Research Initiatives in ARMP

Stewart G. Cober

Cloud Physics and Severe Weather Research Division

Meteorological Service of Canada
Service météorologique du Canada

Outline

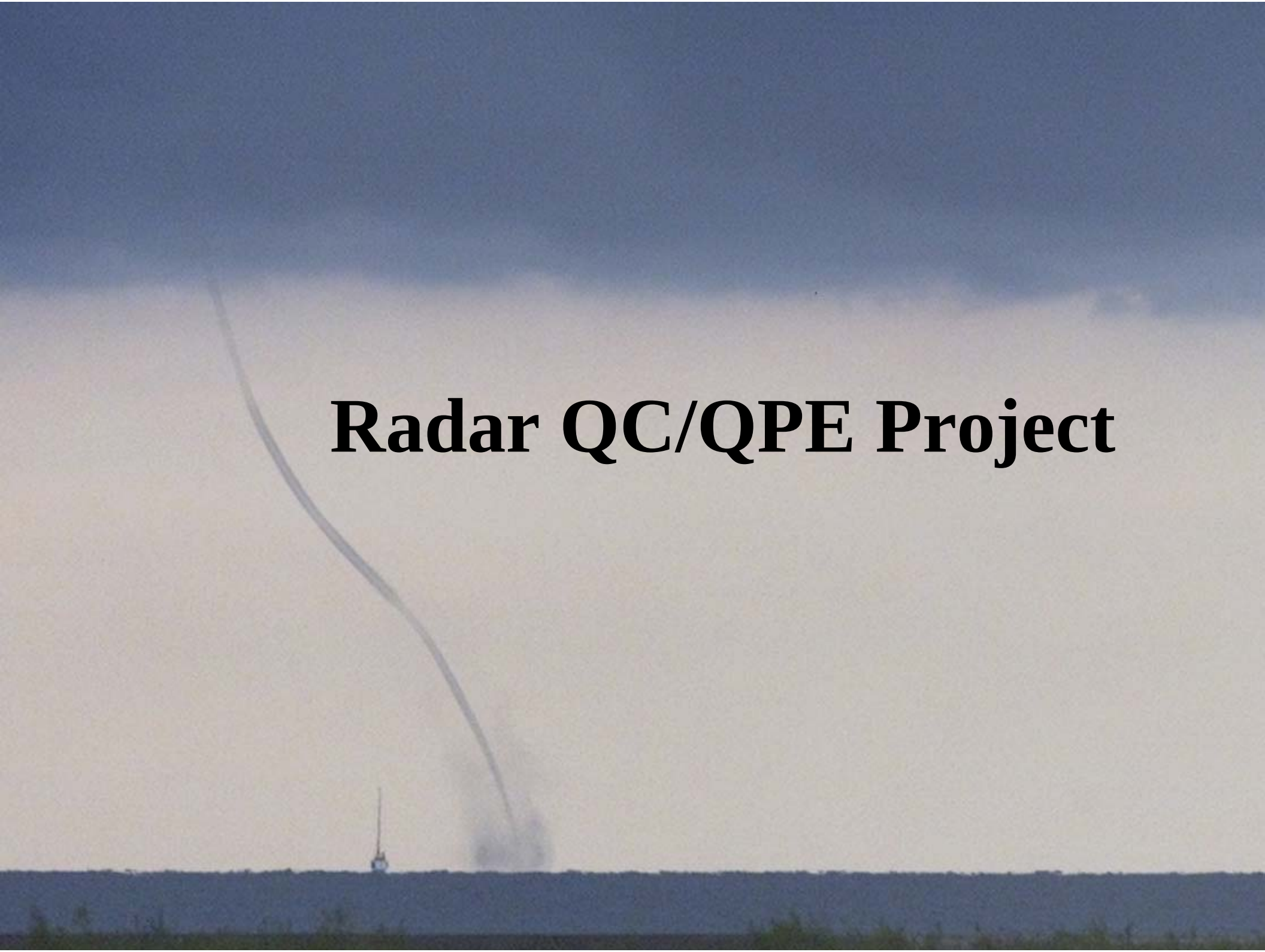
- Strategic Research Themes
- Radar QC/QPE Project
- CloudSat and GPM Projects
- Cloud Parameterizations
- OR National Lab
- Aviation National Lab
- Workstation Project
- Nowcasting Projects


Strategic Research Themes

ARMP Strategic Research Themes

The Division has six long term research themes:

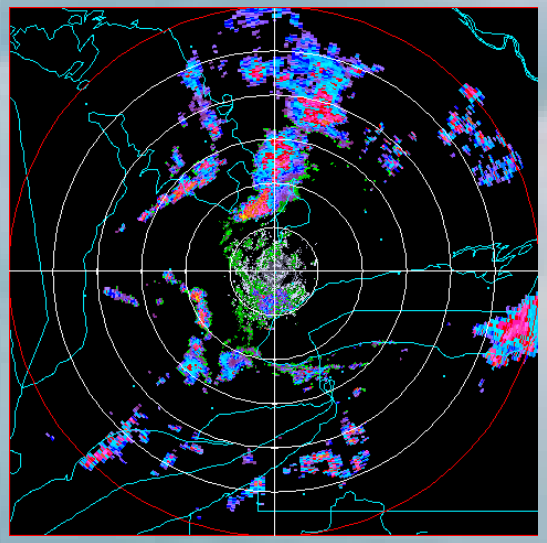
- Radar Applications (Doppler, Polarization, etc.)
- Satellite Applications (CloudSat, GPM, GOES, etc.)
- Cloud Processes (Radiation, Precipitation, Physics)
- Severe Weather Processes (National Labs)
- Aviation Meteorology (National lab)
- Airborne Program (In-situ, Remote, for ACSD)

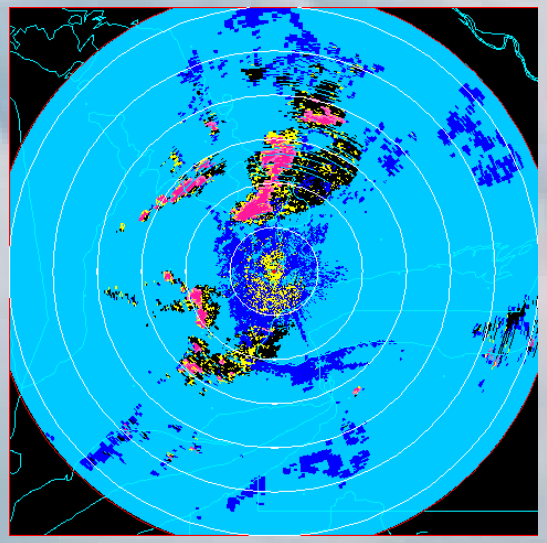


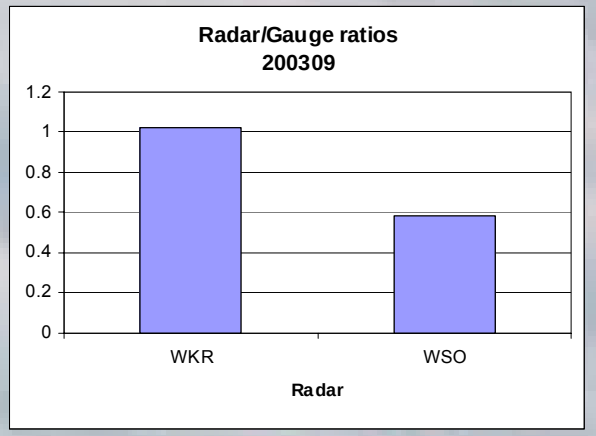
Radar QC/QPE Project

URP QC/QPE Project (2005-2007)

- Version 3.0 of URP is QPE
- Objective is to attempt a coherent integration of the proven QPE techniques we know how to implement now.
- Will bring MSC into line with other met services, but there will remain a considerable amount of work to further improve QPE.
- Innovation in the design of a system that can produce and carry forth error estimates.
- Must have correct Engineering (calibration, pointing), Target Identification (ground clutter, birds, precip), and Artifact Identification (attenuation, bright band)





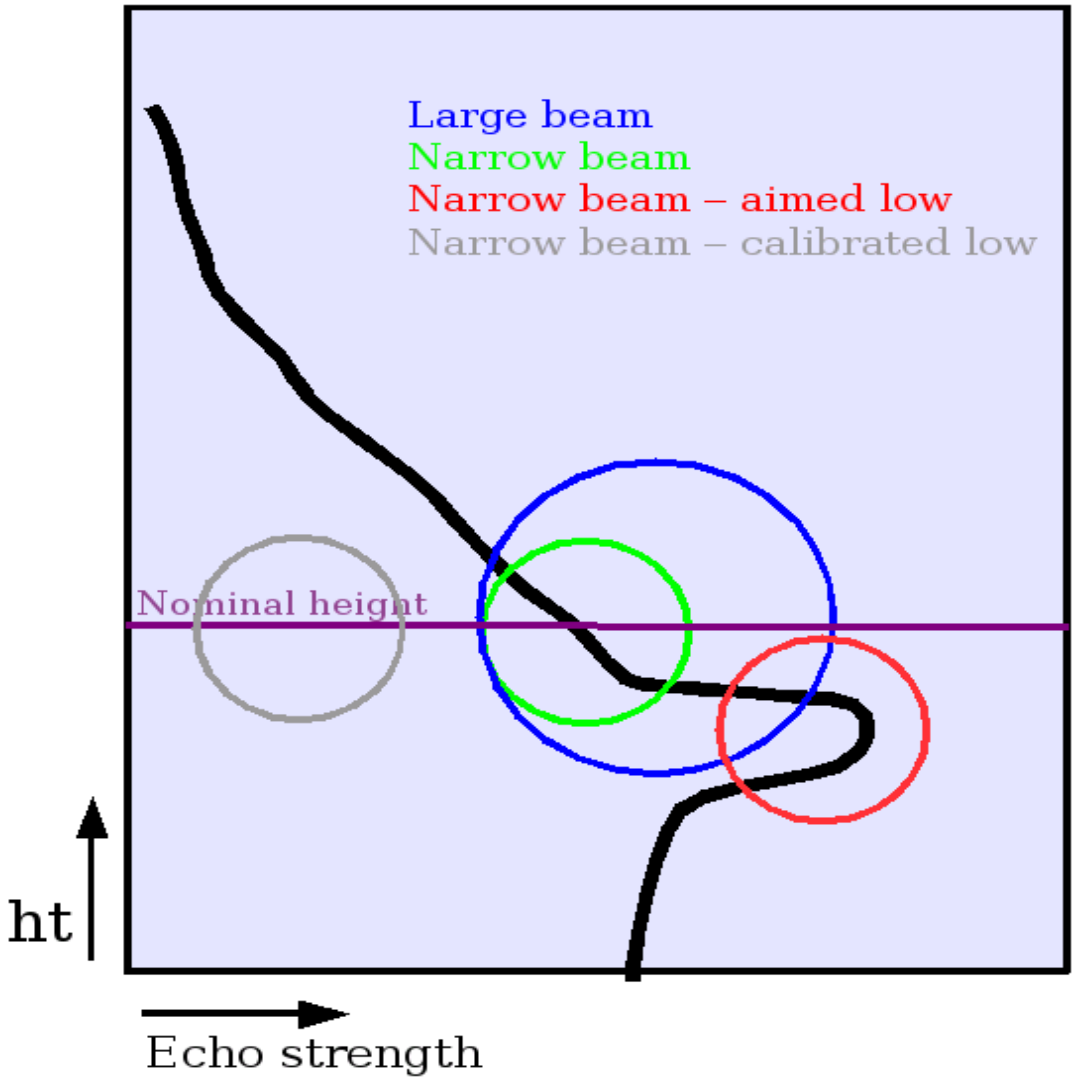


Radar Errors

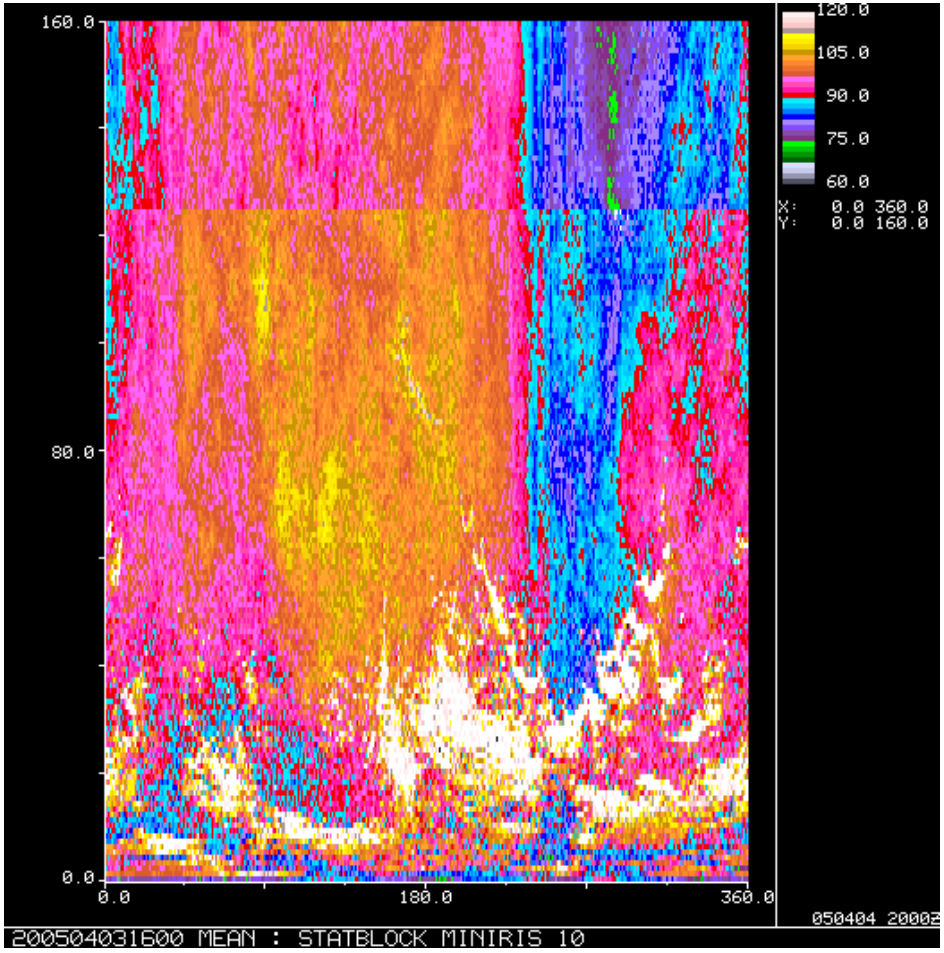
Two radars could report values that differ for both legitimate and erroneous reasons.

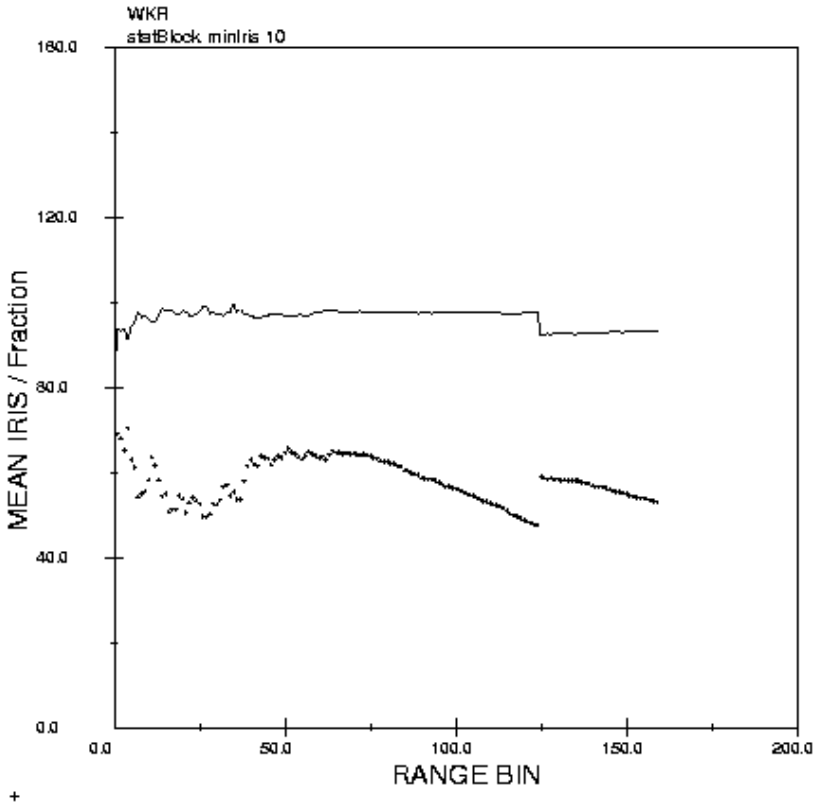
Beams of different sizes result in different values being reported, neither of which is the point value along the beam axis. (Green/blue)

Errors include pointing errors (red) and calibration differences (grey).

