Seasonal variability of diurnal seiches in Gulf of Riga

V. Frishfelds, U. Bethers, J. Sennikovs, A. Timuhins
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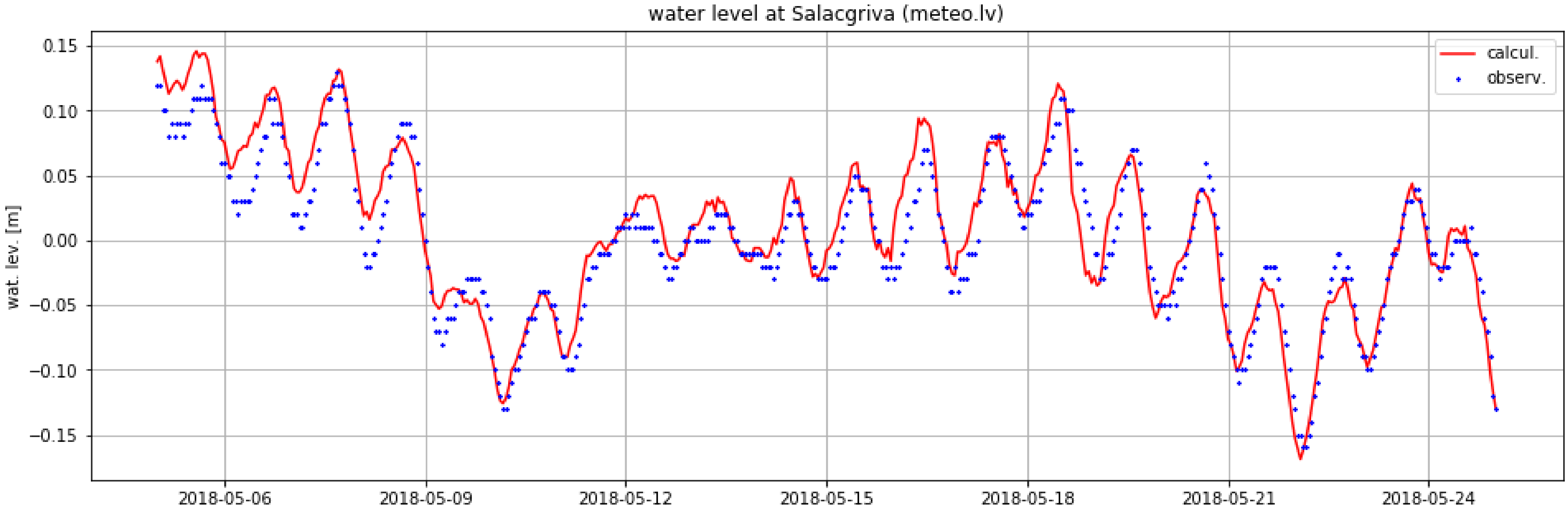

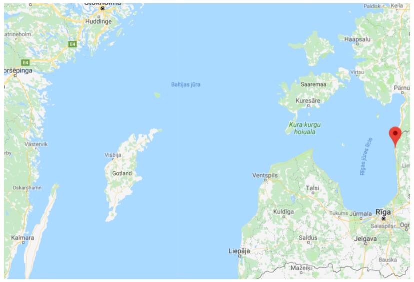

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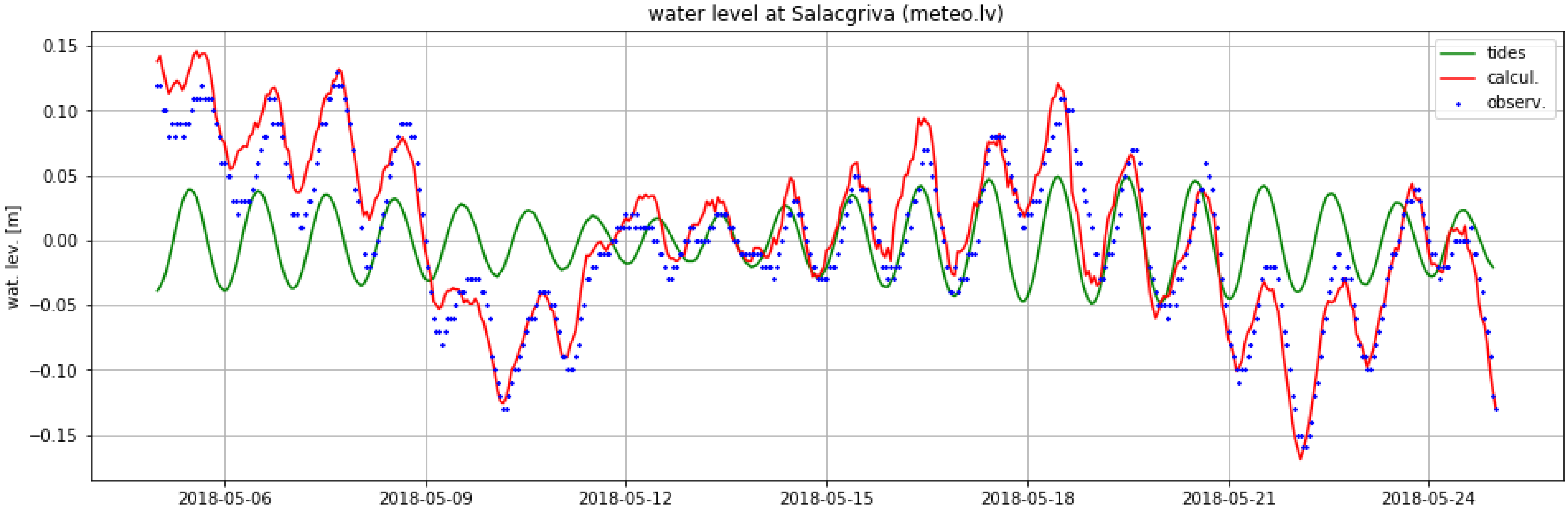
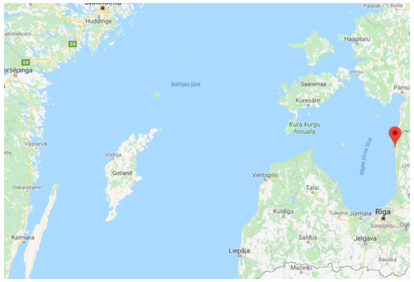
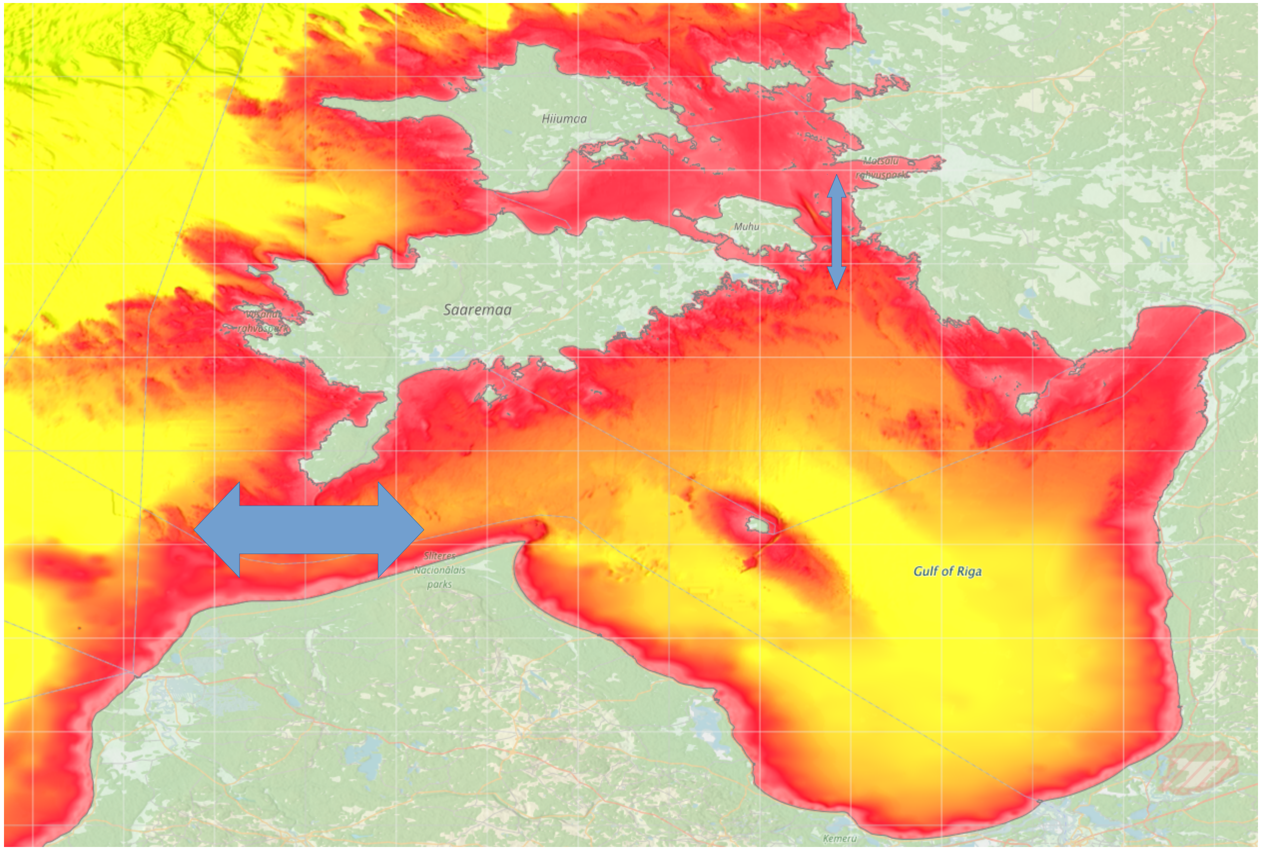




