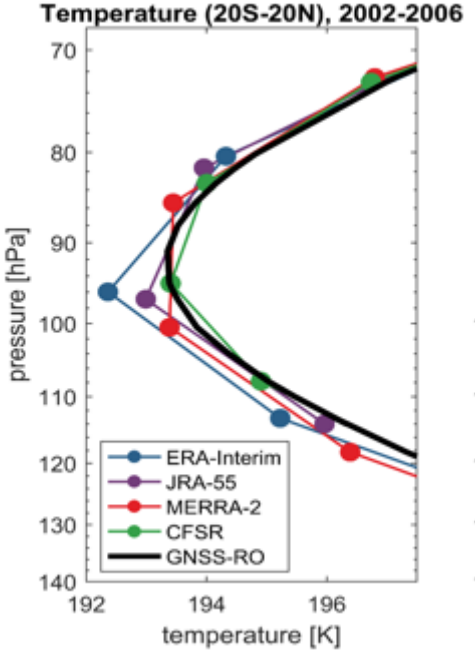


S-RIP: SPARC REANALYSIS INTERCOMPARISON PROJECT



S-RIP evaluates biases in atmospheric parameters such as temperature, wind and ozone.

Example: Tropical tropopause temperatures in comparison to observational (GNSS-RO) data for 20° S-20° N, 2002-2006 show a cold bias.



- Communication platform between researchers and the reanalysis centers.
- Better understanding of differences among reanalyses and their underlying causes.
- Guidance by documenting the intercomparison in peer reviewed papers and SPARC S-RIP report (2019).

See: inter-journal special issue on "The SPARC Reanalysis Intercomparison Project (S-RIP)" in ACP and ESSD

Figures courtesy S. Tegtmeier

SUB-SEASONAL TO SEASONAL PREDICTION: CAN THE STRATOSPHERE HELP?

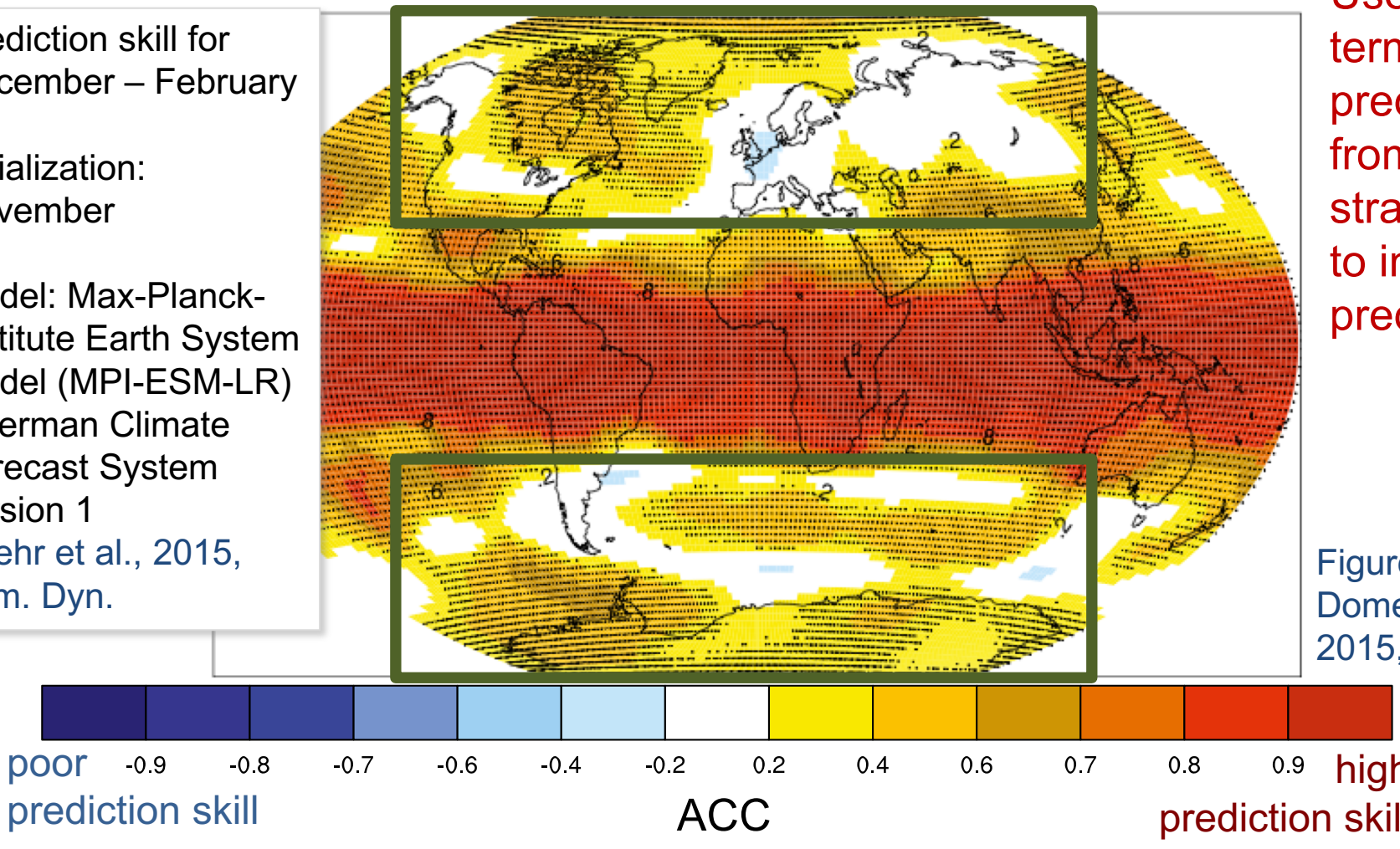
Limited prediction skill outside of the tropics

Prediction skill for December – February

Initialization: November

Model: Max-Planck-Institute Earth System Model (MPI-ESM-LR) / German Climate Forecast System version 1

Baehr et al., 2015, Clim. Dyn.



Use the longer term predictability from stratosphere to improve prediction skill

Figure from: Domeisen et al., 2015, J.Climate.

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USING THE S2S HINDCAST DATABASE

Using all available stratospheric data (Vitart et al., 2016)

