

# Extensions to parameterized orographic drag in CAM

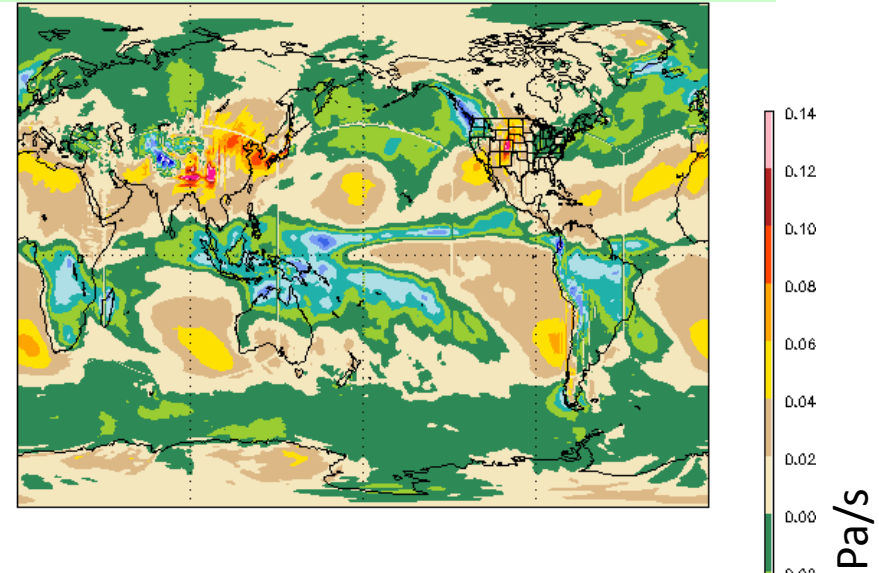
*Julio Bacmeister and Peter Lauritzen* **AMP**



# Overview

- Motivation
- Anisotropic/blocking scheme description
- Results
  - AMIP results
  - CAPT
- Future work

## Smooth topo (smoothing scale~800km)



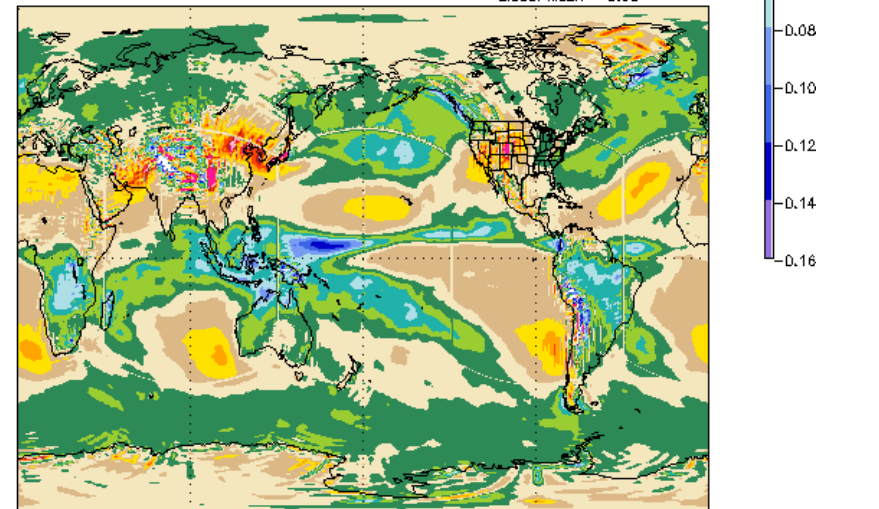
1980-81 DJF mean  $\omega$  fields  
ne30~100km

