Merged radar–aircraft products in GPM–GV

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Introduction and Goals

The overarching goal of this project are to provide value-added geometrically-matched data products for GPM's algorithm development, cloud-resolving modeling, and ground validation community. Multi-sensor data fusion algorithms to match observations of varying temporal and spatial sampling characteristics are performed in an attempt to provide optimal match-ups of aircraft *in situ* and remote sensing data with ground-based scanning radar. The outputs of the data fusion algorithms will be in the form of easy-to-read netCDF files that will enable a large variety of users to access the data for many applications in the GPM community.

Two products are under development for this project:

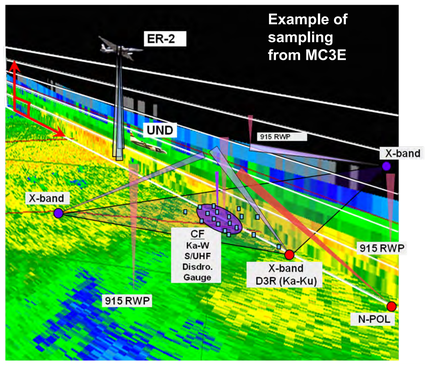
MGRAD: Merged Ground-based Radar-Aircraft Data

MGRAD will match aircraft in situ data with scanning radar PPI and RHI scans along the time series of the aircraft track. This product will allow the development and validation of:

- GV radar algorithms (e.g., rain rate, hydrometeor ID, particle size distribution, sub-pixel spatial variability),
- Satellite algorithm assumptions (e.g., 3-D variation of particle size distributions, particle phase, density, precipitation rate, non-uniform beam filling)
- Cloud-resolving model physics (state variables, microphysical parameters

SatSimRAD: Satellite Simulator Radar-Aircraft Data

SatSimRad will provide matched and gridded satellite simulator products with observations from underlying microphysical aircraft along the flight legs of the satellite simulator aircraft. This product will be particular useful in constructing "columns" of observations for addressing spaceborne algorithm and CRM assumptions. Typical flight patterns where "columns" are envisioned to be particularly useful include bowtie/spiral coordinated flight and racetrack/stacked leg flight patterns from the satellite simulator/microphysical aircraft.



MGRAD methodology

Aircraft location (t,x,y,z – GPS)

Ground-based radar data cf radial format (t,r,ϕ,θ – PPI, RHI)

Convert spatial coordinates to common Cartesian coordinates relative to ground-based radar (x,y,z) using 4/3R beam propagation model

R_h=R_z=500 m T_h=5 min

At each aircraft point, apply a Cressman filter to the radar data in space and time

$$d_s^2 = \left(\frac{x_r - x_a}{R_h}\right)^2 + \left(\frac{y_r - y_a}{R_h}\right)^2 + \left(\frac{y_r - z_a}{R_z}\right)^2$$

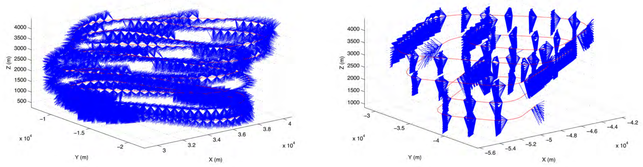
$$d_t^2 = \left(\frac{t_r - t_a}{T_h}\right)^2$$

$$X = \frac{\sum_{i=0}^{n} \omega_s \omega_t X_i}{\sum_{i=0}^{n} \omega_s \omega_t}$$

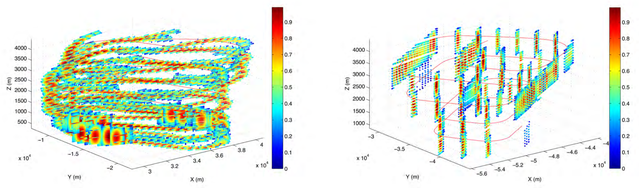
$$\omega_{s,t} = \begin{cases} \frac{1-d^2}{1+d^2} & \text{if } d^2 \le 1 \\ 0 & \text{if } d^2 > 1 \end{cases}$$

Experimenting with other methods, such as Discrete Fourier Transform in t

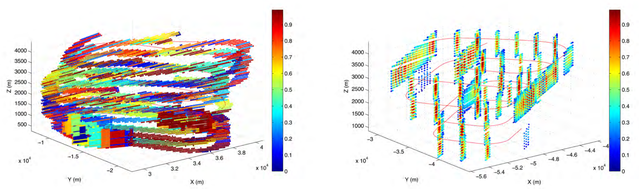
9-21-10 Spiral 1 – PPI Scans 9-21-10 Spiral 3 – RHI Scans



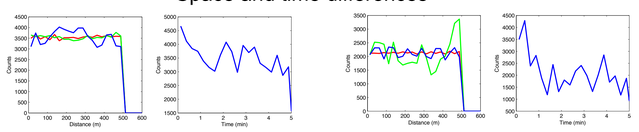
ω_s and aircraft track (red)



