Observations and simulations of winter precipitation types

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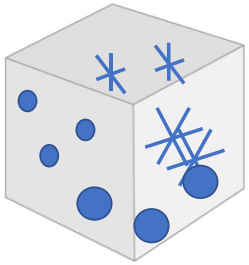
Goal and approach

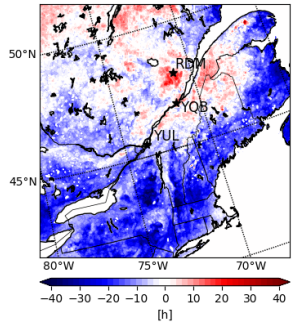
Goal: To better understand atmospheric conditions and processes leading to the many types of winter precipitation

Field projects, automatic measurements

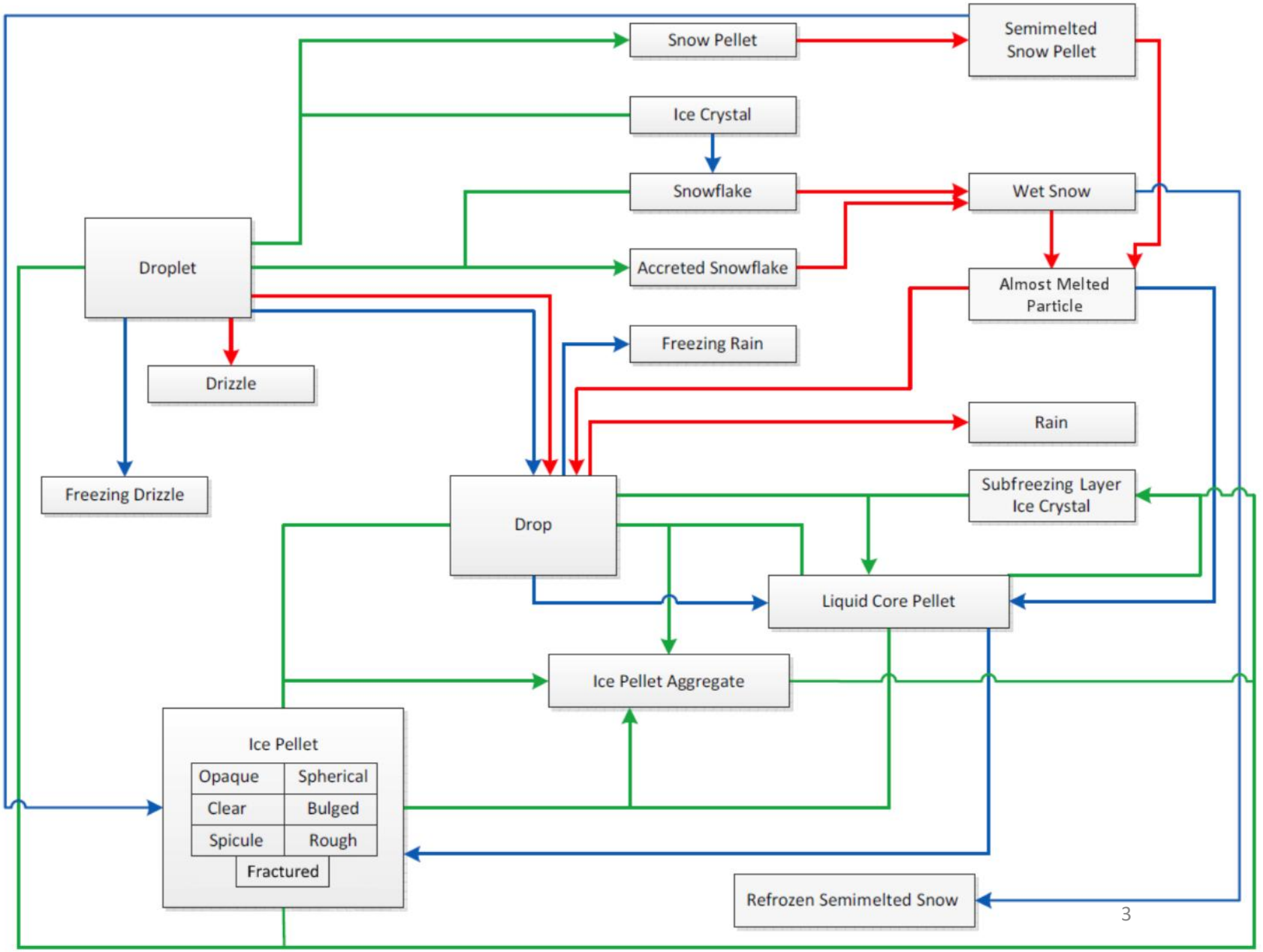


Improve clouds and precipitation microphysics scheme

Use and evaluate atmospheric models



Summary of the formation mechanisms

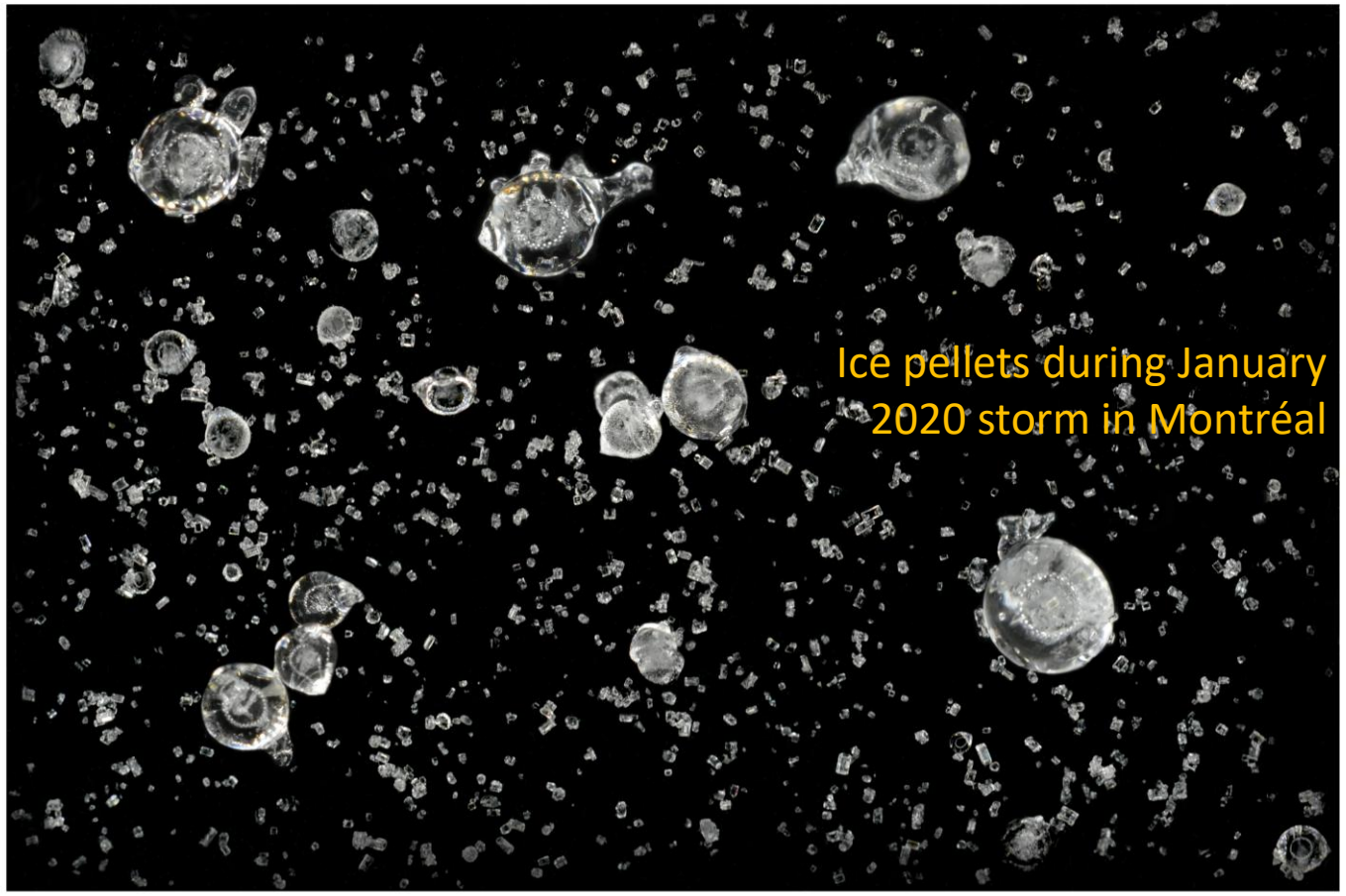


Stewart et al. (2015)

