NASA Participation in the International Collaborative Experiment for the PyeongChang Olympics and Paralympic Winter 2018 Games (ICE-POP)

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- KMA-led, WMO WWRP-sponsored winter precipitation project (Jan-Mar. 2018)
- Objective: Improve understanding and prediction of orographic falling snow

NASA Objective(s): Collaborate with interagency/international partners to:
- Evaluate and improve GPM estimates of orographic snow
- Test and improve NWP, cloud model orographic snow physics
- Serve/test new satellite products in a decision support environment

KMA-NIMS King Air

Coast to mountain SW-NE instrument transect/clusters

South Korea

Addressing larger synoptic scale cyclone and cold-air northeasterly ocean-mountain snow events

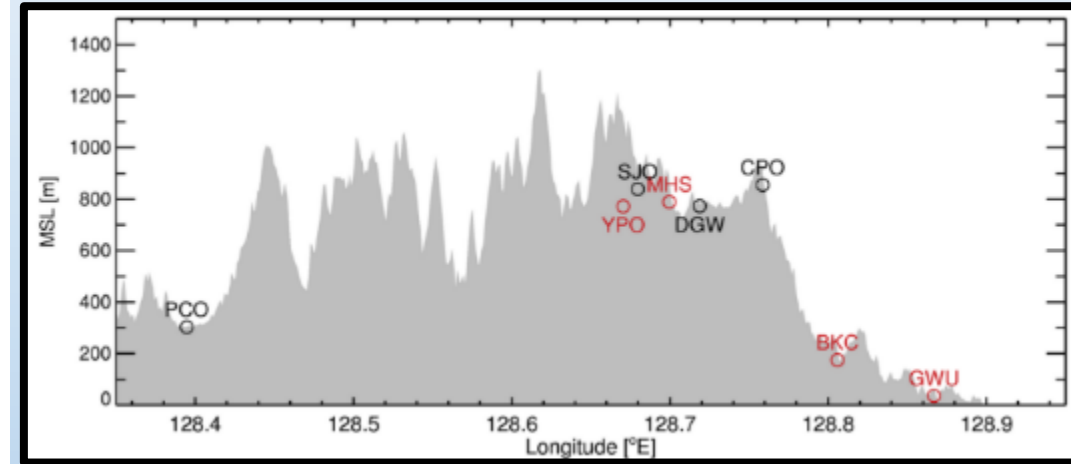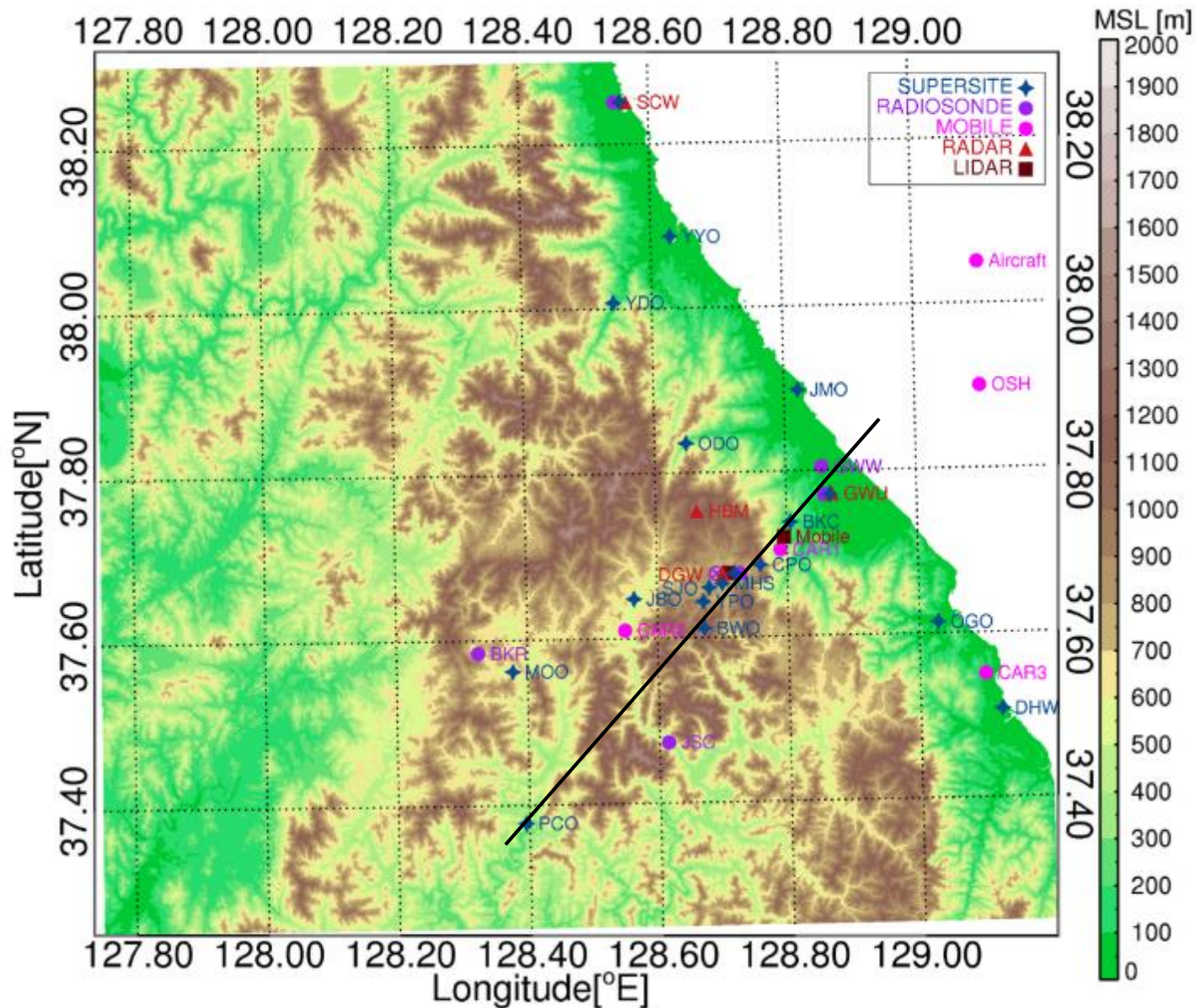*Network, aircraft images courtesy Korean Meteorological Administration*
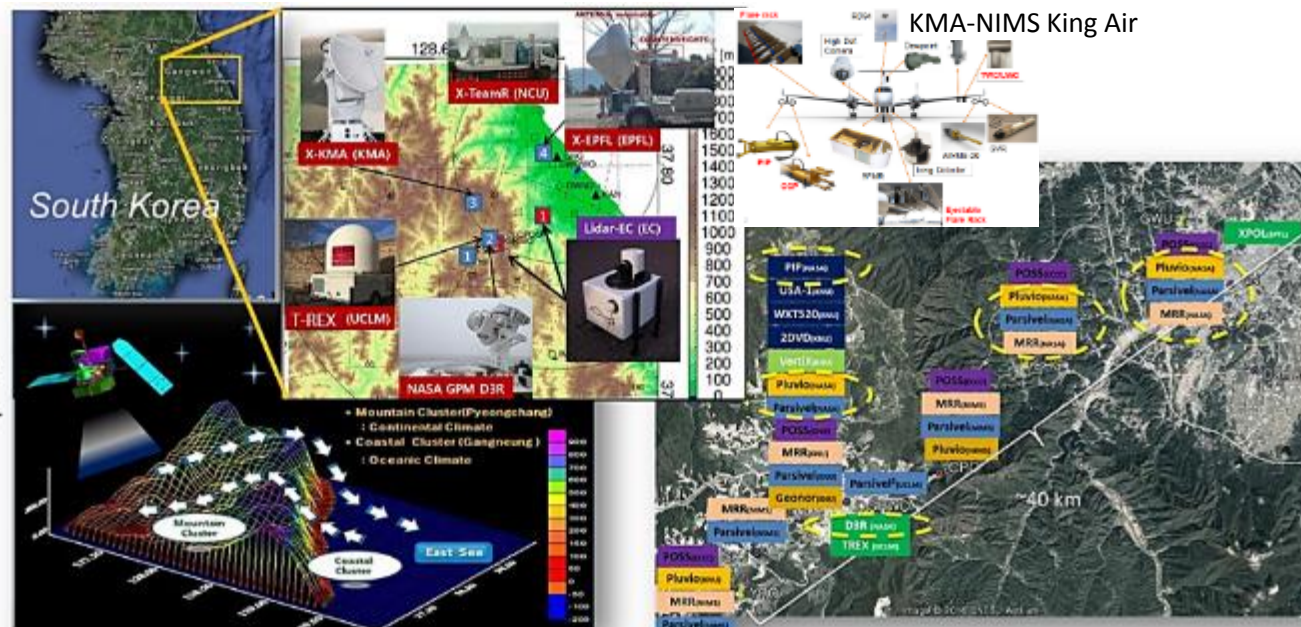
NASA Contributions:
- GPM GV Instruments- D3R, MRRs, PIPS, Pluvios, Parsivels
- SPoRT GPM products (including NRT surface SH/LH fluxes)
- NU-WRF model forecasts/research

