Environment Canada Environnement Canada

Canada

Overview of Data Assimilation (DA) Activities for Weather Forecasting at Environment Canada (EC)

2nd Workshop on Remote Sensing and Modeling of Surface Properties

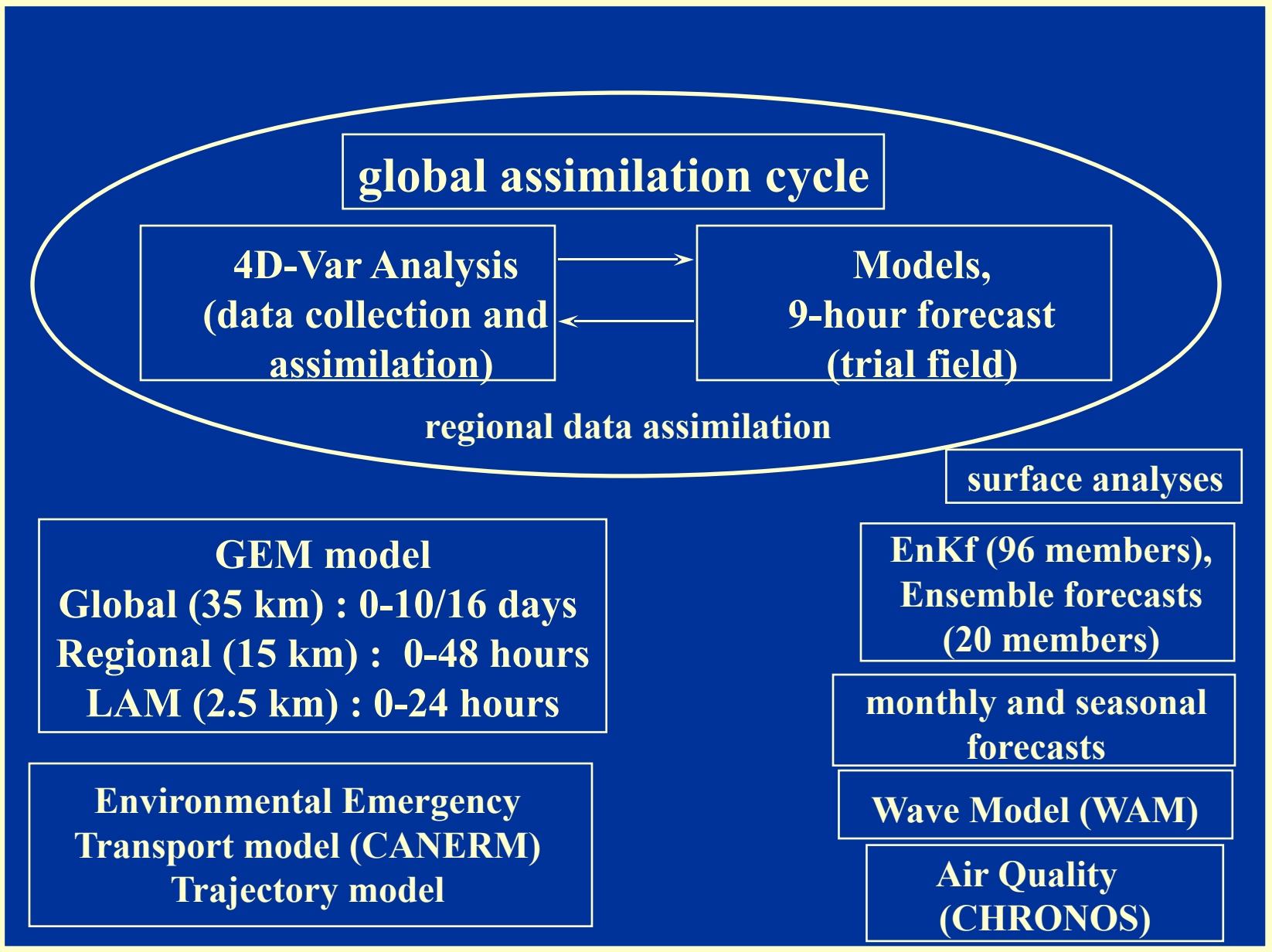
Meteo-France, Toulouse

Godelieve Deblonde

Manager, Data Assimilation and Satellite Meteorology Section

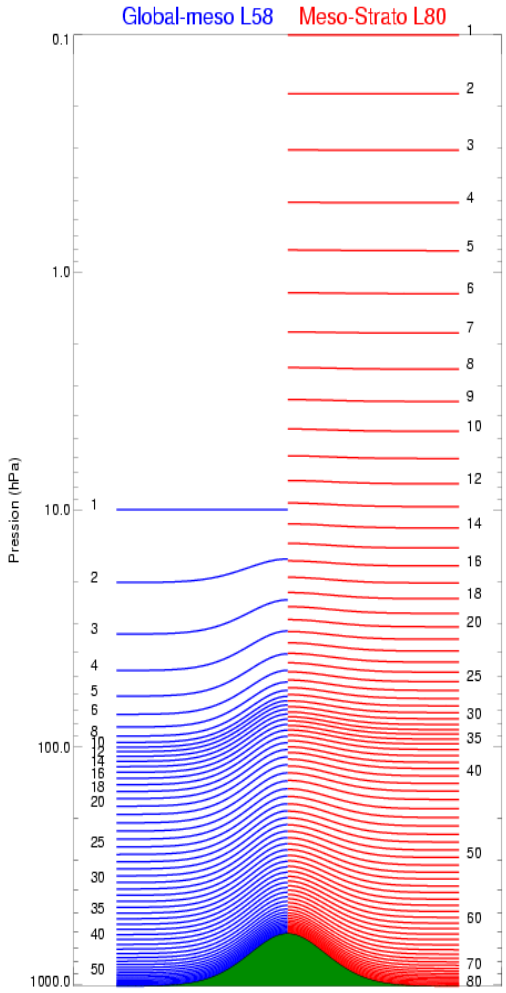
June 9, 2009

MSC OPERATIONAL RUNS: MAIN COMPONENTS



EC Deterministic Analysis and Forecast System

- **GEM (Global Environmental Multi-Scale) Model**
  - **Operational: GEM-Meso**
    - Global grid 800x600 or ~ 33 km
    - Eta vert. coordinate, 58 L
    - Model lid at 10hPa (~ 30km)
  - **In Parallel: GEM-Strato**
    - Global grid 800x600 or ~ 33 km
    - Hybrid vert. coordinate, 80L
    - Model lid at 0.1hPa (~ 65 km)
    - New radiation scheme (Li & Barker)
    - Non-orographic GWD (Hines)
    - New background error statistics



EC Deterministic Analysis and Forecast System (Continued)

