Environment Canada Environnement Canada

Canada

Le nouveau système de modélisation et d'assimilation de surface

Stéphane Bélair,

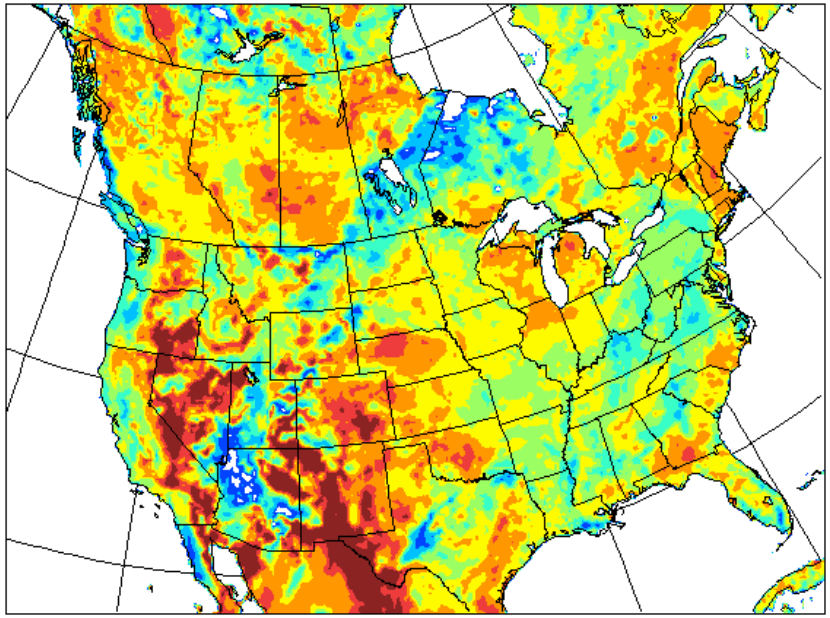
Science and Technology Branch

Environment Canada

22 mai 2009, Dorval

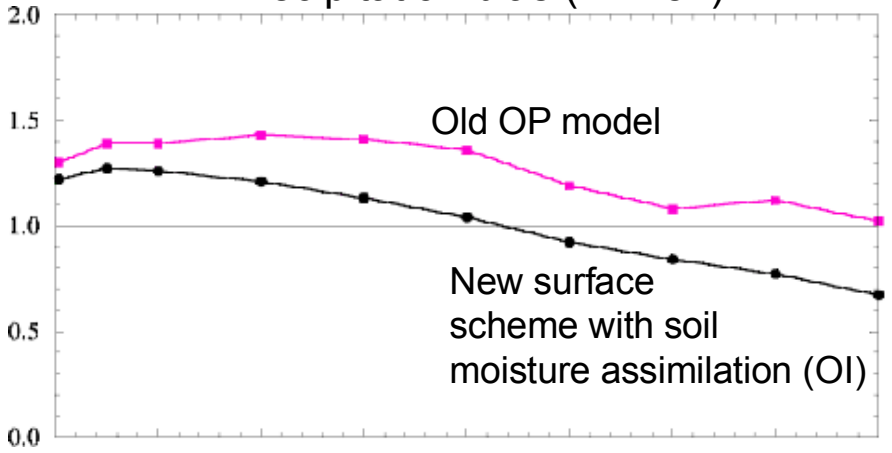
HISTORY: IMPACT of SURFACE PROCESSES (REGIONAL -2001)

Near surface soil moisture

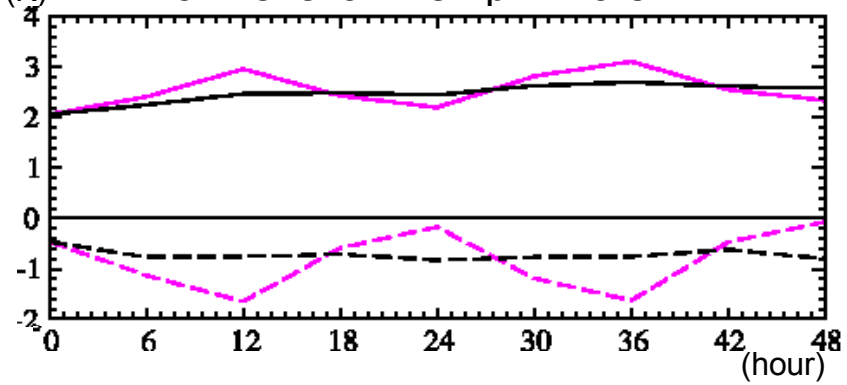


(valid at 1200 UTC 22 October 2004)

Precipitation bias (24-48h)



Low-level air Temp. Errors



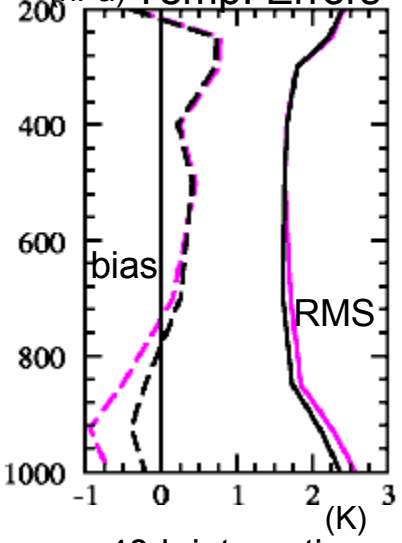
(*Bélair et al*. 2003)

Better soil moisture resulted in significant improvements for:

- Low-level air temp. and humidity
- Diurnal cycle of the PBL
- Precipitation biases

NOTE: mostly in summer

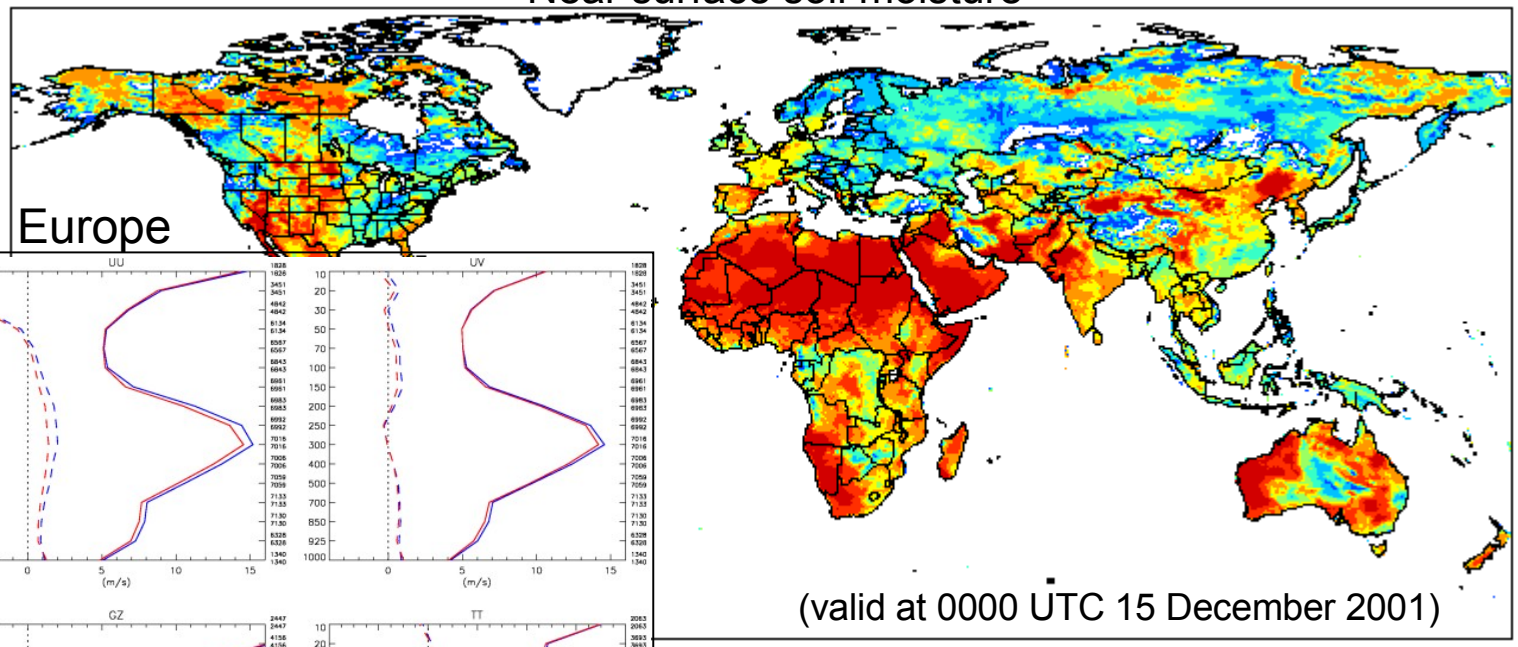
(hPa) Temp. Errors



48-h integrations

HISTORY: IMPACT of SURFACE PROCESSES (GLOBAL -2006)

Near surface soil moisture

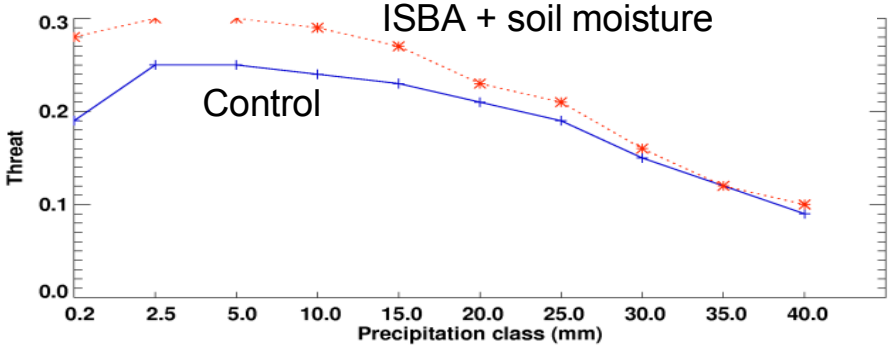


120-h, Europe

Has been implemented in the global forecasting system (31 October 2006).

