Système expérimental de prévision à la surface pour les Jeux Olympiques de Vancouver

Natacha Bernier et Linying Tong

Stéphane Bélair

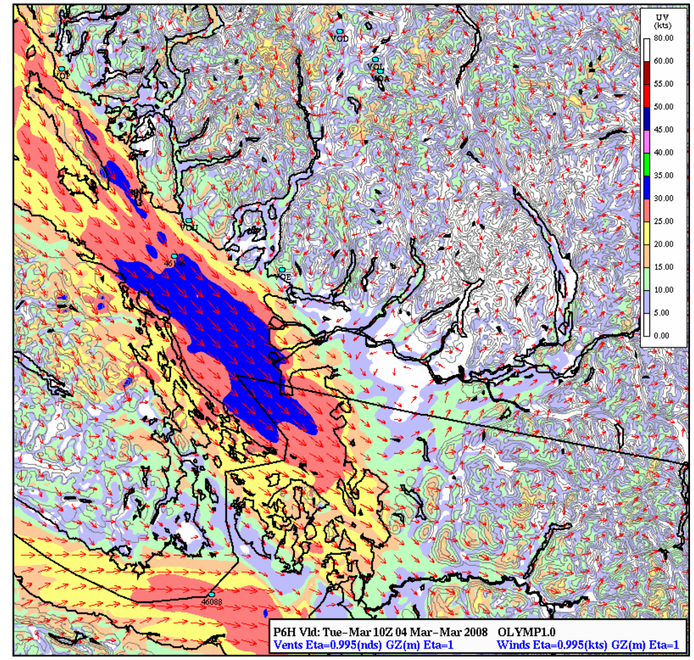
avec la collaboration de:

Maria Abrahamowicz, Bernard Bilodeau, Marco Carrera, Nathalie Gauthier, Lily Ioannidou, Sylvie Leroyer, et Alain Patoine

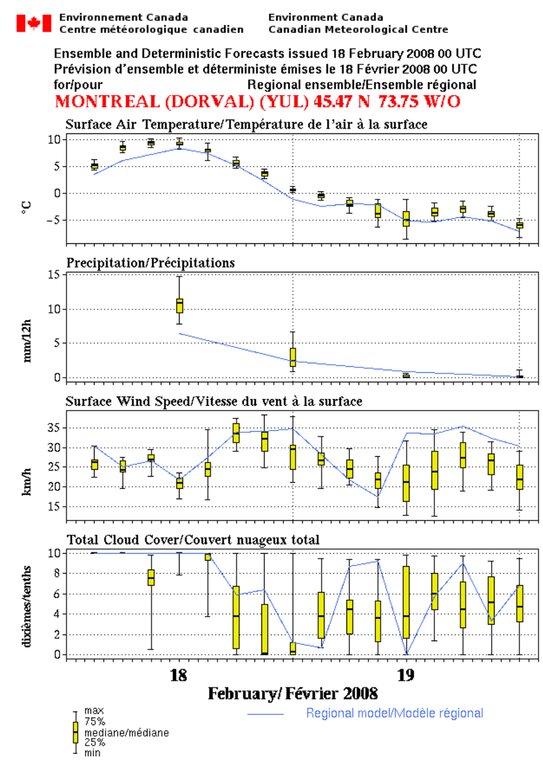
Environment Canada's NWP Activities Related to the 2010 Vancouver Olympic Games

Experimental NWP system with 3 components:

- **High-resolution deterministic LAM (1 km) (Lead: J. Mailhot)**

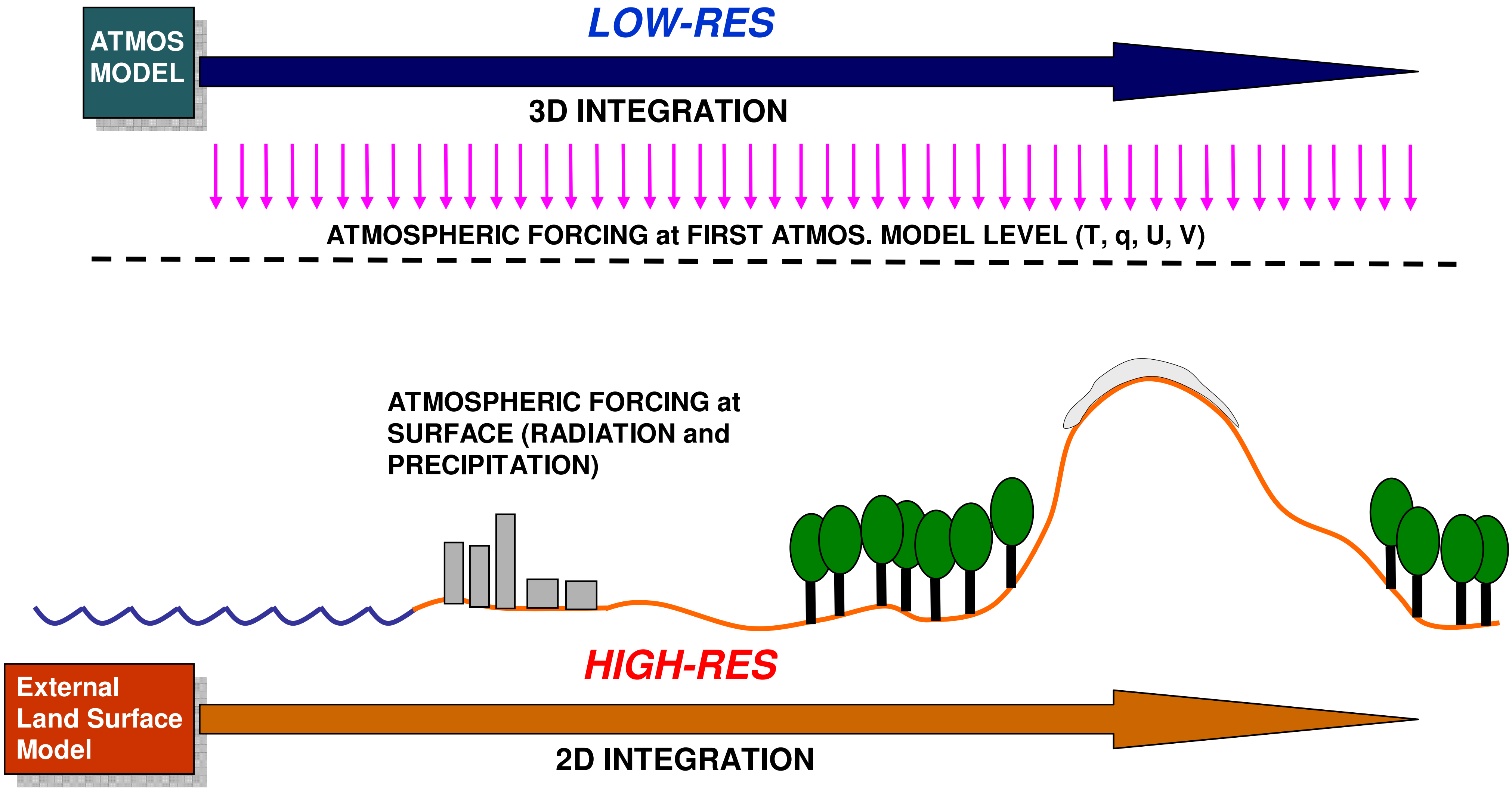


- **Regional Ensemble Prediction System (Lead: M. Charron)**



- **Microscale land surface system (Lead: S. Bélair)**

Concept of external land surface modeling (again!)

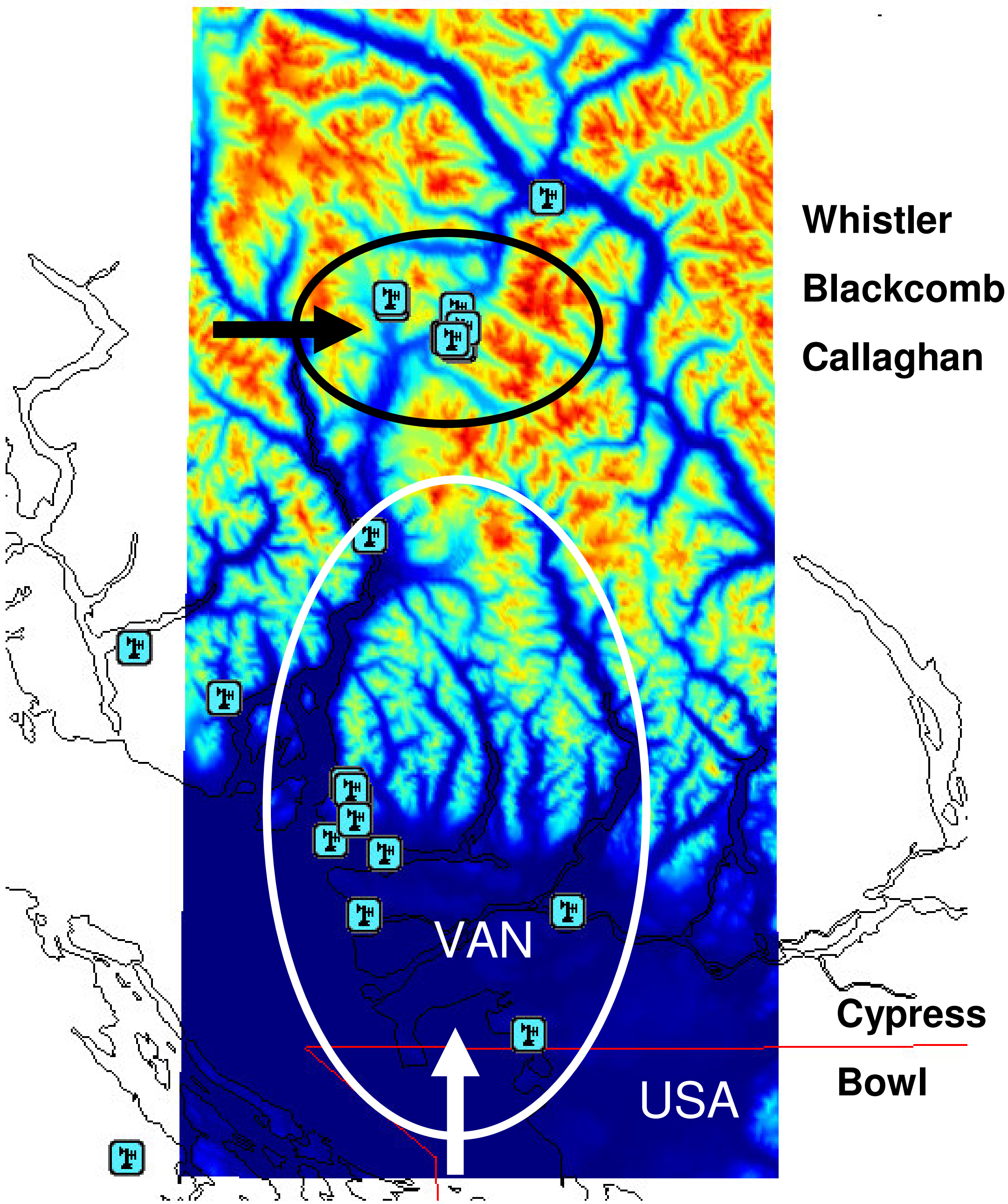


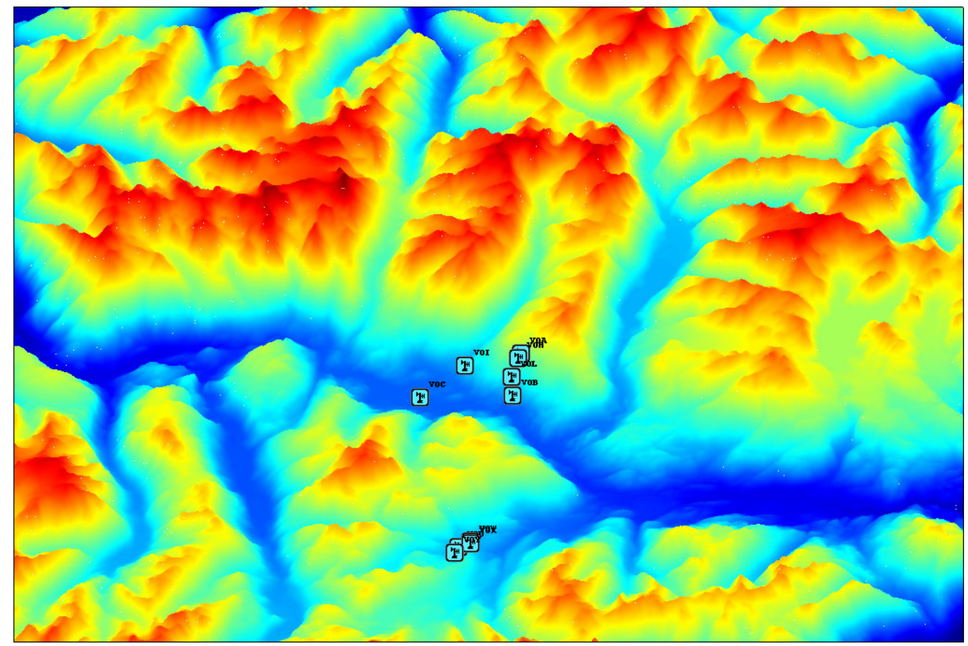
With horizontal resolution as high as that of surface databases (e.g., 100 m)

