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An Open Science Approach for Wind Energy V&V: The GABLS3 Case Study

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Wind Energy Science Conference, Lyngby, 27 June 2017

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Context

European Cloud Initiative https://ec.europa.eu/digital-single-market/en/%20european-cloud-initiative

The **European Cloud Initiative** will strengthen Europe's position in data-driven innovation, improve competitiveness and cohesion, and help create a **Digital Single Market** in Europe.

Provide EU science, industry and public authorities with:

- a world-class **data infrastructure** to store and manage data;
- **high-speed connectivity** to transport data; and
- ever more powerful **High Performance Computers** to process data

The Cloud Initiative will make it easier for researchers, businesses and public services to fully exploit the benefits of **Big Data** by making it possible to move, share and re-use data seamlessly across global markets and borders, and among institutions and research disciplines

The public and private investment needed to implement the European Cloud Initiative is estimated at **€6.7 billion**. The Commission estimates that, overall, **€2 billion in Horizon 2020** funding will be allocated to the European Cloud initiative

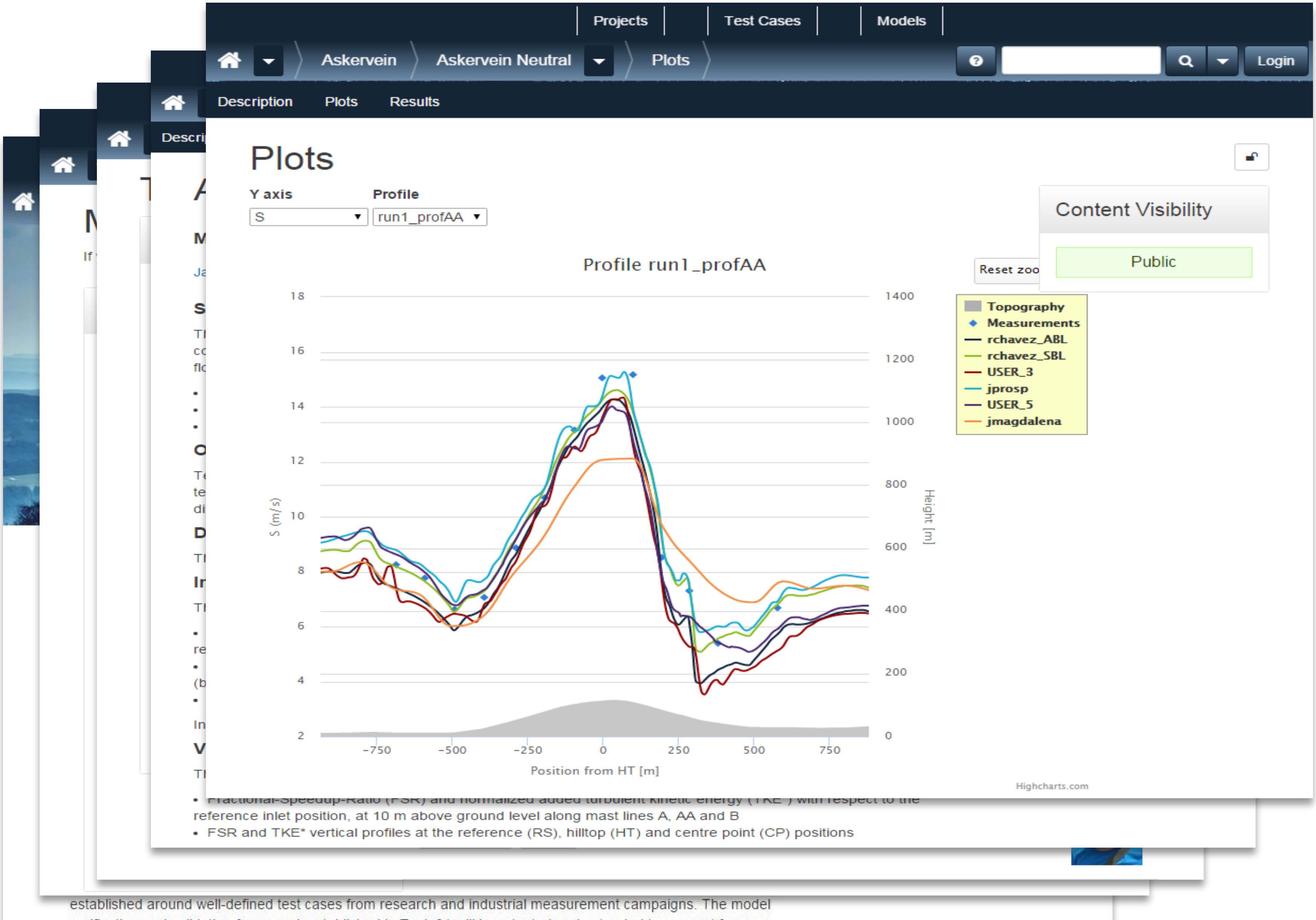
“Digitizing” Wind Energy

- IRPWind – Design of the Wind Energy portal for data discovery and exploitation
- Marine Renewables Infrastructure Network (MaRINET2)
  - Pan-European infrastructure for ocean & marine data management (SeaDataNet.org)
- New European Wind Atlas (NEWA)
- IEA Task 31 Wakebench Phase 2
- A2e DAP
  - Atmosphere to Electrons, Data Archive and Portal

Background reading

Towards an European e-infrastructure for Wind Energy
Gancarski (2017). EERA IRPWind Mobility report, January 2017
https://doi.org/10.5281/zenodo.818094