### *CAM-SE is noisy*

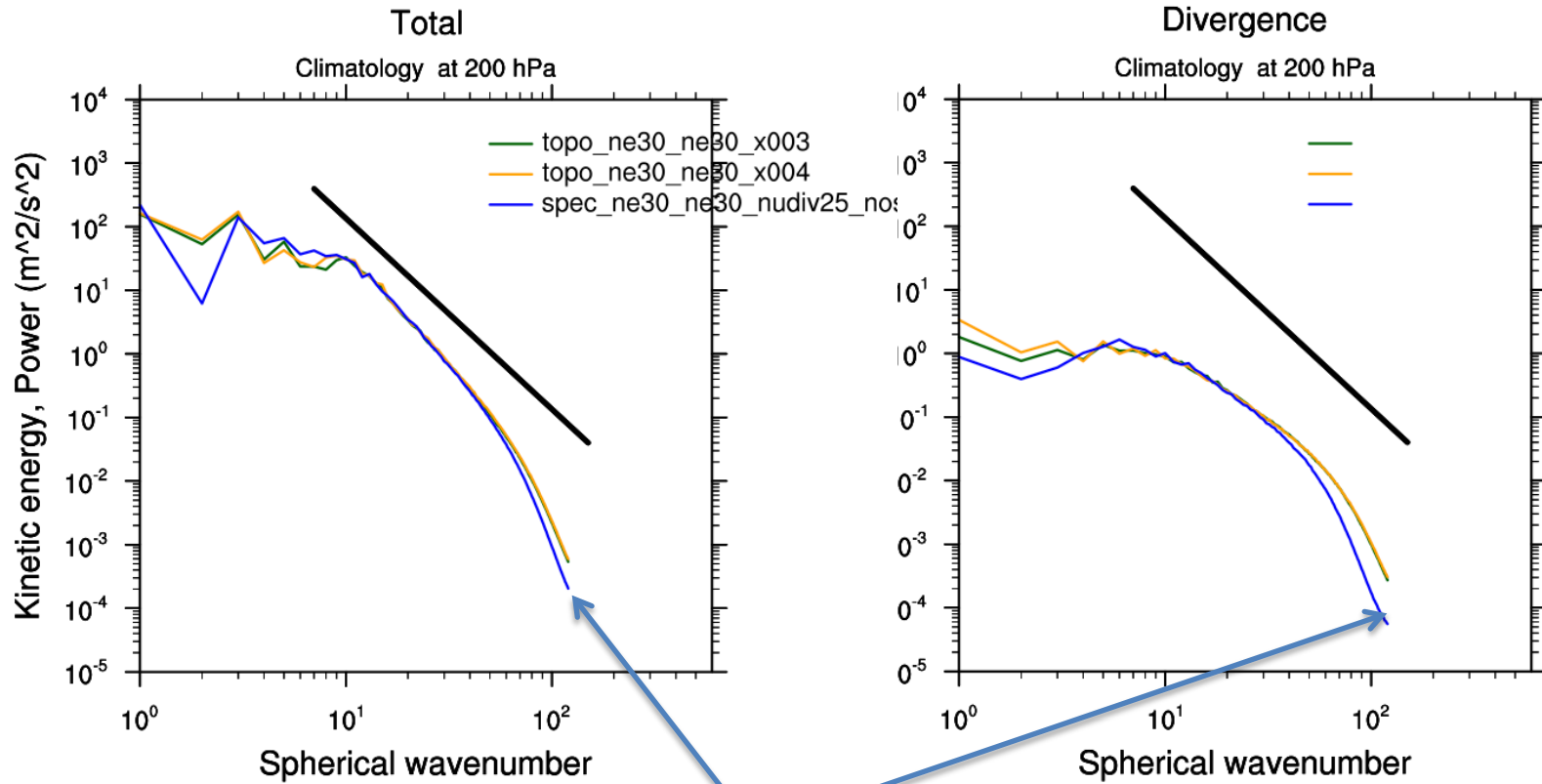
2 approaches to mitigate this

- smoother topo
- increased divergence damping

## "Rough" topo (smoothing scale~400km)

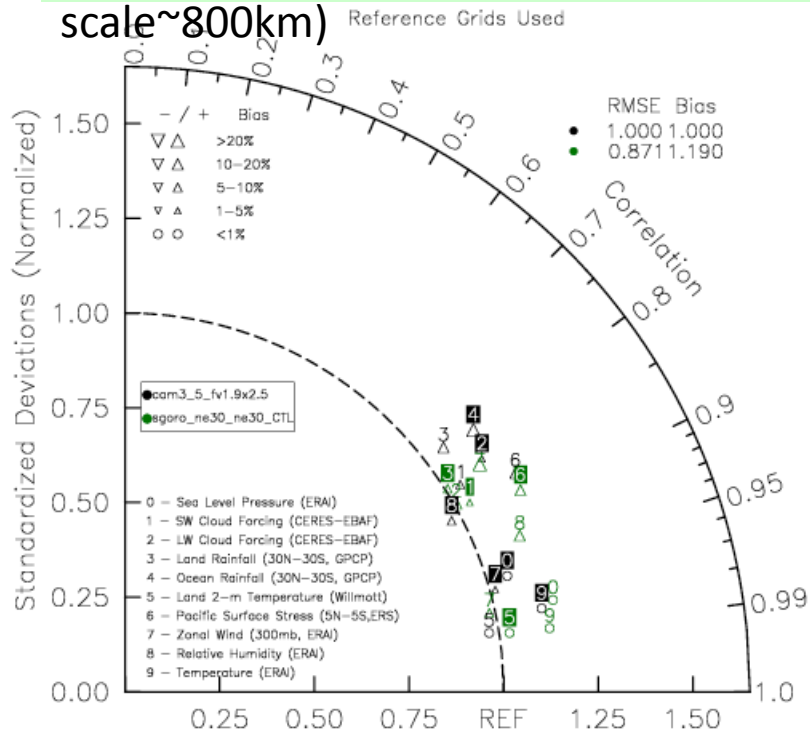


# Energy spectra

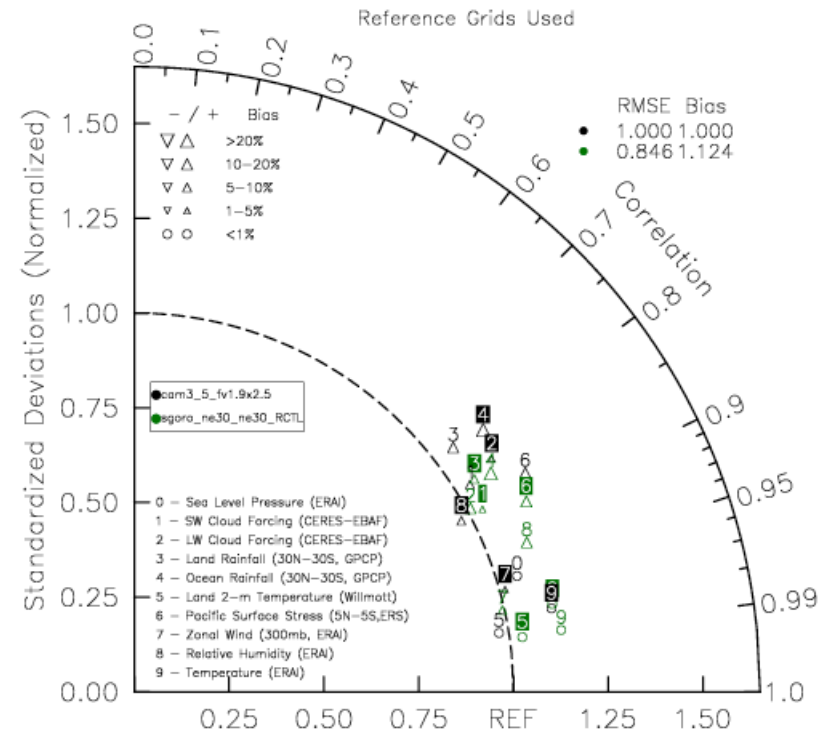


increased divergence  
damping impacts spectra

## Smooth top (smoothing scale~800km)

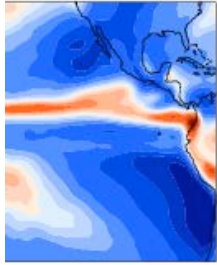


## "Rough" top (smoothing scale~400km)

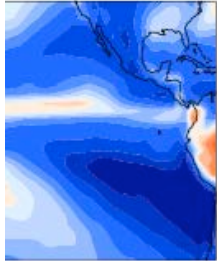


Climate somewhat better overall with rougher topography

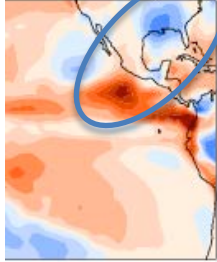
Smooth topo



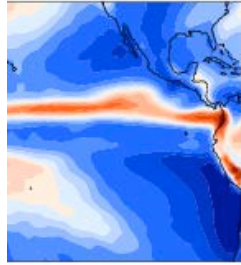
mm/day



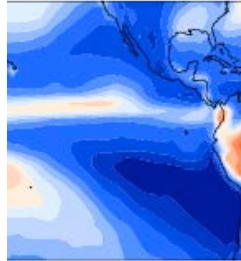
mm/day



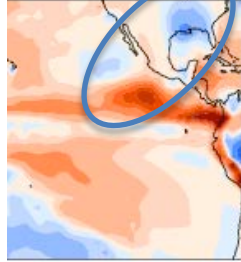
"Rough" topo



mm/day



mm/day

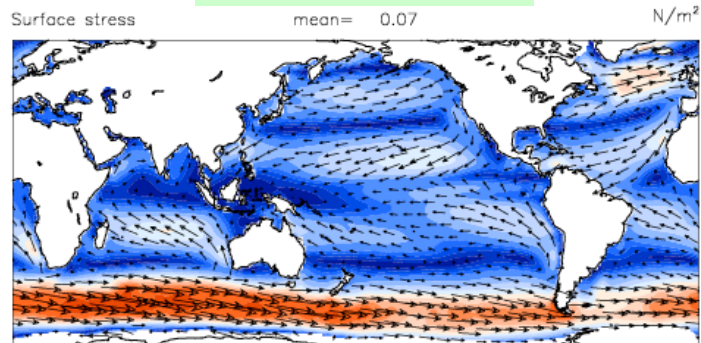


1980-90 DJF mean  
Precipitation

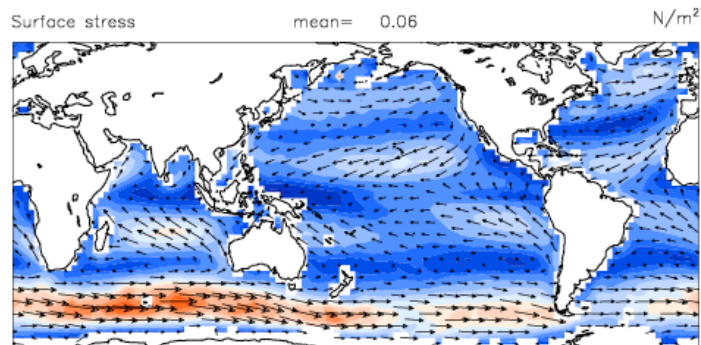


