How the SWOT errors will vary regionally and temporally (and how this may impact on the restitution of the fine-scale signal)

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Introduction

- The quality of the observation depends on the signal to error ratio

- In June, we showed that SWOT’s observability is a complex issue

Goal of this talk:
To discuss the regional and temporal variability of SWOT’s errors

- Illustrated with two major errors:
  - Random noise for $\lambda<100\text{km}$
  - Wet tropo for $\lambda\sim100\text{km}$

Fraction of the total error as a function of $\lambda$

Credits: Esteban-Fernandez et al (SWOT Error budget document)
Variability of the (sub)mesoscale signal

- Seasonal variability of (sub)Mesoscale intensity (e.g. Zhai et al, 08)
- Lag between small and large scales

Credits: Sasaki, Klein, Qiu & Sasai, Nature Commun. 2014
Variability of the (sub)mesoscale signal

Altimeter Spectral Slopes (from Jason-2)

December to February

June to August

- Spectral slope exhibits regional and seasonal variability
- Minor increase in spectral slopes in summer
- More small-scale mixed layer instabilities in winter: kicks up the tail & reduces the slope

Credits: Dufau et al (in prep)
Noise is a function of Significant Wave Height

- White noise the limiting factor for small mesoscale with altimetry
- The white noise floor depends on significant wave height conditions
- Magnitude changes for AltiKa (Ka-band) and slope changes with SAR mode

![Graph showing white noise level of the 20 Hz record](image)

Credits: Thibaut et al
Example of noise variability on nadir altimetry

1hz noise floor measured in Jason-2 spectra

December to February

Winter in the northern hemisphere

June to August

Winter in the southern hemisphere

Credits: Dufau et al (in prep)
What should we expect with KaRIN images?

- White noise changes with the cross-track position in swath
- White noise increases with SWH due to surfboard effect (intense in near-range)
- Far from trivial wherever high SWH values are commonplace (e.g. southern ocean)

>30cm RMS at 1km x1km pixels under a storm with ~8meters SWH

Credits: Ulbelmann et al, SDT June 2014
Wet troposphere correction and residual

Wet Troposphere

Residual for a 1-beam radiometer correction

Residual for a 2-beam radiometer correction

Credits: Ulbelmann & Fu
Variability of the wet tropo error

- Wet troposphere residual exhibits geographical and temporal variability
- The spectral slope of the WTC residual as well

Credits: S.Brown, 2013

Credits: Ulbelmann et al
Other SSH errors and their variability

- KaRIN’s SSH might also be sensitive to rain cells or sigma0 blooms. Variability similar to what is observed on AltiKa
- Geoid reference or Mean Dynamic Topography models not perfect
- Other effects (tides, roll, phase...) not discussed today but also complex

Mean Sea Surface error (cm)

Corrupted AltiKa data due to RAIN

Corrupted AltiKa data due to $\sigma_0$ bloom

% of edited data

Credits: Schaeffer et al

Credits: Poisson et al (in prep)
Conclusions

- Project analyses ensure that SWOT will provide a L2 product that meets the science requirements (global, 1D spectra)
- In practice, mesoscale observability in KaRIN images will exhibit much regional and temporal variability
- (sub)Mesoscale observability requires to understand variability in the signal and in the errors
- Some sources (noise depending on SWH, wet tropo, geoid...) are relatively easy to understand. Oceanographers can already acquire first-hand experience with scientific simulators
- More complex effects will be analyzed in the frame of the ADT and more realistic simulations (e.g. Sigma0-related errors and OBP stress cases)
Thank you for your attention
Stack-up of the allocations as a fraction of the total SSH requirement

- The error budget document gives a detailed view of the nature and properties of SWOT’s errors
- New error sources (and new corrections) w.r.t nadir altimetry

Source: SWOT Error budget document
Stack-up of the allocations as a fraction of the total SSH requirement

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Source: SWOT Error budget document
Baseline roll allocation and 1-km product

- 1D spectra can hide the spatial complexity / coherence of some errors within a SWOT image
- Better differentiators must be used to handle directional errors
Geographical variability of the SSH and observable scales

- Nadir altimetry highlights geographical variability in observable scales
- Good consistency between the geographical patterns seen by all sensors
- Observability is better with AltiKa (35-75km) or Cryosat-2 in SARM (20-50km) than with Jason-2 (50-90km)
- SWOT observability limit with baseline errors is 5-30 km
Dealiasing rapid signals

• KaRIN’s topography will be the sum of many components
• De-aliasing high-frequency (stationary) signal is necessary
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150km peak from S2 aliasing period
Internal waves and internal tides

- Internal tides and their interactions are going to be a big challenge for SWOT in certain areas.
- Combined usage of SAR and optical image is precious to understand these signals or to validate the phase prediction of models.
- Can we detect, correct, or filter out these components for SWOT users interested in slower SSH components?

Source: CNES

Source: ESA
Decomposition of the requirements in allocations

L2 SRD

SSH ERROR SPECTRUM < 1,000 km

SYSTEMATIC ERRORS

RANDOM ERRORS

MEDIA/WAVE ERRORS

Wet tropo retrieval errors

Ionosphere, SSB, dry tropo errors

POD

CoG

Disturbances

Pointing knowledge

Pointing control

DORIS (GPS) measurement error

DORIS On-board position knowledge

KaRIn Systematic + Random

SNR, resolution

Deployment accuracy

Mechanical and electrical stability

Gyro roll knowledge error
Example of SSH spectrum with median energy level at L=10 km

SSH maps filtered at 11 km, 240 m and 36 m
Link between standard-deviation and population (one VS two sided)

- $\mu - 2\sigma; +\infty = 97.7\%$
- $\mu - \sigma; +\infty = 84\%$
- $\mu \pm \sigma = 68\%$
- $\mu \pm 2\sigma = 95.4\%$
- $\mu \pm 3\sigma = 99.73\%$