Development of the Canadian Precipitation Analysis (CaPA) and the Canadian Land Data Assimilation System (CaLDAS)

Marco L. Carrera, Vincent Fortin and Stéphane Bélair

Meteorological Research Division

Environment Canada

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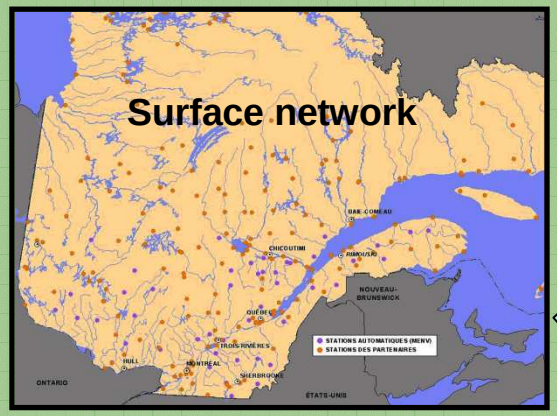
Objectives : Canadian Precipitation Analysis (CaPA)

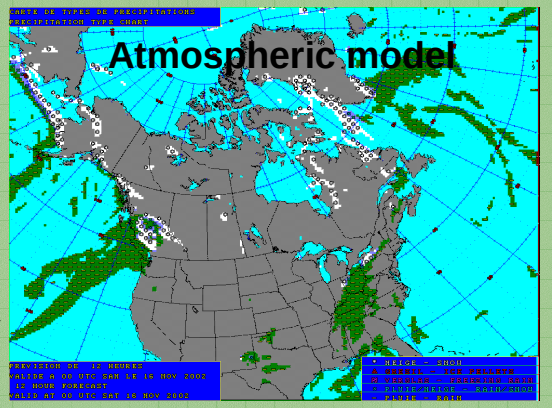
- *Combine different sources of information on precipitation into a single, near real-time analysis.*

- ***Use this analysis to** :*
  - *perform quantitative precipitation forecast (QPF) verification;*
  - *provide input precipitation forcing for Environment Canada's land-surface and hydrology modeling systems, including the Canadian Land Data Assimilation System (CaLDAS) which is currently under development;*
  - *perform nowcasting of precipitation;*
  - *climate and drought monitoring and case study analysis*

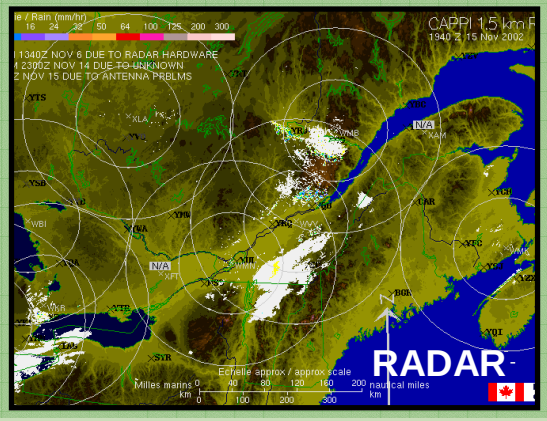
Information Sources : Precipitation

Direct and Indirect measurements





CaPA



Characteristics of each data source

- **Surface network in Canada**
  - *Density is often less than the correlation length scale*
  - *Direct interpolation of station data can be dangerous*
- **Radar data in Canada**
  - *Incomplete radar coverage*
  - *Calibration issues still need to be resolved*
- **Satellite imagery at latitudes > 45º**
  - *Detection of clear sky areas possible*
  - *Quantitative precipitation estimates lack the necessary accuracy*
- **Short-term forecast from atmospheric model**
  - *Available everywhere*
  - *relatively good quality for lead times between 6h and 24h owing to the data assimilation process used to initialize the model*

CaPA Methodology

- *CaPA is designed to combine different types of observations of precipitation with a first guess (or background field) to obtain a gridded analysis of precipitation. Background field (or first-guess) is a 6-hour precipitation forecast from the regional GEM (Global Environmental Multiscale) model.*

- *CaPA is constructed using the Optimum Interpolation (OI) procedure, which is already used at the Canadian Meteorological Centre to produce screen-level analyses of several meteorological variables (e.g., SST, snow depth, dew point depression).*