Ocean to Summit Instrument Transects

Courtesy: G. Lee

Ground Instrument Supersites

West ←   Mountain ranges   → East

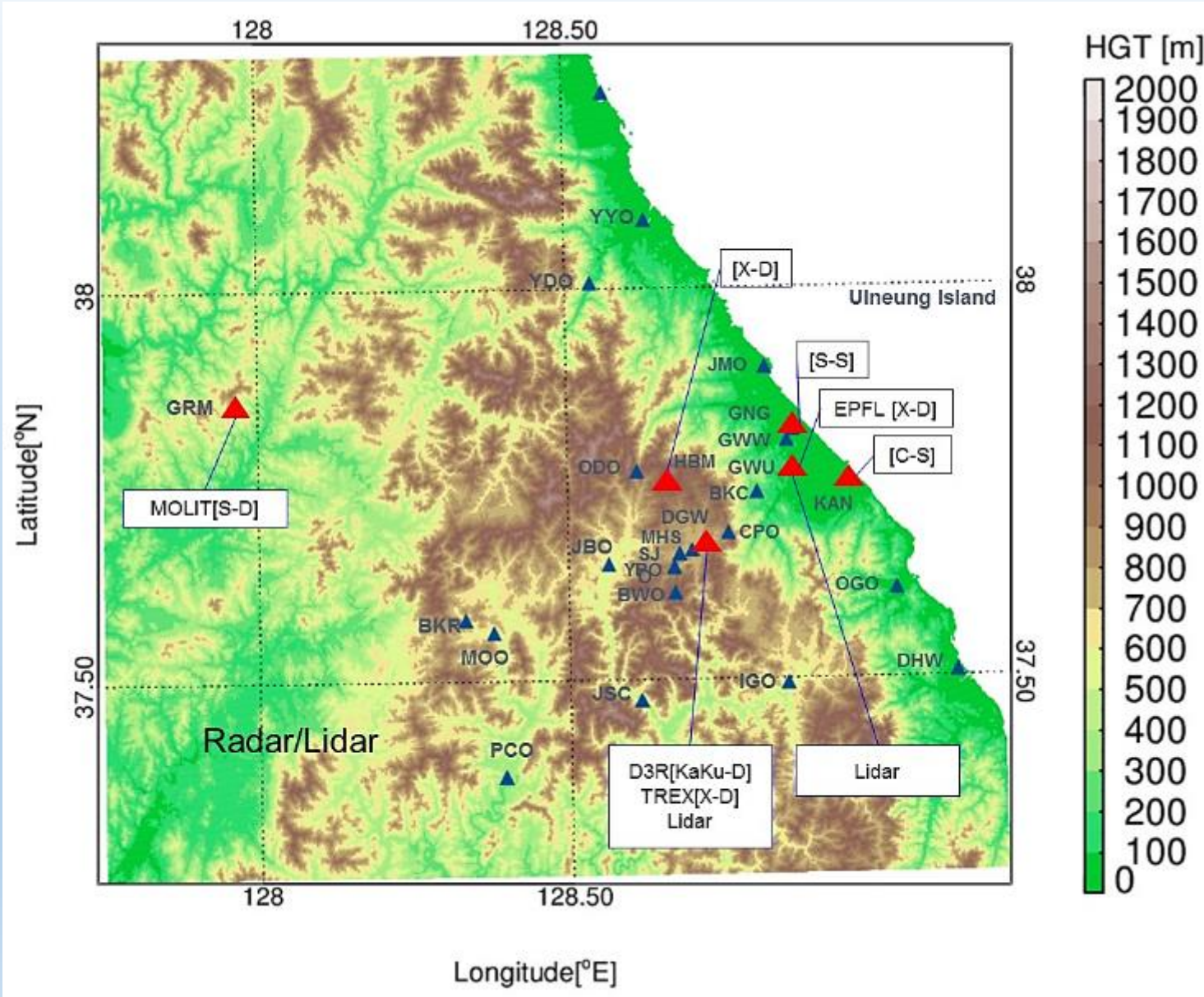| YPO	MHS	CPO	BKC	GWU
MRR-2	MRR-2	MRR-2	MRR-2	MRR-2
Parsivel^2	Parsivel^2 (DFIR)	Parsivel^2	Parsivel^2	Parsivel^2
POSS	POSS	POSS	POSS	POSS
Pluvio^2 200 (Belfort Double Alter shield)	Pluvio^2 400 (DFIR + Tretyakov + Alter shield)	Pluvio^2 200 (No shield)	Pluvio^2 400 (Tretyakov + Alter shield)	Pluvio^2 400 (Tretyakov + Alter shield)
Raingauge	Raingauge	Raingauge	Raingauge	Raingauge
	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		
	Parsivel^1	Automatic cloud observation system		
		AWS		

Belfort Double Alter

Double Fence Intercomparison Reference
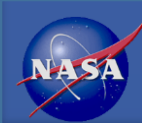
Tretyakov + Alter

Single Alter

Images Courtesy G. Lee, KNU, Korea

Multi-frequency, Polarimetric Radar Coverage

S--band (S),
X-band (X),
Ka-Ku,
C-band (C),
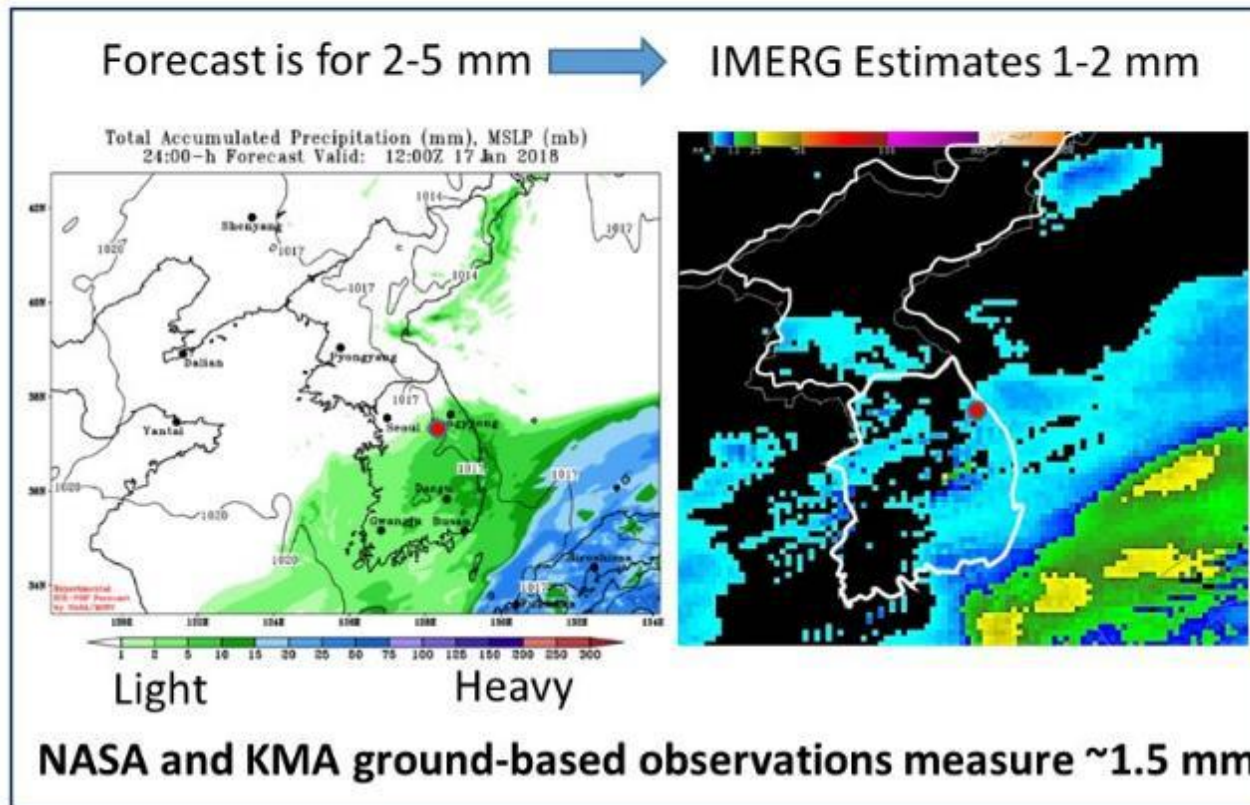D= Dual-Pol,
S=Single pol

