Modeling Wind Flow in IP3 basins

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(Photo: Matt MacDonald)

Outline

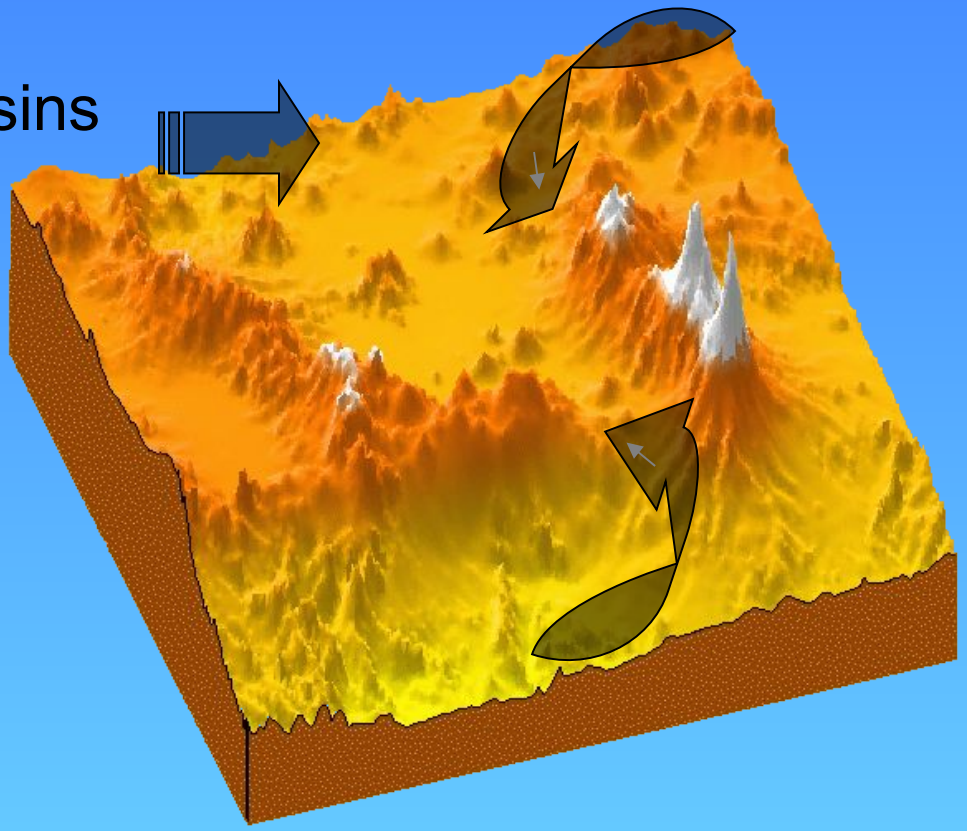
- Overview
- Objectives
- Dynamical downscaling
  - Marmot Creek
  - Numerical Model
- Example of the dynamical downscaling technique in IP3 basins
- Status and next steps

Overview

- Wind speed, turbulent transfer and wind flow direction are crucial for many IP3 processes
  - Blowing snow, intercepted snow unloading
  - Snow/ice turbulent transfer before and during melt
  - Evaporation, soil thaw
- IP3 Basins are complex terrains and so require mesoscale prediction of wind fields
- This presentation will focus on current efforts to use the GEMLAM/MEC system to predict wind flow over Marmot Creek

Objectives

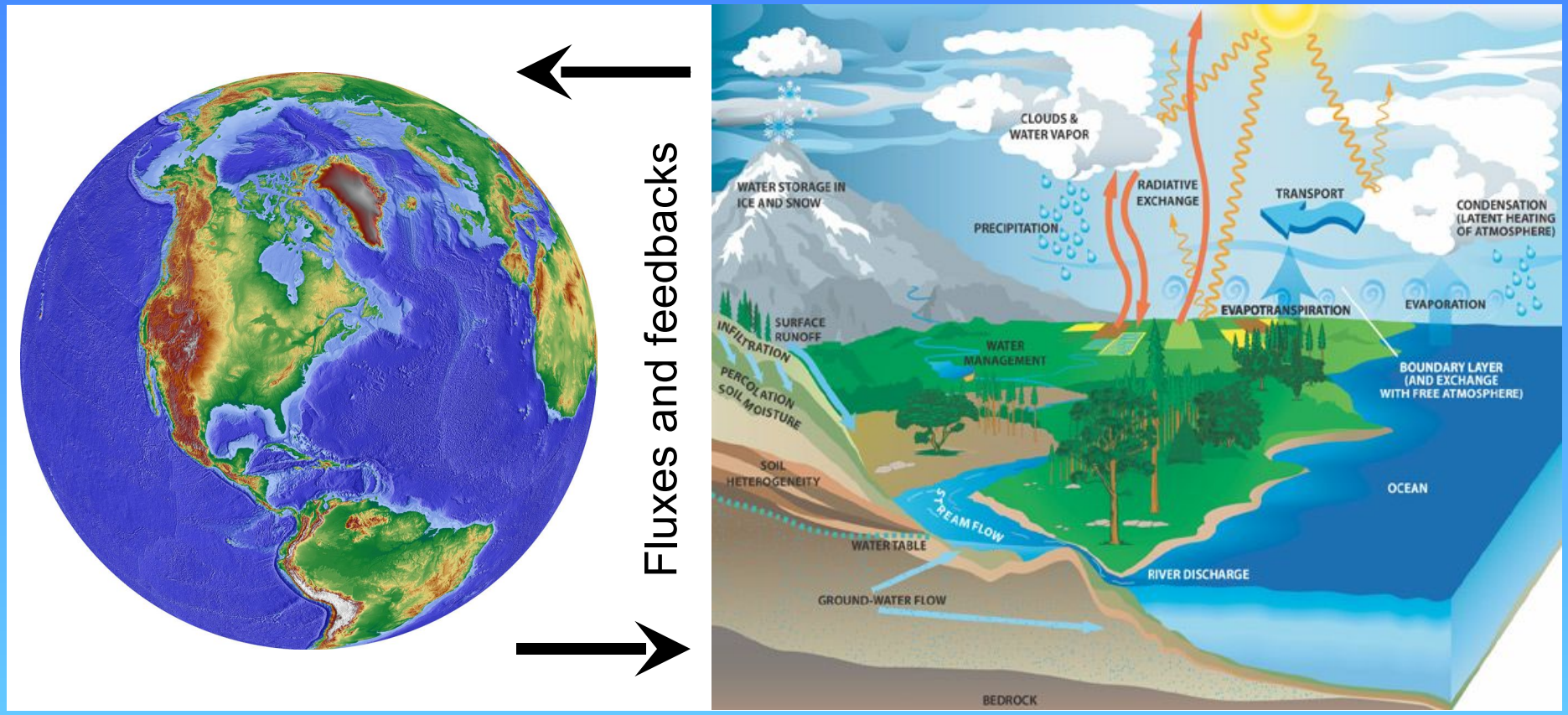
- Relationship between topography and windflow. Are there preferred regions of convergence, divergence, acceleration, deceleration, flow separation?
- Evaluate the sensitivity of the GEM model wind field outputs to initial conditions
- Demonstrate GEM for IP3 basins



