Propagating Uncertainties and Error Correlation Structures through Retracking and Sea State Bias Correction

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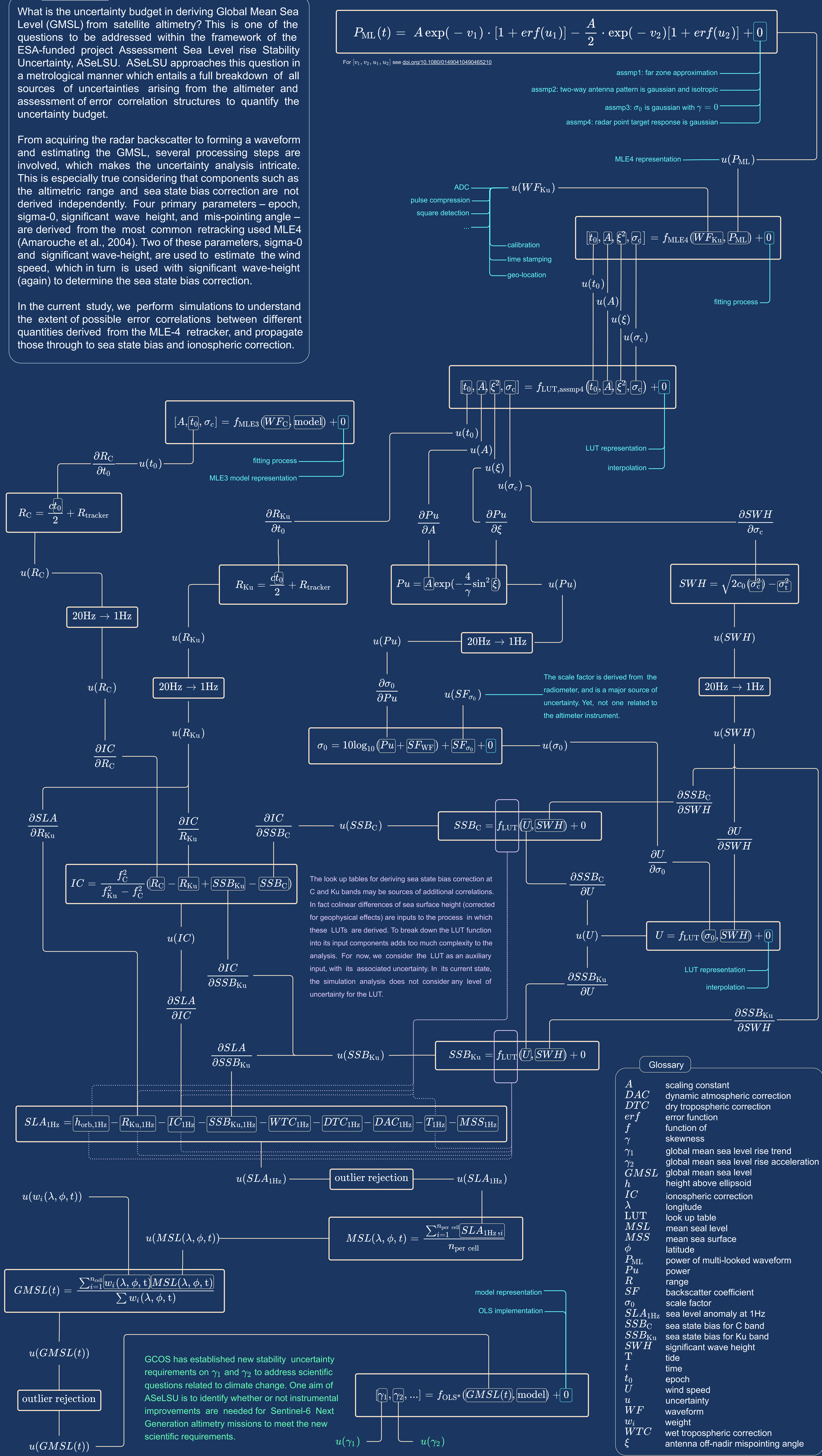
introduction

What is the uncertainty budget in deriving Global Mean Sea Level (GMSL) from satellite altimetry? This is one of the questions to be addressed within the framework of the ESA-funded project Assessment Sea Level rise Stability Uncertainty, ASeLSU. ASeLSU approaches this question in a metrological manner which entails a full breakdown of all sources of uncertainties arising from the altimeter and assessment of error correlation structures to quantify the uncertainty budget.

