



# Recent tests with the operational CNMCA-LETKF system

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# Outline

- Operational CNMCA-LETKF system
- Experiments
  - ◆ new observations assimilation:
    - GPS (ztd)
    - MODE-S
  - ◆ DFI
  - ◆ SPPT (COSMO reference version)
  - ◆ COSMO with single precision real
- Recent changes in operations
  - ◆ pseudo-RH variable assimilation (J. Liu,2007)

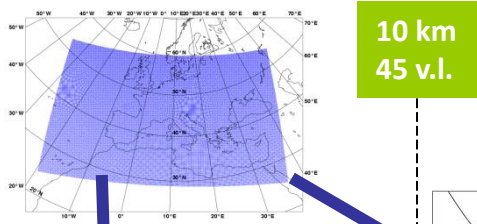




# OPERATIONAL NWP SYSTEM

LETKF analysis ensemble (40+1 members) every 6h using RAOB (also 4D), PILOT, SYNOP, SHIP, BUOY, Wind Profilers, AMDAR-ACAR-AIREP, MSG3-MET7 AMV, MetopA-B scatt. winds, NOAA/MetopA-B AMSUA/MHS and NPP ATMS radiances + Land SAF snow mask, IFS SST analysis once a day

## Ensemble Data Assimilation:



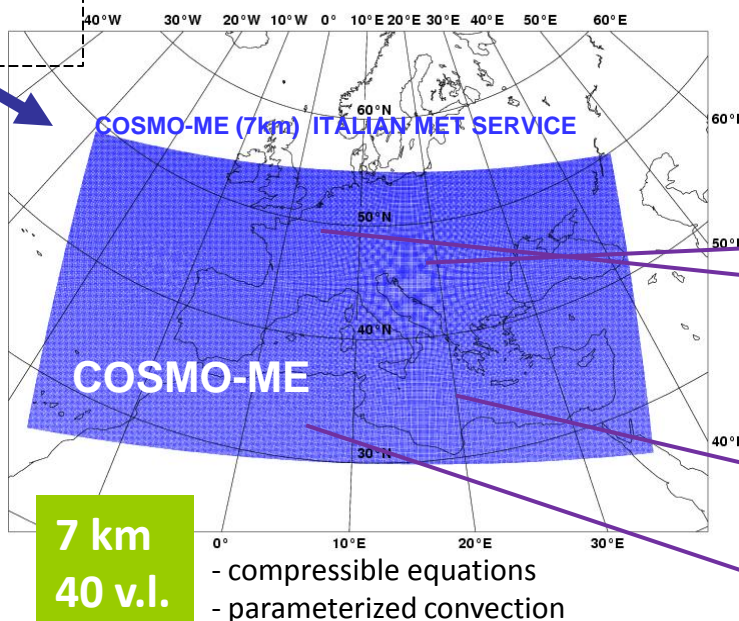
LETKF Analysis

Deterministic Analysis

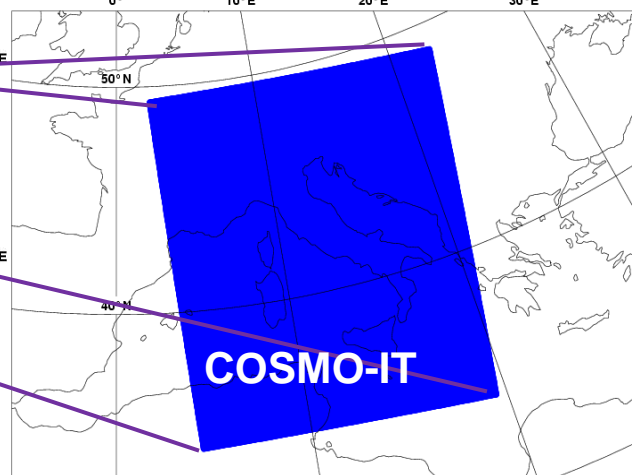
## Local Area Modeling:

2.8 km  
65 v.l.

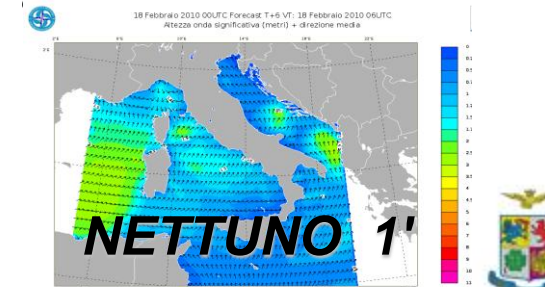
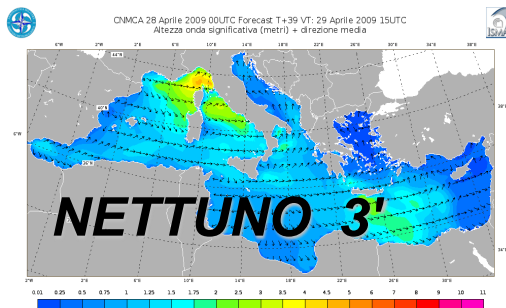
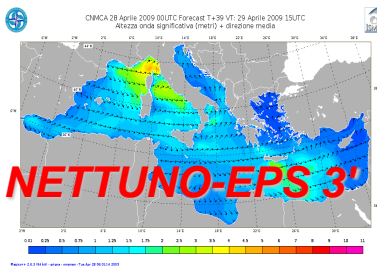
- compressible equations
- explicit convection



COSMO-IT (2.8km) ITALIAN MET SERVICE



Ensemble Prediction System:



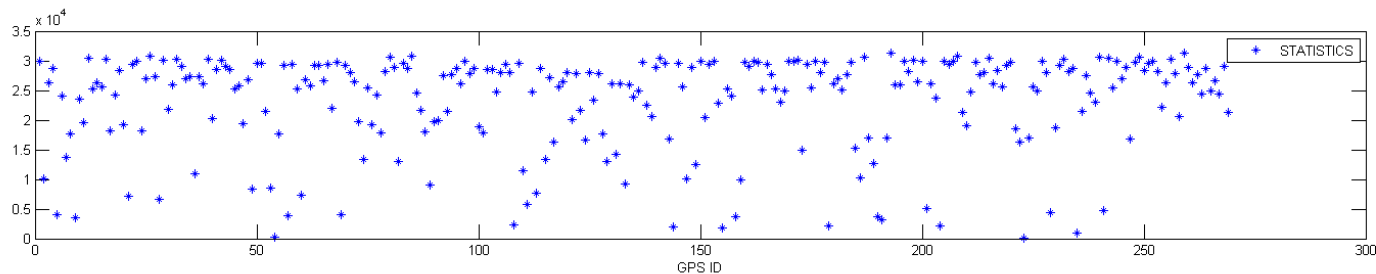
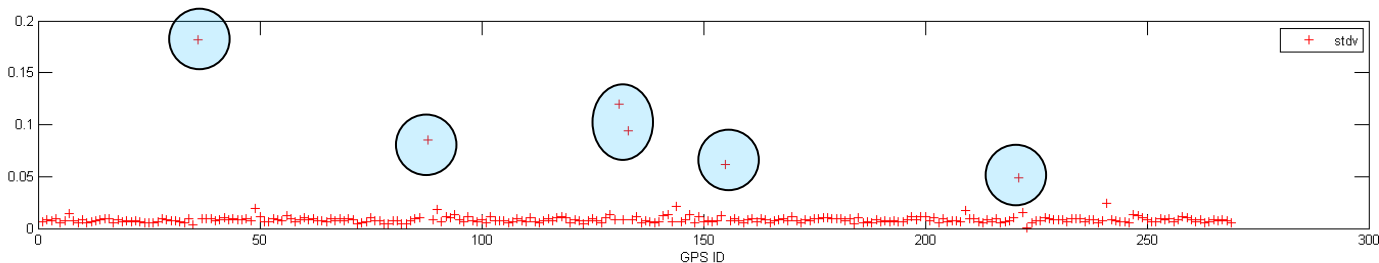
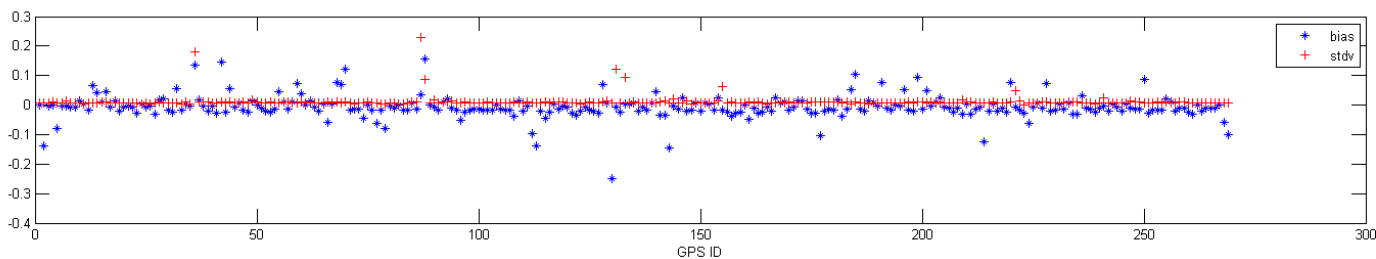


# GPS (ztd) MONITORING/ASSIMILATION

Assimilation from 10nov2014 to 10dec2014:  
MEAN: OBS-FG  $-0.0225E-02$   
STDV : OBS-FG  $0.9499E-02$   
NUMBER OF OBSERVATIONS : 33632