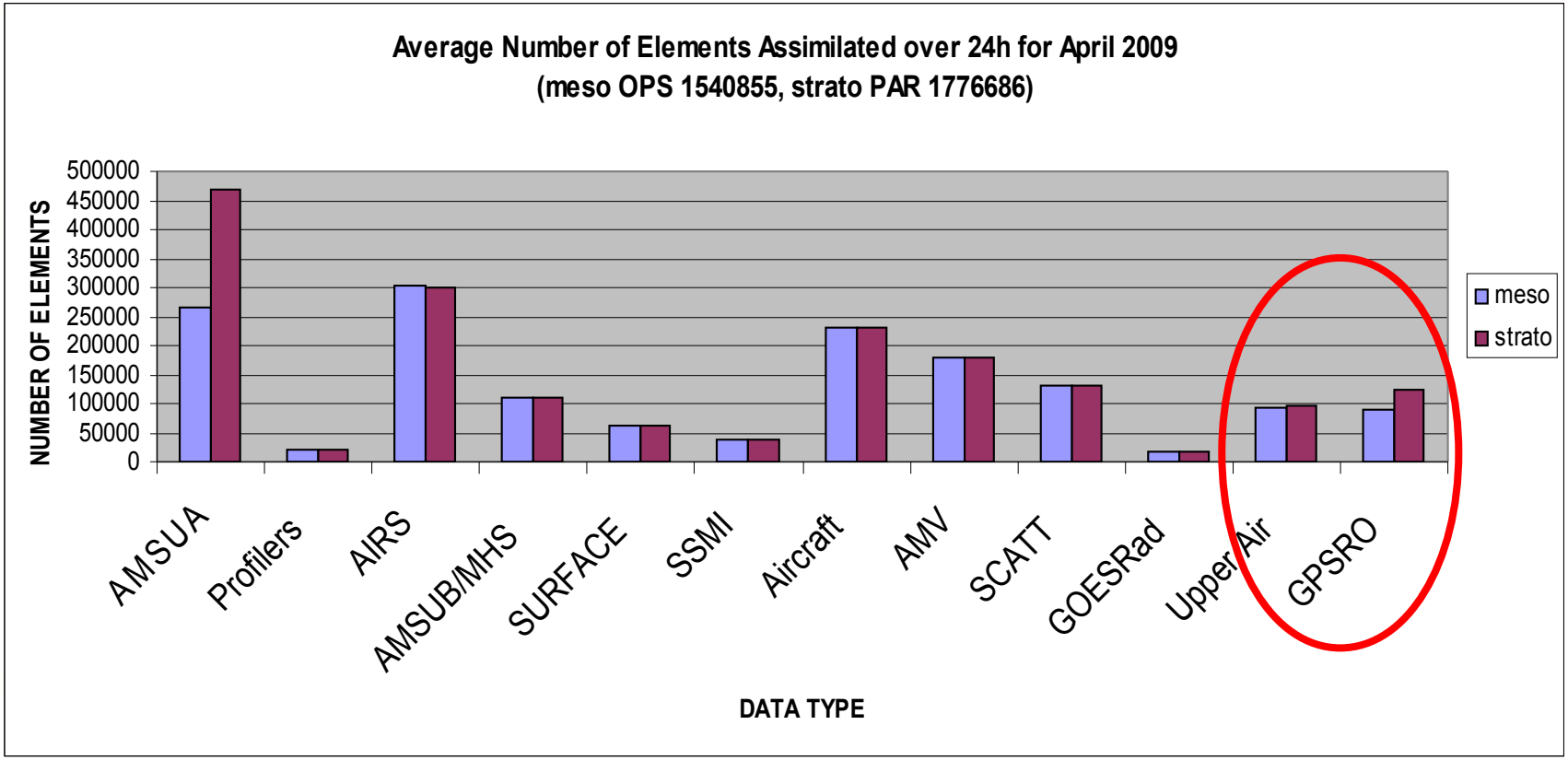
4D-Var (6h Window)				
Outer Loop	**Number of Inner Loops**	**Simplified Physics**	**Low-Resolution Analysis Increments**	**High Resolution Trajectory**
1	30	-PBL	(Lon 1.5^{o}x Lat 1.5^{o}) T108 L58	(Lon 0.45^{o}x Lat 0.3^{o}) L58
2	25	-PBL -SGO -Stratiform Precipitation -Deep Convection (inactive)	(Lon 1.5^{o}x Lat 1.5^{o}) T108 L58	(Lon 0.45^{o}x Lat 0.3^{o}) L58

SGO: Sub-Grid Scale Orography; PBL= Planetary Boundary Layer

EC Deterministic Analysis and Forecast System (Continued)

- **Off-Line Dynamic bias correction for radiances** (15 day sliding window) ***but static bias correction for AMSU-A channels 11-14.***
- **RTTOV8.7 to assimilate radiances**
- **Global Model Drives a Regional System**
  - ***Assimilate same observation set as in global system***
  - Global Variable Resolution over North America (15 km)
  - 58 or 80 vertical levels
  - 3DVAR FGAT assimilation with 6h spin-up
  - New 4 (0, 6, 12,18Z) x 48h forecasts per day
- **Note: Global EnKF uses QC and Bias Corrected observations based on 4D-Var**

Average Number of Observations Assimilated per 24h period- April 2009



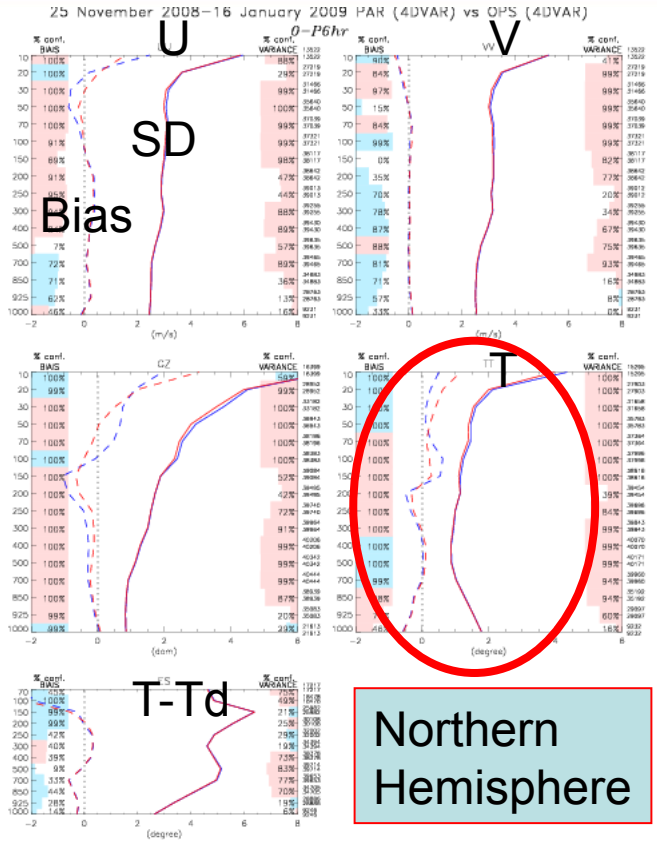
GEM-Meso OPS: Operational system –model lid at 10hPa
GEM-Strato PAR: Parallel system –model lid at 0.1 hPa

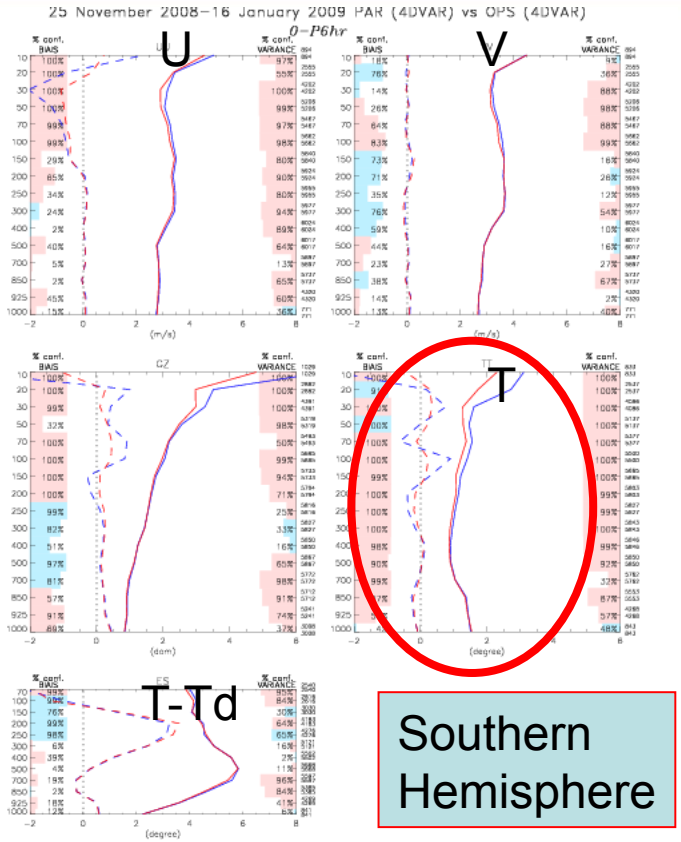
Latest Observations Operationally Assimilated

- **GPS RO –refractivity profiles**
  - Project started in 2003 (funding from the **Canadian Space Agency**)
  - Tests with CHAMP, SAC-C, GRACE, COSMIC, METOP-GRAS
  - Acceptance for parallel run: June 2008
  - Operational implementation of COSMIC (March 12, 2009) & METOP-GRAS, GRACE (March 31, 2009)
  - Impact of GPSRO data positive in general
    - Very good in the stratosphere
    - Moderately good in tropics
    - Weak but positive impact in N Hemisphere
    - Very positive in S Hemisphere, especially high latitudes
    - Helps the radiance bias correction
  - Tropical troposphere is most challenging
- Operational addition of **METOP ASCAT** (100 km resolution), **MODIS Direct Broadcast Winds** from CIMMS on March 31, 2009

