Interreg III B

Alpine Windharvest

ALPINE WINDHARVEST

Development of information base regarding potentials and the necessary technical, legal and socio-economic conditions for expanding wind energy in the Alpine Space*

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Digital Relief Analysis

(Abstract of Work Package 7)

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Alpine Windharvest Homepage: http://www.sbg.ac.at/pol/windharvest

ALPINE WINDHARVEST

…is an interdisciplinary research project funded by the EU Interreg IIIB “Alpine Space Programme” (Project No. A/I-2/3.1/5) and by national and regional co-financing bodies of the project partners. The project started in May 2002 and will end at the end of April 2005.

Background of the project:

Wind power became a leading renewable energy technology in flat terrain, especially near shore. While the alpine space also promises some excellent wind locations, much of the knowledge and experience accumulated about wind power so far cannot simply be transferred to the alpine setting.

The lack of experience concerns all levels of government confronted with problems of siting, spatial planning, nature protection/environmental impact analyses, road and electric grid requirements, appropriate tariff regulation etc. The project aims at remedying these deficiencies.

This lack of experience also regards entrepreneurs, investors and even producers of equipment given the special climatic and geological conditions. This increases economic risks, inhibits site exploration and planning activities even for attractive locations. The small number of existing projects in the alpine space impedes standard procedures.

Lack of experience also affects the acceptance of wind power by nature protection organisations and local residents. There is much need for additional knowledge and information; standard models for the resolution/mediation of conflicts will be useful.

For this reason, it is essential to pool the limited experience with wind power in the alpine space for synergy effects, cross-fertilisation and greater efficiency in developing data sets, methods, approaches and solutions for public and private actors, particularly since many of the underlying phenomena are trans-national while most research so far was primarily national (e.g. meteorology).

A common approach will facilitate a harmonised European approach to the problems under consideration, particularly with regard to government policy.

Main activities:

Develop knowledge basis for deploying wind energy:

a) Methods and instruments for identifying wind energy potential in complex terrain more efficiently (meteorologists, geographers, digital relief analyses and actual wind measurements; includes pilot measurements on specific locations).

b) Deal with problems peculiar to wind turbines in alpine conditions (blade icing; access - need for special mounting equipment); standardise technologies, estimates of access requirements (roads and grid). Common approaches for entire alpine space will create bigger market for improvements and induce responses from equipment manufacturers.

c) Analyse ecological impact of turbines in different alpine settings on fauna and flora according to altitude, soil/rock and meteorological conditions; establish check list of factors for whole alpine space. Develop strategies to minimise impact. Improve information for local/ regional authorities.

d) Analyse and compare legal, social, political and economic framework conditions for deployment of wind power in alpine space and their impact on its competitiveness. Formulate regulatory proposals.

e) Prepare methods of resolving conflicts between wind power and other interests (environmental organisations, local residents, hunting). Improve visualisations (more difficult in alpine terrain), standardise participation in administrative procedures and mediation. Facilitate work of local and regional authorities.

f) Measure potential contribution of this energy source to regional development, particularly when joined with hydro storage and electricity generation from biomass.

Alpine Windharvest Report Series:

The Alpine Windharvest Report Series is published by the Alpine Windharvest partnership network in order to disseminate the results of the project to the interested public and to experts in the field. Reports are edited by the responsible project partner(s) who commissioned and approved the report according to our internal division of labour. Reports can be downloaded from our homepage. Printed versions can be directly ordered from the project coordinator by e-mail: dieter.pesendorfer@sbg.ac.at.

Further information: http://www.sbg.ac.at/pol/windharvest

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Digital Relief Analysis

Abstract of Work Package 7

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1. Introduction

1.1. Objectives

In the Interreg IIIB (Alpine Space Program) project "Alpine Windharvest", the "digital relief analysis" work package dealt with the particularities of the Alpine topography and their influence on wind resources and the use of wind power.

The following main objectives were pursued:

- to give an overview of the wind potential of the whole Alpine Space
- to develop a regional GIS analysis methodology for identifying suitable sites for wind power production
- to develop application oriented tools for planning Alpine wind power projects

1.2. Involved institutes and companies

Suisse Eole, the Swiss association for the promotion of wind energy, was project partner and leader of the work package. Contact person: Reto Rigassi (reto.rigassi@eicher-pauli.ch).

Meteotest, a private company based in Bern, Switzerland, offering a wide range of meteorological and GIS services, was mandated by Suisse Eole with the coordination and implementation of the work package. Contact person: Beat Schaffner (schaffner@meteotest.ch).