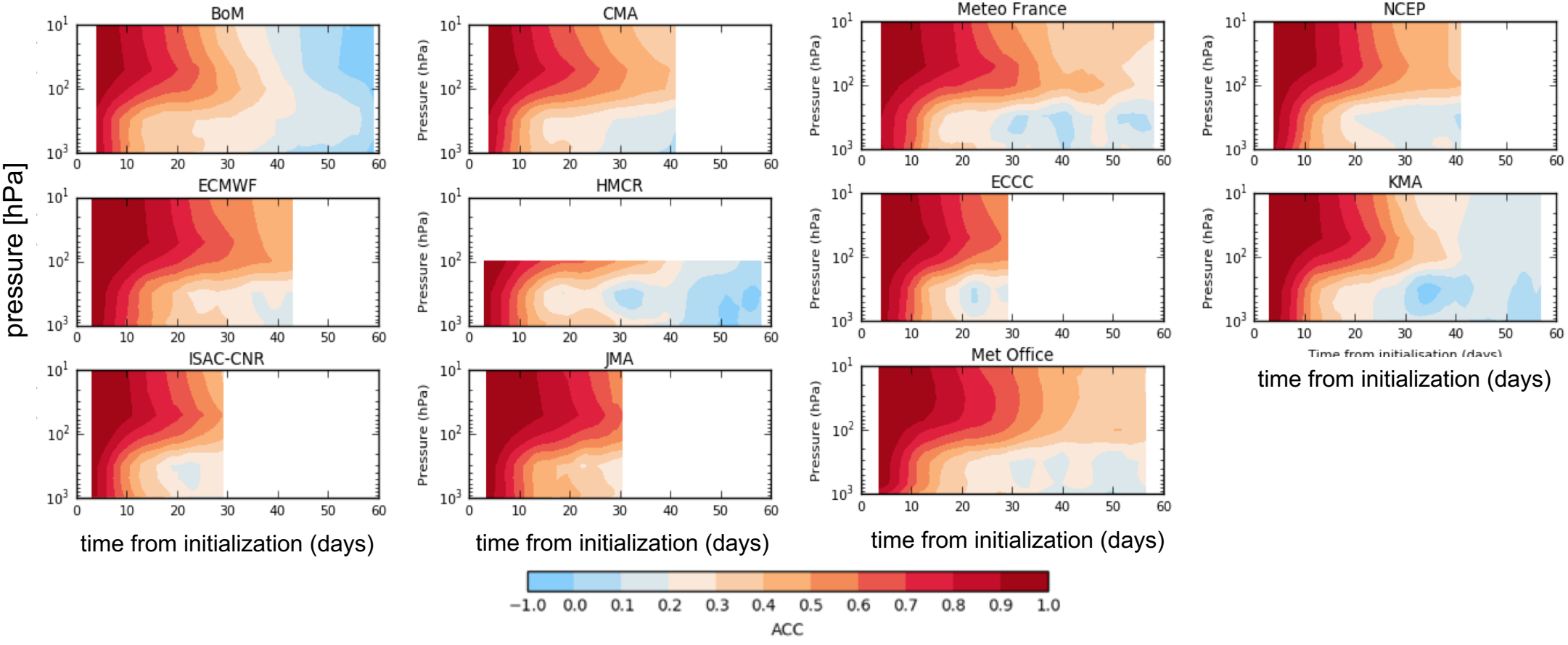
	Model	Rfc length	Resolution	Rfc period	Rfc frequency	Ensemble size
*	BoM	D 0-61	T47 L17	1981-2013	6/month	33
*	CMA	D 0-59	T106 L40	1994-2014	6/month	4
*	ECCC	D 0-31	0.45°x0.45° L40	1995-2014	Weekly	4
*	ECMWF	D 0-46	T639/319 L91	1997-2016	2/week	11
	HMCR	D 0-61	1.1°x1.4° L28	1985-2010	Weekly	10
*	CNR-ISAC	D 0-32	0.75°x0.56° L54	1981-2010	Every 5 days	1
*	JMA	D 0-33	T319 L60	1981-2010	3/month	5
*	KMA	D 0-60	N216 L85	1991-2010	4/month	3
	CNRM-Meteo	D 0-60	T255 L91	1993-2014	2/month	15
	NCEP	D 0-44	T126 L64	1999-2010	6/month	4
*	UKMO	D 0-60	N216 L85	1993-2015	4/month	4

* used in this analysis

Figure: H. Kim

COMPARING S2S PREDICTABILITY IN THE TROPOSPHERE AND THE STRATOSPHERE

In general, the stratosphere is more predictable than the troposphere

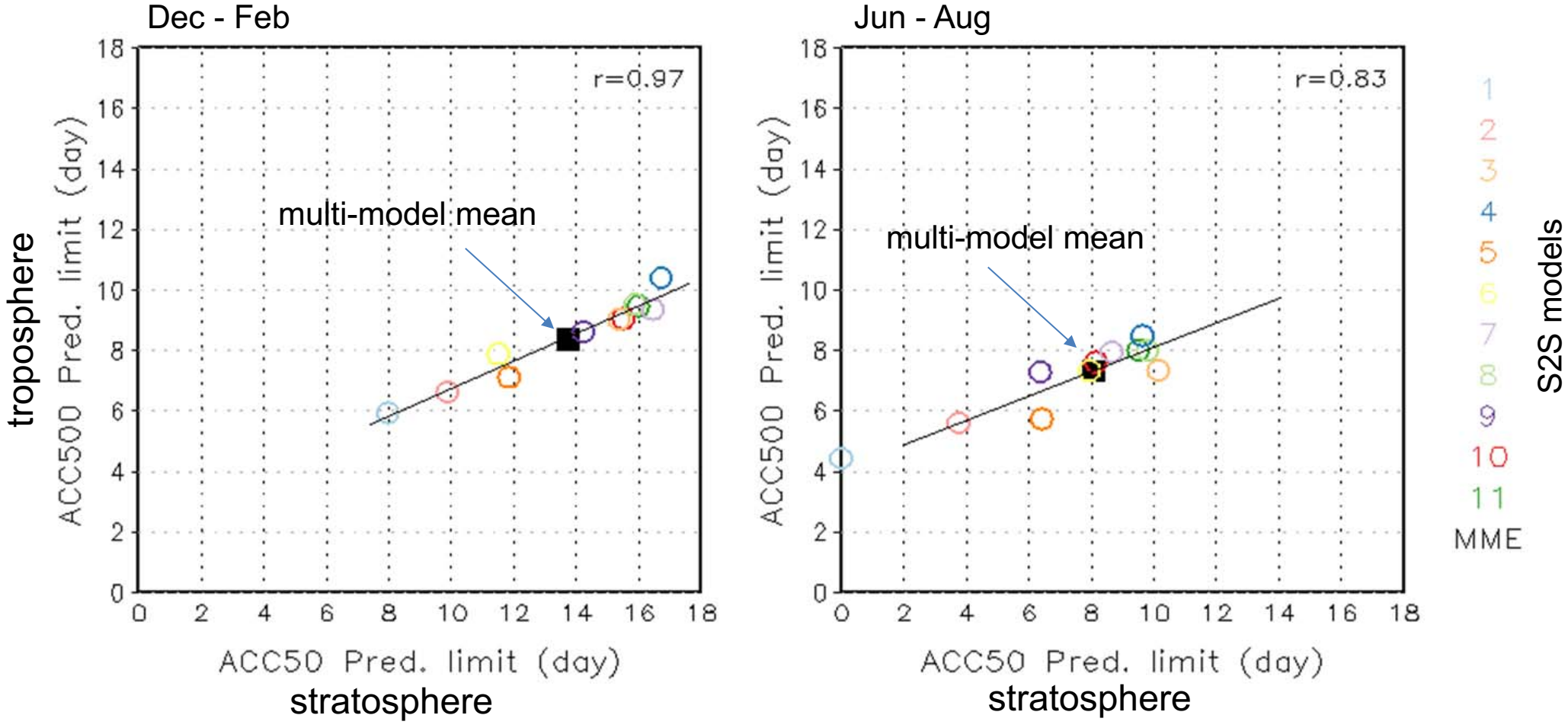


Anomaly correlation coefficient for the winter Northern Hemisphere atmosphere at 60N / 10hPa
Stratosphere: zonal mean. Troposphere: N. Atlantic / Europe