GPS RO Impact on GEM-meso 6h Forecasts versus Radiosondes

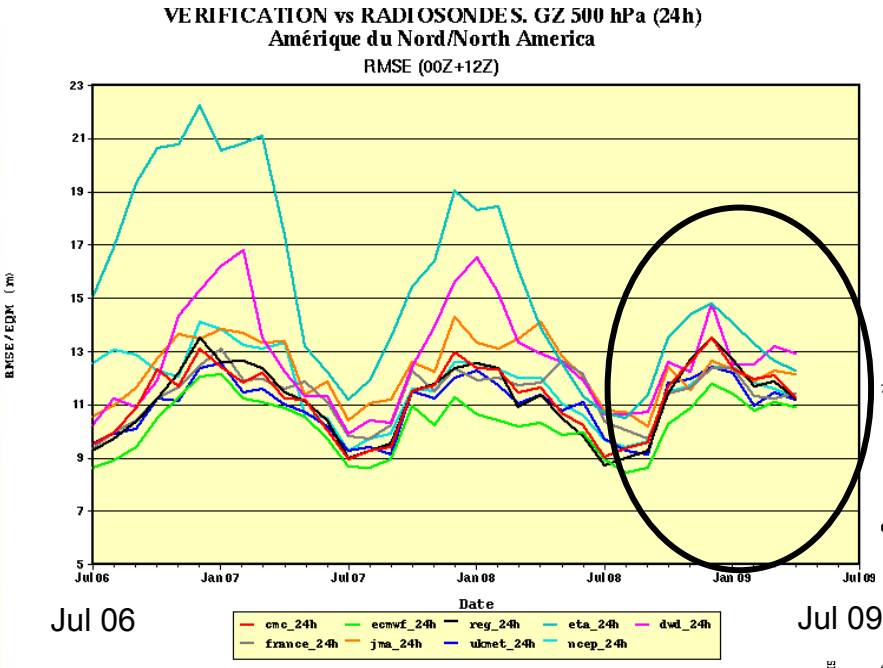
WITH GPS
WITHOUT GPS





winter 2008/09

RMSE of the 500 hPa Geopotential Height Forecasts (Operational System) Against North American Radiosondes

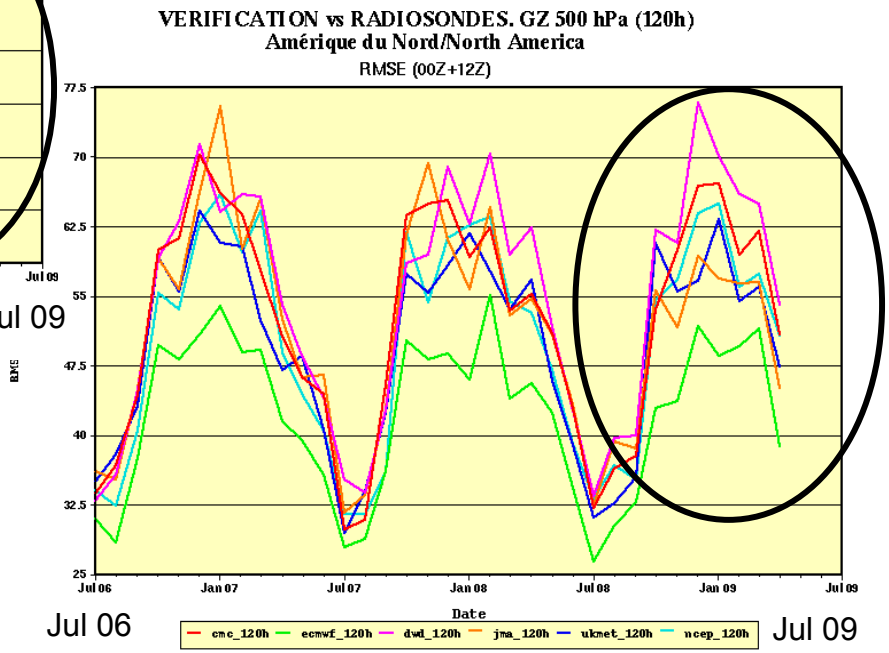


Jul 06

Jul 09

24h

120h



Jul 06

Jul 09

GEM-STRATO II (Operational Spring 2010)

- Better forecasting of tropical depressions (convection scheme)
- Increase resolution for 4D-Var inner loop (T108 → T180)
- Increase in data assimilated:
  - ***AMSU/MHS from MetOp and NOAA 19***
  - CSR (Geo-rad) data – 5 GEO (Water Vapor Channel)
  - Moisture data from AMDAR
  - SSM/IS
  - IASI (128 + ~20 out of 616 channels from NOAA/NESDIS)
- Reduced horizontal thinning for satellite radiance data:
  - 250km → 150km (~twice the volume of data assimilated)
- Use of RTTOV-9
- Unified bias correction scheme for all radiance data
- Shorter window for dynamic radiance bias correction (15d →7d)
- New SST analysis (MSC/Development)

New EC/MSC SST Analysis

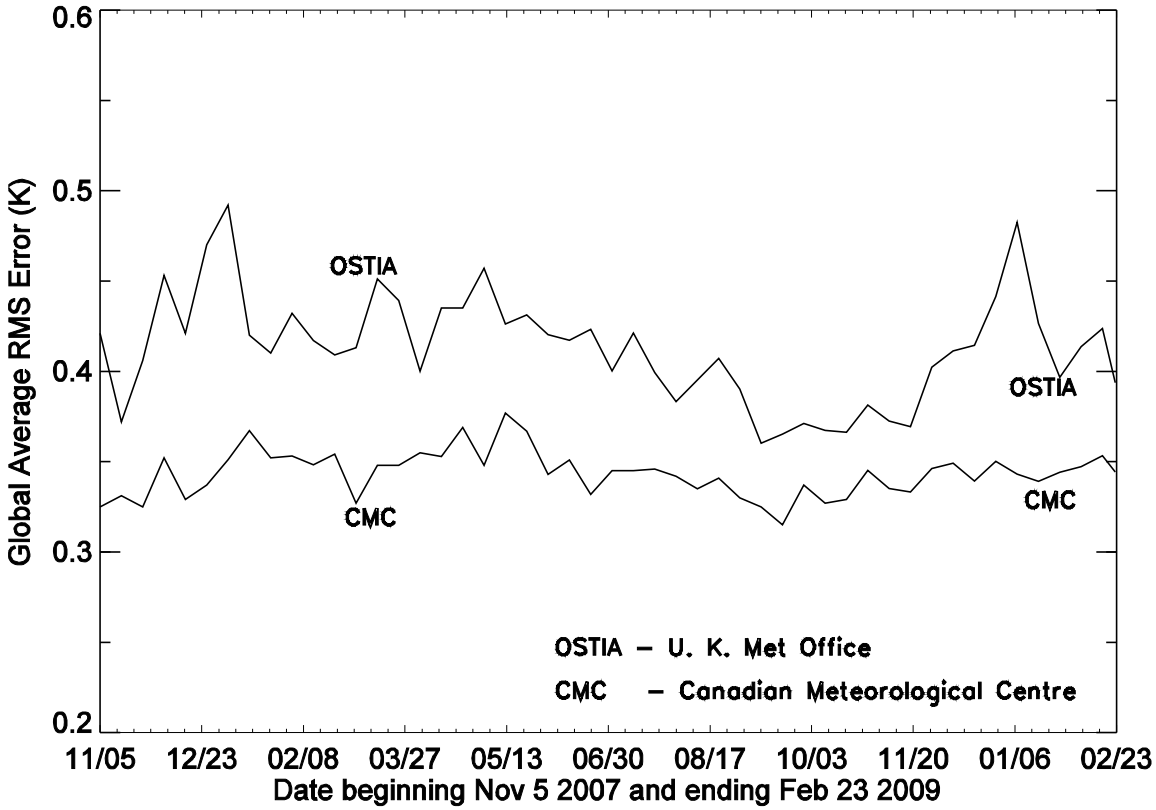
ANALYSIS SYSTEM

- Optimal Interpolation (0.33 deg)
- Once a day
- Published in Sept. 08 QJRMS, 134 (B. Brassnet)

MAIN CHANGES

- Incorporating AMSR-E, AVHRR18 and METOP-A retrievals
- Improving analysis resolution 0.33° → 0.2°
- Reducing the background error correlation length scales
- Adding ice information

