CENER | NATIONAL RENEWABLE ENERGY CENTRE

BIOMASS, CSP & WIND RESOURCE ASSESSMENT

NATIONAL RENEWABLE ENERGY CENTRE

CENTRO NACIONAL DE ENERGÍAS RENOVABLES

Kuwait, June, 2013

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GOBIERNO DE ESPAÑA | MINISTERIO DE INDUSTRIA, ENERGÍA Y TURISMO | MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Ciemat

Gobierno de Navarra

Cener participation in EU-GCC Clean Energy Network

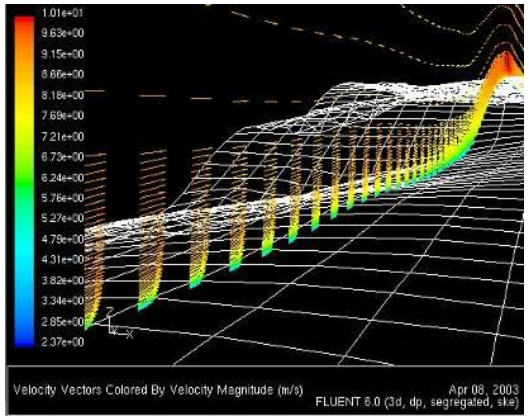
Decission group: Renewable Energy Sources

Conveners from CENER: Dr. Manuel J. Blanco and Dr. Marcelino Sánchez

Active participation in training seminars, workshops and EU-GCC meetings:

- Training seminar on Concentrated Solar Thermal Power Plants. Seville, November 2011.
- Training seminar on Wind resource assessment and prediction. Oman, February 2012.
- Workshop on Energy efficiency and Demand Side Management. Bahrain, December 2012.
- Training seminar on RES integration in the Grid. Oman, May 2013.

Wind Energy



Wind resource assessment and Forecasting (EPR)

Wind mapping from global to mesoscale to microscale

Site assessment and wind farm design

Wind power forecasting

CFD modeling of atmospheric boundary layer and wake flows

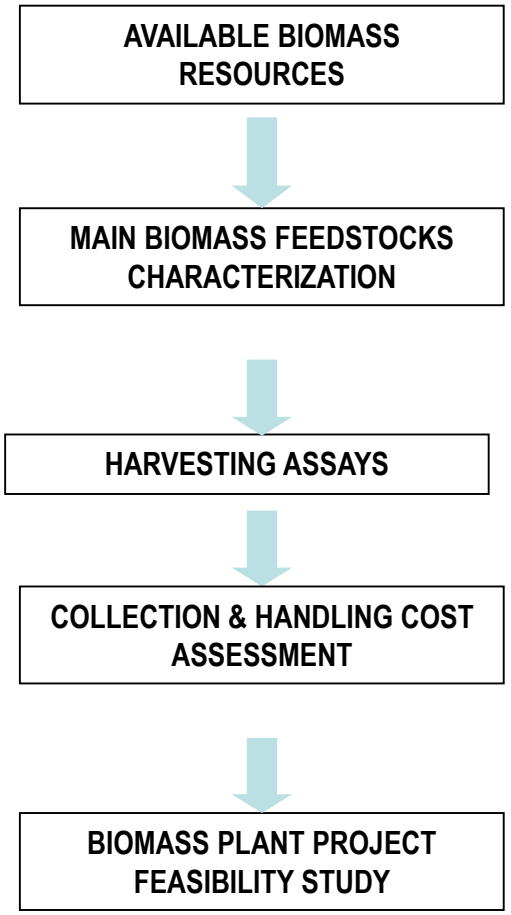
Standardization of wind assessment methodologies

A team of 14 researchers with different backgrounds (Maths,Engineering, Physics)

Biomass resource assessment and logistic

Biomass Resources Assessment, Production and Sustainable Management:

- Biomass resources assessment in an area(forestry and agricultural)
- Supply & logistics studies (systems and costs)
- Solid Biofuels energetic characterization
- GHG & Energy balances. Sustainability studies
- Solid Biofuels Production (including pelletization and torrefaction)



Numerical Weather Prediction

SKIRON mesoscale model developed by University of Athens

- Operational forecasts: wind power forecasting
- Climatology studies: wind mapping at resolutions of some km

WAM oceanographic model

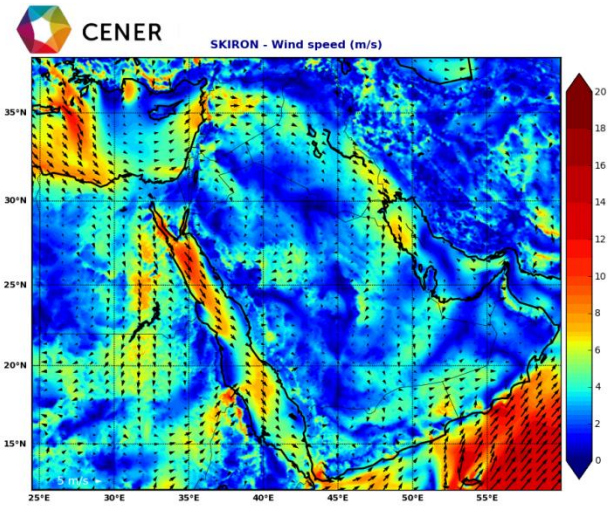
- Wave assessment and forecasting

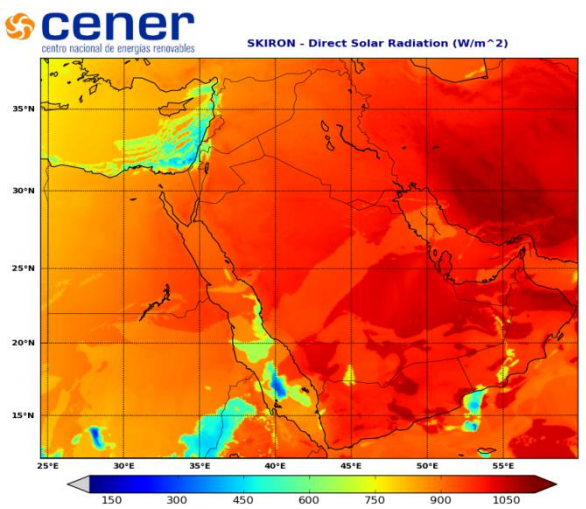
Physical-statistical downscaling SKIRON-WRF-WAsP/CFD

- High resolution wind mapping (~100m)
- Vref assessment
- Using linear and CFD models

High resolution GIS integrated wind farm design

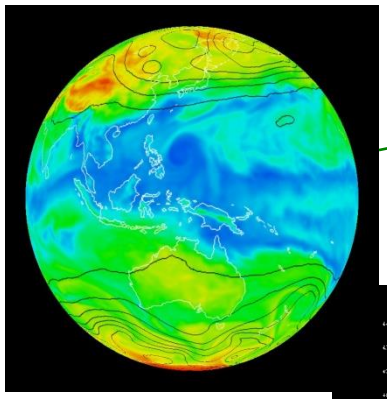
- Feasibility mapping
- Life-cycle assessment





