

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

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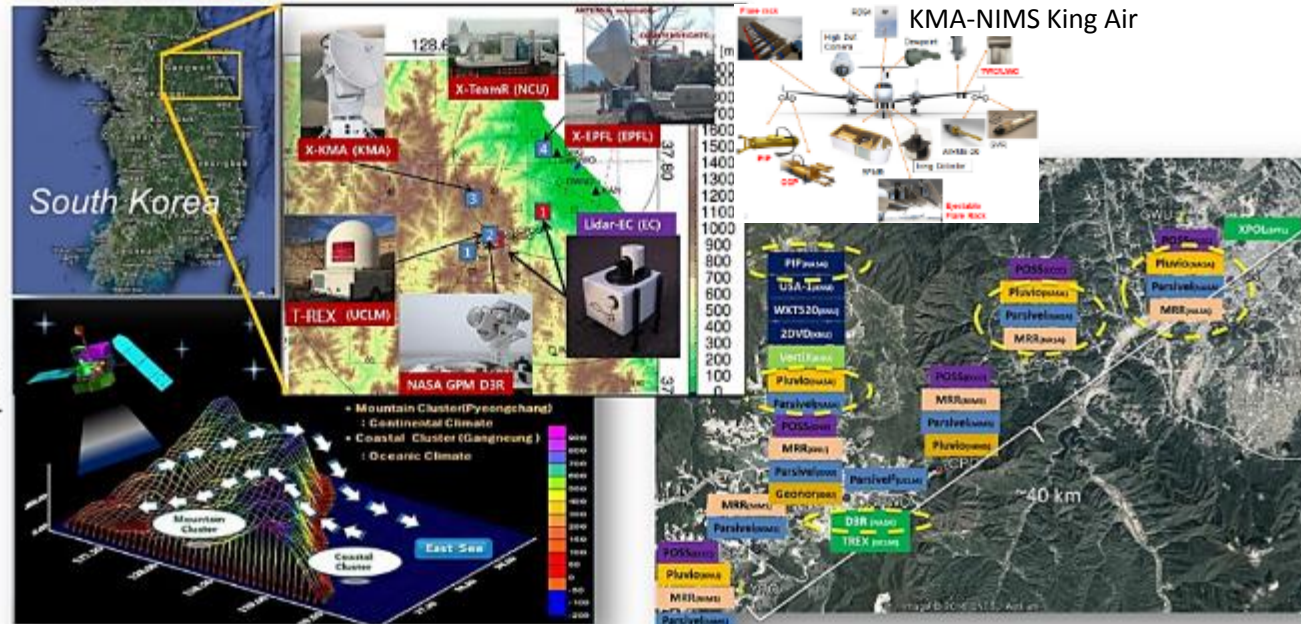
- KMA-led, WMO WWRP-sponsored winter precipitation project (Jan-Mar. 2018)
- Objective: Improve understanding and prediction of orographic falling snow

**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

Coast to mountain  
SW-NE instrument  
transect/clusters

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

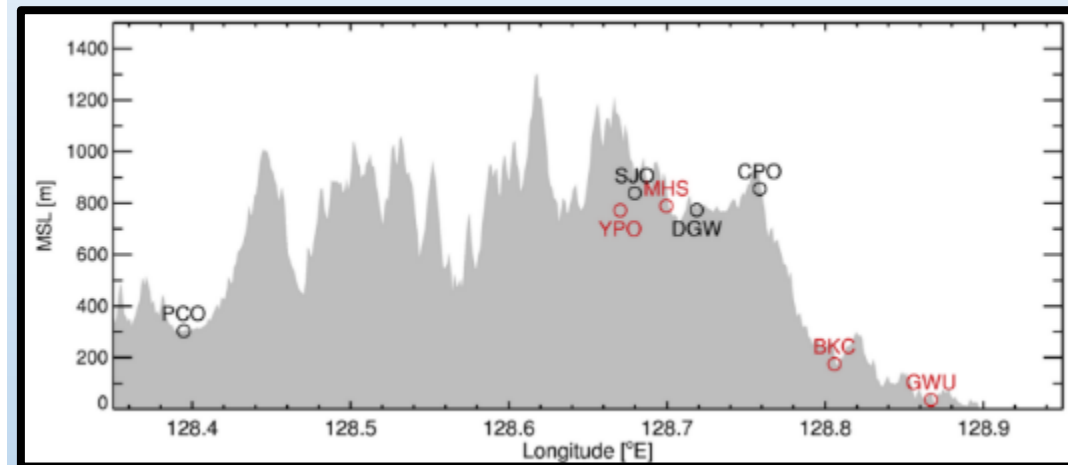
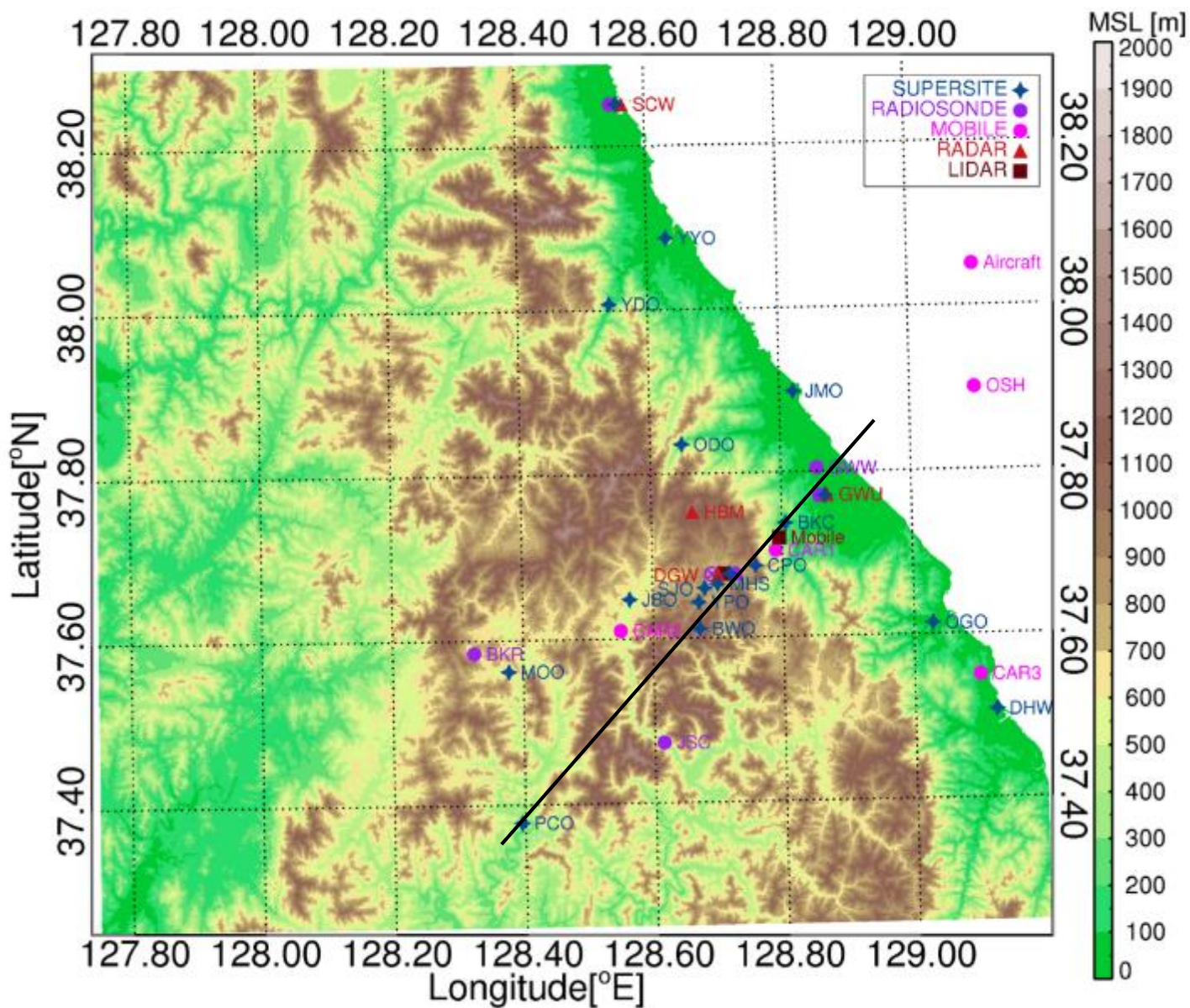


