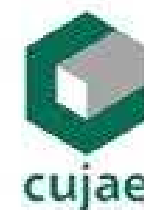


USE OF HURRICANE DATA TO ASSESS THE INFLUENCE OF FOAM AND SPRAY ON SAR IMAGERY AND ALTIMETER DATA

(a first attempt)

Eugenio Pugliese Carratelli^{2,3}; Luis Fermin Cordova¹; Roberto Lamazares¹; Ferdinando Reale^{2,3}; Francisco J. Ocampo Torres⁴

- 1) CUJAE Havana - CUBA
- 2) C.U.G.R.I. Naples and Salerno - ITALY
- 3) University of Salerno – ITALY
- 4) CICESE-Ensenada – MEXICO





OBJECTIVES

Some work was carried out on RADARSAT-1 hurricane SAR data, integrating it with simple hurricane wind models.

The final objective is to improve the understanding of the effects of whitecaps on SAR imagery and Radar Altimetry Data.

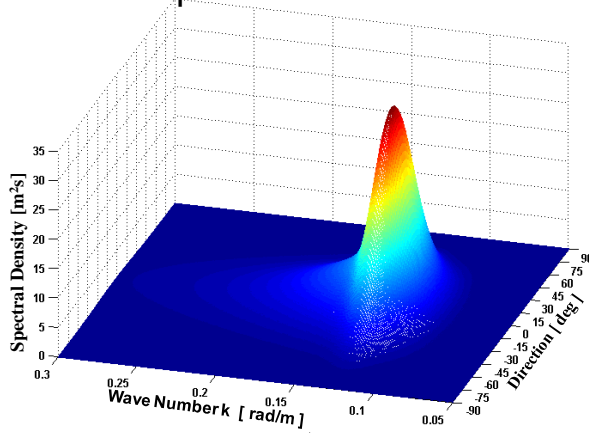
Radar backscattering data from a sea fully covered by foam and spray— as it is mostly likely to be during an hurricane — may provide information on the scattering properties of the foam covered fraction of less strong sea states.





Simulation of SAR images

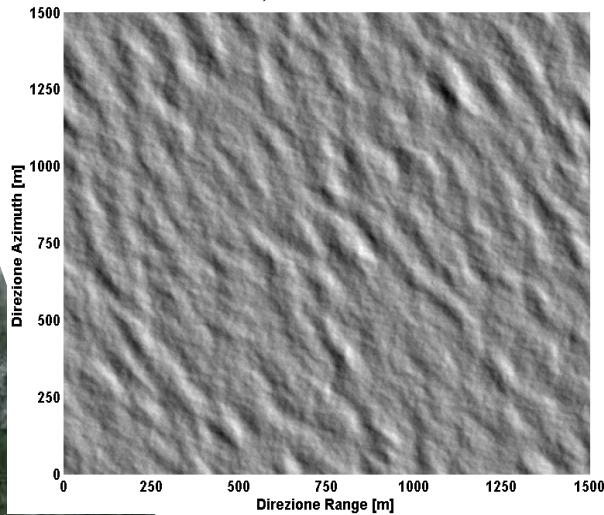
Sea Spectrum



From: Pugliese Carratelli E., Reale F., Dentale F.
"Reconstruction of SAR Wave Image Effects
through Pseudo Random Simulation"
Envisat Symposium 2007, Montreux, Switzerland

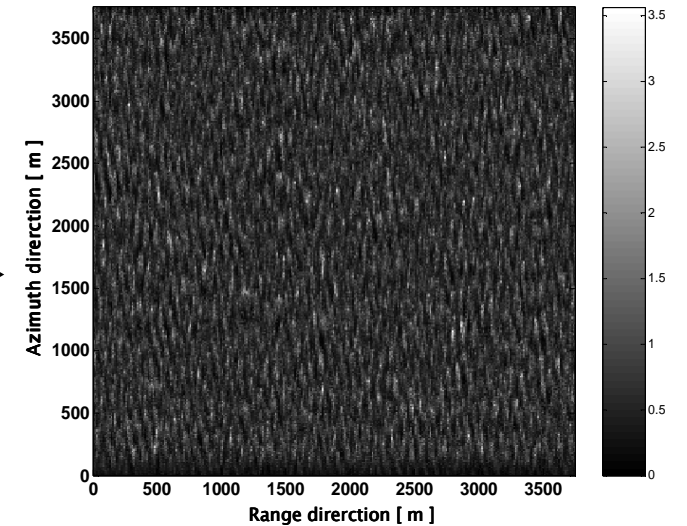


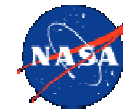
Simulation of sea state



Simulation of
Radar section σ_0

SAR IMAGE WITH WHITECAPS pixel dimension 12.5m x 12.5m

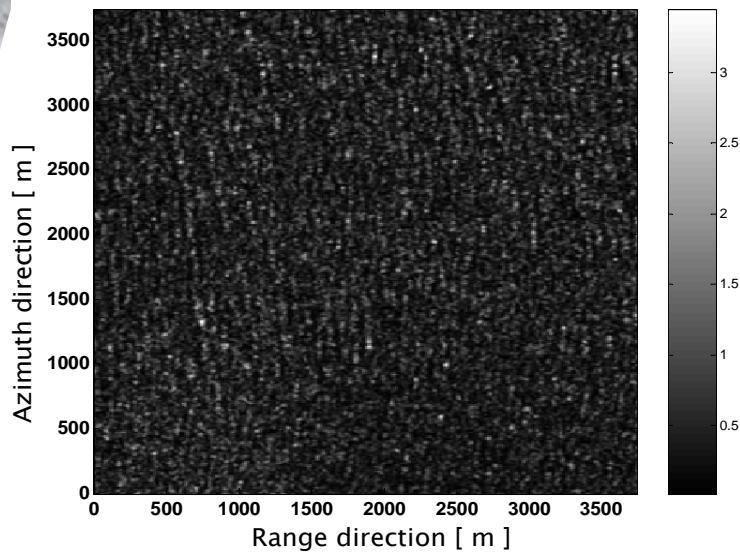




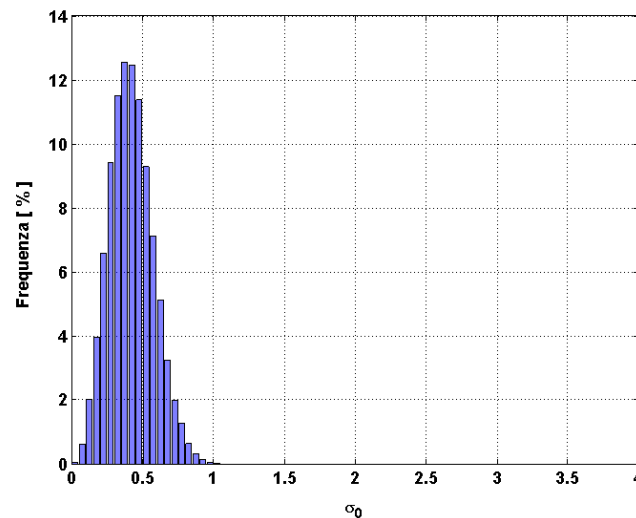
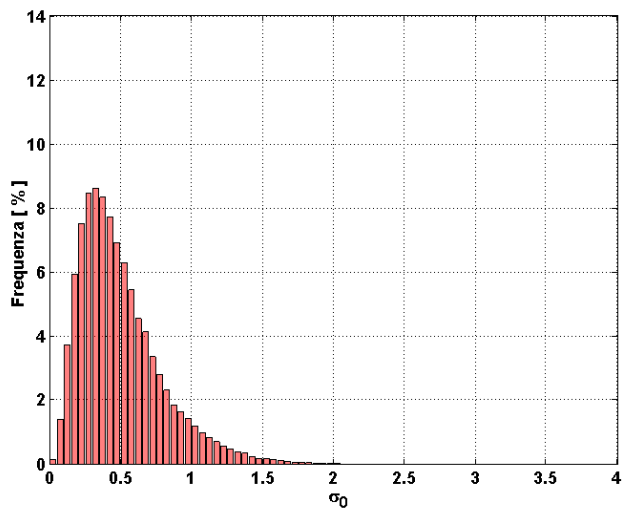
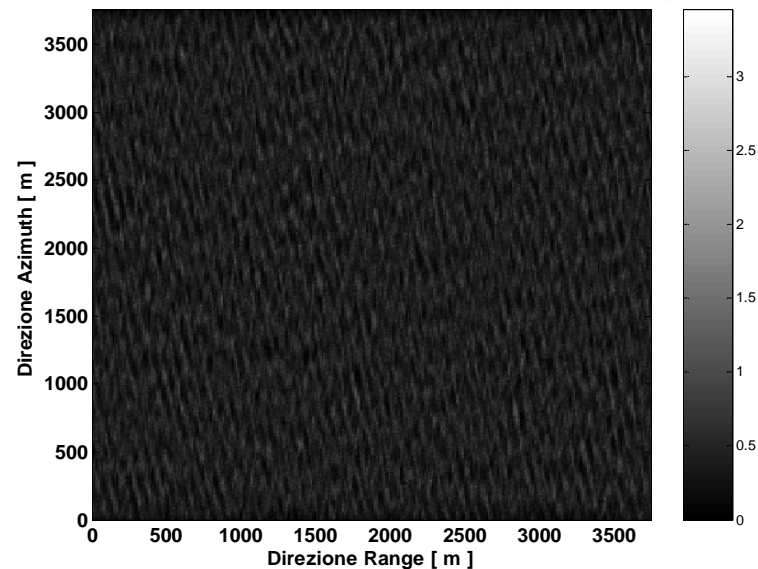
Simulation of SAR images

