

# ***Climate model extension of surface drag/momentum budget intercomparison***

Protocol for climate models:

*Easy but uninformative. Comprehensive but impossible.*

*Broad but shallow. Deep but narrow ...*

- Interannual variability – CAM example

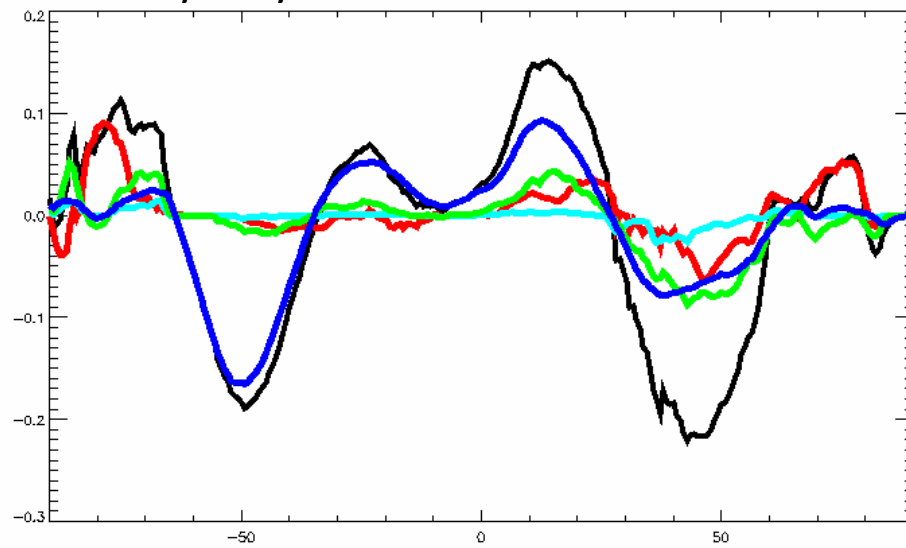
Leveraging a collaboration with ISSI GW project

Where to go next?

- Momentum budget vs just surface drag
- Sensitivity runs (1D SCM? 3D?)