**NASA Contributions:**

- GPM GV Instruments- D3R, MRRs, PIPS, Pluvios, Parsivels
- SPoRT GPM products (including NRT surface SH/LH fluxes)
- NU-WRF model forecasts/research

Network, aircraft images courtesy Korean  
Meteorological Administration

# Ocean to Summit Instrument Transects



Courtesy: G. Lee

# Ground Instrument Supersites

West ←

Mountain ranges

→ East

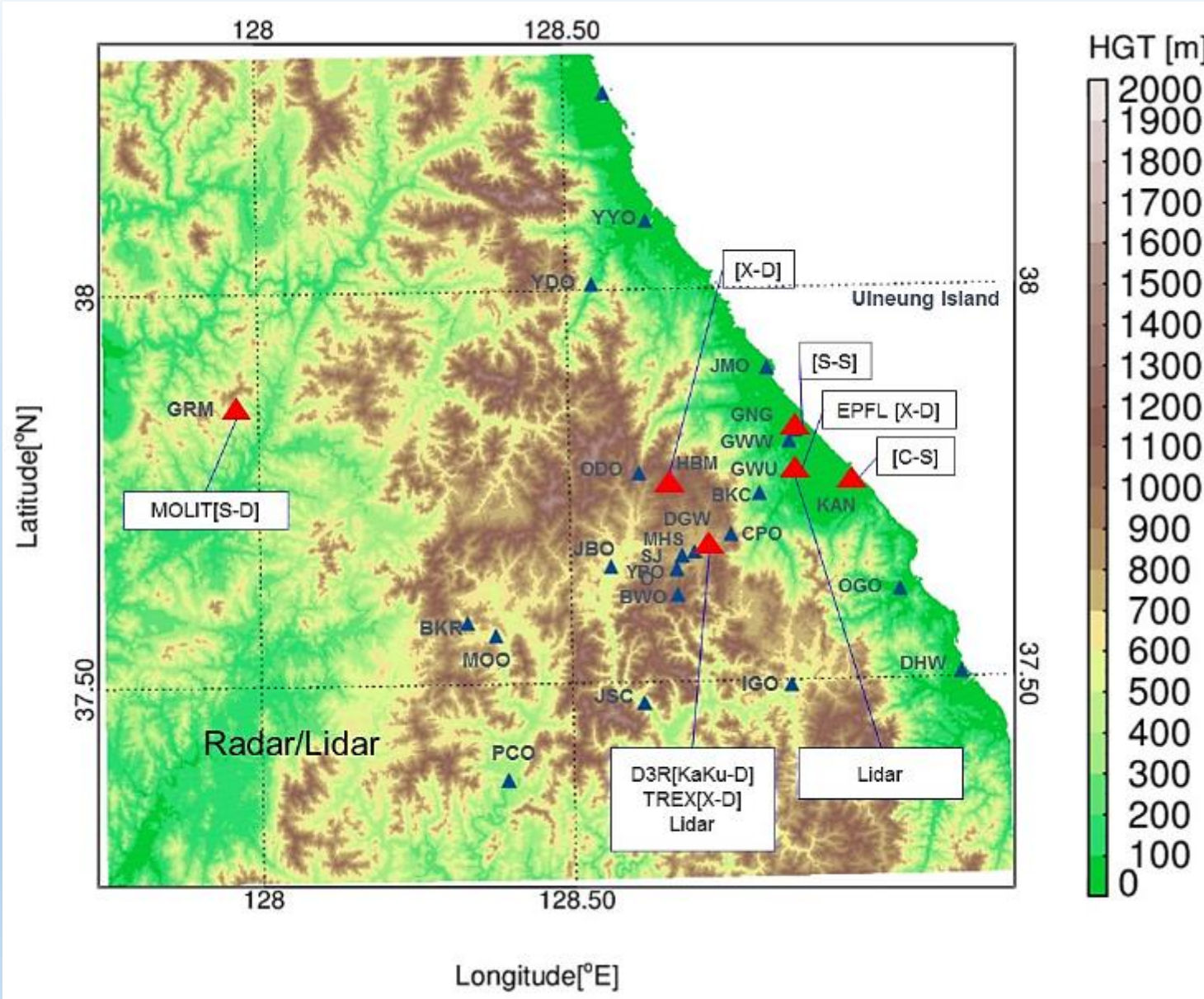


YPO	MHS	CPO	BKC	GWU
MRR-2	MRR-2	MRR-2	MRR-2	MRR-2
Parsivel <sup>2</sup>	Parsivel <sup>2</sup> (DFIR)	Parsivel <sup>2</sup>	Parsivel <sup>2</sup>	Parsivel <sup>2</sup>
POSS	POSS	POSS	POSS	POSS
Pluvio <sup>2</sup> 200 (Belfort Double Alter shield)	Pluvio <sup>2</sup> 400 (DFIR + Tretyakov + Alter shield)	Pluvio <sup>2</sup> 200 (No shield)	Pluvio <sup>2</sup> 400 (Tretyakov + Alter shield)	Pluvio <sup>2</sup> 400 (Tretyakov + Alter shield)
Raingauge	Raingauge	Raingauge	Raingauge	Raingauge
	2DVD (DFIR)	Ceiliometer	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 <sup>1</sup>	Automatic cloud observation system		
		AWS		

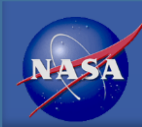


Images Courtesy G. Lee, KNU, Korea

# Multi-frequency, Polarimetric Radar Coverage



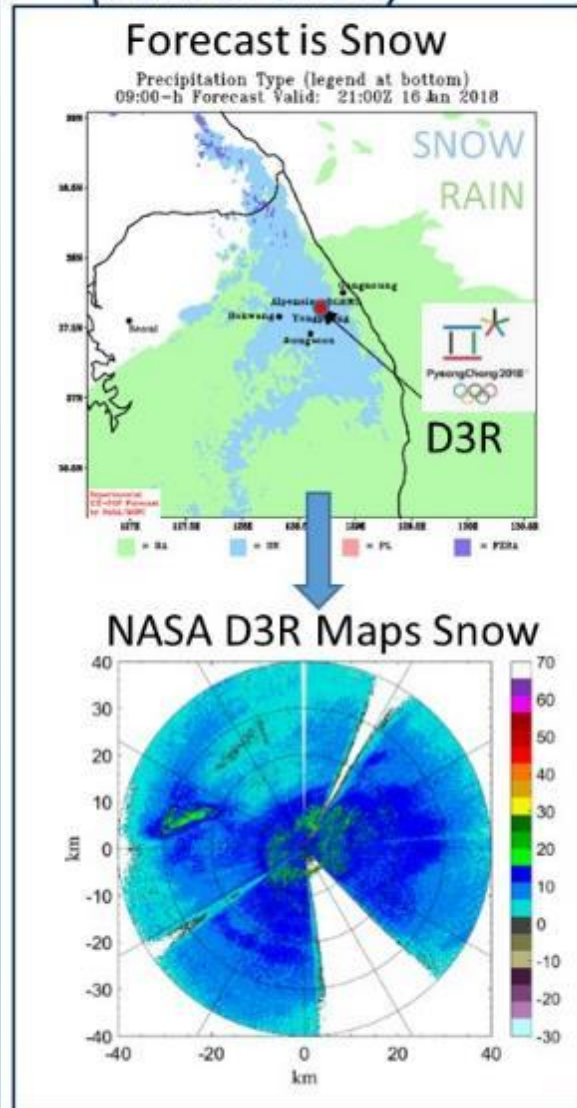
S--band (S),  
X-band (X),  
Ka-Ku,  
C-band (C),  
D= Dual-Pol,  
S=Single pol