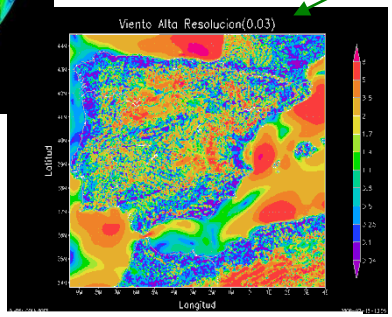
Numerical Weather Prediction

Mesoscale models use to obtain wind resource maps: Methodology



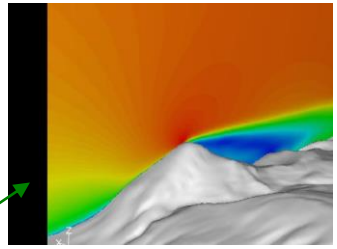
GFS
1º x 1º

SKIRON
0.05º x 0.05º

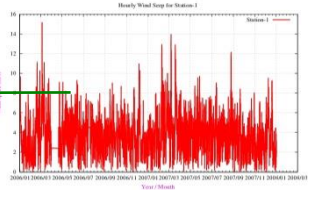


HOURLY
WIND
VALUES

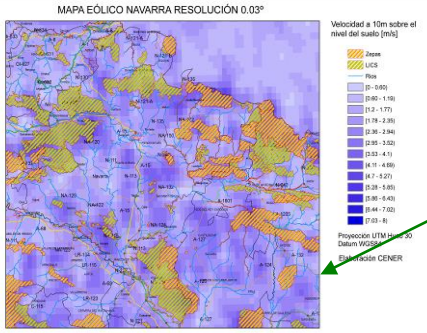
WAsP_CFD



VALIDATION ← FILTERING ← MEASURED

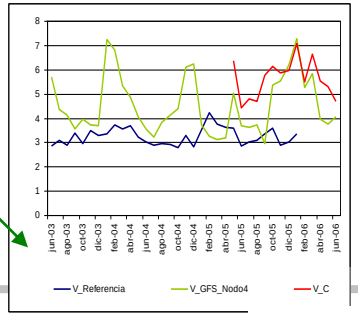


WINDMAP



GIS

HOURLY
TIME SERIES

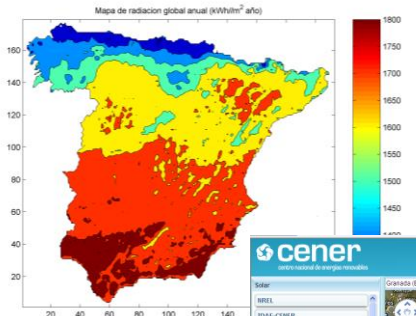


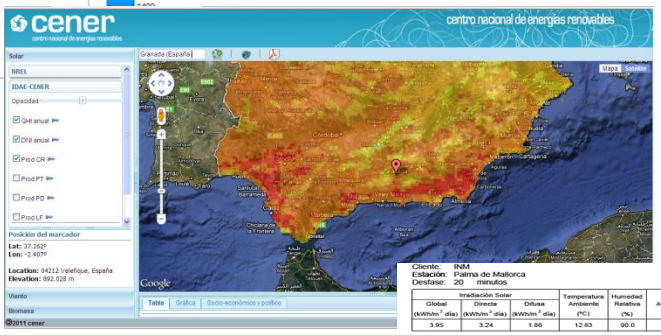
WEB
SERVICE

Solar Resource Assessment

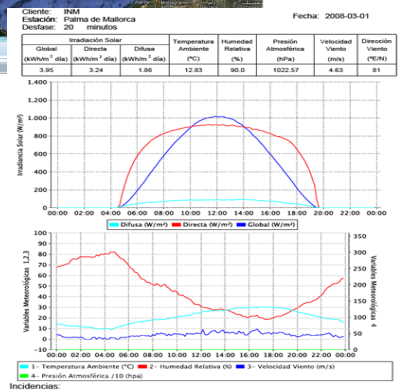
Solar Resource Assessment

Country or Regional Level





Specific Location (Preliminary)

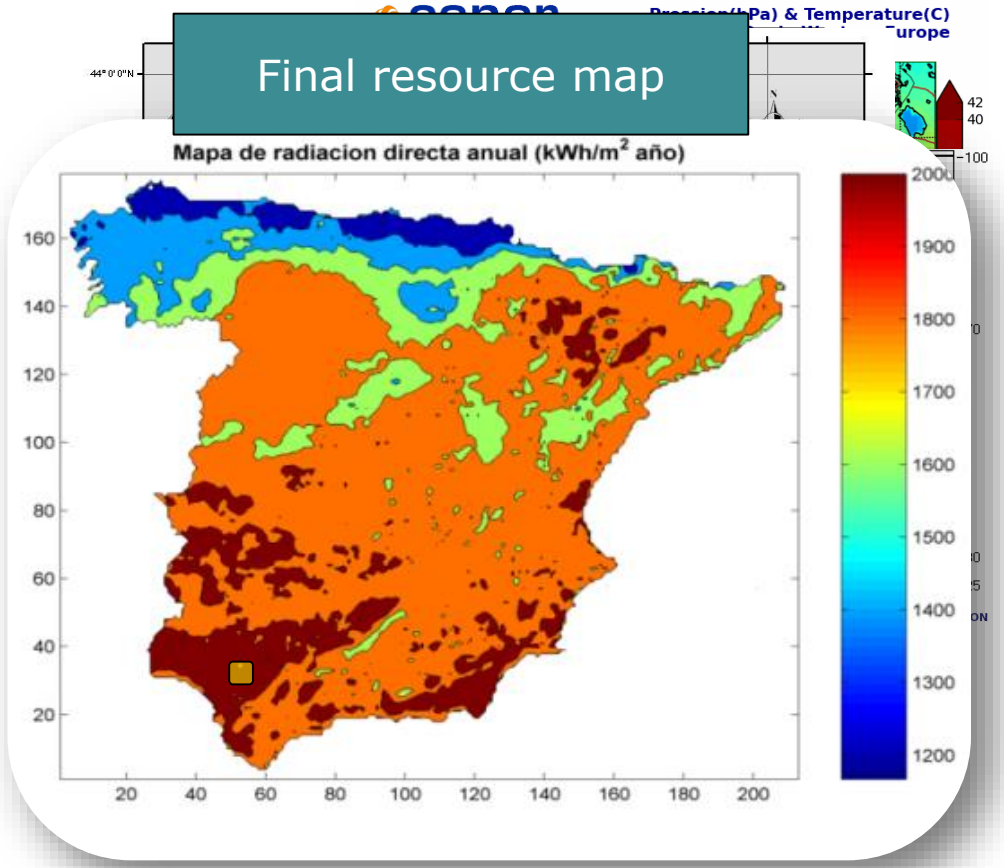


Specific Location TMY Generation

Country or Regional Level

- Generation of initial maps
- Identification of similar areas
- Fit of models to correct or combine initial maps
- Generation of final source map

Final resource map



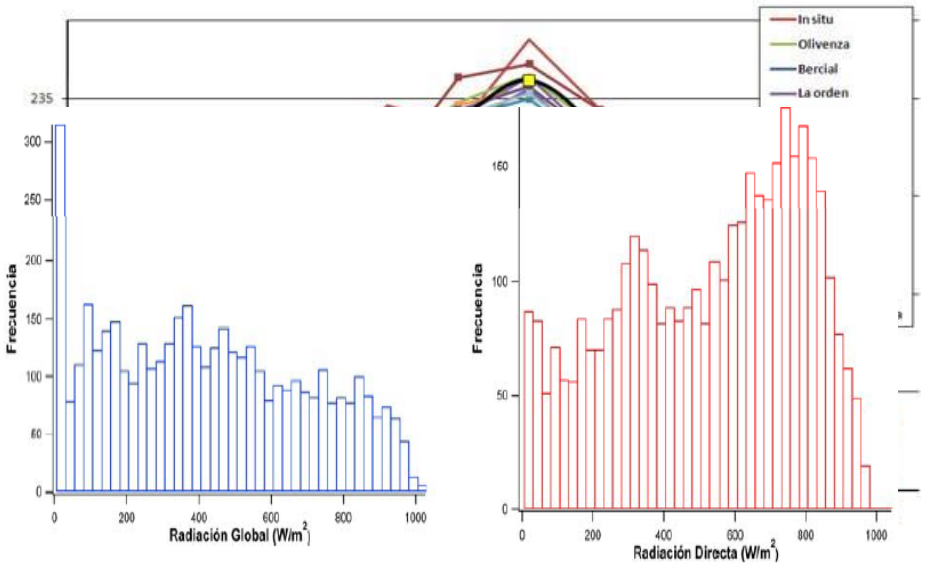
Specific Location

Long term estimation at monthly level:

- Design meteorological year for simulation purposes
- Analysis of GHI solar radiation data bases, including satellite and NWPM
- Long term GHI monthly values