Ecowatt, a private company in the renewable energy field from Graz, Austria, was contracted with carrying out GIS analyses in Austria and Italy. Contact person: Heimo Truhetz (h.truhetz@ecowatt.at).

The **Scientific Research Centre of the Slovenian Academy for Sciences and Arts** at the Institute of Anthropological and Spatial Studies in Ljubljana, Slovenia, was contracted with performing GIS analyses for Slovenia. Contact person: Tomaz Podobnikar (tomaz@zrc-sazu.si).

Additionally, the work package was generously supplied with in-kind contributions by the involved regions as well as essential data by the other Alpine Windharvest project partners.

2. Alpine Space Wind Map

2.1. Background

Although several wind maps covering parts of the Alpine Space have previously been compiled, no wind map covering the whole Alpine Space existed prior to the "Alpine Windharvest" project. It was therefore decided to compile such a wind map in order to make a consistent data base on wind energy resources in the Alpine Space available to authorities, wind energy promoters and any other interested parties.

2.2. Survey of meso scale mapping methodologies

A survey of methodologies to produce meso scale wind maps was carried out. There are two general approaches to wind modeling and mapping on this scale.

The **numerical flow modeling** approach is usually performed with meso scale meteorological flow models. Meteorology is calculated based on large scale reanalysis data for a certain period in the past. Wind climatologies are aggregated from the results. The results may be refined by subsequent micro scale modeling.

The second approach is based on **statistical wind modeling**. Wind statistics measured by meteorological stations are interpolated using statistical models that take into account topography.

The two approaches may be combined when results from flow models are weighed using observed wind statistics.

2.3. Alpine Space wind map methodology

For the Alpine Space wind map, a statistical model approach based on wind measurements was adopted. Elevation data from the Space Shuttle Topography Mission (SRTM[1]) data set was interpolated to a grid with a horizontal resolution of 250 m and errors were patched using local elevation data sources or interpolation algorithms. Roughness was determined from the CORINE[2] and Swiss land use data sets (fig. 1). Wind data was collected from approximately 600 stations (fig. 2) and standardized. Wind speed was interpolated spatially and in function of altitude. The data was corrected for roughness and specific terrain forms.

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1 http://www.dlr.de/srtm

2 http://dataservice.eea.eu.int/dataservice/metadetails.asp?id=571

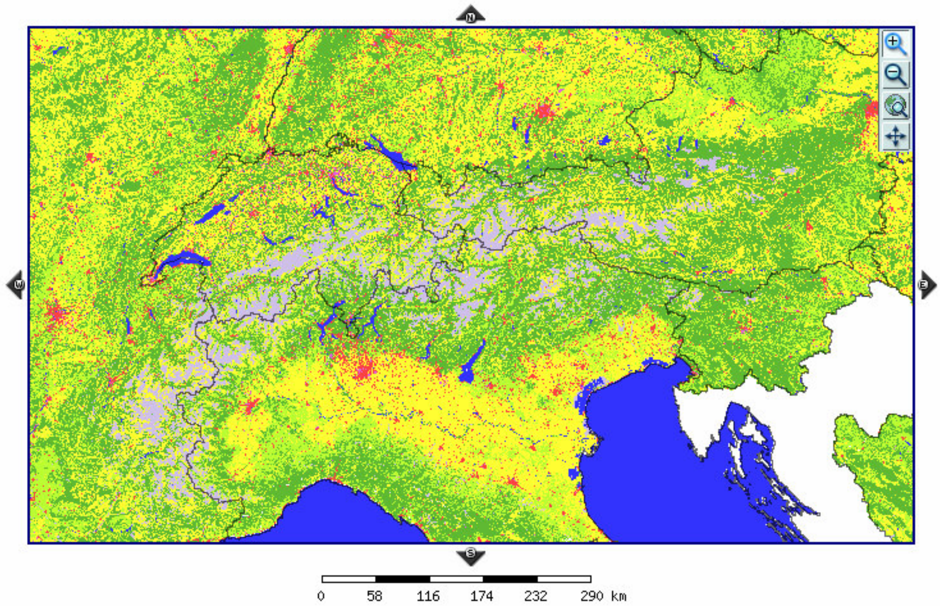

Fig. 1: Land use data set compiled as input for modeling of the Alpine Space Wind Map.

