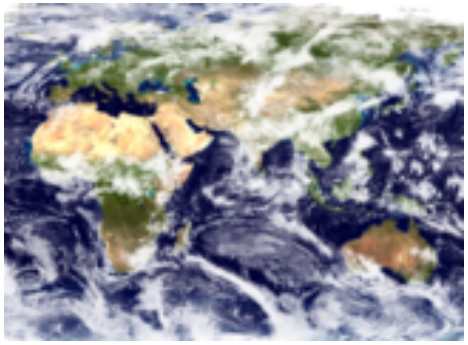
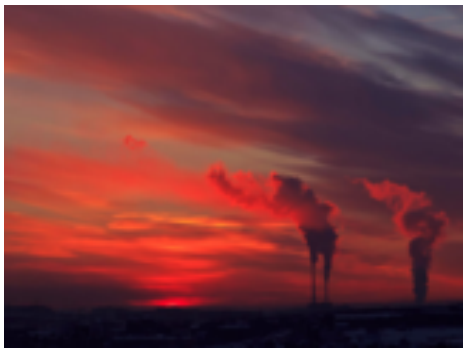
SPARC's 3 Main Themes



Atmospheric dynamics and predictability

Understanding atmospheric dynamics and climate variability to provide better climate predictions on scales from seasonal all the way to centennial.



Chemistry and climate

Understanding the three-way coupling between chemical, dynamical, and radiative processes and their effects on climate, including modulation of climate sensitivity.

Long-term records for climate understanding

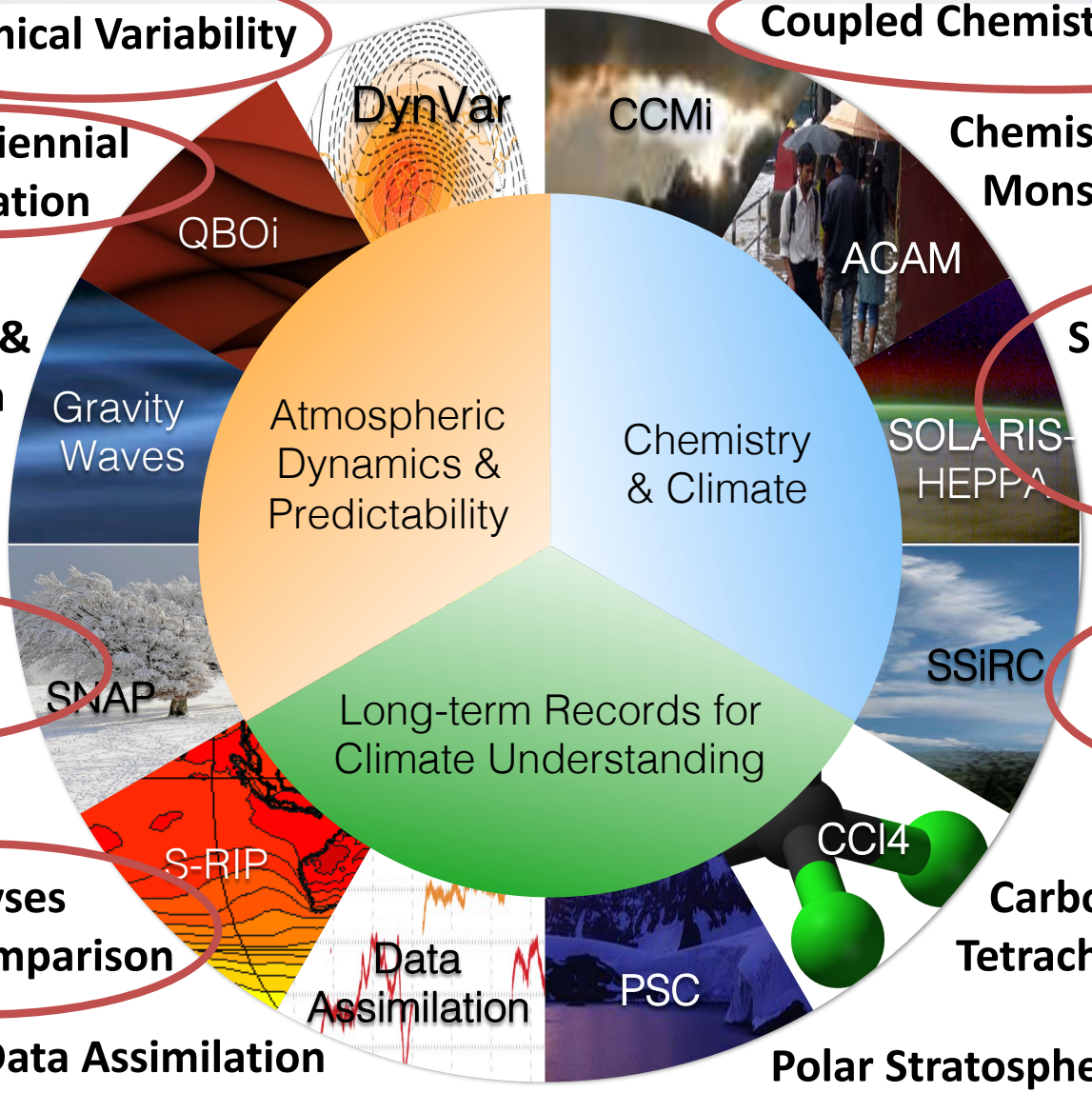
Promoting the creation, analysis, and interpretation of long-term climate observations that require international cooperation.

