Dynamics and microphysics of snowfall associated with a warm conveyor belt over Korea

J. Gehring[1], A. Oertel[2], É. Vignon[1], A. Berne[1]

Environmental Remote Sensing Laboratory, EPF Lausanne, Switzerland
Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland

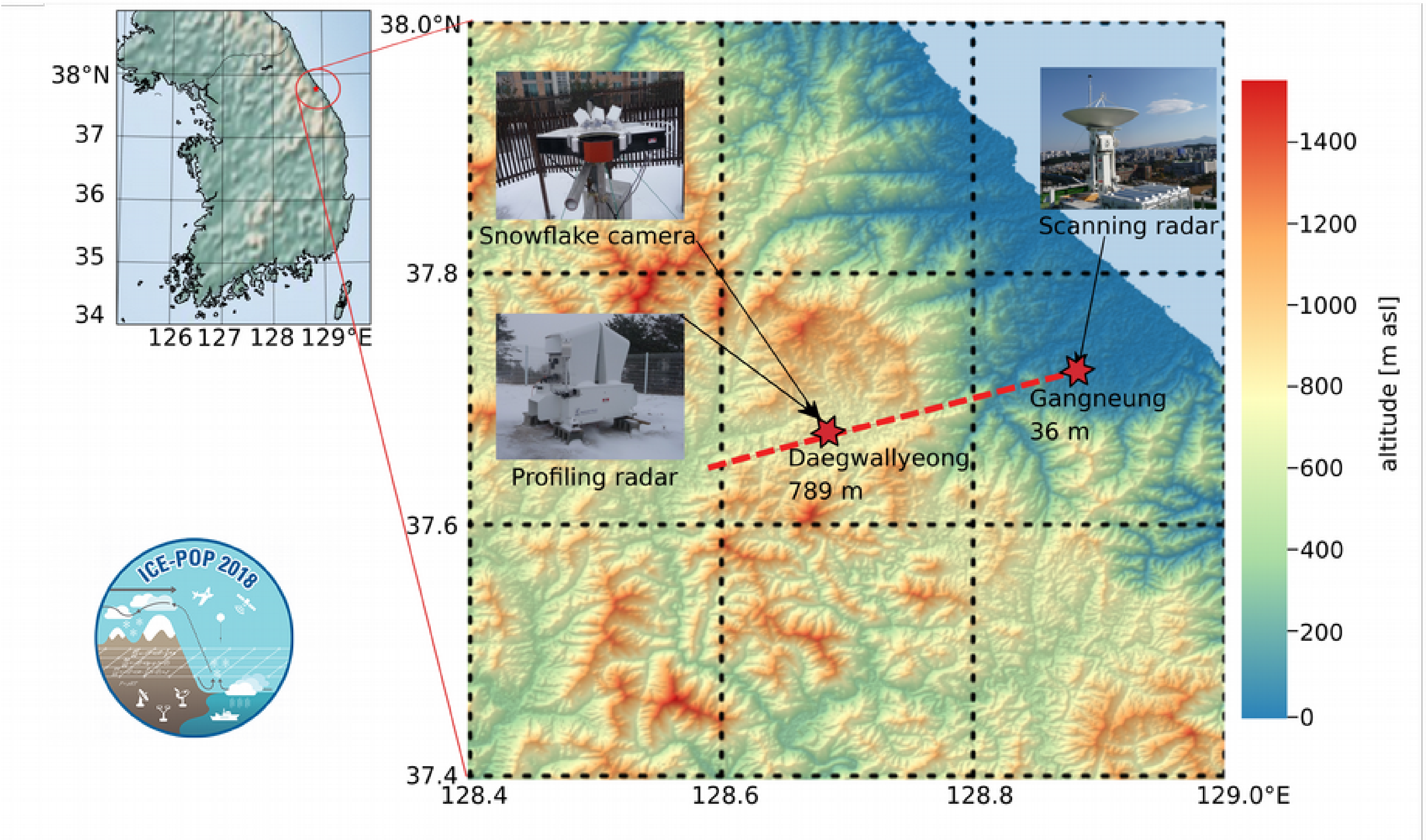
ECMWF workshop warm conveyor belt
11th March 2020, all over the world

