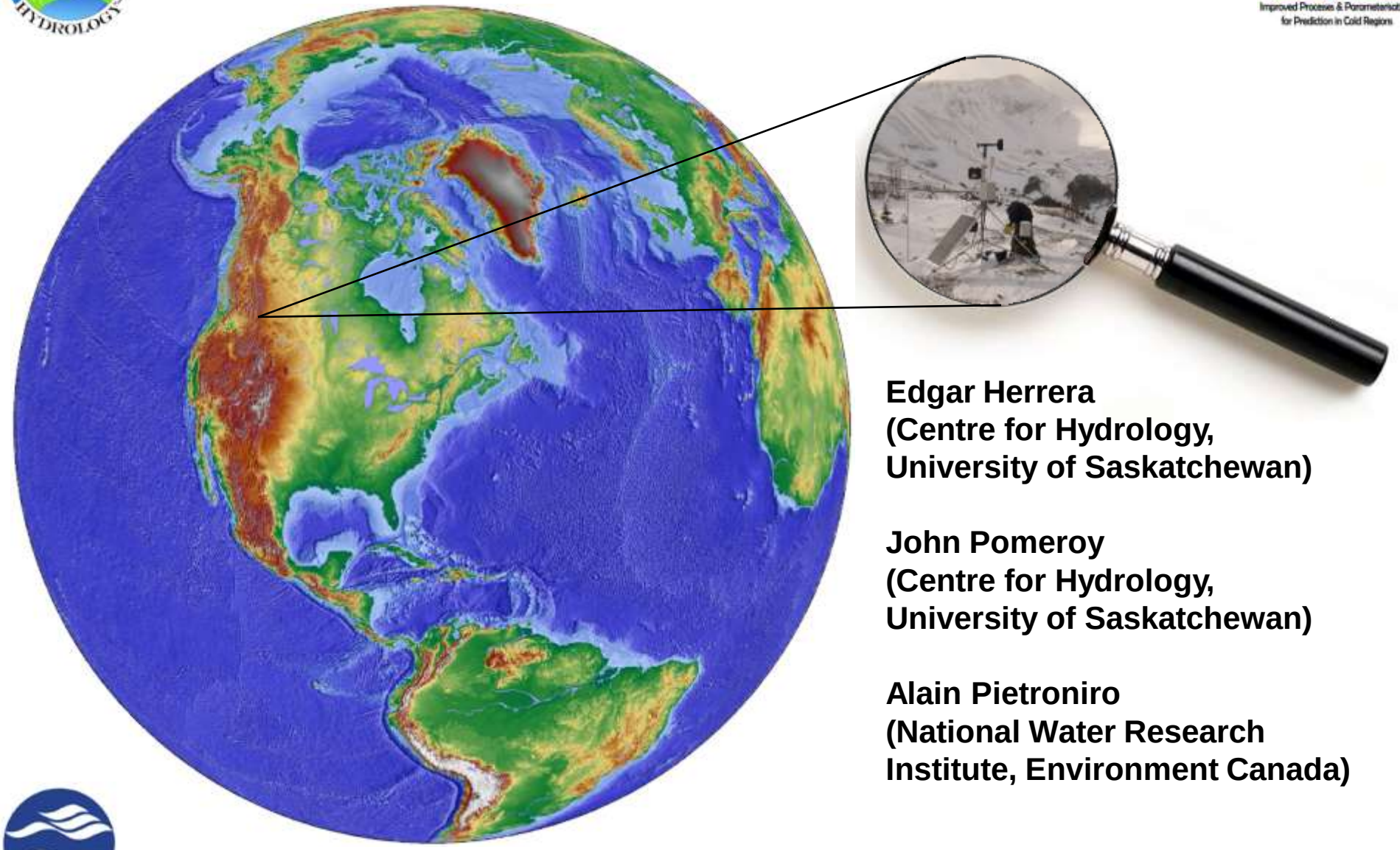
Multiscale interactions in IP3 basins



Edgar Herrera
(Centre for Hydrology, University of Saskatchewan)

