



Wind climate simulation over complex terrain

(Mountain Meteorology)

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Mountain Meteorology

local mountain climates and human adaptation

airflow dynamics, the dynamic effect of terrain on wind

the thermal effect of hills and slopes on local circulations

the influence of major mountain ranges on global circulations and climate

Mountain meteorology



Main characteristics of the mountaineous atmosphere:

the flow field is complex

the vertical temperature gradient is roughly $-1\text{ }^{\circ}\text{C} / 150\text{ m}$

Scales of interaction of complex terrain with atmospheric phenomena :

Synoptic scale fronts and waves

Mesoscale mountain-valley circulations

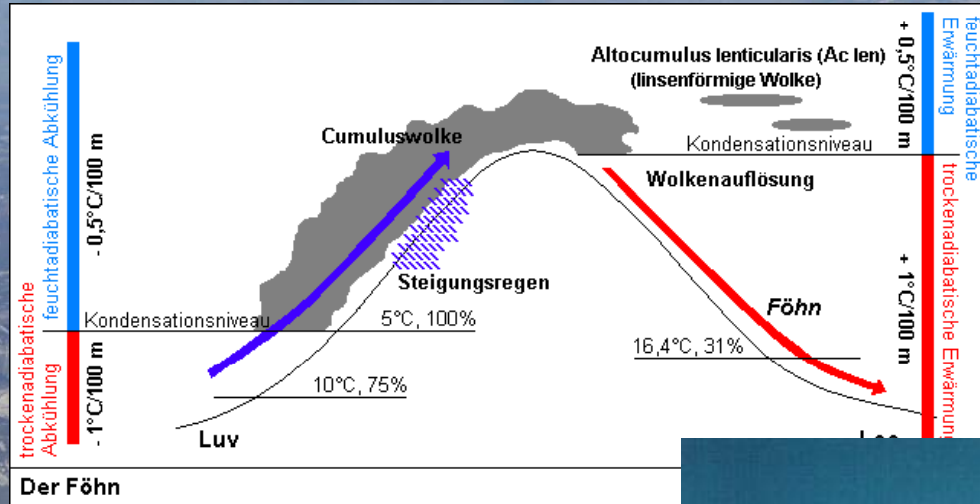
Individual convective cells

Scales of interest range from a few meters (flow separation) to

thousands of kilometers (flow blocking / monsoons)

