Recent experiences in event forecasting and connections to TEAM-X from ZAMG perspective

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ZAMG
Zentralanstalt für Meteorologie und Geodynamik

TEAM-X Programme and Applications Webinar, 6 May 2020

Outline

1. Supporting forecasters at the Olympics 2010-2018

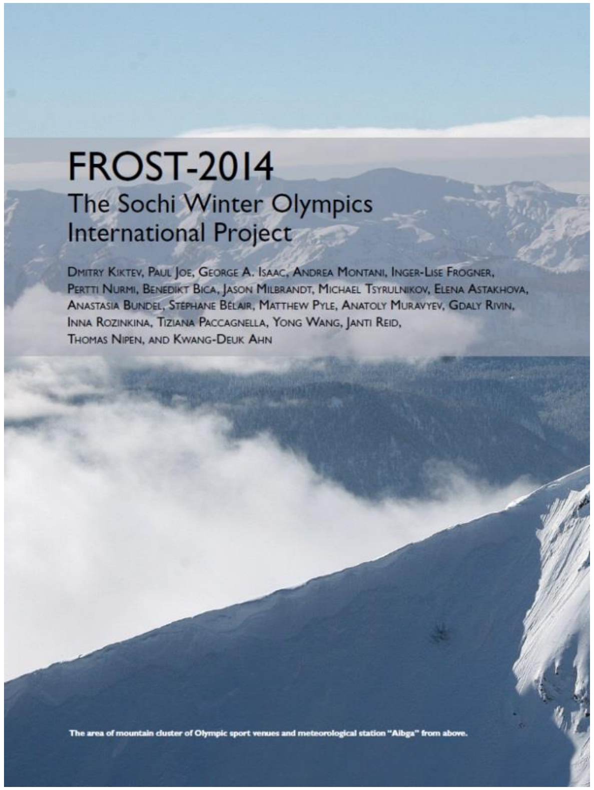
2. Survey of forecasters at ZAMG: Input for TEAM-X

Scientific motivation

- Isaac, G.A., Joe, P.I., Mailhot, J. *et al.* Science of Nowcasting Olympic Weather for Vancouver 2010 (SNOW-V10): a World Weather Research Programme Project. *Pure Appl. Geophys.* **171,** 1–24 (2014).

- Kiktev, Dmitry *et al.* (2017). FROST-2014: The Sochi winter Olympics international project. *Bulletin of the American Meteorological Society*. **98**. 1908–1929. 10.1175/BAMS-D-15-00307.1.

- ICE-POP 2018: http://155.230.157.230:8080/Icepop_2018/index.jsp



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Scientific motivation

- *"The SNOW-V10 international team* ***augmented the instrumentation*** *associated with the Winter Games and several new* ***numerical weather forecasting and nowcasting models were added****. Both the additional observational and model data were available to the forecasters in real time. This was an excellent opportunity to* ***demonstrate existing capability in nowcasting and to develop better techniques*** *for short term (0–6 h) nowcasts of winter weather in complex terrain."*
  (Isaac et al., 2014)

- *"… FROST-2014 (FROST - Forecast and Research in the Olympic Sochi Testbed) was targeted at the* ***advancement and demonstration of state-of-the art nowcasting and short-range forecasting systems for winter conditions in mountainous terrain****. […] An enhanced network of in-situ and remote sensing observations supported weather predictions and their verification. Six nowcasting systems […], nine deterministic mesoscale numerical weather prediction models (with grid spacings down to 250 m), and six ensemble prediction systems […] participated in FROST-2014."*
  (Kiktev et *al.*, 2017)

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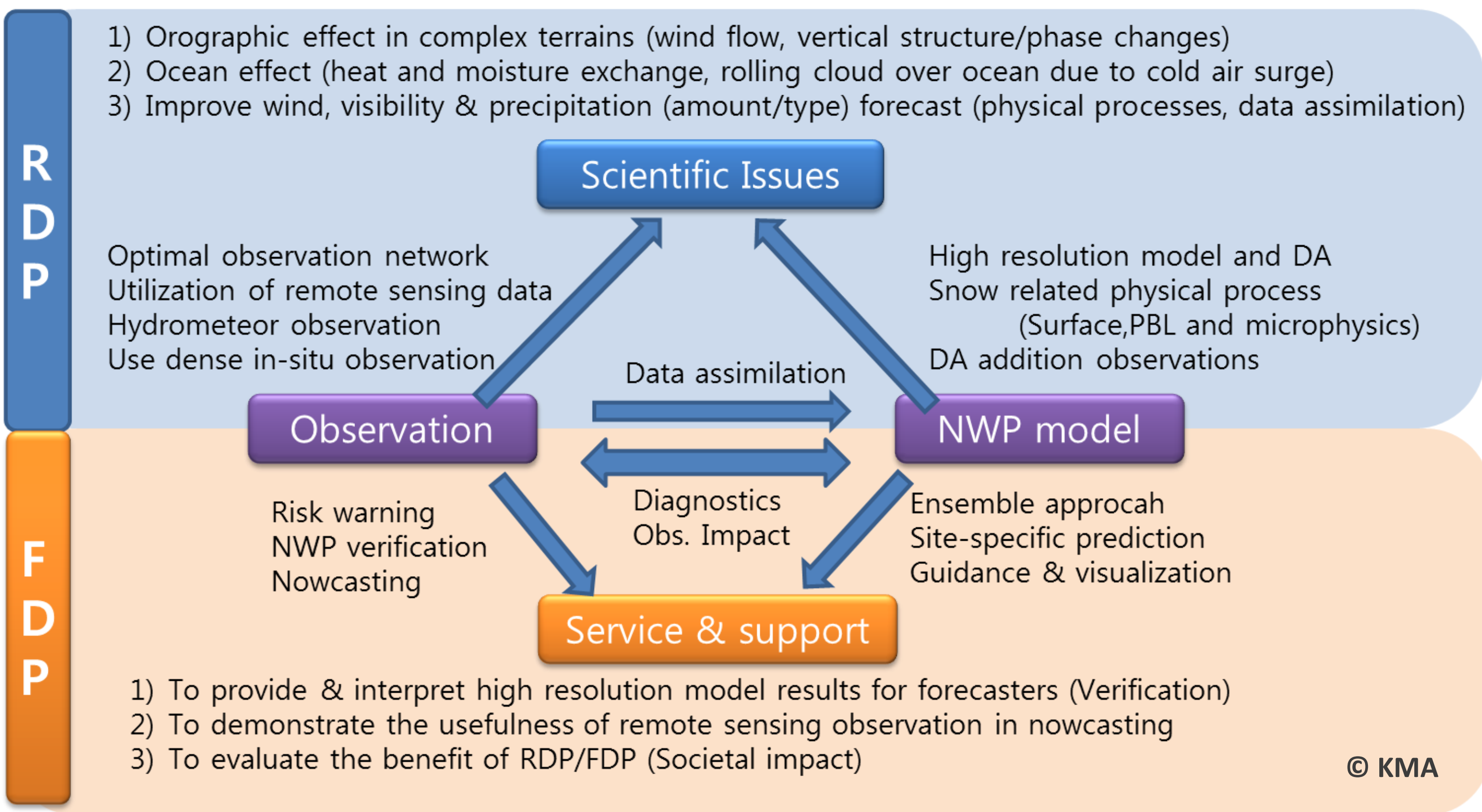
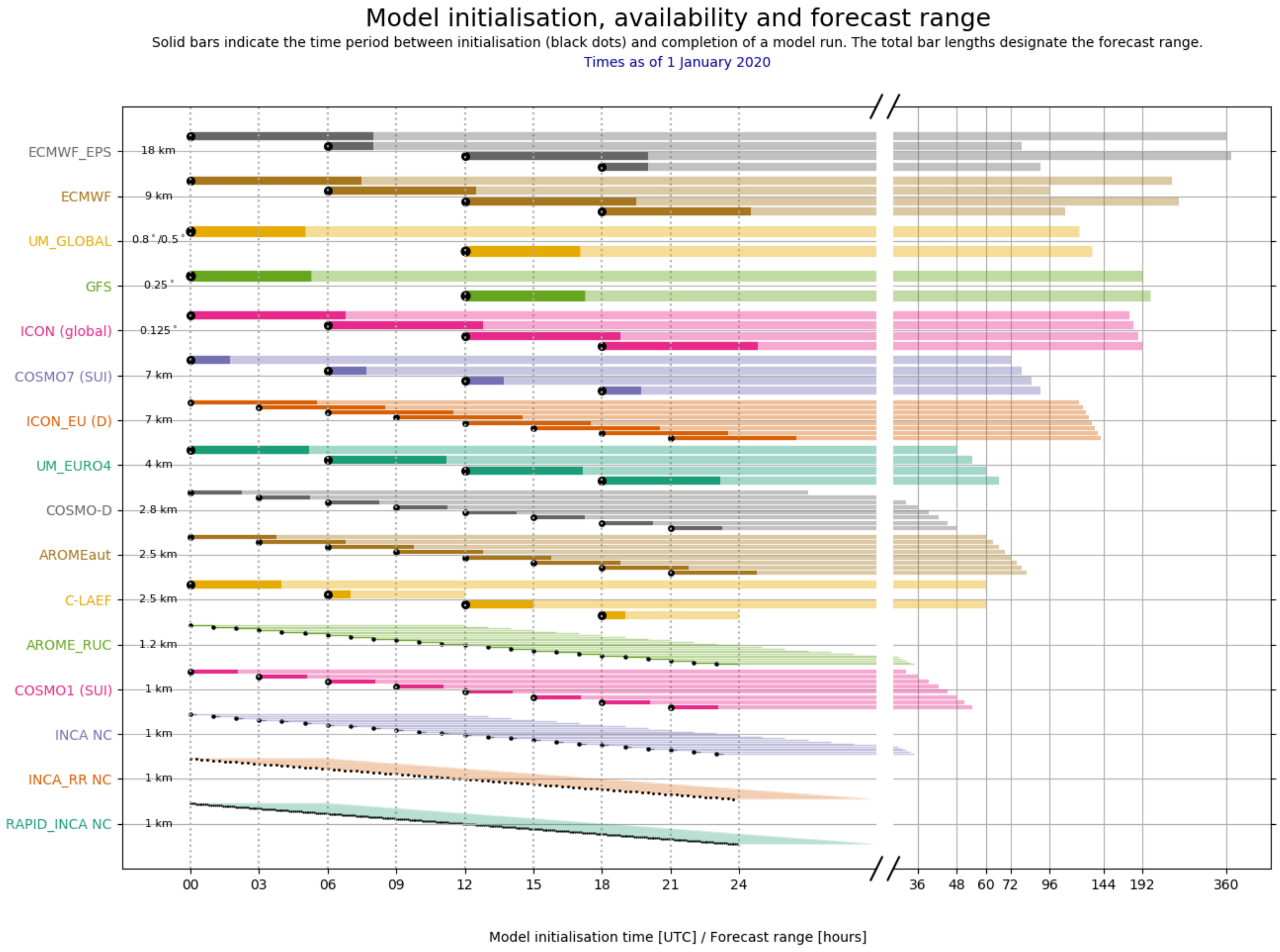
ICE-POP 2018: Goal and scientific challenges