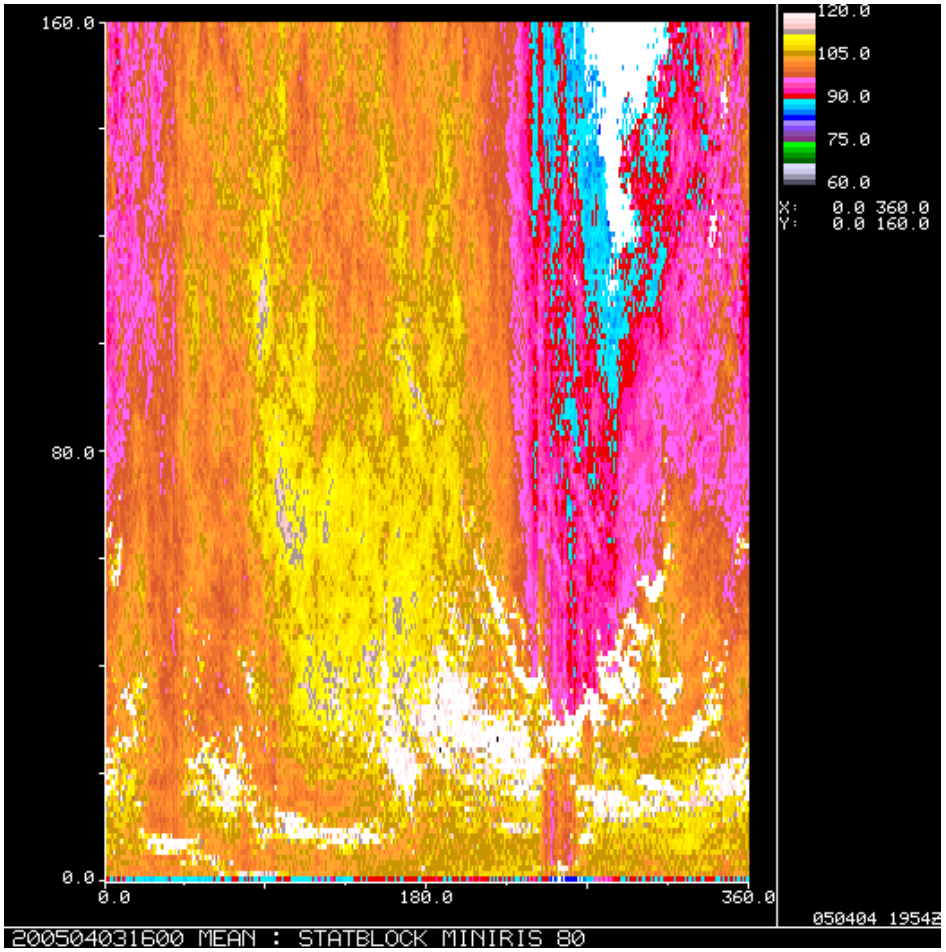


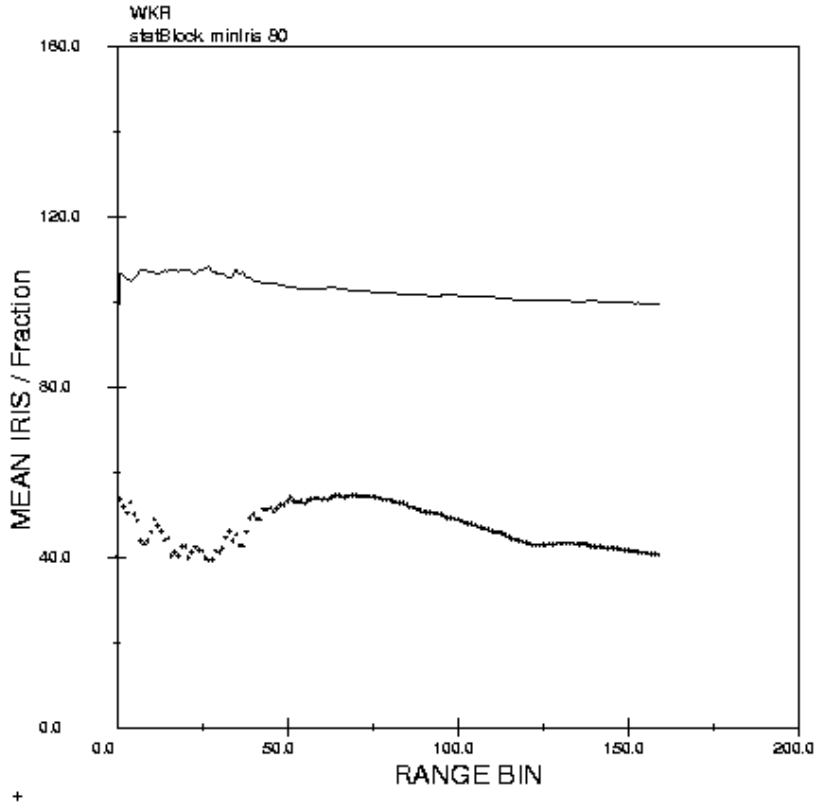
Correcting Radar Bias Errors (1)



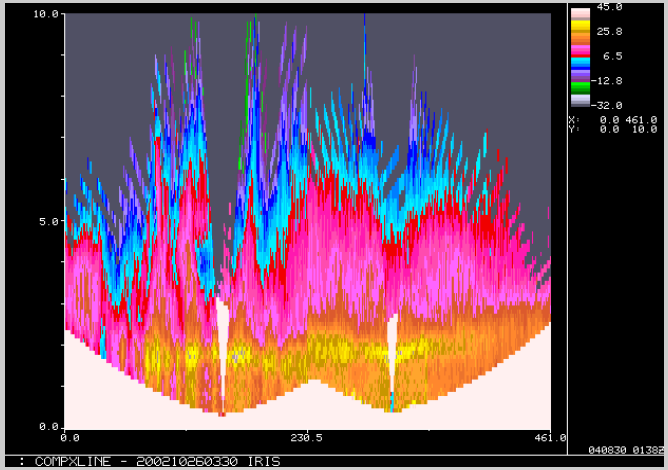


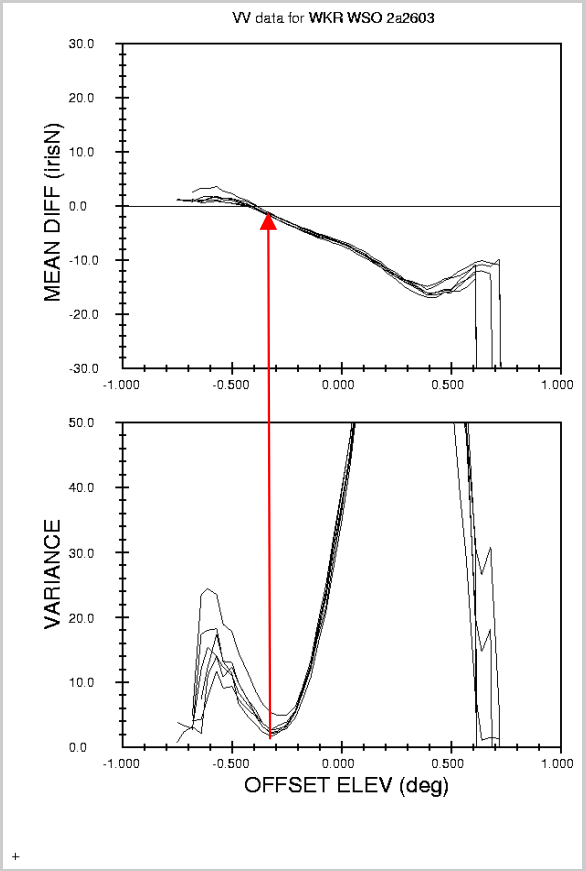
Correcting Radar Bias Errors (2)

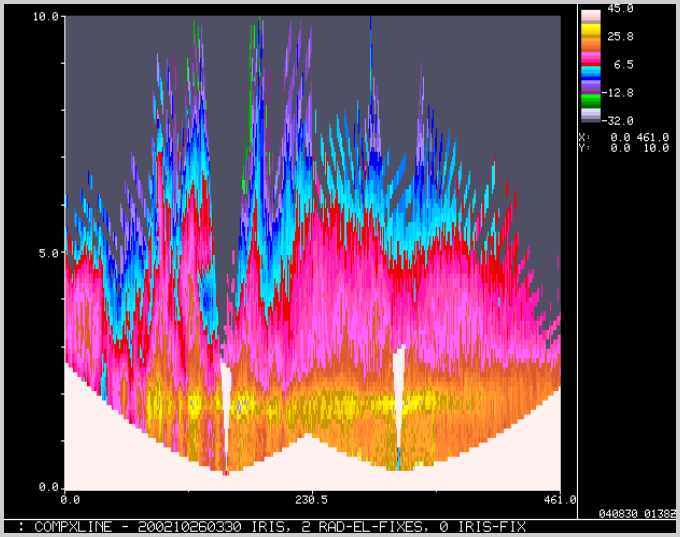


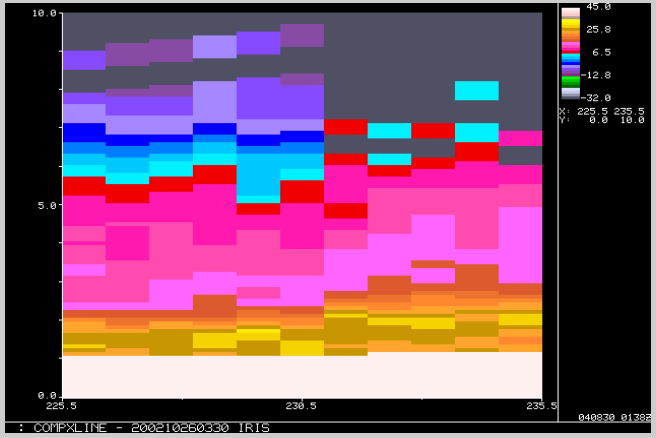


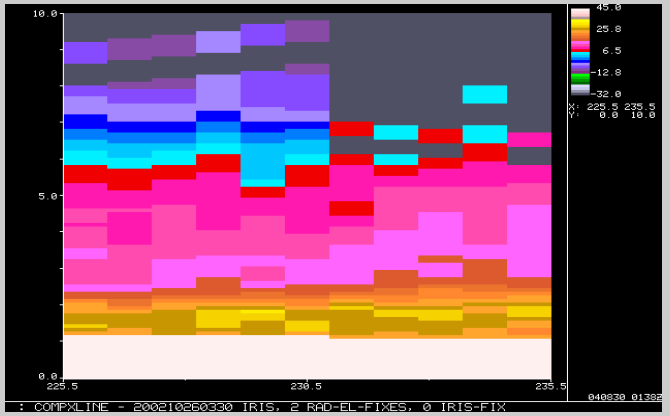
Pointing Errors 26 Oct 2002 0330 UTC



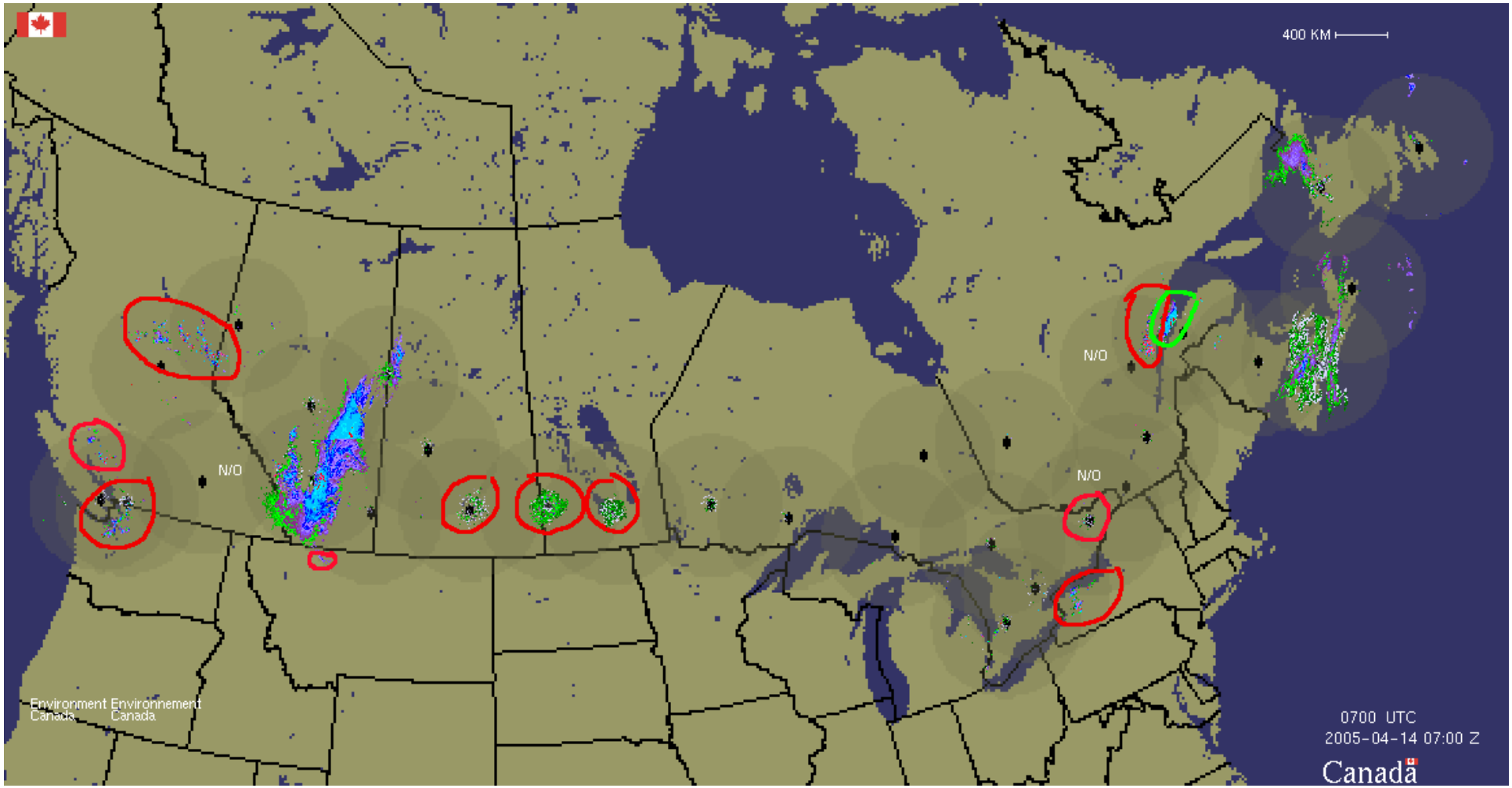




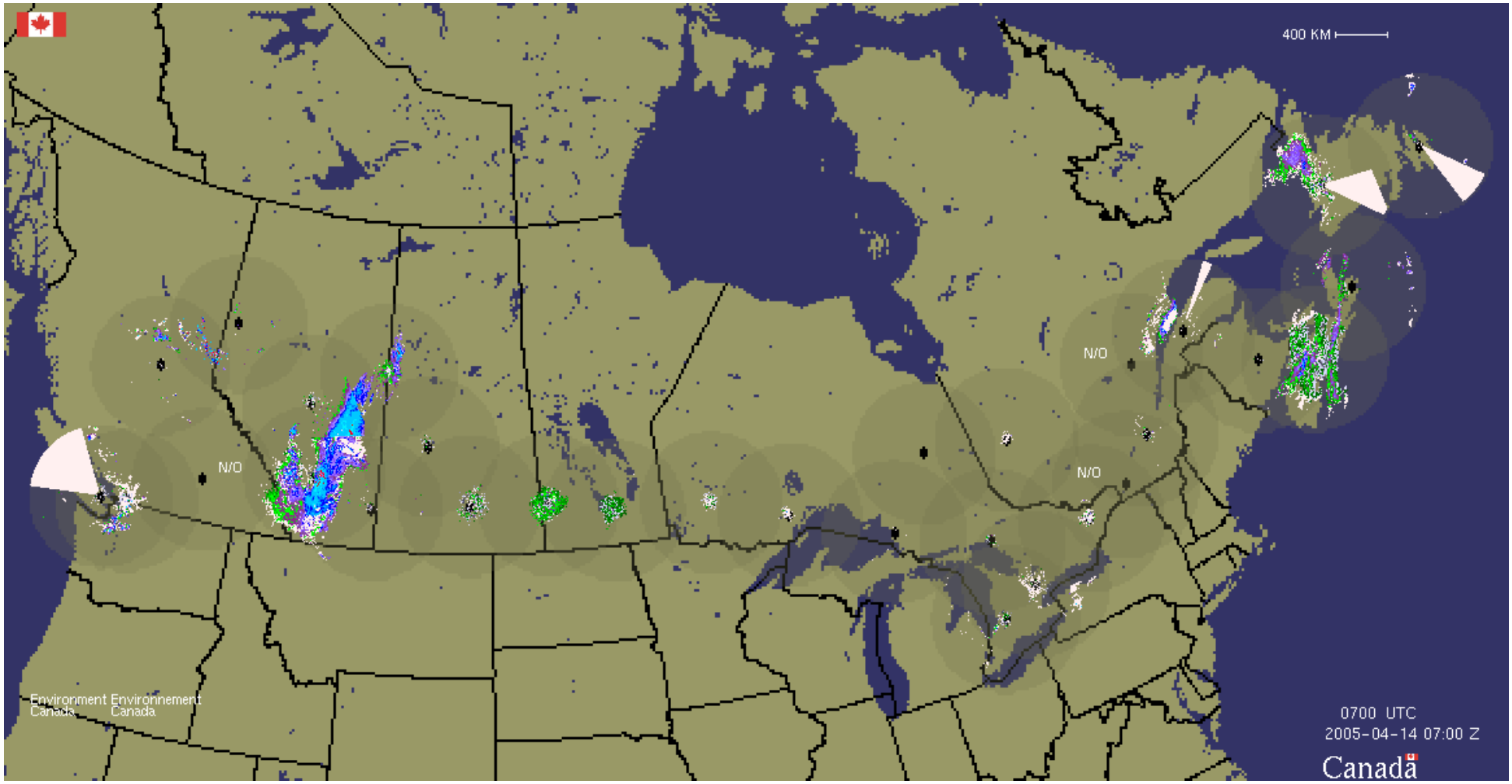




Operational URP Precipitation Module

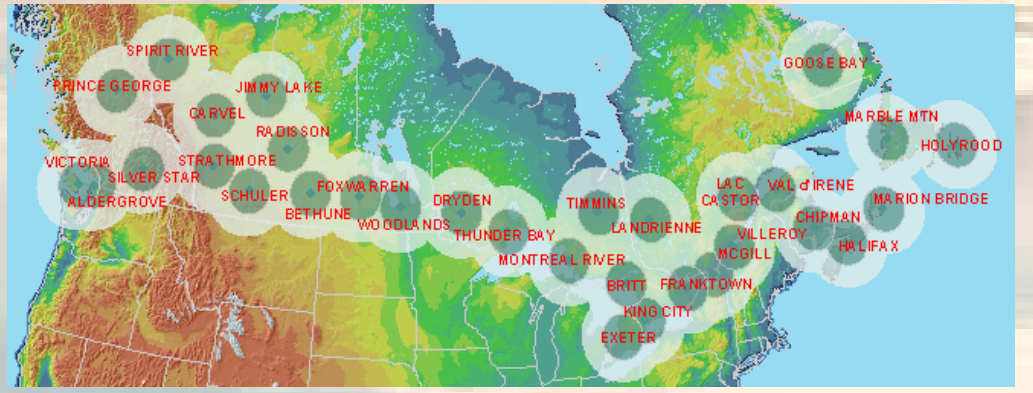


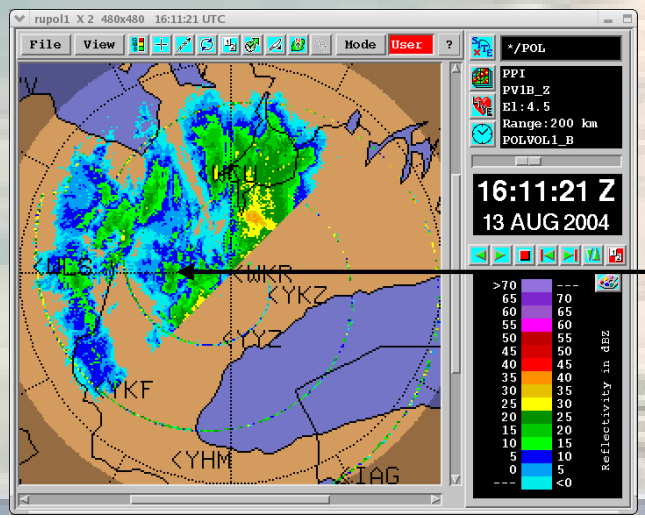
Semi-Operational Precipitation Module



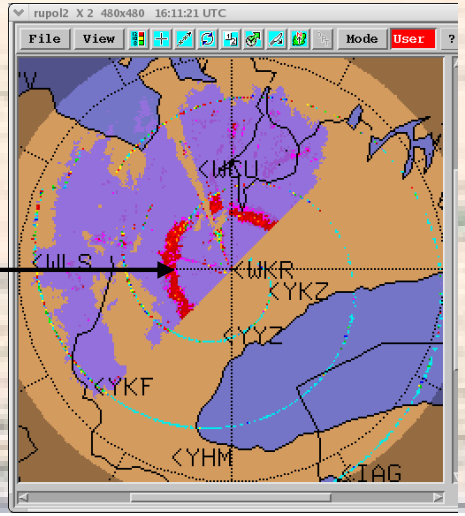
Polarization of King and Radar Applications (2005-2013)

