



**Barcelona
Supercomputing
Center**

Centro Nacional de Supercomputación



**EXCELENCIA
SEVERO
OCHOA**

Wind energy production vulnerability: a quality-driven selection

Carlo Lacagnina

Use case and requirements

Use case example:

Use case question: “Are there trends in surface wind speed in the Alps over last 50 years to estimate the actual vulnerability of investments in wind energy production?”

The same question towards the data inventory means: “Which are the data records suited to analyze trends in this rather small region?”



The next step is building a **user requirement** table containing the technical specification of the relevant variable

Requirements	Coverage	Temporal resolution	Horizontal resolution	Record length
best	Alps	hourly	6 km x 6 km	50 yrs (1979 – 2019)
acceptable	Alps	sub-daily	10 km x 10 km	40 yrs

Copernicus Climate Change Service (C3S)








So now our users go to one of the most important climate data services: C3S to look for the dataset supporting their decision



Copernicus is the European Union's Earth observation programme coordinated and managed by the European Commission

Copernicus provides a unified system through which vast amounts of data are fed into a range of ***thematic information services***. One of those is the ***Copernicus Climate Change service (C3S)***, which aims at providing comprehensive information about past, present and future climate to a wide range of users (e.g. policy makers, scientists, business operators)

User requirement table

	In situ temperature, relative humidity and wind profiles from 2006 to March 2020 from the GRUAN reference network <small>In situ temperature, relative humidity and wind profiles from 2006 to March 2020 from the GRUAN</small>
	Climate data for the European energy sector from 1979 to 2016 derived from ERA-Interim <small>The dataset contains wind speed, precipitation, relative humidity, global horizontal irradiance</small>
	CMIP6 climate projections <small>-surface wind, Eastward wind, Evaporation including sublimation and transpiration, Grid-cell area for ocean</small>
	Arctic regional reanalysis on single levels from 1998 to 2019 <small>and top of atmosphere fluxes, precipitation, cloud, humidity, wind, pressure, snow and sea variables</small>
	Ocean surface wave indicators for the European coast from 1977 to 2100 derived from climate projections <small>'s Wave Model (Stand Alone WAM, SAW) forced by surface wind and accounting for ice coverage in polar</small>
	ERA5 monthly averaged data on single levels from 1979 to present <small>in the dataset/application are: 100m u-component of wind, 100m v-component of wind, 10m u-component</small>
	ERA5 hourly data on single levels from 1979 to present <small>-component of wind, 100m v-component of wind, 10m u-component of neutral wind, 10m u-component of wind, 10m v</small>

Browsing the C3S, I find that some data is about wind speed

The assessment of the available datasets against the user requirements results

Colors indicate up to which level user requirements are satisfied:

Red -> not acceptable;
Orange -> acceptable; **Green** -> best

Dataset	Coverage	Temporal resolution	Horizontal resolution	Record length
In-situ GRUAN profiles	1 station in the Alps	sub-daily	meters around station	14 yrs (2006 – 2020)
Global reanalysis (e.g. ERA5, ERA5-Land)	Global	hourly	8 km x 8 km	71 yrs (1950 -2021)
Regional reanalysis UERRA	Europe	hourly	5.5 km x 5.5 km	58 yrs (1961 – 2019)
Climate data for the energy sector	Europe	daily	40 km x 40 km	37 yrs (1979 – 2016)

Documentation jungle

Ok, I understood that reanalysis products fit my application, but...

Now I have to figure out which dataset to use and how to use it

Any user guide? Any way to explore how data look like? Are there limitations to take into account? Any uncertainty characterization?



ERA5-Land hourly data from 1981 to present

Overview Download data Quality assessment Documentation

- [ERA5-Land online documentation](#)

Further and more detailed information relating to the ERA5-Land dataset can be found in the Copernicus Knowledge Base web link above.

