Extensions to parameterized orographic drag in CAM

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Overview

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

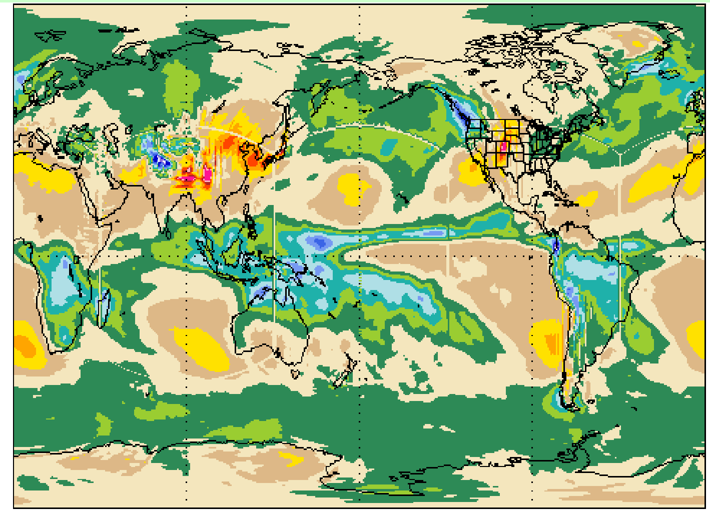
1980-81 DJF mean ω fields
ne30~100km

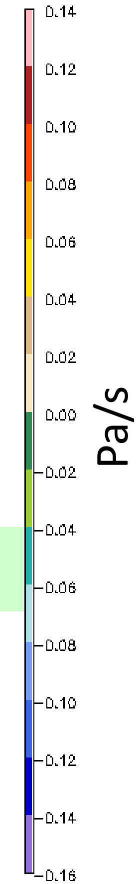
CAM-SE is noisy

2 approaches to mitigate this

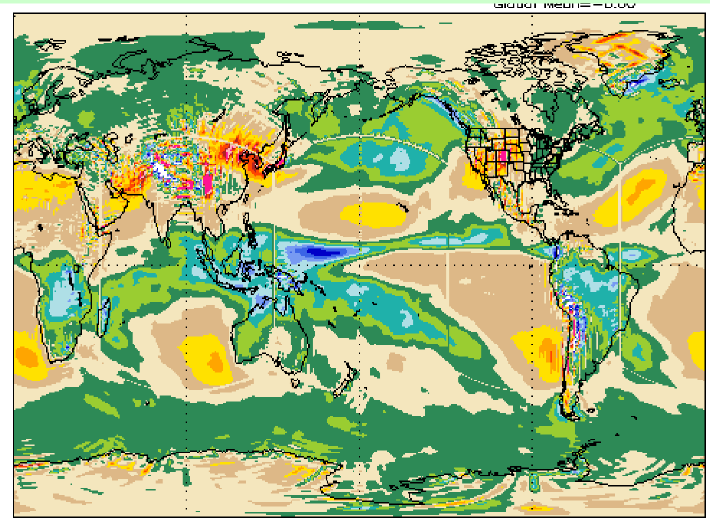
- smoother topo
- increased divergence damping

Smooth topo (smoothing scale~800km)

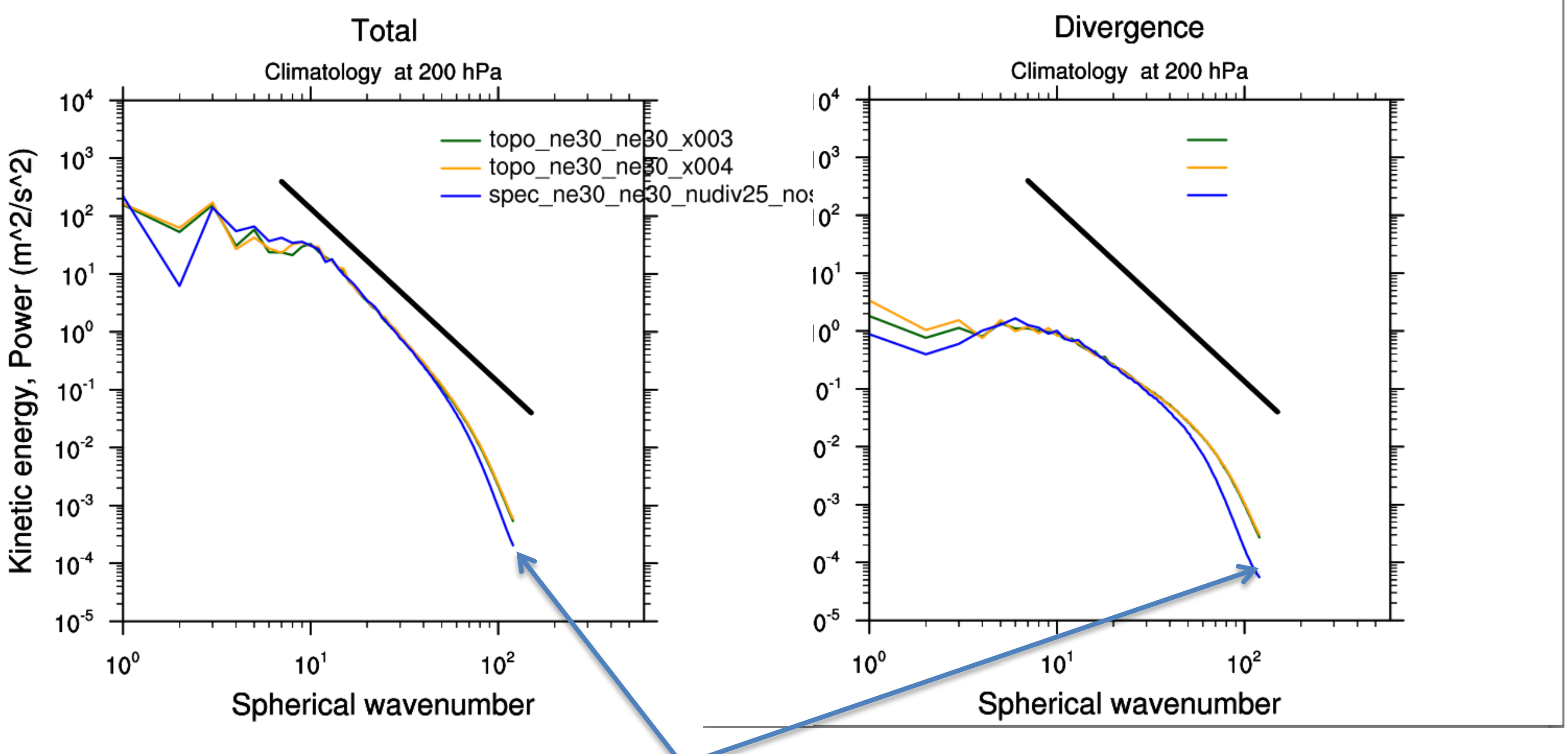




“Rough” topo (smoothing scale~400km)