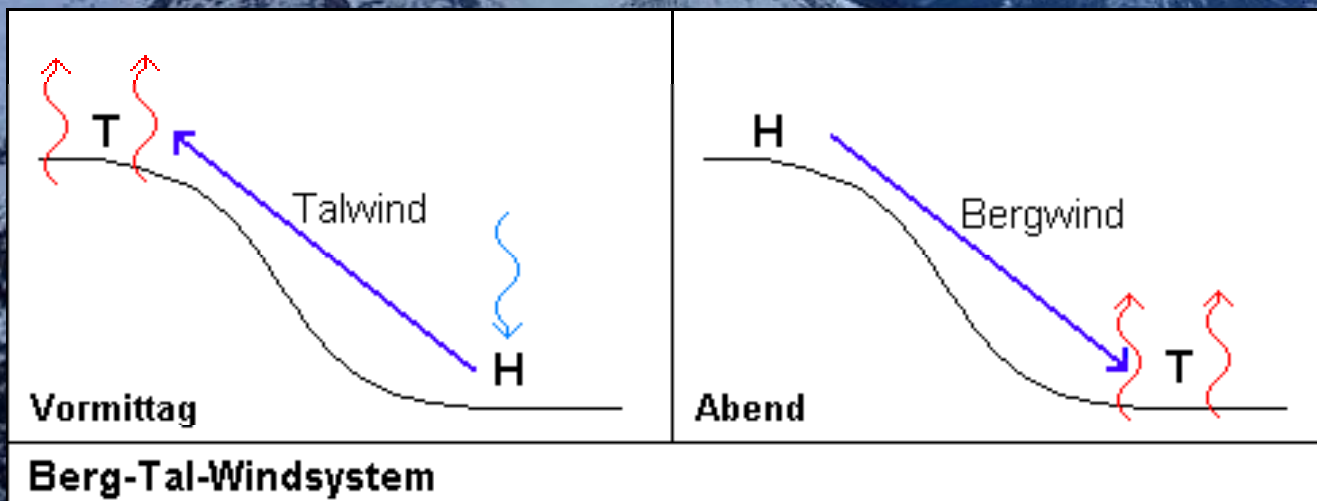
Föhn

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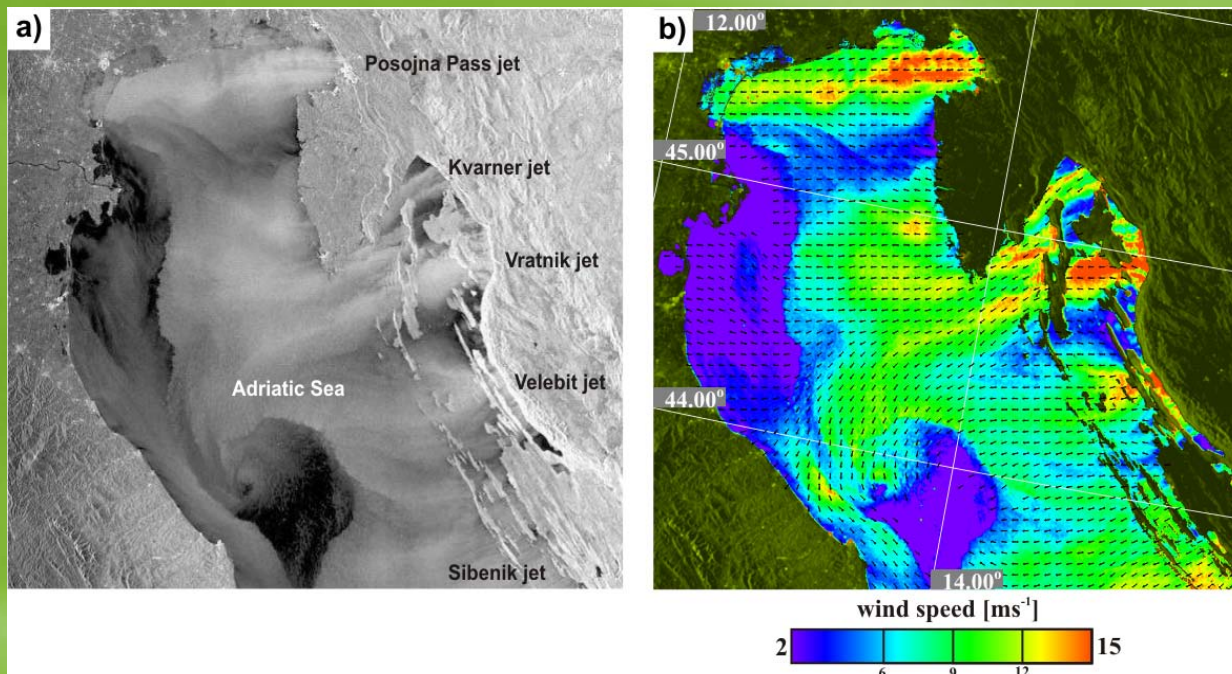
mountain and valley wind

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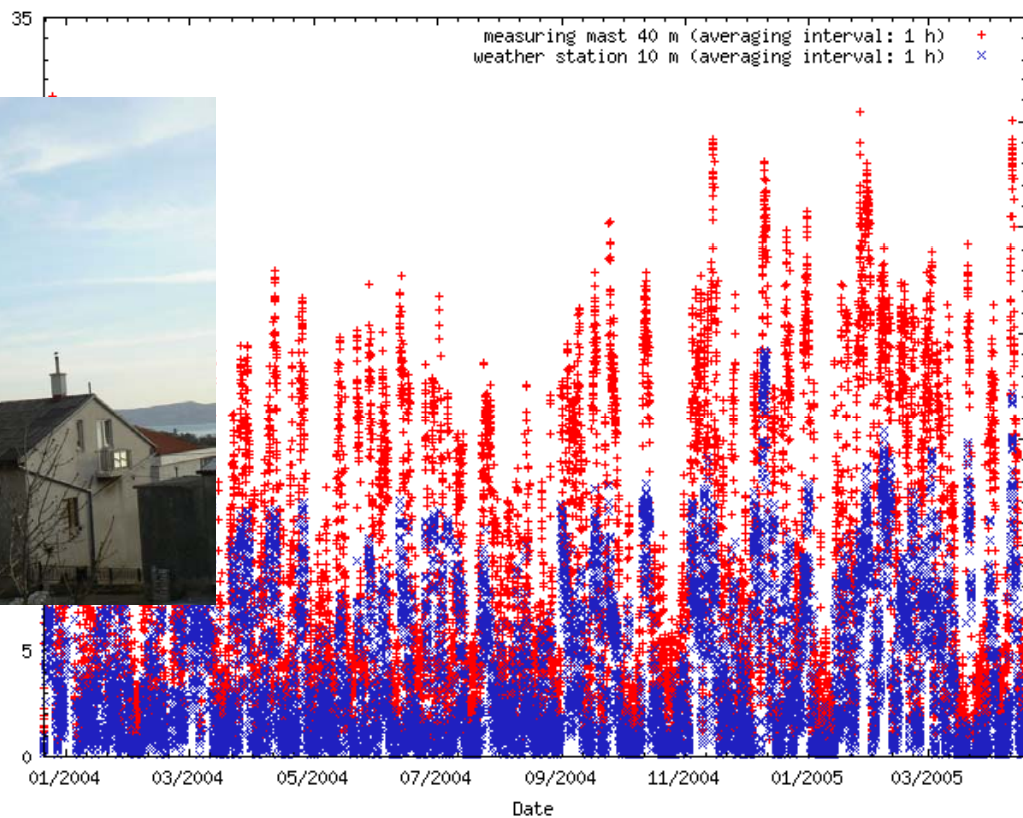
Bora



Envisat ASAR WSM image acquired on 14 January 2006 at 2053 UTC over the northern section of the Adriatic Sea during a (weak) winter bora event. (b) Corresponding wind field retrieved by WiSAR from the ASAR data. © ESA



