Sigma-0 blooms in the Envisat Radar Altimeter data

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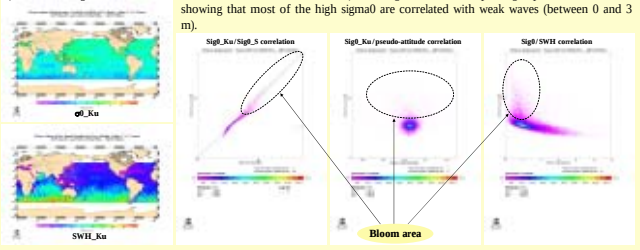
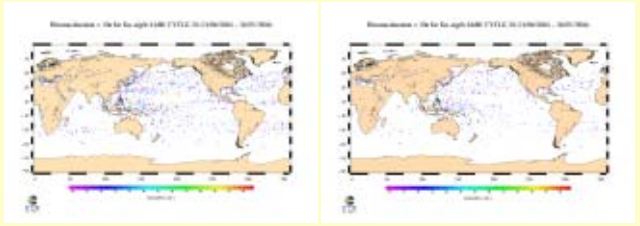
Abstract : Data from satellite altimeters are often degraded by the occurrence of unrealistically high values of the ocean surface radar backscatter cross sections (sigma-0). Various studies on Topex and Jason-1 altimeters data have shown that these events called "sigma-0 blooms" affect almost 6% of the over ocean measurements. It has been shown (Mitchum, Tournadre, …) that blooms occur most of the time, but perhaps not always, in regions of climatologically weak winds. Surface slicks could also be the cause of sigma-0 blooms. In any case, contamination of altimeter data by "sigma-0 blooms" is an important issue if we consider that only 60% of the sigma-0 bloom events seem to be rejected by classical altimeter data flagging.
The aim of this sutdy is to give a comprehensive description of the blooms occurrence (where, when and how long) which is important because many people of the community that make use of the altimetric data are generally unaware of this phenomenon. Statistical characteristics of sigma bloom events are presented using 1-Hz data as well as 20-Hz data. Analysis is done for many cycles of Envisat data distributed along the year and also on local and limited data sets. Moreover, we show how waveforms are corrupted and we propose criteria to characterize their occurrences. The analysis is performed on Ku-band data but relation with S-band data is also considered. Spatial and temporal correlations with geophysical parameters (wind, waves …) are highlighted. Besides the precise characterisation of the blooms, one of the major interests of the study concerns the estimation of the errors induced by these events on the estimated altimetric parameters.

Bloom events during Envisat cycle 28 (June 21th, 2004 to July 26th, 2004)

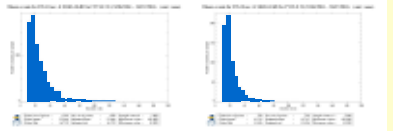
The following figures characterize the RA-2 data for cycle 28. Dispersion diagrams have been obtained with 1Hz data. In these 3 diagrams the sigma blooms measurements are identified showing that both backscattering coefficients are impacted (elevation of sig0 Ku and C with a small trend between 15 and 20 dB), showing that there is no privileged pseudo-attitude and showing that most of the high sigma0 are correlated with weak waves (between 0 and 3 m).



The following maps shows the locations and durations of the bloom events detected during cycle 28. Is considered a bloom event, a segment of data for which the sigma naught coefficient is greater than 15 dB (left figure, 18 dB for right figure) for at least 10 seconds. The colors represent the duration time of the events.

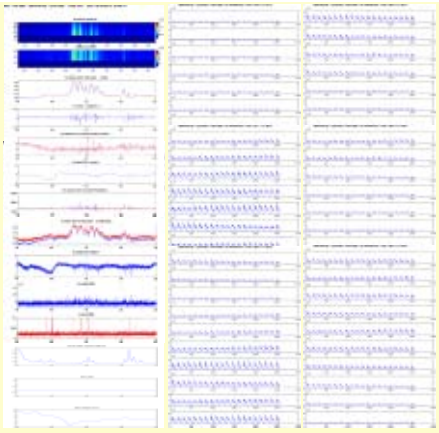


Most of the blooms events are located in the north hemisphere (in July 2004) which is coherent with the fact that blooms are correlated with weak sea states. The durations of the events is mainly between 10 to 25 seconds which is also showed in the histograms



Example of bloom event on 18-Hz data

We present here an example of bloom detected during Cycle 28 on pass 255 (30-06-2004). The waveforms are raw waveforms without any on-board AGC compression, allowing to see the variations of the returned power.
On the left column, many other parameters are plotted at a 1-Hz rate such as SWH, Sigma0, Mispointing angles, SSH, Peakiness, Liquid water content, Wind speed, Rain flag and at a 20-Hz rate such as MQE (Mean Quadratic Error). Individual waveforms are also plotted on the two right columns showing that their shapes are not modified during all the event. They are sometimes in accordance with the Hayne's model even when then sigma naught coefficient is high. The bloom is characterized by an increase of the noise of the MQE, attitude and peakiness.

