LIGHT PRECIPITATION VALIDATION EXPERIMENT AT HELSINKI TESTBED

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ABSTRACT

The Light Precipitation Validation Experiment (LPVEx) is planned for the Gulf of Finland in September-October 2010. LPVEx is a collaboration between NASA CloudSat, NASA Global Precipitation Mission Ground Validation program, University of Helsinki, FMI and Environment Canada. The goal of the experiment is characterizing the potential for CloudSat cloud radar, the GPM dual-frequency precipitation radar and passive microwave sensors to detect light precipitation and evaluate their estimates of rainfall intensity in high latitude, shallow freezing level environments.

The experiment will take place in the Helsinki Testbed area. The University of Wyoming King Air aircraft, equipped with particle probes and W-band cloud radar, will be used during the experiment. In addition to ground based instrumentation that is present within the testbed, three dual-polarization C-band radars will be available for the experiment. Two sites, one coastal and one inland, with extensive ground based instrumentation, i.e. 2D-video and Parsivel disdrometers, snow water equivalent sensors, and all weather precipitation gauges, are also established.

INTRODUCTION

Precipitation is an essential part of our life and a critical component of global energy and hydrological cycle. Precipitation influences and is influenced by Earth's climate. It has immense societal and economic impact. Reliable global precipitation measurements, therefore, are critically important for our understanding of water and energy cycle and prediction of weather and climate [1]. Space based measurements, when combined with comprehensive ground validation and calibration, can provide accurate and global datasets.

It was observed that light precipitation is a large contributor to the global water cycle. More than 50% of precipitation in mid-latitudes and 80% - in high-latitudes occur in the form of light precipitation with intensities smaller than 2 mm/hr [2,3]. Its contribution is largest at higher latitudes where agreement between distinct spaceborne sensors is worst [4]. Furthermore, ongoing development of new algorithms for detecting and quantifyinrg light precipitation suffers from the lack of a dedicated ground-validation datasets with which to evaluate and refine their products.

To augment our knowledge of light precipitation microphysics and expand ground-validation dataset the Light Precipitaton Validation Experiment (LPVEX) is planned for the Gulf of Finland in 2010. LPVEX is a collaboration between NASA CloudSat [6], NASA

