



Open Science in the New European Wind Atlas

JAVIER SANZ RODRIGO (CENER), JAKOB MANN (DTU), JULIA GOTTSCHALL (Fraunhofer IWES)

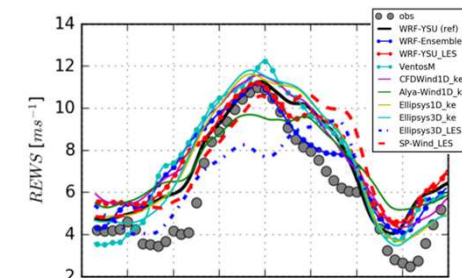
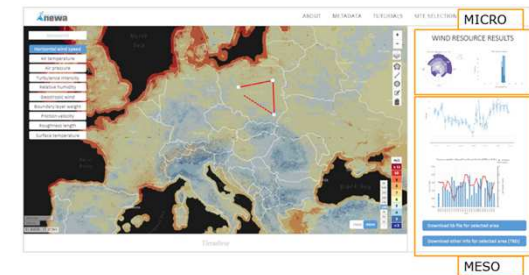
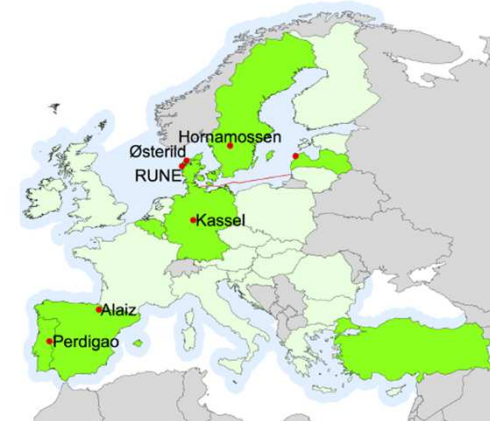
On behalf of the NEWA consortium

WindEurope2017, Amsterdam, 28 November 2017



Objectives of the NEWA Project

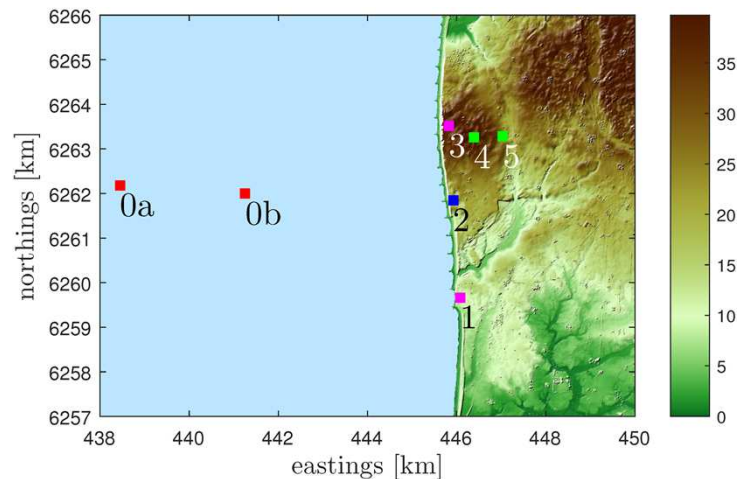
- Development of a high-value data base of **high-fidelity experiments**
- Development of methodologies for wind resource assessment and wind turbine site suitability based on a **mesoscale to microscale** mode-chain
- Publication of a **European Wind Atlas** database accessible through a web interface
- Definition of a **verification and validation framework** for the model-chain based on the experimental campaigns and means to quantify the **uncertainties** of the wind atlas



Coastal and Offshore Experiments

RUNE (Denmark)

Scanning lidars to investigate near-shore wind resources



Peña A, et al. (2016)

FerryLIDAR (Baltic Sea)

Ferry-mounted profiling lidar to verify NEWA offshore wind atlas in the Baltic

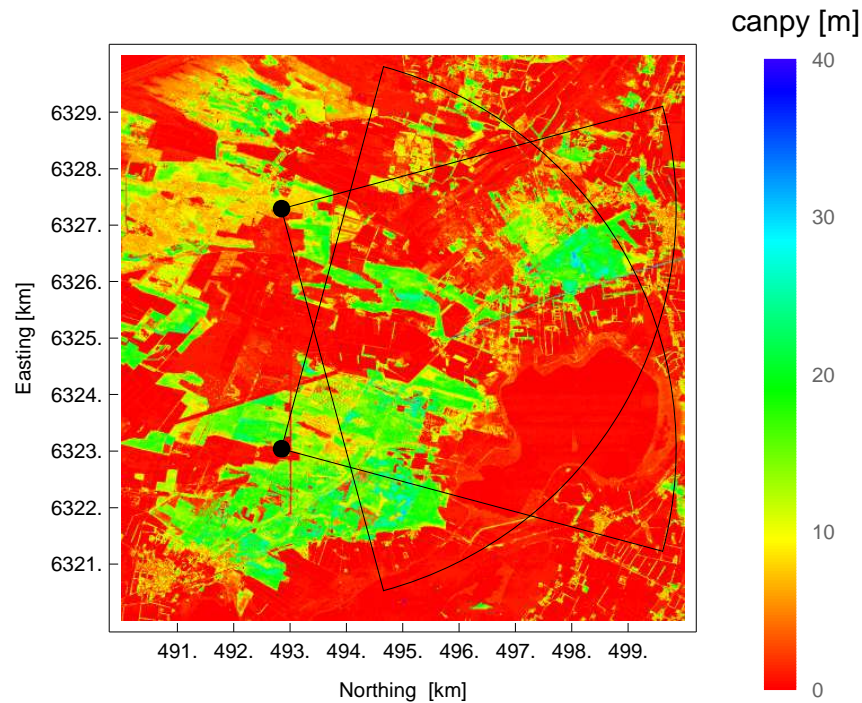


Gottschall J, et al. (2017)

