

SMAP Data in the Canadian Land Data Assimilation System (CaLDAS) and Potential Impact on Environmental Prediction Systems

SMAP Canadian Workshop, Montreal Biosphere, October 2009

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*Science and Technology Branch,
Environment Canada*

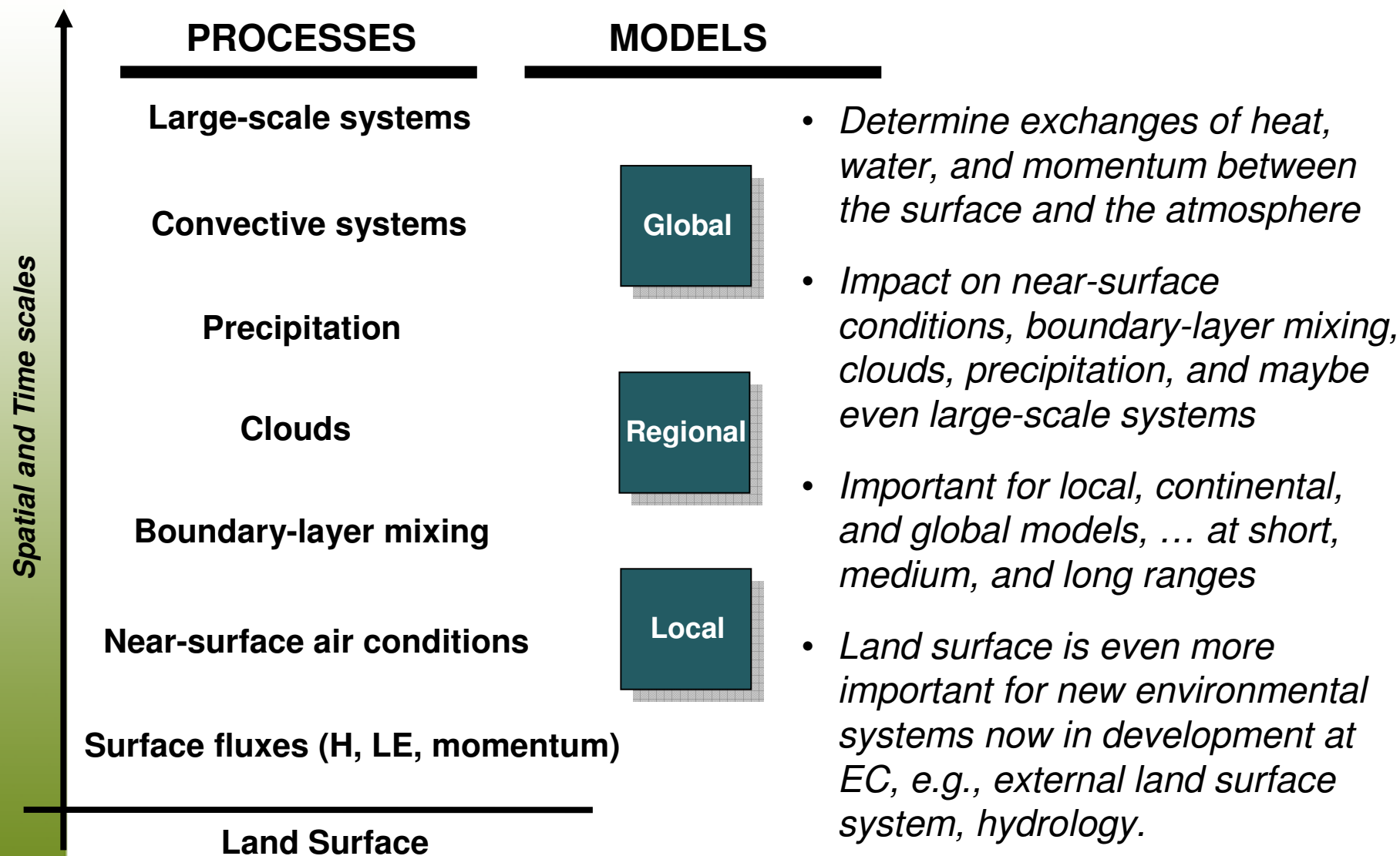


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Environnement
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SOIL MOISTURE and NUMERICAL WEATHER PREDICTION (NWP)

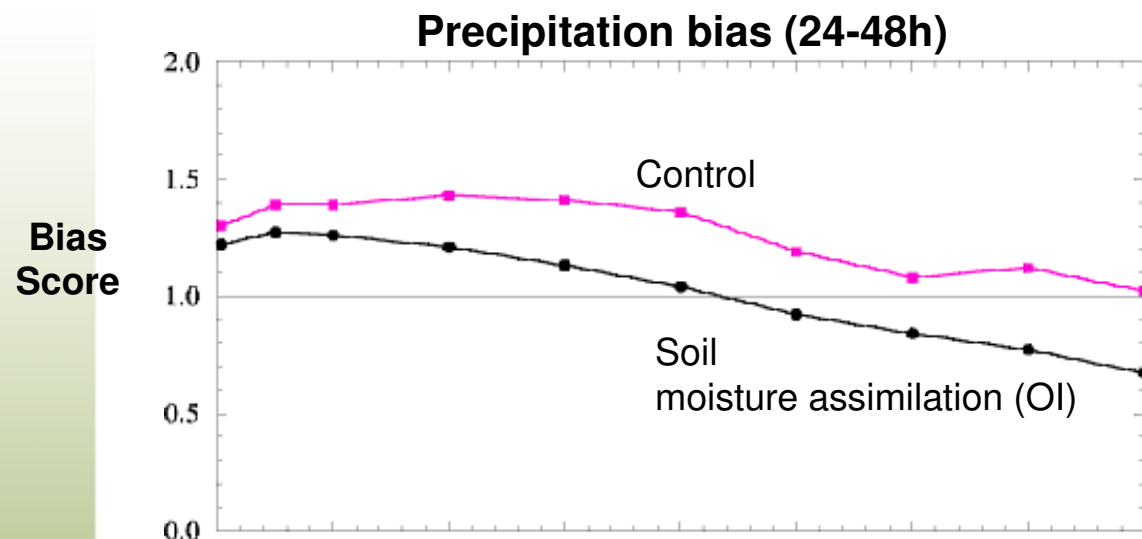


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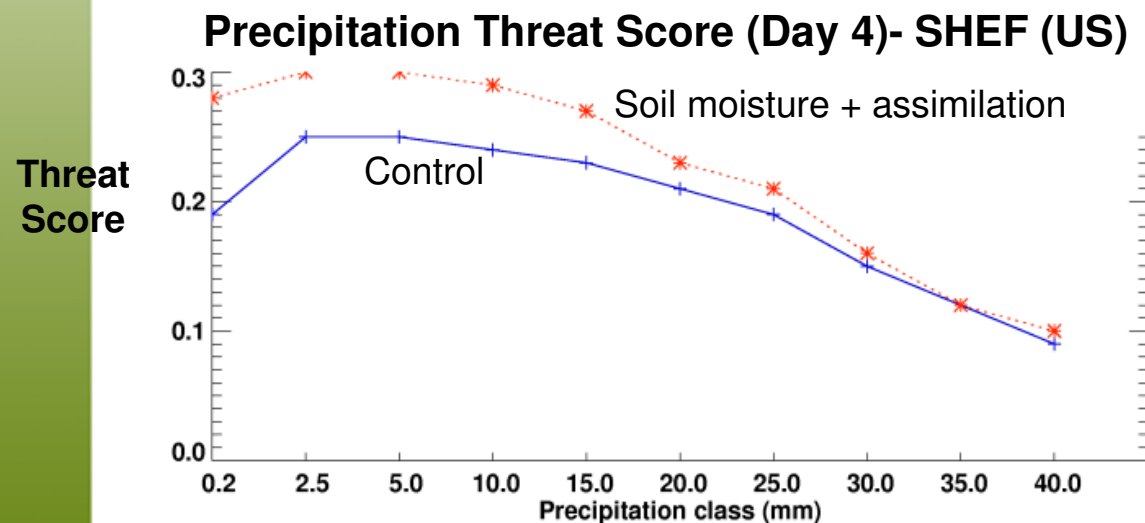
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IMPACT on PRECIPITATION



