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Optimizing ADM-Aeolus' vertical sampling for the stratosphere

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Overview

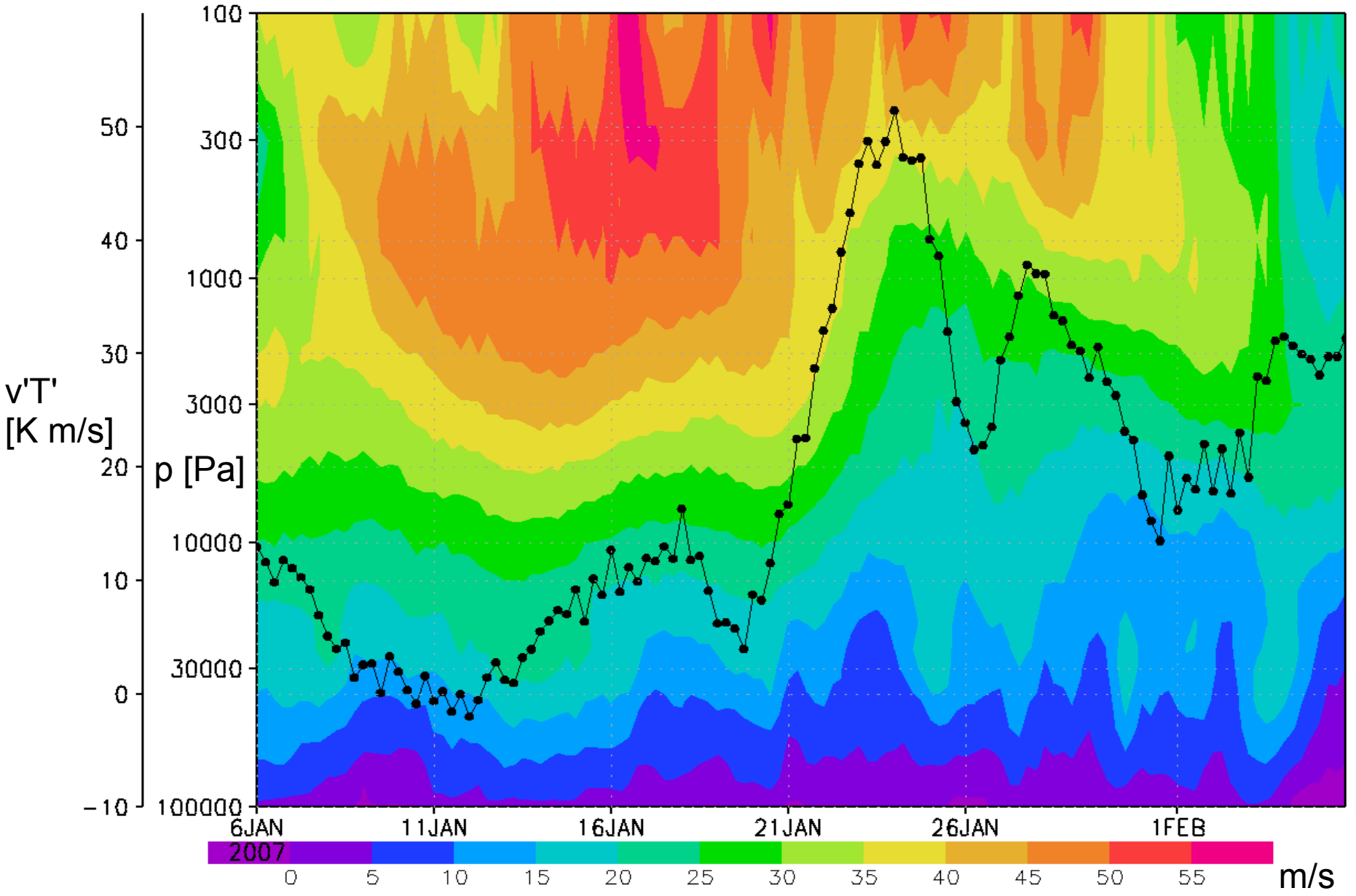
- Vertical sampling for ADM-Aeolus
- Ensemble Data Assimilation (EnDA) as an OSSE-alternative
- Setup of ECMWF ifs
- Results:
  - Impact: radiosondes vs. ADM-Aeolus
  - Impact for different vertical sampling scenarios
- Summary

Atmospheric Dynamics Mission

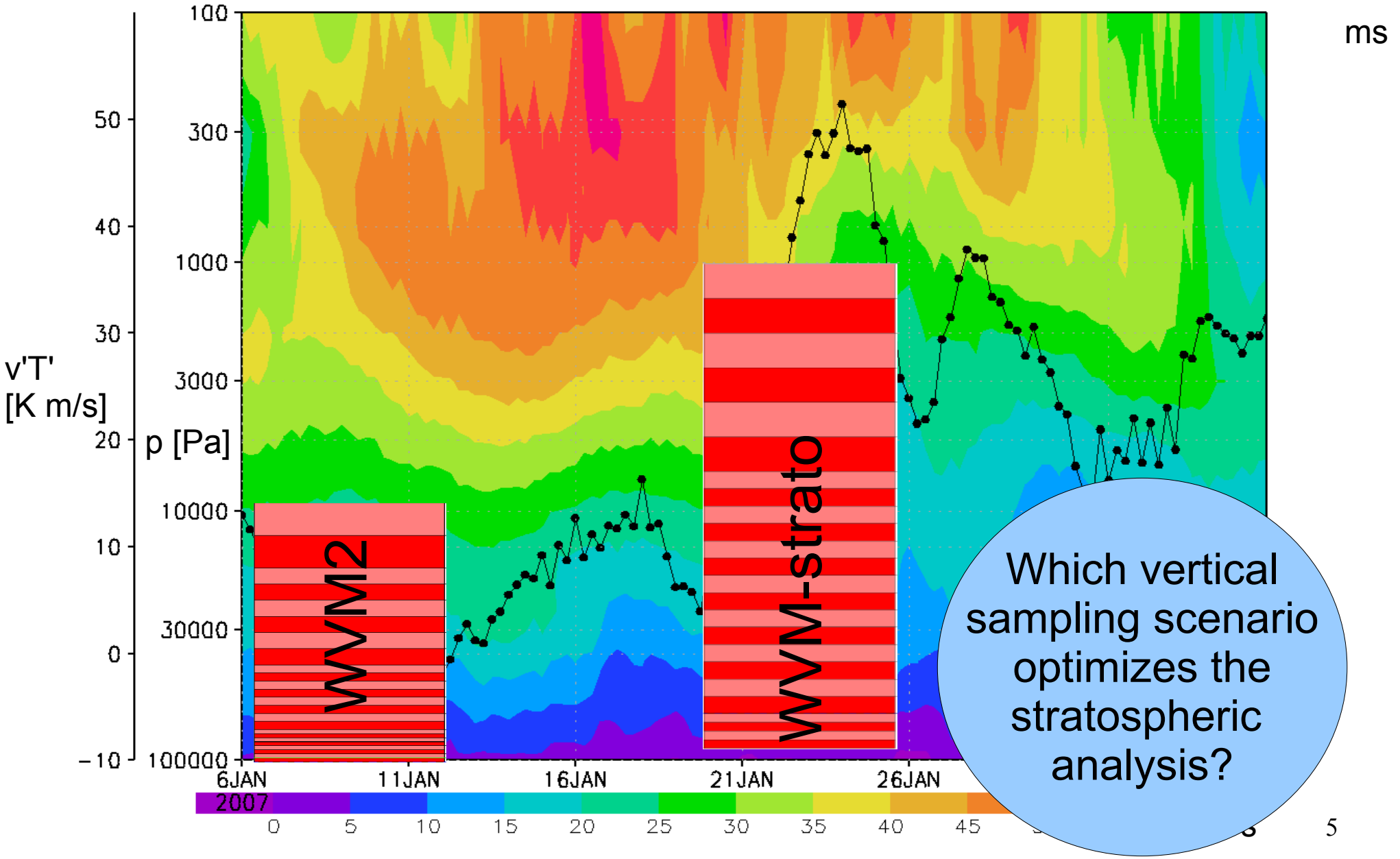
ADM - Aeolus

- Doppler Wind Lidar yields vertical profiles of the line-of-sight wind
- Flexible vertical resolution with 24 channels for Mie and Rayleigh channel
- Accuracy: 2-3 m/s
- Secondary products: aerosol and cloud properties
- Planned launch in 2012

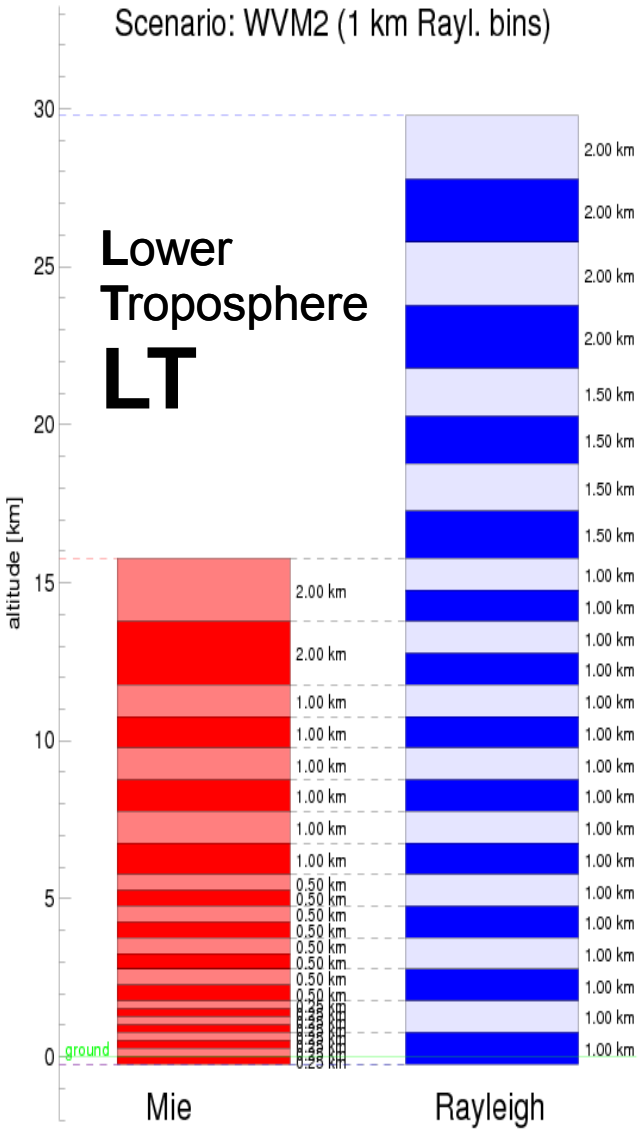
Control analysis: zonal mean zonal wind (shaded) and vertical eddy activity flux (45N-75N, 100hPa, line)

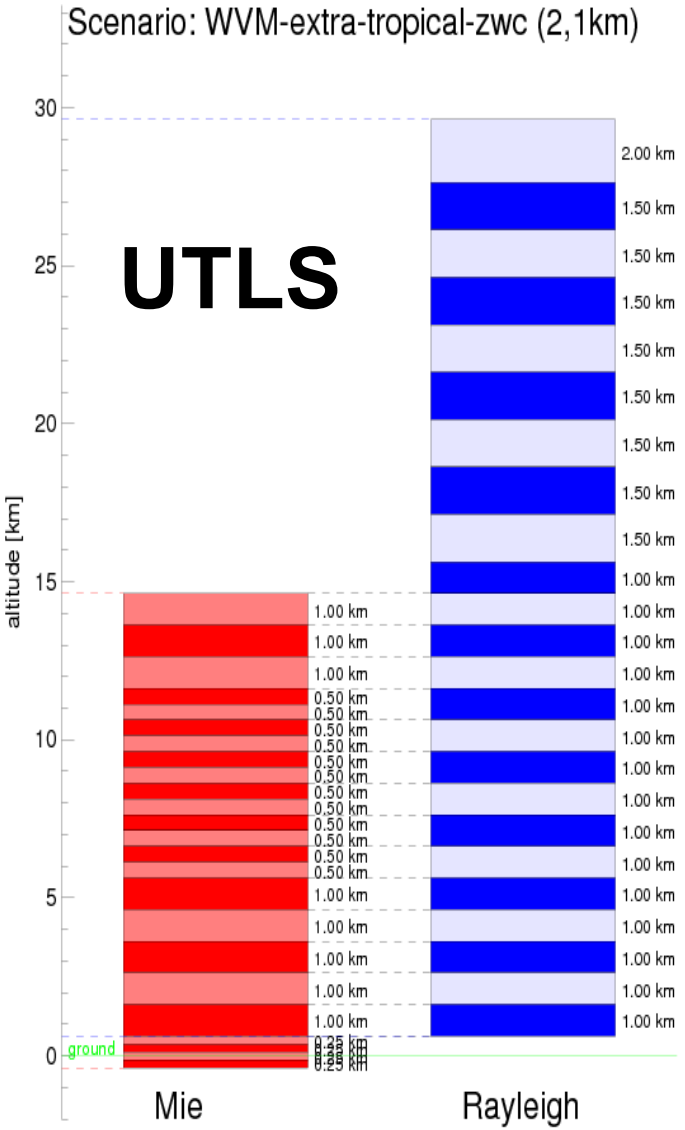


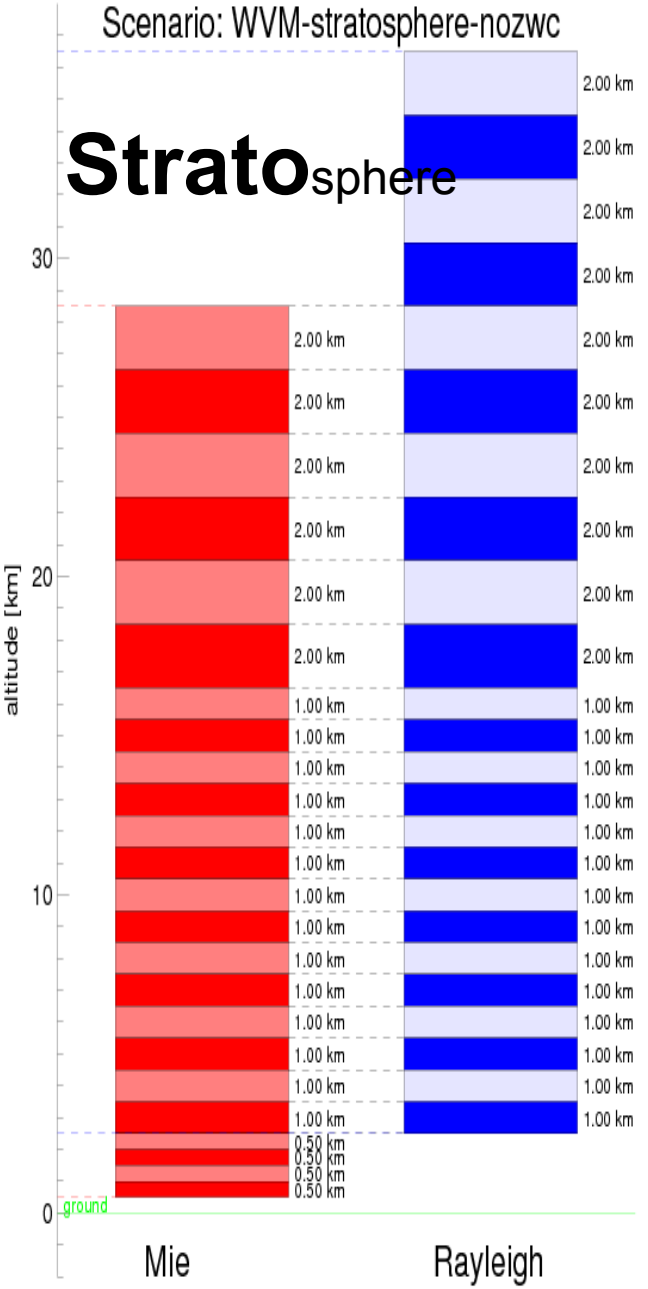
Sampling alternatives for ADM-Aeolus (Mie-channel)



