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2017 DRAGON 4 SYMPOSIUM

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Coastal Ocean Surface Wind from SAR

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Introduction

Context

- ESA is now processing Sentinel-1 data acquired over ocean up to Level-2 products.
  - Routine processing is done over European seas only.
  - Data are available in less than 24h (6-12h in fact) on scihub.
  - At the end of summer, the data processing up to Level-2 should be global and NRT (on Copernicus Hub).

- This product contains ocean surface wind speed and direction at 1 km resolution
  - There is no specific algorithm for coastal areas
  - There is no quality flag included in the Level-2 product

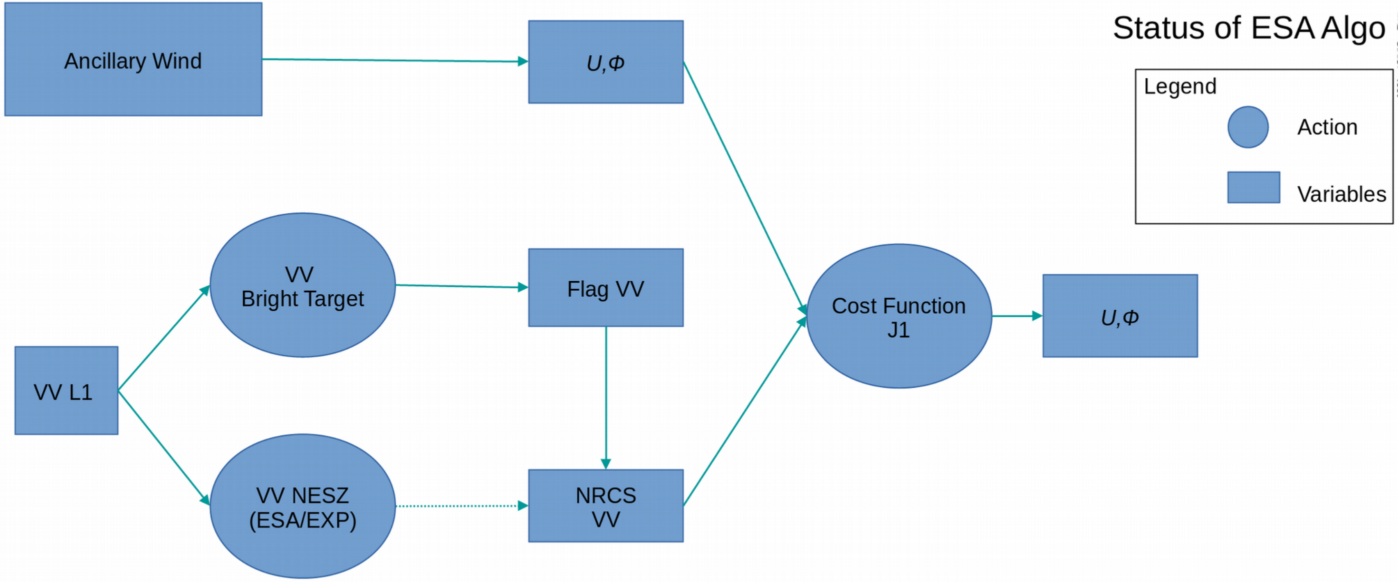
- GaoFeng-3 SAR has been succesfully launched last summer.
  - SOA aims at producing ocean surface wind field.

Introduction

Motivations

- Process a first set of Sentinel-1 Level-1 data up to Level-2 ocean surface wind field over China and assess the quality
- Propose a new strategy for Sentinel-1 wind inversion including
  - Qualification of Level-2 products
  - Use of other radar parameters than NRCS-VV
- Assess the algorithm performances on GF-3
- Provide cases study of complex situations (for instance with convective systems, upwelling) with relevant model and/or ancillary data for both ocean and atmosphere
- Set a common toolbox for wind analysis between GaoFeng-3 and sentinel-1

