SPARC DynVar

Modelling the Dynamics and Variability of the Stratosphere-Troposphere System

SPARC DynVar Activity Report

October 2009 – January 2011

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

WCRP World Climate Research Programme

SPARC DynVar

Modelling the Dynamics and Variability of the Stratosphere-Troposphere System

DynVar is an activity of the World Climate Research Program's (WCRP) Stratospheric Process and their Role in Climate (SPARC) project. DynVar was launched in 2007.

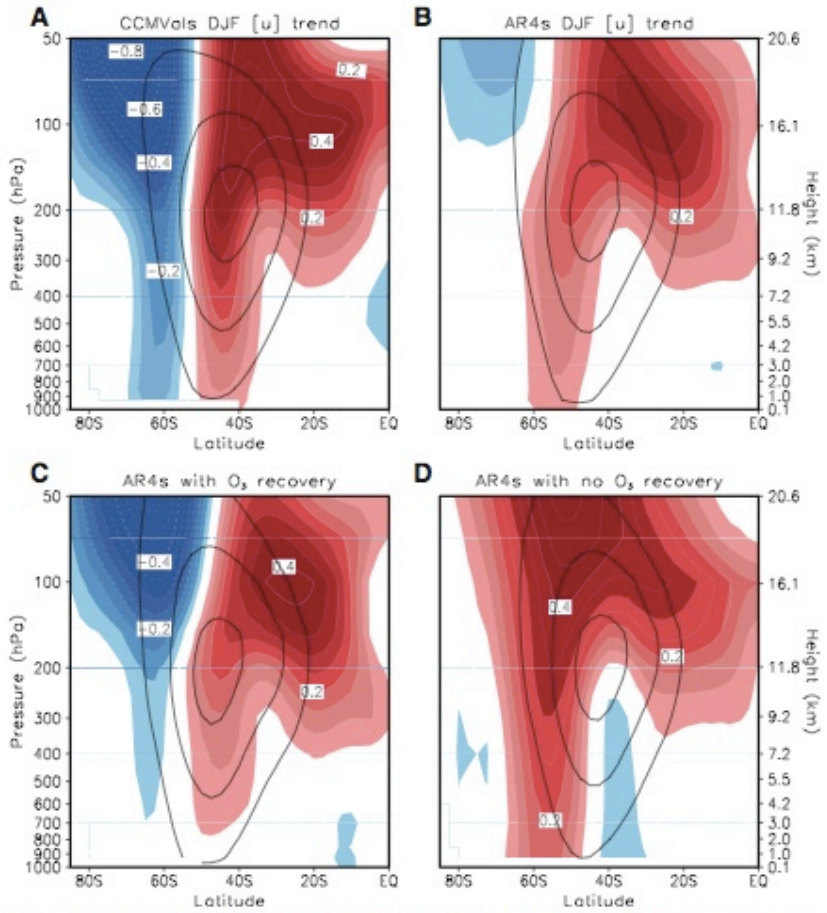
DynVar Activity Focus: Identify, understand and model the role of dynamical processes in the connections between the stratosphere / troposphere / ocean and sea-ice, at all time scales.

Motivation: There is now considerable evidence of a two way connection between the troposphere and the stratosphere. Few known examples follow.