Dynamical downscaling

Coupling Atmospheric / Hydrological Models ?

Hydro (meteoro) logical cycle



Dynamical downscaling

- **Measurements and Regional Climate Model simulations will be used to address the project objectives**

- **Comparison of simulations**

VS

- **Measurement campaigns**
- **Small scale models**

Case of study: 4th November, 2007

Marmot Creek (50° 57’ N, 115° 10’ W):

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

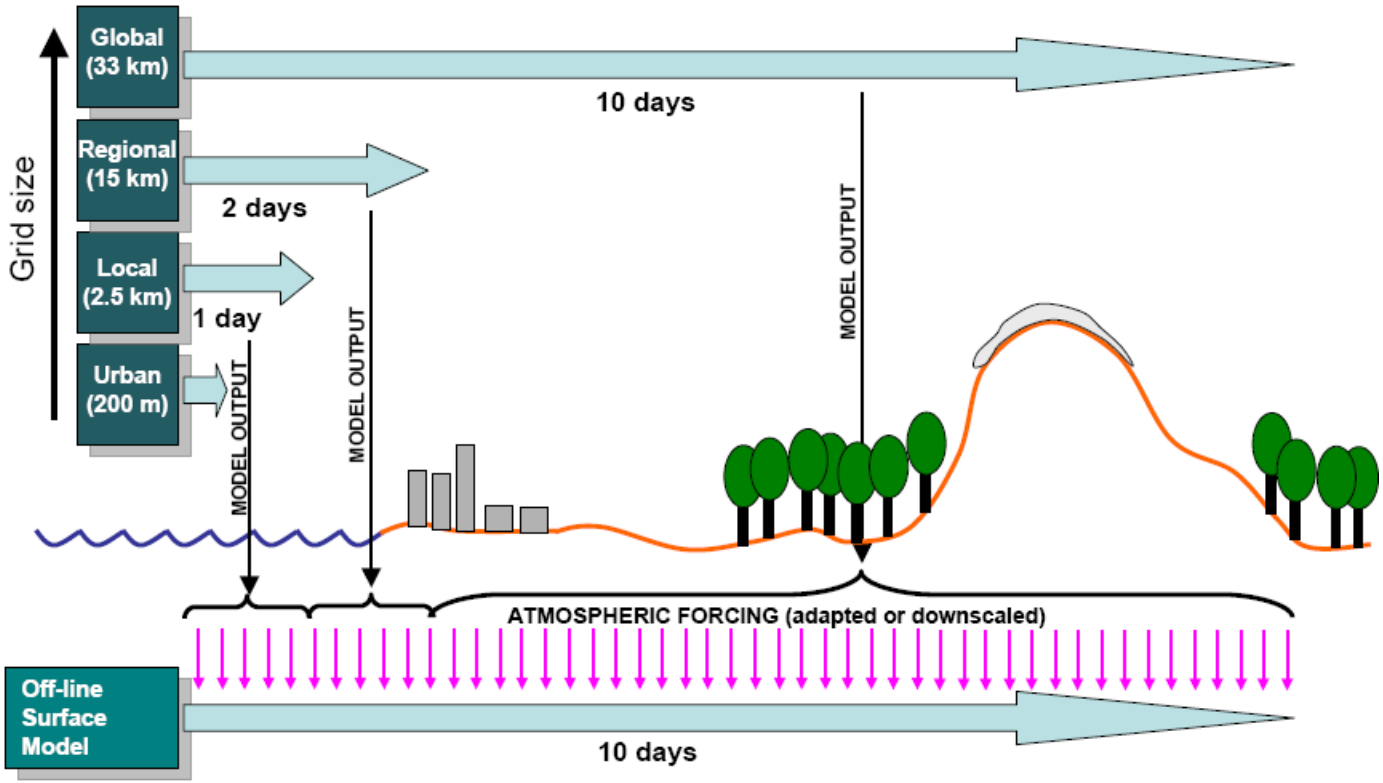
Dynamical downscaling

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)

