

Assimilation of TRMM-PR bright band heights

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Bright band and the melting layer

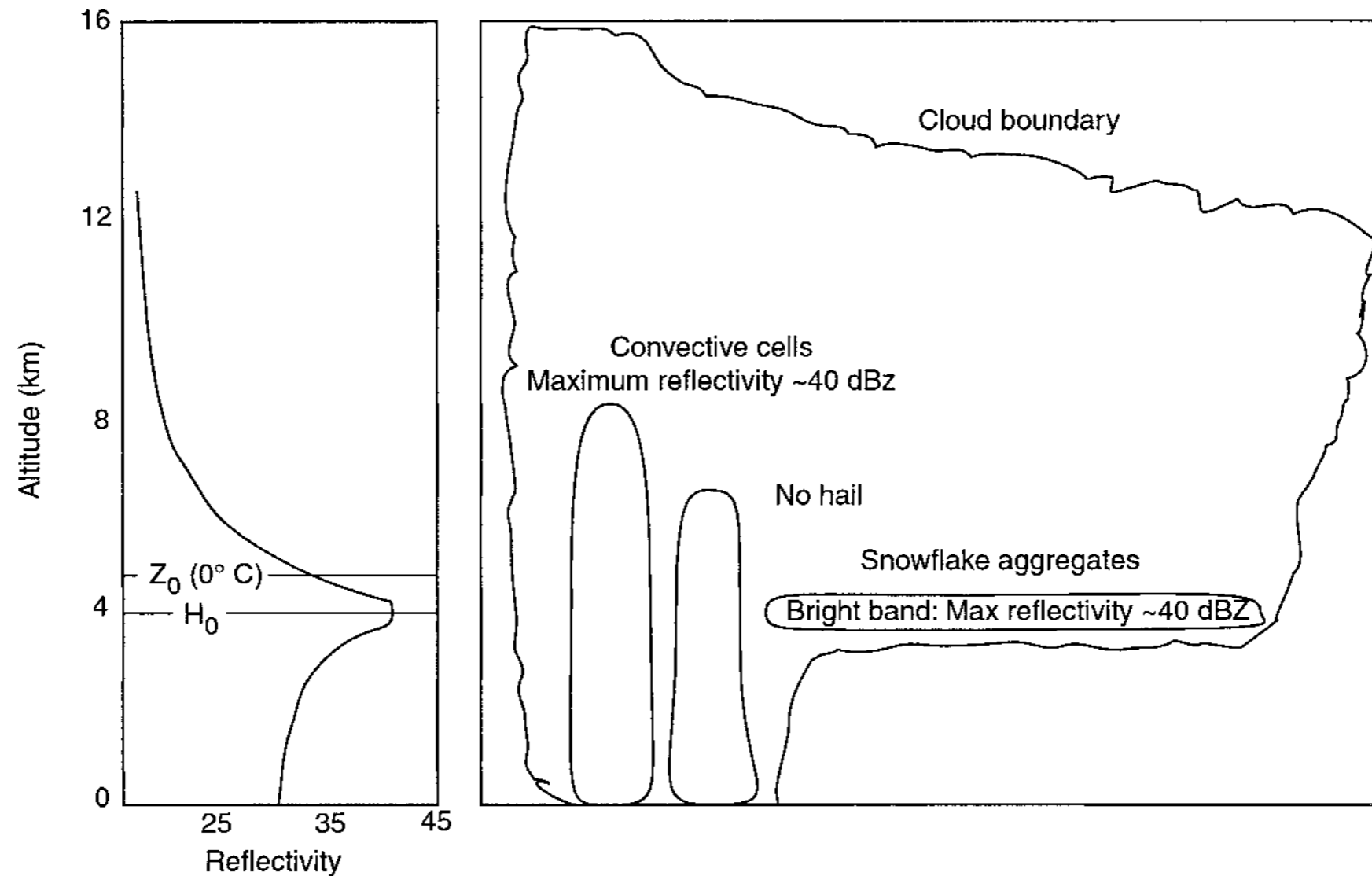


FIG. 1. Schematic cross section through tropical convection showing the altitude of the 0°C isotherm and the melting layer (bright band) in the stratiform rain region (after Leary and Houze 1979).

Bright band heights

- TRMM PR 2A23 (Awaka et al. 2009)
- strong echo from the melting layer
- several hundred m below 0C height (Harris et al. 2000)
- directly measured, cloudy area data in the middle to lower troposphere
- complementary to conventional, radiance and GPS RO observations

Bright band heights and 0C height in reanalysis

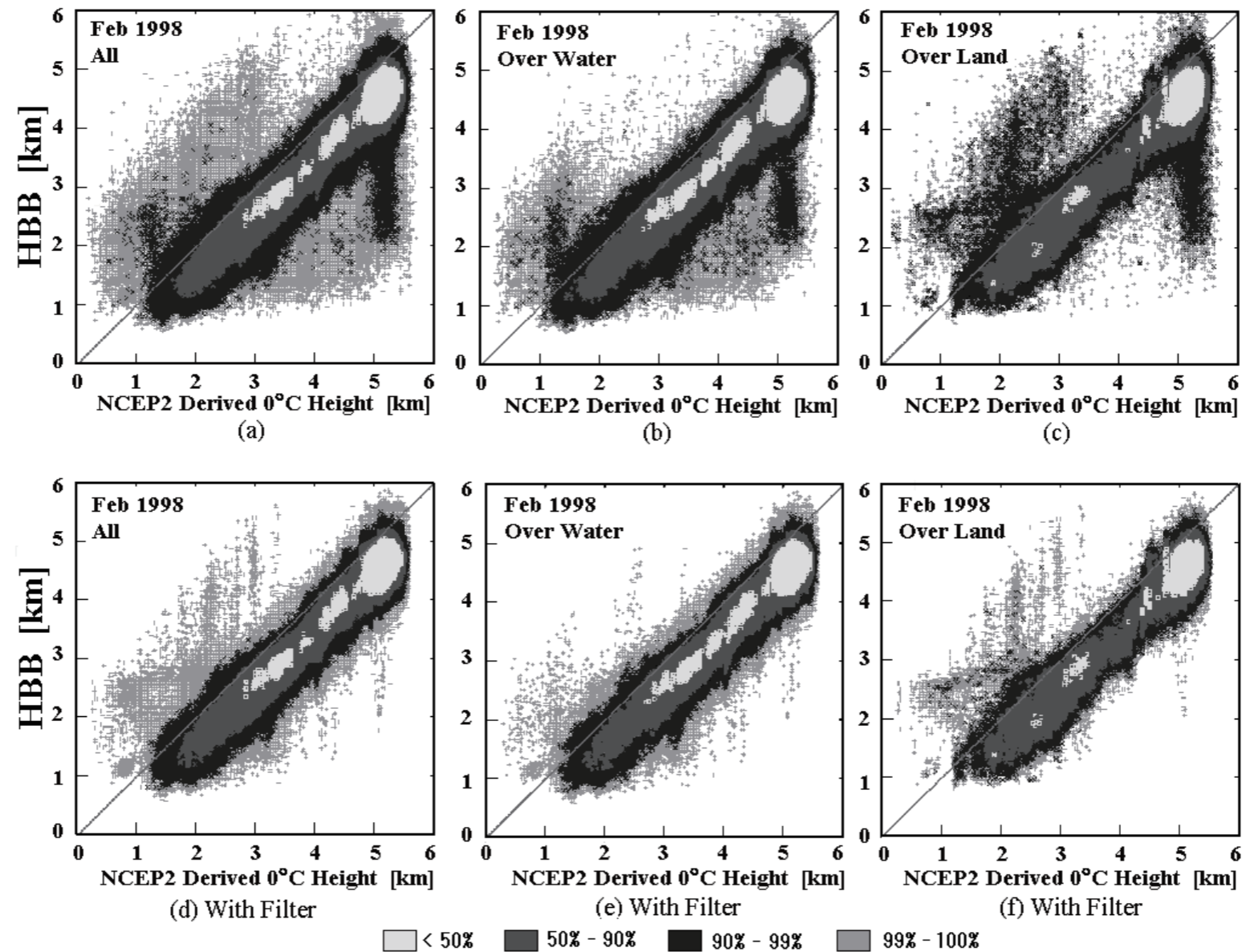
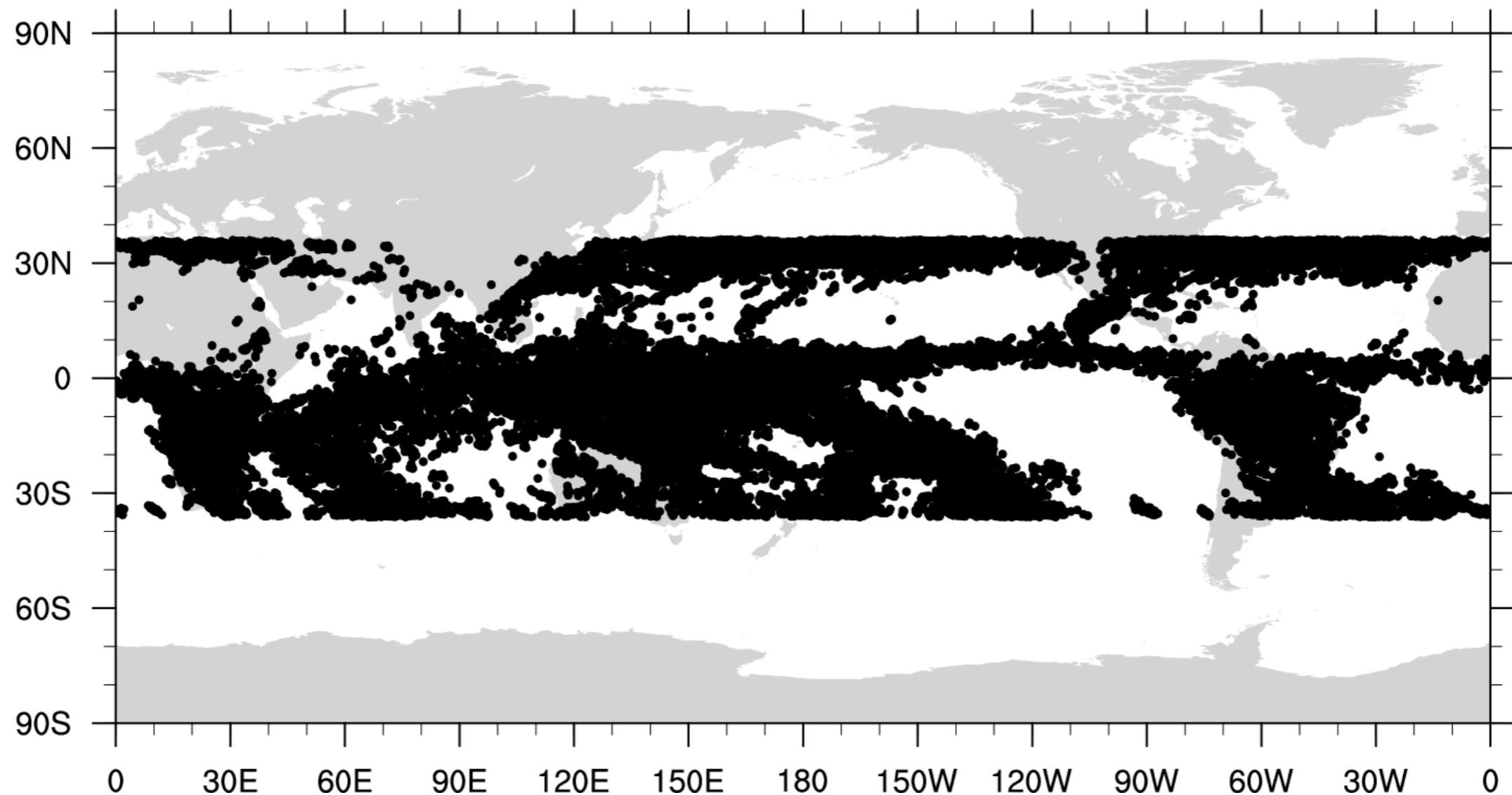


Fig. 4. Scatterplot of HBB versus NCEP2 derived 0°C height ($H_{\text{freezeNCEP2}}$) in February 1998. Upper panels depict the original case, and lower panels, the case after applying the simple filter explained in the text. Panels (a) and (d) present scatterplots using all the data (over water+land); panels (b) and (e), the scatterplots using the data over water; and panels (c) and (f), the scatterplots using the data over land. Data points were prepared in the form of a two-dimensional histogram with a grid interval of 0.02 km \times 0.02 km.

