Towards different error characterization for different applications

An Introduction to the splinter session:
"Quantifying Errors and Uncertainties in Altimetry Data"

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Mercator Ocean

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Introduction

- **This talk: replacing “**Remaining geographical or seasonal correlations in the errors” **by** “Towards different error characterization for different applications”
  - Meaningful examples of altimeter error characterization are given
  - But this talk is also an introduction of the Splinter Session: “Quantifying Errors and Uncertainties in Altimetry Data”
  - A “cross-cutting” splinter sessions: all splinters should contribute
- **The conventional error budget table**
  - RSS of several orbit contributions
  - Recent estimations with consolidated hypotheses
- **Examples of spatial characterisation of the errors**
- **Examples of temporal characterisation of the errors**
- **Conclusions**

The “conventional” error budget

	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)*

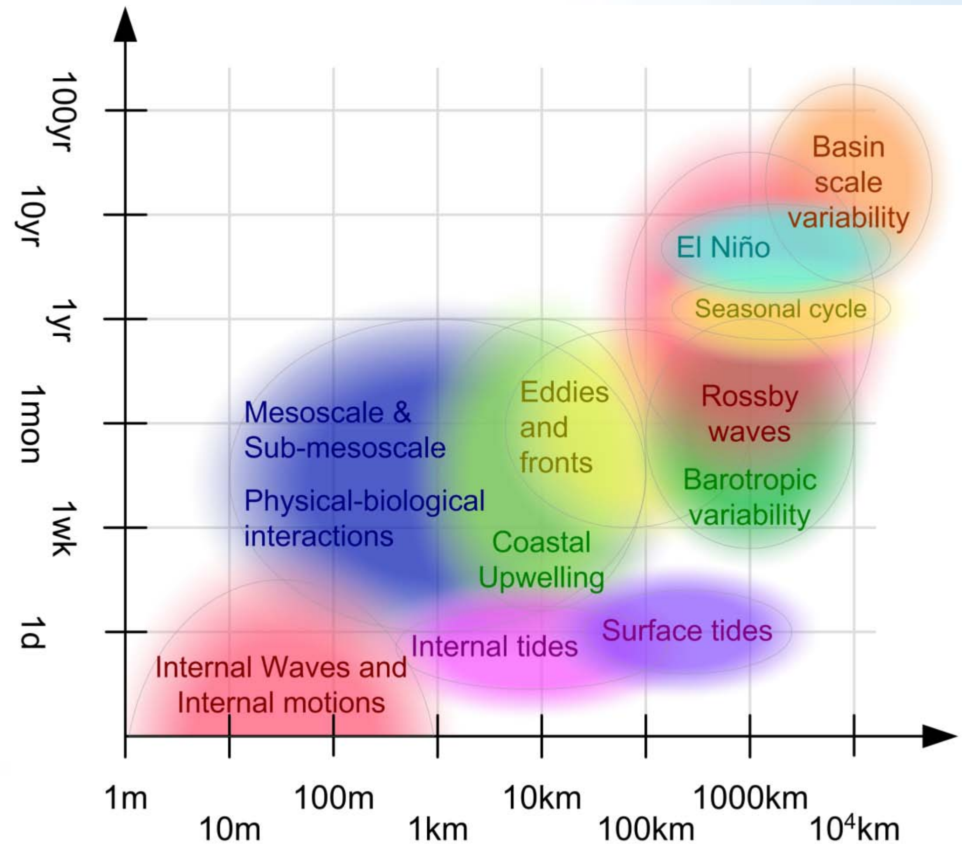
OSTM/JASON-2 ERROR BUDGET (in centimeters)
(for 1 sec average, 2 meters SWH, 11 dB sigma naught)

- **A classical presentation**
- **Purpose: is the altimeter system “within specifications”?**
- **Mixes white noise, media errors, long wavelength errors, HF/LF errors in a single RSS calculation**
- **The answer is more complicated:**
  - depends on targeted applications (needs)
  - and on the considered wavelengths/frequencies

“is the system within specifications?” / “Are user and science application requirements fulfilled?”