Bora





Bora

Can we simulate Bora events ?

annual variability of number of events

estimate Bora influence at particular sites

forecast of events – warning system



mesoscale models

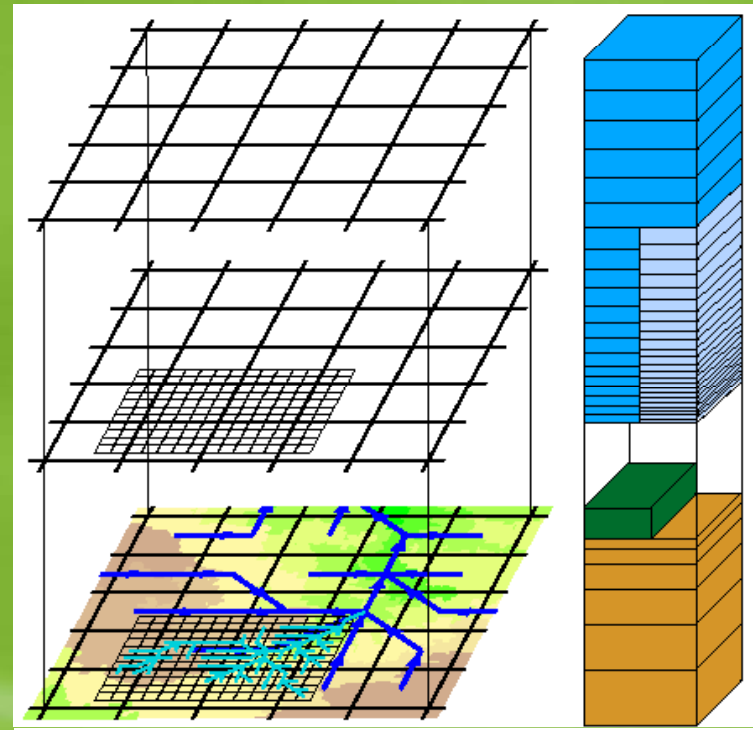
Mesoscale models are based on the full set of governing equations and appropriate physical parameterizations.

The simulation domain may range between some 10 km to some 1000 km,
The horizontal grid resolution may range from 1 km to some 10 km.

Because they describe all relevant physical processes they can simulate

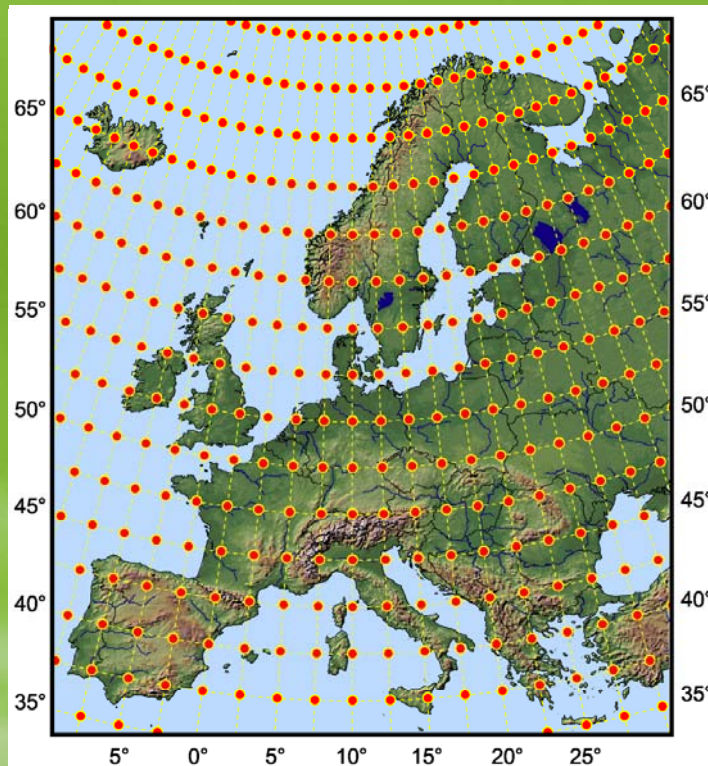
temperature dependent processes
(diurnal, annual cycle)

local wind systems
(lake-sea, mountain-valley ...)





