Seasonal dependence of low frequency variability in an idealised GCM

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Motivation

Planetary-Scale Baroclinic Instability and MJO, Straus and Lindzen (observations)

Intrasesaonal Variability in Dry Atmospheric Model, Lin, Brunet and Derome (model)

Abstract 1

relationship between eastward propagating planetary waves of zonal wavenumber in the zonal wind (u) with phase speeds (1-10 m/s), frequencies (30-60 days) in extratropics and low frequency waves in tropics (associated with MJO)

eastward propagating waves M=1 have strong maxima at 200hPa in the tropics (13 S 13 N);the standing wave variance is maximum in N midlatitudes; similar properties with M=2

for a base point (32 N, 200hPa) -coherence for phase speeds (1-10 m/s) with upper levels (tropics 13 N, 180 degrees relative phase shift)

strong cross-equatorial coherence between fluctuations at 13 N and 13 S

coherence(subtropics 32 N-tropics 13 N)indicates a potential dynamical instability(MJO organization)

conection between planetary wave baroclinic instability and MJO variance

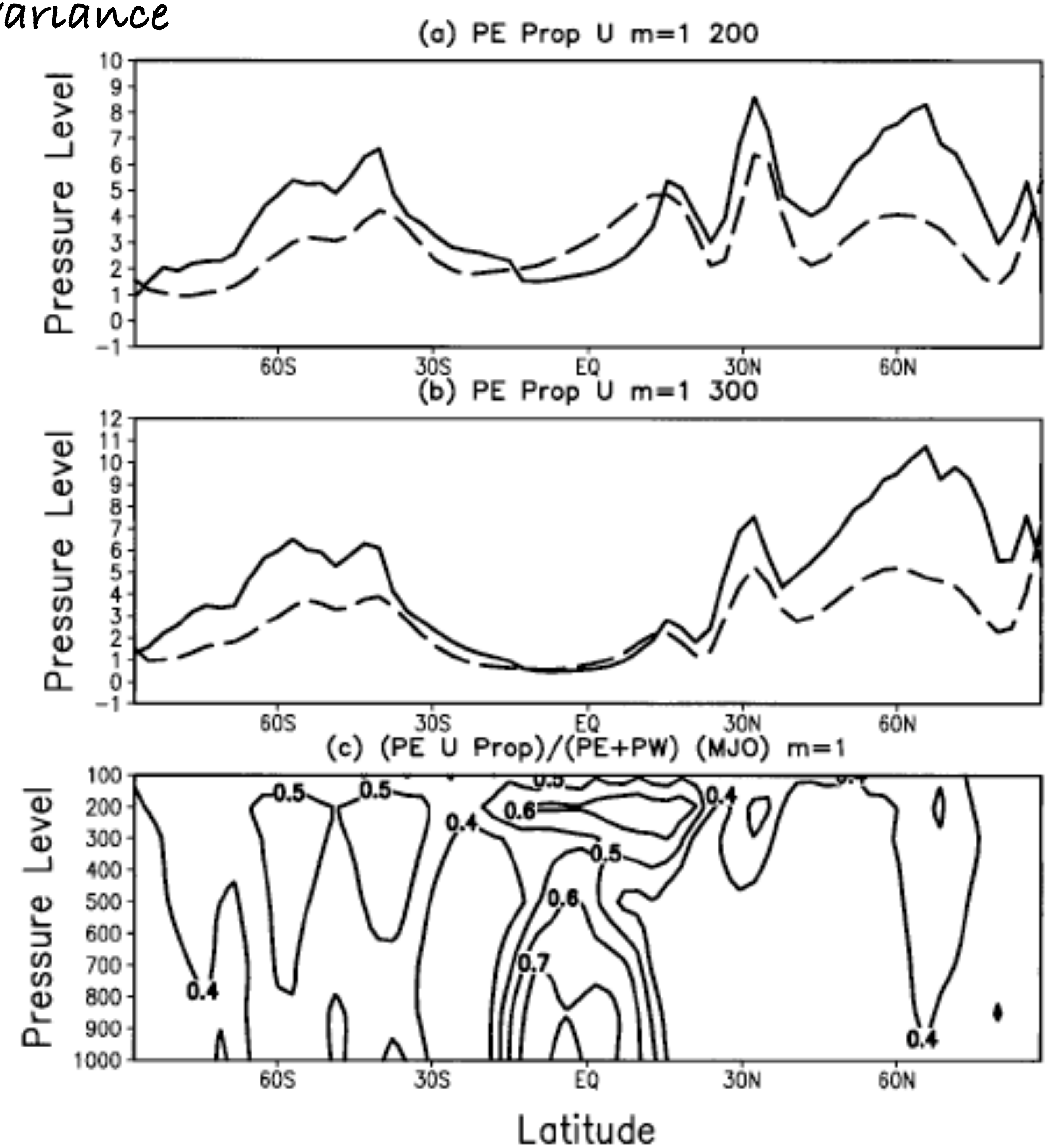
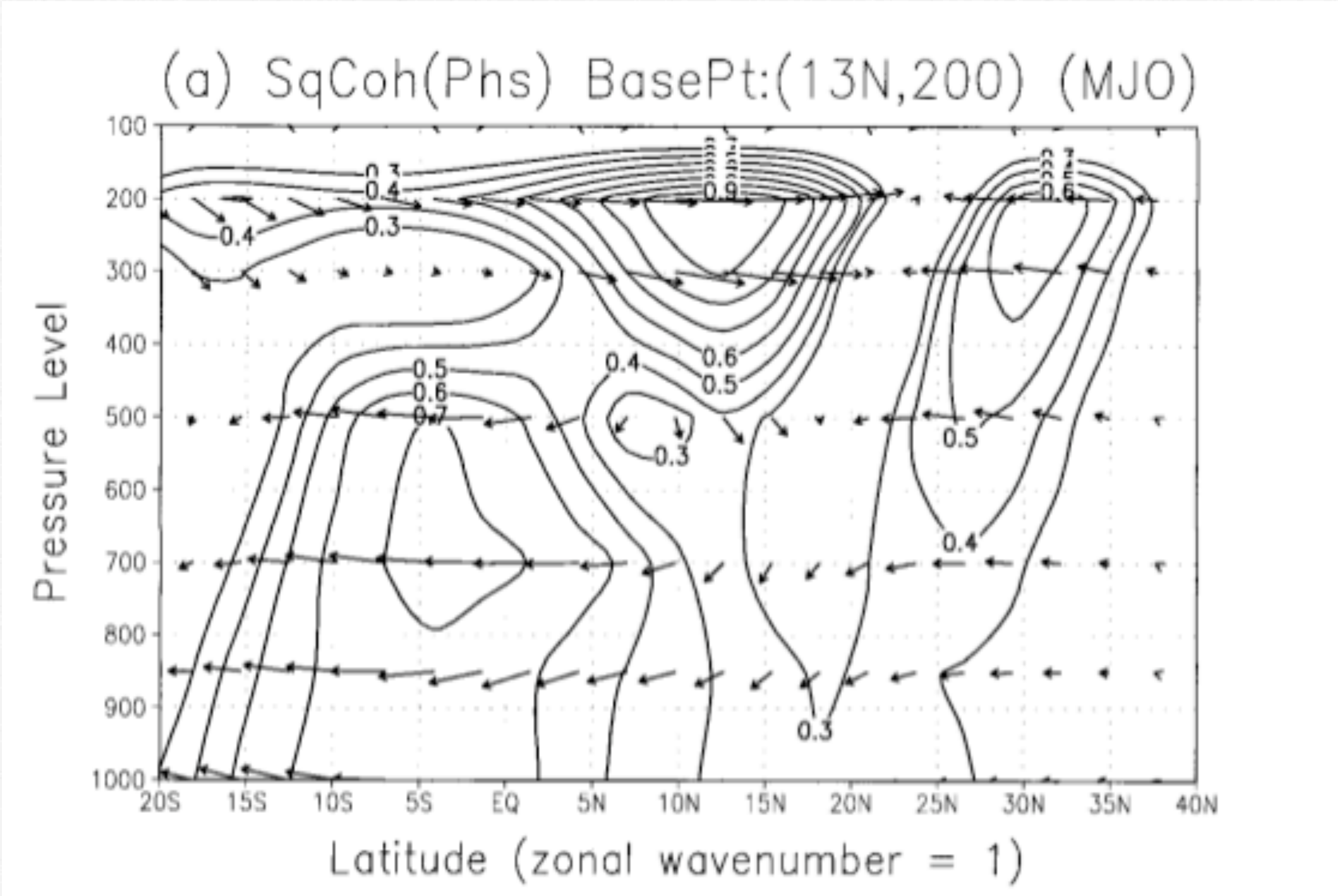


FIG. 5. (a) Eastward propagating wave variance PE+ at 200 hPa for zonal wavenumber m = 1, summed over frequencies that correspond to phase speeds 1–10 m s⁻¹ (solid line), and summed over MJO frequencies (corresponding to periods of 30–60 days, dashed line). (b) Same as in (a) but for 300 hPa. (c) Normalized eastward propagating wave variance, PE+/(PE + PW), where each term is summed over MJO frequencies.



base point (13 N, 200hPa)

Abstract 2

lot of tehniques are used to define tropical waves (time filtering, space-time spectral analysis)

model of tropical atmosphere (oscillations with intraseasonal time scales and Kelvin waves)

oscillation (coherent eastward propagation in the 250 hPa velocity potential) is stronger in E hemisphere than in W hemisphere

interactions between tropics and extratropics flows-responsible for simulated intraseasonal variability

analysis reveals-tropical influence occurs in Northern Pacific

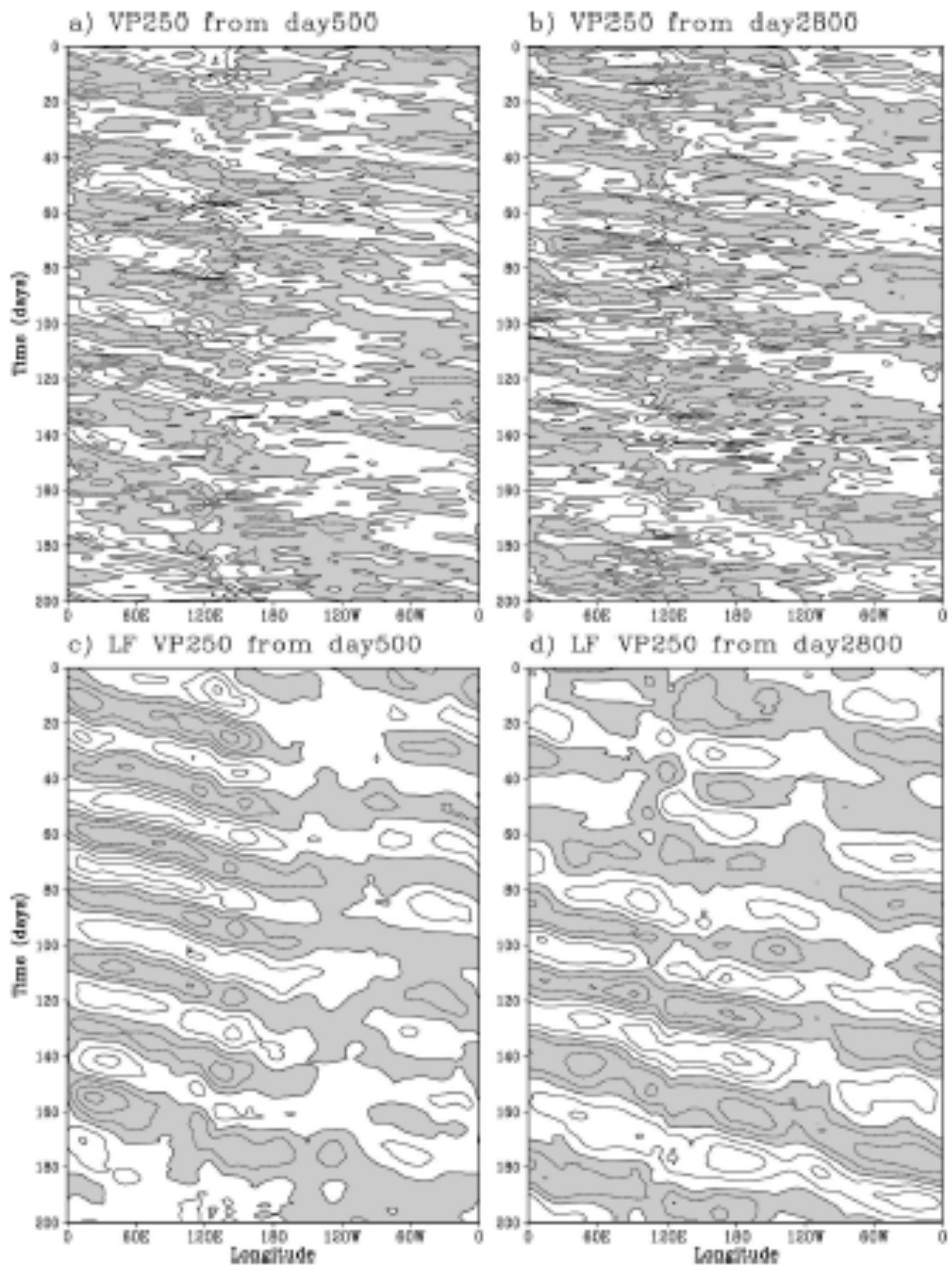


FIG. 3. Time–longitude diagram of 250-hPa velocity potential averaged between 10°S and 10°N for (a) unfiltered data starting from day 500, (b) unfiltered data starting from day 2800, (c) 20–100-day band filtered data starting from day 500, and (d) 20–100-day band filtered data starting from day 2800. The CI is 3×10^6 m^2 s^{-1} in (a) and (b), and 1.5×10^6 m^2 s^{-1} in (c) and (d). Negative values are shaded.

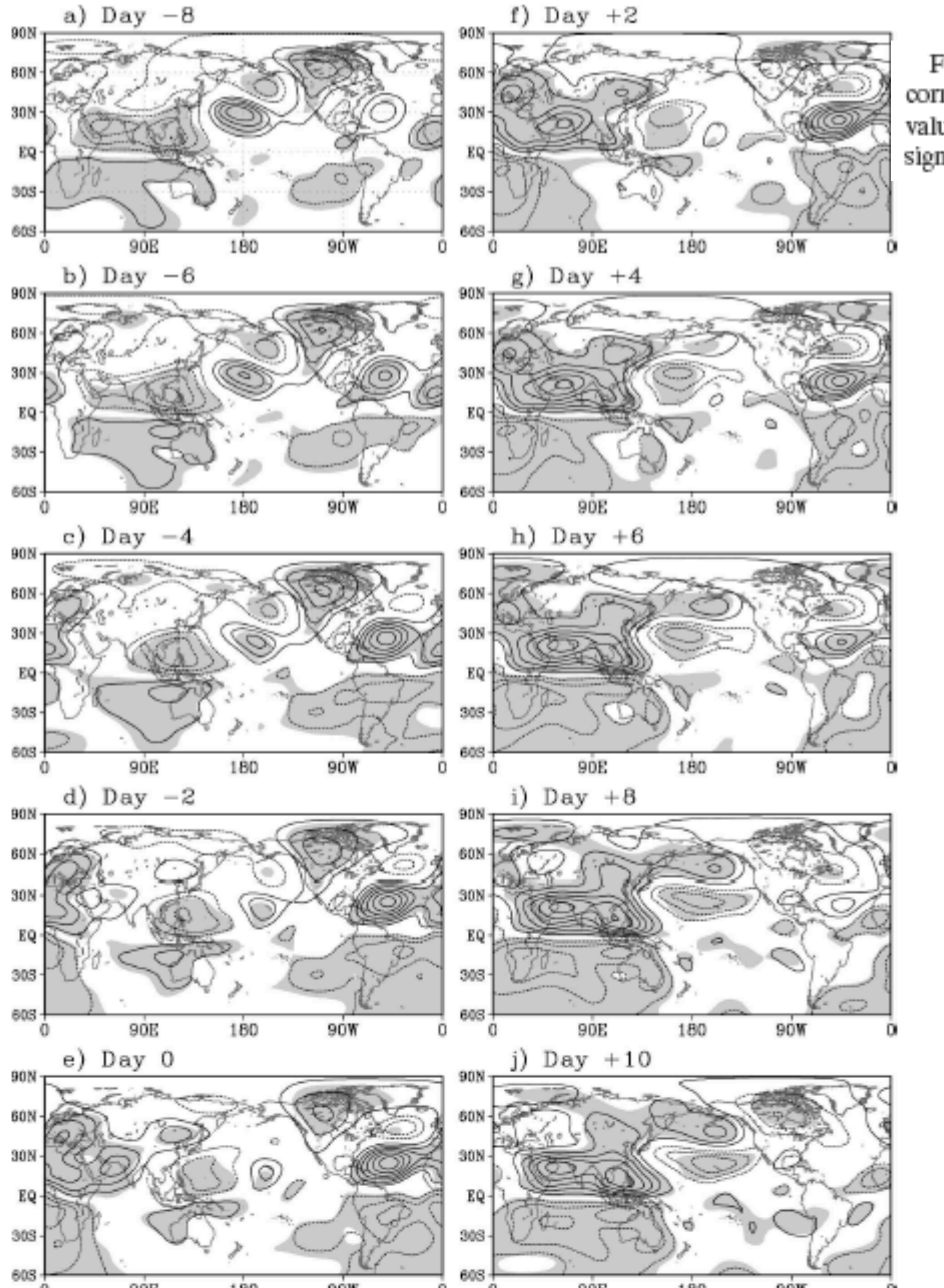


FIG. 10. Lag regression of 250-hPa streamfunction with the TIV index. The amplitude corresponds to one std dev of the TIV index. The CI is 4×10^5 m^2 s^{-1}. Contours with negative values are dashed. The zero line is omitted. The shaded areas represent regressions with a significant level of 0.05 according to a two-tailed Student's t test.