Uninodal oscillations Baltic proper – Gulf of Riga

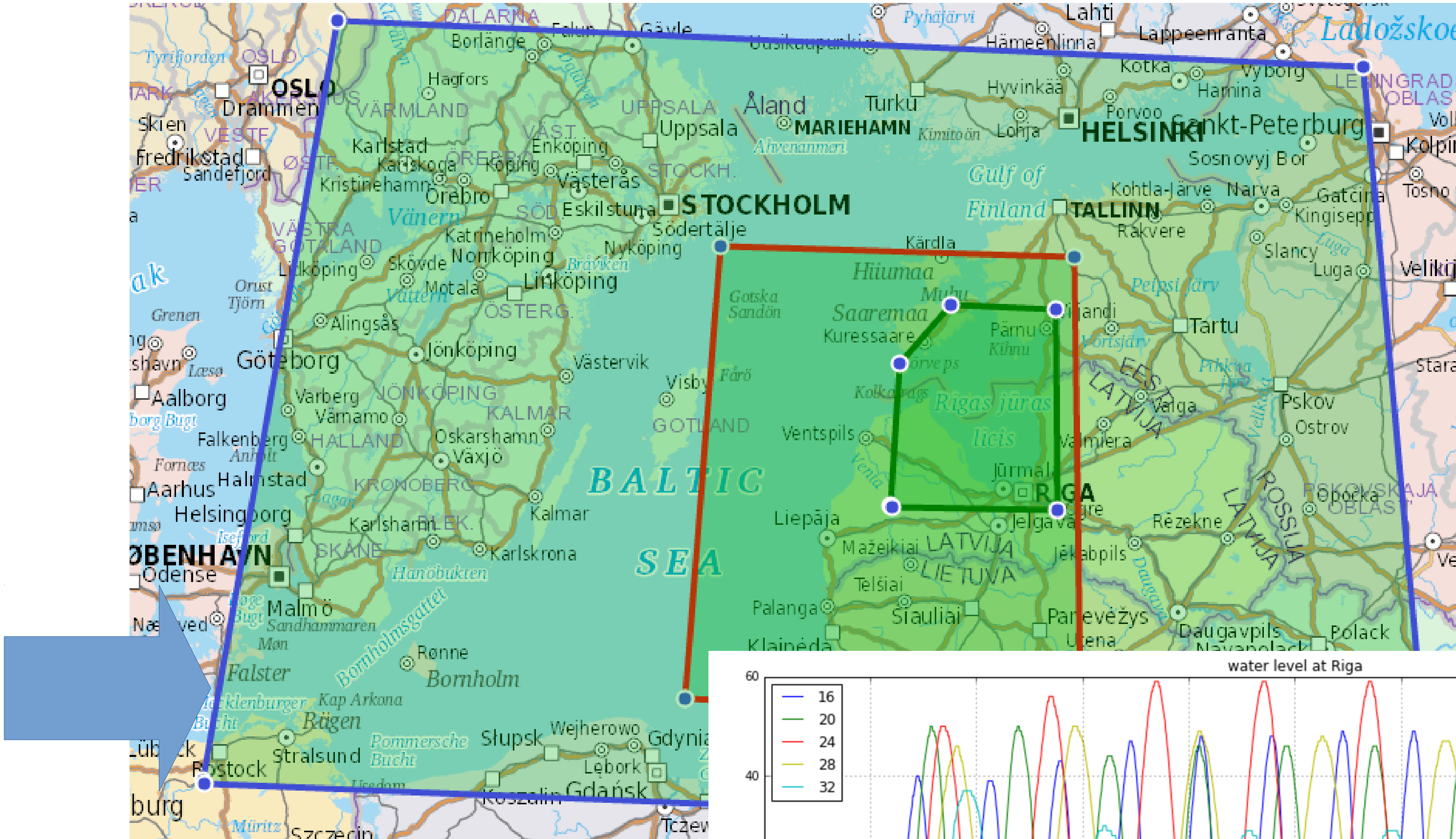


For water level in Gulf:

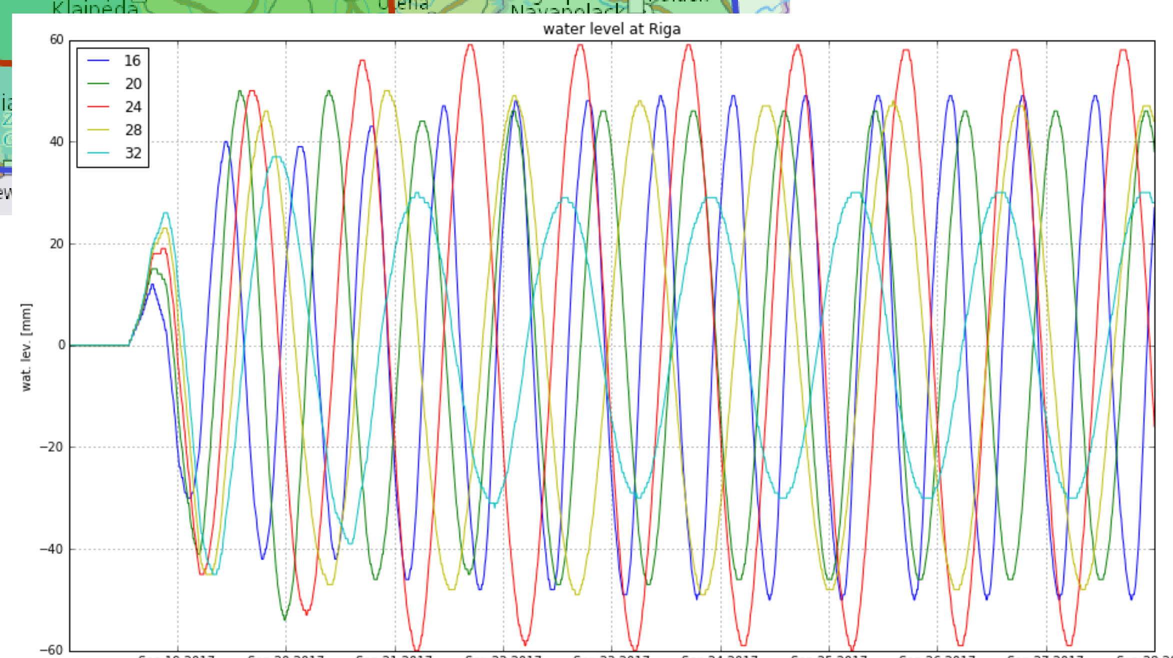
$$\omega_{Gulf} = \sqrt{\frac{gA_{Irbe}}{L_{Irbe}A_{Gulf}}}$$

