U.S. NAVAL RESEARCH LABORATORY

SPARC Report to the Working Group on Numerical Experimentation (WGNE)

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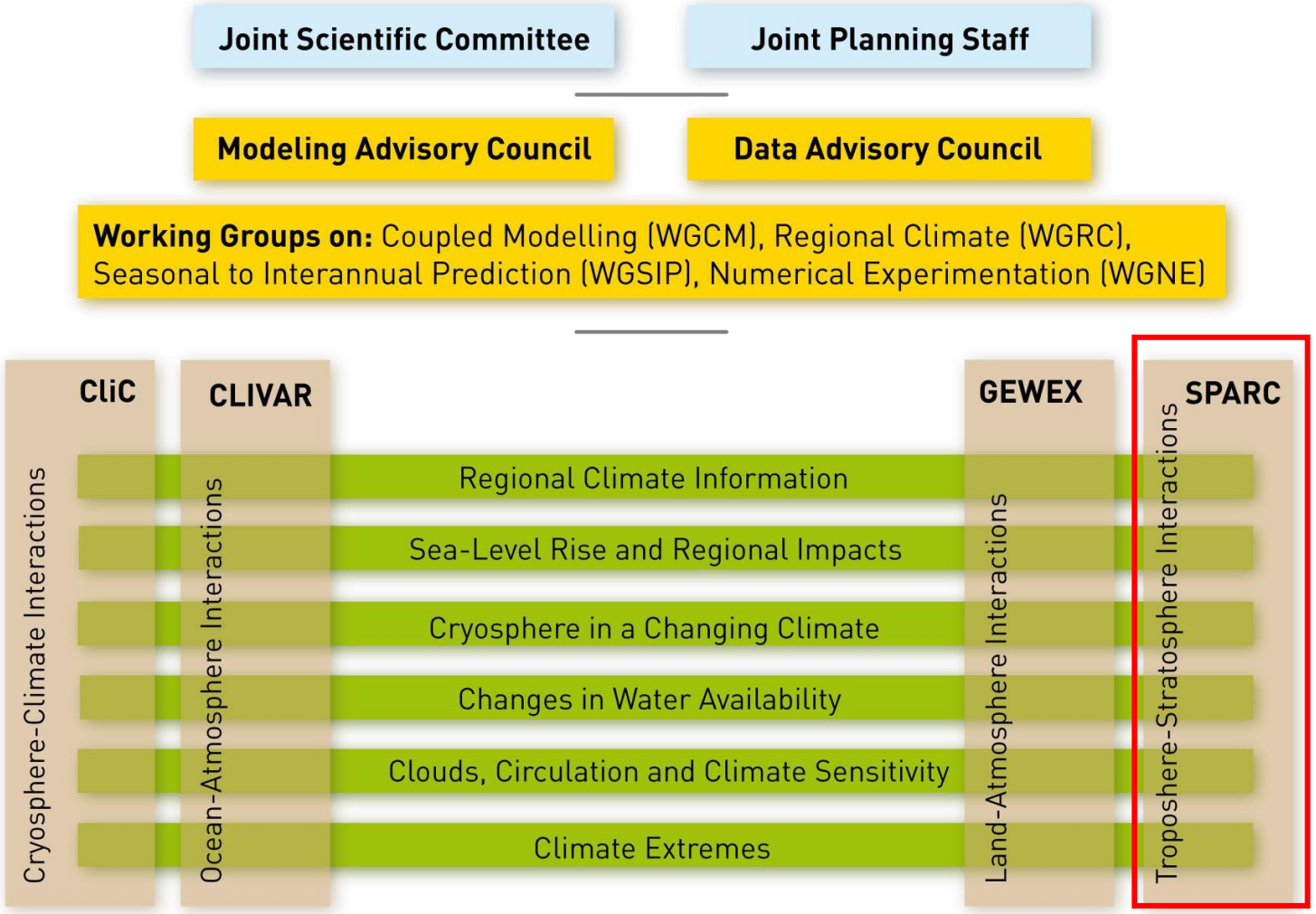
WGNE Session 2
10 October 2017
Exeter, UK

SPARC
Stratosphere-troposphere Processes And their Role in Climate

WCRP Organization



SPARC Tasks Include:

- Research coordination through SPARC activities
- General Assemblies and WCRP Conferences
- Newsletters
- Assessment Reports
- *http://www.sparc-climate.org/*

Next SPARC General Assembly will be 1-5 October 2018 in Kyoto.