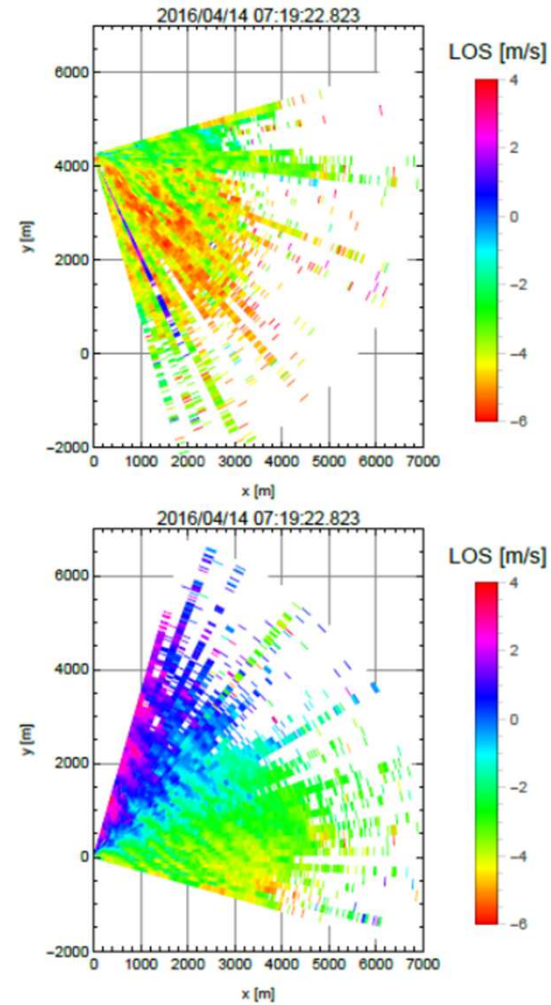
Forested Landscape Experiments

Østerild Balconies (DK)

Flat terrain with heterogeneous forest.
Two horizontally scanning lidars on 250 m masts.

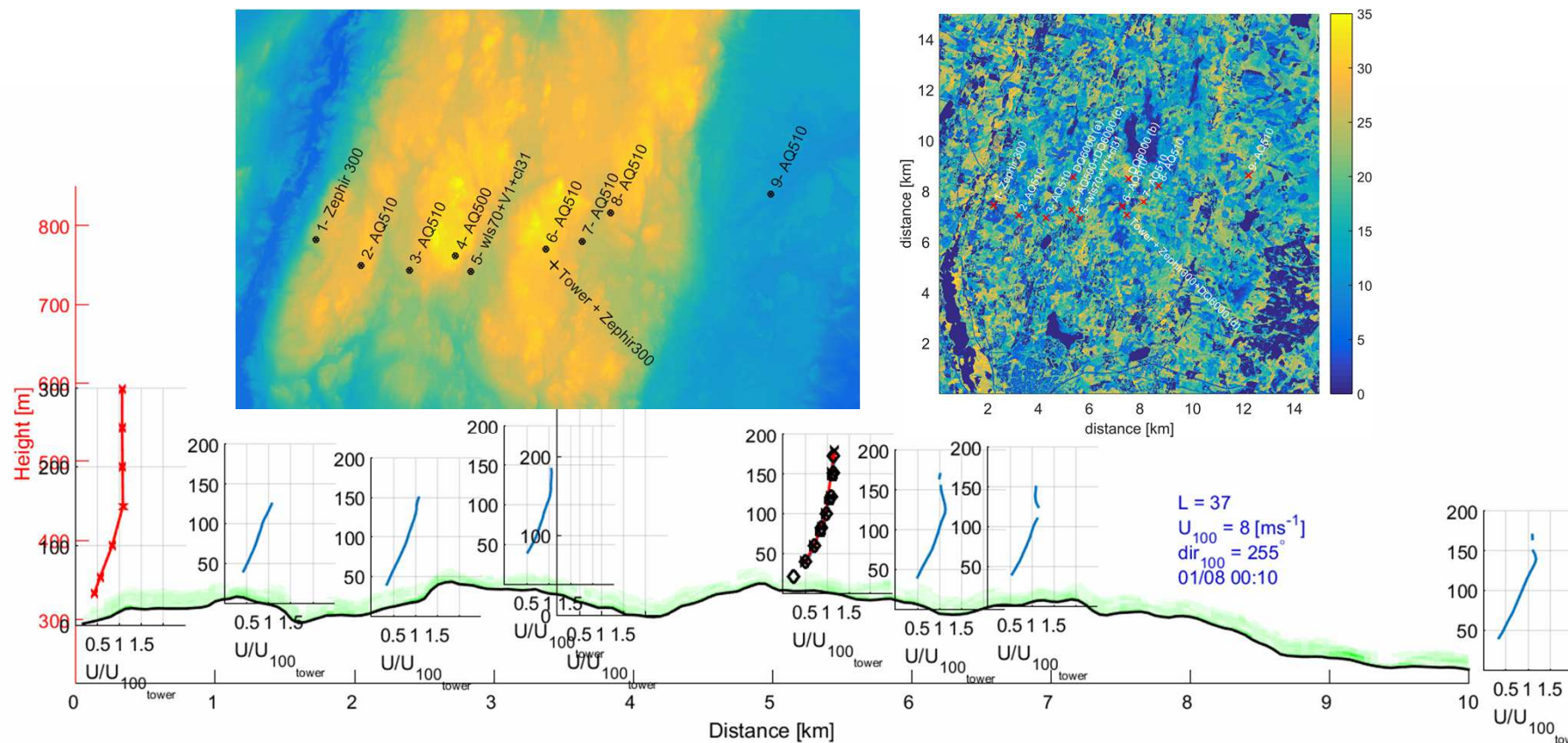


Karagali et al. (2017)



Hornamossen (Sweden)

Sodars, lidars and mast on a transect in rolling hills with forest.