M. Otsmann, U. Suursaar, T. Kulla. Transactions on the Built Environment, **40**, 1999

Modelling of forced seiches by HBM

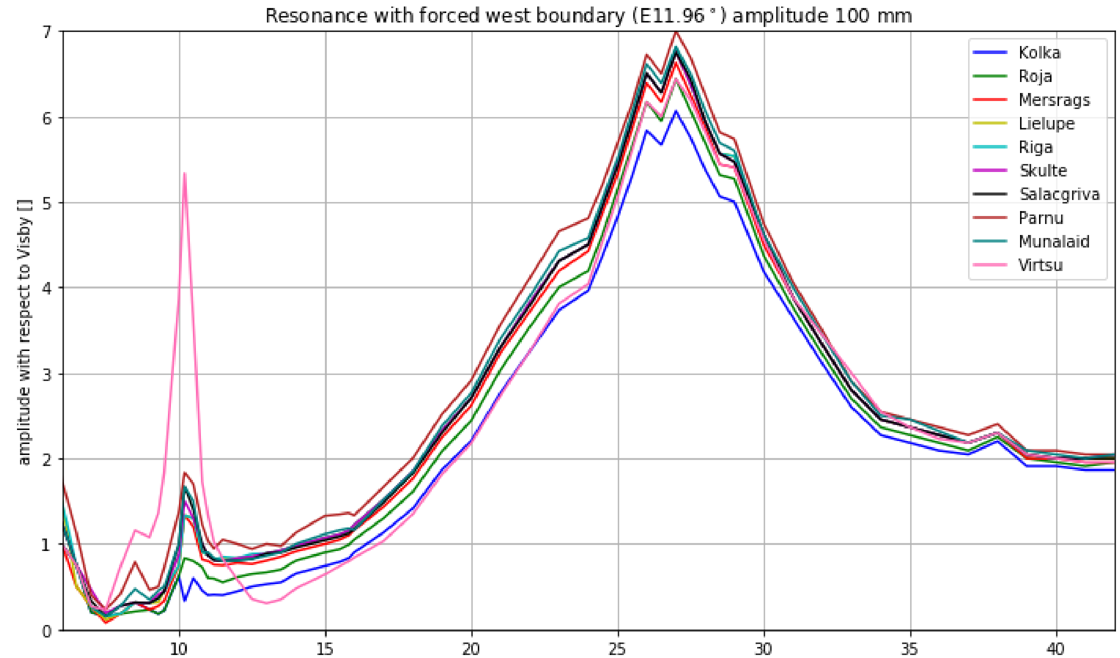


Western wet boundary is oscillated by amplitude of 10 cm

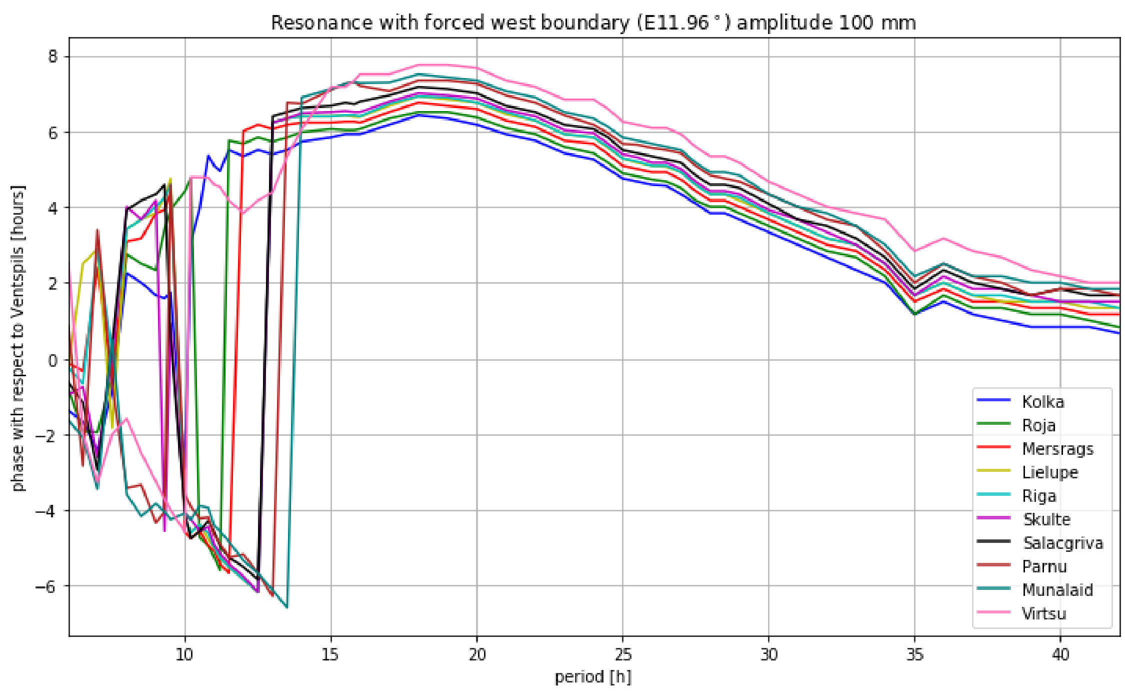


Homogeneous liquid, no other forces

Amplitude, phase – period in Gulf of Riga



Relative amplitude with respect to Visby

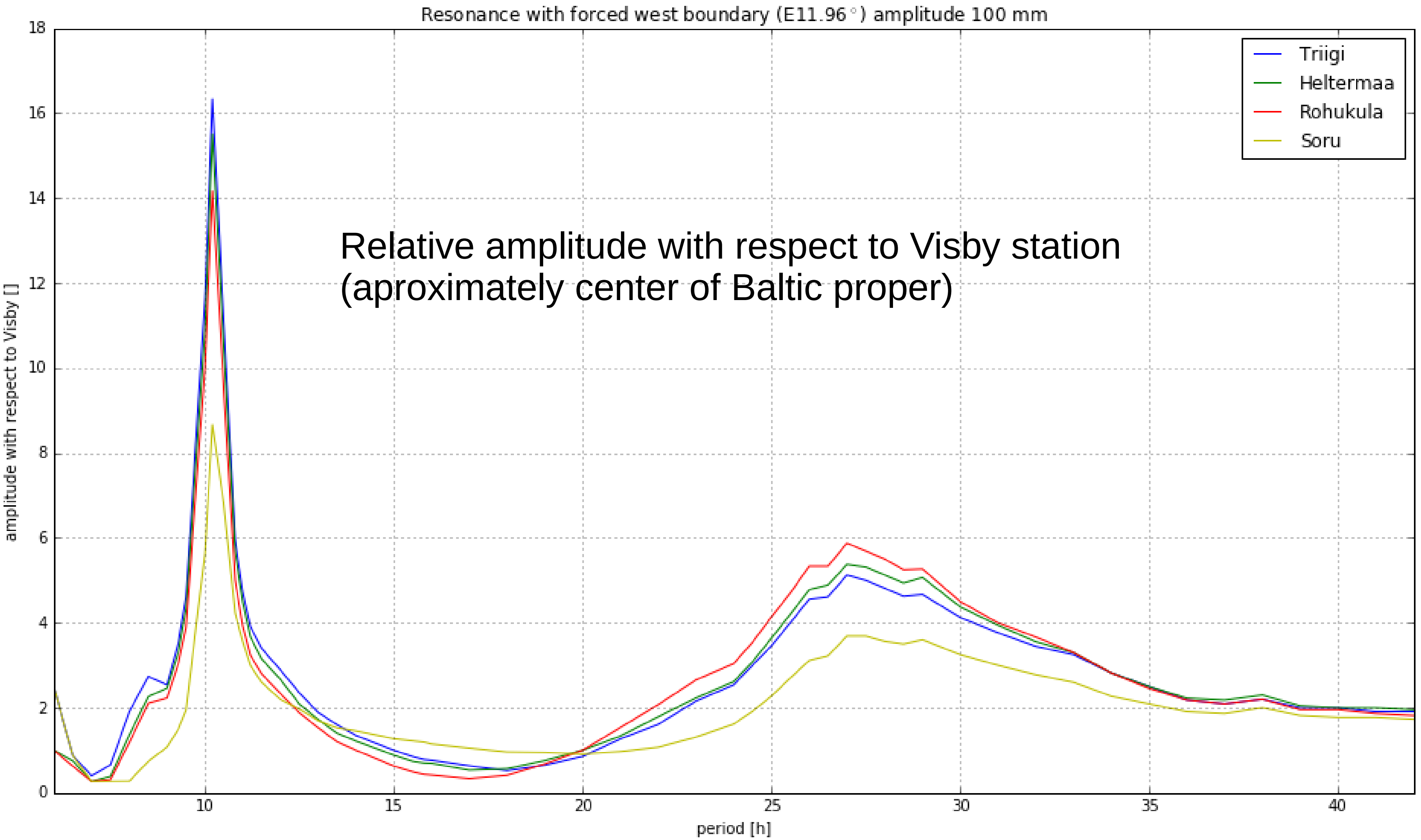


Phase in hours with respect to Ventspils

~6 h

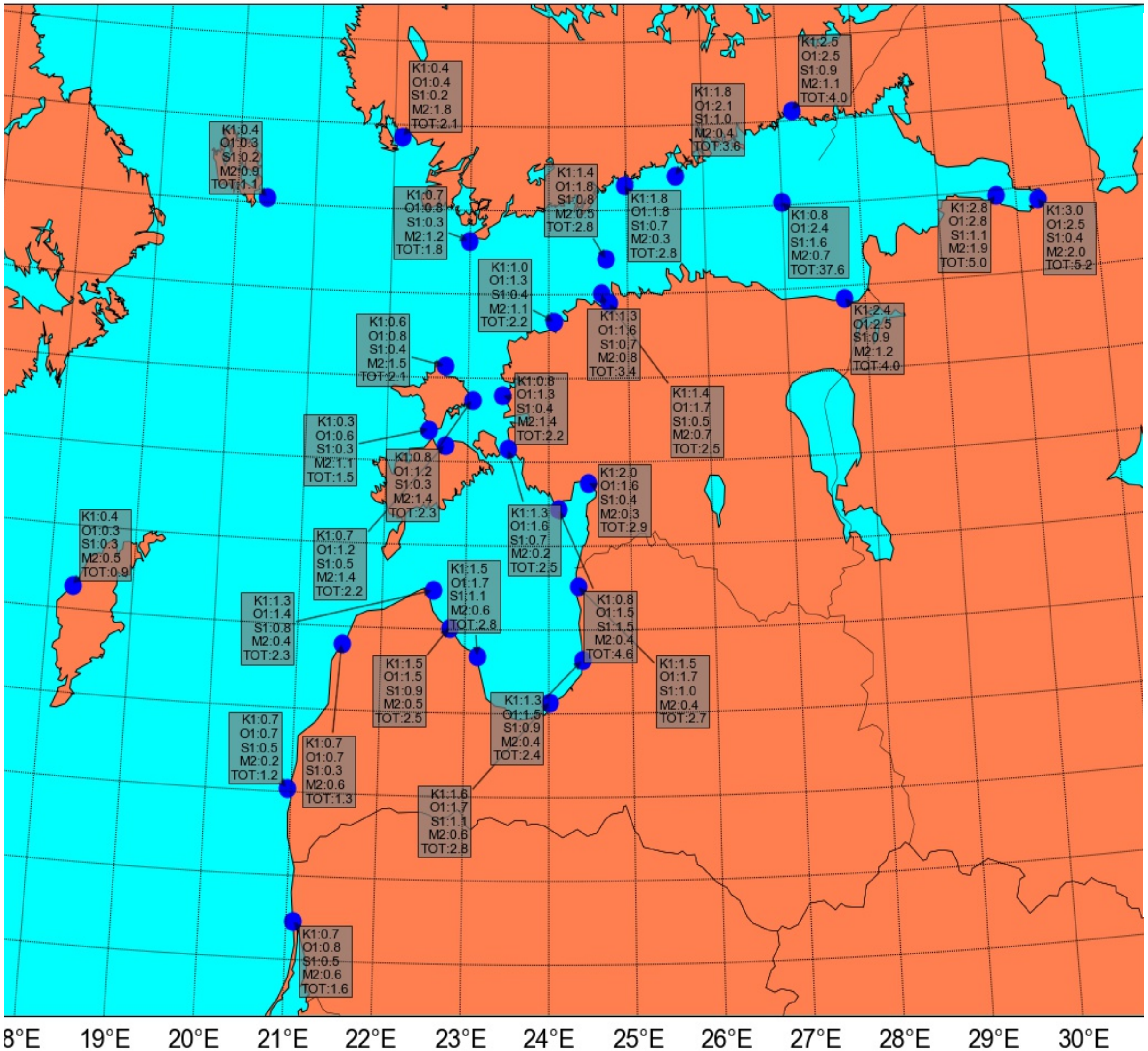
MJ Lilover, U Lips, J Laanearu, J, Liljebladh, Aquat.sci, 1998