EPFL

ETH zürich

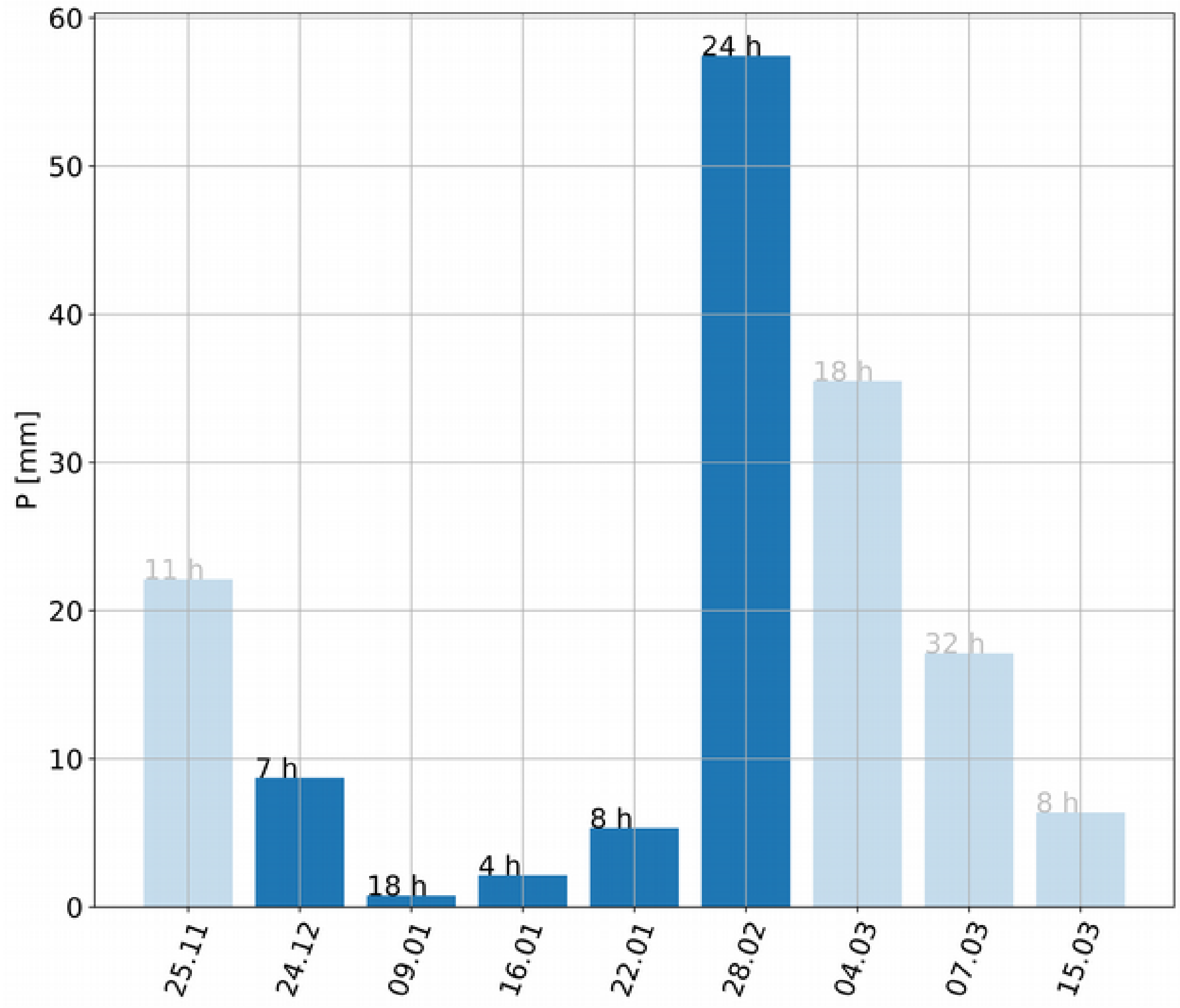
ICE-POP 2018

The ICE-POP 2018 campaign

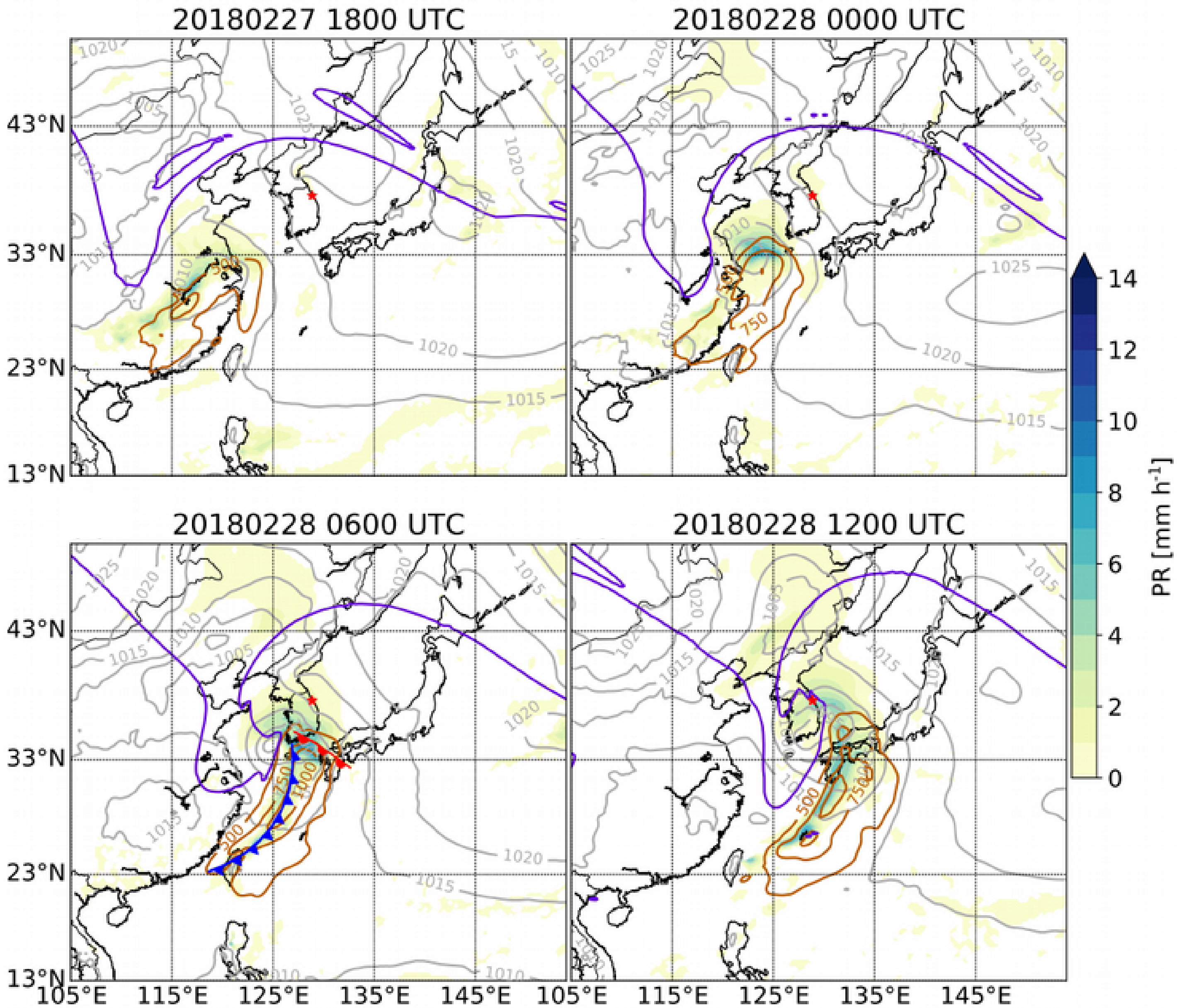


- Measurement campaign to support the PyeongChang 2018 Olympic winter games organised by the Korean Meteorological Administration
- Scanning X-band dual-polarisation Doppler radar, profiling W-band Doppler radar, multi-angle snowflake camera