Courtesy G. Lee, KNU, Korea

Precipitation _Type_ (Rain or Snow)

Forecast is Snow

Precipitation Type (legend at bottom)
09:00-h Forecast Valid: 21:00Z 16 Jan 2018

SNOW
RAIN

D3R

NASA D3R Maps Snow
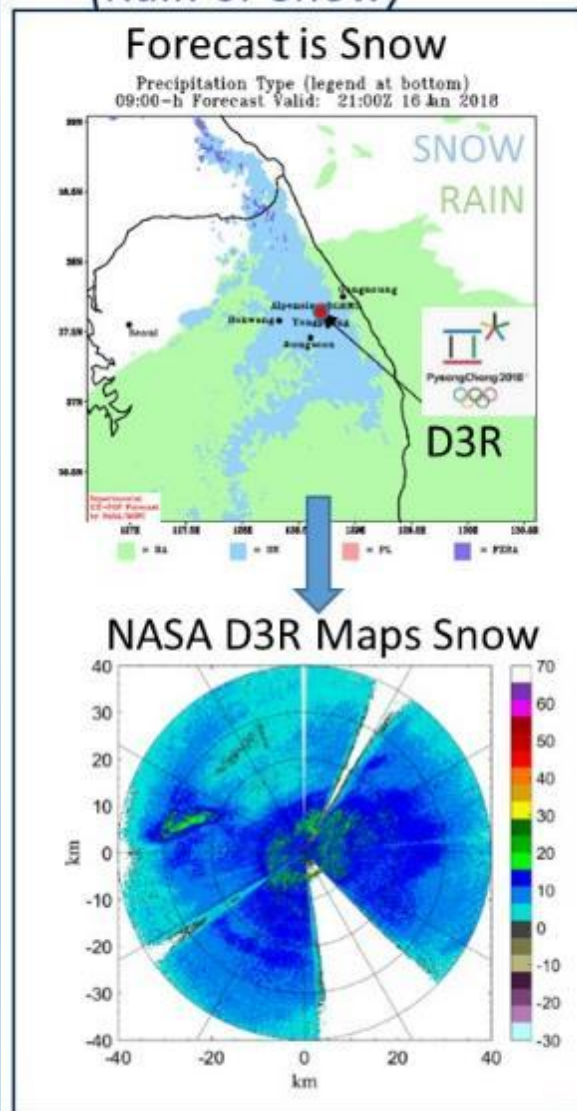
Precipitation _Amount_ (24-hr estimate)

Forecast is for 2-5 mm ➡ IMERG Estimates 1-2 mm

Total Accumulated Precipitation (mm), MSLP (mb)
24:00-h Forecast Valid: 12:00Z 17 Jan 2018

Light   Heavy

NASA and KMA ground-based observations measure ~1.5 mm

Forecast, GPM IMERG, and ICE-POP observations agree on precipitation type and amount for an early ICE-POP snow event near PyeongChang.

These comparisons will continue as ICE-POP progresses

NU-WRF Real-time Model Configuration for ICE-POP

2m Temperature (C), MSLP (mb), 10m Wind (m/s)
24:00-h Forecast Valid: 12:00Z 08 Feb 2018

9-km outer grid

3-km Korea nest

1-km "Olympics" nest

NASA Unified-WRF (NU-WRF) Model Features:

- 4x daily 24-hour forecasts
- Initialized 00/06/12/18z
- Half-hourly output on nests
- 62 vertical levels
- PBL: MYJ; LSM: Noah
- SW/LW Radiation: NASA/GSFC schemes within NU-WRF
- Microphysics: NASA/GSFC 4-ice graupel+hail
- Cumulus: Grell-Freitas (9km only)
- ICs/BCs: NCEP/EMC GFS
- SSTs: 2-km NASA SPoRT MODIS+VIIRS product
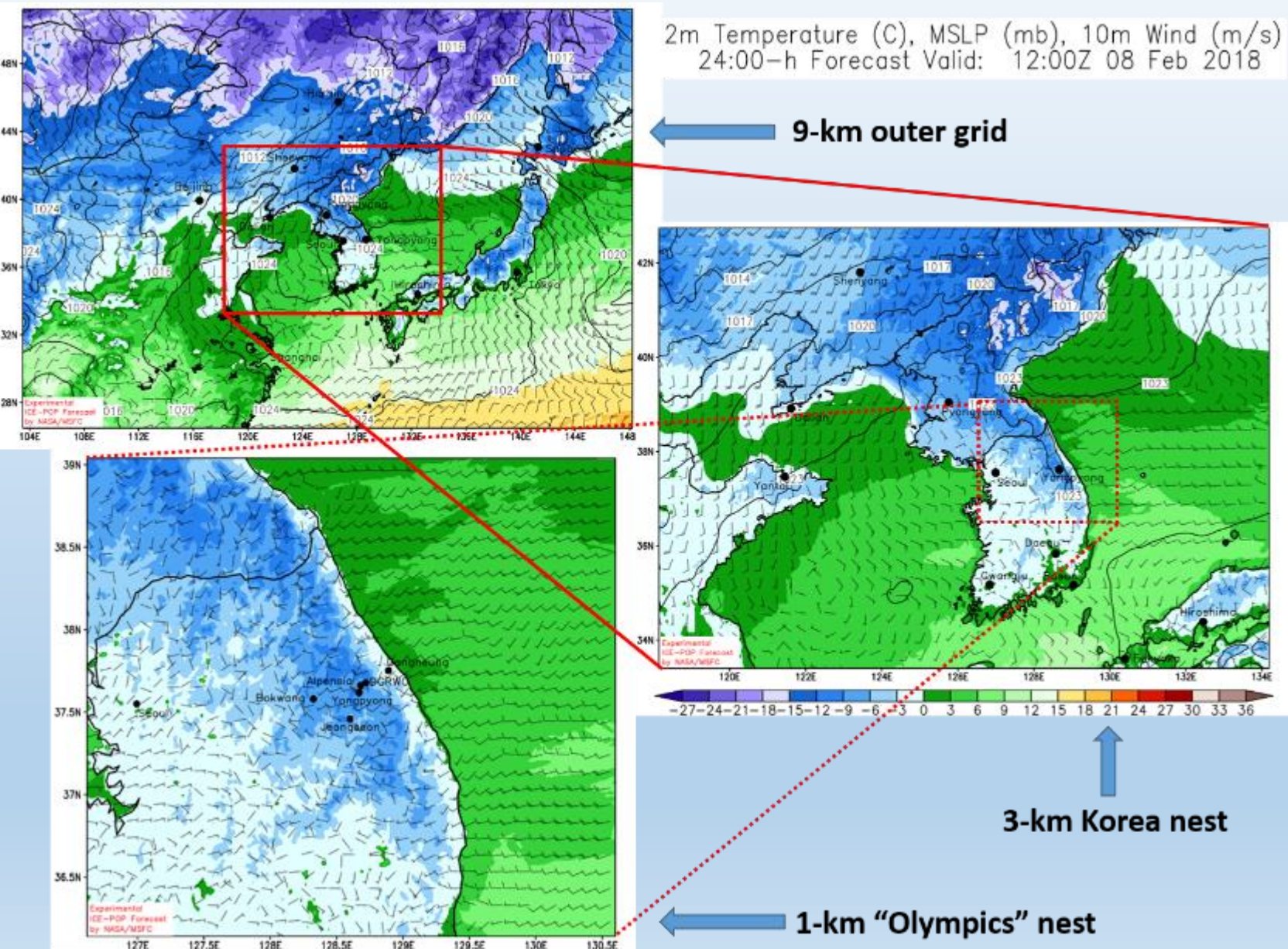
Observations and Simulations from High-Impact Events:
## 11 February High Winds Delayed Mens' Downhill
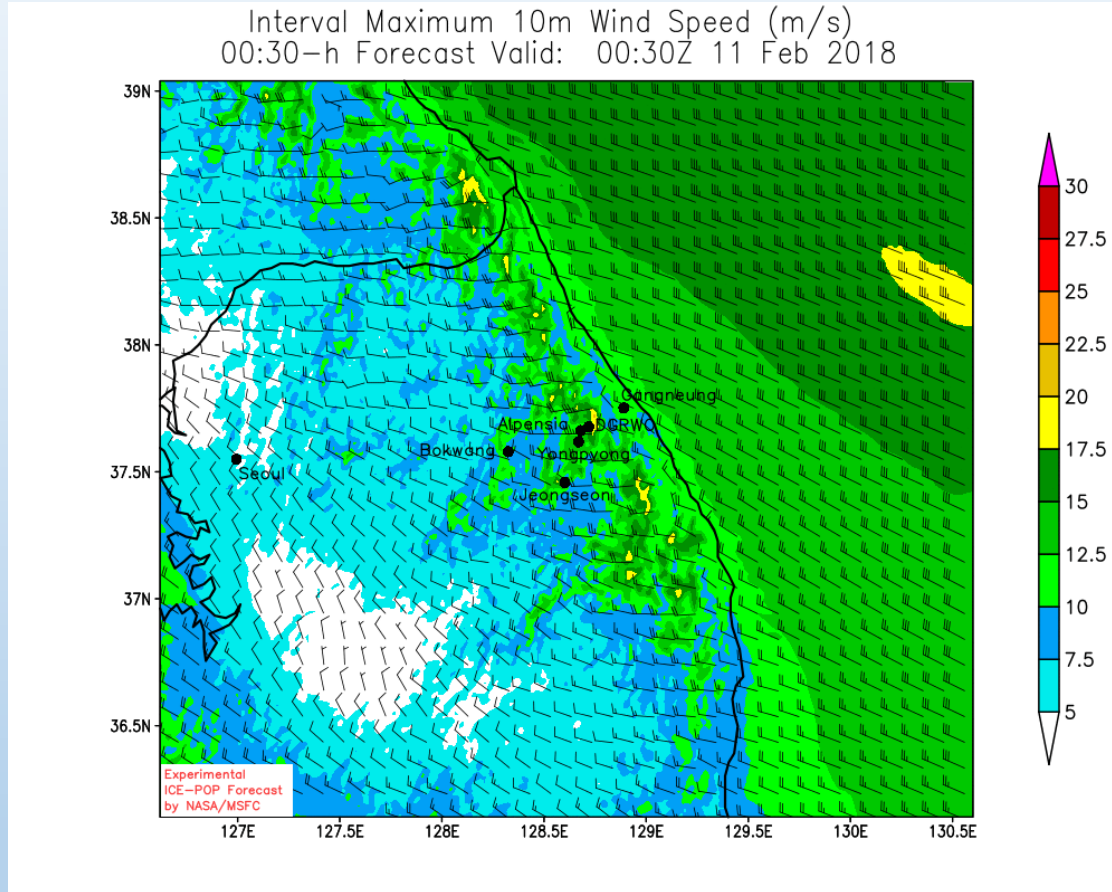
(above) Animation of 30-min interval maximum 10m wind speeds from NU-WRF 1km nested grid.