SPARC

Activity Overview

SPARC
Stratosphere-troposphere
Processes And their Role in Climate

WCRP
World Climate Research Programme



Dynamical Variability

Quasi-biennial Oscillation

Gravity Waves & Momentum Budget

Assessing Predictability

Reanalyses Intercomparison

Data Assimilation

Coupled Chemistry Modeling

Chemistry in Asian Monsoon Region

Solar & High-Energy Particle Influences

Stratospheric Sulfur

Carbon Tetrachloride

Polar Stratospheric Clouds

Dynamic Variability (DynVar)

Coordinators: **Elisa Manzini (MPI, Hamburg) and Edwin Gerber (NYU)**

- Focuses on the interactions between atmospheric variability, dynamics, and climate change, with a particular emphasis on the two-way coupling between the troposphere and stratosphere.
- DynVar promotes the development and use of coupled atmosphere-ocean-sea-ice general circulation models, with the atmospheric component extending to above the stratopause.

Key questions:

- How do ***dynamical processes contribute to persistent model biases*** in the mean state and variability of the atmosphere, including biases in the position, strength, and statistics of blocking events, storm tracks, and the stratospheric polar vortex?
- How does the stratosphere affect climate variability at intra-seasonal, inter-annual, and ***decadal time scales***?
- What is the role of dynamics in shaping the climate response to anthropogenic forcings (e.g. global warming, **ozone depletion**) and how do dynamical processes contribute to uncertainty in future climate projections?

Dynamic Variability (DynVar)

Selected Relevant papers:

- Charlton-Perez, et al. 2013: **On the lack of stratospheric dynamical variability in low-top versions of the CMIP5 models, J. Geophys. Res. Atmos., 118, 2494–2505,** doi: 10.1002/jgrd.50125
- Scaife, A. A., et al. 2014: Predictability of the quasi-biennial oscillation and its northern winter teleconnection on seasonal to decadal timescales, Geophys. Res. Lett., 41, 1752–1758, doi:10.1002/ 2013GL059160.
- Butler, A.H et al. 2016: **The Climate-system Historical Forecast Project: do stratosphere-resolving models make better seasonal climate predictions in boreal winter?** Q.J.R. Meteorol. Soc., 142: 1413–1427. doi:10.1002/qj.2743

