A-p08 AFES–LETKF Experimental Ensemble Reanalysis 2

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Summary

- an experimental ensemble reanalysis dataset for five years
- a successor of AFES–LETKF experimental ensemble reanalysis (Miyoshi et al. 2007a, ALERA)
- produced with a forecast model with improved physics and an updated analysis scheme
- larger ensemble size and more output forecast variables
- used as a reference of observing system experiments to evaluate field campaigns

See also

- A-p35: Akira Yamazaki, Storm Tracks and Low-Frequency Variabilities in AFES-LETKF Experimental Ensemble Reanalysis 2
- Wednesday Session 11: Nobumasa Komori, Development of an Ensemble-based Data Assimilation System with a Coupled AtmosphereOcean GCM

System overview

AFES–LETKF ensemble data assimilation system (ALEDAS) 2

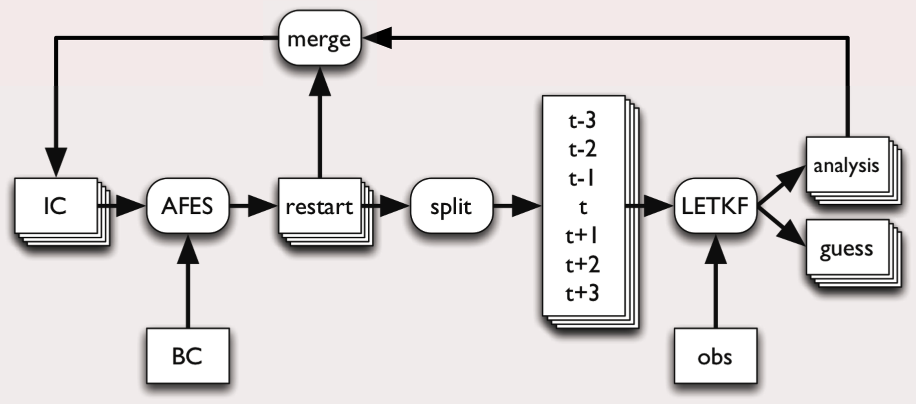

Figure 1 : Data flow of ALEDAS2 (Enomoto et al. 2013).

Forecast model

- Atmospheric General Circulation Model for the Earth Simulator (AFES) version 3.6 (Numaguti et al. 1997; Ohfuchi et al. 2004; Enomoto et al. 2008)
- Spetral transform, Eulerian advection
- Radiation: mstrnX (Sekiguchi and Nakajima 2008)
- Convection: Emanuel (Emanuel 1991; Emanuel and Živković-Rothman 1999; Peng et al. 2004)
- Cloud: Gaussian PDF with std from moist Mellor–Yamanda level 2 (Kuwano-Yoshida et al. 2010)
- Land-surface: MATSIRO (Takata et al. 2003)
- Reduced 5-day forecast RSMD of 500 hPa geopotential height from 52.1 m of AFES 2.2 T159L48 used in ALERA to 48.9 m of AFES 3.6 T119L48 in ALERA2

Analysis scheme

- Local transform ensemble Kalman filter (Hunt et al. 2007; Miyoshi and Yamane 2007)
- Analysis

$$\bar{\mathbf{x}}^{\mathrm{a}} = \bar{\mathbf{x}}^{\mathrm{f}} + \mathbf{X}^{\mathrm{f}}\tilde{\mathbf{P}}^{\mathrm{a}}(\mathbf{Y}^{\mathrm{f}})^{\mathrm{T}}\mathbf{R}^{-1}(\mathbf{y}^{\mathrm{o}} - \bar{\mathbf{y}}^{\mathrm{f}}) \quad (1)$$

$$\tilde{\mathbf{P}}^{\mathrm{a}} = \left[(k-1)\mathbf{I} + (\mathbf{Y}^{\mathrm{f}})^{\mathrm{T}}\mathbf{R}^{-1}\mathbf{Y}^{\mathrm{f}}\right]^{-1} \quad (2)$$

- Ensemble update

$$\mathbf{X}^{\mathrm{a}} = \mathbf{X}^{\mathrm{f}}\left[(k-1)\tilde{\mathbf{P}}^{\mathrm{a}}\right]^{1/2} \quad (3)$$

