SHOC Satellite Hurricane Observation Campaign

Introduction

SHOC main objective is to organize a 2 months campaign during the 2016 hurricane season in order to gather extreme wind observations from new European spaceborne sensors and additional reference data. As opposed to altimeter, scatterometer or radiometer missions, Synthetic Aperture Radar missions have a limited duty cycle and can operate in several acquisitions modes, yielding to possible conflicts between users. The primary objective of SHOC is thus to maximize Sentinel-1 acquisitions over hurricanes to feed research and development activities without critically impacting other existing services.

SHOC campaign has been proposed to European Space Agency (ESA) by LOPS in the framework of ESA SEOM (Scientific Exploitation of Operational Missions) study. This is a joint study with NOAA, CLS, ODL and NORUT.

Objectives

More generally, this campaign aims at collecting observations over hurricanes in order to provide a synoptic view of hurricane development and evolution during the hurricane season, not only using Sentinel missions but also a wide variety of spaceborne measurements, with additional inputs from airborne in-situ measurements as a reference and model outputs.

In particular for Atlantic, the last update predictions from NOAA for the 2016 season indicates an 85% chance that season will either be near-normal

or above-normal. It should be the more intense since 2012. The outlook calls for a 70% probability for each of the following ranges of activity during the 2016 hurricane season:

- 12-17 Named Storms, which includes Alex in January
- 5-8 Hurricanes, which includes Alex in January
- 2-4 Major Hurricanes
- Accumulated Cyclone Energy (ACE) range of 85%-150% of the median.

For reference, the 1981-2010 period averages are 12 named storms, 6 hurricanes and 3 major hurricanes. These predictions are from NOAA 2016 Hurricane Season Outlook issued 2016 August 11. However the campaign considers also east pacific (Typhoon) and and west pacific area.

The main outcome of this expected campaign is targeting Research & Development. The availability and co-location of numerous in-situ observations, spaceborne and airborne measurements are key points for:

1. Improving of geophysical parameters retrieval schemes during extreme events – in particular for wind, waves and ocean surface velocities derived from SAR,
2. Investigating the possibility to derive new geophysical parameters,
3. Understanding of complex and rare phenomena like hurricanes.
4. Continue the joint study of hurricane extreme high winds and hurricane wind-generated waves.
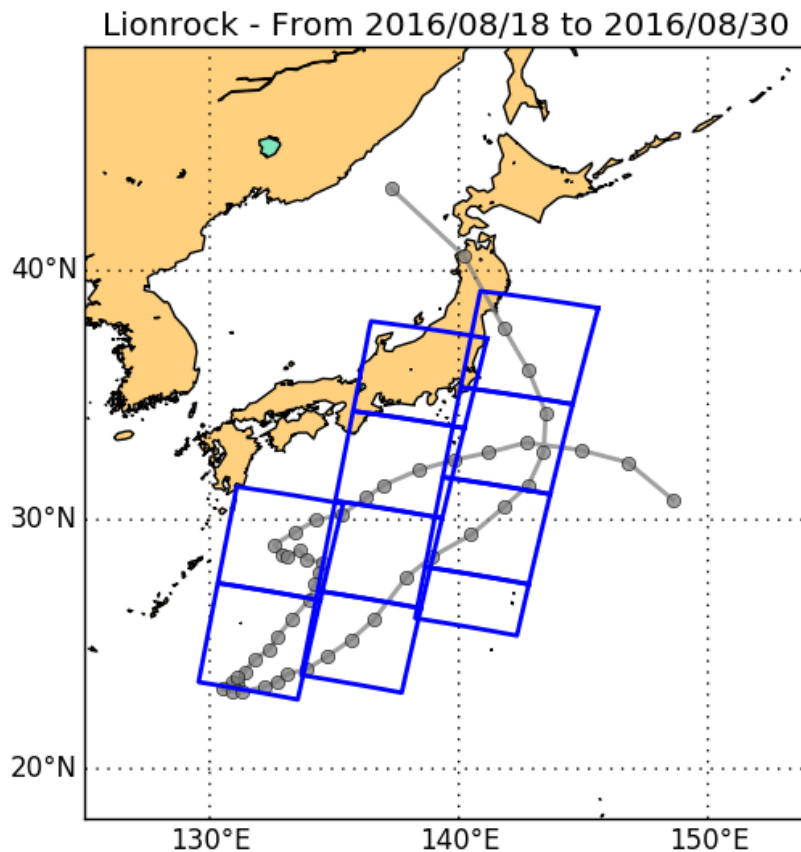
Illustration 1: Example of acquisitions for one given hurrican. Here it is LyonRock Typhoon. Grey line is its trajectory. 4 Sets of acquisitions were planned. We got 3 sets of good acquistions with Sentinel-1 A (blue lines).