World Climate Research Programme

Son et al. Science 2008

CCMVal Models



AR4 Models

AR4 Models with O3 Recovery

AR4 Models without O3 Recovery

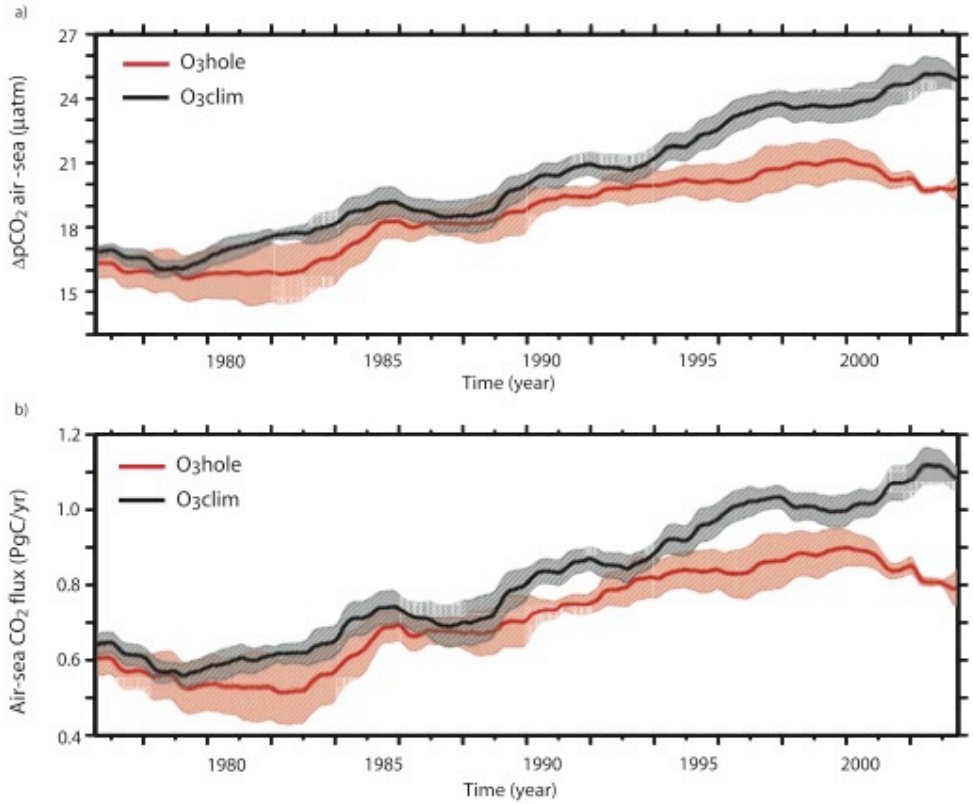
Fig. 2. Trends in December-to-February (DJF) zonal-mean zonal wind. The multimodel mean trends between 2001 and 2050 are shown for the CCMVal models (**A**), the AR4 models (**B**), the AR4 models with prescribed ozone recovery (**C**), and the AR4 models with no ozone recovery (**D**). Shading and contour intervals are 0.05 ms^{-1} $decade^{-1}$. Deceleration and acceleration are indicated with blue and red colors, respectively, and trends weaker than 0.05 ms^{-1} $decade^{-1}$ are omitted. Superimposed black solid lines are DJF zonal-mean zonal wind averaged from 2001 to 2010, with a contour interval of 10 ms^{-1}, starting at 10 ms^{-1}. EQ, equator.

Impact of ozone recovery on SH DJF zonal mean U trend

Lenton et al, GRL, 2009

IPSL Carbon cycle model ("low top")

pCO2 air-sea



without ozone hole

with ozone hole

Air to sea CO2 flux

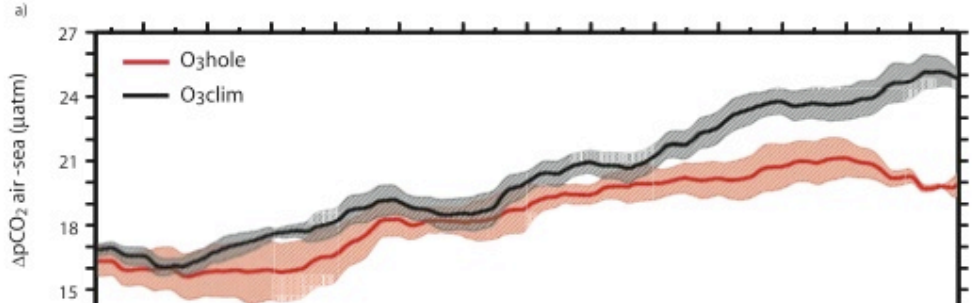
Figure 2. (a) Spatially averaged ΔpCO_2 (south of 40°S), showing that accounting for stratospheric ozone depletion (O_3hole) reduces ΔpCO_2 (relative to O_3clim), in response to increased upper ocean carbon concentration (Figure 1b). (b) Integrated air to sea CO_2 flux (south of 40°S) showing stratospheric ozone depletion (O_3hole) significantly reduces CO_2 uptake (relative to O_3clim), and is strongly correlated with changes in ΔpCO_2. The values of ΔpCO_2 and CO_2 fluxes represent the ensemble mean, while the shaded area represents the standard error of the mean. CO_2 fluxes and ΔpCO_2 are smoothed with 36-month running mean filters.