- Distance-based covariance localization (Miyoshi et al. 2007b)

$$w(r) = \exp\left[-\frac{1}{2}\left(\frac{r}{\sigma}\right)\right] \quad (4)$$

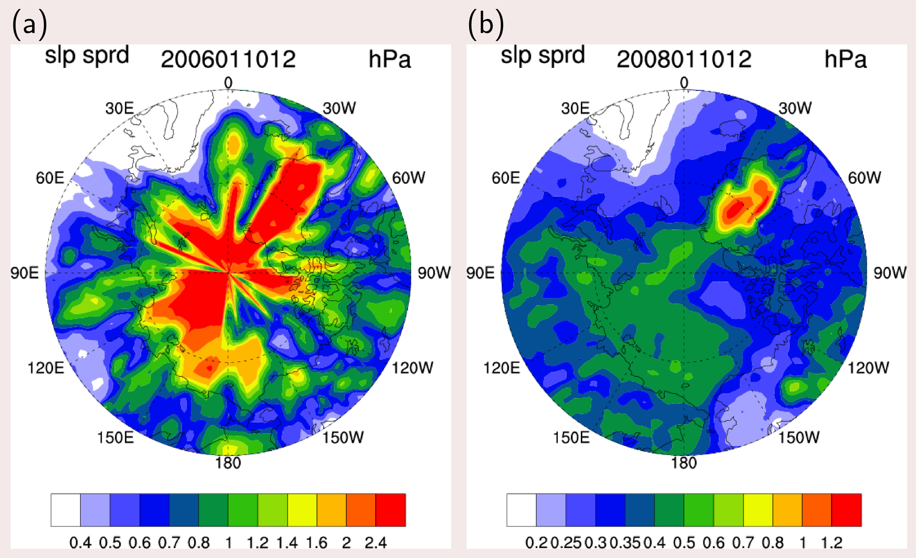

Figure 2 : The analysis ensemble spread of sea-level pressure in the Arctic (a) on 10 January 2006 in ALERA and (b) on 10 January 2008 in ALERA2 (Enomoto et al. 2013).

Specifications

	ALEDAS	ALEDAS2
AFES version	2.2	3.6
AFES resolution	T159L48	T119L48
Ensemble size	40	63+1
Covariance localization	21×21×13	400 km/0.4ln p
Spread inflation	0.1 (multiplicative)	
Observations compiled by	JMA	NCEP
SST	weekly OISST (Reynolds et al. 2002)	daily OISST Reynolds et al. (2007)

Table 1 : A comparison of the configurations of ALEDAS and ALEDAS2 with some modifications (Enomoto et al. 2013).

- five years in two streams (overlapped about a month)
- stream2008: from 6 UTC 1 January 2008 to 0 UTC 30 August 2010
- stream2010: from 6 UTC 1 August 2010 to 0 UTC 5 January 2013
- 8 members per node on the Earth Simulator 2

Observation thinning

- radiosondes: 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50 and 10 hPa
- reports from aircraft and satellite retrievals: one in every 4 values
- wind profilers: one in every 3 levels (St-James and Laroch 2005)

Comparison with precipitation estimates

- reasonable intensity at peaks
- too much weak precipitation, partly due to model bias and to ensemble averaging
- ensemble spread mainly from convection
- impressive correspondence between satelite-based estimation