Italian stations

Period : April 2014 -March 2015



Monitoring using CNMCA-LETKF system







# GPS ASSIMILATION

## Forecast verification

Thinning: 80 km

Observation error = 6 mm

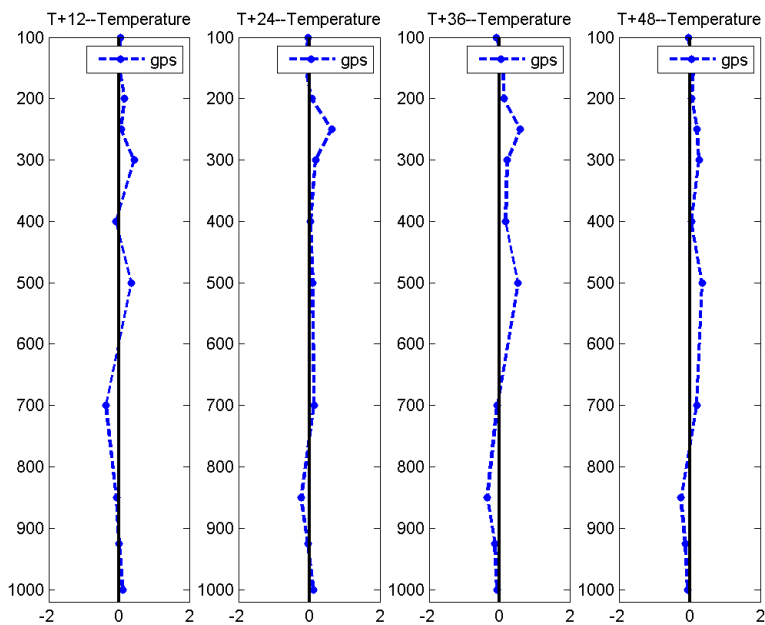
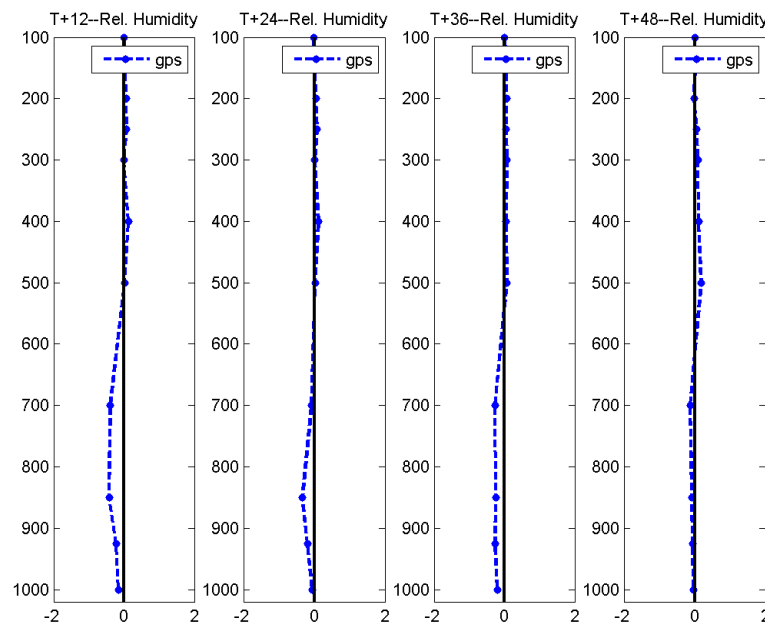
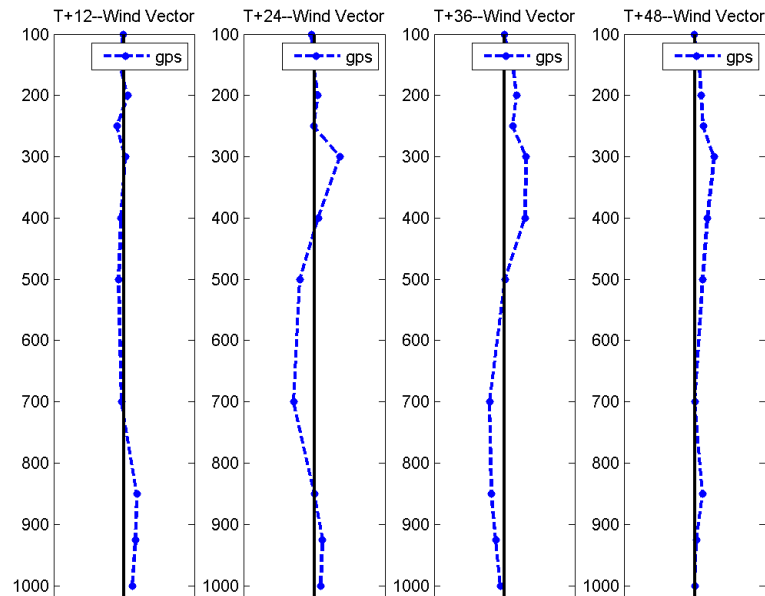
Static bias correction

Relative difference (%) in RMSE, computed against IFS analysis, with respect to

**reference** run without GPS

for 00 UTC COSMO forecasts from 11-nov 2014 to 10 dec 2014

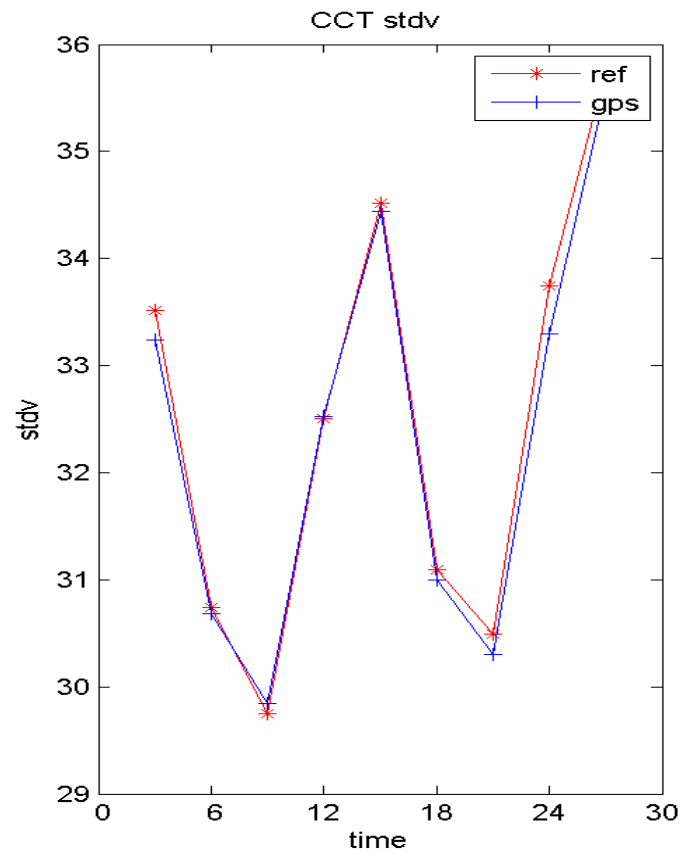
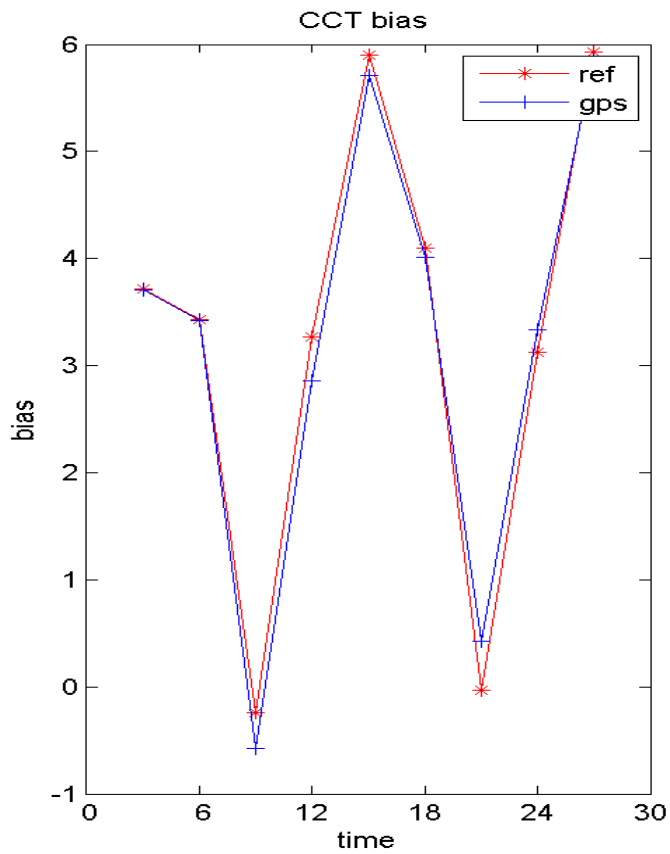
*negative value = positive impact*





# GPS ASSIMILATION

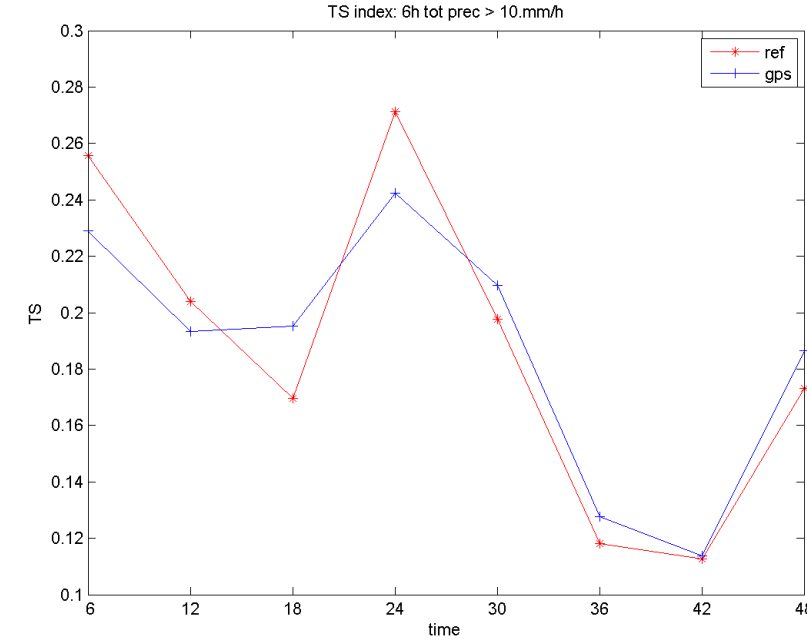
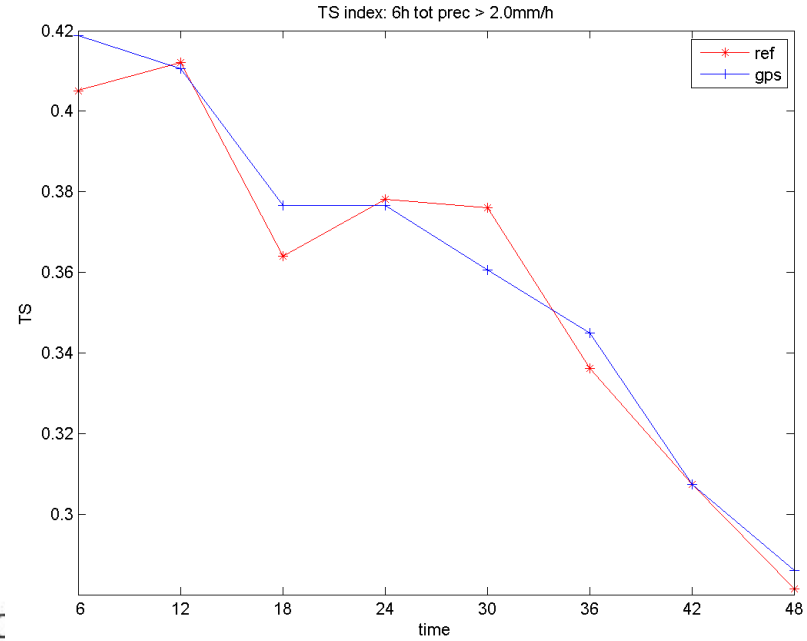
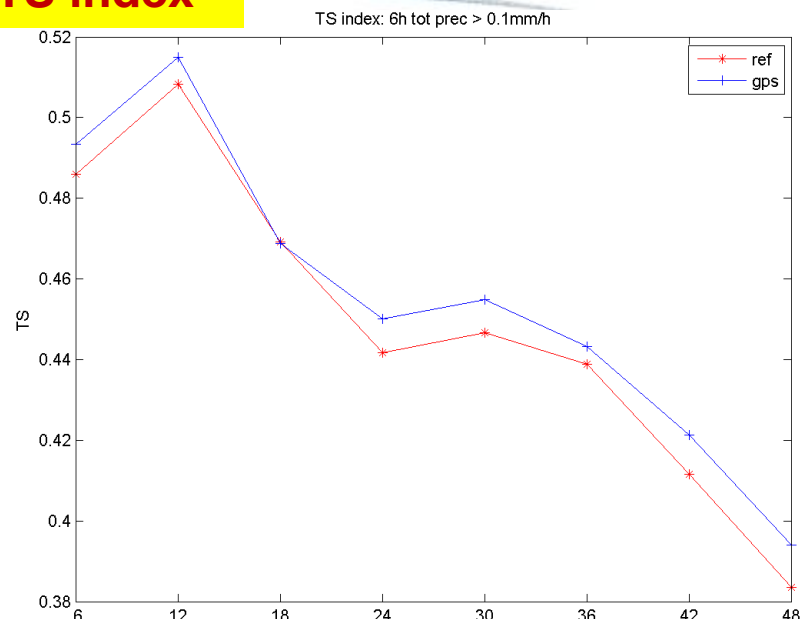
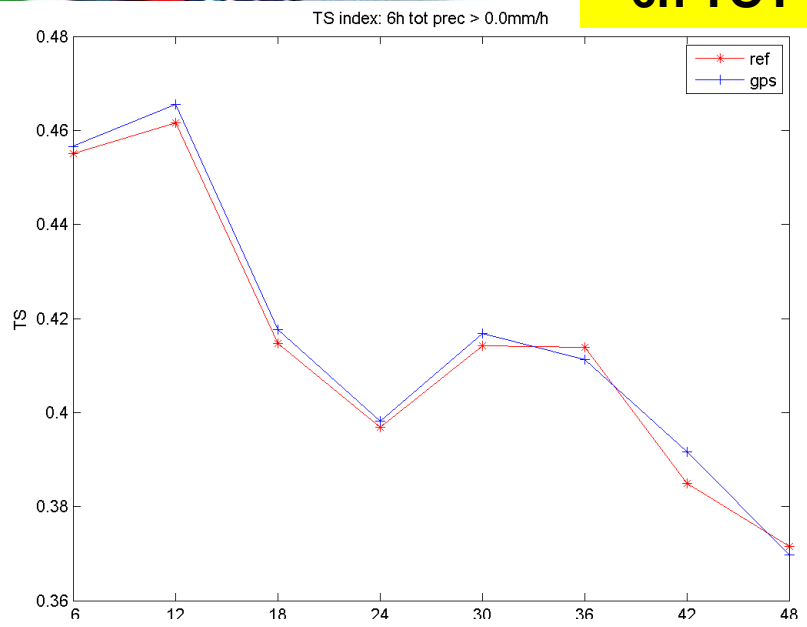
## forecast verification with obs