NCEP/NCAR reanalysis data



globally available

2.5 x 2.5 ° spatial resolution

every 6 hours

1948 – present

no inhomogeneities
due to change of
analysis techniques



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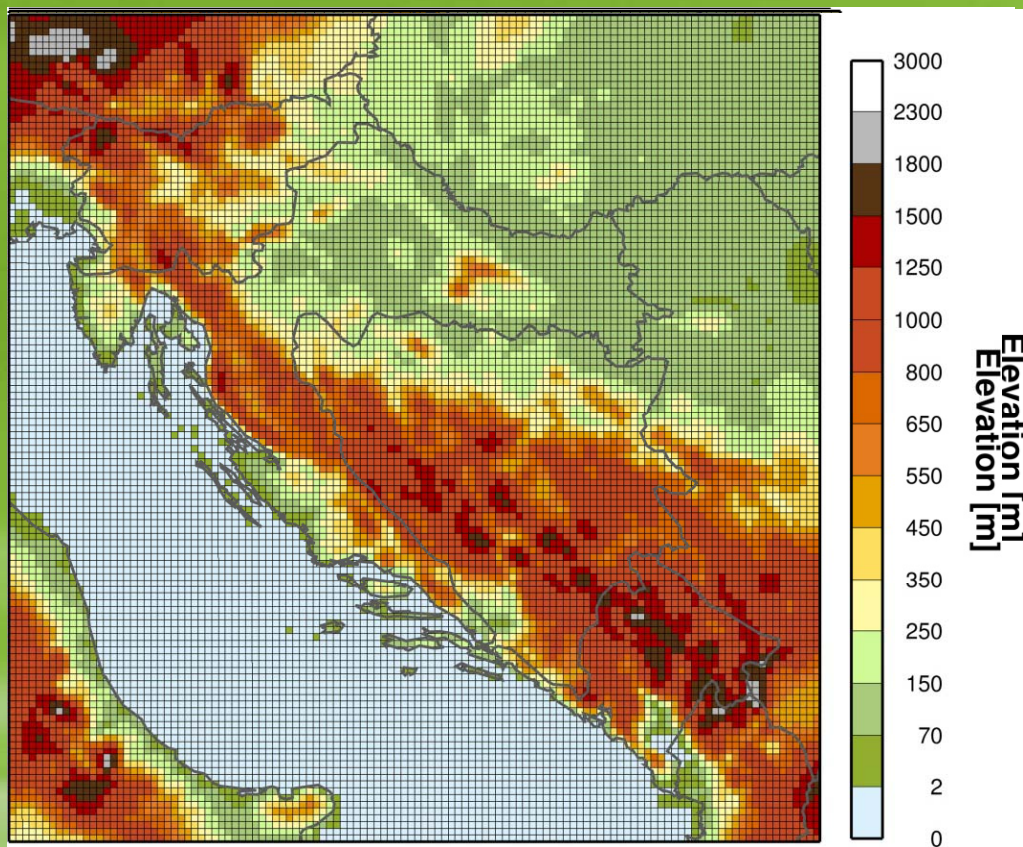


