High-resolution atmospheric angular momentum functions from different ECMWF data classes

Journees "Systèmes de référence spatio-temporels"

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High-resolution atmospheric angular momentum functions

GGOS Atmosphere

- funded by the FWF, the Austrian Science Fund
- based on a common data stream from the ECMWF, four prime quantities are determined in a consistent way:
    - ❖ Atmospheric Angular Momentum Functions AAM
    - ❖ Atmospheric Pressure Loading Corrections APL
    - ❖ Atmospheric Gravity Corrections AGC
    - ❖ Atmospheric Delays

http://ggosatm.hg.tuwien.ac.at/

High-resolution atmospheric angular momentum functions

Earth rotation excitation at daily and sub-daily periods, investigated with 2 different sets of AAM functions:

1. **6-hourly AAMF** from standard ECMWF data:

   'Atmospheric model' analysis

2. **3-hourly AAMF** from the reorganized assimilation system:

   'Atmospheric model (delayed cut-off)'

- cut-off time = latest possible arrival time for observations
- analysis cycles are combined with short-term forecasts in order to delay cut-off time and make products available earlier

Time span: 1 July 2004 to 30 June 2010

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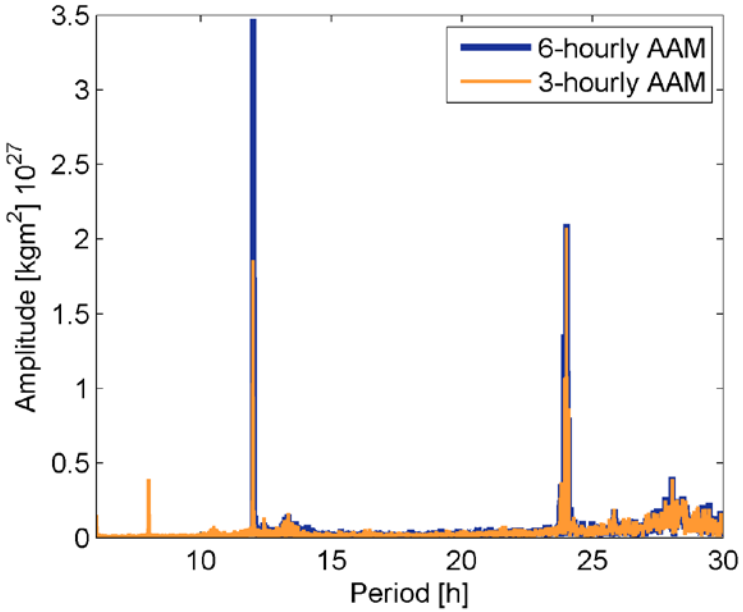
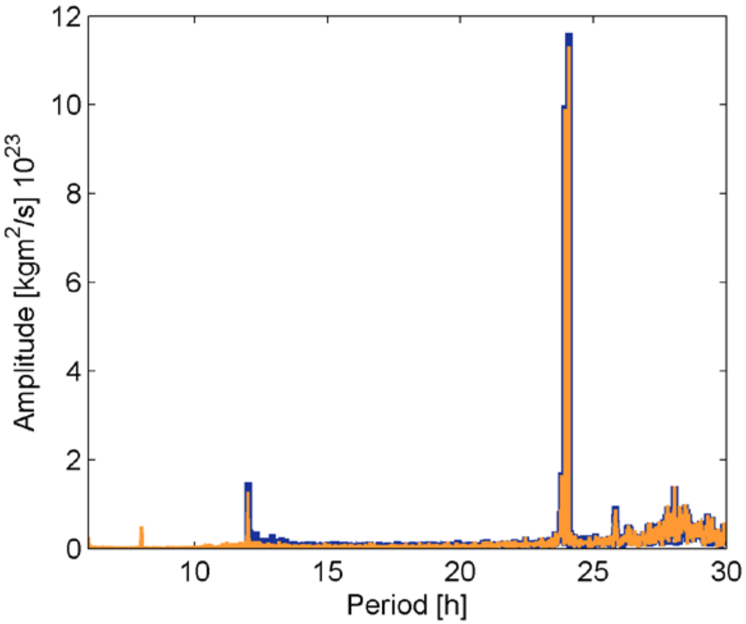
Amplitude spectra of AAM components:

inertia tensor due to atmosphere, component c_{23}



relative angular momentum, component l_1



- 6-hourly sampling restricts resolution in semi-diurnal band
- good agreement in these one-sided spectra