(*Bélair et al.*)

Precipitation Threat Score (Day 4)- SHEF



OBJECTIVES / REQUIREMENTS for the NEW LAND SURFACE MODELING and ASSIMILATION SYSTEM

*) **Provide accurate analysis of current state of the land surface, including the following variables**

albedo,
emissivity
vegetation characteristics (leaf area index and fractional coverage)
soil moisture
snow conditions (coverage, water equivalent, density)
temperatures

*) **Improve environmental predictions from EC's operational systems, including**

deterministic NWP systems (regional, global, LAM)
ensemble prediction systems (regional, global)
hydrology

Provide operational products that could be useful to other Government departments, like for example

Agriculture and Agri-Food Canada (AAFC)
Natural Resources Canada (NRCan)

FIRST THINGS FIRST: the TEAM (right now)

WINDS

EPiCC+CRTI

Sylvie Leroyer

Linying Tong

Nathalie Gauthier

Douglas Chan

MODELING

Yi-Ching Chung

Natacha Bernier

Denis Jacob

Maria Abrahamowicz

HYDROLOGY

GenPhysX

Bernard Bilodeau

CaLDAS

Marco Carrera

Libo Wang

Sheena Solomon

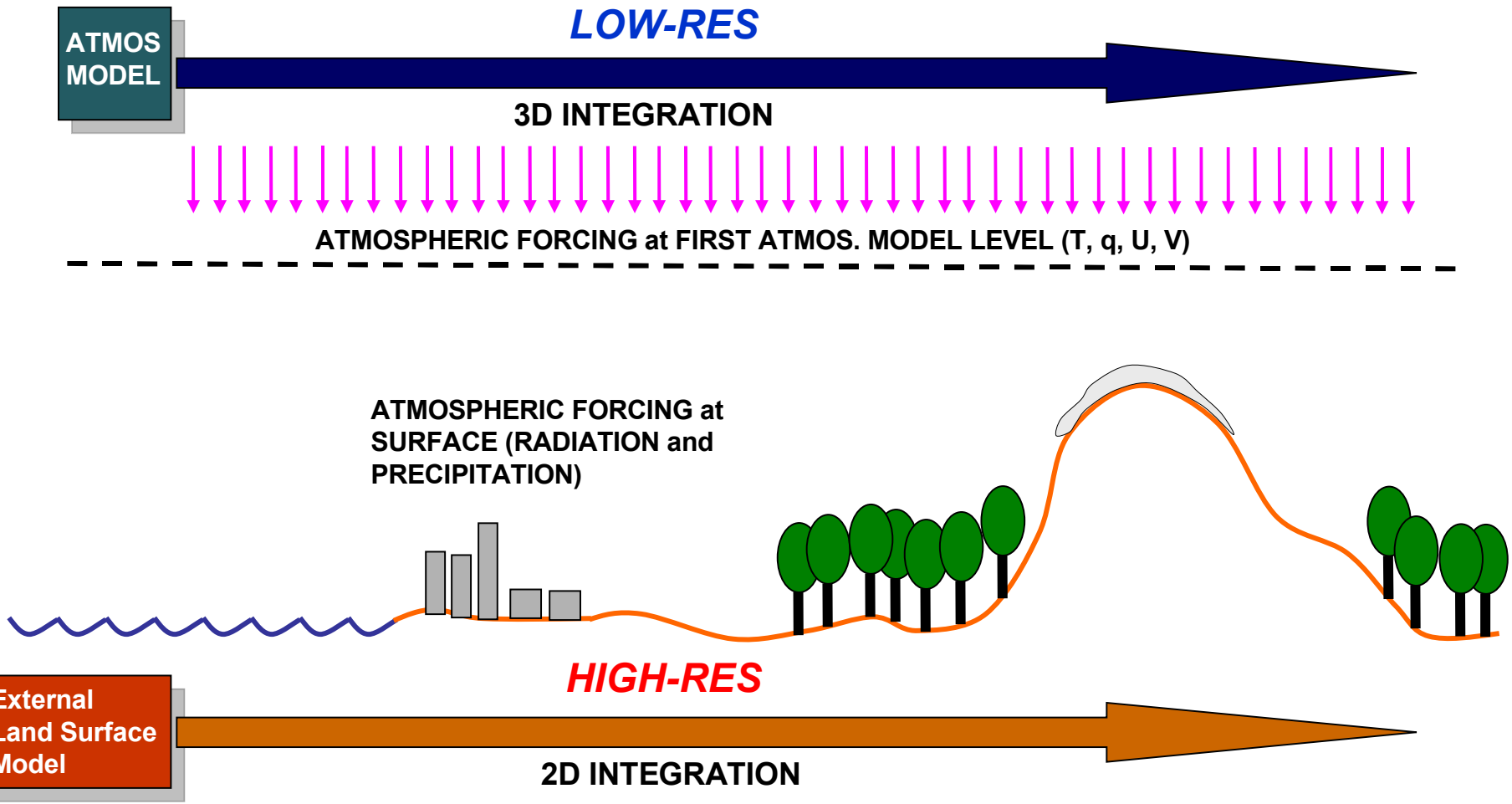
NWP

Funding from EC, CSA-GRIP, EPiCC, CRTI, IPY

Le nouveau système de modélisation et d'assimilation de surface

AVERTISSEMENT: Cette présentation inclut des images que certains auditeurs peuvent juger inappropriées. Elle ne fournit pas une démonstration rigoureuse qui pourrait mener à une implémentation opérationnelle immédiate. Elle a plutôt pour but d'introduire les nouveaux systèmes de surface présentement développés en recherche, ainsi que d'autres présentations qui vont suivre dans l'année. Elle est destinée à un public averti.