UERRA regional reanalysis for Europe on single levels from 1961 to 2019

Overview Download data Quality assessment Documentation

- [UERRA product user guide v3.3 \(PDF\)](#)
- [Known issues in UERRA](#)
- [Documenting the UERRA system \(PDF\)](#)

Describes the model setup, verification tools and archiving choices.

ERA5 hourly data on single levels from 1979 to present

Overview Download data Quality assessment Documentation View

- [ERA5 online documentation](#)
- [Renamed variable: form ocean waves 10m wind to ocean surface stress equivalent 10m neutral wind](#)

The reason for the change was a parameter name clash between variables in ERA5 wind and ERA5 ocean waves.

In situ temperature, relative humidity and wind profiles from 2006 to March 2020 from the GRUAN

Overview Download data Quality assessment Documentation

General product information

- [Product user guide \(PUG\) \(PDF\)](#)
The product user guide summarizes the characteristics of the dataset(s) in a concise manner with focus on space and time extent and resolution, data format
- [GRUAN official website](#)
Official website describing the GRUAN concept and providing general background information
- [Full specification of the Common Data Model for in situ observations. \(PDF\)](#)
Latest version of the Common Data Model for in situ observations.

Vaisala RS92 radiosondes

Metsel RS-11G radiosondes

Documentation looks heterogeneous across datasets, difficult to compare

Quality assessment tab

UERRA regional reanalysis for Europe on height levels from 1961 to 2019

Overview Download data Quality assessment Documentation

This is a new feature, work in progress. Should any inconsistency be found, please report to copernicus-support@ecmwf.int

The CDS datasets are assessed by the Evaluation and Quality Control (EQC) function of C3S independently of the data supplier. EQC encompasses a framework of processes available through the CDS. During the EQC process, the documentation provided with the dataset is scrutinized and data are checked for usability and reliability.

Variable: 5.
Wind speed ✕ Relative humidity ✕

Variable: Relative humidity

Last updated on 24/03/2021

Variable: Wind speed

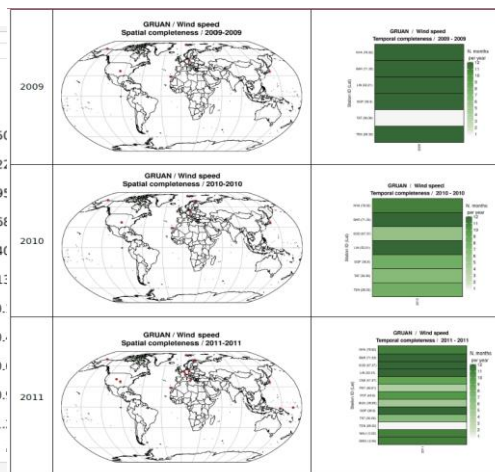
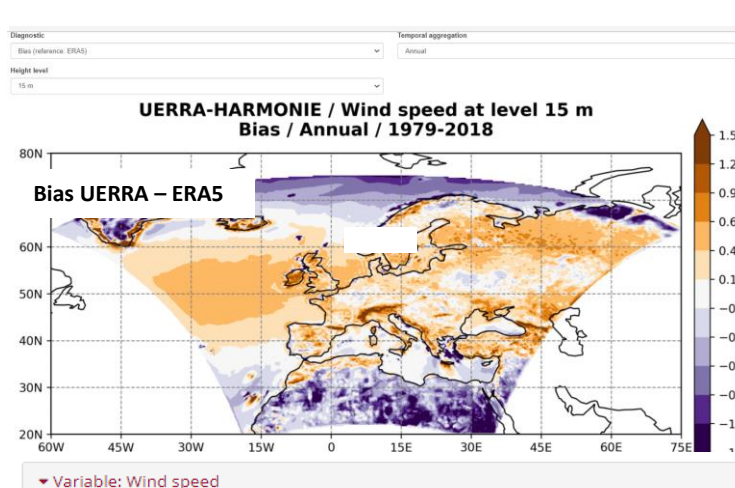
Last updated on 24/03/2021