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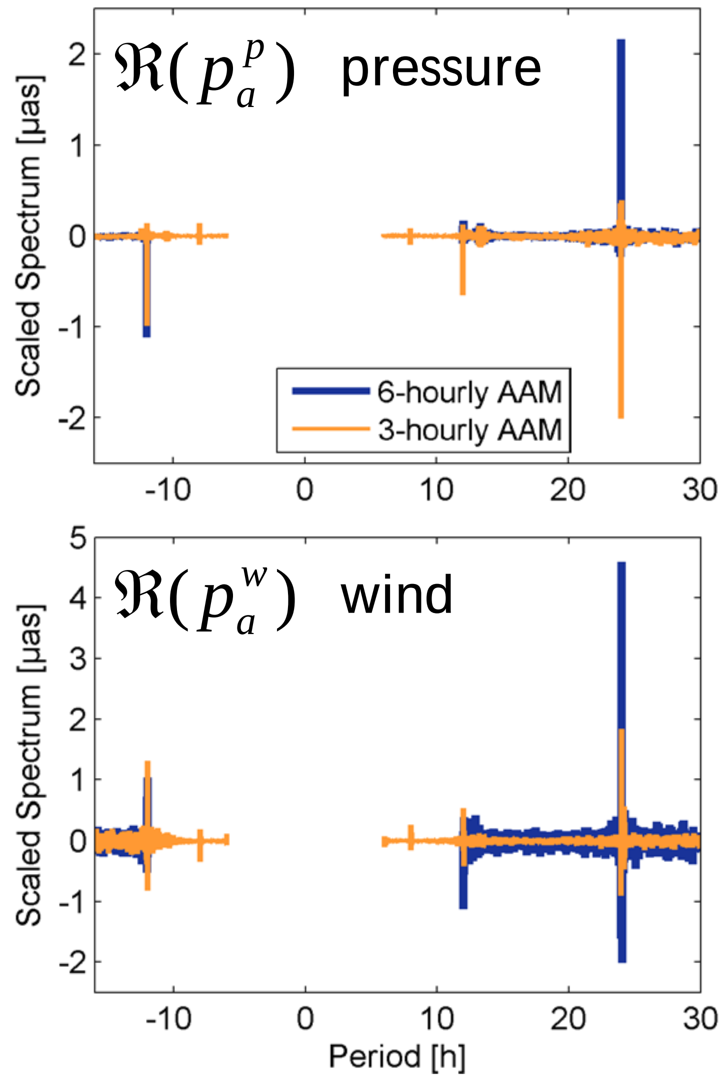
Conversion to atmospheric excitation:

- AAM $\rightarrow$ AAMF
- Convolution of equatorial AAMF with transfer function of Brzezinski et al. [2002] in frequency domain

  $\rightarrow$ atmospheric exc. of polar motion: $p_a(\sigma)$

Two-sided spectra:

- Different signs of peaks
- 6-hourly wind term noisier



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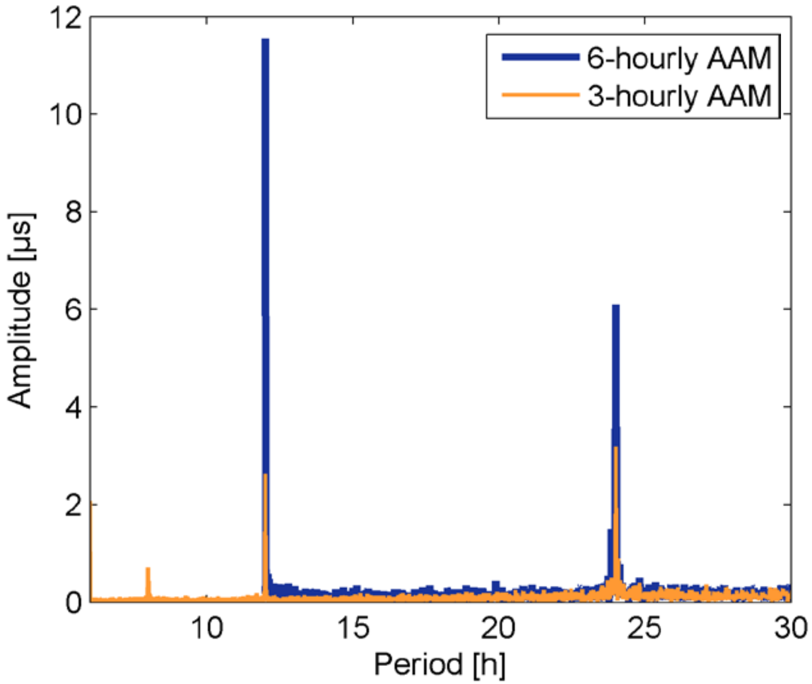
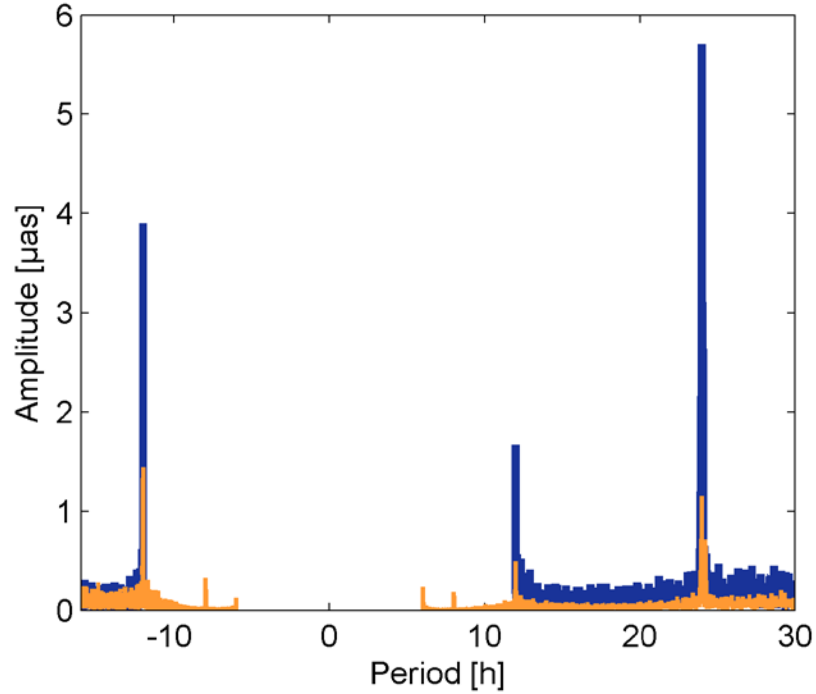
Atmospheric excitation:

LOD



Polar motion



- amplitude estimates (and noise) are smaller for 3-hourly AAM
- peaks in polar motion < 2 µas

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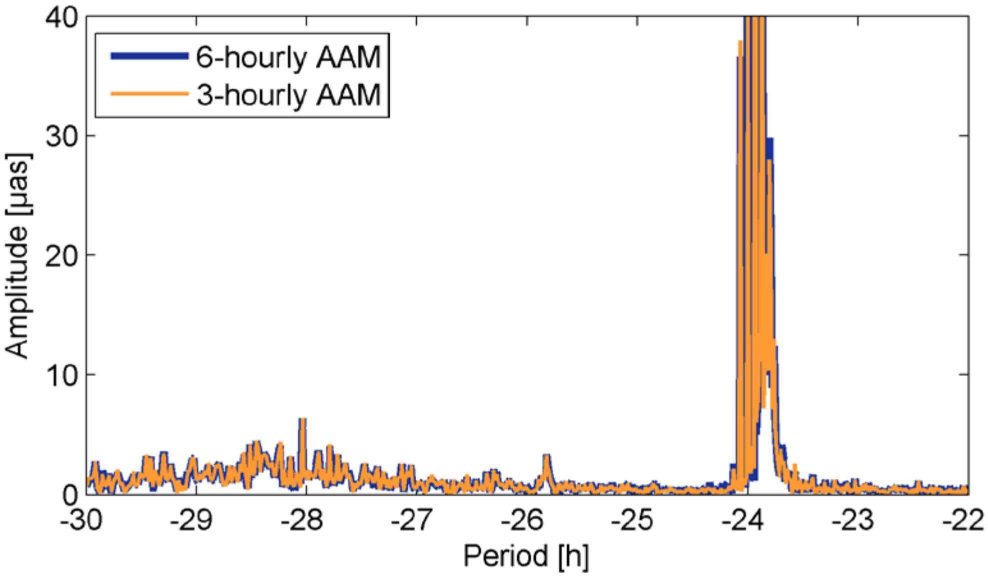
Nutation:

The good agreement seen in the one-sided spectra emerges in this band!