# GPS ASSIMILATION: forecast verification with obs

## 6h TOT PREC TS index



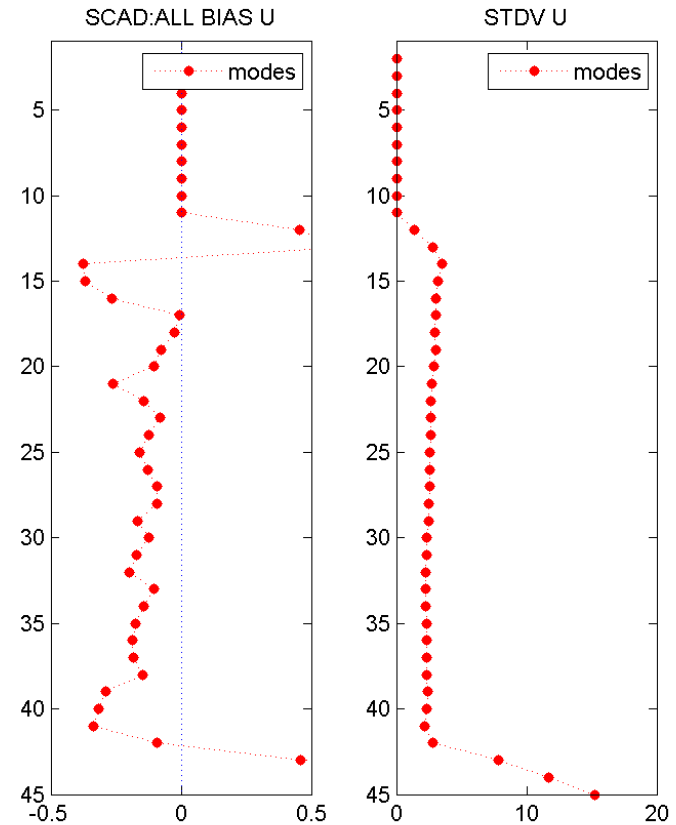
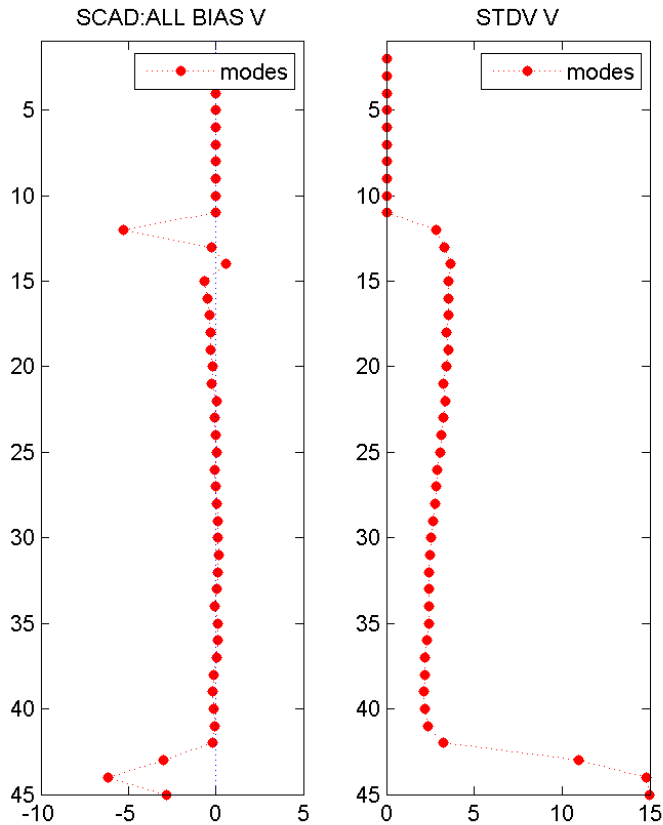


# MODE-S MONITORING

1 JAN – 1 APR 2015

MODES in BUFR format from KNMI

Monitoring using  
CNMCA-LETKF system

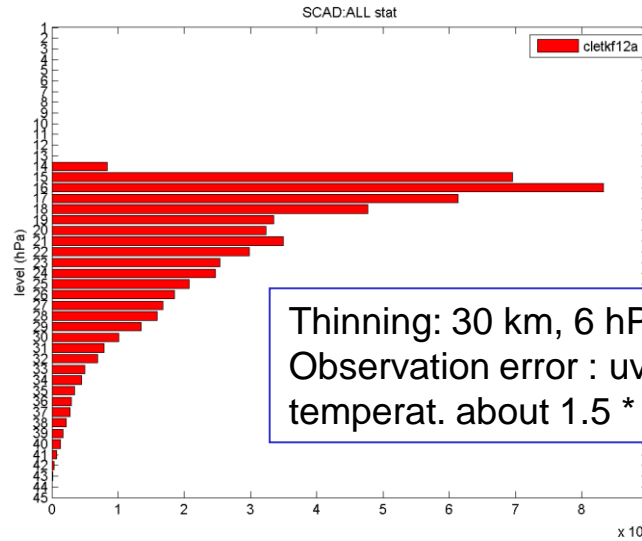
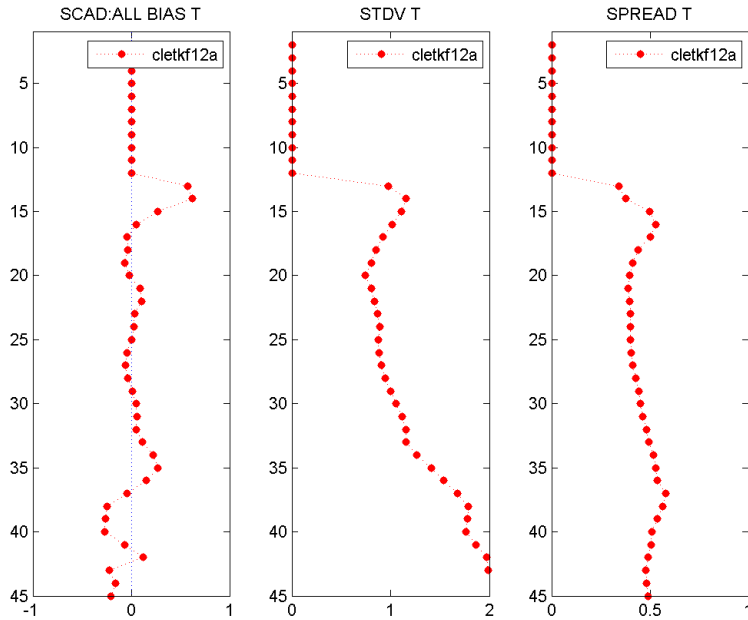




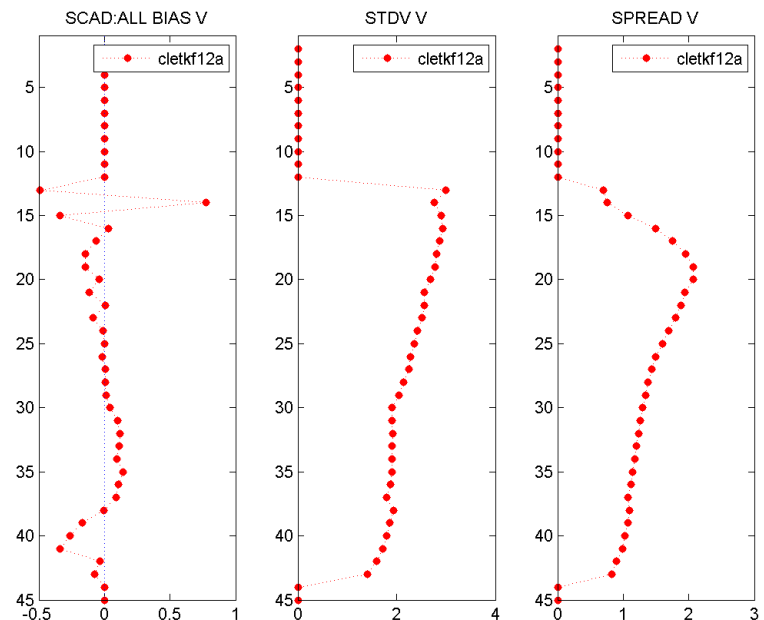
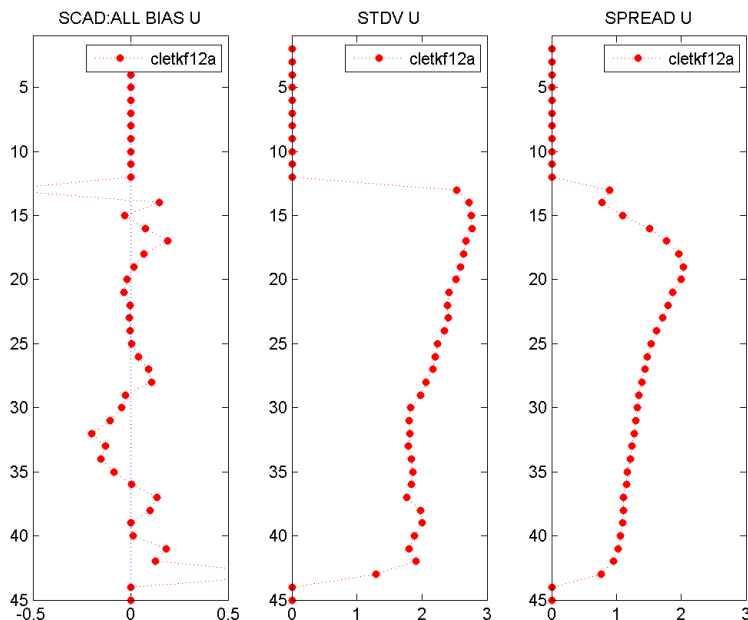


# MODE-S ASSIMILATION

## MODE-S OBS INCR STATISTICS from 10nov2014 to 10dec2014



Thinning: 30 km, 6 hPa  
Observation error : uv-wind as AMDAR,  
temperat. about 1.5 \* AMDAR T error