Chosen sampling scenarios







Ensemble Data Assimilation (EnDA)

Analysis and its error:

$$x^a = f(x^b, y, y_{adm})$$

$$\varepsilon^a = \frac{\partial f(x^t, y^t)}{\partial x^b}\varepsilon^b + \frac{\partial f(x^t, y^t)}{\partial y}(\varepsilon^o + \varepsilon^o_{adm}) + O(\varepsilon^2).$$

Ensemble analysis with perturbed background and observations and its error:

$$\hat{x}^a = f(x^b + \zeta, y + \eta, y_{adm} + \eta_{adm})$$

$$\hat{\varepsilon}^a = \frac{\partial f(x^t, y^t)}{\partial x^b}(\varepsilon^b + \zeta) + \frac{\partial f(x^t, y^t)}{\partial y}(\varepsilon^o + \varepsilon^o_{adm} + \eta + \eta_{adm}) + O(\varepsilon^2)$$

Ensemble analysis difference:

$$\delta\hat{x}^a = \frac{\partial f(x^t, y^t)}{\partial x^b}\delta\zeta + \frac{\partial f(x^t, y^t)}{\partial y}(\delta\eta + \delta\eta_{adm}) + O(\varepsilon^2).$$

After Zagar et al. (QJRMS 2005)

Ensemble Data Assimilation (EnDA)

Analysis and its error:

$$x^a = f(x^b, y, y_{adm})$$

$$\varepsilon^a = \frac{\partial f(x^t, y^t)}{\partial x^b}\varepsilon^b + \frac{\partial f(x^t, y^t)}{\partial y}(\varepsilon^o + \varepsilon^o_{adm}) + O(\varepsilon^2).$$

Ensemble analysis difference:

$$\delta\hat{x}^a = \frac{\partial f(x^t, y^t)}{\partial x^b}\delta\zeta + \frac{\partial f(x^t, y^t)}{\partial y}(\delta\eta + \delta\eta_{adm}) + O(\varepsilon^2).$$

- Choose $\delta\zeta$ and $\delta\eta$ according to ε^b and ε^o Then the Ensemble analysis differences is an estimate for the analysis error.

- Similar: Ensemble forecast spread is an Estimate for the forecast error.

After Zagar et al. (QJRMS 2005)

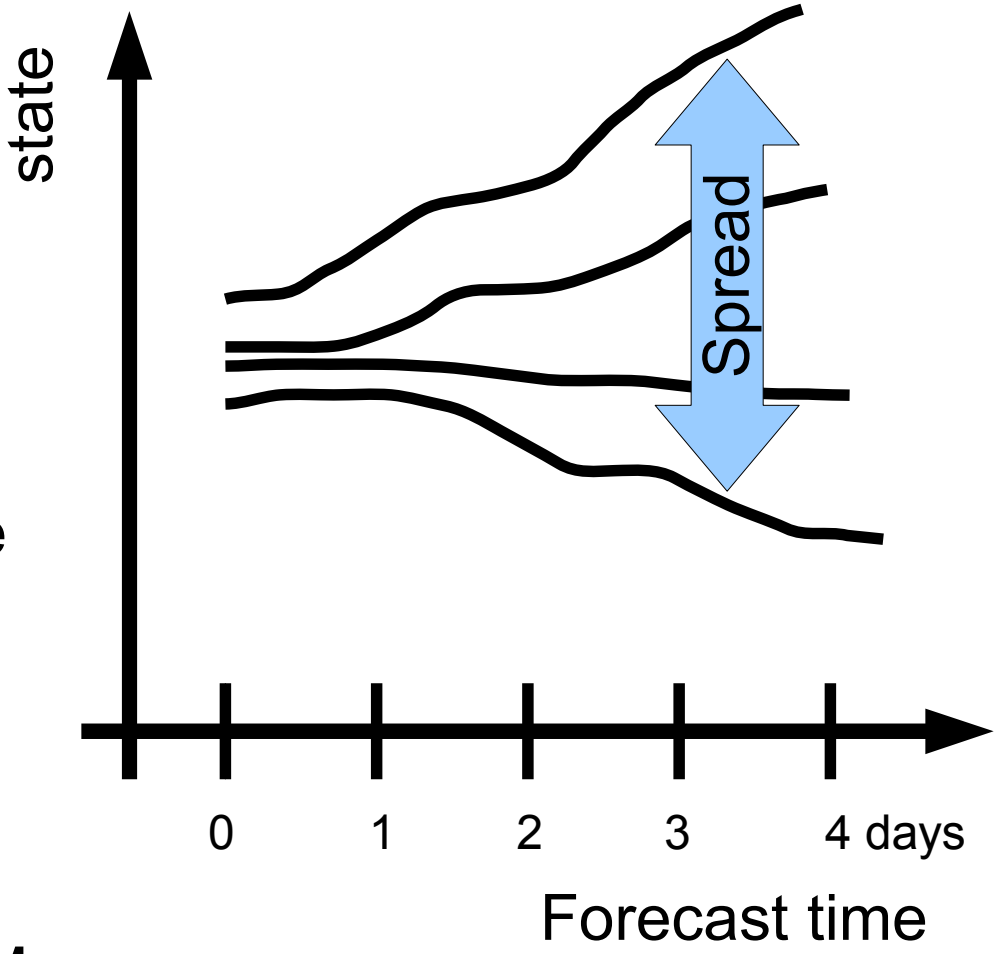
Setup and experiments

- Ifs model cy35r2, Resolution: T399, 91 levels
- Dates: 2007-01-01 to 2007-01-31

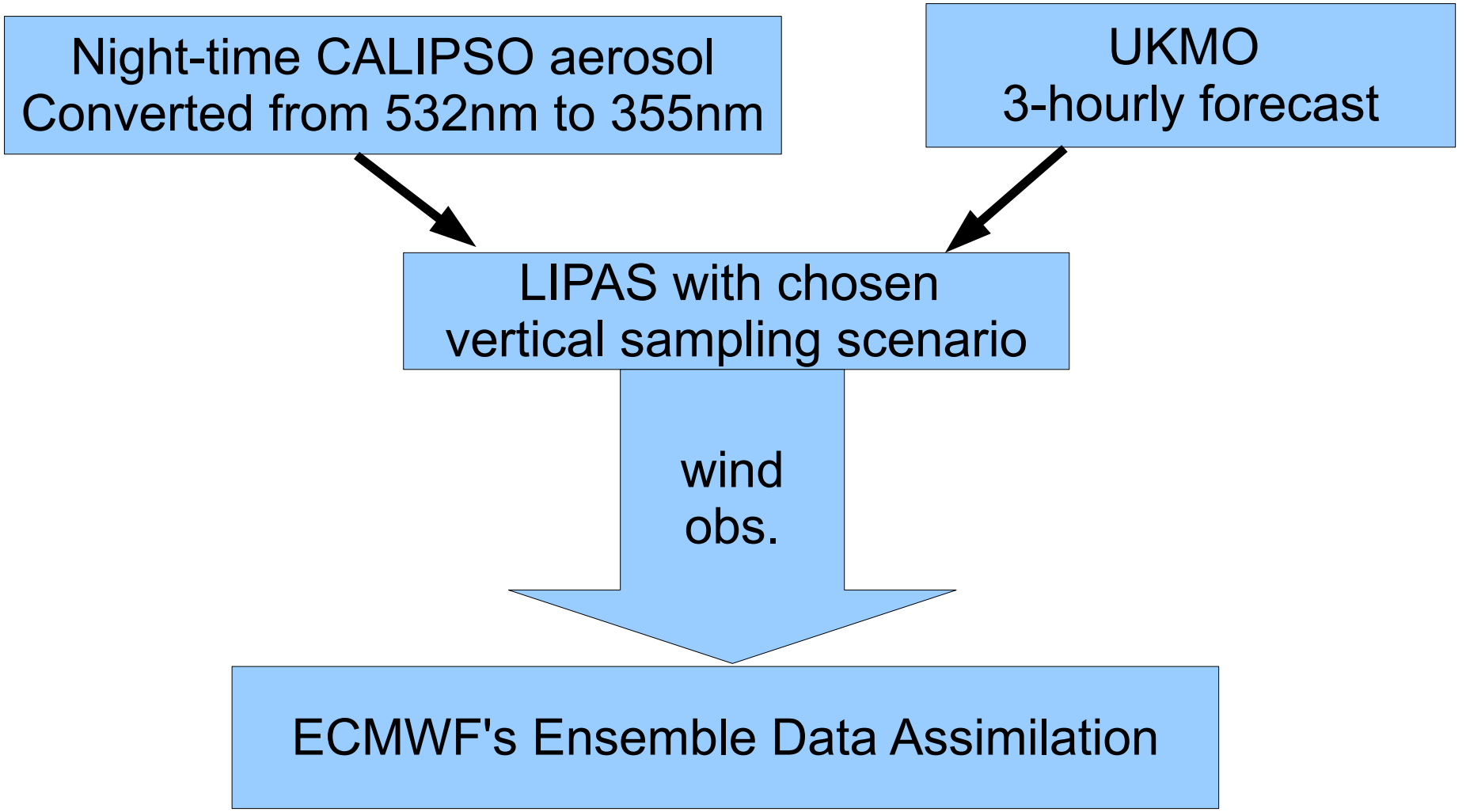
Ensemble Data Assimilation with perturbed observations:

- **Control**
- **NoSondes**: no radiosonde observations included
- **ADM-LT with wvm2**: ADM, more Mie in lower troposphere
- **ADM-UTLS with et_zwc2**: ADM, more Mie in UT/LS
- **ADM-strato with wvm-stratosphere-nozwc**: future ADM, with higher stratospheric obs.