From acquiring the radar backscatter to forming a waveform and estimating the GMSL, several processing steps are involved, which makes the uncertainty analysis intricate. This is especially true considering that components such as the altimetric range and sea state bias correction are not derived independently. Four primary parameters – epoch, sigma-0, significant wave height, and mis-pointing angle – are derived from the most common retracking used MLE4 (Amarouche et al., 2004). Two of these parameters, sigma-0 and significant wave-height, are used to estimate the wind speed, which in turn is used with significant wave-height (again) to determine the sea state bias correction.

In the current study, we perform simulations to understand the extent of possible error correlations between different quantities derived from the MLE-4 retracker, and propagate those through to sea state bias and ionospheric correction.



Glossary

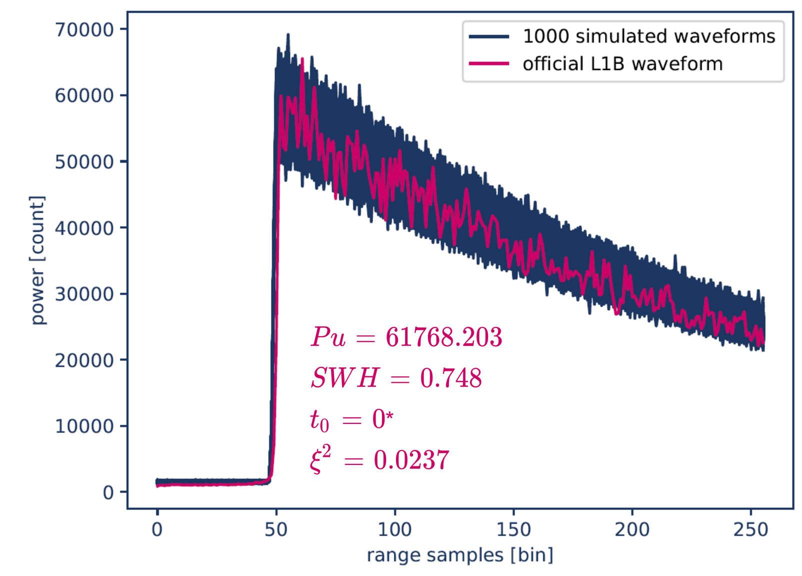
A	scaling constant
DAC	dynamic atmospheric correction
DTC	dry tropospheric correction
erf	error function
f	function of
γ	skewness
γ_1	global mean sea level rise trend
γ_2	global mean sea level rise acceleration
$GMSL$	global mean sea level
h	height above ellipsoid
IC	ionospheric correction
λ	longitude
LUT	look up table
MSL	mean seal level
MSS	mean sea surface
ϕ	latitude
P_{ML}	power of multi-looked waveform
Pu	power
R	range
SF	backscatter coefficient
σ_0	scale factor
SLA_{1Hz}	sea level anomaly at 1Hz
SSB_{C}	sea state bias for C band
SSB_{Ku}	sea state bias for Ku band
SWH	significant wave height
T	tide
t	time
t_0	epoch
U	wind speed
u	uncertainty
WF	waveform
w_i	weight
WTC	wet tropospheric correction
ξ	antenna off-nadir mispointing angle

