Results of the study on future altimeter mission orbit determination – application to Jason-CS

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Introduction - context

In the context of Post-EPS (EUMETSAT's follow-on Polar System),
- Eumetsat wants to suggest optimal orbit candidates for a reference altimeter mission planned from 2018 onwards.
- we consider multi-missions context with Sentinel-3
- A major objective is to reduce mission costs

This study is directly applicable to Jason-CS orbit
- To replace Jason's orbit which is too expensive (high latitude and low inclination orbit)
- We consider nadir altimeter, high resolution, non sun-synchronous long term reference mission
- Major requirement is to have an error budget of the same order of Jason's series
- Ocean signals observation are a priority: climate, tides, mesoscale …

This study benefits from more than 15 years of accurate space altimetry (TP,Jason, EN).

Methodology

1. Pre-selection of new altimeter orbit candidates according several criteria (altitude, inclination, cycle duration, tides …)
2. Assessment in a multi-satellite context (purely geometrical sampling analysis)
   1. To filter out suboptimal orbit choices (e.g.: no S3A / S3B redundancy)
   2. To highlight potentially optimal choices ⇒ 3 orbit candidates chosen
3. Evaluation of the impact of orbit candidates for different applications and issues
   1. Mean Sea Level trends and climate signals
   2. Budget error - POD
   3. Costs
   4. Mesoscale observation – operationnal oceanography

1. Pre-selection of new orbit candidates

1. **Global recommendations from passed/planned altimeter missions : GFO, TP, Jason, Envisat, Sentinel-3 …**
   - Altitude between 800 and 1400 km (Berthias 2008) : air-drag and solar radiation exposure trade-off
   - Repeat cycle between 10 and 35 days
   - High inclination to get more polar ocean observations
   - No sun-synchronous orbits because they do not allow aliasing of daily signals
2. **New selection criteria considering user/experts requirements**
   - Climate, costs, tides aliasing, mesoscale

⇒ A small pool of suitable orbit options was selected to analyze and understand the impact of orbit characteristics.

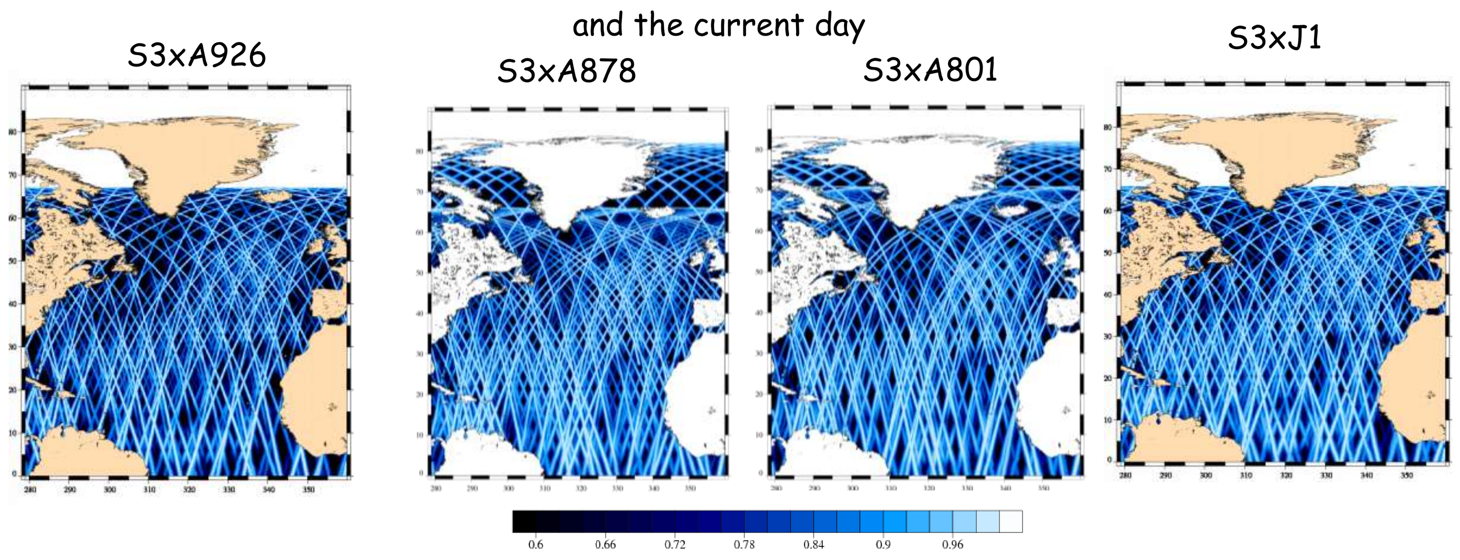
Description of the three orbits selected

