

# Application Development for Operations (Oral)

## **Are SAR wave spectra from Sentinel-1A ready for operational use in the wave model MFWAM?**

*Lotfi Aouf (Département Marine et Océanographie Météo-France, France), Alice Dalphiné (Département Marine et Océanographie, Météo-France, France)*

## **Improved Representation of Eddies in Fine Resolution Forecasting Systems Using Multi-Scale Data Assimilation of Satellite Altimetry**

*Zhijin Li (JPL, US)*

## **NOAA Operational Satellite Derived Oceanic Heat Content Products**

*Eileen Maturi (NOAA/NESDIS/STAR, US), David Donahue (NOAA/NESDIS/OSPO, US), Nick Shay (RSMAS - University of Miami, US), Jodi Brewster (RSMAS - University of Miami, US), Jerry Guo (MAXIMUS, US)*

## **On the use of recent altimeter products in NCEP ocean forecast system for the Atlantic (RTOFS Atlantic)**

*Liyang Liu (NOAA, US), Carlos Lozano (NOAA, US), Avichal Mehra (NOAA, US), Dan Iredell (NOAA, US)*

## **Operational Oceanography in support of the search for MH370**

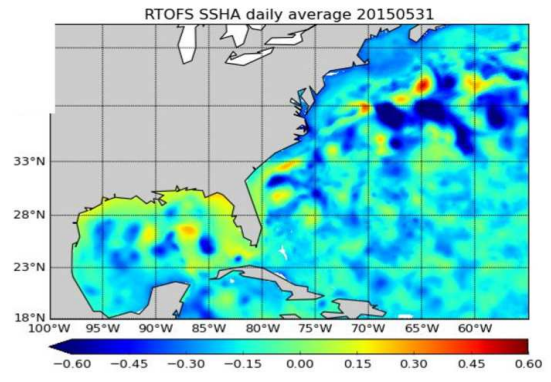
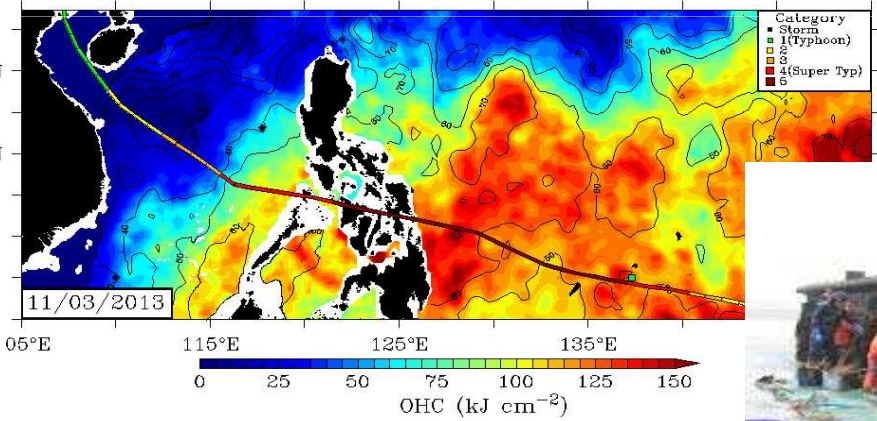
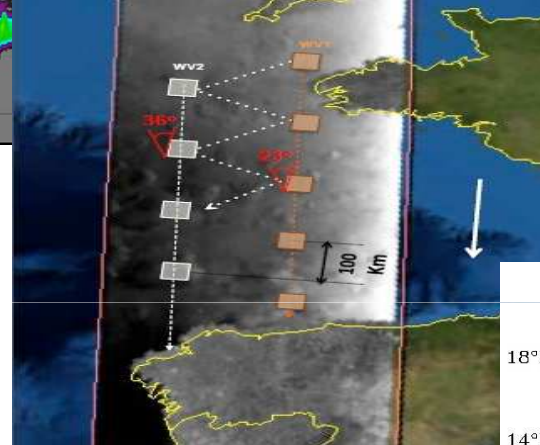
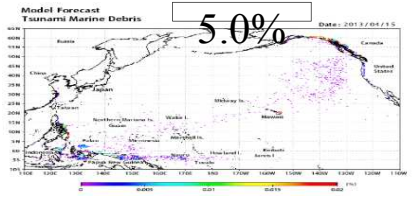
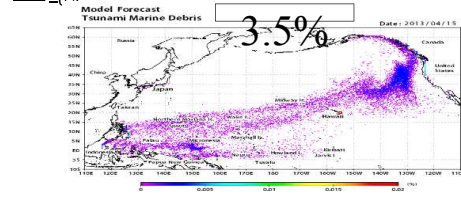
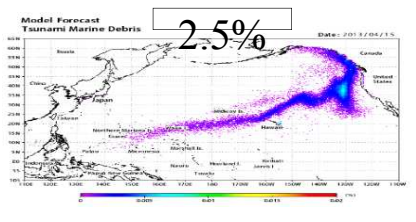
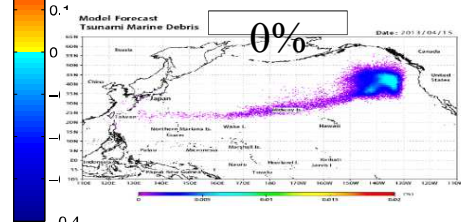
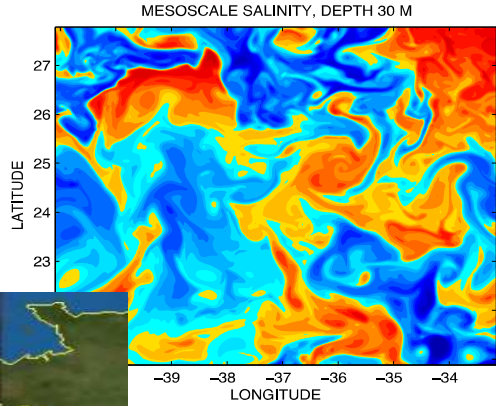
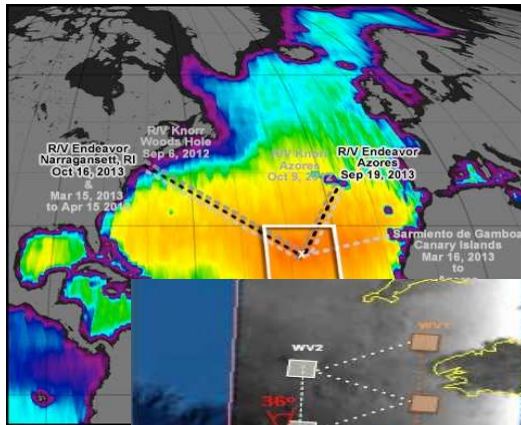
*David Griffin (CSIRO, Australia)*