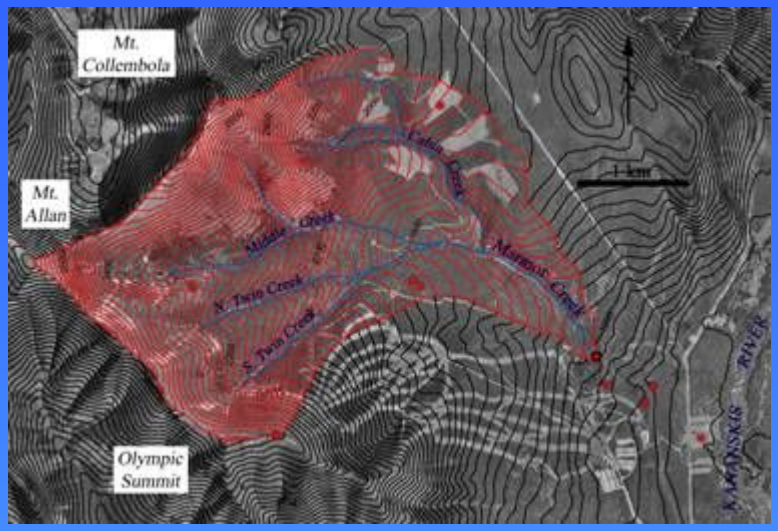


With horizontal resolution as high as that of surface databases (e.g., 200 m)

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

(from Belair et al.)

Marmot Creek

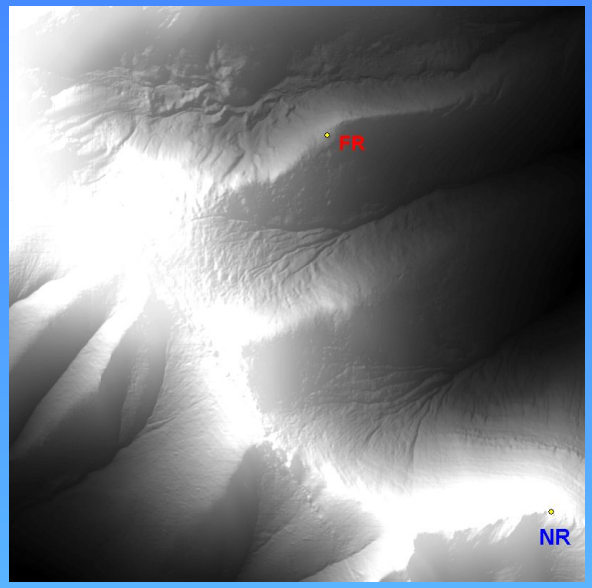


Description:

Area: 9.4 km²
Location: 50° 57’ N, 115° 10’ W
Elevation: 1585 to 2085 m
Average slope: 39%

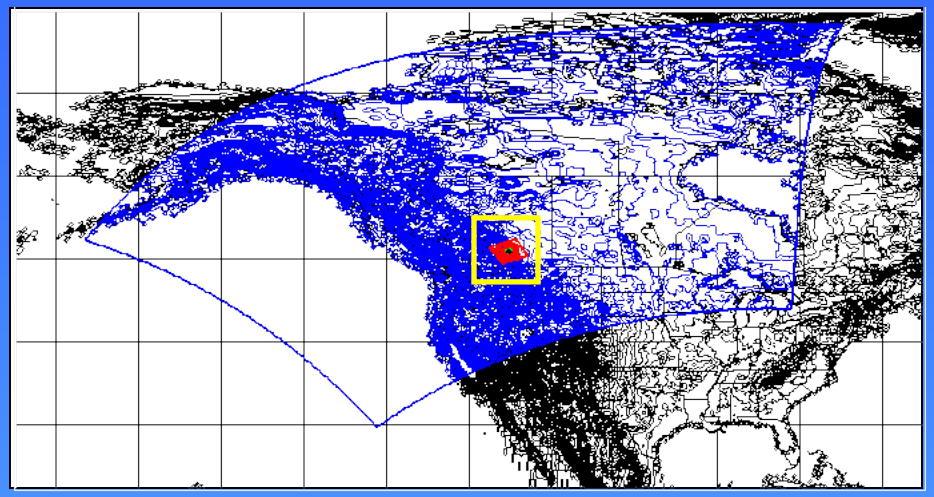
Fisera Ridge Station (FR)

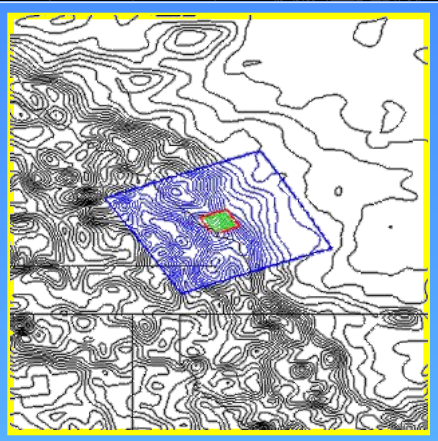
Location: 50° 56’ 50” N, 115° 8’ 30” W
Elevation: 2319 m
Data available: Jan 2007 - present.
Instrumentation: air temperature (TT)
relative humidity (RH)
wind (UV)
up/downwelling shortwave radiation
up/downwelling longwave radiation
snow depth (SD)
precipitation gauge (PR)



(Images from Matt MacDonald)

Nested cascade method





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)

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

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

3 GEM LAM
Period : 4/11 2007 00 UTC
Grid 88 x 88, Δ X=500 m, Δ t=10 s
Driver : Grid 2
Topography fields: 90m
Spin-up: 4 hours