Impact of ozone depletion on ocean carbon uptake

Lenton et al, GRL, 2009

IPSL Carbon cycle model ("low top")

pCO2 air-sea

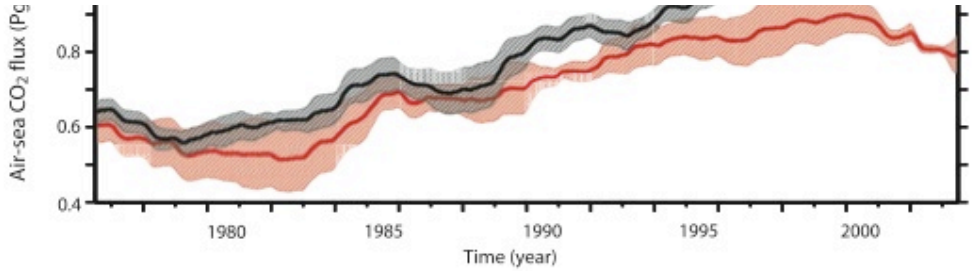


without ozone hole

with ozone hole

Mediating role of dynamical processes between the ozone and carbon changes?

CO2 flux



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Impact of ozone depletion on ocean carbon uptake

Baldwin, Gillett et al. Ch 10, CCMVAL SPARC Report Nr5 (Eds. Eyring, Shepherd, Waugh)