**REGIONAL
FORECASTING SYSTEM
(2001)**

48 CASES



**GLOBAL
FORECASTING SYSTEM
(2006)**

116 CASES

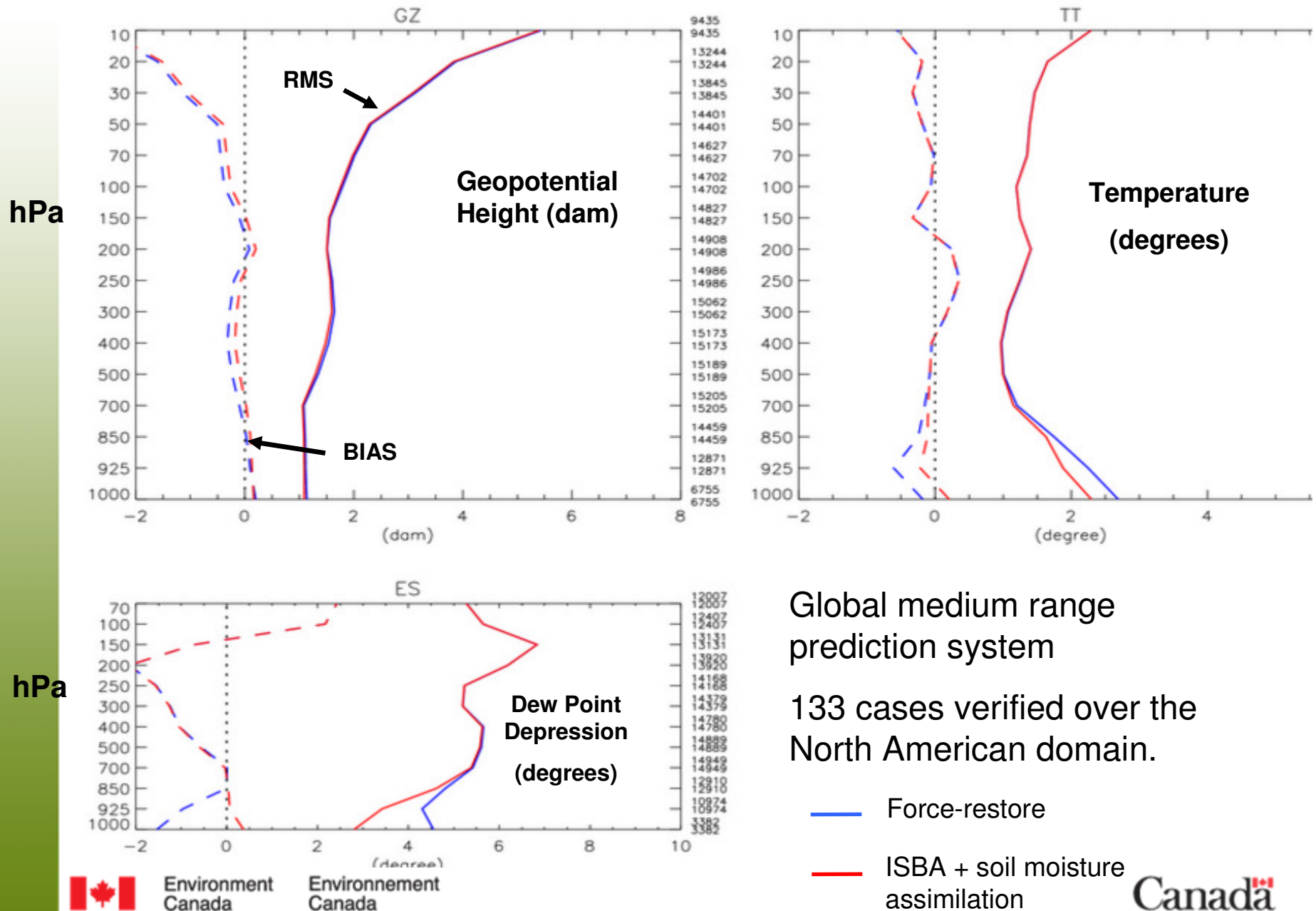


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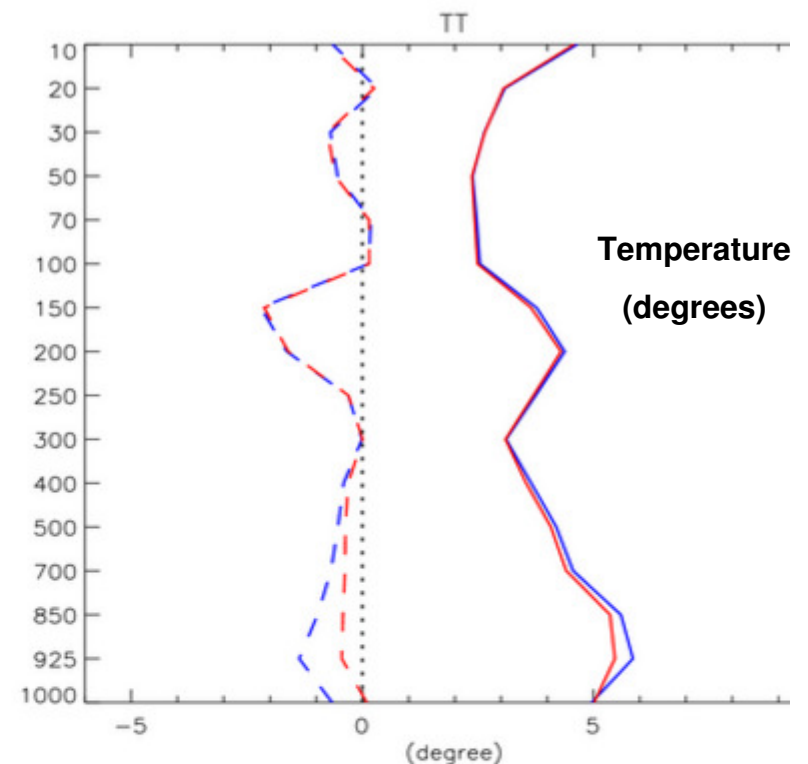
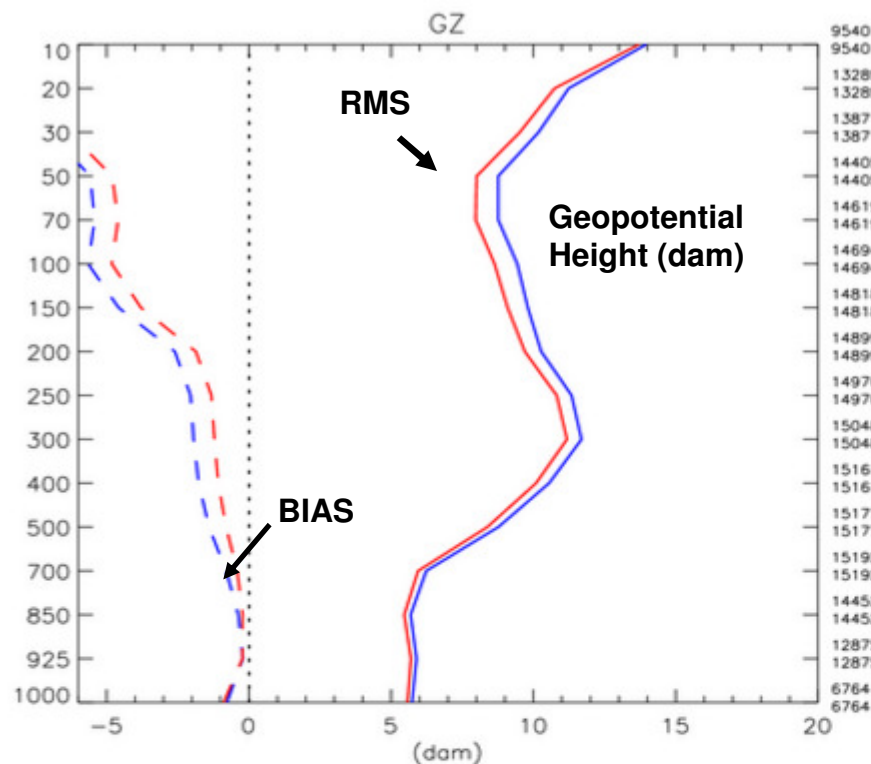
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IMPACT on LARGE SCALE (UPPER-AIR) EVALUATION (24h; day 1)

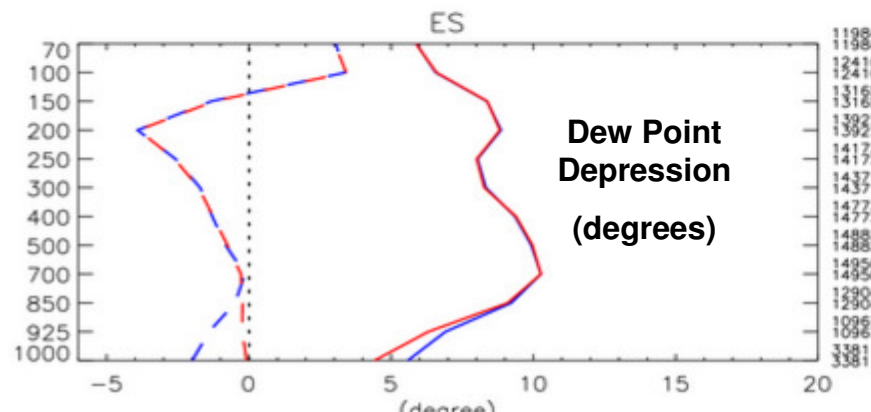


IMPACT on LARGE SCALE (UPPER-AIR) EVALUATION (144h; day 6)

hPa



hPa



Global medium range prediction system

133 cases verified over the North American domain.