# Annual mean surface stress 1980-1990

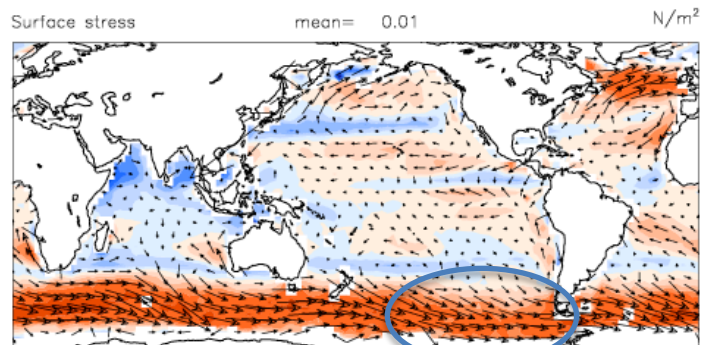
Smooth topo



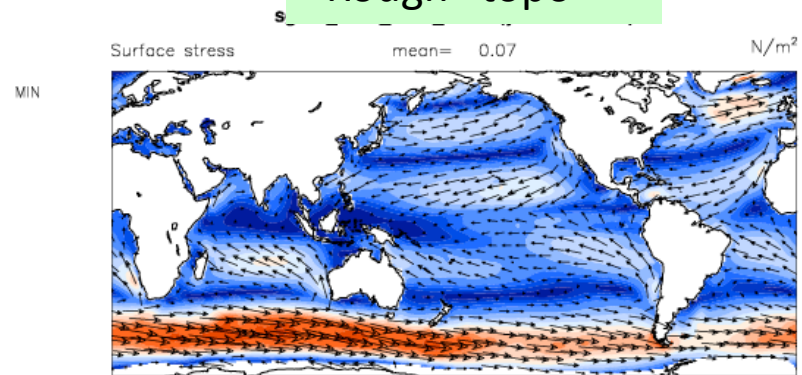
ERS



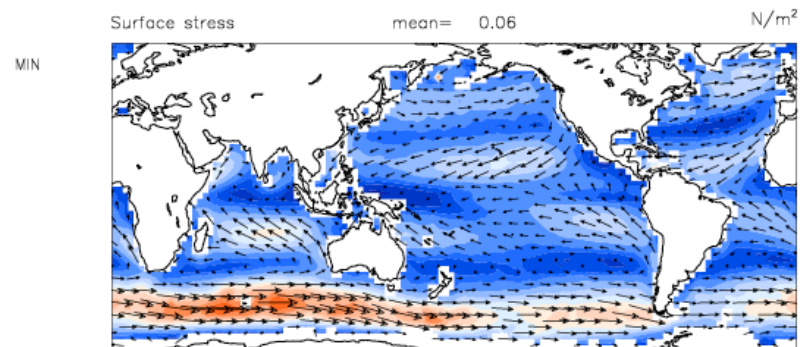
sgoro\_ne30\_ne30\_CTL - ERS



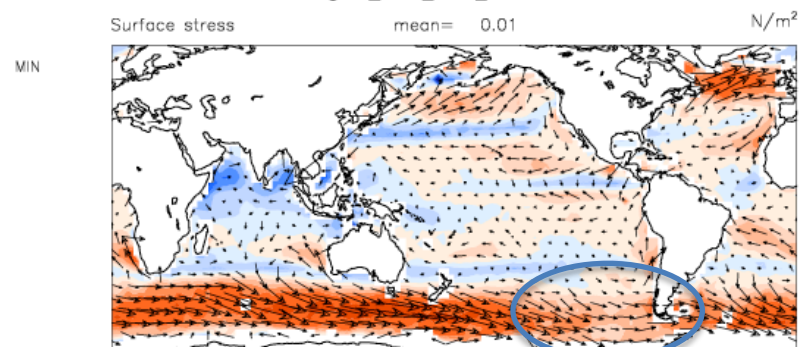
"Rough" topo



ERS

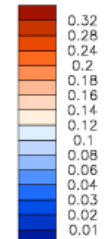


sgoro\_ne30\_ne30\_RCTL - ERS

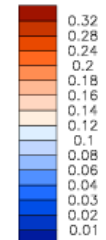


ANN

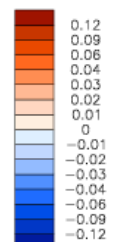
MIN = 0.00 MAX = 0.29



MIN = 0.00 MAX = 0.22



MIN = -0.20 MAX = 0.08



# New orographic drag scheme

- Anisotropy
- Low-level processes (blocking)
- Lee-wave trapping
- Multiple ridges and scales



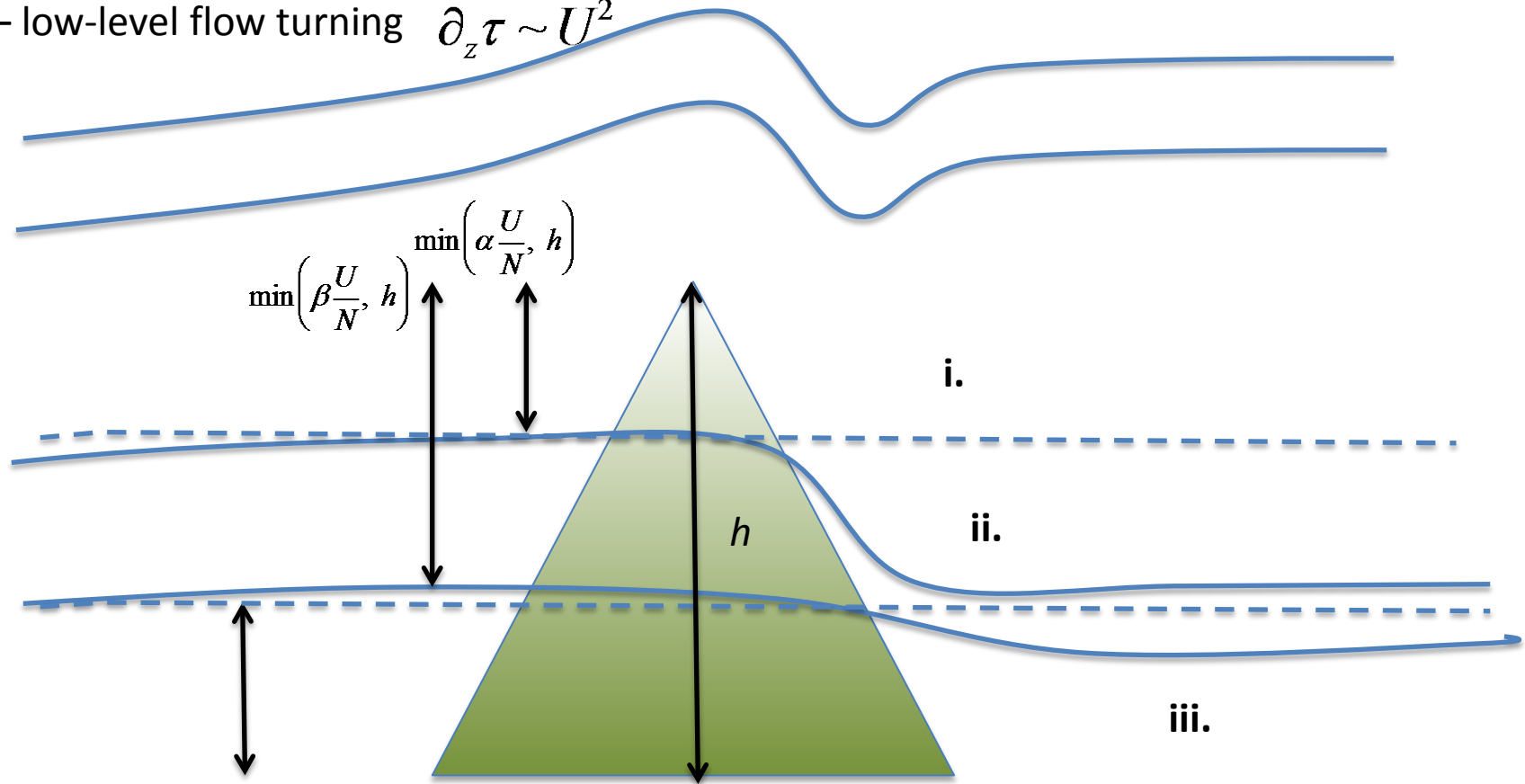
# Blocking, low-level turning

(follows Scinocca&McFarlane 2000)

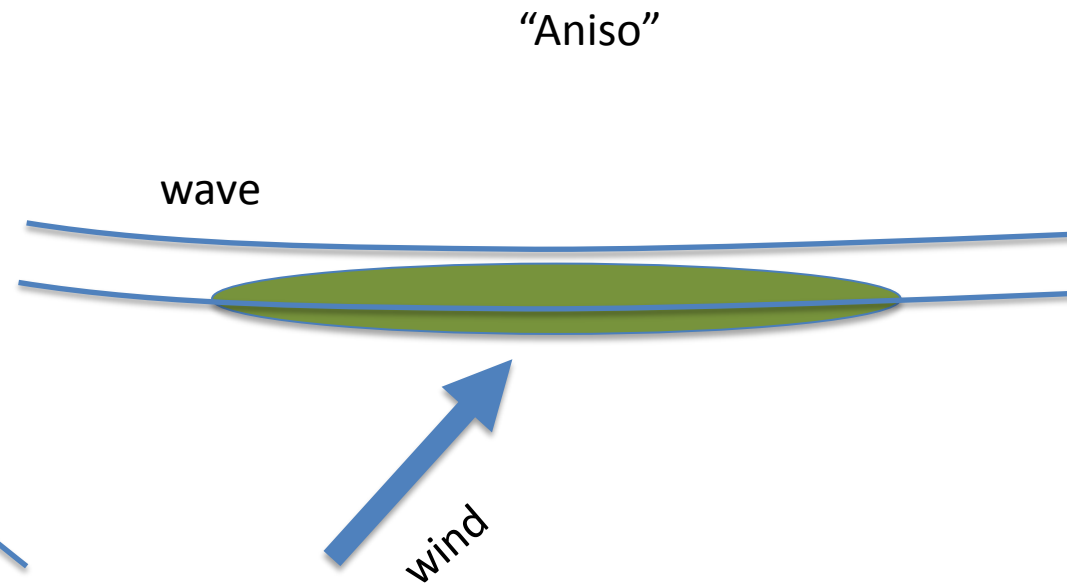
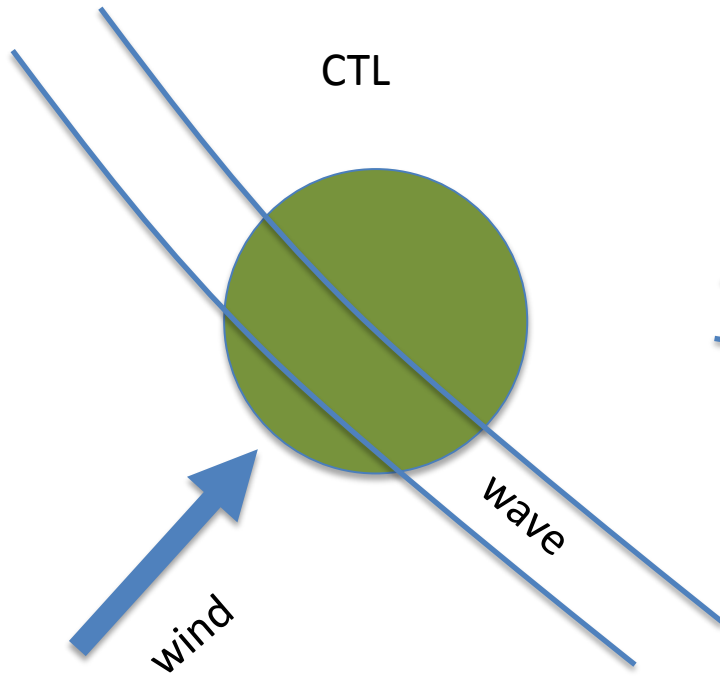
i – vertically propagating waves  $\partial_z \tau$  via saturation