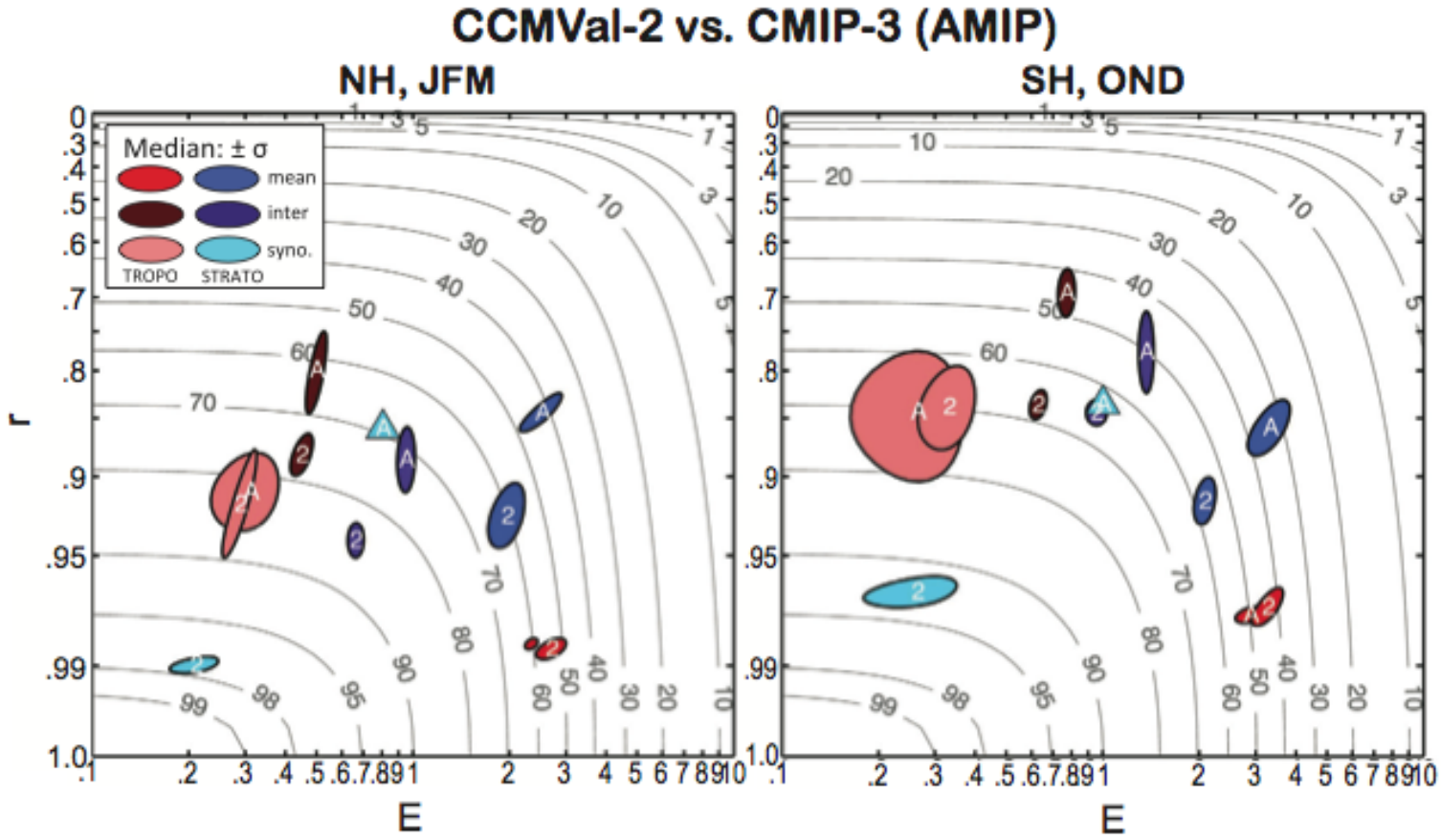
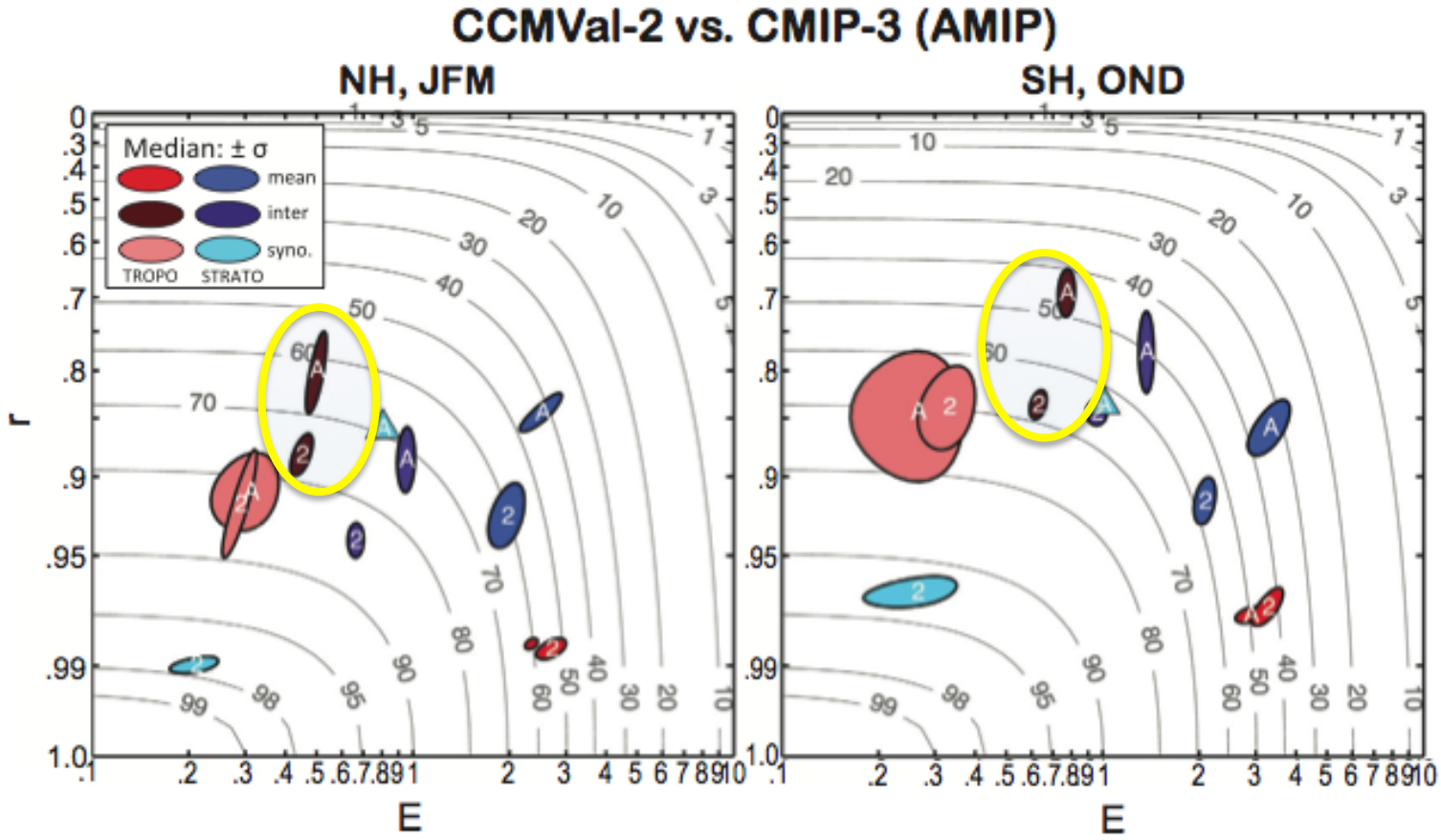