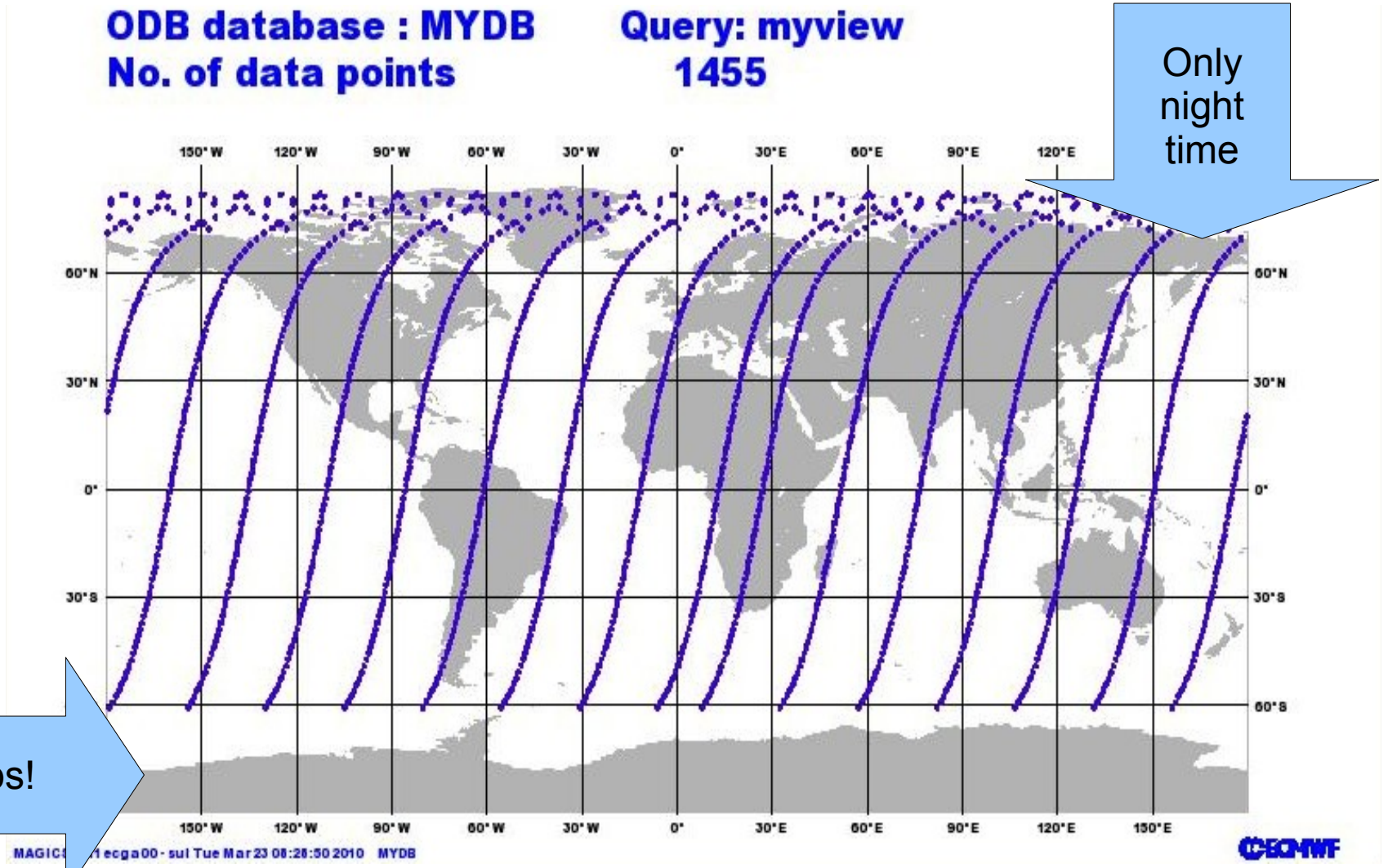
Ensemble forecast



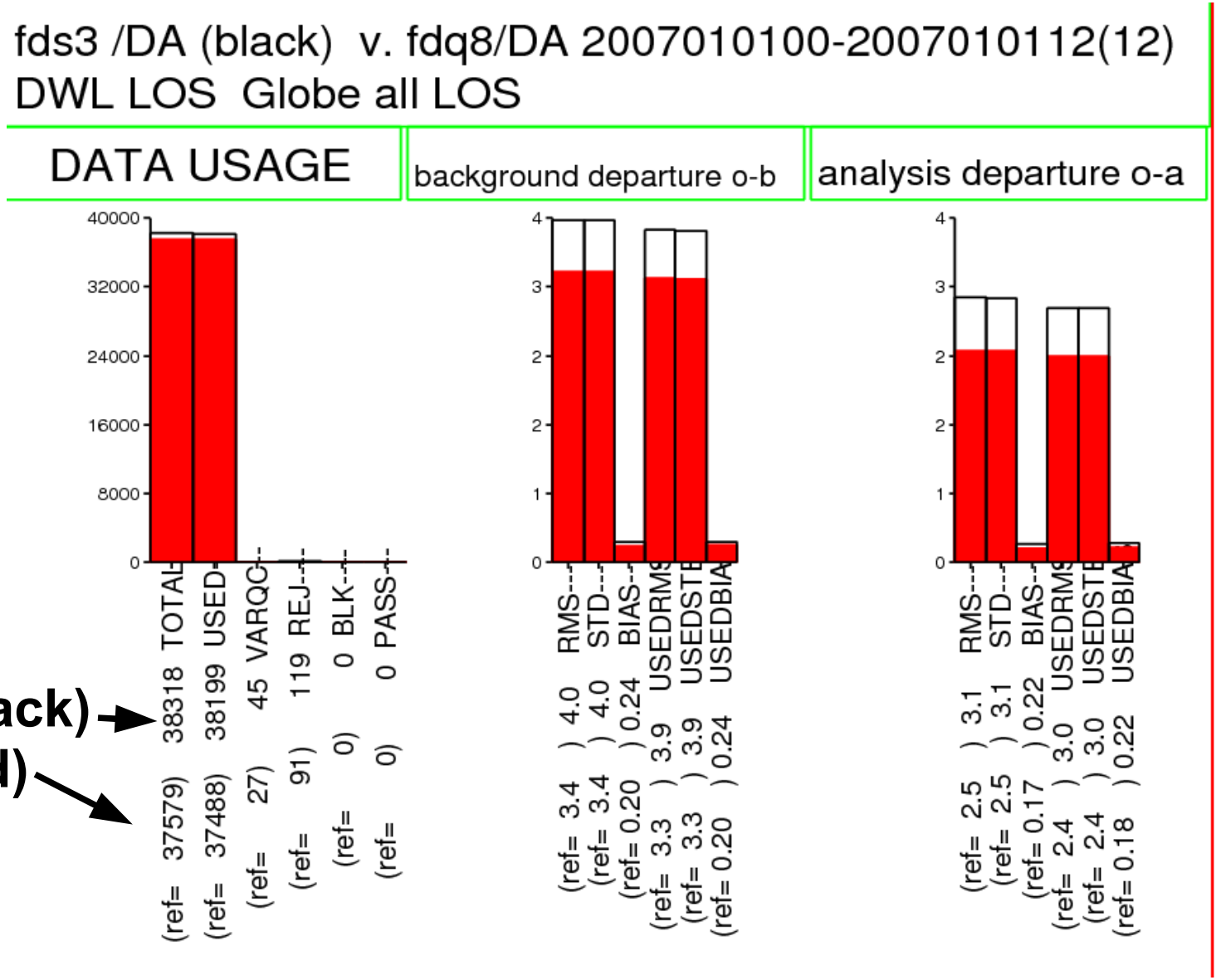
Artificial ADM-observations



Simulated ADM obs for one day



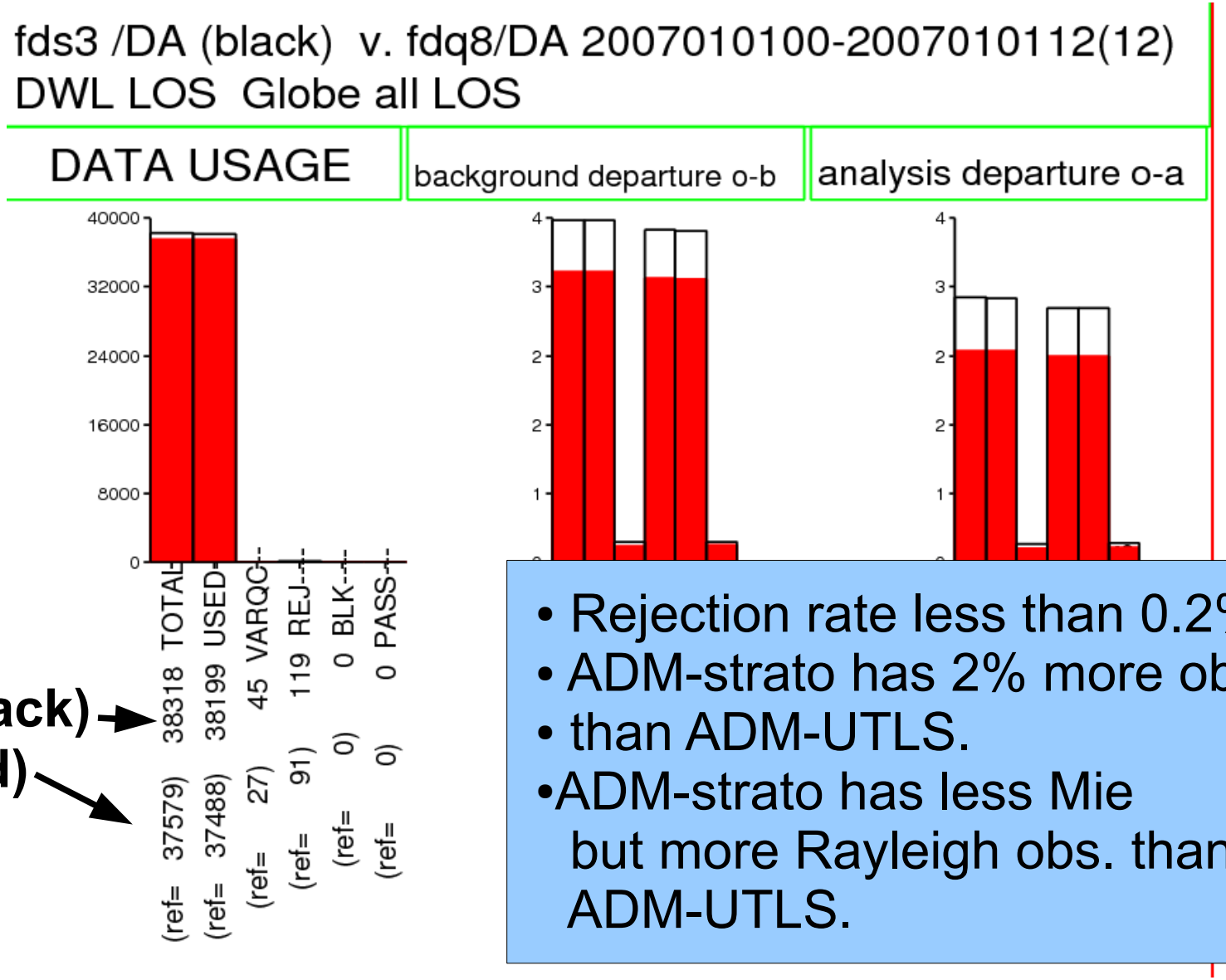
Observation statistics



ADM-strato (black)

ADM-UTLS (red)

Observation statistics

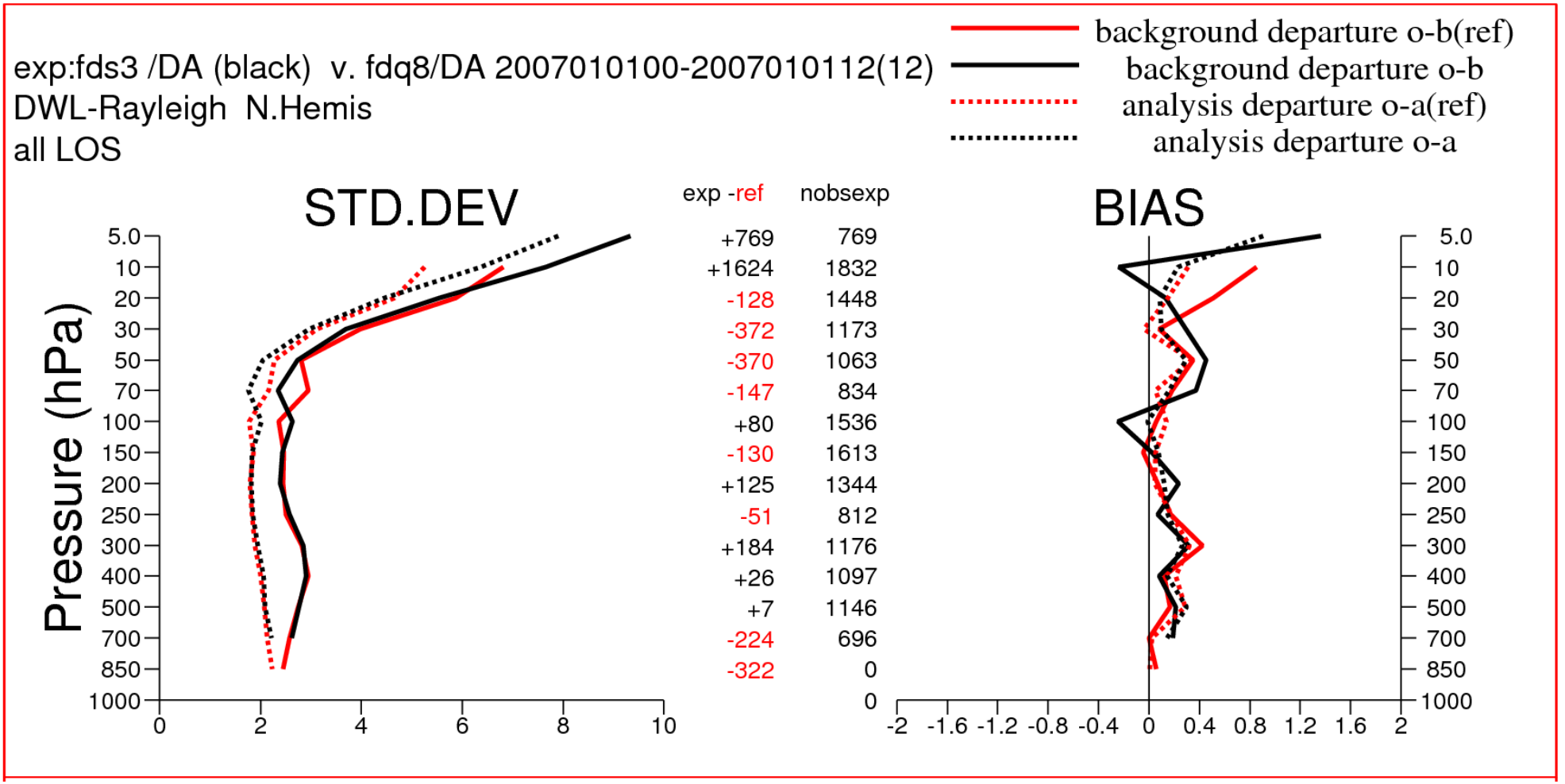


ADM-strato (black)

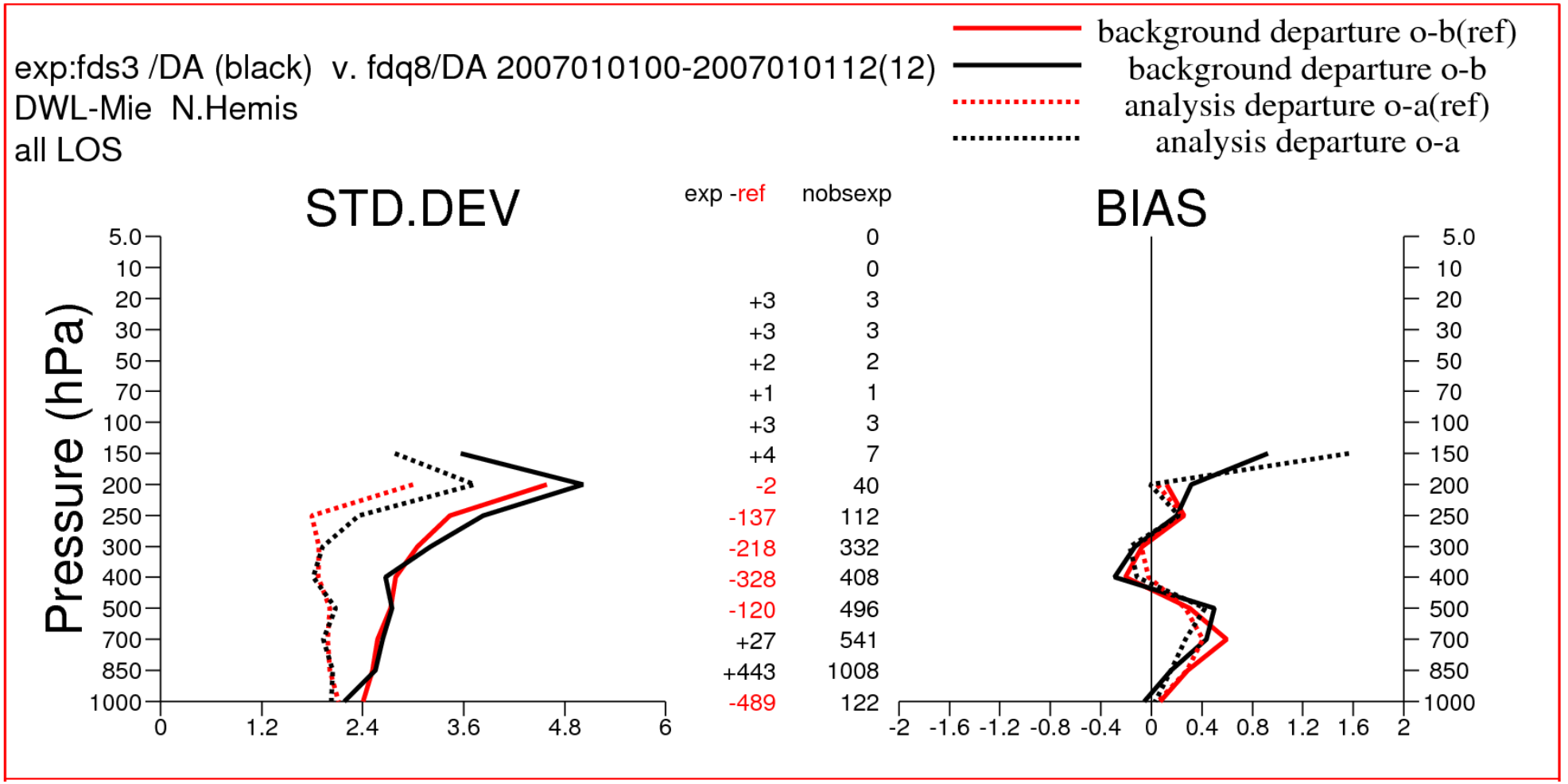
ADM-UTLS (red)

- Rejection rate less than 0.2%.
- ADM-strato has 2% more obs.
- than ADM-UTLS.
- ADM-strato has less Mie but more Rayleigh obs. than ADM-UTLS.

