Sea level error budget session Introduction/Overview

From a global system error budget to application-specific error budgets

What we have

- Classical performance assessment
- Noise, media, orbit errors + Absolute error (bias), and Stability (drift)
- The classical error budget is system oriented
  - Purpose : “within specifications ?”
  - Does not include errors from external corrections or references
  - A mix of very different error types : e.g high frequency noise vs large scale orbit errors

Altiv	H 1/3 = 2 m	H 1/3 = 4 m	H 1/3 = 6 m	H 1/3 = 8 m
OGDR (combined Ku + C)	2.5	3.8	4.6	5.4
IGDR and GDR (Ku Band) Requirement Before Ground Retracking	2	3.1	3.8	4.4
IGDR and GDR (Ku band) Requirement After Ground Retracking	1.7	2.4	2.8	3.3

Altimeter Noise as a function of Significant Wave Height
(1 sec average)

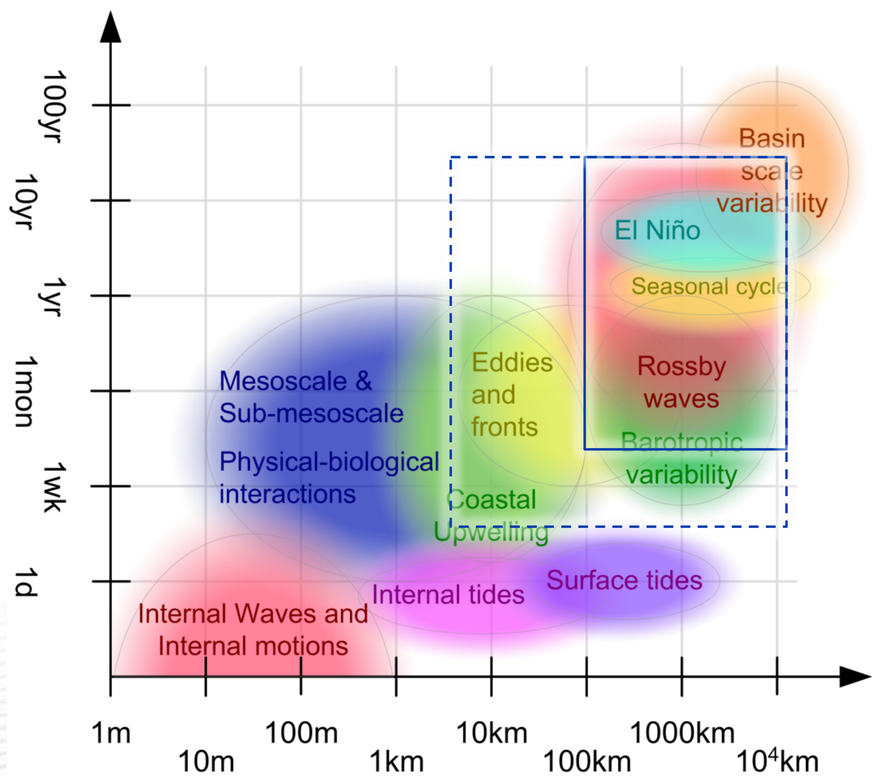
(a) Combined Ku + C measurement
*(b)*Ku band after ground retracking
*(c)*Averaged over 1 sec
*(d)*Assuming 320 MHz C bandwidth
*(e)*Filtered over 100 Km
*(f)*Can also be expressed as 1% of H1/3
*(g)*After ground retracking
*(h)*Real time DORIS onboard ephemeris
*(i)*Which ever is greater
*(j)*On global mean sea level, after calibration

	OGDR **3 hours**	**IGDR** **1 to 1.5 days**	**GDR** **40 days**	**GOALS**
Altimeter noise	2.5 *(a)(c)(d)*	1.7 *(b)(c)(d)*	1.7 *(b)(c)(d)*	1.5 *(b)(c)(d)*
Ionosphere	1 *(e)(d)*	0.5 *(e)(d)*	0.5 *(e)(d)*	0.5 *(e)(d)*
Bias	3.5	2	2	1
Dry troposphere	1	0.7	0.7	0.7
Wet Troposphere	1.2	1.2	1.2	1
Altimeter range RSS	**5**	**3**	**3**	**2.25**
RMS Orbit (Radial component)	10 *(h)*	2.5	1.5	1
Total RSS sea surface height	**11.2**	**3.9**	**3.4**	**2.5**
Significant wave height	10% or 0.5 m *(i)*	10% or 0.4 m *(i)*	10% or 0.4 m *(i)*	5% or 0.25 m *(i)*
Wind speed	1.6 m/s	1.5 m/s	1.5 m/s	1.5 m/s
Sigma naught (absolute)	0.7 dB	0.7 dB	0.7 dB	0.5 dB
System drift				1mm/year *(j)*