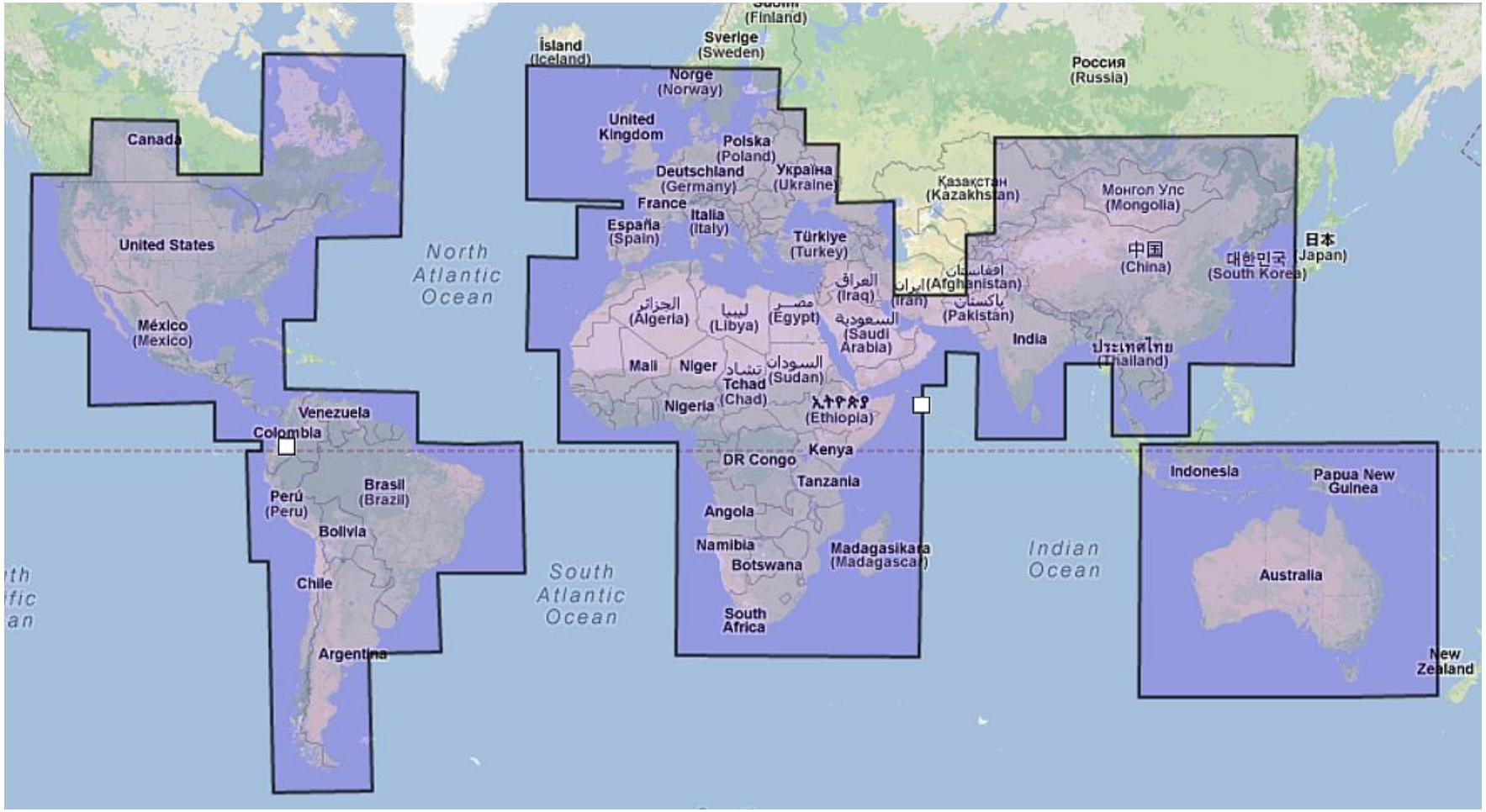
Annual hourly series:

- GHI hourly values from estimations or synthetic generation.
- DNI hourly values estimation using statistical and classic models.



Histograms of hourly GHI (left) and hourly DNI (right)

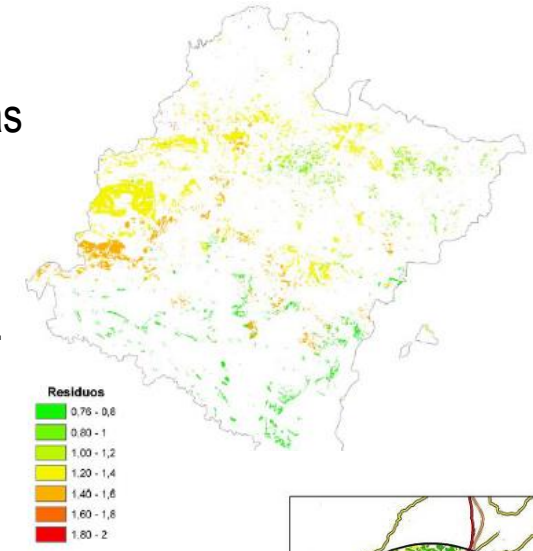
Numerical Weather Prediction



Biomass resource assessment and logistic: Methodology

Biomass Resources Assessment is based on:

- Statistical data about the agricultural yield or forest areas
- Residues production index
- Land Uses and cover maps
- Other complementary thematic cartography information.
- GIS tools

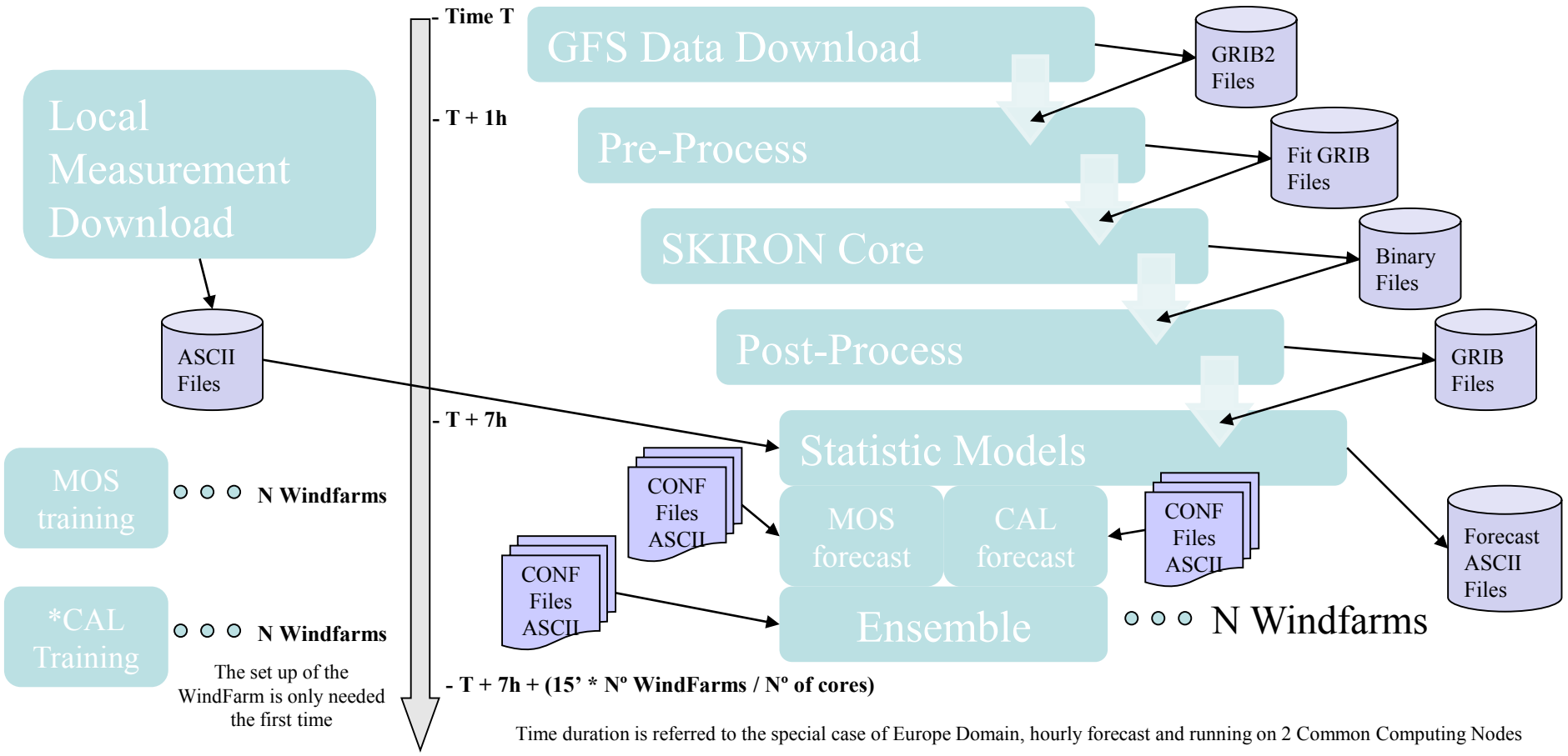


As a result, it is achieved:

- Biomass amount available in region and the energy potential production
- Best location for a biomass plant in an area
- Cost of biomass supply
- Future information for the biomass logistic management in a plant.

