

Testing the ALARO0 baseline on Croatian operational domain

Abstract

ALARO0 baseline has been tested using cycle AL38T1 and namelist parameters as recommended in the ALARO0 baseline namelist documentation on the domain used for operational forecast in the Croatian Meteorological and Hydrological Service. Horizontal resolution in the domain is 8 km on 37 levels in the vertical. The contributions of various processes and assumptions were tested by varying namelist parameters and running 72 hour forecasts for the two whole months, for January and May 2014. Tests with higher vertical resolution on 73 levels in the vertical and non-hydrostatic dynamics were also performed. The contribution of cycling of prognostic TKE, cloud liquid water and ice, rain, snow, updraft, downdraft vertical velocities and mesh fractions, and prognostic detrainment through the assimilation cycle was computed for January and May 2014.

Introduction

The first reference is the operational forecast. It is run using AL32T3 but it differs with some of the ALARO switches due to complaints from the forecast office regarding cloudiness and temperature forecast in cases with low stratus and fog during the cold part of the year. The main difference arrives from the switch LRNUMX=F that uses random overlap assumption for cloudiness (random maximum overlap if TRUE). As will be described further in more detail, the switch enables better forecast of temperature at 2m and cloudiness during winter, especially in situations with low stratus and fog. Consequently, significant portion of improvements in the radiation scheme was switched off too, since it had little or no contribution. The namelist switches that are different in the operational suite using AL32T3 from the ALARO values are listed in Table 1.

Table 1. Parameters are different in the operational suite than in alaro.

Parameter	oper	alaro0	function
LRNUMX	F	T	F for random overlap, true for maximum random overlap
LRMIX	F	T	Exchange between layers combines maximum and minimum optical depths
LRPROX	F	T	Do not use LRMIX for adjacent layers
LRSTAB	F	T	Stabilisation of NER terms for long timesteps
LRTDL	F	T	Nonlinear computation of LRPROX
LRTPP	F	T	Continuous temperature profile for LRPROX
L3MT	F	T	Prognostic deep convection
LCVRA	T	F	Diagnostic deep convection
LFPCOR	T	F	Used for diagnostic convection scheme
LSTRA	T	F	Main switch for old stratiform precipitation
LSTRAPRO	T	F	Prognostic microphysics outside 3MT, can be false if L3MT

The operational suite uses prognostic schemes for TKE, cloud water and ice, rain and snow, but uses diagnostic convection scheme. The cycling of variables in the data assimilation suite with 3Dvar does not include TKE and prognostic condensates. On 1st January 2014, the operational suite switched from coupling files of ARPEGE produced in Meteo France to the files of IFS produced in ECMWF.

Table 2. Parameters that changed values from the operational suite to ALARO0 baseline.

Parameter	Old	New	function
QXRAL	100.	130.	Parameter in Xu-Randall cloud scheme
HUCRED	0.33	1.00	Parameter for critical RH profile adjustment
SCLESPR	18000	248000	Liquid condensation Length scale
SCLESPS	6000	15500	Solid condensatio length scale
RAUTEFR	$2*10^{-3}$	10^{-3}	Inverse autoconversion time for rain
RAUTEFS	$2*10^{-3}$	10^{-3}	Inverse autoconversion time for snow
LCVGQM	F	T	Modulation of humidity convergence closure
LENTCH	F	T	Memory in adaptive entrainment
GCVALFA	$3*10^{-5}$	$4.5*10^{-5}$	Main coefficient for buoyancy modulation of entrainment
GDDEVF	0.5	0.12	Efficiency coefficient of downdraft

ALARO0 forecast was run up to 72 hours starting from 00 UTC operational analysis for each day in the period from 1st July 2013 until 30th June 2014 and coupled to the coupling files used in the operational suite (the ARPEGE one for 2013 and the IFS files for 2014). The forecasts were compared to the operational forecasts by computing bias (BIAS), root mean square (RMS) error and standard deviations (SD) for each month in the period using VERAL verification package (Figures 6 to 18).

The operational suite has large positive bias of moisture in the upper troposphere and close to surface and a negative bias for the layer 850 to 700 hPa. There is a significant improvement in ALARO0 baseline forecasts of the scores for relative humidity in the upper troposphere for each month in the whole period. The ALARO0 baseline scores for temperature and humidity at 2 meters are significantly worse in late autumn and winter, better in spring and early autumn and slightly better in summer. It was important to find if there is a model set-up that could reduce the deterioration of the ALARO0 baseline forecast of RH and temperature at 2 meters in winter.

A number of tests has been performed to estimate the impact of various parameters that can be controlled via namelist by running 72 hour forecasts starting from operational analyses for 00 UTC run for each day in January and May 2014. Some of the tests and short description of the results are listed in Table 4. The figures are in the end of the document.

Thermodynamic adjustment

acnebcond.F90

The liquid and solid length scales for the adjustment process define the dependency of the critical relative humidity on horizontal resolution. Once tuned should stay the same.

The switch LXRDCEV=T activates Xu-Randall type of thermodynamic adjustment. The dependency of the vertical profile of critical relative humidity on horizontal resolution has changed. The critical relative humidity profile approaches 1 more slowly with increasing horizontal resolution.

In the old scheme the combined length scale is

$$L_{old} = \frac{1}{\frac{FONICE}{SCLESPTS} + \frac{FONICE}{SCLESPPR}}$$

for SCLESPTS=6000. And SCLESPPR=18000.

The critical relative humidity profile is computed using PHUC array computed in aplpar

$$RH_c = \frac{(HUCRED * PHUC + 1 - HUCRED)\Delta x + L_{old}}{\Delta x + L_{old}}$$

The recommended value is HUCRED=1, so that the above formula reduces to

$$RH_c = \frac{PHUC\Delta x + L_{old}}{\Delta x + L_{old}}$$

In the new scheme, the combined length scale is

$$L_{new} = \frac{1}{\frac{FONICE}{SCLESPTS^{0.3}} + \frac{FONICE}{SCLESPPR^{0.3}}}$$

in the ALAR00 baseline documentation it is recommended that it uses new values SCLESPTS=15500 and SCLESPPR=248000.

The critical relative humidity profile is computed using the formula

$$RH_c = \frac{(HUCRED * PHUC + 1 - HUCRED)\Delta x^{0.3} + L_{new}}{\Delta x^{0.3} + L_{new}}$$

for HUCRED=1, it reduces to

$$RH_c = \frac{PHUC\Delta x^{0.3} + L_{new}}{\Delta x^{0.3} + L_{new}}$$

Larger critical relative humidity means that more water vapour stays in the atmosphere.

If one wants to keep the critical relative humidity profile as close as possible to the old one, the new values for SCLESPTS and SCLESPPR can be computed from the old ones. The procedure is described below.

$$RH_c^{old} = RH_c^{new}$$

$$\frac{PHUC\Delta x + L_{old}}{\Delta x + L_{old}} = \frac{PHUC\Delta x^{0.3} + L_{new}}{\Delta x^{0.3} + L_{new}}$$

$$PHUC\Delta x^{1.3} + PHUC\Delta x L_{new} + L_{old}\Delta x^{0.3} + L_{old}L_{new} = PHUC\Delta x^{1.3} + PHUC\Delta x L_{old} + L_{new}\Delta x + L_{old}L_{new}$$

$$L_{new} = \frac{(PHUC - 1)\Delta x^{0.3}L_{old}}{(PHUC - 1)\Delta x}$$

$$L_{new} = \frac{L_{old}}{\Delta x^{0.7}}$$

for $FONICE = 1$ we have $L_{new} = SCLESPS_{new}^{0.3}$ and $L_{new} = \frac{L_{old}}{\Delta x^{0.7}} = \frac{SCLESPS_{old}}{\Delta x^{0.7}}$ so

$$SCLESPS_{new} = \left(\frac{SCLESPS_{old}}{\Delta x^{0.7}}\right)^{\frac{1}{0.3}}.$$

for $FONICE = 0$ we have $L_{new} = SCLESPR_{new}^{0.3}$ and $L_{new} = \frac{L_{old}}{\Delta x^{0.7}} = \frac{SCLESPR_{old}}{\Delta x^{0.7}}$ so

$$SCLESPR_{new} = \left(\frac{SCLESPR_{old}}{\Delta x^{0.7}}\right)^{\frac{1}{0.3}}.$$

For the values used in the operational suite, SCLESPS=6000 and SCLESPR=18000 and horizontal resolution of 8 km, the new values of the parameters are SCLESPS=3066. and SCLESPR=119407. The values for these parameters recommended in the ALARO0 baseline documentation are SCLESPS=15500 and SCLESPR=248000. Three experiments were performed, in experiment AL SCLESPS=3066. and SCLESPR=119407., in AM SCLESPS=3066. and SCLESPR=248000. And in experiment AN SCLESPS=15500. and SCLESPR=119407.

The scores for the experiments with reduced length scales for the adjustment, AL, showed improvement in temperature and relative humidity at 2 meters for May and deterioration for January. There was an overall decrease in relative humidity throughout the atmosphere, this has improved the scores in upper troposphere and close to surface, but worsen the scores in the layer from 850 to 700 hPa where the bias of relative humidity is negative (Figure 31).

In the experiment where only the length scale for solid condensates was reduced, there is a reduction of positive bias in the upper troposphere without deterioration of negative bias in the 850-700hPa layer (Figure 32).

In the experiment where only the length scale for liquid condensates was reduced, the score is negative for the 850-700hPa layer (Figure 33).

Increasing values of the liquid and solid length scales for the adjustment process mean increasing the combined length scale, so the critical relative humidity is closer to 1 for any resolution and depends less on horizontal resolution and critical relative humidity computed in aplpar.

Lower values of the liquid and solid length scales for the adjustment mean less water vapour stays in the atmosphere.

Tuning of RMULACVG

accvud.F90

The closure in the deep convection scheme is based on moisture convergence (Kuo type closure) but it is modulated so that part of converging moisture is consumed in condensation and the rest is enhancing the moist static energy. This leads to a mixed type of closure

- the moisture convergence closure for intensive deep convection and
- CAPE closure for weak deep convection.

Lower RMULACVG means less immediate consumption of water vapour in condensation. According to ALAR00 baseline documentation. The value of this tuning parameter depends on horizontal resolution in the following way

$$RMULACVG = \min(25, \max(1, (\Delta x / 1200)^2))$$

where Δx is taken in meters.

This means that RCMULACVG varies from 1 to 25 for the range of horizontal resolutions from 1.2 to 6 km. It should be 1 for mesh sizes below 1.2 km and 25 for mesh sizes above 6 km.

Table 3. RMULACVG for different horizontal resolutions.

Δx in meters	$(\Delta x / 1200)^2$	RMULACVG
8000	44	25
4000	11	11
2000	2.8	2.8

The vertically integrated moisture convergence is computed as

$$ZCVG = \Delta t * ZS4$$

It modifies moisture convergence if the switch LCVGQM is activated.

$$ZCVG = ZCVG * \max(0, \min(1, ZSIG2 * RMULACVG))$$

where

$$ZSIG2 = (ZS15 + ZCVG) / (ZS16 + ZS17) \text{ for convectively active layers.}$$

So the final vertical integral is

$$ZSIGB = (ZS15 + ZCVG * ZSIG2 * RMULACVG) / (ZS16 + ZS17) \text{ for convectively active layers.}$$

The scores for relative humidity in the experiment with $RMULACVG=1$ are shown in Figure 36.

Tuning of QXRTGH

acnebn.F90

QXRTGH is a parameter in Xu-Randall cloudiness computation that is active when LQXRTGH=T. According to the ALARO0 baseline documentation, it is dependent on vertical resolution and the value recommended for 87 levels is 1.6, while the value of 3.5 is recommended for 40 levels.

A number of experiments has been performed with different values of QXRTGH using ALARO0 baseline in 38T1 in 8 km horizontal resolution on 37 and 73 levels in the vertical.

Relative humidity is computed as the ratio q_v/q_{sat} . If LQXRTGH, it is modified using tanh curve and QXRTGH parameter. This modified relative humidity profile is used later in the routine in the computations of the convective cloudiness.

$$RH_{mod} = \left(\frac{1 - e^{-2RH^{QXRTGH}}}{1 + e^{-2RH^{QXRTGH}}} \right)^{\frac{1}{QXRTGH}}$$

The dependency of the corrected RH on QXRTGH is shown in figures 4 and 5 (different scales) for different input RH values (different colours).

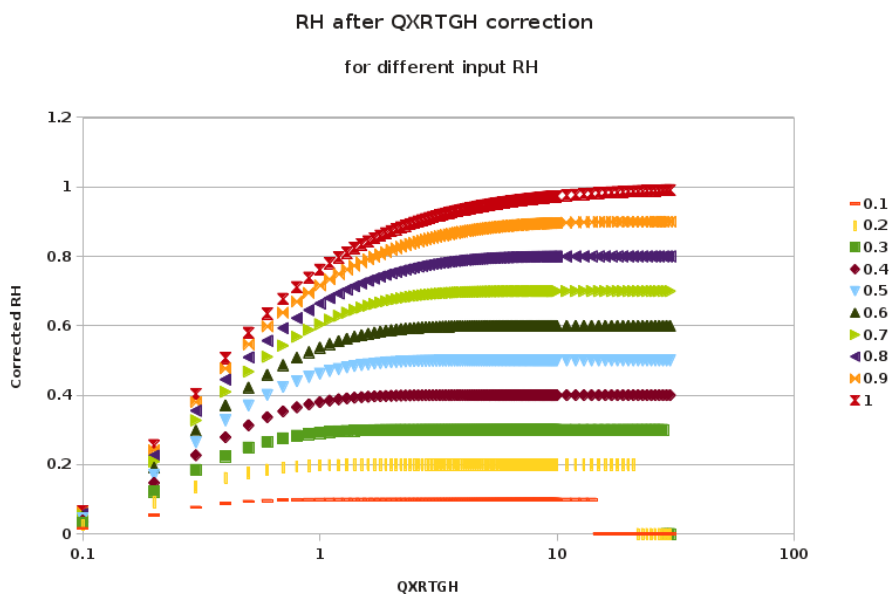


Figure 4. The dependency of corrected relative humidity on parameter QXRTGH for different input relative humidities (logarithmic scale).

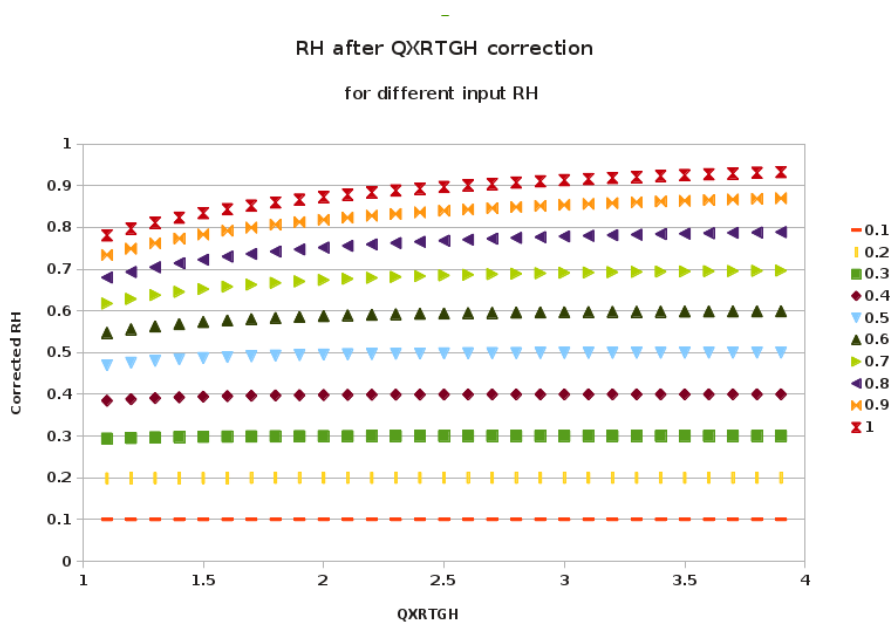


Figure 5. The dependency of corrected relative humidity on parameter QXRTGH for different input relative humidities (linear scale).

This modified relative humidity is used for diagnosing convective cloudiness

$$C_s = RH^p \left(1 - e^{\frac{-\alpha_0 q_s}{(1-RH)^{\gamma q_s}}} \right)$$

for $p = QXRR = 0.25$, $\gamma = QXRDEL = 0.5$ and $\alpha = QXRAL = 130..$

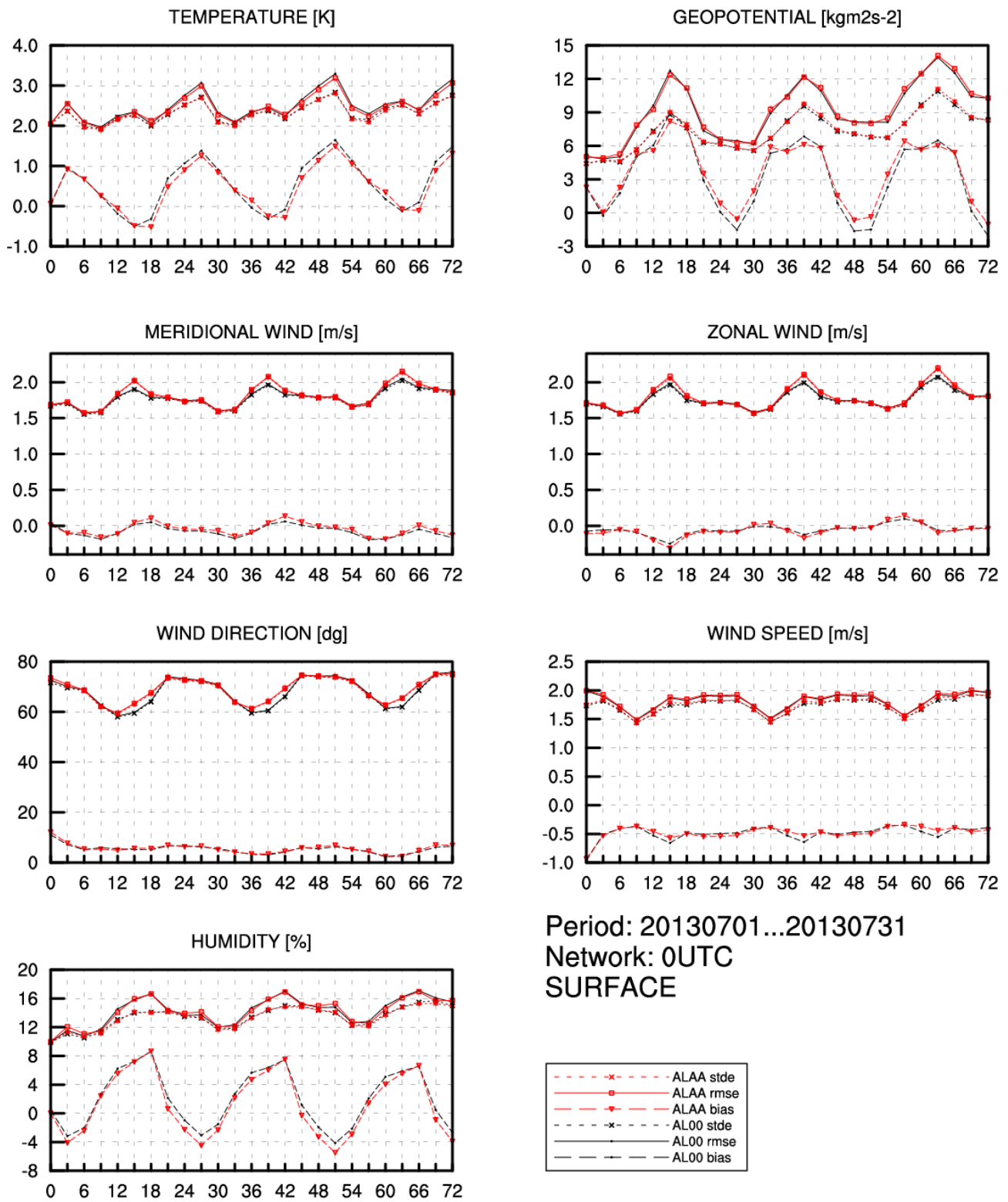
Tests with ALARO0 baseline in 8 km horizontal resolution on 37 and 73 levels in the vertical were performed for various values of QXRTGH (some of them intentionally unreasonable) for January and May 2014. In the test with QXRTGH=0.1 on 37 levels, the scores were worse. Using QXRTGH=16 on 37 levels, the scores were slightly worse in the test with operational initial files, but the scores were improved for the test with cycling of prognostic condensates, TKE and convective variables. Using QXRTGH=1.6 on 37 levels does make forecasts of temperature and relative humidity at 2 meters worse, but using this value on 73 levels improves the forecast only in January (Figure 40), not in May (Figure 41). Finally, keeping QXRTGH=3.5 when increasing vertical resolution from 37 to 73 levels does not make forecast worse (Figure 42).