- Polarization of King completed November 2004
- King will join McGill as Canadian Polarized radars
- Application of results will require a comprehensive research and validation effort
- Applications: Artifacts, ground clutter, particle identification, precip rate, phase

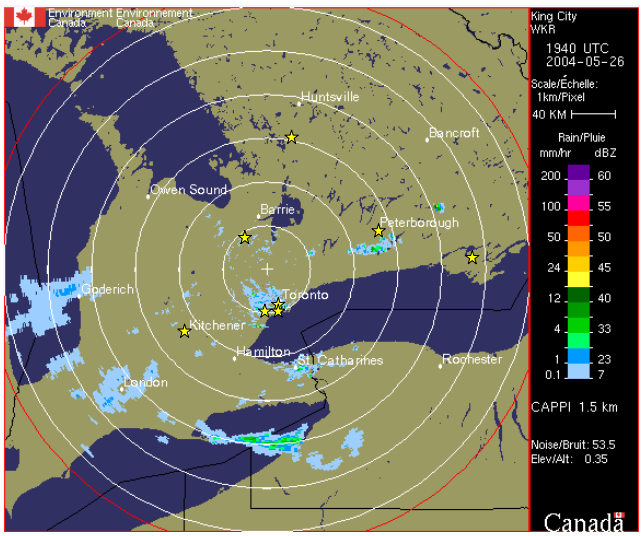


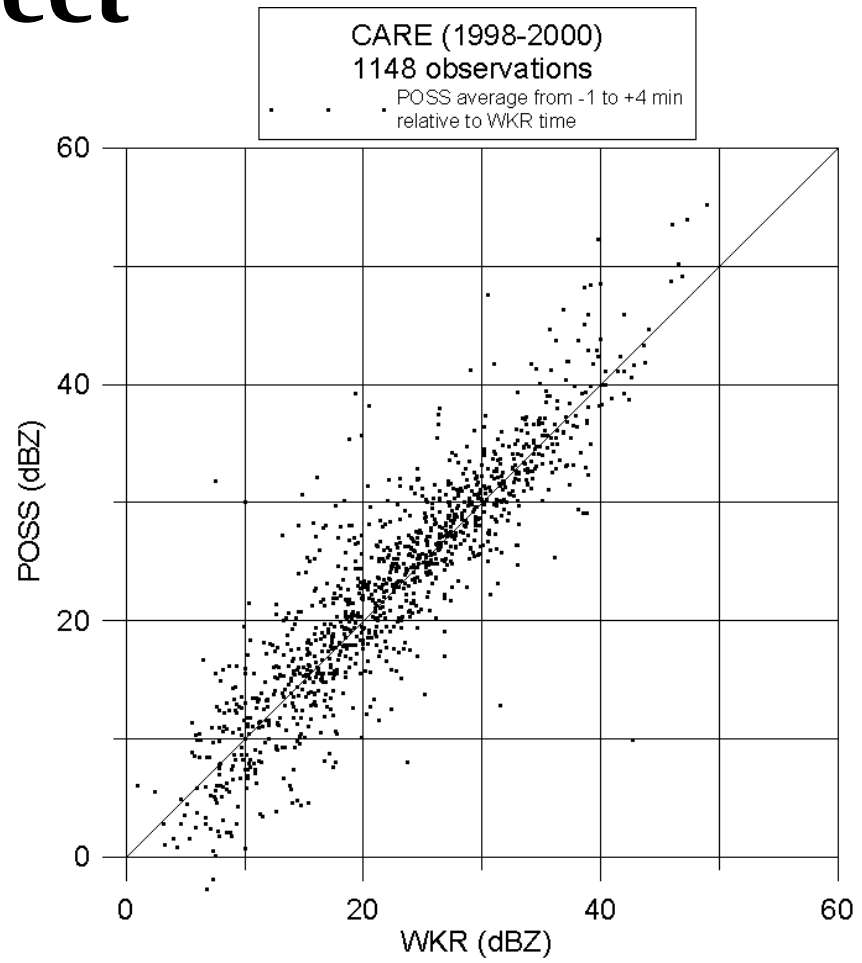


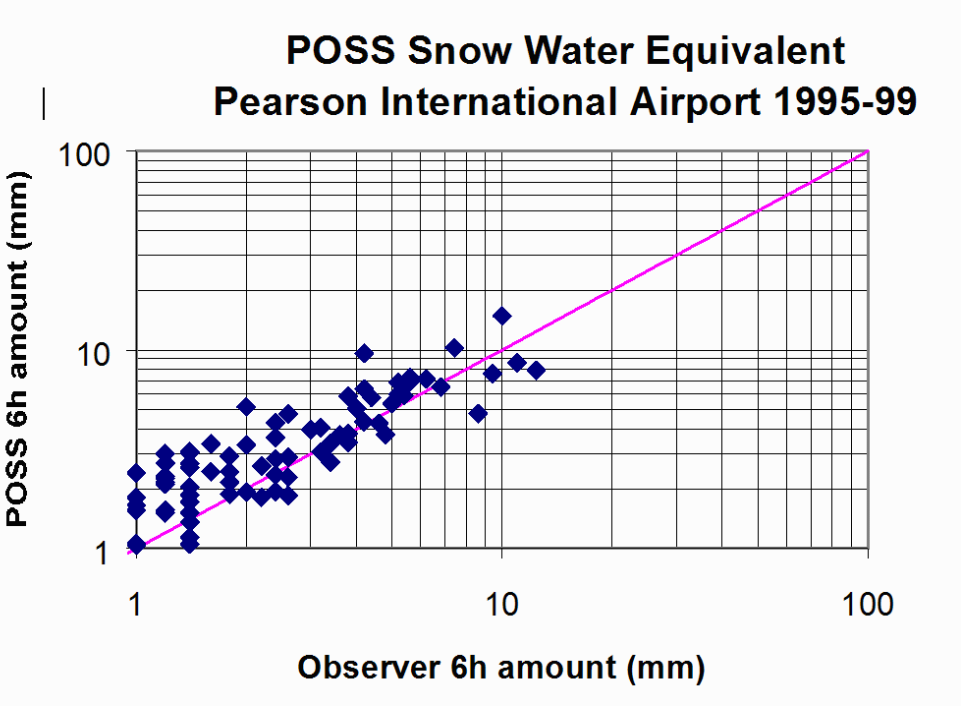
Mixed particle types near 0°C detected by ρ_{hv} but not by Z

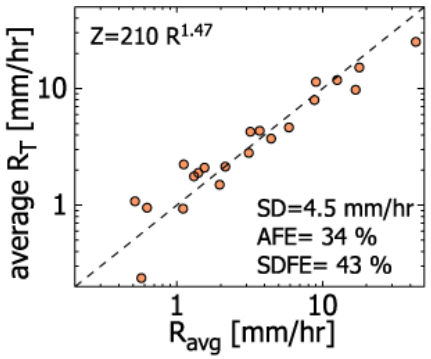


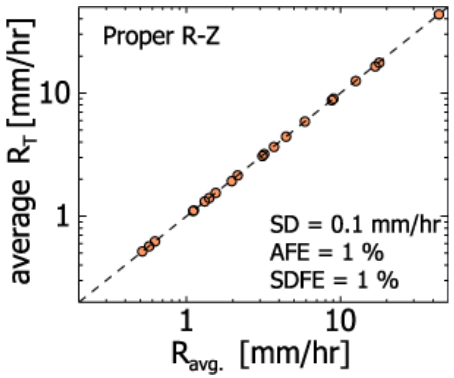
POSS Applications Project









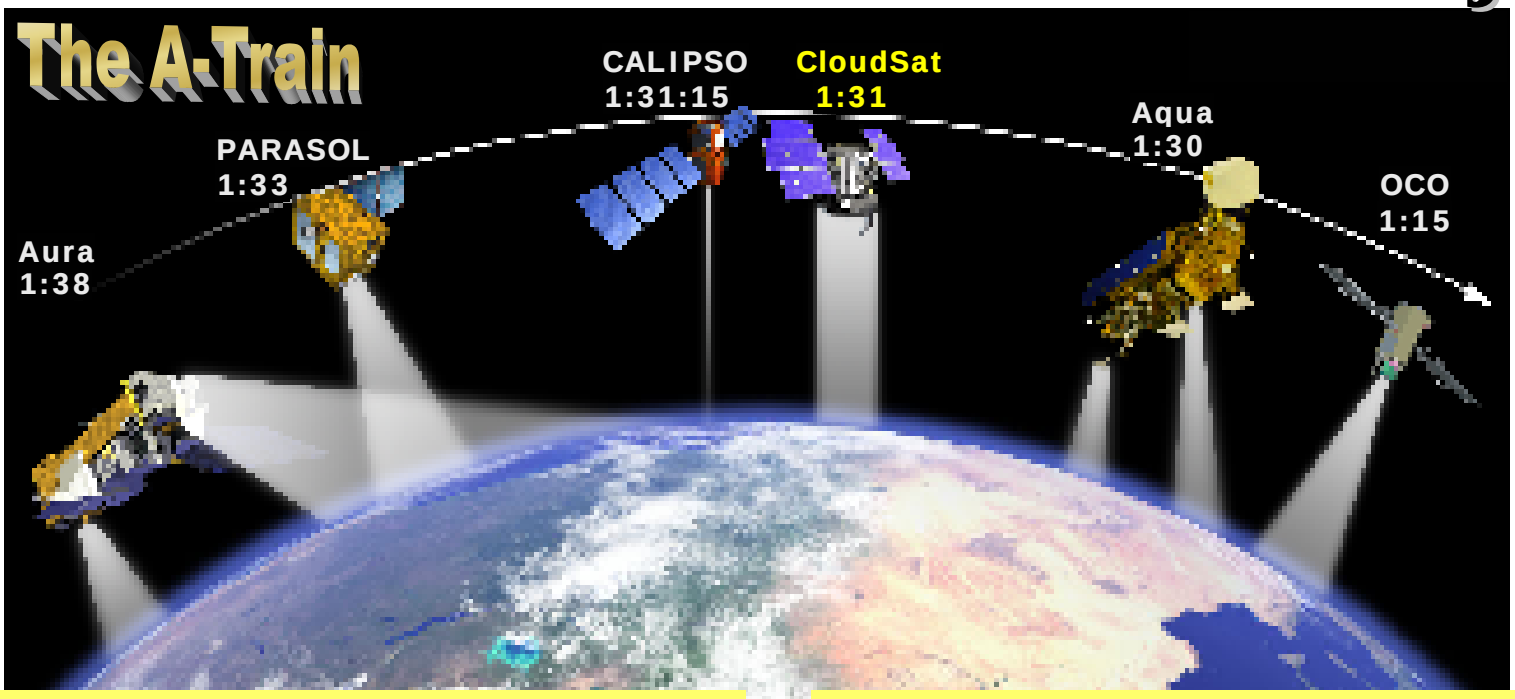


Radar QC/QPE Project Team

- Norman Donaldson (QC/QPE)
- Paul Joe (Radar, NinJo)
- Dave Hudak (Polarization, CloudSat)
- Sudesh Boodoo (QPE support)
- Peter Rodriguez (Polarization support)
- Bob Paterson (QPE/Polarization support)
- Brian Sheppard (POSS applications)
- Jean-Francois Mahfouf (CaPA application)
- Rob Nissen? (PYR)
- Dave Patrick (PNR)
- Paul Ford? (OR)
- Christine Best (NRP)
- Rick Jones (CMC)
- Susan Wild (IT)

CloudSat and GPM Projects

CloudSat/CALIPSO Validation Project



- This proposal will undertake a thorough and careful evaluation of the quality of the CloudSat products as they apply to *Canadian climate*.
- The focus will be stratiform cold season cloud systems and high latitude cloud systems.
- This will complement other studies that are planned in Europe, the U.S., Japan and Australia.
- A joint effort between the three branches of ACSD, several Canadian universities and other US organizations.

- 94 GHz radar with 1.4 km horizontal resolution and 500 m vertical resolution.
- Sun-synchronous orbit at 705 km and inclination of 98.2º.
- Allows nearly simultaneous views of the Earth from distinct instrument payloads.
- Launch Readiness Date July 31, 2005.
- Validation project during 9 Jan 2006 – 24 April 2006.
- Four 12-day IOP periods with 5-7 flights/IOP

Canadian Space Agency | Agence spatiale canadienne

CloudSat Products

Standard Products	Experimental Products
Calibrated Radar Reflectivities	Precipitation type
Cloud Geometric Profile	Rain amount
Cloud Type	Snow amount
Precipitation Occurrence	Cloud phase
Cloud Liquid Water Content	Cloud Microphysics
Cloud Ice Water Content	
Optical Depth	
Fluxes and Heating Rates	

CloudSat Validation Strategy

I. Surface Network Observations
Radar and surface measurements

Independent verification of basic cloud properties and precipitation

II. Enhanced Measurement Sites - CARE, Bratt's Lake and the Arctic sites
Additional remote sensing
Advanced surface measurements

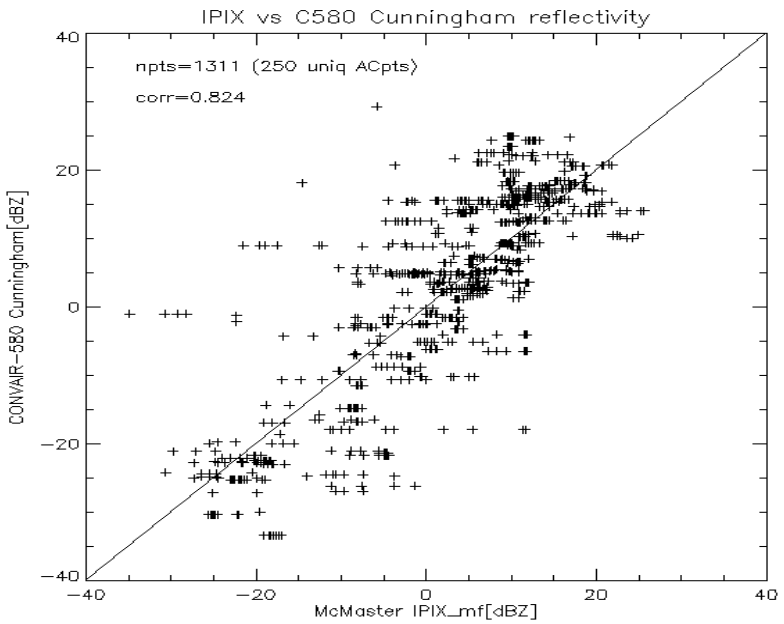
Independent verification of derived cloud properties and validation of assumptions in algorithms

III. Targeted Field Campaigns at CARE
Cloud physics research aircraft
Mobile units

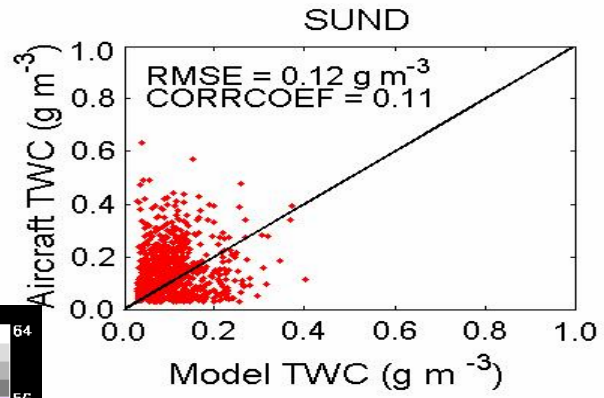
Microphysics/radiation/dynamics process studies for algorithm development

