

Wind analyst or site engineer:

expert on wind climates with no
much interest on climate

(unknown source)

Climate Service working on Wind Energy:

specialists in **climates** and also **wind**,
who lack understanding about the
notion of “**site**”

(another unknown source)

What do users expect from CCCS Renewable Energies (Wind & Solar)



Gil Lizcano

Vortex R&D Team

@ 2nd ECMWF Climate Change Service Workshop

June 2014



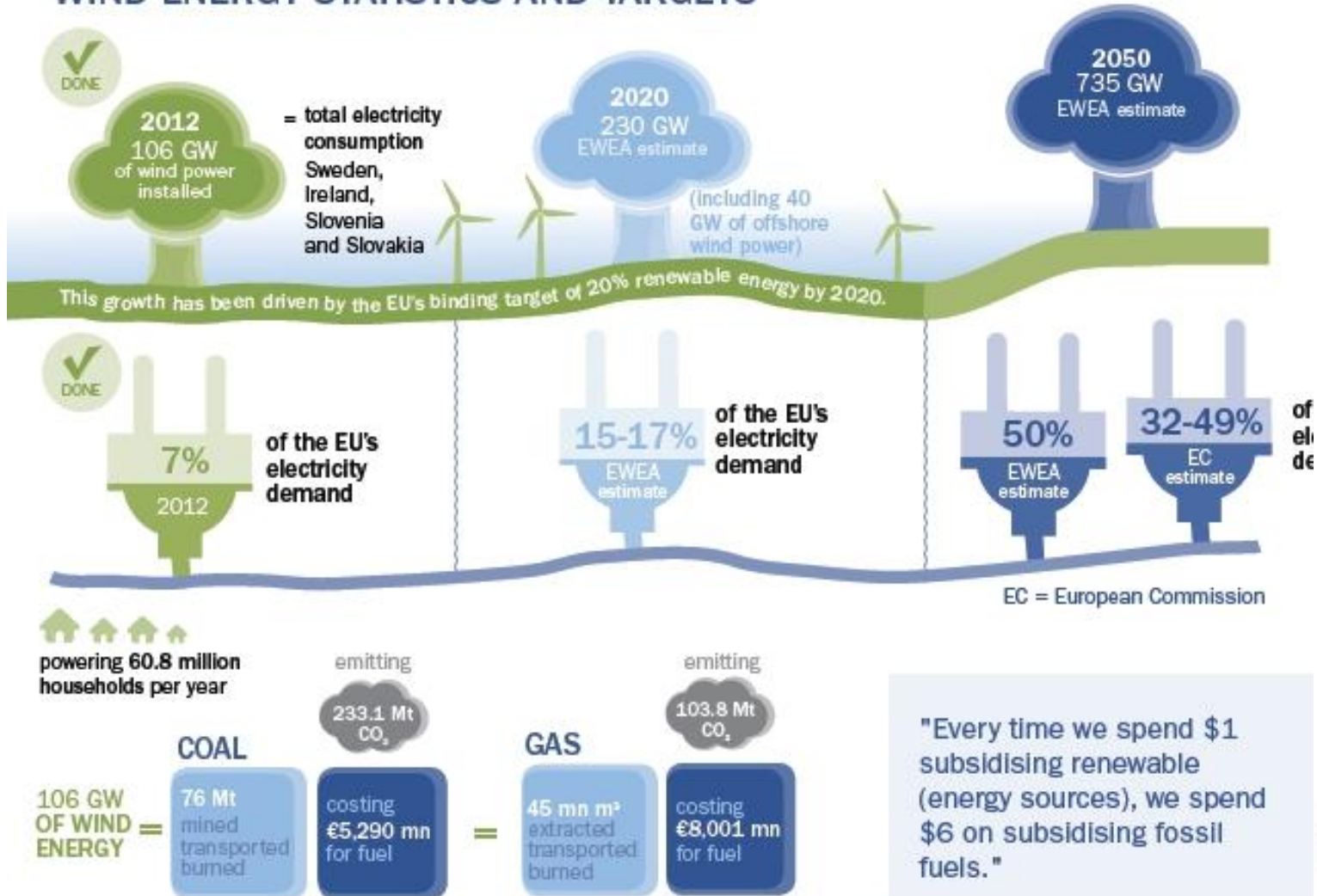
→ Who are the users?

→ What do they do?

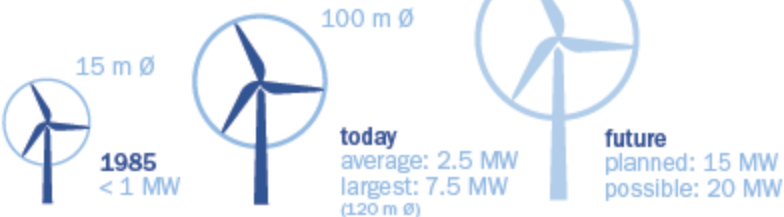
→ What would they like to do?



WIND ENERGY STATISTICS AND TARGETS



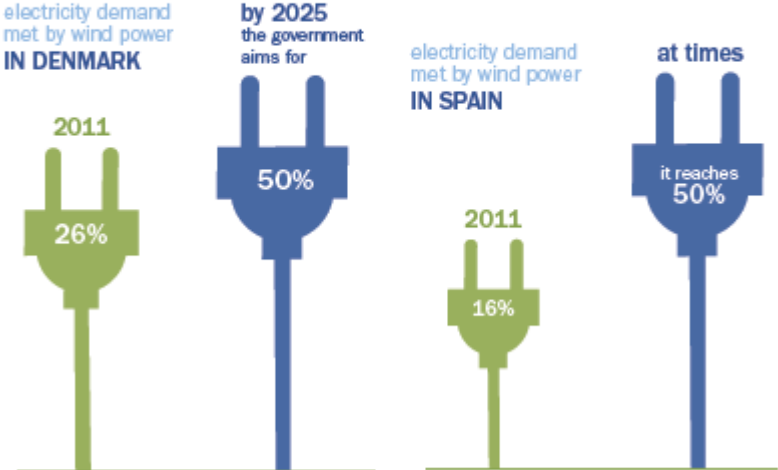
TECHNOLOGY



Wind turbine manufacturers are also developing longer blades and lighter rotors in order to optimise and increase energy production.