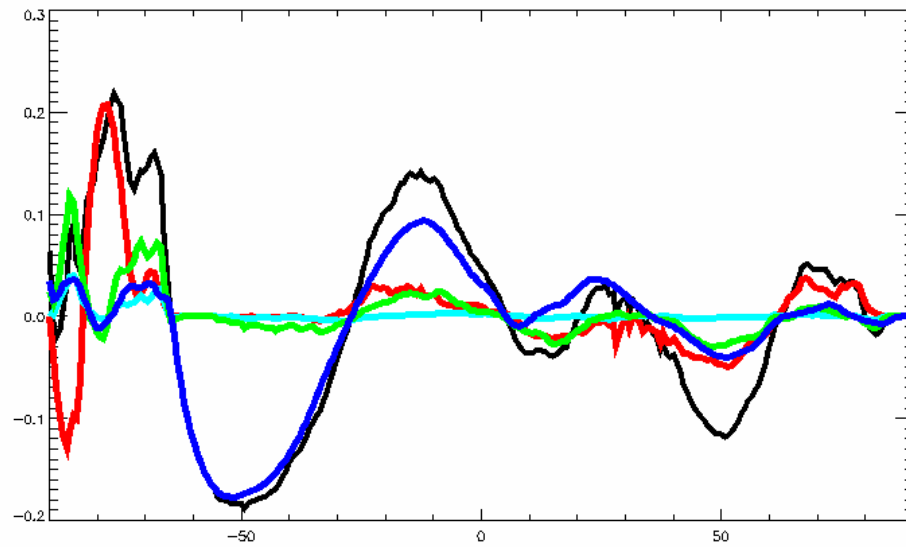
Inter-annual variability in CAM

January 20-year mean from CAM5 ne30 60L

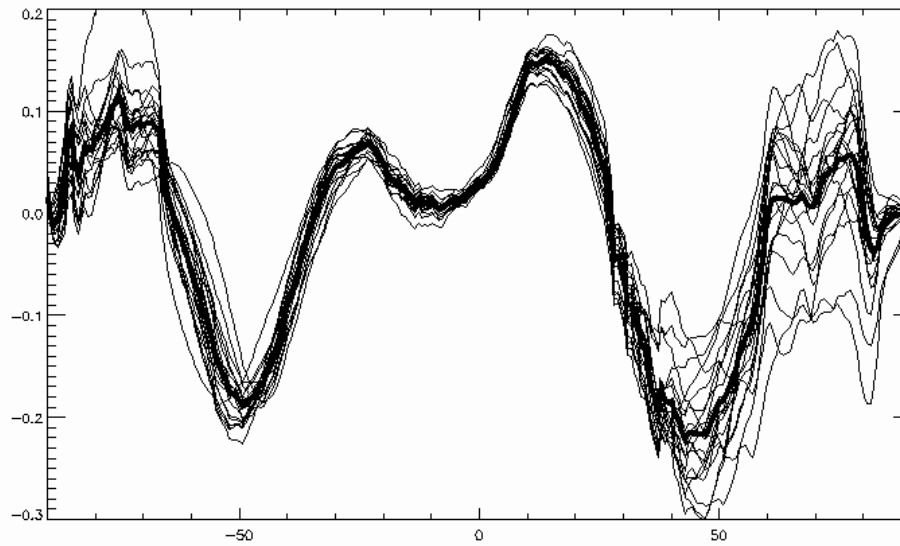


- Total
- Resolved
- TMS
- Non-oro PBL
- GW

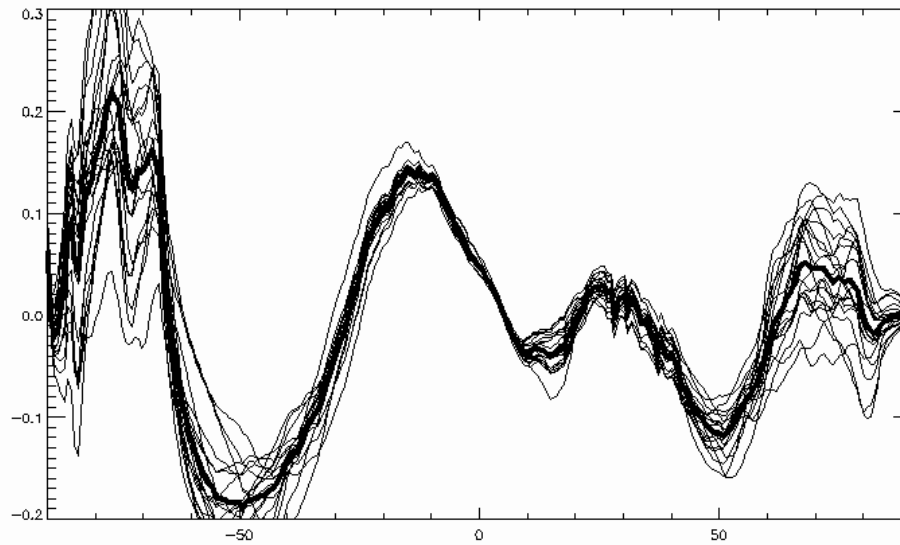
July 20-year mean from CAM5 ne30 60L