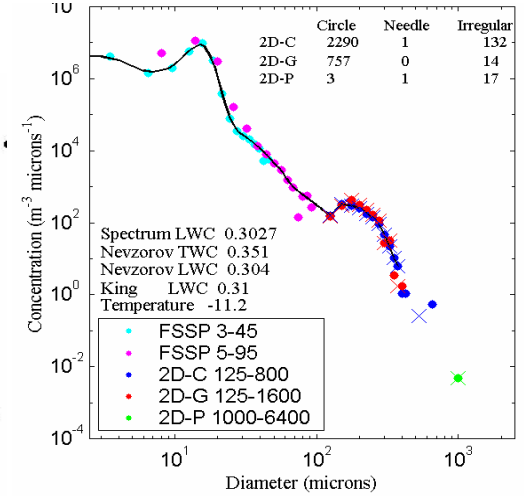
Remote Sensing and Model Validation

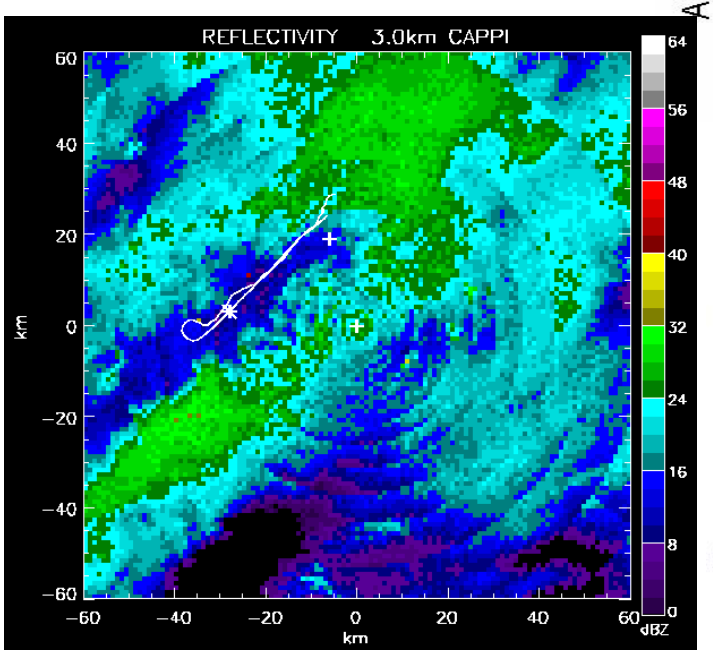
Reflectivity Comparison

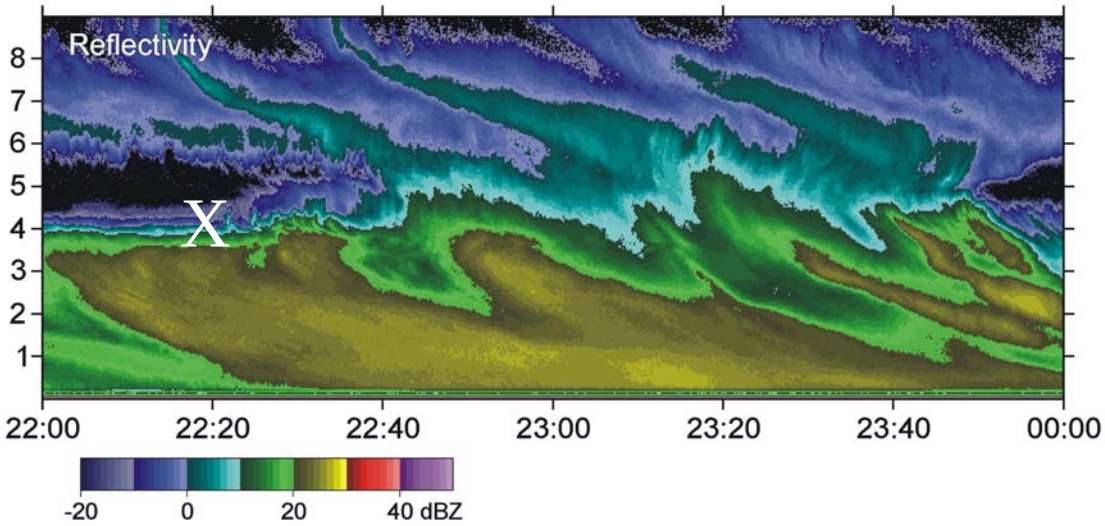


Model TWC Comparison

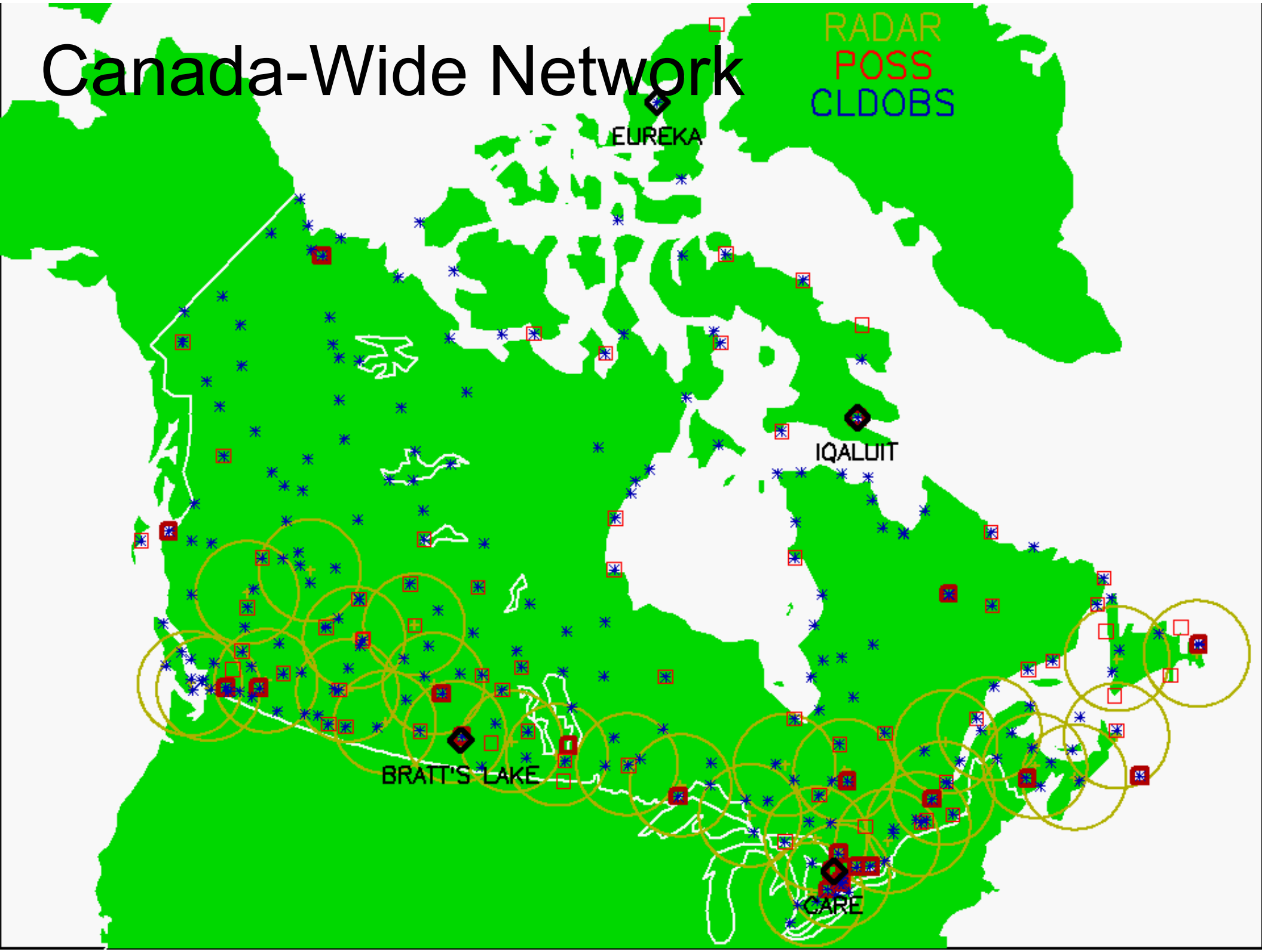




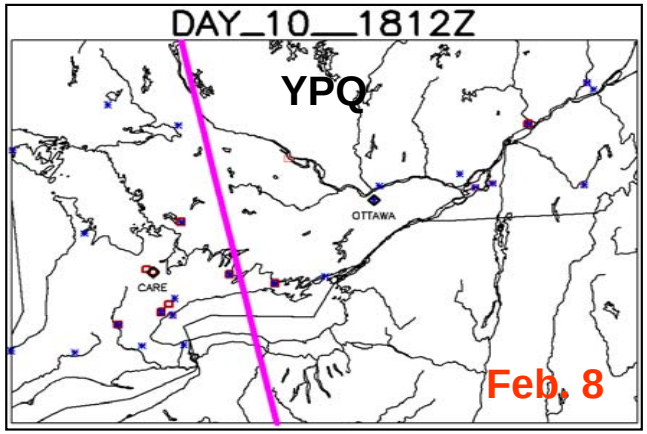


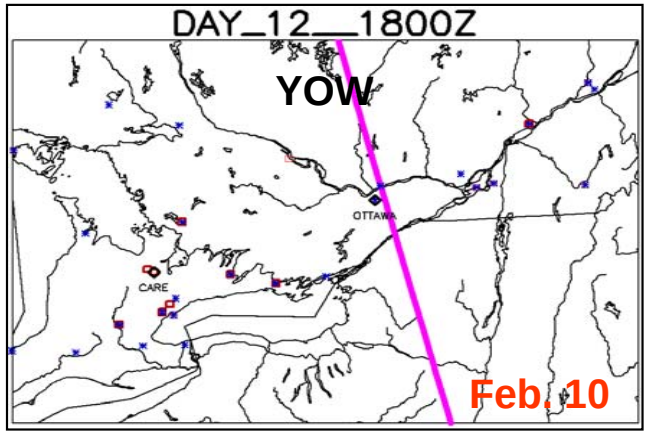


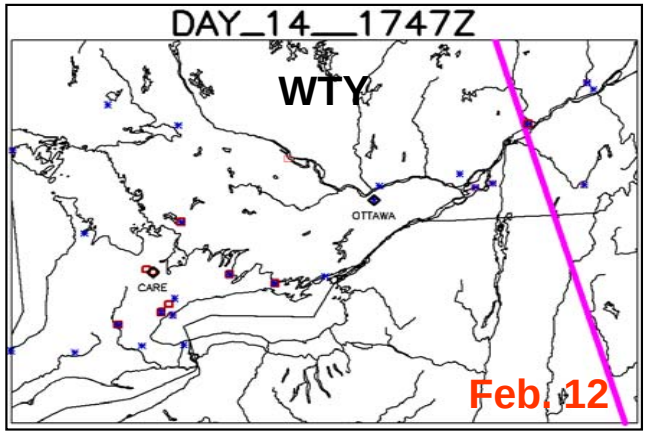
Canada-Wide Network

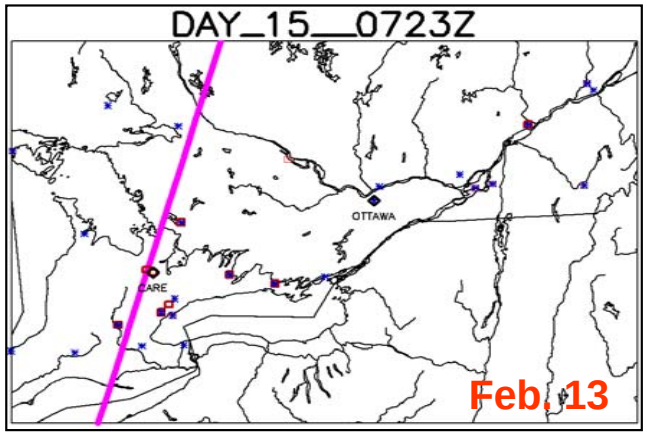


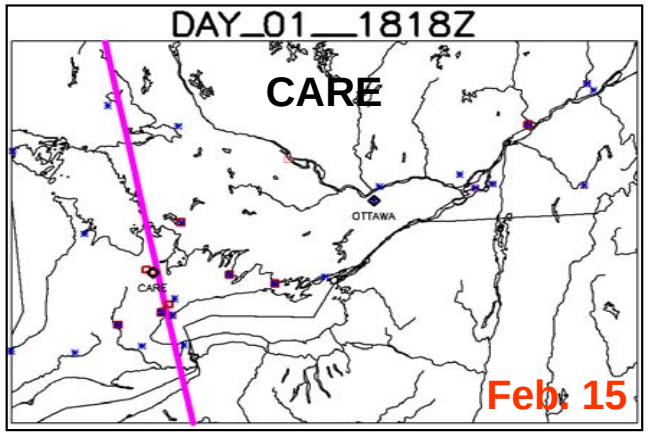
Summary of Potential Orbits during an IOP

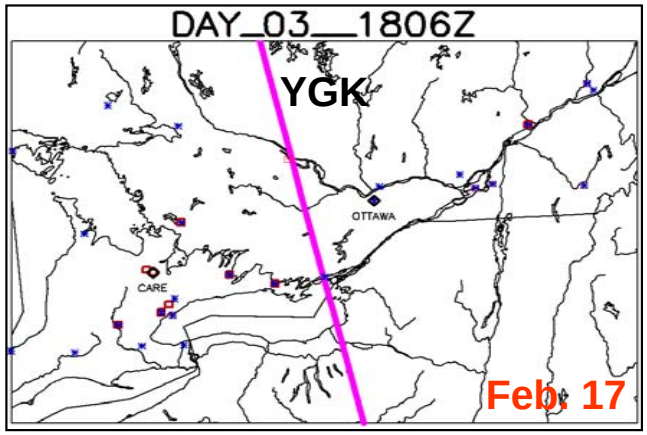


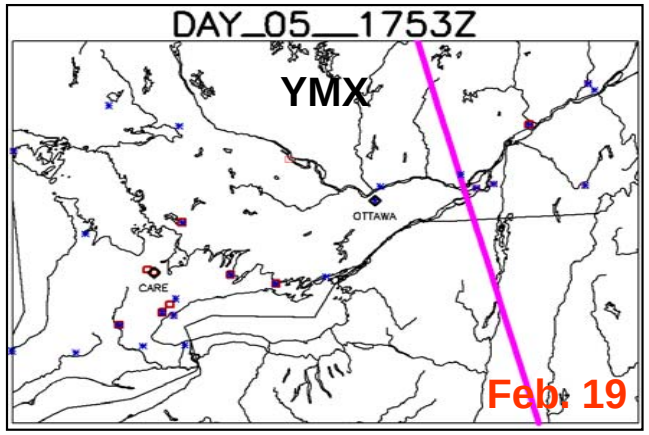












dates are for IOP-2

Canada

GPM Reference Concept

OBJECTIVES

- *Understand horizontal & vertical structure of rainfall, its macro- & micro-physical nature, & its associated latent heating*
- *Train & calibrate retrieval algorithms for constellation radiometers*

Core

Constellation

OBJECTIVES

- *Provide sufficient global sampling to significantly reduce uncertainties in short-term rainfall accumulations*
- *Extend scientific and societal applications*

EGPM

Core Satellite

- *TRMM-like spacecraft (NASA)*
- *H2-A rocket launch (NASDA)*
- *Non-sun-synchronous orbit*
  - *~ 65° inclination*
  - *~400 km altitude*
- *Dual frequency radar (NASDA)*
  - *K-Ka Bands (13.6-35 GHz)*
  - *~ 4 km horizontal resolution*
  - *~250 m vertical resolution*
- *Multifrequency radiometer (NASA)*
  - *10.7, 19, 22, 37, 85, (150/183 ?) GHz V&H*

Constellation Satellites

- *Pre-existing operational-experimental & dedicated satellites with PMW radiometers*
- *Revisit time*
  - *3-hour goal at ~90% of time*
- *Sun-synch & non sun- synch orbits*
  - *600-900 km altitudes*

Precipitation Processing Center

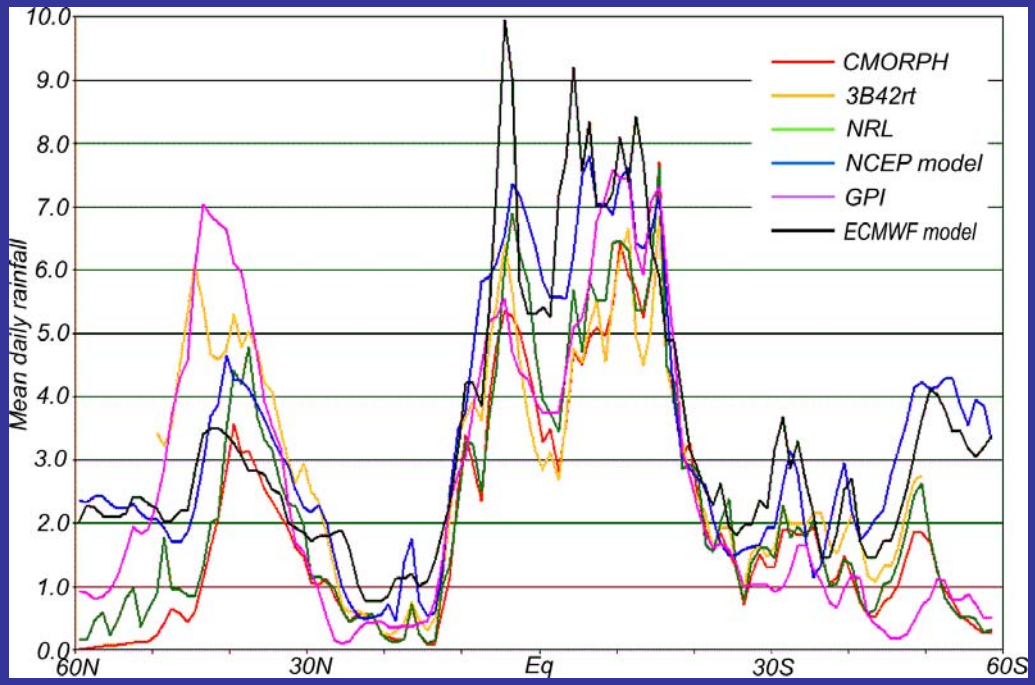
- *Produces global precipitation products*
- *Products defined by GPM partners*

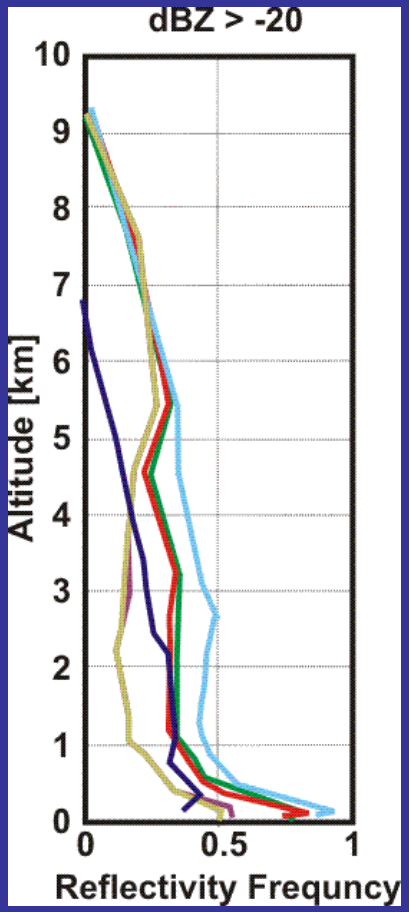
Precipitation Validation Sites for Error Characterization