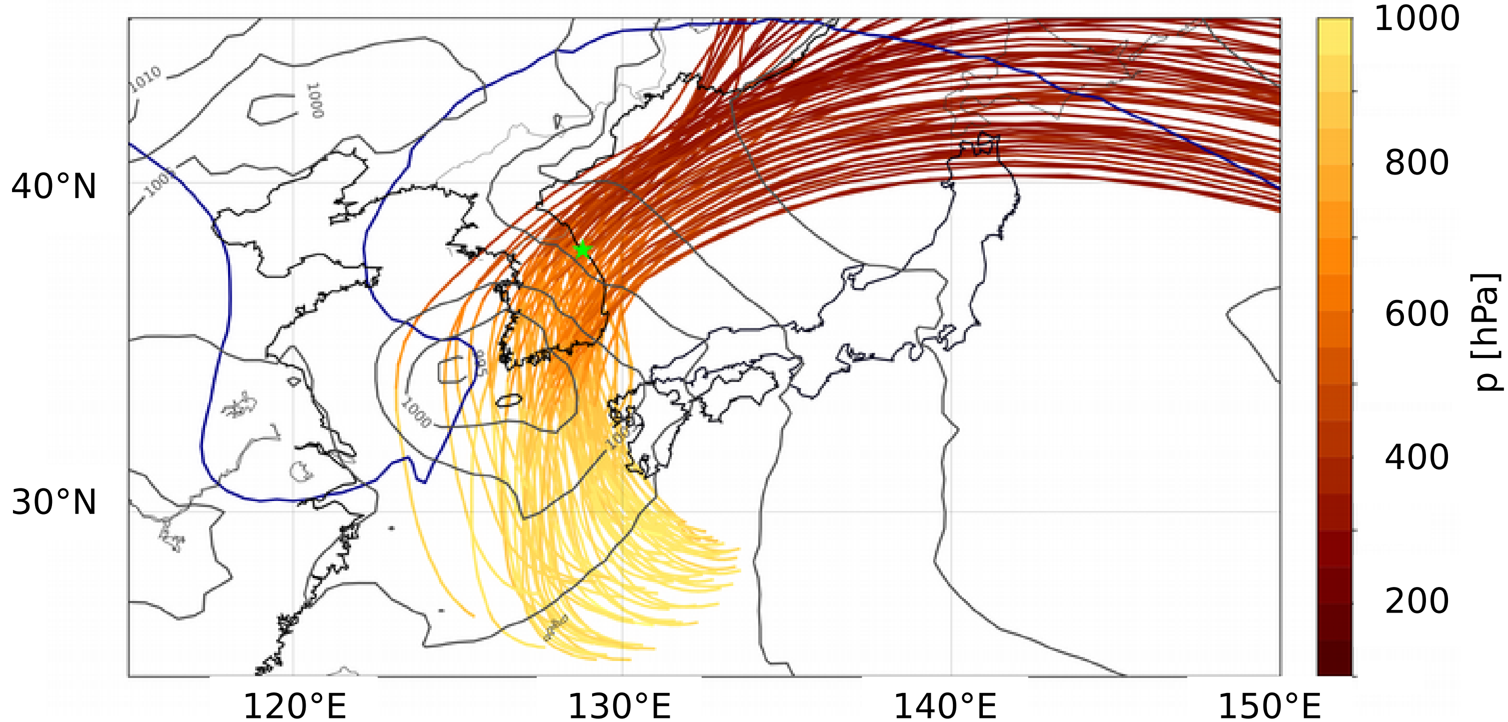
Precipitation events



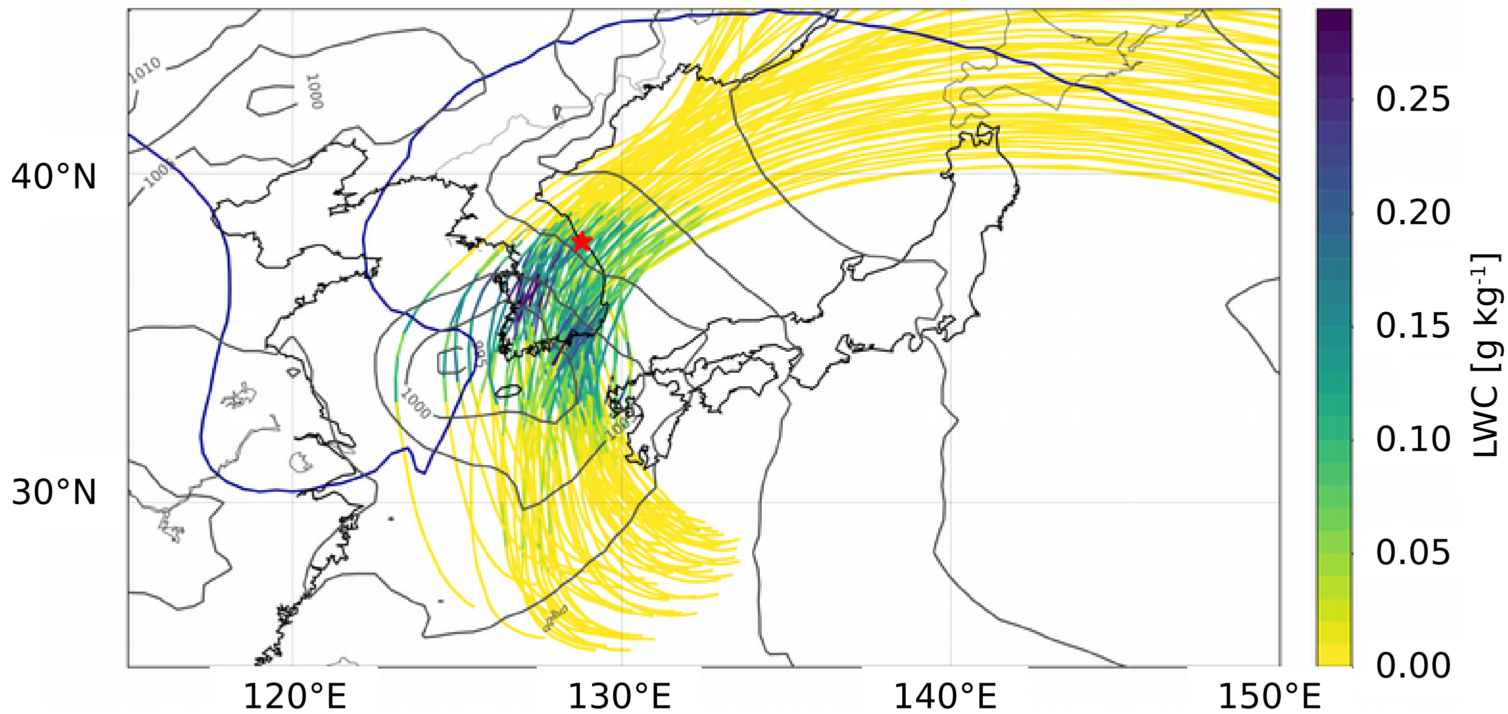
- Campaign from **15 Nov 2017** to **18 Mar 2018**
- **Dry winter** season with few precipitation events: 61% of DJF climatology
- **28 Feb 2018** event: 62% of DJF 2018 precipitation and 29% over the campaign



- Prominent PV streamer associated with a surface low pressure
- Intensification of the extratropical cyclone
- Strong integrated vapour transport (above 1000 kg m^{-1} s^{-1})
- System passes over the south of the Korean peninsula



