

# The Azimuth Cut-Off Method to Estimate Wind Speed under Extreme Weather Conditions

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→ **SEASAR 2018**

Advances in SAR Oceanography

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# Summary



- Motivations
- Azimuth cut-off method
- Tropical cyclone application
- Conclusions



## HURRICANE HUNTERS



## REMOTE SENSING



## SCATTEROMETER



- Microwave radars
- Resolution in the order of tens kilometers
- Designed for wind retrieval in moderate wind conditions
- However, they can be exploited to study tropical cyclone

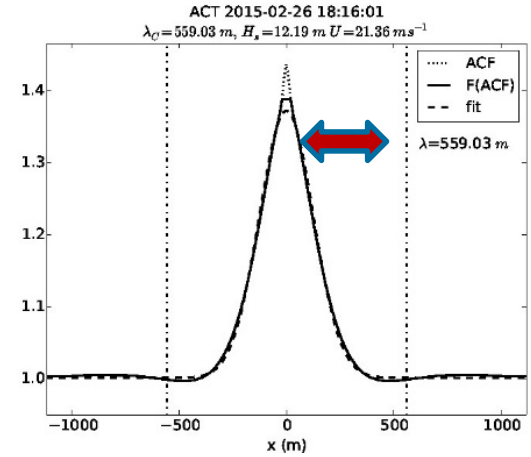
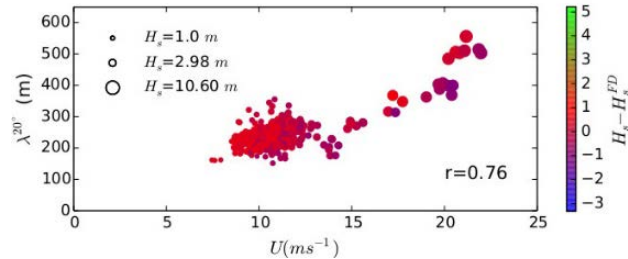
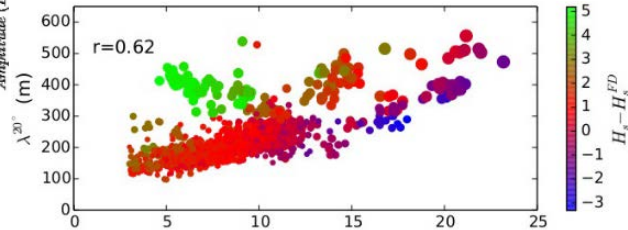
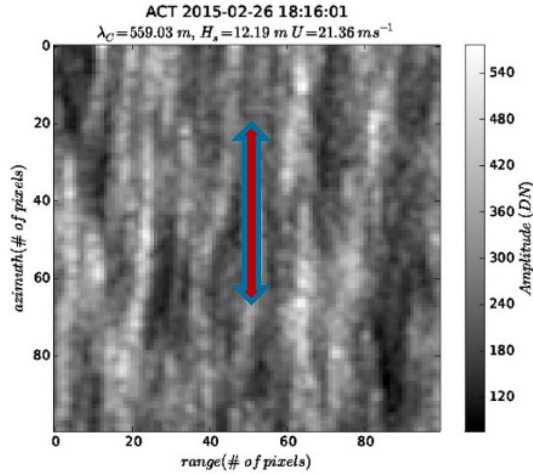
## SYNTHETIC APERTURE RADAR (SAR)

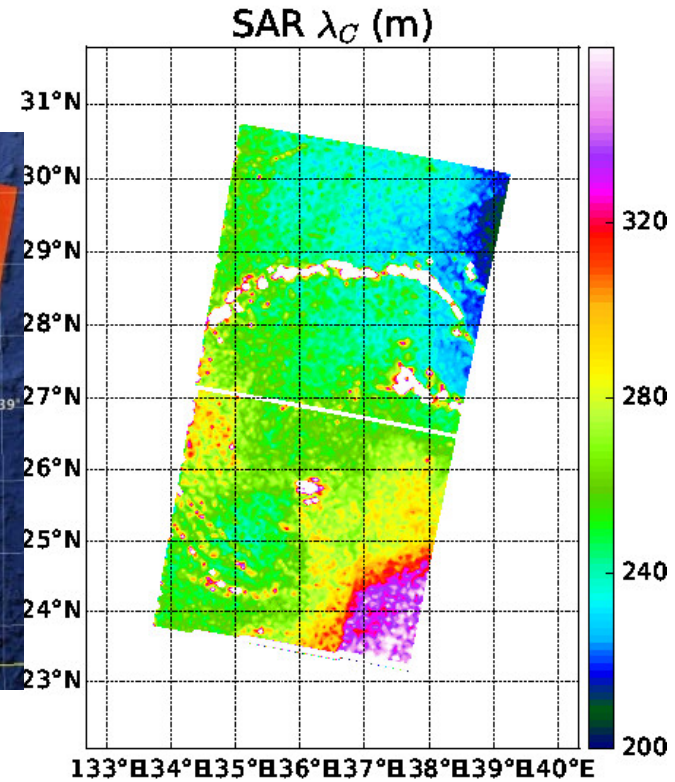
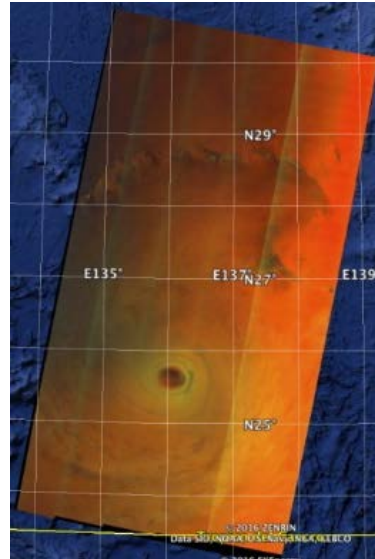
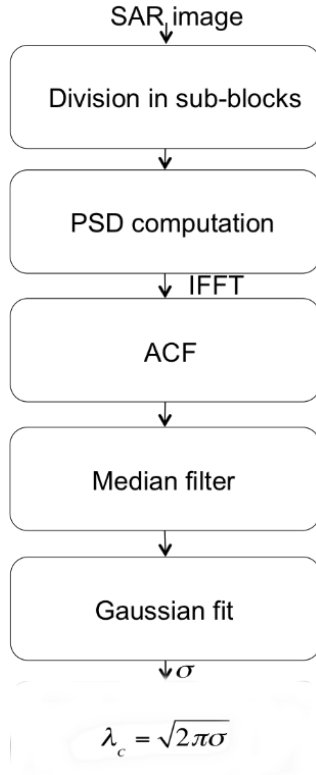


- Microwave radars
- Finer spatial resolution
- Wind retrieval through the use of the same Geophysical Model Function (GMF)
- SAR data to monitor tropical cyclone

