ARCWIND PROJECT

Regional Surface Wind Analyses Estimated from Remotely Sensed Observations

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Summary

This report provides an overview of surface wind analyses estimated mainly from satellite observations, over ARCWIND Oceanic area (Figure 1). The analyses are available for a long period (1992 – 2018) at synoptic times (00h:00, 06h:00, 12h:00, and 18h:00 UTC) as 6-hourly averaged winds with over a grid map of 0.25° in latitude and longitude.

In this project, the main wind sources are derived from scatterometer wind observations. Several papers provide details about scatterometer physics, retrieval methods and processing, calibration and validation, and objective method. The readers may find some relevant references in (Bentamy et al, 2017, and Desbiolles *et al*, 2017). For more than twenty years, scatterometers on polar-orbiting satellites provide valuable information on both wind speed and direction, with good spatial sampling over the global oceans (Bentamy *et al*, 2017). The latest scatterometers such as SeaWinds onboard the QuikSCAT satellite, ASCAT-A/B onboard METOP-A/B, and

RapidScat onboard the International Space Station (ISS) provide surface winds with high spatial resolution of 12.5km.

One the main objective of ARCWIND project dealing with the characterization of wind resources, is the determination of regular in space and time wind fields, estimated from scatterometer in combination with ancillary remotely sensed data such as radiometer winds at regional scale. Two SSM/I and SSMIS radiometers are used as ancillary data for the calculation of satellite wind fields (also named wind analyses).

The calculation of satellite wind analyses, based on the objective method described in (Bentamy et al, 2012), requires the use of Numerical Weather Prediction (NWP) surface winds. To achieve the calculation of a long times series of satellite and analyses over ARCWIND oceanic area, the European Centre for Medium-range Weather Forecasts (ECMWF) re-analysis ERA Interim is used. The resulting surface wind analyses are estimated at synoptic times (00h:00, 06h:00, 12h:00, 18h:00 UTC), with a grid point of 0.25° in longitude and latitude. Figure 1 shows an example of four consecutive wind analyses.

