Copernicus Land Service Data
At Work in the Wind Energy Sector

Morten Lybech Thøgersen, mlt@emd.dk
EMD – Wind R&D

Copernicus Global Land User Conference
@ Météo-France, Toulouse, October 23-25th 2018

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This Presentation

1. Introduction
- EMD and our activities
- Wind energy and the need for accurate geo-data

2. Models – The Model Chain
- Mesoscale and downscaling
- Microscale

3. Land-Surface Data with Cases/Applications
- Maps
- Forests
- Roughness
- Elevations

1. Introduction – EMD

An independent software and consulting company, operating worldwide with many cooperation partners

Since 1986
Aalborg, Denmark

>4000 users
windPRO

~30 employees
- Sales
- Research
- Software
- Consultancy

Foundation owned

Fonden Energi- & Miljødata
www.emdfonden.dk

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1. Introduction – EMD Activities

Software

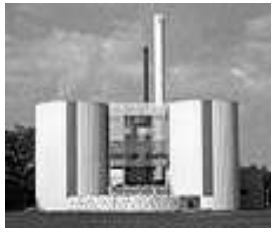
- Development and sale of **windPRO** software for design and planning of wind farm projects.
- Development and sale of **windOPS** web-based software service for online production surveillance of existing turbines.
- Development and sale of **energyPRO** software or techno-economic analysis and optimization of cogeneration / trigeneration projects.
- Development of customer-made **energyTRADE** software solutions for optimal daily production planning at co- and tri-generation plants based on forecast data.
- Software training courses worldwide.

windPRO

windOPS

energyPRO

energyTRADE



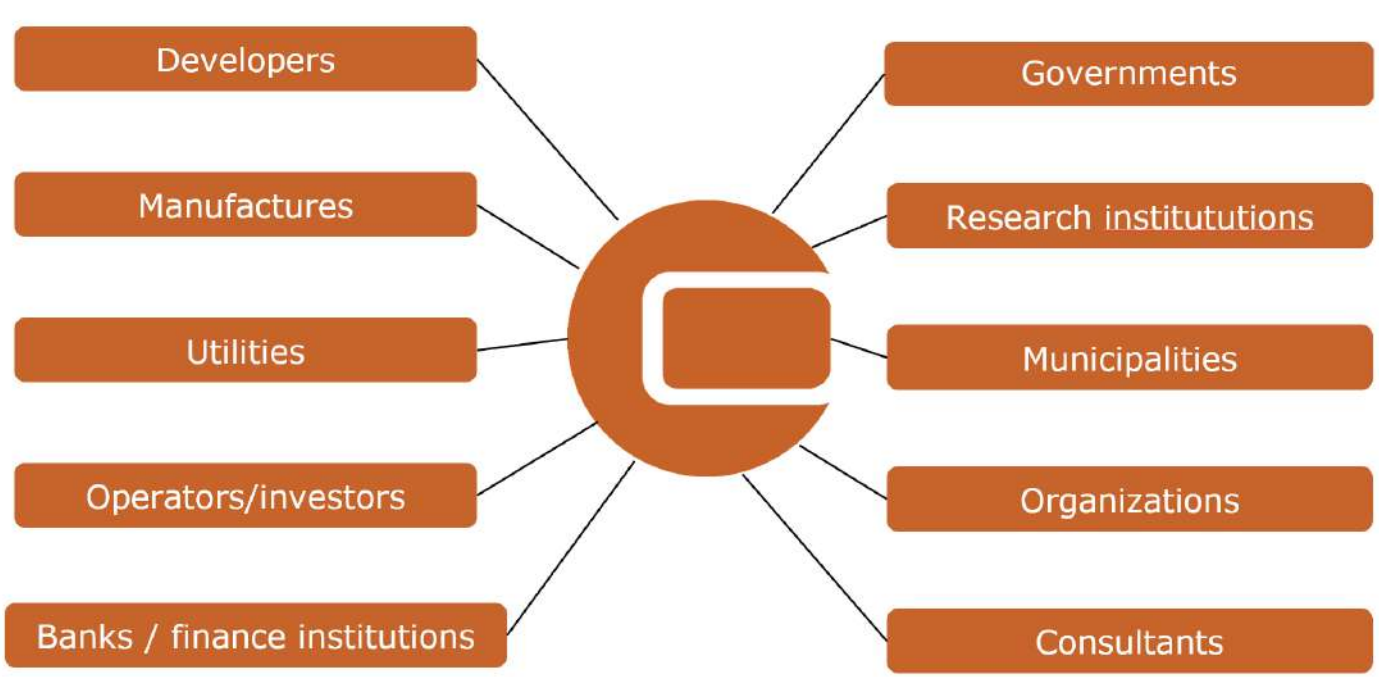
Research & Development

- Participation in energy research projects funded by the Danish government and different EU institutions.

Consultancy Services

- Worldwide consultancy services within wind energy and other types of renewable energy projects.

1. Introdution - EMD Customers

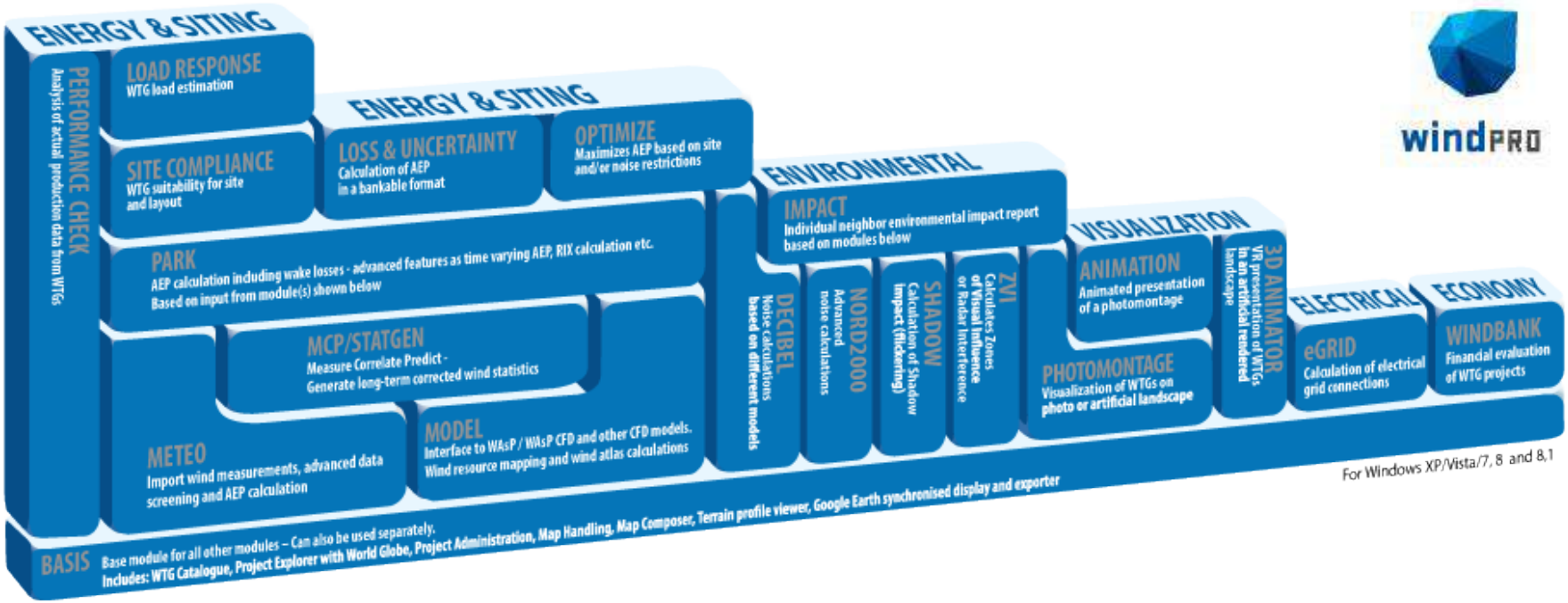


1. Introduction EMD - windPRO Software

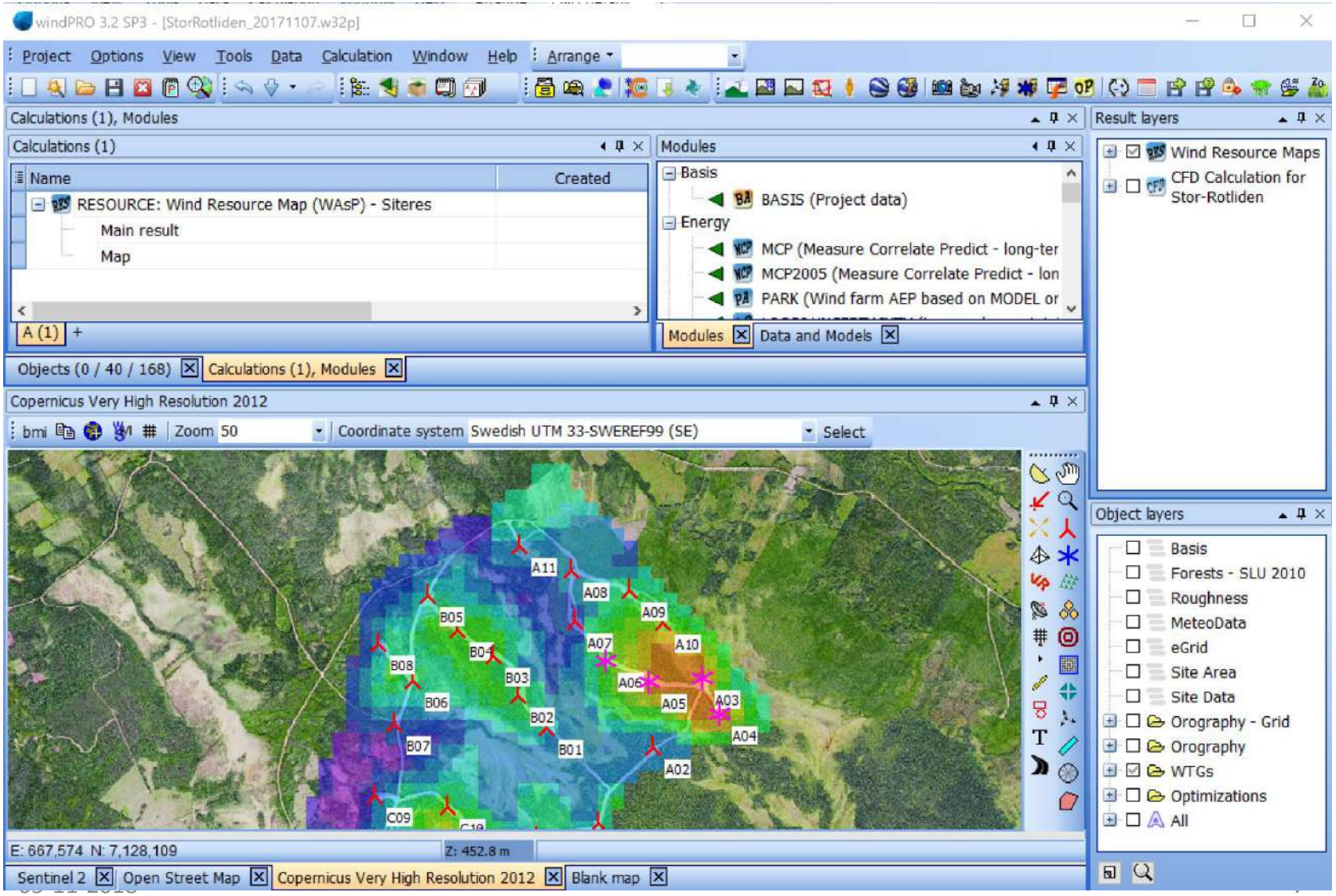
The windPRO software fulfills all demands in for project design and planning of new wind farms