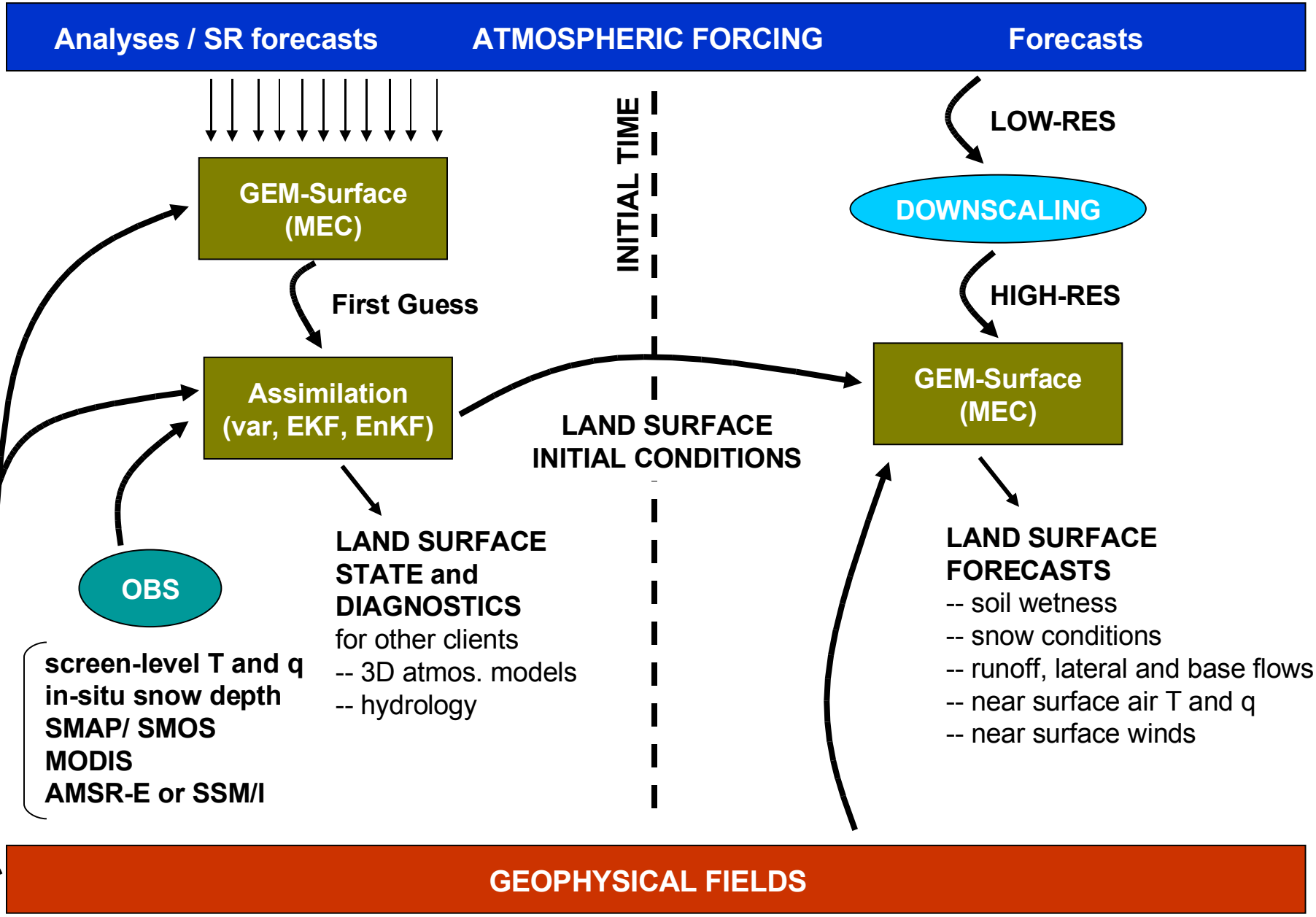
EXTERNAL LAND SURFACE MODELING



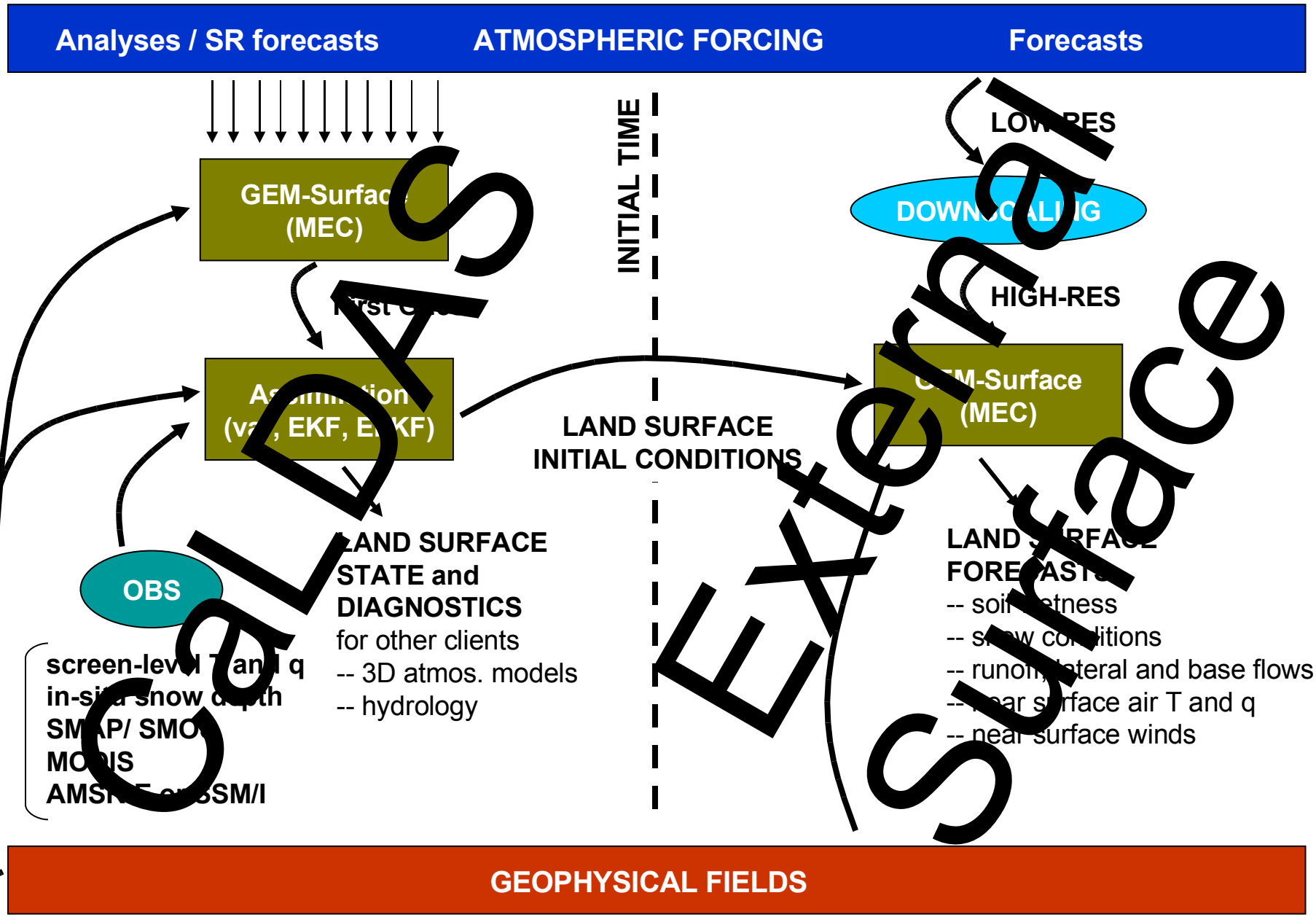
With horizontal resolution as high as that of surface databases (e.g., 100 m)

Computational cost of off-line surface modeling system is *much less* than an integration of the atmospheric model

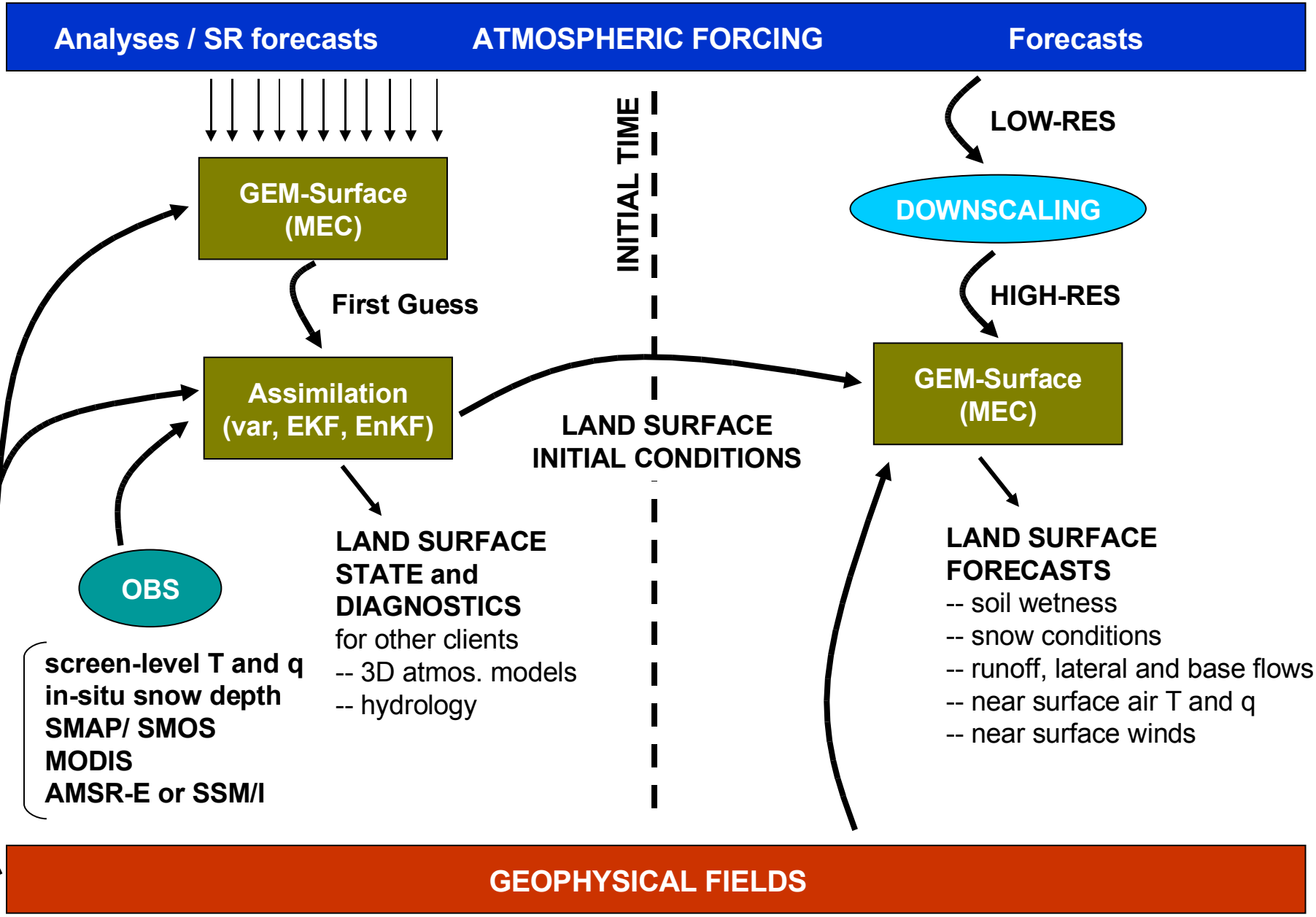
The LAND SURFACE SYSTEM



The LAND SURFACE SYSTEM



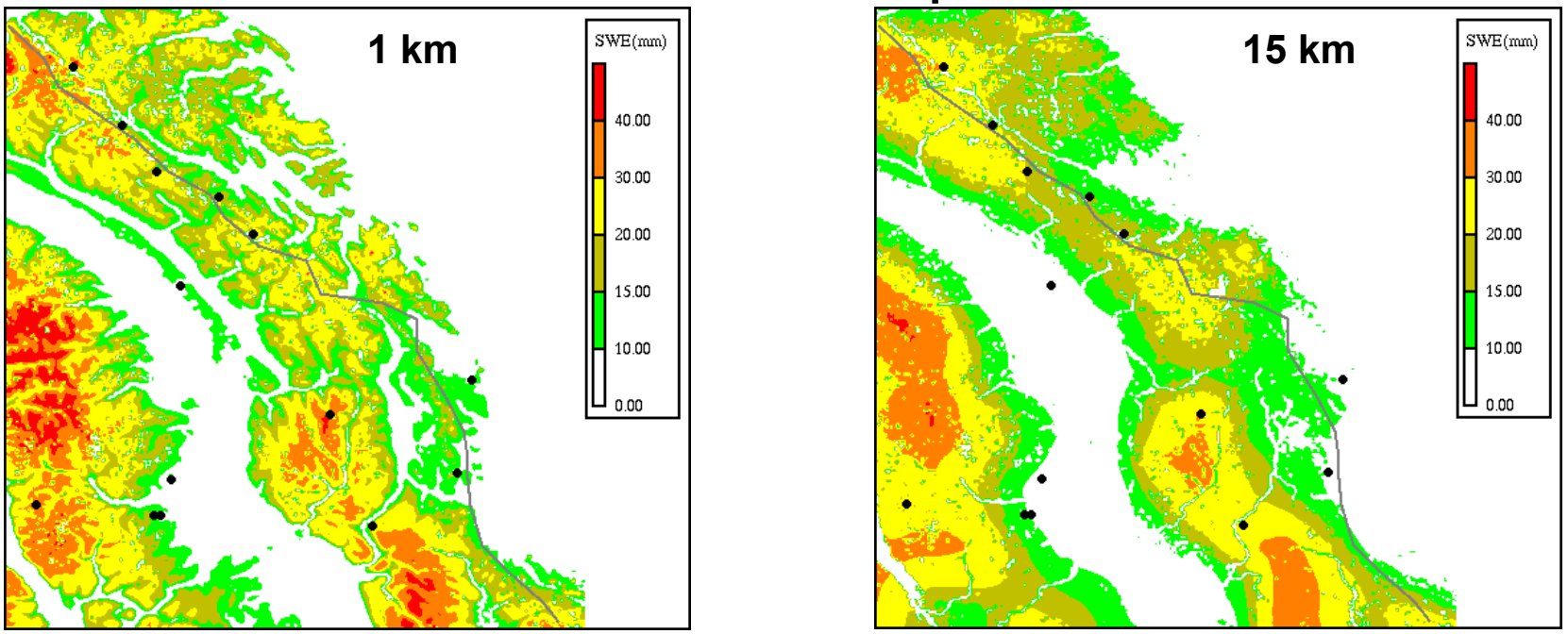
The LAND SURFACE SYSTEM



HIGH-RESOLUTION MODELING of LAND SURFACE (NAESI)