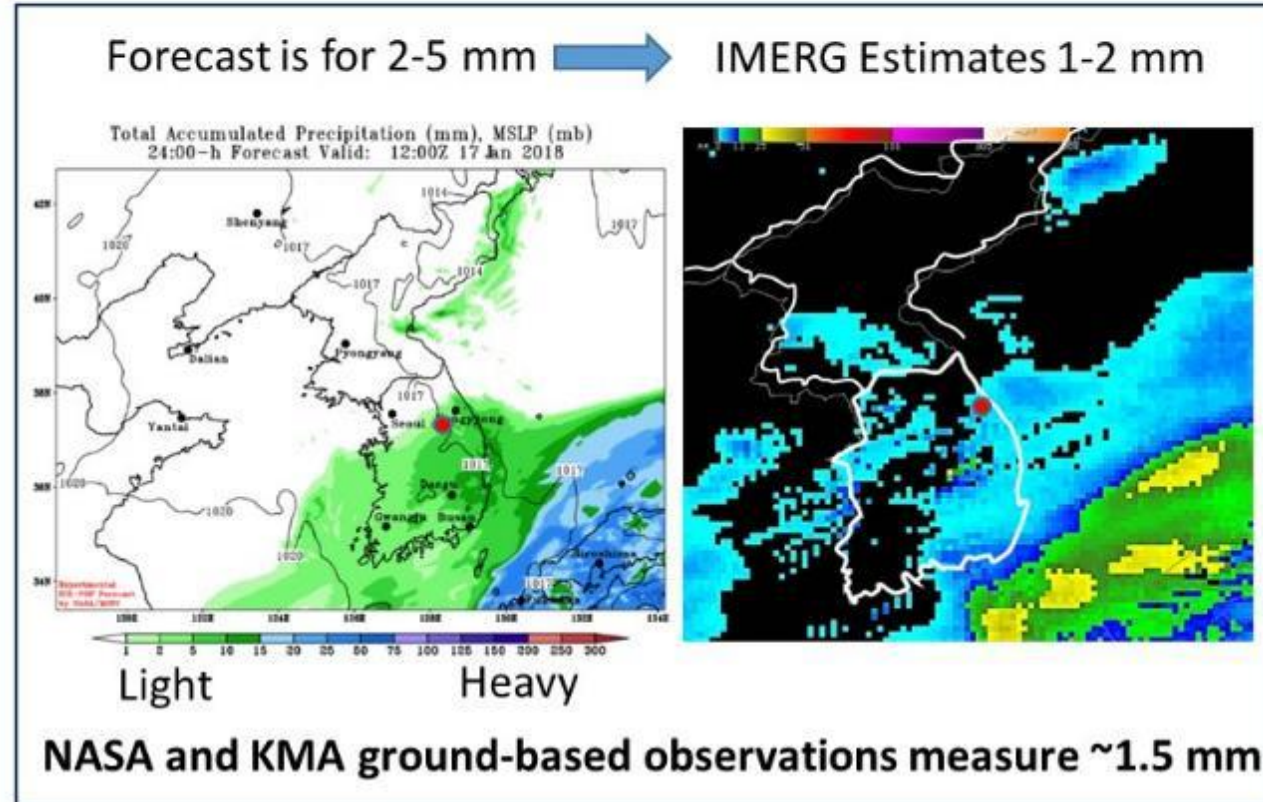
# ICE-POP Campaign examining agreement between forecast and remote/in situ snowfall observations over complex terrain



## Precipitation Type (Rain or Snow)



## Precipitation Amount (24-hr estimate)



**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

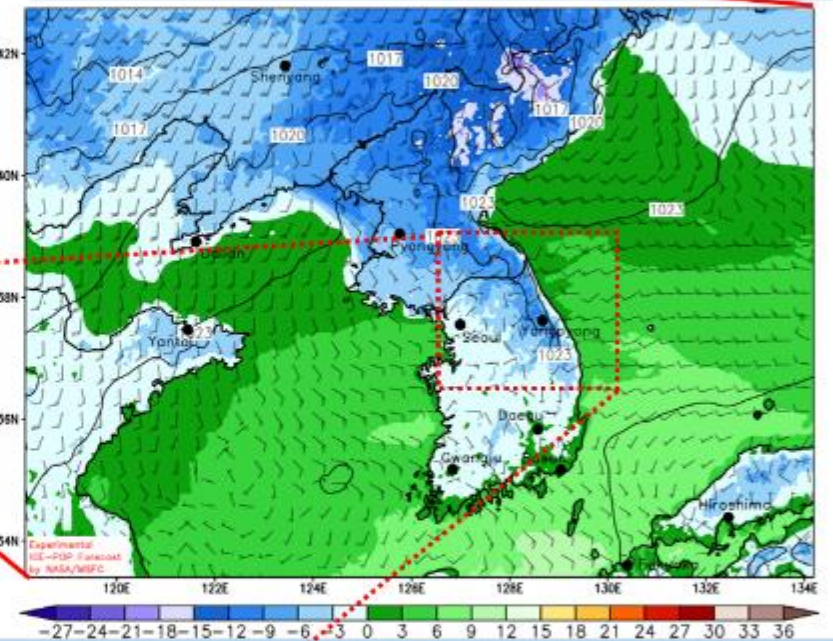
# NU-WRF Real-time Model Configuration for ICE-POP

## 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

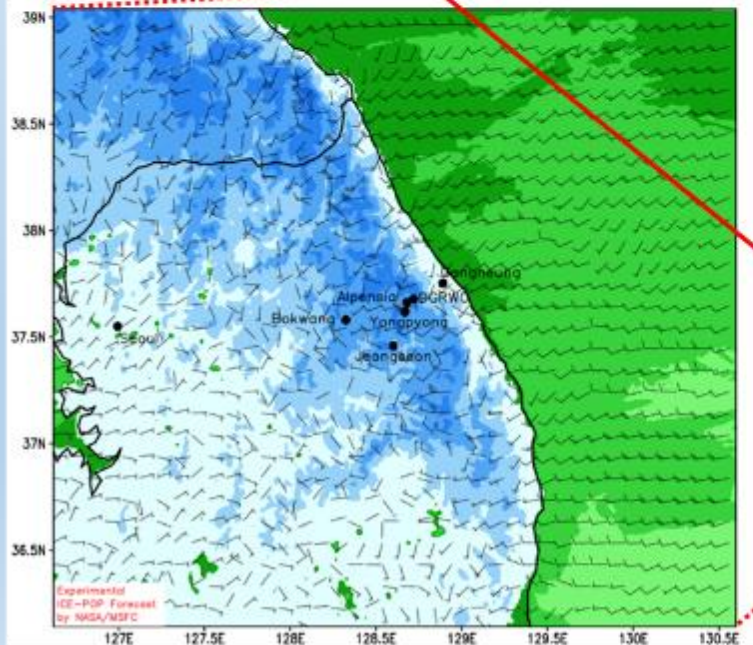
2m Temperature (C), MSLP (mb), 10m Wind (m/s)  
24:00-h Forecast Valid: 12:00Z 08 Feb 2018