OSTM/JASON-2 ERROR BUDGET (in centimeters)
(for 1 sec average, 2 meters SWH, 11 dB sigma naught)

What users want to observe

- For each specific application domain, a dedicated global altimeter SYSTEM error
- how much does each error term alter the observation of each ocean process ?
  - Climatologists want to know MSL errors (global, local…)
  - Oceanographers need precise and complete error estimates as entry of ocean model assimilation
  - Not only static (estimated once), but dynamic error estimates (accounting for sensor evolutions, geophysical variations)
- Global sampling ability of one Jason is limited to 20 days and 300 km but can be improved if 3 or 4 satellites are used
- Can be locally or regionally higher (along track, crossovers, high latitudes)
- Improving the space/time sampling extends the application domain but also modifies the error structure



The approximate space and time scales of phenomena of interest. (derived from Dickey et al, and Chelton et al 2001)

Typical error budget that users need

- Ideally, a user-oriented error budget should also include:
  - the error budget from external corrections: dynamic atmospheric correction, tidal model...
  - the error budget from reference fields: mean sea surface, mean dynamic topography, mean profiles (repeat track analysis)...
  - Because all components of the altimetry system contribute to the SSH error they use
- Absolute errors (as opposed to relative)
- Geographical distribution (map...)
- Temporal evolution : natural processes, algorithm change, aging degradation
- Space (d_x) and time (d_t) correlation scales of the error
- Possible correlations with ocean signals or with other errors

Approximate space/time decomposition

(order of magnitude only)

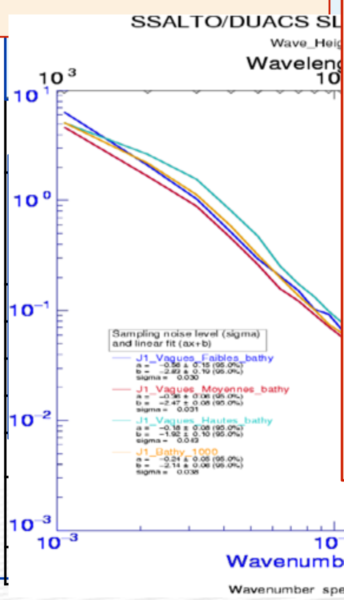
Good confidence
Moderate confidence or needs further investigation
To be confirmed; no suggestion of methods for the determination

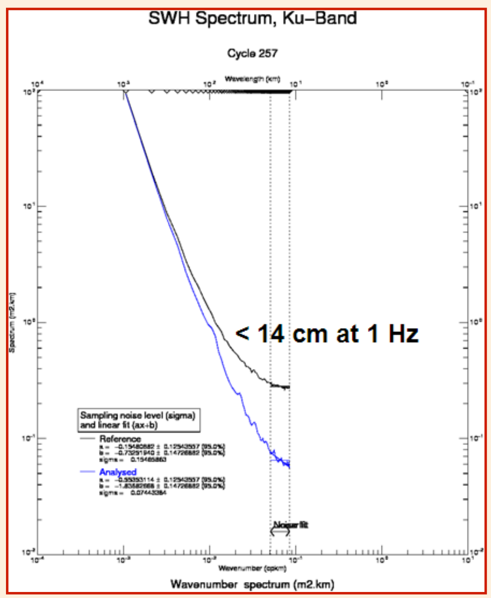
1 Hz data	Space				Time			
Open Ocean	50 km	500 km		Bias	20 d.	1 y.		Drift
Range	2 to 4 cm	ε ?	ε ?	A few cm	< 0.5 cm	ε ?	ε ?	negligible
Sea state bias	< 1 cm	?	a few cm	A few cm	?	?	?	0.05 to 0.1 mm/y
				mm	0	< 2 cm	< 1 cm	Gl... 0.1 locally