Table 4. List of experiments, the code of the experiment is in the first column and the same one is used in the figures (mint the small and large letters), description of the change with respect to the ALAR00 baseline, and short description of the result.

code	description	result
AA a0	38T1 Alaro0 baseline in 8km, 37 levs, hydrostatic	Compared to 00, improved T2m and RH for May, worse for January 2014. RH always better for 500-250 hPa layer, used for reference in all ax and AX experiments (Figs 6-22)
00	Operational forecast	Used for reference for AA only (Figs 6-22)
ar	LRNUMX=F random overlap	Compared to AA, the T2m and RH are almost back to operational values. (Figs 23)
as	LVOIGT=F, LRTPP=F, LRTDL=F	neutral
at	LVOIGT=F, LRTPP=F, LRTDL=F, LRSTAB=F, LRPROX=F, LRMIX=F	Similar to as
au	LVOIGT=F, LRTPP=F, LRTDL=F, LRSTAB=F, LRPROX=F, LRMIX=F, LNEWSTAT=F	Similar to at
az	LVOIGT=F, LRTPP=F, LRTDL=F, LRSTAB=F, LRPROX=F, LRMIX=F, LNEWSTAT=F, LRNUMX=F	Scores as for 00
ap	LSEDCL=F	Worse humidity close to tropopause (Fig 24)
aq	RMULACVG=44	No significant difference
ab	LCVGQM=F, LENTCH=F	Slightly worse to neutral (Fig 25)
ac	GCVAlFA=3*10 ⁻⁵ , GDDEVF=0.5	Improved geopotential (Fig 26)
ak	NEINI=0	Improved geopotential in first 6 hours (Fig 27)
al	LSLHD_W=F, LSLHD_T=F, LSLHD=F for all GFLs	Worse geopotential (Fig 28)
am	LSLHD=T for all GFLs	neutral
AL	SCLESPTS=3066, SCLESPT=119407	Improved T2m and RH2m, lower RH bias (Figs 29, 30, 31)
AM	SCLESPTS=3066	Improved T2m and RH2m, improved RH overall (Fig 32)
AN	SCLESPT=119407	Worse RH bias (Fig 33)
AP	TVFI=0.16	Improved RH above 500 hPa (Fig 34)
AQ	TVFL=0.04	neutral
AO	RPHI0=2500.	Improved T2m and RH2m for

code	description	result
		January, neutral for May
AR	TVFL=0.01	neutral
AS	RPHI0=12500.	Improved T2m, RH2m and RH in January, neutral for May (Fig 35)
AT	SCLESPTS=3066., TVFI=0.16	Improved T2m, RH2m and RH
AU	RMULACVG=1	Improved RH slightly (Fig 36)
AV	SCLESPTS=3066., TVFI=0.16, RPHI0=12500.	Improved T2m, RH2m and RH (Fig 37)
AX	SCLESPTS=3066., TVFI=0.16, RPHI0=12500., RMULACVG=1	Worse than AV
AI	Initial files with cycling of TKE, prognostic condensates and convective variables	Slightly worse T2m and RH2m, geop RH and T in the first 6 hours (Figs 38 and 39)
AJ	AI + QXRTGH=16	Improved T2m and RH2m with respect to AI
AK	AA + QXRTGH=16	worse T2m and RH2m
AB	AA + QXRTGH=1.6	worse T2m and RH2m, 3D neutral
AC	73 levels QXRTGH=1.6	Improved T2m and RH2m in January, worse in May, worse RH and improved T at 250 hPa (Figs 40 and 41)
AH	73 levels QXRTGH=3.5	As AC, but more intensive (Fig 42)
ag	LAPRPXPK=F, LREGETA=F	Worse geopotential, better surface (Fig 43)
ai	LVERTFE=T, NDLNPR=0, XIDT=0 (vertical finite elements)	Improved geop, T and wind at 30 hPa (Fig 44)
aj	NDLNPR=0 only	Worse geop, T wind on 20-30 hPa
an	RRDXTAU=123 (stronger numerical diffusion)	Improved T2m and top of atm, worse surf geop, wind and in tropopause (Fig 45)
AY	Initial files with cycling of TKE, prognostic condensates and convective variables, TVFI=0.16, SCLESPTS=3066., RPHI0=12500	Better surface and RH (Fig 46,47)

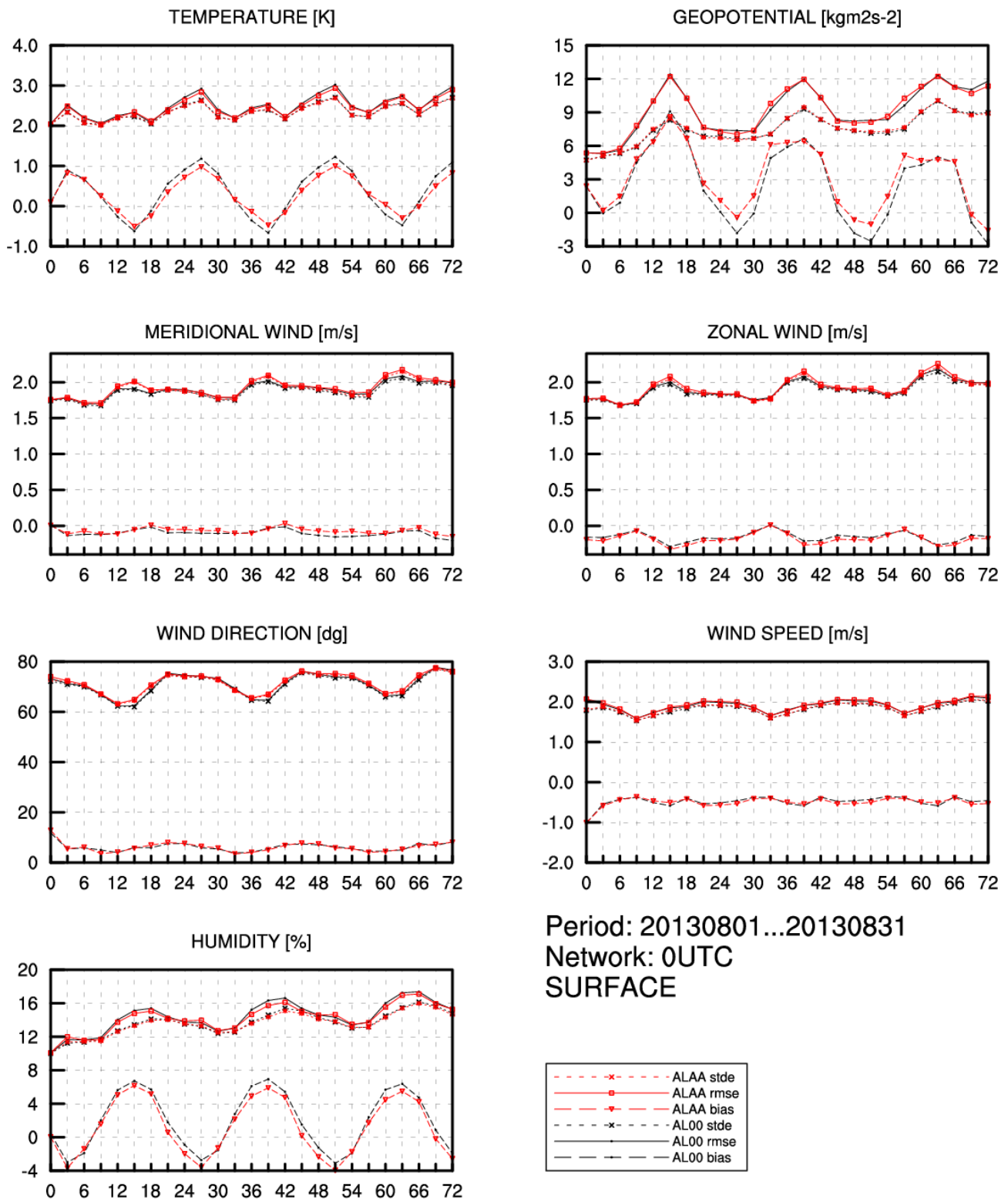
Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Tue Jul 29 08:32:37 UTC 2014

Figure 6. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for July 2013.

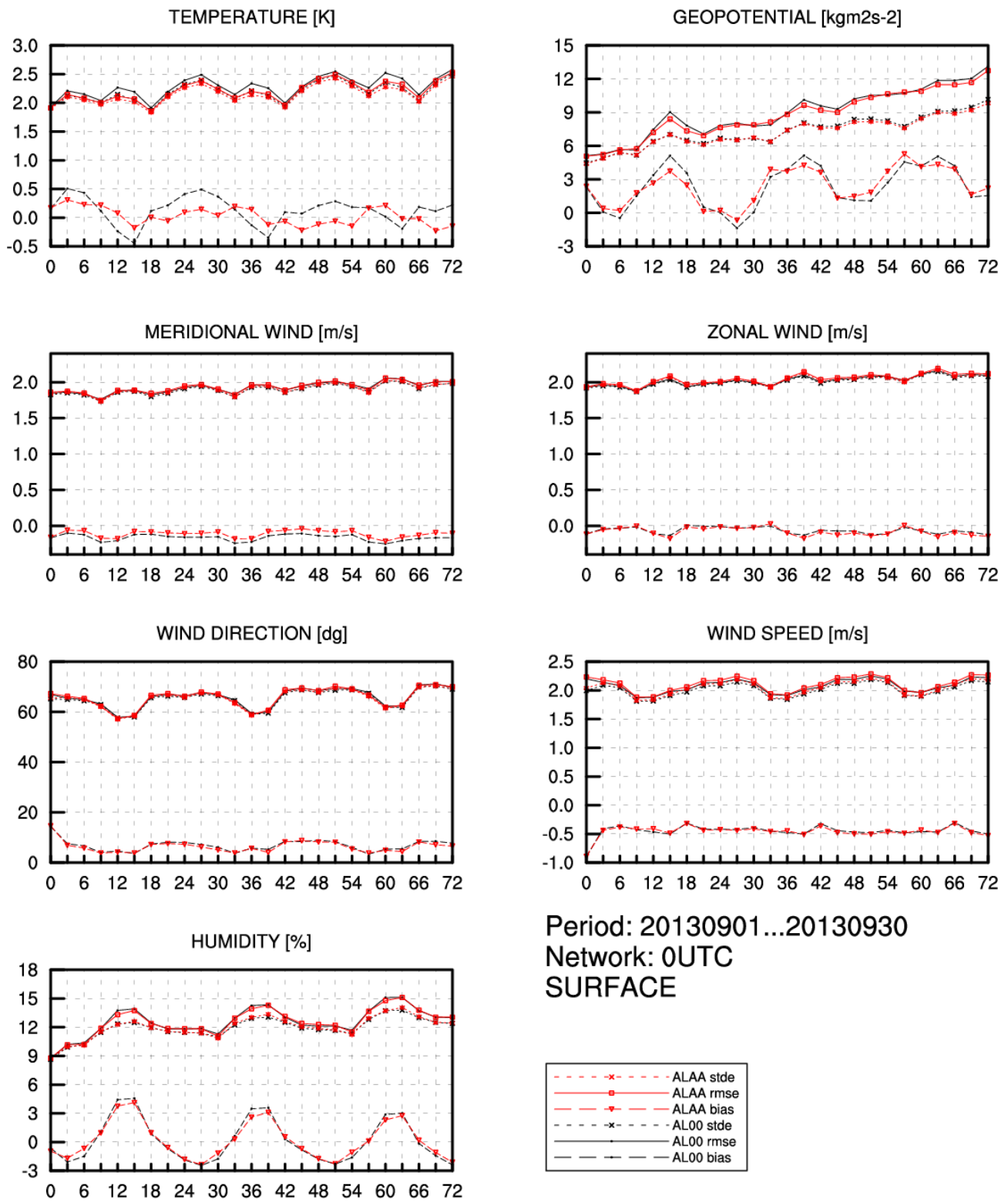
Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Tue Jul 29 08:37:00 UTC 2014

Figure 7. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for August 2013.

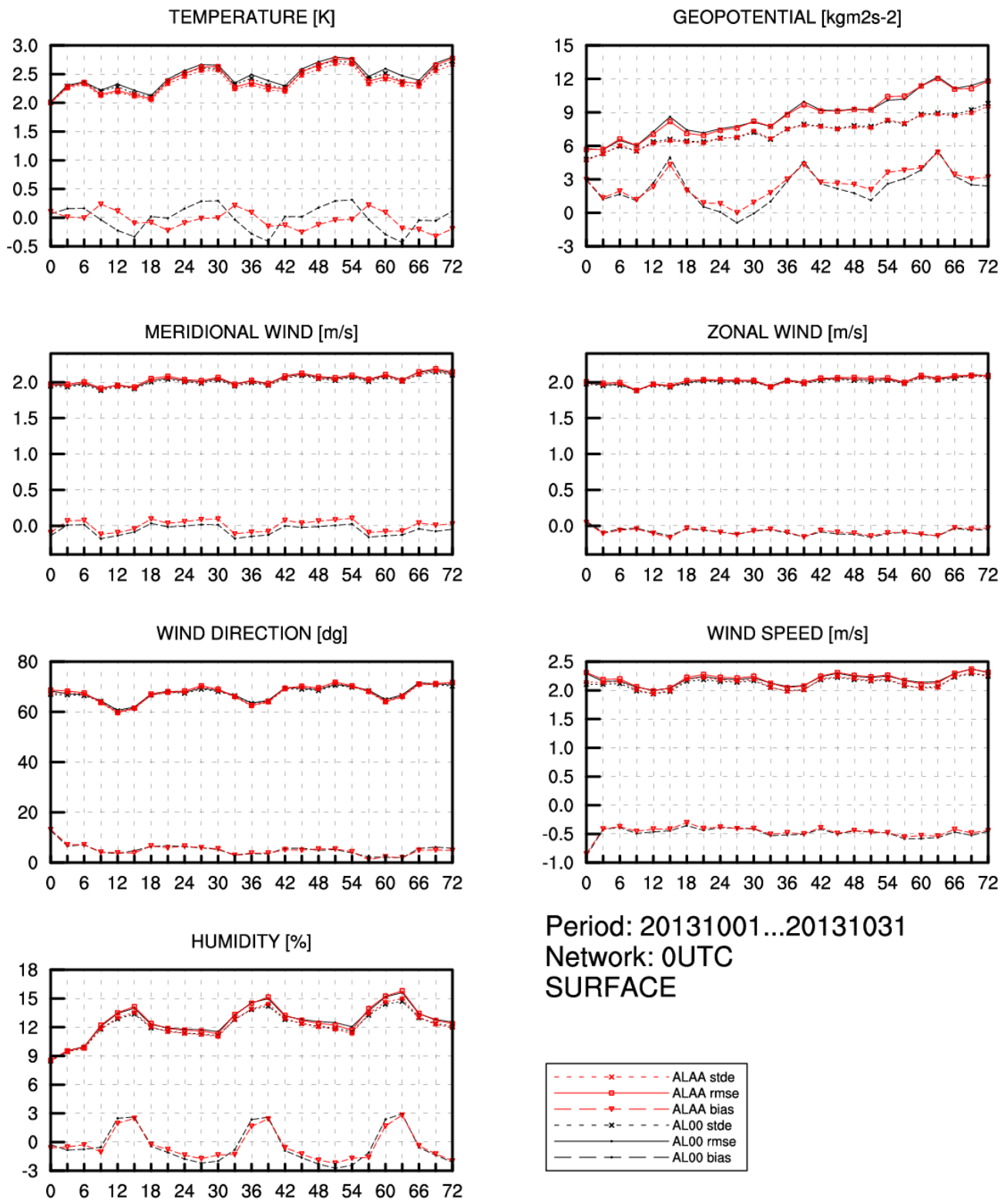
Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Tue Jul 29 08:39:49 UTC 2014

Figure 8. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for September 2013.

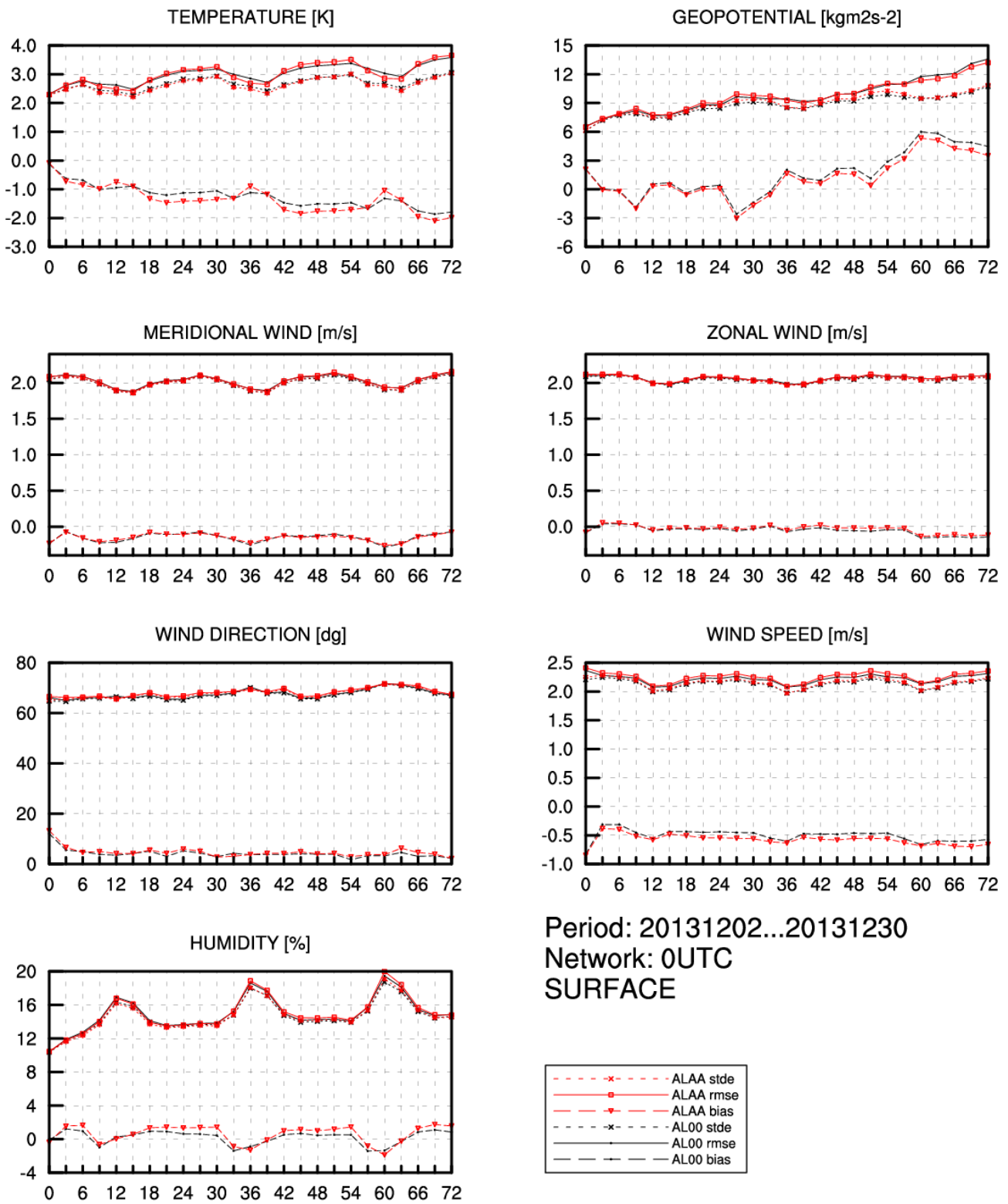
Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Tue Jul 29 11:58:30 UTC 2014

Figure 9. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for October 2013.

