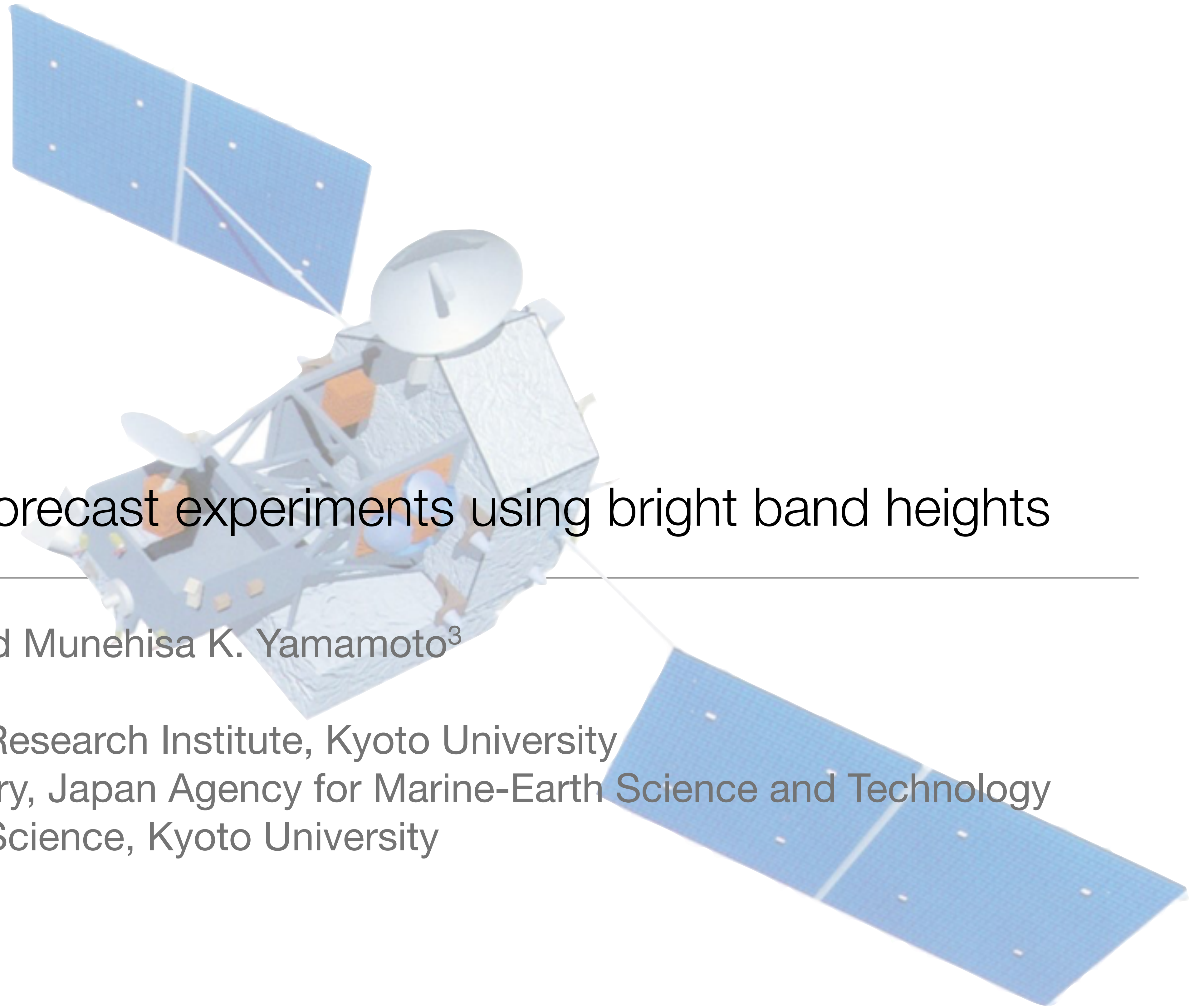

Assimilation and forecast experiments using bright band heights

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Data Assimilation Seminar
AICS RIKEN, Kobe, Japan

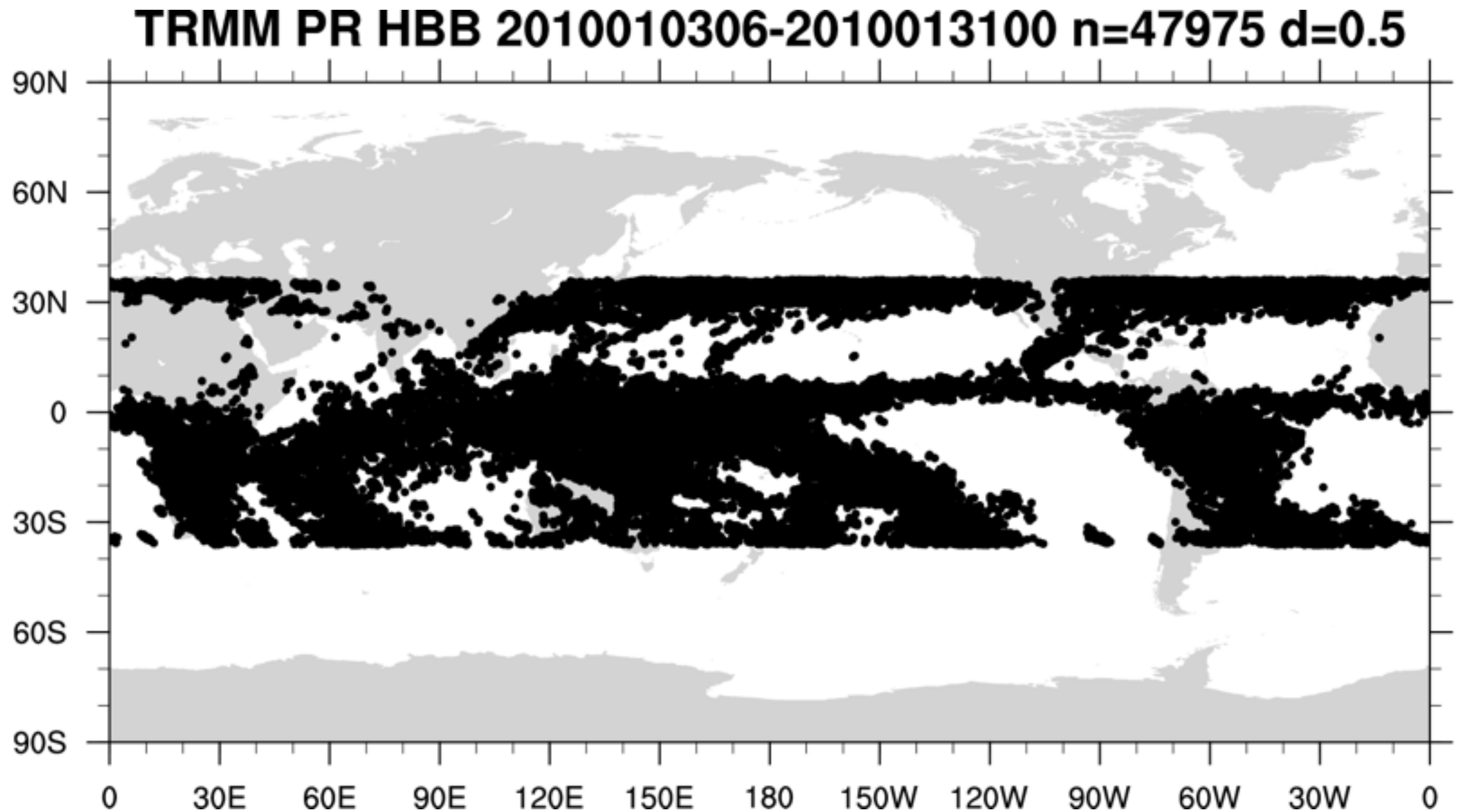
Contents

- Bright band heights in TRMM 2A23
- Global atmospheric ensemble reanalysis ALERA2
- Observing system experiments
- Forecast verification

Bright band heights

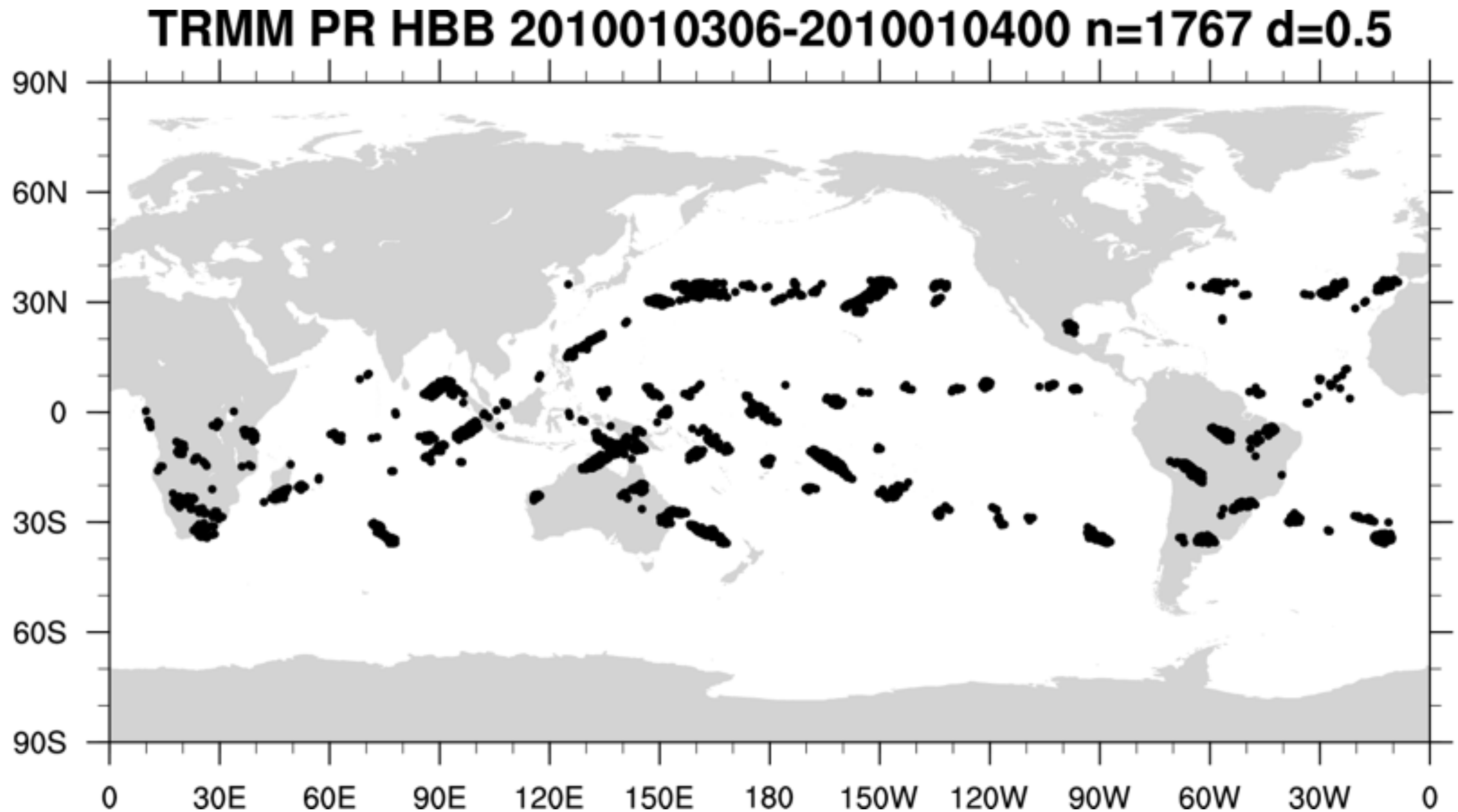
Bright band height superobservations for 28 days in Jaunuary 2010

2170037 original reduced to 47975 superobservtions

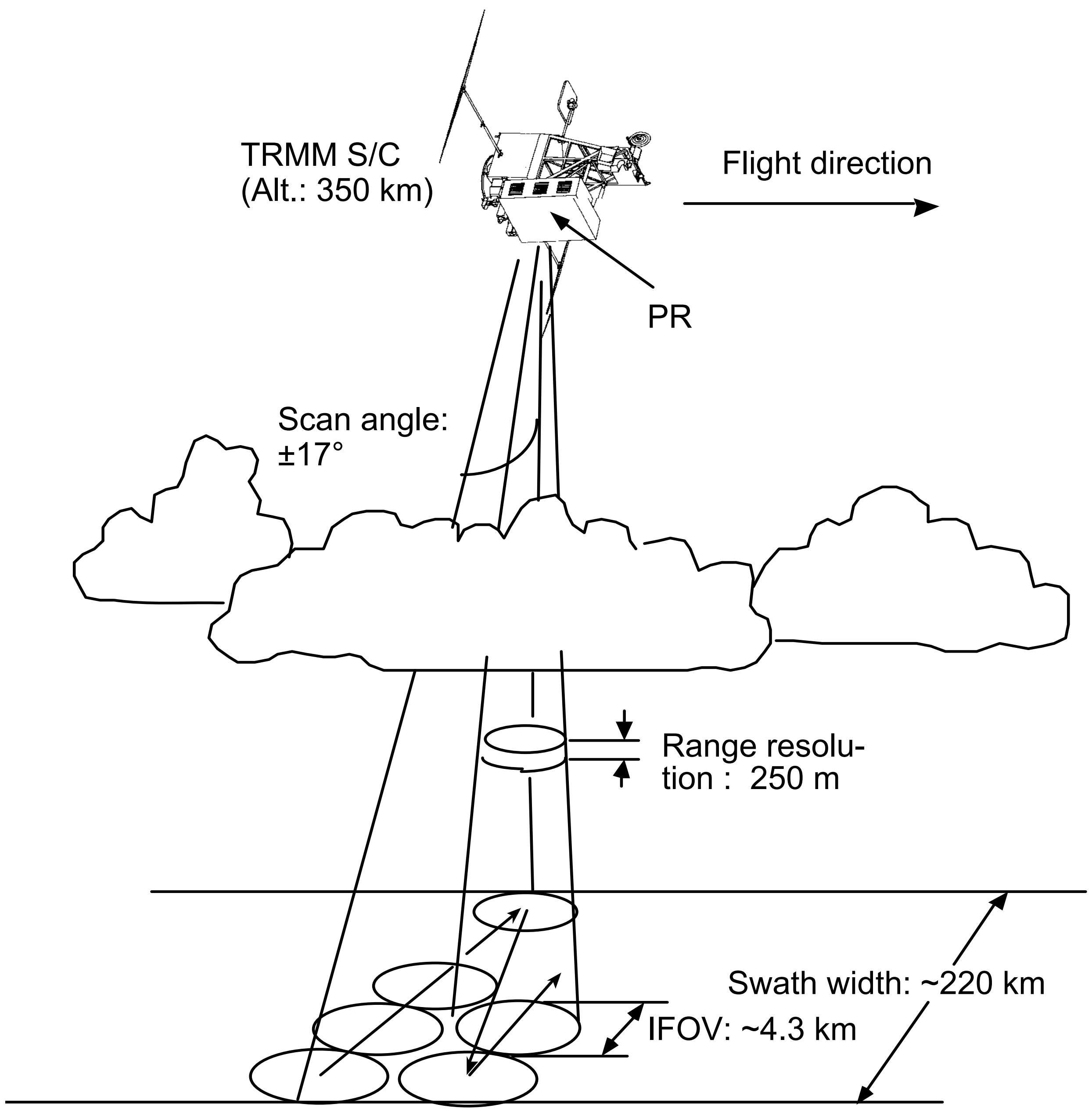


Bright band height superobservations for a day in Jaunuary 2010

82133 original reduced to 1767 superobservtions



TRMM PR



TRMM PR Algorithm Instruction Manual ver. 7

Table 1. Characteristics of TRMM PR.

Satellite altitude	350 km (before boost)
	400 km (after boost)
Frequency	13.8 GHz
Range resolution	250 m (normal sample)
	125 m (over sample)
Scan angles	-17° to +17° (49 angle bins)
Angle bin number:	
Normal sample	1-49
Over sample	11-39 (for surface)
Over sample	20-30 (for rain)
Horizontal resolution	4.3 km (before boost)
	5.0 km (after boost)
Observable range	15 km above mean sea level
Swath width	215 km (before boost)
	245 km (after boost)

Altitude change was conducted in August 2001.

Awaka et al. 2009

Bright band and the melting layer

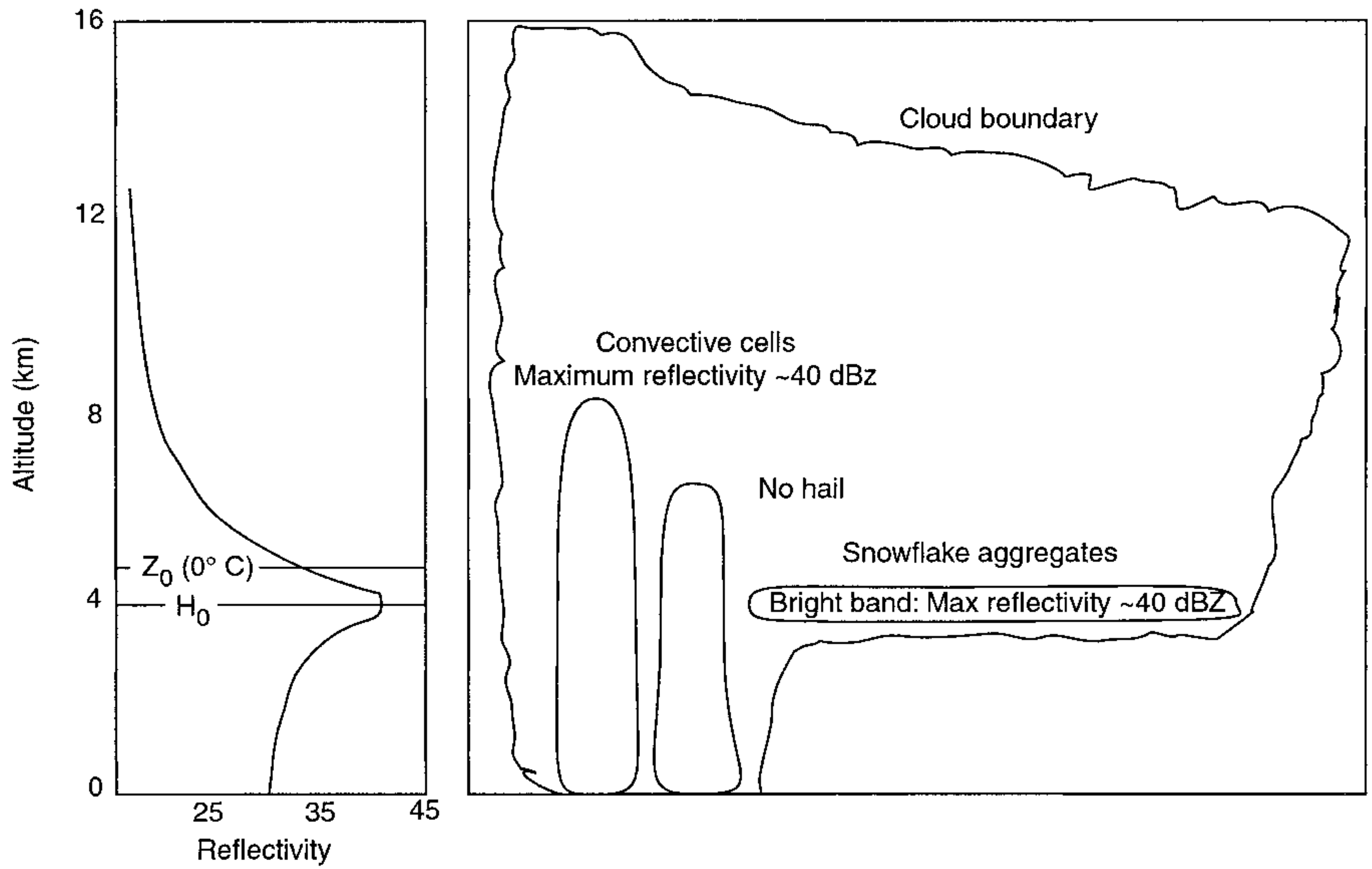
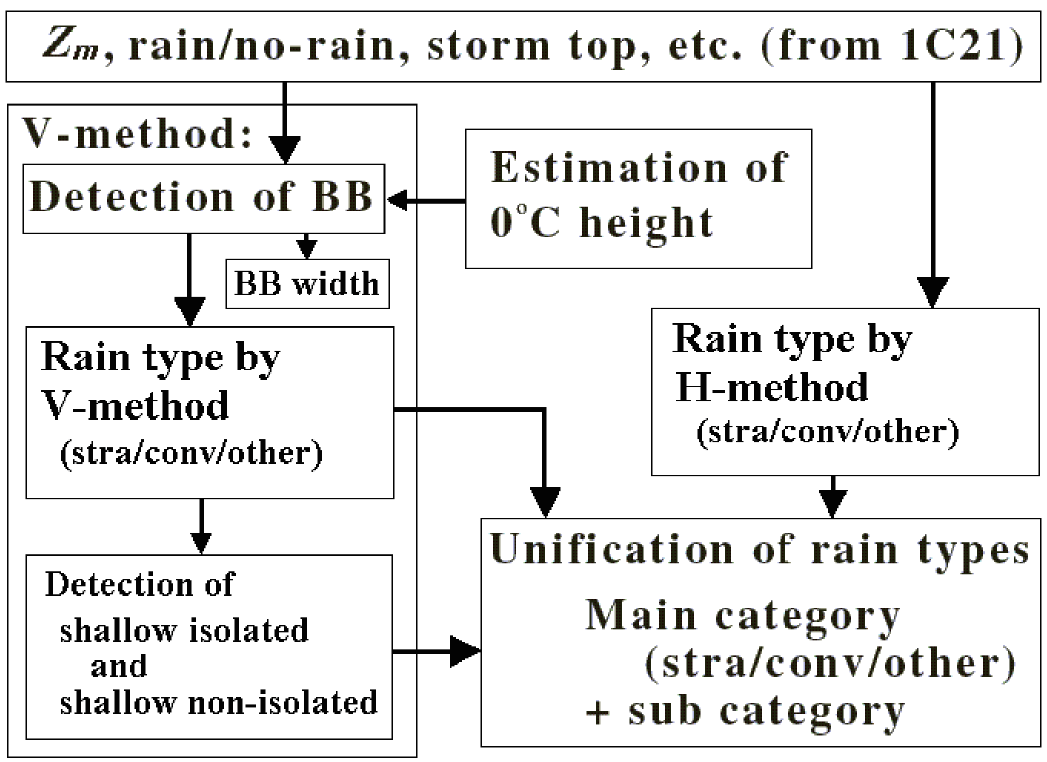


FIG. 1. Schematic cross section through tropical convection showing the altitude of the 0°C isotherm and the melting layer (bright band) in the stratiform rain region (after Leary and Houze 1979).