Rayleigh-obstat NH
ADM-UTLS (red) and ADM-strato (black)



Mie-obstat NH:
ADM-UTLS (red) and ADM-strato (black)



Impact estimates from EnDA

Ensemble spread $$s = \frac{1}{N_{dates}} \sum_t \sqrt{\frac{1}{N_{ens}-1} \sum_i \left(x_i - \overline{x} \right)^2}$$

with

N_dates – number of forecast dates (twice per day) = 52

N_ens – number of ensemble members (10)

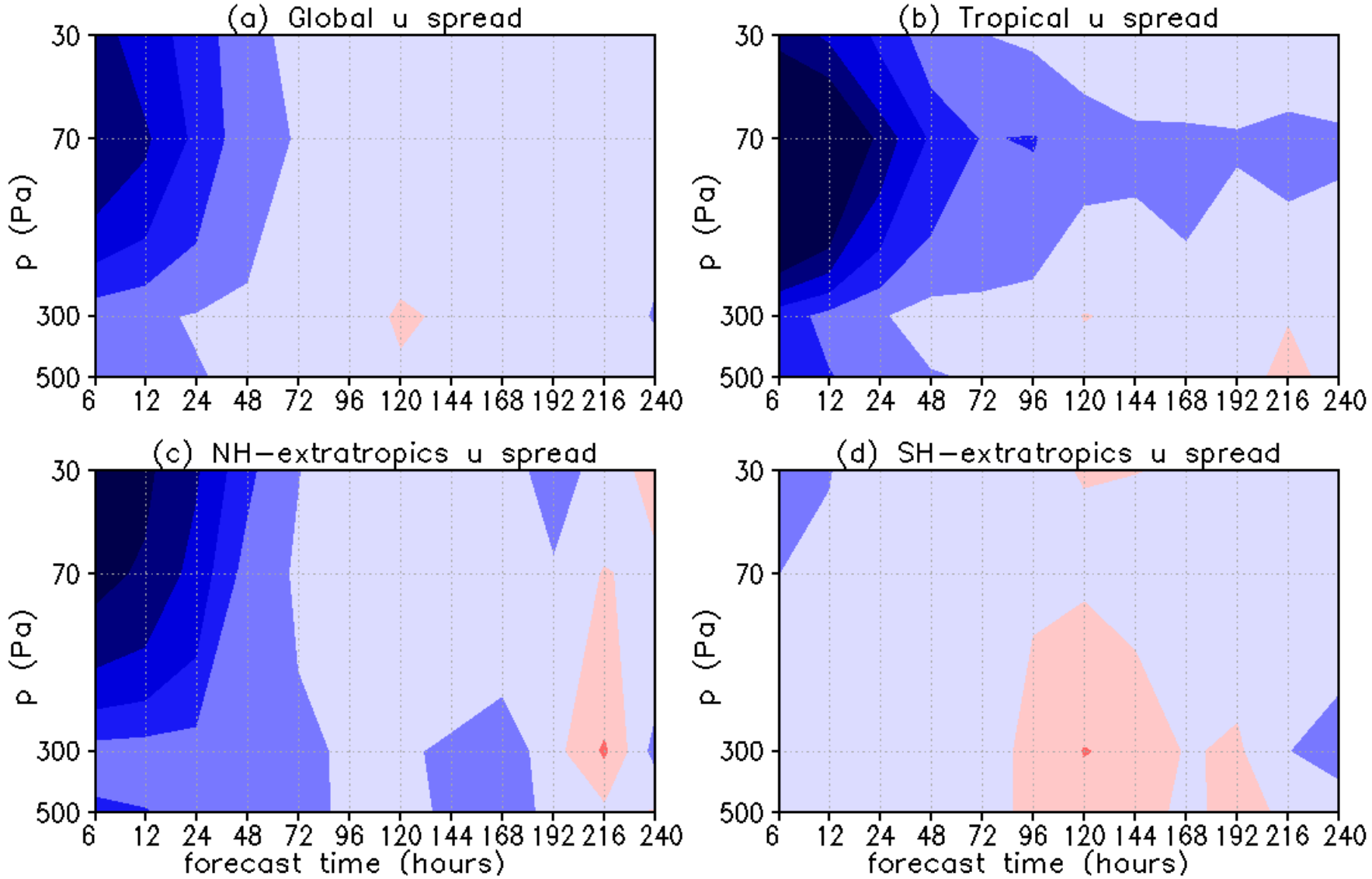
$\overline{x}$ – Ensemble mean

Estimate impact from difference of two EnDA experiments, e.g.

$$I_{Sondes} = s_{Control} - s_{NoSonde}$$

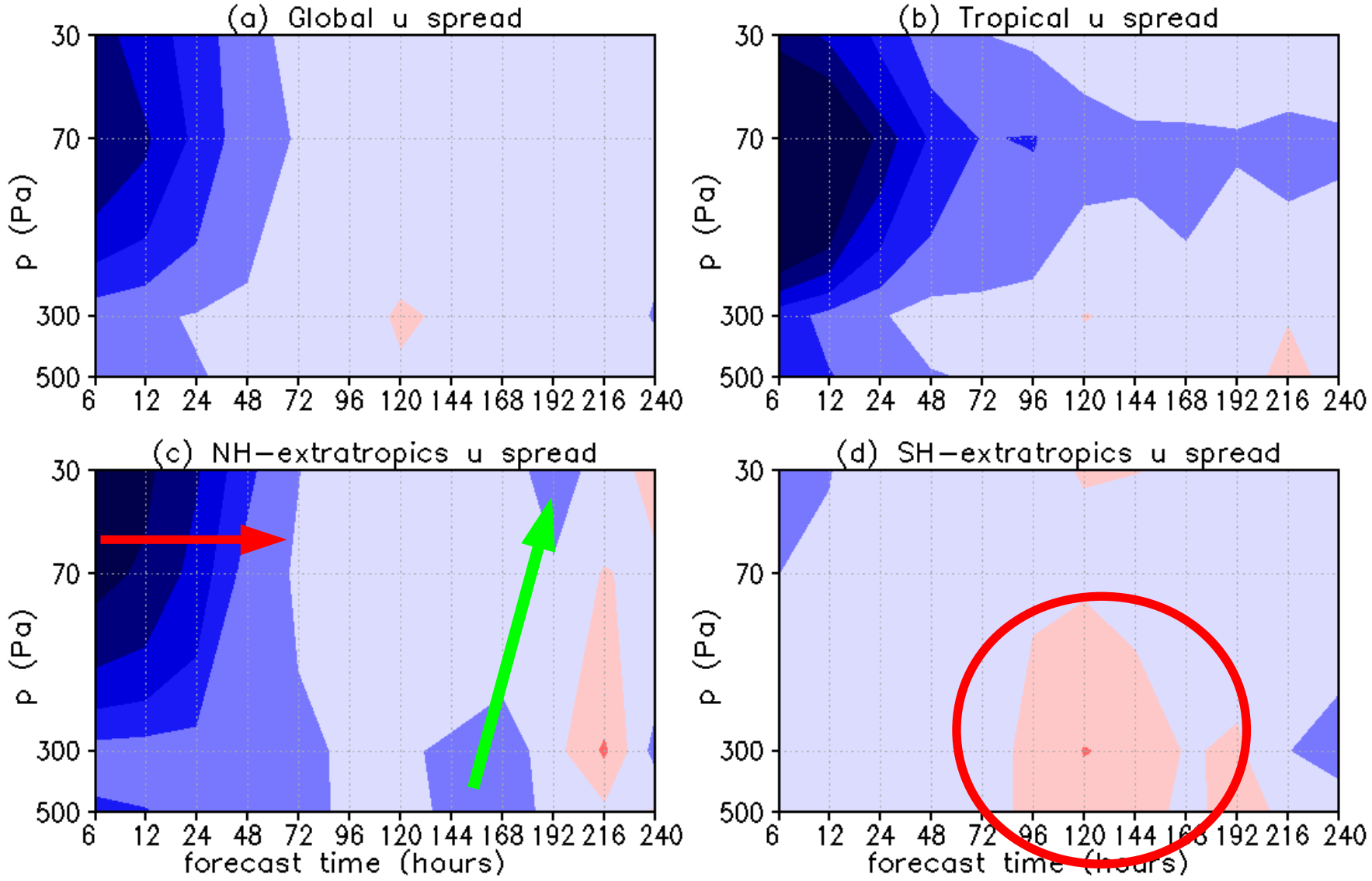
Zonal wind-impact Sondes: Control – NoSonde

averages over only 95%-significant points

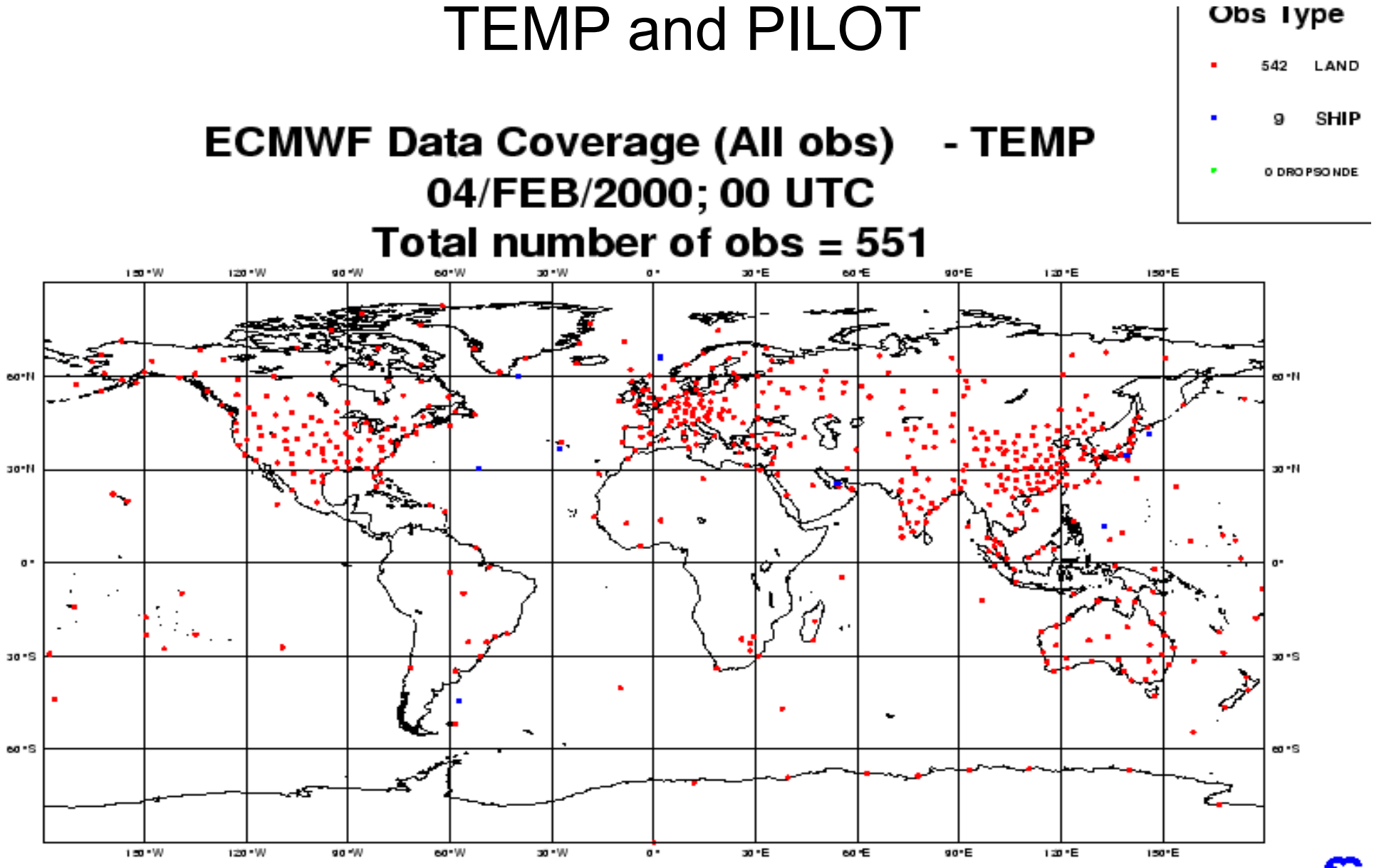


Zonal wind-impact Sondes: Control – NoSonde

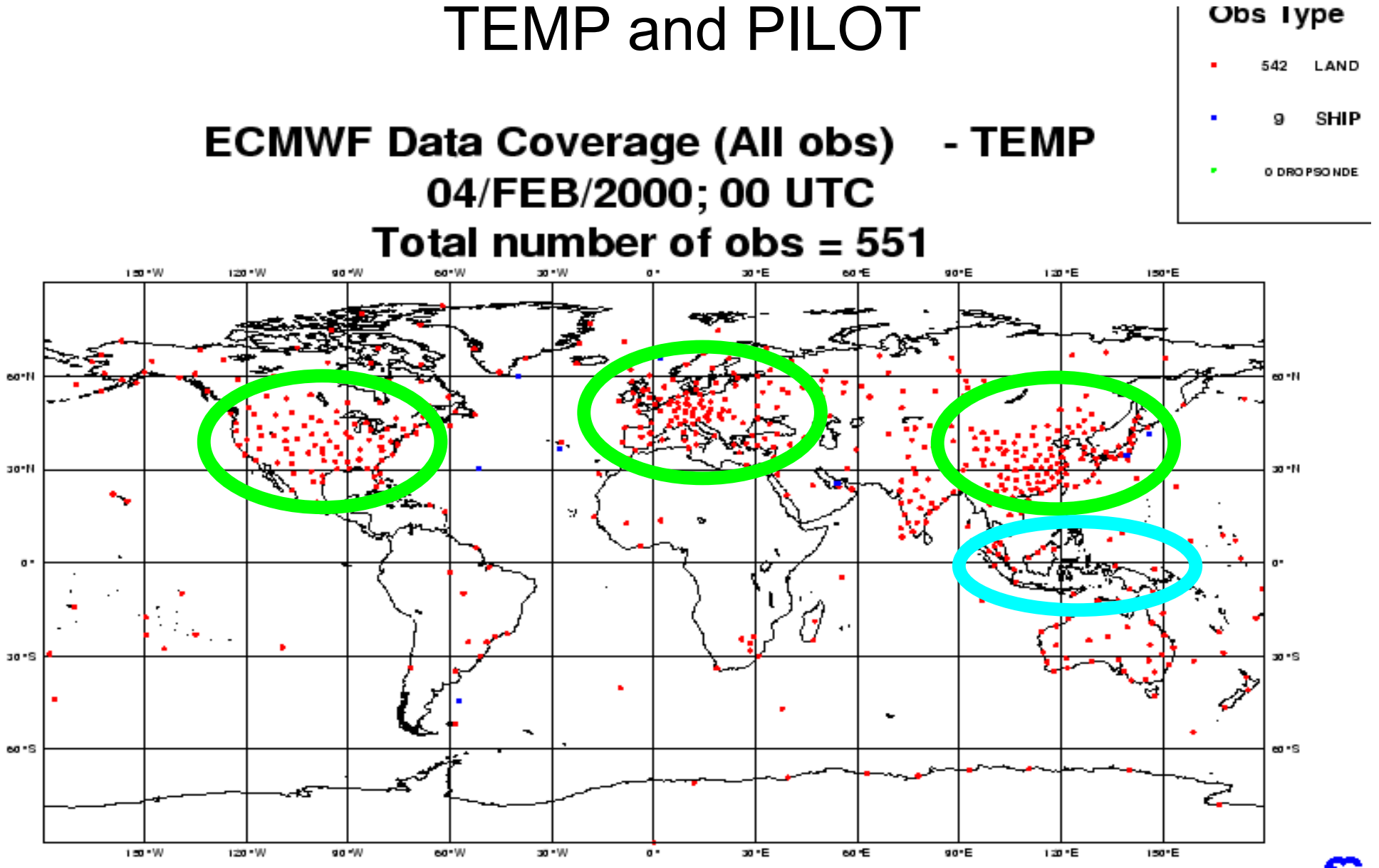
averages over only 95%-significant points