Ice crystals and ice pellets can eliminate freezing rain

Reminder: Ice pellet formation processes

- Homogeneous nucleation; T is not low enough
- Freezing of partially melted particles
- Collisionnal freezing of supercooled drops

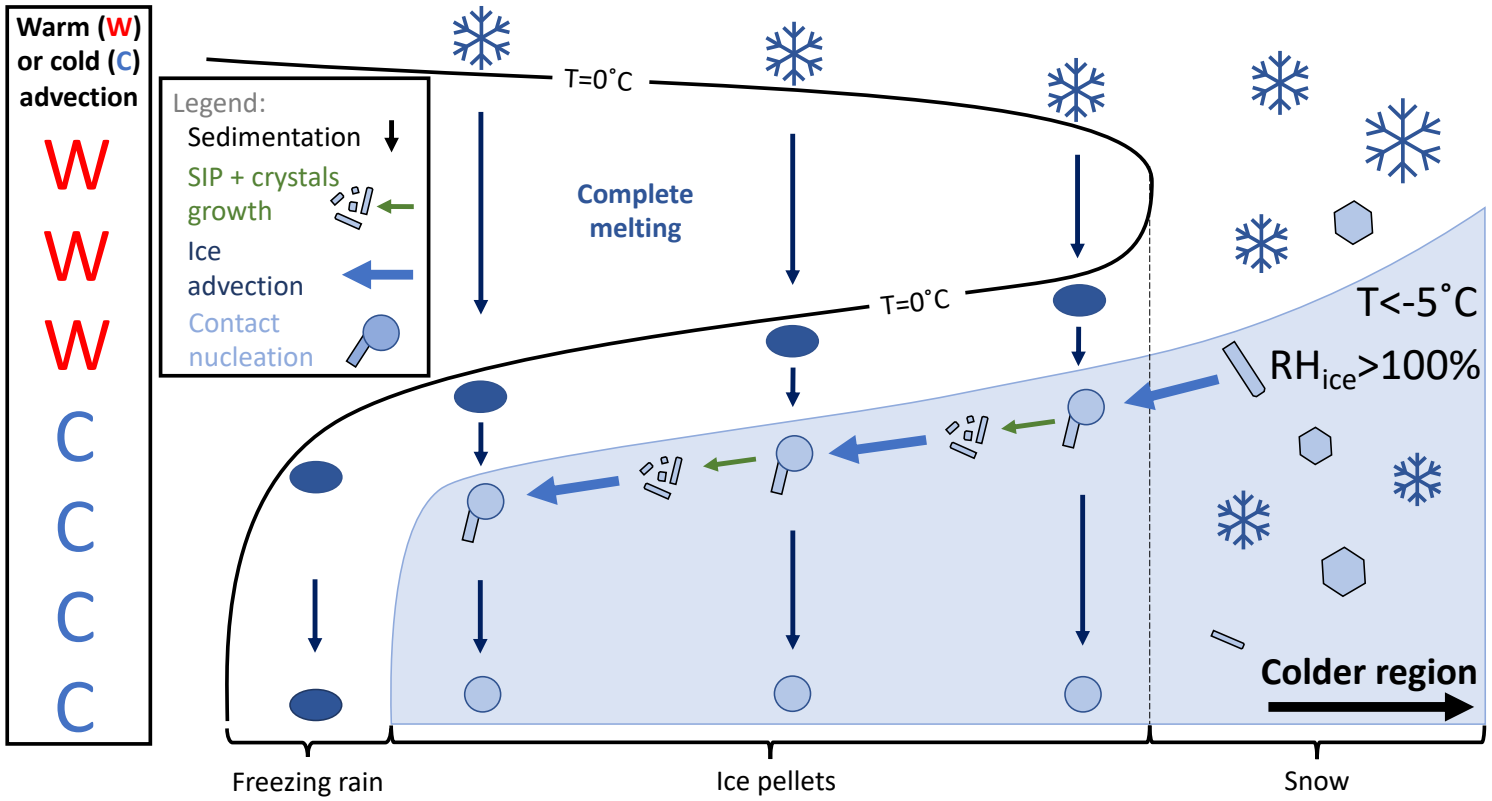


M. Lachapelle – Photo en compétition *Preuve par l'image 2022*

Presence of ice crystals over Montreal

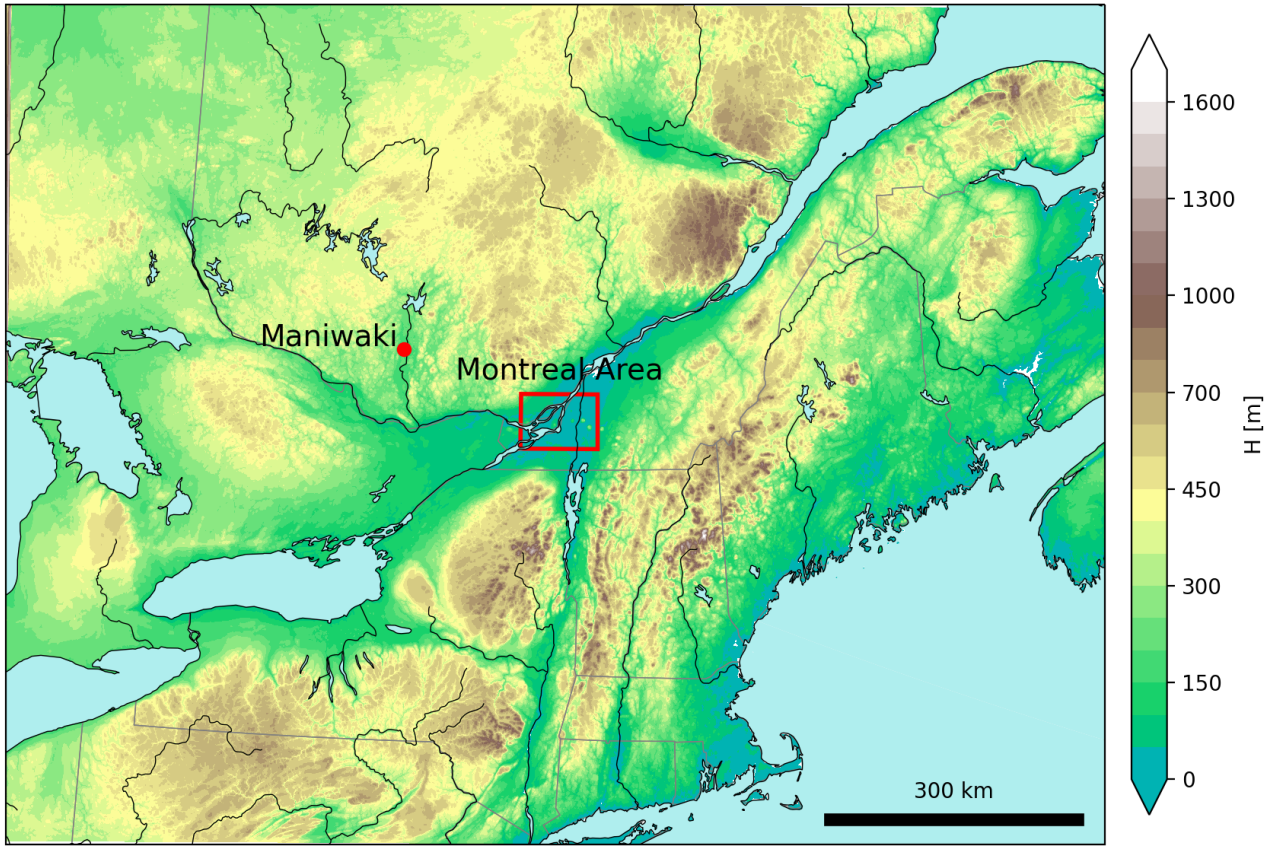
Proposed conceptual model:

- Favorable conditions for ice crystals production north
- Ice crystals may have been advected to the region
- Or?



Lachapelle and Thériault (2022)

High resolution simulations are conducted to verify the hypothesis

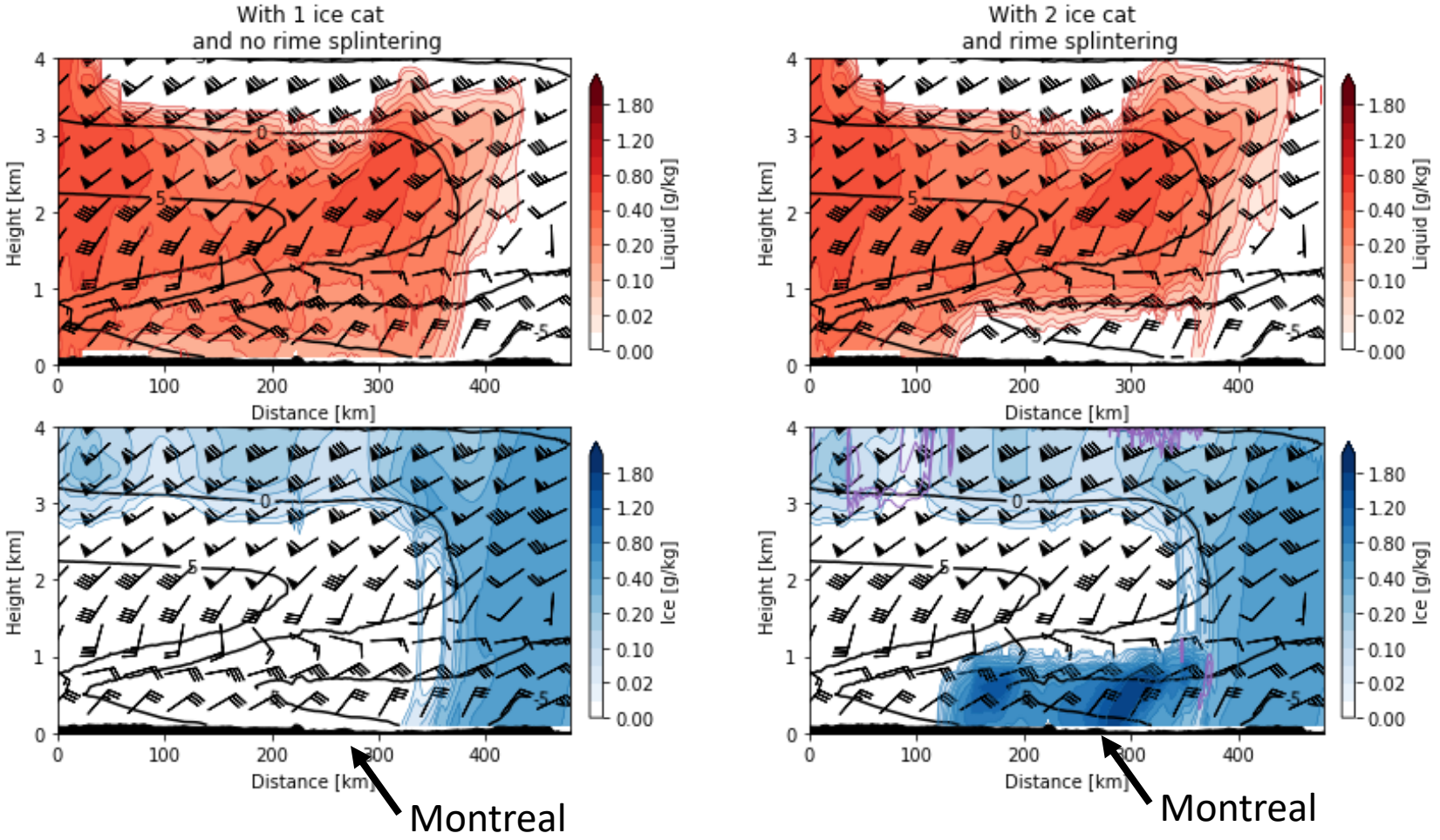


- Model: Global Multiscale Environmental (GEM) model
- Horizontal resolution : 1 km
- Timestep : 30 sec.
- Period : 0000 UTC 10 Jan 2020 until 0000 UTC 14 Jan 2020
- Surface Scheme : ISBA
- Microphysical scheme: P3 (multiple categories and prediction of the liquid fraction)
- Convection scheme : None

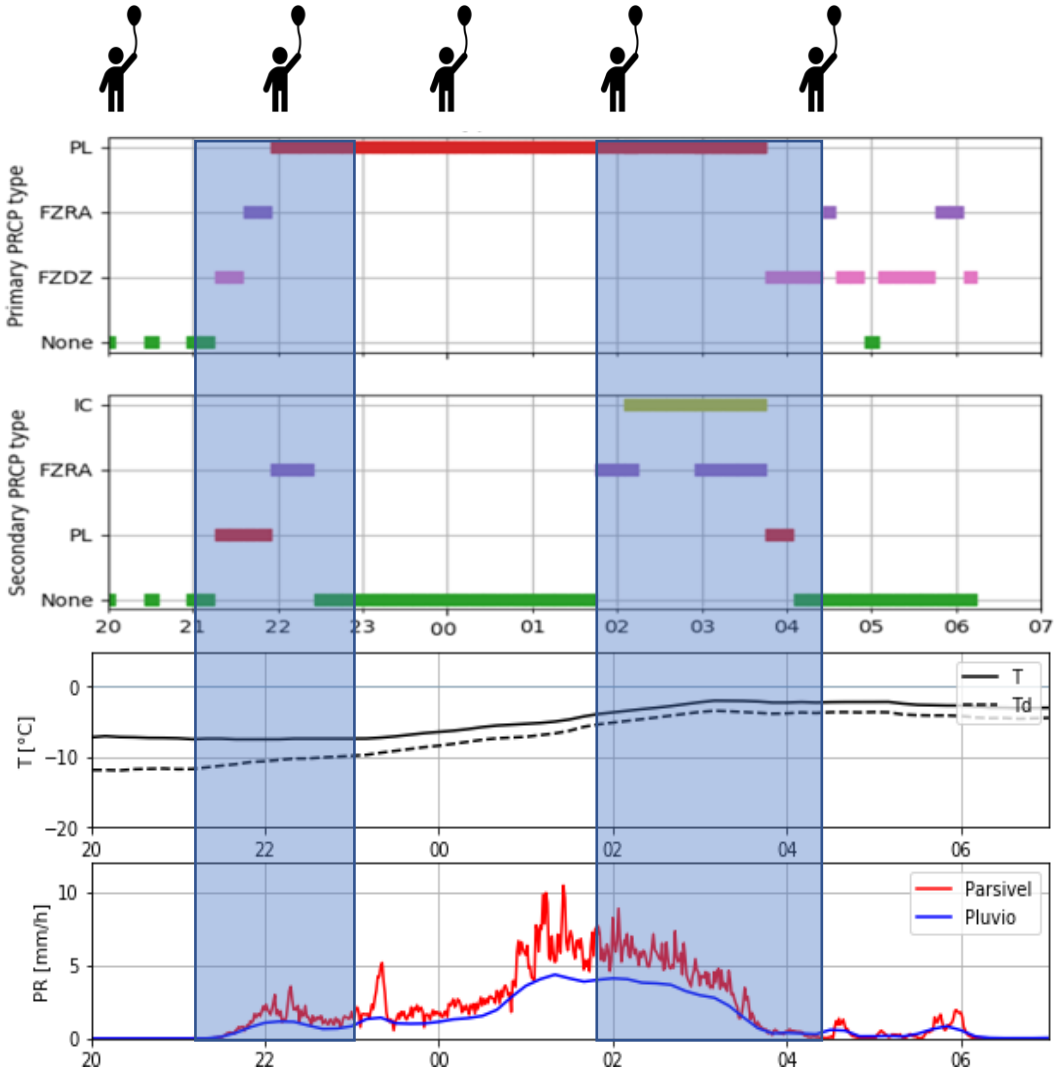
Lachapelle et al. (2023, In preparation)