## **Predictability of marine debris motion, simulated with numerical models and diagnosed using oceanographic satellite data**

*Nikolai Maximenko (IPRC/SOEST, University of Hawaii, US), Jan Hafner (IPRC/SOEST, University of Hawaii, US), Amy MacFadyen (NOAA Emergency Response Division, US), Masafumi Kamachi (Meteorological Research Institute, Japan Meteorological Agency, Japan)*



# Applications to Operations



# Application Development for Operations (Poster)

## **DUACS sea level products, a step beyond with Jason-3 and Sentinel-3**

*Yannice Faugere (CLS Space Oceanography Division), Isabelle Pujol (CLS), Frederic Briol (CLS), Claire Dufau (CLS), Antoine Delepoulle (CLS), Gerald Dibarboure (CLS), Damien Desjonquere (CNES), Nicolas Picot (CNES)*

## **20 years of reprocessed Lyapunov exponents from altimetry available on Aviso**

*Marie Isabelle Pujol (CLS), Yannice Faugere (CLS), Francesco d'Ovidio (LOCEAN - IPSL), Rosemary Morrow (LEGOS), Jean-Damien Desjonquères (CNES), Nicolas Picot (CNES)*

## **DT2014 version of Ssalto/DUACS products: 21 years Sea Level products reprocessed**

*Marie Isabelle Pujol (CLS), Yannice Faugere (CLS), Guillaume Taburet (CLS), Jean-Damien Desjonquères (CNES), Nicolas Picot (CNES)*

## **Validation of Cryosat-2 SAR Wind and Wave Products**

*Saleh Abdalla (European Centre for Medium-Range Weather Forecasts (ECMWF)), Salvatore Dinardo (Serco/ESRIN), Jérôme Benveniste (European Space Agency/ESRIN)*

## **Satellite Altimetry Sea Surface Height Anomaly Processing at the Naval Oceanographic Office's Altimetry Data Fusion Center**

*Carolyn Cooper (Naval Oceanographic Office)*

## **Operational ocean data assimilation/prediction system for the western North Pacific at JMA**

*Toshiyuki Sakurai (Japan Meteorological Agency), Mikitoshi Hirabara (Japan Meteorological Agency), Masakazu Higaki (Japan Meteorological Agency), Norihisa Usui (Meteorological Research Institute), Yosuke Fujii (Meteorological Research Institute), Hiroyuki Tsujino (Meteorological Research Institute)*





## DUACS SEA LEVEL PRODUCTS, A STEP BEYOND WITH JASON-3 AND SENTINEL-3

**The DUACS System**

The DUACS (Data Unification and Altimetry Combination) system has produced, as part of the CNES/ESA and AVISO contracts and since 1st May will produce in the frame of the Copernicus Marine Environment and Monitoring Service (CMEMS), high quality multi-satellite Sea Level products for oceanographic applications, climate forecasting centers, hydrography & biology communities.