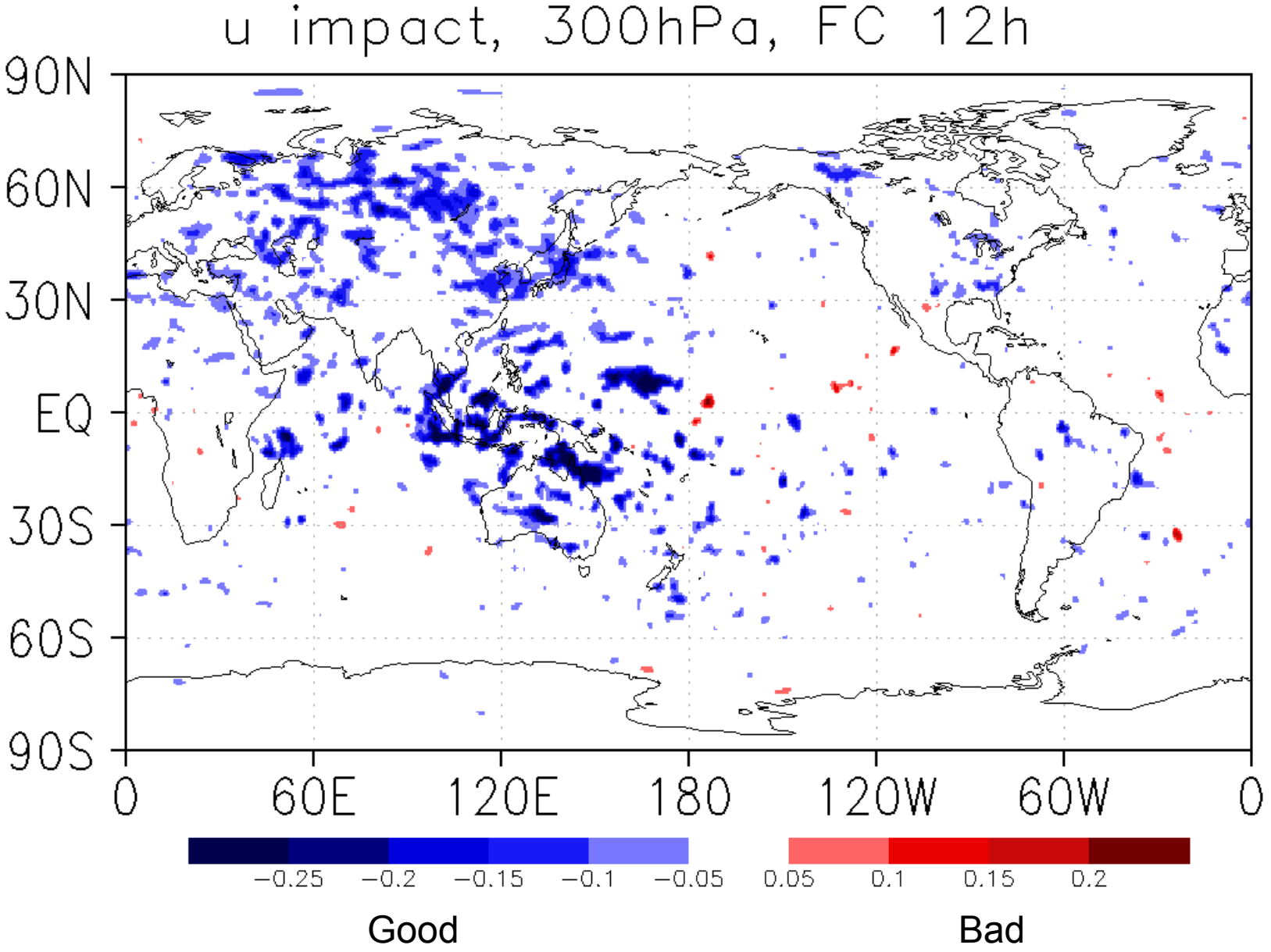
NoSonde – Control: removed observations TEMP and PILOT



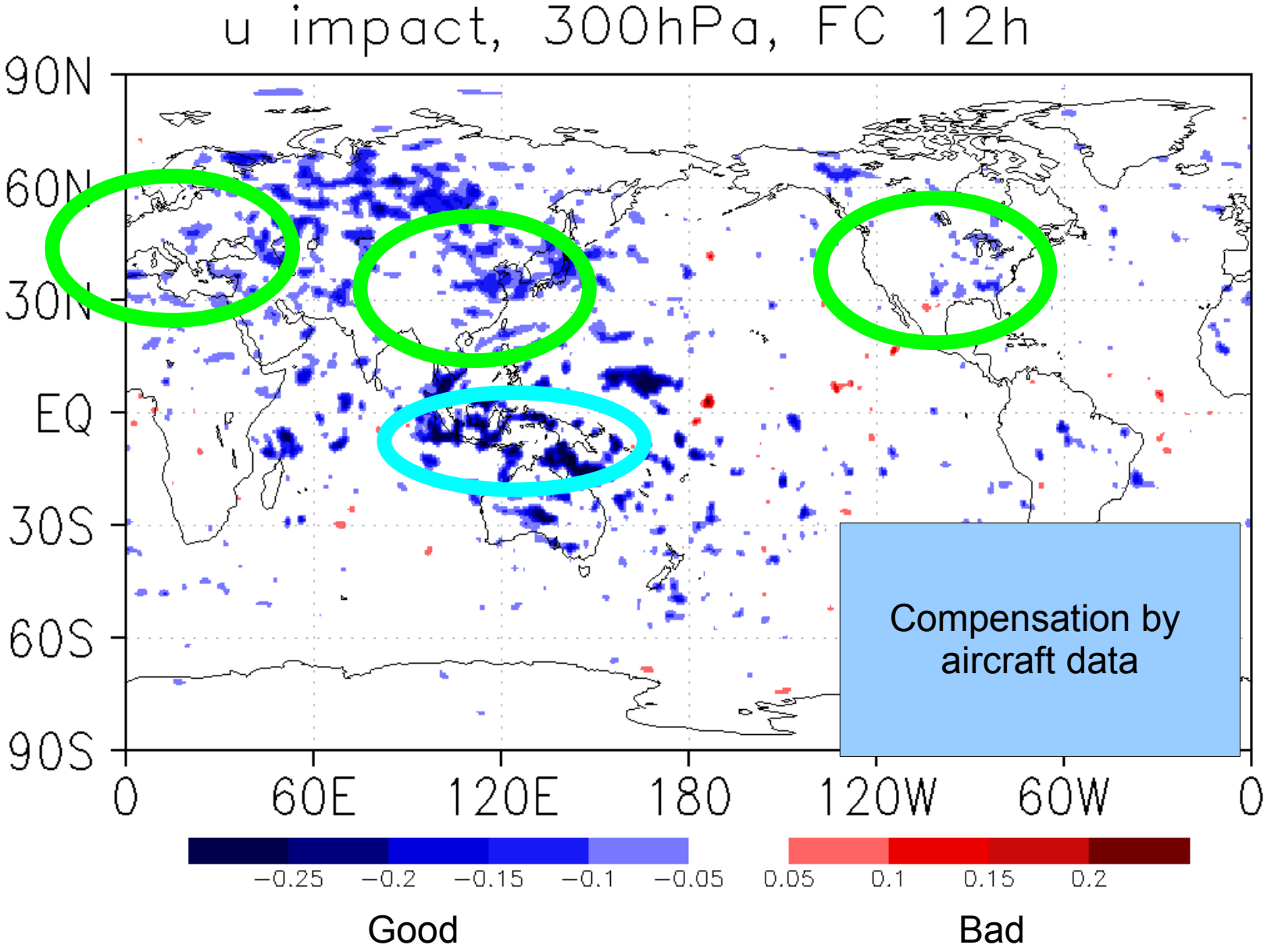
NoSonde – Control: removed observations TEMP and PILOT