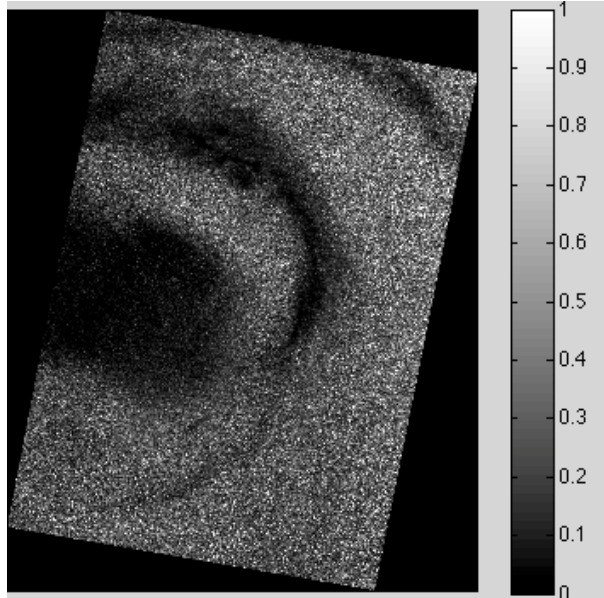


# Azimuth cut-off





# Typhoon Megi



**DATASET:**  
TerraSAR-X ScanSAR  
mode

**Date:** October 21, 2010  
**Time UTC:** 22:05:16

**Resolution:** 8.25 m

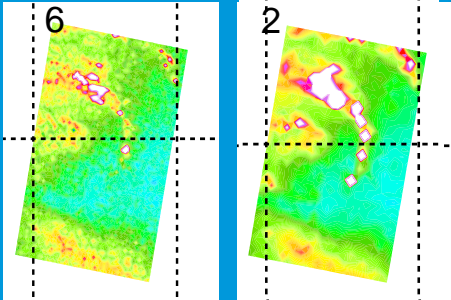
# Azimuth cut-off

## Resolution 8

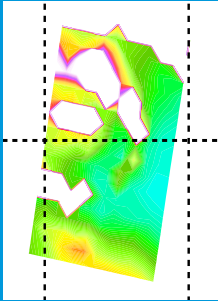
256x25  
512x51

6

2



1024x102

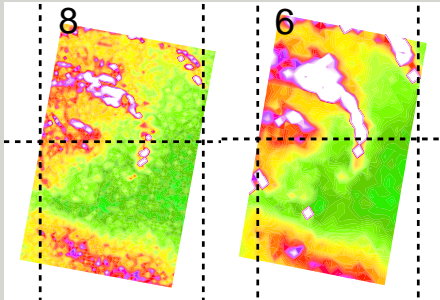


## Resolution 17

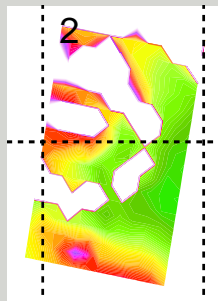
128x12  
256x25

8

6



512x51

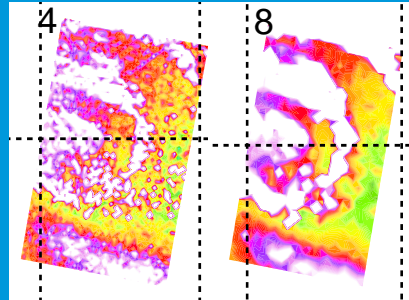


## Resolution 33

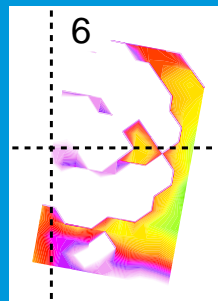
64x6  
128x12

4

8



256x25

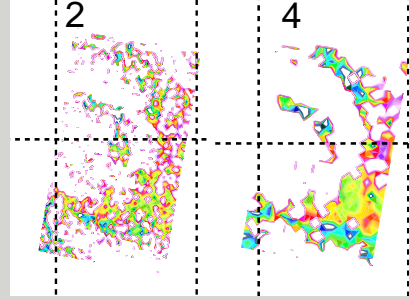


## Resolution 66

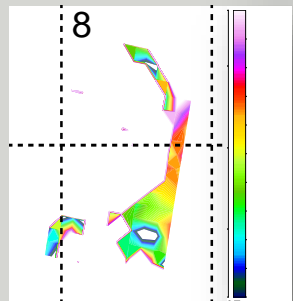
32x3  
64x6

2

4



128x12





# Azimuth cut-off

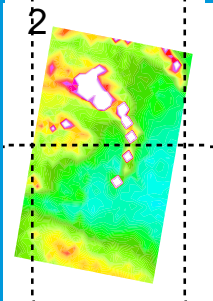
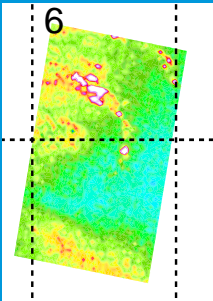
## Resolution 8 m

256x25

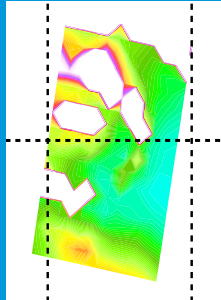
512x51

6

2



1024x102



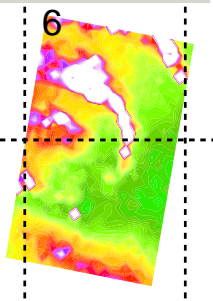
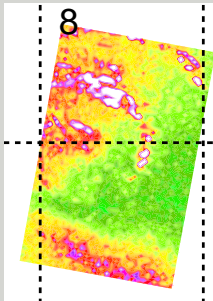
## Resolution 17 m

128x12

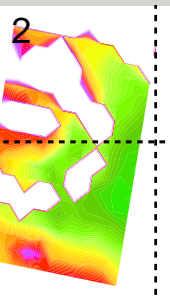
256x25

8

6



512x51



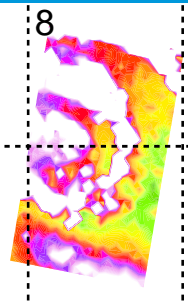
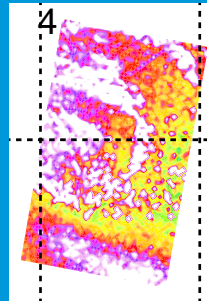
## Resolution 33 m

64x6

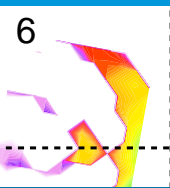
128x12

4

8



256x25



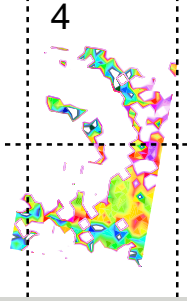
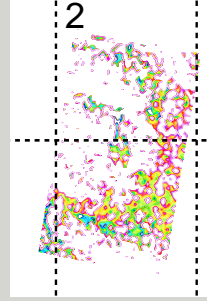
## Resolution 66 m