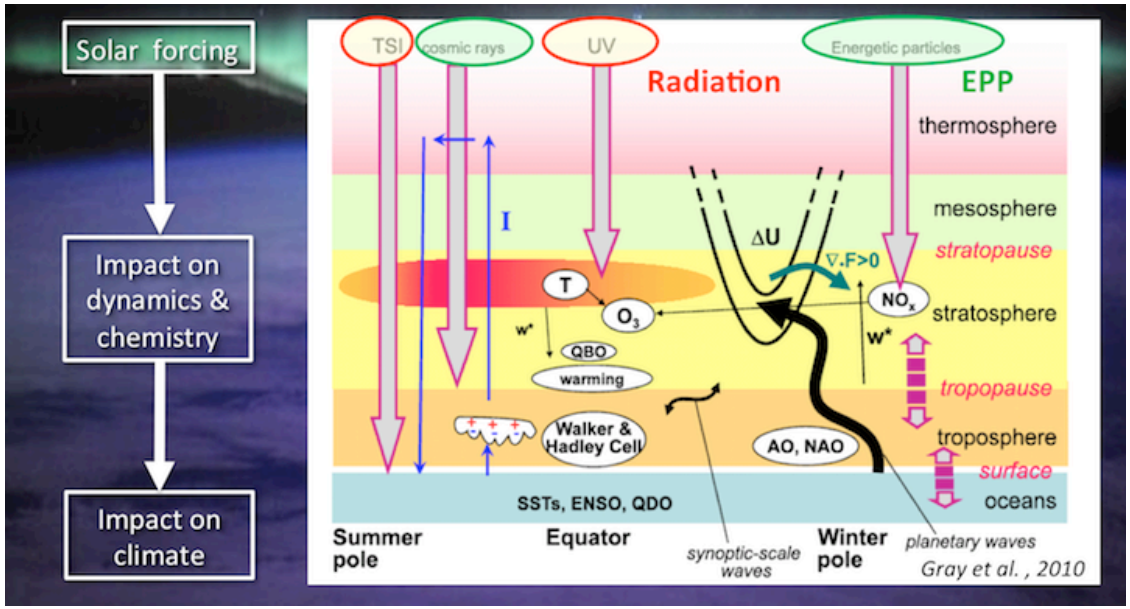
New Initiative (CMIP6):

- Gerber, E., & Manzini, E. 2016. **The Dynamics and Variability Model Intercomparison Project (DynVarMIP) for CMIP6: Assessing the stratosphere-troposphere system.** *Geoscientific Model Development, 9*, 3413-3425. doi:10.5194/gmd-9-3413-2016.
- Goal: to evaluate and understand the role of dynamics in climate model biases and in the response of the climate system to external forcing.

Solar Influence on Climate
SOLARIS-HEPPA

***Coordinators*:**

Katja Matthes (GEOMAR) and Bernd Funke (CSIC)



Key questions:

- What is the characteristic of the observed solar climate signal?
- What is the mechanism for solar influence on climate?
- How do the different natural and anthropogenic forcings interact?

Solar Influence on Climate
SOLARIS-HEPPA

Provided Forcing Data sets for CMIP6 (both historical and future simulations)-relevant for decadal predictions

- Matthes, K., et al. 2016: Solar Forcing for CMIP6 (v3.1), Geosci. Model Dev. Discuss., doi:10.5194/gmd
- Gillett et al. 2016: Detection and Attribution Model Intercomparison Project (DAMIP), Geosci. Model Dev. Discuss., doi:10.5194/gmd

SOLARIS-HEPPA working groups have been established to systematically analyse the SPARC Chemistry-Climate Model Initiative (CCMI) experiments with respect to the solar (irradiance and particle) forcing

- Will allow a joint evaluation of solar cycle signals with a special focus on relevance for surface climate. Addressing questions such as whether the 2-year lagged signal in the North Atlantic is due to atmosphere-ocean interaction or not.

