



Solar Cycle and QBO effects on planetary wave amplitude from chemistry-climate model simulations and ERA-40 reanalysis data

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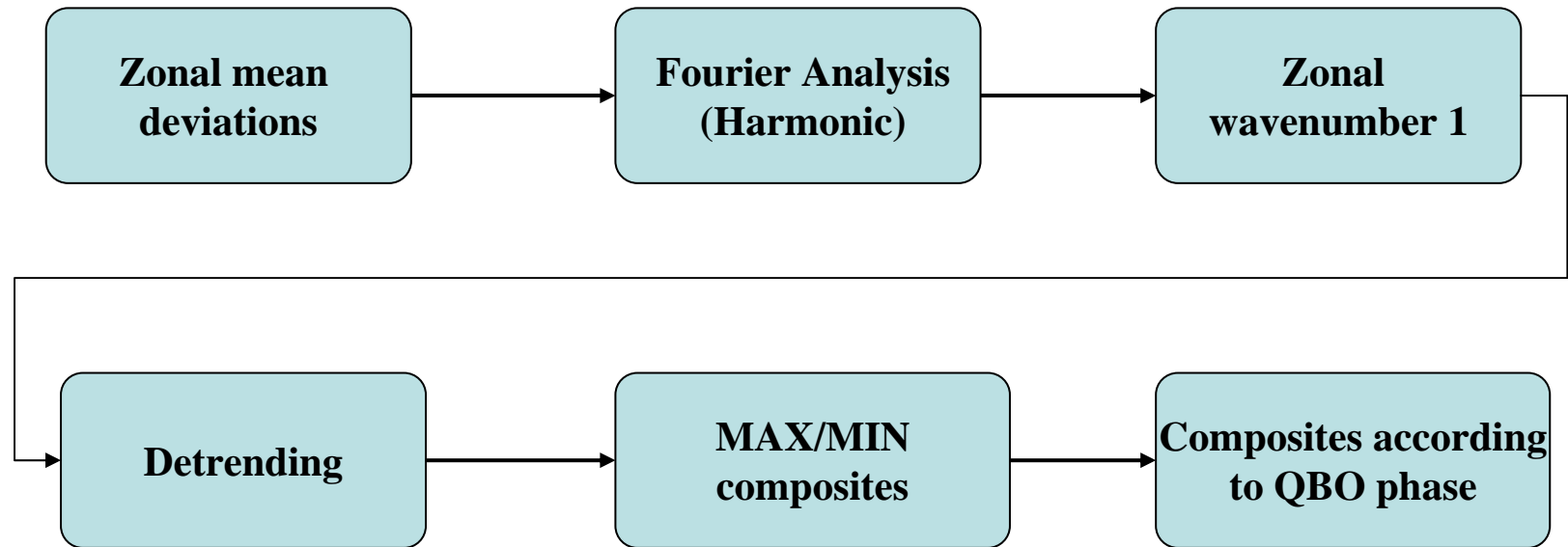
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Calculating the Zonal Wavenumber 1 Amplitude...



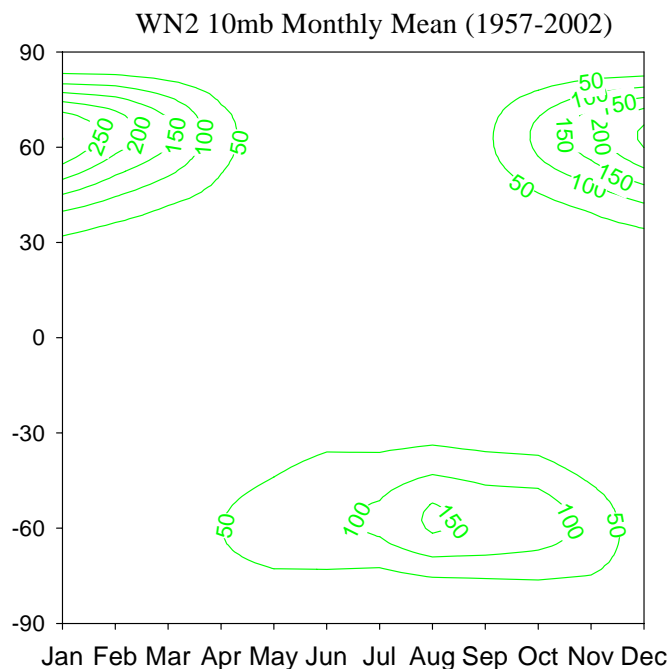
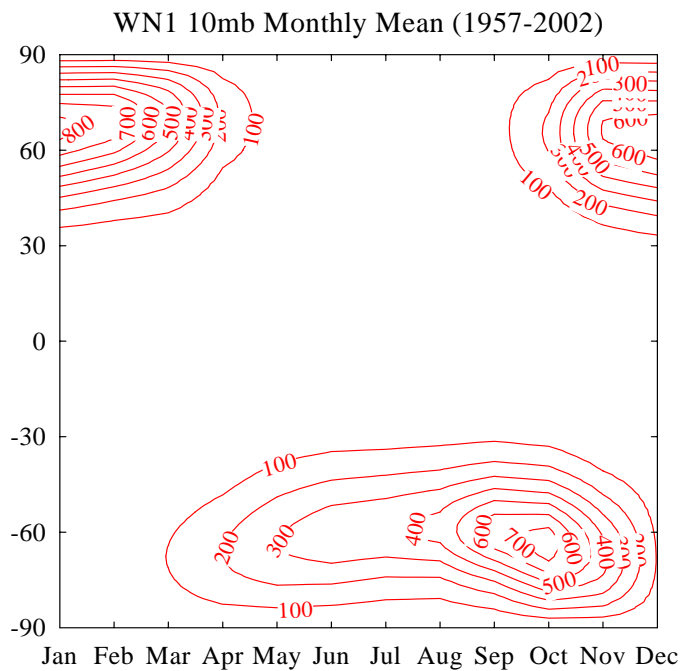