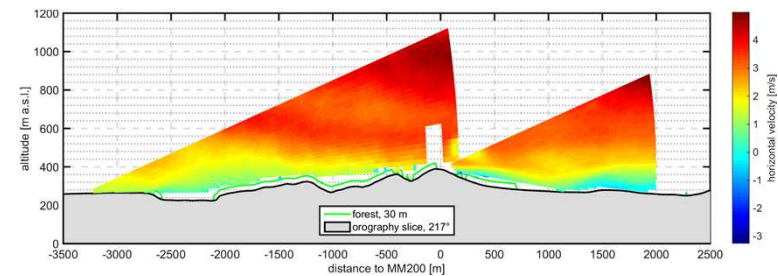
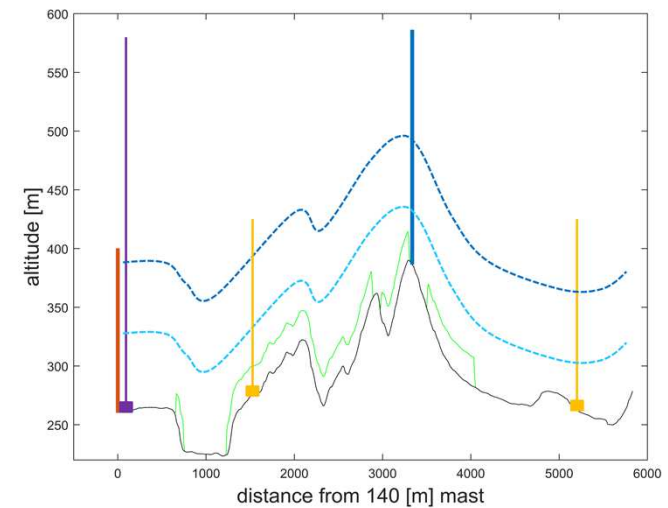
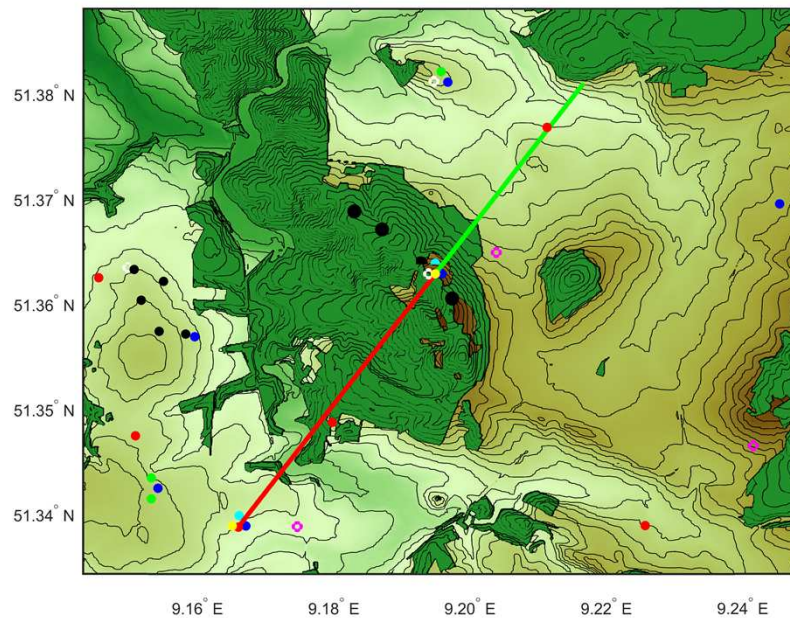


Arngvist et al. (2017)

Isolated Forested-Hill Experiment

Rödeser Berg (Germany)

A tall forested hill with six scanning lidars, profiling lidars, sodar, and two met masts.

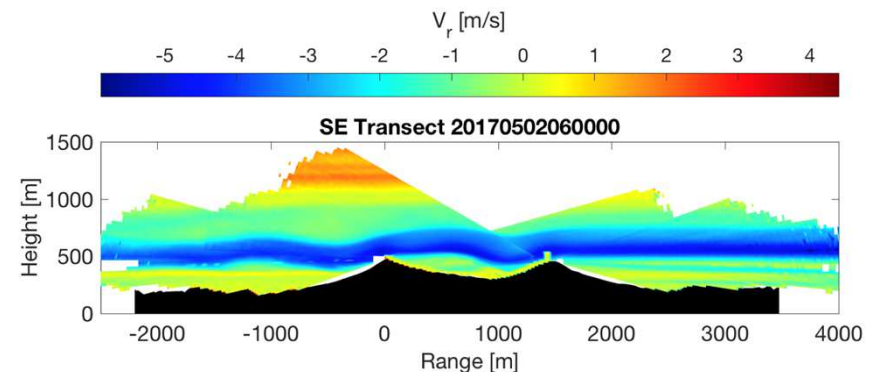
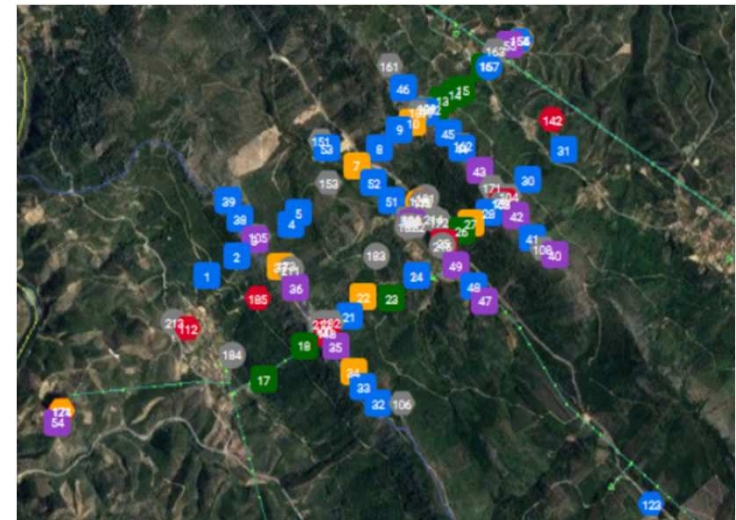


Kühn P, et al. (2017)

Complex Terrain Experiments

Perdigão (Portugal)

- Most comprehensive dataset for model evaluation in complex terrain to date
- Participation of 21 institutions (13 European + 8 USA) from 7 countries contributing with 72 field participants
- 186 3D sonic anemometers on 50 masts
- 20 scanning lidars + 7 profiling lidars
- Various temperature profilers, balloon launched every six hours, radars, etc

