Oceanographic Studies for the SWOT Project

Understanding the 2-D sea surface height signal

Understanding the 2-D error budget contributing to SSH

Projecting fine-scale SWOT observations into sampling holes & vertically

Sampling & observability of the ocean signal with SWOT orbit

CalVal activities

Data Products & Applications
1. Understanding the 2-D sea surface height signal

- Study the 2-D ocean signals impacting on SSH – especially in the 15-200 km wavelengths not well observed by nadir altimetry. These include mesoscale eddies, sub-mesoscale fronts and filaments, internal waves, internal tides, coastal tides, SSH signals, certain surface waves.

- Study and understand their geographical variations (high and low eddy energy regions, tropics, mid-latitudes and high-latitudes) and their seasonal and interannual variations (role of varying stratification, temperature and salinity changes, different atmospheric forcing)

- Types of study : High resolution model simulations of ocean currents and waves & tides, analysis of alongtrack altimeter data (J2, AltiKa, CR2-SAR), multi-satellite data (SST, ocean colour, SAR), in-situ observations, AirSWOT

- Who? Principally SDT members, supported by CNES/NASA

**SWOT SDT Science Splinter Sessions : Wed afternoon**

- Understanding the 2-D sub-mesoscale
- High-frequency signals (tides, internal tides & waves)
Wednesday oceanography splinter 1 : 3:00 pm
“Understanding of 2-D sea surface height signals”

Relevant Scientific topics:

1. Meso- and submesoscale dynamics impacting on SSH in the 15-200 km wavelengths
2. Relevance and handling of ageostrophic signals
3. Interaction between submesoscale, mesoscale, and large-scale circulation
4. Need and merging of nadir-looking altimeter
5. Insights from submesoscale-resolving OGCM simulations

4 Presentations & Discussion
High-frequency dynamics for SWOT—tides, internal waves, surface waves

Scientific goals: To better understand and characterize the aliasing of high-frequency tides, internal waves, and surface waves, and implications for the estimated geostrophic motions

Technical issues: Aliasing due to 22-day temporal sampling

7 presentations & Discussion
2. Understanding the 2-D error budget contributing to SSH observations over the swath

- SWOT systematic instrument errors – roll error, phase error, baseline dilation error, timing and mispointing errors, etc
- Orbit errors
- Random interferometric errors – thermal noise/speckle, geometric decorrelation, angular decorrelation
- Sea-state errors – wind & wave effects on interferograms, sea-state bias effects
- 2-D media errors – including correction for wet & dry tropospheric delay, ionospheric delay, etc

*Types of study*: Ocean simulator: interferometry -> L2, wave models, 2-D estimations of media errors from satellite observations and models, POD, AirSWOT observations under different wind-wave conditions

*Who? Project led studies, supported by expert SDT members*

**SWOT SDT Meeting**:
- *Error Budget & mission performance discussion (Tues afternoon)*
- *Algorithm Development and CalVal planning (Thurs morning)*
3. Projecting fine-scale SWOT observations horizontally & vertically

- Multi-mission, multi-scale mapping of SWOT SSH and nadir altimetry SSH (S3, J-CS, ..)
- Multi-captor, multi-scale mapping of SWOT velocity and nadir altimetry, SST, ocean colour, S3 SAR velocities
- SQG techniques based on HR SSH and atmospheric forcing (SST, wind)
- Analytical modeling techniques (advection)
- Data assimilation

*Types of study*: High resolution model simulations of ocean currents and waves & tides combined with Ocean L2 error simulations. Multi-captor and multi-mission studies based on existing satellite observations, techniques could be tested with AirSWOT observations

- Who? Principally SDT members, including Mercator, CLS-AVISO with some support from NASA/CNES project. Will impact on ocean applications (6).

**SWOT SDT Science Splinter Sessions**: Thurs afternoon
- Projecting fine-scale SWOT observations horizontally & vertically
2D to 3D dynamics from SWOT

Scientific goals:
Projecting fine-scale SWOT observations into sampling holes (full 2D) and vertically (3D) [Focus on the mesoscale-sub-mesoscales, i.e. the low-freq. component of SSH]

Technical issues:
The limited SWOT sampling in time (21d repeat) vs rapid motion of fine-scales (few days) Complexity of the 3D structure, validity of QG, SQG, ...

Main questions to be discussed:
- How much 2D signal can we reconstruct into sampling holes (in time and space)?
  → Optimal interpolation? Need to go beyond? Data assimilation?
- How to use SWOT data to reconstruct some of the 3D ocean dynamics?
  → Capabilities of data assimilation?
  → How does simple dynamic schemes (SQG, ...) perform compared to assimilative OGCMs?
  → Synergy with external obs (Argo, other high res surface sensors, ...)?
The first part of the session is dedicated to DA in OGCMs, with first an overview of conventional altimetry assimilation, and then SWOT perspectives.