Figure: J. Knight

COMPARING S2S PREDICTABILITY IN THE TROPOSPHERE AND THE STRATOSPHERE

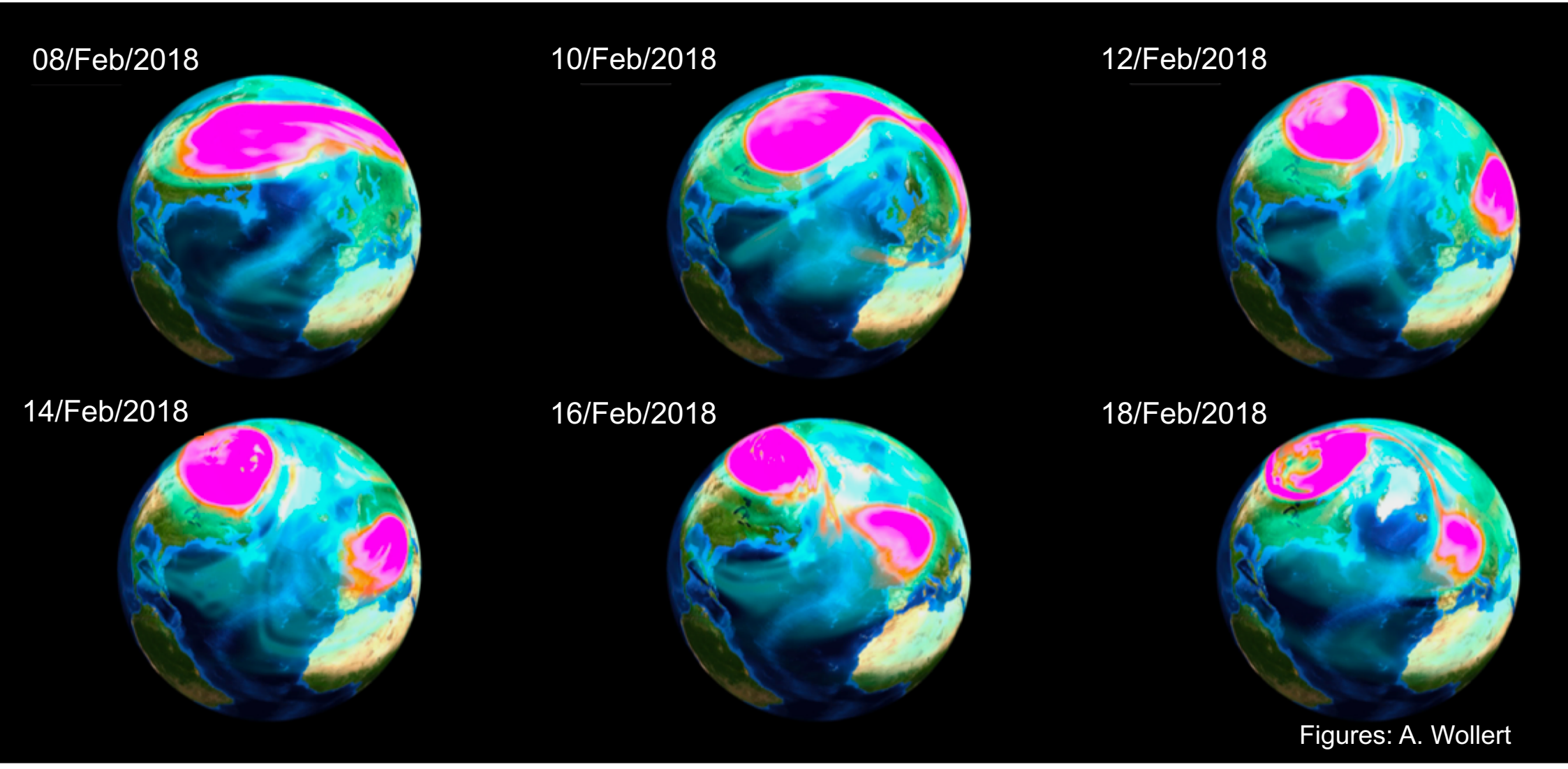
High skill in the troposphere correlates with high skill in the stratosphere



prediction limit = the lead time when the ACC drops below 0.6

Figure: H. Kim

THE SUDDEN STRATOSPHERIC WARMING EVENT ON FEBRUARY 12, 2018



PREDICTABILITY OF EXTREME STRATOSPHERIC EVENTS (NH)

SSW events are often not predictable on S2S timescales

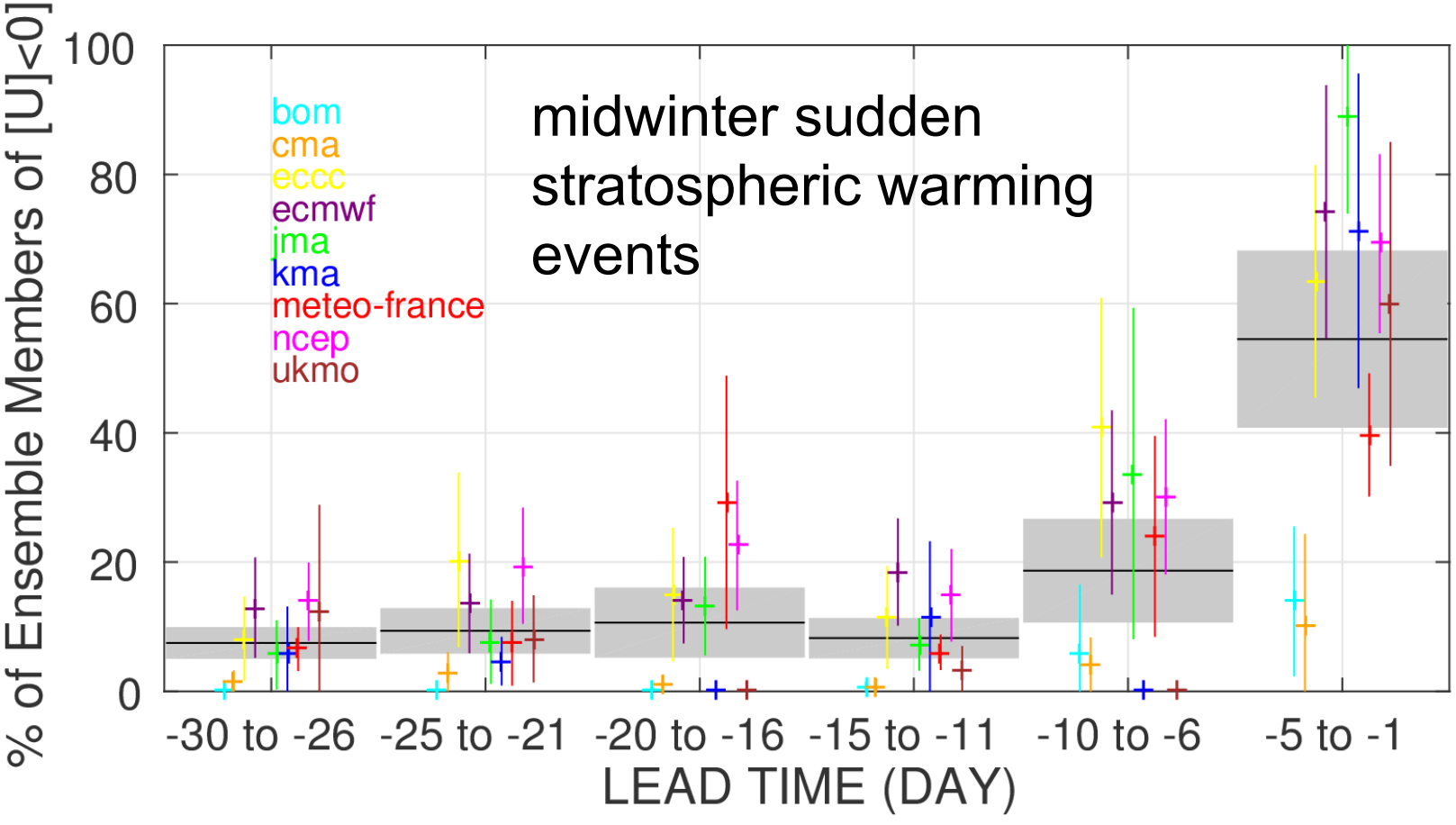
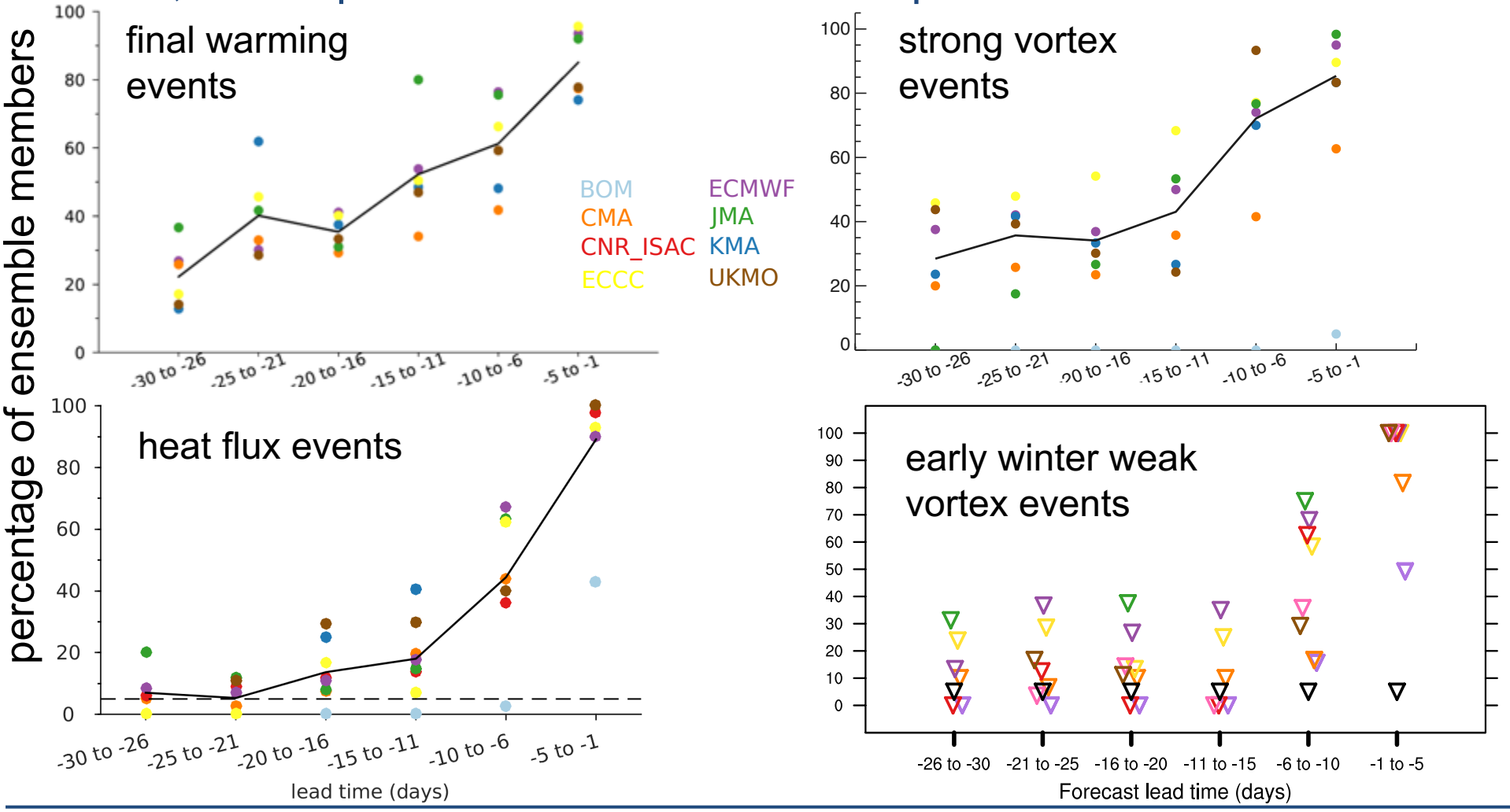


