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Future space missions planned for high-resolution observations

J. Lambin, CNES

Altimetry for oceans and hydrology, Lisbon, October 2010

Scope

- “High resolution” as “higher resolution than current capabilities”
- “High resolution” as “observing small structures”
- “High resolution” as “multi-scale capability”

Towards higher resolution in altimetry

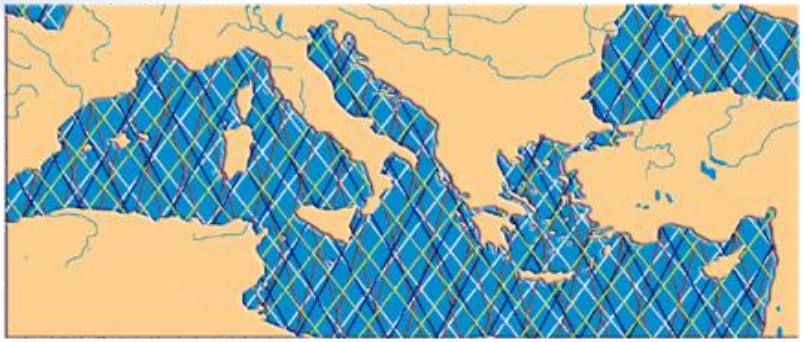
- **Until now, almost(*) all altimetry missions have been based on standard pulse-limited Ku-band altimetry**
  - **Profiling technique => no resolution per se**
    - Sampling along-track: 350 m @ 20 Hz echoes
    - Across-track space/time separation dependent on orbit characteristics
    - Footprint diameter of several kilometers

Jason-1

(*) 2 notable exceptions: IceSat, Cryosat

Enhancing “resolution” with profiling altimetry

- **More altimeters**
  - Reduce across-track separations
  - 2001-2005: TP/J1/GFO/ENVISAT



- **SAR mode**
  - Much better along-track sampling
  - Currently flying: Cryosat-2 mission
  - Upcoming: Sentinel 3A & B (2013, 2017)

- **Ka-band altimetry:**
  - ⇒smaller footprint
  - higher PRF (pulse repetition frequency), hence
  - ⇒ better along-track sampling
  - Upcoming in 2011: AltiKa/SARAL