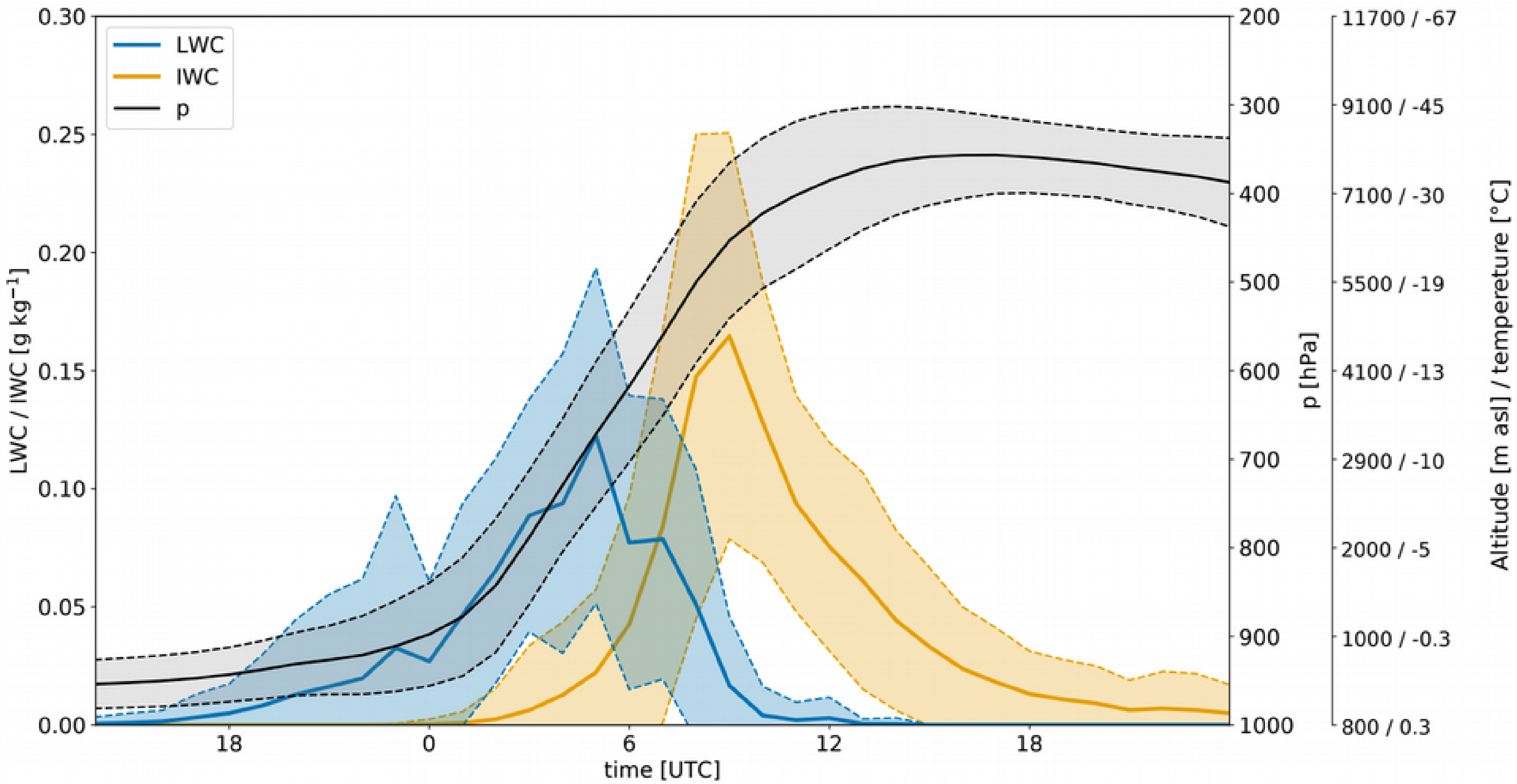
- Strong ascent over PyeongChang



- Strong ascent over PyeongChang
- Liquid water content (LWC) increases drastically in the ascent of the WCB

Goal: investigate the impact of the **warm conveyor belt** (WCB) on the observed **microphysics** of this intense precipitation event

1) Which microphysical processes were involved?
2) How did the flow conditions in the WCB influence the observed microphysics?



- Production of supercooled liquid water (SLW) during the ascent
- Above 700 hPa, liquid water content (LWC) decreases to the benefit of cloud ice

Radar variables

Reflectivity

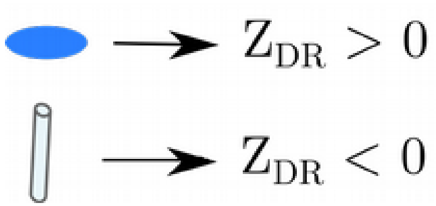
$Z_h = \int N(D)\, D^6 dD$ [mm^6 m^{-3}]

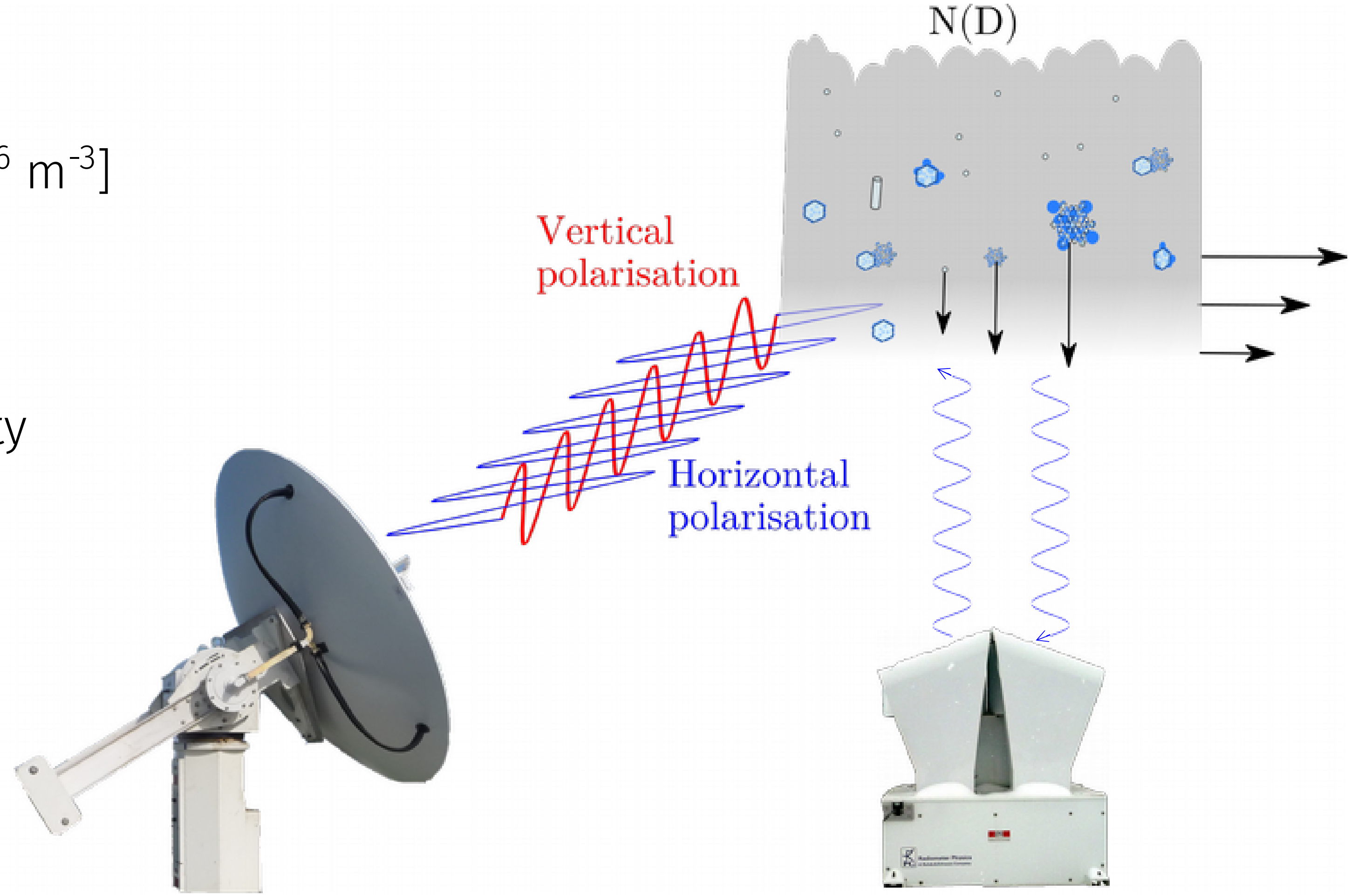
$Z_H = 10 \log_{10}(Z_h)$ [dBZ]