← 9-km outer grid

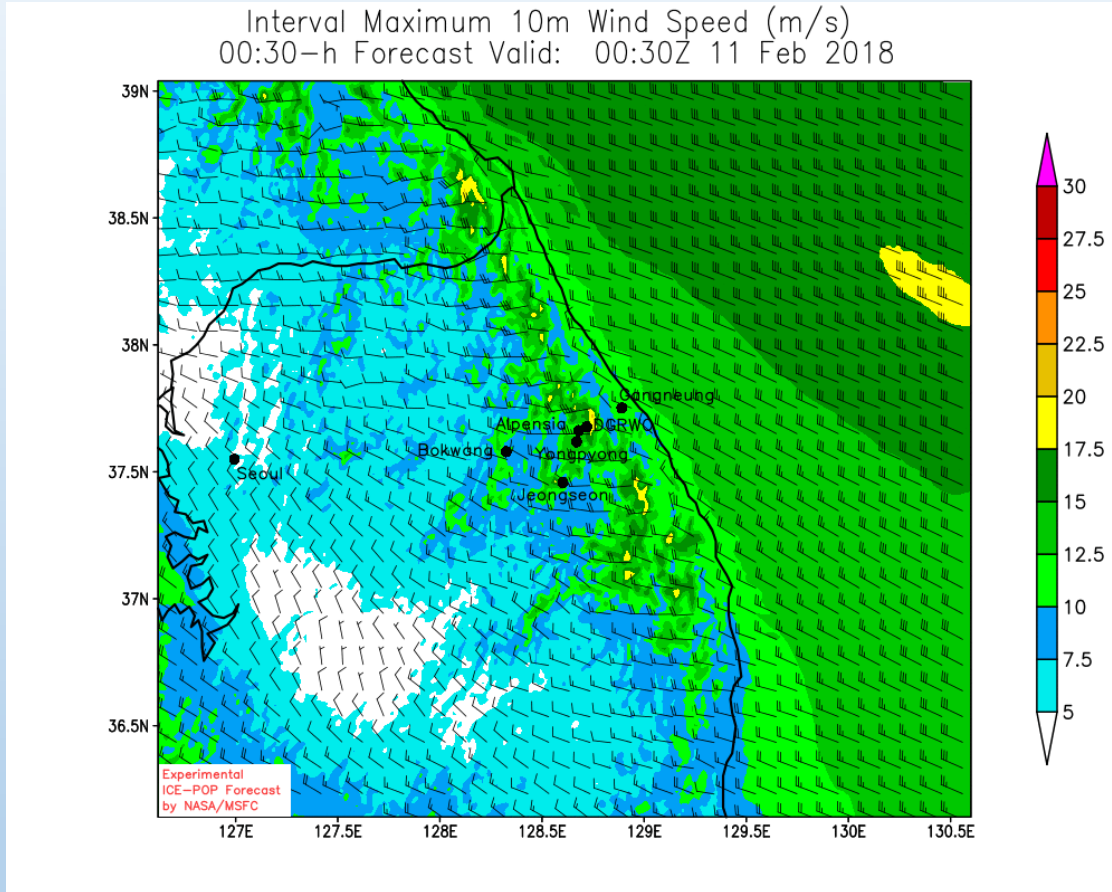


↑ 3-km Korea nest

← 1-km "Olympics" nest

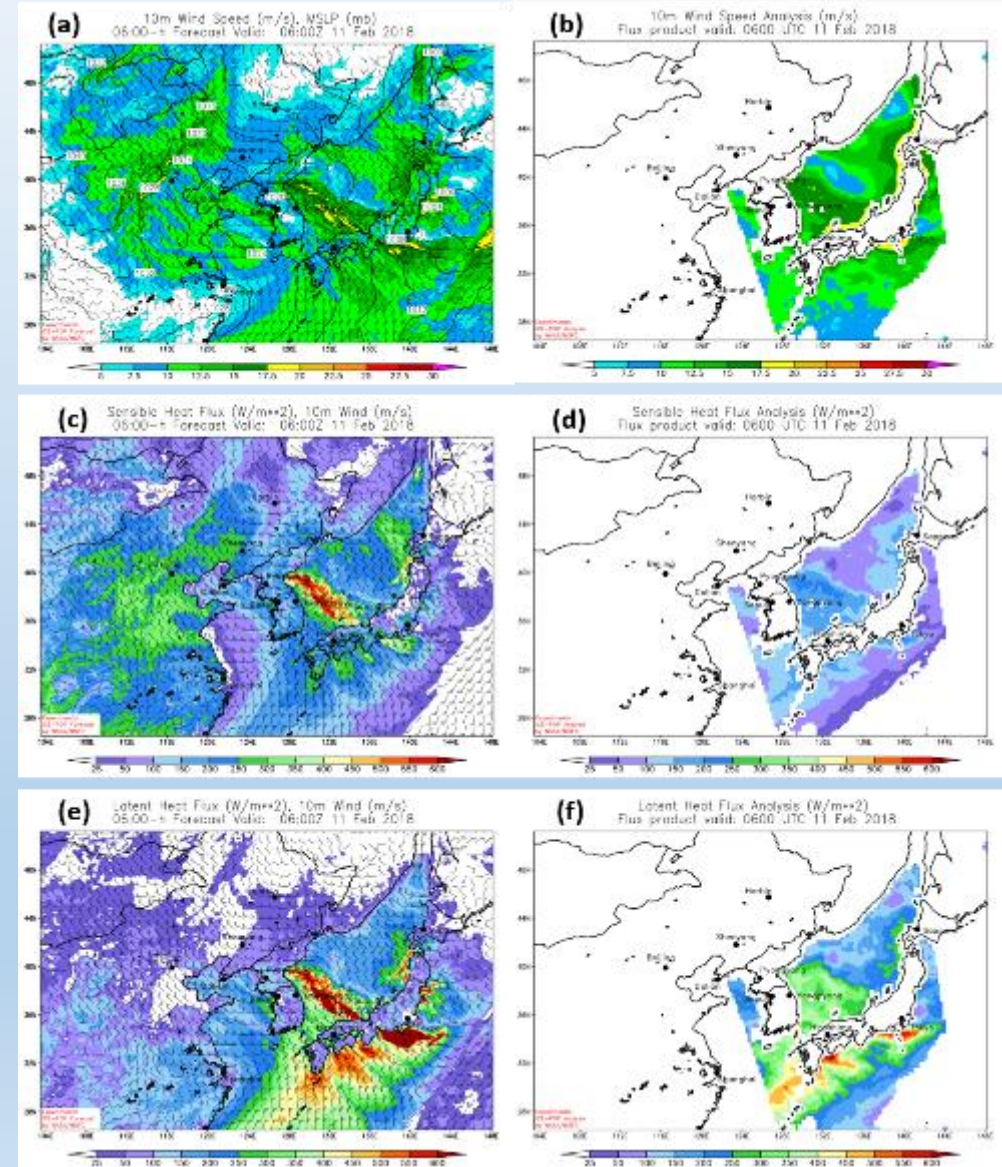


# Observations and Simulations from High-Impact Events: *11 February High Winds Delayed Mens' Downhill*



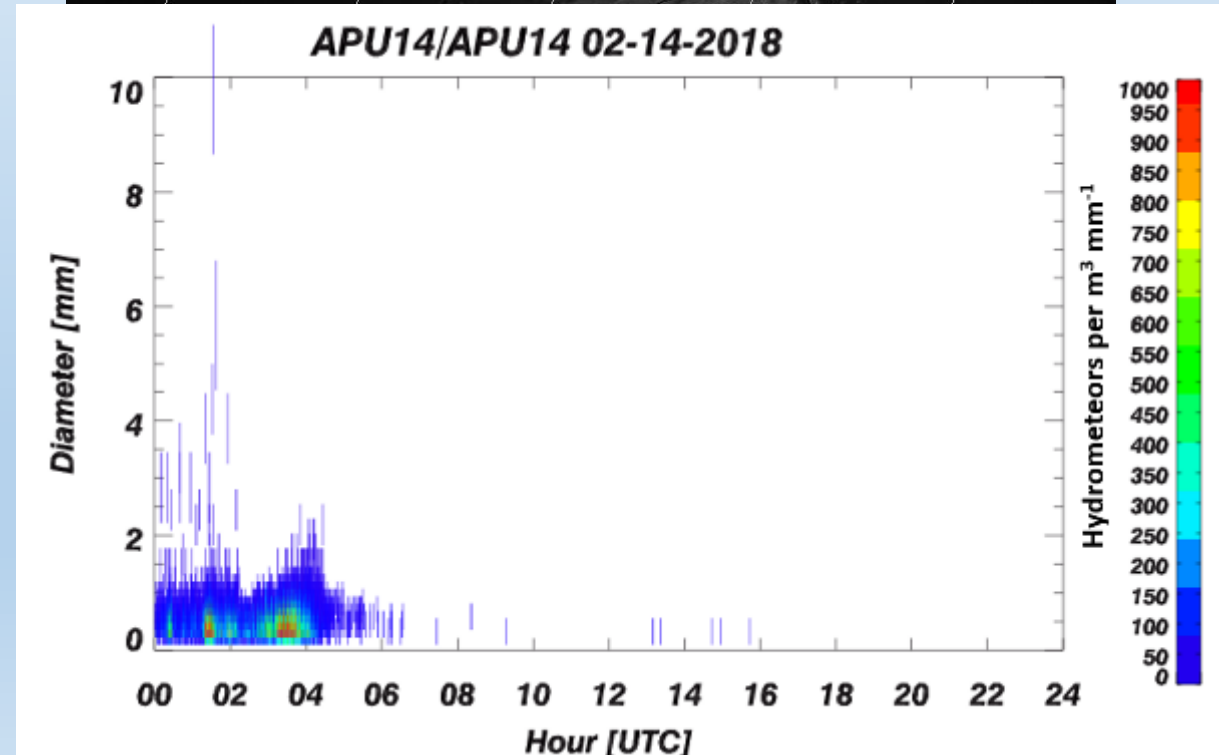