Lag regression on index (based on EOF-spatial patern that represents tropical variability)

Idea

look at interactions between latitudes on different timescales and spatial scales

Timeseries of Fourier coefficients of stream function and velocity potential which describe different wavenumbers in the longitude direction for each latitude (zero coefficient-zonal mean)

48 complex coefficients

48 latitudes (24 in each hemisphere)

each file- 10800 records, once per day for a period of 30 years (360 days)

find amplitude, phase speed (phase, phase differences)

Why stream function(psi) and velocity potential(chi)?

midlatitudes: geostrophical balance
horizontal motion
rotational motion; stream function

tropics: vertical divergent motion; velocity potential

explicit transients: a simple GCM

Let's reconsider the definition of our forcing function *g*.
Recall the development equations:

data

$$\frac{d\Phi}{dt} = L\Phi + \Phi^{\dagger} Q\Phi + f(t)$$

model

$$\frac{d\Psi}{dt} = L\Psi + \Psi^{\dagger} Q\Psi + g$$

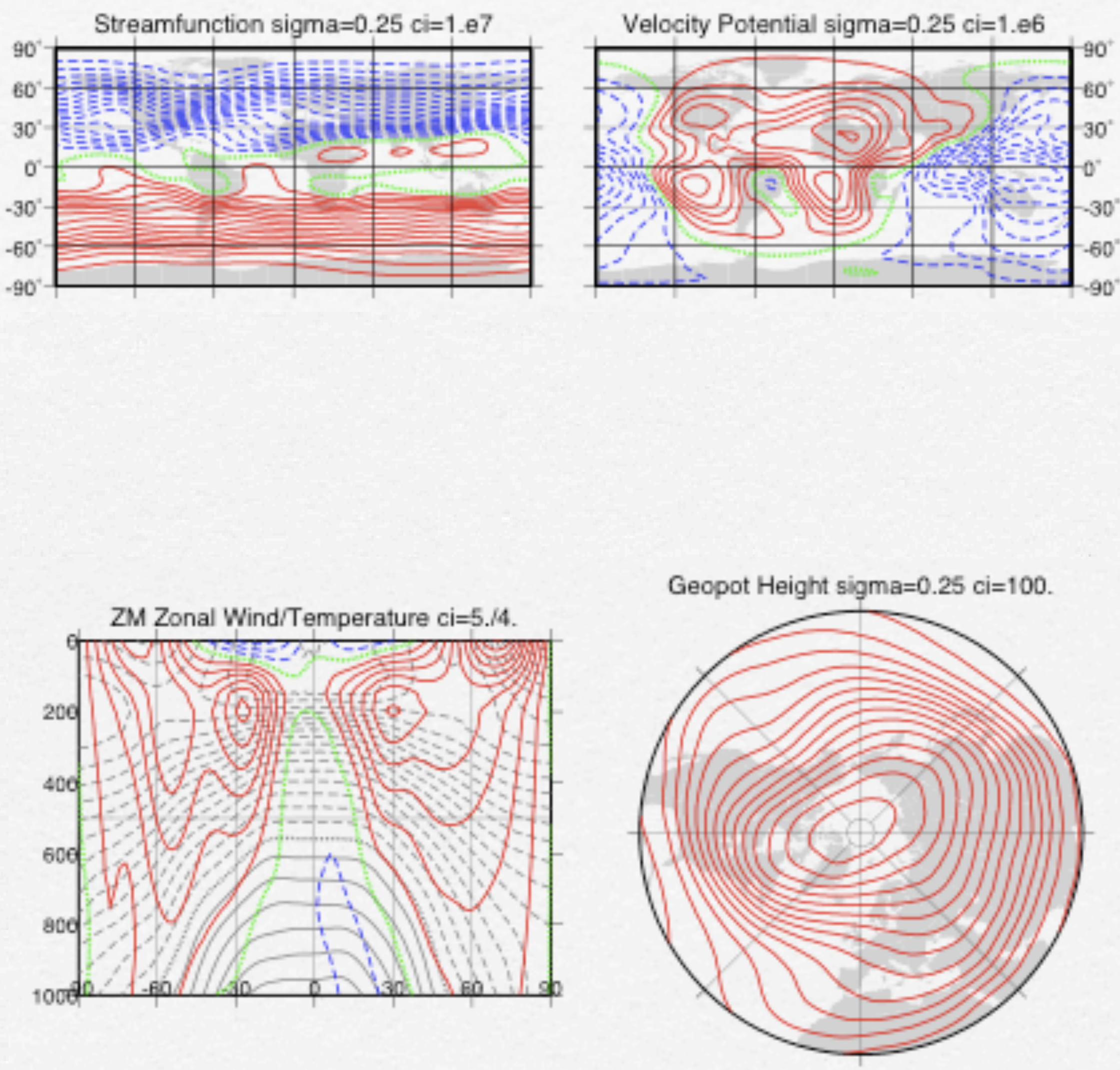
If we set $g = \overline{f}$ then this is the same as setting $g = -L\overline{\Phi} - \overline{\Phi}^{\dagger} Q\overline{\Phi} - \overline{\Phi'^{\dagger} Q\Phi'}$

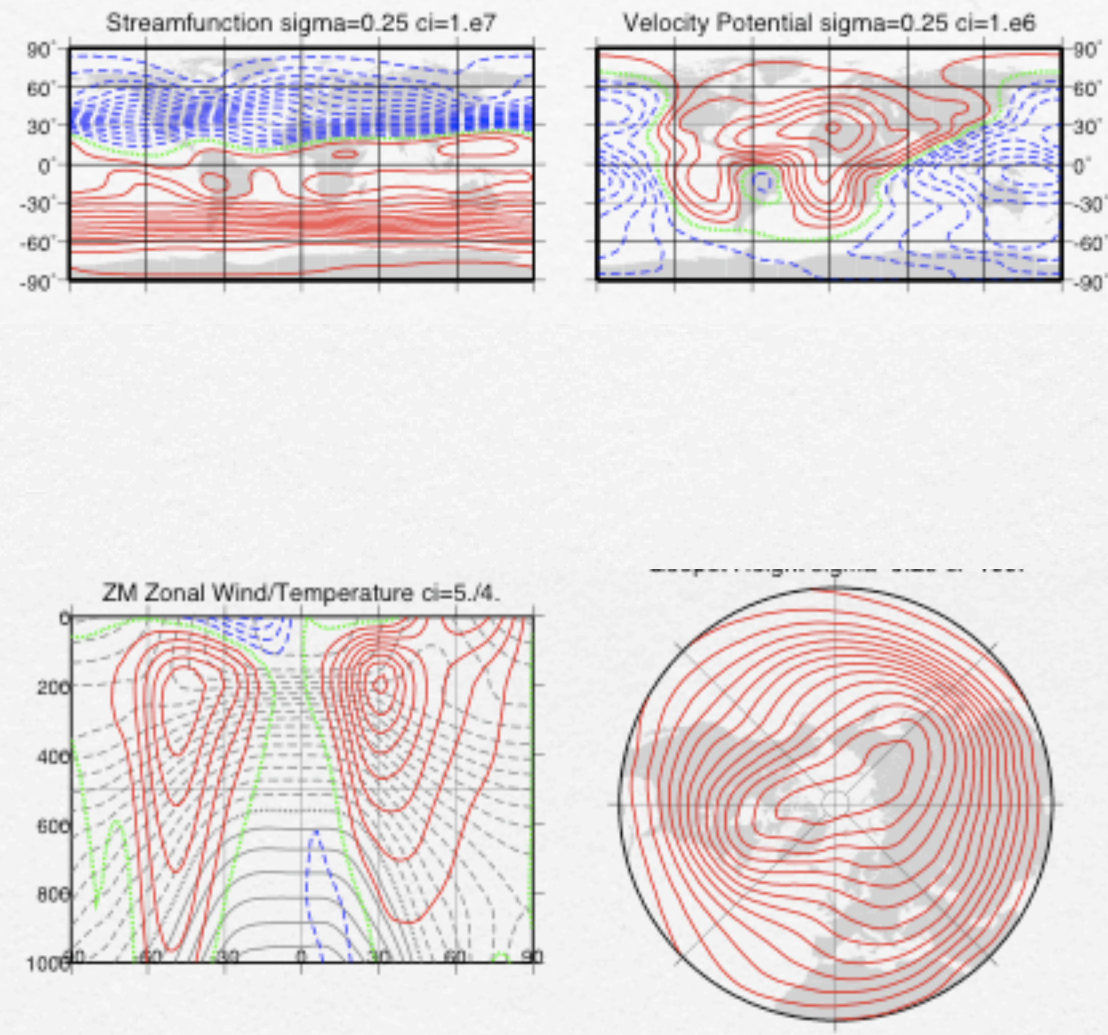
i.e. we have subtracted out the time-mean "forcing" due to the transients.

Again, we can calculate this forcing by initializing the unforced model from a series of values of Φ and then taking the time-average.

If the model is now initialized with $\overline{\Phi}$ it will develop in time. In fact we hope it will develop its own explicit transient activity. And we hope that it will be realistic. But there is no guarrantee that this "simple GCM" will have a realistic climatology. The only thing that is guarranteed is that:

$$L\overline{\Psi} + \overline{\Psi}^{\dagger} Q\overline{\Psi} + \overline{\Psi'^{\dagger} Q\Psi'} = L\overline{\Phi} + \overline{\Phi}^{\dagger} Q\overline{\Phi} + \overline{\Phi'^{\dagger} Q\Phi'}$$