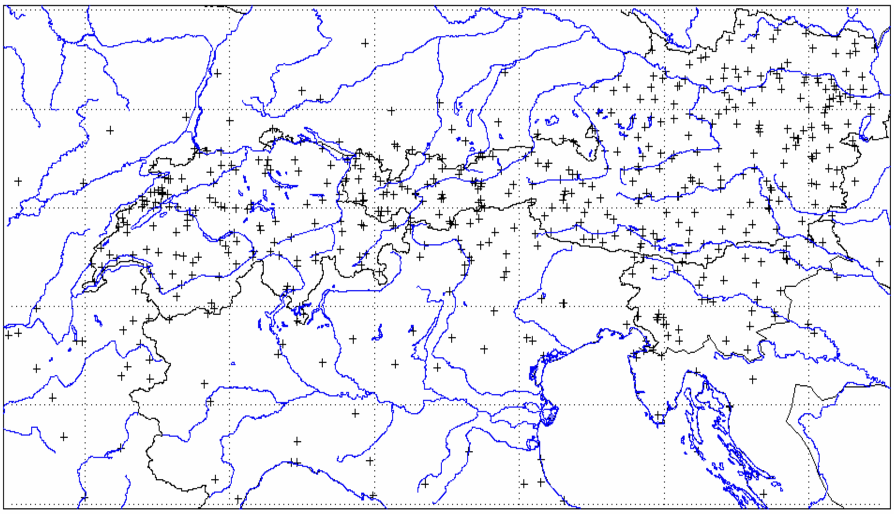

Fig. 2: Wind measurement stations included in the Alpine Space Wind Map.

2.4. Results

The resulting wind maps show mean wind speeds at different heights with an accuracy of ±1.5 m/s (fig. 3). They are available as interactive maps on the internet[3]. The survey, the methodology employed as well as the results were documented[4].

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3 http://stratus.meteotest.ch/windharvest