32x3

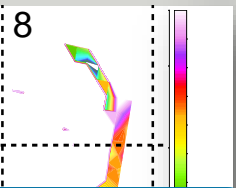
64x6

2

4

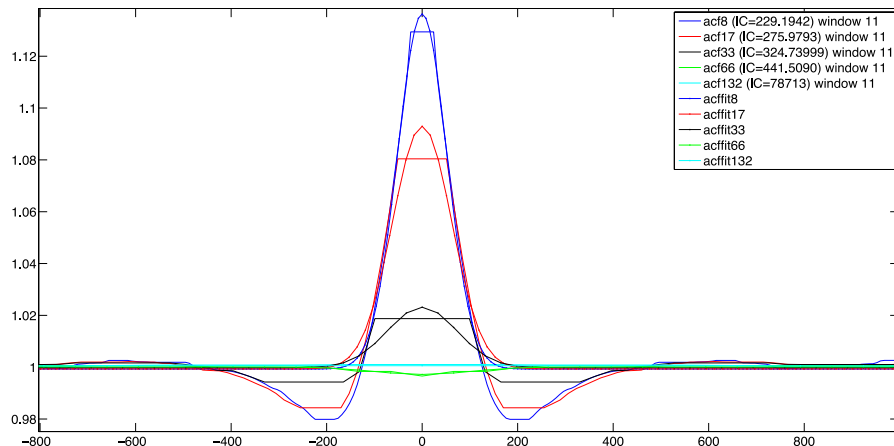


128x12

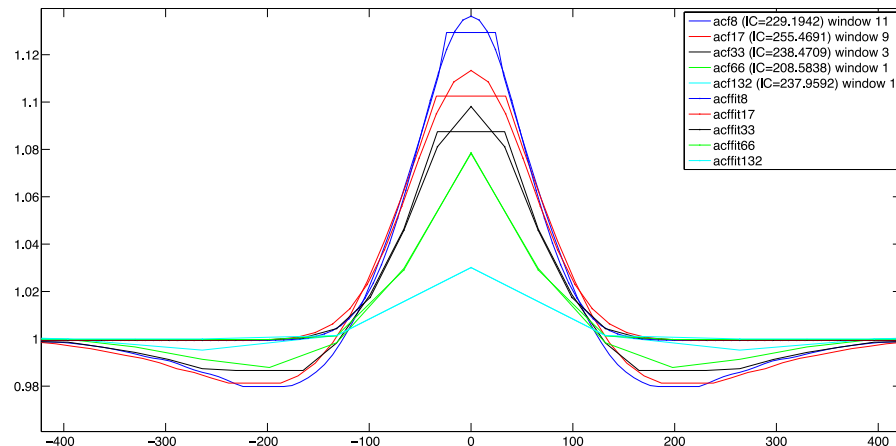


$\lambda_c \sim F(\text{Pixel spacing, Box size, Homogeneity})$

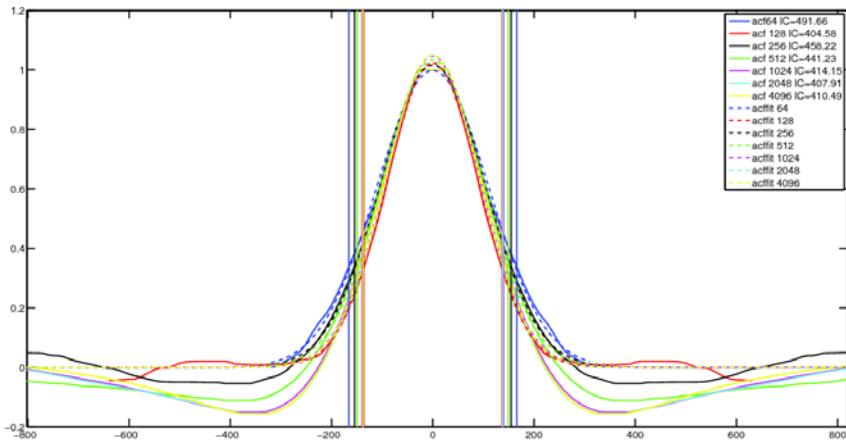
## Acf fits at different resolutions and fixed median filter window



## Acf fits at different resolutions and variable median filter window



$\lambda_c \sim F(\text{Pixel spacing}, \text{Box size}, \text{Homogeneity})$   
Median filter window should be fixed at about 100-120 m



- The width of the Gaussian fit does not change significantly
- Long tails for all the ACF except 64 x 64

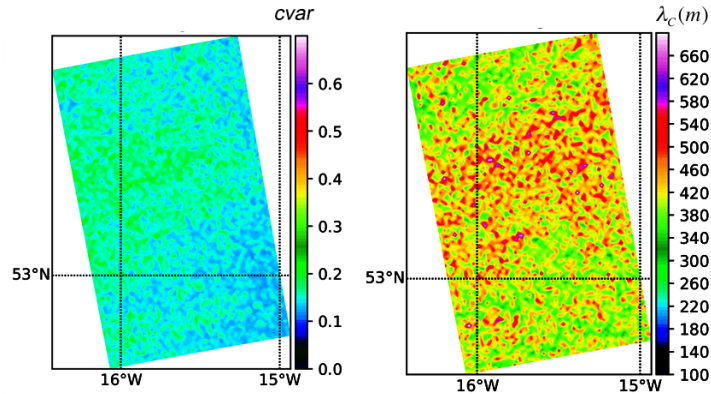
$\lambda_c$  ESTIMATED USING FIXED MEDIAN FILTER WINDOW AND VARYING THE BOX'S SIZE.

Box size (pixels)	$\lambda_c$ (m)
64 × 64	491.66
128 × 128	404.58
256 × 256	458.22
512 × 512	441.23
1024 × 1024	414.15
2048 × 2048	407.9
4096 × 4096	410.49

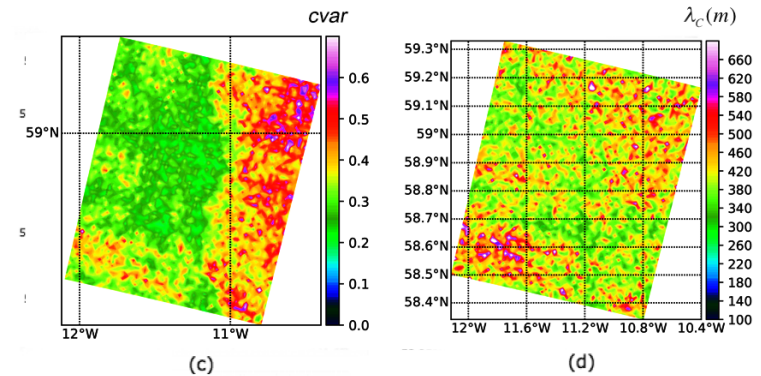
$\lambda_c \sim F(\text{Pixel spacing}, \text{Box size}, \text{Homogeneity})$