Windbench 2.0: V&V Repositories for Wind Energy



Challenge

Redesign of Windbench from a data repository to an open-science platform

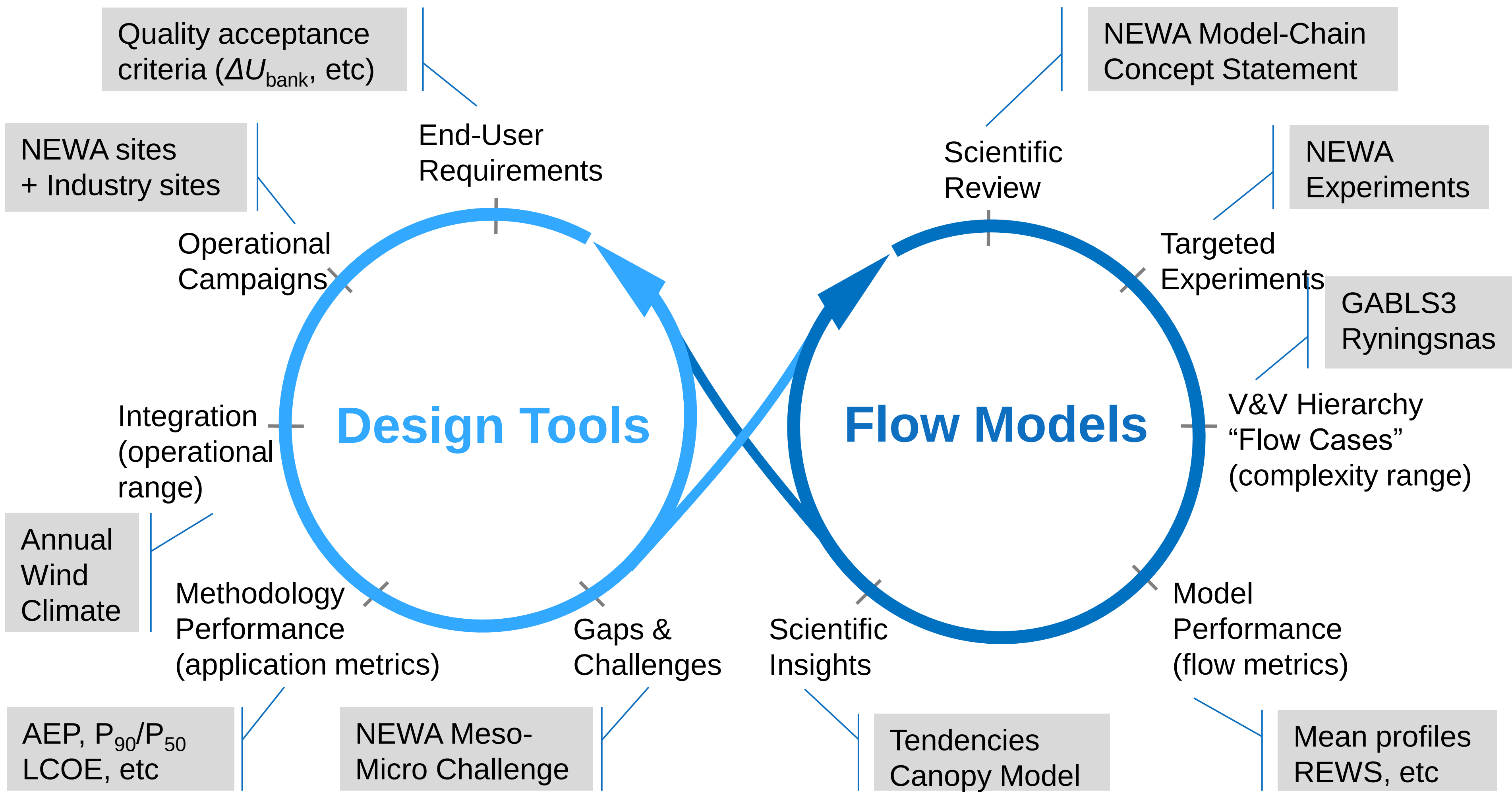
- Simple and powerful
- Integrated into your workflow

Solomon Hykes, DockerCon 2017
https://youtu.be/hwkqju_BXEo

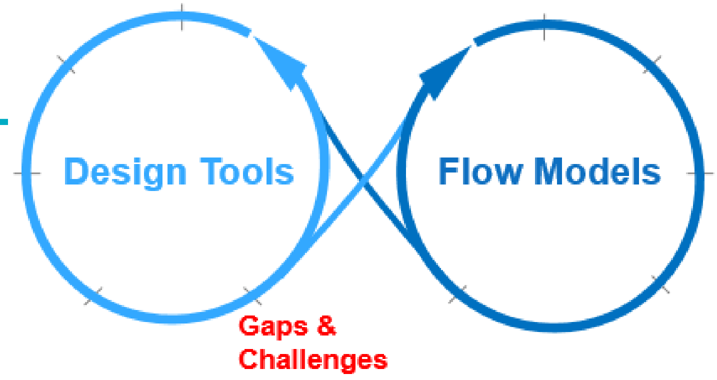
Solution

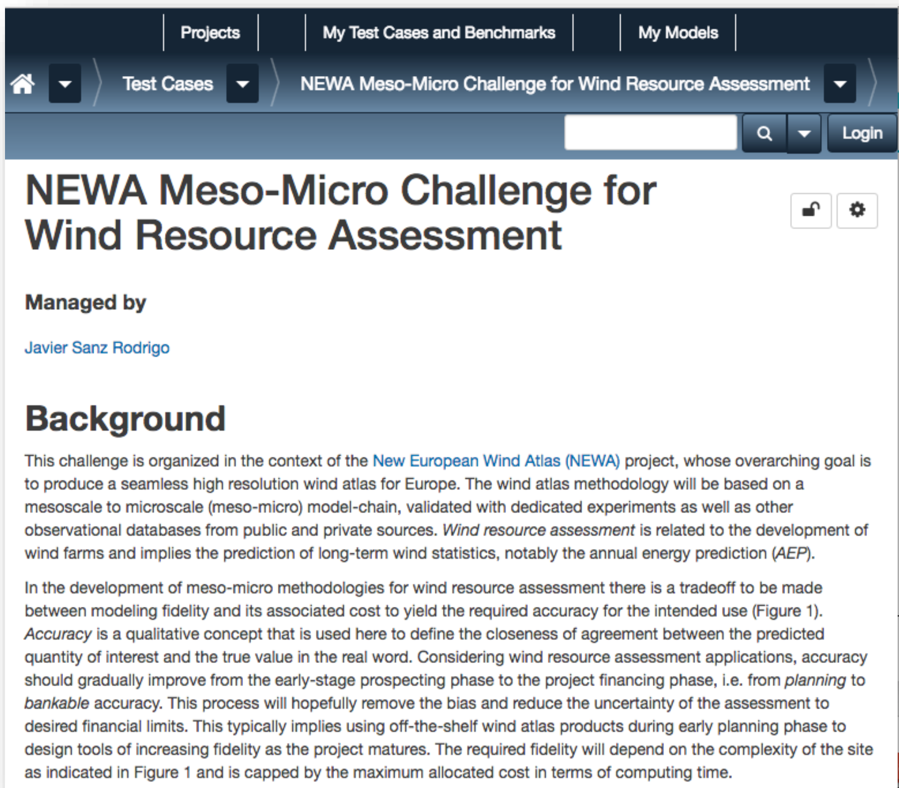
GABLS3

Windbench Proccess: Ambidextrous V&V, the NEWA case



NEWA Meso-Micro Challenge





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Test Cases › NEWA Meso-Micro Challenge for Wind Resource Assessment

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NEWA Meso-Micro Challenge for Wind Resource Assessment

Managed by

Javier Sanz Rodrigo

Background

This challenge is organized in the context of the New European Wind Atlas (NEWA) project, whose overarching goal is to produce a seamless high resolution wind atlas for Europe. The wind atlas methodology will be based on a mesoscale to microscale (meso-micro) model-chain, validated with dedicated experiments as well as other observational databases from public and private sources. *Wind resource assessment* is related to the development of wind farms and implies the prediction of long-term wind statistics, notably the annual energy prediction (*AEP*).