ERA-40 Reanalysis data



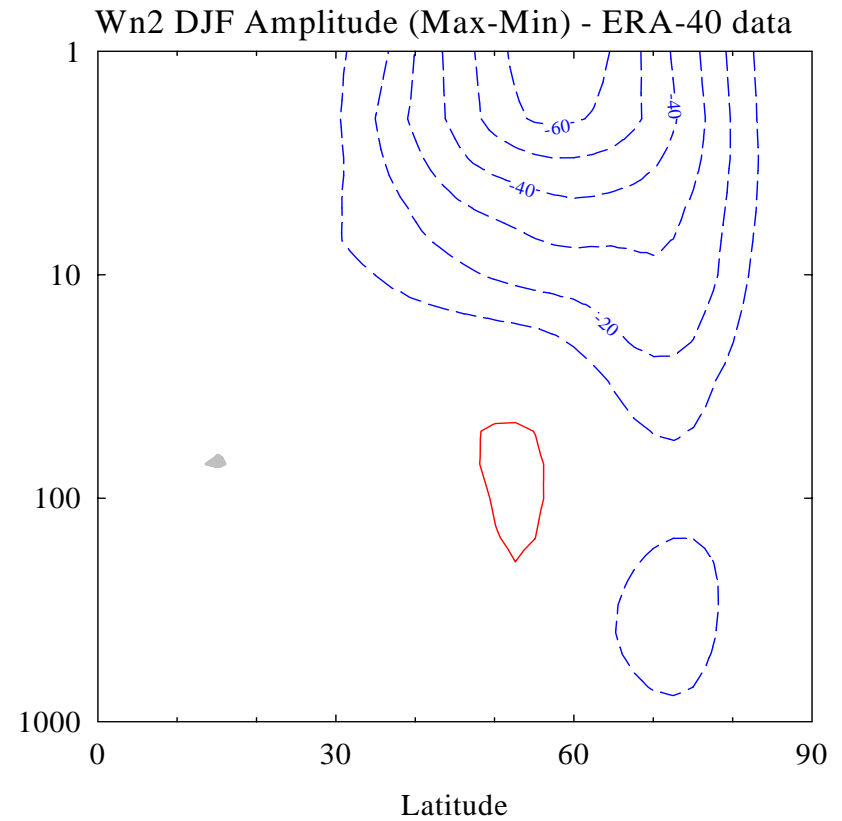
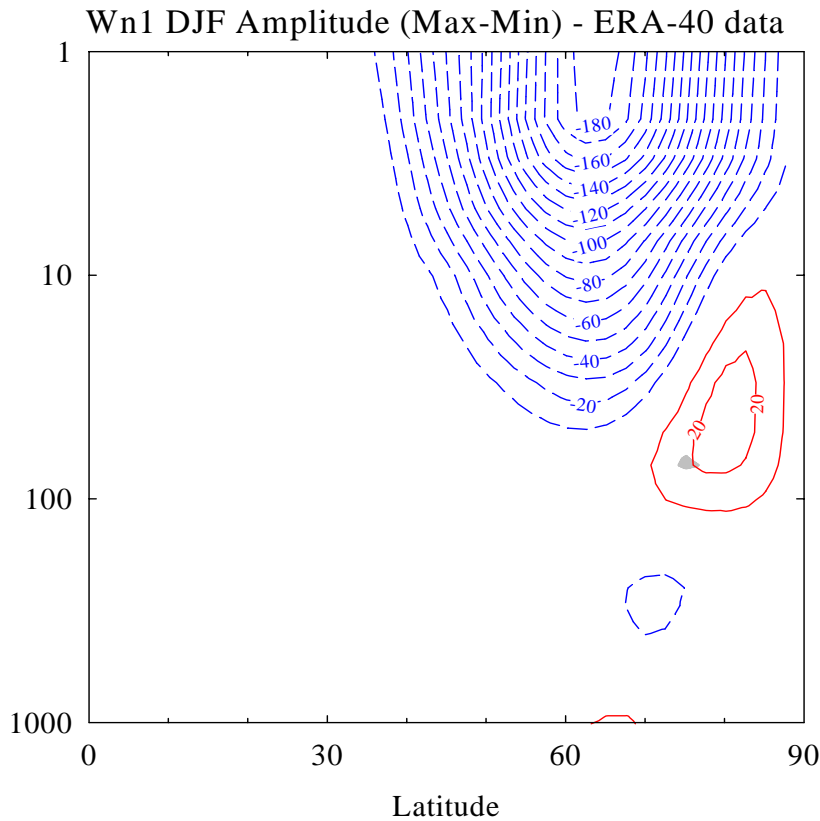
Monthly mean geopotential heights from ERA-40 reanalysis data (up to 1 hPa)

- Four solar cycles (1963-2002)
- 3 consecutive years for each Max/Min period
- Solar Activity index: F10.7 cm radio flux





The solar signal on PW1 and PW2-ERA-40 data



- ✓ Both WN1 and WN2 MAX amplitudes are smaller
- ✓ The results are statistically insignificant