Preliminary results

- Air parcel trajectories suggest that precipitation particles were advected from the north (snow region)
- The use of 2 ice categories :
  - It allows secondary ice production
  - Ice crystals collide with supercooled drops to produce ice pellets



WINTRE-MIX provides additional information to study freezing rain-ice pellet transitions (IOP#5)



First transition: 2120 to 2220 UTC

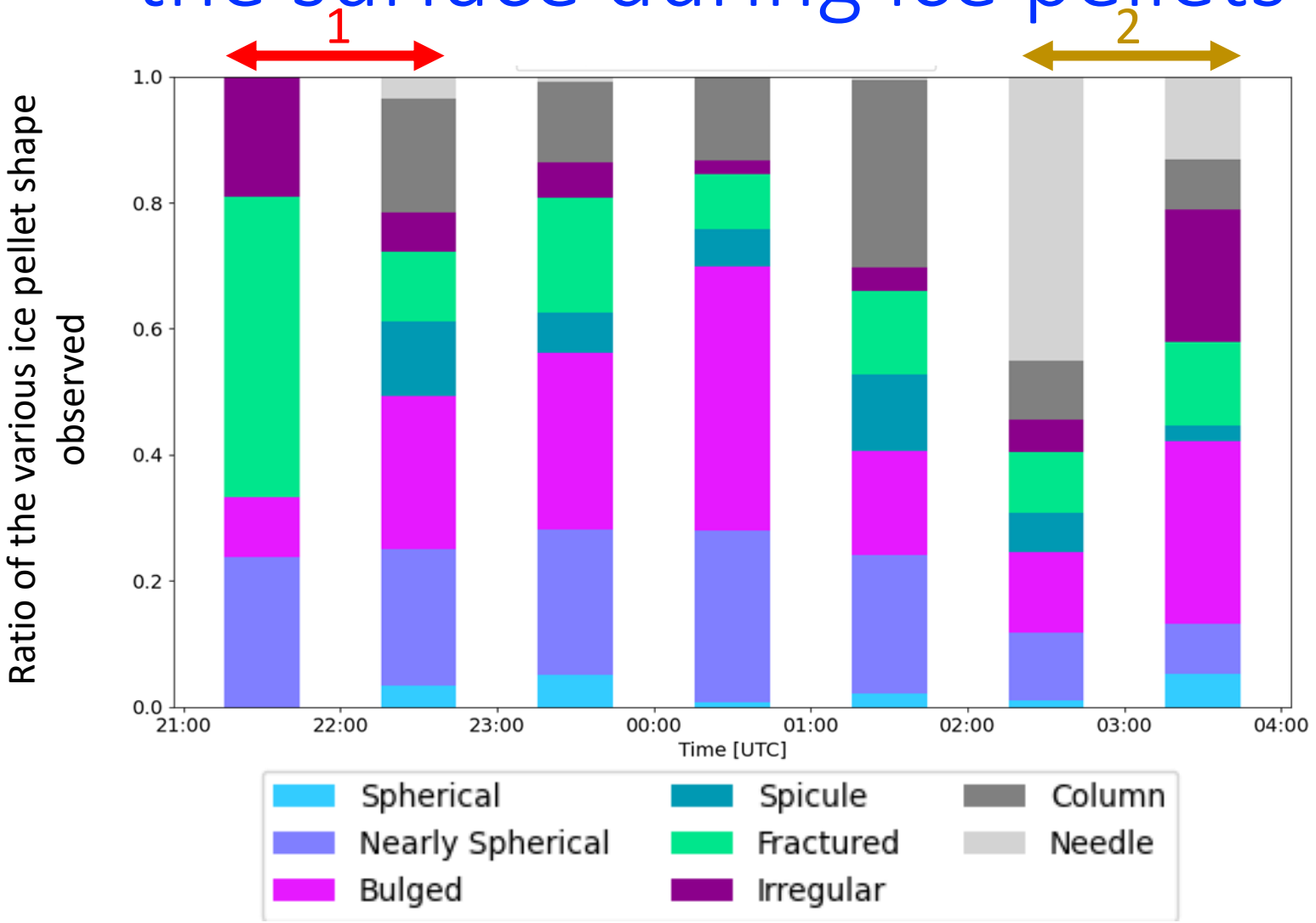
- Air temperature → around -7.5°C
- Freezing drizzle/rain + Ice pellets → Ice pellets
- Precipitation rate ↑

Second transition: 0150 to 0410 UTC

- Air temperature ↑ from -4 °C to -2 °C
- Ice pellets, liquid core pellets and needles → FZDZ
- Precipitation rate ↓

Girouard et al. (2023, In preparation)

Evolution of the occurrence of ice crystals at the surface during ice pellets



- Transition 1:
  - Mainly ice pellets
- Transition 2:
  - Ice pellets combined with some needles and columns
- Ice crystals starts to reach the surface after the onset of ice pellets
- Shape of ice pellets varies