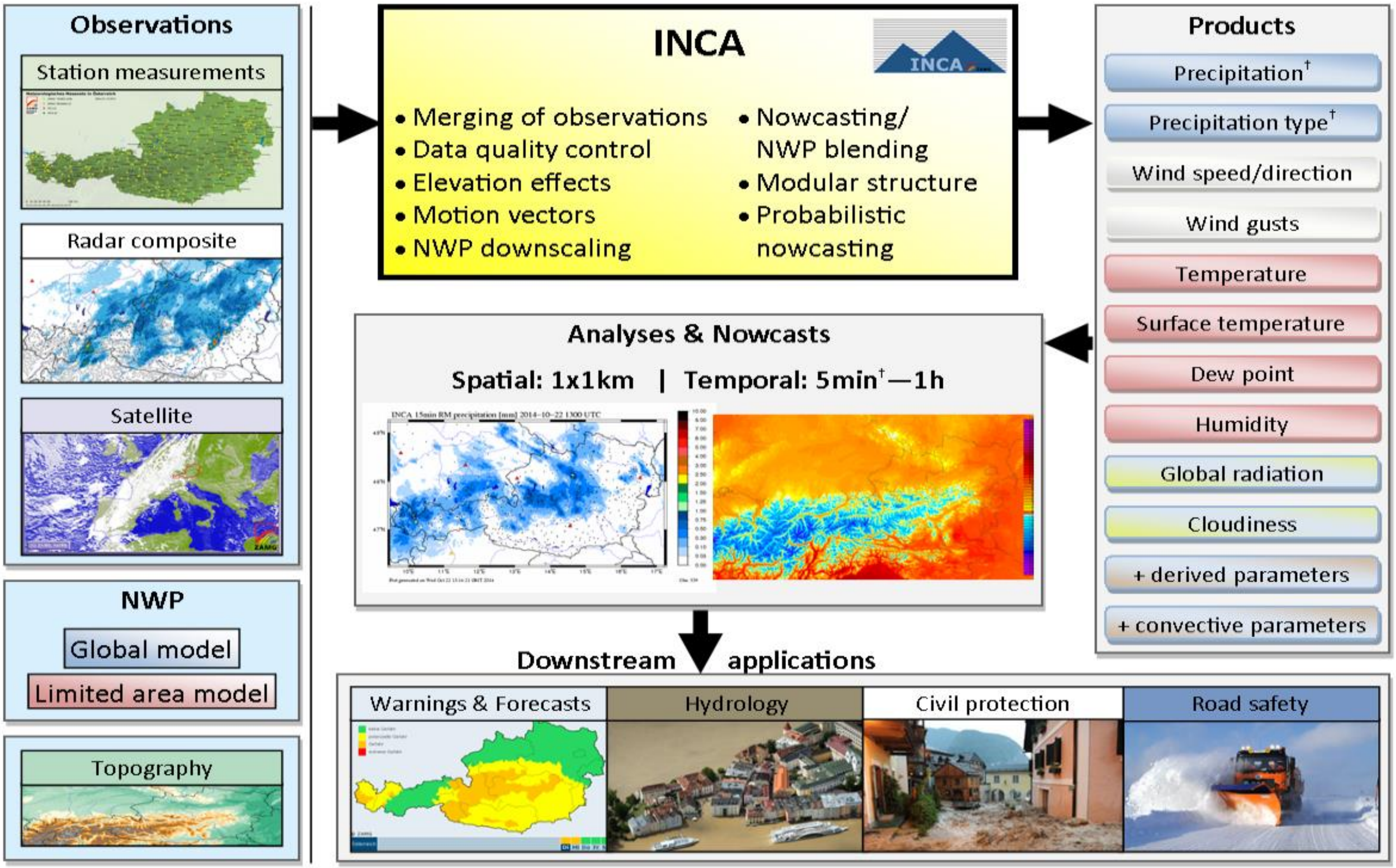
Lead agency: KMA (Dong-Kyou Lee, Sangwon Joo)
10 participating countries (AU, **AT**, CA, CN, FI, RU, KR, ES, CH, US)
16 participating organisations
WMO/WWRP RDP/FDP endorsement since 27 Nov 2015
Goal: Advance prediction of winter weather based on intensive observations



General overview of NWP models used at ZAMG



INCA system overview



INCA motivation & concepts

Initial motivation for INCA (~2005):

- Low skill of NWP models within nowcasting range
- Latency of NWP models
- Need for real time incorporation of observations
- Need for computationally efficient nowcasting
- Need for „non-classical" analyses and nowcasts
- Application in severe weather warning and flood forecasting

INCA deterministic

- INCA Analysis
- INCA Analysis + INCA Nowcast
- INCA Analysis + INCA Nowcast + AROME Forecast
- INCA Analysis + INCA Nowcast + AROME Forecast + ECMWF Forecast
- INCA Analysis + INCA Nowcast + OPT Forecast

INCA probabilistic

- INCA Ensemble Analysis + INCA Ensemble Nowcasting + + ALARO LAEF + ECMWF Ensemble

Various domains, spatial resolutions, forecast steps, update frequencies, forecast ranges, ways of dissemination, . . .

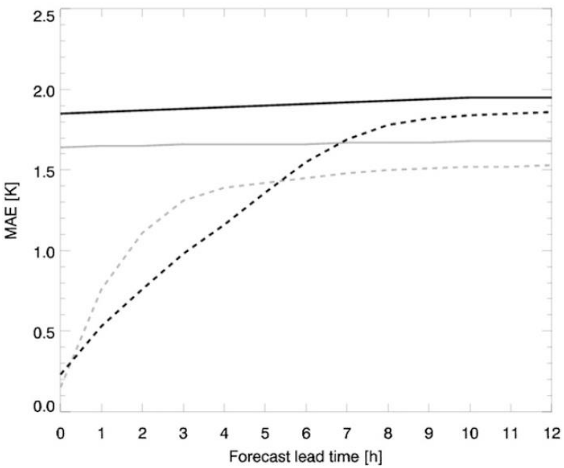


FIG. 12. INCA (dashed lines) and ALADIN (solid lines) MAEs of temperature, averaged over all stations, for July 2009 (gray) and January 2010 (black).

TABLE 2. Results of the INCA analysis cross validation for a summer and a winter month. Shown are the bias (mean error), MAE, and RMSE. For the wind components and for precipitation relative values are given as well.

	July 2009			January 2010		
	Bias	MAE	RMSE	Bias	MAE	RMSE
T (°C)	0.0	0.9	1.3	0.0	1.1	1.6
u (m s^{-1})	−0.1	1.1	1.5	0.0	1.1	1.5
v (m s^{-1})	0.1	1.0	1.3	0.2	1.0	1.3
u_{rel} (1)	−0.00	0.57	0.79	0.00	0.51	0.71
v_{rel} (1)	0.08	0.50	0.67	0.09	0.44	0.59
RR (mm)	0.01	0.04	0.24	0.00	0.02	0.05
RR_{rel} (1)	0.09	0.48	1.24	−0.06	0.27	0.46
RR West (mm)	0.01	0.04	0.22	0.00	0.02	0.04
RR East (mm)	0.01	0.04	0.31	0.00	0.02	0.05

Haiden T, Kann A, Wittmann C, Pistotnik G, Bica B, Gruber C. 2011. The Integrated Nowcasting through Comprehensive Analysis (INCA) System and Its Validation over the Eastern Alpine Region.
Weather and Forecasting, 26/2, 166-183, doi: 10.1175/2010WAF2222451.1

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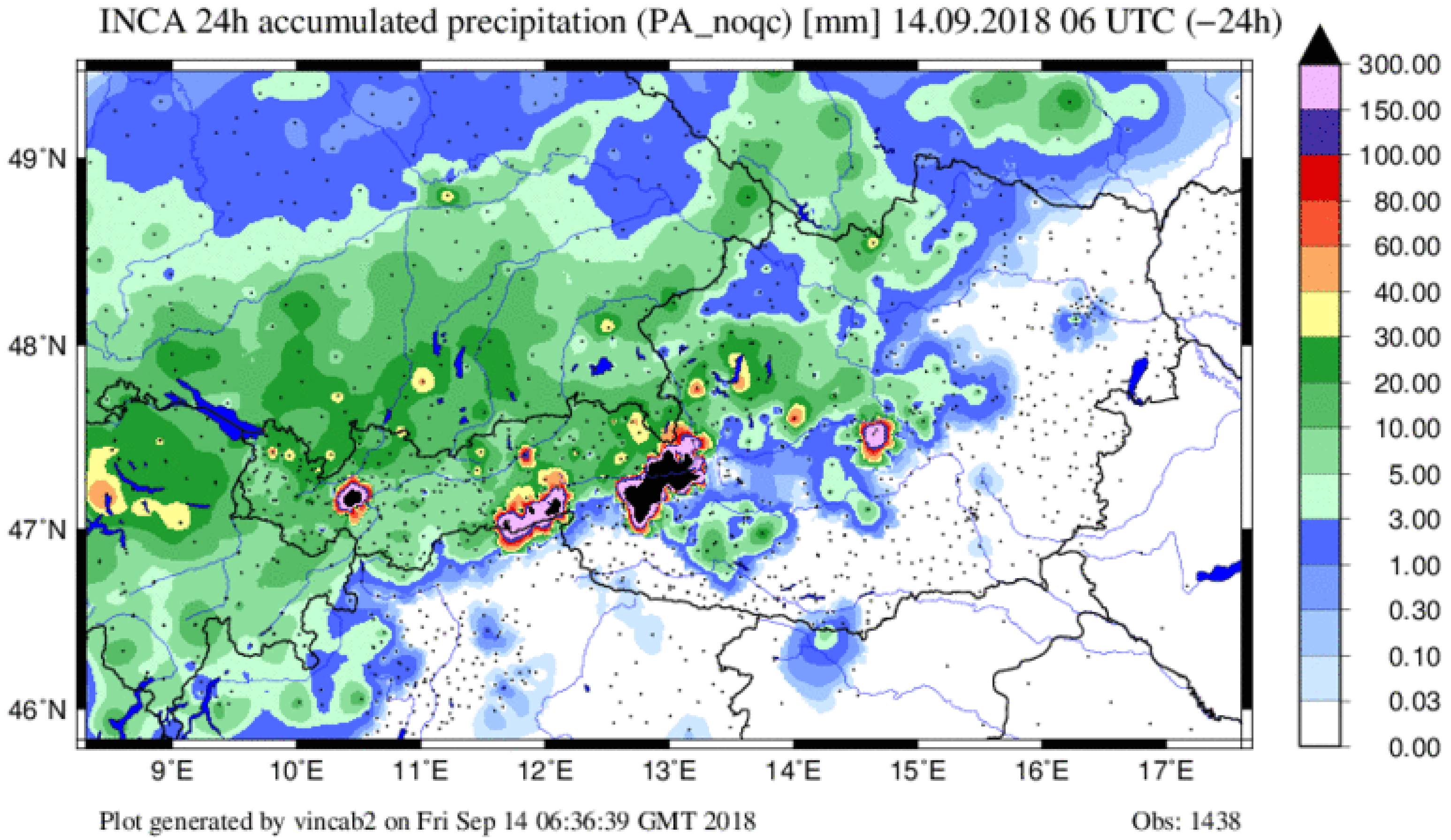
Raingauge interpolation without QC