(right) Comparison between NU-WRF 9-km grid [left column] 10m winds, sensible, & latent heat flux to passive microwave oceanic retrievals [right column]
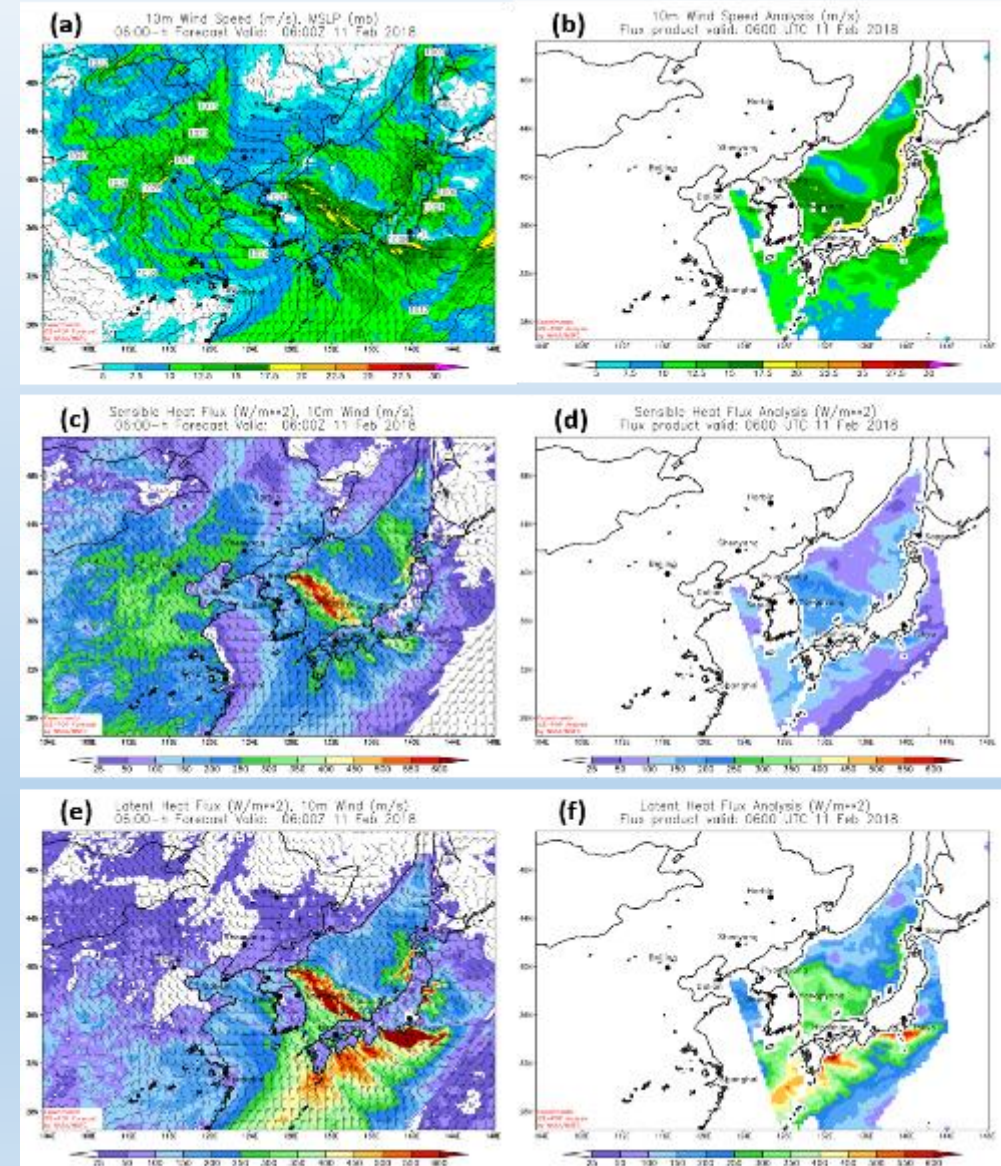
Observations and Simulations from High-Impact Events:
## *14 Feb Shallow Snow & High Winds Disrupted Skiing on Jeongseon Hill*
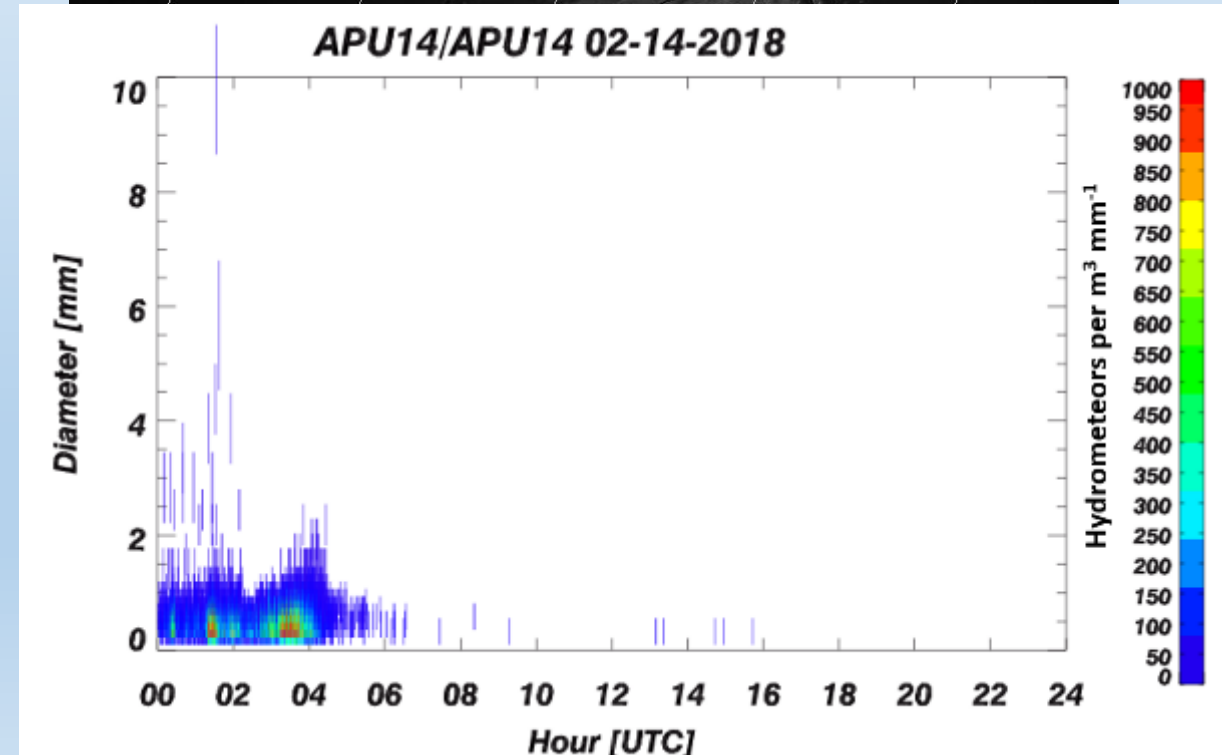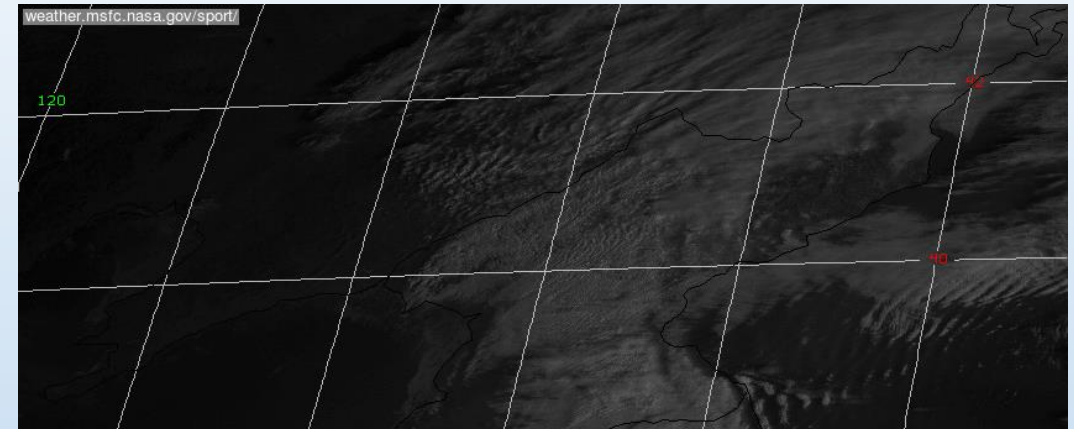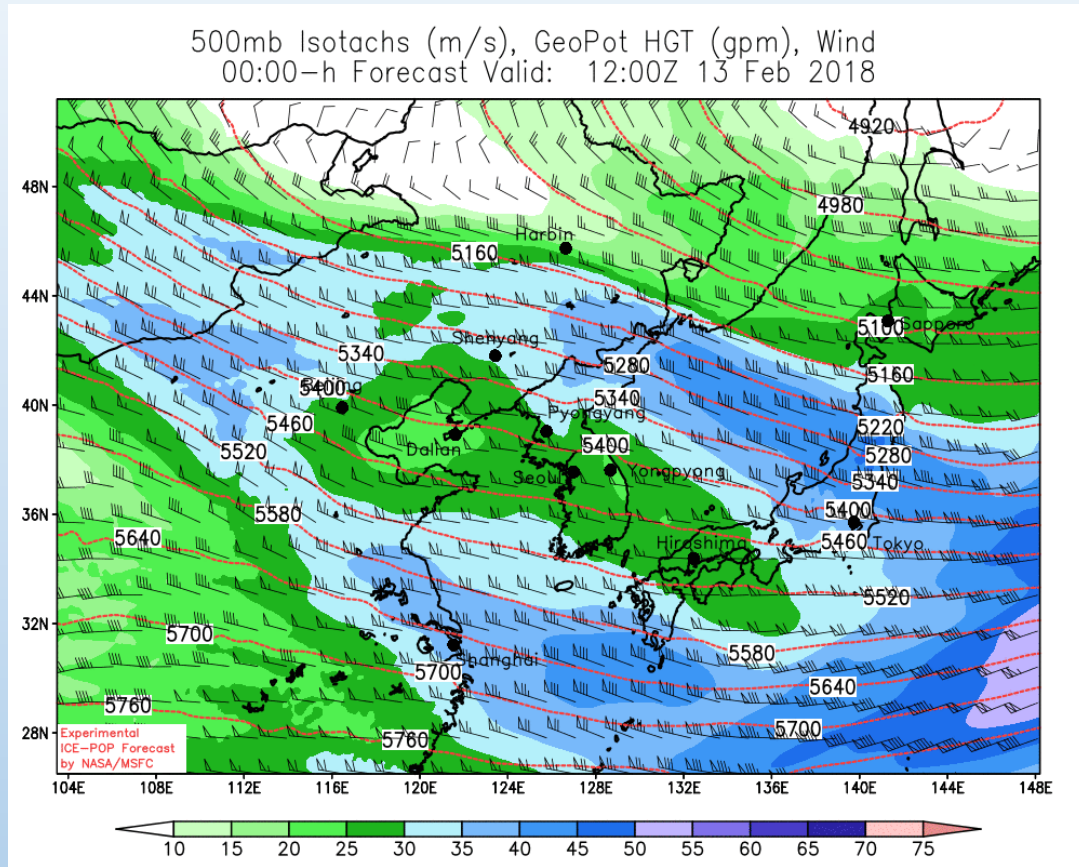
(above) Animation of 3-hourly 500-mb isotachs from NU-WRF 9km grid