3 Presentations

The second part is dedicated to 2D sampling issues and 3D reconstruction from simplified models/ dynamic schemes, with or w/o external obs.

3 Presentations

The above questions could be discussed at the issue of these talks, in particular:

→ DA in OGCMs **versus** simplified dynamic schemes to retrieve 2D/3D ?

→ The need for external sensors (SST, color, argo, ...) may be clarified. Some implications for Air SWOT campaigns?
4. Sampling & Observability of the ocean SSH signal with SWOT orbit

- Impact of sampling on the detection of 2-D SSH signals described in (1).
- Aliasing of high-frequency SSH signals in SWOT observations

- Types of study: Ocean L2 error simulator to be applied to different satellite observations and high resolution model simulations of ocean currents and waves & tides, AirSWOT observations

- Who? Project and SDT members

SWOT SDT Sessions: None (discussed in June)
5. CalVal Activities

Global cross-calibration
• Operational SWOT-SWOT crossover analysis of SSH + errors
• SWOT-nadir altimeter crossover error analysis (SWOT nadir & J-CS, S3)

Regional CalVal
• SWOT-in-situ analyses for SSH & velocities – glider lines, tide gauges, bottom pressure gauges, current meter arrays and ship-borne ADCP, underway SSS & SST data, surface drifter currents, GPS buoys, longterm altimetric CalVal sites (Harvest, Corsica, …)
• Specific Airborne campaigns – AirSWOT, Kuros( CFOSat), high-resolution radiometry for SST & wet tropo
• Types of study : AirSWOT observations compared to other satellite and in-situ data. Sampling of projected SWOT sampling & errors derived from high resolution model simulations of ocean currents and waves & tides combined with Ocean L2 error simulations. Projected CalVal sites tested or chosen from error analysis.

• Who? SDT members, and NASA/CNES project studies

SWOT SDT Meeting :
• Algorithm Development and CalVal planning (Thurs morning)
6. Data Products & Applications

- L2 SSH and slope ocean products (swath products) will be produced by the project
- External HR data products are required (geoid, bathymetry MSS, tide models, internal tide models, ...)
- Gridded products will be required for most applications. This will depend on activities listed in (4).

- Types of study: Simulating data products and volume in L2 GDR form, and a 2-D SLA swath format. Development and validation of HR external data products against HR nadir altimetry (eg SAR) or AirSWOT.

- Who? NASA/CNES project studies, support from SDT & external scientists for external products, and gridding procedures from (3).

SWOT SDT Meeting:
- Algorithm Development and CalVal planning (Thurs morning)
- Applications program & splinter (Thurs)
Wednesday oceanography splinter 1 : 3:00 pm

“Understanding of 2-D sea surface height signals”

Presentations:

1. Roger Samelson: *Effect of mesoscale vs. submesoscales on eddy amplitude time series*
2. Billy Kessler: *Submesoscale jets and squirts observed in Solomon Sea glider data*
3. Alex Kurapov: *Submesoscale features in a 2-km resolution eastern Bering Sea simulation*
4. Gerald Dibarboure: *Short wavelength correlated errors of altimetry: implications for SWOT*
Presentations

• ZhongXiang Zhao: Tidal corrections (M2 internal tides)
• Richard Ray: Tidal corrections (State-of-the-art assimilative models for open and coastal ocean)
• Jay Shriver: Internal tide non-stationarity, frequency content, and simulated altimeter sampling in a high-resolution global tide-plus-circulation model
• Sarah Gille: Tidal SSH signal in Mendocino Channel
• Benoit Laignel: Estuaries
• Pierre de May and Nadia Ayoub: High-frequency dynamics (including internal waves) in the Bay of Biscay
• Fabrice Ardhuin: Infragravity waves
The first part of the session is dedicated to DA in OGCMs, with first an overview of conventional altimetry assimilation, and then SWOT perspectives

- Along-track assimilation in the coastal ocean model off Oregon, Alex Kurapov
- Ensemble-based data assimilation and downscaling in coastal regions, Pierre De Mey
- Assimilation of SWOT simulated observations in ocean model, Elisabeth Remy

The second part is dedicated to 2D sampling issues and 3D reconstruction from simplified models/ dynamic schemes, with or w/o external obs.

- Potential perspectives of a dynamic interpolation scheme for SWOT, Clement Ubelmann
- Submesoscale reconstructions of ocean currents from Lagrangian techniques, Guillaume Lapeyre
- Overview of the meeting “2Dto3D ocean dynamics from satellite observations” in Brest, last Dec. Bertrand Chapron/Clement Ubelmann

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