Status of ESA Algo

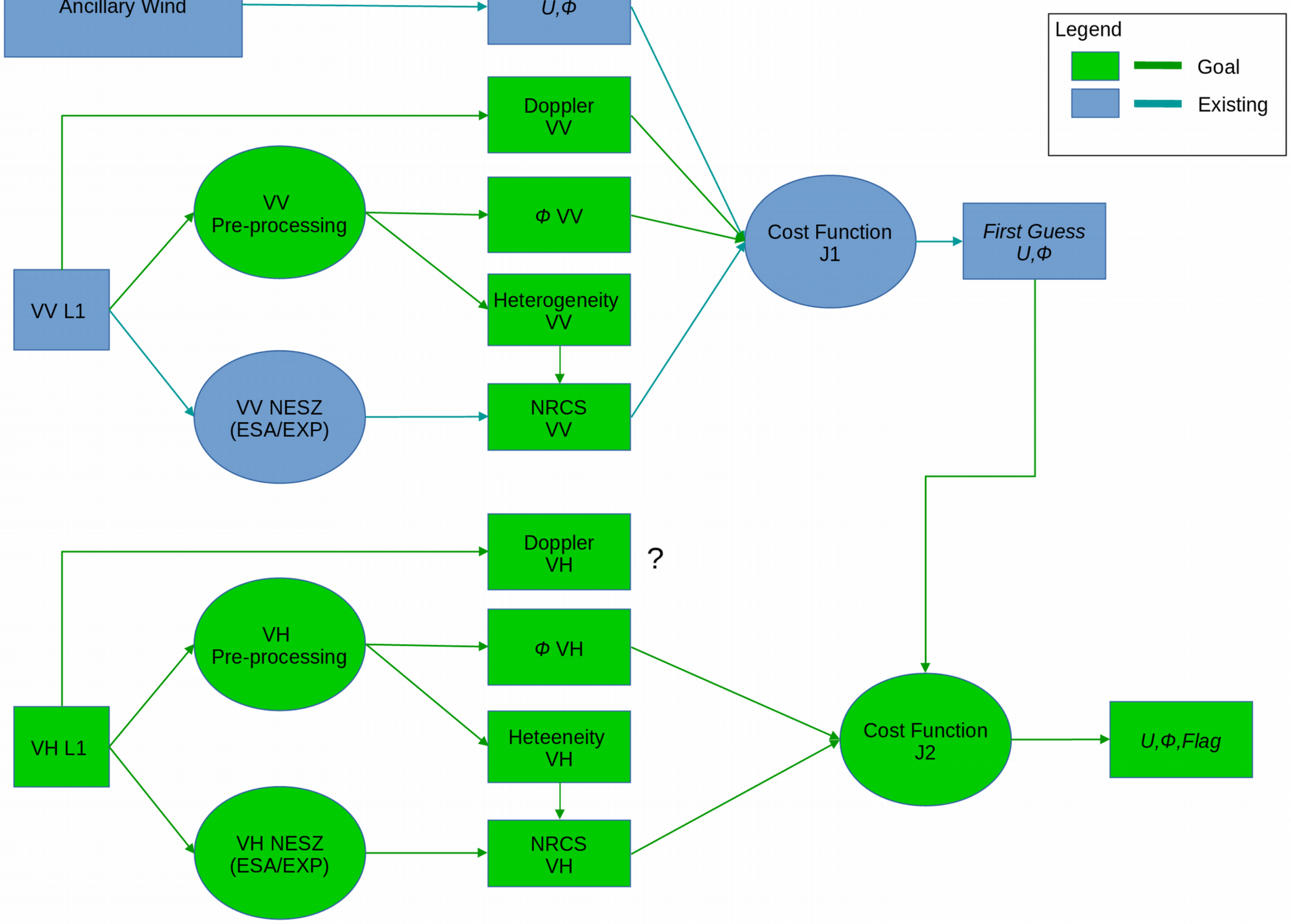


$$J(\mathbf{u}) = \underbrace{\left(\frac{\sigma^0 - \mathrm{CMOD}(\mathbf{u})}{\Delta\sigma^0}\right)^2}_{\text{NRCS term}} + \underbrace{\left(\frac{\mathbf{u} - \mathbf{u}_B}{\Delta\mathbf{u}}\right)^2}_{\text{A priori model term}}$$

The cost function is too simple:

- No use of Doppler, cross-polarized channel
- GMF is very often used out of its validity range

New Wind Algo



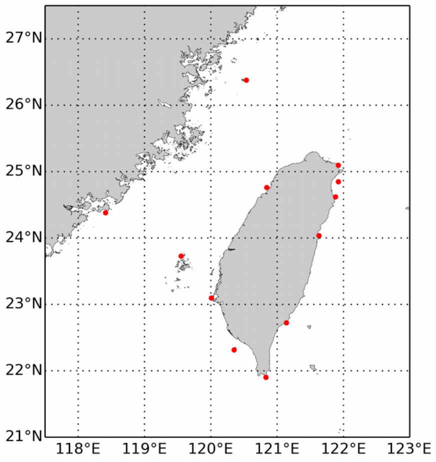
Planning for Year 1

- Area of interest & Data collection
- Set up a first version of the SARWING prototype algorithm for Sentinel-1
- Application of the algorithm to GF-3 (Wang He Presentation, Wednesday)
- Massive Sentinel-1 data processing system
- Wind & Pre-processing parameters assessment

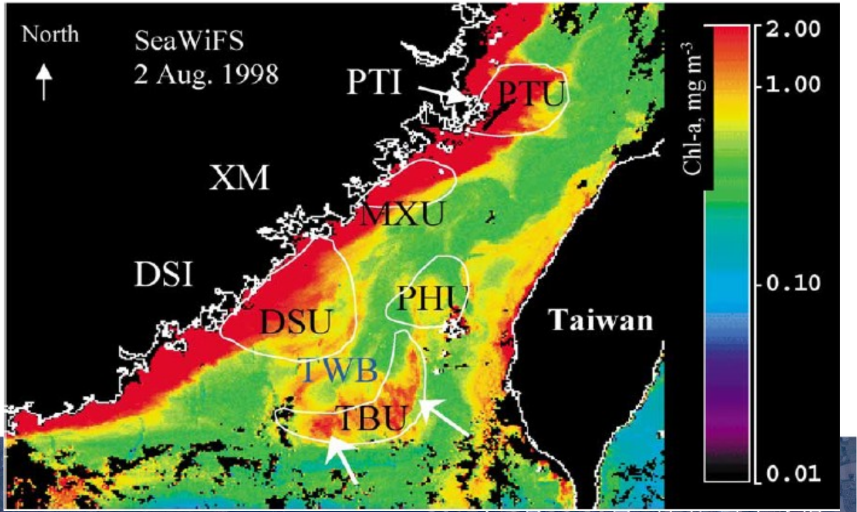
Areas of Interest

- China & Taiwan coasts
  - More than 10 buoys are available
  - They give Hs and wind speed

➡ We use these buoys for wind speed algorithm validation



➡ This is a complex area with upwellings, ocean surface currents, typhoon and heavy rain
Taiwan mountains also strongly affect the locally wind regimes.

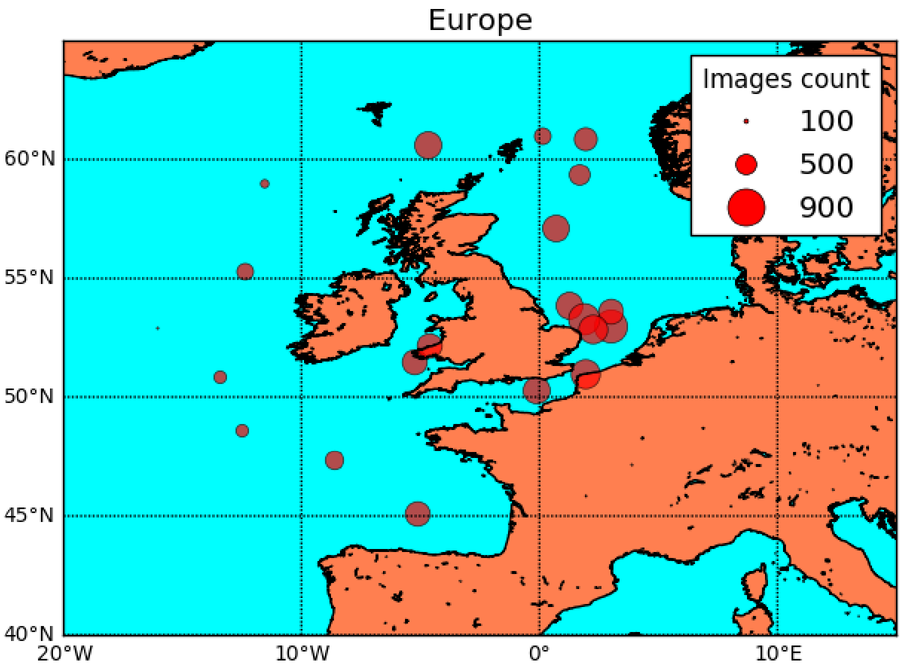


Areas of Interest

- European Seas

  - We have a lot of Sentinel-1 data acquired
  - ESA Level-2 product is available
  - There are several buoys. 19 Have been selected.They measure both
    - Wind speed
    - Wind direction

