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

V. Corcione; F. Nunziata; M. Portabella; G. Grieco; M. Migliaccio

→ SEASAR 2018

Advances in SAR Oceanography

7–10 May 2018 | ESA–ESRIN | Frascati (Rome), Italy
Summary

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

HURRICANE HUNTERS

REMOTE SENSING
Motivations

- 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

• Finer spatial resolution
• Wind retrieval through the use of the same Geophysical Model Function (GMF)
• SAR data to monitor tropical cyclone
Azimuth cut-off

ACT 2015-02-26 18:16:01
\( \lambda_c = 556.03 \text{ m}, H_s = 12.19 \text{ m} \ U = 21.36 \text{ m s}^{-1} \)

\[ r = 0.62 \]

\[ r = 0.76 \]
Azimuth cut-off

\[ \lambda_c = \sqrt{2 \pi \sigma} \]

SAR image

- Division in sub-blocks
- PSD computation
- IFFT
- ACF
- Median filter
- Gaussian fit
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
- 1024x102

Resolution 17
- 128x12
- 256x25
- 512x51

Resolution 33
- 64x6
- 128x12
- 256x25

Resolution 66
- 32x3
- 64x6
- 128x12
Azimuth cut-off

Resolution 8 m
256x25, 512x51

Resolution 17 m
128x12, 256x25

Resolution 33 m
64x6, 128x12

Resolution 66 m
32x3, 64x6

\[ \lambda_c \sim F(\text{Pixel spacing, Box size, Homogeneity}) \]
Azimuth cut-off

Acf fits at different resolutions and fixed 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
Azimuth cut-off

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

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

Choice of the smallest box size
Azimuth cut-off

Sentinel-1A Dataset 1

\[ \text{cvar} = \frac{\text{var}(\sigma_0)}{\text{mean}(\sigma_0)^2} \]

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

A preliminary analysis of cvar can be useful to apply IC approach.
Azimuth cut-off

\[ \chi^2 = \text{chisquare}(\text{acf-acffit}) \]

\[ 2\lambda_c / \sqrt{(2)\pi} \]
Azimuth cut-off

\[ \lambda_c = a + bU_{10} \]
Azimuth cut-off

Validation with ECMWF

\[
\frac{|SWH - SWH_{FD}|}{SWH_{FD}} = \text{TH}
\]

TH = 1

corr = 0.8134

57% of dots considered

TH = 3

corr = 0.7981

82% of dots considered
Azimuth cut-off

Validation with HY-2A

TH=0.1
- corr=0.8767
- 12% of dots considered

TH=1
- corr=0.8317
- 64% of dots considered

TH=3
- corr=0.8260
- 83% of dots considered
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’Oceanographie Spatiale, Ifremer
Tropical cyclone application
Tropical cyclone application

Chi2 map

Corr=0.6740

Corr=0.7851
Tropical cyclone application
Tropical cyclone application

Chi2 map

Corr = 0.2635

Corr = 0.3273
Tropical cyclone application

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

- $U_{10}$ 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)
Tropical cyclone application

Inverse wave age

Chi2 map
Tropical cyclone application

Inverse wave age

Chi2 map
Conclusions

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

Advances in SAR Oceanography

7–10 May 2018 | ESA–ESRIN | Frascati (Rome), Italy