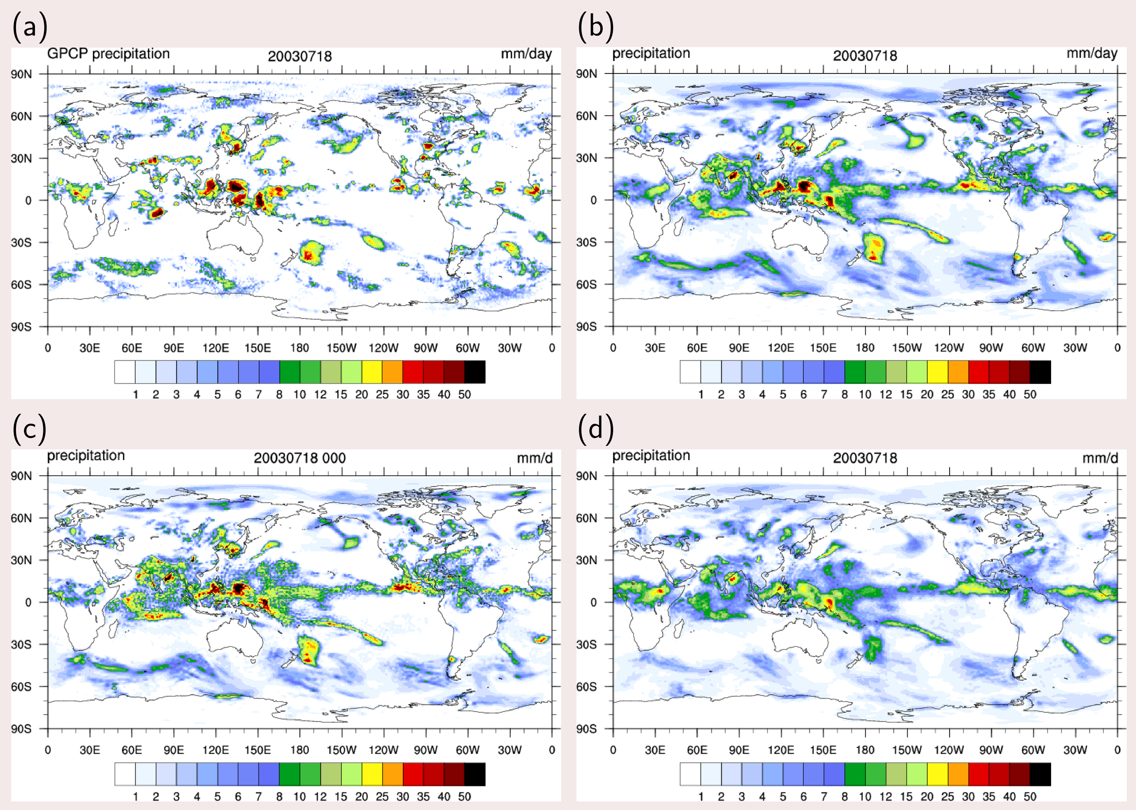

Figure 3 : Daily precipitation (mm d^{-1}) on 18 July 2003 from (a) Global Precipitation Climatology Project (Adler et al. 2003, GPCP) analysis, (b) the ensemble mean, (c) control (forecast from the ensemble mean) and (d) ensemble spread of ALERA2 6-hour forecast. (Enomoto et al. 2013).

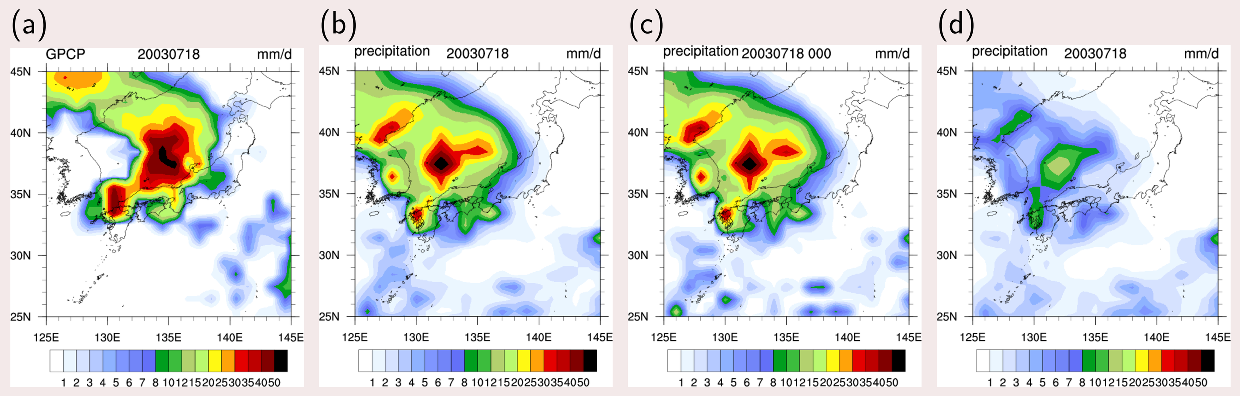

Figure 4 : As in Fig. 3 but near Japan (Enomoto et al. 2013).

