

Performance of Global Ensemble Prediction System for extremely warm days over Asia in spring 2018



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Introduction

- In February 2018, Japan experienced cold weather, and it followed by extremely warm weather in March. Most S2S models successfully predicted this abrupt change from cold to extremely warm periods with the lead time of 2-3 weeks (forecasts initialized on 15 February).
- JMA Global Ensemble Prediction System (JMA-GEPS; JMA 2019) predicted wave energy propagation from stratosphere towards troposphere after stratospheric sudden warming (SSW), and represented the wave pattern over Eurasia well.
- To understand the origins of extremely warm event over Japan, some relaxation experiments are carried out in which several regions of the atmosphere are relaxed towards analysis data as to artificially reduce the development of forecast errors.

Datasets

- Analysis Data:** Japanese 55-year Reanalysis (JRA-55; Kobayashi et al. 2015)
 - Forecast Data:** JMA-GEPS and S2S database (Vitart et al. 2017)
- Operational one month forecast of JMA-GEPS runs every Tuesday and Wednesday. To compare with other S2S model forecasts having different initial date, we operated additional JMA-GEPS forecasts on Thursday (initialized on 8 and 15 February).

Table 1: Specifications of the JMA-GEPS.

JMA Global EPS (GEPS)

Main targets	Typhoon forecast, One-week to One-month forecast
Frequency	4 times a day when TC exists, 2 times a day otherwise
Forecast range	5.5 days (06,18UTC), 11 days (00,12UTC) 18 days (00,12UTC on Sat. and Sun.) 34 days (00,12UTC on Tue. and Wed.) ※1
Ensemble size	27 up to 11 days, 13 afterwards
Resolution	TL479L100 (approx. 40 km, model top: 0.01 hPa) up to 18 days, TL319L100 (approx. 55 km) afterwards
Initial perturbations	SV (NH, TR and SH) + LETKF
Model ensemble	Stochastically Perturbed Physics Tendency (SPPT)
Boundary perturbations	Perturbations on SST

※1 JMA plans to extend forecast range of every 00UTC,12UTC initials to 18 days from June 2019.