Main atmospheric tides:

Diurnal tides [h]		Semi-diurnal tides [h]	
π1	24.13214		
P1	24.06589	T2	12.01645
S1	**24.00000**	**S2**	**12.00000**
K1	23.93447	R2	11.98360
ψ1	23.86930		
ϕ1	23.80448		

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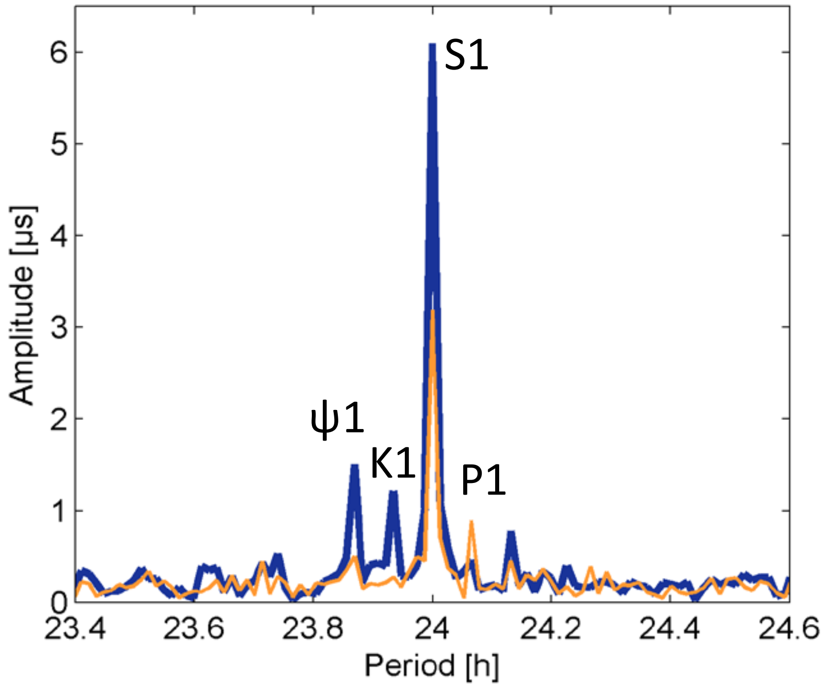
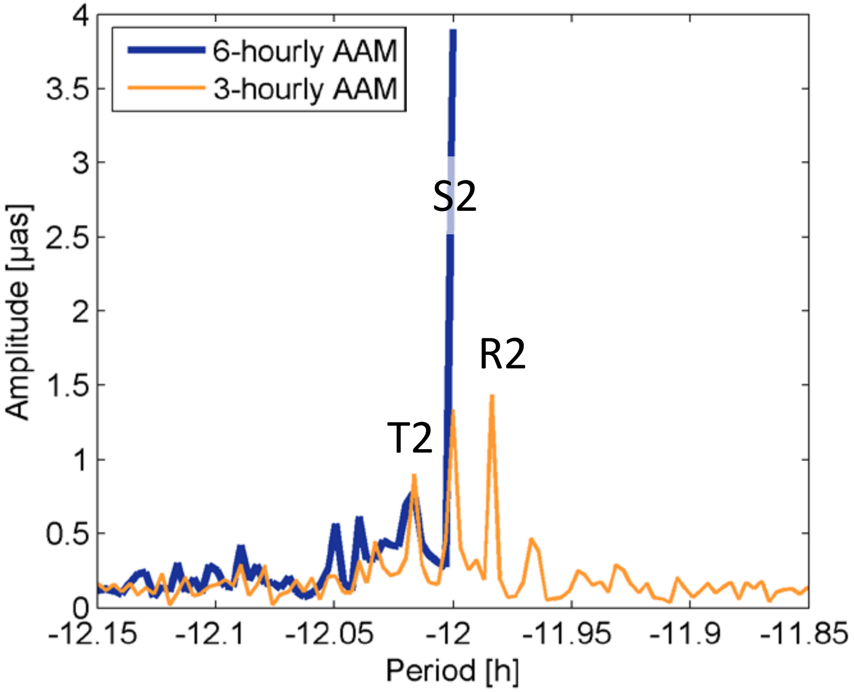
By-eye detection of atmospheric tides:

LOD



Polar motion



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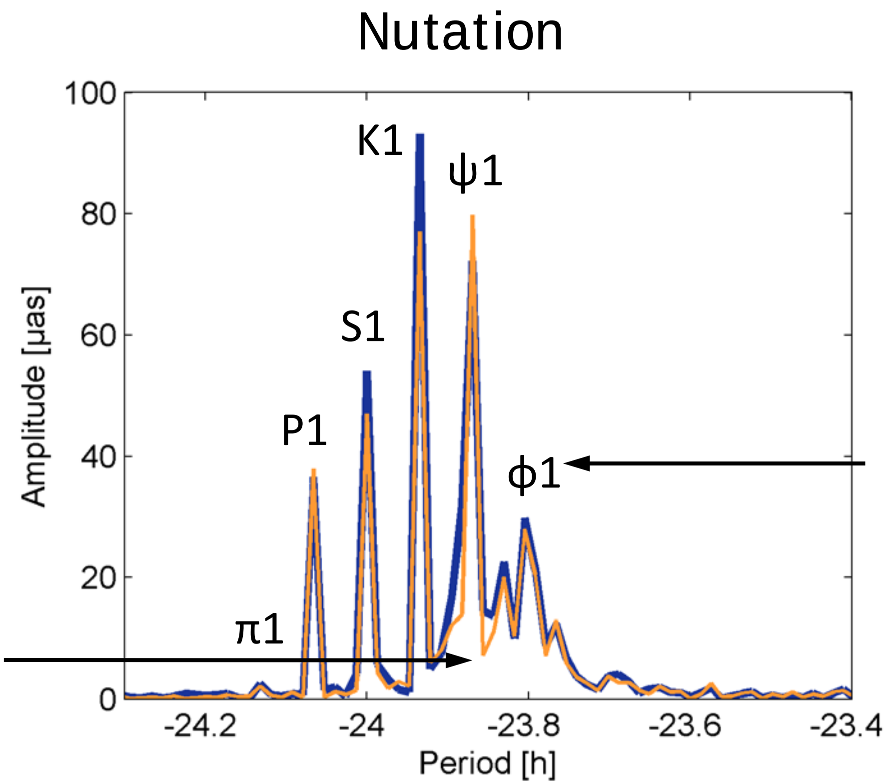
By-eye detection of atmospheric tides:



retrograde semi-annual wobble in celestial frame

Spectral content around NDFW is amplified

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Least squares adjustment on atmospheric excitation:

- Axial excitation modeled as $l(t)=\sum_{j=1}^{ntides} a_j \cos(\omega_j t) + b_j \sin(\omega_j t)$

  j ... partial tide with frequency ω and
  unknown Fourier coefficients a and b

  → phase and mean amplitude of tidal wave

- Equatorial excitation adjusted similarly, but real and imaginary part treated separately, yields real pro-/retrograde and imaginary pro-/retrograde amplitudes

  → pro-/retrograde phases and mean amplitudes of tidal wave

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Least squares adjustment: mean amplitudes from 3-hourly AAMF

nutation amplitudes

	Period [h]	equ. progr.	equ. retrogr.	axial
π1	24.13214	0.4	2.1	0.5
P1	24.06589	0.4	37.9	0.9
S1	**24.00000**	**1.1**	**47.0**	**3.2**
K1	23.93447	0.7	77.0	0.3
ψ1	23.86930	0.2	79.8	0.5
ϕ1	23.80448	0.0	27.9	0.2
T2	12.01645	0.5	0.9	0.6
S2	**12.00000**	**0.2**	**1.3**	**2.6**
R2	11.98360	0.3	1.4	0.5

amplitudes in [μas] (equatorial) and [μs] (axial)

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Counteraction of pressure and wind terms in 3-hourly AAMF:

- leads to small amplitudes
- = cancelling out when adding pressure term spectrum and wind term spectrum in frequency domain:

equatorial case: $$\left|p_a\right| = \sqrt{\Re(p_a)^2 + \Im(p_a)^2}$$

$$\Re(p_a) = \Re(p_a{}^p) + \Re(p_a{}^w)$$

$$\Im(p_a) = \Im(p_a{}^p) + \Im(p_a{}^w)$$

- visible in the time evolution of spectral content:
  - ❖ sliding window Fourier transform
  - ❖ normalized Morlet wavelet transform