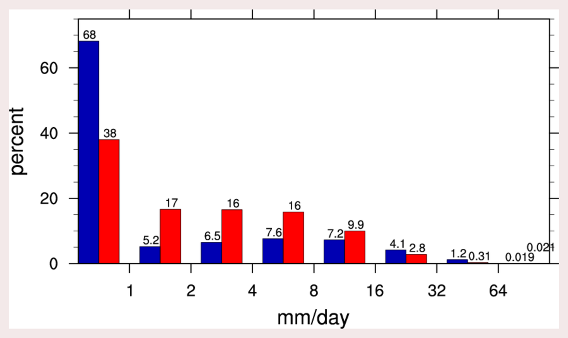

Figure 5 : Histogram of precipitation in July 2003. Blue and red bars represent GPCP and ALERA2, respectively. Numbers on the bars indicate the percentage in a bin (Enomoto et al. 2013).

Comparison with existing reanalysis

- ALERA2 agrees well with JRA25 with difference comparable to the analysis ensemble spread.
- Disagreement over mountains is probably due to hypsometric schemes.
- The analysis ensemble spread reflects observation density.
- The analysis ensemble spread is large in boreal winter.

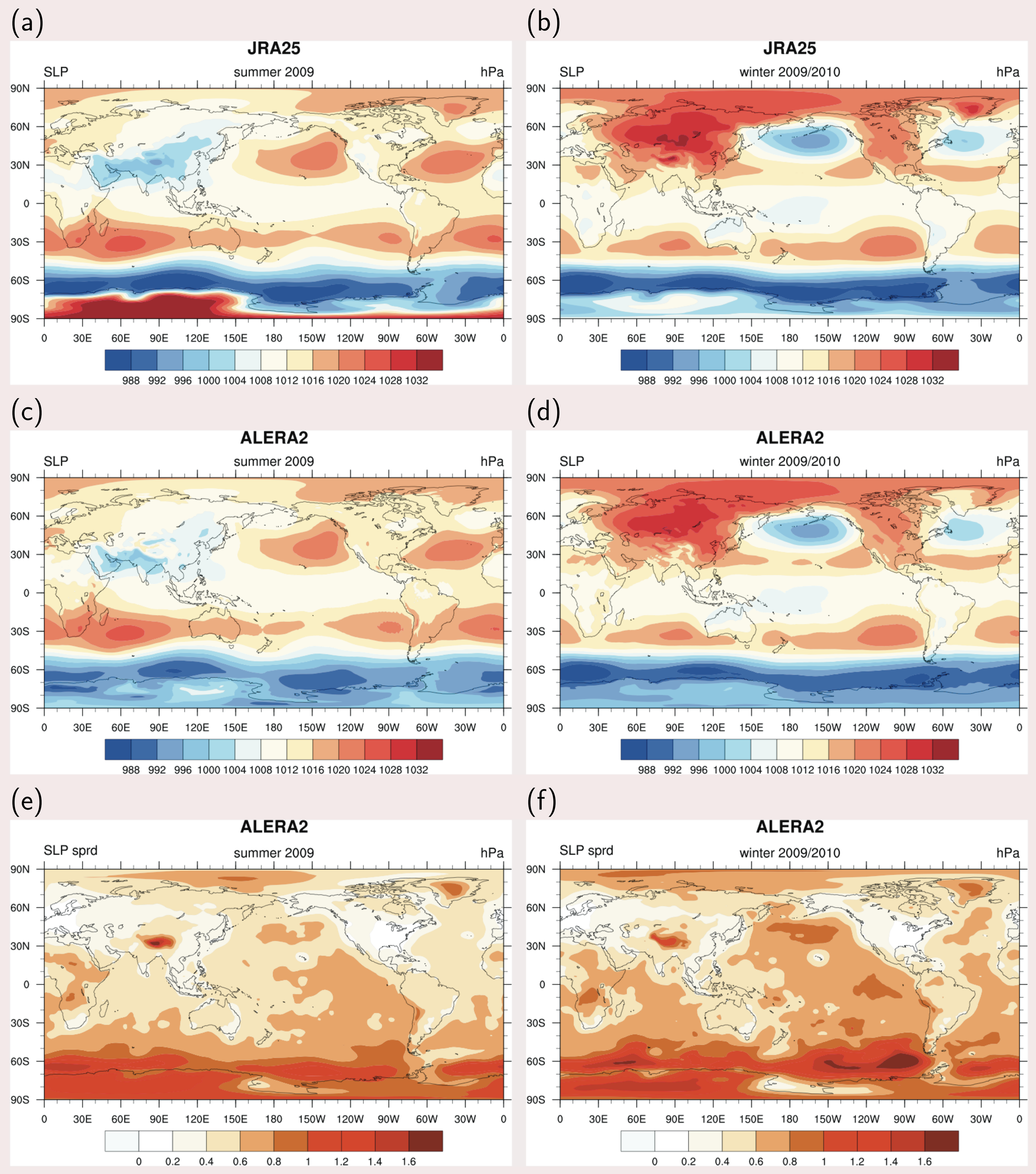

Figure 6 : Sea-level pressure (hPa) in JRA25 (Onogi et al. 2007) (a, b) and in ALERA2 (c, d) and its analysis ensemble spread (hPa) in ALERA2 (e, f) averaged for JJA (a, c, e) and DJF (b, d, f) in 2009.

Observing-system experiments: impact of Arctic radiosondes

- R/V *Mirai* Arctic cruise 2010