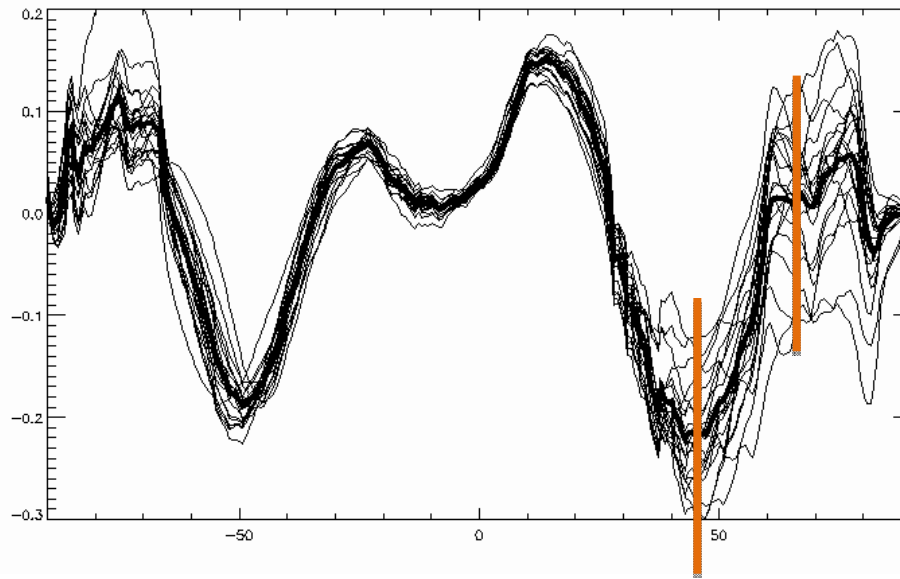
January 20-year mean from CAM5 ne30 60L



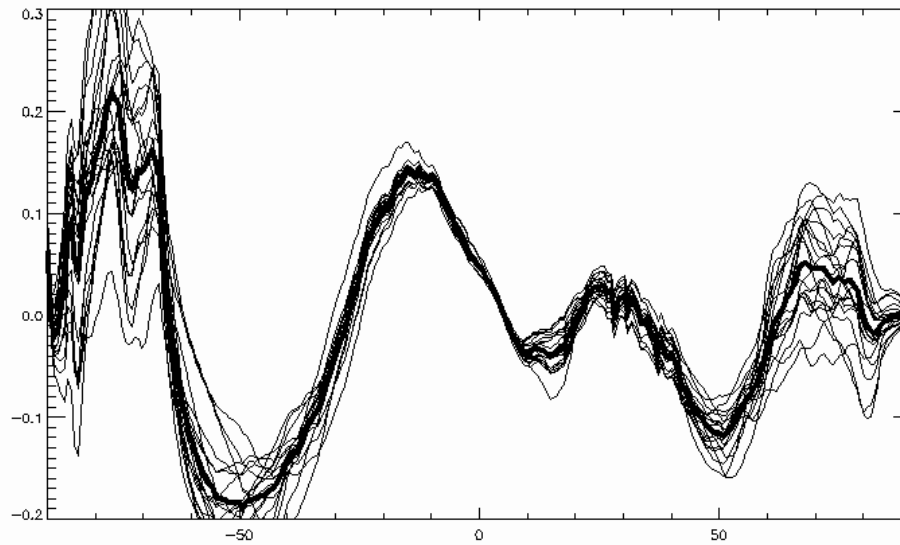
July means 1980-1999 from CAM5 ne30 60L



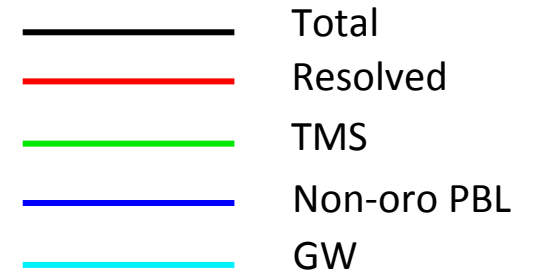
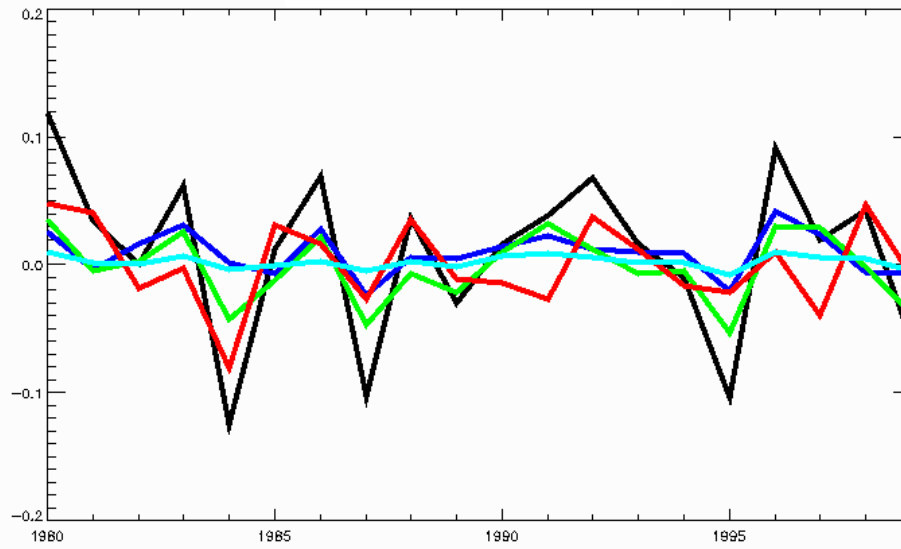
January 20-year mean from CAM5 ne30 60L