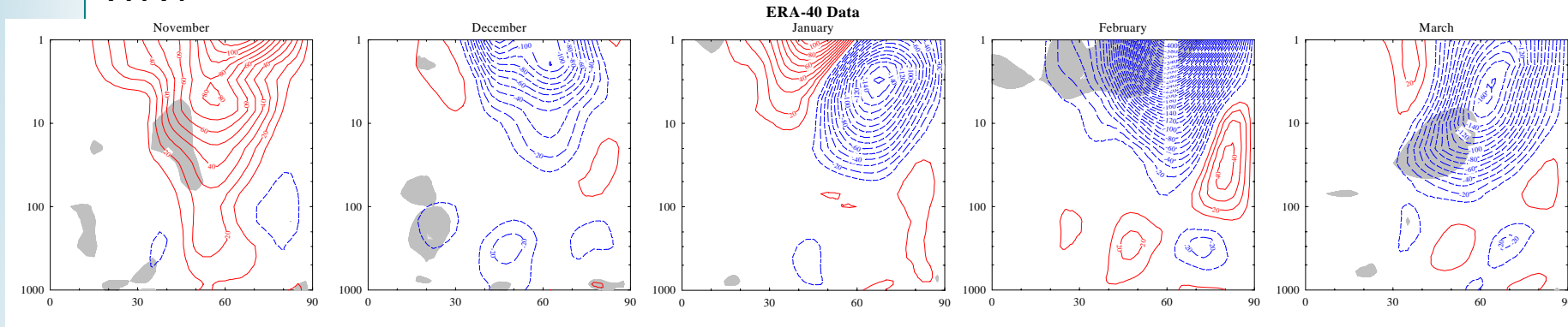




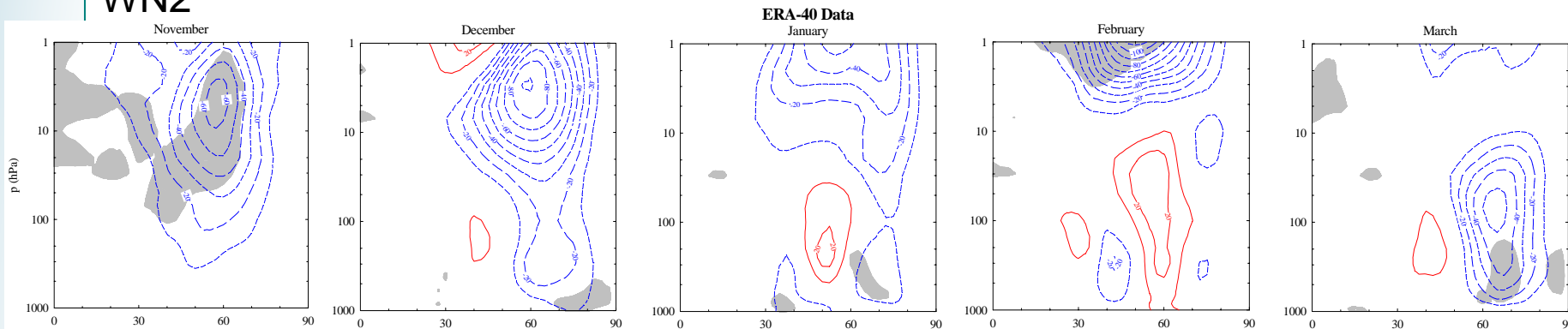
NH winter months-ERA-40 results



WN1



WN2

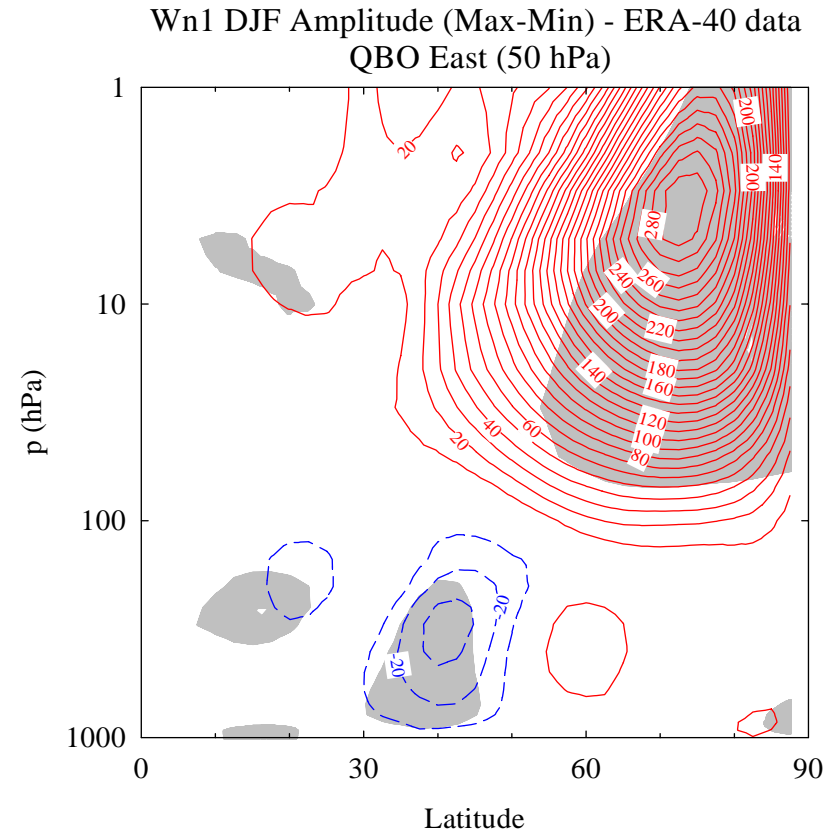
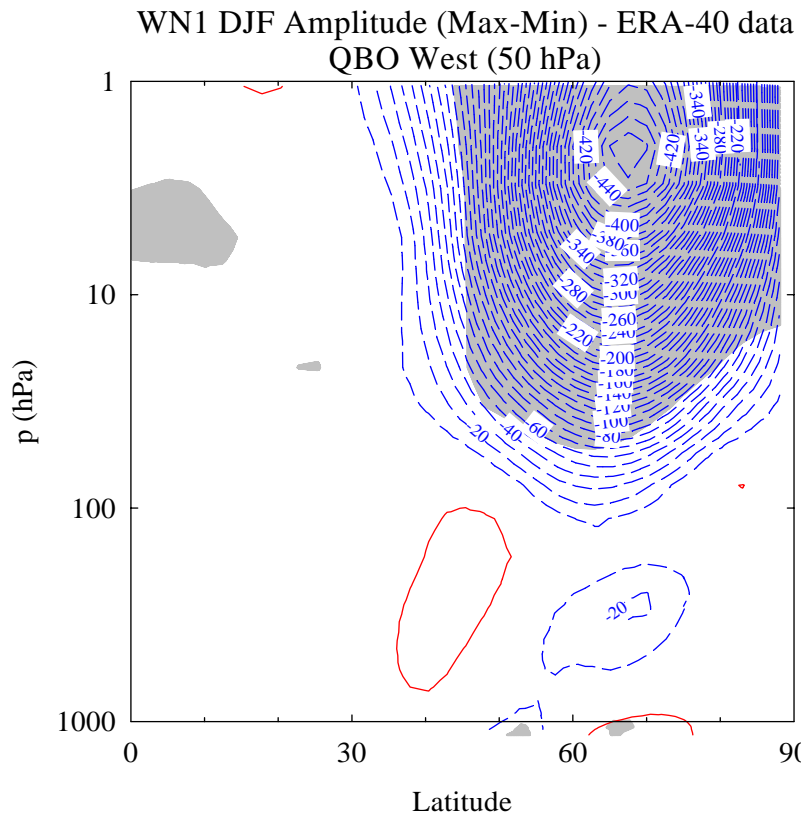


- ✓ The WN1 signal in November is positive and progressively becomes positive and stronger
- ✓ WN1 differences are higher in February(~400 m)
- ✓ Wn2 does not exhibit such alteration and remains positive