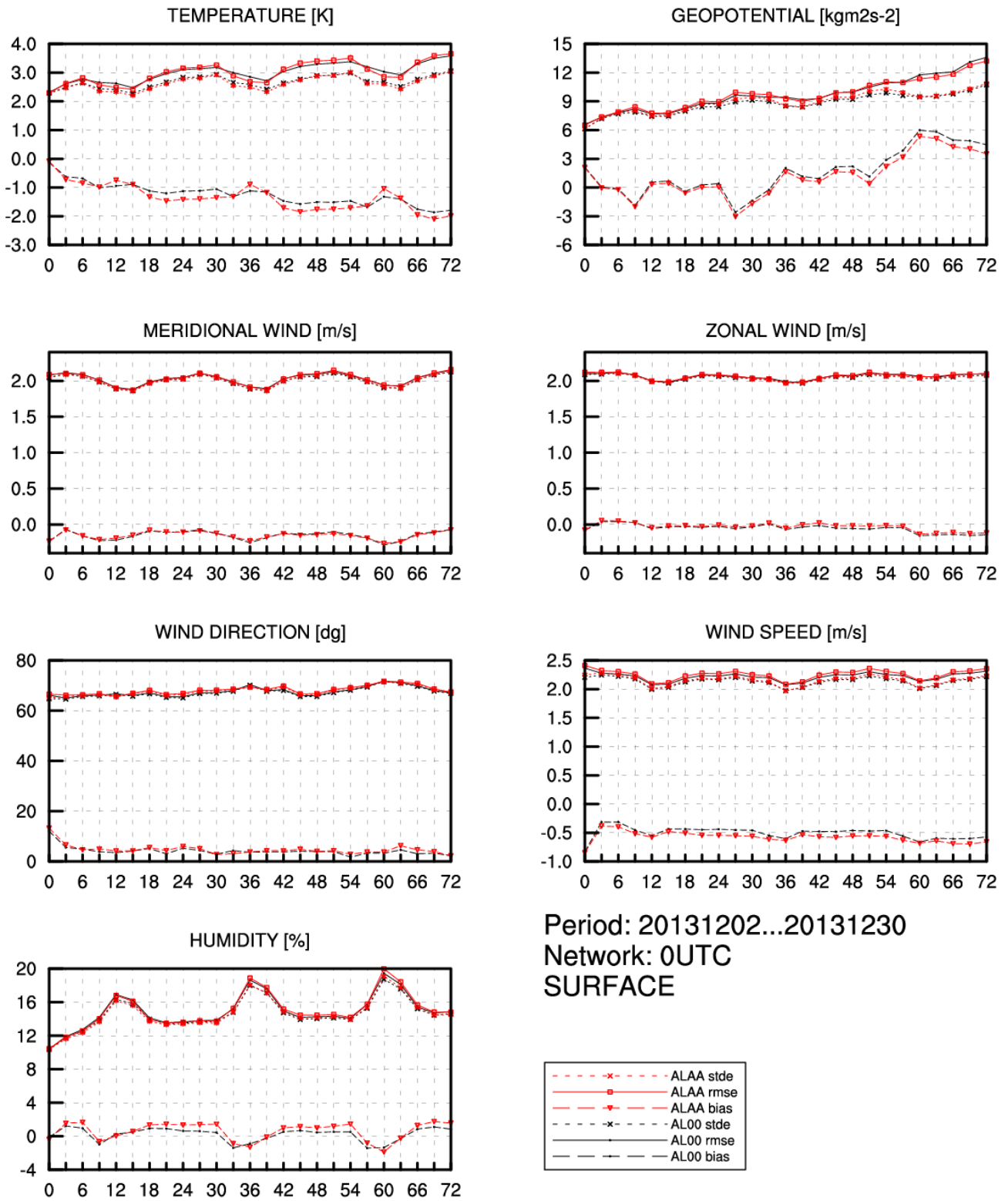
Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Tue Jul 29 12:11:36 UTC 2014

Figure 10. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for November 2013.

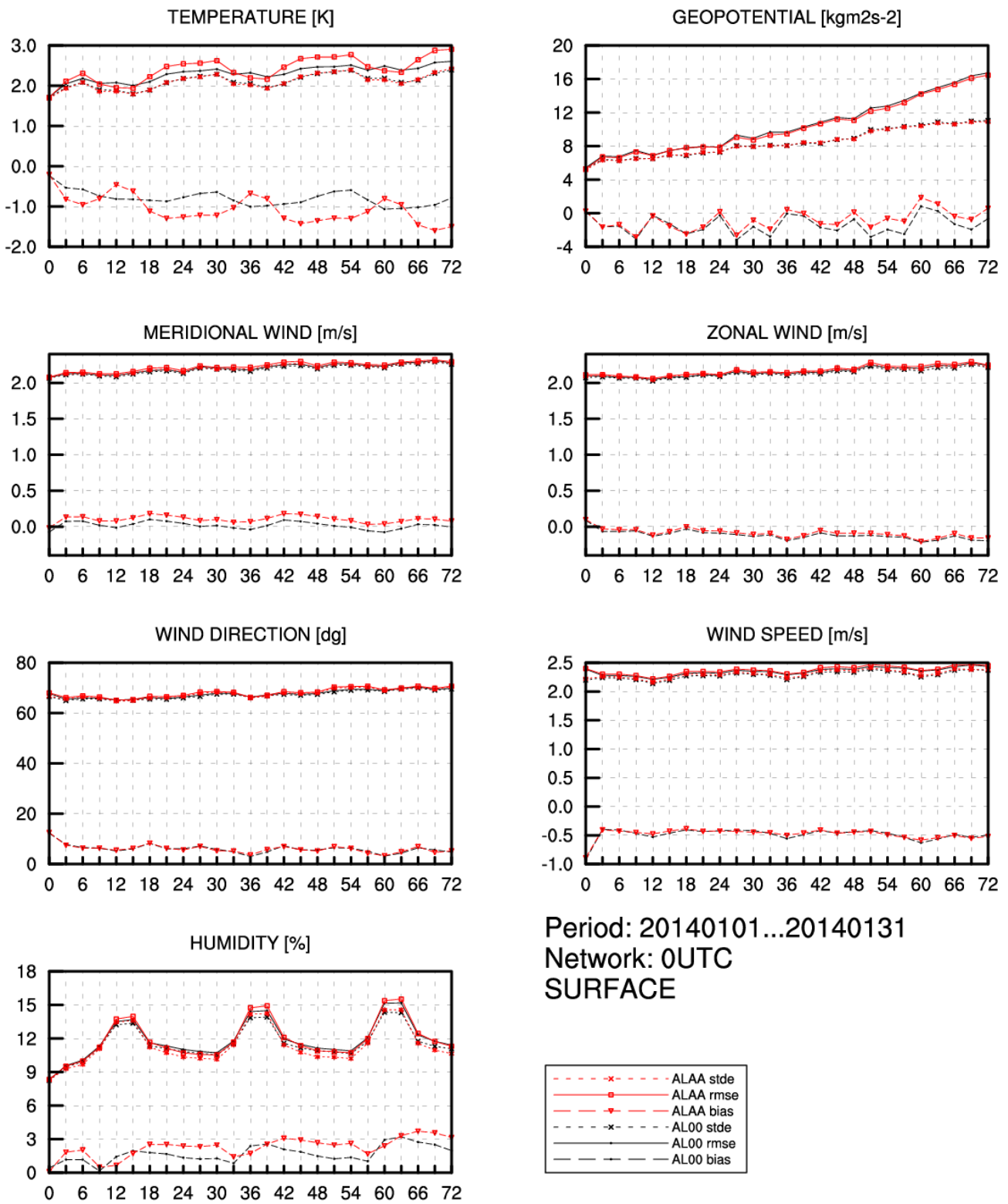
Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Tue Jul 29 12:11:36 UTC 2014

Figure 11. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for December 2013.

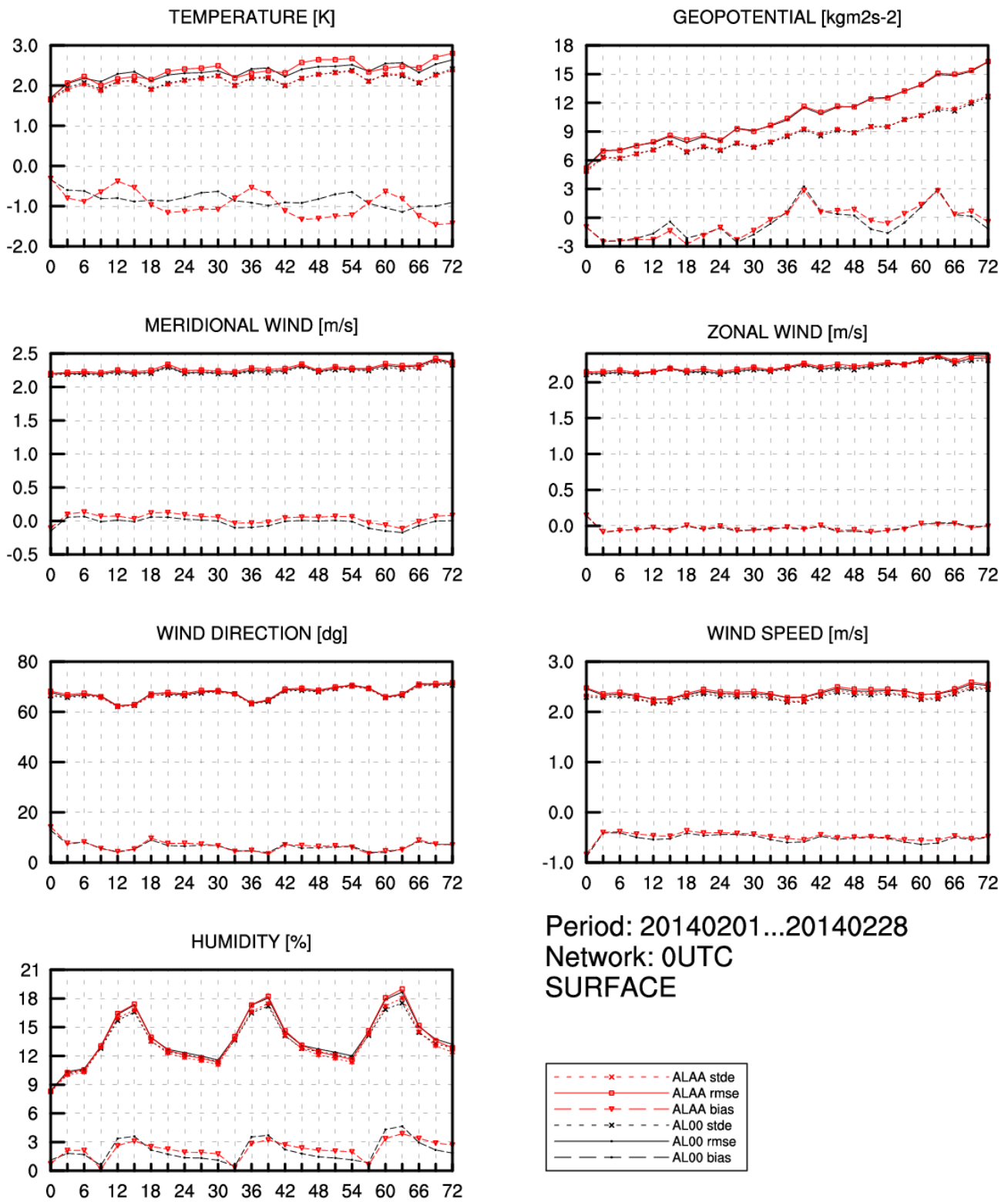
Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Mon Jul 28 07:04:21 UTC 2014

Figure 12. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for January 2014.

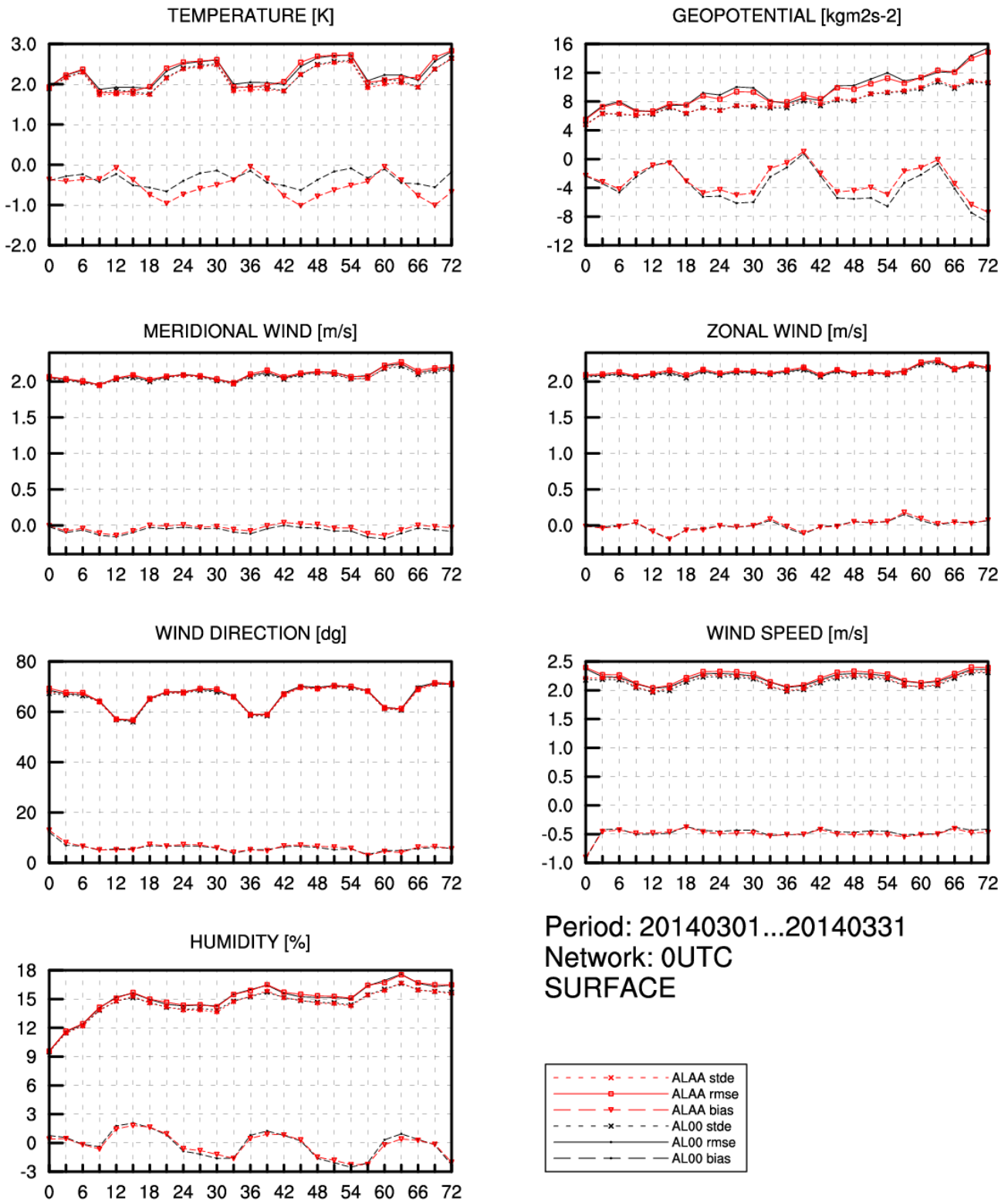
Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Mon Jul 28 09:09:11 UTC 2014

Figure 13. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for February 2014.

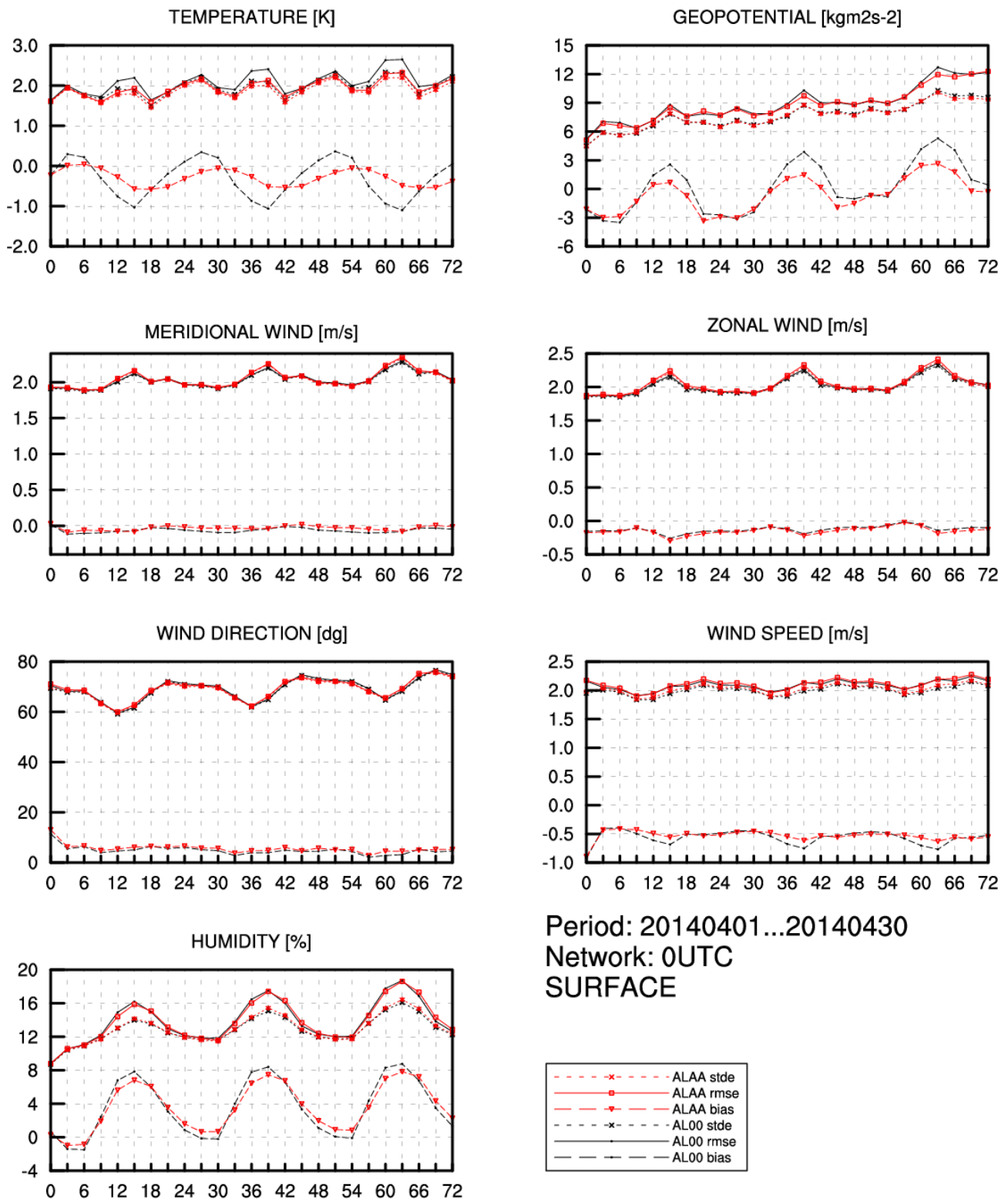
Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Mon Jul 28 09:00:19 UTC 2014

Figure 14. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for March 2014.

