ICE-POP 2018

(International Collaborative Experiment for Pyeongchang Olympic and Paralympic 2018 winter games)

Experiment overview & preliminary results

Oct. 2018

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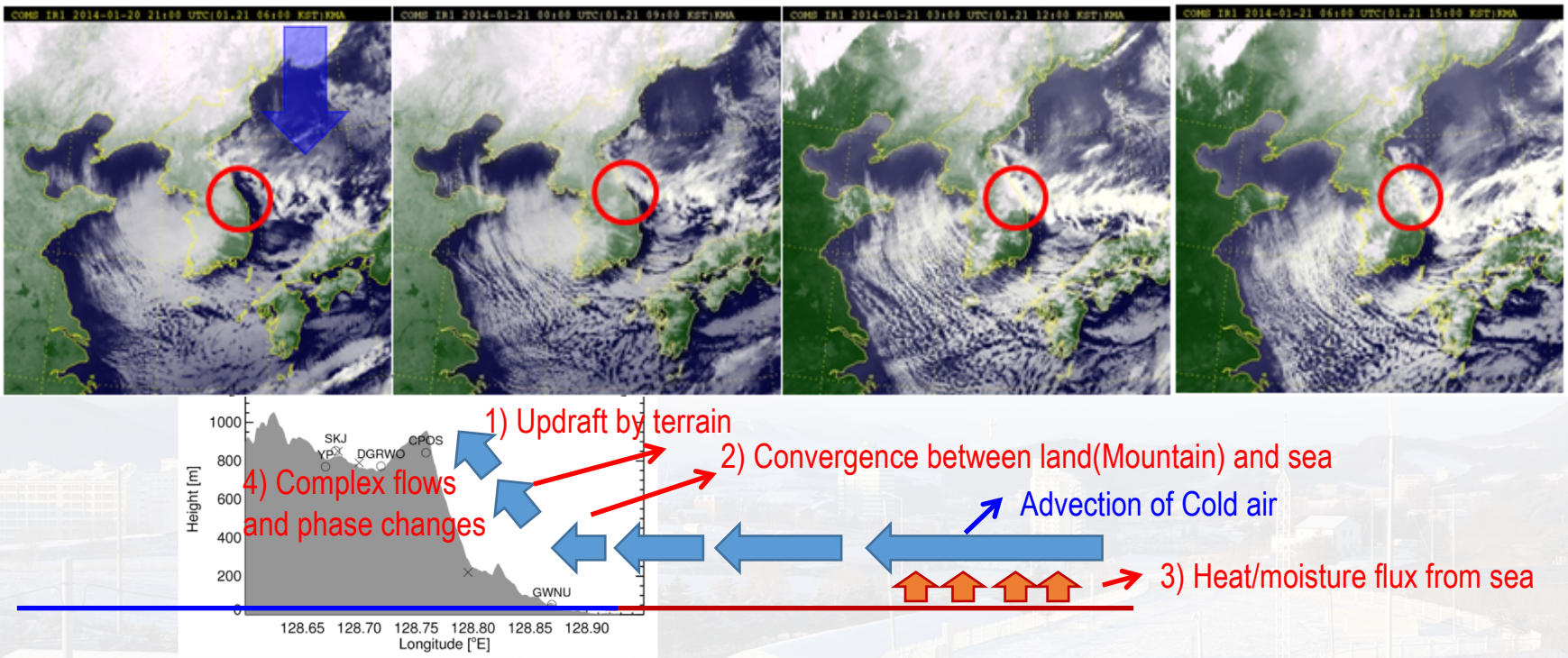
Kyungpook National University

KwangDeuk Ahn
Korea Meteorological Administration
&
Many international participants
(Walter Petersen, Francisco Tapiador, Alexis Berne, …)

Scientific issue: Mechanism

- Mechanism for East Snow Storm(ESS) 2014. 1. 21 case

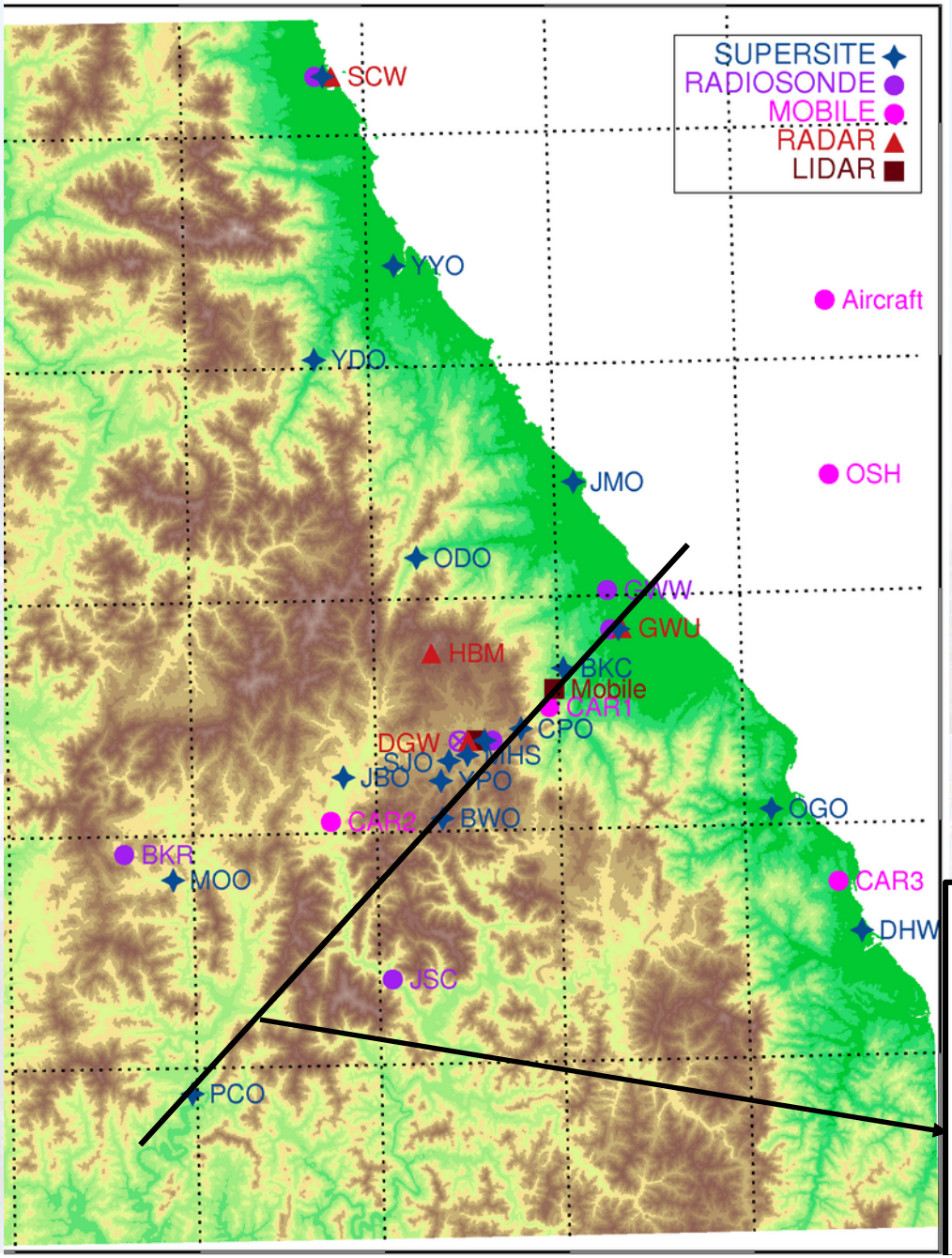


- East Snow Storm caused by cold outbreak over East Sea
  - Low predictability in NWP, few observation in ocean
- Scale interaction and transition
  - Air-sea interaction, Synoptic to mesoscale transition
- Microphysical(precip.) phase change
  - Ocean – Coastal Area – Steep topography – High/complex terrain

Scientific issue: Numerical weather prediction

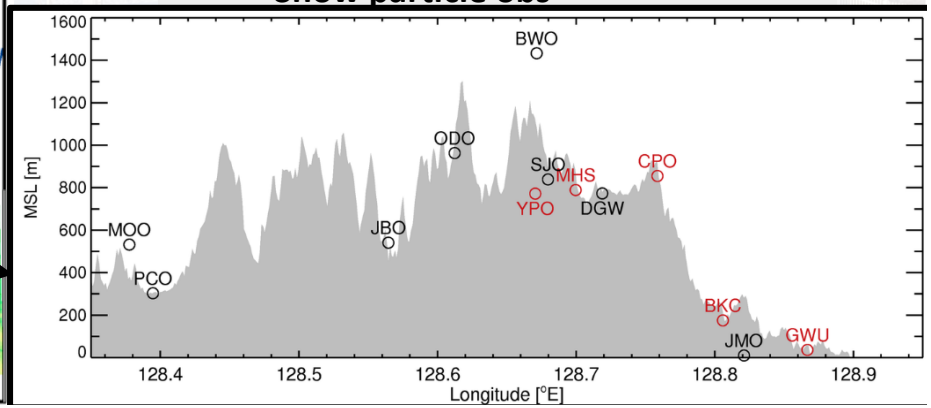
- Seamless Prediction
  - Nowcasting(0-6h) – Very Short Range Forecast(6-12h) – Short Range Forecast(12h ~)
    FINECAST, INCA, MAPLE → CAN, VDAPS
    → COSMO, GEM-LAM, KMPAS, LADPS, NU-WRF
  - Suitable data assimilation(DA): 3DVAR, 4DVAR, Hybrid, OA
  - Different methods and models:
    Can we combine them to generate seamless fcst?
    → Inter-comparison of Participant model
- Predictability of NWP over mountainous, complex terrain
  - Air-sea interaction, orographic Effect.
  - Necessity of high resolution DA and high resolution full 3D NWP model
  - Can high resolution NWP give promising results?
    Suitable physics? observation?
    → comparison with IOP observation results
- Toward advanced physics in NWP
  - Advanced microphysics(MP) in NWP for winter precipitation
    → Inter-comparison of MP, Improvement of new MP (Milbrandt & Morrison)
  - Visibility Parameterization

Observational networks: limitation and improvement

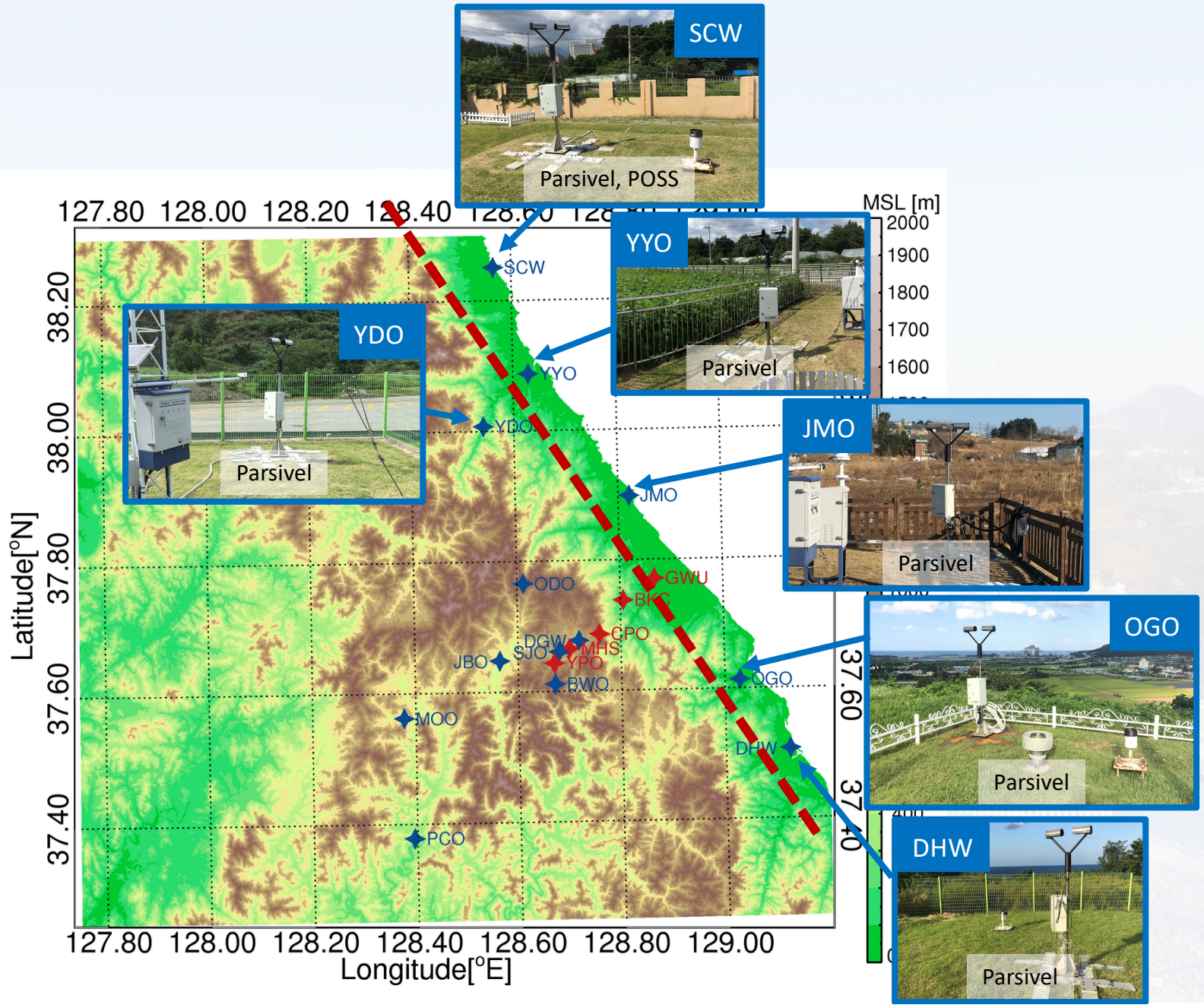


<ICE-POP 2018 Obs networks>

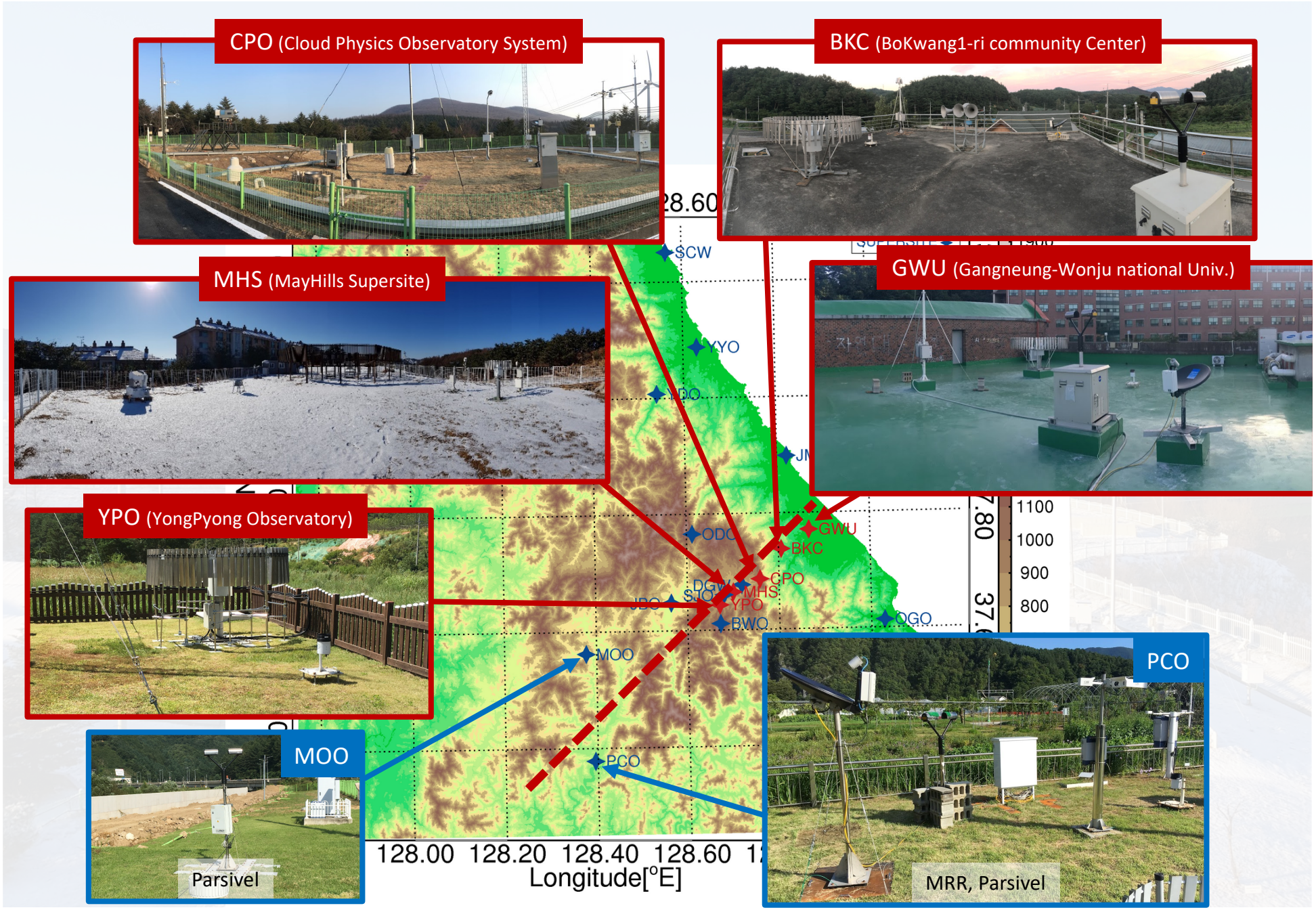
- ❖ Upper air sounding
  - ✓ **High temporal/spatial sounding**
  - ✓ **Wind obs at upstream/downstrem**
- ❖ Remote sensing obs
  - ✓ **Low-level radar obs**
  - ✓ **3-D winds**
  - ✓ **Cloud obs**
- ❖ Microphysical obs
  - ✓ **Microphysical obs along flow**
  - ✓ **Microphysical obs along the east coast**
  - ✓ **Snow particle obs**