Amplitude – frequency in Väinameri sea

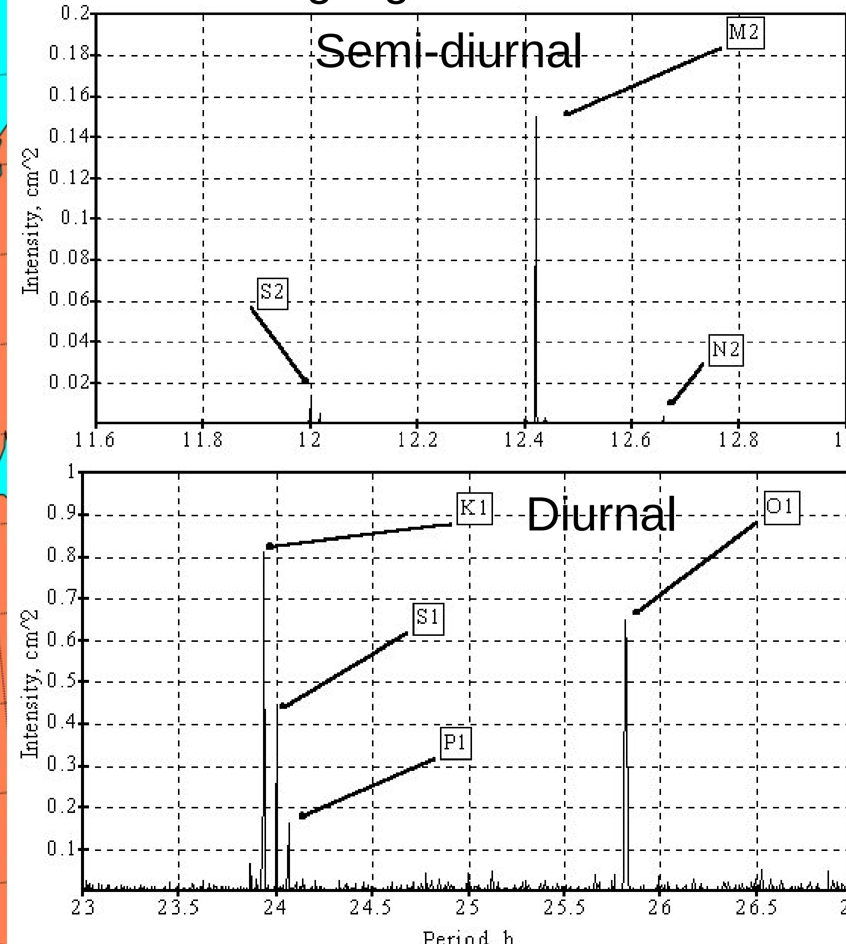


Relative amplitude with respect to Visby station (aproximately center of Baltic proper)

Fourier spectrum of water level

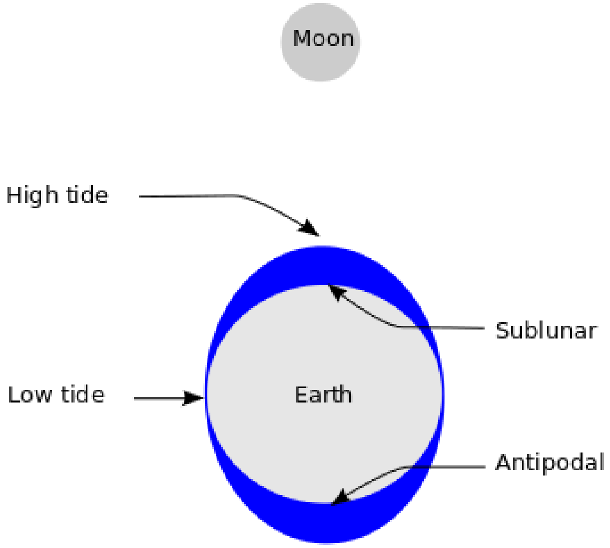


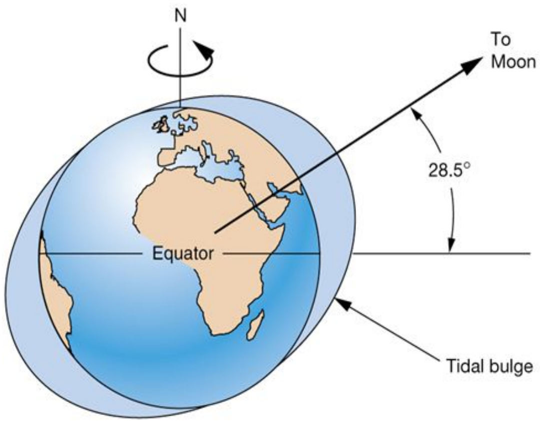
Daugavgriva station



M. Keruss, J. Sennikovs. Determination of tides in Gulf of Riga and Baltic Sea. Proc. International Scientific Colloqium 'Modelling of Material Processing', Riga, May 28 - 29, 1999.

Principal gravitational tidal components

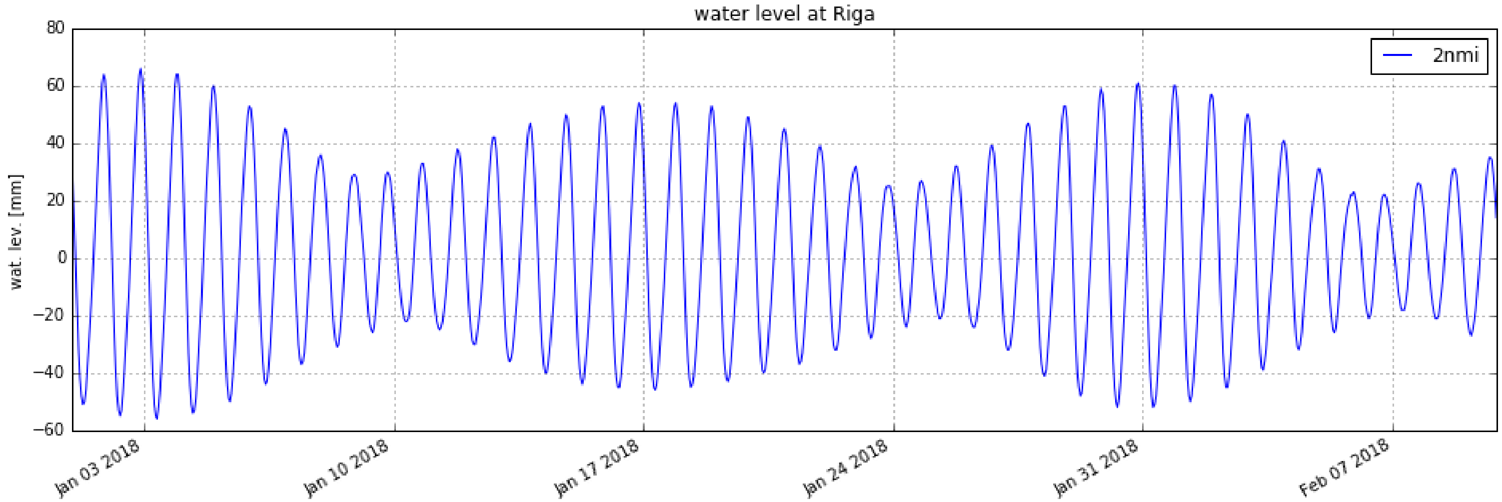




Sun crosses the same meridian = 1 day	**S_2=12 h** S_1=24h	**Semi-diurnal**
Moon crosses the same meridian = 1.035 days	**M_2=12.42 h** M_1=24.84 h	
Declination of the Moon = 1/ (1/1.035±1/27.32) days	**K_1=23.93 h** **O_1=25.82 h**	**Diurnal**
Declination of the Sun = 1/ (1±1/365.24) days	**K_1=23.93 h** **P_1=24.07 h**	

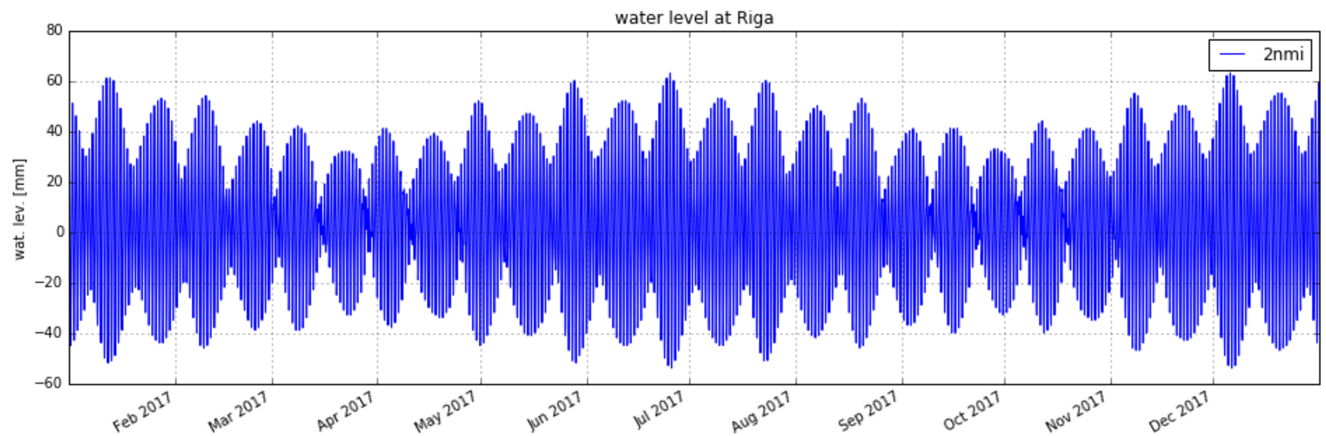
Amplitude of S_1 component: $S_1 = 0.005\,K_1$

