Impact of satellite and conventional observations on the performance of the ECMWF data assimilation system by OSEs

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Presented by Erik Andersson

ECMWF

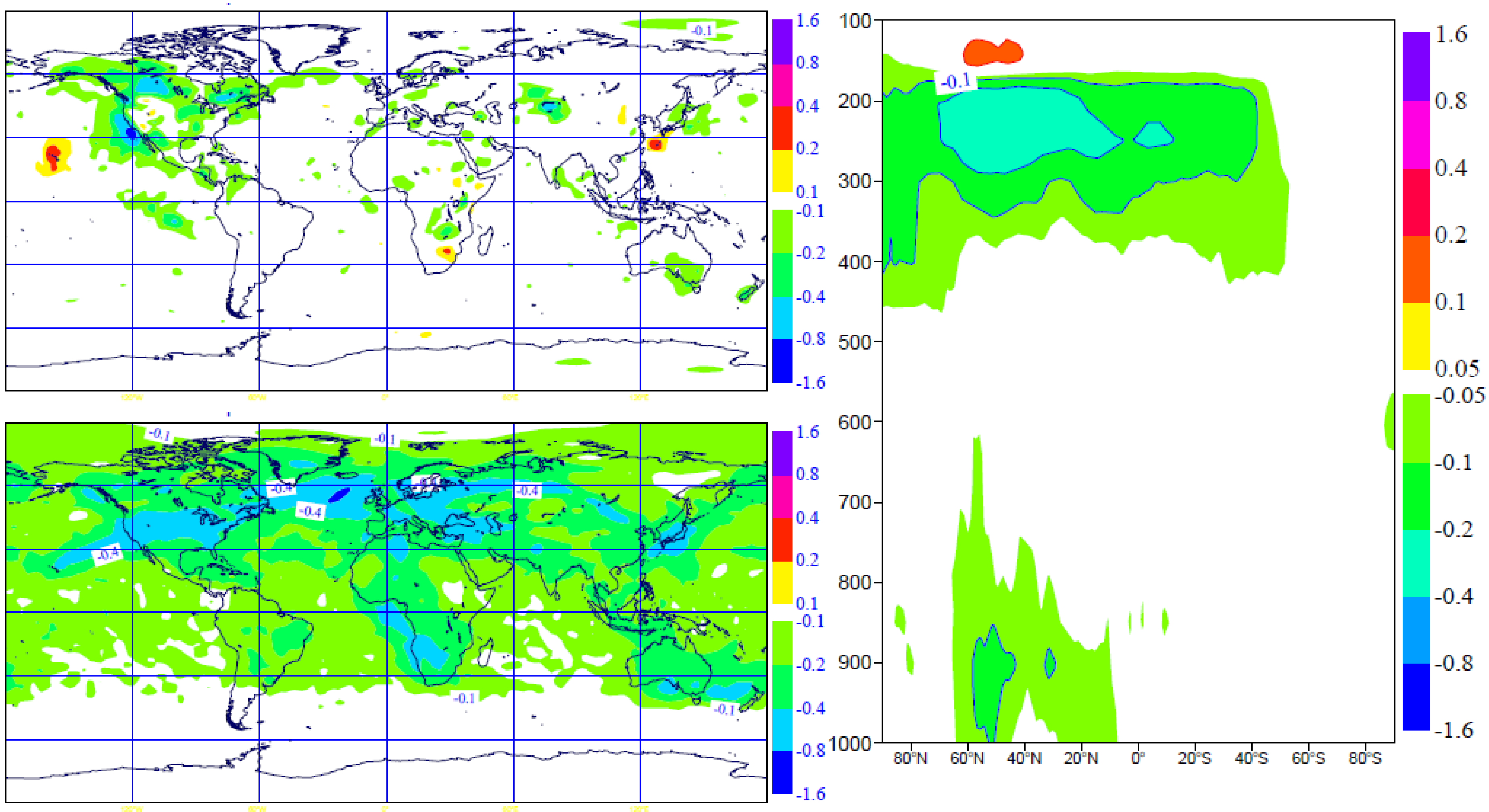
Outline

1. Radiosonde denial OSE
2. Aircraft denial OSE
3. Radiosonde data denied above 50 hPa
4. OSEs to quantify the interaction between terrestrial and space-based observing systems in terms of mean state (bias correction)
5. Network design studies for Europe (EUCOS)

RS and aircraft data have significant effects on the mean atmospheric state

- **Aircraft data warm the analysis, especially at around 250 hPa**
- **RSs warm the analysis at the lower boundary layer, cool it in the mid-troposphere**
- **RSs moisten the analysis over most continental areas in terms of vertical integral (TCWV)**
- **Analysis/guess fit to some other observations shows improvement in the random component, bias component confirms strong aircraft temperature biases (e.g. against GPSRO)**
- **GPSRO density has an impact on mean state and it highly depends on the presence of aircraft/RS: near cruise level GPSRO seems to “fight“ aircraft bias**