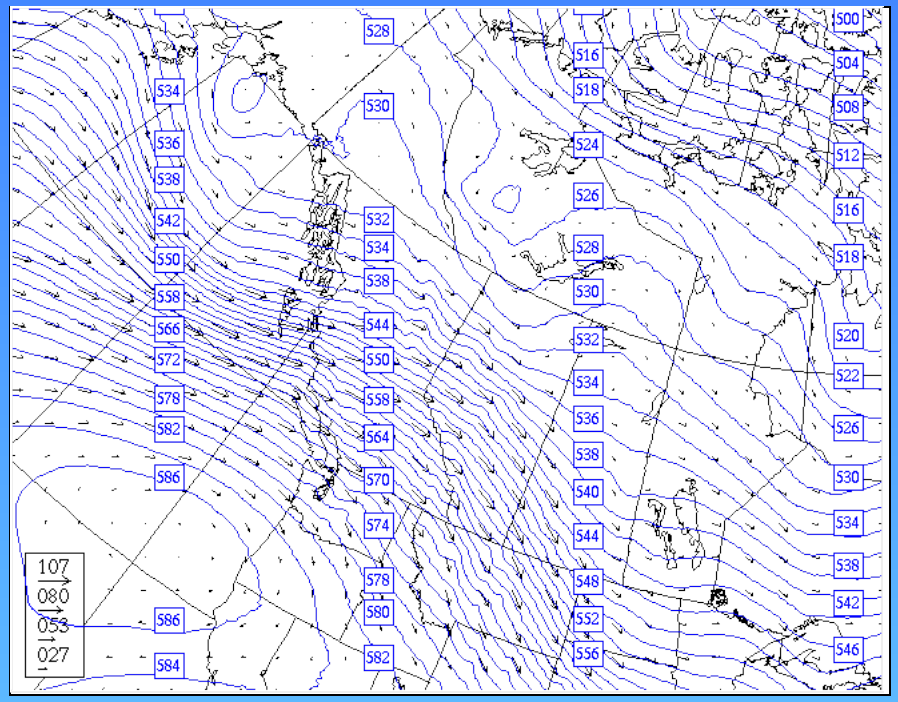
4 MEC
Period : 4/11 2007 00 UTC
Grid 249 x 249, Δ X=100 m, Δ t=10 s
Driver : Grid 3
Topography fields: 90m
Spin-up: 2 hour