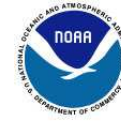
(ESA Envisat- Med. Sea)

Real

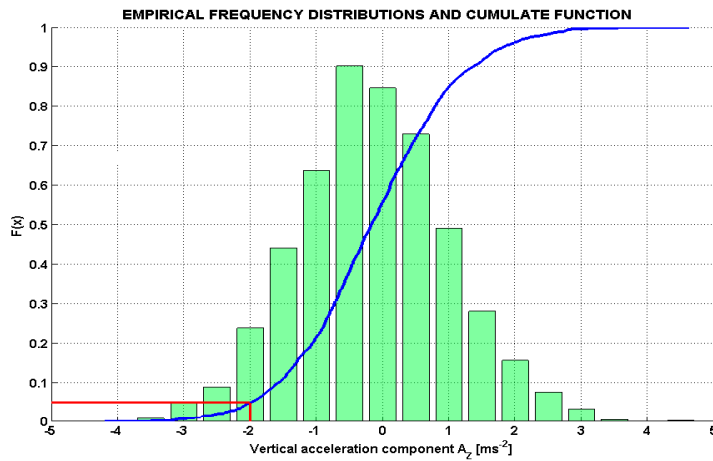


Simulated (No foam)

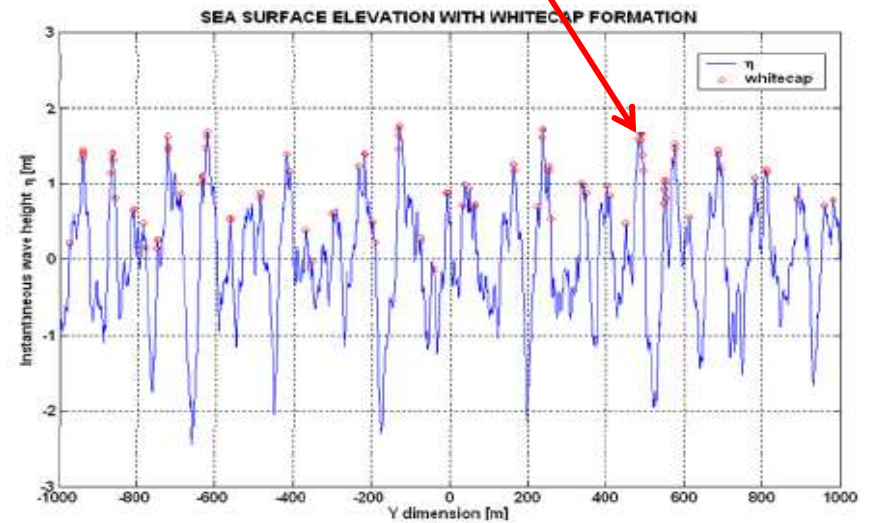




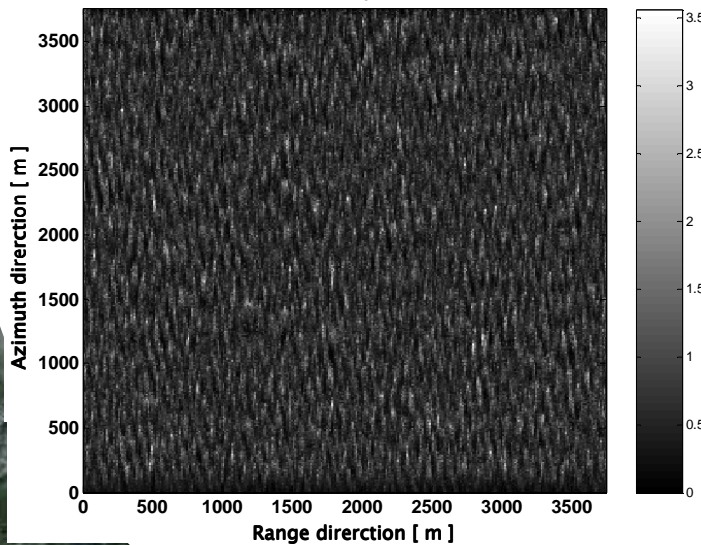
Introducing Whitecap Effects



σ_0 for foam ?



SAR IMAGE WITH WHITECAPS pixel dimension 12.5m x 12.5m



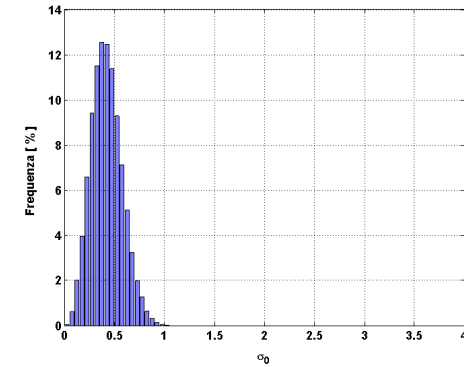
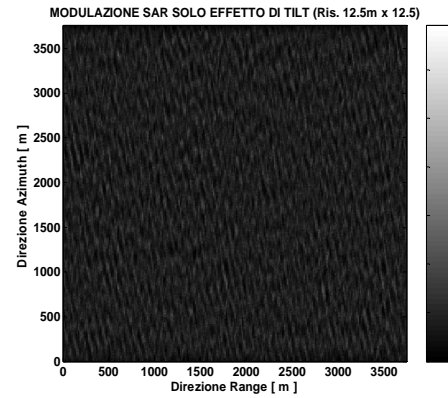
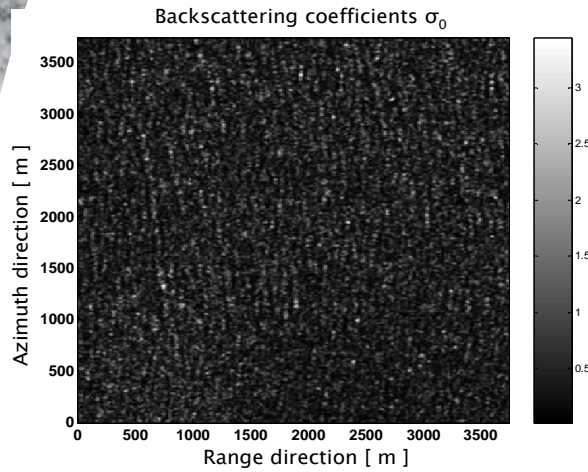
From:
 Pugliese Carratelli E., Reale F., Dentale F., Chapron B. (2008):
 "Simulating the influence of wave whitecaps on SAR images".
 SEASAR 2008, ESRIN, Frascati, Italy



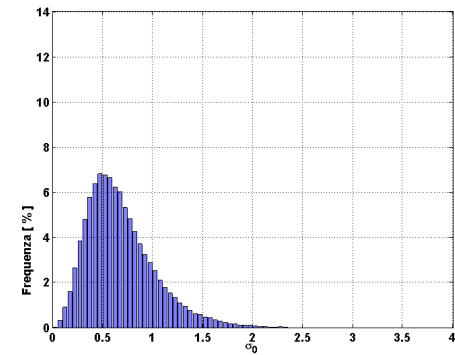
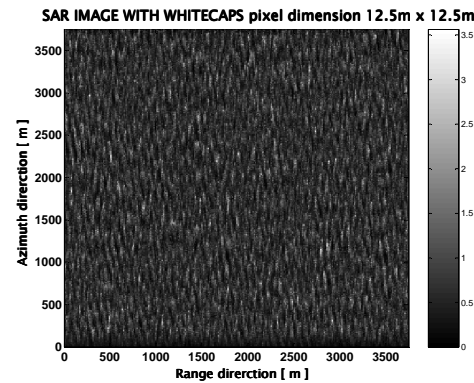
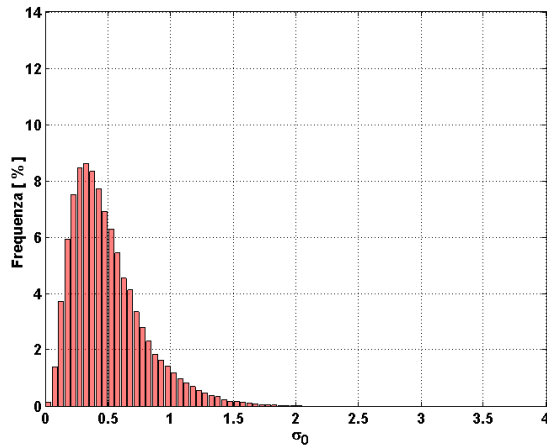
With some assumption for the σ_0 of foam