HF noise depending on rtk (MLE3 or 4),SWH and sea state (bloom, rain, …)

Small impact of potential LUT correction

Potential waves assymetry at





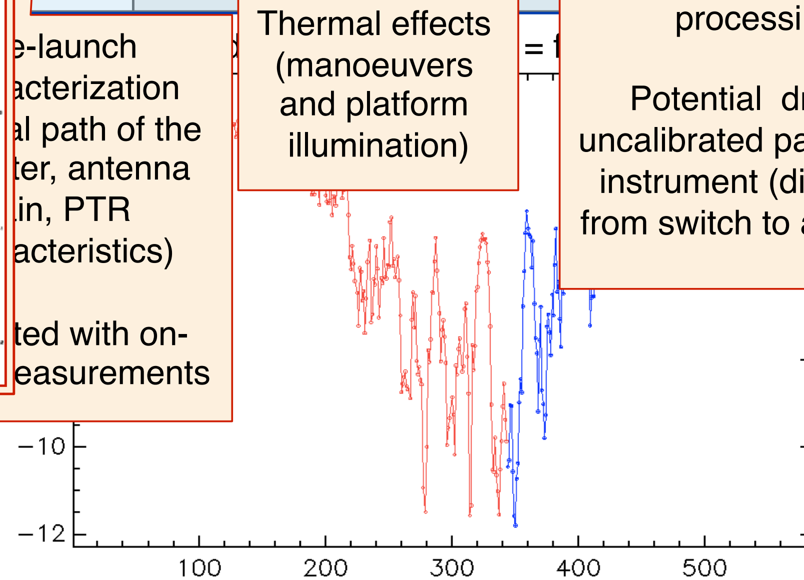
...cm at 1 Hz

Daily cycle
...gnal → error)

...e-launch ...acterization ...al path of the ...ter, antenna ...in, PTR ...acteristics)

...ted with on- ...easurements

RSS < ...



Impact of the daily updated filter and PTR characterisation

Thermal effects (manoeuvers and platform illumination)

Monitoring of the instrumental characteristics (PTR, filters, CNG attenuators …) and correction for them in the ground processing

Potential drift of uncalibrated part of the instrument (distance from switch to antenna)

B/y

...ible

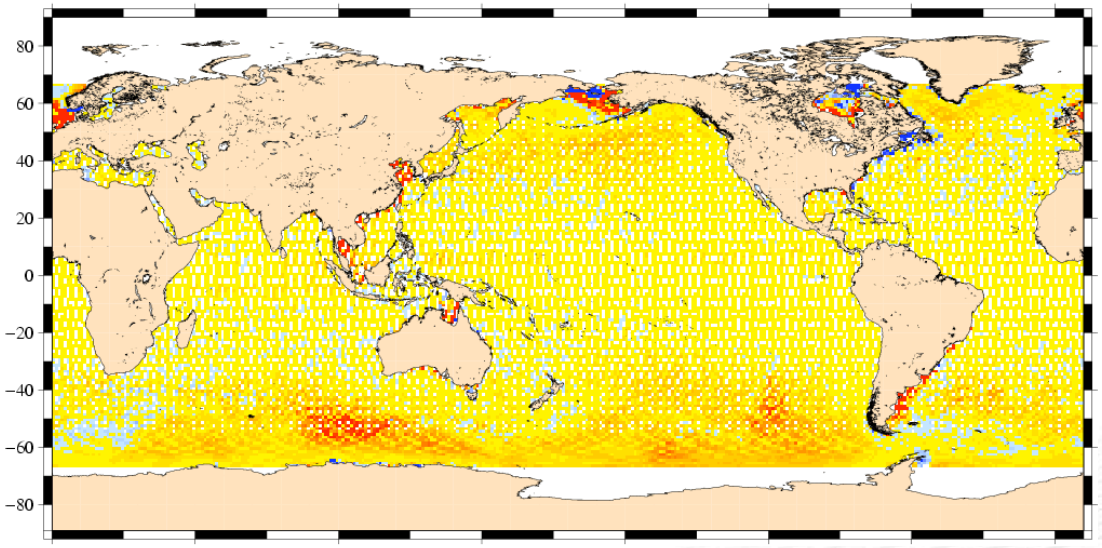
OSTST Mee...