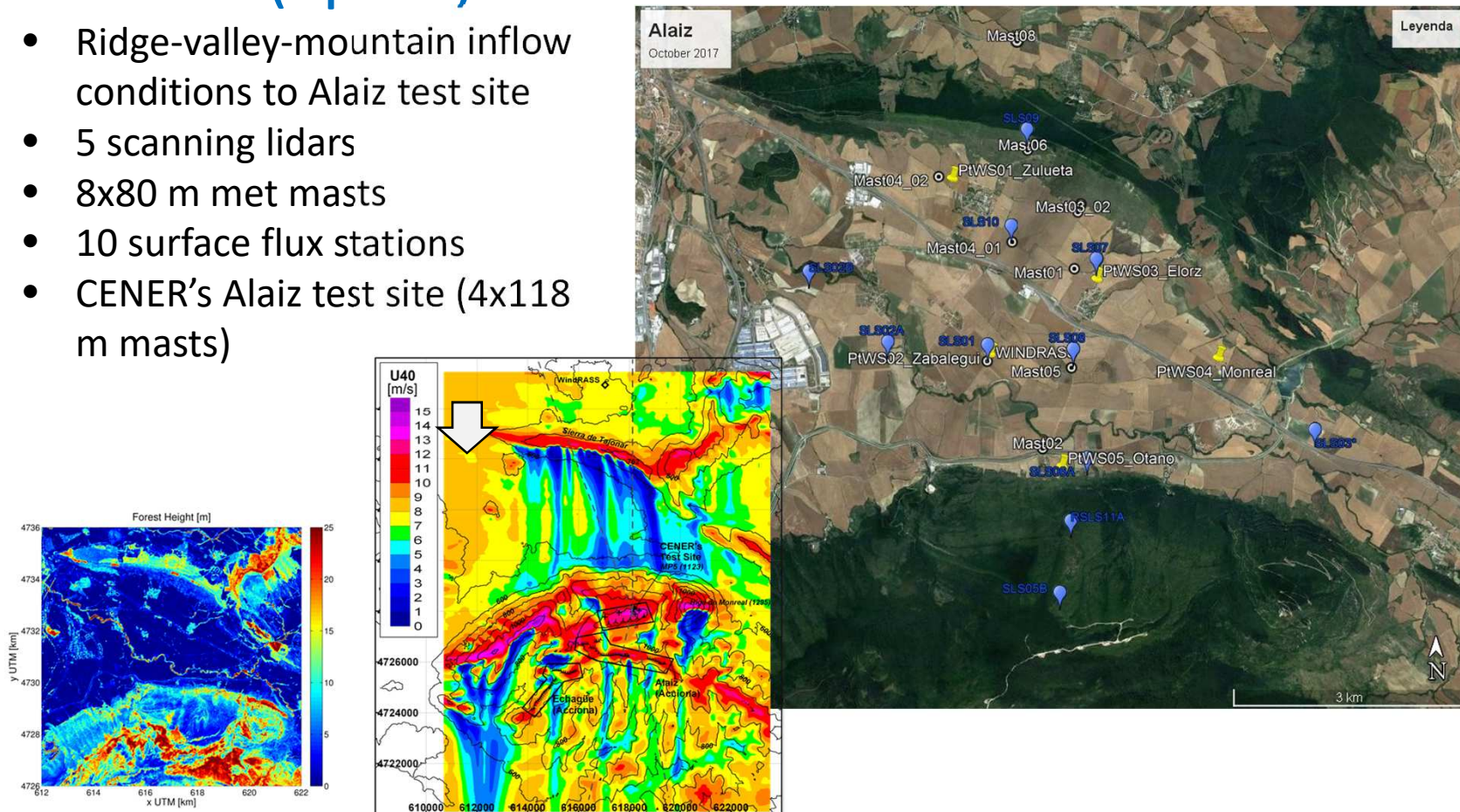


Palma et al. (2017)

Complex Terrain Experiments

ALEX18 (Spain)

- Ridge-valley-mountain inflow conditions to Alaiz test site
- 5 scanning lidars
- 8x80 m met masts
- 10 surface flux stations
- CENER's Alaiz test site (4x118 m masts)

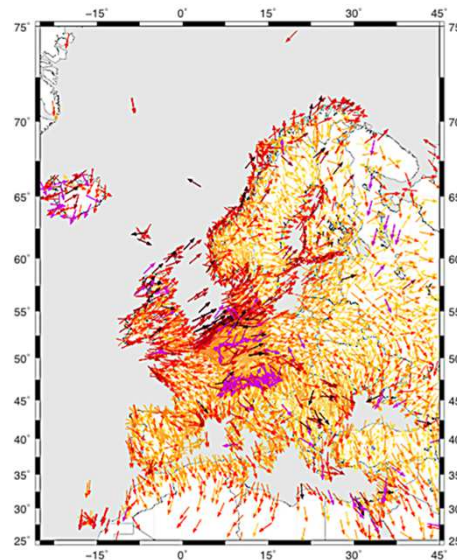


Cantero et al. (2016)