- *The OI technique performs the analysis on innovations (differences between an observation and the corresponding background value). The OI technique requires the specification of error statistics associated with each piece of information used to construct the analysis (i.e., observations and background field).*

Observational Database

- *Observational database used by CaPA consists of surface synoptic reports of 6-hour precipitation accumulations from the **SYNOP** network.*

- *Two networks, a regional surface network RMCQ (Réseau Météorologique Coopératif du Québec) and a MESONET network enhance the CaPA observational database within the province of Quebec (hope to incorporate data from other provincial cooperative networks).*

- *Cooperative (COOP) network of precipitation measurements from the U.S. The COOP network is used for the 24-hr CaPA analysis from 1200 UTC to 1200 UTC.*

Cooperative Observing Network in Quebec

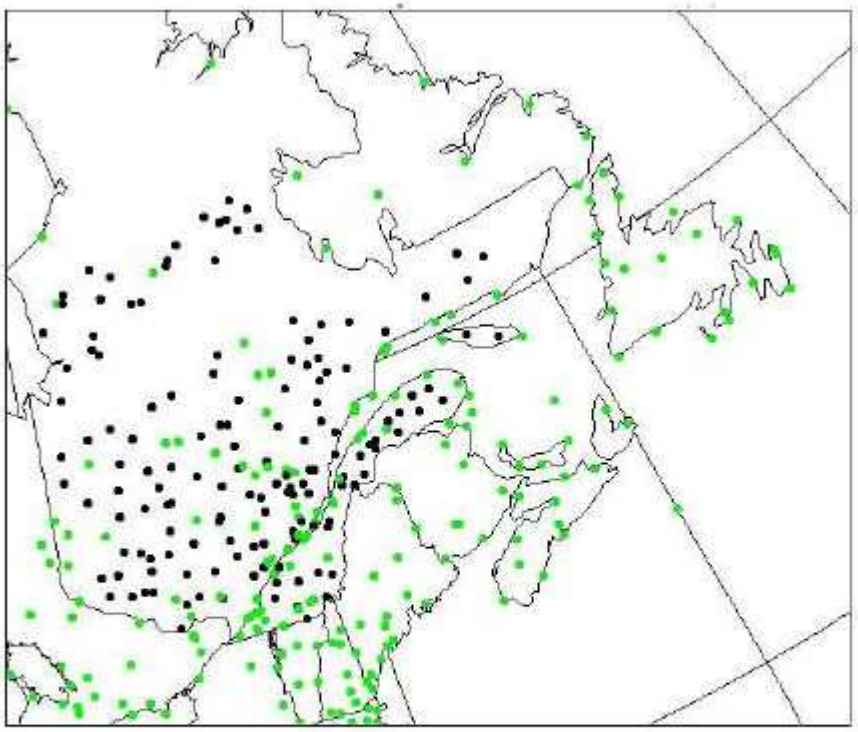


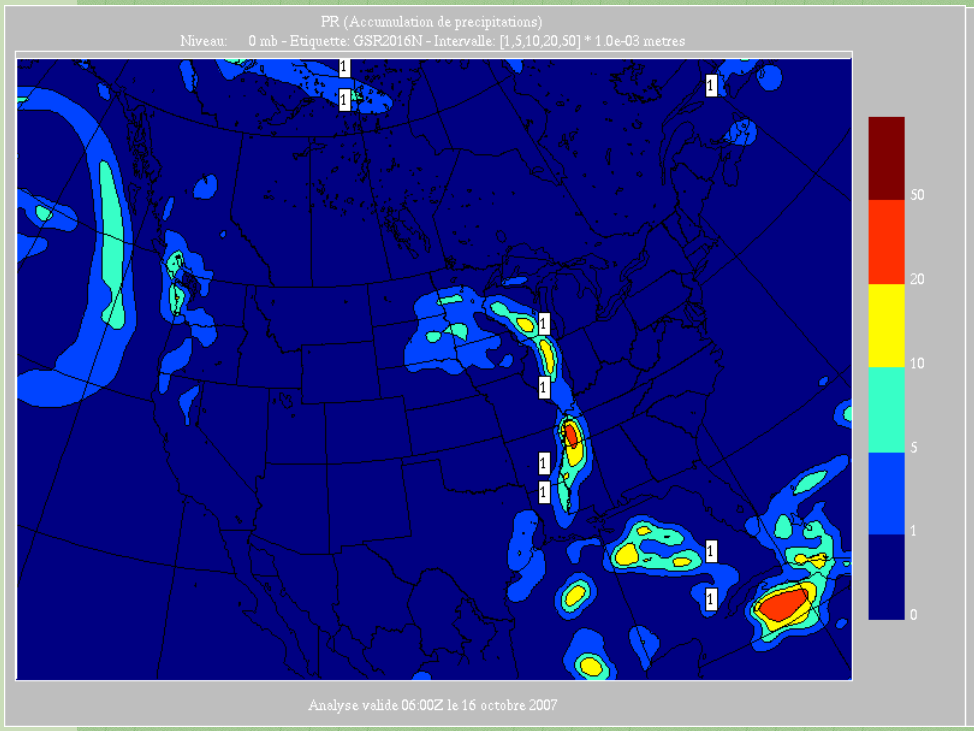
Figure 2: Analysis domain over Québec, The surface stations correspond to available 6-h accumulated precipitation from SYNOP, METAR (grey circles) and RMCQ (black circles) reports for the 02 August 2003 between 06 Z and 12 Z. The number of reports is 404.