Differential reflectivity

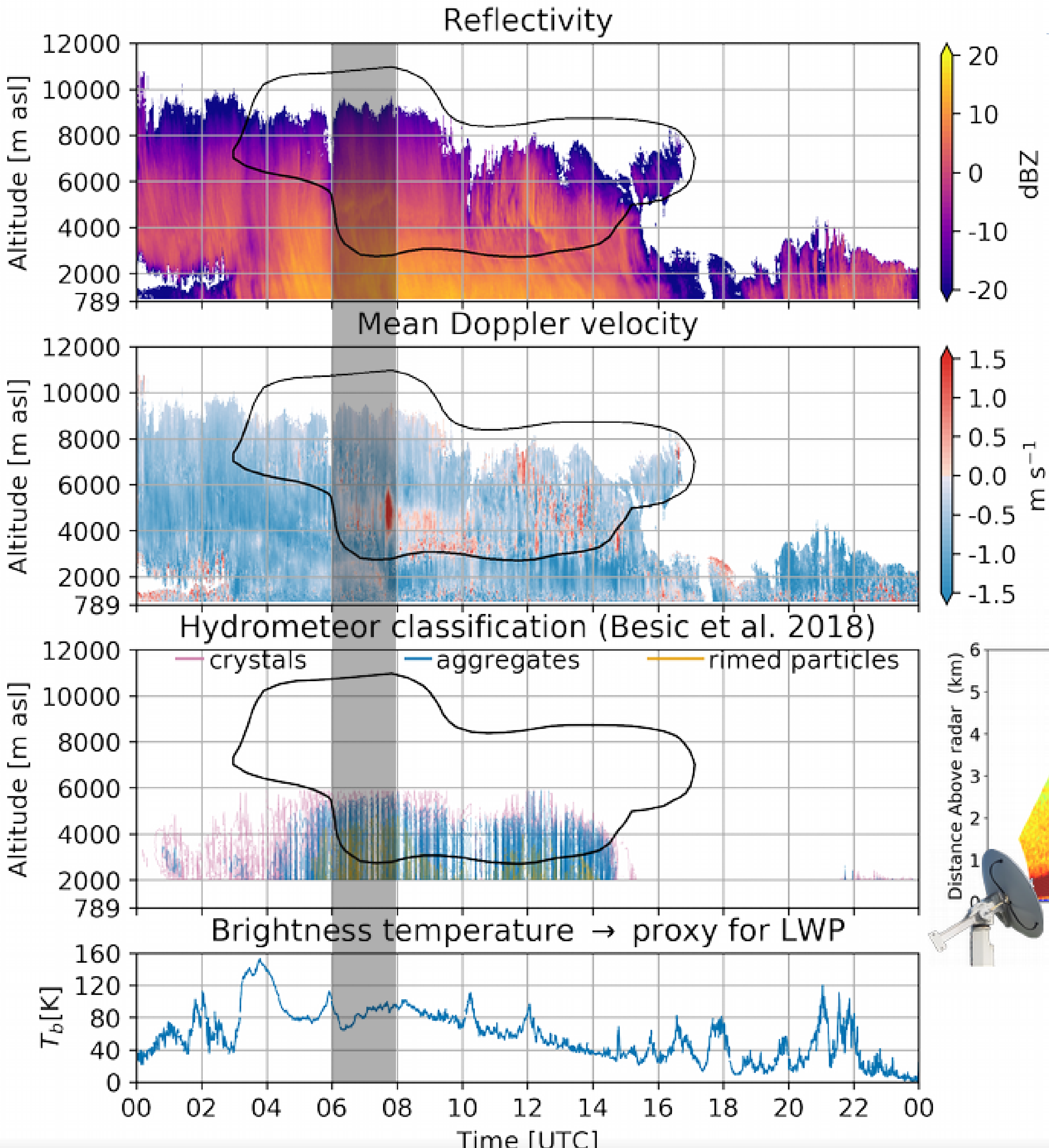
$Z_{DR} = 10 \log_{10}(Z_h / Z_v) =$

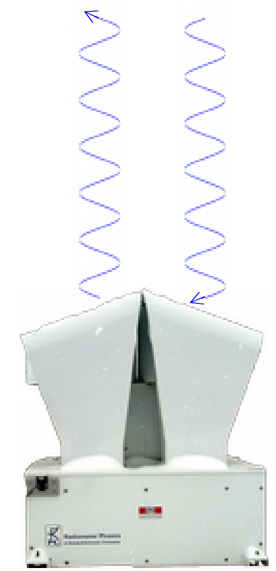
$Z_H - Z_V$ [dB]