Why is the Stratosphere Important for Extended Range Prediction?

Stratosphere &
Mesosphere
10-85 km

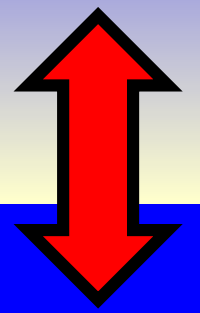
Large Angular Momentum Reservoir
Long Radiative/Dynamical Time Scales
Long Memory (weeks to months)

Data assimilation → initialization and verification of models
Dynamical coupling → stratosphere-troposphere teleconnections

wave momentum & energy

Troposphere
0-10 km

Short Radiative/Dynamical Time Scales
Short Memory (hours to days)



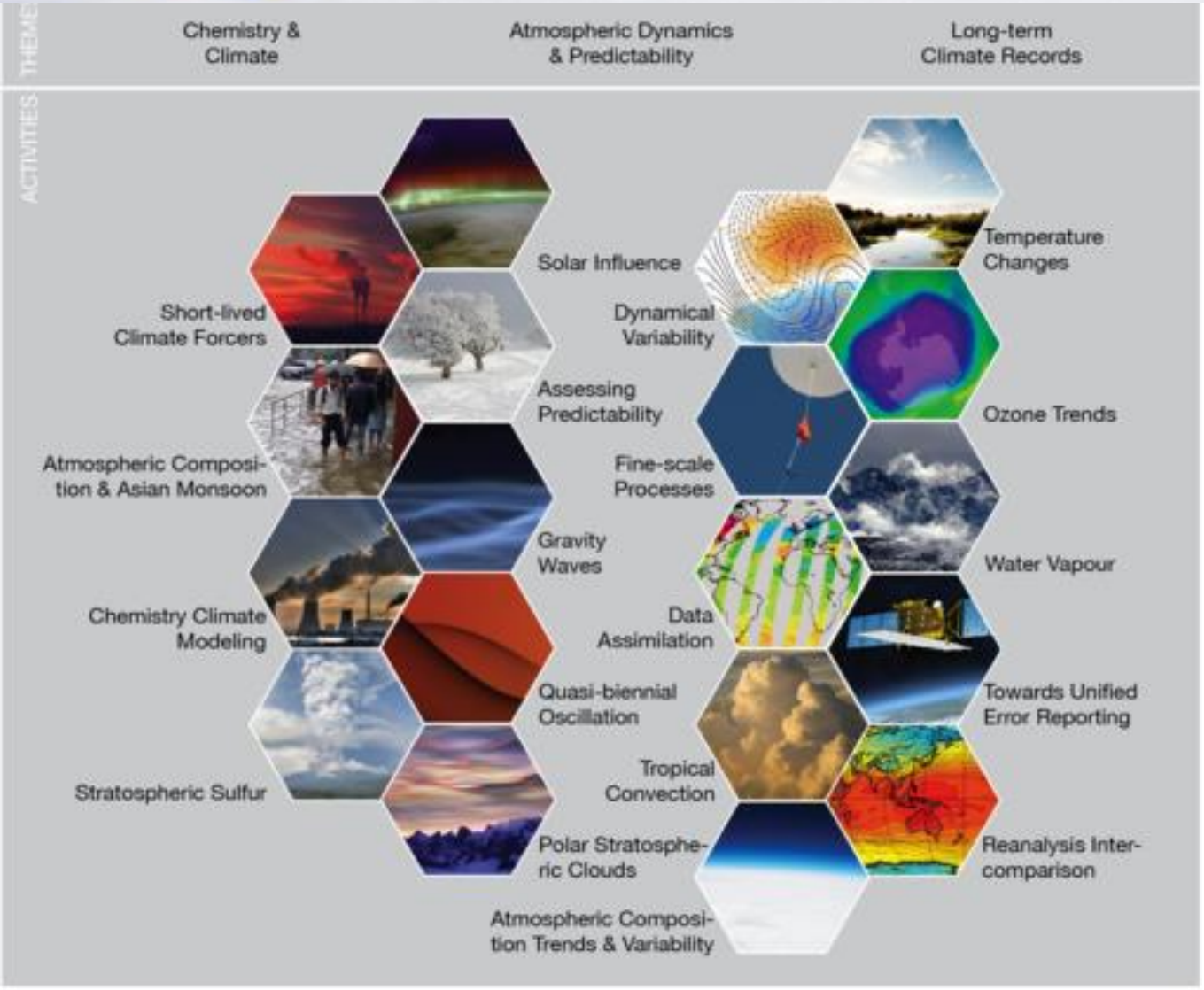
heat

Ocean

Large Heat Reservoir
Long Time Scales, *Long Memory* ***(months to years)***

SPARC
Stratosphere-troposphere
Processes And their Role in Climate

WCRP
World Climate Research Programme



SPARC Activities Related to WGNE

1. **DAWG**: Data Assimilation Working Group
2. **S-RIP:** SPARC-Reanalysis Intercomparison Project
3. **SNAP:** Stratospheric Network for the Assessment of Predictability
4. **QBOi**: Quasi-biennial oscillation intercomparison project
5. **DYNVAR:** Dynamics and Variability of the Stratosphere and Troposphere

1. DAWG: Data Assimilation Working Group

Next Meeting: October 25-27 at ECMWF in Reading (Joint with S-RIP)

Themes:

- Development of new observing systems for the middle atmosphere and Observing System Simulation Experiment (OSSE)
- Stratospheric DA in support of assessing trends in the state of the Upper Troposphere/Lower Stratosphere (UTLS)
- New DA techniques and applications for stratospheric data
- SPARC Activity Updates (What are community needs for stratospheric DA?)