Stratospheric Sulfur and its Role in Climate (SSiRC)

Activity Leads:
Markus Rex (AWI), Claudia Timmreck (MPI), Larry Thomason (NASA)

Coordinates international research activities on:

- Observing, understanding and modeling the processes that control the stratospheric sulfur and aerosol budget,
- Observing stratospheric sulfur and aerosol; reconciling datasets from different instruments,
- Promoting the inclusion of an interactive aerosol layer in global chemistry climate models, and
- Modeling the climate feedback from the stratospheric aerosol layer.

- **A large tropical volcanic eruption will have climate effects on 1-5 year time scale**
- **Modeling systems used for outlooks need to be able to take this climate forcing into account if needed.**

Stratospheric Sulfur and its Role in Climate (SSiRC)

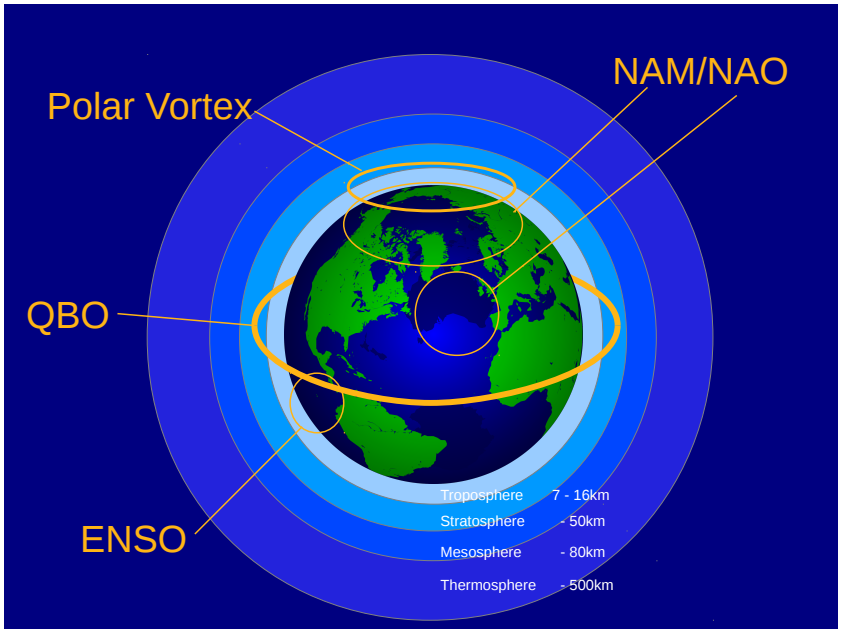
ALARM project (Timmreck):

- Develops Volcano module for medium-term climate predictions system
- Investigates the climate effects of large volcanic eruptions on decadal time scales dependent on the initial state of the ocean, the season and the location of the eruption
- Timmreck, C., H. Pohlmann, S. Illing, and C. Kadow (2016), The impact of stratospheric volcanic aerosol on decadal-scale climate predictions, Geophys. Res. Lett., 43, 834–842, doi:10.1002/2015GL067431.

CMIP6

- Zanchettin, D. et al. 2016:The Model Intercomparison Project on the climatic response to Volcanic forcing (VolMIP): Experimental design and forcing input data for CMIP6. *Geosci. Model Dev.*, **9**, 2701-2719, doi:10.5194/gmd-9-2701-2016.

Quasi-biennial Oscillation
QBOI

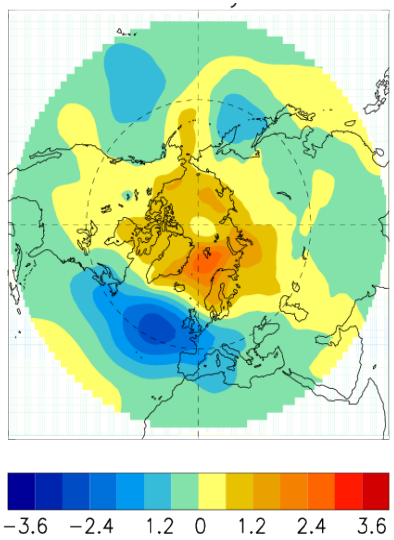


- Early studies by Ebdon and Holton & Tan showed strong links between QBO and high latitude stratosphere **AND** troposphere
- QBO winds in lower stratosphere are linked with **precipitation/convection**, especially during MAM in W-Pacific
- **QBO predictable out to a couple of years at least, so scope for impacting seasonal to interannual forecast skill**