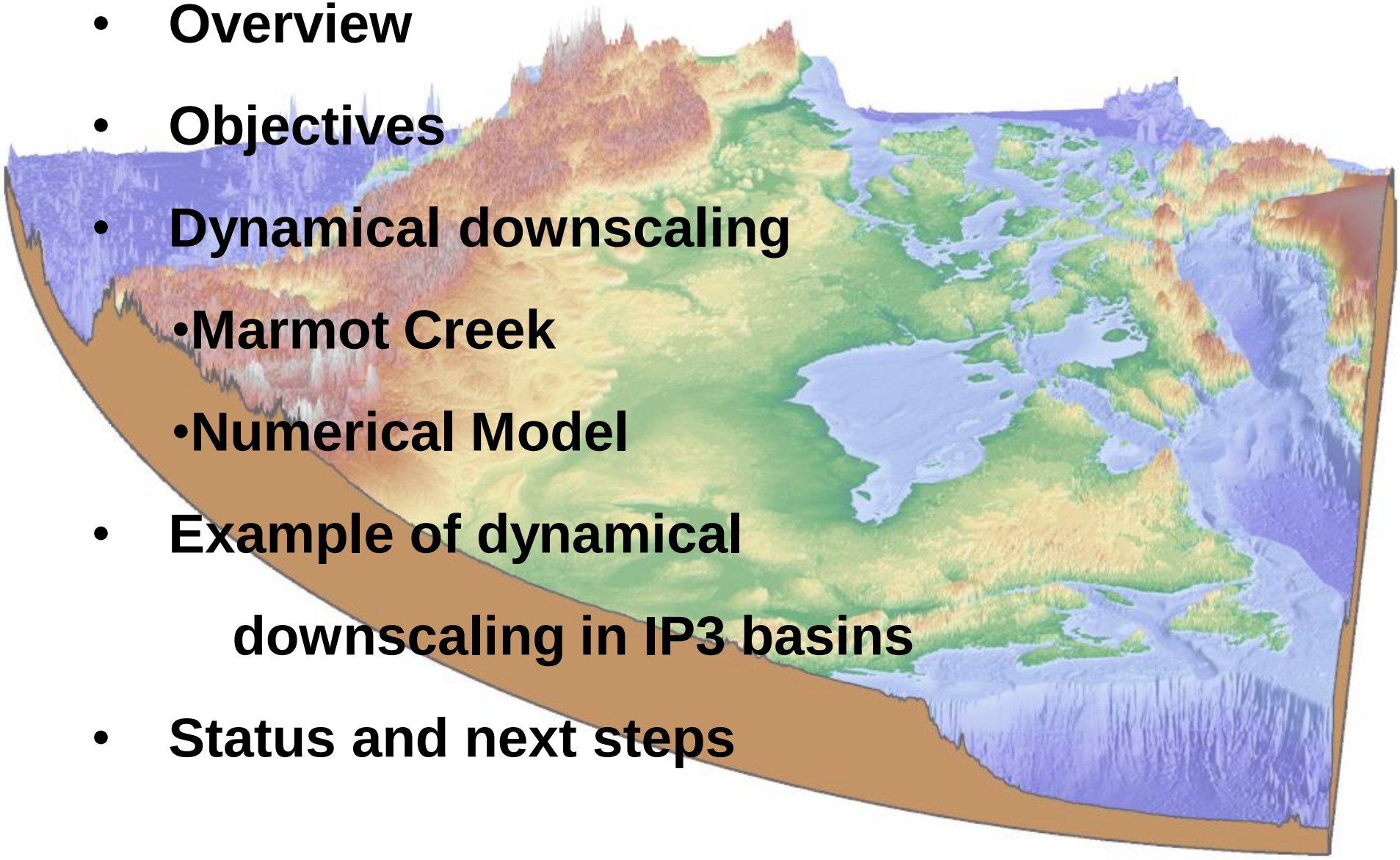
John Pomeroy
(Centre for Hydrology, University of Saskatchewan)

Alain Pietroniro
(National Water Research Institute, Environment Canada)

IP3 Prediction Workshop – Waterloo
17 March 2009

Outline

- Overview
- Objectives
- Dynamical downscaling
  - Marmot Creek
  - Numerical Model
- Example of dynamical downscaling in IP3 basins
- Status and next steps