In the development of meso-micro methodologies for wind resource assessment there is a tradeoff to be made between modeling fidelity and its associated cost to yield the required accuracy for the intended use (Figure 1). *Accuracy* is a qualitative concept that is used here to define the closeness of agreement between the predicted quantity of interest and the true value in the real word. Considering wind resource assessment applications, accuracy should gradually improve from the early-stage prospecting phase to the project financing phase, i.e. from *planning* to *bankable* accuracy. This process will hopefully remove the bias and reduce the uncertainty of the assessment to desired financial limits. This typically implies using off-the-shelf wind atlas products during early planning phase to design tools of increasing fidelity as the project matures. The required fidelity will depend on the complexity of the site as indicated in Figure 1 and is capped by the maximum allocated cost in terms of computing time.

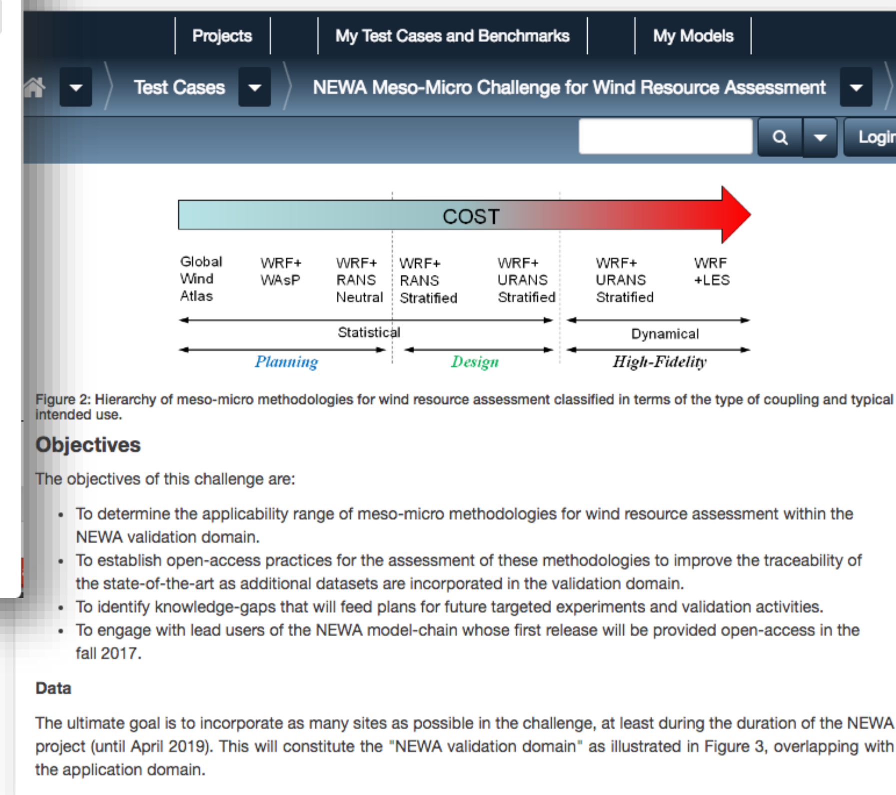

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Figure 2: Hierarchy of meso-micro methodologies for wind resource assessment classified in terms of the type of coupling and typical intended use.

Objectives

The objectives of this challenge are:

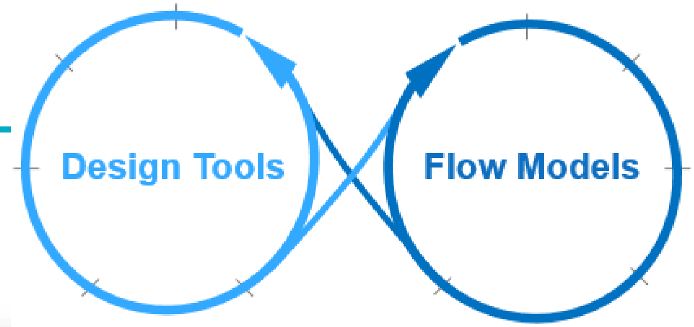
- To determine the applicability range of meso-micro methodologies for wind resource assessment within the NEWA validation domain.
- To establish open-access practices for the assessment of these methodologies to improve the traceability of the state-of-the-art as additional datasets are incorporated in the validation domain.
- To identify knowledge-gaps that will feed plans for future targeted experiments and validation activities.
- To engage with lead users of the NEWA model-chain whose first release will be provided open-access in the fall 2017.

Data

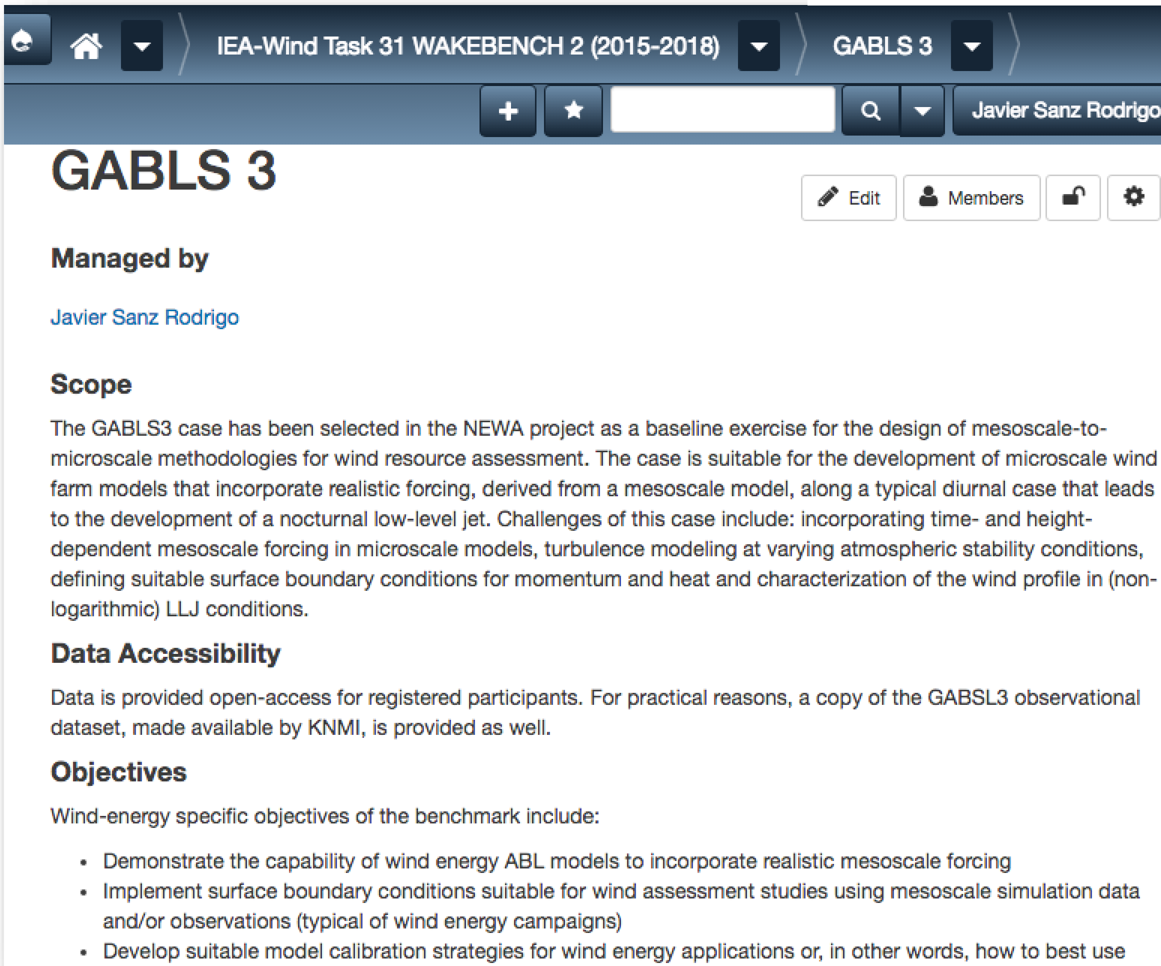
The ultimate goal is to incorporate as many sites as possible in the challenge, at least during the duration of the NEWA project (until April 2019). This will constitute the "NEWA validation domain" as illustrated in Figure 3, overlapping with the application domain.