These products are directly usable and consistent Level 3 along track cross-calibrated SLA and Level 4 products (impulse merged at maps or time series). Another set of products, leveling products, are also delivered: geostrophic currents, Lagrangian fields...

**J3 and S3-SRAL needed as soon as possible in the operational European Marine Service**

Since the 1st of June 2016, Sea level products are delivered as part of the CMEMS L3 and L4 products only produced operationally, in real time, for the global ocean and for European users. After the successful integration of Jason-3 in 2013 and in 2014, and in June 2016, 4 satellites are now used in the DUACS System.

The next key points are the integration of Jason-3 by the end of 2015 and Sentinel 3 in 2016. This is critical since our altimetry level optimized that covers Jason-3 and Sentinel 3 SAR-MODE measurements **as soon as possible after launch**. Revisions of user integration in CMEMS are demonstrated with Jason-3 and AltiKa. These revisions were used operationally in May/June 2016 only a few months after launch.

**Outlook of Sea Level products and the challenge of Sentinel-3 SAR-Mode**

The launch of Sentinel 3 will complete the altimetry constellation, the continuity of the Sea Level Service. Moreover, with its global SAR-MODE coverage, the contribution of Sentinel 3 is generally unique to improve our level products. Expanding the Sea Level Service to a challenging task and with SAR-MODE support from CNES.

The cross-track and temporal resolution of the altimetry constellation will increase with the combination of operational altimetry missions (Jason-3 and Sentinel-3 SAR-MODE) and contributing altimetry missions (Jason-3, SARAL, SWOT) which support the DUACS system, allowing to envision a combination of 5-6 altimeters or more instead of the current 3-4 sensors.

Combined with new imaging techniques, the new Jason-3 products developed by the research community, CMEMS Level 4 products will be available again at the order of 100 km and 1 day (10x better than now).

In the coming years CNES R&D will make it possible to leverage the new technology of Sentinel 3 in Level 3/4. Overcoming the challenges of SAR-M altimetry will provide major upgrades.

## DT2014 version of Ssalto/DUACS products: 21 years Sea Level products reprocessed

**Change of the reference period**

The reference year (1993, 1994) period historically used to reference the Ssalto/DUACS SLA products has been changed for the new 20-year (1993,2012) period. As a consequence the mean annual signal has more consistent statistics and seasonal variations.

**Mesoscale better resolved**

All the different changes implemented in the new version of the DT products lead to a more precise and representative of the mesoscale structures.

**Global along track products**

The altimeter noise reduction on along track products estimated with a 60km filter is a strong impact on coastal areas (Fig 1).

**Coastal areas and high latitudes**

Along track defined coast to the coast. Main features defined to be used:
 

- Improved consistency with tide gauge observations for global (Fig 2) and regional (Mediterranean Sea) (Fig 3) products.
- Improved consistency with altimetry measurements in the open boundary (open boundary line) (Fig 4).
- Improved altimetry in high latitudes areas in both along track and maps (Fig 5).

**Internal wave signature**

Realistic signature of the M2 internal tide has been undertaken both on along track (Duacs et al., 2014) and on maps (Fig 6). They are now available in the DT products. They include a description of the geostrophic current estimated in the region with high variability of the M2 internal tide (Fig 7).

**In Summary**

The DT 2014 version of Ssalto/DUACS products will be available to the users in the next few weeks. The DT 2014 version will be available to the users in the next few weeks.

## 21 YEARS OF REPROCESSED LYAPUNOV EXPONENTS FROM ALTIMETRY AVAILABLE ON AVISO+

**Characteristics of the products available on AVISO+**

- Time span: 1994-2014
- Temporal resolution: 4 days
- Spatial resolution: 1/4 deg
- Spatial coverage: global
- Level: separation: 0.04 dwt
- Final resolution: 0.8 dwt
- Maximum integration window: 100 days
- Default selection

Files based on the maximum eigenvalue of the Cauchy-Green strain tensor and Orientation of the associated eigenvectors are both provided.

**Lyapunov Exponents presentation**

Surface current-derived maps of Lyapunov exponents (LE) provide precise of both Lyapunov transport fronts. The LE give the exponential rate of separation of particle trajectories initiated nearby and advected by surface currents. Large LE values underline regions where the stretching induced by surface currents is strong. It corresponds to intense for high-irreversible daily contours and filaments.

**Source code**

The code used to compute LE is available on AVISO+ (http://www.aviso.oceanobs.com/avisoplus/). The code used to compute LE is available on AVISO+ (http://www.aviso.oceanobs.com/avisoplus/).

**Example of application**

LE can be used to study the many different applications, especially in physical and biogeochemical sciences. The analysis can be used to study the evolution of different structures, especially in order to be placed on the sea floor.