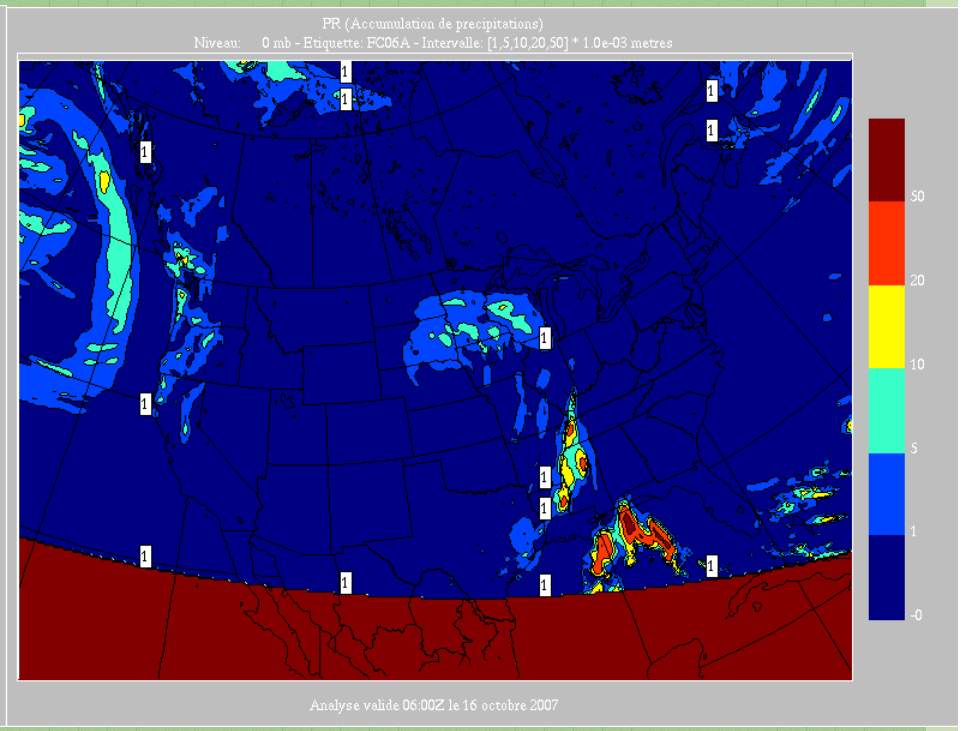
- 100 SYNOP
- 110 RMCQ-BUFR
- 200 RMCQ-BDQ