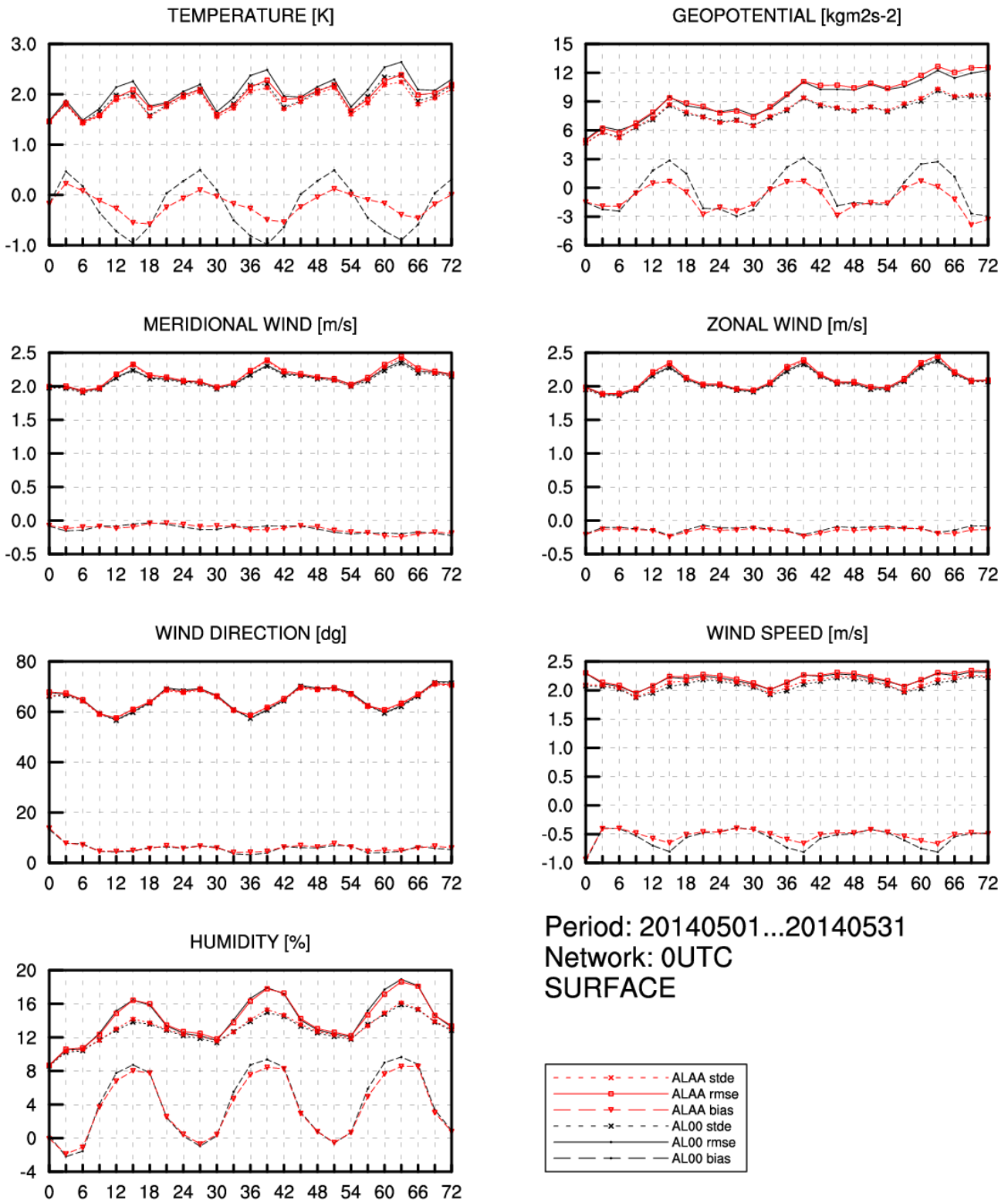
Evolution of scores with forecast range



aladinh@noa.gric.dhz.hr Mon Jul 28 08:55:49 UTC 2014

Figure 15. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for April 2014.

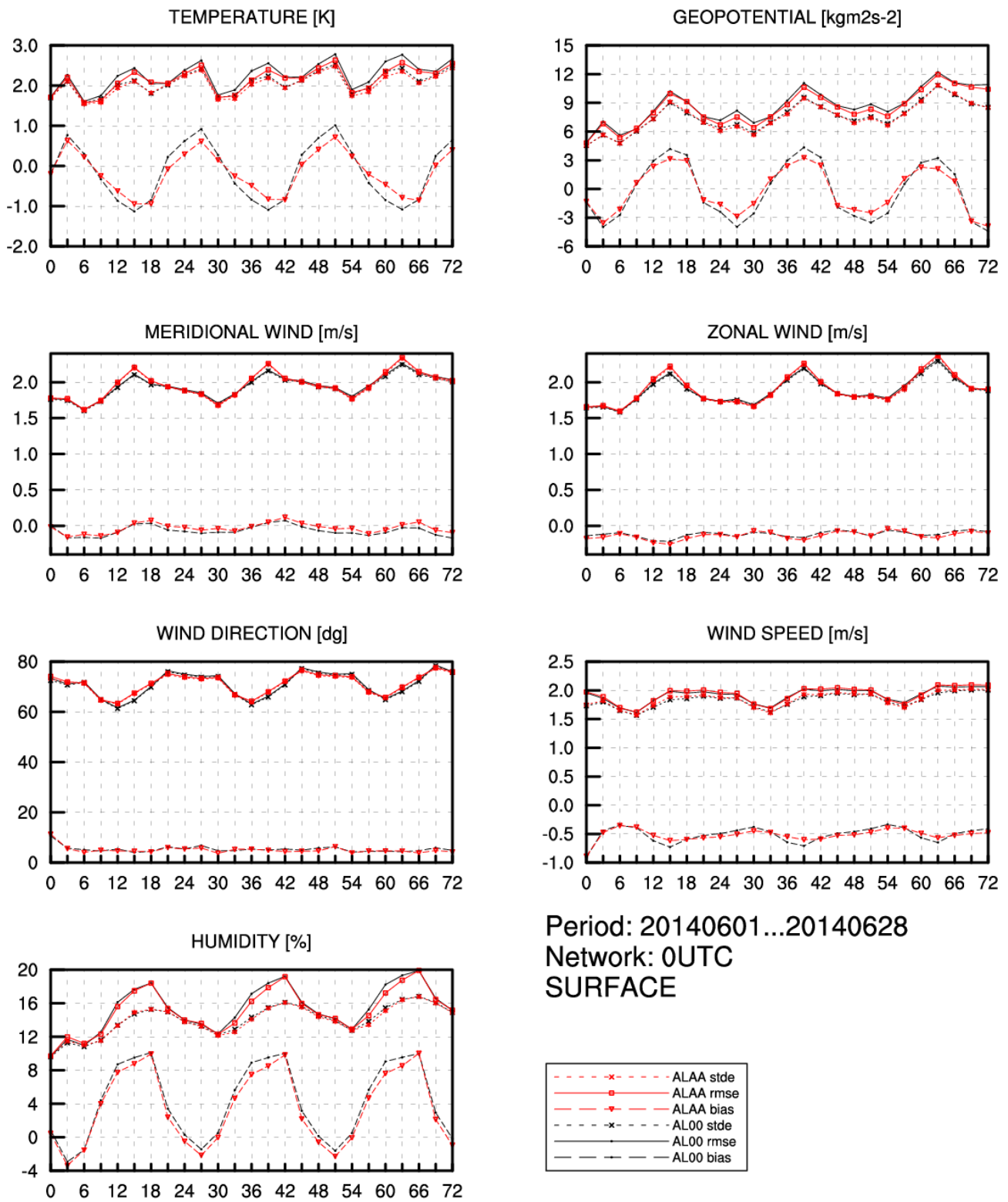
Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Mon Jul 28 08:27:26 UTC 2014

Figure 16. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for May 2014.

Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Mon Jul 28 08:18:34 UTC 2014

Figure 17. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for operational forecast (black) and ALAR00 baseline forecast (red) for June 2014.

Evolution of scores with forecast range

Period: 20130701...20130731 Network: OUTC
 RELATIVE_HUMIDITY (RMSE)

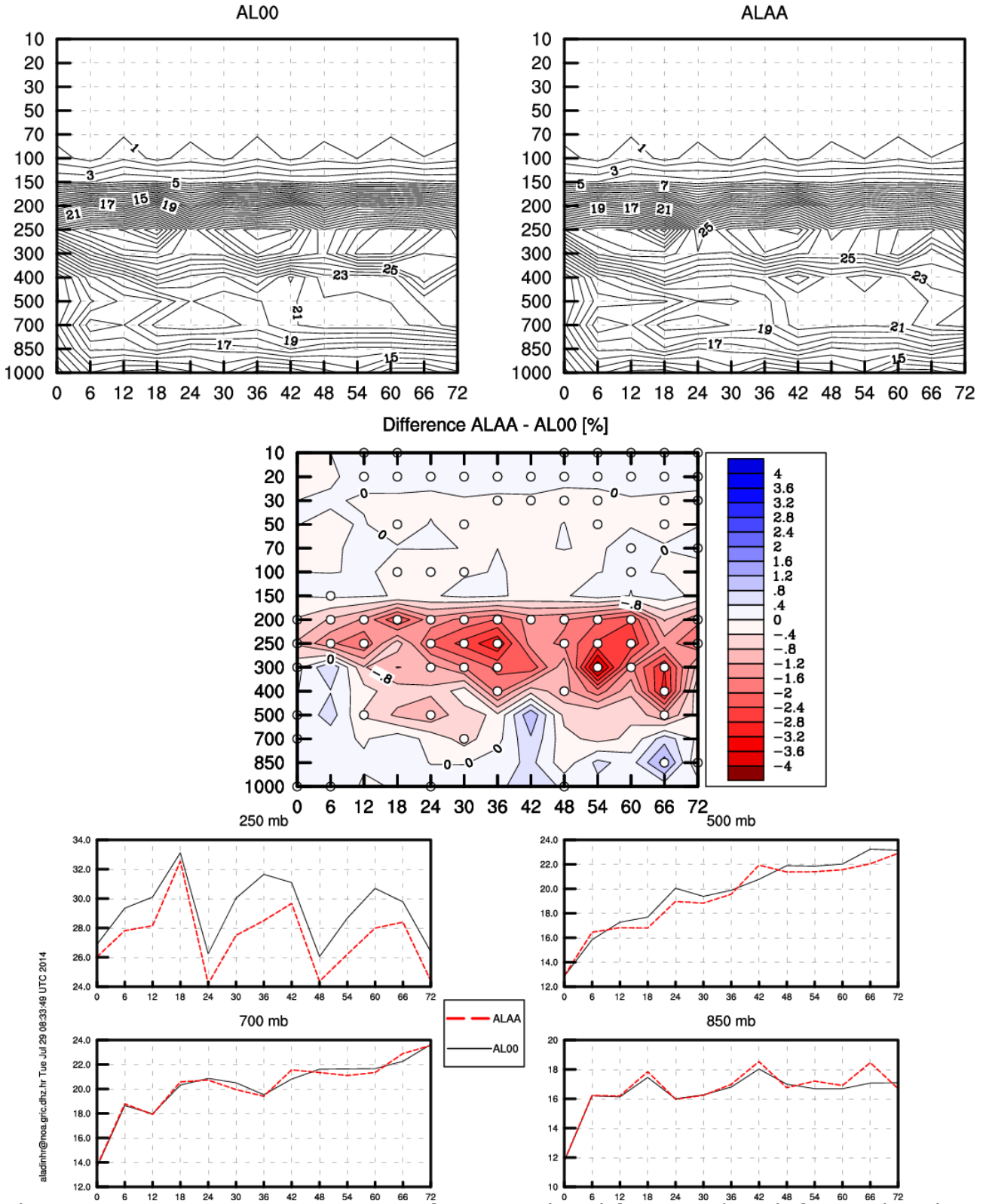


Figure 18. Root mean square error for operational forecast (top left panel and black lines in bottom panels) and ALARO0 baseline forecast (top right panel and red lines in bottom panels) for July 2013.

Evolution of scores with forecast range

Period: 20140101...20140131 Network: 0UTC
 RELATIVE_HUMIDITY (RMSE)

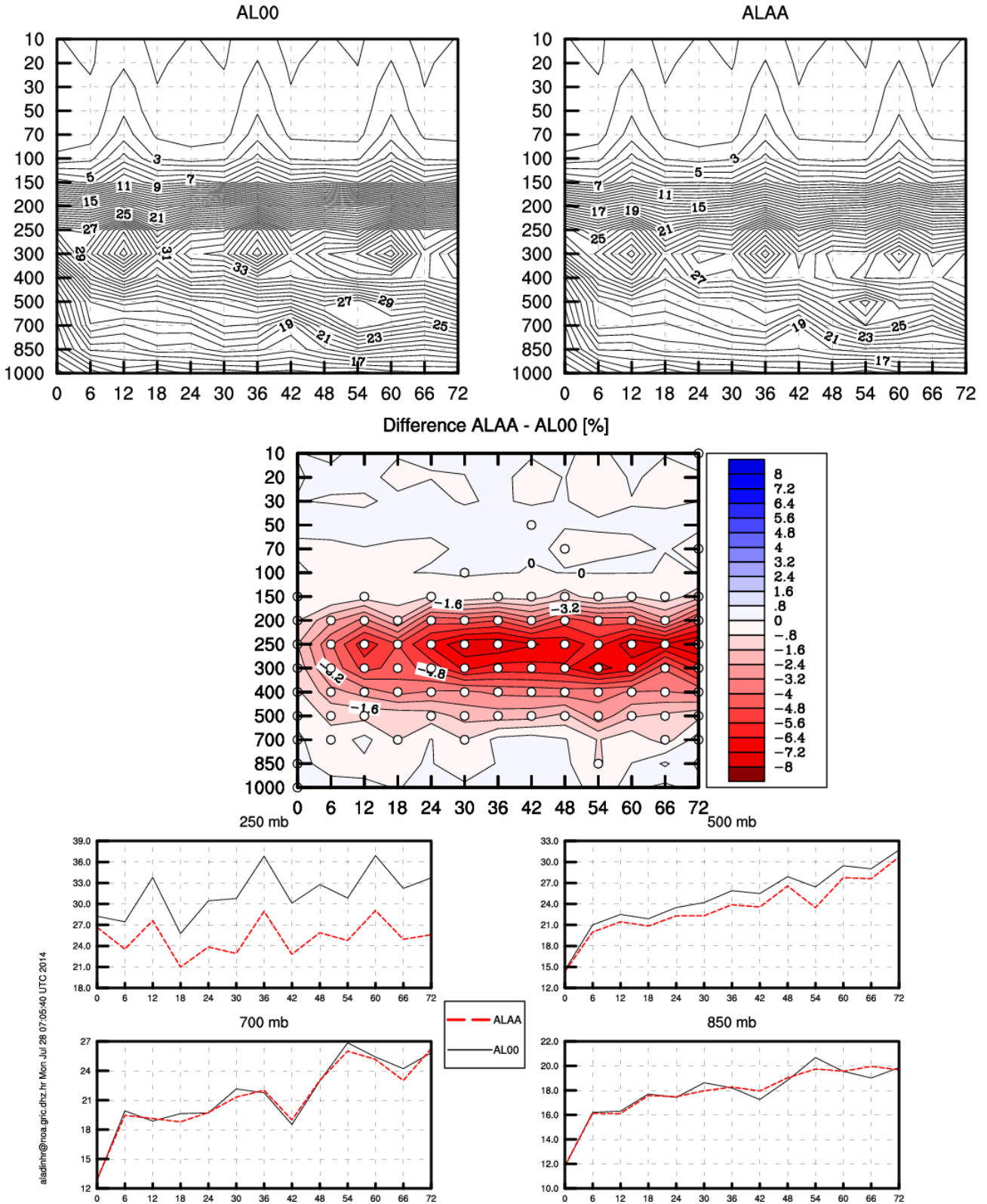


Figure 19. Root mean square error for operational forecast (top left panel and black lines in bottom panels) and ALAR00 baseline forecast (top right panel and red lines in bottom panels) for January 2014.

Evolution of scores with forecast range

Period: 20140101...20140131 Network: 0UTC
 RELATIVE_HUMIDITY (BIAS)

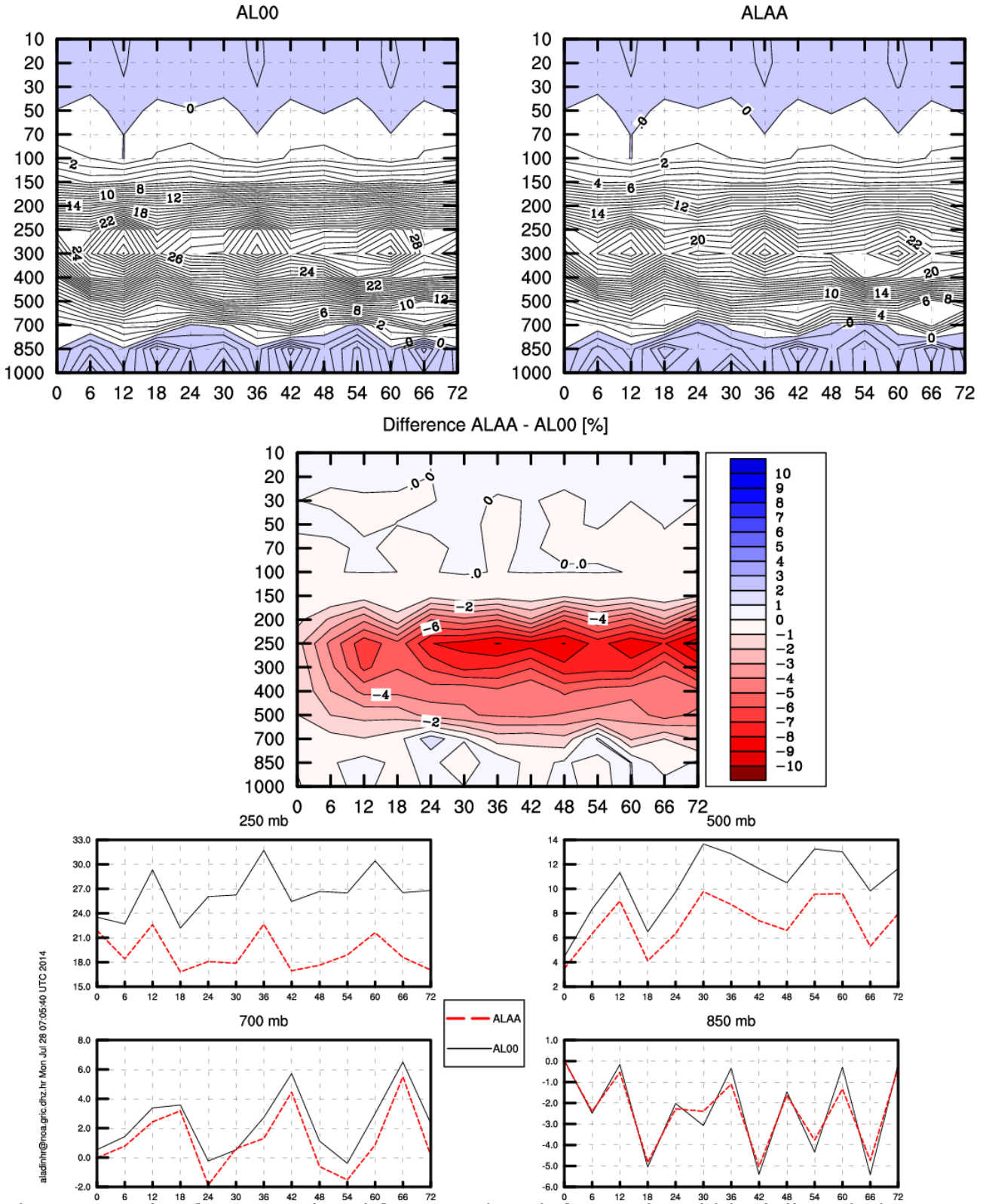


Figure 20. Bias for operational forecast (top left panel and black lines in bottom panels) and ALAR00 baseline forecast (top right panel and red lines in bottom panels) for January 2014.

aladinhr@noaa.gov: Mon Jul 28 07:05:40 UTC 2014

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 RELATIVE_HUMIDITY (RMSE)