Overview

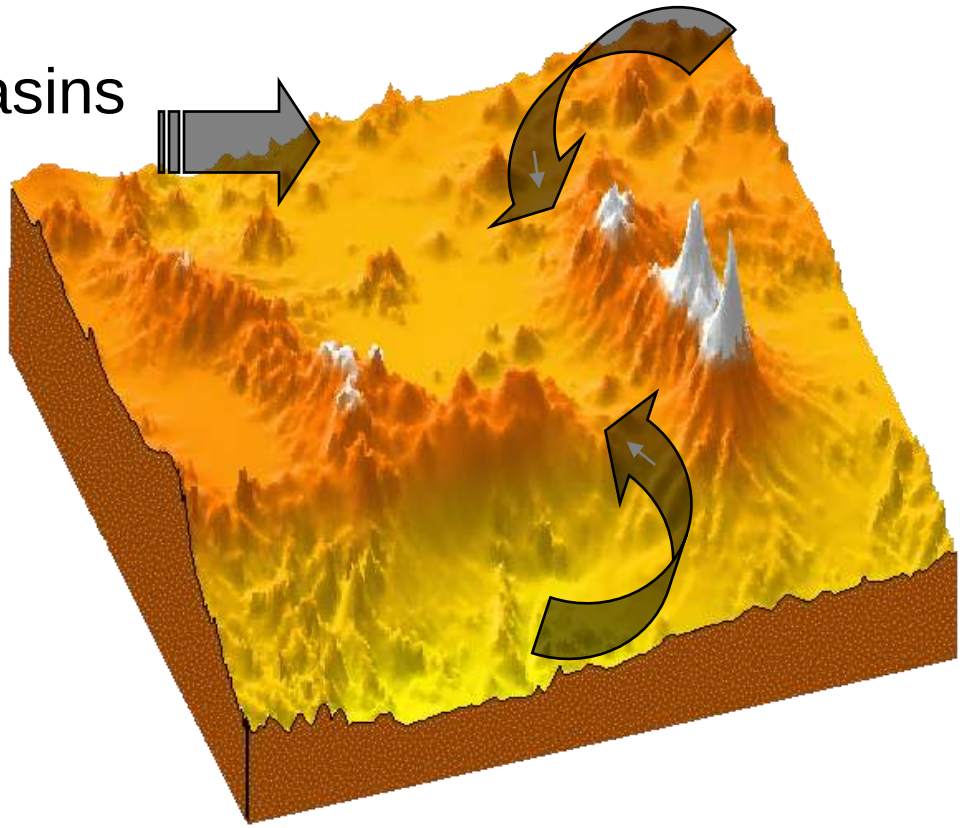
- GEM-LAM/MEC:
  - NWP with the ability to produce small-scale phenomena that are absent in the lateral boundaries of the coarse-scale forcing data
- Blowing Snow Transport Models:
  - Snowcover spatial variability, glacier dynamics and snowmelt runoff are greatly influenced by blowing snow redistribution due to the wind-flow in the atmospheric boundary layer
- IP3 Basins:
  - Wind speed, turbulent transfer and wind flow direction are crucial for many cold regions hydrological processes
    - Blowing snow, intercepted snow
    - Snow/ice turbulent transfer before and during melt
    - Evaporation, soil thaw
- This presentation will focus on the optimal downscaling strategy for the GEM-LAM/MEC system for snow simulations in mountains

Atmospheric Models

- GEM-LAM General Environmental Model – Limited Area Model: based on MC2, full atmospheric column, precip, convection, simplified ISBA LSS,
- MEC Modélisation Environnementale Communautaire: based on MC2, detailed LSS or MESH, 3 levels in atmosphere (lowest 20 m)

Objectives

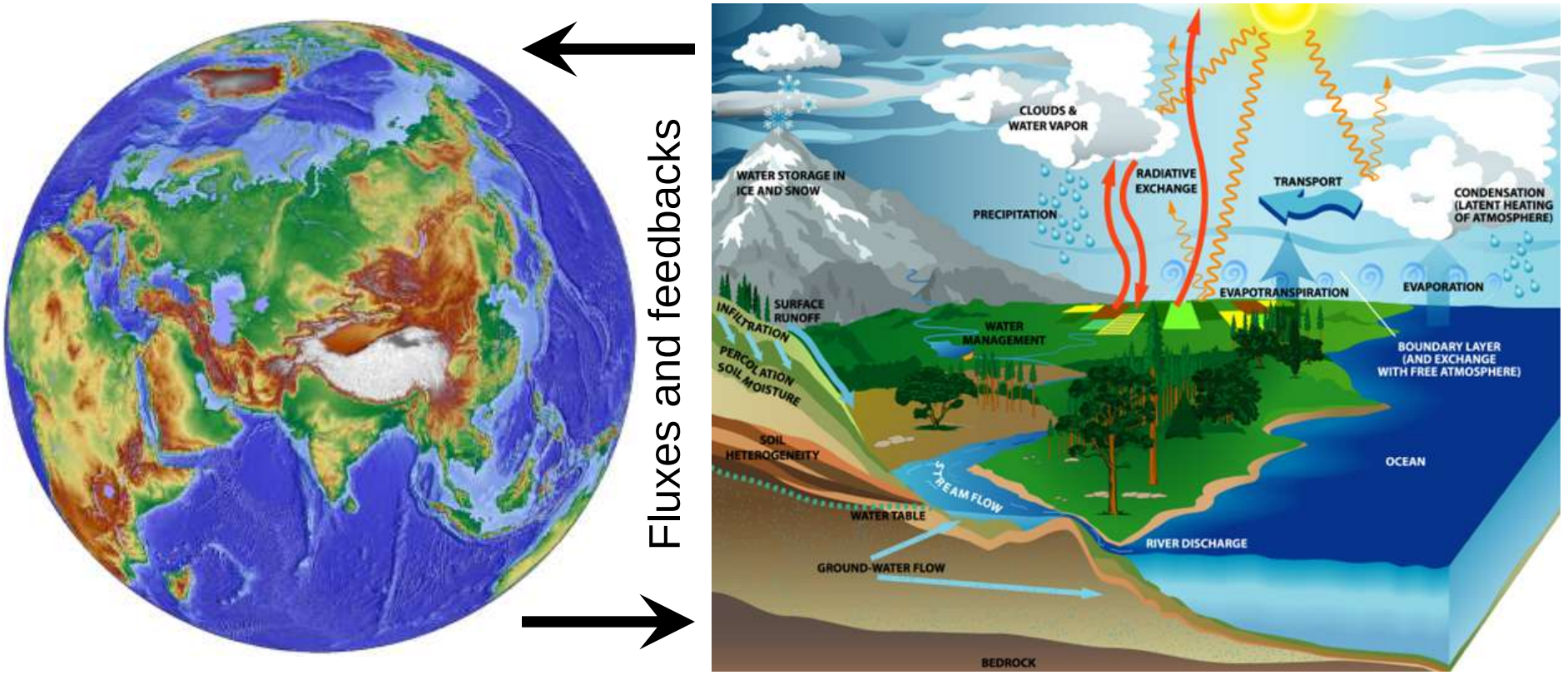
- Evaluate the sensitivity of the GEM model wind field outputs to initial conditions
- Relationship between topography and windflow. Are there preferred regions of convergence, divergence, acceleration, deceleration, flow separation?
- Demonstrate GEM for IP3 basins