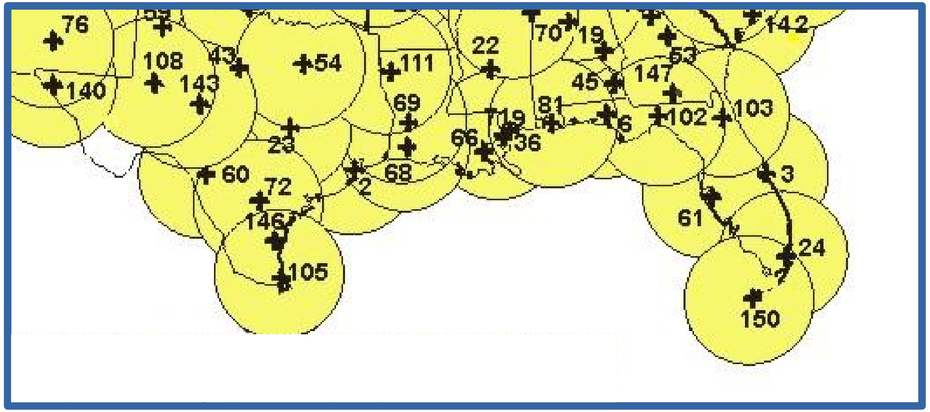
We use this data for wind algorithm validation. There is a specific focus on wind direction in this area.

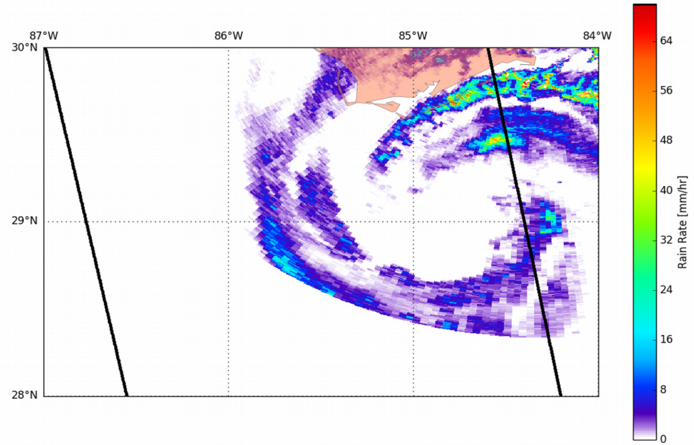


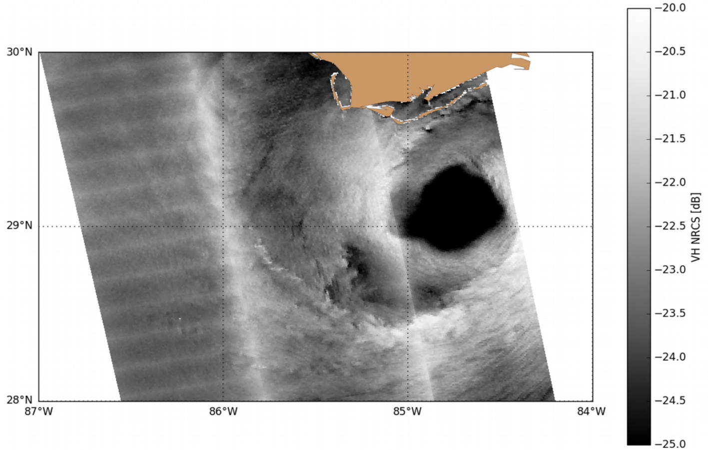
Areas of Interest

- Gulf of Mexico
-
  - Sentinel-1 data are routinely acquired
  - Rain radar data are available

We use this data to investigate rain signature in SAR images







Areas of Interest

Data collection (SAR)

- All data are routinely collected over China/Taiwan area

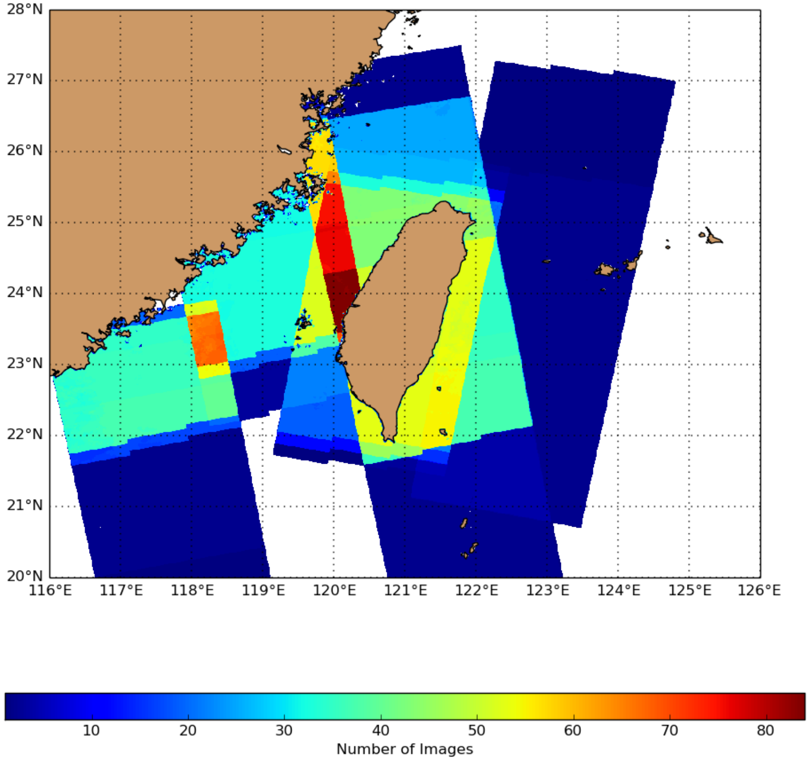
246 products 2015-2017

- All data are routinely collected over European buoys

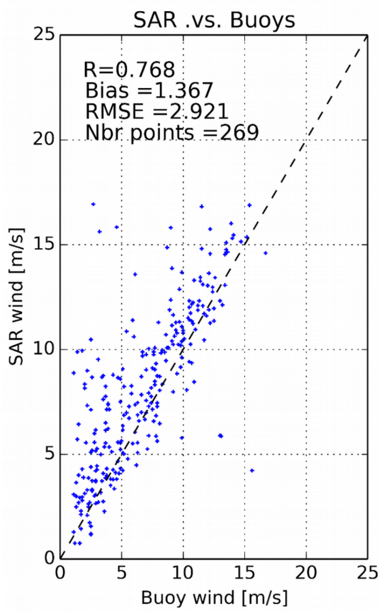
2783 products 2014-2017

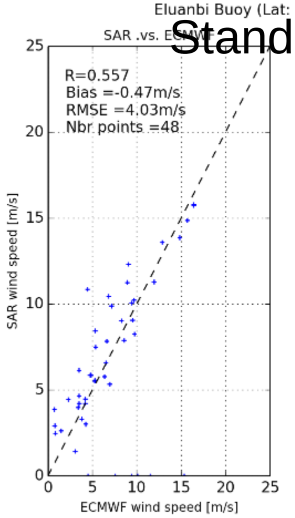
- Few data have been collected over Gulf of Mexico