4 Schaffner et al., 2005: Alpine Space Wind Map. Alpine Windharvest Report No. 7-2.

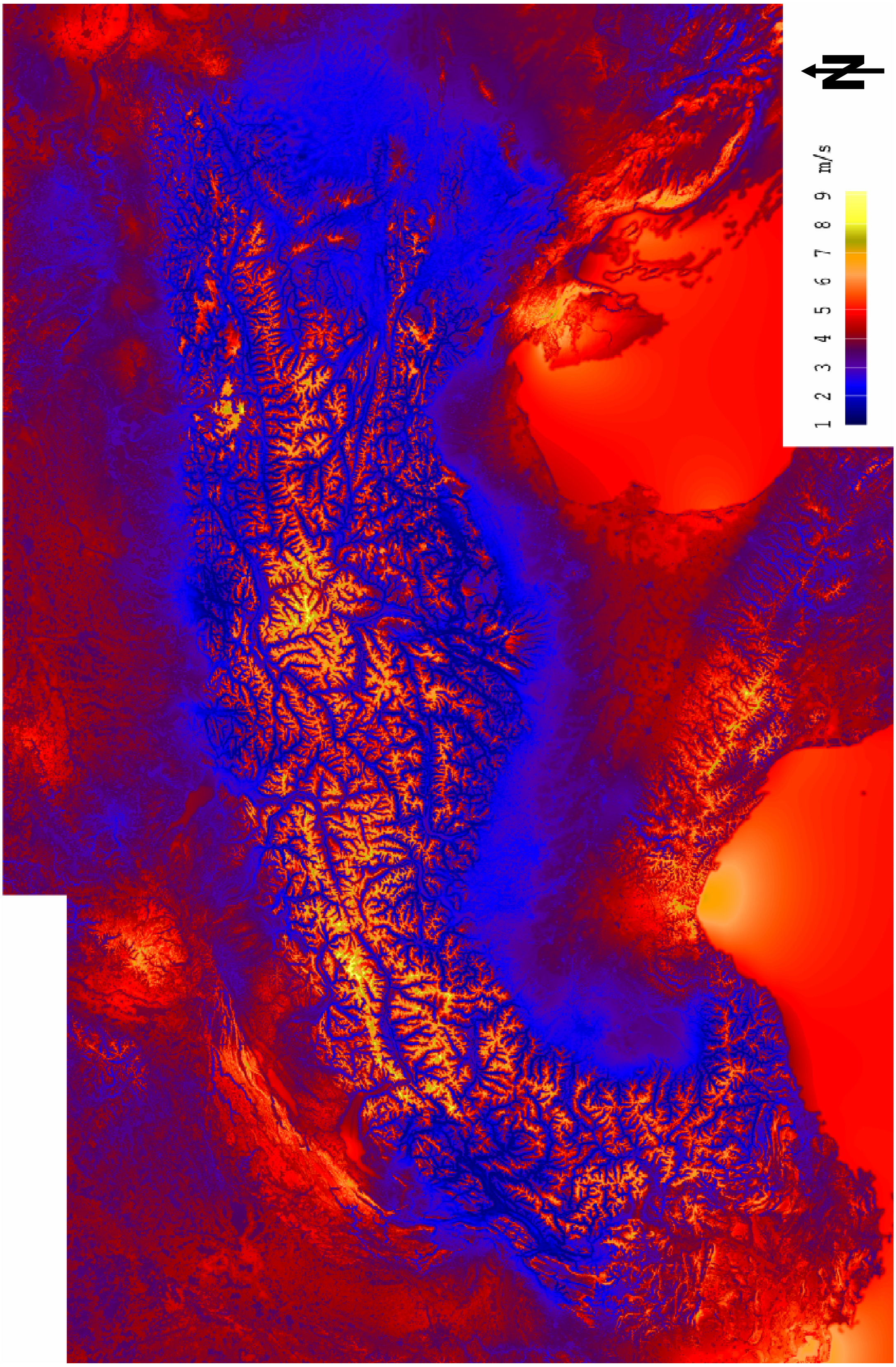

Fig. 3: The Alpine Space wind map. Mean wind speed is displayed at 100 m above ground.

3. GIS Analysis for Wind Energy

3.1. Background

The objective was to establish a methodology for regional Geographical Information System (GIS) analyses to identify promising sites for wind energy. The methodology should be efficient, significant and simple to adapt to any area within the Alpine Space (or elsewhere).

In Switzerland, a comprehensive study to identify preferable sites for wind energy was performed in 2004[5]. The GIS methodology employed in the framework of that study was adapted as a generally applicable GIS analysis methodology for identification of suitable sites for wind power in the current study.

3.2. Procedure

The methodology consists of three main steps (fig. 4):

1. Identify the limiting factors for wind power production within the considered region. For each factor, determine distinct exclusion criteria (thresholds or classes) that indicate which sites are not suitable for wind power production.

2. Compile a GIS layer for each of the limiting factors. Each of these intermediate layers indicates unsuitable sites for wind power production according to the corresponding criteria.

3. Aggregate the layers into a result layer. Any sites not indicated as unsuitable in any of the intermediate layers is considered as suitable for wind power production in the result layer.

The analysis can be tuned in order to give a more "optimistic" or a more "pessimistic" result, according to the general characteristics of the test area and depending on the knowledge about the situation that is available beforehand. As long as the choices are well documented and the parameters remain in a realistic range, the models contribute to decision making in the evaluation of wind power project sites.

