Application of MET for the Verification of the NWP Cloud and Precipitation Products using A-Train Satellite Observations

Paul A. Kucera, Courtney Weeks, Barbara Brown, and Randy Bullock

National Center for Atmospheric Research/Research Applications Laboratory
Boulder, Colorado USA

IPWG5
11-15 October 2010

Outline

- Introduction
- MET Overview
- Motivation
- Example Comparisons
- Future Work

Introduction

- We recently started a project to demonstrate the application of the NCAR Model Evaluation Tools (MET) for forecast evaluation using A-train (currently focused on CloudSat) observations
- The goal of the project is to create a common toolkit for integrating satellite observations in a framework that permits meaningful comparisons with numerical model output
  - Evaluate forecast products and features to determine when and why forecasts are sometimes deficient
- Develop tools that can easily extend to precipitation validation of satellite products

MET Overview

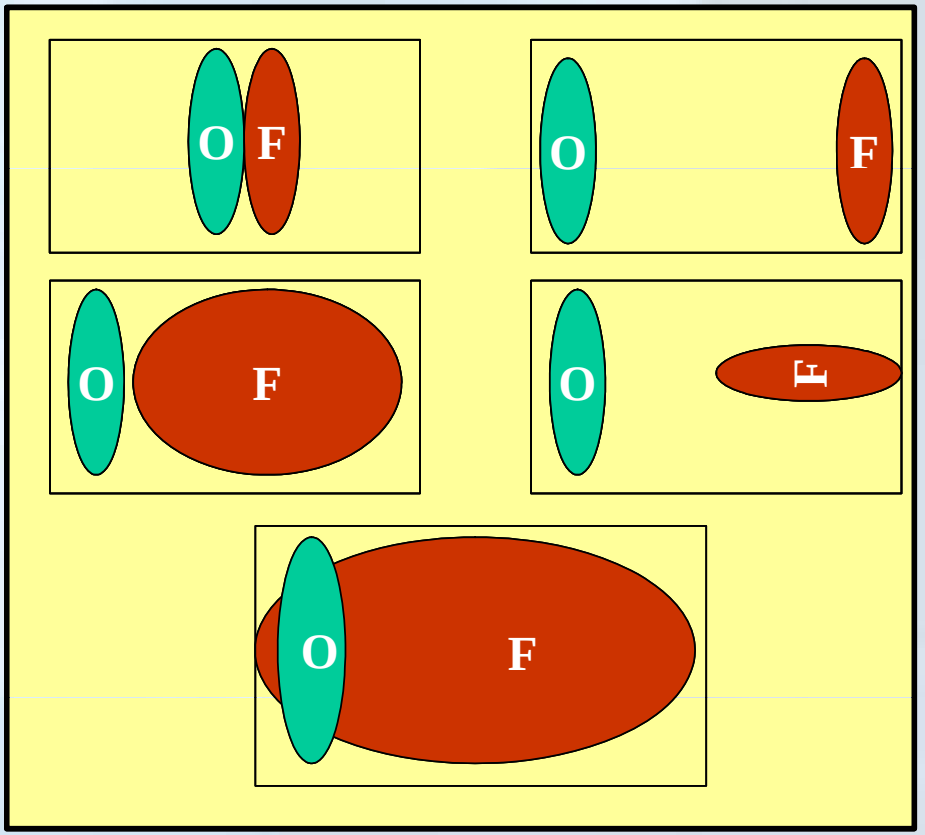
- MET was originally developed to support the Developmental Testbed Center (DTC) at NCAR and is a community resource:
  - It is a stand alone software package that is associated with the Weather Research and Forecasting (WRF) system.
  - Available at: http://www.dtcenter.org/met/users/downloads/

MET Overview

- MET is designed to evaluate a variety of datasets (e.g., rain gauge, radar, satellite, NWP products). The following statistical tools are available:
  - Grid-to-point (e.g., NWP or satellite precipitation products to rain gauge)
  - Grid-to-grid validation (e.g., NWP precipitation to satellite or radar precipitation products)
  - Advanced spatial validation techniques
    - Compare precipitation “features” in gridded fields

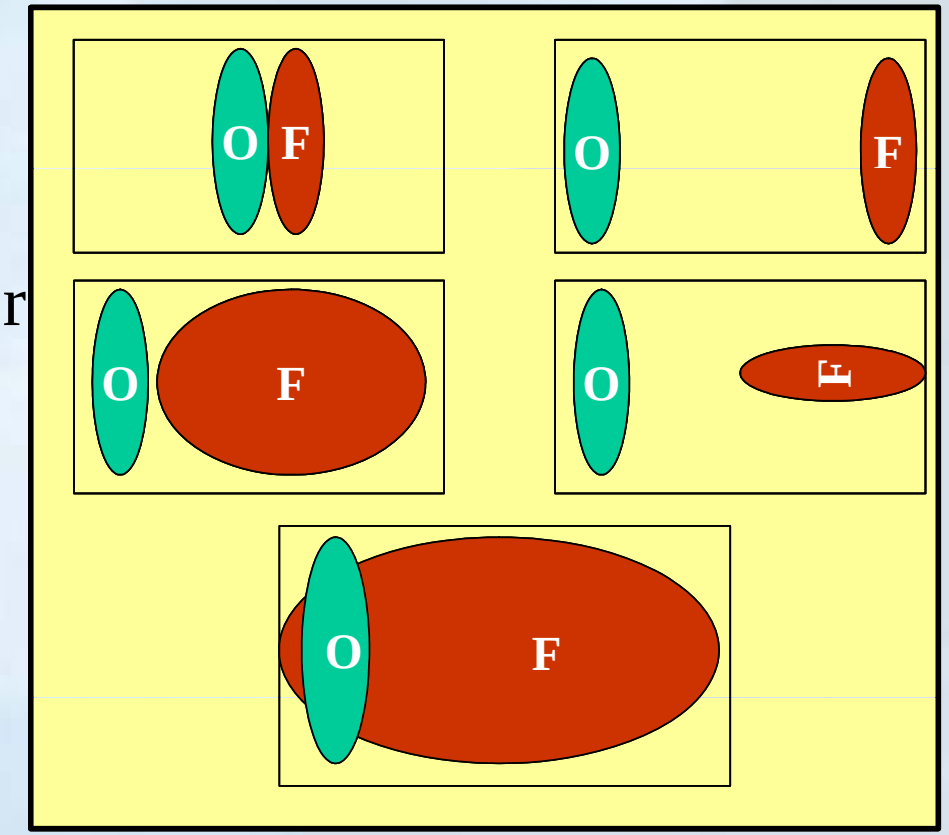
Motivation

- Most evaluation studies rely on the use of standard measures to quantify the quality of forecasts or observed fields:
  - Mean error
  - Bias
  - Mean absolute error
  - Root mean squared error
  - . . .



Motivation

- Traditional statistics are often not able to account for spatial or temporal errors:
  - Displacement in time and/or space
  - Location
  - Intensity
  - Orientation errors
- There has been recent studies to develop spatial evaluation techniques