Forest biomass resource map in Navarra Region

Prediction Process Scheme



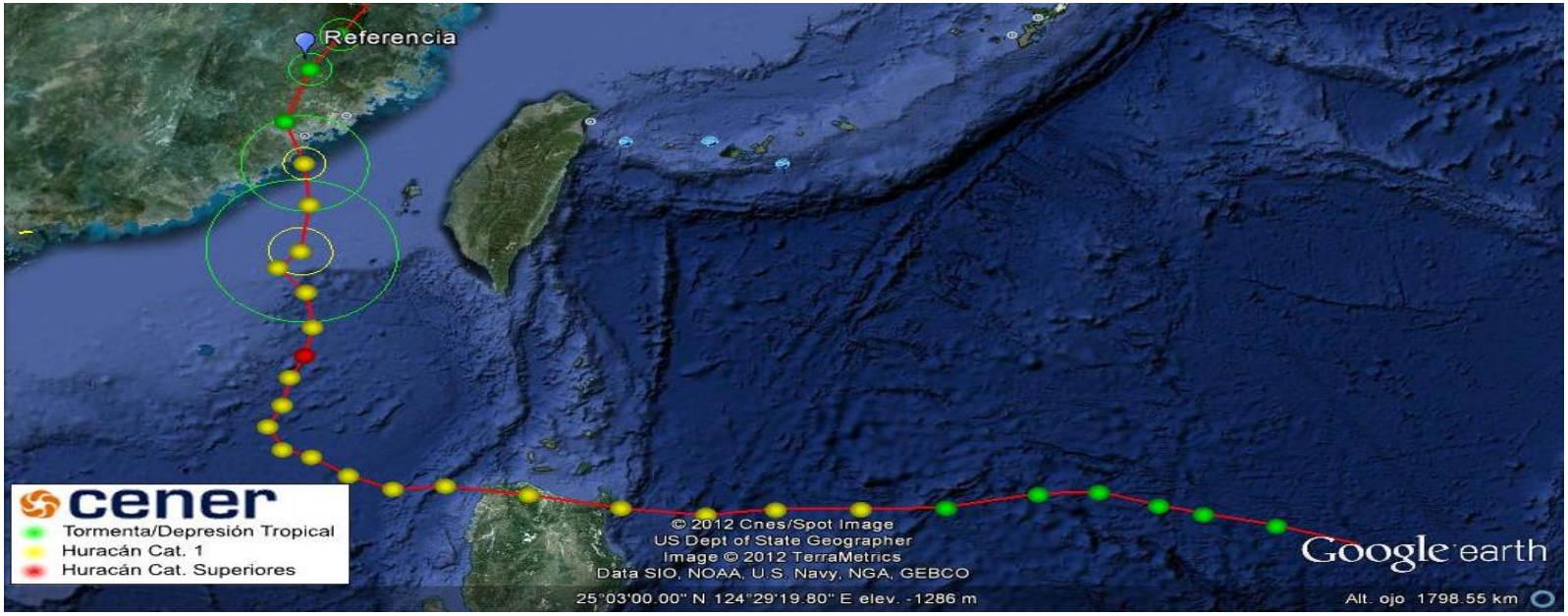
Prediction Process Scheme

Times based on the domain of Europe

SKIRON	• 7 hours (24 cores)
MOS (each windfarm)	• Training: 1 hour (1 core) • Forecast: few seconds (1 core)
CAL (each windfarm)	• Training: Some hours (1 core) It will directly depend on the reading speed of the storage disk and amount of data needed (how long the training is wanted) • Forecast: 5-10 minutes (1 core)
Ensemble (each windfarm)	• Forecast: few seconds (1 core)

Extreme wind speed in hurricane areas

- No local measurements needed.
- Validation of the methodology possible if measurements available.
- Calculations based on databases with more than 150 years or records
- Risk reduction when exploring new countries in tropical areas
- A software with automatic reports, visualization of hurricane paths



Microscale flows

Classical micrositing based on WAsP

- Participation in MEASNET
- Focus on audit studies

CFD.Wind, in-house development of atmospheric boundary layer models based on open-source CFD (OpenFoam)

- ABL forzed by geostrophic wind, Coriolis and limited-length-scale k-ε turbulence modeling
- Stable ABL based on local scaling

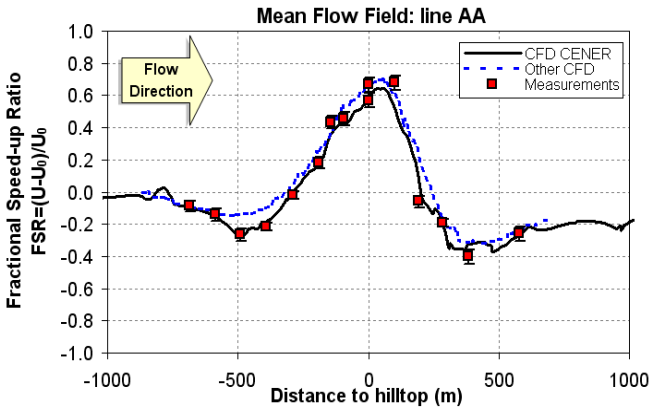
CFD.Wake, in-house far wake model embedded in CFDWind