Bright band height superobservations for 28 days in Jaunuary 2010

2170037 original reduced to 47975 superobservtions

TRMM PR HBB 2010010306-2010013100 n=47975 d=0.5

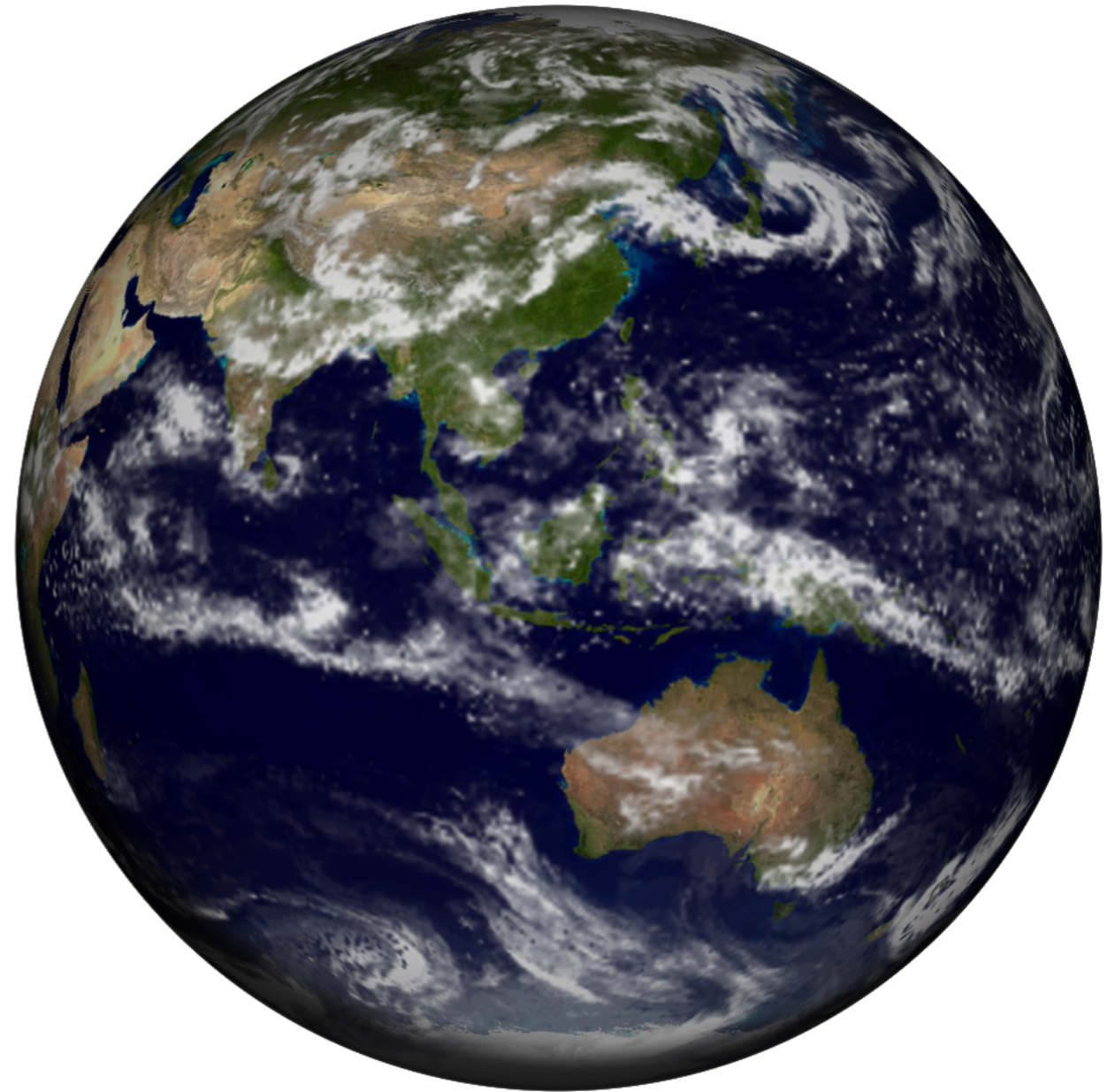


Observing system experiments

- Reference: ALERA2 stream2008
- modified LETKF to accept height level data
- 0°C observations with 0.5 K error at hbb+362 m
- grouped by 6 hourly analysis time with ± 3 h window and rounded to the hour
- superobservations of bright band heights
- from 0 UTC 3 January to 0 UTC 31 January 2010

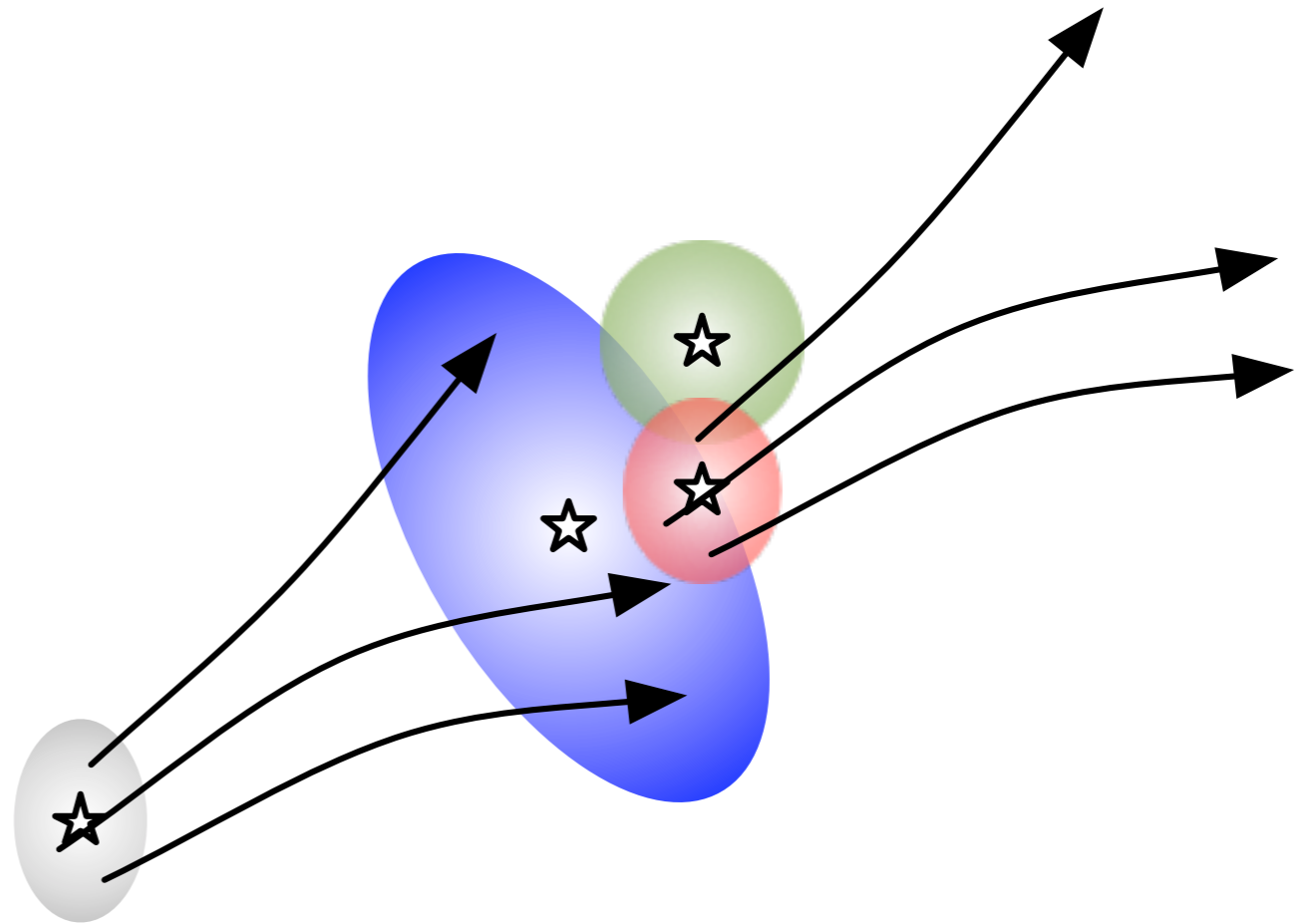
AFES

- Atmospheric general circulation model for the Earth Simulator
- Spectral transform Eulerian advection (Numaguchi et al. 1997; Ohfuchi et al. 2004; Enomoto et al. 2008)
- Emanuel convective scheme
- Improved PDF cloud scheme (Kuwano-Yoshida et al. 2010)



LETKF

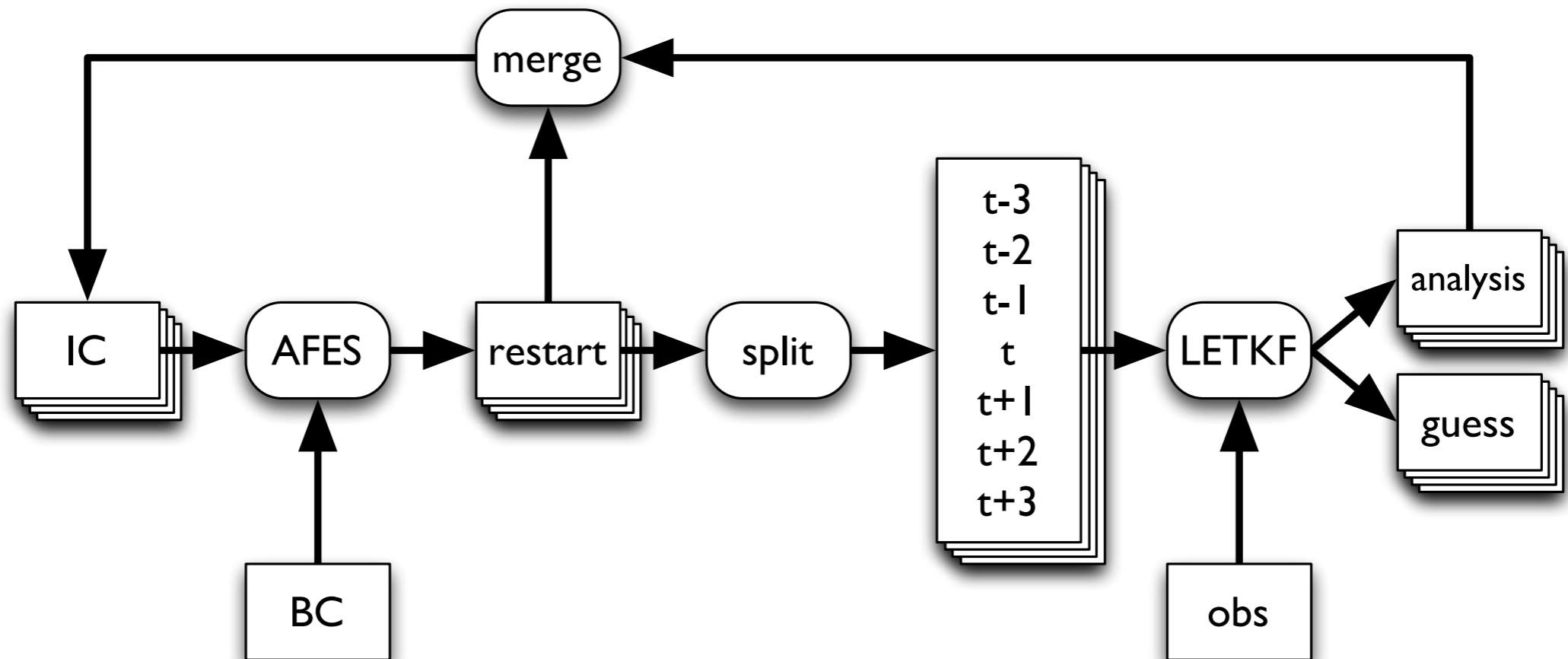
- Local ensemble transform Kalman filter
- Hunt et al. 2007;
Miyoshi and Yamane 2007
- Highly efficient on parallel computers
- Assimilate observations into the ensemble mean
- Time evolution of forecast covariance matrix
- Localization and inflation