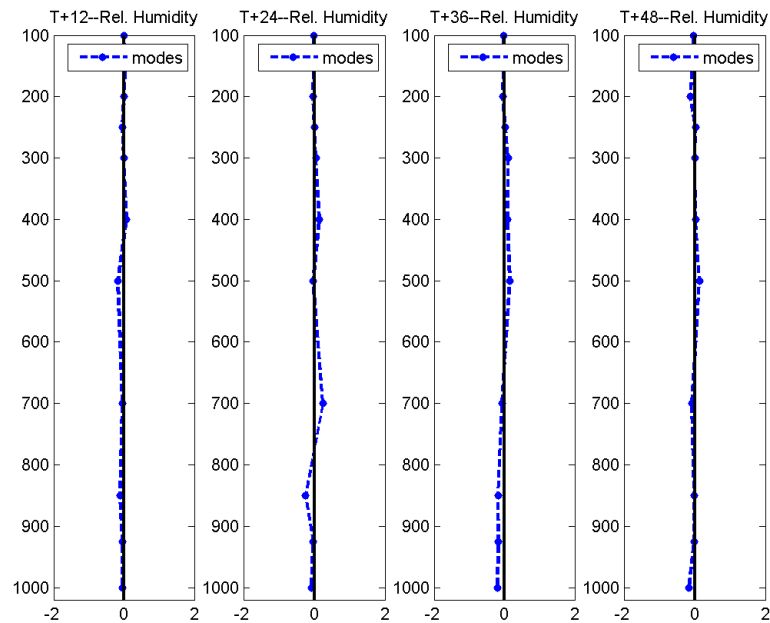
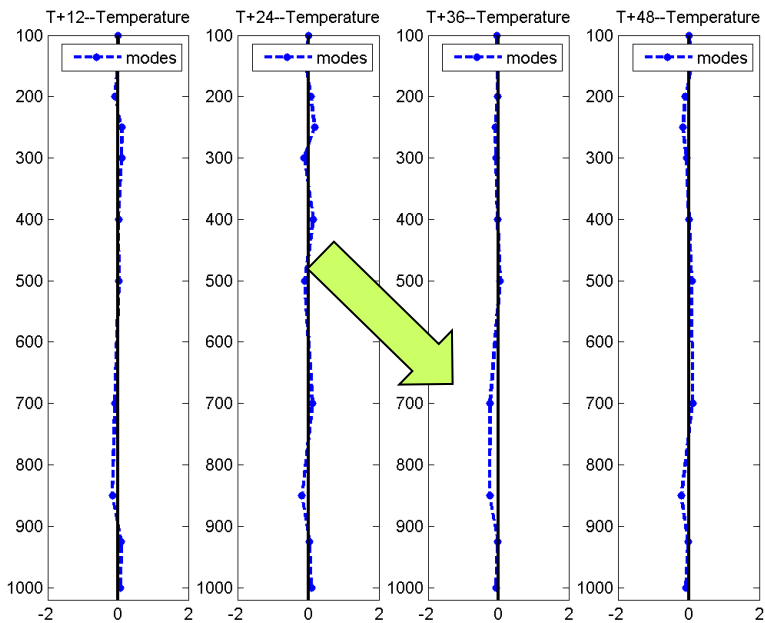
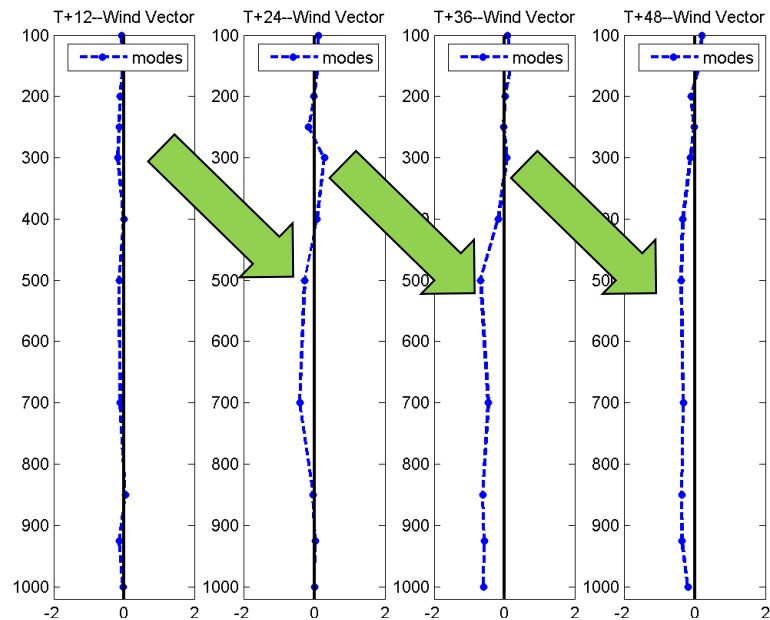
# MODE-S ASSIMILATION

## Forecast verification

Thinning: 30 km

Relative difference (%) in RMSE, computed against IFS analysis, with respect to **reference** run without MODE-S for 00 UTC COSMO forecasts from 11-nov 2014 to 10 dec 2014

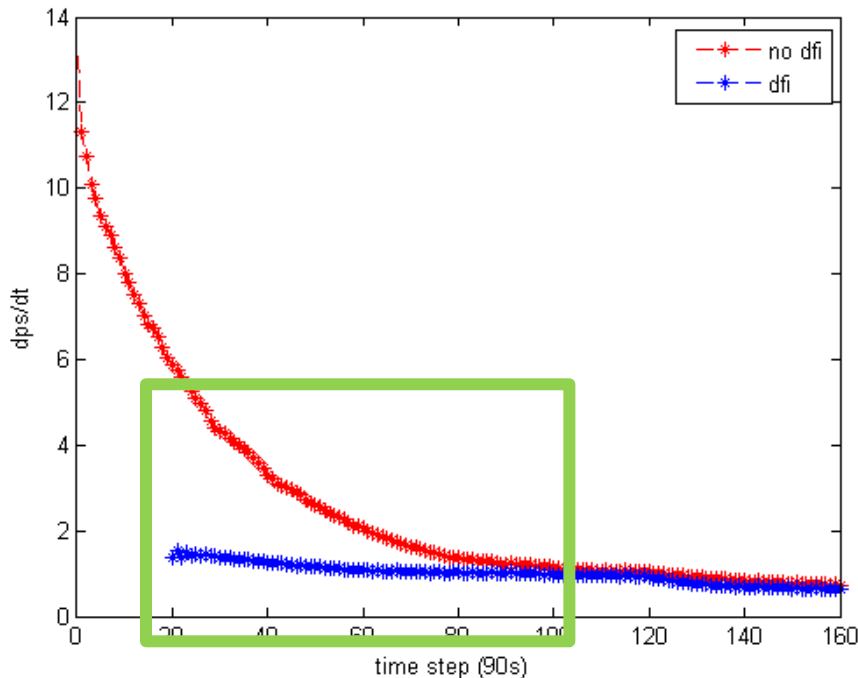
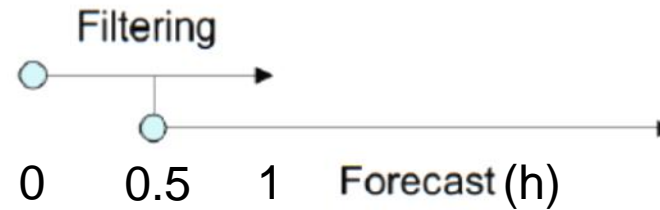
*negative value = positive impact*





# DIGITAL FILTER INIT. tests

DFL:  
(Lynch and Huang, 1994)



DFI original:

All prognostic variables are filtered

DFI new:

- qv filtered but corrected to maintain saturated grid point at 0.5h step of filtering run

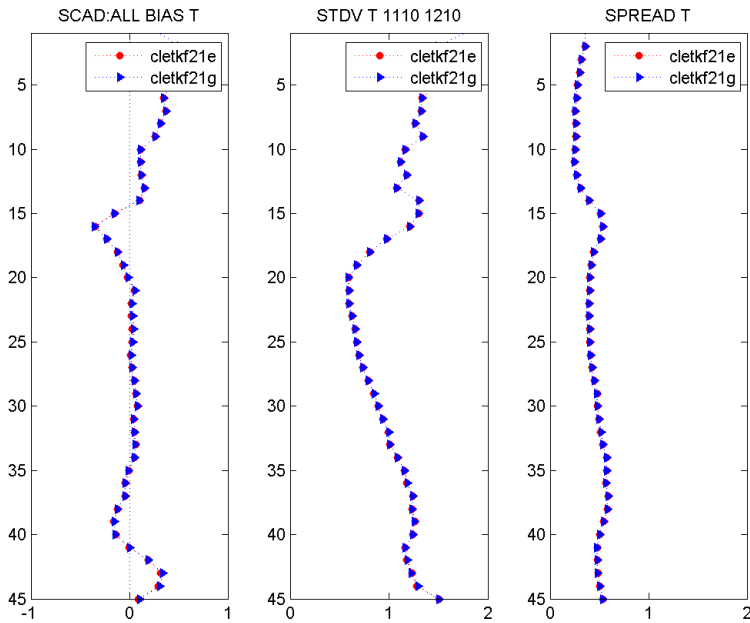
- qx initialized with instantaneous values valid at 0.5h step of filtering run



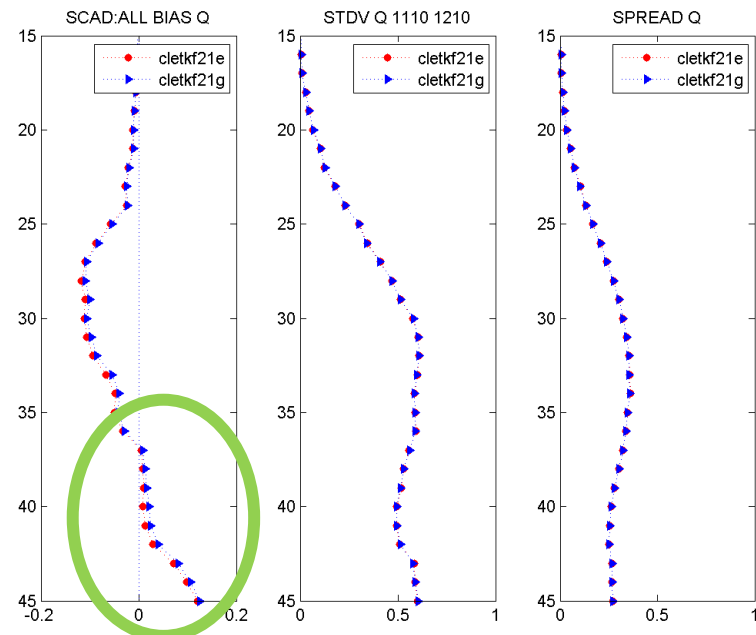
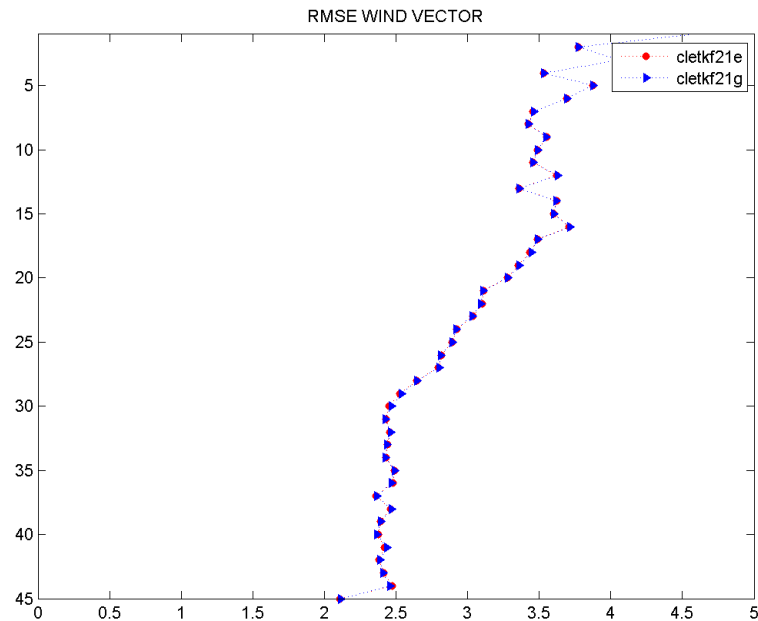


