14th International Winds Workshop: 25 April 2018

Assimilation Impact of the LEOGEO AMVs on East Asia

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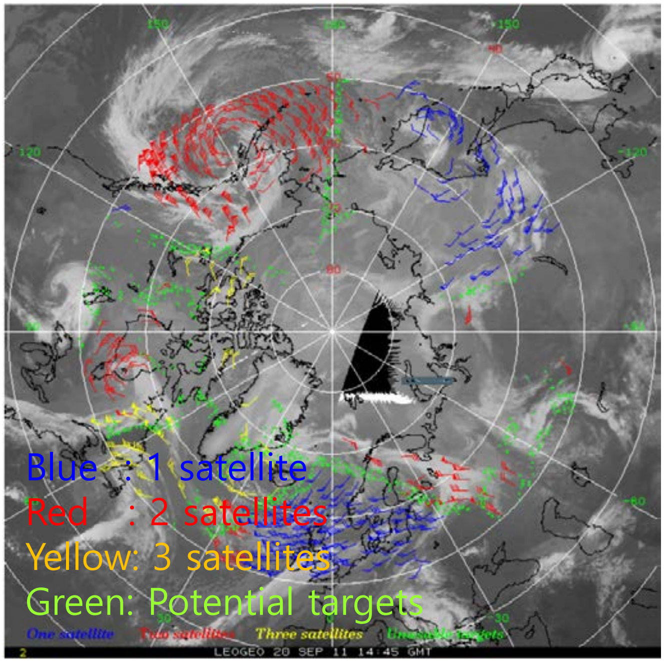
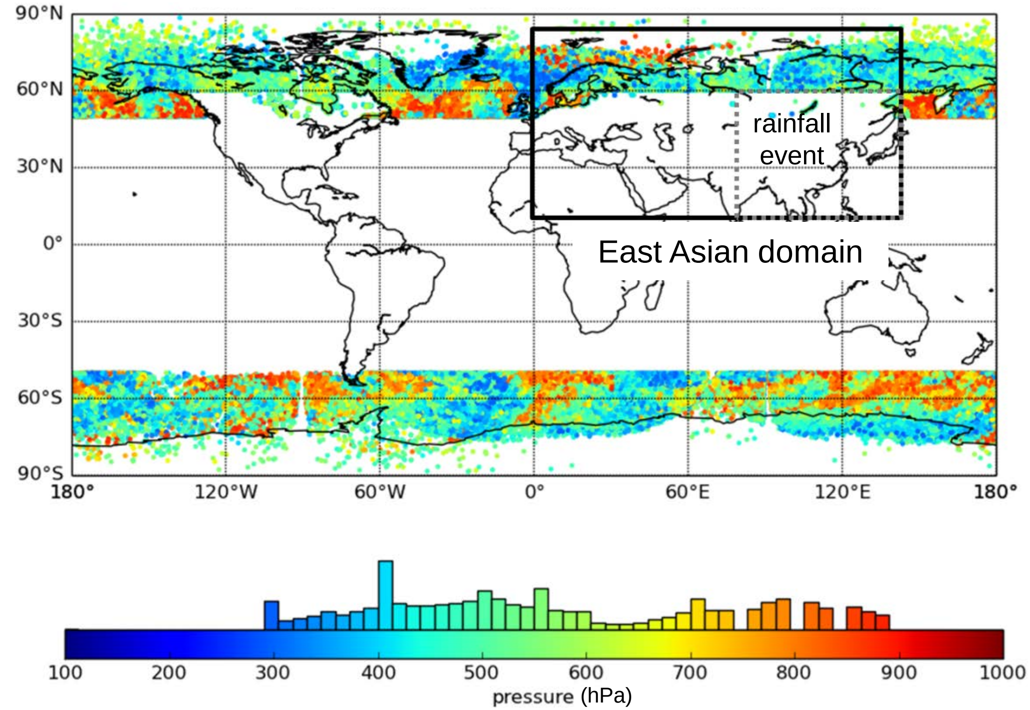
LEOGEO AMVs

LEOGEO satellite derived winds



Santek et al. (2016, IWW13)

Spatial distribution of LEOGEO AMVs

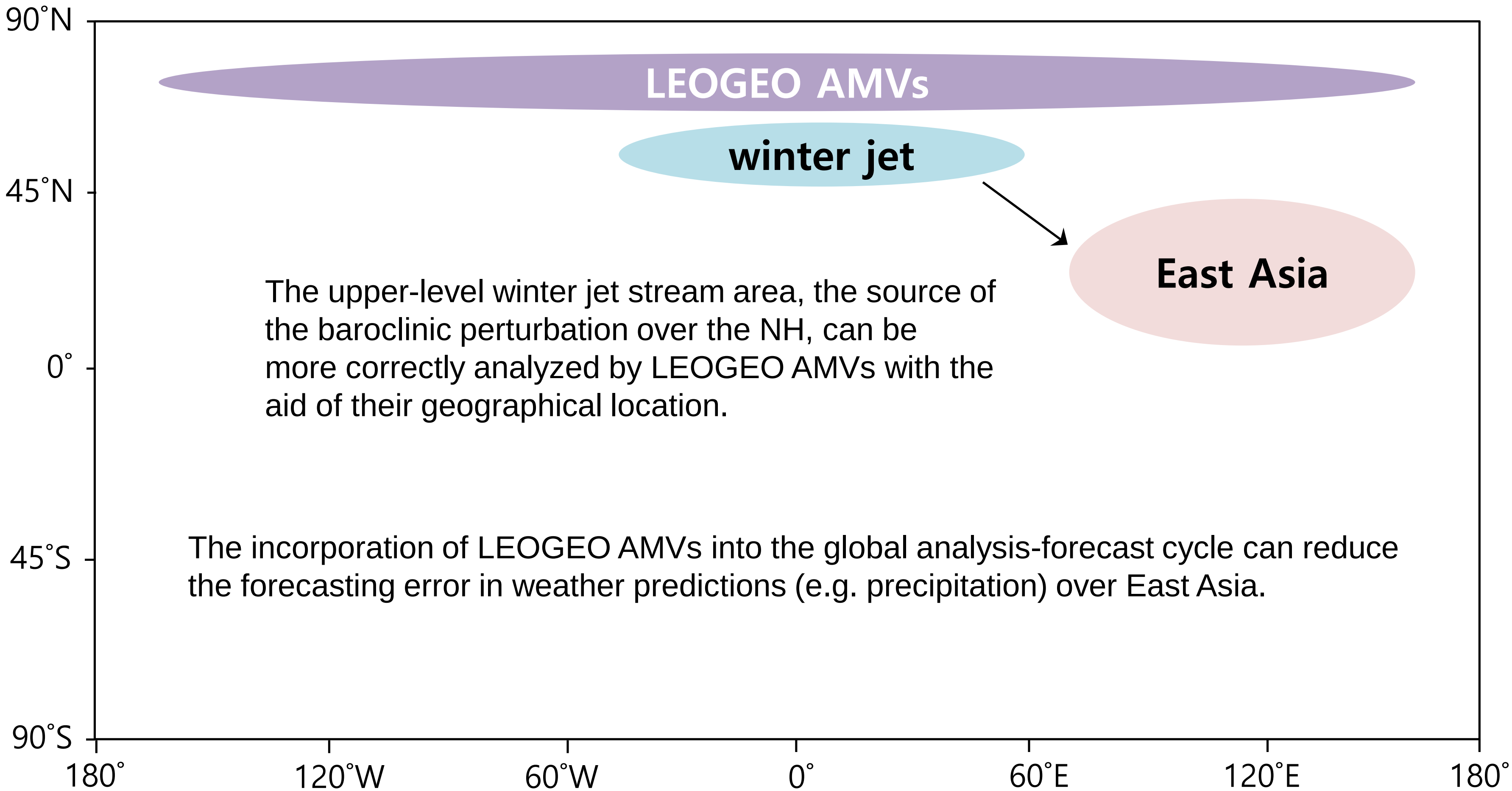


LEOGEO AMVs have been used in the latitudinal zone from approximately 60° to 70° (300-900 hPa, QI > 50). In winter season, spatial blacklisting is applied to remove jet winds in the Northern Hemisphere (NH).