The QBO effect on Solar signal – 50 hPa

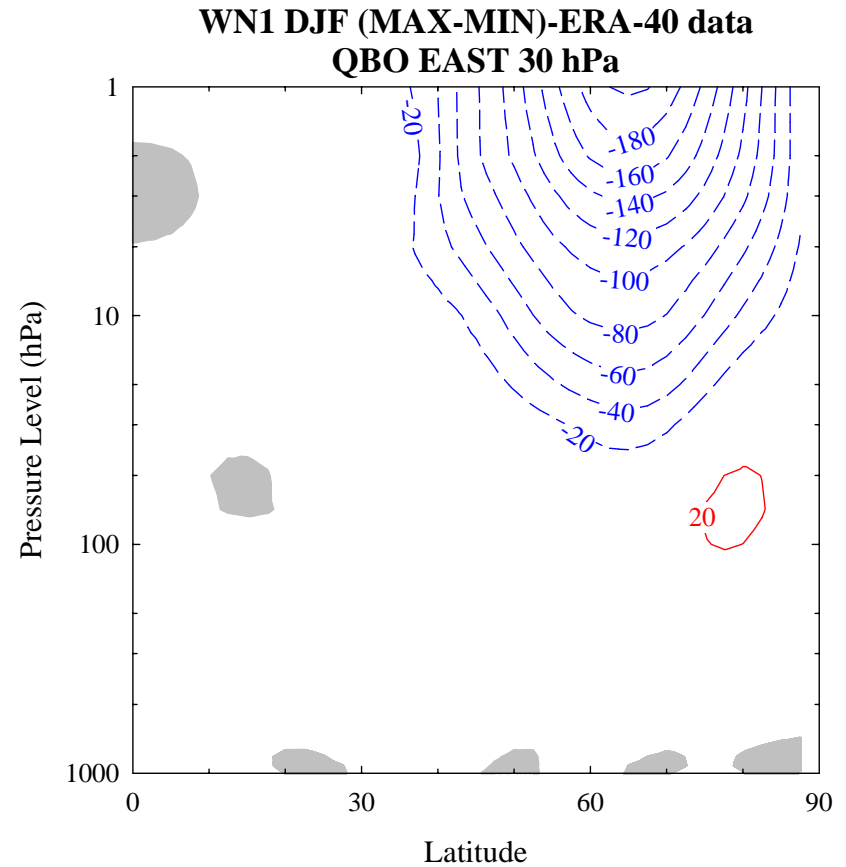
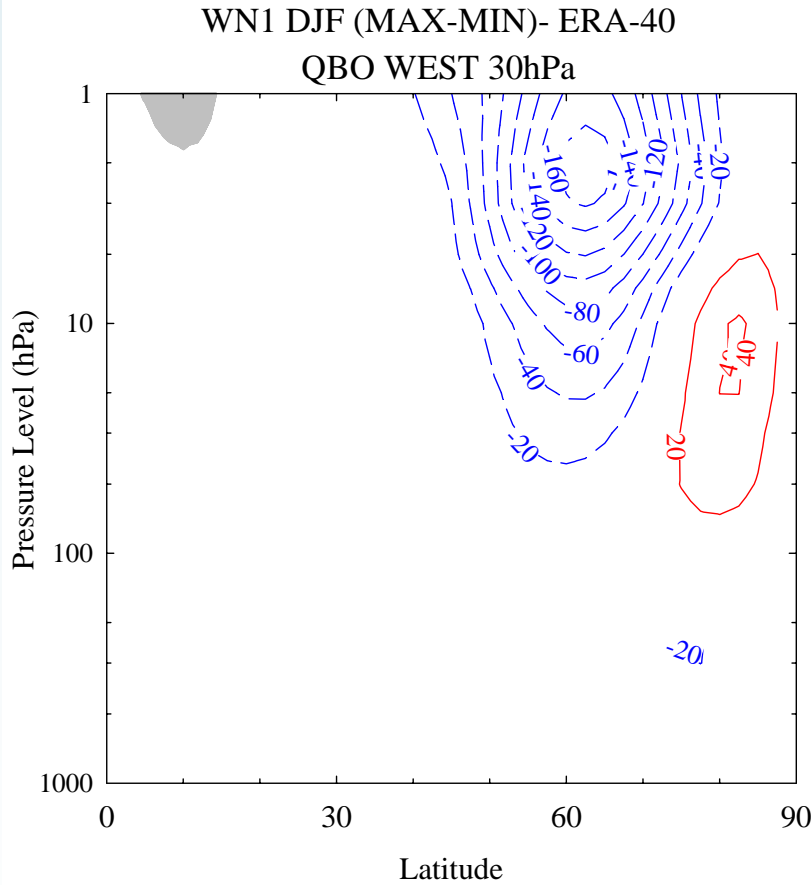


- ✓ The solar signal has opposite sign for west and east phase
- ✓ Differences are statistically significant
- ✓ The differences are higher when months with equatorial winds less than 5 m/s are excluded





The QBO effect on Solar signal – 30 hPa

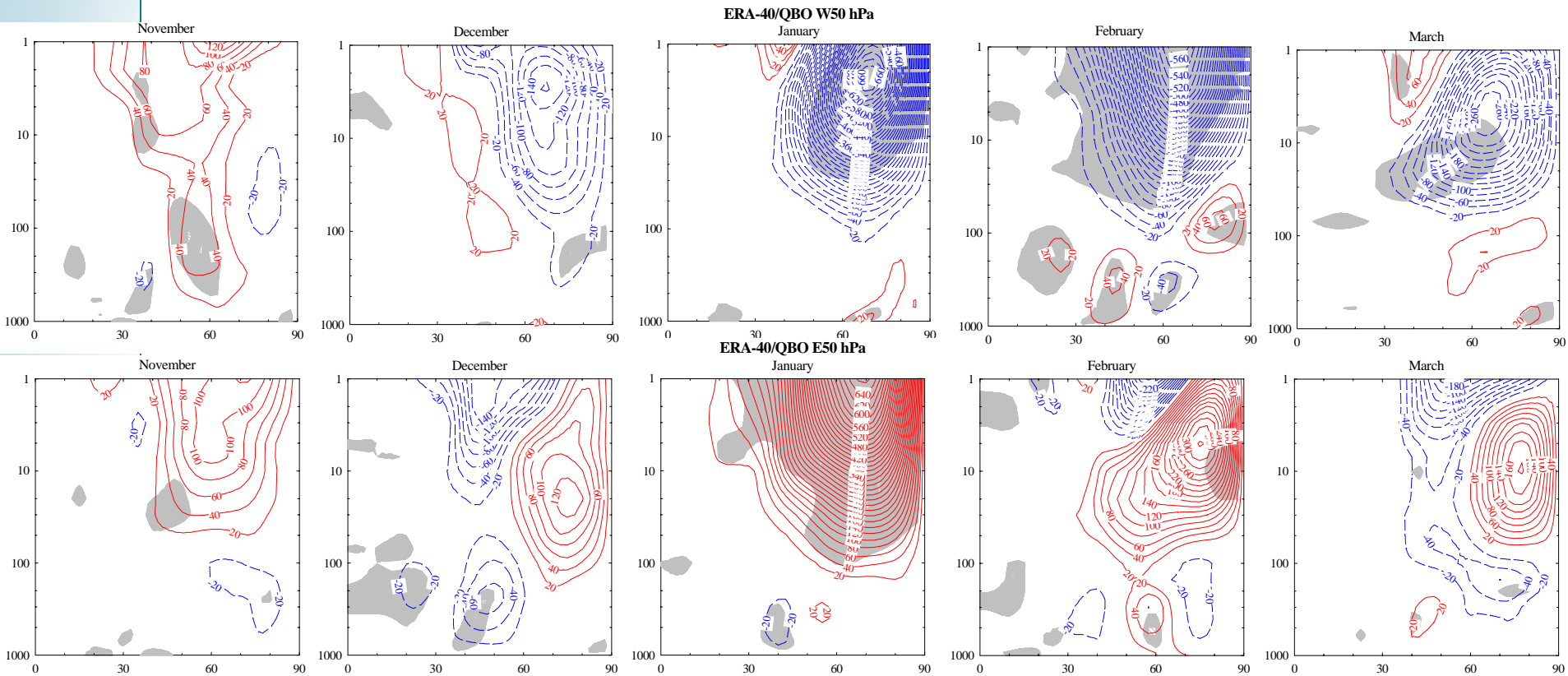


- ✓ No signal reversal detected
- ✓ The results are statistically insignificant





Winter monthly means-QBO effect



- ✓ November shows positives values for both QBO phases
- ✓ Maximum values in January (almost 600 gpm)