Influence of tides in water level in Daugavgriva

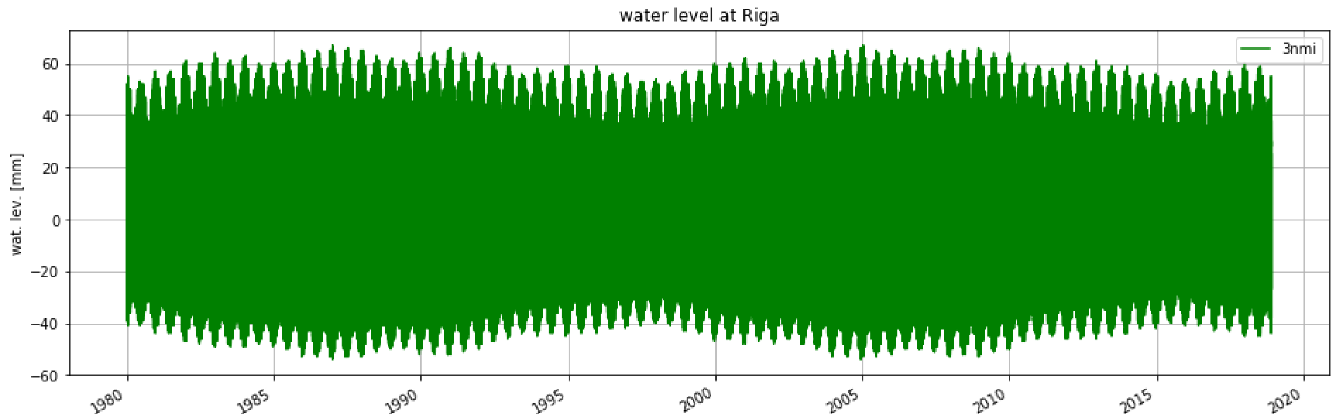


HBM model with homogeneous water, only tidal forces

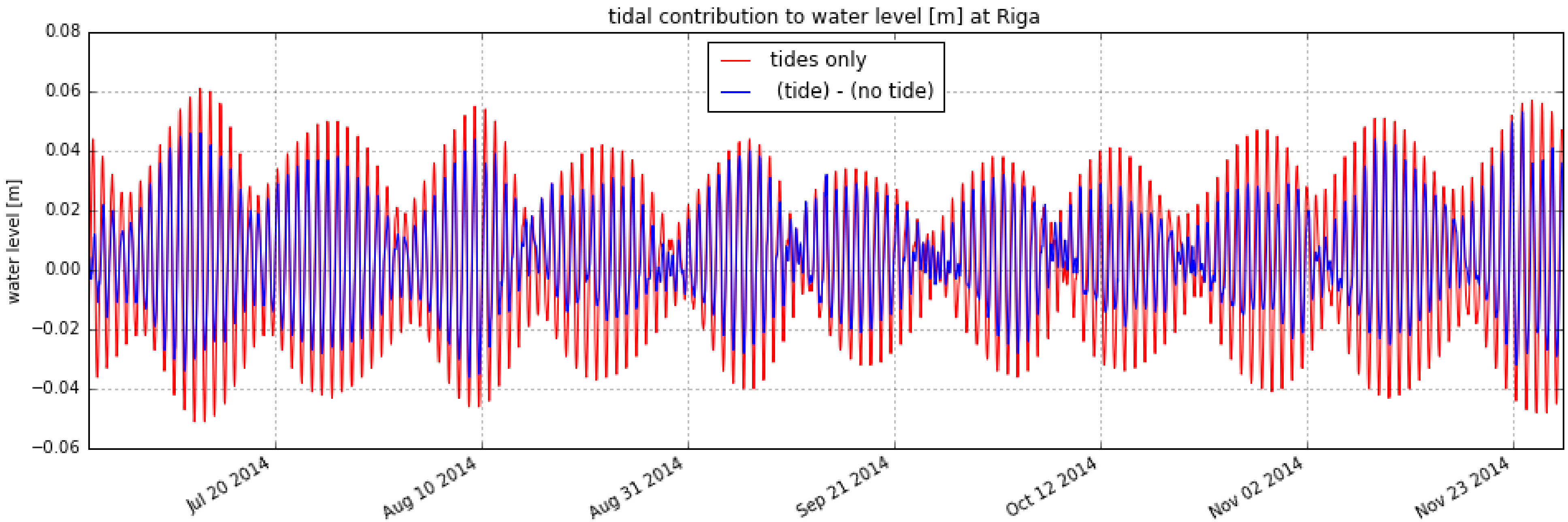
Yearly change in tidal amplitudes. Effect of Sun's declination



18.61 year cycle. Lunar orbit is changing ±5º against Earth orbit



Tidal influence on water level in real conditions

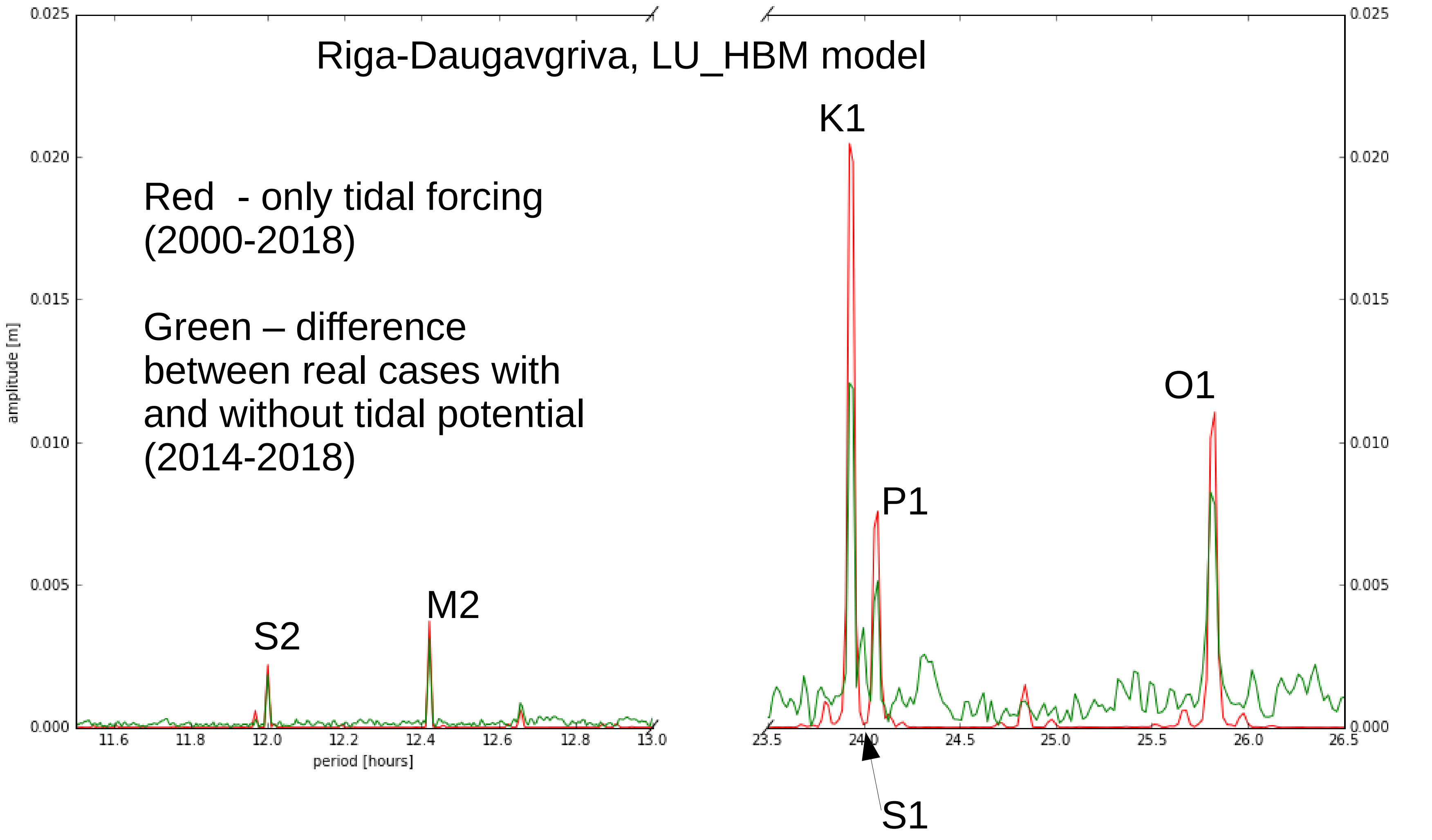


Red – only tidal forces for homogeneous liquid

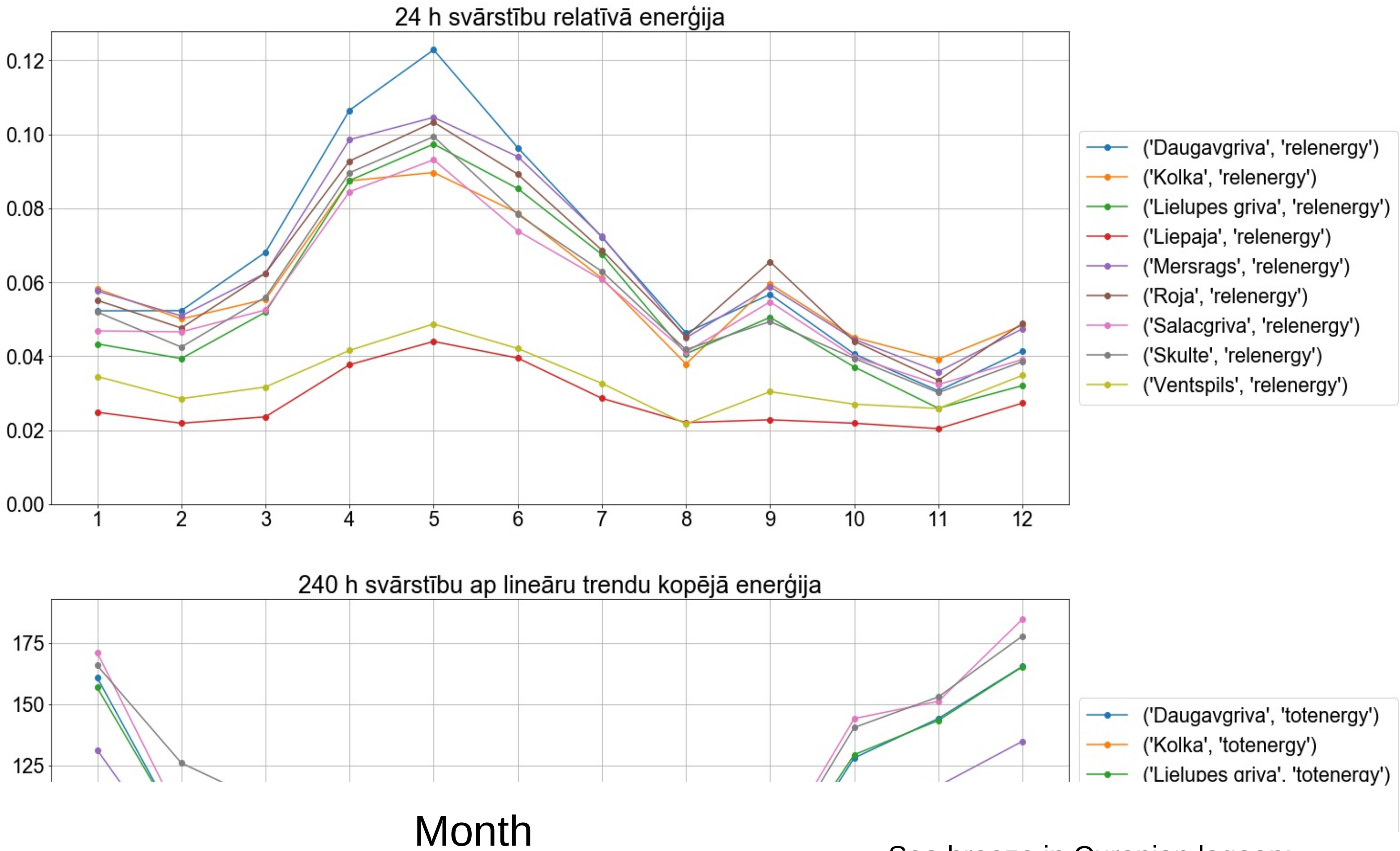
Blue – difference between real cases of with and without tides: atmospheric forcing (DMI HIRLAM), stratification, boundary conditions, etc.