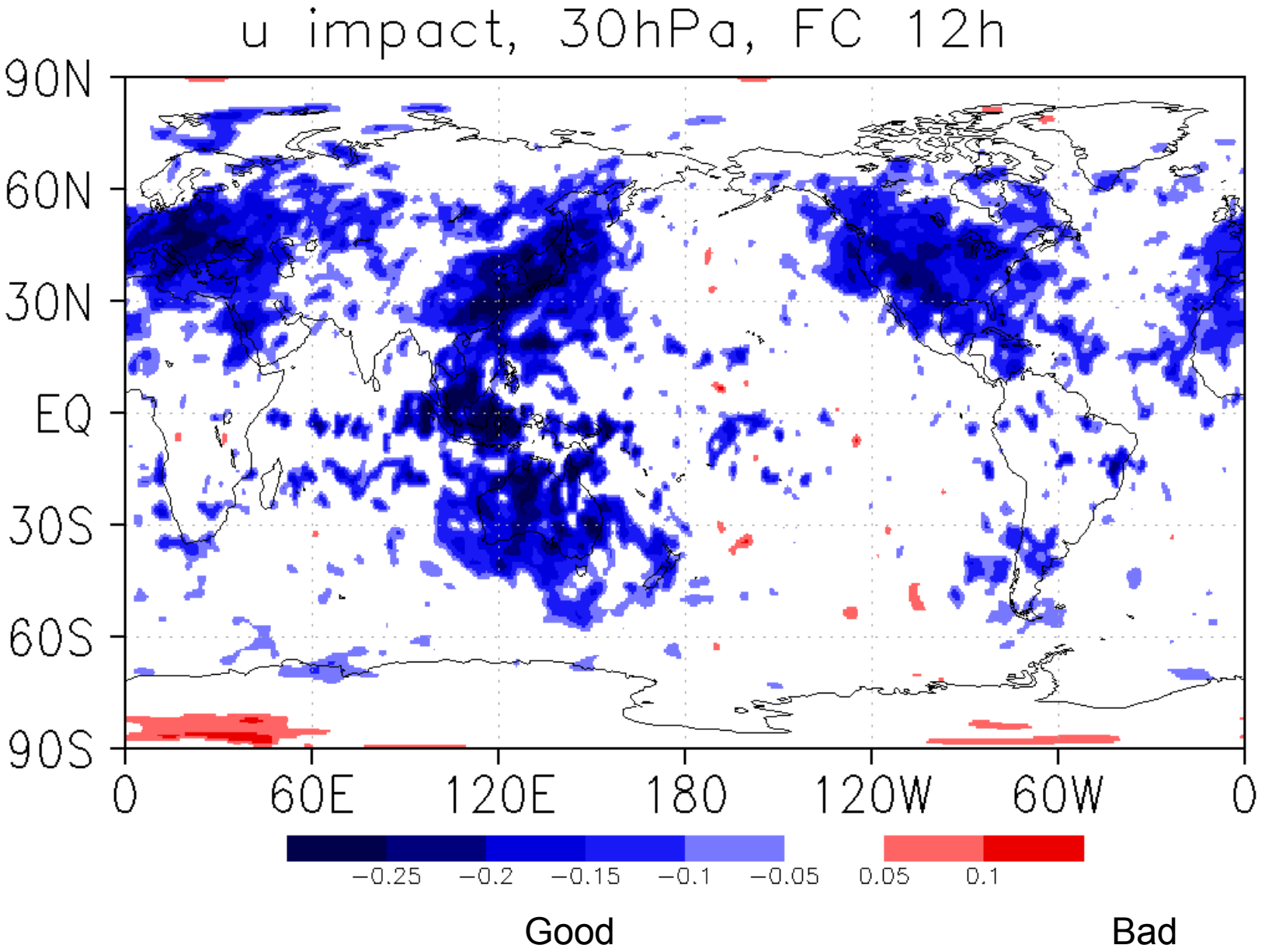
Zonal wind-impact Sondes in troposphere



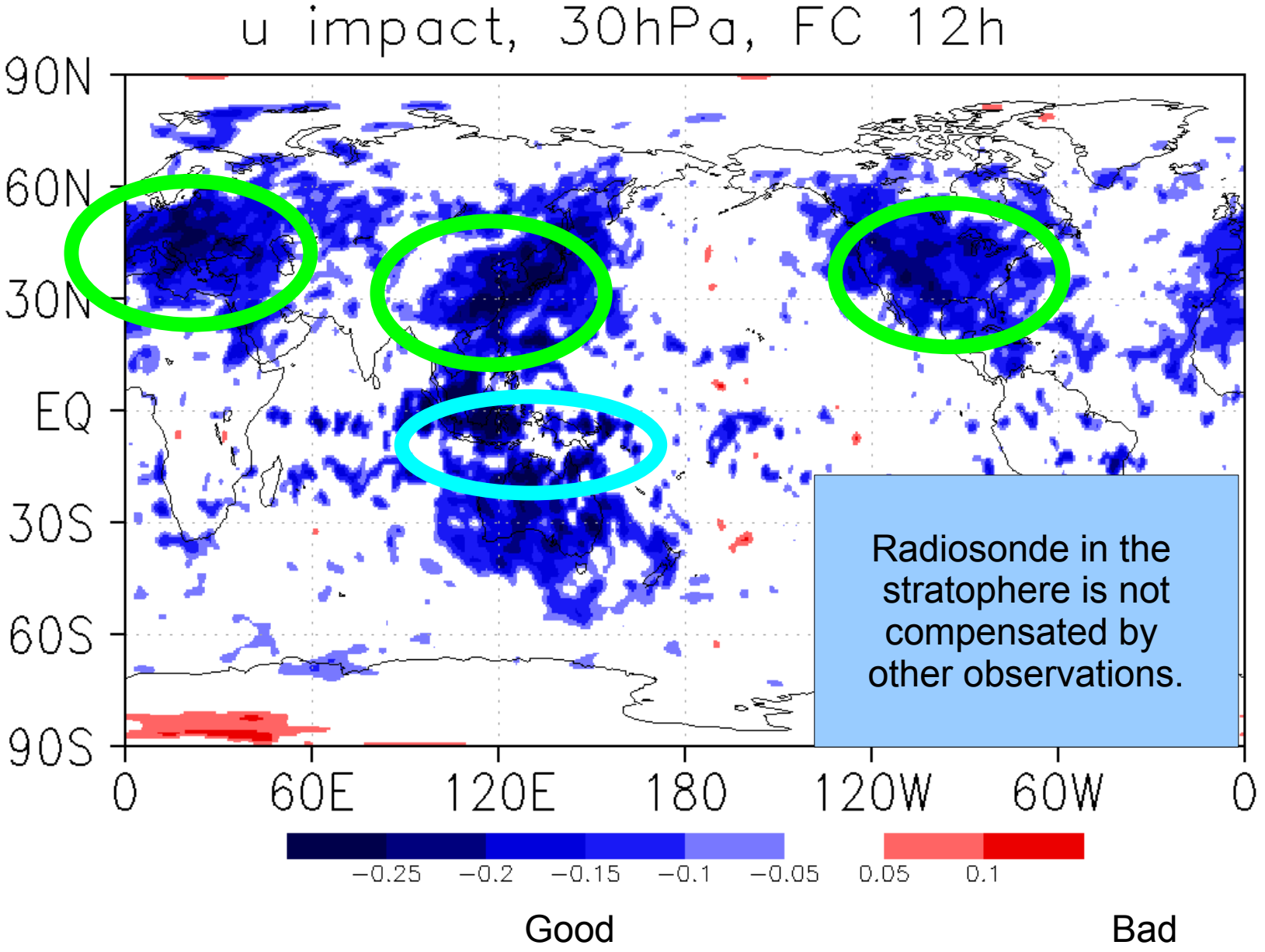
Zonal wind-impact Sondes in troposphere



Zonal wind-impact Sondes in stratosphere

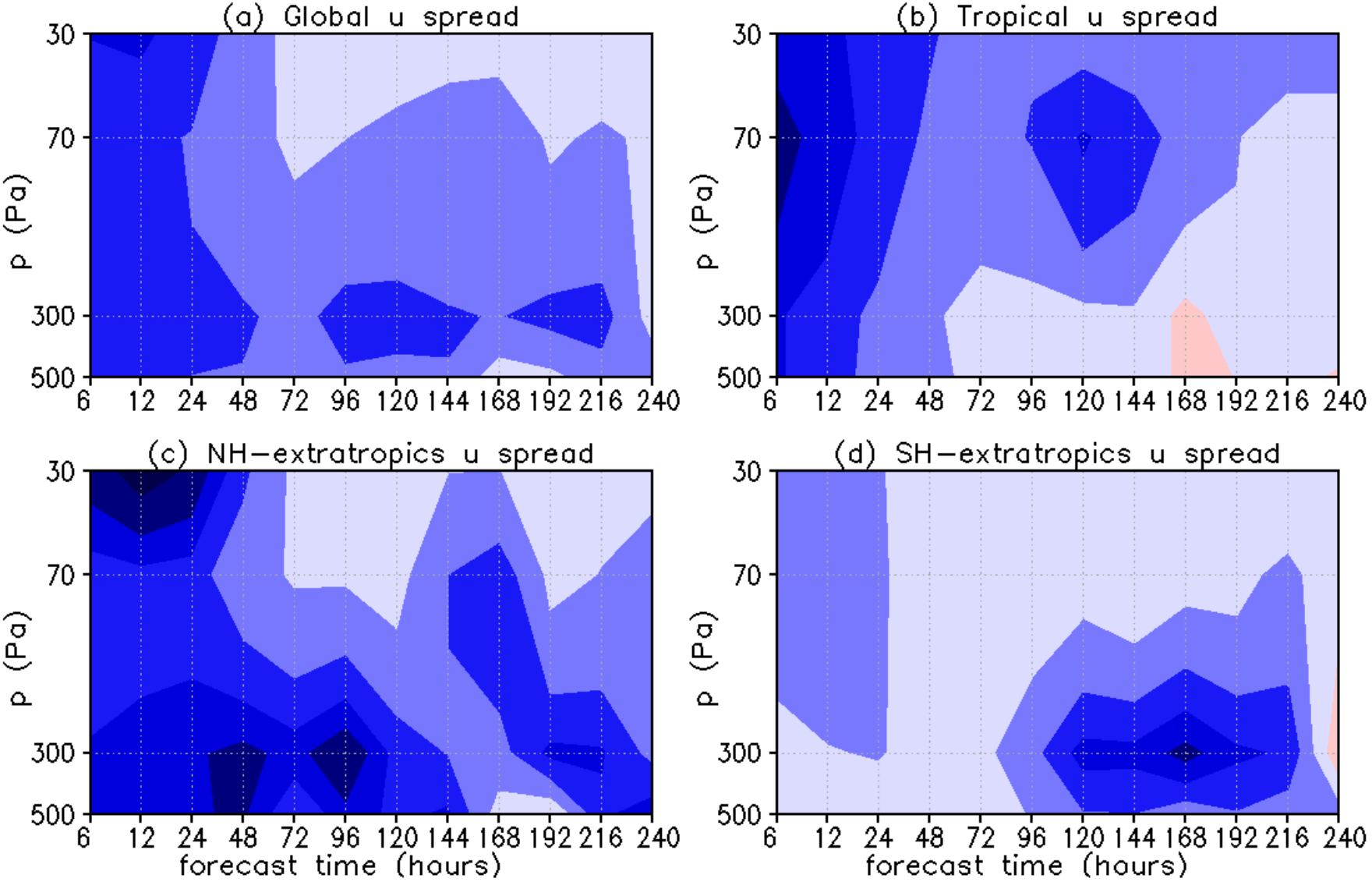


Zonal wind-impact Sondes in stratosphere



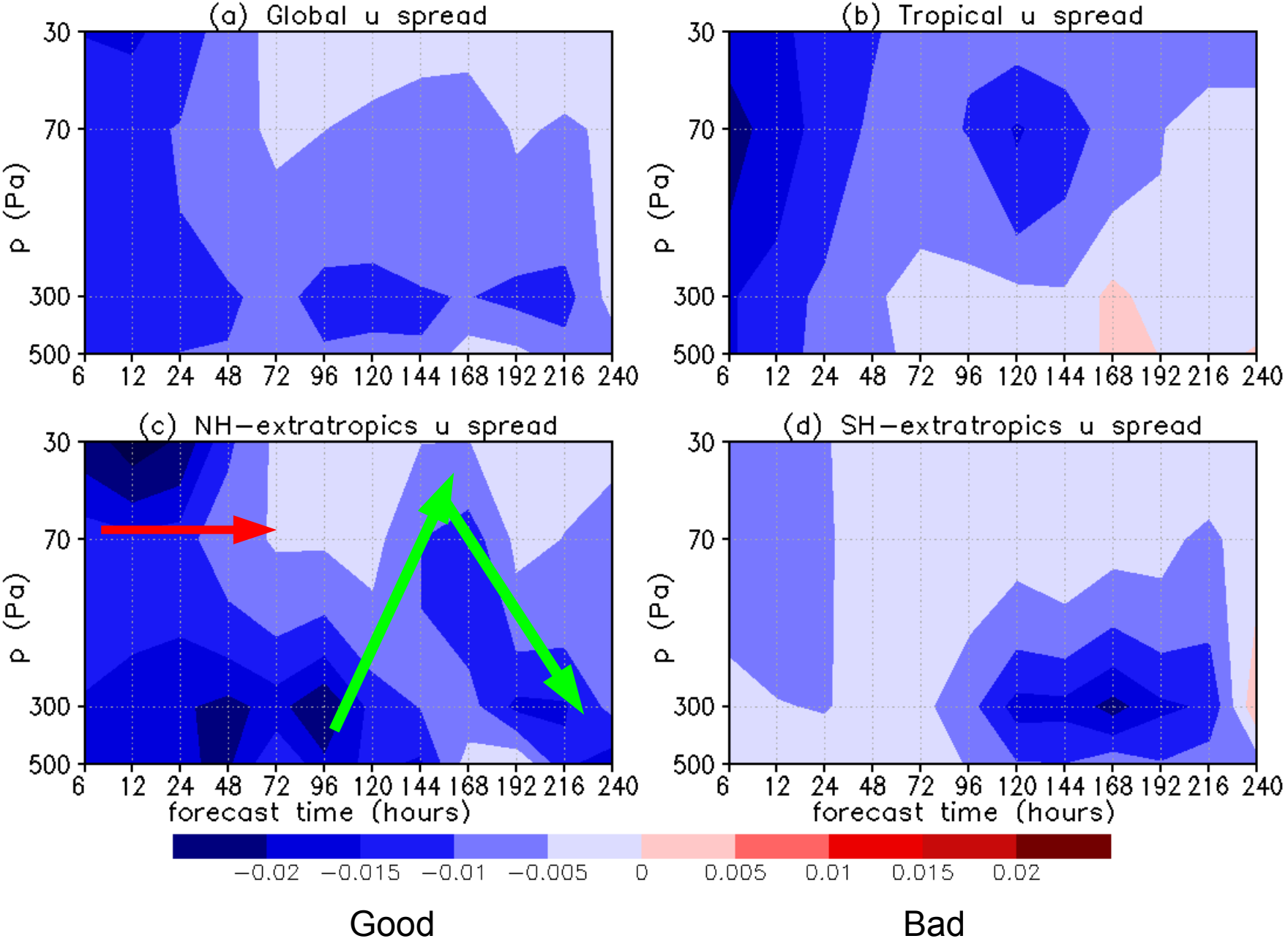
Zonal wind-impact ½-ADM: UTLS - Control

averaged only over 95%-significant data

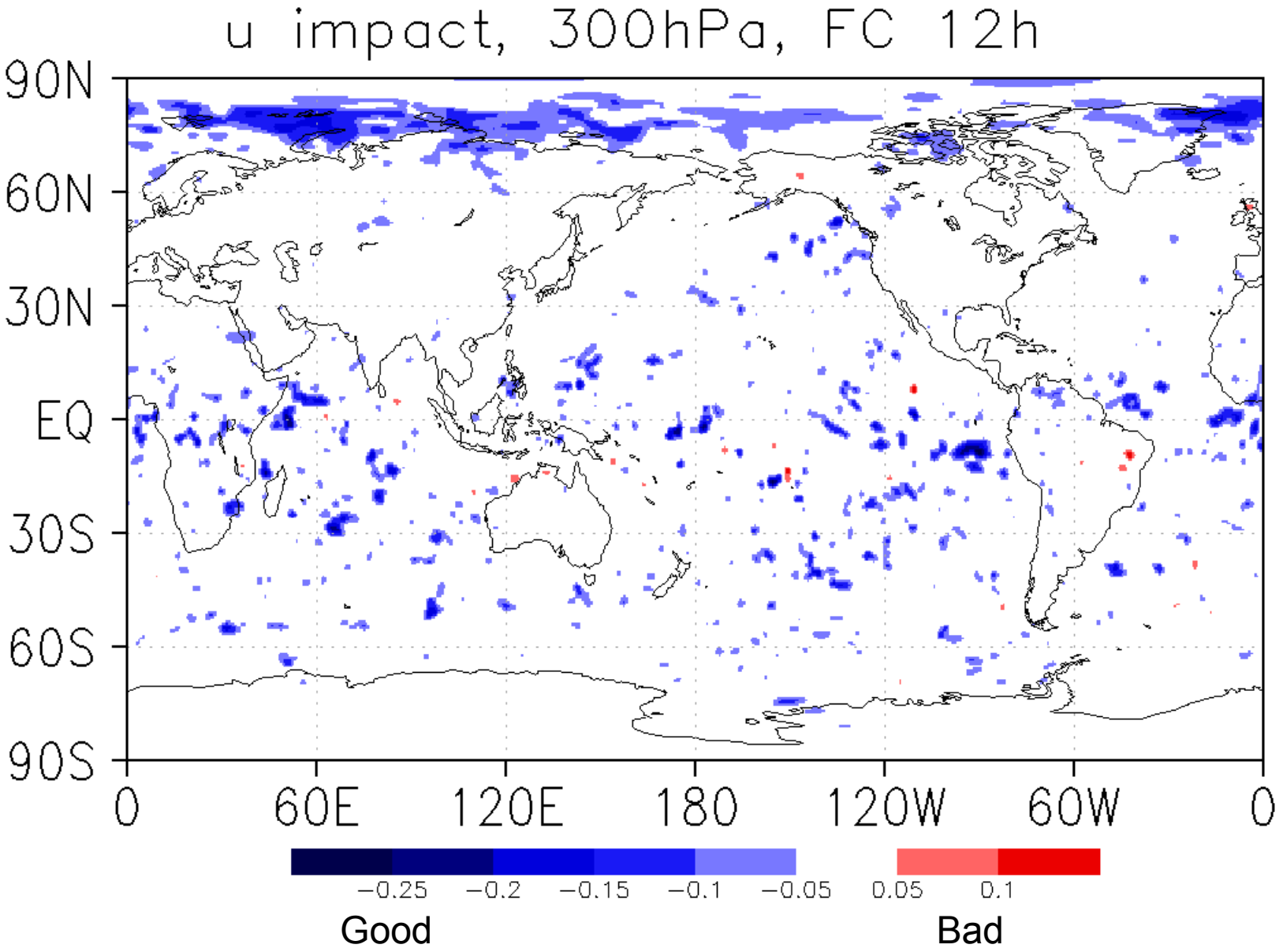


