Impact of satellite repeat period and gravity recovery resolution on ocean tide aliasing periods

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Introduction

Ocean tides cause notable aliasing errors for space-borne gravimetry missions like GRACE. Due to undersampling from satellite orbits, high-frequency tidal signals will alias into long wavelengths of gravity signals. In satellite gravity recovery, orbit data within a specific time interval are used to obtain the spherical harmonic representation of the global gravity field. In this process, selected data are combined and averaged both in time domain and spatial domain. In this case, the classical approach dealing with sampling of the "original" periodic signals may not be applicable on the "averaged" data.

In case of repeat orbits, the spectrum of tidal aliasing periods is known and the tide errors can be corrected from the recovered gravity field in a post-processing mode, thus repeat orbits are chosen in this study. Given the repeat orbit patterns and the resolution of solutions, we investigate and analyse their impact on the aliasing periods and amplitudes of the ocean tide components.

Dataset and scenarios

The data and scenarios used in the simulation are indicated in Table 1.

Table 1: *Simulated scenarios*

data	orbit			solution	
input	formation type	β/α [rev./day]	I [deg.]	time resolution (T) [day]	time length [year]
only ocean tide error: EOT08a - GOT4.7 (M2)	GRACE-like single pair	172/11	92	5, 11, 14, 22, 29, 38	5
		460/29	115	11, 29	
		460/29	89.5	11, 29	

Aliasing period determination

Given the original period of the signal and the sampling frequency, the aliasing period can be computed from the following formula (Parke et al., 1987; Schlax and Chelton, 1994; Han et al., 2004; Visser et al., 2010):

$$\frac{1}{T_\mathrm{a}} = \mathrm{abs}\left[\mathrm{mod}\left(\frac{1}{T_\mathrm{k}}+\frac{1}{T_\mathrm{N}},\frac{2}{T_\mathrm{N}}\right)-\frac{1}{T_\mathrm{N}}\right] \qquad (1)$$

in which T_a is the aliasing period, T_k is the original period of the signal and $2T_\mathrm{N}$ is the sampling period. In the case of satellite orbiting with repeat period, the sampling period is the α nodal day transformed into corresponding solar day .

In simulation stage, an alternative approach to get the aliasing period is to compute the mean of power spectral density(PSD) in geoid height, as indicated in Figure 2.