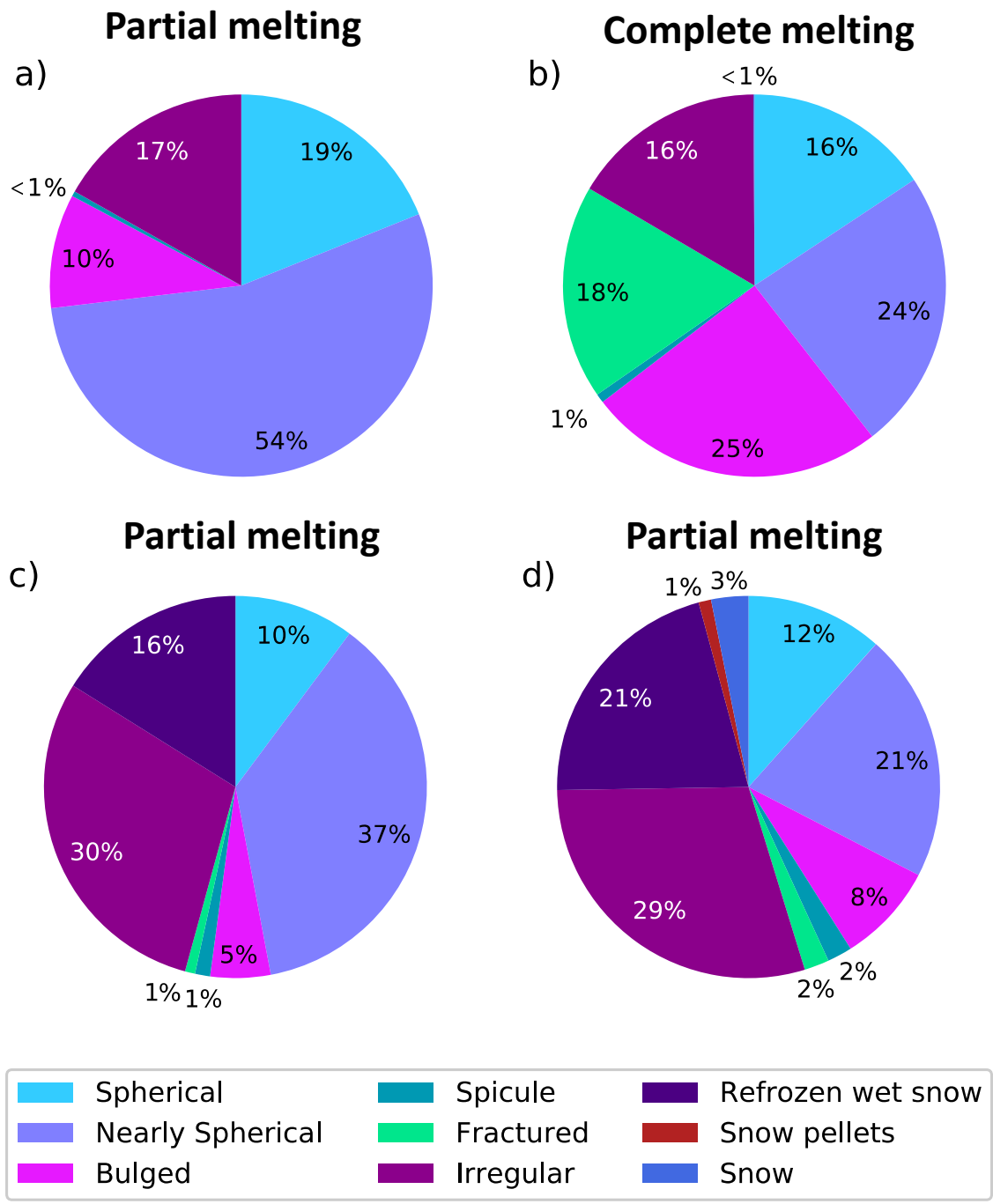
Comparison of the occurrence of ice pellets shape during other events

Partial melting :

- More irregular and refrozen wet snow

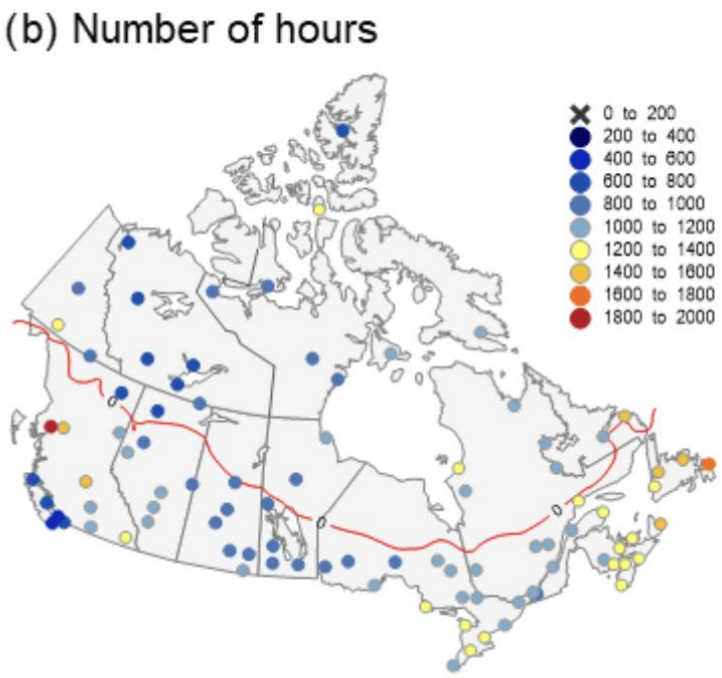
Complete melting:

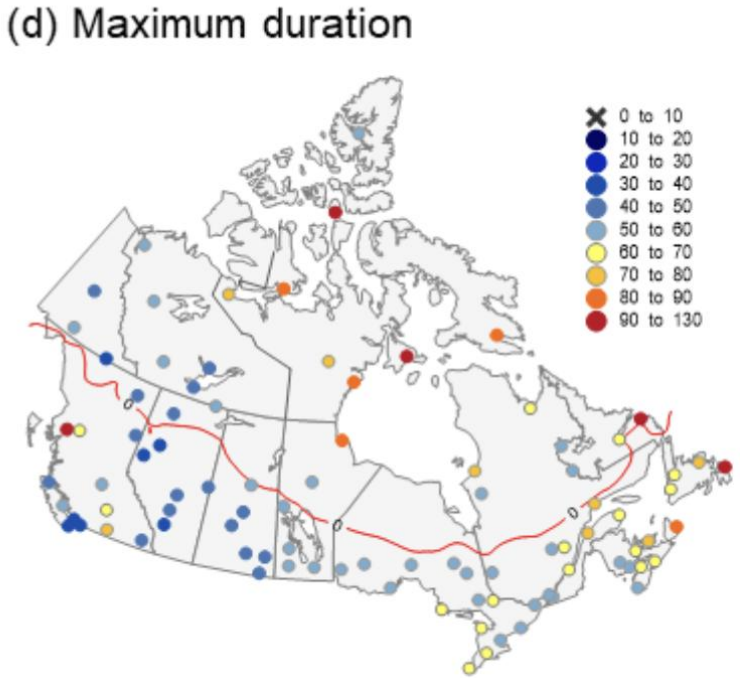
- More fractured ice pellets (18%) and buldged particles
- More bulged particles

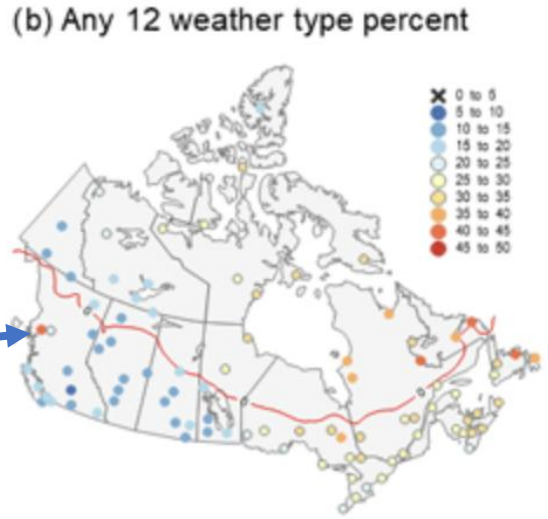


Lachapelle et al. (2023, submitted)

Near-0°C conditions over Canada







- Near-0°C conditions are common in Canada
- There is a maximum at Terrace, BC and ~40% of the time with precipitation
  - Average duration: 11 h and up to 39 h with freezing rain (Cardinal et al. 2023, In preparation)
- Factors leading to near-0°C
  - Latent heat from freezing and melting
  - What is the contribution of the latent heat releases from freezing near the surface during freezing rain? (Sujan Basnet, PhD candidate)