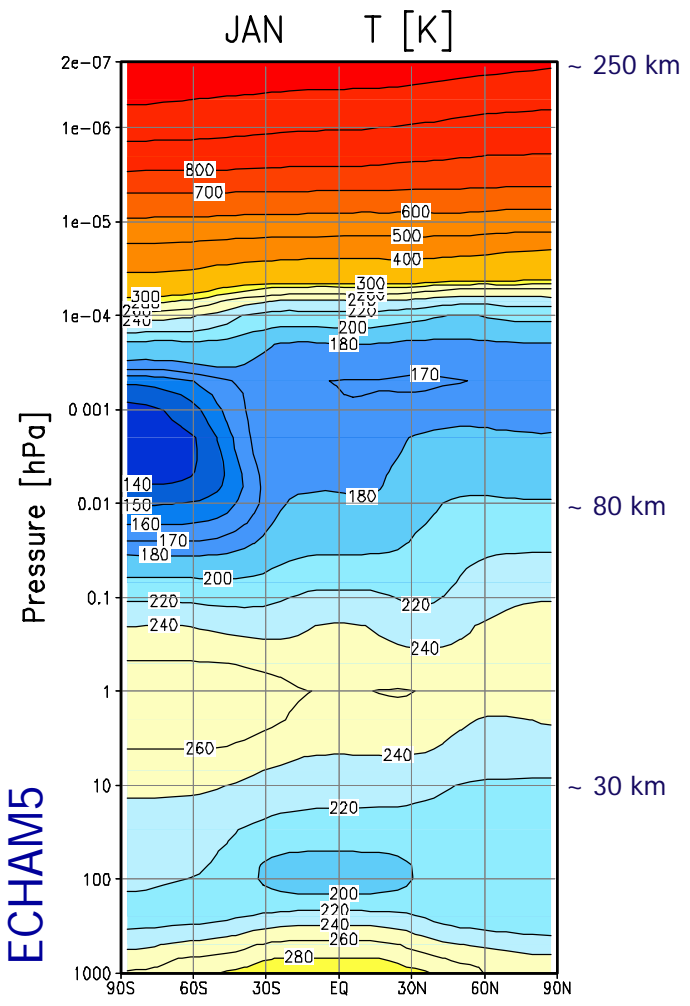
HAMMONIA – Hamburg Model of the Neutral and Ionized Atmosphere



HAMMONIA

MAECHAM5

ECHAM5



Solar Heating (near UV, vis. & near IR)

Solar Heating (SRB&C, Ly-a, EUV)

IR Cooling

IR Cooling (non-LTE)

Chemical heating

Surface Fluxes

Clouds & Convection

Turbulent Diffusion

Gravity Wave Drag

Molecular Processes

Ion Drag

Neutral (and Ion) Chemistry (MOZART3)

Schmidt et al., (2006) J. Climate
Giorgetta et al., (2006) J. Climate





Monthly mean geopotential heights from the T31 L119 layer version (up to 250 km)

35-year time slice experiments for solar max, solar min,

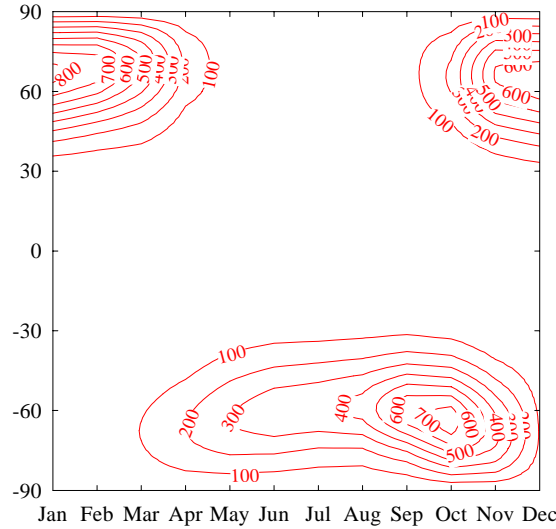
- GHG conditions according to the 1990s
- SSTs fixed to climatological values
- irradiance depending on wavelength (1nm resolution) from Lean et al. (JGR, 1997)
- solar minimum (September 1986)
- solar maximum (November 1989)



Climatology Comparison

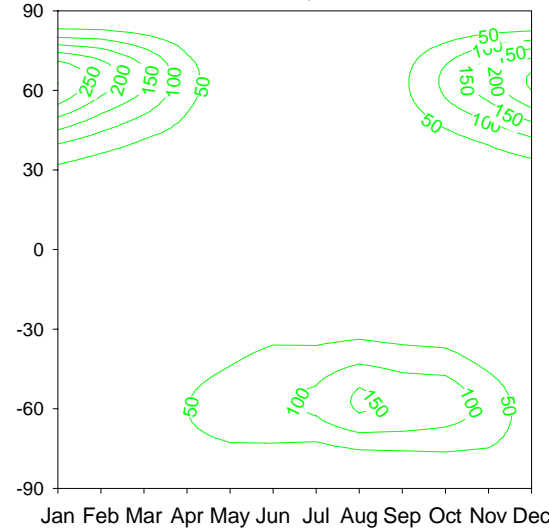


WN1 10mb Monthly Mean (1957-2002)



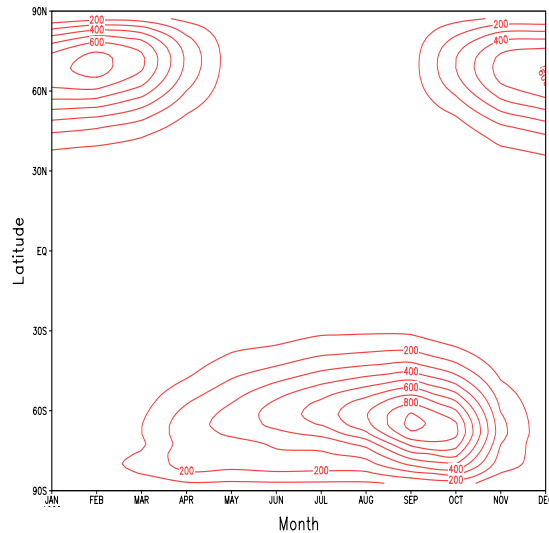
WN1

WN2 10mb Monthly Mean (1957-2002)