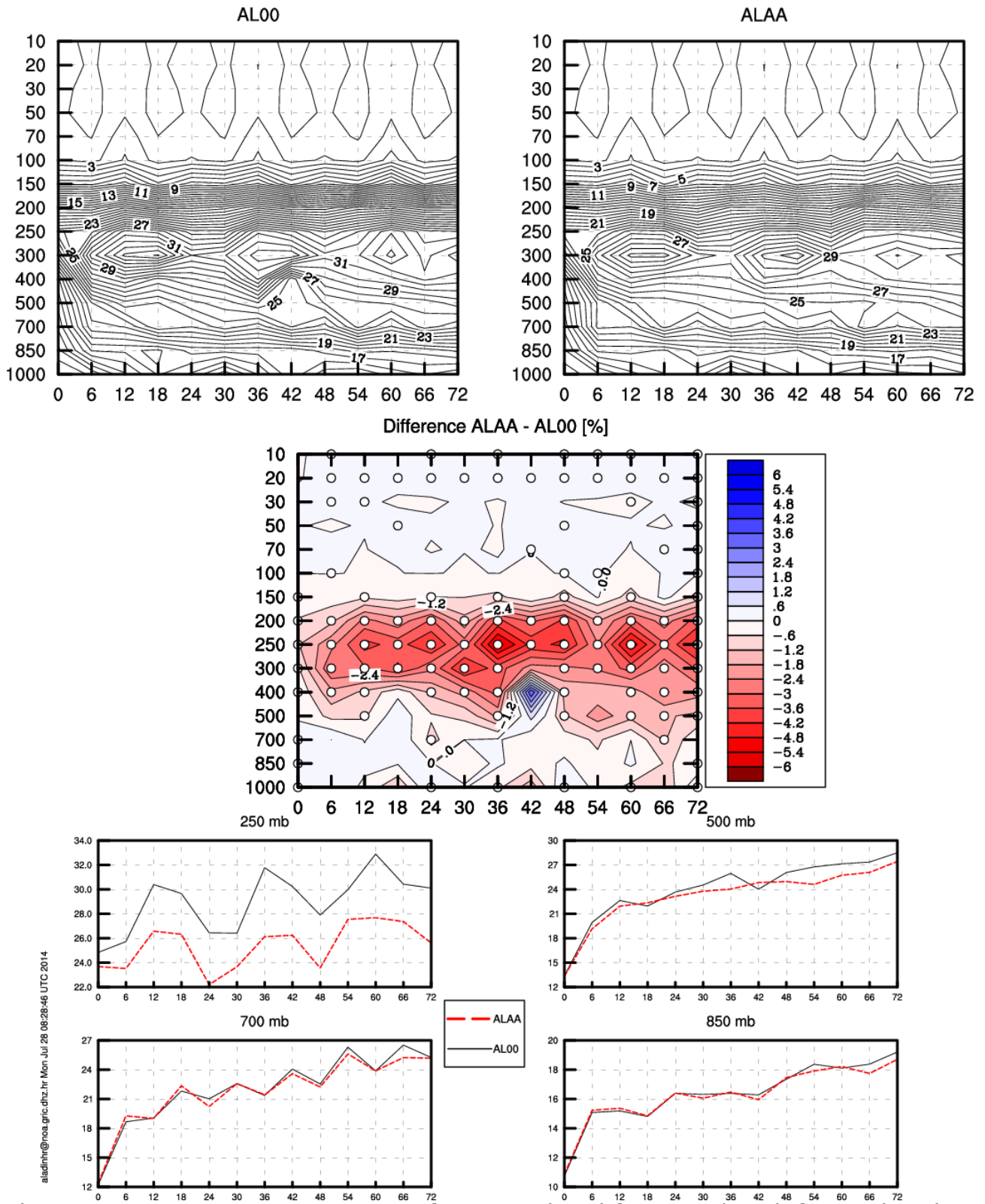


Figure 21. Root mean square error for operational forecast (top left panel and black lines in bottom panels) and ALARO0 baseline forecast (top right panel and red lines in bottom panels) for May 2014.

aladin@noaa.gov Mon Jul 28 08:28:46 UTC 2014

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 RELATIVE_HUMIDITY (BIAS)

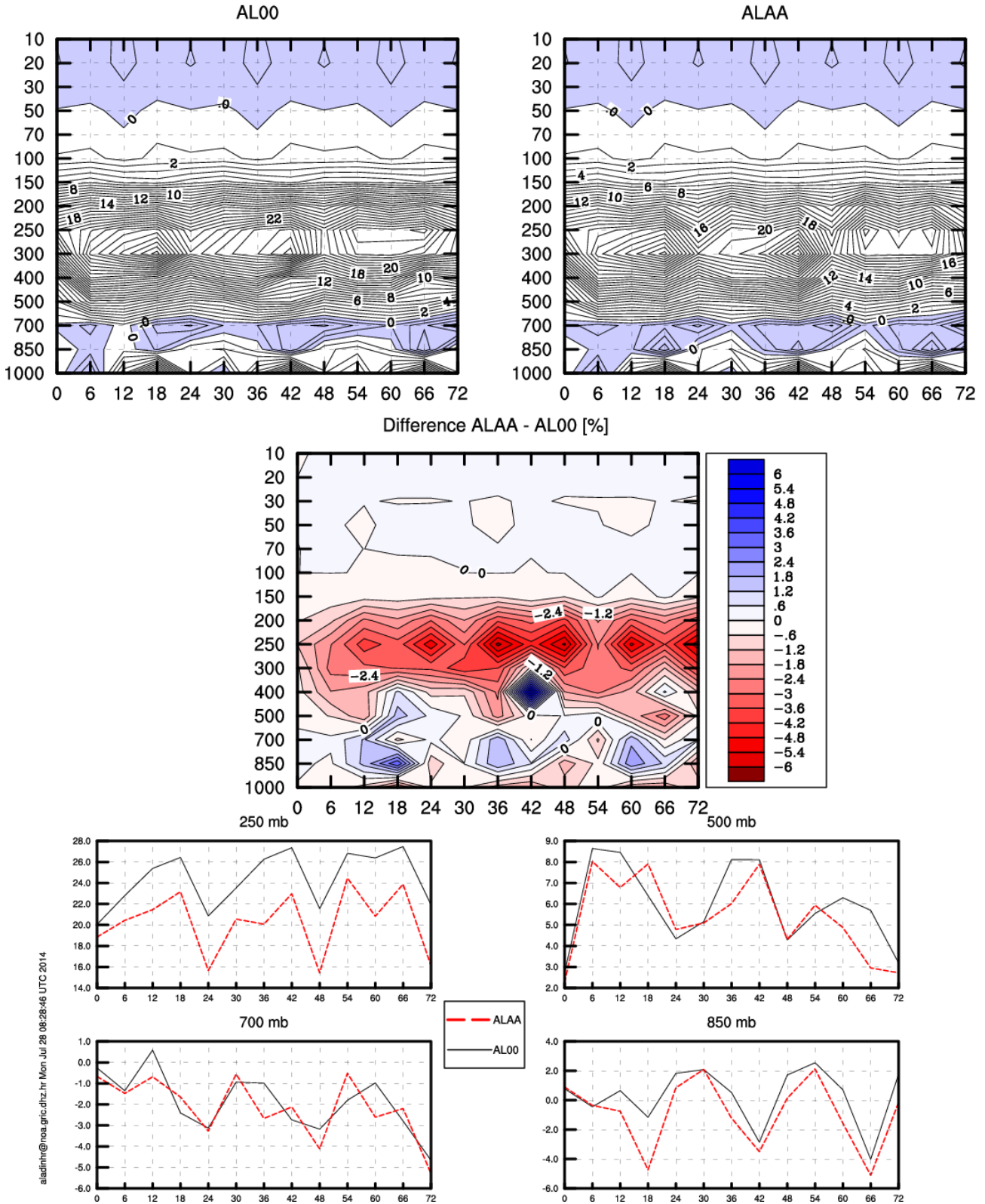
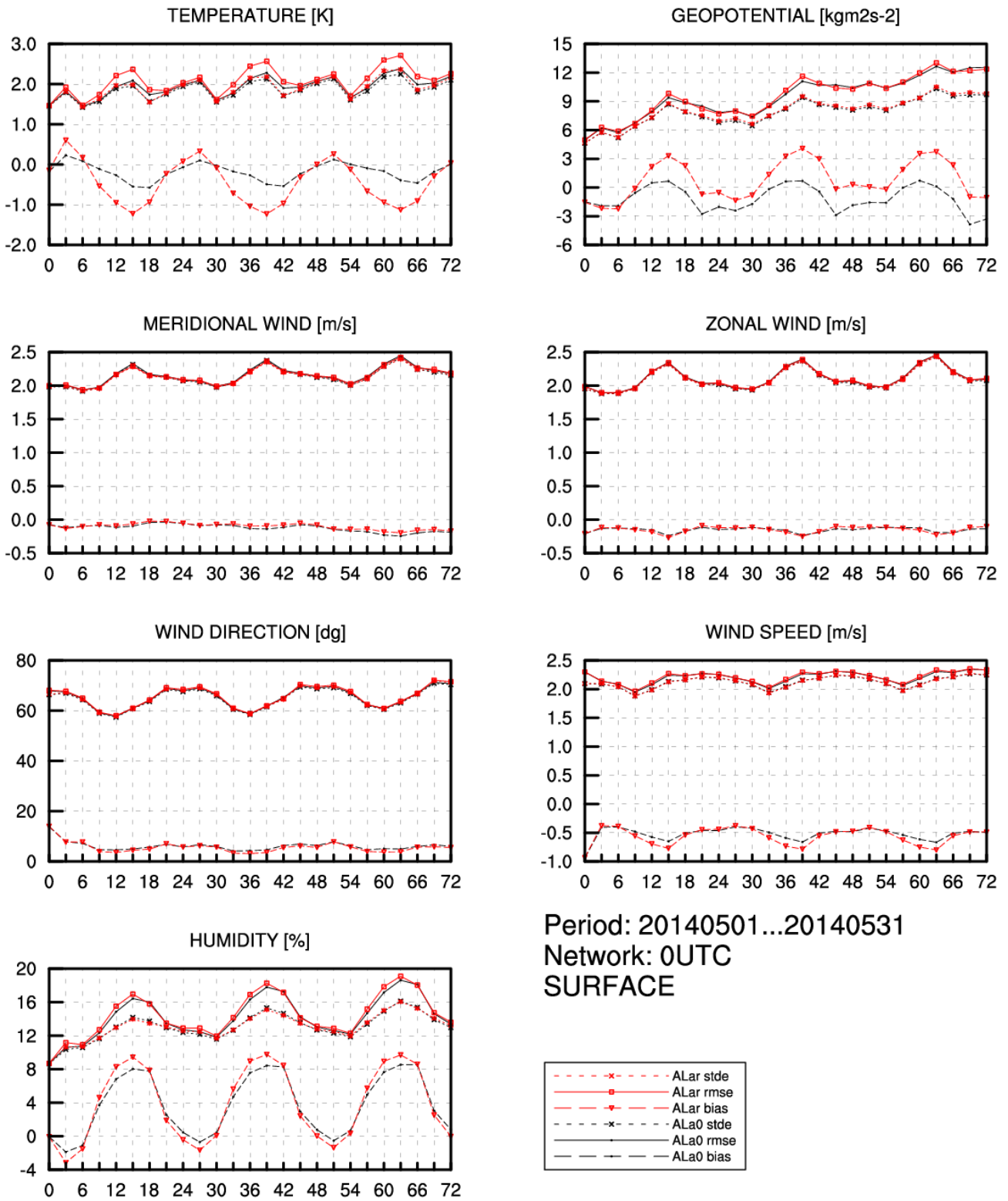


Figure 22. Bias for operational forecast (top left panel and black lines in bottom panels) and ALARO0 baseline forecast (top right panel and red lines in bottom panels) for May 2014.

aladin@noaa.gov, Mon Jul 28 08:28:46 UTC 2014

Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Sun Jun 29 22:10:43 UTC 2014

Figure 23. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for ALAR0 baseline (black) and experiment with ALAR0 baseline and LRNUMX=F forecast (red) for May 2014.

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 RELATIVE_HUMIDITY (RMSE)

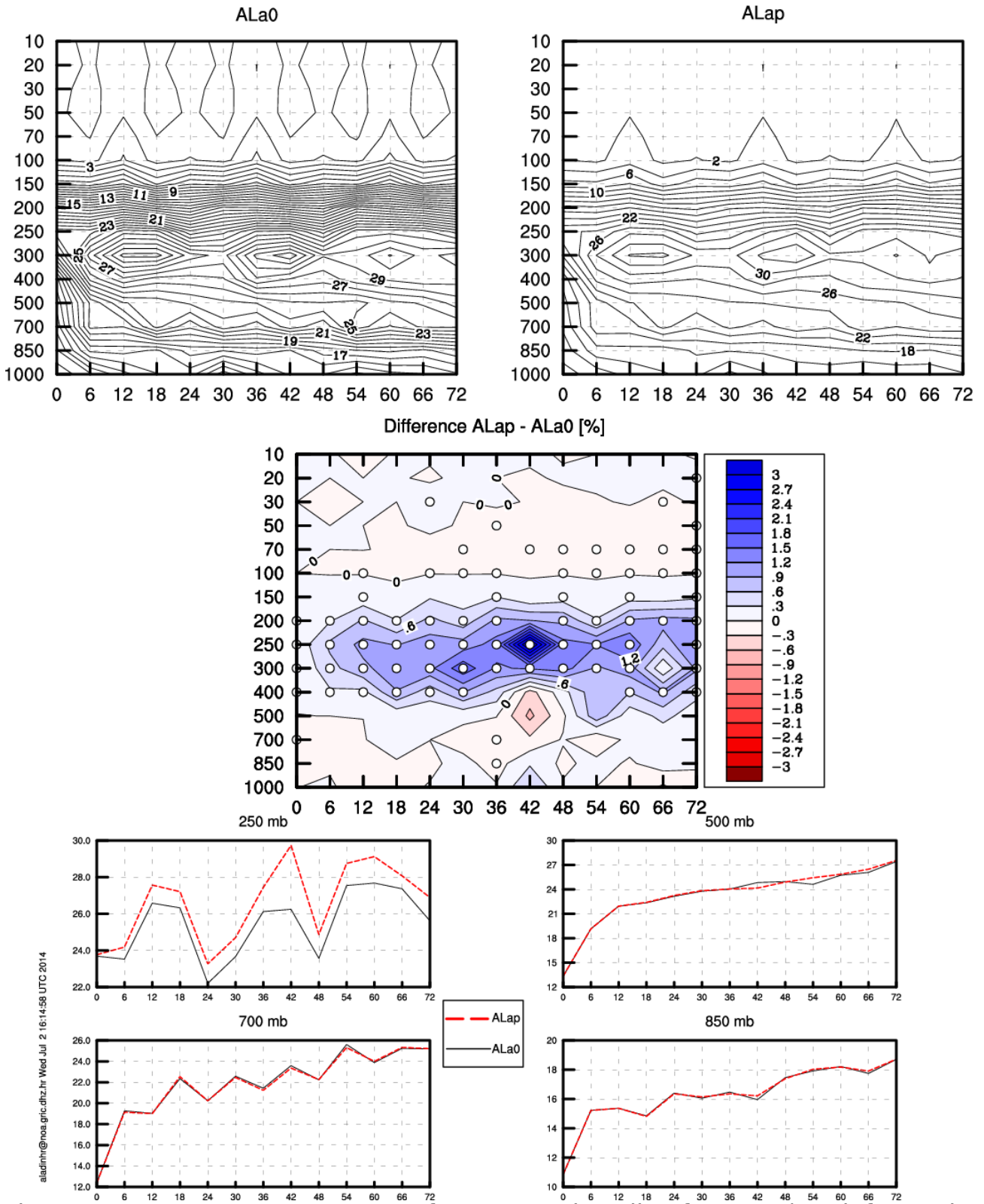


Figure 24. Root mean square error for ALARO0 baseline forecast (top left panel and black lines in bottom panels) and experiment with LSEDCL=F (top right panel and red lines in bottom panels) for May 2014.

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 RELATIVE_HUMIDITY (RMSE)

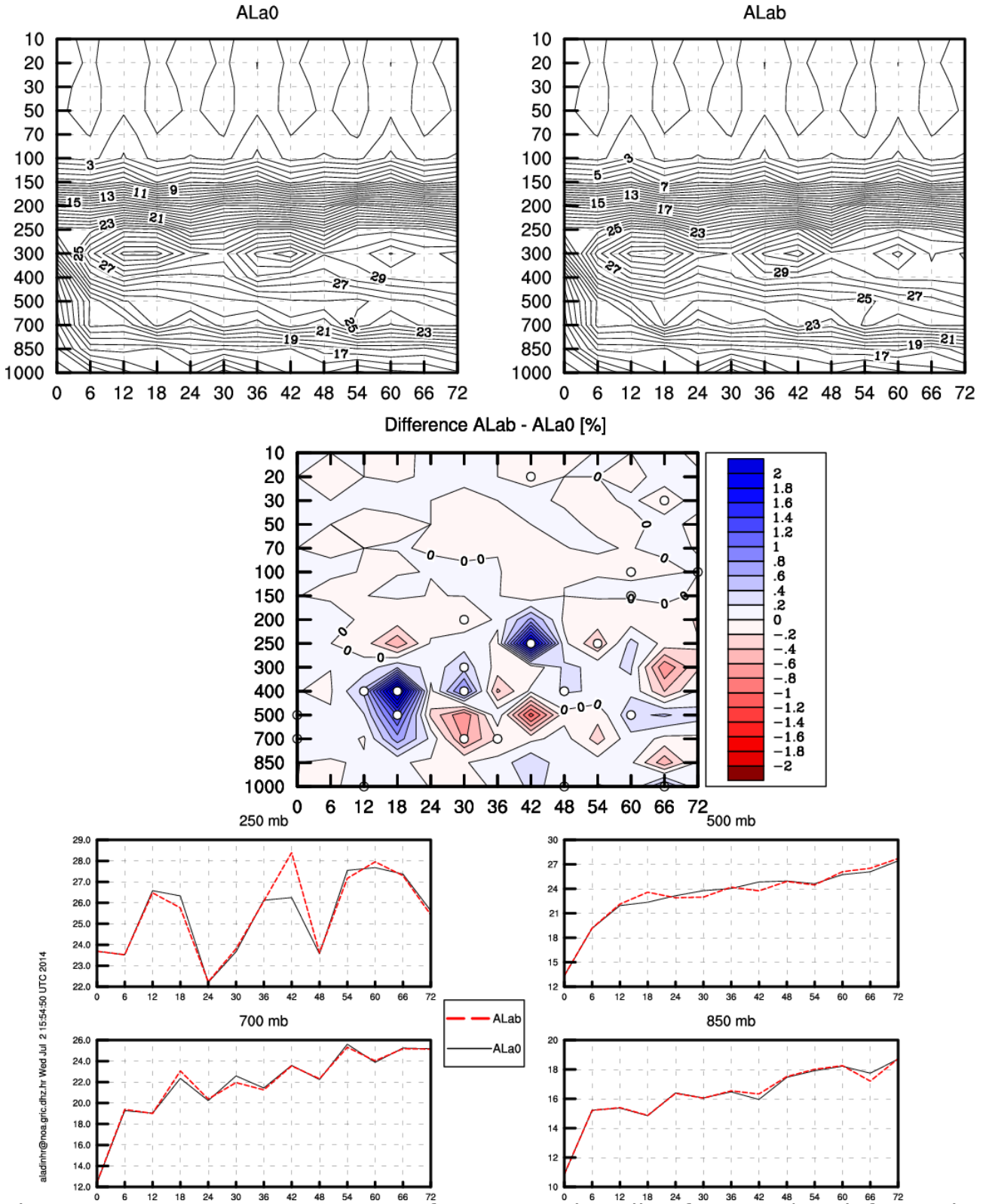


Figure 25. Root mean square error for ALARO0 baseline forecast (top left panel and black lines in bottom panels) and experiment with LCVGM=F and LENTCH=F (top right panel and red lines in bottom panels) for May 2014.