Harris et al. 2009

Detection of bright bands



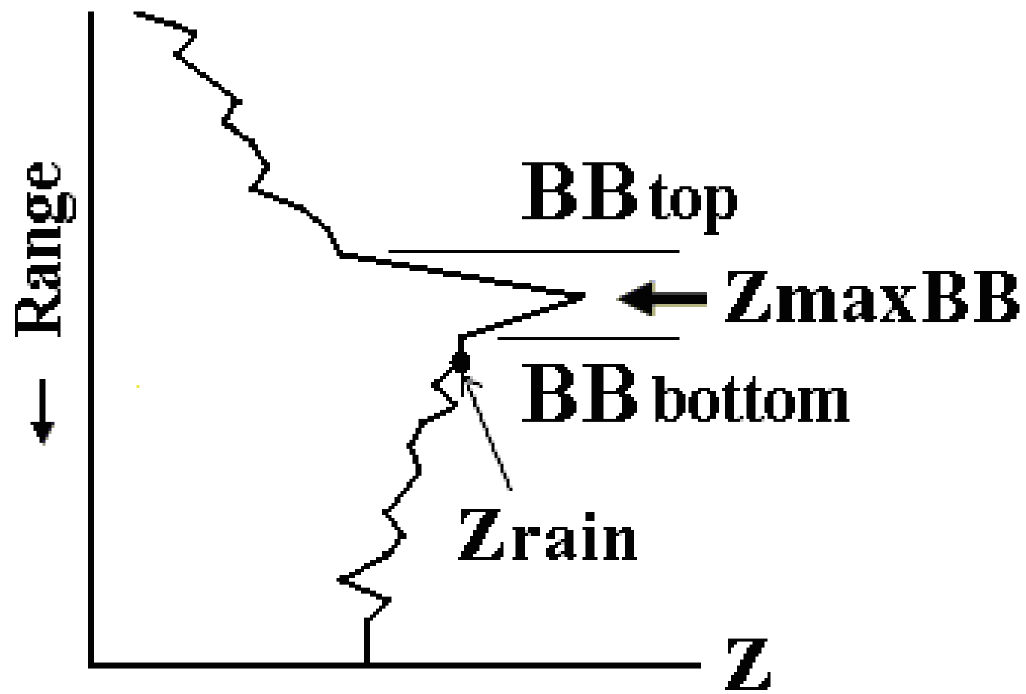


Fig. A1. Schematic illustration of BBtop, BBbottom, ZmaxBB, and Zrain.

Awaka et al. 2009

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

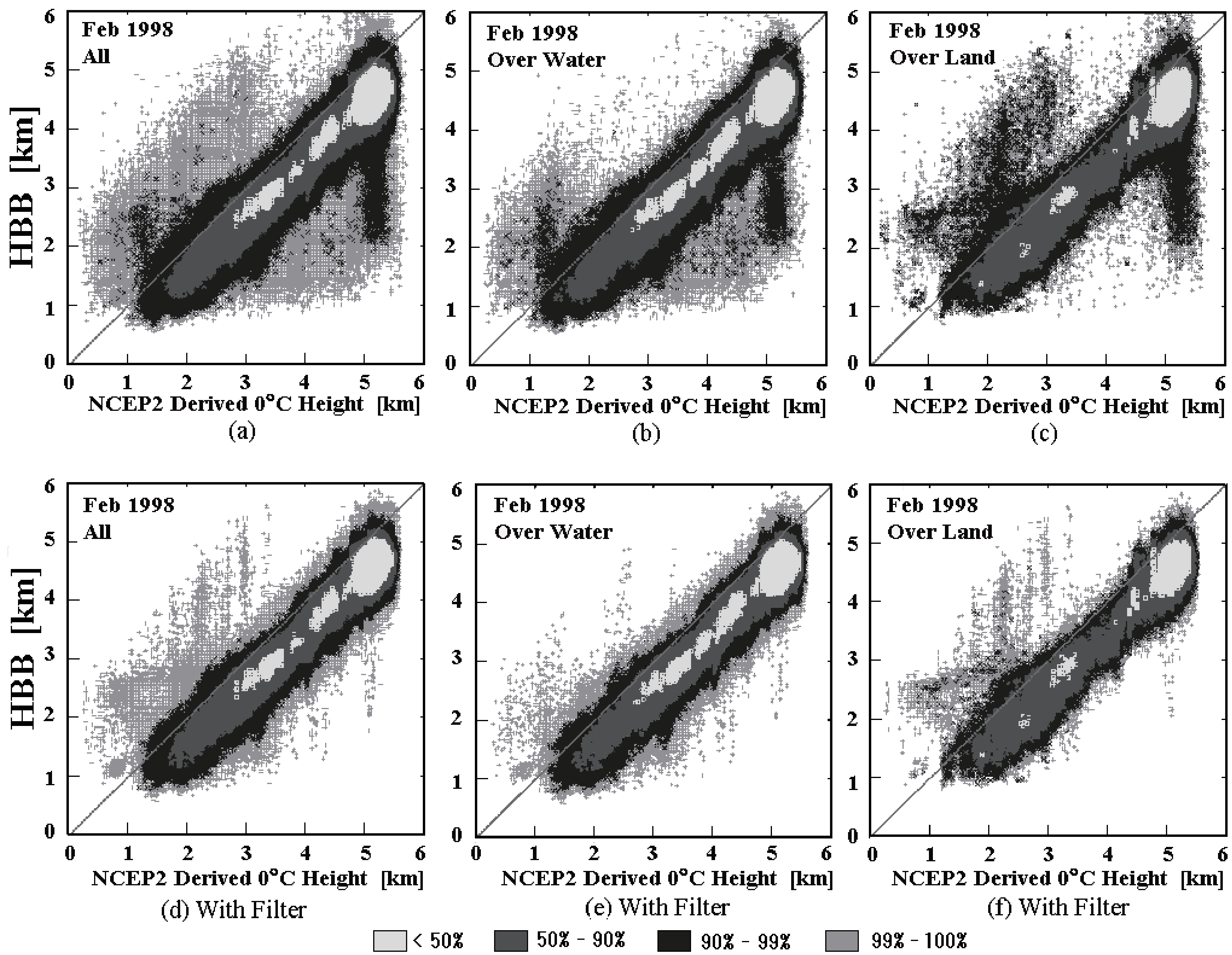
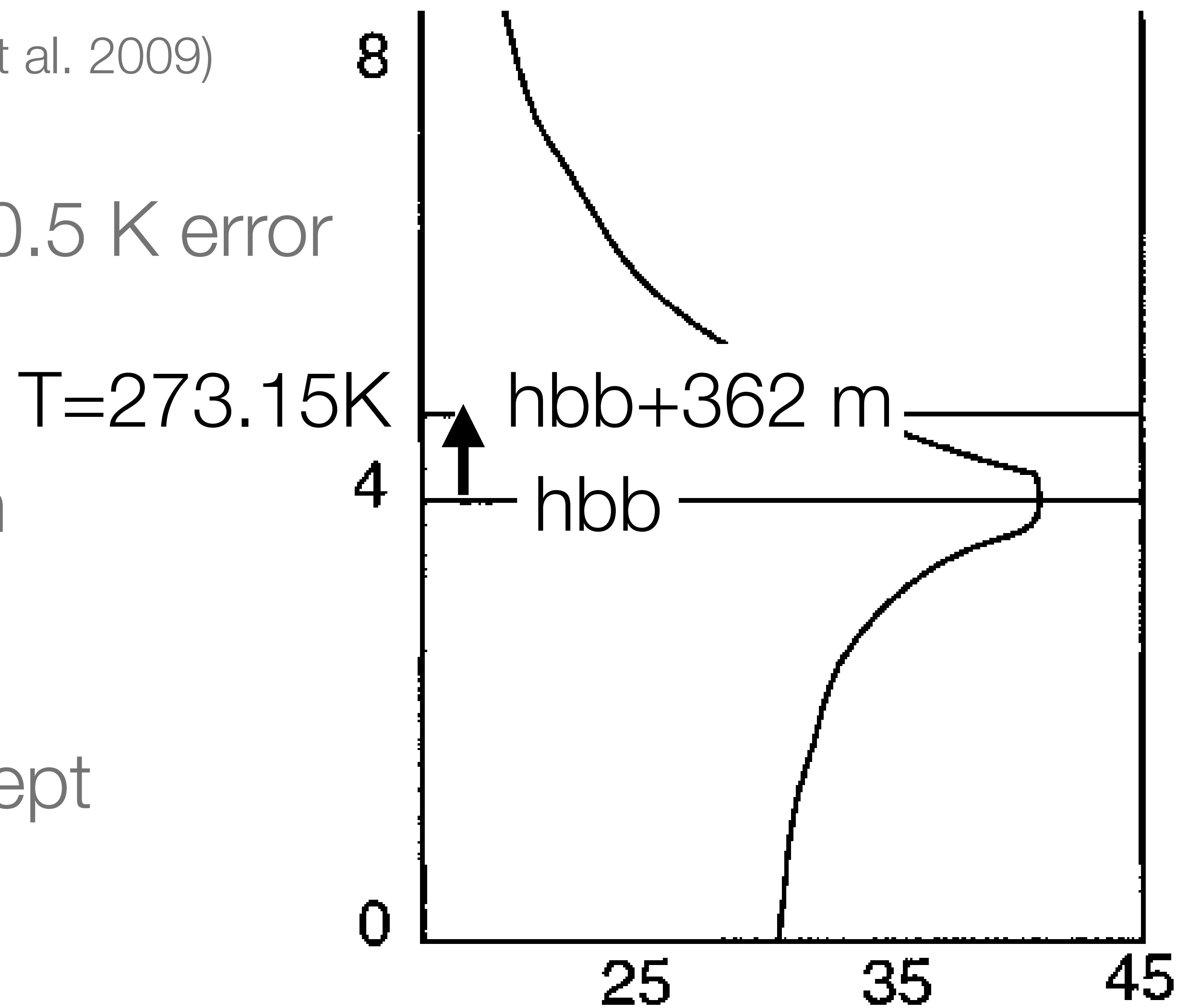


Fig. 4. Scatterplot of HBB versus NCEP2 derived 0°C height (HfreezeNCEP2) in February 1998. Upper panels depict the original case, and lower panels, the case after applying the simple filter explained in the text. Panels (a) and (d) present scatterplots using all the data (over water+land); panels (b) 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 × 0.02 km.

Awaka et al. 2009

Bright band heights as 0°C temperature observations

- TRMM PR 2A23 (Awaka et al. 2009)
- 0°C observations with 0.5 K error at hbb+362 m
- Superobservations with a radius of 0.5°
- modified LETKF to accept height level data



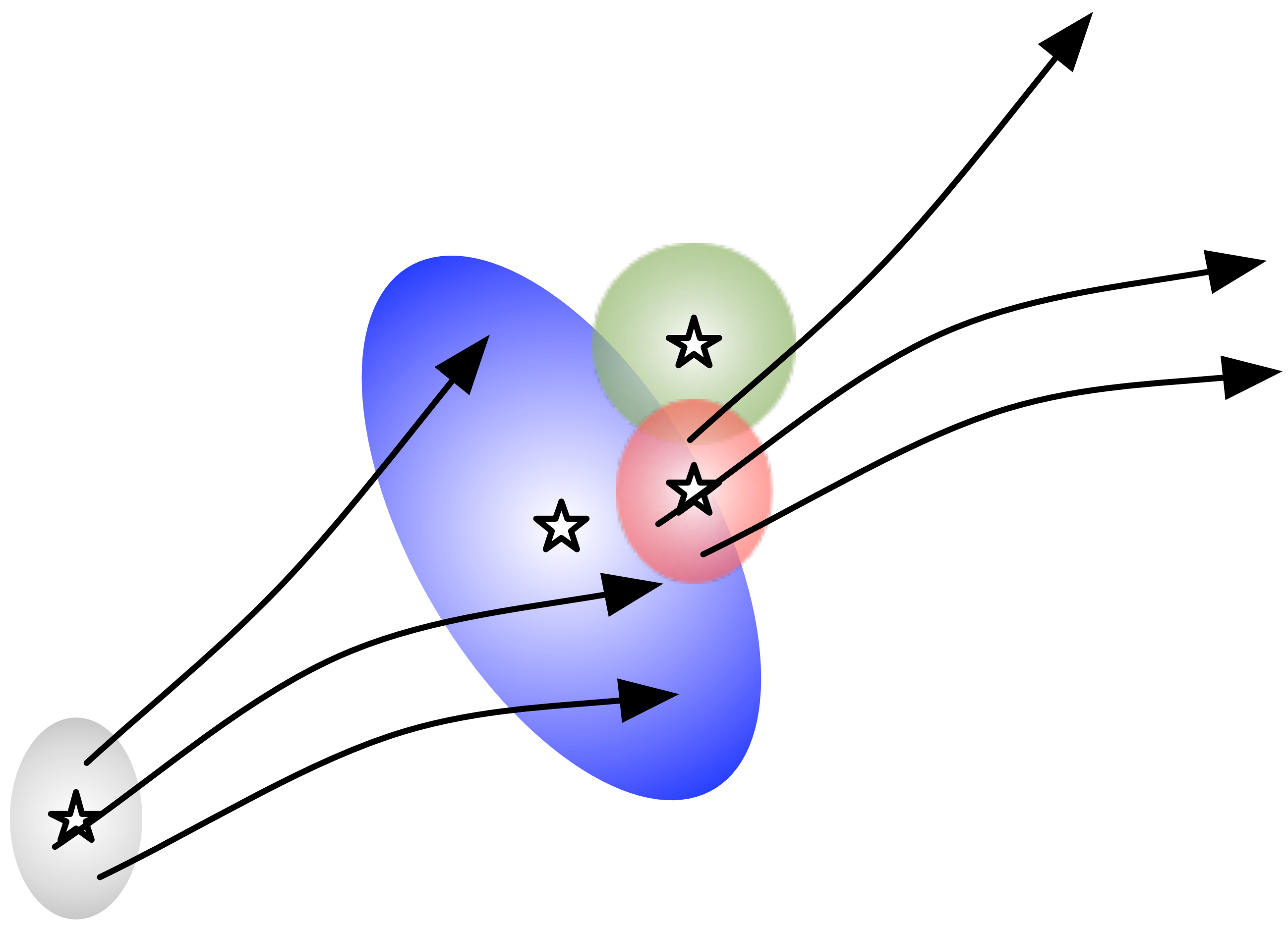
Global atmospheric ensemble reanalysis ALERA2

AFES

- Atmospheric general circulation model for the Earth Simulator
- Spectral transfrom 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

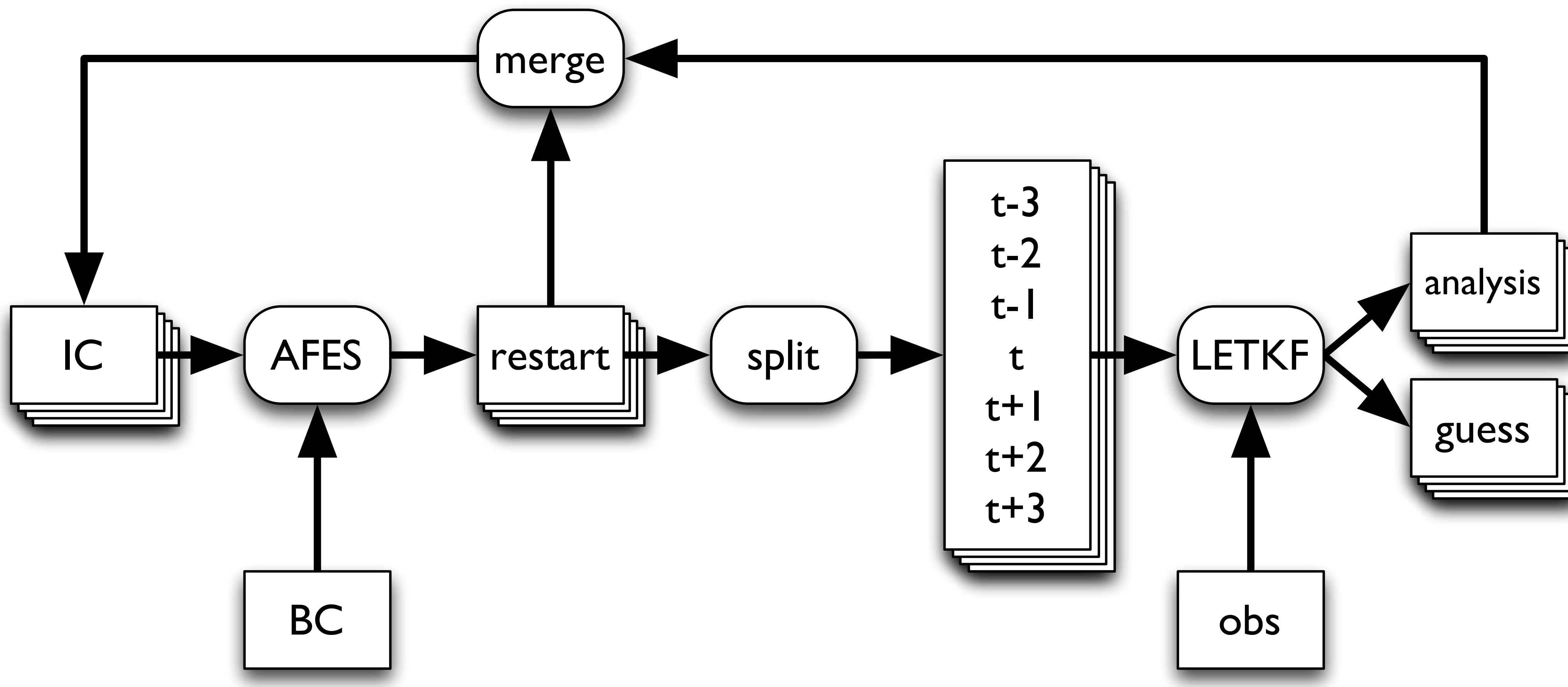
- Local ensemble transform Kalman filter
- Hunt et al. 2007;
  Miyoshi and Yamane 2007
- Highly efficient on parallel computers
- Assimilate observations into the ensemble mean
- Time evolution of forecast covariance matrix
- Localization and inflation