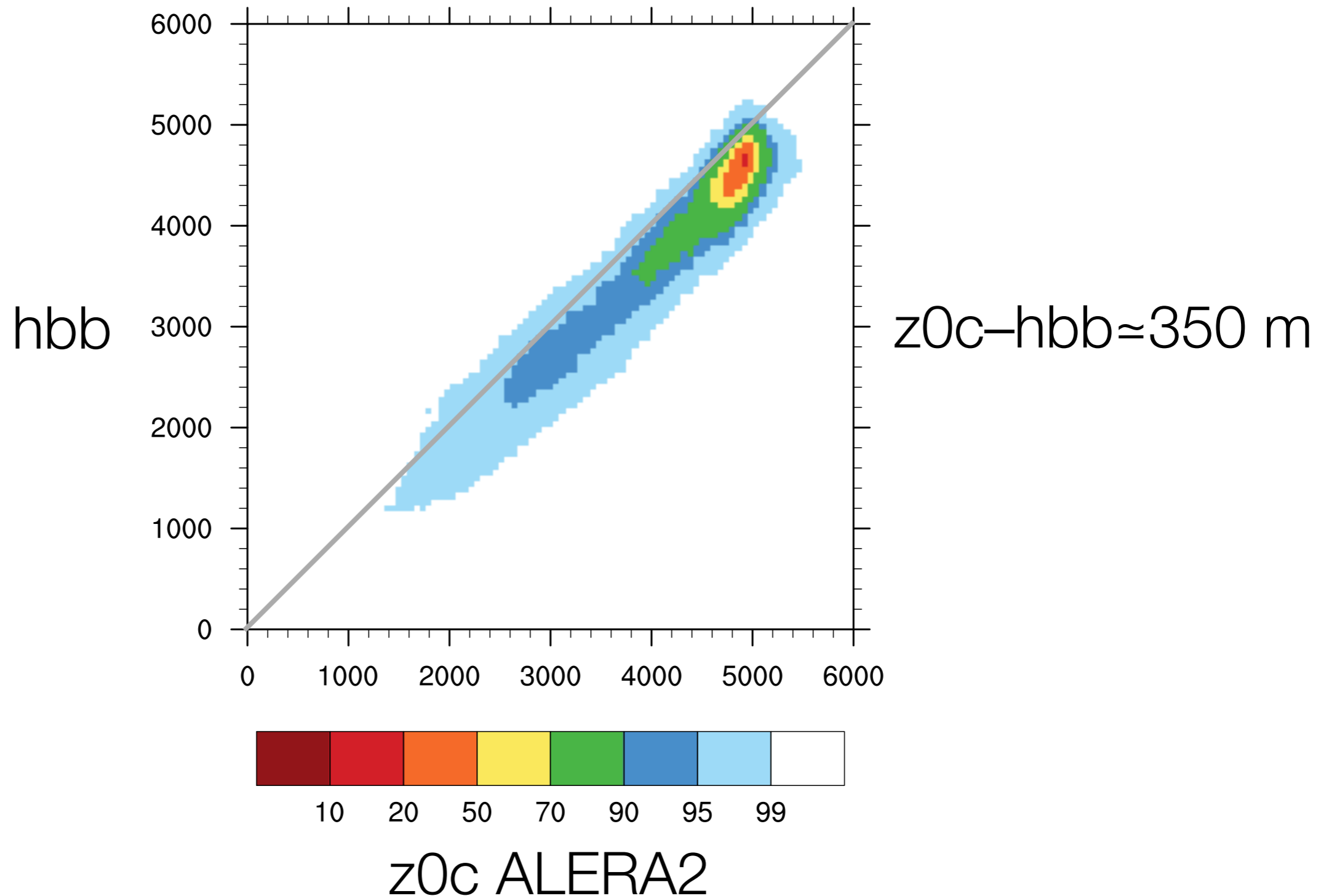
ALERA2: AFES–LETKF experimental ensemble reanalysis 2

- stream 2008: 6 UTC 1 January 2008—0 UTC 30 August 2010
- stream 2010: 6 UTC 1 August 2010—0 UTC 5 January 2013
- AFES 3.6 T119L48 ($1^\circ \times 1^\circ$, 48 levels) 63 + 1 members
- Covariance localization: 400 km/0.4 ln p
- 10 % multiplicative spread inflation
- NCEP PREPBUFR archived at UCAR
- daily OISST (Reynolds et al. 2007)
- available from JAMSTEC