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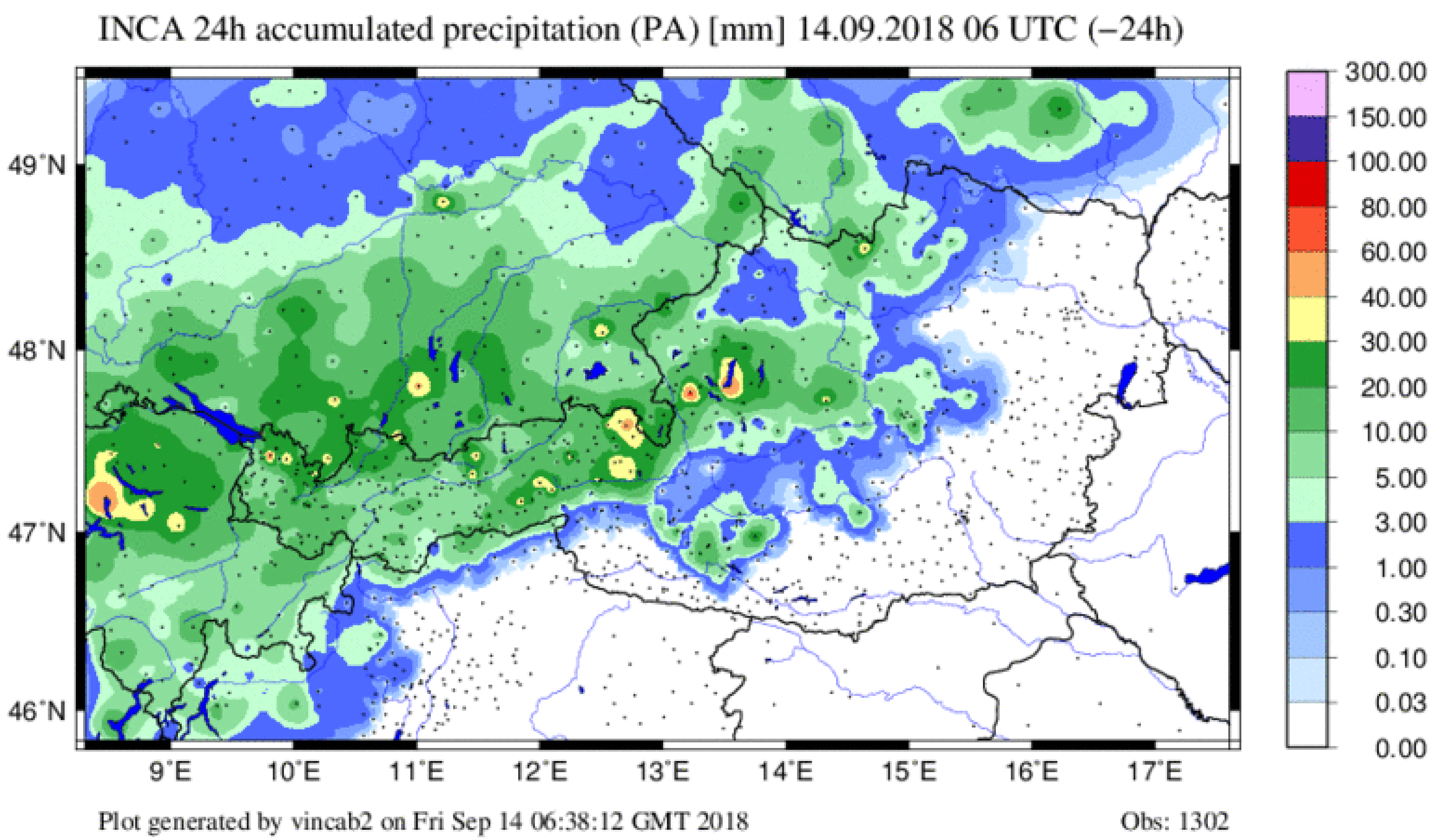
Raingauge interpolation with QC



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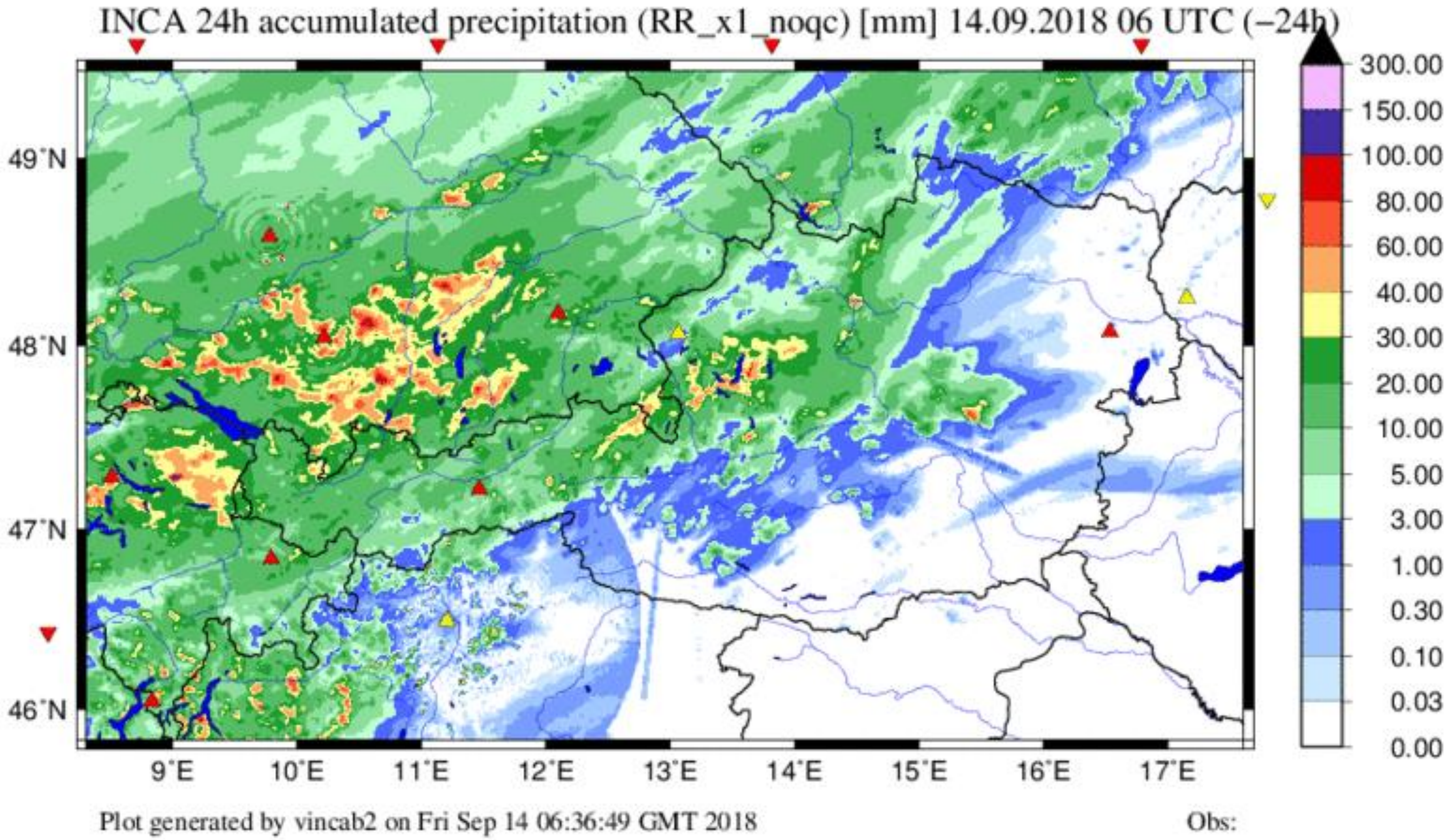
Radar composit without QC



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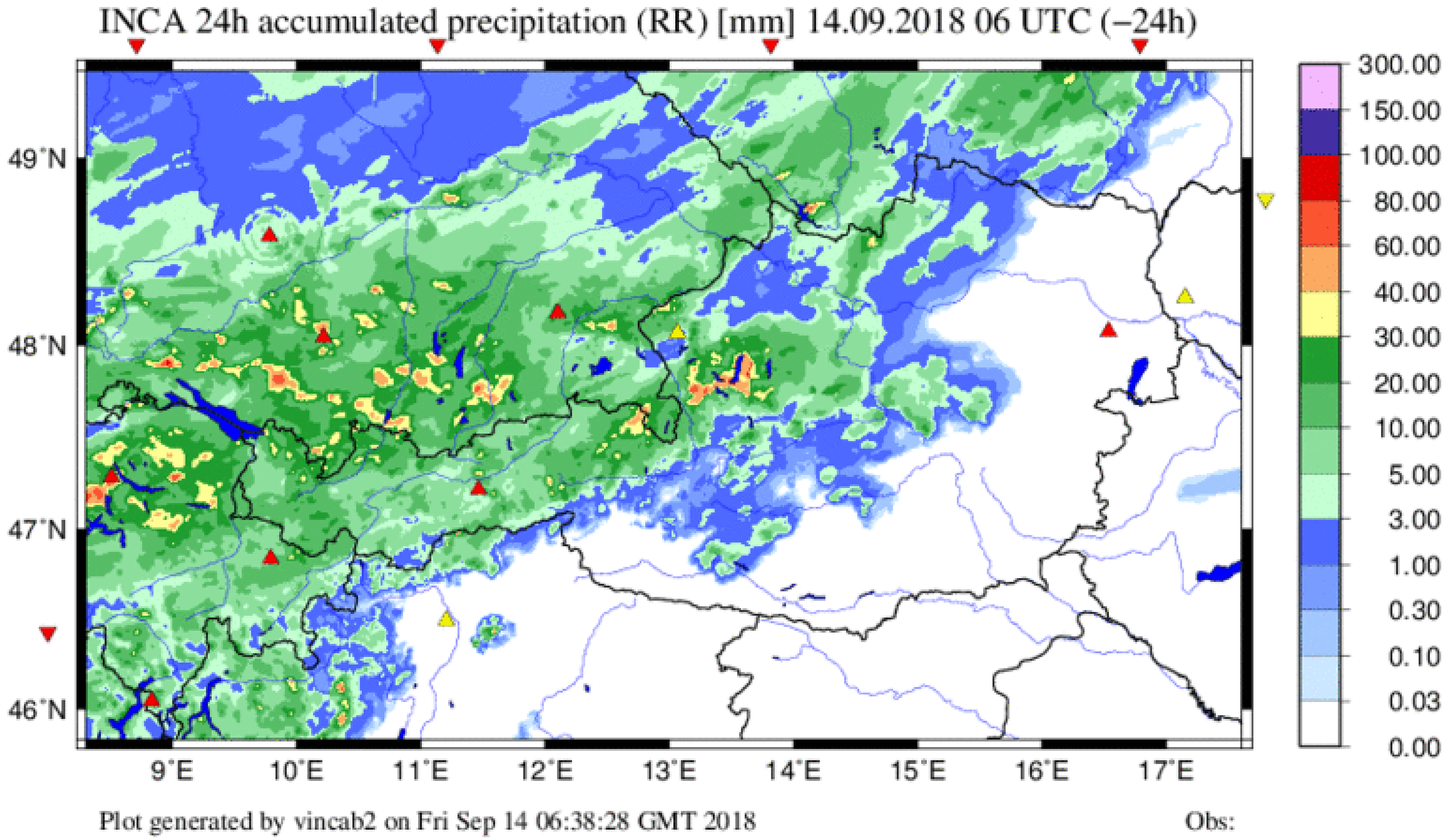
Radar composit with QC