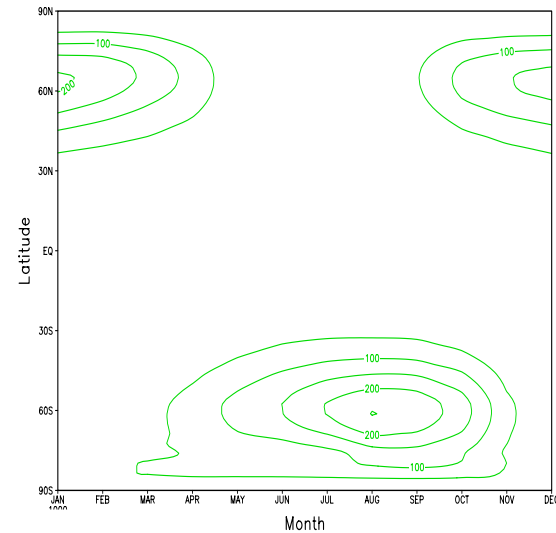


WN2

WN1 at 10hPa-HAMMONIA



WN2 at 10hPa-HAMMONIA



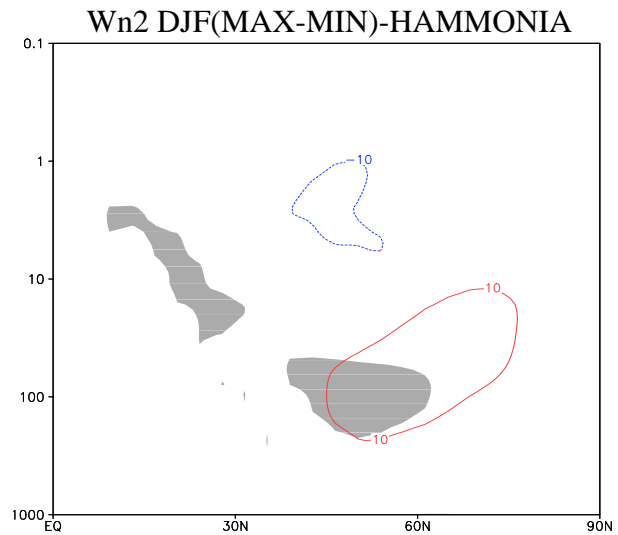
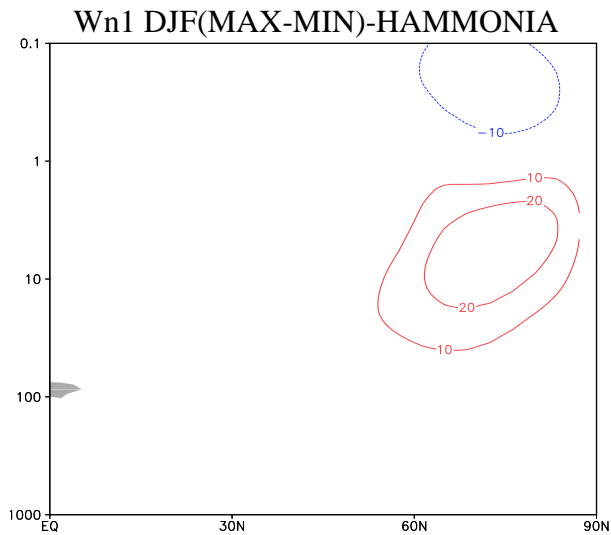
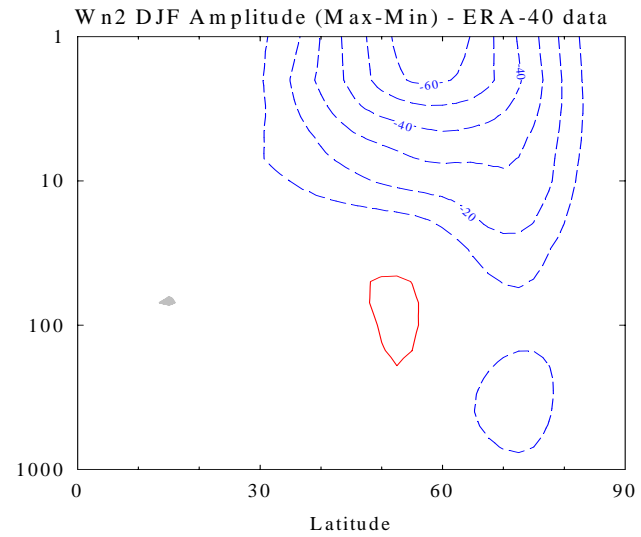
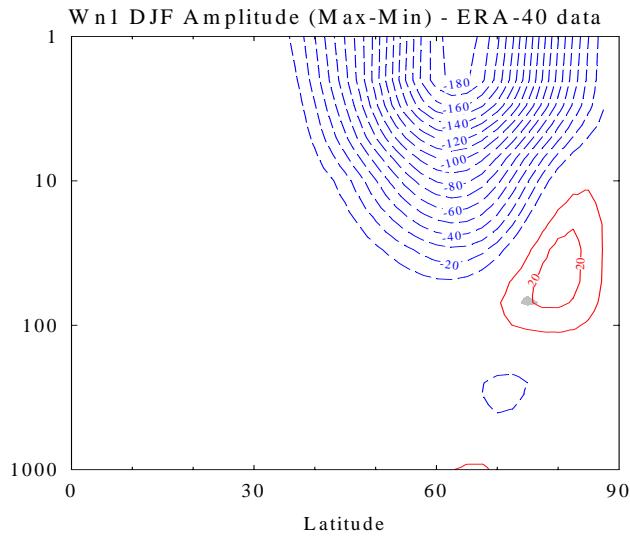
✓ The maximum values are delayed almost 1 month in NH and precede 1 month in SH.

✓ Our model generates higher amplitudes in SH.