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°x1°, 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)

ALERA2 data flow



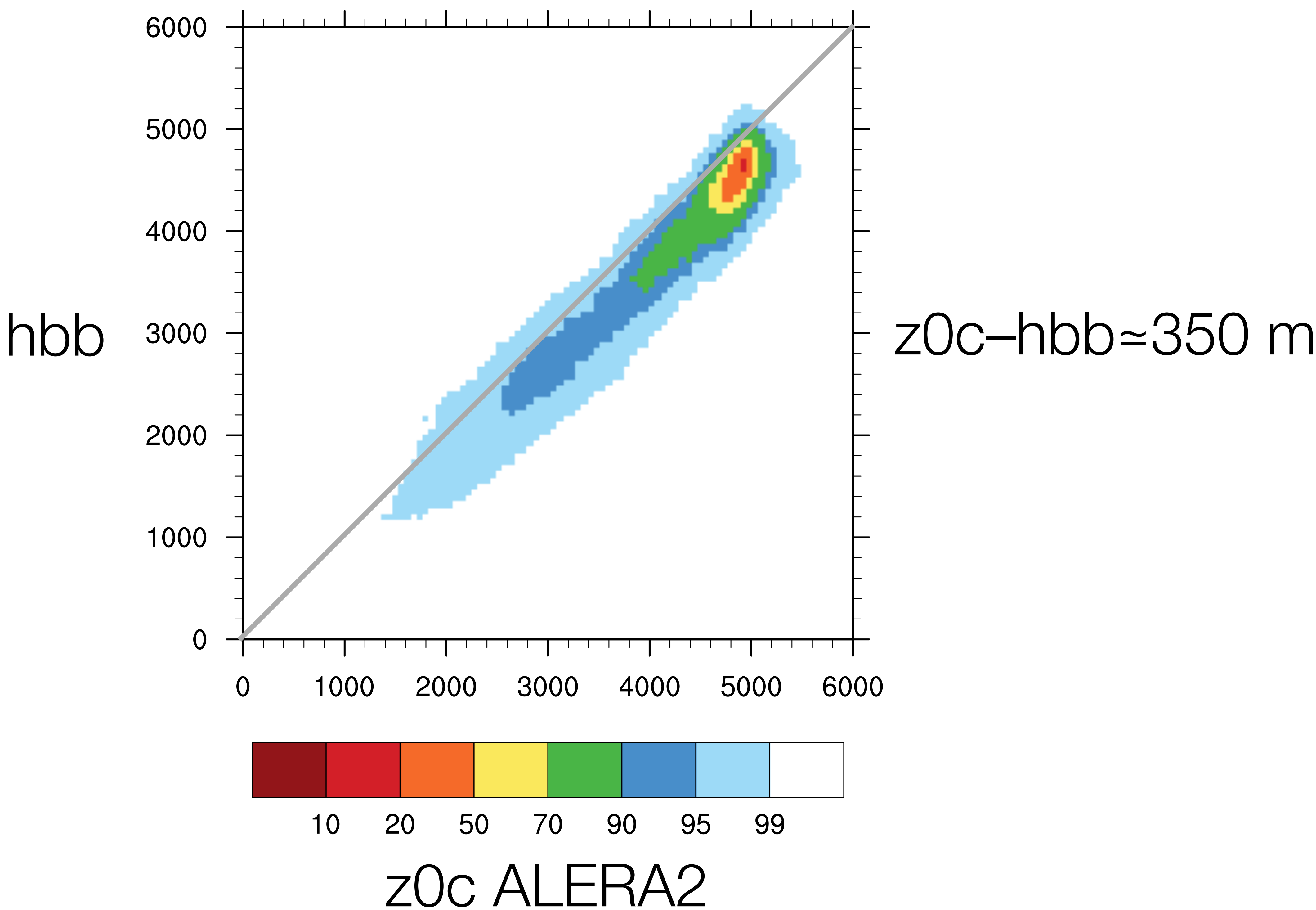
Observing system experiments

Observing system experiments

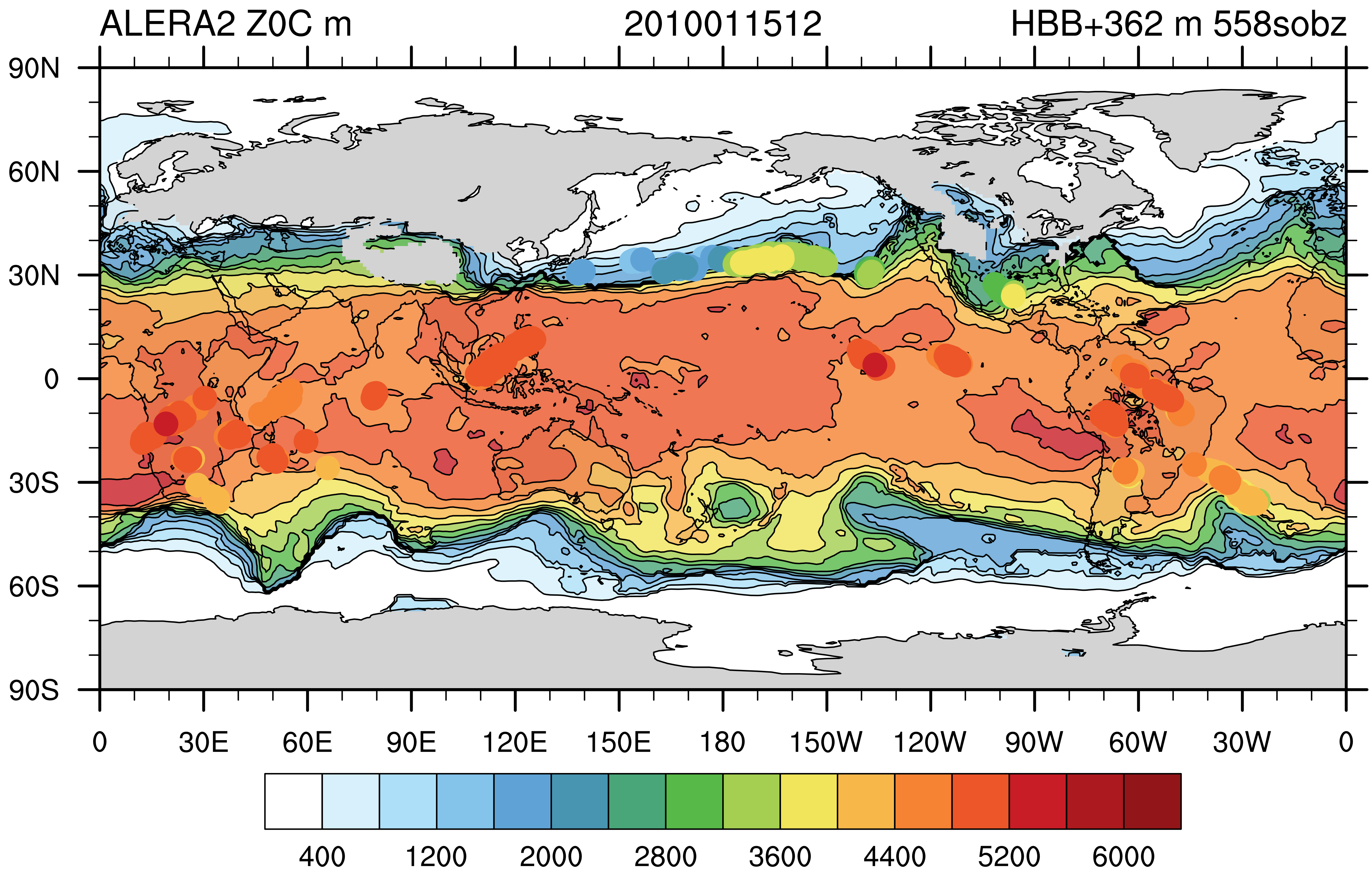
- Reference: ALERA2 stream2008
- modified LETKF to accept height level data
- grouped by 6 hourly analysis time with ±3 h window and rounded to the hour
- superobservations of bright band heights
- from 0 UTC 3 January to 0 UTC 31 January 2010

Bright band height superobservations

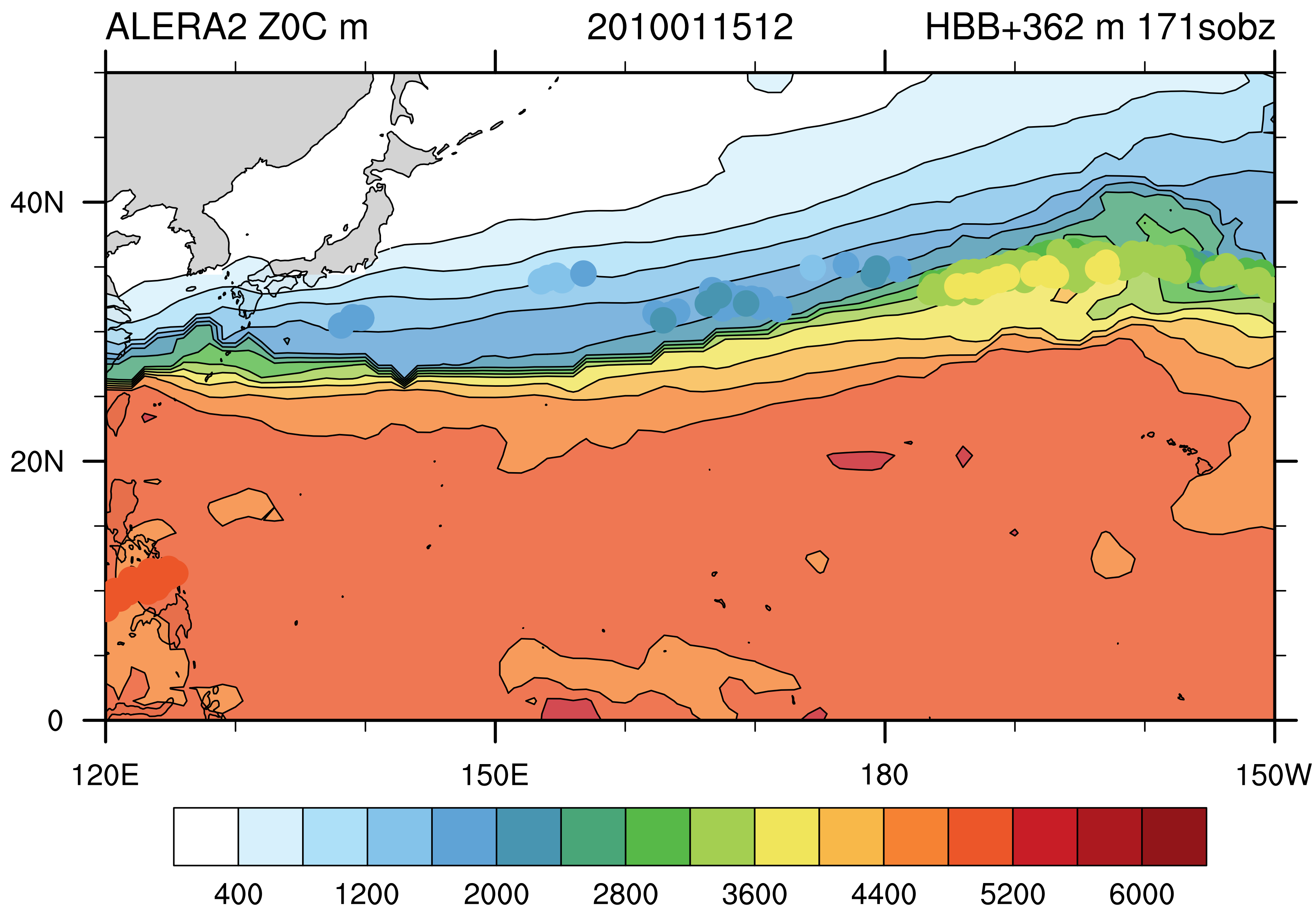
ALERA2 0C height and bright band heights: statistics for January 2010



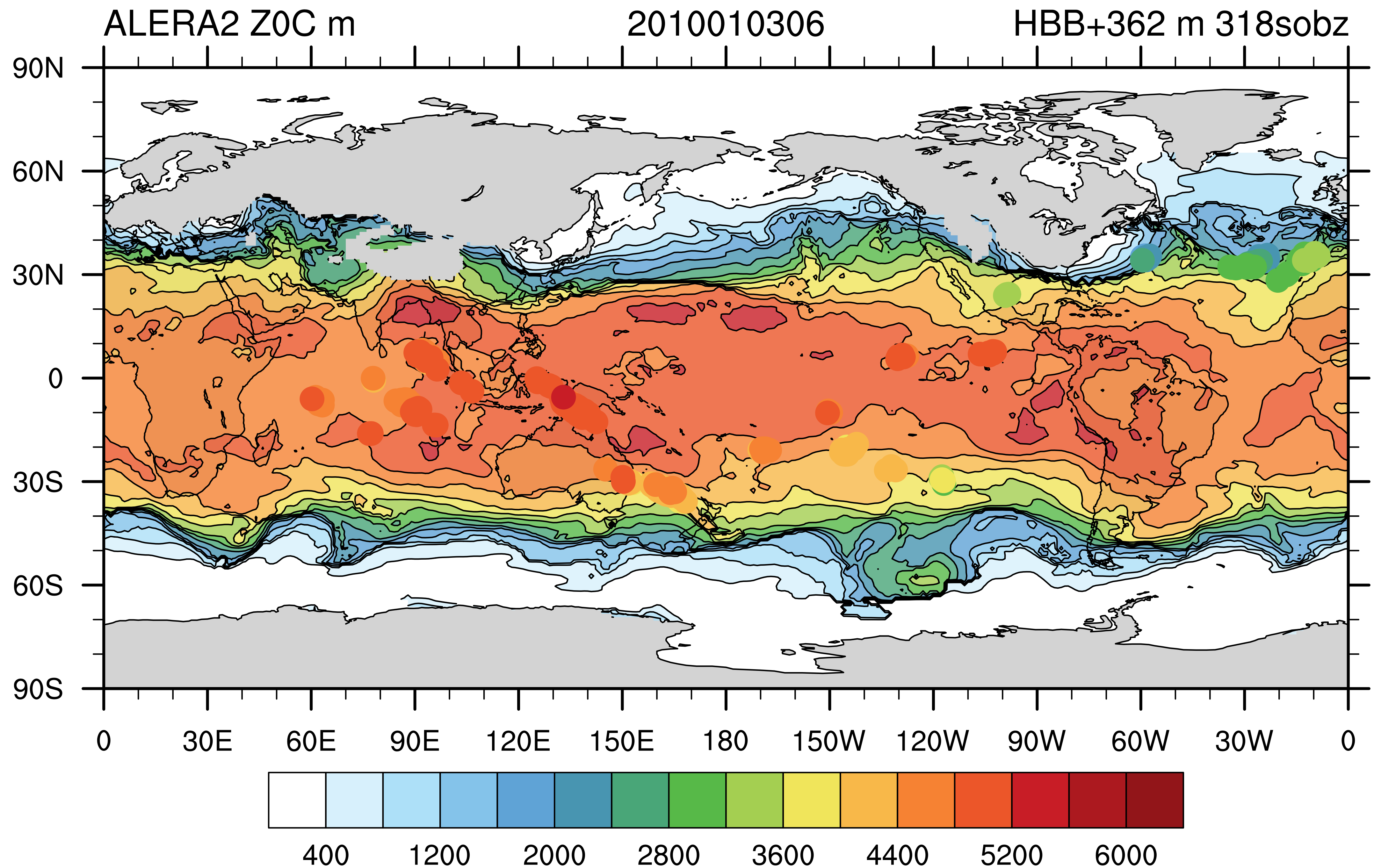
ALERA2 0C height and bright band heights in 12 UTC ±3 h window on 15 January 2010



ALERA2 0C height and bright band heights in 12 UTC ±3 h window on 15 January 2010 near Japan