CaPA vs Current Global OI Precipitation Analysis

6-hr Precipitation Accumulation Ending

0600 UTC 17 October 2007 (mm)



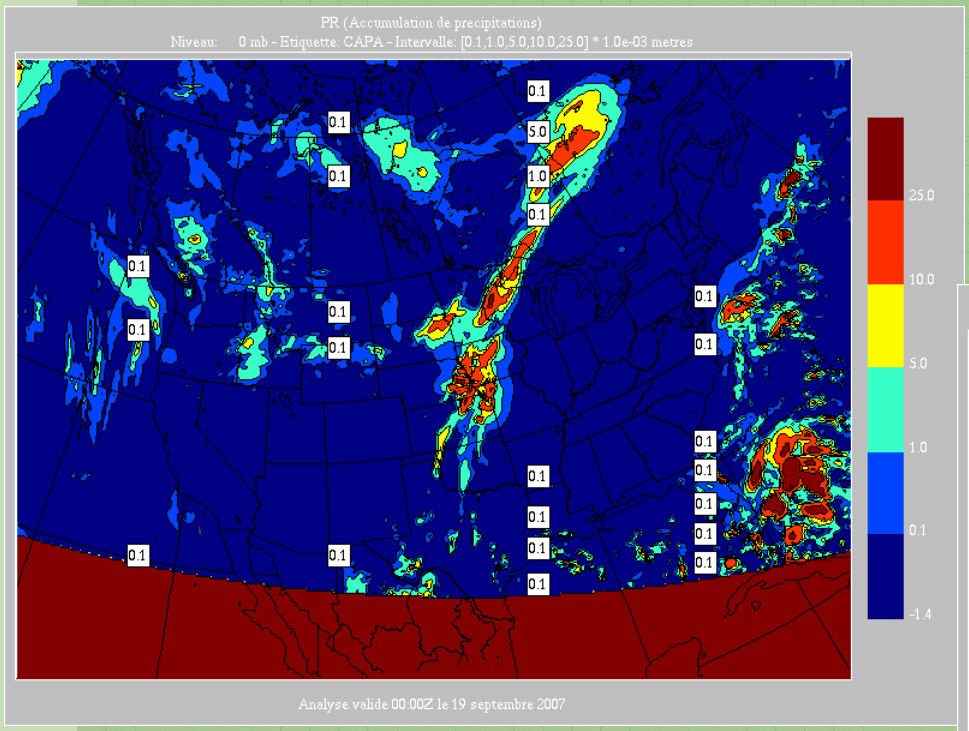


Global OI Precipitation Analysis

Meso-global GEM as background

CaPA Precipitation Analysis

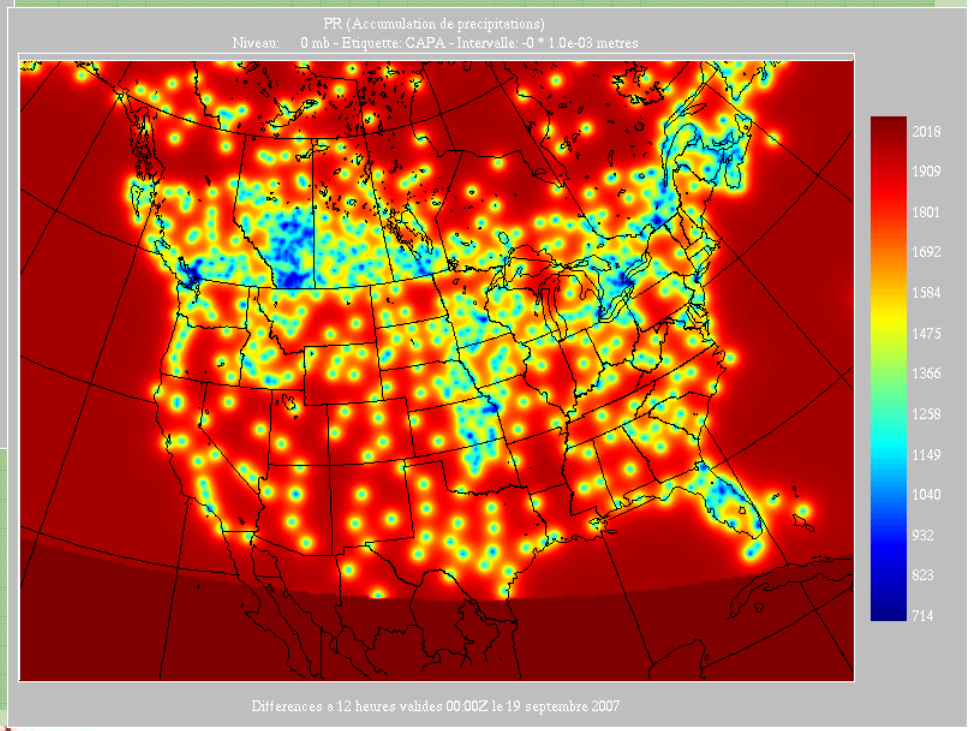
Figures Produced every 6-hours



CaPA Analysis

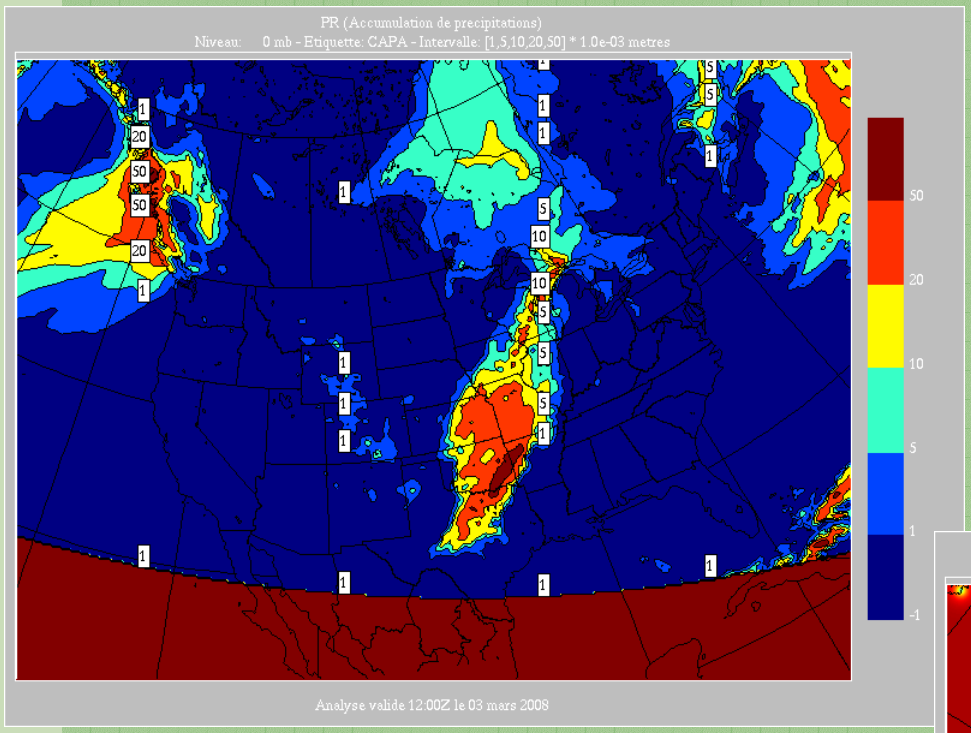
Standard Error of CaPA Analysis