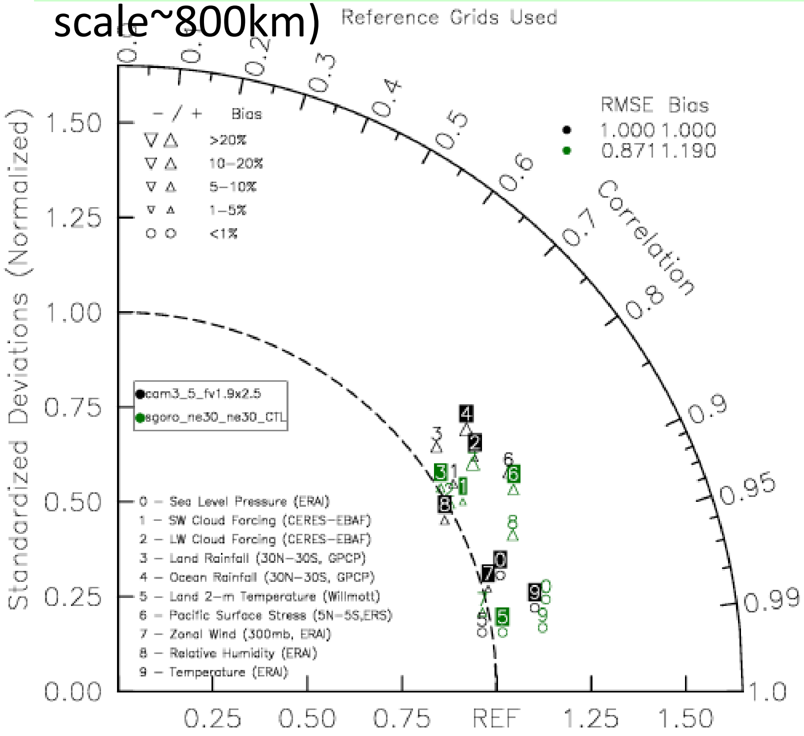


Energy spectra

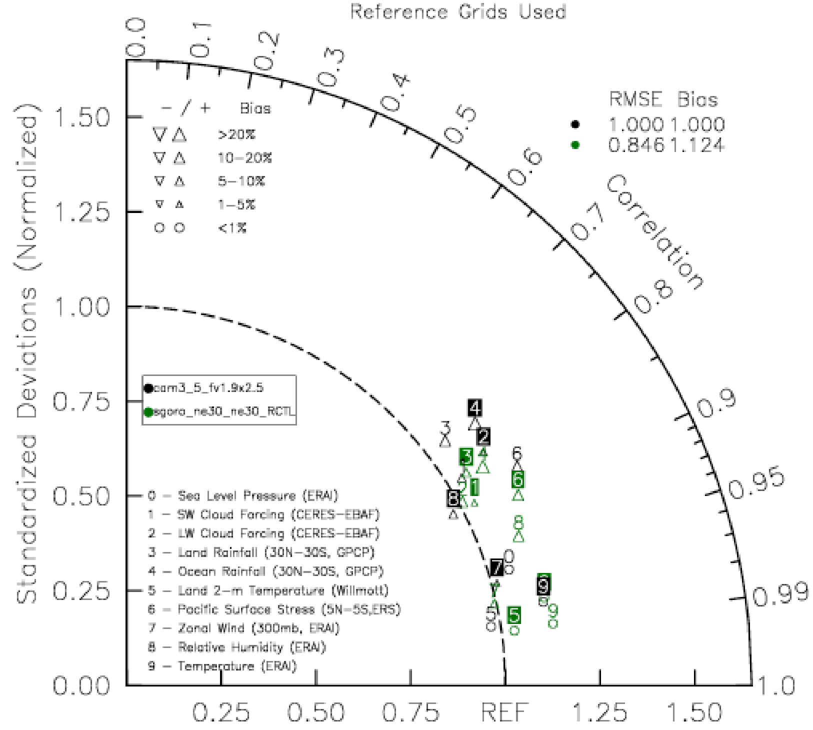


increased divergence damping impacts spectra

Smooth topo (smoothing scale~800km)

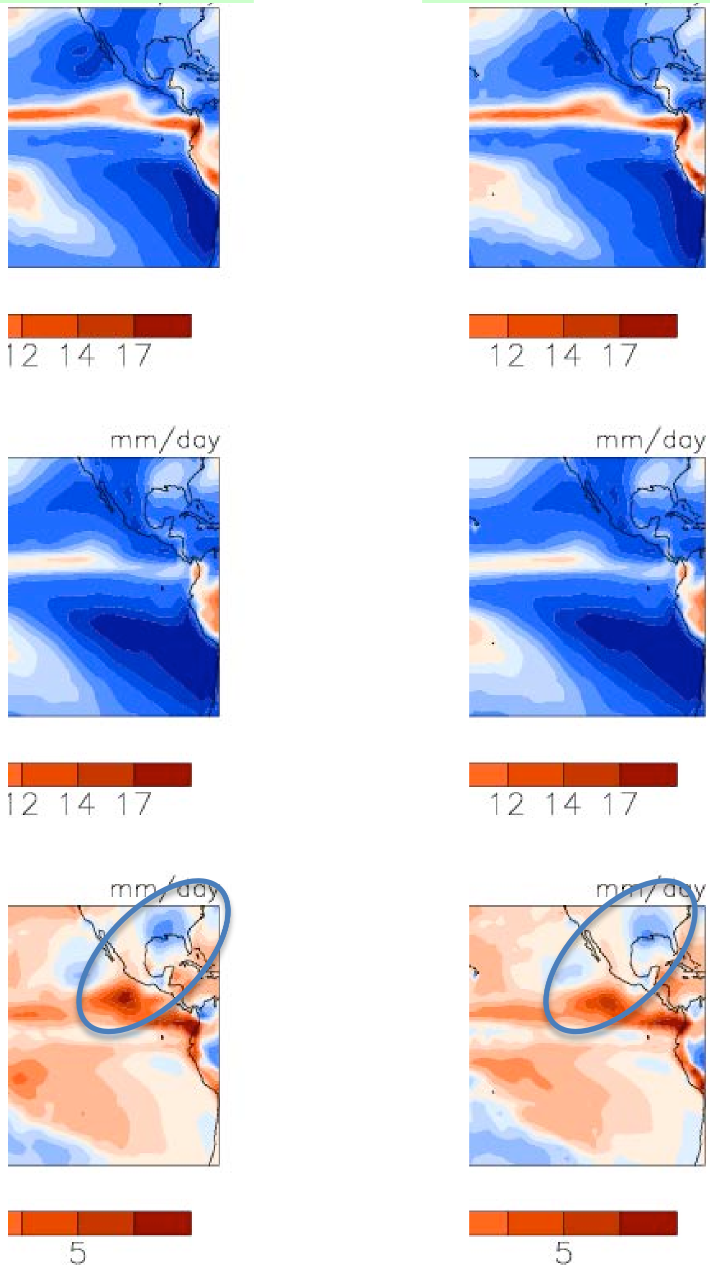


“Rough” topo (smoothing scale~400km)