Supersites: along-barrier



Supersite: cross-barrier



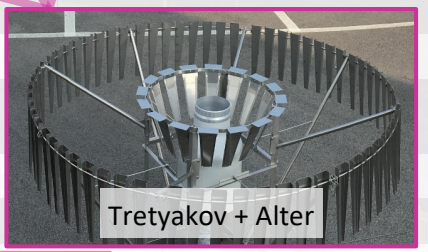
Supersite: cross-barrier

Valley | Mountain top | Coast

YPO	MHS	CPO	BKC	GWU
MRR-2	MRR-2	MRR-2	MRR-2	MRR-2
Parsivel²	Parsivel² (DFIR)	Parsivel²	Parsivel²	Parsivel²
POSS	POSS	POSS	POSS	POSS
Pluvio² 200 (Belfort Double Alter shield)	Pluvio² 400 (DFIR + Tretyakov + Alter shield)	Pluvio² 200 (No shield)	Pluvio² 400 (Tretyakov + Alter shield)	Pluvio² 400 (Tretyakov + Alter shield)
	2DVD (DFIR)	Ceilometer	2DVD	
	PIP	Radiometer	PIP	
	VertiX	Ultrasonic snow meter		
	WProf	MPS TRwS514		
	MASC (DFIR)	Fog monitor (FM-120)		
	Geonor (Single Alter shield)	PWD22		
	WXT520	Sentry visibility sensor		
	USA-1	FSSP		
	Parsivel¹	Automatic cloud observation system		
		AWS		

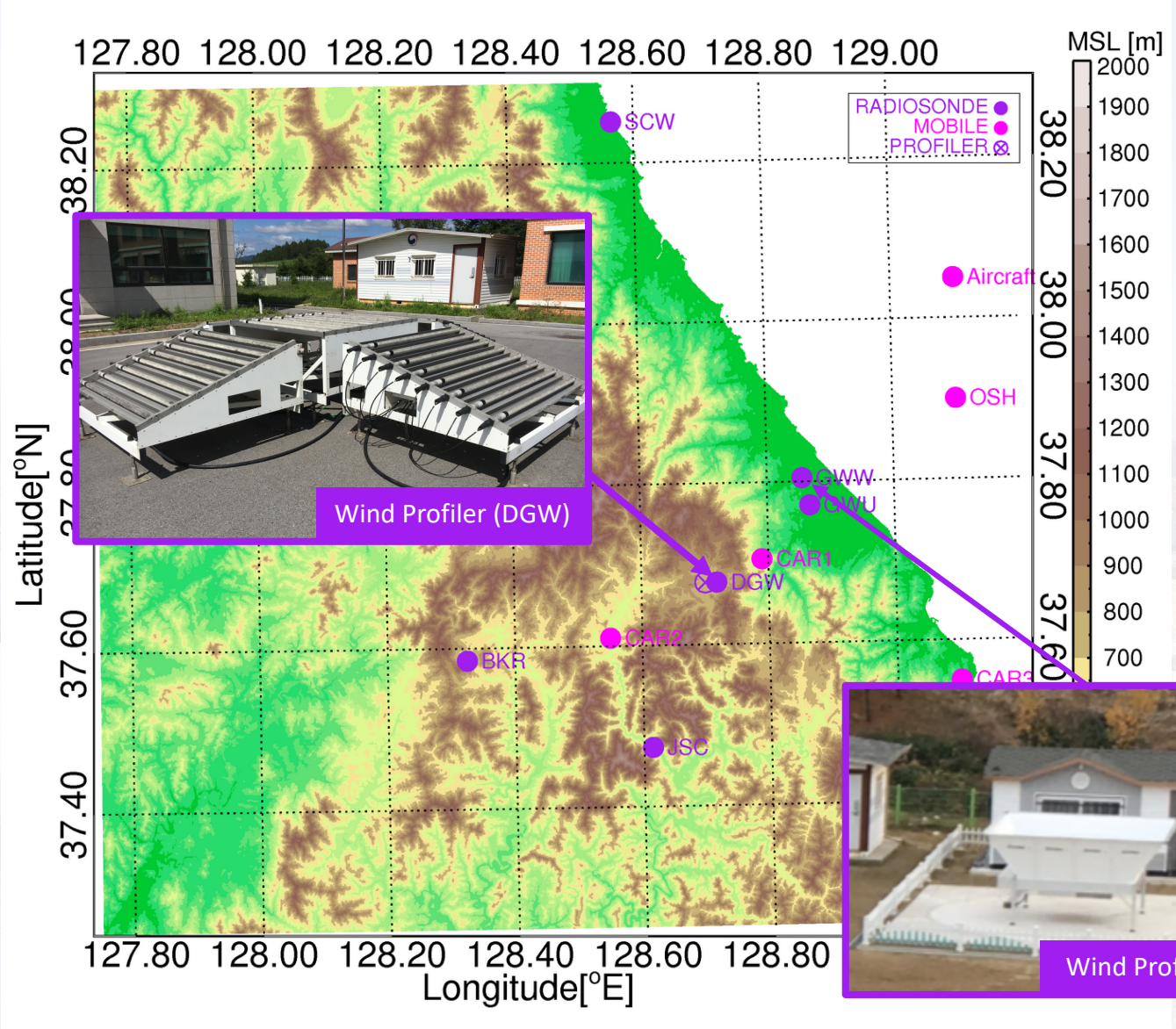
Belfort Double Alter

Double Fence Intercomparison Reference

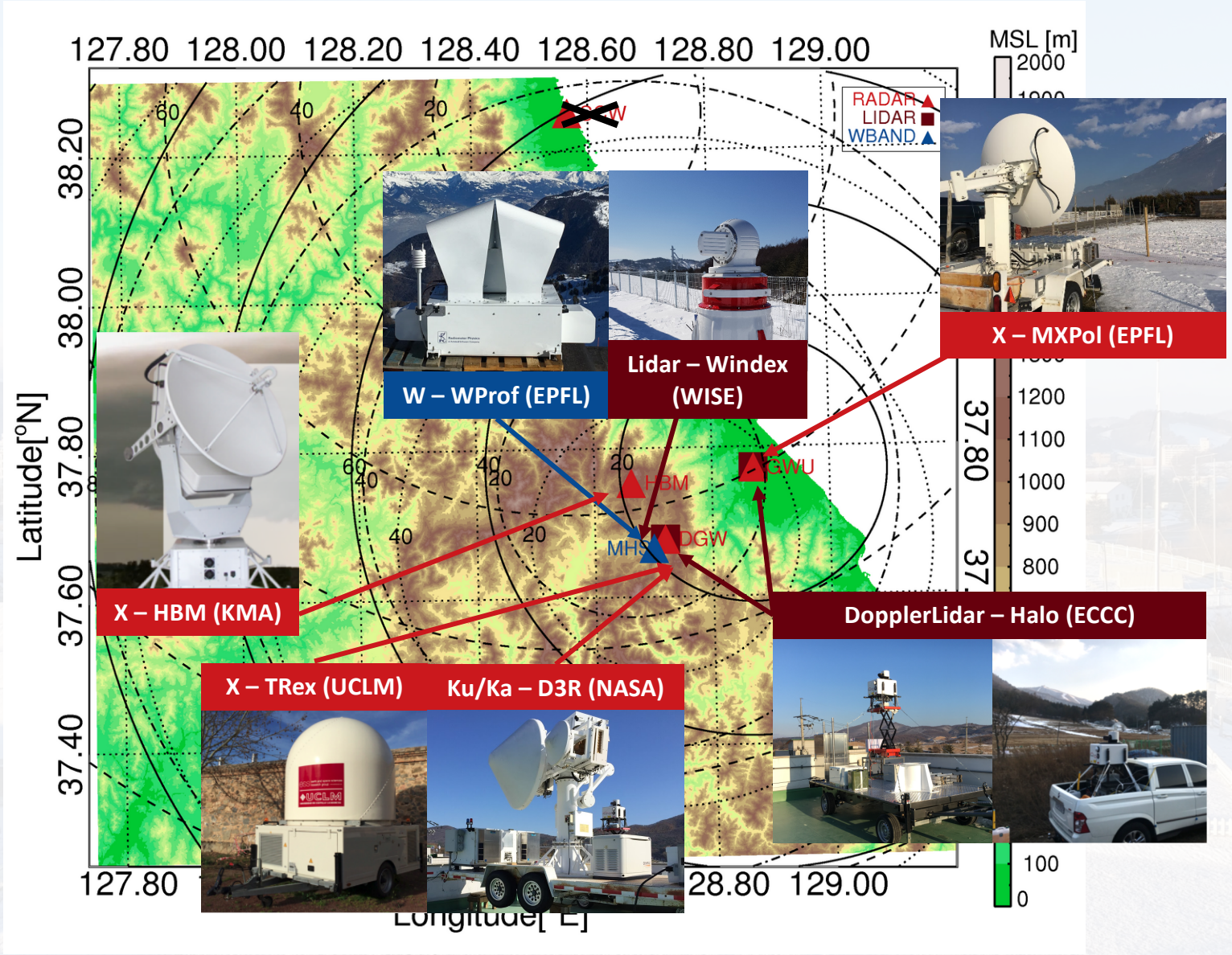

Tretyakov + Alter

Single Alter

Upper-air obs



Remote sensing



Remote sensing

DGW – D3R (NASA)

5 min (2 RHIs, 4 PPIs, 1 90PPI)
- **RHI**: 51, 331°
- **PPI**: 4, 5, 6, 7°
- **Birdpath**: 90°

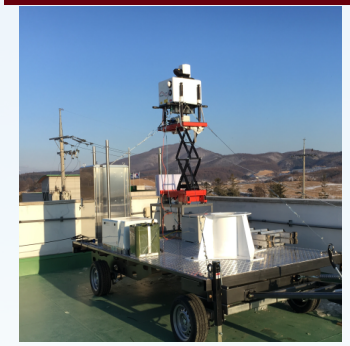
DGW – T-Rex (UCLM)

5 min (2 RHIs, 6 PPIs, 1 90PPI)
- **RHI**: 51.5,330.5°
- **PPI**: 4, 5.1, 6.4, (8), 12.7, (19.8°)
- **Birdpath**: 90°

GWU – MXPol (EPFL)

5 min (2 RHIs, 6 PPIs, 1 90PPI)
- **RHI**: 227, 317°
- **PPI**: 2, 3, 4.5, (6.8), 10.1, (15°)
- **Birdpath**: 90°

Doppler Lidar (DGW)



12 min (2 RHIs, 4 PPIs, VP)
- **RHI**: 51.5, 330°
- **PPI**: 4, 8, 14, 25, 80°
- Vert. Pointing

Doppler Lidar (MHS)

12 min (2 RHIs, 7 PPIs, VP)
- **RHI**: 257, 347°
- **PPI**: 5, 7, 10, 15, 30, 45, 80°
- Vert. Pointing

Doppler Lidar(GWU)

12 min (2 RHIs, 4 PPIs, VP)
- **RHI**: 227, 317°
- **PPI**: 4, 8, 14, 25, 80°
- Vert. Pointing

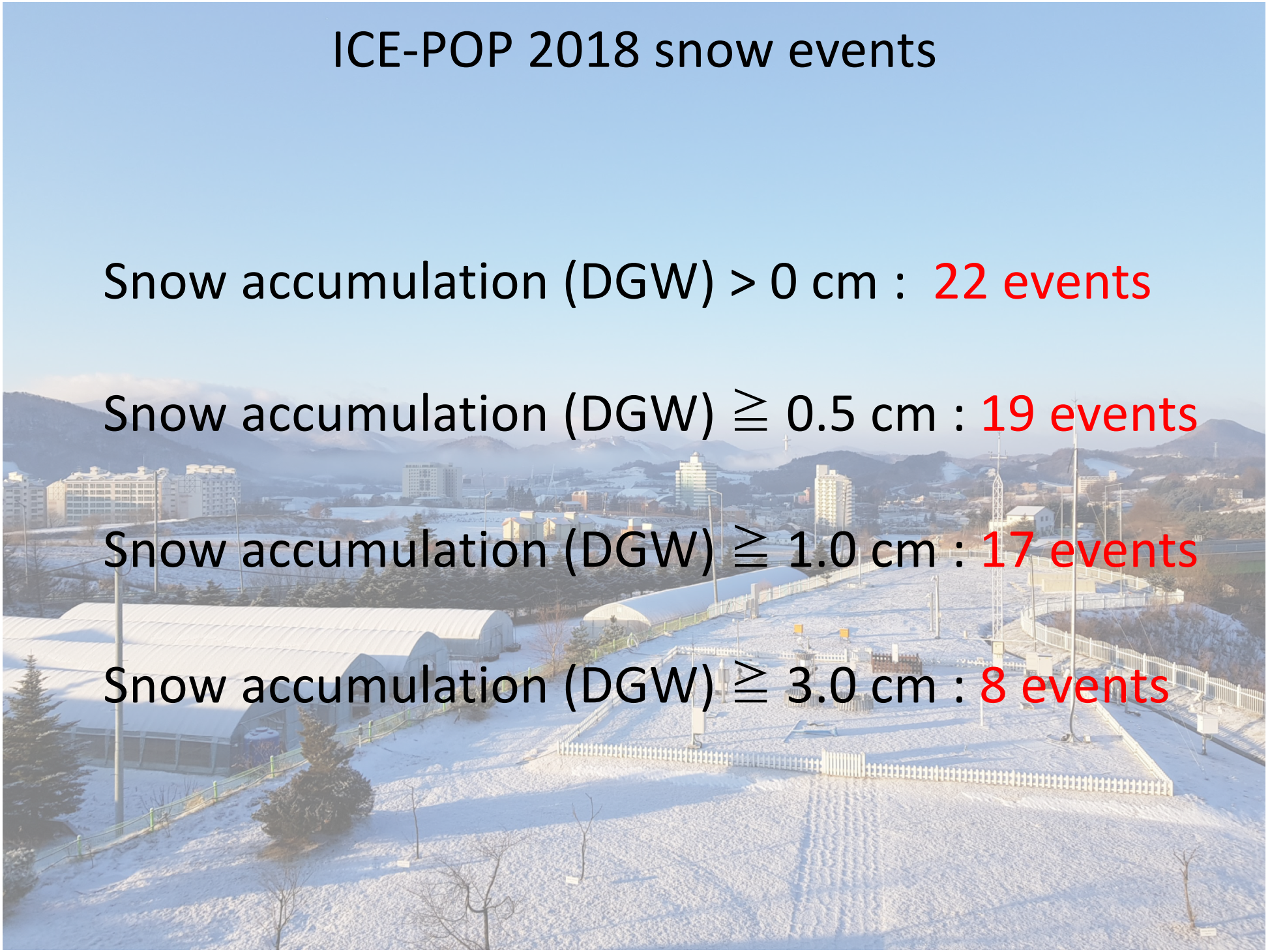
ICE-POP men and women

NASA D3R radar (Oct. 2017)

Spain UCLM T-REX radar (Nov. 2017.)