Figure: M. Taguchi

PREDICTABILITY OF EXTREME STRATOSPHERIC EVENTS (NH)

Overall, stratospheric events are difficult to predict on S2S timescales

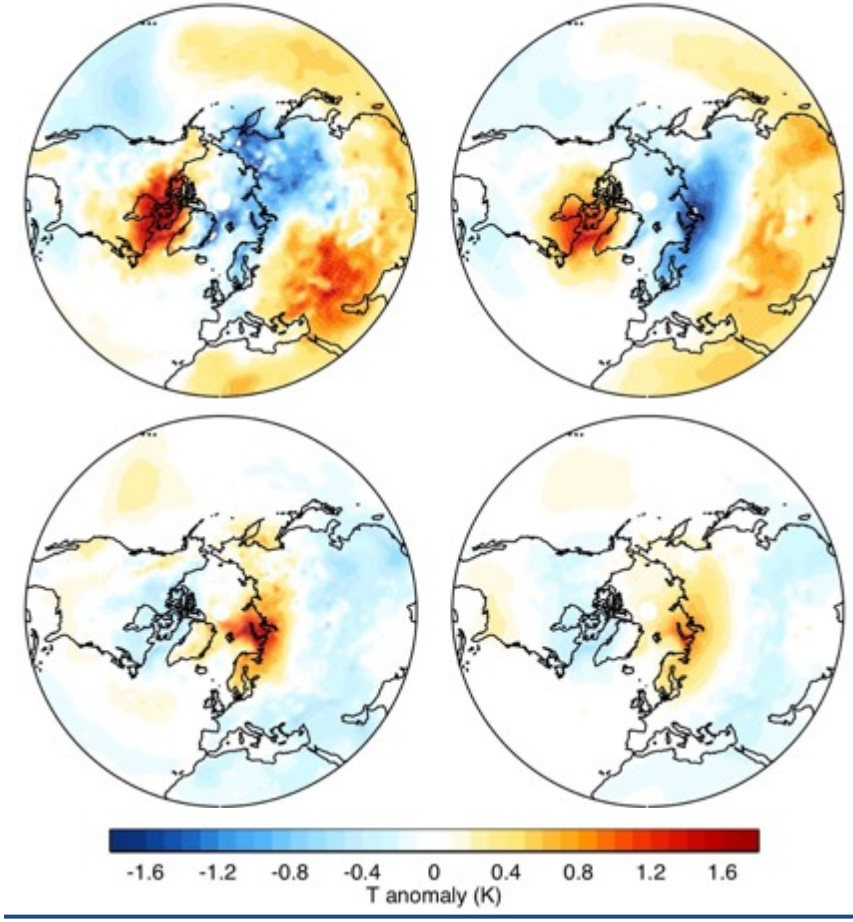


Figures: A. Karpechko, A. Butler, A. Lang, E. Dunn-Sigouin

SURFACE IMPACT AFTER STRATOSPHERIC EVENTS

SSW and strong vortex events have opposite surface impacts

ERA-interim multi-model mean



2m temperature anomaly (week 3 + 4) after:

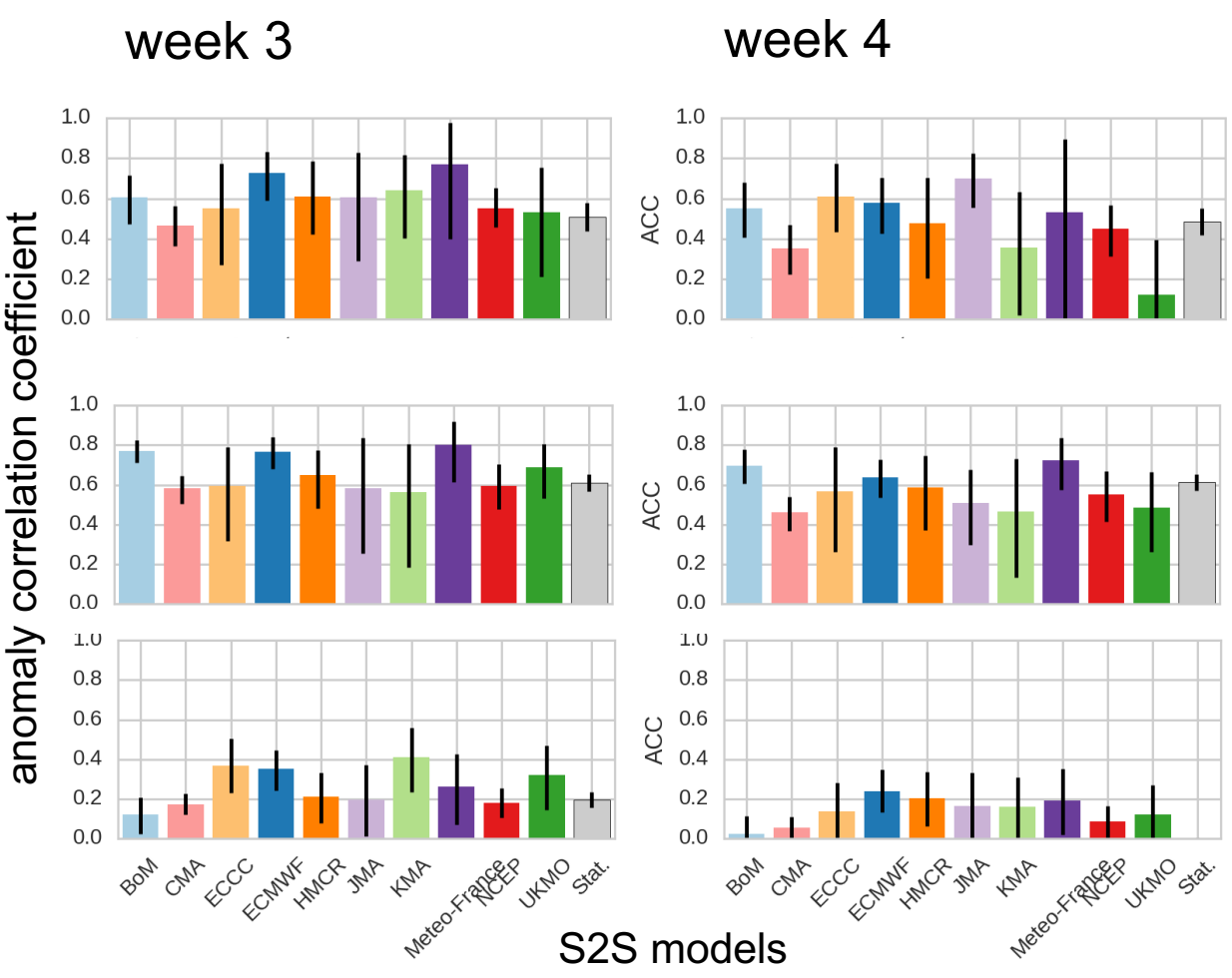
weak vortex events (SSW):
negative NAO

strong vortex events:
positive NAO

Figure: I. Simpson

SURFACE PREDICTABILITY AFTER STRATOSPHERIC EVENTS IS INCREASED

Stratospheric events increase surface predictability on S2S timescales



Predictability (ACC) at 1000hPa (polar cap average) after:

weak vortex events (SSW)

strong vortex events

neutral vortex
(minimal stratospheric influence)

Figure: A. Charlton-Perez

SURFACE PREDICTABILITY AFTER STRATOSPHERIC EVENTS IS INCREASED

- A well represented stratosphere improves surface forecasts for teleconnections from e.g. ENSO

[Domeisen et al., 2015; Butler et al., 2016]

- Nudging stratospheric state towards observations can substantially increase skill in extratropical troposphere

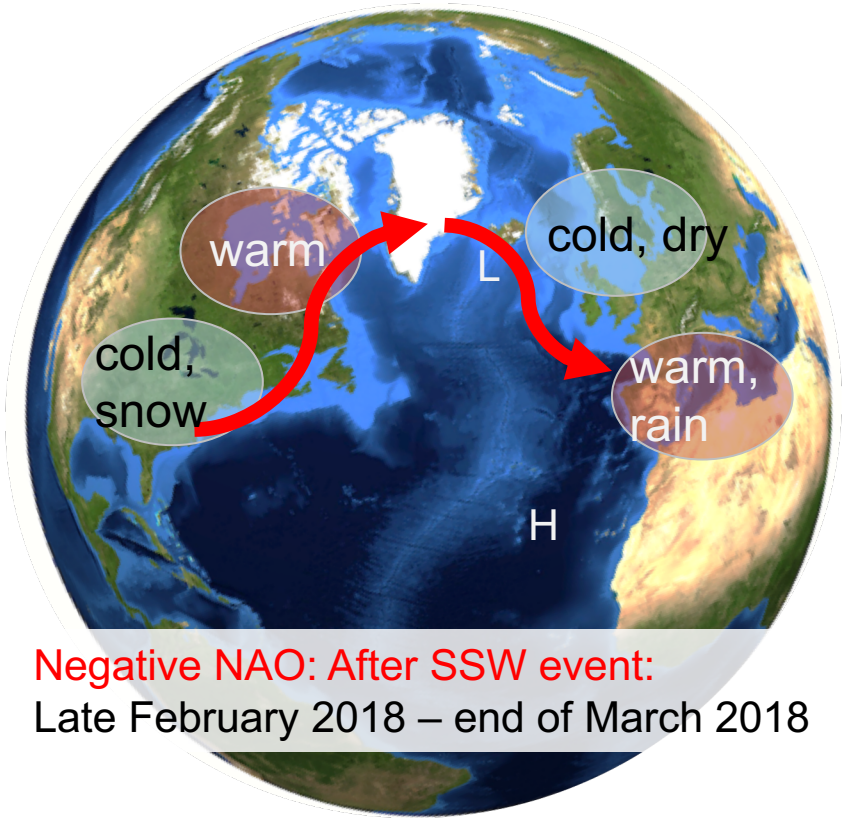
[Charlton et al. 2004; Scaife and Knight 2008; Douville 2009; Hansen et al. 2017; Jia et al. 2017]

- Splitting hindcasts into groups initialized during strong, weak, and neutral vortex conditions show enhanced S2S surface climate prediction for stratospheric extremes.

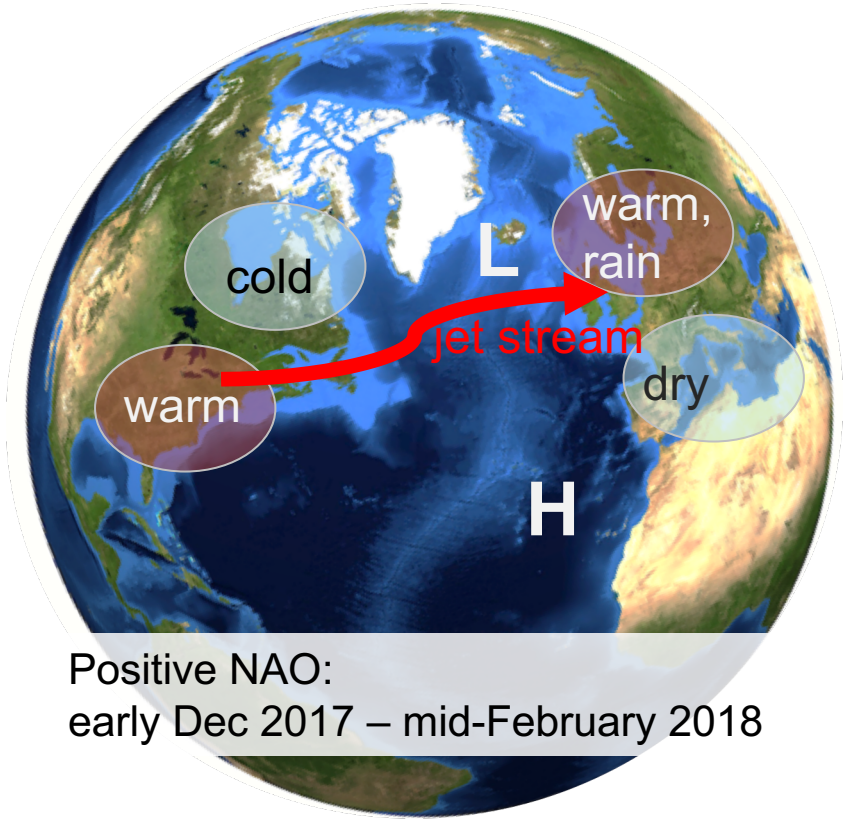
[e.g., Mukougawa et al. 2009; Sigmond et al. 2013, Tripathi et al. 2015]

STRATOSPHERIC INFLUENCE ON OUR WEATHER

Negative NAO tendency after a sudden stratospheric warming event



Negative NAO: After SSW event:
Late February 2018 – end of March 2018



Positive NAO:
early Dec 2017 – mid-February 2018

Sudden stratospheric warming events lead to a wavy jet stream with cold weather in northern and central Europe.