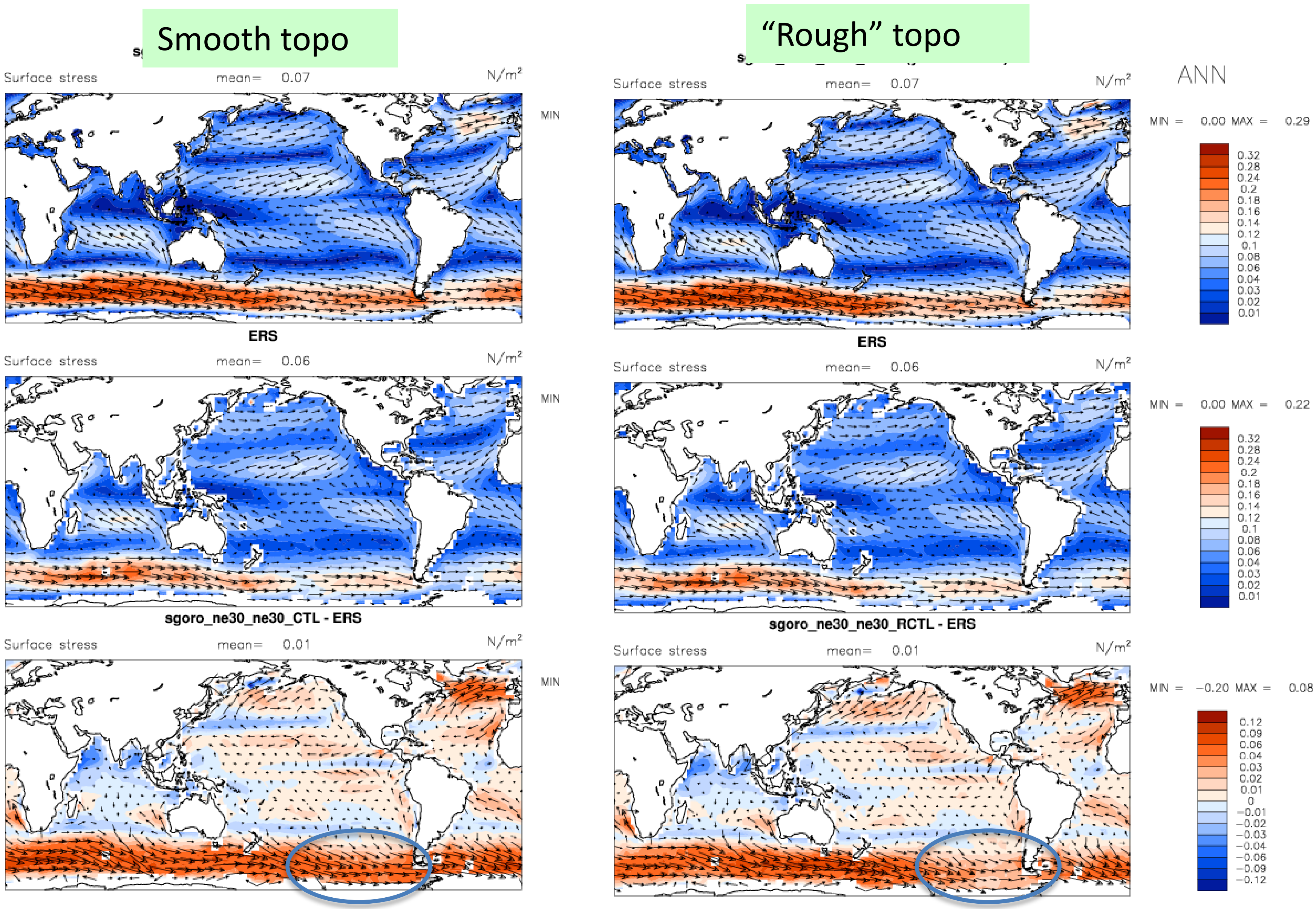
Climate somewhat better overall with rougher topography

Smooth topo | "Rough" topo



1980-90 DJF mean Precipitation

Annual mean surface stress 1980-1990



New orographic drag scheme

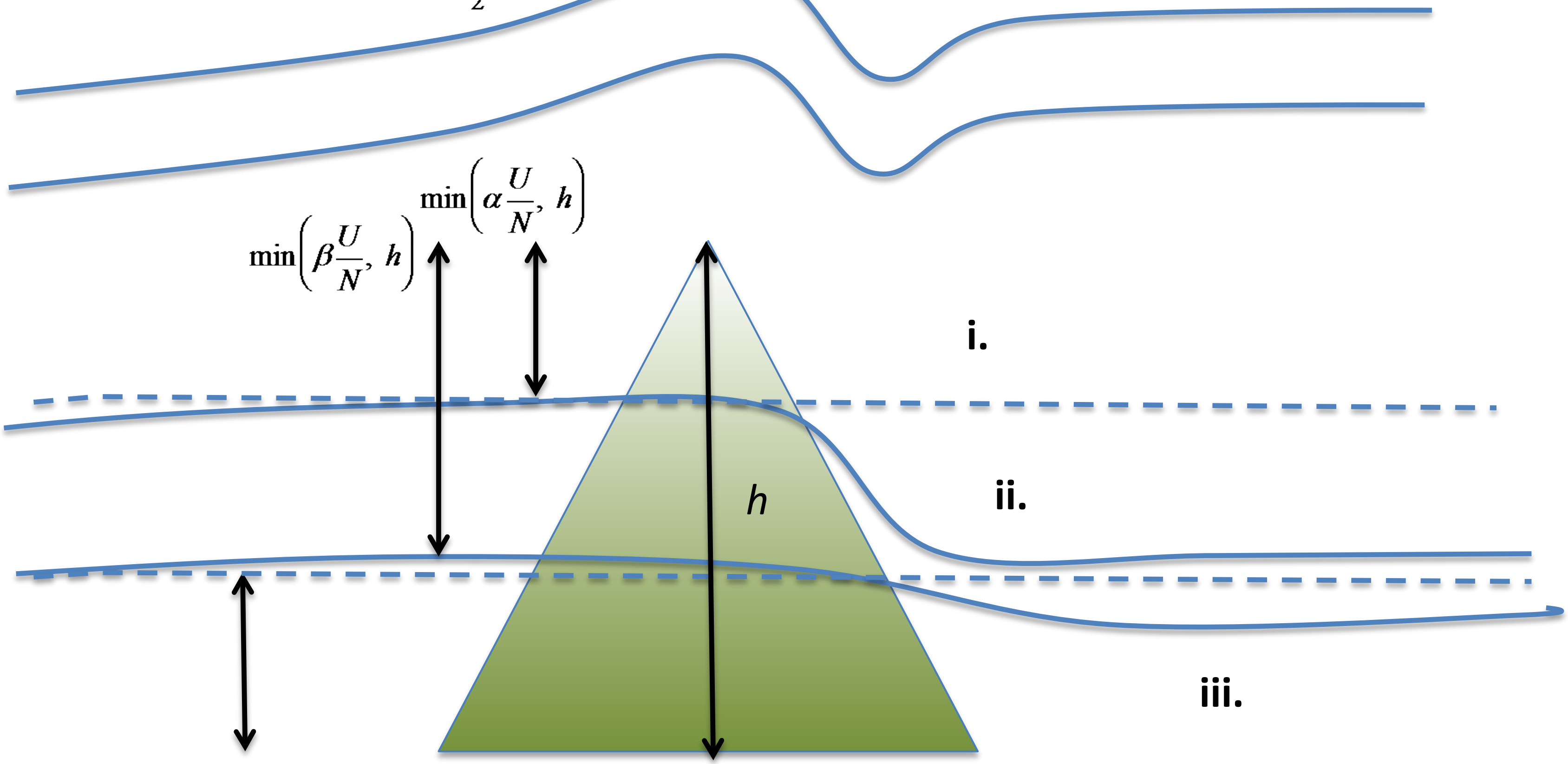
- Anisotropy
- Low-level processes (blocking)
- Lee-wave trapping
- Multiple ridges and scales

Blocking, low-level turning
(follows Scinocca&McFarlane 2000)

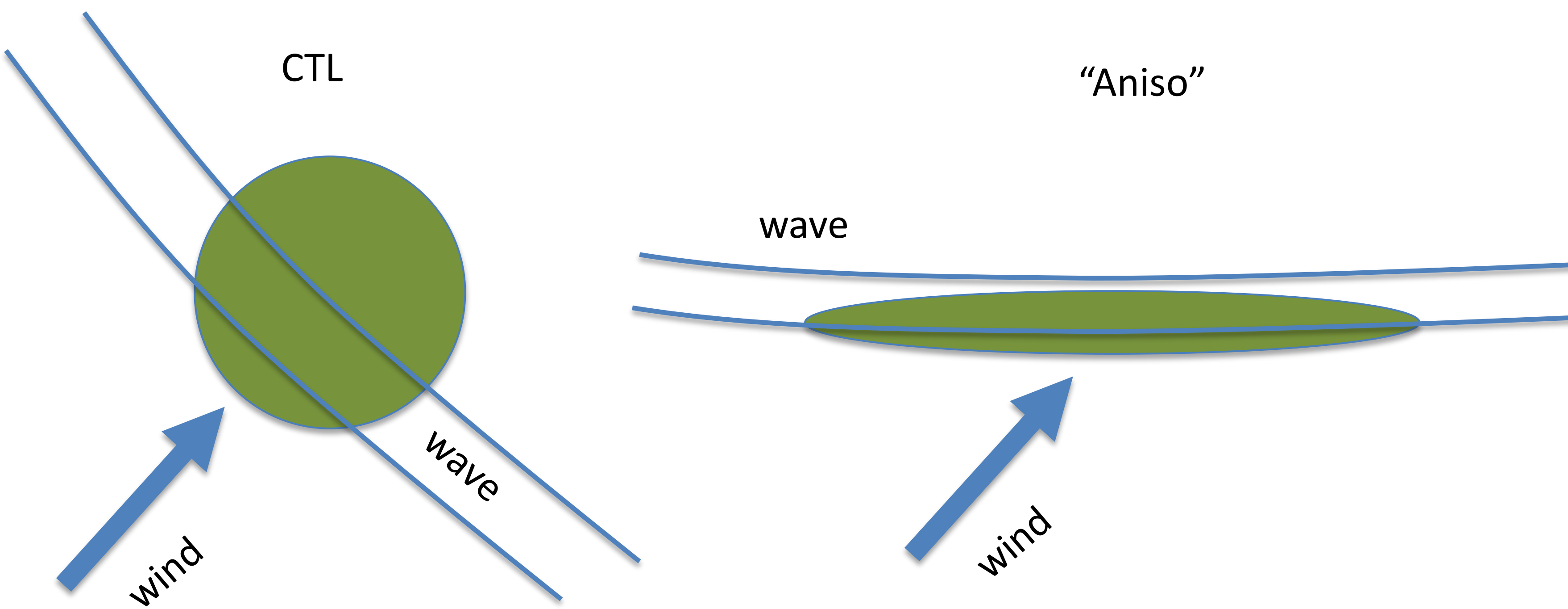
i – vertically propagating waves $\partial_z \tau$ via saturation