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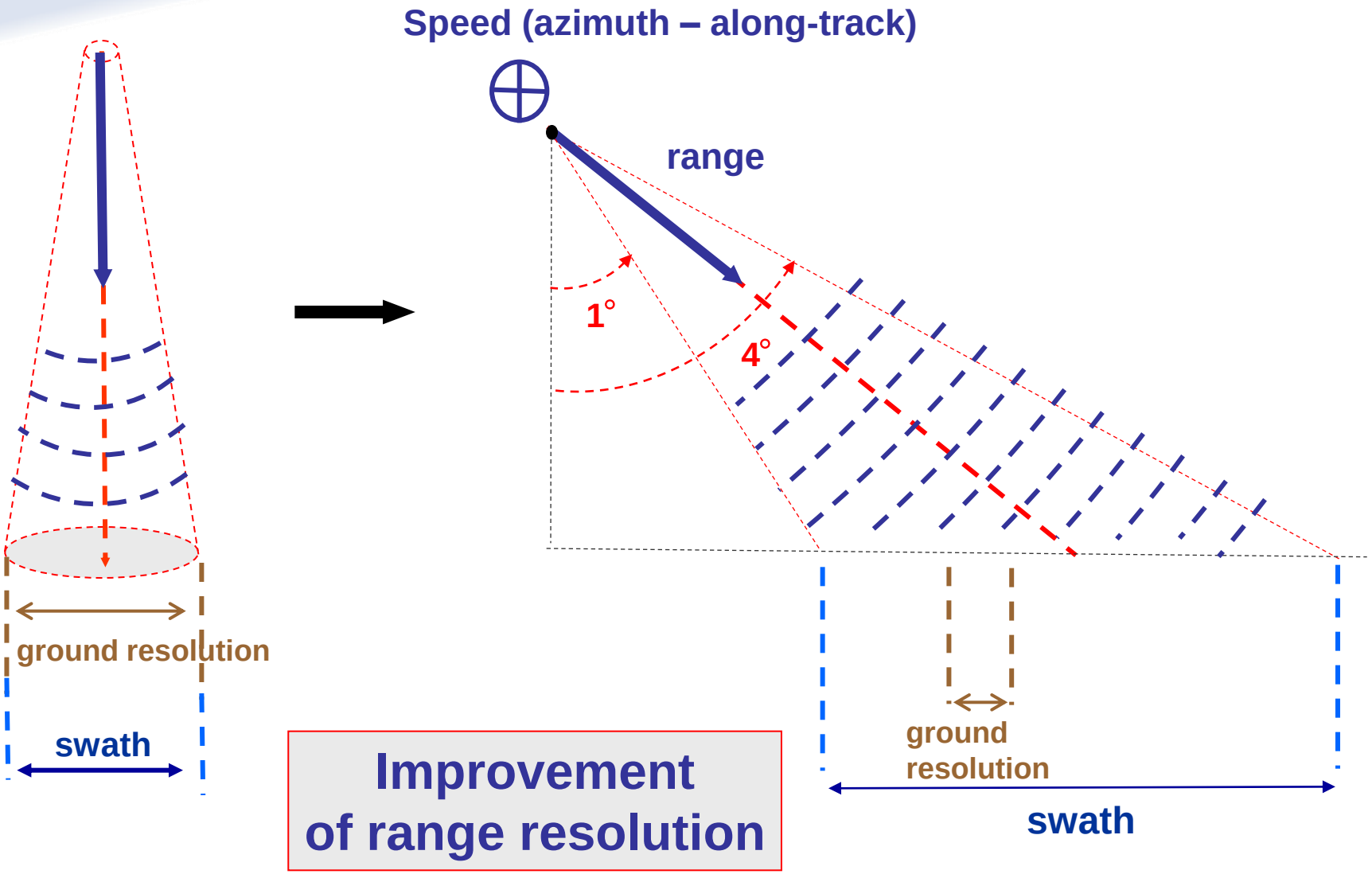
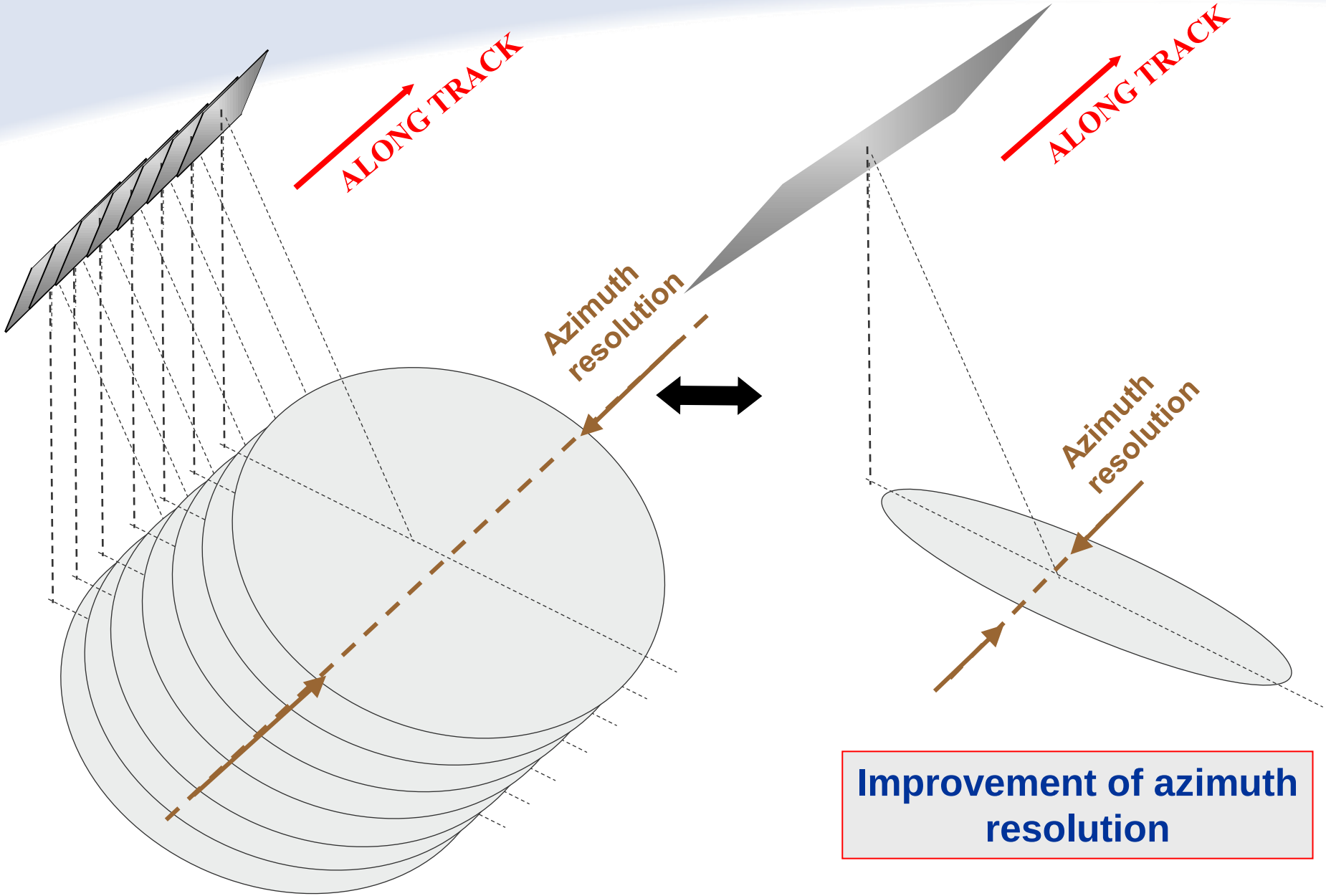
From nadir altimetry to swath altimetry (courtesy J.-C. Souyris)