Figure 10.4: Median uncertainty comparison between CCMVal-2 (REF-B1) ("2") and CMIP3 (AMIP experiment) ("A") for u, v, and T combined. For clarity, individual model outcomes are not shown. For CMIP3, daily variability in the stratosphere is only based on the GFDL_CM2.1 model and thus the median estimate is replaced by a light blue triangle. See caption Figure 10.3 for additional information.

Baldwin, Gillett et al. Ch 10, CCMVAL SPARC Report Nr5 (Eds. Eyring, Shepherd, Waugh)



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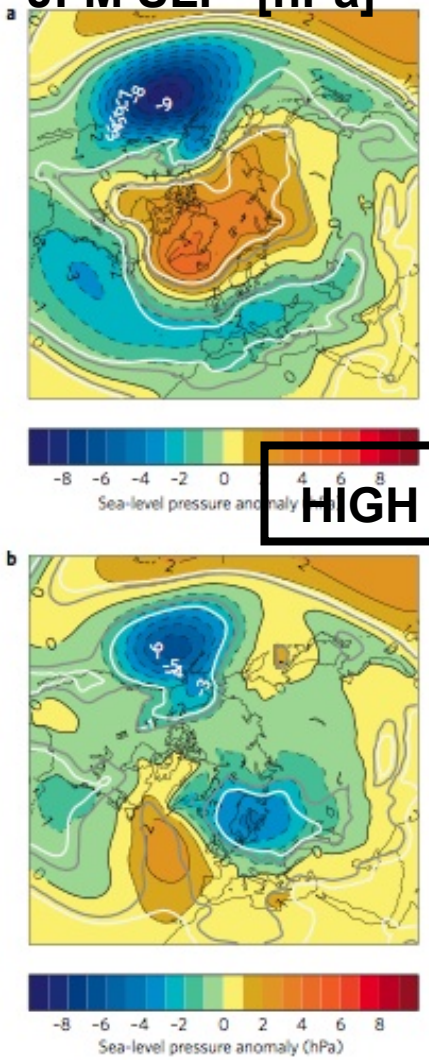
Inter-annual tropospheric variability better simulated in the CCMval2 than in the CMIP3 AMIP models

Ineson and Scaife, NG, 2009

JFM SLP [hPa]