HOW WELL DO WE PREDICT THE NAO ON SEASONAL TIMESCALES?

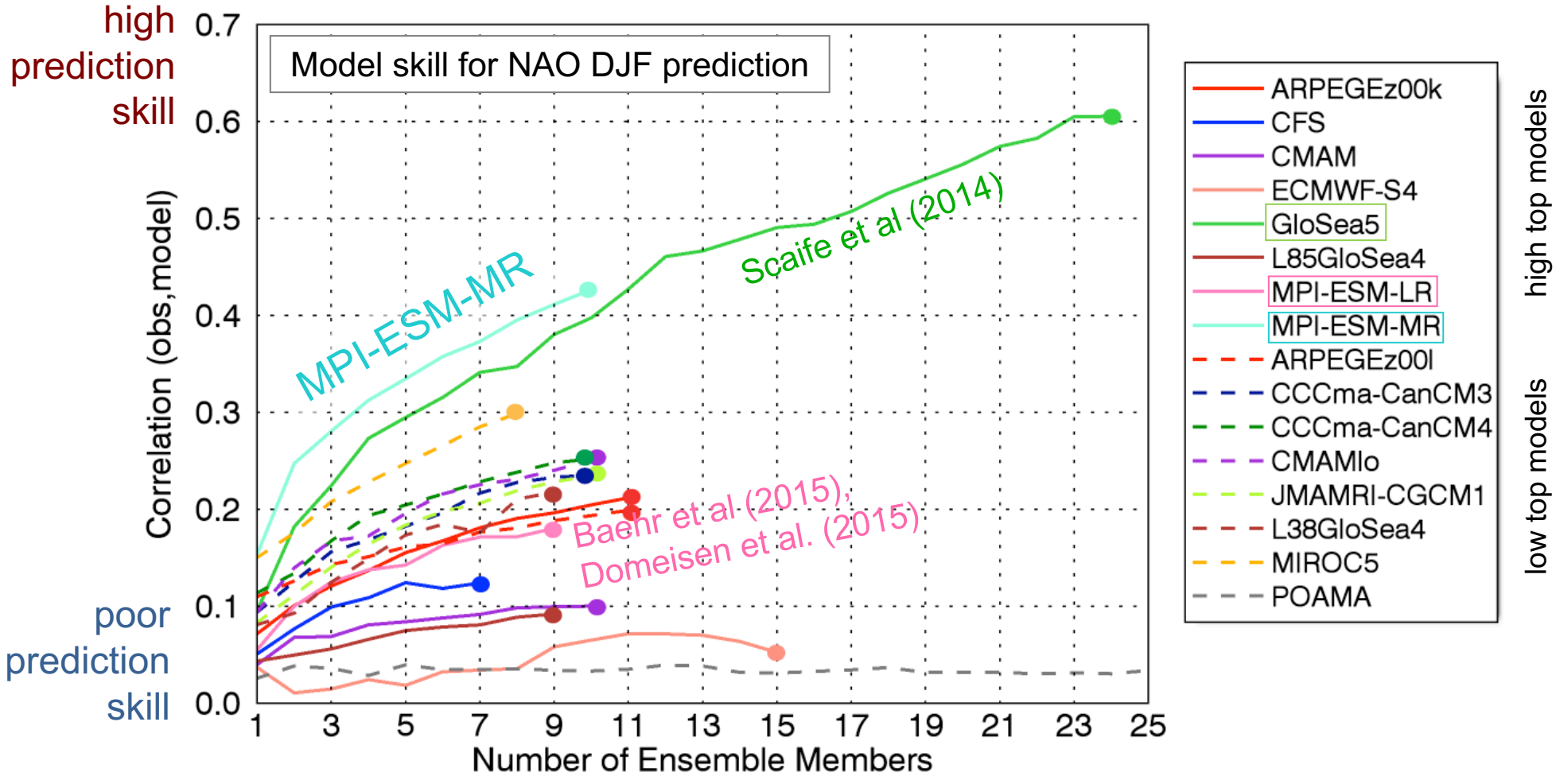
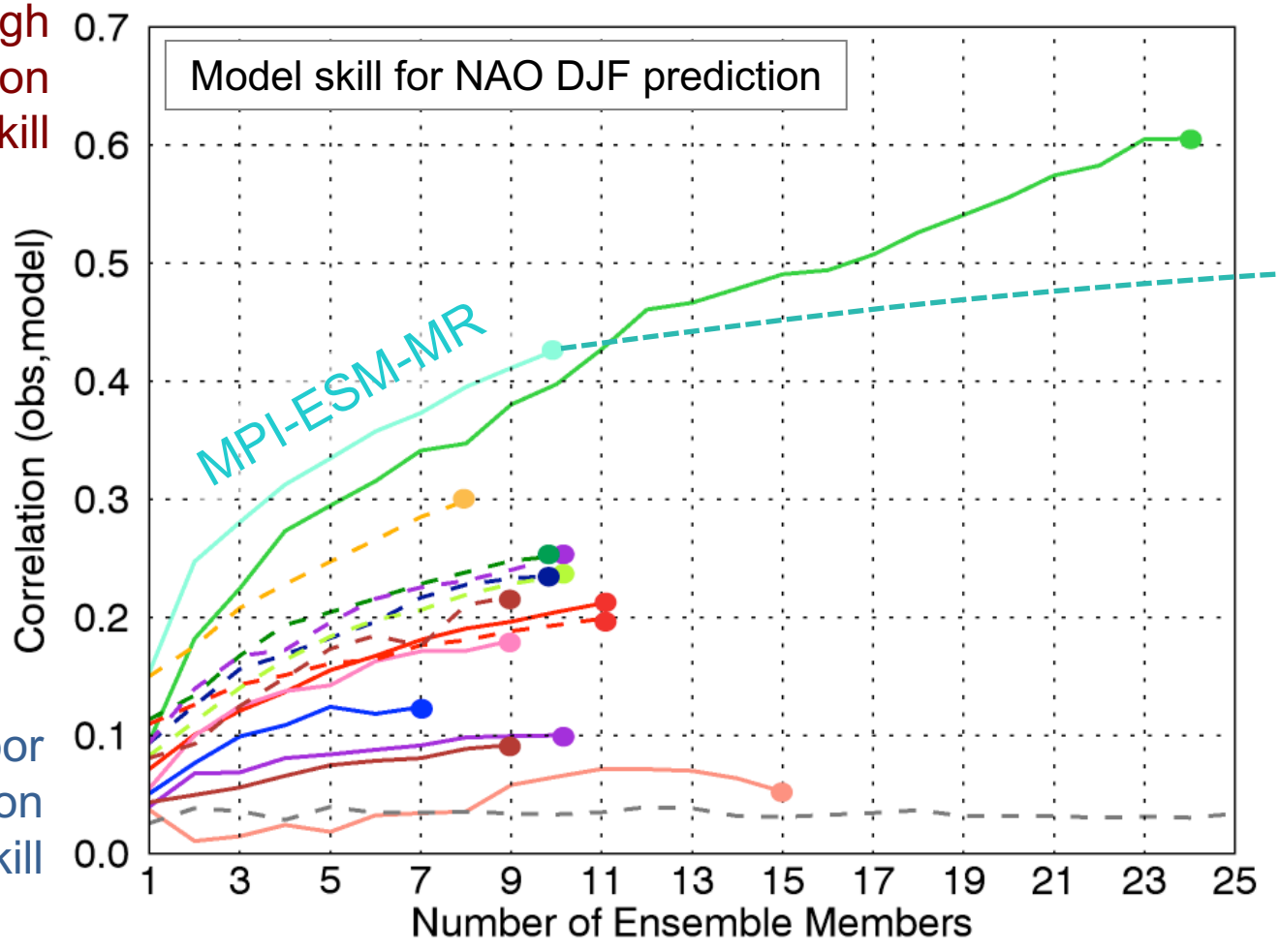