# DIGITAL FILTER INIT. tests

RAOB OBS INCR STATISTICS  
from 10nov2014 to 10dec2014



dfi\_orig  
vs  
dfi\_new



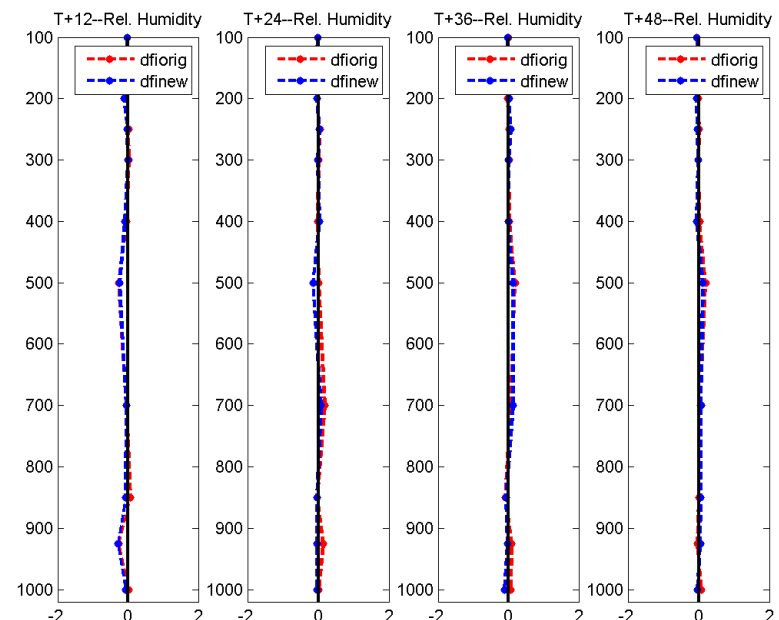
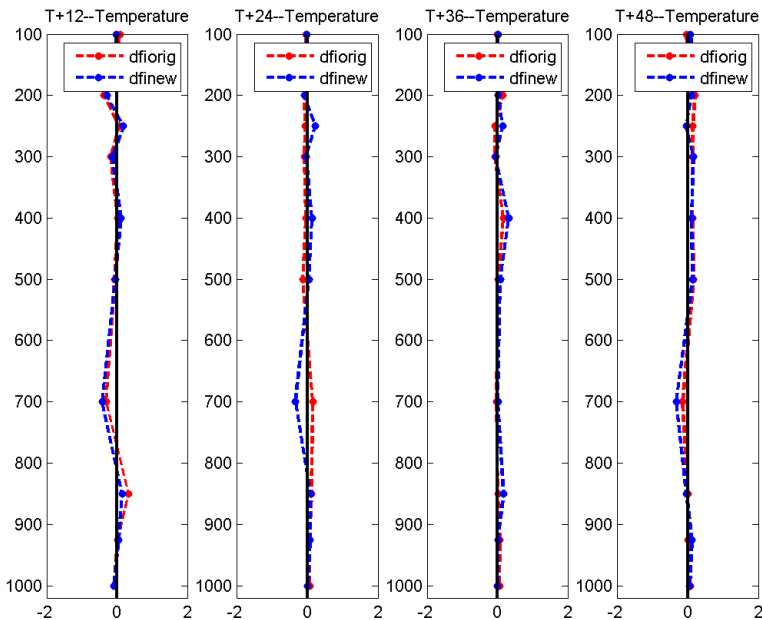
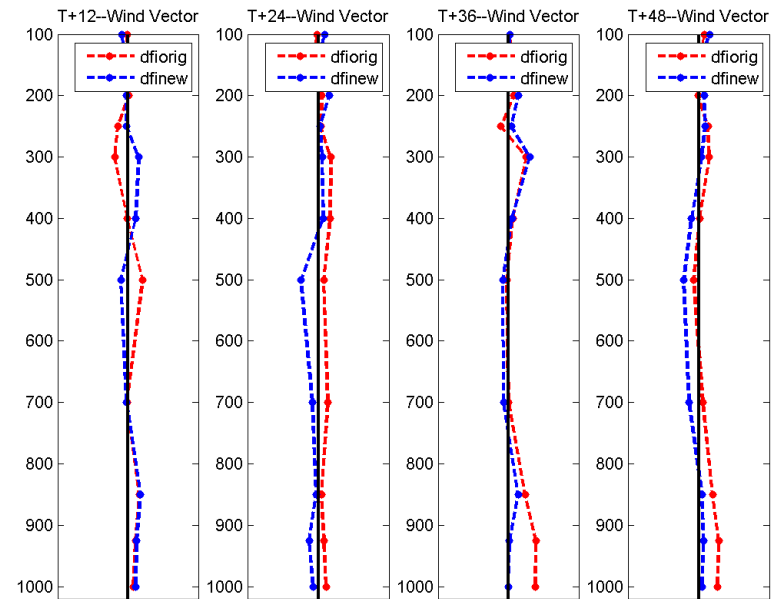


# DIGITAL FILTER INIT. tests

Relative difference (%) in RMSE, computed against IFS analysis, with respect to the **reference** run without DFI for 00 UTC COSMO forecasts from 11-nov 2014 to 10 dec 2014

*negative value = positive impact*

**dfi\_new**  
 VS  
**dfi\_orig**



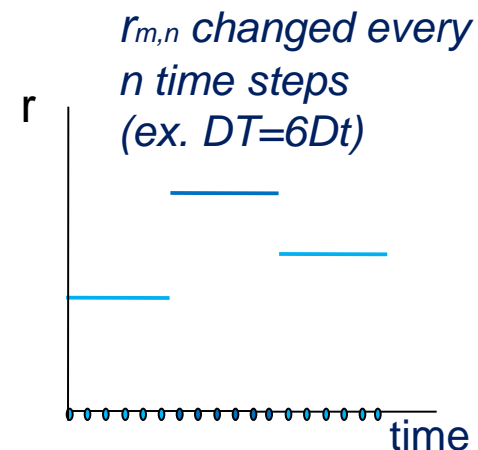
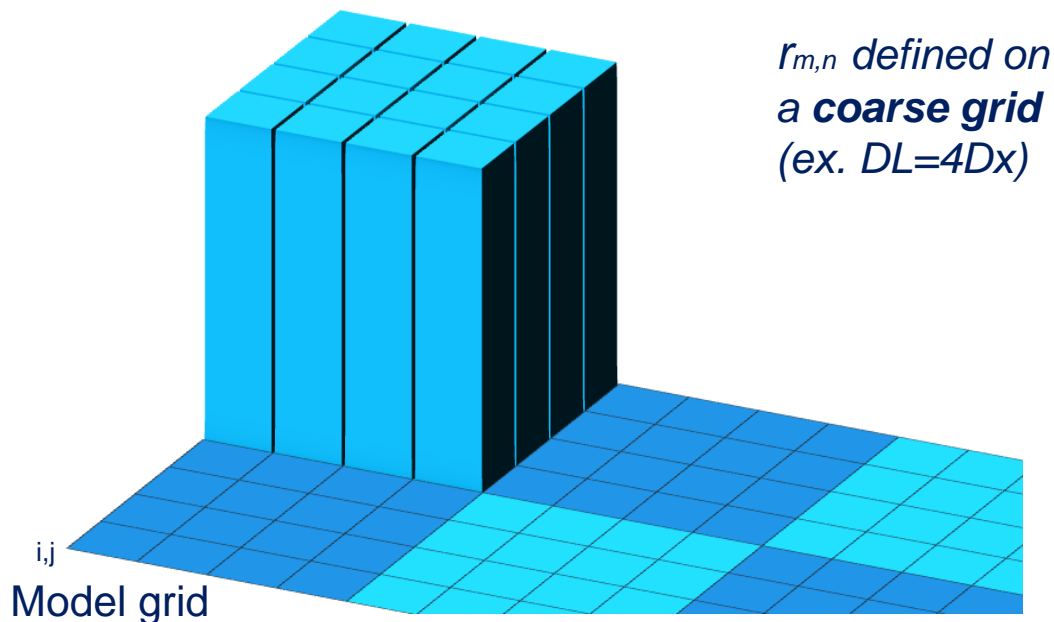




# Stochastic Perturbed Physics Tendency

- Model uncertainty could be represented also with a stochastic physics scheme (Buizza et al, 1999; Palmer et al, 2009) implemented in the prognostic model
- This scheme perturbs model physics tendencies by adding perturbations, which are proportional in amplitude to the unperturbed tendencies  $X_c$ :

$$X_p = (1 + r \mu) X_c$$



**Included in COSMO Reference Version (Torrìsi et al)**

Random numbers are drawn on a horizontal coarse grid from a Gaussian distribution with a stdv (0.1-0.5) bounded to a certain value (range =  $\pm 2-3$  stdv) and interpolated to the model grid to have a smoother pattern in time and horizontally in space. Same random pattern in the whole column and for  $u, v, t, qv$  variables.