Quasi-biennial Oscillation
QBOI

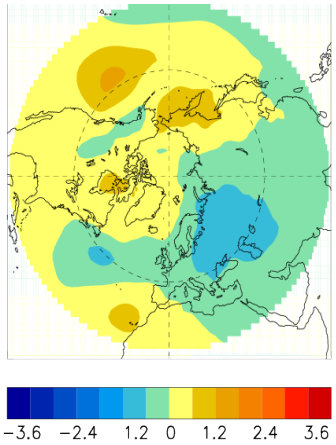
- Eastward/westward QBO linked with poleward/equatorward shift in Atlantic jet-stream in observations
- Seasonal and decadal forecast models *kind of* reproduce sign of teleconnection, but it is generally **very weak**
- **Scope for significant improvement in seasonal-interannual forecasting.**

Analyses

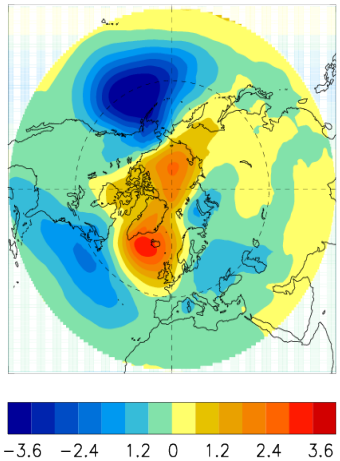


Scaife et al, 2013

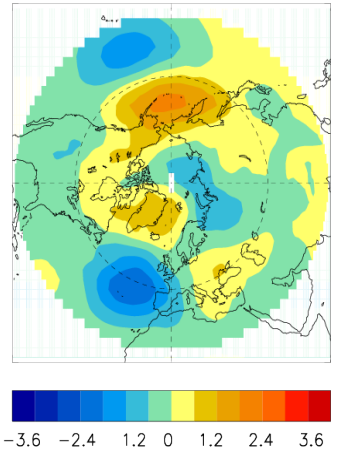
DePreSys v2



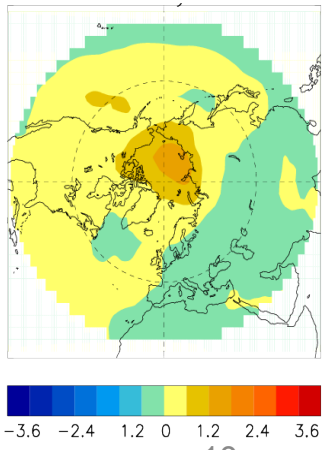
GloSea5



MiKlip



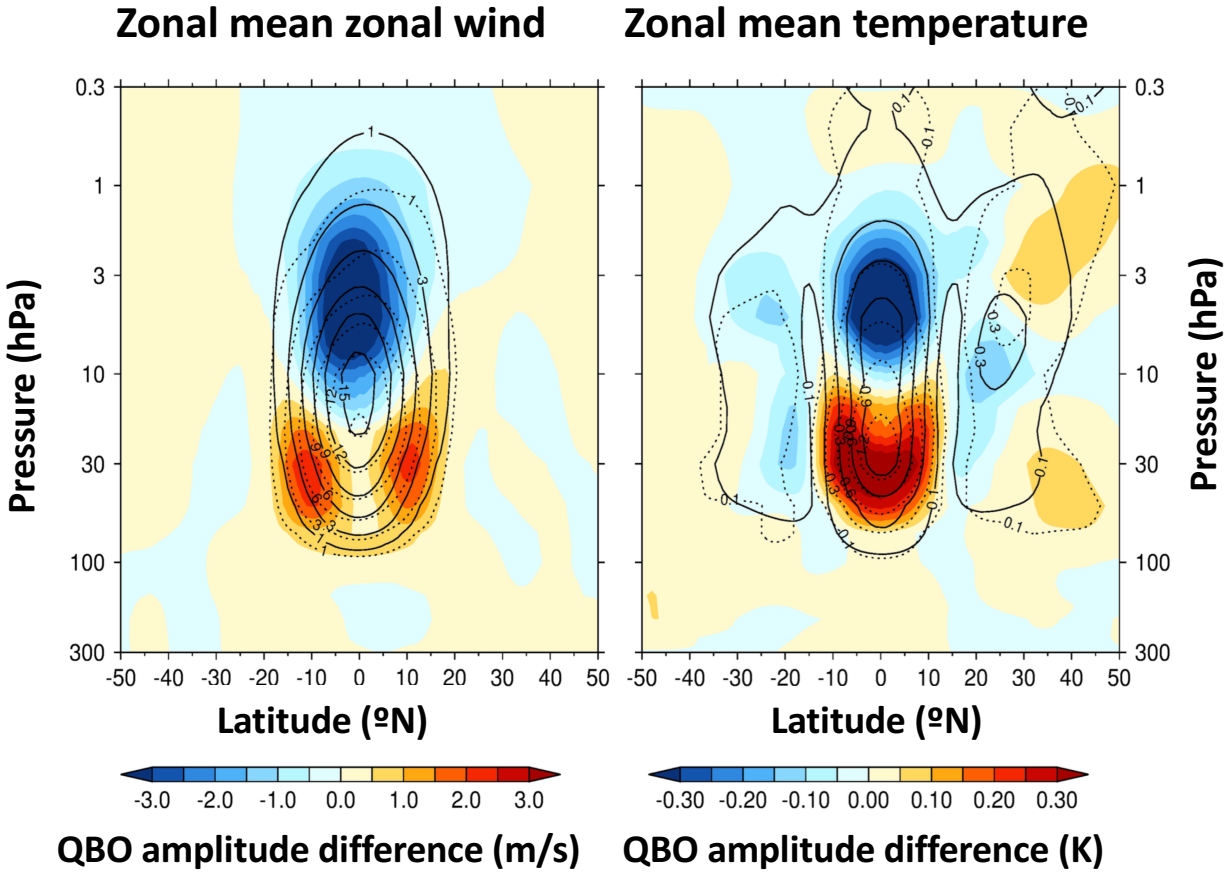
ECMWF



Quasi-biennial Oscillation
QBOI

QBO Comparison between Models and Reanalyses

- Comparison of GCMs (CMIP5 & CCMVal-2) and reanalysis datasets.
- Peak QBO amplitude placed too high (solid lines, opposite) compared to mean reanalyses (dotted)
- Mean QBO amplitude asymmetry (east/west phases) well captured.
- Crucially GCMs do not penetrate to the **lowermost stratosphere** and are **too narrow** there
- How do these biases translate to tropospheric teleconnections and to predictability (i.e**. directly relevant to the Near-Term Climate Prediction Grand Challenge**)