Swiss EPFL MXPOL radar(Nov. 2017)

ICE-POP 2018 snow events



Snow accumulation (DGW) > 0 cm : 22 events

Snow accumulation (DGW) ≧ 0.5 cm : 19 events

Snow accumulation (DGW) ≧ 1.0 cm : 17 events

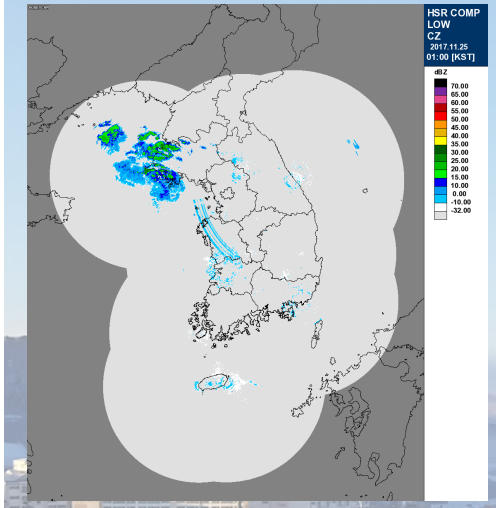
Snow accumulation (DGW) ≧ 3.0 cm : 8 events

Eight major snow events

	Events	Snow acc. (DGW)	Prevailing Winds (DGW)	Snow Acc. (GWN)	Prevailing Winds (GWN)
1	2017.11.25	17.6 cm	W	6.8 cm	W
2	2017. 12. 23. - 12. 25.	5.1 cm	W-E-W	3.5 cm	W-NW-W
3	2018. 01. 22.	7.0 cm	W	5.1 cm	NW
4	2018. 02. 27. - 03. 01.	41.2 cm	E	9.5 cm	E
5	2018. 03. 03. - 03. 05.	21.3 cm	E	8.0 cm	N
6	2018. 03. 07. - 03. 09.	13.6 cm	E	3.5 cm	N
7	2018. 03. 14. - 03. 16.	7.4 cm	E	6.9 cm	N
8	2018. 03. 19. - 03. 21.	3.4 cm	E	4.3 cm	E

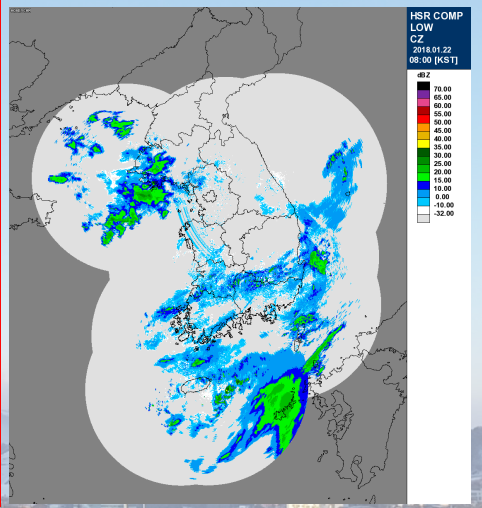
Eight major events

2017.11.25.

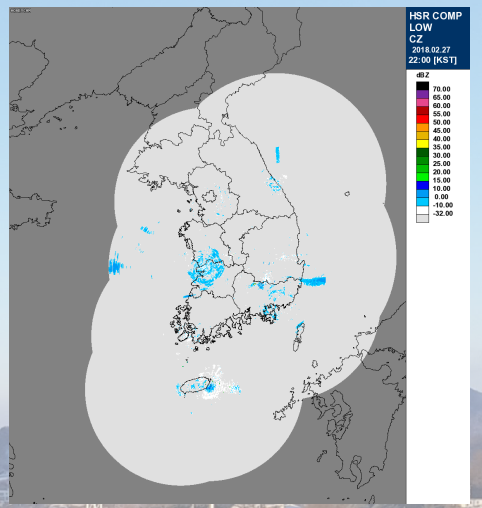


2017.12.23~12.25.

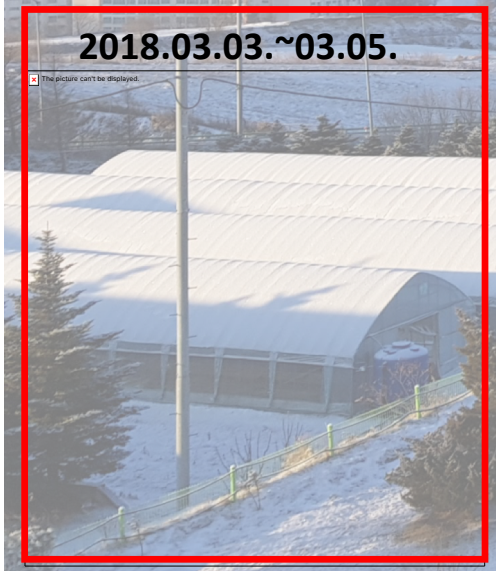
2018.01.22.



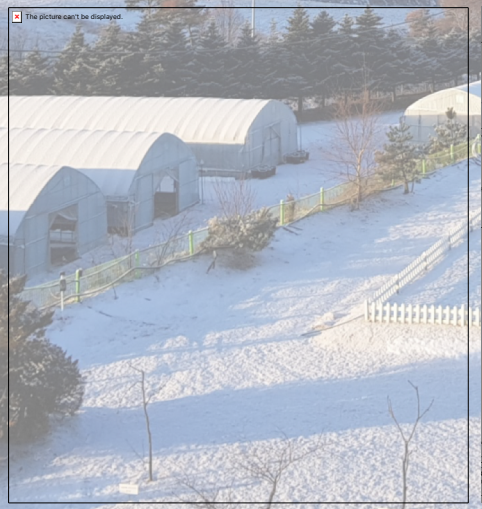
2018.02.27.~03.01.



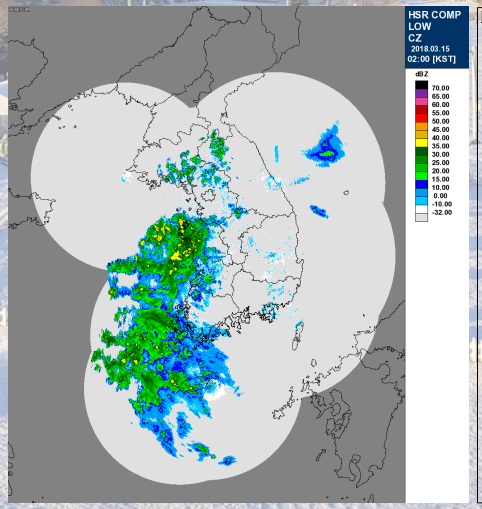
2018.03.03.~03.05.



2018.03.07~03.09.

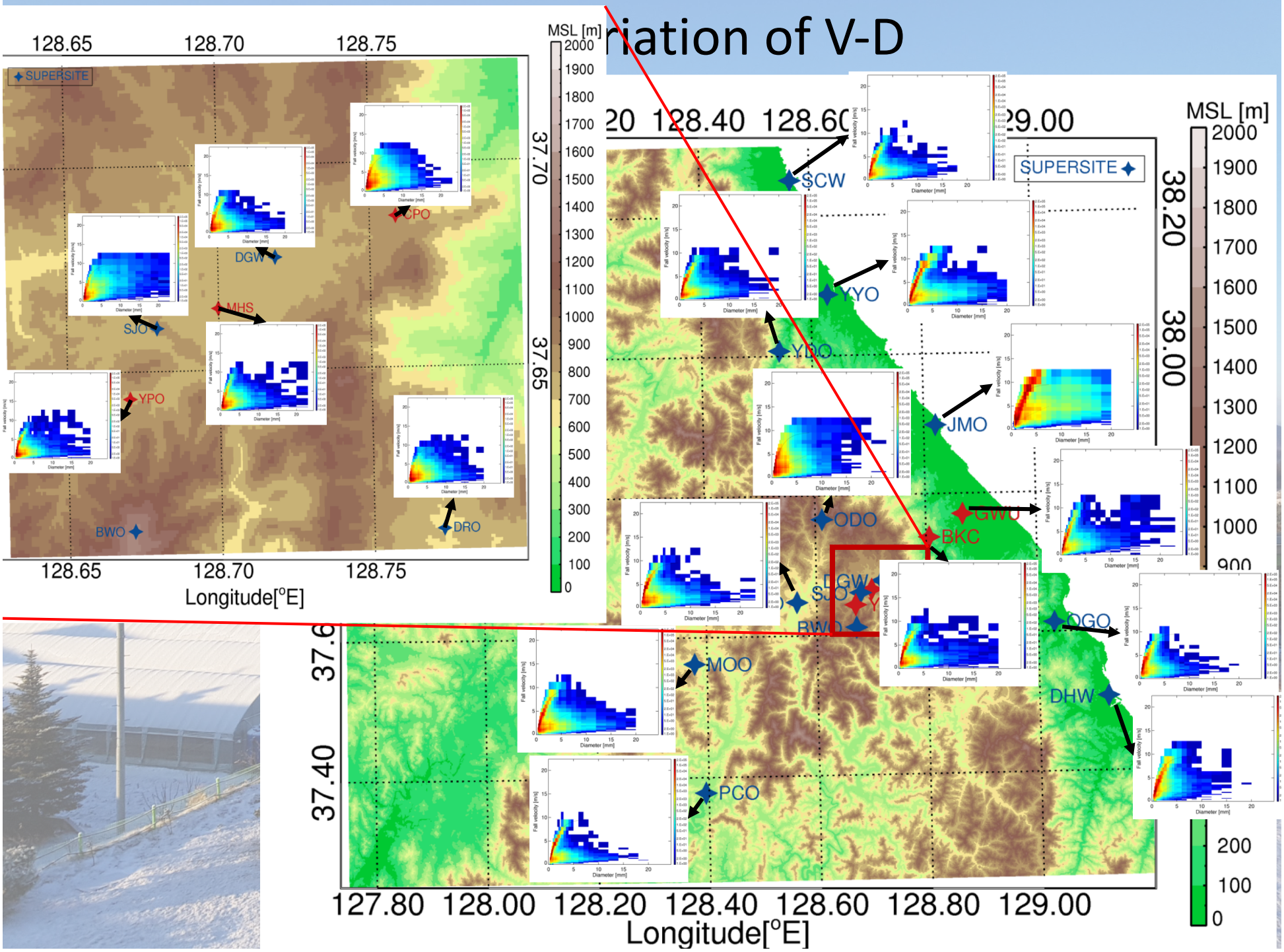


2018.03.14.~03.16

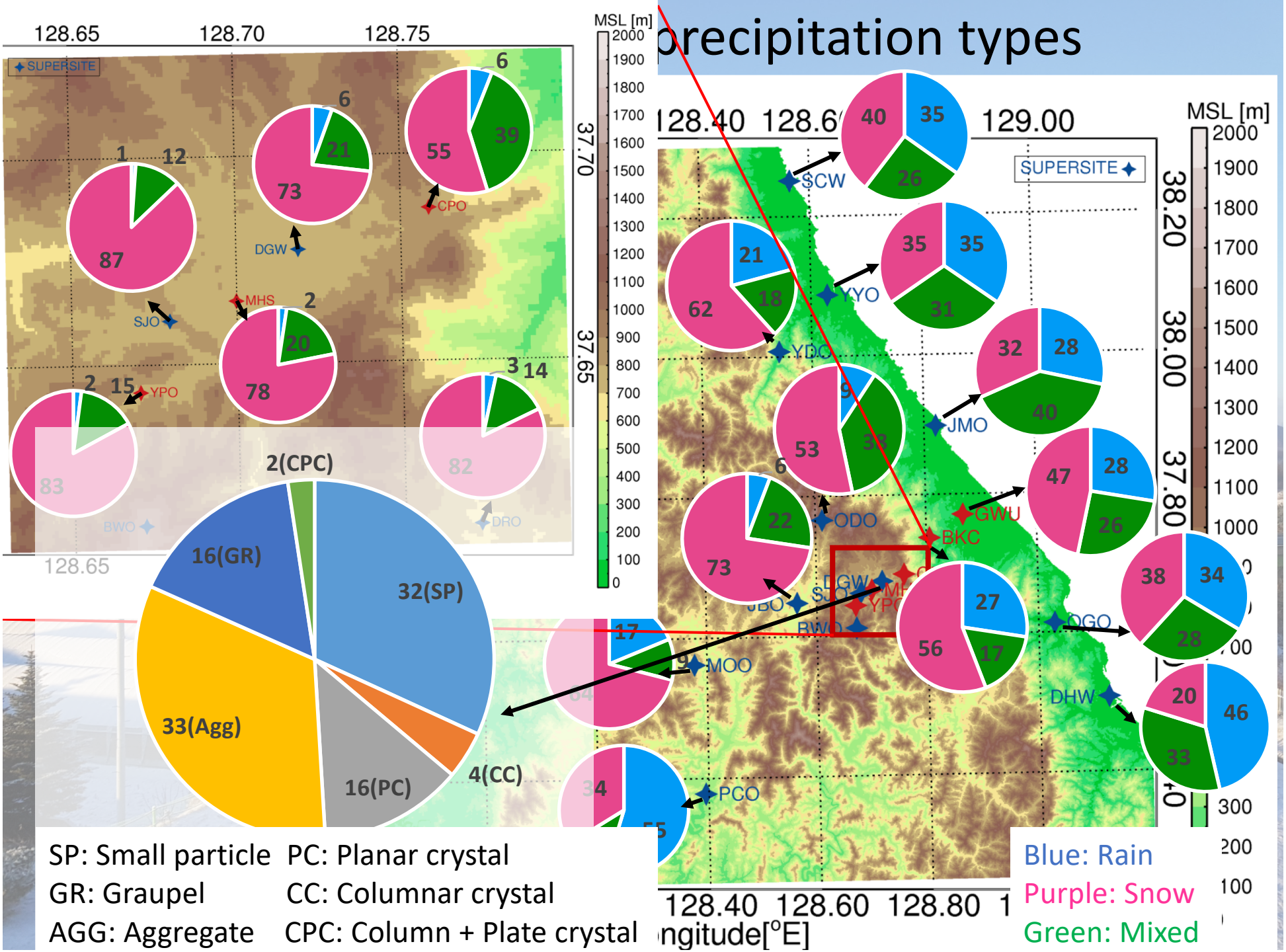


2018.03.19.~03.21.