Analysis Comparison Against Argo Floats



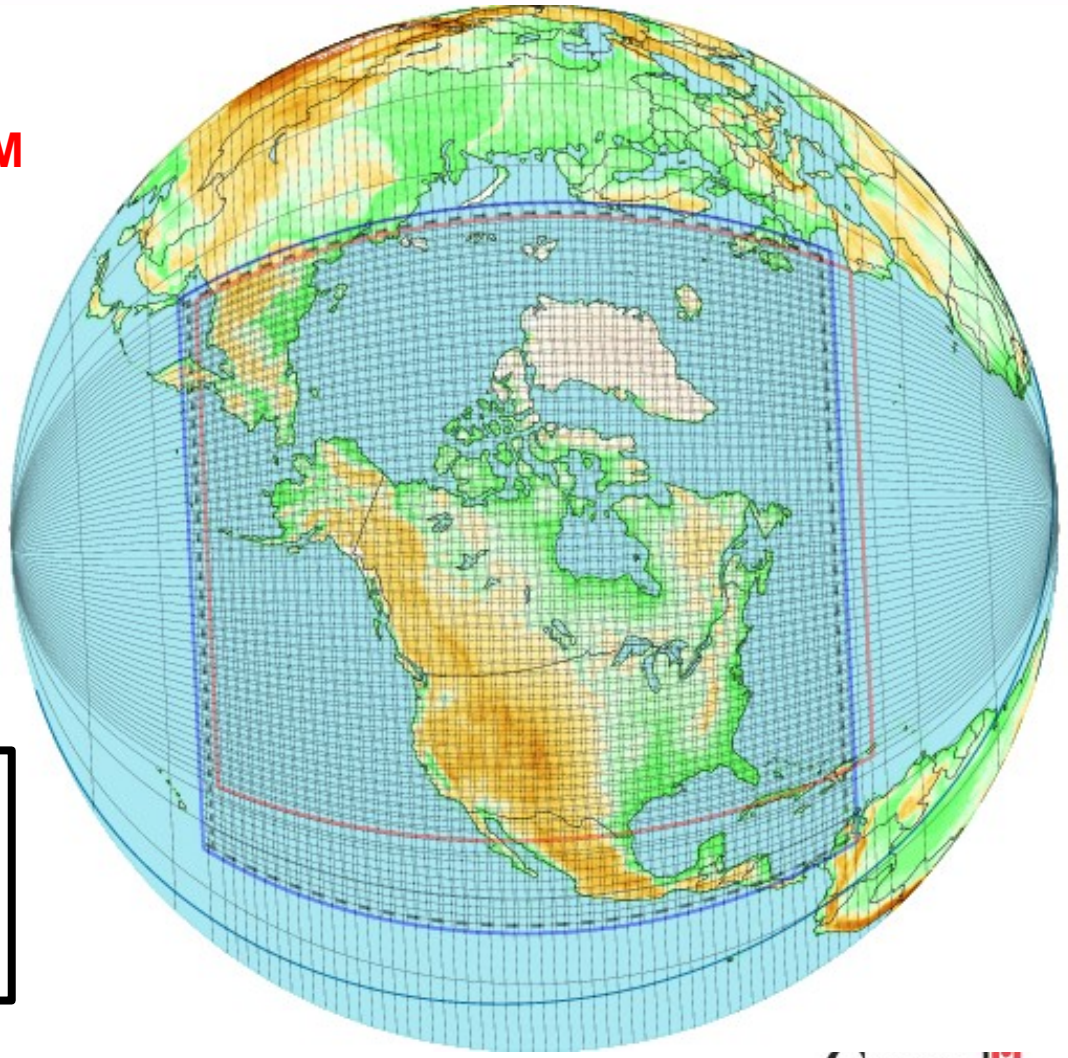
NCOF=National Center for Ocean Forecasting

Next Regional System: REG LAM 3D-Var

Red: Current constant resolution portion of GEM regional grid (15 km)

Blue: Proposed GRID of new REGIONAL LAM, 15-km (649x564) with 3D-Var assimilation at 55 km on LAM domain (173x149)

Boundary conditions provided by GEM global at 55 km, run during the LAM data assimilation step

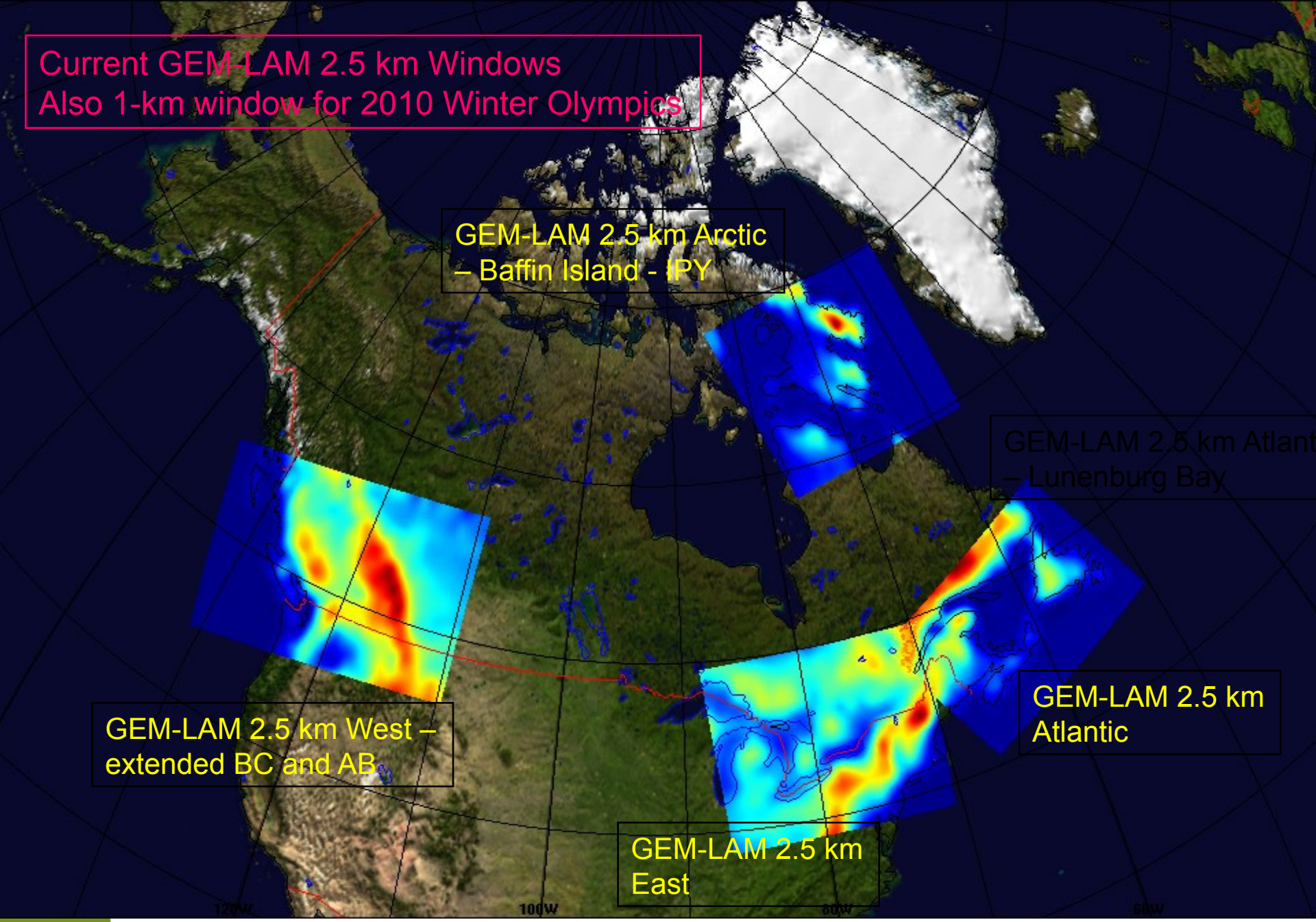


Replacing REGIONAL Model with GEM-LAM at Continental Scale

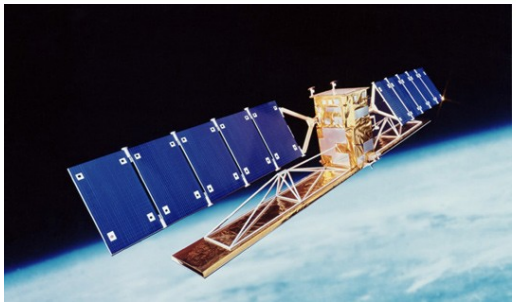
- **REGIONAL LAM (North America)**
  - Separate analysis/forecast from the global system
  - Increments at 55 km rather than current 150 km (T108 or 1.5°)
  - Initial forecast quality to be very similar to that of the operational regional due to conservative approach taken (3D-Var).
  - 4DVAR also possible
- **Many improvements to be included after 2010 Olympics**
  - Diabatic initialization (improving initial vertical motions). Coherent balance between moist physical processes and vertical motion via diabatic tangent linear balance operators in variational analysis (Fillion et al. 2007)
  - Increasing vertical and horizontal resolution, as well as that of the analysis, especially boundary layer. Target is ~10kmL80.
  - Incorporation of meso-scale observations (e.g. radar, BL profilers, satellite, etc.) (cannot be done in global which is still at T108 or 1.5° for the analysis).
  - Background Error Covariance from Ensemble Prediction System

