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Sea Surface Wind - The SARWIND LG-Mod algorithm

Why is the Sea Surface Wind (SSW) field important?

Sea Surface Wind (SSW) represents an essential variable which is important in many fields of application, such as oceanography, marine meteorology, marine oil spill monitoring and wind energy resources. Furthermore, SSW field may be crucial in the monitoring of coastal ecosystems as well as in the planning of conservation and restoration actions in marine/coastal protected areas (PAs). Due to the complex land/sea interactions which take place in coastal areas, Numerical Weather Prediction (NWP) models provide reliable wind fields for off-shore areas, but their accuracy is drastically reduced in the proximity of the shorelines. Synthetic Aperture Radar (SAR) systems can be used to give wind information (i.e., speed and direction) at high spatial resolution in coastal areas, when favourable wind regime conditions occur.

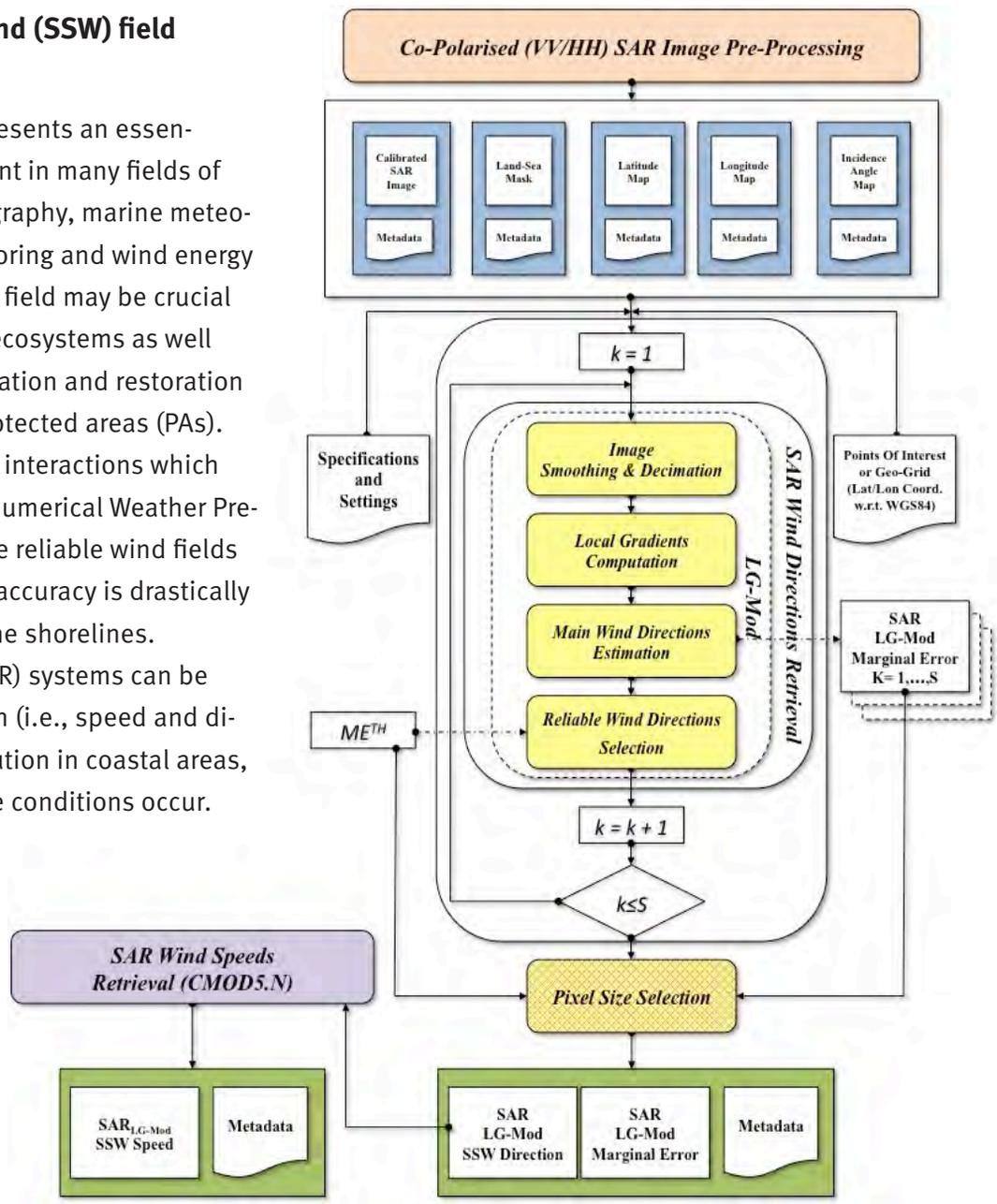

Figure 1.
The SARWIND LG-Mod algorithm (ver. 4.01)

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What is the SARWIND LG-Mod algorithm?

