I. INTRODUCTION

Atmospheric processes are continuous in space and time. ORLANSKI (1975) proposed a set of scales that include the micro-, meso- and macroscales. Table 1.1 shows these three definitions, which have gained wide acceptance, despite an even newer proposal by FUJITA (1981).

Tab. 1.1: Scale definitions of ORLANSKI (1975)

Scale	**Range**	**Examples**
Microscale-γ	<20 m	Turbulence, plumes, roughness
Microscale-β	20-200 m	Dust devils, thermals, wakes
Microscale-α	200-2000 m	Tornadoes, short gravity waves
Mesoscale-γ	2-20 km	Thunderstorm convection, complex terrain flows, urban effects
Mesoscale-β	20-200 km	Nocturnal low-level jets, cloud clusters, sea breezes
Mesoscale-α	200-2000 km	Fronts, low-pressure systems, hurricanes
Macroscale-β	2000-20000 km	Baroclinic waves
Macroscale-α	>20000 km	Tidal waves

A meteorological numerical model is a simplified abstraction of the real atmosphere, which is valid for a certain length and timescale. The model is given by a set of equations and the corresponding numerical solvers. Within the model, a scale dependent discretization of the atmosphere in space and time is necessary. Temporal and spatial resolutions of a mesoscale model are better than in a macroscale model but coarser than in a microscale model. For this study, the mesoscale-γ and β are of interest, and horizontal resolutions of 200 m, 250 m and 1000 m are used. The flow configuration in the mesoscale is depending both on hydrodynamic effects (e.g. flow channelling, roughness effects) and inhomogeneties of the energy balance mainly due to the spatial variation of surface characteristics (e.g. land use, vegetation, water), but also a consequence of terrain aspect and slope. From the air-pollution point of view, thermal effects are most interesting, as they are of particular importance at times of a weak synoptic forcing, i.e., bad ventilation conditions.

Mesoscale models are used for purposes ranging from weather forecasting, to air-quality regulatory applications, and to basic research. Over the last decade, sophisticated mesoscale models like RAMS[1], MC2[2] or MM5[3] were developed. The physical complexity of these

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[1] RAMS: **R**egional **A**tmospheric **M**odeling **S**ystem, developed at Colorado State University. The RAMS-homepage is probably the best source for further information: http://rams.atmos.colostate.edu/

models allows today’s most accurate simulations. However, its use needs expensive computational resources as well as years of professional experience. Instead I planned to run simulations on an ordinary PC, using a model, whose application is learnable within a few weeks.

To acquire spatially distributed information in two or three dimensions, a model is often the only possibility. In the mesoscale, the objects of interest vary on small distances, thus requiring spatially highly resolved information. Just imagine the number of measurement stations necessary, if an area of 10×10 km^2 would have to be sampled on a 200 m resolved grid. The logistic and financial expense prohibits measurements of that kind. Figure 1.1 shows a model domain subset, where measurement stations are placed at a model’s horizontal resolution of 200 m. Especially for planning aspects, a high resolved spatial dataset is necessary. Furthermore a model allows to simulate impacts of future developments like land-use changes. For example, air-pollution studies help to determine locations for industrial expansion, so that air quality in urban areas is negatively affected as little as possible.

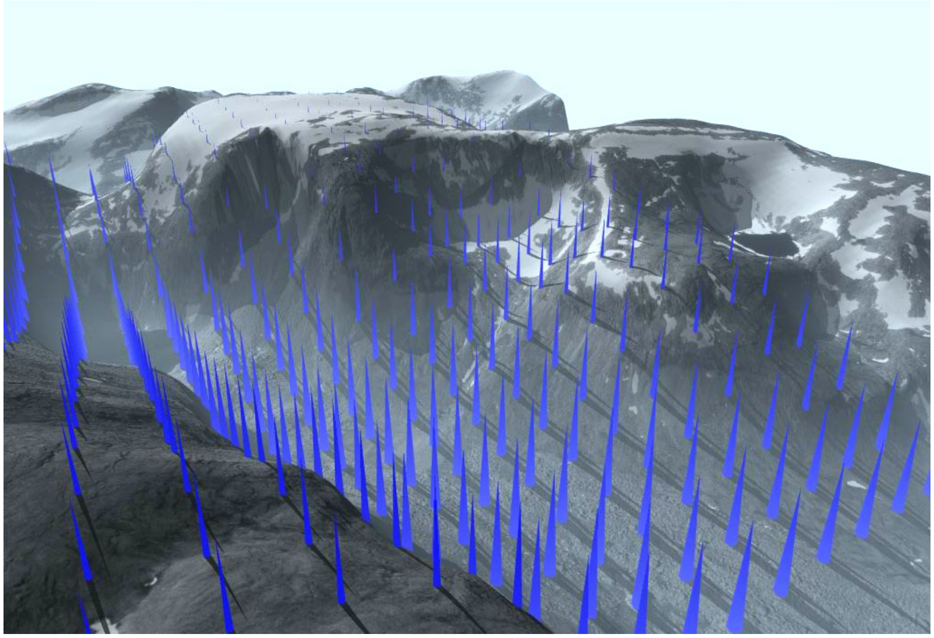

Figure 1.1: A theoretical setup of measurement stations in the Kärkevagge Valley to acquire a spatial dataset at a horizontal resolution of 200 m.

Mesoscale models also help understanding processes by allowing full control over environmental parameters. Hence it is possible to determine the steering factors of a

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[2] MC2: The Canadian Mesoscale Compressible Community model. http://limex.meteo.mcgill.ca:8080/badri/mc2.html

[3] MM5: The Fifth-Generation NCAR / Penn State Mesoscale Model. Certainly the best reference is the official homepage: http://www.mmm.ucar.edu/mm5/mm5-home.html

phenomenon and also to test sensitivity against changes in environmental conditions. Scientific goals of mesoscale modelling include accurate numerical simulations of mesoscale processes to understand the role of synoptic scale parameters for generation and evolution of mesoscale phenomena, to find the limits of predictability by means of sensitivity studies, and to understand interactions of the mesoscale with smaller and larger scales.

LAYOUT OF THIS STUDY

In this study, the mesoscale model MetPhoMod is used to simulate synoptically driven and thermally induced wind fields in complex terrain. By evaluating different simulations, MetPhoMod's applicability at resolutions as small as 200 m is tested. In **Chapter 2**, a brief model description will be given, which focuses on important points for a user of MetPhoMod. In **Chapter 3,** the model domains are defined, and preliminary studies necessary for modelling are carried out. The chapter will determine the model time needed to adjust to imbalances in initial conditions, and illustrate the importance of high spatial resolutions. Since mesoscale modelling is also an initial-value problem, a model for computing initial temperature and humidity profiles is presented. But initial values also control the energy balance by surface parameters, introducing the need for spatial land-cover information. A satellite-image based land-use classification and an optimisation of surface parameters is carried out in Section 3.7. First, simple simulations with MetPhoMod will show energy balances for different land cover-types. In **Chapter 4**, the model's applicability at small scales is tested. For that purpose, model results are compared with measurements and another mesoscale model called MSFD. High wind-speed events are simulated both for the Kärkevagge Valley in northern Sweden in Section 4.1, and for the Swiss Jura near Basel in Section 4.2.1. The sensitivities of the flow to wind speed and stability are examined in Sections 4.1.1 and 4.1.2, respectively. Finally the model is used to investigate the Möhlin Jet. This simulation is thermally driven. Results are in extremely good agreement with measurements. The good model performance allows to explain the jet genesis. Even though each section involving modelling draws its own conclusions, the most important results are summarized again in **Chapter 5**.