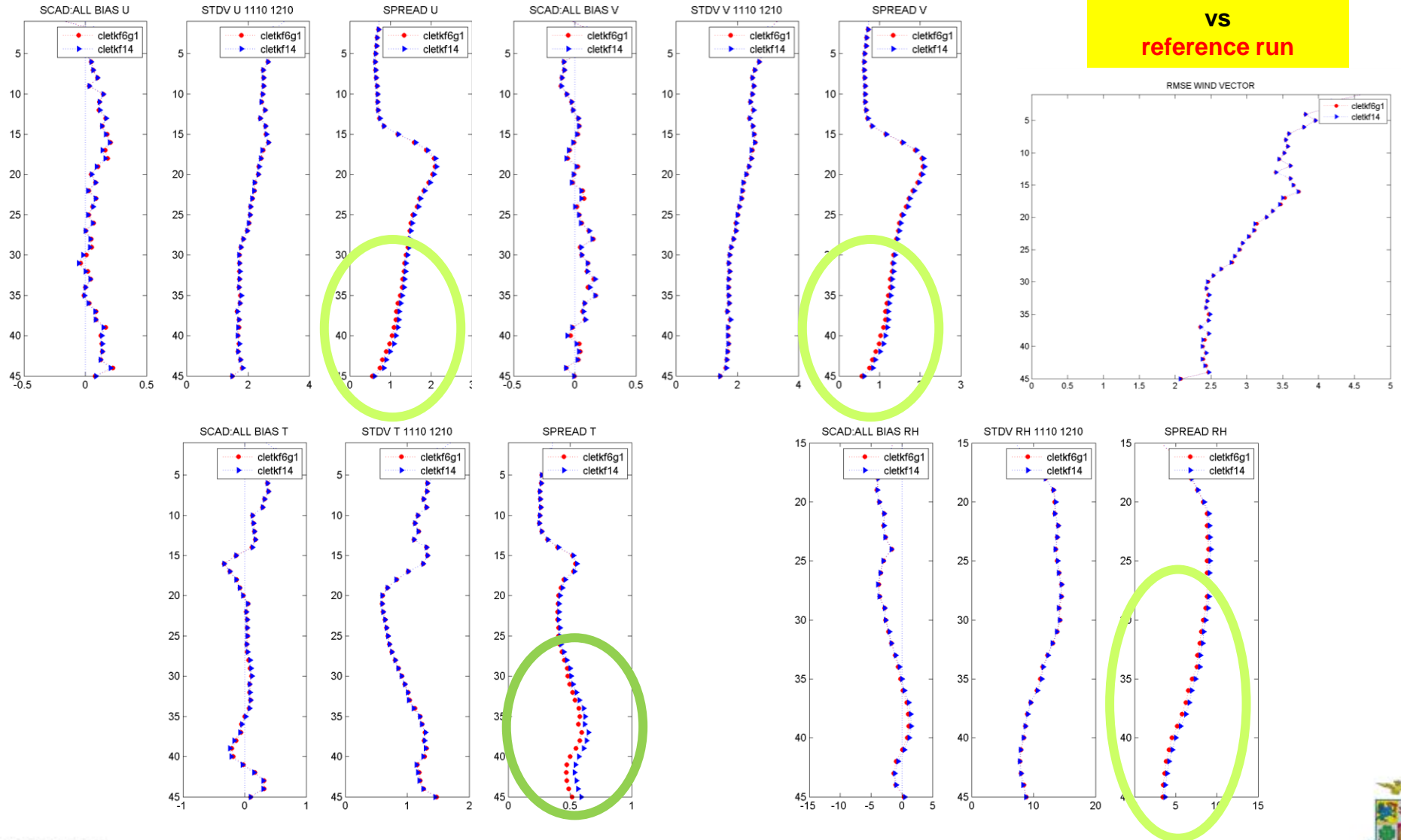




# STOCHASTIC PERTURBED PHYSICS TENDENCIES (SPPT)

RAOB OBS INCR STATISTICS from 10nov2014 to 10dec2014

**SPPT  
vs  
reference run**

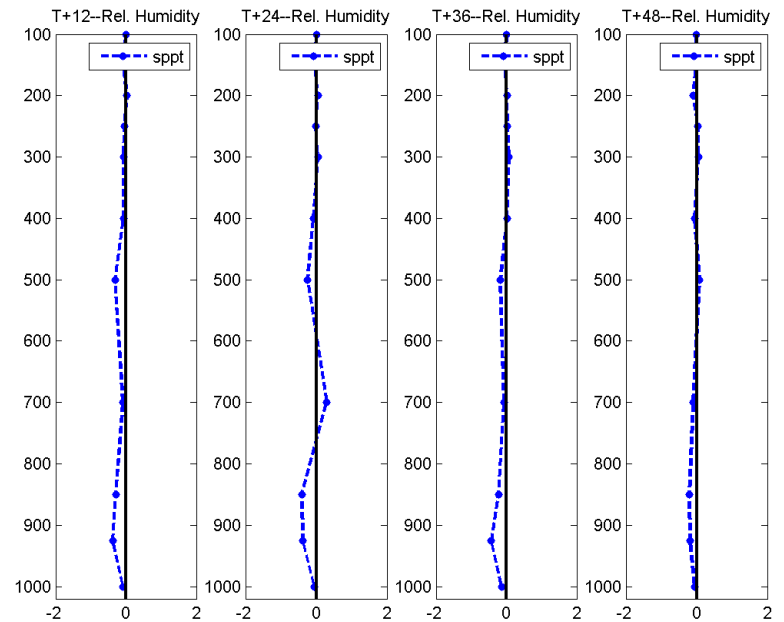
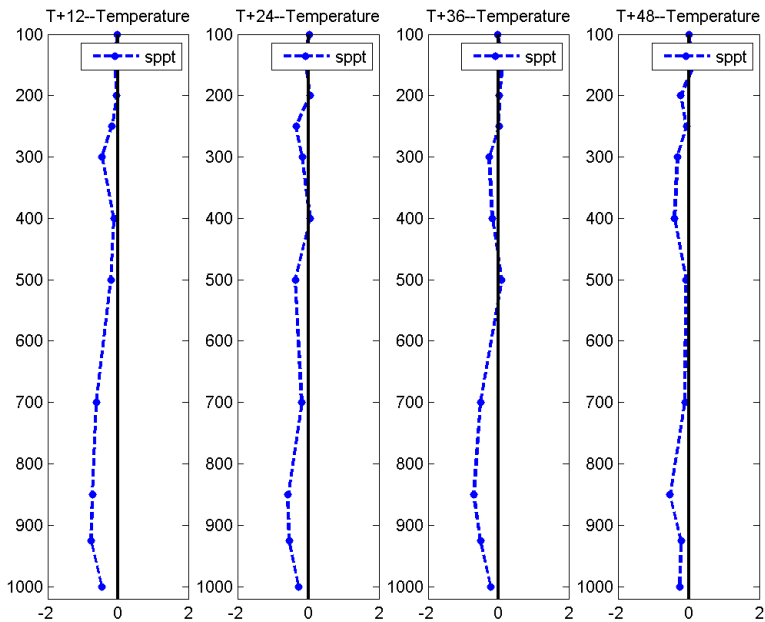
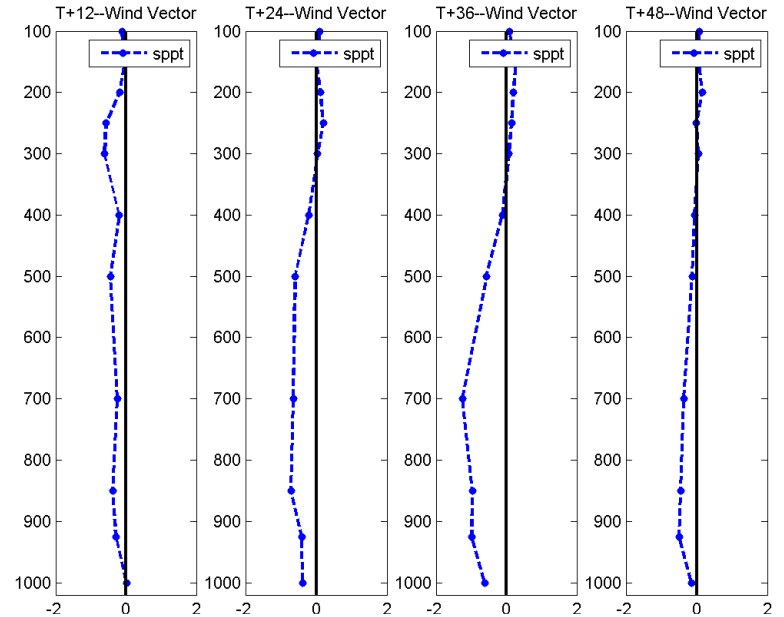




# SPPT

## Forecast verification

Relative difference (%) in RMSE, computed against IFS analysis, with respect to **reference** run without SPPT for 00 UTC COSMO forecasts from 11-nov 2014 to 10 dec 2014  
*negative value = positive impact*

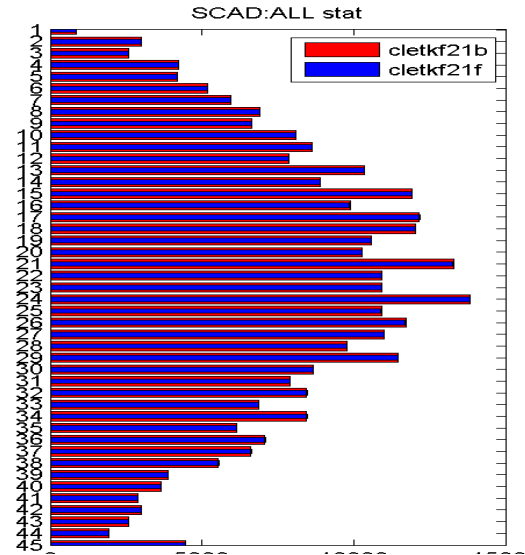
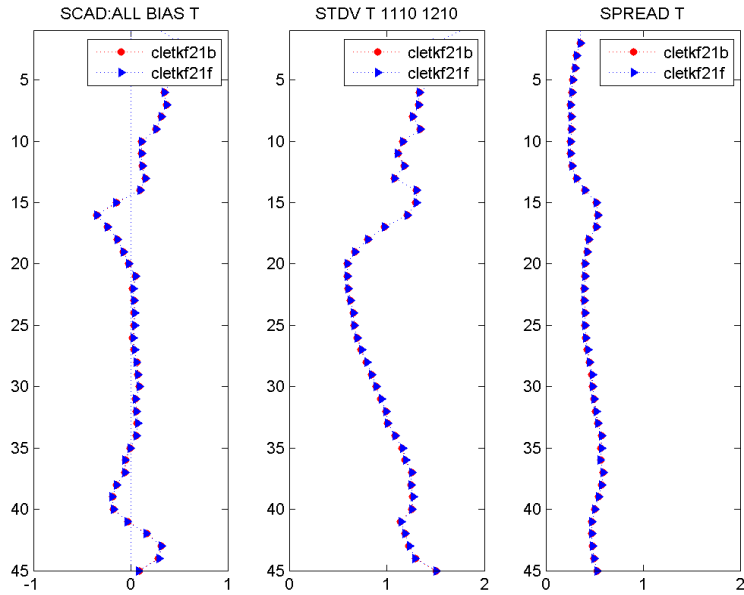




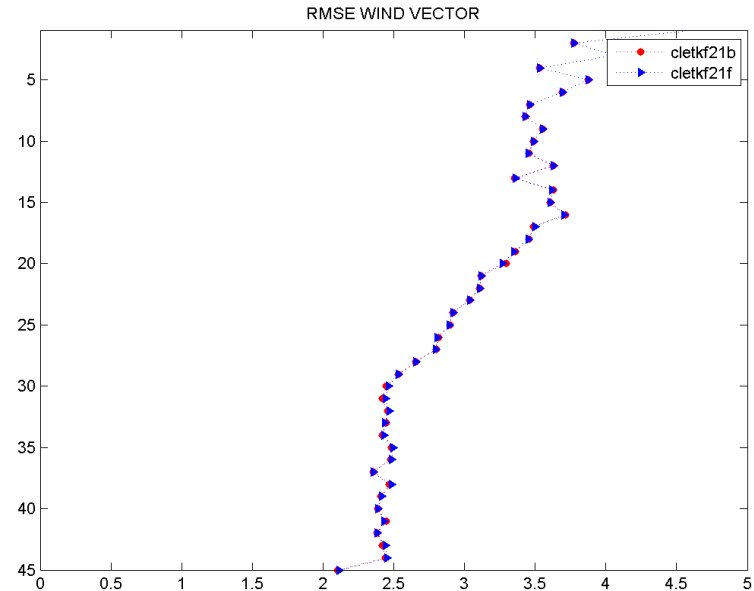
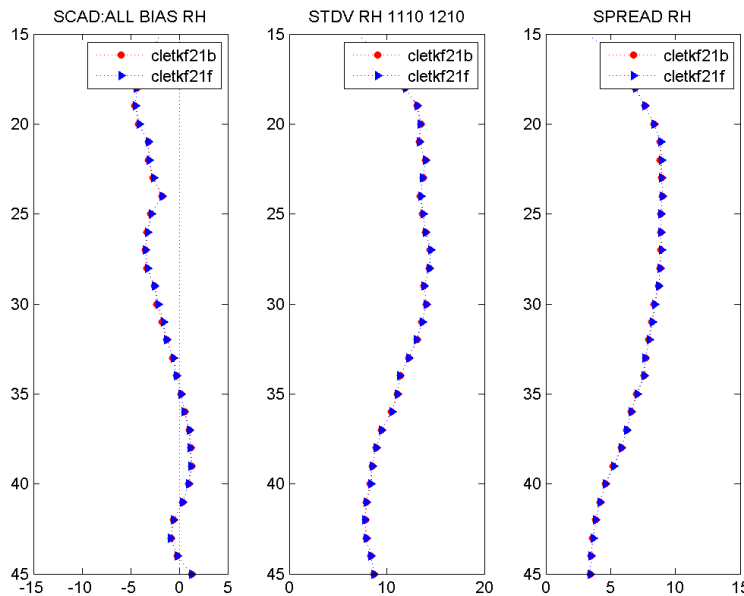
# COSMO with Single Precision Real