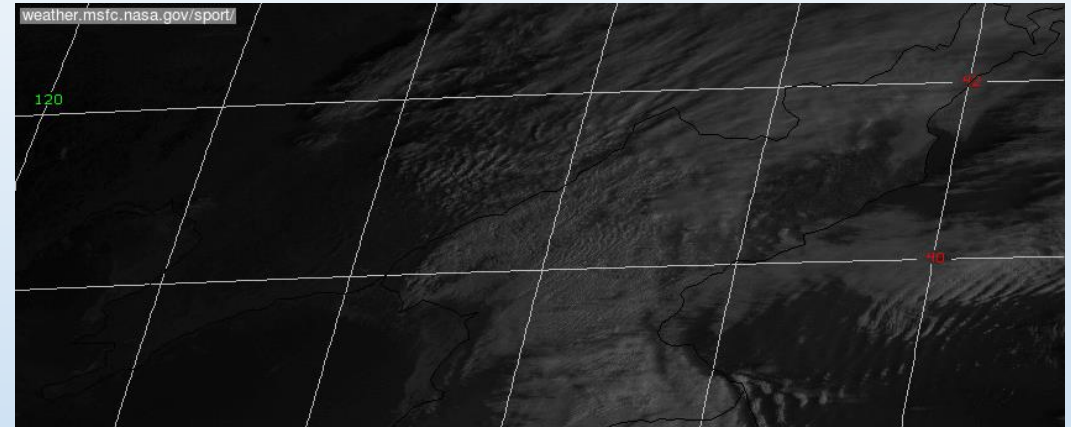
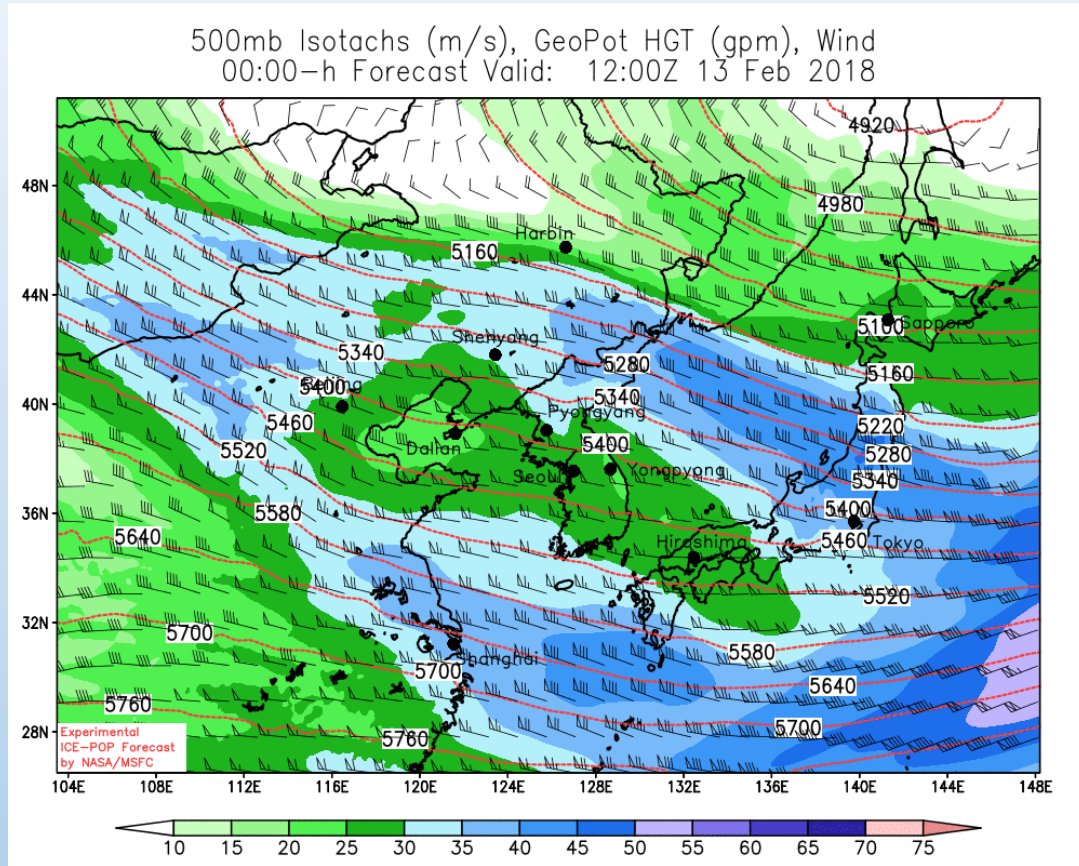
(above) Animation of 30-min interval maximum 10m wind speeds from NU-WRF 1km nested grid.

(right) Comparison between NU-WRF 9-km grid [left column] 10m winds, sensible, & latent heat flux to passive microwave oceanic retrievals [right column]



