Higher vertical resolution in CAM – Do we need it?

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ESSL's Climate & Global Dynamics
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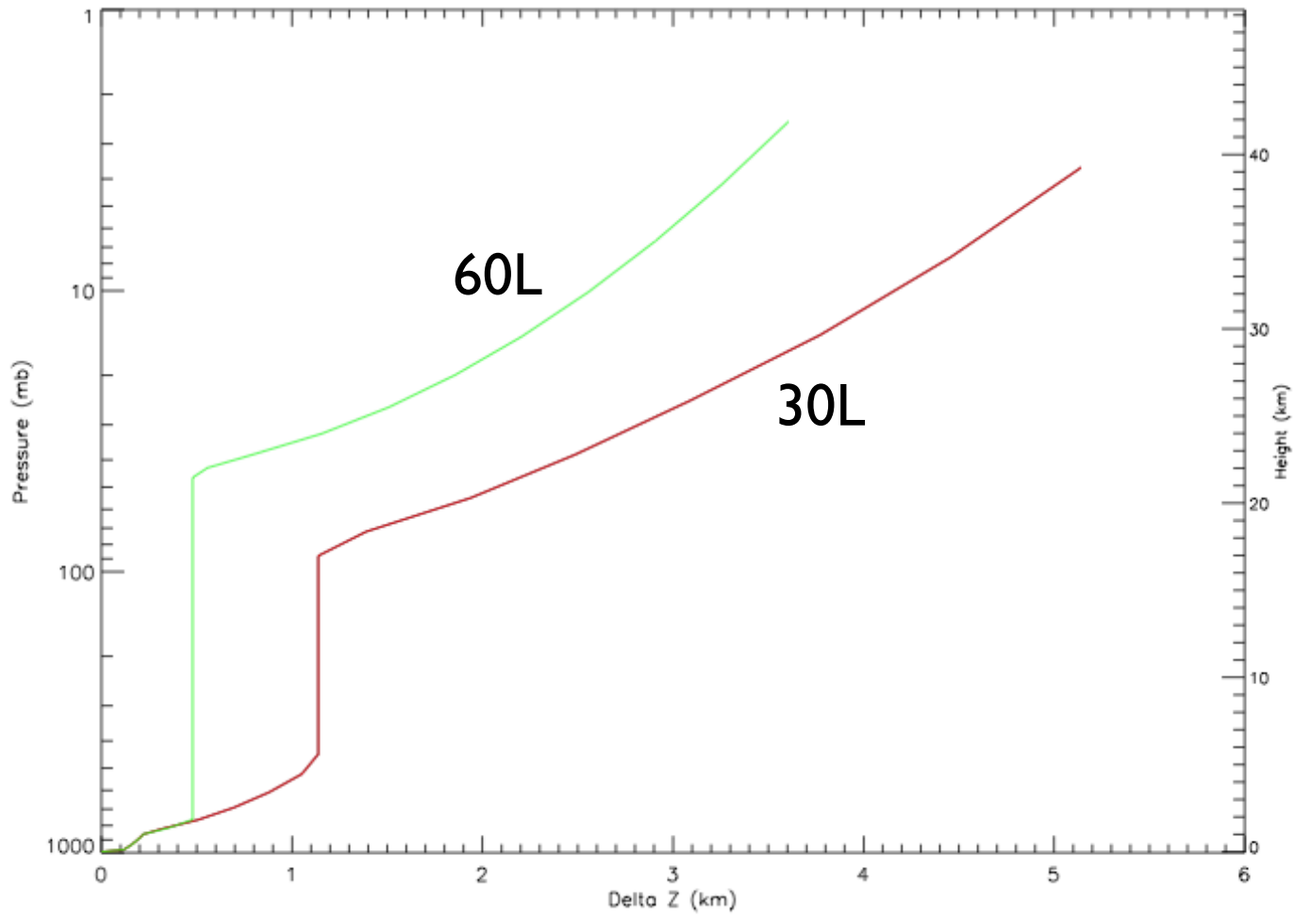
Motivation:

- Horizontal resolution of CAM has increased substantially while vertical resolution has not
  2004: CAM3: 26 levels T42 ~ 300 km
  2013: CAM5: 30 levels ne30 ~ 100 km
- For extratropical disturbances, dz/dx = f/N (Linzden & Fox-Rabinovitz, 1989, Boville 1991)

  For ne30, 45N: dz = (f/N) x dx ~ 0.02 x 100 km ~ 500m
- Every previous increase in model's resolution was motivated by ability to represent certain aspect of physics or dynamics better

60L vs 30L model:



30L model: ~ 1200 m resolution in troposphere/lower stratosphere

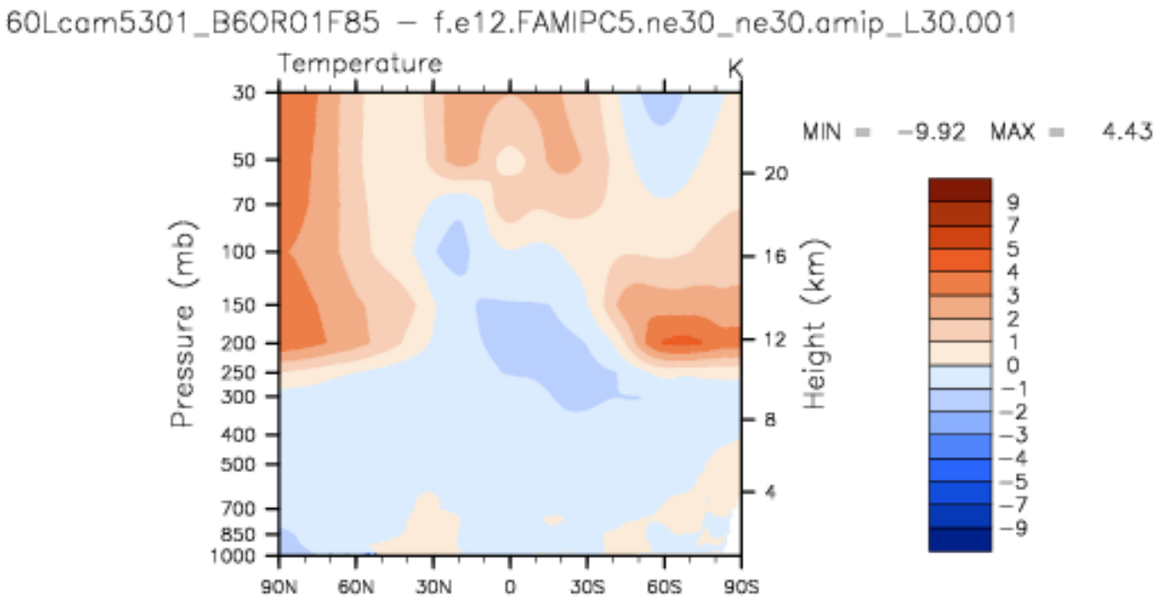
60L model: ~ 500 m resolution in troposphere/lower stratosphere

Models to Compare:

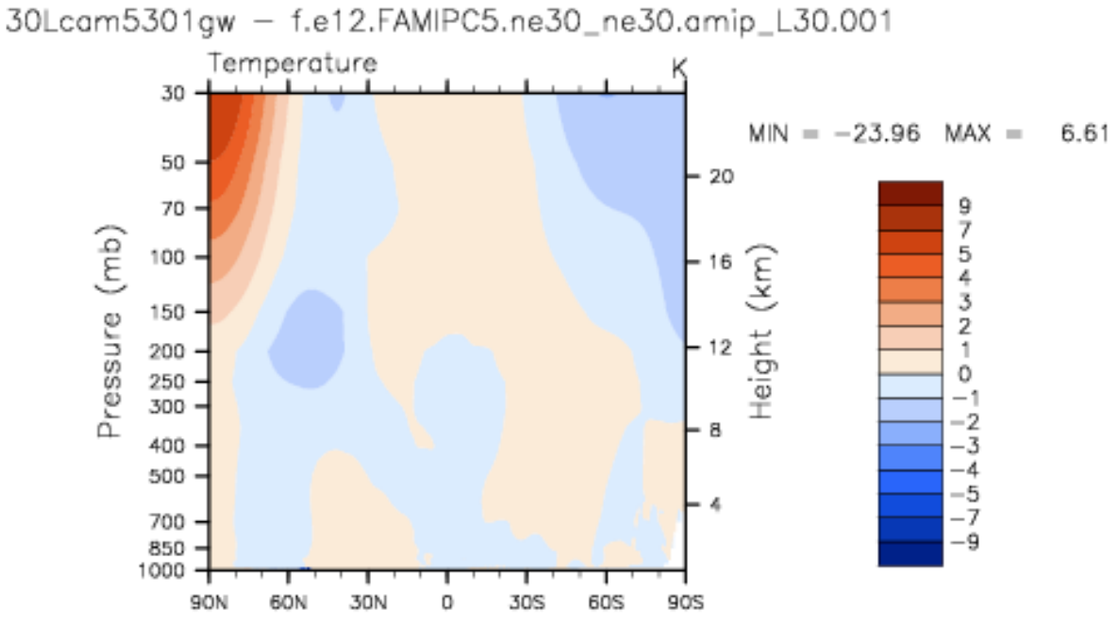
- 30L: f.e12.FAMIPC5.ne30_ne30_amip_L30.01 50 yrs
- 60LGW (Best 60L model): 50 yrs
  - tuned GW Oro (effgw_oro=0.0625 instead of 0.125)
  - non-orographic waves (frontal & convective with tuning)
- 30LGW (Oro and non-oro GW changes) 20yrs
- 60L (no physics changes) 20 yrs

DJF Temperature:

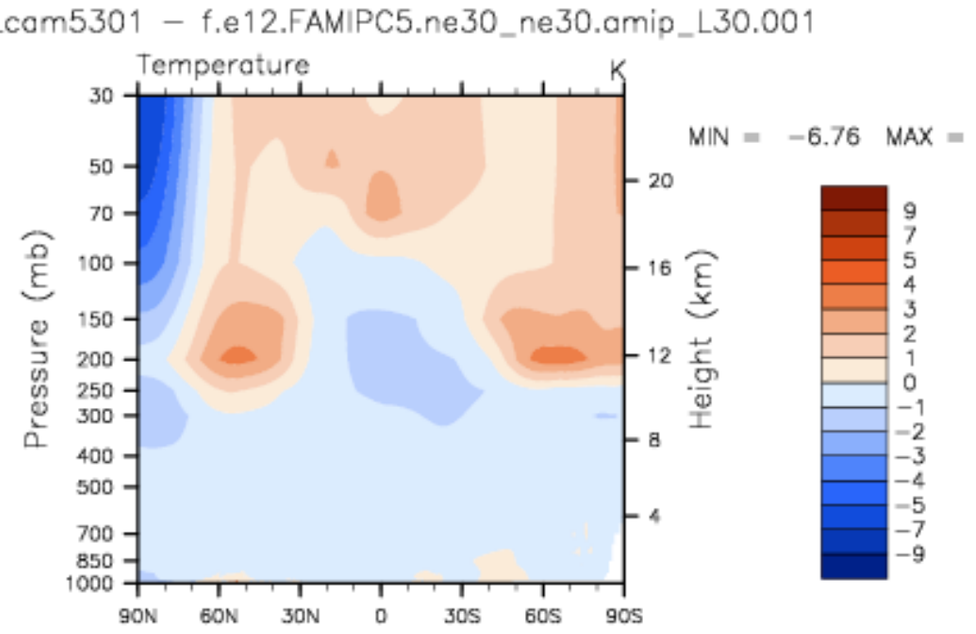
60LGW - 30L



30LGW - 30L

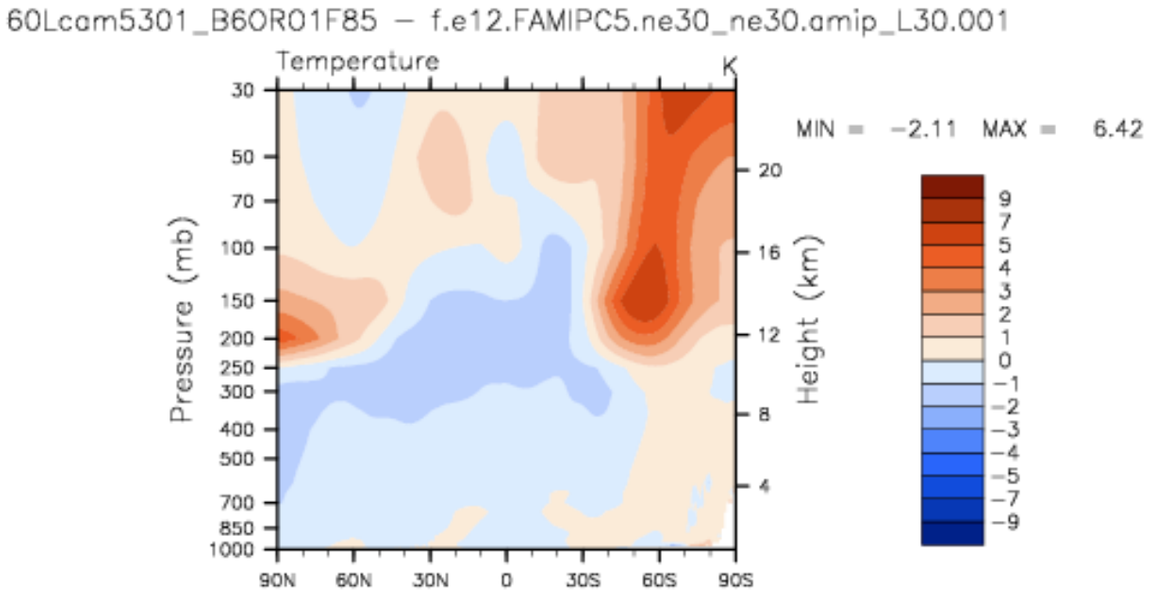


60L - 30L

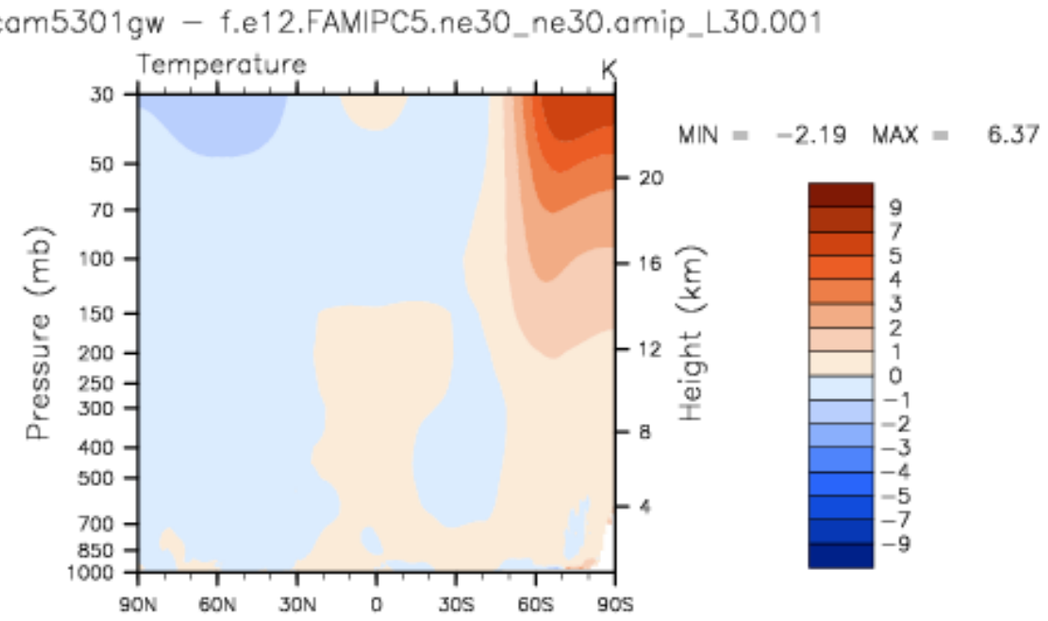


JJA Temperature:

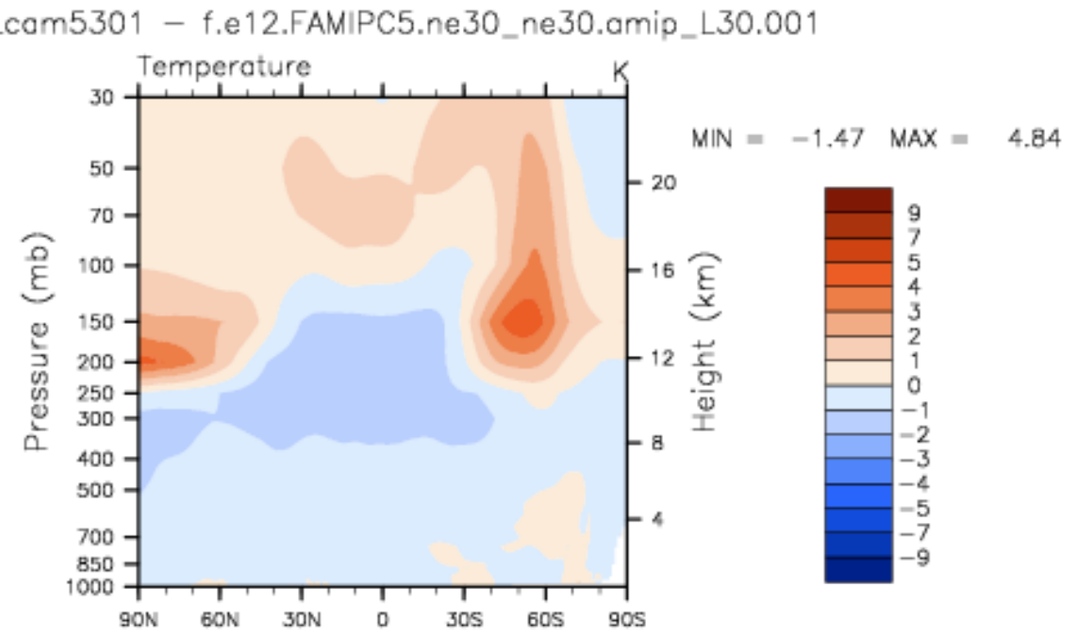
60LGW - 30L



30LGW - 30L



60L - 30L



Temperature biases from OBS:

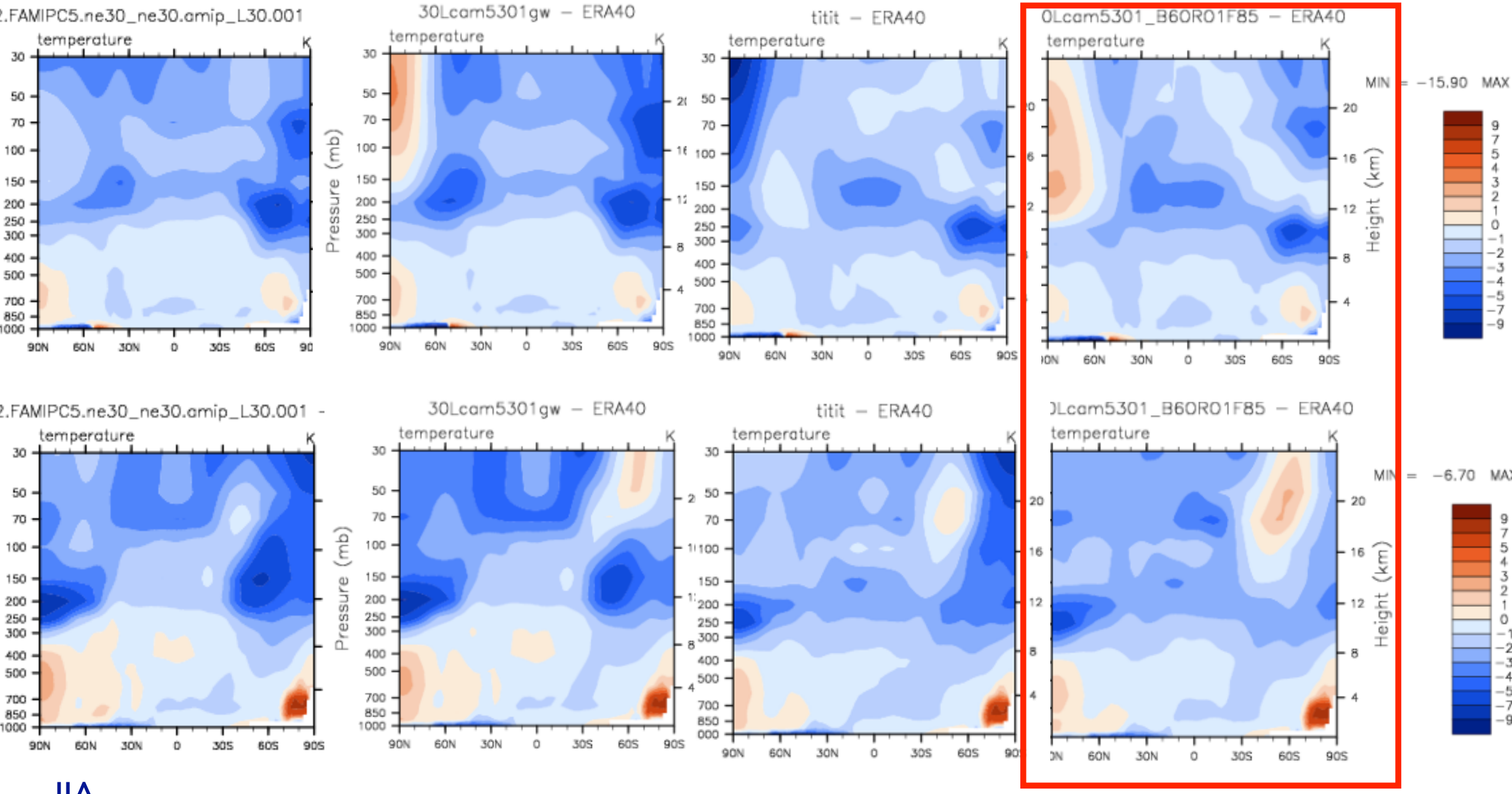
DJF

30L

30LGW

60L

60LGW



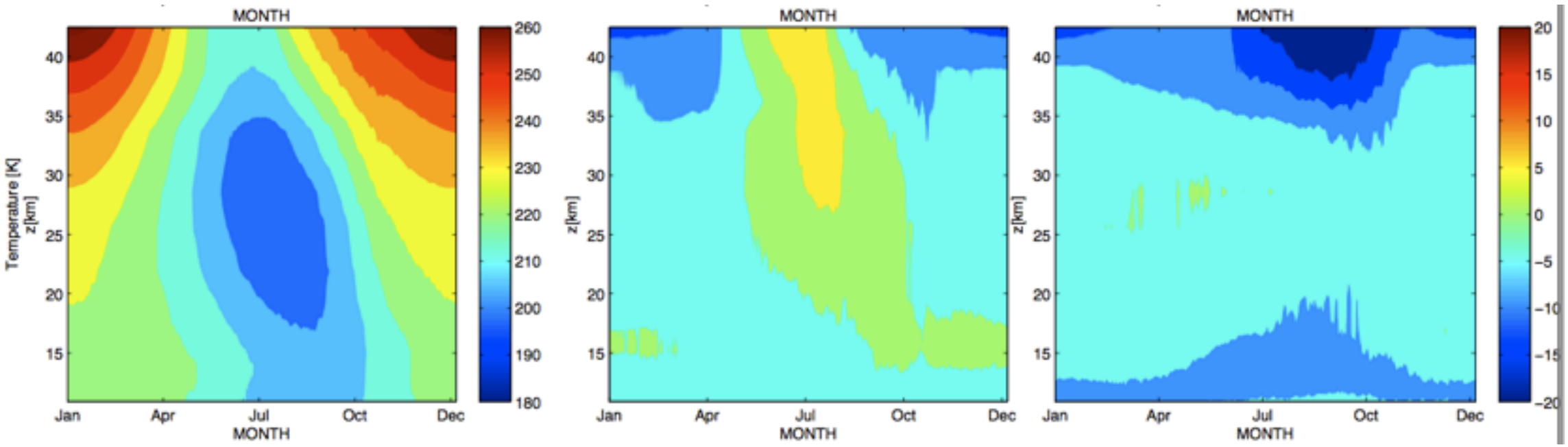
JJA

60S Seasonal Cycle:

T

60LGW

30L

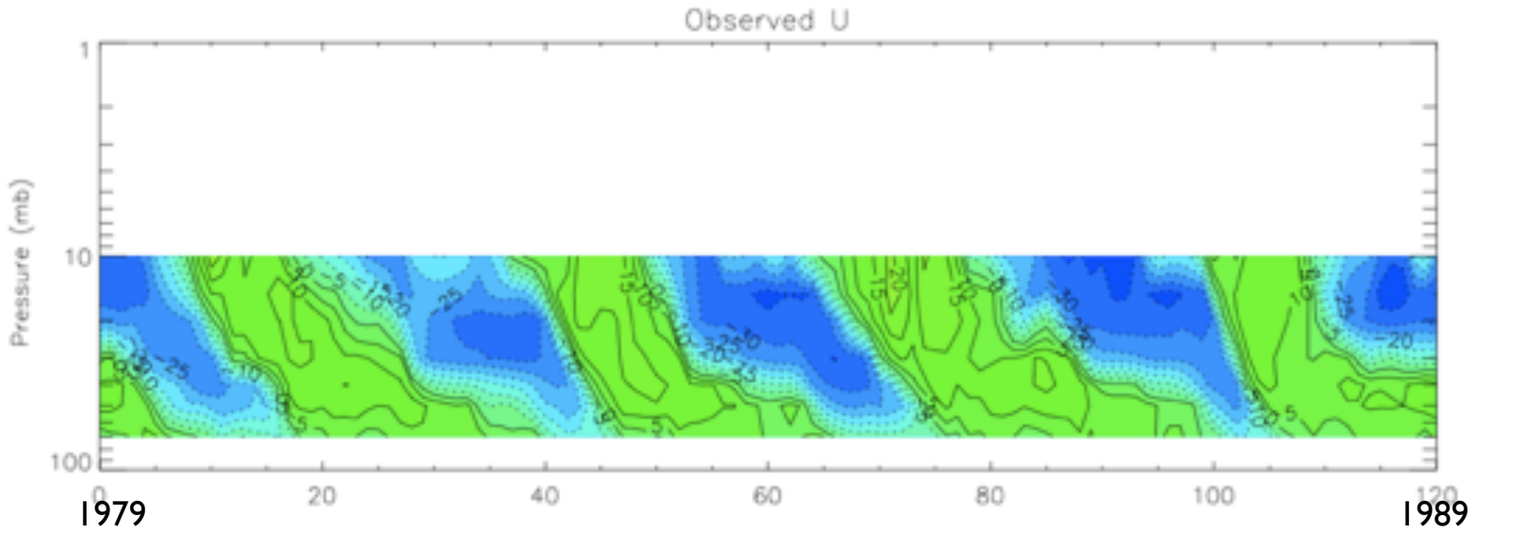


Temp diff from OBS

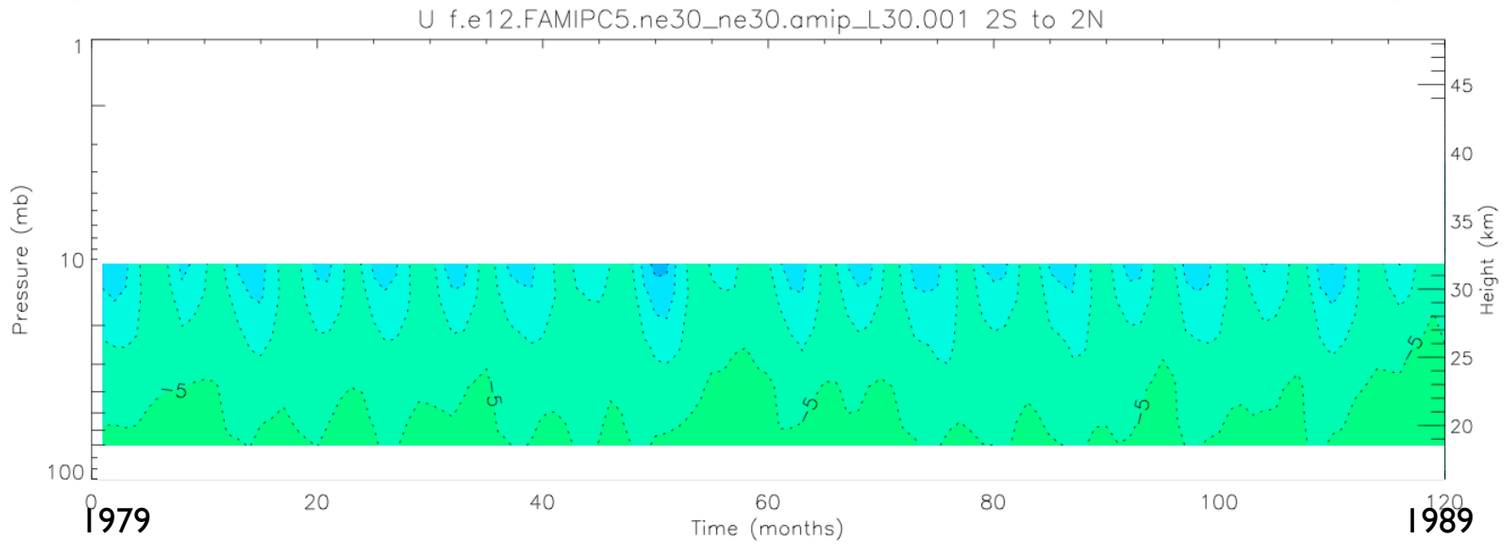
Talk to JF about improvements in CHEM-CAM

Tropical Winds:

OBS

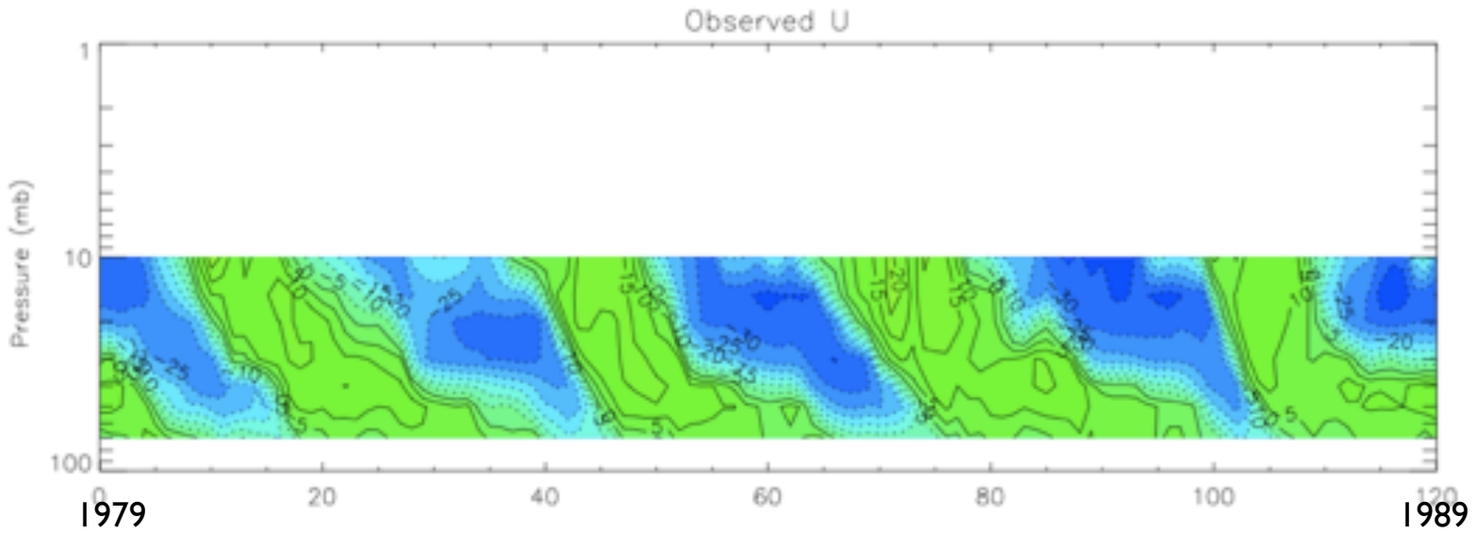


30L

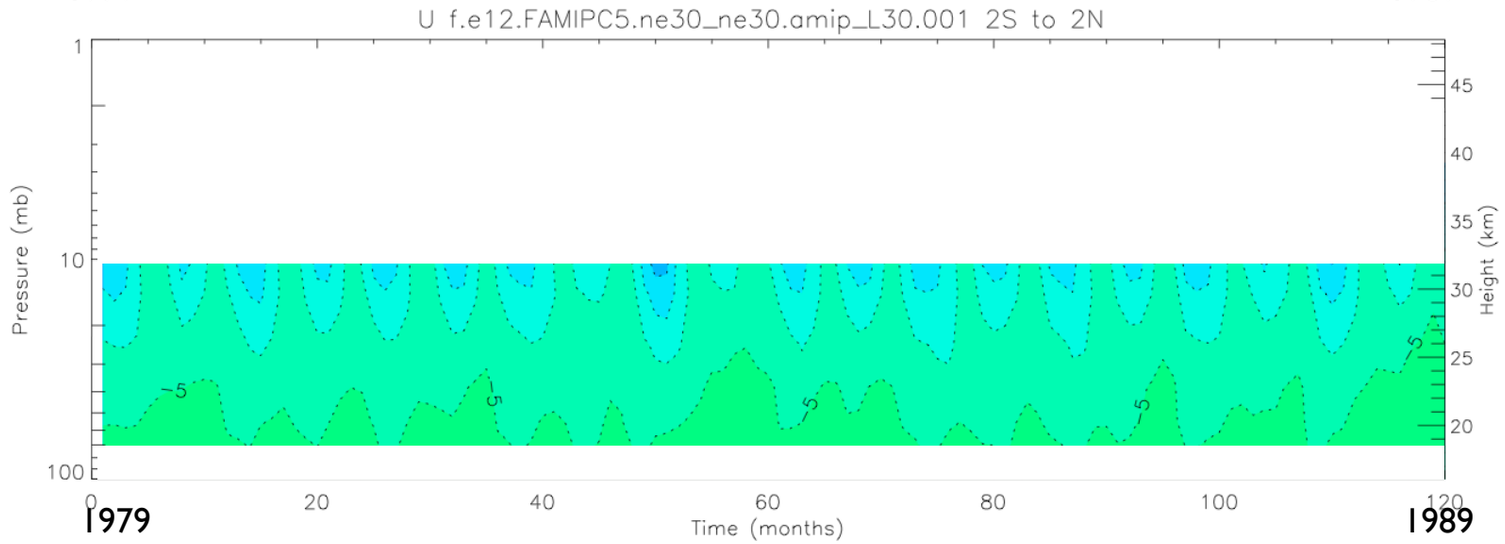


Tropical Winds:

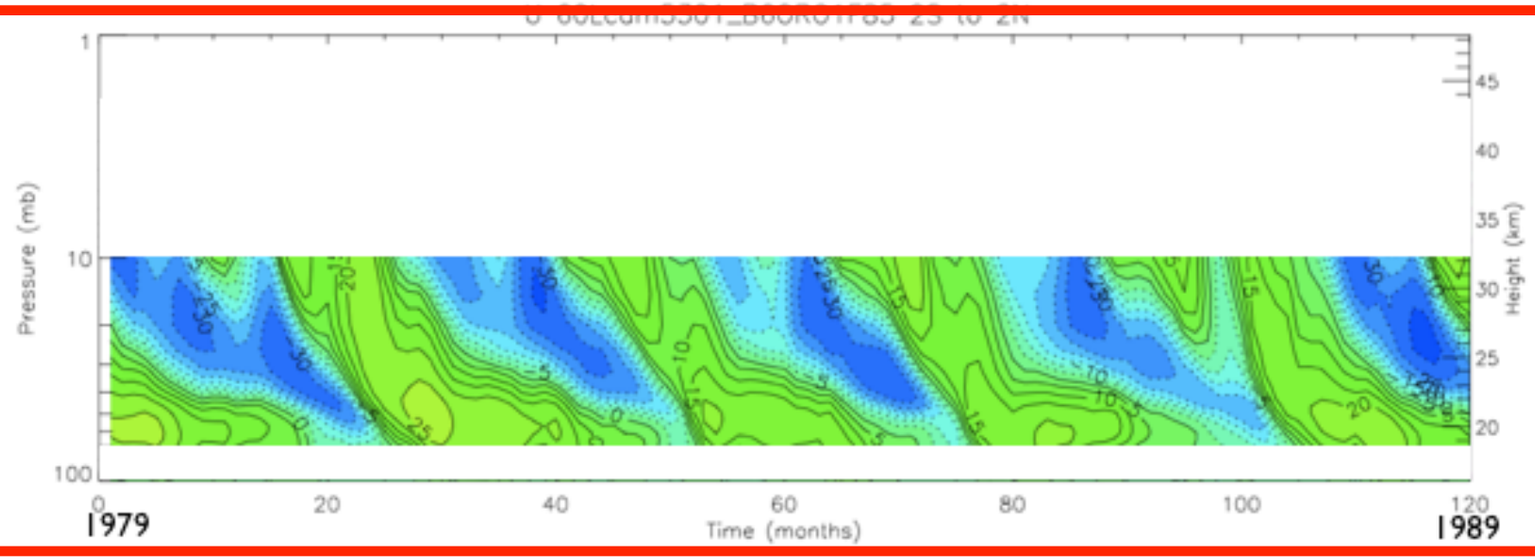
OBS



30L



60LGW

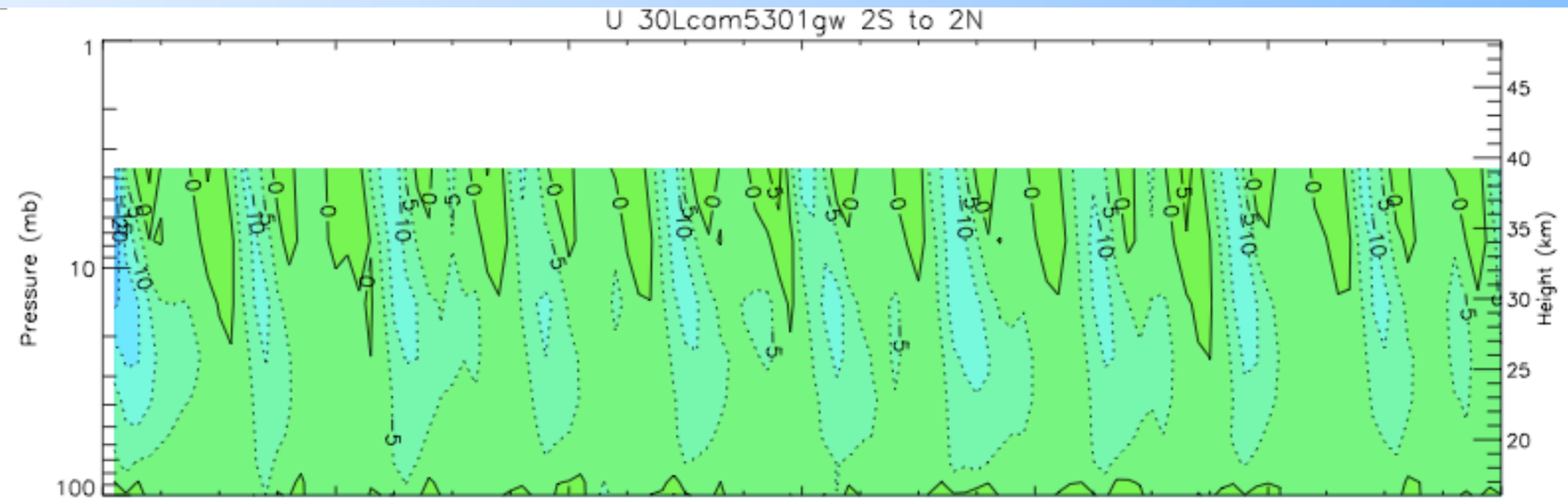


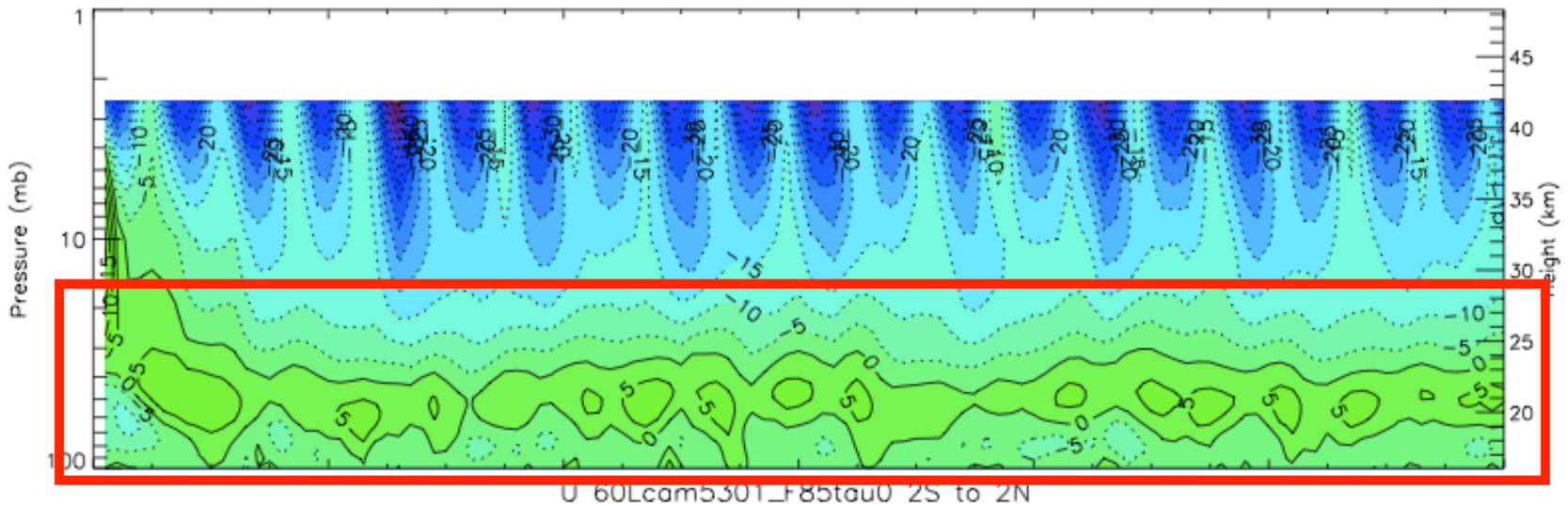
QBO:

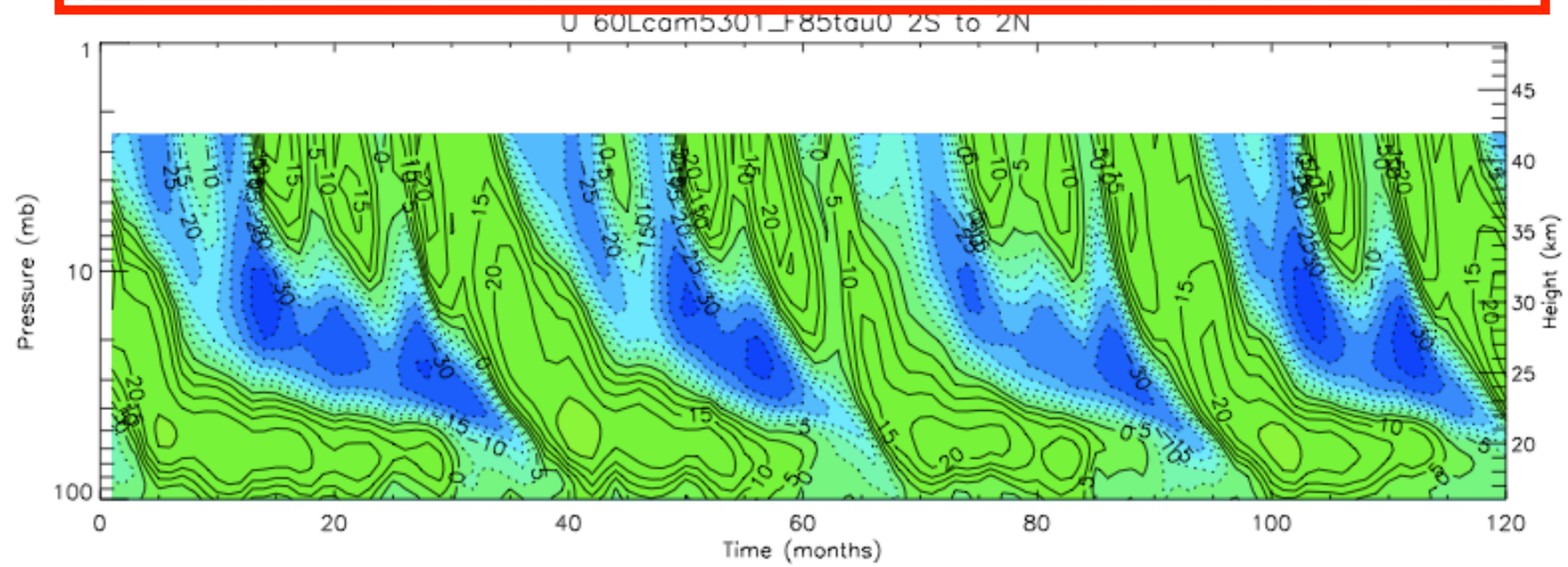
30LGW

60L

60LGW

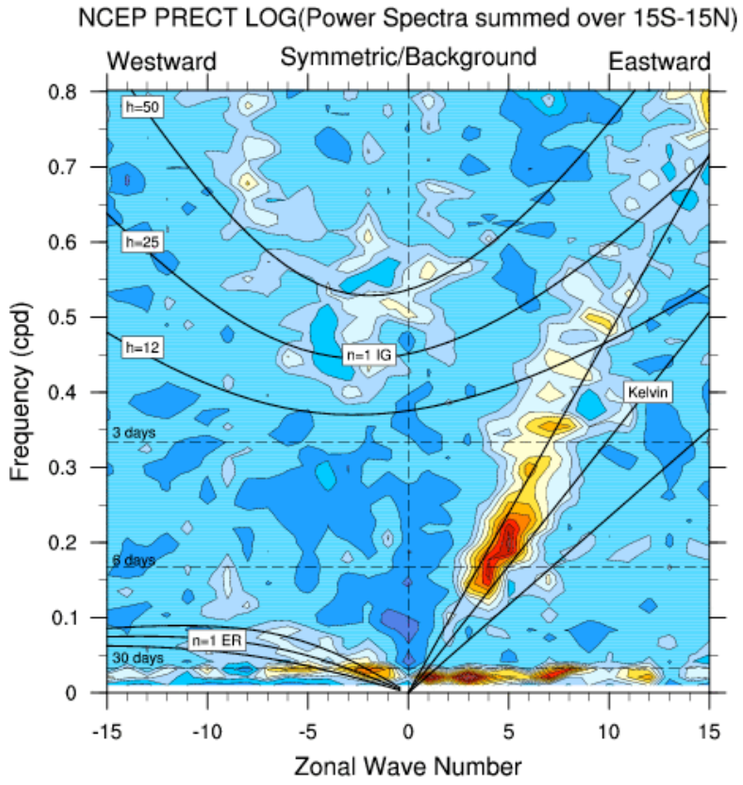




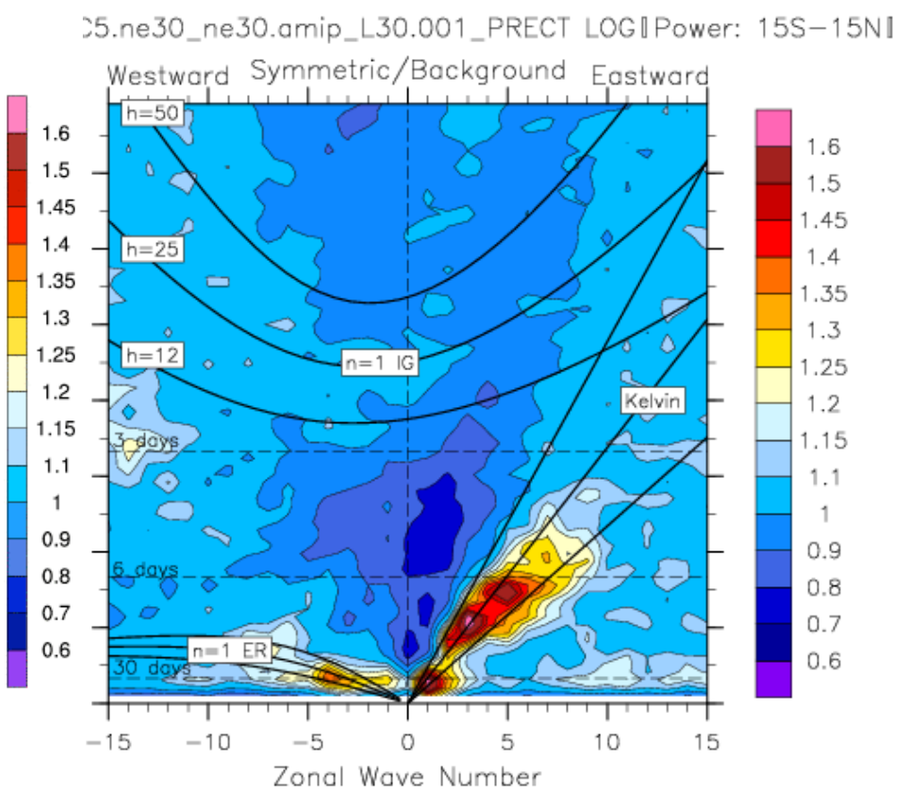


Variability:

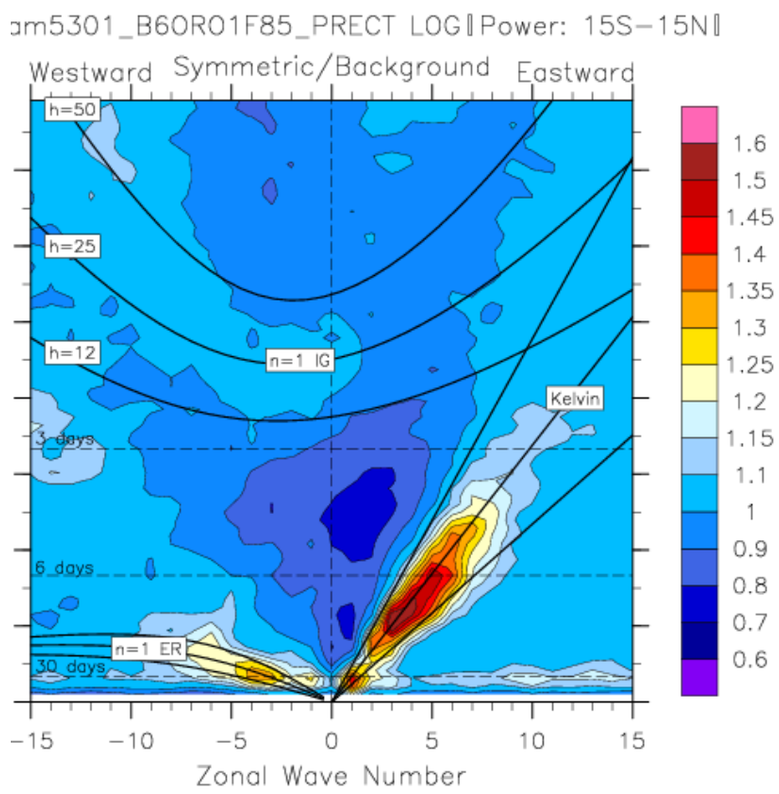
OBS



30L



60LGW

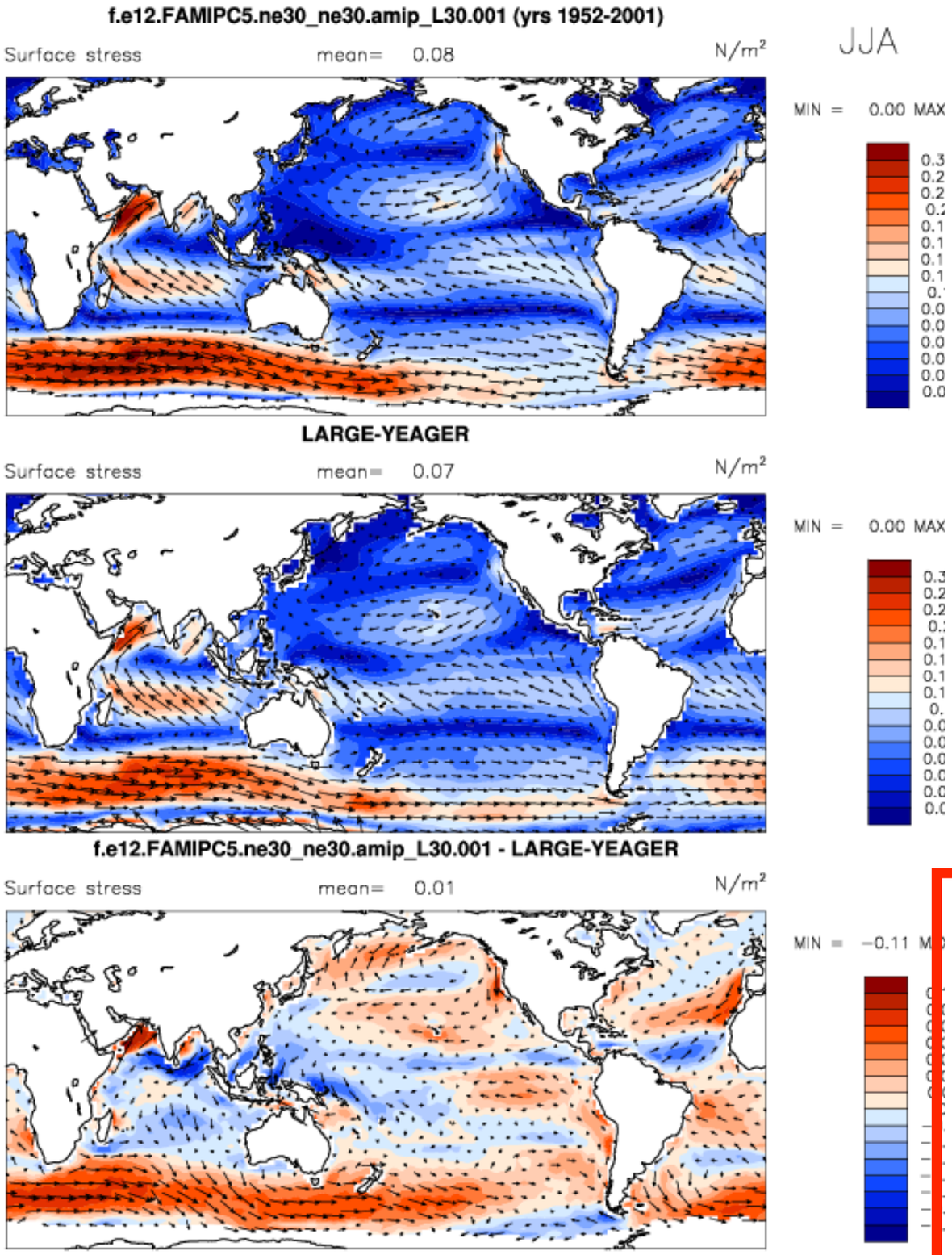


Why is a QBO important?

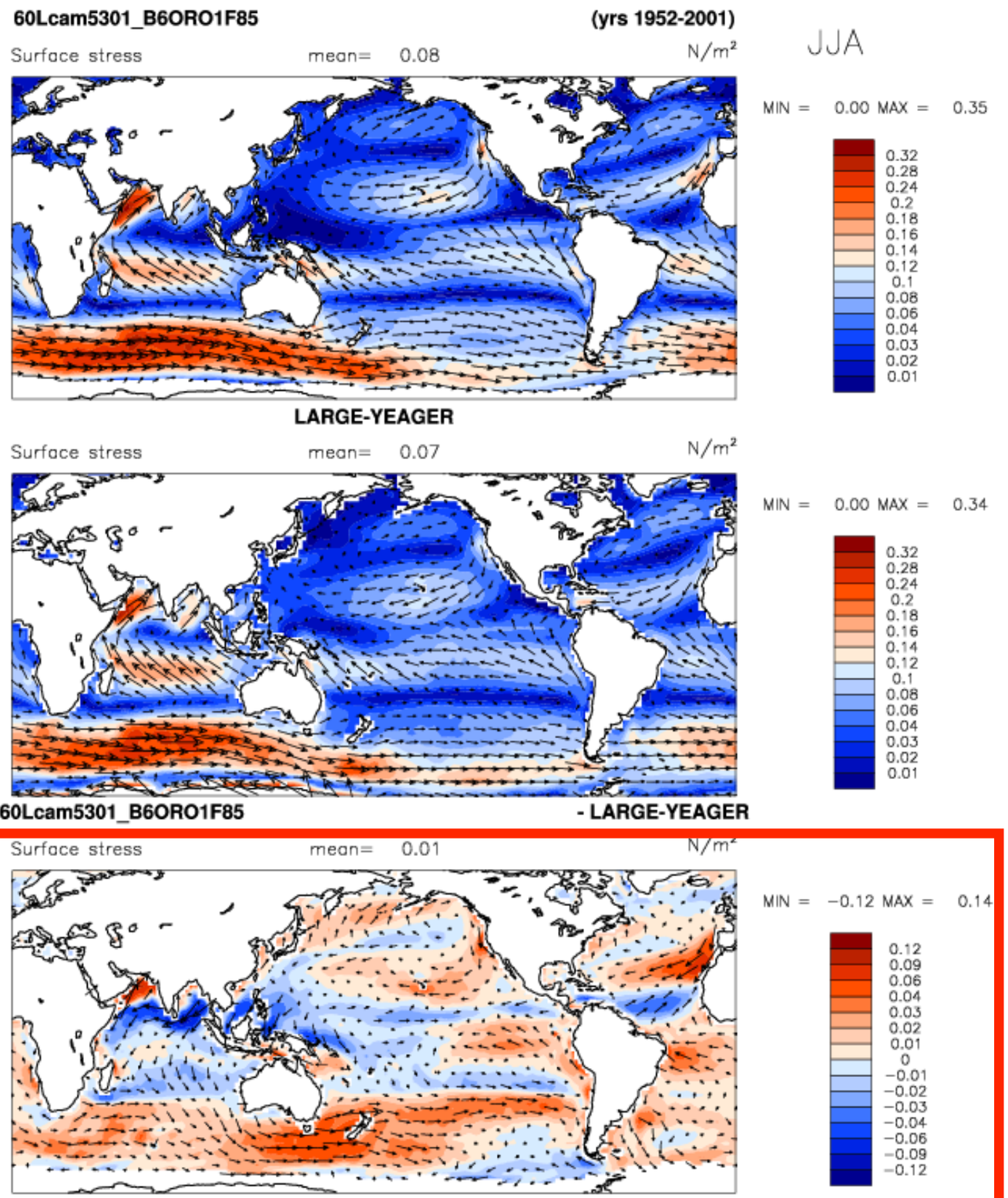
- QBO affects the polar vortex (Holton and Tan 1980)
- QBO affects the Arctic Oscillation (AO) (eg.: Baldwin 1998)
- QBO affects tropospheric greenhouse gases (Hamilton and Fan 2012)
- QBO affects hurricane formation (Gray 1984)
- QBO can influence ENSO (e.g: Gray and Knaff 1992)
- Observational record too short: model studies are needed to really understand effects of the QBO

Surface Stresses:

30L-OBS



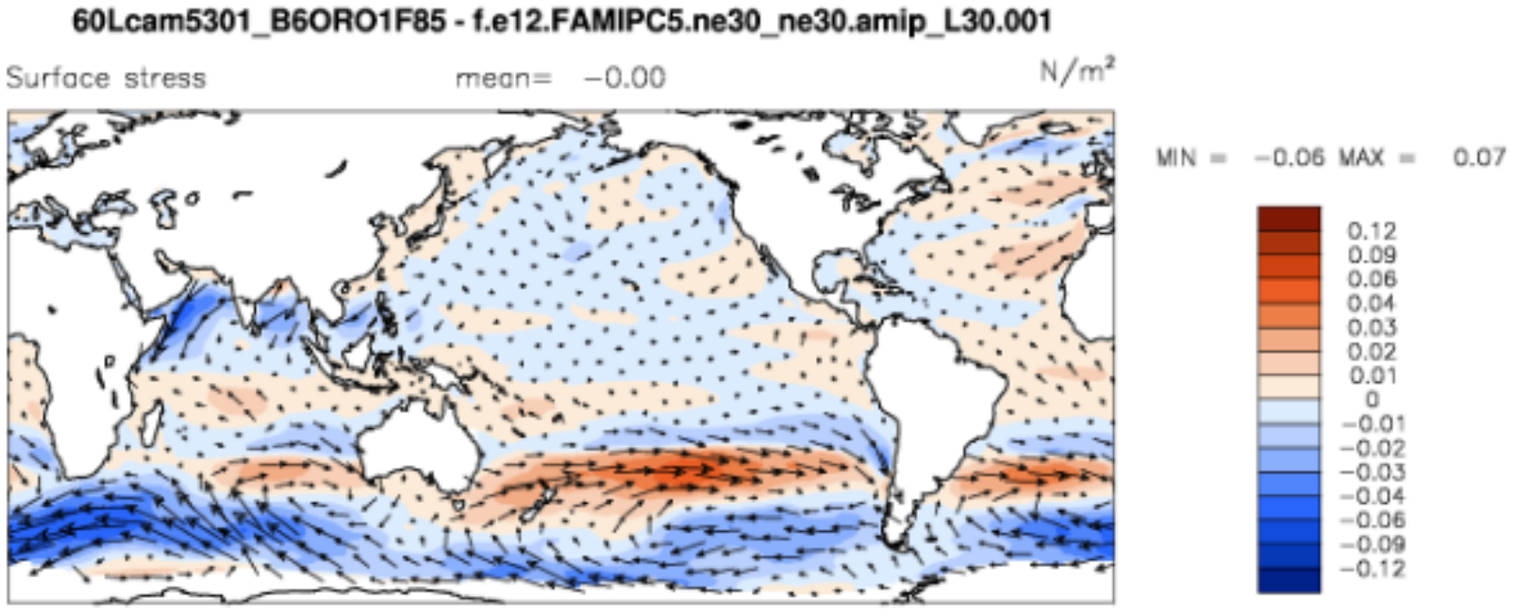
60LGW-OBS



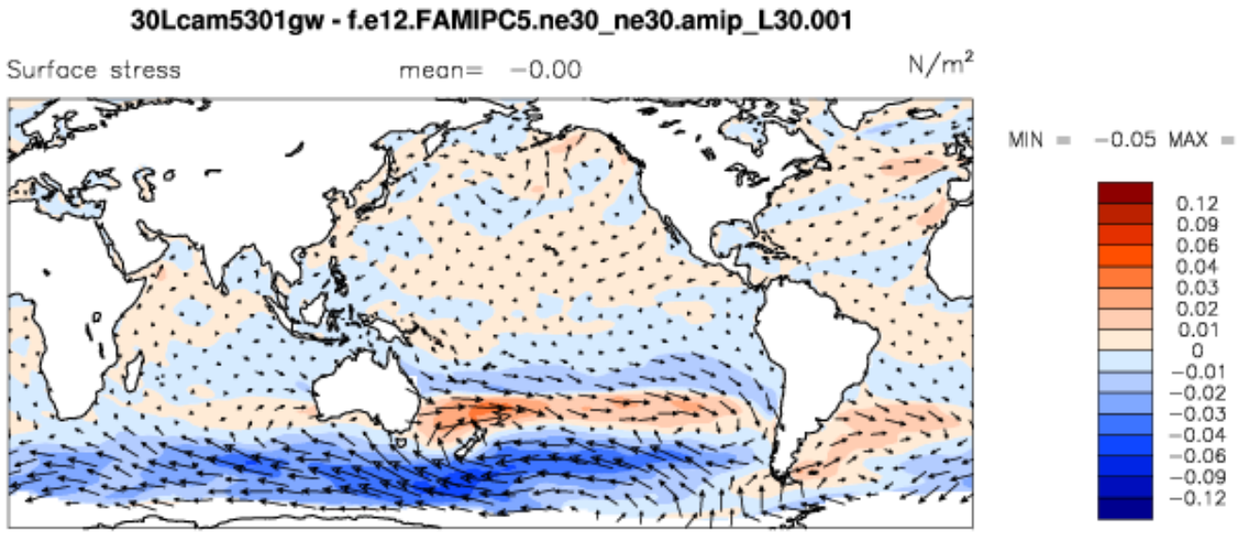
Surface Stresses:

JJA

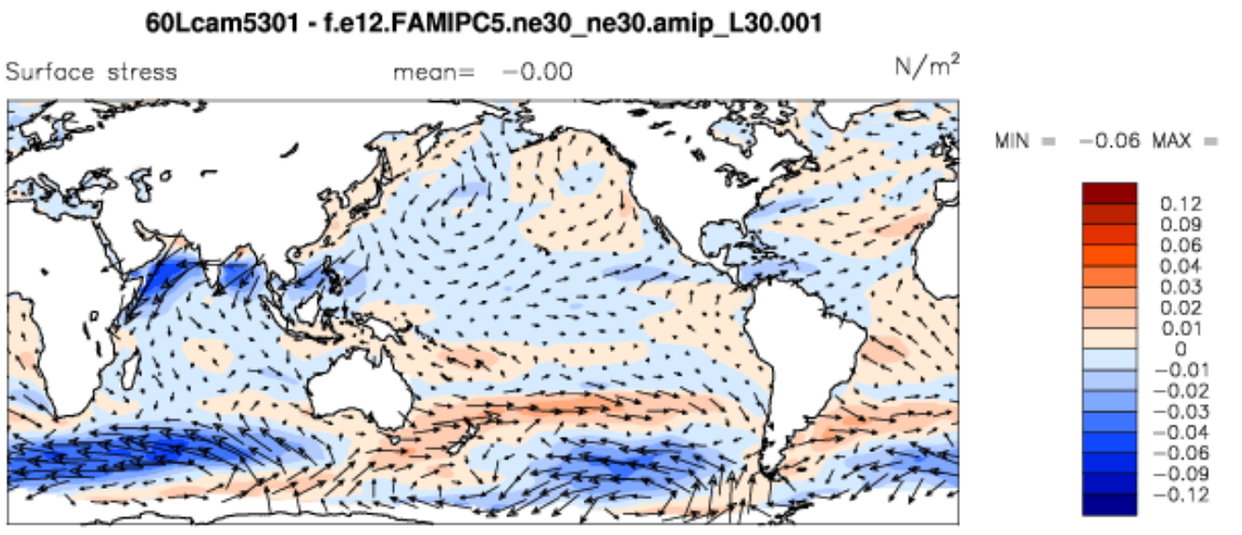
60LGW - 30L



30LGW - 30L

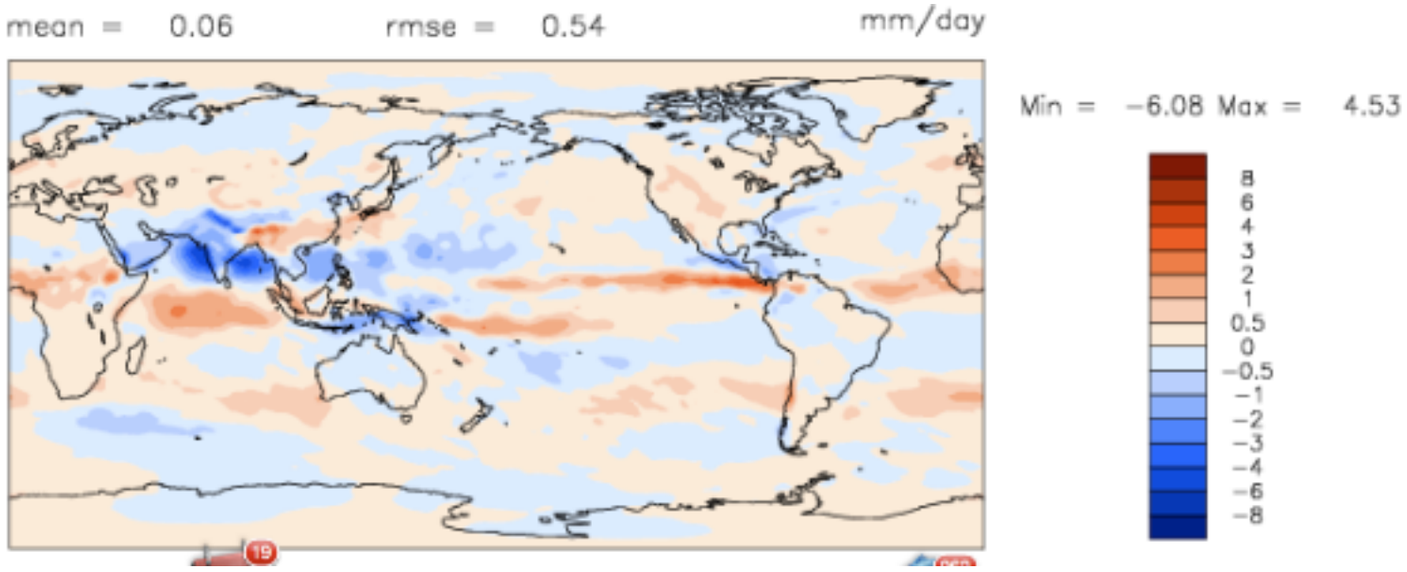


60L - 30L

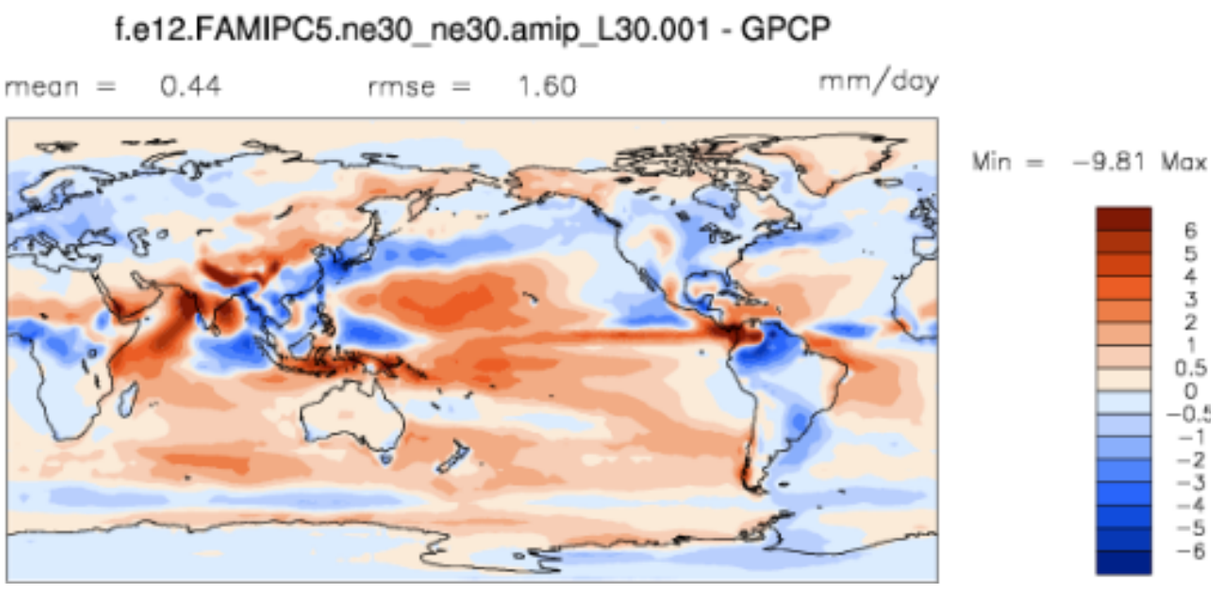


JJA Precip Rate:

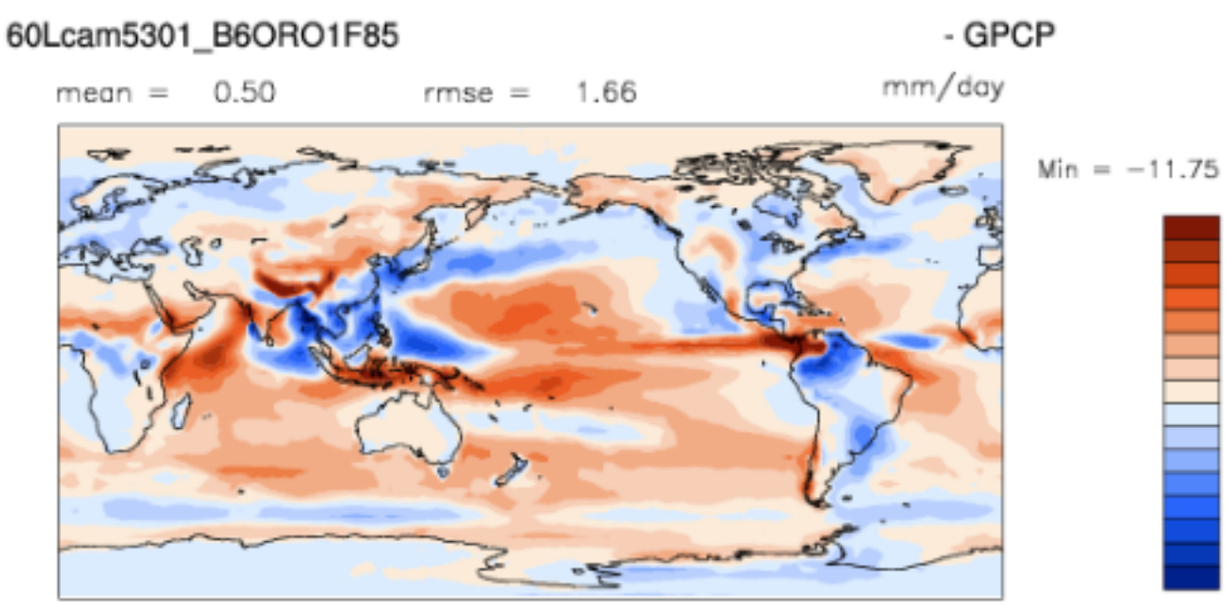
60LGW - 30L



30L - OBS



60LGW - OBS



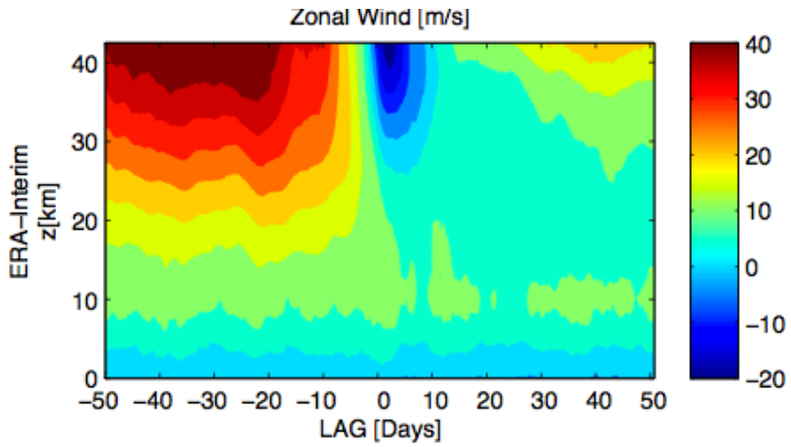
SSWs:

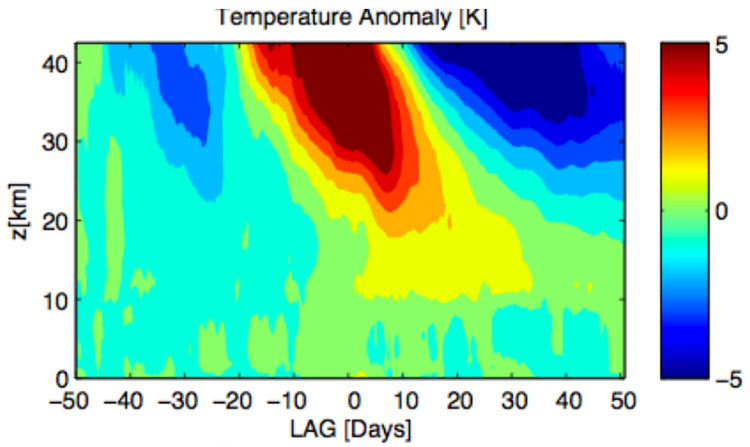
U anomaly

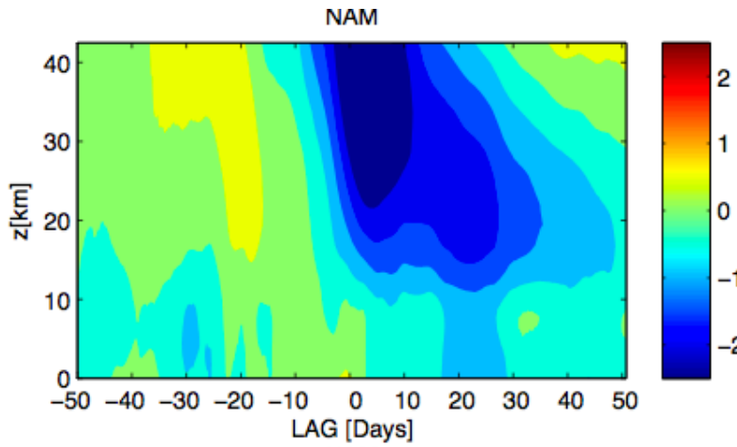
T anomaly

NAM

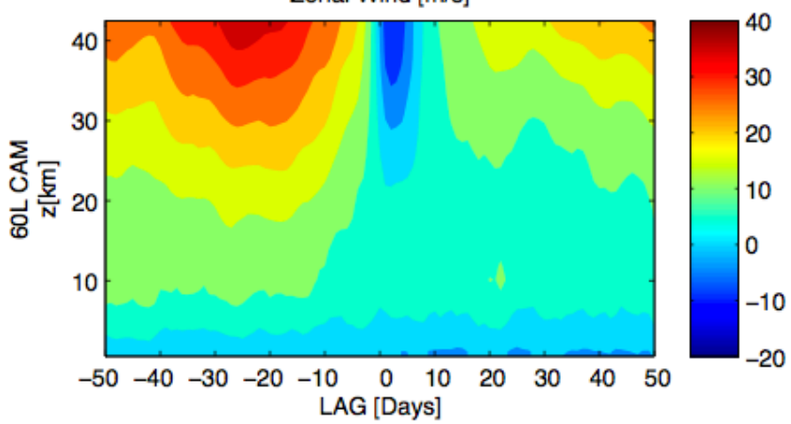
ERA

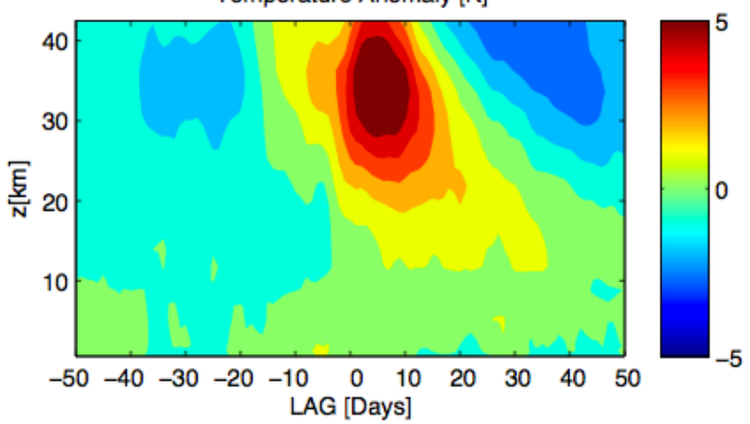


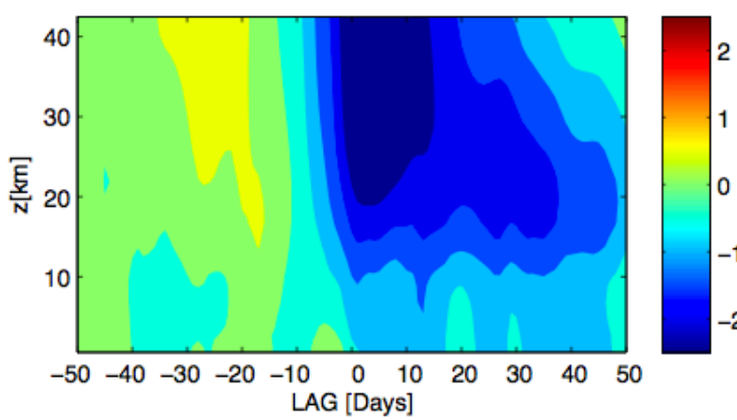




60L







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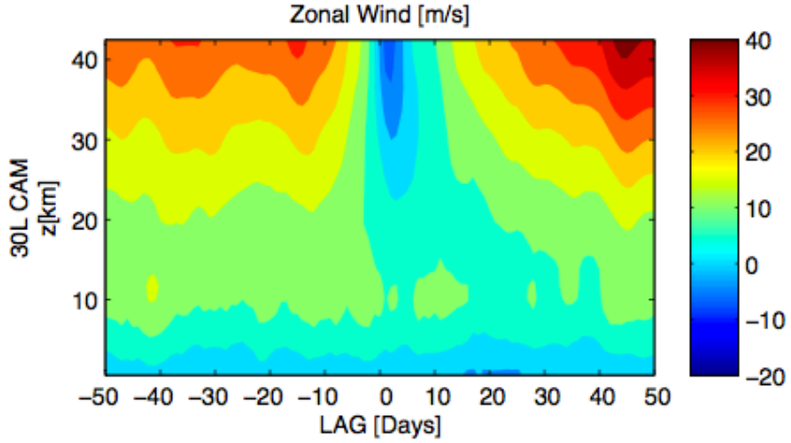
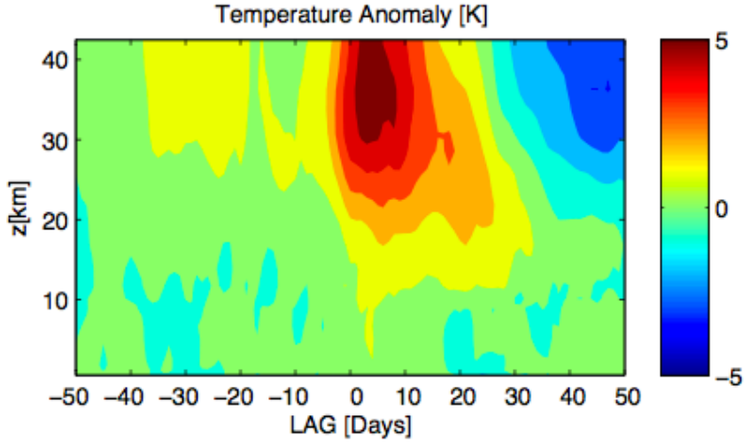
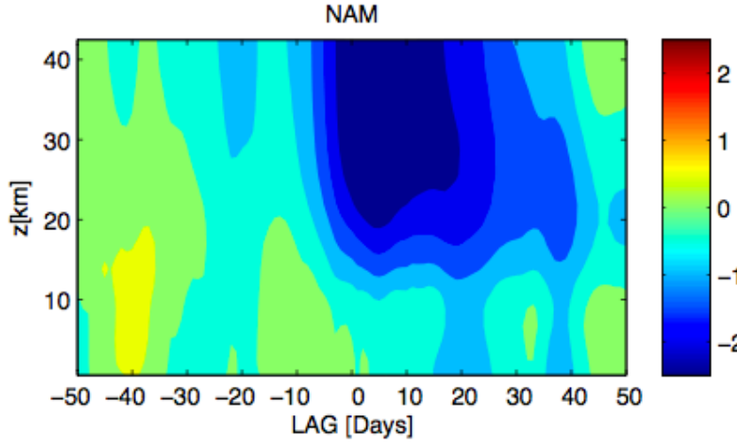






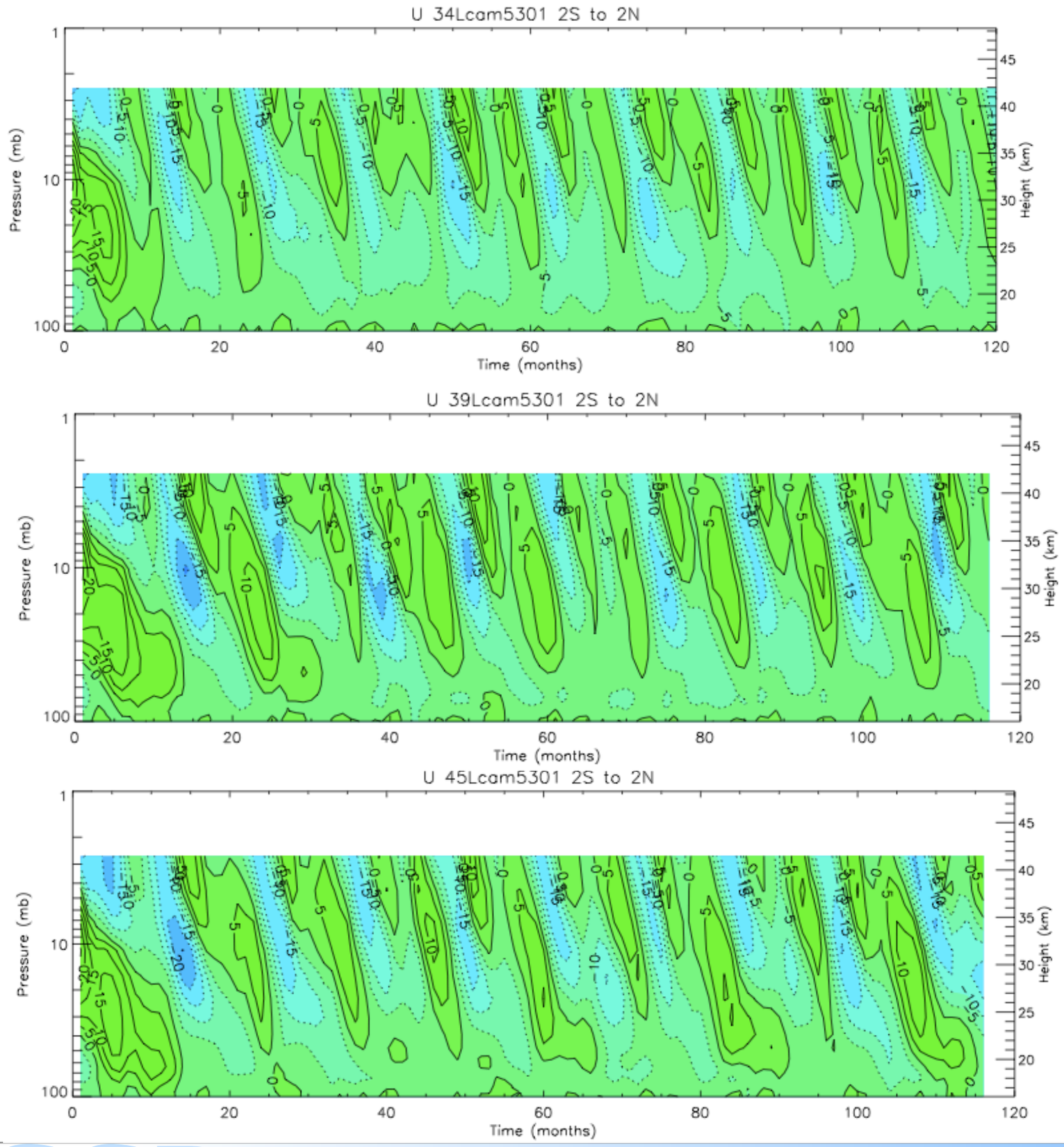
See Ari Solomon's poster for more info!

Can we have coarser resolution?