Used satellites: Meteosat-10, FY-2D, GOES-13/15, MTSAT-2, NOAA-15/18/19, MetOp-A/B
- Resulting AMVs are a mix of LEO-LEO (10%), LEO-GEO (25%), and GEO-GEO (65%) (Warrick, 2015)

Objective

To investigate the impact of the assimilation of LEOGEO AMVs on the accuracy of global model forecast over East Asia



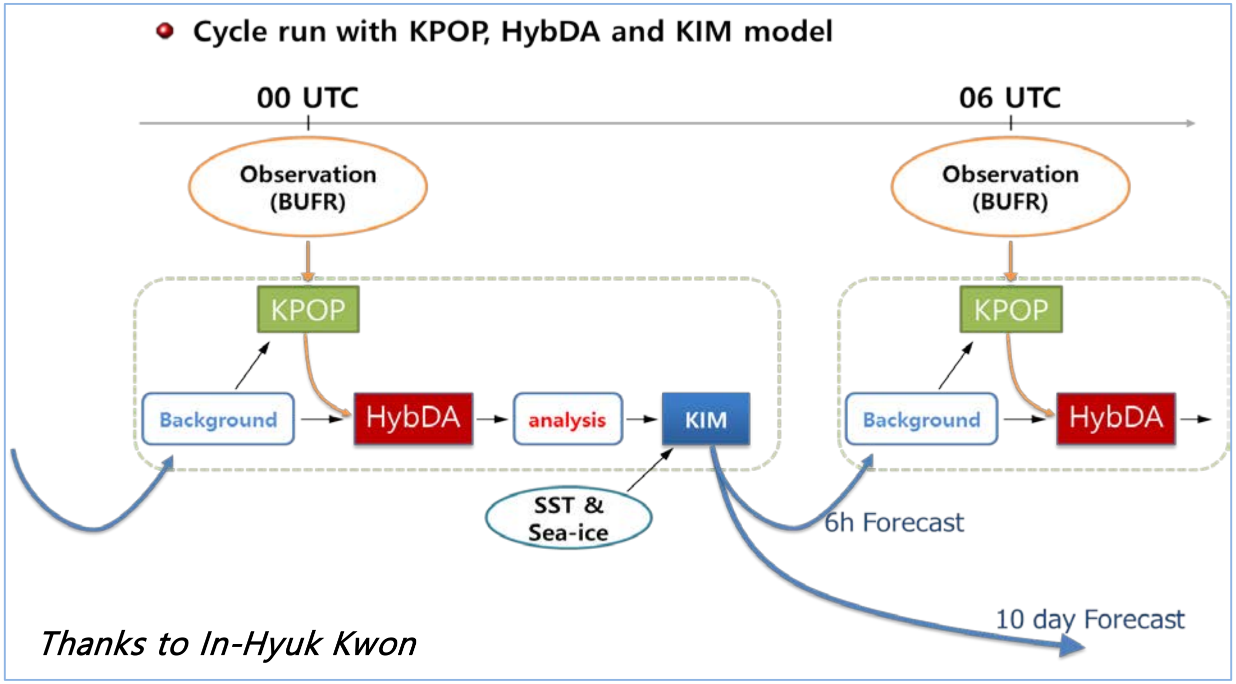
The upper-level winter jet stream area, the source of the baroclinic perturbation over the NH, can be more correctly analyzed by LEOGEO AMVs with the aid of their geographical location.

The incorporation of LEOGEO AMVs into the global analysis-forecast cycle can reduce the forecasting error in weather predictions (e.g. precipitation) over East Asia.

Experiment

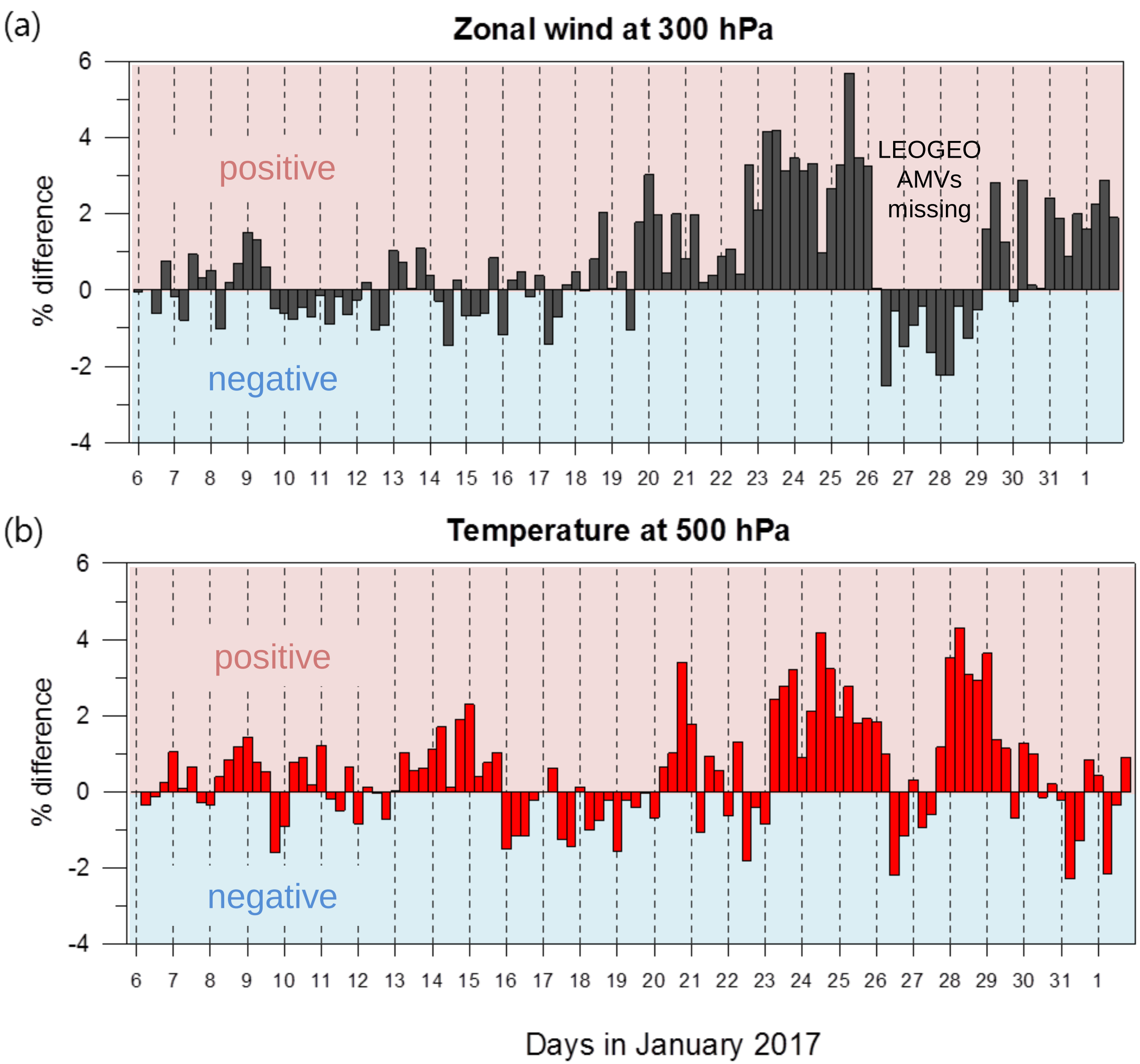
- **Period:** 2017010600 ~ 2017020118 UTC (27 days)
- **Cycle system:** semi-real time KIAPS operational version 2.5
  - KIM (Korean Integrated Model): 25 km, 0.3 hPa
  - HybDA (3-dimensional Data Assimilation system): 100 km, 0.3 hPa
  - KPOP (KIAPS Package of Observation Processing)
- **Observations:** sonde, surface, aircraft, GPS-RO, AMSU-A, MHS, IASI, scatwind, AMV
- **Validation:** ECMWF IFS analysis and KMA synoptic weather chart

- CTL: KIM v2.5 cycle **- EXP:** CTL + LEOGEO AMVs → Thinning: 100 km x 100 km x 100 hPa with ±3-hr time window