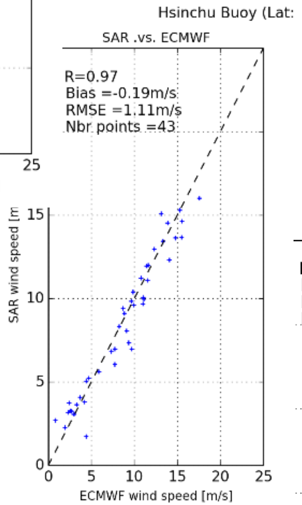
To Be Done

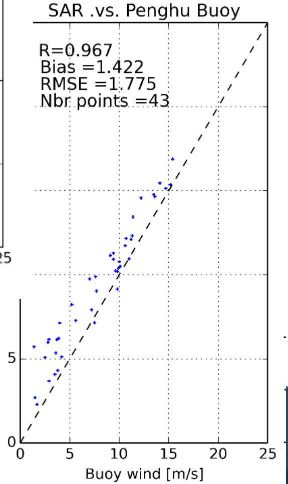


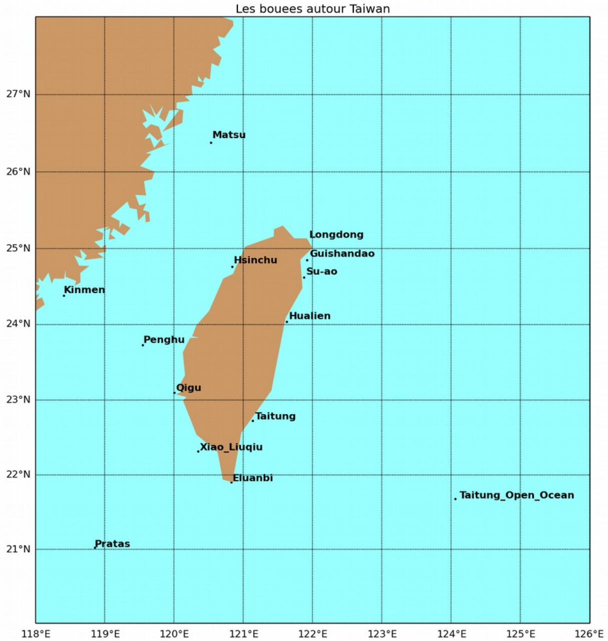
Standard wind speed validation



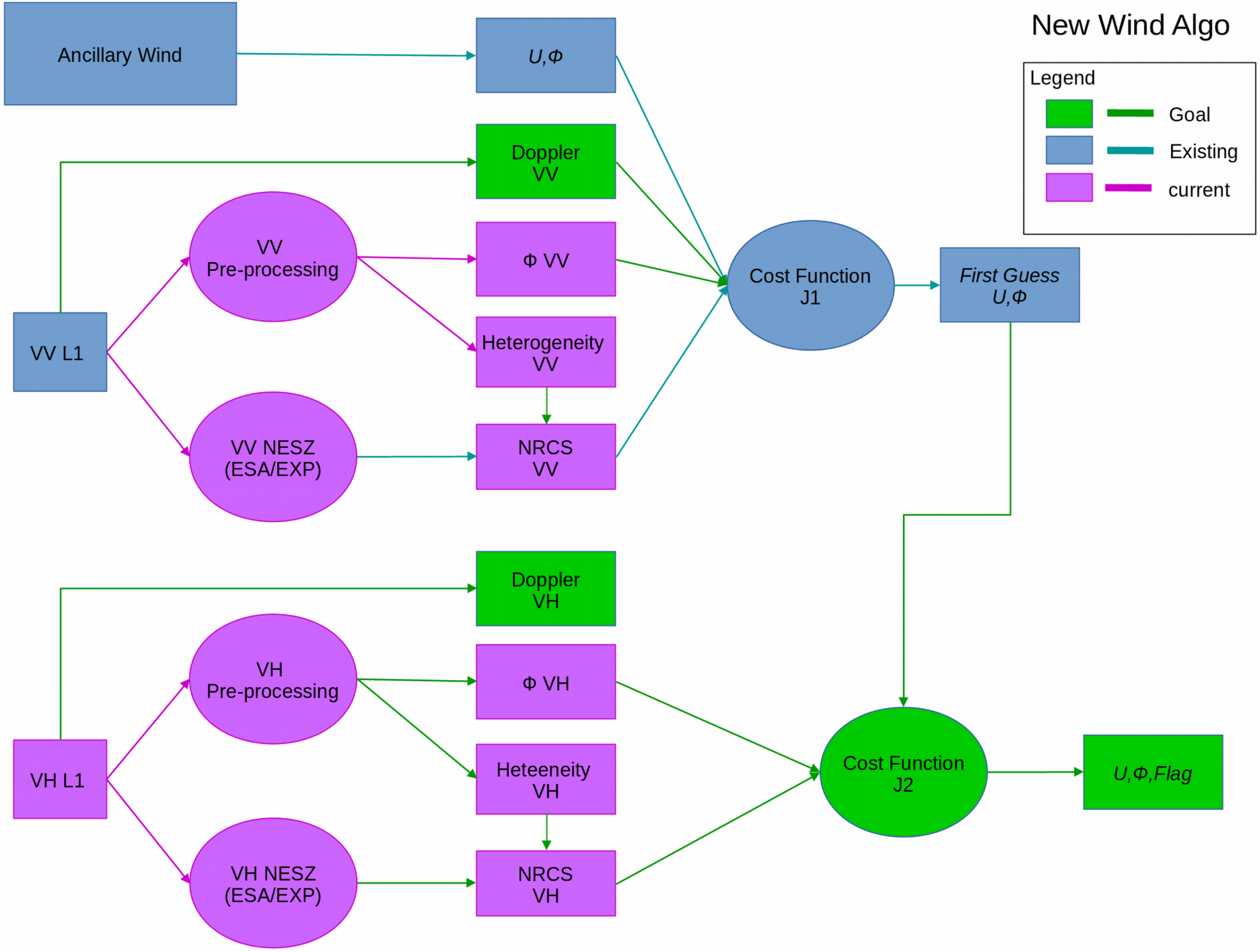








New Wind Algo



Wind Direction & Heterogeneity

Both wind direction and heterogeneity are extracted from the Local Gradient computation