Force-restore

ISBA + soil moisture assimilation

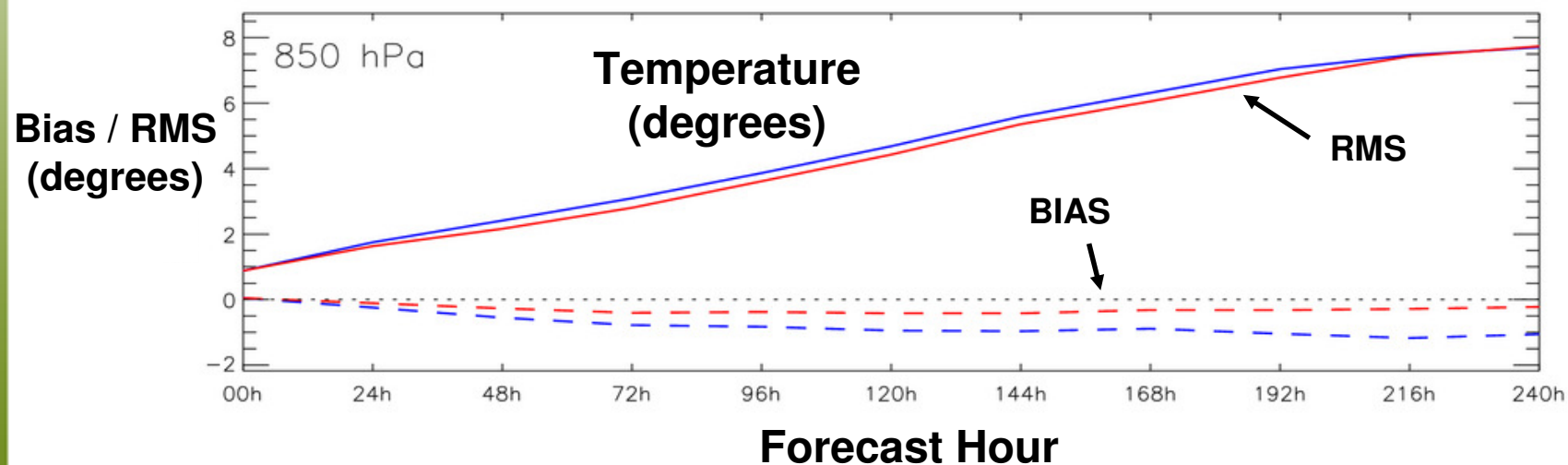
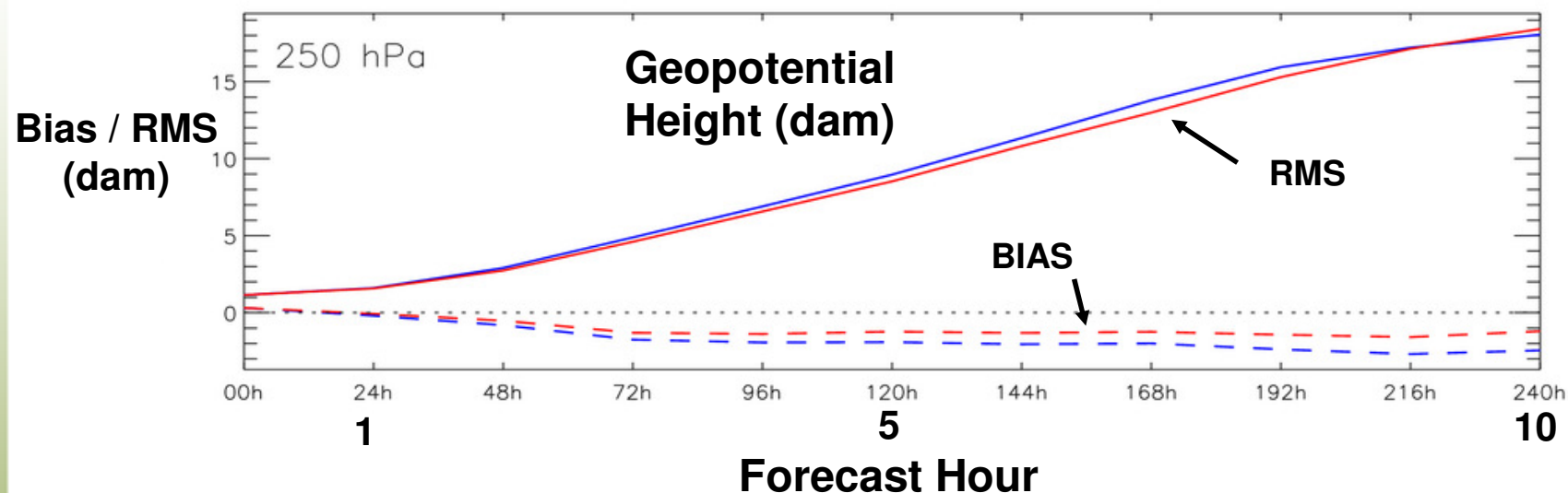


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IMPACT on LARGE SCALE (UPPER-AIR) EVALUATION



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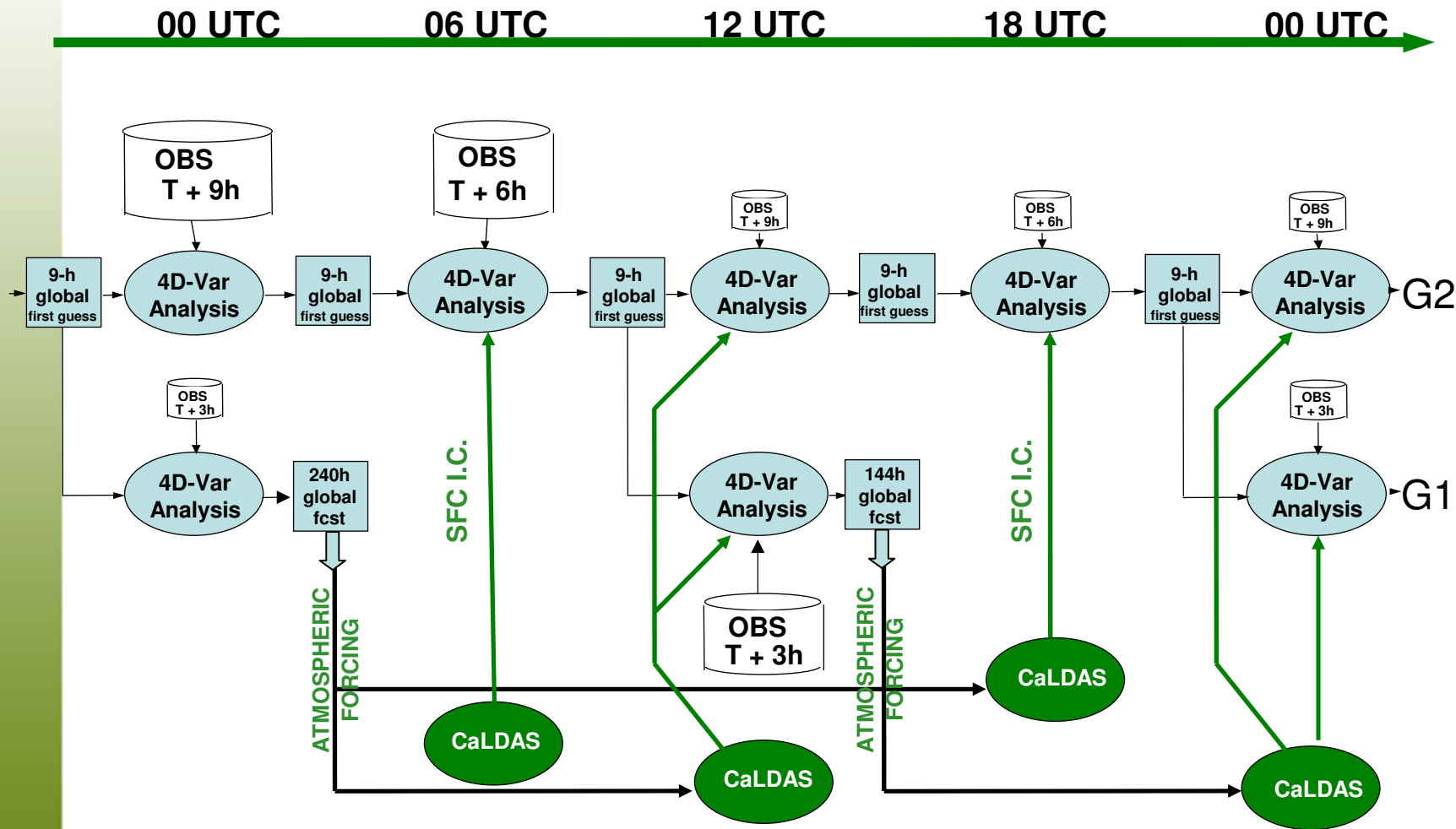
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— Force-restore

— ISBA + soil moisture
assimilation

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CaLDAS within the Global model data assimilation cycle