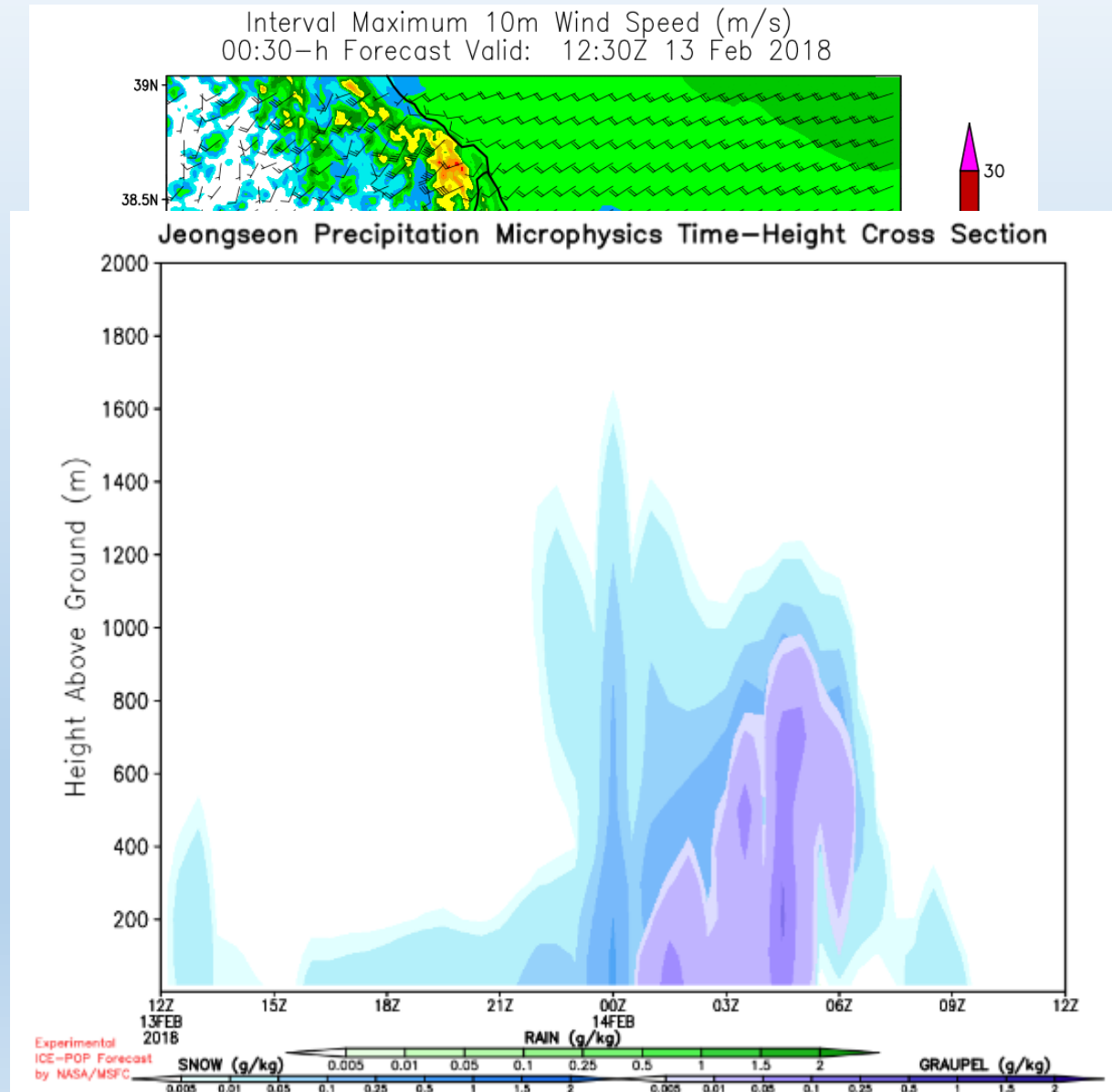
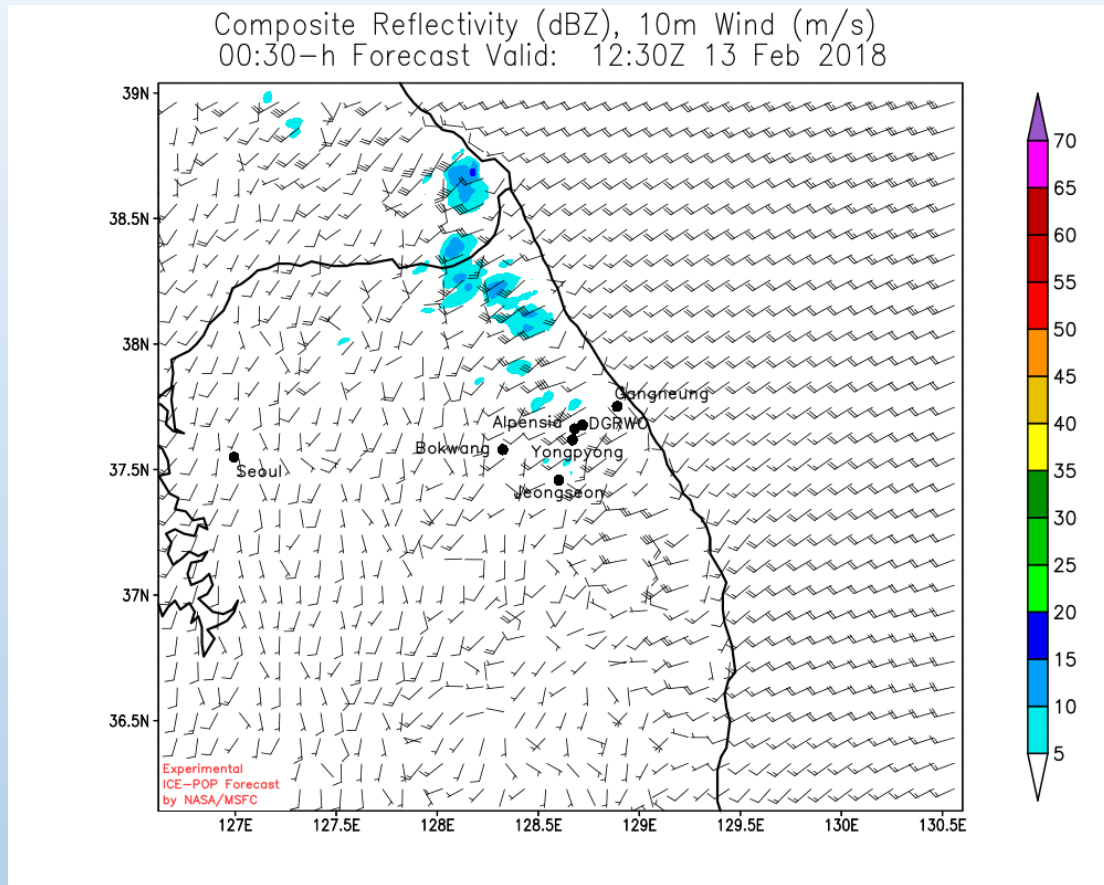


# Observations and Simulations from High-Impact Events: 14 Feb Shallow Snow & High Winds Disrupted Skiing on Jeongseon Hill



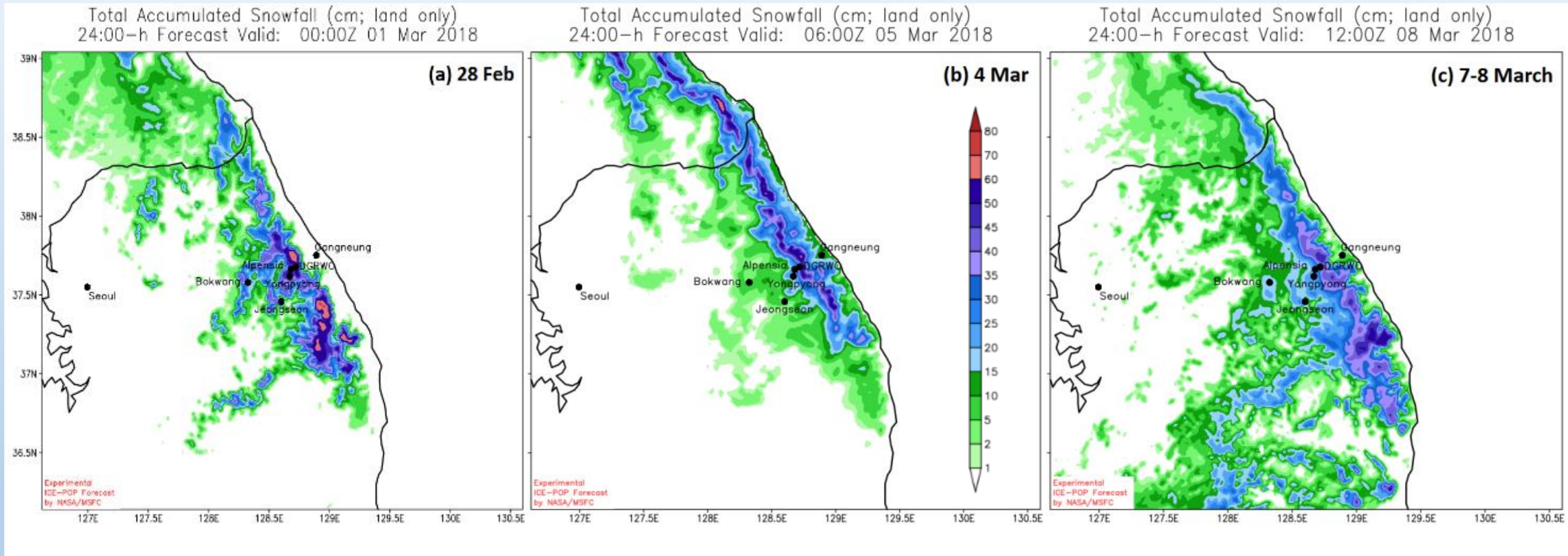
- (above) Animation of 3-hourly 500-mb isotachs from NU-WRF 9km grid
- (right) Animation of visible satellite imagery from JMA Himawari
- (bottom-right) Disdrometer measurements, showing high concentration of primarily small hydrometeors between 01-04z

