FUSION OF QUIKSCAT SCATTEROMETER AND RADARSAT-1 SAR DATA FOR WIND SPEED DISTRIBUTION ESTIMATION USING A BAYESIAN APPROACH.

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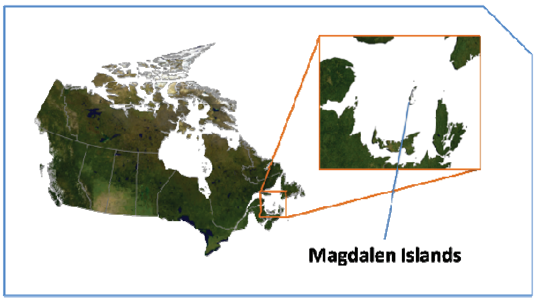
INTRODUCTION

Wind resource assessment is a key factor to any successful wind energy project. Traditionally, numerical mesoscale and/or microscale models are the preferred tools in producing wind atlas. However, numerical models in offshore complex environments must be validated or improved. And in some conditions, such as in turbulent coastal areas or regions where meteorological observations are sparse, numerical models may not be fully reliable. A second type of dataset is available to assess the sea surface winds in coastal regions: remote sensing data. Scatterometer data are now assimilated in most national weather forecast center and studies have demonstrated the technology's potential in a wind atlas perspective [1, 2]. Scatterometer sensors have a great potential because large database of daily observations are readily available. Yet their coarse resolution and large land mask prevent them from becoming a standard tool of wind resource assessment in coastal environment. To overcome this problem, another type of remote sensing sensor has been studied to gain in resolution and allows wind retrieval in coastal environment: Synthetic Aperture Radar (SAR). This second source of data allows wind speed retrieval at sub-kilometre resolution (~400m) [3, 4]which is a great benefit. However, the low revisit frequency of the sensors, the data cost and the fact that these captors' data acquisition is non continuous make it almost impossible to obtain a database large enough to estimate the wind resource of a region [1, 5, 6].



The present paper focuses on the fusion of a RADARSAT-1 SAR and QuikSCAT scatterometer dataset using a bayesian approach. The approach proposed aims at taking advantage of both the large scatterometer database and SAR fine resolution.

WIND RESOURCE ASSESSMENT

In order to assess the wind resource for a given site, we need to estimate wind speed distribution parameters. Generally in wind engineering, it is assumed that wind speed distribution follows a Weibull distribution which has two parameters: scale parameter A and shape parameter, K. The Weibull distributionfits generally well the data and has an explicit distribution function. To estimate the parameters A and K, the maximum likelihood estimator (ML) is considered most efficient [6]. The ML technique is applied on a representative speed wind sample, in our case, instant wind speed extracted from satellite data (QuikSCAT or RADARSAT-1 SAR)

METHODS

Wind resource of the region under study (Magdalen Islands, Eastern Canada) is first assessed offshore with only QuikSCAT data. A Bayesian approach is then applied on high resolution wind speed maps derived from a dataset of 81 RADARSAT-1 SAR scenes, using the Weibull distribution parameters estimated from QuikSCAT data as prior information. The results obtained offshore are then extrapolated to the coastal region using a co-kriging technique.

Offshore

The offshore region is considered to be the region where QuikSCAT data are available, i.e. ~25km off the coast. First, in order to obtain the scale and shape parameters' distribution at mesoscale resolution (~50km), a bootstrap of 100 iterations of ML estimates from 250 independent QuikSCAT data is realised for each pixel where a minimum of 1000 data is available. It is assumed that the parameters estimates follow a gamma distribution; the estimates are thus fitted to a gamma distribution using ML estimators. Then, using QuikSCAT gamma distribution of the shape and scale parameters as prior information on the microscale wind speed distribution, a Metropolis-Hastings algorithm is used to draw samples from the scale parameter posterior distribution at microscale resolution. Once it has converged, the stationary and ergodic chain resulting has the property of having the same distribution as the posterior distribution of the parameter to be estimated, i.e. the scale parameter A at microscale resolution. Because the shape parameters is more complex to estimate but less variable than the scale parameters, only the scale parameter A is estimated through MCMC algorithm.

Coastal region

The results obtained offshore are then extrapolated to the coastal region (region where only SAR data is available) using a co-kriging technique. The RSO wind speed median and Interquartile range are used as co-variable to extrapolate both the mesoscale shape and microscale scale parameter.

PRELIMINARY RESULTS

- The values obtained offshore at mesoscale resolution from QuikSCAT dataset present features similar to the Canadian Wind Atlas (http://www.windatlas.ca/en/index.php).
- The Bayesian approach presents general features similar to the bootstrap method (see Figure 2), but finer structures can also be observed.
- Most of the abrupt variations present when using only SAR data to estimate the scale parameter is smoothed by the Bayesian approach.
- The standard deviation of the Bayesian approach is comparable to the standard of the bootstrap estimates, even slightly inferior.

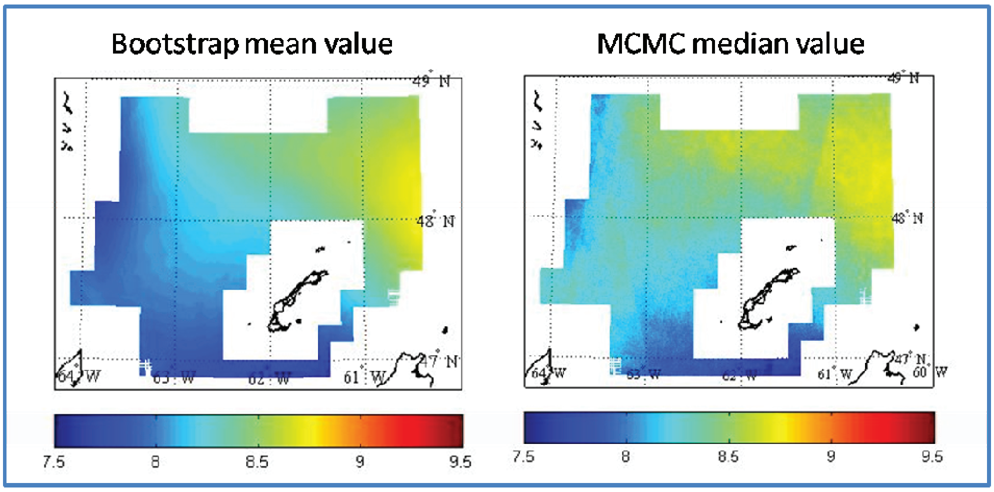


Figure 2 Weibull Scale Parameter estimate offshore.

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