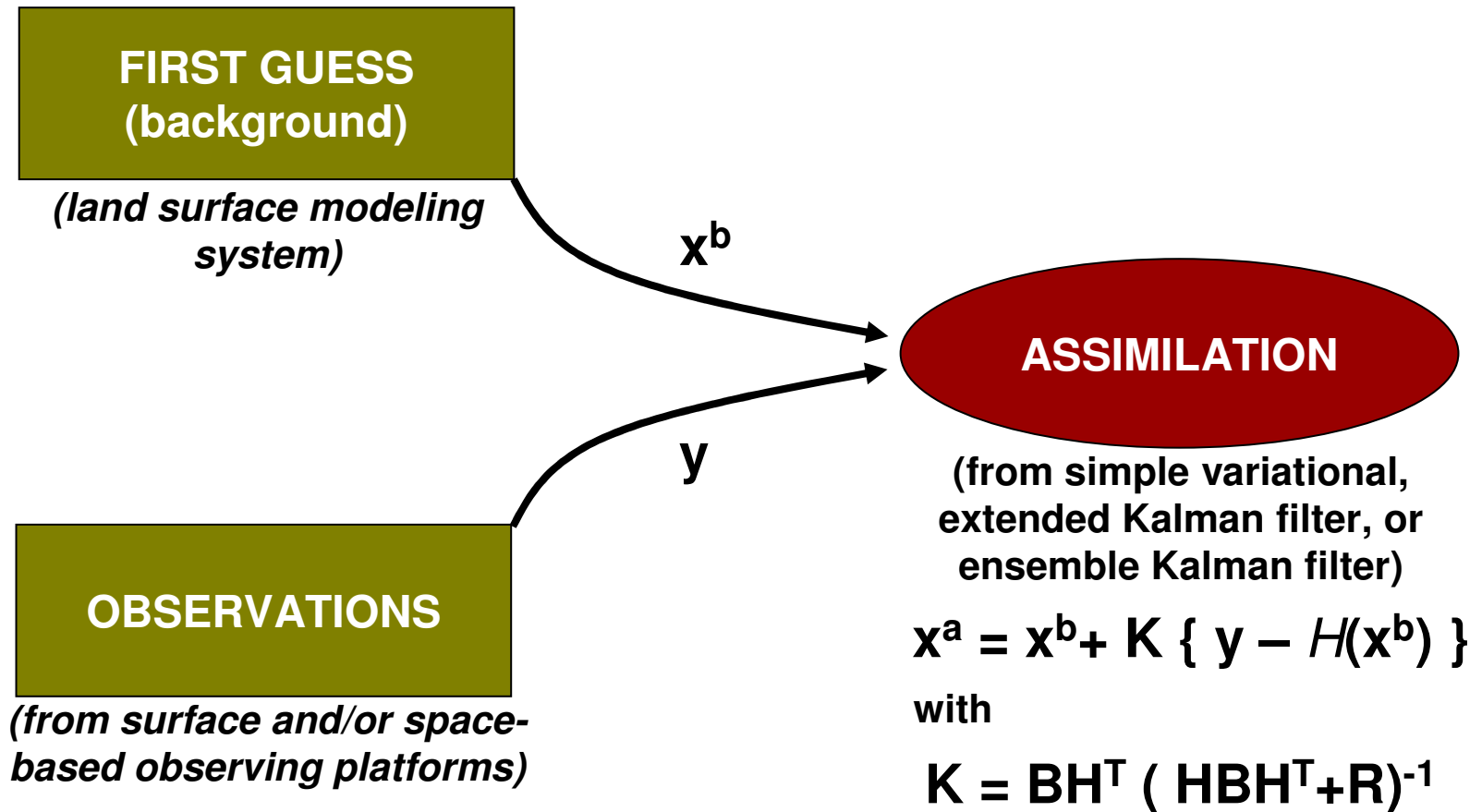
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G2 = Global Assimilation Cycle
G1 = Global Forecast Run

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GENERAL CONCEPT of LAND DATA ASSIMILATION

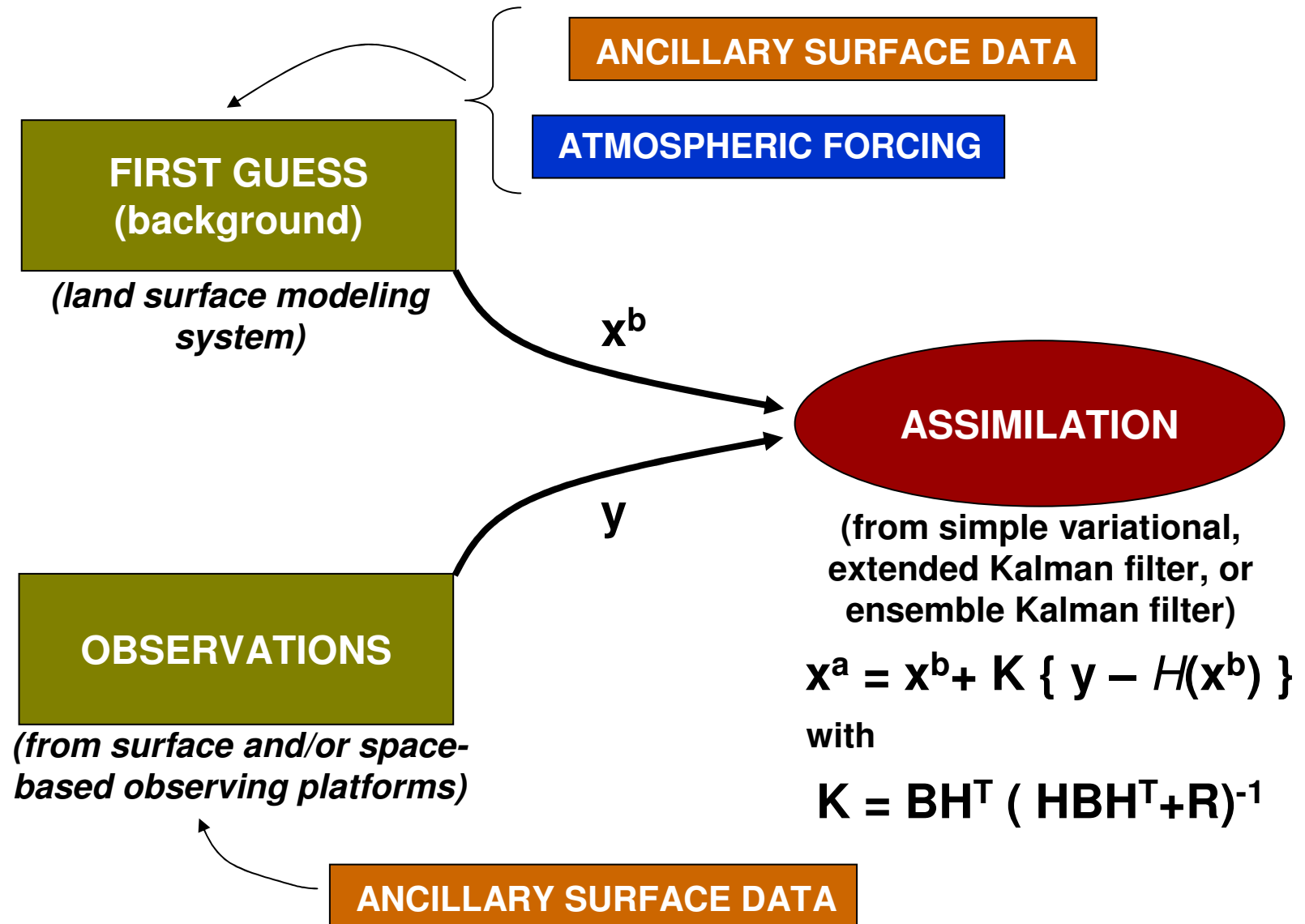


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GENERAL CONCEPT of LAND DATA ASSIMILATION