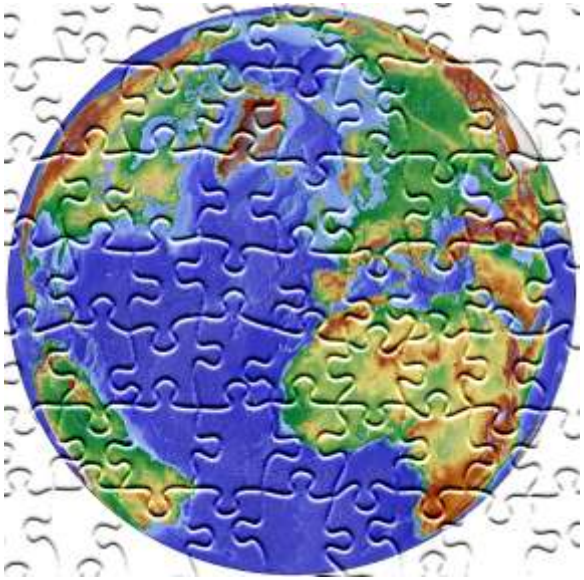
Dynamical downscaling

Coupling Atmospheric / Hydrological Models ?

Hydro (meteoro) logical cycle

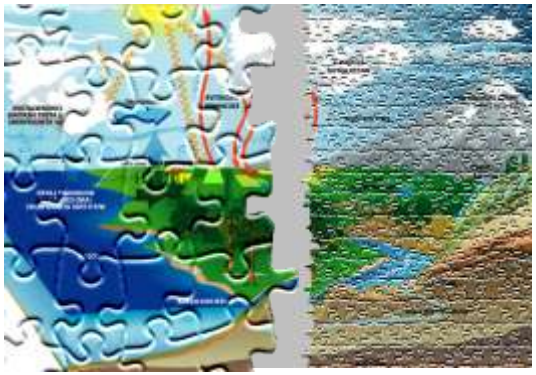


Dynamical downscaling

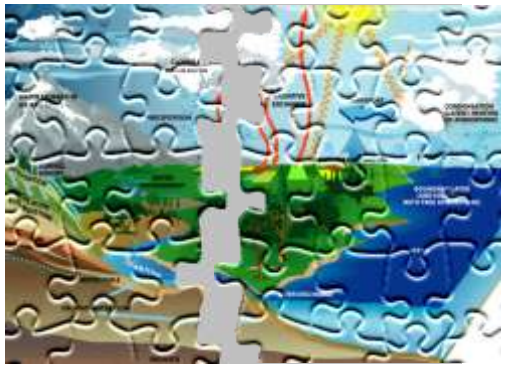


Scale does Matters !

Downscaling



?



Coupling

Dynamical downscaling

Downscaling Demonstration:

Drive the MEC system at 500m spatial resolution with two initial conditions:

1. Forcing data from GEM-LAM at 2.5km spatial resolution (downscaling)
2. Forcing data from GEM-LAM at 500m spatial resolution (coupling)

Case study: 4th November, 2007

Marmot Creek (50° 57’ N, 115° 10’ W):

Montane and sub-alpine forest with alpine tundra ridgetops (Rocky Mountain Front Ranges); 9.4Km^2