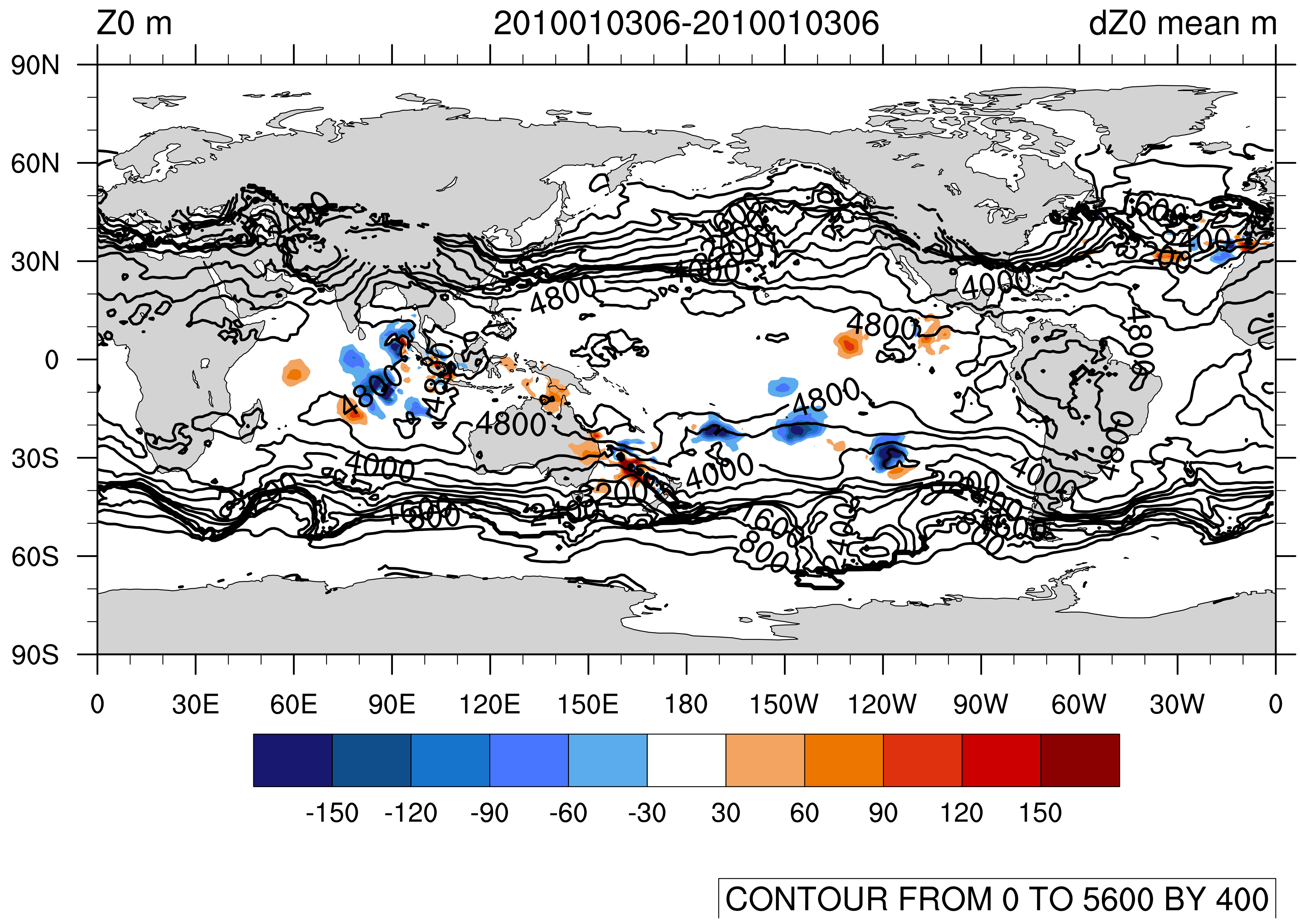


ALERA2 0C height and bright band heights in 6 UTC ±3 h window on 3 January 2010

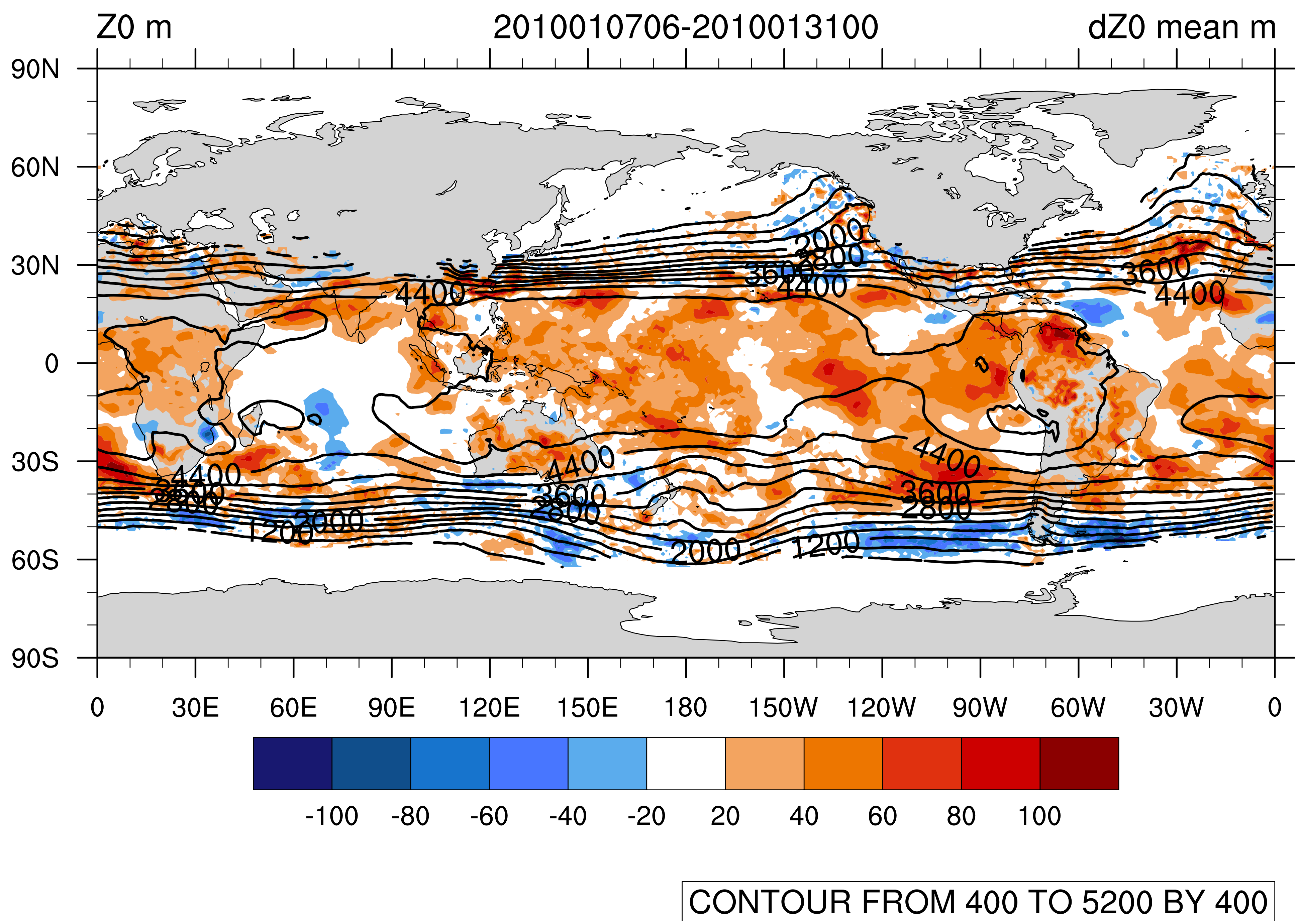


Impact of added observations

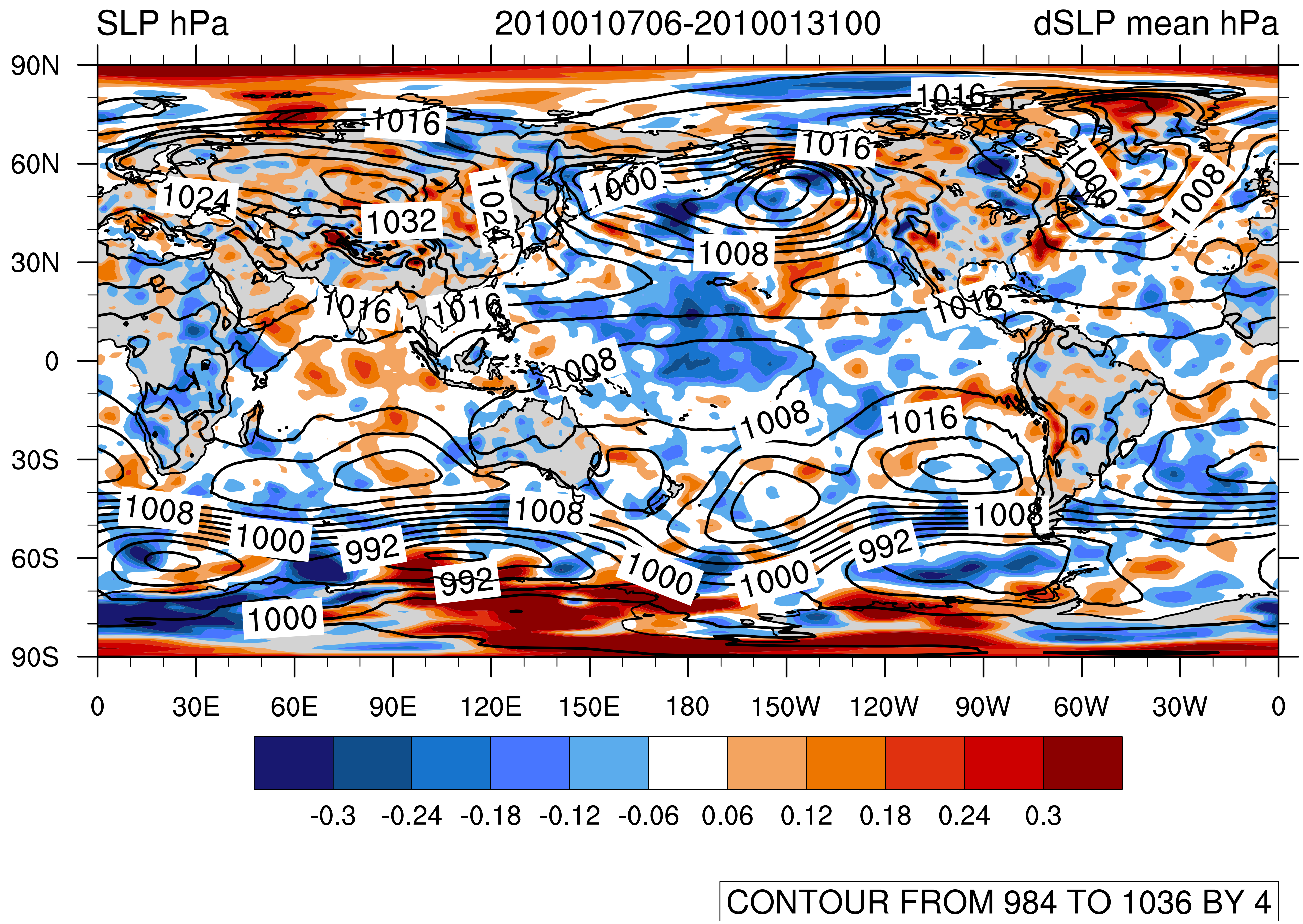
Initial impact on the freezing level height



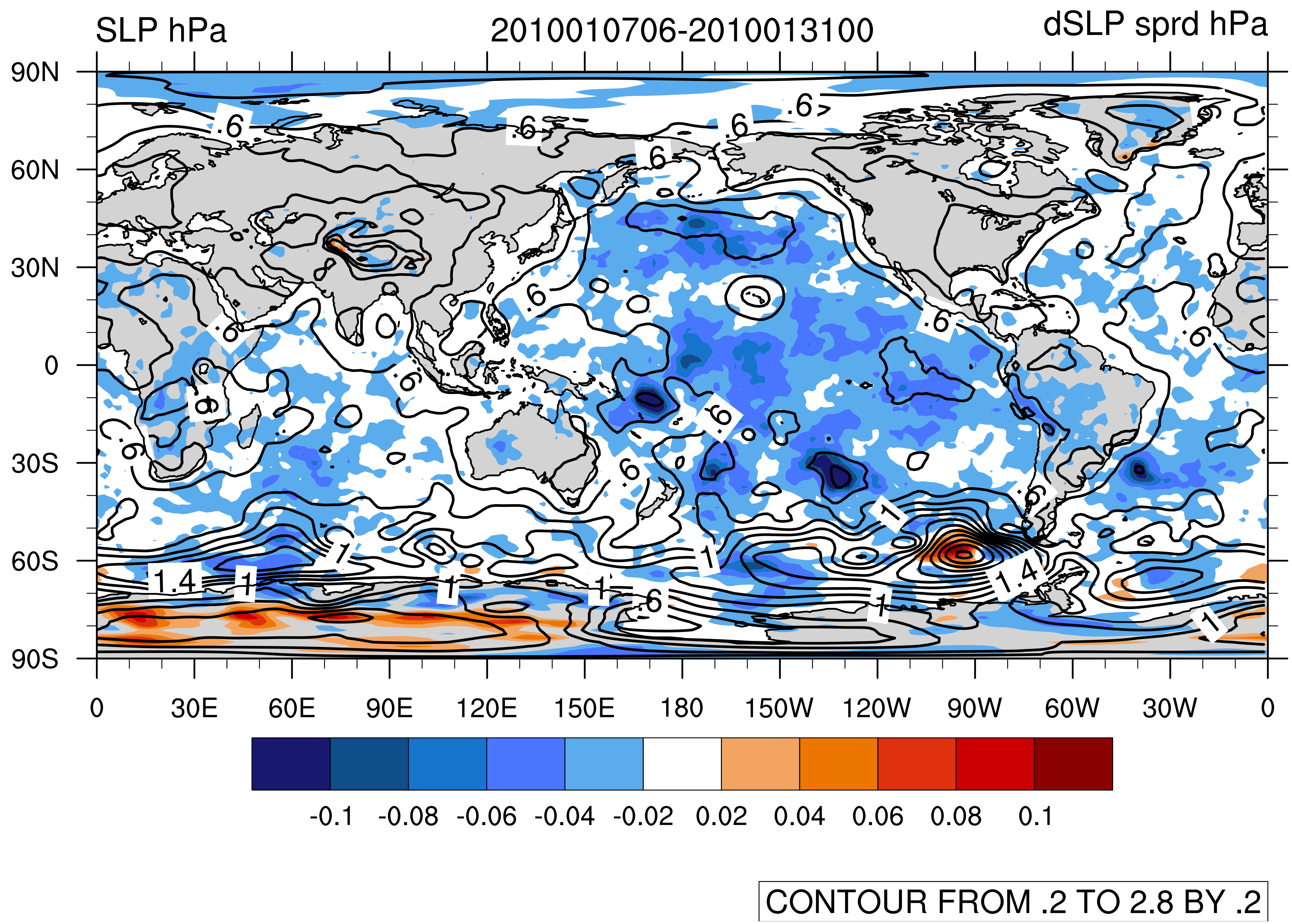
Impact on the freezing level height



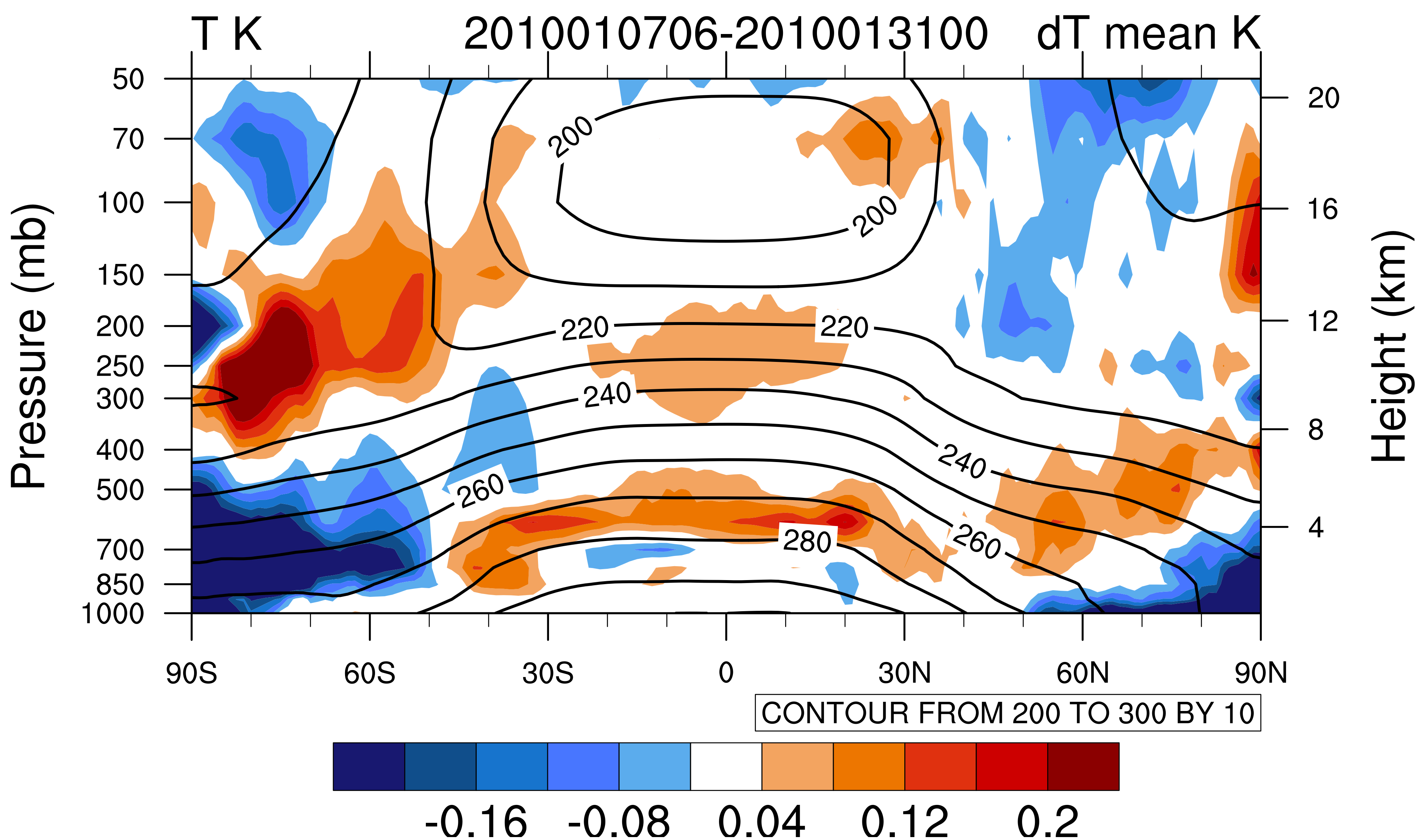
Impact on ensemble mean sea-level pressure



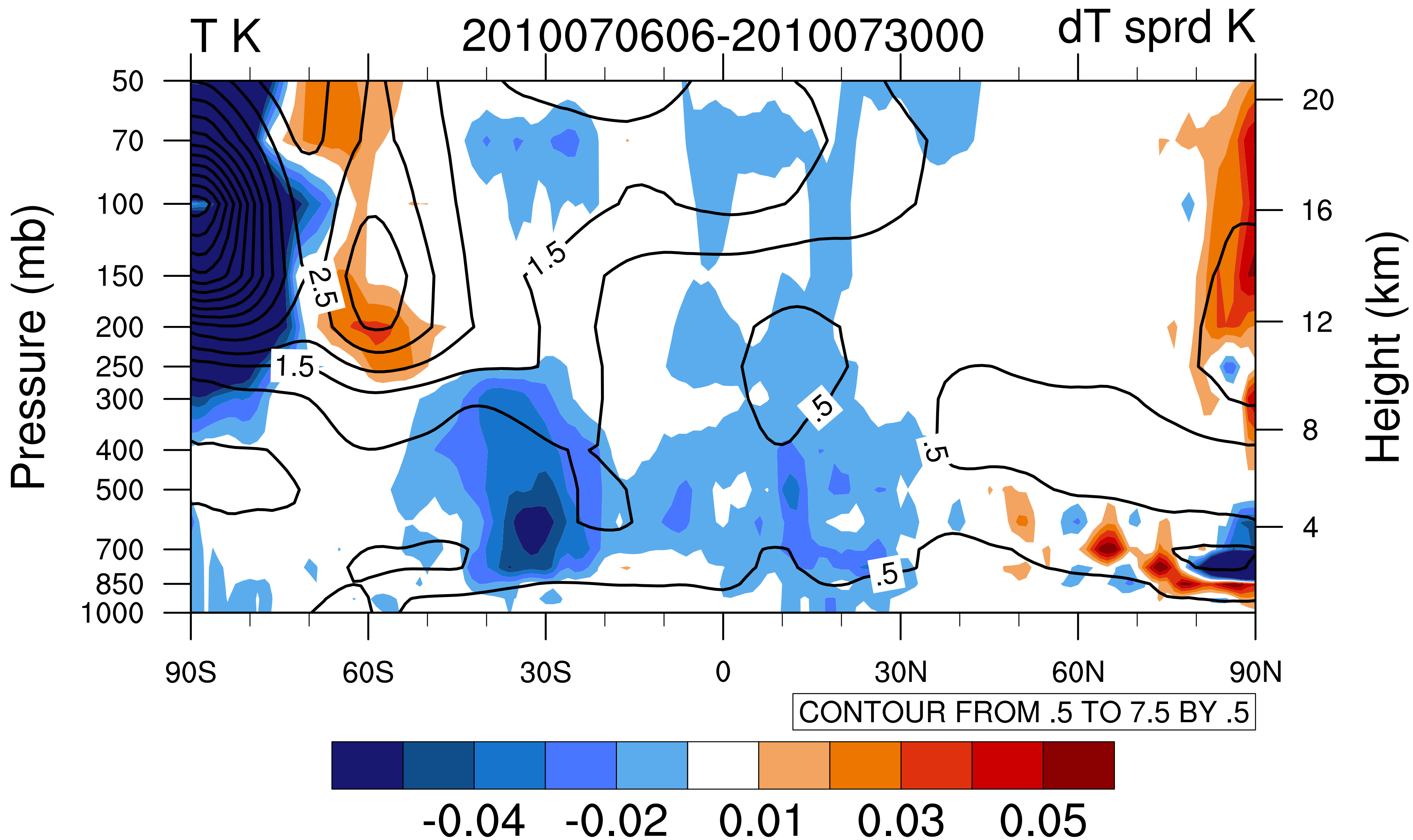
Reduction of *SLP* analysis ensemble spread