Applications, domains of interest

- **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)



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

2012 Splinter session: new results and requirements

- **Climate / GMSL/ seasonal large scale errors:**
  - Esselborn et al.
  - Ablain et al.
  - Cazenave et al.
  - Leuliette et al.
- **Spatial/temporal error characterisation**
  - Fu et al.
  - Ponte and Quinn
  - Philipps et al. (poster)
- **Error estimation/specification for assimilation into ocean models:**
  - Oke et al.
  - Remy et al.
  - Cosme et al. (poster)
- **Coastal:**
  - Birol et al. (poster)
- **Reference Surfaces errors (Mean Dynamic Topography):**
  - Horvath et al. (poster)
- **Wind/waves:**
  - Abdalla and Jansen

Revisiting the “conventional” Error budget
Philipps et al. (see Poster)

- **Error es**
  - Globa
  - Time
  - Other (Ablain et al., Le
- **Differen used:**
  - Spec
  - Differ and Jason-2 during
  - Differ s,…)

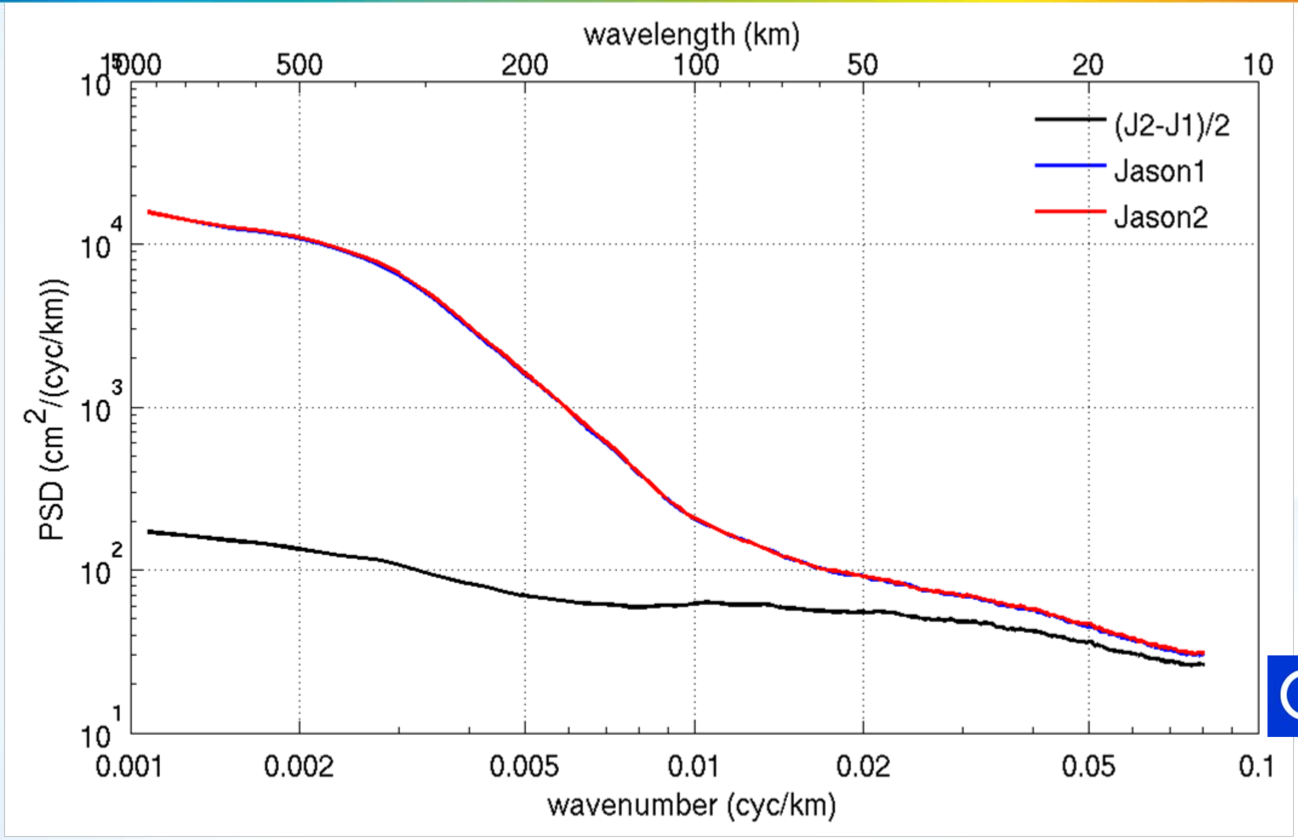
Error budget		Specifications OGDR	Specifications IGDR	Specifications GDR	Error (<10 days) OGDR	Error (<10 days) IGDR	Error (<10 days) GDR	GOAL
Parameters and corrections for raw sea surface height calculation	Altimeter range	>1.7 cm[a,b,c]			>1.6 - 1.7 cm			1.5 cm[a,b,c]
	Ionosphere	1 cm[d,c]	0.5 cm[d,c]		>1 cm[h] / >0.2 cm[i]			0.5 cm[d,c]
	Sea State Bias	3.5 cm	2 cm		>0.4 cm			1 cm
	Dry troposphere	1 cm	0.7 cm		0.4-0.7 cm	0.3-0.7 cm		0.7 cm
	Wet troposphere	1.2 cm			>0.2 cm			1 cm
	Rms Orbit (radial component)	10 cm[e]	2.5 cm	1.5 cm	>3.7 cm	>1.7 cm	>1.0 cm	1.5 cm
Altimeter parameters	Significant wave height	10% or 50 cm[f]	10% or 50 cm[f]		13 cm			5% or 25 cm[f]
	Wind speed	1.6 m/s	1.5 m/s		1 m/s			1.5 m/s
	Sigma0 (absolute)	0.7 dB			0.11 dB			0.5 dB
Raw sea surface height		11 cm[A]	3.9 cm[A]	3.4 cm[A]	> 4.2 cm[A]/-	> 2.6 cm[A] - 2.8 cm[B]	>2.1 cm[A] - 2.4 cm[B]	2.5 cm[A]
Final sea surface height		?	?	?	< 5.0 cm[C]	< 4.1 cm[C]	< 4.0 cm[C]	