riation of V-D



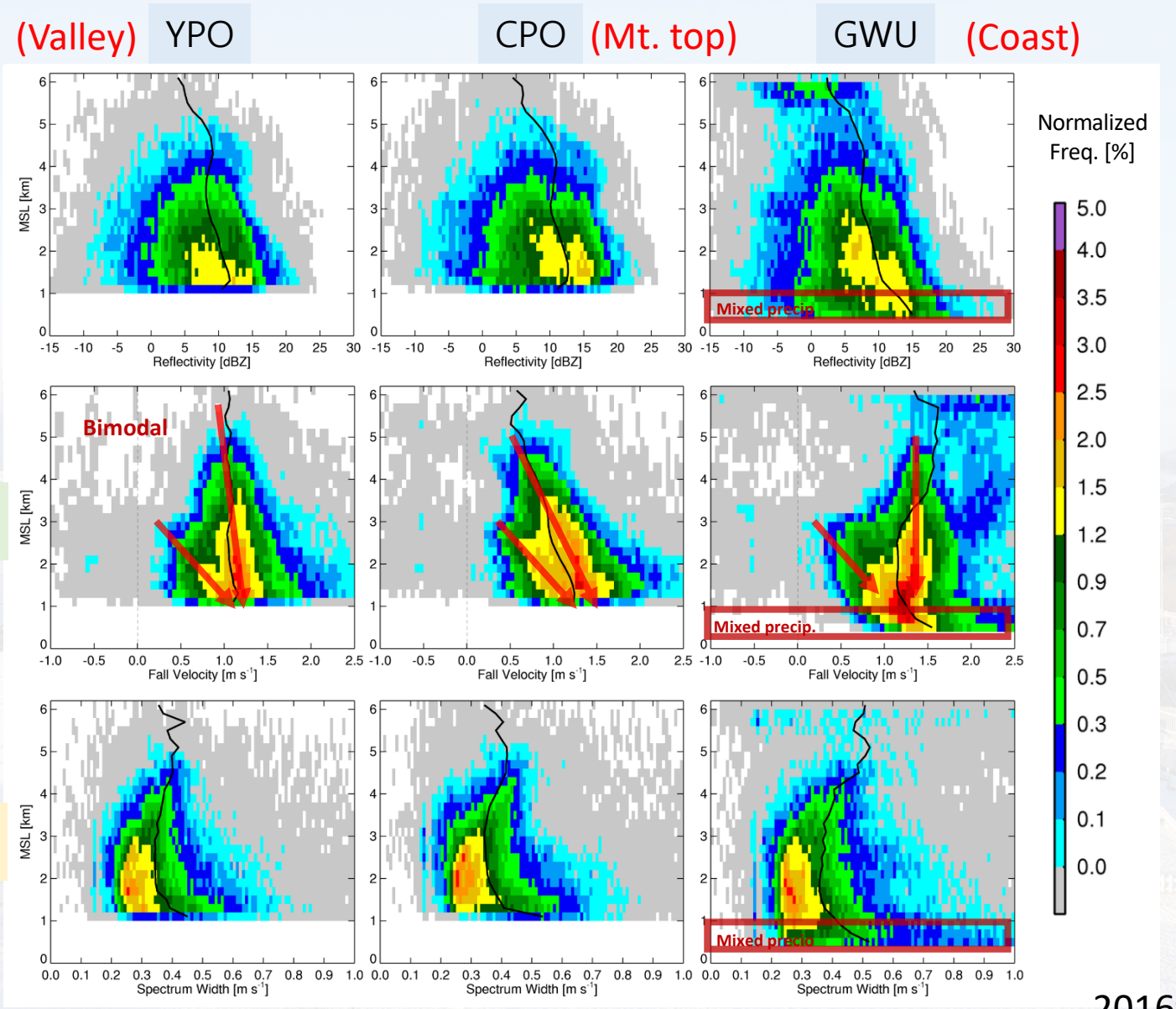
precipitation types



SP: Small particle PC: Planar crystal
GR: Graupel CC: Columnar crystal
AGG: Aggregate CPC: Column + Plate crystal

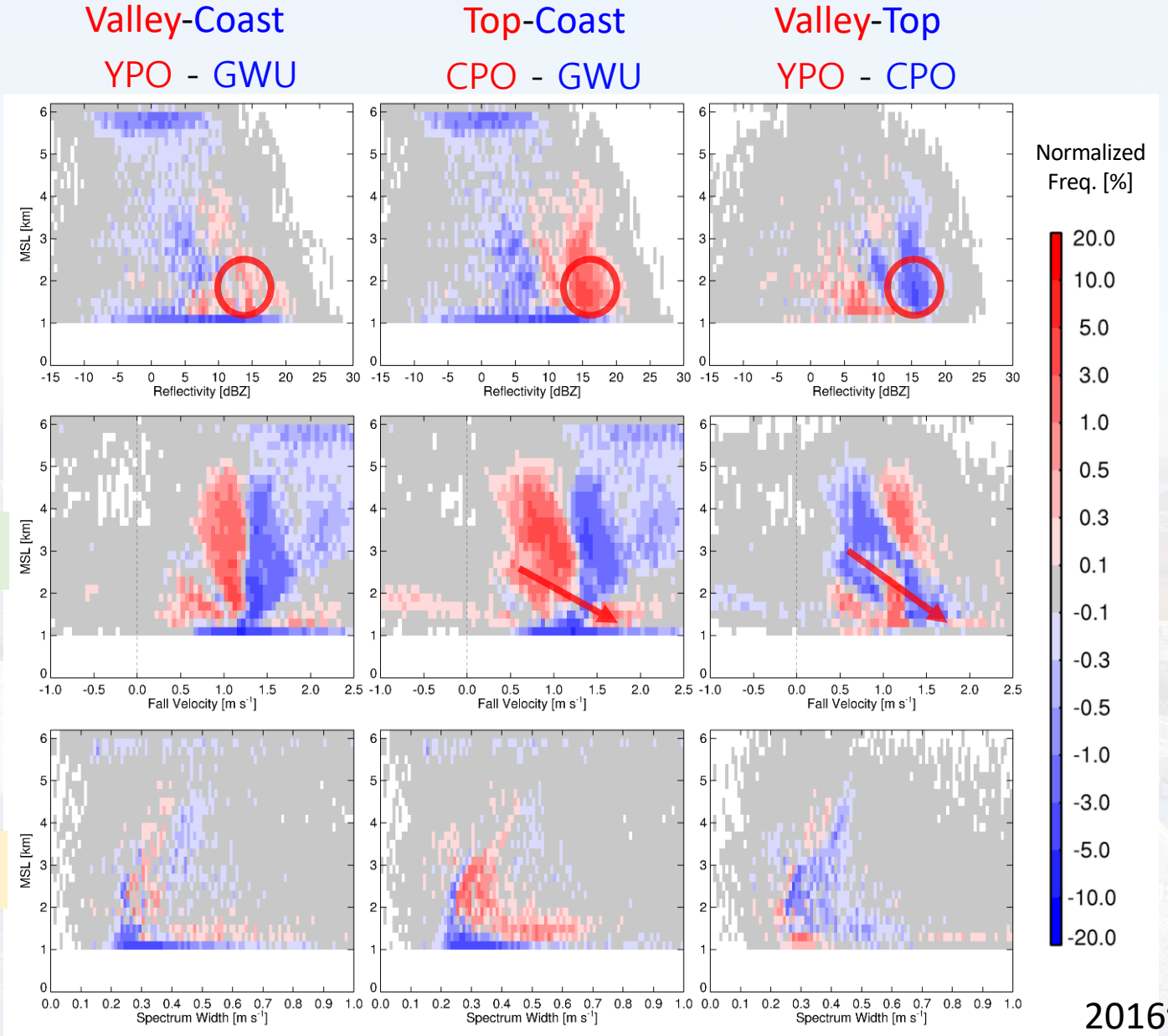
Blue: Rain
Purple: Snow
Green: Mixed

Modulation of vertical structure by topography



2016~2017

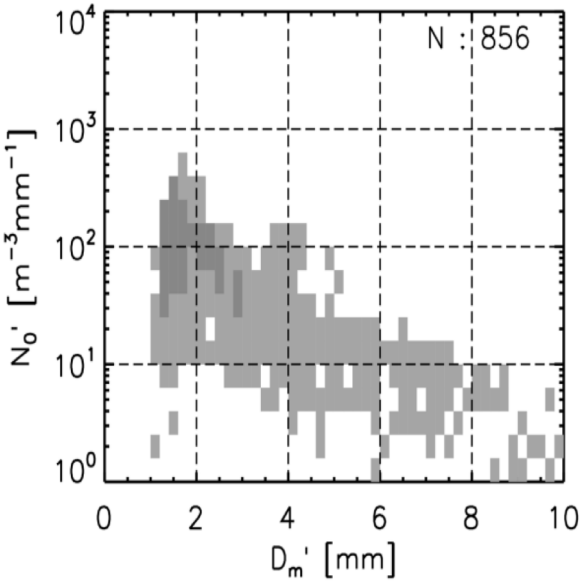
Modulation of vertical structure by topography



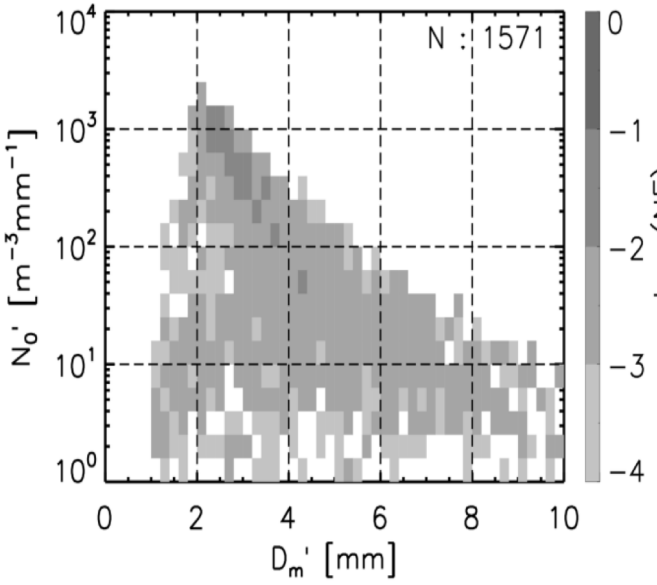
2016~2017

Modulation of vertical structure by topography

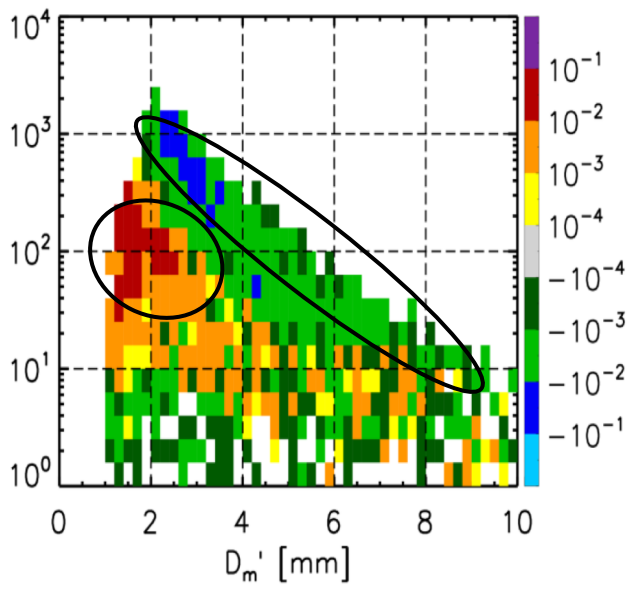
West sites



East sites



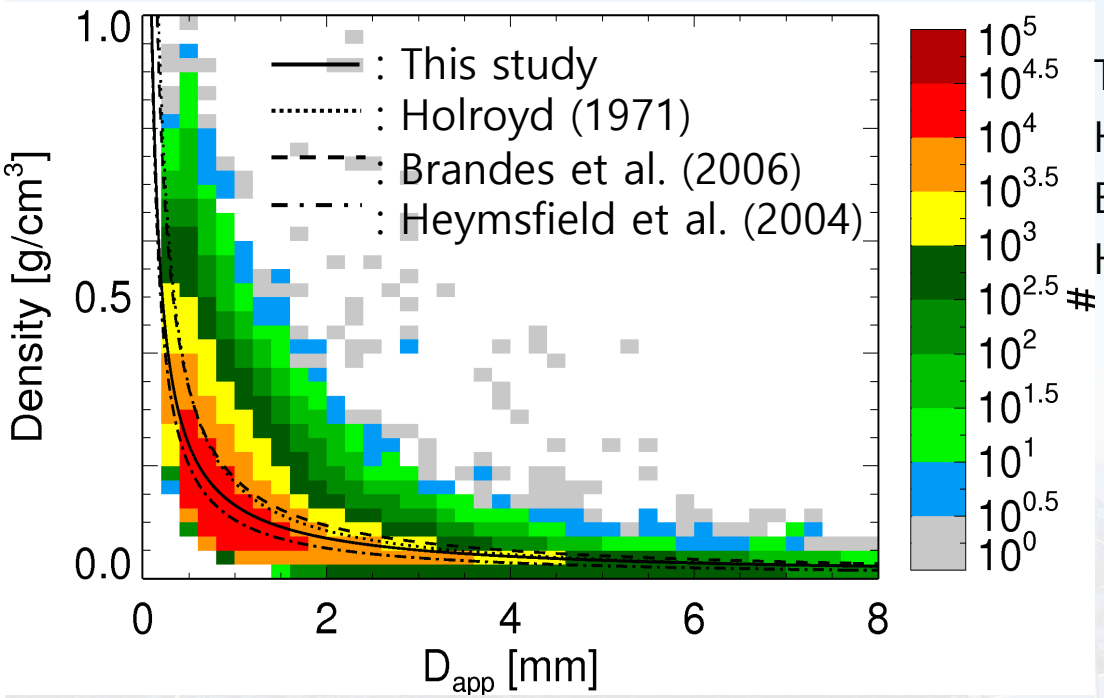
ΔNF: West sites – East sites



2016~2017

Snow particle density

All events

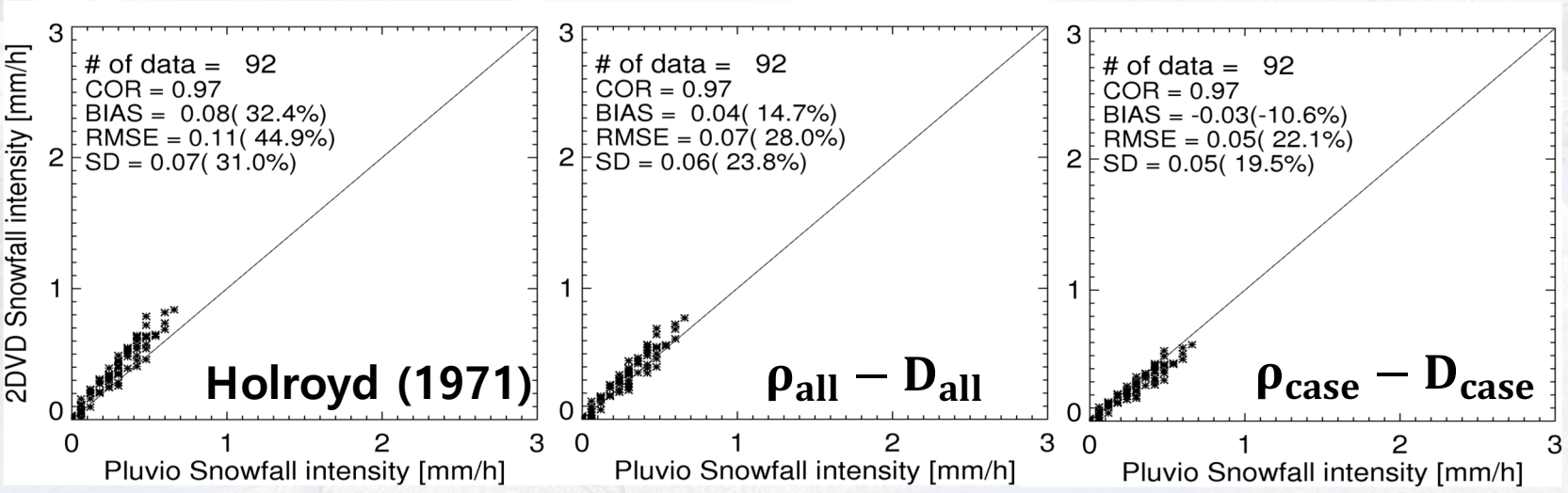


This study: $\rho = 0.124 D_{app}^{-0.856}$

Holroyd(1971): $\rho = 0.17 D_{app}^{-1}$

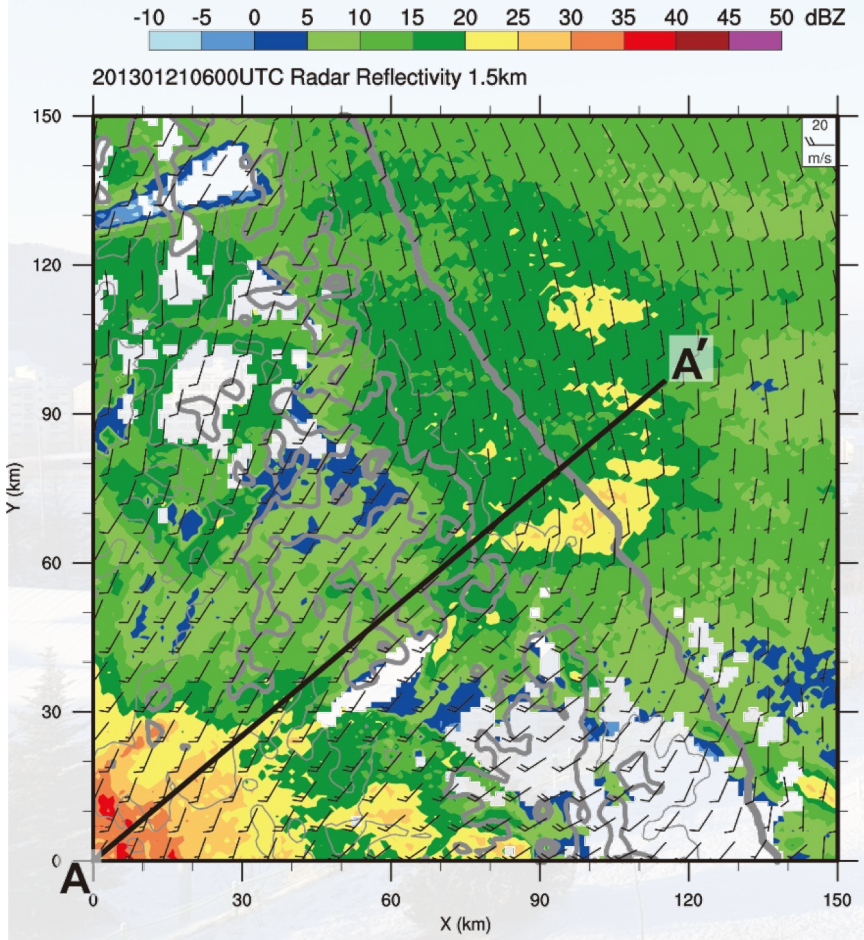
Brandes et al. (2006): $\rho = 0.178 D_{app}^{-0.922}$