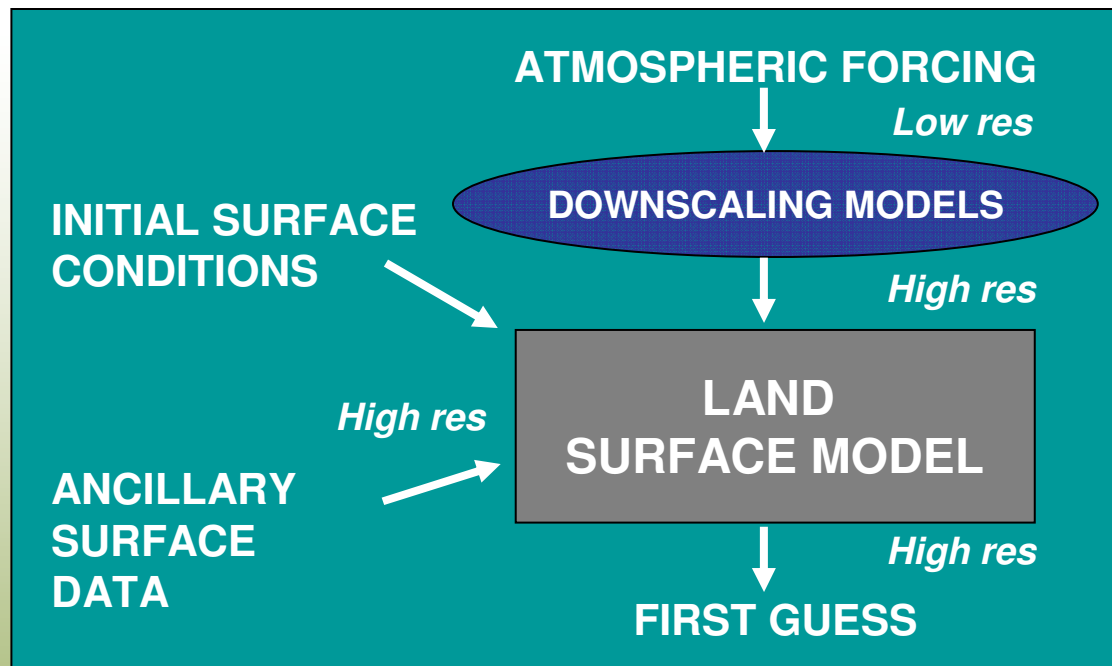


FIRST GUESS (BACKGROUND) MODELING

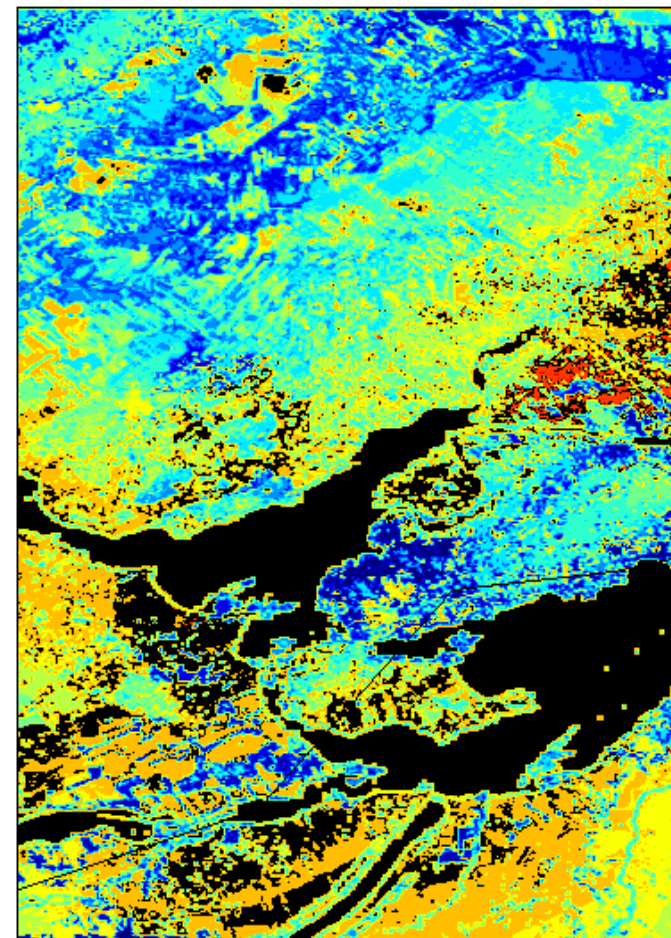


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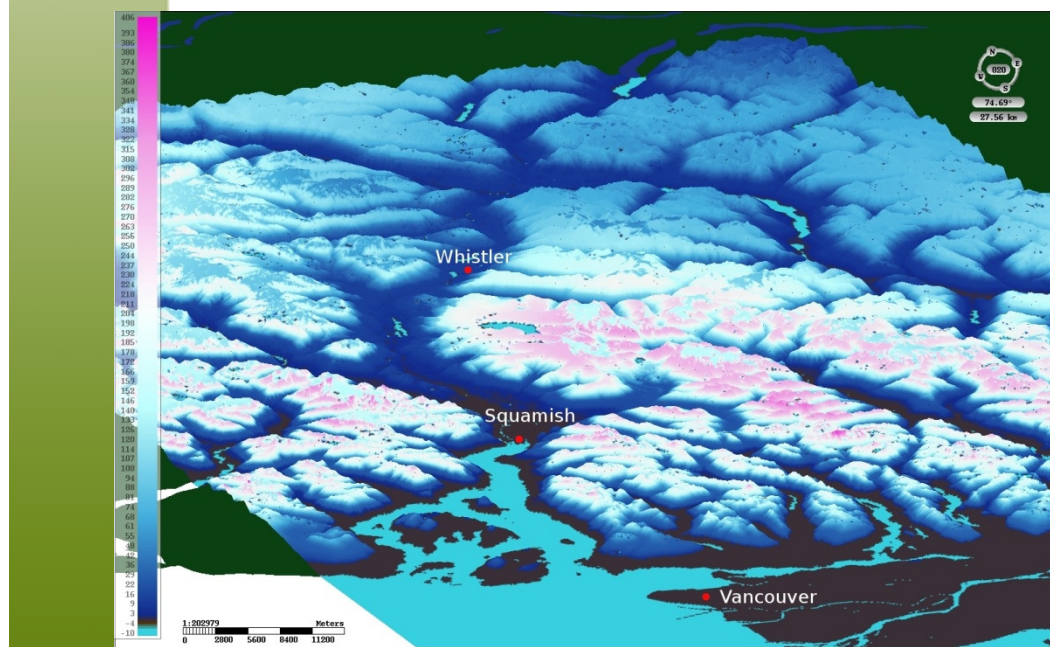
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Soil Water Index



(100m, Montreal region)



} Snow Depth (cm)
(100m, Vancouver Olympic region)

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ANCILLARY SURFACE DATA

Orography

USGS-GTOPO30 (~900m)
SRTM-DEM (~90m)
CDED1 (~20m)

Land use / land cover

USGS-GLCC (~1km)
NTDB (~20m)
EOSD (~25m)
CCRS-2005 (~300m)
GlobCover-2005 (~300m)
Circa-2000 (~30m)

Soil texture

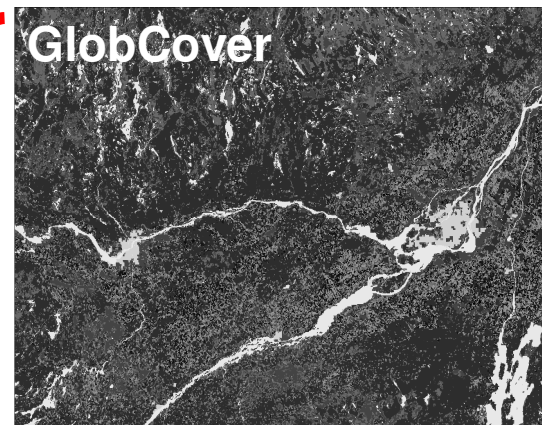
FAO (~8km)
STATSGO (~1km)
AAFC-SLC
Harmonized World Soil Db

Land / water fractions

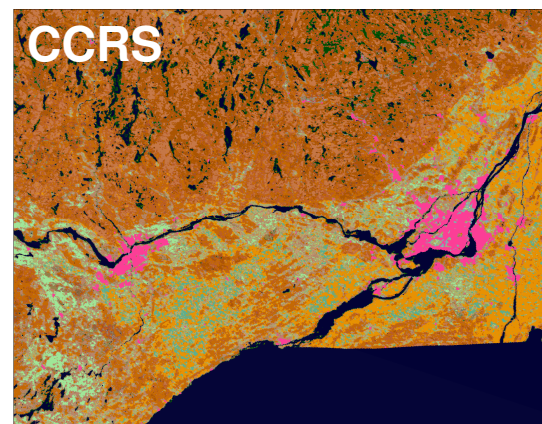
CanVec (~20 m)
USGS-GLCC (~1km)
GlobCover (~ 300 m)

Other databases for **urban** environment

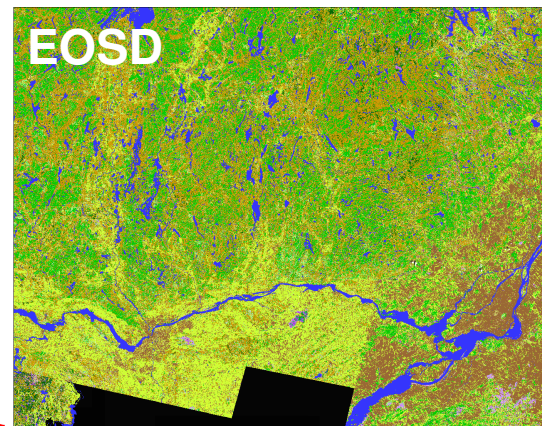
GlobCover



CCRS



EOSD



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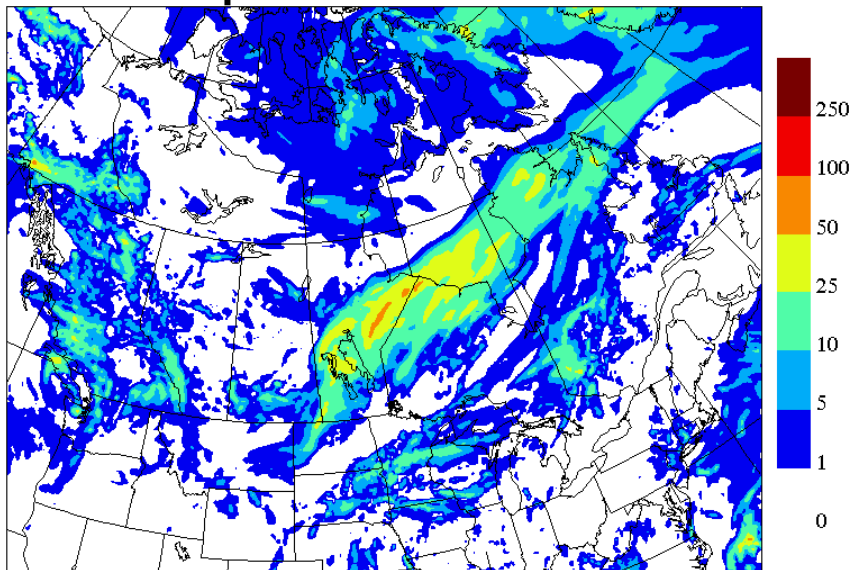
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(Belair, Leroux, Chan)