	Altitude (km)	Inclination (°)	Cycle duration (day)	Sub-cycle (day)	S1 aliasing (days)	Tide separation(years)
A878	878	66	10	1	100.97	3.5
A926	926	67	13	4	105.64	-
A801	801	71	22	7	115.05	6
Jason	1336	66	10	3	117.47	-

2. Assessment in a multi-satellites context

The orbit geometry determines the geographical coverage, the space/time sampling by the altimeter measurements and thus the type of applications that can be addressed. The approach is a purely geometrical sampling analysis.
- We consider only 2-satellites constellations with Sentinel-3
- This optimisation is not universal, as only a truly optimised constellation yields a significantly better sampling (e.g. J1+TP); but we want to detect very poor sampling (= much redundancy)
- Analysis is limited to the signals which can be resolved by multi-satellite altimetry (7-15 days, 75-150 km)
- Base metrics used are : Ocean coverage, Observable scales , Sampling quality and homogeneity, Mesoscale structure detection and long-term monitoring, Cross-overs angles and scattering for currents and cross-calibration

Instantaneous correlation between available NRT measurement and the current day



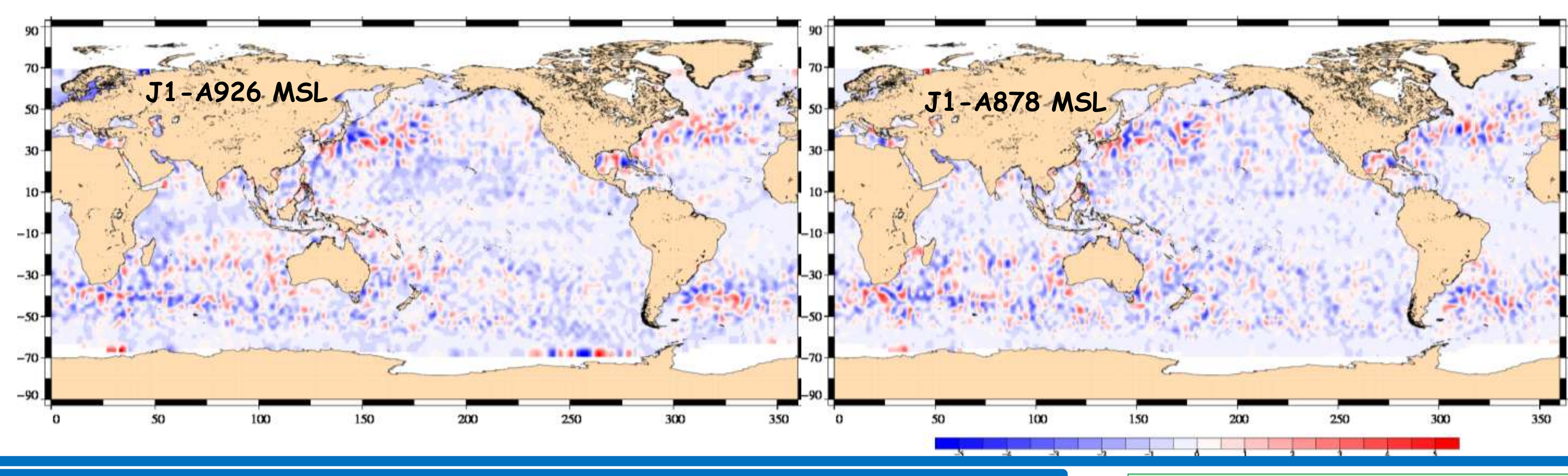
3. Evaluation of the impact of orbit candidates for different applications