(Marco Carrera, Dorothée Charpentier, Vincent Fortin, Isabelle Doré)

Mean Snow Water Equivalent

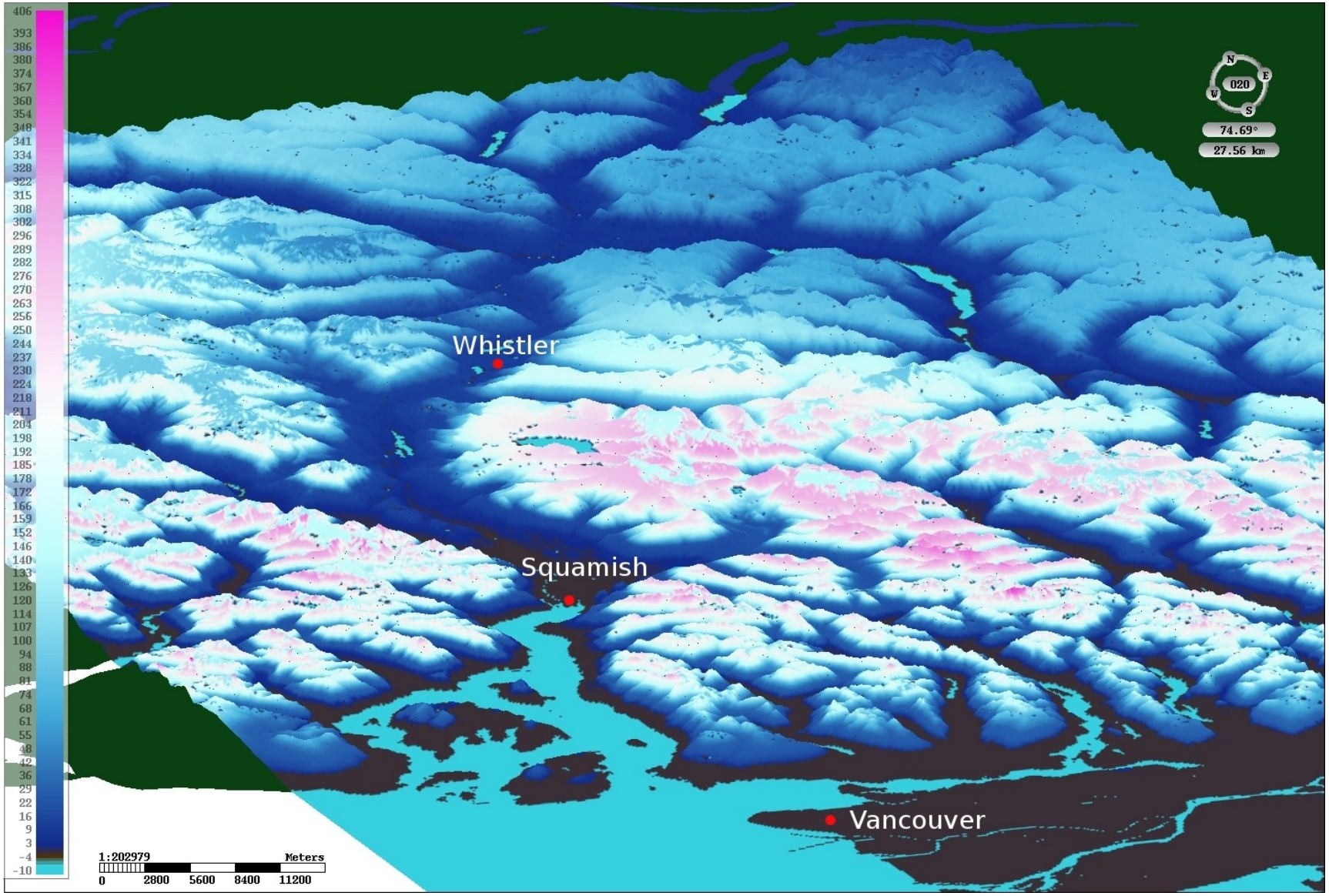


Valid during Winter 05-06

Prototype version of an external land surface system was tested in the context of NAESI. Integrations for 2004-2007 with an offline 1-km land surface system were performed.

HIGH-RESOLUTION MODELING of LAND SURFACE (VO2010)

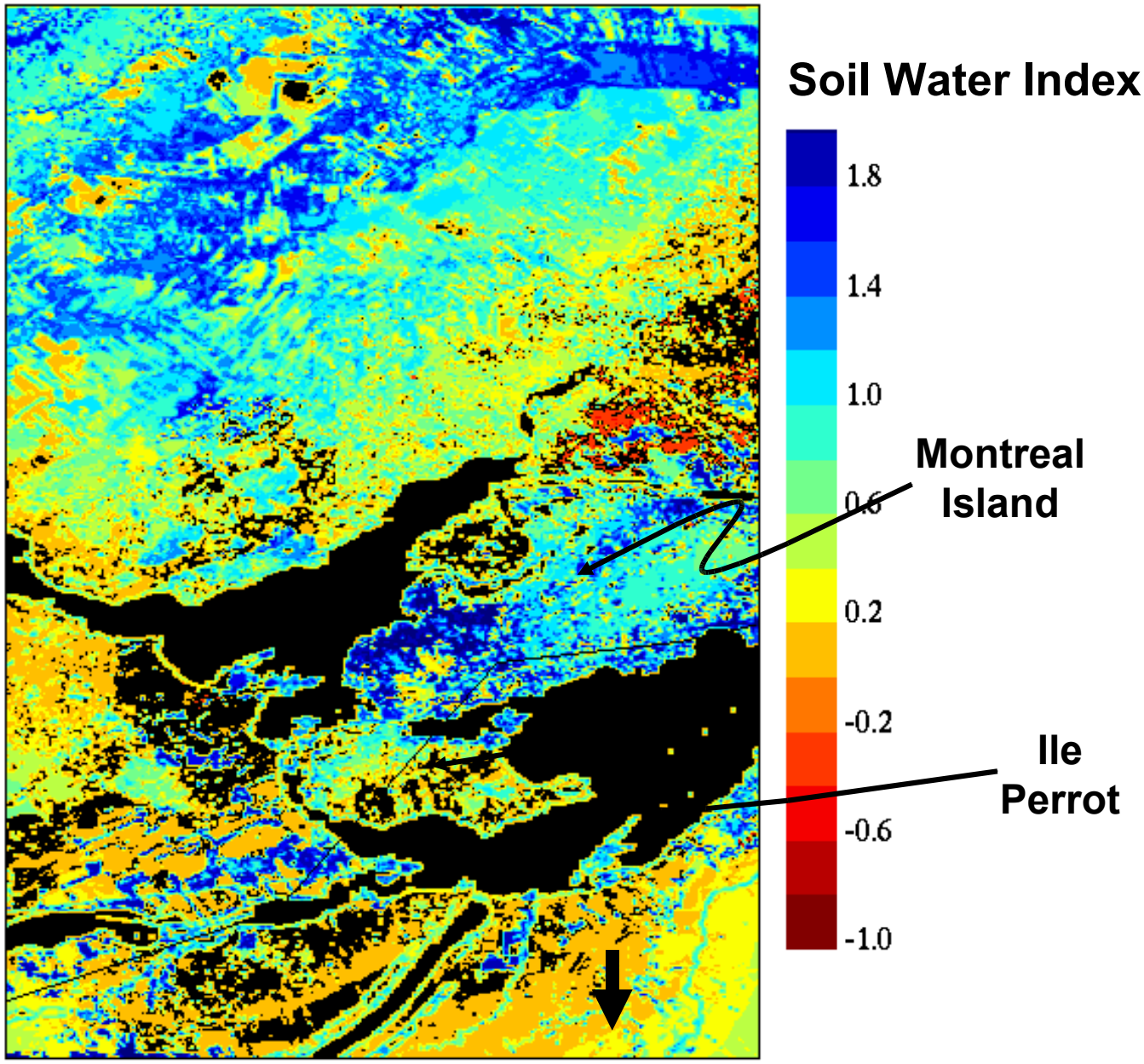
(Natacha Bernier, Linying Tong, Maria Abrahamowicz)



HIGH-RESOLUTION MODELING of LAND SURFACE (CRTI/EPiCC))