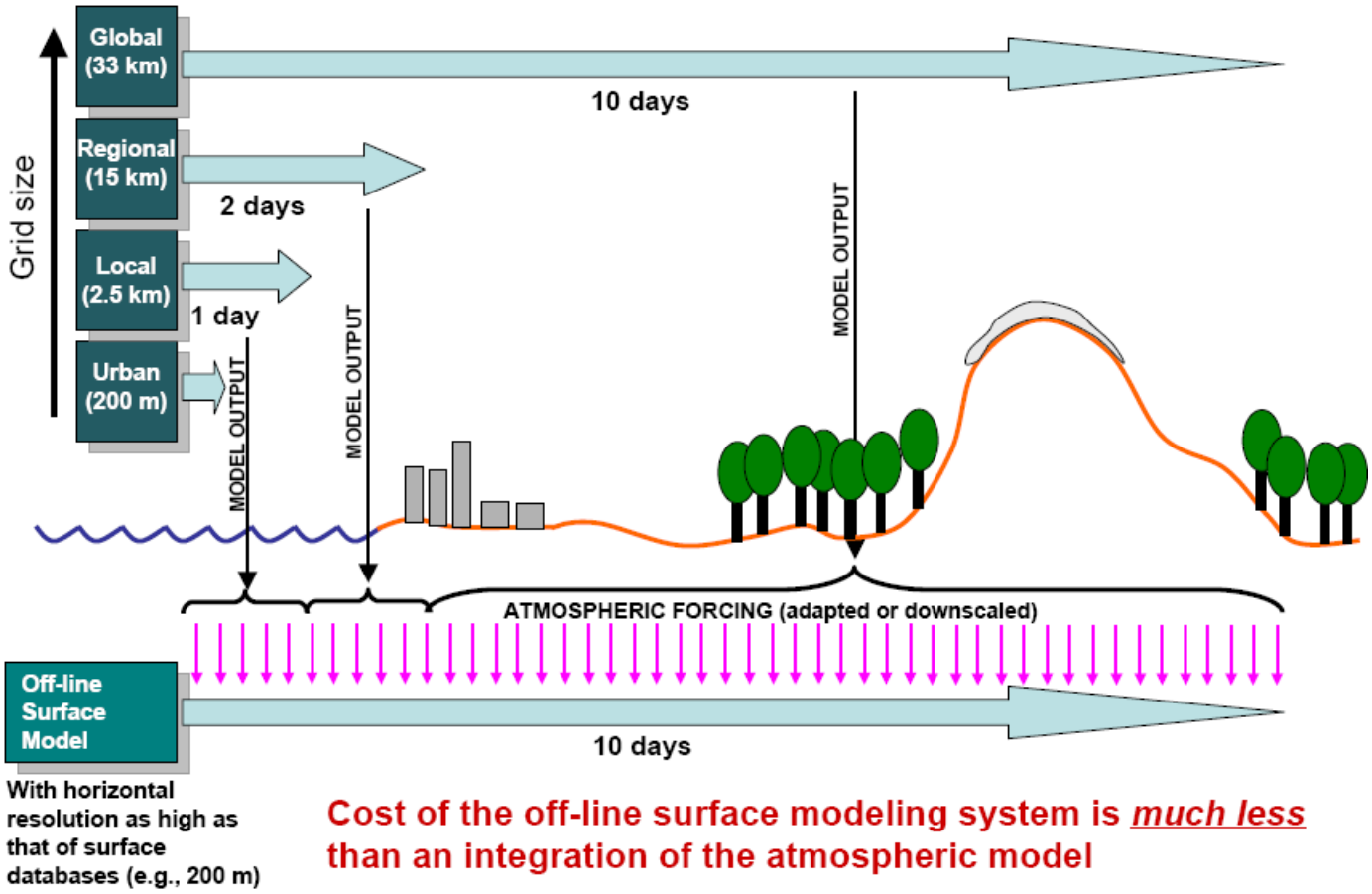
Dynamical downscaling

Numerical Models: GEM (Canadian Global Environment Model)

MEC (Modélisation Environmentale Communautaire)

GEM	MEC
Entry	Entry
Dynamics	Dynamics
Physics	Physics
Radiation	Radiation
Surface	Surface
Turbulence	Turbulence
Clouds and precip	Clouds and precip

(only do what is necessary to run the surface in an external manner)