3.1. Impact of orbit candidates on MSL trend estimations

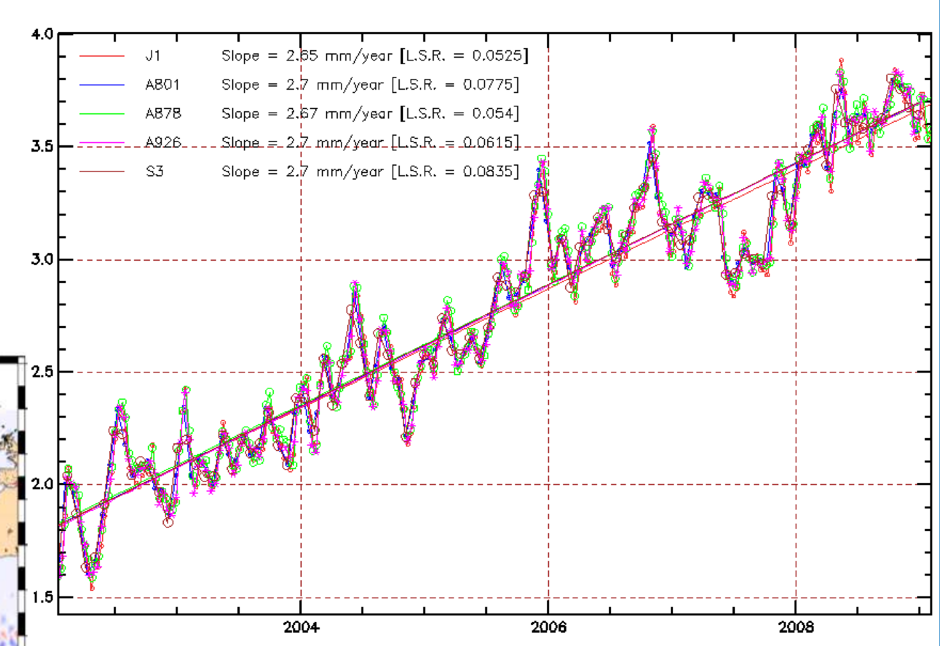
We focus on the Jason-1 period (cycles 1 to 261). The long term ocean state is modeled by the best observed products available (weekly altimeter merged maps available at CLS; *Aviso 2006*). The maps are interpolated along each satellite tracks and regional and global MSL tendencies can be deduced (*Ablain et al. 2009*).

Global MSL estimations are weakly impacted by the satellite tracks definition (difference < 0.05 mm/y).
Concerning regional MSL, some differences (2 mm/y) appear between J1 and A801, A926 or S3, in West Indian Ocean, North and Baltic Seas and North Pacific Ocean. No difference between J1 and A878 trends which have similar cycle (10 days).

Regional MSL trend differences (mm/year)