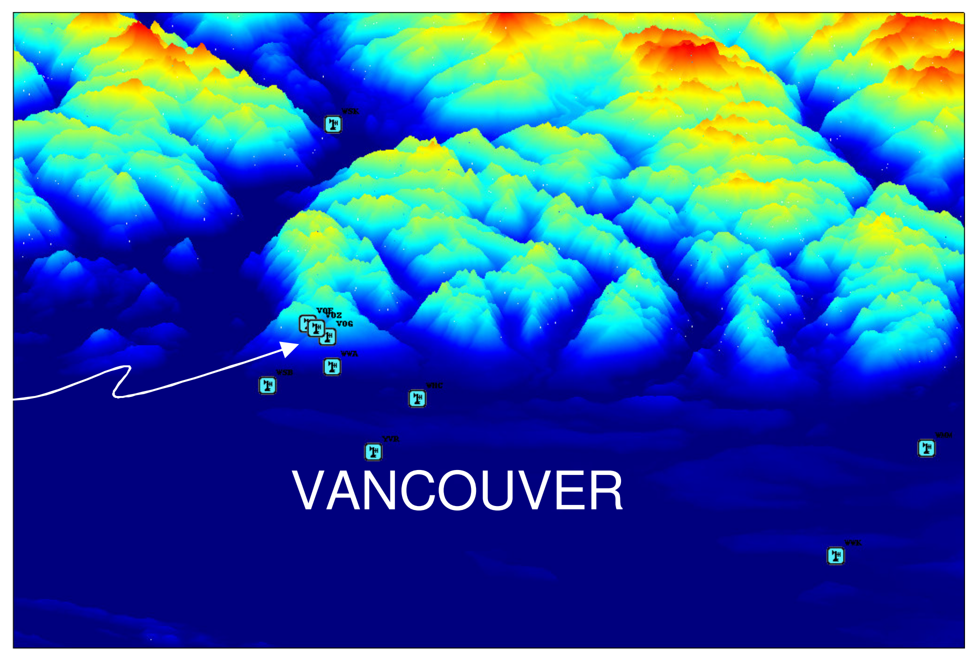
Computational cost of off-line surface modeling system is *<u>much less</u>* than an integration of the atmospheric model

Applications to the 2010 Vancouver Games: Two surface systems: “2D” and “Point”

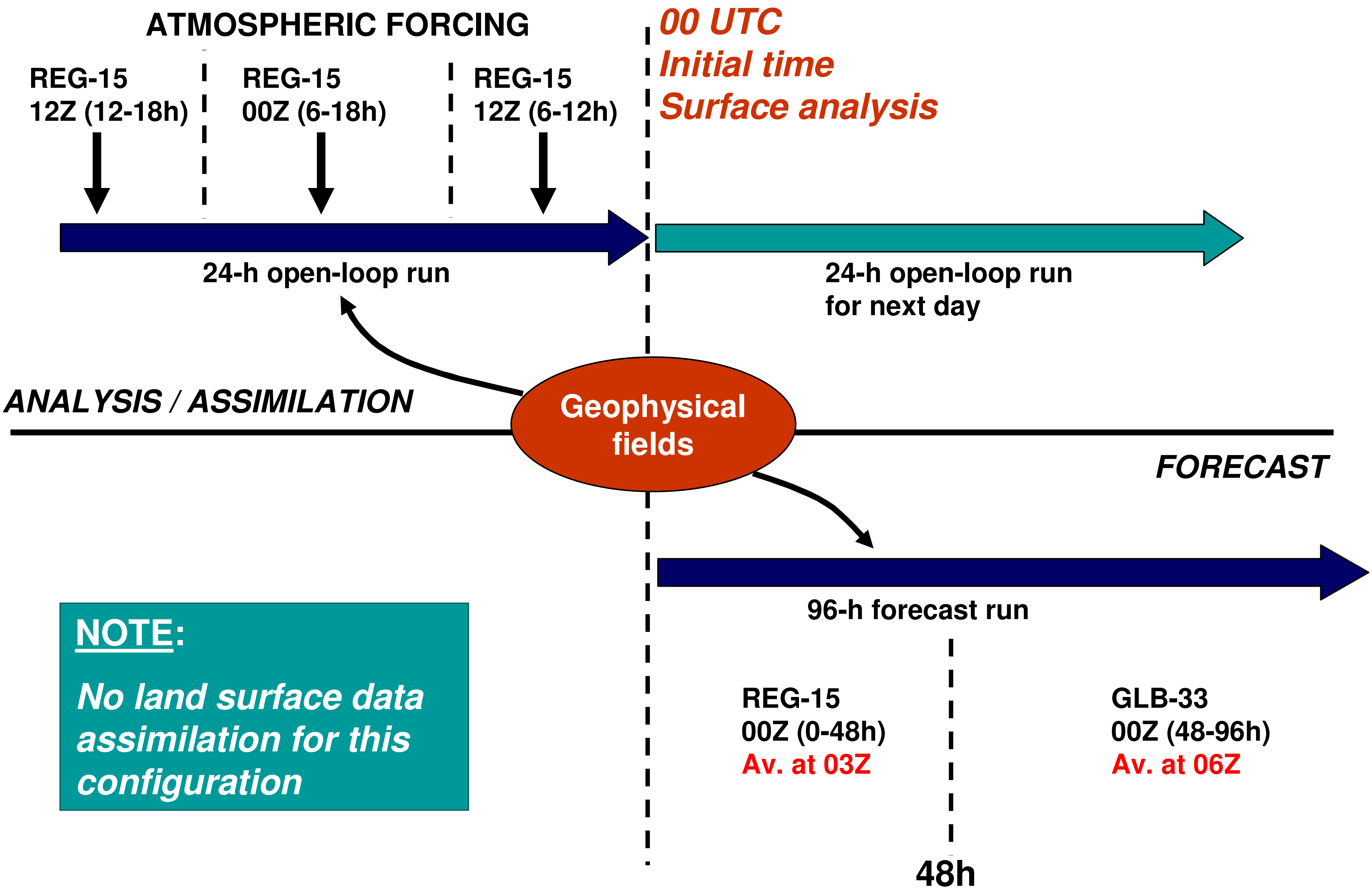
1400 x 1800 computational grid (100-m grid size)



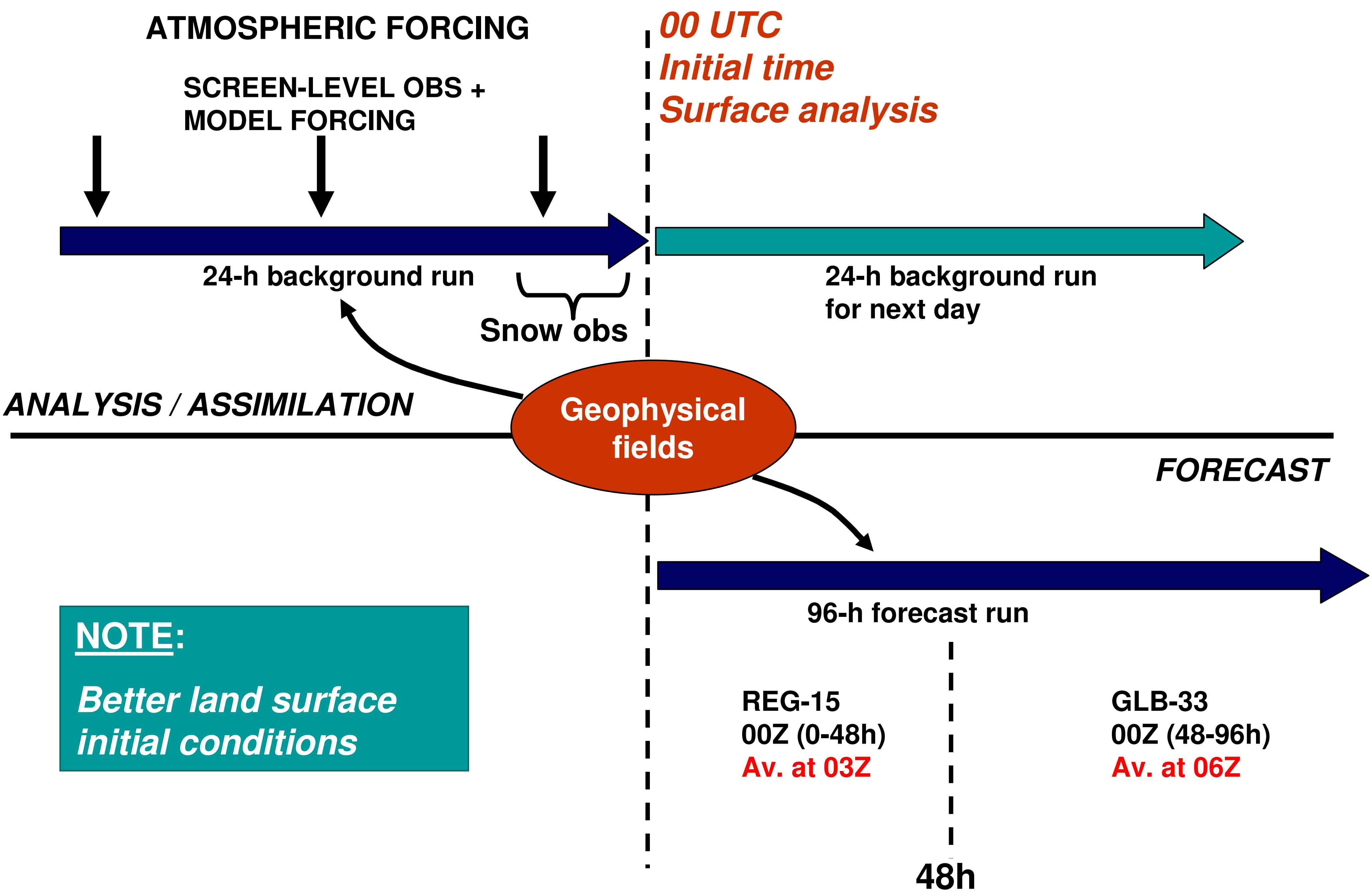




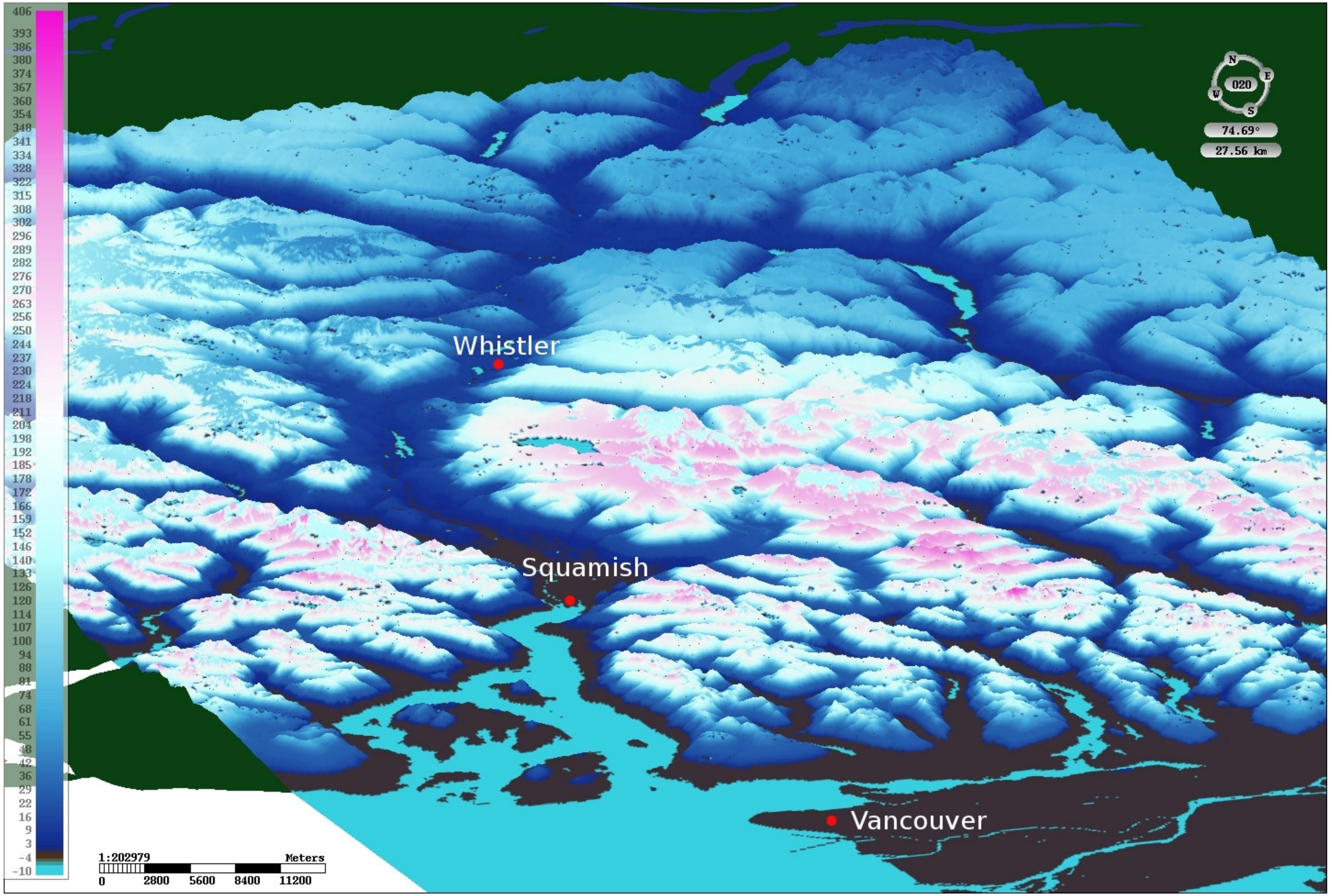
Experimental real-time "2D" land surface system