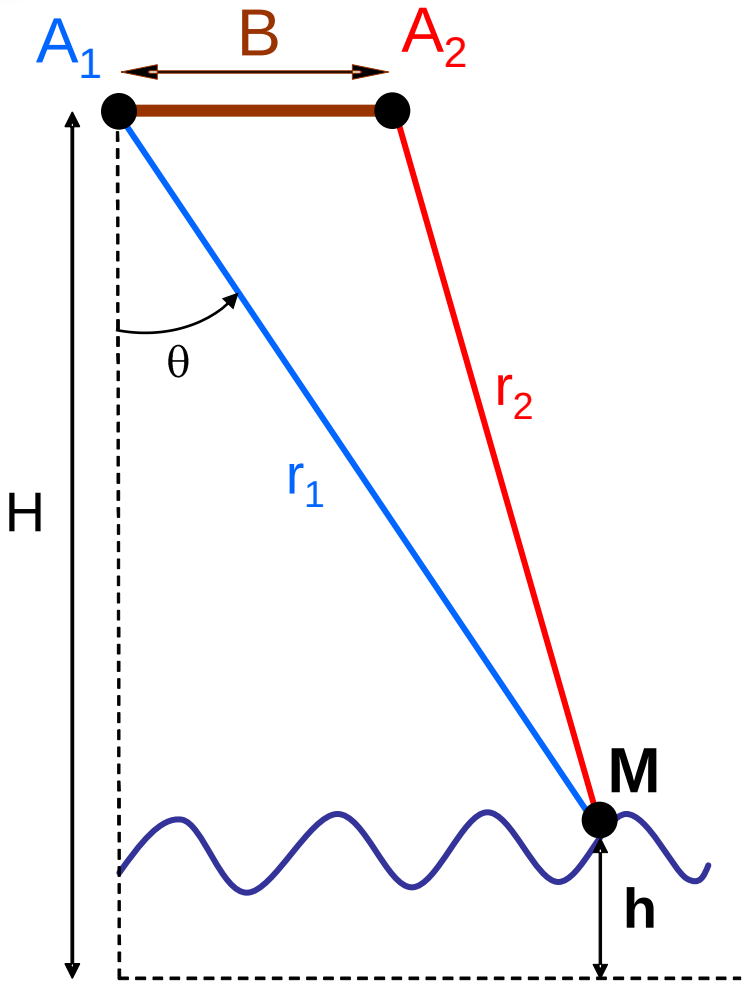


From nadir altimetry to swath altimetry



Improvement of azimuth resolution

From nadir altimetry to swath altimetry



Interferometric Phase (r_1-r_2)