http://windbench.net/newa-meso-micro-challenge-wind-resource-assessment

GABLS3: Benchmark Guide



V&V Hierarchy
"Flow Cases"
(complexity range)



GABLS 3

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Scope

The GABLS3 case has been selected in the NEWA project as a baseline exercise for the design of mesoscale-to-microscale methodologies for wind resource assessment. The case is suitable for the development of microscale wind farm models that incorporate realistic forcing, derived from a mesoscale model, along a typical diurnal case that leads to the development of a nocturnal low-level jet. Challenges of this case include: incorporating time- and height-dependent mesoscale forcing in microscale models, turbulence modeling at varying atmospheric stability conditions, defining suitable surface boundary conditions for momentum and heat and characterization of the wind profile in (non-logarithmic) LLJ conditions.

Data Accessibility

Data is provided open-access for registered participants. For practical reasons, a copy of the GABSL3 observational dataset, made available by KNMI, is provided as well.

Objectives

Wind-energy specific objectives of the benchmark include:

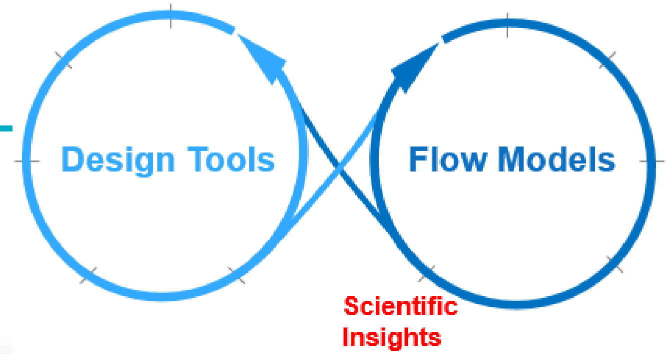
- Demonstrate the capability of wind energy ABL models to incorporate realistic mesoscale forcing
- Implement surface boundary conditions suitable for wind assessment studies using mesoscale simulation data and/or observations (typical of wind energy campaigns)
- Develop suitable model calibration strategies for wind energy applications or, in other words, how to best use