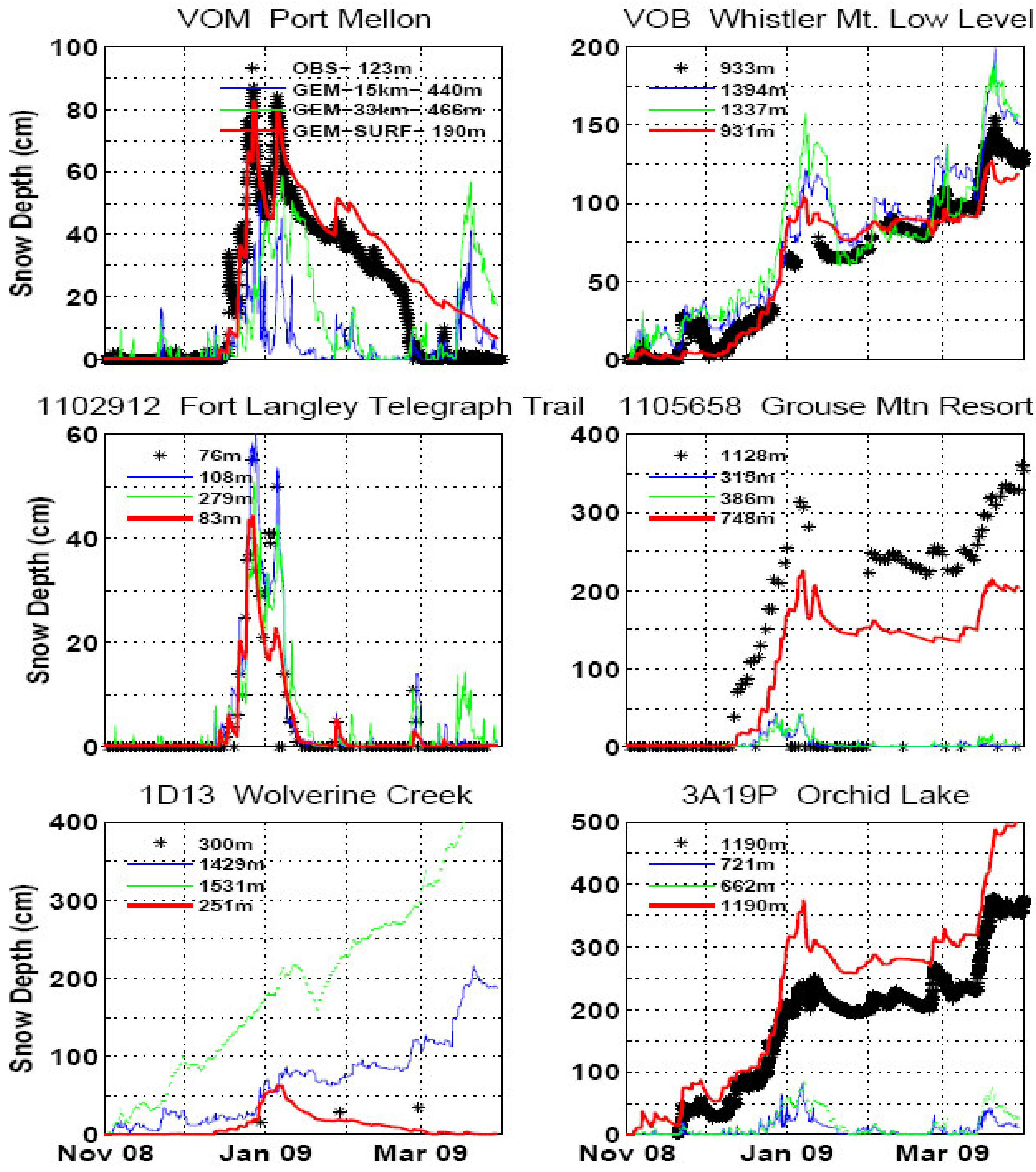
Experimental real-time "point" land surface system



Two-dimensional snow analysis (an example)



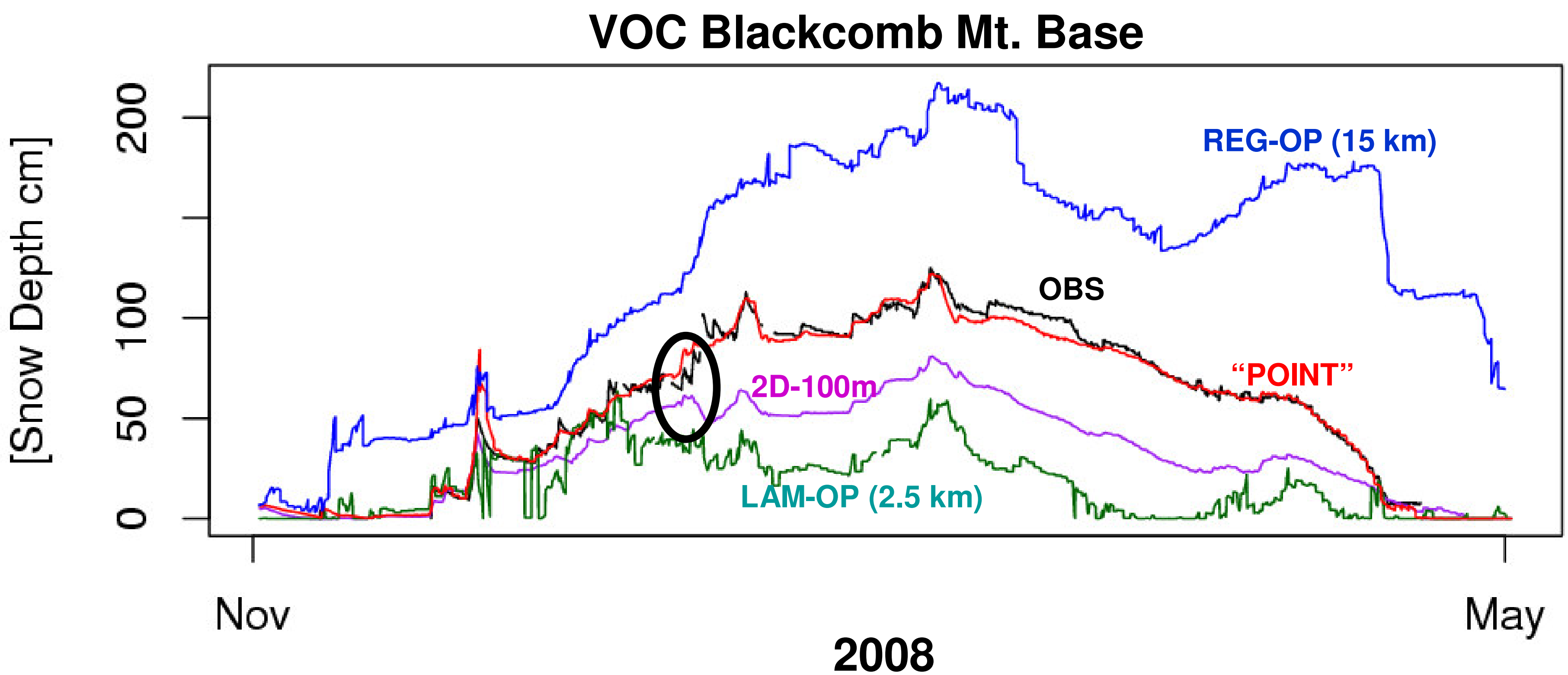
Two-dimensional snow analysis against surface observations



Close relationship with height of observations and of model outputs, ... but not always...

(Bernier et al. 2010, part I)

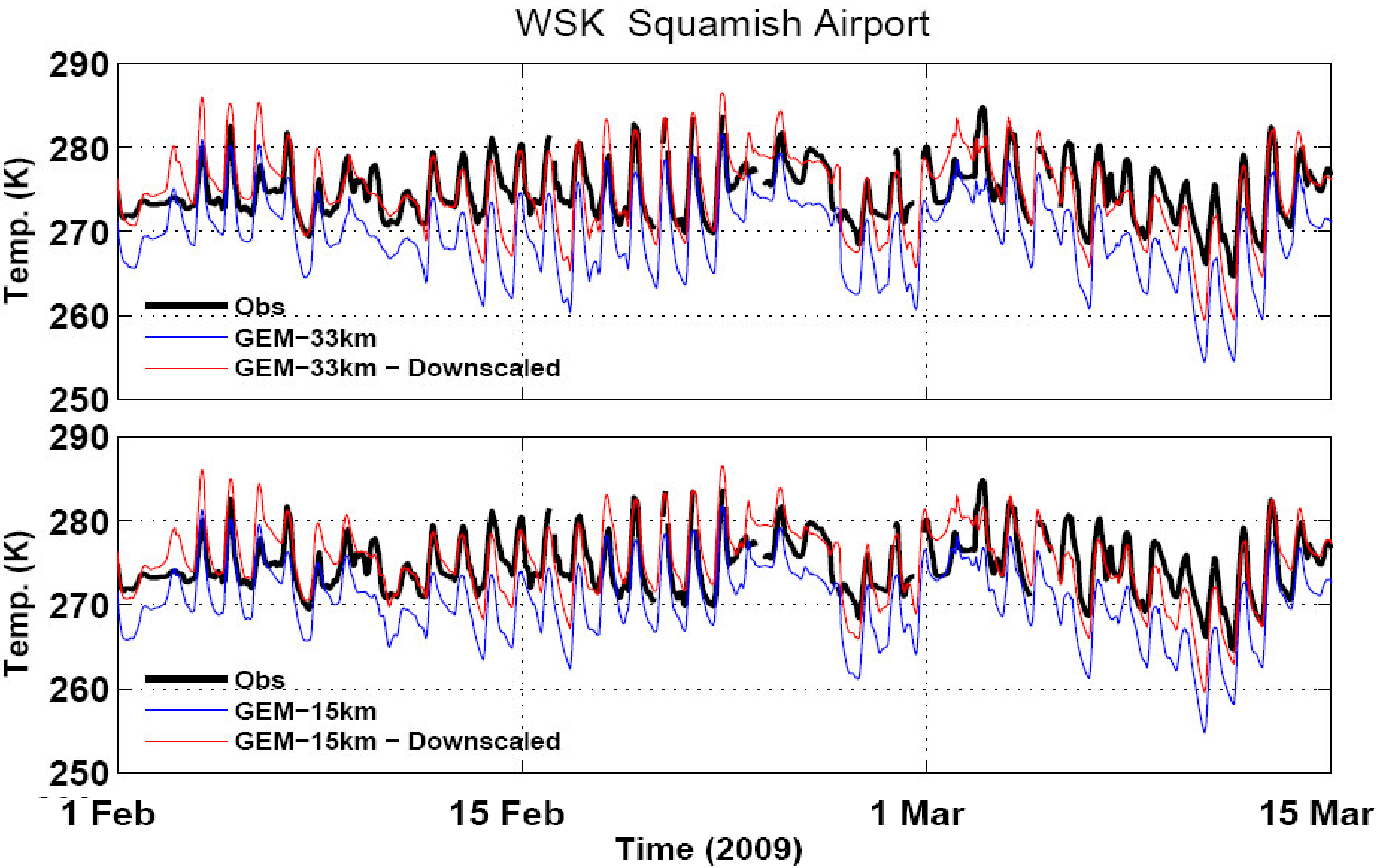
Verification of "point" snow analysis at VOC



Atmospheric forcing (e.g., precipitation phase) is of crucial importance for the 2D system (without assimilation of surface snow obs)

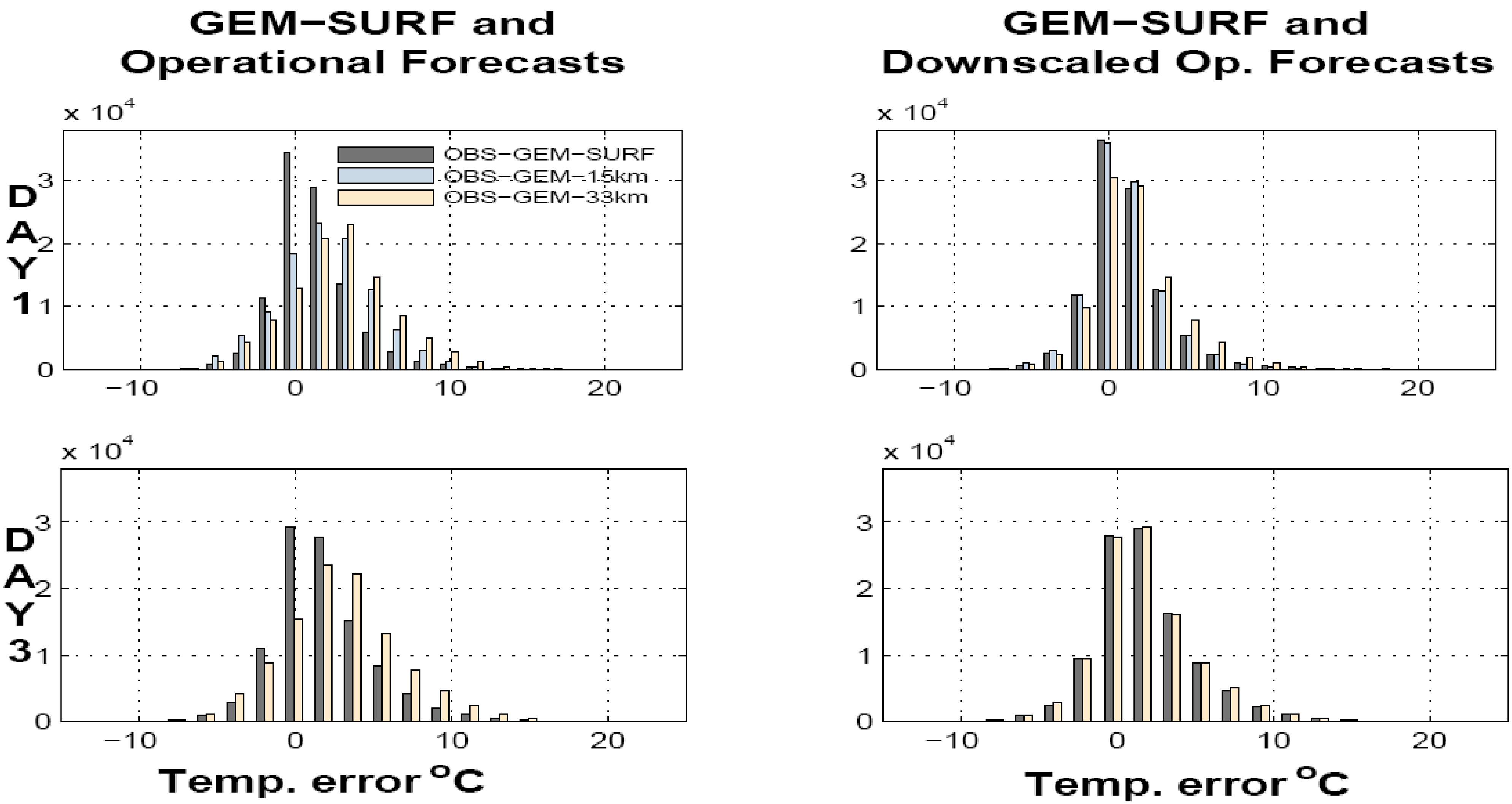
As could be expected, "point" system is right on target (because of the asssimilation of surface snow data)