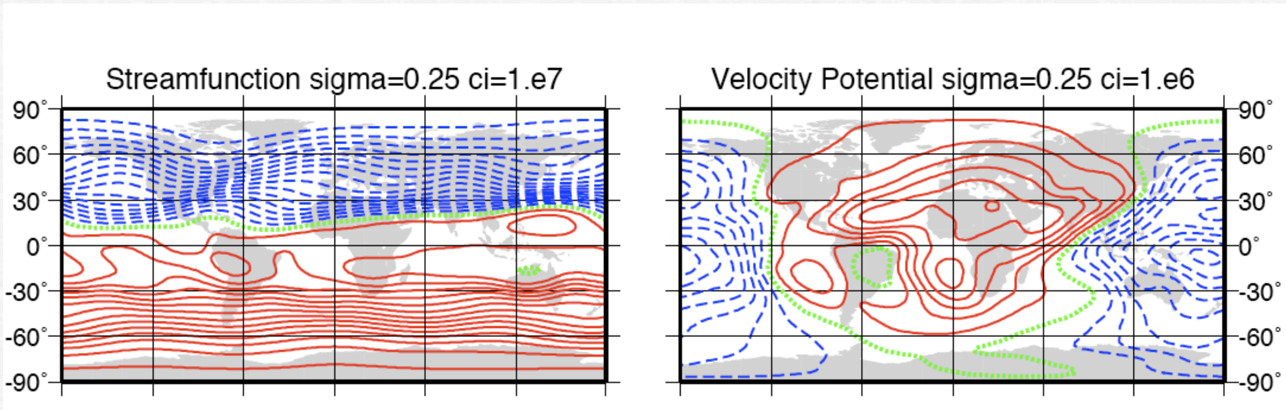


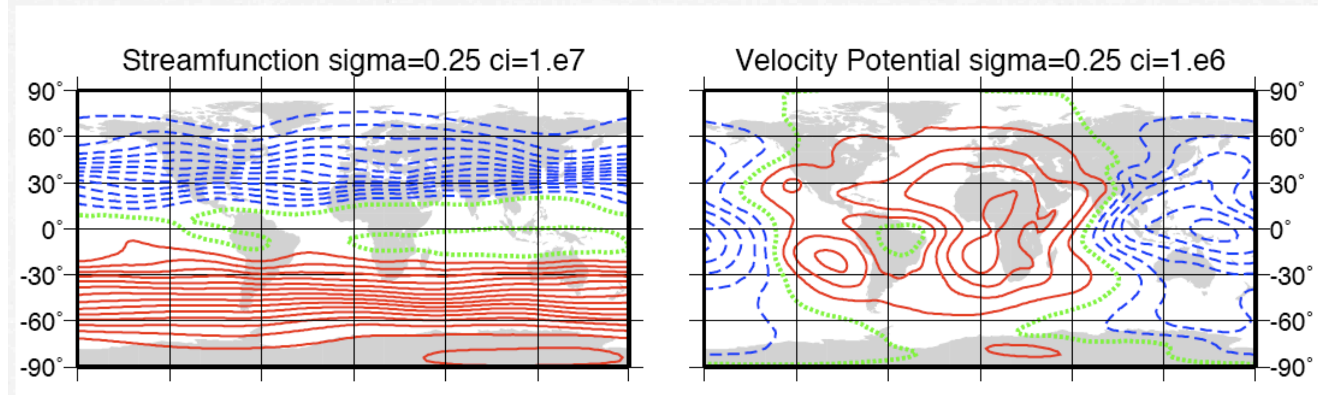


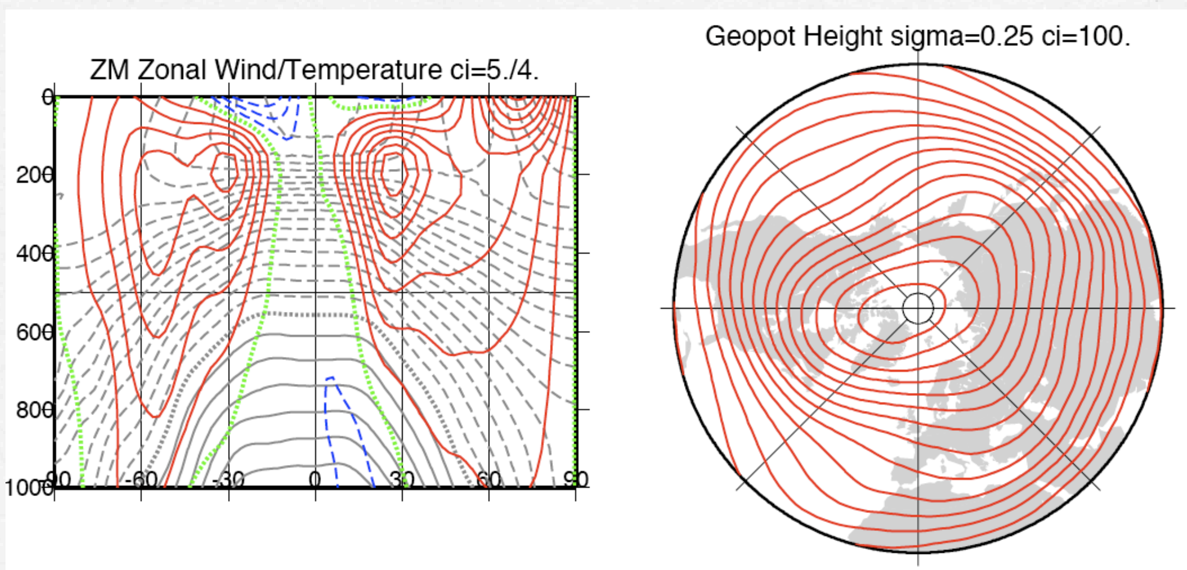
model 100 yr run

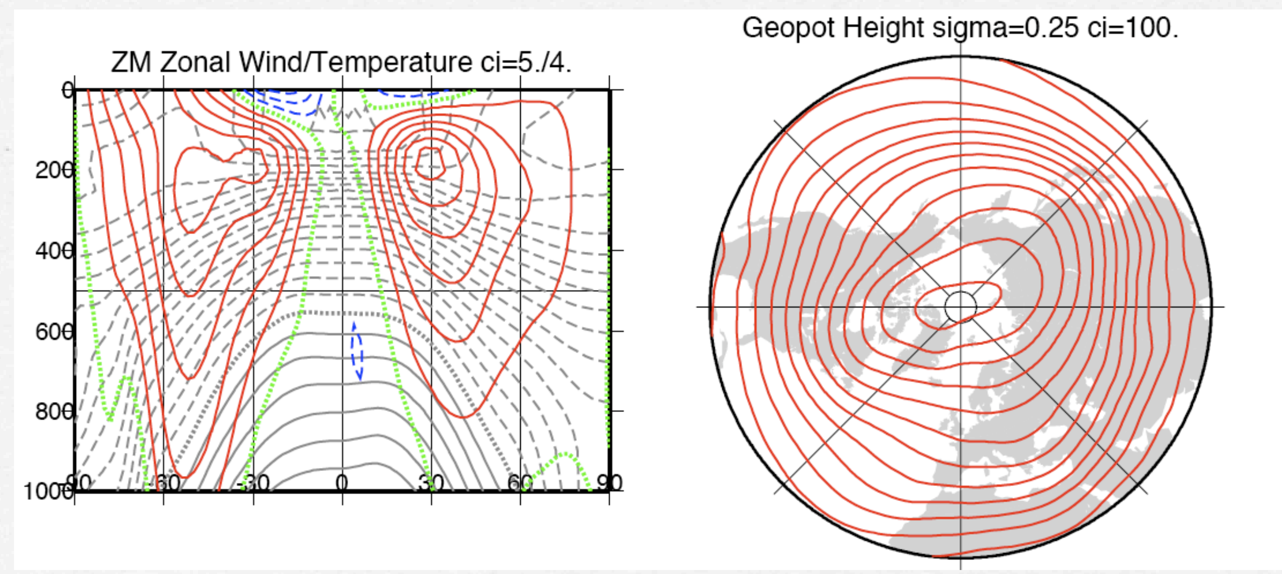
data

DJF





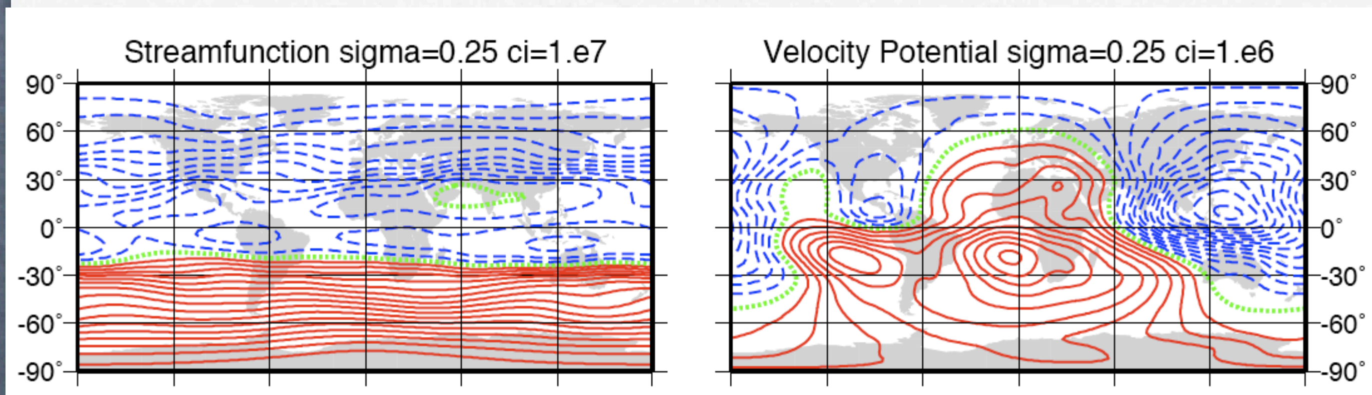


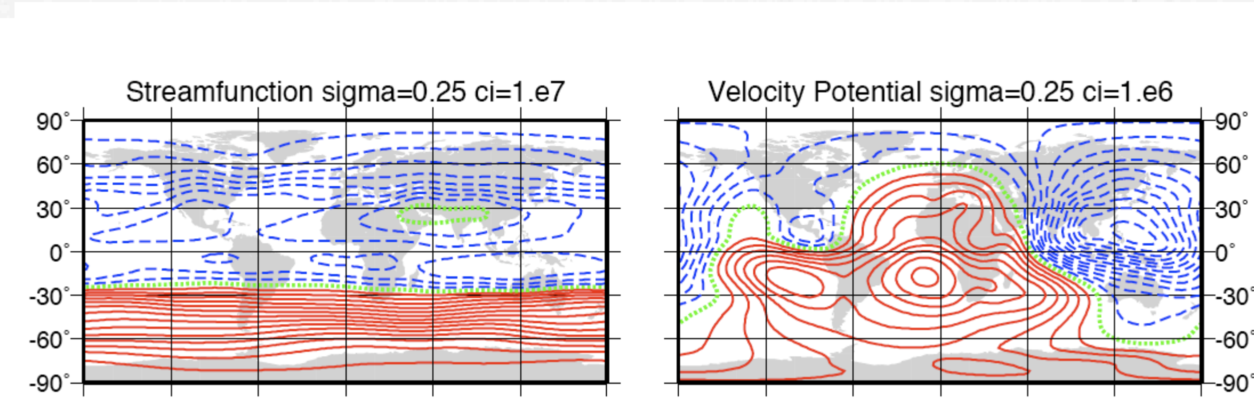


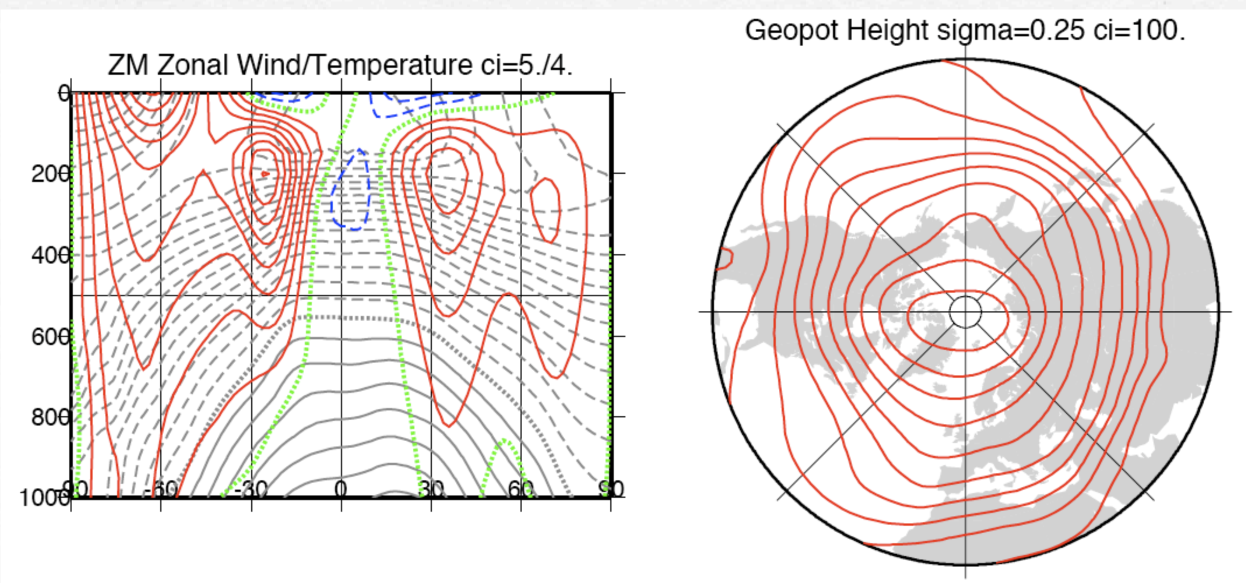
model

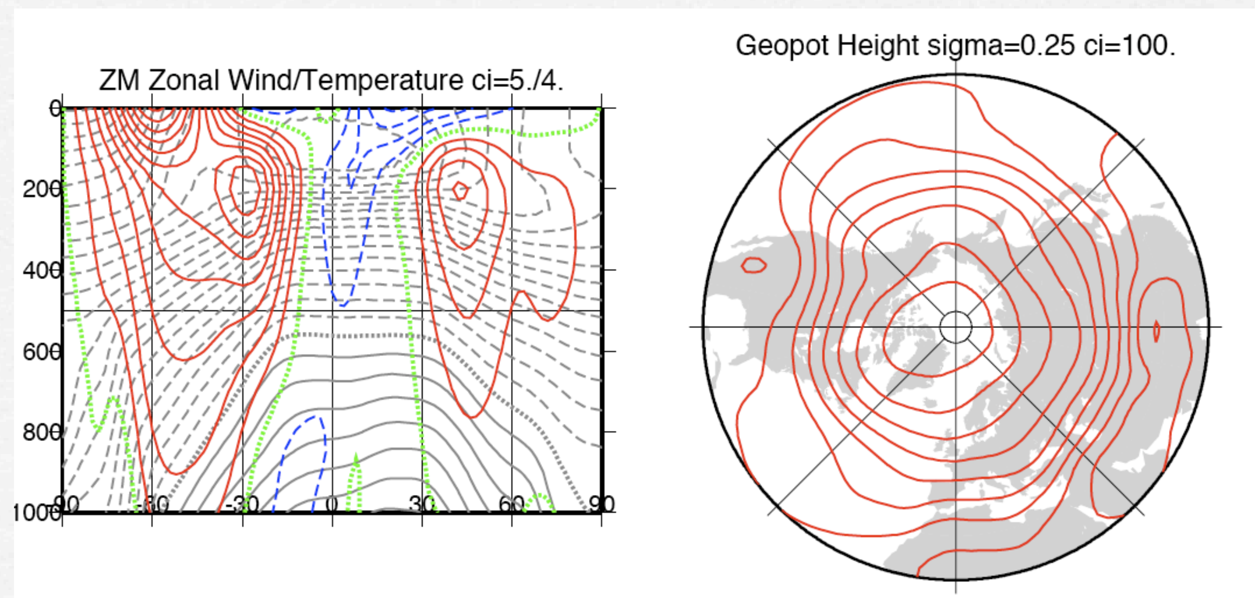
data

MAM