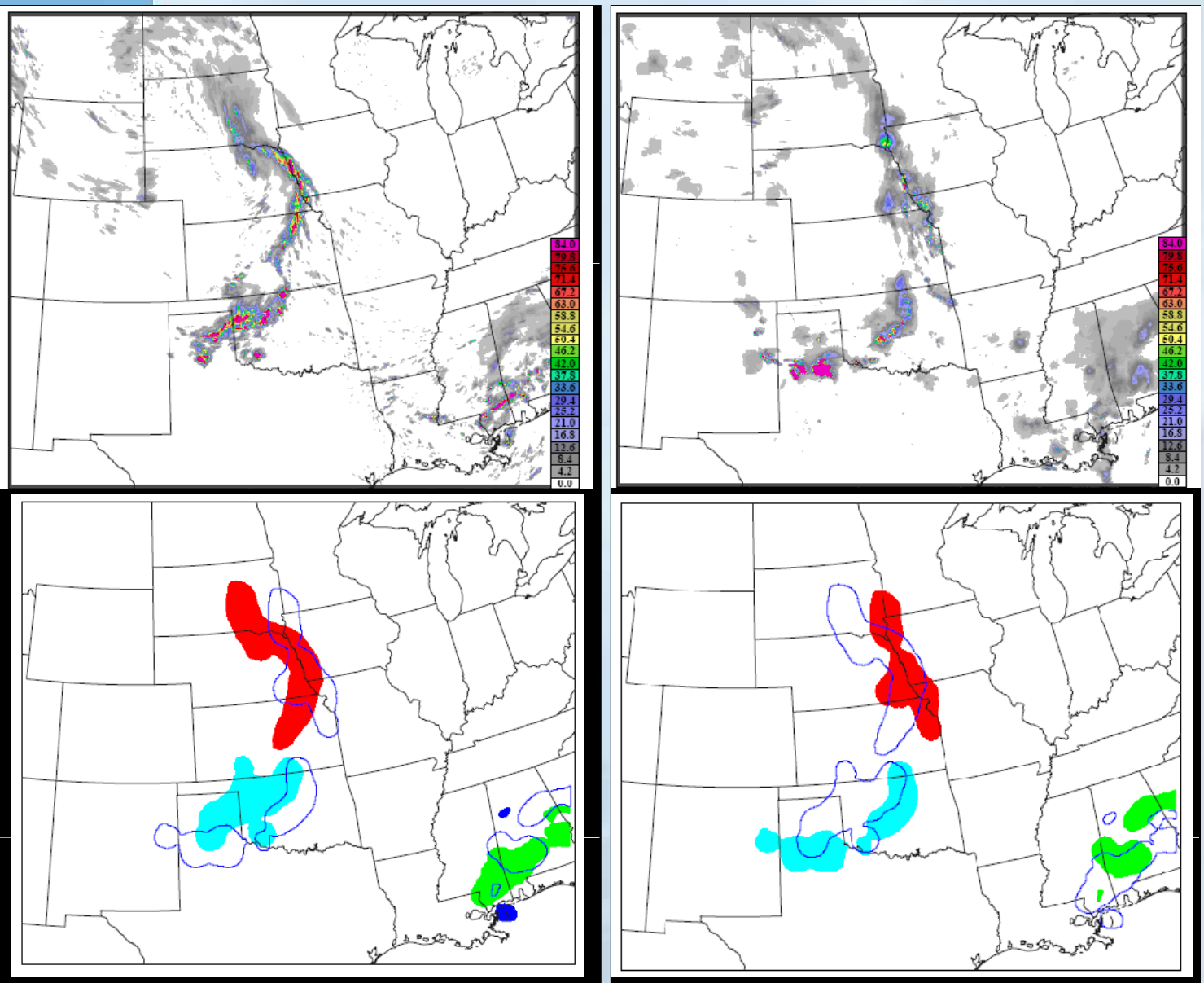
Motivation

- There are several spatial methods that are currently being developed:
  - Neighborhood
  - Scale separation
  - Field deformation
  - Features-based
- We have been developing a feature-based method called MODE

Method for Object-based Diagnostic Evaluation (MODE)

24-h precip forecast

Precip analysis



MODE results indicate

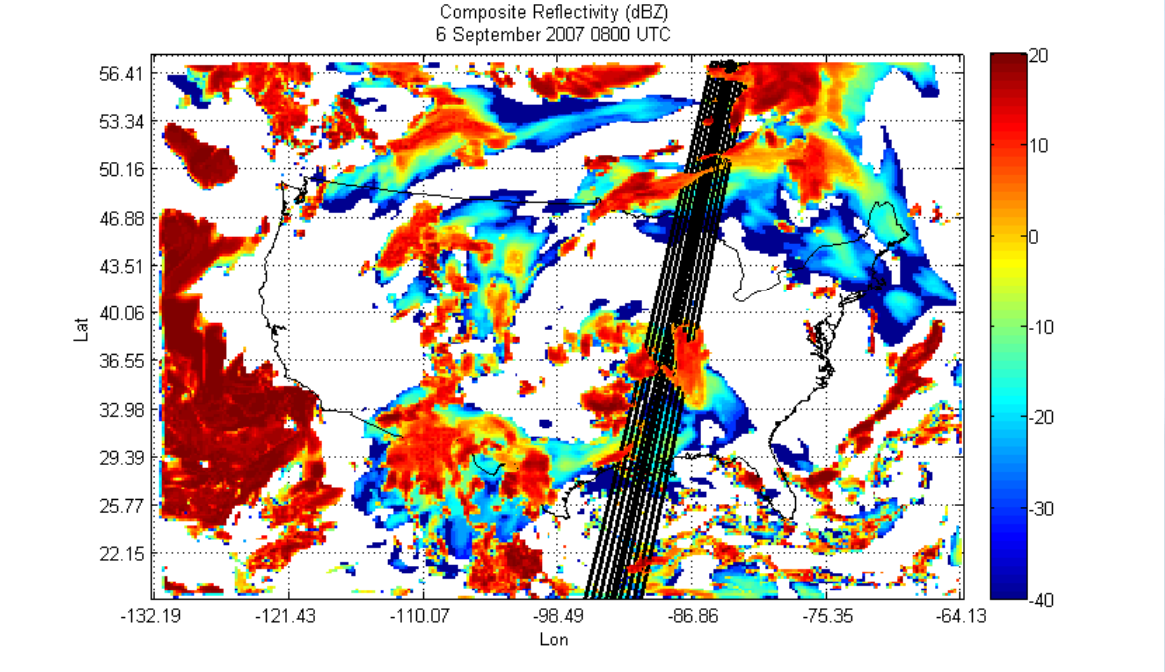
Slightly displaced (centroid distance)
Too intense (median intensity)
A little large (ratio of areas)

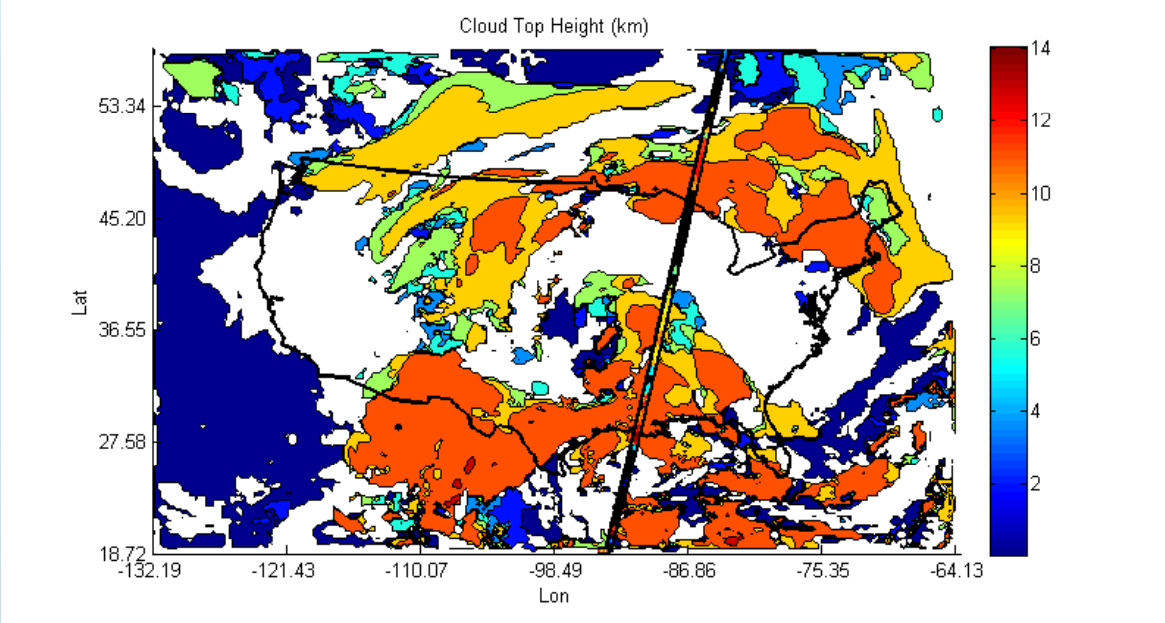
In contrast:

Example CloudSat/NWP Comparisons

- We performed our comparison using the RUC (http://ruc.noaa.gov/) cloud top height and derived reflectivity products at a spatial resolution of 20 km over the continental US
- Performed a seasonal correlation study for different cloud types