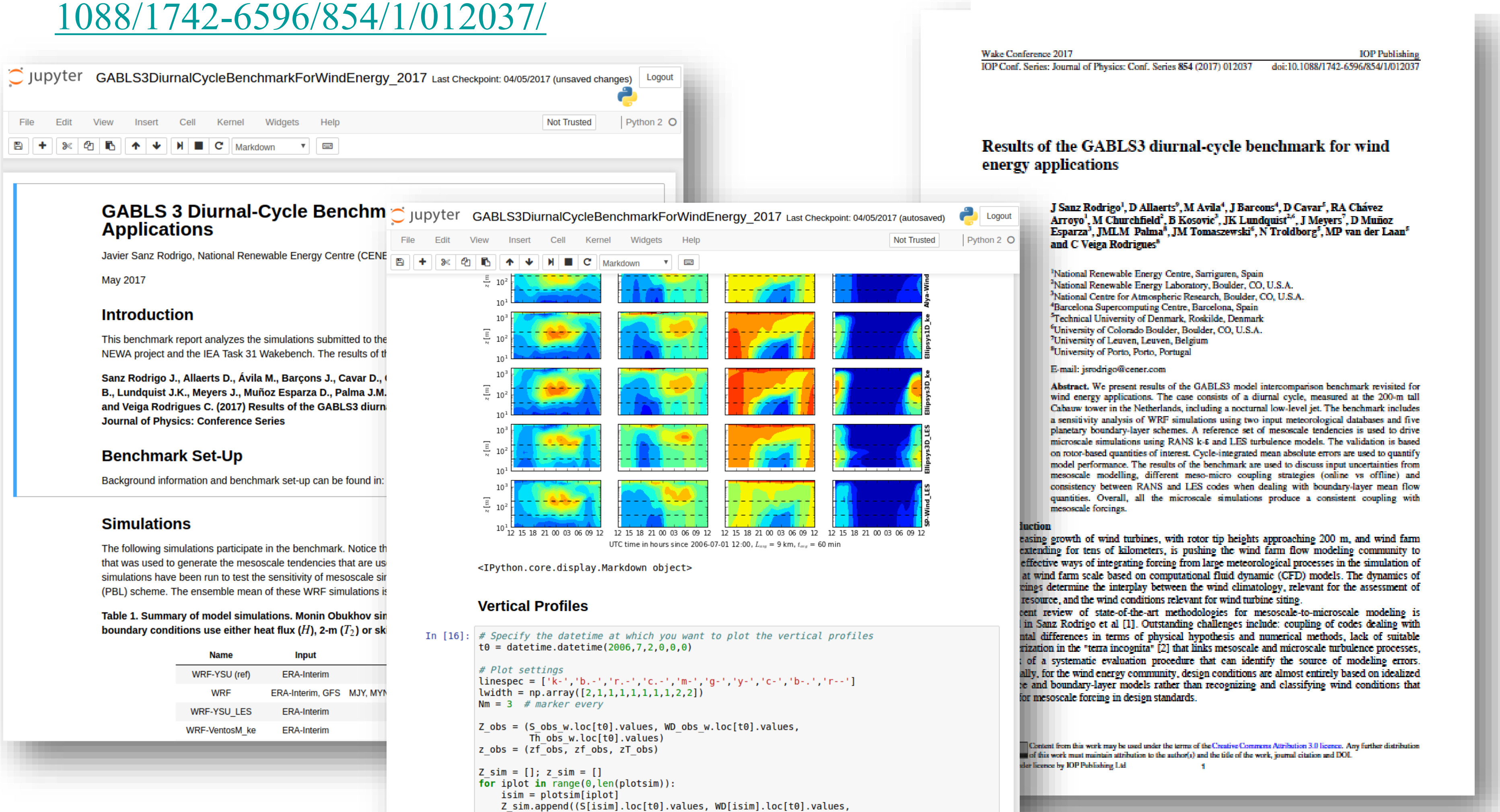
http://windbench.net/gabls-3

GABLS3: Benchmark Notebook

GABLS3_CFDWind1D.ipynb – link available soon

http://iopscience.iop.org/article/10.1088/1742-6596/854/1/012037/

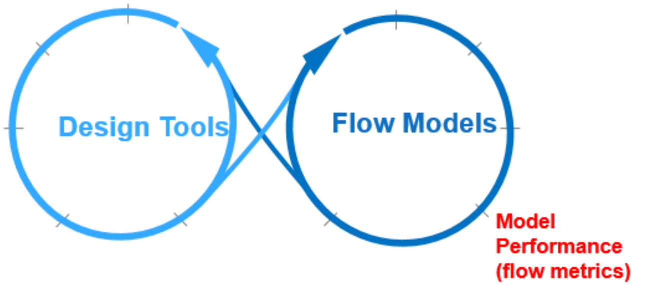


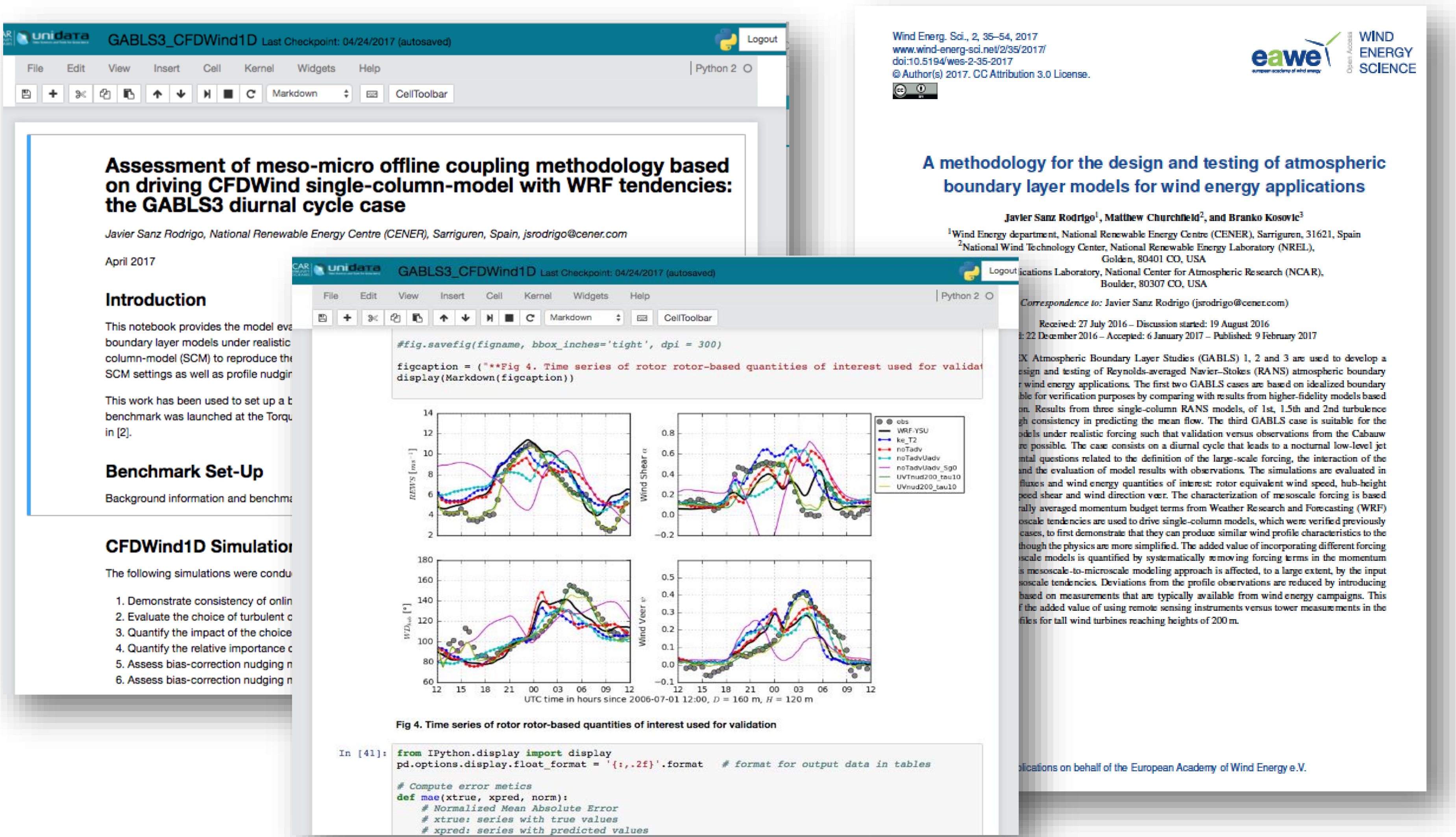


GABLS3: CFDWindSCM Evaluation Notebook

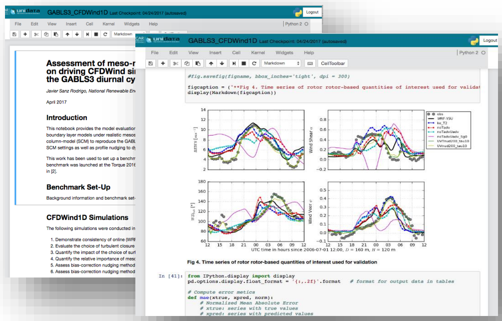
http://35.187.167.148/notebooks/GABLS3_CFDWind1D.ipynb?token=846e2646cdeec2bd155ddc5ef96fbce35877384a723152ae

http://www.wind-energ-sci.net/2/35/2017/





GABLS3: CFDWindSCM Evaluation Notebook



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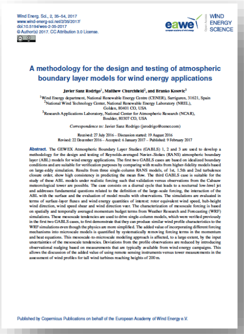