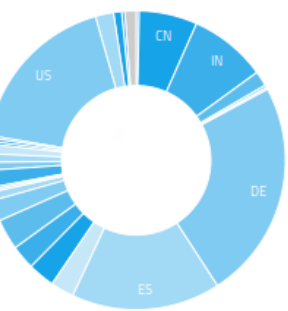
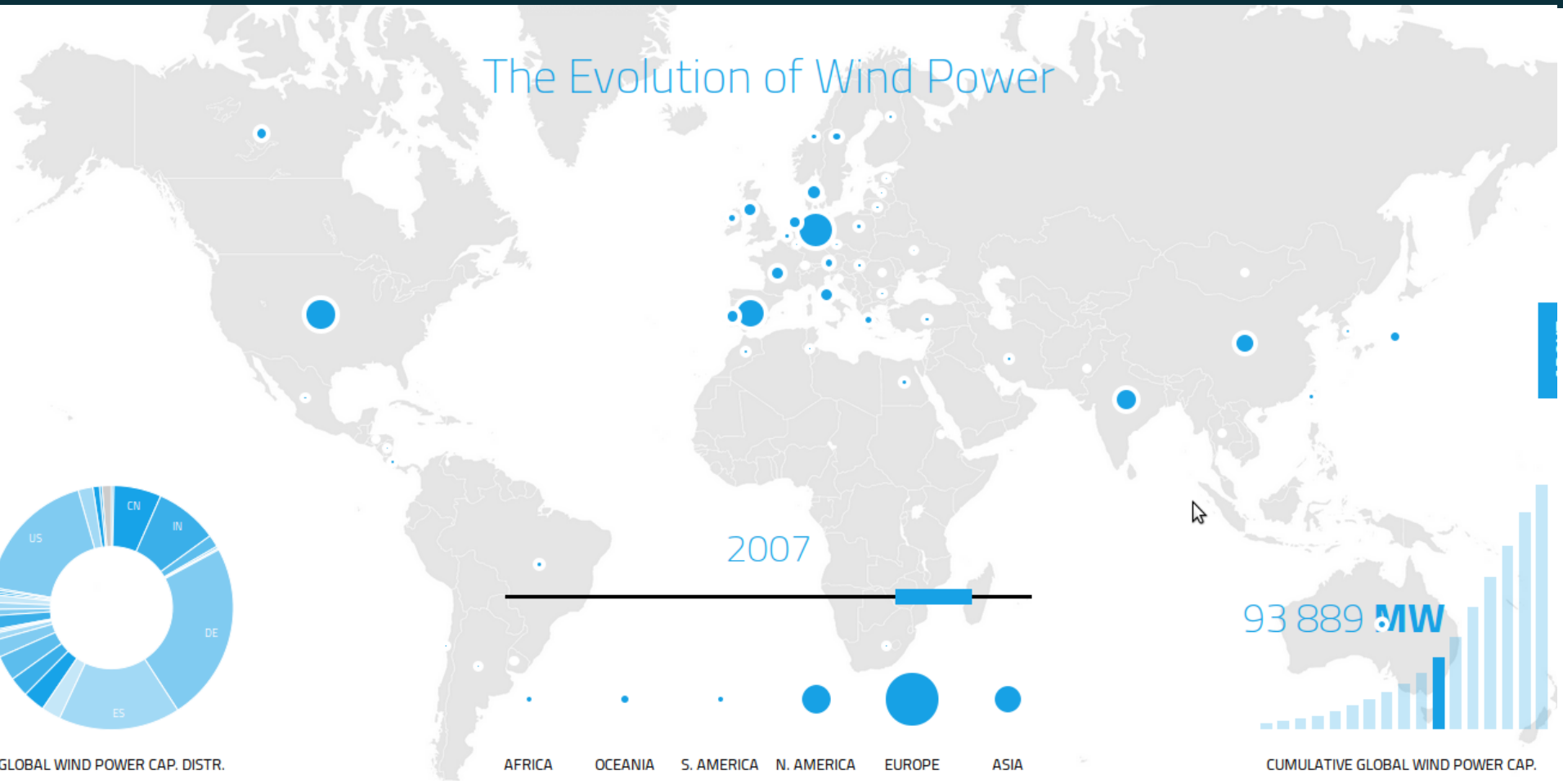
EUROPE'S ELECTRICITY SUPPLY

Grid operators can integrate large amounts of wind power:

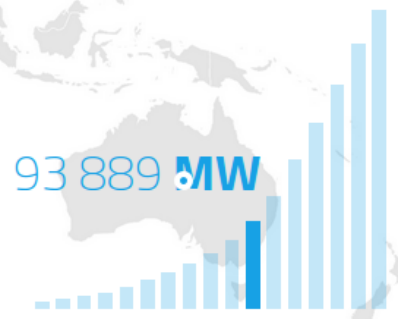


SOURCE: EWEA, <http://www.ewea.org/wind-energy-basics/facts/>

The Evolution of Wind Power

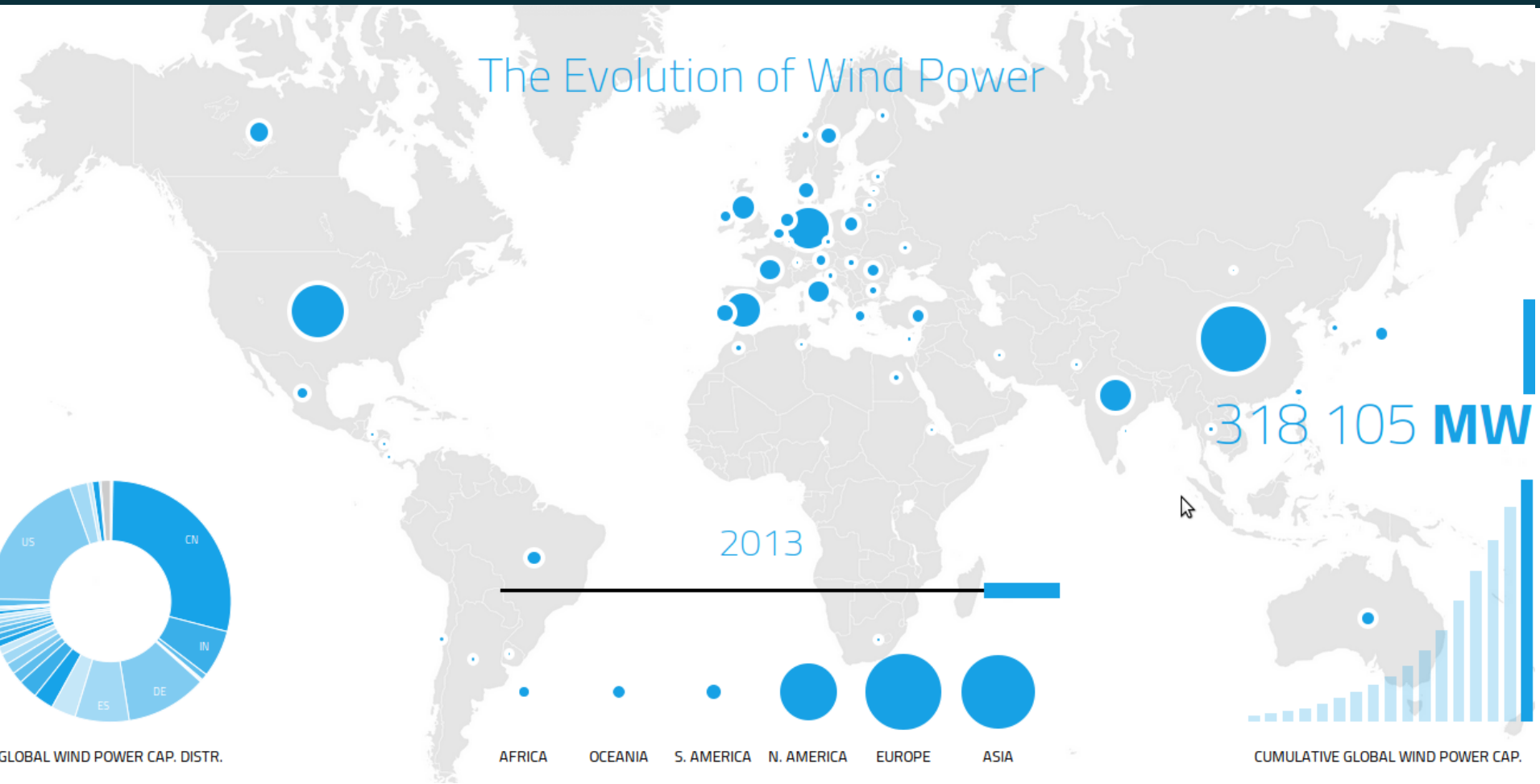


GLOBAL WIND POWER CAP. DISTR.



CUMULATIVE GLOBAL WIND POWER CAP.

SOURCE: Data from [The Wind Power](#), [GWEC](#) and [Wikipedia](#). Design by [Breeze](#).
<http://www.breezesystem.com/resources/evolution-of-wind-power/>



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<http://www.breezesystem.com/resources/evolution-of-wind-power/>

→ @ClimateServices: better information

→ @Industry: #Global Market

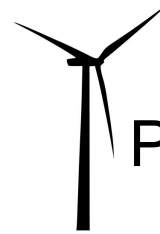
→ #Information & Technology



@EWEA EVENT 2014 Conference, Resource Assessment Sessions

- Power curves in the real world: Are we achieving what's on the tin?
- The model chain: Can we improve?
- Optimising measurement strategies to maximise project value:
- Wind turbine noise: A limiting factor of the deployment of onshore wind turbines in Europe?
- Reanalysis data: A viable alternative to conventional ground based measurements?
- Wakes: Do we need different models for onshore and offshore wind farms?
- Wind speed predictions: Are we at the limit of our knowledge or can we improve?
- Forecasting: Are they being integrated into the business processes?
- Remote sensing devices: Toys or tools?

Pre-Construction



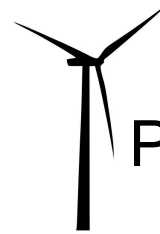
Post-Construction

Feasibility
Assess average and percentiles of
project production

Return on investment (INDUSTRY)
Maximize benefits according to market
demand and O&M (OWNERS)
Inject and balance the energy in the
grid (TSO)



Pre-Construction



Post-Construction

Feasibility
Assess average and percentiles of
project production

RETROSPECTIVE tools
(reanalysis and derived
products)

Return on investment (INDUSTRY)
Maximize benefits according to market
demand and O&M (OWNERS)
Inject and balance the energy in the
grid (TSO)

FORECASTING tools
(mostly short term)

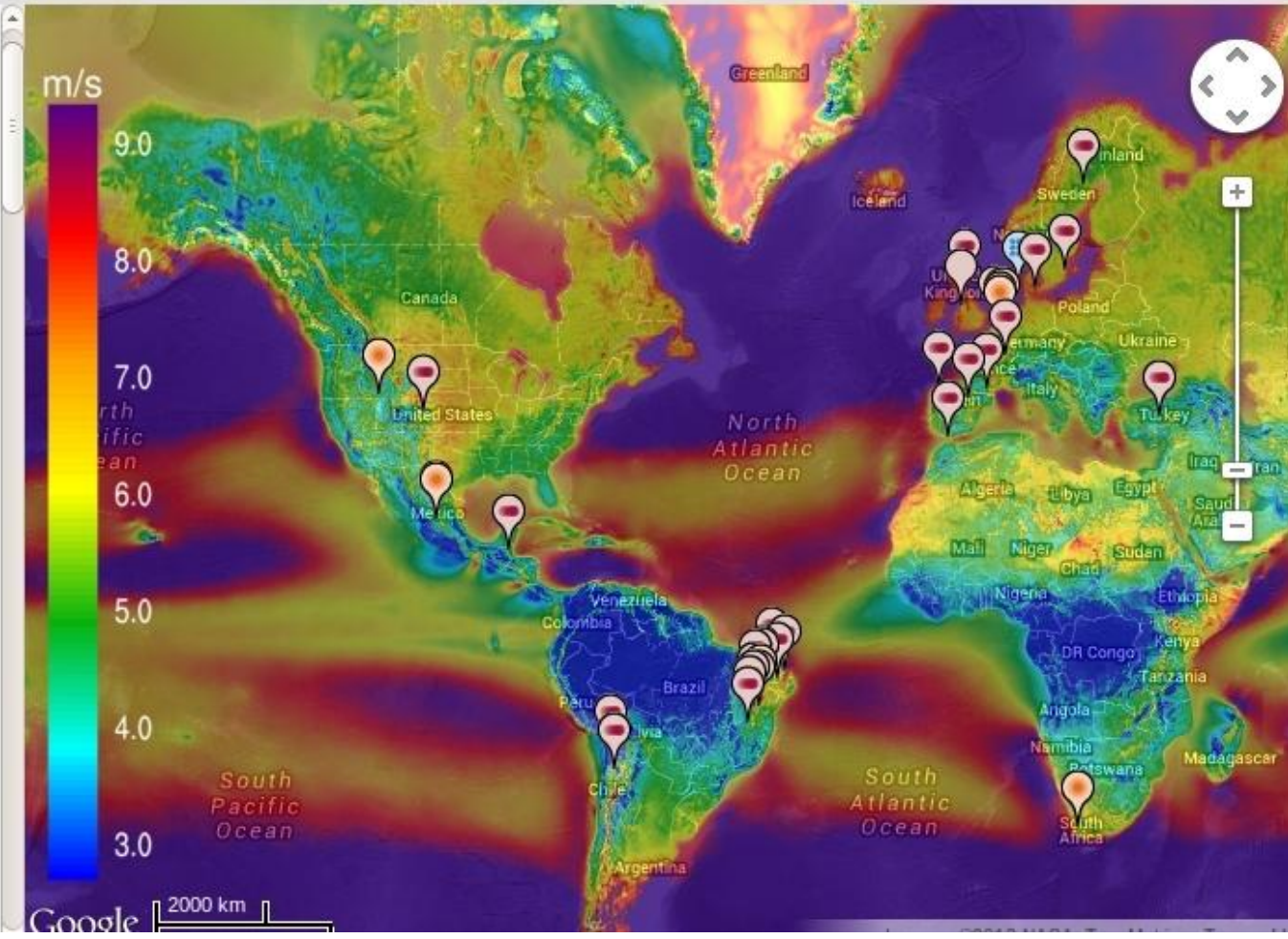
- ★ **Project Developers**
 - Iberdrola, Next Era, E-ON, DONG, Suzlon
- ★ **Manufacturers**
 - Alstom, Vestas, Enercon, Siemens, GE, Sinovel, Goldwind
- ★ **Consultancies**
 - DNV-GL, Natural Power, Sgurr, Hatch, Ecofys, Mott-MacD
- ★ **Information Services (*middleware*)**
 - Vortex
- ★ **Institutions/Academy**
 - World Bank/ESMAP, IRENA, DTU, ForWind, NREL
- ★ **TSO**
- ★ **Finance/Insurance**

