

# SPARC DynVar

Modelling the Dynamics and Variability of the Stratosphere-Troposphere System



## SPARC DynVar Activity and its relevance to CLIVAR

### DynVar Committee Members:

Elisa Manzini (Coordinator), Amy Butler, Natalia Calvo,  
Andrew Charlton-Perez, Edwin Gerber, Marco Giorgetta,  
Adam Scaife, Tiffany Shaw and Shingo Watanabe

### Ex-Officio Members:

Judith Perlwitz, Lorenzo Polvani and Fabrizio Sassi

DynVar web site: <http://www.sparcdynvar.org>



# SPARC DynVar

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## Motivation:

- A 2-way dynamical connection between the stratosphere and tropospheric weather and climate has potential to provide a source of predictability, at both extra-tropical and tropical latitudes.
- However, the potential source of predictability emerging from the stratosphere – is largely not represented or misrepresented in current models for climate prediction.



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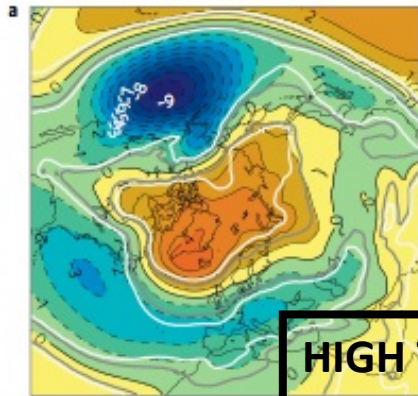


- **Sudden stratospheric warming events** are extreme dynamical events of the polar upper atmosphere with remote potential influence on surface weather and climate at middle-high latitudes. Typically these events occur during the boreal winter season – but their statistics for the austral winter are still uncertain.
- In the equatorial stratosphere, positive and negative zonal winds fully encircling the globe are alternating each other, with an approximate periodicity of 28 months, e.g. the so-called **Quasi-Biennial Oscillation (QBO)**.



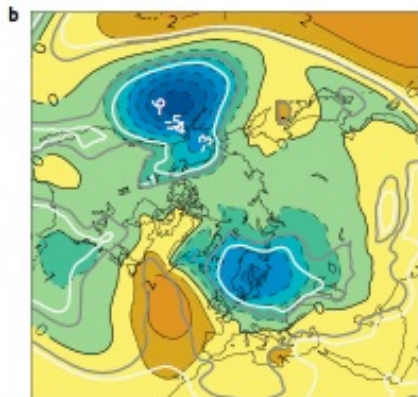
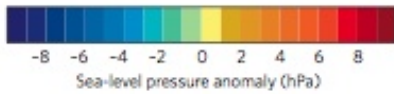
Ineson and Scaife, NG, 2009

JFM SLP [hPa]

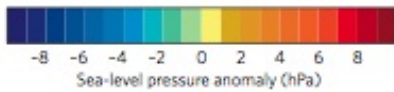


ENSO  
with SSW

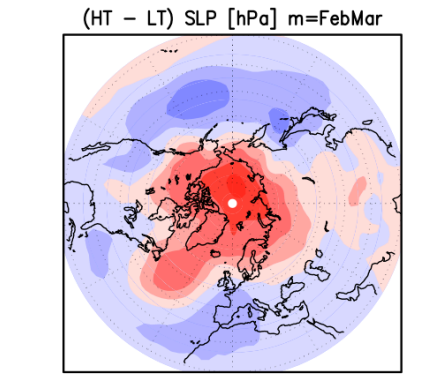
**HIGH TOP MODEL**



ENSO  
without SSW

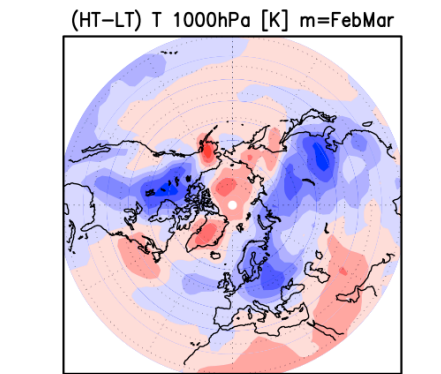
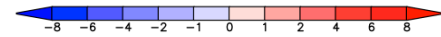


Cagnazzo and Manzini, JC, 2009

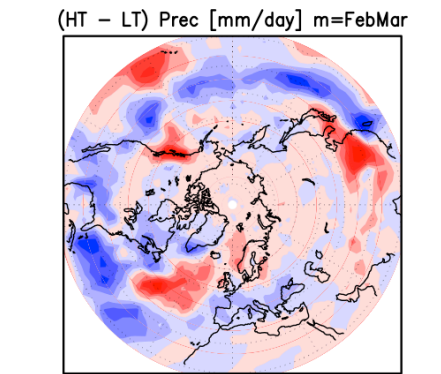
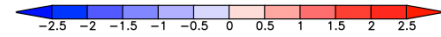