Real

Simulated (**No** whitecaps)



Simulated (**With** whitecaps)

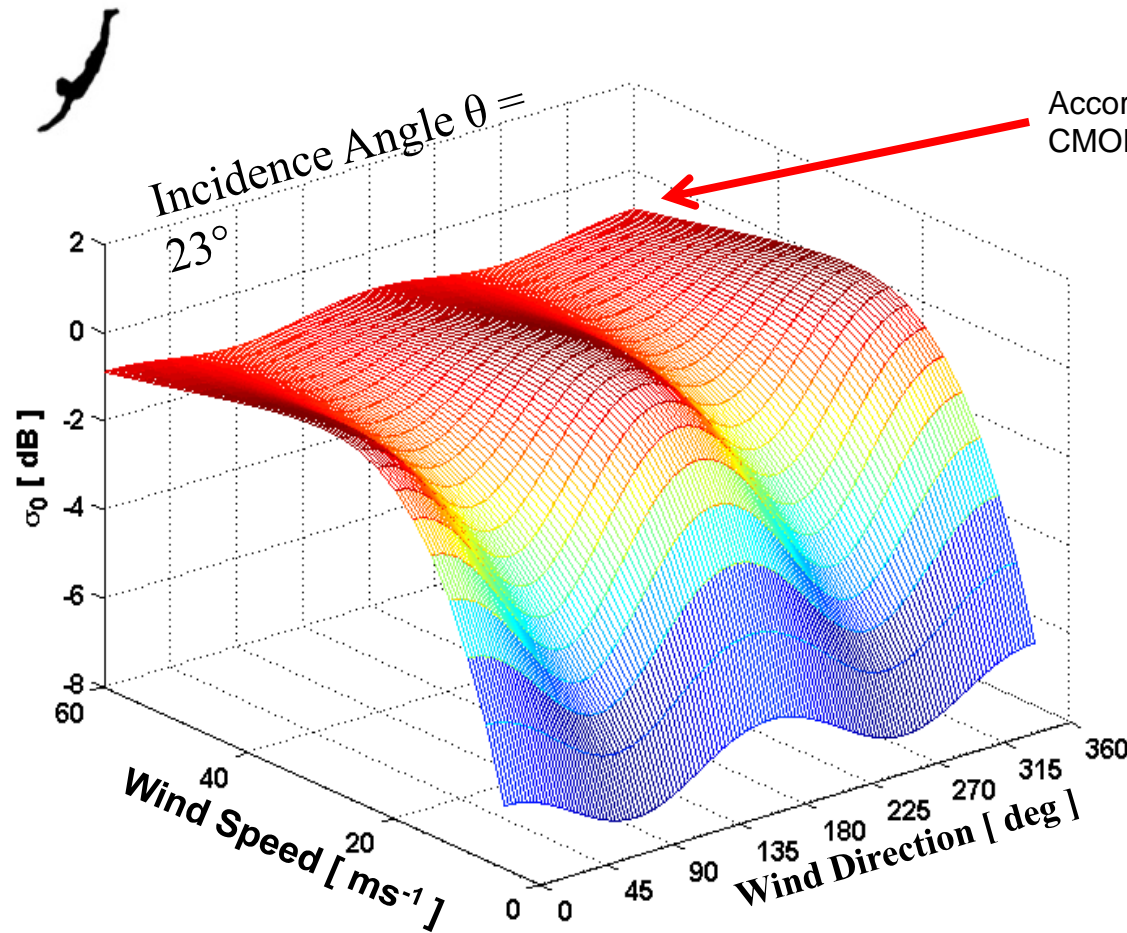


Introducing whitecaps does bring SOME improvement



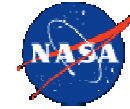


Finding the backscattering properties of foam might provide better results

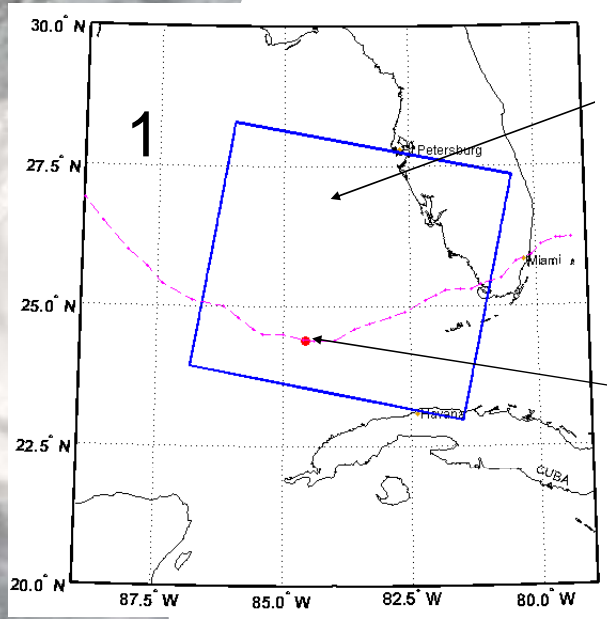


Hurricane information might help

$$\sigma_{\text{lin}}^{\theta} = B_0 \left[1 + B_1 \cos(\phi) + B_2 \cos(2\phi) \right]^{1.6}$$



2 DATASETS EXAMINED SO FAR



RADARSAT-1 SAR image SWA
27 August 2005
Acquisition time: 11:29 (GMT)

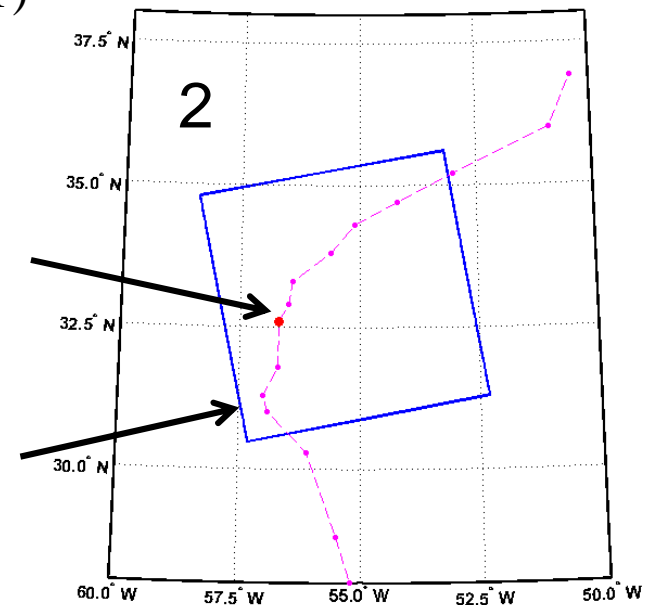
DATASET 1

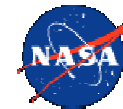
KATRINA hurricane location on
27 August 2005 at 11:30 (GMT)

MARIA hurricane location on 05
September 2005 at 21:00 (GMT)

DATASET 2

RADARSAT-1 SAR image SWB
05 September 2005
Acquisition time: 21:36 (GMT)





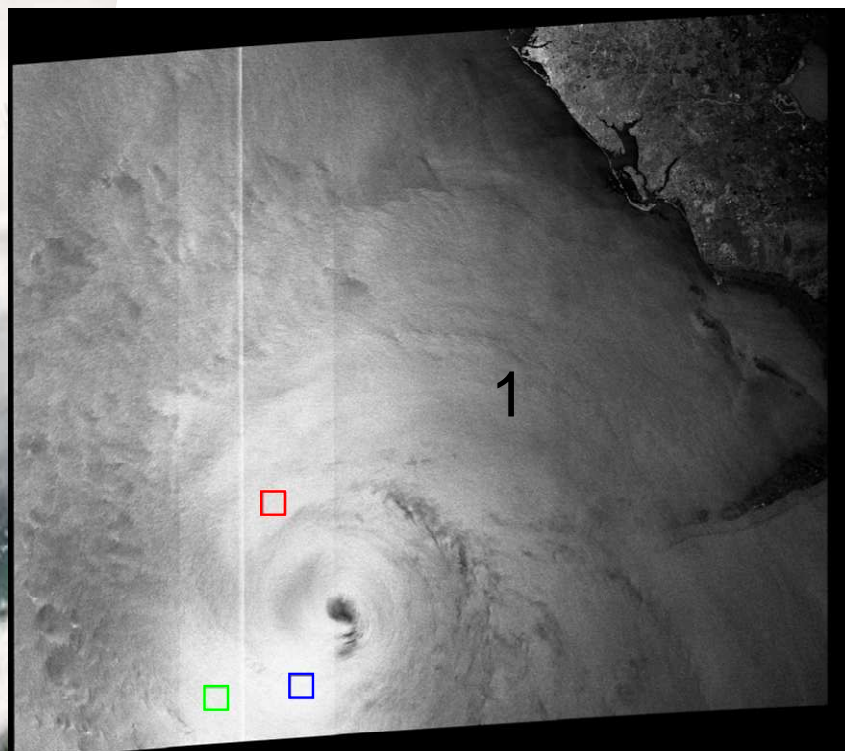
DATASET 1: Some problems with the data **RADARSAT-1 SAR of hurricane Katrina**