Orbit error decomposition

Source	T/P (mm)	Jason-1 (mm)	Systematic	Rationale
Orbit determination 'noise'	**13**	**8**	1/rev, variable in phase and amplitude	Intercomparison of similar orbits
Static gravity field	**1**	**1**	1-2 mm 'order 1' pattern	GIF31a vs EIGEN-GL04C
Tide model	**3**	**2**	1-2 mm slowly varying 'order 1' pattern	CSR3.0 vs FES2004
Atmosphere/ocean/hydrology	**3**	**2**	1-2 mm varying 'order 1' pattern	GRACE RL04 atmosphere/ocean
Solar radiation pressure	**4**	**2**	few mm 120-day Z-variation	3% scale error, T/P more complex
Station/data errors *	**3**	**2**		ITRF2000 vs ITRF2005
GPS satellite orbits	**0**	**2**	uncertain	uncertain
Reference frame (origin)	**2**	**2**	few mm bias and 0.5-1 mm/yr drift in Z	geocenter time series estimates
Geocenter motion	**2**	**2**	2-6 mm annual variation in Z	geocenter time series estimates
RSS error	**15**	**9**		

- From John Ries (Hobart meeting)

De-aliasing altimetric data of high frequency effects



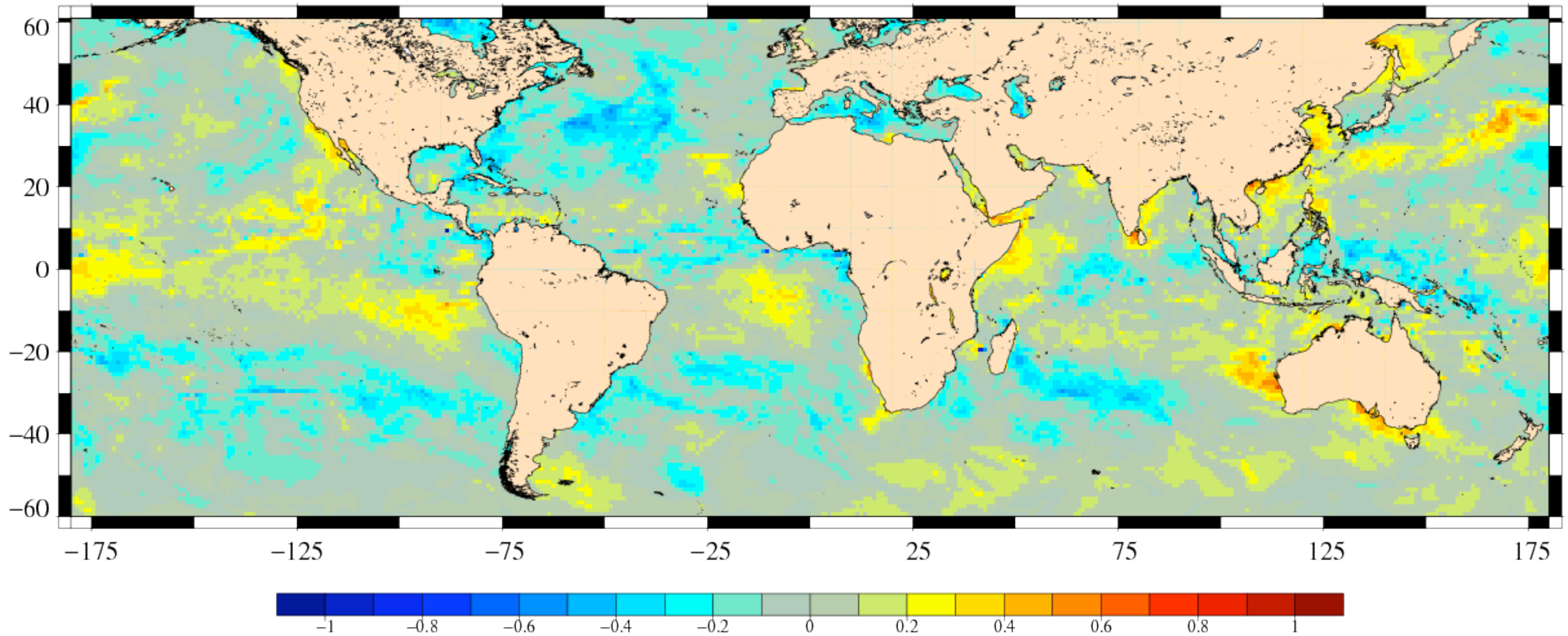
color bar ± 20 cm^2

- High Frequency signals aliased by altimetry: lower frequency errors
- Sea level variance accounted for by the most recent recent corrections relative to simple IB

Ponte et al.