- period: from 2 September to 27 October
- cyclogenesis: observed on 25 September
- CTL: ALERA2 (radiosonde observations from *Mirai* assimilated)
- OSE: removed radiosonde observations north of 70°N.
- local impact: 5-K difference near the tropopause at cyclogenesis and tropopause temperature anomalies persistent for 2 weeks
- remote response: anomalies in subpolar and mid-latitude jets

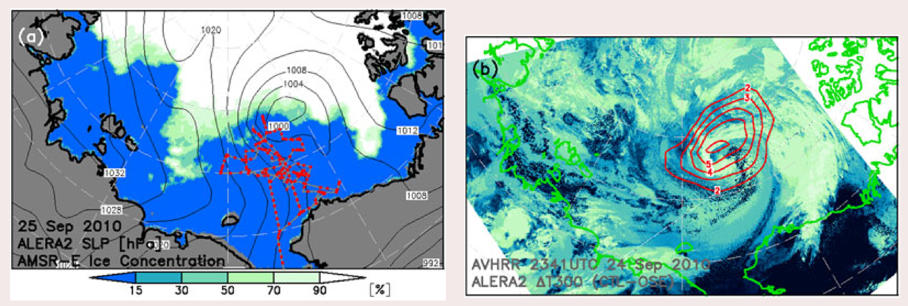

Figure 7 : Sea-ice concentration derived from the Advanced Microwave Scanning Radiometer for Earth Observing System (AMSR-E) on 25 September 2010 with the track of R/V *Mirai* (gray line) and radiosonde stations (red dots). Sea-level pressure analysis CTL is shown as contours (hPa). (b) NOAA/AVHRR infrared image at 2341 UTC, 24 September 2010, with temperature difference between analysis CTL and OSE at 300 hPa shown as red isotherms (°) (Inoue et al. 2013).