FM SLP [hPa]

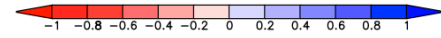
**ENSO for  
HIGH - LOW TOP  
MODELS**



FM T@1000 hPa [K]



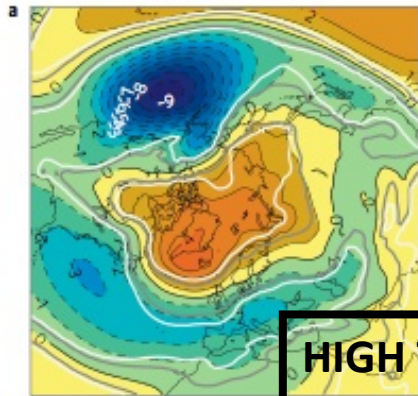
FM PRECIP [mm/day]



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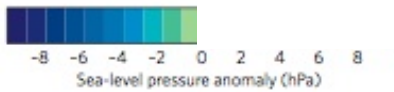
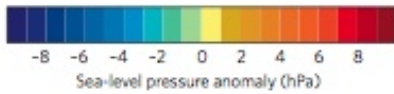
Ineson and Scaife, NG, 2009

JFM SLP [hPa]



ENSO  
with SSW

**HIGH TOP MODEL**

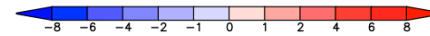
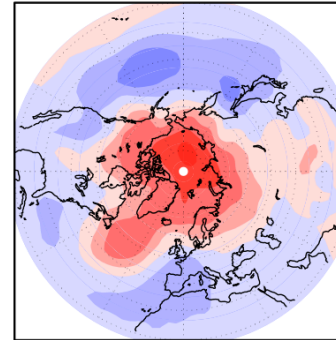


SLP pattern changes in the ENSO signal stratified by either the occurrence of SSW or the location of the model top support an active role of stratospheric variability in the climate system.

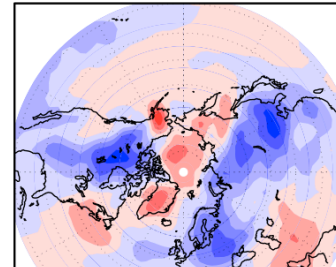
1m/day]

Cagnazzo and Manzini, JC, 2009

(HT - LT) SLP [hPa] m=FebMar



(HT-LT) T 1000hPa [K] m=FebMar



FM SLP [hPa]

**ENSO for  
HIGH - LOW TOP  
MODELS**

FM T@1000 hPa [K]



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# QBO effects on the tropical circulation?

(Giorgetta et al., Clim. Dyn., 1999; Collimore et al., J. Climate, 2003; ...)

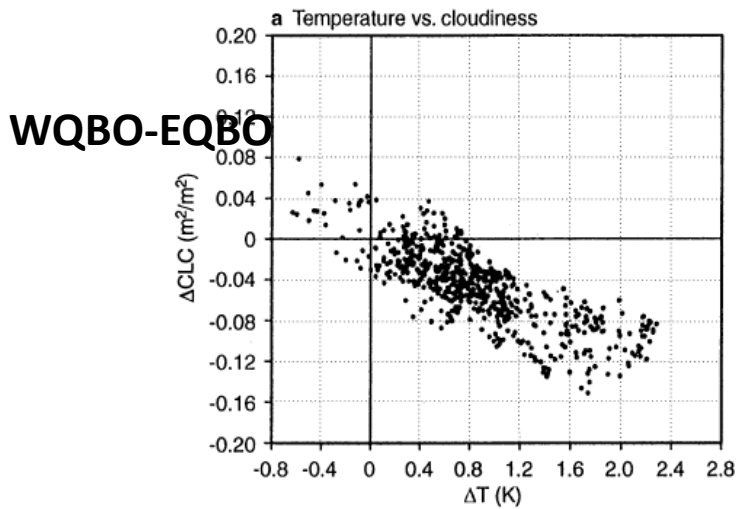


Fig. 3 a Scatterplot of the climatological differences between W-QBO and E-QBO of cloudiness  $\Delta CLC$  and temperature  $\Delta T$  at 100 hPa in June, for all gridpoints between 15°N and 15°S in areas