- ***Briefing on new ERA5 reanalysis***

ERA5

Replacement for ERA-Interim, currently in production, using:

- a 2016 (rather than a 2006) version of the ECMWF data assimilation system
- ~30km (rather than ~80km) horizontal resolution and 137 (rather than 60) levels
- new analyses of sea-surface temperature and sea-ice concentration
- various new and reprocessed satellite data records

providing:

- hourly output fields (already released for 2010-2016)
- an observational feedback archive
- uncertainty estimates from a 10-member ensemble data assimilation
- a land-surface analysis downscaled to ~9km horizontal resolution

from 1979 onwards, with:

- prompt operational extension forward in time
- a subsequent extension to cover the period from 1950 to 1978

ECMWF Copernicus Europe's eyes on Earth European Commission

Slide courtesy of A. Simmons

In summary

Performance of ERA5 in the troposphere is generally better than that of ERA-Interim:

- improved global hydrological and mass balance
- smaller biases in precipitation
- refinement of temperature variability and trends
- better fit to observations and better medium-range forecasts

Performance of ERA5 is mixed in the stratosphere and mesosphere:

- better tropopause temperatures and lower-stratospheric humidities in the tropics
- sharper representation of small-scale dynamical features
- better late-winter ozone distributions in the Antarctic
- larger temperature biases, which vary more over time; better from late 2006
- problematic tropical winds at high levels

Prospects:

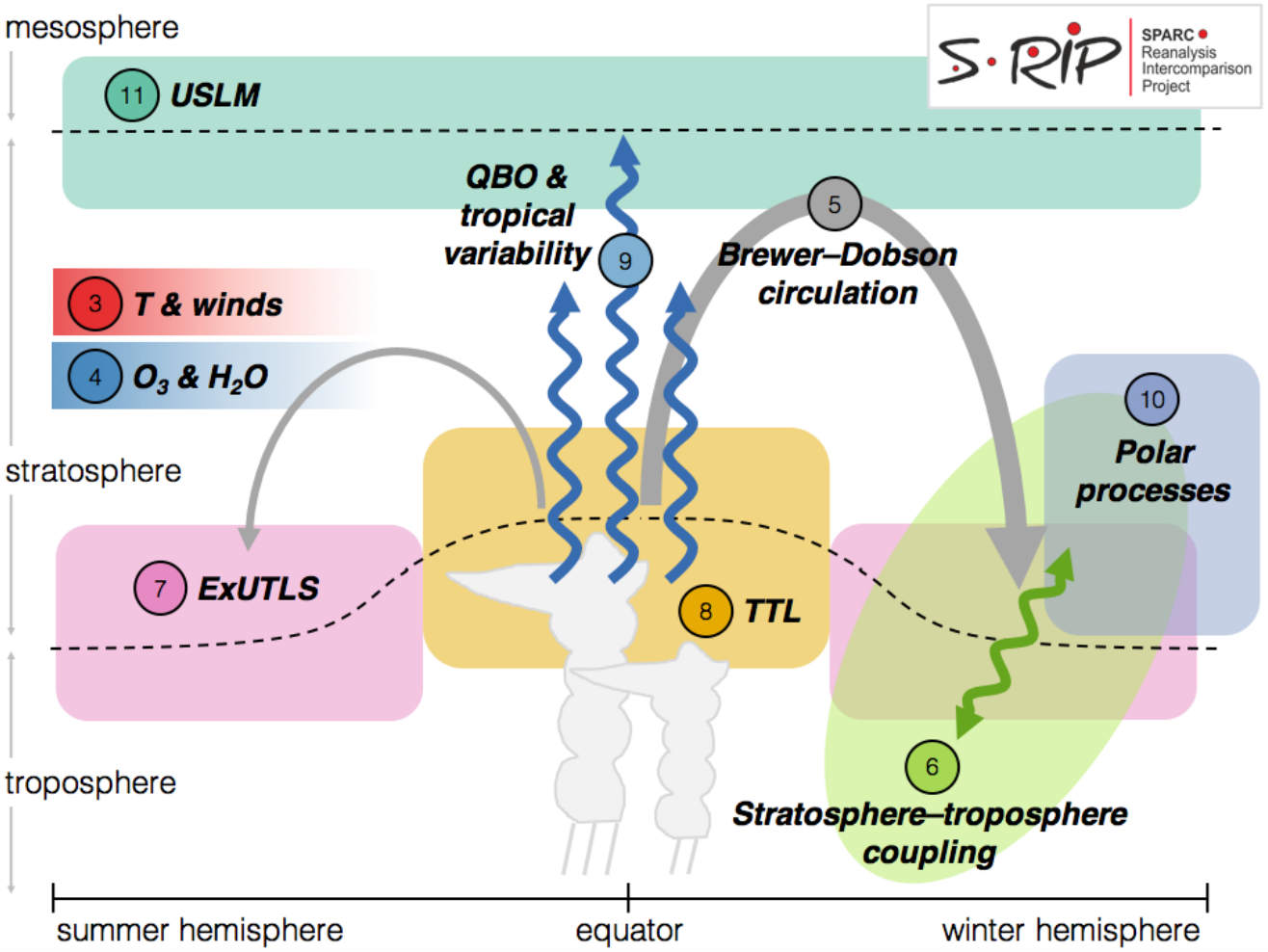
- good overlap from 2007 should enable merging with ERA-Interim where needed
- issues to be addressed for ERA6 are clear, and progress is already being made

ECMWF Copernicus Europe's eyes on Earth European Commission

Slide courtesy of A. Simmons

2. SPARC Reanalysis Intercomparison Project (S-RIP)

https://s-rip.ees.hokudai.ac.jp/



Slide courtesy of M. Fujiwara

Global atmospheric reanalyses currently available.

Reanalysis Center (Contacts for S-RIP)	Name of the Reanalysis Products
ECMWF (R. Dragani)	ERA-40, ERA-Interim, (ERA-20C), (CERA-20C)
JMA (Y. Harada)	JRA-25, JRA-55
NASA (K. Wargan)	MERRA, MERRA-2
NOAA/NCEP (C. Long, W. Ebisuzaki)	NCEP R-1, NCEP R-2, CFSR
NOAA & Univ. Colorado (G. Compo, J. Whitaker)	(20CR)

Notes:

- ERA-20C, CERA-20, and 20CR: The "surface-input" reanalyses (surface obs. only assimilated)
- The JRA-55 family also includes
  - "JRA-55C" (conventional obs. only assimilated)
  - "JRA-55AMIP" (no obs. assimilated; SST specified)