About Vortex

- Vortex is wind conditions & resources global modeling engine
- Facilitate access to complex atmospheric modeling chain
- Working on-demand
- Our core is mesoscale atmospheric model WRF
- Our sources are Re-Analysis families
- about 40.000.000 km² of complete screening resource maps
- over 50,000 year of virtual hourly times series of wind information
- We are not a consultancy but a wind resource information service
- We do not charge engineering hours but CPU hours

www.vortex.es

- Recently used runs (10 Runs)
- 36515 United Kingdom
- 35855 Pozo Almonte
- 35834 Inova BA
- 35833 SL02-01
- 35832 SL01-01
- 35018 Idaho
- 34936 LU-P-0104, 27737 Abad
- 34550 Baldy, Belize
- 33647 Sj Piauí - y10
- 33665 Coremas - 10y
- creyab (1 Runs)
- 36515 United Kingdom
- solar (12 Runs)
- 35855 Pozo Almonte
- 35834 Inova BA
- 35833 SL02-01
- 35832 SL01-01



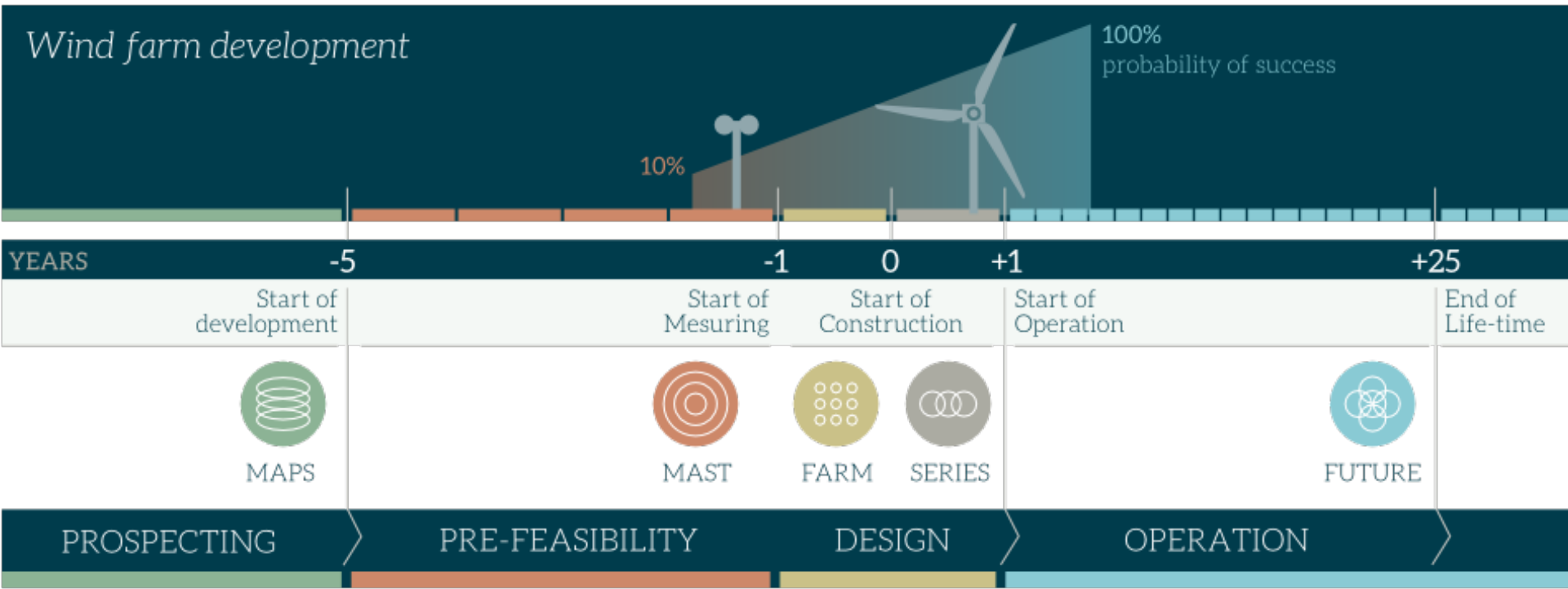
Pre-Construction

- ★ Pre-screening resource information ~ 1km
- ★ Site-analysis ~ 100m
- ★ Long-term references
- ★ Extremes conditions: Vref (50y), Icing, Dust
- ★ Metocean: wave topology