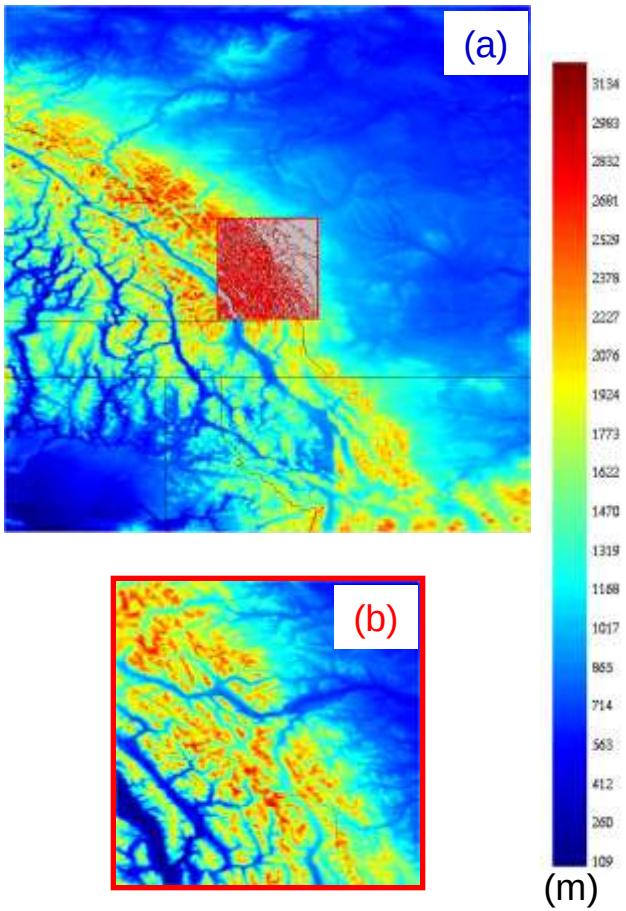


With horizontal resolution as high as that of surface databases (e.g., 200 m)

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

(from Belair et al.)

Topography



Centre: (50° 56’ 50” N, 115° 8’ 30” W)

Conditions for November 4th, 2007

- Spin-up limitation
- One way nesting
- Wide range of circulation (all scales)

GEM-LAM
Period : 3/11 - 4/11 2007 00 UTC
Grid 312 x 254, ΔX=15 km , Δt=900 s
Driver: CMC Analyses
Topography fields: 1 km
Spin-up: 5 days

a GEM-LAM
Period : 4/11 2007 00 UTC
Grid 99 x 99, ΔX=2.5 km, Δt=60 s
Driver : Grid 1
Topography fields: 90m
Spin-up: 12 hours

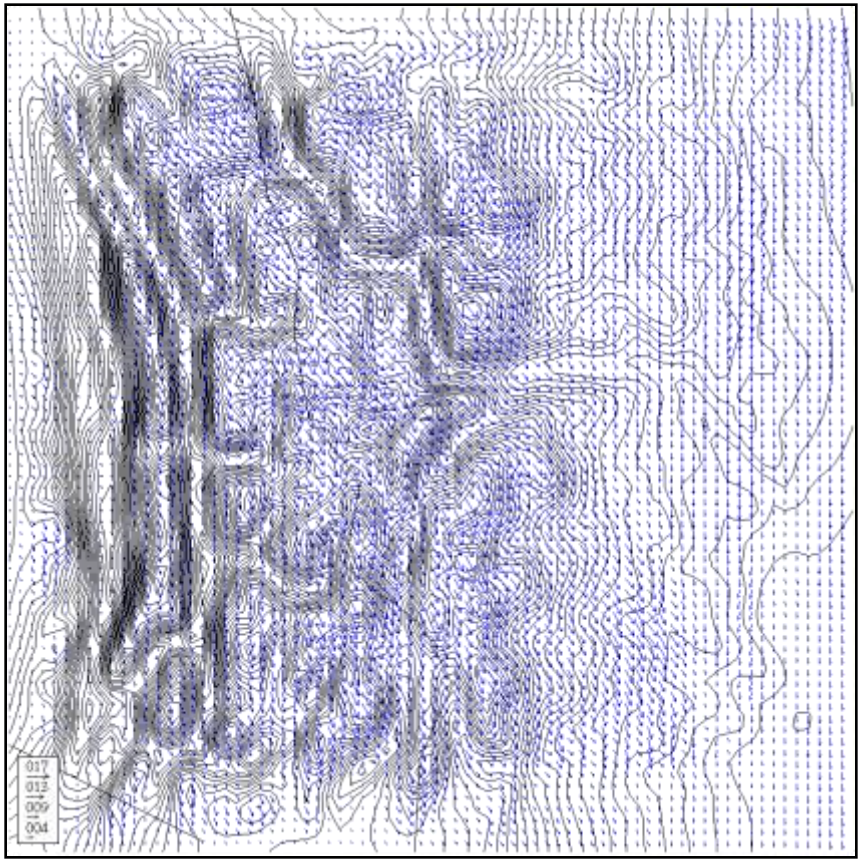
b GEM-LAM / MEC
Period : 4/11 2007 00 UTC
Grid 88 x 88, ΔX=500 m, Δt=10 s
Driver : Grid 2
Topography fields: 90m
Spin-up: 4 hours