Mekis et al. (2020, HESS) and Stewart et al. (2023) submitted

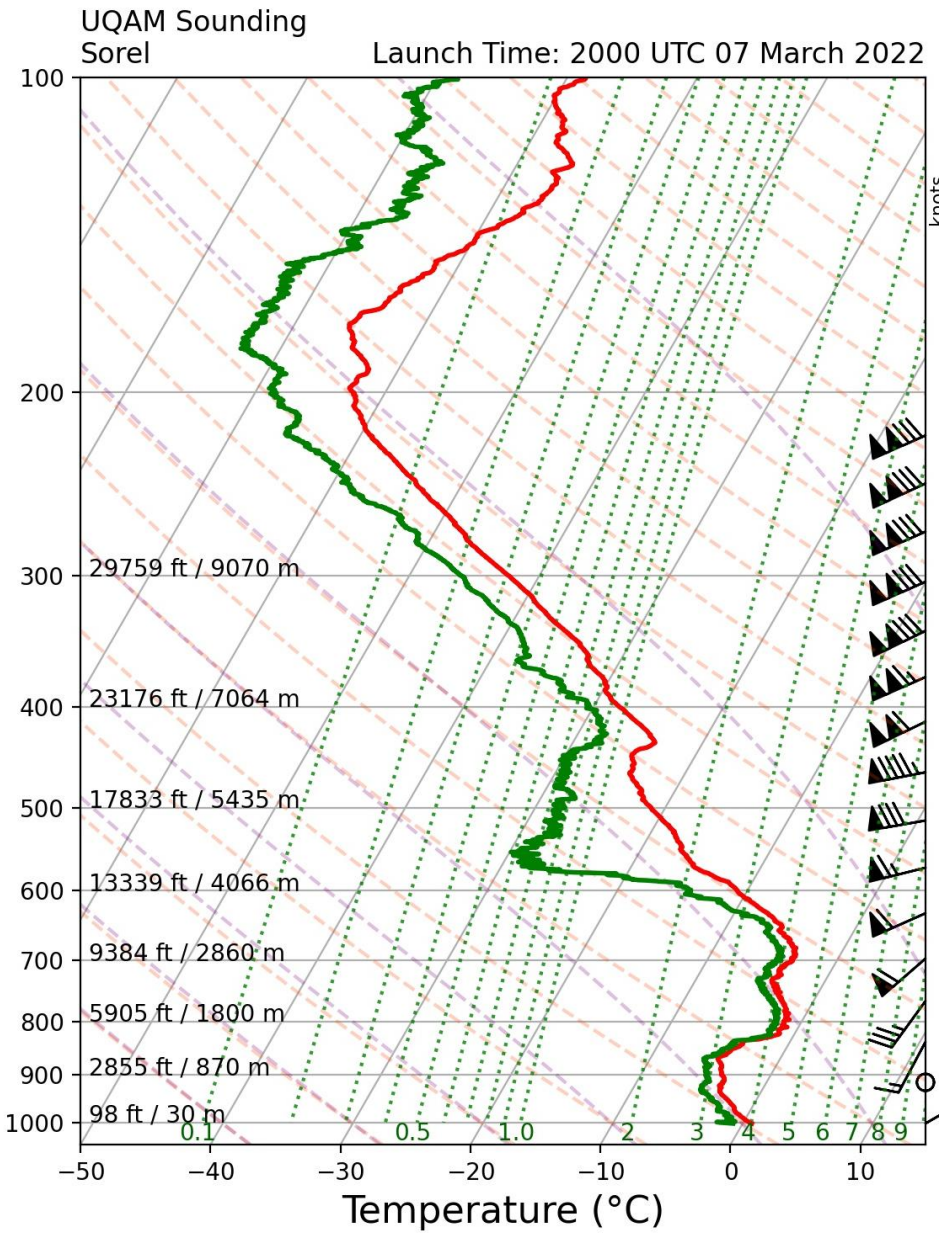
Future work and collaboration

- Modelling activities will be used to continue studying the microphysical processes leading to winter precipitation types
- Radar information could be used to identify the flow field during freezing rain/ice pellets over southern Quebec
- Research aircraft could be used to identify particle types falling in the melting layer and the refreezing layer during freezing rain/ice pellets

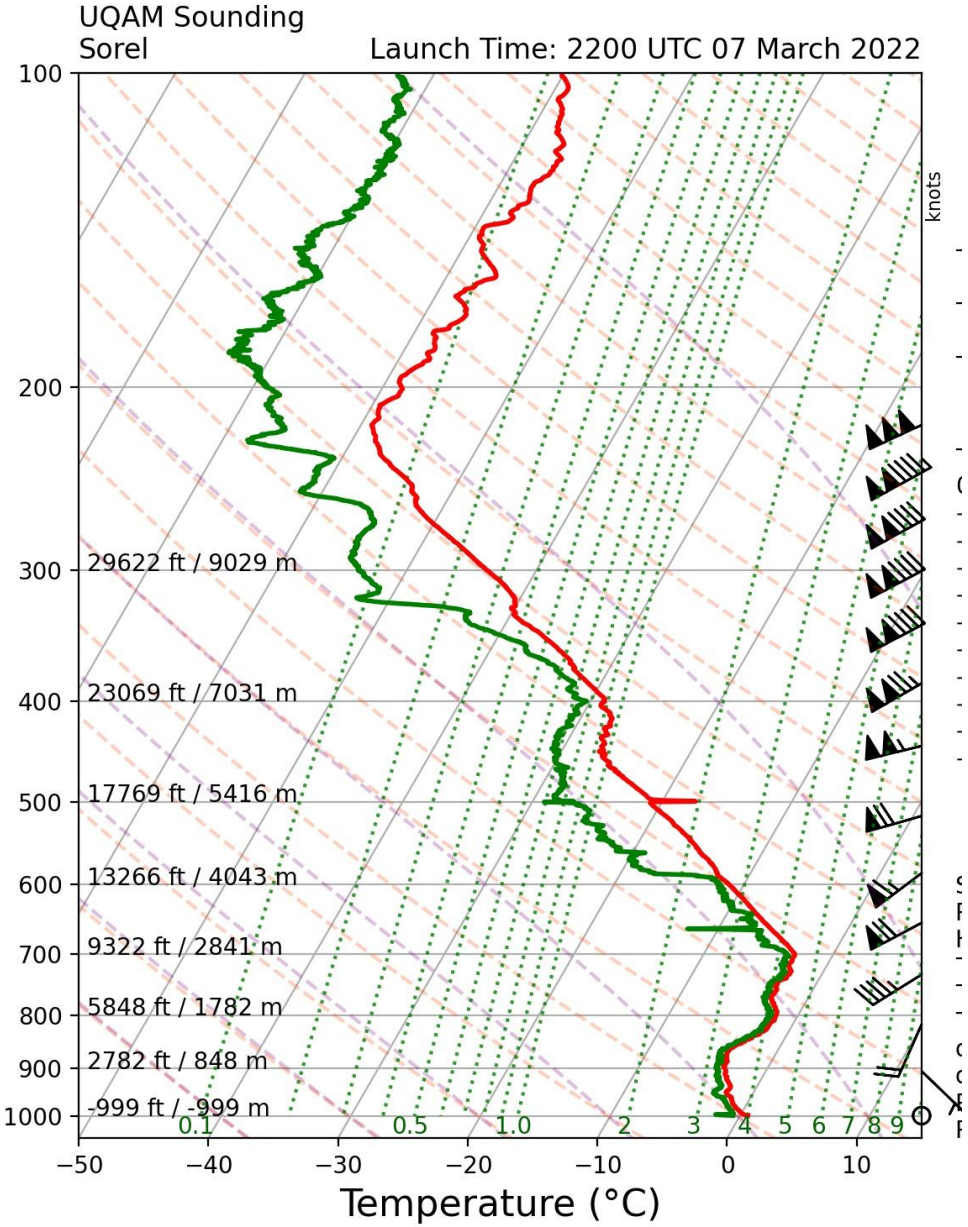
Thank you!