Choice of the smallest box size

## Sentinel-1A Dataset 1



## Sentinel-1A Dataset 2

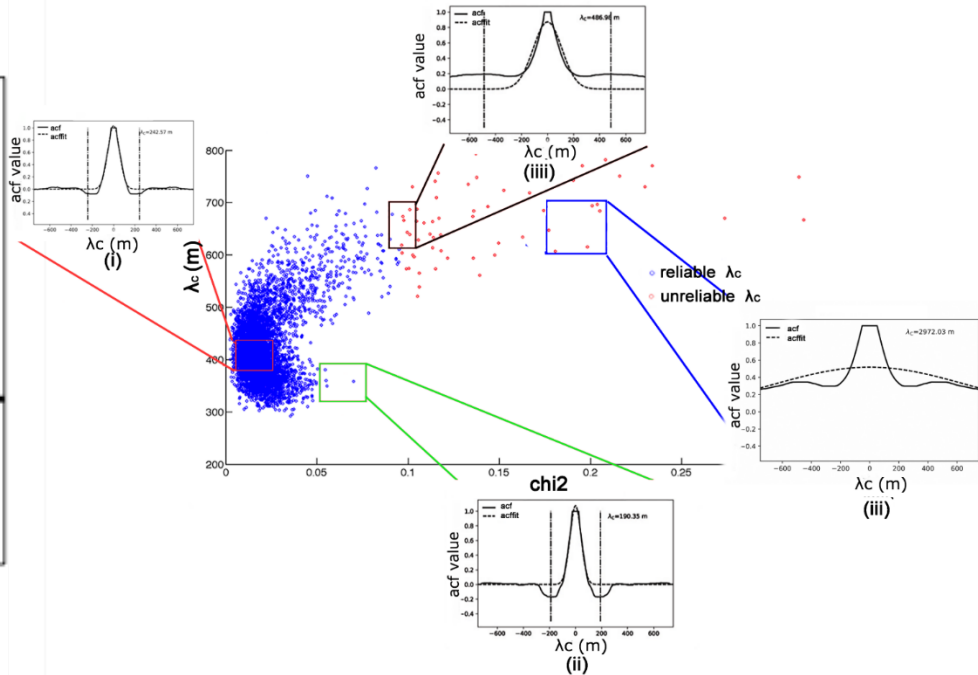
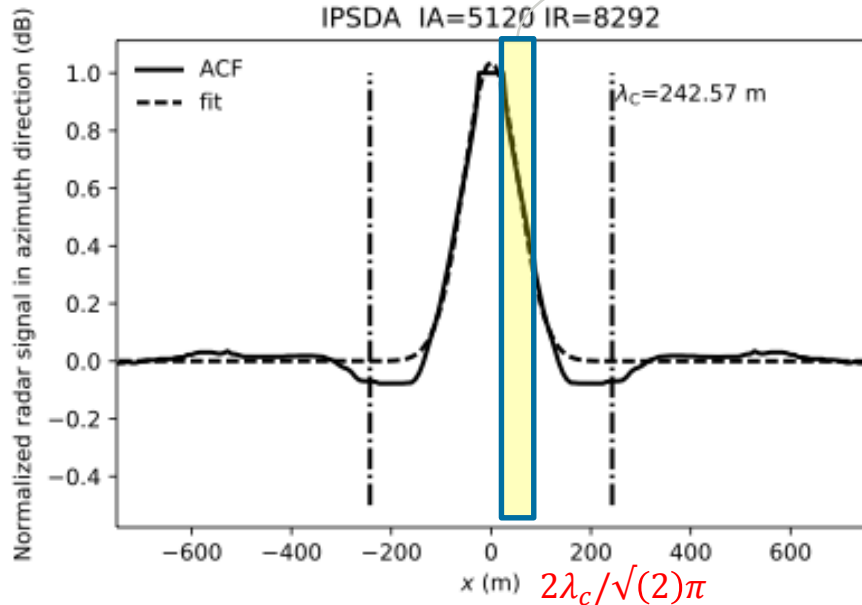


$$cvar = \frac{var(\sigma_0)}{mean(\sigma_0)^2}$$

$\lambda_c \sim F(\text{Pixel spacing, Box size, Homogeneity})$   
 A preliminary analysis of  $cvar$  can be useful to apply IC approach

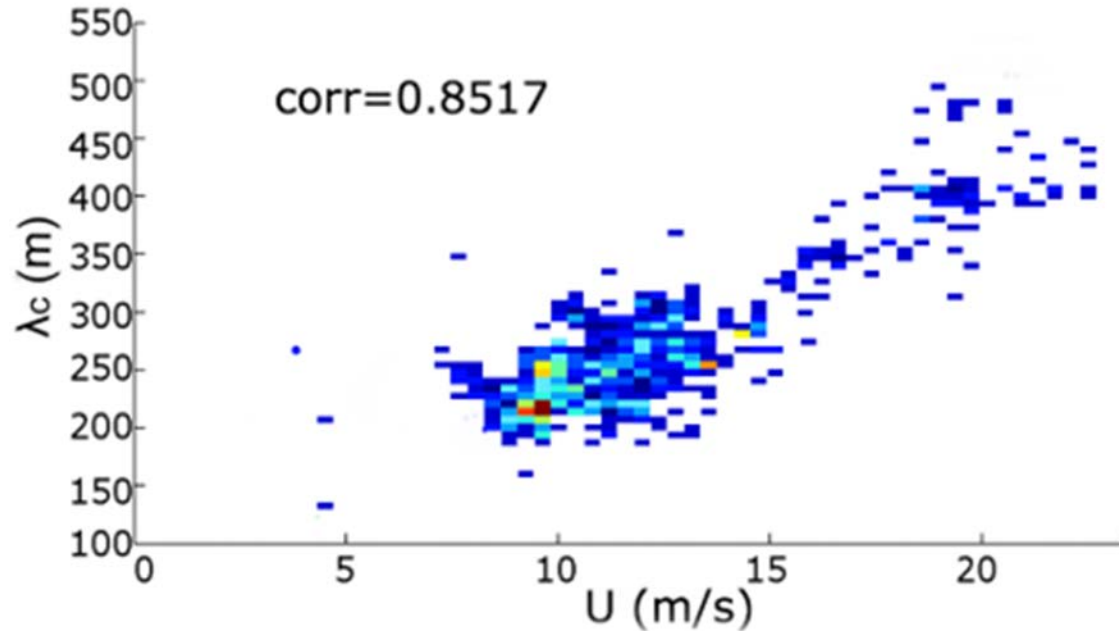


Chi2=chisquare(acf-acffit)



