THE HELSINKI TESTBED: A MESOSCALE MEASUREMENT, RESEARCH, AND SERVICE PLATFORM

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1. INTRODUCTION

Since 2005, the Finnish Meteorological Institute (FMI) and Vaisala Corporation have established and maintained a mesoscale weather observational network in southern Finland. The Helsinki Testbed (HTB) is an open research and quasi-operational program designed to provide new information on observing systems and strategies, mesoscale weather phenomena, urban and regional modeling, and applications in a high-latitude (60^{o}N) coastal environment. The HTB and related programs feature several components: observing system design and implementation, small-scale data assimilation and very short-range numerical weather prediction, public service, and commercial development of applications. Specifically, the observing instrumentation focuses on meteorological observations of meso-gamma-scale phenomena that are often too small to be detected adequately by traditional observing networks. The domain of the HTB covers much of southern Finland and the Gulf of Finland. In particular, more than 40 communication masts, 60–100-m high, are equipped with weather transmitters at multiple height levels. Additionally, radio soundings and ceilometer measurements have been made, aerosol particle and gas concentration are measured by SMEAR-3 station, a wind profiler, three dual-polarimetric and two Doppler weather radars make continuously observations. The HTB supports the development and testing of new observational instruments, systems and methods in concentrated field experiments. Currently the HTB typically serves more than 20000 weekly users and more than 600 have registered for the service in order to use historical data records. More information regarding HTB can be found from web site http://testbed.fmi.fi/

2. DESCRIPTION OF NETWORK

The domain of the Helsinki Testbed is roughly 150 km by 150 km, covering much of southern Finland and the Gulf of Finland, including the city of Helsinki (Fig. 1). The skeleton of the HTB network was established with

the existing observation networks of FMI (45 sites) and the Finnish Road Administration (160 sites in whole Finland) in the area. These were supplemented with the following new sites and instrumentation. To achieve a dense network of weather stations, more than 100 Vaisala WXT510 weather transmitters were placed around HTB. Most of these stations were installed in cell phone base-station masts in more than 40 locations. Two or four transmitters were typically deployed at different heights in a mast to derive stability and bulk profiles of temperature and humidity. Additional weather transmitters were installed only at ground level with an especially dense network in urban areas.

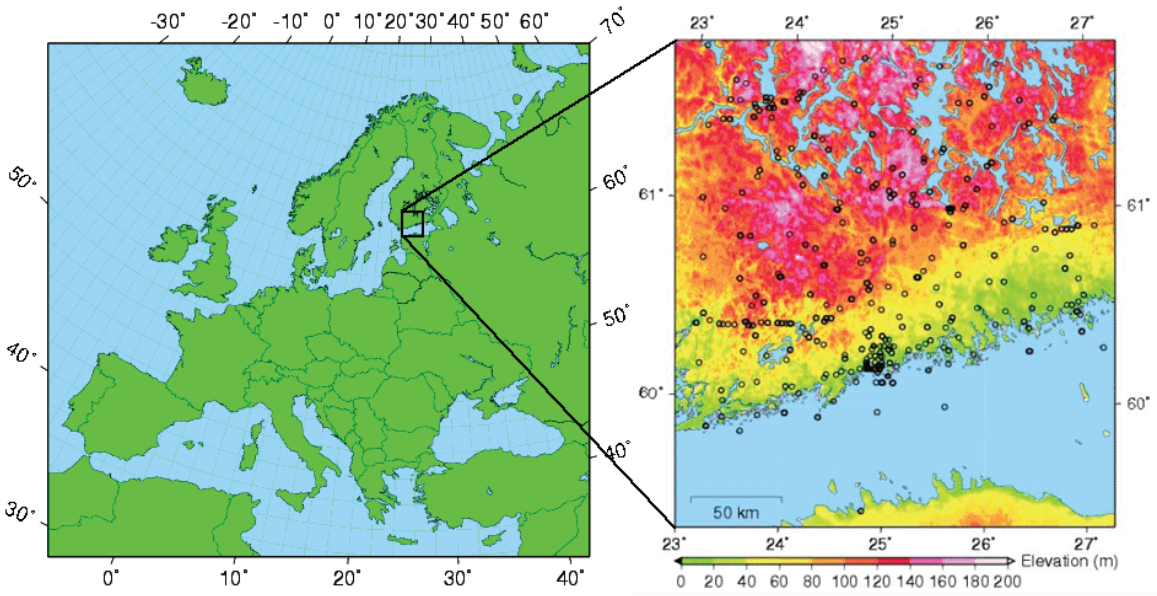

Figure 1. Location of the Helsinki Testbed domain at the south coast of Finland (on the left), and topography of the area with all observing sites (on the right). At the Finnish coastline, the densest group of circles on the coast identifies the location of city of Helsinki.

Since 2005, other data sources have included, for example, an increased number of radio-soundings (during campaigns), ceilometers, precipitation weighing gauges, a wind profiler with radio acoustic sounding system, an RD-69 disdrometer, precipitation occurrence sensor systems (POSS), a hydrometeor size detector, special versions of weather transmitters equipped with photosynthetically active radiation (PAR), CO2, or drop-size distribution capability, total lightning location system, a Doppler lidar, and a Doppler sodar. Currently the area is covered by four Doppler radars, three of which have dual-polarimetric capabilities. The instrumentation deployed in the HTB is introduced in Table 1. After the original campaigns, the number and type of observations have evolved, but most of these observations have continued to serve the public and research efforts.