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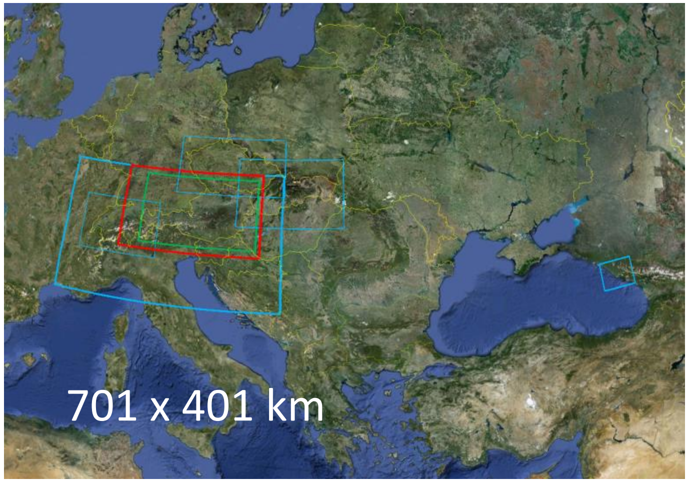
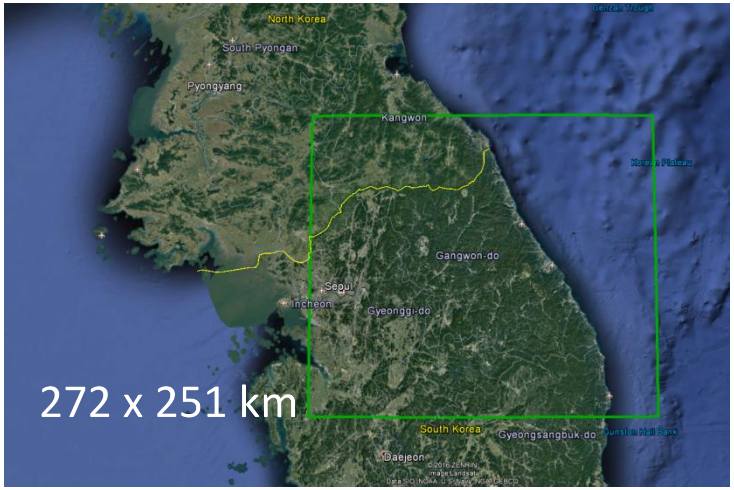
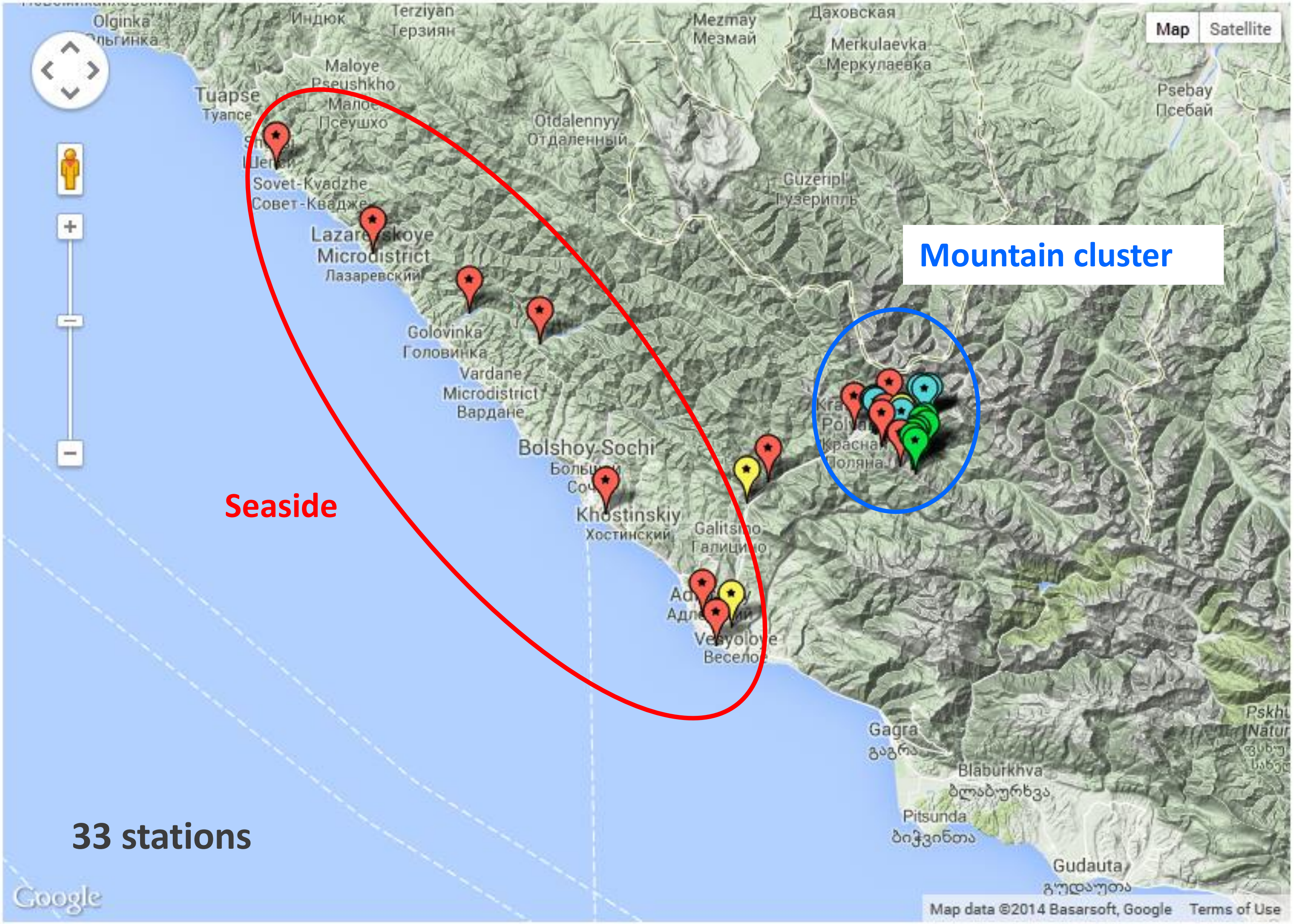
Comparison of INCA domains





INCA for FROST-2014



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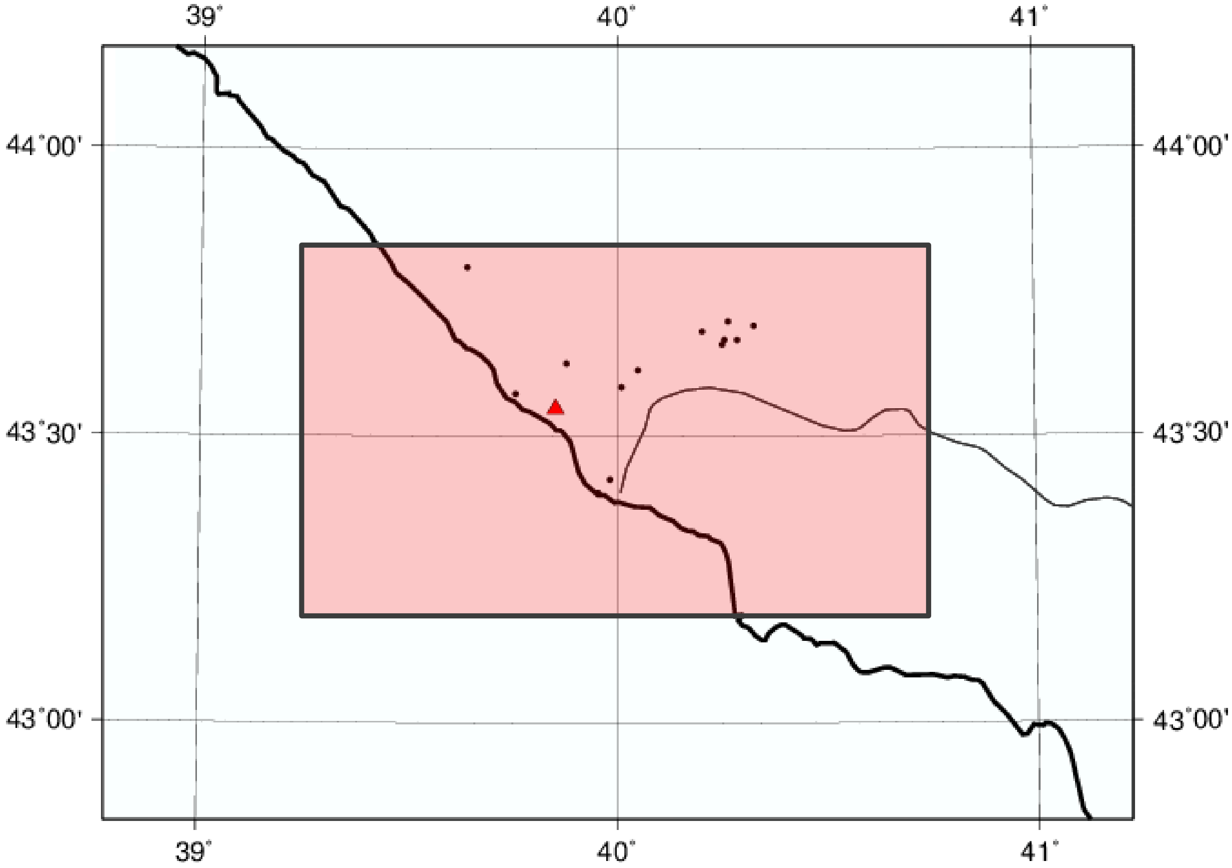
Sotchi: Domain size & station density

- INCA domain size for Sochi 2014 („INCA_RU“)
- 180 • 140 km = 25.200 km^2
- 33 (19) meteorological stations
- One stations represents 760 km^2 (1330 km^2)

- Standard INCA domain size
- 700 • 400 km = 280.000 km^2
- ~ 1000 meteorological stations
- One station represents 280 km^2



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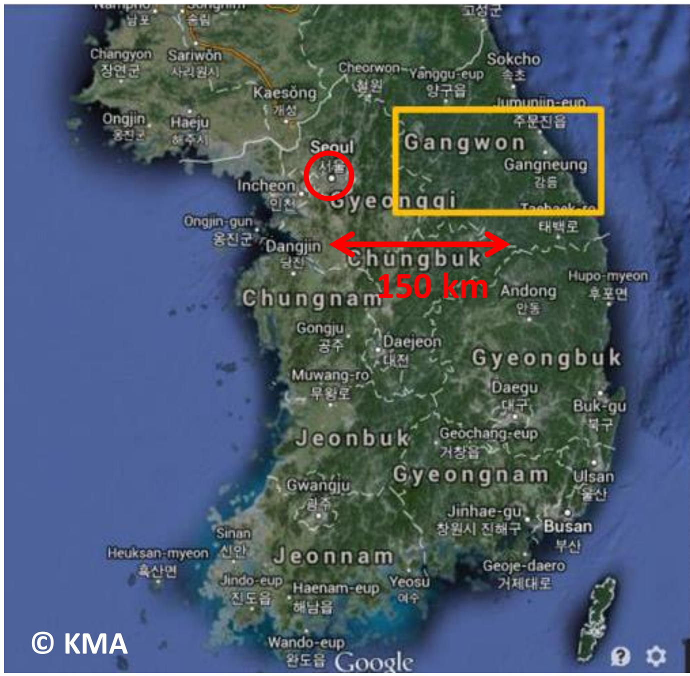
PyeongChang 2018 venues



Austria: 83.879 km²
South Korea: 100.284 km²

Pyeongchang Mountain Cluster: Alpine climate (773 m a.s.l., -5.5°C, 53 mm in Feb.)
Gangneung Coastal Cluster: Coastal climate (26 m a.s.l., 2.2°C, 69 mm in Feb.)