Temporal and geographical distribution

NN(TB18.7,TB23.8, TB34,γ800,SST)



Upgrading the wet tropo inversion algorithm reduces the error but changes its geographical distribution

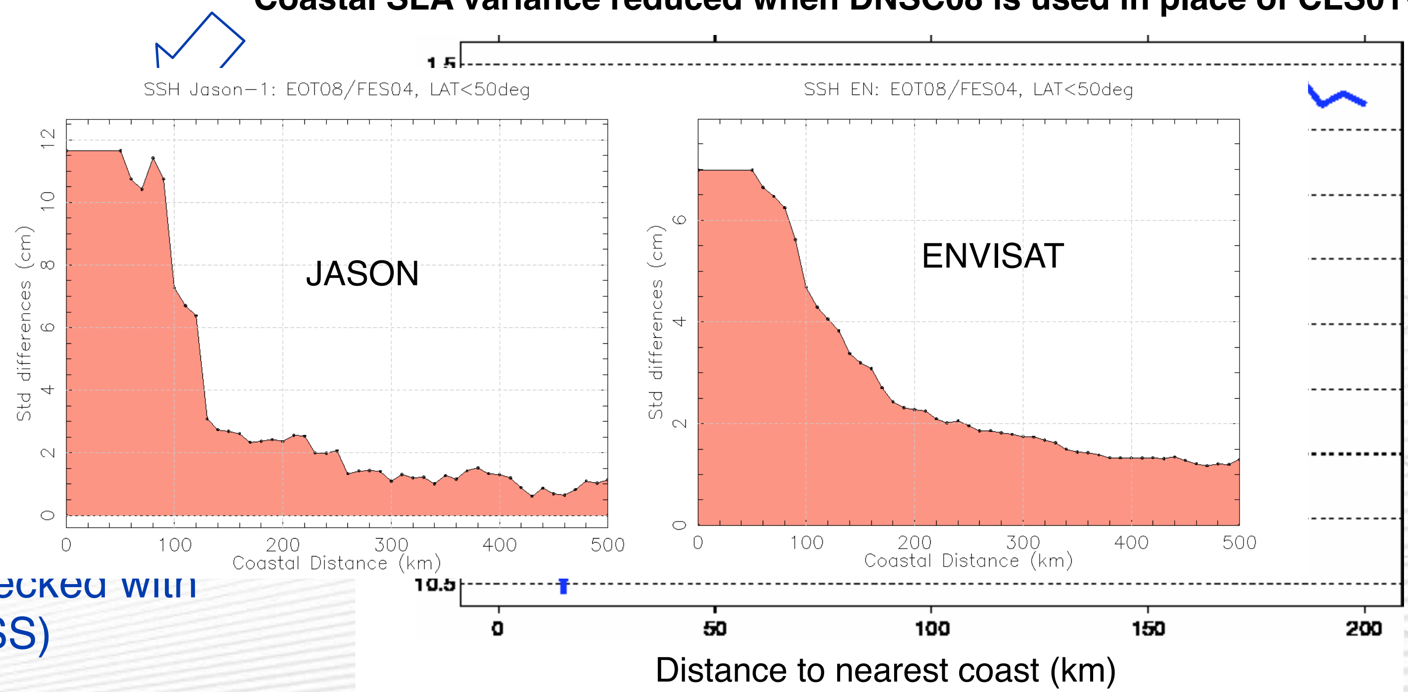
Temporal and geographical distribution

- Some error terms increase significantly when :
  - Distance to shore decreases : radiometer wet tropo, MSS, waveform distorsion…
  - Bathymetry decreases : tides or DAC