$$\lambda_c = a + bU_{10}$$

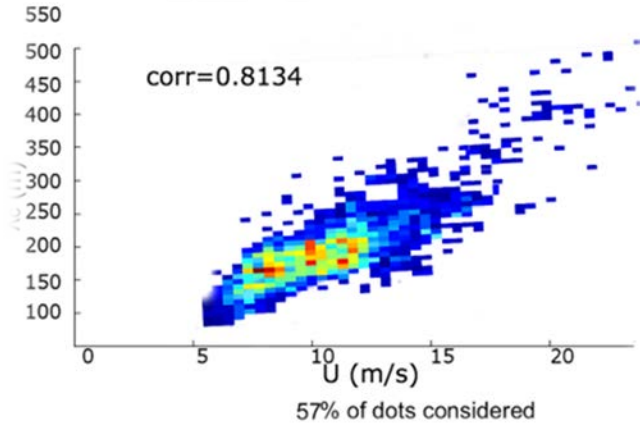
## Validation with ECMWF



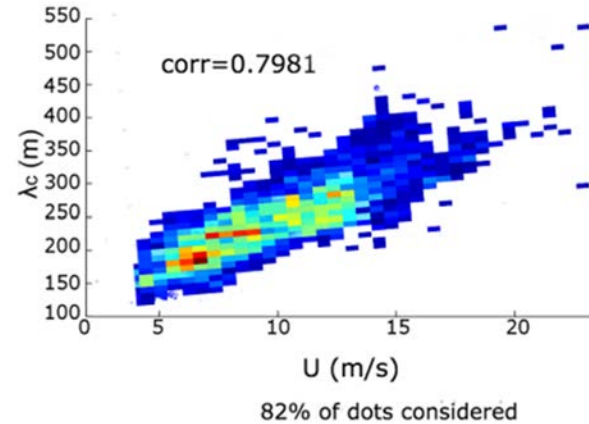
## Validation with ECMWF

$$\frac{|SWH - SWH_{FD}|}{SWH_{FD}} = TH$$

TH=1

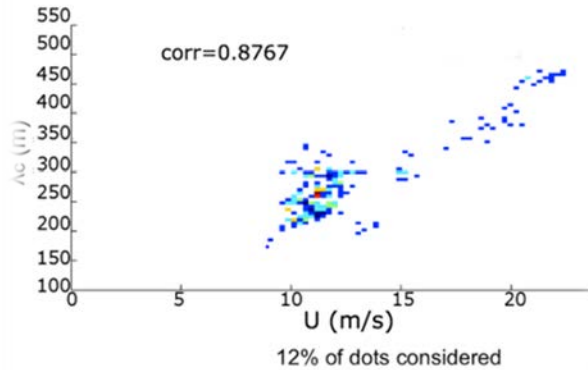


TH=3

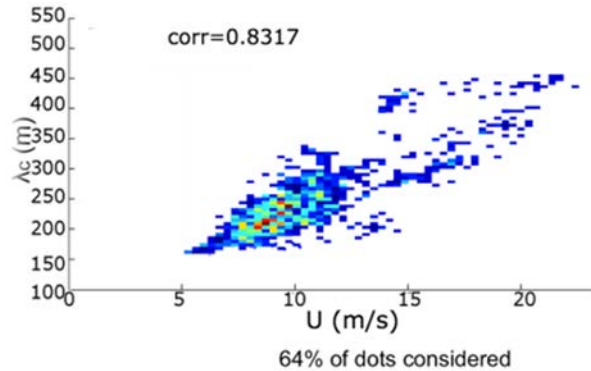


## Validation with HY-2A

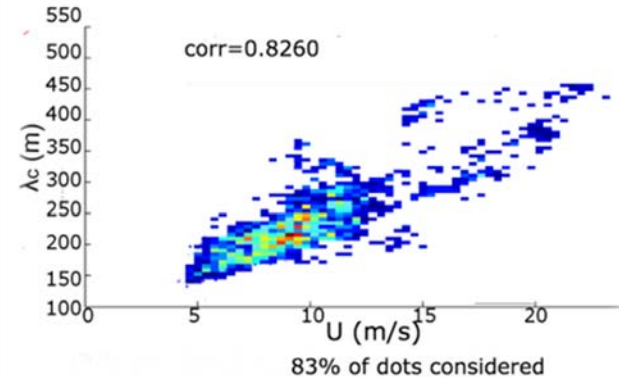
### TH=0.1



### TH=1

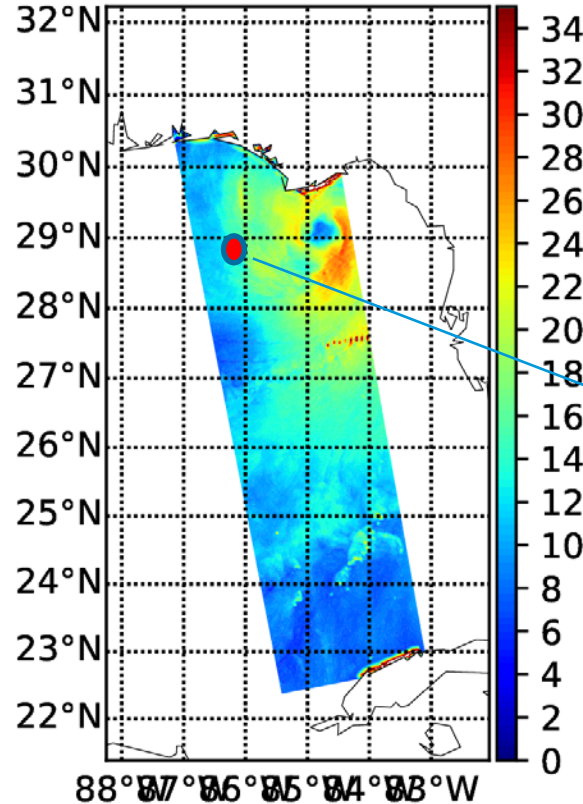


