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Interactive comment on "Measuring currents, ice drift, and waves from space: the Sea Surface KInematics Multiscale monitoring (SKIM) concept" *by* Fabrice Ardhuin et al.

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We thank the reviewer for the thoughtful and thought-provoking remarks that have led to important changes in the manuscript. Below a point-by-point reply. In bold are the reviewer comments and our comments follow in normal font.

This paper describes the concept of a space mission that will utilize the Doppler shift of radar returns to measure the ocean surface velocity, wave parameters, and sea ice drift. However, the small incidence angle of 12 degrees is highly undesirable for meeting the main mission objectives of ocean surface velocity, as well as sea ice drift for the following reasons:

1. Any measurement errors would be amplified by a factor of 1/sin (12 degrees), or about 4.8.

We understand the reviewer concerns, but the question of errors should always be considered in the context of signal to noise ratio (SNR). Indeed, although the signal of the horizontal current is reduced by a factor 4 when going from, say, 55° to 12°, the noise is reduced by a factor 100 (20 dB) for average wind speeds (6 to 8 m/s, Yurovsky et al. 2016). As a result the SNR is better at 12° compared to larger incidence angles.

2. The Doppler shift is heavily contaminated by the radial motions of the waves. The correction for wave bias is very strenuous without much assurance.

Besides noise, measurements indeed contain a wave bias which varies little with incidence angle (from 6 to 20 degrees) because the wave orbital velocities are the same in all directions. It is thus correct that, relative to the current signal, this is amplified by 1/sin (θi).

In the end, the wave bias is of the same order of magnitude for Ka band at 12° as it is for C band at 23°, which corresponds to the wave mode data on Envisat used by Chapron et al. (2005) and Collard et al. (2008), and from which it was possible to measure the equatorial currents very clearly using a proxy based on modeled wind. Here we wish to correct the wave bias more precisely so that we do not need to average the data over many passes. A preliminary algorithm is described here. We expect that it will be perfected in the coming years.

3. The narrow swath makes the revisit time at a given location insufficient to sample the high-frequency motions like inertial currents and tidal currents that would overwhelm the low-frequency ocean currents that are the mission's main objectives. As noted in the paper, more than daily revisit will take place only at latitudes higher than 75 degs.

Surface currents contain many contributions (tides, near-inertial motions . . .), that – in the case of coastal regions – are very well revealed by HF radars (e.g. Kim 2014). The sampling is certainly not ideal to resolve all these. This question raises the issue of how the data will be used. It is the same question with the diurnal aliasing in QuikScat wind measurements, and the relative variability of currents on a 3-day time scale and at 30 km resolution may be comparable to the variability of winds on a 12h time scale and at 25 km resolution. We have thus added the following sentences in the introduction:

As detailed below, the Sea Surface KInematics Multiscale monitoring (SKIM) mission, propose to use map surface waves and currents with 6-km footprints with a 4 m resolution in range. These footprints are distributed across a 270 km wide swath, but do not cover the entire swath, leaving a gap between the features smaller than 6 km resolved with a footprint, and the features larger than 20 km fully mapped across the swath. As the ocean is viewed in less than 1 minute during a single pass, the observed scene is basically a snapshot in which many ocean processes are aliased. Only those current features that vary on time scales of several days, or that have a constant phase and amplitude such as tides, can be measured without ambiguity. Evidence from High Frequency radars in coastal areas suggests that even near-inertial motions are coherent over time scales as large as 6 days at mid-latitudes **?**. Hence measured currents, even if every 3 days only, can provide useful constraints on the ocean circulation.

Another issue raised by the question is which contributions are least predictable and thus most useful in a data assimilative prediction system. We note that good results have already been obtained for tides and inertial motions in the past (Stammer et al. 2014, Jing et al. 2014).

Stammer, D. et al. (2014). Reviews of Geophysics Accuracy assessment of global barotropic ocean tide models. Reviews of Geophysics, 52, 243–282. http://doi.org/10.1002/2014RG000450.

Jing, Z., Wu, L., Ma, X. (2015). Improve the simulations of near-inertial internal waves in the ocean general circulation models. Journal of Atmospheric and Oceanic Technol-

ogy, 32(10), 1960–1970. http://doi.org/10.1175/JTECH-D-15-0046.1

The coverage of SKIM over time scales of 1' and 1" in Fig 1 is way overstretch.

The meaning of the scales in Figure 1 is now clarified in the caption: 1' is the maximum time lag between two views of the same ocean region over one single pass: flying at 7 km/s with a 270 km swath diameter gives 38 s maximum time lag. And the acquisition frequency if around 4 Hz (dt = 0.23 s) for all beams. Hence these two time scales define the range of time within a "snapshot".

Although the mission would take advantage of the spare parts of the SWIM instrument, they impose the limitation on the incidence angle and therefore are really a wrong choice for meeting the mission science objectives. This is somewhat like using the spare parts of a cheap ordinary car to build a sports car hoping to win the Formula One race. The mission might serve the role of demonstrating the technique, but it is highly unlikely that the mission would advance the knowledge of ocean surface circulation.

"Spare parts" is an exaggeration: SKIM is not using "spare parts" but builds on an existing design, with Ka band instead of Ku, a larger reflector (1.2 m instead of 0.8 m), and, most importantly Doppler capability which requires a very high PRF because of geometrical decorrelation. As for a "race", SKIM is now in phase A with ESA and this will certainly help raising the profile of all proposals for measuring ocean circulation with Doppler. The fact that some components inheriting from previous missions certainly helped fitting in the tight budget of ESA Earth Explorer 9, not very different from the budget of SMOS. Clearly technological readiness level (TRL) was a big issue for this Earth Explorer 9. The incidence angle of 12° gives a 270 km swath for a 690 km orbit. This yields a revisit time of 3 days at mid latitudes that is consistent with the dynamical evolution time of 60 km wavelength patterns in the mesoscale field.

Given the preliminary result of Envisat we are thus confident that SKIM can deliver very useful data on ocean dynamics, in particular near the equator.

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