Later Improvements (2010+)

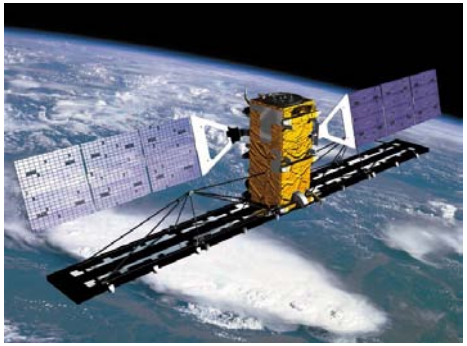
- **LAM at km scale**
  - More frequent analysis (1h versus 6h interval)
  - Analysis resolution can be as high as the forecasting model
  - Focus on PBL moisture and convective stability
  - Coupling with surface (CaLDAS)
- **High Resolution Data Assimilated (3D/4D-Var)**
  - SAR wind speed
  - Ground-based radar (radial winds)
  - Ground-based radiometers
  - Wind Profilers


Current GEM-LAM 2.5 km Windows
Also 1-km window for 2010 Winter Olympics
GEM-LAM 2.5 km Arctic – Baffin Island - IPY
GEM-LAM 2.5 km Atlant – Lunenburg Bay
GEM-LAM 2.5 km West – extended BC and AB
GEM-LAM 2.5 km Atlantic
GEM-LAM 2.5 km East
120W
100W
80W

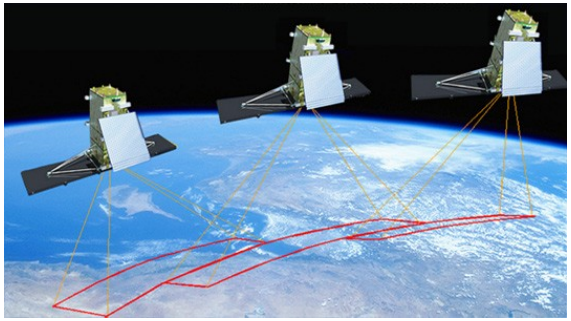
Canada's Radarsat Program



- 1995 –
- polar orbiting SAR at ~800 km
- C-band (5-cm) HH polarization
- first ScanSAR

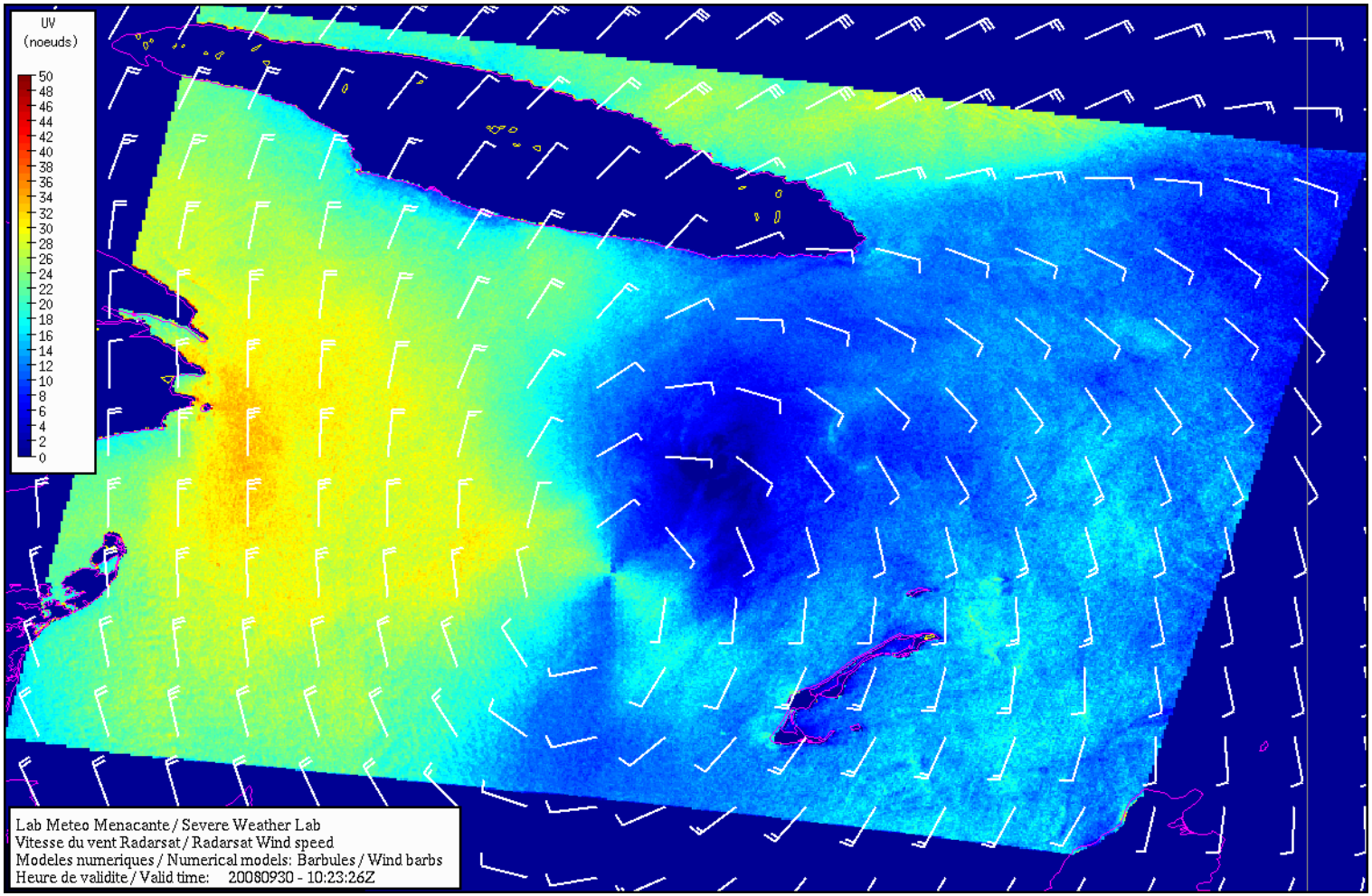


- 2007 –
- HH,VV,HV,VH (quad pol) available
- ftp archive of most scenes



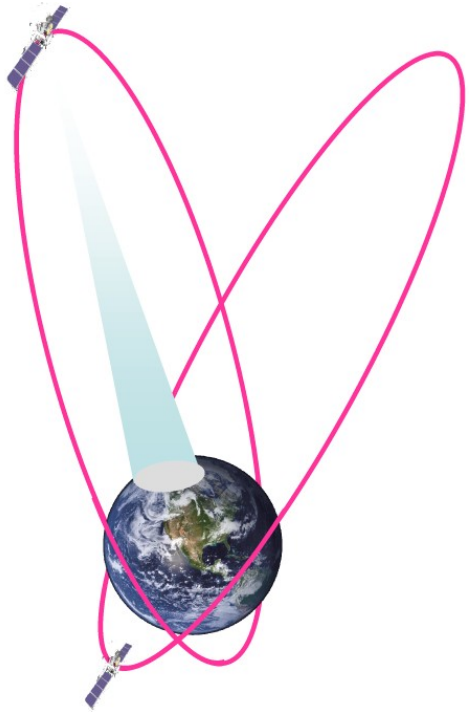
- 2014, 2015, 2016 –
- equally spaced at ~600 km
- ScanSAR with compact polarimetry (circular send, H and V receive)

RADARSAT I Wind Speed



Polar Communications & Weather Satellite

- Mission led by the **Canadian Space Agency**
  - DND, EC, NRCan are partners
  - Reliable communications in the high latitudes (> 70N)
  - Provide high temporal/spatial resolution meteorological data > 50N (e.g. AMV's)
- Concept of 2 satellites in **Molniya 12h orbit** (i.e. Quasi -Geostationary)
- **ABI-like imager** (15-30 minute refresh rate), **2016** timeframe
- Proto-operational (demonstration but NRT data stream)
- Phase 0 completed Fall 2008
- Phase A underway, **opportunities for international cooperation are being examined**
- Mission funding not yet secured (should happen at end of phase A)
- Possibility of broadband radiometer, chemistry payload
- EC: PI Louis Garand; Lead of the PCW project office –Mike Manore (MSC)



