

SPARC Dynamics & Variability Project

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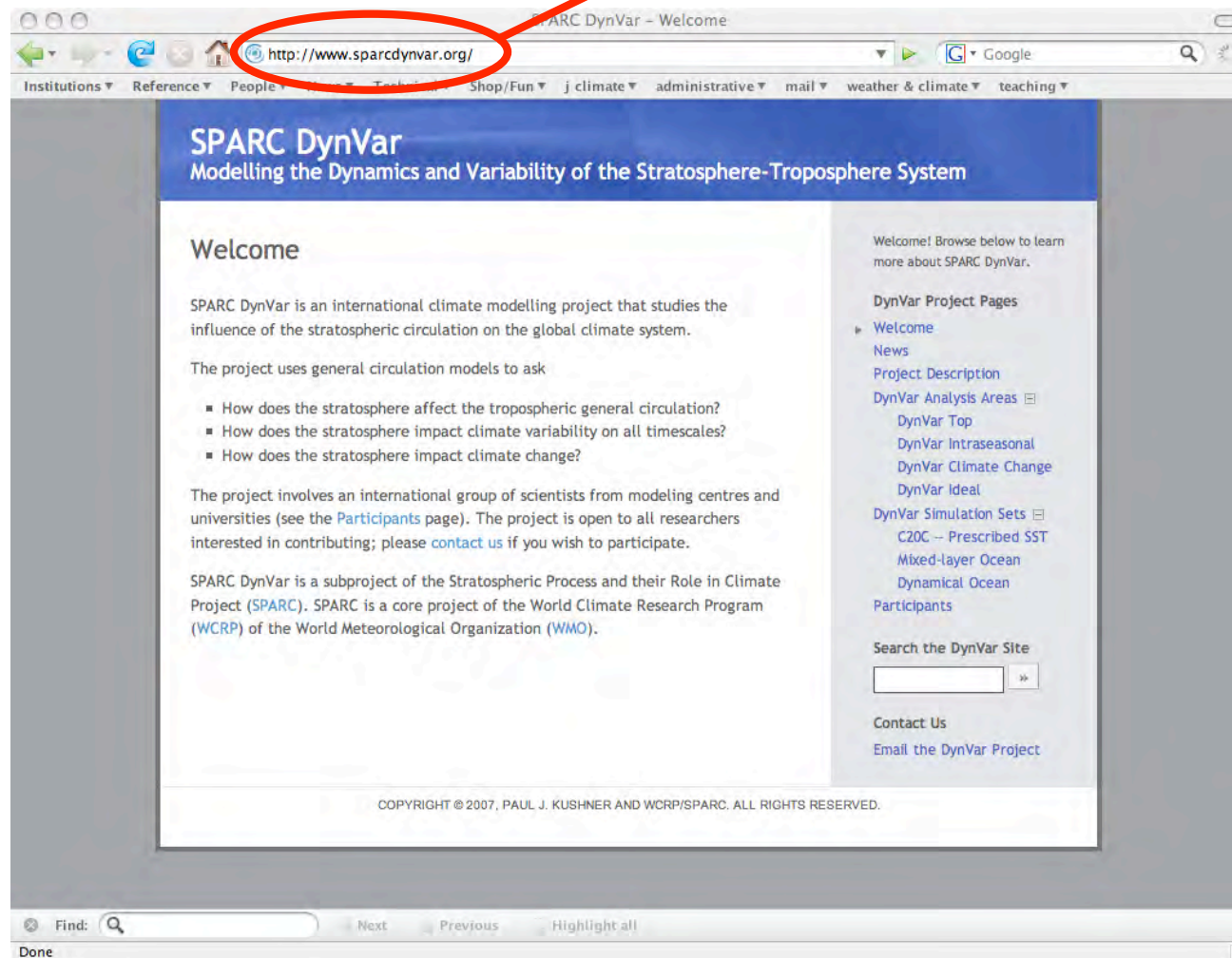
Elisa Manzini

Lorenzo Polvani



See also ...

