Satellite data used in the New European Wind Atlas

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Publication date: 2016

Document Version
Peer reviewed version

Citation (APA):
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VindkraftNet 29 November 2016, E.On Malmö, Sweden

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Content

✓ New European Wind Atlas (NEWA)

✓ Satellite data
  • Objectives
  • Synthetic Aperture Radar
  • Scatterometer
  • Passive microwave

✓ First results

✓ Conclusion
Purpose and structure of NEWA

- Accurate mapping of wind conditions for the estimations of resources and loads
- Development and testing of the model chain
- A series of atmospheric field experiment to validate the model and atlas.

NEWA budget

- Experiments: 50%
- Model chain: 30%
- EU Atlas: 20%

9 national funding agencies from 8 countries
30 partners

http://www.neweuropeanwindatlas.eu/

Jakob Mann, DTU, coordinator

Years 2015 to 2020 ERA NET+
Experiments in the New European Wind Atlas

- EU countries
- NEWA partners
- Offshore coverage
- Experimental sites
New European Wind Atlas
Satellite data
Satellite data:
Objectives for NEWA offshore wind atlas

- ENVISAT ASAR data archive to cover all of Europe
- Sentinel-1 data to cover all of Europe
- Validate Sentinel-1 wind fields
- Merge ENVISAT ASAR and Sentinel-1 to a complete SAR wind atlas

- Possibly integrate with NEWA’s modeling chain:
  - higher-resolution model wind directions as input
  - lifting of satellite winds beyond 10 m

- Use ASCAT wind statistics for comparison to models
- Use SSM/I wind statistics for comparison to models

- Compare satellite data to ship lidar data

- Sea surface temperature input to models
SAR wind data archive at DTU

- 30,000+ ENVISAT ASAR scenes (2002-2011)
- 36,000+ Sentinel-1 A/B SAR scenes (2014->)
SAR Ocean Products System (SAROPS)

- Evolved from the APL/NOAA SAR Wind Retrieval System
  http://fermi.jhuapl.edu/

- SAR wind retrieval in near-real-time

- DTU covers the European seas (routine)

- Merete Badger operates SAROPS at DTU
Mountain gravity waves

November 6, 2006

*Envisat ASAR 10-m wind speed*

*Cloud image*
Open cells

*Envisat ASAR 10-m wind speed*

*Cloud image*
Wind resource mapping

- Sector: All
  - $U_{c} = 7.77$ m/s
  - $P_e = 523$ W/m²
  - Emergent
  - Combined

Energy density (W/m²)
Chain of processes

Download and pre-processing → SAR → GFS → Ice → SAROPS → Wind maps → S-WAsP → Wind resource maps (10 m) → WRF + MOST → Wind resource maps (100 m)

Wind retrieval (APL/NOAA) → Wind resource assessment (DTU) → Wind resource extrapolation (DTU)
The New European Wind Atlas (NEWA)

- Envisat ASAR and Sentinel-1 A/B
- Extrapolation to different heights up to 100 m
- Extensive measurement campaigns and modeling

Coverage of the satellite based atlas in NEWA

(image courtesy Google Earth)
Preliminary 10-m atlas for Europe

Envisat ASAR and Sentinel-1A/B combined
SAR for coastal applications (RUNE)

DD) Scanning lidars for dual Doppler scan
S) Scanning lidar for PPI scans
P) Profiling lidar,
H) Høvsøre met mast

Dotted line) Transect for lidar and SAR measurements
Scatterometer: ASCAT
ASCAT data analysis
ASCAT Winds

- ASCAT 12.5 coastal product (swath)
- 2015 data
- Wind speed and direction statistics
ASCAT

Mean wind speed at 10m

Domains: Perdigão

NorthWest

Data availability
ASCAT
Mean wind speed at 10m

Data availability
Passive microwave: SSM/I
SSM/I data analysis
SSM/I and WRF key information

Wind speed analysis based on SSM/I version 7 data from satellites F8, F10, F11, F13, F14, F15, F16, and F17.

The SSM/I point data are each an average of the values of the four surrounding 0.25*0.25 degree pixels.