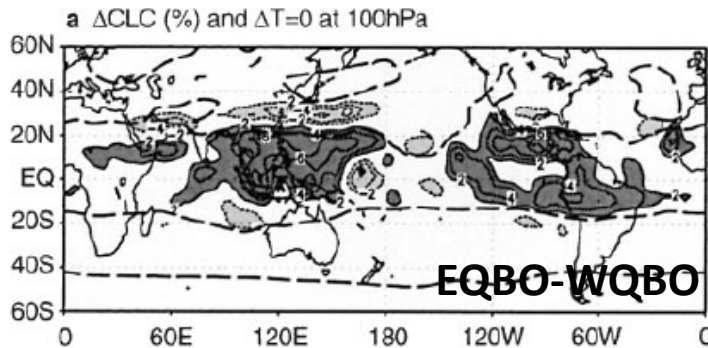


Fig. 5 a Cloudiness difference E-QBO-W-QBO at 100 hPa in July, dark/light shading for positive/negative differences exceeding 2%, the long dashed zero isoline shows  $\Delta T = 0$

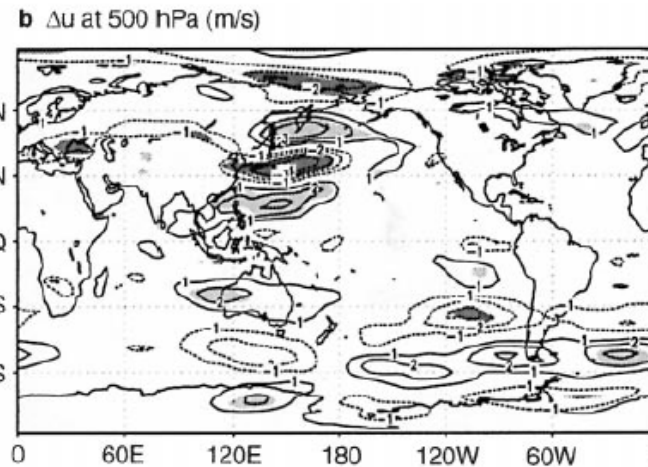


Fig. 6a-c Zonal wind difference E-QBO-W-QBO at a 200hPa, b 500 hPa and c 850 hPa in July/August. Shading indicates statistical significance following a two sided *t*-test at the 5% level

The QBO changes the temperature at the tropopause, and the occurrence of high level cloudiness in model simulations (Giorgetta et al., 1999) and observations (Collimore et al., 2003). Model simulations show also effects on monsoons, proposed in earlier statistical studies (Yasunari, 1989).



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Modelling the Dynamics and Var