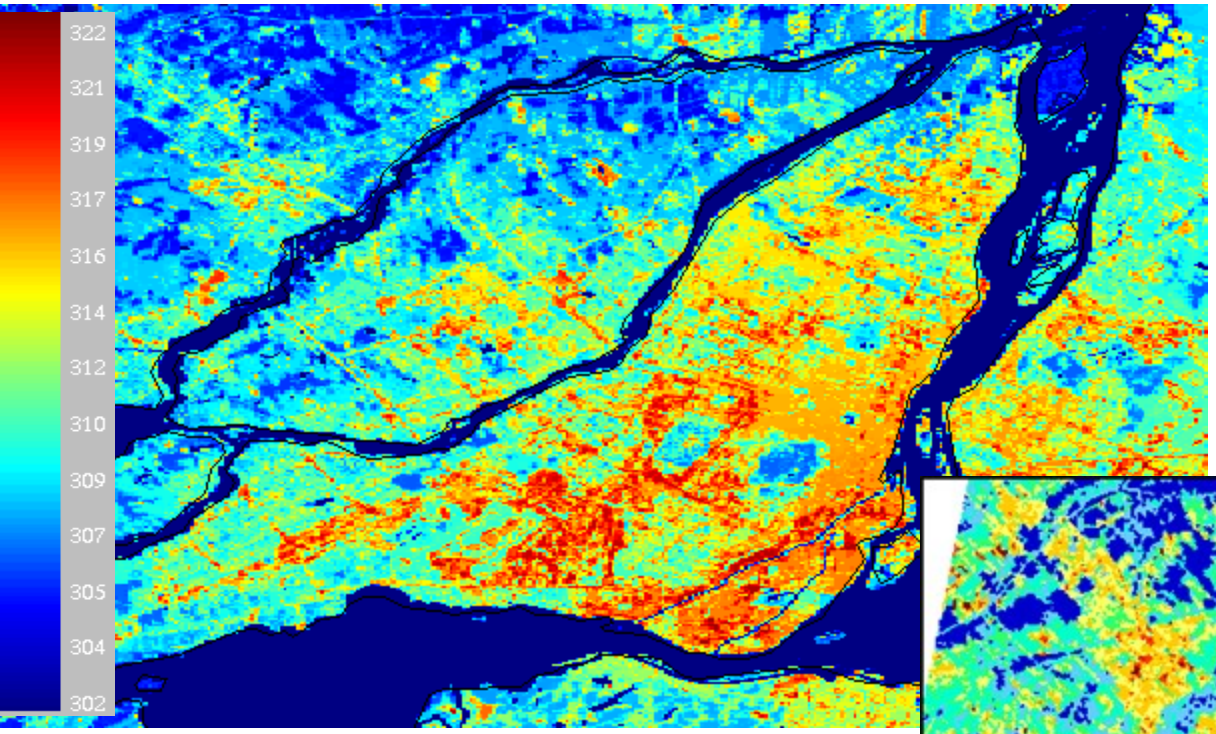
(Sylvie Leroyer)

(Valid on
1 August 2008)

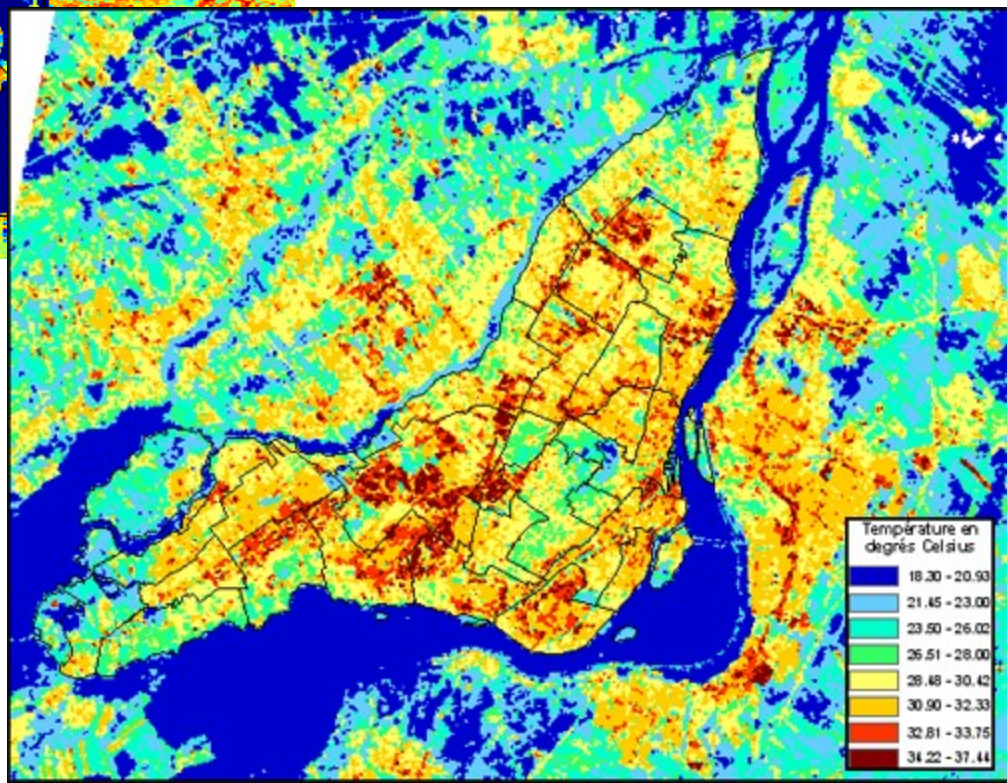


(Leroyer et al)

HIGH-RESOLUTION EXTERNAL MODELING of URBAN HEAT ISLANDS – RADIATIVE SURFACE TEMPERATURES



Landsat 5,
11 August 2001, 1500 UTC
(Guay and Beaudouin 2005, UQAM)
Pixel size : 120 m

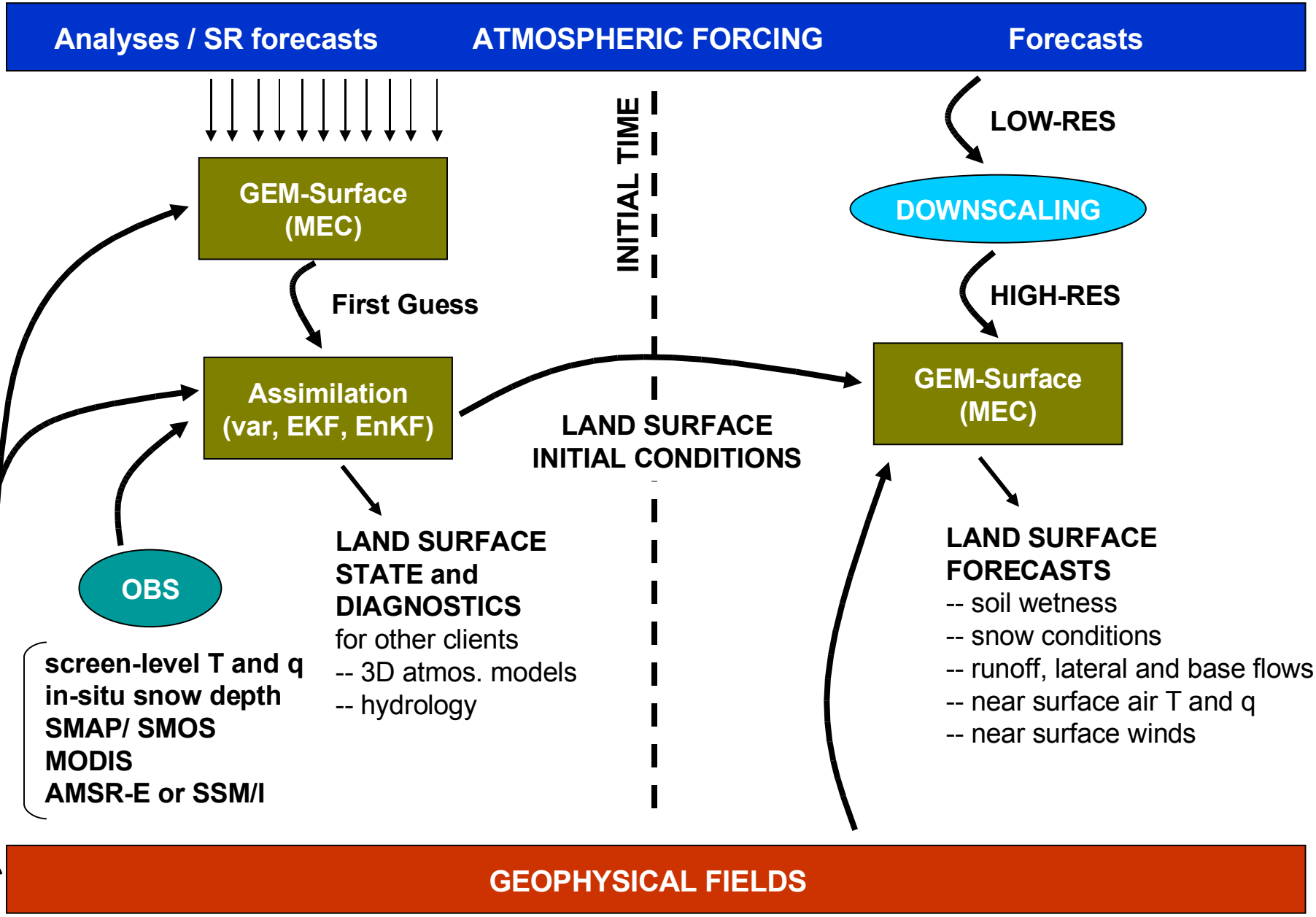


External land surface model,
With Town Energy Balance model,
27 June 2005, 1500 UTC
Grid size : 120 m

(Leroyer et al)

PETITE PAUSE SANTE ...

The LAND SURFACE SYSTEM



LAND DATA ASSIMILATION

CURRENTLY OPERATIONAL

Soil moisture *analyses are produced from screen-level observations using optimal interpolation technique.*

Terrestrial ***snow*** *analyses are obtained from an offline assimilation of in-situ surface measurements, also using the optimal interpolation technique*

Vegetation *characteristics are specified using look-up tables based on land use / land cover databases*

FOCUS with CaLDAS

Improve first guess for soil moisture, snow, and vegetation (high-resolution modeling)

Assimilate space-based remote sensing data for soil moisture and snow

Better specify land surface geophysical characteristics (orography, vegetation, albedo, ...) using high-res databases and remote sensing

ASSIMILATION PROCESS (ENSEMBLE KALMAN FILTER)

INITIALISATION

OBS → BIAS CORRECTION (NORMALISATION) y_{t+1}

PERTURBED FORCING and SURFACE CONDITIONS

FIRST GUESS ← ENSEMBLE RUNS LOOP $x_{t+1}^{i-} = M x_t^{i+} + q_{t+1}^i$

- OBS OPERATOR $y_{t+1}^i - H\left(x_{t+1}^{i-}\right)$
- PERTURBED OBS
- INNOVATIONS

OBSERVATIONS ERROR COVARIANCES R_{t+1}

GAIN MATRIX $K_{t+1} = \left(BH^T\right)_{t+1} \left\{ \left(\mathbf{HBH^T}\right)_{t+1} + R_{t+1} \right\}^{-1}$

ANALYSIS ← INCREMENTS and UPDATES $x_{t+1}^{i+} = x_{t+1}^{i-} + K_{t+1} \left\{ y_{t+1}^i - H\left(x_{t+1}^{i-}\right) \right\}$