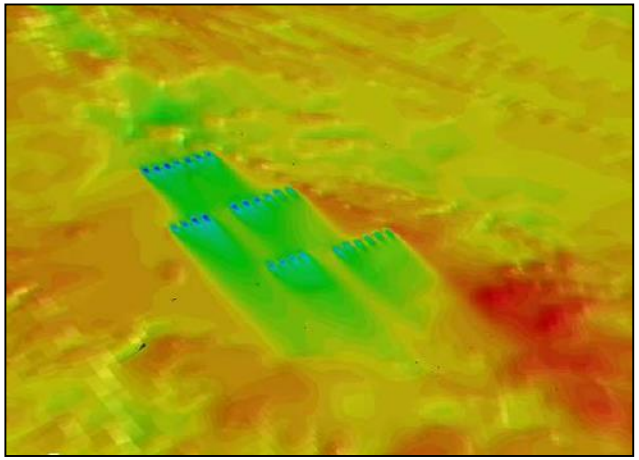
- Actuator-disk concept

CFD.Forest, CFD.Urban CFD.Load under development

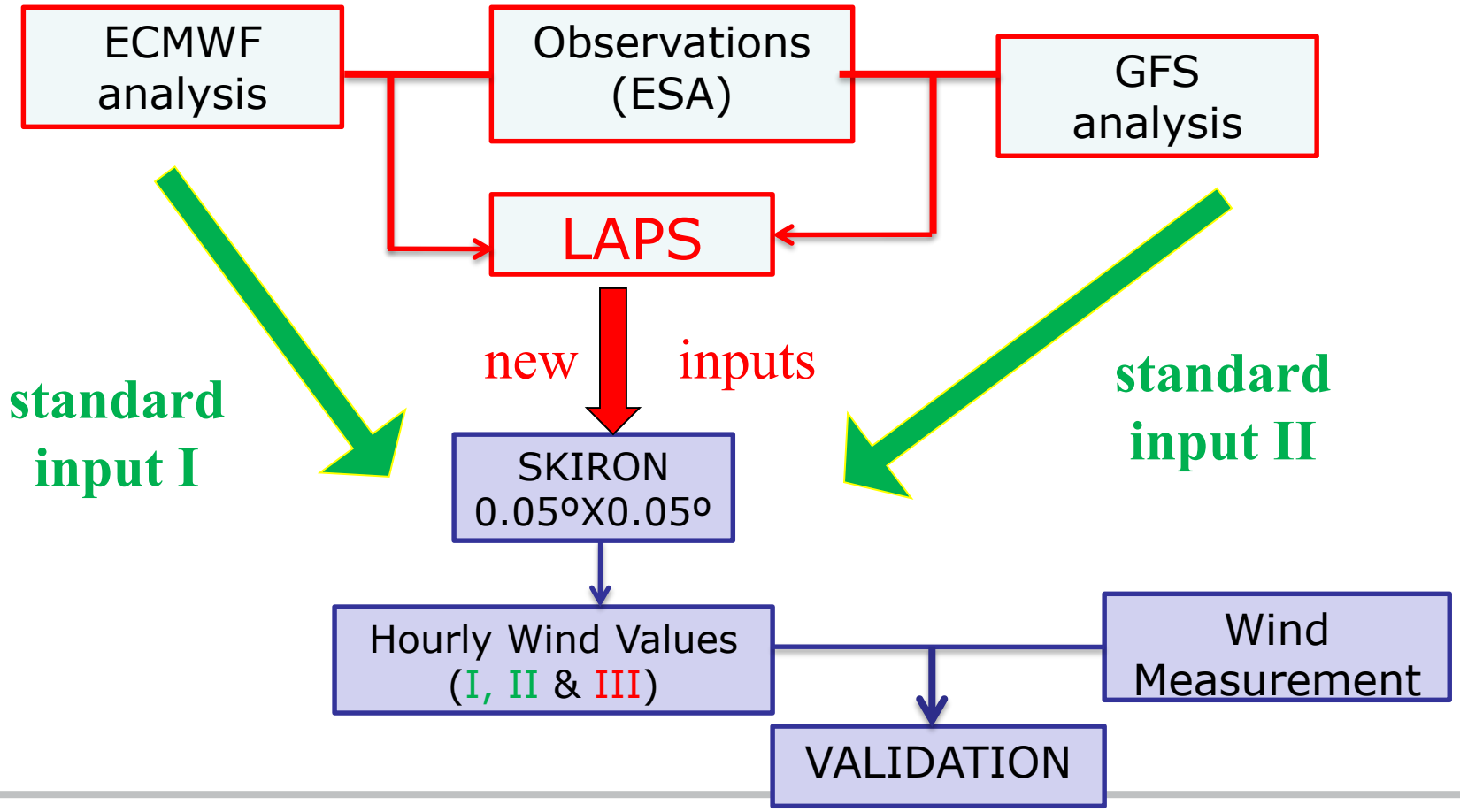
Continuous model validation and standardization

- Windbench model evaluation web portal





Key projects: ISSWIND Supporting Services for Wind Power Industry

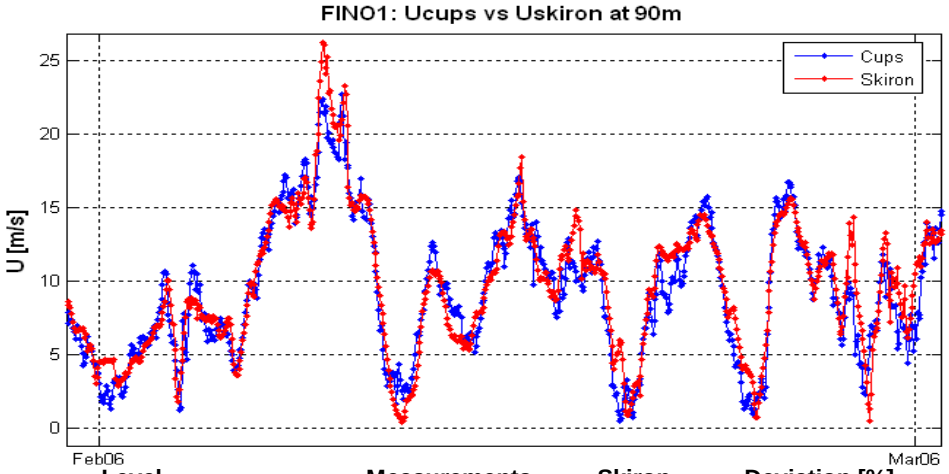


Key projects: Great Lakes Wind Map. Offshore wind assessment

Mesoscale modelling proves to be very competitive in offshore conditions

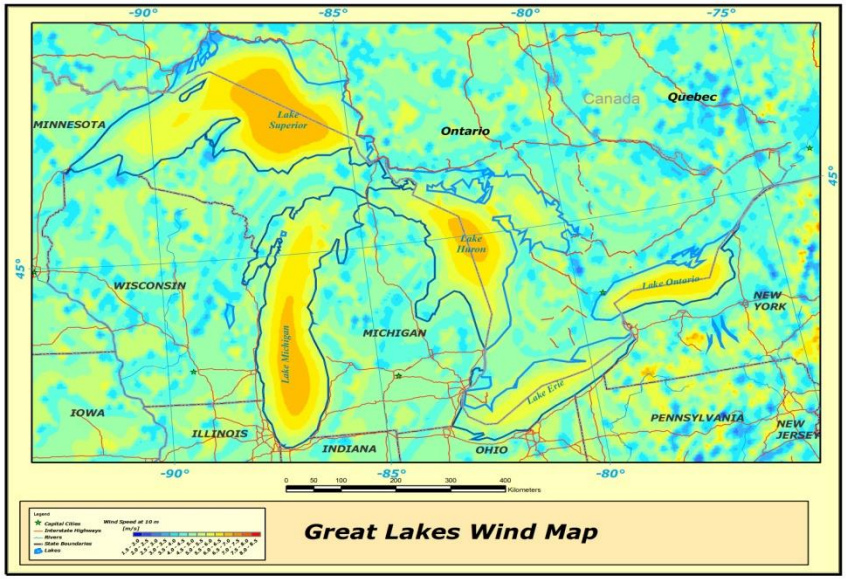
Generation of long-term virtual met masts with validation based on met masts and buoys

Fino1: 100m met mast



Level		Measurements	Skiron	Deviation [%]
90m	Um [m/s]	9.55	9.55	-0.01%
	k	2.42	2.42	0.00%
	A [m/s]	10.75	10.75	0.00%
50m	Um [m/s]	9.01	8.96	-0.54%
	k	2.54	2.52	-0.79%
	A [m/s]	10.12	10.07	-0.49%