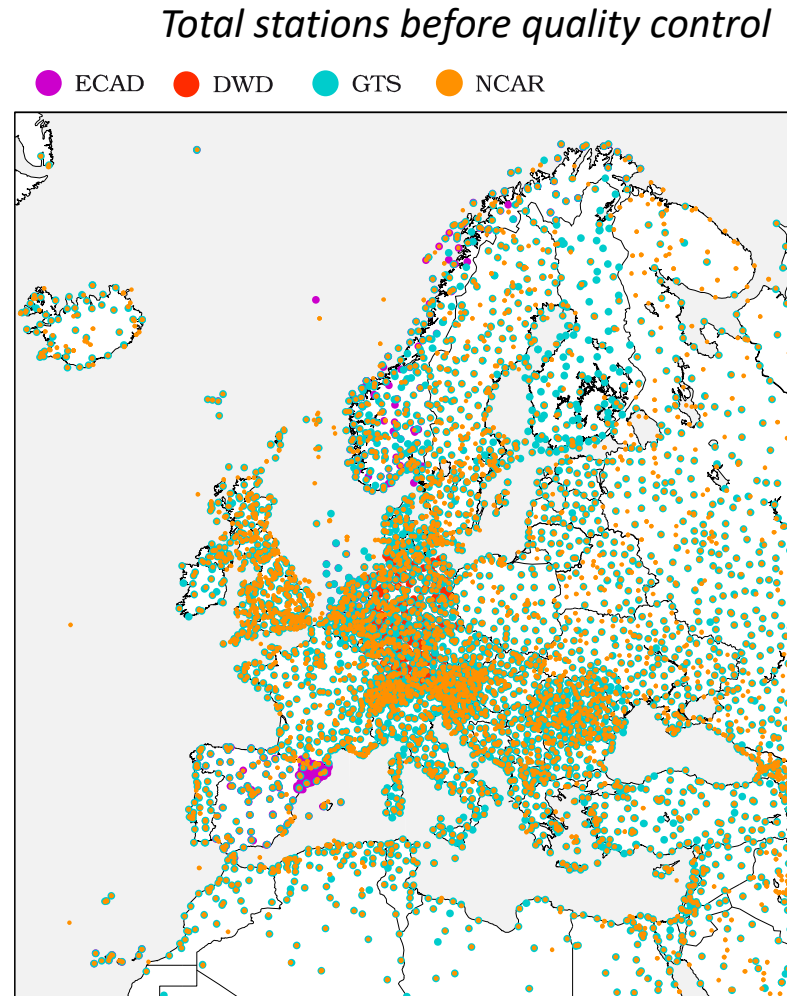
Wind Surface European Database (WiSED)

WiSED

- Characterization of the whole European territory.
- 15000+ long term series.
- Wind speed and direction.
- Specific Quality Control procedure for wind observations



Gonzalez Rouco F, et al. (2017)



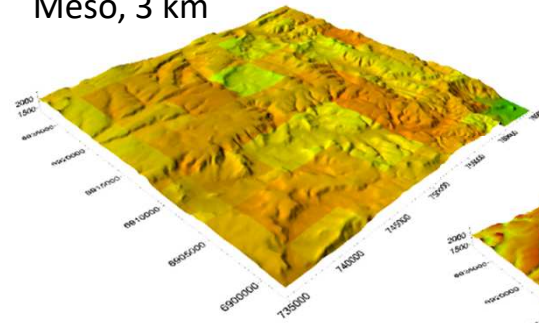
NEWA Open Source Model-Chain

Wind Atlas

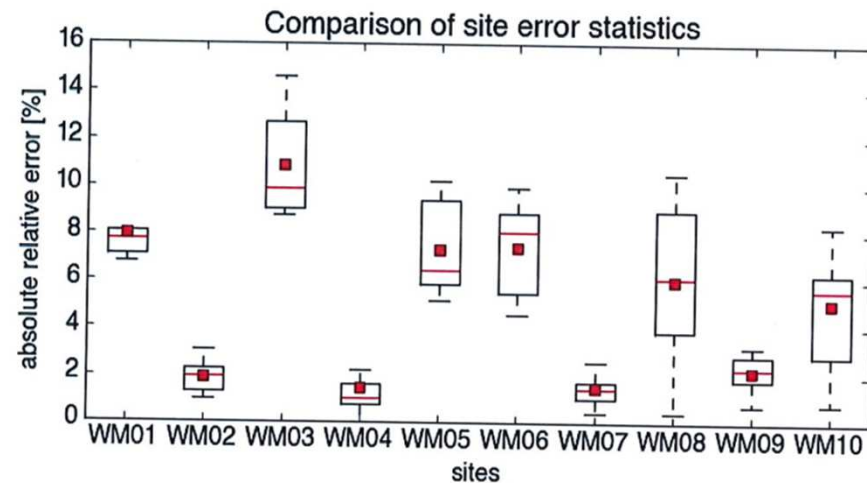
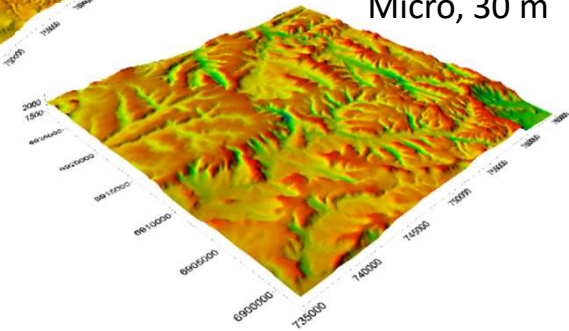
WRF-WAsP

- Driven by **ERA5** reanalysis
 - 30-year wind atlas integration at 3 km resolution with WRF
 - Time-series
 - Downscaling to 30 m using WAsP generalized wind methodology
 - Statistics
 - Mesoscale multiphysics ensemble
 - Uncertainties
- Open-source WRF config. files and modified source code

Meso, 3 km



Micro, 30 m



Hahmann A, Mortensen NG, et al. (2017)

NEWA Open Source Model-Chain

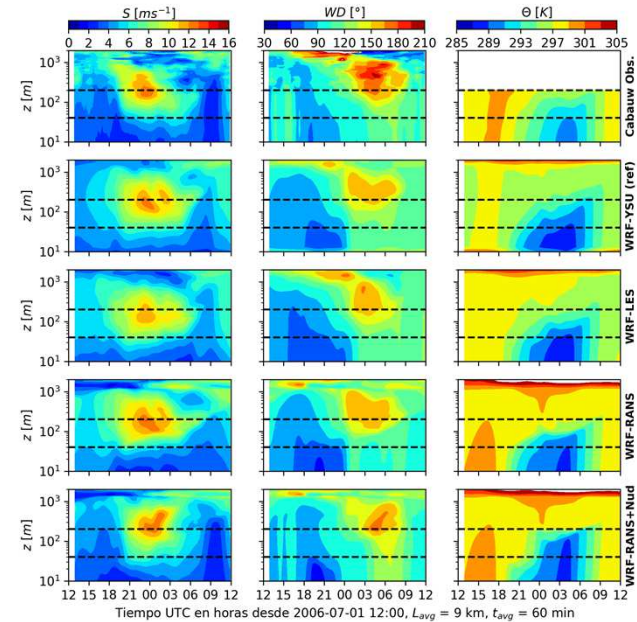
Microscale Models for Siting

- Based on RANS or LES
- Driven by mesoscale forcings
- Diurnal-cycle thermal stratification
- Surface-layer characterization based on aerial lidar scans of vegetation canopy

