Global Hydrology Resource Center

Data User Guide

GPM Ground Validation Weather Research and Forecasting (WRF) Images LPVEx

Introduction

The GPM Ground Validation Weather Research and Forecasting (WRF) Images LPVEx includes model data simulated by the Weather Research and Forecasting (WRF) model for the GPM Ground Validation Light Precipitation Validation Experiment (LPVEx). This field campaign took place around the Gulf of Finland in September and October of 2010. The goal of the campaign was to provide additional high-latitude, light rainfall measurements for the improvement of GPM satellite precipitation algorithms. The WRF model provided simulations of the precipitation events that were observed during the campaign. The LPVEx WRF dataset files are available from September 20 through October 20, 2010 in netCDF-3 format.

Notice:

The WRF model data files are not available for each day of the September 20 to October 20, 2010 observation period. WRF model simulations were run for days when operations took place.

Citation

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Keywords:

NASA, GHRC, PMM, GPM GV, University of Helsinki, Gulf of Finland, LPVEx, WRF, numerical weather prediction, parameterizations, precipitation

Campaign

The Global Precipitation Measurement mission Ground Validation (GPM GV) campaign used a variety of methods for validation of GPM satellite constellation measurements prior to and after the launch of the GPM Core Satellite, which launched on February 27, 2014. The instrument validation effort included numerous GPM-specific and joint agency/international external field campaigns, using state of the art cloud and precipitation observation infrastructure (polarimetric radars, profilers, rain gauges, and disdrometers). These field campaigns accounted for the majority of the effort and resources expended by the GPM GV mission. More information about the GPM mission is available on the PMM Ground Validation webpage.

The Light Precipitation Validation Experiment (LPVEx) sought to characterize high-latitude, light precipitation systems by evaluating their microphysical properties and utilizing remote sensing observations and models. This campaign was a collaborative effort between the CloudSat mission, GPM GV mission, the Finnish Meteorological Institute, Environment Canada, the United Kingdom's National Environment Research Council, Vaisala Inc., and the University of Helsinki. The campaign took place in September and October of 2010 in Northern Europe in the areas surrounding the Gulf of Finland (Figure 1). One of the objectives of the experiment was to evaluate the performance of satellite measurements when estimating rainfall intensity in high-latitude regions. This data collection had the purpose of improving high-latitude rainfall estimation algorithms and understanding of light rainfall processes. The campaign utilized coordinated aircraft flights, atmospheric profile soundings, ground precipitation gauges, radar measurements, and coordinated satellite observations to identify light precipitation properties and the spatial distribution of those properties. More information about the GPM LPVEx campaign can be found on the LPVEx Field Campaign webpage.