Aircraft data warm the analysis, especially at around 250 hPa



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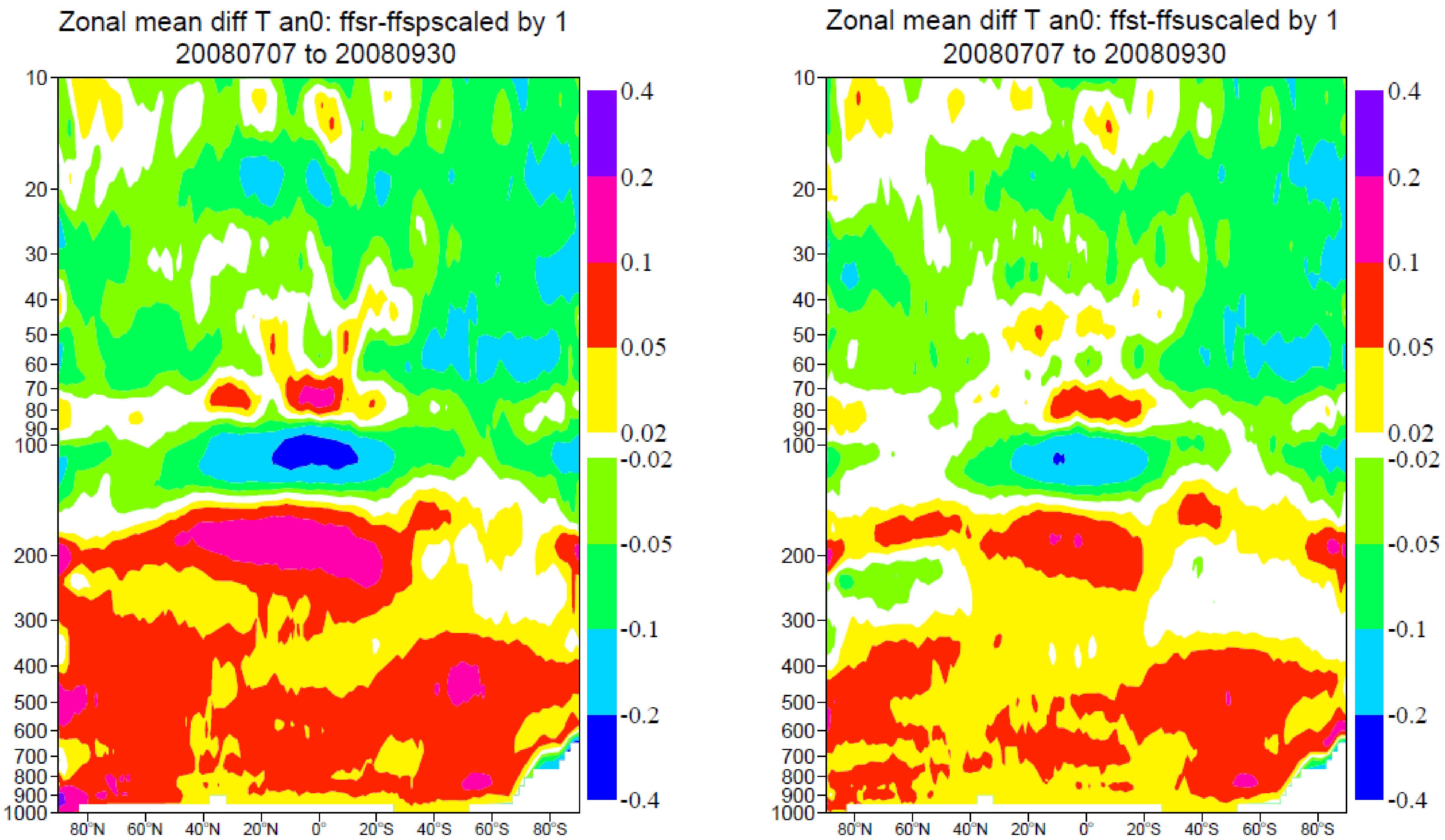
GPSRO impact when no RS (left), no aircraft (right)

(green/blue means additional GPSRO data increase T)



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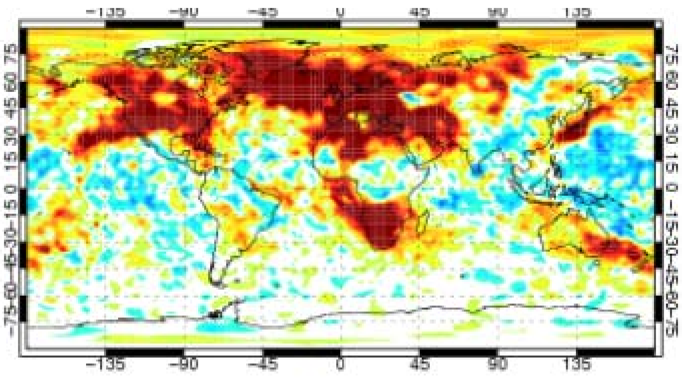
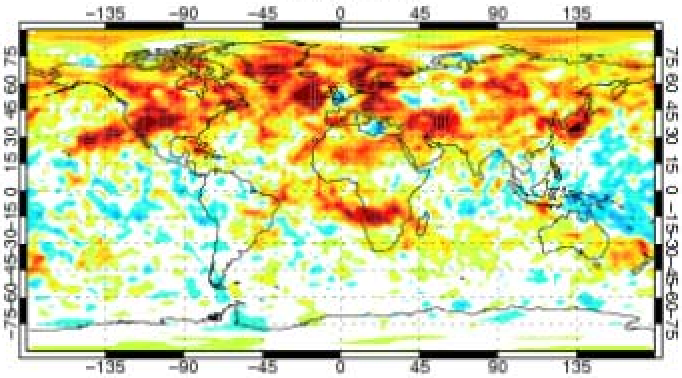
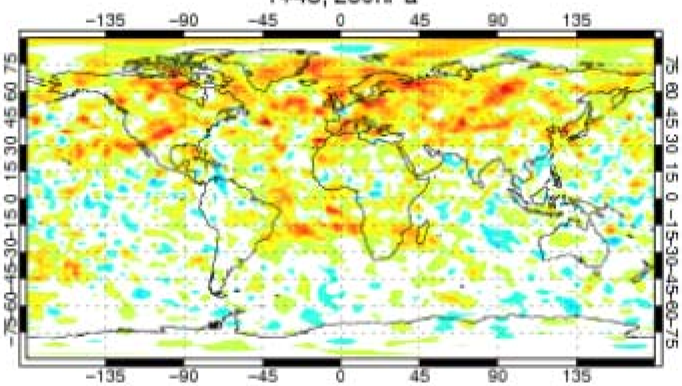
RS and aircraft data improve forecast scores