- *Select/globally distributed ground validation "Supersites" (research quality radar, up looking radiometer-radar-profiler system, raingage-disdrometer network, & T-q soundings)*
- *Dense & frequently reporting regional raingage networks*

Climate

- Large uncertainties in model precipitation estimates
- Large uncertainties in observational precipitation estimates
- No TRMM-like observations in extra-tropics

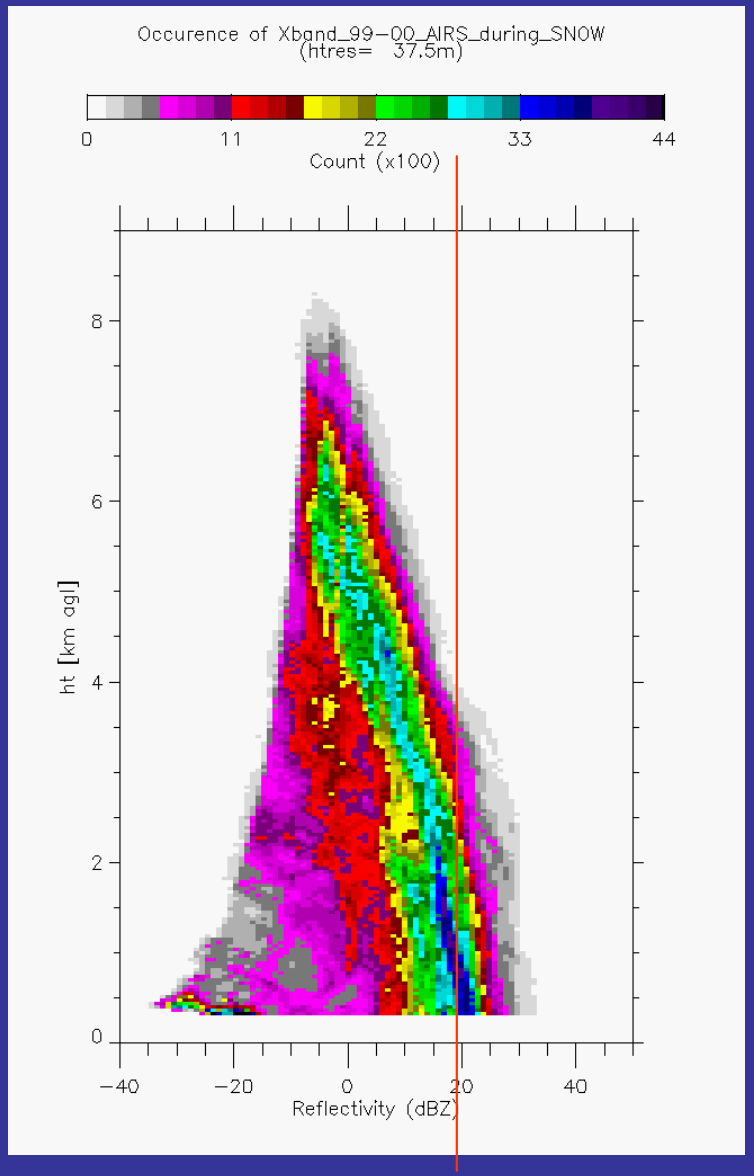




Improved global observations and model physics is needed

Courtesy of Chris Kidd, Birmingham
Zhang/Lohmann, Dalhousie

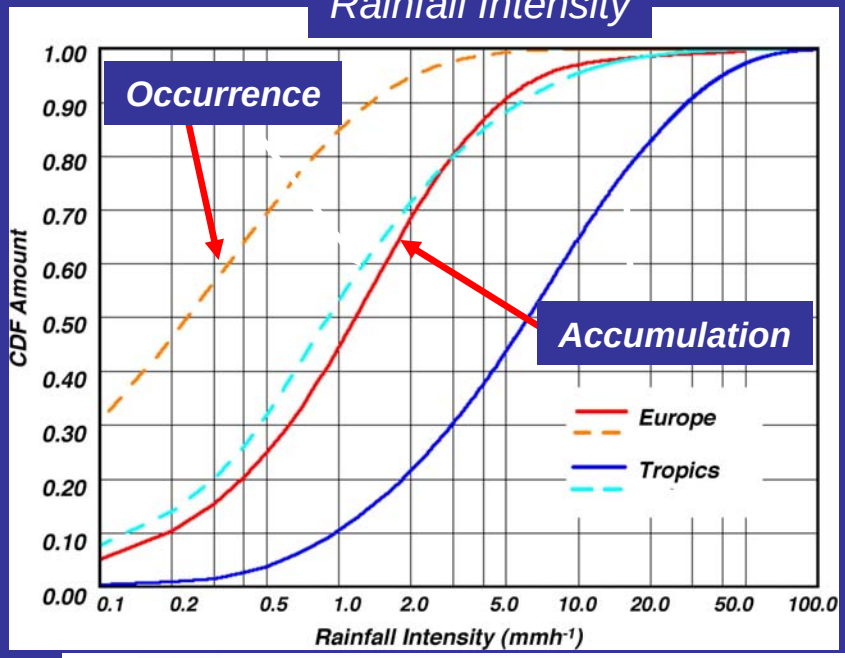
Sensitivity Requirements

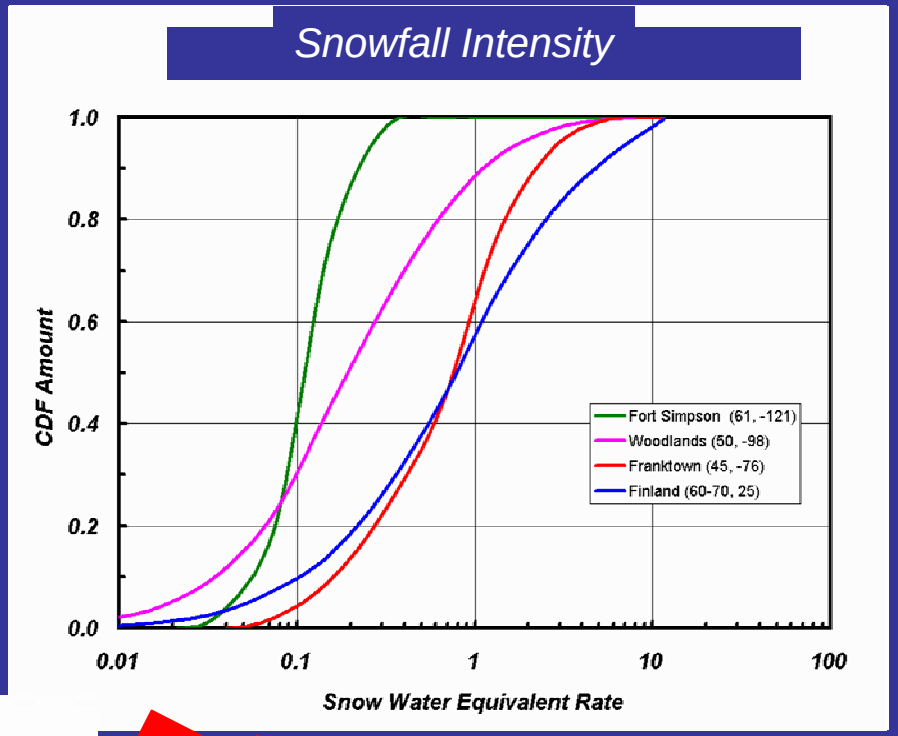


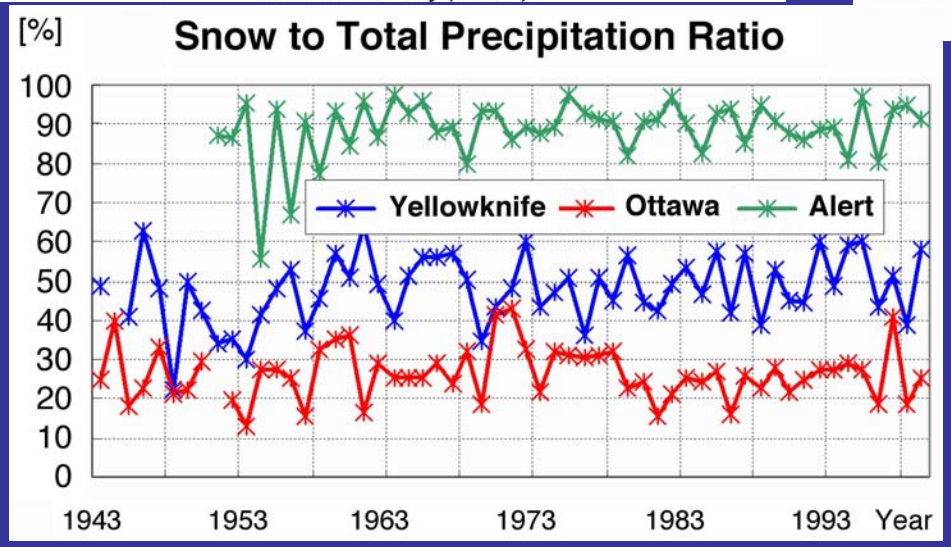
X-Band VPR
Montreal Area

David Hudak MSC
Peter Rodriguez MSC

CDF's of Snowfall and Light Rain

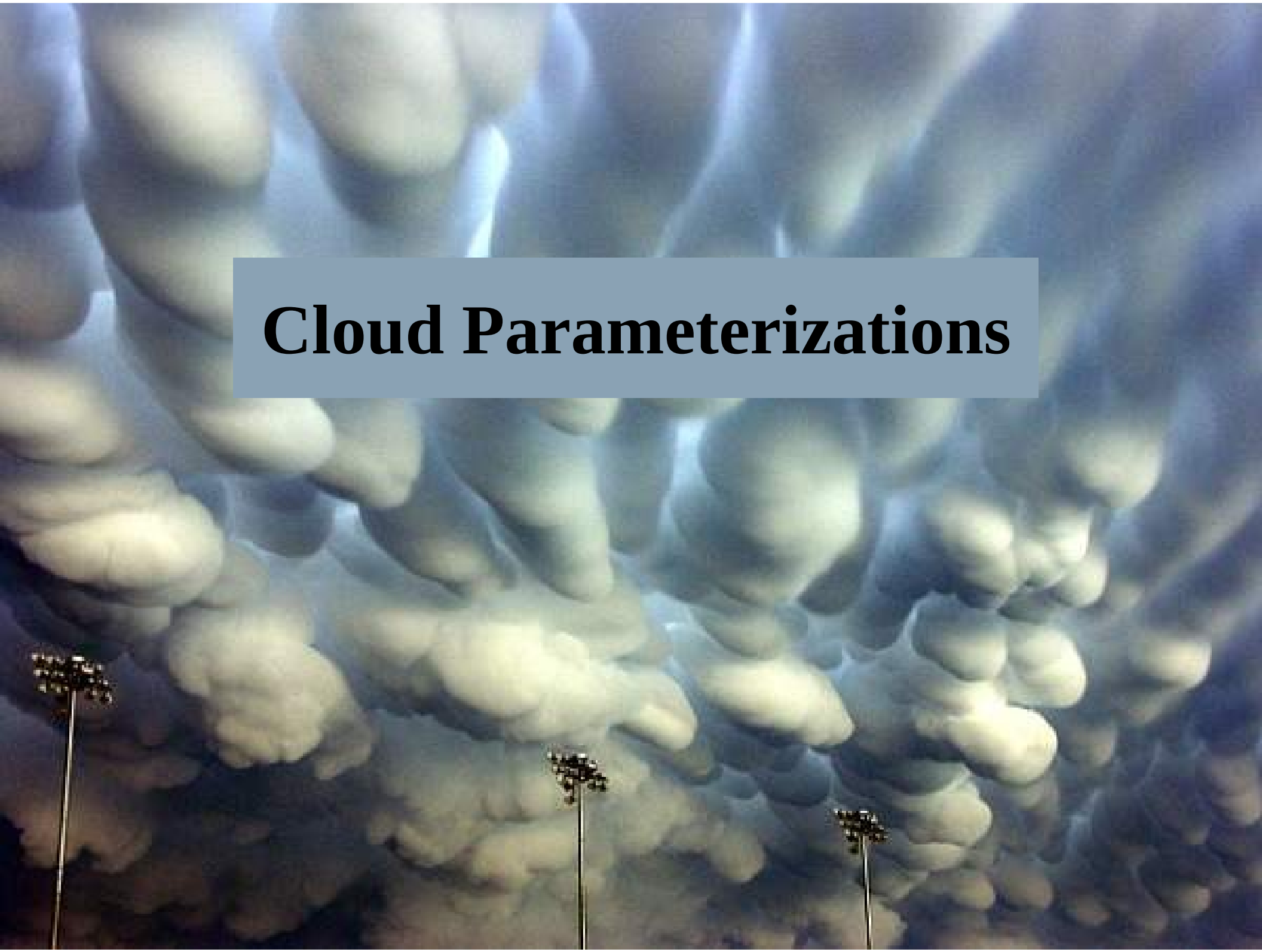






At higher latitudes:

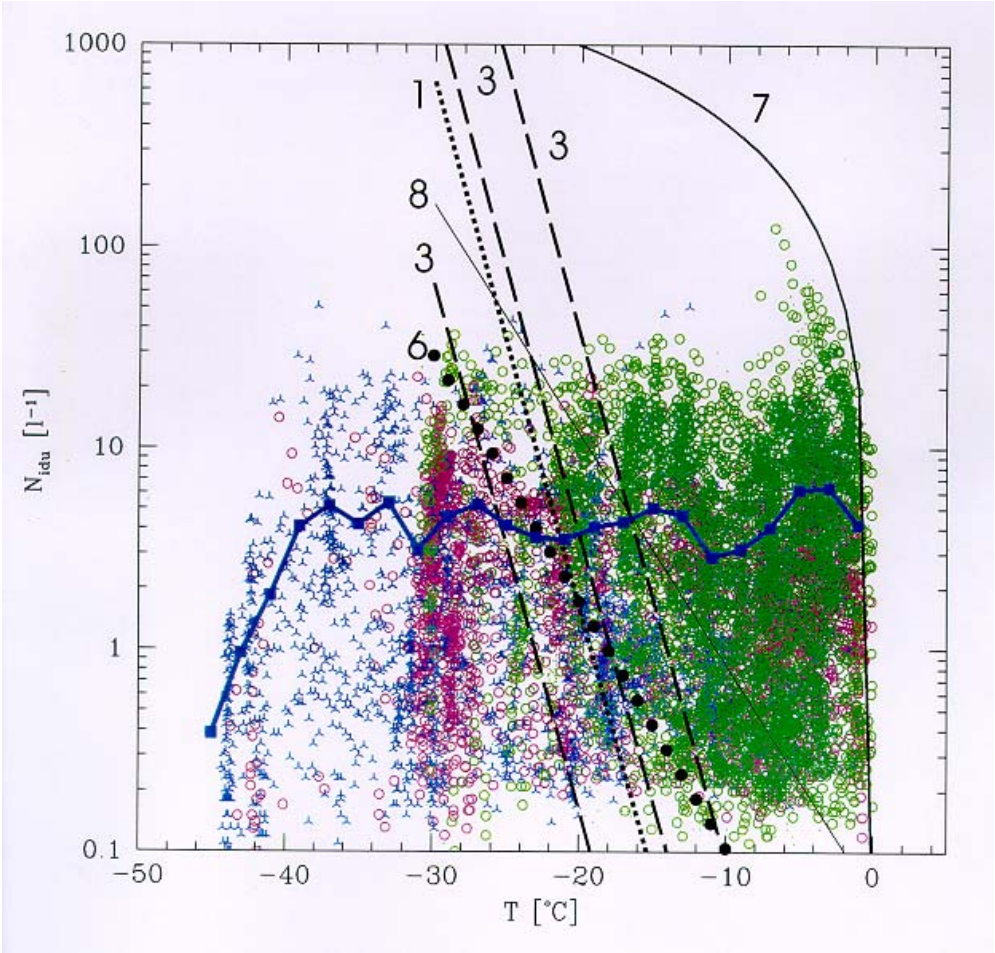
- **larger fraction of precipitation is 'light'**
- **percentage of solid precipitation high**

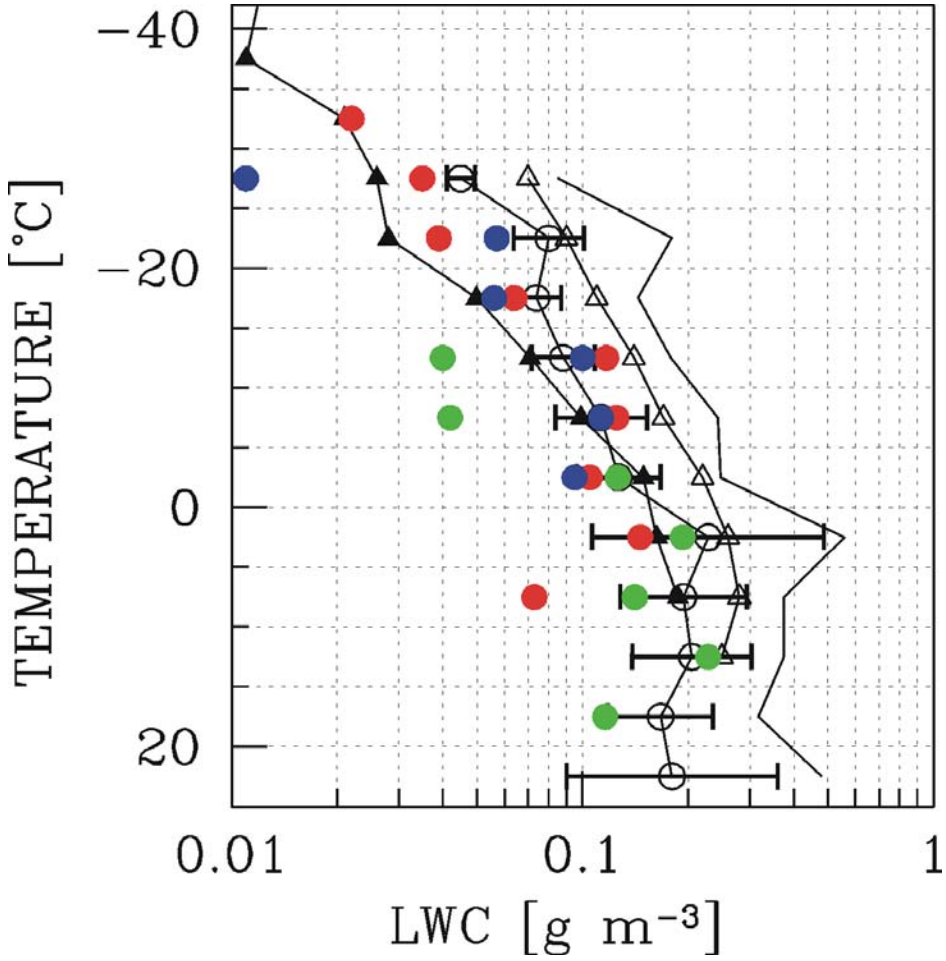

Cloud Parameterizations

Cloud Microphysics Data Base

- ~ 185 Research flights over 10 years
- > 200,000 km of in-flight observations
- > 65,000 in-flight 3-km observations
- ~ 60% of observations were in-cloud
- Detailed microphysics observations (spectra, moments, LWC/IWC/TWC, concentrations, etc.)
- Applications include parameterization, process understanding, trend validation, direct validation