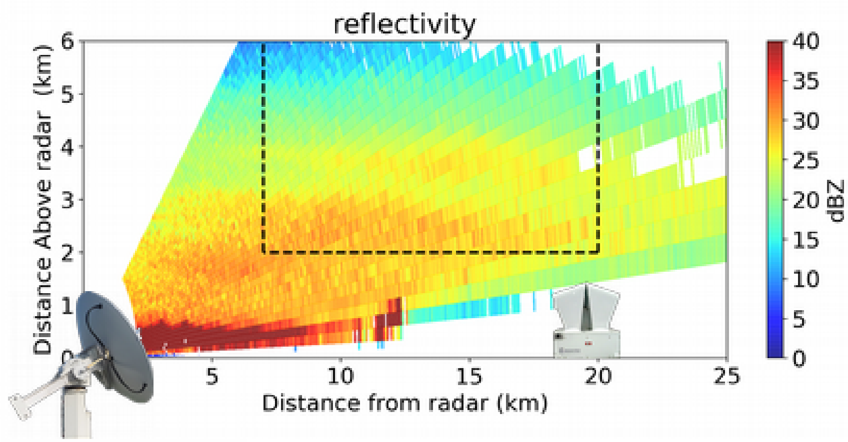




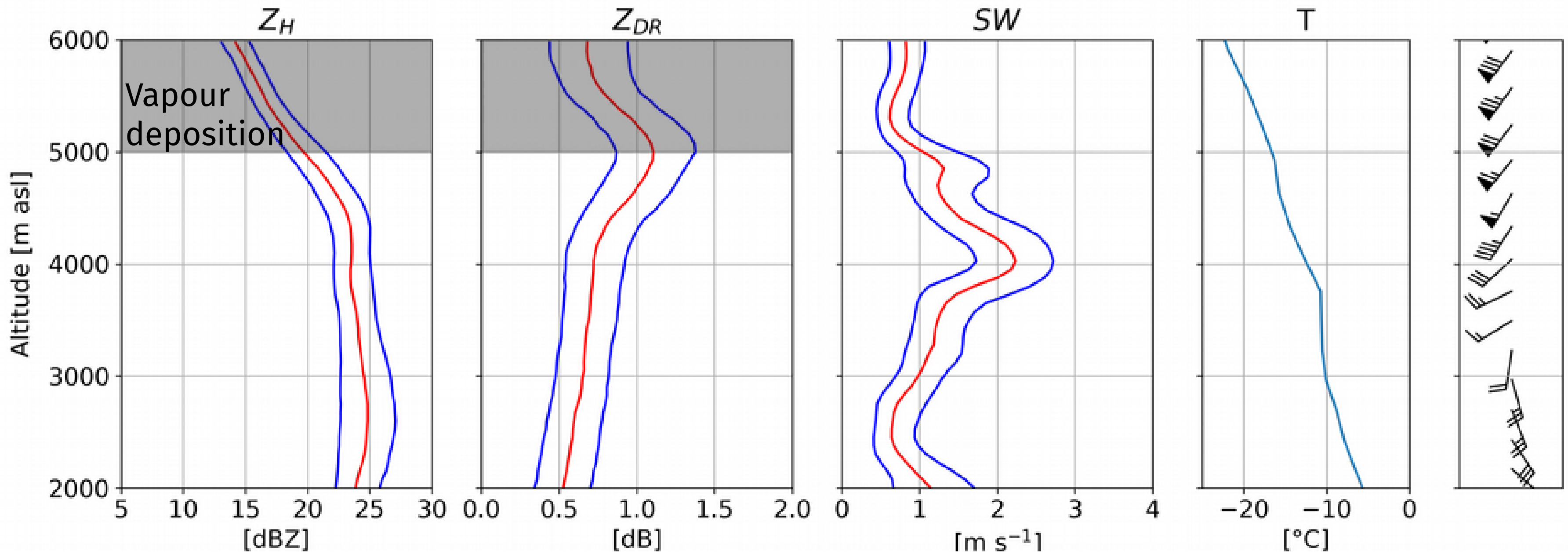
Mean Doppler velocity = mean of the distribution of Doppler velocities
Spectral width (SW) = standard deviation of the distribution of Doppler velocities


Reflectivity
Altitude [m asl]
12000
10000
8000
6000
4000
2000
789
20
10
0
-10
-20
dBZ
Mean Doppler velocity
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
m s^{-1}
Hydrometeor classification (Besic et al. 2018)
crystals
aggregates
rimed particles
Brightness temperature → proxy for LWP
T_b[K]
160
120
80
40
0
00 02 04 06 08 10 12 14 16 18 20 22 00
Time [UTC]



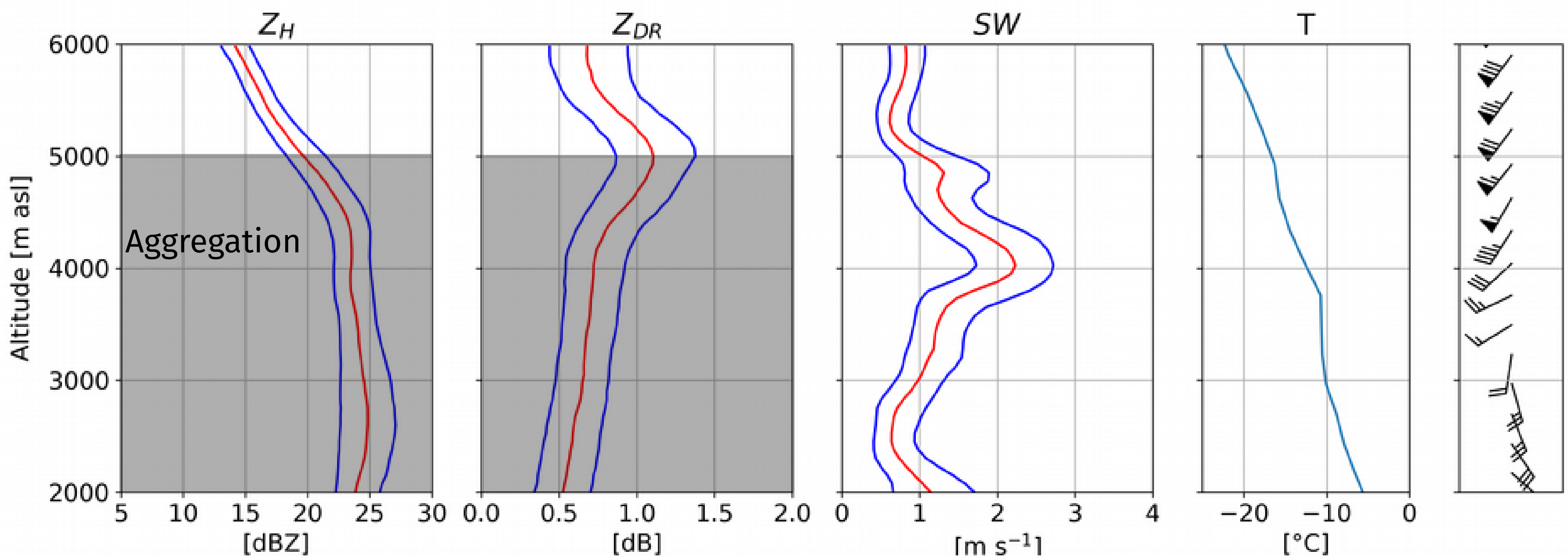

reflectivity
Distance Above radar (km)
Distance from radar (km)
0 1 2 3 4 5 6
5 10 15 20 25
40 35 30 25 20 15 10 5 0
dBZ

Embedded convection, riming and aggregation: 06 to 08 UTC



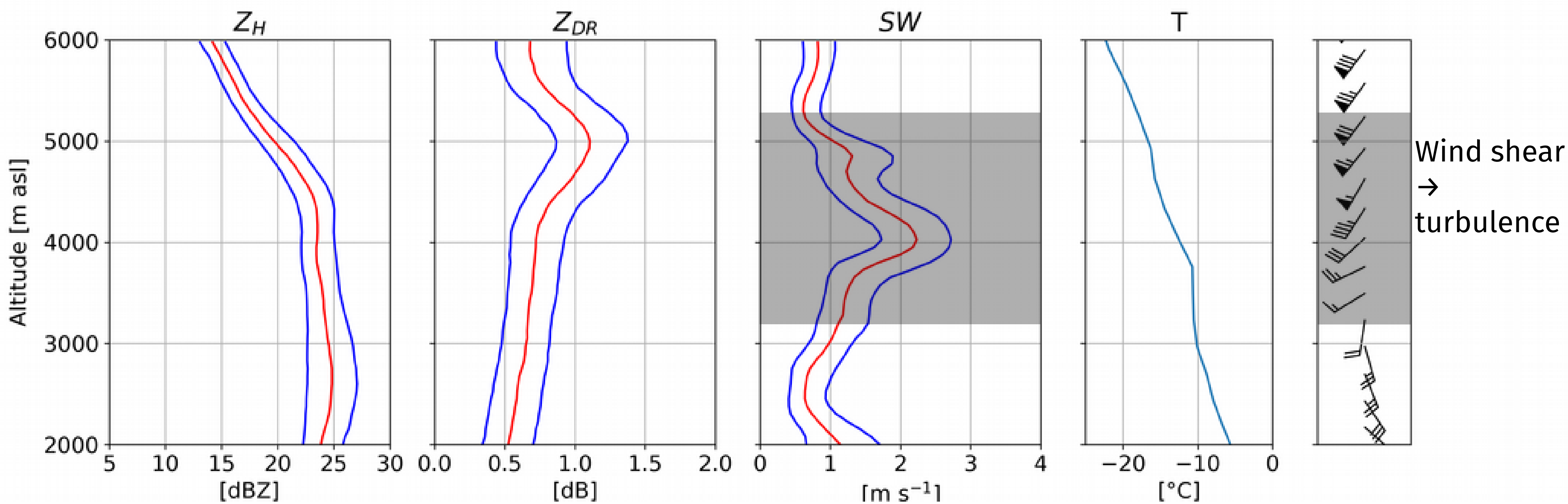
- Z_H ⬆ and Z_{DR} ⬆ → vapour deposition