(right) Animation of visible satellite imagery from JMA Himawari

(bottom-right) Disdrometer measurements, showing high concentration of primarily small hydrometeors between 01-04z

Observations and Simulations from High-Impact Events:
## *14 Feb Shallow Snow & High Winds Disrupted Skiing on Jeongseon Hill*
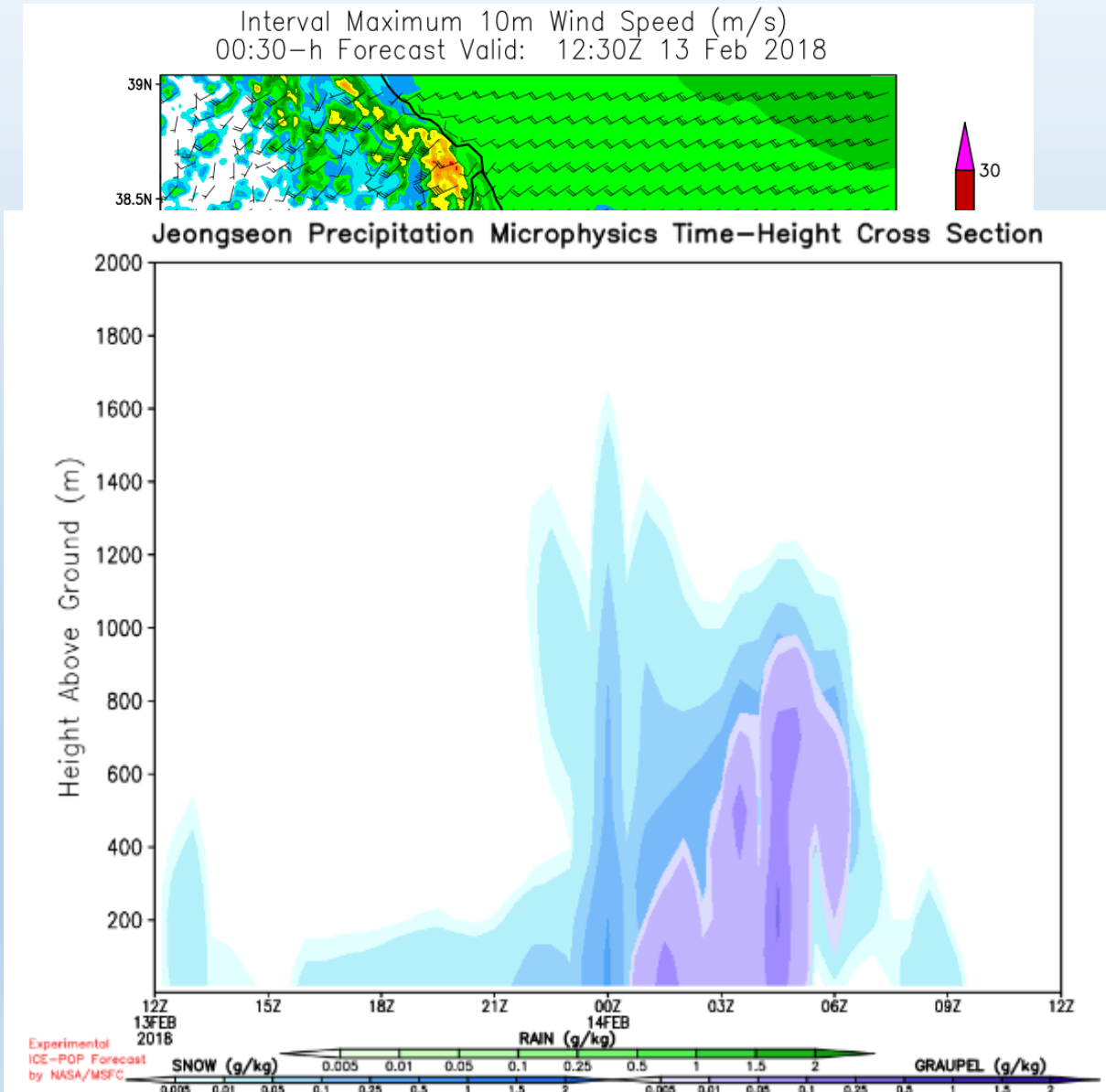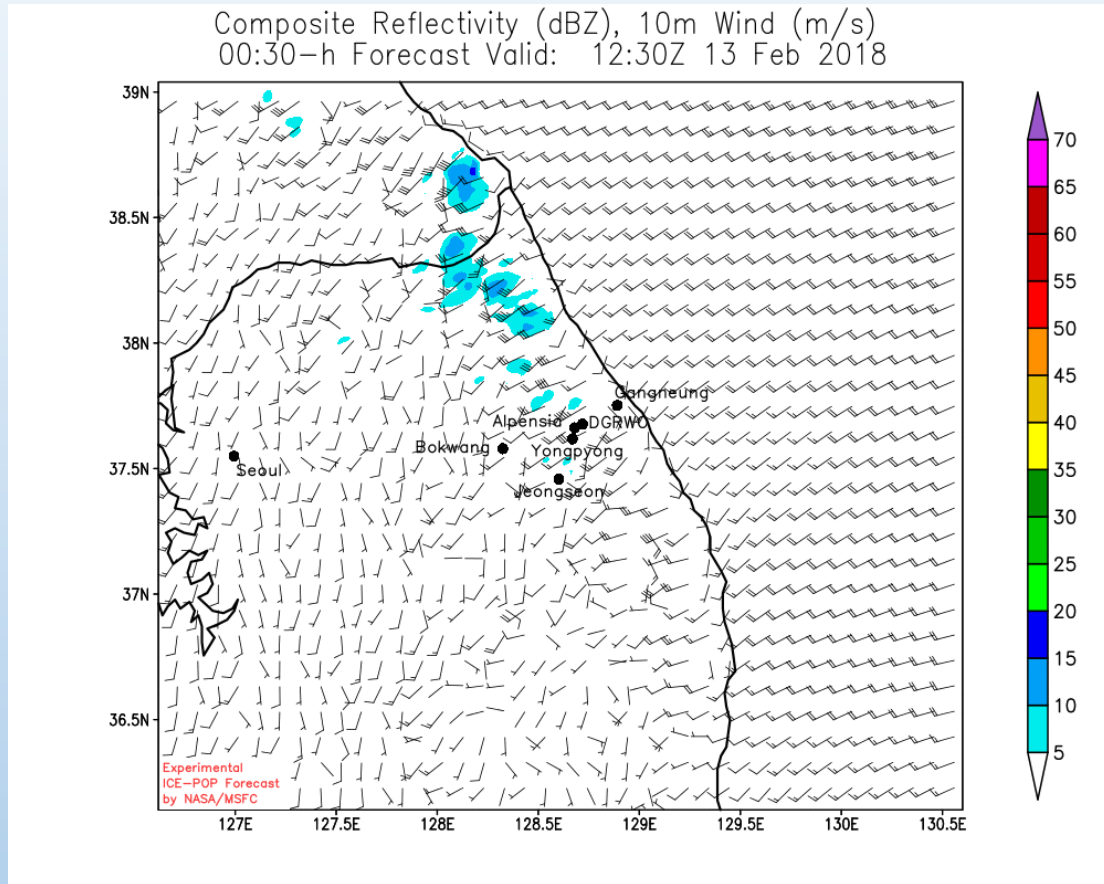
(above) Animation of 30-min Comp. reflectivity from 1-km grid

(right) Animation of 30-min interval maximum 10m wind speed

(bottom) Time-height cross section in lowest 2km AGL of precipitation microphysical mixing ratios

Observations and Simulations from High-Impact Events:
## *Three Significant Snowstorms between Olympics (Feb) and Paralympics (Mar)*
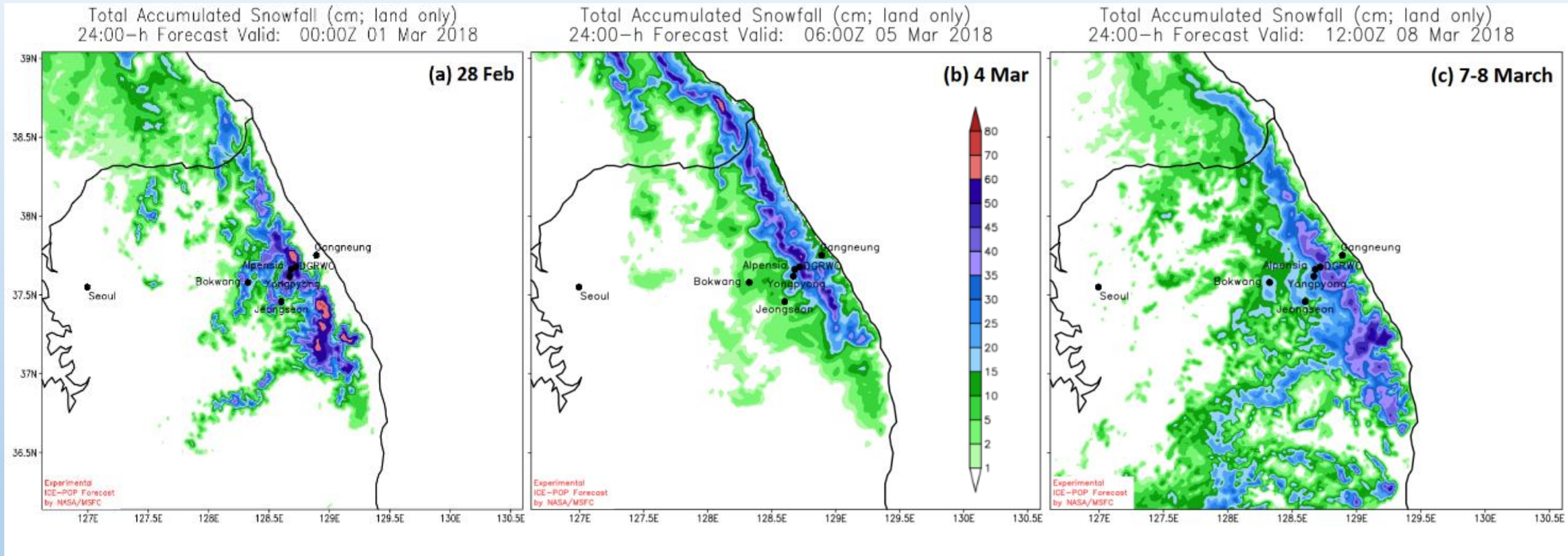
Twenty four-hour simulated snow accumulation [in cm] from the NU-WRF 1-km grid for snowstorm events on (a) 28 February, (b) 4 March, and (c) 7-8 March 2018.