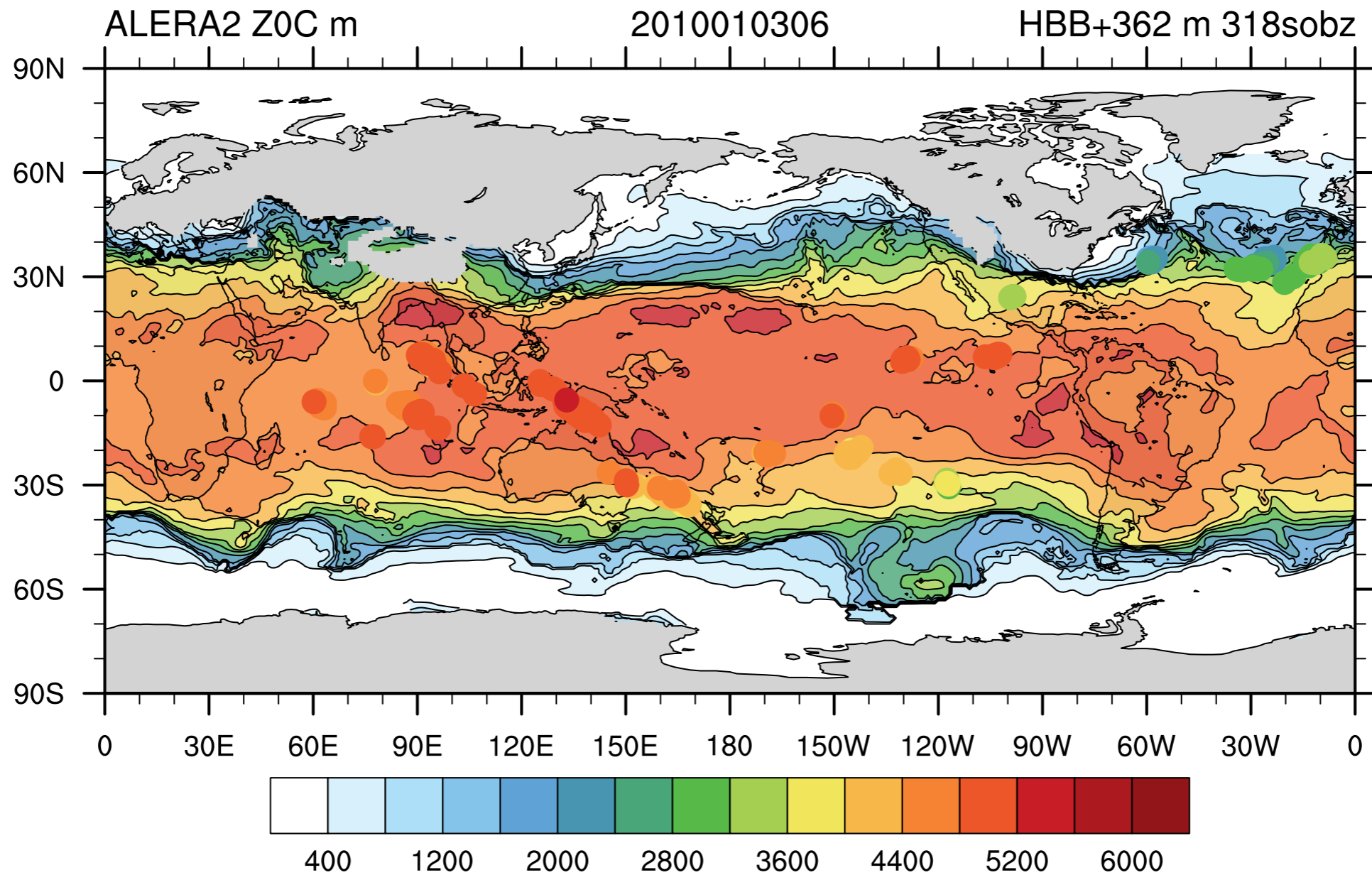
ALERA2 data flow



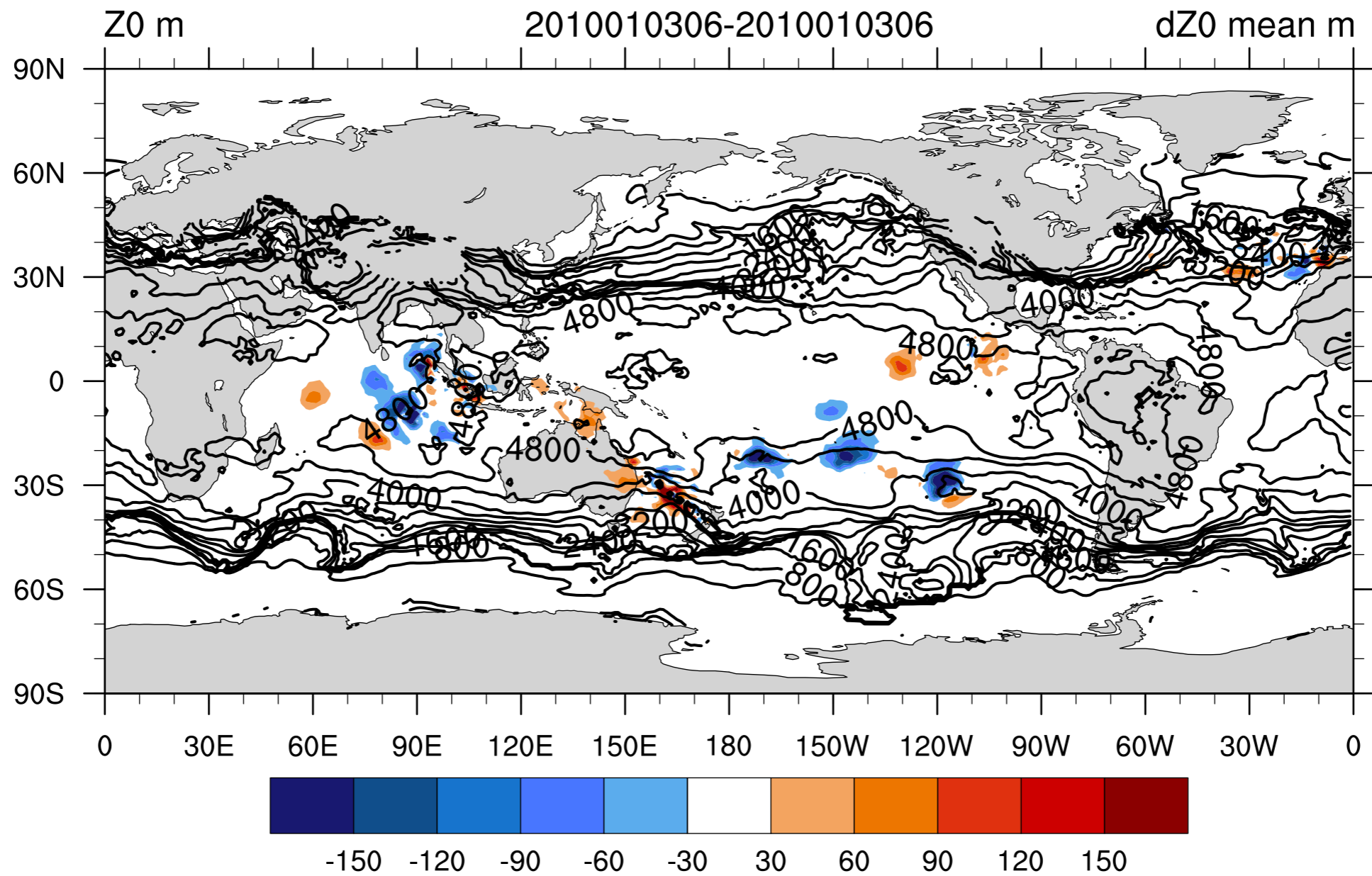
ALERA2 0C height and bright band heights: statistics for January 2010