Developed by EMD International A/S since 1992

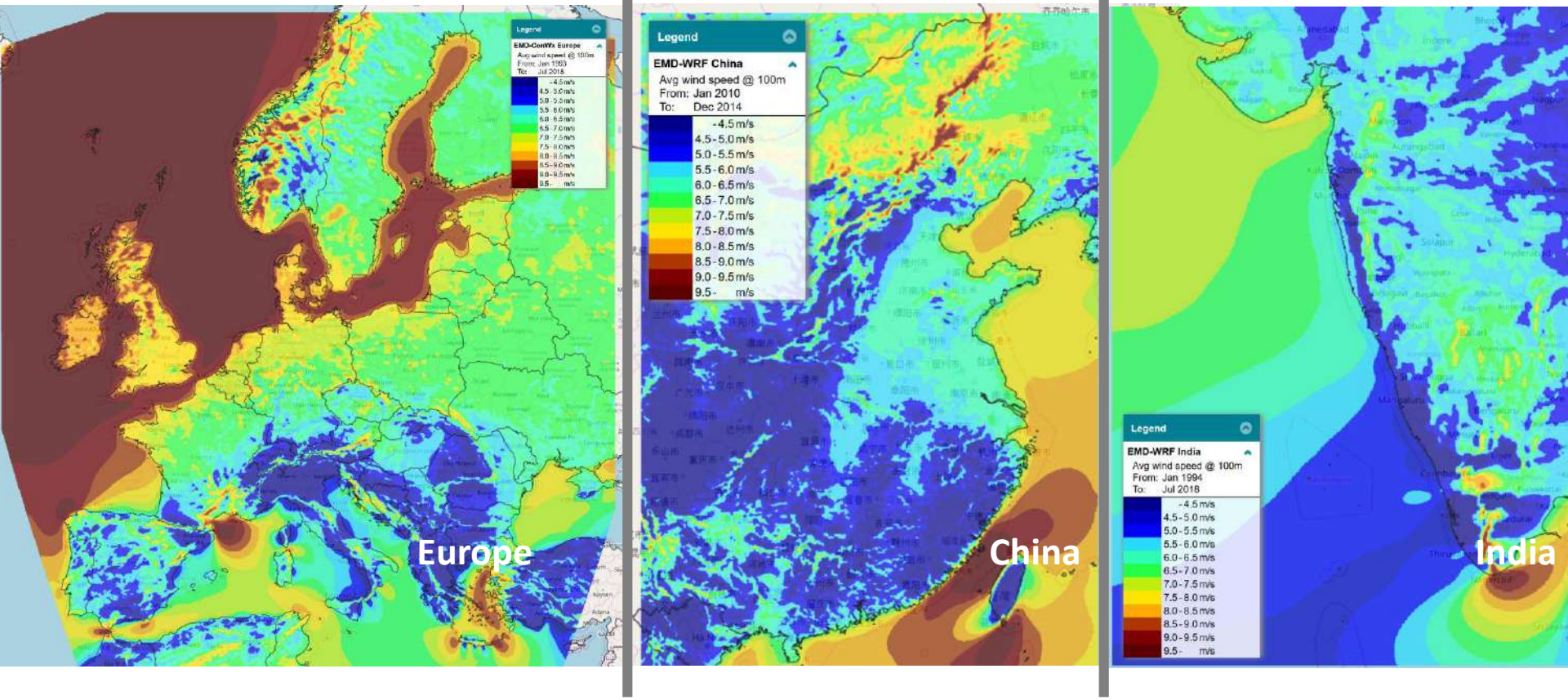
The software package is used by over 2,400 companies and institutions worldwide in more than 90 countries, including all leading manufacturers, utilities, developers and consultants.



1. Introduction - windPRO



1. Introduction – Accurate prediction is crucial!



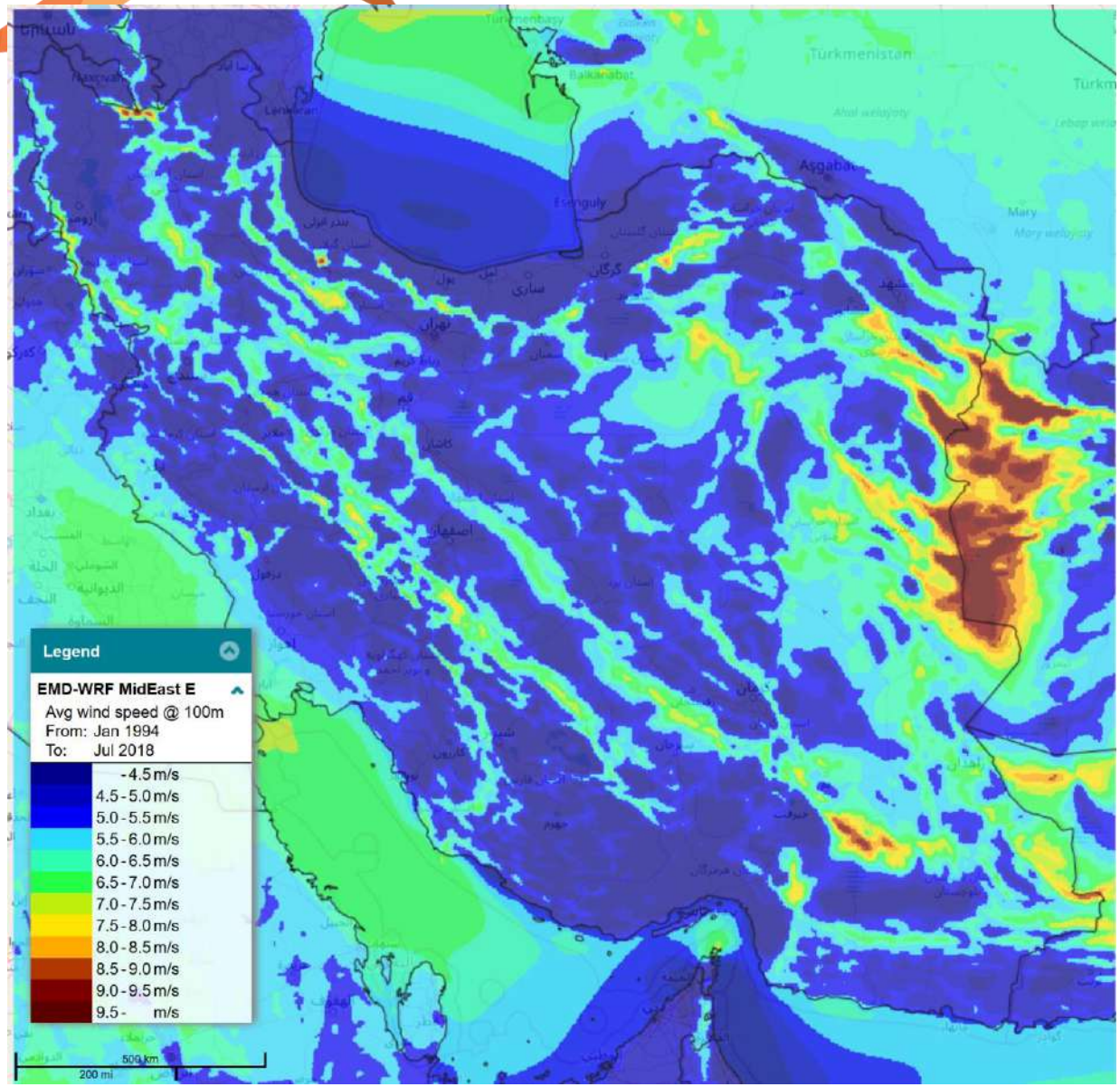
±5% difference in wind prediction can decide if to develop the site or not

The accuracy of wind maps are often less than ±20%.

Thus, uncalibrated wind resource maps are just rough (but useful) guides to locate sites

-> Detailed studies - possibly with a tall (100m+) meteorological tower - are a must!

2. Models – **Siting**



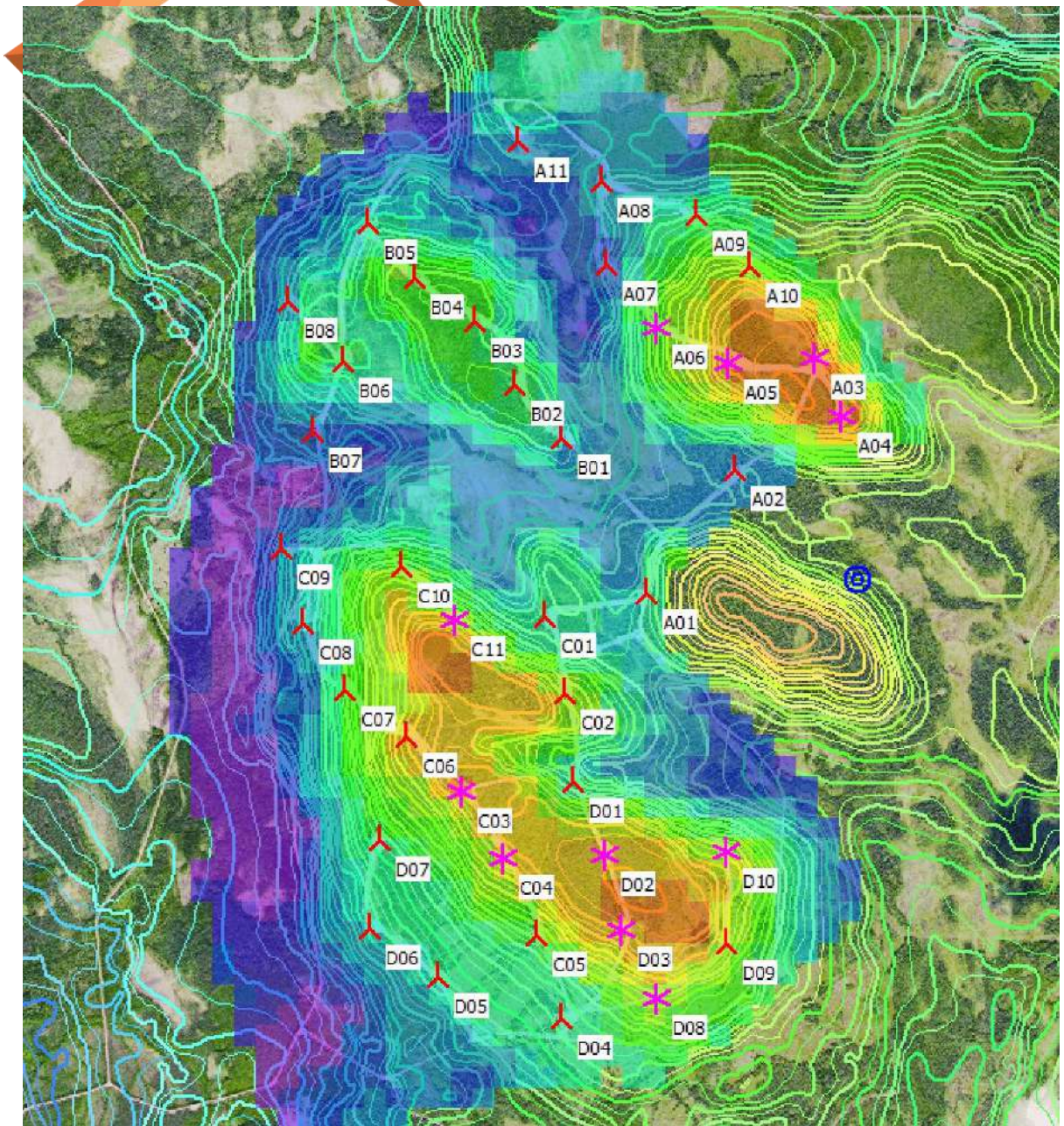
Siting –

Where to look for sites?