13 competition venues in total: 7 existing, 6 new

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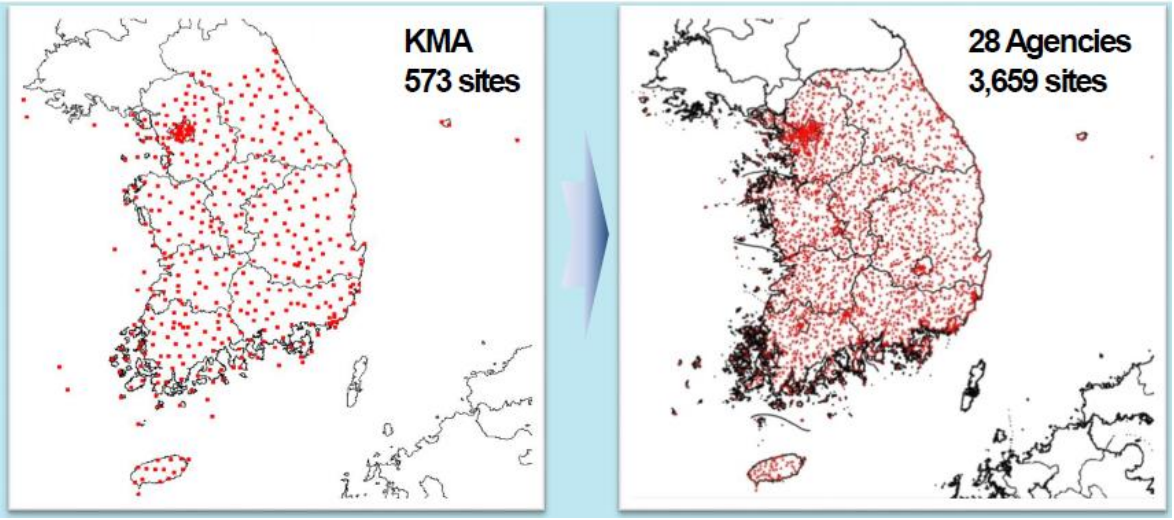
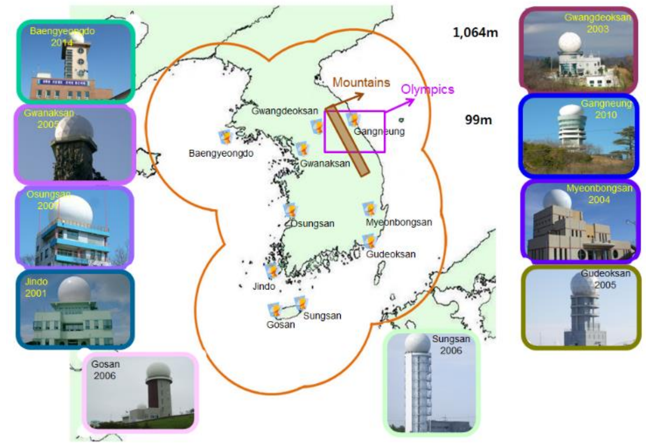
Observation network





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- Ground station network, 11+16 WXs
- Upper level network: 8 Radio soundings, 12 wind profilers, 105 ceilometers, 238 visibility sensors, ...
- Ocean network: 110 sites + 1 ship
- Satellite, Aircraft, Observation vehicle

Ideal setting for NWP development and evaluation

Nation	Institution	Instrument
Canada	ECCC	Lidars, Precipitation Occurence Sensor System (POSS)
South Korea	KNU	VertiX, TEAM-R
Spain	UCLM	Snow radar, Parsivels
Switzerland	EPFL	Snow and cloud radar
USA	NASA	Pluvio, Parsivel, PIP, MRR, D3R
USA	SUNY	Cloud radars

Alpensia Ski Jumping Centre
Ski jumping K125 start (2572)
o ID : 2572
o Height : 884m
o Latitude : 37° 39′ 40.91″
o Longitude : 128° 40′ 44.13″
Ski jumping K98 Start(2573)
o ID : 2573
o Height : 862m
o Latitude : 37° 39′ 40.55″
o Longitude : 128° 40′ 45.66″
Ski jumping K125 Jump (2555)
o ID : 2555
o Height : 845m
o Latitude : 37° 39′ 42.00″
o Longitude : 128° 40′ 45.96″
Ski Jumping (879)
o ID : 879
o Height : 851m
o Latitude : 37° 39′ 37.72″
o Longitude : 128° 40′ 46.58″
Ski jumping K98 Jump(2574)
o ID : 2574
o Height : 831m
o Latitude : 37° 39′ 41.92″
o Longitude : 128° 40′ 47.38″
LH
NH
Ski jumping Landing(2575)
o ID : 2575
o Height : 785m
o Latitude : 37° 39′ 43.95″
o Longitude : 128° 40′ 49.66″
K60
K35
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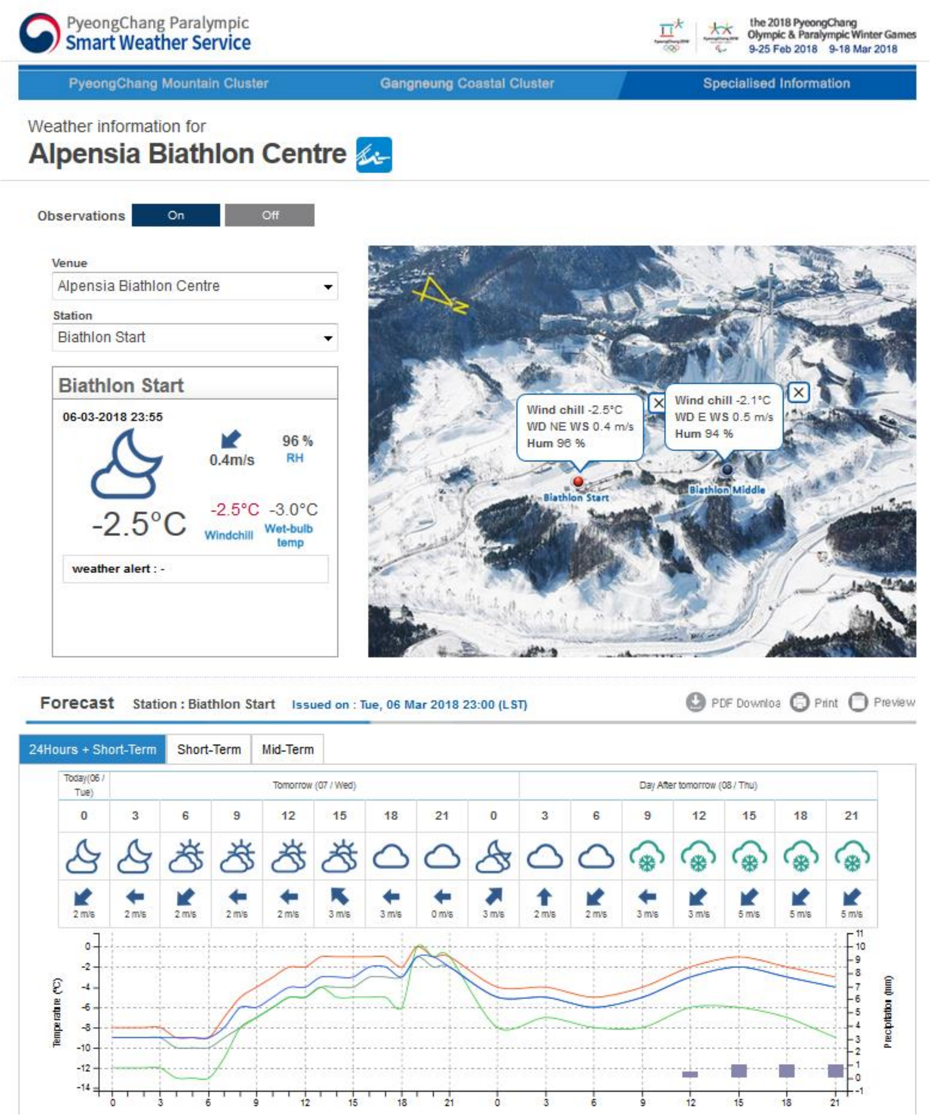
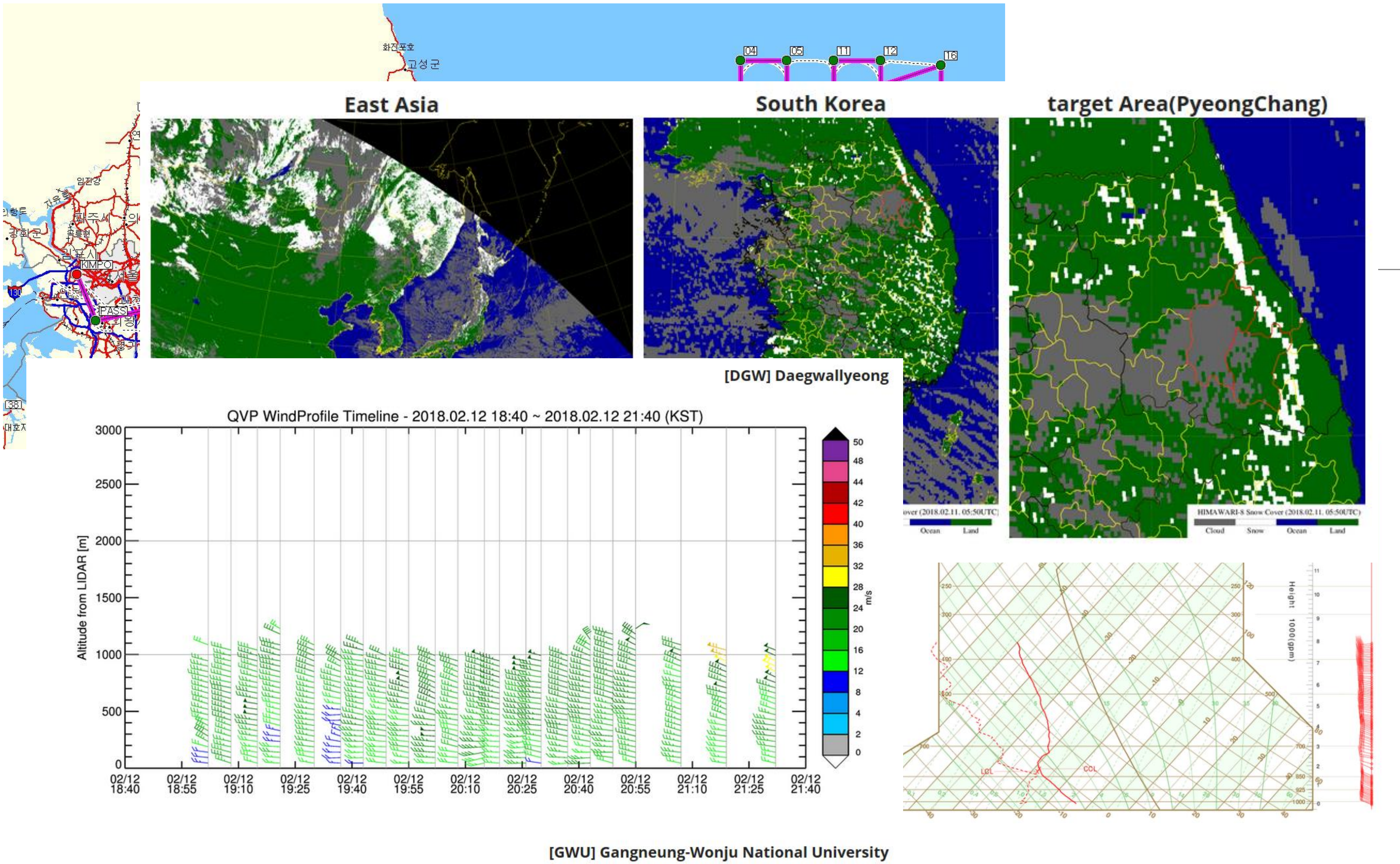
Portals for media and public

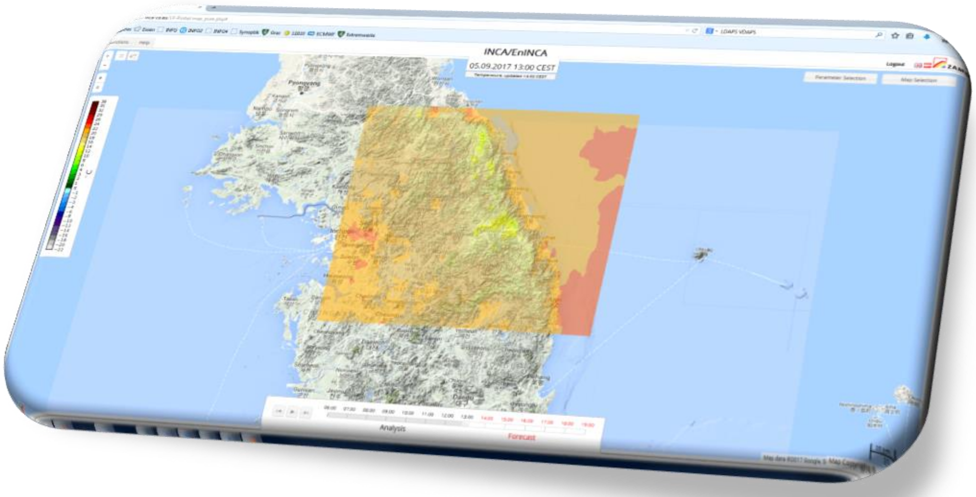


Professional information – vertical profiles, soundings, satellite images, LIDAR, etc.