ALERA2 0C height and bright band heights in 6 UTC ± 3 h window on 3 January 2010

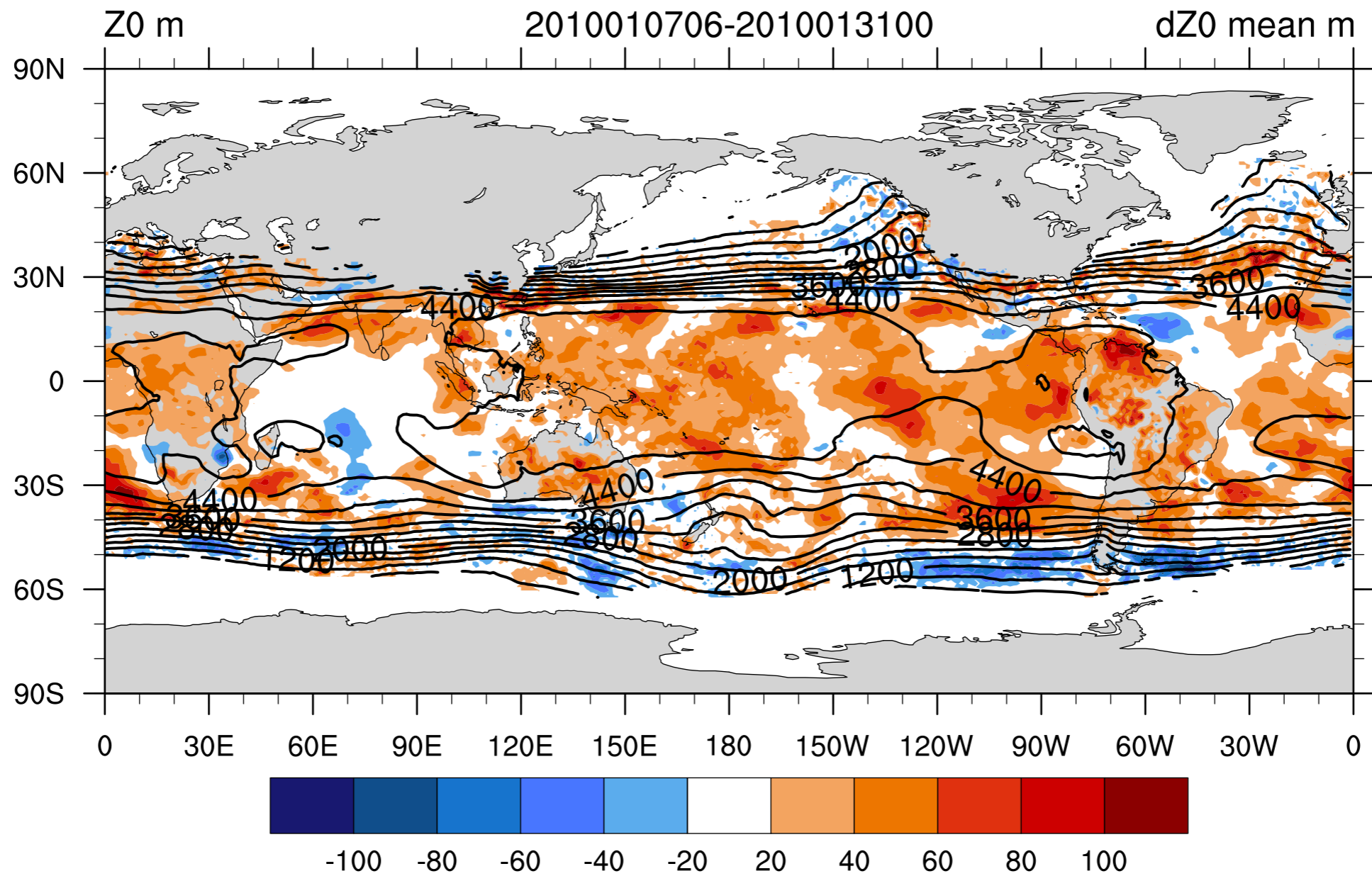


Initial impact on the freezing level height

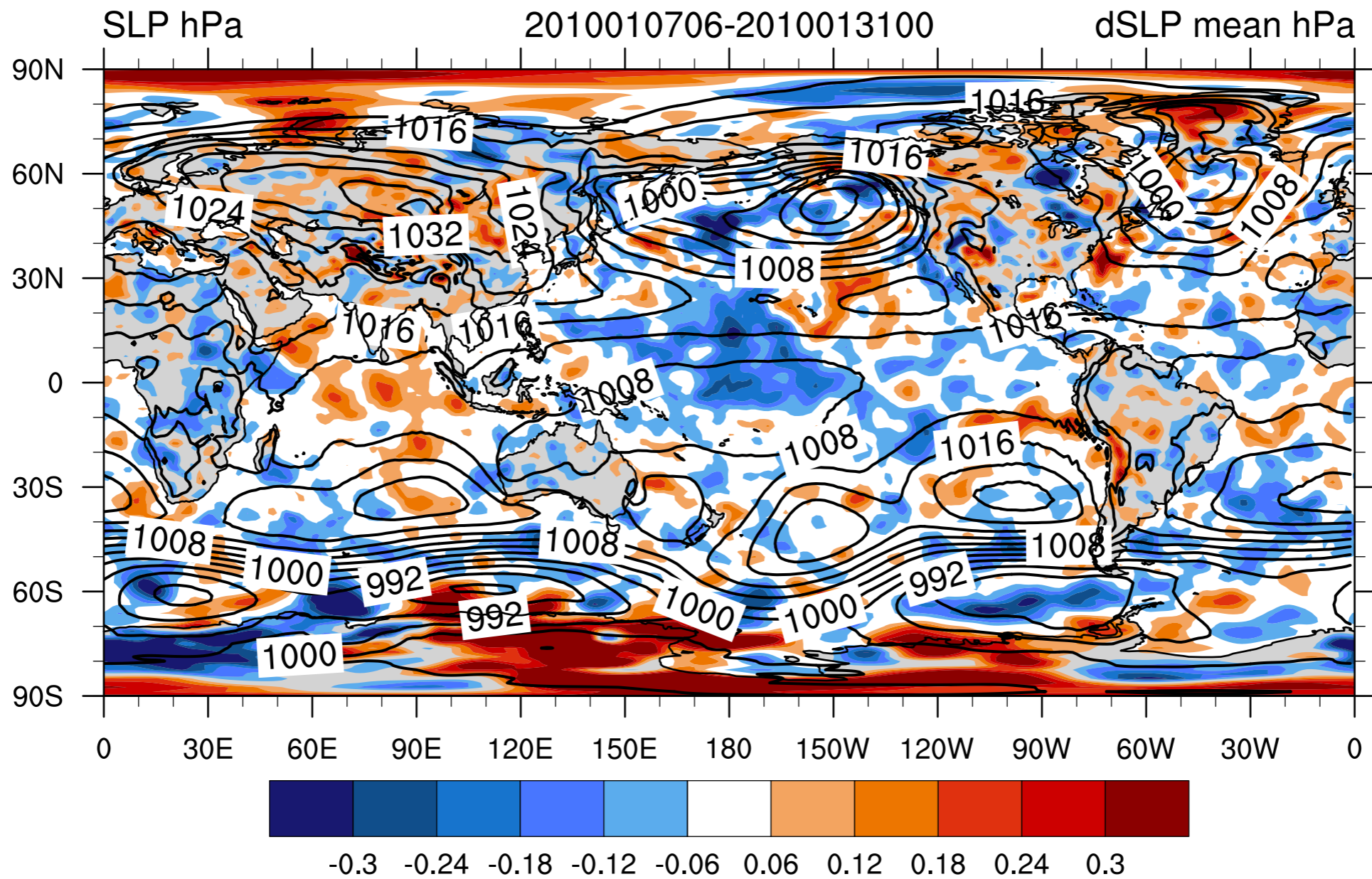


CONTOUR FROM 0 TO 5600 BY 400

Impact on the freezing level height

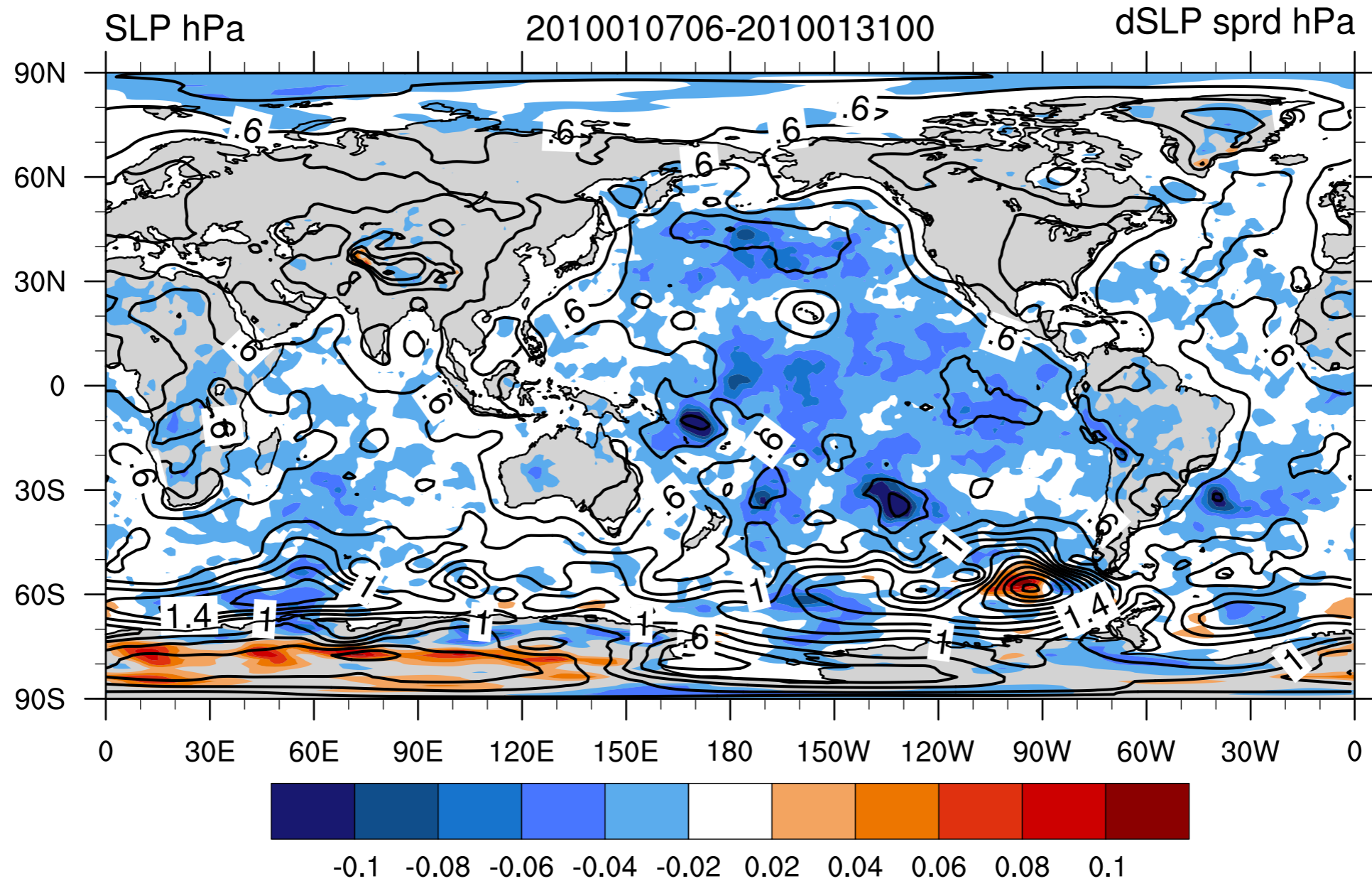


Impact on ensemble mean sea-level pressure