Apogee: ~39,500 km
Perigee: ~600 km

Canada

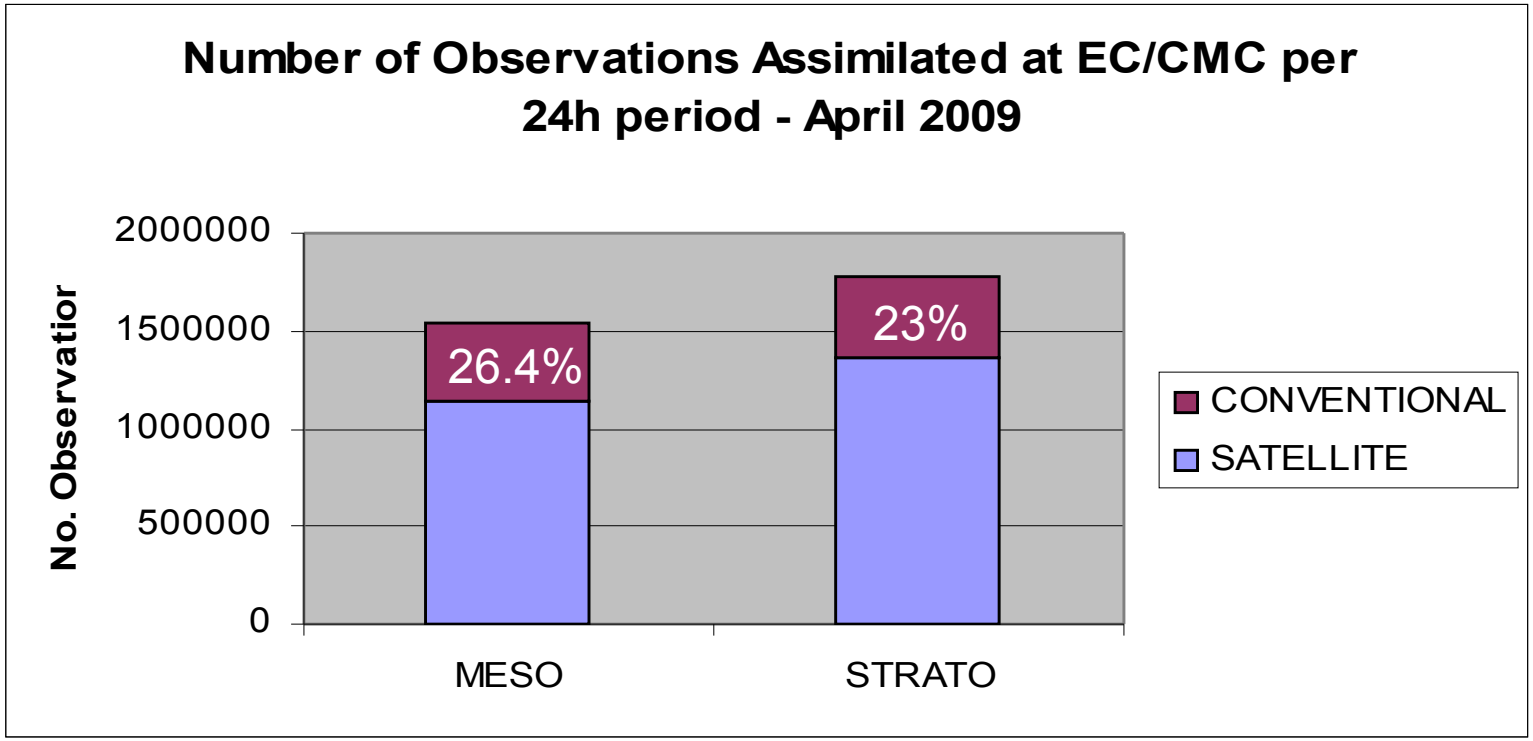
Two other EC/ASTD presentations at this workshop:

1. IR surface sensitive channels (S. Heilliette)

2. Canadian Land Data Assimilation System (M. Carrera)

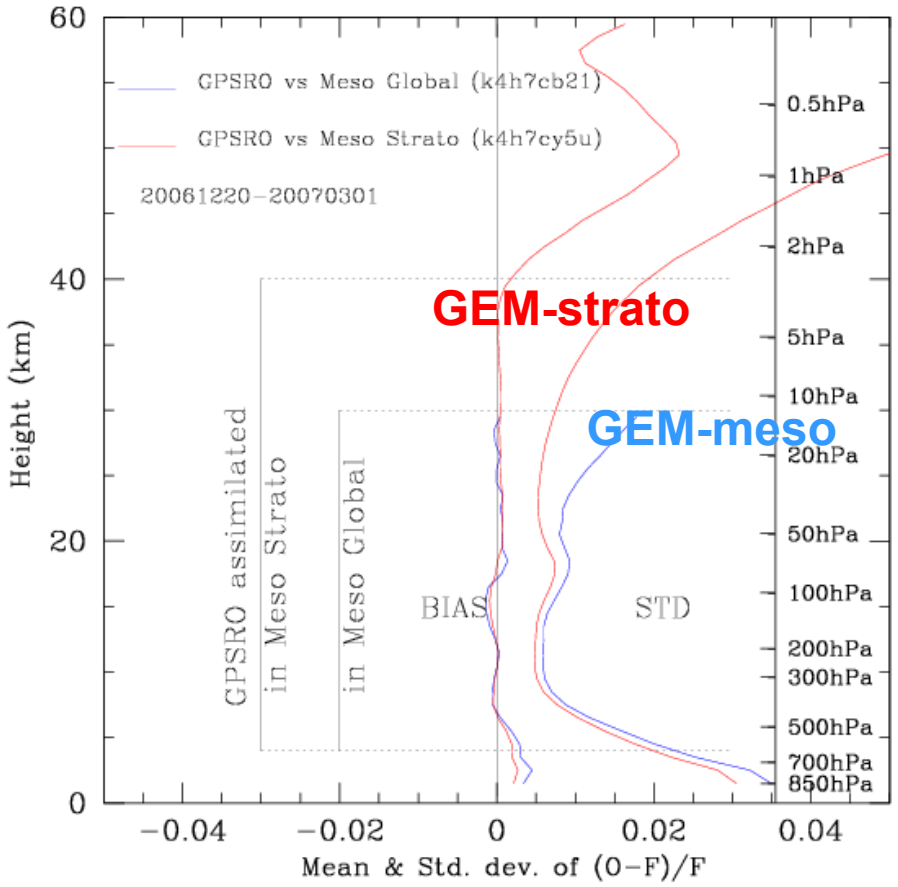
BACKUP SLIDES

Average Number of Observations Assimilated per 24h period- April 2009



GPS RO Observations in GEM

Fractional Refractivity Increment (%)



winter 2006/07

New EC/MSC SST Analysis

INPUT DATA

- NAVO retrievals for NOAA-17, NOAA-18 and METOP-A (45,000 /day from each source)
- **AMSR-E retrievals from RSS gridded on a 0.25° grid (65,000 /day)**
- A/ATSR retrievals from ESA in BUFRr format (17,000 /day)
- Proxy ice data based on the CMC ice analysis (9,000/ day)
- Ships (1500 /day)
- Drifters (1200 /day)
- Moored buoys (200 /day)

ANALYSIS SYSTEM

- Using OI on 1080x540 grid (0.33 deg)
- Once a day
- **Published in Sept. 08 QJRMS, 134 (B. Brassnet)**