Figure: Butler et al (2016), QJRMS

HOW WELL DO WE PREDICT THE NAO ON SEASONAL TIMESCALES?

high prediction skill

poor prediction skill



0.49
30 ensemble members

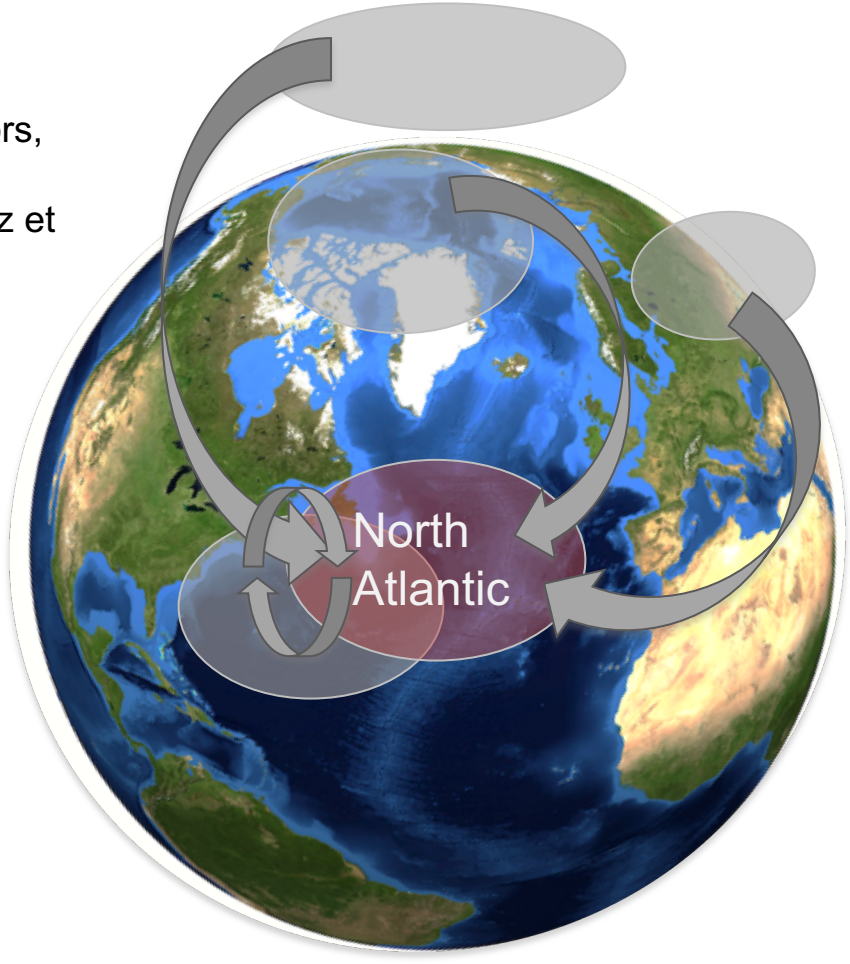
Dobrynin et al, 2018, GRL

Figure: Butler et al (2016), QJRMS

ADD STATISTICAL FORECAST TO IMPROVE NAO SKILL

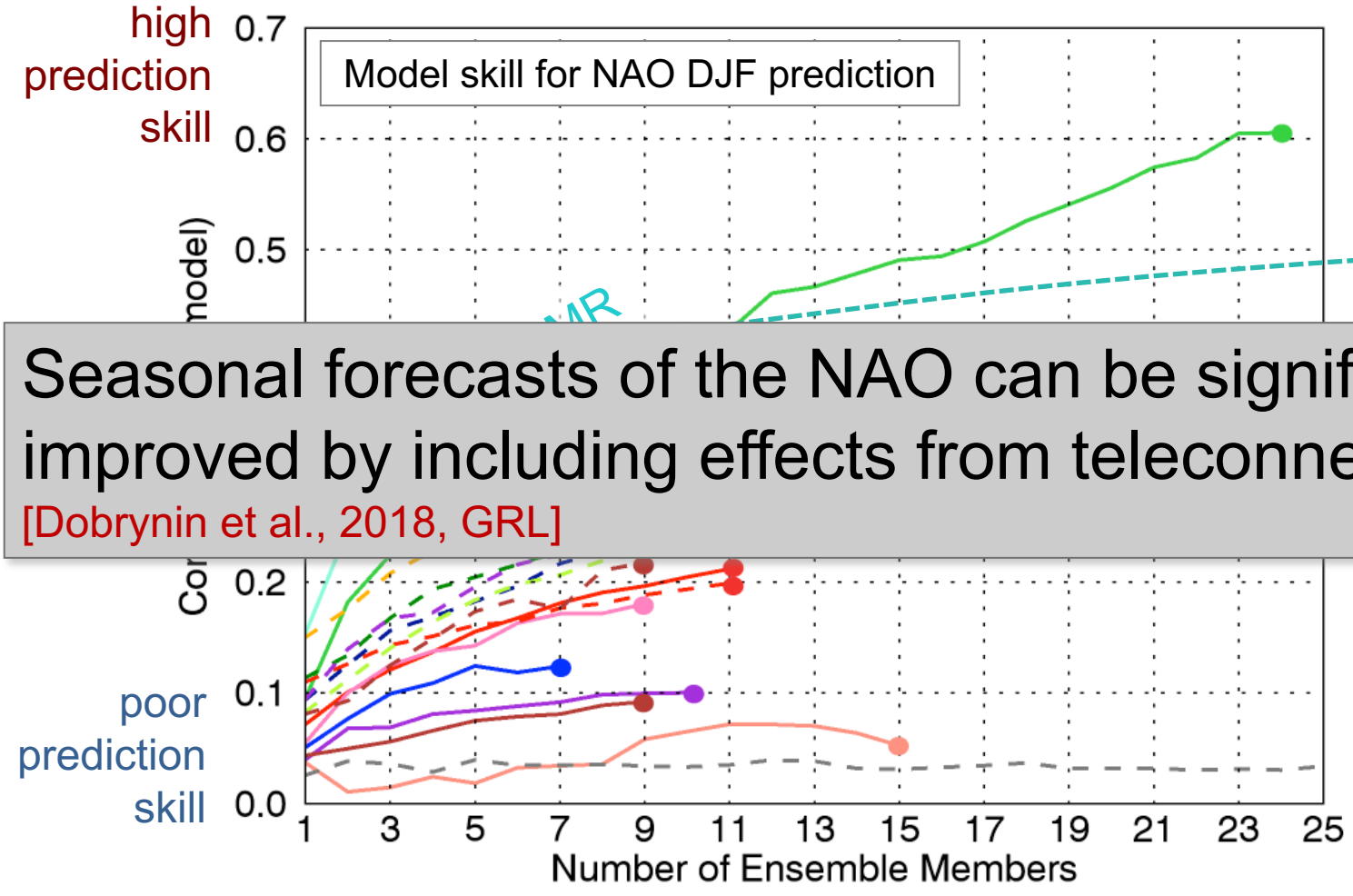
Statistical predictors: SST, snow cover, sea ice, stratosphere

For more info on these predictors, see also: e.g. Cohen & Jones, 2011, Karpechko, 2015, Duchez et al., 2016



Dobrynin et al, 2018, GRL

HOW WELL DO WE PREDICT THE NAO ON SEASONAL TIMESCALES?