# Observations and Simulations from High-Impact Events: *14 Feb Shallow Snow & High Winds Disrupted Skiing on Jeongseon Hill*



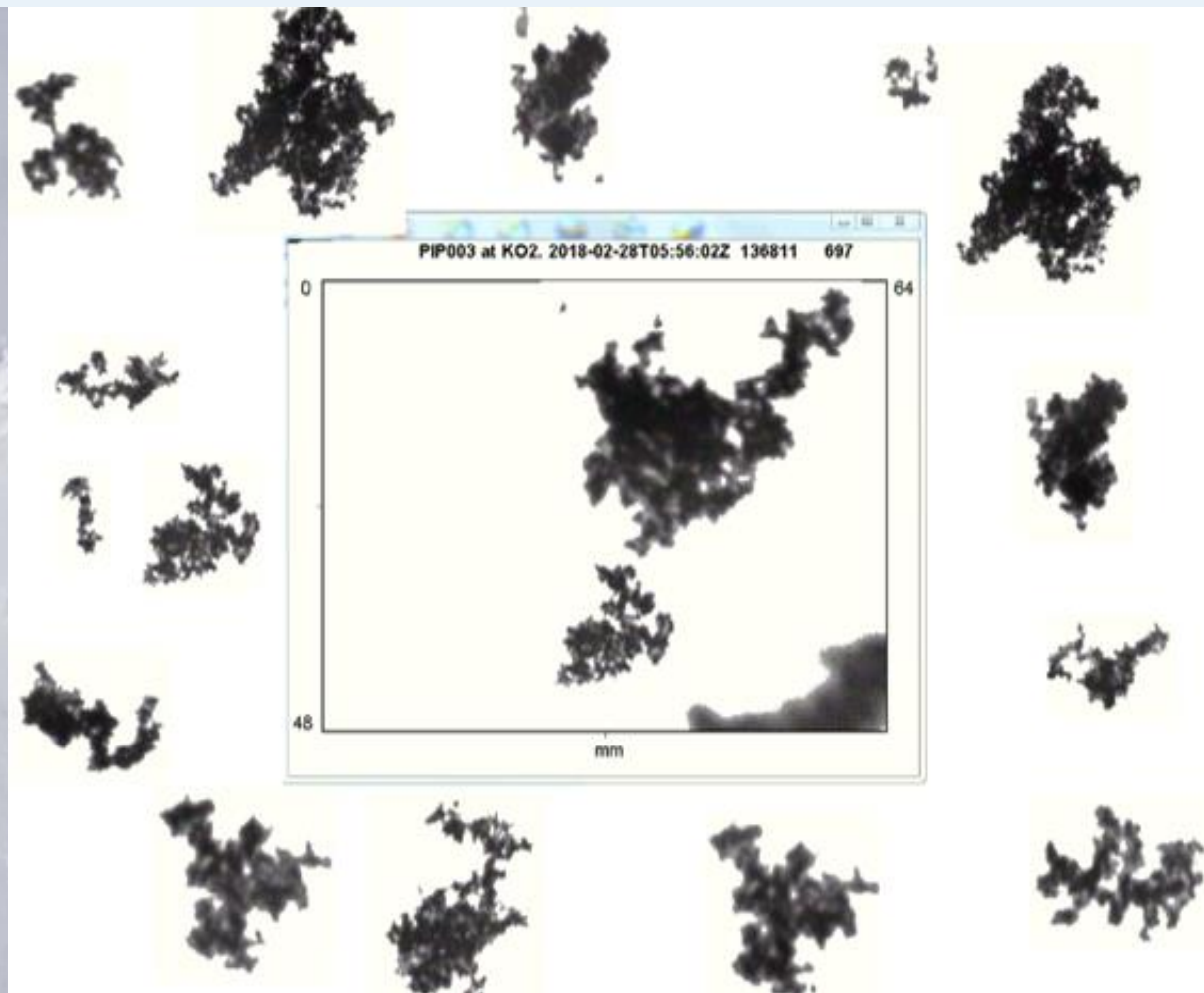
(above) Animation of 30-min Comp. reflectivity from 1-km grid  
(right) Animation of 30-min interval maximum 10m wind speed  
(bottom) Time-height cross section in lowest 2km AGL of precipitation microphysical mixing ratios