- * SPARC Newsletter this summer
- * *www.sparcdynvar.org*



Outline

- * Background, project description
- * Activities in the last year
- * Activities in the coming year
- * Discussion

Background

- * The developing picture of strat-trop linkages:
 - The stratospheric and tropospheric circulation are two-way coupled via eddy mean-flow interactions.
 - Strat representation in GCMs influences trop circulation and climate change responses.
 - Seasonal timescale strat-trop coupling has predictive value.

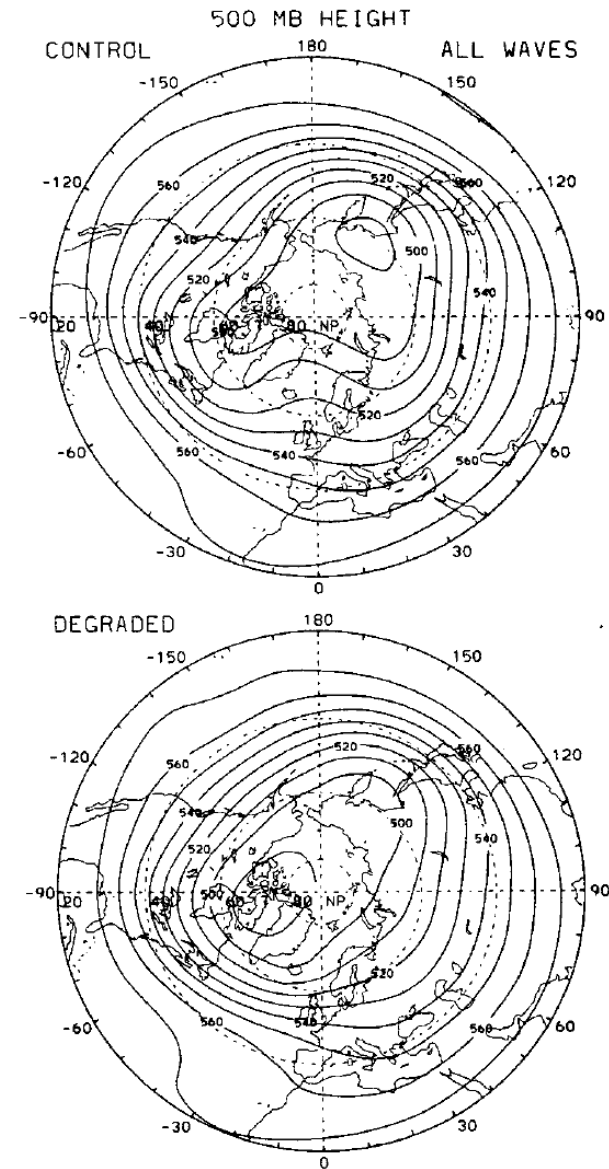
(Key papers by Boville, Kuroda & Kodera, Baldwin & Dunkerton, Shindell et al., Thompson & Solomon, Gillett & Thompson)

Boville 1984

* Making the cold pole problem worse . . .

→ Leads to tropospheric flow that is too zonal.

→ Reduces transient eddy activity.