S-RIP Achievements and Plans

https://s-rip.ees.hokudai.ac.jp/

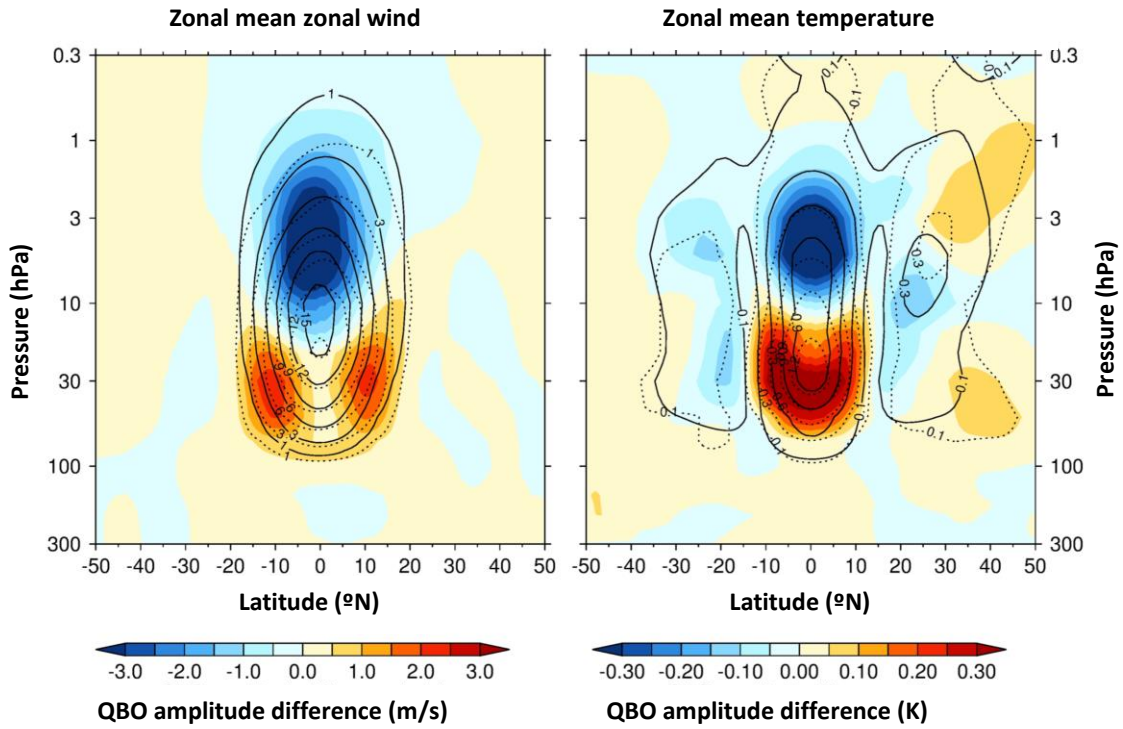
- The inter-journal **special issue** on "The SPARC Reanalysis Intercomparison Project (S-RIP)" in Atmospheric Chemistry and Physics (ACP) and Earth System Science Data (ESSD)
  - **https://www.atmos-chem-phys.net/special_issue829.html**
  - **18 papers** (including those under review) currently
  - Fujiwara et al., "**Introduction to the SPARC Reanalysis Intercomparison Project (S-RIP) and overview of the reanalysis systems**" (for Chaps. 1 & 2)
  - Long et al., "**Climatology and interannual variability of dynamic variables in multiple reanalyses evaluated by the SPARC Reanalysis Intercomparison Project (S-RIP)**" (for Chap. 3)
  - Davis et al., "**Assessment of upper tropospheric and stratospheric water vapour and ozone in reanalyses as part of S-RIP**" (for Chap. 4)
- Will contribute to the 5th International Conference on Reanalysis (ICR5)

Slide courtesy of M. Fujiwara

3. SPARC-QBOi

Model Biases: good enough for teleconnections?

- Comparison of GCMs and reanalyses.
- Peak QBO amplitude placed too high (solid lines, opposite) compared to mean reanalyses (dotted)
- Model QBOs do not penetrate to the **lowermost stratosphere** and are **too narrow**
- How do these biases impact tropospheric teleconnection predictability (e.g. **Madden-Julian Oscillation**)?