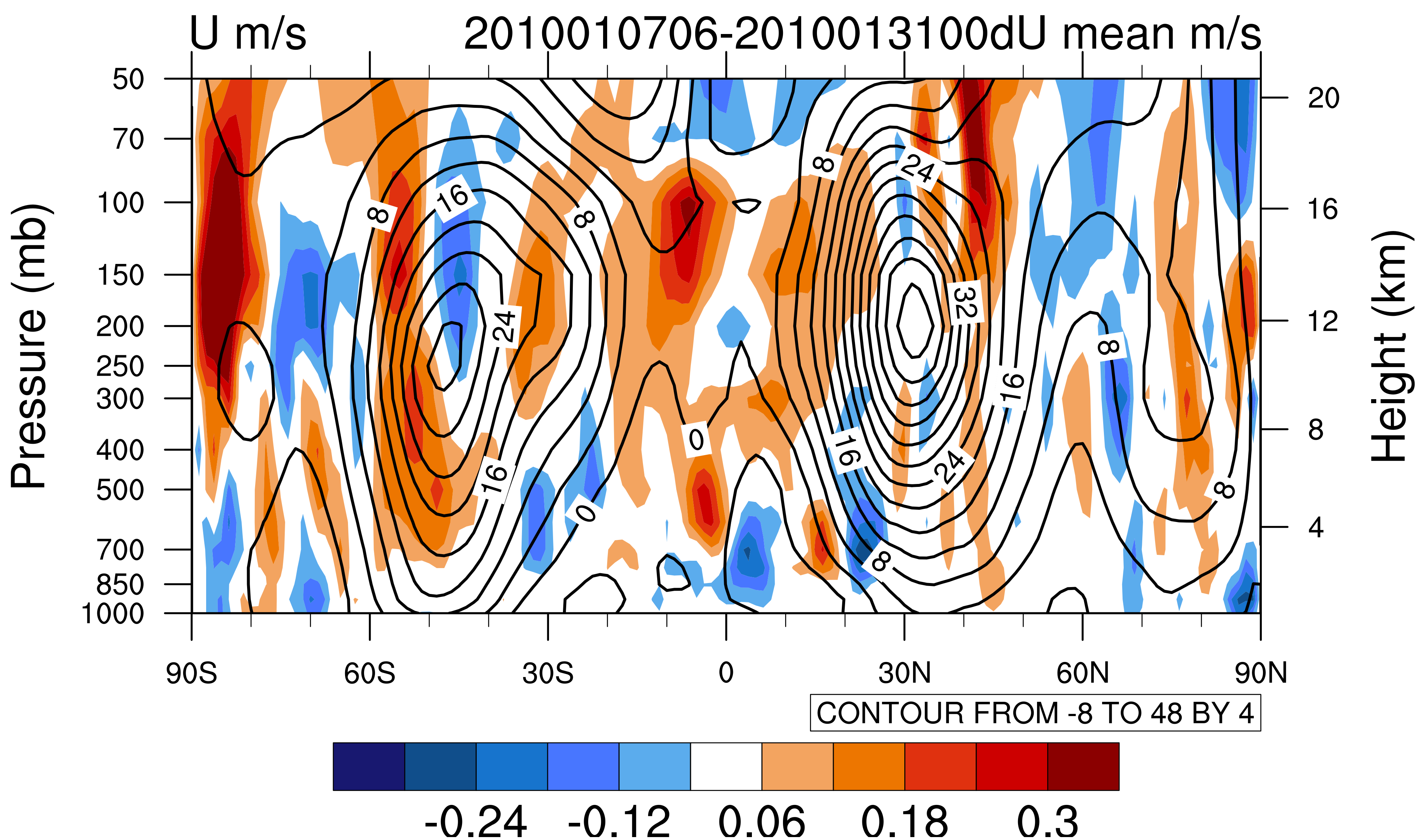
Impact on ensemble mean temperature



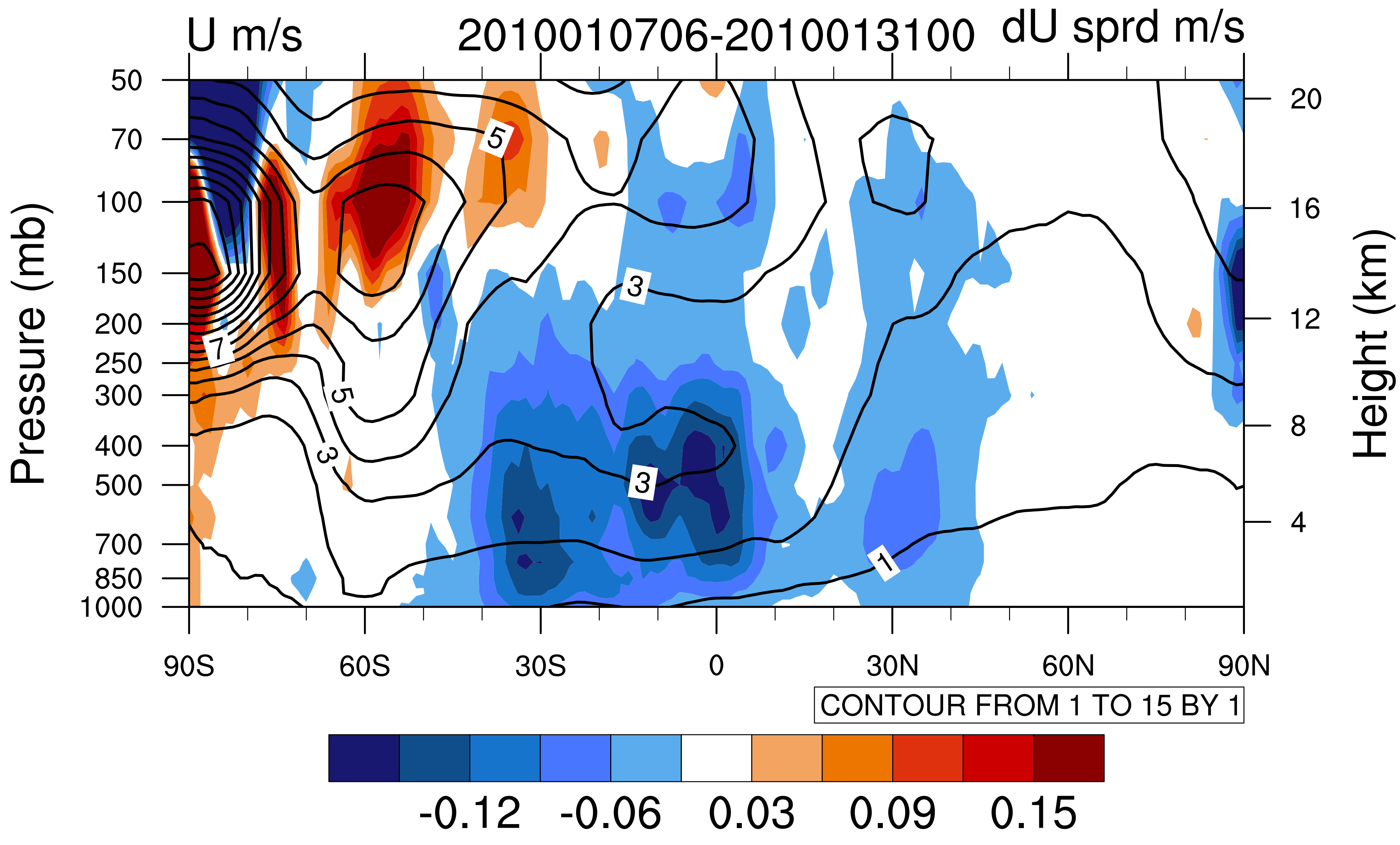
Reduction in *T* analysis ensemble spread



Impact on ensemble mean zonal wind

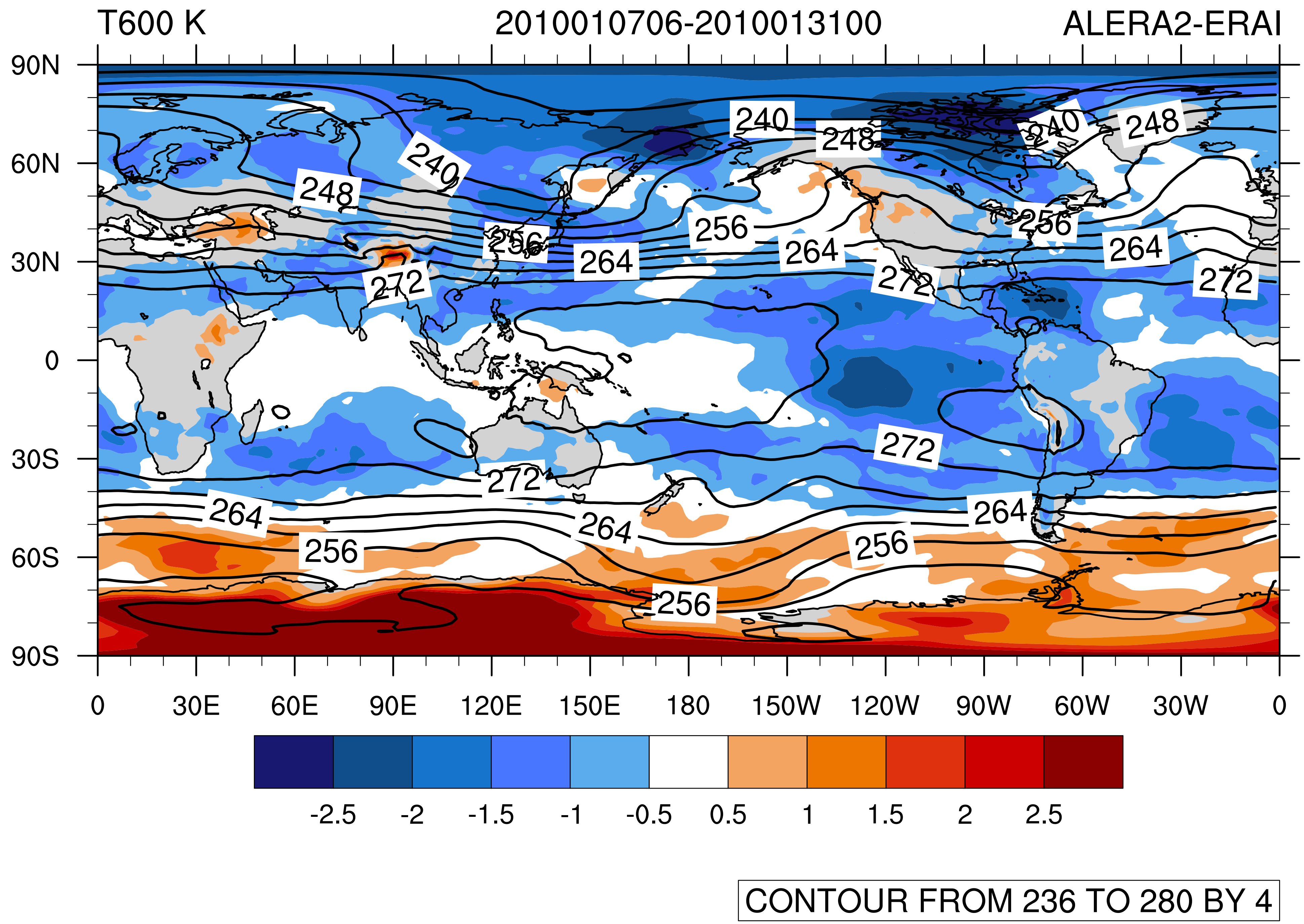


Reduction in *U* analysis ensemble spread

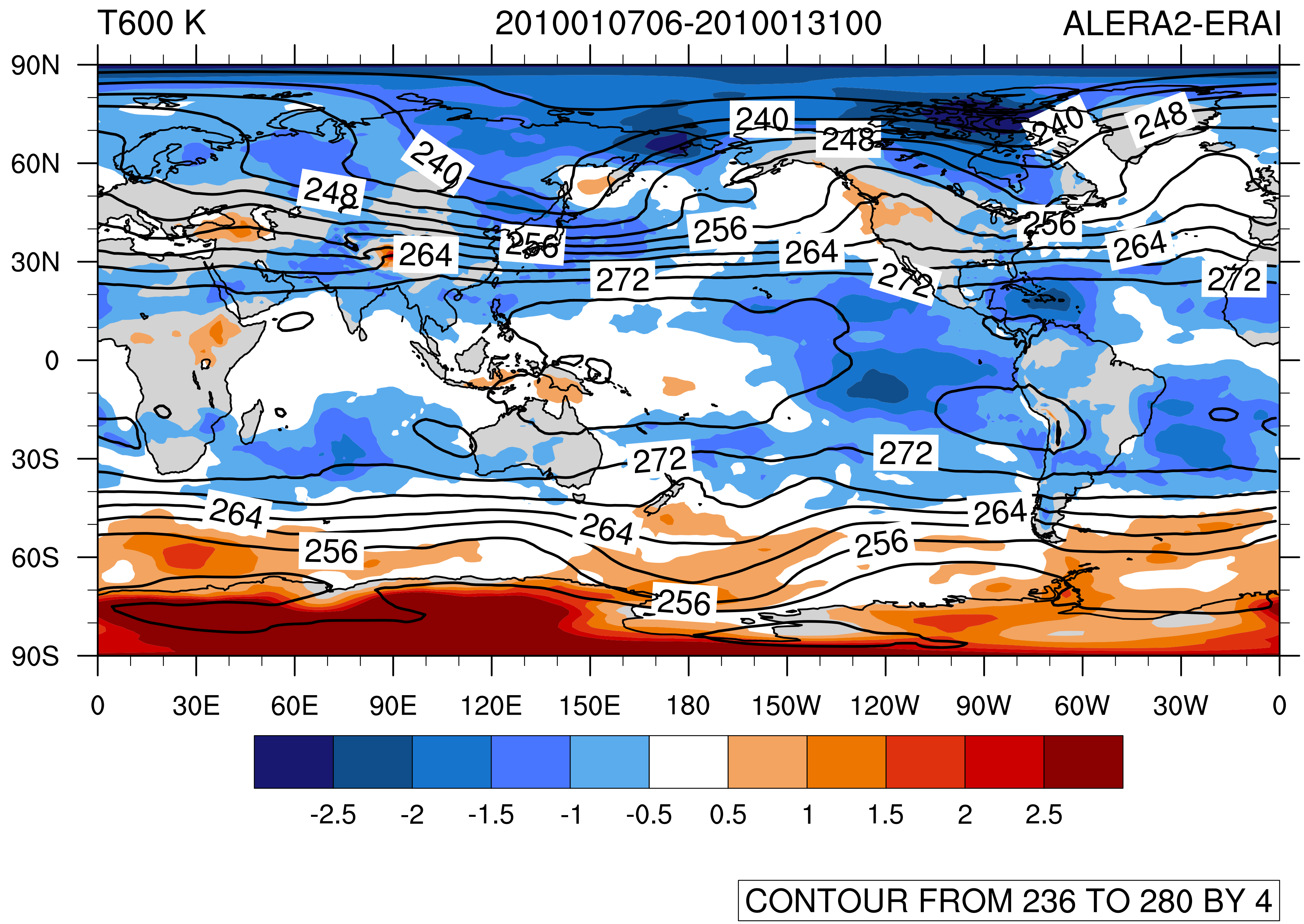


Bias agains ERA-Interim

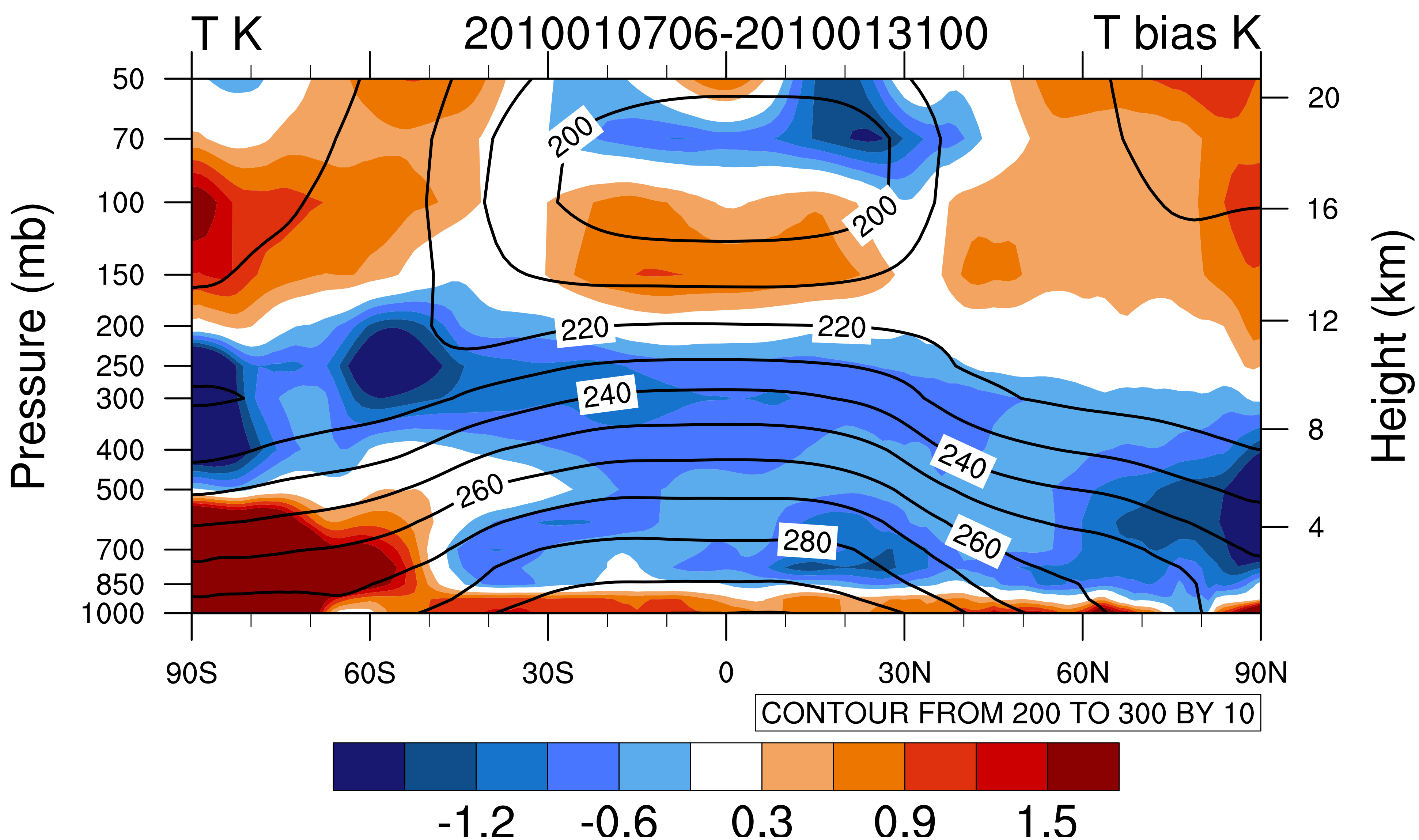
ALERA2 *T* bias against ERA-Interim at 500 hPa



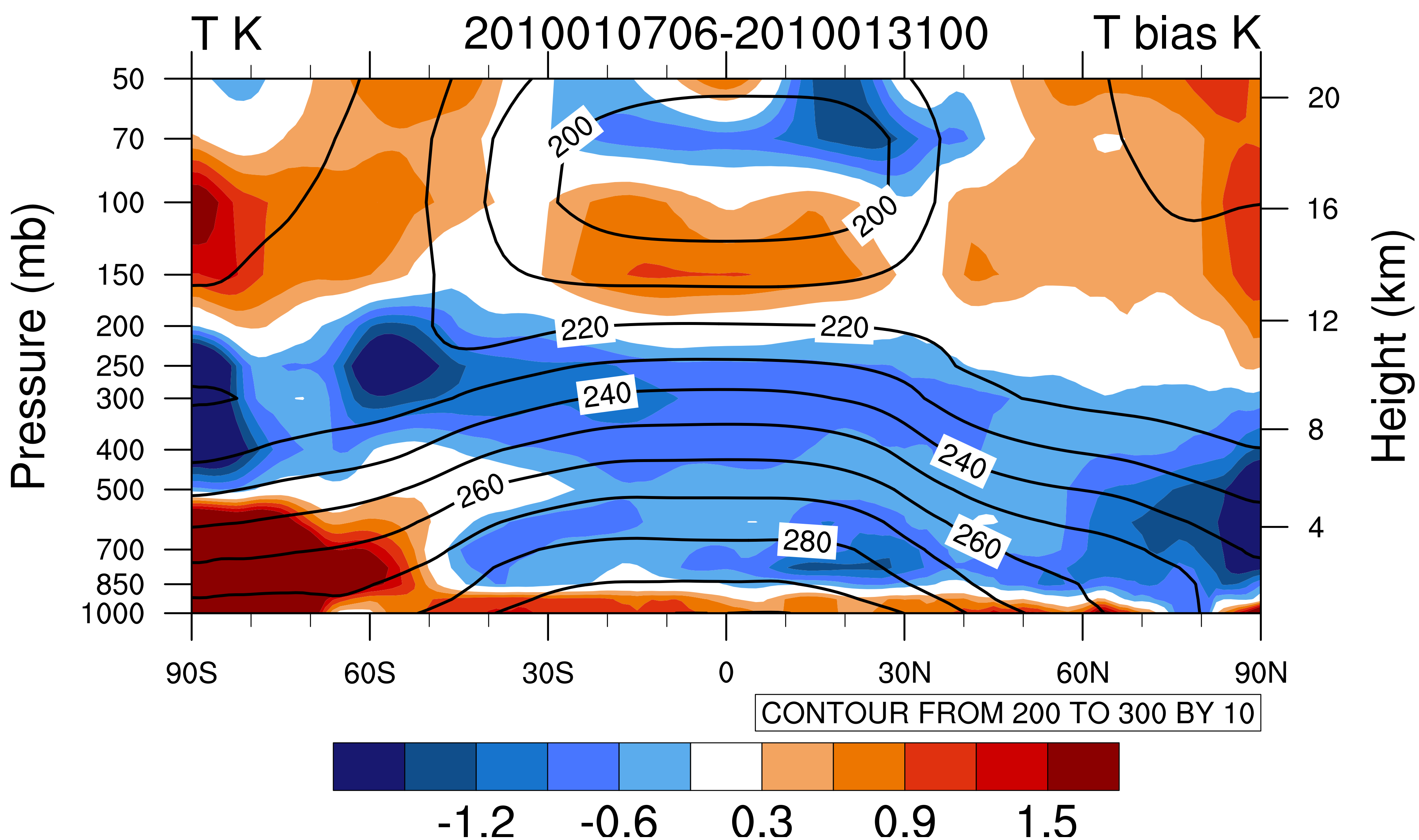
ALERA2 with bright band heights
T bias against ERA-Interim at 500 hPa