MAIN CHANGES

- Incorporating AMSR-E, AVHRR18 and METOP-A retrievals
- Improving analysis resolution 0.33° → 0.2°
- Reducing the background error correlation length scales
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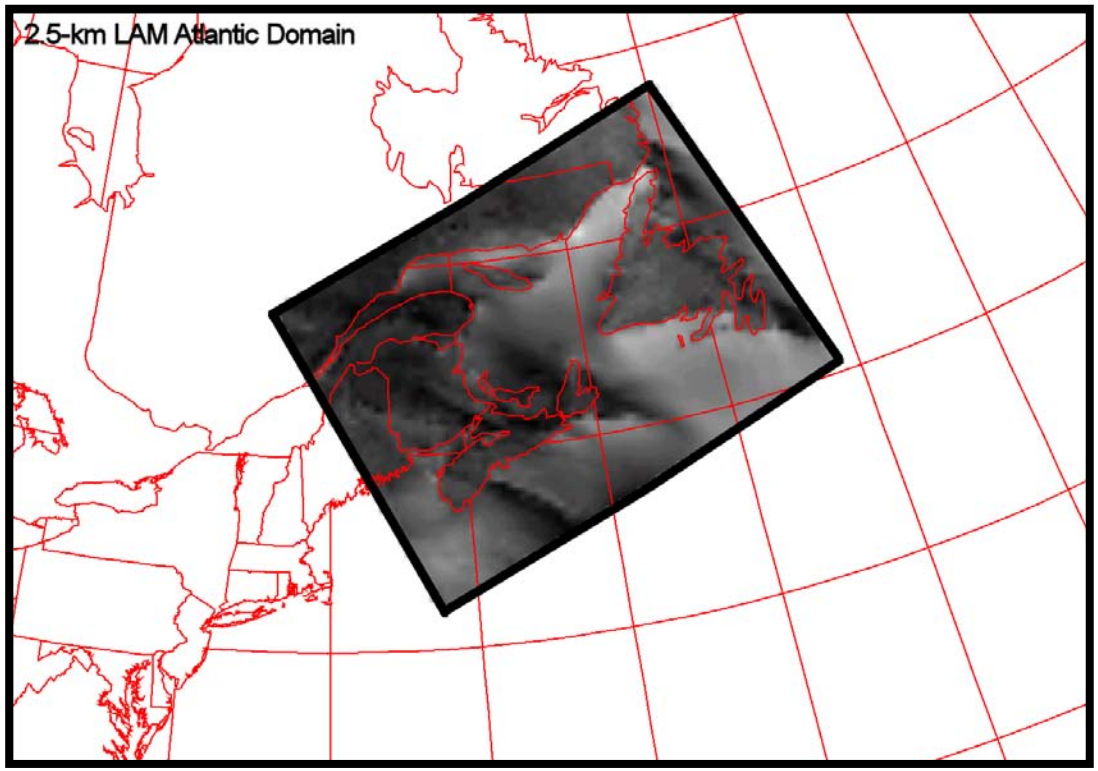
Assimilation of SAR Backscatter into GEM LAM 2.5 Atlantic Window: Project co-funded by CSA



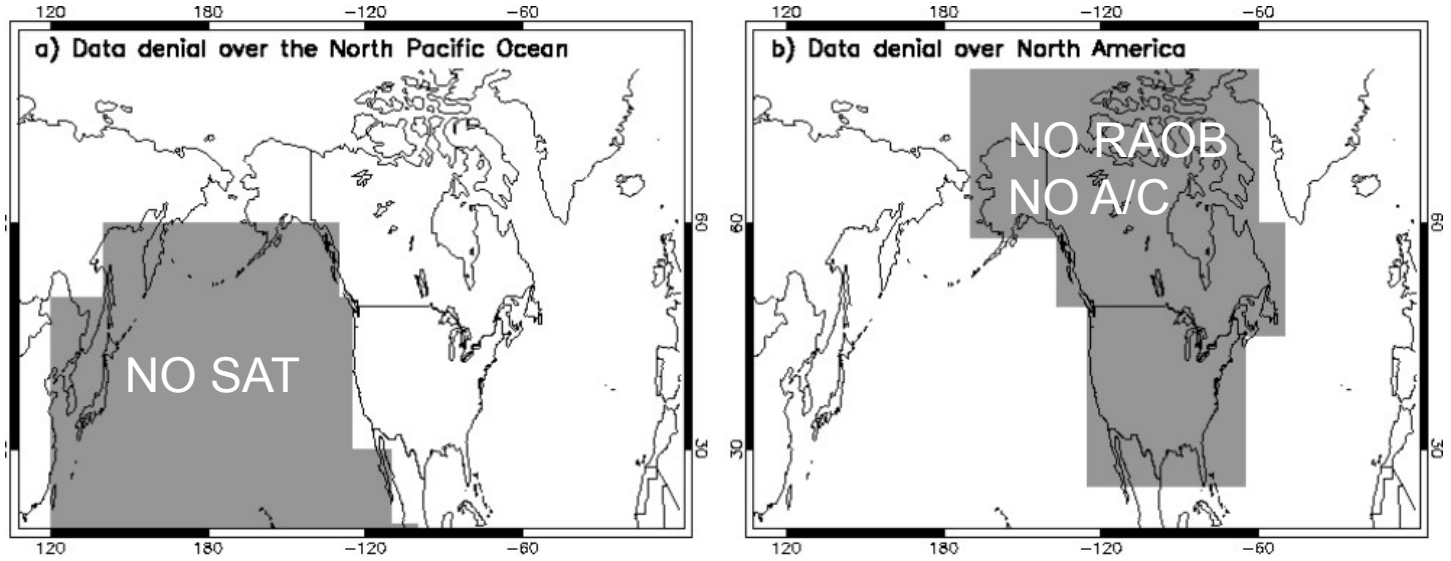
OSE's: January & February 2007

Forecast RMSE reduction for Z500 over North America in the MSC forecast systems over the recent years

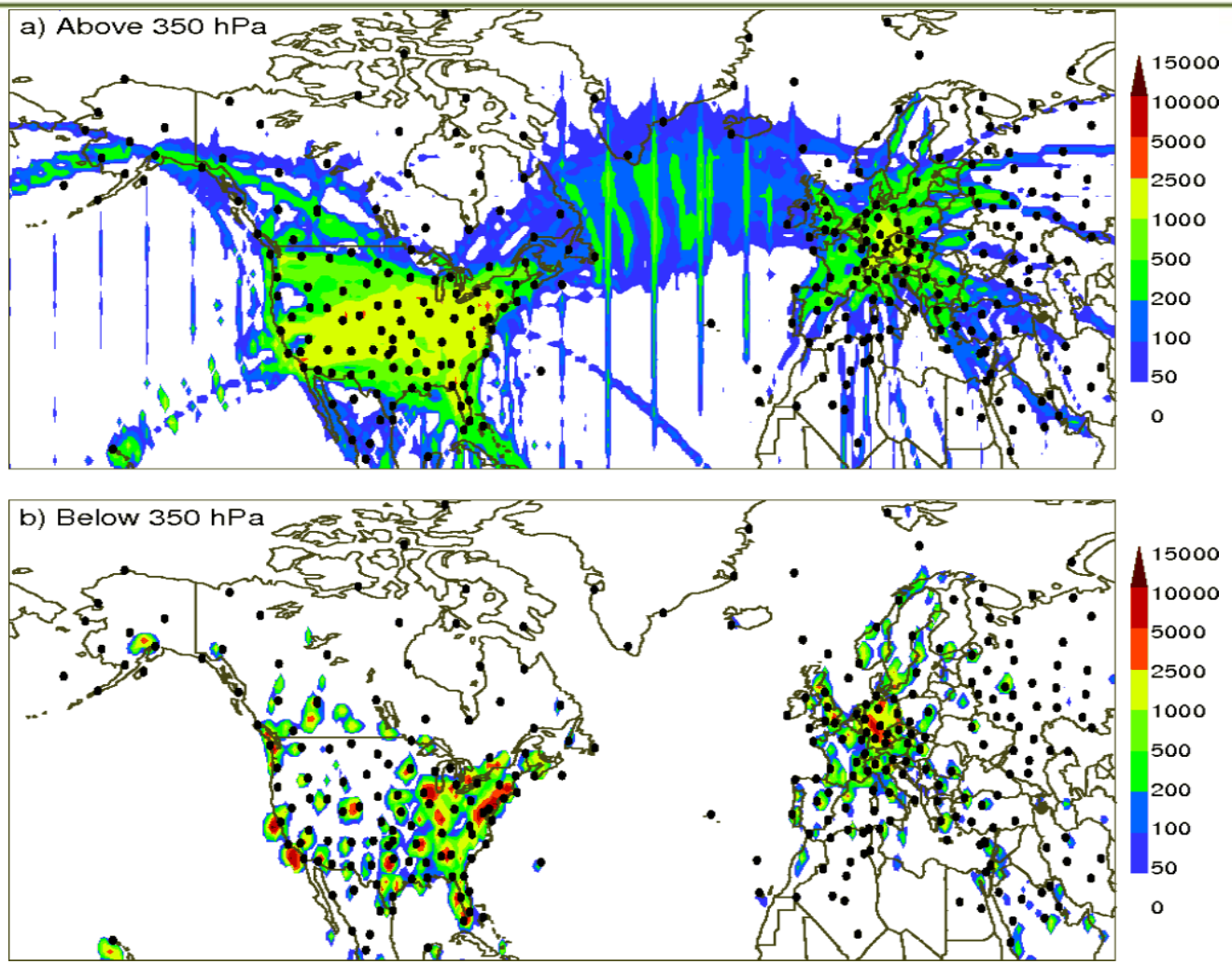
$$\mathrm{FI} = 100 \times \frac{RMSE(\mathrm{exp}) - RMSE(\mathrm{cnt})}{RMSE(\mathrm{cnt})}$$