1200 m

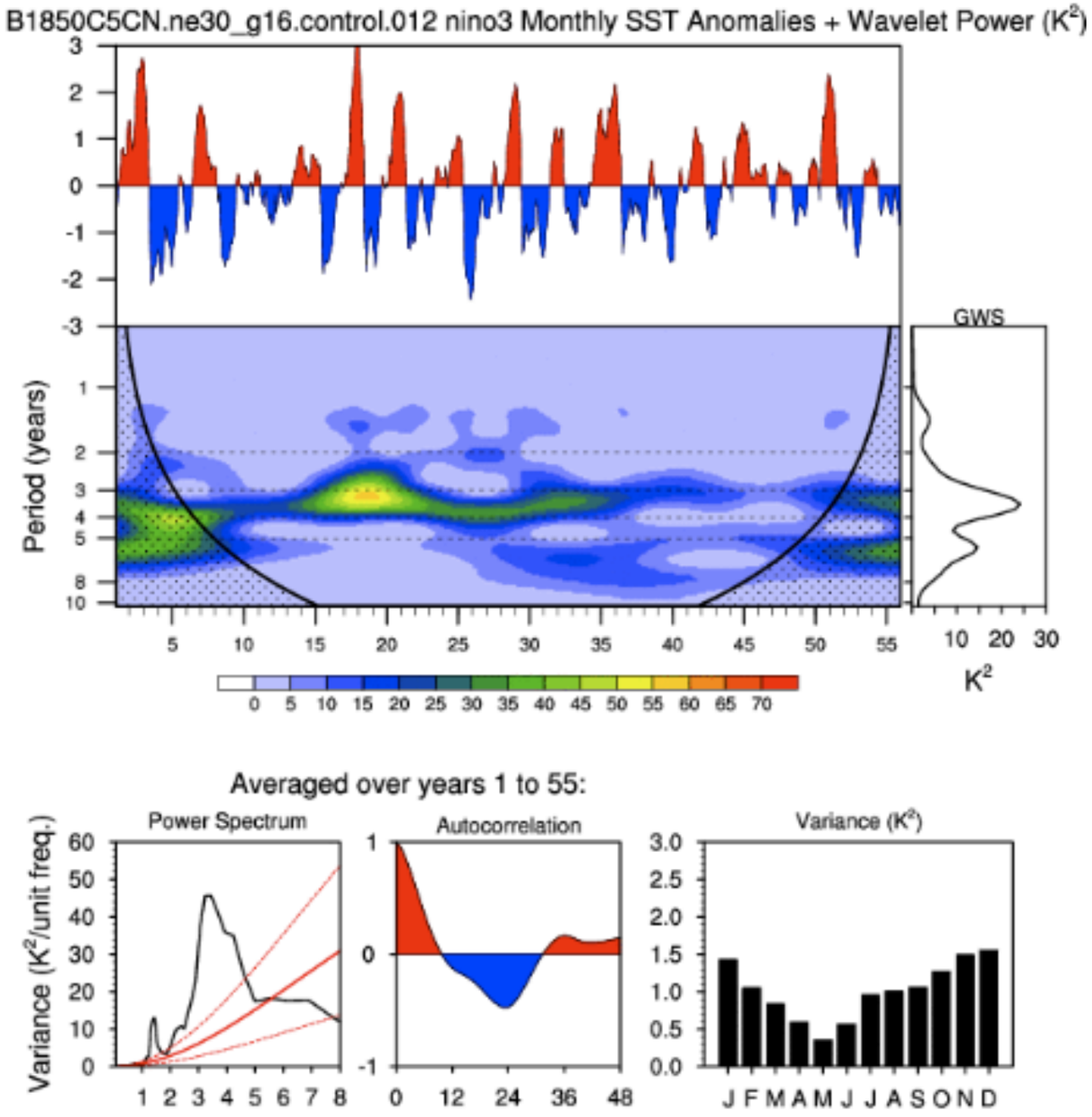
900 m

700 m

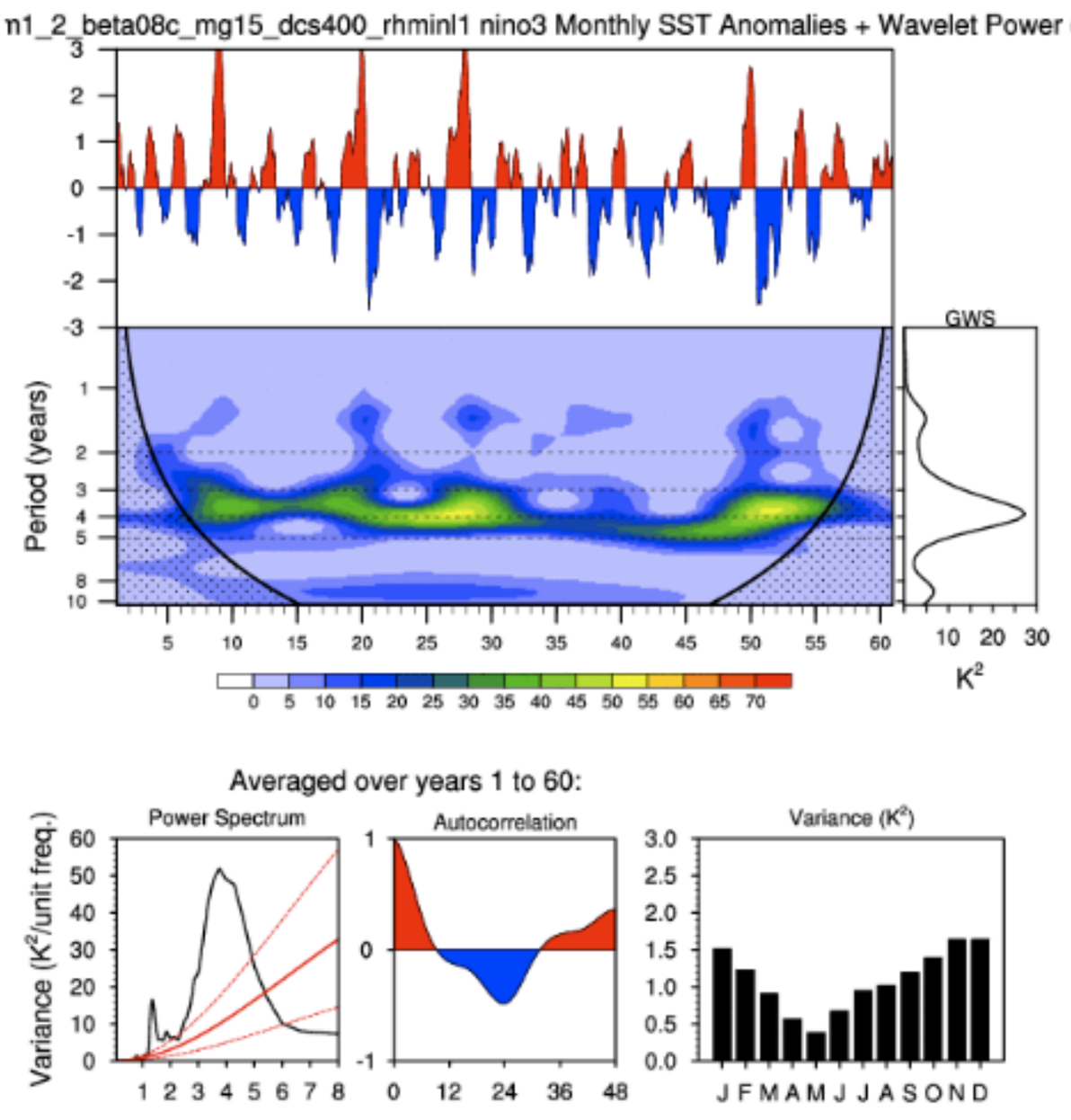


Coupled Run:

30L



60LGW



Reasons to adopt non-oro GWs:

- Clear improvements to UTLS and stratospheric temperatures
- Significant improvements to surface stresses
- Consistency with WACCM
- Responds to changing climate: GWs tied to convection and fronts

Reasons to run with 500 m vertical resolution:

- Consistency with horizontal resolution changes
- Clear improvements to UTLS and stratospheric temperatures
- Representation of QBO
- Representation of SSWs and strat-trop coupling
- Coupling of Tropical and Extra-tropical Dynamics
- 25 km horizontal resolution? does it makes sense to run with 1200m vertical resolution?

  - Better resolution of mesoscale/synoptic scale vertical structure; eg.: gw's, etc
  - influence of QBO on cyclones

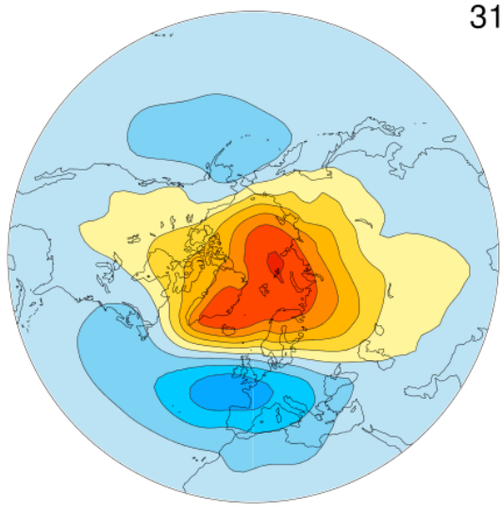
Topics for Discussion:

- Non-orographic GWs: optional or default?
- 500m vertical resolution: optional or default?
- use 30L or 60L for starting point to increase BL resolution?
- use 30km/60L instead of 25km/30L model?

DJF PSL NAM

OBS

31



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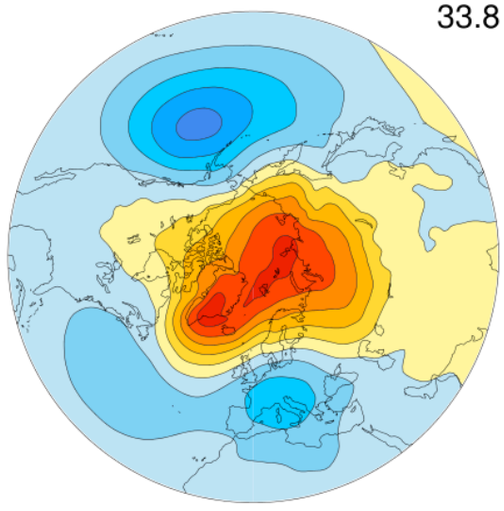

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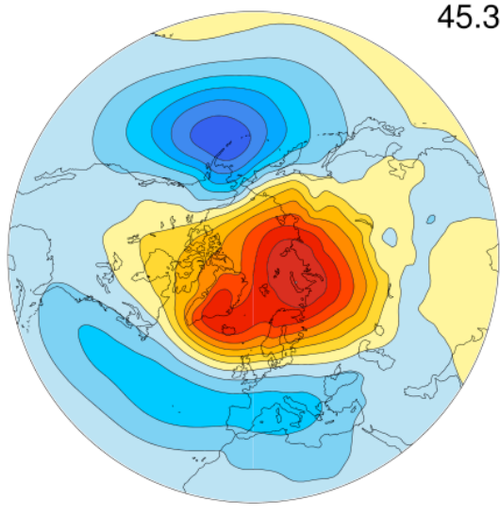
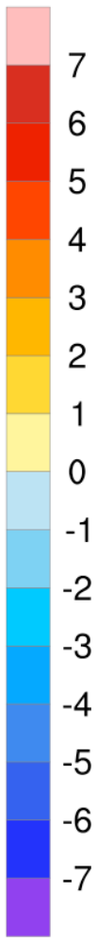
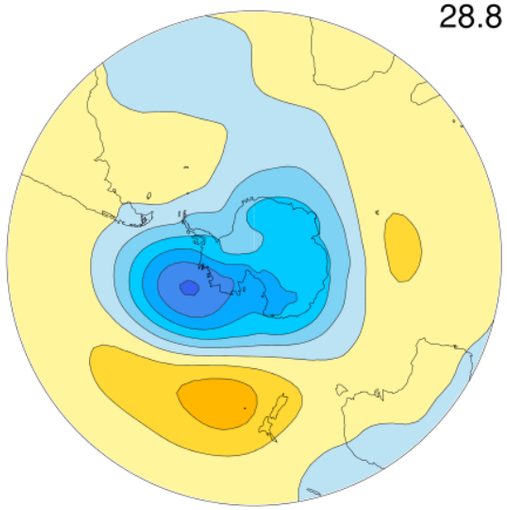




JJA PSL SAM

OBS

28.8



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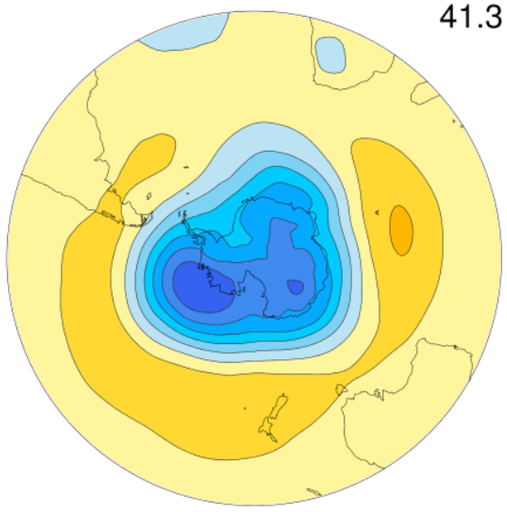

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