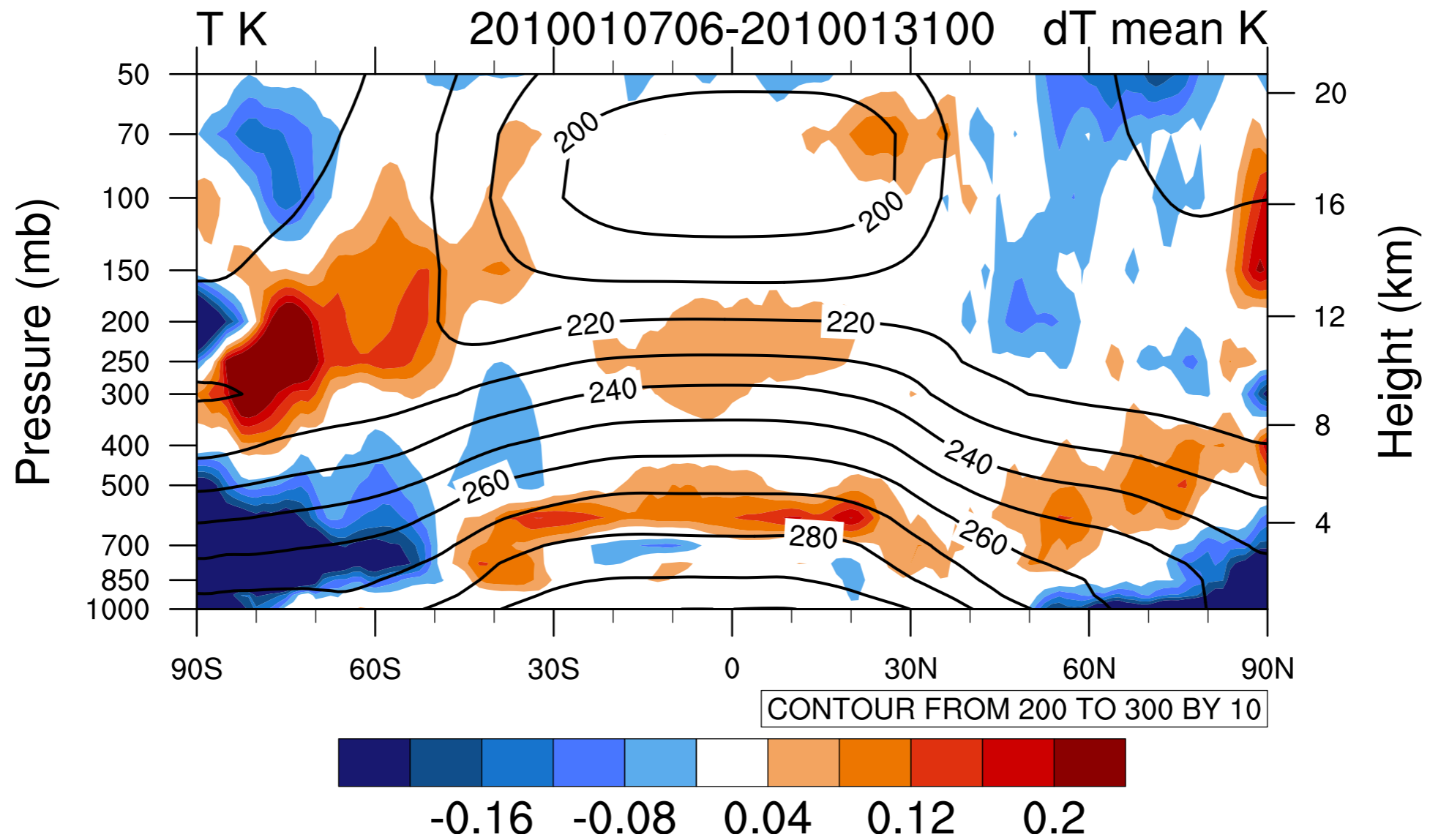
CONTOUR FROM 984 TO 1036 BY 4

Reduction of *SLP* analysis ensemble spread

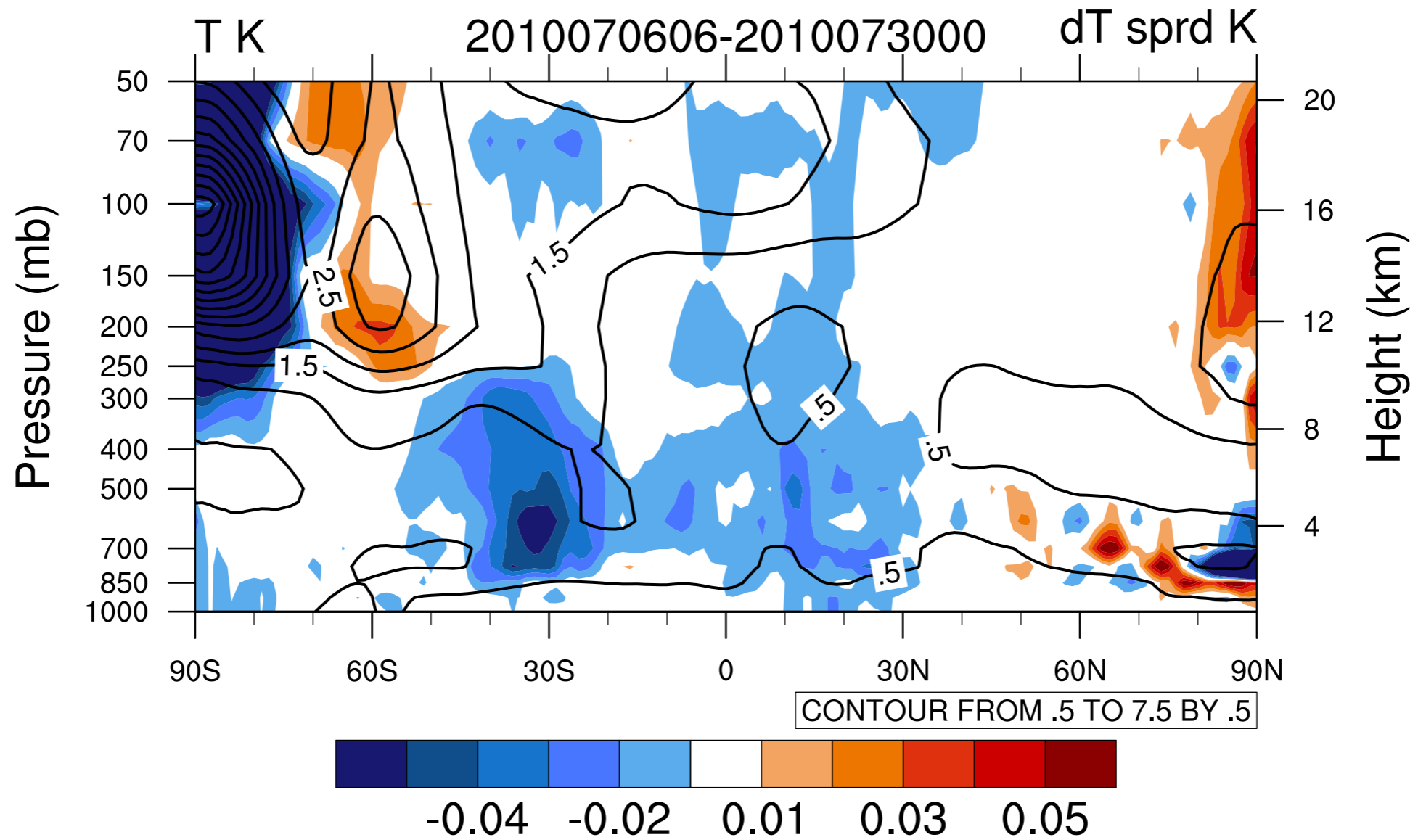


CONTOUR FROM .2 TO 2.8 BY .2

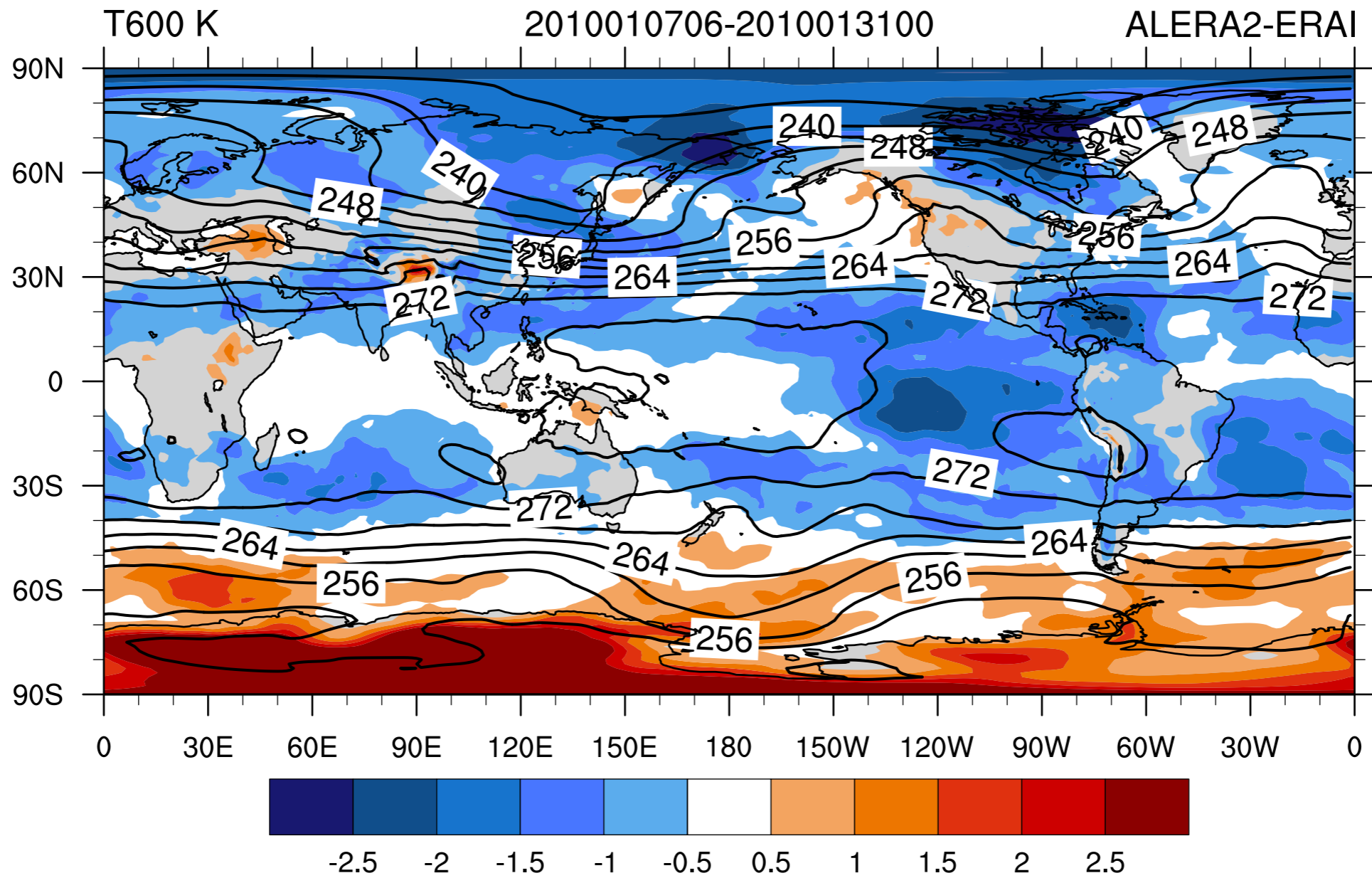
Impact on ensemble mean temperature



Reduction in T analysis ensemble spread



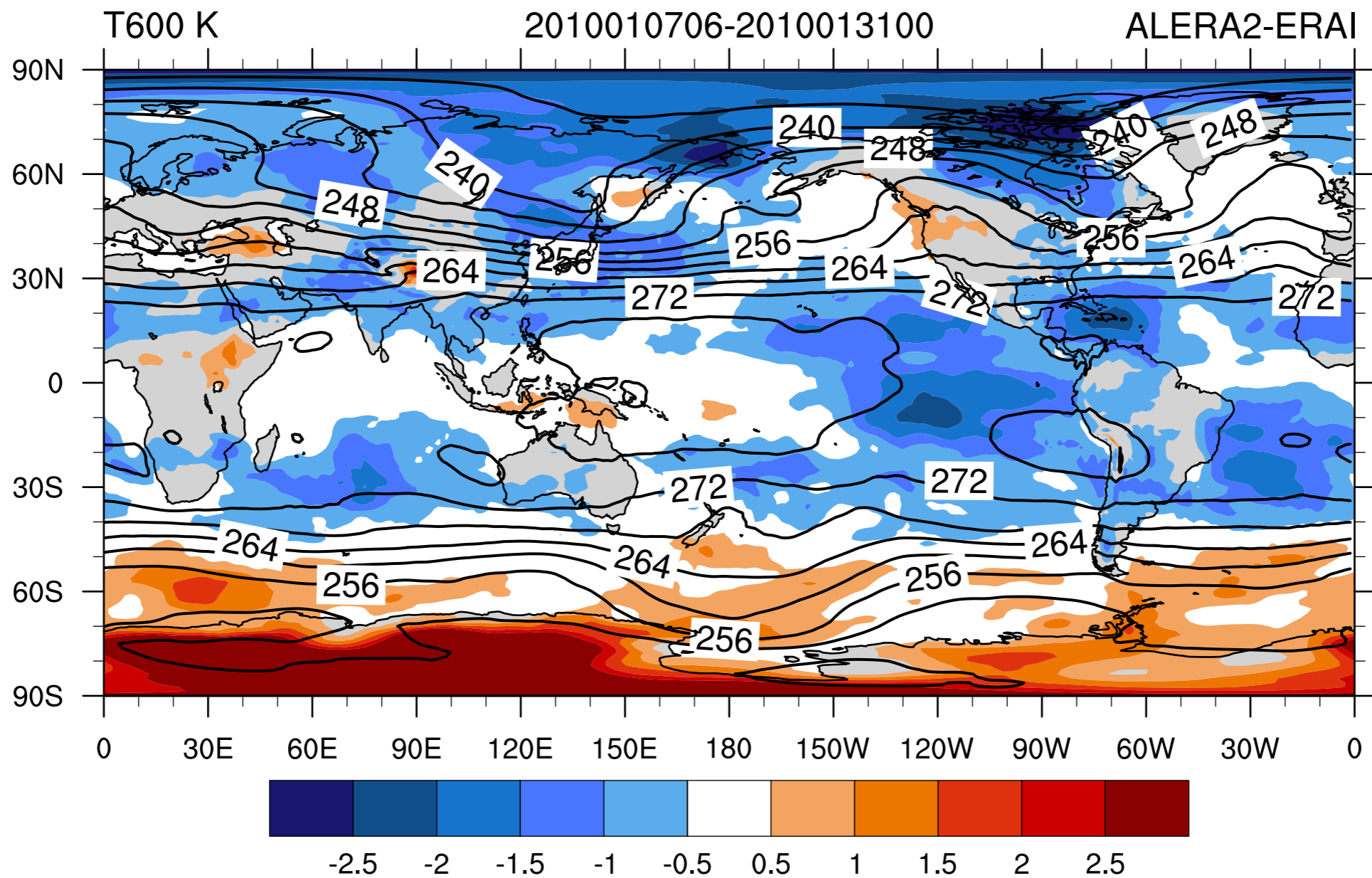
ALERA2 T bias against ERA-Interim at 500 hPa