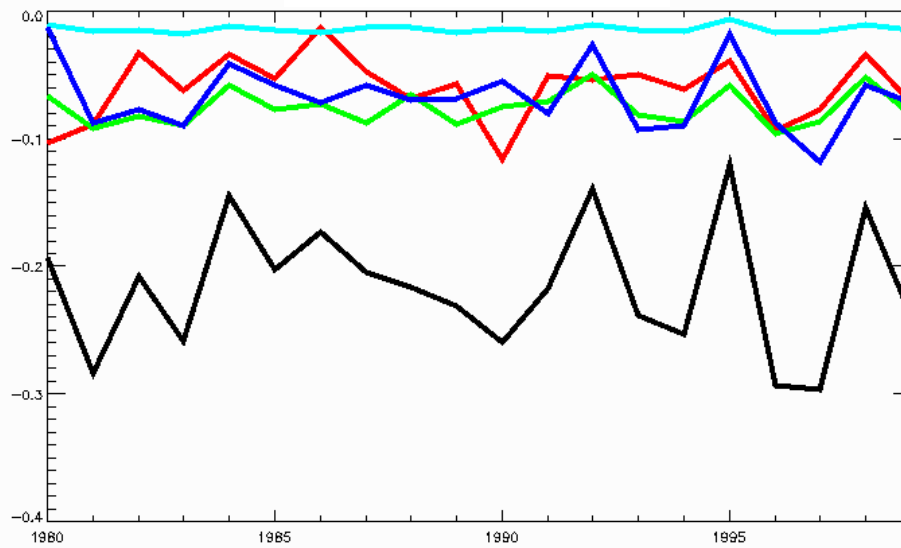
July means 1980-1999 from CAM5 ne30 60L



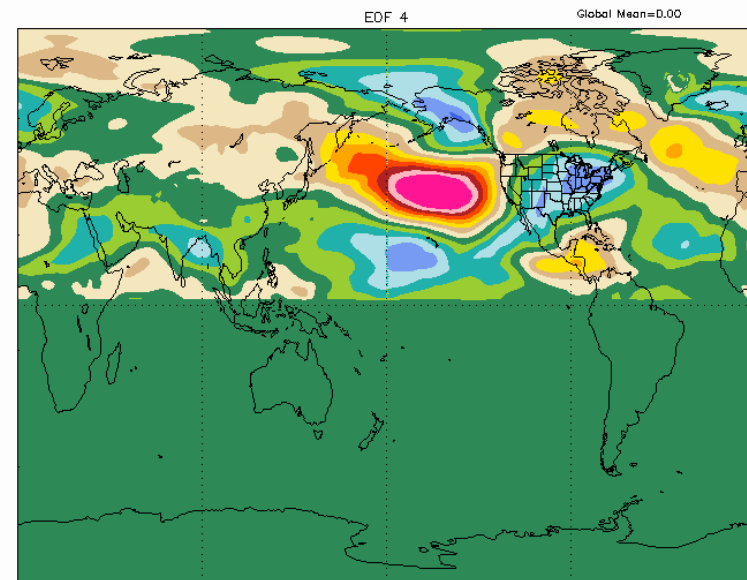
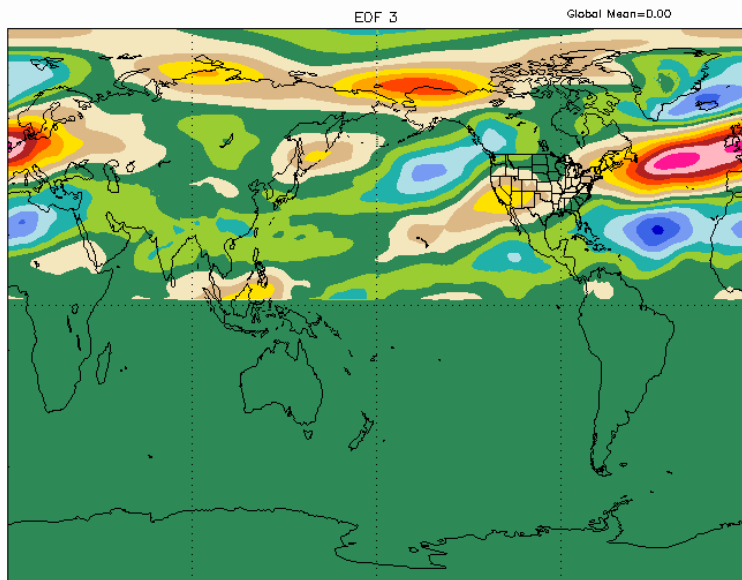
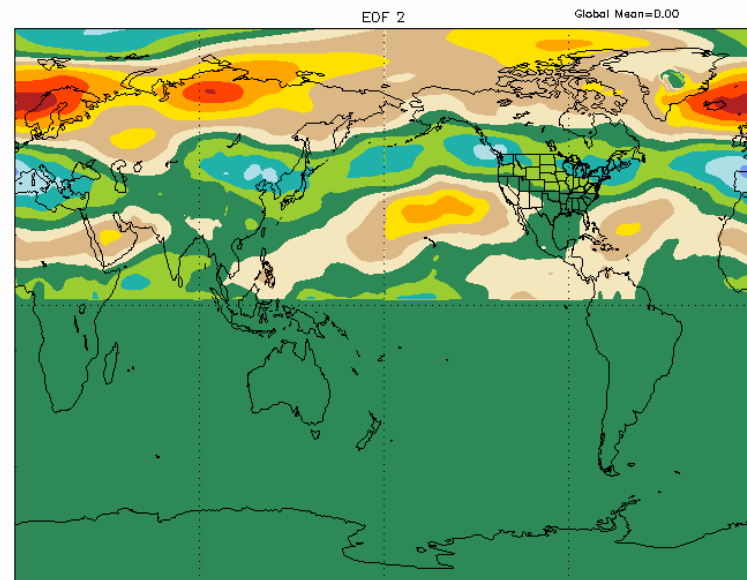
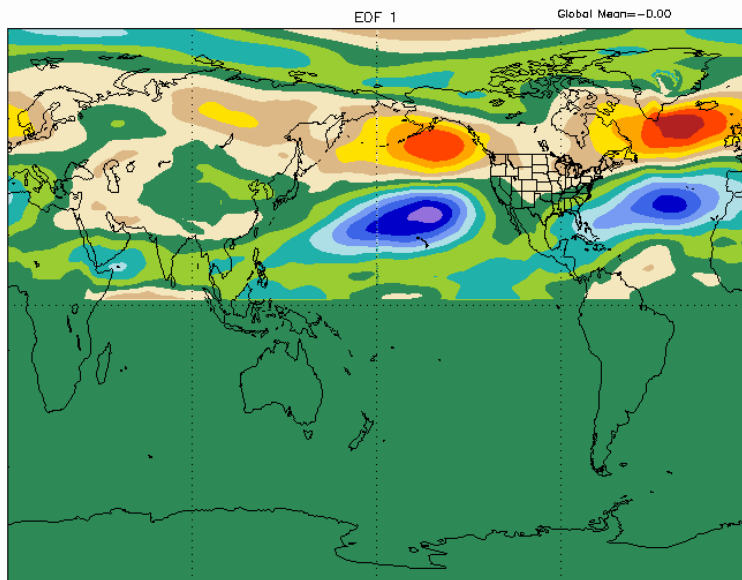
### 65°N January