INTRODUCTION 6.	USER DOCUMENTATION	ACCESS	INDEPENDENT ASSESSMENT
Dataset overview	User guide 1.	Toolbox compatibility	Data check
Temporal and spatial coverage and resolution	Scientific methodology	Archive	Expert evaluation 4.
Providers	Uncertainty quantification		Dataset maturity
Dataset version	Validation 2.		Key strengths and limitations 3.
Data update	Inter-comparison		

The “Quality assessment” tab offers homogeneous information across datasets, easy to compare:

1. I find the user guide to understand how to use my data
2. I find uncertainty and validation characterization
3. I see the known issues and limitations of this dataset
4. I can explore how the data look like and evaluation methods used
5. I can explore each variable separately
6. I get a comprehensive overview of the dataset characteristics

Quality assessment tab



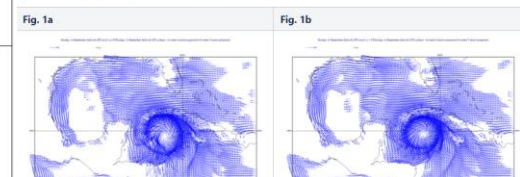
ERA5: large 10m winds

Created by Paul Benson, last modified by Michela Guisti on Feb 11, 2021

A few times per year, the analysed low level winds, eg the 10m winds, become unrealistically large in a particular location, which varies amongst a few apparently preferred locations. The largest values seen so far are about 300 ms^{-1} .

From 19 February 2020, the ERA5 system examines the 10m wind components and if the magnitude of either component exceeds 50 ms^{-1} then the analysed parameters are replaced with the "4v" parameters. These latter parameters are similar to the analysed ones, but don't usually suffer from such large values.

The choice of a 50 ms^{-1} cut off is an arbitrary one, which could miss spurious values that are less than 50 ms^{-1} . It is also possible that this cut off point could penalise realistic winds, such as in hurricanes. However, given the spatial resolution of ERA5 data, it is thought that in general, 10m wind components higher than 50 ms^{-1} are not realistic for this resolution, even if the observed magnitude is higher, as is the case for Hurricane Ivan in the Caribbean on 12 September 2004. This case is illustrated in Fig. 1, below, where the analysed winds are compared with the 4v winds. The minimum value of the analysed 10 metre V wind components is -53 ms^{-1} (see Table 2) whilst the minimum value of the 4v 10 metre V wind components is -29 ms^{-1} . Even though the analysed wind speeds are not as large as the observed ones (the estimated peak wind speeds for Ivan were of order 70 ms^{-1}), the 4v winds are thought to give a more realistic representation of the winds, for this resolution.



Last updated on 24/03/2021

INTRODUCTION

Dataset overview

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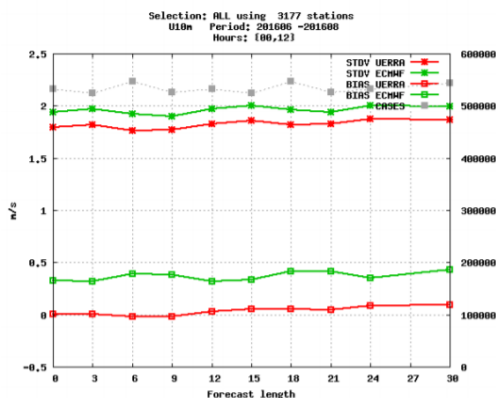
INDEPENDENT ASSESSMENT

Data check

Expert evaluation

Dataset maturity

Key strengths and limitations



Guided by the "Quality assessment" tab, the user can understand that:

- ☐ UERRA performs better than global reanalysis
- ☐ ERA5 has known issues in simulating wind speed
- ☐ In-situ GRUAN provides better measurements but it offers only 1 station in the Alps for 7 years and with temporal gaps