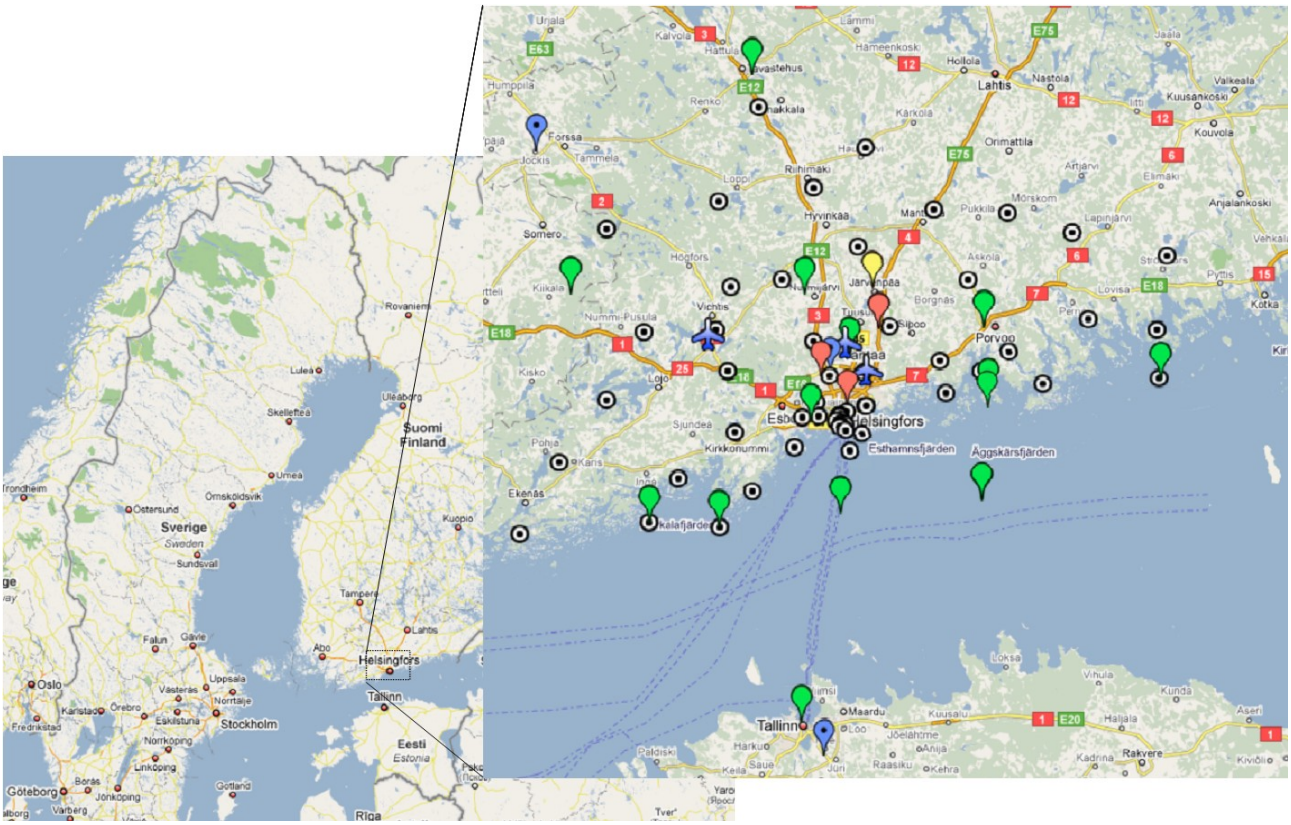

Figure 1. Helsinki Testbed mesoscale measurement network. Green balloons depict locations of FMI automatic weather stations. Locations of Vaisala Weather transmitters (capable of rainfall obs.) are shown by circles. Red balloons indicate positions of Weather Radars; UH Kumpula C-Band dual-pol radar, Vaisala Kerava C-Band dual-pol radar, FMI Vantaa C-band dual-pol radar. Yellow balloon shows location of UH Järvenpää C-Band transportable radar. Blue balloons depict locations of sounding stations.

Global Precipitation Mission Ground Validation program [7], University of Helsinki and FMI. The goal of the experiment is to characterize the ability of CloudSat cloud radar and the GPM dual-frequency precipitation radar (DPR) and passive microwave sensors (TMI) to detect light rain and evaluate their estimates of rainfall intensity in high latitude, shallow freezing level environments.

HELSINKI TESTBED

Finnish Meteorological Institute, Vaisala Inc. and University of Helsinki have established a mesoscale weather testbed in the greater Helsinki area. The testbed is open and comprehensive platform for research and development by companies, universities and research institutes worldwide. The testbed consists of a network of surface and tower based temperature, humidity and precipitation sensors, FMI automatic weather stations. A typical FMI AWS carries out observations of temperature, humidity, visibility, wind speed and direction, air pressure, precipitation, present weather cloud base and snow depth.
Additional to the testbed sensors four C-band weather radars are operating in the Helsinki testbed area. Three of those radars are polarimteric weather radars, operated by FMI, Vaisala and University of Helsinki. The University of Helsinki group also operates one Doppler weather radar that is mostly used to collect Doppler spectra observation at vertical pointing. In Fig. 1 the Helsinki Testbed area and available measurement equipment is shown. The radar locations are shown by red and yellow balloons. The Northern most radar, shown by the yellow baloon, is the vertically pointing radar that is used to record