Embedded convection, riming and aggregation: 06 to 08 UTC



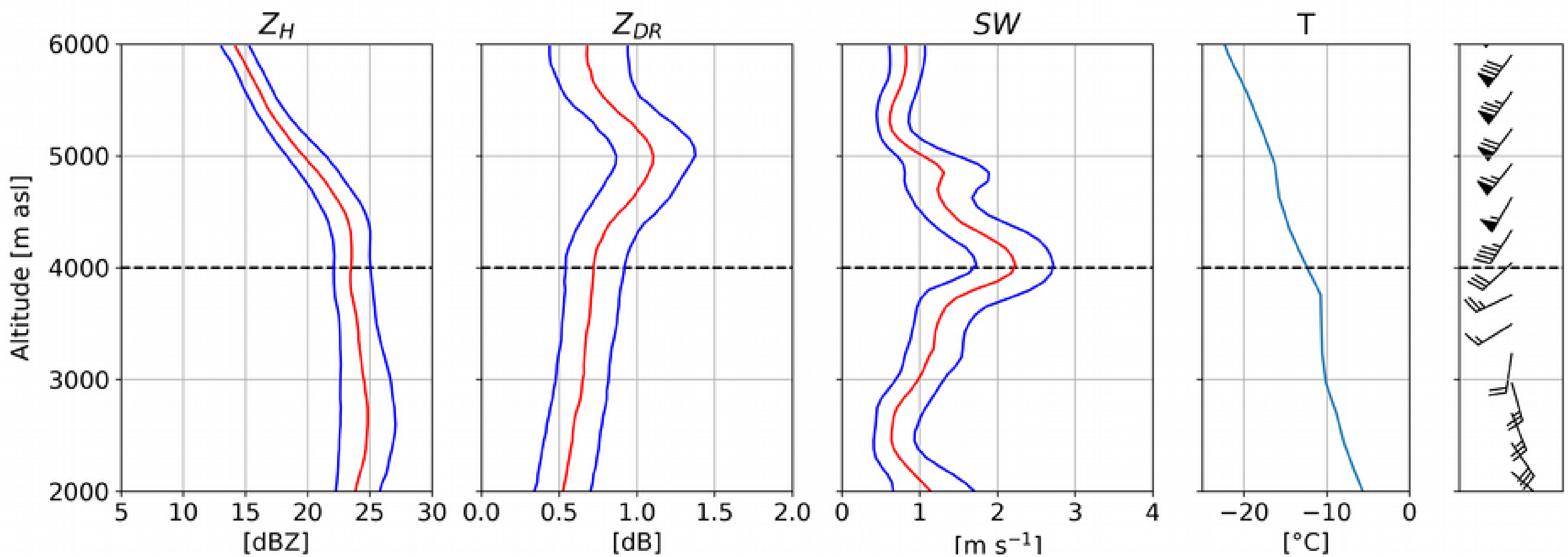
- Z_H ⬆ and Z_{DR} ⬆ → vapour deposition
- Z_H ⬆ and Z_{DR} ⬇ → aggregation

Embedded convection, riming and aggregation: 06 to 08 UTC

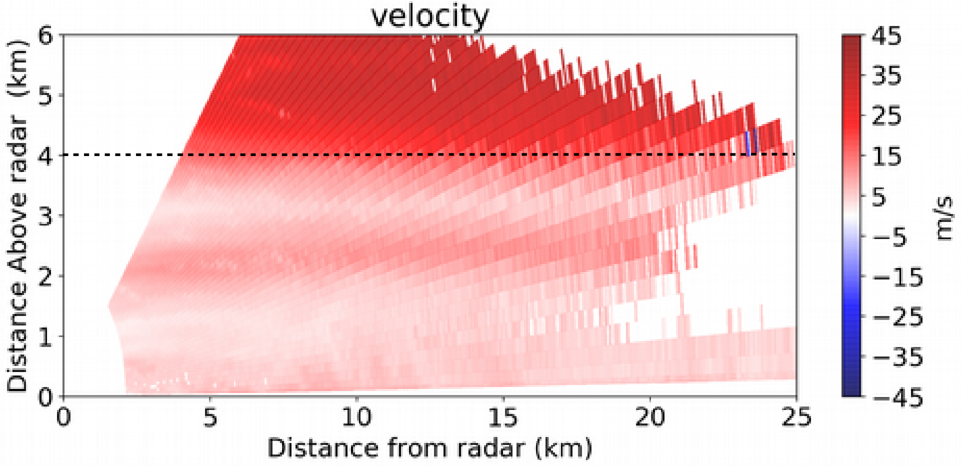


- Z_H ⬆ and Z_{DR} ⬆ → vapour deposition
- Z_H ⬆ and Z_{DR} ⬇ → aggregation
- Turbulence enhances aggregation