Local Gradient Method

The gradient operator that we chose to compute local gradient is Scharr filter. This operator also named as optimized Sobel filter has the advantage to be have better rotational symmetry.

$$D_x = \frac{1}{32}\begin{pmatrix} 3 & 0 & -3 \\ 10 & 0 & -10 \\ 3 & 0 & -3 \end{pmatrix}$$

and its transpose:

$$D_y = D_x^T$$

We apply this operator to the SAR images by convolving with images' amplitude A, defined as the square root of the Normalized Radar Cross Section (NRCS)[1]:

$$G' = (D_x + iD_y)(A)$$

We square the gradients G' and we reduce and smooth G' with the operator R_2:

$$G'' = R_2(G'^2)$$

Wind Direction & Heterogeneity

Heterogeneity is computed from 4 parameters

- The first parameter detects areas that are not open ocean surfaces, as land or sea ice
- The second parameter detects the interior of narrow image features, as slicks, internal waves, or fronts.
- The third parameter allows to discard high illumination pixels.
- The fourth parameter detects the edges of narrow image features, as slicks, internal waves, or fronts.
- The four parameters are then combined to give 0 or 1 value for each pixel

Wind Direction & Heterogeneity

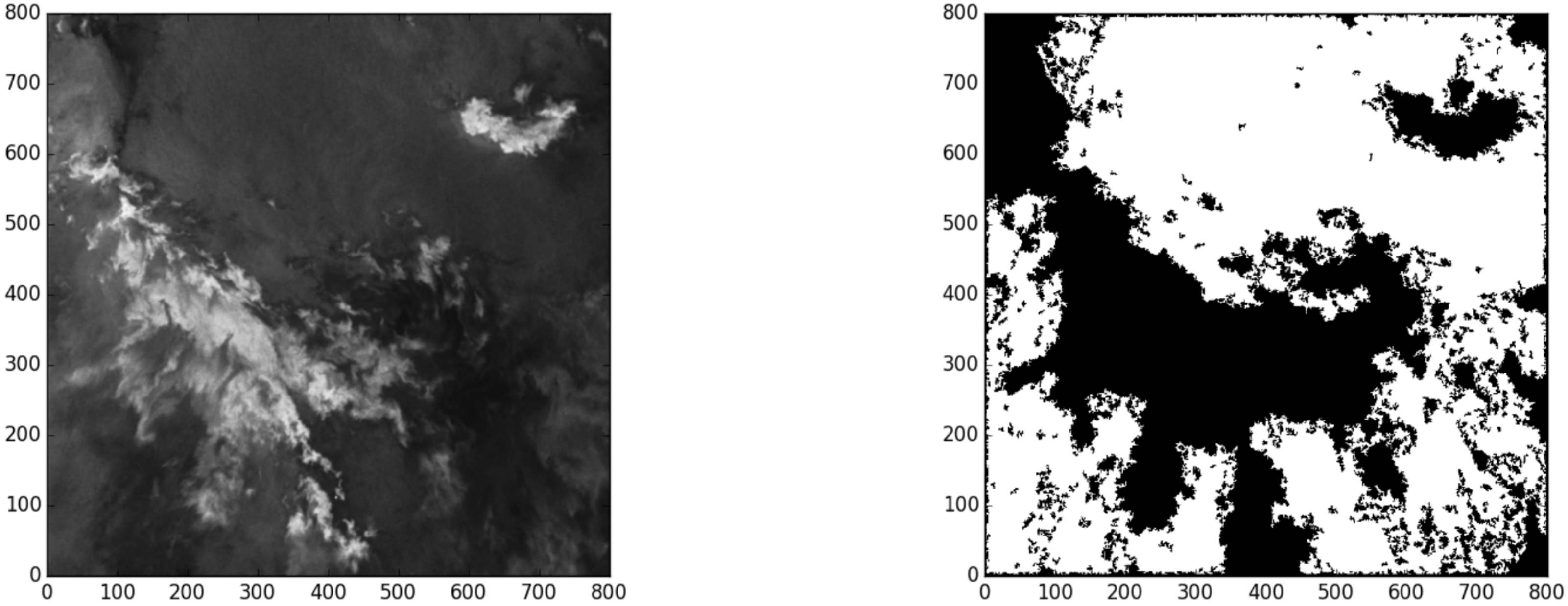
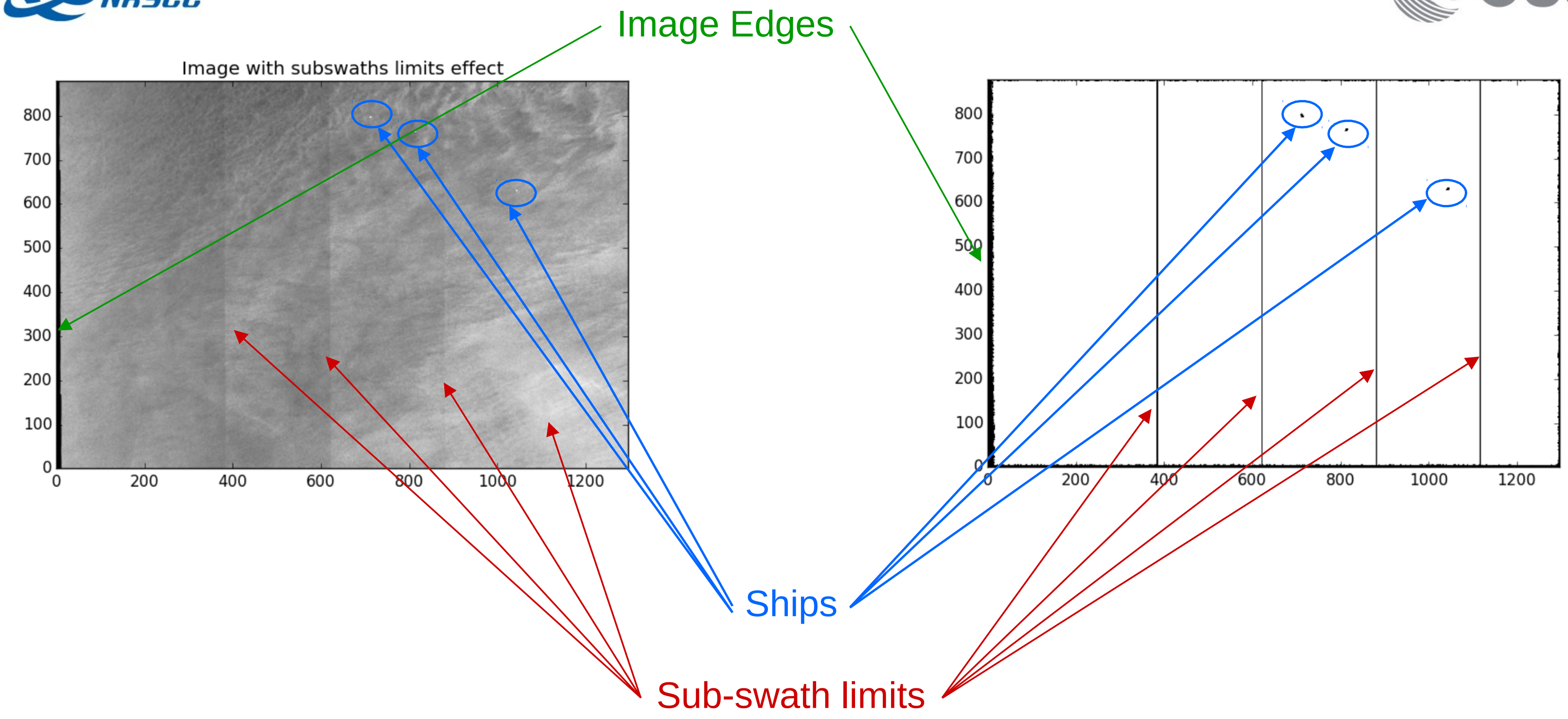