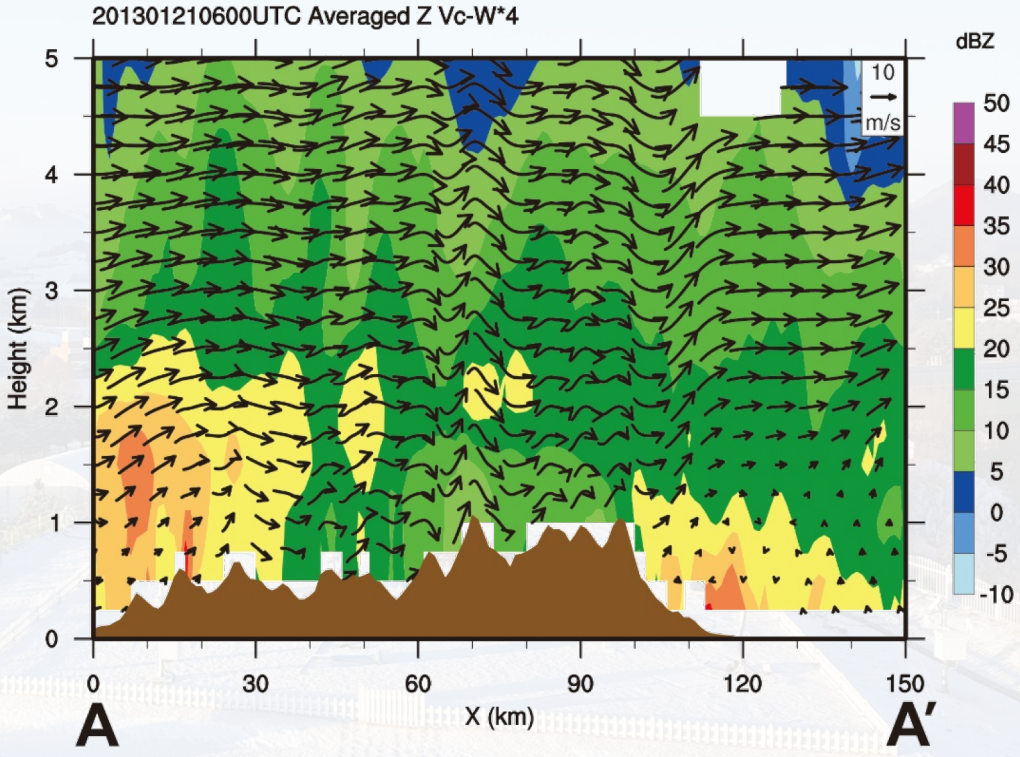
Heymsfield et al. (2004): $\rho = 0.104 D_{app}^{-0.95}$



High resolution wind retrieval

WISSDOM: 6 radars (GDK,GNG,KAN,SBS,JWN,WNJ)

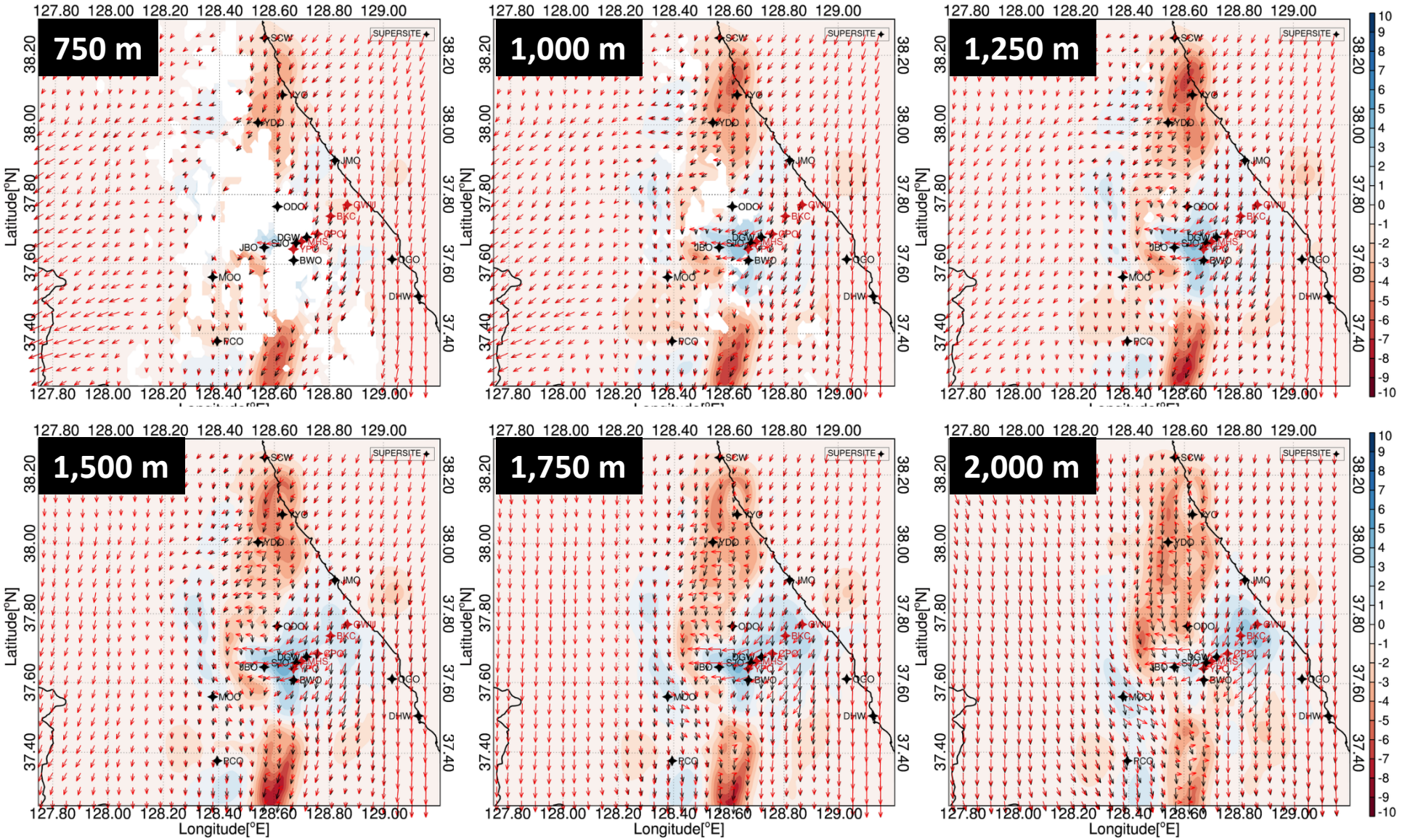




High resolution winds: Effect of X-band radars

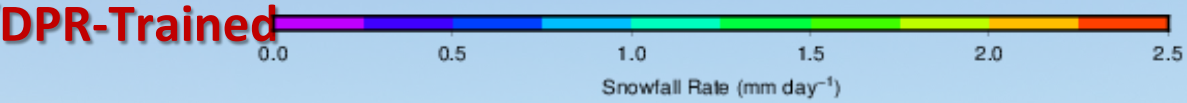
5 March 2018 04UTC

Color shade: wind speed difference ((OPS+X) –OPS)



MW satellite snowfall rate

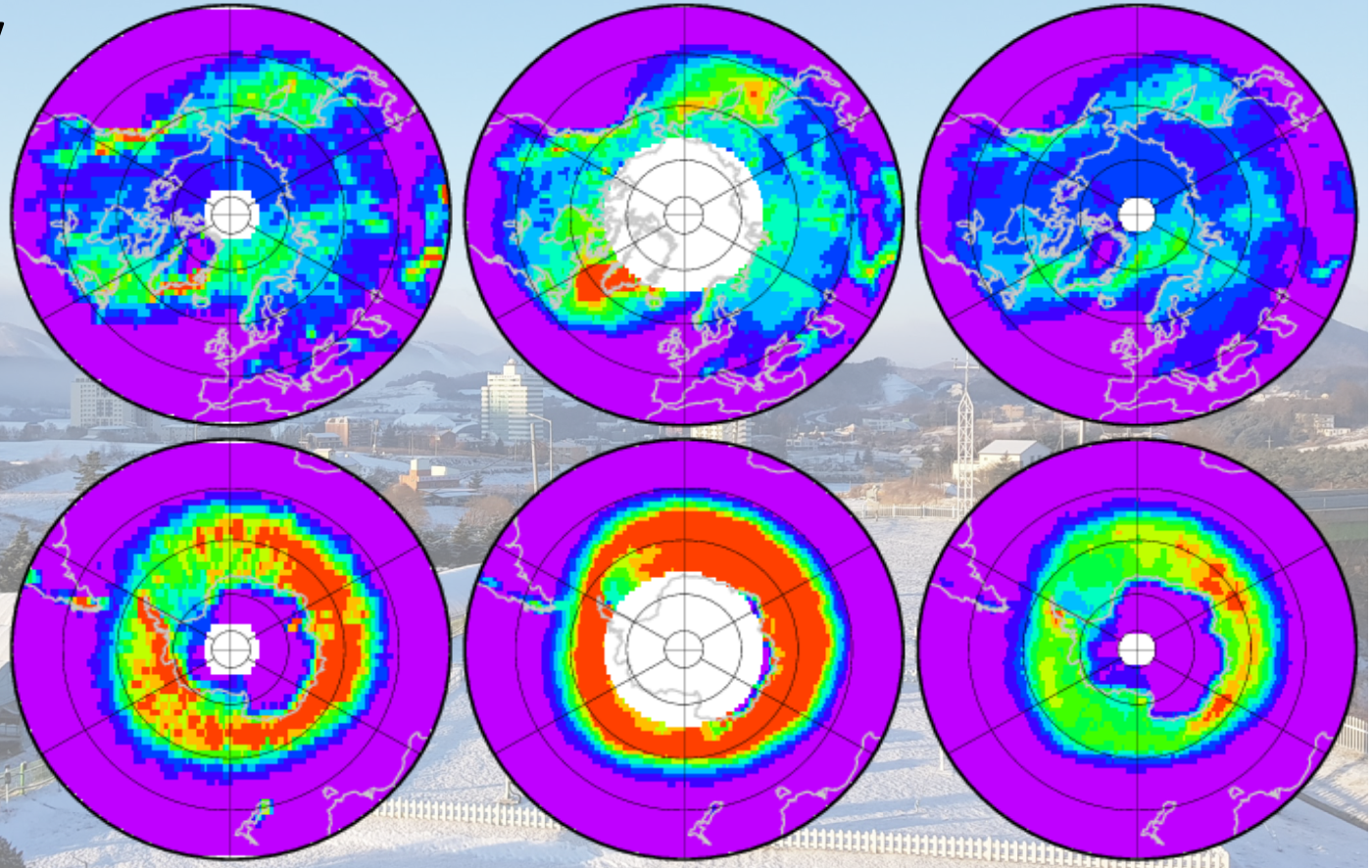
CloudSat and/or GPM/DPR-Trained



Snowfall climatology

NH

SH



Consider CloudSat Obs as truth, the GMI and MHS retrievals show similar patterns of snowfall

CloudSat
4 years (2007-2010)

GMI
Trained by CloudSat & DPR
3 years (2014.03-2017.02)

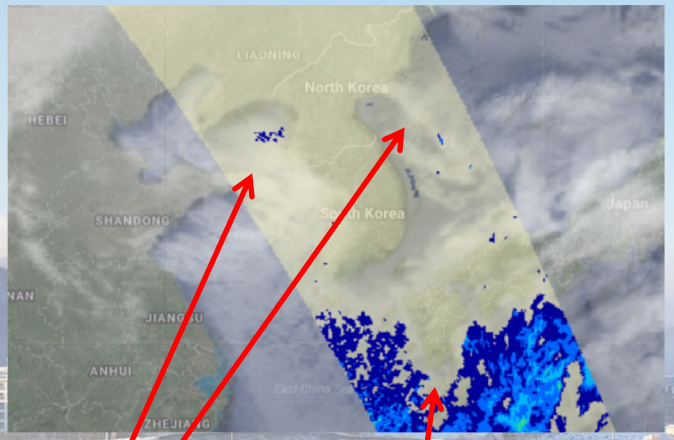
MHS
Trained by CloudSat
4 years (2007-2010)

From National Meteorological Satellite center

MW satellite snowfall rate

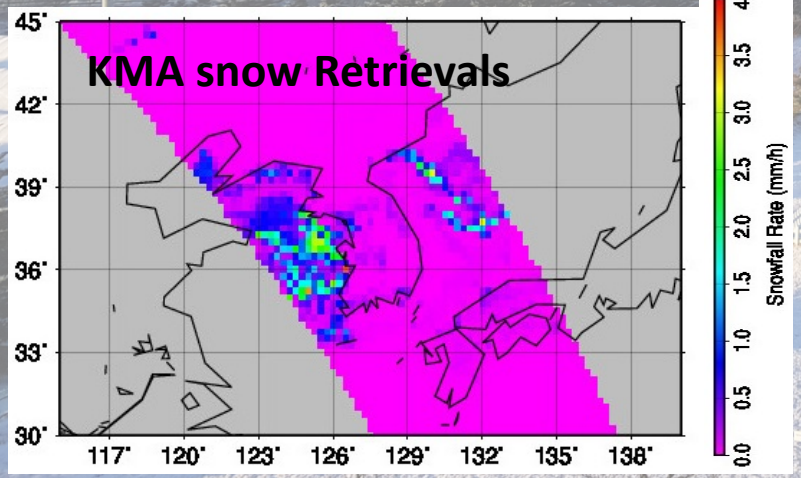
Jan. 23, 2016

NASA Precipitation

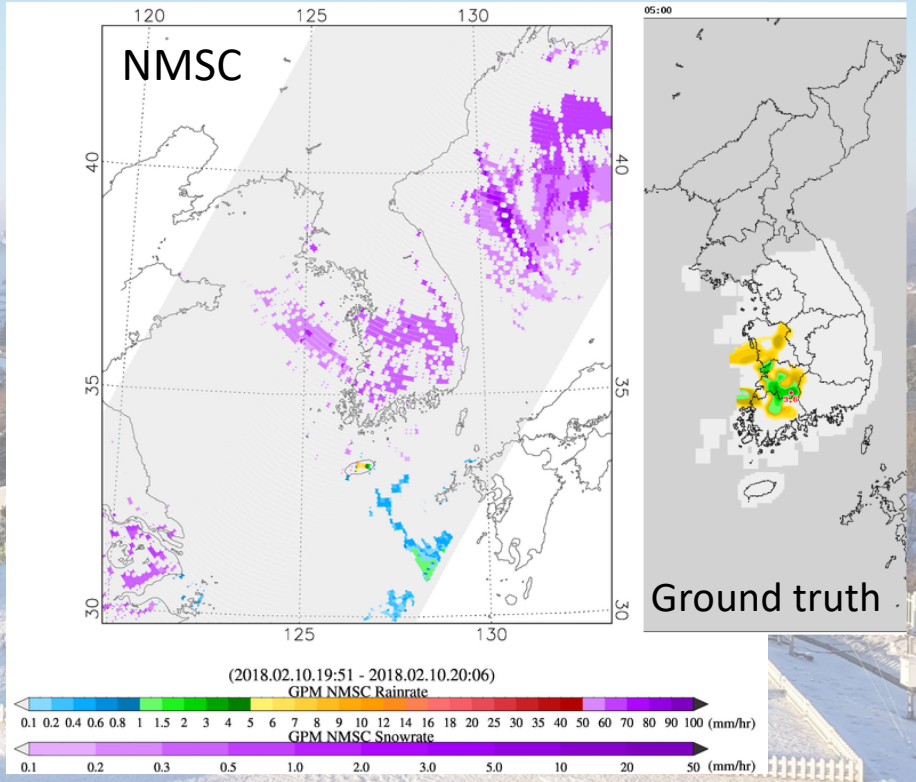


Missing snow?