Baseline

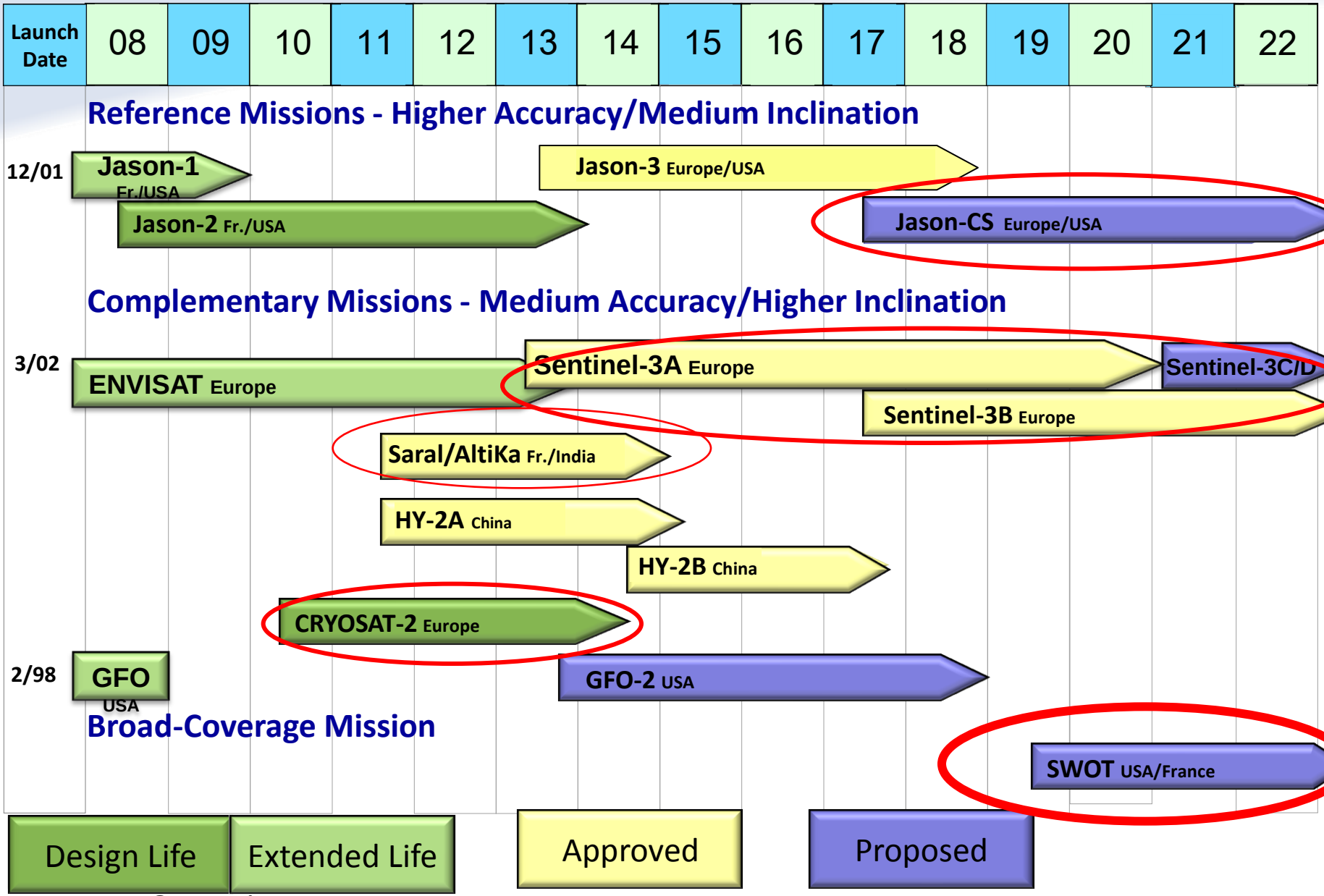
$$h = f(H, B, r_1, \Phi)$$

Orbit
(DORIS, GPS)