Zonal wind-impact ½-ADM: UTLS - Control

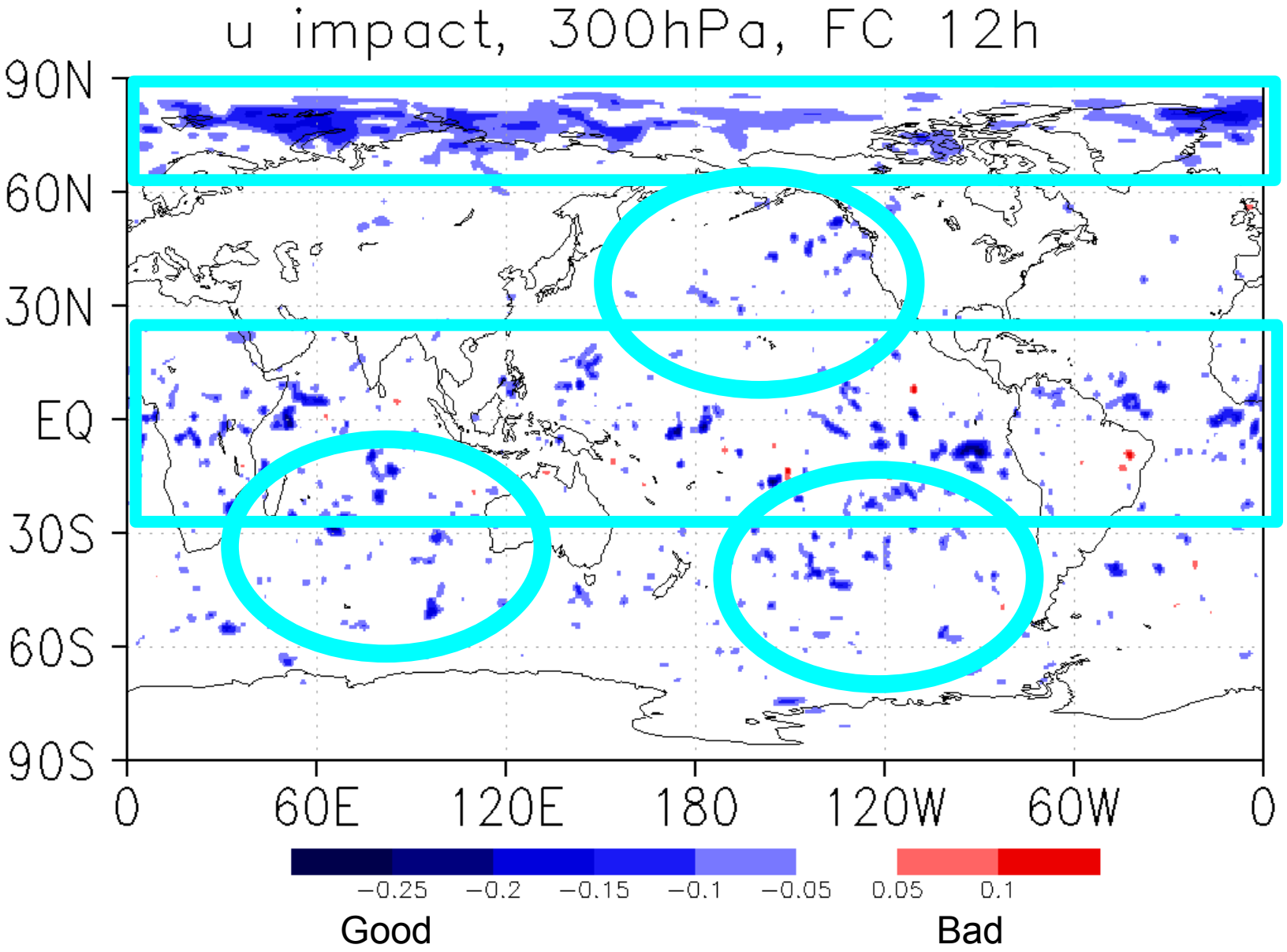
averaged only over 95%-significant data



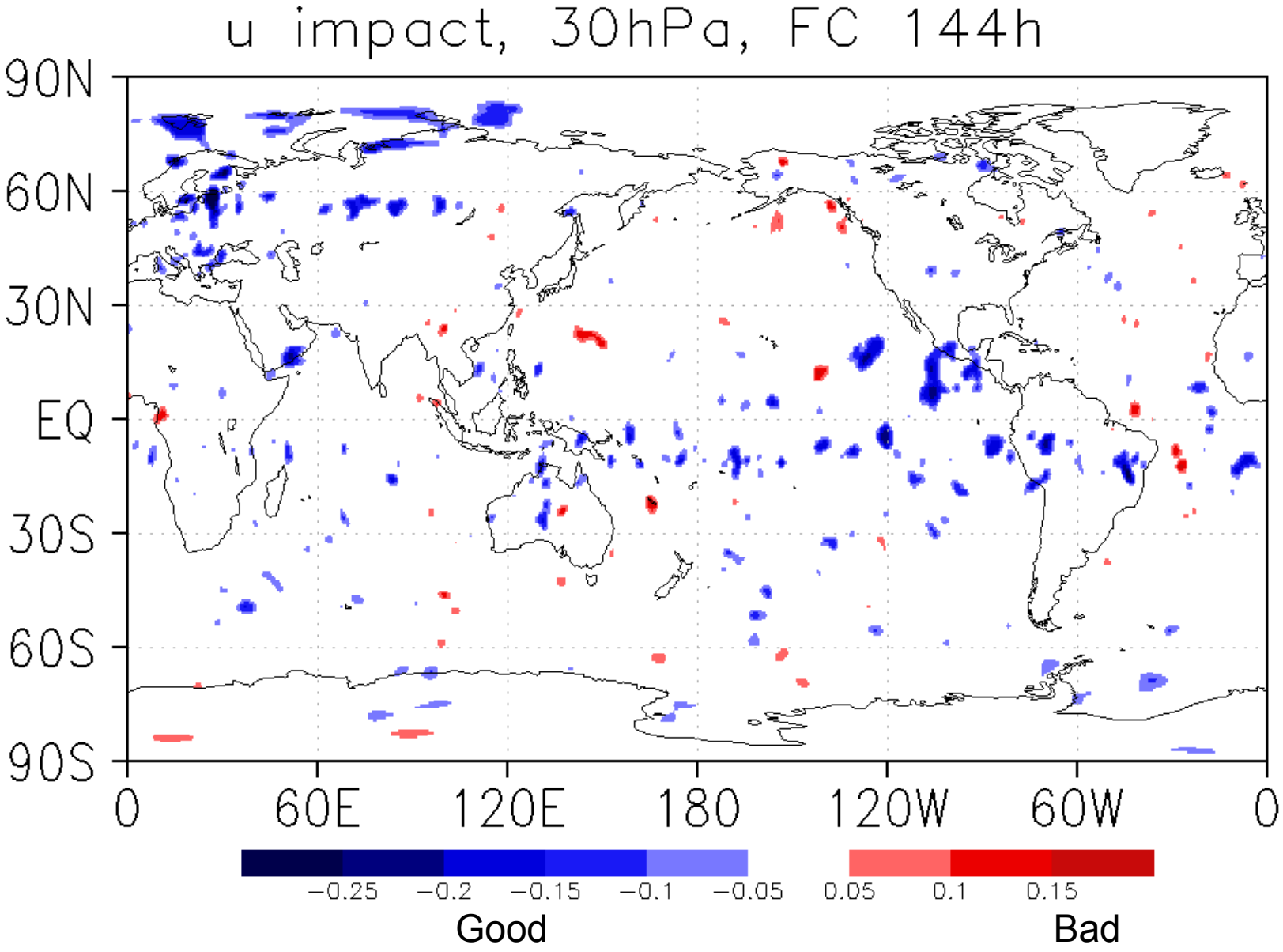
Tropospheric zonal wind-impact ½-ADM UTLS



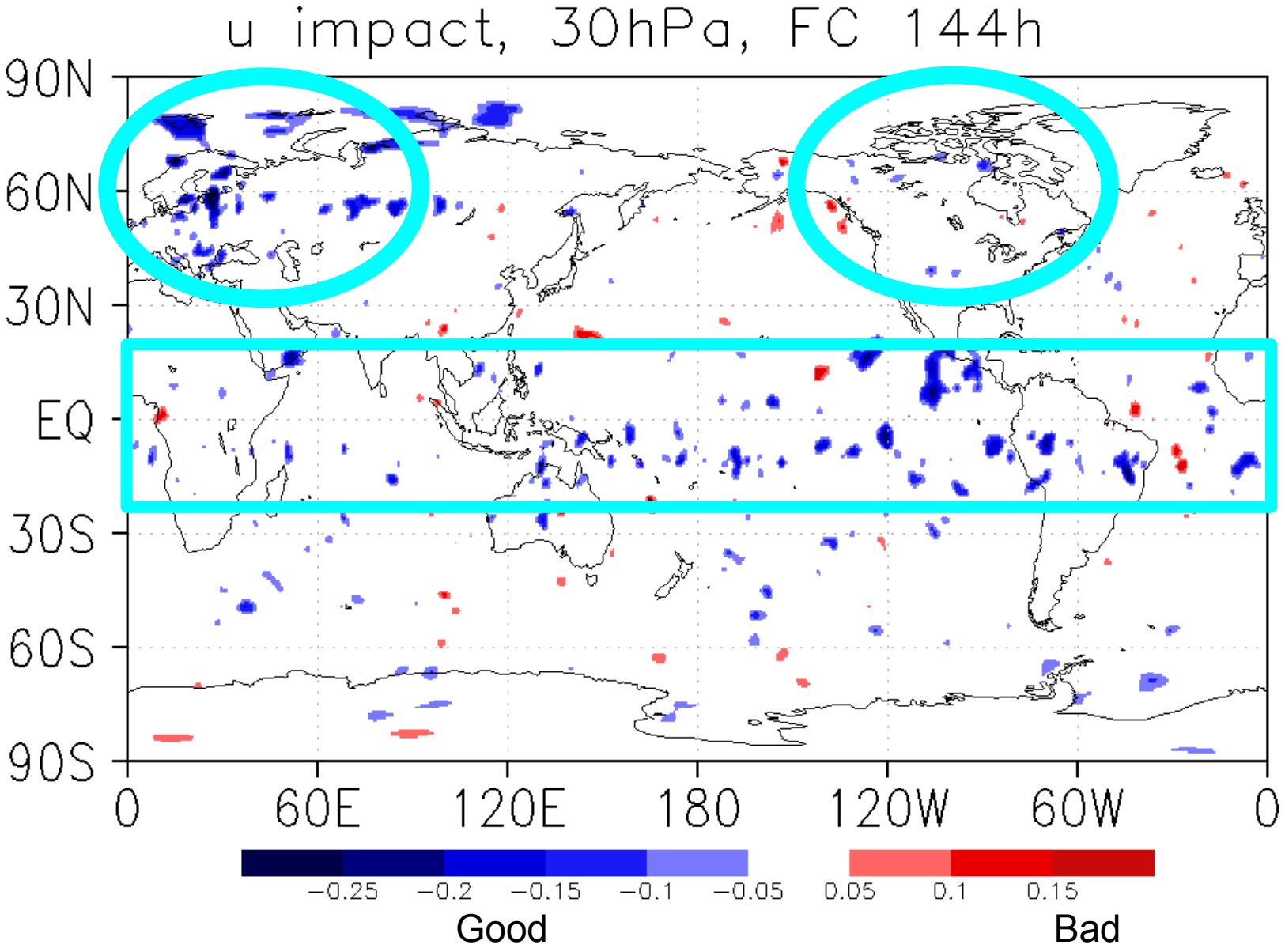
Tropospheric zonal wind-impact ½-ADM UTLS



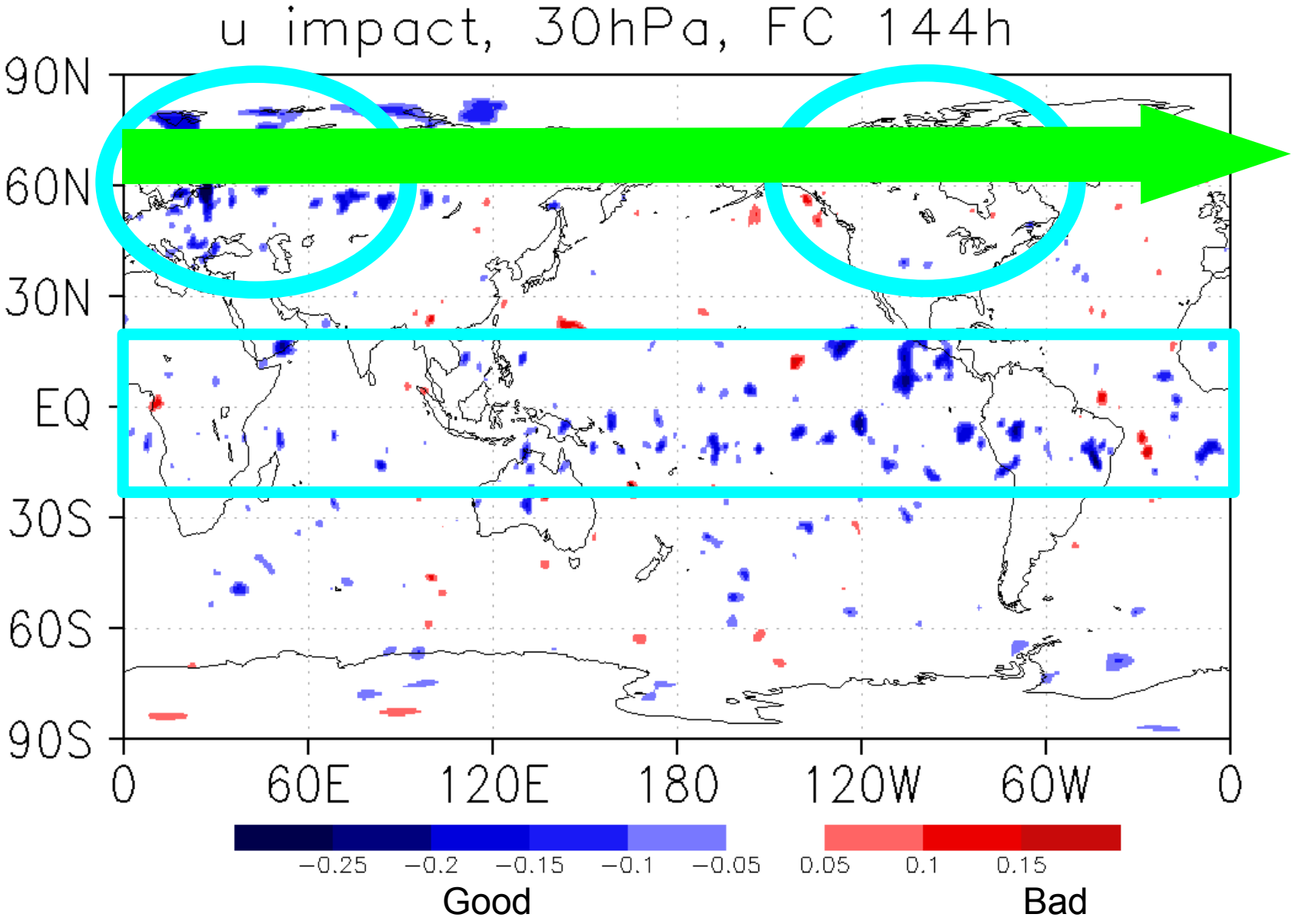
Stratospheric zonal wind-impact ½-ADM UTLS



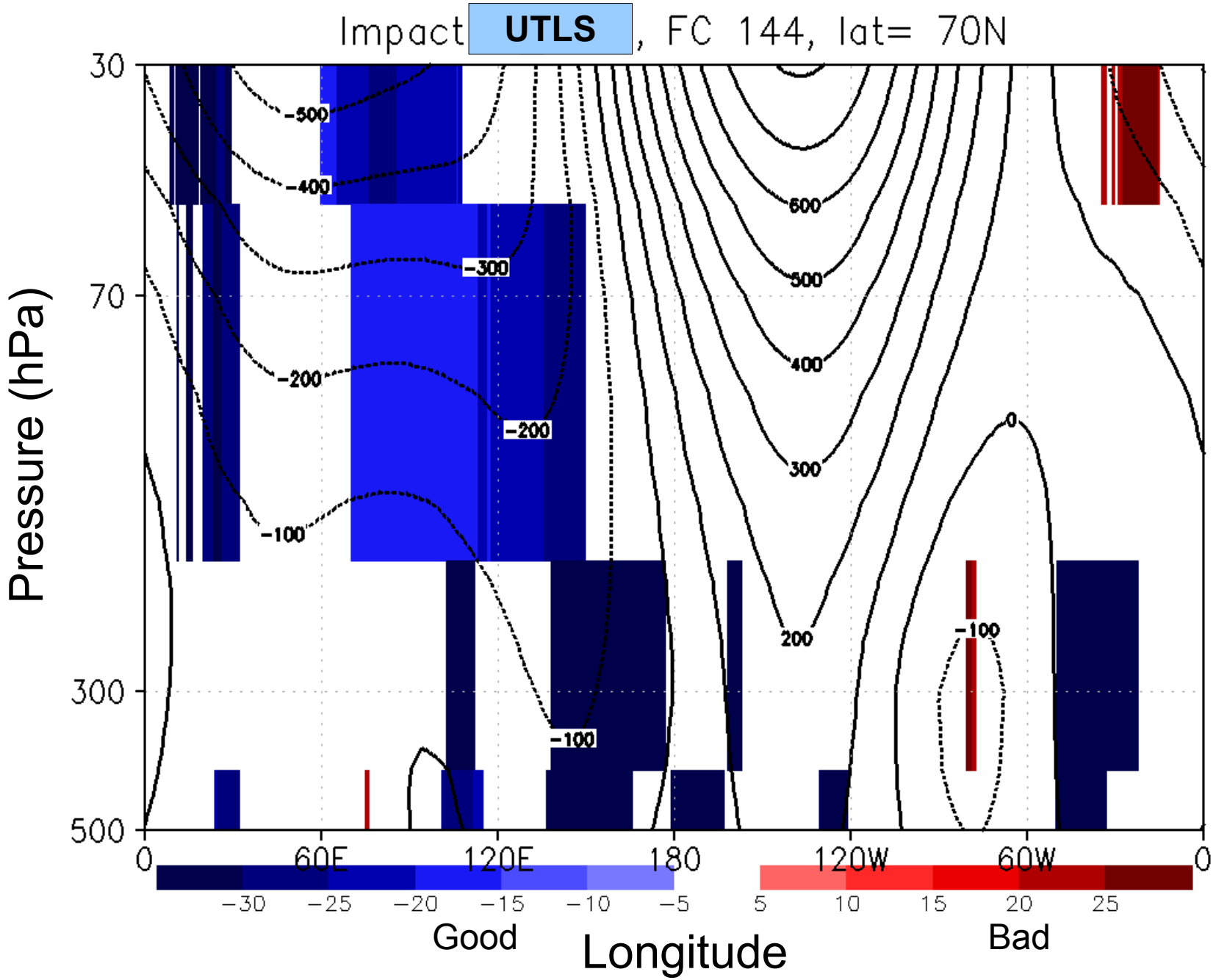
Stratospheric zonal wind-impact ½-ADM UTLS