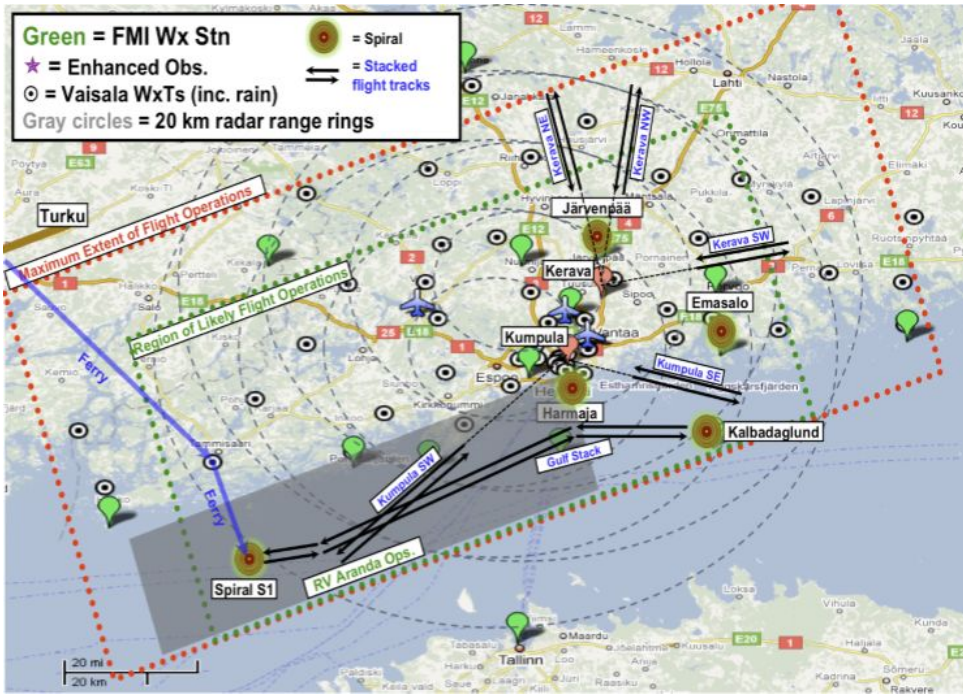

Figure 1: LPVEx field campaign study area along the Gulf of Finland
(Image source: [LPVEx Science Plan])

Instrument Description

The Weather Research and Forecasting (WRF) model is an open-source numerical weather prediction (NWP) model system designed for research and operational applications. Its development involved various organizations including the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Air Force, the U.S. Naval Research Laboratory, the University of Oklahoma, and the Federal Aviation Administration (FAA). A NWP model is essentially a computer program that runs mathematical simulations of the Earth's atmosphere, largely based on the governing equations of motion, to determine a future state of the atmosphere given a set of initial conditions. These models also include parameterizations which are components of a numerical model that cannot be explicitly calculated because they are too small scale or complex. Their values are therefore determined using a simplified approach. WRF can use actual atmospheric data as initial conditions or use idealized conditions. From there, the model simulates the various atmospheric processes to determine the resulting atmospheric conditions at some time period from the initial state. Because WRF can be used for research or operational purposes, it can take on a wide variety of configurations for use by different user groups. More information about the WRF model is available on the NCAR WRF Model webpage.

Investigators

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Data Characteristics

The GPM Ground Validation Weather Research and Forecasting (WRF) Images LPVEx consists of hourly WRF model data files in netCDF-3 format. The netCDF-3 files are compressed and stored as .gz files. Once unzipped, each data file will contain the model simulated data for various parameters. Each file is valid for a particular hour of the simulation. These data are available at a Level 4 processing level. More information about the NASA data processing start time levels is available on the EOSDIS Data Processing Levels webpage. The characteristics of this dataset are listed in Table 1 below.

Table 1: Data Characteristics

Characteristic	Description
Platform	Weather Research and Forecasting (WRF) model
Spatial Coverage	N: 61.880 , S: 58.264 , E: 28.314 , W: 20.805 (Finland)
Spatial Resolution	400 x 400 horizontal grid points
Temporal Coverage	September 20, 2010 - October 20, 2010
Temporal Resolution	Hourly
Parameter	Atmosphere and surface variables (e.g. temperature, latent heating, soil moisture)
Version	1
Processing Level	4

File Naming Convention

The GPM Ground Validation Weather Research and Forecasting (WRF) Images LPVEx dataset files are in netCDF-3 format, compressed as a .gz file. The files are named using the following convention:

Gzipped files: lpvex_MDL_WRF[GCE|SBM]_wrfout_d02_YYYYMMDD_hhmmss.gz

Unzipped files: MDL.WRF[GCE|SBM]_wrfout_d02_YYYY-MM-DD_hh_mm_ss

Table 2: File naming convention variables

Variable	Description
[GCE|SBM]	Parameterization schemes: GCE = Goddard Cumulus Ensemble SBM = Spectral-Bin Microphysics
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
hh	Two-digit hour in UTC
mm	Two-digit minute in UTC
ss	Two-digit second in UTC

.gz	Gzip archive file

Data Format and Parameters

The GPM Ground Validation Weather Research and Forecasting (WRF) Images LPVEx dataset consists of WRF model output data for simulations of precipitation events during LPVEx. The dataset files are stored as .gz archive files. Once unzipped, there are netCDF-3 files containing data valid for a particular hour of the simulation. The data fields contained in each netCDF-3 file are listed in Table 3 below.