Operational Forecast Performance

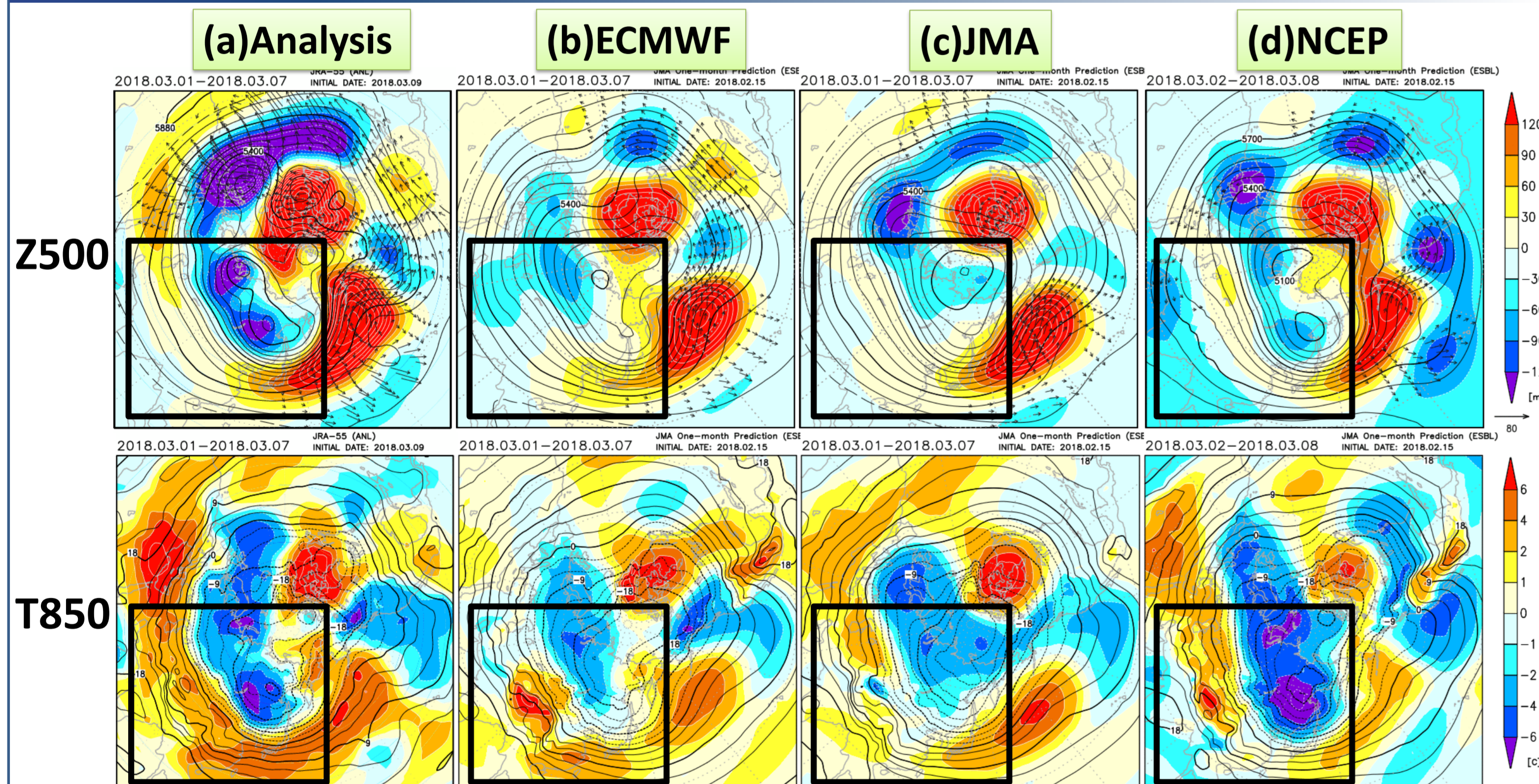


Fig 1: (top) Geopotential height and anomalies at 500hPa level (bottom) temperature and anomalies at 850hPa level for the period 1-7 March: (a)JRA-55, (b)ECMWF, (c)JMA-GEPS, (d)NCEP. (b)-(d) show ensemble mean forecast initialized on 15 February. Anomalies are deviation from 1981-2010 average of JRA-55.

- The ensemble forecasts from 15 February predicted T850 negative anomalies over northern Eurasia and positive anomalies over southern Eurasia. Most of S2S models could not represent the anomalies correctly in forecasts initialized on 8 February before SSW occurrence (not shown).
- The operational JMA-GEPS ensemble mean forecasts with lead times of 3-4 weeks, initialized on 14 February, recorded the highest skill since March 2001.
- Downward wave energy propagation from stratosphere over Eurasia is also predicted well in forecasts initialized on 14 February.

Table 2: Anomaly correlation coefficient of Northern Hemisphere (20°N-90°N) 500hPa geopotential height in ensemble mean forecasts. The initial dates are from 31 January to 28 February.

	1week	2week	3-4weeks	1-4weeks
31 January	0.909	0.480	0.195	0.548
7 February	0.918	0.385	0.479	0.607
14 February	0.928	0.878	0.817	0.894
21 February	0.938	0.847	0.492	0.843
28 February	0.960	0.668	0.363	0.776