Post-Construction

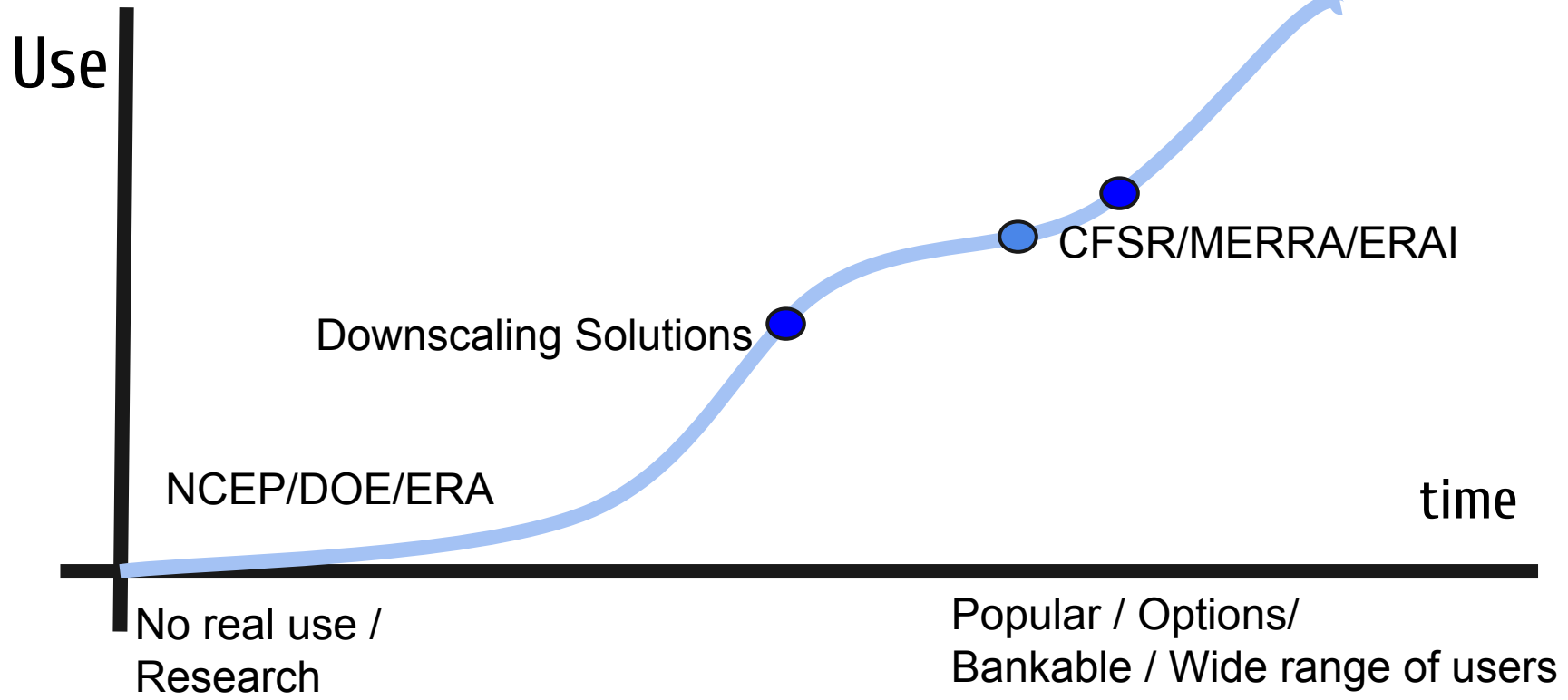
- ☐ Intraday and day-ahead Resource & Power forecast
 - ☐ Project by project
 - ☐ Porto-folio (combo solar-wind)
- ☐ Other forecasts (lighting, icing ...)
- ☐ SS2S Forecasts
- ☐ Near-Term Forecast & Climate Change

Wind farm development



Pre-Construction

Saturation?



Climate Representativity

Source: Vortex internal validation

Over 200 certified windmasts (**155** employed)

One full annual cycle cross-validations Observed against Modeled
Re-analysis and 3Km WRF downscaling

R ² Monthly	10th pctl	25th pctl	Median	75th pctl	90th pctl
CFS + WRF	0.73	0.82	0.89	0.94	0.96
CFS	0.43	0.66	0.82	0.90	0.95
MERRA + WRF	0.74	0.80	0.88	0.94	0.96
MERRA	0.54	0.71	0.86	0.93	0.97
ERA-Interim + WRF	0.75	0.82	0.89	0.94	0.97
ERA-Interim	0.58	0.72	0.83	0.91	0.95