Figure 3.4: Filter effect on a tuile

Wind Direction & Heterogeneity

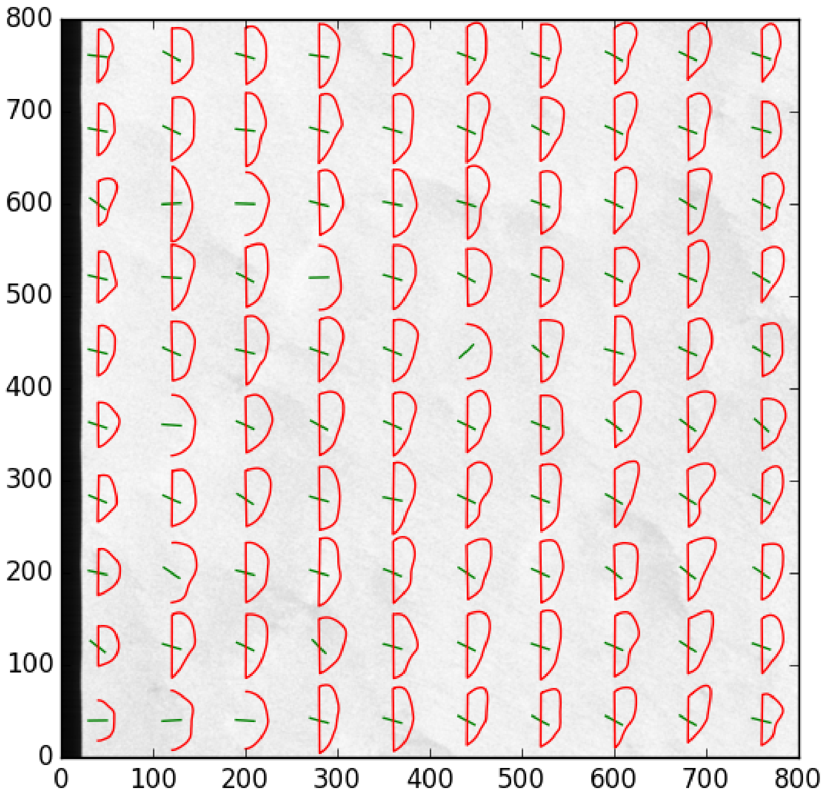


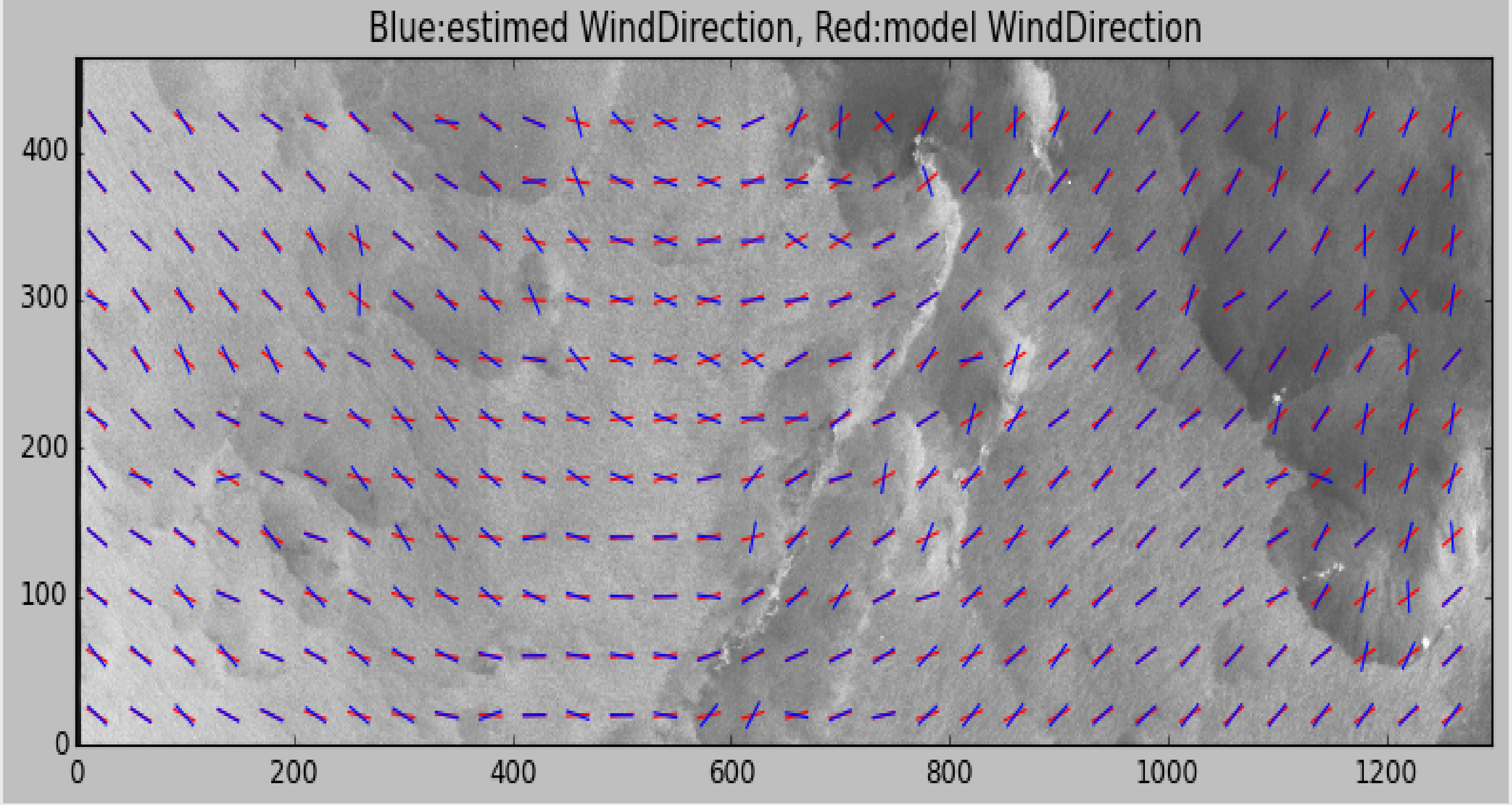
Wind Direction & Heterogeneity

Different gradients are present on the SAR images because of

- noises
- waves
- other no wind features.