ALERA2 zonal mean *T* bias against ERA-Interim

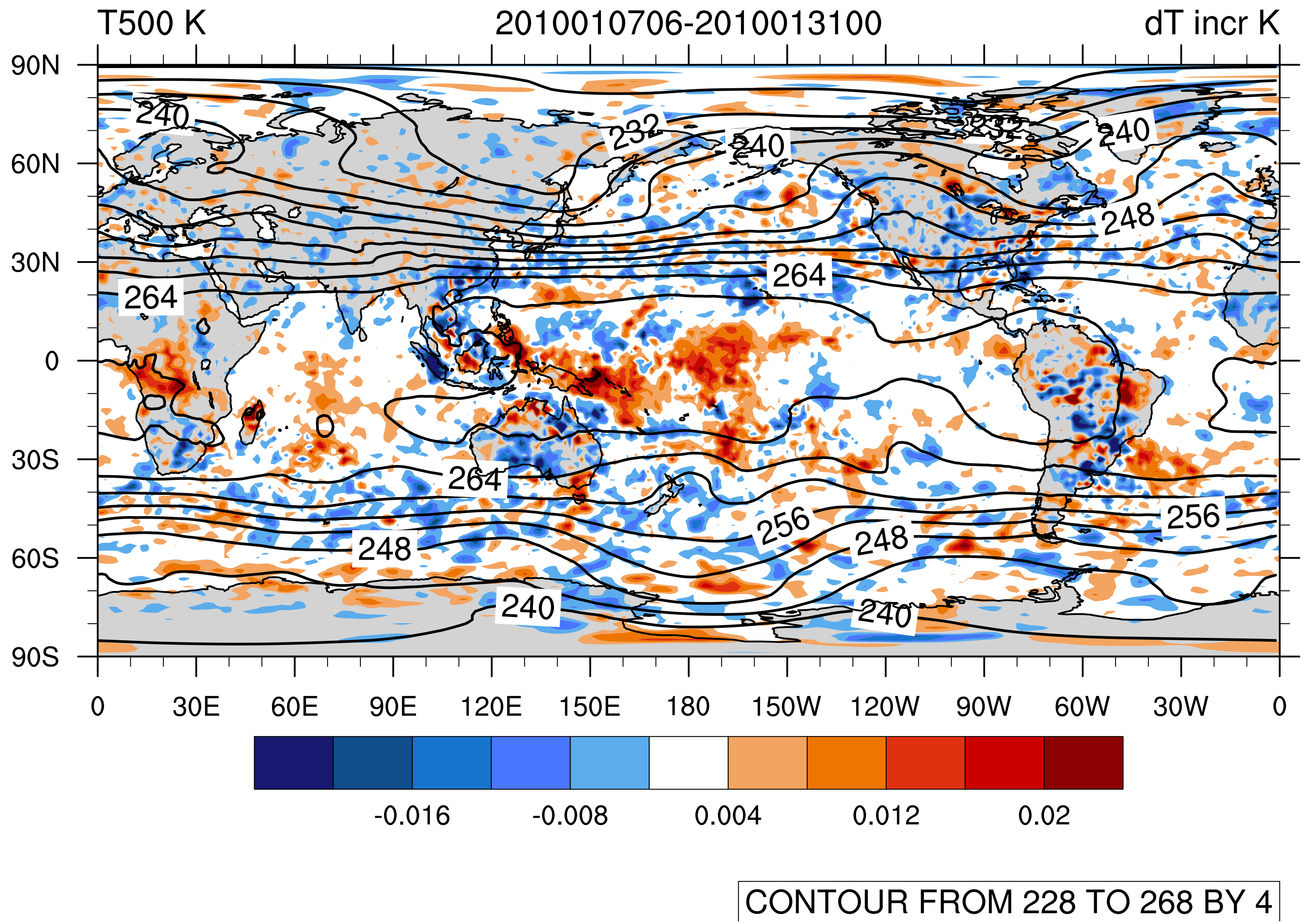


ALERA2 with bright band heights
zonal mean *T* bias against ERA-Interim

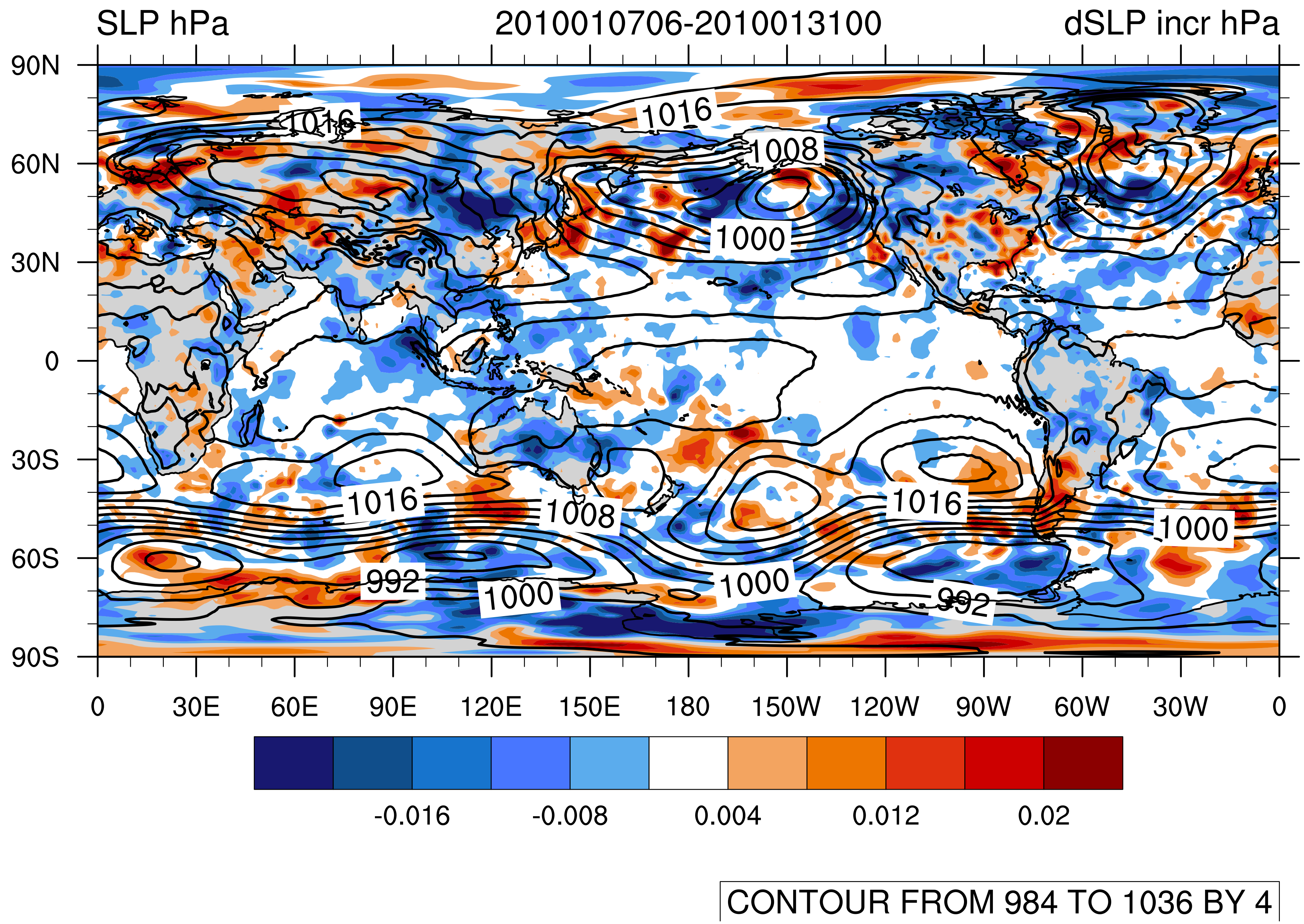


Changes in analysis increment

Change in *T* analysis increment at 500 hPa

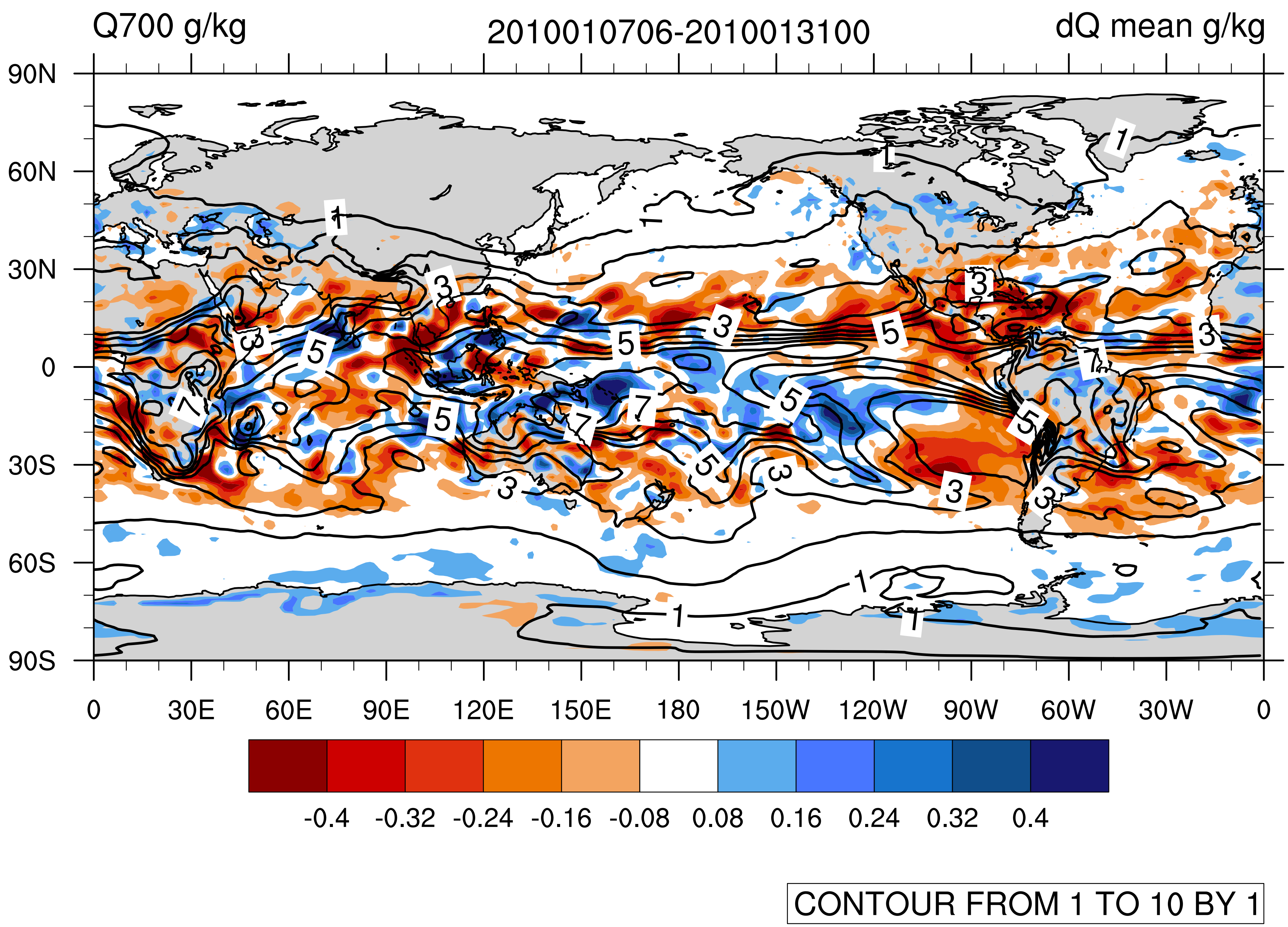


Change in *SLP* analysis increment

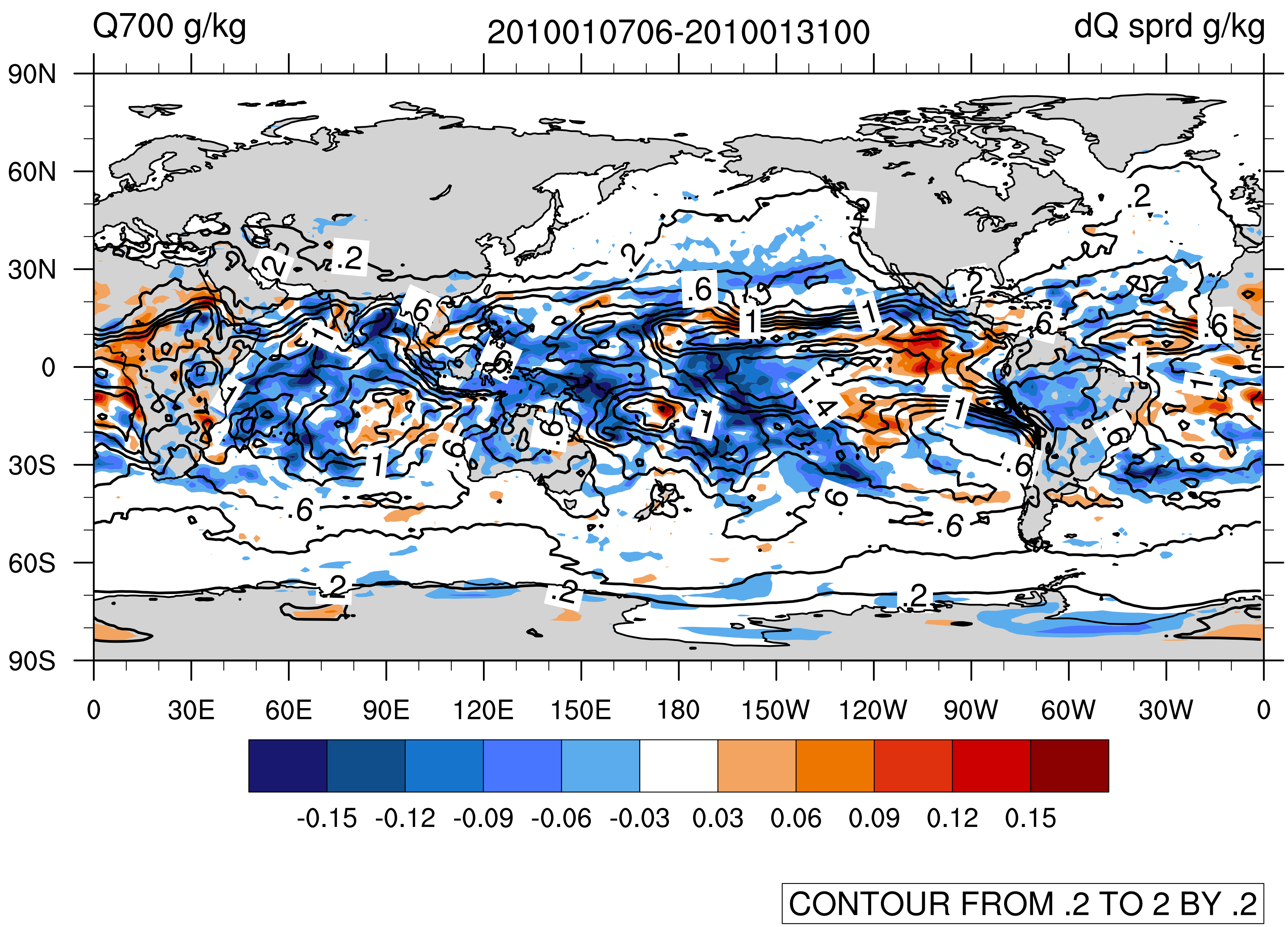


Impact on hydrological cycle

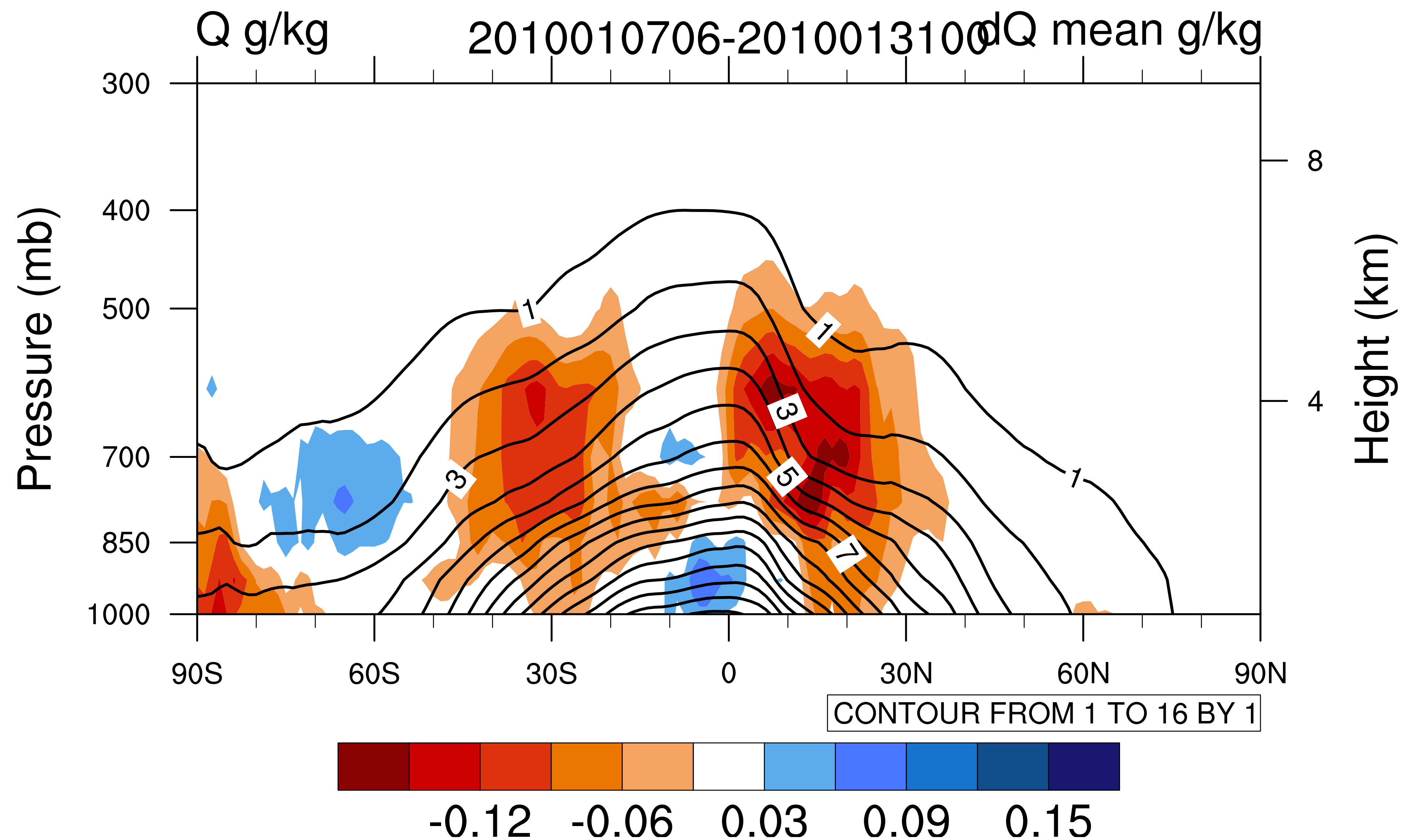
Impact on Q at 700 hPa



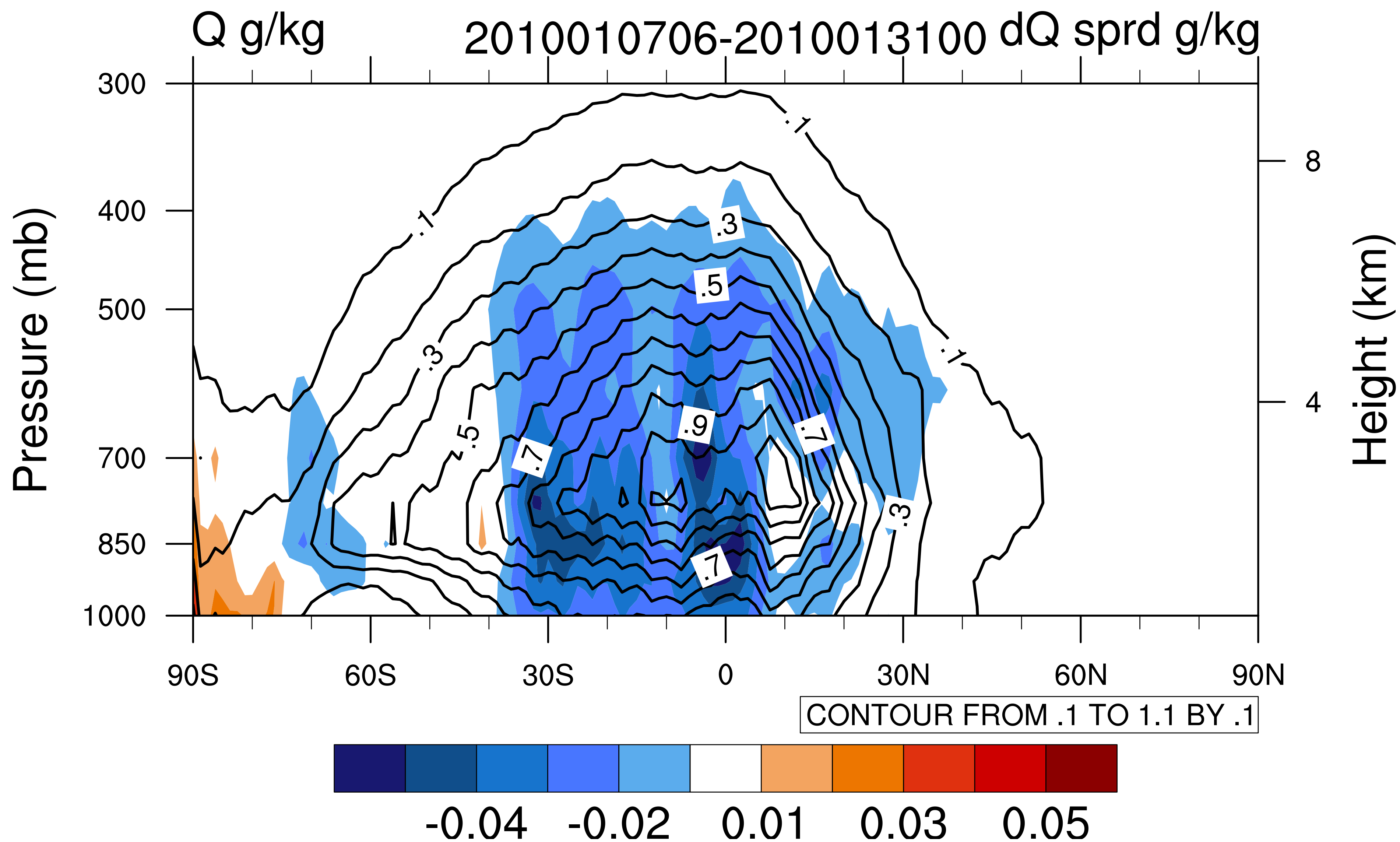
Reduction of *Q700* analysis ensemble spread



