Effects of diabatic cooling of melting snow: February 13-14 case study

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Workshop
27 September 2012
Whistler Mountain

Photo by K. Rasmussen
Precipitation types

- Diabatic cooling of melting snow often produced an $0^\circ$C isothermal layer.
Precipitation types

- Diabatic cooling of melting snow often produced an 0°C isothermal layer.
Mechanisms
Mechanisms

Vertical Air Motion

Temperature

Phase Changes

Phase Changes

Liquid

Vapor

Solid

COOLING

WARMING

Previous studies showed that abrupt changes in the flow field was associated with a change in precipitation phase. – Steiner et al. 2003
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Example: Flow in the valley

This abrupt change in flow field from down- to up- valley is associated with the change in precipitation types. – Steiner et al. 2003
Challenges during the 2010 Olympics

Whistler area is associated with very complex terrain and often experienced rain and snow during the winter season, as well as poor visibility.
Science and Nowcasting Olympic Weather for Vancouver 2010

Examples of the main goals are:

▶ To improve our understanding and ability to forecast precipitation amount and type
▶ To improve our understanding and ability to forecast/nowcast low cloud, and visibility
▶ To improve forecasts of wind speed, gusts and direction
▶ To develop better forecast system production system(s)
“The men’s downhill skiing competition, the marquee Alpine race of the Winter Games, has been postponed to Monday from Saturday because successive days of rain and warm weather have created slushy conditions on the course at Whistler Creekside.”
Objective and approach

The objective of this study is to better understand the relative effects of diabatic cooling and warm air advection on February 13-14, 2010.

- We will focus on Whistler Mountain and Callaghan Valley.
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- We will focus on Whistler Mountain and Callaghan Valley.
1200 UTC 13 February - 500 mb
QUESTION: How important was the diabatic effect of melting snow compared to warm advection?
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Precipitation rate and temperature

![Graph showing precipitation rate and temperature over time at different elevations.](image-url)
Precipitation rate and temperature

[Graph showing precipitation rate and temperature over time for different altitudes.]

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Rain-snow line

Case Study: 1200 UTC 13 Feb - 1200 UTC 14 Feb
Whistler Mountain

UQAM 12 / 23
Vertical temperature and wind profiles

Wind direction

Above the shear layer:
- South

Below the shear layer:
- Variable
- Variable

1800 UTC 0000 UTC
Vertical temperature and wind profiles

Wind direction

Above the shear layer:
- South

Below the shear layer:
- Variable
- Variable
- North
Case Study: 1200 UTC 13 Feb - 1200 UTC 14 Feb
Whistler Mountain

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- Variable
- North
- South
The precipitation transition region moved upward.
Overview

[Map of Whistler Mountain with annotations and lines indicating the rain-snow line]
Case Study: 1200 UTC 13 Feb - 1200 UTC 14 Feb

Whistler Mountain

Radar: 73 deg cross-section

At 2100 UTC

Reminder: DOWN- and UP- valley flow
Case Study: 1200 UTC 13 Feb - 1200 UTC 14 Feb
Whistler Mountain

Radar: 73 deg cross-section

Radial Doppler Velocity

At 2100 UTC

0000 UTC

0300 UTC

Reminder: DOWN- and UP- valley flow
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Reminder: DOWN- and UP- valley flow
Case Study: 1200 UTC 13 Feb - 1200 UTC 14 Feb
Whistler Mountain

Rain-snow line

Radar: 73 deg cross-section

Radial Doppler Velocity

Reflectivity

At 2100 UTC 0000 UTC 0300 UTC 0600 UTC 0900 UTC

Reminder: DOWN- and UP- valley flow
Rain-snow line

Case Study: 1200 UTC 13 Feb - 1200 UTC 14 Feb
Whistler Mountain

Radar: 73 deg cross-section

Radial Doppler Velocity

![Image of Radial Doppler Velocity graph]

At 2100 UTC 0000 UTC 0300 UTC

0600 UTC 0900 UTC 1200 UTC

Reminder: DOWN- and UP- valley flow

- This abrupt change in flow field from down- to up- valley was commonly observed during MAP. – Steiner et al. 2003

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Rain-snow line

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Whistler Mountain

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Case Study: 1200 UTC 13 Feb - 1200 UTC 14 Feb

Callaghan Valley

Ski jump

Callaghan Valley, VOD:

Precipitation rate

Temperature

Wind speed
Temperature and wind speed

The vertical green line indicates when precipitation started on Whistler Mountain.
Reminder
Case Study: 1200 UTC 13 Feb - 1200 UTC 14 Feb
Callaghan Valley

Radar: 360 deg cross-section

At 2100 UTC

Reminder: DOWN- and UP- valley flow
Case Study: 1200 UTC 13 Feb - 1200 UTC 14 Feb
Callaghan Valley

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Case Study: 1200 UTC 13 Feb - 1200 UTC 14 Feb

Callaghan Valley

Radar: 360 deg cross-section

Reminder: DOWN- and UP- valley flow
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Callaghan Valley

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Radial Doppler Velocity

At 2100 UTC 0000 UTC 0300 UTC
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At 2100 UTC
0000 UTC
0300 UTC

0600 UTC
0900 UTC
1200 UTC

Reminder: DOWN- and UP- valley flow

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Flow in the valley

As observed by Steiner et al. 2003:

- **UP-valley** flow before precipitation started.
- **DOWN-valley** flow after precipitation started.
Flow in the valley

As observed by Steiner et al. 2003:

- **DOWN-valley** flow after precipitation started.
Summary and future work

- The February 13-14 case study demonstrates an example of the importance of quantifying the diabatic cooling of melting snow relative to the warm advection. For example:
  - the change in wind speed and direction at lower elevations, and
  - a stronger cooling at lower elevation after the onset of precipitation.
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- model sensitivity tests,
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Need to help develop higher accuracy radar retrievals.
Merci ! Any Questions ?