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 GEOPOTENTIAL (RMSE)

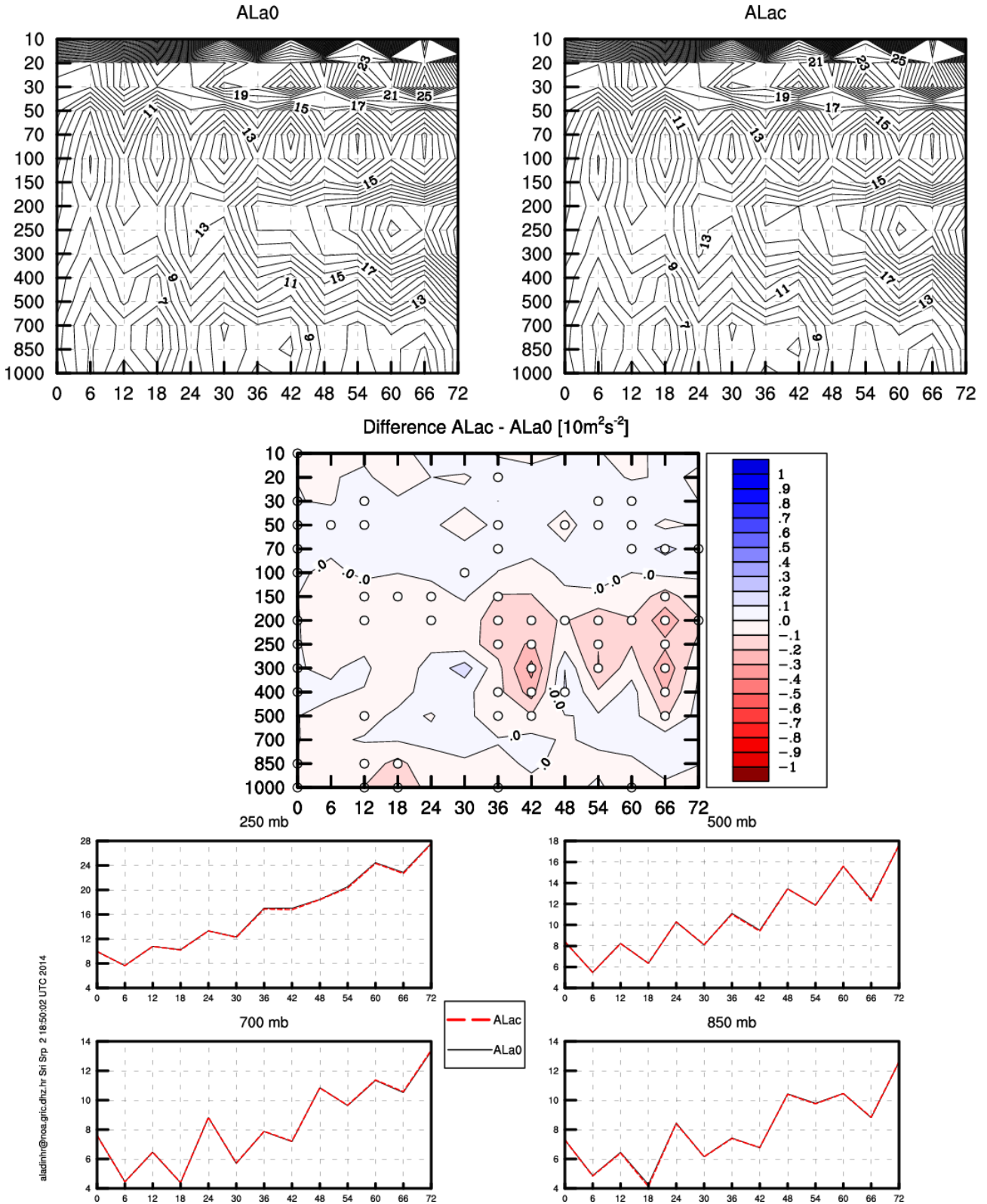


Figure 26. Root mean square error for ALARO0 baseline forecast (top left panel and black lines in bottom panels) and experiment with $GCVAlFA=3 \times 10^{-5}$ and $GDDEVF=0.5$ (top right panel and red lines in bottom panels) for May 2014.

alaadinh@noaa.gov, 21 Sep 2014 18:50:02 UTC

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 GEOPOTENTIAL (RMSE)

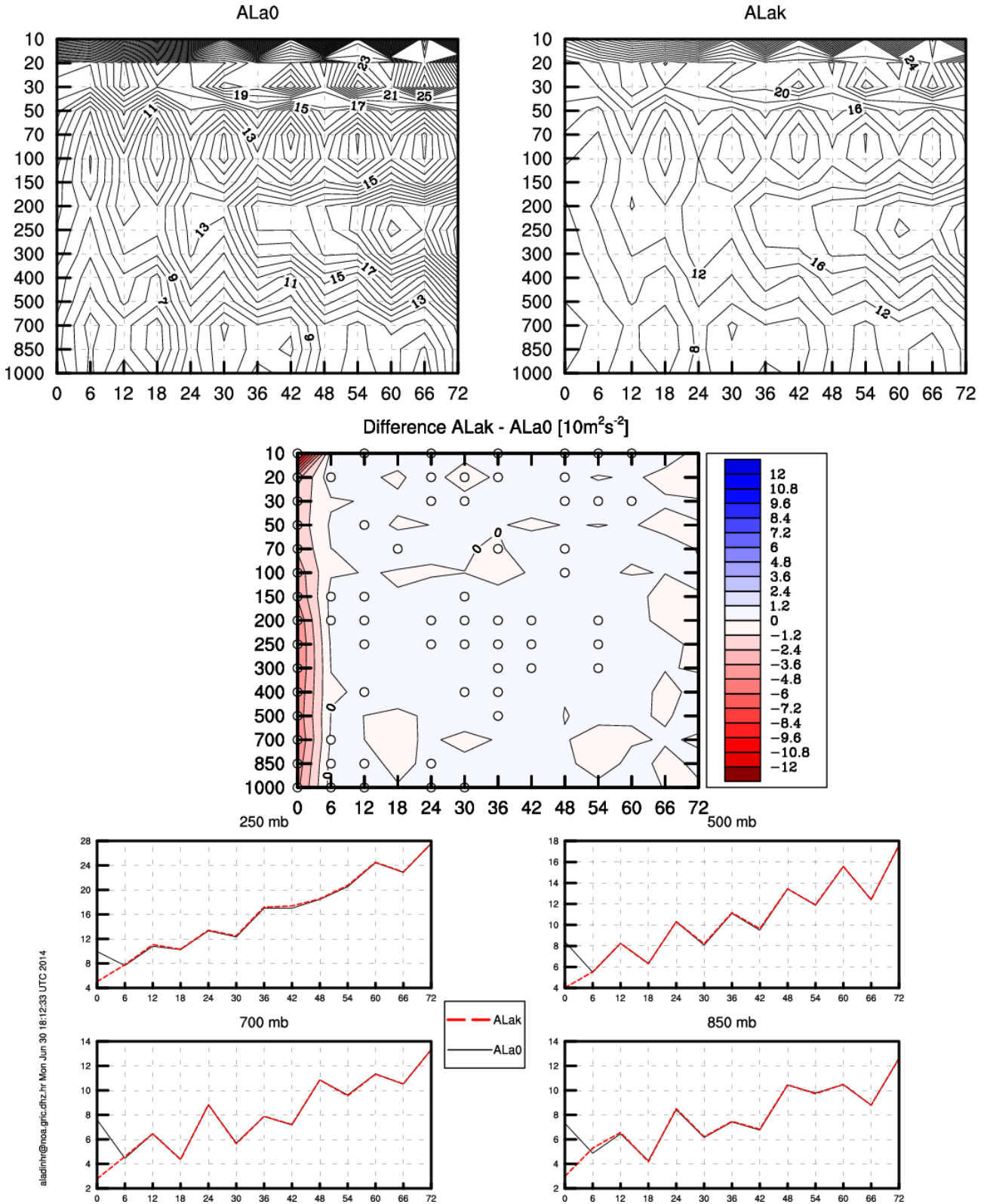


Figure 27. Root mean square error for ALARO0 baseline forecast (top left panel and black lines in bottom panels) and experiment with NEINI=0 (top right panel and red lines in bottom panels) for May 2014.

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 GEOPOTENTIAL (RMSE)

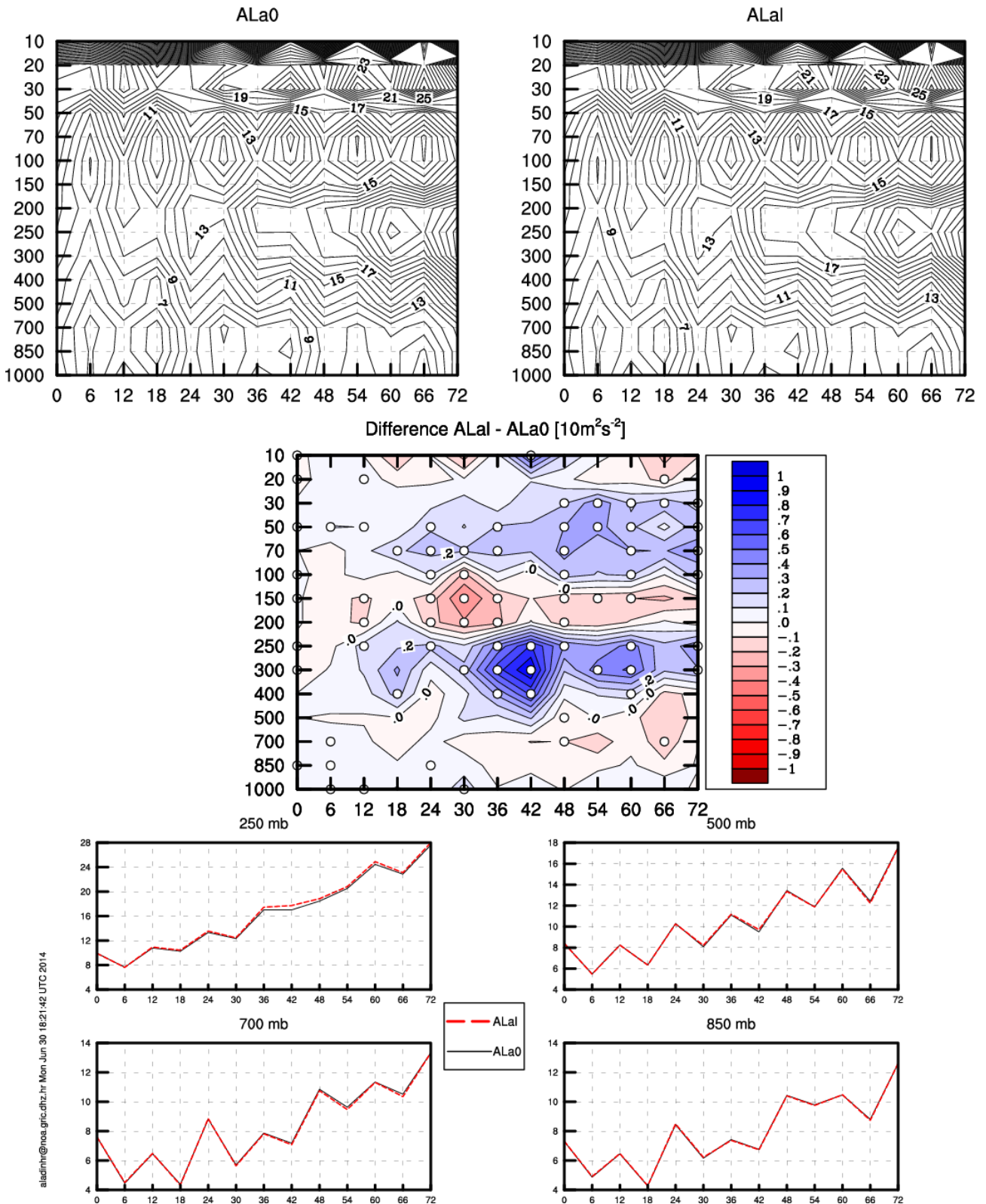
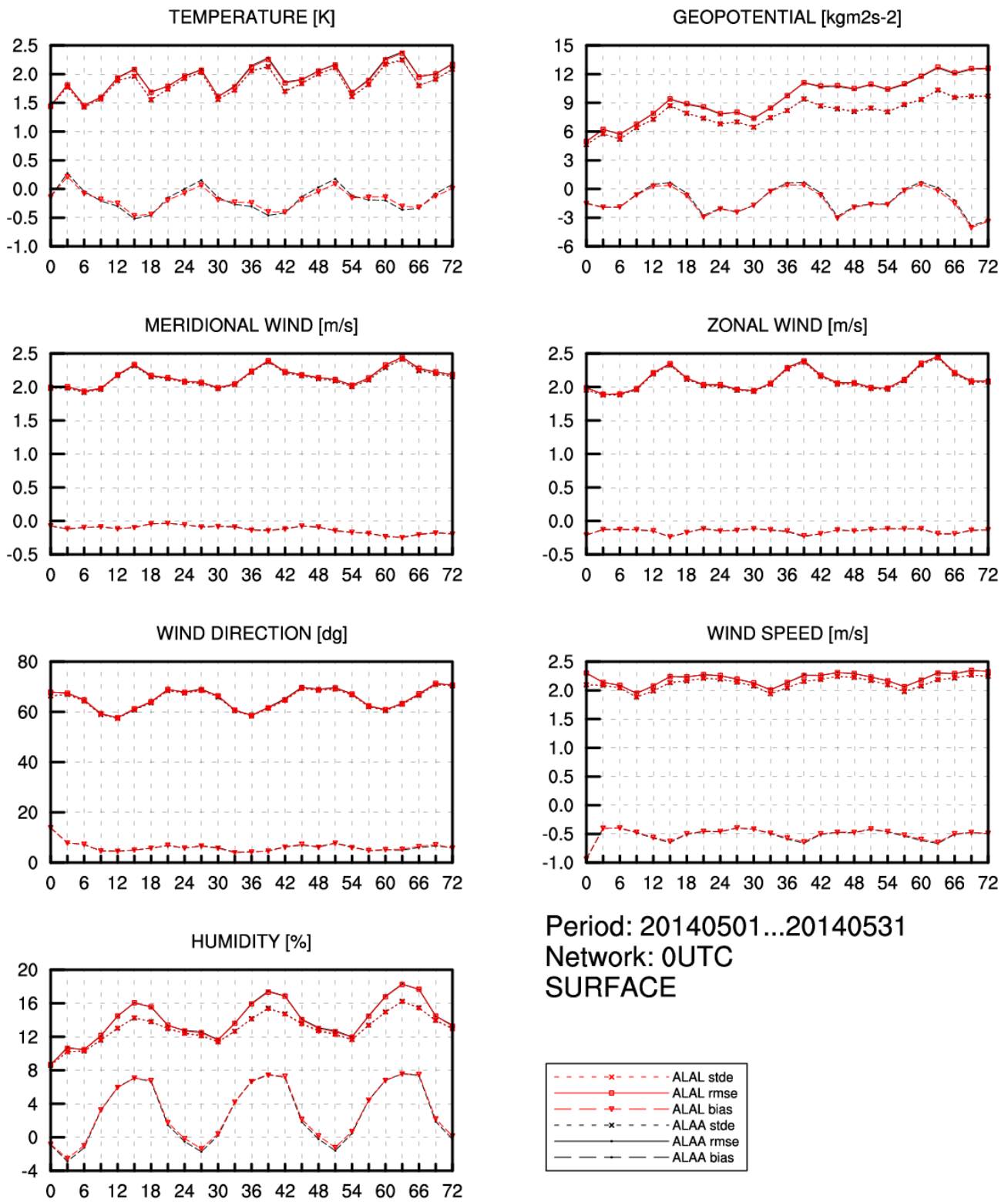


Figure 28. Root mean square error for ALARO0 baseline forecast (top left panel and black lines in bottom panels) and experiment with LSLHD=F (top right panel and red lines in bottom panels) for May 2014.

Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Tue Aug 26 19:05:27 UTC 2014

Figure 29. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for ALAR00 baseline (black) and experiment with ALAR00 baseline and SCLESPS=3066 and SCLESPR=119407 forecast (red) for May 2014.

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 RELATIVE_HUMIDITY (RMSE)

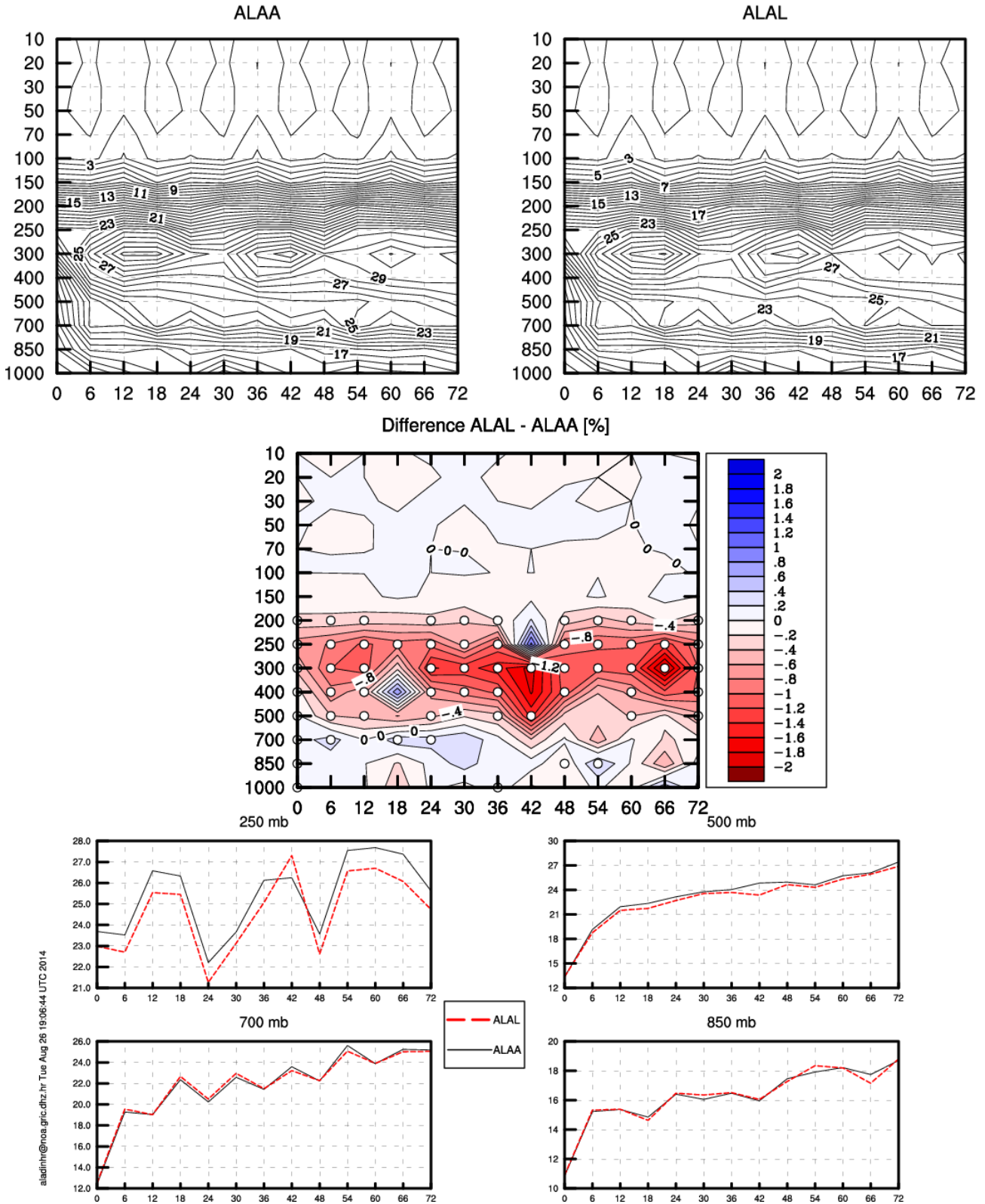


Figure 30. Root mean square error for ALARO0 baseline forecast (top left panel and black lines in bottom panels) and experiment with SCLESPS=3066 and SCLESPR=119407 (top right panel and red lines in bottom panels) for May 2014.