Schenzinger et al, *Geosci. Model Dev.*, 2017

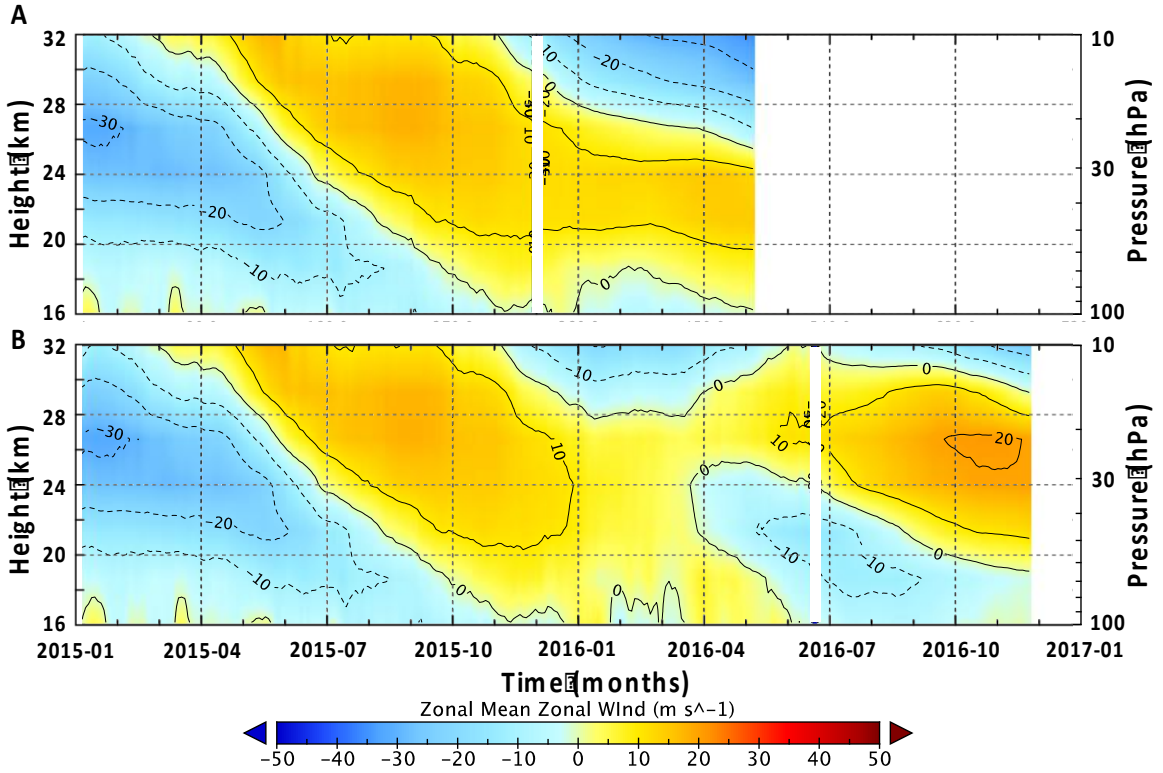
Joint SPARC Dynamics & Observations Workshop, Kyoto, 9-14 October