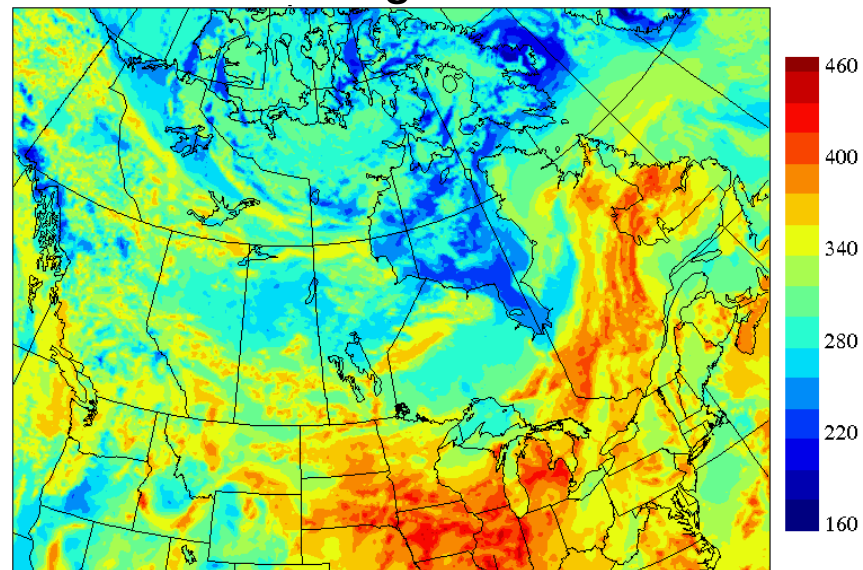
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ATMOSPHERIC FORCING

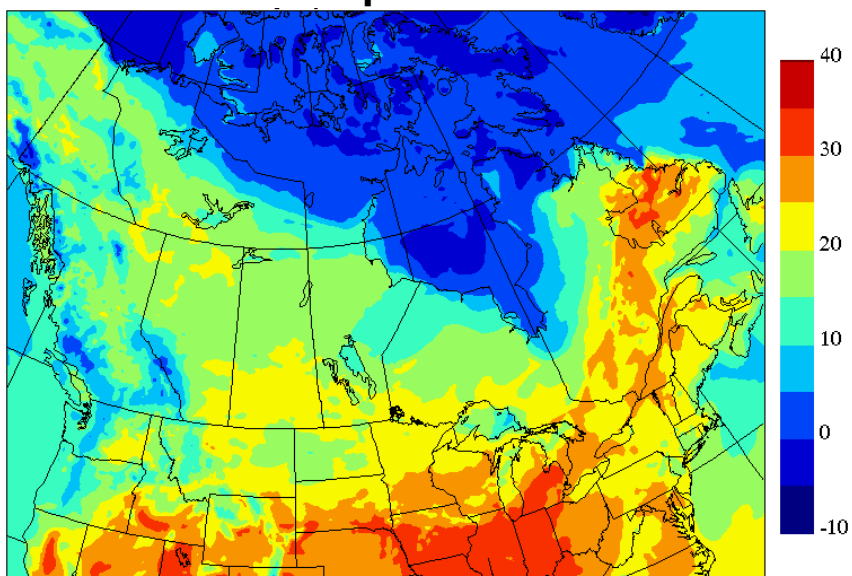
Precipitation Accumulation



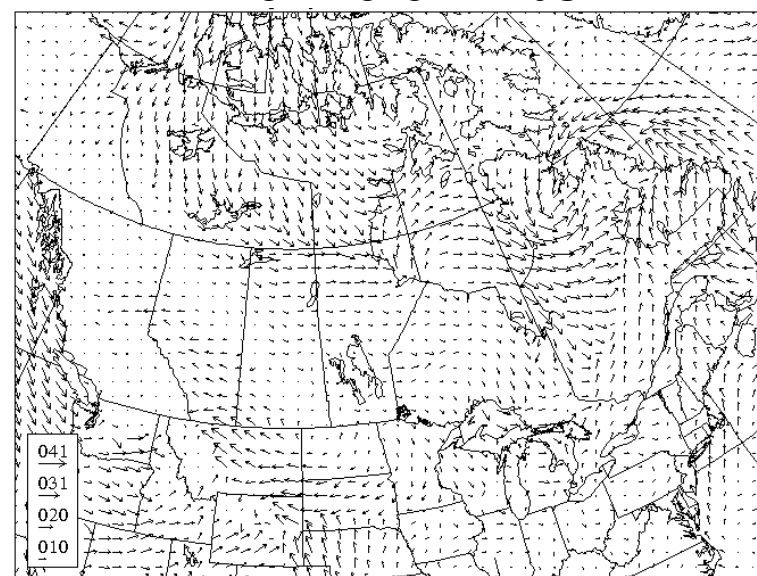
Downwelling LW Radiation



Air Temperature



Low-Level Winds



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**48-h numerical prediction
valid : 0000 UTC 17 June 2007**

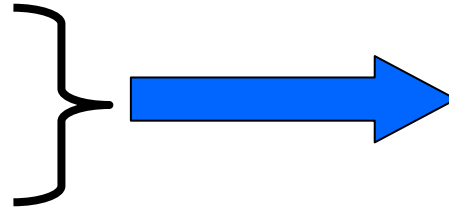
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CANADIAN PRECIPITATION ANALYSIS (CaPA)

Surface obs

Satellite and radar obs

Model outputs



Correction of a first guess field using a weighted average following:

$$x_a^j = x_b^j + \sum_{i=1..N} w^{ij} (y_o^i - y_b^i)$$

The background (first guess) is given by our best model products.

The weight matrix is given by

$$W = (B + O)^{-1} b$$

where B and O are the background and observations error covariance matrices and b is the error covariance between vector between an observation i and a background value j.

Analysis error :

$$[\sigma_a^j]^2 = [\sigma_b^j]^2 - \sum_{i=1}^N w^{ij} b^i$$

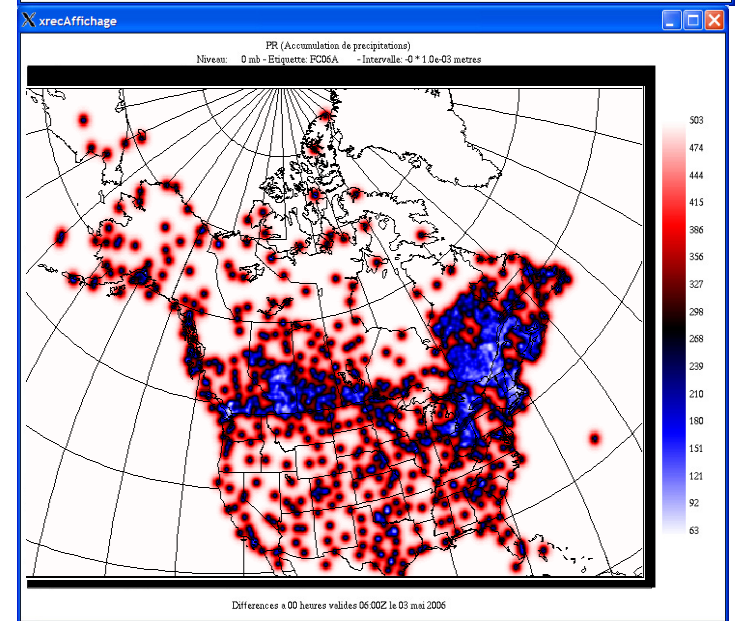
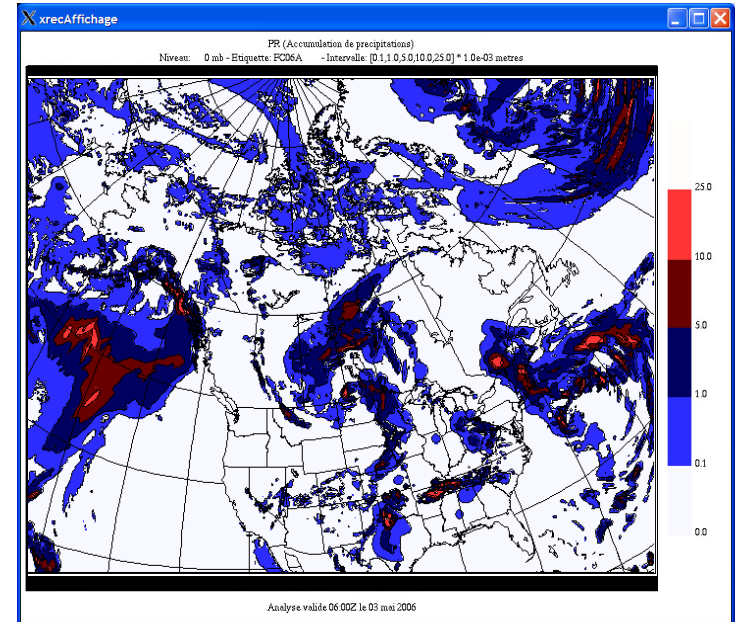


(Fortin, Mahfouf, Brasnett, Gagnon)