### TH=3





# Tropical cyclone application



## Hurricane Hermine

Buoy Station 42039  
28.788 N 86.008 W

01/09/2016 h: 23:50

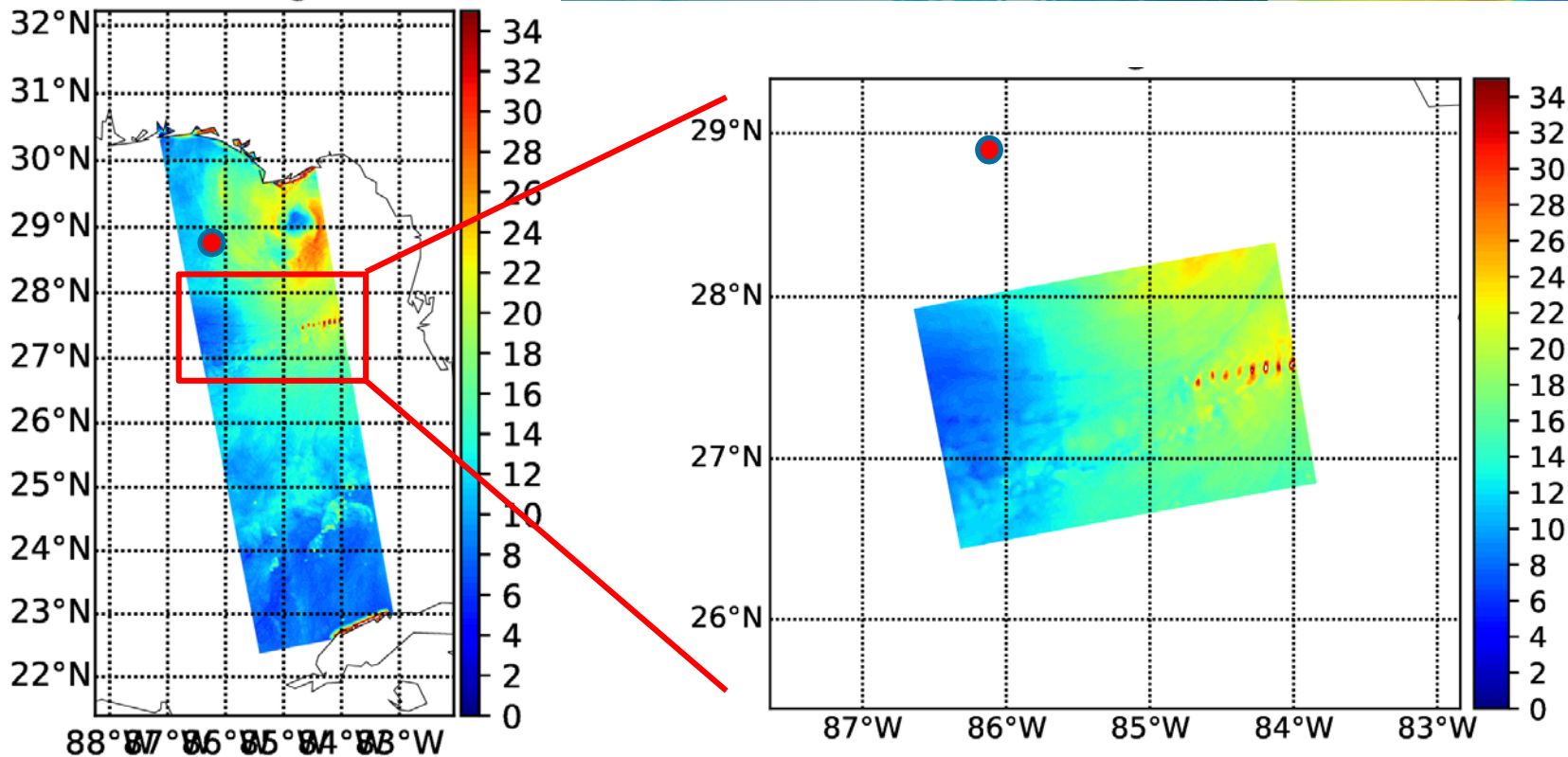
ws=16.6 m/s

29/08/2016 h: 09:00

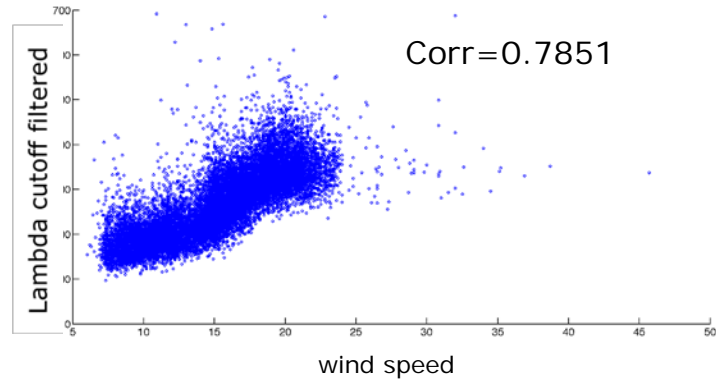
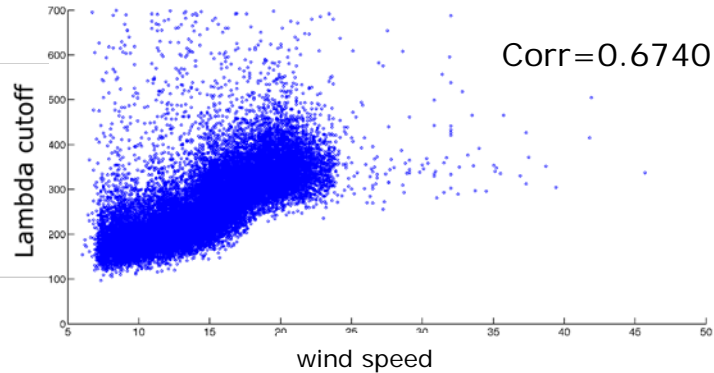
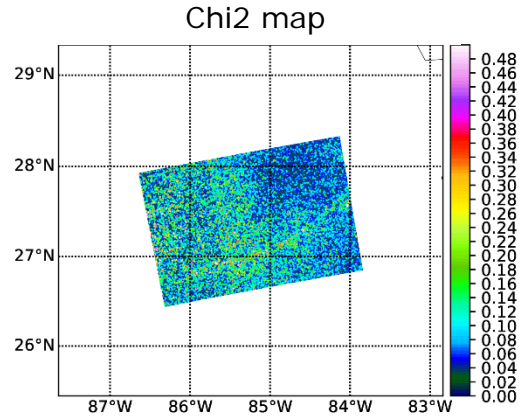
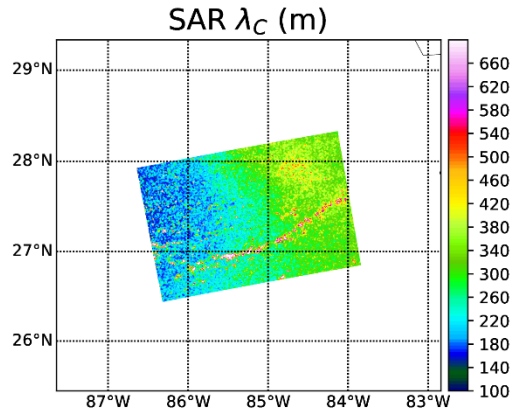
ws=9,7 m/s