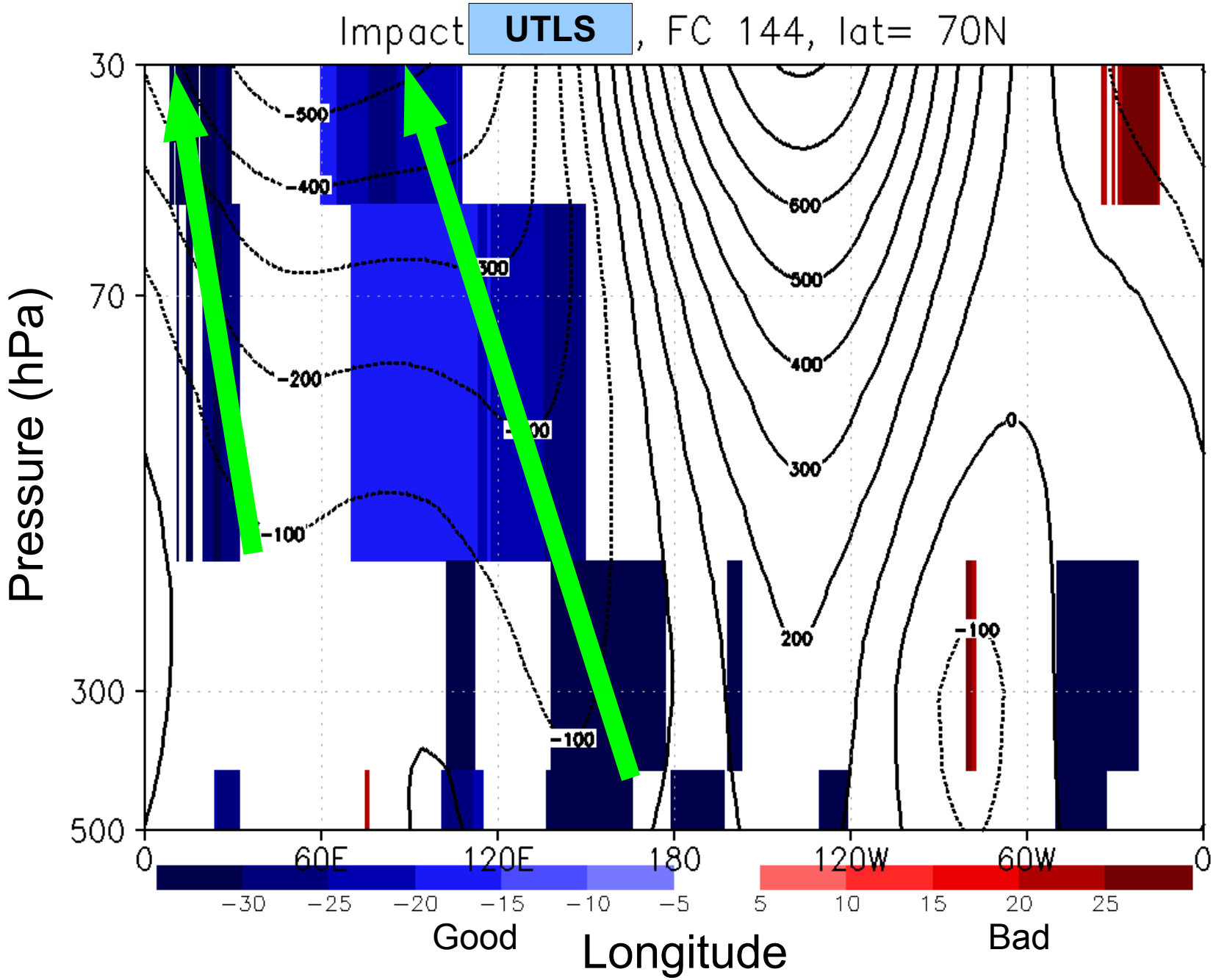
Stratospheric zonal wind-impact ½-ADM UTLS



ADM UTLS geopot.-impact and mean geopotential eddy

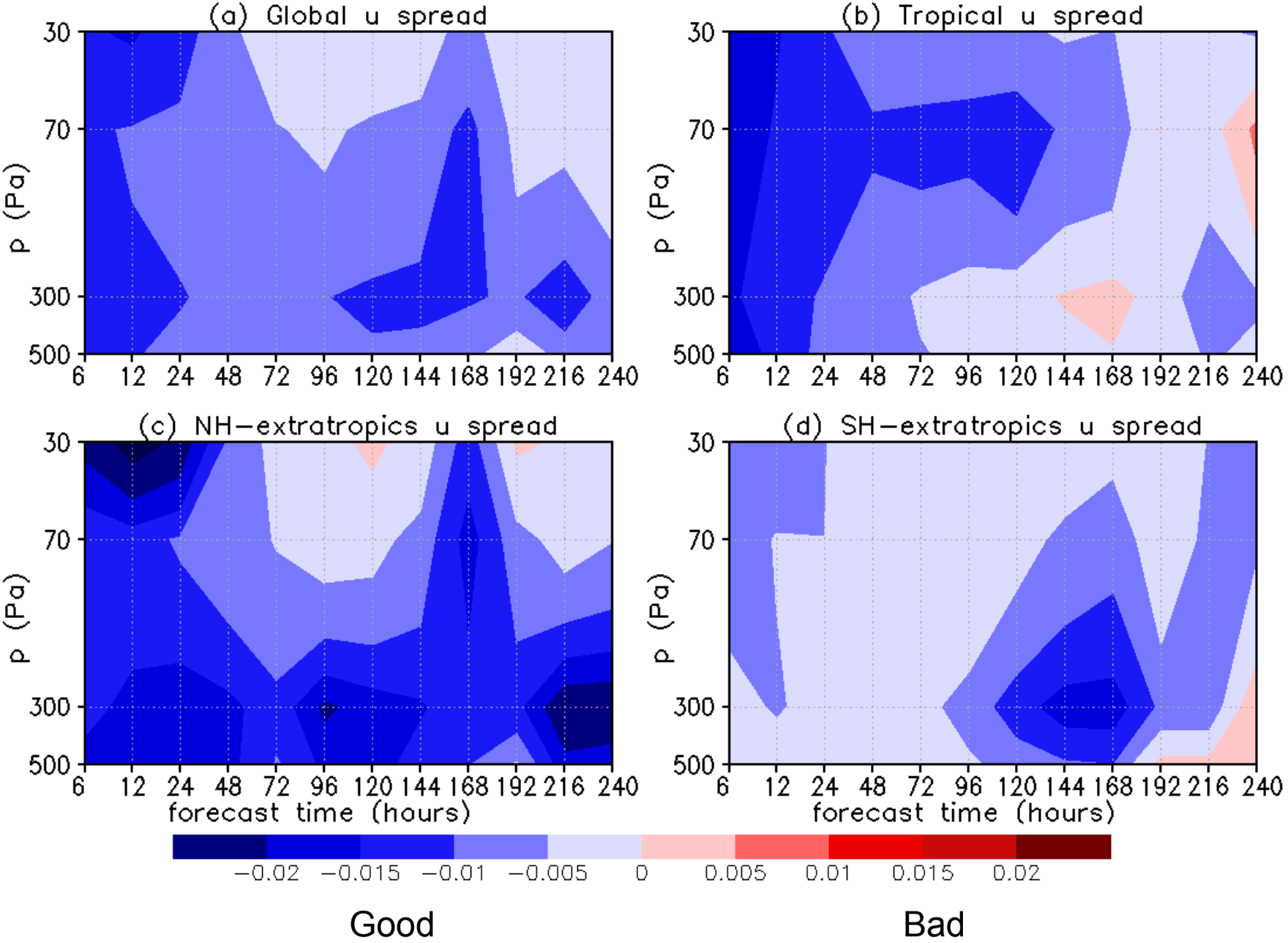


ADM geopotential-impact and mean geopotential eddy



Zonal wind-impact ½ ADM: strato - Control

averaged only over 95%-significant data



Zonal wind-impact ½ ADM: strato - Control

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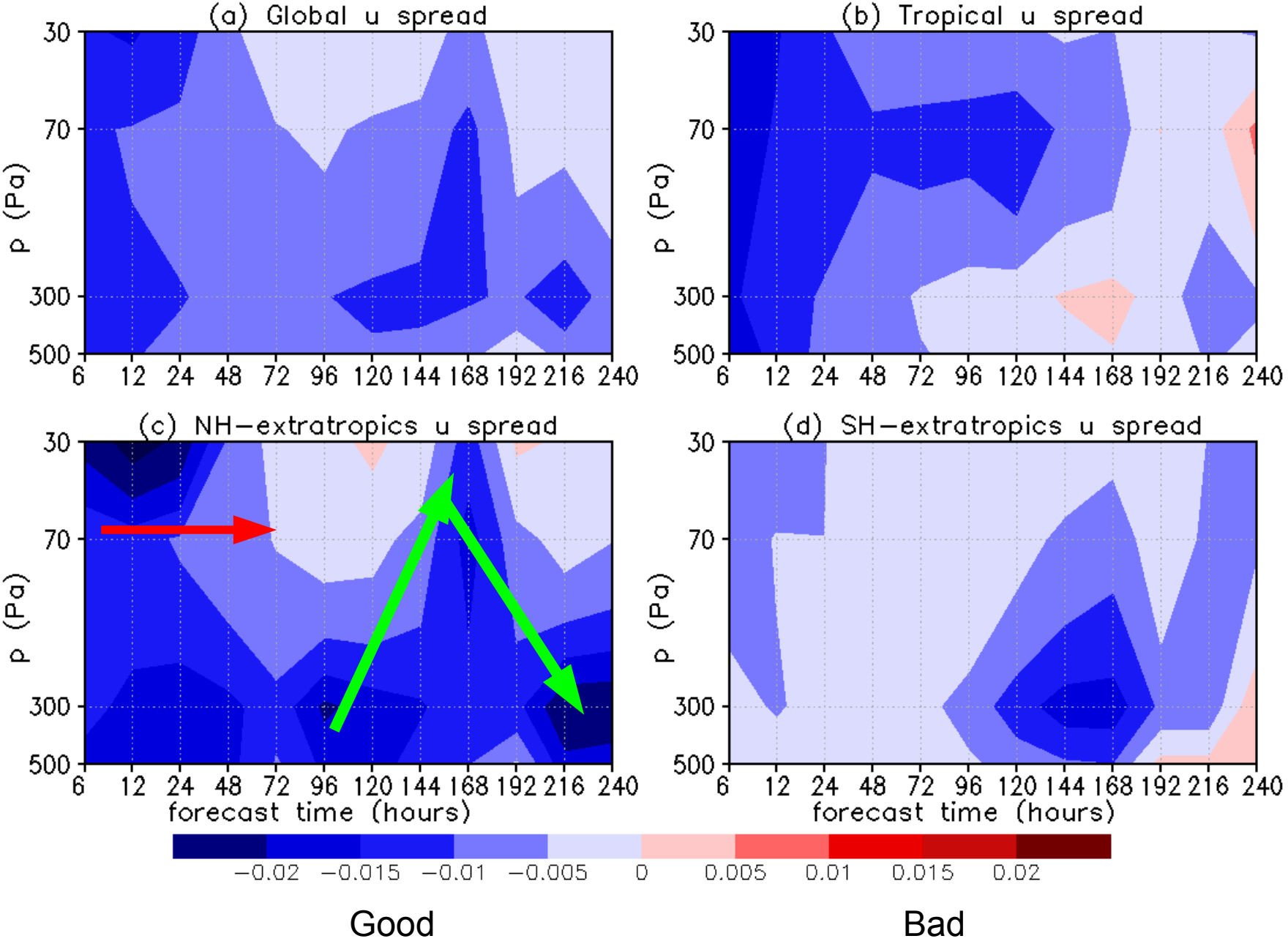

Zonal wind-impact ADM: strato - UTLS

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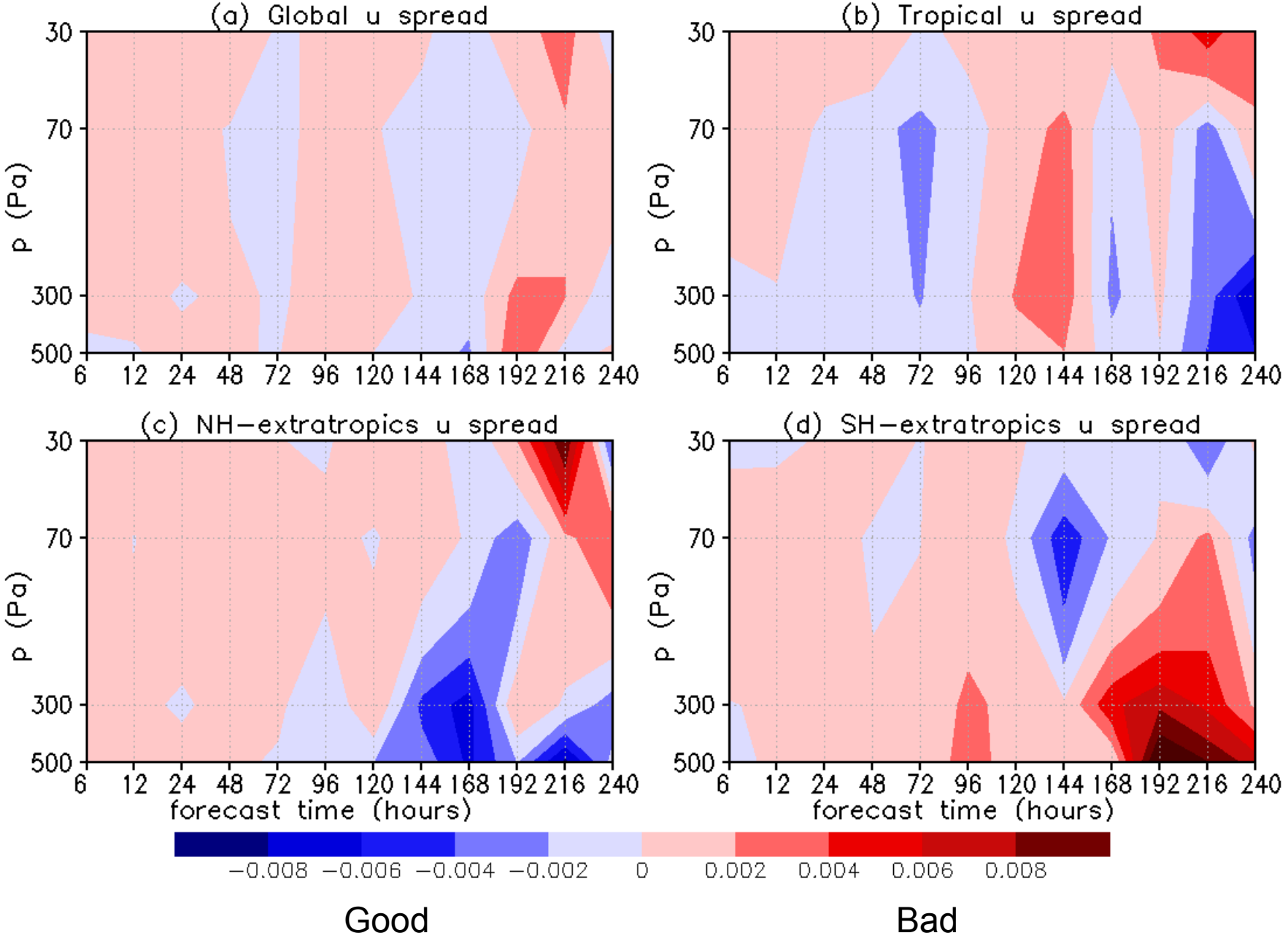

Summary

- **Impact of new observing systems** can be simulated with Ensemble Data Assimilation experiments.
- ADM impact **comparable** to radiosonde impact.
- ADM impact **regions**: Oceans, tropics, Arctic
- **Vertical propagation of ADM impact** at forecast time 4-7 days. Impact seems to propagate vertically with large-scale Rossby waves.
- Impact difference for different vertical sampling scenarios is **unclear**.

Acknowledgements:

- ESA contract 20940/07/NL/JA
- Julian Heming from UK met office for data