5 BFE, BUWAL, ARE, 2004: Konzept Windenergie Schweiz – Methode der Modellierung geeigneter Windpark-Standorte

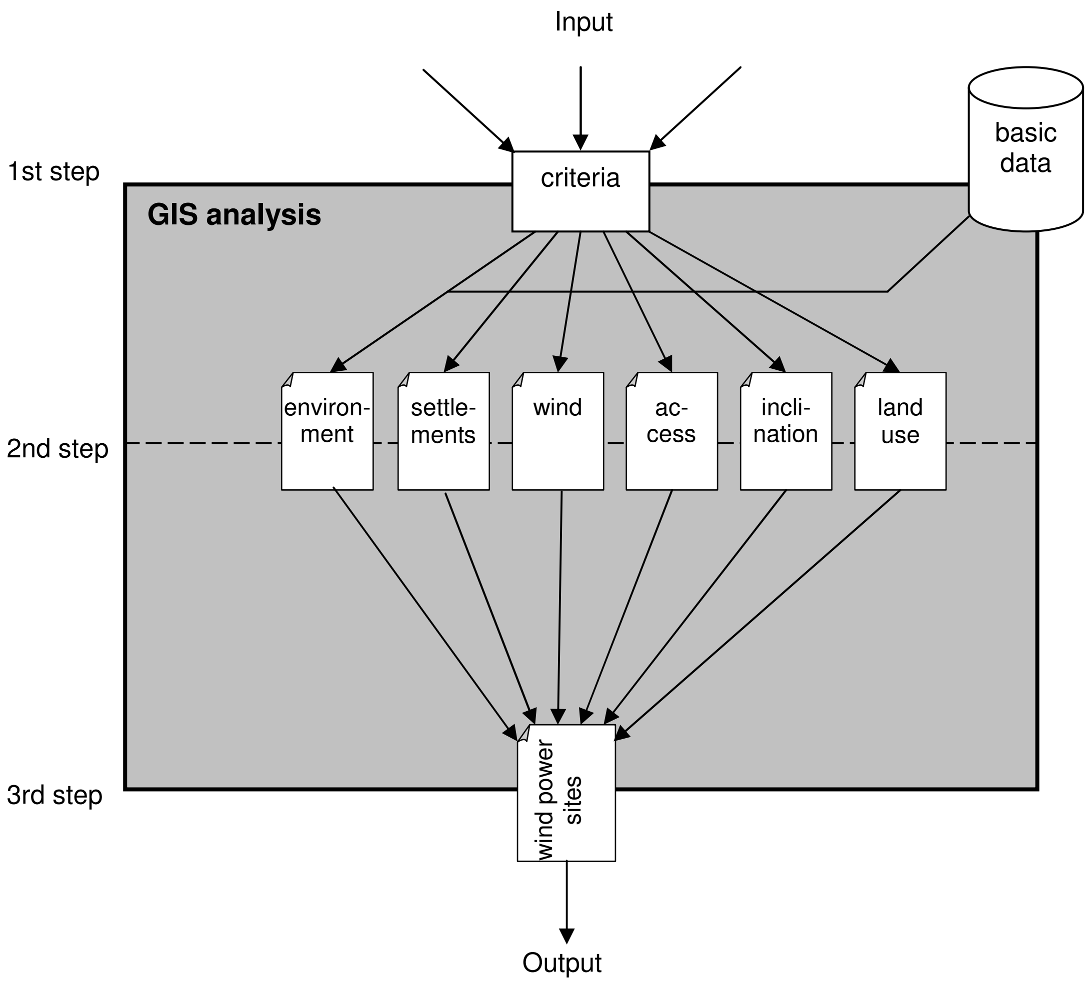

Fig. 4: General GIS analysis procedure for identifying sites suitable for wind power production.

3.3. Case Studies and Results

The GIS analysis methodology was implemented in 4 test areas in Austria, Italy, Slovenia and Switzerland. The results are documented in separate reports and on the internet[6] as interactive maps (fig. 5).

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[6] http://stratus.meteotest.ch/windharvest