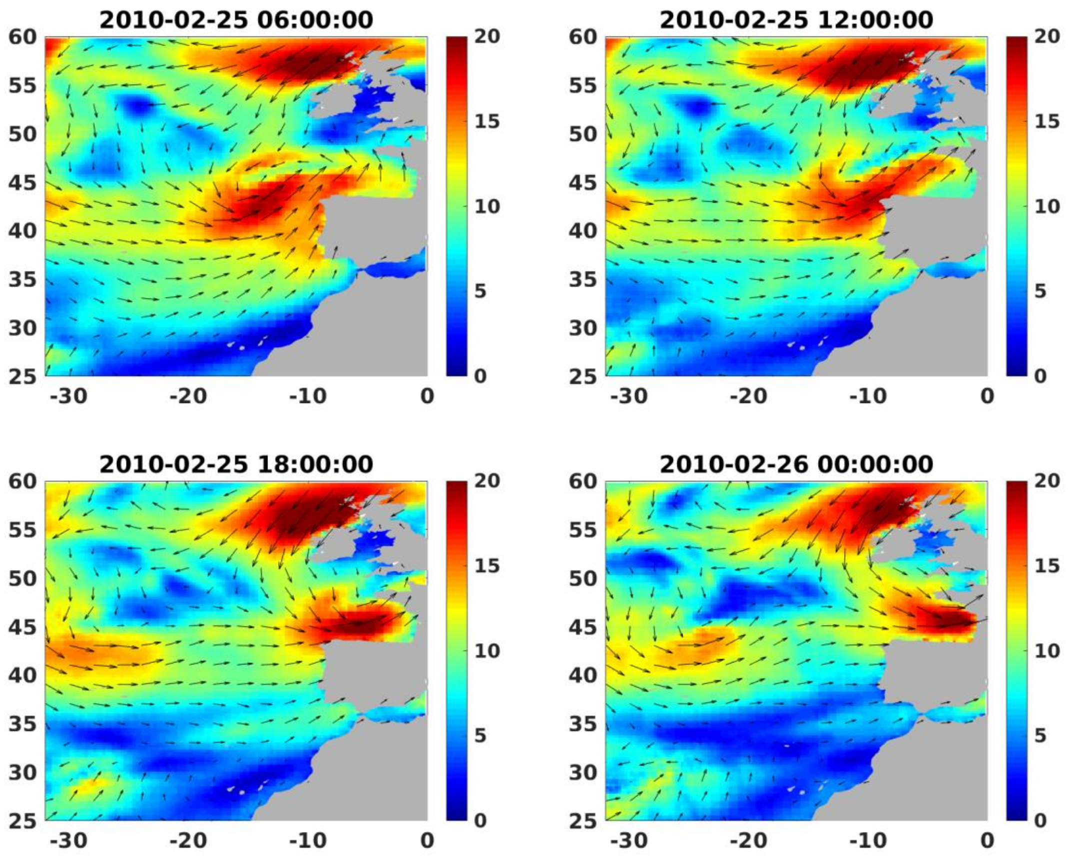

Figure 1: 6-hourly wind analyses estimated from satellite and ERA Interim data along the period 25 February 2010 06h:00UTV through 26 February 2010 00h:00 UTC. Color indicates wind speed in m/s, and black arrows indicate wind direction.

1 Satellite Wind Analysis Determination and Accuracy

The regular (in space and time) wind fields are estimated from reprocessed (and available) and near real time scatterometer and radiometer data in combination with ERA Interim wind re-analyses. They are calculated based on the use of various remotely sensed wind observations. The wind retrievals (equivalent neutral wind velocities at 10 m) from scatterometer missions since 1992 have been used to build up a 27 years atmospheric climate series. Optimal temporal interpolation and kriging methods have been applied to provide continuously surface wind speed and direction estimates over the global ocean on a regular grid in space and time. The associated parameters such as wind stress amplitude and components, wind vector and stress divergence, and wind vector and stress curls are also provided. The use of ancillary data sources such as radiometer data (SSM/I, SSMIS, WindSat) and atmospheric wind reanalyzes (ERA-Interim) has allowed building a blended product available at 1/4° spatial resolution and every 6 hours from 1992 to 2016. The remotely sensed data are provided by IFREMER (ERS-1 and ERS-2), NASA/JPL (QuikSCAT and RapidScat), EUMETSAT OSI (ASCAT-A and ASCAT-B), CNSA (HY-2A), ISRO (OceanSat-2), from Remote Sensing System (SSM/I SSMIS, and WindSat). The NWP re-analysis, ERA Interim is from ECMWF.

The analysis is performed for each synoptic time (00h:00; 06h:00; 12h:00; 18h:00 UTC) and with a spatial resolution of 0.25° in longitude and latitude over global ocean. The method details may be found in (Bentamy and Croizé-Fillon, 2012)[1]. Details related to data, method, and accuracy issues would be found in the following referenced publications (Desbiolles *et al*, 2017), (Bentamy *et al*, 2012, 2013, and 2017)

The accuracy of blended wind fields is mainly determined through comprehensive with buoy data available over ARCWIND area. Buoy data are extracted from the European Marine Observation and Data Network (EMODnet) (http://www.emodnet.eu/). Figure 2 shows wind mooring locations. The wind buoy data include wind speed at the anemometer height, wind direction (or the corresponding zonal and meridional wind components), sea surface and air temperatures, and relative humidity (or dew point). As satellite wind observations and analyses correspond to wind at 10-m above the ocean surface, the buoy winds are converted to 10-m equivalent neutral wind '(ENW) using coare3.0 parameterization (Fairall *et al*, 2003).