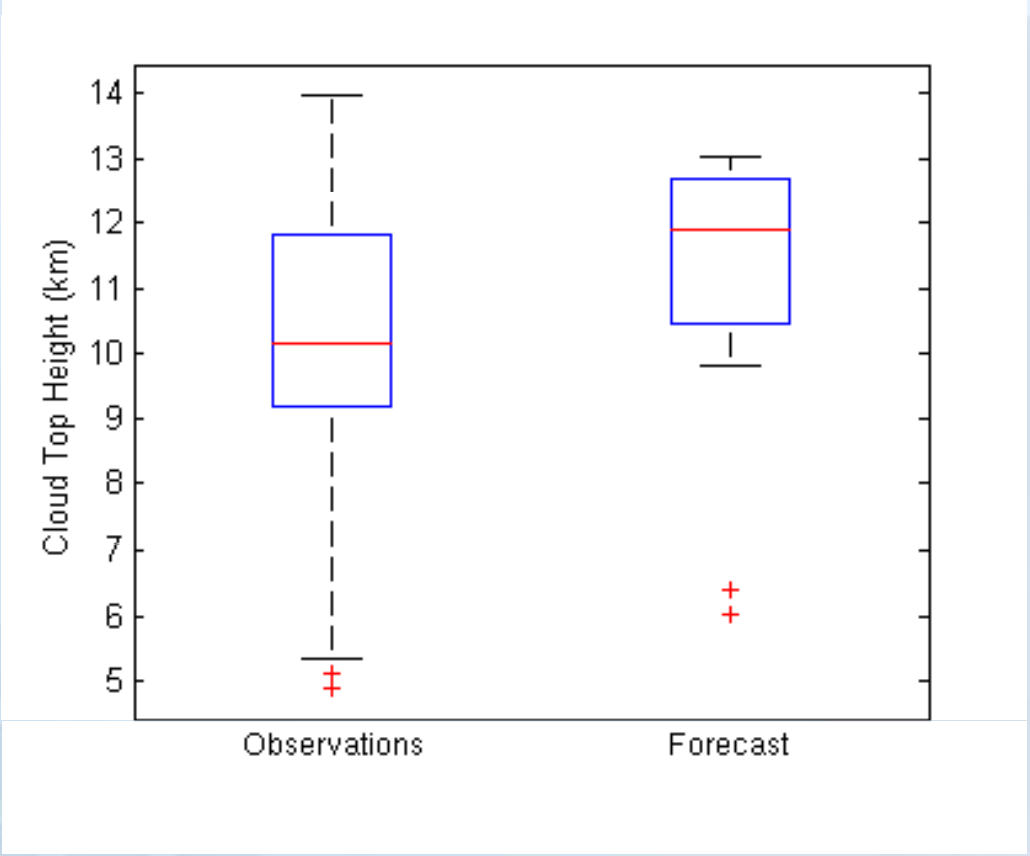
Example: 06 September 2007





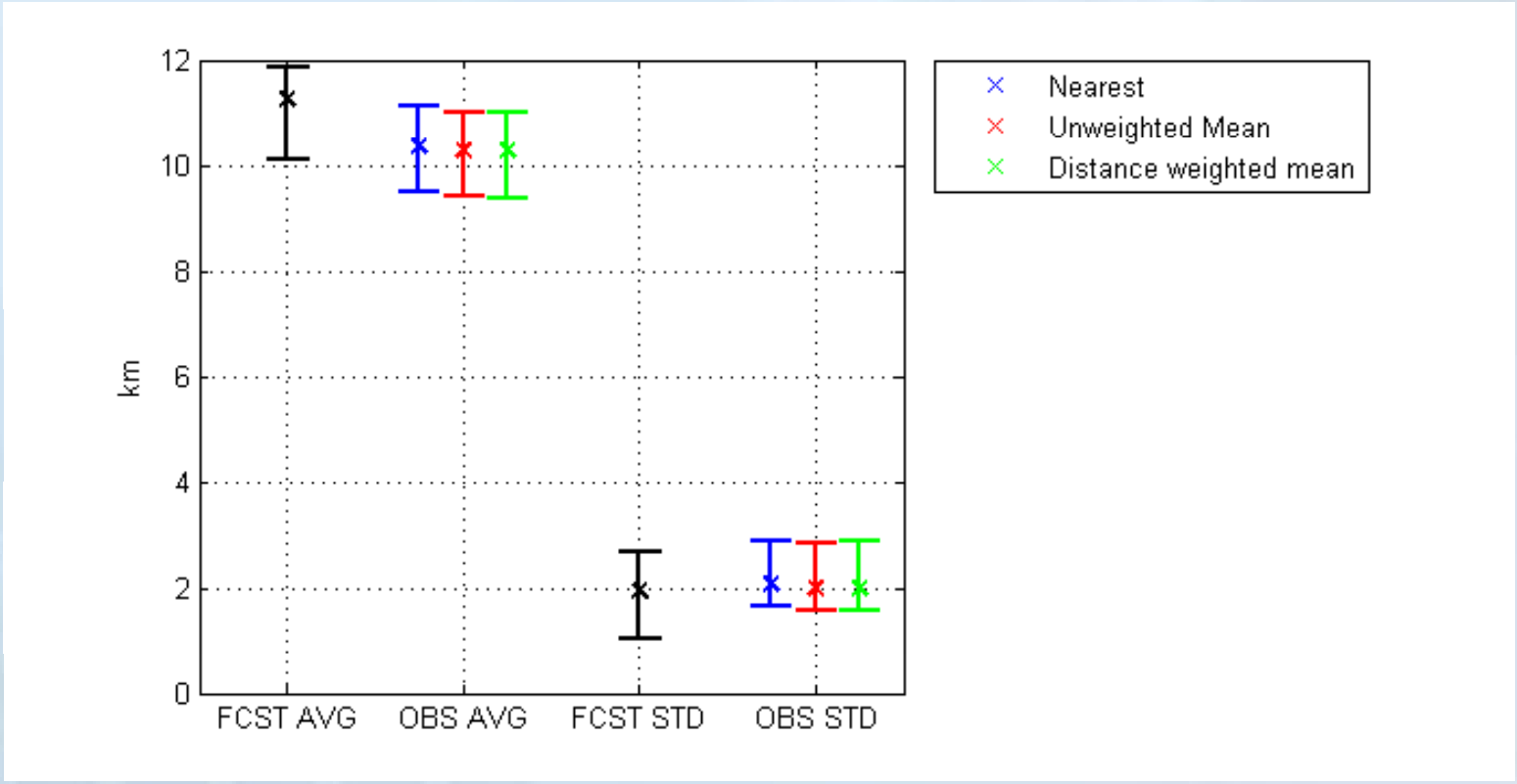
Standard Statistics

- Cloud Height Distributions along the track



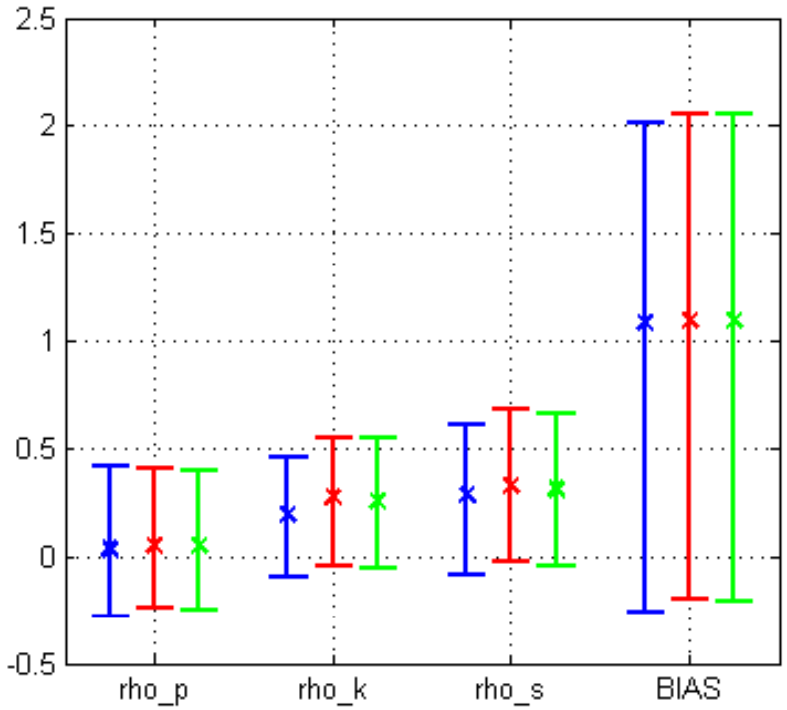
Standard Statistics

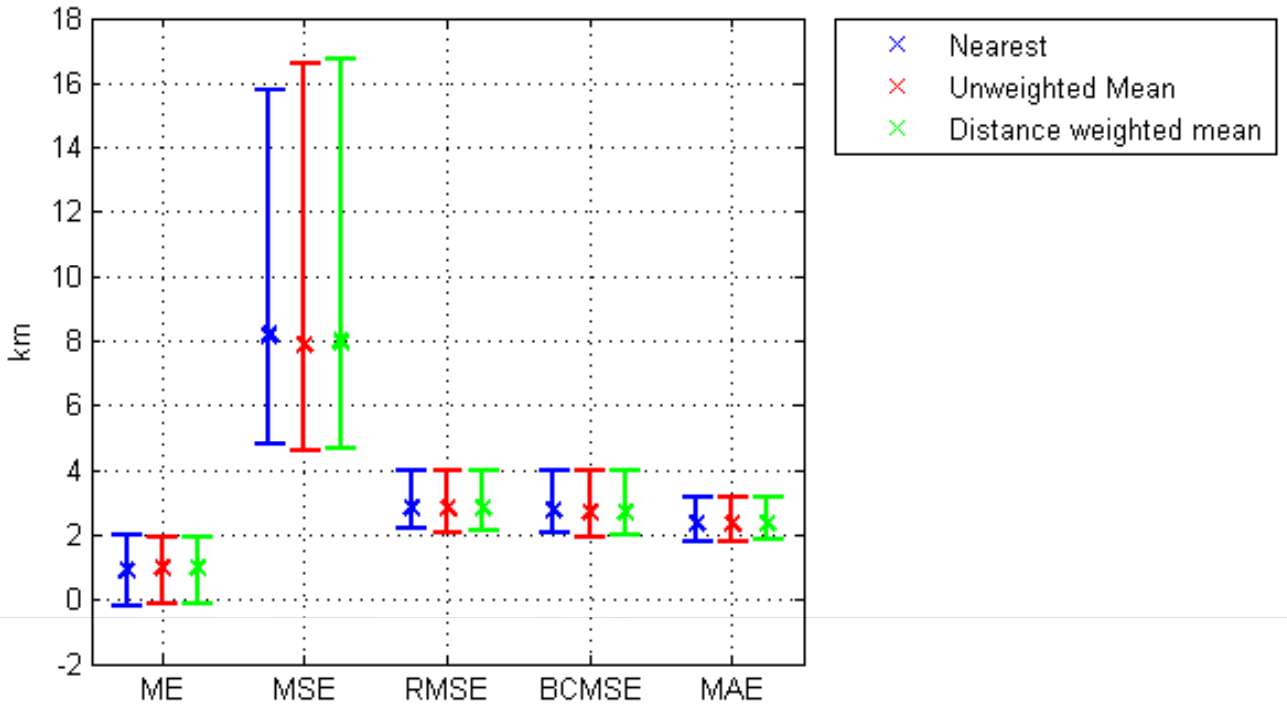
- Forecast mean and standard deviation with 95% confidence intervals
  - Different weighting methods