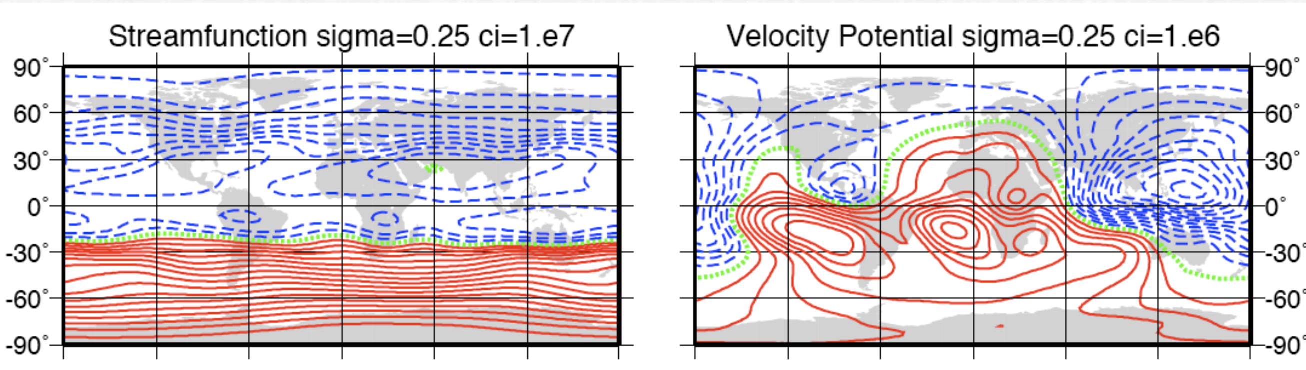


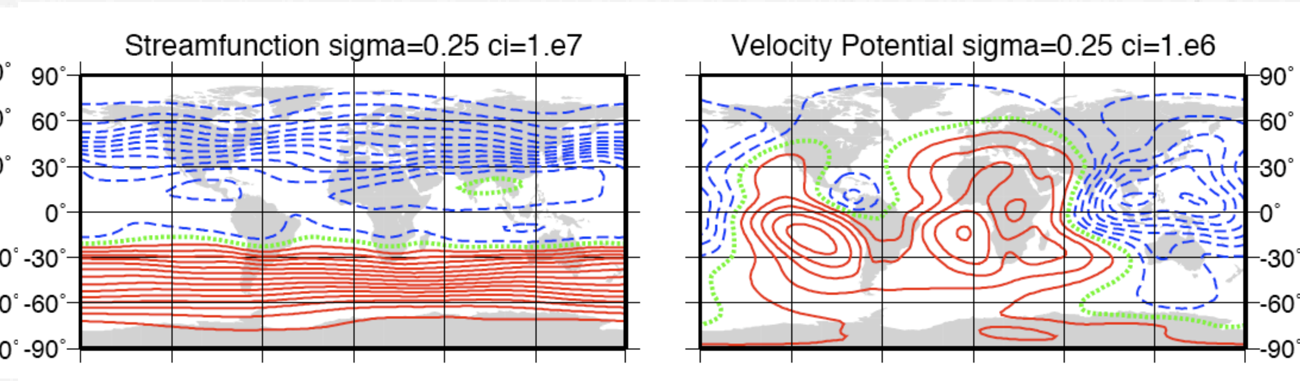


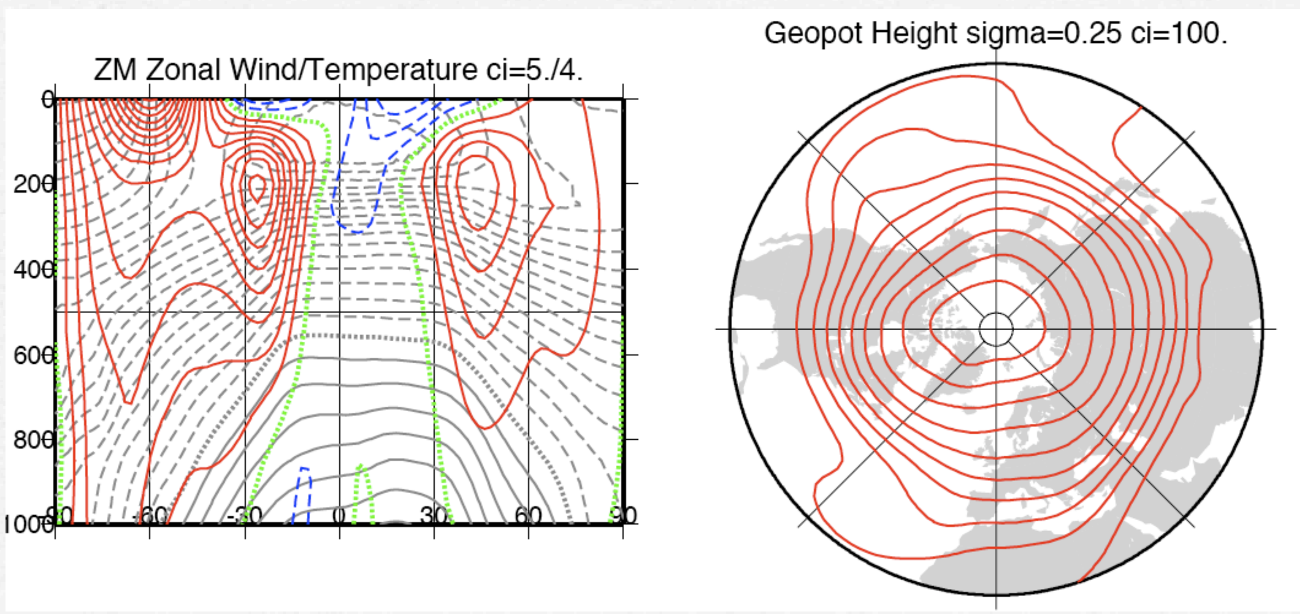
model

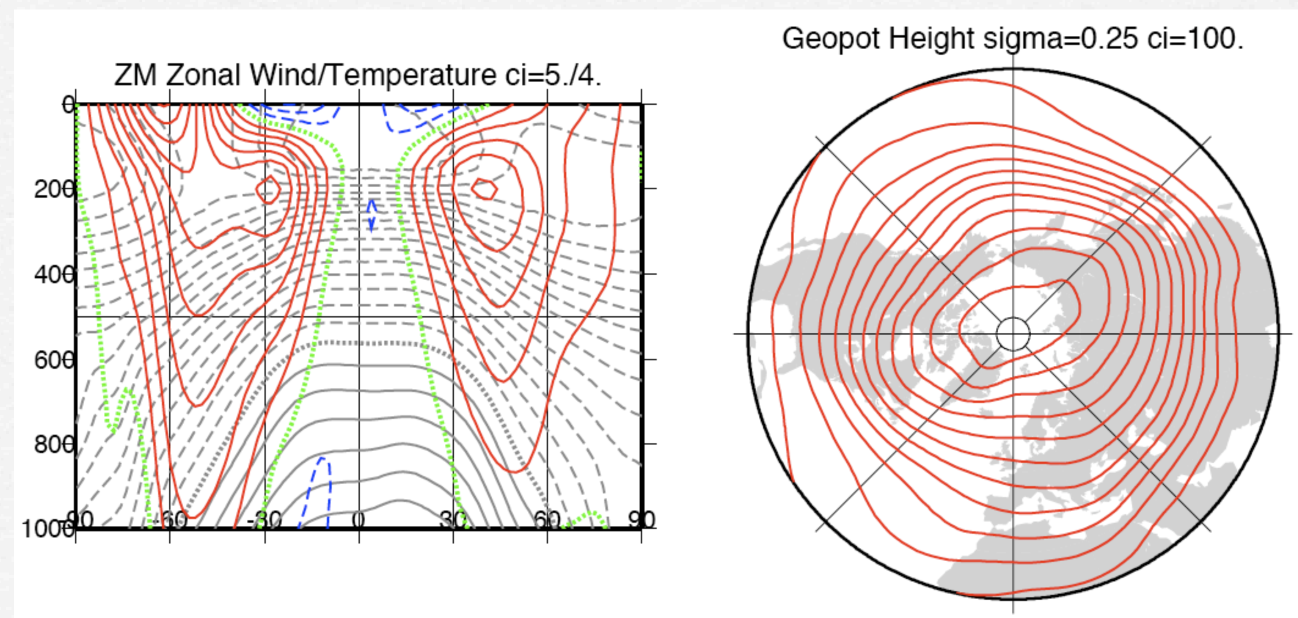
data

JJA







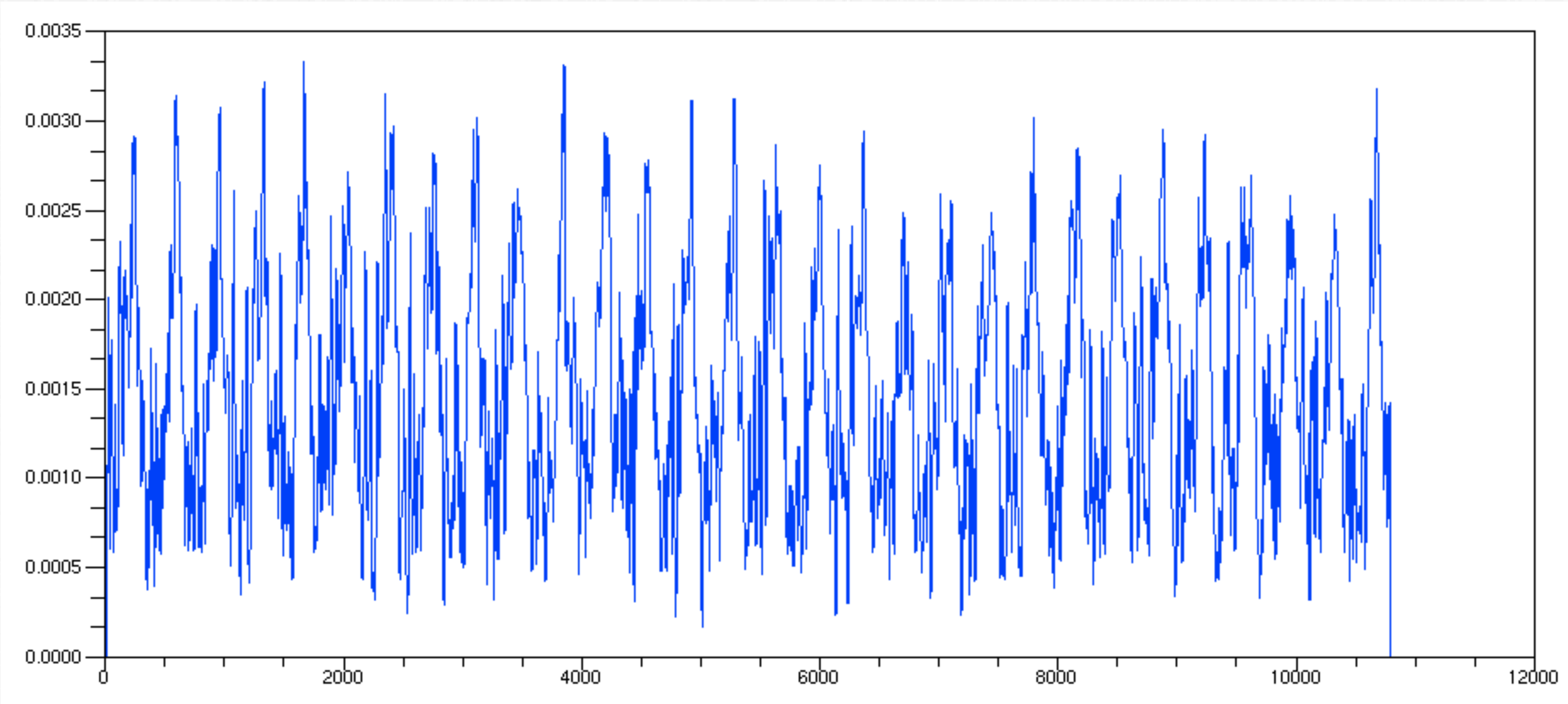


model

data

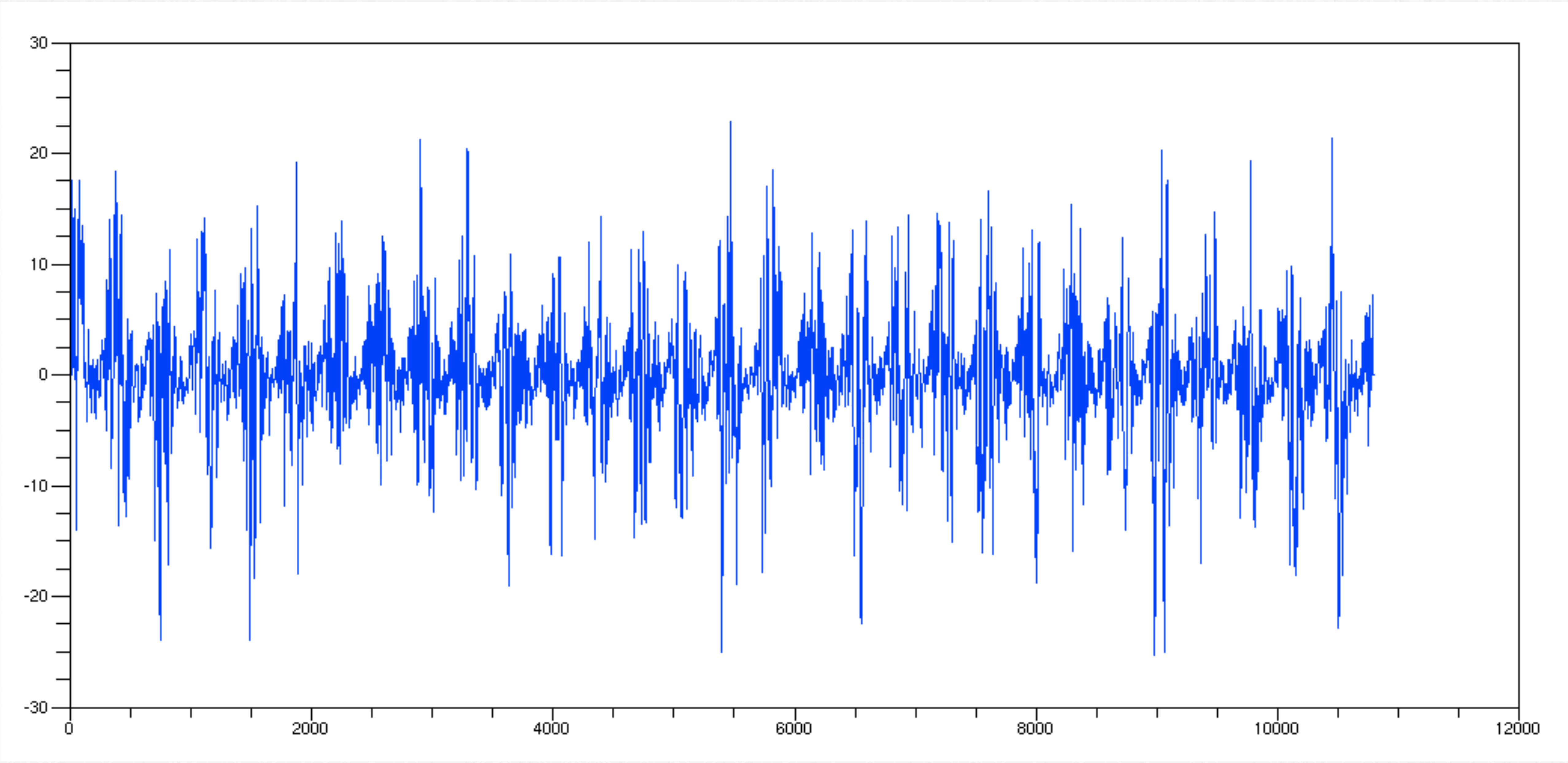
SON

amplitude M1_psi 30 yr 32 N (10 day running mean)



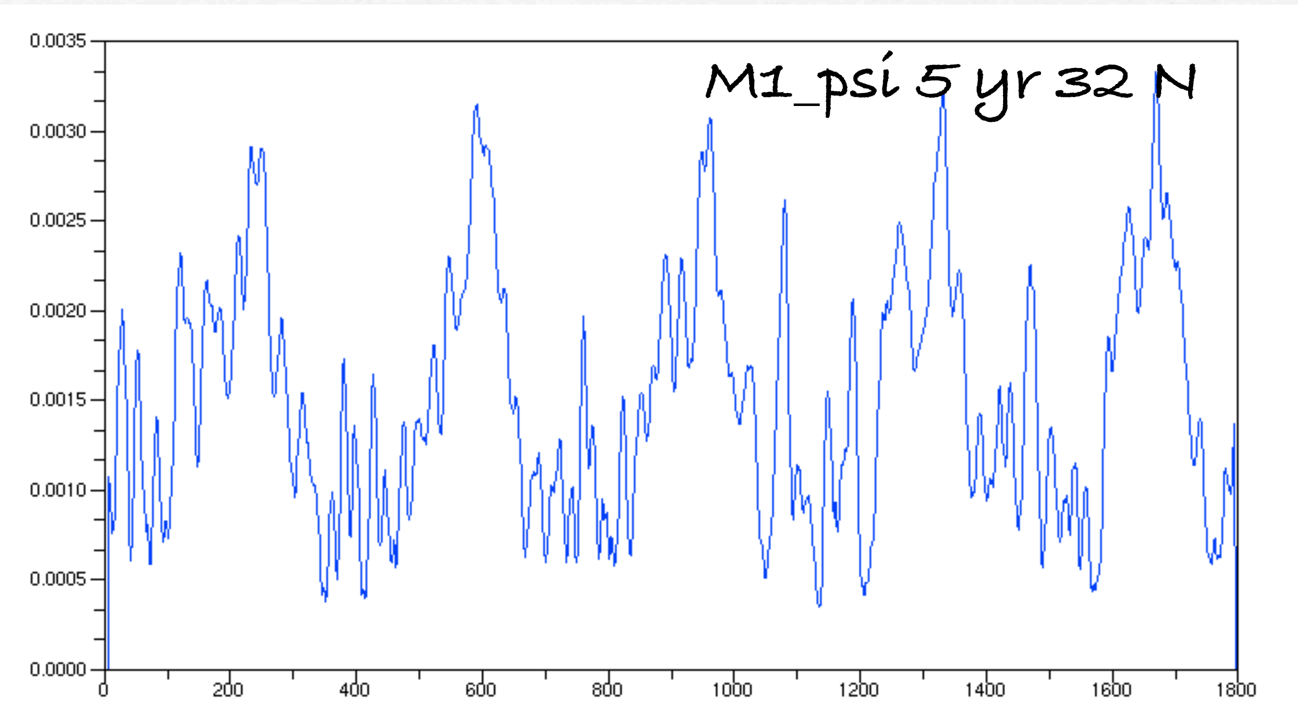
days (period of 30 years)