Screen-level air temperature from the "2D" land surface system



(Bernier et al. 2010, part I)

Screen-level air temperature error distributions for the "2D" system

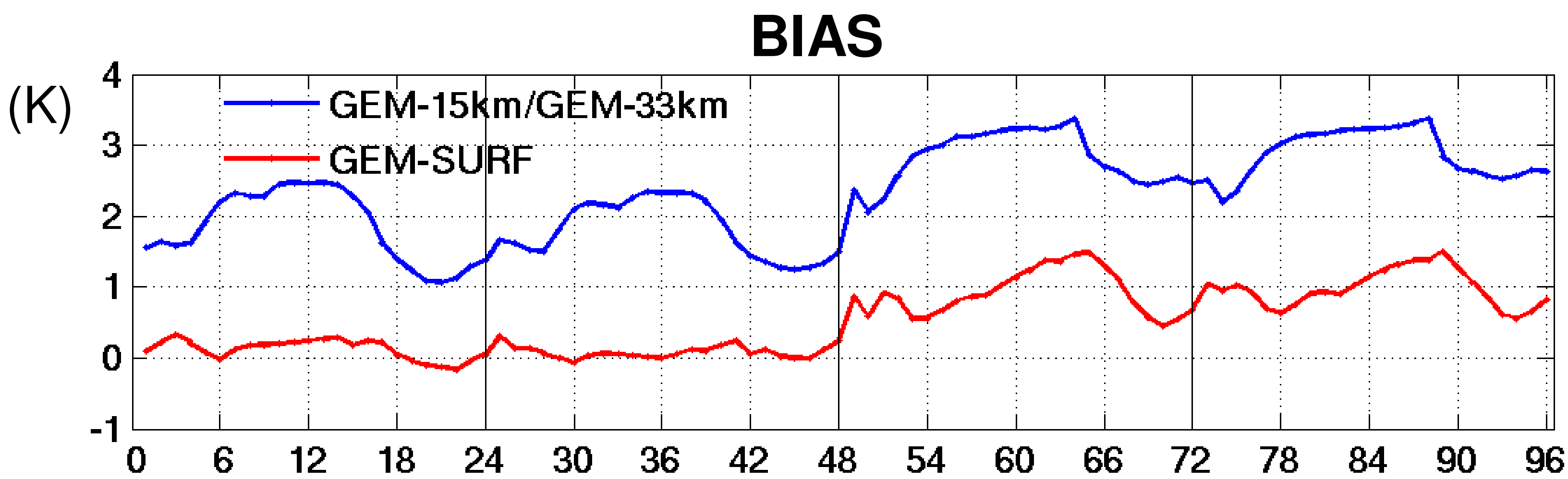


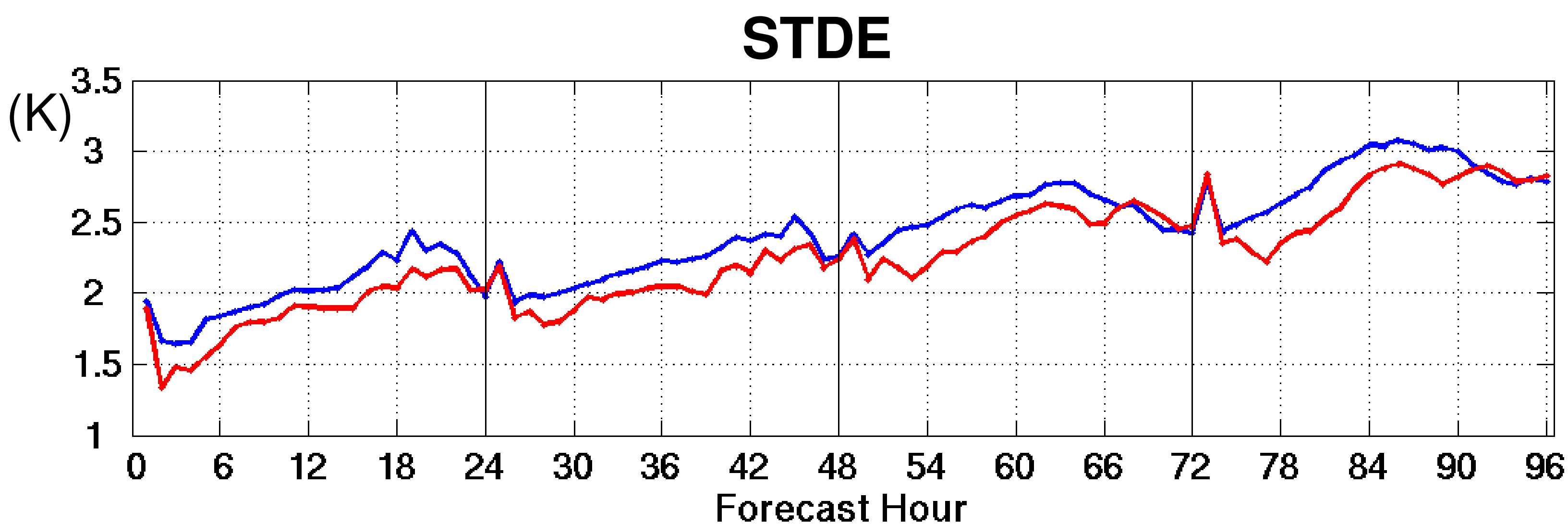
Removes bias, but just slightly better than a simple downscaling of the REG-15 and GLB-33 models (strong effect of orography, versus surface cover types + no land surface assimilation in 2D system)

(Bernier et al. 2010, part I)

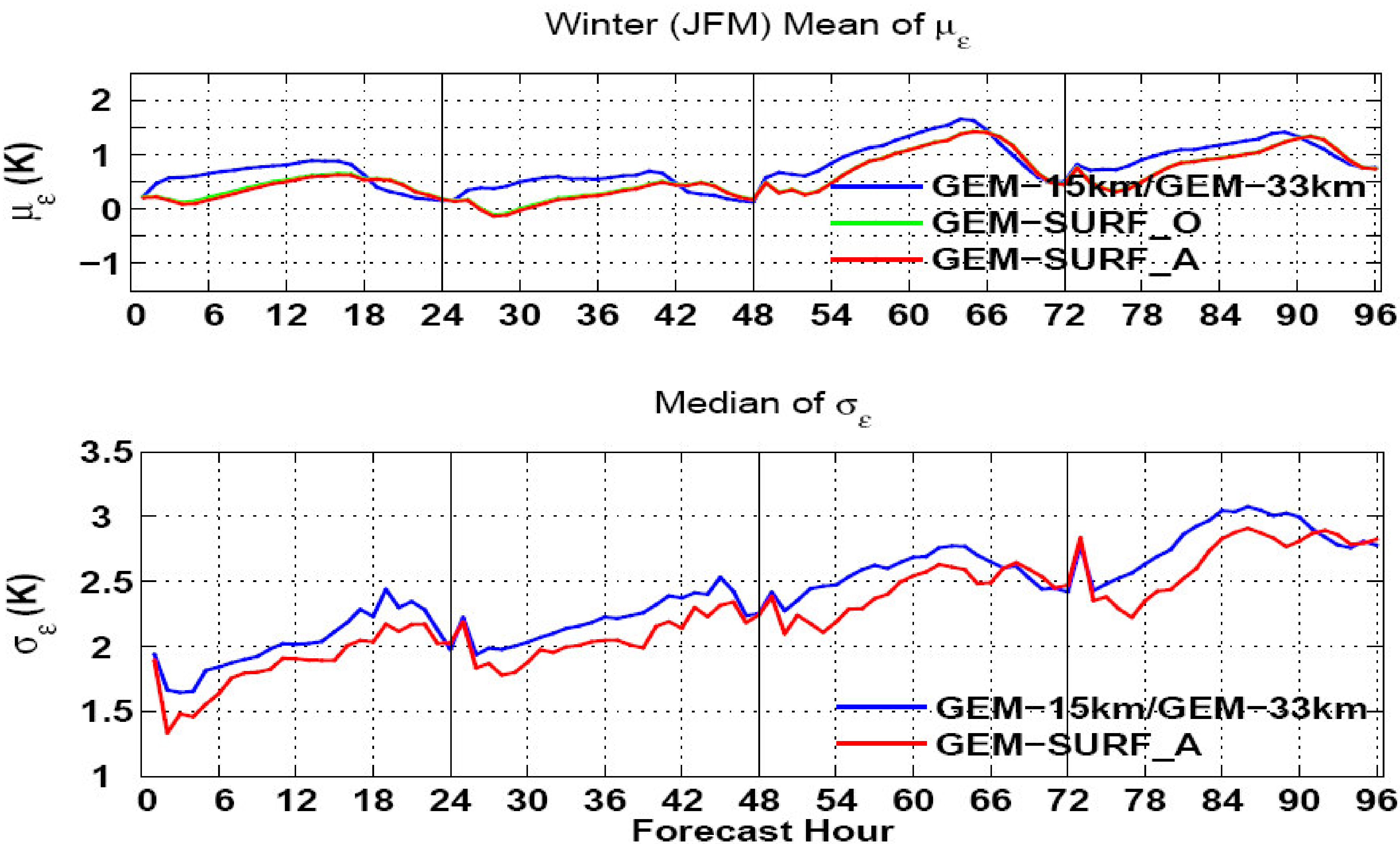
Objective evaluation of screen-level air temperature from the "Point" system

Screen-level air temperature – 1 January to 31 December 2008





Objective evaluation of screen-level air temperature from the "Point" system (against "downscaled" REG-15 and GLB-33)



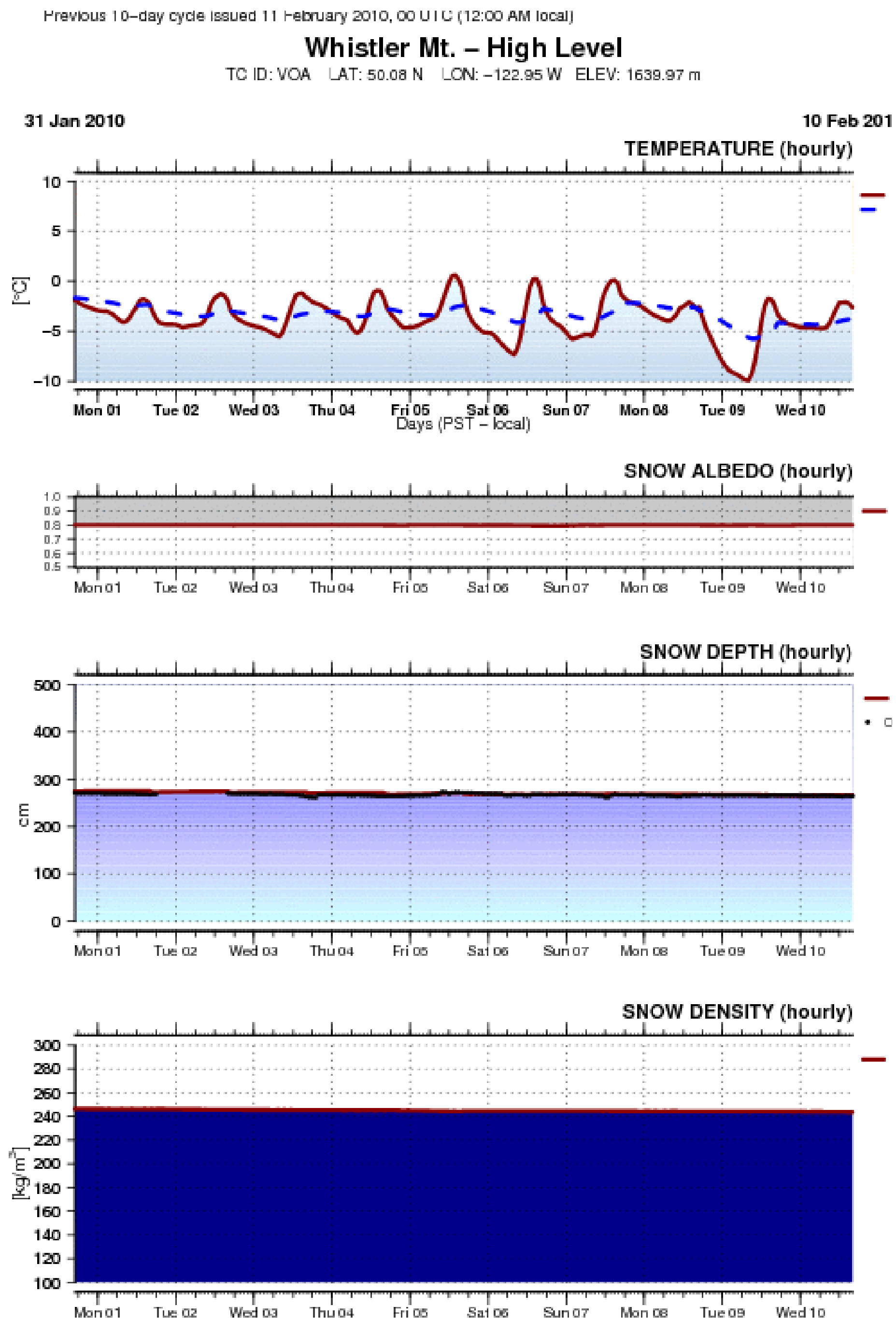
(Bernier et al. 2010, part II)