Observations and Simulations from High-Impact Events:
Three Significant Snowstorms between Olympics (Feb) and Paralympics (Mar)

PIP003 at KO2, 2018-02-28T05:56:02Z   136811   697
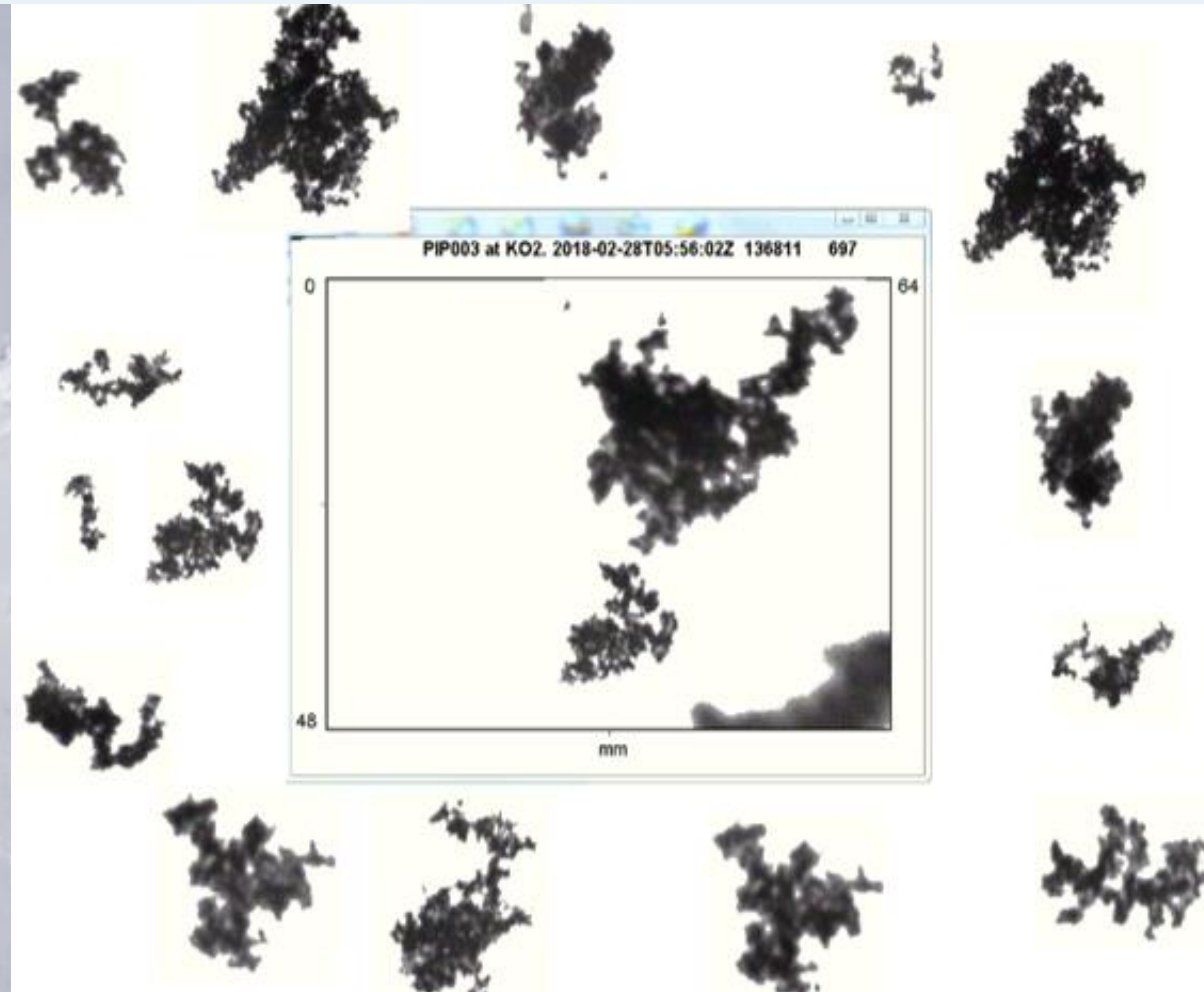
NASA Precipitation Imaging Package (PIP; left) and PIP observations of 2.5+ cm diameter snowflakes, associated with 28 February snowstorm (*courtesy: Kwonil Kim, KNU*)