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

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

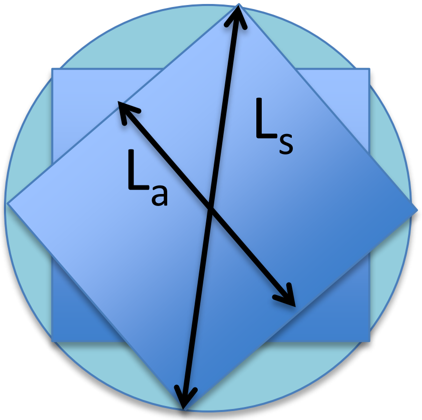


Anisotropy



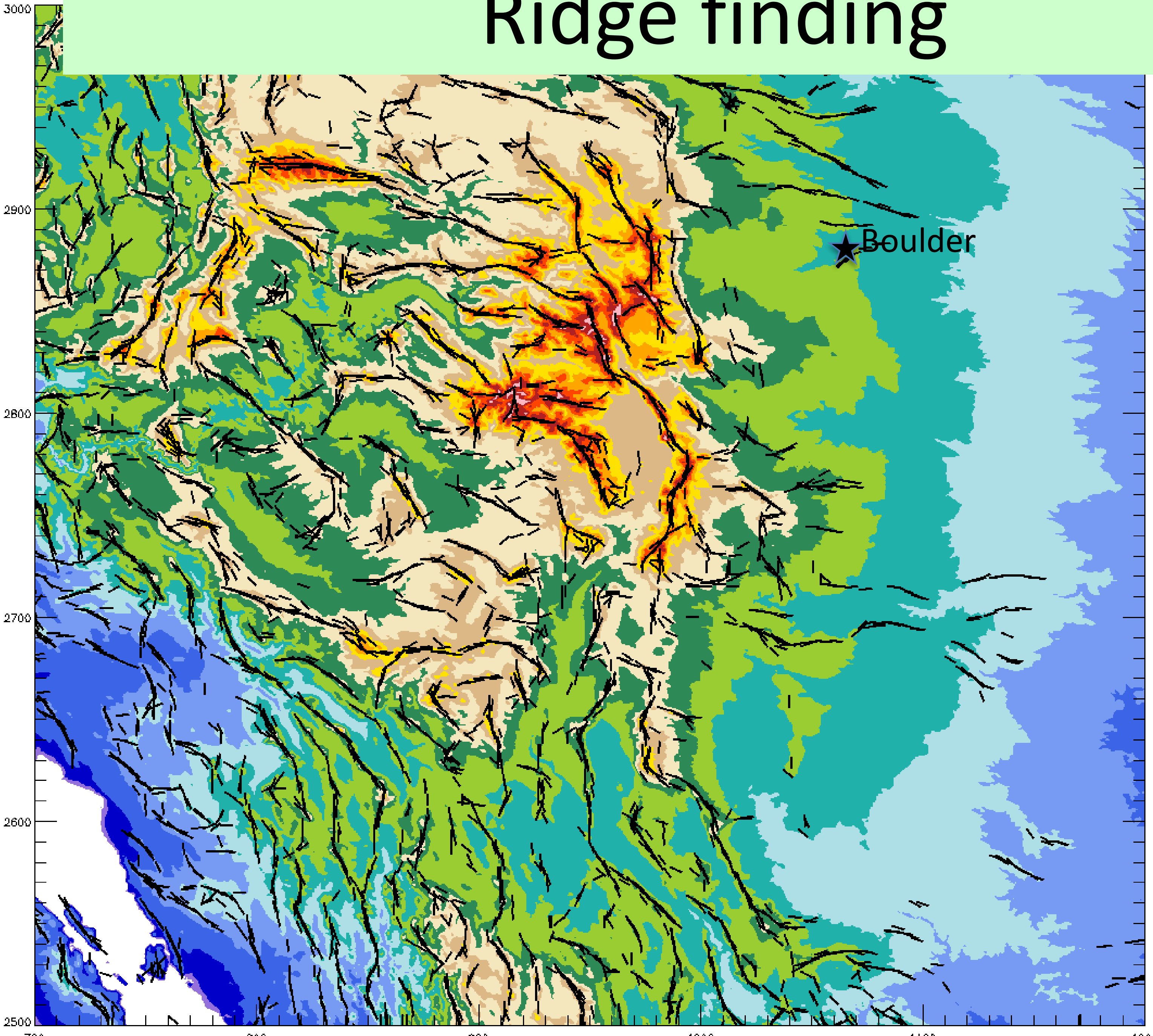
Ridge finding

- Smooth (Bandpass) topography (scale ~ L_s)
- Calculate variances of mean cross-sectional profiles at 16 different orientations on L_axL_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~80km

Further innovations/complications

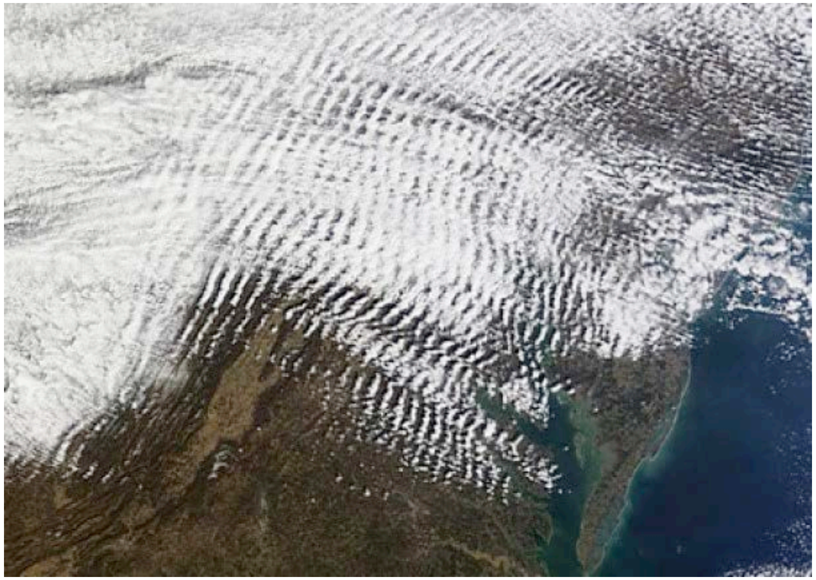
Multiple ridges possible in any AGCM gridbox depending on remapping from topo grid

2 families of ridges:

- Meso β 800km-80km
- Meso γ 80km-3km

Trapped lee wave parameterization.
Uses width estimate to calculate

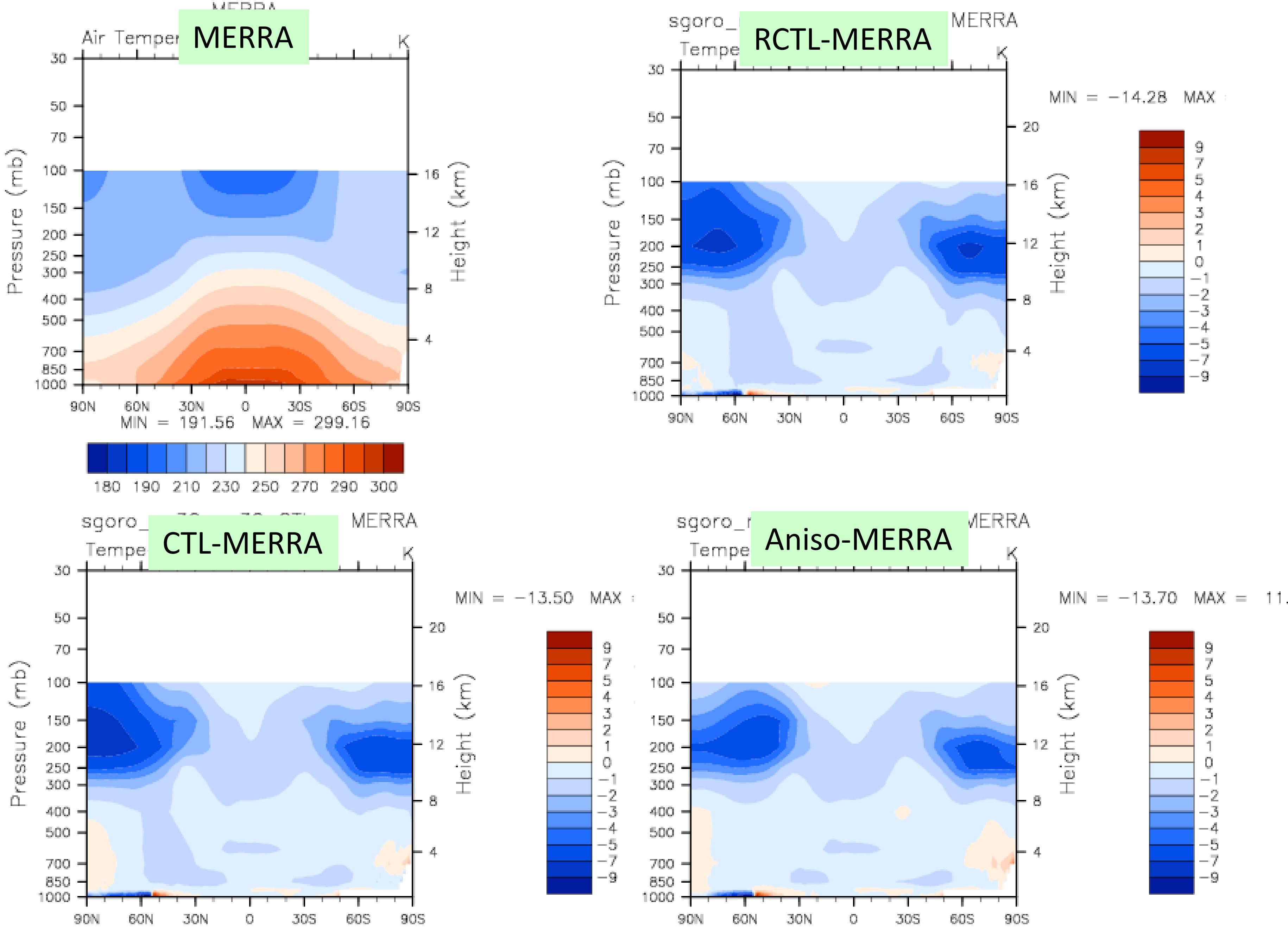
$$m^2 = \frac{N^2}{U^2} - k^2$$



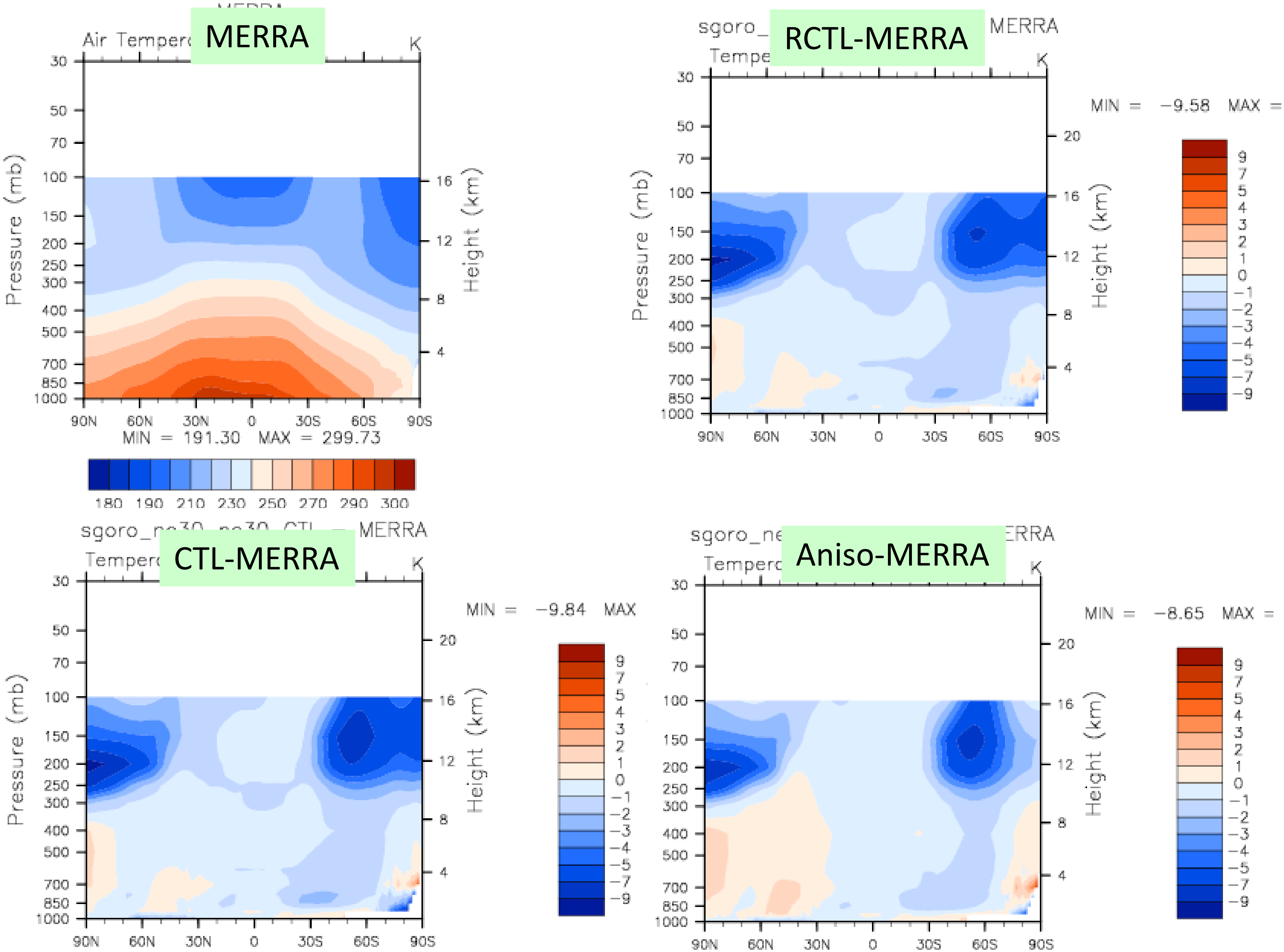
AMIP runs 1/1979-1/1990

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