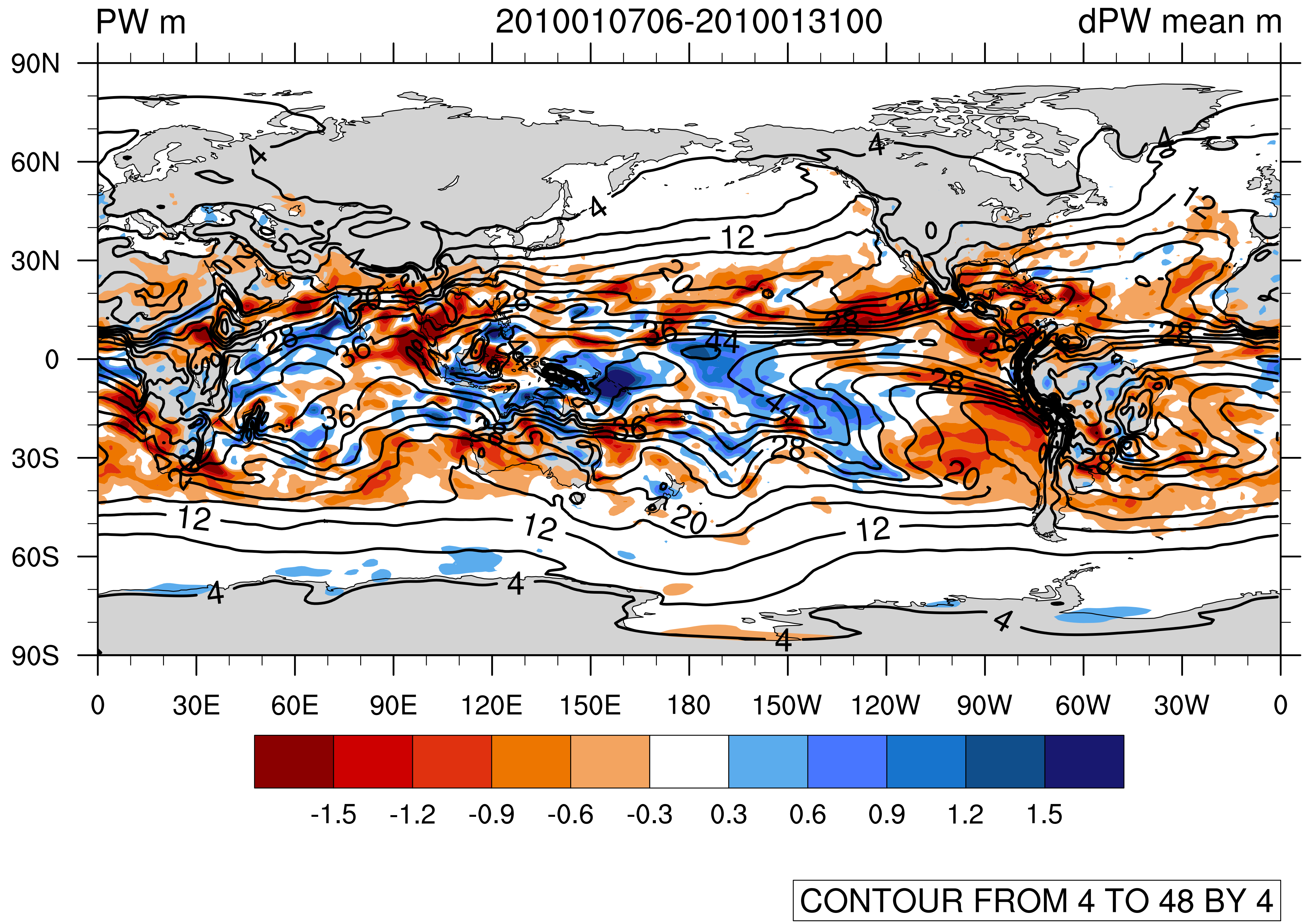
Impact on ensemble mean humidity



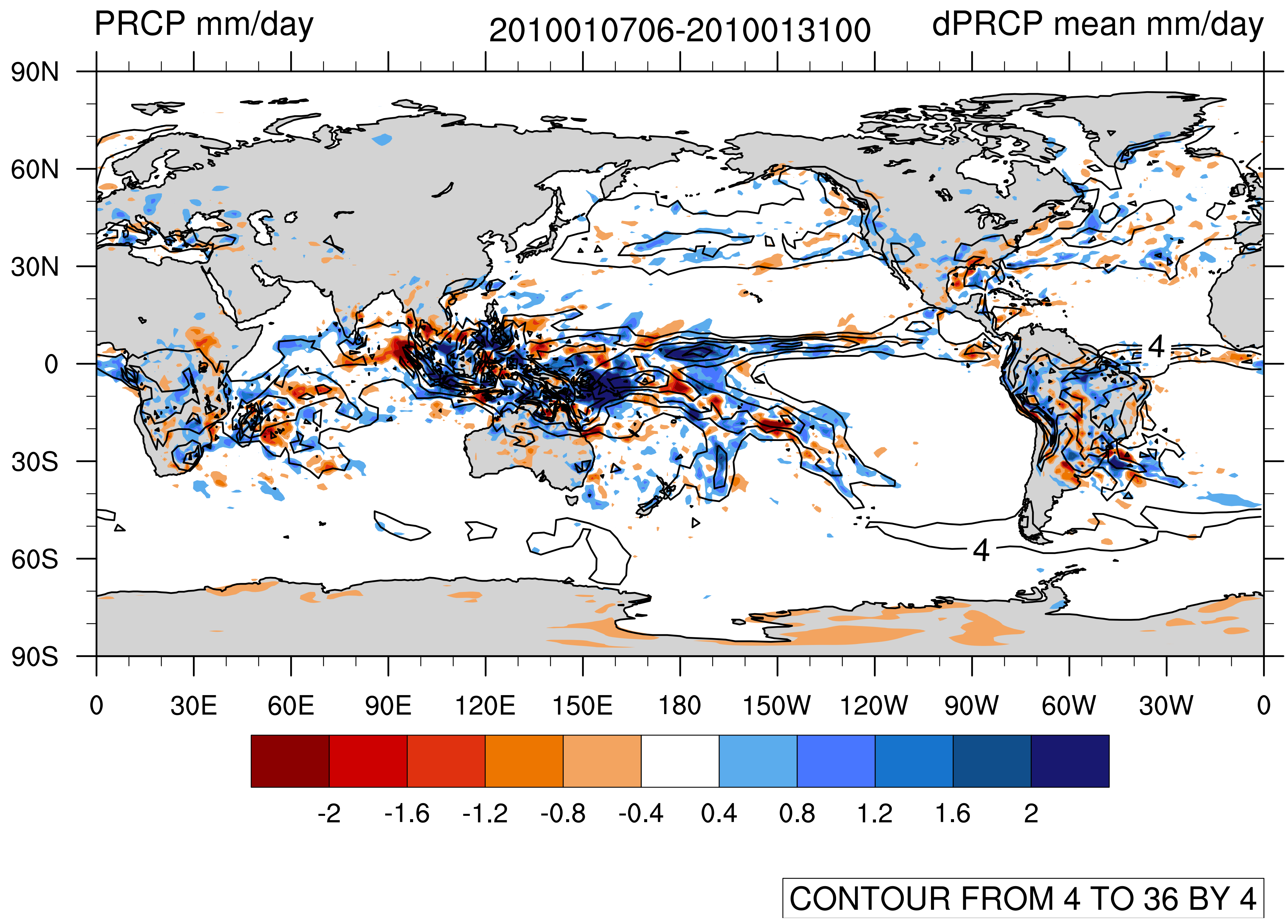
Reduction in *Q* analysis ensemble spread