Results

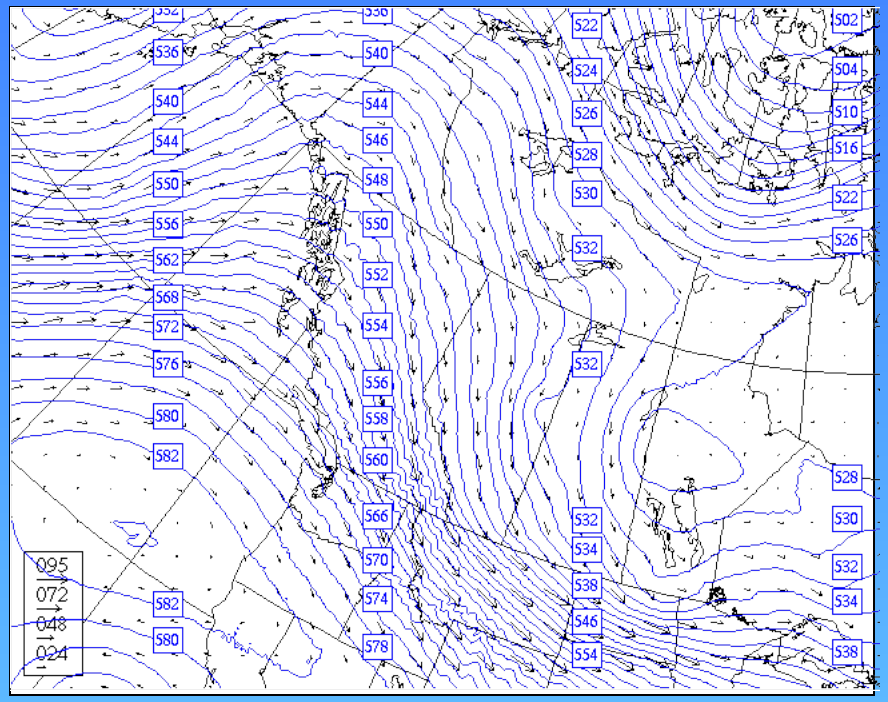
Synoptic Conditions

Contours: Geopotential 500 mb

Vectors: Wind Field

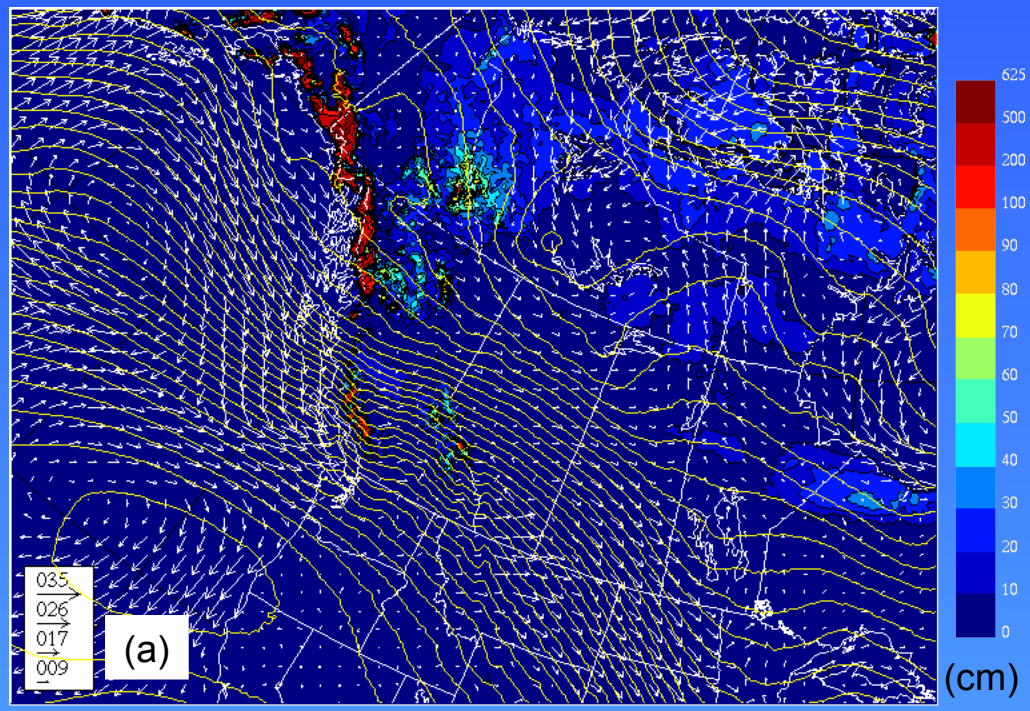


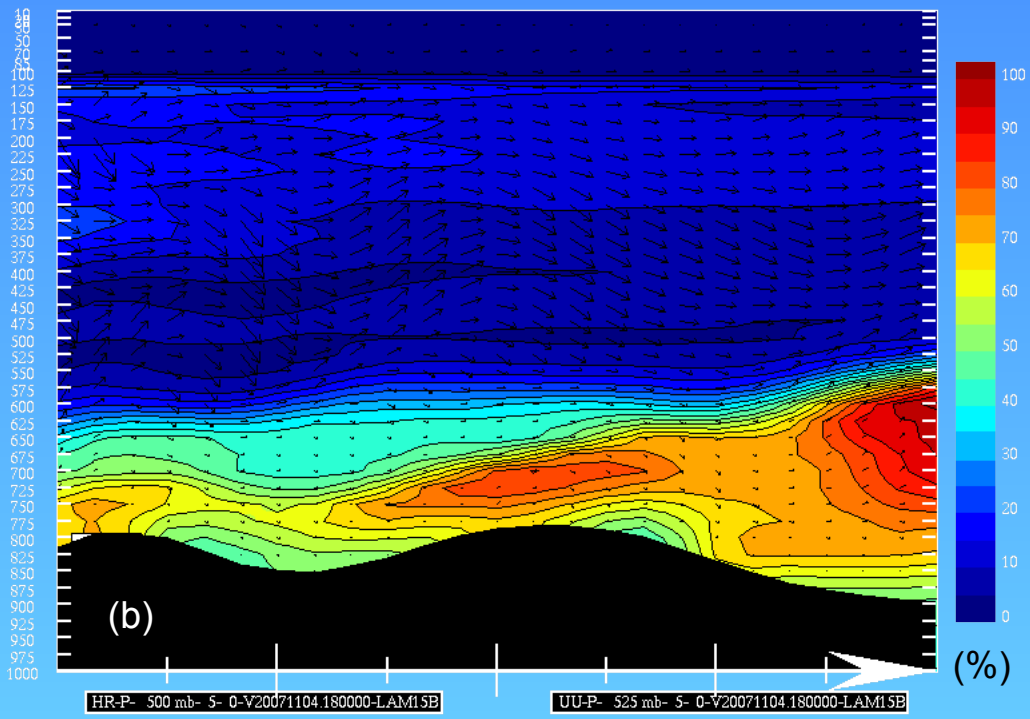
4/11/2007 00UTC



5/11/2007 00UTC

Simulation 15 km





4/11/2007 1200UTC

GEM-LAM

Grid: 15 km