a Ku-band after ground retracking
b Averaged over 1 sec
c Assuming 320 MHz C-bandwidth
d filtered over 100 km

e real time doris onboard ephemeris
f whichever is greater
h non filtered value
i filtered over 300 km

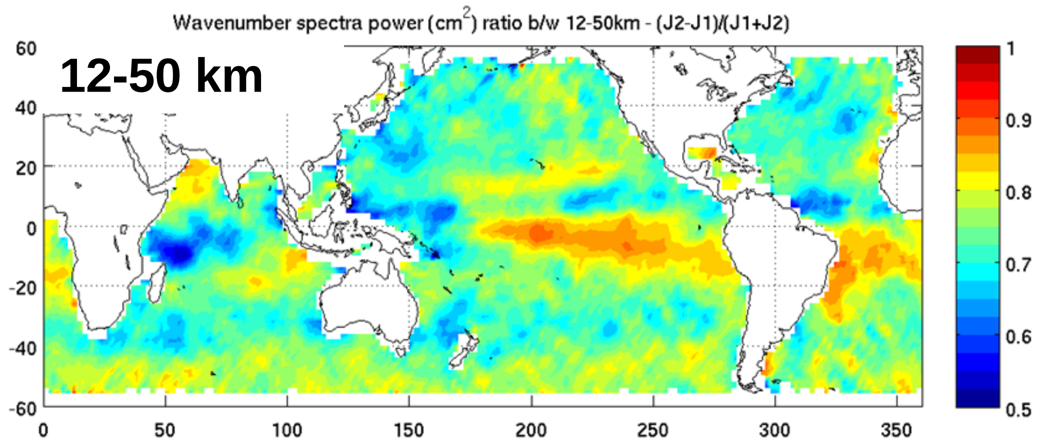
A Computed with , Assuming that errors in the table are uncorrelated (which is not the case).
B from formation flight phase (jason-1/ Jason-2)
C from cross-over computations of jason-2 data