Five major conditions have to be fulfilled:

1. Wind resource & economical feasibility
2. Acceptable climatic conditions
3. No major environmental or neighbour conflicts
4. Acceptable infrastructure
5. Cooperating landowner

2. Models – **Micro Siting**



Micro Siting –

How to place the turbines?

Where to place a meteorological tower?

Five major conditions have to be fulfilled:

1. Wind resource & economical feasibility
2. Acceptable climatic conditions
3. No major environmental or neighbour conflicts
4. Acceptable infrastructure
5. Cooperating landowner

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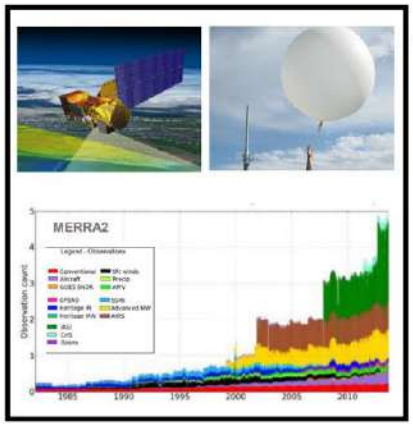
2. Models – The Model Chain

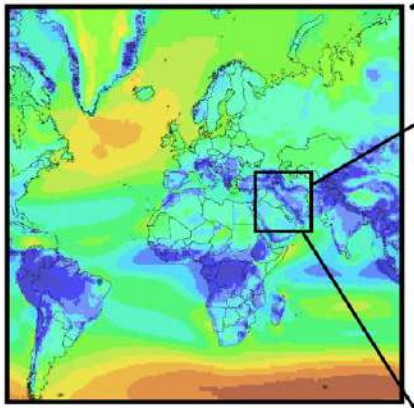
OBSERVATIONS



DATA: IN-SITU AND REMOTE OBSERVATIONS

ERA-5 RAW DATA

DATA ASSIMILATION / REANALYSIS



DATA: GLOBAL / SYNOPTIC SCALE:

Reanalysis Data: ECMWF ERA5
Spatial Resolution: ~35km

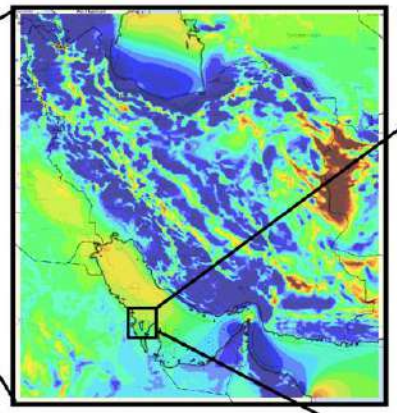
Typical model scales: ~100 km's
Time-series data, 1 hourly resolution

EMD-WRF OD

EMD-WRF MESOSCALE MODELLING

Data Input:
- ERA5 Boundary Data
- Globcover Terrain

Model Execution:
- Standard EMD-WRF setup
- Spatial resolution ~ 3 km



DATA: MESOSCALE:

Time series, wind speed and direction
Spatial Resolution: ~3 km
Temporal resolution: 1 hour

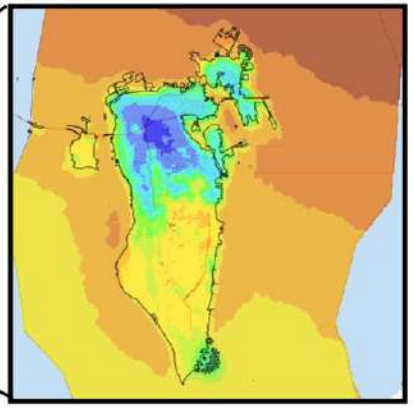
Typical model scales: ~10 km's

DOWNSCALING

EMD-MESO/MICRO DOWNSCALE MODELLING

Data Input:
- Mesoscale time series and terrain
- Detailed, high-resolution microscale terrain

Model Execution:
- WAsP version 11+
- windPRO version 3.1+

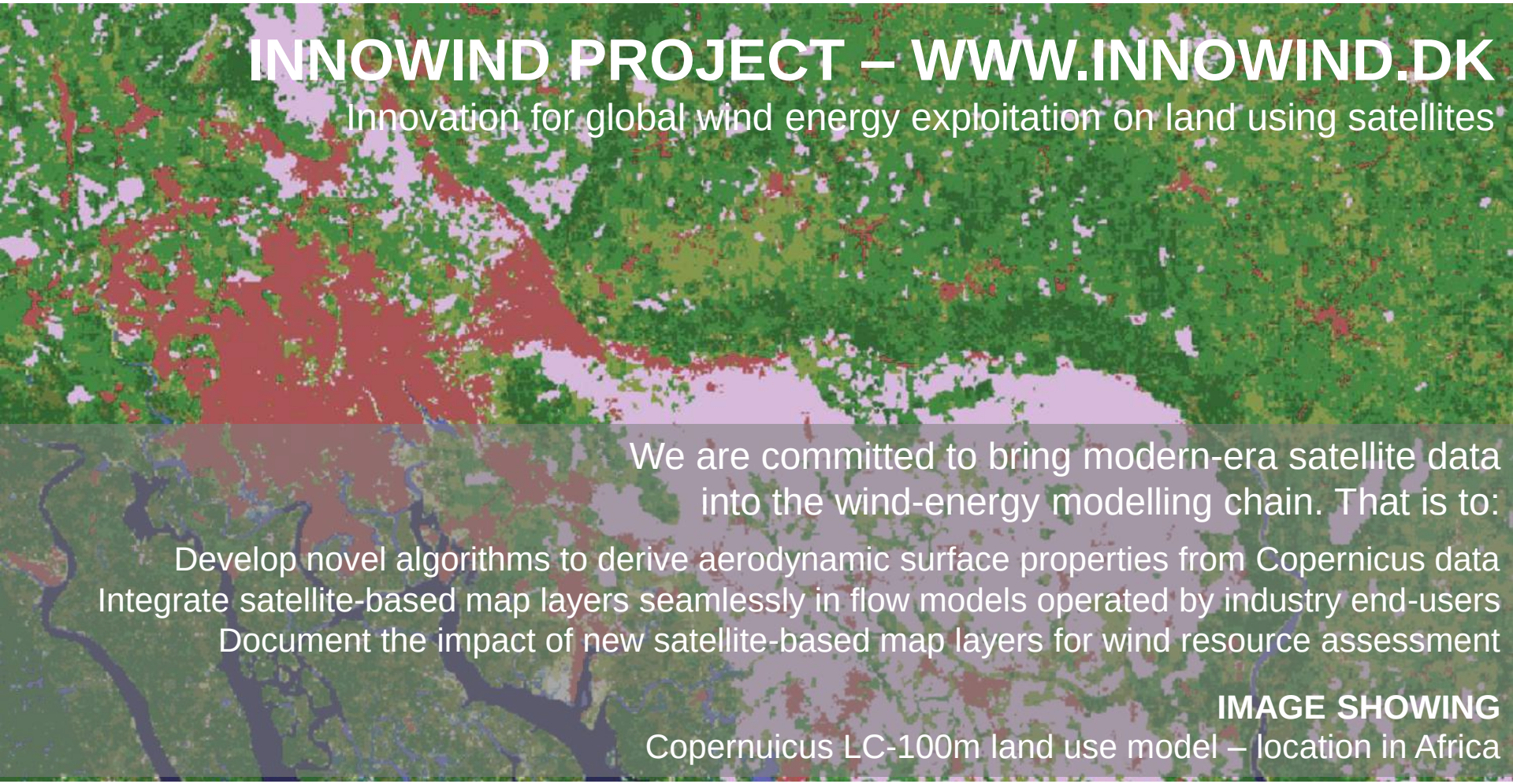


DATA: MICROSCALE:

Time series & statistical data, wind speed and direction
Spatial Resolution: ~250m
Temporal resolution: 1 hour

Typical model scales: ~10 m's

2. Models, Data for Mesoscale & Microscale



INNOWIND PROJECT – WWW.INNOWIND.DK

Innovation for global wind energy exploitation on land using satellites

We are committed to bring modern-era satellite data into the wind-energy modelling chain. That is to:

Develop novel algorithms to derive aerodynamic surface properties from Copernicus data
Integrate satellite-based map layers seamlessly in flow models operated by industry end-users
Document the impact of new satellite-based map layers for wind resource assessment

