Light Precipitation Validation Experiment; goals and instrumentation

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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 (GPM) 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. It is planned that 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, will also be established.

In the paper we cover in more detail goals, instrumentation and available infrastructure for LPVEx.

1. 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 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.

2. 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 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 all three 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.

© Proceedings of the 8th International Symposium on Tropospheric Profiling, ISBN 978-90-6960-233-2
Delft, The Netherlands, October 2009. Editors, A. Apituley, H.W.J. Russchenberg, W.A.A. Monna

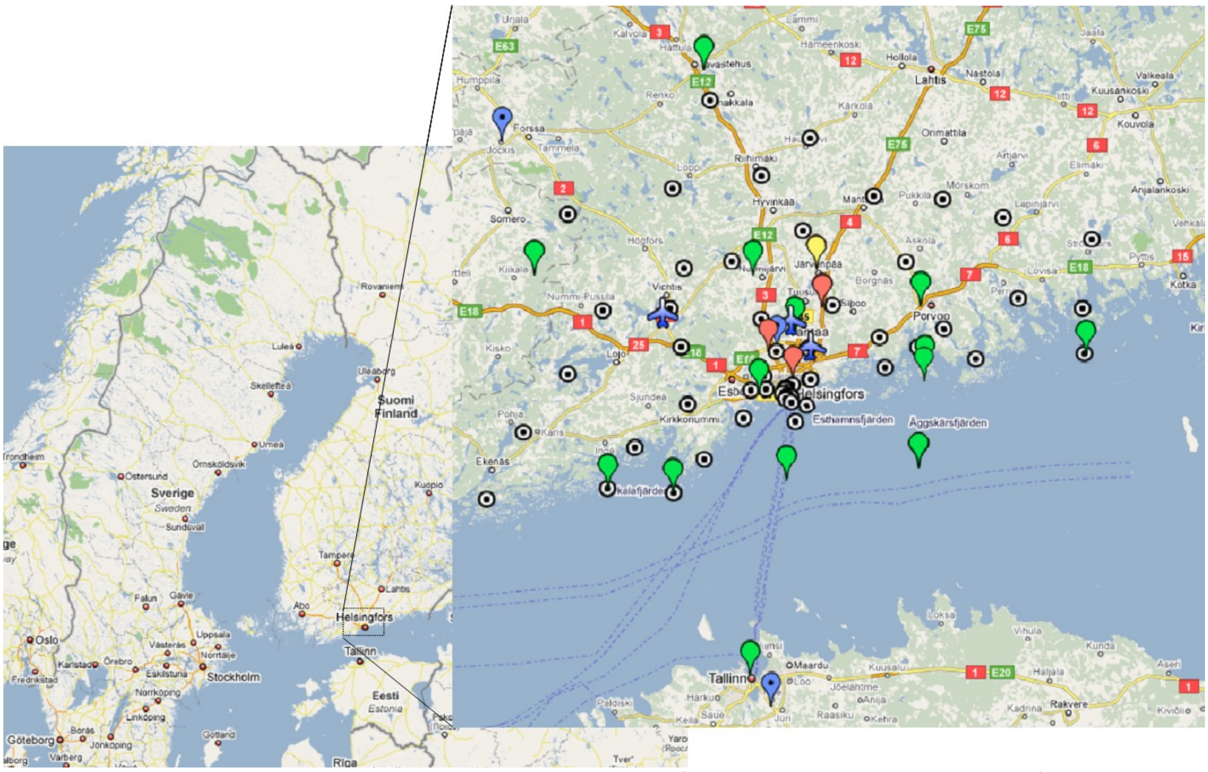

Figure 1. Helsinki Testbed mesoscale measurement network. Green balloons depict locations of FMI automatic weather stations. Locations of Vaisala Weather transmitters (capable of rainfall obs.) are shown by circles. Red balloons indicate positions of Weather Radars; UH Kumpula C-Band dual-pol radar,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

3. 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 two sites, one coastal and one inland, that host ground based instrumentation will be established. Tentatively the coastal site will be located on Harmaja Island (about 3 km from the coast of Helsinki), 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 equivalent sensors. GPM GV team will provide this equipment.

We are planning to install some of the ground based precipitation measurement instrumentation on a research vessel *Aranda,* which will be sailing 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.

4. CLOUDSAT-WEATHER RADAR JOINT MEASUREMENTS OF PRCIPITATION

One of the biggest uncertainties in GPM retrieval algorithms is how the algorithms will work in cases of shallow light precipitation that are common in northern latitudes. Unfortunately, Ku /Ka - band radar observations are not readily available to study performance of the algorithms in those cases. To augment the lack of observations, we have developed a procedure that can be used to simulate the output of the GPM Ku /Ka radar in realistic snowfall scenarios. The inputs of the simulation are coinciding CloudSat W-band radar and C-band weather radar observations.