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



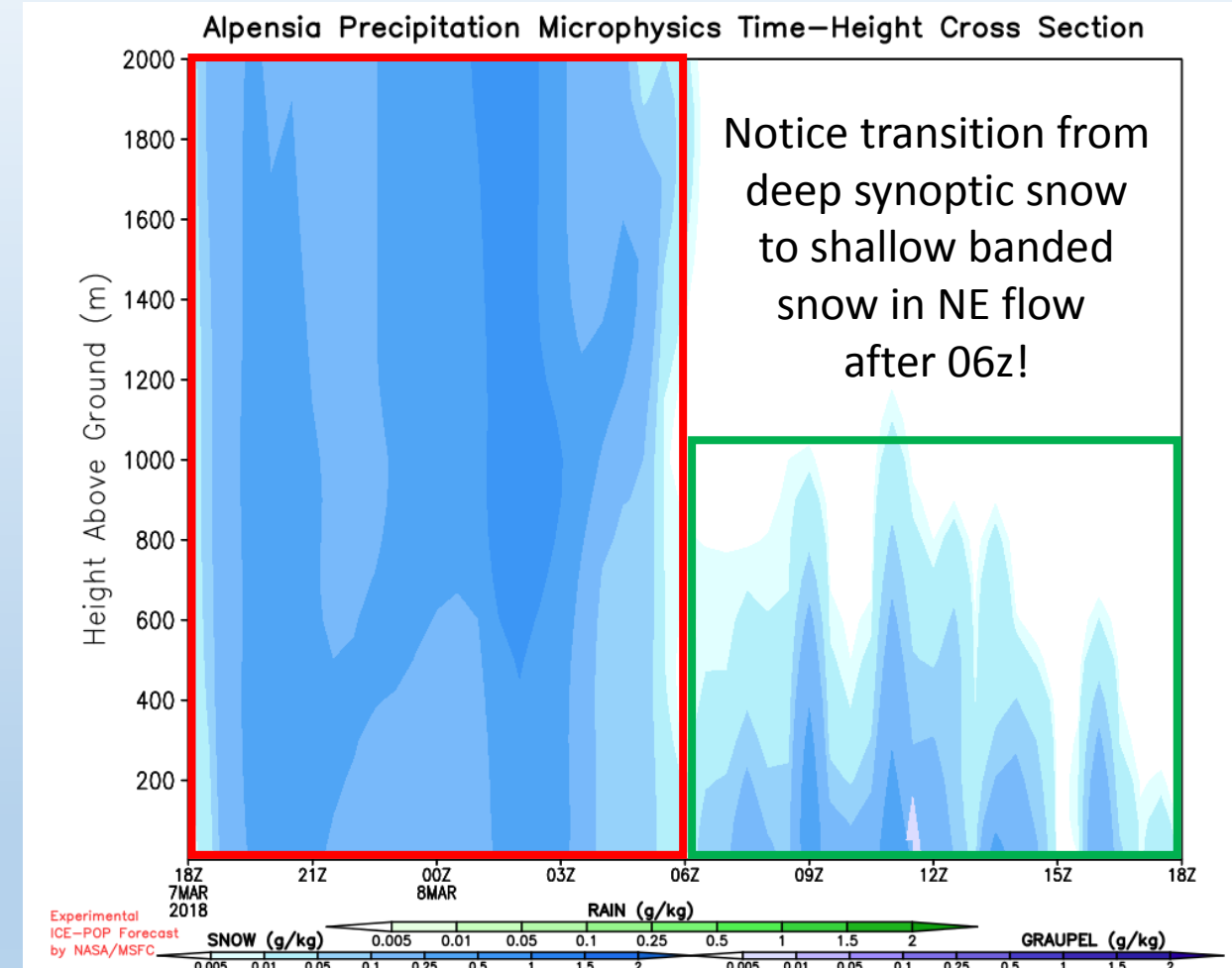
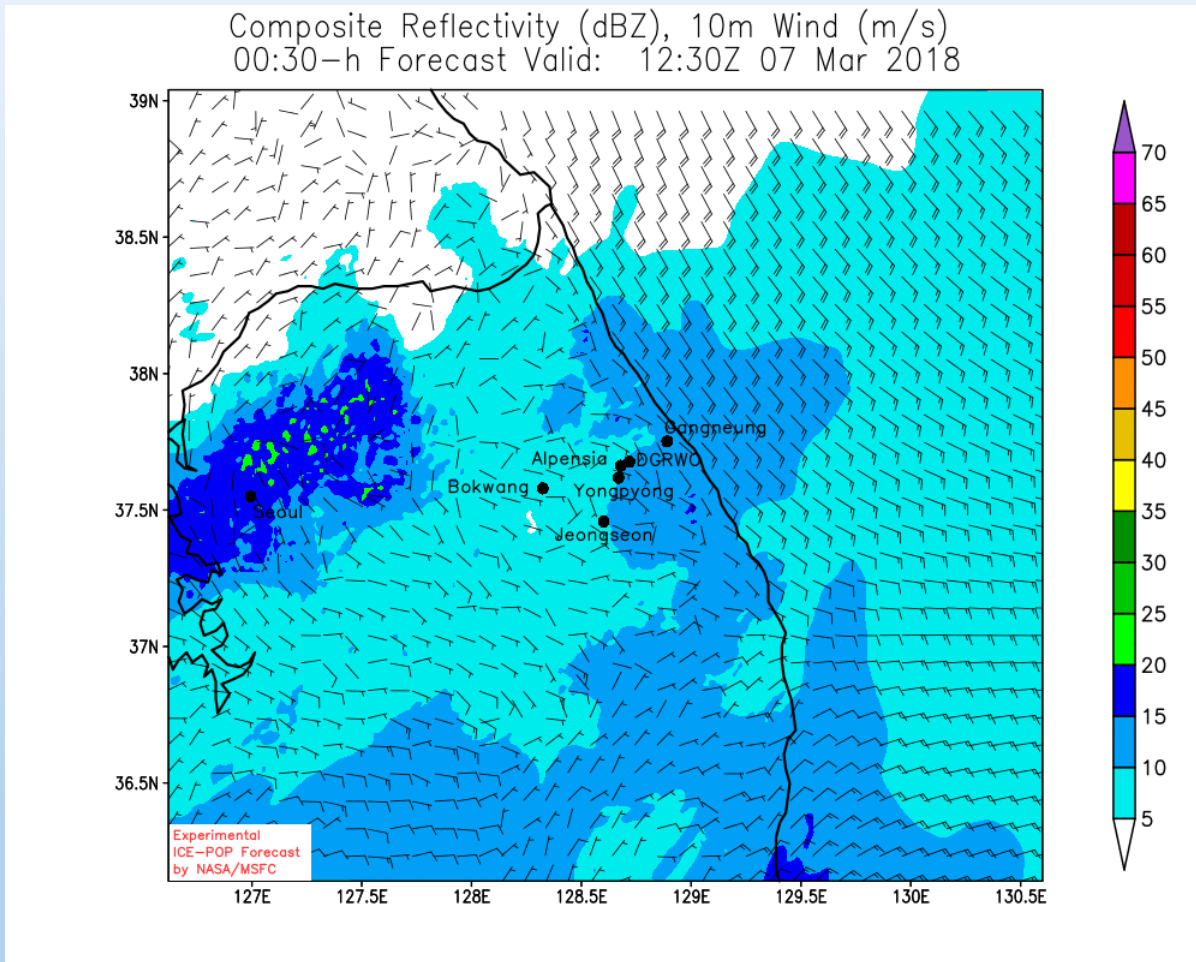
Twenty four-hour simulated snow accumulation [in cm] from the NU-WRF 1-km grid for snowstorm events on (a) 28 February, (b) 4 March, and (c) 7-8 March 2018.

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



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

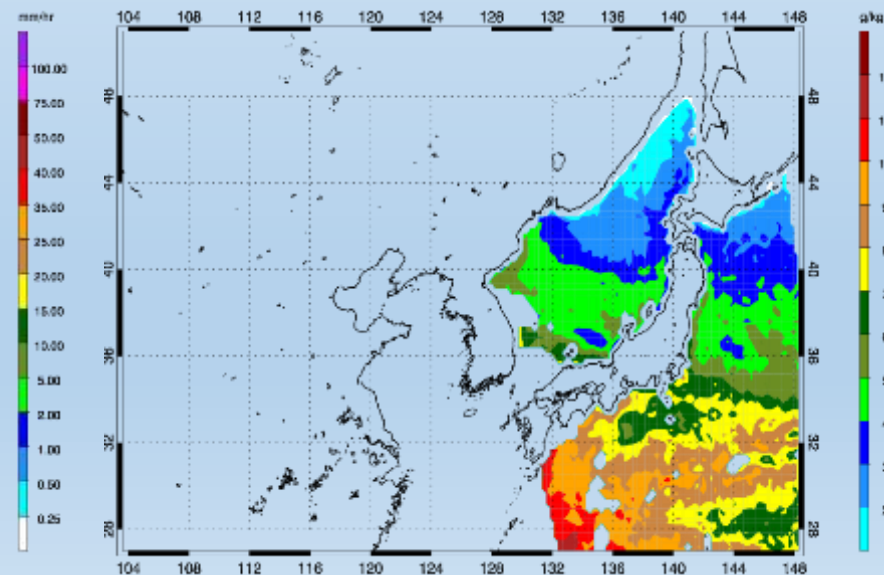
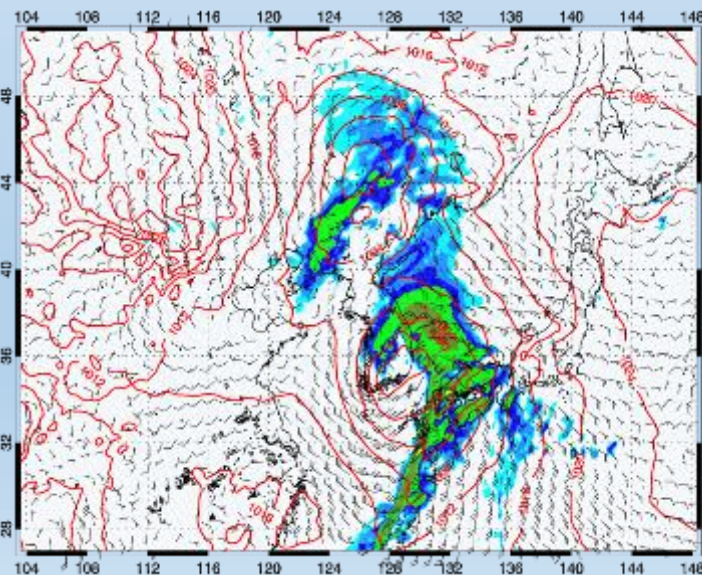
**Objective:** Conduct data assimilation of retrieved surface temperature, moisture, and wind speed product from L1C GPM data; to assess the data impact on snowstorm forecast through case studies observed by ICE-POP.

**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

**Acknowledgement:** *We are grateful for the opportunity provided by the Korean Meteorological Agency (KMA) and to the support provided by the World Meteorological Organization (WMO) making possible the ICE-POP 2018 weather research and development projects during the Olympic and Paralympic Winter Games PyeongChang2018.*