S_1 component (24 h) is absent in pure gravitational model

But the amplitude of K_1 (23.93 h) is increased.

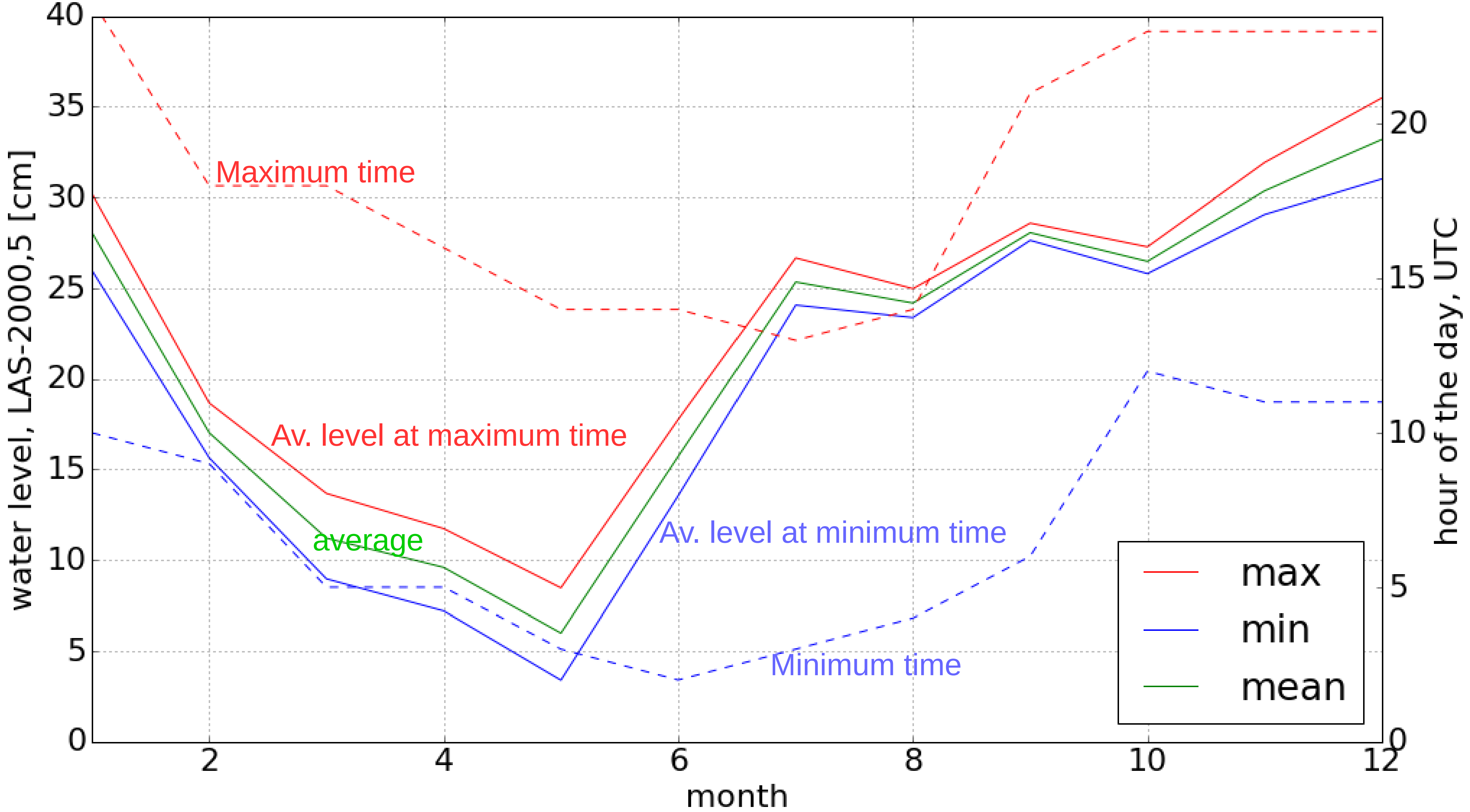


Amplitude of S_1 component: relative intensity in observations

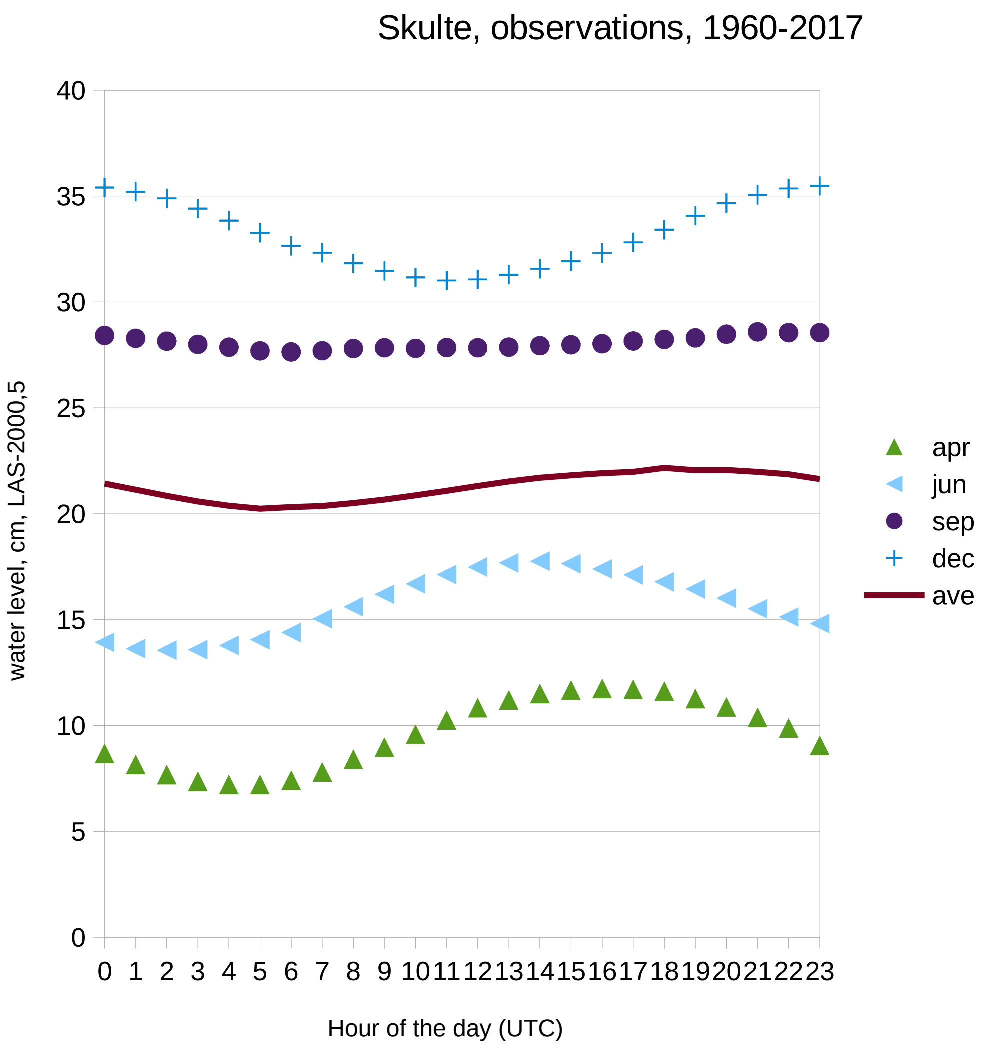


Sea breeze in Curonian lagoon:
A.Rabinovich, I.Medvedev, Oceanology, 2015, Vol. 55, pp. 319

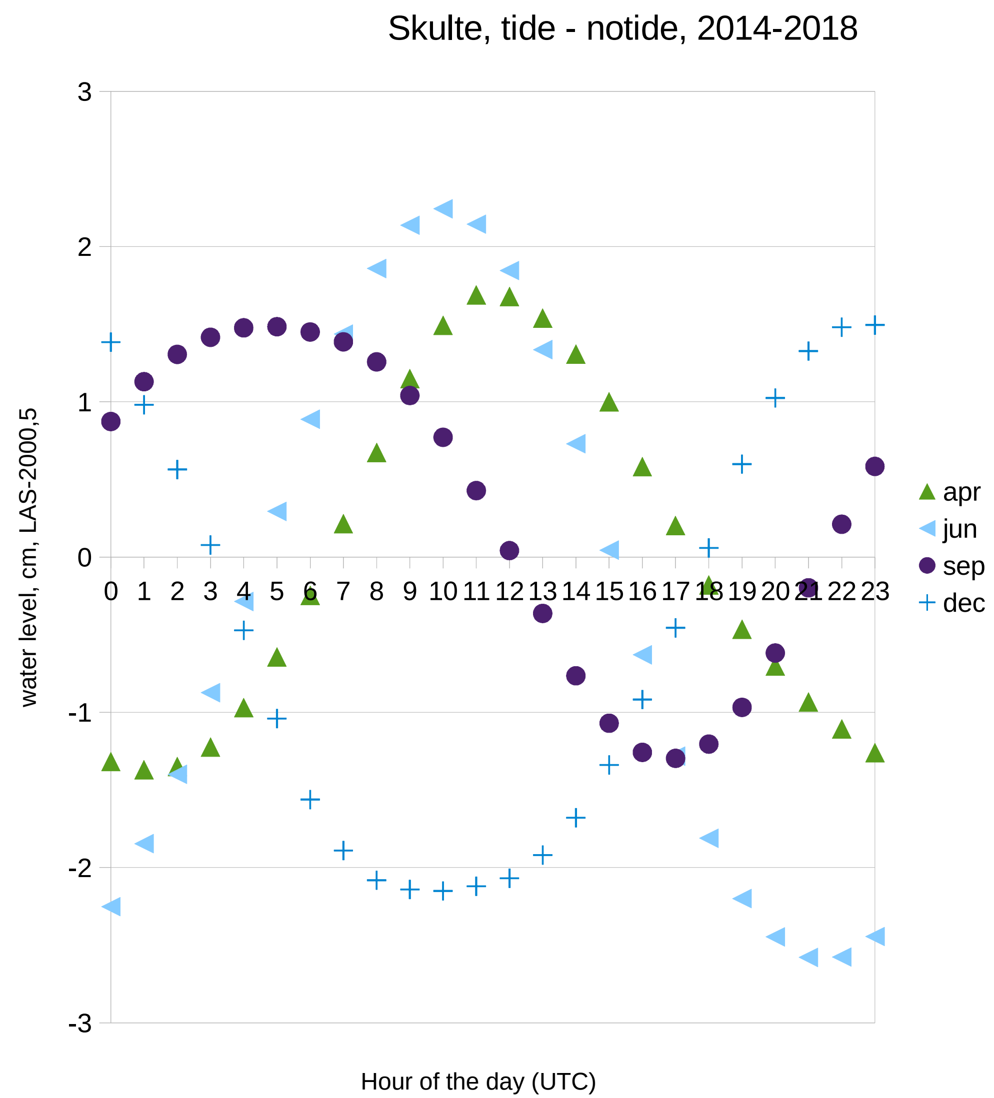
Water level observations (1960-2018) in Skulte