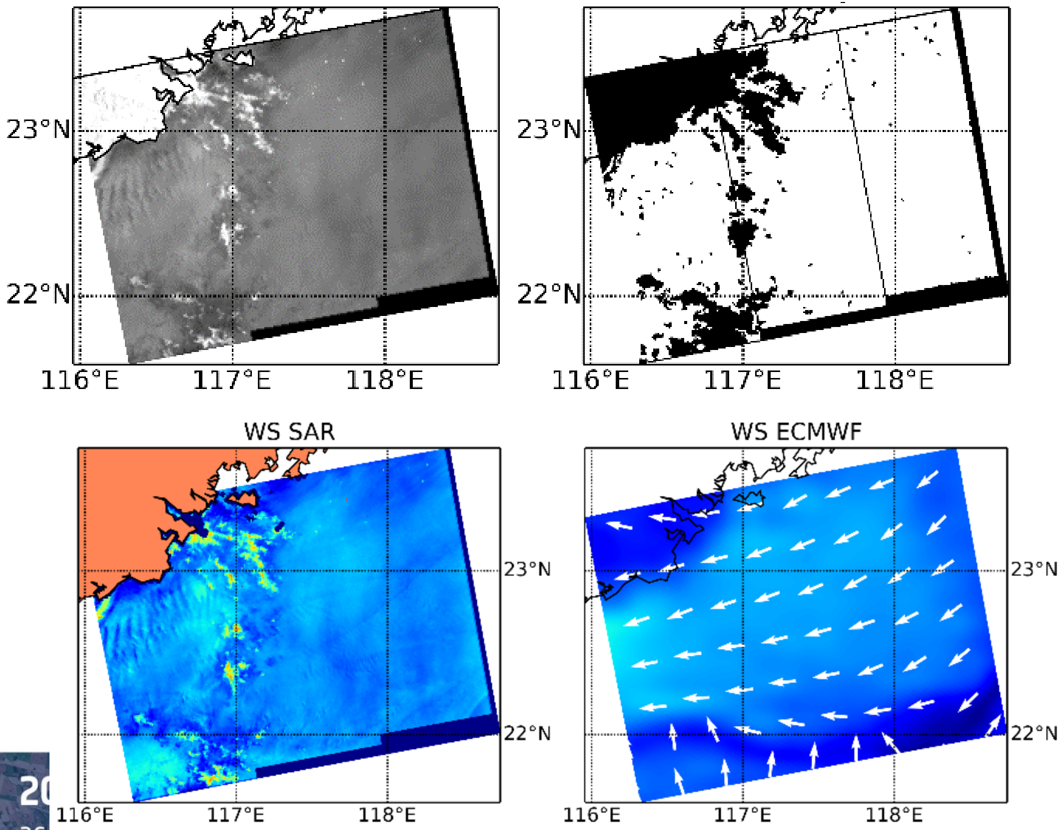
We select the most present direction of gradients.

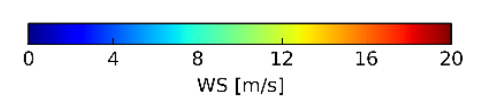


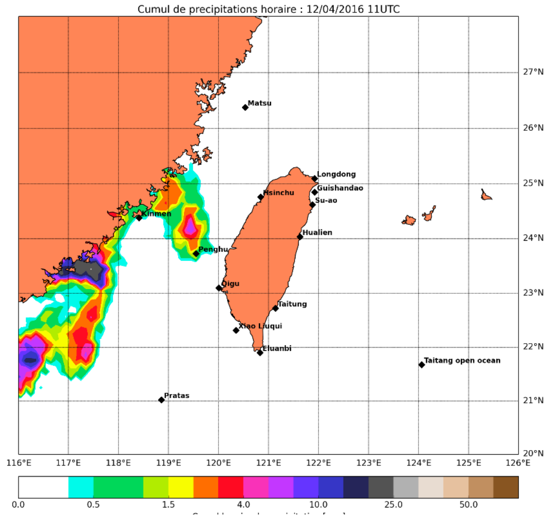


Blue:estimed WindDirection, Red:model WindDirection
0
100
200
300
400
0
200
400
600
800
1000
1200

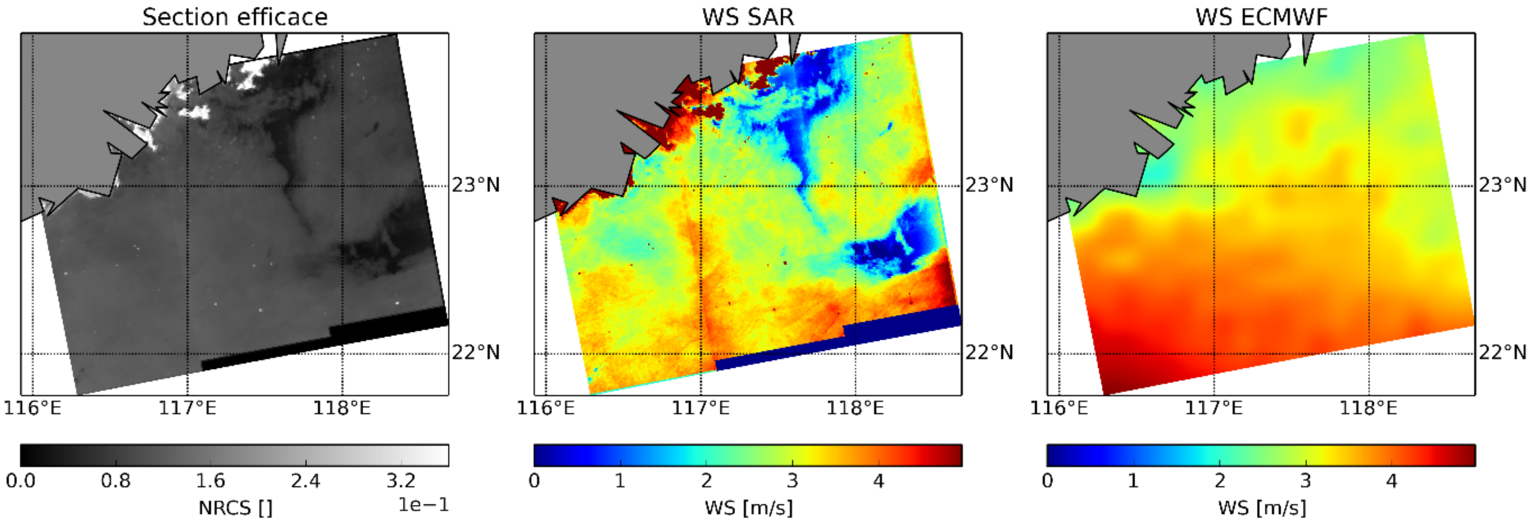
Cases studies
Rain Detection & Impact on wind speed