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
RELATIVE_HUMIDITY (BIAS)

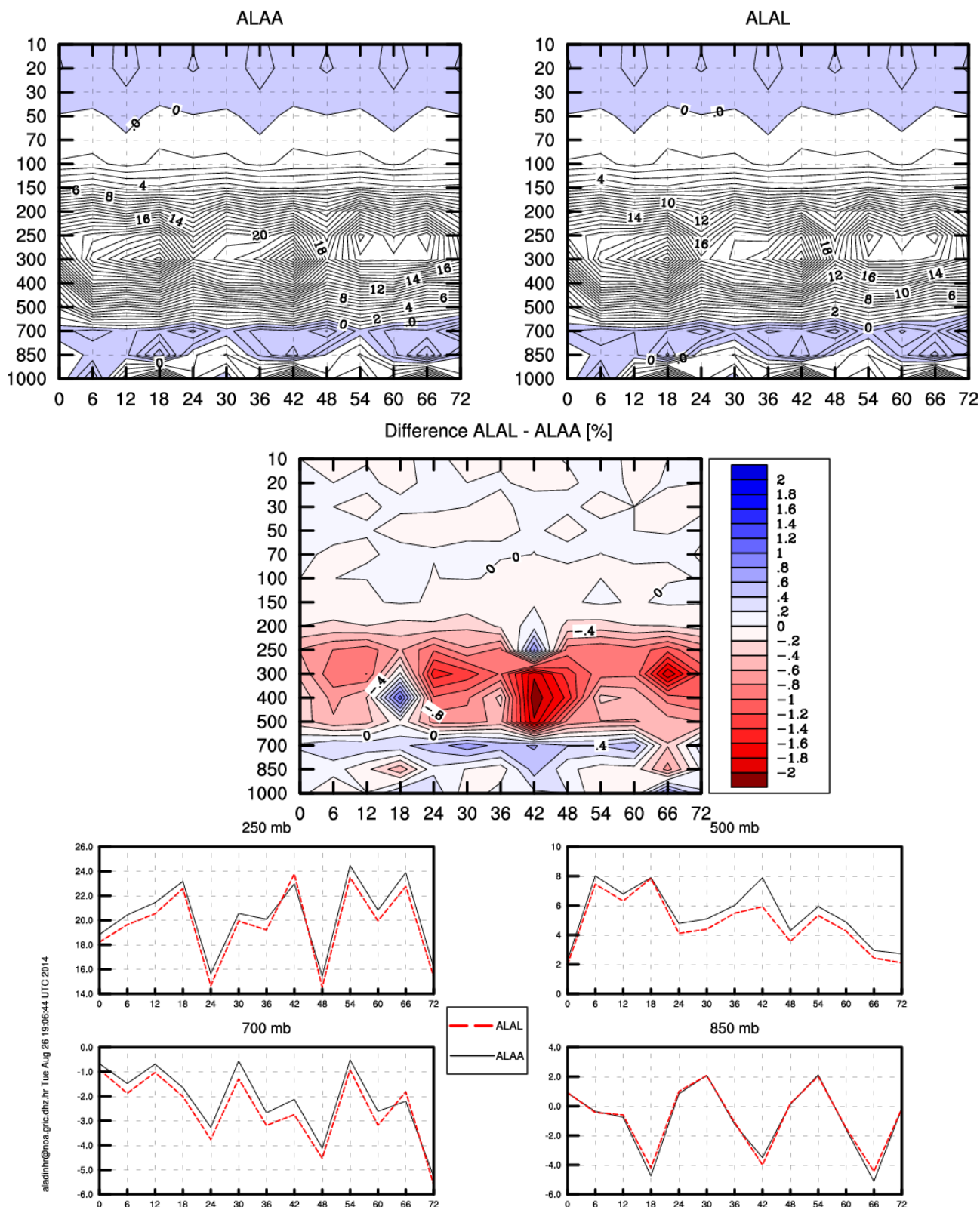


Figure 31. Bias for ALAR00 baseline forecast (top left panel and black lines in bottom panels) and experiment with SCLES=3066 and SCLES=119407 (top right panel and red lines in bottom panels) for May 2014.

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 RELATIVE_HUMIDITY (BIAS)

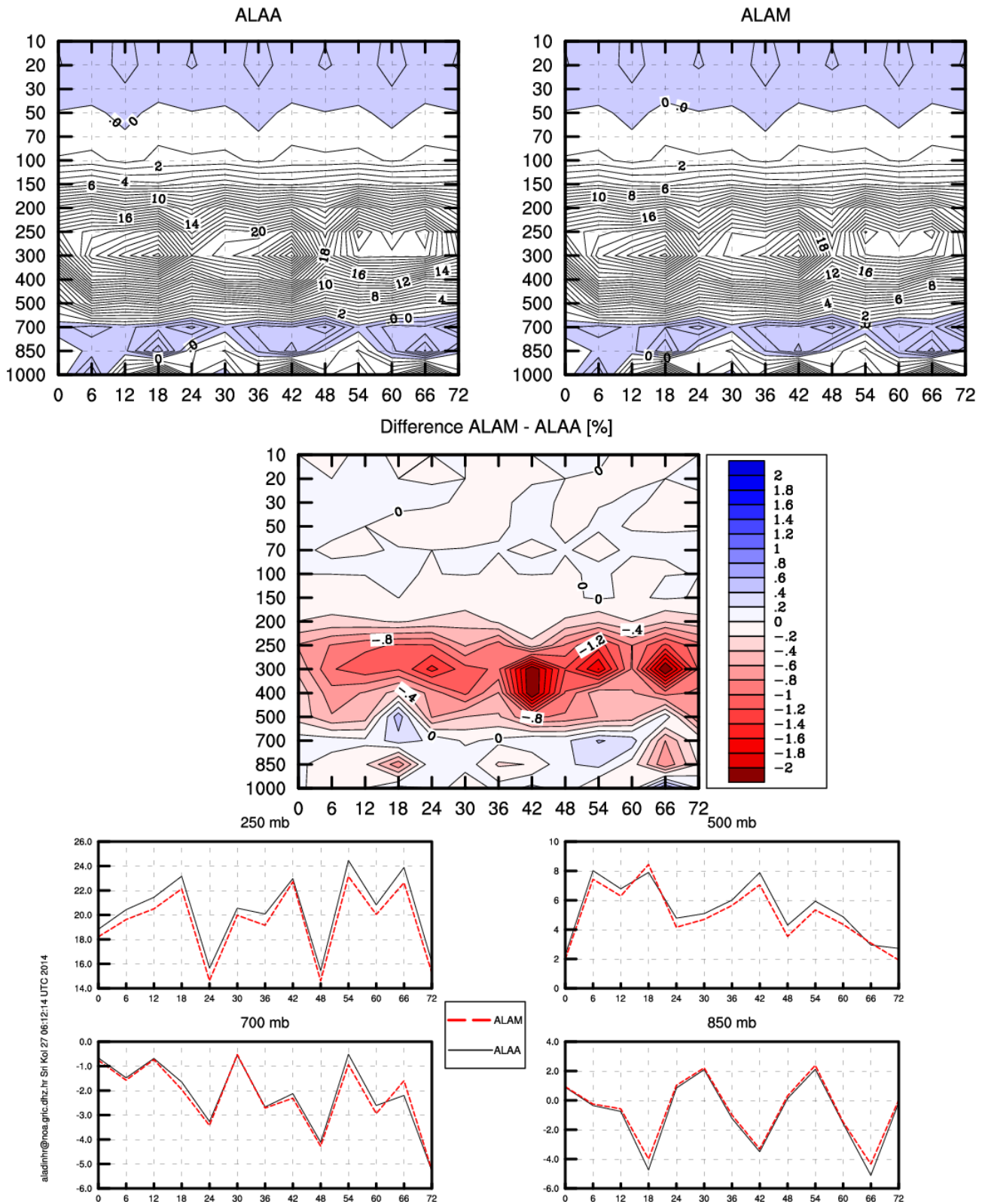


Figure 32. Bias for ALAR00 baseline forecast (top left panel and black lines in bottom panels) and experiment with SCLESPS=3066 (top right panel and red lines in bottom panels) for May 2014.

aladinhr@noaa.gov, 27 May 2014 06:12:14 UTC

Evolution of scores with forecast range

Period: 20140501...20140531 Network: OUTC
 RELATIVE_HUMIDITY (BIAS)

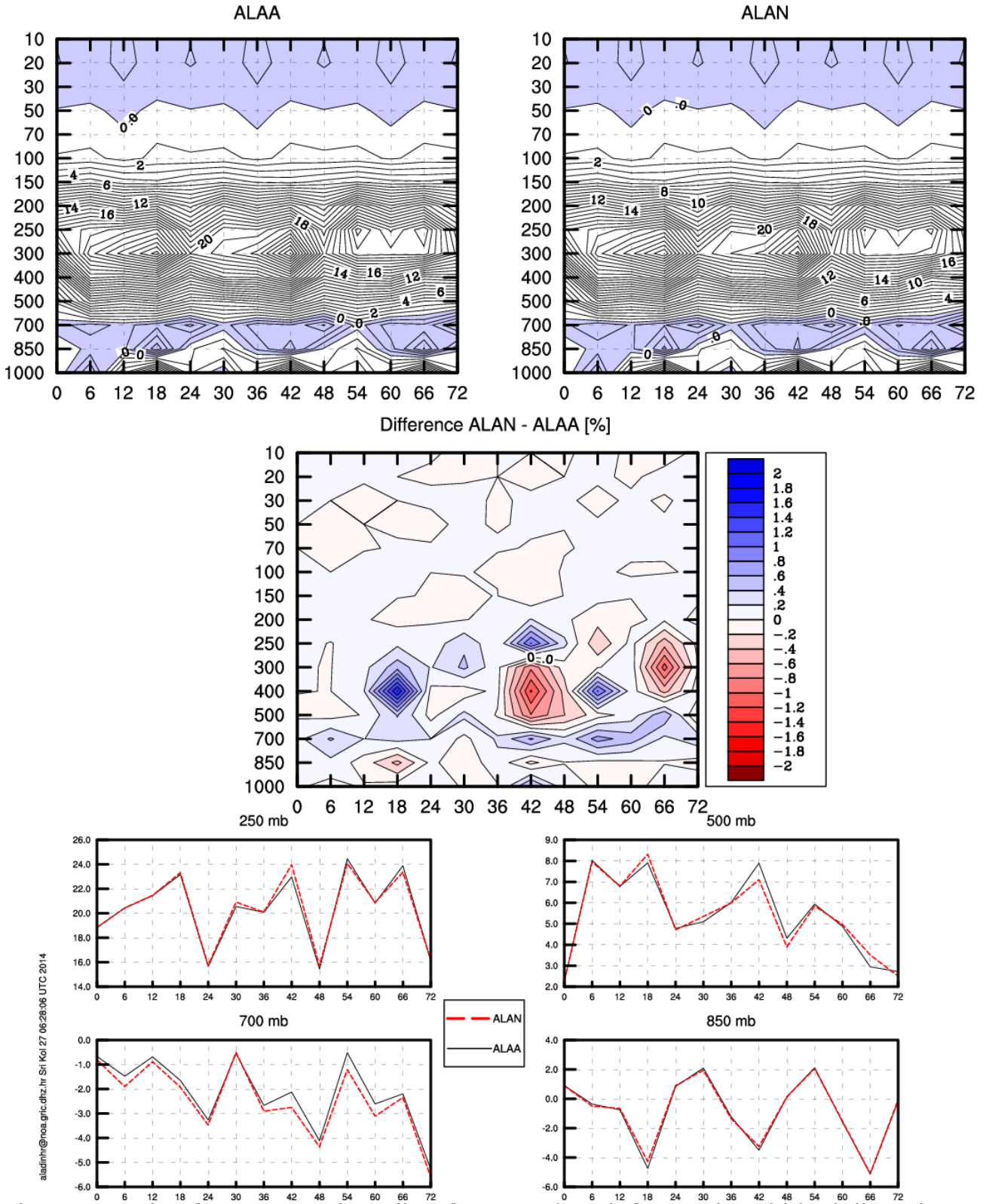


Figure 33. Bias for ALAR00 baseline forecast (top left panel and black lines in bottom panels) and experiment with SCLESPR=119407 (top right panel and red lines in bottom panels) for May 2014.

aladinhr@noaa.gov; 27 06:28:06 UTC 2014

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 RELATIVE_HUMIDITY (RMSE)

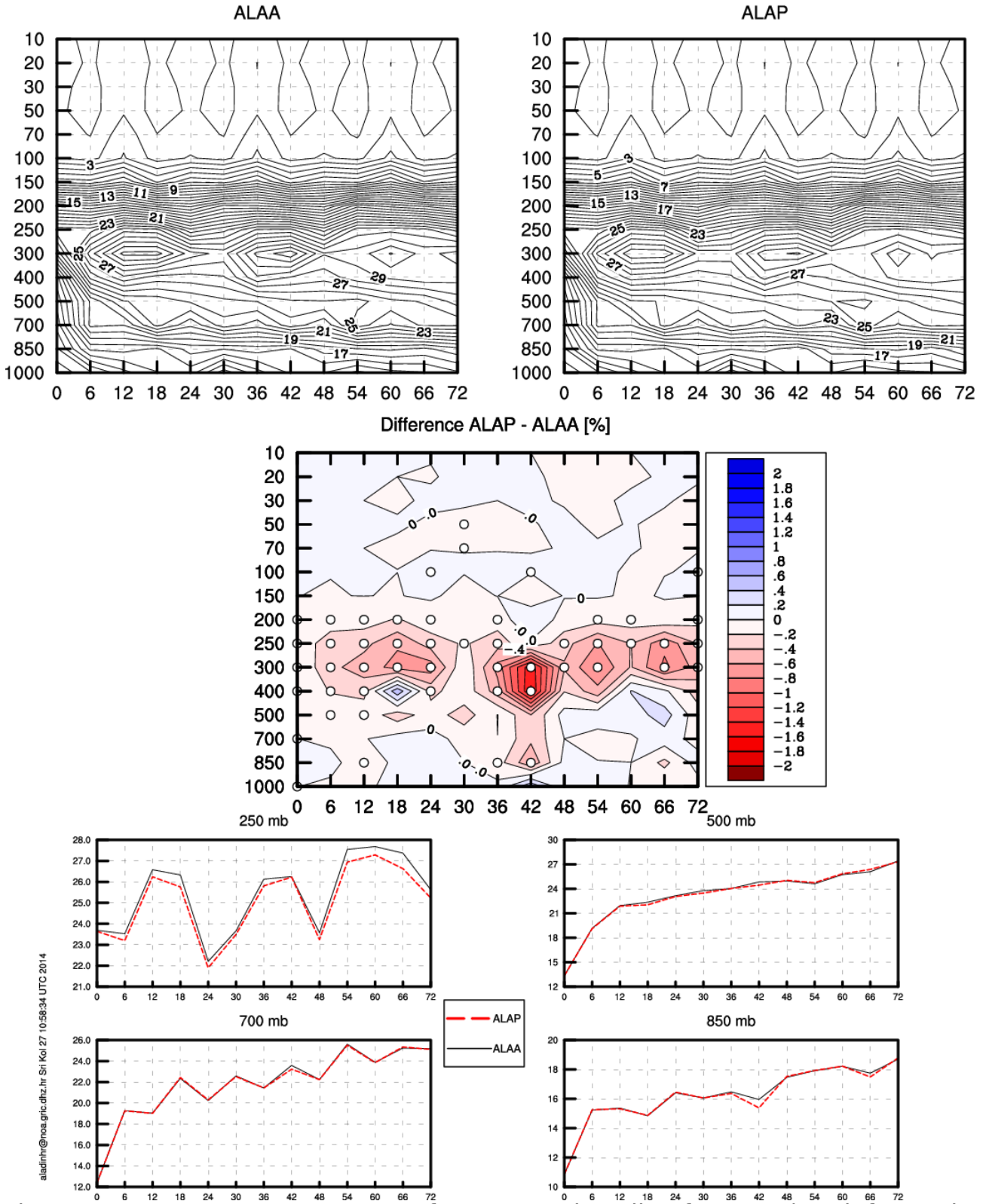


Figure 34. Root mean square error for ALARO0 baseline forecast (top left panel and black lines in bottom panels) and experiment with TVFI=0.16 (top right panel and red lines in bottom panels) for May 2014.

aladinhr@noaa.gov, hr Srfi Kol 27 10:58:34 UTC 2014

Evolution of scores with forecast range

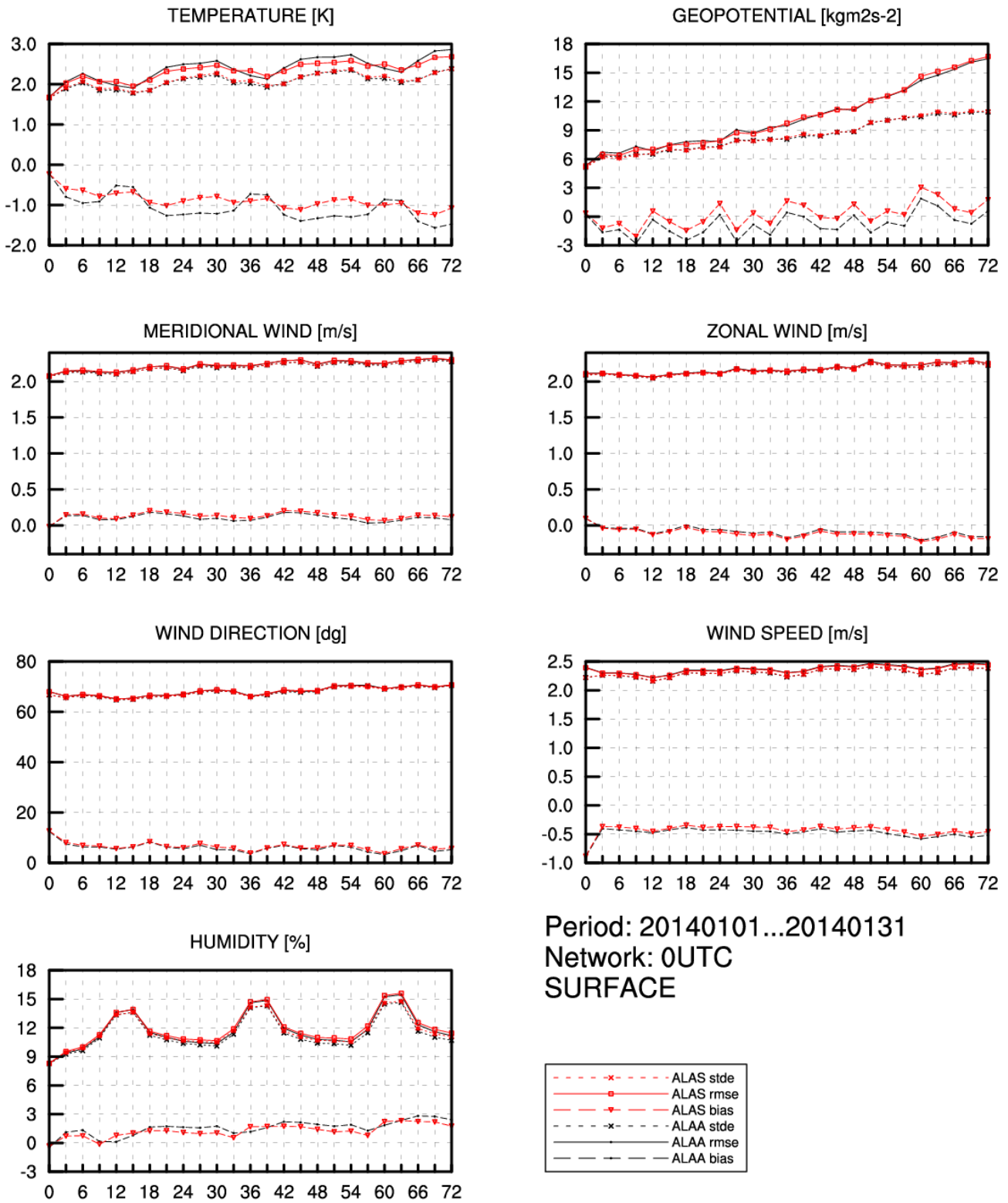


Figure 35. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for ALAR00 baseline (black) and experiment with ALAR00 baseline and RPHI0=12500 forecast (red) for January 2014.