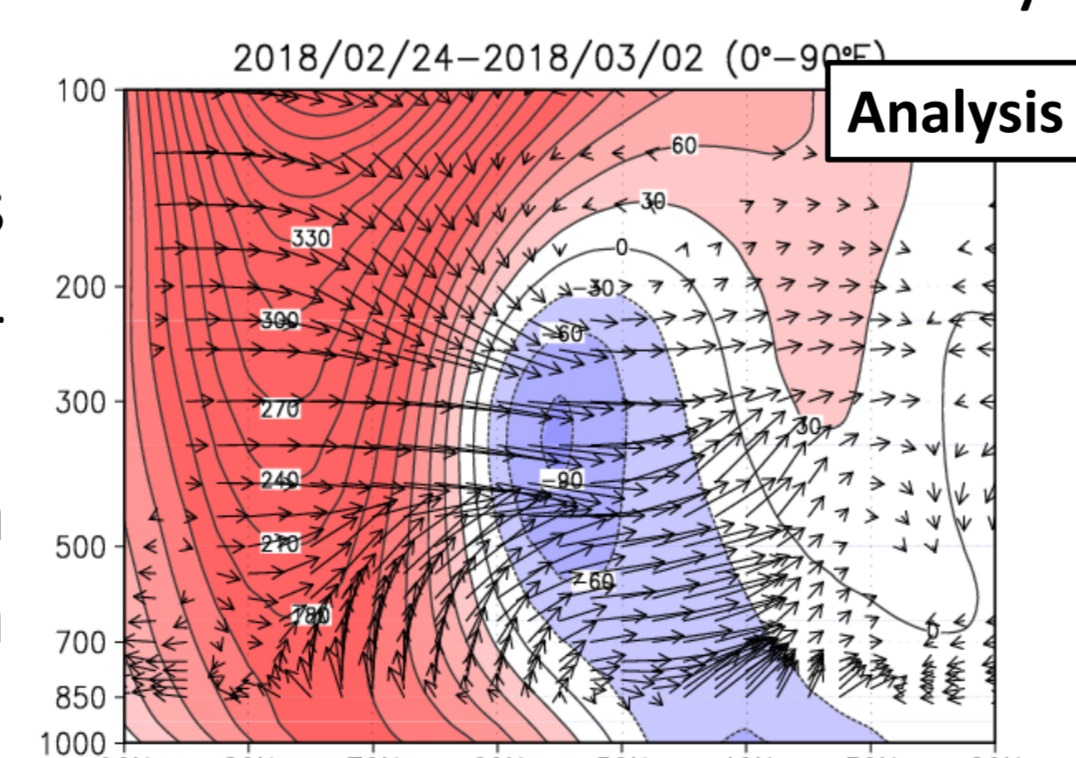


Fig 3: Latitude-height cross section of time-averaged geopotential height anomalies and wave activity flux (m^2/s^2) with reference of Takaya and Nakamura (2001). Longitudinal average: 0°E-90°E.

Summary

- Forecast performance of JMA-GEPS initialized from 14 February 2018 is the highest in the last twenty years.
- Additional relaxation experiments indicate the possibility that stratospheric polar vortex played an important role in predicting extremely warm days over East Asia in March 2018.

Setting of Additional Experiment (initialized from 8 Feb.)

- Relaxation experiment (Jung et al. 2010, Jung 2011) runs by adding an extra term of the following equation to the JMA-GEPS:

$$\frac{\partial X}{\partial t} = F_{mt}(X) + \lambda(X_{ref} - X)$$

X : prognostic variables
 X_{ref} : reference field (analysis)
 F_{mt} : prognostic equation of X
 λ : relaxation coefficient (set to 0.1 h^{-1})

- Relaxed regions are defined as below:

	Longitude	Latitude	Vertical Layer
CNTL	No relaxation		
Exp1	0°-360°	60°N-90°N	above 100hPa (Stratosphere and Mesosphere)
Exp2	160°E-150°W	5°N-25°N	all layers

The objective of Exp2 is to understand the influence of active convection on anti-cyclonic circulation over Mid-Pacific. This circulation is considered to intensify warm advection in East Asia.

- Forecasts are started at 12UTC 8 February when most S2S models could not predict the anomaly pattern correctly.