T+24; 200hPa

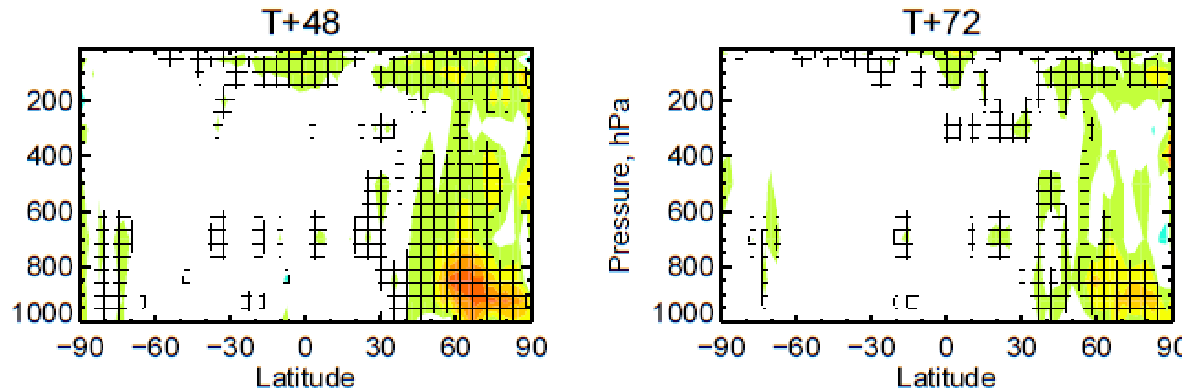


T+48; 200hPa

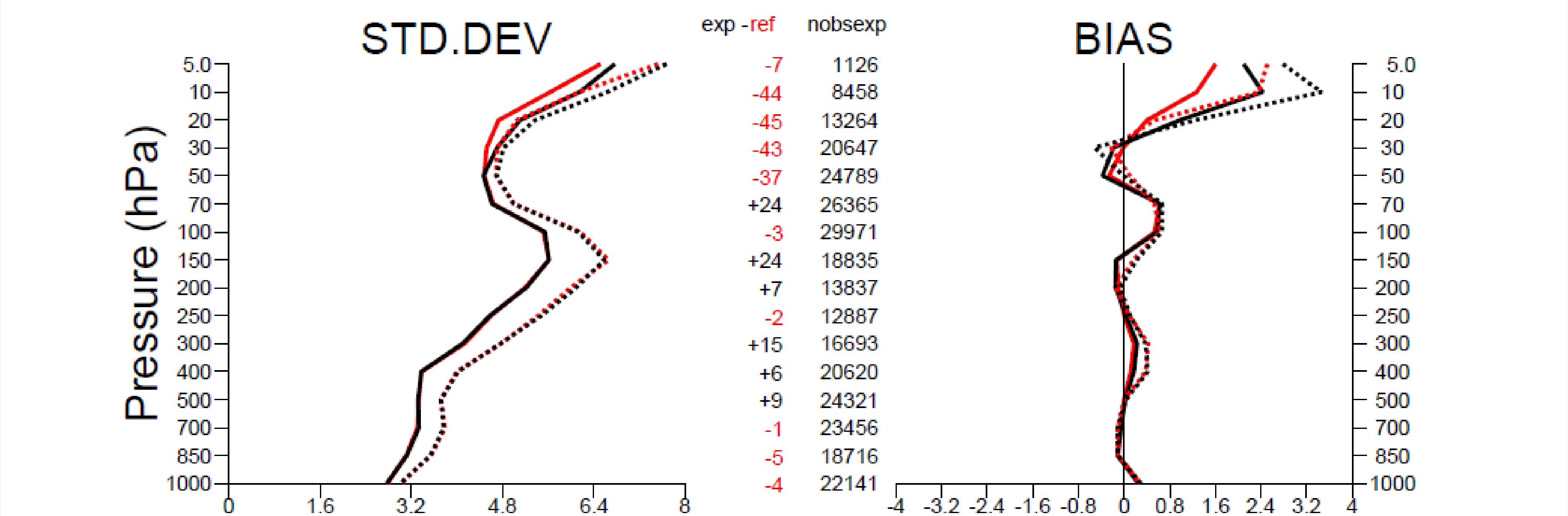


T+72; 200hPa

- **At cruise level aircraft impact (left) dominates, at lower troposphere radiosondes (below) dominate but not over Europe and North America**
- **Their forecast impacts can be detected through verification against AMSU-A and MHS**



Radiosonde data denied above 50 hPa



Fit of 48h forecast (solid) and 96h forecast (dashed) to radiosonde zonal winds in the Tropics from the stratospheric radiosonde denial (black) and Reference (red) experiments with 5% GPSRO data coverage. Left panel shows standard deviations, right panel shows biases. Statistics computed from 00 and 12UTC forecasts between 7 July and 17, August, 2008.

RS, aircraft and GPSRO as anchors for radiance bias correction

- **VarBC bias corrections for satellite radiance data (AQUA and MetOp AMSU-A) are affected by data coverage, but RS impact is surprisingly small wrt GPSRO's role in anchoring the bias correction**
- **However, some specific bias structures in the vertical are undetectable by GPSRO (ambiguity).**
- **Aircraft data are affected by biases that need to be corrected (implemented in 2011)**