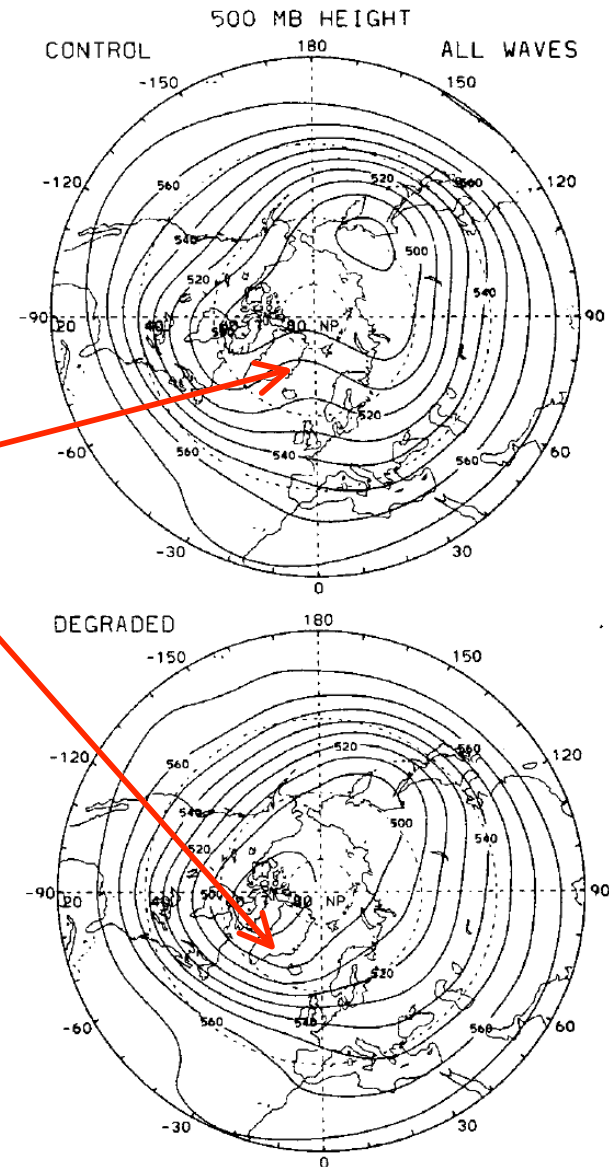


Boville 1984

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The SPARC Dynamics & Variability Project

- * DynVar aims to study stratospheric influence on tropospheric climate using AGCMs as the main tools.
- * We regard the stratospheric circulation as an Earth-System process, and aim to document the costs and benefits of including a realistic strat component in an Earth Systems Model.
- * The project fits within the “Strat-Trop Coupling” initiative of SPARC and we are thinking of a 5-year duration.
- * The project’s membership is open . . .

DynVar Aims & Characteristics

- * We ask how GCMs' stratospheric representation affects tropospheric climate, variability, and climate responses.

- * Distinctive aspects from other SPARC activities:
 1. Stronger emphasis on tropospheric metrics.
 2. Comparison of high-top and low-top models.
 3. Investigation of ocean-atmosphere coupling.
 4. Requirement that participating GCMs satisfy basic specs.
 5. Focus on processes that do not hinge on coupled chemistry feedbacks or solar influences.
 6. Inclusion of a significant theoretical component.

Analysis Areas & their Coordinators

We identify four *Analysis Areas* where we can place specific research subprojects:

A: DynVar Top (Sassi and Giorgetta)

Strat representation influence on circulation and variability of coupled ocean-atmosphere-cryosphere system.

B: Dynvar Intraseasonal (Perlwitz)

Intraseasonal strat-trop coupling, with a view to seasonal prediction.

Analysis Areas & their Coordinators

C: DynVar Climate Change (Manzini)

Focuses on stratospheric control of response to climate forcings.

D: DynVar Ideal (Polvani)

Analysis of strat influence using simplified models and other theoretical approaches.

AGCM Requirements

- * Initial focus is on extratropical circulation, involves dynamics of synoptic-to-planetary scale waves.
 - *So we require horizontal resolution corresponding to T42 or finer.*
- * High-top models should represent well the vertical structure of the stratospheric circulation.
 - *So we require vertical resolution corresponding to L35 or finer, and sponge layer & lid above the stratopause (1 mb).*
- * Signal-to-noise ratio of stratospheric influence on troposphere expected to be small.
 - *So we need long runs and multiple member ensembles.*

Simulation Sets

- * We want to elucidate the role of the stratosphere for various degrees of coupling to the land-ocean surface.
- * We have outlined three sets of simulations ...