ω_t and aircraft track (red)



Space and time differences



Plans for each project

Canadian CloudSat-CALIPSO Validation Project (C3VP)
January 2007, CARE Site, Canada
MGRAD: NRC Convair 580 and EC King City C-band

Light Precipitation Validation Experiment (LPVEX)
September-October 2010, Helsinki, Finland
MGRAD: UW King Air and Kumpula, Kerava, and Vantaa C-Band radars

Mid-latitude Continental Convective Clouds Experiment (MC3E)
April-June 2011, ARM CART Site, Oklahoma, USA
MGRAD: UND Citation and NASA NPOL S-band and DOE CSAPR C-band radar
SatSimRAD: NASA HIWRAP Ku-Ka-band radar and AMPR/ CoSMIR radiometers

GPM Cold Season Experiment (GCPEX)
January-February 2012, CARE Site, Canada
MGRAD: UND Citation and NRC Convair 580 and EC King City C-band, NASA D3R Ku-Ka-band radar
SatSimRAD: NASA APR-2 Ku-Ka-band AMPR/CoSMIR radiometers

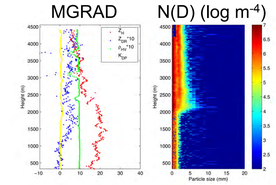
GPM Orographic Experiment TBD
MGRAD and **SatSimRAD** will be created with available observations comparable to other projects

Reanalyze TRMM field campaigns?

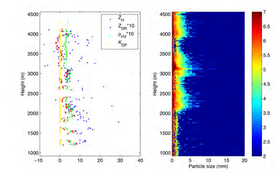
Examples from LPVEX

9-21-10 Spiral 1

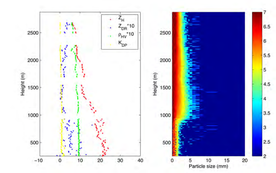
MGRAD NCAR 2D N(D) (log m^{-4})



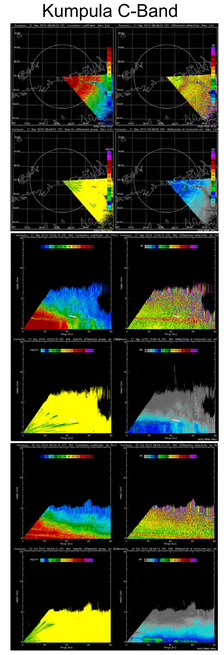
9-21-10 Spiral 3



10-20-10 Spiral 2



Kumpula C-Band

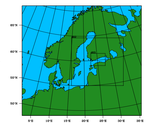


Application: WRF-CRM validation for LPVEX

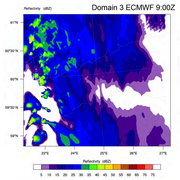
WRF-ARW version 3.2.1
25km-5km-1km nested domains
Microphysics: Goddard, WSM6, WDM6
Radiation: RRTMG PBL: YSU
Cumulus: Kain-Fritsch (outer domain only)
Run time:
- September 21 case: 12Z September 20 – 00Z September 22

GFS and ECMWF-interim initialization

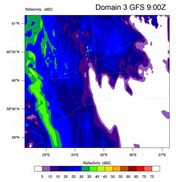
Nested Simulation Domains:



Domain 3 ECMWF 9:00Z

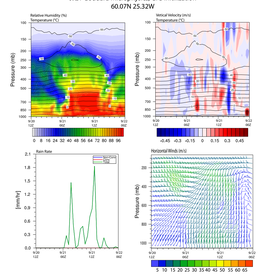


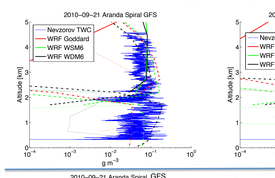
Domain 3 GFS 9:00Z

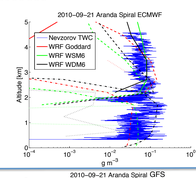


GFS simulation overview:

9/21 Goddard Microphysics, GFS Initilization
60.07N 25.32W

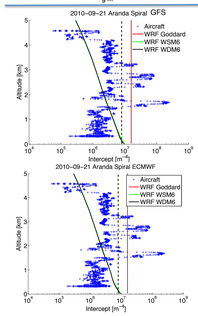


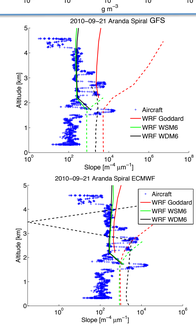




Aranda King Air spiral water contents (q), blue

WRF simulations
Solid-q ice
Dash-q snow
Dot-q cloud
Dot Dash-q rain





Aranda King Air spiral 2D probe observed exponential DSD parameters

WRF simulations
Top: GFS
Bottom: ECMWF
Solid-snow
Dash-rain

Acknowledgments

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