Cloud Physics Parameterizations



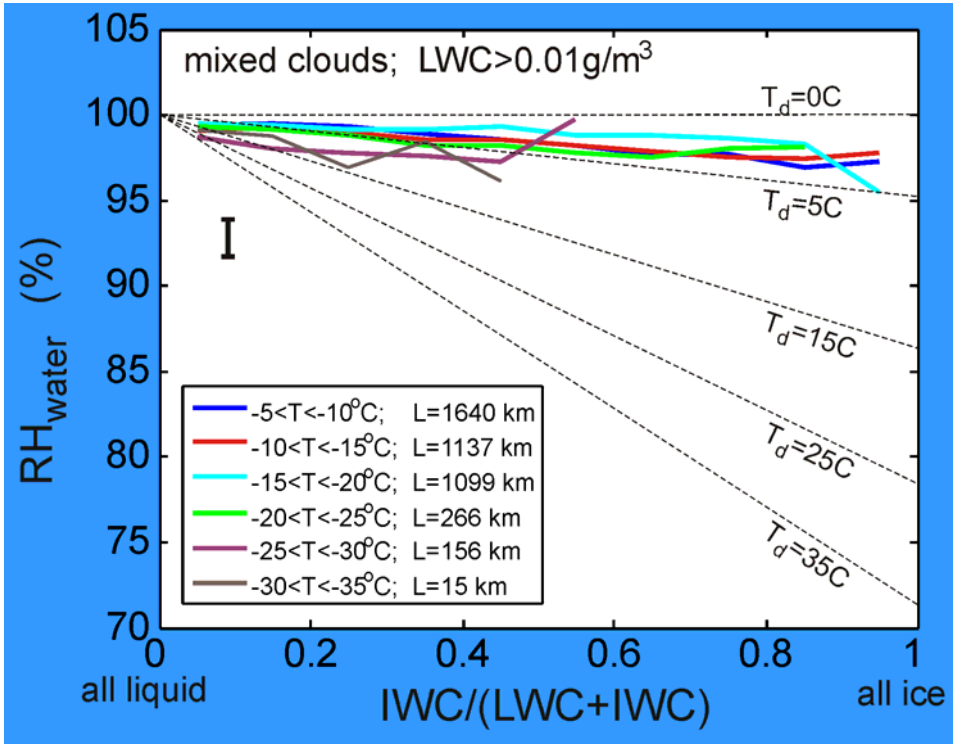


Gultepe, I., and Isaac, G. A., 1997: to GCMs. ***J. Climate***. 10, 446-452.

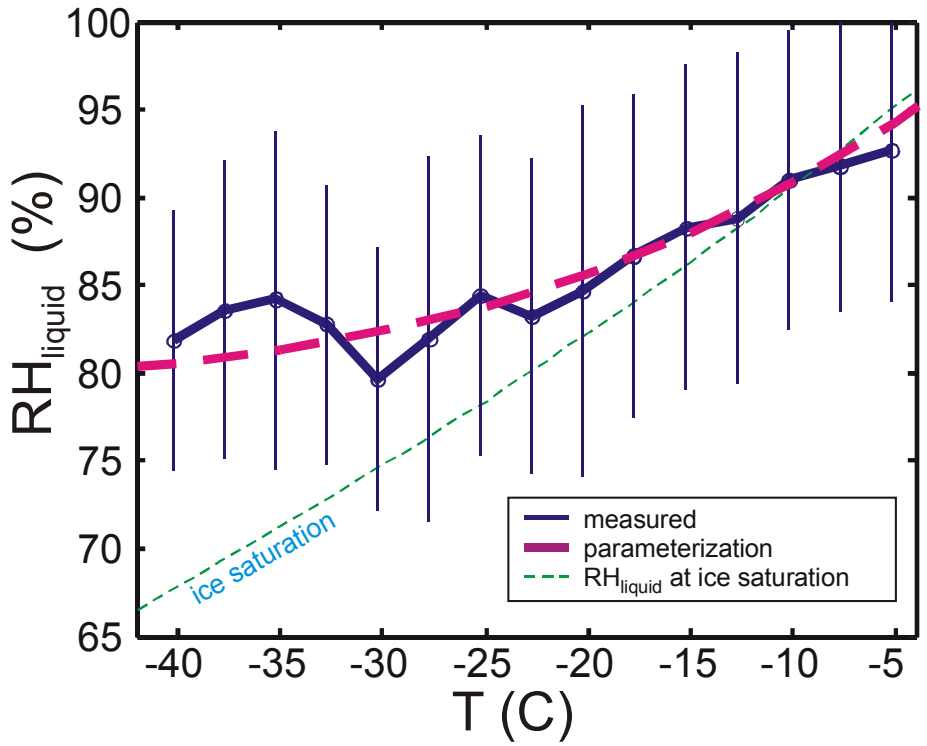
Gultepe, I., G. A. Isaac, and S. G. Cober, 2001 ***Inter. J. of Climatology***, 21,1281-1302.

Cloud Physics Processes

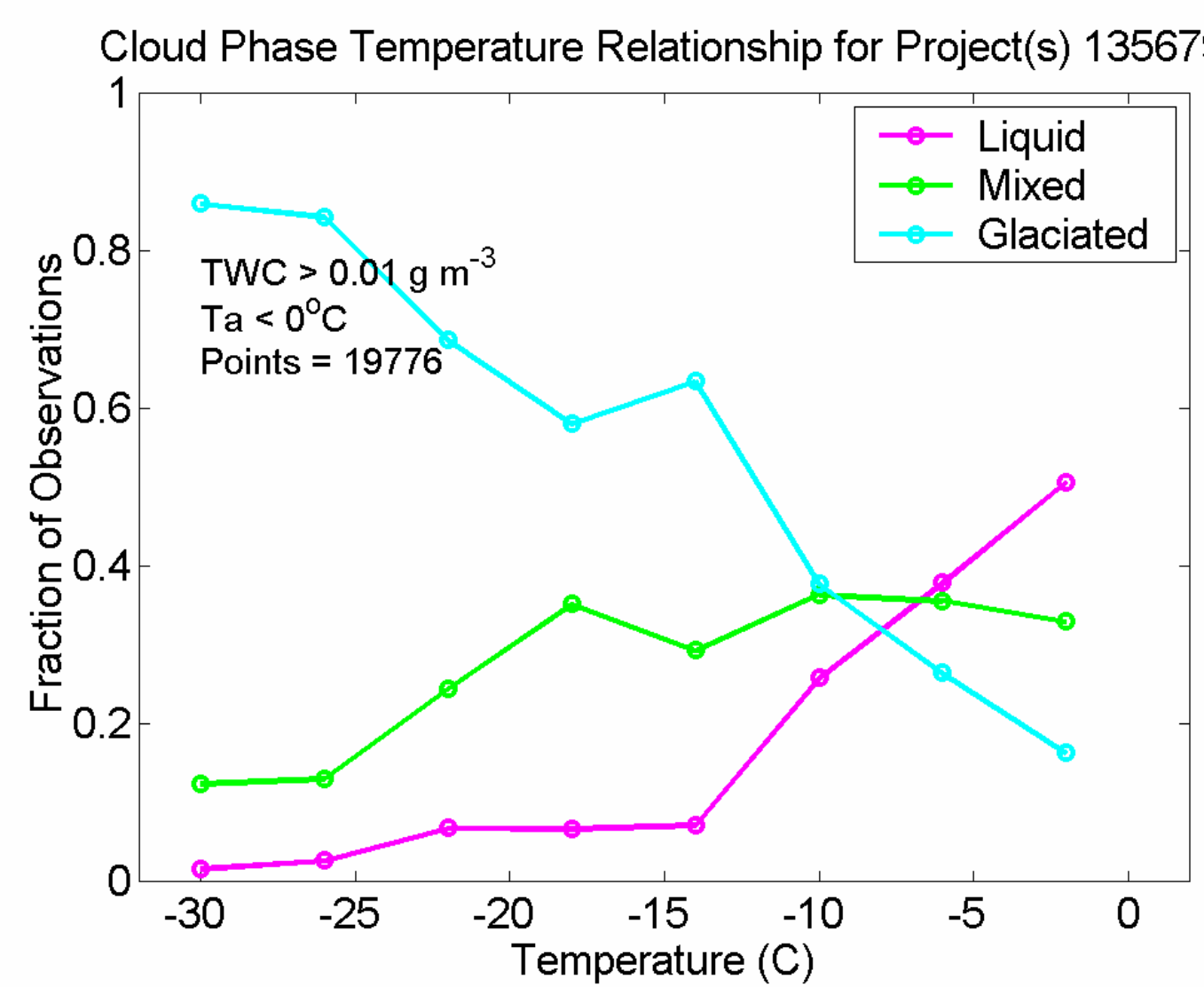
Relative Humidity in Mixed Clouds



Relative Humidity in Ice Clouds

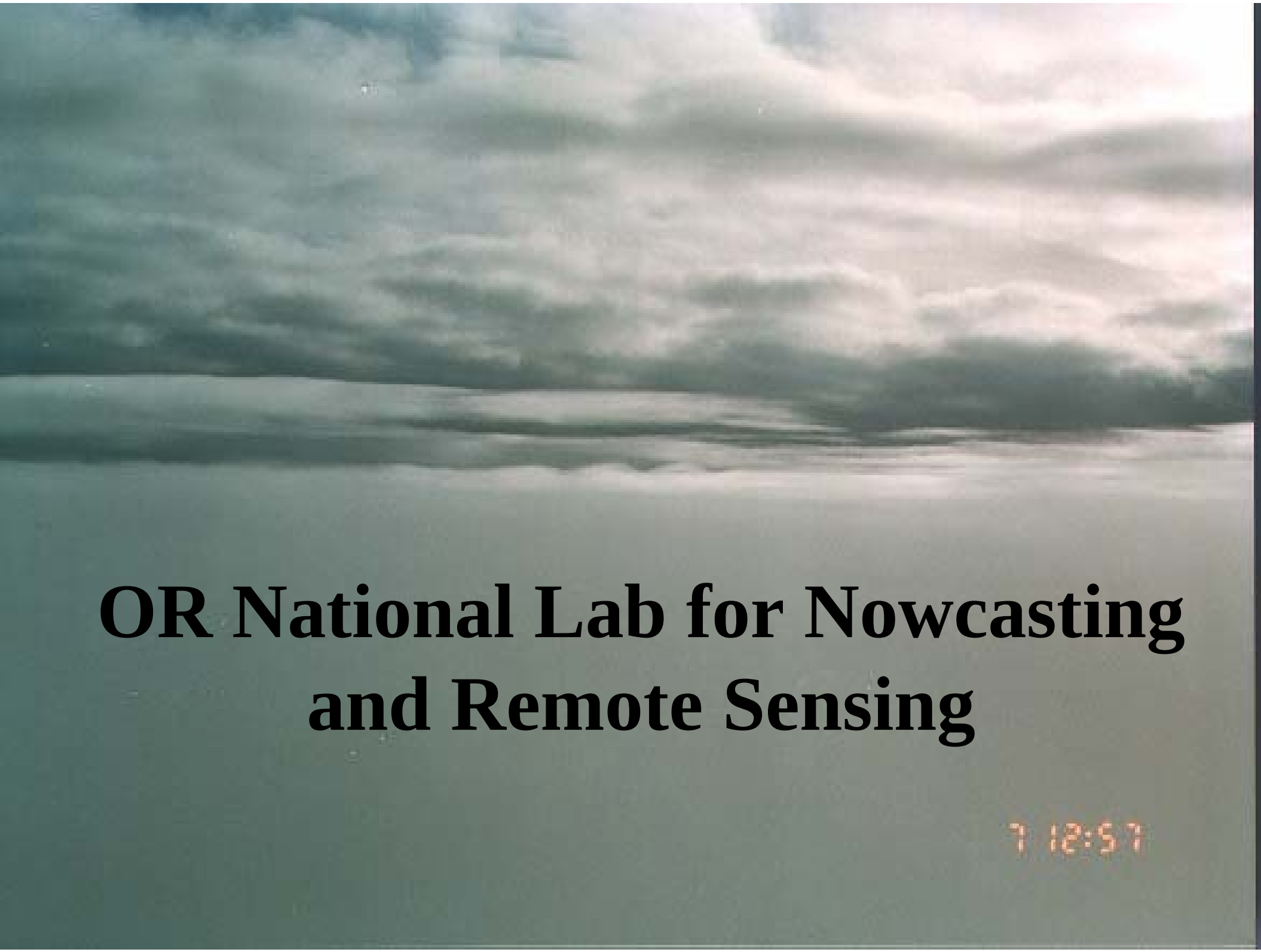


Phase Versus Temperature



Radiative Transfer Algorithm

- New radiative transfer algorithm has been installed in the CCCma GCM single-column model.
- Plan to perform initial tests it in the full GCM in 2005.
- Already implemented in the ECMWF forecast model, the NCAR-CAM GCM, and GFDL's GCM.
- Plan for application of radiative transfer model in diagnostic mode to estimate time series of cloud-radiative sensitivities (i.e., the radiative half of climate feedback mechanisms).
- Seven publications describing algorithm (5 in 2004)


OR National Lab for Nowcasting and Remote Sensing

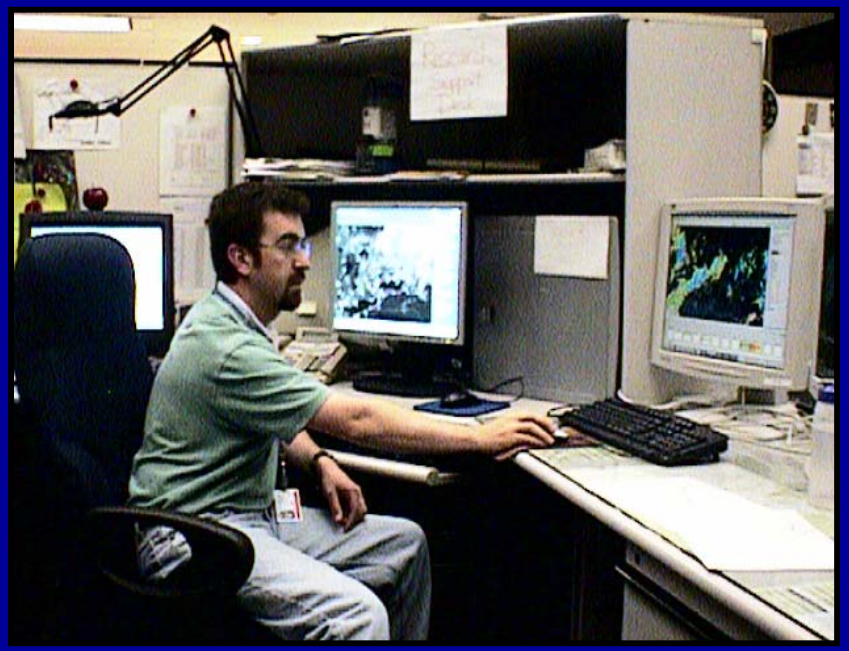
OR NRSML Planning

(Nowcasting and Remote Sensing Meteorology Lab)

- Radar Severe Weather Applications Meteorologist
- Radar QC/QPE Meteorologist
- Satellite Applications Meteorologist
- Nowcasting Techniques Researcher

Research Support Desk at OSPC

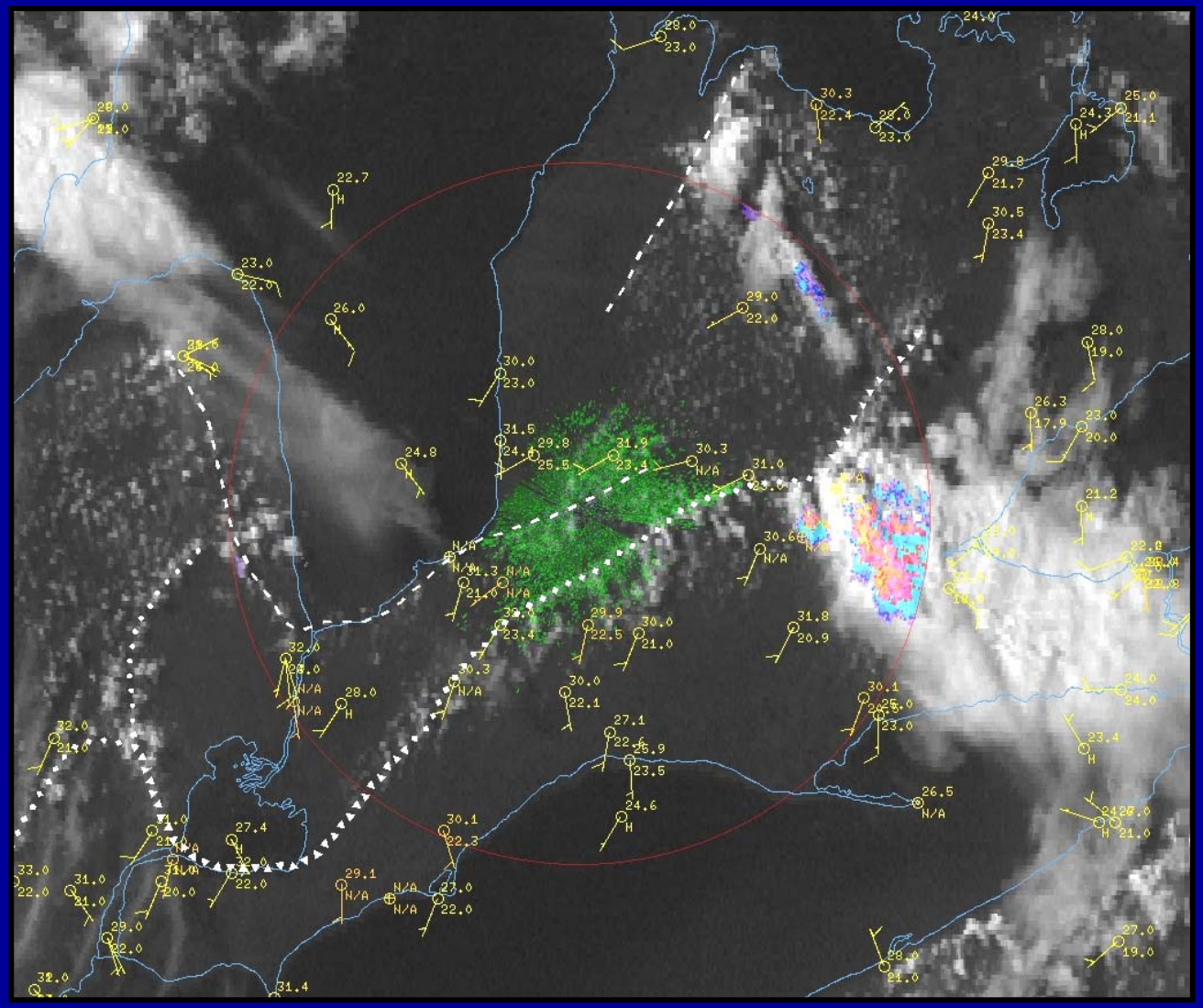
2004 pilot was first attempt to bring a research scientist into operations area for direct daily contact with forecasters