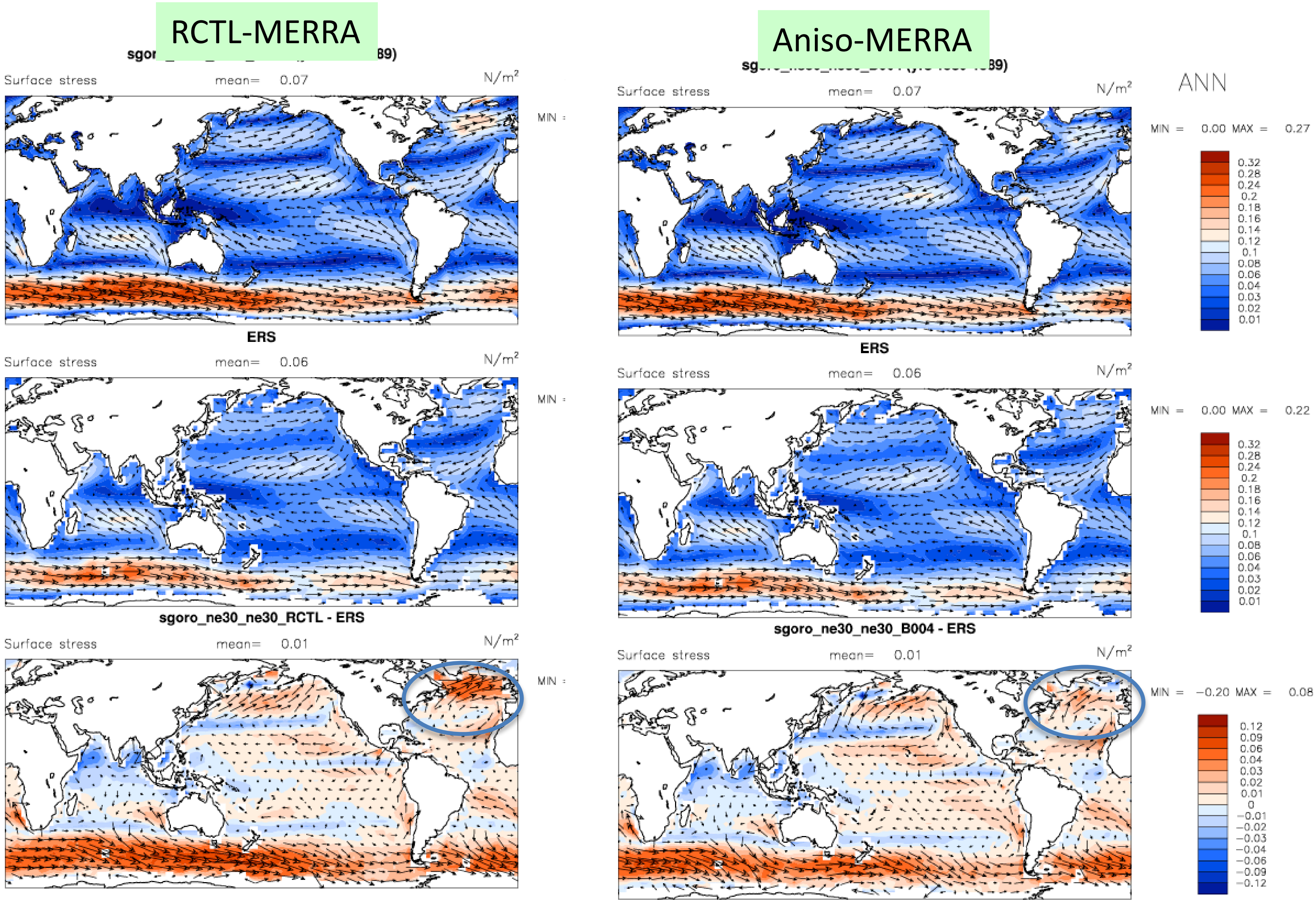
DJF Zonal mean temperatures

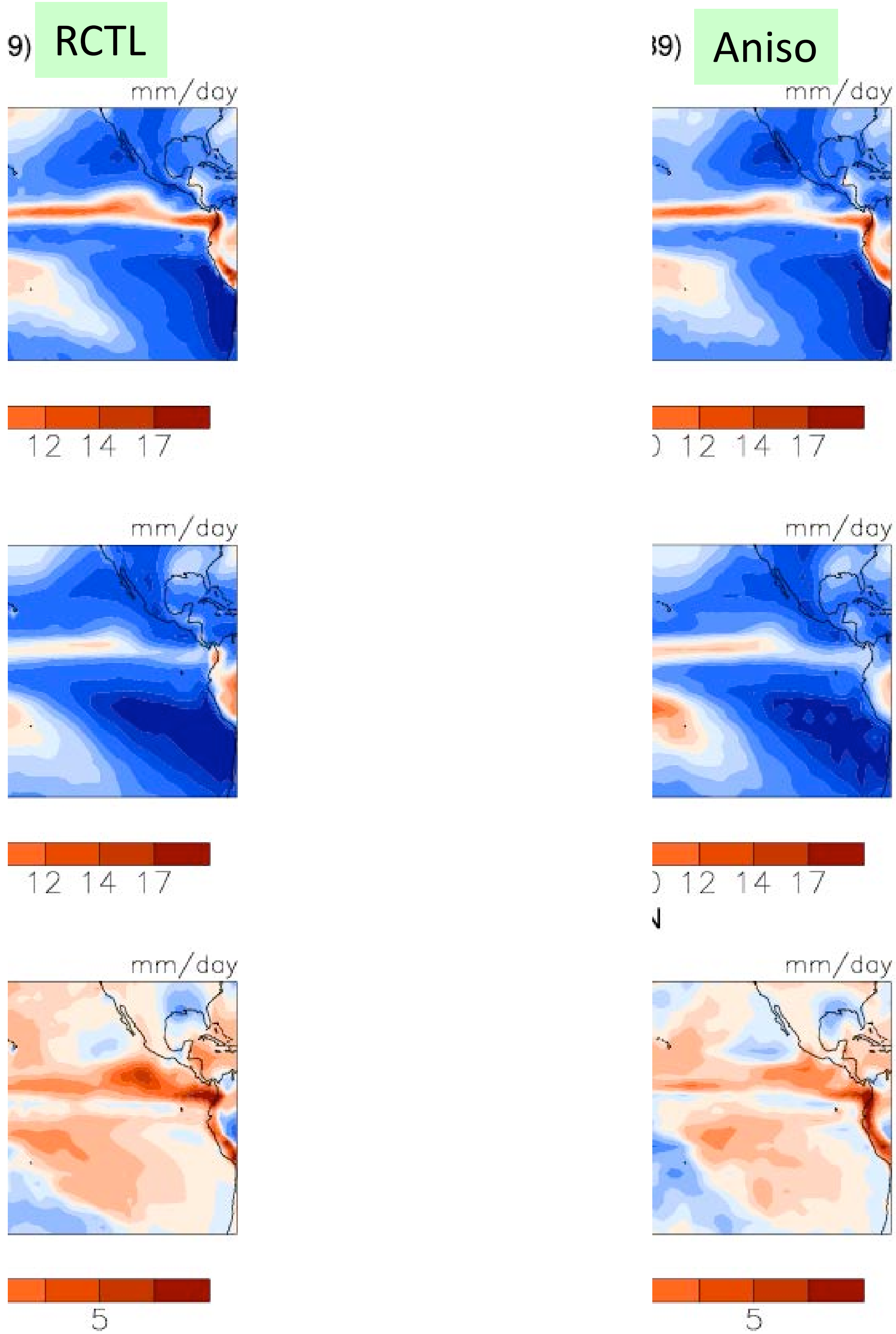


JJA Zonal mean temperatures



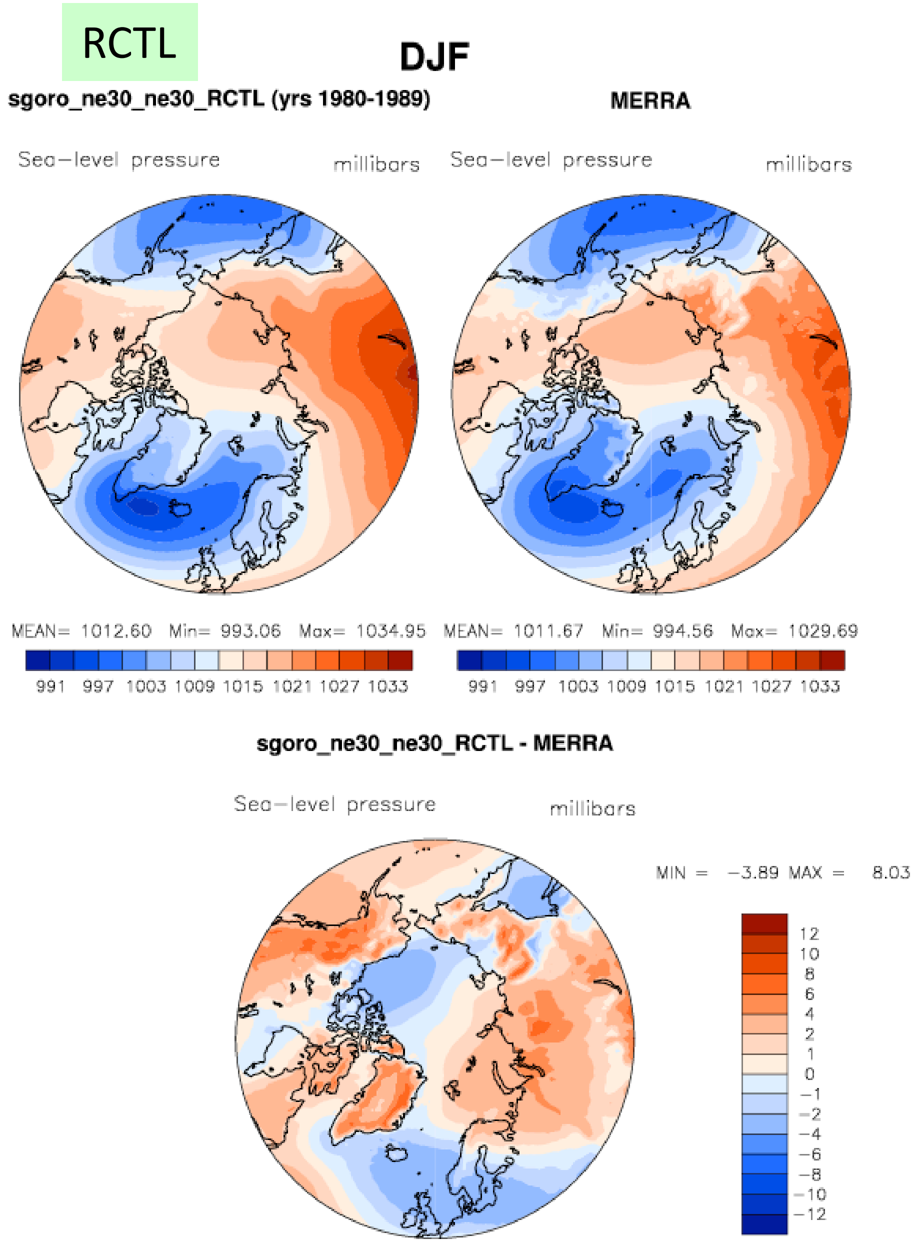
Annual mean wind stress

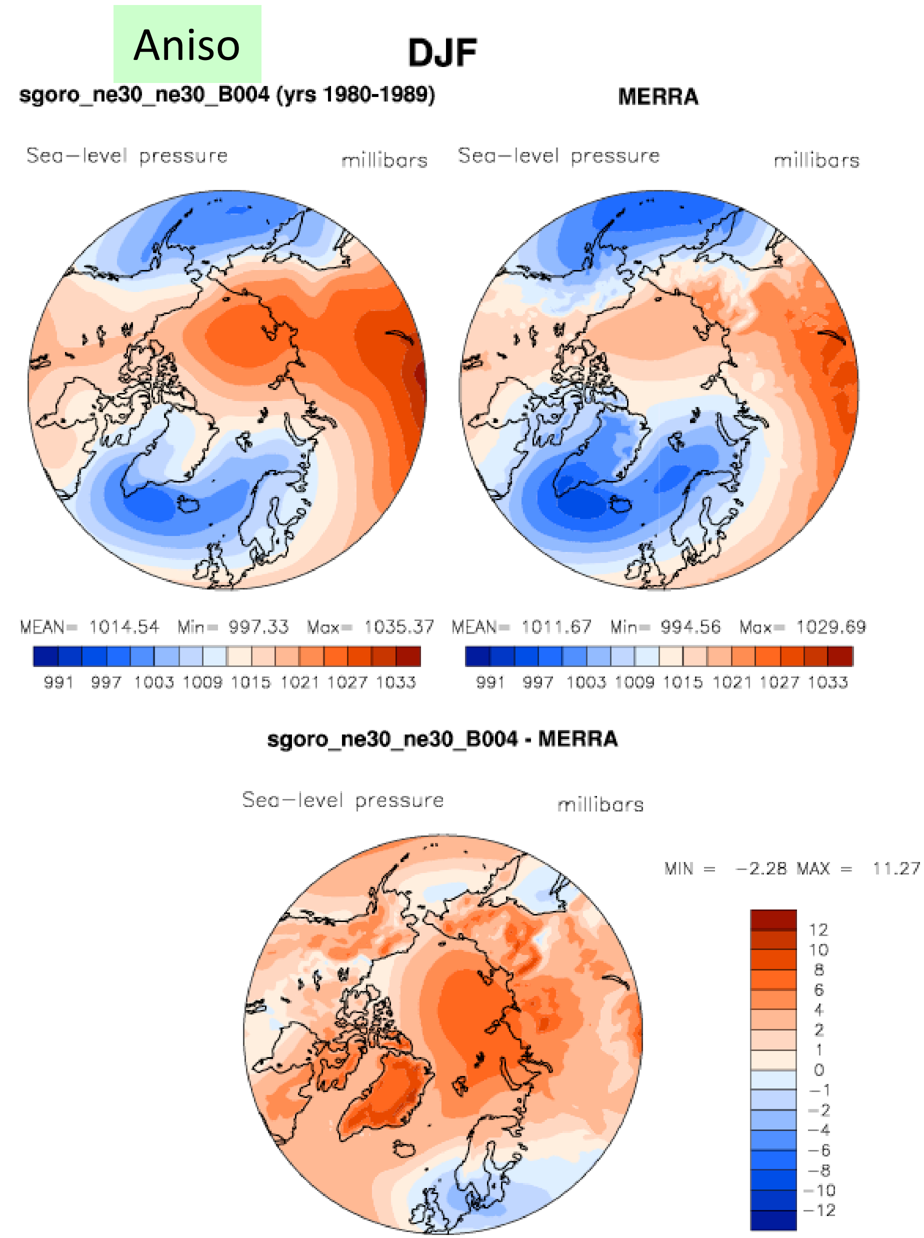




1980-90 DJF mean Precipitation

DJF mean sea-level pressure

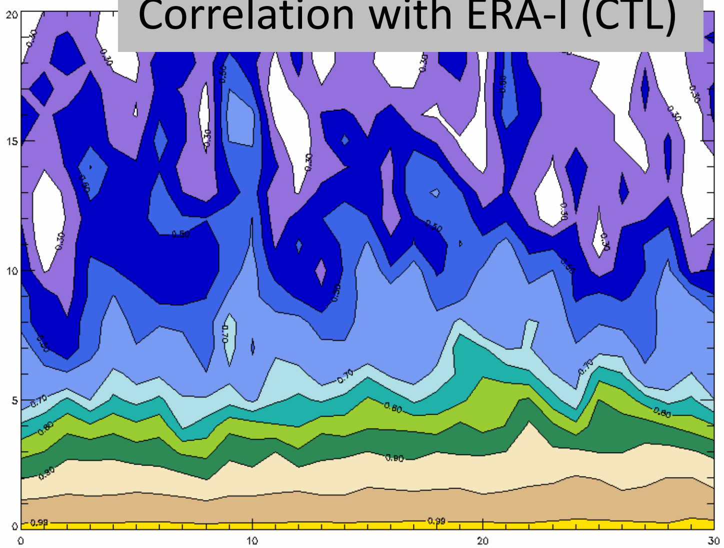