An addition to the HTB in 2007 was the University of Helsinki's and FMI's SMEAR-III urban measuring station consisting of a 31-m tower equipped with meteorological instrumentation at several heights. Measurements include profiles of the temperature, wind, and radiation components. The fluxes of sensible heat, momentum,

carbon dioxide and water vapor are measured by the eddy-covariance technique. Next to the tower is situated an air-conditioned container where a diversity of aerosol particle and gas concentration instrumentation is located. Aerosol measurements include size distributions, chemical composition, and optical properties [1]. Specifically, instrumentation includes a condensation particle counter, a twin differential particle sizer, an aerodynamical particle sizer, an aethalometer, an ambient particulate monitor, a filter dynamics measurement system, TEI 49, TEI43CTL, TEI42S, and Horiba APMA 360 analyzers.

Table 1. Instrumentation in the Helsinki Testbed.

No.	**Site type**
46	FMI weather stations
34	FMI precipitation stations
5	New weighing precipitation gauge stations
13	Off-line temperature loggers in greater Helsinki area
22	Weather transmitters at surface level
191	FRA road weather stations with the total of 58 road weather cameras
311	**Surface weather stations, total**
44	Pairs of weather transmitters in cell phone base station masts
5	Optical backscatter profilers (new ceilometers)
6	FMI ceilometers
2	FMI C-band Doppler radars
3	Dual polarization Doppler radar
3	RAOB sounding stations
1	UHF wind profiler with RASS
-	Total lightning network
4	Visiting research instruments: 2 POSS precipitation occurrence sensor systems (Environment Canada) 1 Doppler lidar (University of Salford, United Kingdom) 1 Doppler sodar (Finnish Defense Forces and VTT)

3. CAMPAIGNS AND TESTBED EVOLUTION

Helsinki Testbed was initially designed to demonstrate the benefits of meteorological observations and forecasting addressing meso-gamma scale weather phenomena, which typically last from a few minutes to several hours. Although Helsinki Testbed was conceived by FMI and Vaisala, other corporate and governmental agencies contributed by providing their data, showing the private or societal need, acting as end-users, and funding the project. Real-time data was planned to be publicly available and measurements were to be done during five month-long specific measurement campaigns between August 2005 and August 2006. For convenience, each of the campaigns were named with a typical mesoscale phenomenon or activity of that season: August 2005 Nowcasting, November 2005 Precipitation type, January-February 2006 Stable boundary layer, May 2006 Sea breeze, and August 2006 Convection.

One major benefit of a dense observing network is to be able to assimilate more data into analysis and/or prediction model systems. To predict the weather even at short lead-time, it is essential to know as accurately as possible the current state of the atmosphere and thus provide the best possible starting conditions for the prediction [2]. In order to test and benefit the merging of the extensive amount of observational datasets in the HTB area (Surface measurements, satellites, radars, soundings, aviation reports etc), FMI has implemented the Local Area and prediction System LAPS developed by NOAA (http://laps.fsl.noaa.gov/).

LAPS is an assimilation model, which ingests all available observations together with first-guess meteorological fields from the latest ECMWF model forecast (resolution of approximately 25 km) to create a 3D-analysis of the atmosphere. There are currently two LAPS domains used at FMI: one covering southern Finland (1-km horizontal resolution, slightly wider than the HTB setup area) and one for the whole Finland (3-km resolution). LAPS uses a vertical pressure coordinate system with the resolution set to 25 hPa.

4. COOPERATION THROUGH RESEARCH PROJECTS

The Helsinki Testbed has attracted several R&D projects to take benefit of its mesoscale weather observations. These projects encompass more than 15 projects so far ranging from academic theses to R&D performed by commercial companies. There are both national and international projects. HTB has served as development test site for several weather radar related projects employing dual polarization weather radar. Examples of such a project include development of Hydroclass hydrometeor classification algorithm, studies of multidisciplinary use of polarimetric weather radar (birds and insects) and development of pattern recognition algorithms. One of the projects made possible by the HTB was a four-year project funded by the Finnish Academy (the Finnish equivalent of the National Science Foundation) to study the interaction of fronts with the near-surface boundary layer. Currently, the HTB has been accepted to serve as one official calibration and validation ground-site for the NASA's Global Precipitation Measurement (GPM) satellite mission (http://gpm.gsfc.nasa.gov/). This has induced the interest of other satellite communities with the NASA's Cloudsat ground campaign in autumn 2010 that will also support GPM algorithm development

11. REFERENCES

[1] Järvi, J., Hannuniemi, H., Hussein, T., Junninen, H., Aalto, P. P., Hillamo, R., Mäkelä, T., Keronen, P., Siivola, E., Vesala, T. & Kulmala, M. 2009: The urban measurement station SMEAR III: Continuous monitoring of air pollution and surface–atmosphere interactions in Helsinki, Finland. *Boreal Env. Res.* 14 (suppl. A): 86–109.

[2[Bengtsson L., M. Ghil and E. Kallen 1981: European Centre for Medium Range Weather Forecasts. Dynamic meteorology : data assimilation methods, Springer-Verlag, New York.