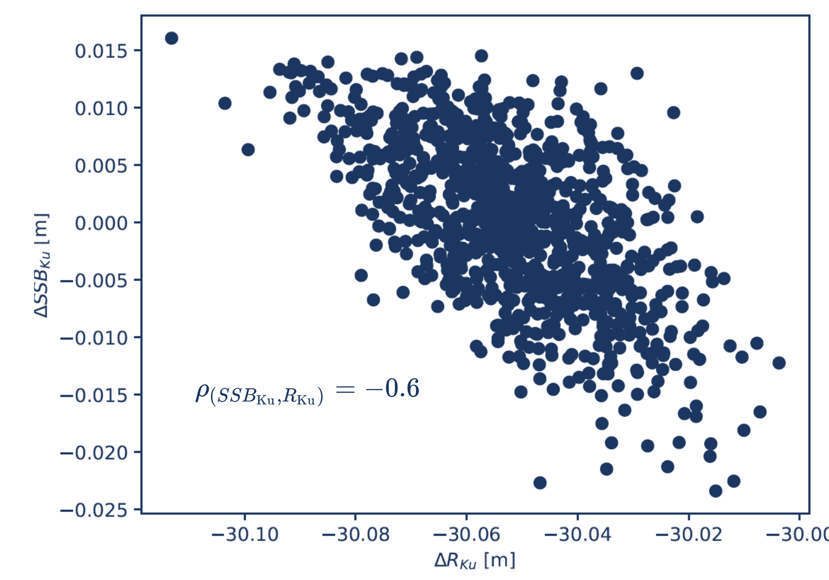
simulation

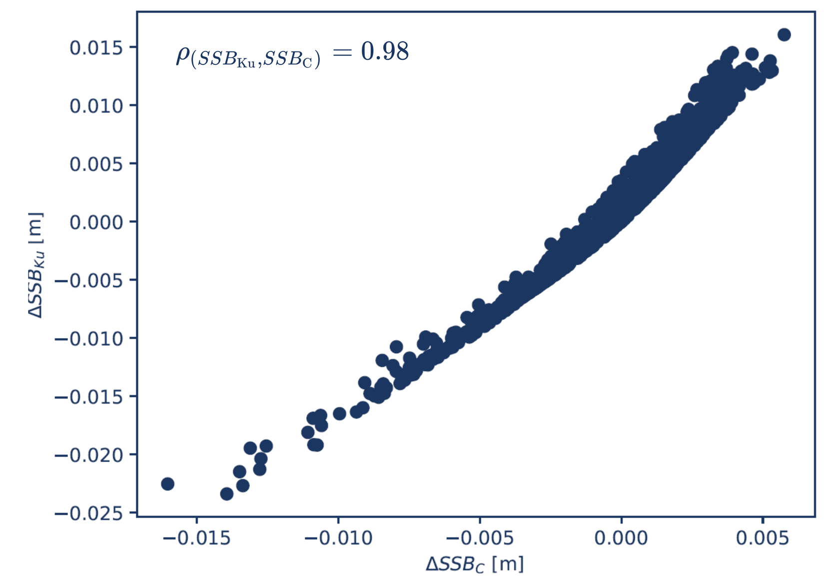
Our simulation aims at identifying and characterizing error correlation structures between intermediary parameters which i) are affected by the uncertainties of the instrumental component of an altimetry system, and eventually ii) affect the uncertainty of the Global Mean Sea Level product. We

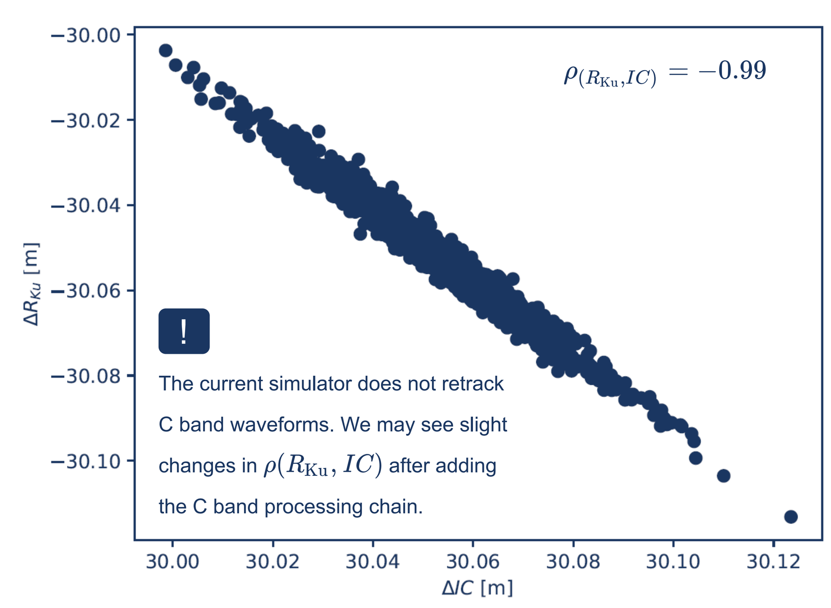
1. simulate LRM waveforms of Sentinel-6 Michael Freilich,
2. vary thermal and speckle noise levels to generate a set of inputs for Monte Carlo analysis,
3. retrack the waveforms using MLE4,
4. derive σ_0, U, SSB_{Ku}, SSB_{C}, and IC, and
5. investigate relevant correlation structures

Our simulation shows moderate to strong correlations between the pairs (SSB_{Ku}, IC), $(SSB_{\mathrm{C}}, R_{\mathrm{Ku}})$, and $(SSB_{\mathrm{Ku}}, R_{\mathrm{Ku}})$, and significant correlations for (R_{Ku}, IC) and $(SSB_{\mathrm{C}}, SSB_{\mathrm{Ku}})$. See figures.









From a metrological point of view, the uncertainty budget for $GMSL$ cannot be defined unless all error correlations are considered. The uncertainty tree diagram in this poster shows instances where correlations might exist. According to our simulation, correlations at many of those instances are significant.

In the next steps we will i) integrate more of the actual complexity in deriving $GMSL$ into our simulation scheme, and ii) characterize correlation structures under different physical circumstances.

acknowledgement

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