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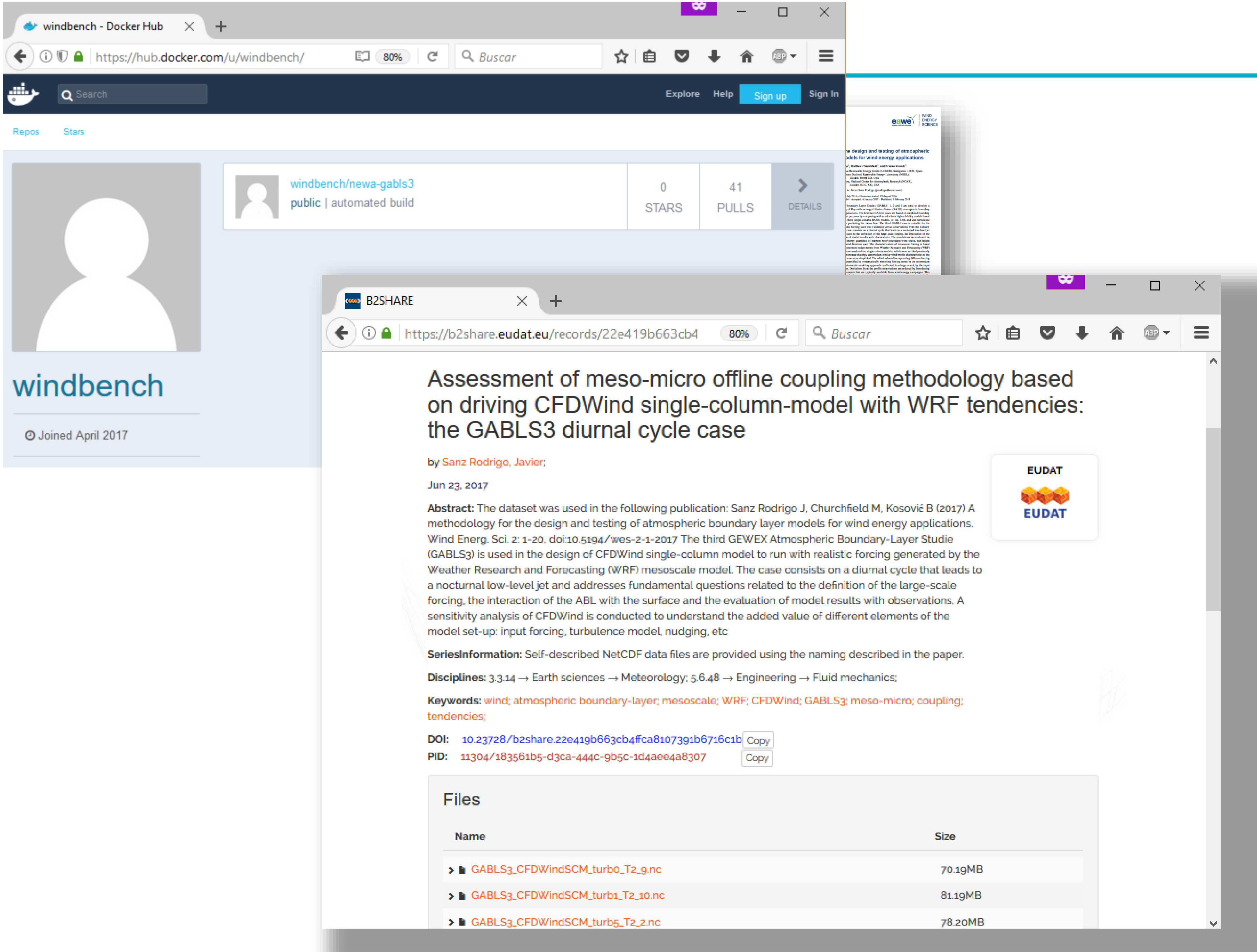
windbench - Docker Hub
https://hub.docker.com/u/windbench/
Explore
Help
Sign up
Sign In
Repos
Stars
windbench/newa-gabls3
public | automated build
0
STARS
41
PULLS
DETAILS
windbench
Joined April 2017
B2SHARE
https://b2share.eudat.eu/records/22e419b663cb4
Assessment of meso-micro offline coupling methodology based on driving CFDWind single-column-model with WRF tendencies: the GABLS3 diurnal cycle case
by Sanz Rodrigo, Javier;
Jun 23, 2017
Abstract: The dataset was used in the following publication: Sanz Rodrigo J, Churchfield M, Kosović B (2017) A methodology for the design and testing of atmospheric boundary layer models for wind energy applications. Wind Energ. Sci. 2: 1-20, doi:10.5194/wes-2-1-2017 The third GEWEX Atmospheric Boundary-Layer Studie (GABLS3) is used in the design of CFDWind single-column model to run with realistic forcing generated by the Weather Research and Forecasting (WRF) mesoscale model. The case consists on a diurnal cycle that leads to a nocturnal low-level jet and addresses fundamental questions related to the definition of the large-scale forcing, the interaction of the ABL with the surface and the evaluation of model results with observations. A sensitivity analysis of CFDWind is conducted to understand the added value of different elements of the model set-up: input forcing, turbulence model, nudging, etc
SeriesInformation: Self-described NetCDF data files are provided using the naming described in the paper.
Disciplines: 3.3.14 → Earth sciences → Meteorology; 5.6.48 → Engineering → Fluid mechanics;
Keywords: wind; atmospheric boundary-layer; mesoscale; WRF; CFDWind; GABLS3; meso-micro; coupling; tendencies;
DOI: 10.23728/b2share.22e419b663cb4ffca8107391b6716c1b Copy
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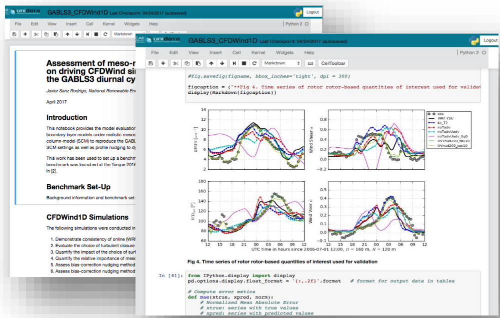
GABLS3: CFDWindSCM Evaluation Notebook



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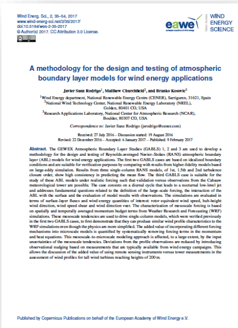

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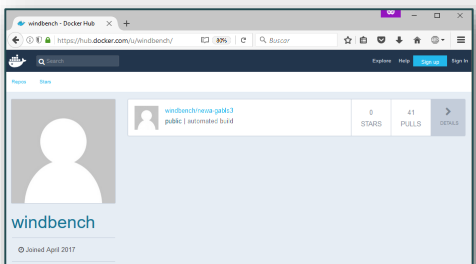

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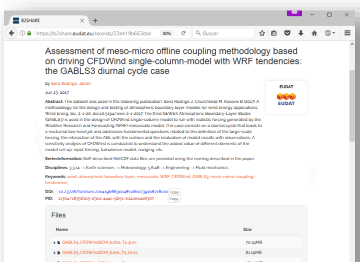