Simulation Sets

- * *Set A: Prescribed SST C20C Simulations*
 - AGCM simulations with historical SSTs and forcings that mesh with the forcings of the CLIVAR C20C & CCMVal forcings
- * *Set B: Mixed Layer Ocean*
 - Preindustrial and 2XCO₂ equilibrated simulations.
- * *Set C: Dynamical Ocean*
 - Control and transient climate forcing experiments.

Where DynVar Fits in SPARC, WCRP, etc.

- * We are trying to tie in to existing plans at the modeling centres.
- * We aim to feed useful data and analyses to CCMVal, SOLARIS, etc.
Participants can use DynVar data without defining a new DynVar project.
- * We will coordinate with the CLIVAR C20C project, which feeds into IPCC.
- * In the discussion we'll talk about other links.

Activities in the Last Year

- * We started the project in October 2006.
- * We developed our project structure between December 2006 and June 2007.
- * We wrote a SPARC Newsletter that was published this summer.
- * We promoted the project at the CLIVAR C20C and SPARC CCMVal workshops.
- * We set up a simple website at sparcdynvar.org
- * We are carrying out preliminary analyses to help define science goals for the project.

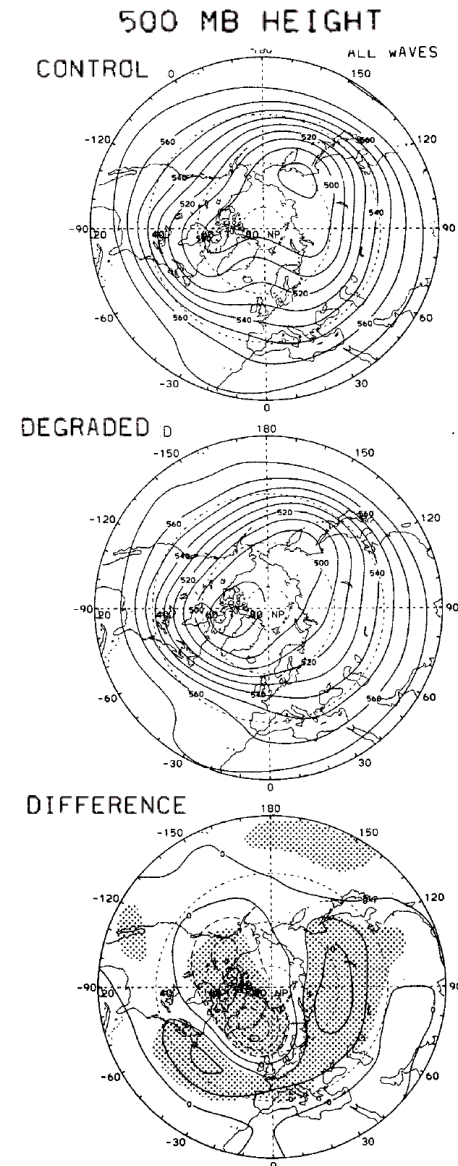
Preliminary Analyses

A bit now, more in Santorini . . .



Stratospheric Influence on Tropospheric Climate

- * Boville 1984 showed that the strength of the strat polar vortex is tied to storm track structure.
- * I will show how we reproduce his result (qualitatively) in a current generation model.
- * We can pin the difference on changes to vertical resolution.