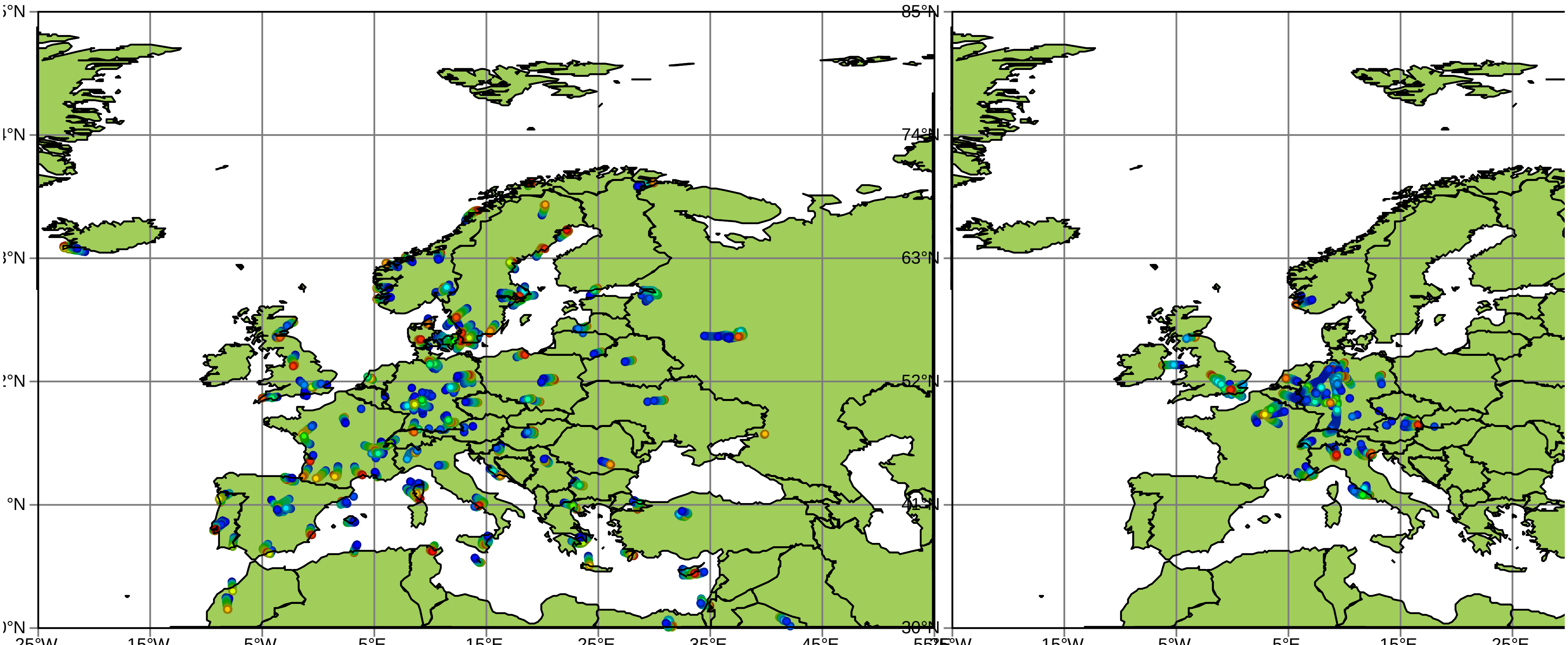
Network design scenarios

- **Sc1, Baseline scenario: Full oper obs coverage outside Europe; GUAN radiosonde network, flight level aircraft data, aircraft profiles of less than 3 hourly visited airports and full remaining part of the observation network inside Europe.**
- **Sc2, Control scenario: Full oper obs coverage everywhere**
- **Sc3a: Full oper obs coverage outside Europe; European radiosonde network slightly reduced with a <u>100km thinning</u> distance, all aircraft data and the full remaining part of the obs network inside Europe.**
- **Sc3b: Like Sc3a, but radiosonde <u>thinning performed only at 12UTC</u> analysis.**
- **Sc4: Like Sc3a but <u>250km thinning</u> distance for radiosondes and aircraft data over Europe.**
- **Sc5: Like Sc4 but <u>500km thinning</u> distance.**

AMDAR thinning

Scenario-4, 250km thinning distance, data below 500hPa

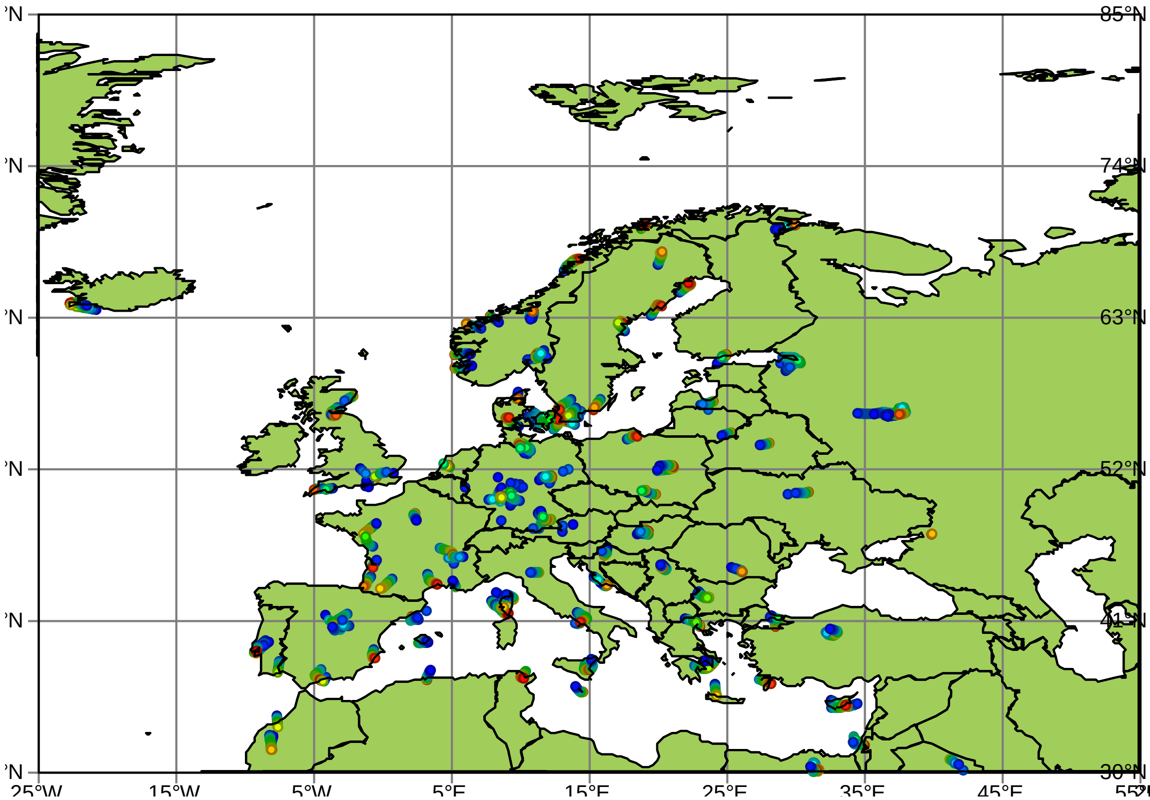
USED **BLACKLISTED**



AMDAR thinning

Scenario-5, 500km thinning distance, data below 500hPa

USED



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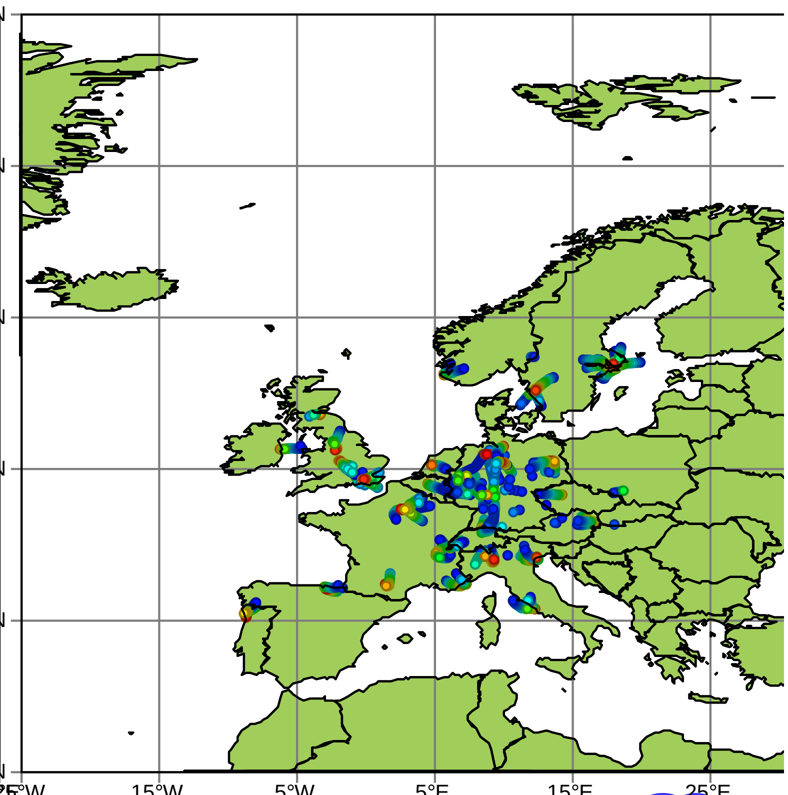