Goals:

- provide severe weather desk with ongoing mesoscale analysis using both research and operational tools
- introduce new tools and techniques to forecasters
- provide interactive training with real-time data
- identify science needs / gaps

Research Support Desk at OSPC

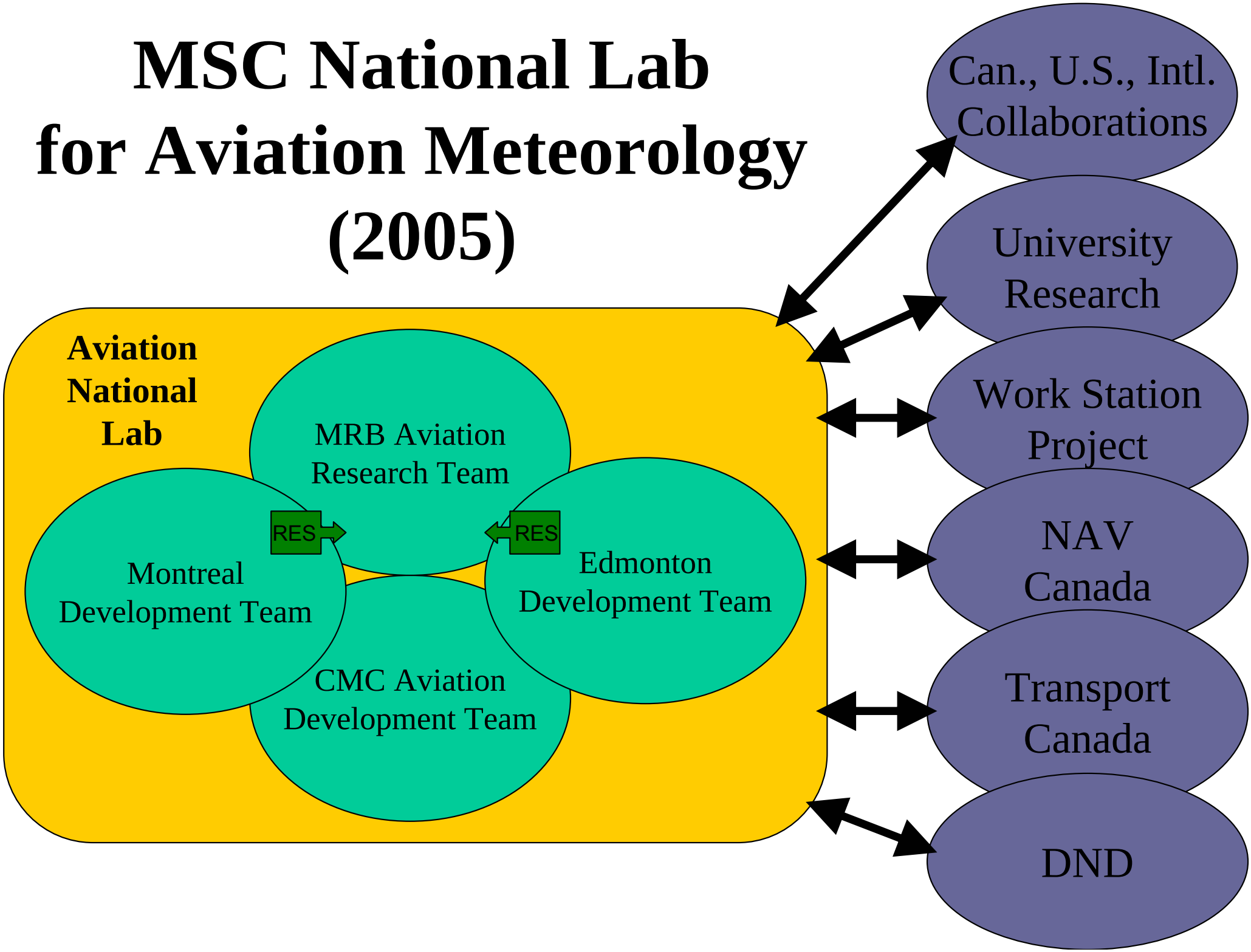


For 2005:

- Sills and Leduc on the desk
- Full test with all feeds including NWP
- Focus on meso-analysis and severe weather nowcasting using Aurora
- Visits to other regions planned for 2006


Aviation National Lab

MSC National Lab for Aviation Meteorology (2005)

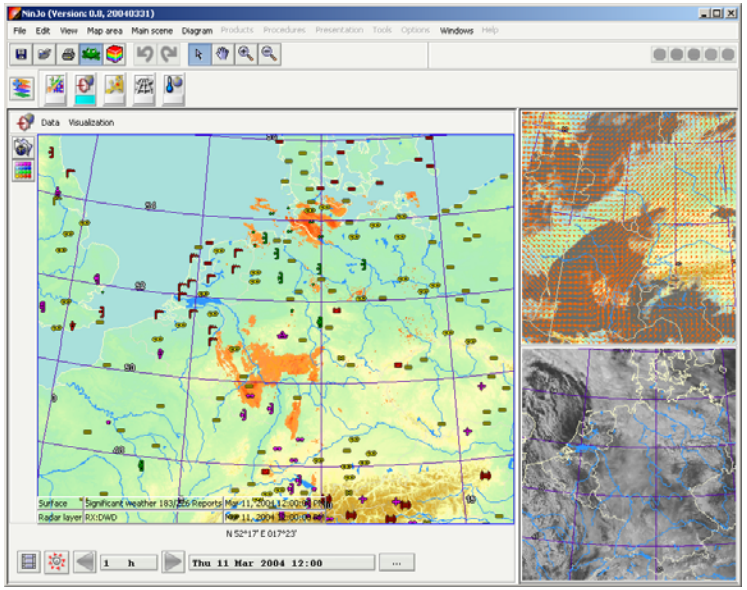


Nav Canada Proposals 2005

- TAF Improvement Science (regression techniques versus fuzzy logic techniques)
- TAF Visualization Development (within the workstation project)
- HUB Forecasting Demonstration (linking weather and airport traffic decision mechanisms)
- Forecast Products (improving usefulness of icing, turbulence, GFA and other aviation products)
- User/client R&D Needs Assessment

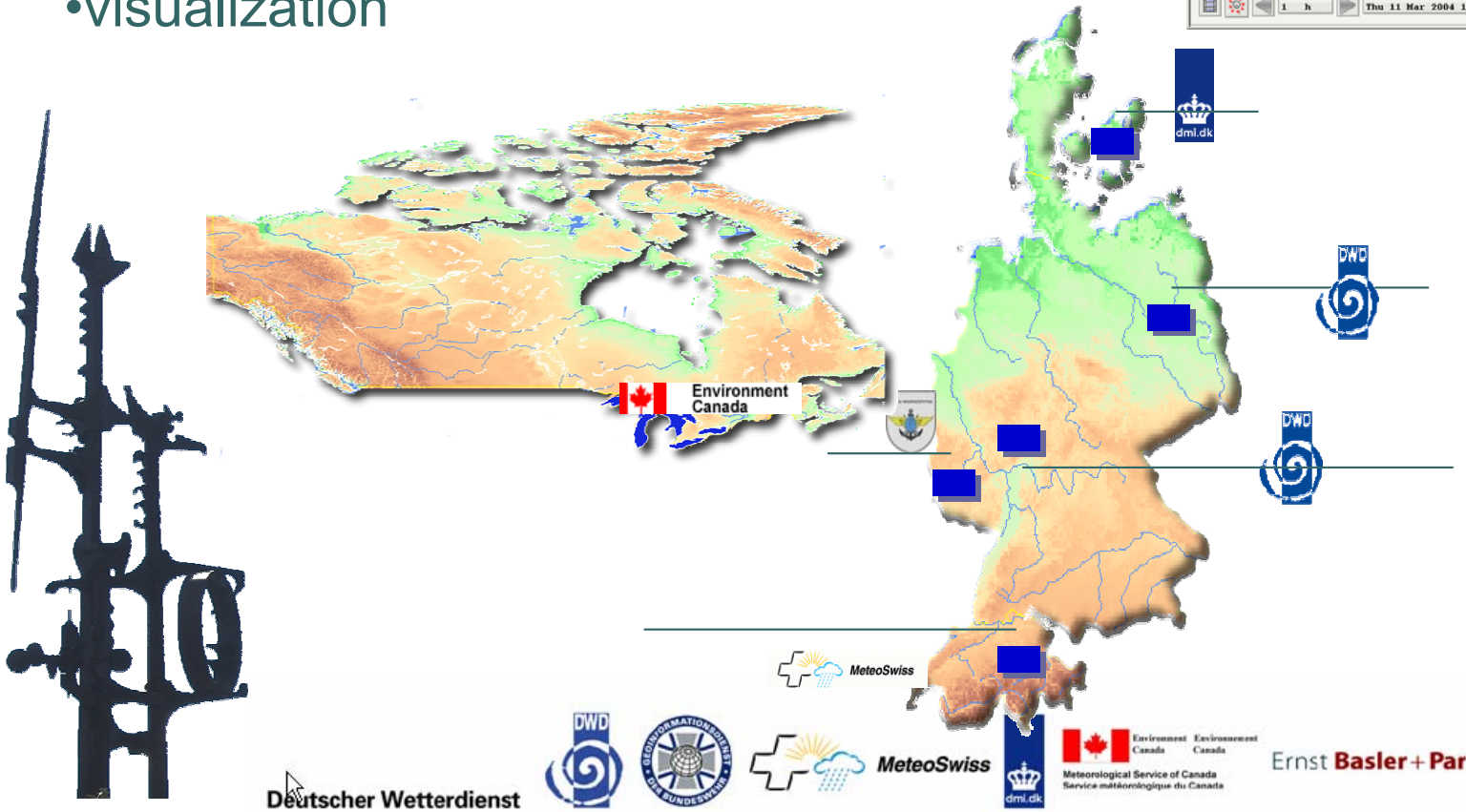
Workstation Project

What is NinJo?



Consortium of five partners

- MSC involvement 2 years
- 1.0 release date 28.02.2005
- 1.0 deployed by DWD, DMI, MCH, BGS
- visualization



- Licensing
- New Partners

Deutscher Wetterdienst
MeteoSwiss
Meteorological Service of Canada
Service météorologique du Canada
Ernst Basler + Partner
s d & m
software design & management

What is workstation?

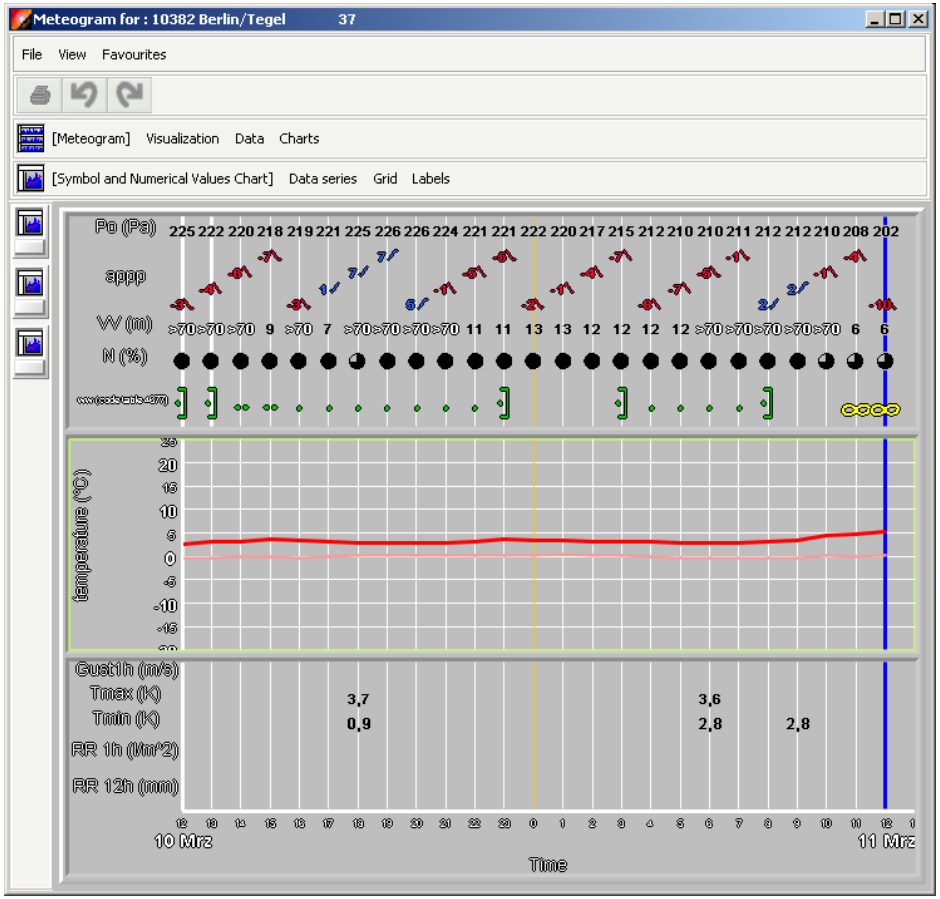
- NinJo
  - Initially “data” visualization system to improve analysis and diagnosis
  - Stepping stone to production
  - Stepping stone to forecast applications
    - e.g., automatic monitoring, warning functionality, “weather in the box”
- NinJo plus integration with MSC Apps, DMF
  - Bullprep, Scribe, Roving TAF, others
  - DMF/PdB
- Vehicle for Technology Transfer
  - Science introduction into forecasting, NL, STT
  - Training, Weather Event Simulator
- Vehicle to bring order to applications/software
  - SMB, CMO, Kill List

Why do we need a *new* workstation?

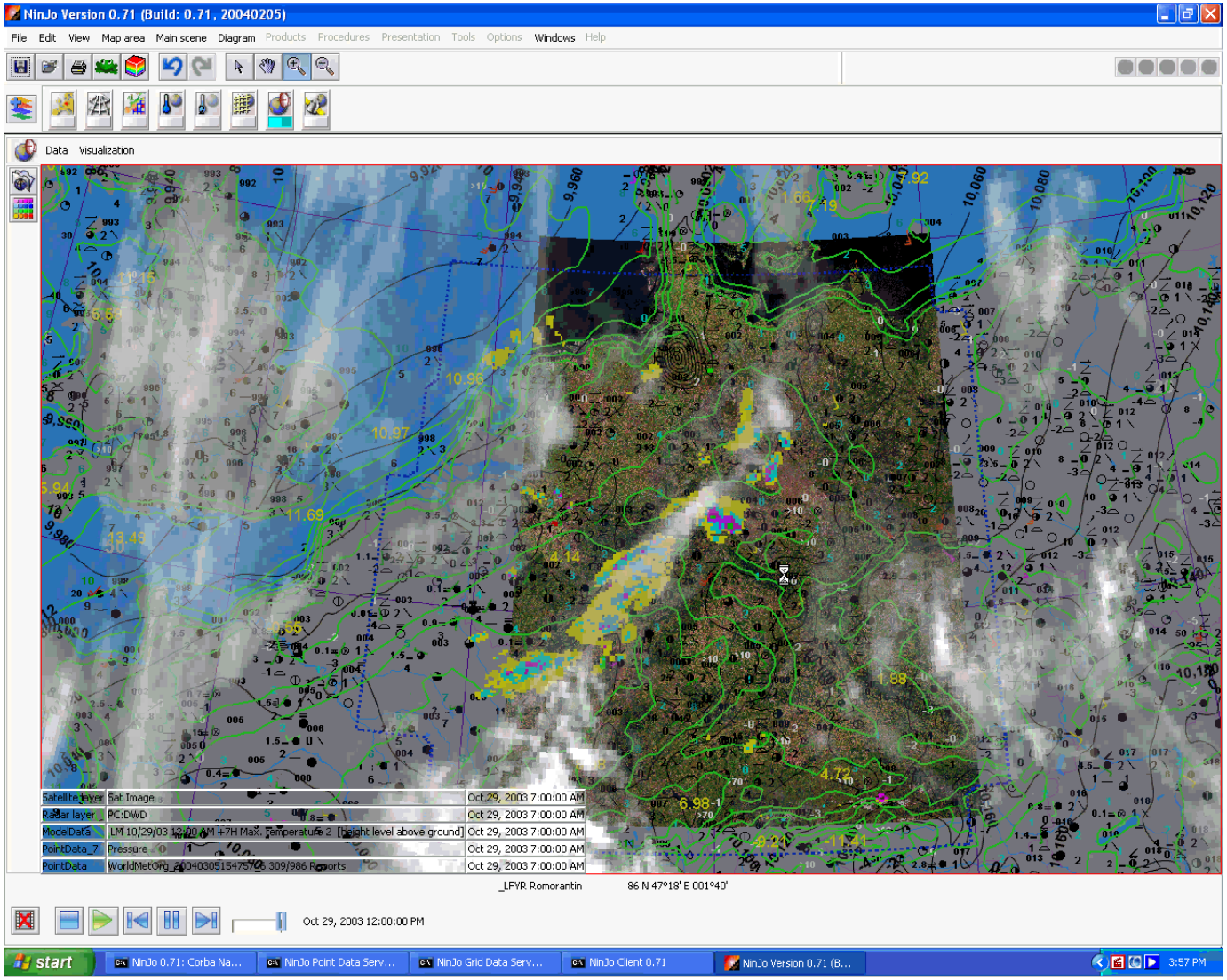
- Need to move forward on science
- Need to move forward on rapid tech transfer
- Need to have way forward on forecast applications
- Need a way forward on production
- Need to reduce IT support and infrastructure costs
- Logical path from current situation
  - Integrated data bases, single data base
  - Integrated data and applications