- Due to know
  geoid conne
  (oceanogra

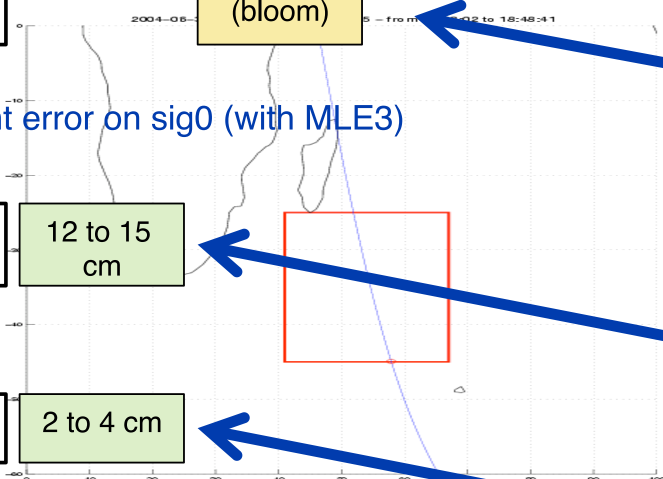
- This effect v
  disappear w
  upcoming M
  SLOOP pro
  (already checked with
  regional MSS)

Coastal SLA variance reduced when DNSC08 is used in place of CLS01v1



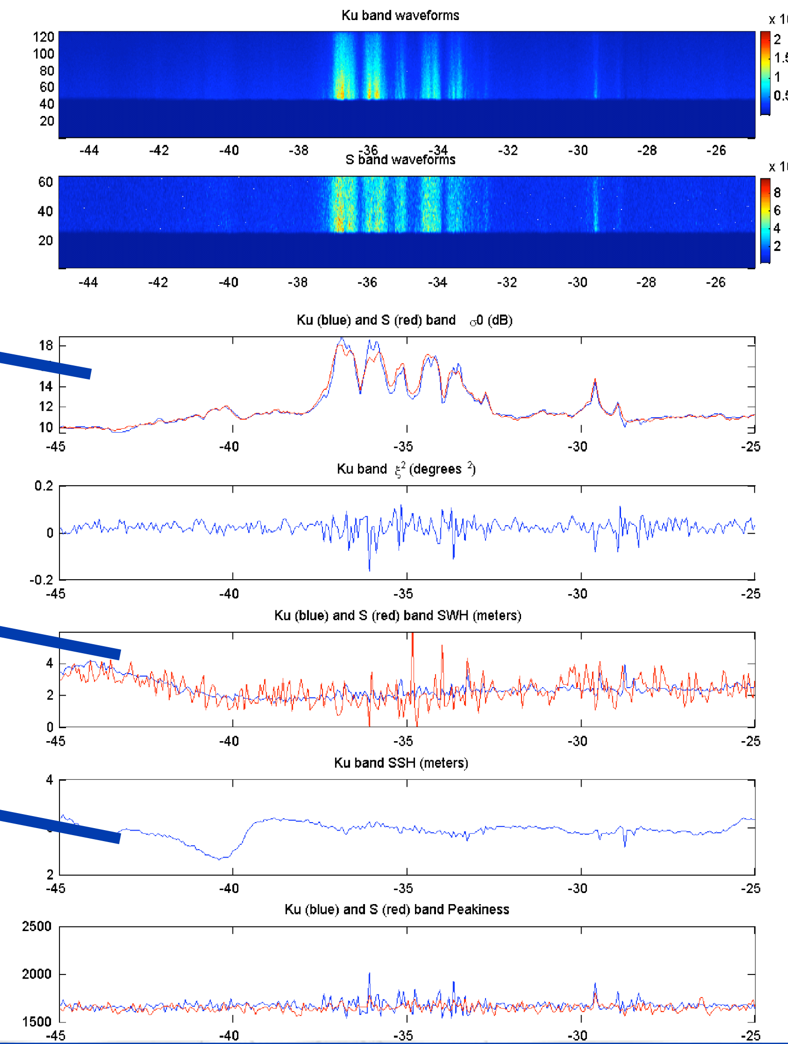
One error source, different signatures (Sig0 bloom)

	50 km	500 km
Sigma0		High (bloom)
SWH	12 to 15 cm	
Range	2 to 4 cm	



➔ Coherent error on sig0 (with MLE3)