File identification: 51220_27Aug05_112841_112955_SCW

Image details

SCENE START TIME (GMT):	AUG 27 2005 at 11:28:41.084
SCENE STOP TIME (GMT):	AUG 27 2005 at 11:29:55.057
ABSOLUTE ORBIT NUMBER:	51220
PASS TYPE:	DESCENDING
BEAM MODE:	(A) = W1 + W2 + W3 + S7
PRODUCT TYPE:	SCANSAR WIDE (SCW)
DATA FORMAT:	RADARSAT CEOS
NUMBER OF IMAGE LINES:	9852
NUMBER OF IMAGE PIXELS:	11122
PIXEL SPACING:	50.000 m

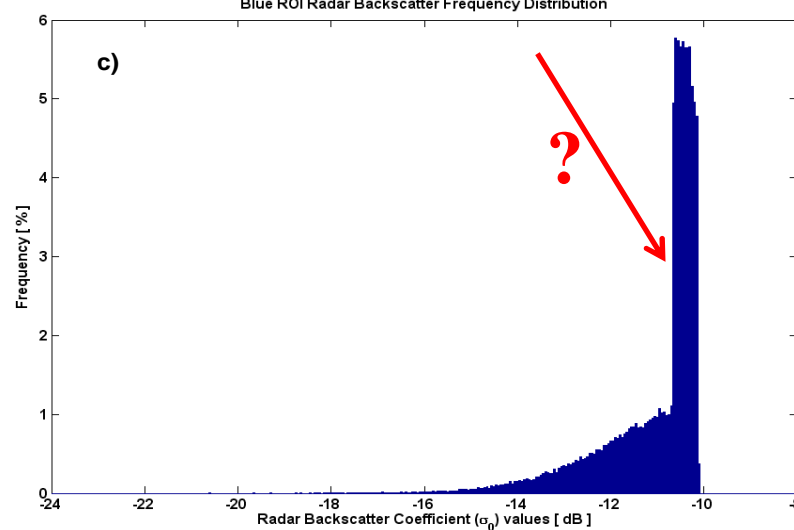
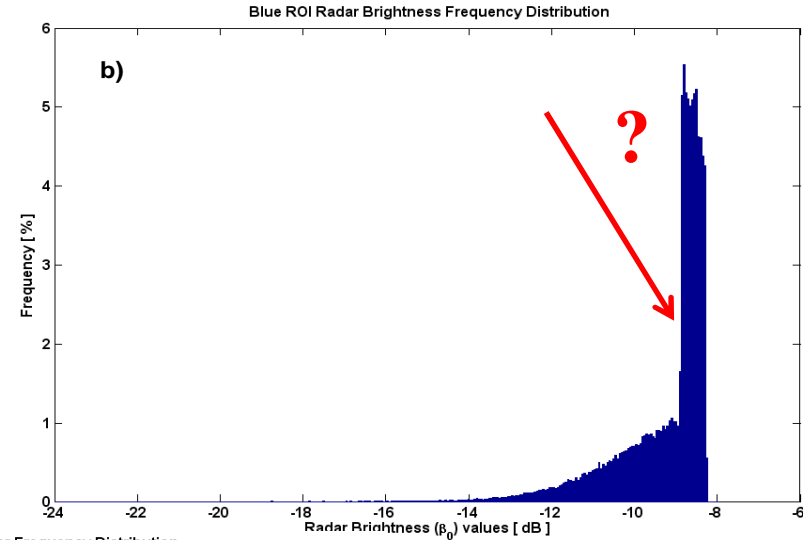
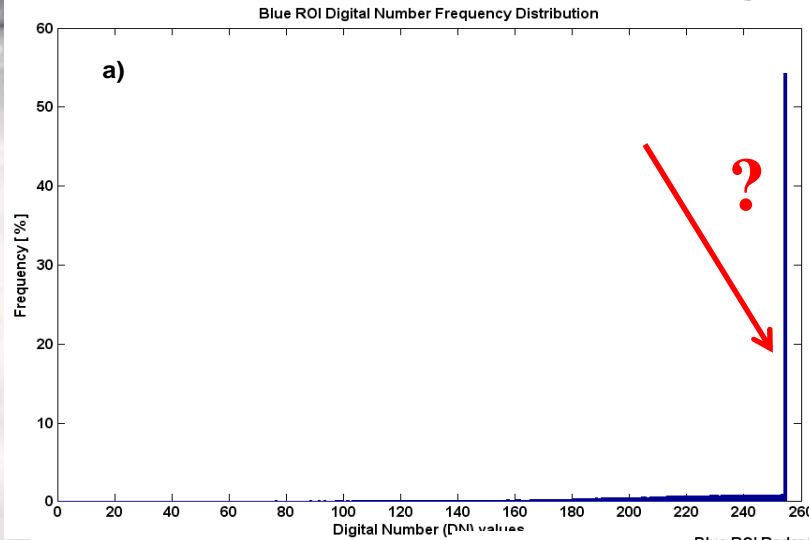


Three Regions Of Interest (ROI) of
300 x 300 pixels highlighted in
colour



DATASET 1: Some problems with the data

Distribution of Radar Brightness: most of the values out of field





DATASET 2: **RADARSAT-1 SAR of hurricane Maria**

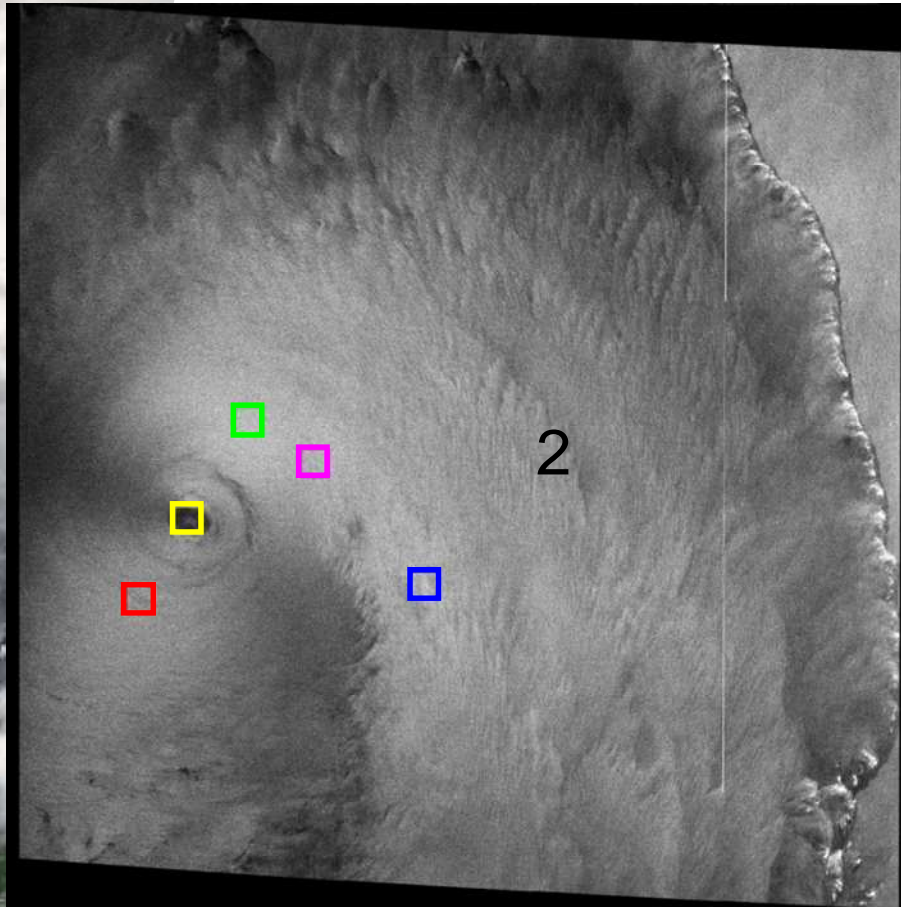
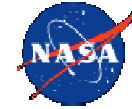