Rain

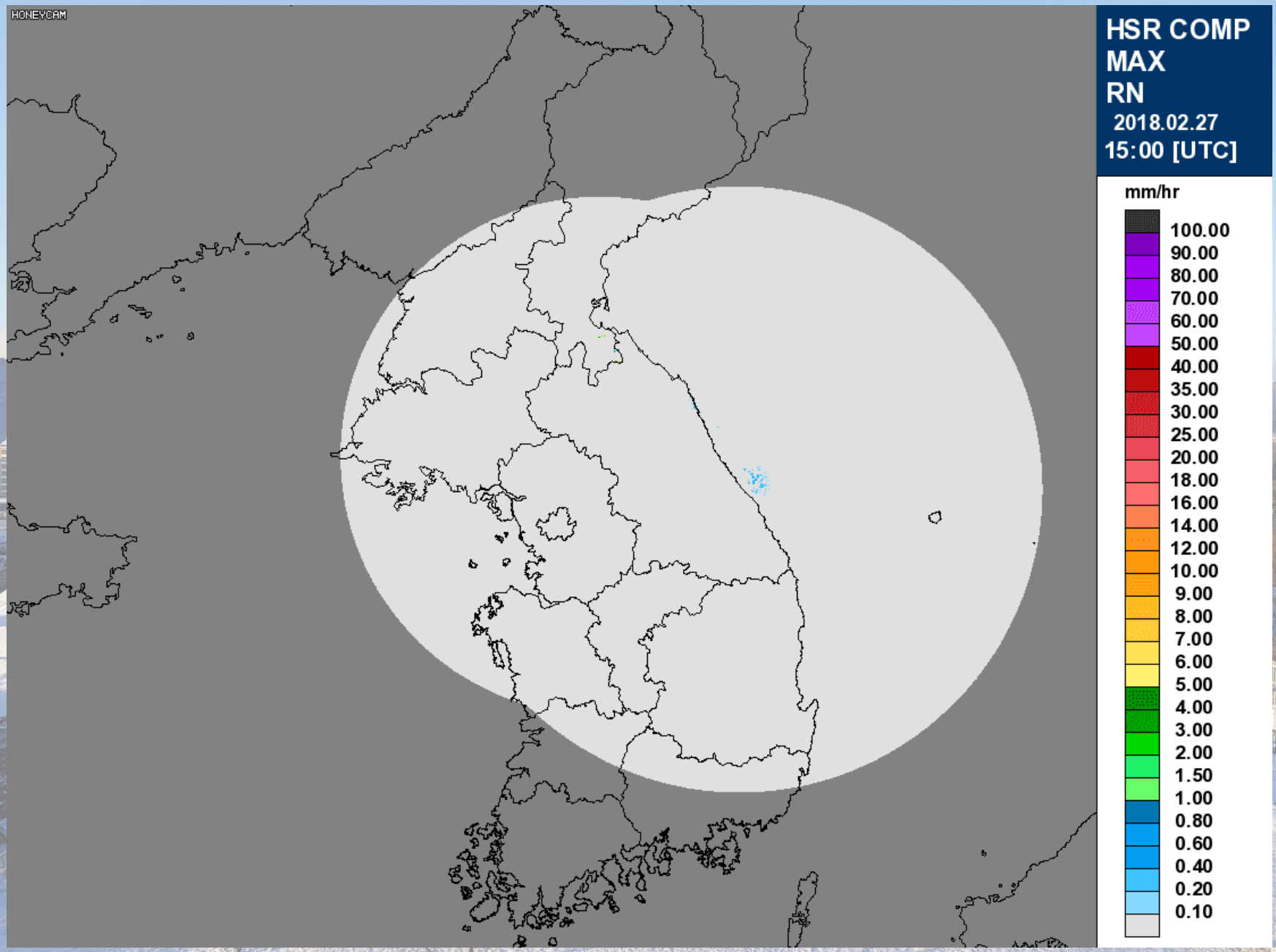


2018-02-11 05:10 [KST]

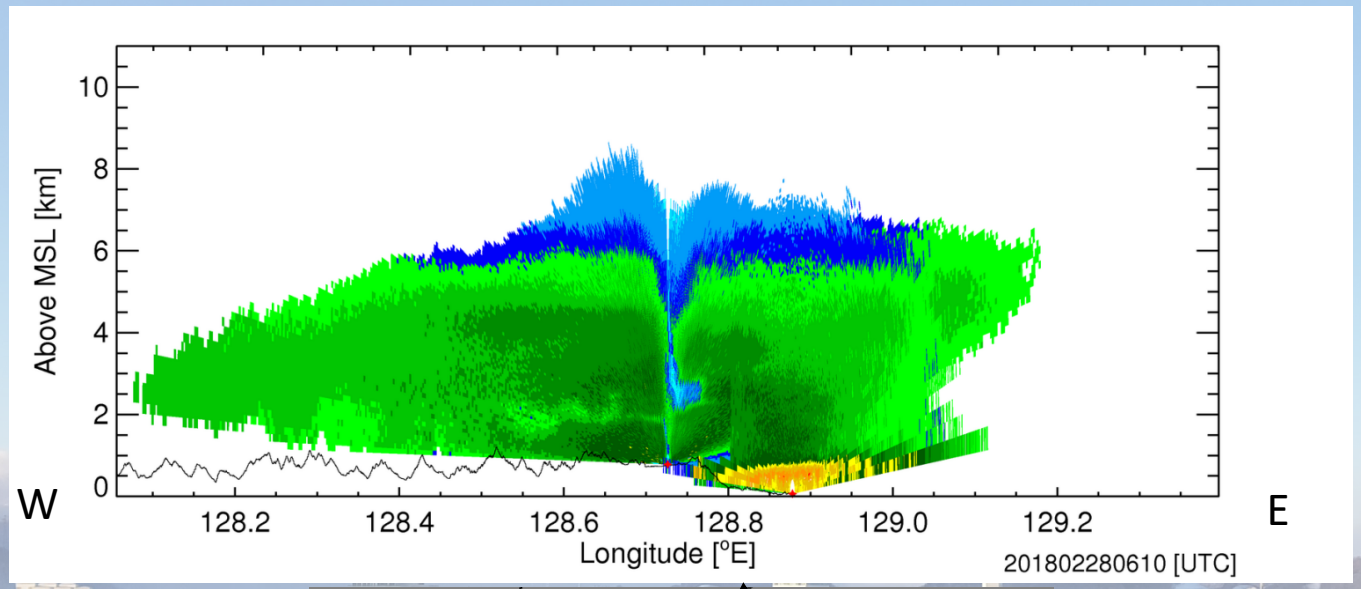


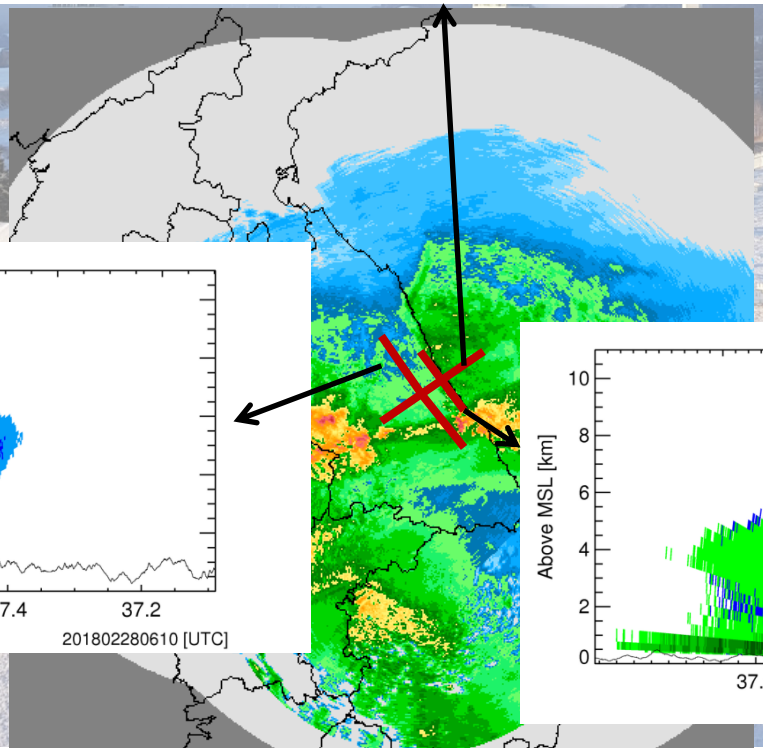
From National Meteorological Satellite center

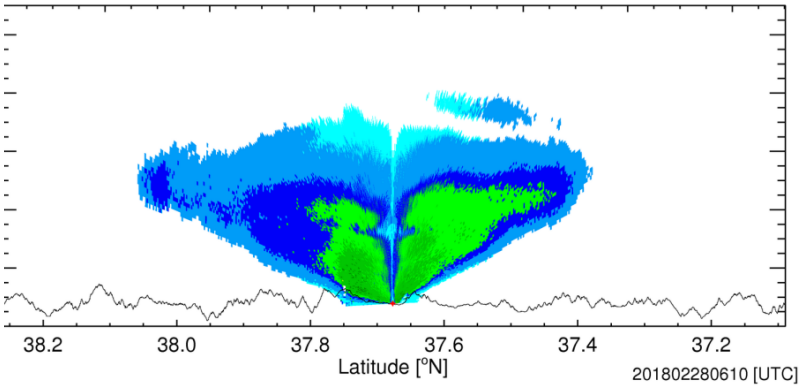
Radar snowfall rate: 28 Feb ~ 1 March 2018