RESULTS

BASELINE vs CONTROL (RMS(exp)-RMS(ctl))/RMSavg

T850 + 12h

Relative Diff in RMS of fc-Error: RMS(fc_f5ur - an_1) - RMS(fc_f5sh - an_1)
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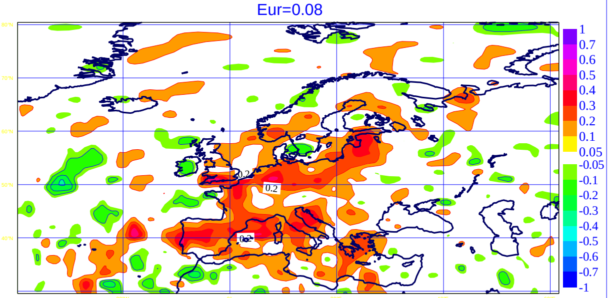
Eur=0.08



RH700 + 12h

Relative Diff in RMS of fc-Error: RMS(fc_f5ur - an_1) - RMS(fc_f5sh - an_1)
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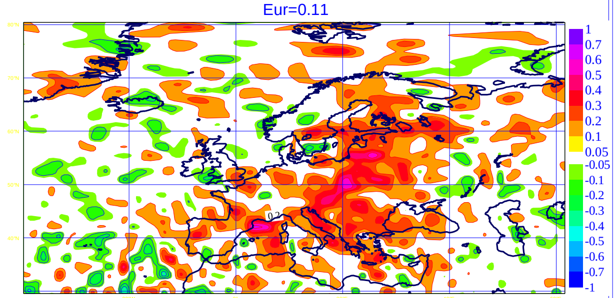

Z500 +12h

Relative Diff in RMS of fc-Error: RMS(fc_f5ur - an_1) - RMS(fc_f5sh - an_1)
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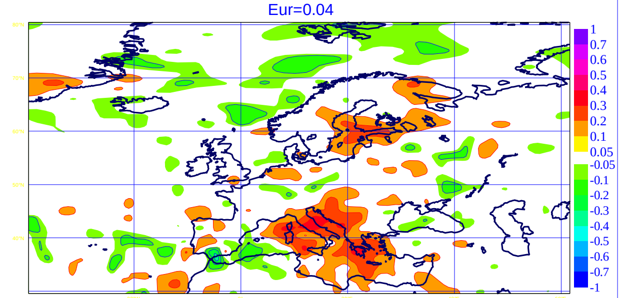
Eur=0.04



T850 + 36h

Relative Diff in RMS of fc-Error: RMS(fc_f5ur - an_1) - RMS(fc_f5sh - an_1)
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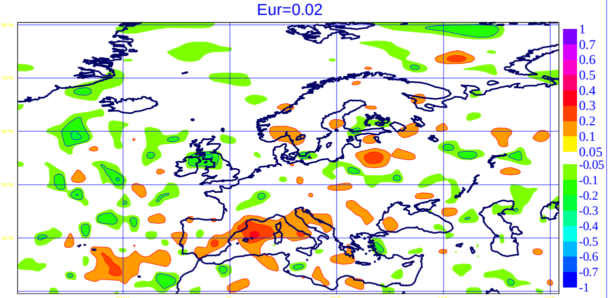
Eur=0.02



RH700 + 36h

Relative Diff in RMS of fc-Error: RMS(fc_f5ur - an_1) - RMS(fc_f5sh - an_1)
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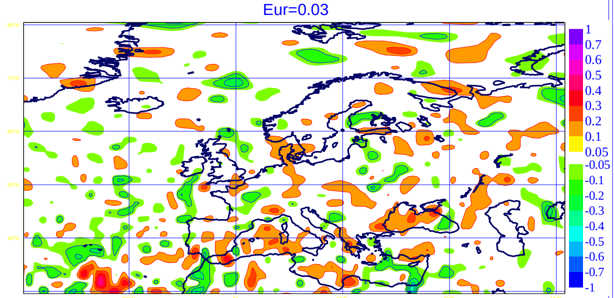

Z500 +36h

Relative Diff in RMS of fc-Error: RMS(fc_f5ur - an_1) - RMS(fc_f5sh - an_1)
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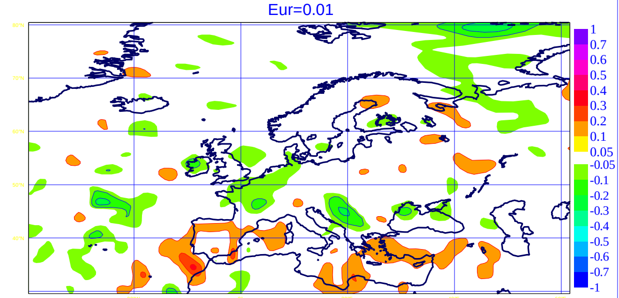
Eur=0.01



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RESULTS

SC5 (500km) vs CONTROL (RMS(exp)-RMS(ctl))/RMSavg

T850 + 12h

Relative Diff in RMS of fc-Error: RMS(fc_f5v5 - an_1) - RMS(fc_f5sh - an_1)
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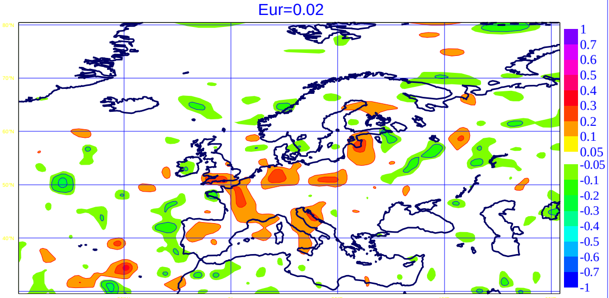
Eur=0.02



RH700 + 12h

Relative Diff in RMS of fc-Error: RMS(fc_f5v5 - an_1) - RMS(fc_f5sh - an_1)
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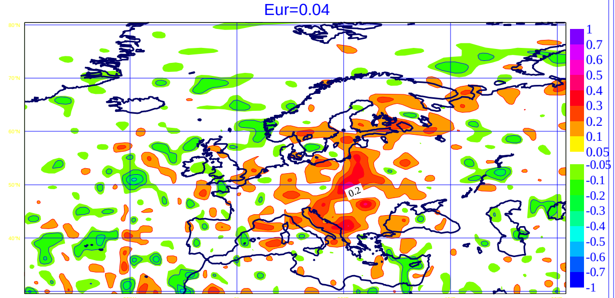
Eur=0.04