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Orography



Domain 24 48 km x 48 km

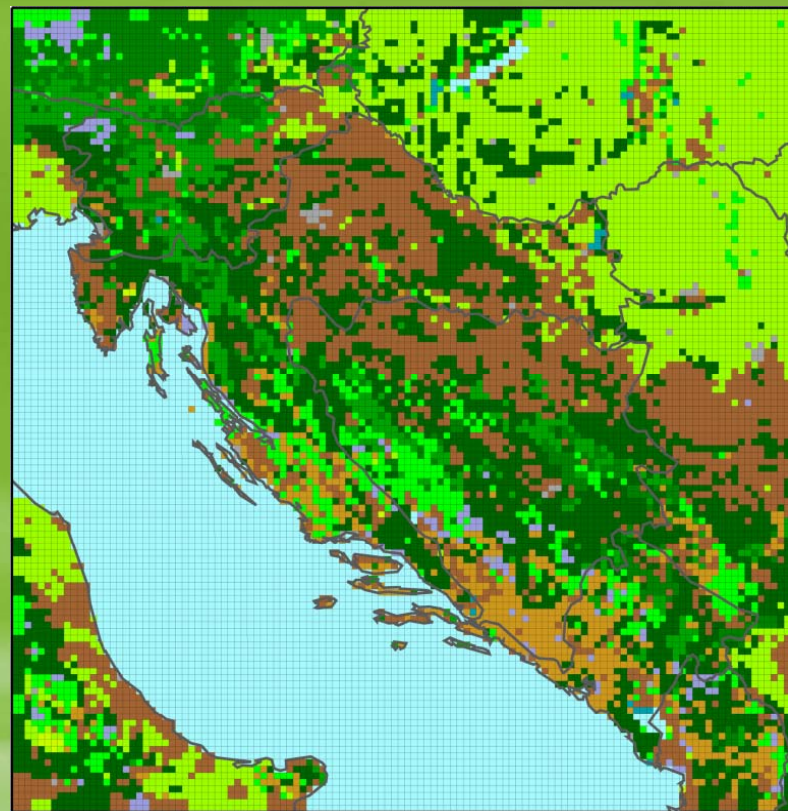




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Land-use

Domain 2 – 485km515km

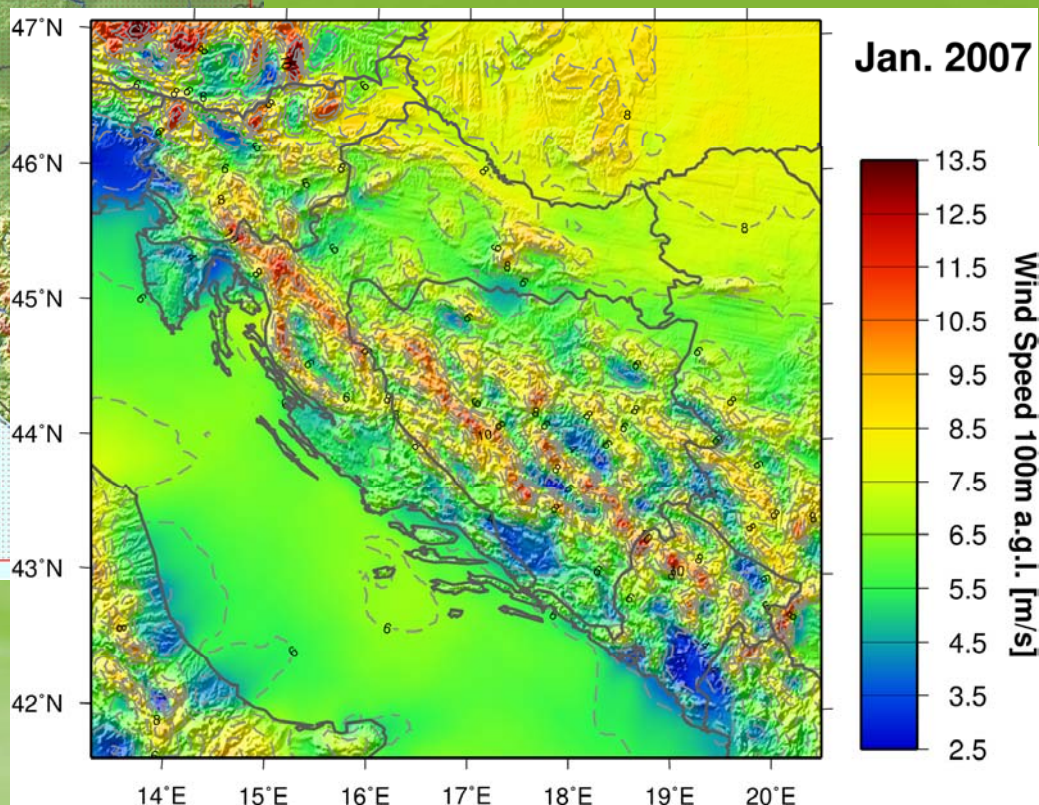
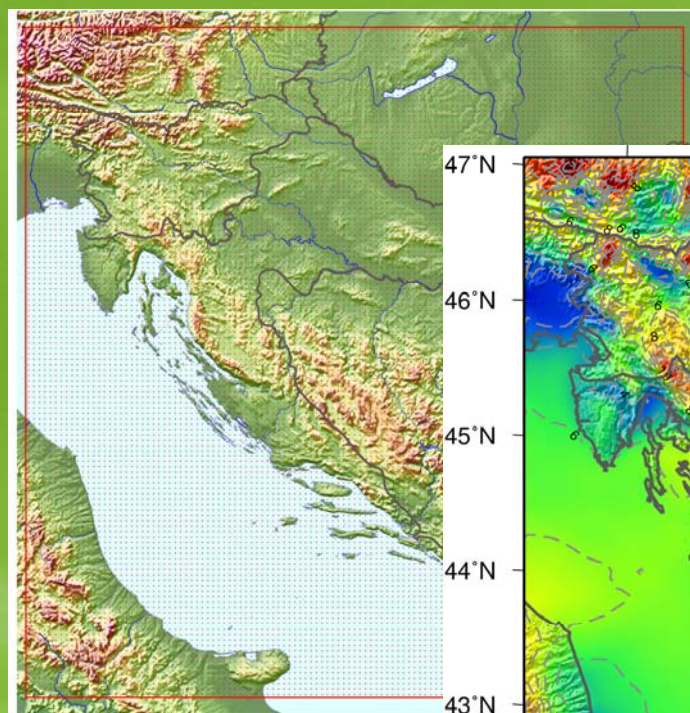


- No data
- Snow or Ice
- Bare Grnd. Tundra^a
- Mixed Tundra
- Wooden Tundra
- Herb. Tundra
- Bar. Sparse Veg.
- Wooded wetland
- Herb. Wetland
- Water Bodies
- Mixed Forest
- Evergrn. Needlf.
- Evergrn. Broadlf.
- Decids. Needlf.
- Decids. Broadlf.
- Savanna
- Mix Shrb./Grs.
- Shrubland
- Grassland
- Crop./Wood Mosc :
- Crop./Grs. Mosaic :
- Mix. Dry/Irrg.C.P.
- Irrg. Crop. Past.
- DryInd Crop. Past. :
- Urban