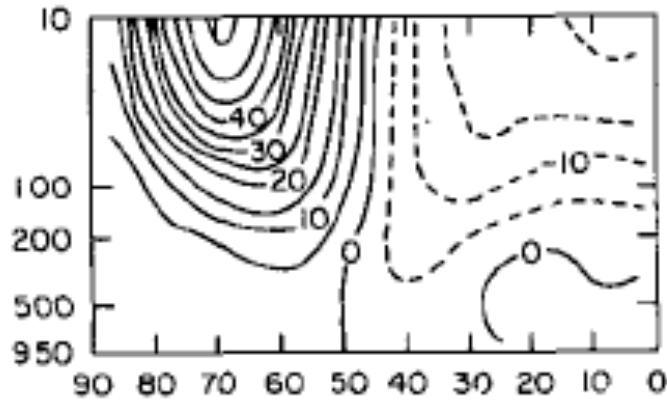


Boville 1984

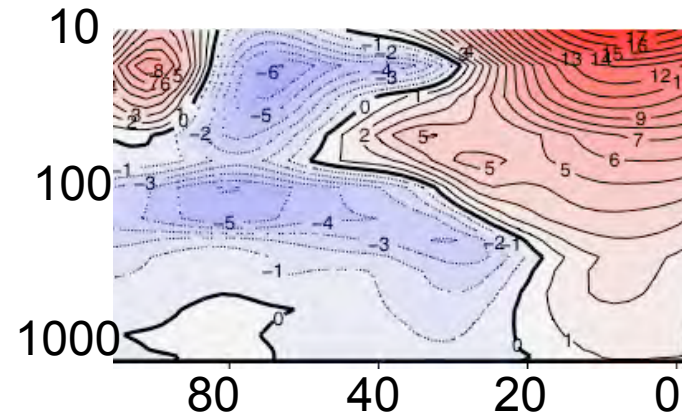
Stratospheric Influence on Tropospheric Climate