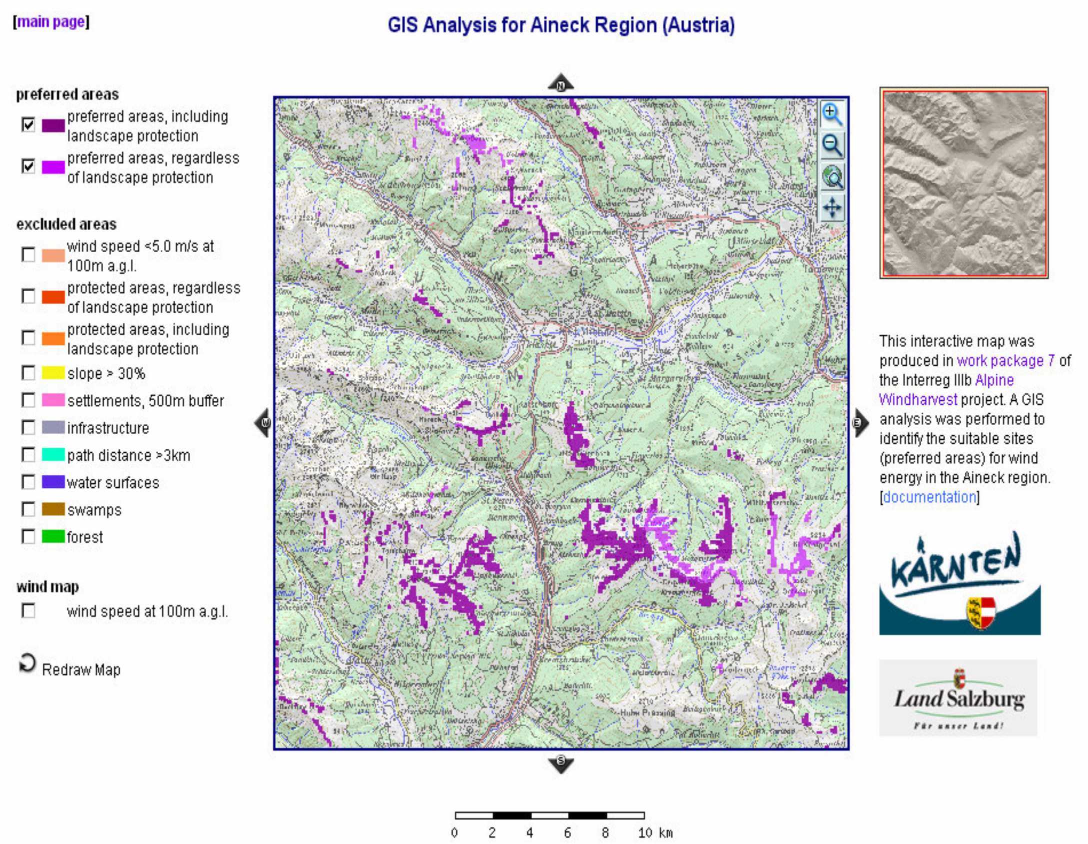

Fig. 5: GIS analysis result for Aineck, Austria (screenshot of the interactive map available at http://stratus.meteotest.ch/windharvest). The preferred areas for wind power projects are shown in purple. Light purple areas are within landscape protection zones.

3.4. Validation and conclusions

It was found that the established methodology is efficient. It is quite simple to implement and the results are significant. The identified areas generally corresponded very well with the sites known to be suitable beforehand, while unsuitable sites were eliminated.

In the case studies, criteria where defined to the best knowledge of the mandated institute. For more concise results, which could for example be used as the basis for a comprehensive regional or national wind power concept, the criteria for suitable/unsuitable sites will usually have to be defined in a socio-political process.

4. CFD Wind Modeling

4.1. Background

Besides the difficulties posed by harsh meteorological conditions for measurements, one of the main challenges for wind power projects in Alpine terrain is modeling of the wind resources. Wind modeling is an essential step in the process of a wind power project. A detailed knowledge of the local wind resources is required to optimize the wind park layout (turbine types, positions and hub heights) in order to enhance power production. Model results are also required to predict power production and to estimate power losses due to park effect (i.e. wake effects of wind turbines on one another), which are basic input data to financial planning.

In flat or moderately hilly terrain, established wind modeling tools such as WAsP[7] produce reliable results. In complex Alpine terrain however, these tools are not reliable. Therefore, more complex modeling techniques such as Computational Fluid Dynamics (CFD) are required. A few years ago, only supercomputers were able to handle the required calculations. Today however, personal computers deliver the required performance. With the PC software WindSim[8], a CFD modeling interface specifically designed for wind power planning is now commercially available.

4.2. Case Studies

CFD wind modeling with WindSim was performed for 4 regions with 7 "hot spots" in Austria, Italy, Slovenia and Switzerland in order to gain know-how on CFD modeling in complex Alpine terrain, validate modeling results and promote wind power projects at the mentioned hot spots.

Figure 6 shows an example of a wind resource map modeled by WindSim near the Brenner Pass in Austria.

4.3. Validation and conclusions

Validations of the modeling results were performed by comparisons of modeled to measured wind climatologies and by comparing modeled vertical wind profiles to profiles measured by SODAR (fig. 7).

It was shown that WindSim provides a CFD modeling solution that fulfills the requirements for wind modeling in this type of terrain, in contrast to WAsP or similar diagnostic models.

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[7] http://www.wasp.com

[8] http://www.windsim.com

Discrepancies between modeled and measured data could mainly be ascribed to terrain discretizations inherent to modeling as well as insufficient representation of obstacles, especially forests and hedges (fig. 8).

As is the case with any model of this type, WindSim is especially suitable for extrapolations of measurements from high enough masts to hub height in nearby terrain with similar characteristics as the measurement site. High quality measurements at a height of at least 30 m above ground within the modeled park perimeter as well as detailed digital terrain models are essential as input data.

Validation, conclusions and recommendations were documented[9].