INCA specifications for ICE-POP 2018

- **INCA settings**
- Parameters: **T2m (1.5m), RH2m (1.5m), wind, gusts, visibility, precipitation, precipitation type**
- Lambert conformal conical projection, Bessel 1841 ellipsoid; Reference latitudes λ_0=128.28; ϕ_1=30; ϕ_2=60
- Domain extension: λ_{min}=126.68, ϕ_{min}=36.62, λ_{max}=129.93, ϕ_{max}=38.85
- Mesh size: **1 km x 1 km**
- Grid points: **NX=272, NY=251**
- Vertical levels: From 0 to 1600 m, with equal spacing of 200 m for all parameters except wind (125 m)
- Time resolution and update frequency: **1h**, except for precipitation products in **10min** resolution
- Analyses and Nowcasts up to **+6h leadtime**
- Output: **Analysis and forecast fields in grb2 format; point forecasts in ascii format**
- Graphical visualisation: KMA and ZAMG



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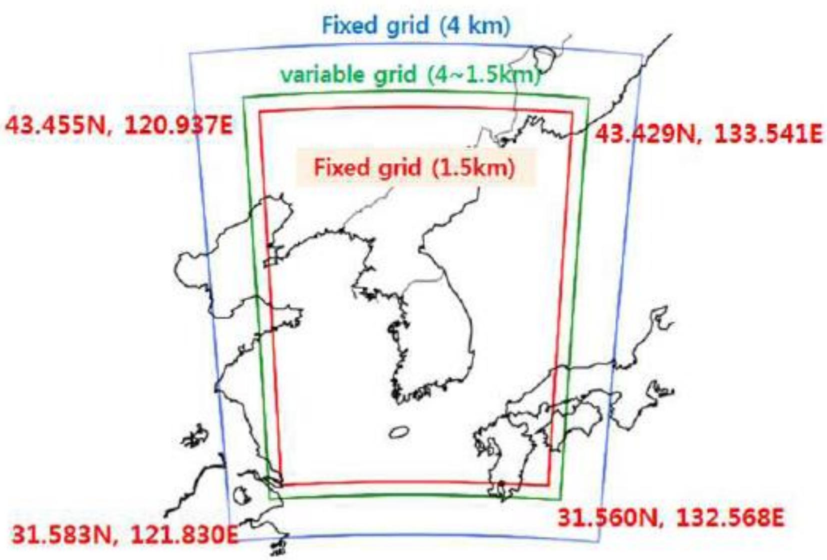
INCA specifications for ICE-POP 2018

Analysis background

- LDAPS / VDAPS incl. full data assimilation
- Horizontal resolution: 1.5 km (inner domain) – 4 km (near lateral boundary)
- Vertical resolution: 70 vertical levels
- 1h update, 45-60 min delay, grb-format
- Time step: 1 hour

VDAPS Domain



- Variable grids: 1.5km (inner domain) ~ 4km (near lateral boundary)
- Inner fixed resolution (1.5km) domain: 682 (W-E) 882 (S-N)
- 24 pressure levels: **1000, 975, 950, 925, 900, 875, 850 ,750, 700**, 650, 600, 550, 500, 450, 400, 350, 300, 250, 200, 150, 100, 70, 50 hPa

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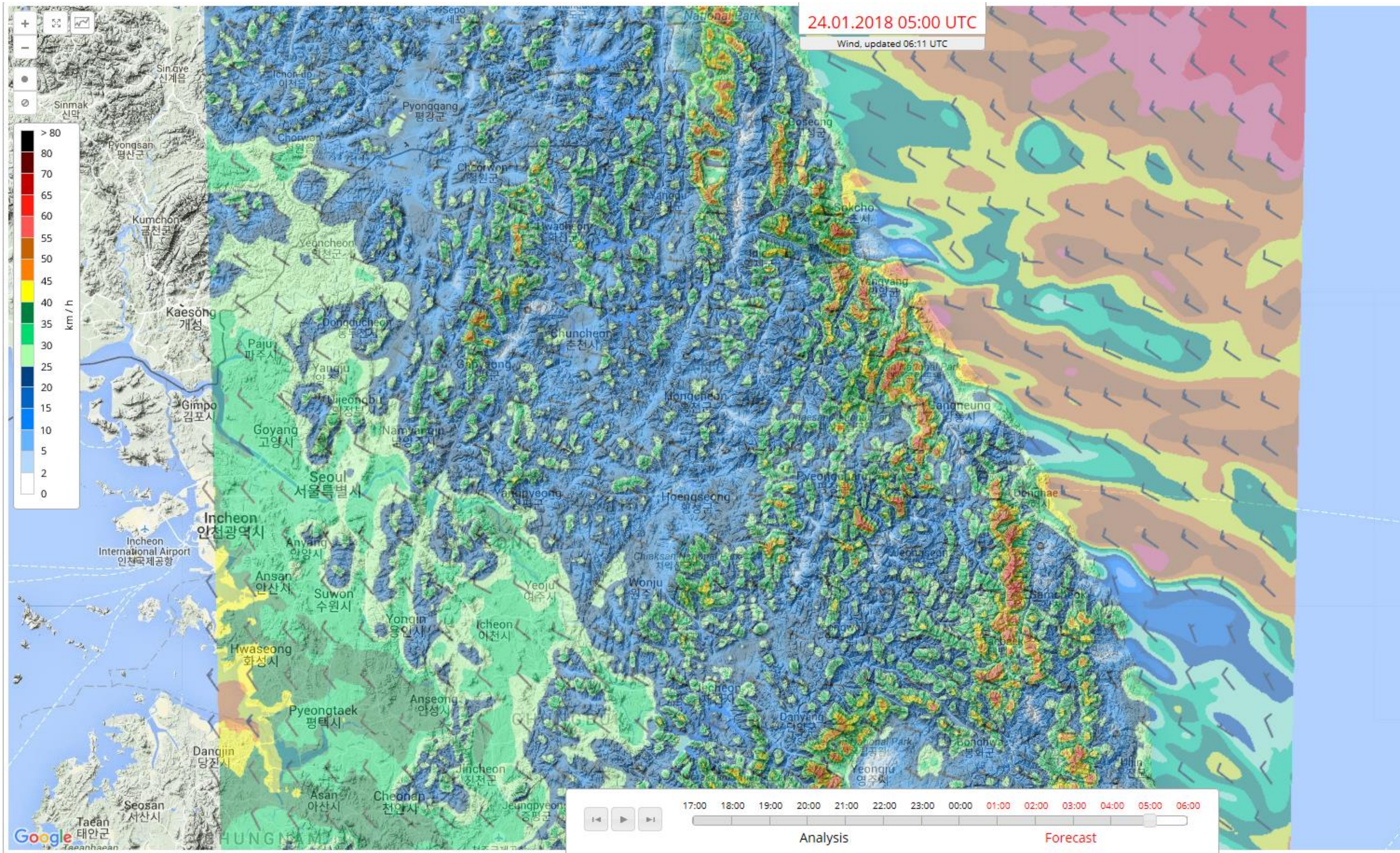
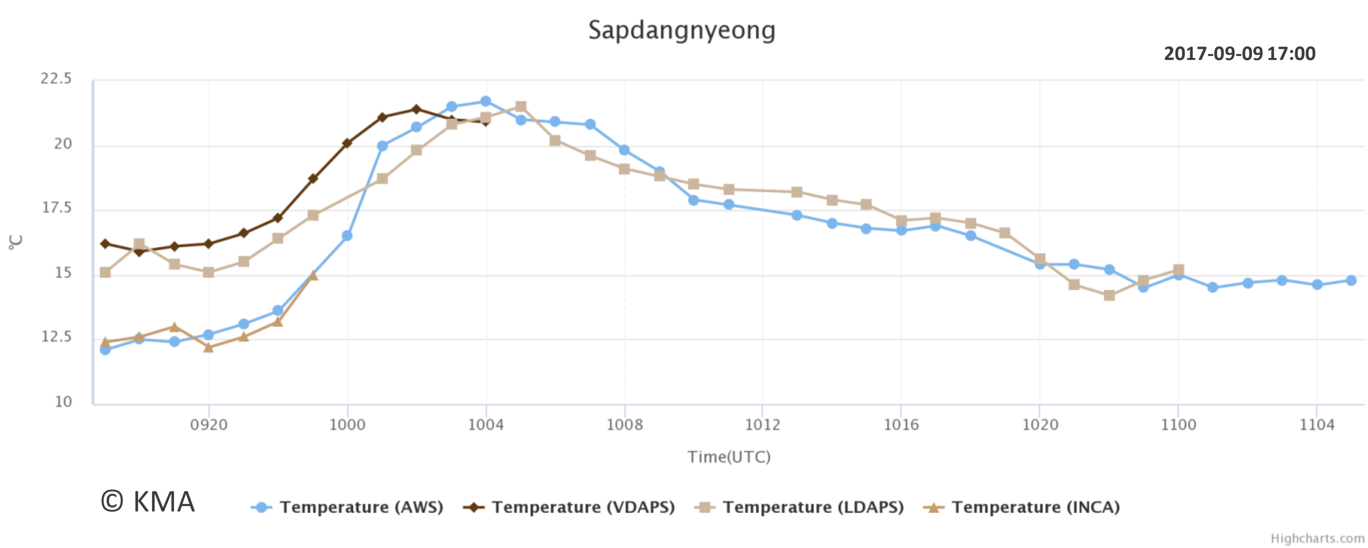
INCA wind – 24 Jan 2018 05 UTC



Point forecast locations for Pyeongchang 2018

Venues	id no.	위치		altitude(m)	Desciption
		lat	lon		
Alpensia Ski Jumping Centre	2575	37.662208	128.680462	785	Ski Jumping Landing
Alpensia Biathlon Centre	2557	37.663755	128.687290	757	Biathlon Start
Alpensia Cross-Country Skiing Centre	2577	37.663897	128.684789	764	Cross-country Start
Alpensia Sliding Centre	2554	37.654353	128.681965	813	Sliding Finish
Yongpyong Alpine Centre	2560	37.612989	128.671767	1,414	Alpine GS Start
	2579	37.618446	128.668860	1,180	Alpine GS Middle2
	2561	37.621578	128.664814	975	Alpine GS Finish
Jeongseon Alpine Centre	2584	37.445418	128.598923	1,370	Alpine DH Start
	2586	37.457433	128.601828	919	Alpine DH Middle
	2587	37.464385	128.603100	680	Alpine DH Finish
Bokwang Snow Park(C)	2580	37.578527	128.312698	856	Cross Start
	2581	37.584330	128.322039	664	Cross Finish
Bokwang Snow Park(P)	2588	37.574346	128.323211	874	Slopestyle Start
	2583	37.579428	128.324778	709	Slopestyle Finish
Gangneung	105	37.75147	128.89098	26	
Olympic stadium	미정	37.666900	128.707500	735	