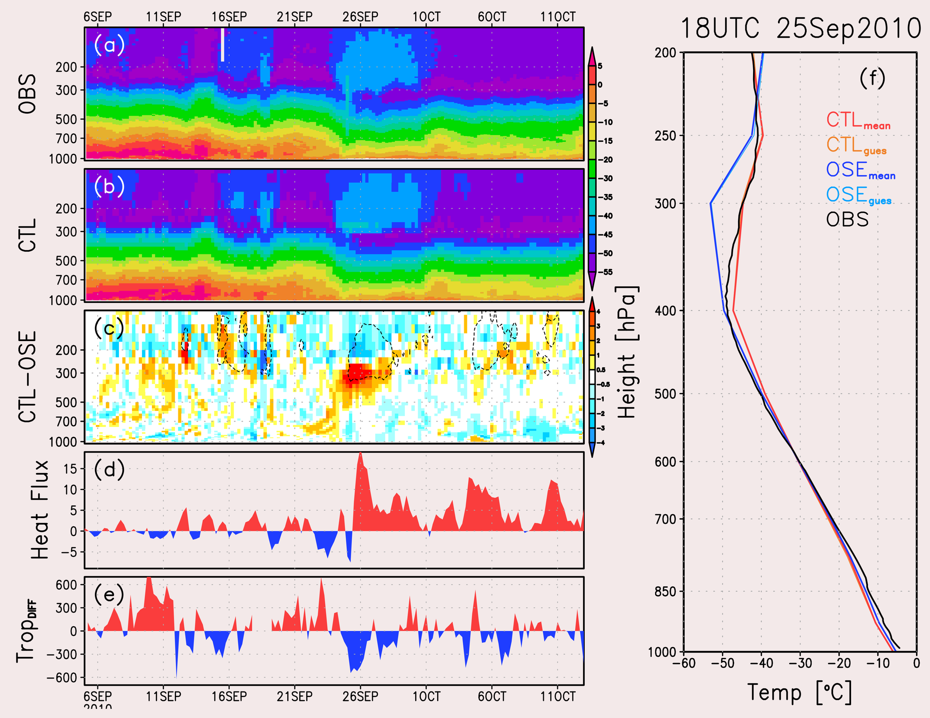

Figure 8 : Time–height cross-sections of air temperature by (a) radiosonde observations and (b) CTL at the closest grid to the radiosonde stations (°). (c) Temperature difference between the CTL and OSE for the ensemble mean (shading) and ensemble spread (contour: enclosed area exceeds 0.5 K), (d) surface heat flux difference (the sum of sensible and latent heat fluxes: W m^{-2}) over the Chukchi Sea (150–180°W, 70–75°N). and (e) tropopause height difference between the CTL and OSE (m). (f) Air temperature profiles at 1800 UTC on 25 September 2010 by CTL, OSE, and observation. Thin lines are ensemble mean first guesses (Inoue et al. 2013).

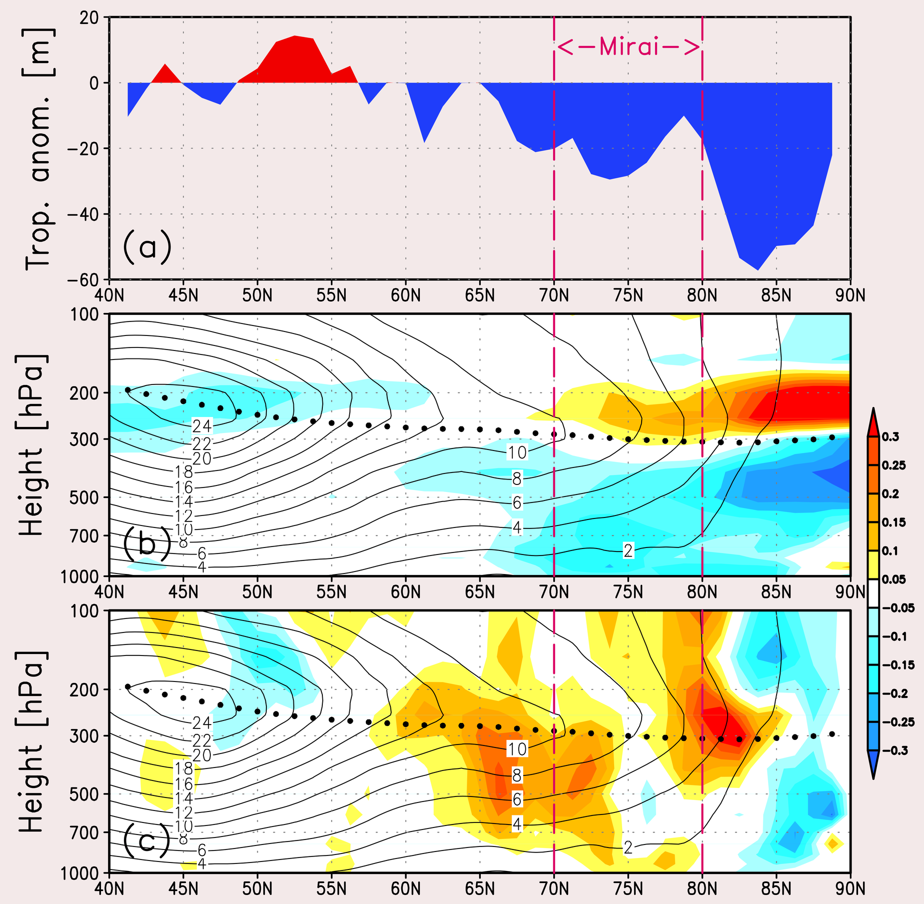

Figure 9 : Difference fields between the CTL and OSE for zonally averaged (a) tropopause height (m), (b) zonal mean air temperature (shading; K), and (c) zonal wind (shading; m s^{-1}) averaged between 24 September and 13 October 2010. Isopleths and dots denote zonal wind in the CTL and the tropopause defined as 3.5 PVU, respectively. The observational zone is depicted by magenta dashed lines (Inoue et al. 2013).

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