Standard Statistics

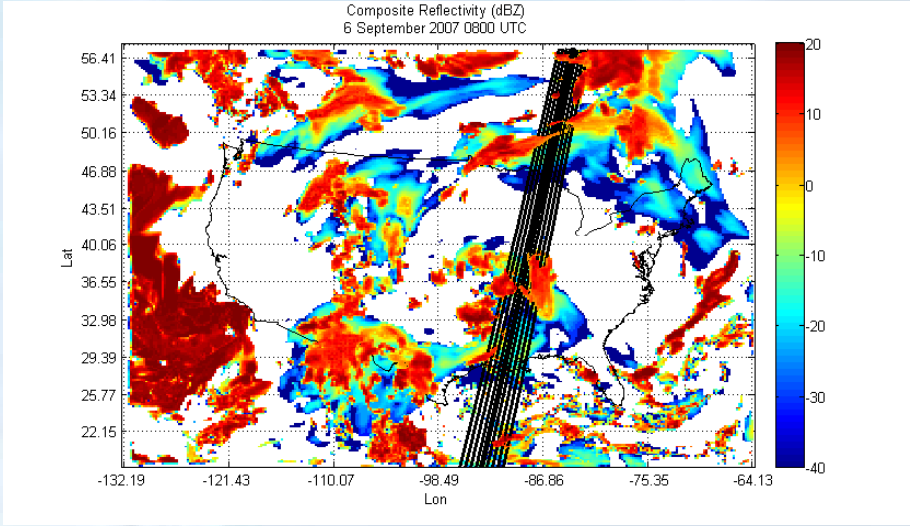
- Correlation (pearson, kendell, spearman), multiplicative bias, mean error, mean squared error, root mean squared error, bias corrected mean squared error and mean absolute error with 95% confidence intervals (boot strap method)

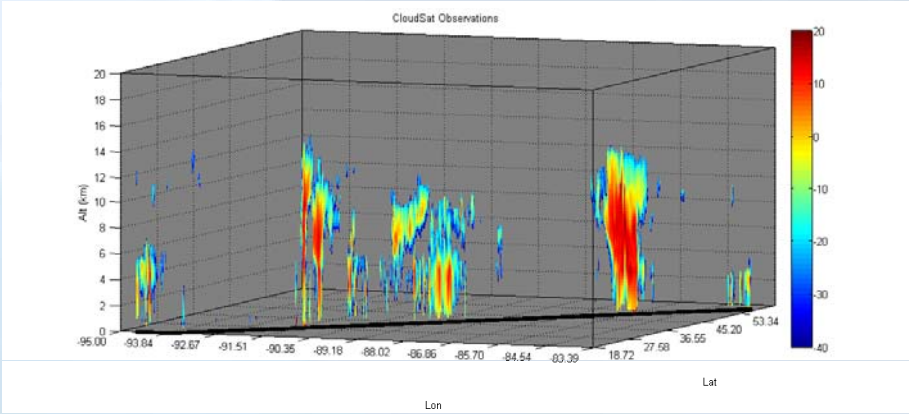




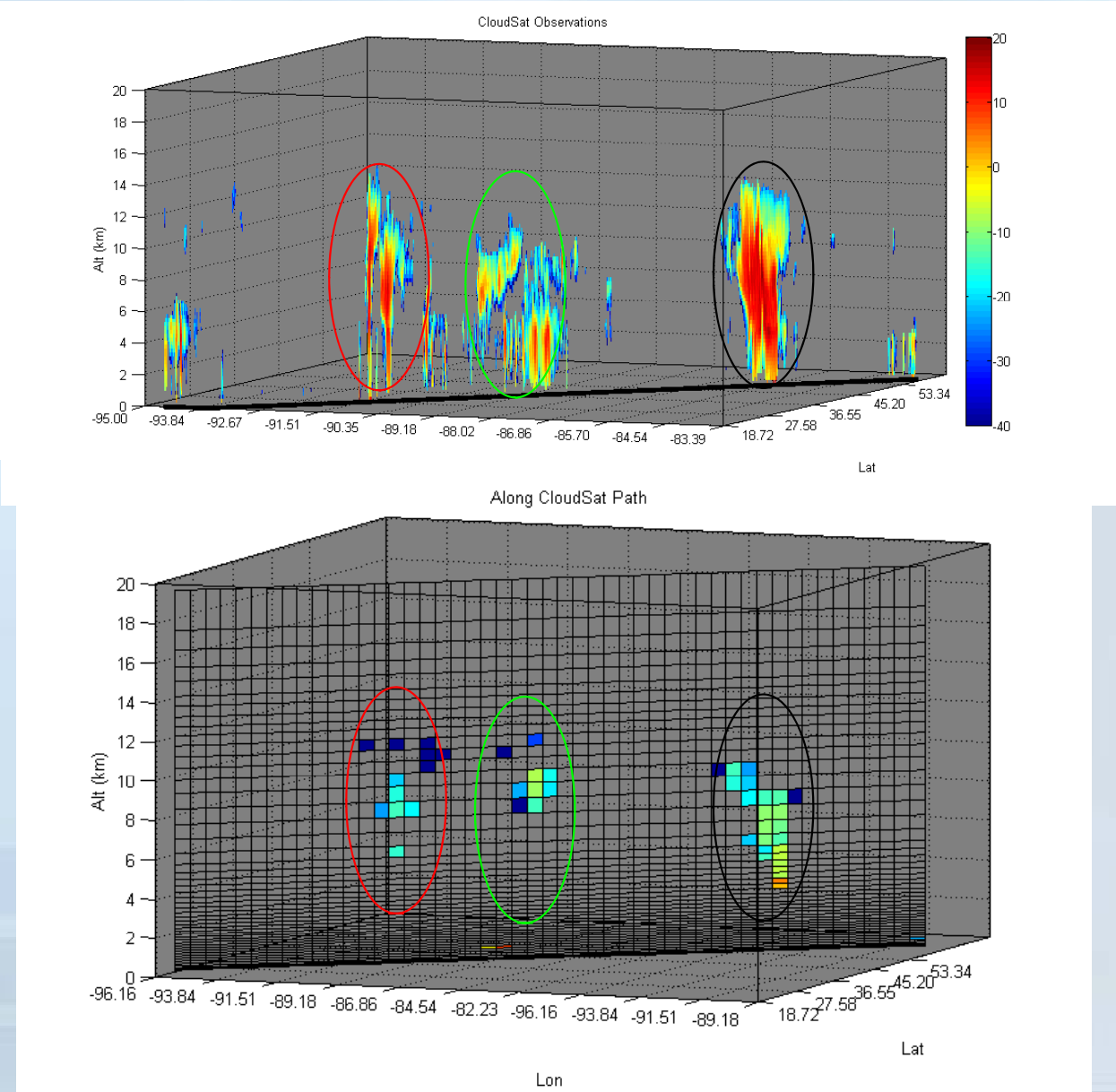
Object based Verification

- MODE is being modified to spatially and temporally search model fields in the vertical to find matched objects:
  - parallel to track, cross track, and temporally
- Next slides show examples of search routines being implemented in MODE