Not in the deterministic run

## RAOB OBS INCR STATISTICS from 10nov2014 to 10dec2014



**Single prec  
vs  
reference run**





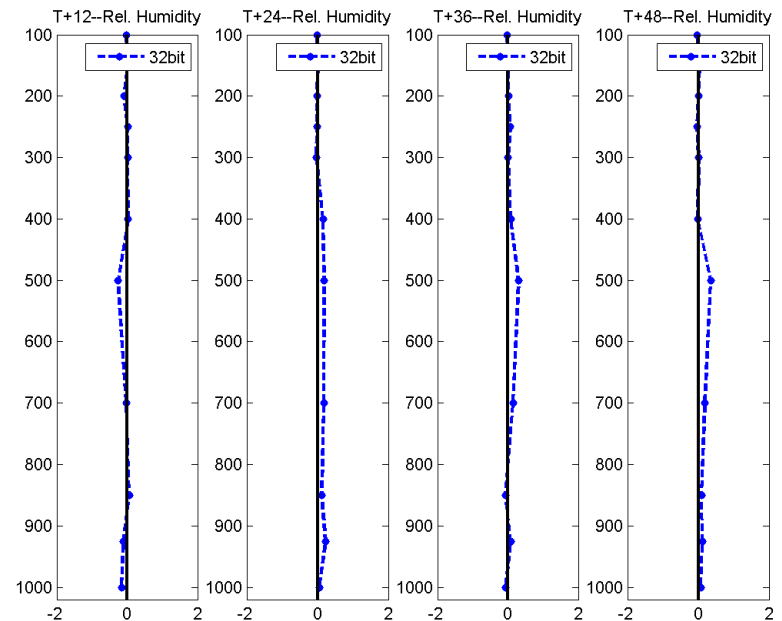
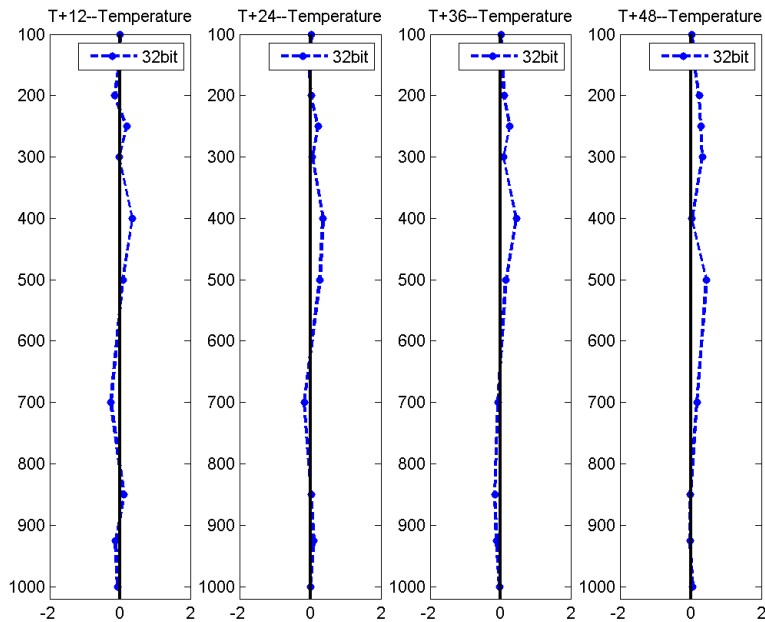
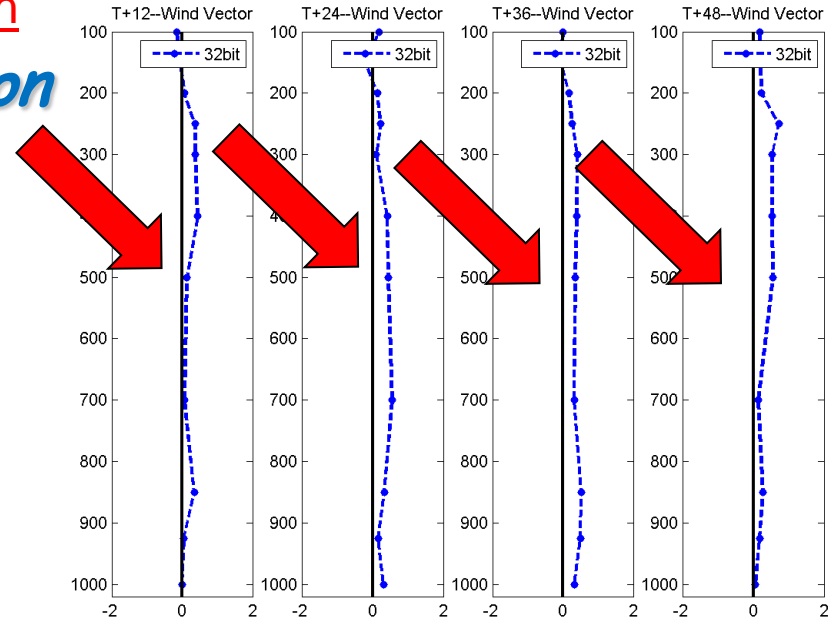
# COSMO with Single Precision Real

Not in the deterministic run

## Forecast verification

Relative difference (%) in RMSE, computed against IFS analysis, with respect to **reference** run with double prec. real for 00 UTC COSMO forecasts from 11-nov 2014 to 10 dec 2014

*negative value = positive impact*







# Changes in CNMCA-LETKF system

## PSEUDO-RH VARIABLE

*Among the other choices of humidity variable types, the best result is from pseudo-RH assimilation. The error distribution of pseudo-RH is more Gaussian than specific humidity observations. It has similar error distribution as the relative humidity observations, but unlike relative humidity observations, it has no error correlation with the other observation variables (J. Liu, 2007, PhD thesis)*

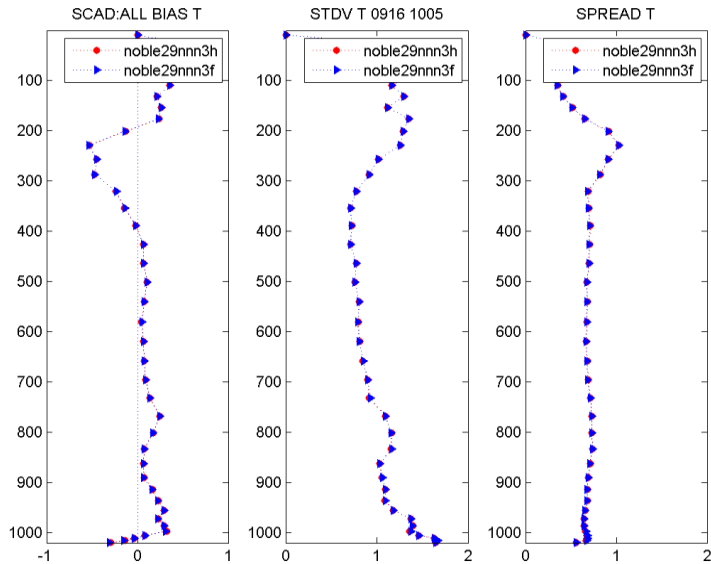
- 1- NEW pseudo-RH variable (J. Liu formulation) : specific humidity observations normalized by the mean saturated specific humidity ( $q_i / q_{sat\_mean}$ )
- 2- OLD pseudo-RH variable  $q_i / q_{i\_sat}$ , defined for each i-member → change of variable: used both in weight computation and linear combination



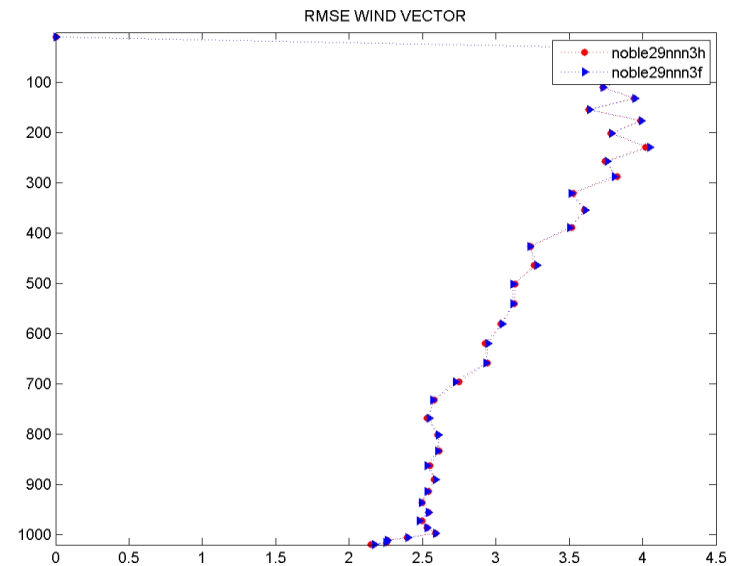
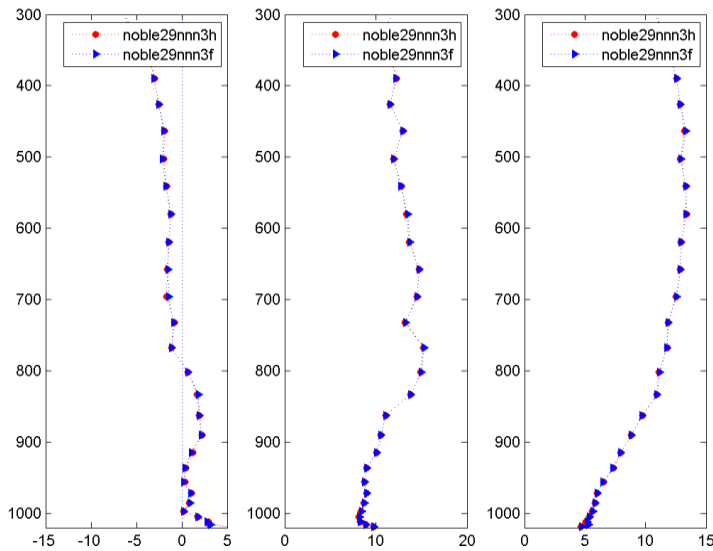
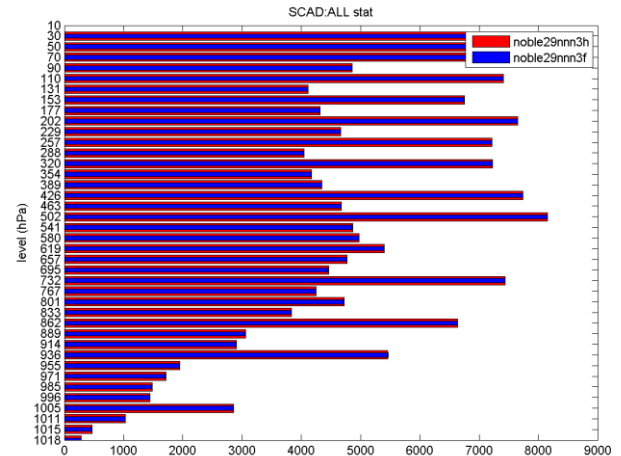