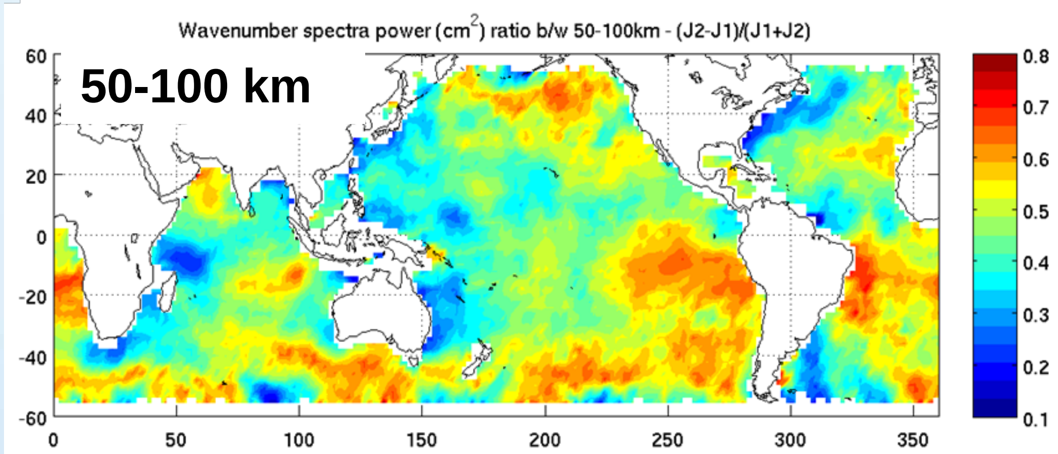
Spatial/temporal errors in J1 and J2 SSH
Ponte and Quinn



- J1, J2 spectra indistinguishable, variable slopes, one break at ~100 km
- Noise spectrum nearly white with single slope ≈ −0.4
- S2N ≈ 10 at wavelengths of 150 km and longer
- Noise, signal spectra similar in slope+magnitude at wavelengths < 50 km