a) Color: Snow Depth

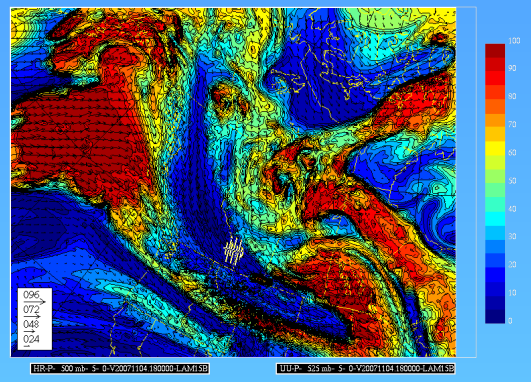
Vectors: Wind Field

Contour: Geopotential, 500 mb

b) Color: Humidity Relative

Vectors: Wind Field

Black: Topography



a) Color: Snow Density

Vectors: Wind Field

Contour: Topography

b) Color: Precipitation

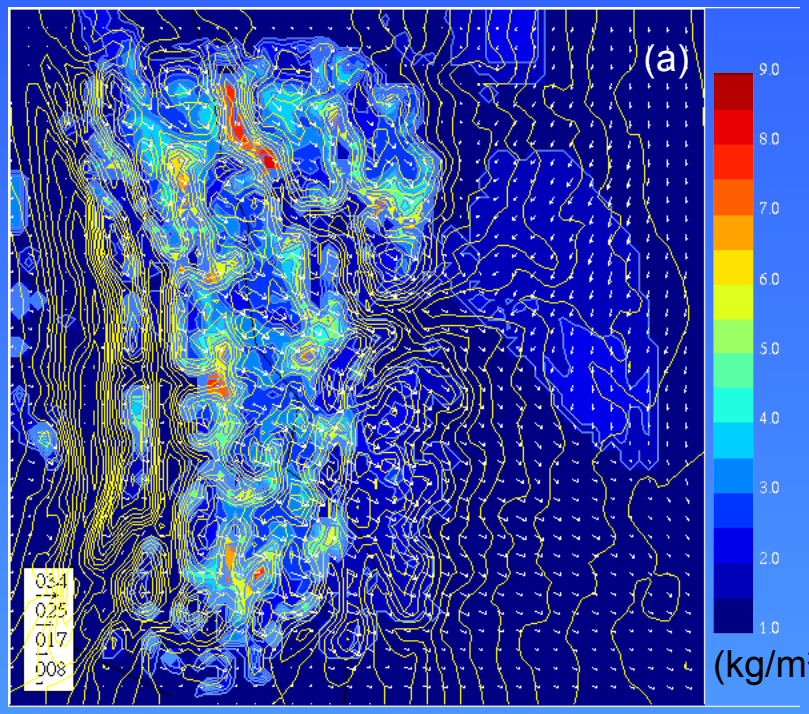