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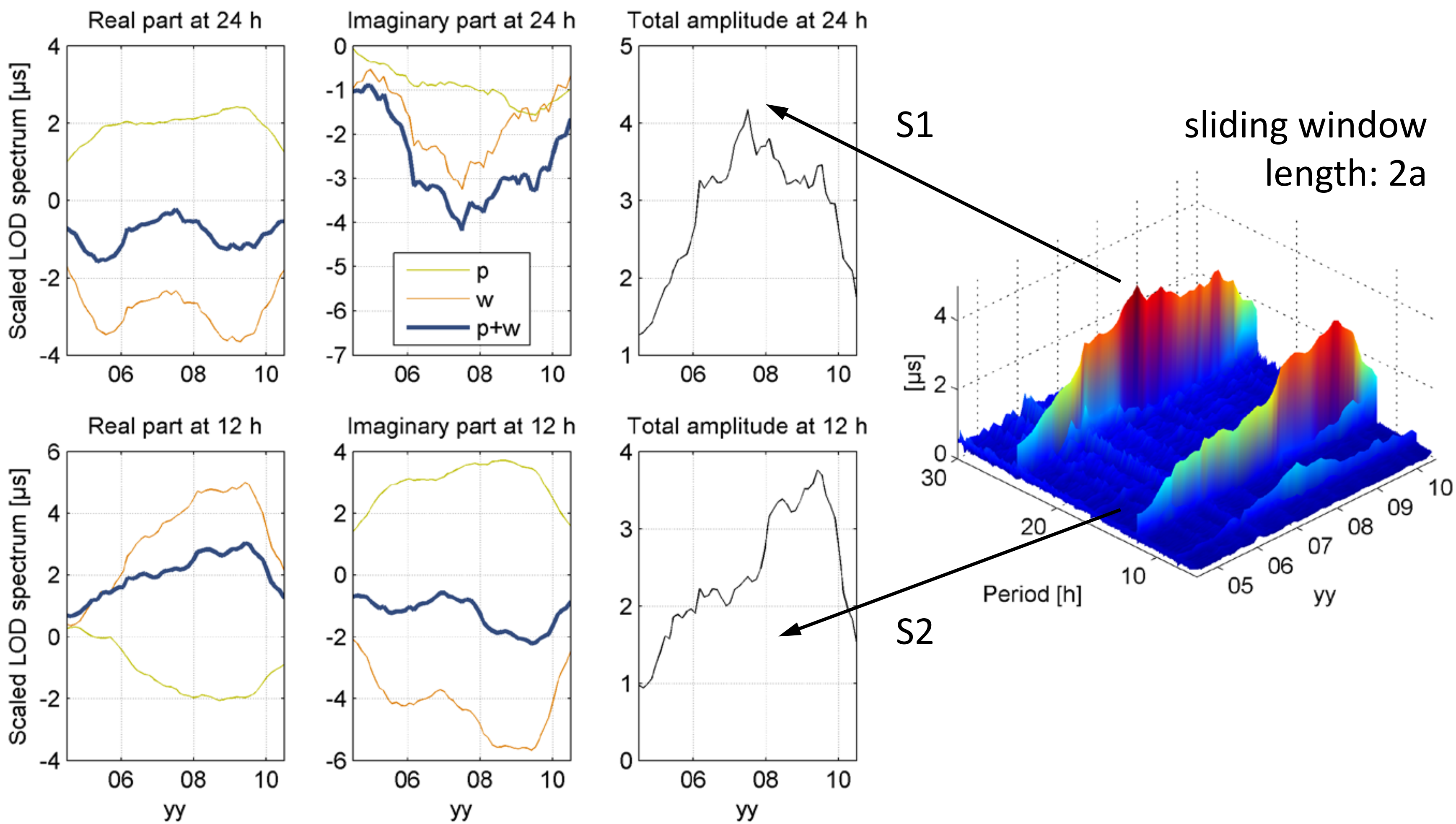
Counteraction in LOD, S1 and S2 band split up:



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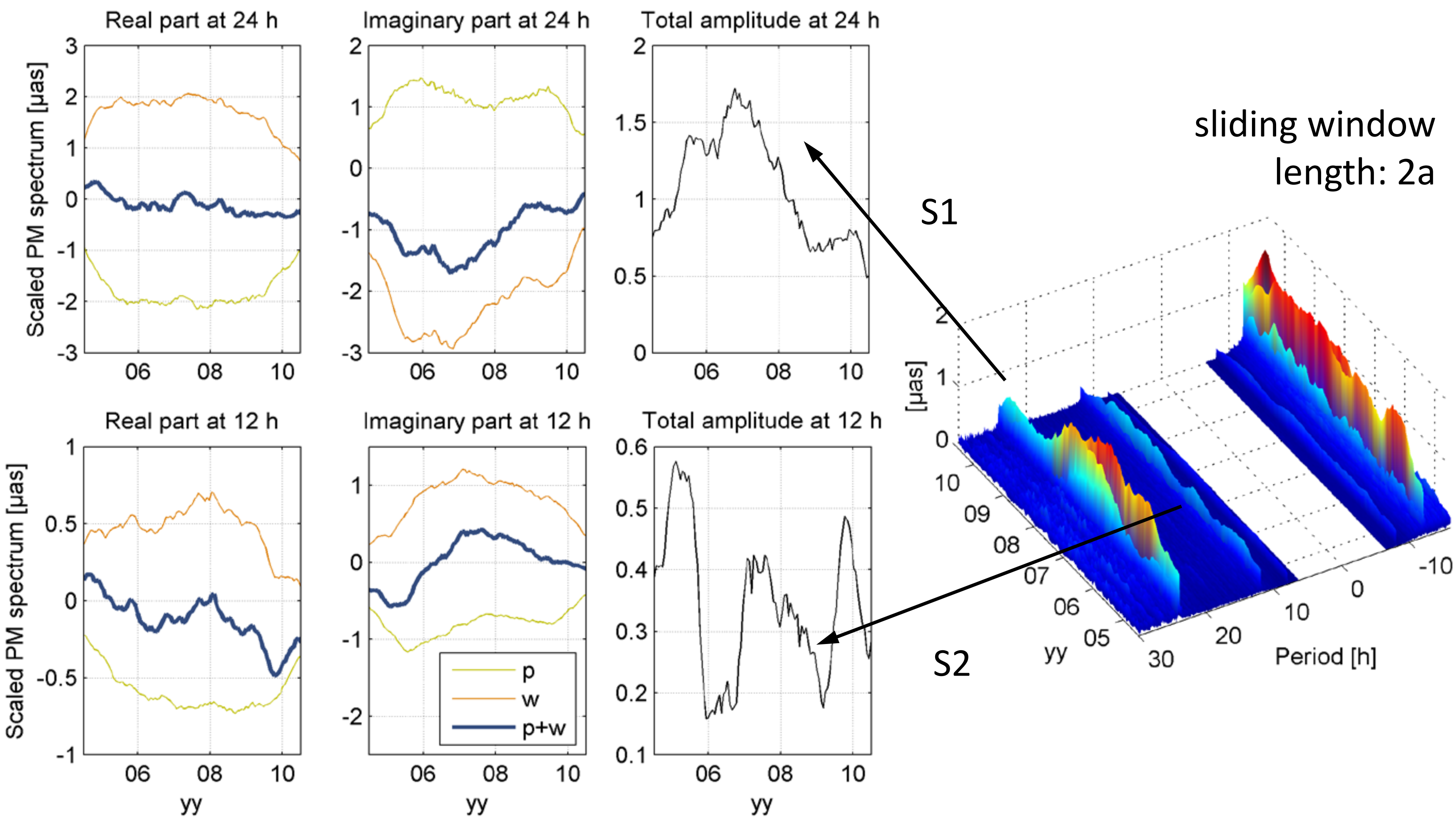
Counteraction in polar motion, S1 and S2 (prograde) band split up:



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Summary, conclusions:

- ❖ Two different ECMWF data classes yield different amplitudes and phases in atmospheric excitation of Earth rotation.
- ❖ However, nutation amplitudes are in good agreement.
- ❖ S2 and its side lobes show up in the delayed cut-off series.
- ❖ Small amplitudes in polar motion and LOD can be ascribed to the ‘counteraction’ of pressure and wind terms.

Outlook:

- ❖ Physical reasoning for counteraction.
- ❖ Of more practical importance: atmospheric forcing of nutation.

The End

Thanks for your attention!