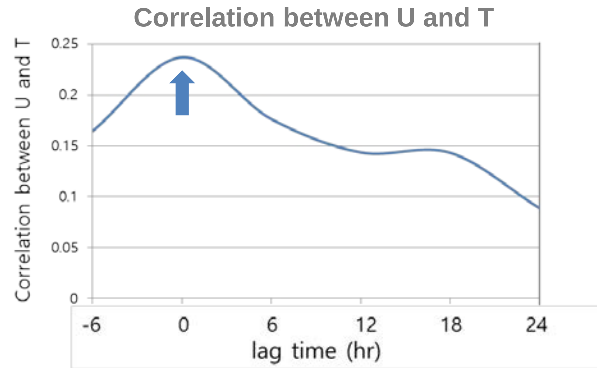
Analysis impact: time-series

Averaging region: 10-85˚N, 0-150˚E



Percent differences of CTL RMSD and EXP RMSD

$$\frac{\text{(CTL RMSD – EXP RMSD)}}{\text{CTL RMSD}} \times 100$$



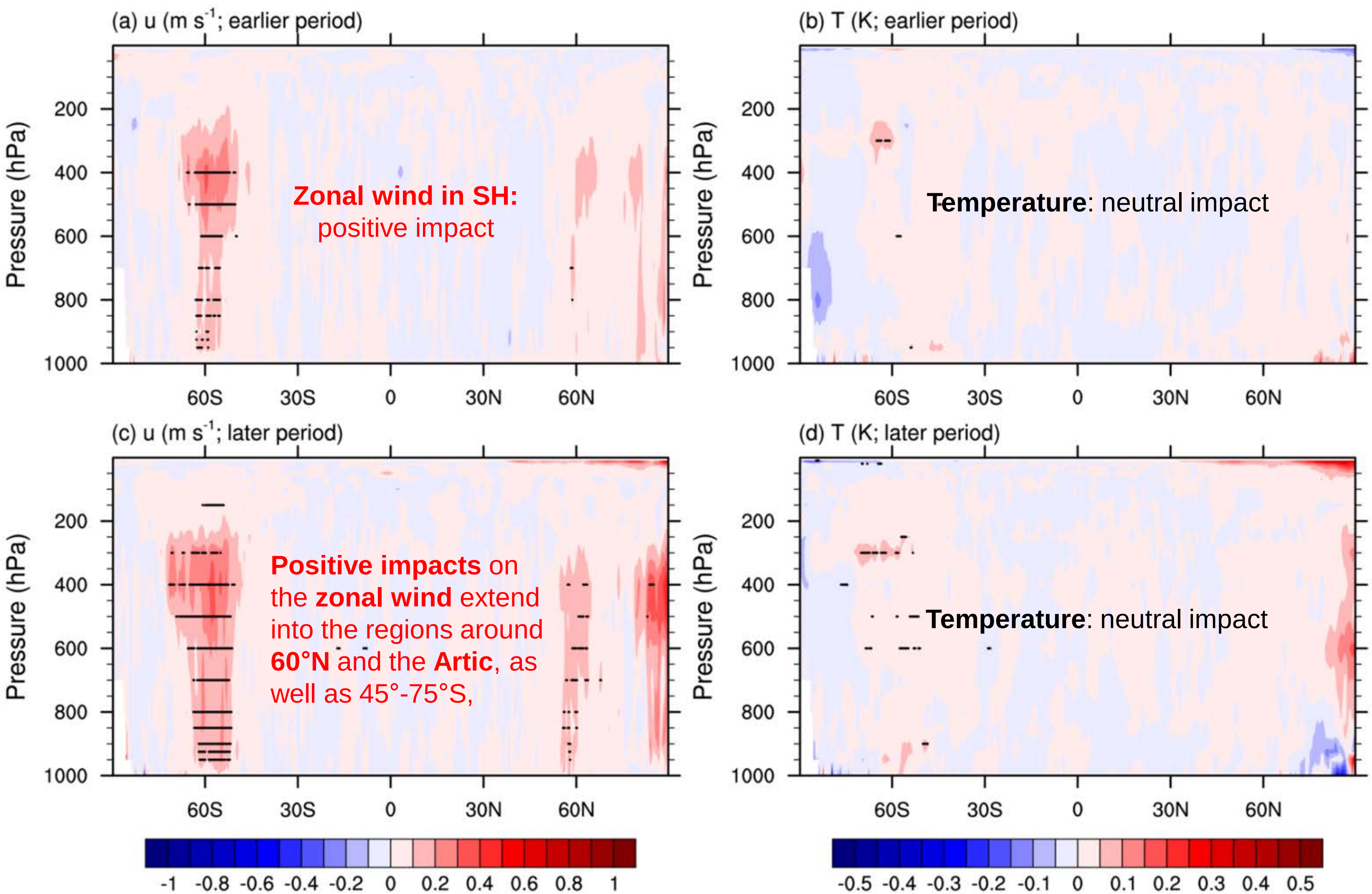
A positive correlation between wind and temperature in RMSD time-series was observed directly; this correspondence shows the analysis improvement in temperature was derived from the thermal wind balance in the background error covariance model of 3D-Var (Song et al., 2017).

Analysis impact: zonal plot

Error reduction of zonal wind and temperature (CTL RMSD – EXP RMSD)

Earlier part
(2017010600-2017011918)

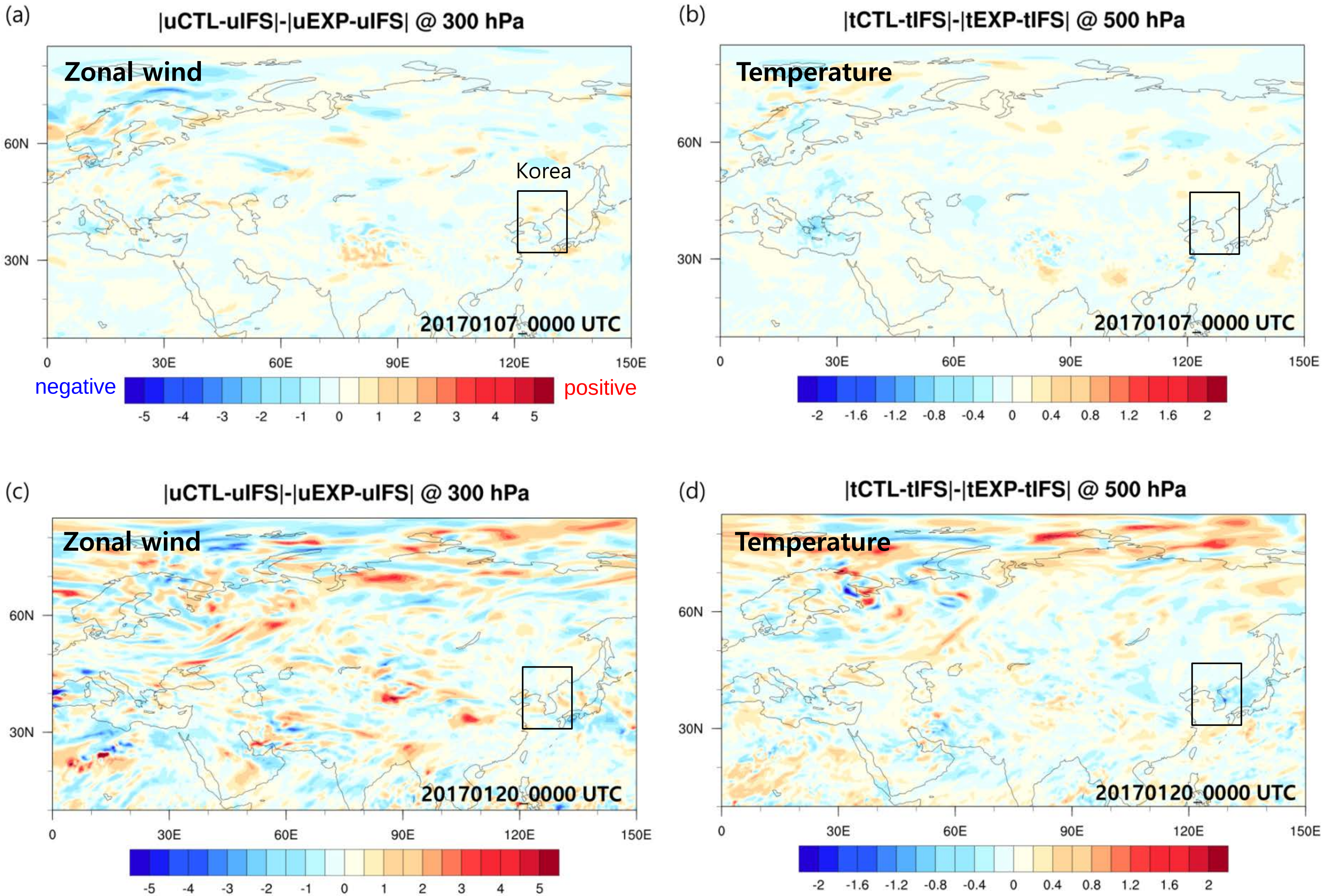
Later part
(2017012000-2017020118)