Embedded convection, riming and aggregation: 06 to 08 UTC

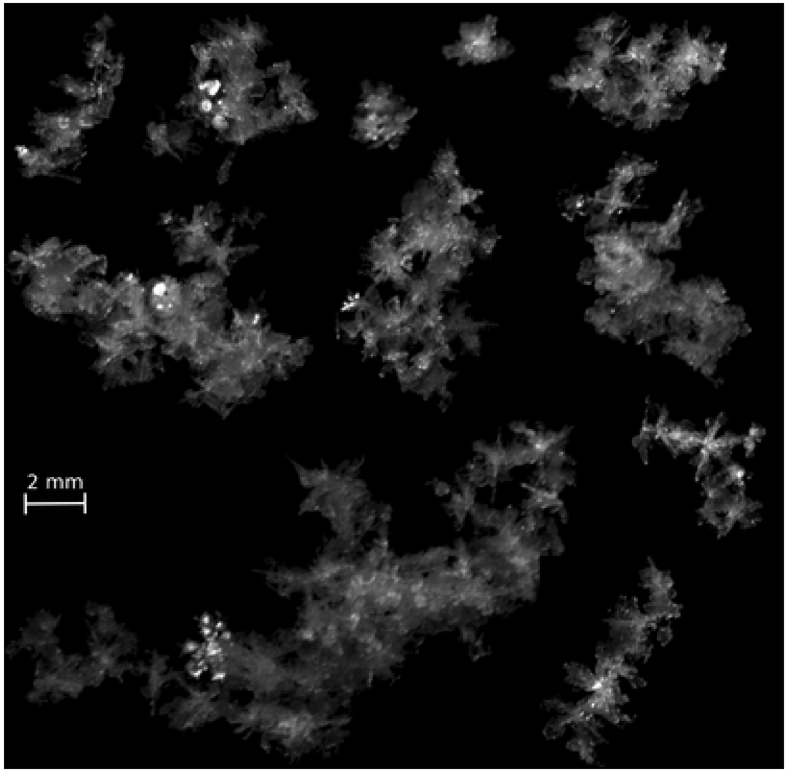


Cross section at 0625 UTC at 11° azimuth

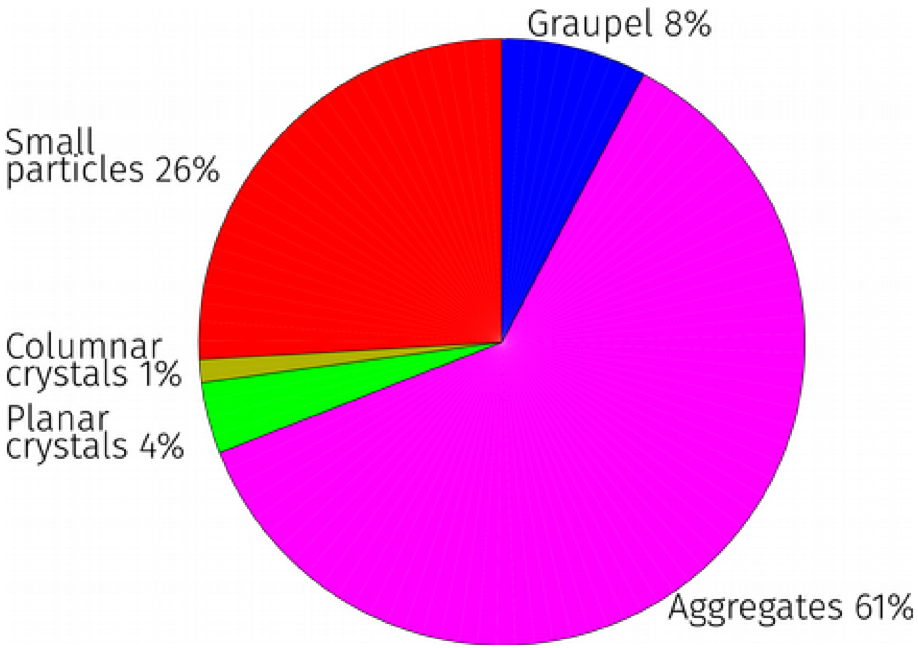


- Z_H ⬆ and Z_{DR} ⬆ → vapour deposition
- Z_H ⬆ and Z_{DR} ⬇ → aggregation
- Turbulence enhances aggregation

Aggregation and riming: snowflake camera 06 to 08 UTC

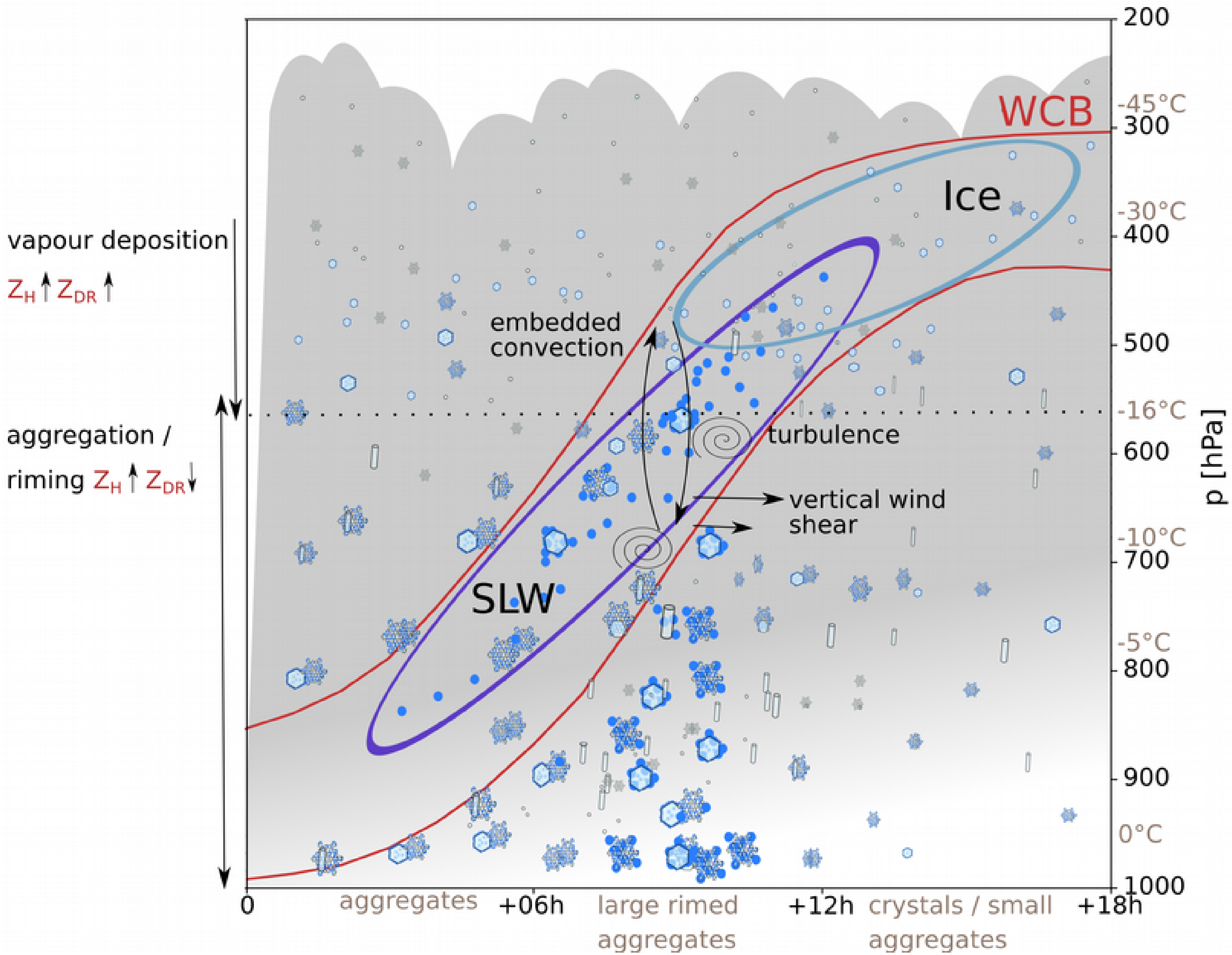


Classification based on MASC images: Praz et al. 2017



- Presence of **large rimed aggregates**
- Majority of **aggregates** followed by **small particles** and **graupel**

Conceptual model



Key findings

1) Which microphysical processes were involved?
- **Vapour deposition** dominated above 5000 m a.s.l.
- **Aggregation** and **riming** interplayed below 5000 m a.s.l.

2) How did the flow conditions in the WCB influence the observed microphysics?
- Production of **SLW** during the strong ascent → **riming**
- Updrafts and **turbulence** due to wind shear → **aggregation**

} intense snowfall

Perspective

Do WCBs strengthen the case for additional observations in future?
Yes, additional field campaigns are needed to further constrain and evaluate the coupling between large-scale dynamical processes and microphysics in models

Manuscript in discussion in ACP: https://doi.org/10.5194/acp-2019-1173

Thank you for your attention!