NinJo Functionality Vr 1.0

- Point data - plots
- Gridded model data
- Satellite
- Radar
- Lightning
- Aerological diagrams
- Meteograms or diagrams
- Interactive Graphics
- Monitoring and alerting (Part 1)
- X - Sections (Part 1)
- Batch operation



Forecaster Workstation Project NinJo (2005)



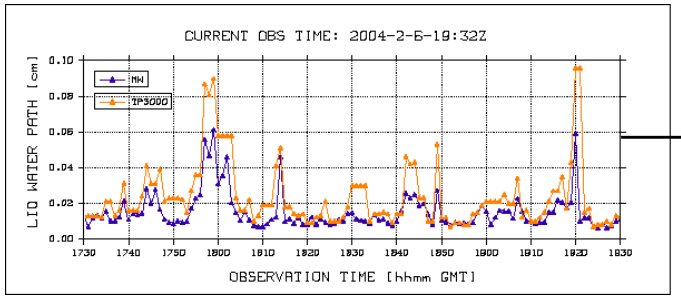
NinJo 1.1 Mid 2005 (point forecast editing, warning layer, field modification)

NinJo 1.2 Late 2005 (nowcasting, object graphics, replay, trajectories)


Nowcasting Projects

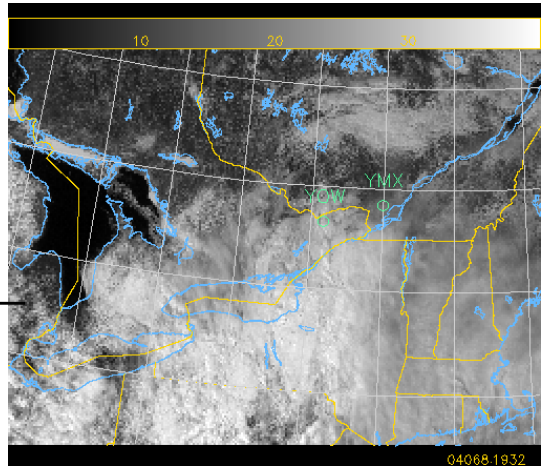
AVISA Algorithm

Radiometers

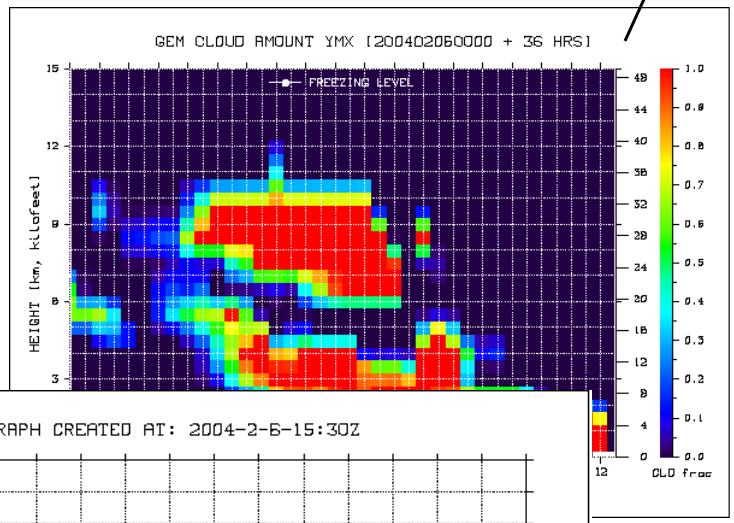


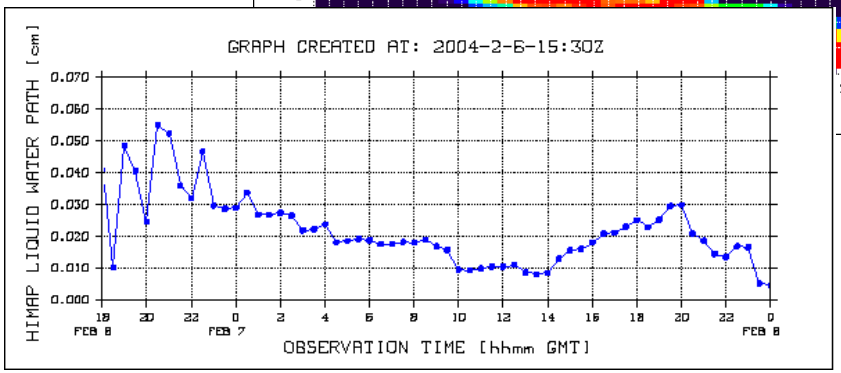
AVISA Input Parameters

GOES Satellite

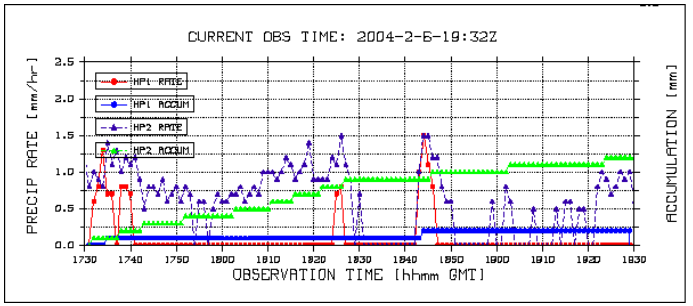


HIMAP & GEM Models

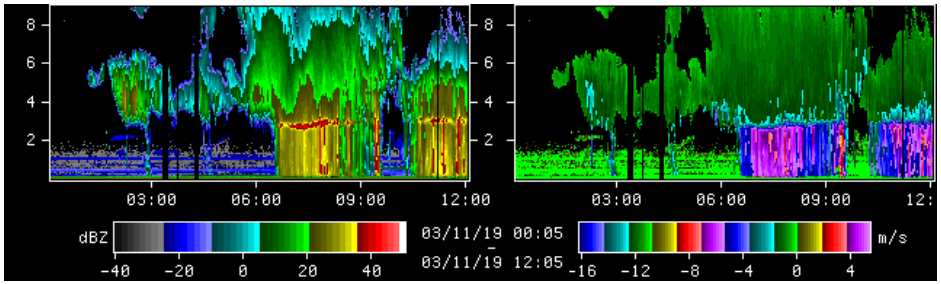




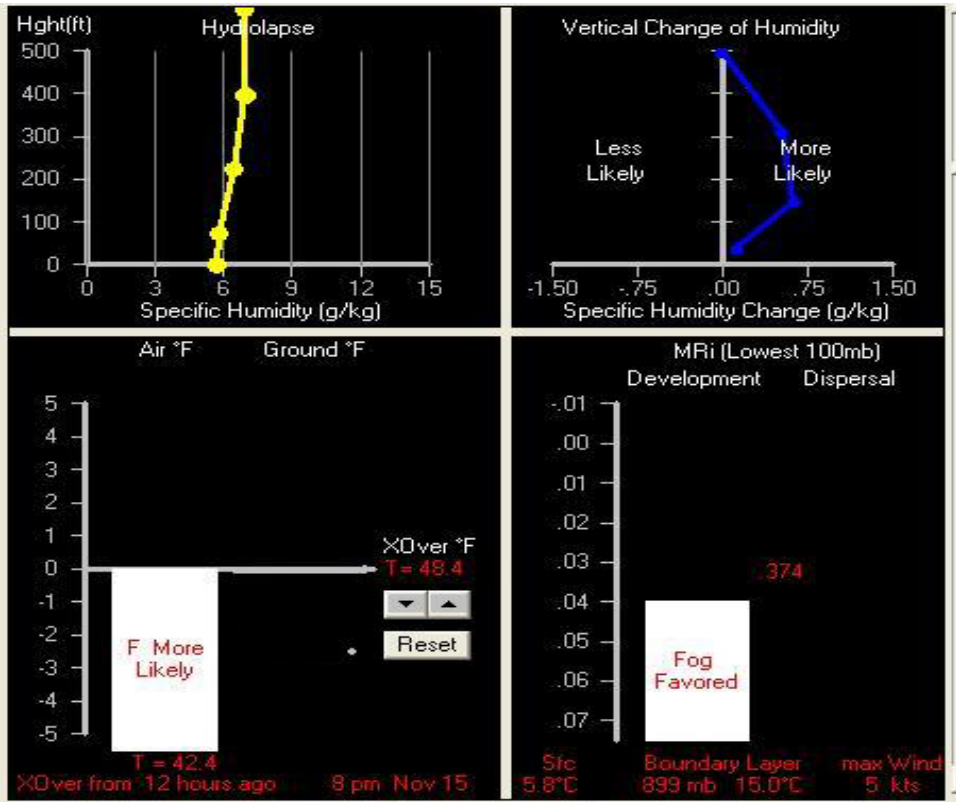
POSS, HP and Met Station



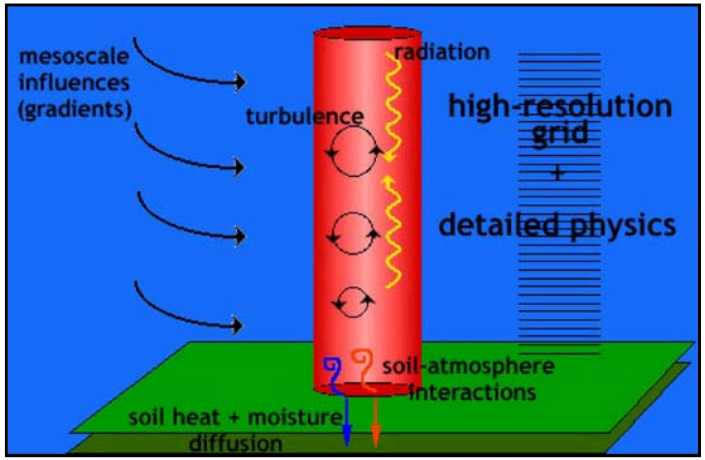
Doppler Radar & VPR

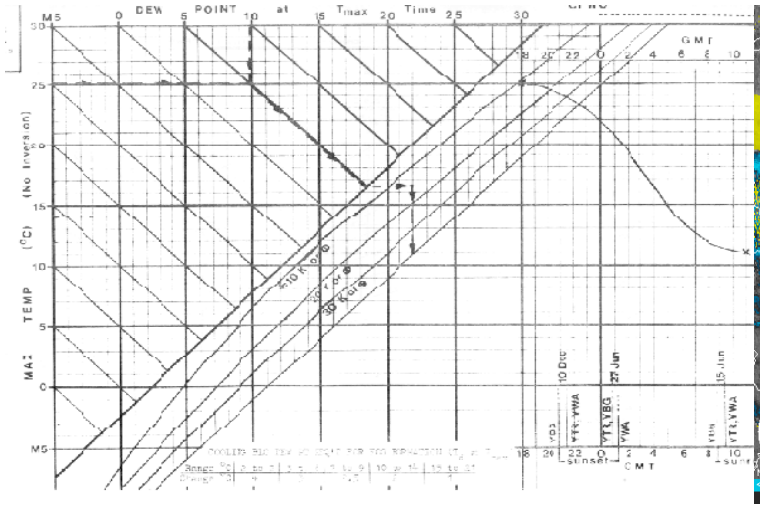


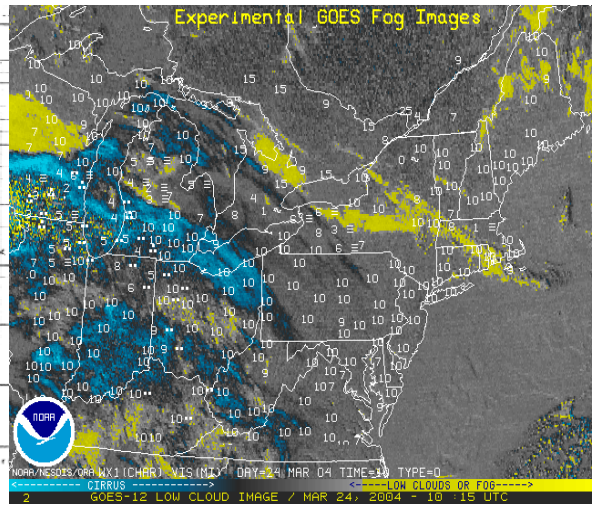
Fog Forecasting Tool (2007)

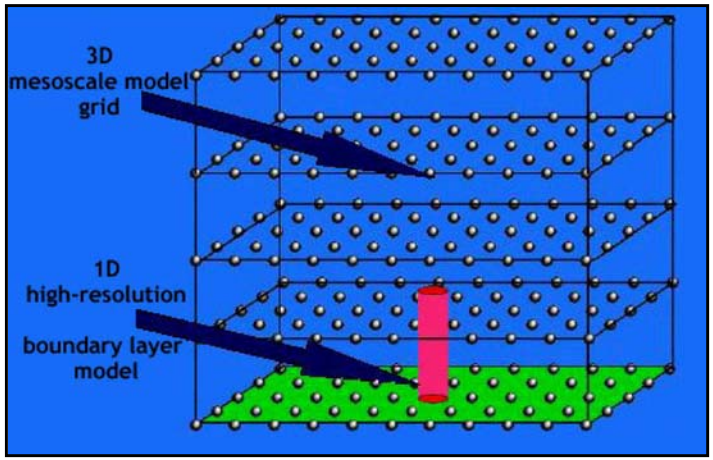


- BUFKIT
- COBEL 1-D model
- Satellite
- Nomograms



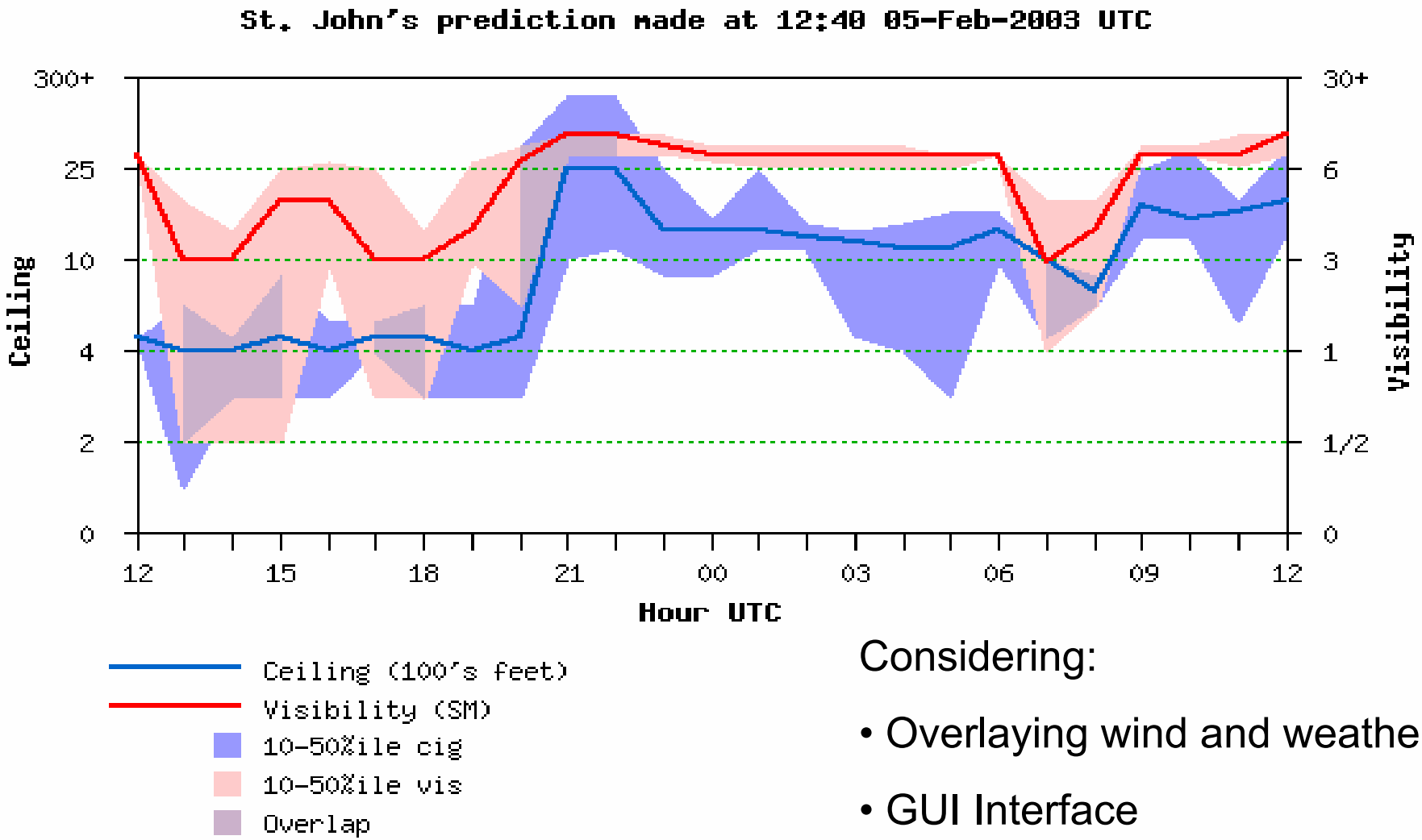






Ceiling and Visibility Prediction Tool (2005)

Probabilistic forecast: 10 %ile to 50%ile cig. and vis. from analogs



Considering:

- Overlaying wind and weather
- GUI Interface
- Plotting recent observations
- Real time verification

Role of the Forecaster

- Organizing Committee for Forecasters Forum II (Science Operations Connection)
- Organizing Committee for Forecasters Forum III
- Optimizing the human-machine mix
- NinJo Project
- National Labs
- WWRP Project on the Role of the Forecaster

Questions