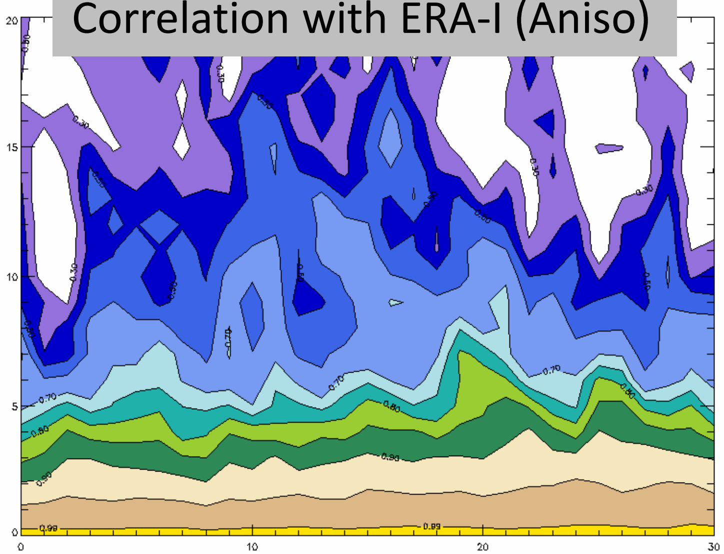


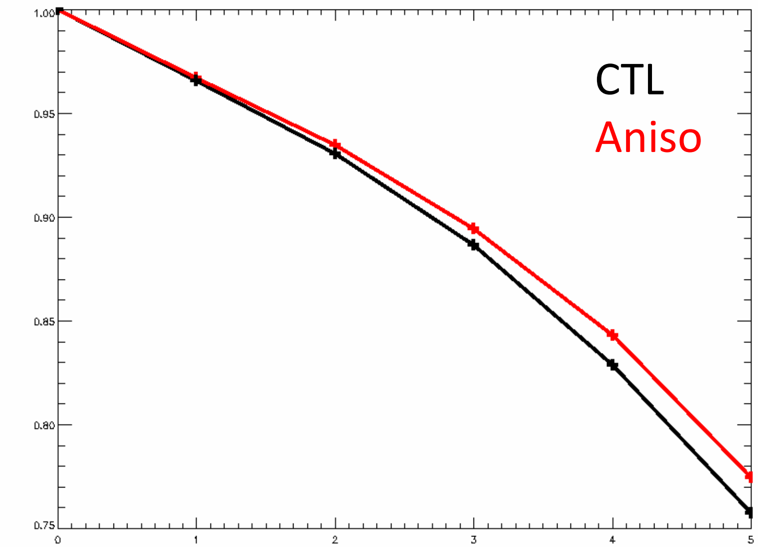
CAPT forecasts 1/2003

- 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

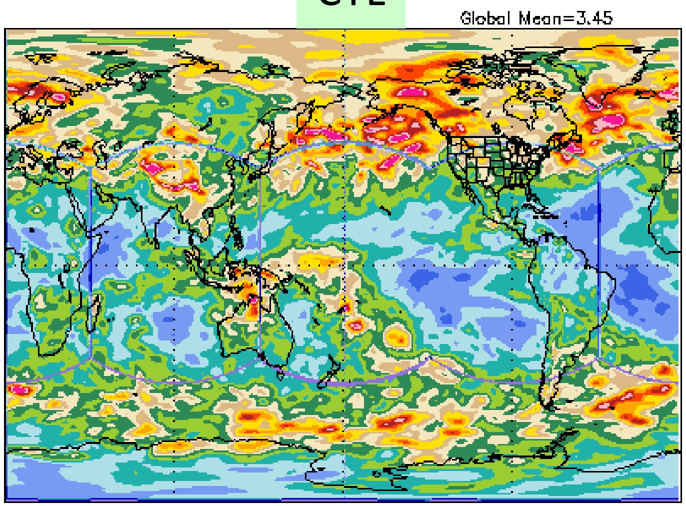




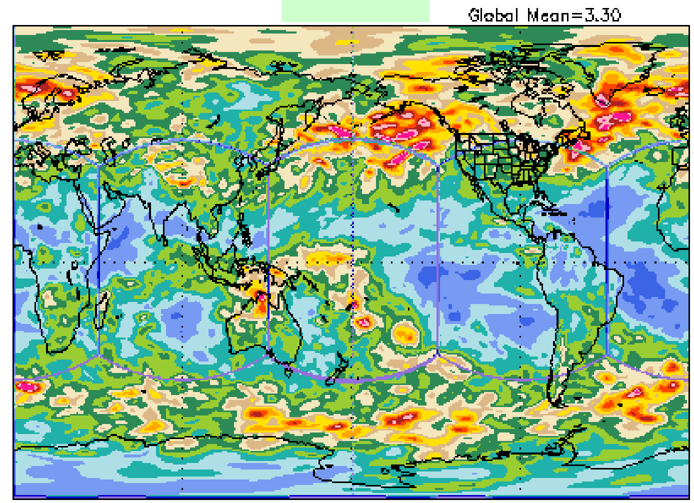


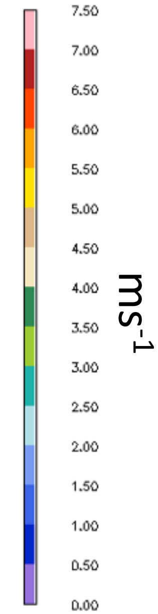