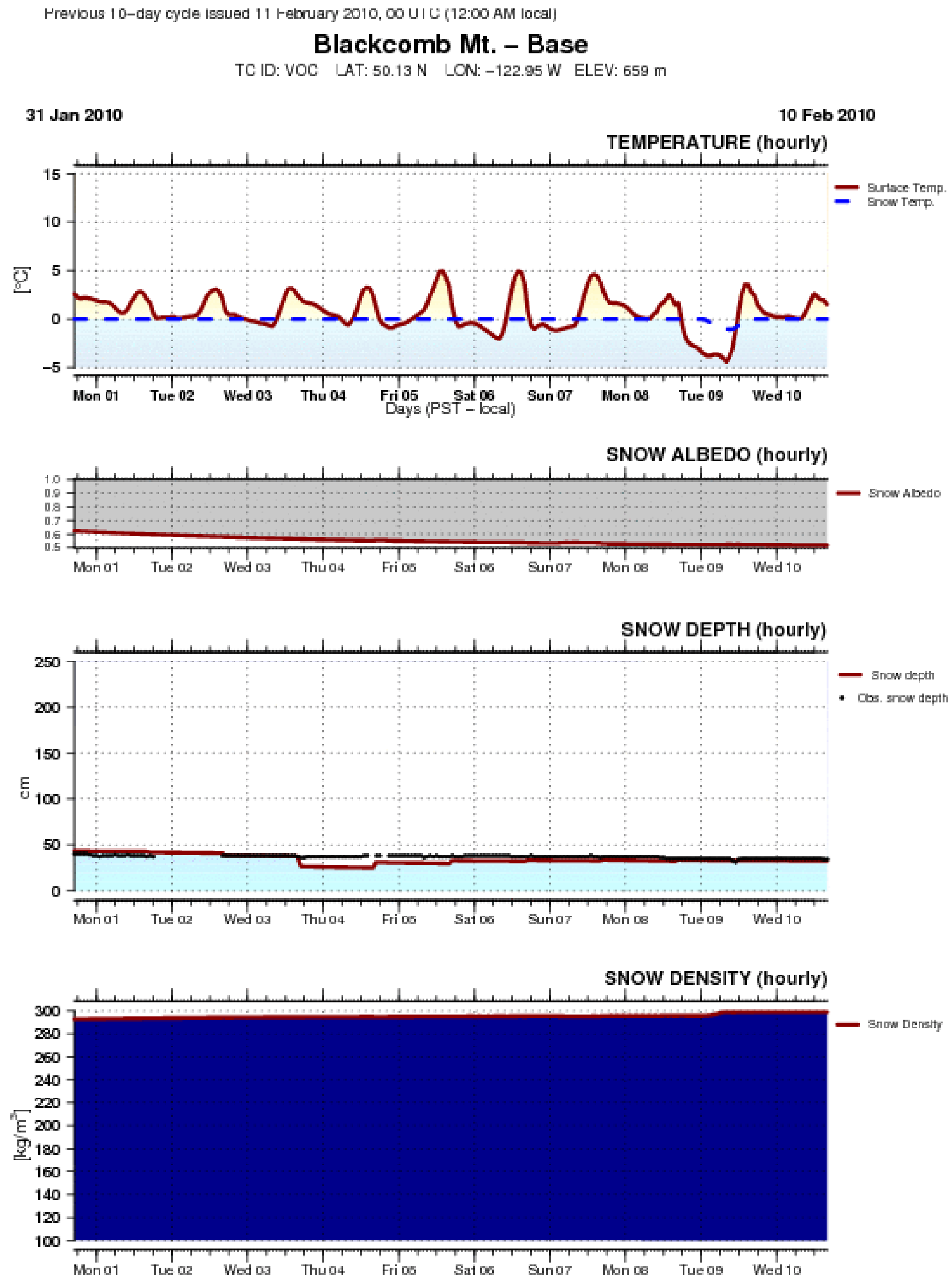
With assimilation (CaLDAS), same kind of improvement should be expected for the 2D system

List of products

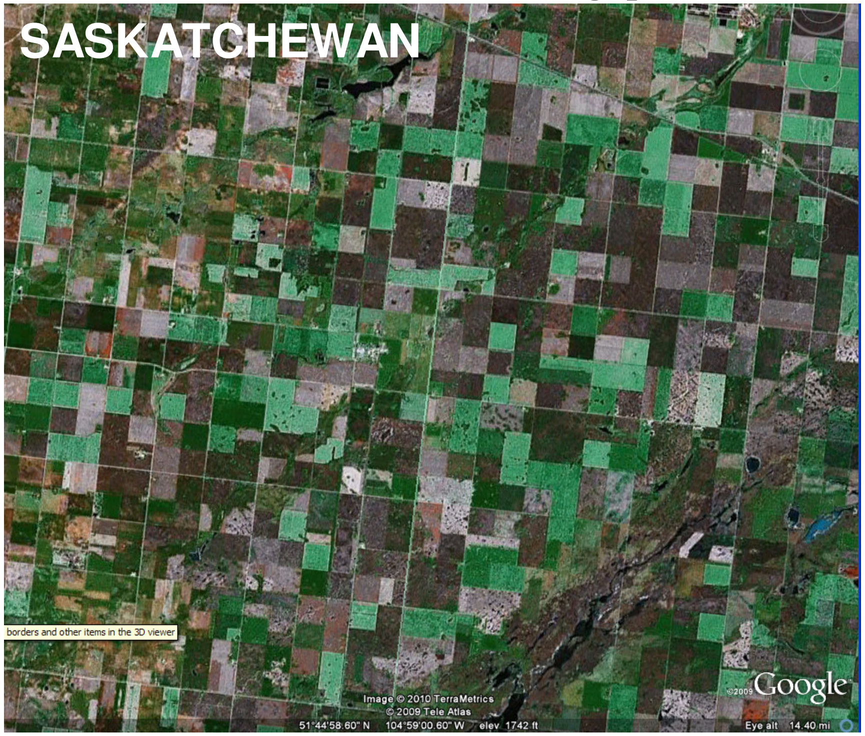
- *Last 10 days meteograms (forcing + screen-level diagnostics from surface system)*
- *Last 10 days surfacegrams (surface prognostic variables – focus on snow conditions)*
- *Next 4 days meteograms (forcing + screen-level diagnostics from surface system)*
- *Next 4 days surfacegrams (surface prognostic variables – focus on snow conditions)*

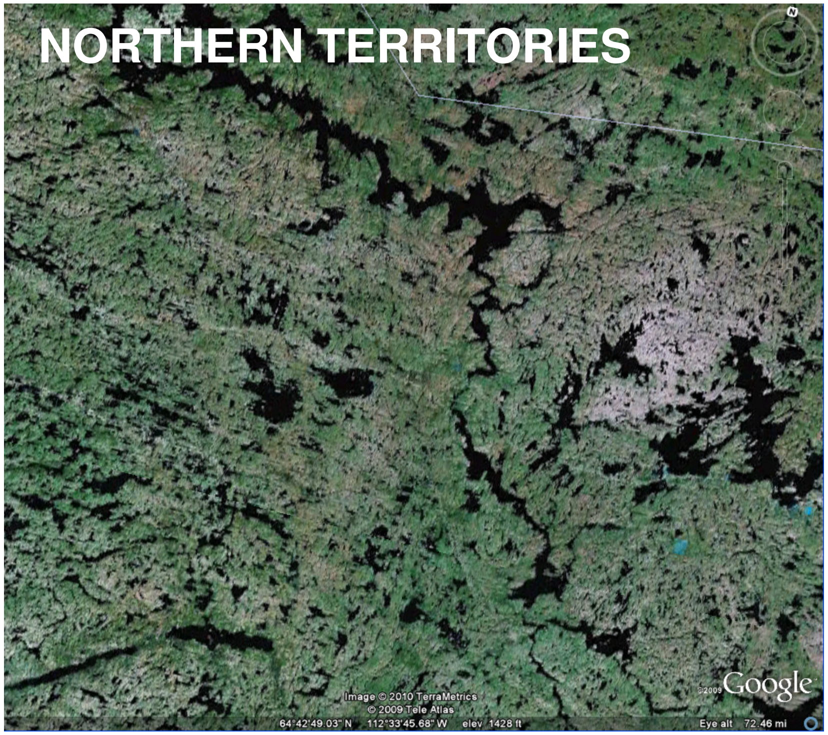
Examples of “Surfacegrams”

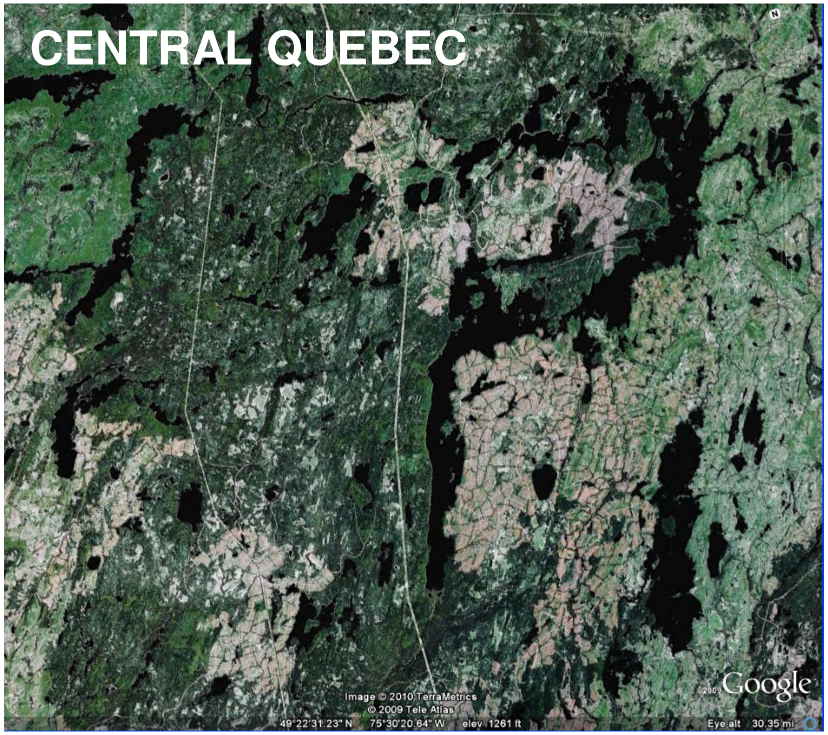




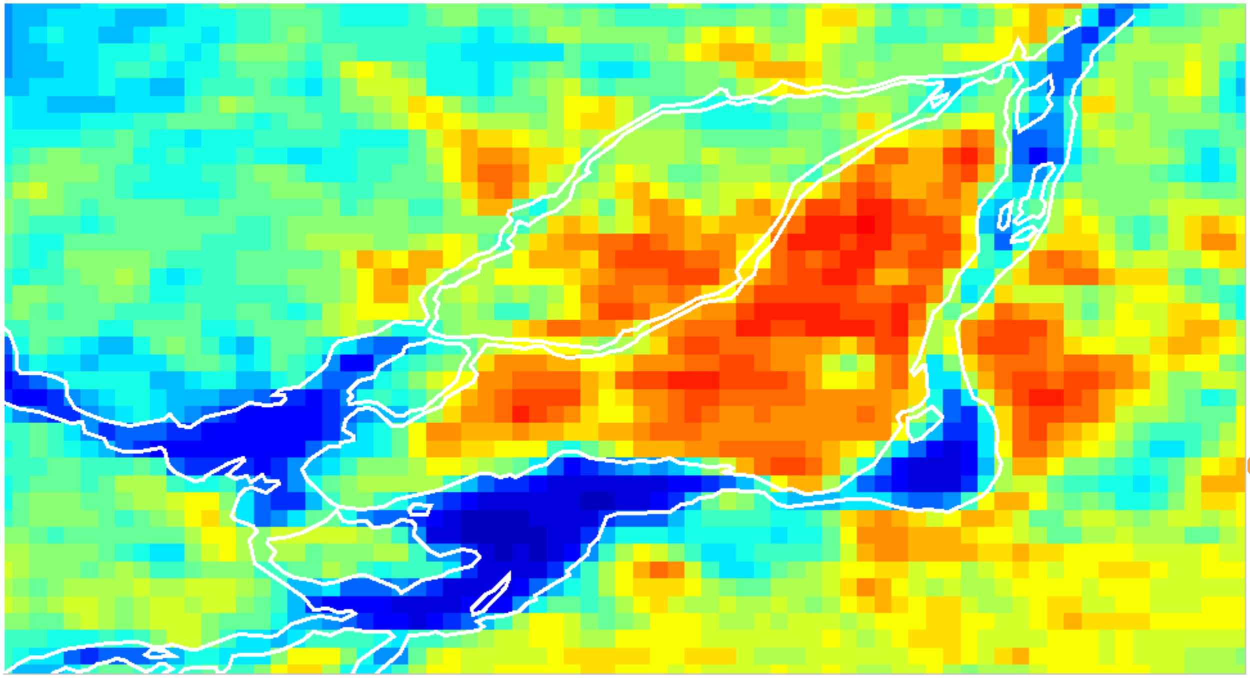
Applications to other types of covers







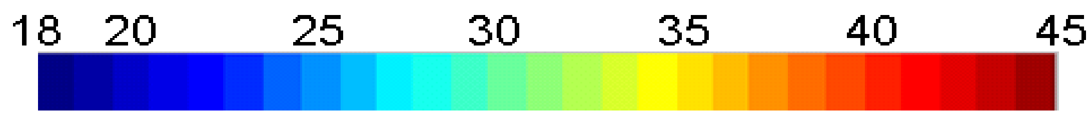
Application to urban meteorology



Comparison with MODIS (1 km)