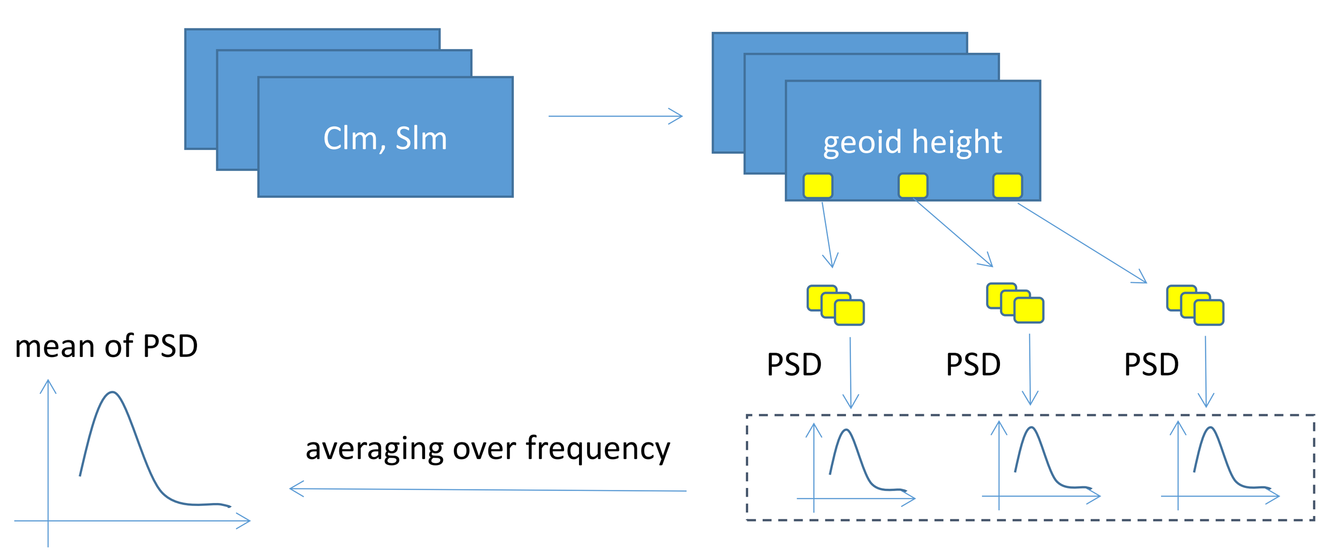

Figure 1: *sketch map to compute the mean of PSD in geoid height*

Results

According to formula (1), the aliasing periods of M2 component corresponding to scenarios listed in Table 1 depend on repeat period and inclination of the satellite, see Table 2. Meanwhile, aliasing period for each scenario is computed from mean of PSD in geoid height as showed in the Figure 2-5. From Table 2 we can see that with same repeat orbit, the inclination has slight influence on the final aliasing period.

Table 2: *aliasing period of M2 from the formula*

β/α [rev./day]	I [deg.]	aliasing period(Ta) [day]
172/11	92	55.7
460/29	115	247.1
460/29	89.5	247.0

One point we can see from Figure 2-5 is that, the aliasing period obtained from mean of PSD in geoid height for all the scenarios are different from that computed by formula (1). That may be because formula (1) represents the relationship between the aliasing period, original signal period and the sampling period, but in the case of gravity field recovery, the recovered gravity field time series is obtained by "averaging" the data in both time and spatial domain with different combination of the original data, which may change the characteristics of the original signal.

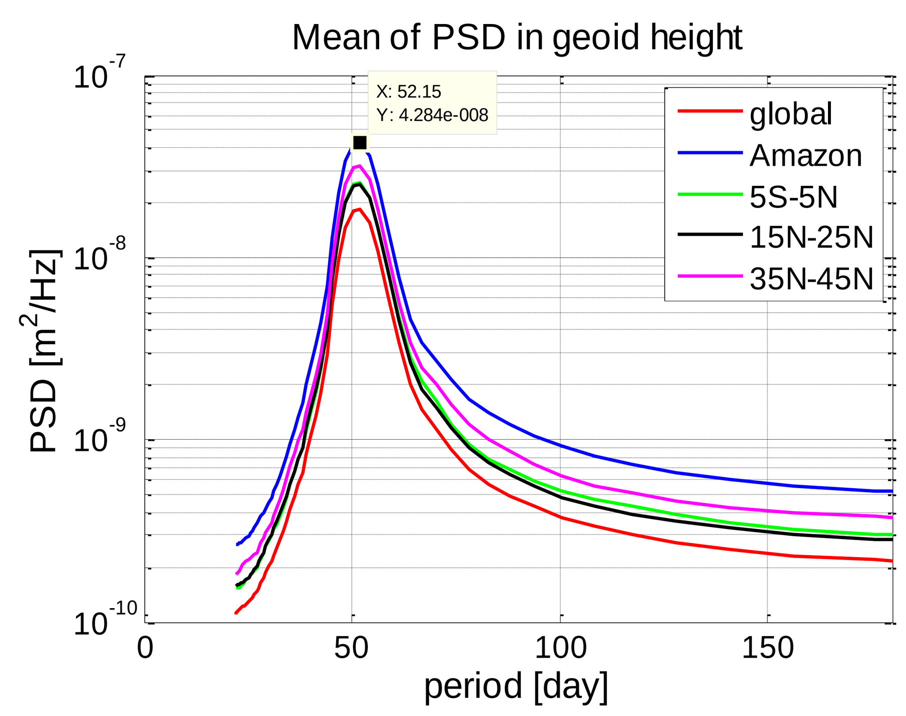

Figure 2: *mean of PSD in geoid height for different areas ($\beta/\alpha = 172/11$, $I = 92°$, $T = 11$)*

Furthermore, if time resolution of the solution T equals to the sampling period α, the same one aliasing period shows up for different areas (see Figure 2), otherwise there will be more than one aliasing periods and also different for the global and polar gap area (see Figure 3). Figure 4 shows that, different inclinations will induce different aliasing period with same repeat period when $T < \alpha$. Figure 5 demonstrates that different time resolutions of the solution will introduce different aliasing periods:
(1) if $T \geq \alpha$, one aliasing period present and with longer T, the total energy of the alaisng error attenuates; (2) if $T < \alpha$, more than one aliasing periods are introduced.