ii - downslope wind layer  $\partial_z \tau \sim U^3$

iii – low-level flow turning  $\partial_z \tau \sim U^2$

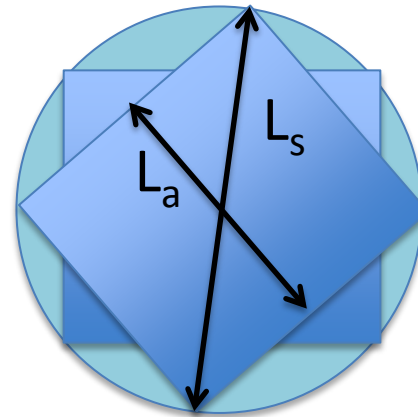


# Anisotropy



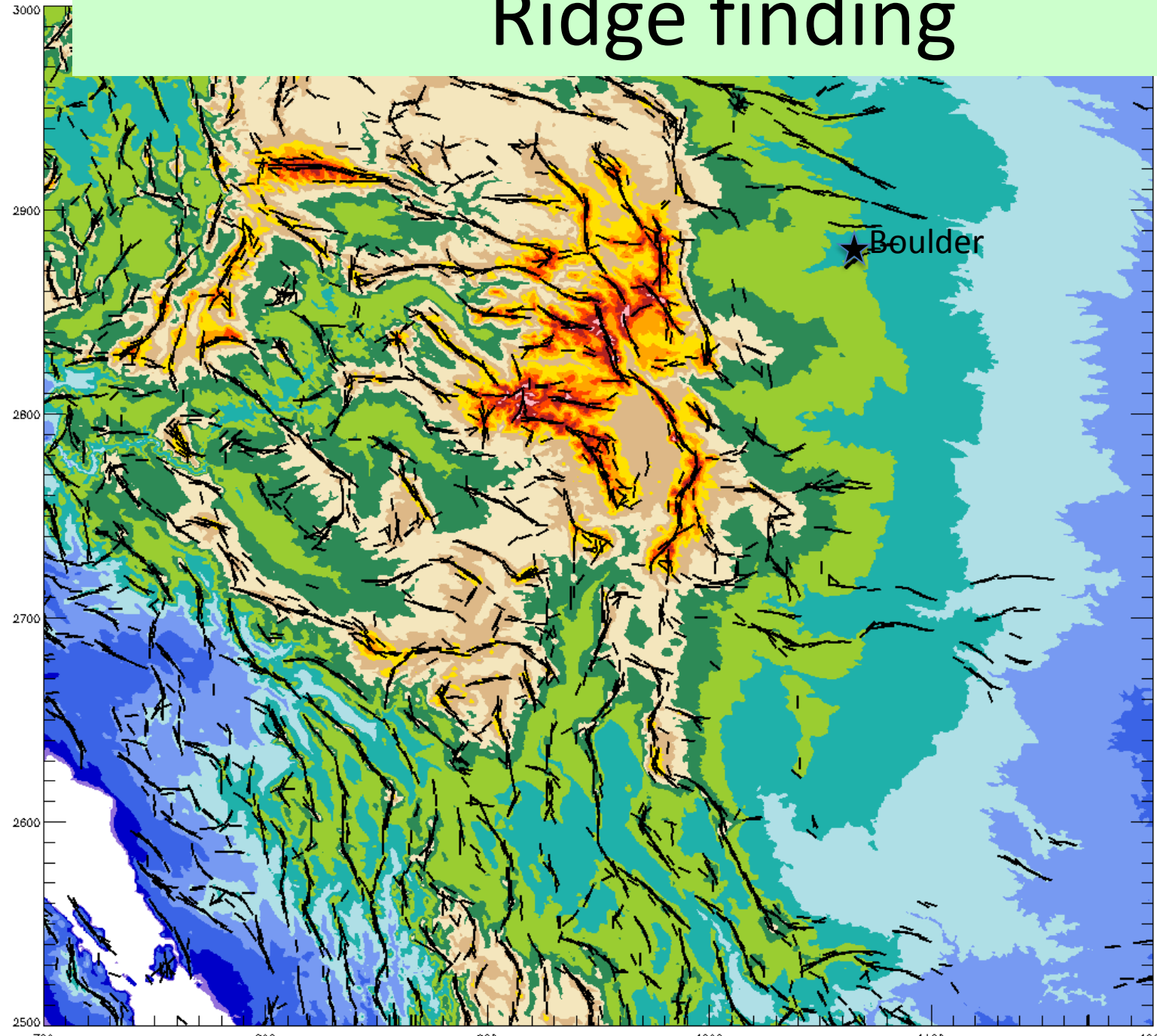
# Ridge finding

- Smooth (Bandpass) topography (scale  $\sim L_s$ )
- Calculate variances of mean cross-sectional profiles at 16 different orientations on  $L_a \times L_a$  domains
- Maximum 1D vs 2D variance determines “ridge” angle



- **Outputs**
  - Orientation
  - Ridge height (different from std. dev. of topo)
  - “quality” ratio of 1D/2D variance
  - Width

# Ridge finding



$L_s \sim 80\text{km}$

# Further innovations/complications

Multiple ridges possible in any AGCM gridbox depending on remapping from topo grid

2 families of ridges:

- Meso  $\beta$  800km-80km
- Meso  $\gamma$  80km-3km

Trapped lee wave parameterization.  
Uses width estimate to calculate

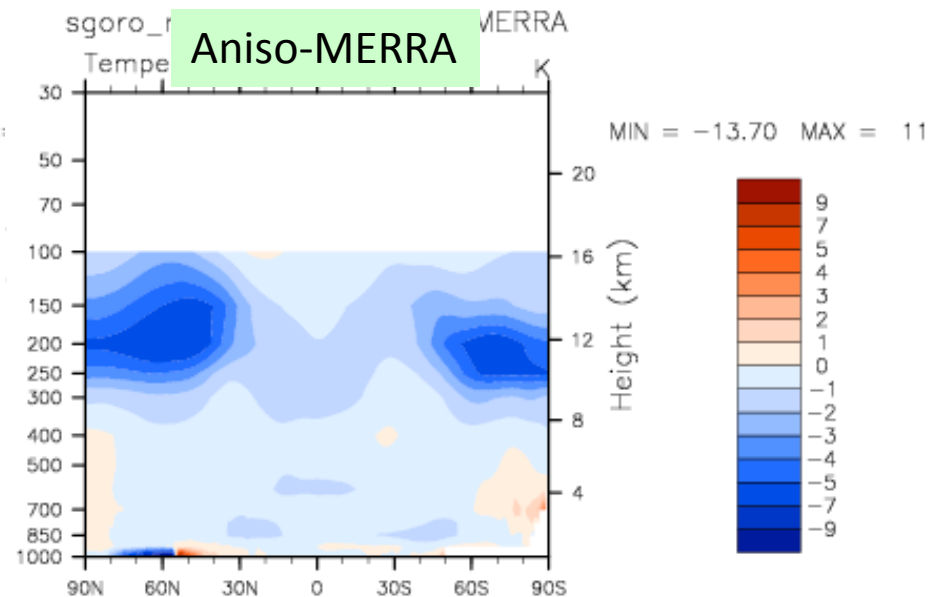
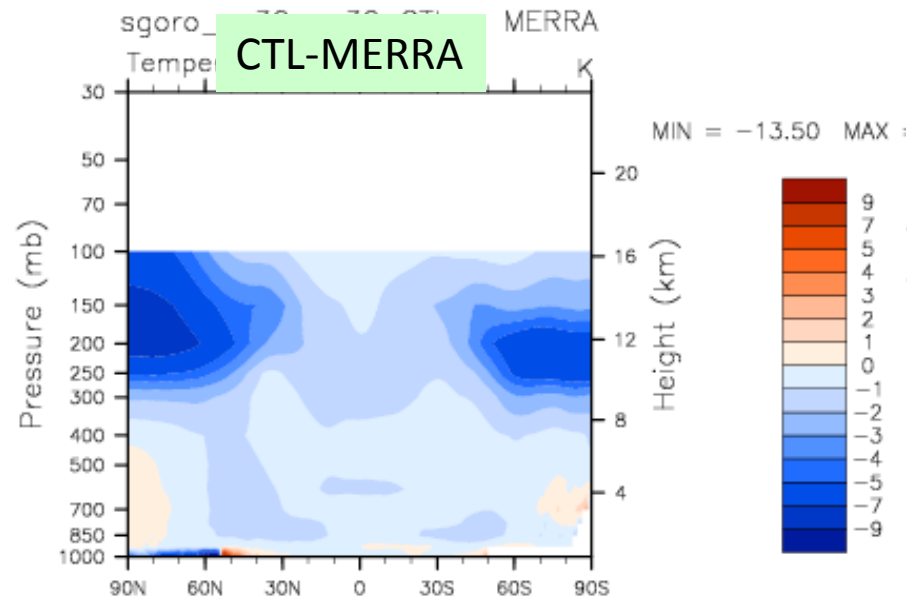
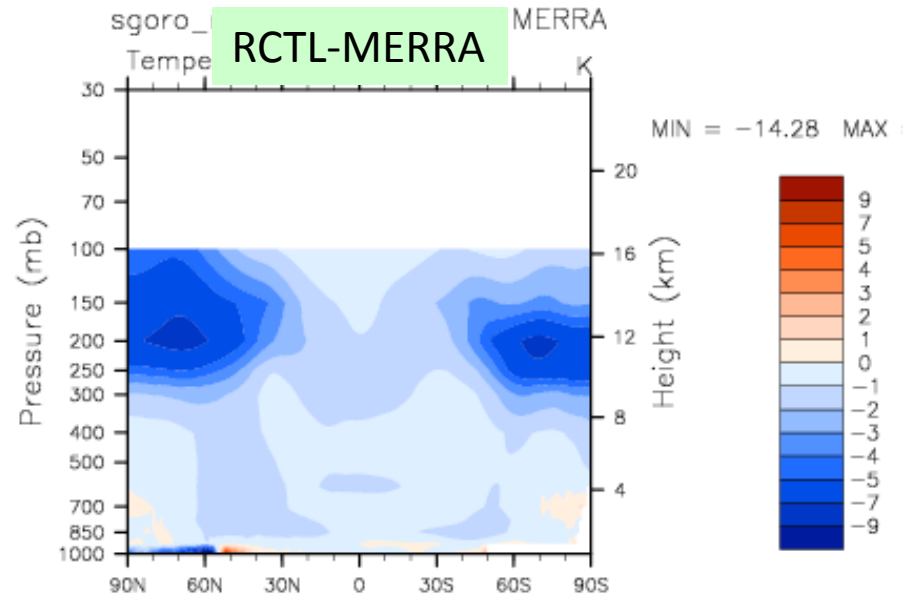
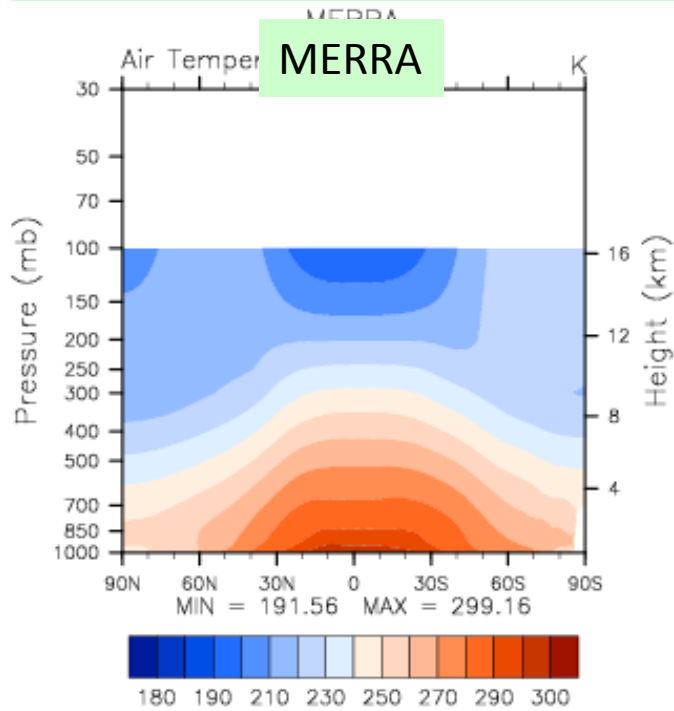
$$m^2 = \frac{N^2}{U^2} - k^2$$