As a starting point of the study, we simulate the dependence of the dual-frequency (DFR) at the GPM frequencies from the C/W-band DFR. For these simulations a wide range of input parameters, such as particle size distributions, snow density, etc., were used. Our simulations, performed with Mie scattering, indicate that the Ku /Ka -band dual frequency ratio can be simulated with good accuracy from the C/W-band DFR. This implies that the GPM snowfall measurements can be simulated from combined data obtained from ground-based and space-based radars.

Table 1: LPVEX intrumentation list

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 pointing)	1	Precipitation Profiling (DSD and melting layer)	UH
UHF Wind Profiler	1	Precip. Profiling (DSD and melting layer)	HTB
2DVD	1-2	DSD/Radar Calibration	GPM
Parsivel Disdrometers	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 Radiometer/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 Sounding 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

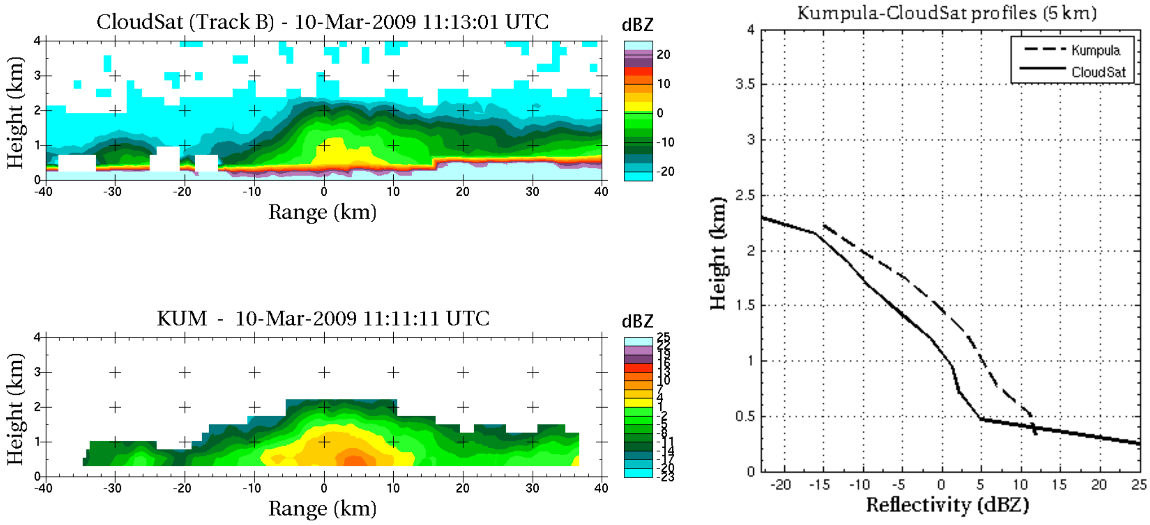

Figure 2. Simultaneous observations of precipitation that took place on March 10, 2009 by using CloudSat and University of Helsinki Kumpula radar.

The results of simulations will be applied to coinciding University of Helsinki C-band weather radar and CloudSat snowfall measurements, to generate synthetic GPM observations. An example of such measurements is shown in Figure 2. To collect these observations, University of Helsinki was carrying dedicated sector volume scans along CloudSat track. The measurements were synchronized with CloudSat overpasses to achieve minimal spatial and temporal differences in observations.

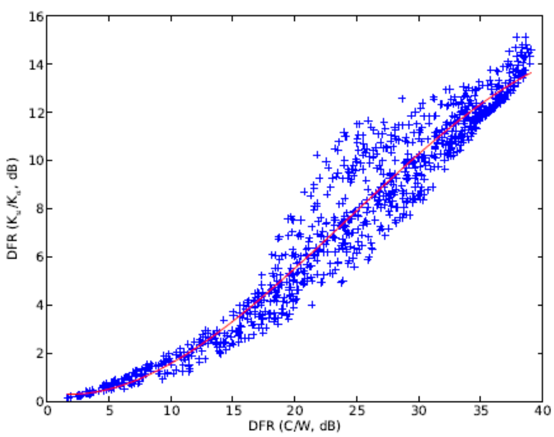

Figure 3. Simulation of dual frequency ratios in snaw fall for Ku/Ka and C/W band radar observations.

In Figure 3. results of simulations are shown. Based on this study synthetic GPM measurements will be created using CloudSat and C-band weather radar observations. During LPVEX validity of the proposed technique will be tested. Furthermore, the proposed procedure will applied to joint King Air W-band radar and weather radar observations.

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