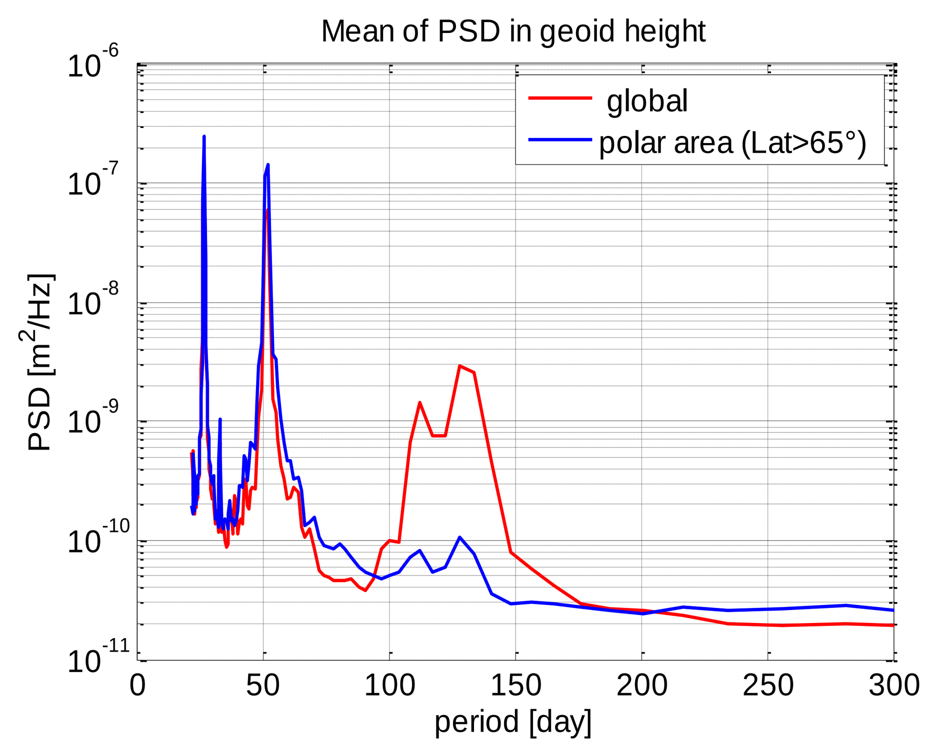

Figure 3: *mean of PSD in geoid height for different ($\beta/\alpha = 460/29$, $I = 115°$, $T = 11$)*