MONITORING

SOIL MOISTURE in CaLDAS (Marco Carrera, Bernard Bilodeau)

DATA

SMOS *– to be launched in July 2009 (ESA)*

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

Screen-level *air temp. and humidity*

SOME ISSUES

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

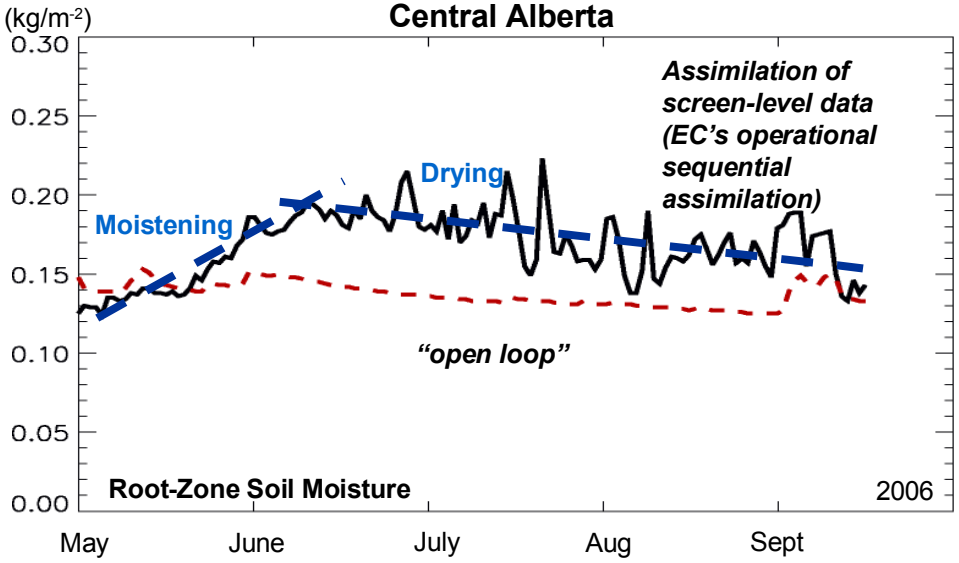
Specification / calculation of **B** *and* **R**

Complementarity between screen-level and microwave data

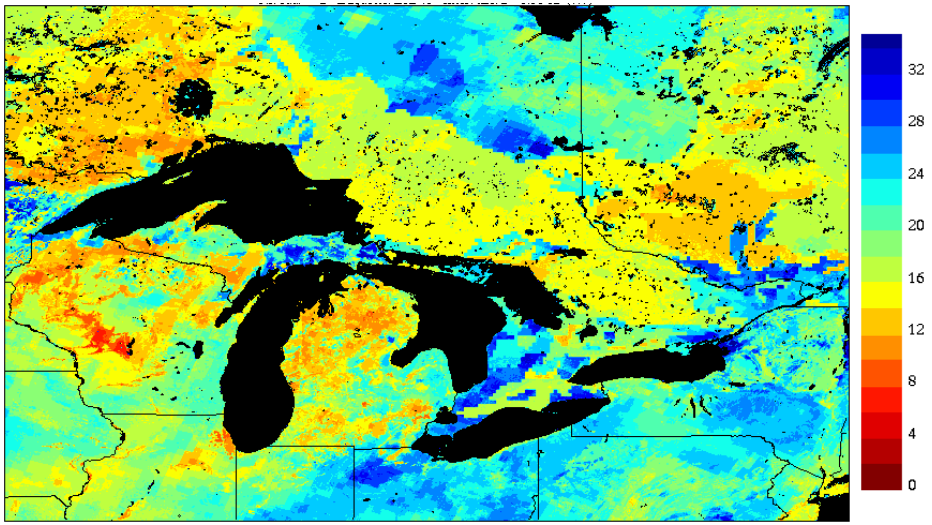
Observation operators (for both passive and active data)

Bias correction / normalisation of soil moisture observations

Incremental assimilation: Low-res increments on high-res first guess



Great Lakes OSSE – Root Zone Soil Moisture



(Valid 0000 UTC 19 May 2007)

(Belair, Bilodeau, Carrera)

TERRESTRIAL SNOW in CaLDAS

(Sheena Solomon, Chris Derksen, Libo Wang)

DATA

MODIS *for fractional snow coverage area*

AMSR-E or SSM/I *for snow water equivalent*

Surface *measurements*

SOME ISSUES

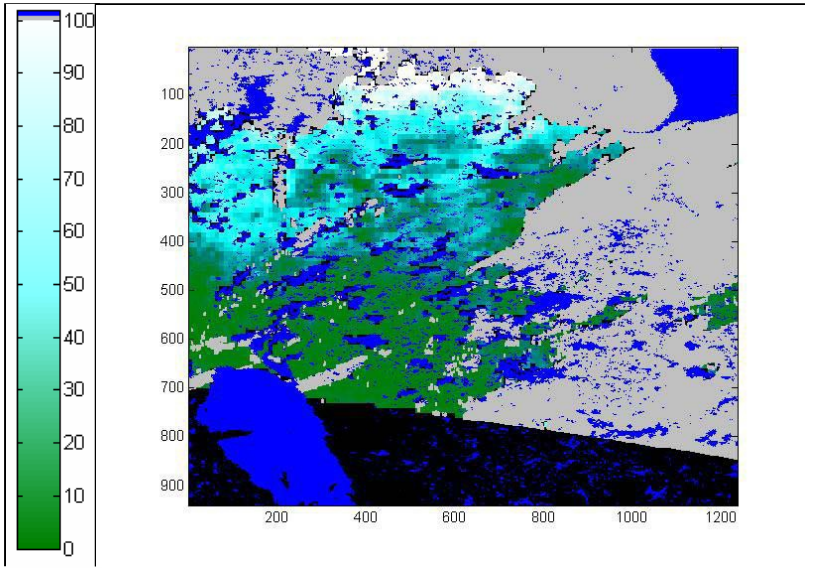
Physical meaning of fractional snow coverage area (fSCA)

Consistency between SWE and fSCA

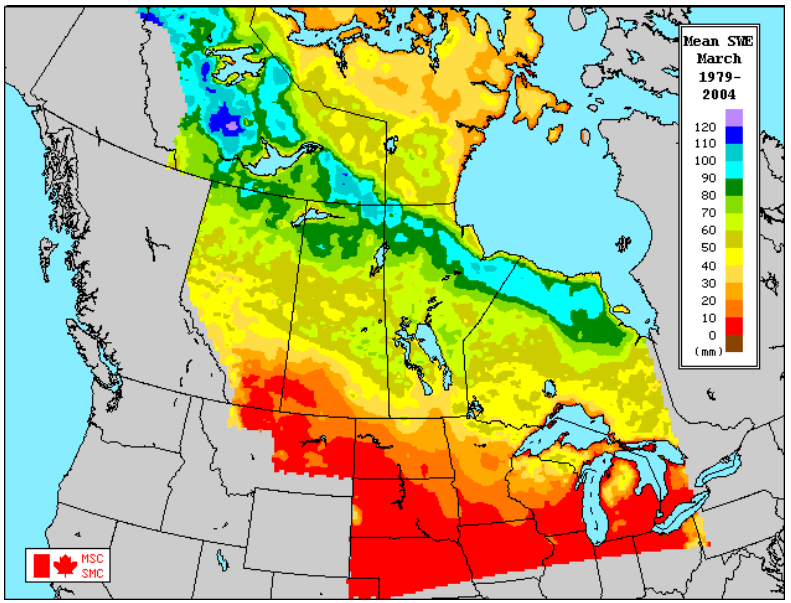
Snow density from in-situ data?

Incremental assimilation: low-resolution increments on high-resolution first guess

Evaluation of impact on both NWP and hydrology



MODIS Derived fSCA

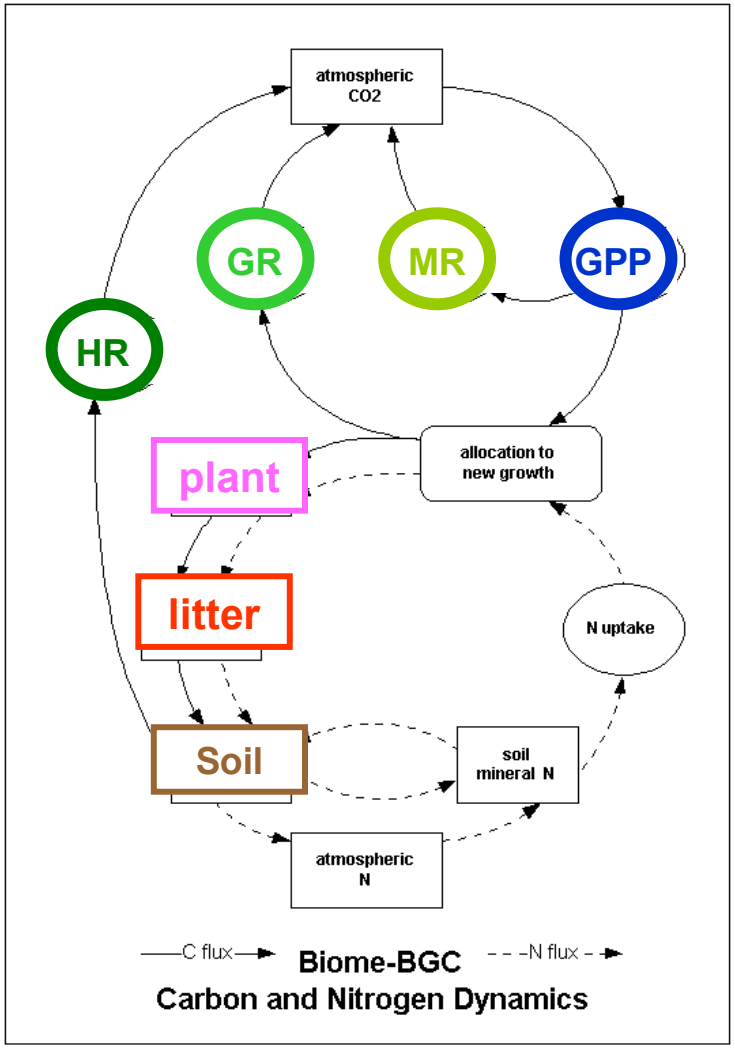


Passive Microwave Derived SWE

VEGETATION CHARACTERISTICS from ECOSYSTEM MODELING

(Douglas Chan, Misa Ishizawa)