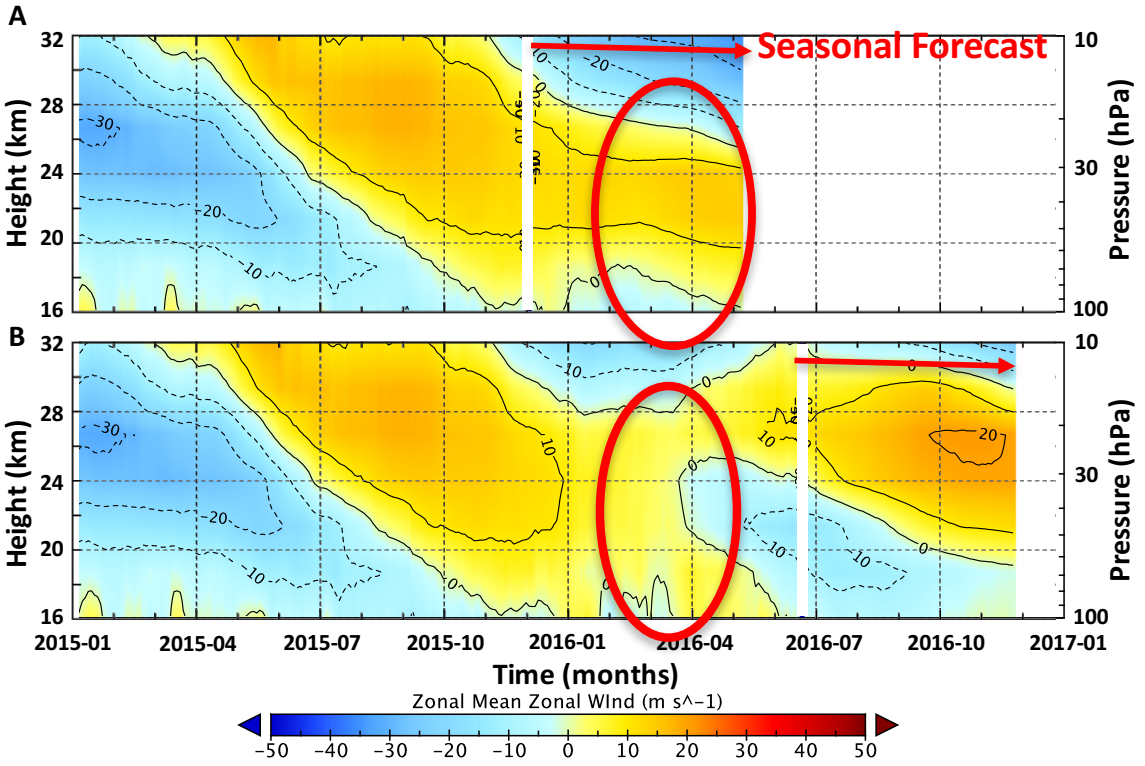


Schenzinger et al, in prep.

Quasi-biennial Oscillation
QBOI

Challenges to Seasonal Forecasting: the 2016 QBO disruption

- QBO was disrupted during 2016
- Extratropical waves responsible for rapid development of westward wind jet within eastward QBO phase
- Seasonal forecasting centres apparently did not anticipate the disruption in advance
- **The lack of predictability of the disruption has significant implications for the possible limits of future seasonal to interannual forecasts.**



Osprey et al, 2016

Other SPARC Activities

IGAC/SPARC Chemistry-Climate Model Initiative (CCMI)

- CMIP6 ozone database
- Non-stationary stratospheric ozone forcing (ozone depletion in hindcast vs recovery in future decadal predictions)

Stratospheric Network for the Assessment of Predictability (SNAP)

- New focus on analysis of the WWRP/WCRP S2S data by the SPARC community

SPARC Reanalysis Intercomparison Project

- Compare all (or most of the newer) reanalysis datasets for various "key" diagnostics,
  - to understand the causes of the differences,
  - to use the results to provide guidance on appropriate usage of various reanalysis products in scientific studies, and
  - to connect such activities with future improvements of these products.
- Outcome: Report (to be published 2018)

SPARC and WCRP Grand Challenges

WCRP/SPARC workshop:

"Challenges for Climate Science - Synergies between SPARC and the WCRP Grand Challenges"

Harnack House, Berlin, Germany 31 October – 01 November 2016

AGENDA 31 October

- 1550 *GC6: Near-term climate prediction* Judith Perlwitz
- 1620 *Predictability after volcanic eruptions* Claudia Timmreck
- 1640 *Lessons from the SNAP activity* A. Charlton-Perez
- 1700 *Miklip – Assessment of decadal climate prediction* Wolfgang Mueller
- 1720 *Solar variability and climate predictability* Katja Matthes
- 1740 *Discussion: SPARC/GC6 links*


Thank you!