Z500 +12h

Relative Diff in RMS of fc-Error: RMS(fc_f5v5 - an_1) - RMS(fc_f5sh - an_1)
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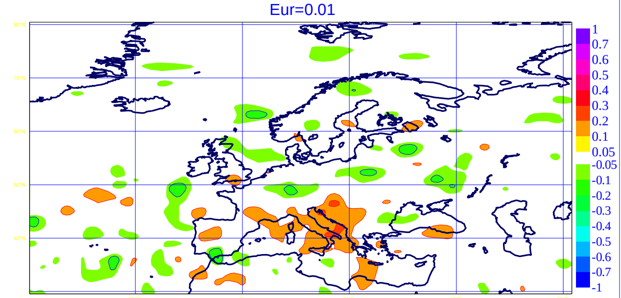
Eur=0.01



T850 + 36h

Relative Diff in RMS of fc-Error: RMS(fc_f5v5 - an_1) - RMS(fc_f5sh - an_1)
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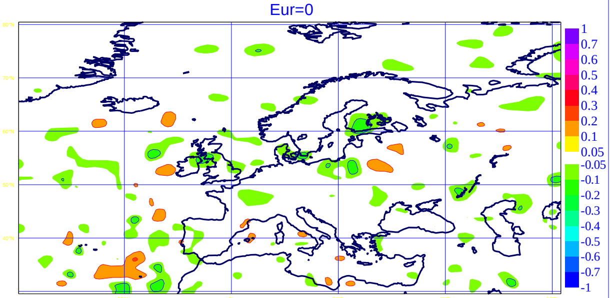
Eur=0



RH700 + 36h

Relative Diff in RMS of fc-Error: RMS(fc_f5v5 - an_1) - RMS(fc_f5sh - an_1)
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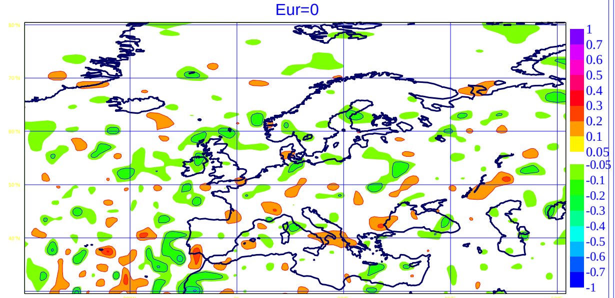

Z500 +36h

Relative Diff in RMS of fc-Error: RMS(fc_f5v5 - an_1) - RMS(fc_f5sh - an_1)
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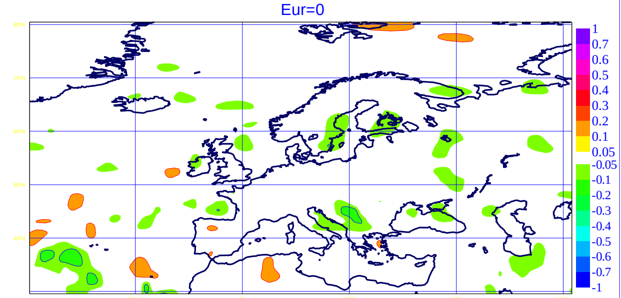

RESULTS

SC3a (100km) vs CONTROL (RMS(exp)-RMS(ctl))/RMSavg

T850 + 12h

Relative Diff in RMS of fc-Error: RMS(fc_f5uv - an_1) - RMS(fc_f5sh - an_1)
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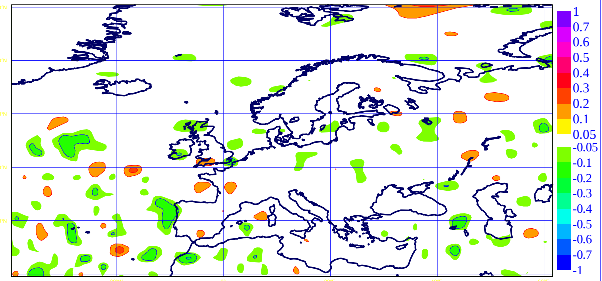
Eur=0



RH700 + 12h

Relative Diff in RMS of fc-Error: RMS(fc_f5uv - an_1) - RMS(fc_f5sh - an_1)
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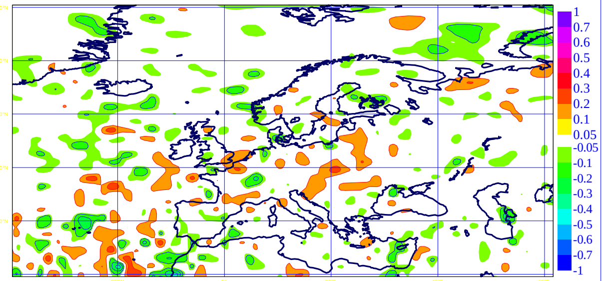
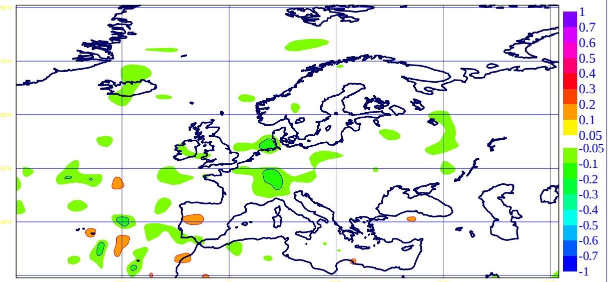


Z500 +12h

Relative Diff in RMS of fc-Error: RMS(fc_f5uv - an_1) - RMS(fc_f5sh - an_1)
Lev=500, Par=z, fcDate=20061222-20070131 0Z, Step=12
Eur=0



T850 + 36h

Relative Diff in RMS of fc-Error: RMS(fc_f5uv - an_1) - RMS(fc_f5sh - an_1)
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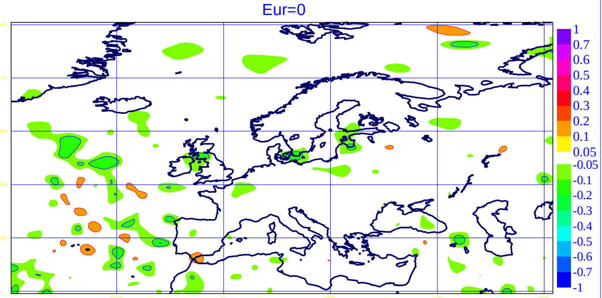
Eur=0