Contour: Topography

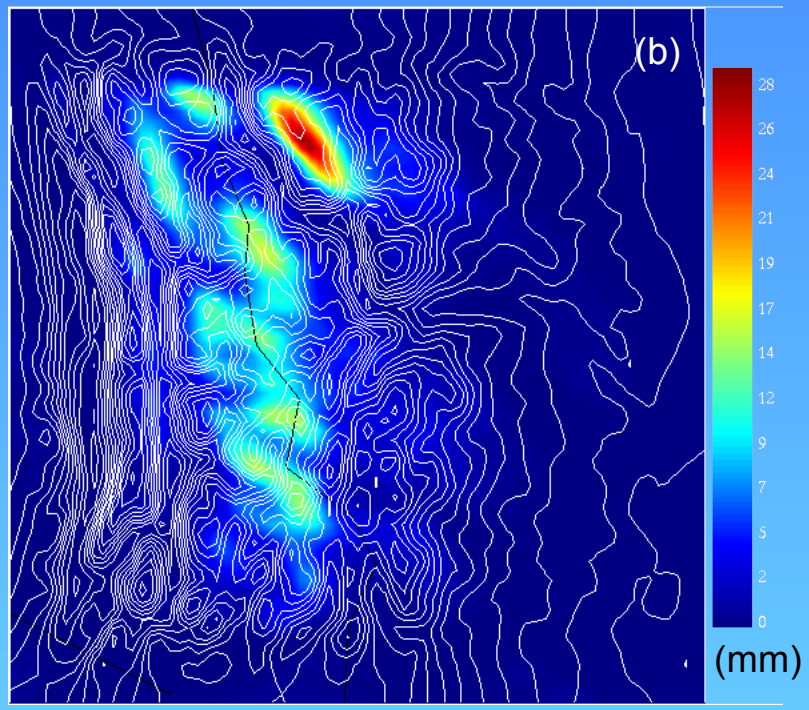
c) Color: Humidity Relative

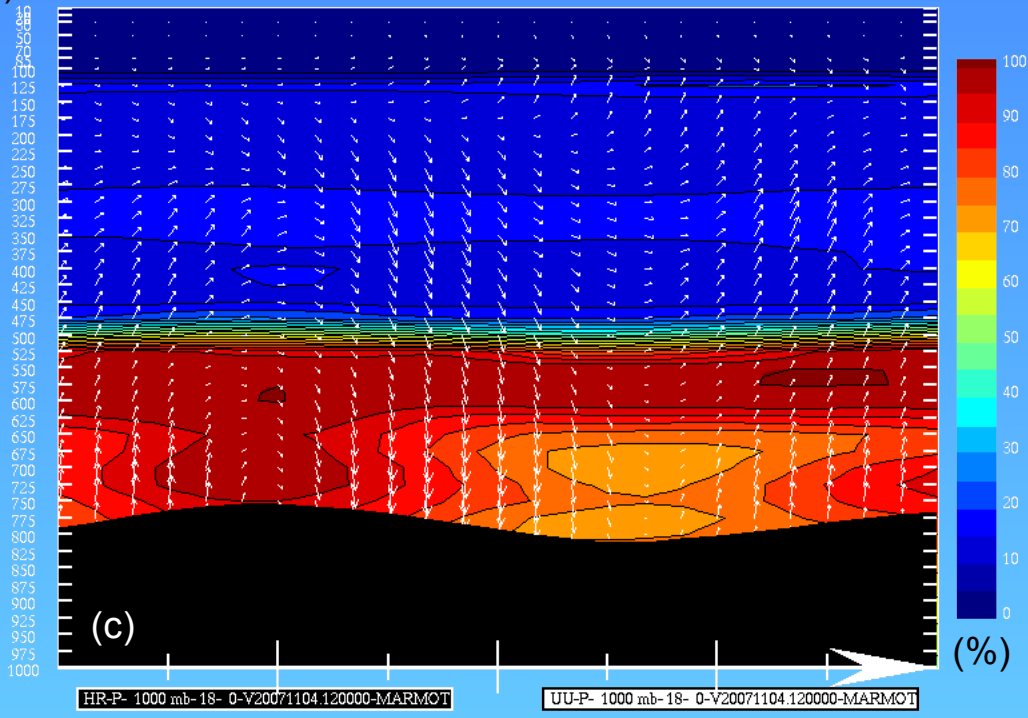
Vectors: Wind Field

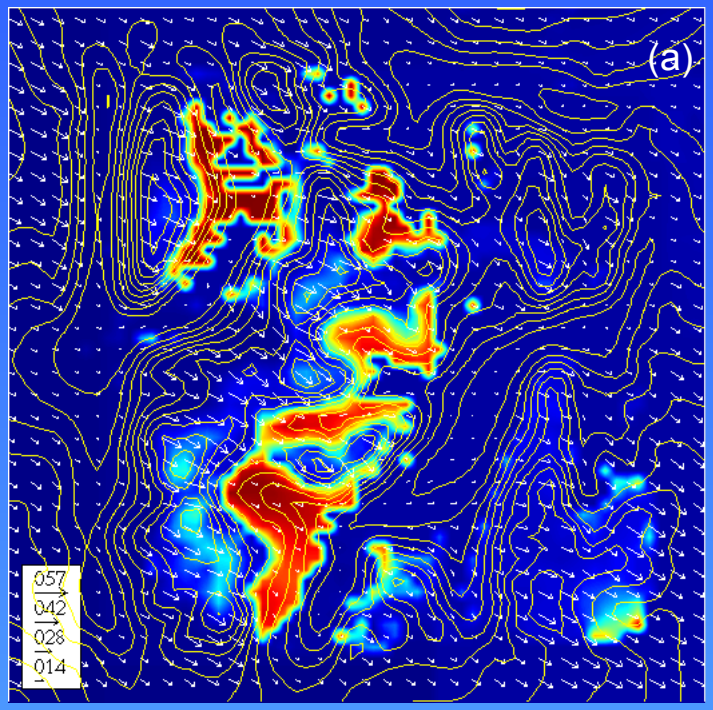
Black: Topography

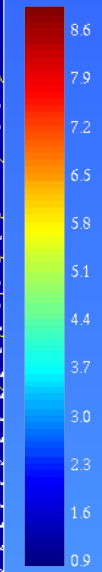
4/11/2007
1200UTC
GEM-LAM
Grid: 2.5 km











(kg/m³)