Results

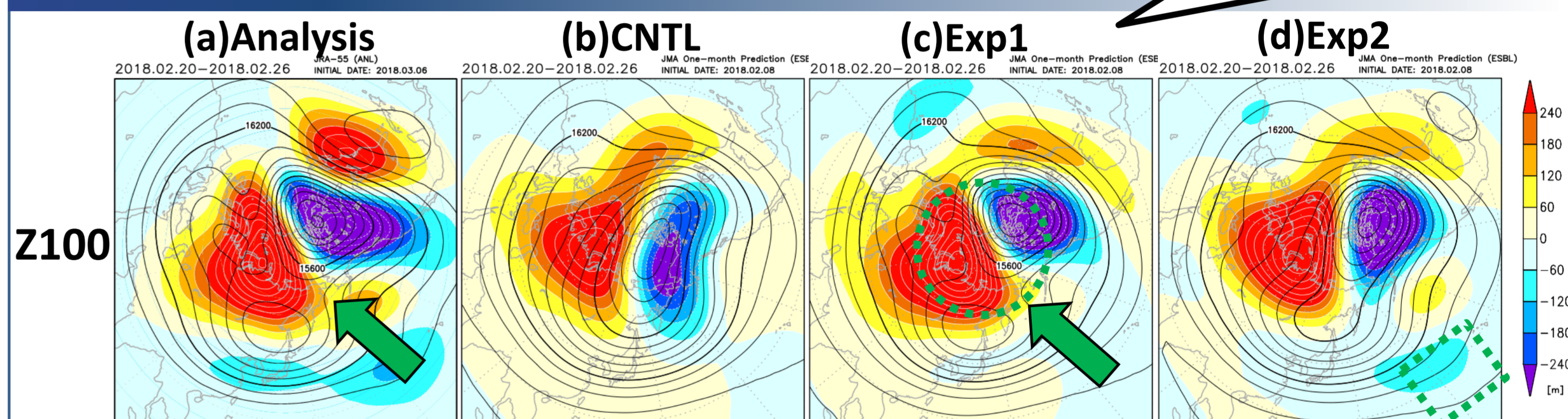


Fig 3: Geopotential height and anomalies at 100hPa level for the period 20-26 February: (a)JRA-55, (b)CNTL, (c)Exp1, (d)Exp2, (b)-(d) are based on ensemble mean data.

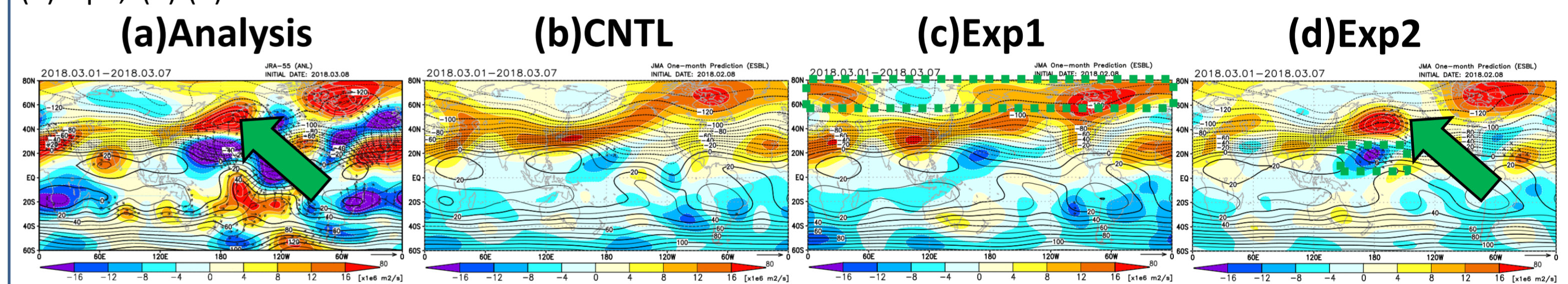


Fig 4: Same as in Fig 3, but for stream function at 200hPa level.

- Exp1 represents splitting of stratospheric polar vortex and its persistence seen in the analysis, though CNTL doesn't represent them correctly (Fig 3).
- Exp2 successfully represents the pair of cyclonic and anti-cyclonic circulation over Mid-Pacific (Fig 4).