Collimore et al, J. Climate, 2003

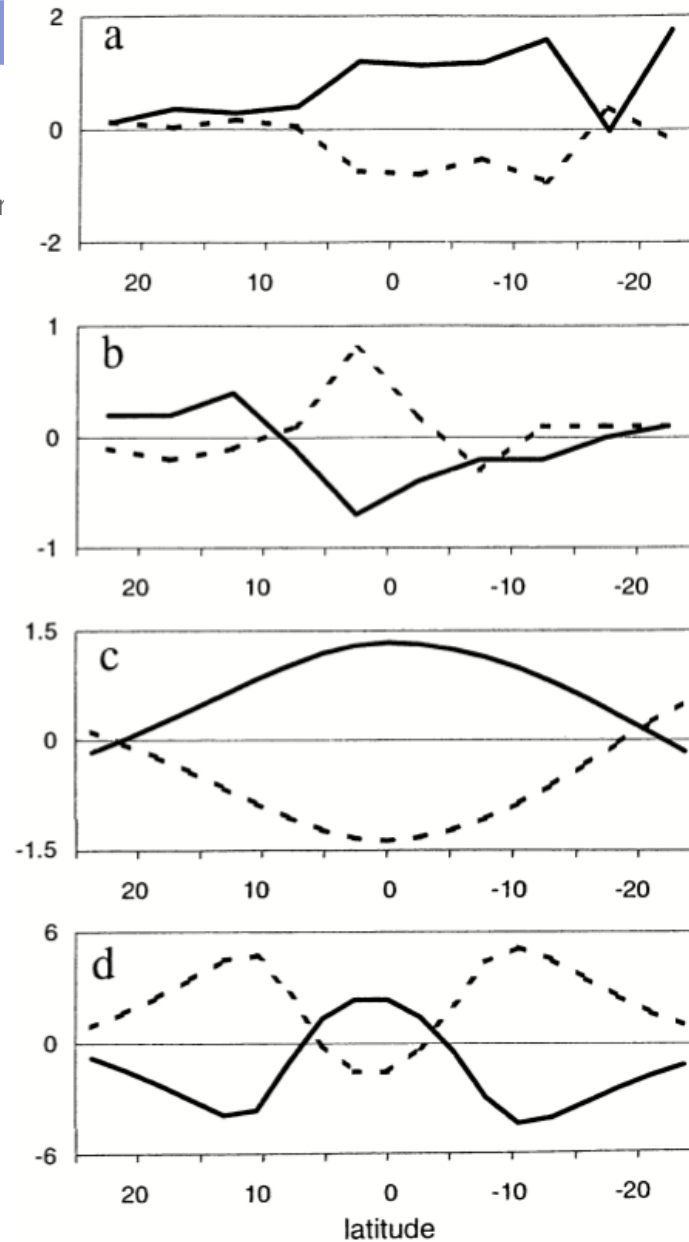


FIG. 3. Zonal mean anomalous (a) OLR in the chronically convective regions ( $\text{W m}^{-2}$ ); (b) HRC (counts  $\times 10$ ); (c) tropopause pressure, 1958–2001 (hPa); (d) absolute values of 50–200-hPa zonal wind shear, 1958–2001 ( $\text{m s}^{-1}$ ). Solid lines are for the QBO west phase; dashed lines are for the east phase.



OLR and HRC from satellite

Tropopause pressure and wind from NCEP analyses



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Modelling the Dynamics and Variability of the Stratosphere-Troposphere System



## DynVar goals:

- Promote coupled atmosphere, ocean, and seaice global models with **high vertical resolution and model tops above the stratosphere.**
  - Systematically assess (-> benchmarking)
    - stratospheric dynamical variability and processes
    - two-way dynamical couplings between the stratosphere and the troposphere and
    - their impacts on tropospheric and surface climate predictability
- > Modelling activity, S-T with emphasis on atm&ocean coupling



# SPARC DynVar

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## 2010-2011:

- DynVar Workshop 2, 3-5 November 2010, NOAA ESRL David Skaggs Research Center, Boulder, CO, USA. 68 participants from around the world
- From the workshop:
  - 10 modelling groups planning/doing CMIP5 runs with “high top models”
  - Taking over the role of analyzing multi-model runs performed for assessments purposed (eg. CMIP5) , with the focus on stratospheric dynamical variability and its impacts (-> 2 Synthesis papers: Charlton-Perez et al and Manzini et al, in preparation)
  - Establishment of Research Topics & Groups
- Reports on SPARC and CLIVAR-EXCHANGE newsletters
- Reviews paper for BAMS (Gerber et al, in preparation)
- Poster Cluster for WCRP OSC (Chair: Shaw)