phase speed (m/s)   M1_psi 30 yr 32N

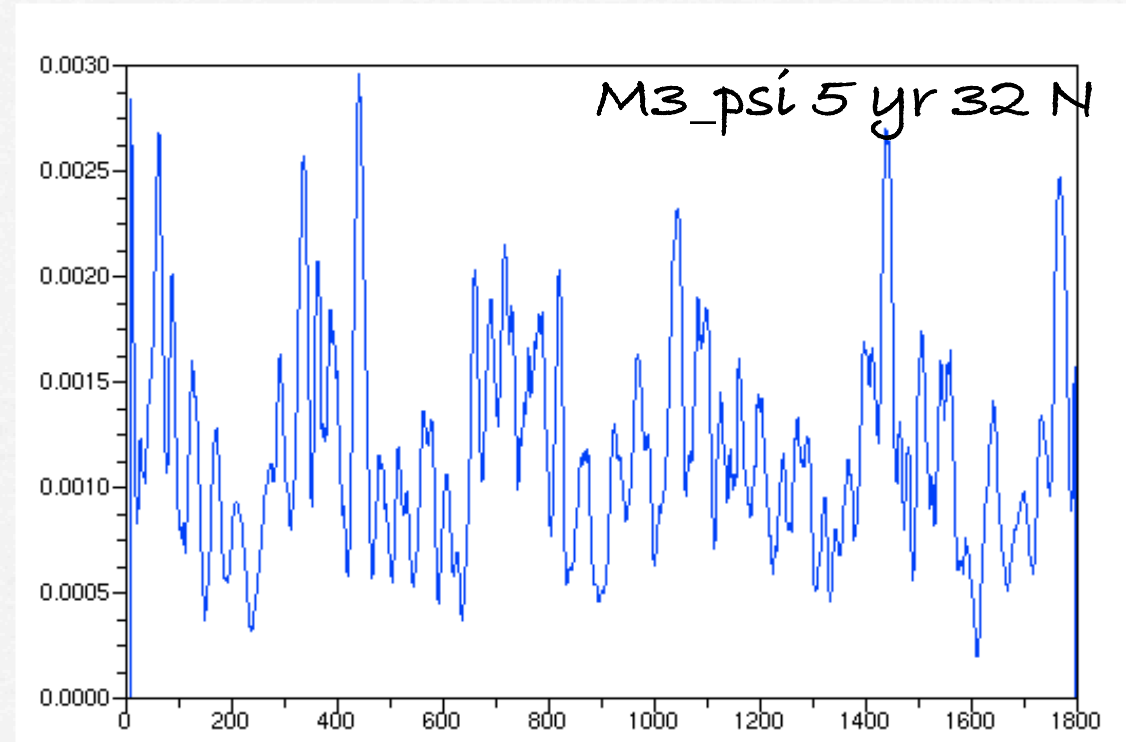


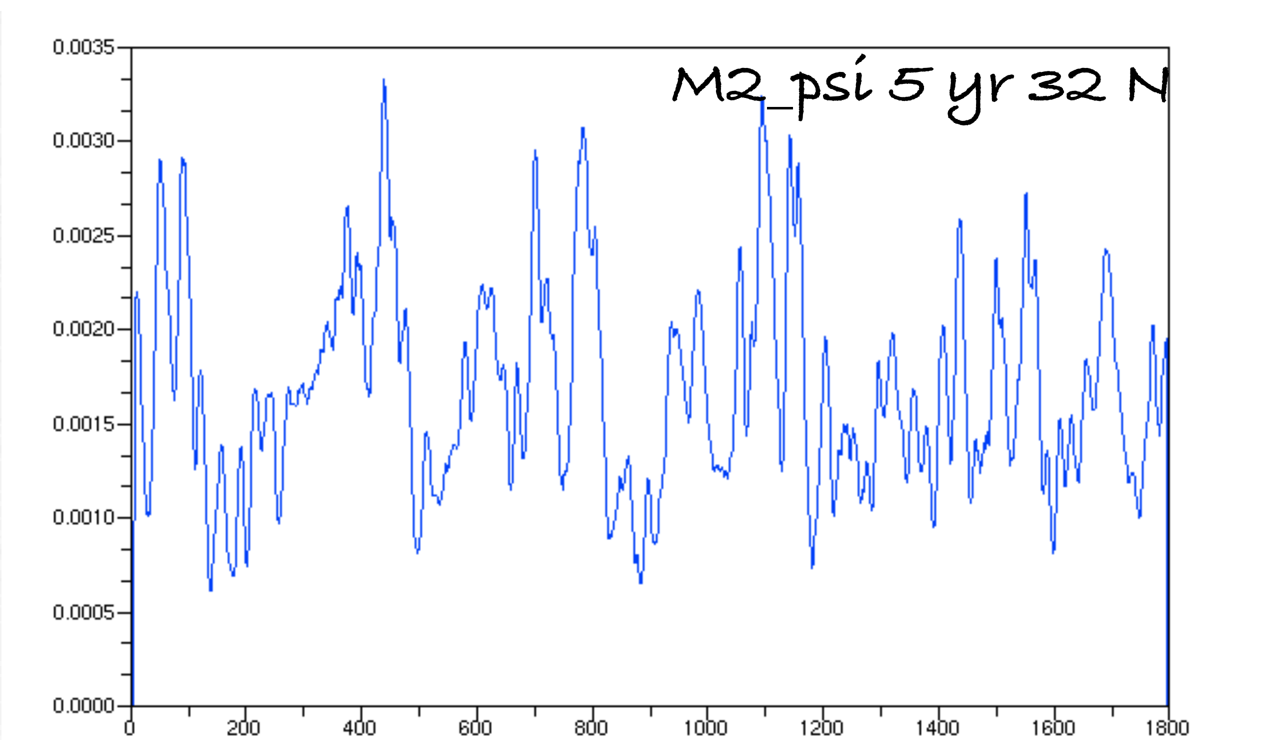
days (period of 30 years)

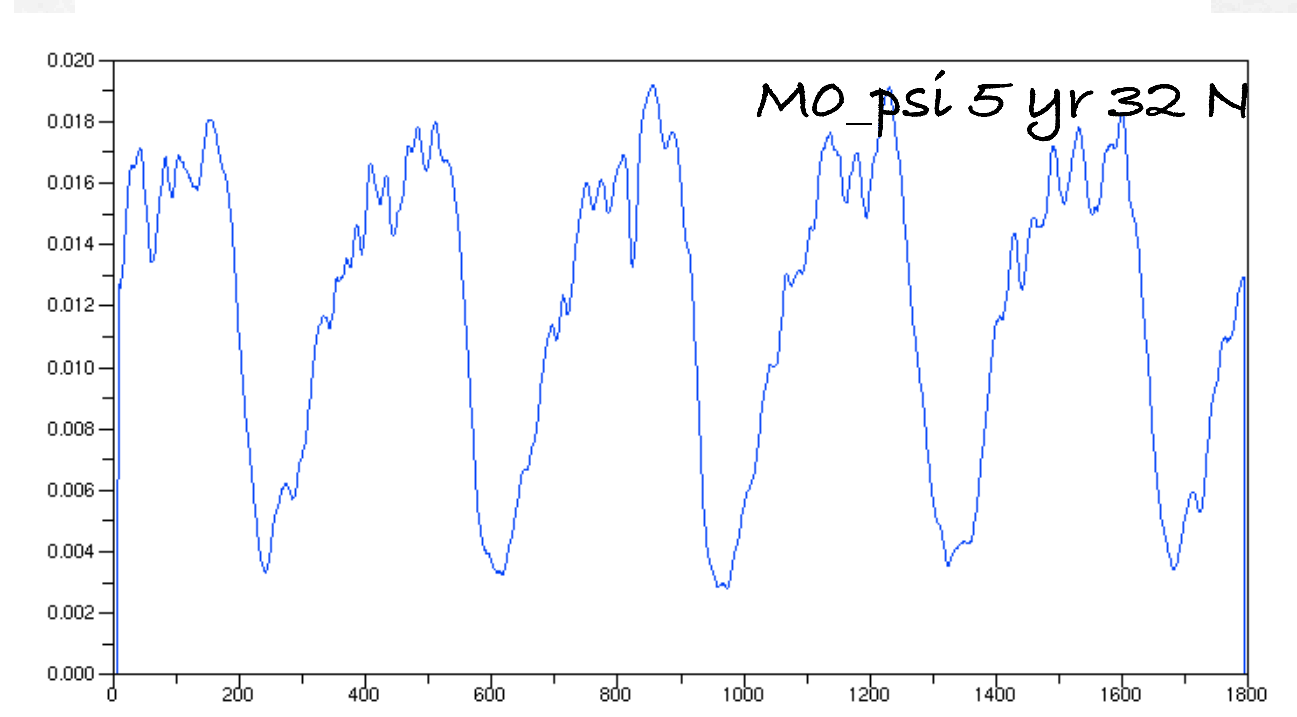
amplitude



amplitude



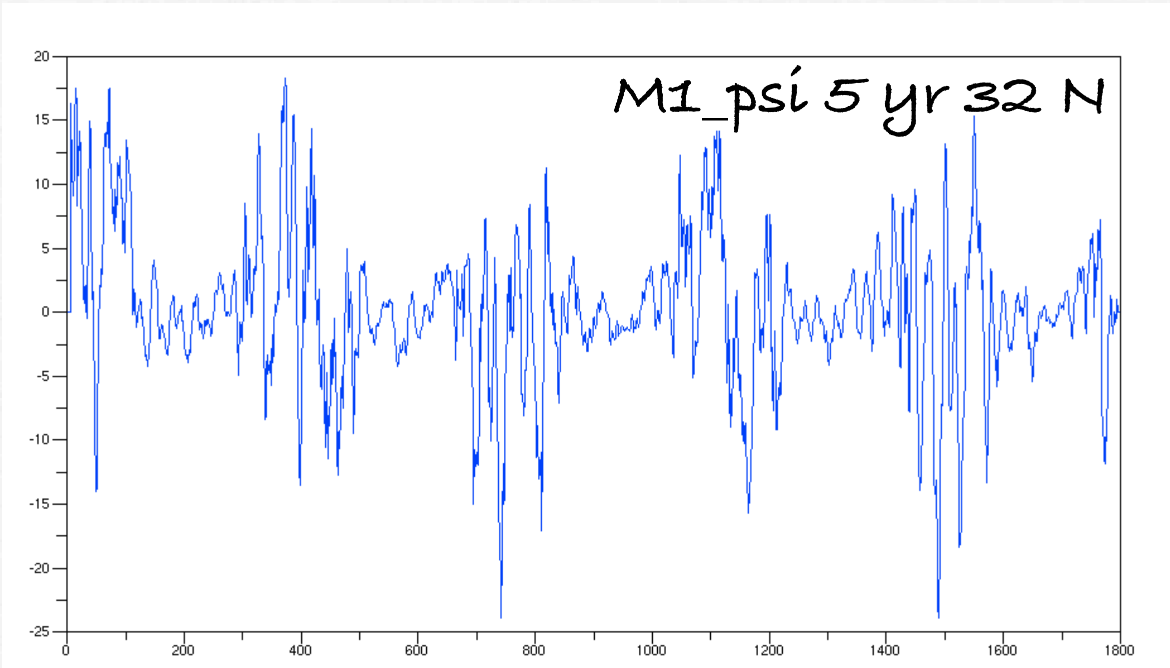




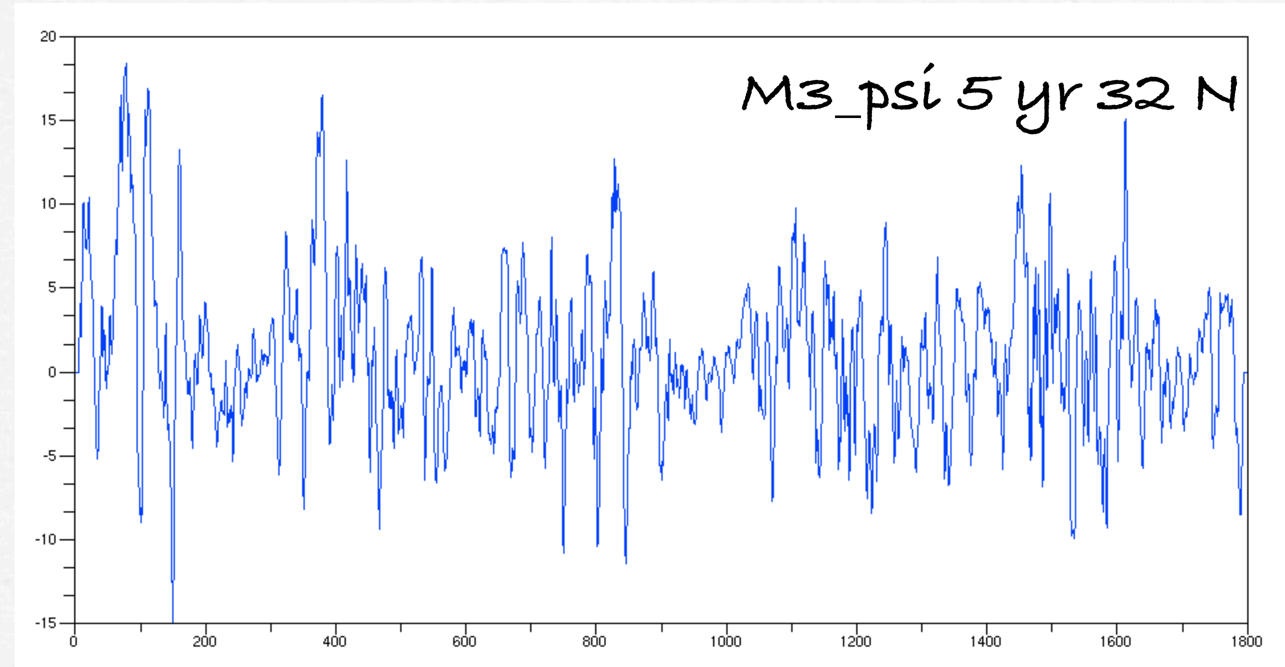
days (period of 5 years)

days (period of 5 years)

phase speed (m/s)

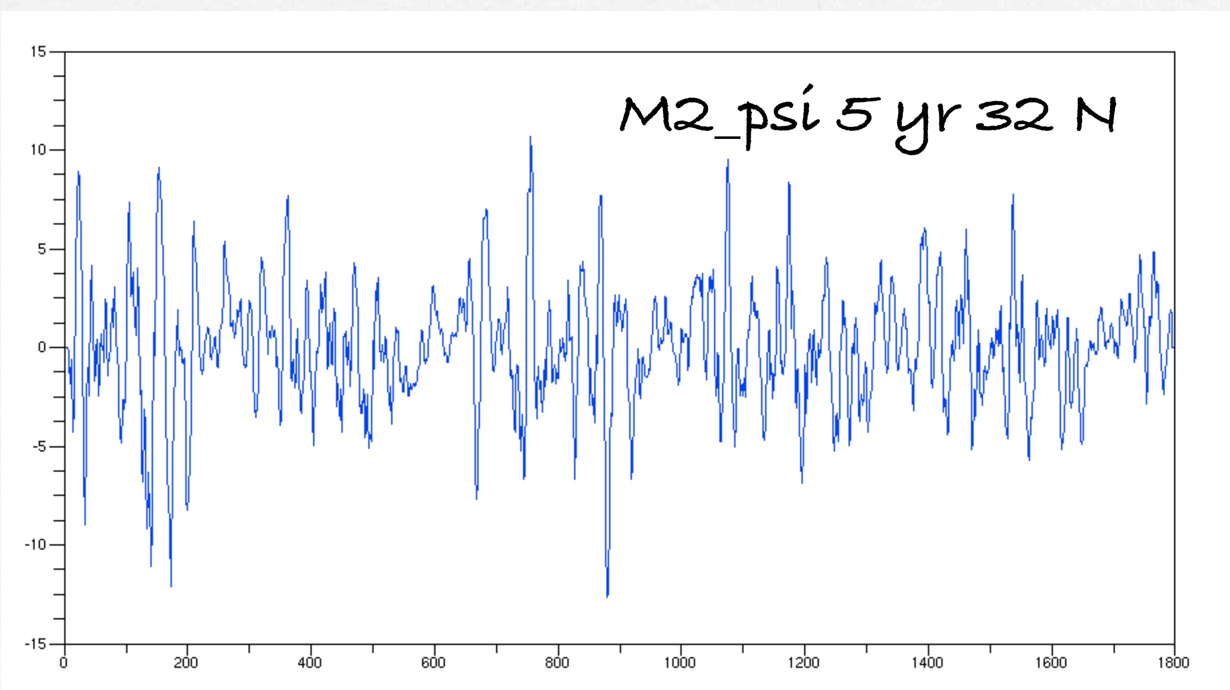


phase speed (m/s)



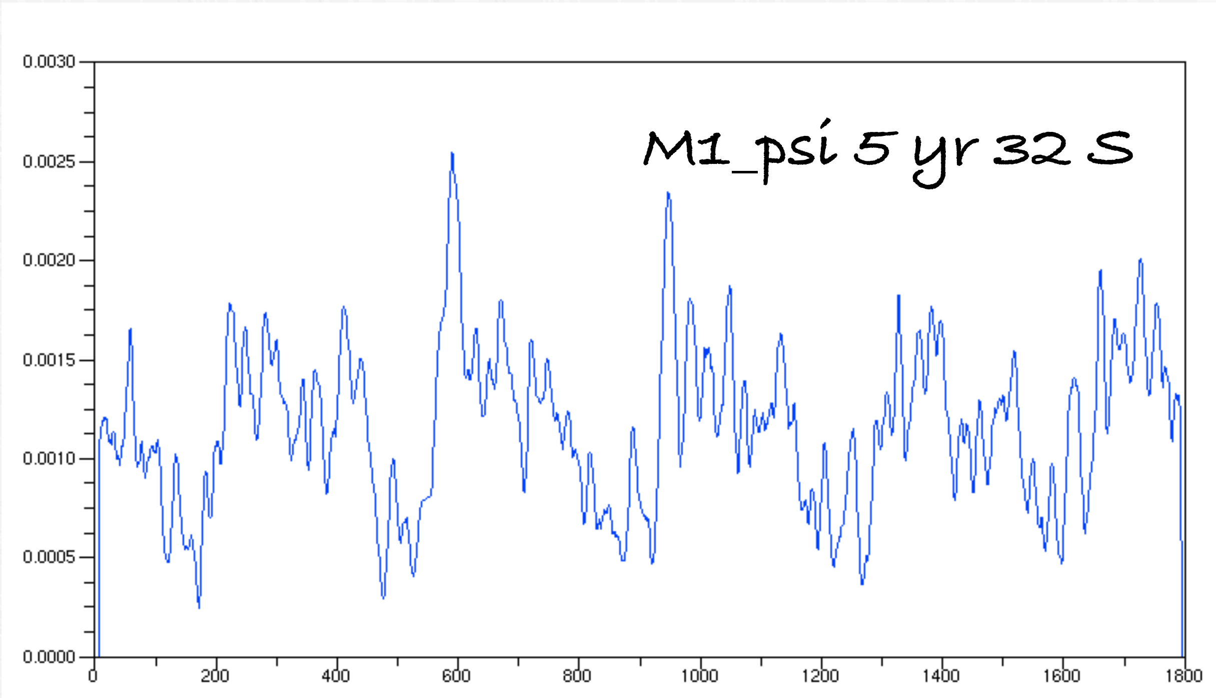
days (period of 5 years)