# LIU PSEUDO-RH VARIABLE

RAOB OBS INCR STATISTICS from 16-09-2012 to 05-10-2012



**OLD PRH  
VS  
LIU PRH**

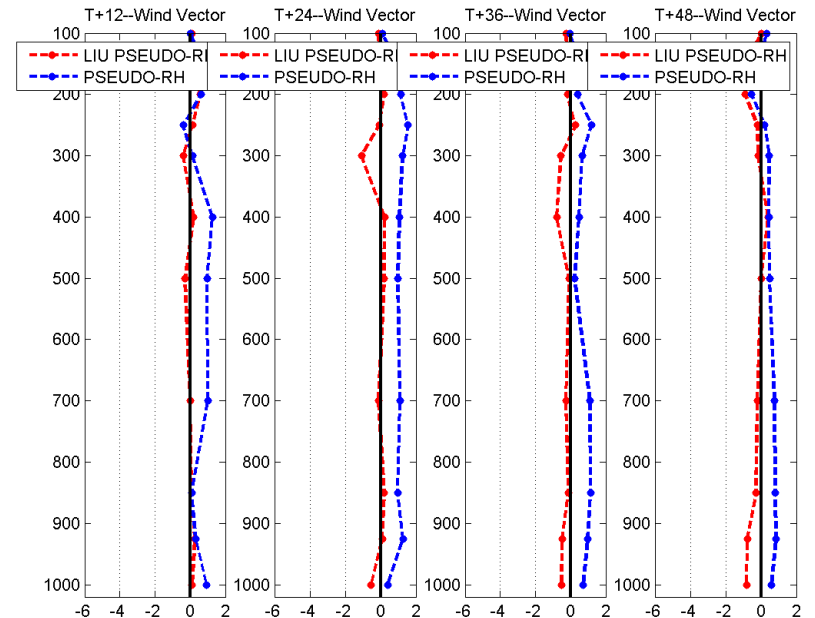
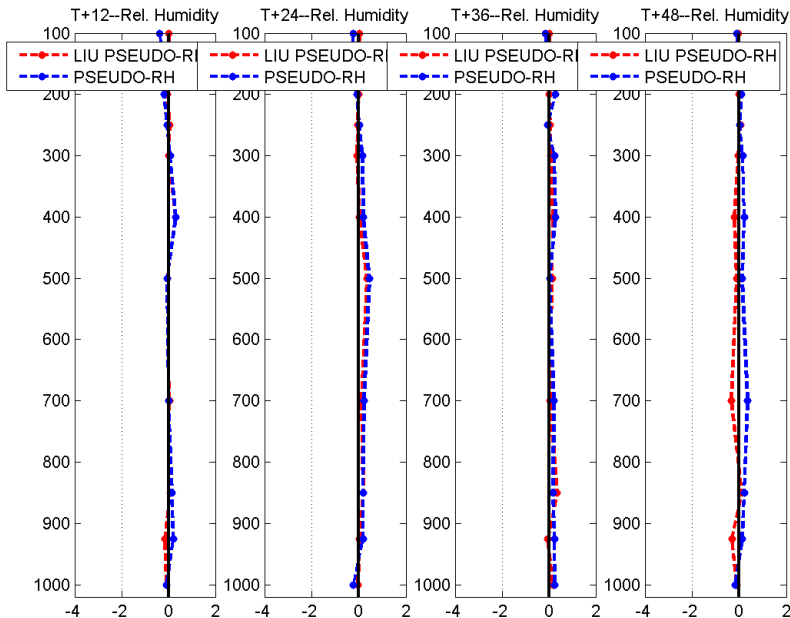
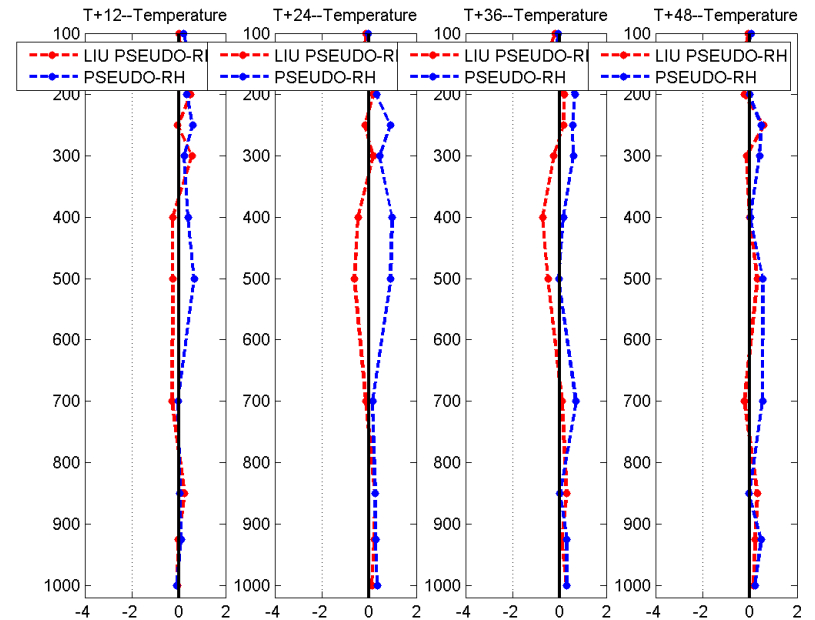




# LIU PSEUDO-RH VARIABLE

Relative difference (%) in RMSE computed against IFS analysis with respect to the reference run with qv for 00 UTC COSMO forecasts from 16-09-2012 to 05-10-2012

*negative value = positive impact*

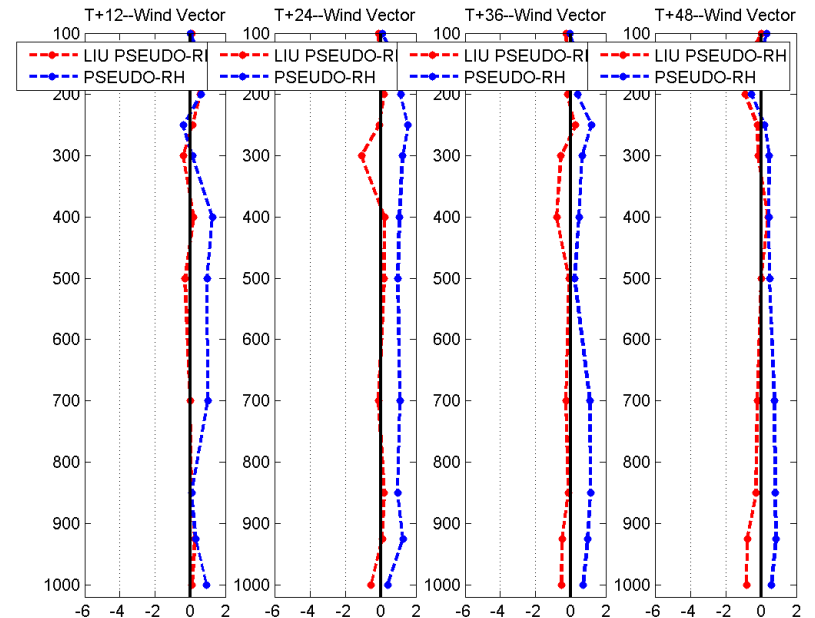
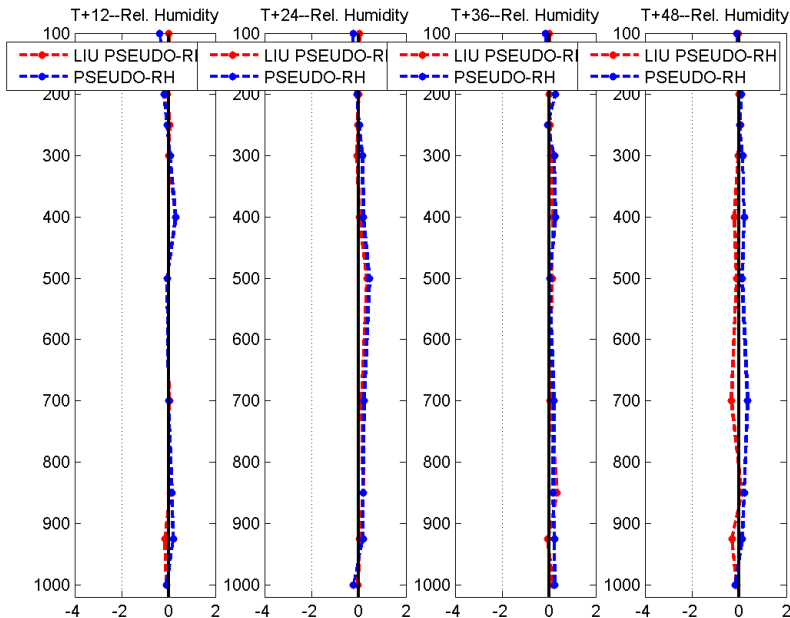
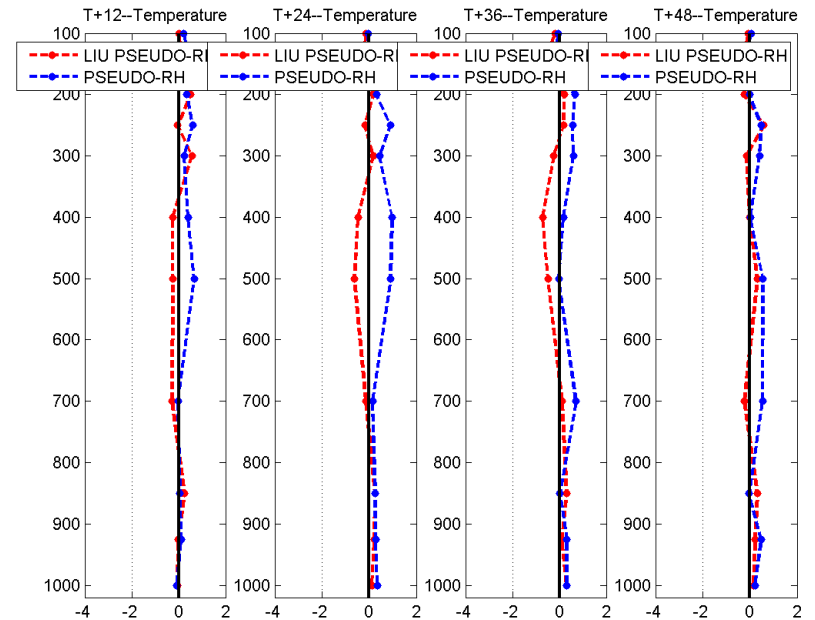




# LIU PSEUDO-RH VARIABLE

Relative difference (%) in RMSE computed against IFS analysis with respect to the reference run with qv for 00 UTC COSMO forecasts from 16-09-2012 to 05-10-2012

*negative value = positive impact*





# Current and future developments

- Tests using COSMO single precision real
- Assimilation of GPS ground stations and MODES is under investigation.
- Monitoring of local automatic stations and satellite derived soil moisture (H-SAF)
- Improvement of radiance vertical localization
- Self-evolving additive inflation/SPPT
  
- H-SAF soil moisture assimilation affecting low level variables
- Shorter assimilation window using KENDA







Thanks for your  
attention!