Courtesy of A. Mouche, Laboratoire d'Océanographie Spatiale, Ifremer

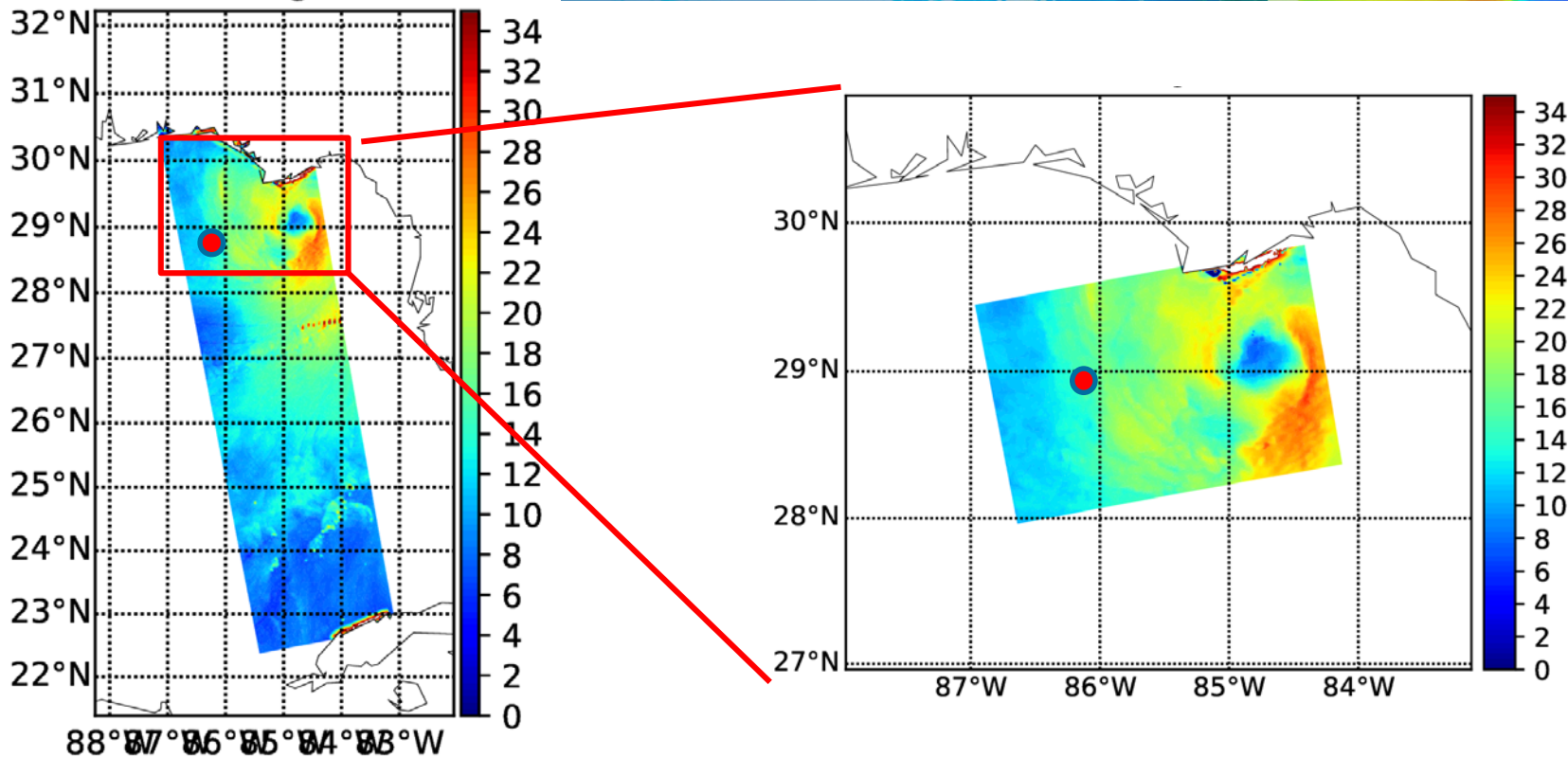
# Tropical cyclone application



# Tropical cyclone application

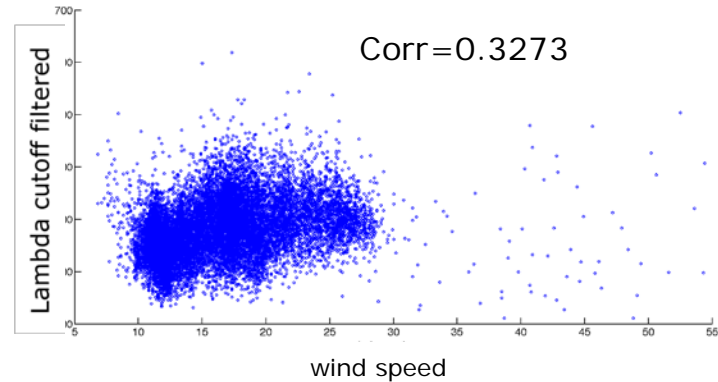
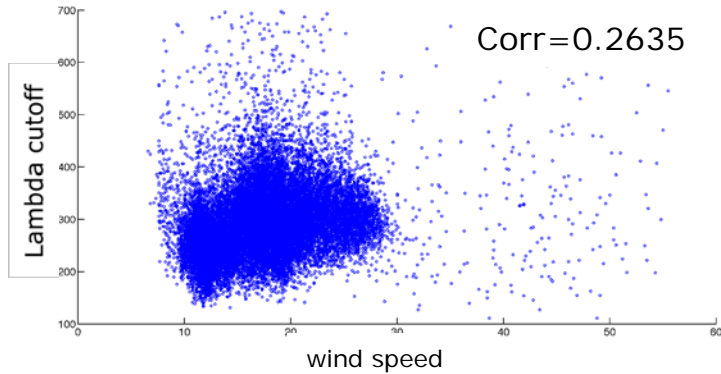
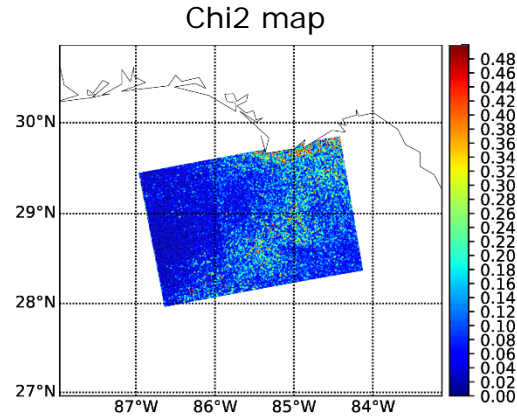
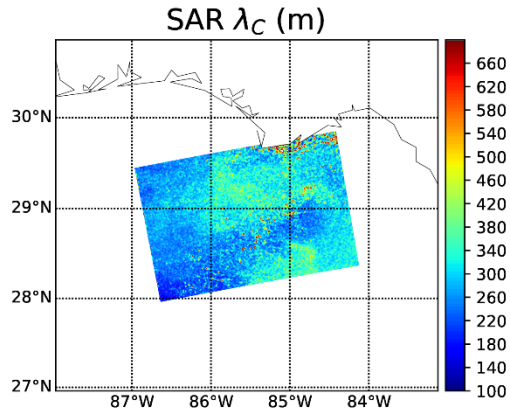