Table 3: Data Fields

Field Name	Description	Unit
ACGRDFLX	Accumulated ground heat flux	J m^{-2}
ACHFX	Accumulated upward heat flux at the surface	J m^{-2}
ACLHF	Accumulated upward latent heat flux at the surface	J m^{-2}
ALBBCK	Background albedo	-
ALBEDO	Albedo	-
AOD_OUT	Aerosol optical depth	-
CANWAT	Canopy water	kg m^{-2}
CF1	2nd order extrapolation constant	-
CF2	2nd order extrapolation constant	-
CF3	2nd order extrapolation constant	-
CFN	Extrapolation constant	-
CFN1	Extrapolation constant	-
COMDBZ	Composite radar reflectivities	dbz
CON	Orographic convexity	-
COSALPHA	Local cosine of map rotation	-
DBZ	Radar reflectivities	dbz
DN	d(eta) values between half (mass) levels	-
DNW	d(eta) values between full (w) levels	-
DZS	Thickness of soil layers	m
E	Coriolis cosine latitude term	s^{-1}
EDT_OUT	EDT from GD scheme	-
EL_MYJ*	Mixing length from Mellor-Yamada-Janjic	m
EMISS	Surface emissivity	-
F	Coriolis sine latitude term	s^{-1}
FNM	Upper weight for vertical stretching	-
FNP	Lower weight for vertical stretching	-
GLW	Downward long wave flux at ground surface	W m^{-2}
GRAUPELNC	Accumulated total grid scale graupel	mm
GRDFLX	Ground heat flux	W m^{-2}
HFX	Upward heat flux at the surface	W m^{-2}
HGT	Terrain height	m

HGT_SHAD	Height of orographic shadow	m
I_RAINC	Bucket for rainc	-
I_RAINNC	Bucket for rainnc	-
ISLTYP	Dominant soil category	-
ITIMESTEP	ITIMESTEP	-
IVGTYP	Dominant vegetation category	-
LAI	Leaf area index	area/area
Lambert	Lambert conformal conic projection	-
LANDMASK	Land mask (1 for land, 0 for water)	-
LH	Latent heat flux at the surface	W m^{-2}
LU_INDEX	Land use category	-
MAPFAC_M	Map scale factor a mass grid	-
MAPFAC_MX	Map scale factor on mass grid, x direction	-
MAPFAC_MY	Map scale factor on mass grid, y direction	-
MAPFAC_U	Map scale factor on u-grid	-
MAPFAC_UX	Map scale factor on u-grid, x direction	-
MAPFAC_UY	Map scale factor on u-grid, y direction	-
MAPFAC_V	Map scale factor on v-grid	-
MAPFAC_VX	Map scale factor on v-grid, x direction	-
MAPFAC_VY	Map scale factor on v-grid, y direction	-
MAX_MSTFX	Max map factor in domain	-
MAX_MSTFY	Max map factor in domain	-
MF_VX_INV	Inverse map scale factor on v-grid, x direction	-
MU	Perturbation dry air mass in column	Pa
MUB	Base state dry air mass in column	Pa
NEST_POS	NEST_POS	-
NOAHRES	Residual of the Noah Surface Energy Budget	W m^{-2}
OA1	Orographic direction asymmetry function	-
OA2	Orographic direction asymmetry function	-
OA3	Orographic direction asymmetry function	-
OA4	Orographic direction asymmetry function	-
OL1	Orographic direction asymmetry function	-
OL2	Orographic direction asymmetry function	-
OL3	Orographic direction asymmetry function	-
OL4	Orographic direction asymmetry function	-
OLR	TOA outgoing long wave	W m^{-2}
P	Perturbation pressure	Pa
P00	Base state pressure	Pa
P_TOP	Pressure top of the model	Pa
PB	Base state pressure	Pa
PBLH	PBL height	m
PH	Perturbation geopotential	m^2 s^{-2}
PHB	Base-state geopotential	m^2 s^{-2}

