The 2D-CWT method

A fully 2-D Continuous Wavelet Transform (2D-CWT), a refinement of the quasi-2D method developed in the previous study (Zecchetto et al., 2002), has been used to extract from the SAR images the aliased wind direction. The method is based on:
- the computation of the 2D-CWT spectrum of SAR image (A) to find the spatial scales and the angles where the energy related to the wind speed is located (B, stars);
- the reconstruction a SAR-like image only with selected scales and angles to evidence the shape of the backscatter structures related to the wind (C);
- the analysis of the shape of these structures (elliptic wind cells) to get the direction of their major axis (D).

Global results of wind direction determination

The left panel reports the scatterplot between the SAR mean wind directions obtained from the SAR images shown in the right pane and those from ECMWF along with their standard deviation. For 83% of cases, the difference is <20°, for 92%, <30°. Only for 5% the difference is >50°. It is important to remark that this is only a proof of consistency, not a validation, because often the model wind directions differ from those measured in coastal areas (left panel below) reporting in-situ vs ECMWF wind directions in the Oristano Gulf.

Some consideration on wind direction validation

There are evident differences in the wind field spatial layout and in the wind speed distributions. In general the SAR derived winds are higher than the in-situ reports (not shown here).

Conclusions

In coastal areas the determination of the wind direction is crucial and should be analyzed with more attention. The 2D-CWT method is working well for any kind of SAR (Envisat ASAR, Sentinel-1a,b, Radarsat-2 and CosmoSkyMed), is reliable and provides wind direction fields without external information with similar variability of the in-situ data. This may be taken as a proxy to assess the reliability of the SAR computed wind directions. The problem of the wind direction determination from SAR is thus virtually solved by the 2D-CWT method: the resulting wind fields have been compared with those derived using WRF model and the OWI ESA wind directions. The results indicate discrepancies which should be investigated. In coastal areas exhaustive validation is very difficult due to the lack of suitable wind reports and local area atmospheric models.

References

Zacchettto S., F. De Biasio, A. della Valle, G. Quattrocchi, E. Cadau and A. Cucco, Wind fields from 2D-CWT, atmospheric model (WRF) and ESA-OWI in the Oristano Gulf area and versus scatterometer data in open ocean.