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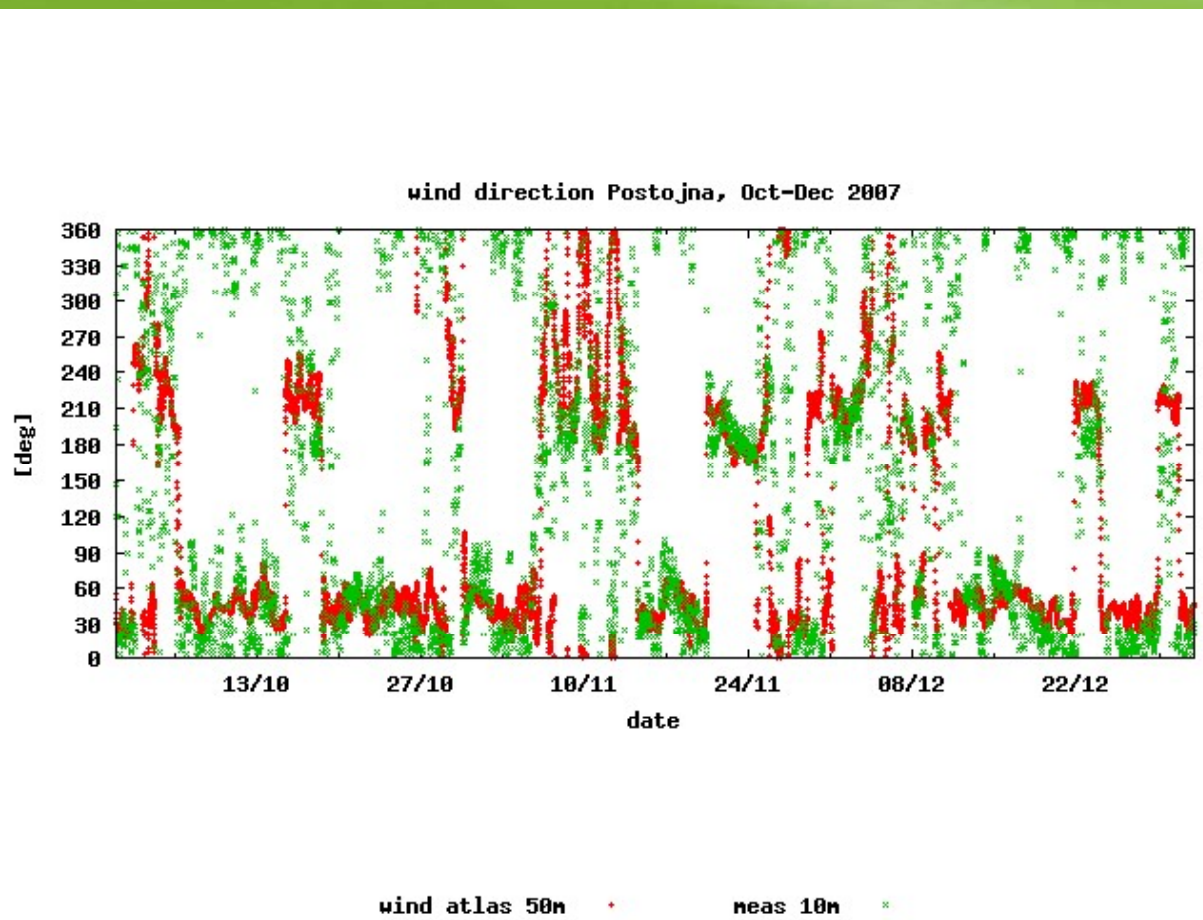
Wind map





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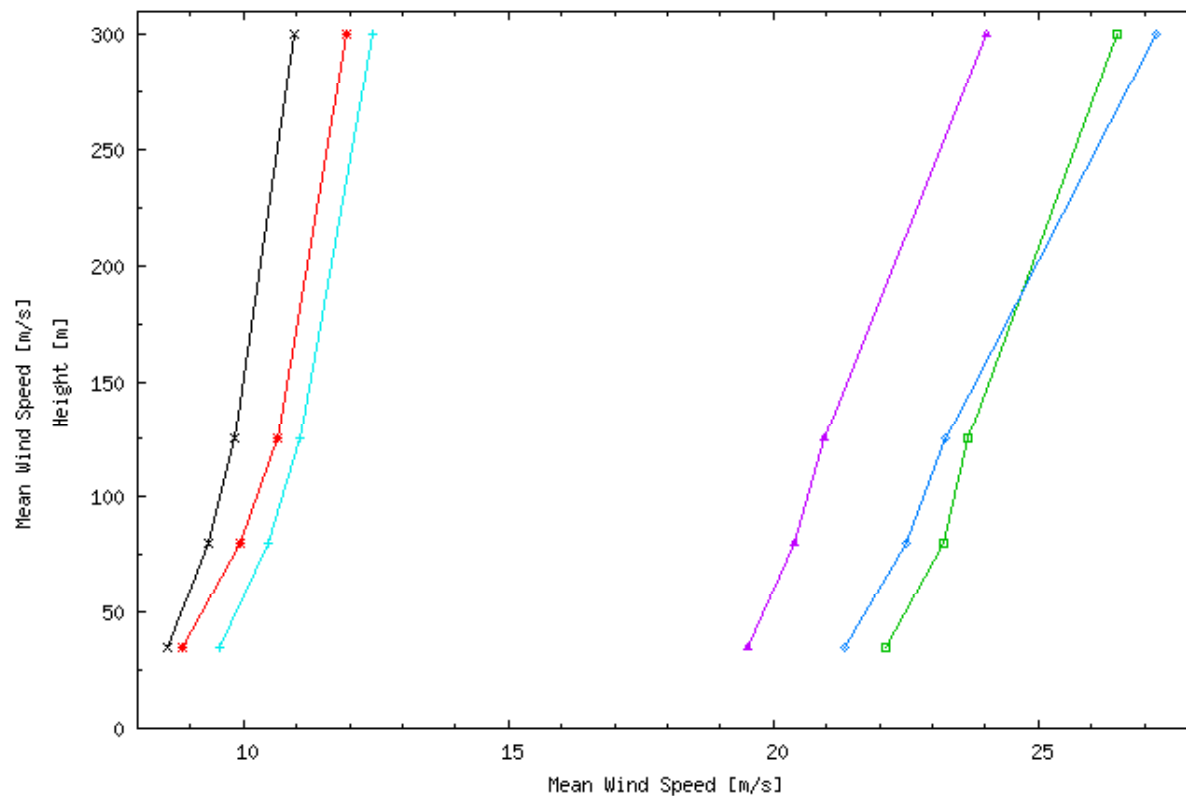
Bora