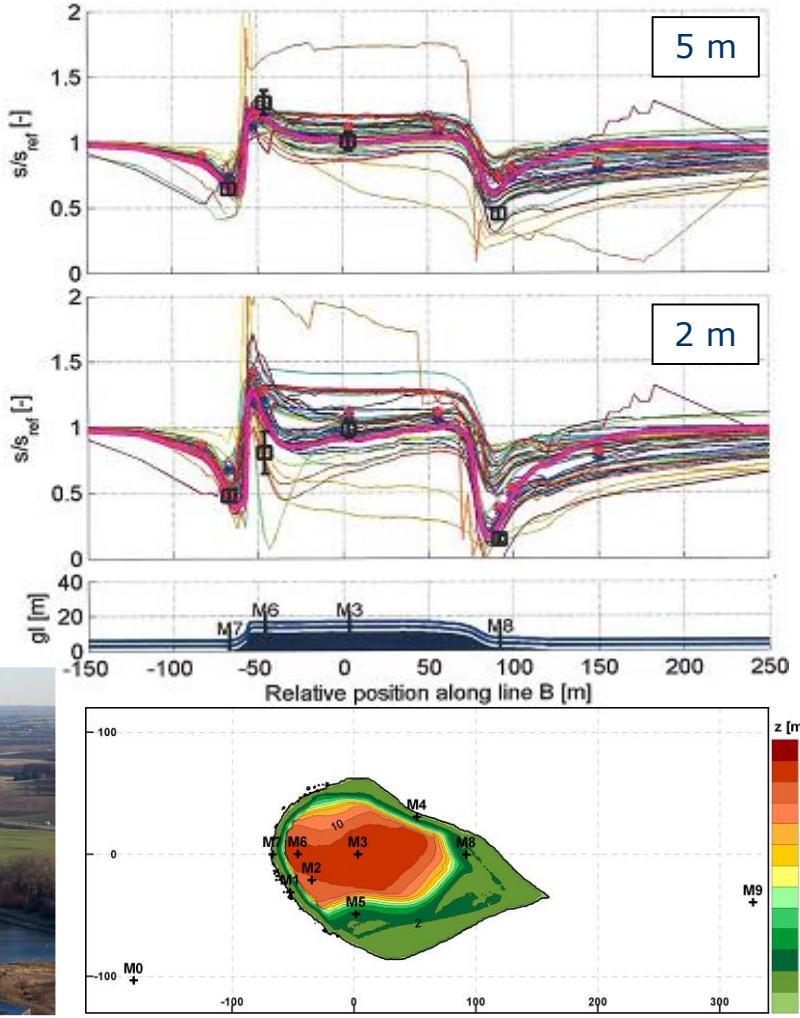
Great Lakes: 50 coastal 10m masts



	GLOBAL	Low Speed (WSmes<4,5 m/s)	Mid speed	High speed (WSmes>6 m/s)
		ALL MET-STATIONS		
Bias [m/s]	0.36	0.96	0.14	0.11
MAE [m/s]	0.66	0.96	0.52	0.53
		SHORE		
Bias [m/s]	0.35	0.96	-0.11	-0.36
MAE [m/s]	0.74	0.96	0.48	0.96
		OFFSHORE		
Bias [m/s]	0.36	-----	0.22	0.48
MAE [m/s]	0.45	-----	0.36	0.58

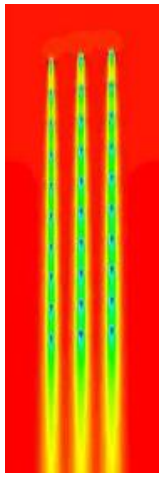
Key projects: Bolund Experiment. CFD.Wind

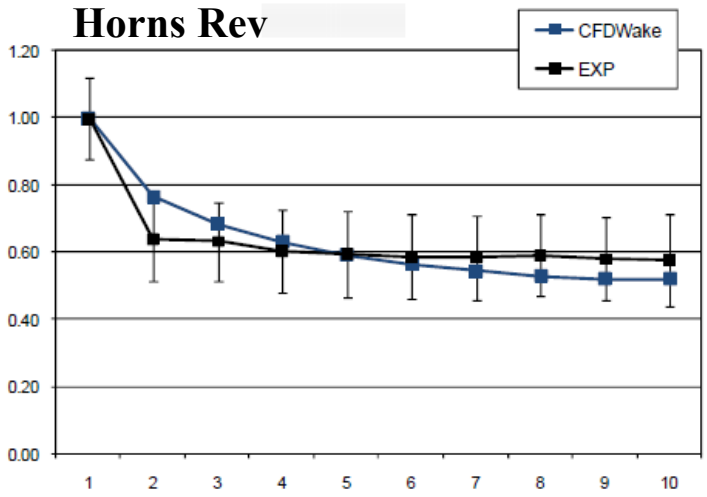
- Bolund experiment carried out by RisoeDTU, co-financed by VESTAS
- Nine 15-m masts equipped with cup and sonic anemometers
- Controlled environment excellent for validation of flow models
- Blind comparison of 52 models (Dec-2009)
- CFDWind2.0 got the best results according to “Risoe’s ranking”: 4% error in wind velocity at 5m level

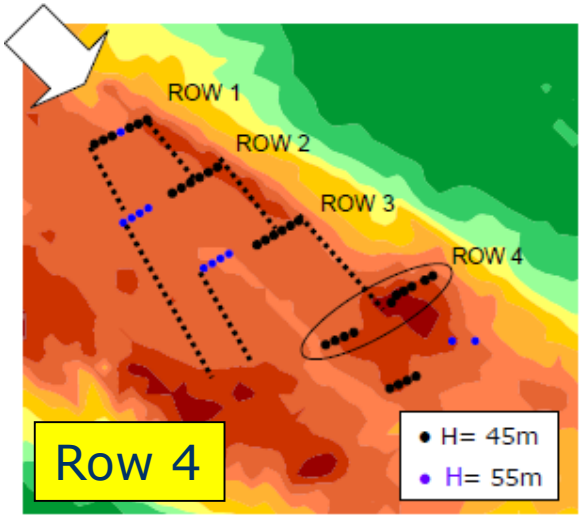


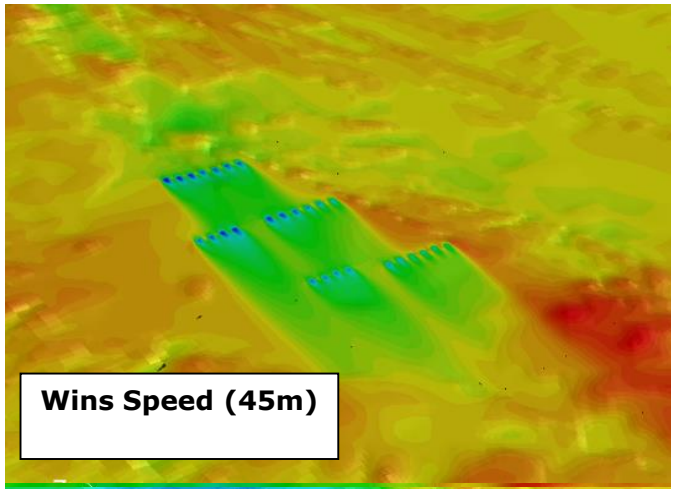
Key projects: FP6-UpWind, CFD.Wake modeling

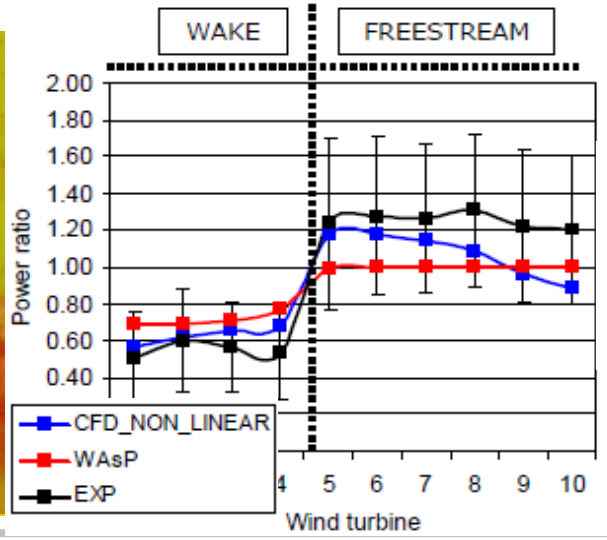
- Benchmarking of wakes models in offshore and complex terrain
- Better results than linear models, specially in complex terrain
- Still high uncertainties in the validation data and the model chain (stability effects, terrain-wake coupling, thrust curve, upwind reference wind speed, etc)