IMAGE SHOWING
Copernuicus LC-100m land use model – location in Africa

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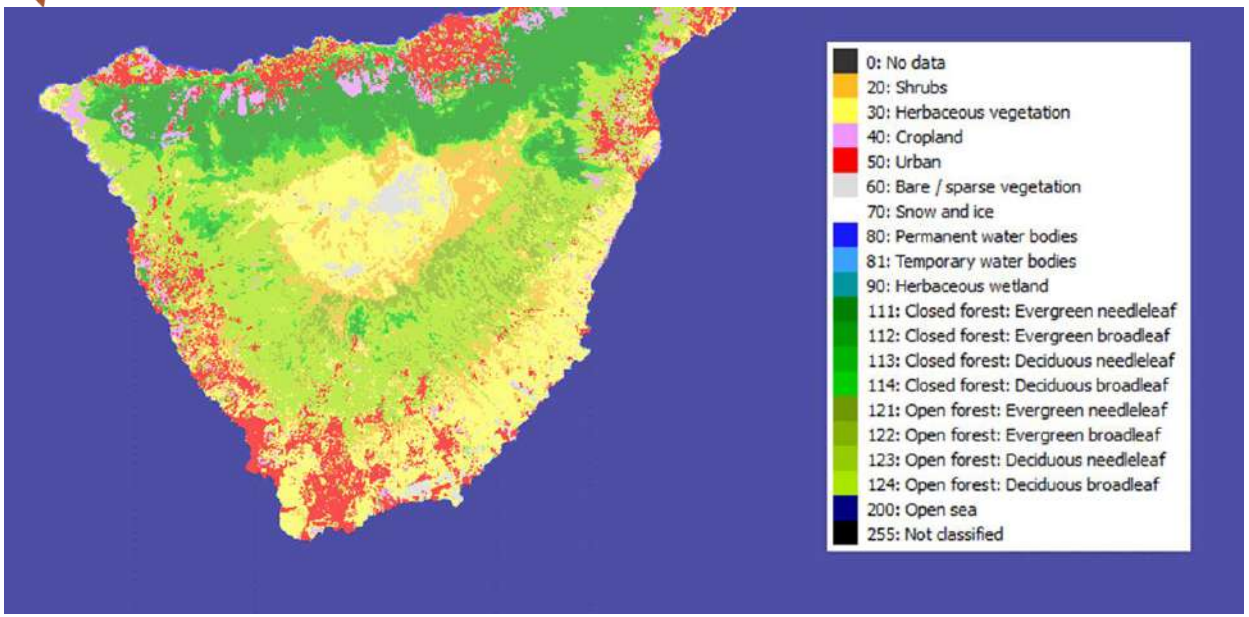
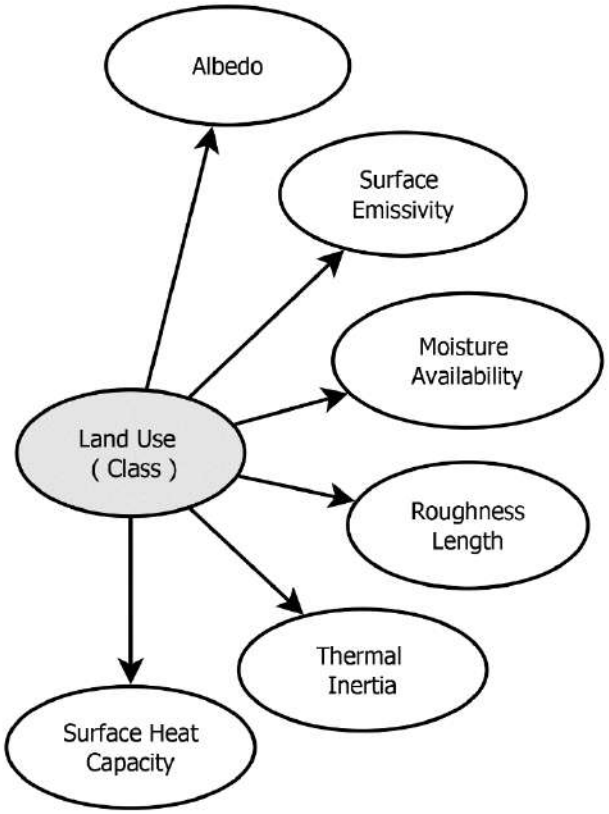
DTU

DHI GRAS

2. Mesoscale Model – Lookup Tables

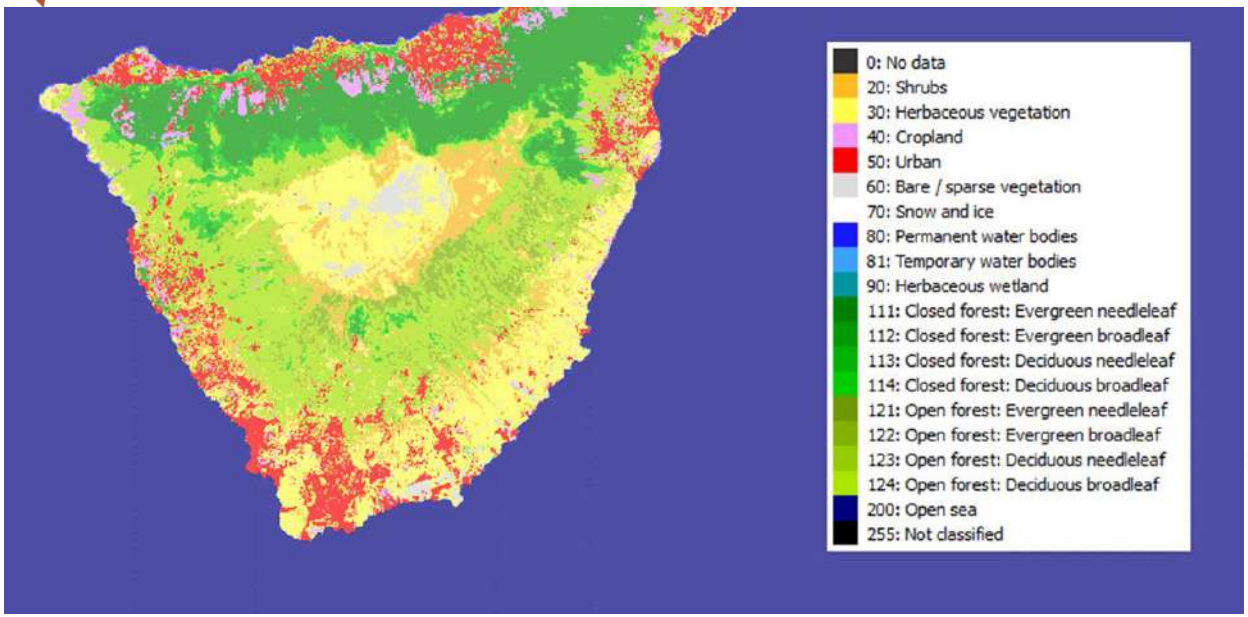


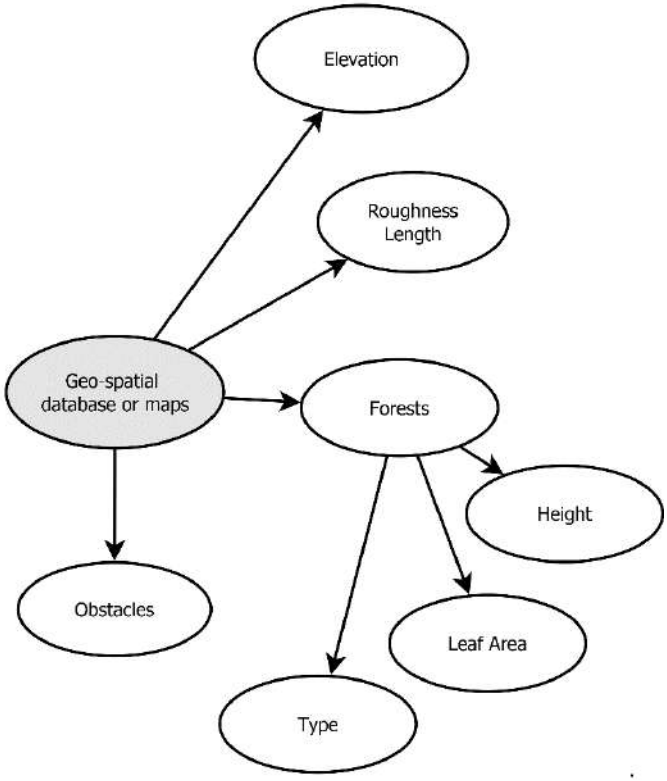


land use index	ALBEDO	SLMO	SFEM	SFZ0	THERIN	SFHC	definition
1	15	0.10	0.88	80	3	18.9	'Urban and Built-Up Land'
2	17	0.30	0.985	15	4	25.0	'Dryland Cropland and Pasture'
3	18	0.50	0.985	10	4	25.0	'Irrigated Cropland and Pasture'
4	18	0.25	0.985	15	4	25.0	'Mixed Dryland/Irrigated Cropland and Pastu
5	18	0.25	0.98	14	4	25.0	'Cropland/Grassland Mosaic'
6	16	0.35	0.985	20	4	25.0	'Cropland/Woodland Mosaic'
7	19	0.15	0.96	12	3	20.8	'Grassland'
8	22	0.10	0.93	5	3	20.8	'Shrubland'
9	20	0.15	0.95	6	3	20.8	'Mixed Shrubland/Grassland'

Reference (lookup table): Esteve, 2015.

2. Microscale Model – Classification





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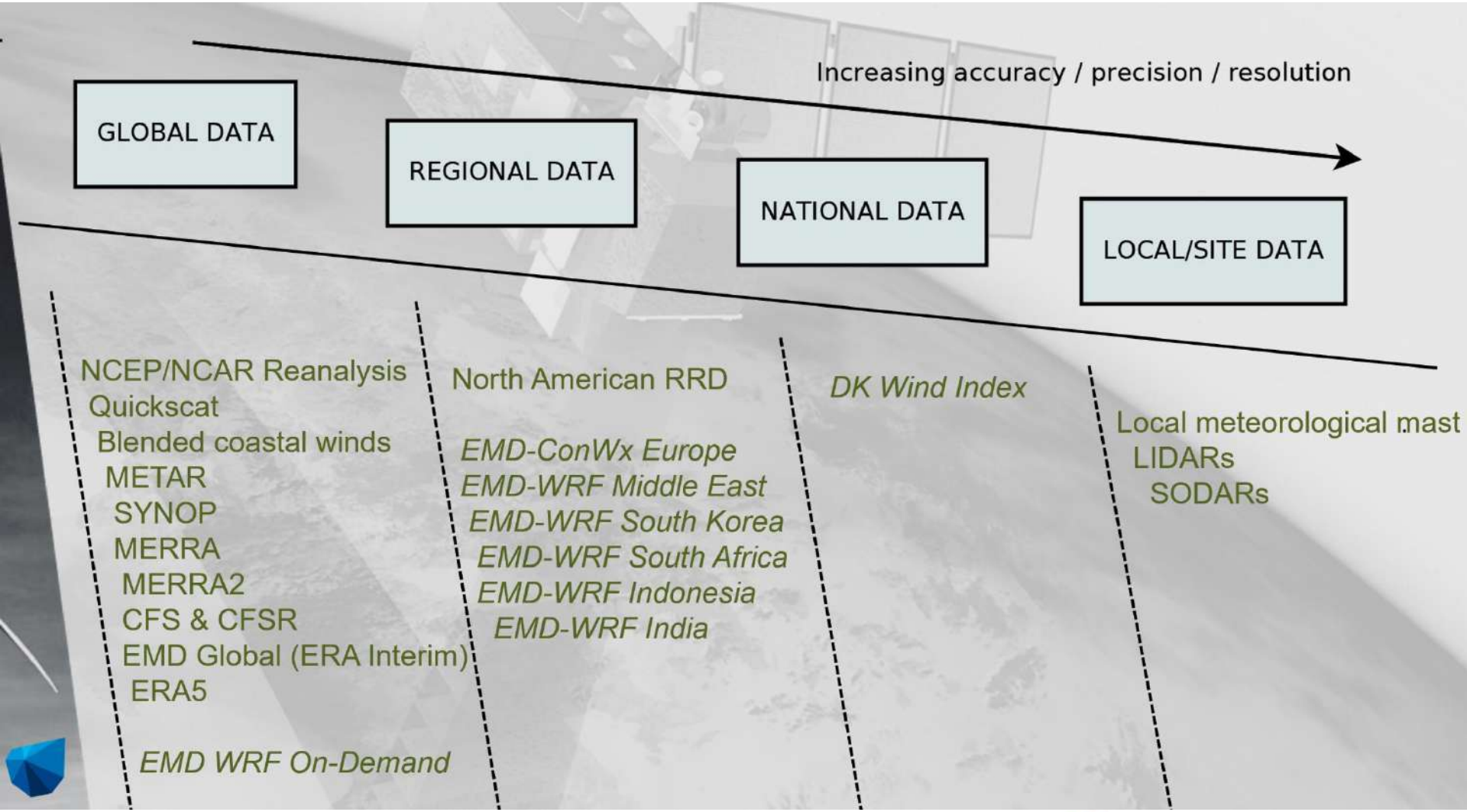
2. Models and Data (1)