Formation of frozen droplets

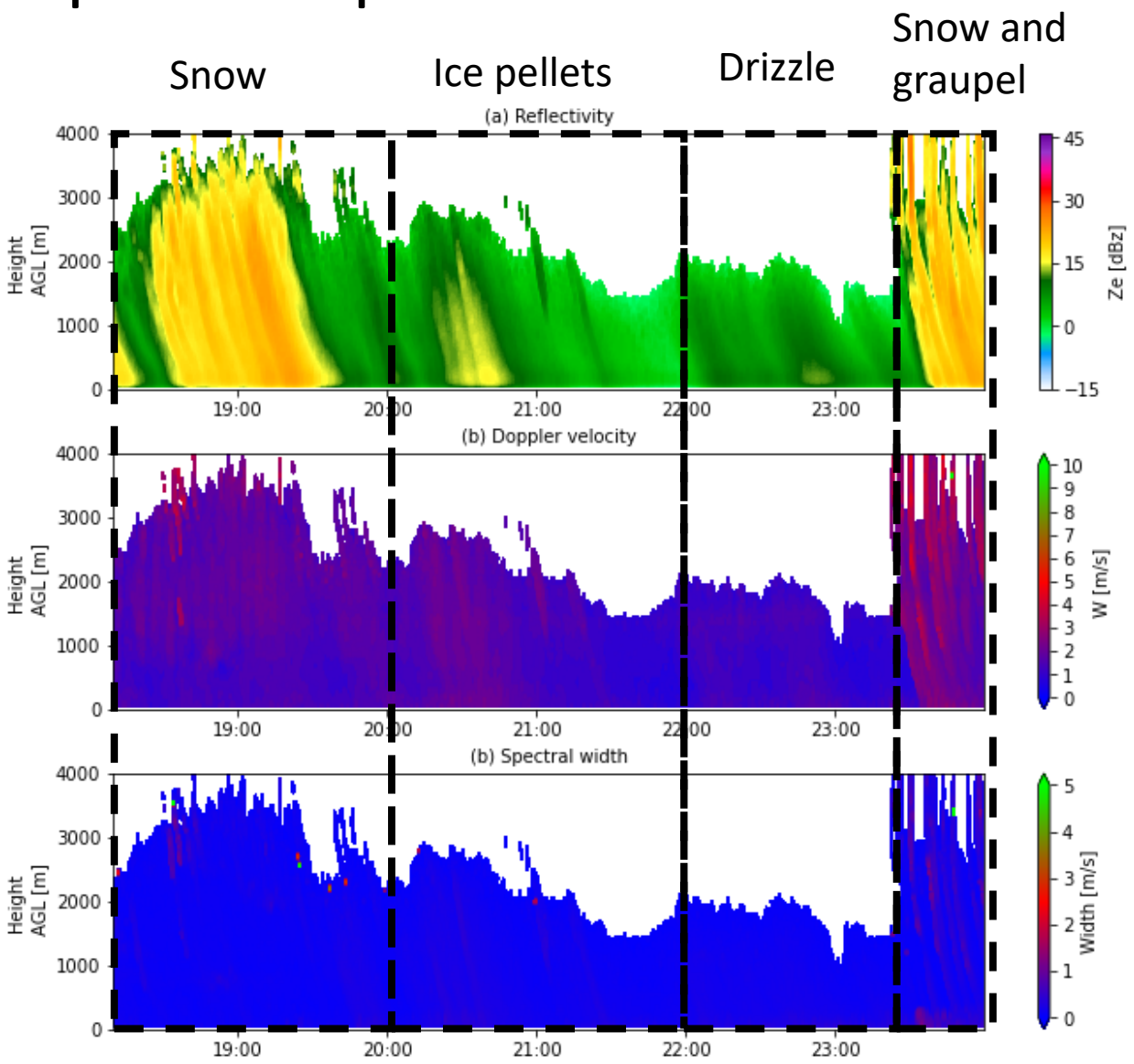
Ice pellets (frozen droplets)