0.83

Added statistical forecast

0.49

Seasonal forecasts of the NAO can be significantly improved by including effects from teleconnections

[Dobrynin et al., 2018, GRL]

It's not just the stratosphere, but the stratosphere is certainly part of the picture

Figure: Butler et al (2016), QJRMS

FOCUS ON IMPROVEMENTS IN MODEL BIASES

- Stratospheric biases:

Model top, vertical resolution, small-scale wave parameterizations

[Marshall and Scaife 2010, Maycock et al. 2011, Charlton-Perez et al. 2013, Shaw et al. 2014, Seviour et al. 2016]

- Tropospheric biases:

precursors to stratospheric variability, tropospheric response to stratospheric forcing

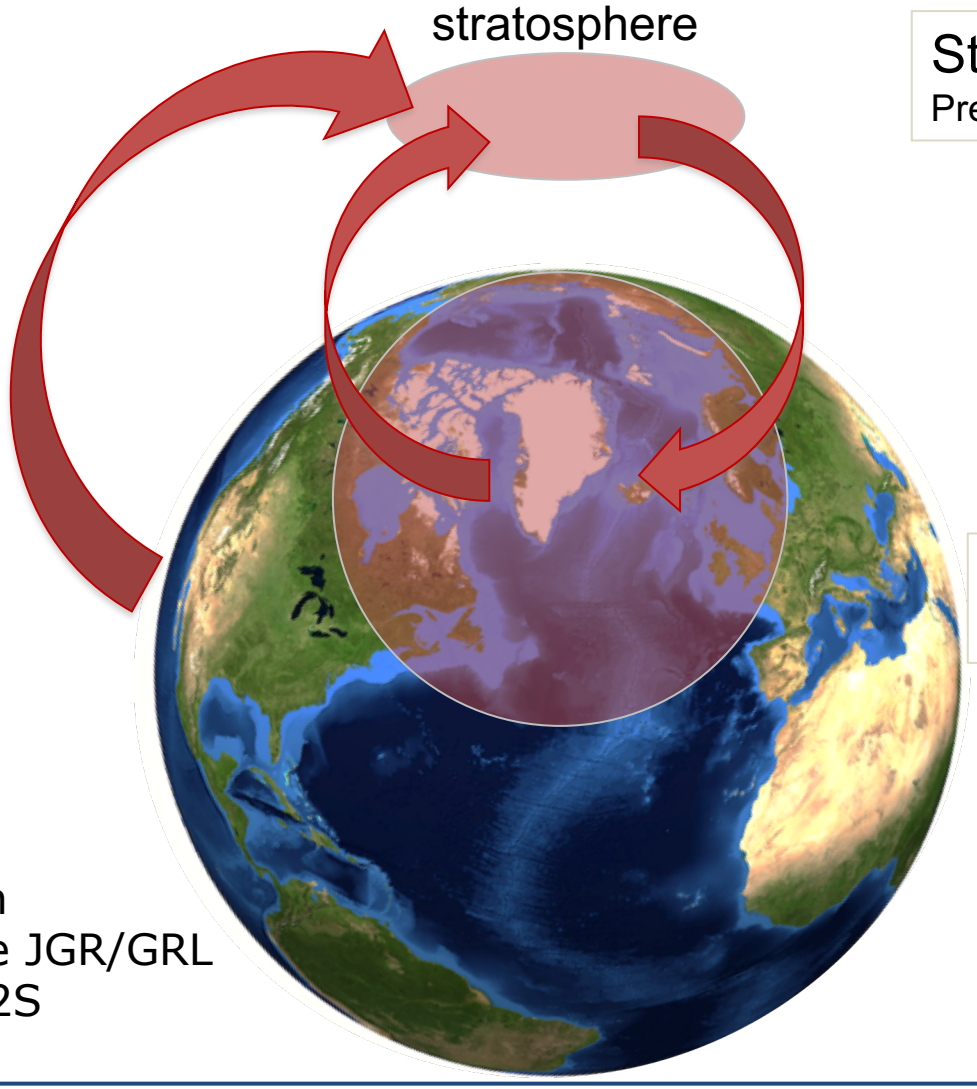
[Garfinkel et al. 2012, 2013]

- Biases in pathways between troposphere and stratosphere: e.g., inability to capture observed QBO influences on extratropical surface in many models

[Scaife et al. 2014, Butler et al. 2016, Garfinkel et al. 2018]

SUMMARY

Although the stratosphere itself exhibits limited predictability on S2S timescales, it is an important factor for adding predictability to the troposphere on S2S timescales



Stratospheric event
Predictability: days to weeks

Tropospheric impact
Persistence: weeks to months

Domeisen et al., in preparation for the JGR/GRL special issue on S2S prediction

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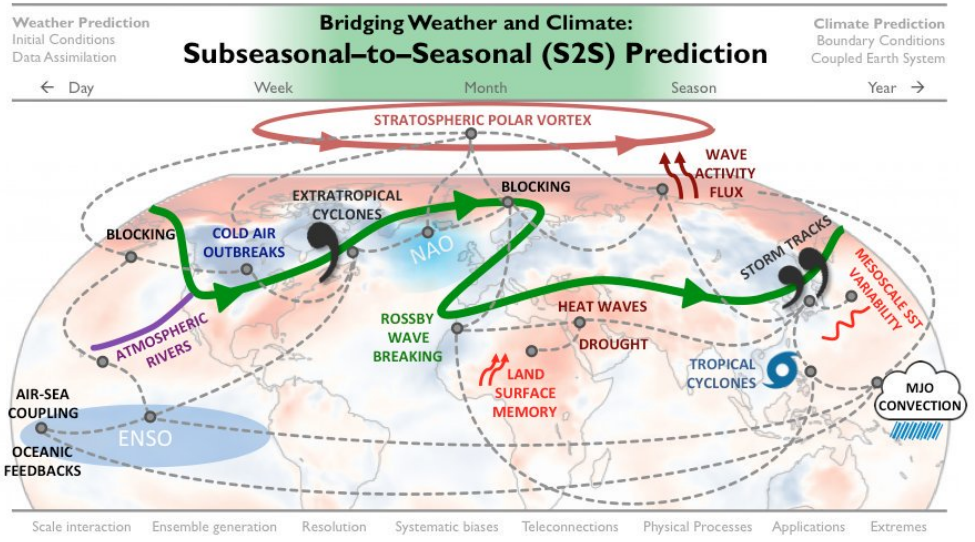
SPECIAL COLLECTION ON S2S: GRL AND JGR

Call for Papers: S2S Prediction joint Special Issue in *JGR-Atmospheres & GRL*



Submissions: 1 May 2018 – 30 April 2019

Bridging the prediction gap between weather and climate forecasts, Subseasonal-to-Seasonal (S2S) prediction is an area of active research addressing the high demand for skillful forecasts on these time scales. The NOAA Modeling, Analysis, Predictions and Projections (MAPP) Program Subseasonal-to-Seasonal (S2S) Prediction Task Force, in affiliation with the international S2S Prediction Project, is spearheading key research and providing a framework for needed weather-climate and research–operational community interactions. This Special Collection will present results from these research initiatives and the broader S2S community. The Collection will feature contributions to the understanding of predictability and processes at S2S time scales, and the potential to advance their operational prediction.

Manuscripts should be submitted through the GEMS websites for JGR Atmospheres and GRL.

Special Collection Organizers & Guest Editors:
E. Barnes (CSU), A. Lang (UAlbany), and K. Pegion (GMU)