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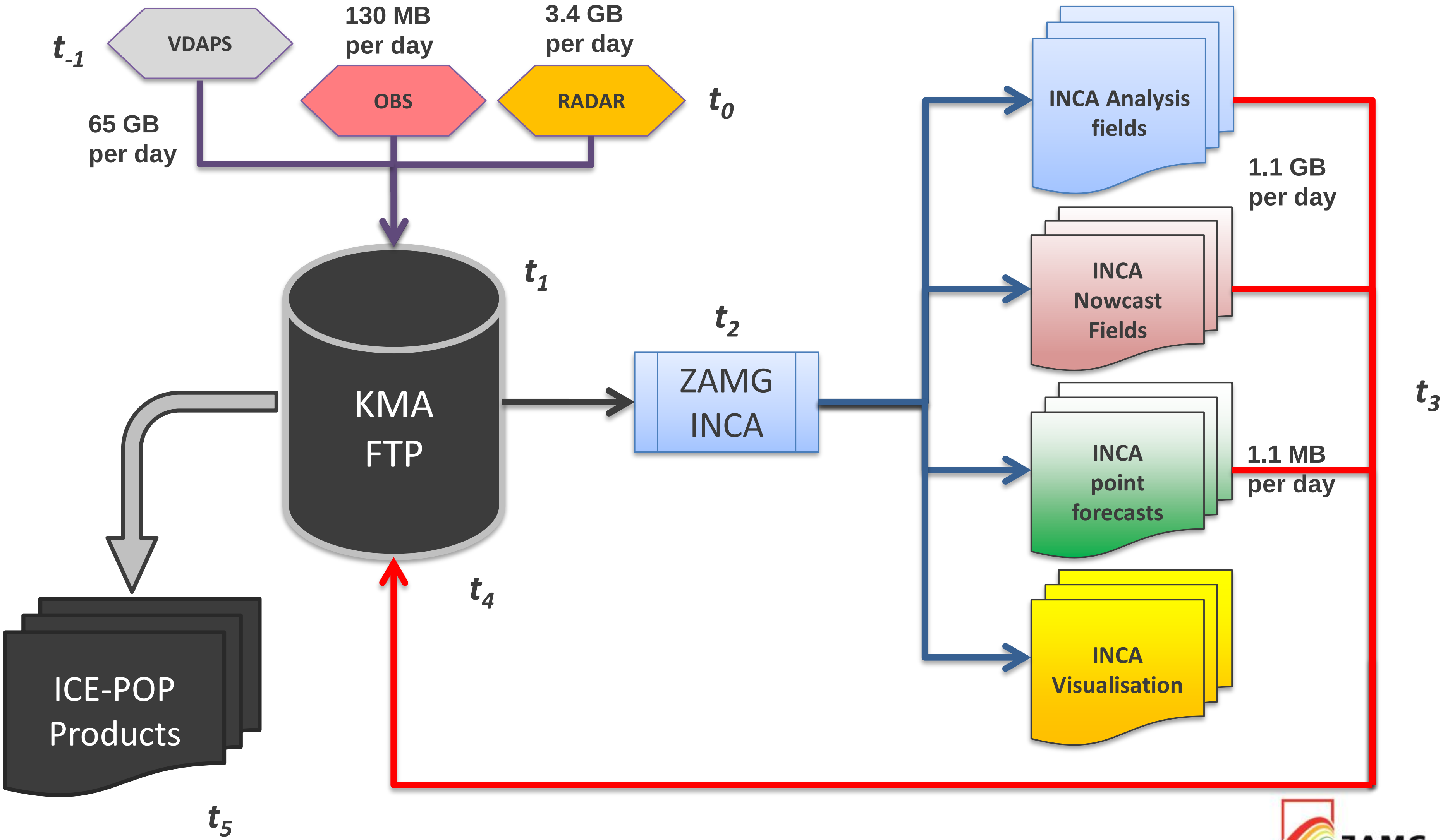
Data flow from ZAMG perspective



(t_5 - t_0)< update frequency !

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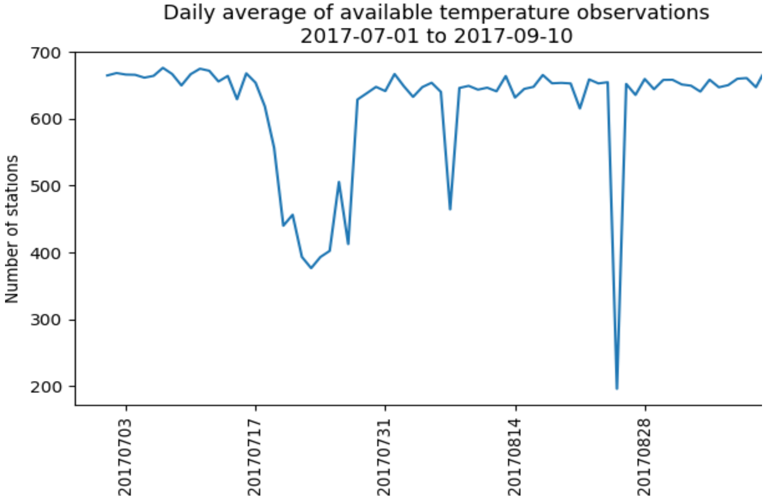
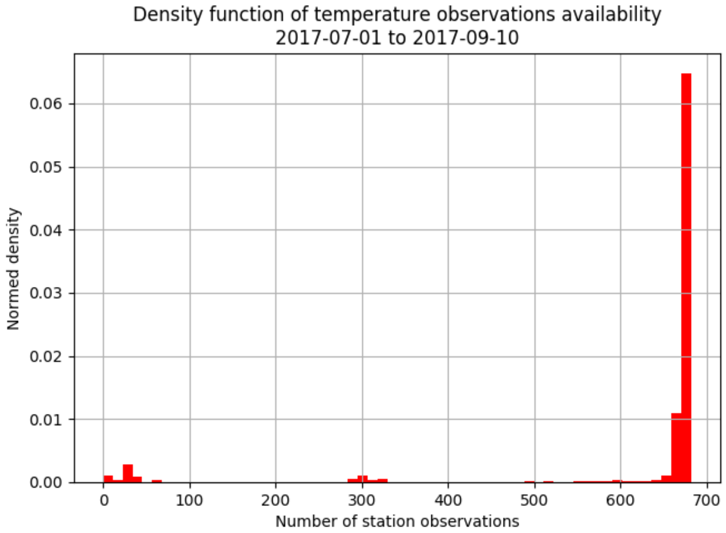
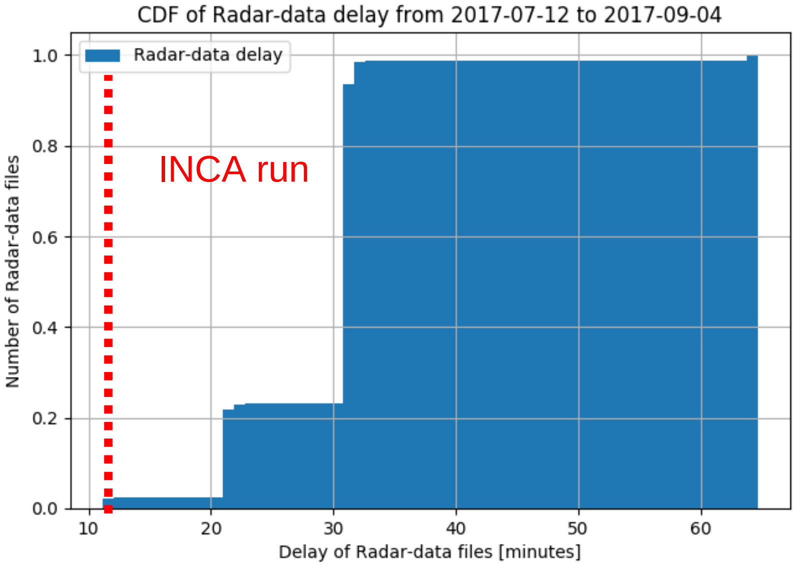
Monitoring of data flow and system stability

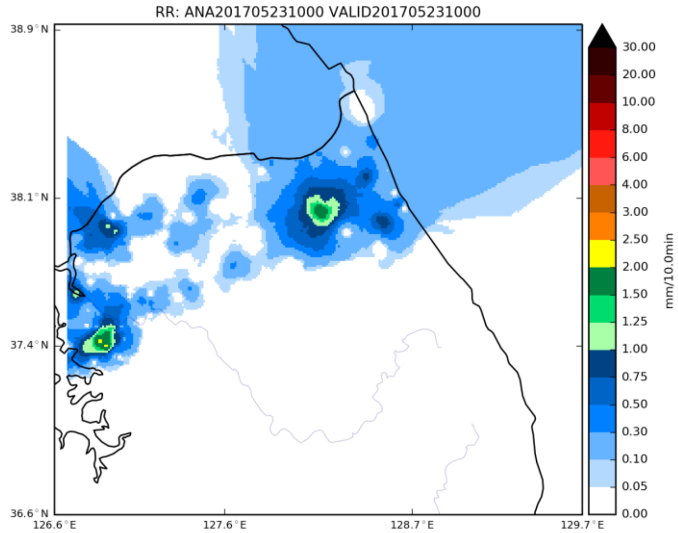


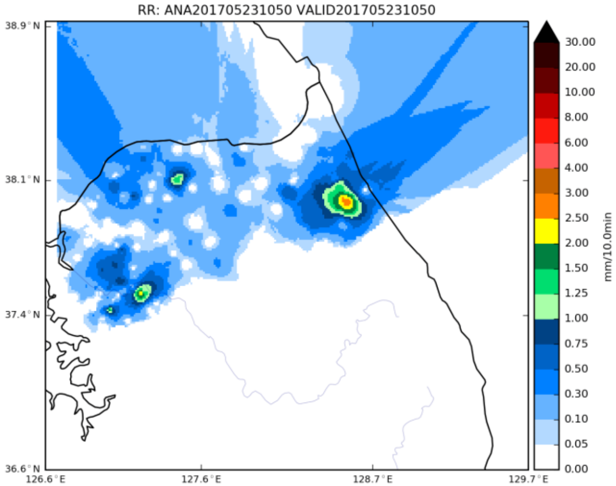
- The availability of rain gauge and radar data initially appeared to be quite unstable.
- In approximately 80 % of the cases radar data have not arrived 20 minutes after analysis date