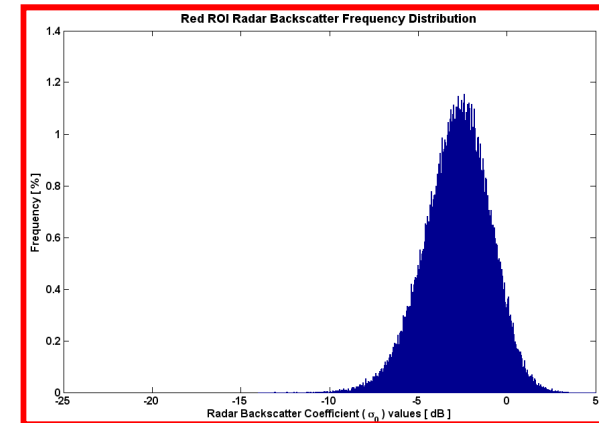
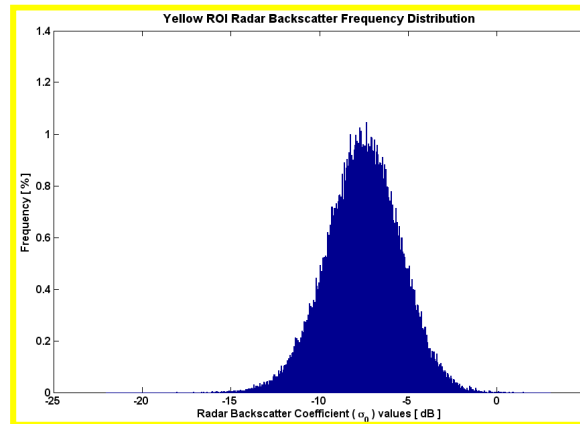
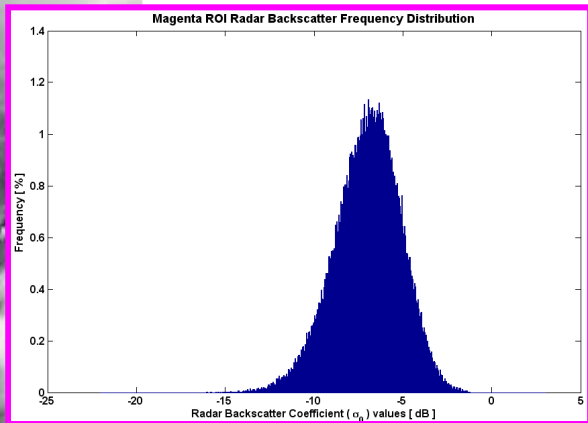
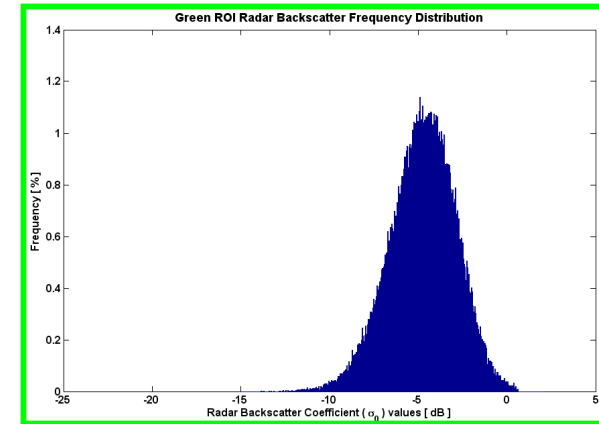
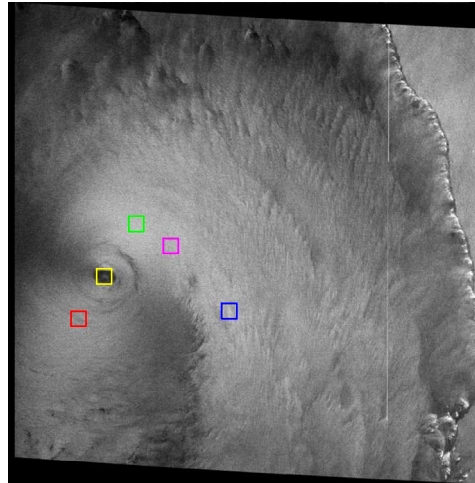
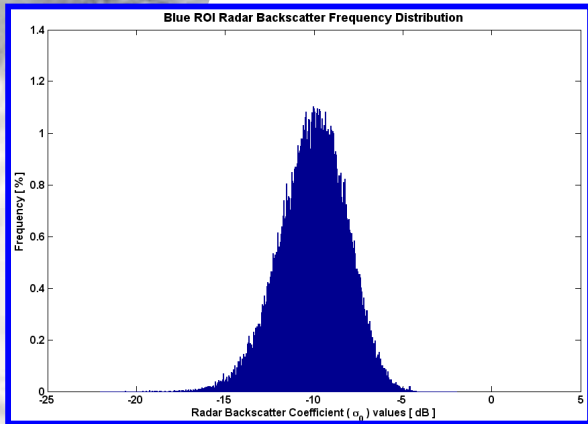
Image details

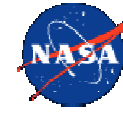
SCENE START TIME (GMT):	SEP 05 2005 at 21:37:58.914
SCENE STOP TIME (GMT):	SEP 05 2005 at 21:36:45.580
ABSOLUTE ORBIT NUMBER:	51335
PASS TYPE:	ASCENDING
BEAM MODE:	(B) = W1 + W2 + S5 + S6
PRODUCT TYPE:	SCANSAR WIDE (SCW)
DATA FORMAT:	RADARSAT CEOS
NUMBER OF IMAGE LINES:	9759
NUMBER OF IMAGE PIXELS:	9709
PIXEL SPACING:	50.000 m

Five different Regions Of Interest (ROI) of 300 x 300 pixels were examined

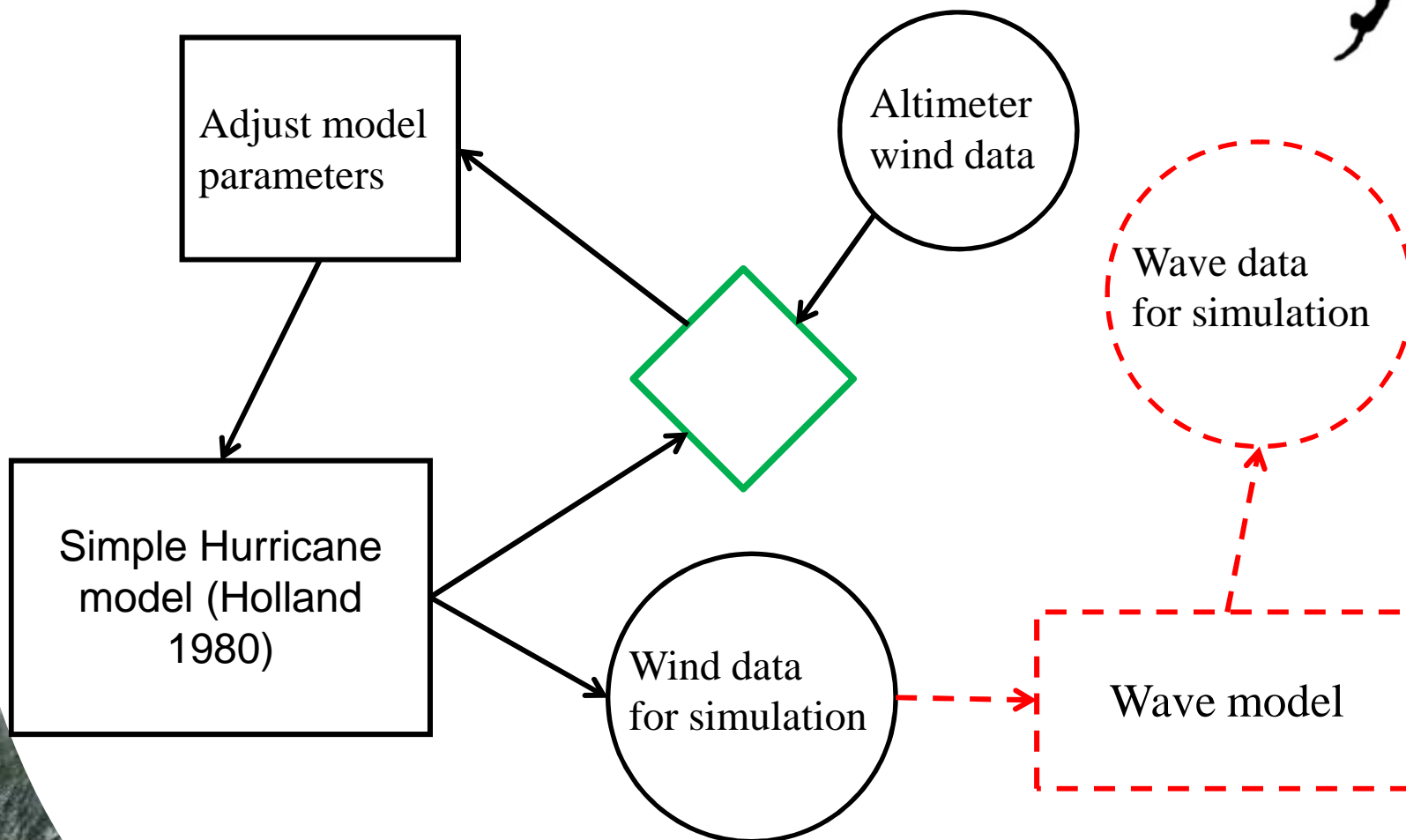


Frequency distributions of σ_0





In order to simulate σ_0 information on the wind is needed (solving direction ambiguity) A simple hurricane model helps