RH700 + 36h

Relative Diff in RMS of fc-Error: RMS(fc_f5uv - an_1) - RMS(fc_f5sh - an_1)
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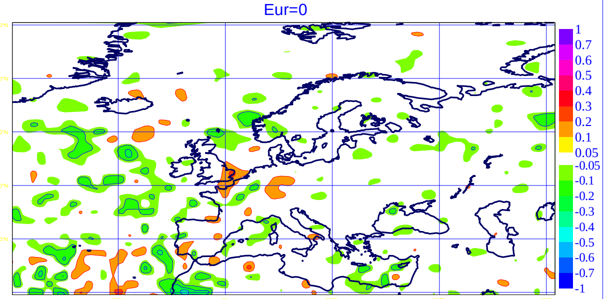
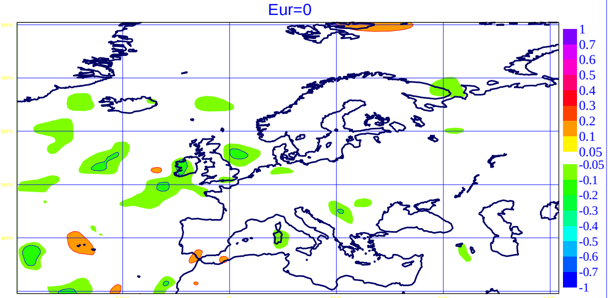
Eur=0



Z500 +36h

Relative Diff in RMS of fc-Error: RMS(fc_f5uv - an_1) - RMS(fc_f5sh - an_1)
Lev=500, Par=z, fcDate=20061222-20070131 0Z, Step=36
Eur=0



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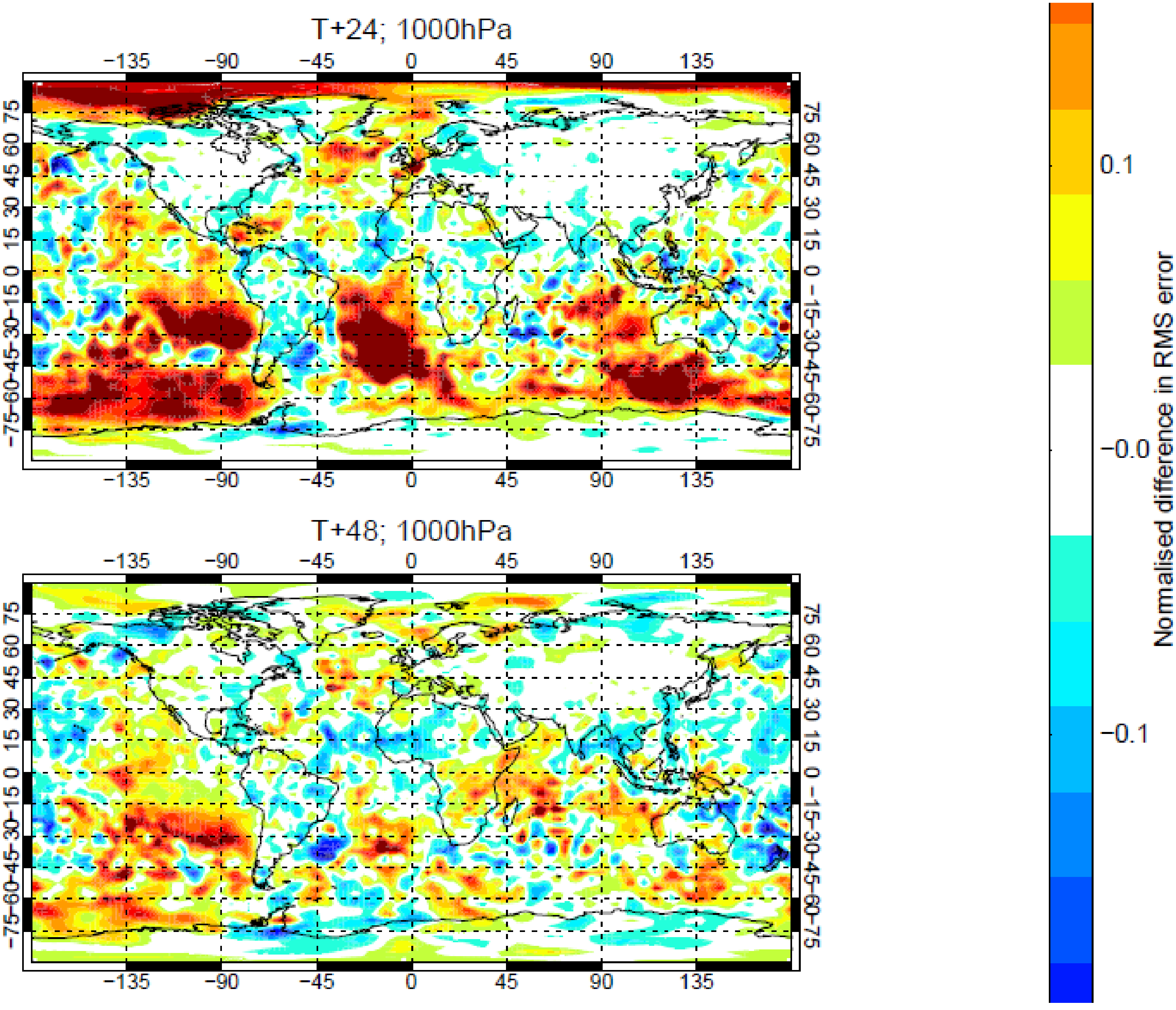
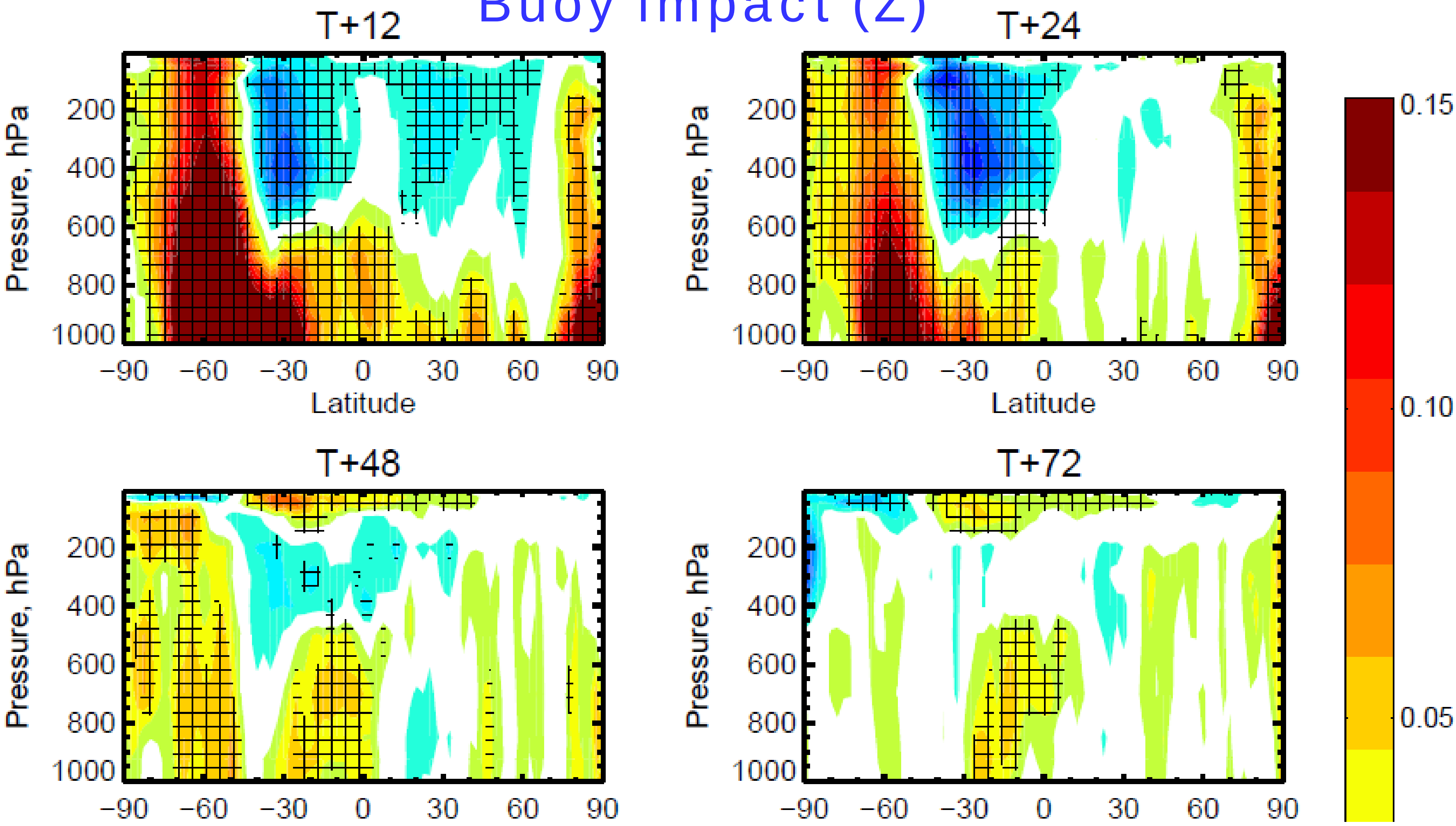
Network design scenarios - results