Key projects: High resolution wind map of Granada. MESO-CFD Downscaling

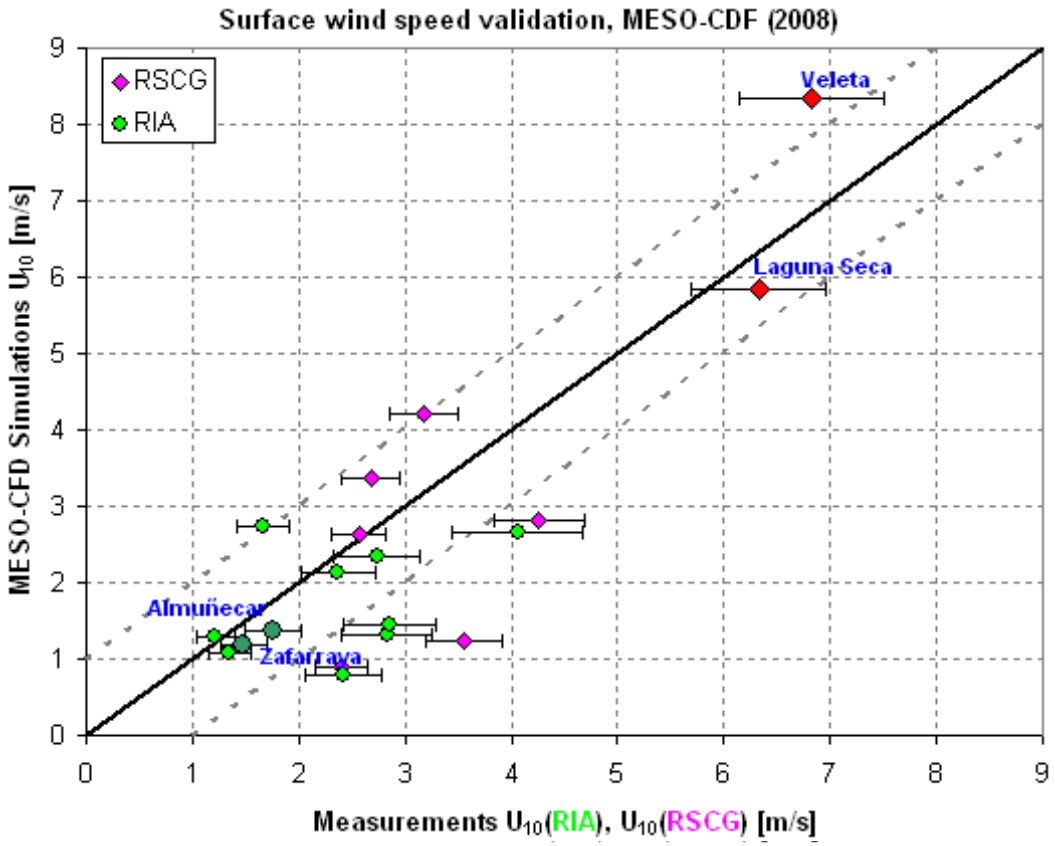
MESO-CFD physical-statistical downscaling

- 100m resolution
- Wind climate distribution at geostrophic level is corrected based on speed-up factors simulated by CFD

High resolution feasibility mapping

Evaluation based on synop observations

- Significant improvement in complex terrain sites



Key projects: IEA Task 31 WAKEBENCH
Benchmarking of wind farm models

CENER is Operating Agent together with NREL

2011-2013

13 IEA countries (80 participants)

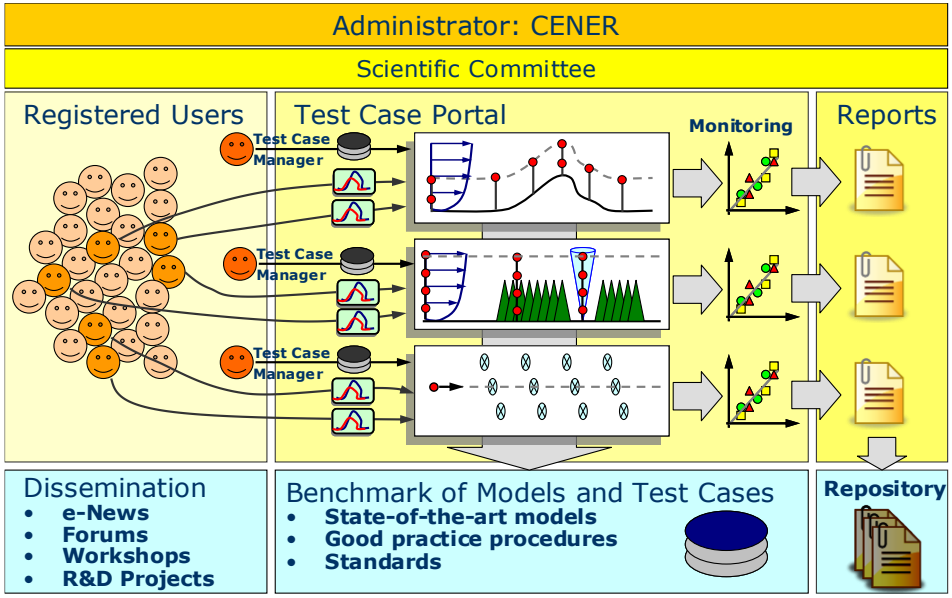
Elaboration of model evaluation protocol for ABL and wake models

Benchmarks of research and industrial test cases

Elaboration of best practice procedures for wind farm model implementation

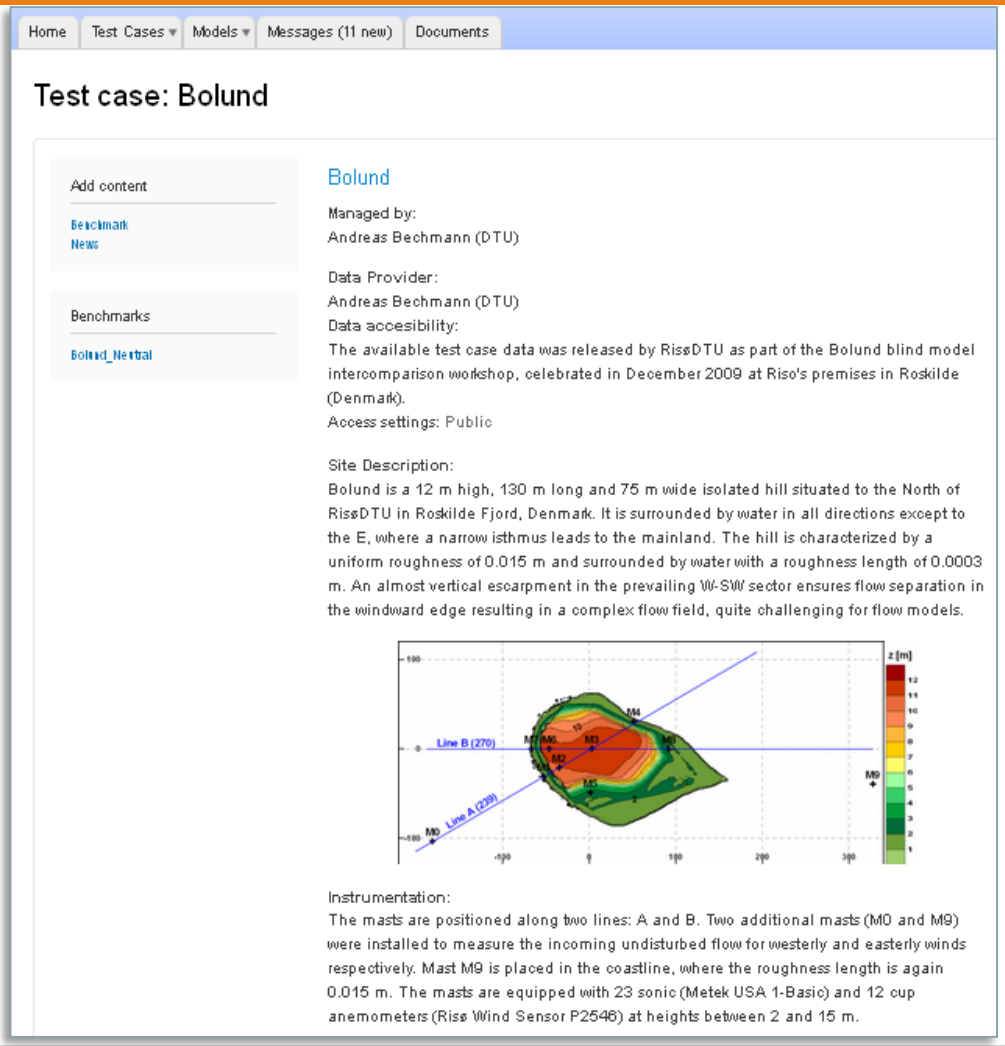
WindBench model evaluation web portal

- Forum for model evaluation activities
- Database of validation test cases



Key projects: IEA Task 31 WAKEBENCH
Benchmarking of wind farm models

- **Administration** of…
  - ❑ User accounts
  - ❑ Catalogue of Models
  - ❑ Test Cases / Benchmarks
  - ❑ Documentation
- **IPR protection** ensured by allowing the Test Case/ Benchmark Manager to control the users accessibility to data
- **Quality ensured by peer-review** from SC members
- Aim for a long-standing and **mutually recognized reference** in the wind community