A simple Hurrican Model (Holland 1980) (Córdoba L., Lamazares R. 2010).

$$V_c(r) = V_{max} \sqrt{\left(\frac{R_{max}}{r}\right)^B \exp\left[1 - \left(\frac{R_{max}}{r}\right)^B\right]}$$

Parameter
To be calibrated
through
Altimeter data

$$R_{max} = 46.29 \exp(-0.0153V_{max} + 0.0166\phi)$$

$$V_{max} = \sqrt{\frac{B(p_n - p_c)}{\rho_e}}$$

B Peakedness
Here Km: 0.7

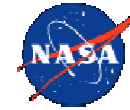
Correction factor due to the speed of displacement of the hurricane, Jelesnianski (1966).

$$U(r) = \frac{rR_{mw}}{R_{mw}^2 + r^2} V_F$$

Vf forward speed of the hurricane

Parameter
Could be calibrated
through
Altimeter data

$$V_{10} = K_m V$$



Altimeter passes and hurricane Maria position on 05 Sep

Envisat P0577 at 00:58

ERS-2 P0577 at 01:30

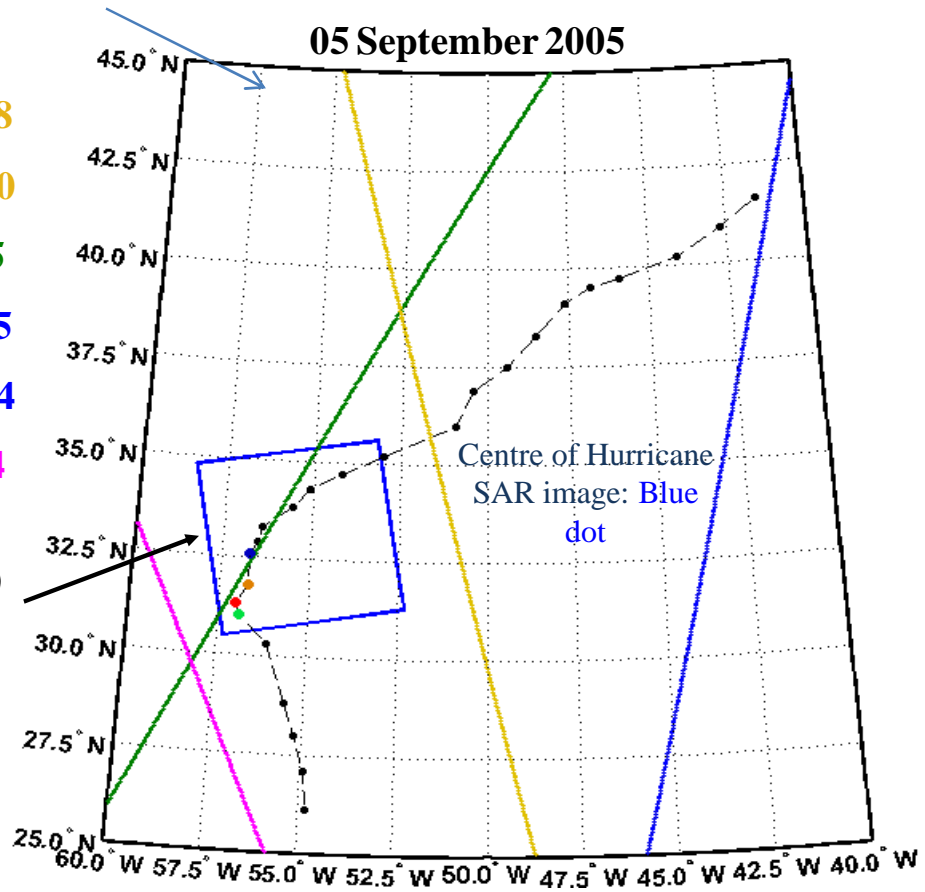
Jason-1 P0013 at 09:45

Envisat P0592 at 13:15

ERS-2 P0592 at 13:44

Jason-1 P0024 at 19:44

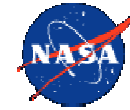
**RADARSAT-1 SCW (B)
SAR IMAGE at 21:36**



ESA and Jason-1 altimeter passes on acquisition image day with hurricane position at time 03:00, 09:00, 15:00 and 21:00.

No Altimeter passes at around SAR image time !

RADARSAT Hurricane Applications Project Workshop



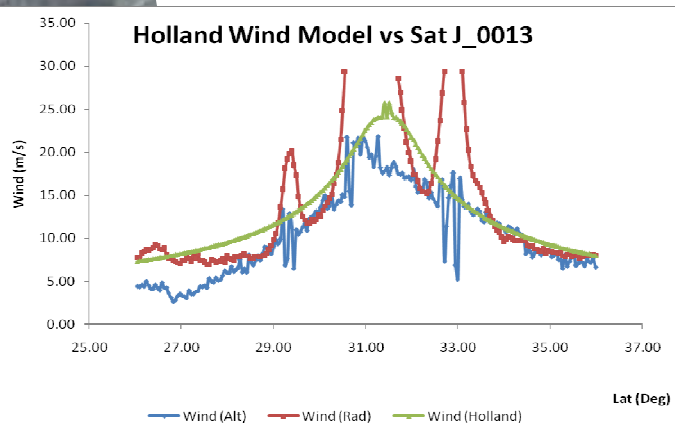
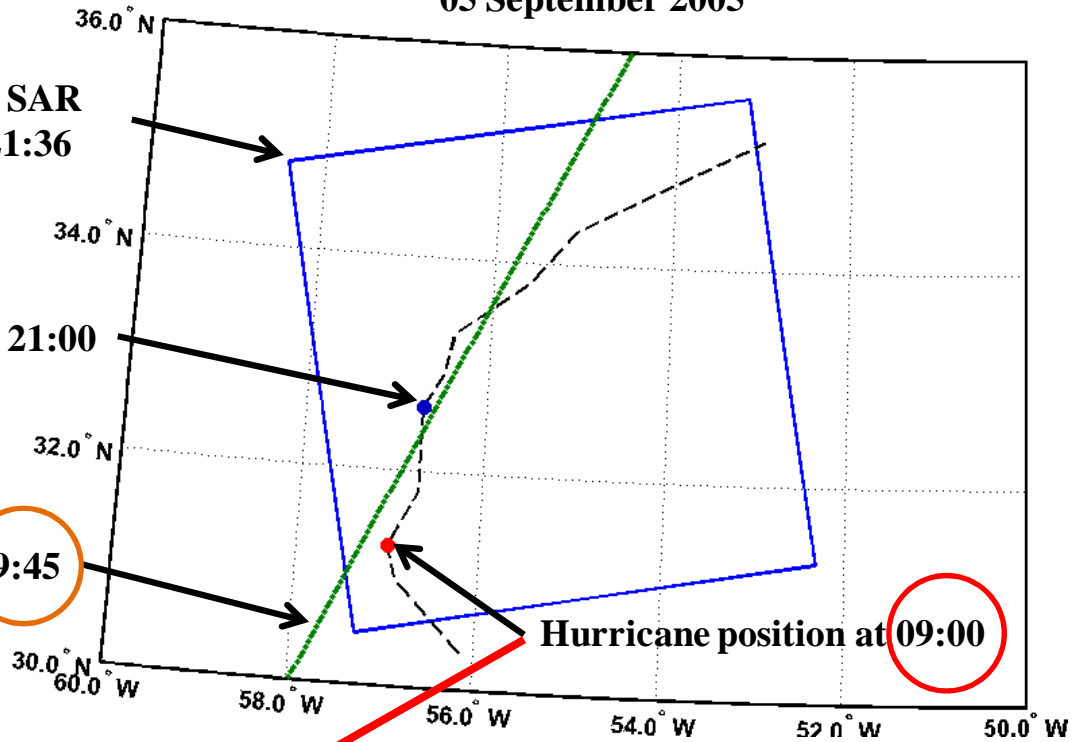
05 September 2005

**RADARSAT SAR
IMAGE at 21:36**

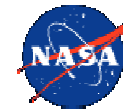
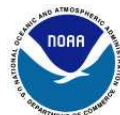
Hurricane position at 21:00

