DRO/DOPS/Laboratoire d'Océanographie Spatiale

Observatory and Research on extreme PHEnomena over the Oceans : ORPHEO

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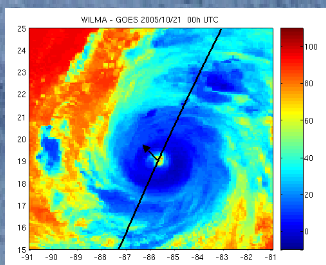
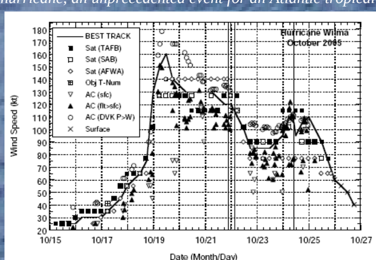
***Abstract**: Extreme weather events are now commonly reported and analyzed thanks to satellite-based observations. These measurements are critical for short term forecasting, but also offer means to better question the role of extreme conditions for the state of ocean at local and global scales and effects on ocean circulation and ocean heat transport. Estimating climate trends from actual data sets covering long time periods and assimilating measurements from different sensors is a tricky task since homogeneity of the data is rarely verified. In combination with other sensors and numerical models, the available 15 years of altimeter data can certainly offer more homogeneous data sets that can be used to better analyze extreme phenomena and their year to year variability. The ORPHEO project aims to fulfil several objectives: 1) better interpretation of satellite-borne sensors signals in extreme surface conditions 2) better understanding of the ocean/atmosphere coupling under such conditions 3) evaluation of distributions / statistics related to extreme events 4) set-up of a tool at Cersat giving access to the collected information combined in a handful way.*

Hurricane Wilma broke records

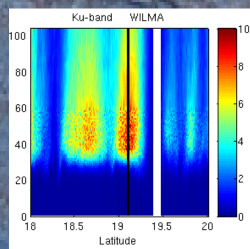


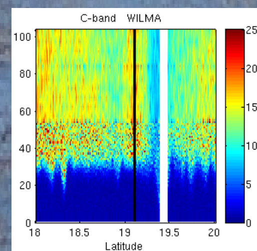
The Jason-1 altimeter intersected hurricane Wilma on October 21, 2005, at 01h55UTC. Wilma had the all-time lowest central pressure for an Atlantic basin hurricane, 882 mb, and the eye of the hurricane contracted to a diameter of 2 nautical miles, the smallest eye known to National Hurricane Center. In the span of just 24 hours, Wilma had intensified from a 60-kt tropical storm to a 150-kt category 5 hurricane, an unprecedented event for an Atlantic tropical cyclone.



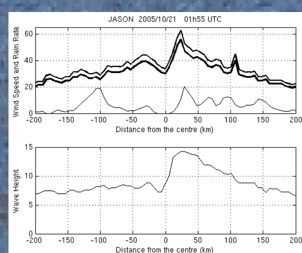
The figure above shows the data (satellite, aircraft) used to estimate the Wilma maximum intensity Vmax. When available, aircraft data are used instead of the Vmax derived from visible/infrared imagery via the Dvorak technique. Aircraft winds are mainly flight level (3 km) measurements reduced to the surface using a 90% constant factor. Considerable scatter is observed between the different Vmax estimates.

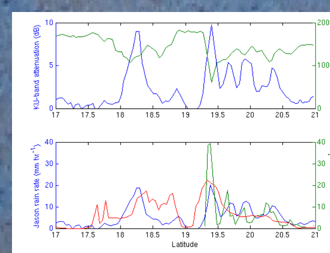
The dual-frequency altimeters: unique sensors to estimate consistent surface wind / waves / rainfall rate information





Jason-1 altimeter waveforms clearly display the signal attenuations encountered in the rainy (eyewall, rainbands) and maximum wind areas. The black bar figures the hurricane Wilma center and the white one the missing data when the altimeter tracker loosed lock. Waveforms have been reprocessed and an iterative scheme using the differential attenuation between C- and Ku-band signals (by example near 18.2° of latitude) is used to compute the Ku-band attenuation by rain and the effective radar cross-section (Quilfen et al., JGR2006).

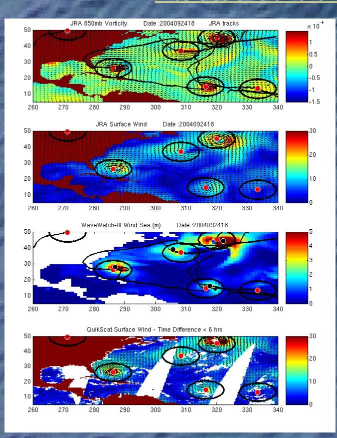




Surface wind (10- and 1-min) and rainfall rate are computed using dedicated algorithms. Altimeter Ku-band rain attenuation compares well with the TRMM/TMI H-pol Tb's, and the Jason-1 derived rainfall rate shows excellent agreement with the TRMM/PR one to depict location of the eyewall and rainbands. Differences in sensor resolution and algorithm limitations explain the differences in absolute values. Maximum 1-min surface winds of 62.7 m/s (122 knt) have been estimated, to compare with the 135 knt aircraft estimate.

Discussion: Extreme events intensity analysis is a major challenge triggered by climate change concerns. Still, uncharacterized errors are associated with maximum surface wind estimates derived from Dvorak analysis and aircraft measurements. Altimeter measurements at nadir show less saturation with increasing wind speed than obtained from scatterometer-like measurements, and good skill to retrieve coherent surface wind / rain structures characterizing each tropical cyclone. However, maximum surface wind speed and rainfall rate estimates certainly also have unknown errors / biases. More insight should thus be given in sea state measurements which can provide integrated parameters related to the storm intensity. In the Wilma case, the Jason-1 significant wave height measurements (Hsmax~15m), combined with a sea state parametric model and information on the hurricane motion speed and size to give a measure of the effective fetch, indicate that the hurricane intensity should be larger than given by the available maximum wind estimates. More frequent altimeter measurements are needed to support such analysis, and wide-swath sea state measurements would provide invaluable information. Better interpretation of SAR measurements is ongoing research and combined wide-swath wind/wave measurements, as foreseen from the SWIMSAT / CFOSAT mission, are mandatory.

Feature tracking and colocation tools to characterize extreme event properties and to derive a database for air/sea interactions and climate studies



A feature tracking tool using the 850 mb vorticity from the JRA25 25-year reanalysis has been operated at Cersat to produce a long term data set of cyclonic events over the oceans. Each event can then be characterized using available data at Cersat (JRA25, WaveWatch-III, active and passive satellite data). Different climate indicators can be derived from the different colocated data sources to insure more consistency.

Wide-swath SAR measurements to map swell properties, kinematic properties of the shorter waves, and features such as cyclone eye size and radius of maximum winds.

This SAR image in hurricane Katrina illustrates the potential of SAR measurements. The hurricane eye is clearly located and important parameters can be estimated, such as the eye size and radius of maximum winds. The primary eyewall and rainbands are depicted from the radar cross-section attenuation. Long swell properties are mapped to help storm surge forecasting, but also to help intensity analysis although the wind seas are not properly retrieved. However, new insight on these wind seas has been recently obtained with the use of the Doppler information, which is linked to the surface kinematic properties (currents, waves, Chapron et al., 2005)