High network density corresponds with lower standard errors

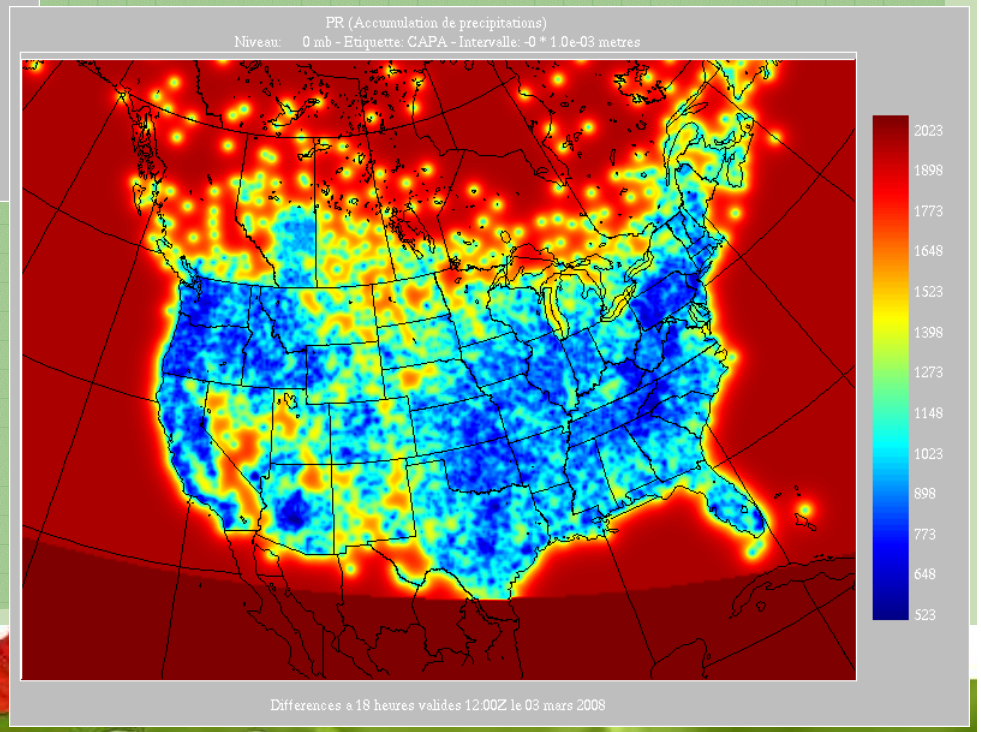


24-h Precipitation Product

CaPA : SYNOP + SHEF



Standard Error



24-hr Precipitation ending 1200 UTC 3 March 2008

CaPA : Current Status

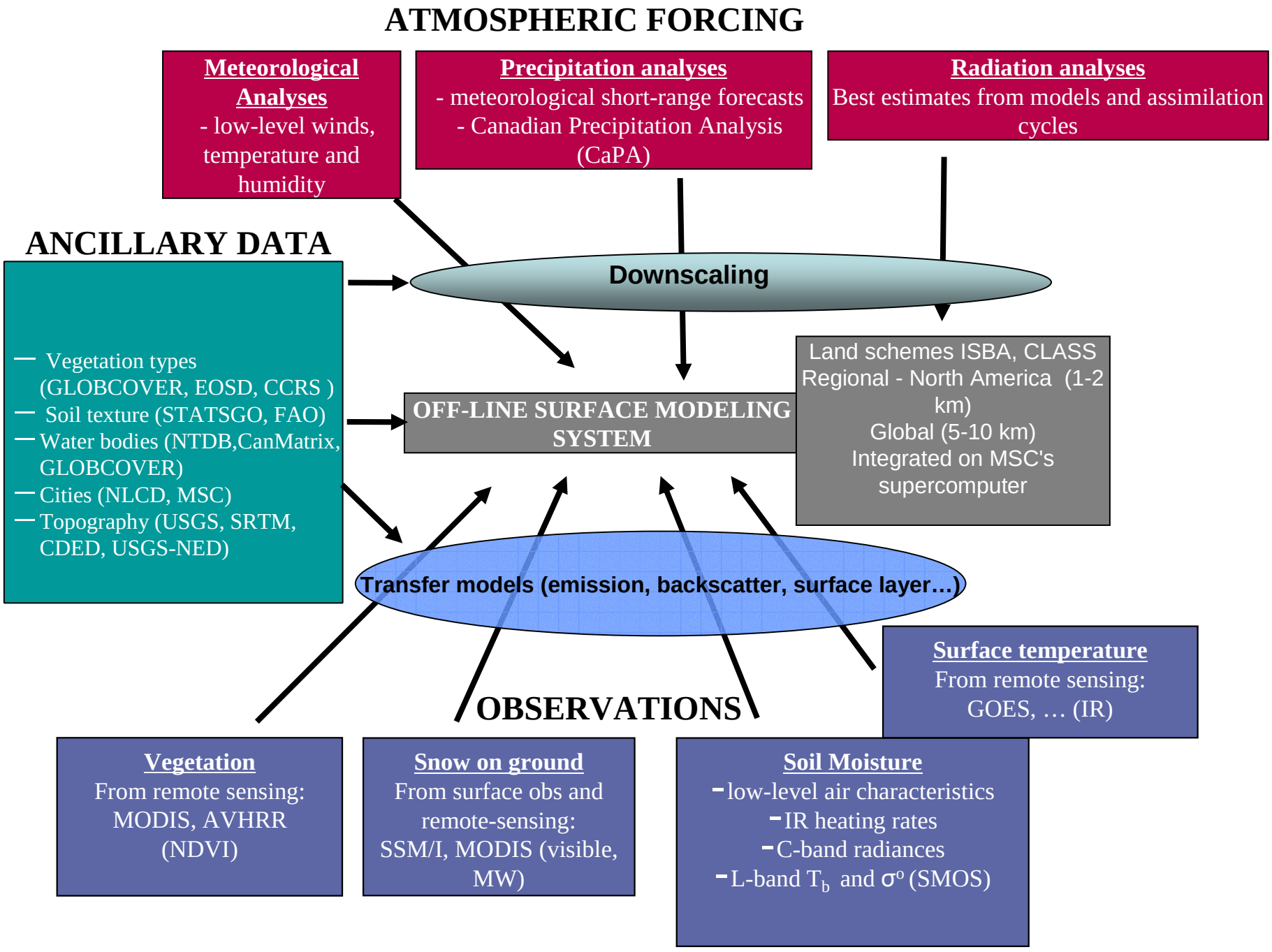
- *CaPA has official been accepted as an operational product and will enter into the operational suite in a parallel run mode.*
- Two analyses will be delivered :
  - *6-hour analysis (every 6-hours) based upon SYNOP data*
  - *24-hour analysis using both SYNOP and US Cooperative data (12Z-12Z)*
  - *The analysis error will be provided for each analysis.*
  - *Users can simply add up successive 6-hour analyses to produce a 24-hour analysis for other time intervals (e.g., 00z-00z)*
  - *Data cut-off will be first tested with a cut-off time of +4hrs.*
- *Available : CaPA retrospective analyses based upon SYNOP data going back to October 2001.*