# Tropical cyclone application





# Tropical cyclone application



$$\text{Inverse wave age} = \Omega = U_{10} \cos \theta / C_p$$

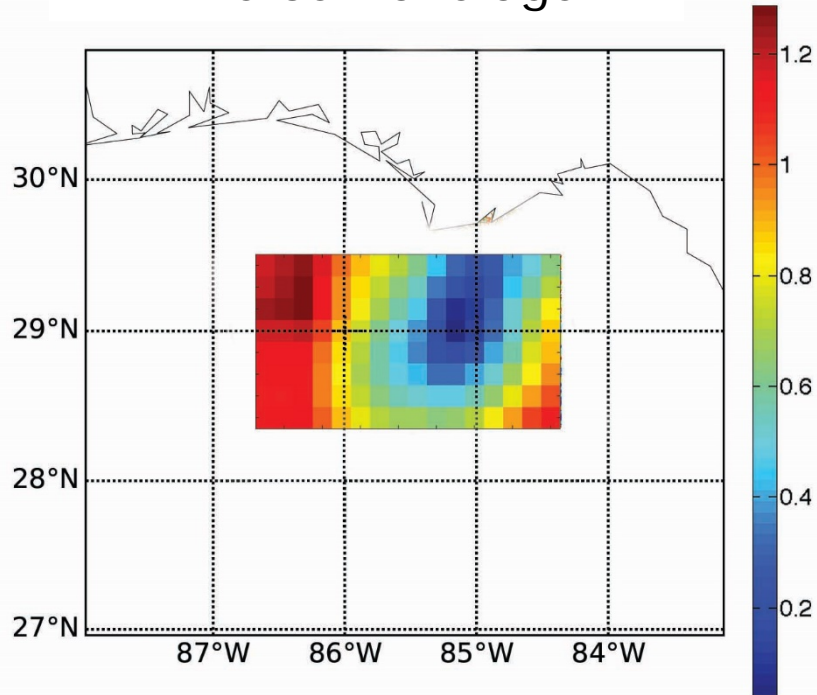
$U_{10}$  wind speed

$\theta$  angle between wind direction and peak wave direction

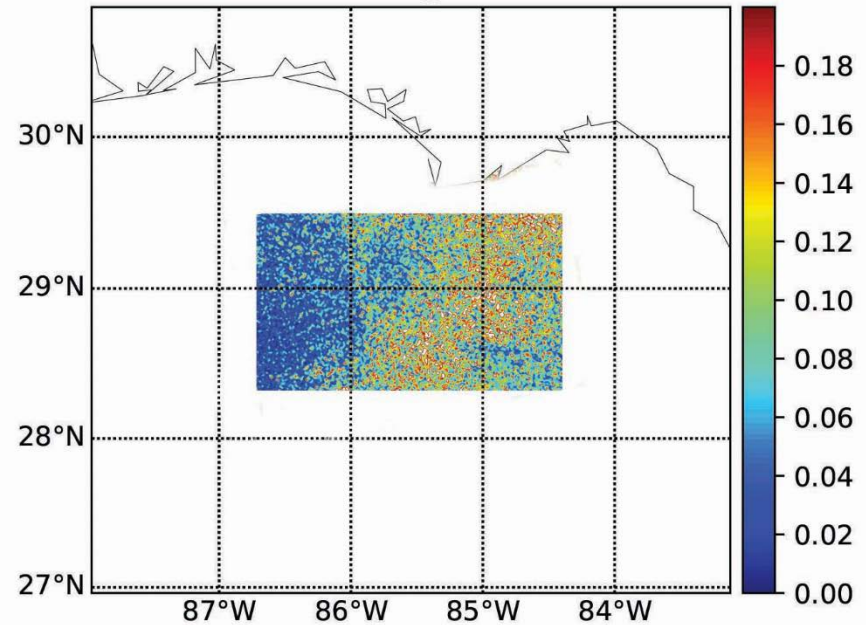
$C_p$  peak phase speed

- $0.15 < \Omega < 0.83$  mixed wind sea state (both wind sea and swell waves)
- $\Omega > 0.83$  wind driven sea state (dominated by wind sea)
- $0 < \Omega < 0.15$  wave driven sea state (swell dominated)
- $\Omega < 0$  counter-swell conditions (wind direction opposite to wave direction)

## Inverse wave age



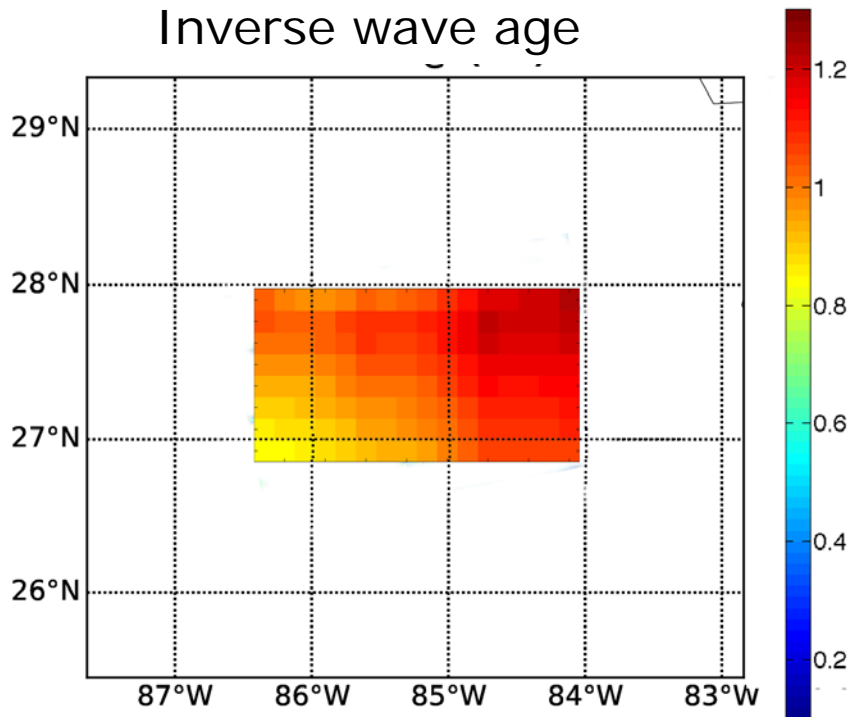
## Chi2 map



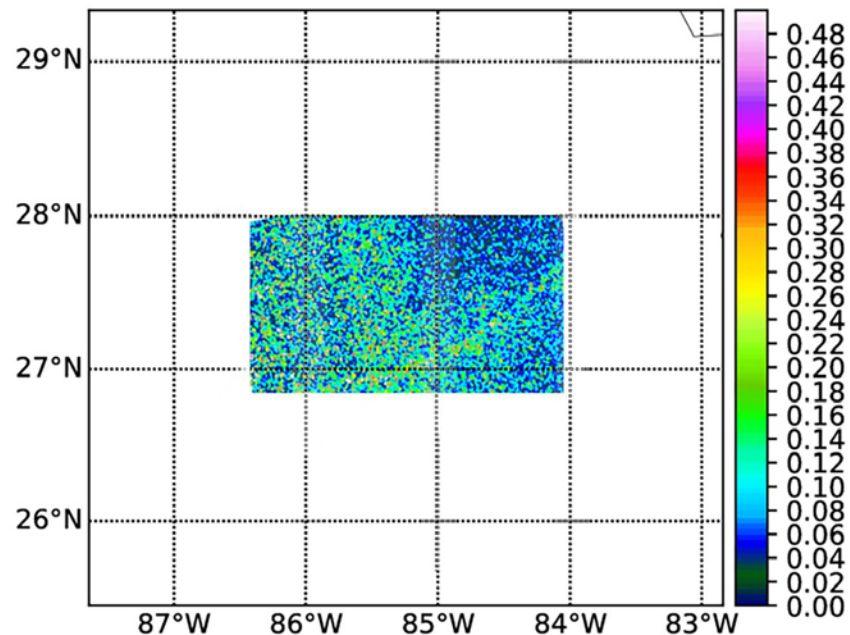
# Tropical cyclone application



## Inverse wave age



## Chi2 map



SAR data have been exploited to retrieve wind speed under extreme wind conditions using a re-tuned azimuth cut off method.

- We found an objective way to estimate lambda cut-off parameters.
- **Misfit analysis** to exclude non reliable azimuth cutoff values.
- Lambda cut-off vs **developing sea condition**
- Lambda cut-off vs **Tropical cyclone case**



# Thank you for attention

→ **SEASAR 2018**

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