PHYSC	Latent heating rate due to condensation	deg s^{-1}
PHYSD	Latent heating rate due to deposition	deg s^{-1}
PHYSE	Latent heating rate due to evaporation	deg s^{-1}
PHYSF	Latent heating rate due to freezing	deg s^{-1}
PHYSM	Latent heating rate due to melting	deg s^{-1}
PHYSS	Latent heating rate due to sublimation	deg s^{-1}
POTEVP	Accumulated potential evaporation	W m^{-2}
PSFC	SFC Pressure	Pa
Q2	QV at 2 m	kg kg^{-1}
QCLOUD	Cloud water mixing ratio	kg kg-1
QFX	Upward moisture flux at the surface	kg m^{-2} s^{-1}
QGRAUP	Graupel mixing ratio	kg kg^{-1}
QICE	Ice mixing ratio	kg kg^{-1}
QRAIN	Rain water mixing ratio	kg kg^{-1}
QSNOW	Snow mixing ratio	kg kg^{-1}
QV_UPSTREAM_X	Upstream qv x-advection	kg kg^{-1} s^{-1}
QV_UPSTREAM_X_TEND	Tendency upstream qv x-advection	kg kg^{-1} s^{-2}
QV_UPSTREAM_Y	Upstream qv y-advection	kg kg^{-1} s^{-1}
QV_UPSTREAM_Y_TEND	Tendency upstream qv y-advection	kg kg^{-1} s^{-2}
QVAPOR	Water vapor mixing ratio	kg kg^{-1}
RAINC	Accumulated total cumulus precipitation	mm
RAINNC	Accumulated total grid scale precipitation	mm
RDN	Inverse d(eta) values between half (mass) levels	-
RDNW	Inverse d(eta) values between full (w) levels	-
RDX	Inverse x grid length	-
RDY	Inverse y grid length	-
RESM	Time weight constant for small steps	-
RHOSN	Snow density	kg m^{-3}
SAVE_TOPO_FROM_REAL	1=original topo from real/0=topo modified by WRF	flag
SEAICE	Sea Ice Flag	-
SFROFF	Surface runoff	mm
SH2O	Soil liquid water	m^3 m^{-3}
SINALPHA	Local sine of map rotation	-
SLWDN	Surface LW downwelling flux	W m^{-2}
SLWUP	Surface LW upwelling flux	W m^{-2}
SMOIS	Soil moisture	m^3 m^{-3}
SNOPCX	Snow phase change heat flux	W m^{-2}
SNOW	Snow water equivalent	kg m^{-2}

SNOWC	Flag indicating snow coverage (1 for snow cover)	-
SNOWH	Physical snow depth	m
SNOWNC	Accumulated total grid scale snow and ice	mm
soilDepth	Soil depth	-
SOILTB	Bottom soil temperature	K
SR	Fraction of frozen precipitation	-
SST	Sea surface temperature	K
SSTSK	Skin sea surface temperature	K
SSWDN	Surface SW downwelling flux	W m^{-2}
SSWUP	Surface SW upwelling flux	W m^{-2}
SWDOWN	Downward short wave flux at ground surface	W m^{-2}
T	Perturbation potential temperature (theta-t0)	K
T00	Base state temperature	K
T2	Temp at 2 m	K
TH2	Pot temp at 2m	K
TH_UPSTREAM_X	Upstream theta x-advection	K s^{-1}
TH_UPSTREAM_X_TEND	Tendency upstream theta x-advection	K s^{-2}
TH_UPSTREAM_Y	Upstream theta y-advection	K s^{-1}
TH_UPSTREAM_Y_TEND	Tendency upstream theta y-advection	K s^{-2}
Time	Synthesized time coordinate from Times(time)	seconds since 1970-01-01 00:00:00
Times	Times	-
TISO	Temp at which the base T turns const	K
TKE_MYJ*	TKE from Mellor-Yamada-Janjic	m^2 s^{-2}
TLP	Base state lapse rate	-
TLWDN	TOA LW downwelling flux	W m^{-2}
TLWUP	TOA LW upwelling flux	W m^{-2}
TMN	Soil temperature at lower boundary	K
TSK	Surface skin temperature	K
TSLB	Soil temperature	K
TSWDN	TOA SW downwelling flux	W m^{-2}
TSWUP	TOA SW upwelling flux	W m^{-2}
U	x-wind component	m s^{-1}
U10	U at 10 m	m s^{-1}
U_G	x-direction geostrophic wind	m s^{-1}
U_G_TEND	Tendency x-direction geostrophic wind	m s^{-1}