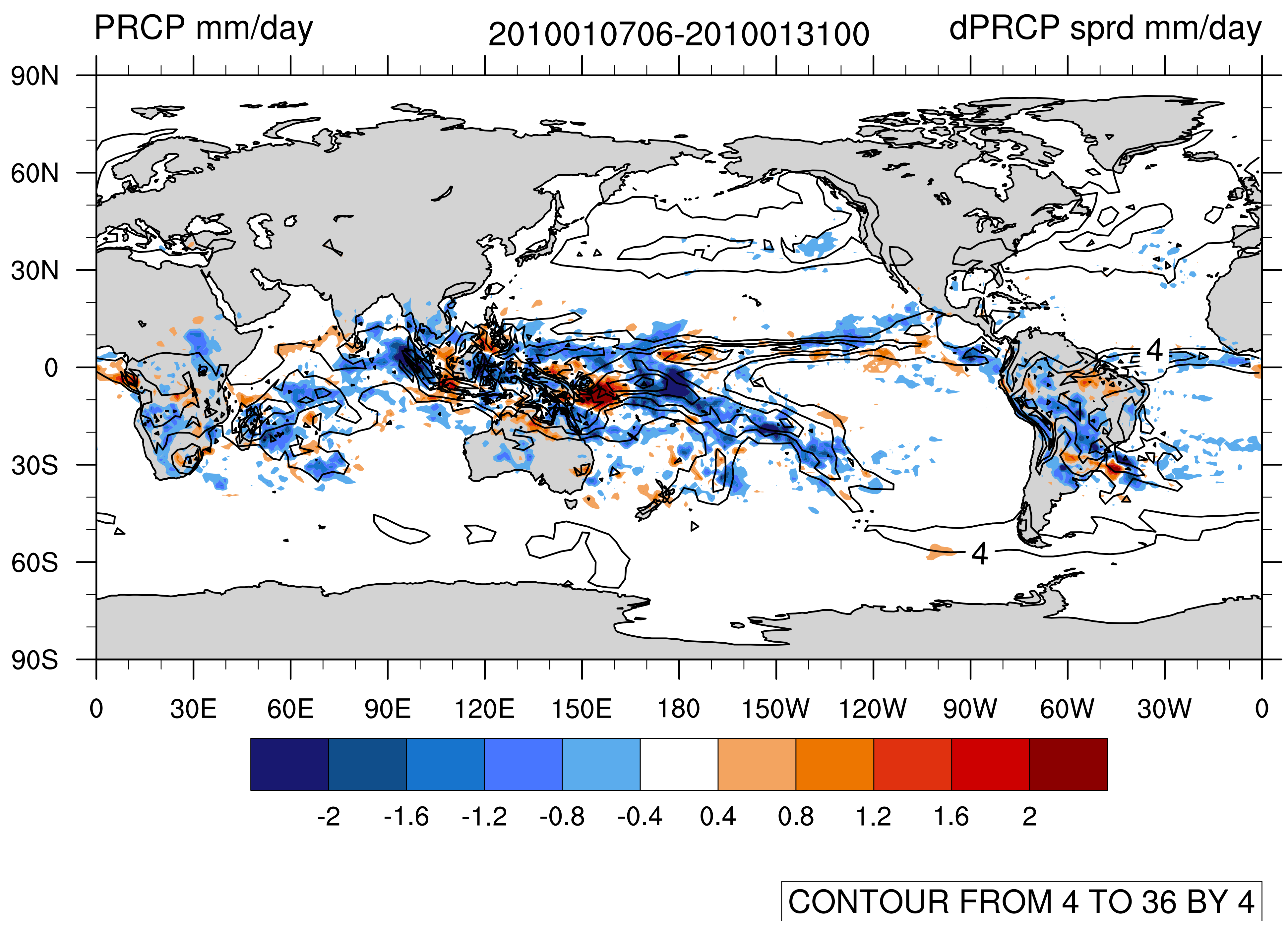
Impact on precipitable water



Impact on precipitation

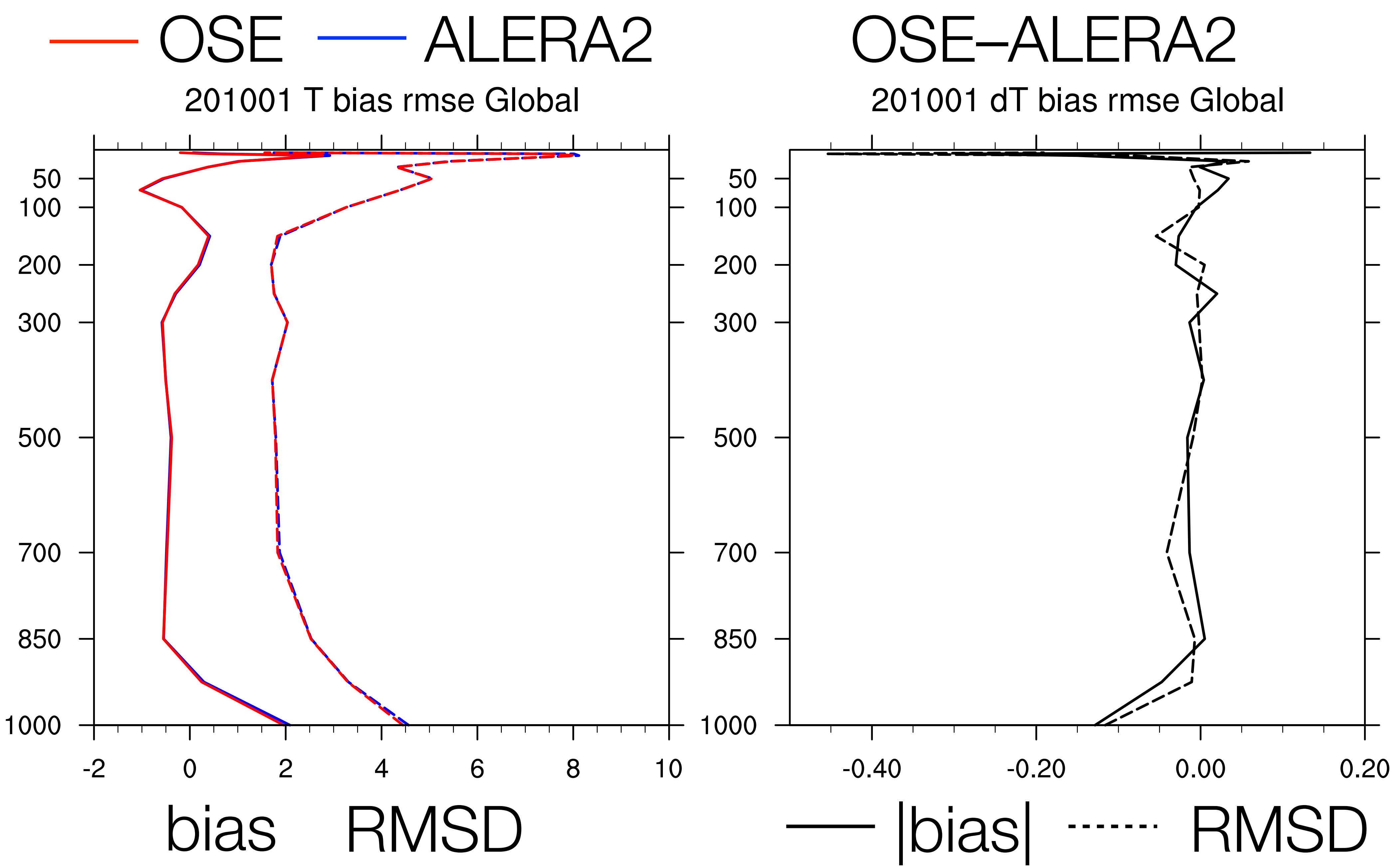


Reduction of precipitation ensemble spread

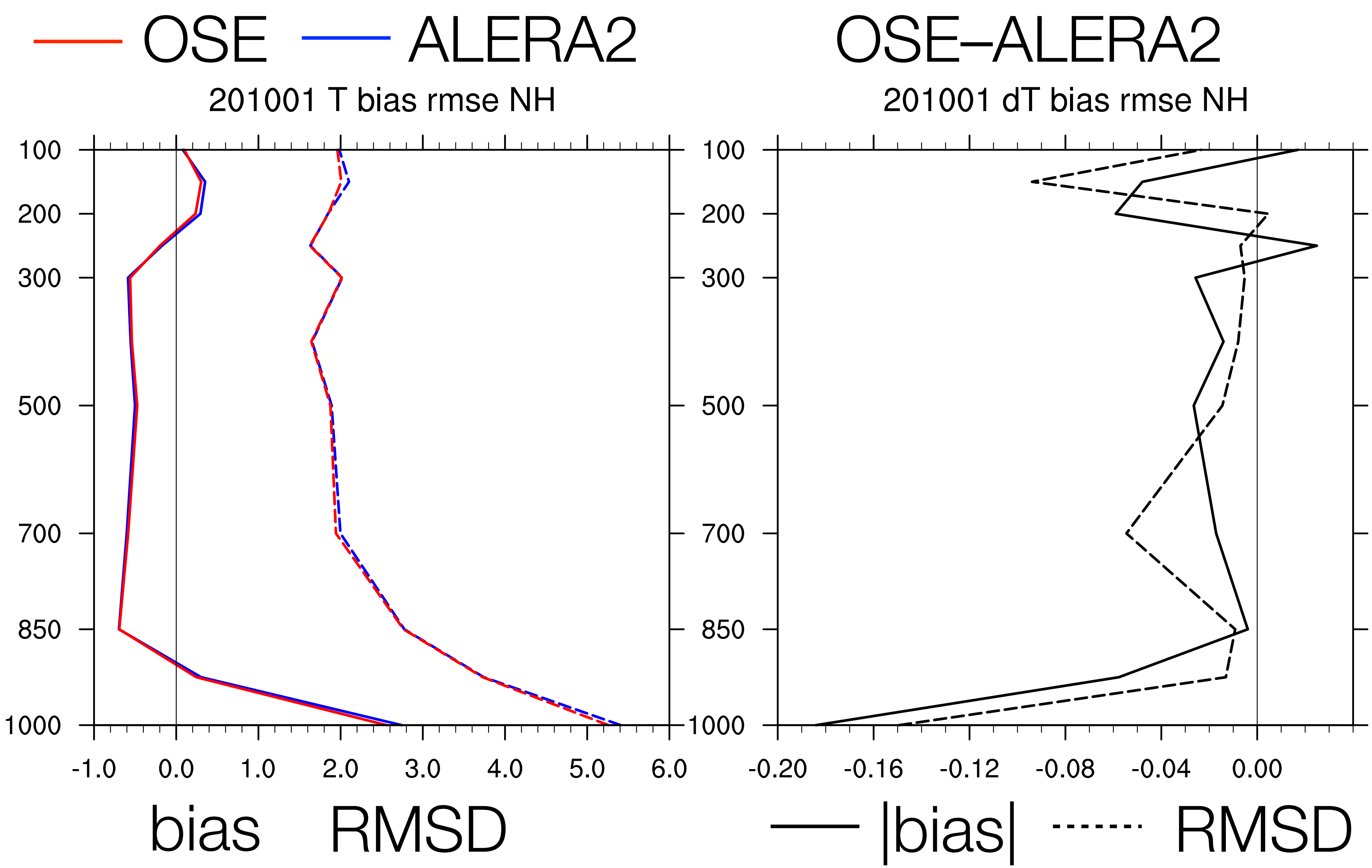


Verification agains radio-sondes

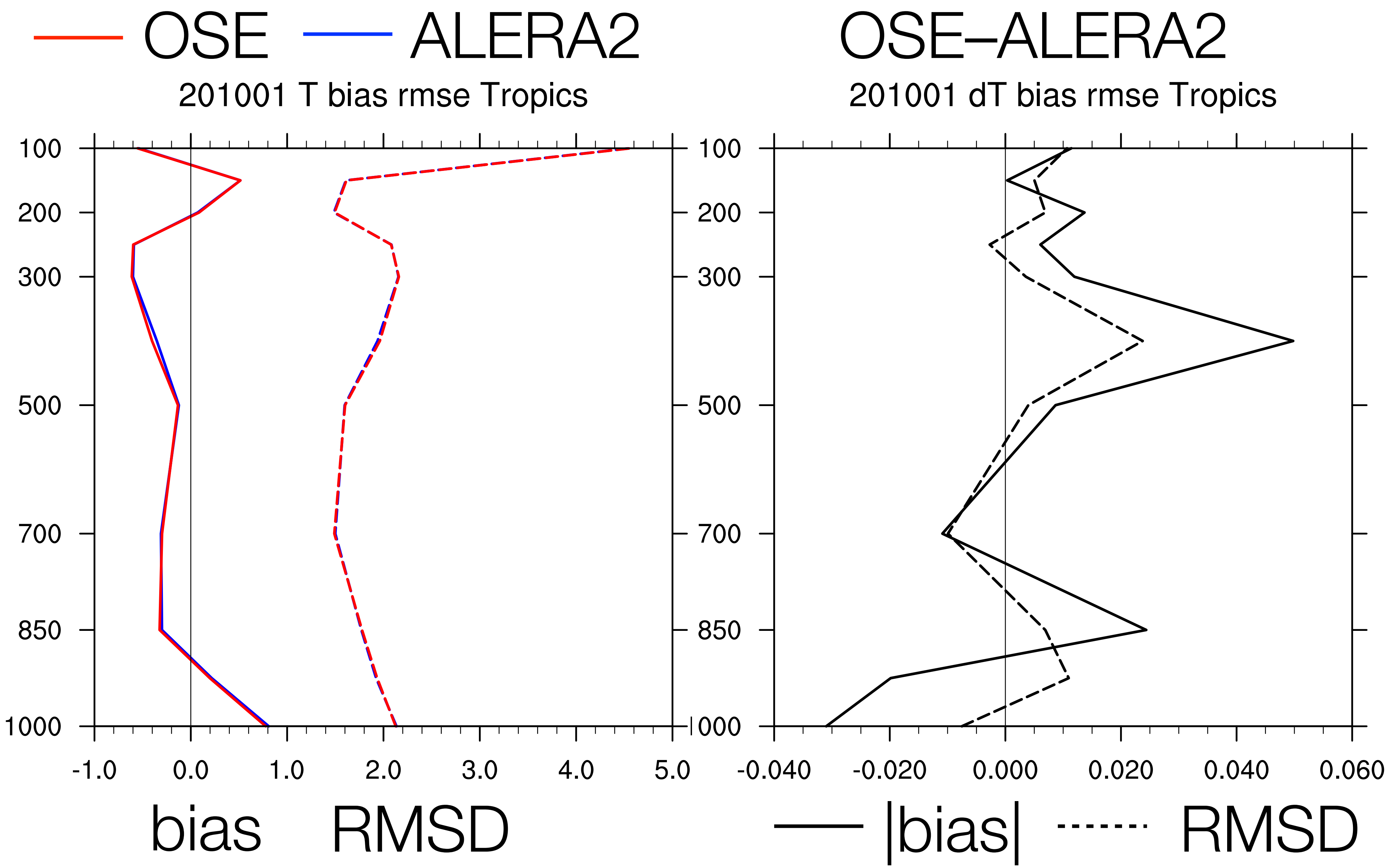
Comparison against radio sondes (global T)



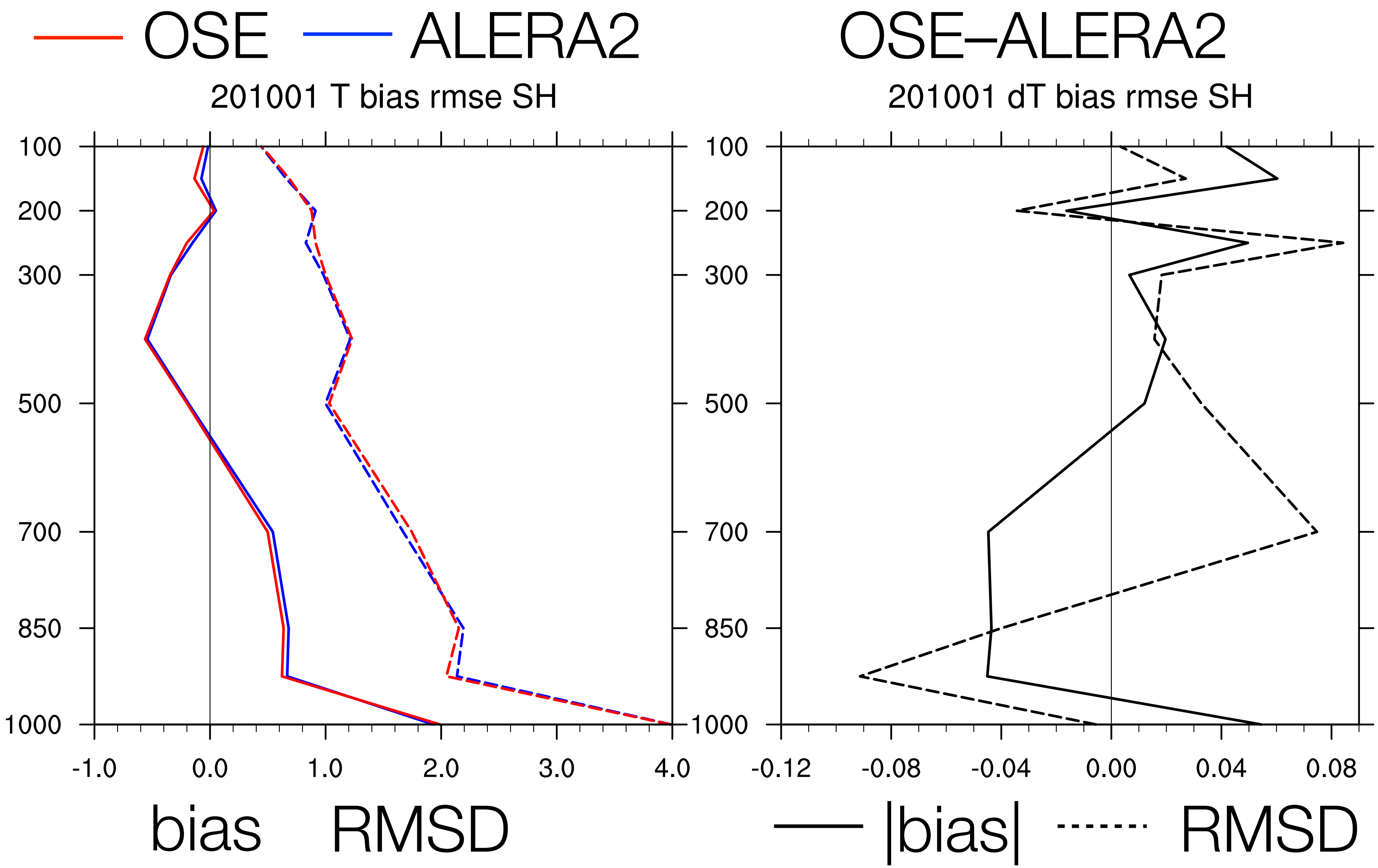
Comparison against radio sondes (NH T)



Comparison against radio sondes (tropical T)

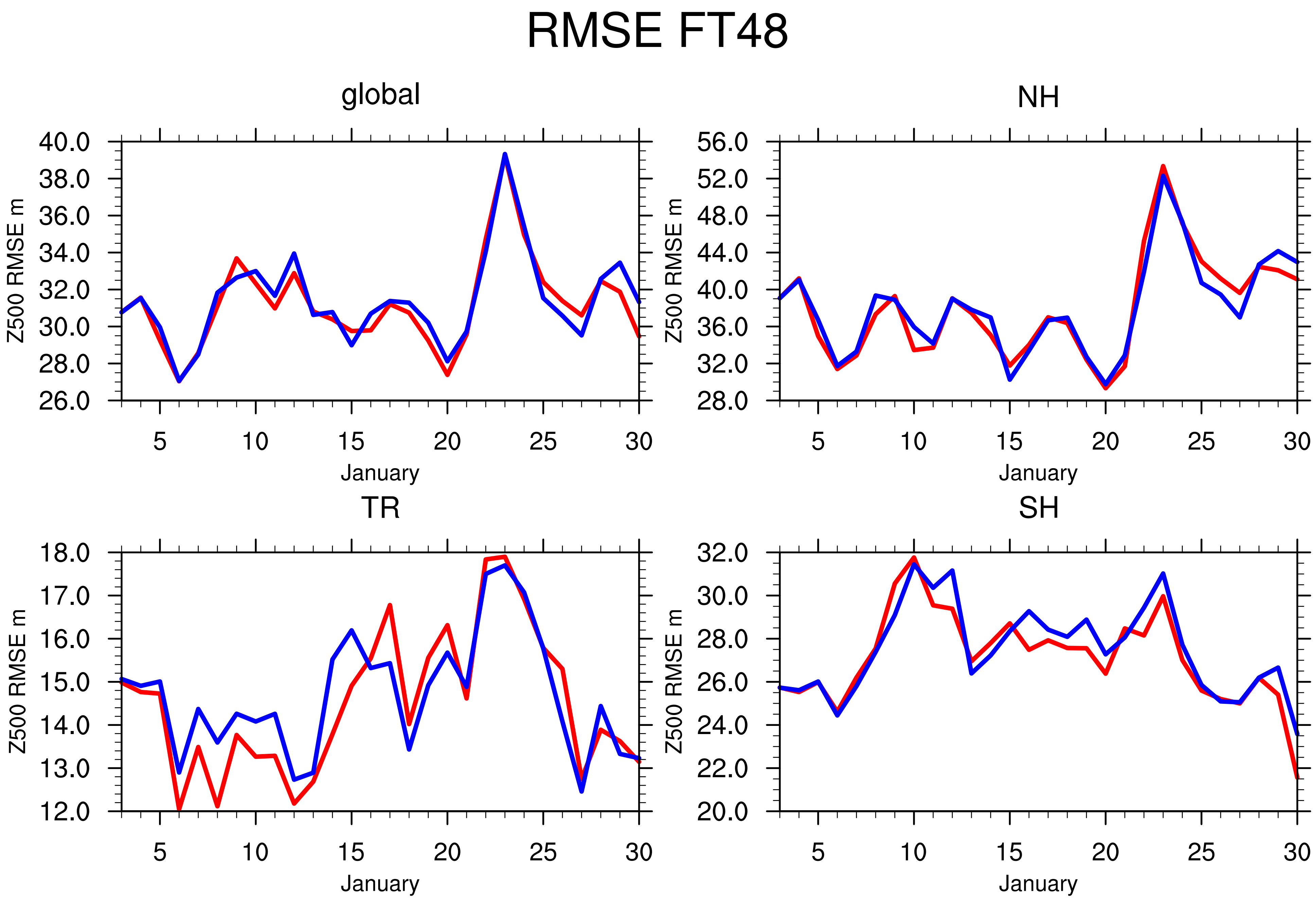


Comparison against radio sondes (SH T)

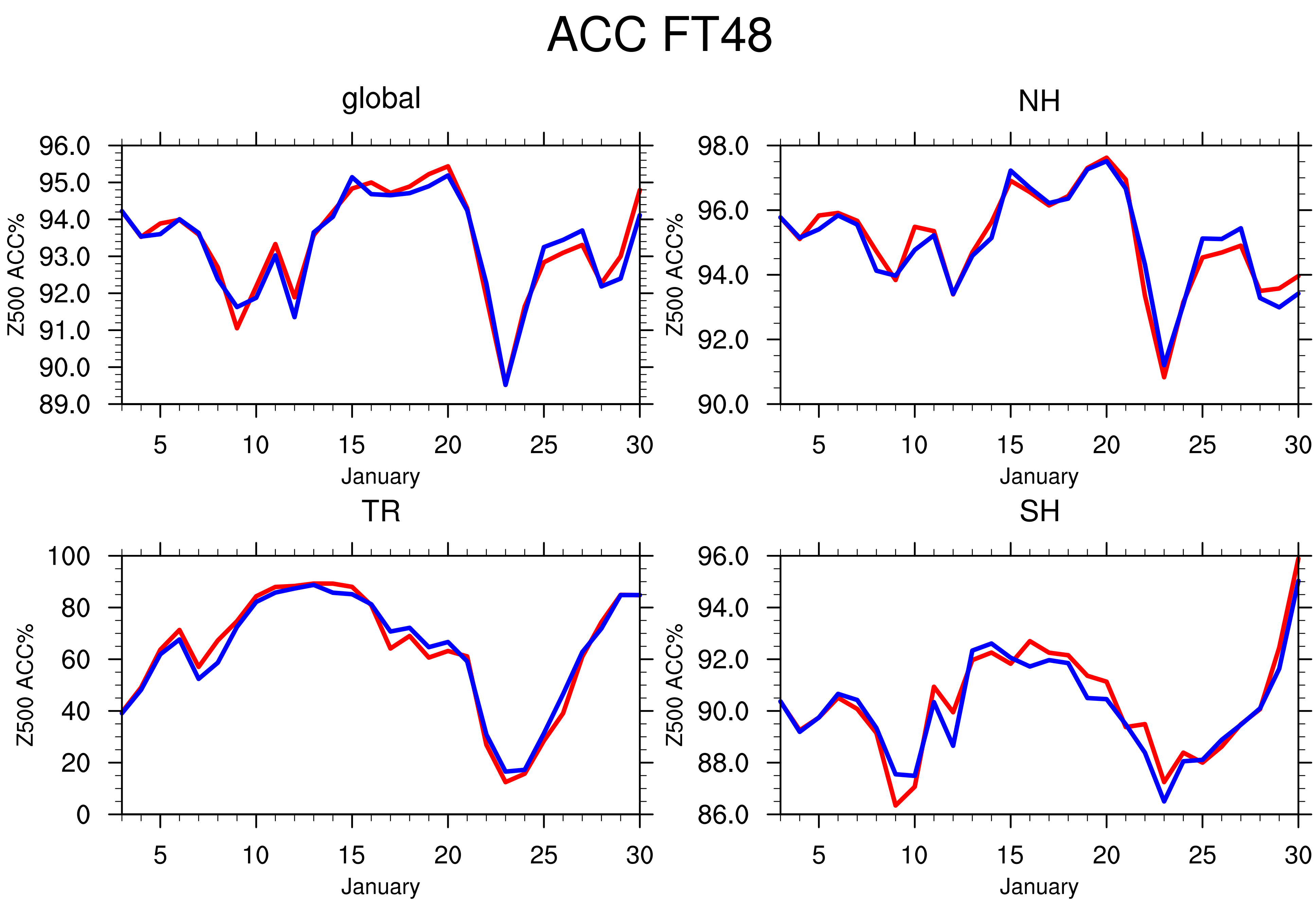


Forecast verification against JRA-55

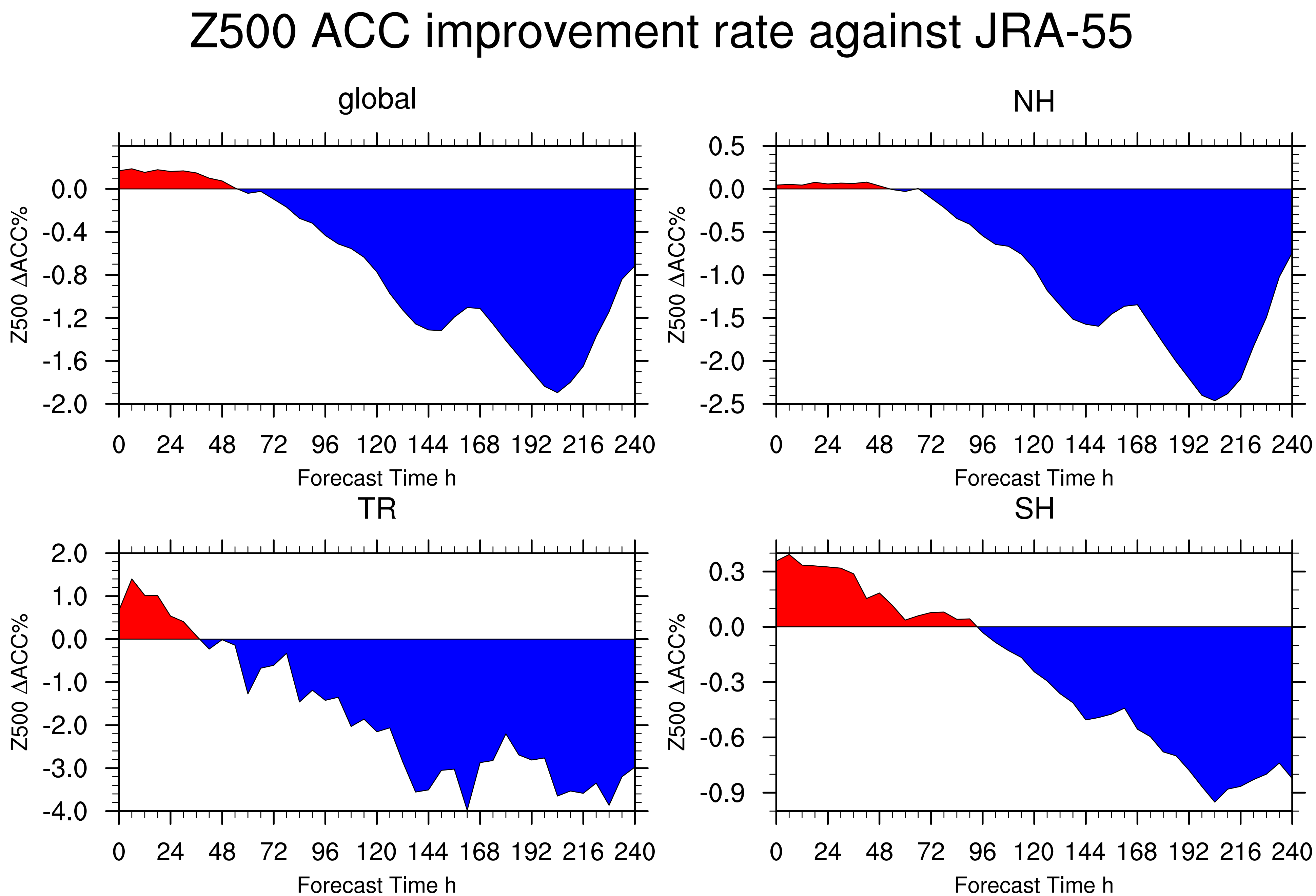
Forecast verification against JRA-55



Forecast verification against JRA-55



Forecast verification against JRA-55



Summary

- Bright band heights can be used as 0 C observations.
- Warmer tropospheric middle troposphere
  with smaller analysis ensemble spread
- Improved guess implied from analysis increment
- Reduced bias against ERA-Interim
- Room for improvement of AFES implied by forecast verification