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Tall wind masts: wind data processing and evaluation

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1. Collect wind data from tall towers
2. Read and process wind speed and wind direction data

INDECIS Raw-Data Set - INDECIS-RDS

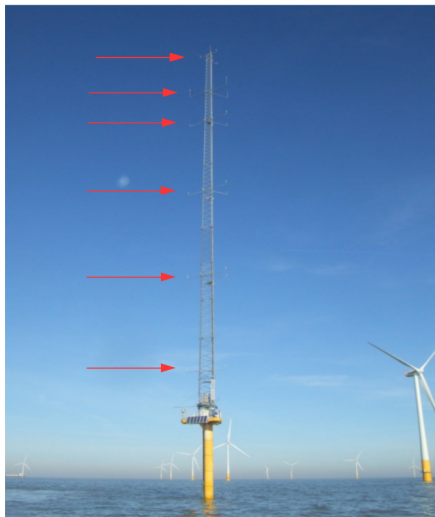
3. QC Procedures (QC Rules) + Homogenization
4. Validation of the Quality Control Software Suite
(Benchmarking experiment)

INDECIS Quality Controlled and Homogenized
Data Set - INDECIS-QCHDS

5. Climate indices calculation



Kentish Flats windfarm, UK



Kentish Flats windfarm, UK

Collection of data from tall towers



Identification of tall towers. Tower metadata:

File Edit View Insert Format Tools Data Window Help

Liberation Sans 10

M4C10

POE_end

List of TallTower Met Masts

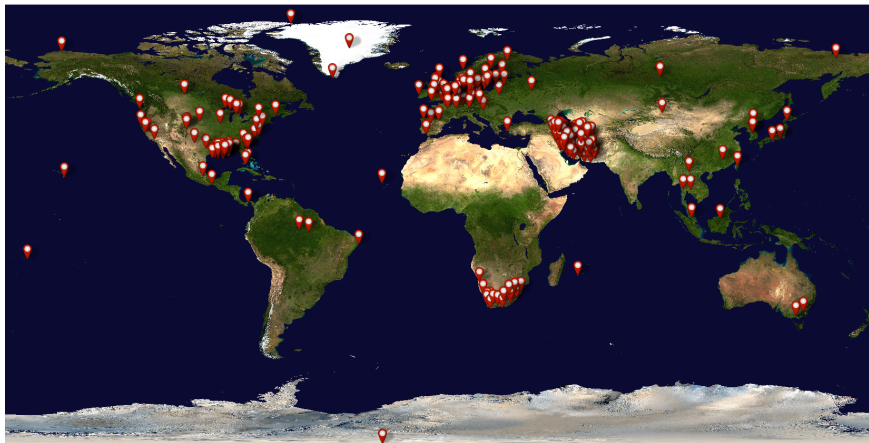
Source	Name	Owner	Long_name	Country	Lat	Lon	Site_elevation	POR_start	POR_end	License	Data_format	Data
BALTEX	cabauw	KNMI	Cabauw	NL				2001	2017	Cesar data pol	NetCDF	UTC
BALTEX	sodankyla	FMI	Sodankyla	FI	51.971	4.926	433	2000	2012			
BALTEX	lindenberg	DWD	Lindenberg	DE	67.3618611	26.63783333		2003	2009	CEOP	ASCII NetCDF	
BALTEX/ ICOS Sweden	norunda	Lund university	Norunda	SE	52.1663	14.1226		1994				
	hamburg	Hamburg university	Hamburg	DE	60.0821688	17.4594662		1995				
	saclay	CEA	Saclay	FR	48.7227	2.142						
FINO	fino1	Fino Project	Fino1	DE	54.01486	6.587639		2003		FINO project	ASCII	
FINO	fino2	Fino Project	Fino2	DE	55.0069	13.1542		2007		FINO project	ASCII	
FINO	fino3	Fino Project	Fino3	DE	55.195	7.158		2009		FINO project	ASCII	
ESRL	bao	ESRL	BAO	US				2007	2016	Free	ASCII	UTC
ESRL	mauna_loa	ESRL	Mauna Loa	US	40.05	-105.004		1977	2015			UTC
ESRL	trinidad	ESRL	Trinidad Head	US	19.5362	-155.5763						UTC
ESRL	summit	ESRL	Summit	GL	41.0541	-124.151						UTC
ESRL	samoa	ESRL	Summit	GL	72.58	-38.48						UTC
ESRL	south_pole	ESRL	American Samoa	AS	-14.2474	-170.5644						UTC
ESRL	south_pole	ESRL	South Pole	US	-89.98	-24.8						UTC

Tall Towers Sources for Tall Towers Remote Sensing Farms Surface Rawsondes

Find Find All Match Case

invereo Sectorial Climate Services

Tall towers identified around the globe:



311 tall towers

Tall towers identified in Europe:



93 tall towers

- ▶ 194 sites have been processed (62% of the 311 masts)
- ▶ Storing wind speed and wind direction measurements
- ▶ Common final format (NetCDF)


```
Dimensions:
  time = UNLIMITED ; // (44640 currently)
  latitude = 1 ;
  longitude = 1 ;
  height = 1 ;
Variables:
  float time(time) ;
    time:standard_name = "time" ;
    time:long_name = "hours since 2013-05-01 00:00:00" ;
    time:units = "hours since 2013-05-01 00:00:00" ;
    time:sampling = "minutely" ;
    time:axis = "T" ;
  float longitude(longitude) ;
    longitude:standard_name = "longitude" ;
    longitude:long_name = "longitude" ;
    longitude:units = "degrees_east" ;
    longitude:axis = "X" ;
  float latitude(latitude) ;
    latitude:standard_name = "latitude" ;
    latitude:long_name = "latitude" ;
    latitude:units = "degrees_north" ;
    latitude:axis = "Y" ;
  float height(height) ;
    height:standard_name = "height" ;
    height:long_name = "height" ;
    height:units = "m" ;
    height:positive = "up" ;
    height:axis = "Z" ;
  float windagl27S3(time) ;
    windagl27S3:standard_name = "wind_speed" ;
    windagl27S3:long_name = "Wind speed of sensor 3" ;
    windagl27S3:units = "m s-1" ;
    windagl27S3:_FillValue = -9999.f ;
    windagl27S3:cell_methods = "time: mean" ;

// global attributes:
  :tower_name = "ijmuiden" ;
  :institution = "ECN" ;
  :boom_directions = "240" ;
  :location = "NL" ;
  :offshore = "yes" ;
  :tower_type = "NA" ;
  :creation_time = "2017-11-27-T22:49:42Z" ;
  :links = "https://www.windopzee.net/en/meteomast-ijmuiden-mmij/introduction/" ;
  :history = "" ;
}
```

- ▶ 194 sites have been processed (62% of the 311 masts)
- ▶ Save wind speed and wind direction measurements
- ▶ Common final format (NetCDF)
- ▶ How will be these data integrated in ECA&D portal?
- ▶ Redistribution of wind data. Data policy.
 - ▶ Freely available
 - ▶ Available with conditions
 - ▶ Prohibited transferring to thirds
 - ▶ Not downloadable
- ▶ Updates: final update at the end of the project. Scripts

Quality Control tests list (QCRs):

- ▶ QC During reading data
- ▶ Inspection of metadata and site surroundings for non-recommended installation practices
- ▶ Plausible values test.
Maximum wind speed value: wind speed world record measurement: 113.2 ms^{-1} in Australia
- ▶ Internal consistency tests.
- ▶ Repeated sequences
- ▶ Out of range test

Quality Control tests list (QCRs):

- ▶ Spike test:

Step test: 20 ms^{-1} for 2-min avg wind speed (WMO)
 10 ms^{-1} for 10-min and 30-min data (Jimenez et al., 2010)

- ▶ Rate of change test: excessive rise/fall test

The rate of change between $WS(n-1)$ and $WS(n)$ must be less than the IQR

- ▶ Differences between extreme values of the empirical distribution

- ▶ Flat line test: detect invariable values

- ▶ Attenuated signal test

- ▶ Multi variate test: comparison to other variables and sensors (redundancy)

- ▶ Systematic errors

Software packages for QC and homogenization

- ▶ Climatol (R package)
- ▶ Windographer
- ▶ Action ES0601
- ▶ HOME_R
- ▶ RClimdexExtraQC
- ▶ Acmant, AnClim

Benchmarking experiment

- ▶ Capacity factor (CF):

$$CF = \frac{\text{produced power in a time period } t}{\text{maximum produced power in a time period } t}$$

- ▶ Wind Power Density (WPD):

$$WPD = \frac{1}{2} * \rho * v^3$$

- ▶ Analysis of relations between sectorial data and these indices for specific sites

Comparison between point observations and reanalyses output.

- ▶ Pilot study for wind energy:
North Sea
 - ▶ Important increase of installed power capacity
 - ▶ Compute CF and WPD with seasonal forecast simulations for stations within this region
 - ▶ Comparison with data measured in this region



Here are the main tasks in chronological order:

1. Identify data from tall towers
2. Download, read and transform data into a common format
3. Application of Quality Control Rules
4. Application of the Homogenization techniques
5. Climate indices calculation for wind power: CF and WPD
6. Comparison of the indices with reanalyses output
7. Case study: verification of indices calculated from past seasonal forecasts against those calculated with observations