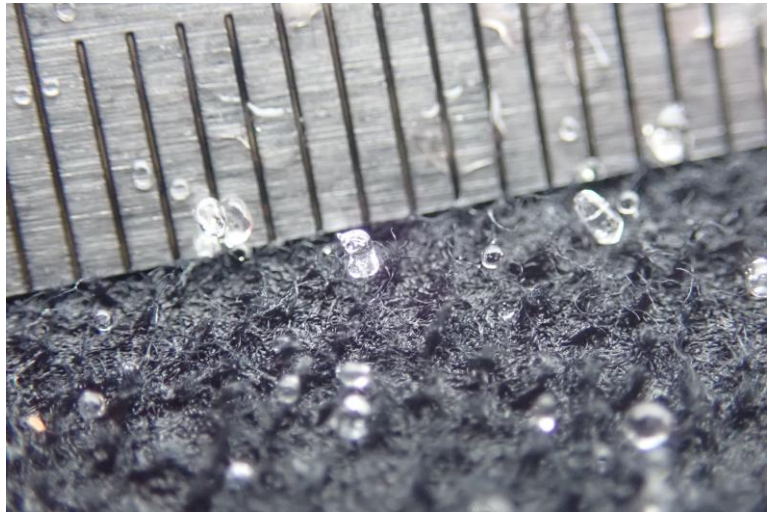


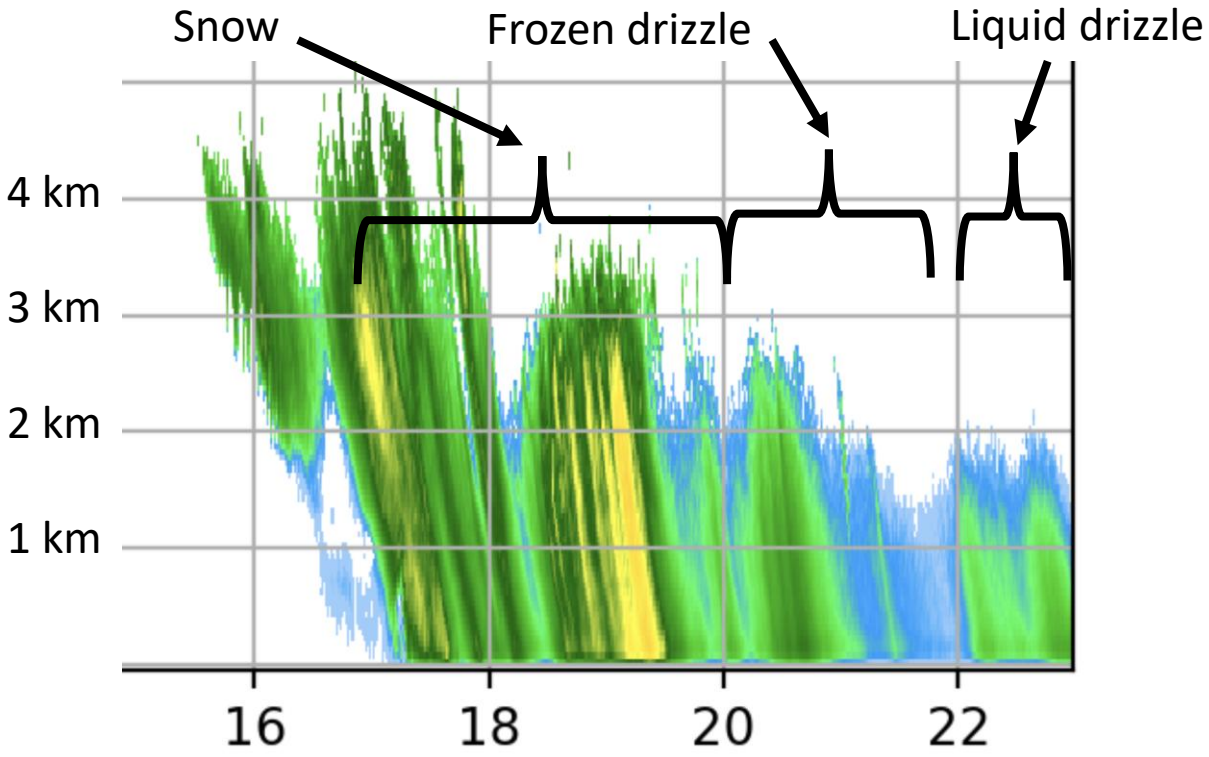
Drizzle

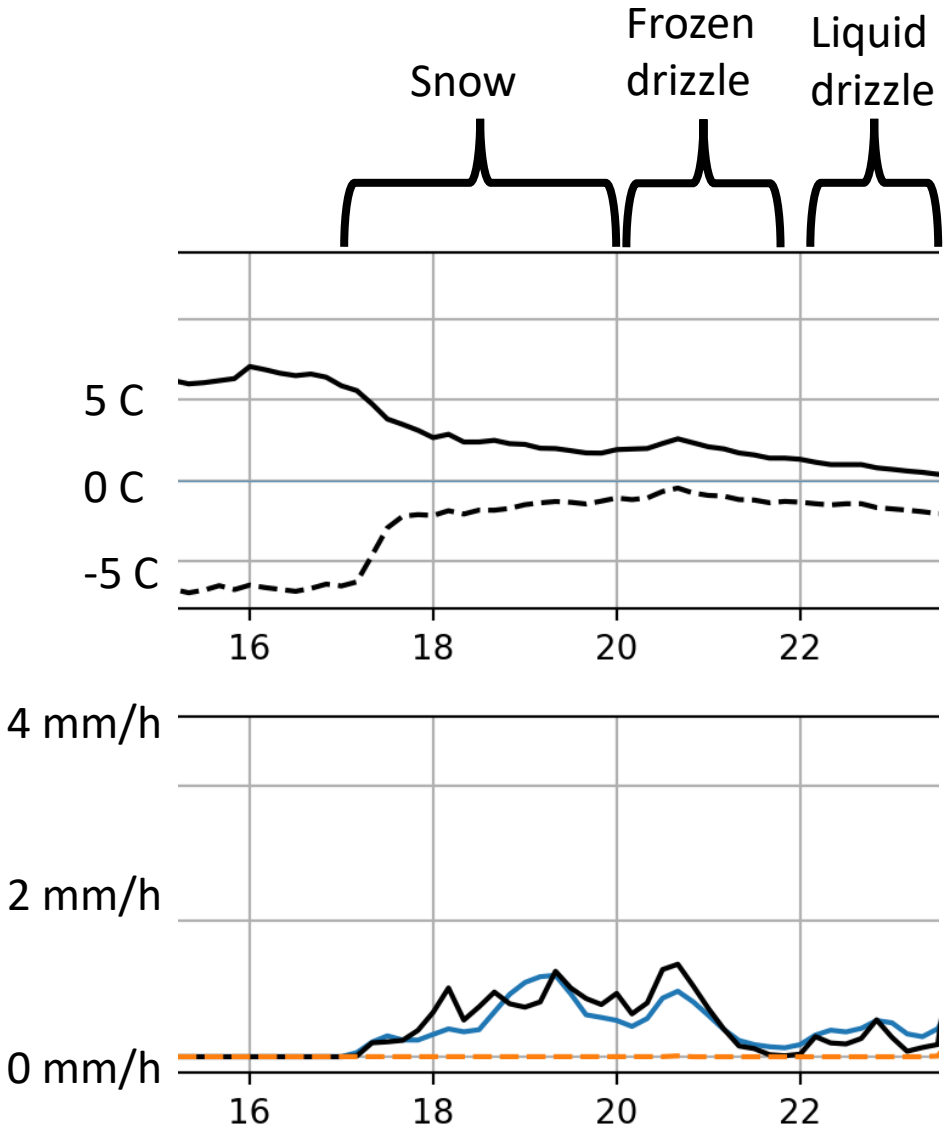


Frozen droplets episode

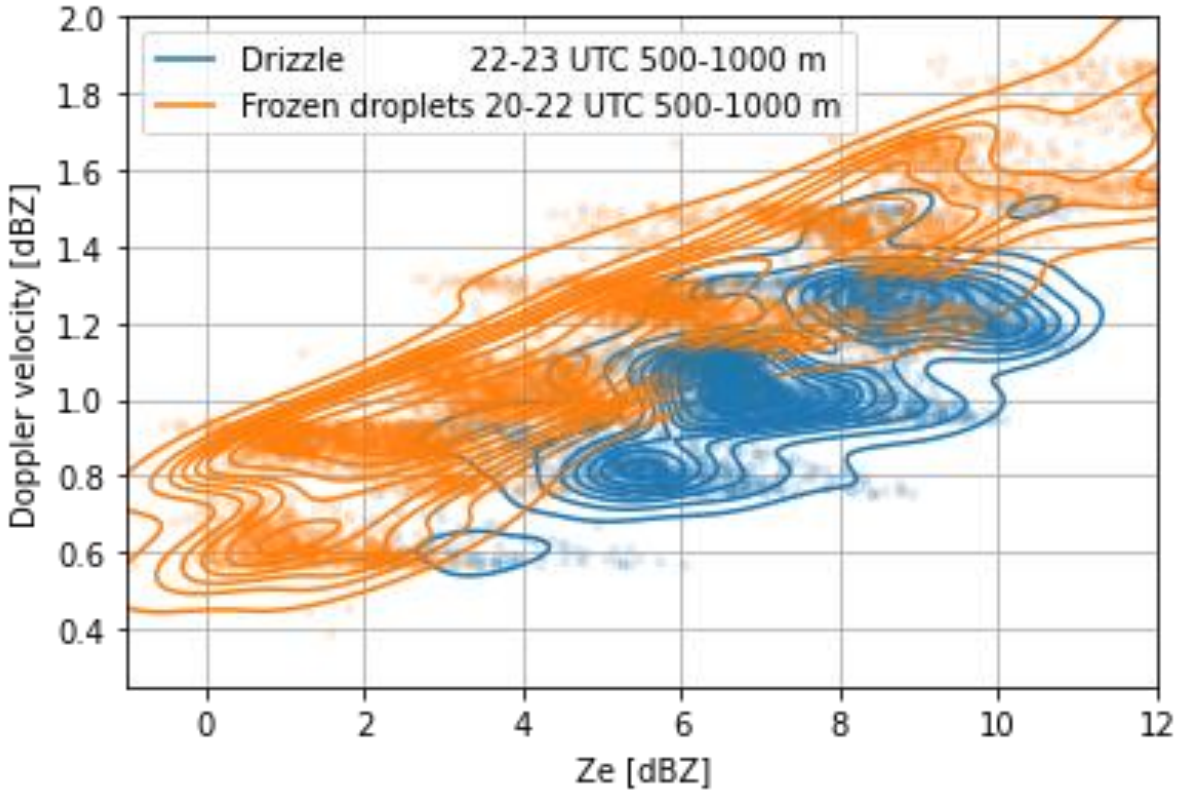





Snow
Frozen drizzle
Liquid drizzle
4 km
3 km
2 km
1 km
16
18
20
22


Snow
Frozen drizzle
Liquid drizzle
5 C
0 C
-5 C
16
18
20
22
4 mm/h
2 mm/h
0 mm/h
16
18
20
22

Doppler velocity space



Flight track on 7 March 2022