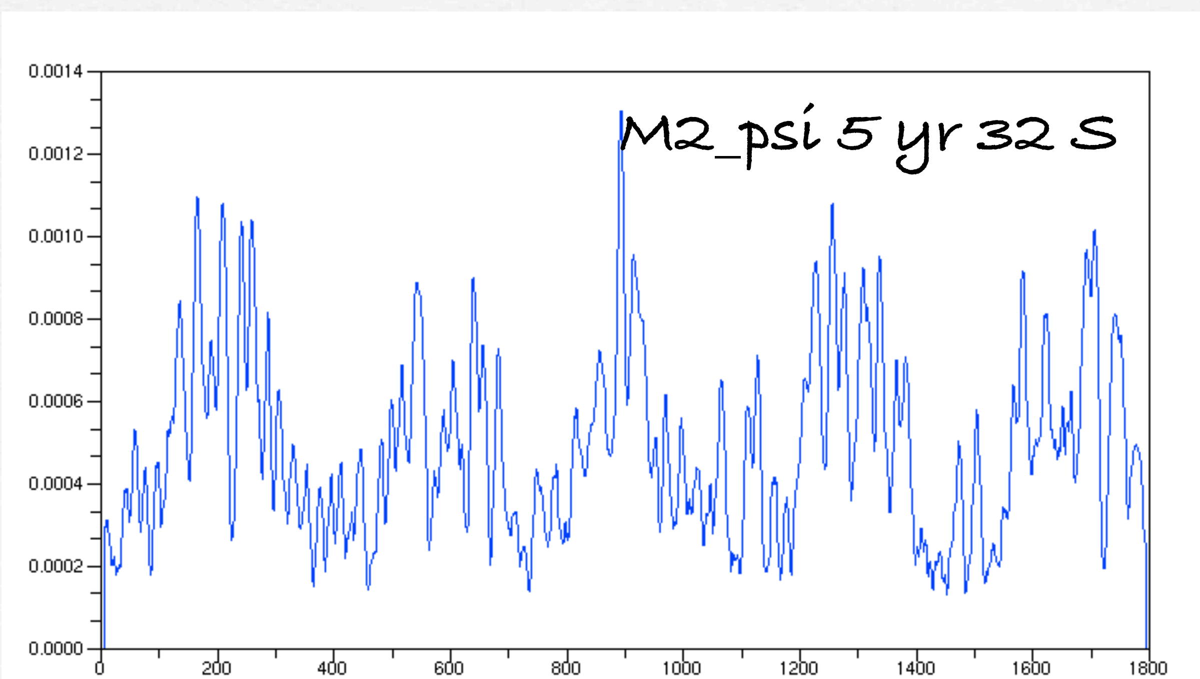
lot of variations (M=1 during winter)



days (period of 5 years)

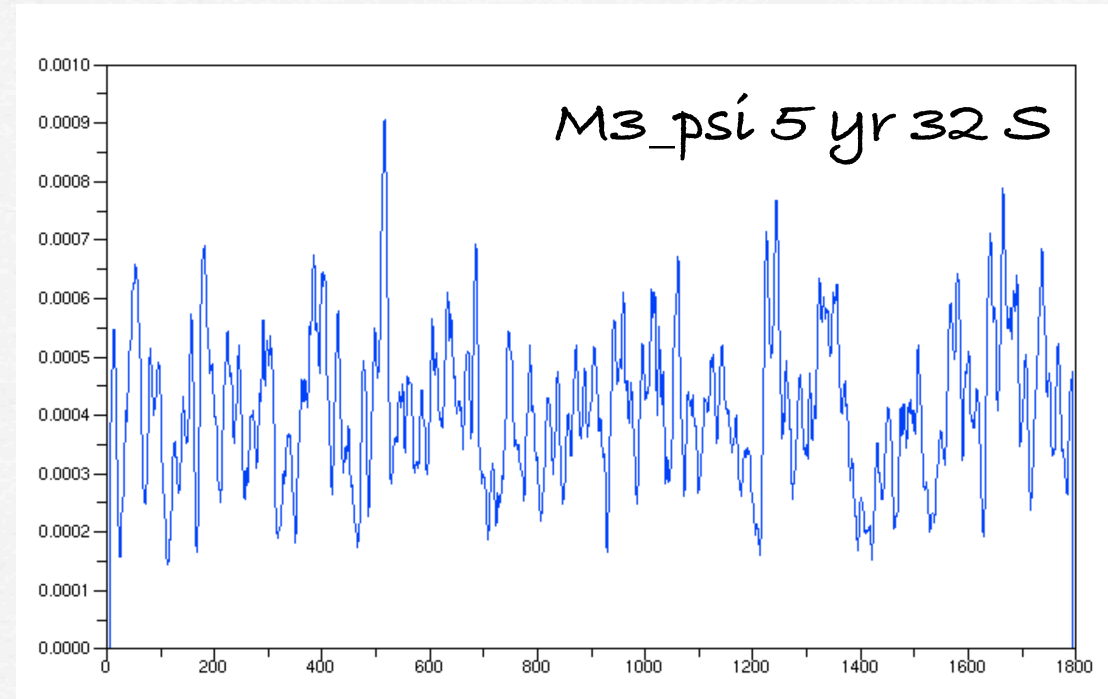
amplitude





days (period of 5 years)

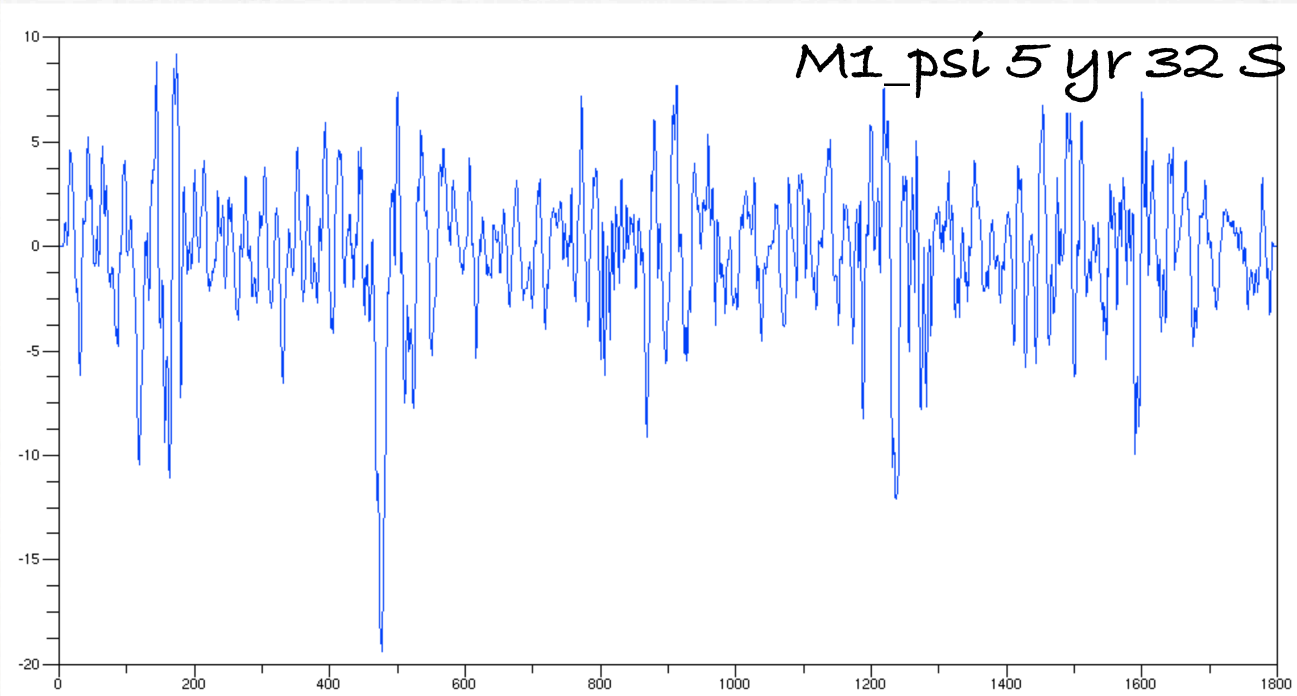
amplitude

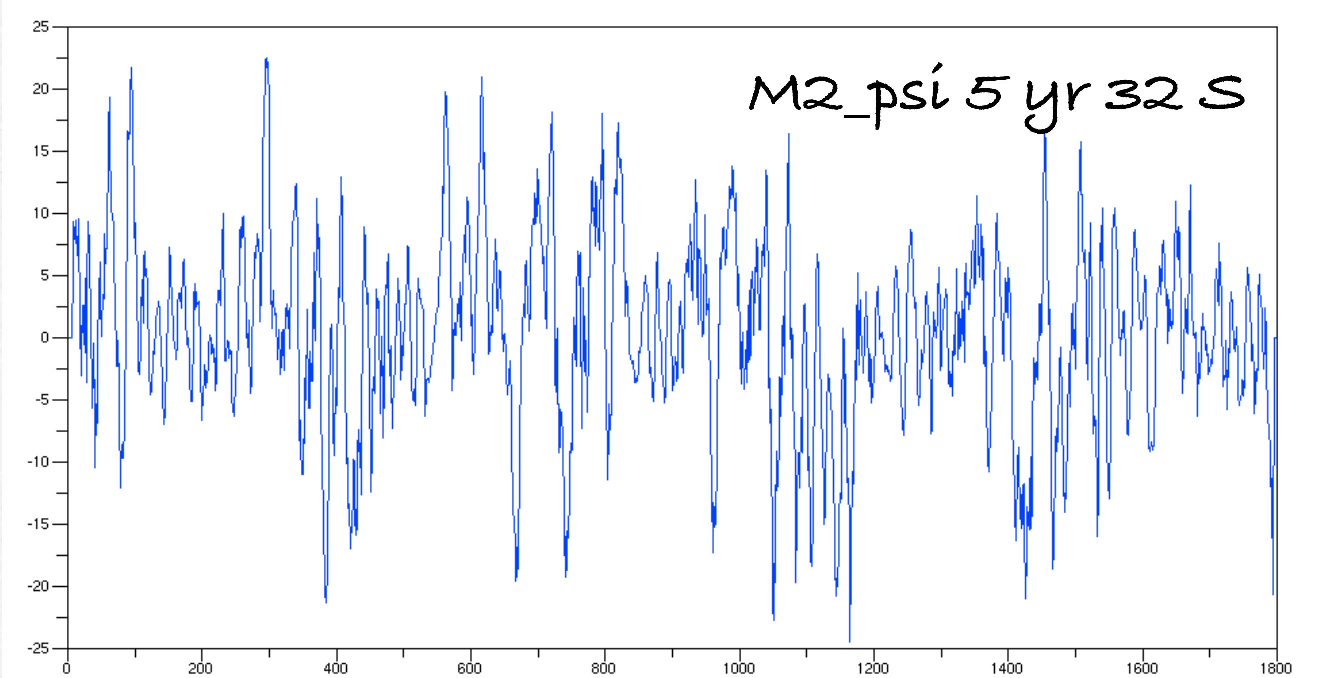


days (period of 5 years)

shifted annual signal (M=1), max amplitude in boreal summer (M=2), annual cycle intraseasonal variability (M=3)

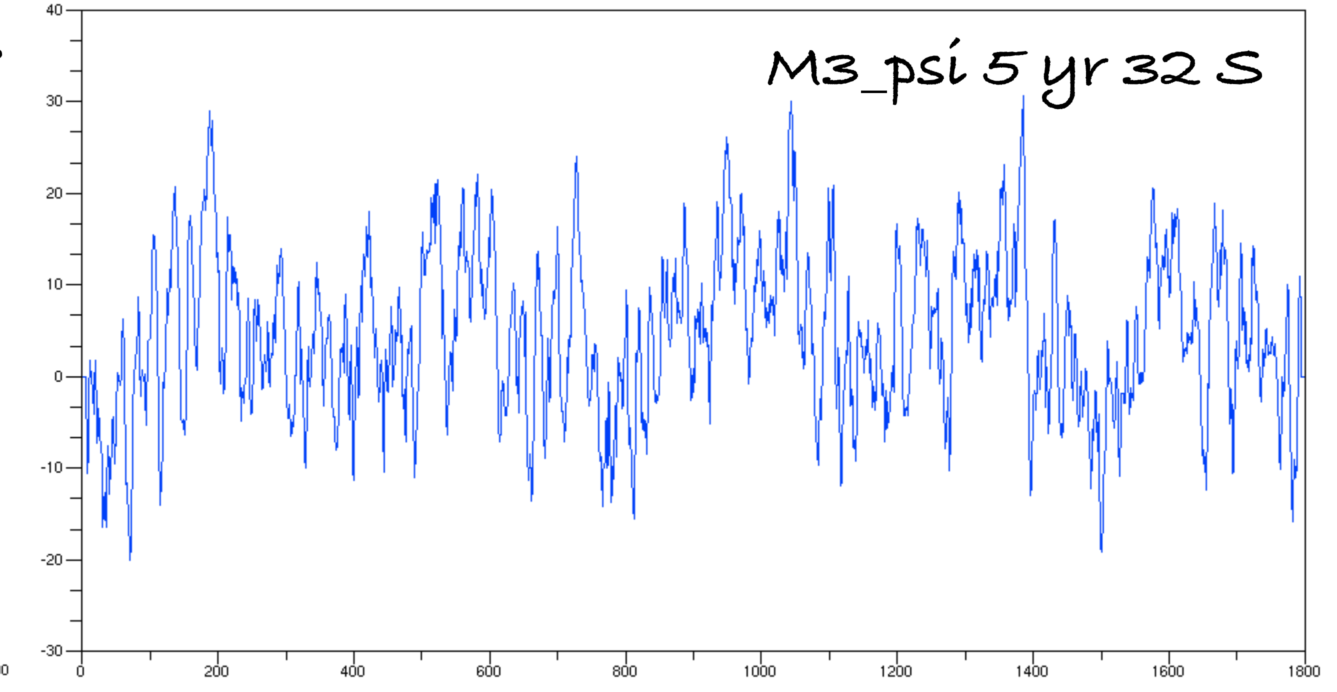
phase speed (m/s)





days (period of 5 years)

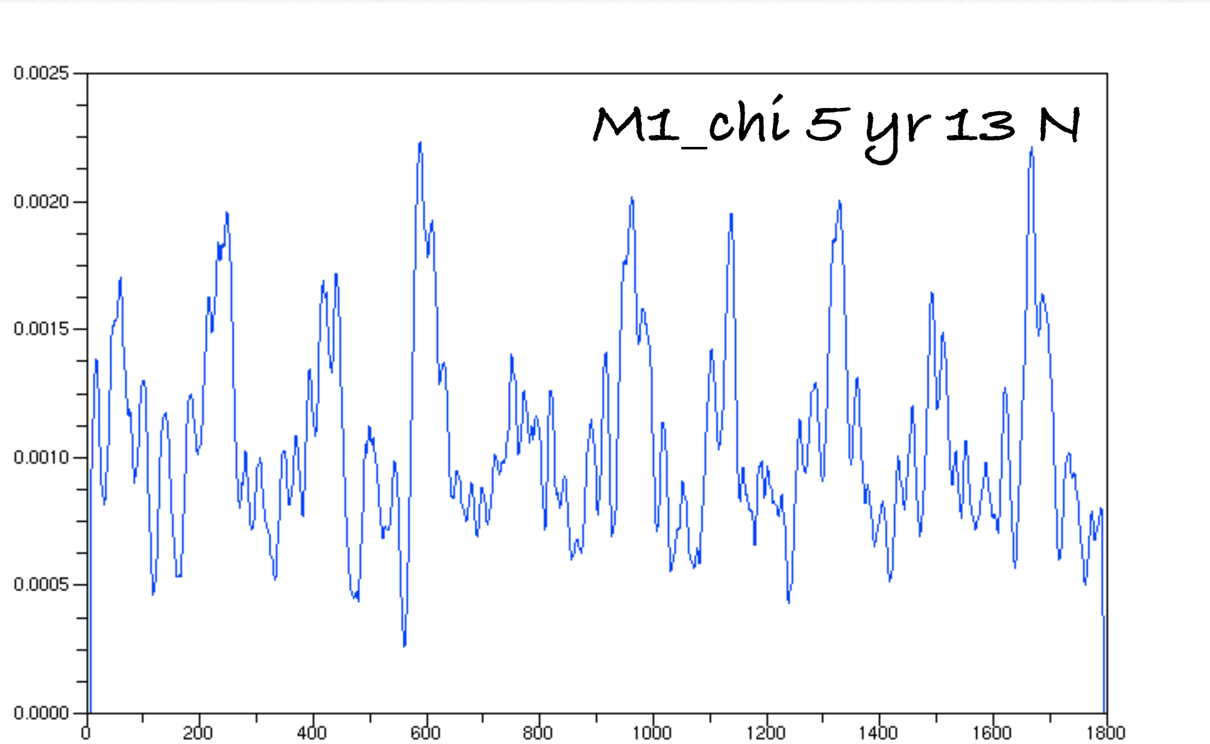
phase speed (m/s)