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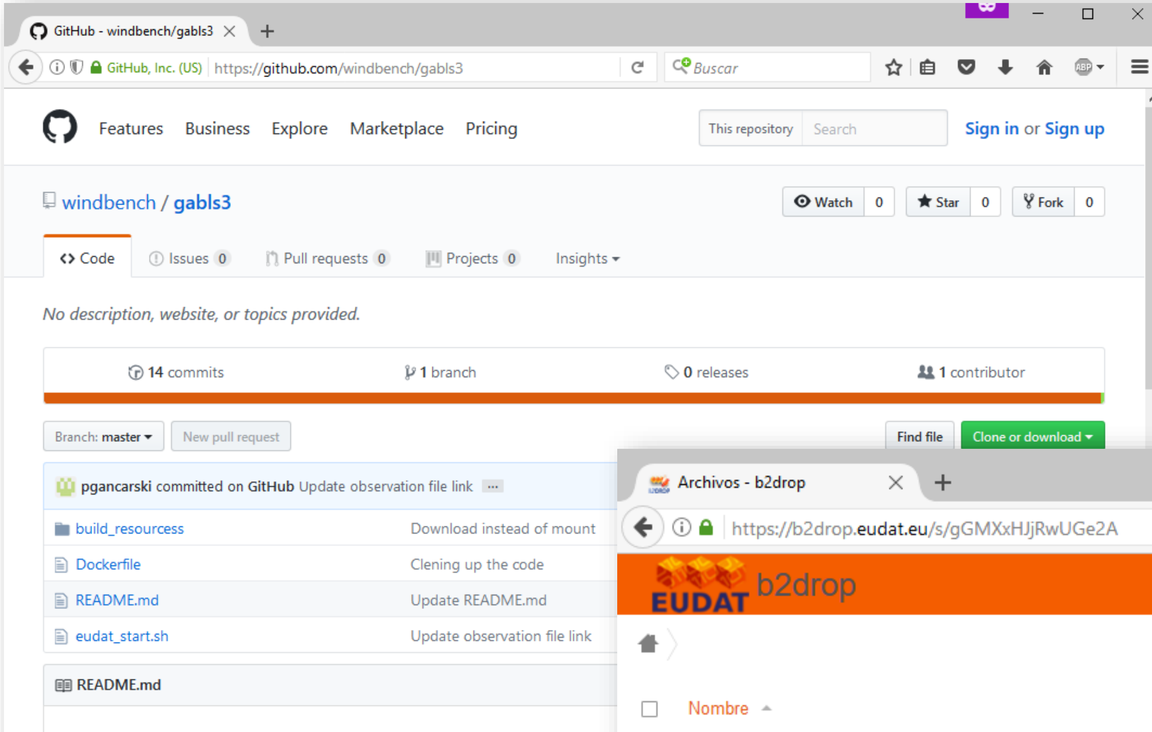

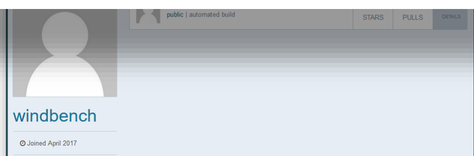

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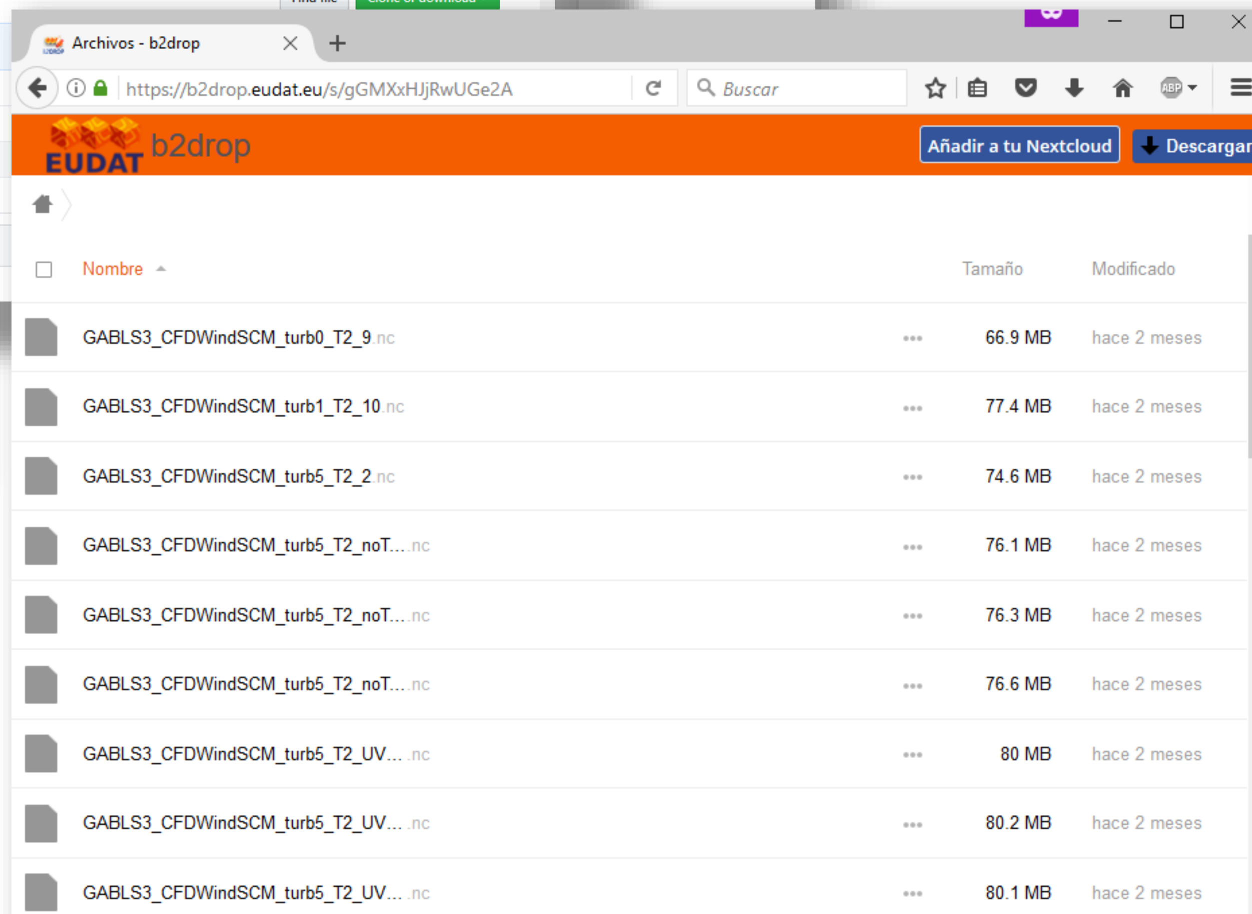
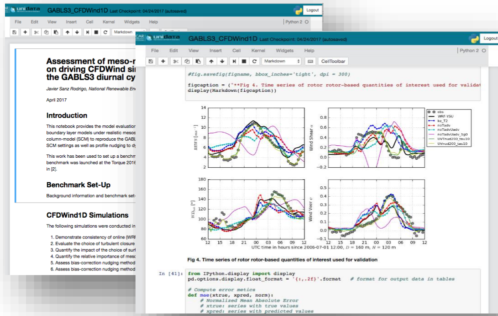


