High Resolution Wind Fields from Satellite Borne SAR

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SAR wind direction retrieval

Wind induced structures

Wind direction derived in the spatial domain

$\left(B^2B_{xy}^4\right)^3 \xrightarrow{\text{Sobel}} \left(B^2B_{xy}^4\right) \Phi$

Binomial filter
2 dim. $B^2$ Filter
2 dim. $B^4$ Filter

Wind direction retrieved from the image spectra

Optimized Sobel-Filter

Horstmann et al., 2002
Wind directions from SAR

10 km x 10 km

ERS-1 SAR image of Rügen, in the Baltic Sea
Aug. 12, 1991
Wind directions from SAR
5 km x 5 km
ERS-1 SAR image of Rügen, in the Baltic Sea
Aug. 12, 1991
Filter for wind retrieval

20 km x 20 km
FFT directions
LG directions

ERS-1 SAR image at the ice edge off the coast of Spitzbergen
24. March 1993
Filter effect on LG method

ERS-1 SAR image at the ice edge off the coast of Spitzbergen 24. March 1993

20 km x 20 km excl. filter incl. filter
ERS-1 SAR image at the ice edge off the coast of Spitzbergen 24. March 1993

Filter effect on FFT method

20 km x 20 km exl. filter incl. filter
SAR wind speed retrieval

Extension for HH-polarization

\[ \sigma_0^{HH} = \frac{(1 + \alpha \tan^2 \theta)^2}{(1 + 2 \tan^2 \theta)^2} \sigma_0^{VV}(u, \phi, \theta) \]

\[ \sigma_{0pol} = a(\theta)u^r(\theta)[1 + b(\theta) \cos \phi + c(\theta) \cos(2\phi)] \]

for VV-Polarization

CMOD4

Horstmann et al., 2000
Regional comparison

RADARSAT-1 ScanSAR image of the South coast of Greenland 1. April 2000

10 ms\(^{-1}\)

ScanSAR

62.00°

Greenland

Julianehaab Bay

Cape Farewell

-48.00° -46.00° -44.00° -42.00° -40.00°
Regional comparison

Comparison of ScanSAR to HIRLAM

RADARSAT-1 ScanSAR image of the South coast of Greenland

1. April 2000

Horstmann et al., 2002
ENVISAT ASAR image of Denmark and its surrounding waters Dec. 21, 2002
Comparison of ScanSAR to the DWD model

Horstmann and Koch, 2003
Comparison to in situ measurements
wind directions

Dankert et al., 2003
Global comparison

- 27 days of ERS-2 SAR imagettes
- Co-located to ERS-2 SCAT wind data

CMOD4
- cor 0.95
- bias 0.01 m/s
- rms 1.0 m/s

Neural Network
- cor 0.96
- bias 0.04 m/s
- rms 0.93 m/s

Horstmann et al., 2003
SAR data allow to measure wind fields with a resolution of up to 300 m.

The accuracy for wind directions is 20° and for wind speeds 1 ms⁻¹.

RADARSAT-1 ScanSAR and ENVISAT ASAR data give good results for both VV and HH polarization.

Wind speed errors in regional comparisons result from the numerical atmospheric models.

Investigation of the effects of wind farms on the local wind field.
Investigations of hurricanes.
Support of wind parks with SAR
Investigation of wind variability with SAR

![Graph showing spectral density vs. wavenumber and wavelength for different offshore distances.](image-url)
Hurricane Floyd
AVHRR NOAA-12
RADARSAT-1
ScanSAR
Sep 15, 1999