U_UPSTREAM_X	Upstream u x-advection	$m s^{-2}$
U_UPSTREAM_X_TEND	Tendency upstream u x-advection	$m s^{-3}$
U_UPSTREAM_Y	Upstream u y-advection	$m s^{-2}$
U_UPSTREAM_Y_TEND	Tendency upstream u y-advection	$m s^{-3}$
UDROFF	Underground runoff	mm
UST	U* in similarity theory	$m s^{-1}$
V	y-wind component	$m s^{-1}$
V10	V at 10 m	$m s^{-1}$
V_G	y-direction geostrophic wind	$m s^{-1}$
V_G_TEND	Tendency y-direction geostrophic wind	$m s^{-1}$
V_UPSTREAM_X	Upstream v x-advection	$m s^{-2}$
V_UPSTREAM_X_TEND	Tendency upstream v x-advection	$m s^{-3}$
V_UPSTREAM_Y	Upstream v y-advection	$m s^{-2}$
V_UPSTREAM_Y_TEND	Tendency upstream v y-advection	$m s^{-3}$
VAR	Orographic variance	-
VEGFRA	Vegetation fraction	-
W	z-wind component	$m s^{-1}$
W_SUBS	Large-scale vertical velocity	$m s^{-1}$
W_SUBS_TEND	Tendency large-scale vertical velocity	$m s^{-1}$
x	Synthesized GeoX coordinate from DX attribute	-
x_stag	Synthesized GeoX coordinate from DX attribute	-
XICEM	Sea ice flag (previous step)	-
XLAND	Land mask (1 for land, 2 for water)	-
XLAT	Latitude, south is negative	degree_north
XLAT_U	Latitude, south is negative	degree_north
XLAT_V	Latitude, south is negative	degree_north
XLONG	Longitude, west is negative	degree_east
XLONG_U	Longitude, west is negative	degree_east
XLONG_V	Longitude, west is negative	degree_east
XTIME	Minutes since simulation start	-
y	Synthesized GeoY coordinate from DY attribute	-
y_stag	Synthesized GeoY coordinate from DY attribute	-

z	Eta values from variable ZNU	-
Z0	Background roughness length	m
Z_FORCE	Height of forcing input	m
z_stag	Eta values from variable ZNW	-
ZETATOP	Zeta at model top	-
ZNU	Eta values on half (mass) levels	-
ZNW	Eta values on full (w) levels	-
ZS	Depths of centers of soil layers	m

*Note: These fields (*EL_MYJ* and *TKE_MYJ*) are only listed in the "SBM" WRF netCDF-3 files

Algorithm

Numerical weather models utilize governing equations that describe the physical behavior of the atmosphere, numerical methods that allow computers to solve these equations, and parameterizations which are used to account for processes that cannot be explicitly calculated by the model. The Goddard Cumulus Ensemble (GCE) and Spectral-Bin Microphysics (SBM) parameterization schemes were used for WRF simulations during LPVEx. The GCE and SBM schemes characterize the microphysical precipitation processes that are simulated within the model. More information about how WRF-SBM simulations were used for LPVEx is available in Iguchi et al. (2014).

Quality Assessment

Because WRF is a very user-driven model system, the model regularly receives code contributions and improvements. These modifications are required to undergo thorough testing before being submitted for the model. More information about WRF contribution and testing requirements is available on the NCAR WRF User Support & Contributor Information webpage.

Software

This dataset is in netCDF-3 format and does not require any specific software to read. However, the data is easily readable and viewed in Panoply.

Known Issues or Missing Data

The WRF model data files are not available for each day of the September 20 to October 20, 2010 observation period. WRF model simulations were run for days when operations were conducted.

References

Iguchi, T., Matsui, T., Tao, W., Khain, A. P., Phillips, V. T., Kidd, C., ... Hou, A. (2014). WRF–SBM Simulations of Melting-Layer Structure in Mixed-Phase Precipitation Events Observed during LPVEx. *Journal of Applied Meteorology and Climatology*, *53*, 2710–2731. https://doi.org/10.1175/JAMC-D-13-0334.1

NCAR. (2020). The Weather Research and Forecasting Model. https://www.mmm.ucar.edu/weather-research-and-forecasting-model

Petersen, W., L'Ecuyer, T., & Moiseev, D. (2011). The NASA CloudSat/GPM Light Precipitation Validation Experiment (LPVEx). https://ntrs.nasa.gov/search.jsp?R=20110015768

Related Data

All data collected by other instruments during the LPVEx field campaign are considered related datasets. These data can be located by searching the term 'LPVEX' using the GHRC HyDRO2.0 search tool. WRF model data used in other field campaigns can be located by searching the term 'WRF' in HyDRO2.0 and an example dataset is listed below.

GPM Ground Validation Weather Research and Forecasting (WRF) Images MC3E (http://dx.doi.org/10.5067/GPMGV/MC3E/WRF/DATA101)

Contact Information

To order these data or for further information, please contact:

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