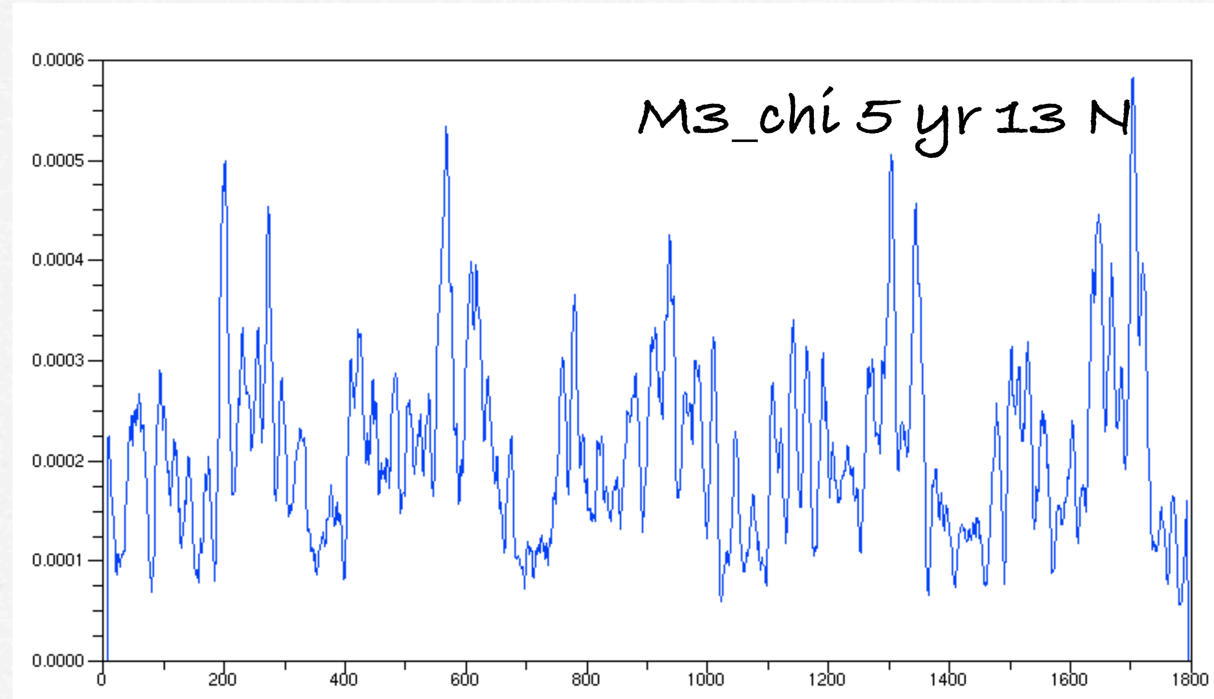
days (period of 5 years)

no annual cycle, const. propagation towards east (M=1), variability in all timescales and very weak annual cycle (M=2)

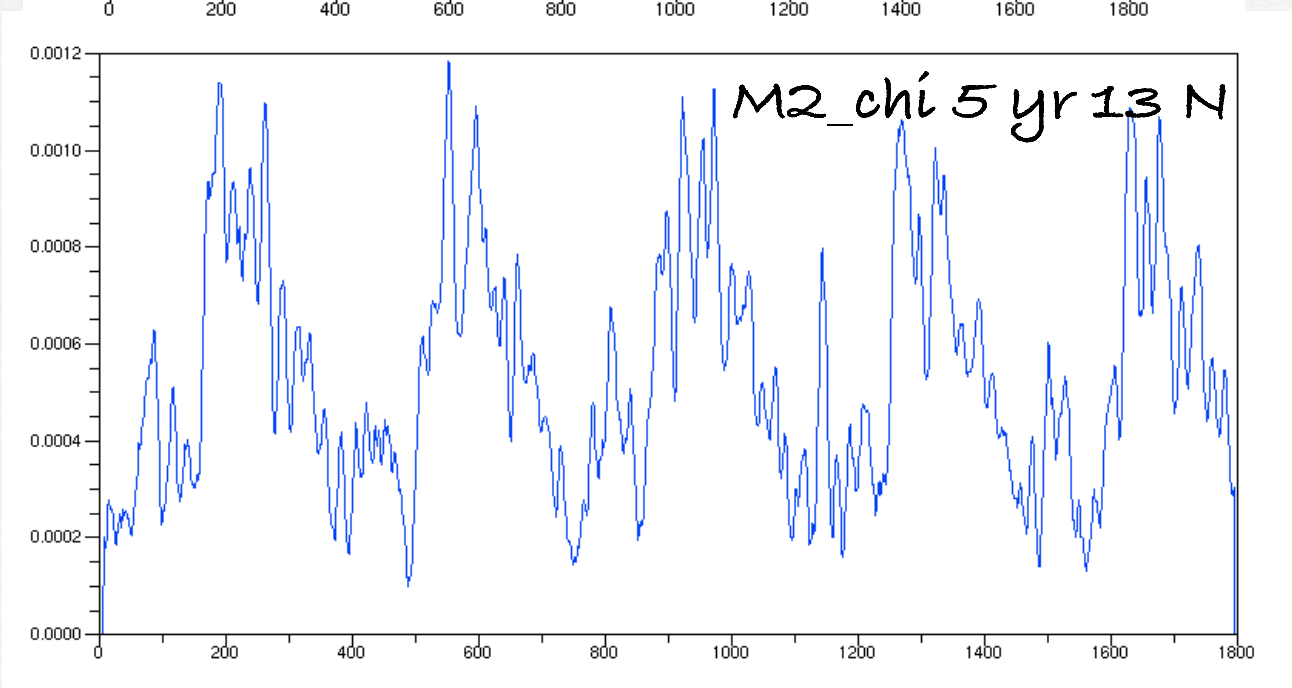
amplitude



amplitude



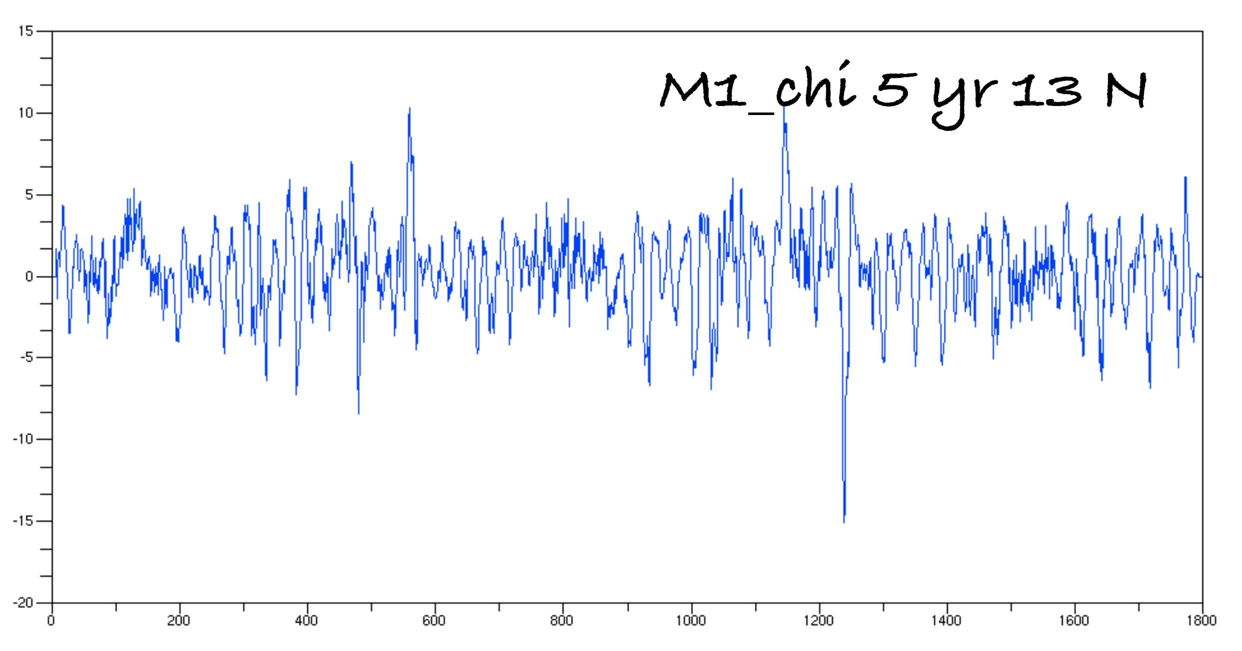
days (period of 5 years)



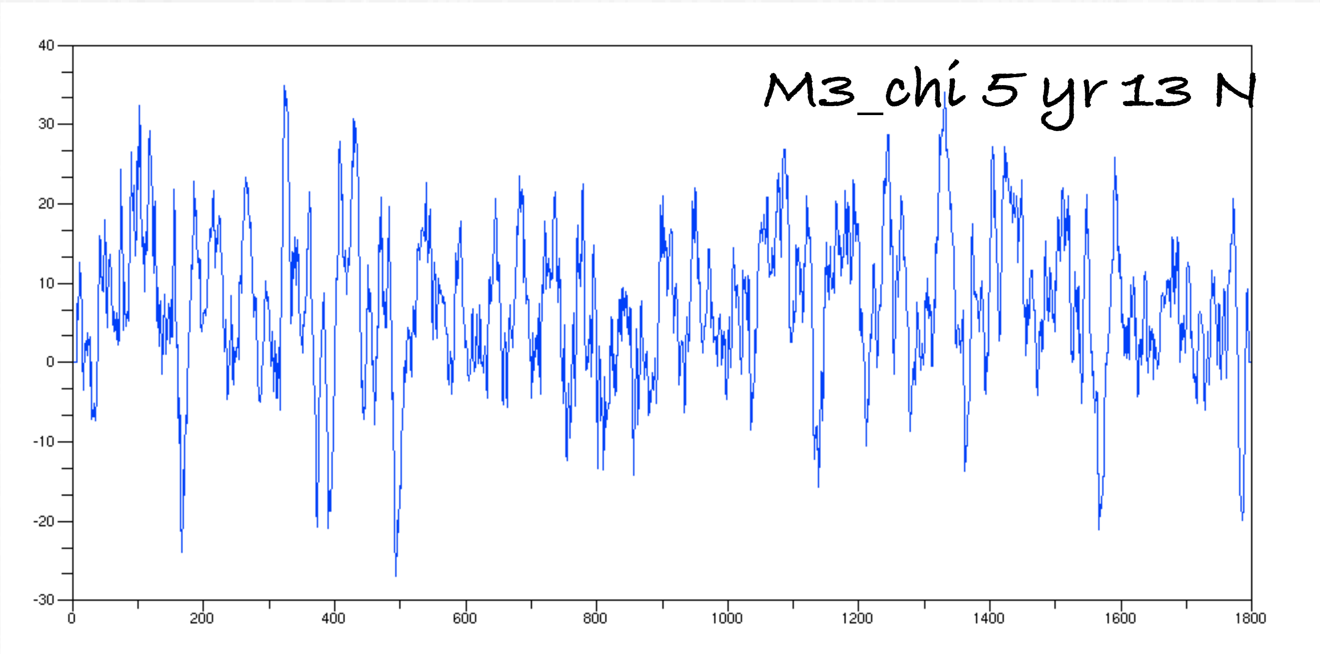
days (period of 5 years)

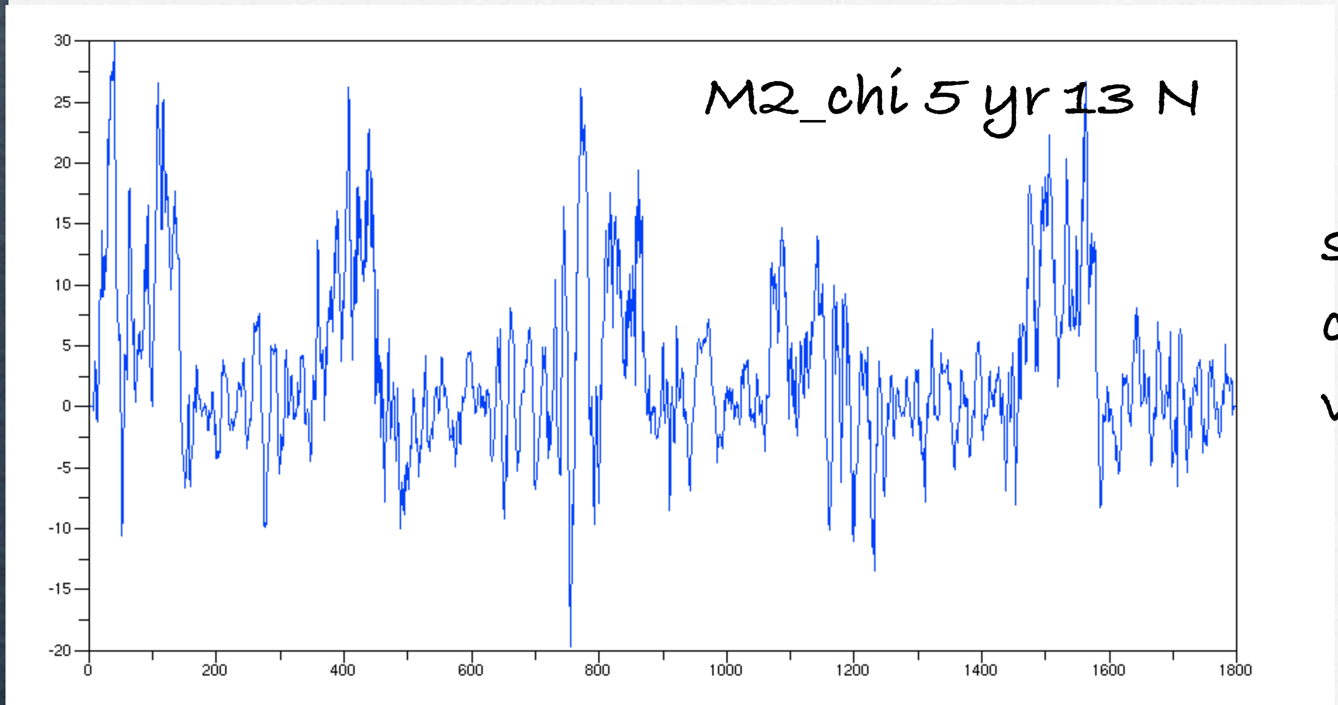
strong annual signal with stronger amplitude in summer (M=2)

phase speed (m/s)



phase speed (m/s)