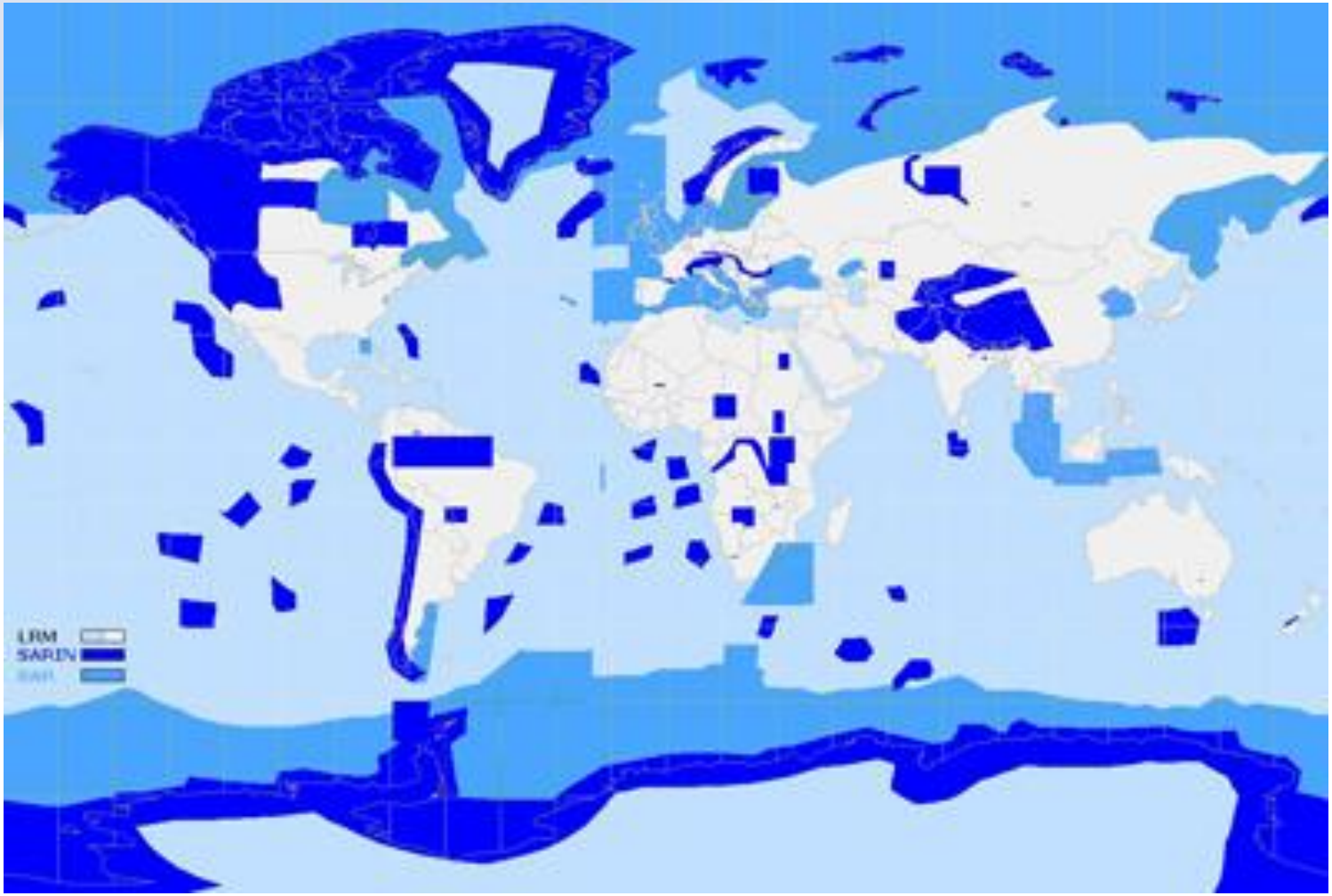
Range (on-board clock)