Daily variations, observations and tidal part



Water level observations

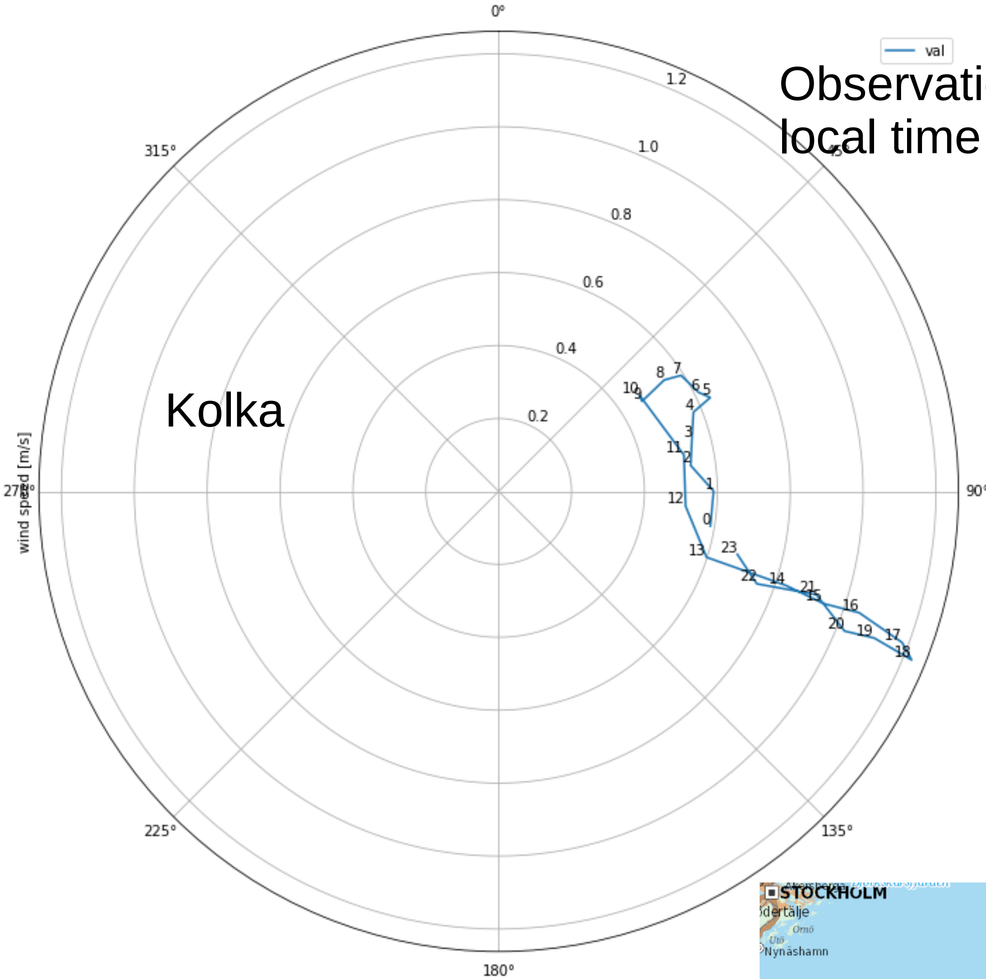


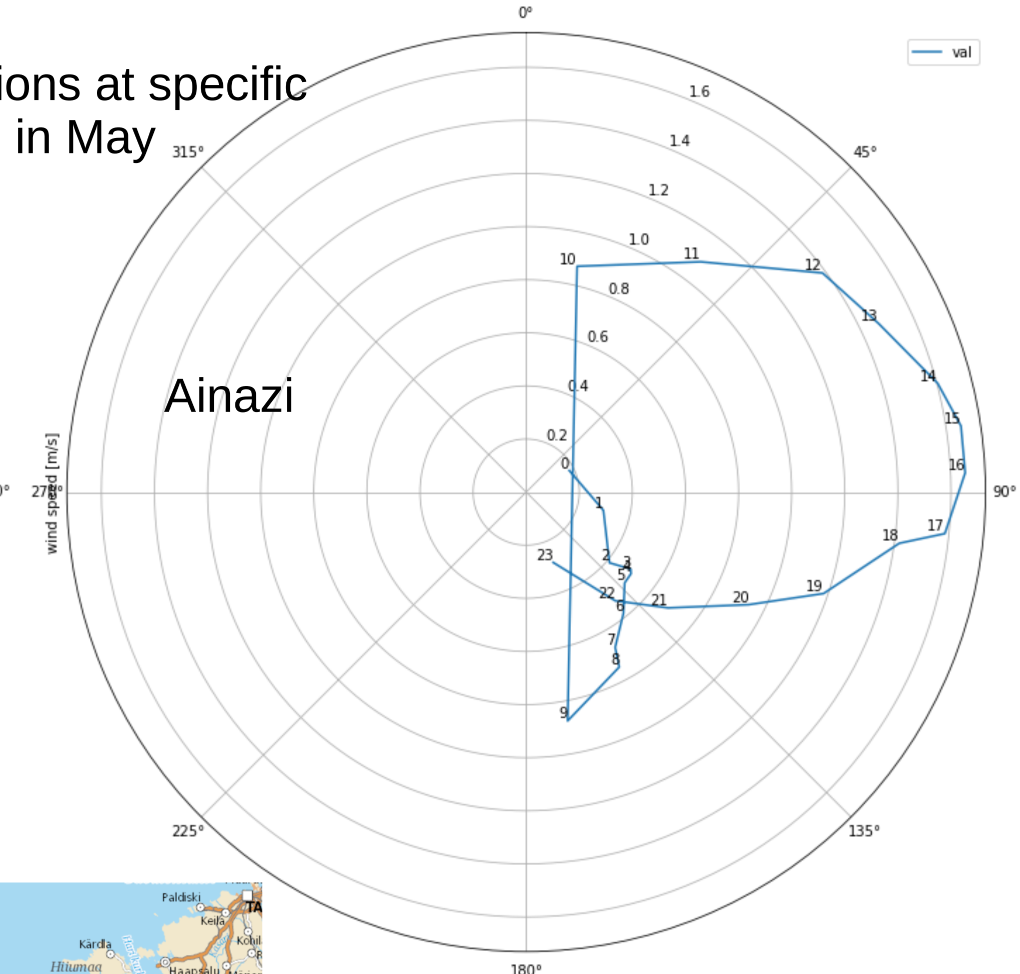
Gravitational tides

Tides stronger with stratification:
M. Müller. Continental Shelf Research 47 (2012) 107

Wind hodograms in May at coastal stations

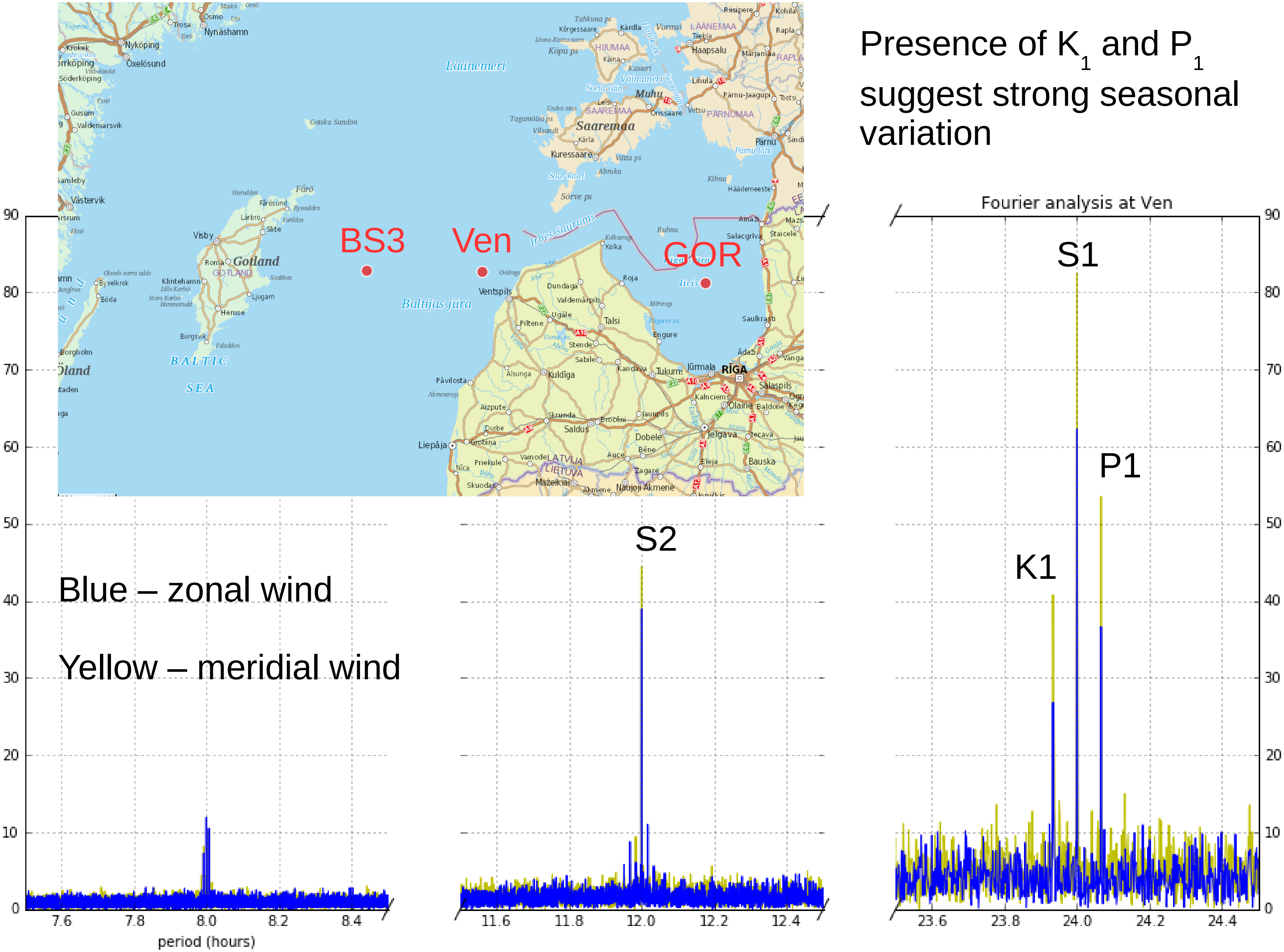
Observations at specific local time in May