GABLS3: CFDWindSCM Evaluation Notebook



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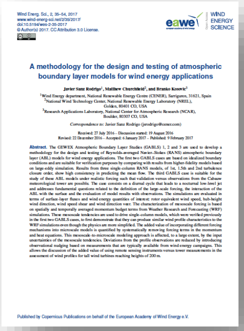

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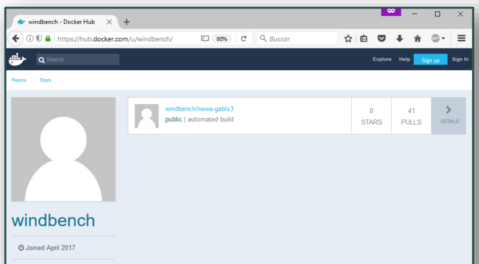

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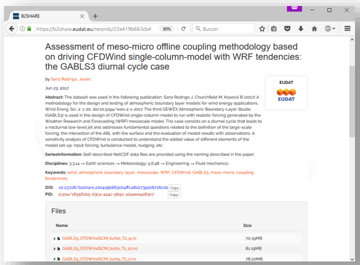

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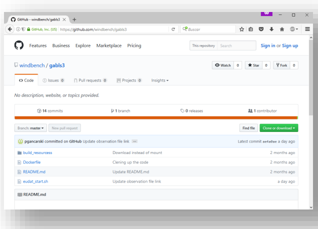
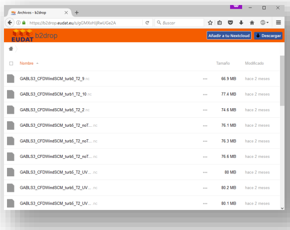


https://github.com/windbench/gabls3



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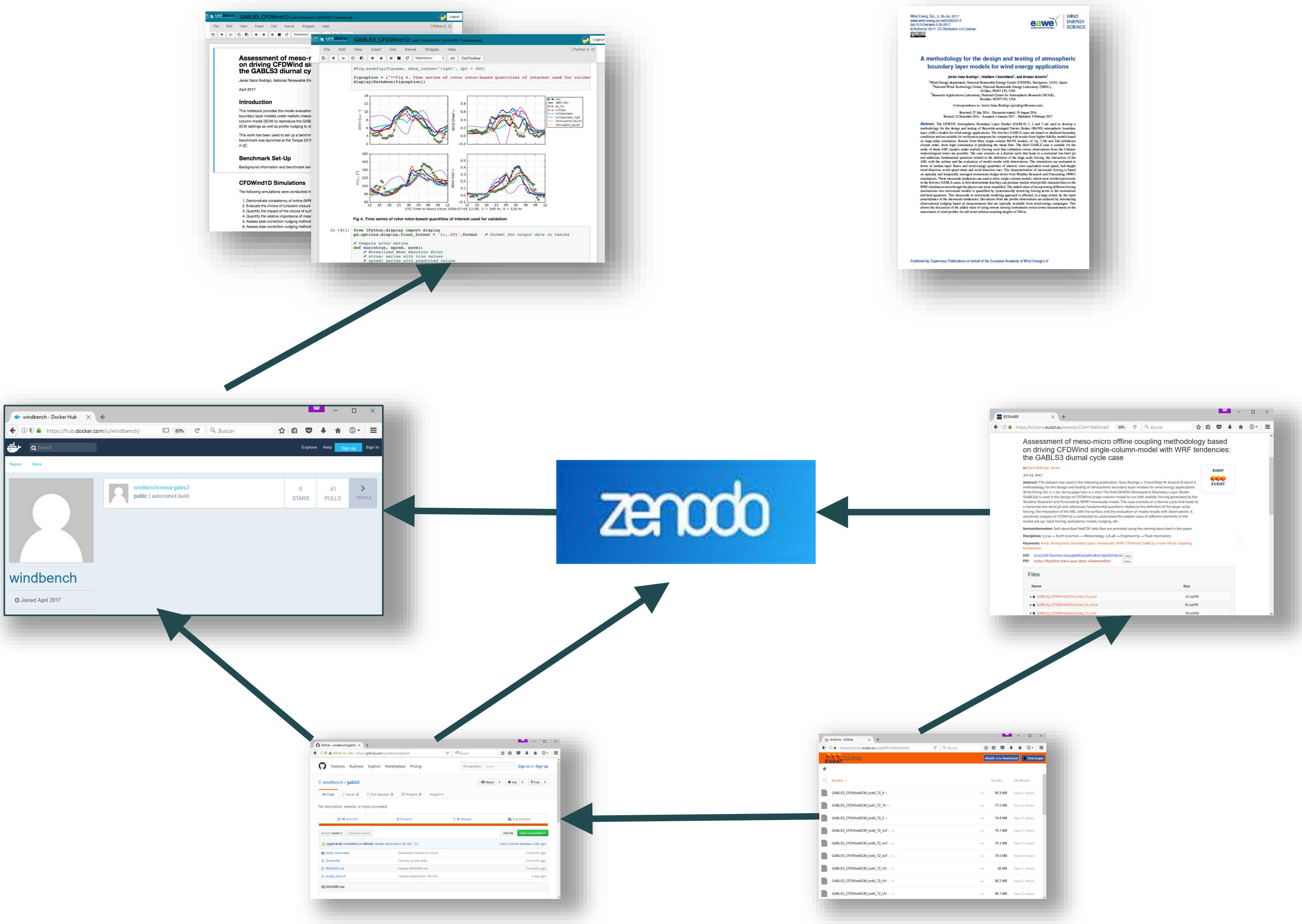

Conclusions and Outlook

- New Windbench design to integrate with European e-infrastructures and promote open science
- Ambidextrous V&V process to combine data from research experiments and operational campaigns
- Pilot for WE portal for data discovery and exploitation (IRPWind/WP2)
- NEWA Meso-Micro Challenge and GABLS3 demo cases

Outlook

- End-user engagement through existing projects: Wakebench, NEWA and A2e
- Implementation through mid-2018

Acknowledgements

This work has been produced with support from the following projects:

- ***MesoWake***, European Comission FP7-PEOPLE-2013-IOF, 624562, http://www.windbench.net/mesowake-2014-2017
- ***NEWA***, European Comission FP7-ENERGY-2013.10.1.2, 618122, http://www.neweuropeanwindatlas.eu/; MINECO, Spain, PCIN-2014-011-C07-02
- ***IRPWind***, European Comission FP7-ENERGY-2013-IRP, 609795, http://www.irpwind.eu/
- ***IEA Task 31 Wakebench Phase 2***, International Energy Agency
- **PRACE-MesoWake**, PRACE 13th Call, MareNostrum, Barcelona

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