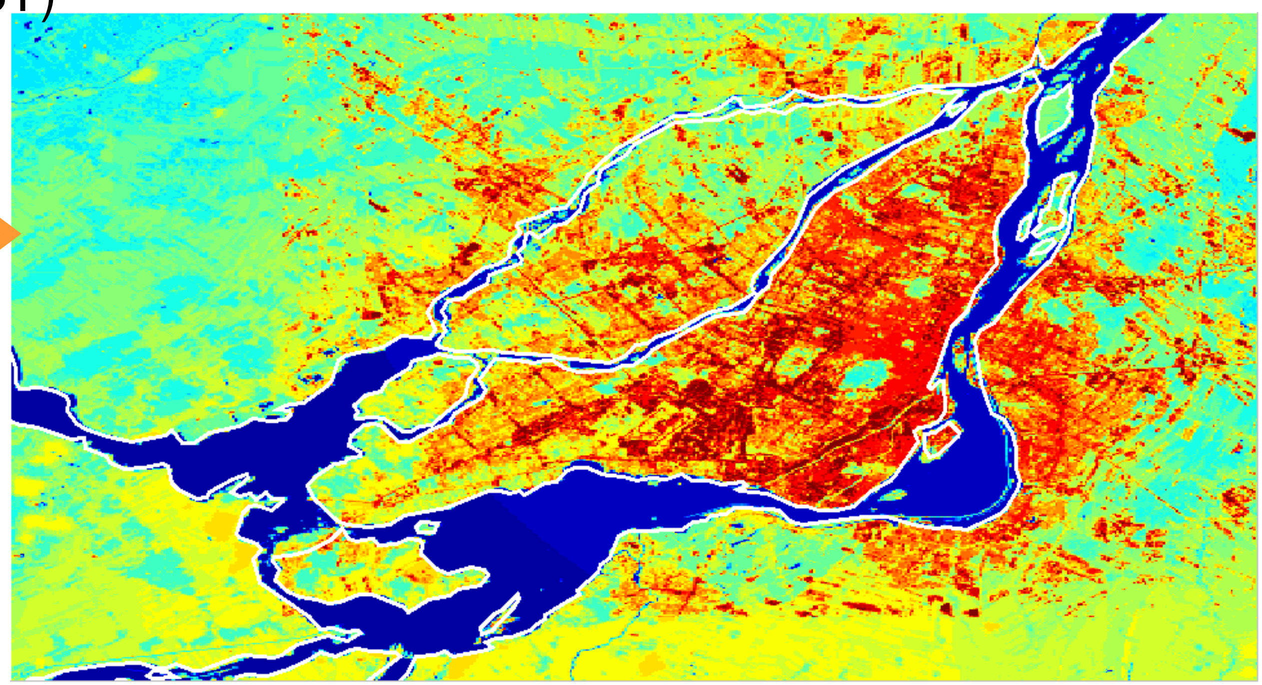
MOD11A1 product
Resolution: 1km
(exactly 928 m)
■ Atmospheric effects corrected
■ Satellite View Angle : 15°

- **Radiative Surface Temperature (°C)**
  July 6th 2008 (10:54 LST)
  Warm and Sunny



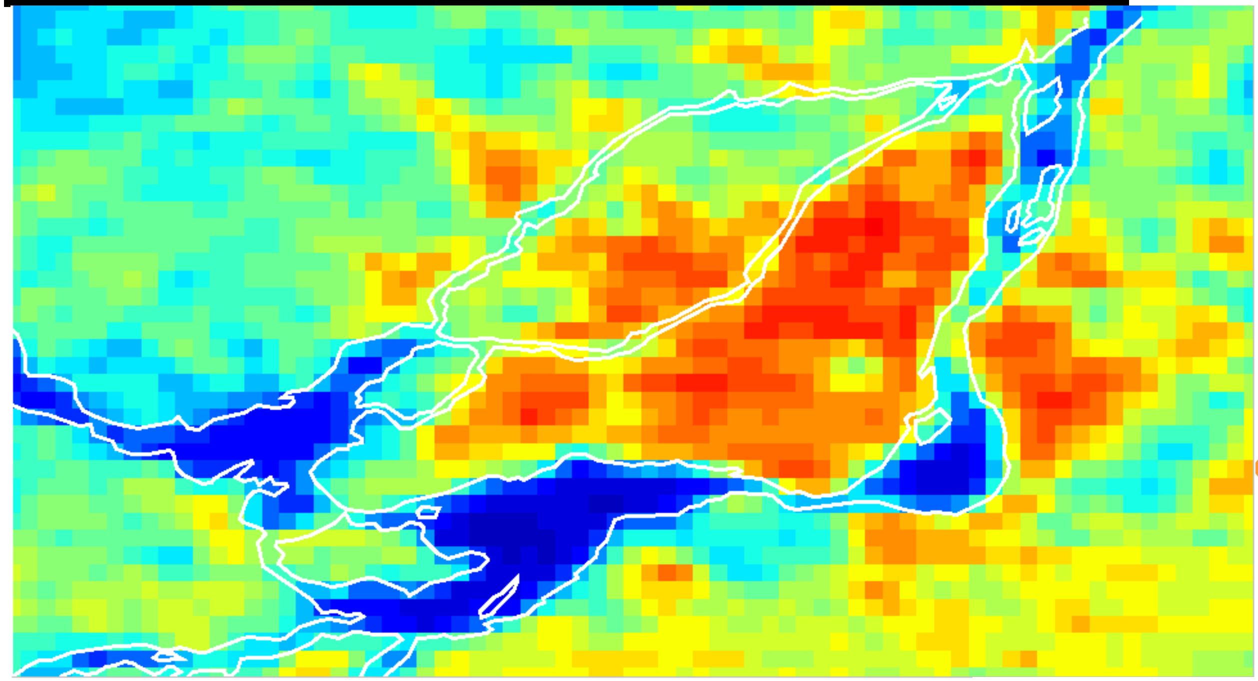
Urban off-line modeling system
Resolution: 120 m

Z_{0h}: Kanda (2007)



(Leroyer et al., 2010)

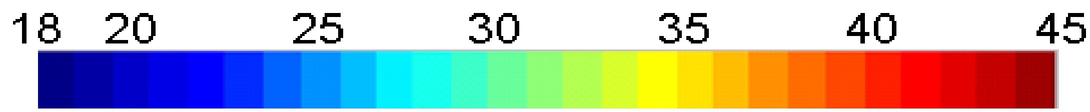
Application to urban meteorology



Comparison with MODIS (1 km)

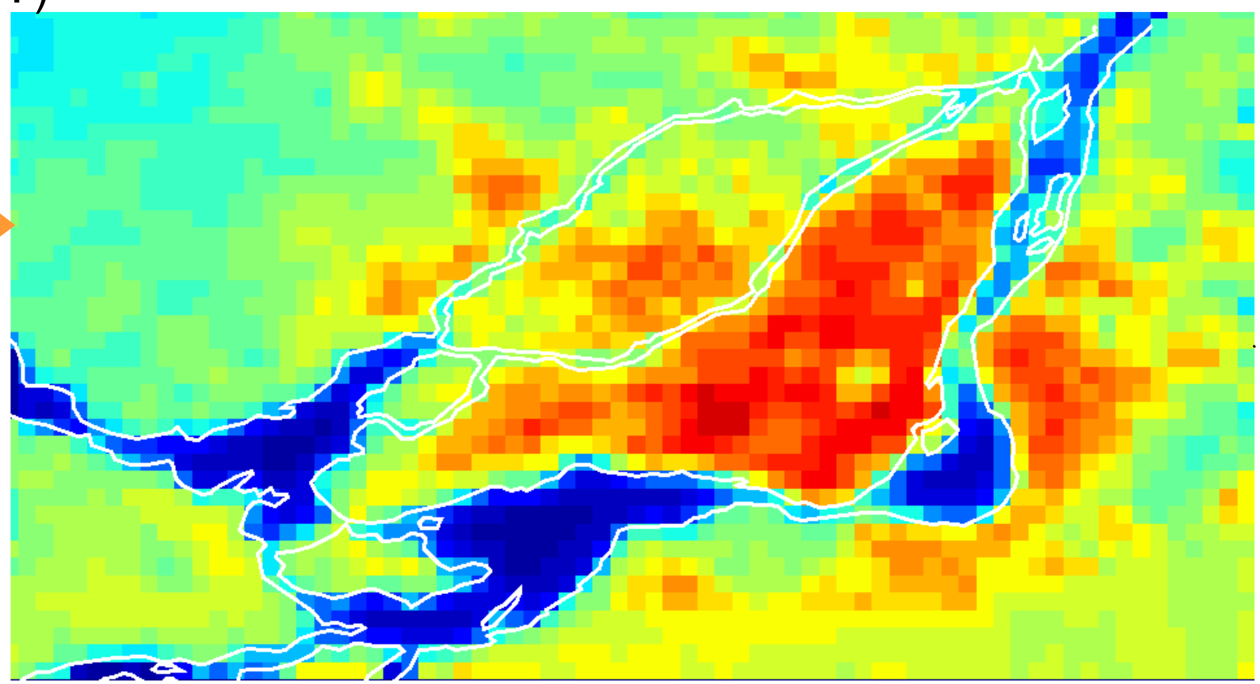
MOD11A1 product
Resolution: 1km
(exactly 928 m)
■ Atmospheric effects corrected
■ Satellite View Angle : 15°

• **Radiative Surface Temperature (°C)**
July 6th 2008 (10:54 LST)
Warm and Sunny



Urban off-line modeling system
Resolution: 928 m
→ upscaling

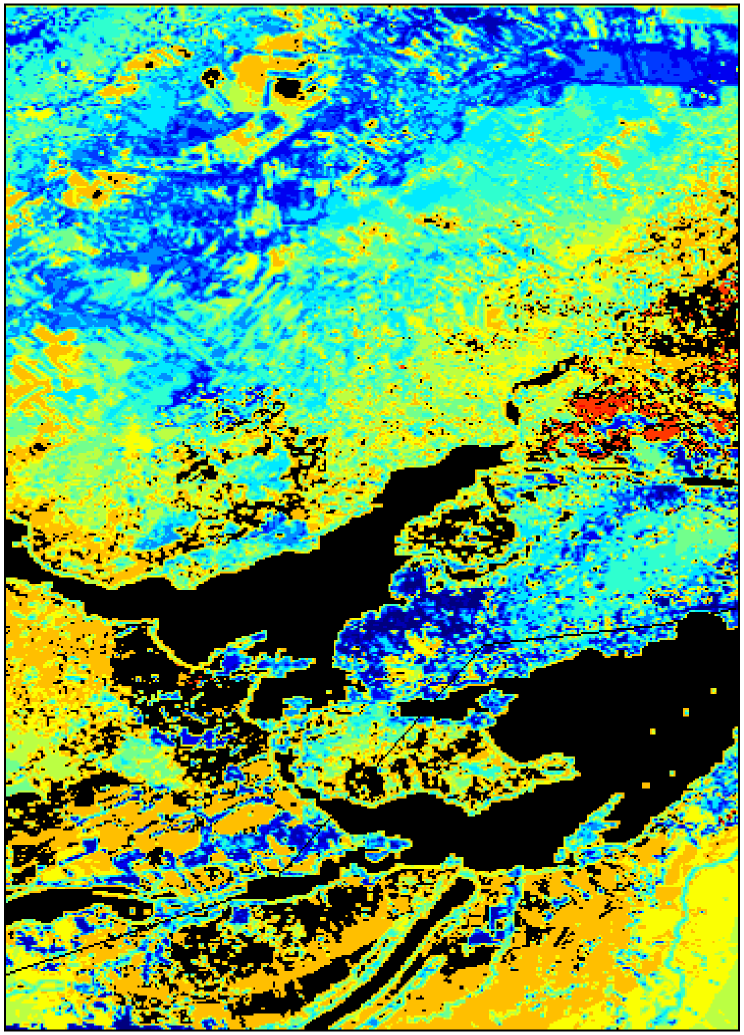
Z_{0h}: Kanda (2007)



(Leroyer et al., 2010)