- **The impact of the upper-air observation denial is the strongest in the first 2 days, it lasts longer (up to 4days) only in the Baseline and Sc5 (500 km thinning), i.e. for the experiments where most observations were removed.**
- **For most of the parameters/levels the impact is stronger in the summer experiments than in the winter ones.**
- **Low level humidity forecasts are most sensitive to the data denial.**
- **100km thinning for radiosondes (scenarios Sc3a-b) hardly shows any forecast degradation.**

Buoy impact, Z 1000 hPa

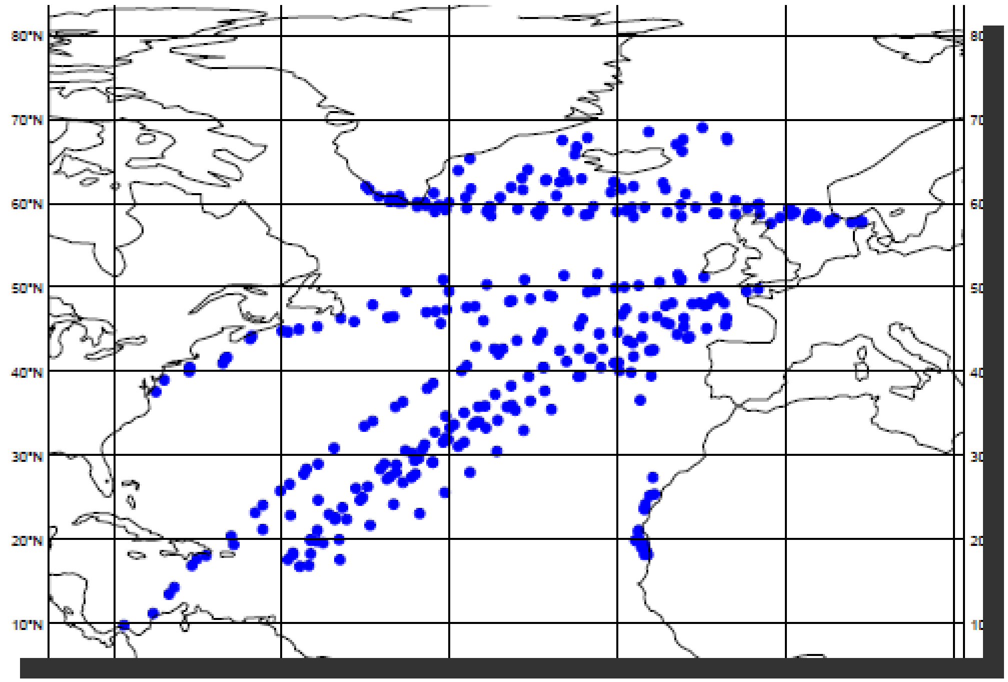


Buoy impact (Z)



- **In a further study, additional E-SURFMAR buoy data locally improve surface pressure FC scores, but this impact is moderate and it lasts up to 24-72h.**
- **Impact of the additional buoy data was clearly seen in extreme weather events.**

Impact of the ASAP fleet



- Clear positive impact in the early range of forecasts
- Clear positive impact in terms of FSO (Met Office & ECMWF)
- Small or difficult to detect impact in the medium range
- Some negative impact in terms of humidity and precipitation. Potential humidity problem indicated also by FSO results.

Summary

- **Global radiosonde and aircraft impacts studied in terms of RMS and bias. (Slides 3 and 6)**
- **GPSRO seems to anchor satellite data more than RS, but with potential ambiguity in vertical structure of bias**
- **stratospheric RS obs are especially important for Tropical wind fc performance**
- **Upper air network redesign study fro Europe: 250km thinning shows some clear degradation, whereas 100km does not**
- **Extra Atlantic buoy observations have clear positive impact**
- **ASAP have clear positive impact in the short range (but some issue with humidity)**

AMMA impact
from Anna Agusti-Panareda

- **The radiosonde humidity bias correction scheme has an important impact over the region where there were many Vaisala RS80 sondes with large relative humidity biases.**
- **After bias correction a better match is obtained with GPS data**
- **The impact of the enhanced radiosonde network is short lived in the FC. The model's boundary layer is too warm and it quickly becomes too deep and well-mixed.**