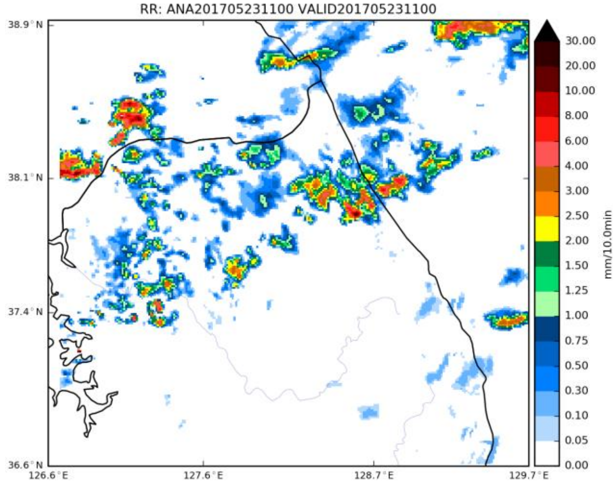




Inhomogeneities in the analyses and nowcasts







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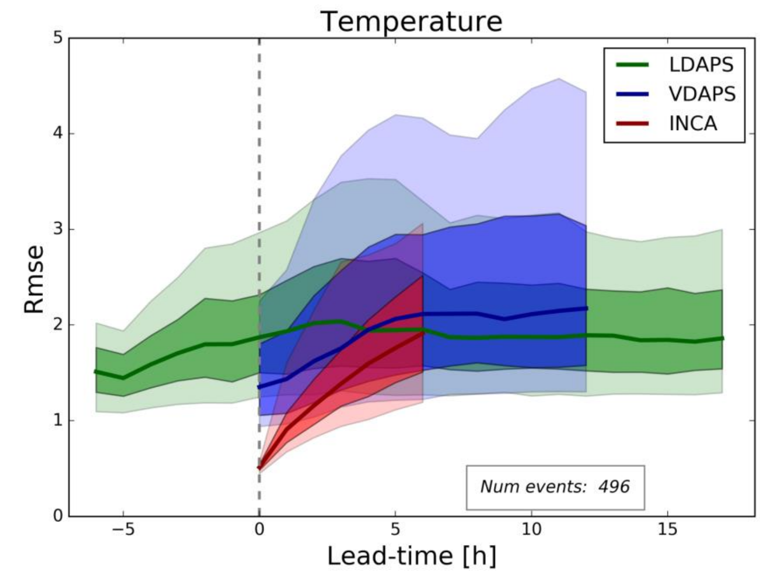
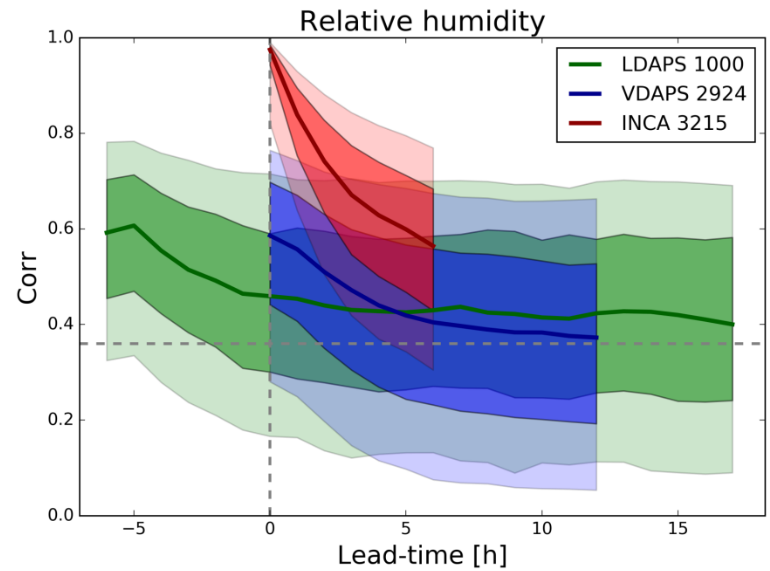
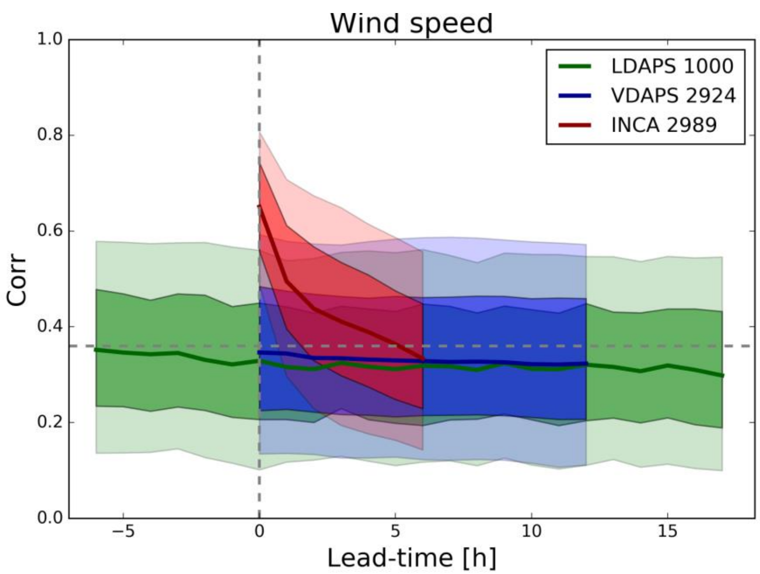
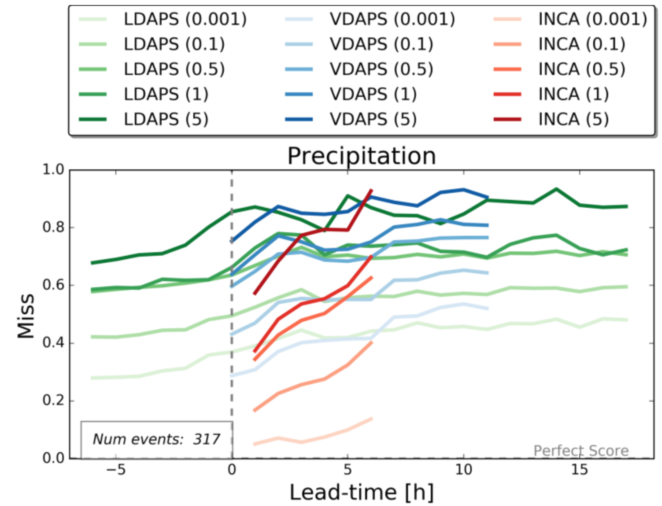
Verification Jan 2017 – Sept 2017









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Men‘s Alpine downwhill 11.2.2018, 11 KST (02 UTC)

High Winds Postpone Men's Olympic Downhill Skiing Event

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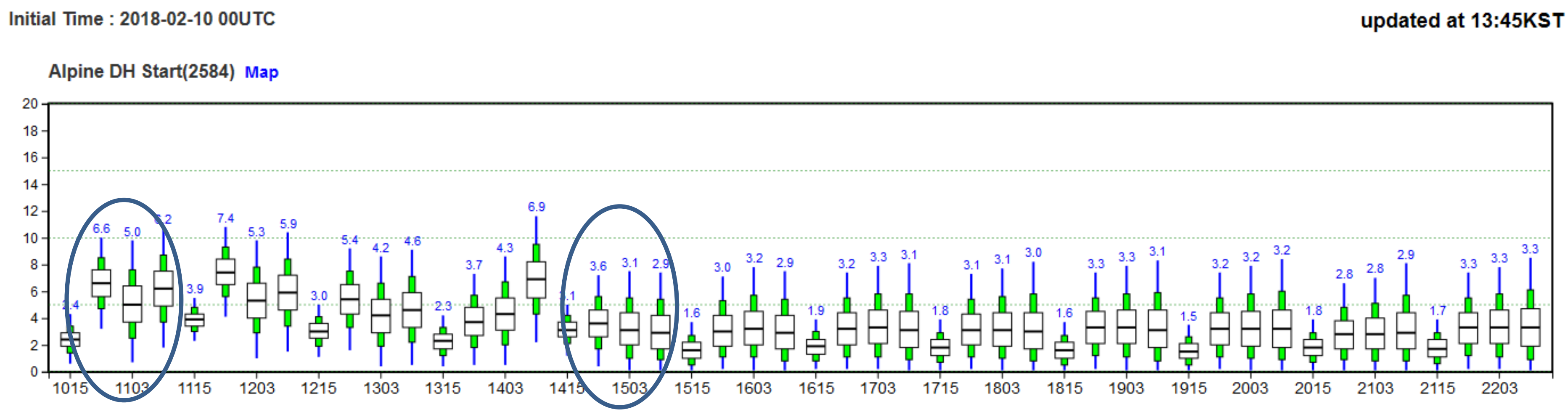
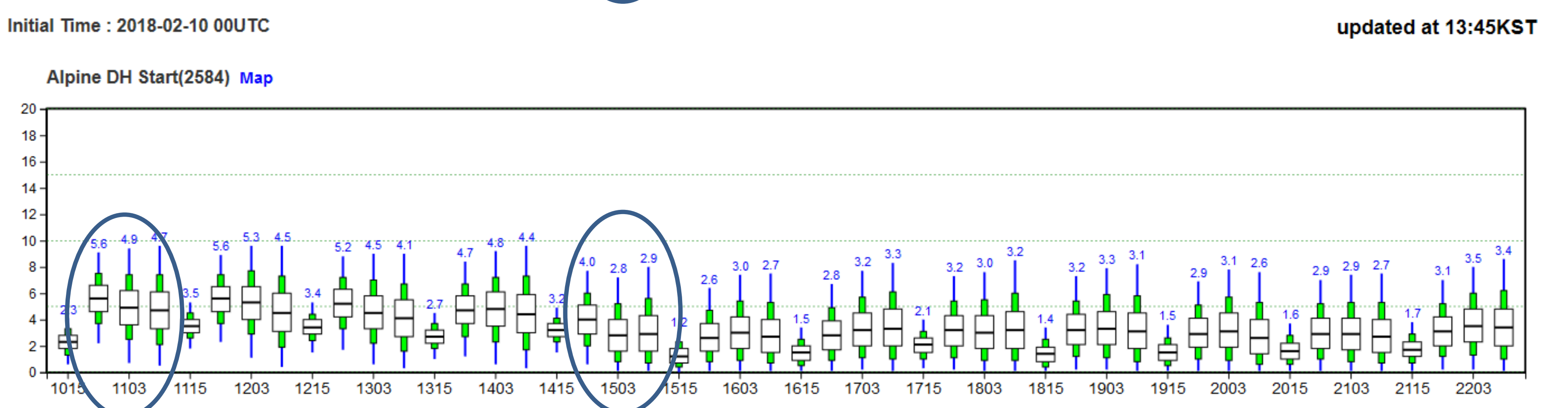
Ensemble FCST, Init 10 Feb 00 UTC (9KST), Wind, medium range
KMA Global Ensemble (top), ECMWF Global Ensemble (bottom)





Postponing men‘s Alpine downhill from Sunday 11 Feb 02 UTC to Thursday 15 Feb 02 UTC

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Survey at ZAMG - Questions

1) What knowledge or capabilities are currently lacking and what would be needed from TEAMx ?

2) Which atmospheric processes are crucial ?

3) Which variables need to be measured or simulated, and at what accuracy or spatiotemporal resolution ?

4) Which processes are particularly poorly understood and how are these hindering predictive capabilities ?

5) Which parameters are not captured well from an instrumental point of view ?

6) Which phenomena are not captured well ?

7) Which parameters or phenomena are not represented well in the models ?

8) Which temporal and spatial resolutions are needed ?

9) Which are the most pressing problems, what should be measured, investigated or modelled to help you with your work ?

Feedback from forecasters (I)

Most things work very well, or much better than 1995 or 2005 ☺
But also demands are higher today.

Convection

- 2 times: High resolution analyses of convective parameters
  There are already a few but number and temporal resolution should be enhanced
- Weakening of convection is crucial as well: at what time in the evening will (non-frontal) convective activity cease ?
- Temporal evolution and intensity of convection
- Convection in models starts too early and is too much bound to complex topography
- Nowcasting of convective cells is most often a kinematic extrapolation, a more dynamical approach including cell growth and decay would be helpful
- Better information on potential wind gusts and potential hail size

Precipitation type

- Observations and forecast of „freezing rain“ should be improved (better integration of vertical profiles and inversions). Very often the forecasts show snowfall, but in fact it is rain freezing on the ground.

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Feedback from forecasters (II)

Wind

- More realistic wind fields in Alpine areas (Föhn valleys, canalisation effects)
- Jumps in the wind field, wind shear, boundary layer height. End users need better and more concise information.

Clouds and fog

- Better ways how to forecast cloud base. Not just derived from CL, CM, CH or humidity. Relevant for flatland and cloudiness in the mountains.
- Forecast of fog on slopes, low cloudiness, cloud bases and tops should be improved for mountaineers and general aviation.
- Indication of freezing drizzle falling out of mountain fog at negative temperatures. Occurs often and is relevant for avalanche warning services.
- Fog and low stratus forecasts in the Alpine forelands need to be improved.

Inversions

- 2 times: Build up and retreat of inversions, especially in moist layers (fog, low stratus)
- Inversions are not captured well. Improvements are highly welcome, both in observation technique and forecasts. Needed for outdoor events, production of artificial snow, etc.

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Feedback from forecasters (III)

Snowfall line

- Observation and temporal evolution of snowfall line. In particular for atypcial vertical profiles, e.g. warm fronts.
- Cold air pools (depth, intensity) and impact on snowfall line.
- A more realistic temporal evolution of cold air pools, especially in inner-Alpine valleys. Connection to air mass blocking.
- Snowfall line is often indicated too low, even outside Alpine valleys and north of the Alps

Other

- A better and more transparent way how to translate uncertainties in forecast variables to end users (maybe something like a more intuitive probability distribution).
- Visibility: Models should provide information on very dry air and perfect view above x meters (a specific altitude).
- Research should be directed towards the boundary layer in the Alpine forelands, specifically moisture and wind fields, because this will become relevant for dispersion modelling.
- If the windfield and the vertical layers were captured better in the models there would be added value for small scale trajectories and multiple other applications.


Thank you!
Questions?
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