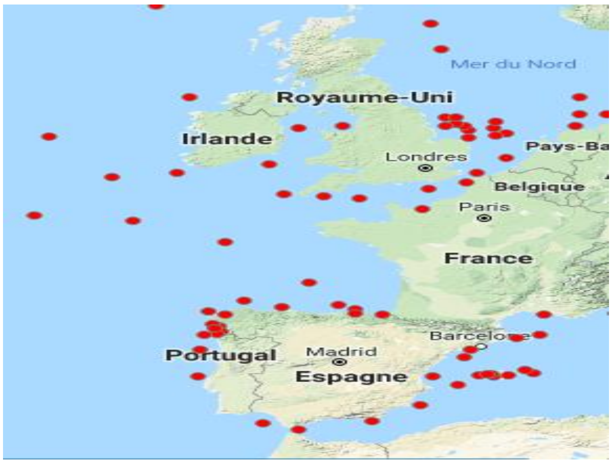

Figure 2: Wind buoys (from EMODNET) locations

For comparison to satellite wind analyses, all valid buoy data available within 3 hours from the epoch analysis times (00h:00, 06h:00, 12h:00, 18h:00 UTC) are arithmetically averaged. The results are referred to as 6-hourly buoy wind estimates. For comparison purpose, buoys and blended 6-hourly data are collocated in space (<25km) and time. Figure 3 illustrates example of 6-hourly wind speed comparisons. It shows results associated with blended winds and with ERA Interim re-analyses. The accuracy of the blended wind analyses is characterized by the first statistical moments of their differences with collocated buoy data (Table 1). The results shown in Table 1 rely on collocated data occurring in offshore and nearshore areas. They also estimated for all wind conditions, including low (<3m/s) and high (>15m/s) wind conditions.

Table 1: Statistical comparison results of collocated 6-hourly buoy and satellite, and buoy and ERA Int, 10m wind speed and direction. They are estimated for the period (March 1992 – December 2018). Bias is defined as the mean difference between buoy and blended winds (in this order). STD, bs, ρ, and ρ^2 indicate the standard deviation, regression symmetrical coefficient, scalar correlation coefficient, and vector correlation coefficient, respectively. The latter varies between -2 and +2.

		Wind Speed				Wind Direction		
	Length	Bias (m/s)	STD (m/s)	bs	ρ	Bias (deg)	STD (deg)	ρ^2
Satellite	126035	-0.21	1.33	0.96	0.93	-3	22	1.62
ERA Int	126035	0.42	1.67	0.94	0.90	-5	23	1.59