Another example: Soil wetness

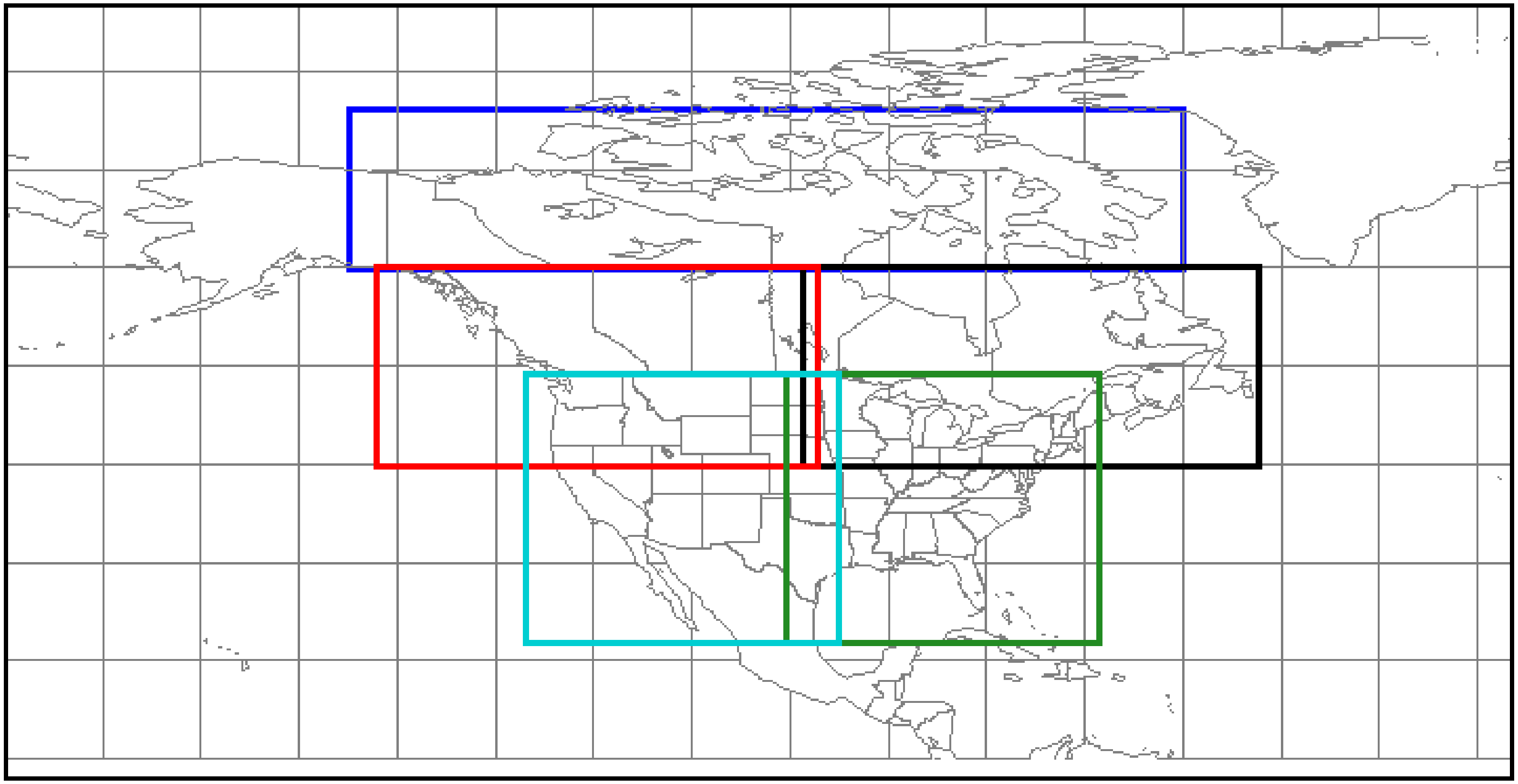
Soil Water Index



(100m, Montreal region)

(Leroyer et al., 2010)

Extension to the entire country + Generation of a 1-km North American "nature run"



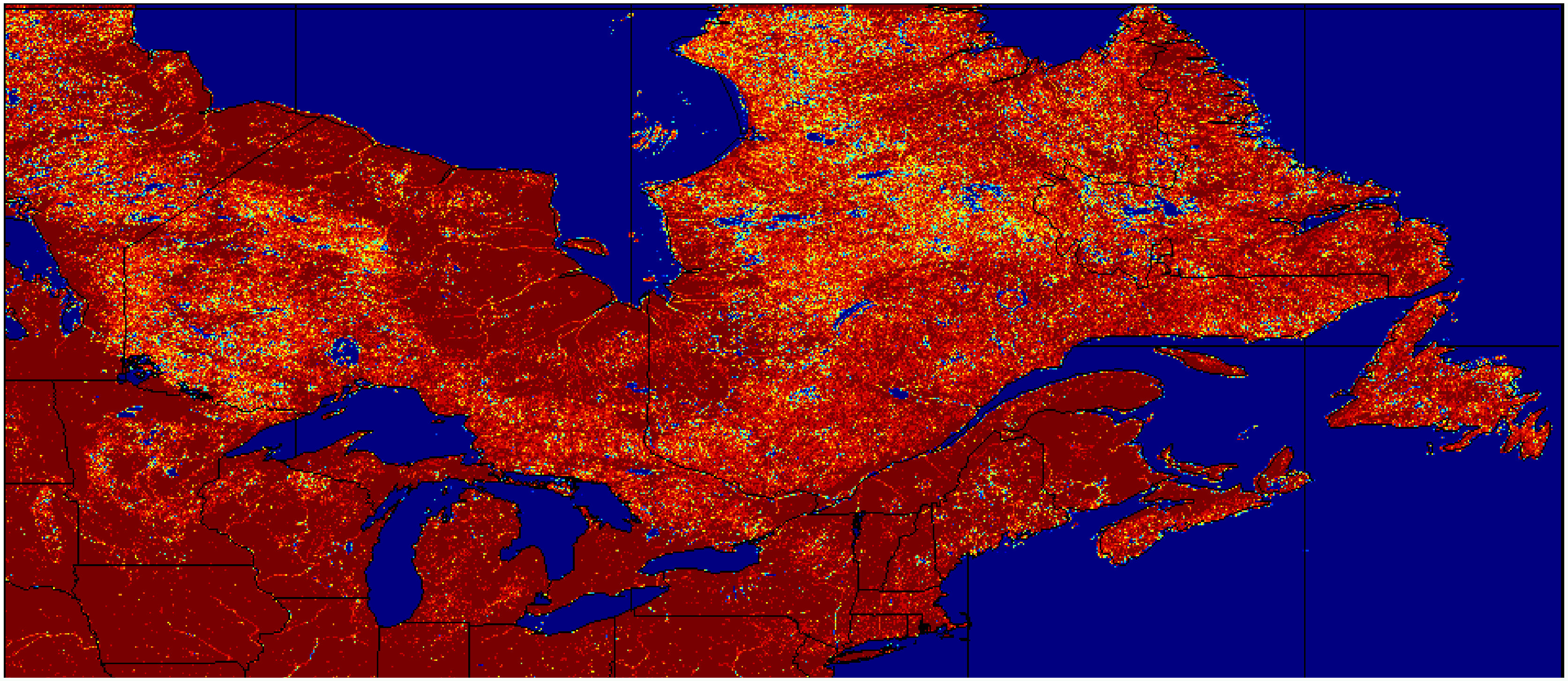
Applications:

Extension of the VO2010 prototype (objective evaluation of all surface and near-surface prognostic variables)

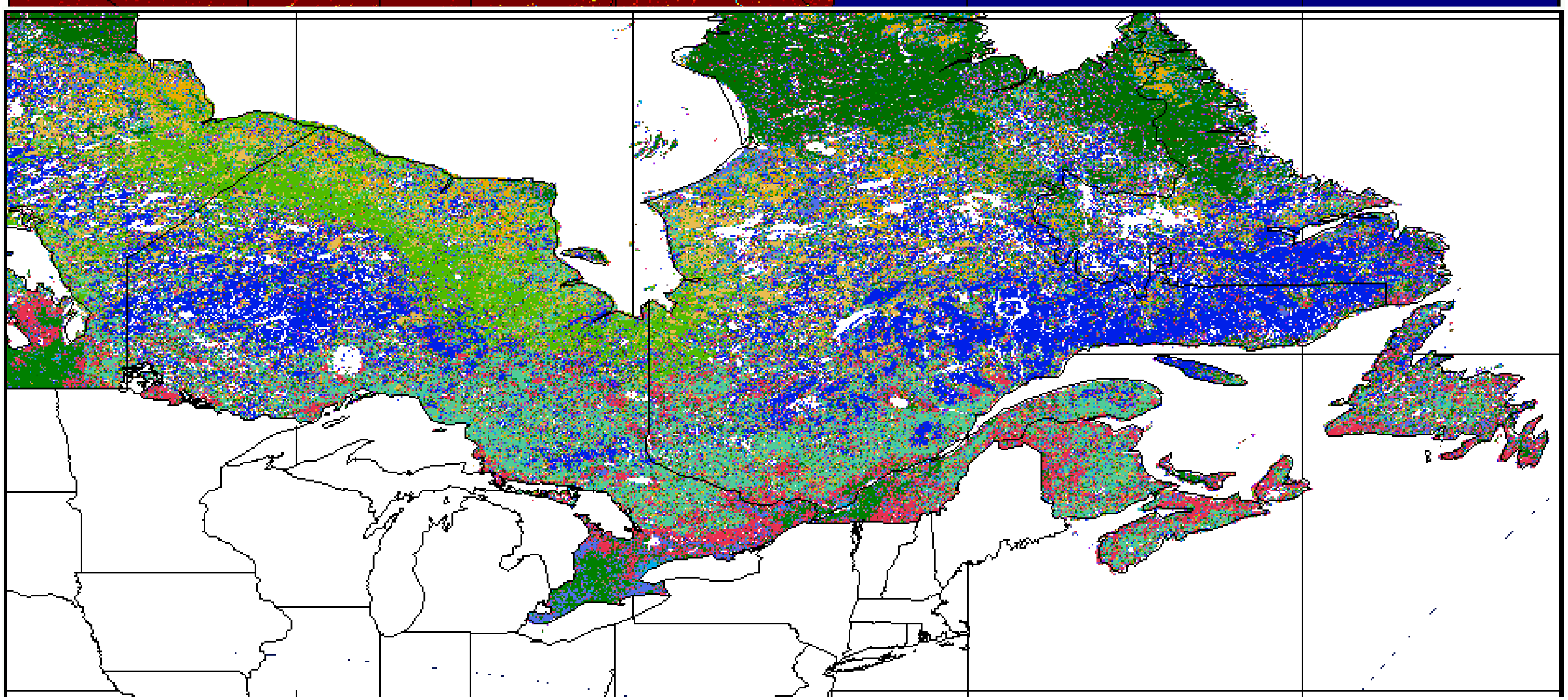
Synthetic data for CaLDAS testing (same will be done by U.S. partners)