# AMIP runs 1/1979-1/1990

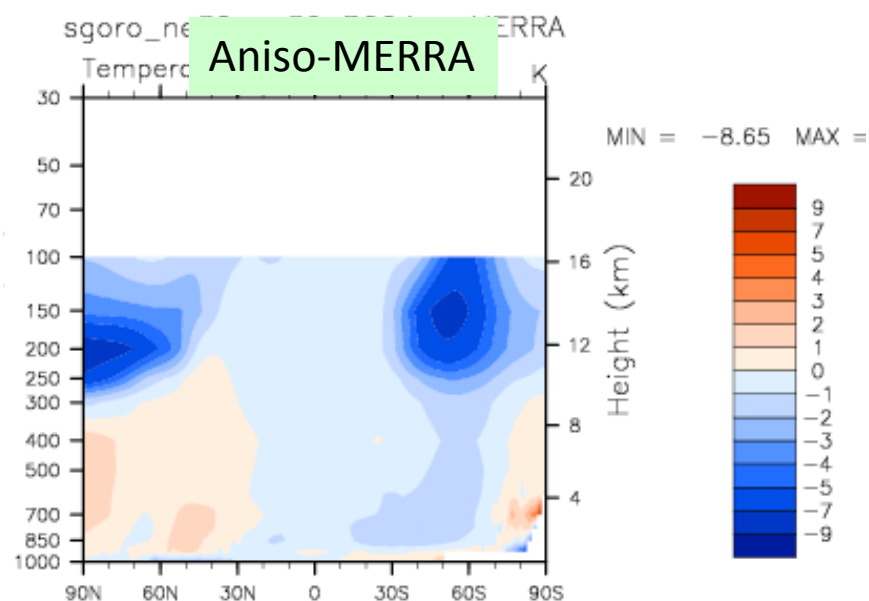
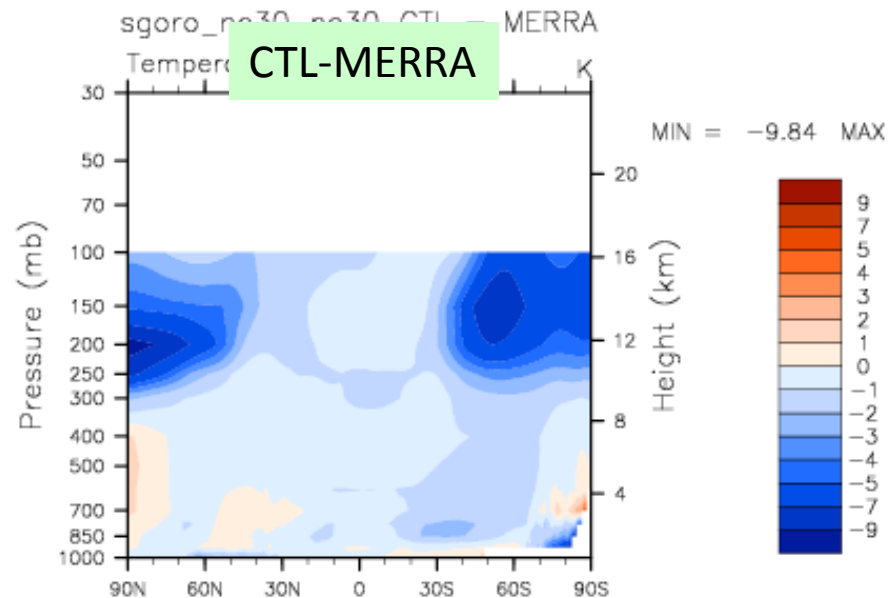
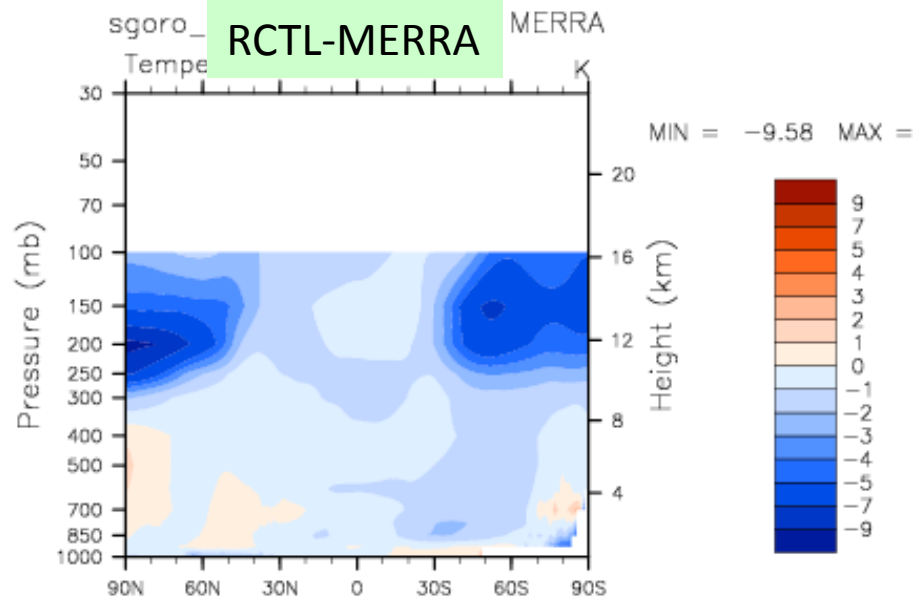
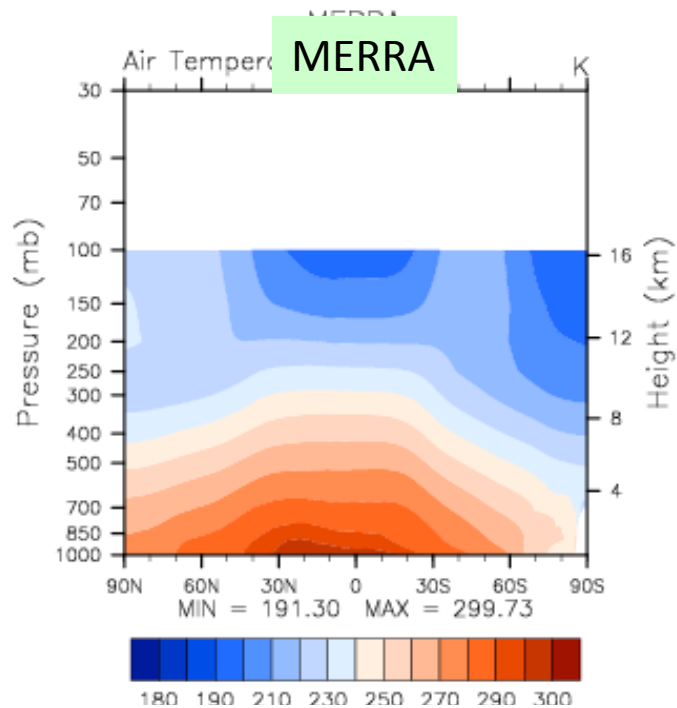
- ne30
- 3 runs
  - **RCTL** - “rough” control. Rougher topo ( $L < 400\text{km}$ ) w/ old isotropic OGW scheme
  - **CTL** - control. Smoother topo ( $L < 800\text{km}$ ) w/ isotropic
  - **Aniso** – new anisotropic scheme w/ blocking, lee-waves etc..
- All still use TMS
- All use *low* value for divergence damping

# DJF Zonal mean temperatures





# JJA Zonal mean temperatures

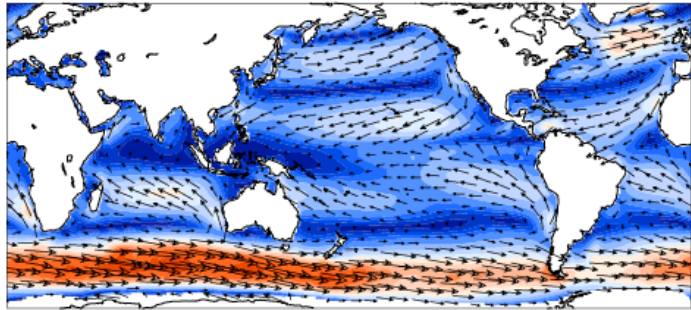


# Annual mean wind stress

RCTL-MERRA

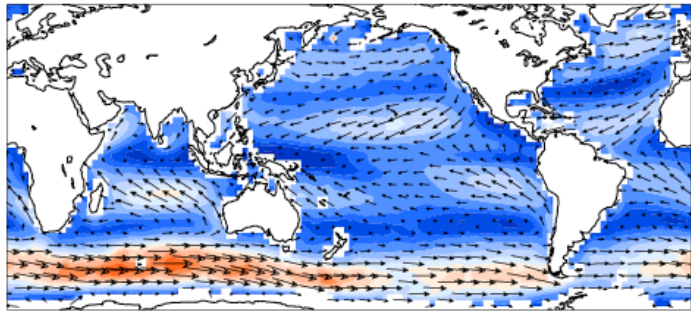
sgor 89)

Surface stress mean= 0.07 N/m<sup>2</sup>



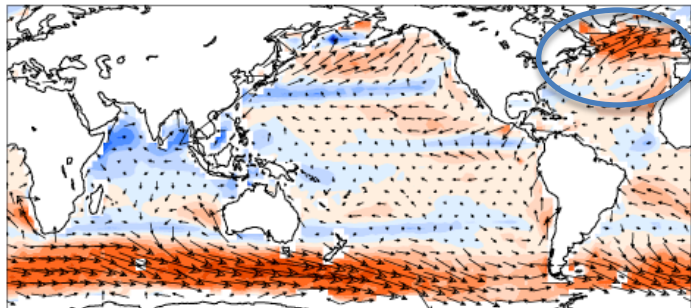
ERS

Surface stress mean= 0.06 N/m<sup>2</sup>



sgoro\_ne30\_ne30\_RCTL - ERS

Surface stress mean= 0.01 N/m<sup>2</sup>

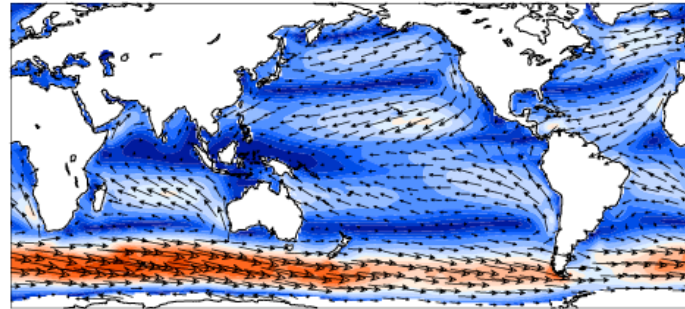


Aniso-MERRA

sg 89)

Surface stress mean= 0.07 N/m<sup>2</sup>

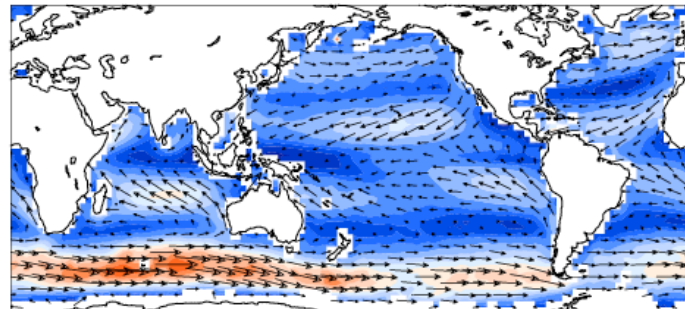
MIN :