CONTOUR FROM 236 TO 280 BY 4

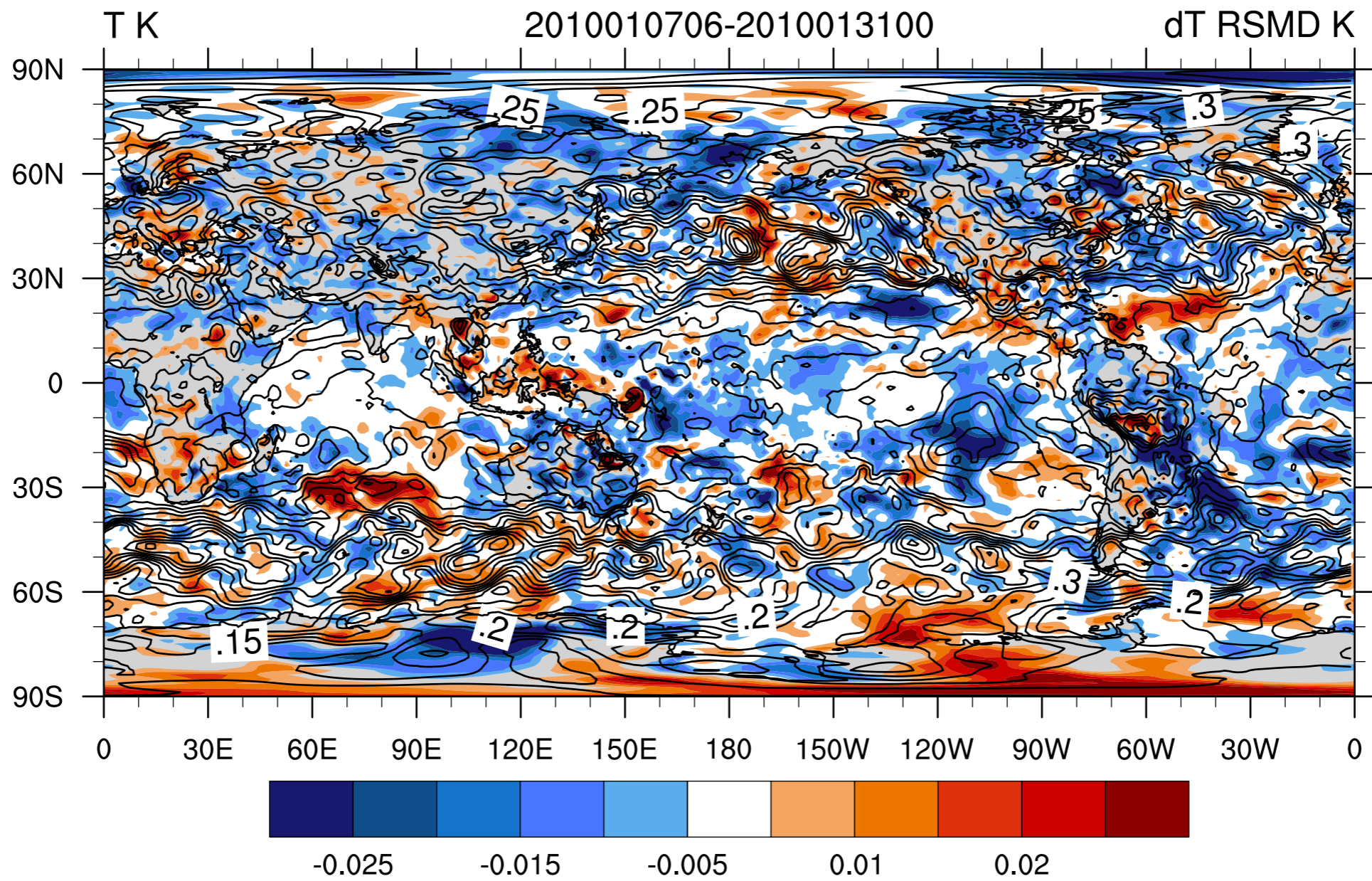
ALERA2 with bright band heights

T bias against ERA-Interim at 500 hPa



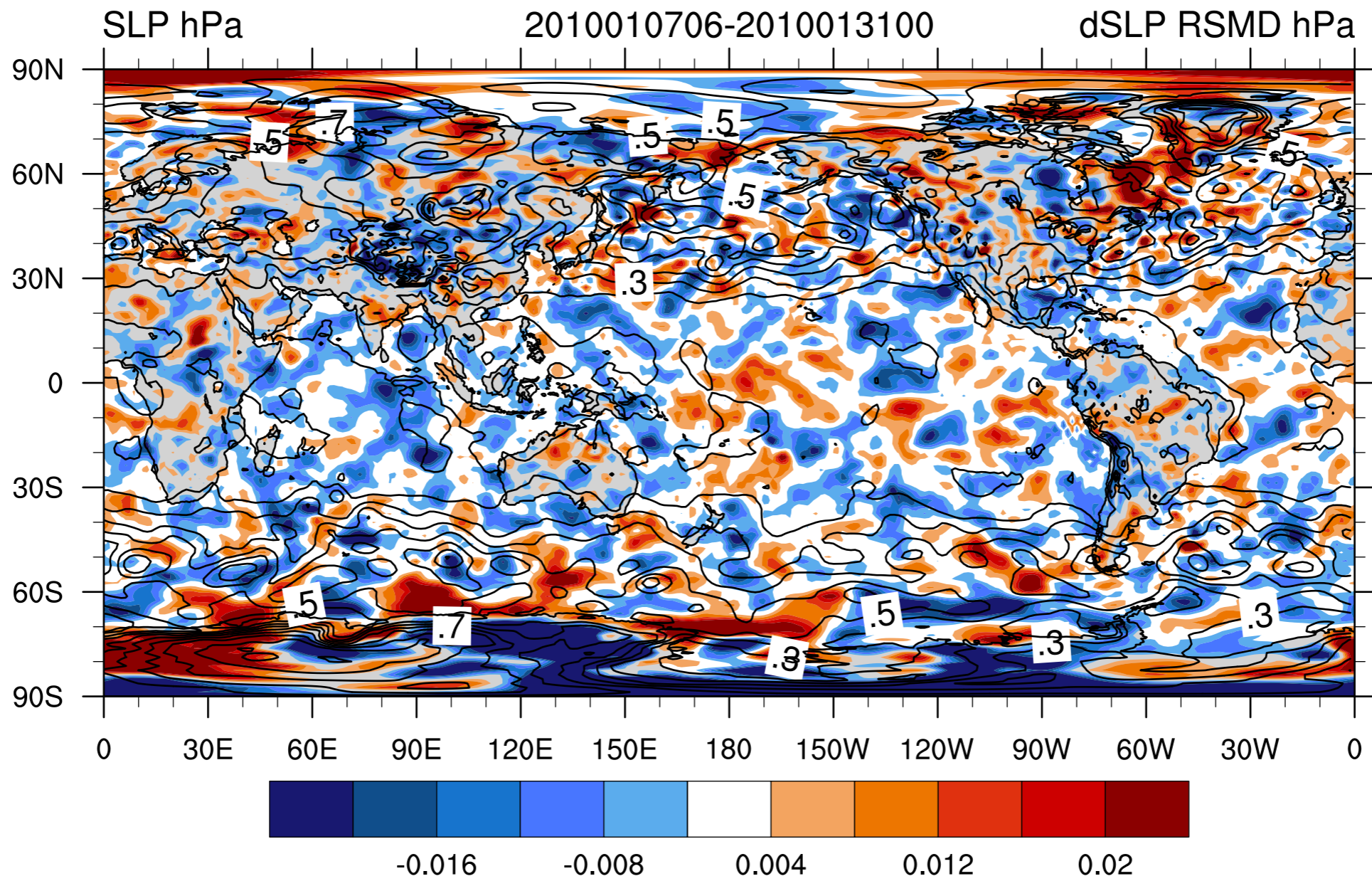
CONTOUR FROM 236 TO 280 BY 4

Change in T RMSD against ERA-Interim at 500 hPa

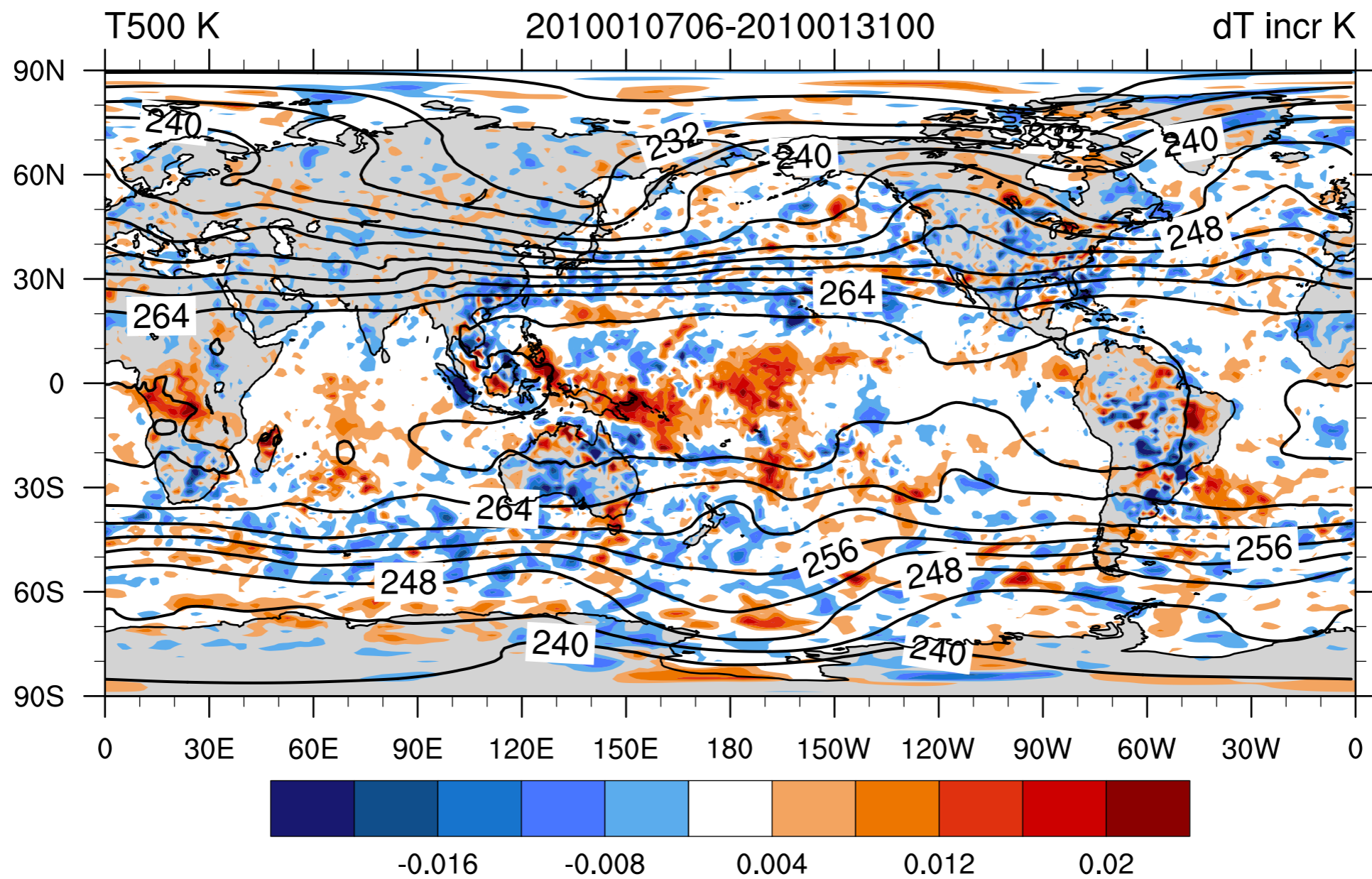


CONTOUR FROM .075 TO .45 BY .025

Change in *SLP* RMSD against ERA-Interim

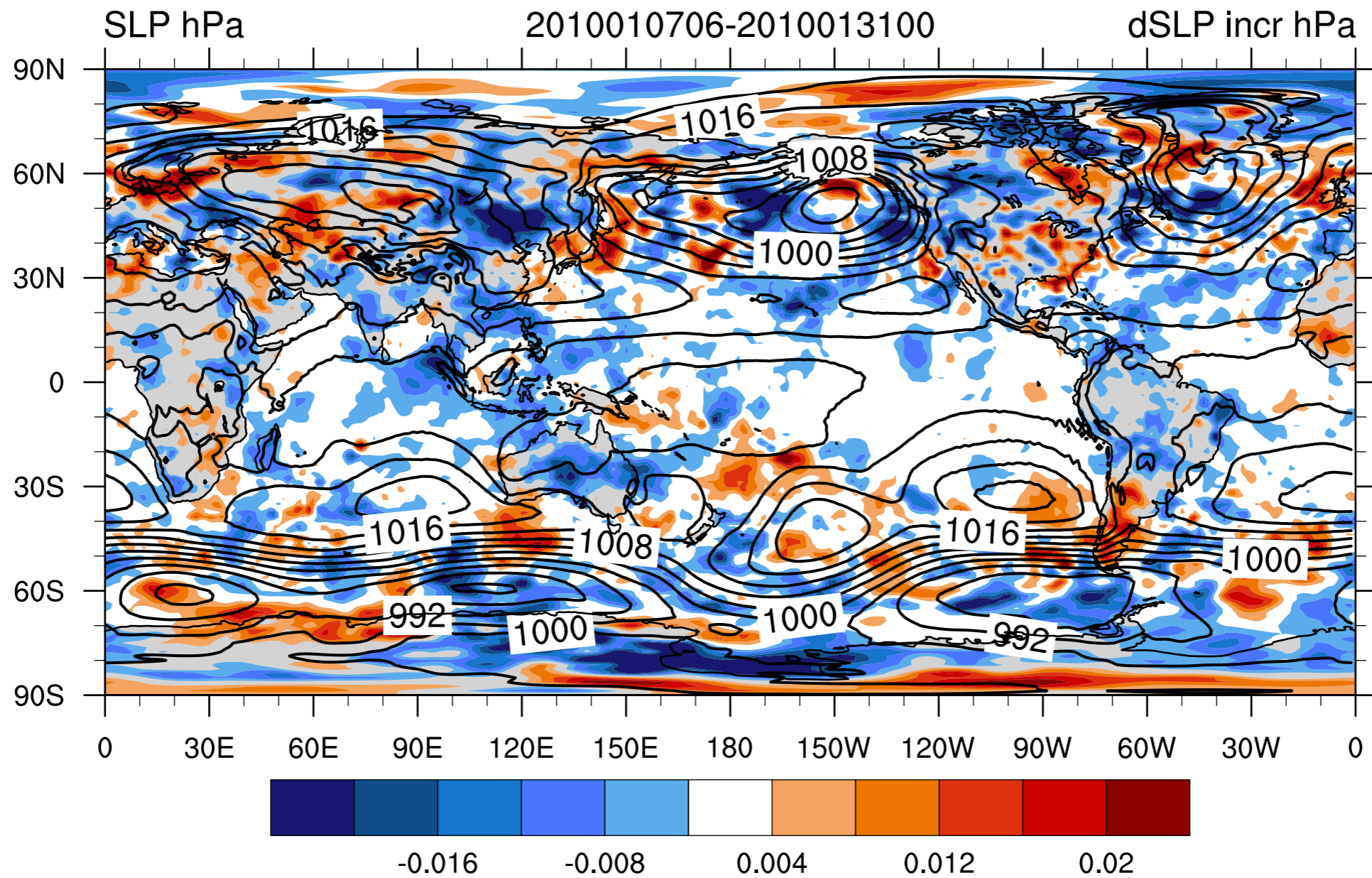


Change in T analysis increment at 500 hPa



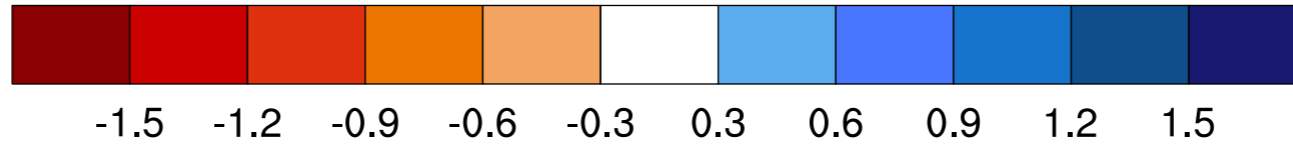
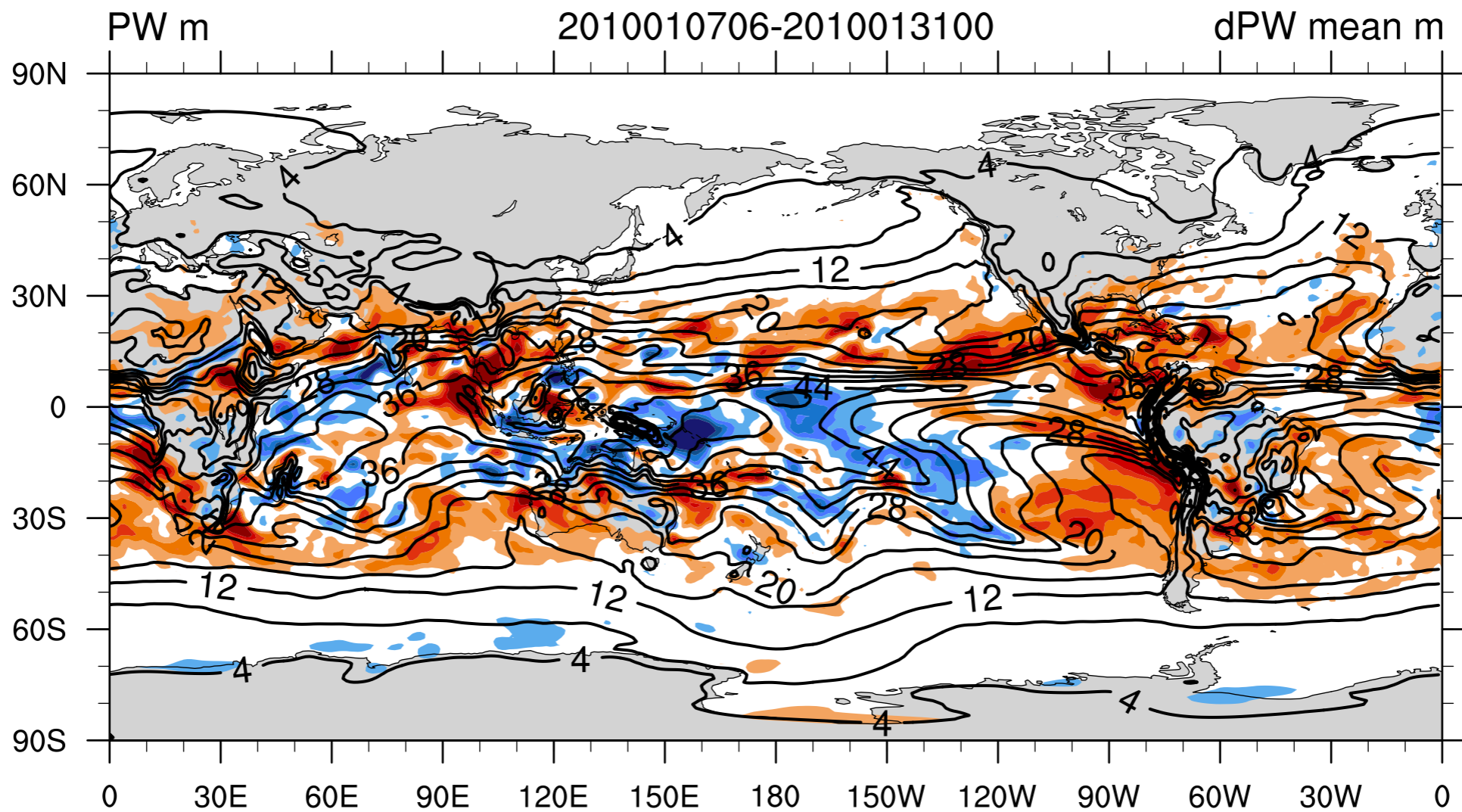
CONTOUR FROM 228 TO 268 BY 4