NCAR CCM Winter Response
to Reduced Strat Diffusion

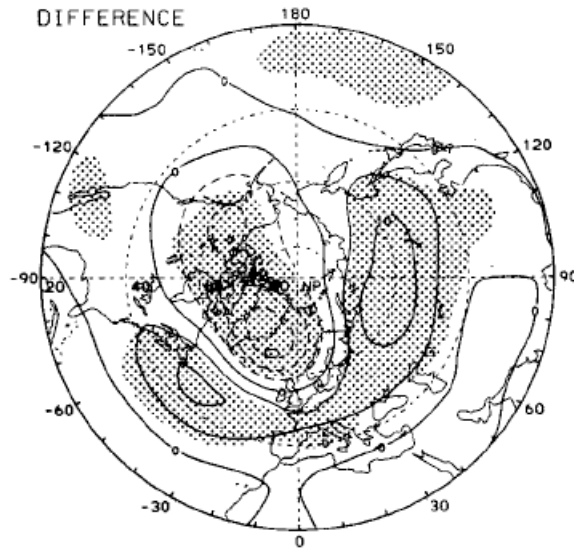
ΔU



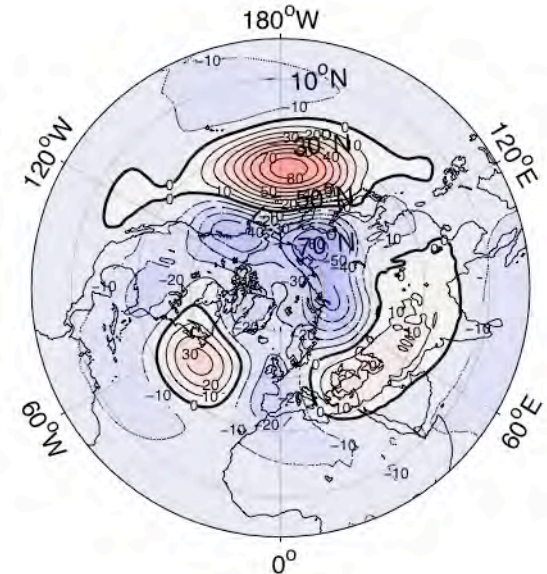
GFDL AM2: DJF
High-top minus low-top



ΔZ_{500}



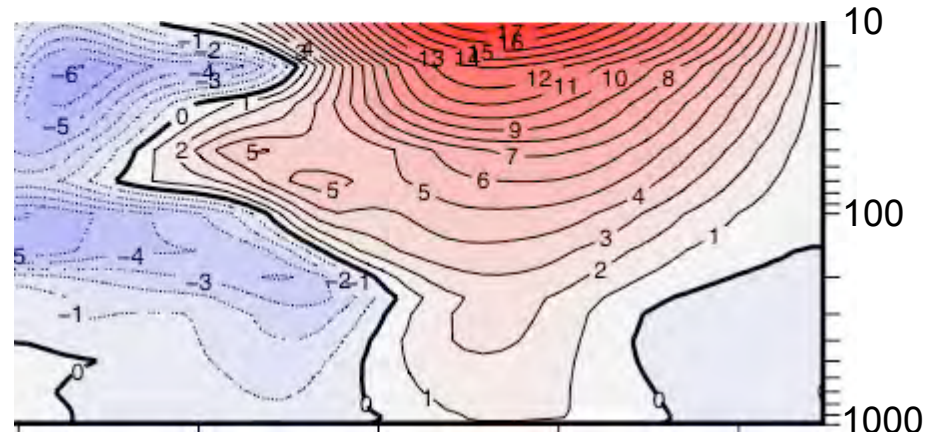
Boville 1984



Steven Hardiman

Decomposing the High-top to Low-top Differences

High-top
minus
Low-top

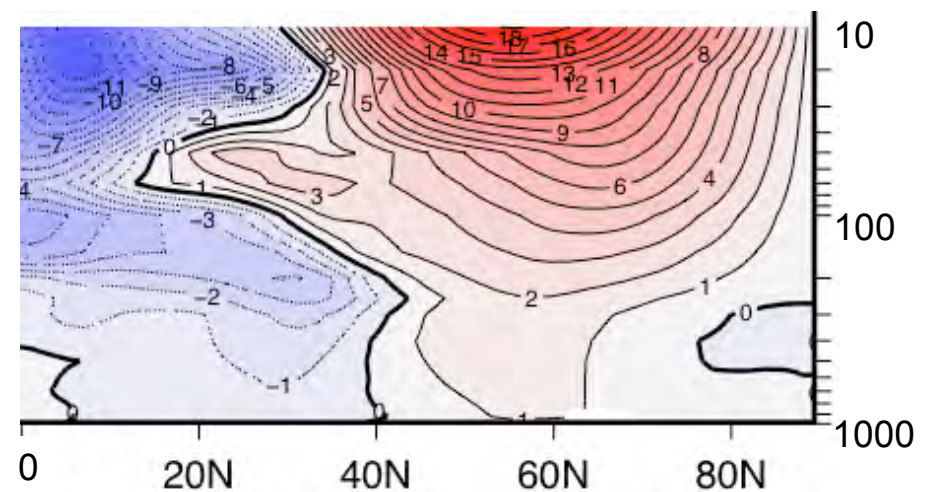


Response to
changing
drag
(Rayleigh to
Non-Oro
GWD)



* In GFDL AM2, the troposphere responds more strongly to the change in vertical resolution.