Spatial/temporal errors in J1 and J2 SHH
Ponte and Quinn



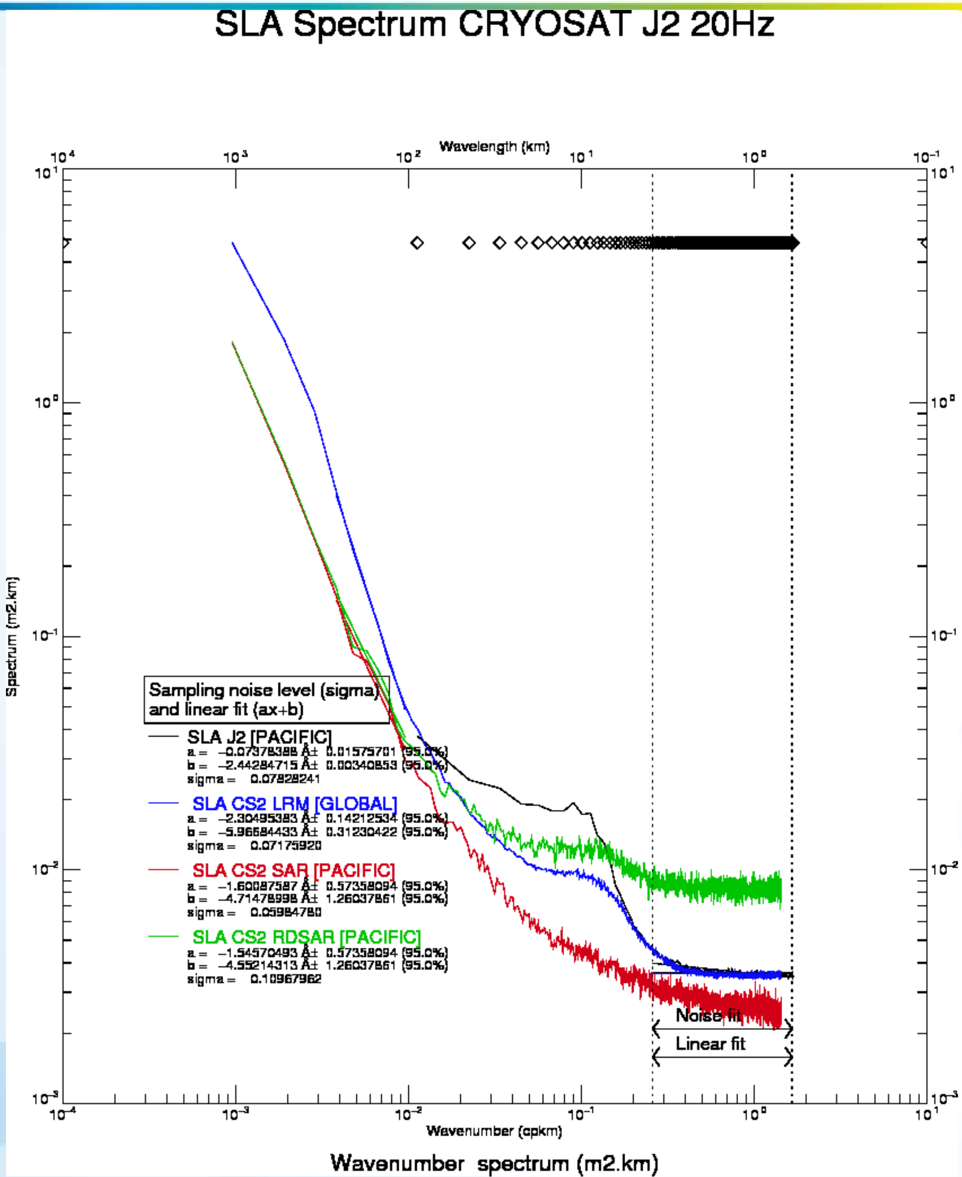


Noise-to-signal ratio:

Var(J1 − J2) / Var(J1) + Var(J2)

- ❑ **Altimeter measurements for wavelengths < 50 km at the noise level**
- ❑ **Tendency for better noise-to-signal ratios in western basins, where signals can be stronger**

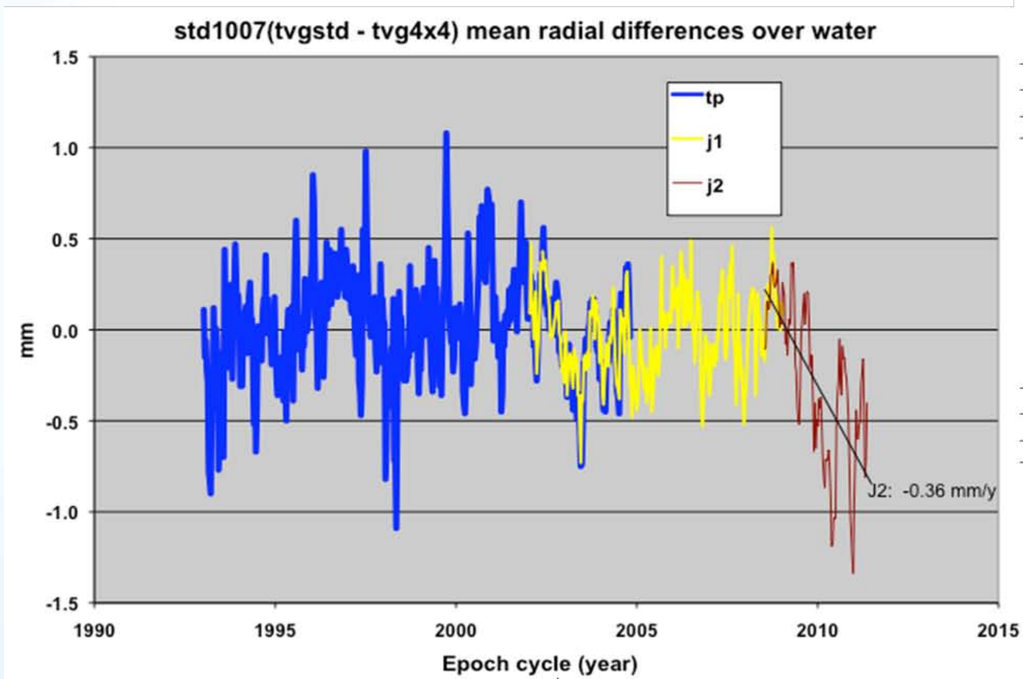
Reducing short wavelength errors with new altimeter techniques