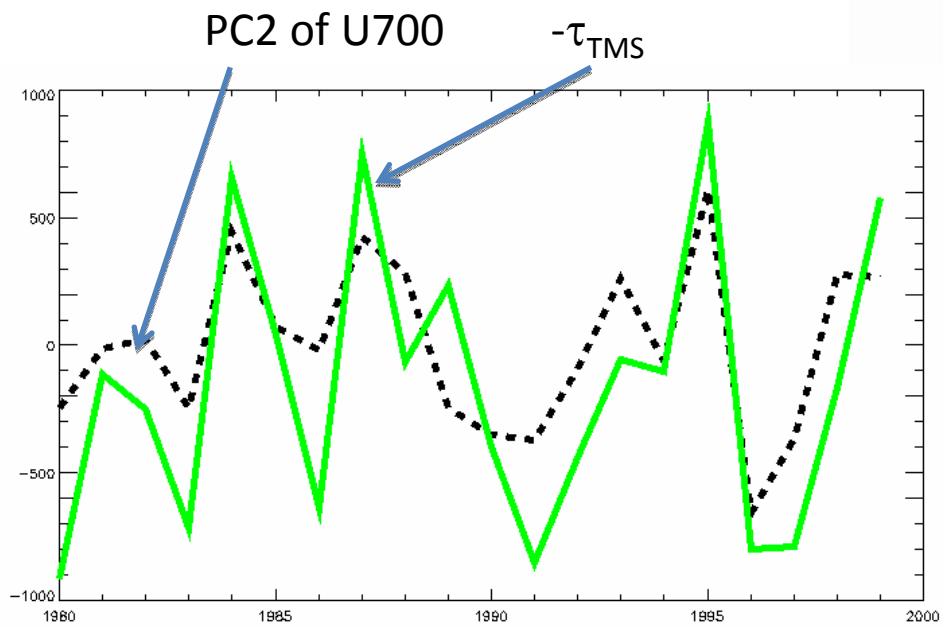
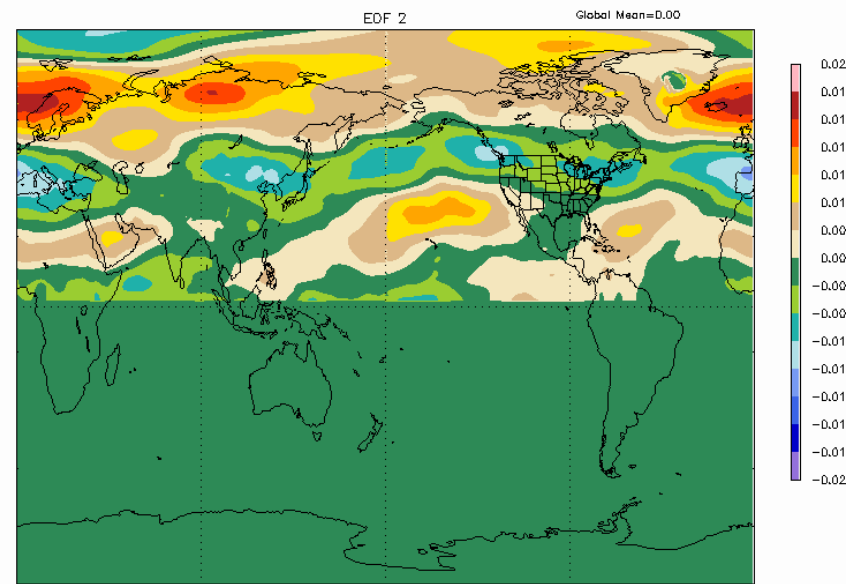