50+ Reanalysis and Remote Sensing Datasets in windPRO:

1) Digital elevation data [11]
2) Roughness data [8]
3) Digital maps / satellite imagery [8]
4) Wind data [19 -20]
5) Wind turbine databases – turbine-locations and turbine-catalogue [4]
6) Forest data [1]

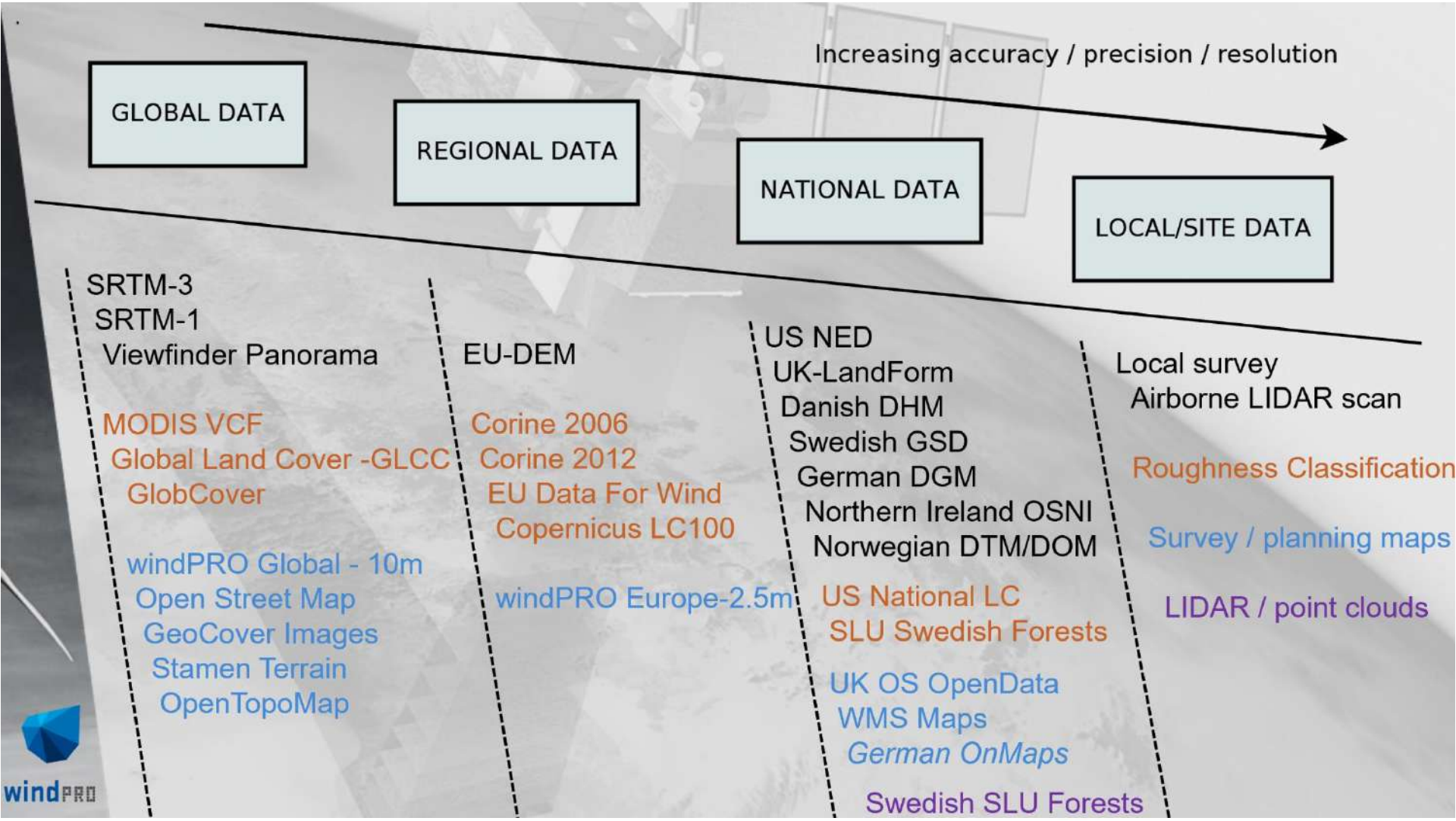
LEGEND
Green = Wind data
Italic = Premium Data or Service

2. Models and Data (2)

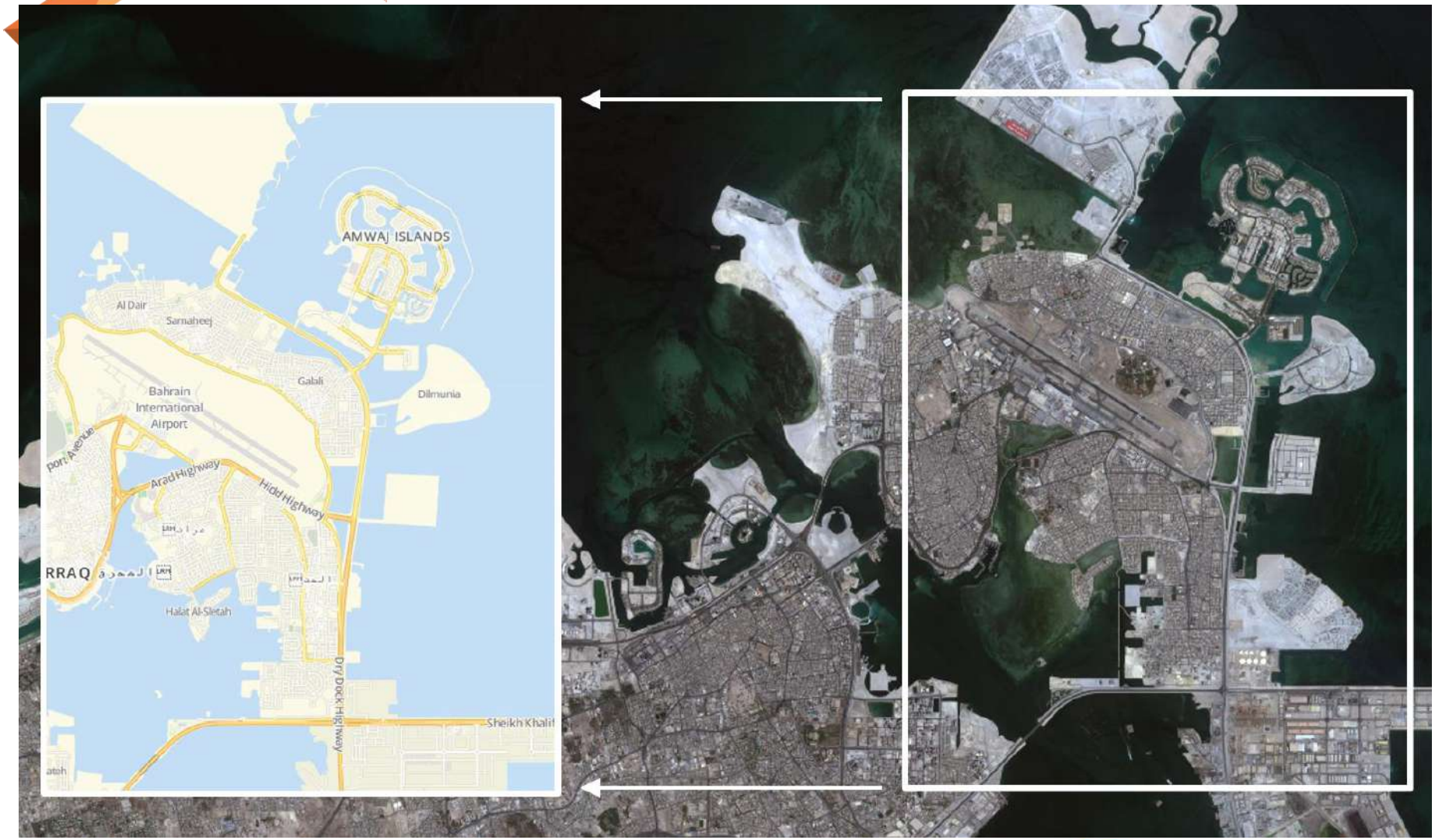


LEGEND
Black = Orography
Orange = Roughness
Blue = Maps
Purple = Forest
Italic = Premium Data or Service