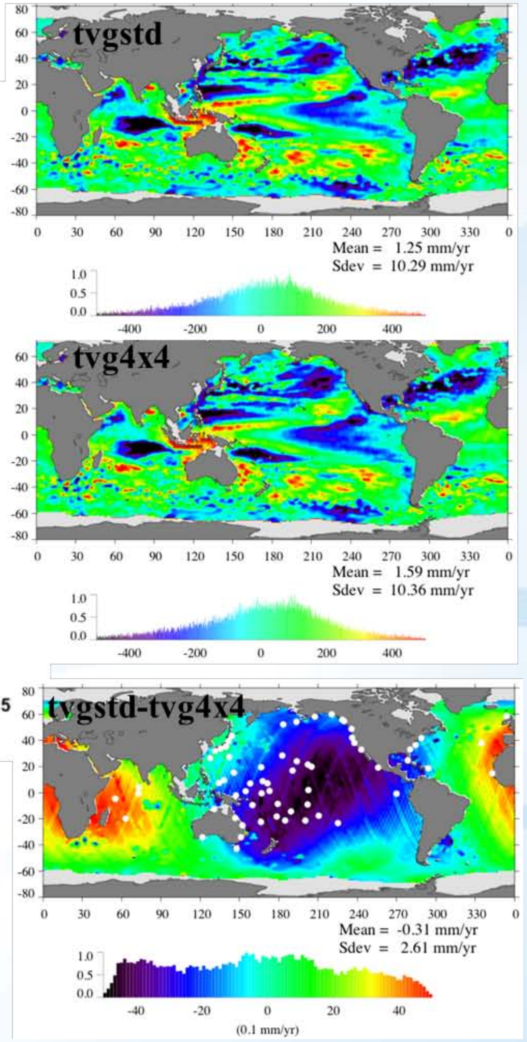
- Results obtained from the CNES CPP SAR mode retracker developed for Cryosat-2
- Reduced noise level improves 10-100km signals
- SAR processing removes spurious spectrum bumps
- Errors could be specified as function of wavelength, not only white noise

Temporal errors in altimetry data series
Beckley et al.

Impact of TVG on Global Mean Sea Level Estimates



Jason-2 MSL Rates



1.25 mm/yr (tvgstd) → 1.59mm/yr (tvg4x4)

Possible Jason-2 MSL underestimation **~ 20%.**

Compromise of accurate accounting of total mass budget over relative short GRACE & Argo observation period (*Beckley et al., 2011*).

Temporal errors in altimetry data series
Ablain et al.

- Orbit Error characterization for climate signals
- Strong collaboration between POD teams and CalVal teams

- Application-oriented approach : climate, this slide
- Error decomposition: trend, inter annual, periodic (different periods)

Spatial Scales	Temporal Scales	Orbit solutions errors
GMSL	Long-term evolution	< 0.1 mm/yr
	Inter annual signals	< 1mm
	Periodic signals	< 0.5 mm for annual signal
RMSL	Long-term evolution	< 2 mm/yr
	Periodic signals	< 5 mm for annual signal

Summary

- **A dedicated splinter session on quantifying the errors and uncertainties in altimetry:**
  - A cross-cutting activity among all the splinter sessions: thematic and CalVal
  - A specific effort for defining error estimation protocols
  - Going further than the “simple” error budget table
  - Separating spatial and temporal errors
  - Characterisation of the errors according to wavelength/frequencies to address specific applications
  - Users, applications should be engaged in defining the requirements, depending on their domain:
    - Climate scientists are pushing a lot: good improvements in error characterisation in the last few years
    - Other applications should also be more engaged: e.g. assimilation into ocean models