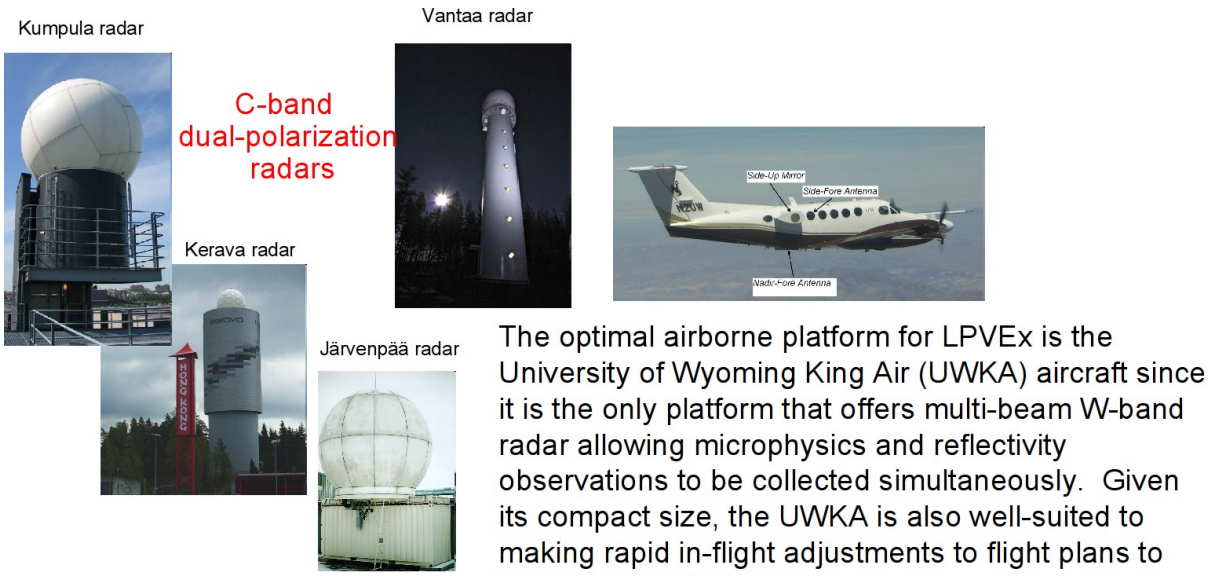

Figure 2. LPVEX radars and aircraft.

Doppler spectra at different heights.
The Helsinki Tesbed data is archived by FMI and is available from the FMI web-service [7]. UH archives data from three research radars. Overview of the radar observations is available from a research web page (http://www.atm.helsinki.fi/~mleskine/POMO/pomotus.html) and data is freely available by a request.

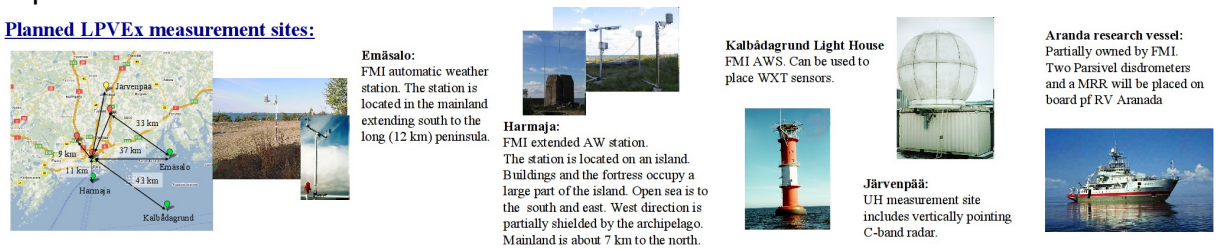

Figure 3. Locations of instrumented ground sites.

LPVEX INSTRUMENTATION

The experiment will consist of coordinated flights within a domain covered by the polarimetric C-band radars. It is planned that University of Wyoming King Air aircraft will be used for the experiment. The NASA CloudSat team provides the aircraft. At least 10 flights are scheduled for the experiment. King Air will be equipped with a cloud radar, 2DP and 2DC particle probes, and aerosol measurement equipment. (see Table 1)
Cloud and rain microphysical properties and cloud radar reflectivity profiles in upward, downward, and sideways pointing configurations will be measured along stacked ~100 km transects over the Gulf of Finland and adjacent land area. These measurements will be carried out by the W-band cloud radar. The ground-based radars will carry out coordinated scans of the aircraft operation area.
During the experiment three sites, two coastal and one inland, that host ground based instrumentation will be established. The coastal sites will be located on Harmaja and Emäsalo islands, and the inland site in Järvenpää next to the University of Helsinki vertically pointing C-band radar. The surface instrumentation for these sites will be extended by one 2D-video disdrometer, three Parsivel disdrometers and snow water