# High top models participating to CMIP5 so far:



Institute / Group	Model	Atmospheric Resolution	Scenario	Contact
CMCC	CMCC-CMS	T63xL95 top=0.01hPa	RCP4.5	<a href="mailto:chiera.cagnazzo@cmcc.it">chiera.cagnazzo@cmcc.it</a> <a href="mailto:piemiuseppe.fogli@cmcc.it">piemiuseppe.fogli@cmcc.it</a> <a href="mailto:sivis.iva@cmcc.it">sivis.iva@cmcc.it</a>
	CMCC-CESM	T31xL39 top=0.01hPa	RCP8.5	
DMI	EC-EARTH	T159xL91 top=0.01hPa	RCP4.5	<a href="mailto:sbuting@dmf.dk">sbuting@dmf.dk</a> <a href="mailto:boc@dmf.dk">boc@dmf.dk</a>
		T159xL61 top=5hPa		
GEOS	GEOS-5	1°x1.25°xL72 top=0.01hPa	Decadal prediction runs	<a href="mailto:Steven.Pawson-1@nasa.gov">Steven.Pawson-1@nasa.gov</a>
GFDL	CM3	~200kmxL48 top=0.017hPa	All 4 RCPs	<a href="mailto:john.austin@noaa.gov">john.austin@noaa.gov</a> <a href="mailto:leo.l.donner@noaa.gov">leo.l.donner@noaa.gov</a> <a href="mailto:larry.borowitz@noaa.gov">larry.borowitz@noaa.gov</a>
GISS	GISS-E	90x144xL40 top=0.1hPa	All 4 RCPs	<a href="mailto:dshindell@giss.nasa.gov">dshindell@giss.nasa.gov</a>
IPSL	IPSL-CM5	144x143xL39 top=65km	RCP4.5	<a href="mailto:Francois.loth@lmd.jussieu.fr">Francois.loth@lmd.jussieu.fr</a>
Met Office Hadley Center / NCAS	HadGEM2	192x145xL60 top=84km	RCP4.5, RCP8.5	<a href="mailto:neal.butchart@metoffice.gov.uk">neal.butchart@metoffice.gov.uk</a> <a href="mailto:stevan.hardiman@metoffice.gov.uk">stevan.hardiman@metoffice.gov.uk</a> <a href="mailto:s.osprey@physics.ox.ac.uk">s.osprey@physics.ox.ac.uk</a> <a href="mailto:gray@atm.ox.ac.uk">gray@atm.ox.ac.uk</a>
MPI-M	MPI-ESM	~360x180xL95 top=0.01hPa	RCP4.5, RCP8.5, RCP2.6	<a href="mailto:marco.giorgetta@zmaw.de">marco.giorgetta@zmaw.de</a>
MIROC	MIROC-ESM	T42xL80 Top=85km	All 4 RCPs	<a href="mailto:wnaba@jamstec.go.jp">wnaba@jamstec.go.jp</a> <a href="mailto:kawamiya@jamstec.go.jp">kawamiya@jamstec.go.jp</a> <a href="mailto:nozawa@nies.go.jp">nozawa@nies.go.jp</a>
	MIROC-ESM-CHEM			
MRI	MRI-ESM1	TL95xL48 (320x160) top=0.01hPa	RCP4.5, RCP8.5 RCP8.5	<a href="mailto:kshibata@mri-jma.go.jp">kshibata@mri-jma.go.jp</a>
NCAR	WACCM4	144x96xL66 top=6x10 <sup>-6</sup> hPa~135km	RCP4.5 (RCP8.5, RCP2.6)	<a href="mailto:skamrith@ucar.edu">skamrith@ucar.edu</a> <a href="mailto:marcia@ucar.edu">marcia@ucar.edu</a> <a href="mailto:marah@ucar.edu">marah@ucar.edu</a>

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## Research Topics & Groups

[<http://www.sparcdynvar.org/research-topics-groups-folder/>]

- **Antarctica: From Ozone to Carbon**  
*Contact: Judith Perlwitz (judith.perlwitz@noaa.gov)*
- **Sudden Stratospheric Warming Events**  
*Contact: Andrew Charlton-Perez (a.j.charlton@reading.ac.uk)*
- **Extratropical Wave Coupling**  
*Contact: Tiffany Shaw (tas2163@columbia.edu)*
- **Annular Modes and Stratospheric Memory**  
*Contact: Edwin Gerber (gerber@cims.nyu.edu)*
- **QBO and Tropical Waves**  
*Contact: Marco Giorgetta (marco.giorgetta@zmaw.de)*
- **Water Vapor**  
*Contact: Chiara Cagnazzo (chiara.cagnazzo@cmcc.it)*
- **Surface Climate, Variability and Change**  
*Contact: Elisa Manzini (elisa.manzini@zmaw.de)*
- **ENSO and QBO**  
*Contact: Natalia Calvo (calvo@ucar.edu)*
- **AMOC and PDO**  
*Contact: Thomas Reichler (thomas.reichler@utah.edu)*
- **Tropopause and the UTLS**  
*Contact: Thomas Birner (thomas@atmos.colostate.edu)*
- **Volcanic forcing**  
*Contact: Matthew Toohey (mtoohey@ifm-geomar.de)*

**Links to Gravity Wave, CCMVal and Solaris Activities of SPARC and SHFP/WGSIP of CLIVAR**



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**2011-2012:**

**SPARC-DynVar / CLIVAR-WGSIP-SHFP Workshop**

**Tentative schedule: 26-30 March 2012, in Hamburg**

**Motivations:**

- Forum for discussion on stratospheric dynamics in the interim period between the last SPARC General Assembly in 2008 and the next one in 2014
- Liaise with CLIVAR
- Report on the analysis of the CMIP5 and SHFP simulations
- Timely with respect to the schedule of AR5 IPCC

**Structure:**

- Based on the DynVar Research Topics, but not limited to them.
- Oral and Poster presentations; Open discussions

**Targets:**

- Duration: One week (4 days and one 1/2 day)
- Participation: 100-120 people



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From a discussion with Marv Geller, first Co-Chair and Co-Funder of SPARC on SPARC goals:

- Provide a sustained contribution to the ozone assessments
- Provide a focus on climate to stratospheric research
- Raise awareness of stratospheric issues within the climate research community
  1. Ozone, solar variability, volcanos and geoengineering
  2. Dynamical variability and processes



# SPARC DynVar

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# THANK YOU



CLIVAR SSG 2-5 May 2011



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