GEM-LAM Results

Forcing data

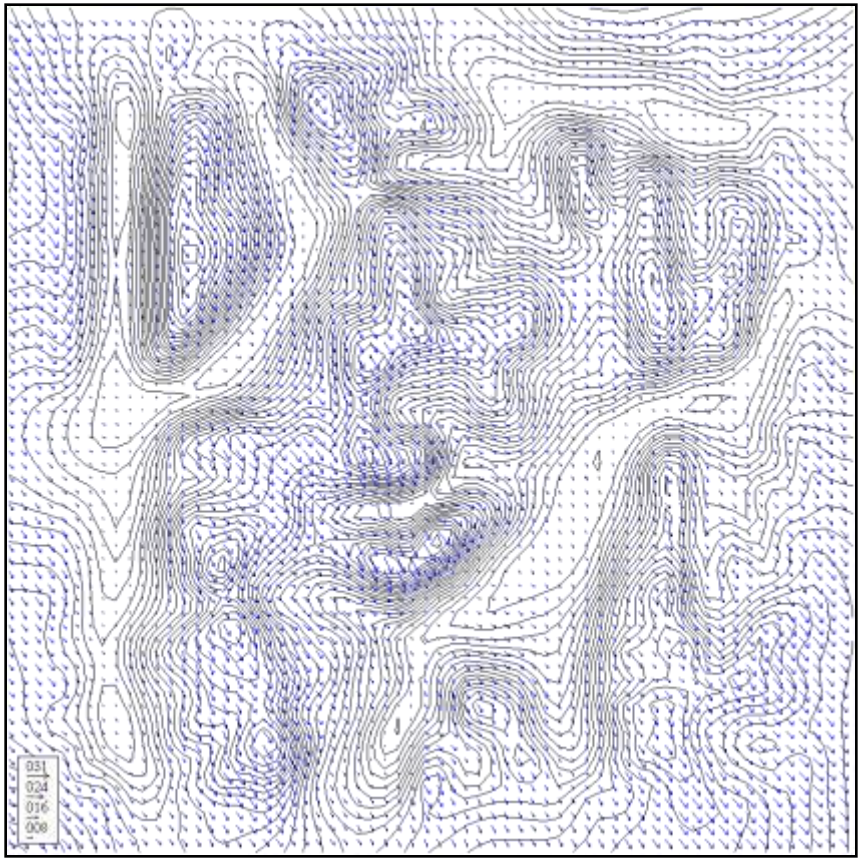
Contours: **Topography**

Vectors: **Wind Field**



5/11/2007 00UTC

Simulation LAM 2.5 km



5/11/2007 00UTC

Simulation LAM 500 m

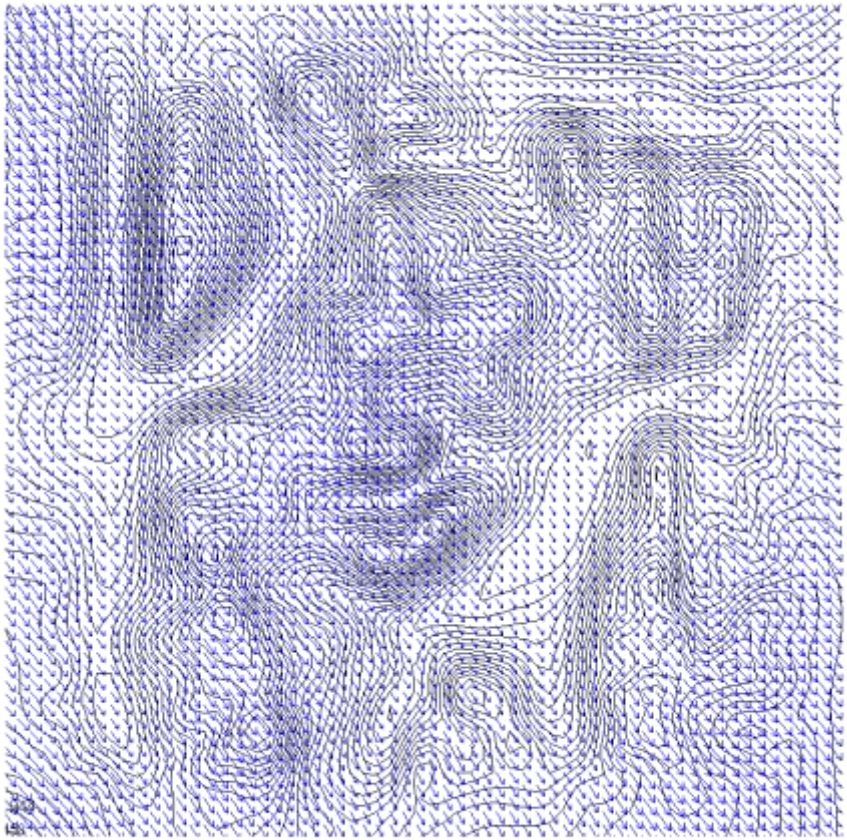
Downscaled =>

MEC Results

Simulations

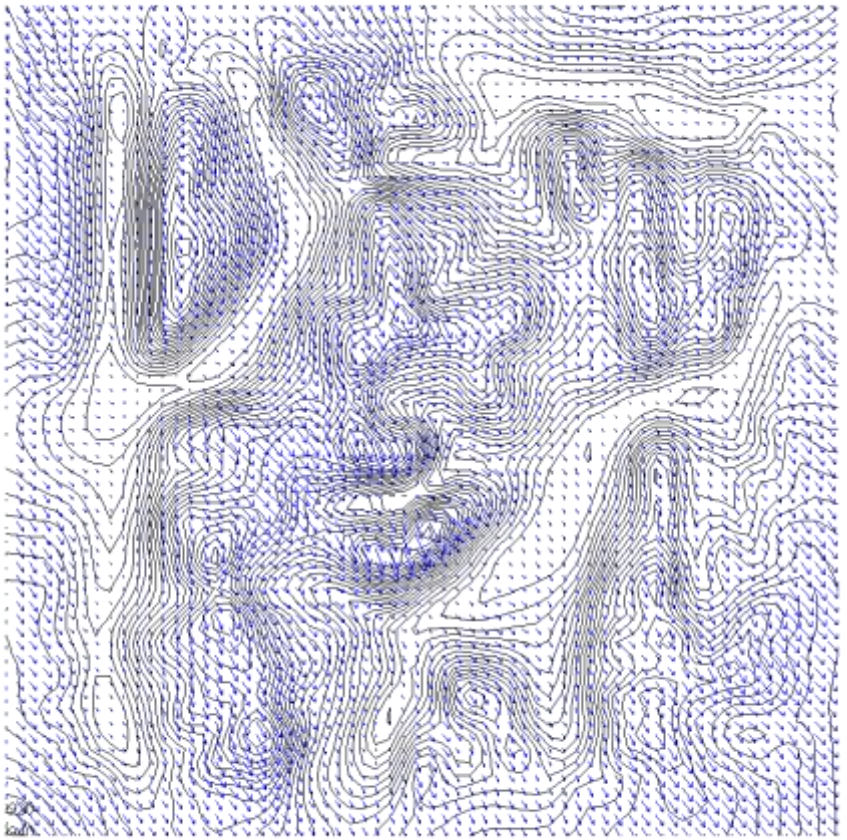
Contours: **Topography**

Vectors: **Wind Field**



5/11/2007 00UTC

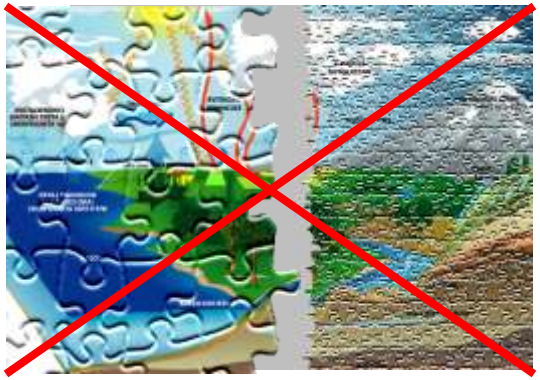
Simulation MEC 500 m
(from LAM 2.5 km)



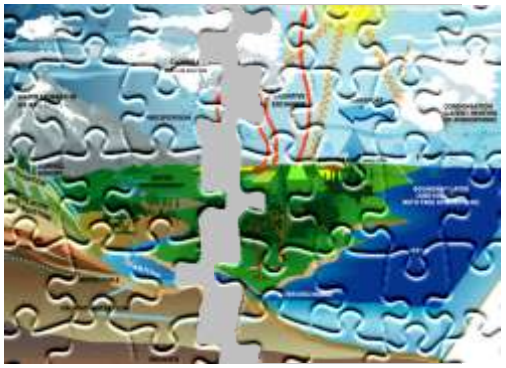
5/11/2007 00UTC

Simulation MEC 500 m
(from LAM 500 m)

Status



LAM (2.5km) MEC (500m)



LAM (500m) MEC (500m)

500m is a high resolution simulation for the GEM-LAM but is possible. However because of the simplistic representation of the surface in GEM-LAM, wind fields at the surface are not realistic. It is therefore necessary to couple GEM-LAM to drive MEC which has the full surface interactions and an improved representation of near surface micrometeorology. MEC itself is highly sensitive to the boundary conditions of the forcing data, but does not contain the dynamics and physics necessary to generate detailed wind flow fields.

Therefore GEM-LAM and MEC must be run in a coupled fashion in high resolution simulations for driving IP3 surface and hydrology models.

Next Steps

-Deploy parameterisations of blowing snow (e.g. MacDonald et al.)
-Compare to basin observations of wind speed, direction, SWE

Thank you !