2. Models and Data (3)



3. Applications & Cases – Maps



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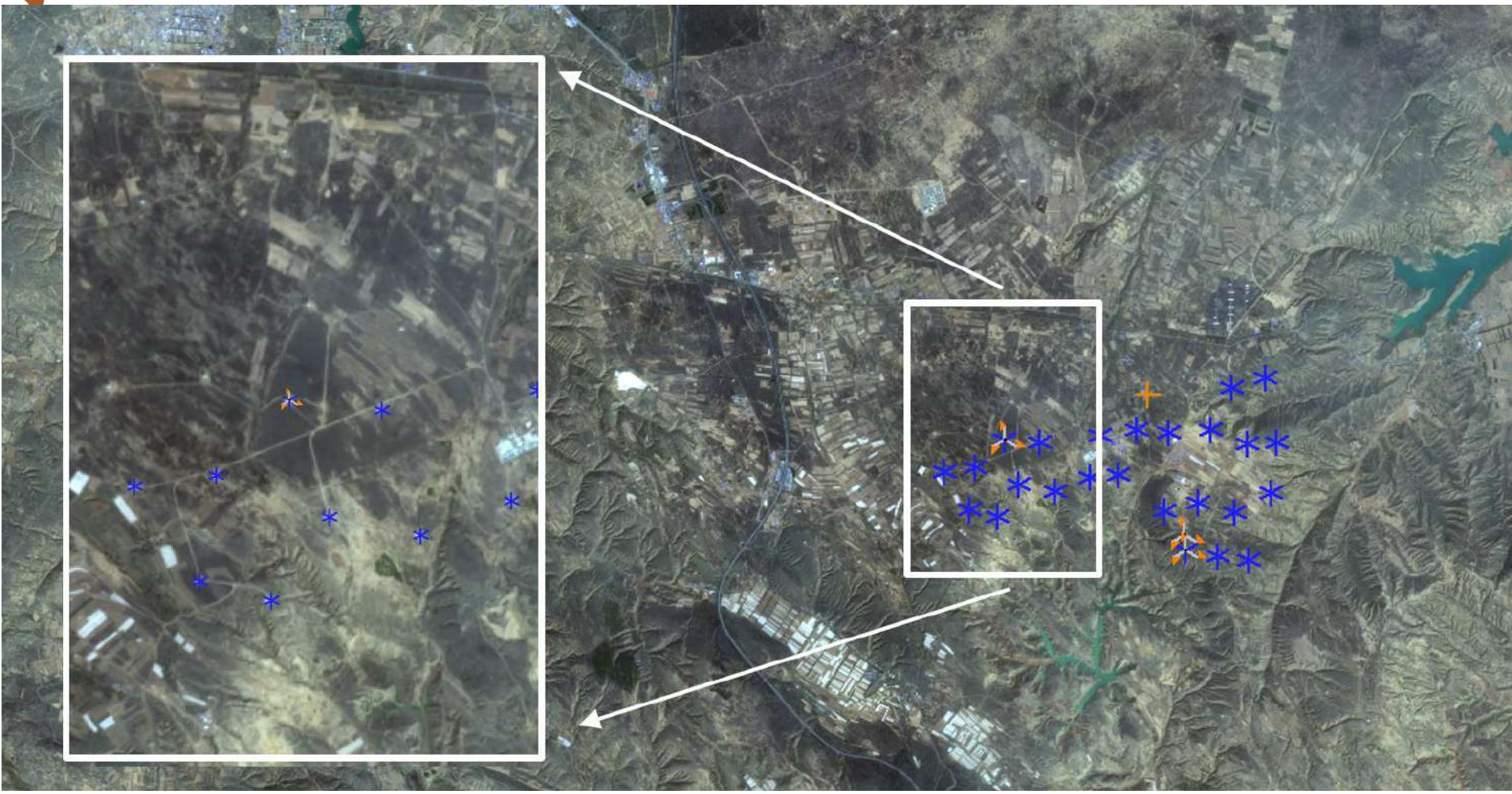
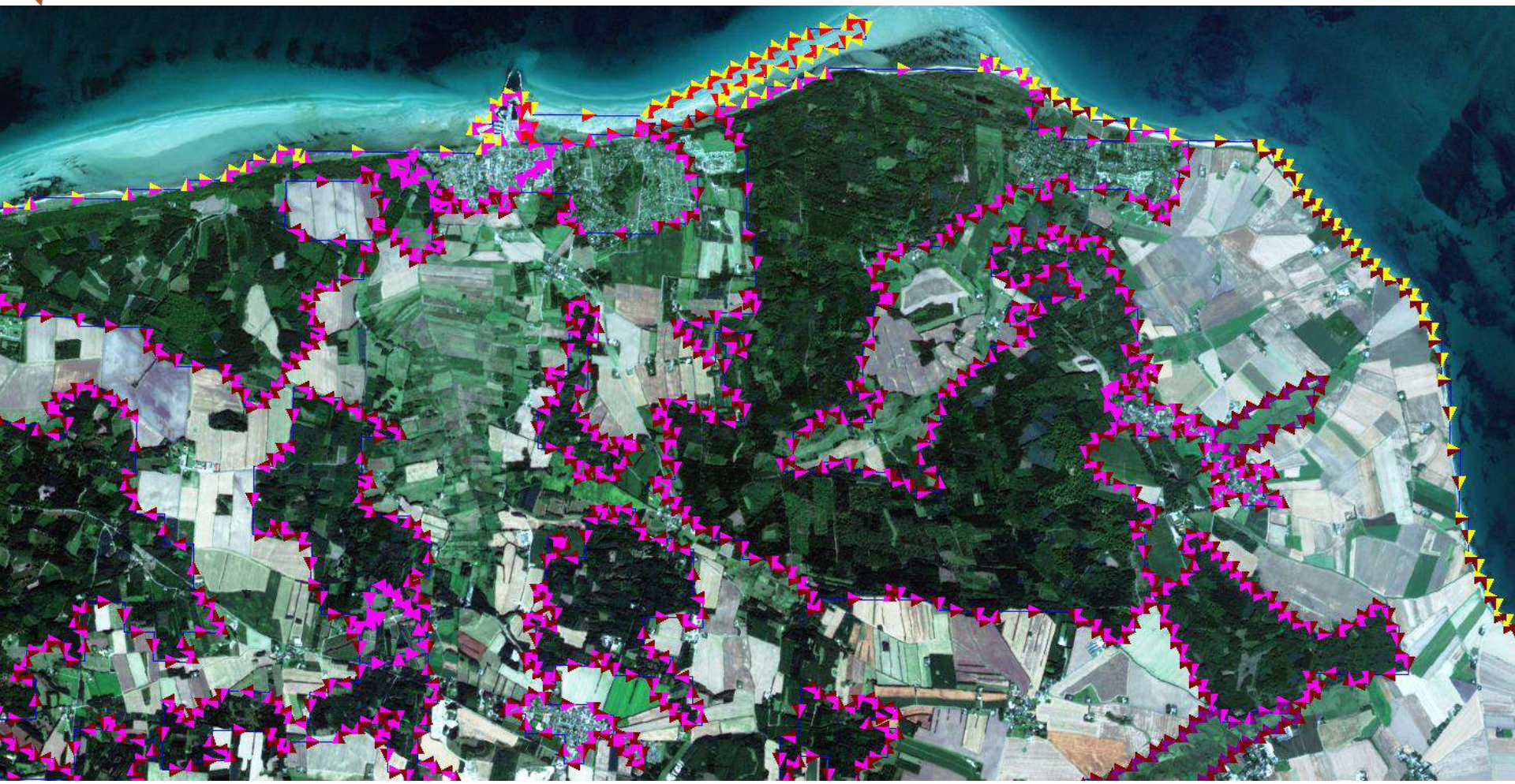
3. Applications & Cases – Maps

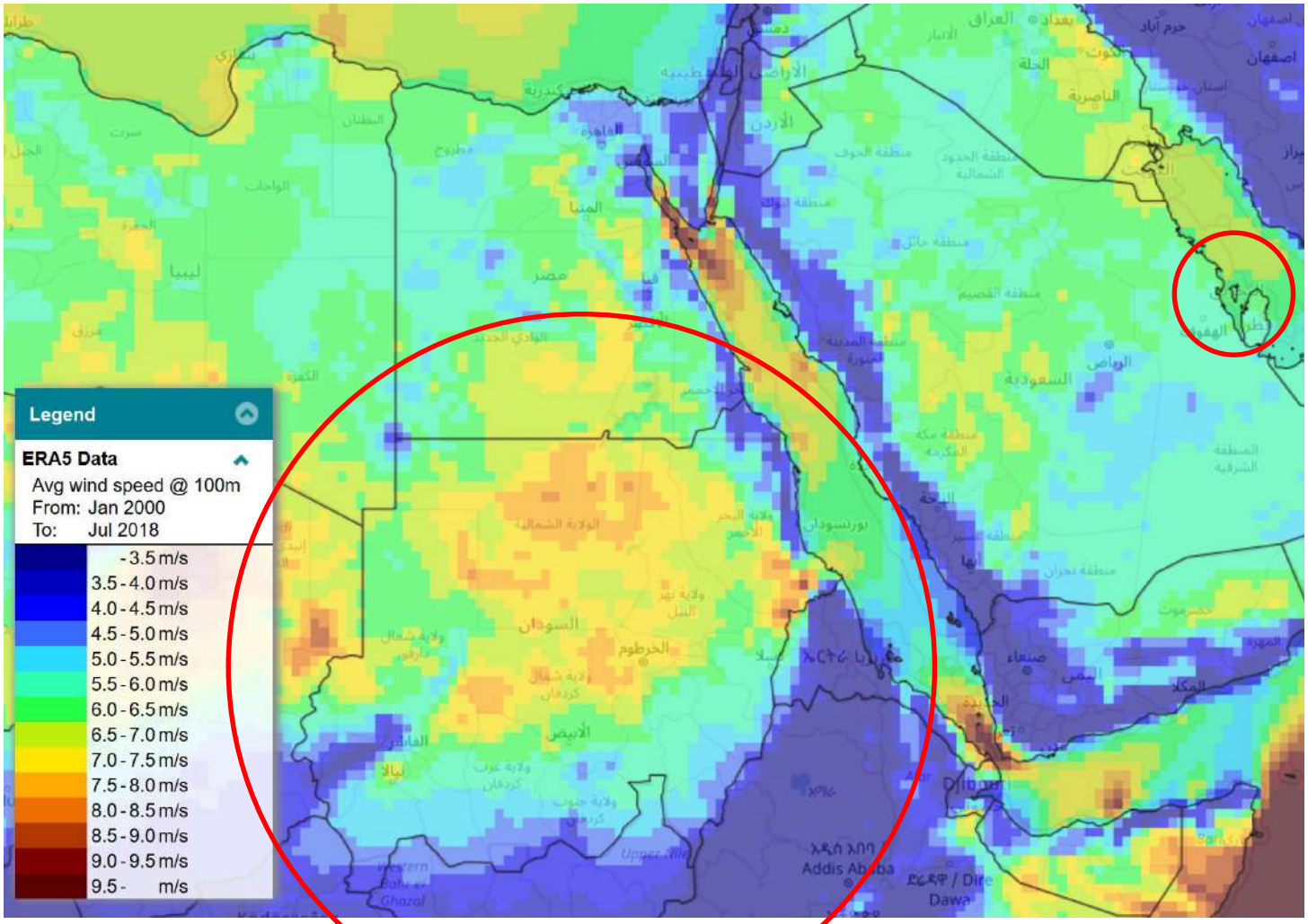


3. Applications & Cases – Roughness Class



Corine 2012 as Roughness Map Input:
http://help.emd.dk/mediawiki/index.php?title=Corine_2012