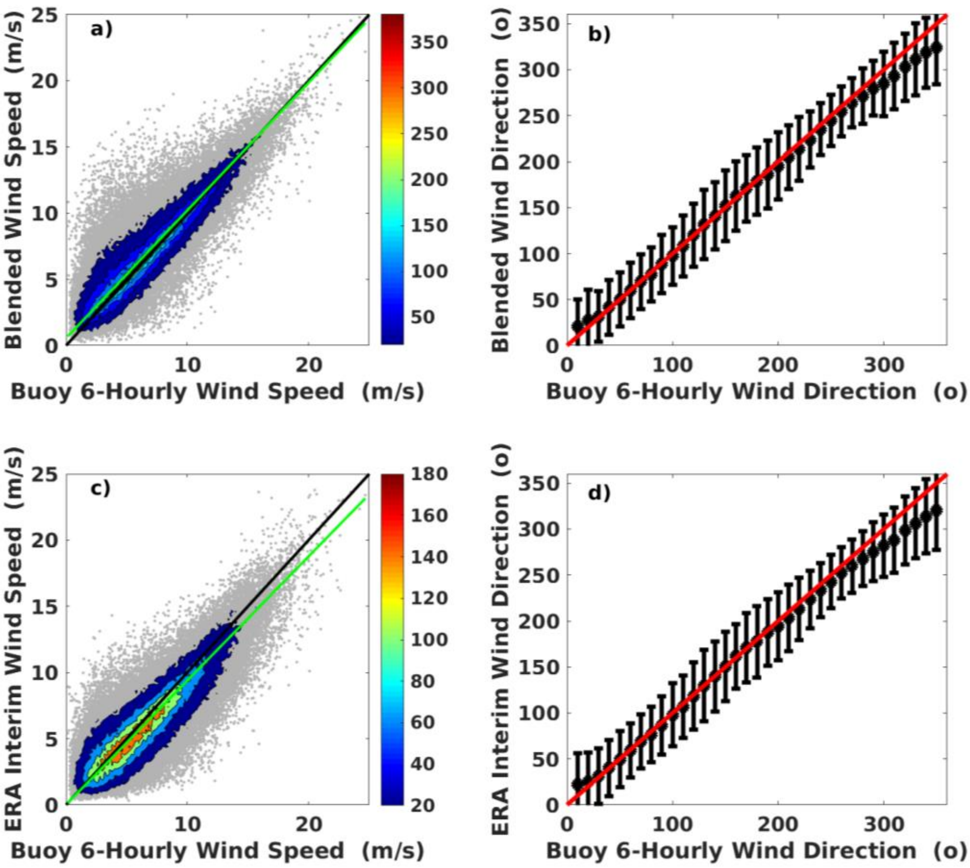

Figure 3: Comparisons of 6-hourly 10m wind speed (a) and c)) and direction (b) and d)) from buoys and satellite analyses (left panel) and ERA Interim (right panel), determined from collocated data occurring during the whole study period 1992 – 2018. Black and green lines indicate perfect (1st bissectrice) and linear regression lines, respectively.

1. Data and File description

Time series of satellite wind analyses, estimated from 1 January 1992 through 31 December 2018, account for 39444 files. Each file is associated to 6-hourly analysis over ARCWIND area. Their format is NetDCF 4.0.

The file name formats are :

ARCWIND_SatelliteWind_Analyses_25km6h_YYYYMMDDHH.nc

Where YYYY, MM, DD, and HH are year, month, day, and hour of analysis.

Example of wind file

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  netcdf ARCWIND_SatelliteWind_Analyses_25km6h_1992010106 {
dimensions:
  dimtime = 1 ;
  dimdepth = 1 ;
  dimlatitude = 140 ;
  dimlongitude = 128 ;
variables:
  float time(dimtime) ;
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          time:Units = "hours since 1900-01-01 00:00:0" ;
          time:valid_min = 806454.f ;
          time:valid_max = 806454.f ;
          time:axis = "T" ;
  float depth(dimdepth) ;
          depth:long_name = "depth" ;
          depth:Units = "m" ;
          depth:valid_min = 10. ;
          depth:valid_max = 10. ;
          depth:axis = "up" ;
  float latitude(dimlatitude) ;
          latitude:long_name = "latitude" ;
          latitude:Units = "degrees_north" ;
          latitude:valid_min = 25.f ;
          latitude:valid_max = 60.f ;
          latitude:axis = "Y" ;
  float longitude(dimlongitude) ;
          longitude:long_name = "longitude" ;
          longitude:Units = "degrees_east" ;
          longitude:valid_min = -32.f ;
```

```
		longitude:valid_max = 0.f ;
		longitude:axis = "X" ;
	short wind_speed(dimtime, dimdepth, dimlongitude, dimlatitude) ;
		wind_speed:long_name = "wind speed" ;
		wind_speed:Units = "m/s" ;
		wind_speed:scale_factor = 0.01 ;
		wind_speed:add_offset = 0. ;
		wind_speed:valid_min = 0s ;
		wind_speed:valid_max = 6000s ;
		wind_speed:_FillValue = -32768s ;
	short eastward_wind(dimtime, dimdepth, dimlongitude, dimlatitude) ;
		eastward_wind:long_name = "eastward wind speed" ;
		eastward_wind:Units = "m/s" ;
		eastward_wind:scale_factor = 0.01 ;
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		eastward_wind:valid_max = 6000s ;
		eastward_wind:_FillValue = -32768s ;
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		wind_vector_curl:valid_min = -32768s ;
		wind_vector_curl:valid_max = 32767s ;
		wind_vector_curl:_FillValue = -32768s ;
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```

```
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		eastward_wind_rms:add_offset = 0. ;
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		eastward_wind_rms:valid_max = 100b ;
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		northward_wind_rms:Units = "m/s" ;
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		northward_wind_rms:add_offset = 0. ;
		northward_wind_rms:valid_min = 0b ;
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		:references = "e.g. See User Guide and (Bentamy et al, 2009, 2010, 2011, 
2015)" ;
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		:bulletin_date = "19920101T060000" ;
		:contact = "abderrahim.bentamy@ifremer.fr" ;
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		:stop_time = "06:00:00" ;
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		:westernmost_longitude = -32.f ;
		:grid_resolution = "0.250 degree" ;
		:file_quality_index = 0s ;
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References

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