## Cryosat-2 Wind & Wave Products: Preparation for Sentinel-3

**Introduction**

The altimetry altimetry wave height (AWH) and the surface wave speed measurements are of considerable importance for weather prediction and for oceanographic applications. In order to ensure the continuity of altimetry, Sentinel-3 will use altimetry wave height (AWH) and the surface wave speed measurements as part of its altimetry products. The altimetry wave height (AWH) and the surface wave speed measurements are of considerable importance for weather prediction and for oceanographic applications. In order to ensure the continuity of altimetry, Sentinel-3 will use altimetry wave height (AWH) and the surface wave speed measurements as part of its altimetry products.

**Significant Wave Height**

Cryosat-2 SAR altimetry wave height (AWH) estimates will be used for the Sentinel-3 altimetry products. The altimetry wave height (AWH) estimates will be used for the Sentinel-3 altimetry products.

**Surface Wave Speed**

Cryosat-2 SAR altimetry wave speed estimates will be used for the Sentinel-3 altimetry products. The altimetry wave speed estimates will be used for the Sentinel-3 altimetry products.

## Satellite Altimetry Sea Surface Height Anomaly Processing at the Naval Oceanographic Office Altimetry Data Fusion Center

**Abstract**

The Naval Oceanographic Office Altimetry Data Fusion Center (NOAODFC) is the primary center for the processing and distribution of altimetry data. The center is responsible for the processing and distribution of altimetry data.

**Satellite Data Output Comparison**

The center is responsible for the processing and distribution of altimetry data. The center is responsible for the processing and distribution of altimetry data.

**Sea Surface Height Anomaly (SSHA)**

The center is responsible for the processing and distribution of altimetry data. The center is responsible for the processing and distribution of altimetry data.

**Satellite-Profile Difference Comparisons**

The center is responsible for the processing and distribution of altimetry data. The center is responsible for the processing and distribution of altimetry data.

**SSHa and SSha RMS Comparison Results**

The center is responsible for the processing and distribution of altimetry data. The center is responsible for the processing and distribution of altimetry data.

## Operational ocean data assimilation/prediction system for the western North Pacific at JMA

**Introduction**

The operational ocean data assimilation/prediction system for the western North Pacific at JMA is a key component of the JMA's oceanographic research and forecasting efforts. The system is a key component of the JMA's oceanographic research and forecasting efforts.

**Outline of MOVE/MRI.COM-WNP system**

The system is a key component of the JMA's oceanographic research and forecasting efforts. The system is a key component of the JMA's oceanographic research and forecasting efforts.

**Performance of current forecasting**

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**Impact of multi-satellite altimeter SLA assimilation**

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# APOP/NRT Round Table

## 1. Jason-2 Extension of Life

- For operations the best scenario is to stay on interleaved track as long as possible.
- Geodetic data may benefit NRT SWOT thru improved MSS. By how much do we expect J-2 EoL to contribute to reducing MSS errors?
- In terms of orbit selection, we endorse G. Dibarboure's selection.
- When we have 6 operational satellites, the incremental benefit of Jason-2 will be less, but this will still not be oversampling the ocean.





## 2. AltiKa Drifting Orbit

- AltiKa has a bigger influence on ocean forecasts than J2 (perhaps even J2+J3).
- Drifting orbit will be sub-optimal, but would be desirable if it ensures significantly longer mission.
- When it's time to move, try to optimize the drifting orbit to benefit the MSS.
- Is there any possibility that the fuel will be consumed prematurely due to station keeping?
- If possible maintain the +/-1km orbit until Jason-3 is launched.



### 3. Other Issues

- Jason-3 Launch Delay
  - Sooner we get Jason-2 into interleaved orbit the better.
  - **It isn't a matter of bridging a gap: we will lose the operational capability all together.**
  - We are living in fear of a losing ocean forecasting: J2 beyond design life; SARAL has health issues; C-2 sampling isn't sufficient for ocean predictions.
  - **However, do NOT launch Jason-3 until it is absolutely safe to do so!**
- COP21 Recommendation
  - We support the altimetry for climate recommendation, but recommend stressing regional as well as global sea level rise, and understanding extreme events.
  - We should also be putting forward recommendations to operational satellite group, such as WMO, IOC,...
- We need to reduce data latency from current 2.5 hours to ~1 hour for wind/wave applications.



# Back to the Future...

- More operational centers than in prior years: JMA, NAVO, NOAA, Meteo-France, ECMWF
- 100+ participants in oral session
- New operational products: OHC from NOAA; Lyapunov exponents from DUACS
- Real-world applications: MH370 & tsunami debris
- We are pushing envelope with operational models to submesoscale
- Synergy with altimetry from Sentinel-3 & Jason-2/3 with SAR wave information from Sentinel-1
- Expand operational outreach & education for users