Jason-1 P 0013 at 09:45

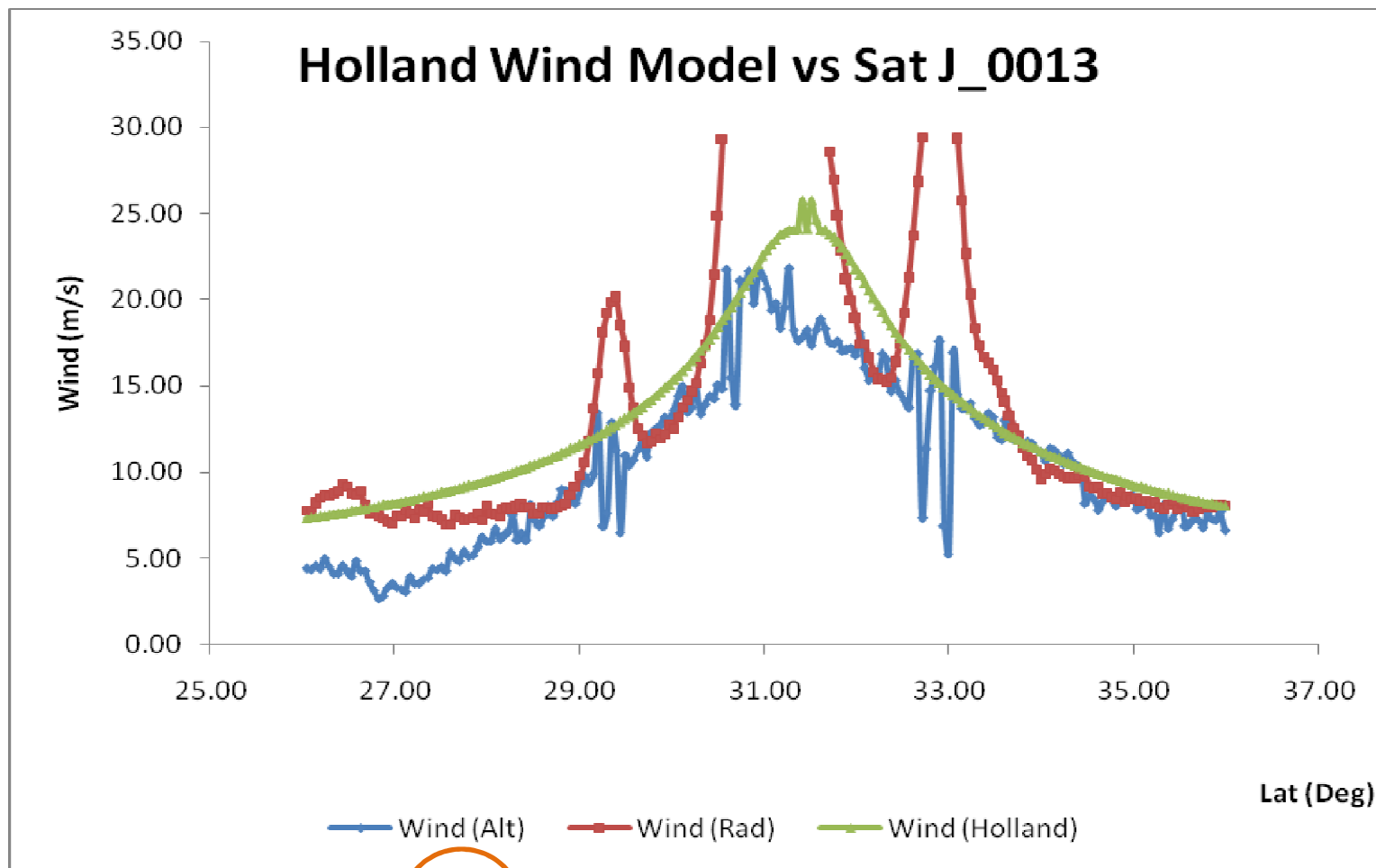
Hurricane position at 09:00



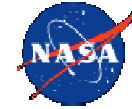
**Model is calibrated at around
09:00. (Red dot)
One useful passage: Jason -1
P0013 at 09:45**



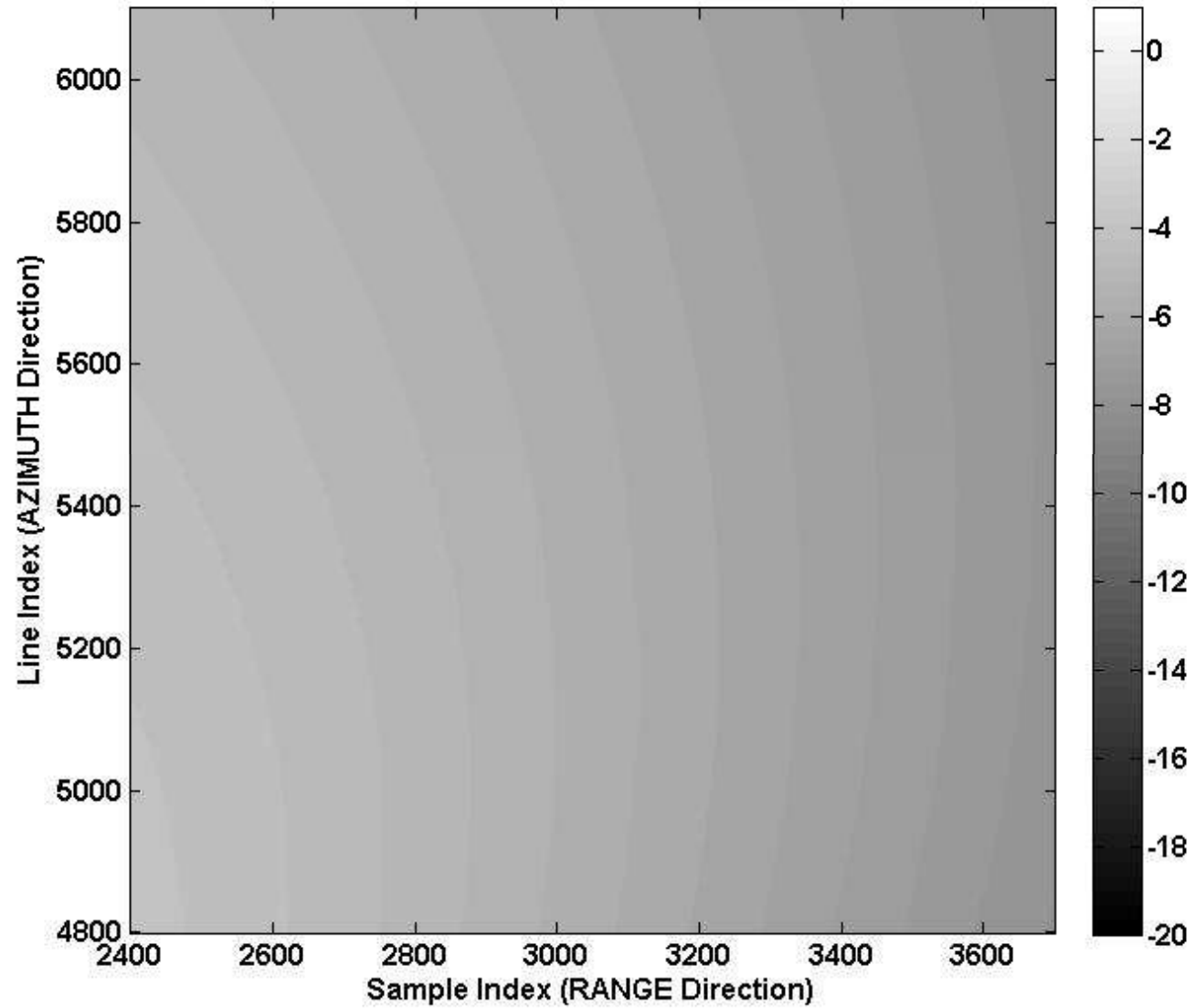
Calibrating Hurricane wind model with satellite altimeter