The algorithm ([1]-[3]) implements a high-resolution off-shore and coastal SSW retrieval by exploiting a single co-polarised SAR image. It is uploaded in the ECOPOTENTIAL Virtual Lab.
It provides the estimation of the local SSW and of the related directional marginal error.
It is applicable when visible wind patterns onto SAR amplitudes occur.
It can provide adequate spatial resolutions (up to 4 km) and good quality estimation of the wind for marine and coastal applications.

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The SARWIND LG-Mod algorithm consists in:

- ***Image Smoothing and Decimation***. A series of edge-preserving smoothing and decimation operations aims at both enhancing wind-induced patterns and mitigating the speckle noise of the input calibrated SAR image.
- ***Local Gradients (LGs) Computation.*** LGs are computed on pixel basis applying optimized Sobel operators to the resized image. All the 'unusable' pixels (e.g., land, artefacts, non-wind features) are previously removed.
- ***Main Wind Directions Estimation.*** The LG direction image is divided into sub-images (or ROIs), according to a defined spatial grid. From Directional Statistics, a confidence interval, with a fixed confidence level (1-α), is associated to the direction estimate within each ROI.
- ***Reliable Wind Directions Selection.*** The final step allows automatically discarding directional estimates that are considered not 'reliable' enough. This can be obtained by setting a suitable threshold of reliability applied to all LG-Mod outcomes.
- ***SAR Wind Speeds Retrieval.*** Exploiting the dependency of SAR Normalized Radar Cross Section (NRCS) on the geometry of acquisitions and wind parameters via semi-empirical Geophysical Model Functions (e.g., CMOD5.N), the inferred wind directions are used as inputs to the inversion procedures for wind speed estimation.

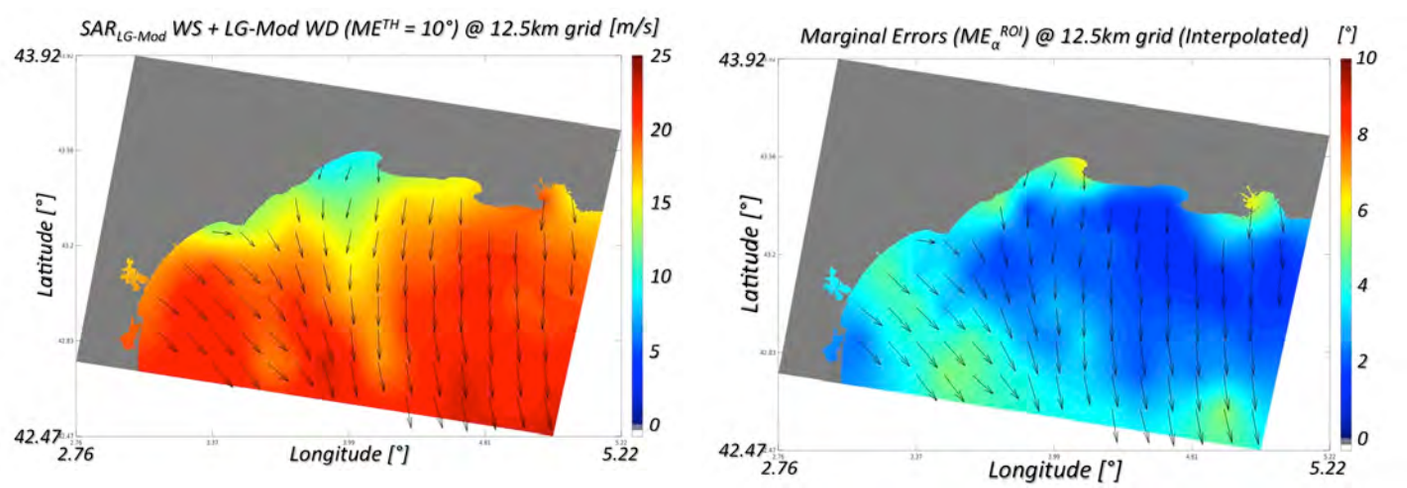

Figure 2. *Examples of LG-Mod outputs: LG-Mod wind direction (WD, black arrows) and the related (left) CMOD5.N-derived wind speed (WS) and (right) Marginal Error (MEαROI) map (background), obtained at 12.5 km-grid, from the Sentinel-1 IW image, 5th Feb 2015. PA: Camargue (France).*

References

[1] Rana, F. M., Adamo, M., Lucas, R., & Blonda, P. (2019). Sea surface wind retrieval in coastal areas by means of Sentinel-1 and numerical weather prediction model data. Remote Sensing of Environment, 225, 379-391. DOI:10.1016/j.rse.2019.03.019.

[2] Rana, F. M., Adamo, M., & Blonda, P. (2018, July). LG-Mod Multi-Scale Approach for SAR Sea Surface Wind Directions Retrieval. In IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium (pp. 3216-3219). IEEE.

[3] Rana, F. M., Adamo, M., Pasquariello, G., De Carolis, G., & Morelli, S. (2016). LG-Mod: A modified local gradient (LG) method to retrieve SAR sea surface wind directions in marine coastal areas. Journal of Sensors, 2016. DOI:10.1155/2016/9565208.