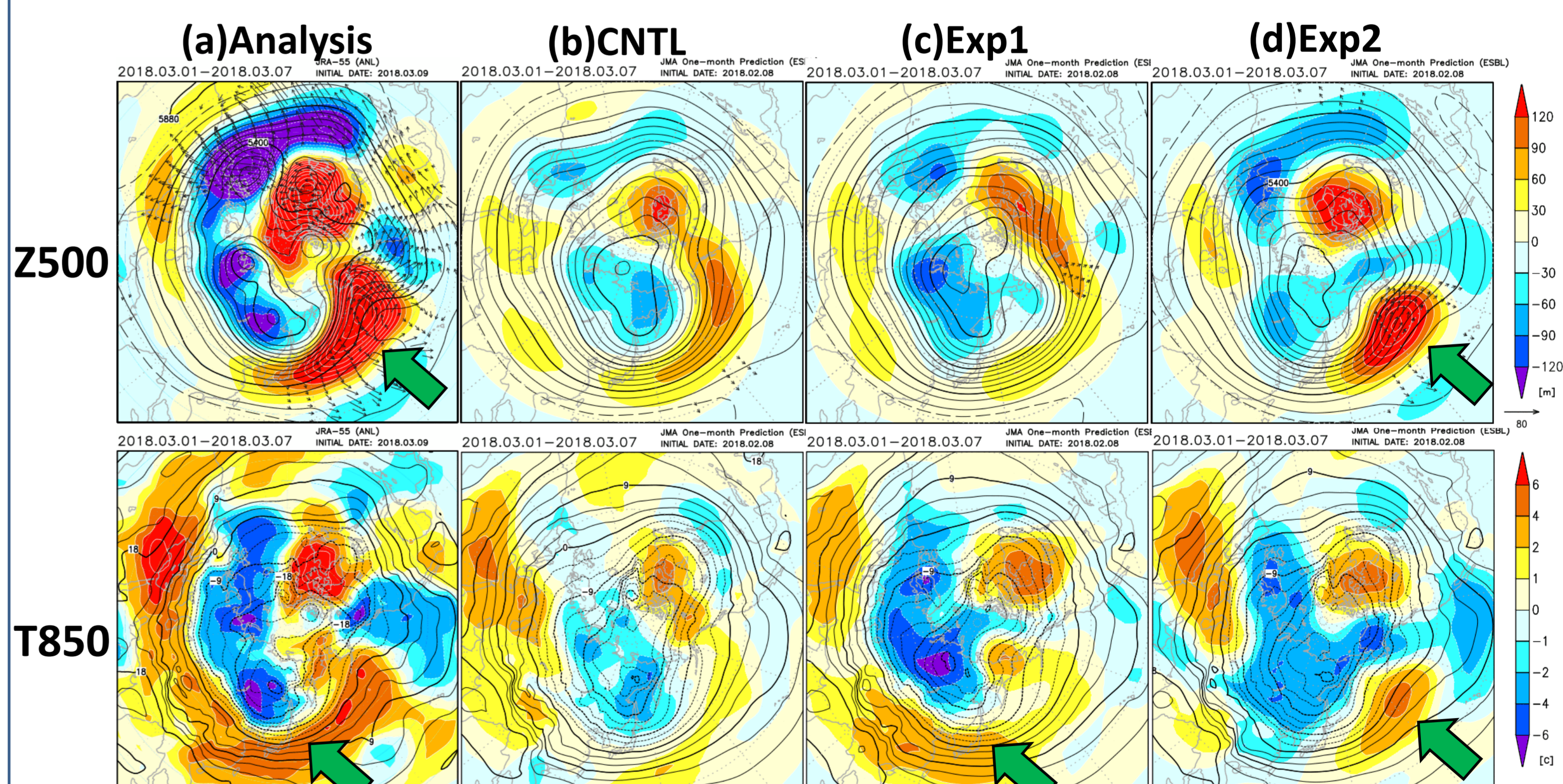


Fig 5: (top) Geopotential height and anomalies at 500hPa level (bottom) temperature and anomalies at 850hPa level for the period 1-7 March: (a)JRA-55, (b)CNTL, (c)Exp1, (d)Exp2, (b)-(d) are based on ensemble mean data.

- Exp1 shows T850 negative anomalies over northern Eurasia and positive anomalies over southern Eurasia through Japan, suggesting contribution from stratosphere.
- Exp2 shows Z500 positive anomalies over North Pacific, but it doesn't seem to extend through Japan because of cold advection from northward.

References

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