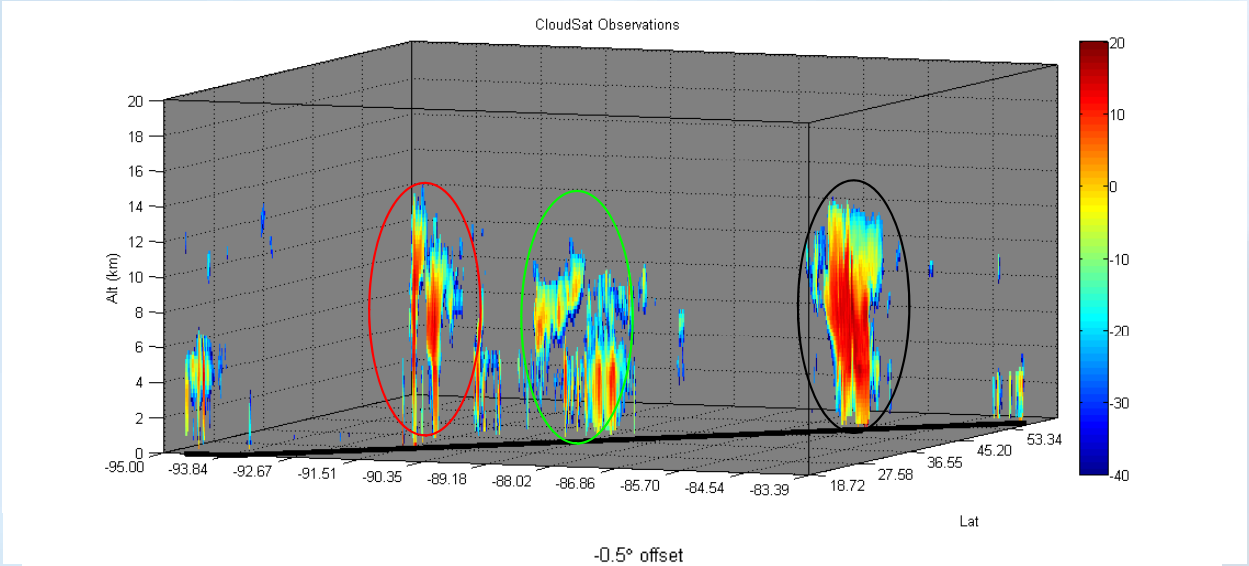




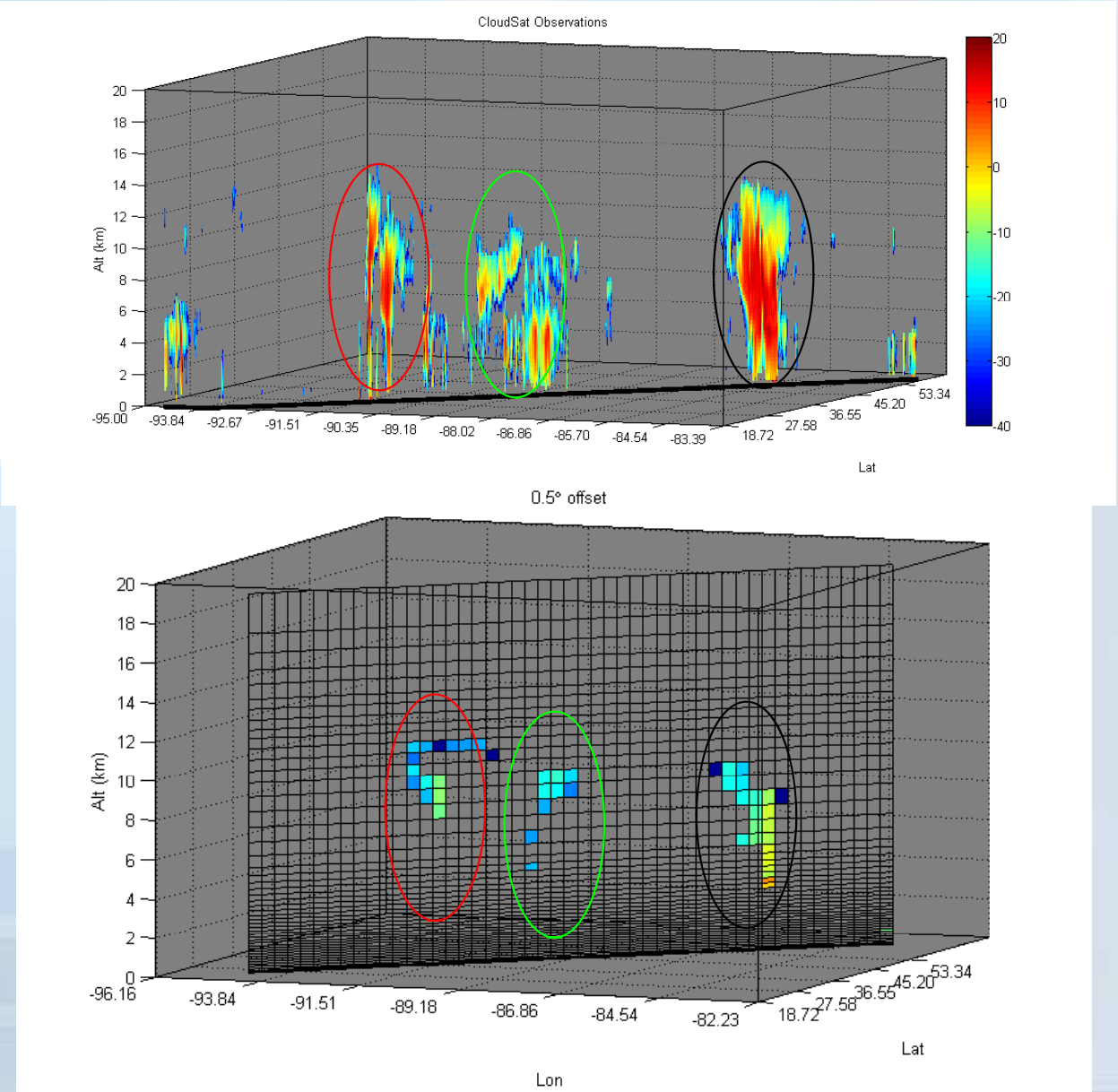
Object-based Comparison: Along Track



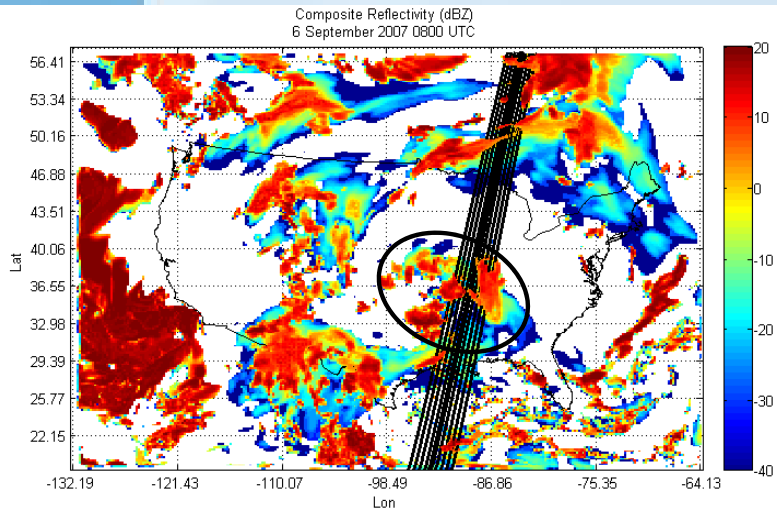
Object-based Comparison: Parallel to Track (Westward)