Climate Representativity

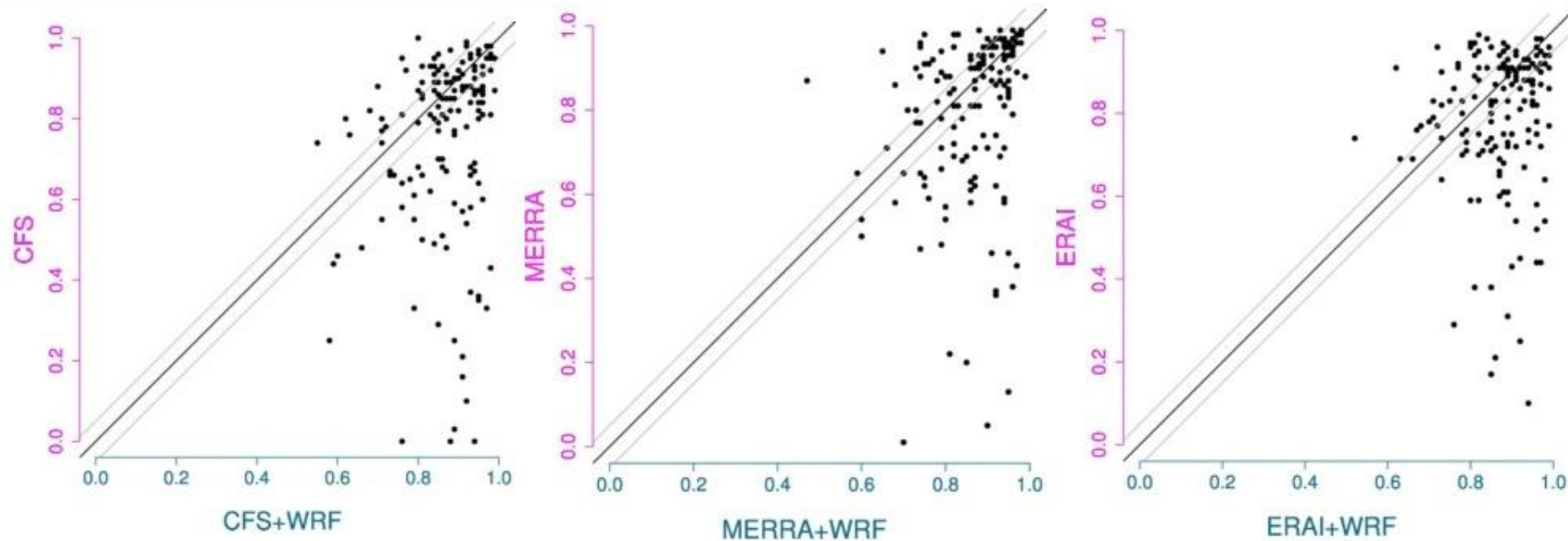
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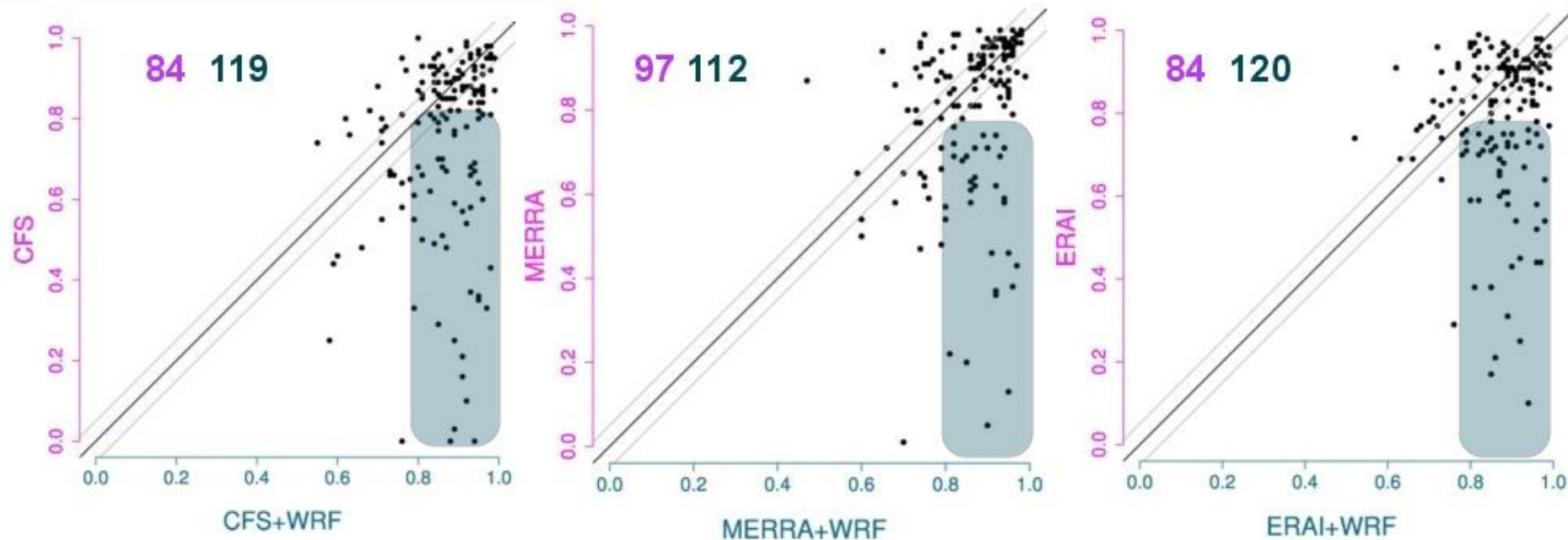
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Climate Representativity



Scatter plot, Monthly R^2 Drivers vs Meso (WRF 3KM), 12 months period

Climate Representativity



Scatter plot, Monthly R^2 Drivers vs Meso (WRF 3KM), 12 months period

Main Issues

Re-Analysis *users perspective*

Lack of resolution to resolve wind conditions

- Daily cycle
- Near-shore conditions
- Extremes
- Directional bias
- Atmospheric stability
- Jets, gravity waves
- ...

Time Consistence

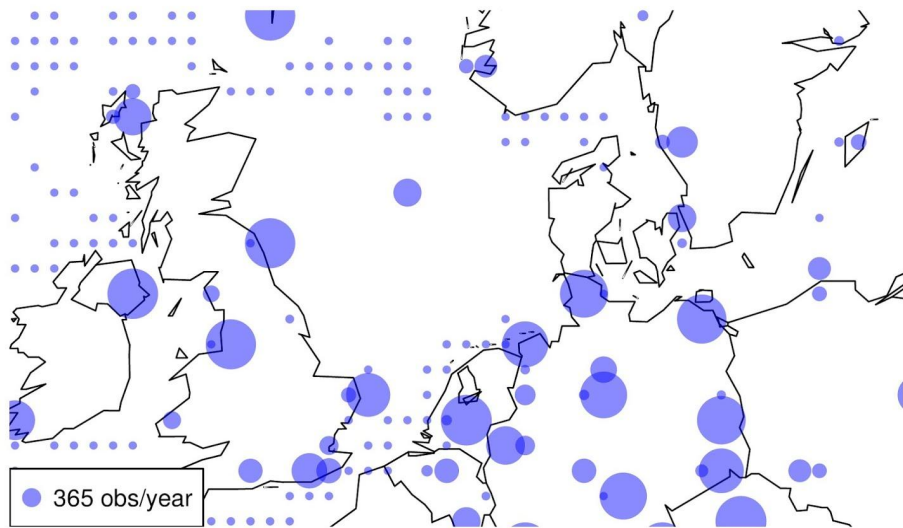
- **COMBO**: Multi-source observed data, data mining and a global/mesoscale model



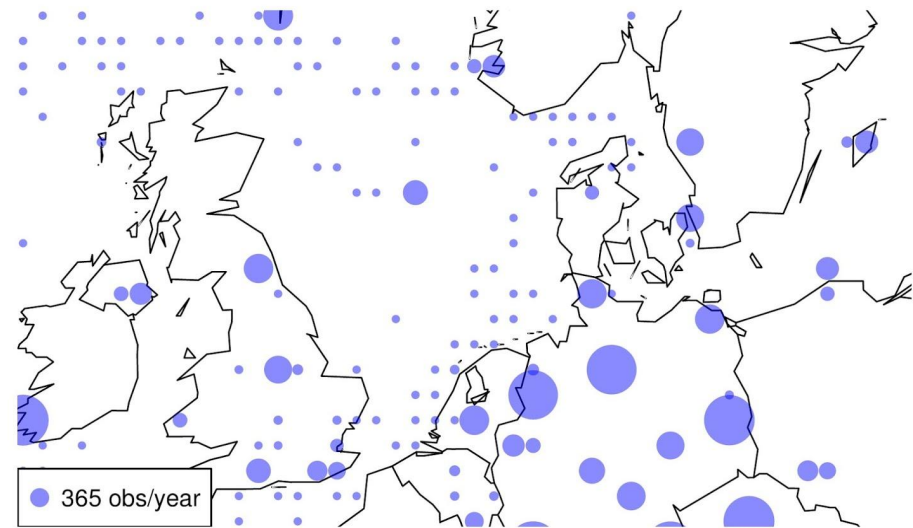
How strongly is the variability constrained by observations?
Does the observing system drive part of the detected variability and the changes over the years?