➔ Increase of the SSH & SWH noise level during bloom events



From P. Thibaut

Towards application-specific error budgets

- Different applications = different errors to be considered
  - MSL → jumps and drifts at global or regional scale
  - Climate → large scale errors, long period errors, overall stability
  - Mesoscale → 50 to 500 km, 5 to 40 days
  - Local high resolution applications (e.g.: geodesy) → noise, high-frequency error

- Wet tropo noise or coastal land contamination are maybe not a problem for climate…
- …but side lobes, inversion algorithm errors and BT drifts are critical

- Global bias, USO drifts or large scale errors are not a problem for geodesy…
- …but high-frequency error, noise minimization, special processing of degraded waveforms can be critical

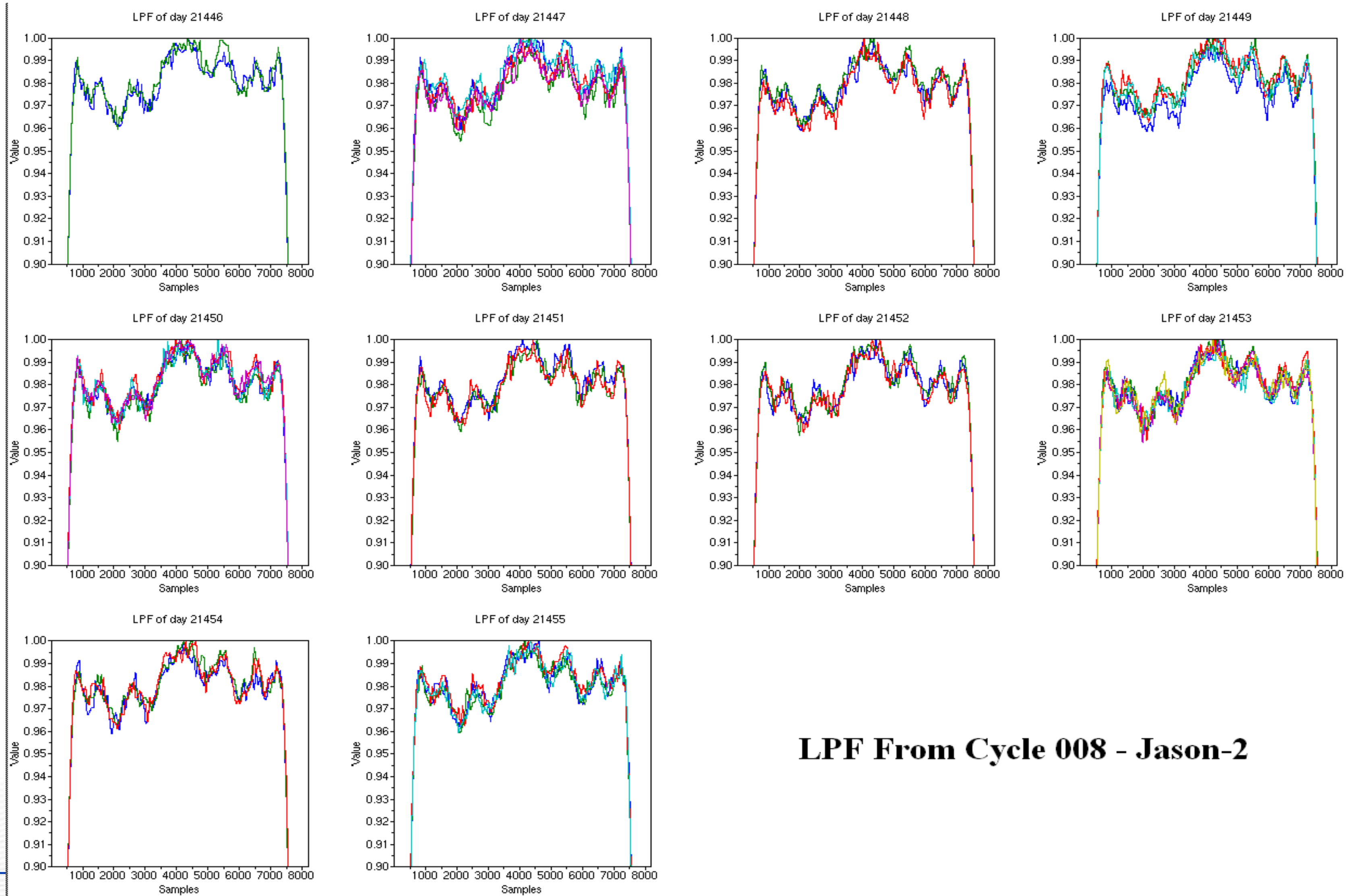
- Other tricky subjects to consider:
  - Some errors are indirectly linked : Tides → Orbit → MSS → MDT
  - Some errors are correlated : retracked parameters are correlated, SSB can absorb orbit errors
  - Some algorithms reduce the error, but increase the correlation, or cause spectral leakage