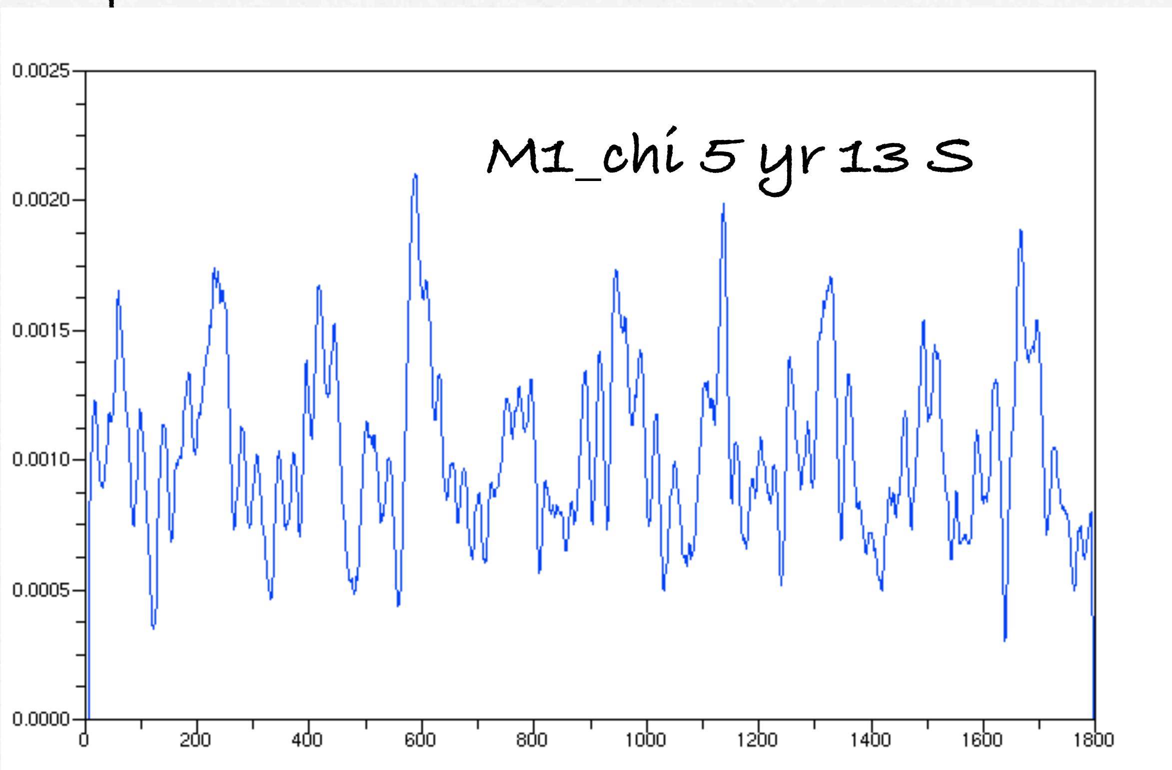


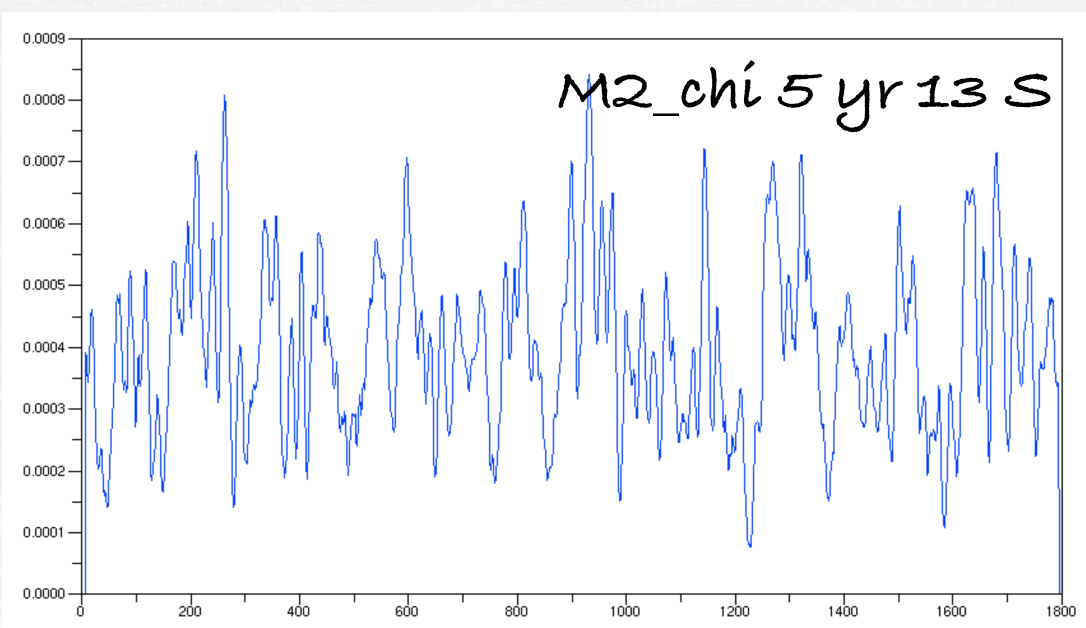
days (period of 5 years)

strong variability (modulated by annual cycle) in winter (M=2) and short time scale variations (M=1,3)

days (period of 5 years)

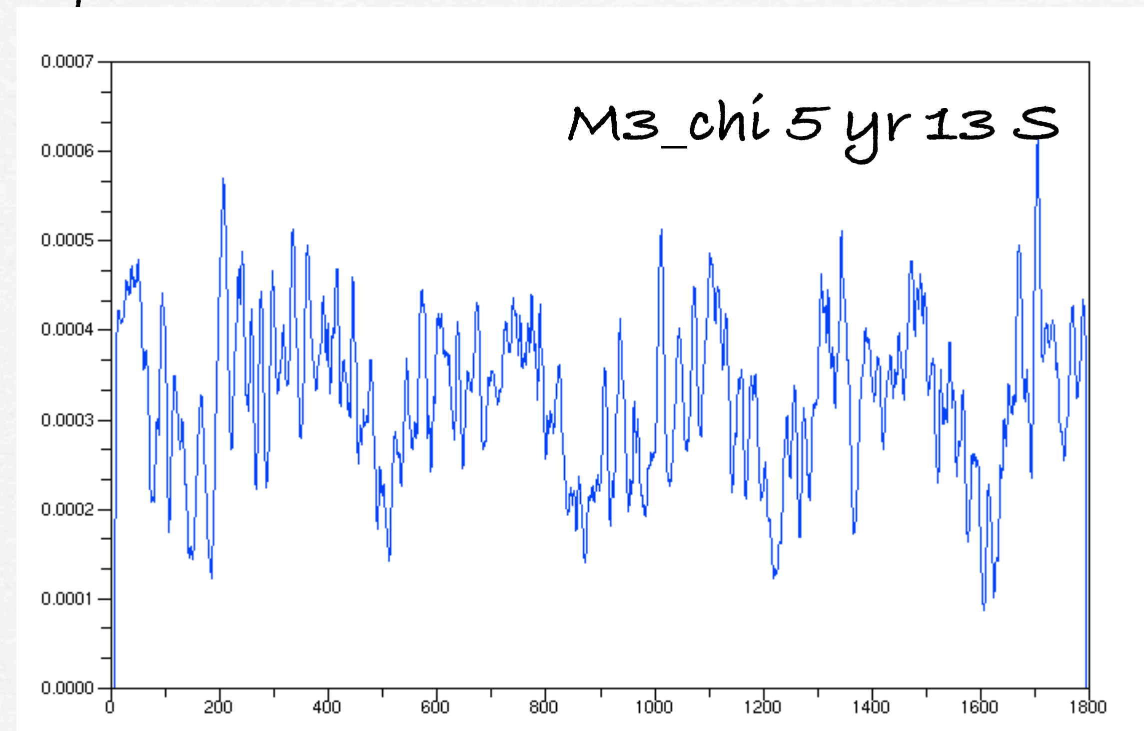
amplitude





days (period of 5 years)

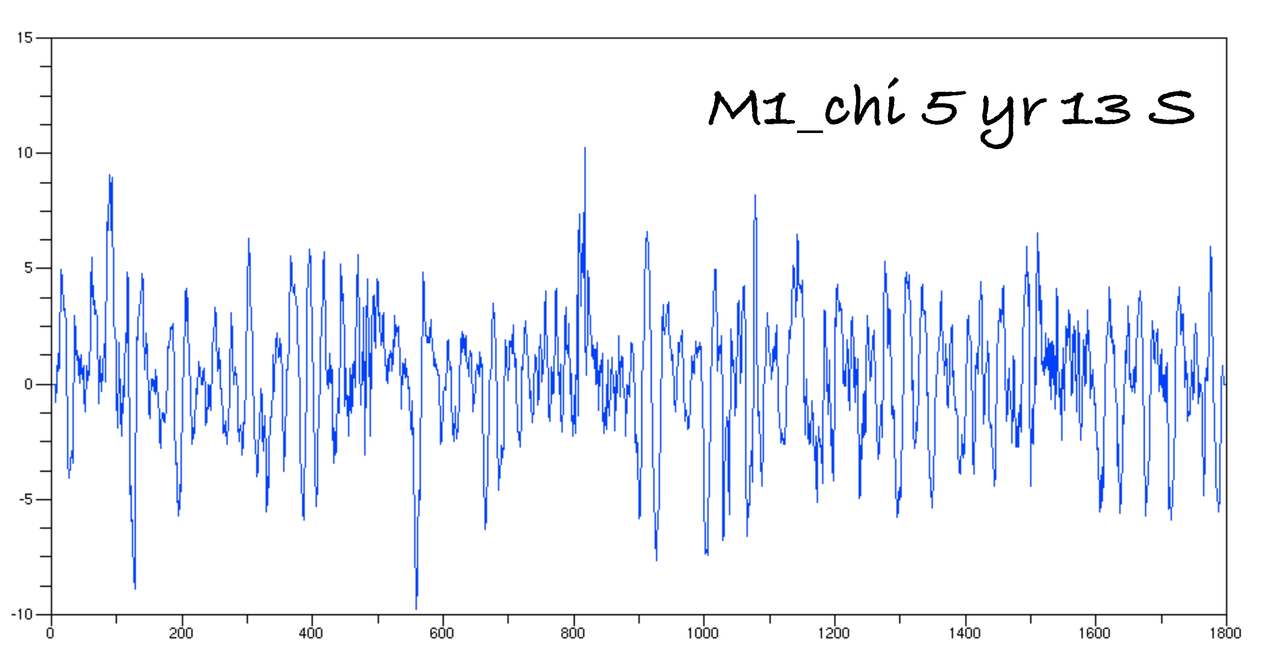
amplitude



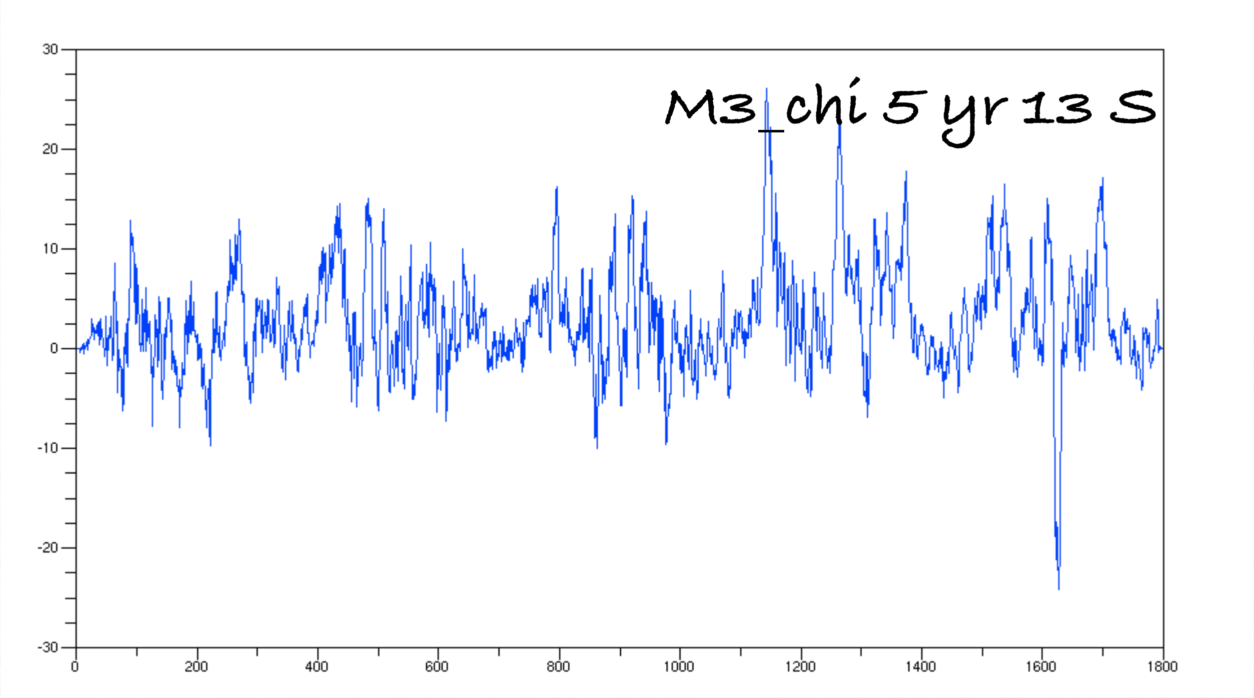
days (period of 5 years)

no annual cycle, variations

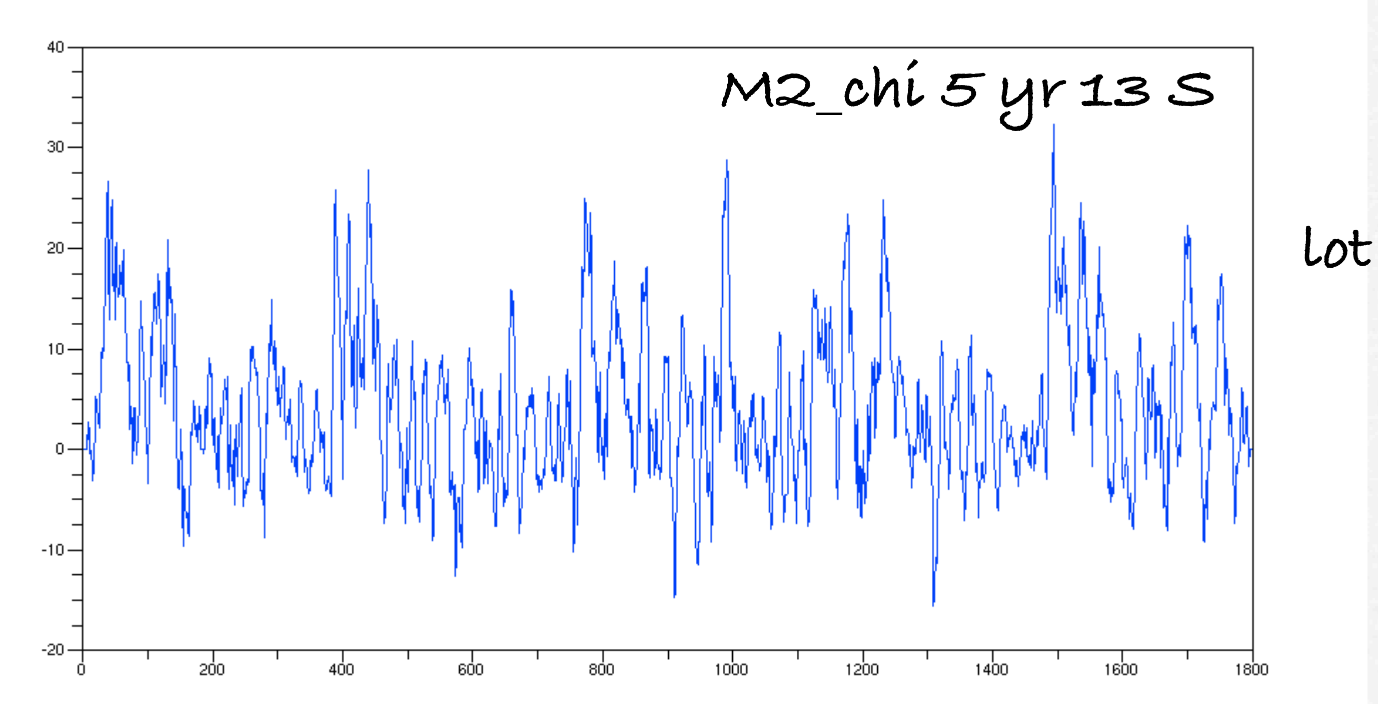
phase speed (m/s)



phase speed (m/s)



days (period of 5 years)



days (period of 5 years)

lot of short time scale variations, noise and no annual cycle

Conclusions

NH: strong amplitude in summer
strong variation in phase speed in winter
13 N same thing (especially M2-MJO spatial scale)

SH: lot of variability and weak annual cycle

for propagating equatorial disturbances winter is the most active even though amplitude is strong in summer (Lin, Brunet, Derome had luck with choosing that season :))

plans for future: coherence between latitudes
physical characterization of propagating phenomena in winter (M=2)