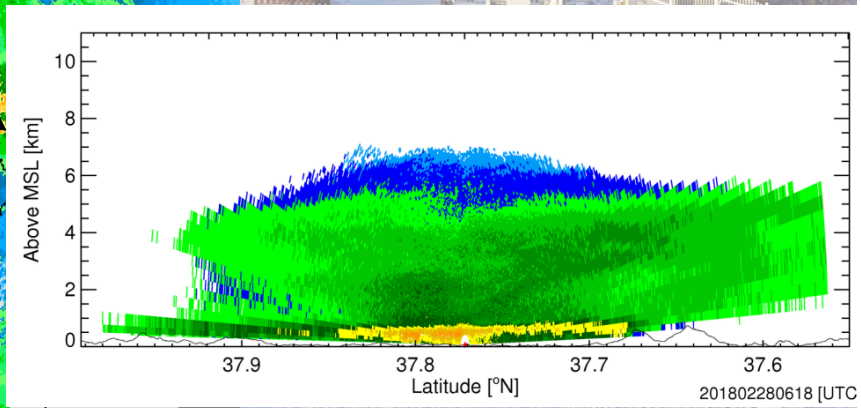


Case: 28 Feb ~ 1 March 2018









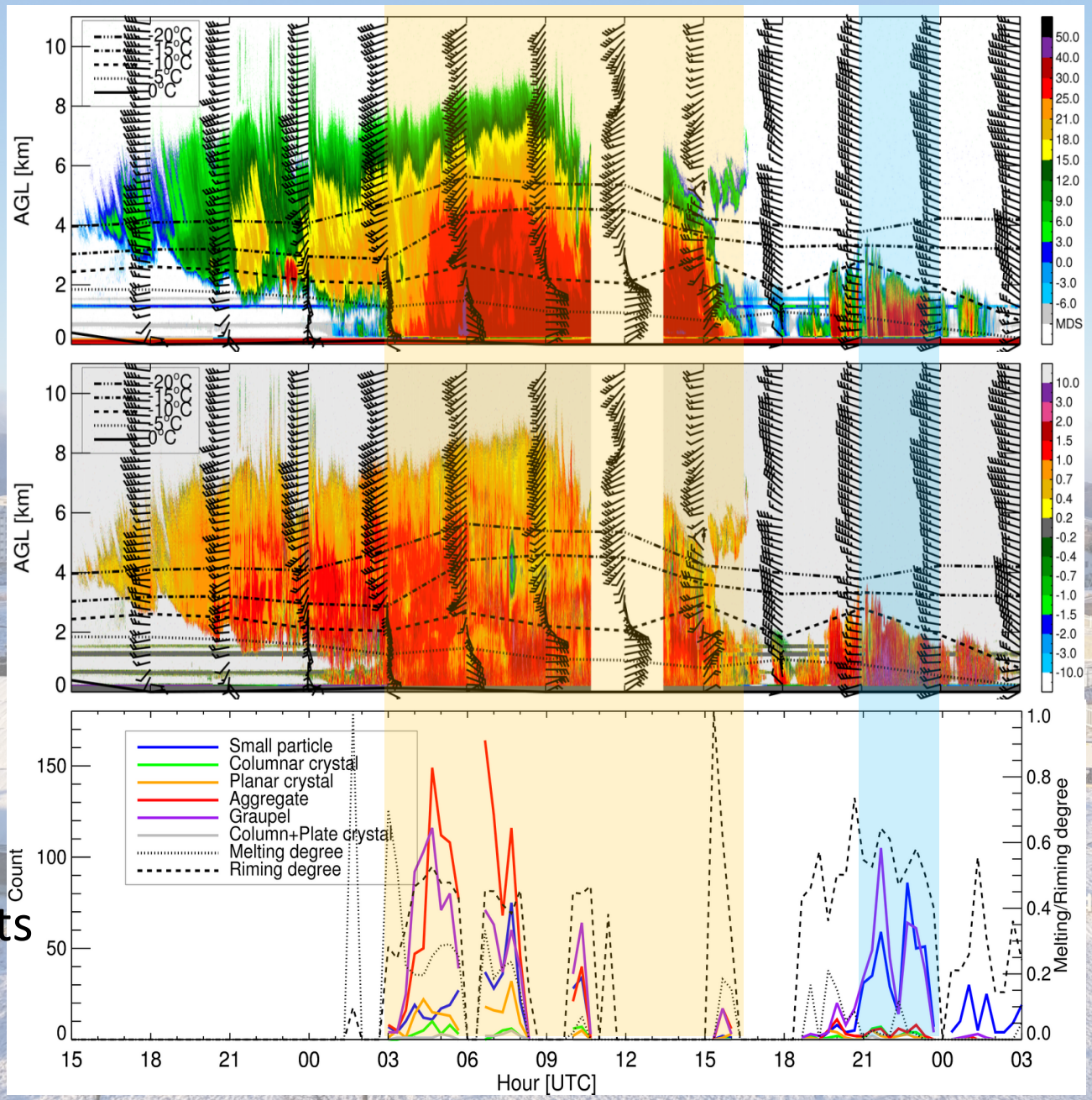
Case: 28 Feb ~ 1 March 2018

VertiX Z

VertiX Vr

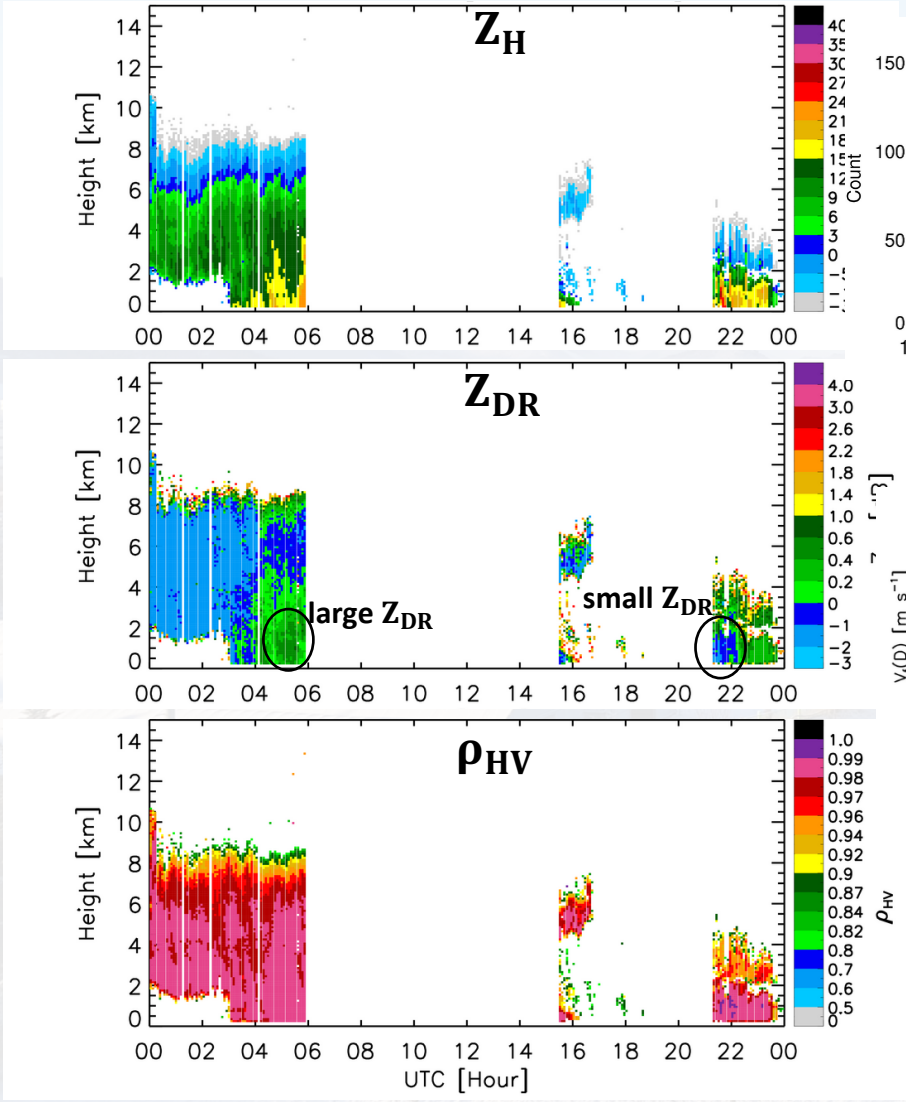
MASC Snow habits

MHS supersite

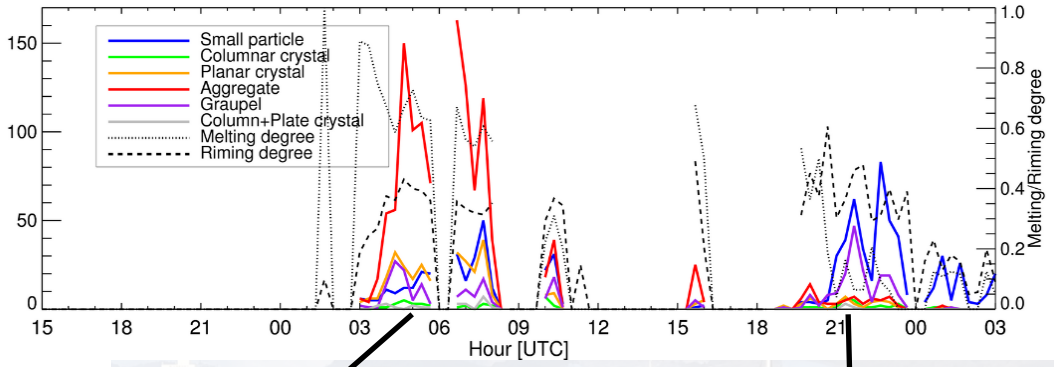


Case: 28 Feb ~ 1 March 2018

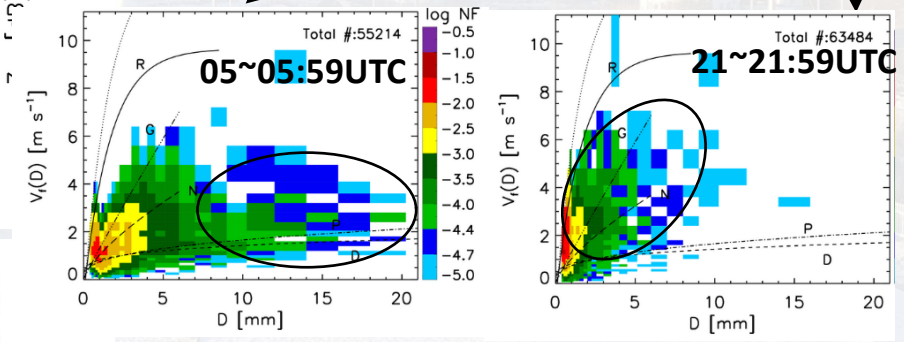
D3R Ku
over MHS supersite



MASC classification

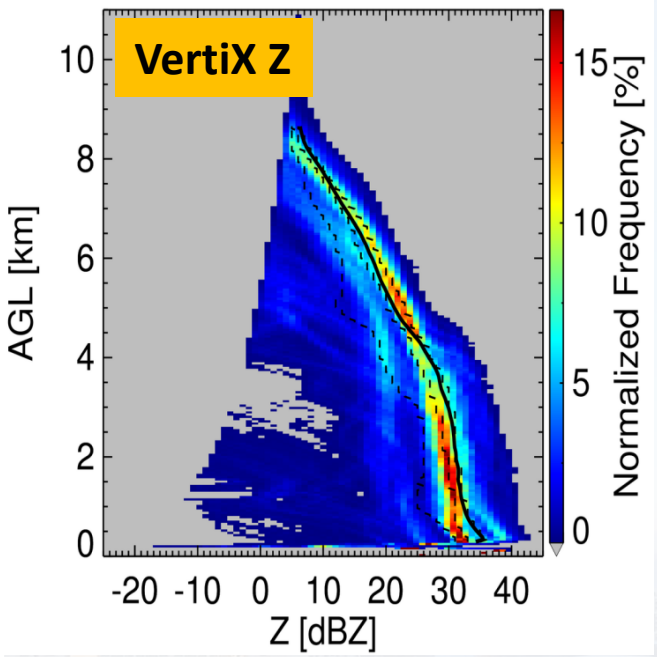


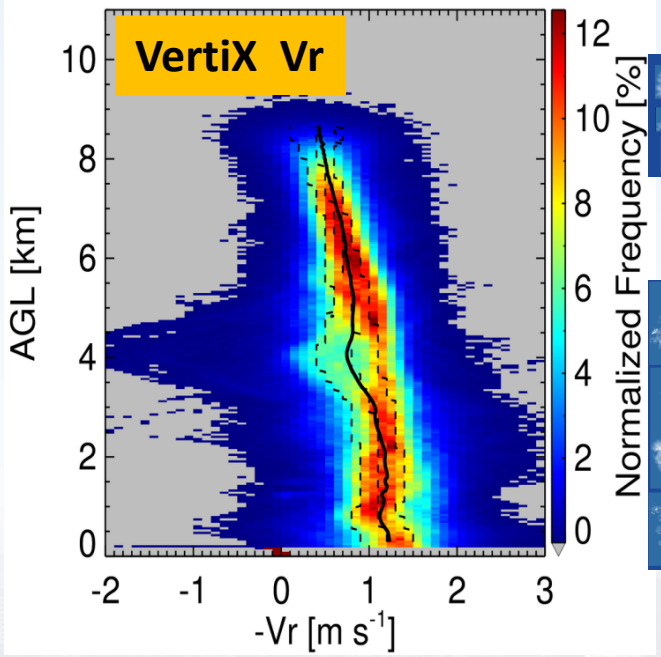
Parsivel V-D (NASA13 DFIR)



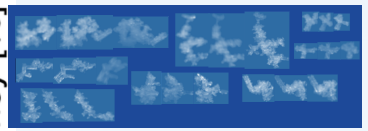
R: Rain
(Atlas et al., 1973)
G: Graupel
N: Needle
P: Plate
D: Dendrite
(Lee et al., 2015)