Work plan?

- Given the maturity of science studies (climate, oceanography) and applications (operational oceanography), the altimeter error budget presentation should now be improved:
  - Of course the current **verification** of **system specifications** is still relevant
  - To address dedicated applications (space/time scales) in a **user-oriented** point of view: **validation** with respect to **mission** (user) **requirements**
  - To consider altimetry as a **System gathering several components** (orbit, altimeter, radiometer, media corrections, external corrections, reference surfaces)
  - To also consider the **multi-mission perspective**: altimetry will no more be only one standalone mission (hopefully)
  - Main drivers when designing a new mission
- This is a vast subject : decomposition into space/time domains leads to a large number of studies to be carried out in each domain of interest
- Error budget is a complex mix of science, technical recipies, external correction
- A collective effort is required. It could be structured through the OSTST membership:
  - Discussing the most relevant period/wavelength decomposition in each domain area (what users need?)
  - Each thematic group (splinter groups already structured within the OSTST) could contribute to a specific row in the global array
  - A recurrent error budget session could synthesize current status and new findings

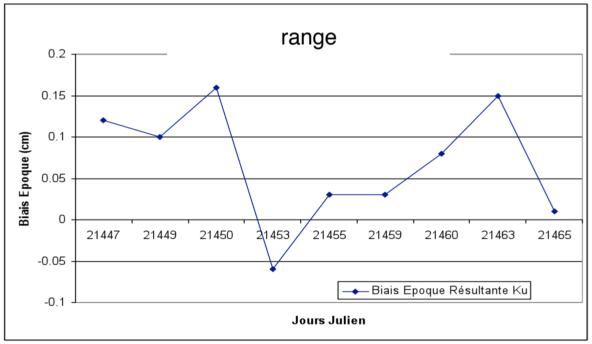
Backup material

Natural variability of the J2 filters (3 filters per day – 10 days)

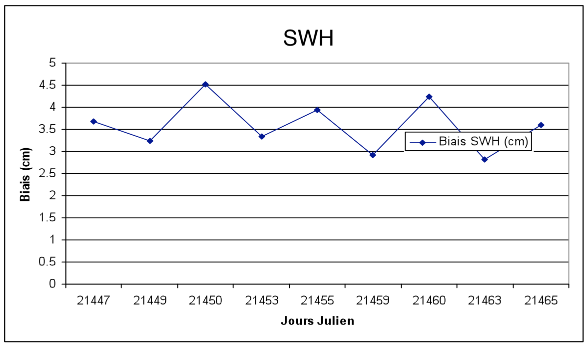


LPF From Cycle 008 - Jason-2

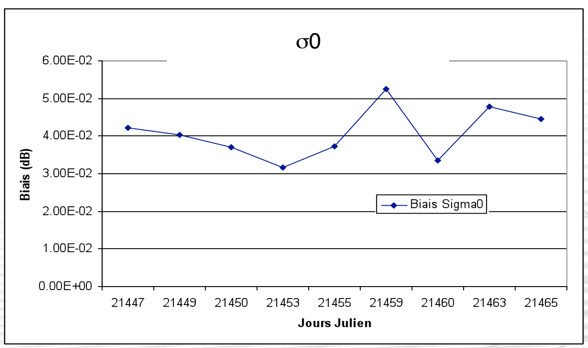
Impact of the J2 filters variability (1 LTM filter per day – 10 days)



➔Range variability = 2 mm



➔SWH variability = 1.5 cm



➔Sig0 variability < 3 E-2 dB

Temporal and geographical distribution

Gain in variance at crossover differences (with tide correction / without)