### 45°N January



# Principal components of NH U 700 hPa (January)

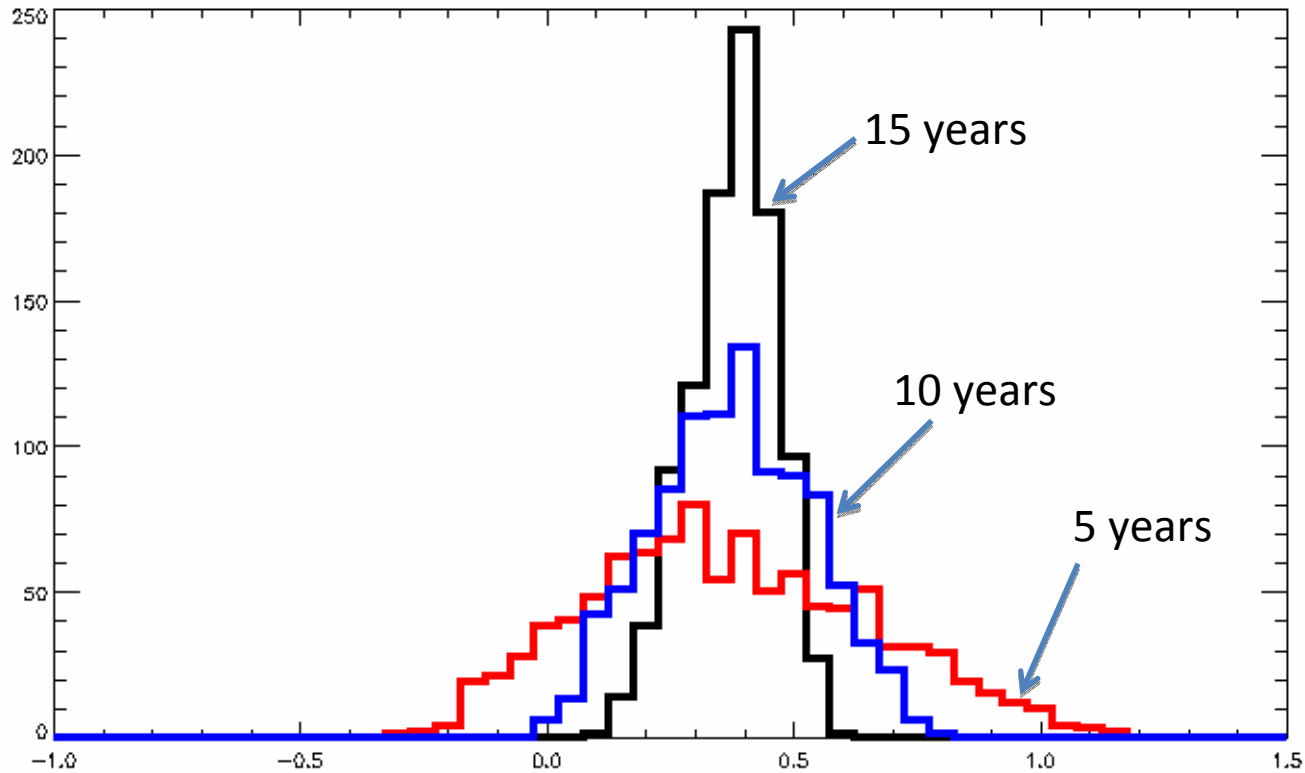




$r = -.82$  (with U850  $r = -.75$ )



PDFs of average January *ratio* of TMS to total surface drag at 65°N. Drawn from 1000 synthetic samples of 20 years