http://www.sparc-climate.org/activities/quasi-biennial-oscillation/

Slide courtesy of S. Osprey

SPARC-QBOi: QBO Disruption a Challenge to Seasonal Forecasting

- 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 forecasts



Osprey et al, *Science*, 2016

http://www.sparc-climate.org/activities/quasi-biennial-oscillation/

Slide courtesy of S. Osprey

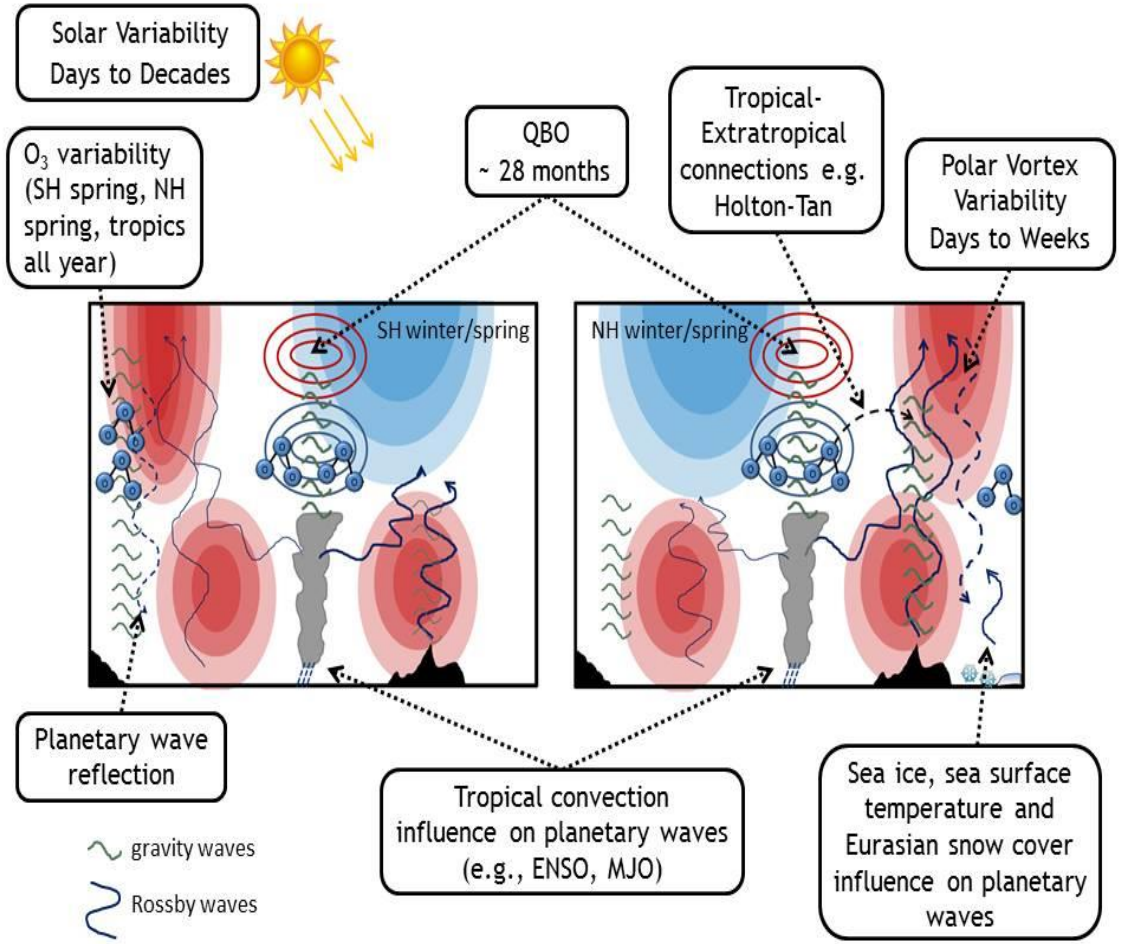
4. SNAP Activity

http://www.sparc-climate.org/activities/assessing-predictability/

- SNAP is continuing to build on its initial work around understanding the role of the stratosphere in predictability
- Recently we have appointed a new co-lead (Amy Butler) and had a significant shift in the membership of our steering panel
- Work is shifting towards the sub-seasonal timescale and interactions with the S2S project in particular

- There are two main current activities:

1. Reviewing our current understanding through a chapter in the forthcoming S2S book (example figure here)
2. An initial study of stratosphere-troposphere coupling on the sub-seasonal timescale led by Daniela Domeisen



Slide courtesy of A. Charlton-Perez

5. Updates from DynVar
Dynamics and Variability of the Stratosphere-Troposphere

- DynVarMIP A diagnostic model intercomparison project within the CMIP6 *(Gerber and Manzini, GMD 2016)*
  - enhanced diagnostics from c. 10 models, focussing on DECK integrations + targeted runs from other MIPs
  - focus on momentum and heat budgets, and ability to assess the circulation in UTLS and stratosphere
- SPARC DynVar Activity
  - At a crossroads, as the latest efforts culminated in the DynVarMIP. Undergoing renewal in leadership.
  - Anticipate shift in focus to predictability and role of stratosphere-troposphere coupling on surface

http://www.sparc-climate.org/activities/dynamical-variability/

Slide courtesy of E. Gerber

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SPARC Report to WGNE

Going forward, WGNE/SPARC interactions could focus on:

- Stratospheric DA for initialization & verification
  → sources of “middle atmosphere” obs. now and in the future?

- Treatment of convection (MJO).

- Treatment of gravity waves (resolved & parameterized, orographic & non-orographic).

- New (better?) verification tools for extended range forecast skill in stratosphere-resolving systems.