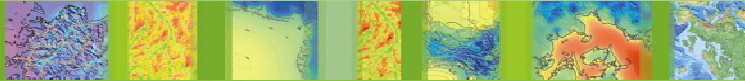


vertical wind profile

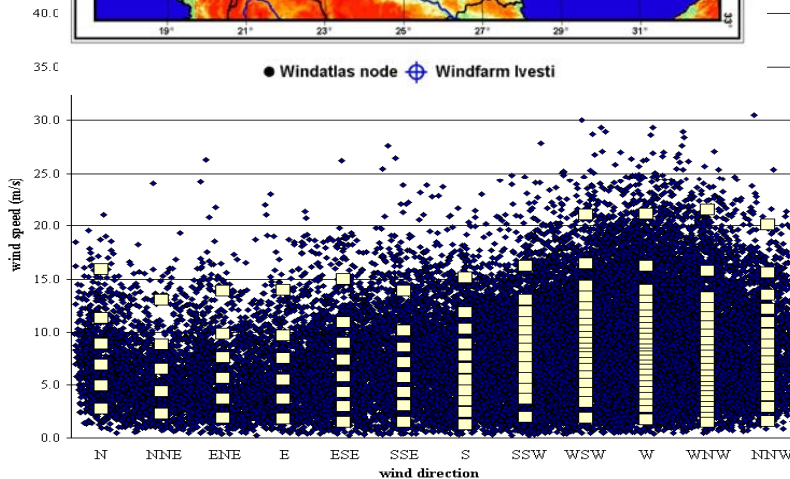
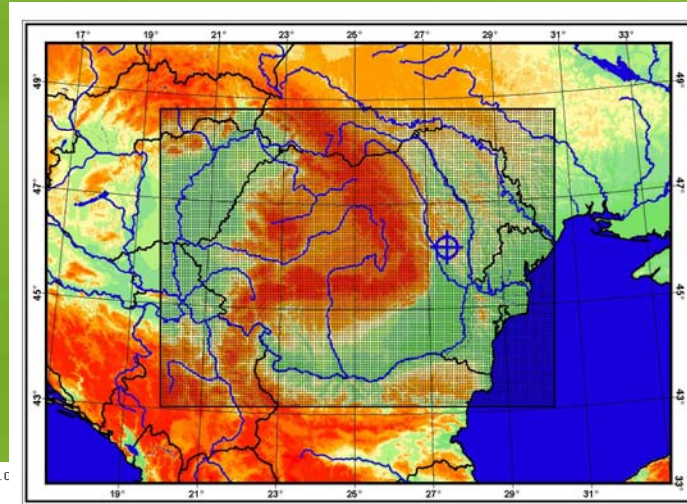
Bora



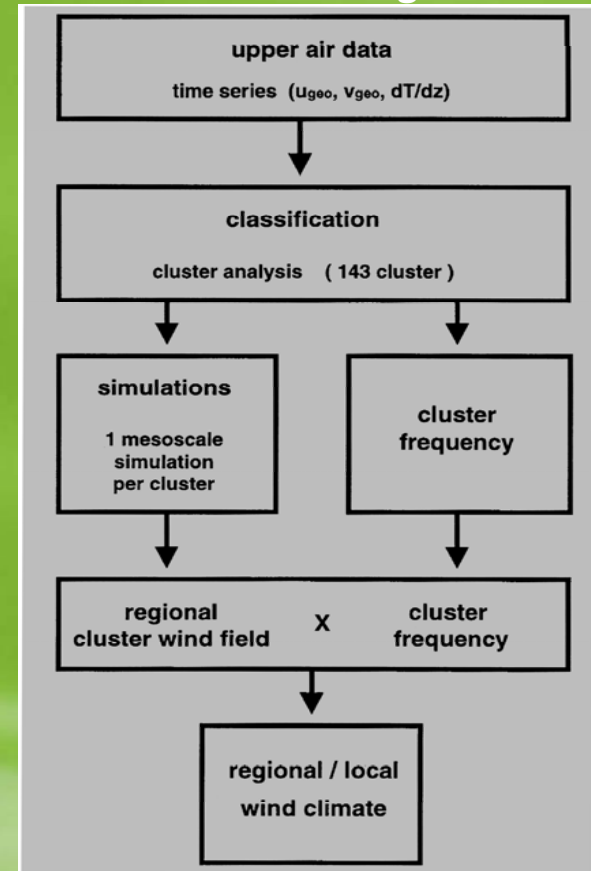
11/01/08 11:00 - 12/02/08 15:50	—	BORA 22/01/08 20:00 - 23/01/08 10:00	—
11/01/08 11:00 - 19/03/08 23:50	—	BORA 11/02/08 03:40 - 11/02/08 11:10	—
no BORA 01/02/08 08:00 - 02/02/08 20:00	—	BORA 08/02/08 14:00 - 10/02/08 12:50	—