ERS

Surface stress mean= 0.06 N/m<sup>2</sup>

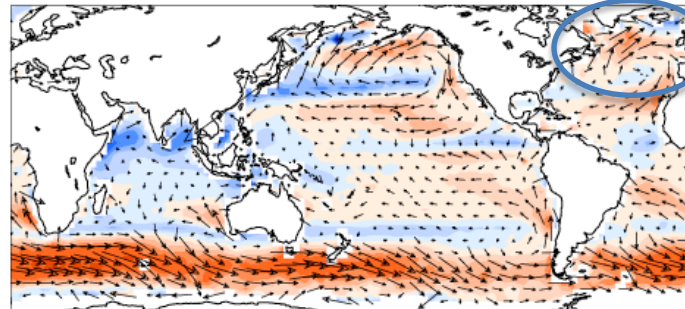
MIN :



sgoro\_ne30\_ne30\_B004 - ERS

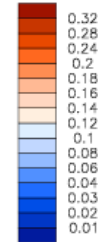
Surface stress mean= 0.01 N/m<sup>2</sup>

MIN :

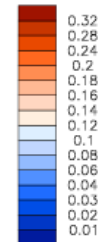


ANN

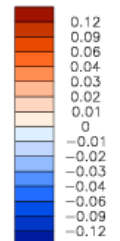
MIN = 0.00 MAX = 0.27



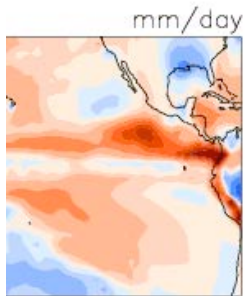
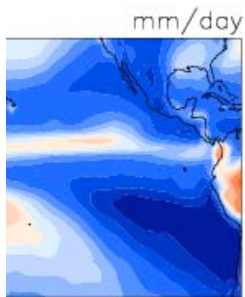
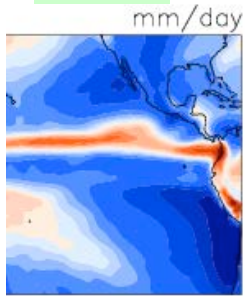
MIN = 0.00 MAX = 0.22



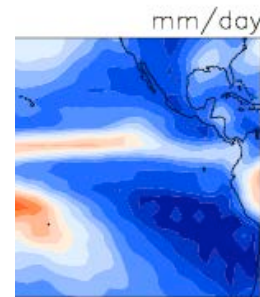
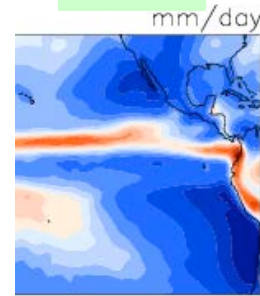
MIN = -0.20 MAX = 0.08



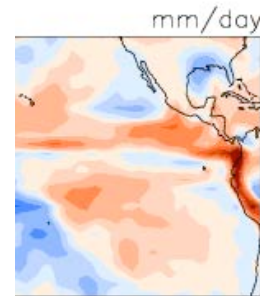
9) RCTL



19) Aniso



↓



1980-90 DJF mean  
Precipitation

# DJF mean sea-level pressure

RCTL

DJF

Aniso

DJF

sgoro\_ne30\_ne30\_RCTL (yrs 1980-1989)

MERRA

sgoro\_ne30\_ne30\_B004 (yrs 1980-1989)

MERRA

Sea-level pressure

millibars

Sea-level pressure

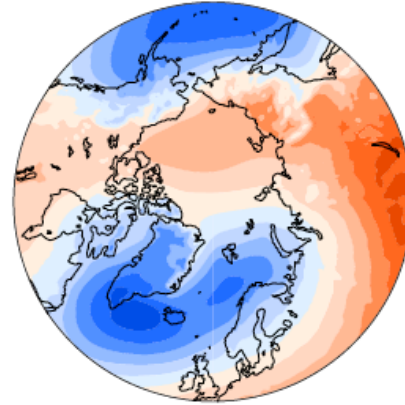
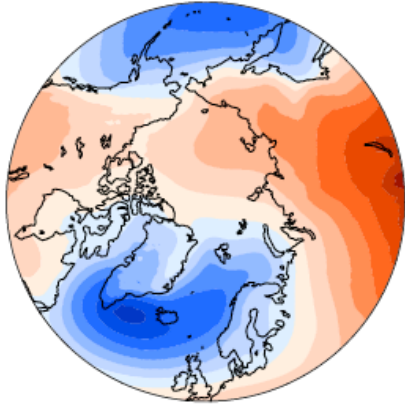
millibars

Sea-level pressure

millibars

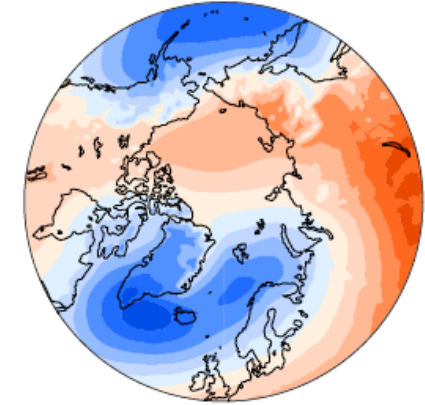
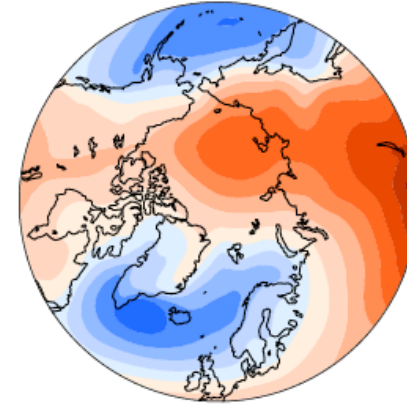
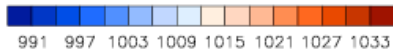
Sea-level pressure

millibars



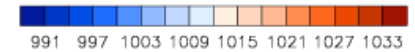
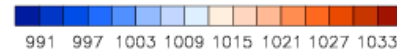
MEAN= 1012.60 Min= 993.06 Max= 1034.95