Biome-BGC



ATMOSPHERIC FORCING from MSC NWP PRODUCTS

Biome-BGC integration

Land use / Land cover databases

"Analyses" of Leaf Area Index

C flux

N flux

Photosynthesis (GPP)

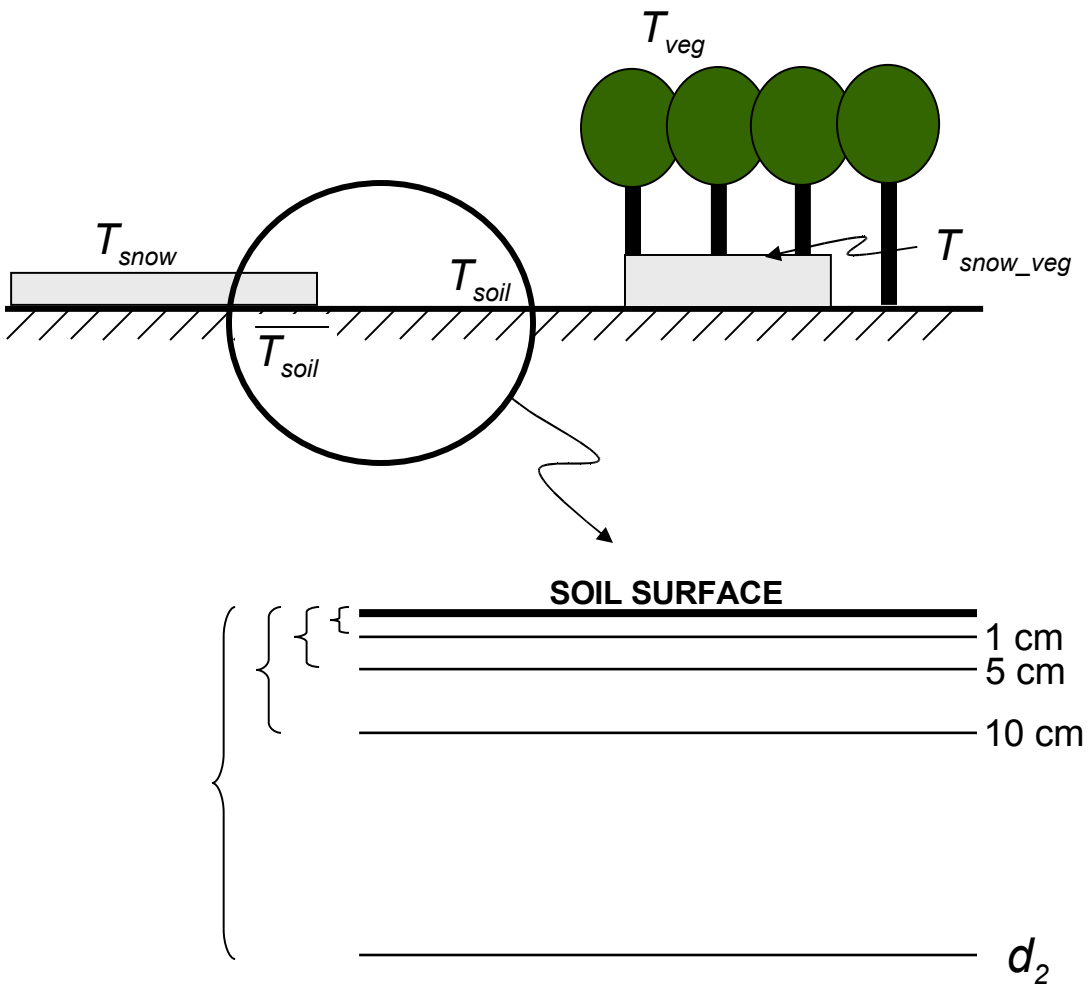
Maintenance Respiration

Growth Respiration

Heterotrophic Respiration

IMPROVEMENTS to LAND SURFACE MODELING

(Maria Abrahamowicz, Marco Carrera)



Due to requirements from new modeling projects and from the land data assimilation system, several changes had to (or will) be made to ISBA:

- *Multi-budget (VO2010)*
- *Modular snow code (CRTI-TEB and CaLDAS-SNOW)*
- *Multi-layer force-restore (CaLDAS-SM)*
- *Lateral flow parameterization (NAESI)*
- z_{0m} / z_{0h} *(EPiCC)*

IMPROVEMENTS to URBAN MODELING

(Sylvie Leroyer,Maria Abrahamowicz)
(in collaboration with Meteo-France)

Improve snow modeling in the urban environment

Include vegetation in urban canyons (treated with ISBA)

Consider asymetric urban canyons

PROSPECTS on EVENTUAL TRANSFER to OPERATIONS

TORONTO ←

Douglas Chan
Misa Ishizawa
Chris Derksen
Libo Wang

Marco Carrera,
Bernard Bilodeau
Natacha Bernier
Yi-Ching Chung
Maria Abrahamowicz
Sheena Solomon
Denis Jacob
Stephane Belair
Vincent Fortin
Ayrton Zadra

Linying Tong
Natalie Gauthier

Alexandre Leroux
Jean-Philippe Gauthier
Serge Trudel

?

EXTERNAL LAND SURFACE SYSTEM → **2010 – 2011**

CaLDAS (first version) → **2011 - 2012**

UPCOMING PRESENTATIONS, with MORE SUBSTANCE ...

Natacha Bernier (VO2010 land surface prediction system)

Bernard Bilodeau (Role of screen-level data in CaLDAS)

Marco Carrera (Assimilation of SMOS / SMAP Tb with CaLDAS)

Douglas Chan (Vegetation / ecosystem modeling)

Yi-Ching Chung (Snow modeling)

Sylvie Leroyer (Urban modeling)

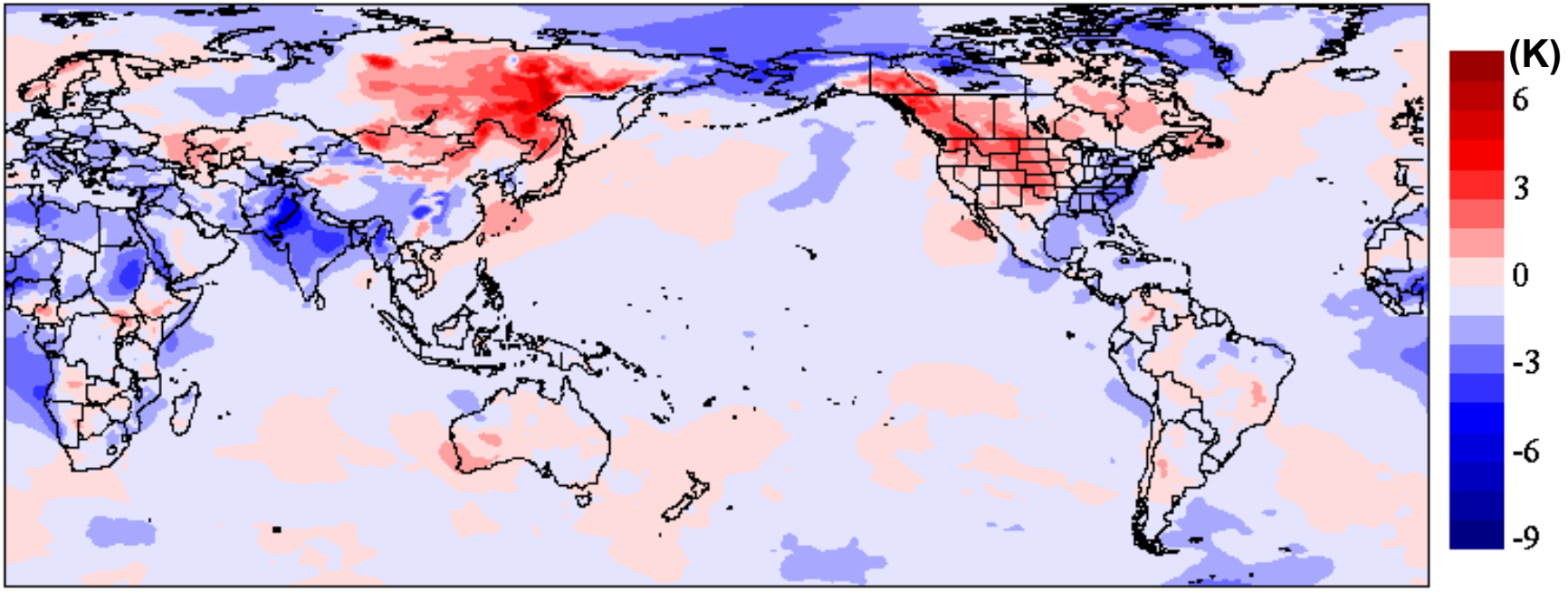
Sheena Solomon (Assimilation of snow in CaLDAS)

Stéphane Bélair (TBD)

EXAMPLE: LARGE-SCALE BIASES with NEW GLOBAL SYSTEM

(Thanks to Michel Roch)