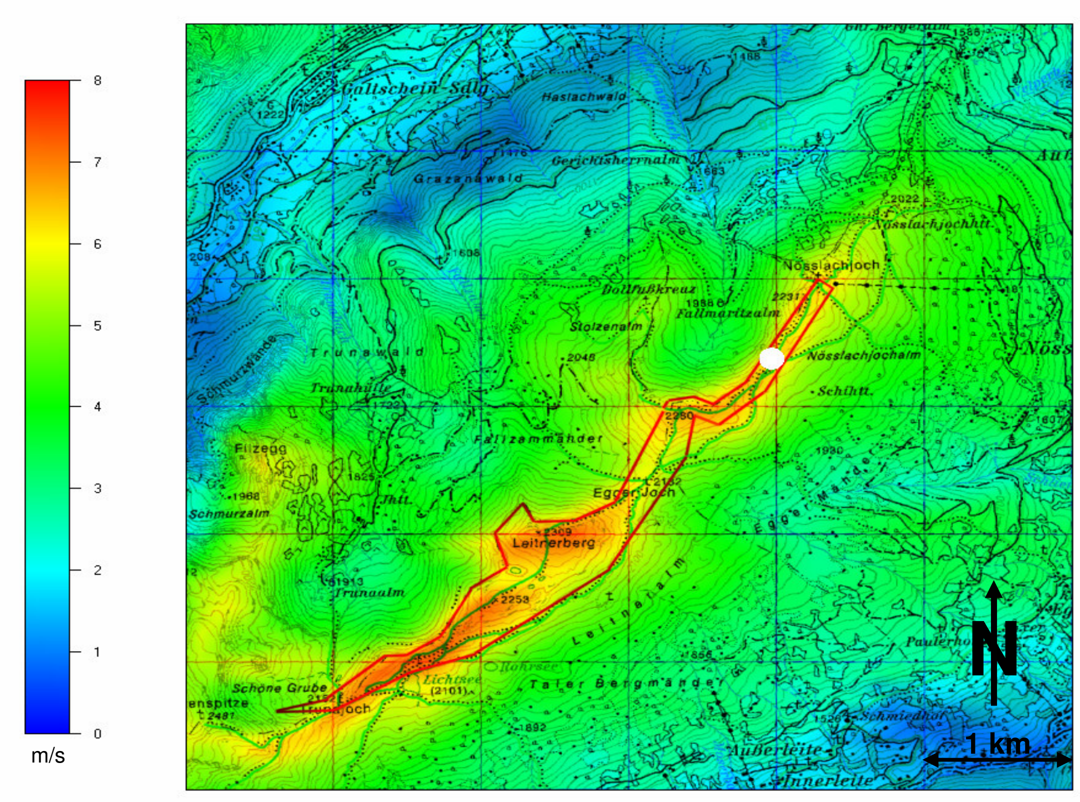

Fig. 6: Wind resources at 50 m above ground for Nösslachjoch, Brenner, Austria. The circle represents the location of the climatology. The red line represents the wind energy perimeter. Background map 1:50'000.

[9] Schaffner et al, 2005: CFD Modeling Evaluation. Alpine Windharvest Report No. 7-7.

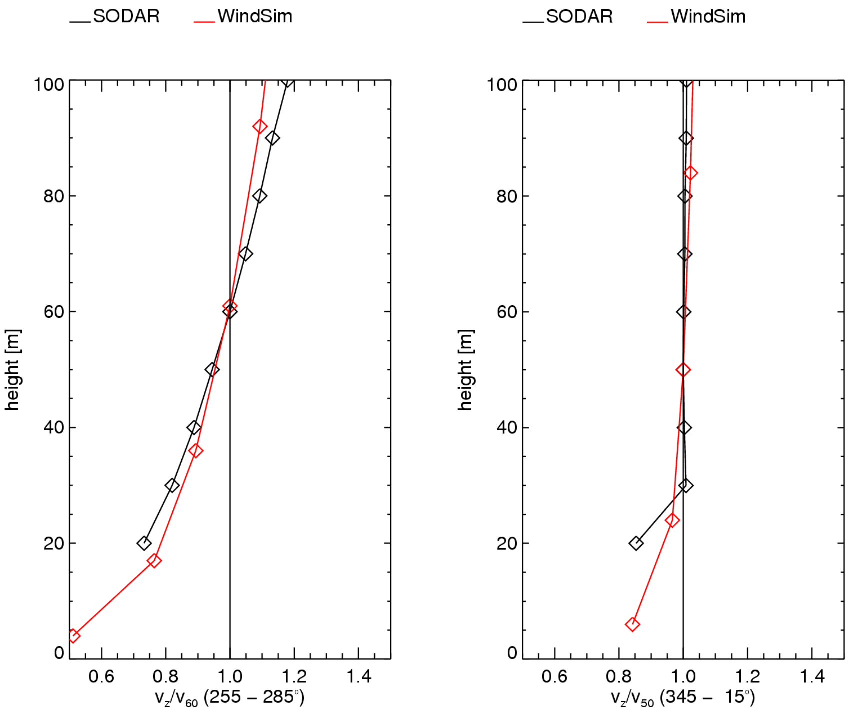

Fig. 7: Comparison between measured (SODAR, black) and modeled (WindSim, red) vertical wind speed profiles at St. Brais, Switzerland (left) and Sattelberg, Austria (right).