Analysis impact: 2D field

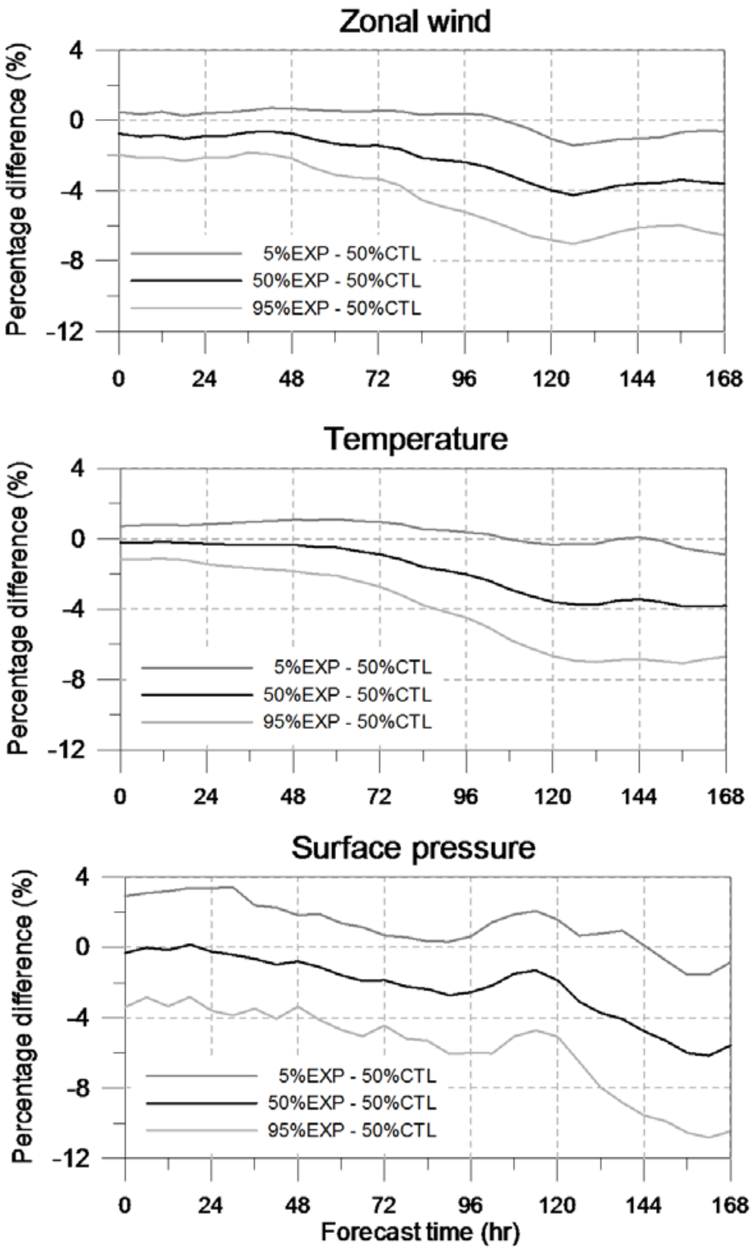
Earlier part
(2017010700)

Later part
(2017012000)



Although the initial impact of assimilated LEOGEO AMVs is less distinguishable, after 6-D forecast-analysis cycle has progressed, the positive impact of LEOGEO AMVs emerges in the higher latitudes over the EA domain for wind and temperature analysis.

Monte-Carlo significance test



After spin-up period, the bootstrapping test (Hesterberg et al., 2003) was used to evaluate the forecast impact of LEOGEO AMVs.

Allowing for repetitions, 100,000 bootstraps with the resultant twenty-five samples were generated randomly to create 100,000 averages for the RMSDs.

Based on these 100,000 bootstraps, the 95%, 50%, and 5% probability levels were identified.

Consequently, these reductions reach a two-tailed 90% statistical significance after a 108-hr forecast lead time for wind and temperature, except at 144-hr forecast, earlier than a 144-hr forecast lead time for surface pressure.

Case study (precipitation event)

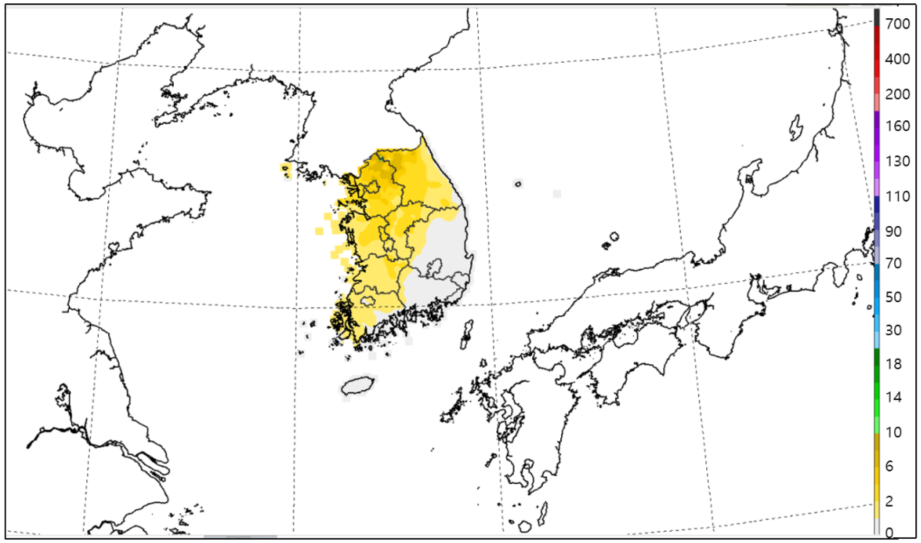
Initial: 20170120_00 UTC

Target: 20170127_00 UTC (168-hr forecast)

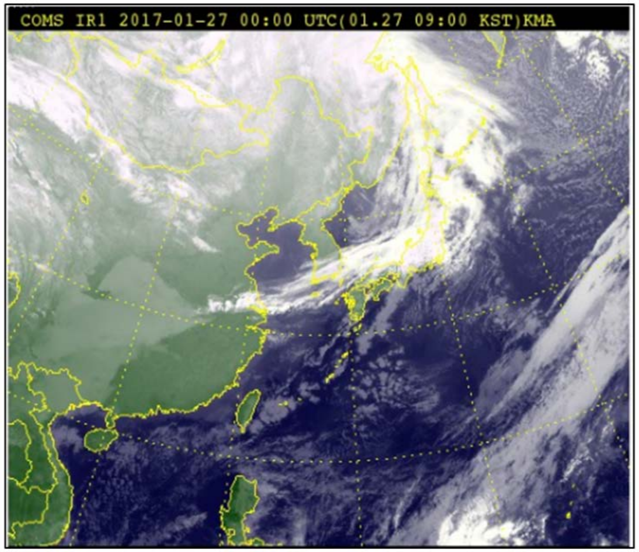
Precipitation event

Precipitation event over East Asia at 0000 UTC on 27 January 2017

(a) Automatic weather station data (AWS) in the Korea Peninsula



(b) COMS IR channel

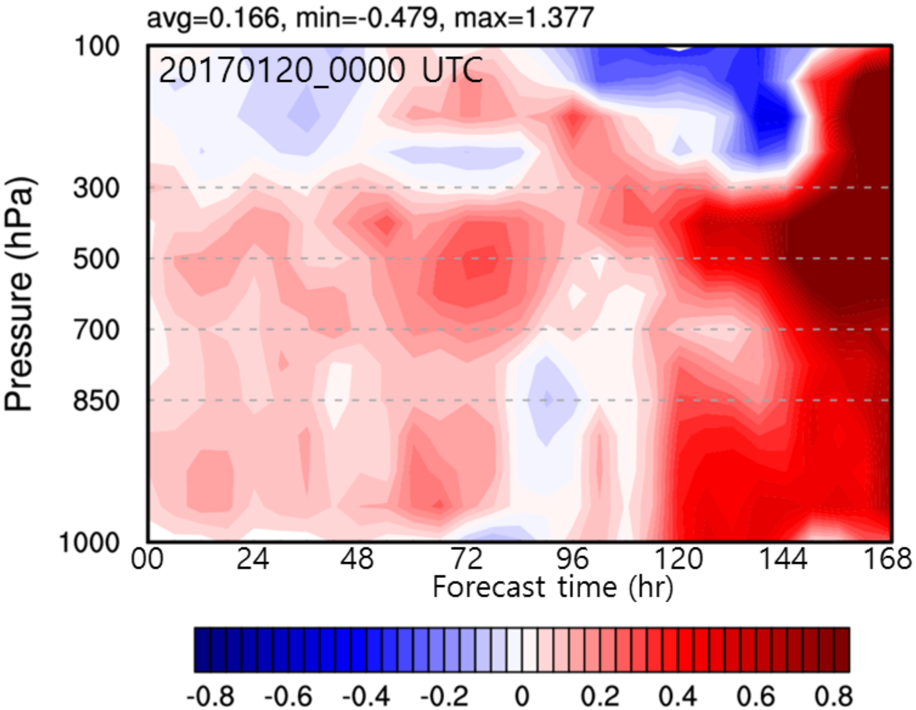


This case was selected based on the precipitation rate (12-hr accumulation summed over the Korean Peninsula: 1126.2 mm) observed in AWS over the Korean Peninsula.