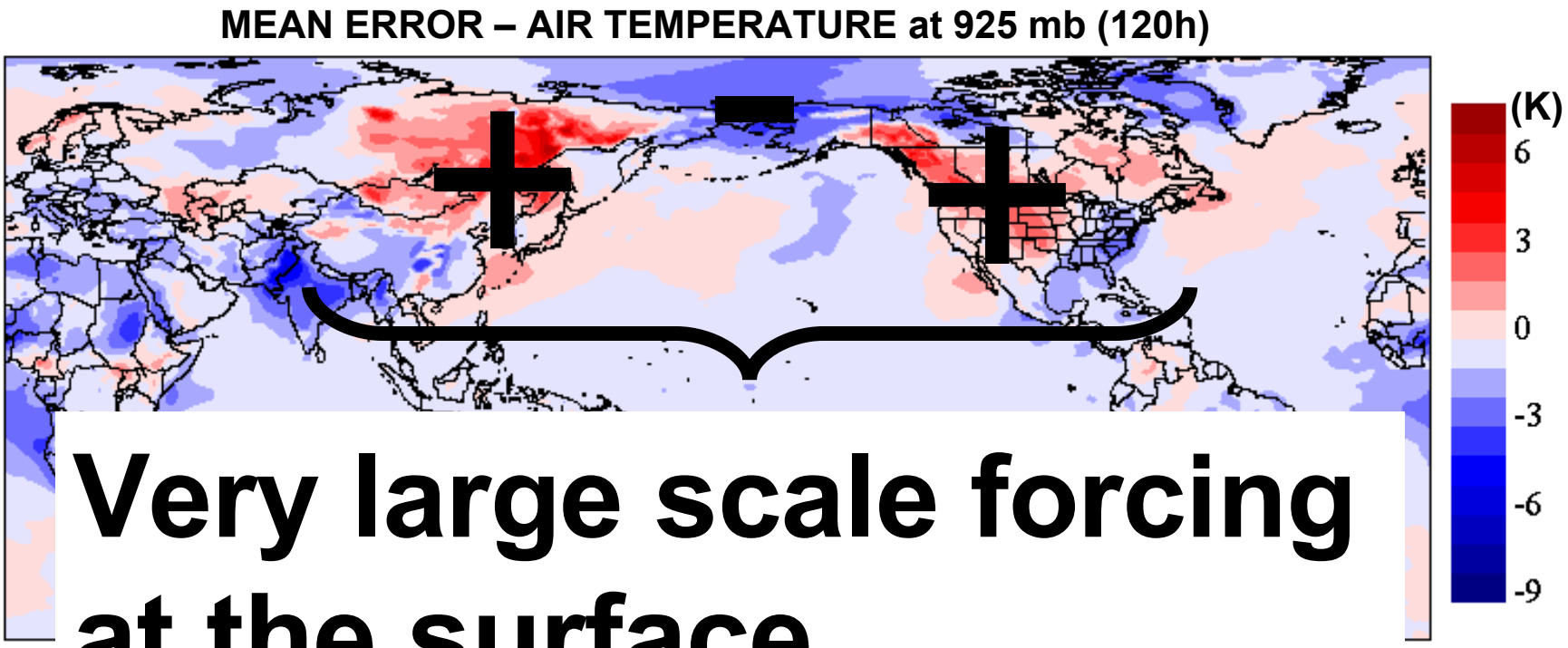
MEAN ERROR – AIR TEMPERATURE at 925 mb (120h)



Final cycles – GLOBAL STRATO – Valid Winter xxxx

EXAMPLE: LARGE-SCALE BIASES with NEW GLOBAL SYSTEM

(Thanks to Michel Roch)



OTHER LAND SURFACE CHARACTERISTICS GEOPHYSICAL DATABASES

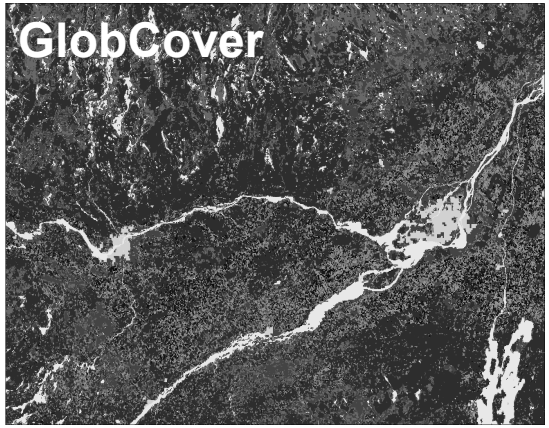
(Alexandre Leroux, Ayrton Zadra, Jean-Philippe Gauthier)

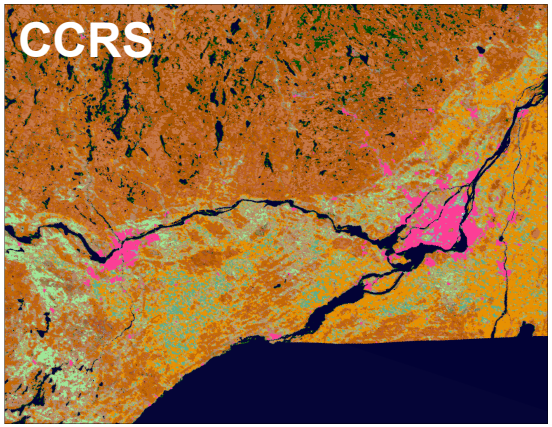
Orography
- USGS-GTOPO30 (~900m)
- SRTM-DEM (~90m)
- CDED1 (~20m)

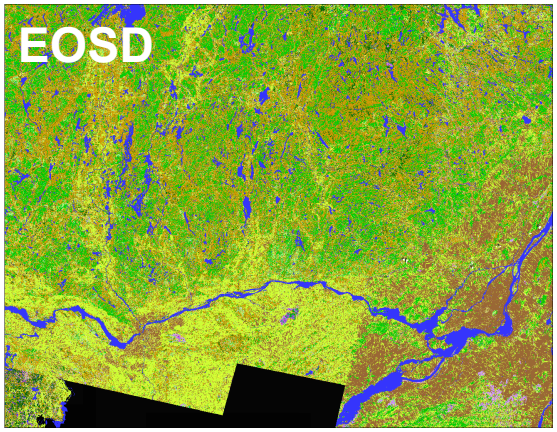
Land use / land cover
- USGS-GLCC (~1km)
- NTDB (~20m)
- EOSD (~25m)
- CCRS-2005 (~300m)
- GlobCover-2005 (~300m)
- Circa-2000 (~30m)

Soil texture
- FAO (~8km)
- STATSGO (~1km)
- AAFC-SLC

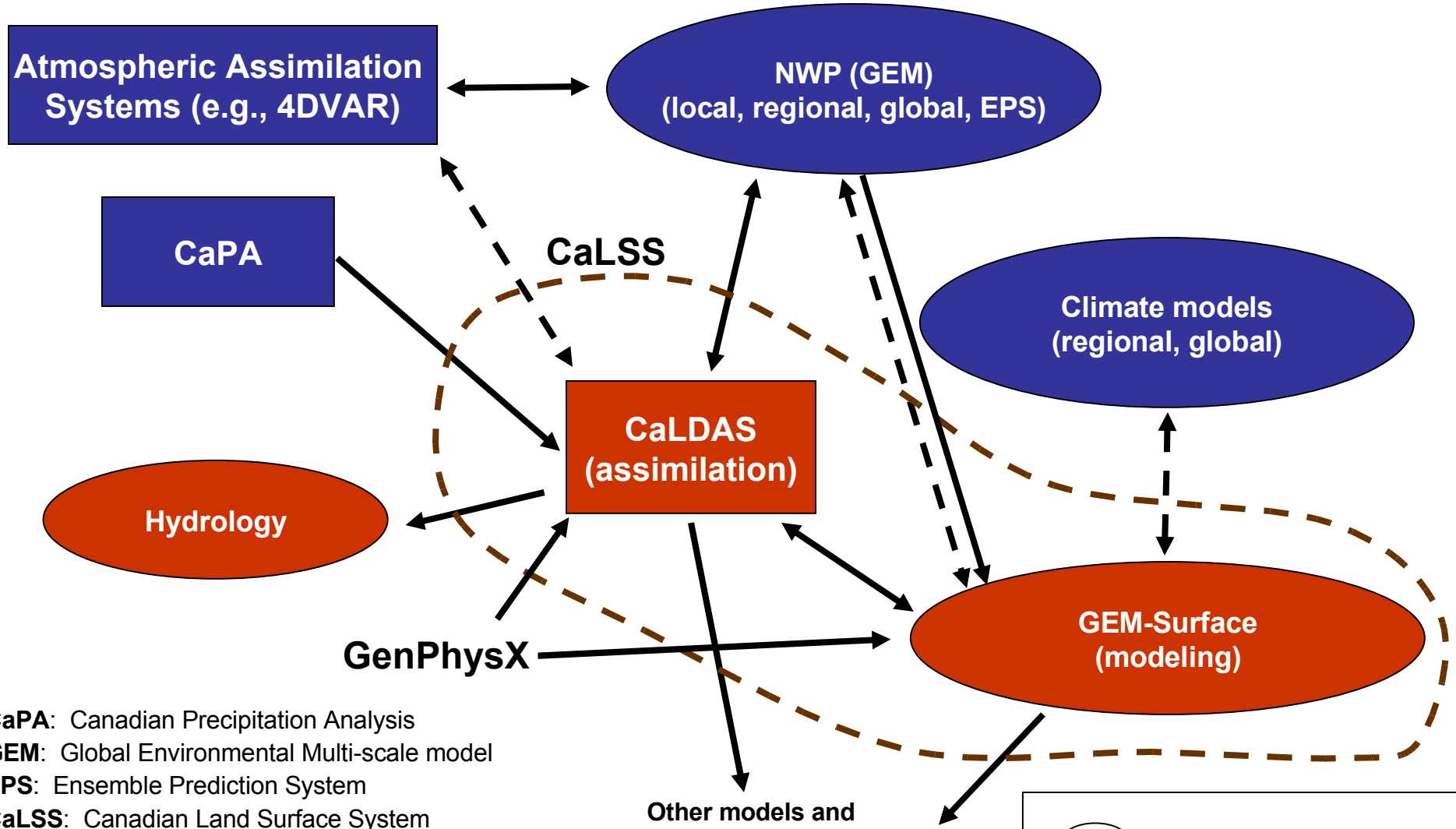
Other databases for **urban** environment and fractional **water** coverage







The CANADIAN LAND SURFACE SYSTEM (CaLSS) and its PLACE in ENVIRONMENTAL MODELING



CaPA: Canadian Precipitation Analysis
GEM: Global Environmental Multi-scale model
EPS: Ensemble Prediction System
CaLSS: Canadian Land Surface System
CaLDAS: Canadian Land Data Assimilation System
GenPhysX: Generator of surface geophysical fields