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OBSERVATIONS FOR LAND SURFACE DATA ASSIMILATION

OPERATIONAL

Surface stations

screen-level obs (Temperature and humidity) + snow depth

New and upcoming

Soil moisture

SMOS*, ... , **SMAP****

Snow

SSM/I*, MODIS*, IMS*

Vegetation

MODIS**

Surface temperature

GOES, MSG

Albedo

MODIS*

**) currently in development*

***) upcoming project*



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(SIMPLIFIED) VARIATIONAL DATA ASSIMILATION

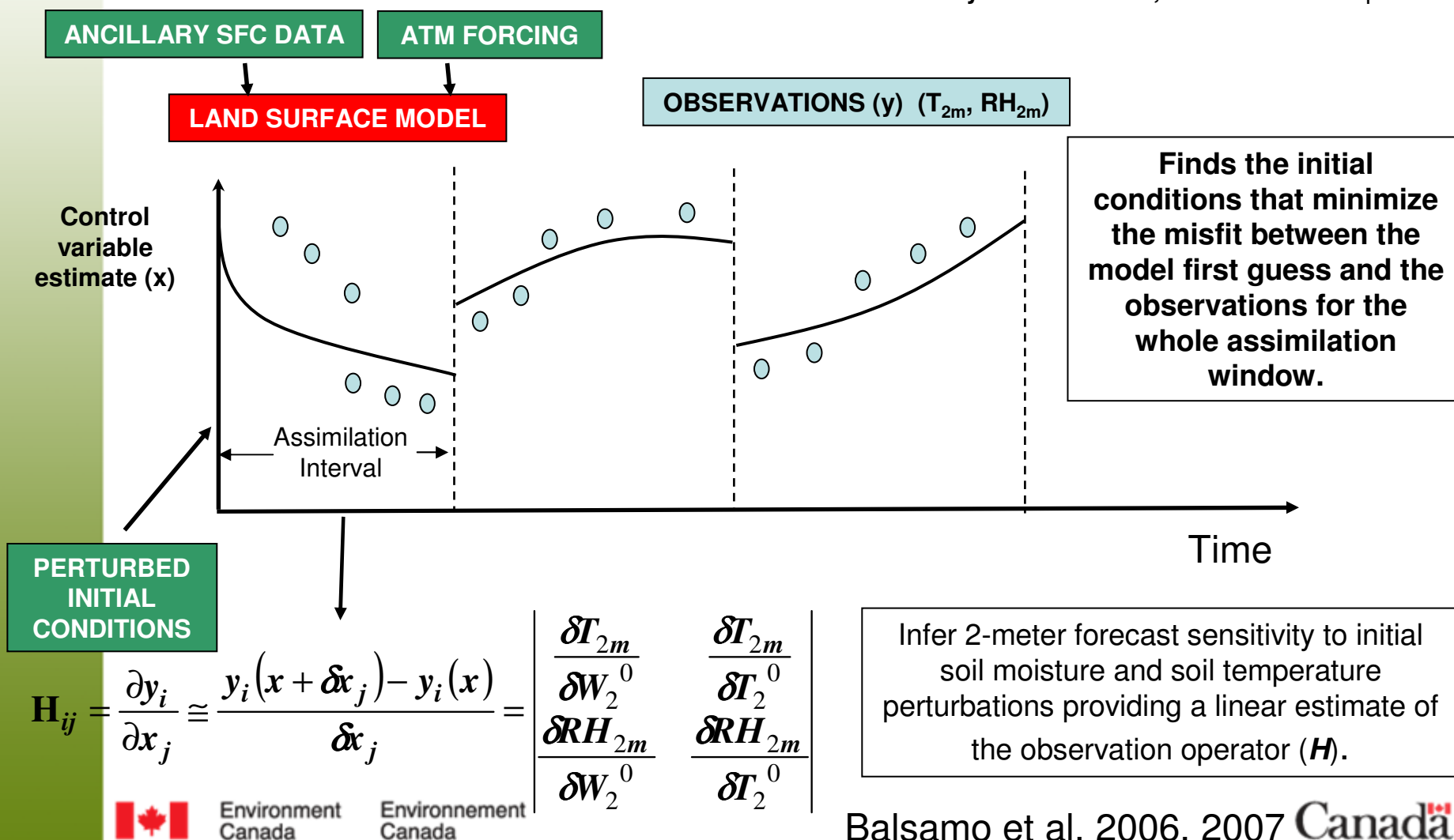
$$J(x) = \underbrace{\frac{1}{2}(x - x^b)^T \mathbf{B}^{-1}(x - x^b)}_{J^b(x)} + \underbrace{\frac{1}{2}(y - H(x))^T \mathbf{R}^{-1}(y - H(x))}_{J^o(x)}$$

x = control vector; x^b = model background

$\mathbf{B}$ = background error covariance matrix

$\mathbf{R}$ = observation error covariance matrix

y = observations; H = observation operator

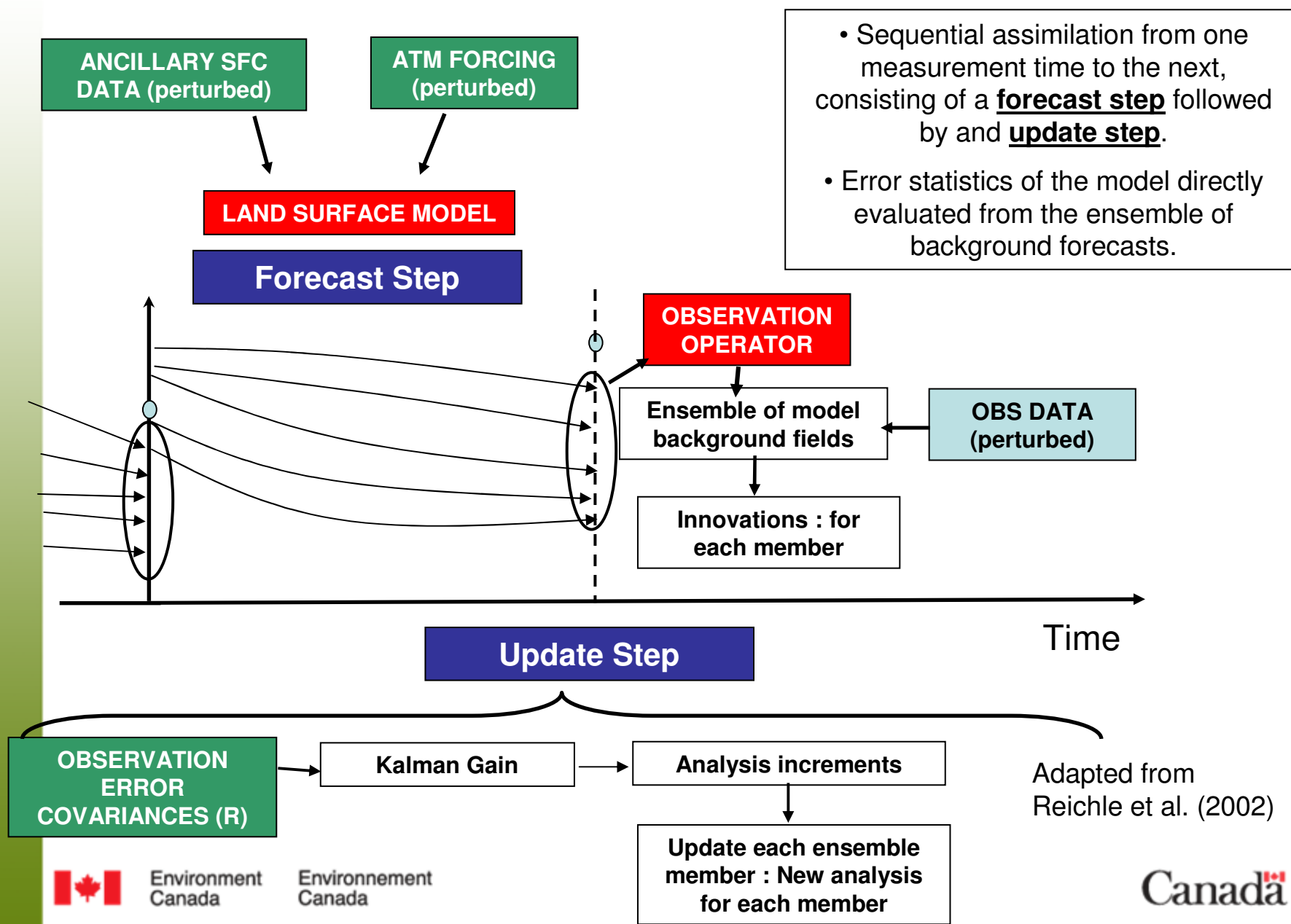


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Balsamo et al. 2006, 2007 

ENSEMBLE KALMAN FILTER

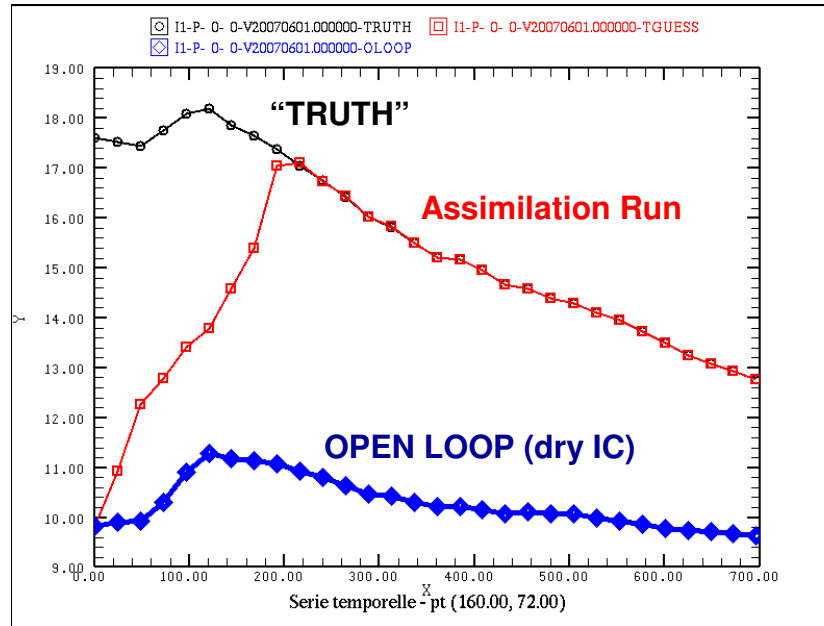


Adapted from
Reichle et al. (2002)