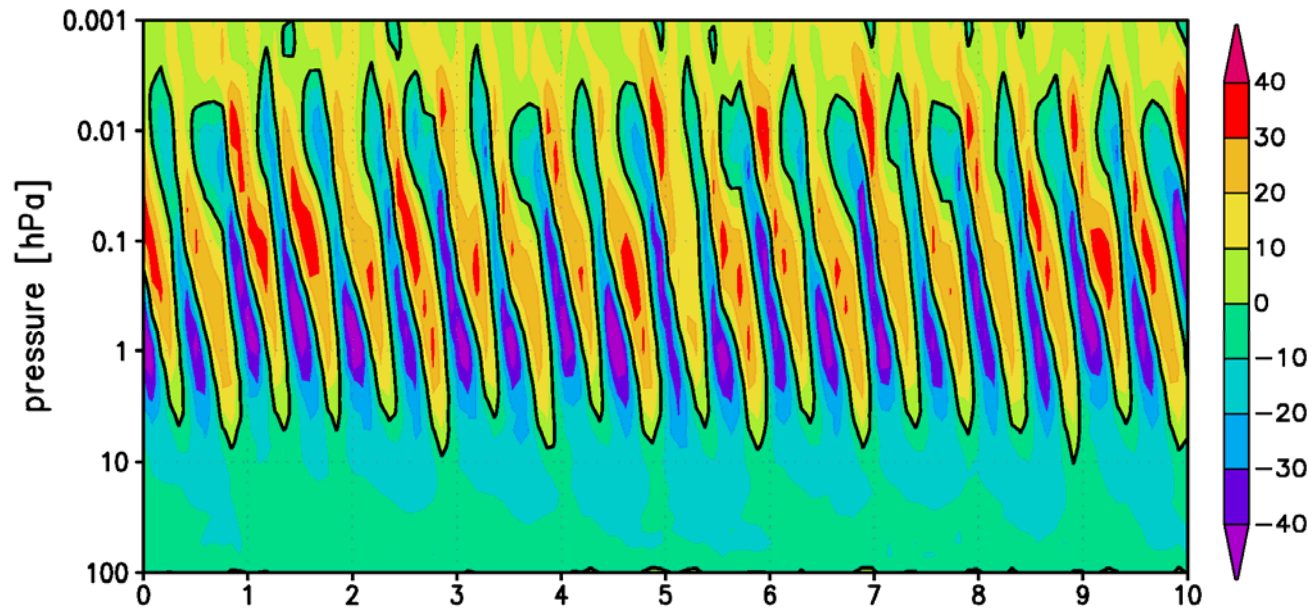


The solar signal on PW1 and PW2-HAMMONIA

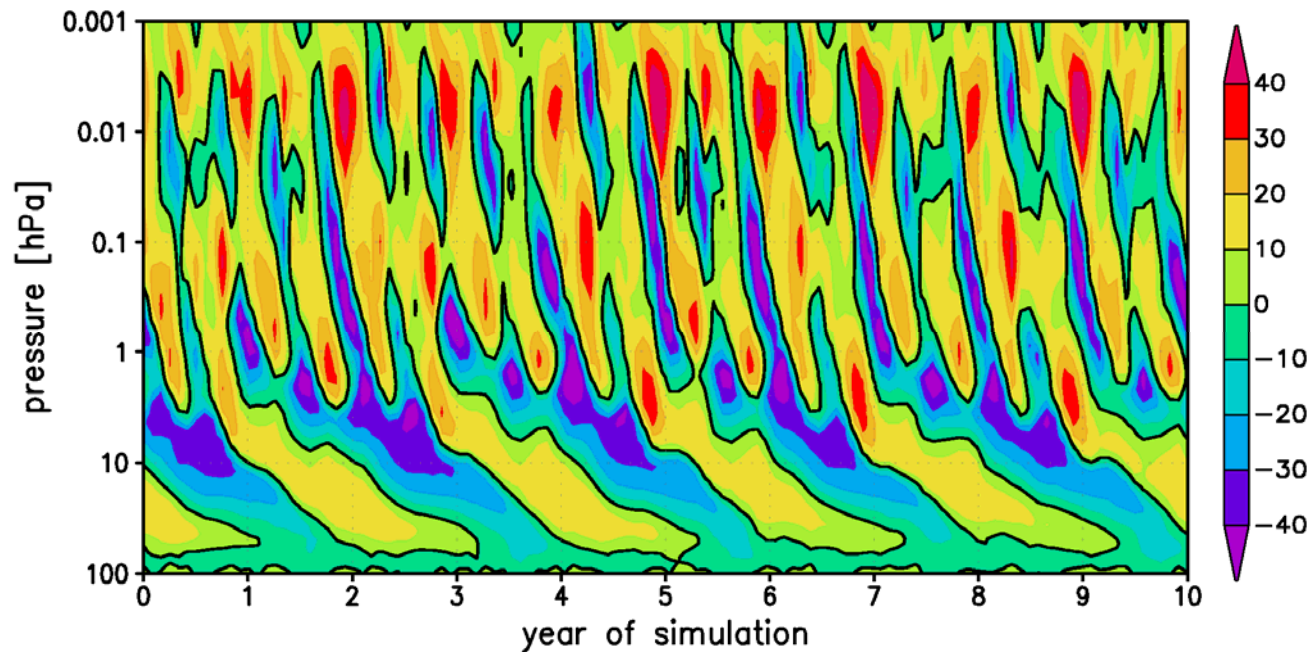




Equatorial zonal wind (m/s) in model versions of different vertical resolution



67 layers
strat. resolution:
~ 2000 m

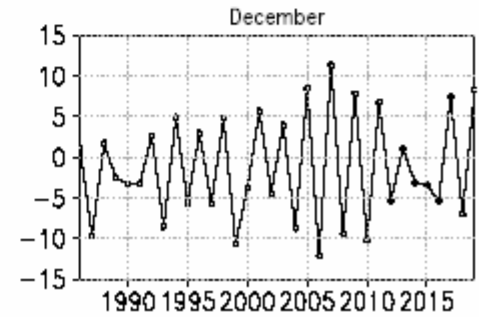
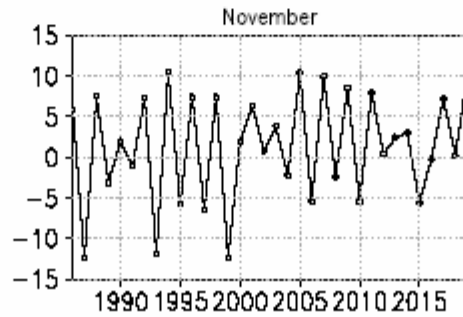
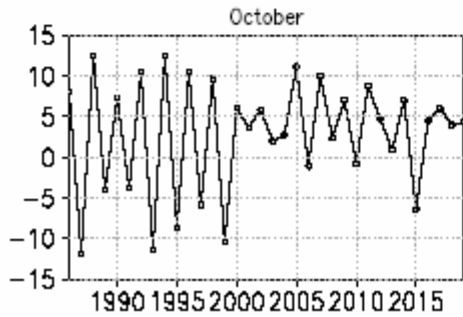
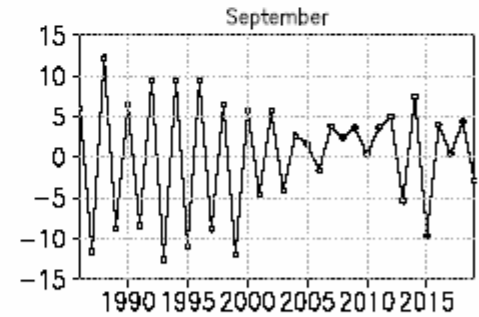
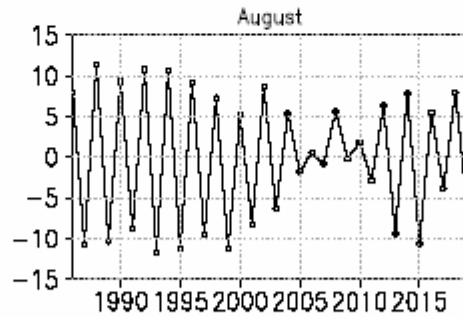
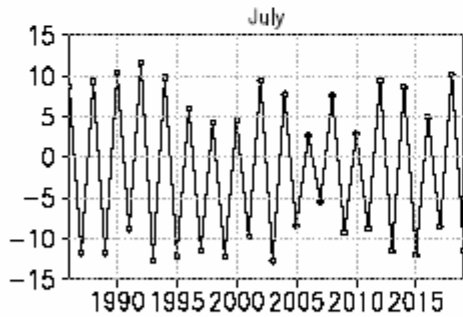
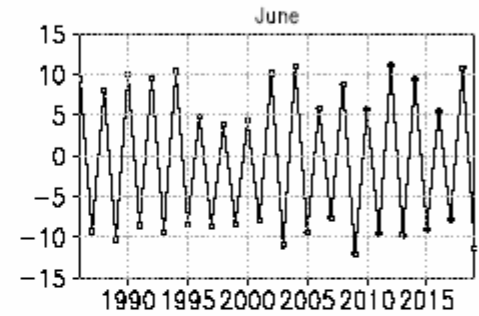
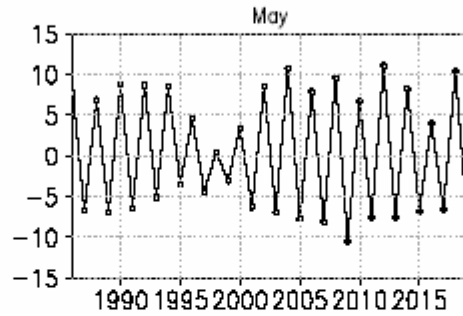
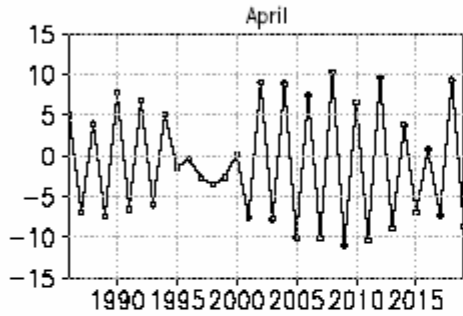
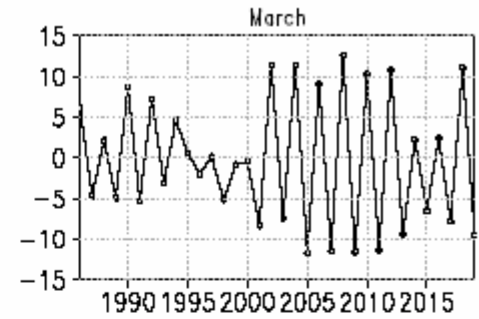
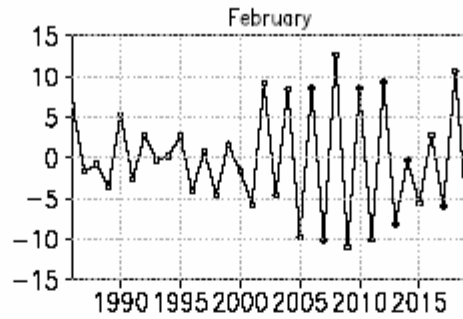
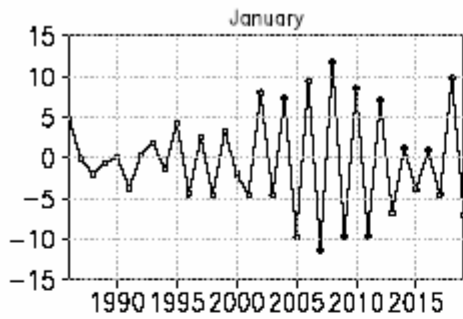