Eventual "3D" synthetic experiment

Examples of High-Resolution Surface Fields

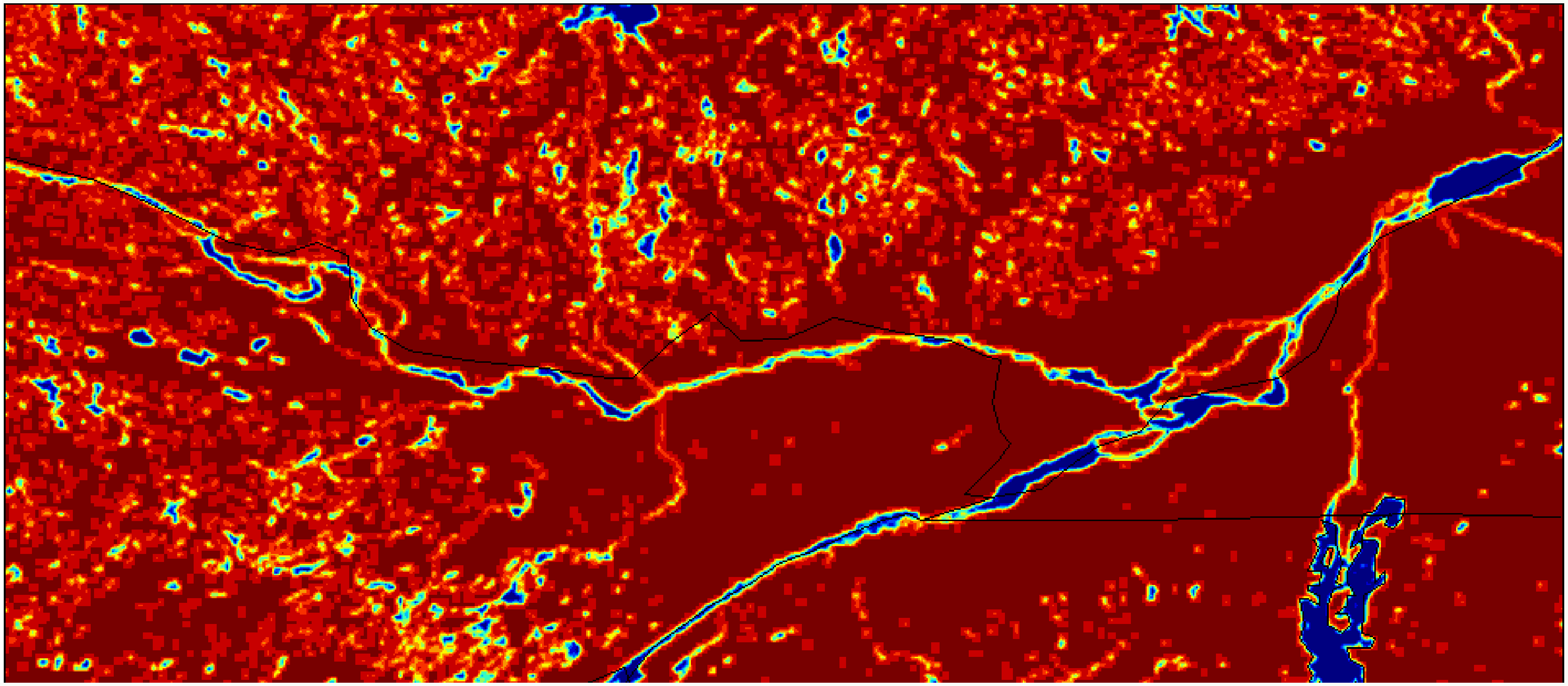


Water / land mask

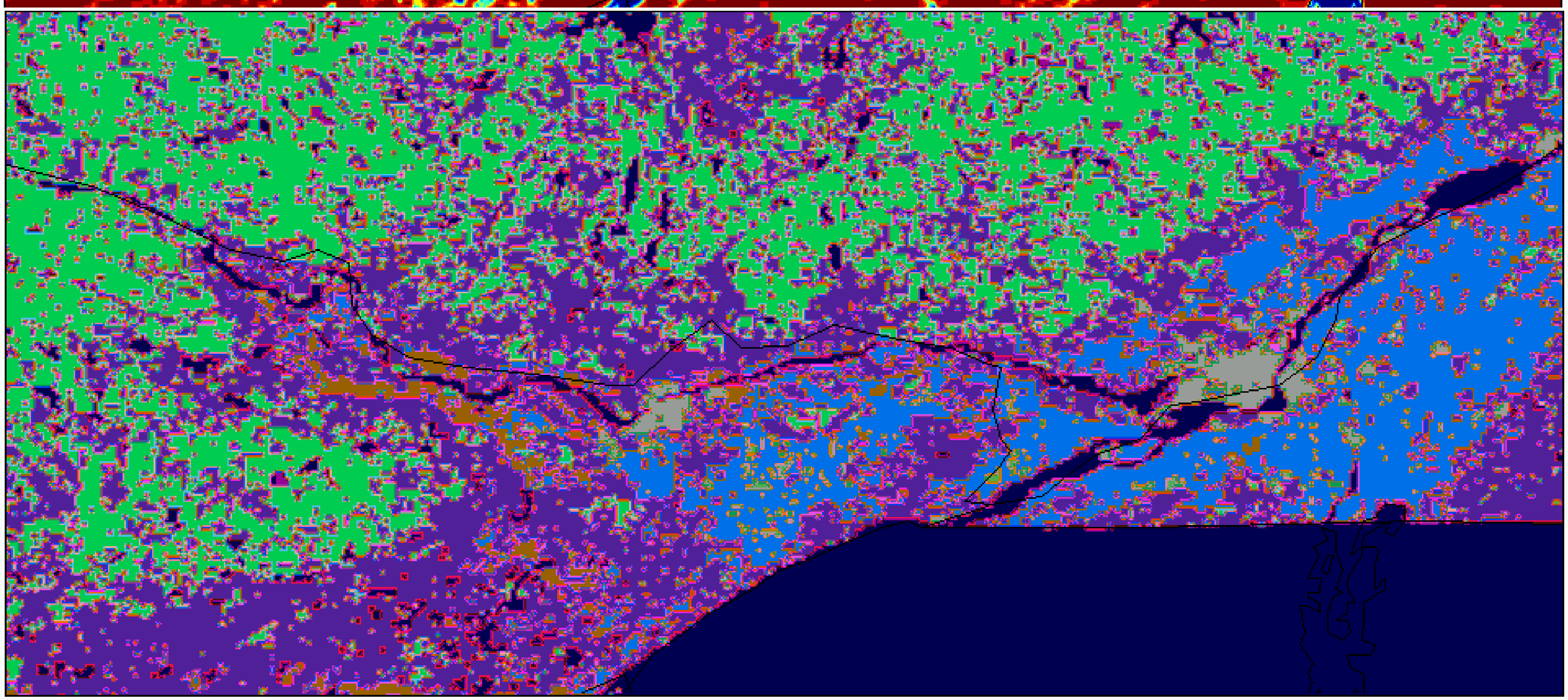


Dominant land cover type

Examples of High-Resolution Surface Fields

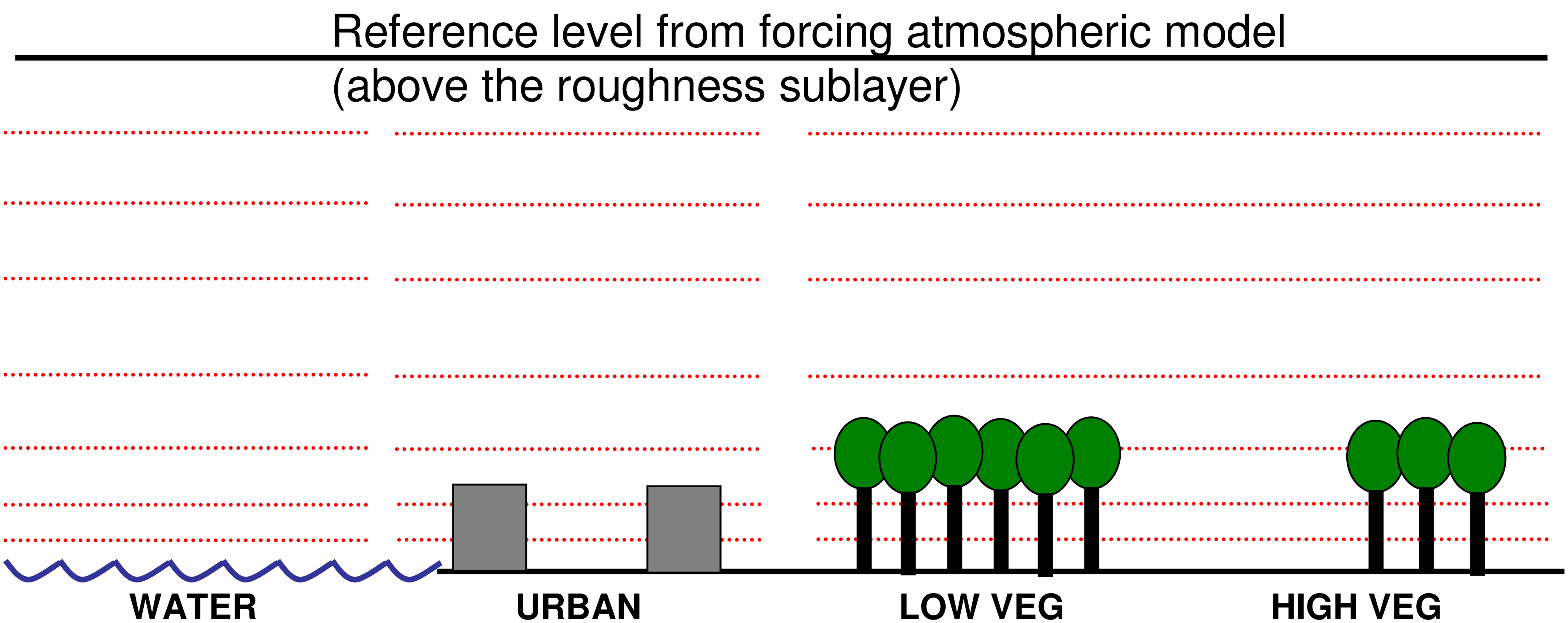


Water / land mask



Dominant land cover type

Including the surface layer in the external system



1D external surface layer model

$$\frac{\partial \theta}{\partial t} = \left(\frac{\partial \theta}{\partial t}\right)_{z=z_a} + \mathrm{Turb}(\theta) + \left(\frac{\partial \theta}{\partial t}\right)_{canopy}$$

$$\frac{\partial U}{\partial t} = \left(\frac{\partial U}{\partial t}\right)_{z=z_a} + \mathrm{Turb}(U) + \mathrm{Drag}(U)$$

$$\frac{\partial q}{\partial t} = \left(\frac{\partial q}{\partial t}\right)_{z=z_a} + \mathrm{Turb}(q) + \left(\frac{\partial q}{\partial t}\right)_{canopy}$$

+ TKE equation

(Stephane Gaudreault and Syed Husain)

Other changes to the land surface modeling system

Includes ...

- New databases for land surface characteristics
- Surface roughness (orography, over water)
- Emissivity and albedo
- CLASS / ISBA / M-ISBA
- TEB
- z0m / z0h ratio
- Surface layer diagnostics
- Distributed drag
- Monitoring and evaluation tools

A Plan to Improve Surface Modeling in CMC's Numerical Prediction Systems

Stéphane Bélair and Lily Ioannidou

With contributions from

Maria Abrahamowicz, Bernard Bilodeau, Marco Carrera, Daniel Deacu, Vincent Fortin, Louis Garand, Alexandre Leroux, Sylvie Leroyer, Jocelyn Mailhot, Michel Roch, Sheena Solomon, Paul Vaillancourt, Marcel Vallée, Ayrton Zadra

8 January 2010: Version 1.0

1. Introduction

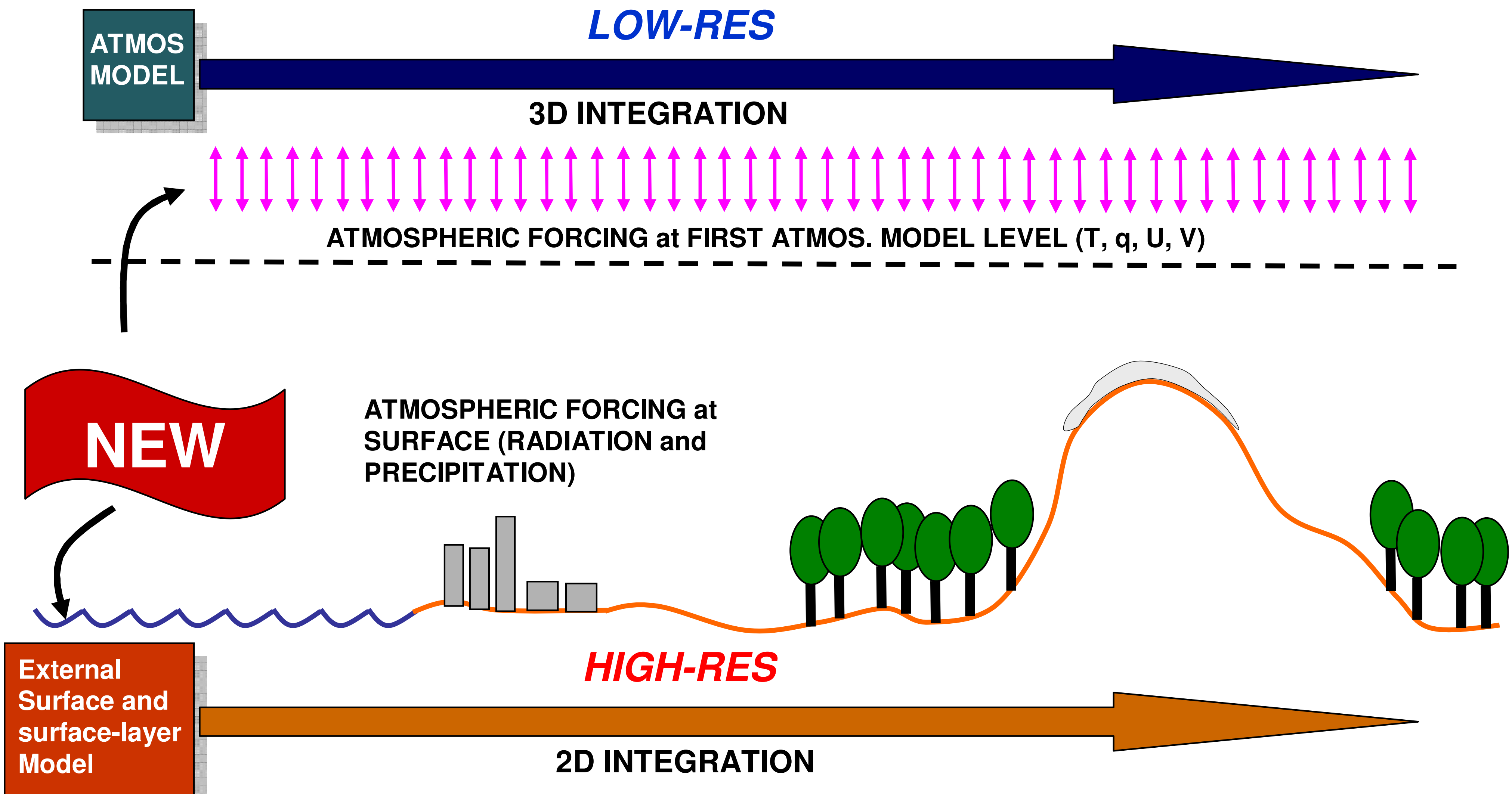
Surface processes play a major role in CMC's operational systems. Exchanges of heat, moisture, momentum, aerosols, and gases between the surface and the atmosphere have a significant impact on several meteorological elements predicted by these systems, from near-surface air characteristics (temperature, humidity and winds), to the vertical structure of the atmospheric boundary layer (i.e., mixing), to the formation of clouds and precipitation, to the evolution of large-scale baroclinic waves, and to the chemical composition of the atmosphere.

The accuracy of surface fluxes, or the quality of their impact on environmental prediction, depend on the following factors:

- Surface ancillary data and surface characteristics;
- Surface initial conditions;
- Surface modeling;
- Coupling with the atmosphere;
- Monitoring and evaluation capabilities.

Our main objective with this document is to propose an action plan to improve the representation of surface processes in order to optimize their impact in CMC's current and upcoming operational systems, both deterministic and probabilistic, for the atmosphere as well as for other environmental applications such as hydrology, agriculture yield production and risk mitigation, forest fires susceptibility indices, and air quality. In the following section, possible improvements to all the factors listed above are described, except for surface initial conditions which are the subject of another document (for the description of the Canadian Land Data Assimilation System – CaLDAS). The final section describes the action plan, including resources requirements and a timeline.

In the future: *Two-way* external surface and *surface-layer* modeling system



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

Outlook

Working on 3 fronts:

- ***External high-res***
- ***In-line surface improvements***
- ***CaLDAS***

Depending on how things go...

2010: Complete development and tests/evaluation
2011: Further tests (including pre-implementation tests)
2012: Implementation ?

Surface fields with GenPhysX...

REGION	TOPO	MASK	VEGETATION	SOIL	STATUS
Canada : North	---------------	GLOBCOVER	GLOBCOVER	USDA+AGRC+FAO	CRASH
Canada : North	---------------	GLOBCOVER	CCRS	USDA+AGRC+FAO	CRASH
Canada : North	---------------	GLOBCOVER	USGS	USDA+AGRC+FAO	CRASH
Canada : East	SRTM	GLOBCOVER	GLOBCOVER	USDA+AGRC+FAO	OK
Canada : East	SRTM	GLOBCOVER	CCRS	USDA+AGRC+FAO	OK
Canada : East	-------------------	CanVEC (holes)*	---------------------	-------------------------	CRASH
Canada : East	CDED50+SRTM	GLOBCOVER	CCRS	USDA+AGRC+FAO	OK
Canada : West	SRTM	GLOBCOVER	GLOBCOVER	USDA+AGRC+FAO	OK
Canada : West	SRTM	GLOBCOVER	CCRS	USDA+AGRC+FAO	Mem. Fault
Canada : West	CDED50+SRTM	GLOBCOVER	CCRS	USDA+AGRC+FAO	OK
Canada : West	-------------------	CanVEC (holes)	-------------------	-------------------	OK : But holes
USA : East	SRTM	GLOBCOVER	GLOBCOVER	USDA+AGRC+FAO	OK
USA : West	SRTM *	GLOBCOVER	GLOBCOVER	USDA+AGRC+FAO	CRASH