a) Color: Snow Density

Vectors: Wind Field

Contour: Topography

b) Color: Precipitation

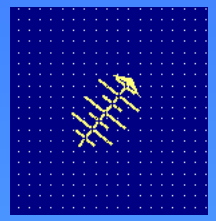
Contour: Topography

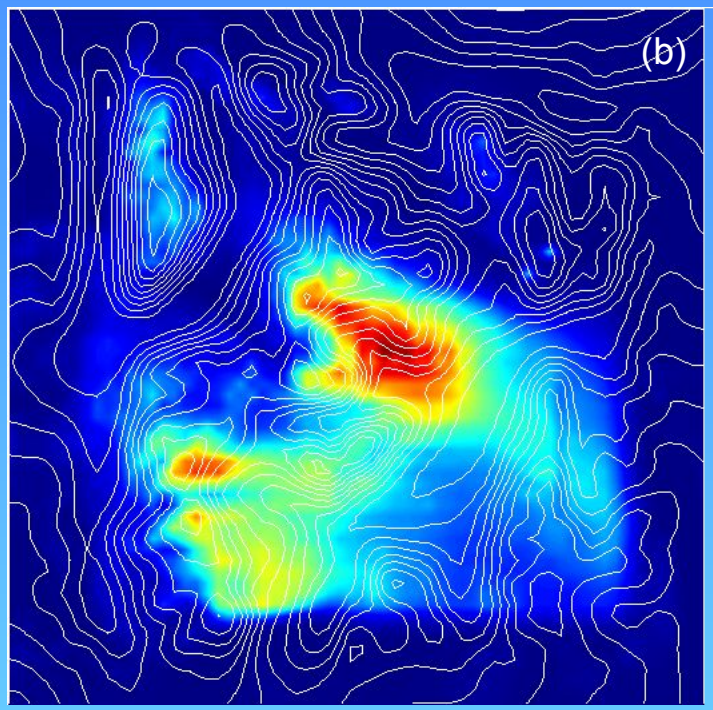
c) Color: Humidity Relative

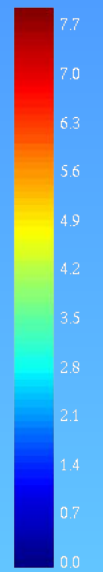
Vectors: Wind Field

Black: Topography

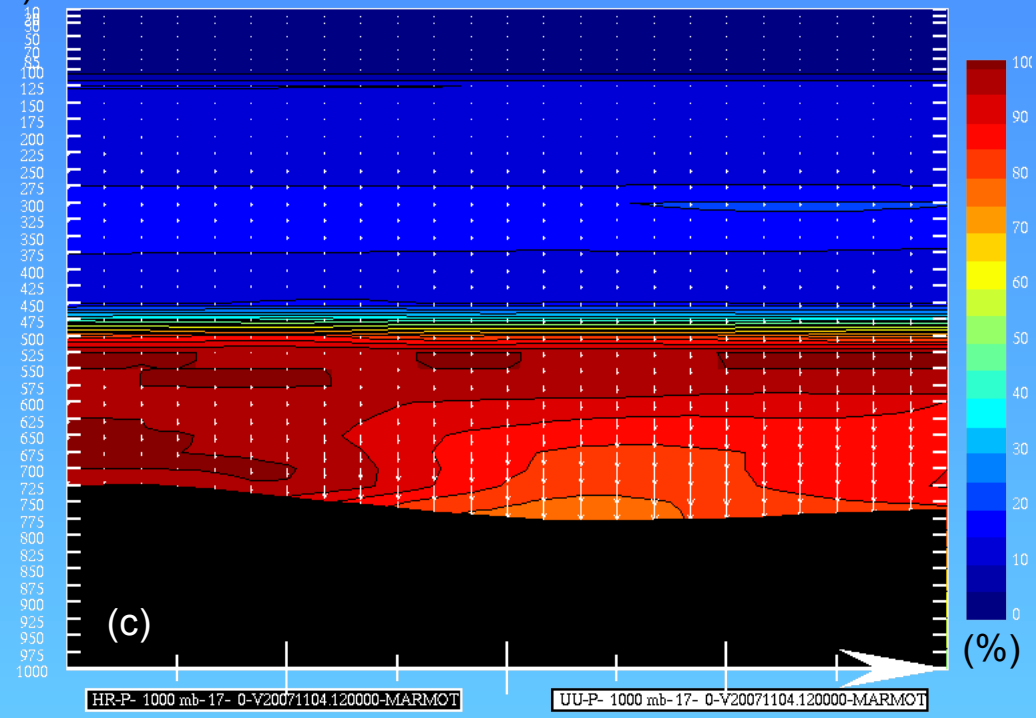
4/11/2007
1200UTC
GEM-LAM
Grid: 500 m



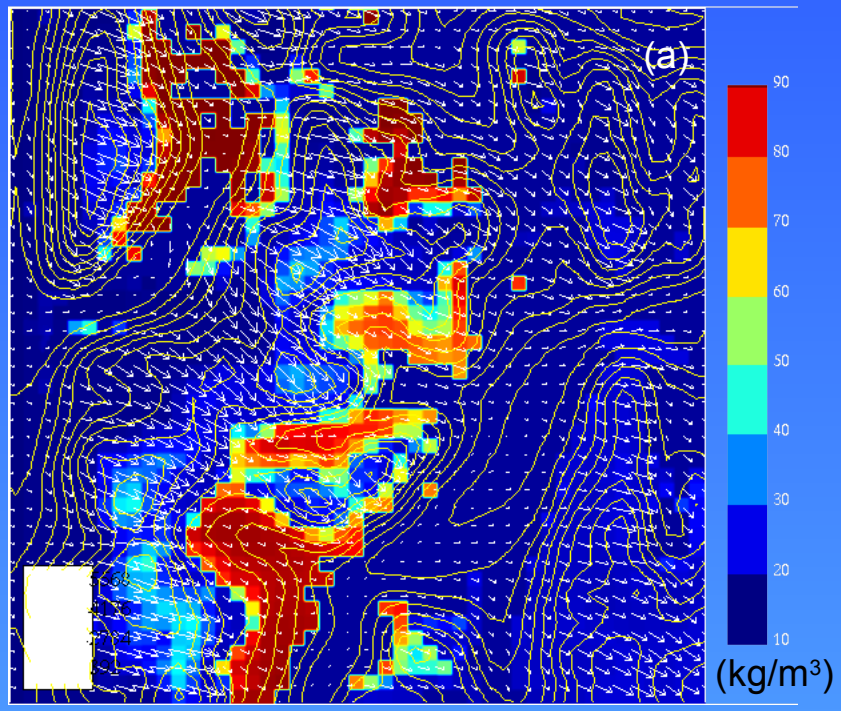




(mm)



(%)



4/11/2007 1200UTC

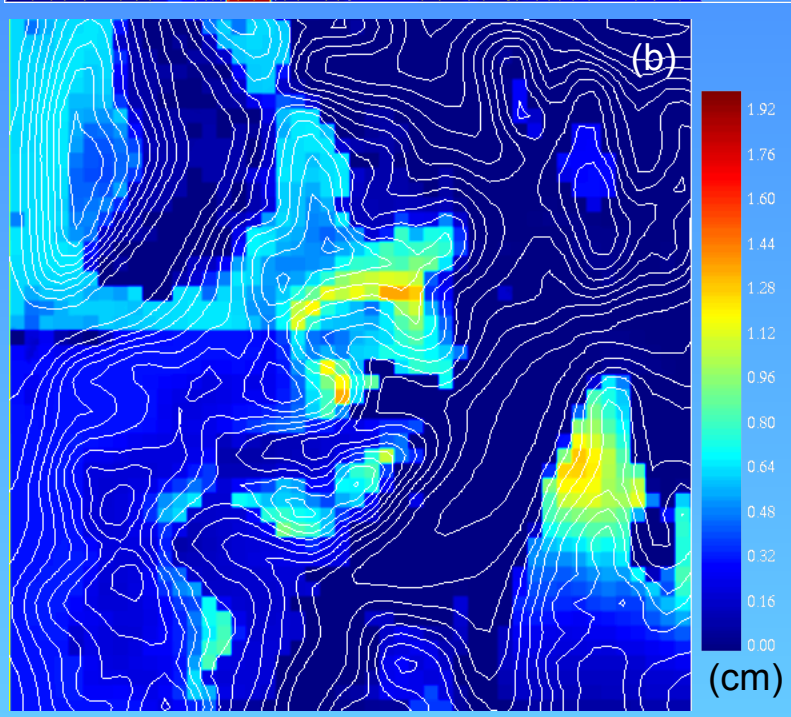
MEC

Grid: 100 m

a) Color: Snow Density

Vectors: Wind Field

Contour: Topography



b) Color: Snow Depth

Contour: Topography

Status and Next Steps

- Model produces promising spatial distribution of snow but requires testing using LiDAR snow depth maps
- Possible to use the cascade technique with the GEM to produce fine-scale wind fields over research basins
- Coupling the GEM-MEC configurations is a reliable technique to understand the atmospheric forcing and feedback
- Spin-up is critical in order to produce reliable output. This can be produced for up to 10 days after initial conditions
- DEM with 90 m resolution improves the wind fields compared to coarse DEM (10 km resolution)
- Next Steps
  - Use of parametrisations of blowing snow (e.g. MacDonald et al.)
  - Compare to basin observations of wind speed, direction, SWE