Future plans for CaPA

- *Incorporate observations from other real-time, quality-controlled, provincial surface co-operative observing networks;*
- *Make use of geostationary satellite data and nowcasting tools to delineate non-precipitating regions;*
- *Develop tools and algorithms to resolve outstanding issues with the incorporation of radar data into CaPA;*
- *Develop methods to reduce the inherent bias with snowfall measurements in CaPA.*

Canadian Land Data Assimilation System (CaLDAS)

- In Environment Canada's current operational systems :
  - **Snow depth** is analyzed using observations from in-situ surface stations ;
  - **Soil moisture** increments are obtained by assimilating screen-level air temperature and humidity data via an optimum interpolation (OI) technique ;
  - **Vegetation characteristics** (e.g., LAI, fractional coverage) are obtained from static land use / land cover databases ;
- In an effort to better represent land surface processes in environmental prediction systems, a new version of the Canadian Land Data Assimilation System (**CaLDAS**) is currently being developed at Environment Canada


ATMOSPHERIC FORCING
Meteorological Analyses
- low-level winds, temperature and humidity
Precipitation analyses
- meteorological short-range forecasts
- Canadian Precipitation Analysis (CaPA)
Radiation analyses
Best estimates from models and assimilation cycles
ANCILLARY DATA
Downscaling
— Vegetation types (GLOBCOVER, EOSD, CCRS)
— Soil texture (STATSGO, FAO)
— Water bodies (NTDB,CanMatrix, GLOBCOVER)
— Cities (NLCD, MSC)
— Topography (USGS, SRTM, CDED, USGS-NED)
OFF-LINE SURFACE MODELING SYSTEM
Land schemes ISBA, CLASS
Regional - North America (1-2 km)
Global (5-10 km)
Integrated on MSC's supercomputer
Transfer models (emission, backscatter, surface layer…)
Surface temperature
From remote sensing:
GOES, … (IR)
OBSERVATIONS
Vegetation
From remote sensing:
MODIS, AVHRR
(NDVI)
Snow on ground
From surface obs and remote-sensing:
SSM/I, MODIS (visible, MW)
Soil Moisture
- low-level air characteristics
- IR heating rates
- C-band radiances
- L-band T_b and σ^o (SMOS)