Wind mapping and site assessment in complex terrain

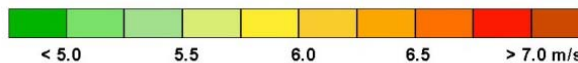
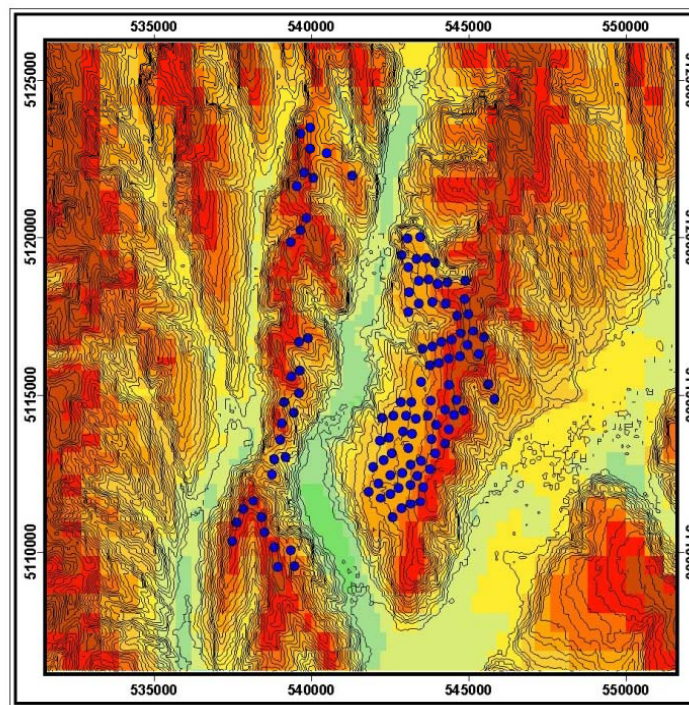
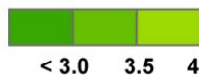
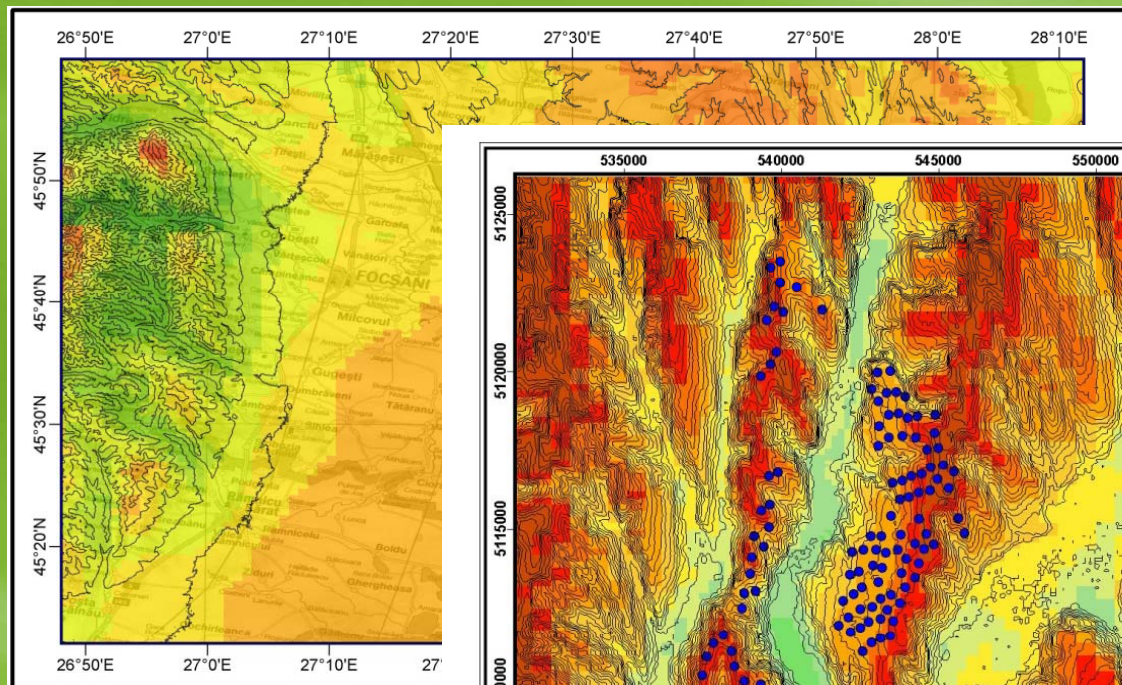


Statistical-dynamical downscaling





Wind mapping and site assessment



Result 100 m

● Ivesti

contour line interval 10 m



conclusions

Wind over complex terrain is very difficult to estimate by observations or model simulations alike

On-site measurements are indispensable

Thank you !

Uncertainty is much larger than for non-complex terrain

Progress by model capabilities and computer resources is on its way but will take some time