Height restitution by interferometry

GLOBAL ALTIMETER MISSIONS: OST-VC roadmap

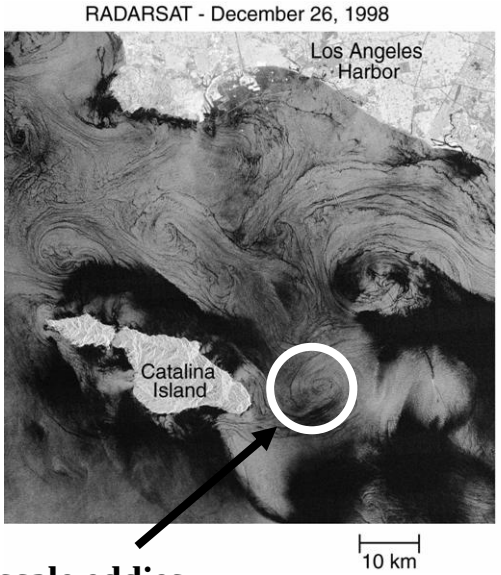


“high –res” altimetry already flying

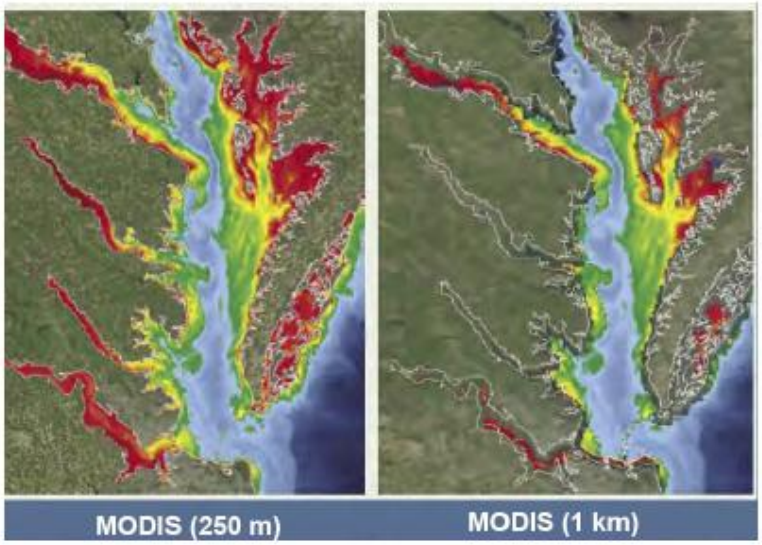


Cryosat validation workshop today => data accessible shortly !?

High-res for small-scale signals



10 km scale eddies Resolvable by SWOT



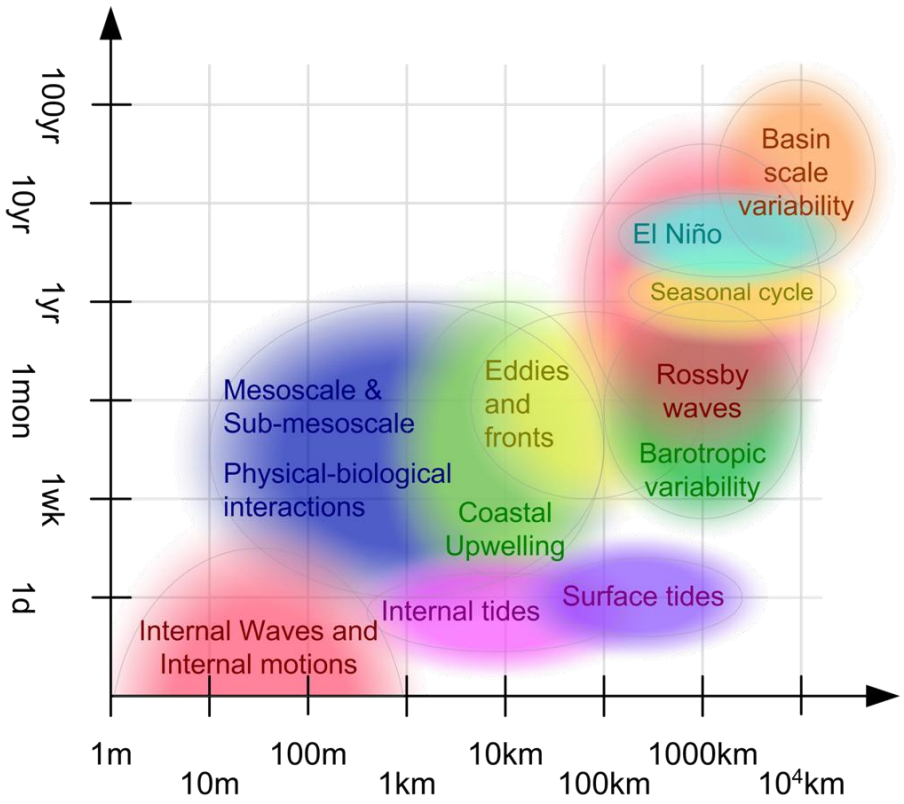
Courtesy B. Arnone

High-resolution: observing small-scale signals

- **Improving space resolution is great, BUT:**
  - **Phenomena that have shorter spatial scale tend to have shorter time scales**