SOIL MOISTURE in CaLDAS

REMOTE-SENSING

SMOS *(L-band) – to be launched in 2009 (ESA)*

SMAP *(L-band) - to be launched in 2013 (NASA)*

NEW APPROACH – NEXT SYSTEM

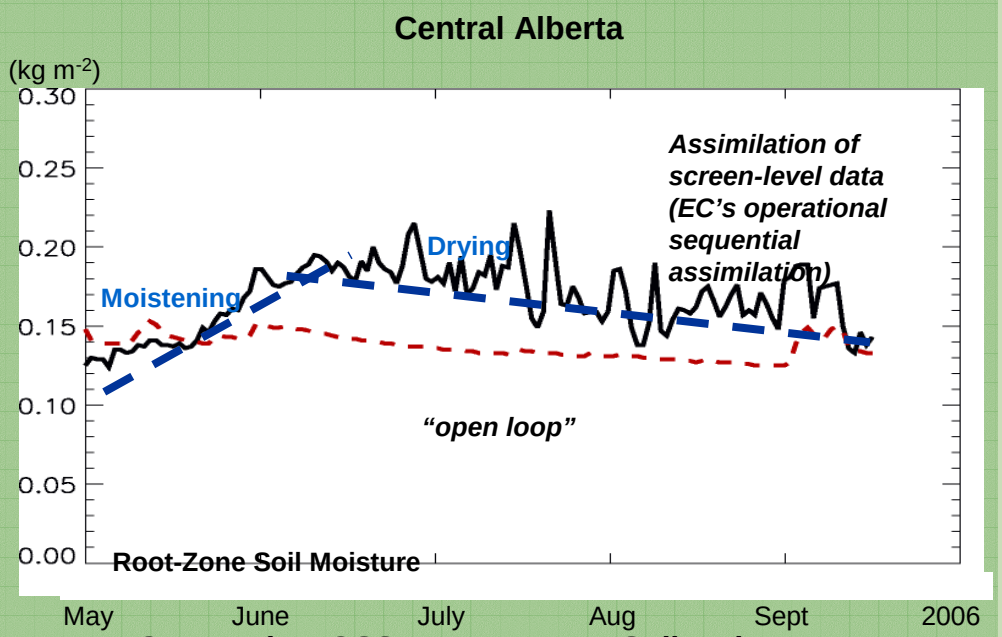
Improved technique for the assimilation of remote sensing data (in addition to screen-level data), based either on variational or Kalman Filter (Extended or Ensemble) approaches.

RESEARCH THEMES

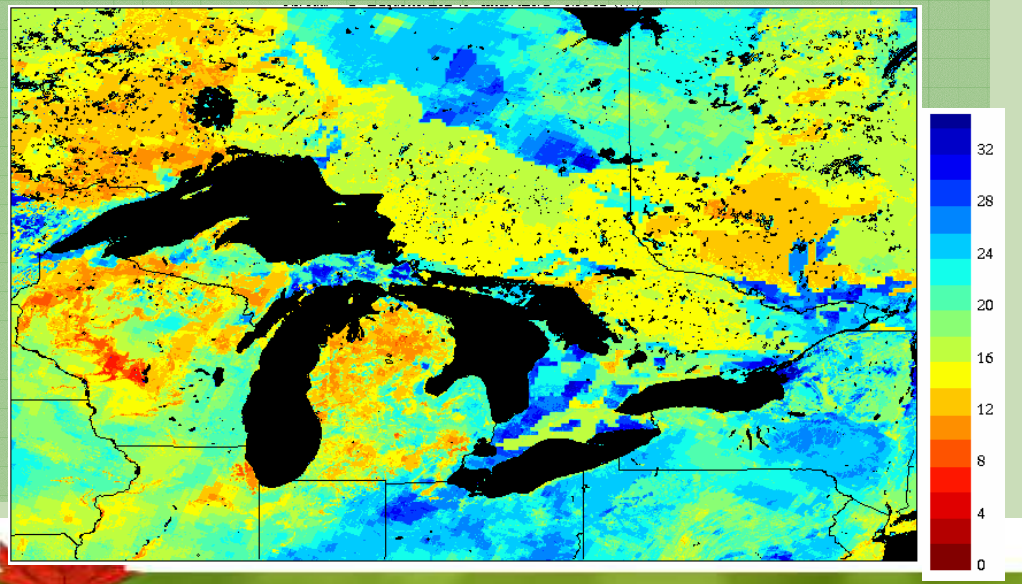
Added value with respect to assimilation of screen-level data only (on NWP and hydrology)

Specification / calculation of **B** *and* **R**

Observation operators (for both passive and active data)



Great Lakes OSSE – Root Zone Soil Moisture



(Valid 0000 UTC 19 May 2007)