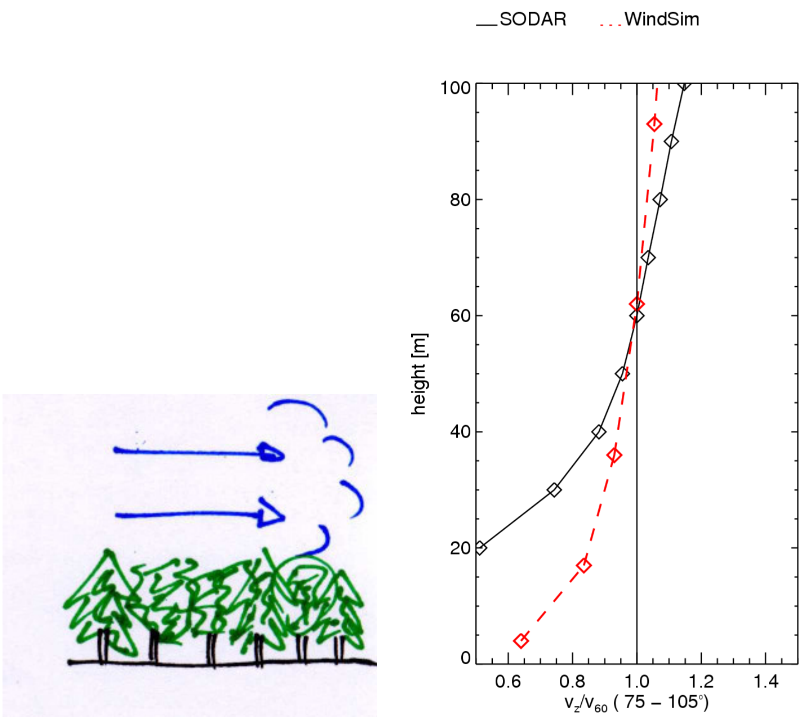

Fig. 8: Comparison between measured (SODAR, black) and modeled (WindSim, red) vertical wind speed profiles at Peuchapatte, Switzerland. Discrepancies are caused by insufficient representation of forest in the model.

5. Documentation

The following reports document activities and results of this work package:

- Alpine Windharvest Report No. 7-2
  Alpine Space Wind Map
  Modeling approach
  B. Schaffner, J. Remund, Meteotest
- Alpine Windharvest Report No. 7-3
  GIS Analyses Methodology
  Workbook and results
  F. Dällenbach, B. Schaffner, Meteotest
- Alpine Windharvest Report No. 7-4
  GIS analyses 'Aineck' and 'Brenner', Austria and Italy
  Documentation of GIS concepts, methods and results
  M. Ehrenreich, O. Frühwald, H. Prassl, H. Truhetz, ecowatt
- Alpine Windharvest Report No. 7-5
  GIS analyses 'Franches Montagnes', Switzerland
  Documentation of GIS concepts, methods and results
  F. Dällenbach, B. Schaffner, Meteotest
- Alpine Windharvest Report No. 7-6
  GIS analyses 'Menina planina', Slovenia
  Documentation of GIS concepts, methods and results
  T. Podobnikar, K. Zaksek, Scientific Research Centre of Slovenian Academy for Sciences and Arts
- Alpine Windharvest Report No. 7-7
  CFD Modeling Evaluation
  Summary of WindSim CFD modeling procedure and validation
  B. Schaffner, R. Cattin, Meteotest
- Alpine Windharvest Report No. 7-8
  CFD Modeling 'Lungnau', Austria
  Documentation of modeling procedure, results and validation
  B. Schaffner, R. Cattin, Meteotest
- Alpine Windharvest Report No. 7-9
  CFD Modeling 'Brenner', Austria and Italy
  Documentation of modeling procedure, results and validation
  B. Schaffner, R. Cattin, Meteotest
- Alpine Windharvest Report No. 7-10
  CFD Modeling 'Franches Montagnes', Switzerland
  Documentation of modeling procedure, results and validation
  B. Schaffner, R. Cattin, Meteotest
- Alpine Windharvest Report No. 7-11
  CFD Modeling 'Menina planina', Slovenia
  Documentation of modeling procedure, results and validation
  B. Schaffner, R. Cattin, Meteotest

Documentation and interactive maps are available at:
http://stratus.meteotest.ch/windharvest