Case: 28 Feb ~ 1 March 2018



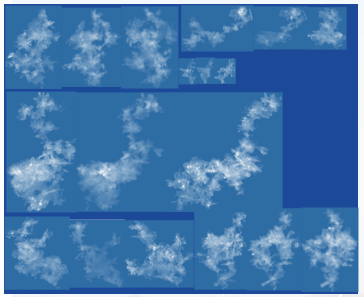


0400-0500 UTC

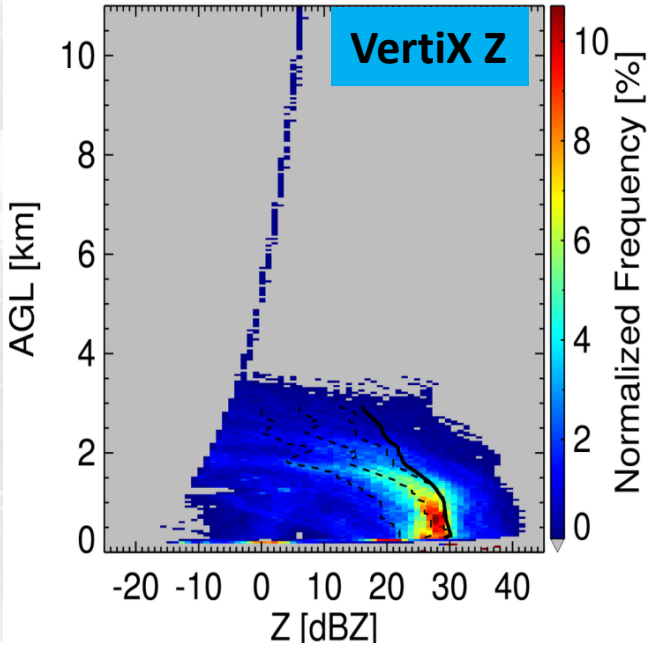


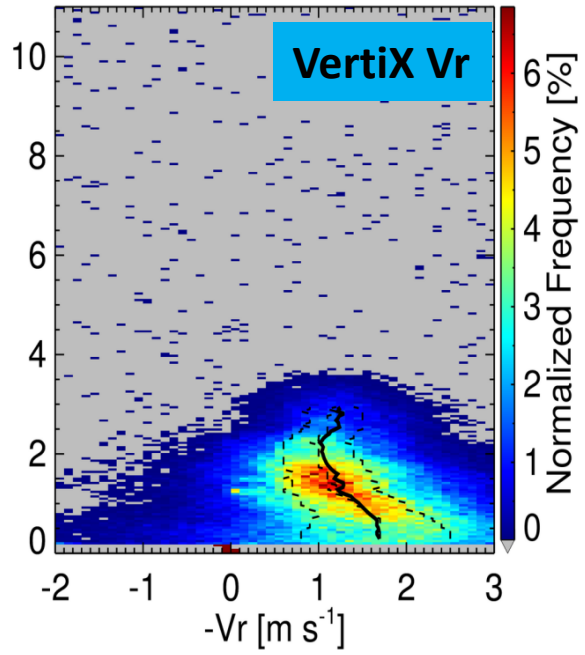
0730-0830 UTC

0530-0630 UTC

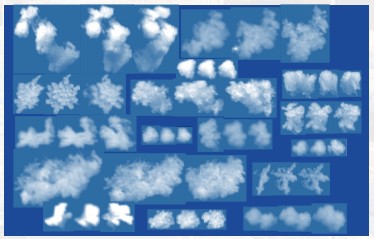


1500-1630 UTC

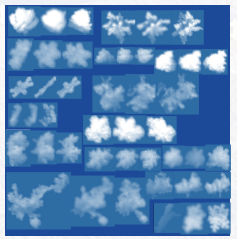




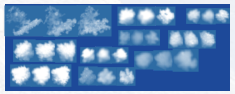
2100-2200 UTC



2200-2300 UTC



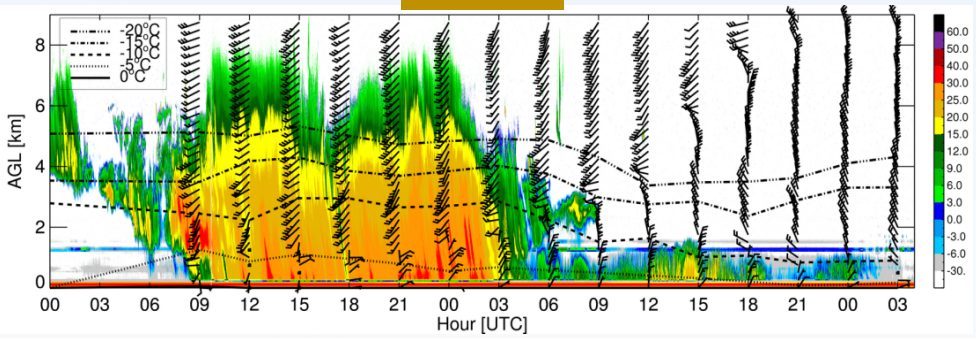
2300-2400 UTC



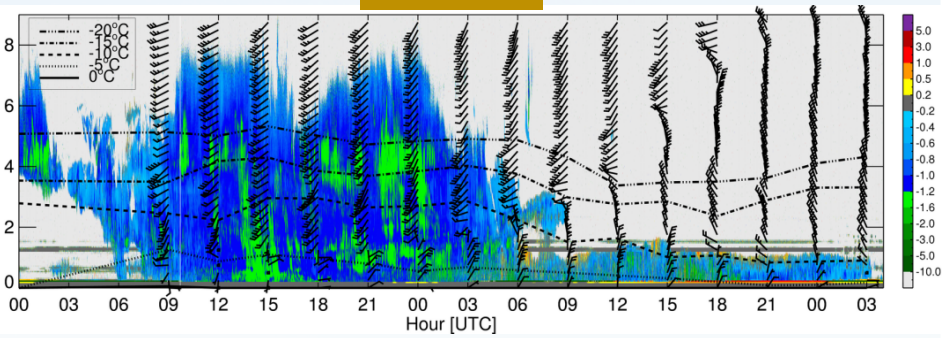
Case : 7 March ~ 9 March 2018

Three-wavelength measurement

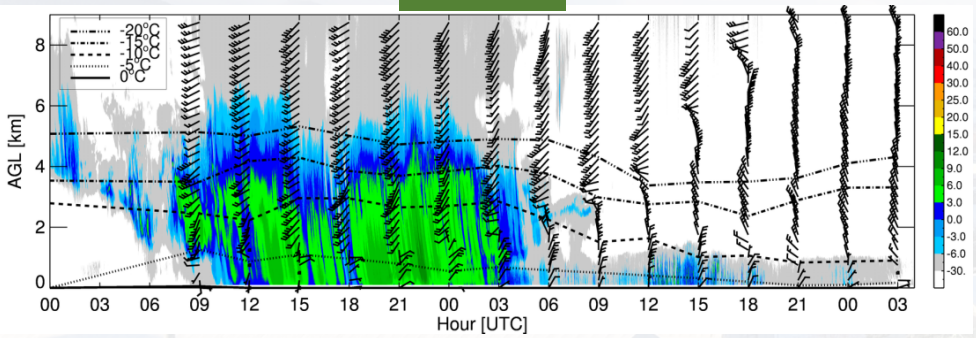
VertiX Z



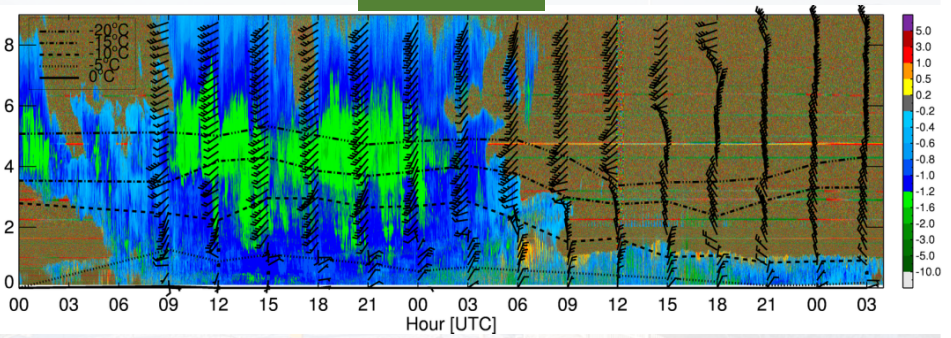
VertiX V_D



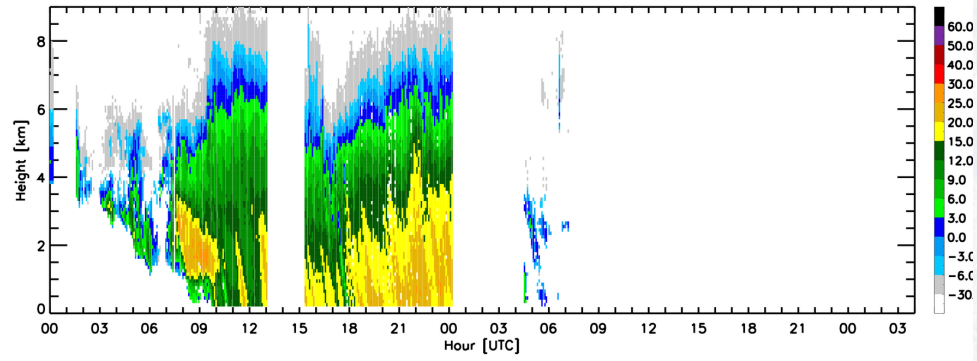
WProf Z



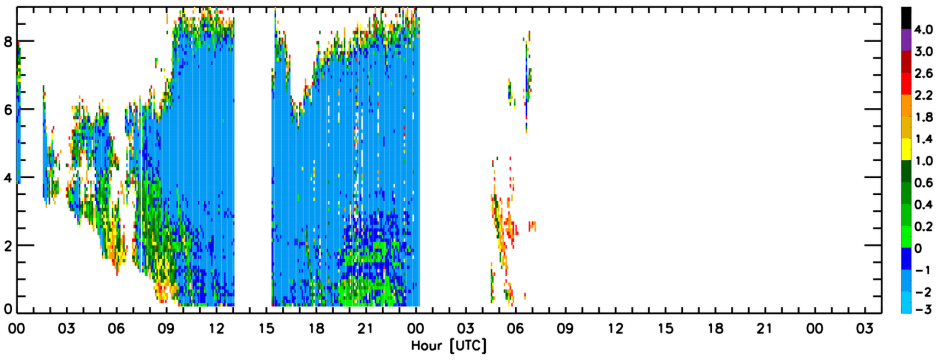
WProf V_D



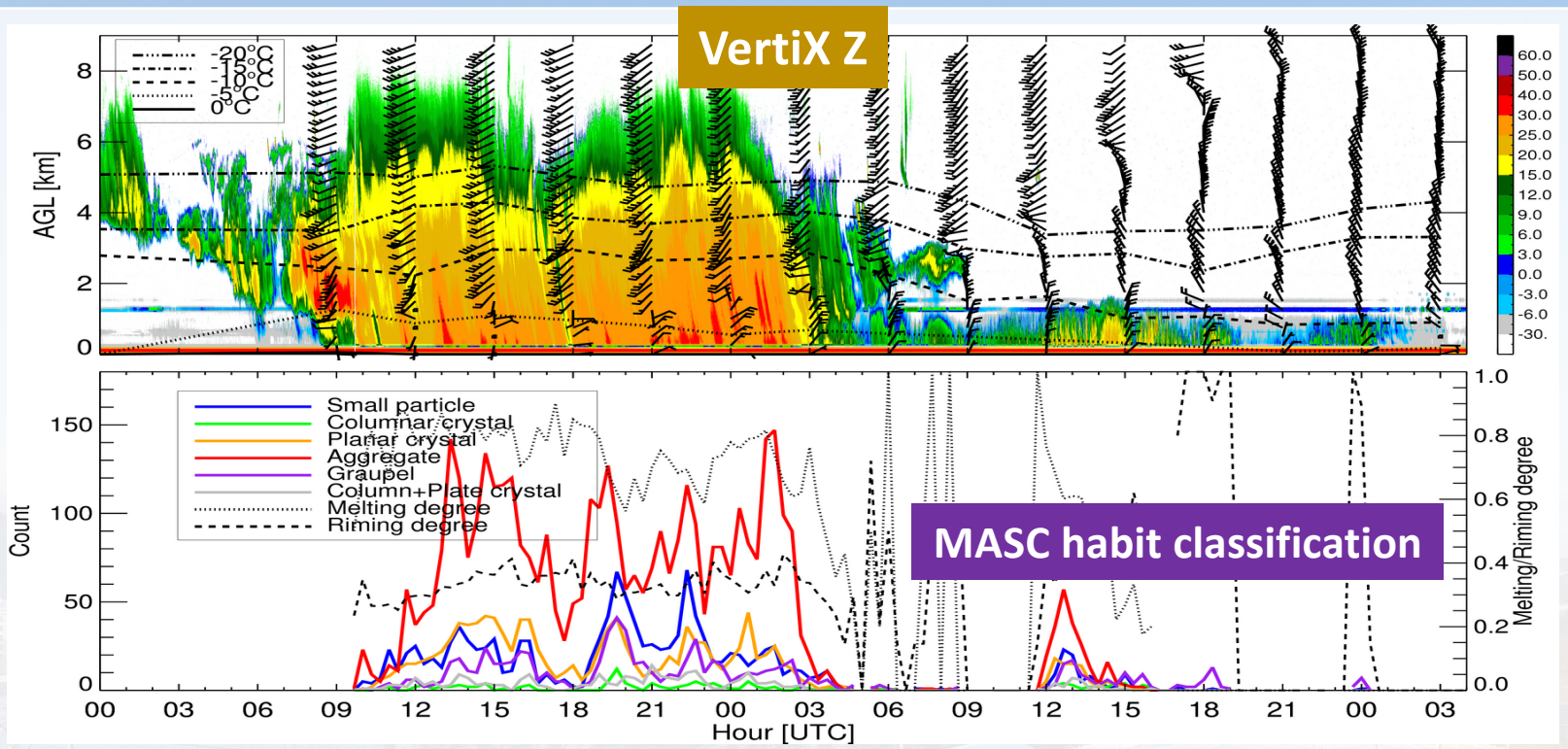
D3R Ku Z

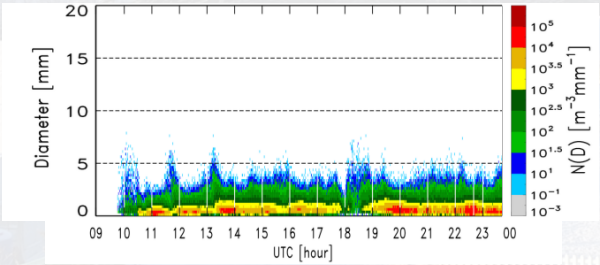


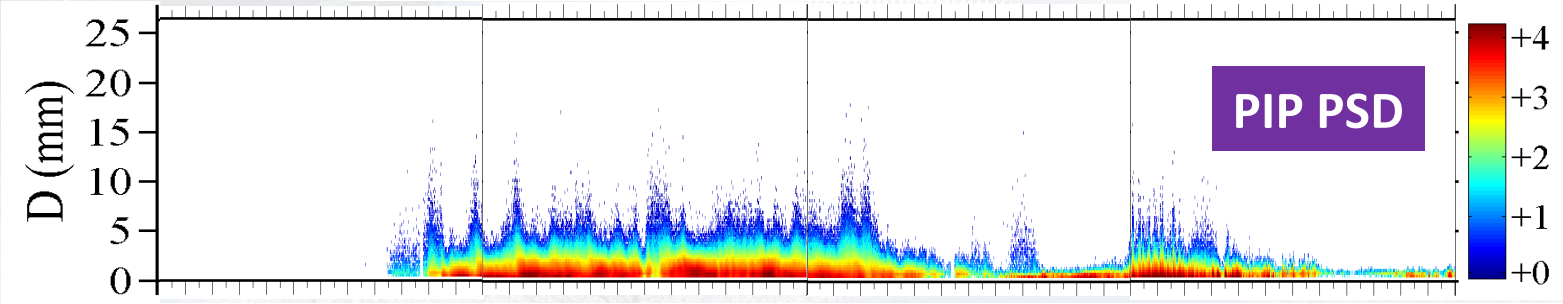
D3R Ku Z_{DR}



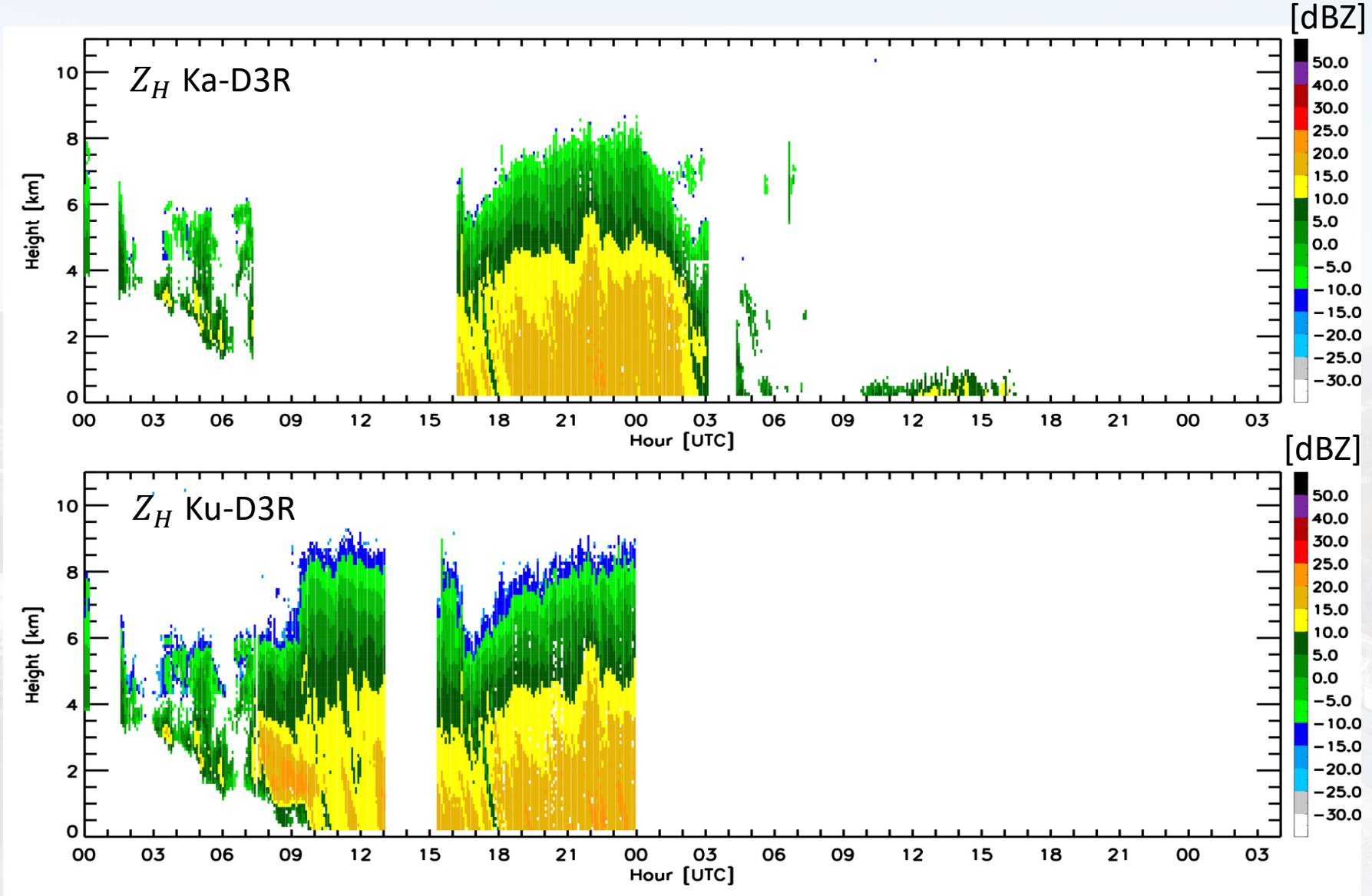
Case : 7 March ~ 9 March 2018



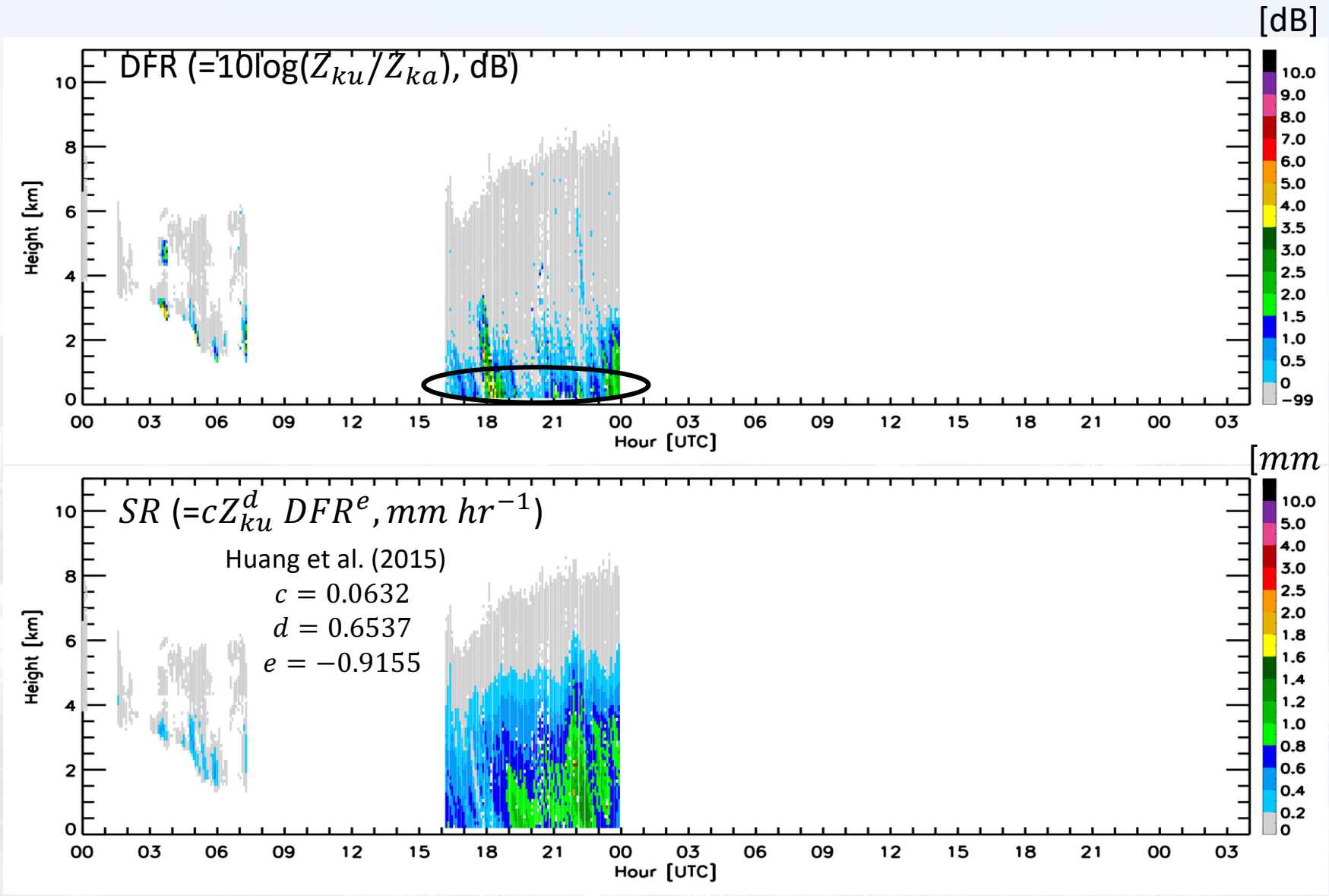




Case : 7 March ~ 9 March 2018



Case : 7 March ~ 9 March 2018



Summary

1. Field experiment ended and in process of data QC

2. Product generation:
   - High resolution NWPs and reanalysis
   - Snowfall rate (Radar and Satellite)
   - high resolution radar/lidar analysis (3D winds, 3D precip. structure)
   - Various microphysical products

3. Analysis:
   - Precipitation mechanism
   - Microphysical characteristics

4. NWP experiment:
   - DA of high resolution observation
   - Comparison of different microphysics scheme and diagnosis/development
   - Verification with high resolution products

5. Next international workshop planned: 26 ~ 30 Nov. 2018 in Jeju Island

ICE-POP international workshop

26 ~ 30 Nov. 2018 in Jeju Island