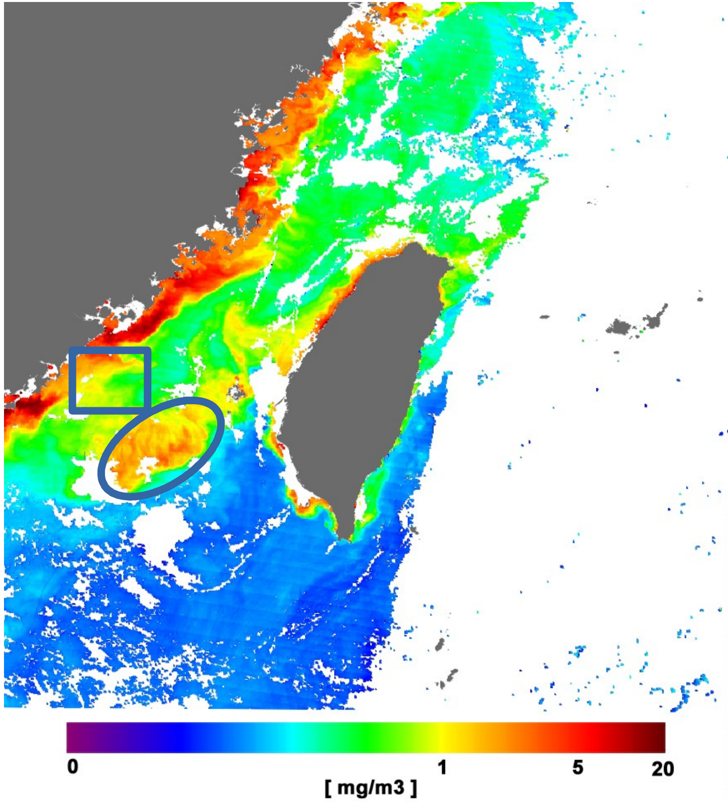


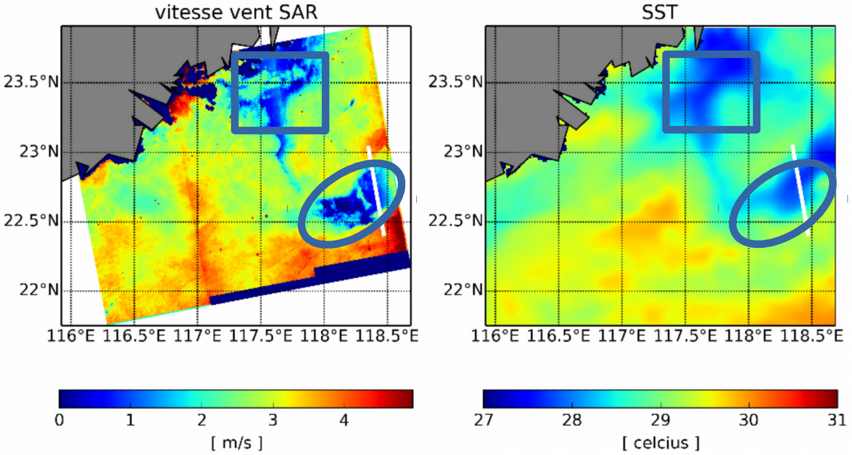


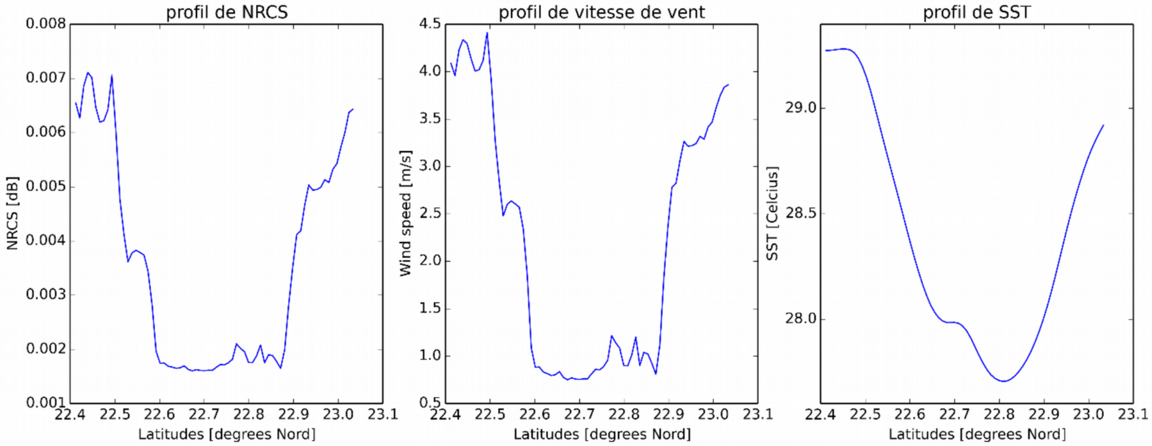
Cases studies
Upwelling



Cases studies
Upwelling







Conclusions

A first version of the wind inversion prototype has been developed

- Heterogeneous areas (where relationship between NRCS and wind are not valid) are detected.
- Automated wind direction is directly retrieved from the SAR images
- Classical wind inversion (same as Sentinel-1 ESA Level-2 processor) has been implemented and can re used for massive data processing

Cases studies with rain and upwelling have been investigated to show

- the expected impact on the NRCS and wind speed if not properly take into account
- how those events could be automatically detected

Perspectives (Year 2)

- Massive wind directions extracted from SAR images are being compared to buoys of the European seas.

- Combination of both co- and cross- polarization is being implemented (see next presentation) and will be validated.

- First wind speed and direction with quality flag should be made available for China/Taiwan sea and compared to buoys.