VARIATIONAL APPROACH: a FEW RESULTS and ISSUES

Root Zone Soil
Moisture

$\text{m}^3 \text{m}^{-3}$



- length of the assimilation window (3-h, 6-h, 12-h, 24-h)
- frequency of assimilation (hourly, 3-hourly, 6-hourly)
- constant B matrix vs evolving B matrix (within the assimilation window)



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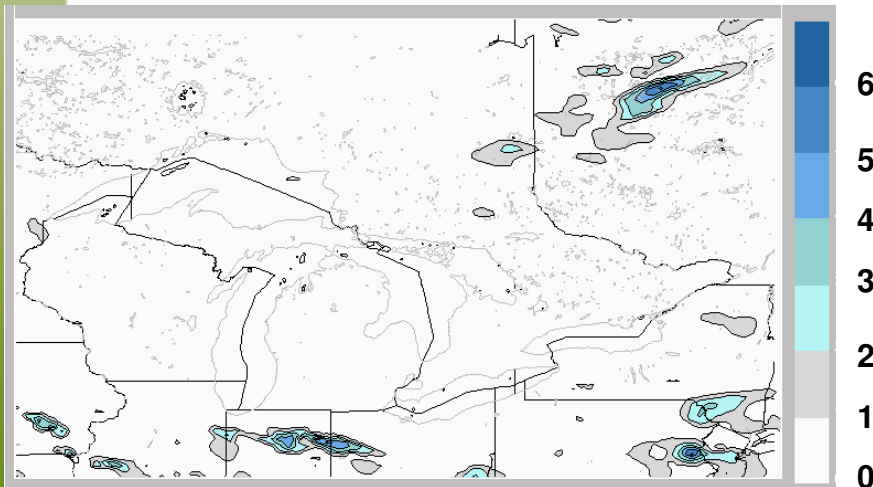
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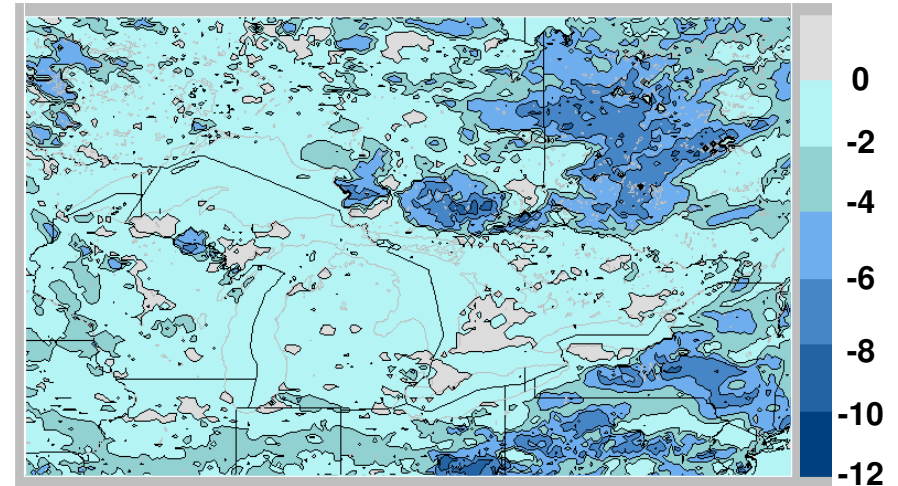
EnKF APPROACH: a FEW RESULTS and ISSUES

- Specification/modeling of the observations error covariance matrix.
- Complementarity between remote-sensing and screen-level observations.

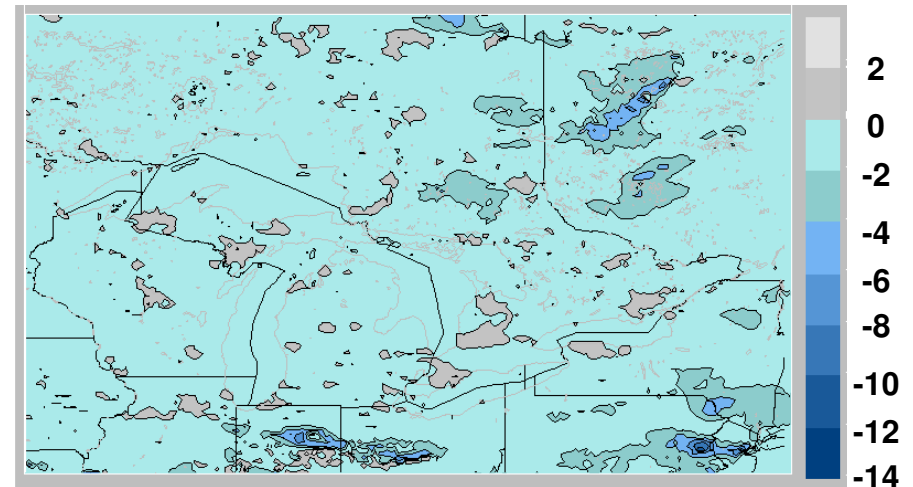
6-hr Precipitation Standard Deviation (mm)
(N=20) 0600 UTC 5 July 2007



Gain Matrix element : Superficial soil moisture
increments w.r.t $Tb_h(L)$ innovations ($10^{-3} K^{-1}$)



Gain Matrix element : Root zone soil moisture
increments w.r.t $Tb_h(L)$ innovations ($10^{-4} K^{-1}$)



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SMAP DATA ASSIMILATION at ENVIRONMENT CANADA (PLANS)

Passive: similar to what is currently being done for SMOS (from the assimilation point of view).

Active: assimilation in a higher-resolution version of CaLDAS (collaboration with AAFC)

TIMELINE: (for CaLDAS development / implementation related to soil moisture)

2010-2011: CaLDAS-SMOS

2011-2012: CaLDAS High-resolution (based on high-resolution background)

2014-2016: CaLDAS-SMAP (Passive. Active ?)

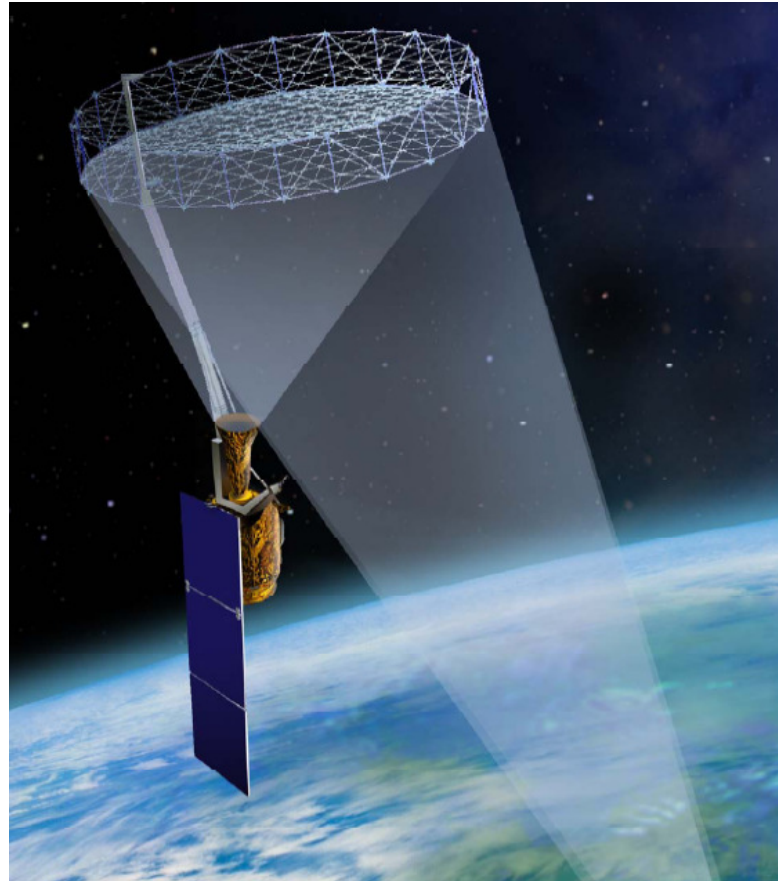


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THANK YOU for your ATTENTION



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