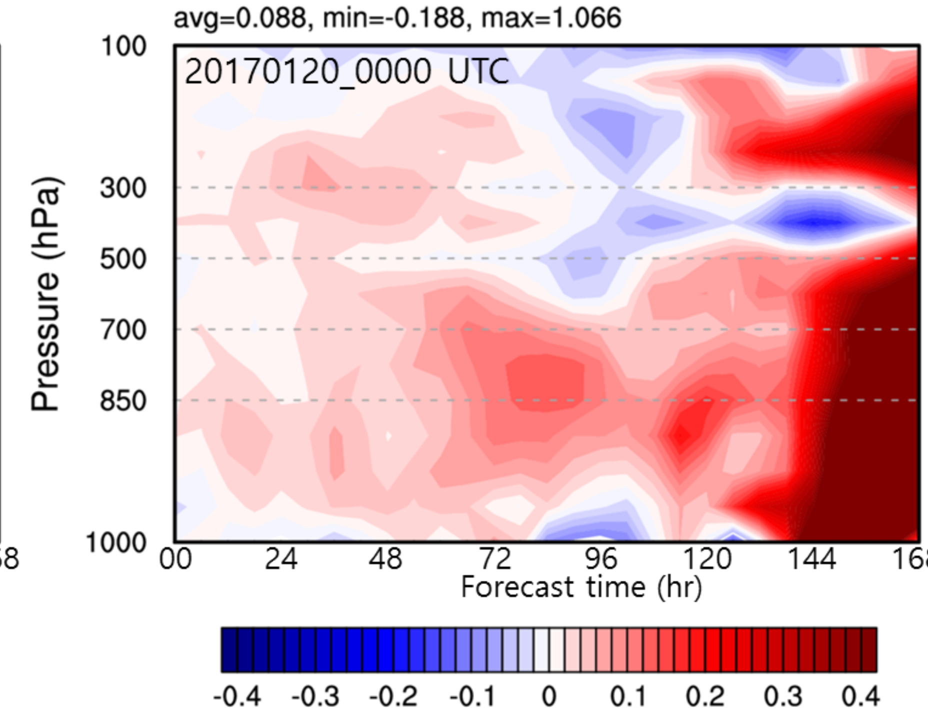
COMS IR channel (10.8 μm) shows a circulation system with a strong westerly and clouds.

Forecast impact: vertical

(a) Error reduction of U (m/s)



(b) Error reduction of T (K)



The positive impact of LEOGEO AMVs is presented consistently in the mid-level of 300-700 hPa.

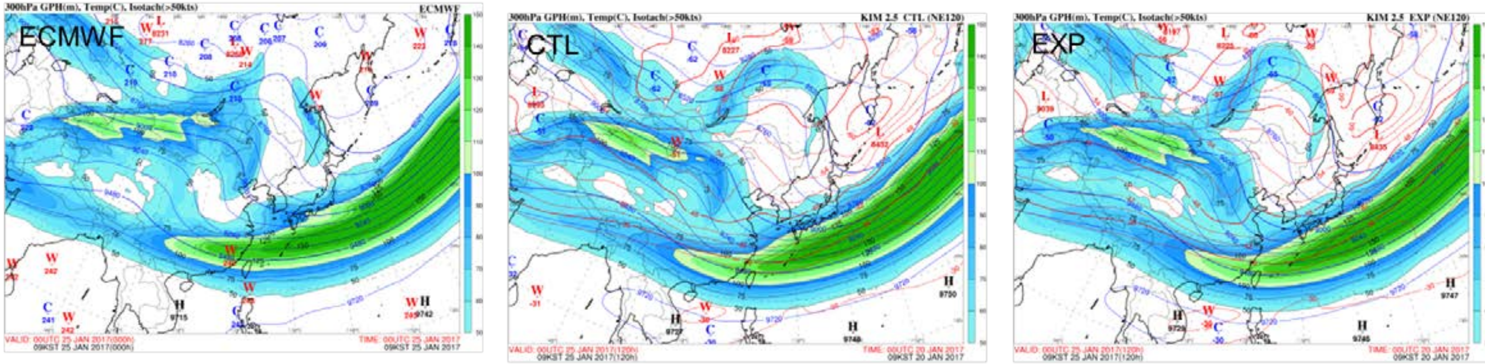
Since 72-hr forecast, positive signal of LEOGEO AMVs in zonal wind starts from the higher level near 100 hPa and is linked up to the surface after 120-hr forecast.

The error reduction of temperature appears mainly below 500 hPa approximately after 30-hr forecast and its dramatic change also appears one day later than that of zonal wind.

Forecast impact: GPH @ 300 hPa

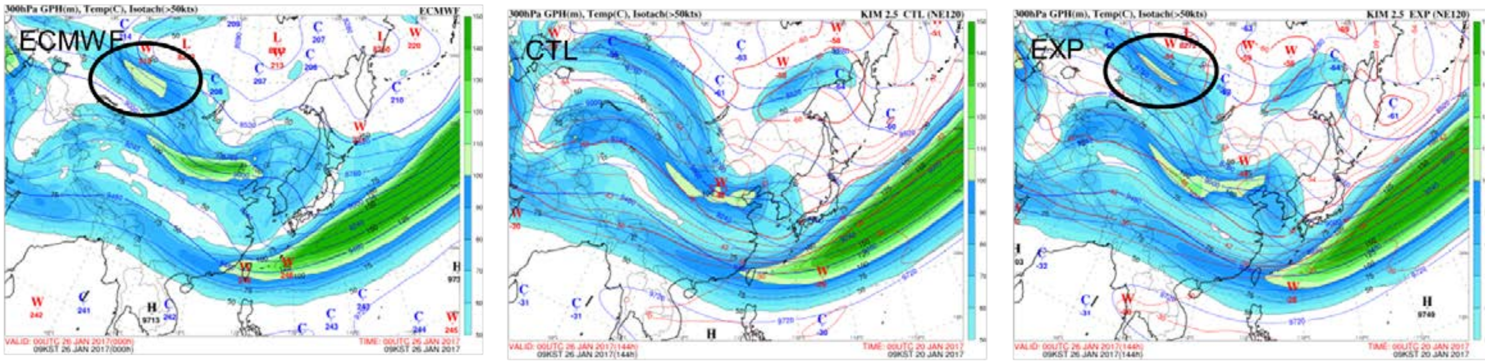
Case study: initial 20170120_0000 UTC

20170125_0000 UTC (120-hr forecast)