→ Open-source URANS model built on OpenFOAM

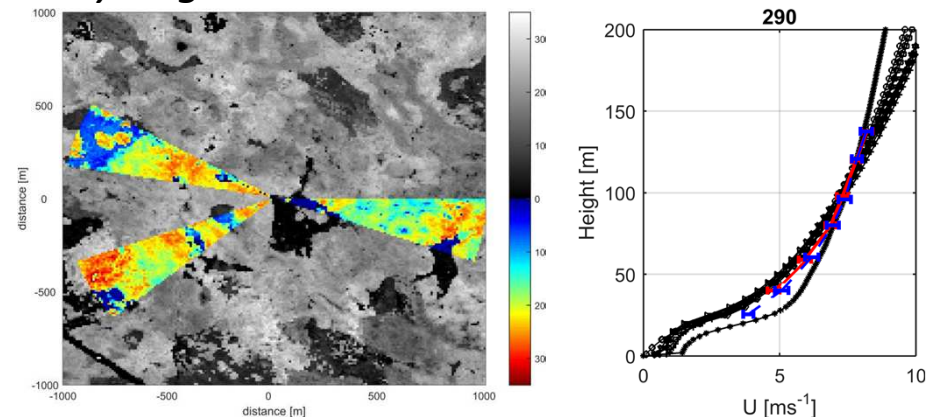
GABLS3

Sanz Rodrigo J, et al. (2017)

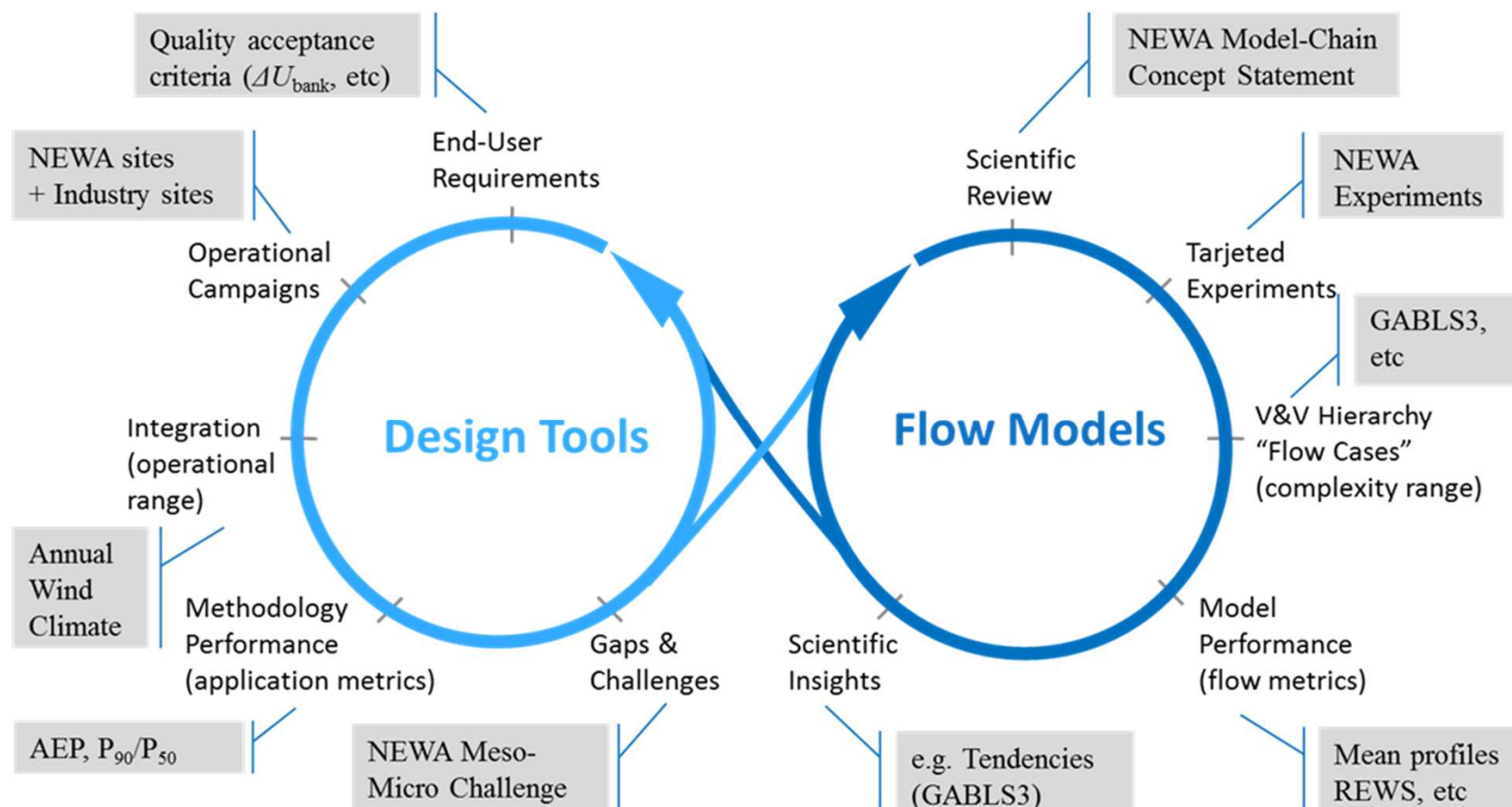


Ryningsnäs

Arnqvist J, et al. (2017)



Verification & Validation Framework



Sanz Rodrigo J, et al. (2017)

Open Science Benchmarking

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Results of the GABLS3 diurnal-cycle benchmark for wind energy applications

J Sanz Rodrigo¹, D Allaerts², M Avila¹, J Barcons¹, RA Chávez Arroyo¹, M Churchfield², B Kosovic³, JK Lundquist^{2,6}, J Meyers⁷ [Show full author list](#)