Time Consistency

RAOB counts @ MERRA Resolution 1995



RAOB counts @ MERRA Resolution 2005

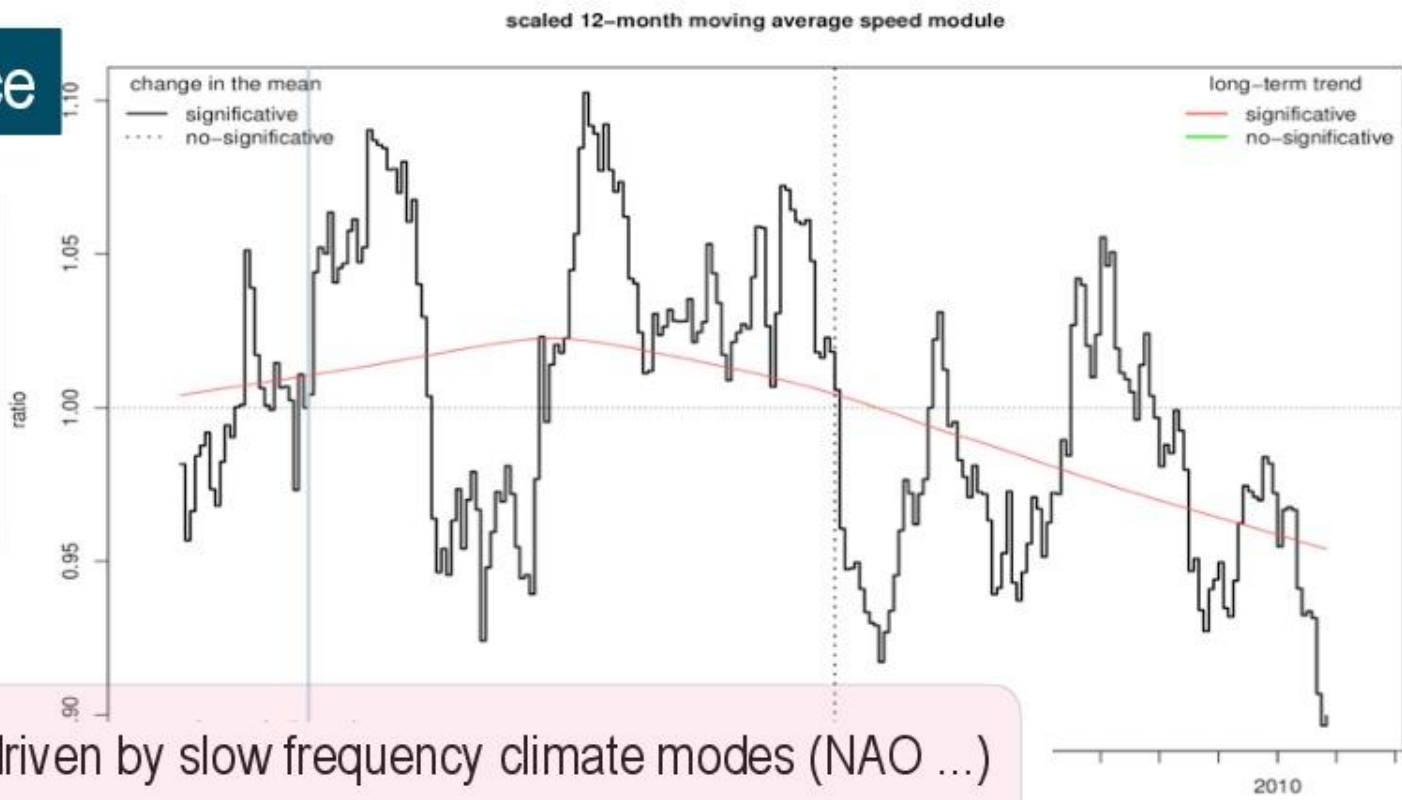


Time Consistency

- Sensitivity Studies: data assimilation
variational methods
- Inspect inside the data: Innovation Statistics
- Inhomogeneity and structural changes tests

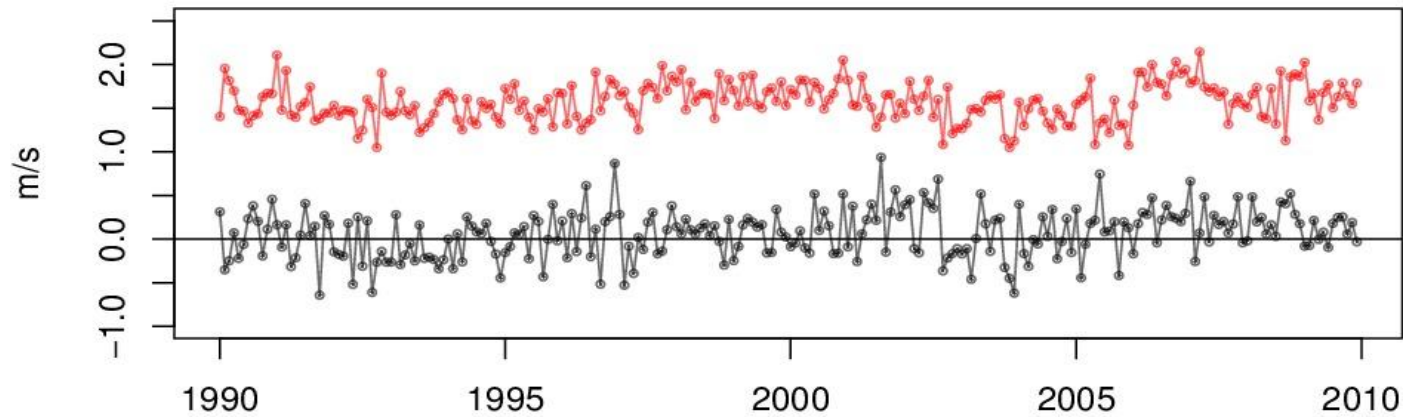
Time Consistence

- Time consistent?
- Change in the structure?
- Change in the mean?
- Change in the variance?
- Artificial trends?