SHOC will also contribute to build and make available a wide variety of data for the community. On a longer time frame and for more pratical applications, this campaign is expected to open new perspectives:

1. Demonstration service for Copernicus: by raising the need for a dedicated multi-mission hurricane observation strategy, SHOC wants to demonstrate the possibility to provide thorough monitoring of these extreme events on a regular basis, which could set the ground for future operational services,

2. Preparation of next European Earth Observation missions: The use of cross-polarization observations for the next generation scatterometer MetOp-SG SCA is crucial for the measurement of intense winds. In this matter, the availability of a wide dataset of C-band measurements in VH polarization from Sentinel-1 and derived GMF (Geophysical Model

Function) will help prepare the exploitation of this future European satellite.
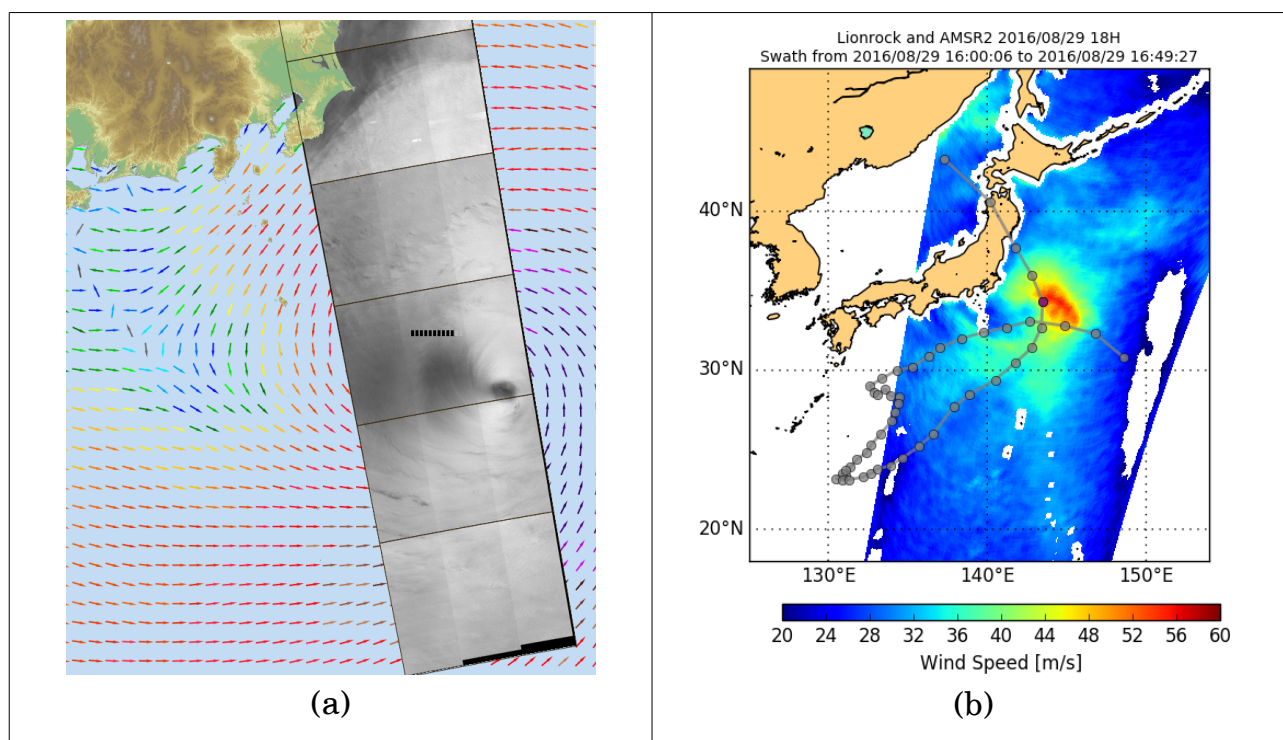