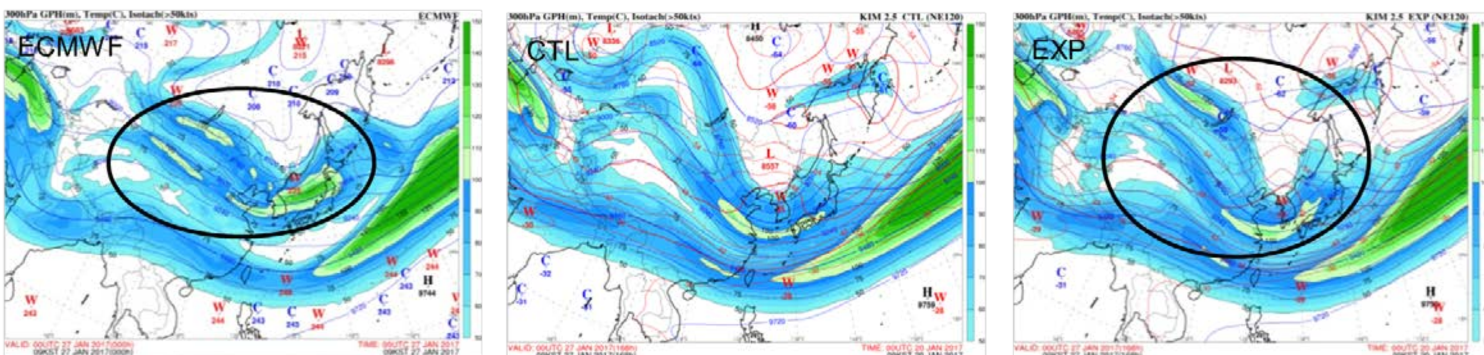
CTL and EXP are similar

20170126_0000 UTC (144-hr forecast)



EXP is superior to CTL

20170127_0000 UTC (168-hr forecast)



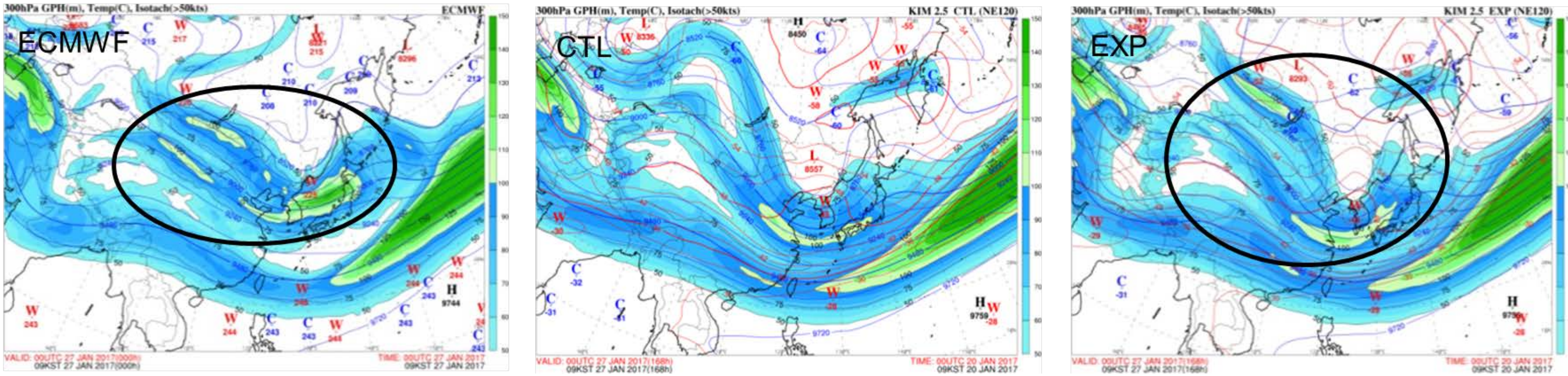
EXP is superior to CTL

Solid line: GPH
Shaded: isotach
Dashed line: temperature

Forecast impact: GPH @ 300 hPa

Case study: initial 20170120_0000 UTC

20170127_0000 UTC (168-hr forecast)



In 120-hr forecast, both experiments of CTL and EXP are very similar to IFS analysis: inflowing jet into Korea clearly appeared at both cases.

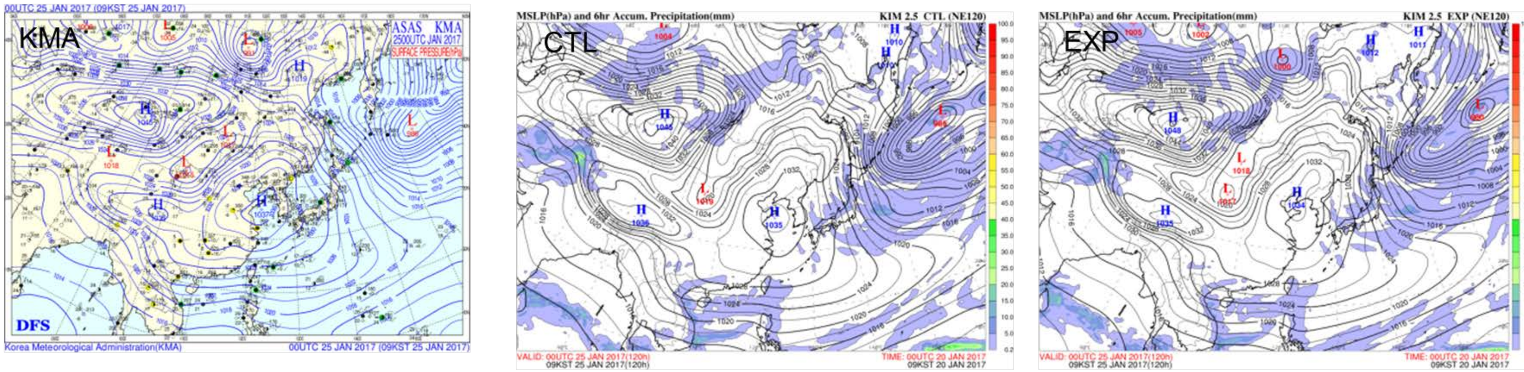
However, the polar core of spilt jet steam disappeared in CTL at 144-hr forecast.

Especially, 168-hr forecast field contains three strong jets around Korean Peninsula. EXP is maintaining well this system relatively and the position of the jet through Korea is closer to that of the IFS analysis .

Forecast impact: surface

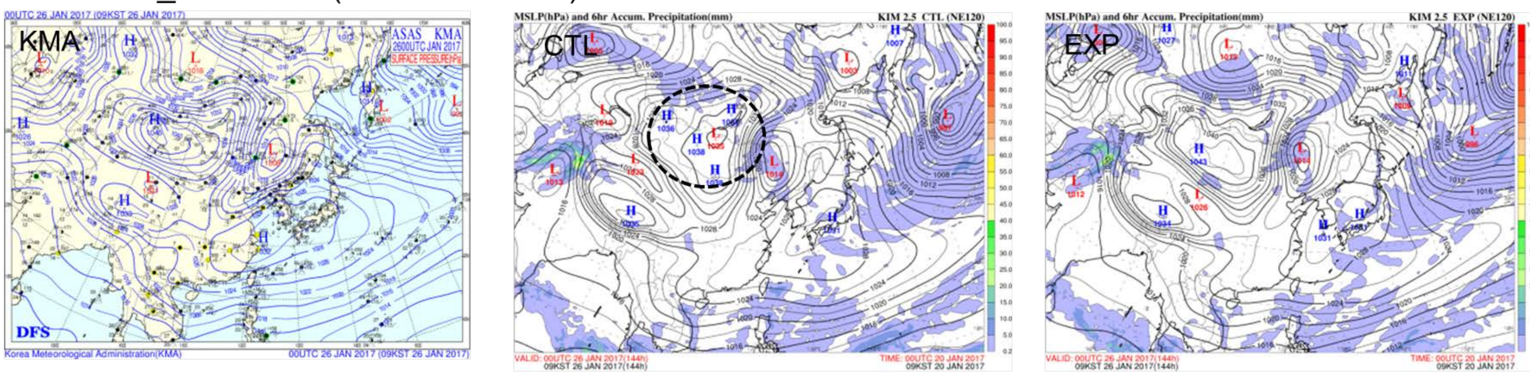
Case study: initial 20170120_0000 UTC

20170125_0000 UTC (120-hr forecast)