Changes can be driven by slow frequency climate modes (NAO ...)
 Composite analysis over extreme years can give some hints
 Check covariance with other fields (temperature, pressure, precip)

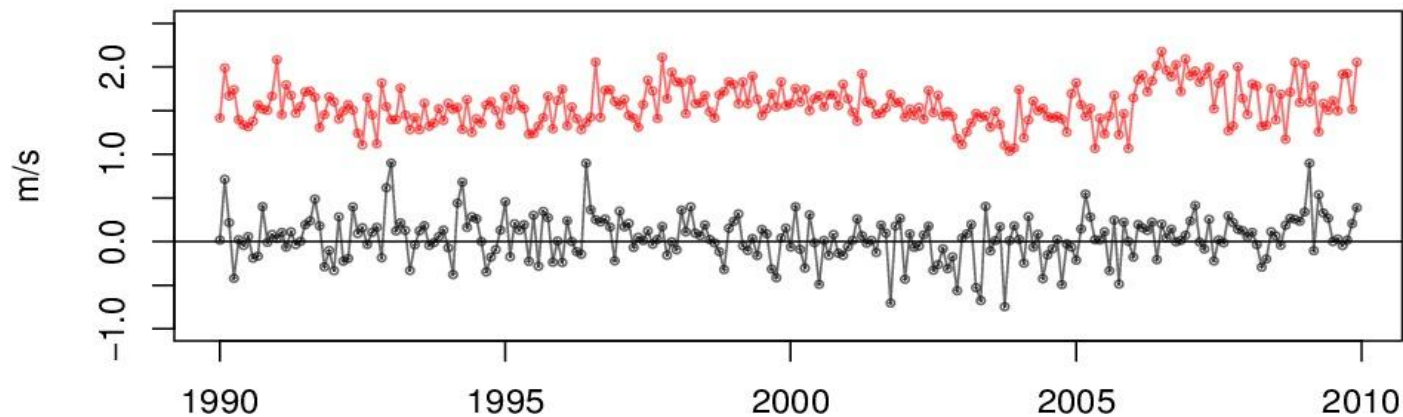
O-F RAOB U-Wind



850 hPa Zonal
WINDS O-F

Monthly **MEAN**
and **STD**

O-F RAOB V-Wind



850 hPa
Meridional
WINDS O-F

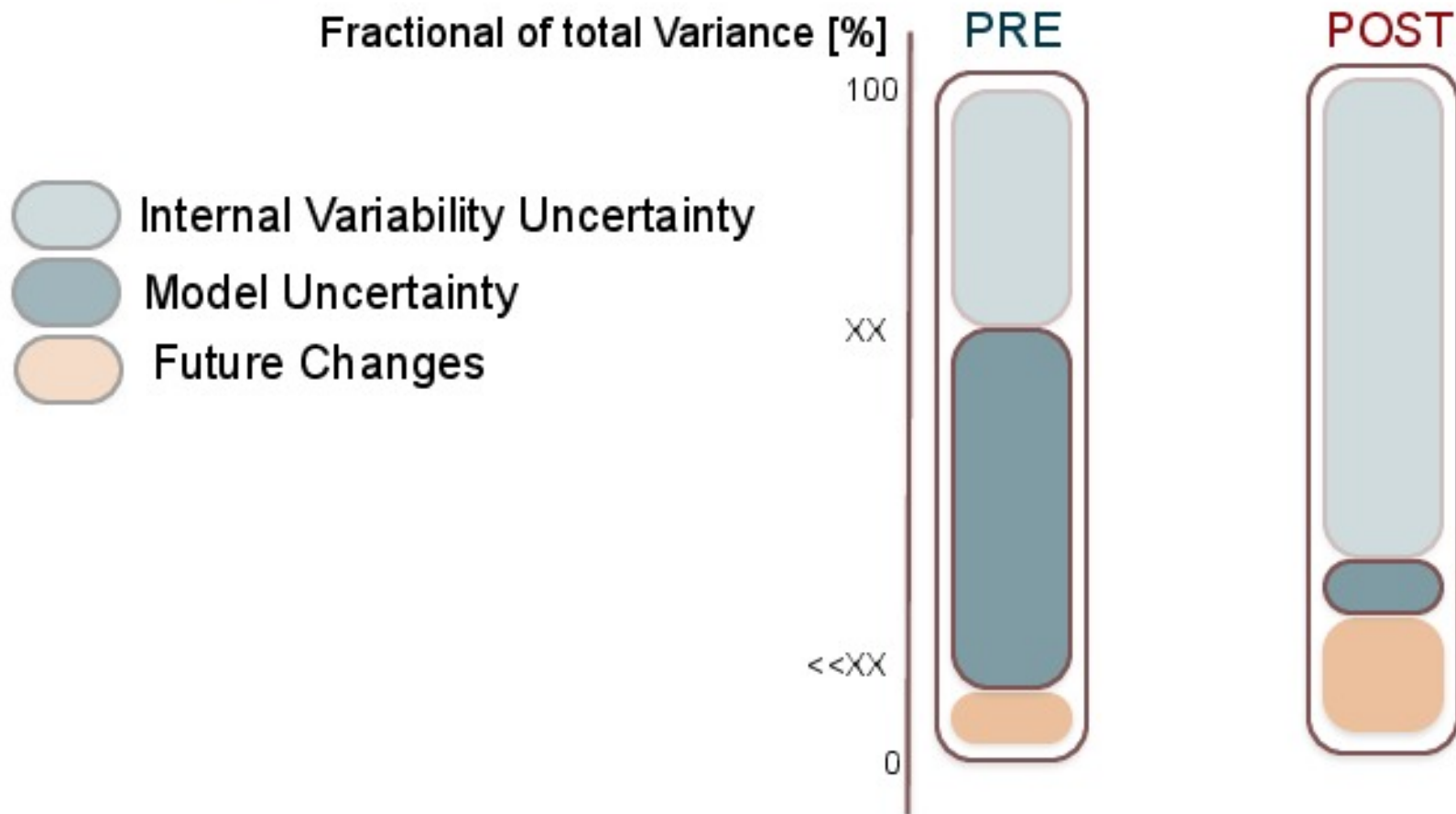
- Reliable climate representativity
- Allowing downscaling through mesoscale models and wind industry softwares
- Wide community of users and experts
- Free, fast and easy to access

- ★ Uncertainty quantification
- ★ Time consistency concern
- ★ Usage of model data (*gridded observations*)

- Saturation: Excess of information

- Aware of existence of S2D predictions
- Interest on inter-decadal variability (last 20-years vs next 20-years)
- Interest in solutions from Sub-seasonal to seasonal
 - ◆ O&M
 - ◆ TSO
 - ◆ Extreme events (icing, ...)
- ★ Low interest from energy traders
- ★ *Experimental* skill, larger uncertainty
- ★ Not clear perspective on climate change impact on resource
- ★ **How sharp are the predictions?**

Partitioning Wind Climate Uncertainty *



* For inspirational work see Hawkings & Sutton, BAMS, 2009 DOI:10.1175/2009BAMS2607.1