Jason -1 P0013 at 09:45

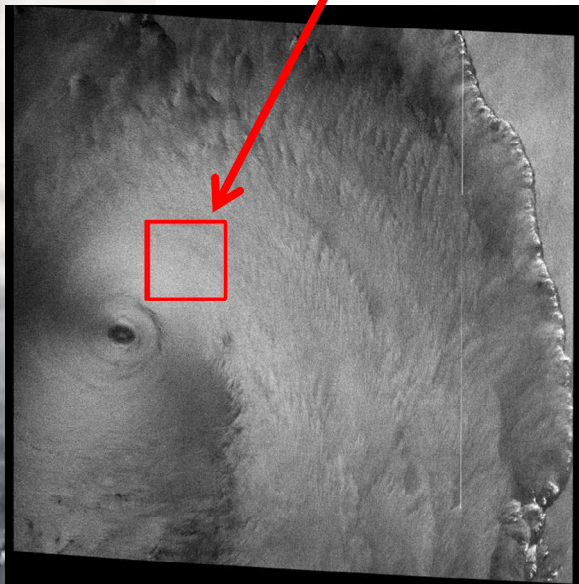


CMOD 5 reconstruction on Holland model windfield map

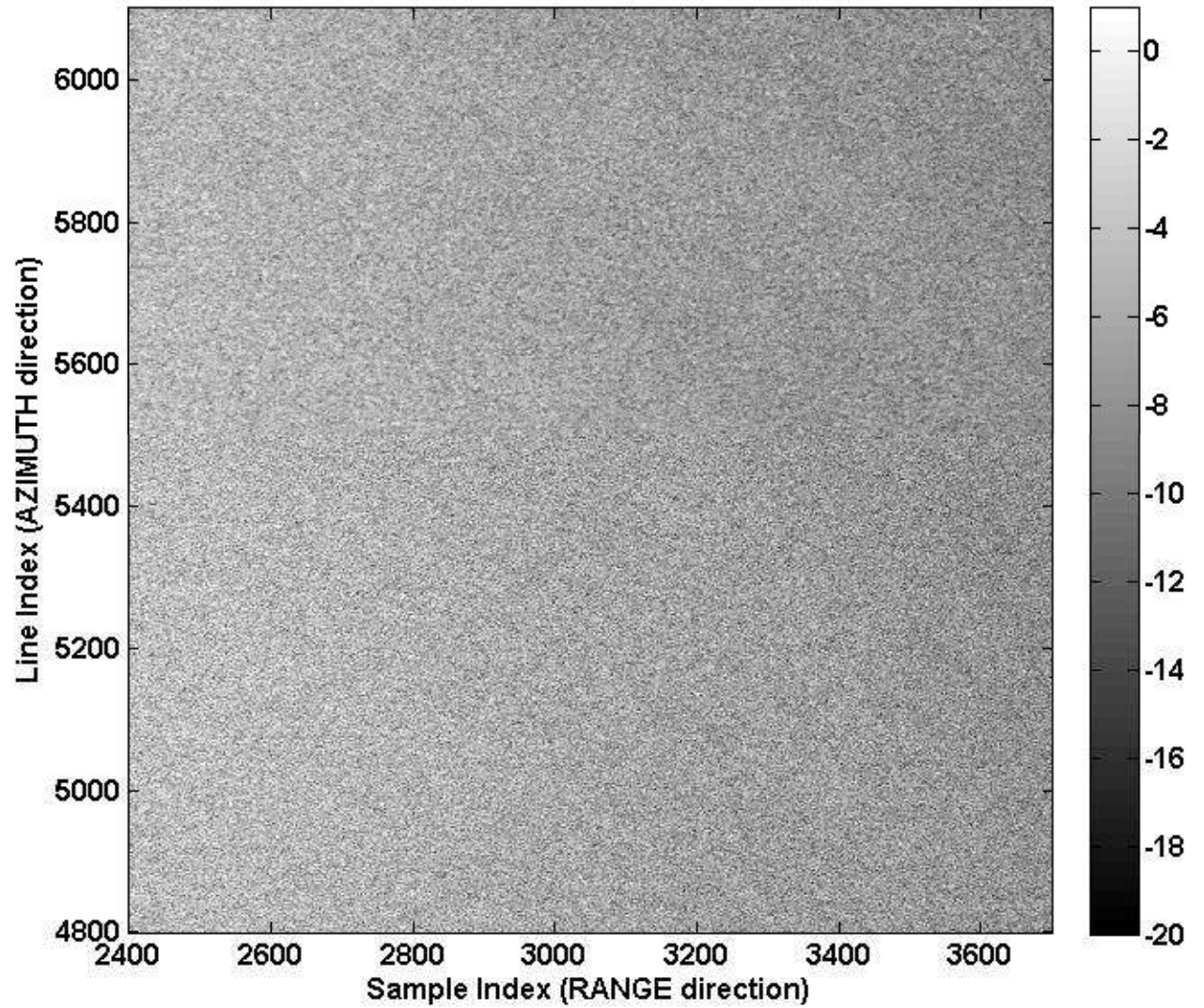




ROI

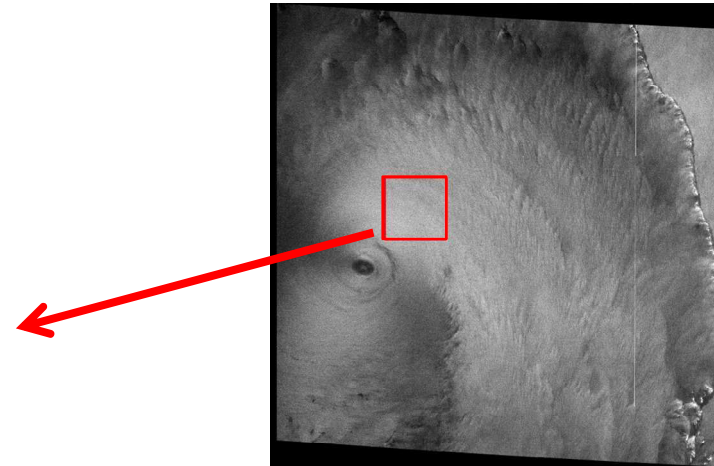
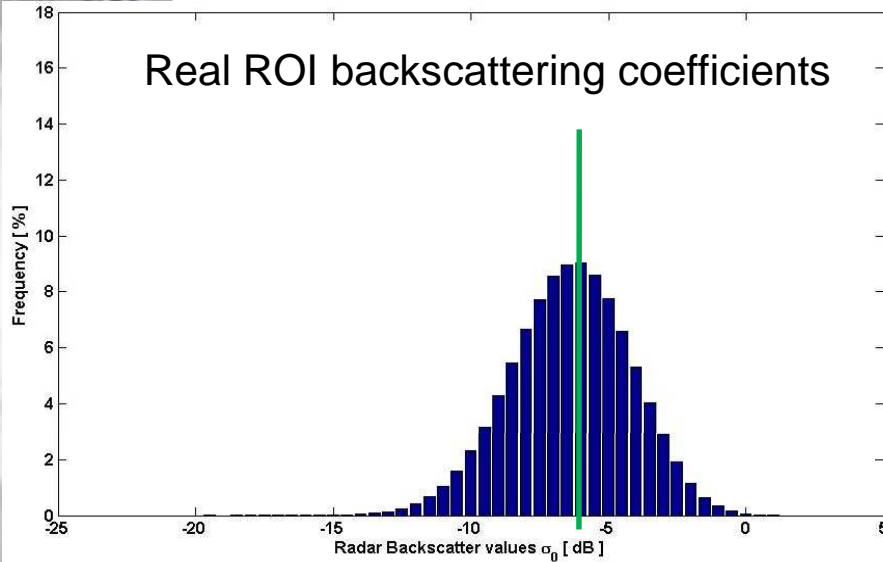


Backscattering coefficients σ_0 of examined ROI [dB]



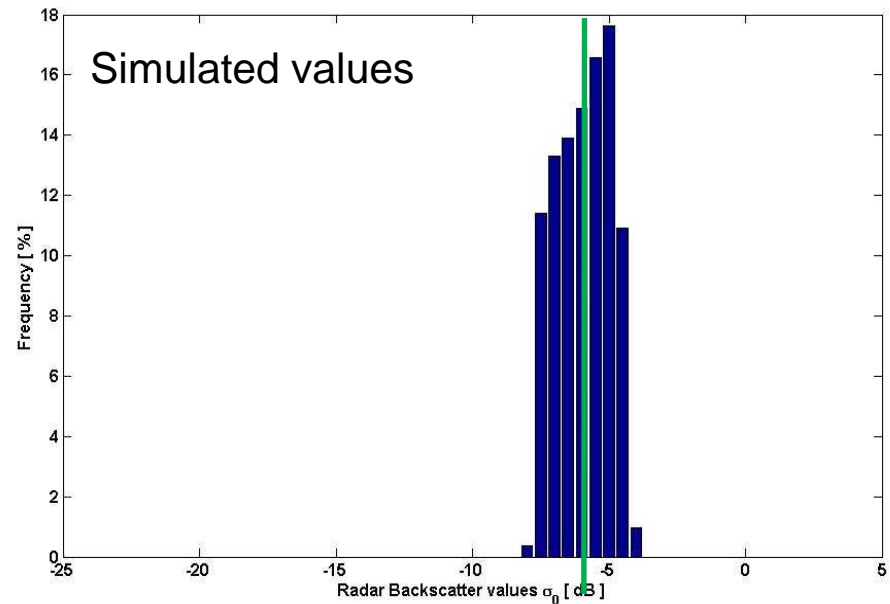


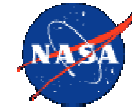
Empirical Frequency Distributions



Average values fit
(... well, no big deal)

Distribution does NOT fit
(waves? whitecaps?)





CONCLUSIONS AND FUTURE WORK

A simple model was employed to provide wind velocity ; its reliability was tested by making use of satellite altimeter data;
It does reproduce σ_0 average values for ROIs of but **not** its spatial distribution

Introducing wave and whitecaps effects might improve results

BUT

possibly a higher resolution is needed

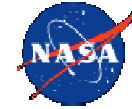
(Fine Quad-Pol Single Look)

**Some problems with
Katerine hurricane data**

!



Using Global or Local Weather models for wind field might also prove useful



ACKNOWLEDGMENTS



Essential help and advice in handling Radarsat data provided by IFREMER - **CERSAT** (Brest, France) is gratefully acknowledged

ESA altimeter and SAR data were supplied by ESA-ESRIN within Project CAT – 1 N° 1172: “Remote Sensing of Wave Transformation”.