Change in *SLP* analysis increment



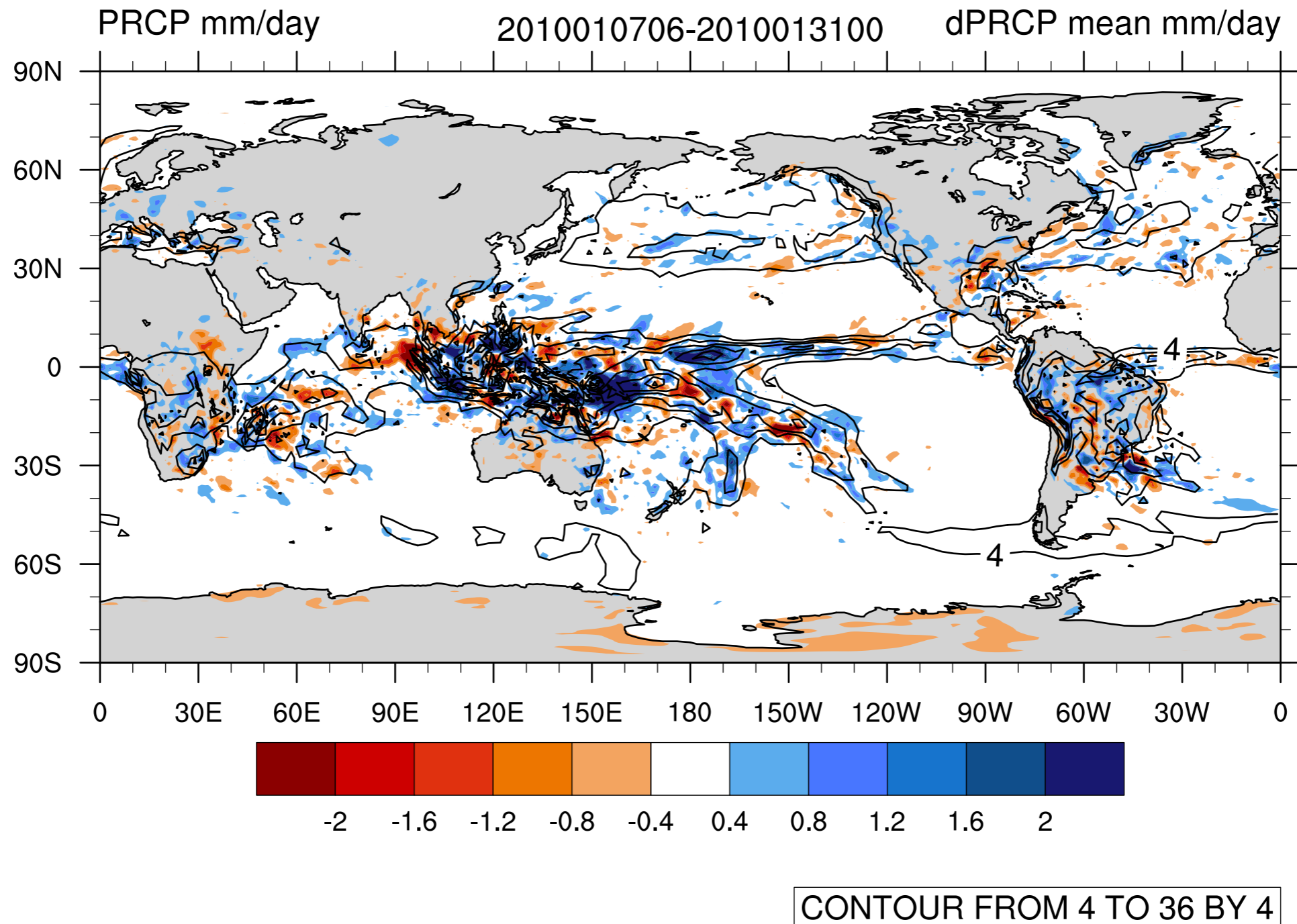
CONTOUR FROM 984 TO 1036 BY 4

Impact on precipitable water

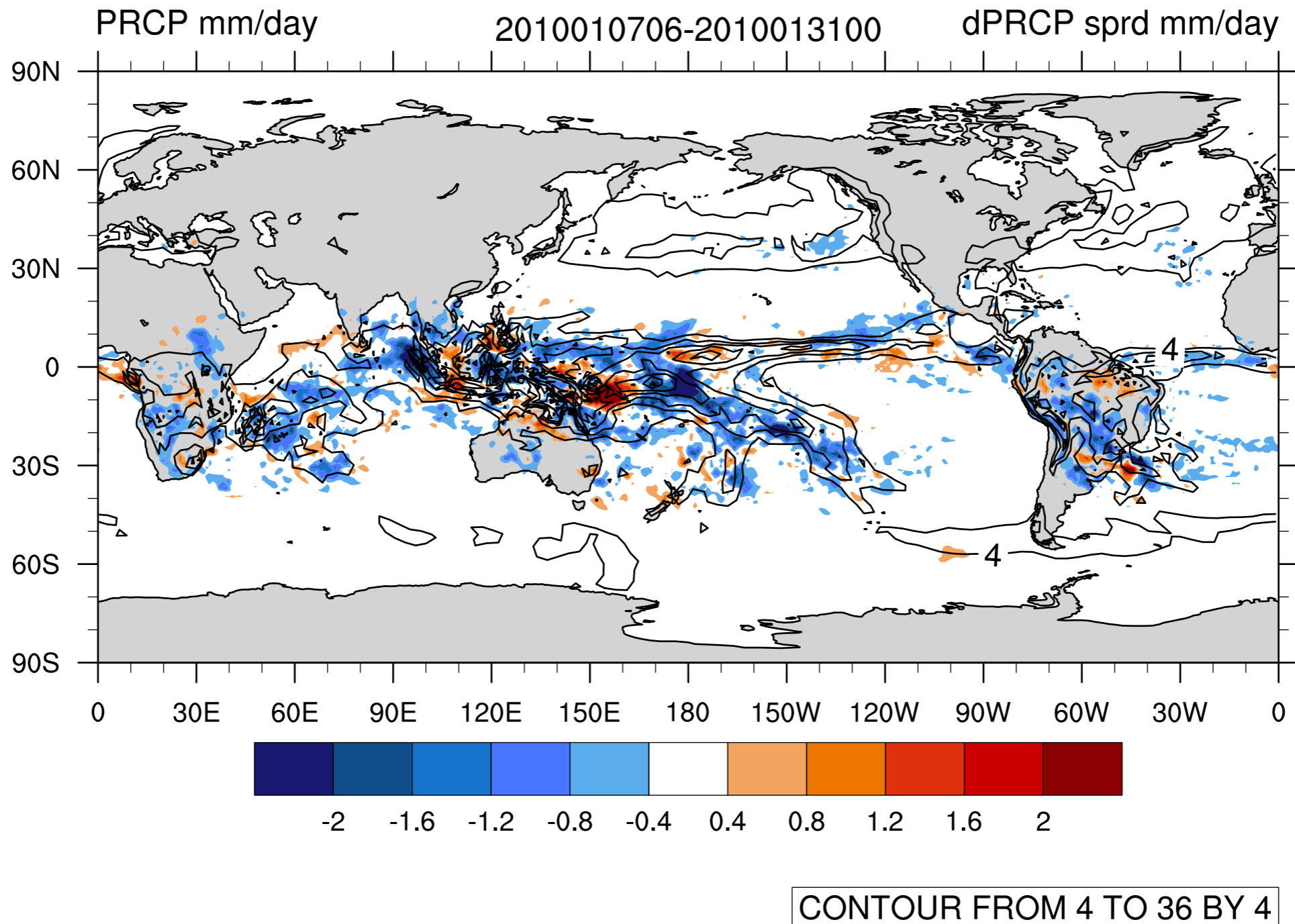


CONTOUR FROM 4 TO 48 BY 4

Impact on precipitation



Reduction of precipitation ensemble spread



Summary

- Bright band heights are about 350 m below the 0 C height in ALERA2.
- Bright band heights are assimilated using modified LETKF that accept height level data.
- Warmer tropospheric middle troposphere with smaller analysis ensemble spread
- Reduced bias against ERA-Interim
- Improved guess implied from analysis increment