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Abstract

We present results of the GABLS3 model intercomparison benchmark for wind energy applications. The case consists of a Cabauw tower in the Netherlands, including a sensitivity analysis of WRF simulations and five planetary boundary-layer tendencies is used to drive mesoscale simulation models. The validation is based on rotor-based mean absolute errors are used to quantify the benchmark are used to discuss input uncertainties. meso-micro coupling strategies (online vs. LES codes when dealing with boundary-layer mesoscale simulations produce a consistent

Abstract

by Sanz Rodrigo, Javier; Allaerts, Dries; Avila, Matias; Barcons, Jordi; Cavar, Dalivor; Chavez Arroyo, Roberto A.; Churchfield, Matthew; Kosovic, Branko; Lundquist, Julie K.; Meyers, Johan; Muñoz Esparza, D; Palma, Jose MLM; Tomaszewski, Jessica M; Trolborg, Niels; van der Laan, M Paul; Veiga Rodrigues, Carlos;

Jun 23, 2017

Abstract: The dataset was produced for the GABLS3 model intercomparison benchmark for wind energy applications, which resulted in the following publication: Sanz Rodrigo J, Allaerts D, Avila M, Barcons J, Cavar Chávez Arroyo R, Churchfield M, Kosovic B, Lundquist JK, Meyers J, Muñoz Esparza D, Palma J, Tomaszewski, Trolborg N, van der Laan M, Veiga Rodrigues C (2017) Results of the GABLS3 diurnal cycle benchmark for wind energy applications. Journal of Physics: Conference Series, 854: 012037. doi:10.1088/1742-6596/854/1/012037. The case consists of a diurnal cycle, measured at the 200-m tall Cabauw tower in the Netherlands, including a nocturnal low-level jet. The benchmark includes a sensitivity analysis of WRF simulations using two input meteorological databases and five planetary boundary-layer schemes. A reference set of mesoscale tendencies is used to drive mesoscale simulations using RANS k-ε and LES turbulence models. The validation is based on rotor-based quantities of interest.

Series information: Each NetCDF data file corresponds to one simulation submitted to the benchmark. Naming corresponds to the model name as described in the paper.

Disciplines: 3314 - Earth sciences - Meteorology; 5648 - Engineering - Fluid mechanics;

Keywords: wind; atmospheric boundary-layer; mesoscale; WRF; CFWind; GABLS3; meso-micro; coupling; tendencies;

DOI: [10.23728/bzshare.f5d5a4g2d8aa4b7998b70abd68f9e1](#) Copy

PID: [11304/eddcdcbac-5f4-4be8-b690-b9b9e6282bf](#) Copy

• Simulation data:
• Evaluation script
• Journal paper: S
layer models for

Scope

The GABLS3 case has been used to test different methodologies for wind energy applications. realistic forcing, derived from realistic forcing. Challenges of this case are varying atmospheric wind profile in (non-loc

Name	Size
Alfa-CFDWindD.nc	4.65MB
CFWindSCM_ke.nc	55.69MB
EllipsysD_TskWRF.nc	921.43KB
Ellipsys3D_LES_TskWRF.nc	611.45KB
Ellipsys3D_TskWRF.nc	814.70KB

Basic metadata

Open Access: True ✓

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Contact Email: jsrodrigo@cener.com

Publication Date: 2017-06-22

zenodo

July 24, 2017

Software Open Access

Assessment of meso-micro offline coupling methodology based on driving CFWind single-column-model with WRF tendencies: the GABLS3 diurnal cycle case

Javier Sanz Rodrigo

In this repository you can find the jupyter notebook that was used to post-process CFWindSCM simulations of the GABLS3 diurnal cycle case. Based on this work a Windbench benchmark for wind energy applications was designed: <http://windbench.net/gabls3>

The input data can be fetched from the EUDAT repository <http://doi.org/10.23728/bzshare.22e419b663cb4ffca8107391b6716c1b> and the validation data from the original GABLS3 website at KNMI: http://projects.knmi.nl/gabls3/gabls3_scm_cabauw_obs_v33.nc

The results were published in the following journal paper: Sanz Rodrigo J, Churchfield M, Kosovic B (2017) A methodology for the design and testing of atmospheric boundary layer models for wind energy applications. Wind Energy. Sci. 2: 1-20, <https://doi.org/10.5194/wees-2-35-2017>

Preview

GABLS3-CFDWindSCM-v1.0.zip

- jsrodrigo-GABLS3-CFDWindSCM-ab12f29
 - gitignore 1.2 kB
 - GABLS3_CFDWind1D.ipynb 551.6 kB
 - LICENSE 35.1 kB
 - README.md 1.1 kB

Available in

GitHub

Publication date: July 24, 2017

DOI: [DOI: 10.5281/zenodo.834356](https://doi.org/10.5281/zenodo.834356)

Keyword(s): gabls3, meso-micro, wind, windbench

Published in: Wind Energy Science: 2 pp. 1-20.

Grants: European Commission

- MESOWAKE - Unified mesoscale to wind turbine wake downscaling based on an open-source model chain (624562)

Related identifiers: Supplement to: <https://github.com/jsrodrigo/GABLS3-CFDWindSCM/tree/v1.0>

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Print: 04/05/2017 (autosaved) Logout

Not Trusted Python 2

Series, 854.