⇒ **For satellite observation, the trade-off between revisit time and coverage is a dilemma**

- **Balance:**
  - **Orbit characteristics: revisit, track spacing, sub-cycles**
  - **Instrument characteristics: field of view / resolution**
  - **Number of satellites**



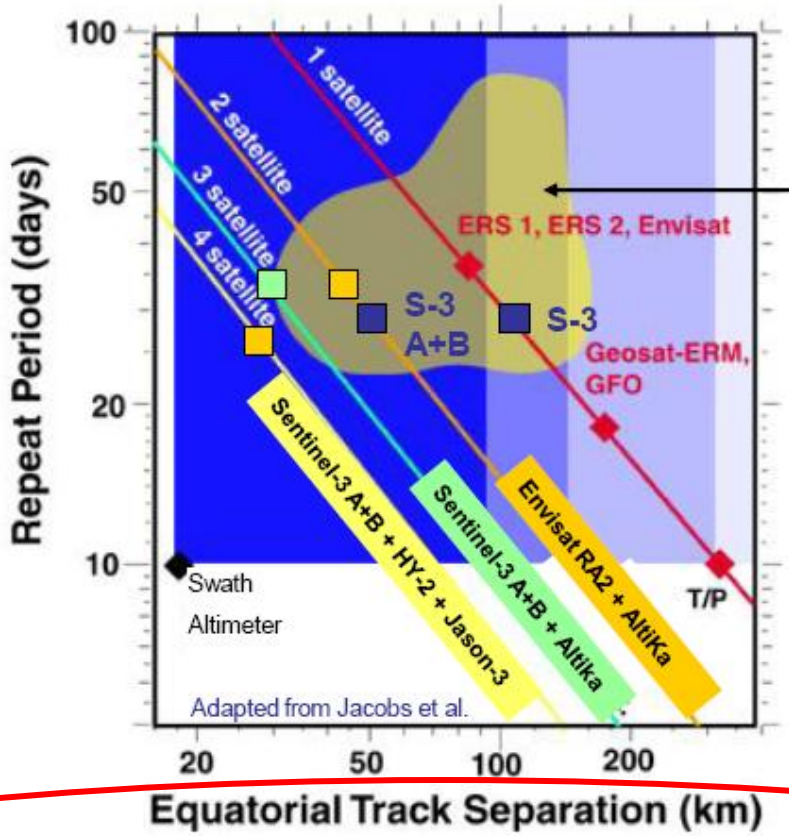
Time-space classification of ocean dynamics

From Dickey et al., Chelton et al. 2001

Usual trade-offs

- **Usually space resolution is set as the priority, especially for new observations**
  - SWOT approach: a 3-day repeat cycle during the calval phase, 22-day repeat during routine
- **Increase the number of satellites is a preferred solution for operational applications**
  - Current OST-VC roadmap
  - Initiatives such as Iridium-NEXT
- **Other approaches (outside of altimetry)**
  - Limit the coverage to some target areas: Venμs, MISTIGRI (see I. Dadou's poster)
  - Geostationary satellites (OCAPI, GeoCAPE)