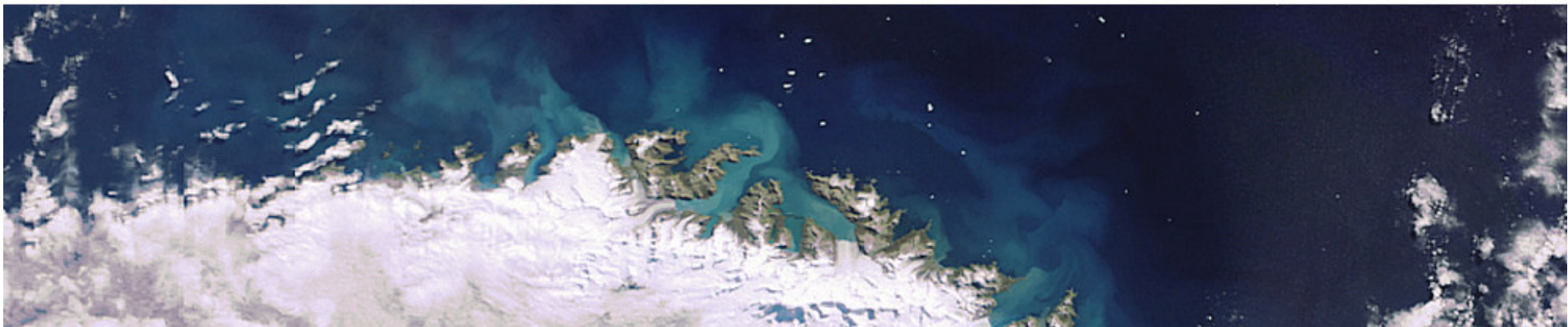
Minimum 10 year runs with drags and low-level U seem reasonable compromise of utility and ease

# Atmospheric Gravity Waves in Global Climate Prediction and Weather Forecasting Applications

ISSI Team led by Joan Alexander



International Team






[Home](#) [Local Guide](#) [Proposal](#) [Publications](#) [Team Members](#)

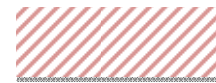
Next meeting March 31-April 4, 2014

<http://www.issibern.ch/teams/gravitywaves/>

Likely participants in surface drag intercomparison (*most leveraged from Joan Alexander's ISSI Gravity Wave Team*)

|                 | Blocking    | Anisotropy | PBL obstacle  |               |
|-----------------|-------------|------------|---|---------------|
| LMDz            | <i>LM97</i> |            |   | F. Lott       |
| GISS (SUNY)     |             |            |   | M. Geller     |
| CAM4            |             |            |   |               |
| WACCM4          |             |            |    | J. Richter    |
| CAM5            |             |            |    |               |
| GEOS5(NASA)     |             |            |   | A. Molod      |
| MERRA (re-anal) |             |            |   | M. Pulido     |
| CMAM            | <i>SM00</i> |            | ??  | C. McLandress |
| NAVGEM          | <i>W03</i>  |            |  | S. Eckermann  |
| HadGEM          | <i>W03</i>  |            |   | A. Bushell    |
| ECHAM           | <i>LM97</i> |            |   | E. Manzini    |

LM97 = Lott and Miller, 1997, QJRMS  
 SM00 = Scinocca and McFarlane, 2000, QJRMS  
 W03 = Webster et al., 2003, QJRMS



Self-described as  
 "crude", "provisional",  
 "temporary" ....

# ISSI GW team proposed analysis of zonal momentum budget based on “transformed Eulerian mean” (TEM) equations

Transformed meridional circulation

$$\begin{aligned}\bar{v}^* &\equiv \bar{v} - \rho_0^{-1}(\rho_0 \overline{v'\theta'}/\bar{\theta}_z)_z, \\ \bar{w}^* &\equiv \bar{w} + (a \cos \phi)^{-1}(\cos \phi \overline{v'\theta'}/\bar{\theta}_z)_\phi.\end{aligned}$$

*Includes parameterized orographic and non-orographic gravity wave tendencies*

Zonal momentum Equation:

$$\begin{aligned}\bar{u}_t + \bar{v}^*[(a \cos \phi)^{-1}(\bar{u} \cos \phi)_\phi - f] + \bar{w}^* \bar{u}_z - \bar{X} \\ = (\rho_0 a \cos \phi)^{-1} \nabla \cdot \mathbf{F},\end{aligned}$$

where,

$$\begin{aligned}\mathbf{F}^{(\phi)} &\equiv \rho_0 a \cos \phi (\bar{u}_z \overline{v'\theta'}/\bar{\theta}_z - \overline{v'u'}), \\ \mathbf{F}^{(z)} &\equiv \rho_0 a \cos \phi \{ [f - (a \cos \phi)^{-1}(\bar{u} \cos \phi)_\phi] \overline{v'\theta'}/\bar{\theta}_z - \overline{w'u'} \};\end{aligned}$$