Laroche et al. 2009a,b

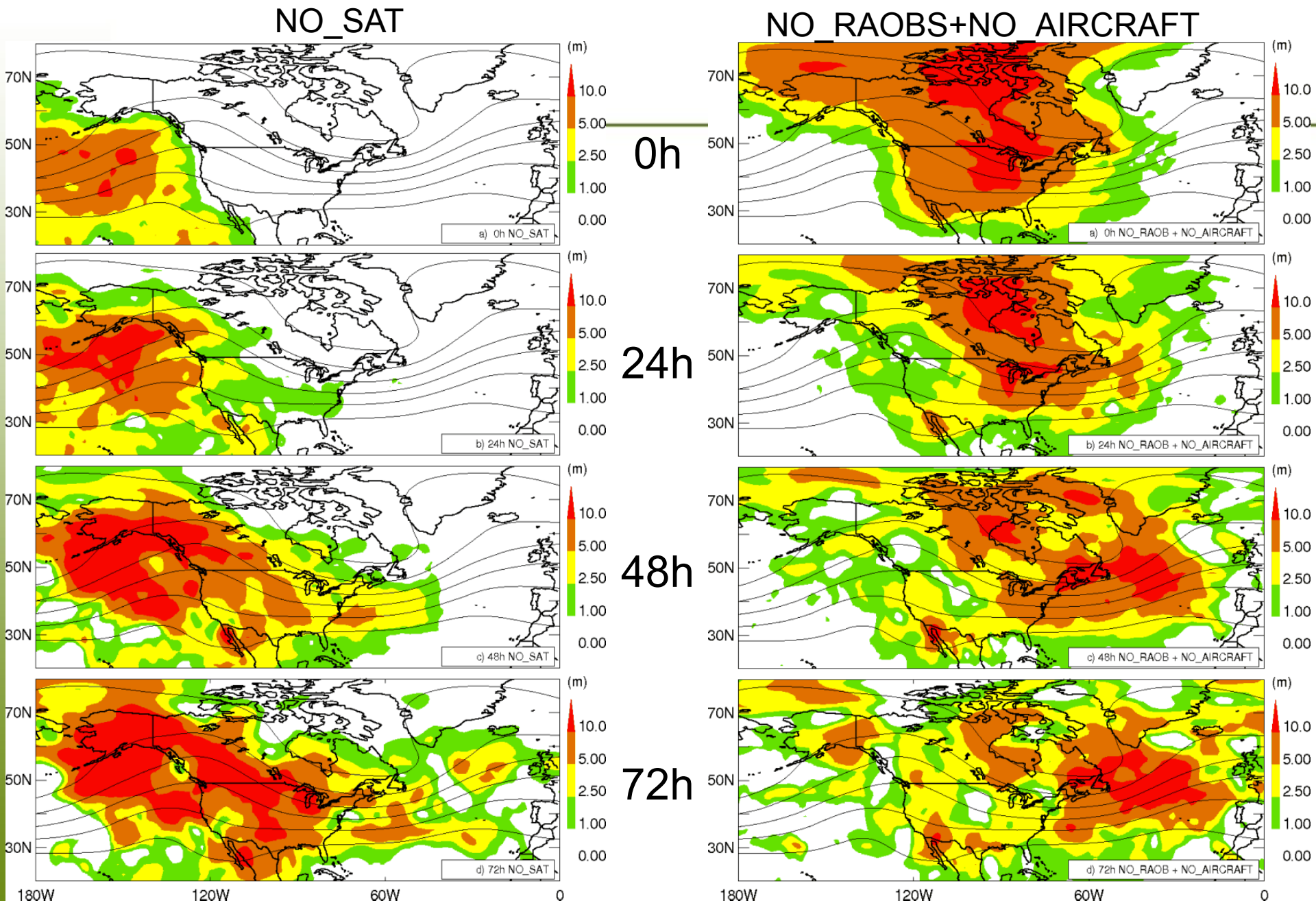
Data Denial Regions



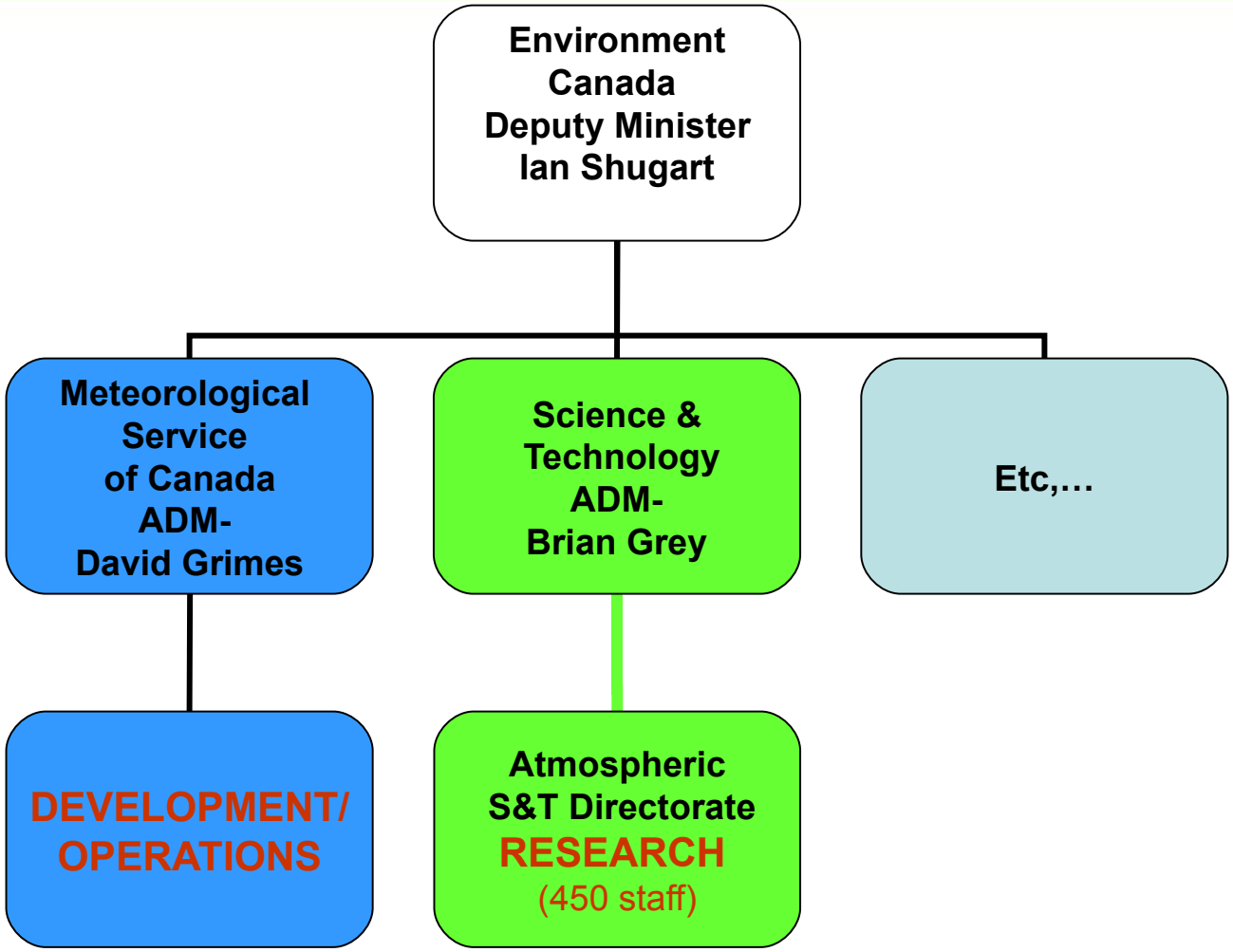
Aircraft Reports Assimilated During January and February 2007 and Radiosonde Stations (black dots)



RMSE Differences for Z500 (4D-Var/100 km)



Research, Development, Operations



EC/ Atmospheric Science & Technology Directorate