119 layers
strat. resolution:
~ 800 m





Monthly Time Series of Equatorial Wind at 50 hPa-MAX

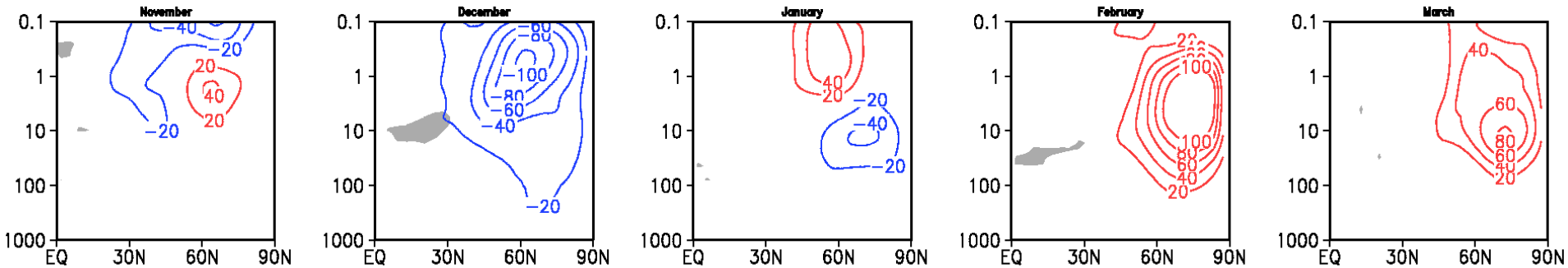




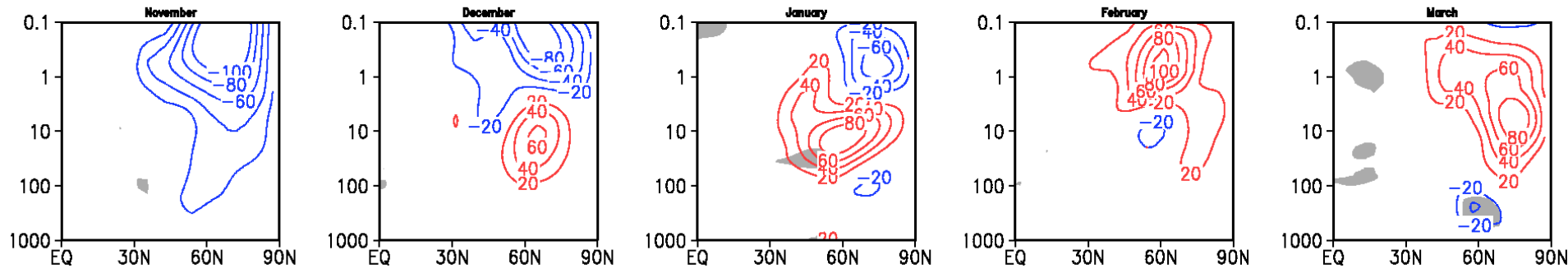
The QBO influence on Solar Signal- HAMMONIA



WN1(MAX-MIN)-QBOw50



WN1(MAX-MIN)-QBOe50



✓ HAMMONIA does not demonstrate a solar signal alteration in NH winter months.

✓ The results are insignificant





Conclusions (1)



- The planetary wave 1 amplitudes are higher during the solar minima, but the statistical significance is small
- The signal is not clear for PW2
- When data are separated according to equatorial winds at 50 hPa the sign of MAX-MIN signal has opposite sign for west and east phase. Results are significant.
- Such a reversal is not apparent for equatorial winds at 30 hPa.
- HAMMONIA can reproduce the seasonal cycle of WN1 and WN2 amplitudes, although it generates slightly higher amplitudes in SH.
- The response of planetary waves to 11-year solar cycle is weaker in HAMMONIA compared to ERA-40 reanalysis and remains insignificant for all winter months.





- Equatorial winds in HAMMONIA have realistic values but their period is strongly locked to 24 months and possibly for this reason a modulation of the solar signal by the QBO is not apparent during winter months.
- There is a dependence of the solar signal on the QBO, but in other months
- Simulations reproduce lower stratospheric equatorial warming and O3 maximum (Schmidt et al., 2006)



Future work:

- Investigate in details the differences of zonal wind, zonal wind shear and buoyancy frequency which determine the vertical propagation of PW
- Perform transient simulations
- Hammonia will be coupled with the MPI-OM ocean model