MEAN= 1011.67 Min= 994.56 Max= 1029.69



MEAN= 1014.54 Min= 997.33 Max= 1035.37

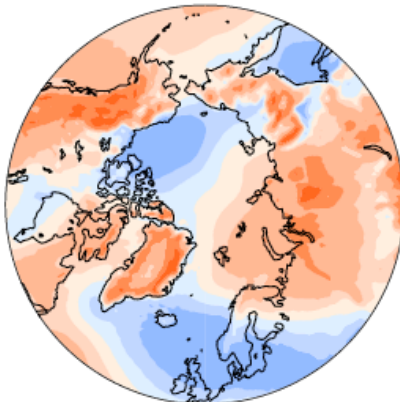
MEAN= 1011.67 Min= 994.56 Max= 1029.69



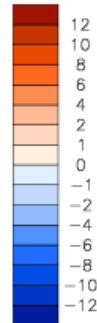
sgoro\_ne30\_ne30\_RCTL - MERRA

Sea-level pressure

millibars



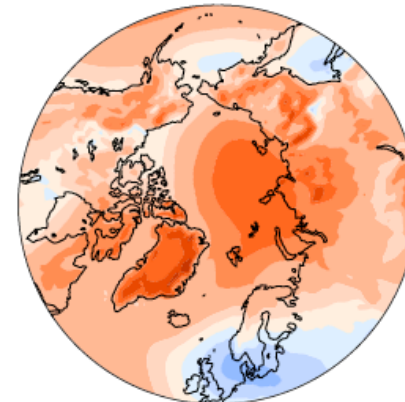
MIN = -3.89 MAX = 8.03



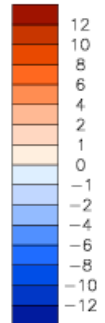
sgoro\_ne30\_ne30\_B004 - MERRA

Sea-level pressure

millibars



MIN = -2.28 MAX = 11.27



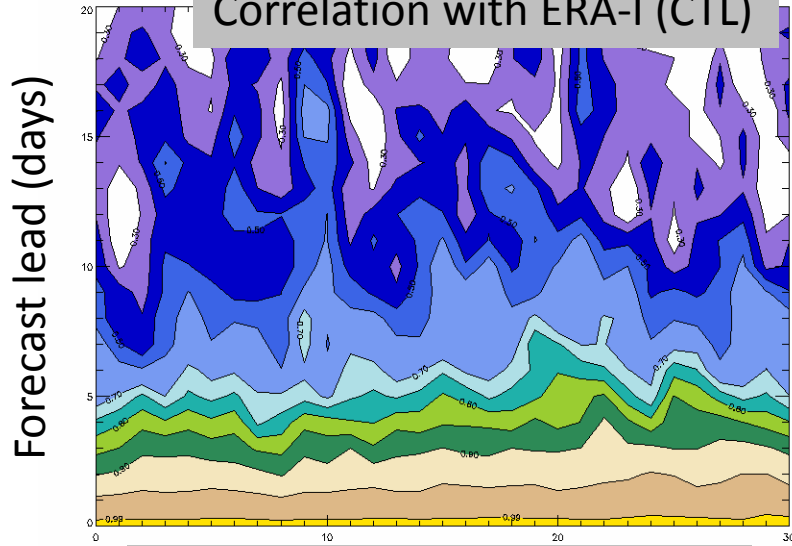


# CAPT forecasts 1/2003

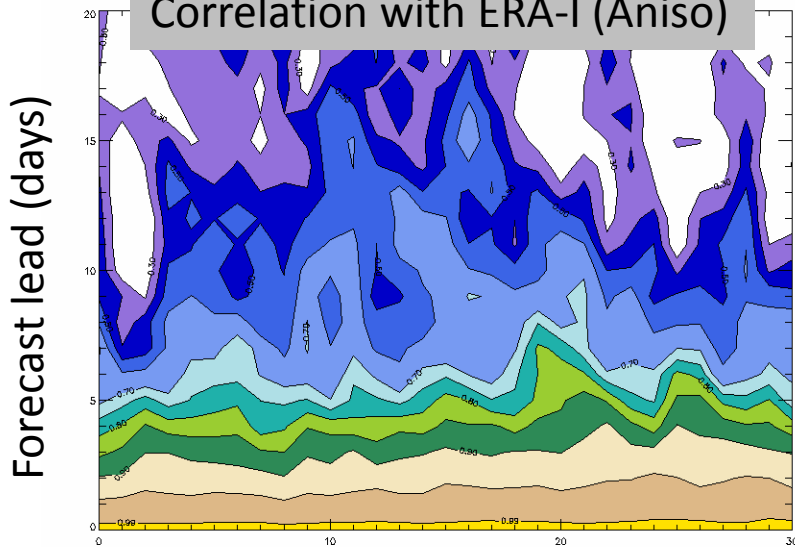
- Forecasts initialized from ERA-I reanalyses
- Once per day 00Z (1/1-1/31) run for 20 days

# Forecasts of U at 700 hPa 1/2003

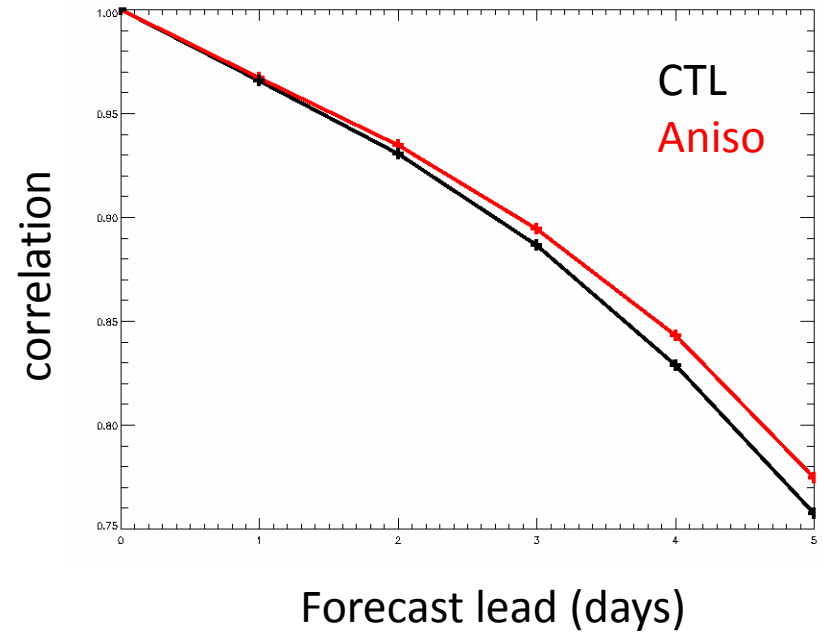
Correlation with ERA-I (CTL)



Correlation with ERA-I (Aniso)



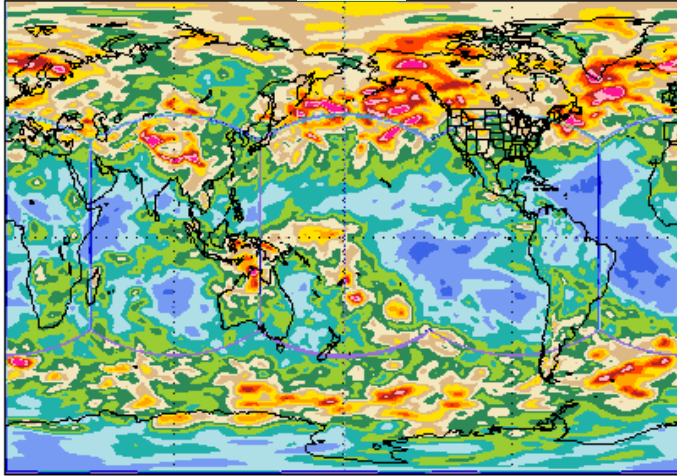
Forecast start day (Jan)



# Mean errors in 0.7-0.95 $\sigma$ -lev $U$ at Day 3

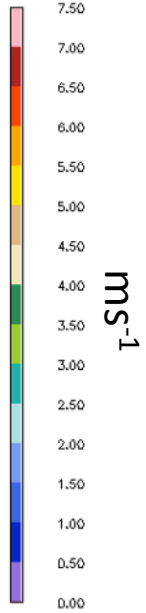
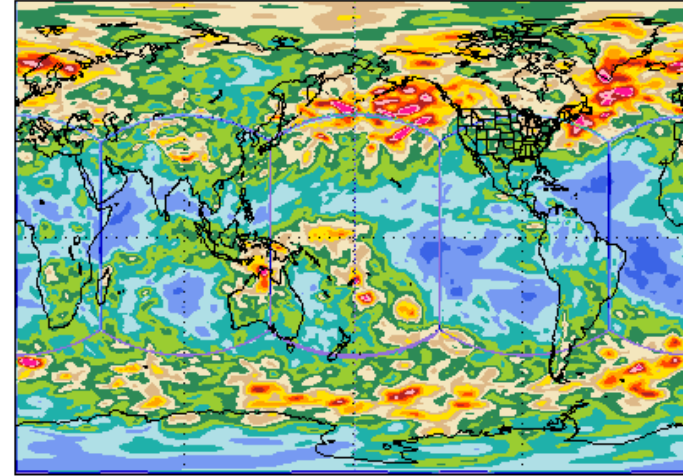
CTL

Global Mean=3.45



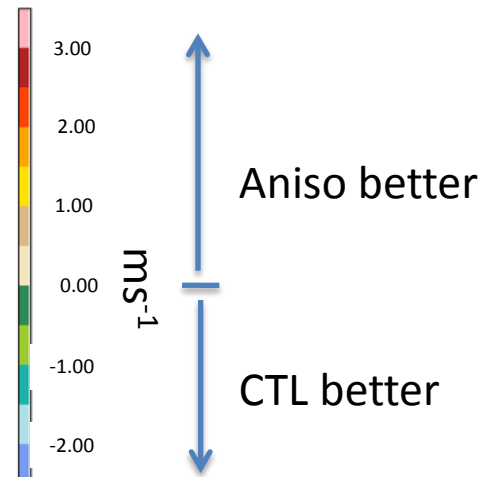
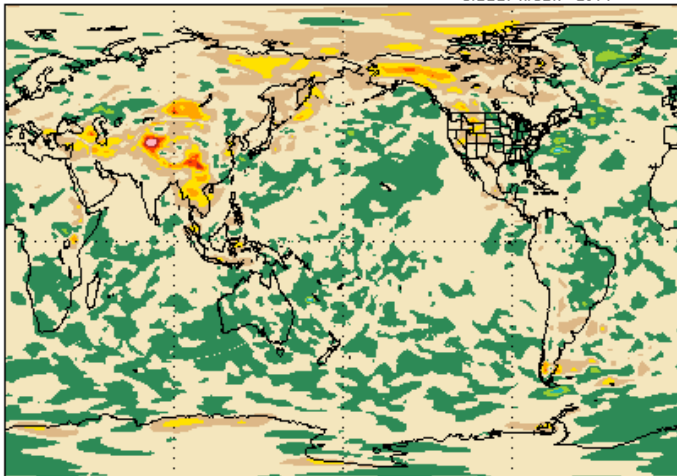
Aniso

Global Mean=3.30



CTL-Aniso

Global Mean=0.14





# Future work

- Tease out relative impacts of
  - Low-level flow parameterization
  - Lee-waves
  - Meso  $\beta$  vs meso  $\gamma$
- High-resolution – ne120
- Anisotropic TMS