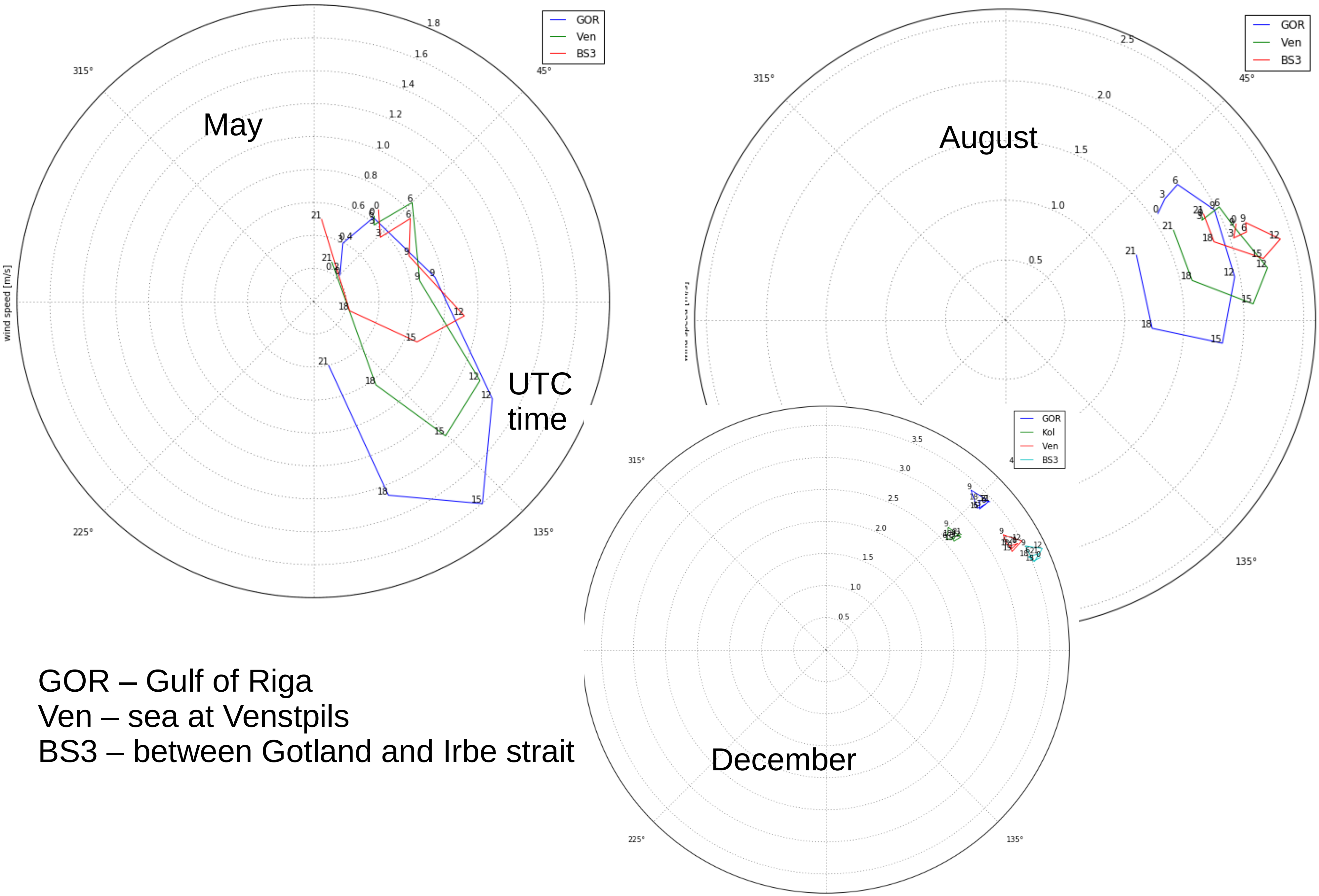


ECMWF ERA wind reanalysis (1979-2018)

Presence of K_1 and P_1 suggest strong seasonal variation

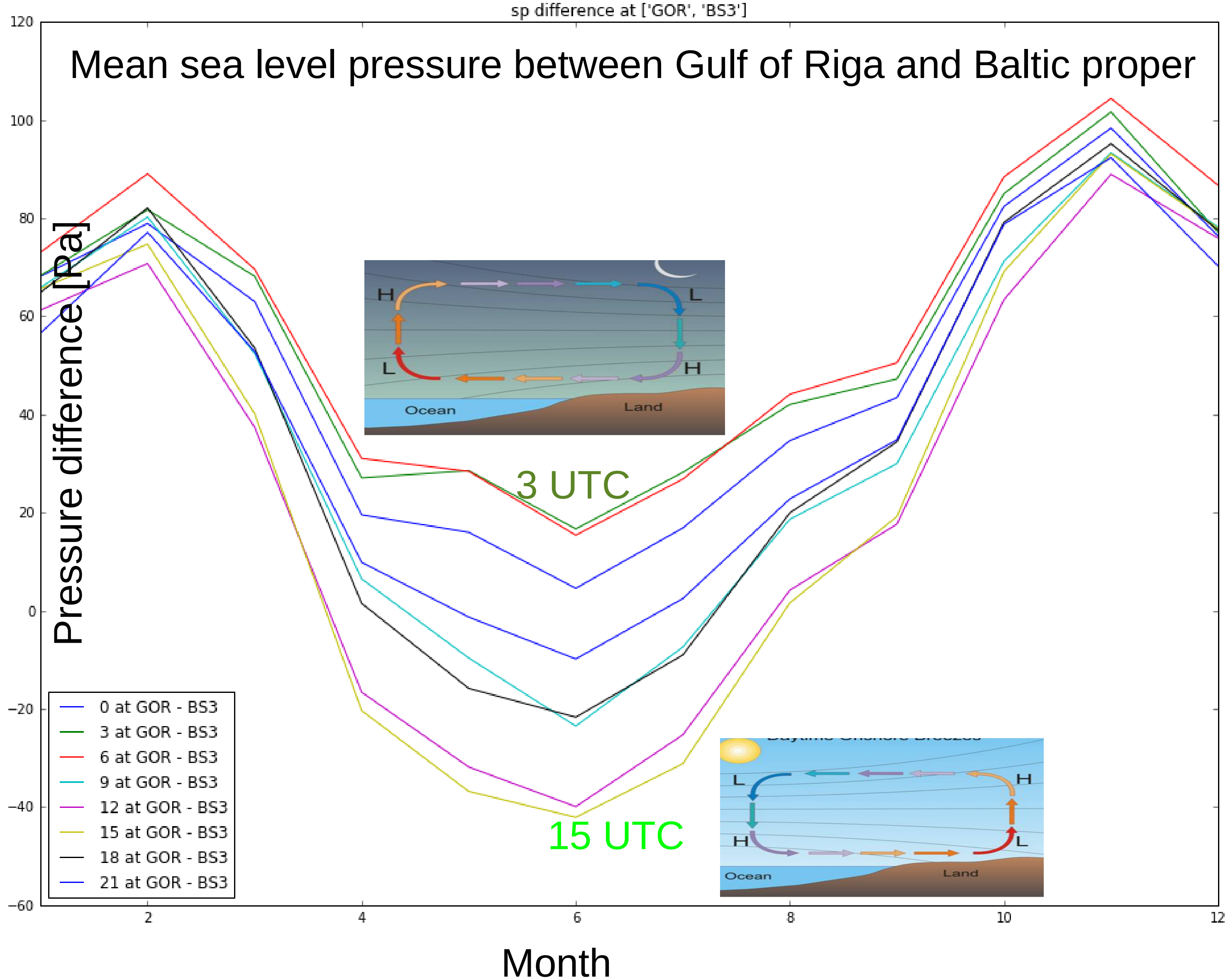


Daily hodogram of sea 10 m wind



GOR – Gulf of Riga
Ven – sea at Venstpils
BS3 – between Gotland and Irbe strait

Average pressure gradient ar various time of the day (UTC)



Conclusions

- Water level in Gulf of Riga in connection with Baltic proper has eigen oscillations with period slightly above 24 h
- All stations in Gulf of Riga have approximately the same amplitude and phase in these oscillations
- Diurnal water level oscillations (phase and amplitude) in most of the year follow the tides, i.e., positions of the Moon and the Sun
- Diurnal oscillations in eastern Baltic sea are strongest in May-April when sea/land breeze is in phase with gravitational tides
- Sea breeze effect is effectively minimised by tides in August-October
- Effective gravitational tides are weaker in winter because of non-linear interaction with stronger atmospheric forcing and weaker stratification

Real oscillations of water level generally follows tidal oscillations