CFWindSCM testing of at

scale-to-mic d farm mod ent of a noct e models, t heat and cl

Vertical Profiles

```
In [16]: # Specify the datetime at which you want to plot the vertical profiles
t0 = datetime.datetime(2006,7,2,0,0,0)

# Plot settings
linespec = ['k-', 'b-', 'r-', 'c-', 'm-', 'g-', 'y-', 'c-', 'b-', 'r-']
lwidth = np.array([2,1,1,1,1,1,2,2])
Nm = 3 # marker every

Z_obs = (S_obs.w.loc[t0].values, WD_obs.w.loc[t0].values,
          Th_obs.w.loc[t0].values)
Z_obs = (zf_obs, zf_obs, zT_obs)

Z_sim = []; z_sim = []
for iplot in range(0,len(plotsim)):
    isim = plotsim[iplot]
    Z_sim.append([S[isim].loc[t0].values, WD[isim].loc[t0].values,
```

Sanz Rodrigo J, et al. (2017)

Wind Atlas Output Parameters

Mesoscale wind atlas

3 km, 30 years, 8 heights up to 500 m

- 30-min **time series** data and statistics
- Profile data: wind speed, direction, temperature
- Other characteristics: surface pressure, Monin-Obukhov length, geostrophic wind, boundary-layer height, friction velocity, roughness length

Additional parameters:

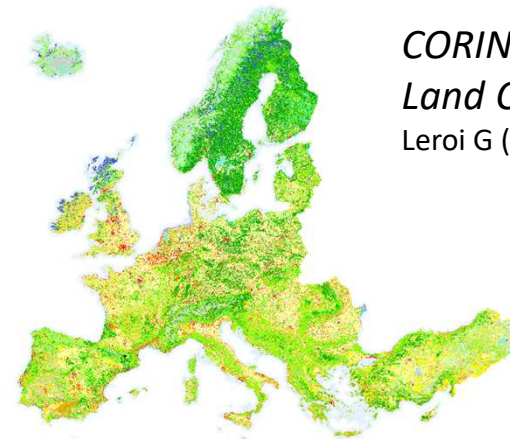
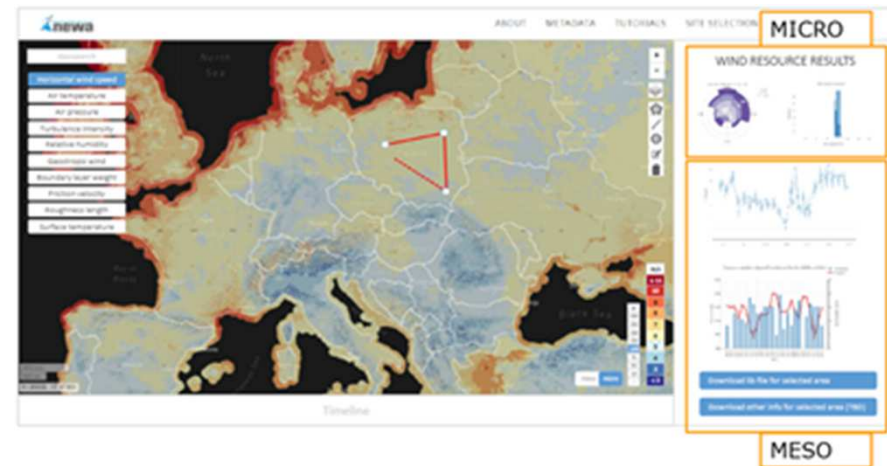
- Extreme winds (applying spectral correction method)
- Icing classes (in particular for cold climate)
- Uncertainty quantification (applying multi-physics-ensemble approach)

Microscale wind atlas

30 m, 3 heights (50 m, 100 m, 200 m)

- Wind resource **statistics**

Bauwens I, et al. (2017)

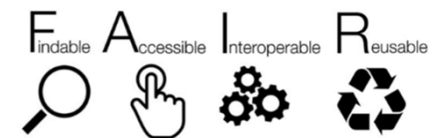


*CORINE
Land Cover 2012*
Leroi G (2017)

Hahmann A, et al. (2017)

Conclusions: Open-Access Resources

- **NEWA open-source model chain** based on WRF and OpenFOAM (beta release in Jan'18)
- **Database of experiments**, released throughout 2018 from the NEWA data server
- **Validation benchmarks** released through Windbench.net and open to external participation within the IEA Task 31 Wakebench
- **EU Wind Atlas database and web interface**, release at NEWA final workshop next to WindEurope 2019 (April 2019)

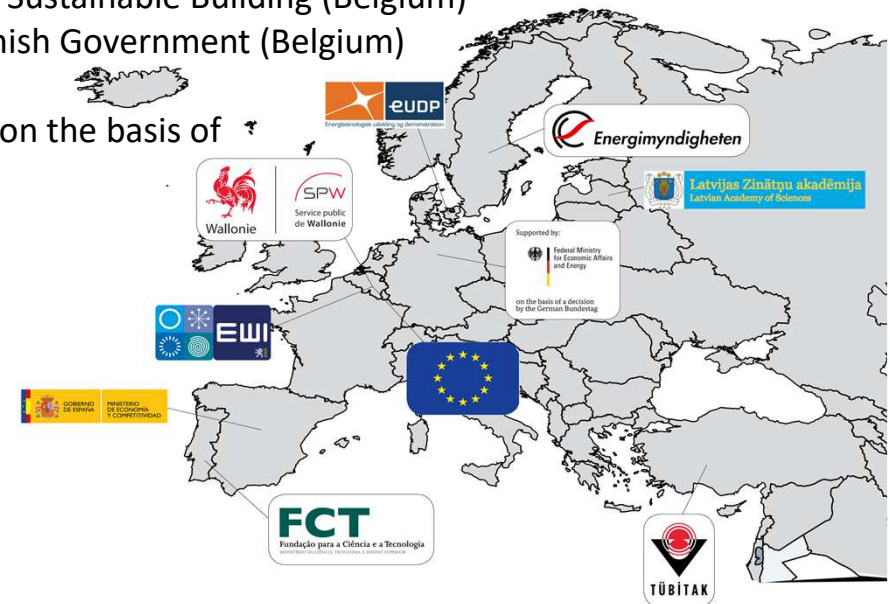


Acknowledgements



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- Public Service of Wallonia, Department of Energy and Sustainable Building (Belgium)
- Department of Economy, Science and Innovation Flemish Government (Belgium)
- Danish Energy Authority (Denmark)
- Federal Ministry for the Economic Affairs and Energy, on the basis of the decision by the German Bundestag (Germany)
- Latvijas Zinatnu Akademija (Latvia)
- Fundação para a Ciência e a Tecnologia (Portugal)
- Ministerio de Economía y Competitividad (Spain)
- The Swedish Energy Agency (Sweden)
- The Scientific and Technological Research Council of Turkey (Turkey)



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