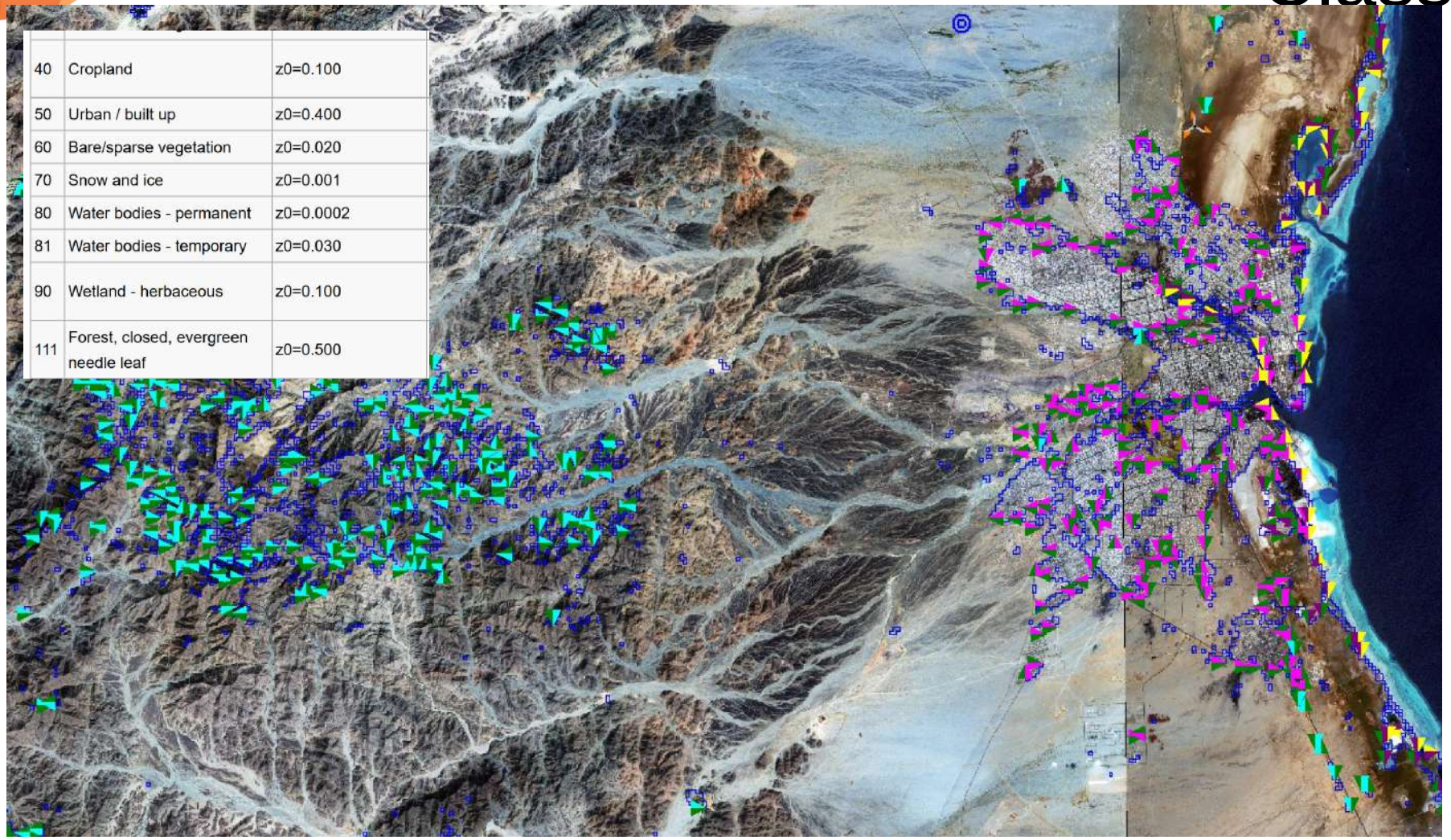
3. Applications & Cases – Roughness Class



Copernicus Global Land Cover Classification – 100m

http://help.emd.dk/mediawiki/index.php?title=CGLS-LC100m

3. Applications & Cases – Roughness Class

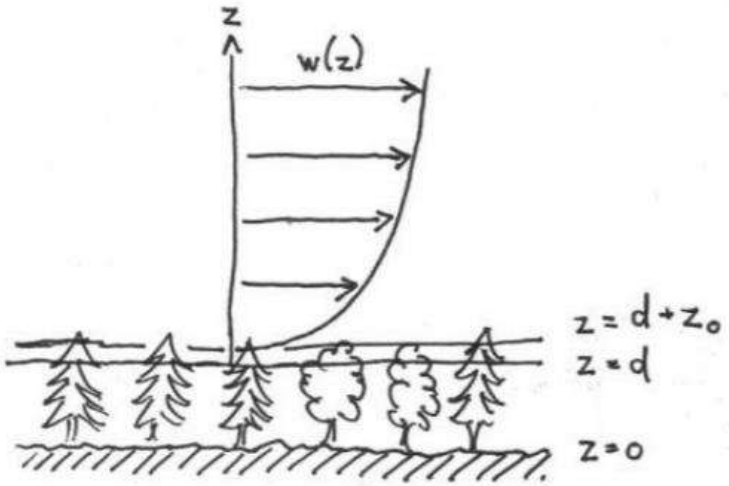


40	Cropland	z0=0.100
50	Urban / built up	z0=0.400
60	Bare/sparse vegetation	z0=0.020
70	Snow and ice	z0=0.001
80	Water bodies - permanent	z0=0.0002
81	Water bodies - temporary	z0=0.030
90	Wetland - herbaceous	z0=0.100
111	Forest, closed, evergreen needle leaf	z0=0.500

Copernicus Global Land Cover Classification – 100m

http://help.emd.dk/mediawiki/index.php?title=CGLS-LC100m

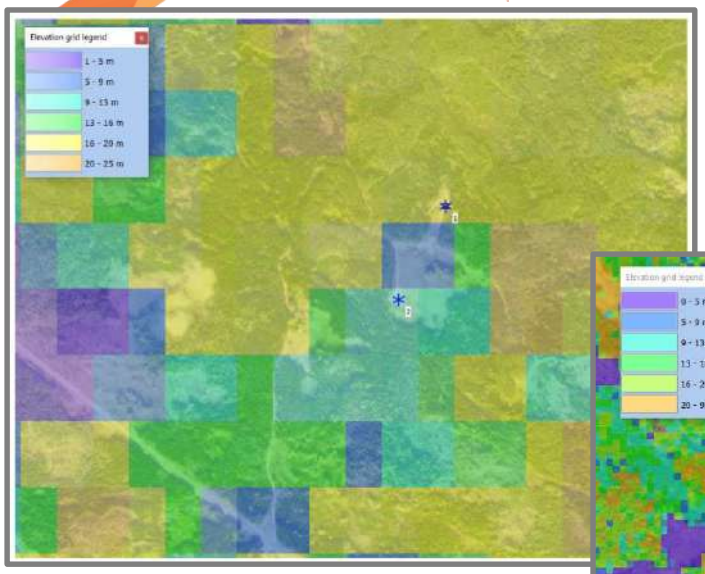
3. Applications & Cases – Forests



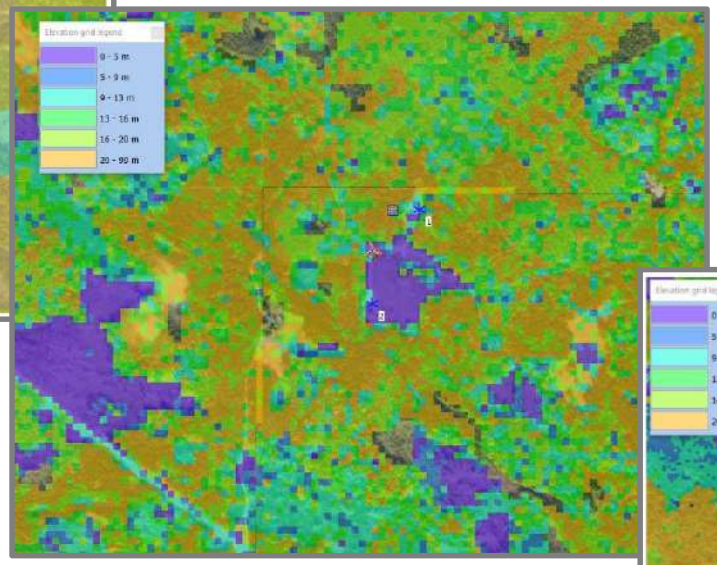
$$w(z) = v_* \frac{1}{\kappa} \ln\left[\frac{z-d}{z_0}\right]$$

	Forest Height (H)	
	Coniferous	Deciduous
Displacement Height (Z_d)	$0.66 \cdot H$	$0.70 \cdot H$
Roughness Length (z_0)	$z_0 = 0.3 \cdot (H - Z_d)$	
Roughness Length (z_0)	$z_0 = \begin{cases} 0.1H \; for \; h > 2.5m \\ 0.1 \; for \; h < 2.5m \\ 0.0001 \; for \; water \; areas \end{cases}$	

3. Applications & Cases – Forests

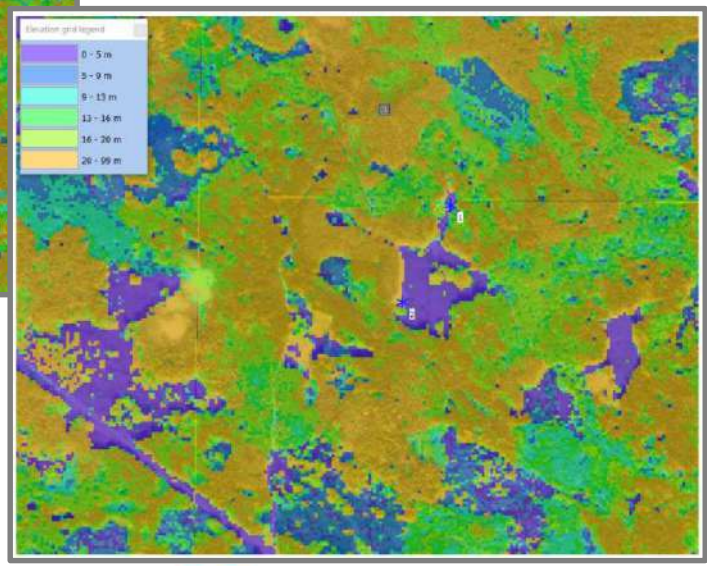


Global model ~ 250m



SE SLU Forest Model ~ 25m

Local LIDAR scan (point cloud) ~ 10m



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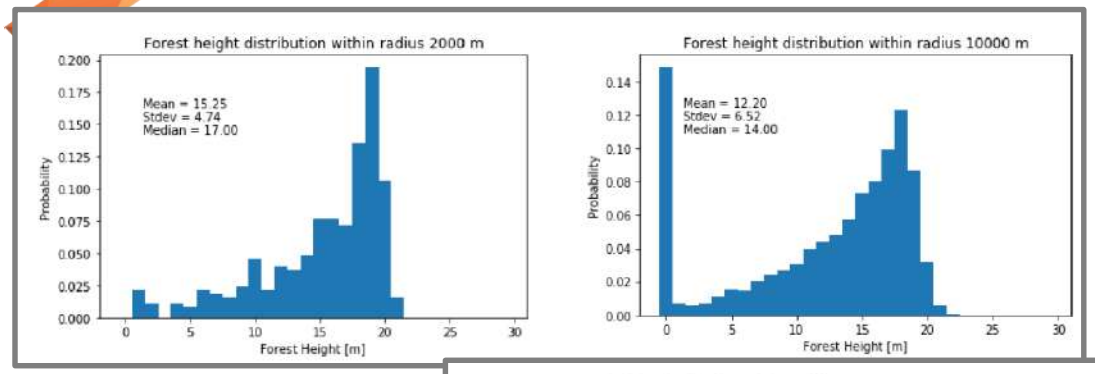
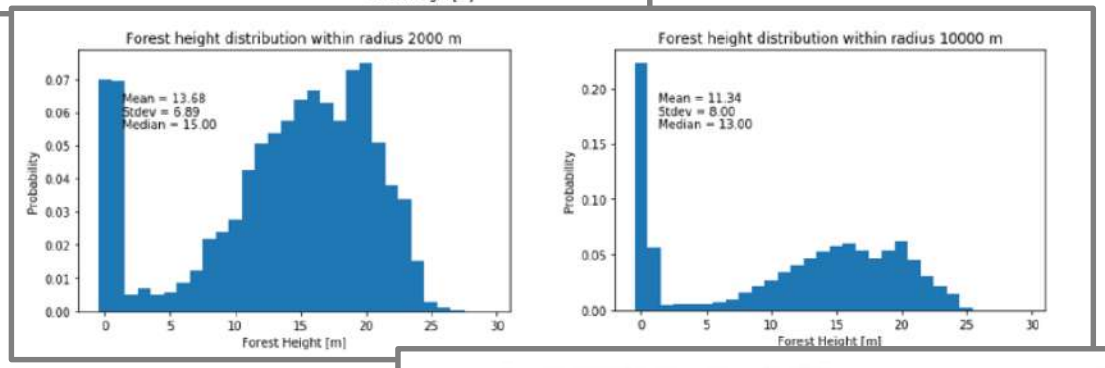
3. Applications & Cases – Forests