WRF from DTU Wind Energy calculations with 10 km grid spacing and output at 1 hour time resolution. WRF data are those from the nearest WRF grid point. This WRF run is not part of NEWA but a preliminary run done for another purpose: WRF: Andrea Hahmann and Patrick Volker.

All for the time interval 1st January 1988 to 31st December 2015. This means 28 full years.

All data are for 10 m above ground.

Poul Astrup has compared SSM/I and WRF.
Accuracy of the SSM/I

The accuracy of the SSM/I series is now of a quality feasible for wind climate studies, i.e., changes in wind speed within 1% per decade can be assessed.

Hasager et al. 2016 Remote Sens. 8, 769; doi:10.3390/rs8090769
WRF preliminary run for Europe

Wind speeds at 100 m, average 1982 to 2015
Comparison SSM/I and WRF stats

Table. Point coordinates and 28 year average of SSM/I and WRF wind speed data

<table>
<thead>
<tr>
<th>Point name</th>
<th>Coordinates</th>
<th>Data count SSM/I</th>
<th>Data count WRF</th>
<th>Wind speed average SSM/I</th>
<th>Wind speed average WRF</th>
<th>Weibull parameters SSM/I</th>
<th>Weibull parameters WRF</th>
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</thead>
<tbody>
<tr>
<td>NW:</td>
<td>5E 56N</td>
<td>51556</td>
<td>245424</td>
<td>8.33</td>
<td>8.28</td>
<td>2.28</td>
<td>9.51</td>
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<tr>
<td>NE:</td>
<td>19E 56N</td>
<td>52116</td>
<td>245424</td>
<td>7.68</td>
<td>7.62</td>
<td>2.32</td>
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<tr>
<td>SW:</td>
<td>4W 45N</td>
<td>43059</td>
<td>245424</td>
<td>7.01</td>
<td>6.94</td>
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<td>SE_S:</td>
<td>30E 35N</td>
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<td>SE_N:</td>
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<td>245424</td>
<td>7.62</td>
<td>7.41</td>
<td>2.40</td>
<td>8.72</td>
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</tbody>
</table>
SSM/I and WRF Weibull distributions

SSM/I

Weibull distributions based on SSM/I over 28 years

WRF

Weibull distributions based on WRF over 28 years

SSM/I and WRF Weibull distributions
SSM/I and WRF annual averages
SSM/I and WRF (North Sea)

Weibull parameters:
SSM/I: $k = 2.28$, $A = 9.51$
WRF:   $k = 2.38$, $A = 9.36$
SSM/I and WRF (Baltic Sea)

Weibull parameters:
SSM/I: $k = 2.32, \ A = 8.89$
WRF: $k = 2.35, \ A = 8.67$
SSM/I and WRF (Atlantic Sea/Biscay)

Weibull parameters:
SSM/I: $k = 1.88, \ A = 7.87$
WRF: $k = 2.12, \ A = 7.87$
SSM/I and WRF (Mediterranean Sea)

Weibull parameters:
SSM/I: $k = 1.71$, $A = 6.27$
WRF: $k = 2.19$, $A = 6.88$
SSM/I and WRF (Black Sea)

Weibull parameters:
SSM/I: $k = 1.92, A = 7.05$
WRF: $k = 2.20, A = 7.28$
Conclusions

• SAR provides **wind speed at** high spatial resolution (1 km by 1 km)
• ASCAT provides wind speed and wind direction (12.5 km by 12.5 km)
• SSM/I provides **wind speed at high frequency** during > 29 years (25 km by 25 km)

• Ocean wind retrievals offshore are valuable for:
  1) Model validation
  2) Offshore wind resource mapping
  3) SAR provides sufficient spatial resolution for the offshore wind atlas

• Limitations of satellite winds:
  Lack of information above the 10-m level above m.s.l.

• Lifting of winds to higher levels is necessary (Badger *et al.* 2016)
Acknowledgements

Satellite data:
The European Space Agency (ESA), OSI SAF KNMI, Remote Sensing Systems

SAR wind retrieval systems:
JHU/APL and NOAA

Funding:
EU-NORSEWInD, Icewind, RUNE, X-WiWa, New European Wind Atlas

Collaboration:
Frank Monaldo & Christopher Jackson, NOAA

ForskEL for funding the RUNE experiment and DTU’s technical staff for the execution