Altimetry Resolution/Sampling



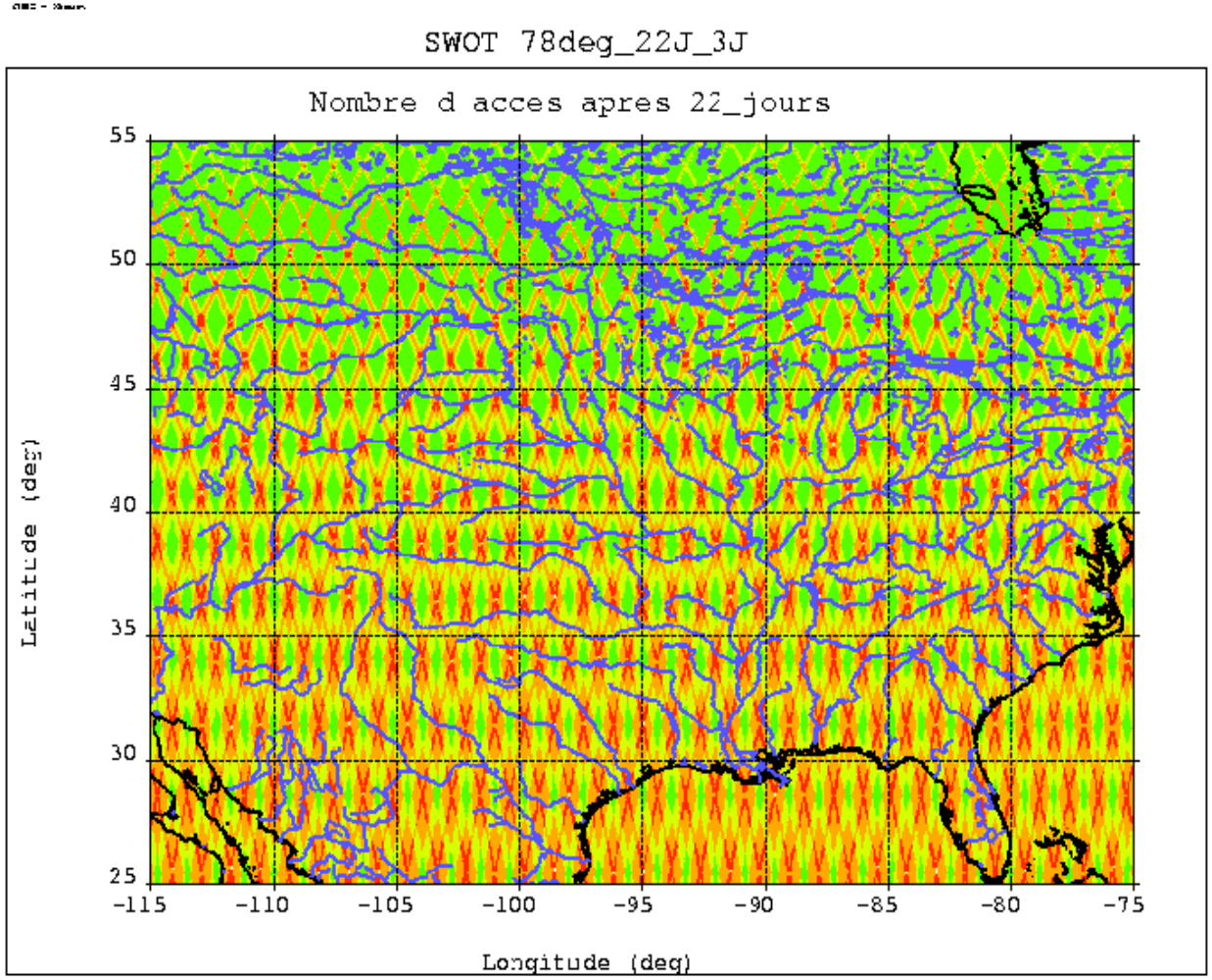
Region of observed mesoscale activity

- Envisat RA-2
- Jason-1 & 2
- SARAL/AltiKa
- HY-2A
- CryoSat-2 SIRAL
- Sentinel-3A,B SRAL
- Jason-3
- GFO-2

Ideal mesoscale sampling requires a coordinated Virtual Constellation of several altimeters: one precise reference mission (tide-free orbit) + 2 or more in optimised sun-synch. orbits. Significant coverage improvement possible with swath altimetry.

Courtesy Mark Drinkwater

SWOT space / time sampling



- **Time/space sampling requirements => how do we fill the holes?**
- **High resolution data within the swath => integration into large scale picture (data or model)?**

Multi-scale capacity

- **Interactions between space and time scales is of major importance, but one observing technique can rarely cover everything**
- **Parameters accessible to observations by space or in situ techniques are neither independent from each other, nor do they include the full information desired**

- **Importance of multi-observations approaches**
  - **e.g. complementarity between SWOT and**
    - Traditional altimetry
    - Sea-state measurements (SAR, CFOSAT)
    - Current measurements (SAR, SWORD, WAVEMILL)

- **Importance of multi-domains approaches (optical, thermic, active & passive MW…)**
  - **e.g. a large majority of the presentation in this meeting**

⇒ **Importance of modelling**
  - **Link between different types of observations**
  - **Inter/extrapolation, assimilation**
  - **A posteriori improvement of the resolution (J. Tournadre talk, SMOS desagregation algorithms…)**