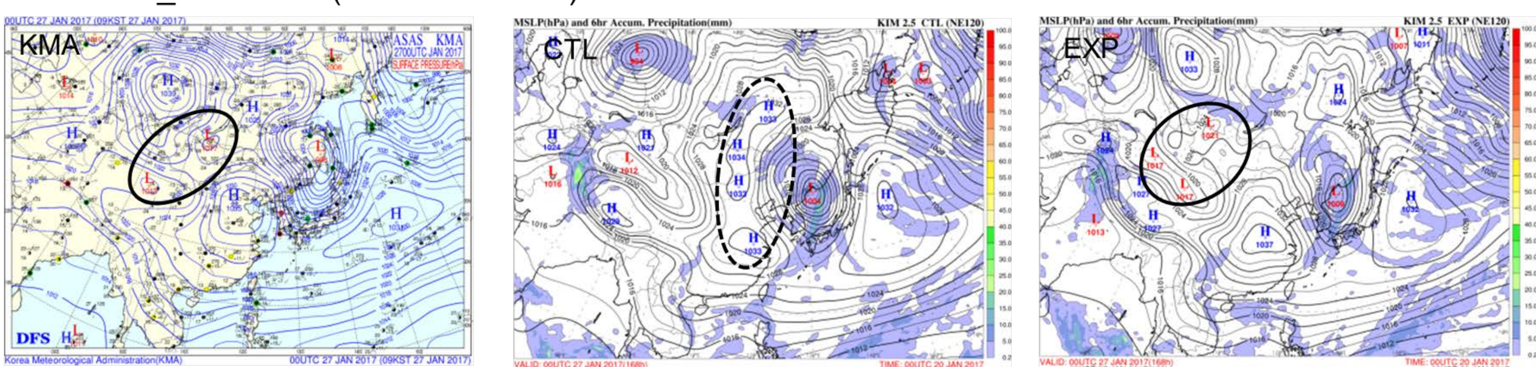
CTL and EXP are similar

20170126_0000 UTC (144-hr forecast)



EXP is superior to CTL

20170127_0000 UTC (168-hr forecast)



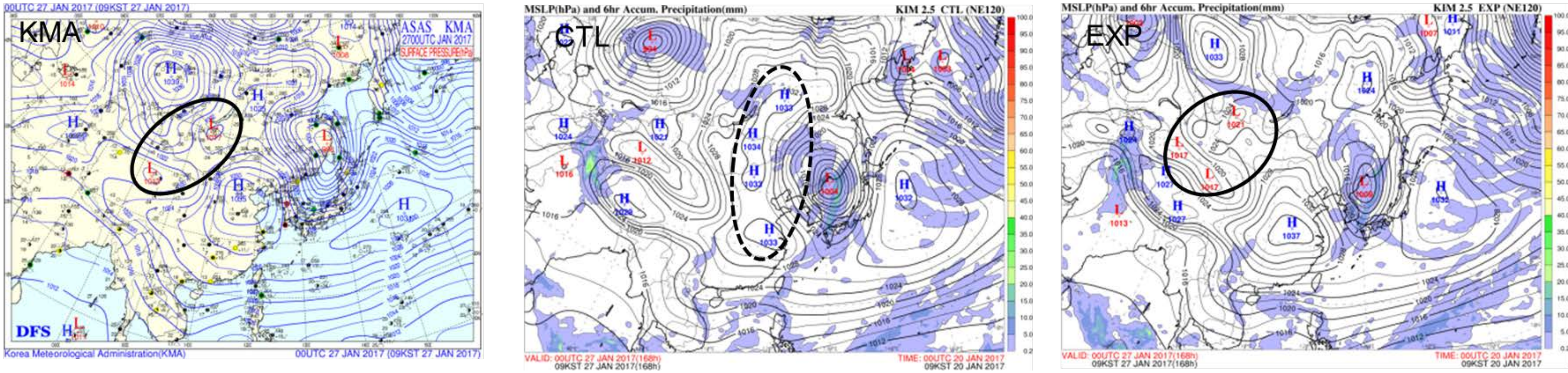
EXP is superior to CTL

Solid line: sea level pressure

Shaded: 6hr accumulated precipitation

Forecast impact: surface

20170127_0000 UTC (168-hr forecast)



The both experiments of CTL and EXP show a good performance until 120-hr forecast.

However, impact of CTL on 144-hr forecast decreased unexpectedly: the low pressure system is located in the middle of high pressure over northcentral China.

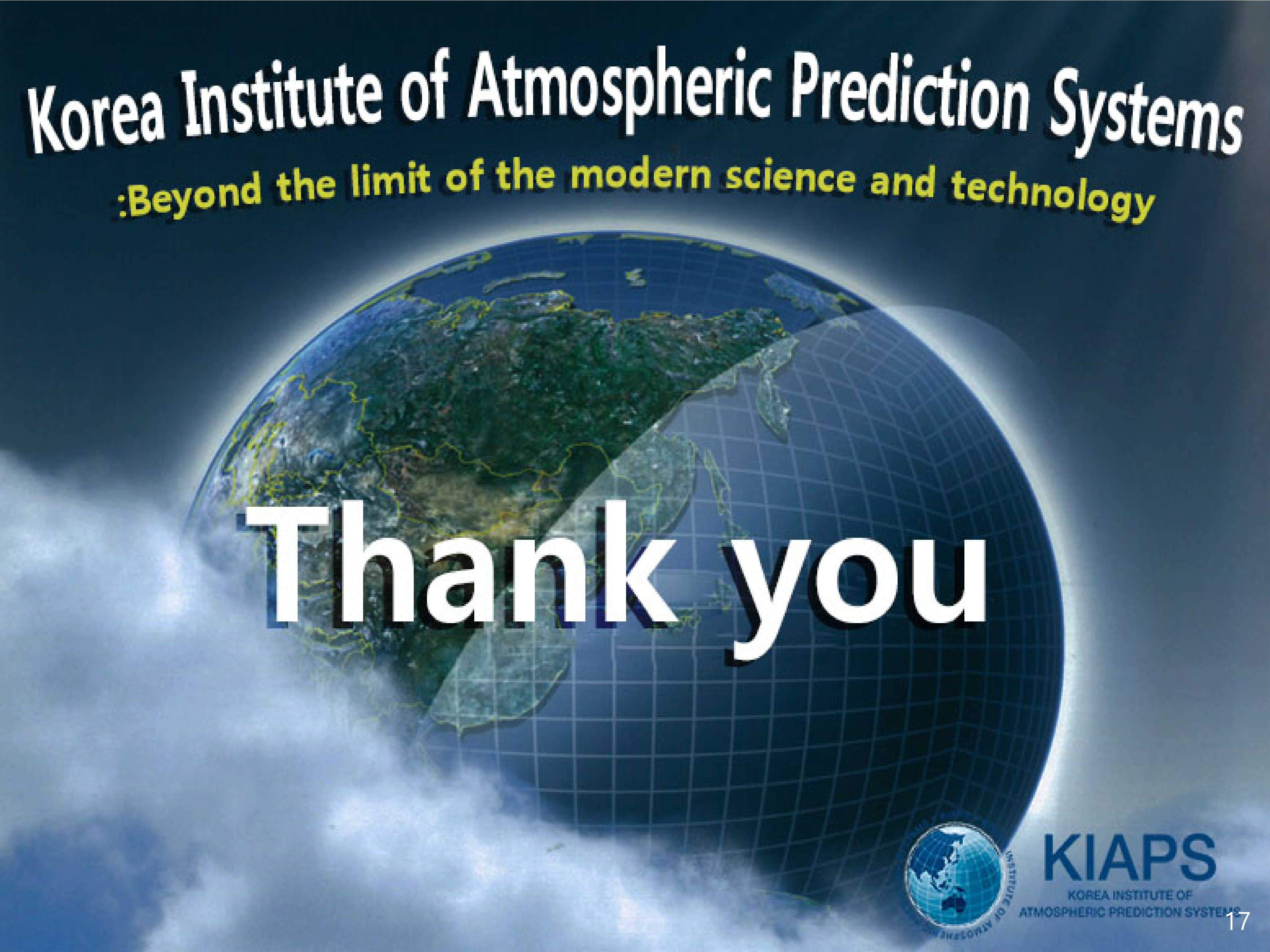
In 168-h forecast, KMA analysis weather chart shows the low pressure following on high pressure in the Northeast of Korea. The pressure system in the EXP is more similar to the reference than that of CTL. The high pressure of CTL is standing with elongated shape at 168-hr forecast, which is strikingly different from the KMA weather chart.

Summary

- Assimilation of LEOGEO AMVs shows a globally significant benefit in wind analysis over the 50°–70° latitude band for all levels.

- Based on a bootstrapping test, the positive forecast impact on wind, temperature, and surface pressure of the LEOGEO AMV assimilation over East Asia has been verified at a 90% statistical significance level.