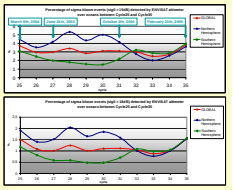


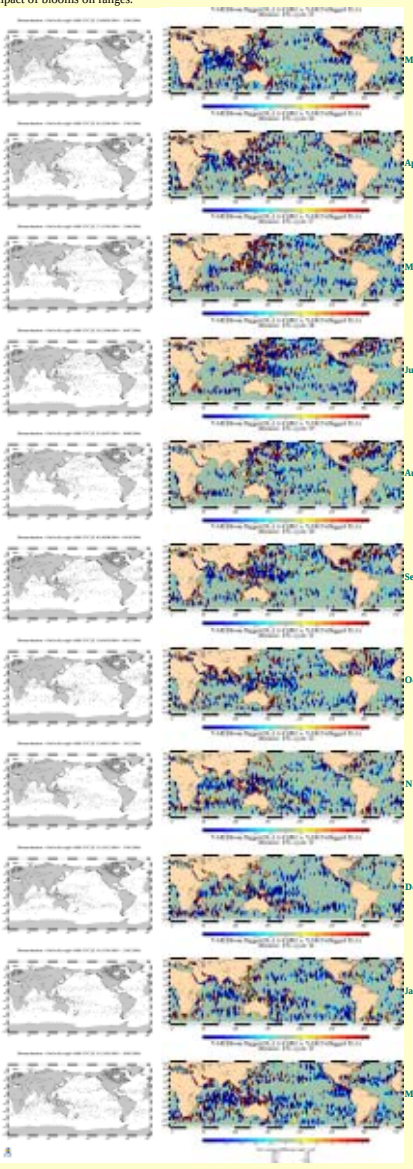
Bloom editing criteria and impact on global performances - Conclusions

We suggest that **the bloom flagging must be adapted to the application**. Indeed, depending on the required level of accuracy, the "editing process" can be more or less conservative. For an application requiring a great precision, the entire bloom events must be edited (sigma0 greater than a threshold during more than 10 seconds) while for less demanding applications, the only waveforms that move away from the Hayne's model have to be discarded (criteria based on MQE, peakiness and pseudo-attitude). We suggest that a multi-state flag could be computed indicating the level of the impact on the range accuracy for example.
The impact of blooms on range is given in the right part of the poster with the gain of variance observed with and without bloom editing criteria. We observe also an increase of the HF content in bloom areas.
The impact of blooms on SWH is very small, not easy to evaluate. An increase of the noise level on SWH is also observed without systematic bias.
The impact of blooms on wind is that an already low wind estimate will become even closer to 0.
It is also important to recall that roughly 40 % of the bloom data are not edited by the calval process.

Spatial and temporal evolution of the bloom events (1 year of data)

One year of Envisat blooms are displayed on the left column showing the seasonnal moving of their locations. The two plots on the right show the evolution of the percentage of bloom events in the altimetric data (with two different detection criteria and with split between north and south hemispheres).
The right column gives for each cycle, the variance gain of the signal with and without blooms editing. The mean variance gain is 0.7 cm2. The main improvements (blue areas) are obtained were blooms have been detected, indicating the level impact of blooms on ranges.





D.Hancock & al.:"GFO Altimeter Engineering Assessment Report: From launch to acceptance", **NASA/TM-2001-209984/VER.1/VOL.1**
G.Mitchum & al.: "Sigma0 blooms in the Topex Radar Altimeter Data", **Journal of Atmos. Oceanatc Tech., 21, 1232,1245**
J.Tournadre & al.: "A satellite altimeter model for ocean slick detection", **Journal of Geophysical Research, To be published, 2005**
F. DeBlasio & al.: "Analysis of Envisat RA2 altimeter sigma-naught bloom events for S and Ku bands backscattering interrogations", **Proc of the 2004 Envisat & ERS symposium, Salzburg, Austria, Sept 2004**
A.Garcia : "Study of the origins of the sigma0 blooms", **Master of Science in Electrical and Computer Engineering, Virginia Polytechnic Institute, June 1999**