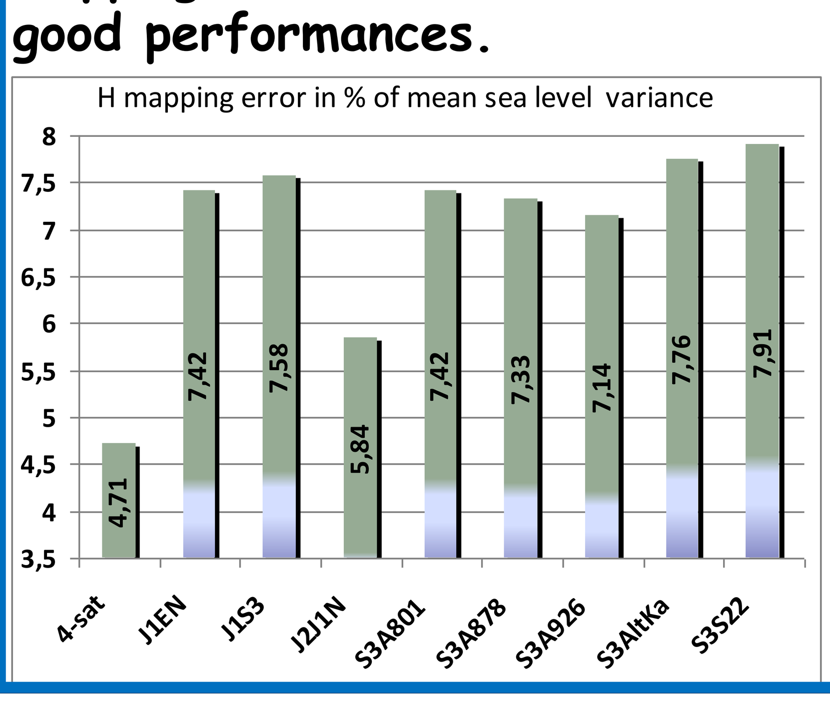


Global MSL trend (cm)

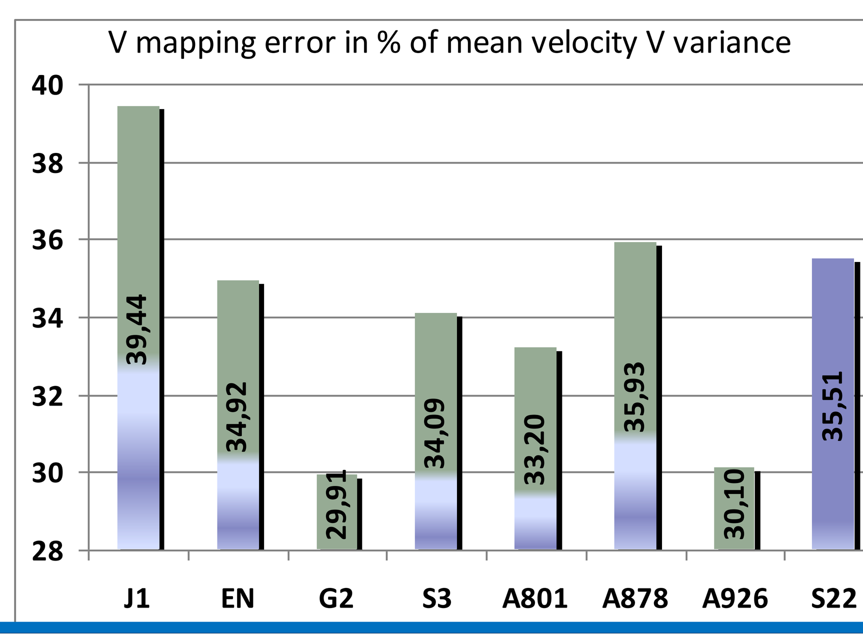


3.2. Mesoscale observation for operationnal oceanography

We run OSSE in a mapping context for the 3 orbit candidates in constellation with S3; results are compared to the well-known constellations. Ocean mesoscale is modelled thanks to MERCATOR-OCEAN global 1/12° simulations (ORCA12). **Results corroborate other studies.** Concerning the 2-sat. const., the optimised J2-J1N has very good performances compared to non optimised ones. **The three orbit candidates have similar results, all better than J1EN or J1S3; A926 shows slighly better performances.**
Concerning mono-satellite constellations, J1 is the worst choice in term of mesoscale mapping, A878 is a bit better due to its lower altitude, while GFO and A926 have very good performances.



Mean mapping error on global ocean for sea level and velocity V .



Conclusions

- Many new orbit candidates are possible.
- A shortlist has been proposed to explore the impact of orbit specificities; this shortlist is not exhaustive.
- A comprehensive methodology has been followed and a robust protocol developed, that could be easily re-used.

- Lower altitudes orbits (800-1000 km) are possible for the future high precision altimetry missions like Jason-CS …
- The selected orbits lead to results as accurate as Jason's, and sometimes better. But results depend on the application specificity (mesoscale, climate, Mean Sea Level).
- Changing the orbit has not a critical impact on the global budget error, and POD accuracy but this demands an optimised configuration (platform, payload and processing).
- Mission lifetime should be improved while cost (launch and payload) would remain constant or improved.

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