*Resolved wave momentum flux*

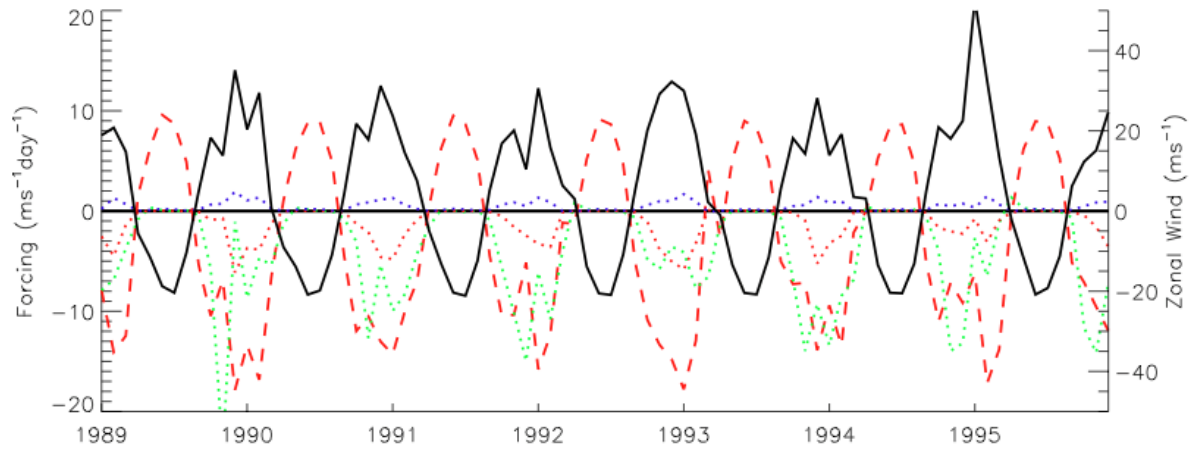
and,

$$\nabla \cdot \mathbf{F} \equiv (a \cos \phi)^{-1} \frac{\partial}{\partial \phi} (F^{(\phi)} \cos \phi) + \frac{\partial F^{(z)}}{\partial z}$$

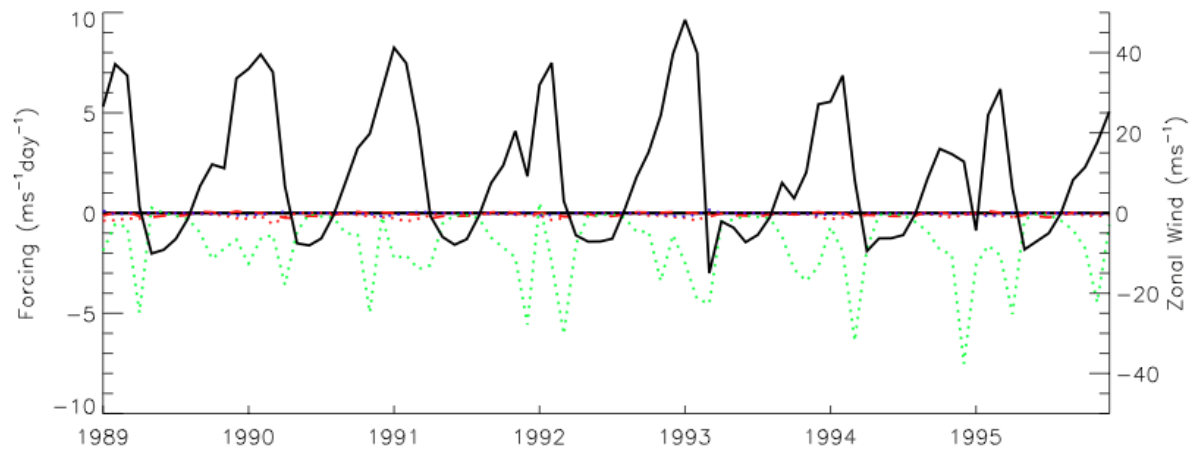
Two models so far have submitted monthly mean fields – HadGEM, CAM. Currently assessing contribution from FU Berlin

# HadGEM results

TEM Momentum Budget: NH 50°-80° 0.1 hPa



TEM Momentum Budget: NH 50°-80° 10.0 hPa



--- USSP    ..... OroG-GWD    ..... Div.F    ..... Advection  
—— Zonal Wind

Andrew Bushell (*Met. Office*), David Long

# *Next Steps*

Complete surface drag analysis of ISSI GW + n models

Extend to momentum budget analysis

SCM/1D studies

Sensitivity runs, e.g., turn off PBL form drag for 10 years (1D or 3D)

Constraints:

- Meridional angular momentum transport ( need  $\overline{uv}$ )
- Observational (John Mitchell WMAC/WDAC ...??)