- Even though its spatial coverage is confined to higher latitudes and the observable variable is wind, not mass, the assimilation of LEOGEO AMVs has a positive impact on the forecast for a synoptic pattern even including wind, temperature and surface pressure over the East Asian domain.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:Beyond the limit of the modern science and technology
Thank you
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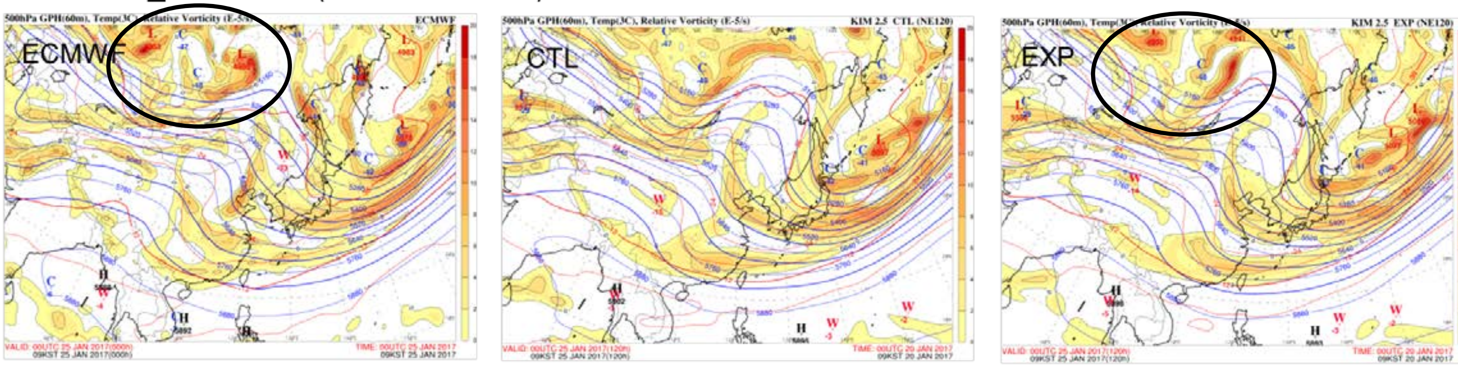
Case study: initial 20170120_0000 UTC

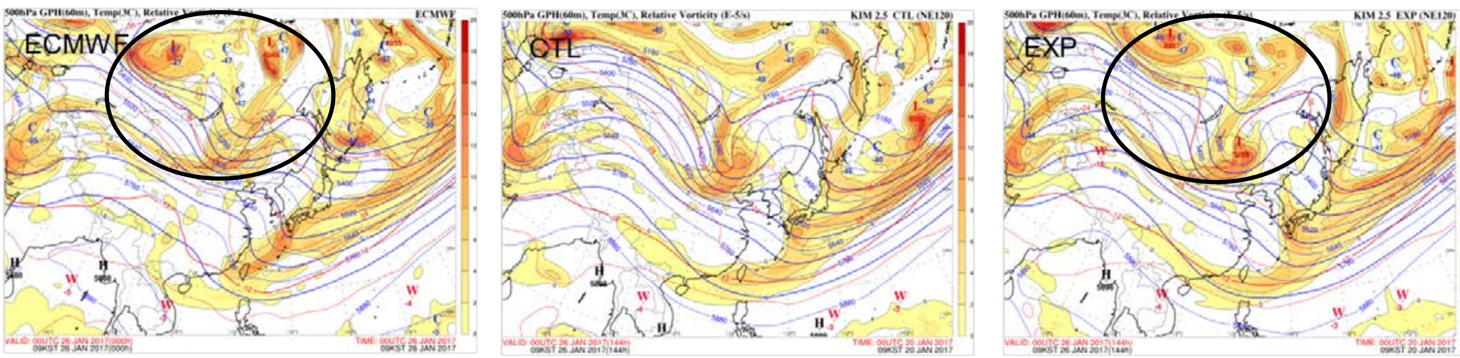
Forecast impact: GPH @ 500 hPa

20170125_0000 UTC (120-hr forecast)



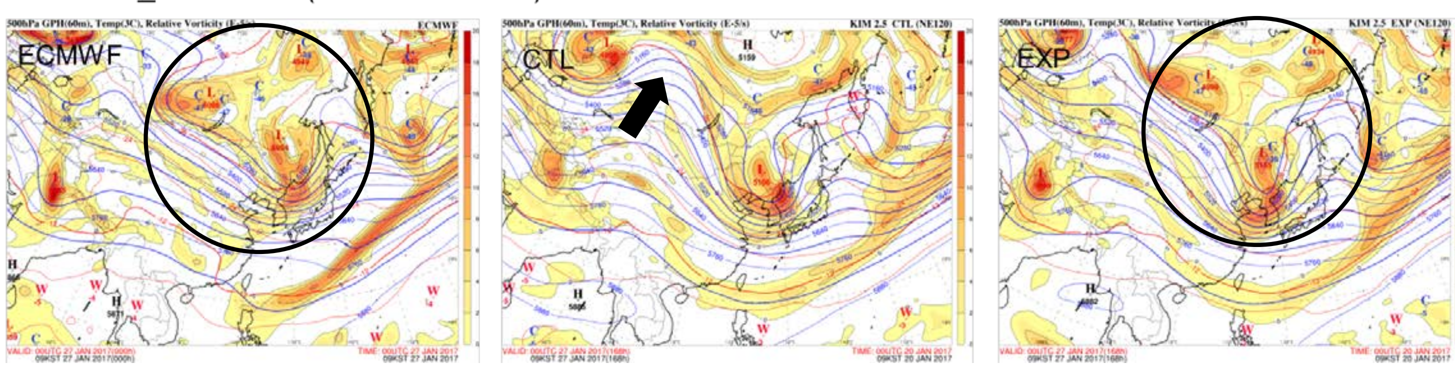
EXP is superior to CTL

20170126_0000 UTC (144-hr forecast)



EXP is superior to CTL

20170127_0000 UTC (168-hr forecast)



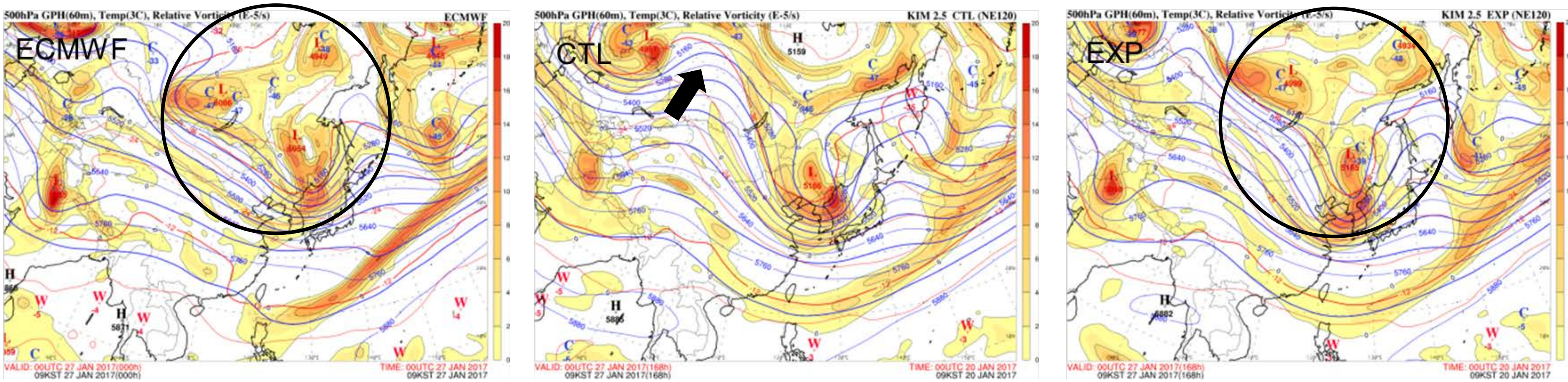
EXP is superior to CTL

Solid line: GPH
Shaded: vorticity
Dashed line: temperature

Forecast impact: GPH @ 500 hPa

Case study: initial 20170120_0000 UTC

20170127_0000 UTC (168-hr forecast)



Arctic system is getting closer to the northern part of the Korean Peninsula. Inflowing pattern of winds at EXP is more similar than that of CTL, compared to IFS analysis.

Low pressure systems, which has a triangle shape, around Lake Baikal are clearly maintained until 168-hr forecast of EXP, while high pressure is located in the left side of Lake Baikal at CTL.

In EXP with LEOGEO AMVs, the intensity of low pressure at the North Pole is stronger than that of CTL initially (not shown). Propagation of the stronger low-pressure system from the Arctic to just the northwest of Lake Baikal finally abandons the intrusion of the high pressure in the case of CTL. The resultant baroclinicity is associated with the polar branch of the jets.