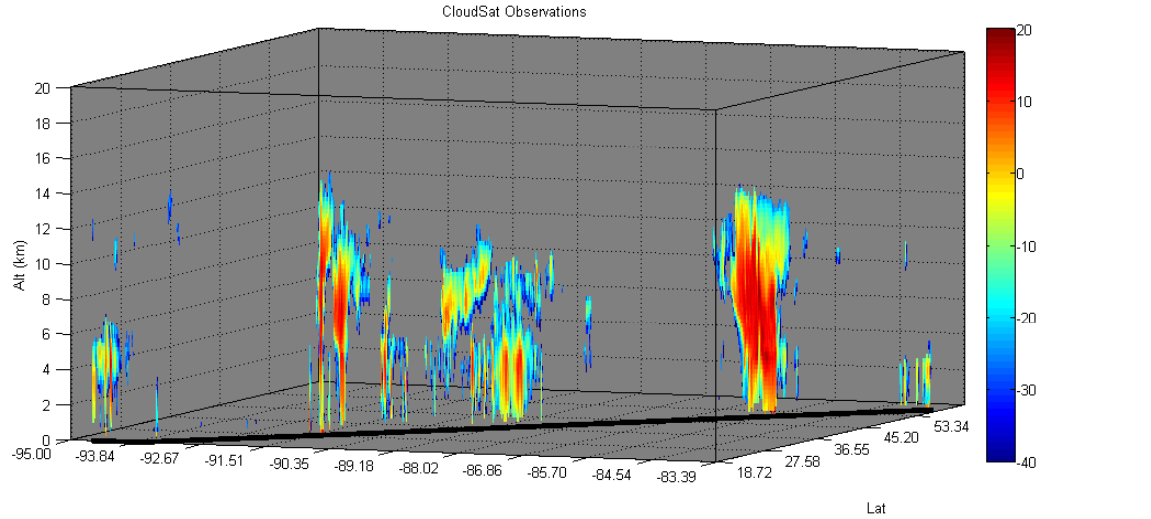


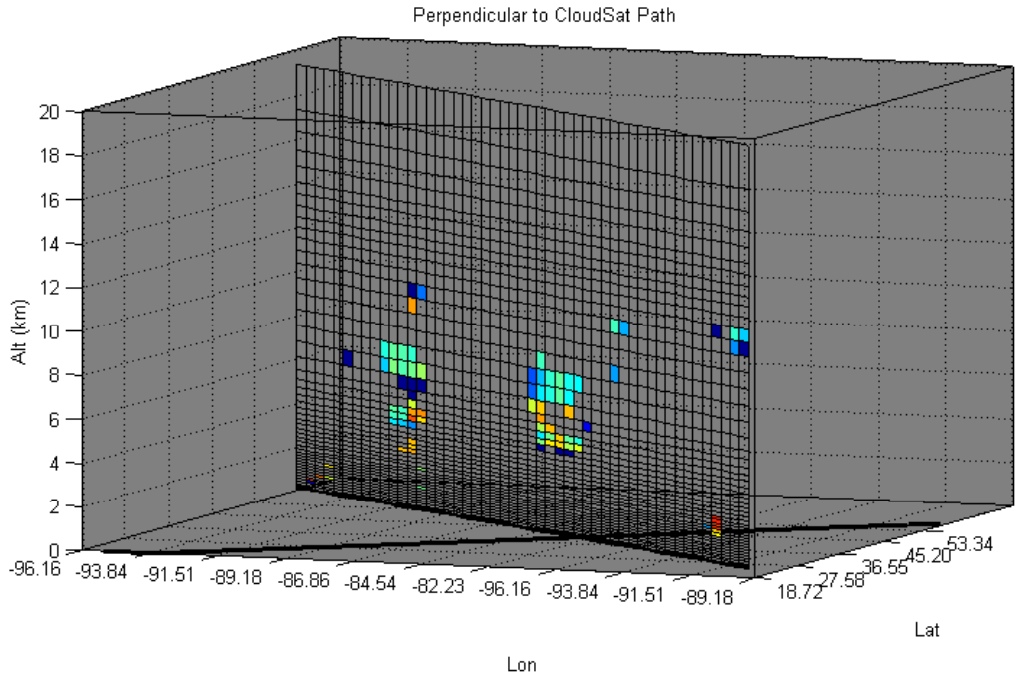
Object-based Comparison: Parallel to Track (Eastward)