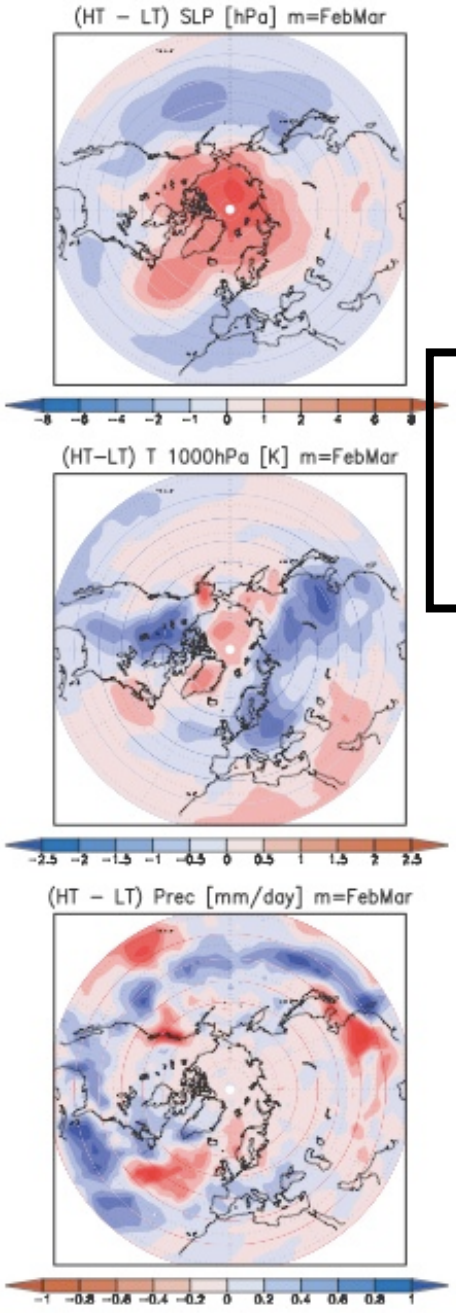
ENSO with SSW

HIGH TOP MODEL

ENSO without SSW

Figure 5 | Modelled surface climate response to El Niño associated with a weak and strong polar vortex. a,b, Composite sea-level pressure anomaly (hPa) for El Niño years with sudden stratospheric warmings (**a**) and El Niño years with no sudden stratospheric warmings (**b**). Anomalies are for January–March as in Fig. 1. Grey and white contours indicate significance at the 95% and 99% confidence levels.

Cagnazzo and Manzini, JC, 2009



FM SLP [hPa]

ENSO for HIGH - LOW TOP MODELS

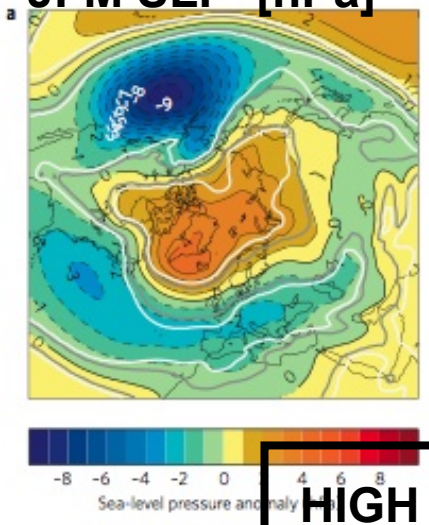
FM T@1000 hPa [K]

FM PRECIP [mm/day]

FIG. 10. High-top minus low-top model difference in the FM ENSO anomaly for (top) SLP (hPa), (middle) 1000-hPa temperature (K), and (bottom) precipitation (mm day^{-1}).

Ineson and Scaife, NG, 2009

JFM SLP [hPa]



ENSO

with SSW

HIGH TOP MODEL

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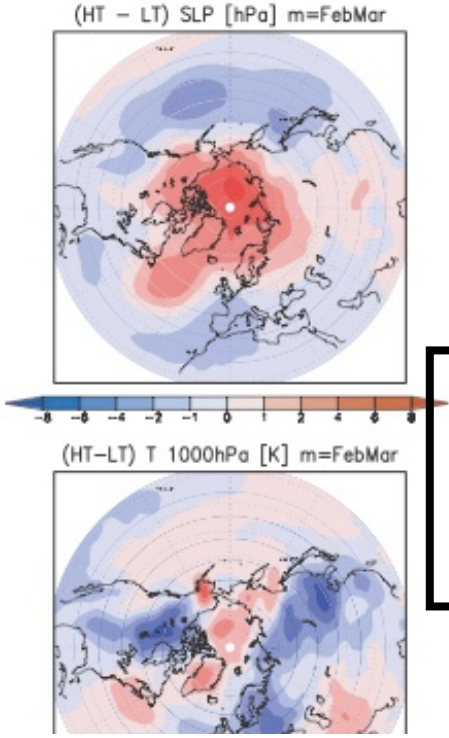

FM SLP [hPa]

ENSO for

HIGH - LOW TOP

MODELS

00 hPa [K]

IP

[mm/day]

FIG. 10. High-top minus low-top model difference in the FM ENSO anomaly for (top) SLP (hPa), (middle) 1000-hPa temperature (K), and (bottom) precipitation (mm day^{-1}).

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.

There is the need to extend these results to climate models ….