Response to
increasing
vertical
resolution &
raising lid

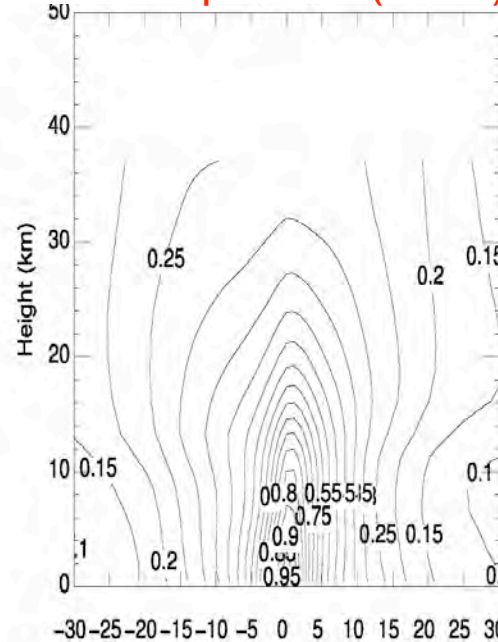


Steven Hardiman

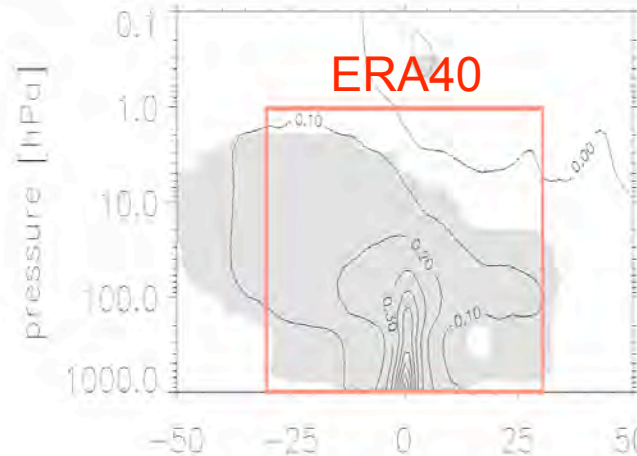
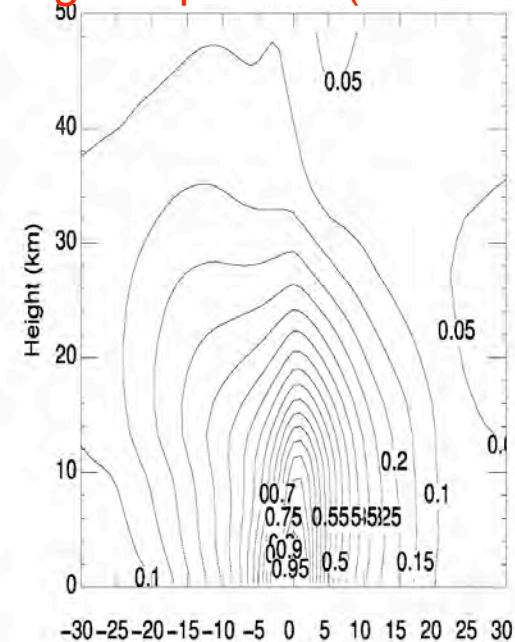
Sassi: Correlations of NAM with AO

- * The High-Top GCM has the observed lag-correlation structure found by Baldwin & Dunkerton.
- * Improved strat representation leads to realistic intraseasonal coupling.

Low-Top GCM (CAM)



High-Top GCM (WACCM)



Christiansen
2005

If only it were so simple ...

- * These results suggest that stratospheric influence might be captured by improving vertical resolution.
- * But this is too simplistic:
 - Orographic gravity wave drag (OGWD) can control the Brewer Dobson circulation response and tropospheric wind response to climate change (Feng Li et al., Sigmond et al.)
 - The timescale of tropospheric variability is very sensitive to dynamical core details and GWD details (Gerber et al., Hardiman et al.)
- * We will have our work cut out for us.

Activities for the Coming Year

- * We will hold a planning workshop at the University of Toronto, March 27-28 2008.
→One day of talks, one day of planning.
- * We aim to begin our database of runs and start analyses in the spring.
- * We aim to highlight first results at the SPARC GA in Bologna.

Three Discussion Points

1. For the workshop, we would like some endorsement/support from SPARC & WCRP.
2. We need SPARC & WCRP's help to produce and publicize precise statements on how strat representation will
 - Improve Earth Systems Models and affect their climate change response.
 - Improve seasonal forecasts.

While we work on the research, SPARC could help make the links to other programs (e.g. CLIVAR C20C, WGSIP, etc.) and to the modelling centres.

Three Discussion Points

3. The issue of gravity wave drag control looms large:
 - Tropical variability and climate sensitivity are strongly controlled by (unresolved) moist processes.
 - How much is the extratropical troposphere similarly controlled by GWD?
 - DynVar will certainly be helped by the Gravity Wave process initiative and will try to produce the necessary runs & diagnostics for GWD evaluation.