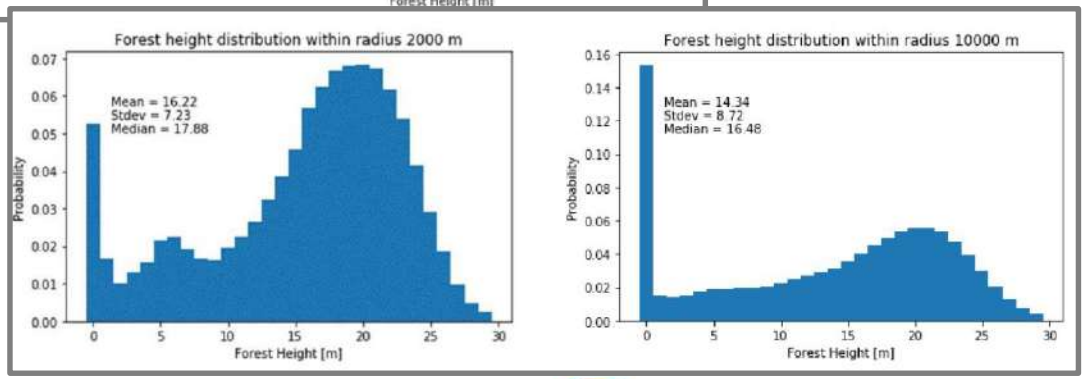


Global model
~ 250m

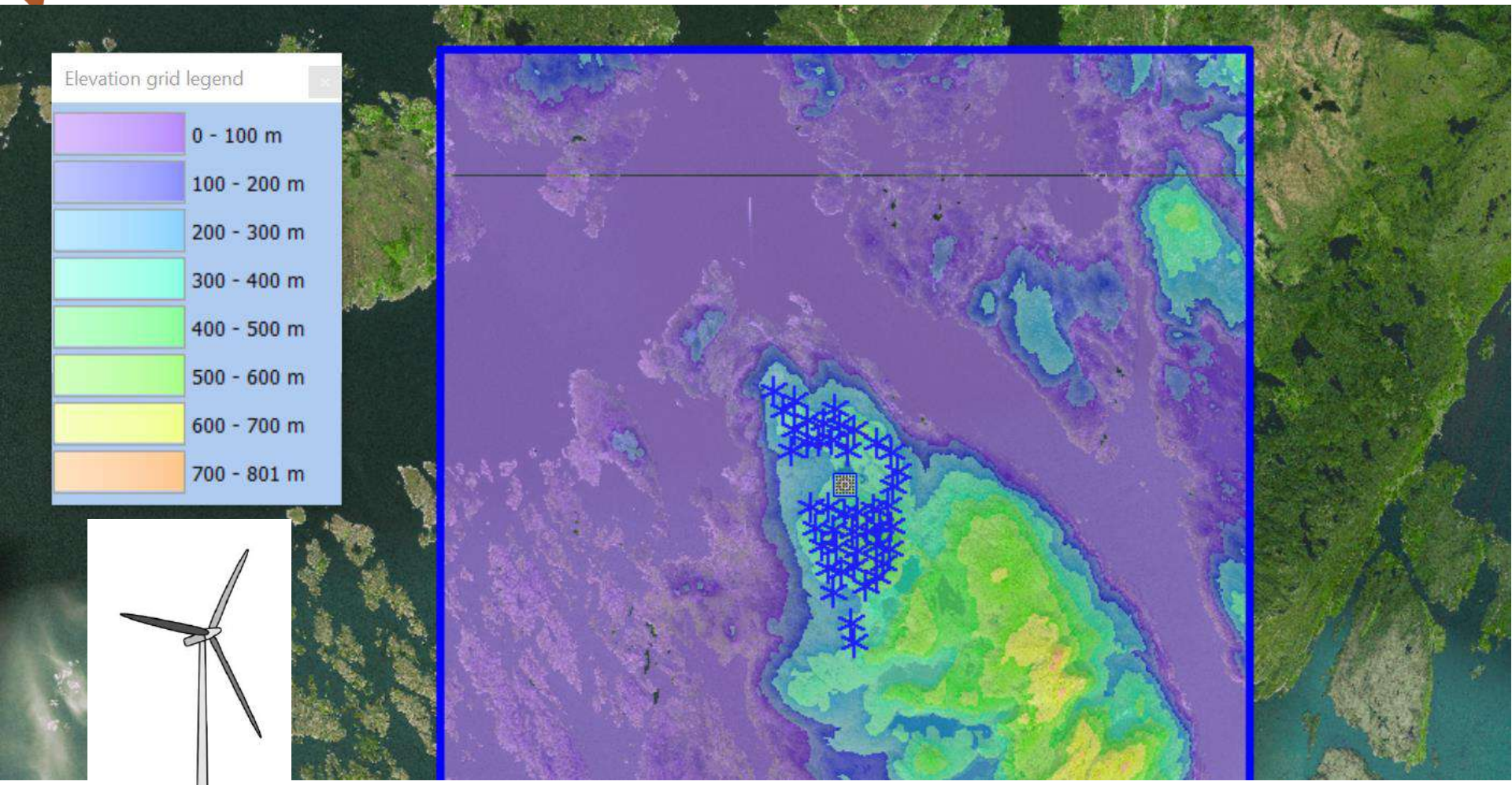


SE SLU Forest Model
~ 25m

Local LIDAR scan
(point cloud) ~ 10m



3. Applications & Cases – DEM



DHM1-MLT	AW3D30
SRTM3	ViewFinder
SRTM1	DHM10-MLT
EU-DEM	

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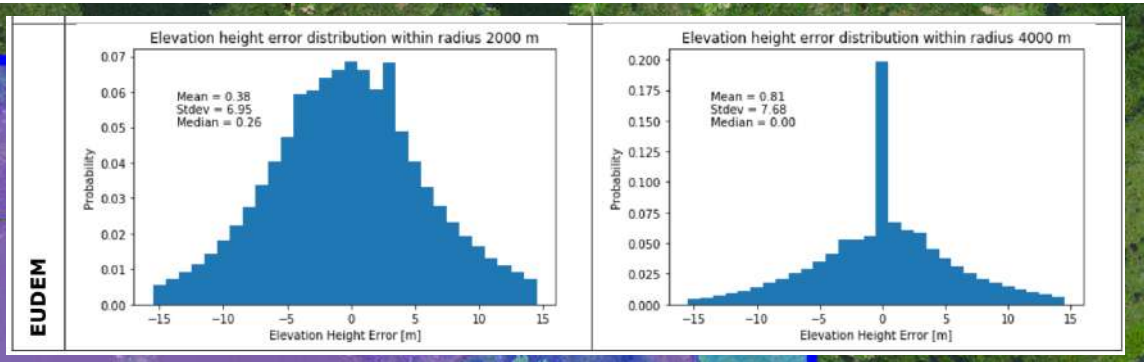
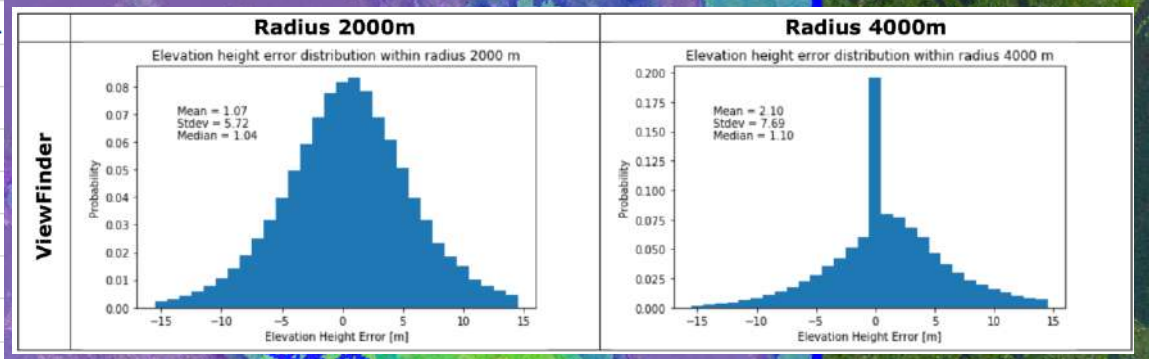
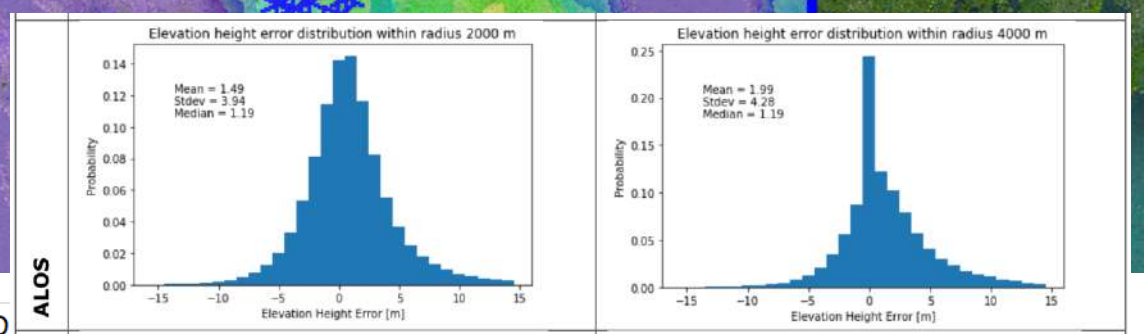
3. Applications & Cases – DEM

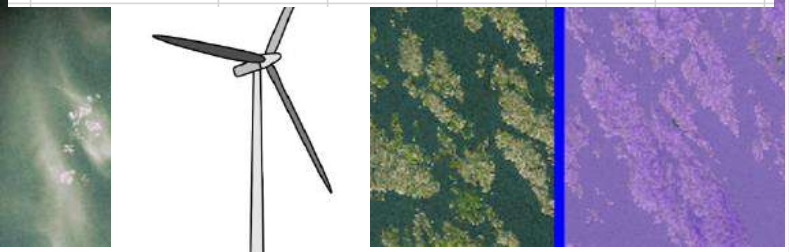
44 Turbine Positions at Midtfjellet - Difference to DHM1

	Mean	StdDev	RMS-E	Min	Max
SRTM3	-2.0	3.1	3.7	-8.6	4.4
SRTM1	-0.6	2.4	2.5	-5.5	4.6
EU-DEM	-4.1	4.9	6.4	-17.6	7.0
AW3D30	0.0	1.8	1.8	-5.0	4.8
ViewFinder	-1.5	2.8	3.2	-7.6	4.1
DHM10-MLT	-0.1	0.3	0.3	-0.9	0.7









SRTM3	ViewFinder
SRTM1	DHM10-MLT
EU-DEM	

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Thank You!

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At Work in the Wind Energy Sector

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