DynVar goal: To systematically assess the impact of the two-way dynamical coupling between the stratosphere and the troposphere on surface climate, by using coupled atmosphere ocean general circulation models (AOGCMs) as the principal tools of investigation.

[Note: AOGCMs are also named climate models]

Modelling promoted by DynVar:

Coupled Atmosphere, Ocean, and Seaice Models with high vertical resolution and model tops above the stratosphere

→ Physical core of an Earth System Model with a well resolved stratosphere

→Two-way troposphere-stratopshere dynamical coupling with a full representation of atmosphere and ocean-sea-ice interactions and climate processes.

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→ **Physical core of an Earth System Model with a well resolved stratosphere**

→**Two-way troposphere-stratopshere dynamical coupling with a full representation of atmosphere and ocean-sea-ice interactions and climate processes.**

[coupling to chemistry not excluded but not required]

Two international projects are including participants employing high top AOGCMs. Multi-model outputs from high top models will become / is becoming available from:

(1) WGSIP's Stratosphere Historical Forecast Project (SHFP).

(2) World Climate Research Programme's (WCRP) Coupled Model Intercomparison Project Phase 5 (CMIP5).

DynVar Role: to focus and facilitate research on these mutli-model output datasets

SPARC DynVar

Modelling the Dynamics and Variability of the Stratosphere-Troposphere System

October 2009 – January 2011 Activity Report

- Change in coordinator: Elisa Manzini followed Paul Kushner, who stepped down in October 2009

- DynVar Workshop 2, on *Modelling the Dynamics and Variability of the Stratosphere-Troposphere System*, 3-5 November 2010, NOAA ESRL David Skaggs Research Center, Boulder, CO, USA

- From the workshop::
  - Restructuring of the DynVar Activity organization
  - Web page extensive update: http://www.sparcdynvar.org/
  - New activities proposed and starting
  - Taking over by DynVar the role of analyzing multi-model runs performed for assessments purposed, with the focus on stratospheric dynamical variability

World Climate Research Programme

DynVar Workshop 2, on Modelling the Dynamics and Variability of the Stratosphere-Troposphere System, 3-5 November 2010, NOAA ESRL David Skaggs Research Center, Boulder, CO, USA

The workshop was kindly hosted by by the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory's (ESRL) Physical Sciences Division in collaboration with the Cooperative Institute for Research in Environmental Sciences (CIRES) at University of Colorado.

CIRES, NOAA, NOAA's Modeling, Analysis, Prediction and Projection (MAPP) Program, the European Commission COMBINE Integrating Project, and the SPARC project of the World Climate Research Program (WCRP) are kindly acknowledged for support.

SPARC DynVar

Modelling the Dynamics and Variability of the Stratosphere-Troposphere System

DynVar Workshop 2, on Modelling the Dynamics and Variability of the Stratosphere-Troposphere System, 3-5 November 2010, NOAA ESRL David Skaggs Research Center, Boulder, CO, USA

Workshop in numbers: 68 participants from 11 countries. USA (35, 10 of which from NOAA in Boulder), Canada (8), United Kingdom (7), Japan (6), Germany (4), France (3), Denmark (1), Israel (1), Italy (1), Norway (1), Spain (1).

The workshop consisted of 11 invited and 41 contributed presentations (11 orals and 30 posters) and was opened by a keynote by Susan Solomon. 45 Abstracts submitted.

World Climate Research Programme

DynVar Workshop 2, on Modelling the Dynamics and Variability of the Stratosphere-Troposphere System, 3-5 November 2010, NOAA ESRL David Skaggs Research Center, Boulder, CO, USA

Topics presented included:
- **decadal variations in stratospheric water vapor**
- **methodologies to diagnose stratosphere-troposphere coupling in both observations and simulations**
- **results from the CCMval report**
- **mechanisms of troposphere – stratosphere interactions**
- **evidence of changes in surface climate related to stratospheric changes**
- **session dedicated to the status of development of high top AOGCMs and their application in the CMIP5 simulations**

=> Workshop report of SPARC Newsletter 36 – January 2011 Issue (Manzini et al 2011)

High top models participating to CMIP5 so far:

Institute / Group	Model	Atmospheric Resolution	Scenario	Contact
CMCC	CMCC-CMS	T63xL95 top=0.01hPa	RCP4.5	chiara.cagnazzo@cmcc.it piergiuseppe.fogli@cmcc.it silvio.gualdi@bo.ingv.it
	CMCC-CESM	T31xL39 top=0.01hPa	RCP8.5	
DMI	EC-EARTH	T159xL91 top=0.01hPa	RCP4.5	shuting@dmi.dk boc@dmi.dk
		T159xL61 top=5hPa		
GEOS	GEOS-5	1ºx1.25ºxL72 top=0.01hPa	Decadal prediction runs	Steven.Pawson-1@nasa.gov
GFDL	CM3	~200kmxL48 top=0.017hPa	All 4 RCPs	john.austin@noaa.gov leo.j.donner@noaa.gov larry.horowitz@noaa.gov
GISS	GISS-E	90x144xL40 top=0.1hPa	All 4 RCPs	dshindell@giss.nasa.gov
IPSL	IPSL-CM5	144x143xL39 top=65km	RCP4.5	Francois.lott@lmd.jussieu.fr
Met Office Hadley Center / NCAS	HadGEM2	192x145xL60 top=84km	RCP4.5, RCP8.5	neal.butchart@metoffice.gov.uk steven.hardiman@metoffice.gov.uk s.osprey@physics.ox.ac.uk gray@atm.ox.ac.uk
MPI-M	MPI-ESM	~360x180xL95 top=0.01hPa	All 4 RCPs	marco.giorgetta@zmaw.de
MIROC	MIROC-ESM	T42xL80 Top=85km	All 4 RCPs	wnabe@jamstec.go.jp kawamiya@jamstec.go.jp nozawa@nies.go.jp
	MIROC-ESM-CHEM			
MRI	MRI-ESM1	TL95xL48 (320x160) top=0.01hPa	RCP4.5, RCP8.5 RCP8.5	kshibata@mri-jma.go.jp
NCAR	WACCM4	144x96xL66 top=$6x10^{-6}$hPa~135km	RCP4.5 (RCP8.5, RCP2.6)	aksmith@ucar.edu rgarcia@ucar.edu marsh@ucar.edu

SPARC DynVar

Modelling the Dynamics and Variability of the Stratosphere-Troposphere System

Restructuring of the DynVar Activity organization and web page:

(1) Enlarge the core of DynVar:

-Committee Members: Elisa Manzini, 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, Fabrizio Sassi

(2) Research Topics & Groups:
http://www.sparcdynvar.org/research-topics-groups-folder/

=> Engage the community at large, divulge news and research results based on the SHFP and CMIP5 model-outputs, promote collaborative research.

World Climate Research Programme

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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.u
- **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

World Climate Research Programme

SPARC DynVar

Modelling the Dynamics and Variability of the Stratosphere-Troposphere System

Activities now starting:

- Review paper on the role of stratospheric dynamics on tropospheric climate for BAMS – Gerber et al

- Synthesis paper 1: Multi-model model comparison of stratospheric climate, variability and change – Charlton-Perez et al

- Synthesis Paper 2: Multi-model high top / low top comparison focused on surface climate, variability and change – Manzini et al

Both synthesis papers will be based on the CMIP5 model-outputs.

Plans for 2011 and 2012

2011:

- Communicate with the research community via the web site and the email list [sparcdynvar] (for instance, on the status of the CMIP5 runs, etc.) aiming at a possible future event(s).
- Review and Synthesis Papers
- Liaise with closely related activity within SPARC

Spring 2012:

- We would like to propose to the SPARC SSG a
SPARC-DynVar and CLIVAR/SHFP one week open Workshop

Possibility: Extend the 2012 workshop to the Arctic and Antarctic SPARC activities now going on in collaboration with CliC.

SPARC DynVar

Modelling the Dynamics and Variability of the Stratosphere-Troposphere System

Proposal for SPARC-DynVar / CLIVAR-SHFP Workshop Spring 2012:

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**
- **Report on the analysis of the CMIP5 and SHFP simulations**
- **Timely with respect to the schedule of AR5 IPCC**

Structure:

- **Based on the Research Topics, but not limited to them.**
- **Workshop, for enabling open discussion on modeling issues**

Duration: One week. Given the large participation in the DynVar Workshop 2, we think that there is potential.

Target participation: 100-150 people

World Climate Research Programme

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THANK YOU

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