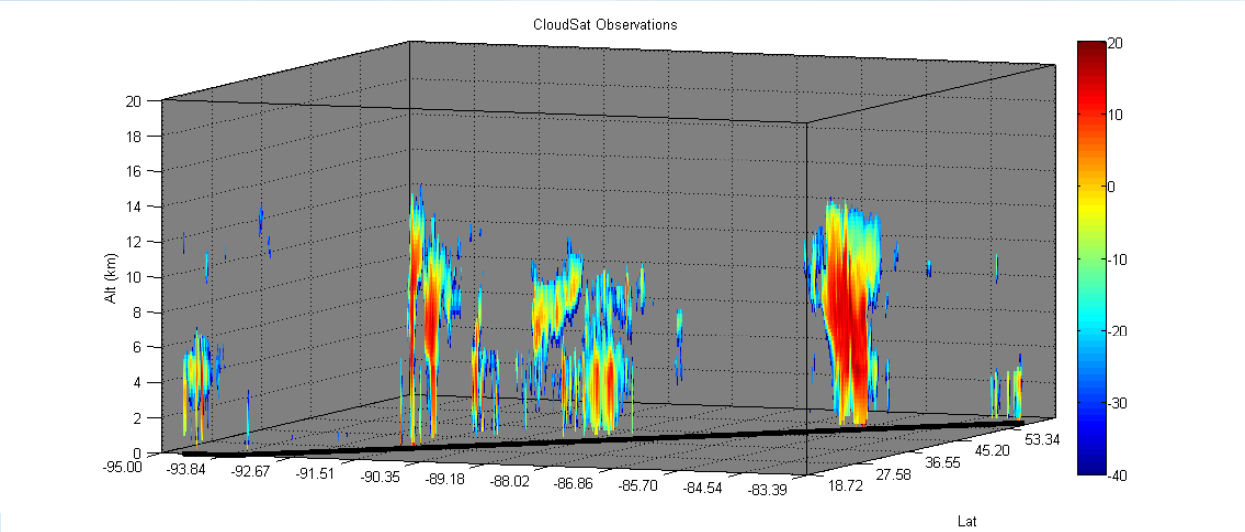
Object-based Comparison: Cross Track

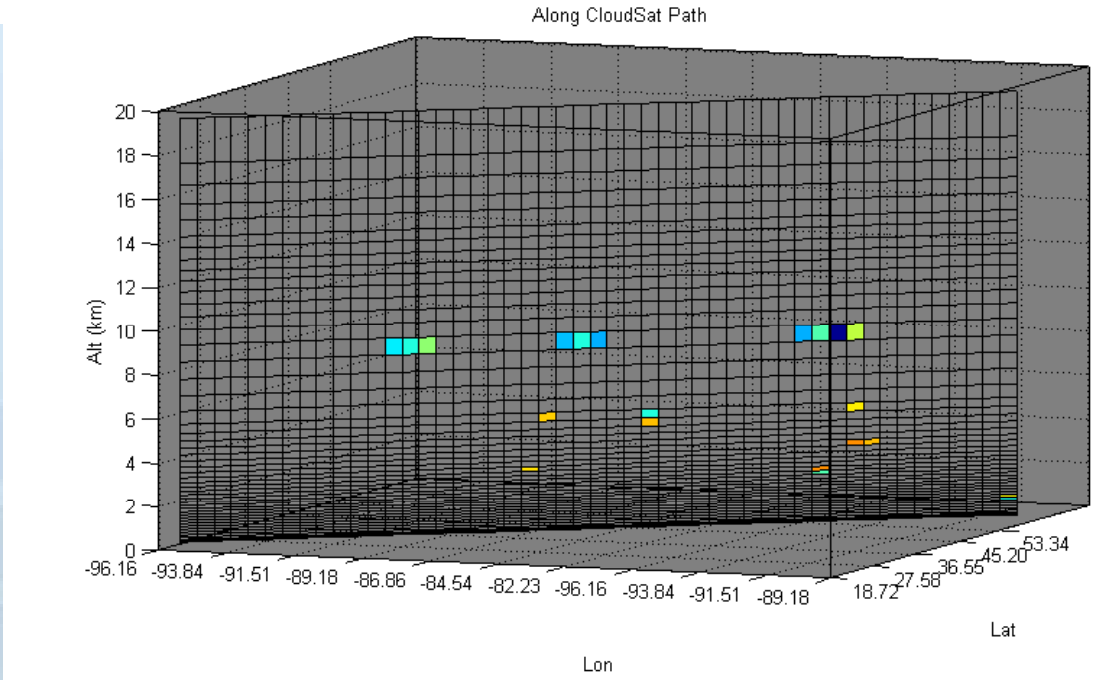




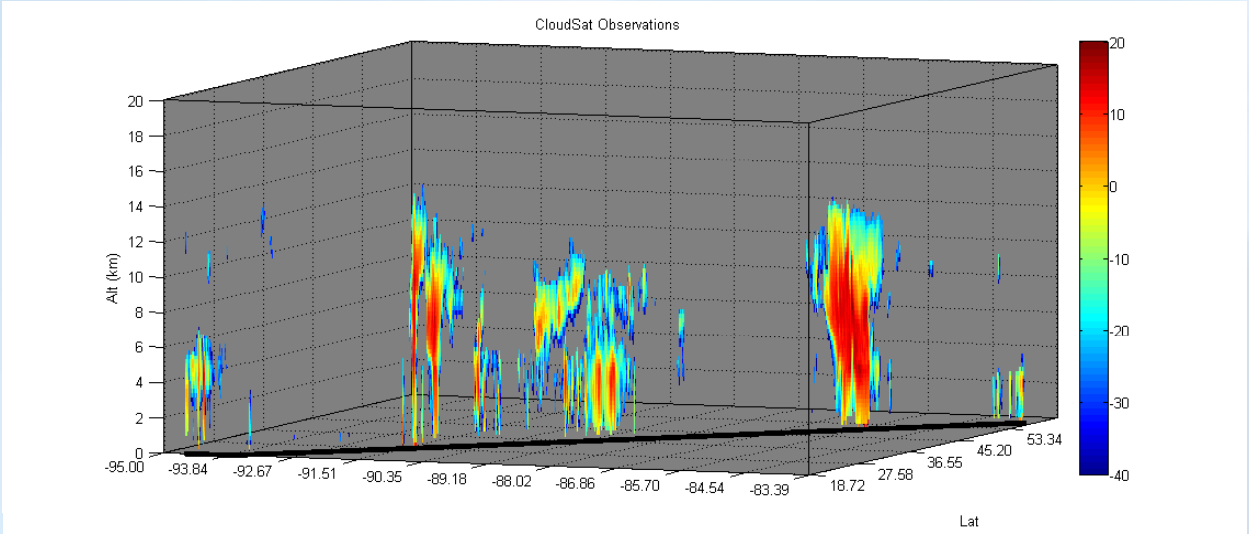


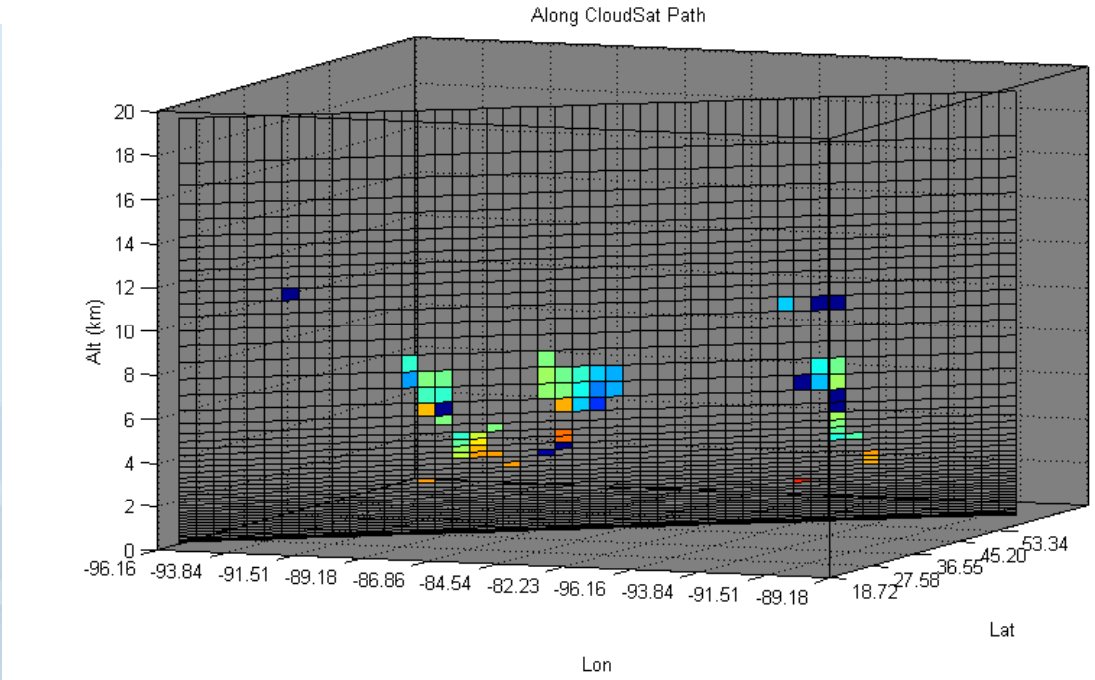
Object-based Comparison: -1 hour (0700 UTC)





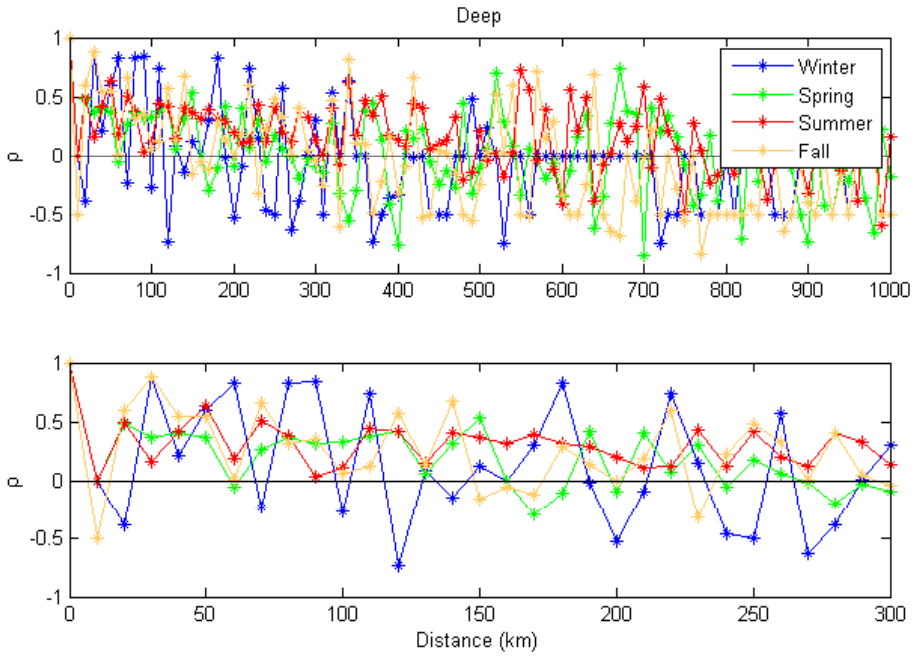
Object-based Comparison: +1 hour (0900 UTC)

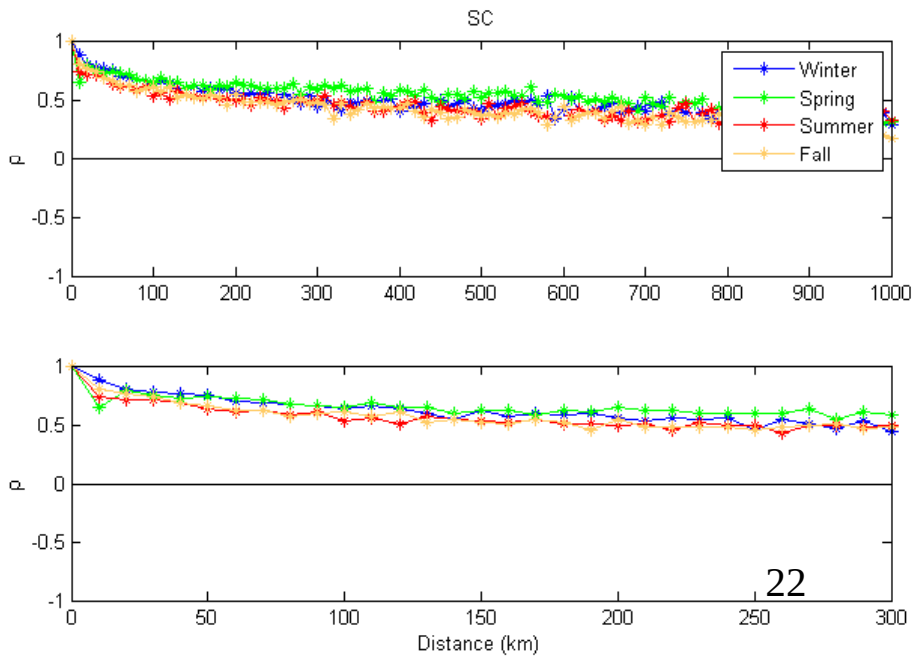




Spatial/Seasonal Comparison

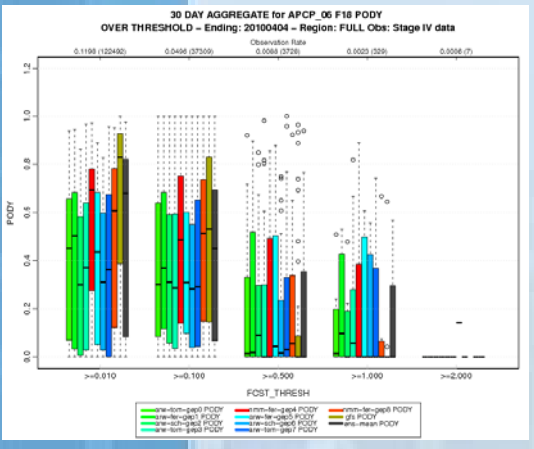
- Spatial Correlation along track for different CloudSat cloud types and for different seasons
- Combine with other datasets (e.g., MODIS) to better understand spatial variability off track