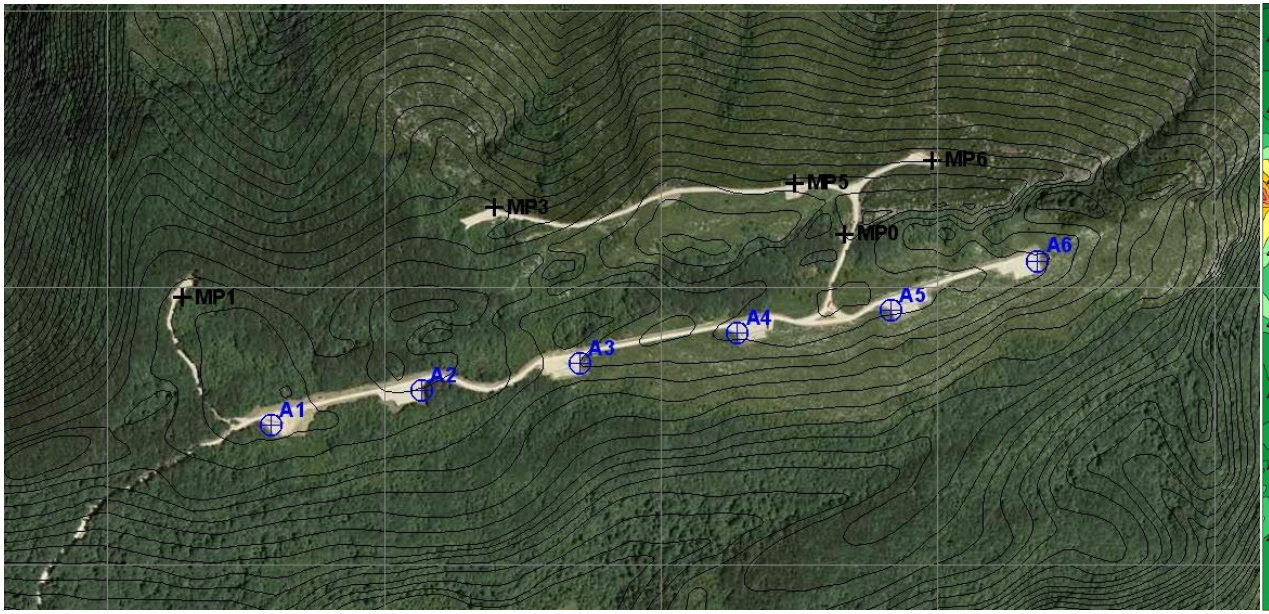
Key projects: Alaiz Test Site
Laboratory for Boundary Layer Meteorology

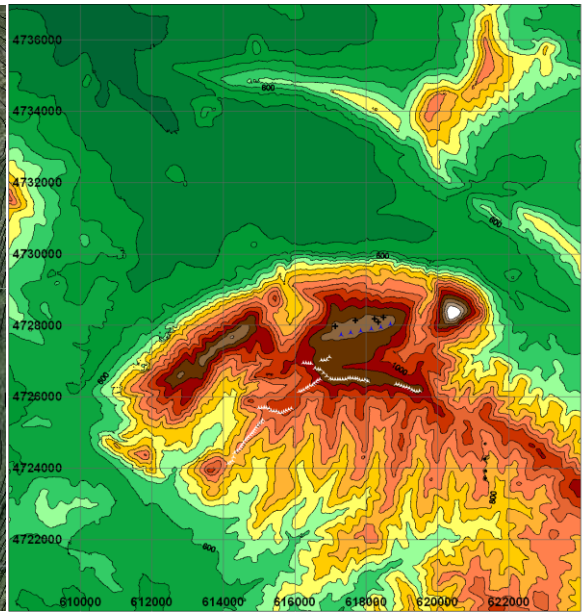
5 reference met masts 120m high

Masts instrumented at 5 levels, Zephir Lidar

BLM studies of flow over mountains, complex terrain, stability effects, forest

Test case for mesoscale and microscale models



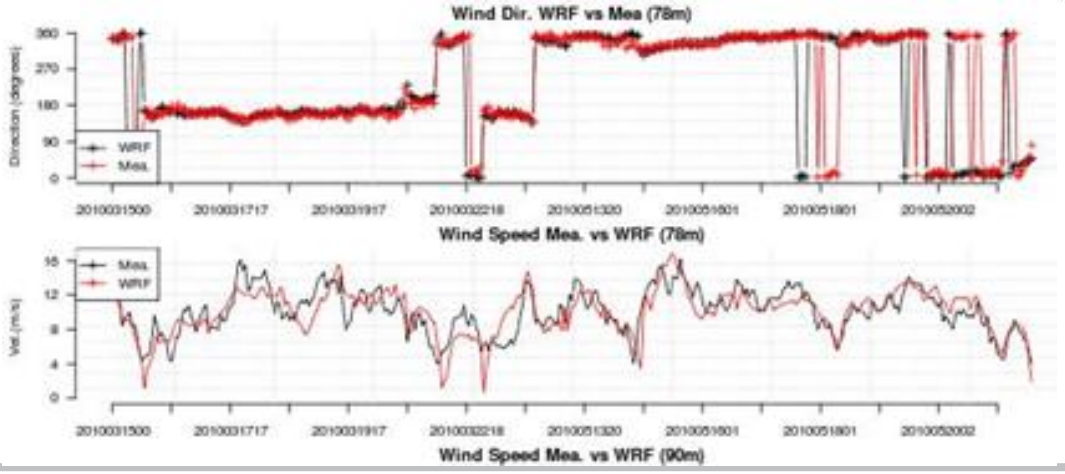


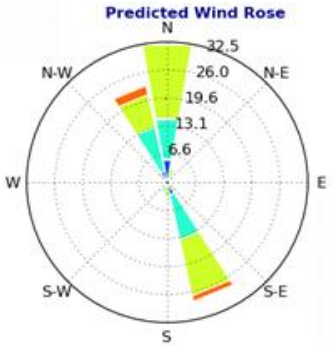
Key projects: Alaiz Secondment in WAUDIT project
Preliminary results

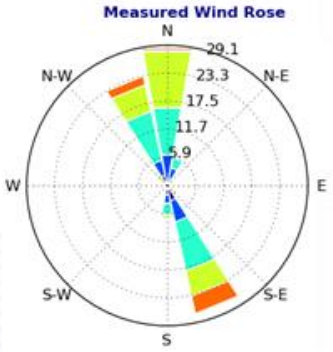
ALAIZ Secondment: 10 WAUDIT fellows/supervisors exploring wind conditions at the Alaiz Test Site: experiments, CFD simulations, mesoscale models, downscaling techniques

First results from high-res mesoscale modeling show good performance

- SKIRON simulation until 0.05º resolution
- WRF-NMM simulation with 2 nested domains
  - Dom1 – 1,67 km, Dom2 – 550m
  - 50 vertical levels
  - SRTM topo / CORINE land-use (90m)







Z [m]	Error SKIRON	Error WRF1	Error WRF2
78	6,3%	0,5%	1,5%
118	7,7%	1,4%	2,1%

THANK YOU VERY MUCH

Gobierno de Navarra

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