Mean errors in 0.7-0.95 σ–lev *U* at Day 3

CTL

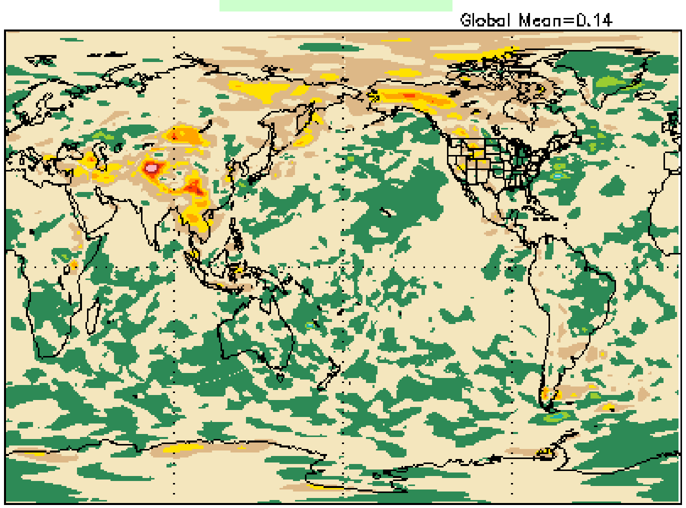


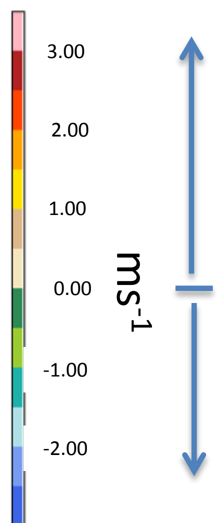
Aniso





CTL-Aniso





Aniso better

CTL better

Future work

- Tease out relative impacts of
  - Low-level flow parameterization
  - Lee-waves
  - Meso β vs meso γ

- High-resolution – ne120
- Anisotropic TMS