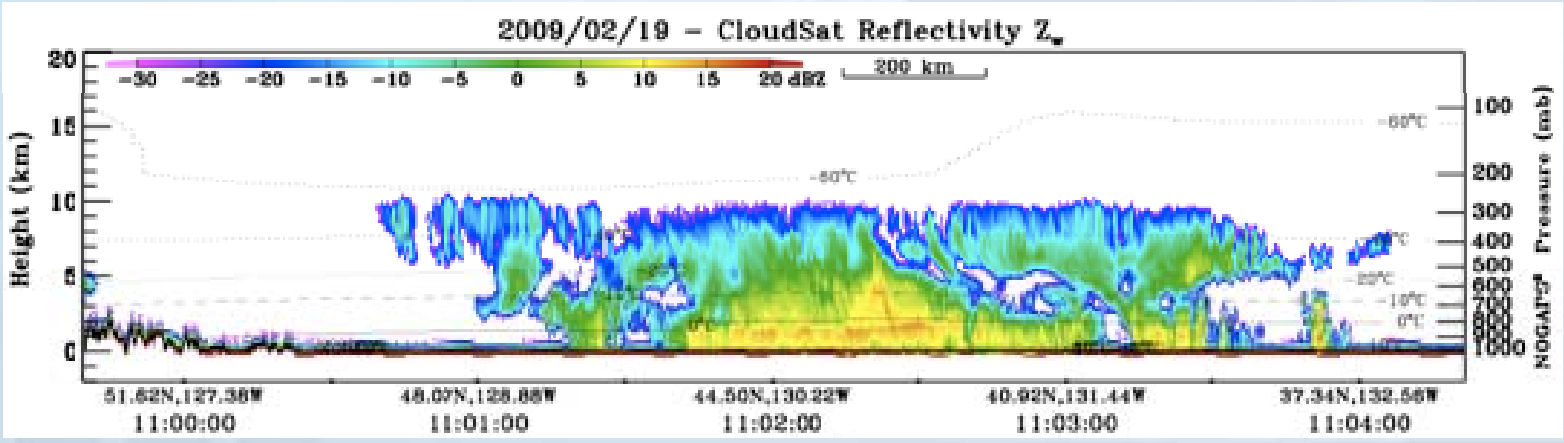




Future Work

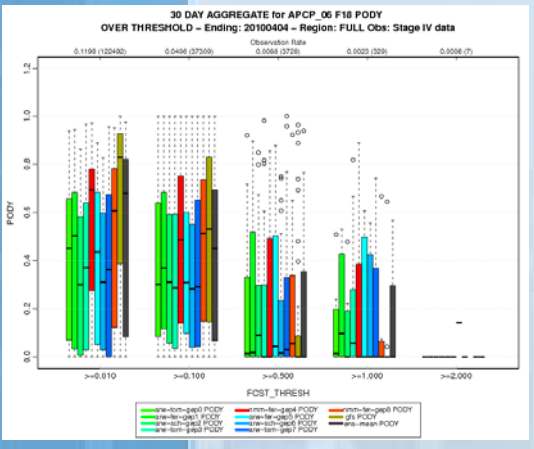
- Future updates to MET will include:
  - Finish implementing read and remap tools for A-Train products into MET
  - Add object-based verification in the vertical plane to MODE
  - Add methods for verifying through in time
  - Improve methods for verifying cloud and precipitation properties
- Implement METViewer Database and Display system

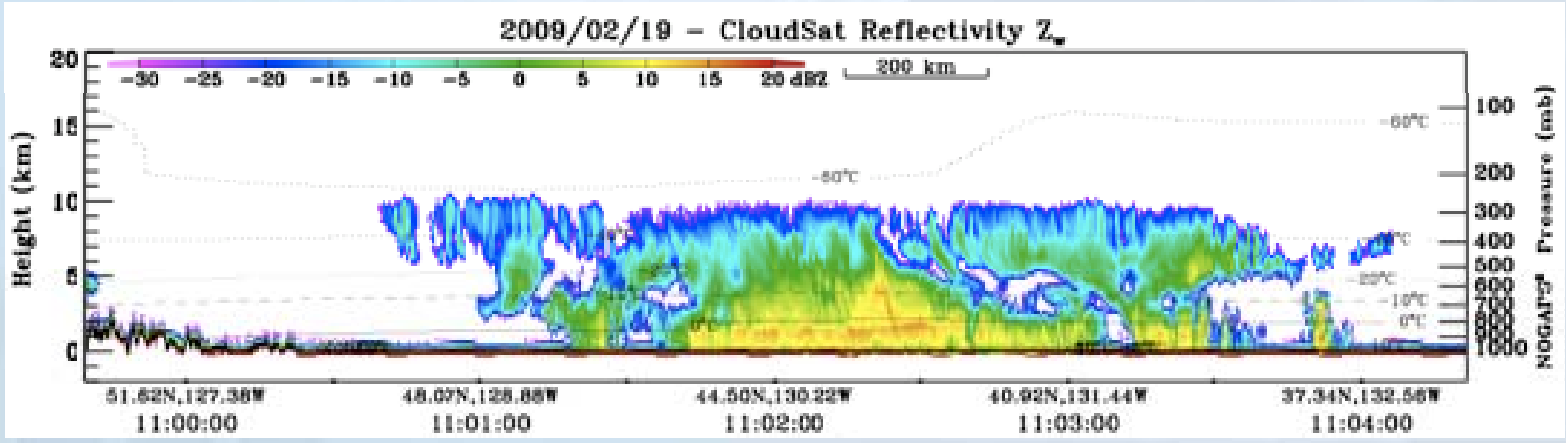




Future Work

- A-train comparisons
  - Reflectivity profiles, cloud top height, cloud base, precipitation, cloud type, cloud phase, etc.
- Currently developing a database of case studies for comparison
  - Tropical storms, multilayer clouds, complex terrain
- The tool is easily extended to other satellite datasets such HRPP, TRMM, GPM, etc.

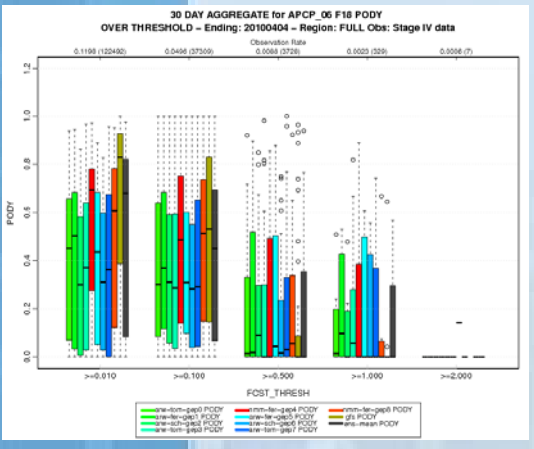


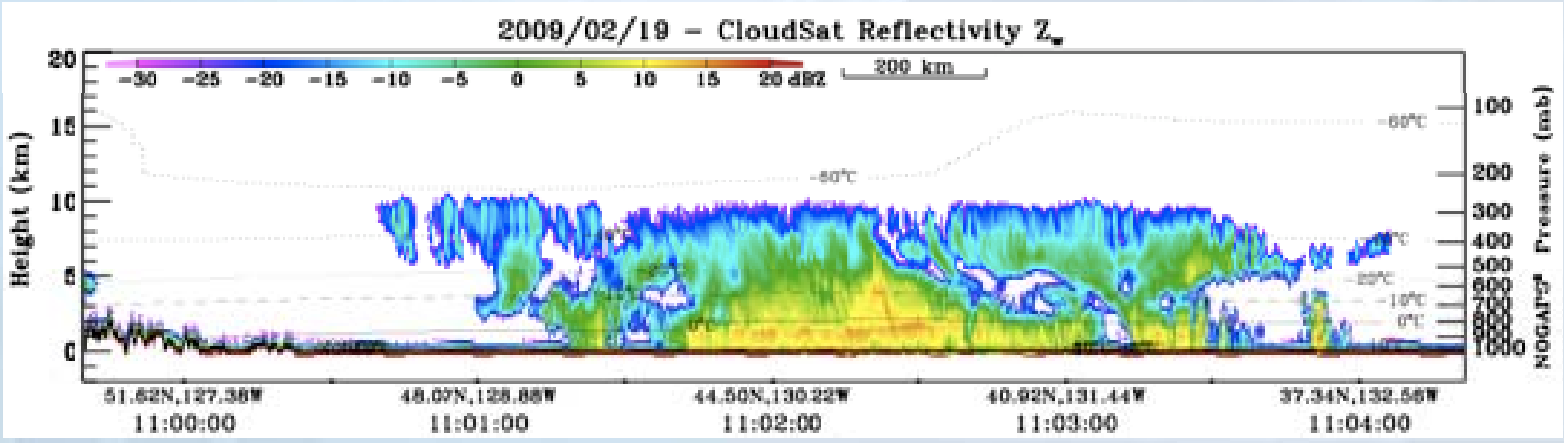


Acknowledgments

- The study is supported by NASA Project: NNX09AN79G

- We used Quickbeam developed at CSU for some of the initial analysis:
  - Haynes, J.M., R.T. Marchand, Z. Luo, A. Bodas-Salcedo, and G.L. Stephens, 2007: A multi-purpose radar simulation package: QuickBeam. Bull. Amer. Meteor. Soc., 88, 1723-1727.





Thank You