Instrument	Qty	Purpose	Provider
Ground			
C-band Dual Pol. Radar (scanning)	3	4-D Precipitation and Ka-Ku simulation (microphysics)	UH/Vaisala/FMI
C-band Doppler (vertically point-ing)	1	Precipitation Profiling (DSD and melting layer)	UH
UHF Wind Pro-filer	1	Precip. Profiling (DSD and melting layer)	HTB
2DVD	1-2	DSD/Radar Calibration	GPM
Parsivel Disdrom-eters	6-10	DSD/precip. Rate	GPM Canada
Joss-Waldvogel	1	DSD/precip. rate	UH
Snow LWE probes	5	SWE/rate on/at ground	GPM (Duke U.)
ADMIRARI Ra-diometer/MRR	1	Combined cloud and rainwater retrievals	U. Bonn
MRR	5	DSD profiling, precip rate, melting layer	U. Birmingham / Environment Canada
Vaisala WXT 520	>10	Precipitation rate at ground	HTB
Weighing gauges	6	Precipitation rate	FMI
Automatic Sound-ing System	1	T/P/RH profiles	Vaisala
Transportable sounding station	1	T/P/RH profiles	UH (Vaisala MARWIN MW12)
Twice-daily Soundings	3	T/P/RH profiles at Tallinn, St. Petersburg, and Jokioinen	FMI
POSS	3	Column DSD/Precip. Rate/type	Environment Canada
SMEAR Aerosol/flux Tower	1	T/RH/CO2, sensible heat, wind, radiation, aerosol size distribution/composition	University of Helsinki
Ceilometers	6	Cloud base height	FMI
Aircraft			
UW King Air			
FSSP	1	Cloud water/ice	CloudSat/GPM
DMT and King Hot wire	2	Cloud liquid water	CloudSat/GPM
Gerber	1	Liquid water	CloudSat/GPM
2DC	1	Particle size distribution and type (0.1 – 0.8 mm)	CloudSat/GPM
2DP	1	Particle size distribution (0.2 -6.4 mm)	CloudSat/GPM
CIP	2	Cloud particle imager (0.15-1.5 mm)	Environment Canada
CDP	1	Cloud droplet spectra (2 – 50 •)	CloudSat/GPM
Nevzorov	1	Liquid and Total water content	Environment Canada
PCASP-100X	1	Aerosol size distribution (0.2-3 um)	Wyoming
UWYO CCNC-100A	1	CCN concentration	Wyoming
W-band Cloud Radar	1	Cloud profiling	Wyoming
Ship			
FIMR RV Aranda	**1**		**FMI**
Weather Mast (T, RH, P, Winds)	1	Surface WX	
Vaisala Digicora Sounding System	1	Atmospheric Sounding	
ADCP/CTD etc. (oceanic)	1	Ocean	
Satellite			
CloudSat	1	W-band reflectivity, Cloud geometric profile, LWC/IWC profile, precipitation type/rate	
MODIS	1	IR TBs, visible TBs, cloud mask, LWP, IWP, effective radius	
AMSR-E	1	Polarized TBs (6.9-89 GHz), SST, CWV, LWP, rain rate	
AMSU-B	1	TBs (89-183 GHz), rain/snow incidence, rain rate	
Model Analysis			**FMI/GPM**
FMI Regional	1	FMI Regional	FMI
CRM/SSM	1	GSFC WRF	GPM
CRM	1	CSU-RAMS	CloudSat

Table 1: List of instrumentation that will be deployed during LPVEX.

equivalent sensors. GPM GV team will provide this equipment.
A number of instruments will be installed on a research vessel Aranda, which will be sailing in the gulf of Finland during the experiment. RV Aranda will operate in the Gulf of Finland during the experiment. That will provide excellent measurement points to validate TMI rainfall estimates and observe rainfall in the marine environment.

CONCLUSIONS

The experiment aim is to answer the following questions.

- What are the minimum rain rates that can be detected by current satellite precipitation sensors in environments with shallow freezing levels (lower than 2 km)?
- How will rainfall detection be improved by proposed future platforms?
- How well can these sensors discriminate rain from falling snow?
- Are the microphysical assumptions, such as raindrop size distribution, cloud water contents, and properties of the melting layer and precipitating ice aloft, currently employed in global satellite precipitation algorithms representative of high latitude precipitation in a statistical sense?
- What is the impact of variability in these microphysical assumptions and those related to vertical structure and spatial inhomogeneity on random errors in retrieved rainfall rate?
- Collectively, are the above inter-sensor differences large enough to explain the wide spread in current satellite estimates of high-latitude rainfall?

The exisitng infrastructure within the Helsinki Testbed in combination with additional ground, aircraft, sea based instruments provide an excelent opportunity to resolve challenges in spaceborne light precipitation observations.

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