Illustration 2: (a) Sentinel-1 A acquired over Lyonrock on 29th august 2016. Colored arrows stand for the closest (in time) ECMWF 10 m height wind vector (0.125°,3h) (b) Collocated wind speed from AMSR2 acquisition.
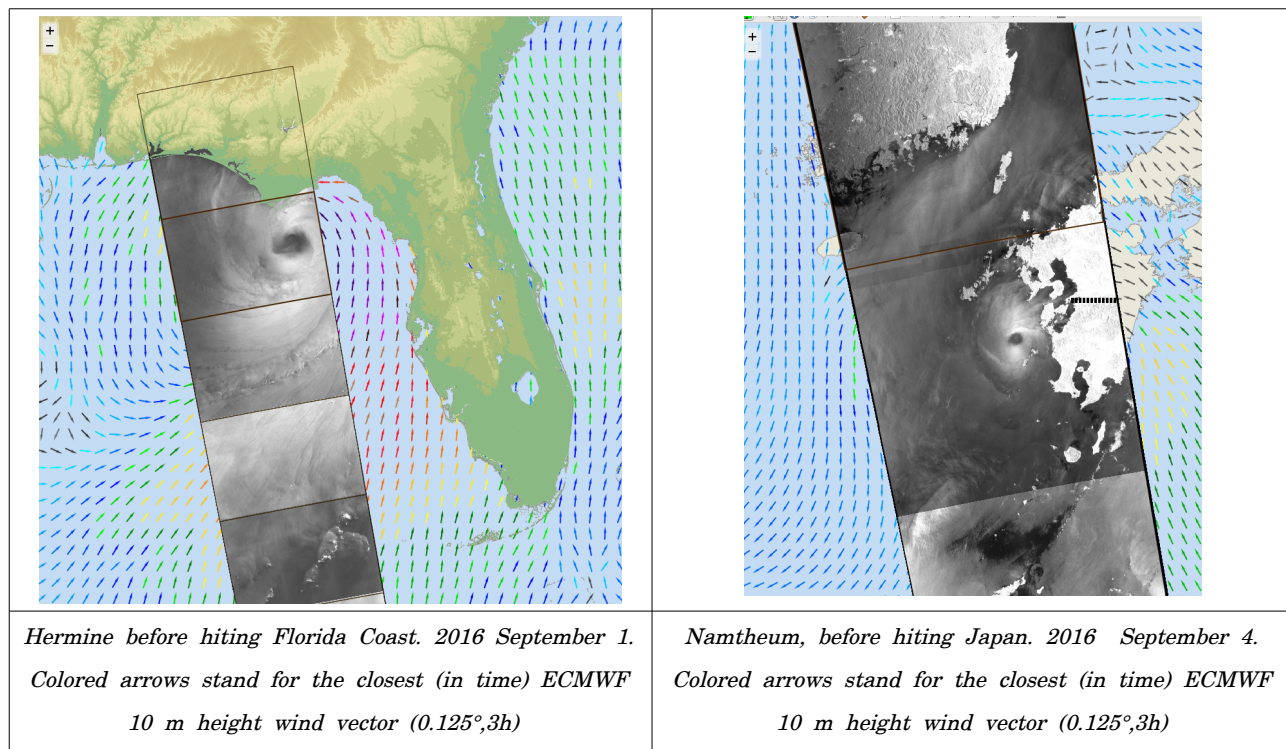
Methodology and Preliminary results

Following the experience of the previous Hurricane Watch program in Canada, we rely on cyclone trajectories forecasts from the US National Hurricane Center. They are routinely sent ESA Sentinel-1 mission planners. They can then plan optimal acquisitions with a very short delay over hurricane with consideration of a specified temporal and spatial buffer as well as possible conflicts with the Copernicus operational services. Figures 1 and 2 show an example of outcome of such a campaign for Lyonrock Typhoon. Based on the hurricane track (grey line on the figure) we planned 4 sets (a set is several subimages) of acquisitions (see Figure (a)). An
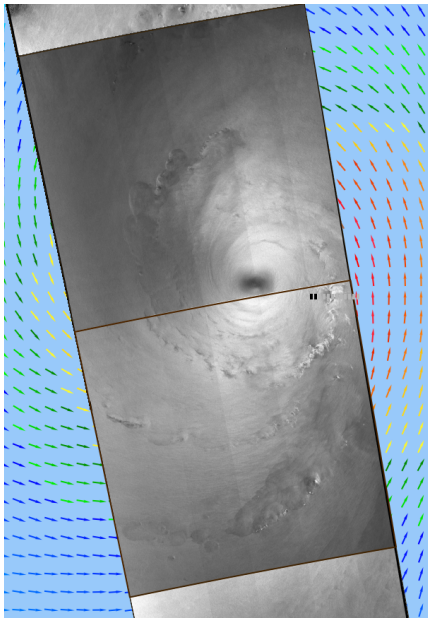
exemple of hit is shown on Figure 2 (b). As an illustration the wind speed as derived by AMSR2 is shown on Figure 2 (c).

To date, we plan more than 20 set acquisitions, capturing eyes, rainbands, extremes winds for Gaston, Lester, Lyonrock, Fiona, Hermine, Kay, Madeline, Namtheum...
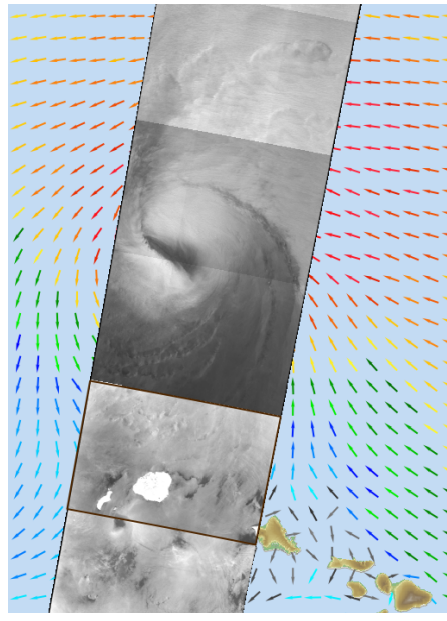
Below are some exemples of acquisitions. The campaign will go on until the end of September. Analysis activities are alreay on going. Results will follow.

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| *Hermine before hiting Florida Coast. 2016 September 1.* *Colored arrows stand for the closest (in time) ECMWF 10 m height wind vector (0.125°,3h)* | *Namtheum, before hiting Japan. 2016 September 4.* *Colored arrows stand for the closest (in time) ECMWF 10 m height wind vector (0.125°,3h)* |

Gaston. 2016 August 29.	*Lester near Haiwai, 2016 Spetember 4*