Observations and Simulations from High-Impact Events:
Three Significant Snowstorms between Olympics (Feb) and Paralympics (Mar)
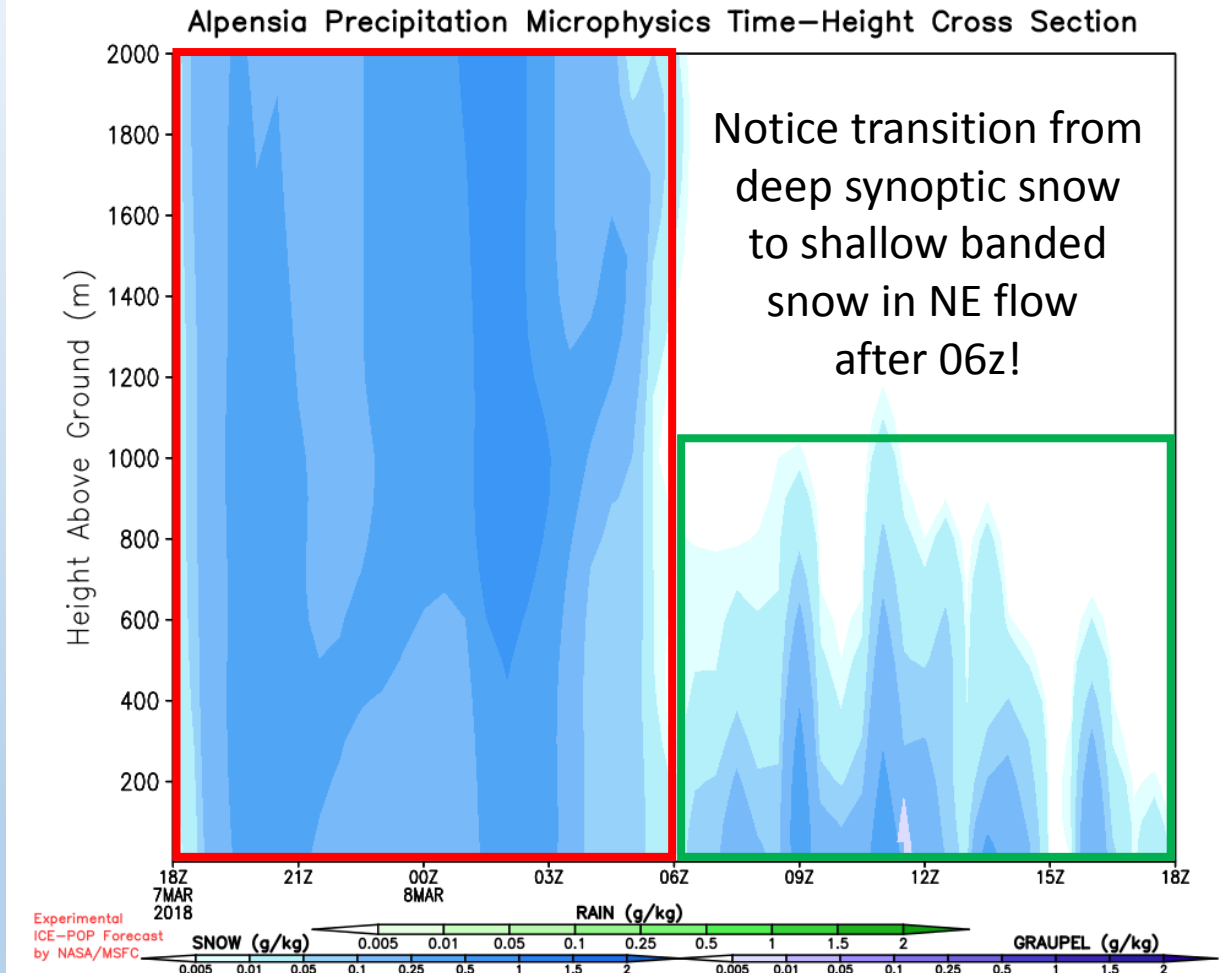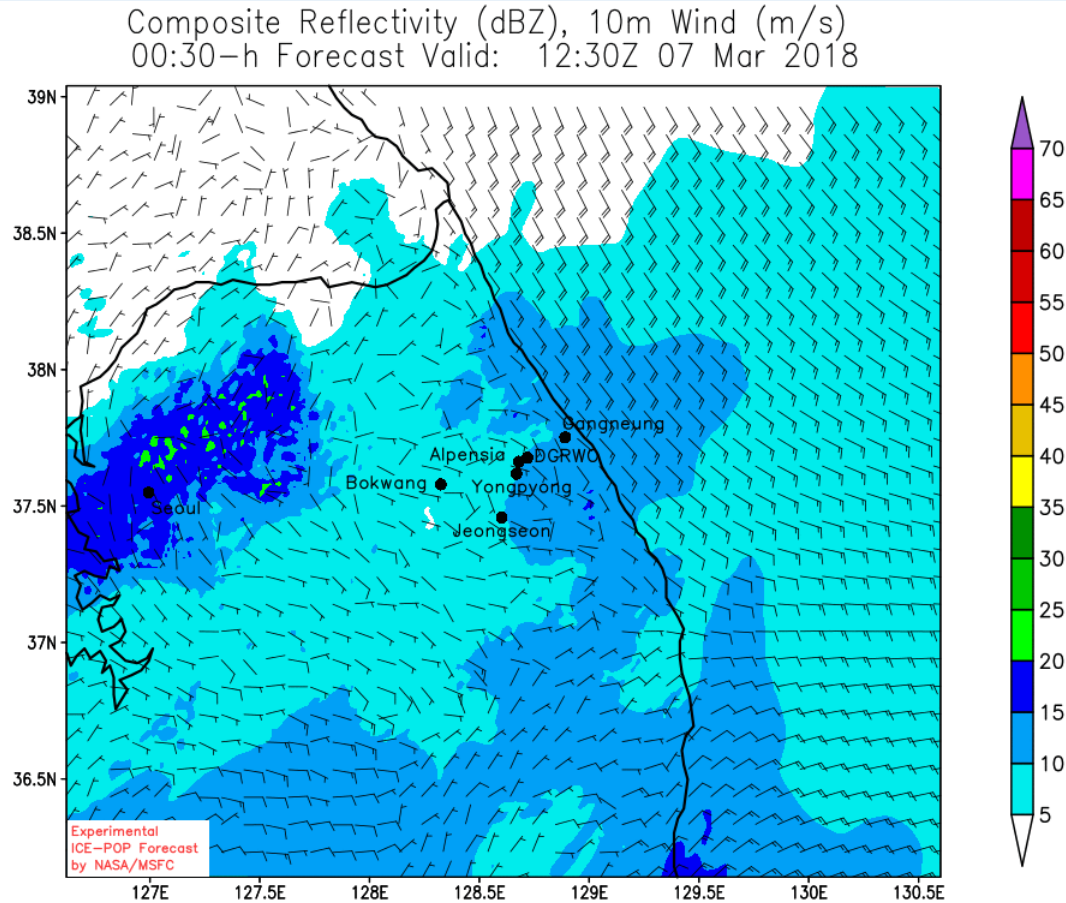
(left) Animation of NU-WRF 1-km grid simulated composite reflectivity, and
(right) Time-height cross section in lowest 2km AGL of precipitation microphysical mixing ratios

# Future Research: ICE-POP Flux Product Data Assimilation

Objective: Conduct data assimilation of retrieved surface temperature, moisture, and wind speed product from L1C GPM data; to assess the data impact on snowstorm forecast through case studies observed by ICE-POP.

Approach: NU-WRF 9 km + 3 km resolution with 62 vertical levels; Community GSI v3.6

Cases: Sea of Japan-effect snow in Japan 15-17 February 2018; Snowstorm in Korea 27-28 February 2018

DA Experiments: Cycled assimilation of the retrieved products every 6 hours;
3D-VAR vs. Ensemble Kalman Filter;
Sensitivity studies and data denial experiments

36-h forecast of precip rate (mm/hr), SLP (hPa) and 10-m wind valid at 1200 UTC 28 Feb 2018
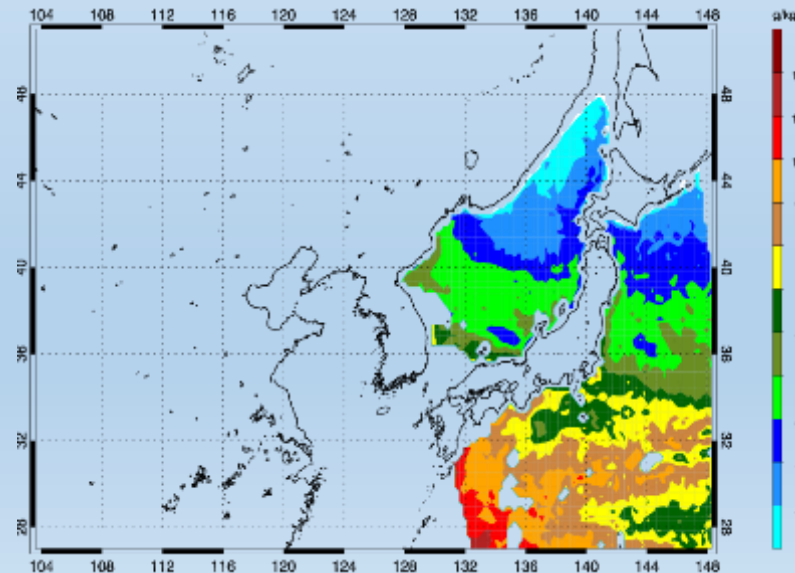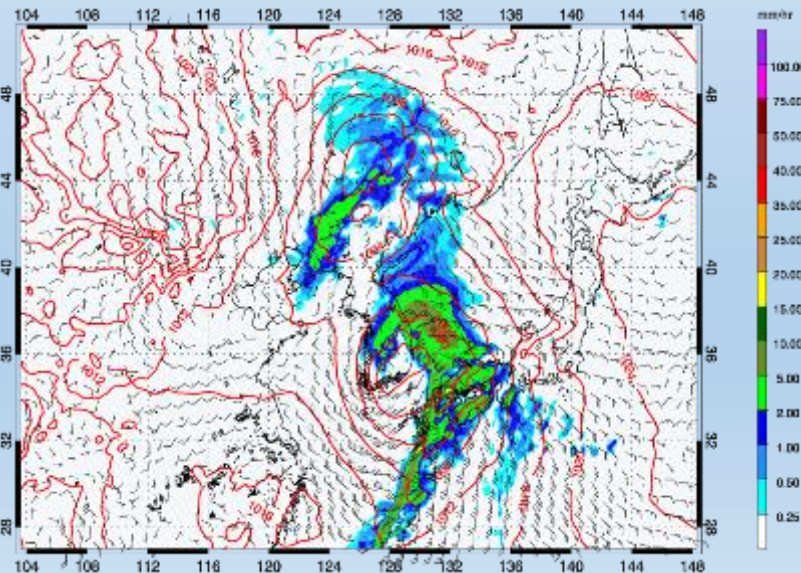
Sample data: retrieved 2-m specific humidity at 0600 UTC 28 Feb 2018

Thank you!!

Questions and Comments Welcome

NASA/SPoRT web: https://weather.msfc.nasa.gov/sport/

Twitter: @NASA_SPoRT

Facebook: NASA.SPoRT