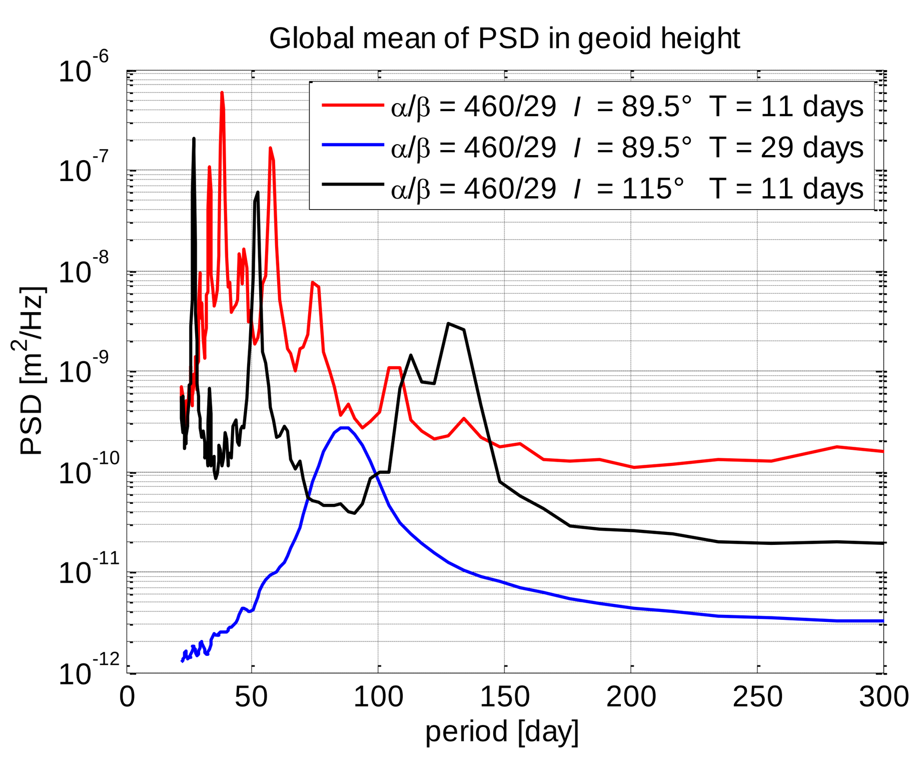

Figure 4: *global mean of PSD in geoid height for different time resolutions of the solutions and inclinations*

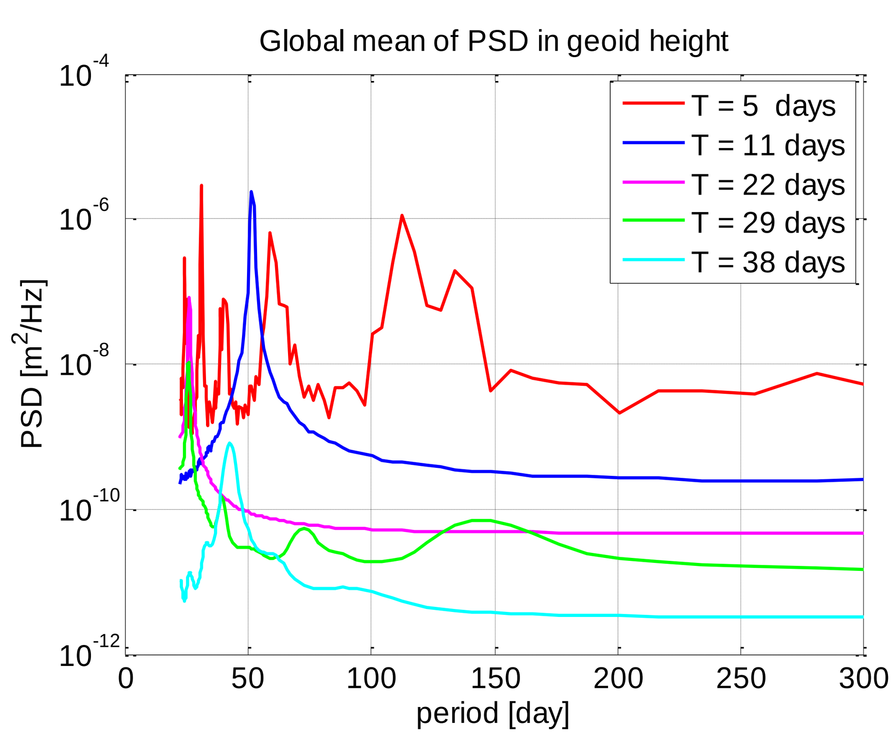

Figure 5: *global mean of PSD in geoid height for different time resolutions of the solutions ($\beta/\alpha = 172/11$, $I = 92°$)*

Conclusions

- Aliasing periods of the ocean tides not only depend on the repeat period and inclination of the satellite, but also on the resolution of the solution. Different T can introduce different aliasing periods with the same repeat period and inclination.
- If the resolution of the solution T is smaller than repeat period α , more than one aliasing periods will be induced. In this case, the globe and the polar gap area will have different aliasing periods.
- Longer T will weaken the aliasing error level in general.

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