aladinhr@noa.gric.dhz.hr Fri Aug 29 08:38:48 UTC 2014

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 RELATIVE_HUMIDITY (BIAS)

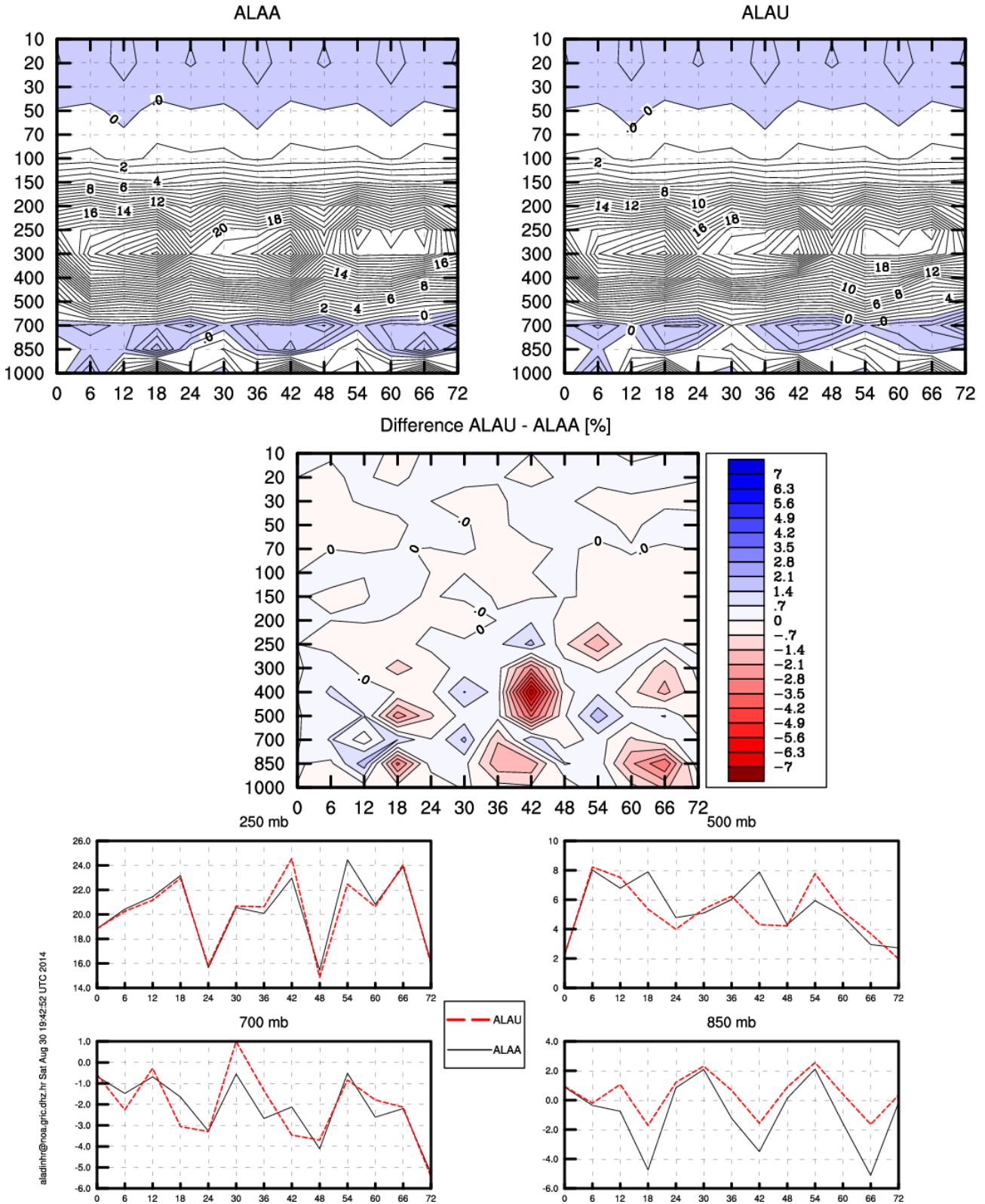


Figure 36. Bias for ALAR00 baseline forecast (top left panel and black lines in bottom panels) and experiment with RMULACVG=1 (top right panel and red lines in bottom panels) for May 2014.

aladinhr@noaa.gov:hr Sat Aug 30 19:42:52 UTC 2014

Evolution of scores with forecast range

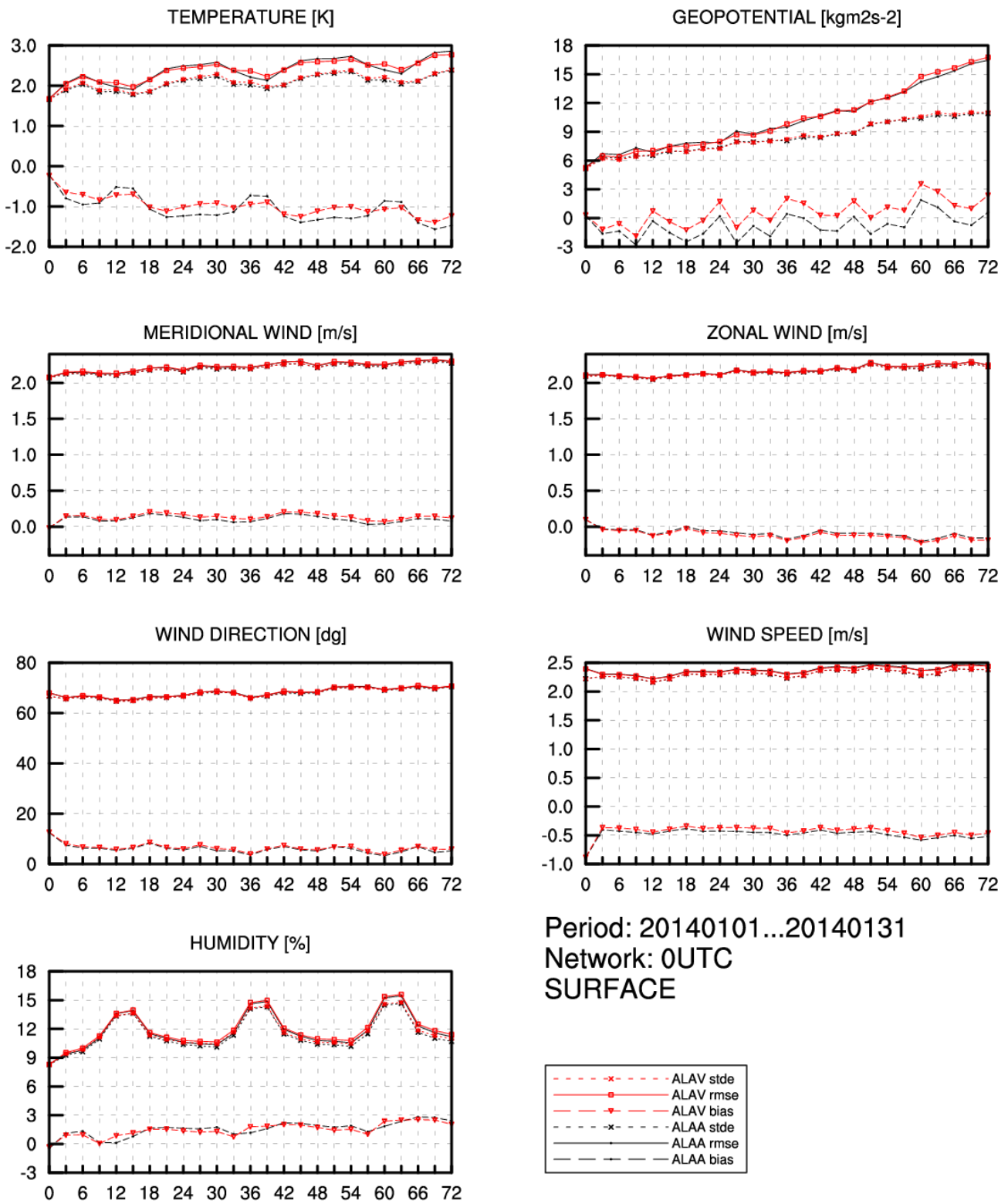
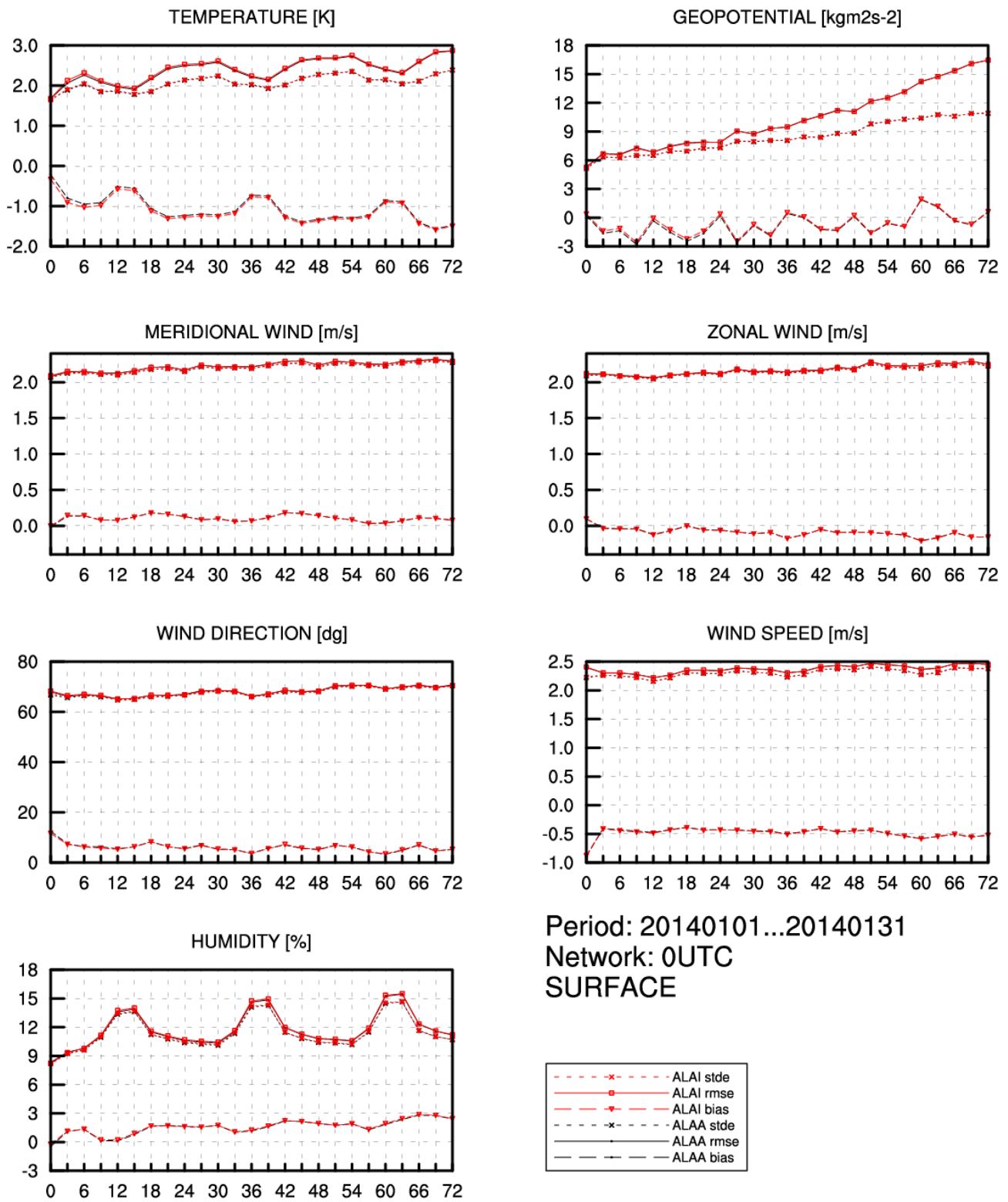


Figure 37. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for ALARO0 baseline (black) and experiment with ALARO0 baseline and SCLESPS=3066, TVFI=0.16 and RPHI0=12500 forecast (red) for May 2014.

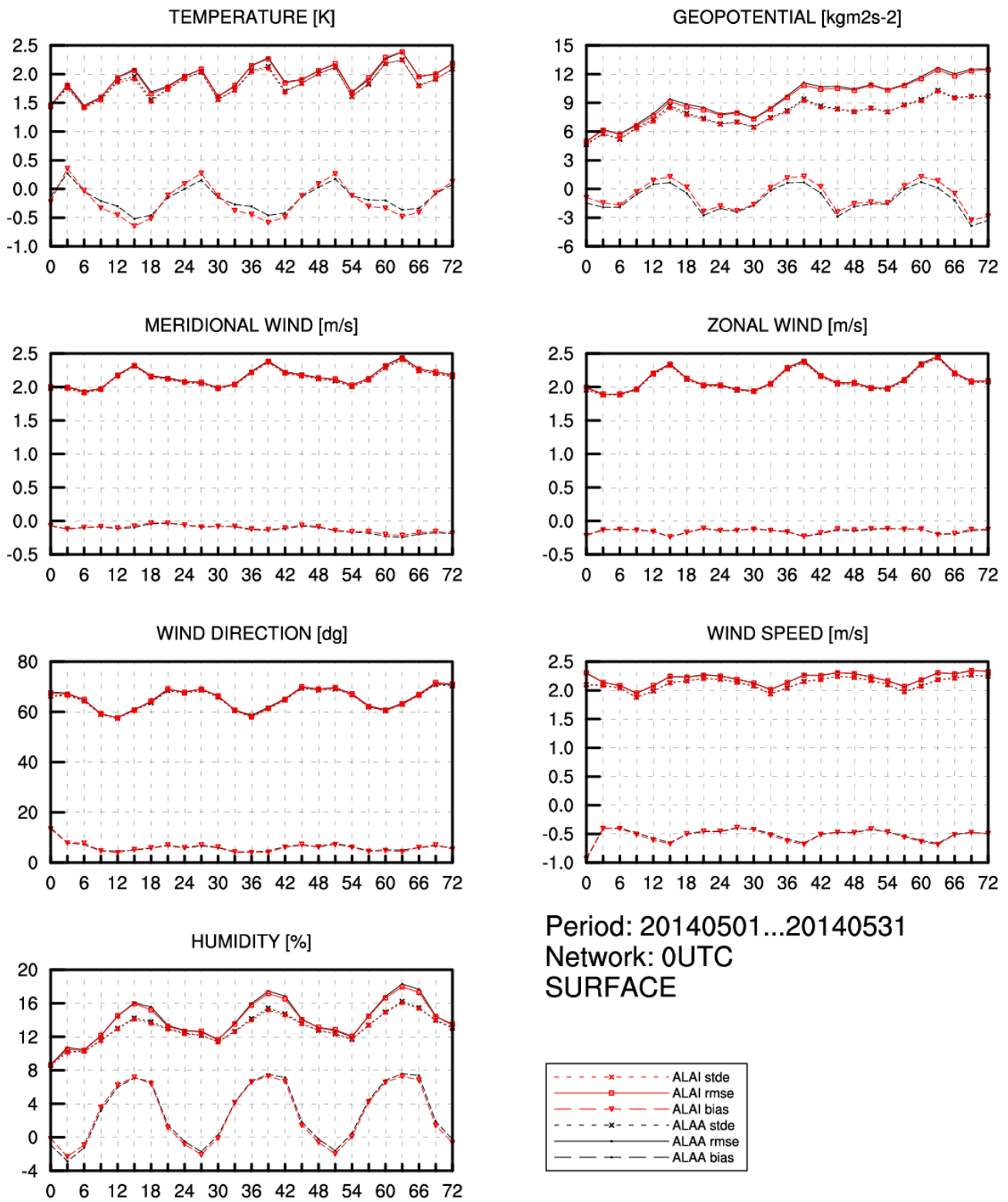
Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Tue Sep 2 11:49:04 UTC 2014

Figure 38. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for ALARO0 baseline (black) and experiment with ALARO0 baseline and cycling of prognostic cloud water and ice, rain and snow and convective variables (red) for January 2014.

Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Fri Aug 22 07:58:58 UTC 2014

Figure 39. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for ALARO0 baseline (black) and experiment with ALARO0 baseline and cycling of prognostic cloud water and ice, rain and snow and convective variables (red) for May 2014.

Evolution of scores with forecast range

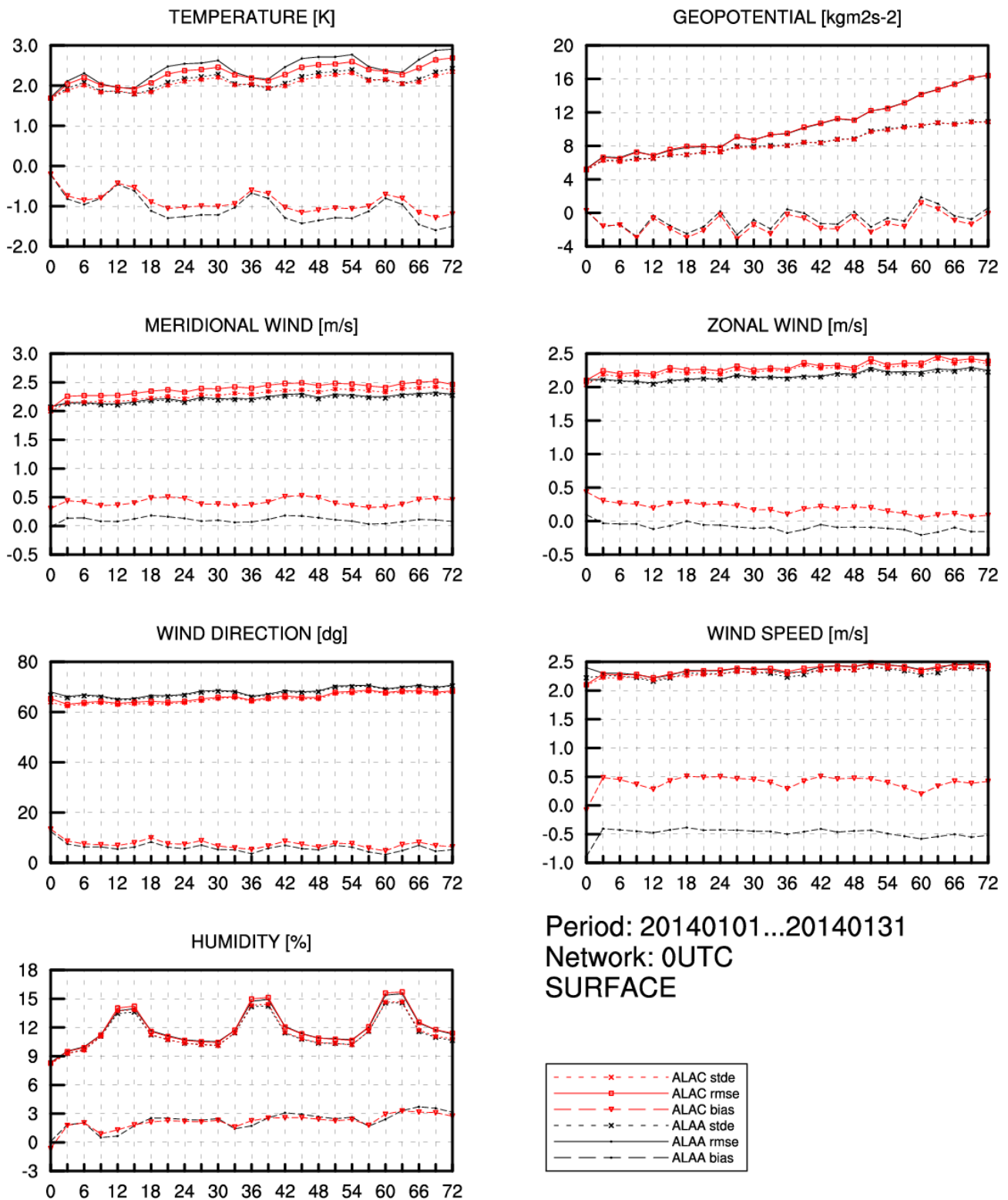


Figure 40. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for ALARO0 baseline (black) and experiment with ALARO0 baseline and 73 levels and QXRTGH=1.6 (red) for January 2014.

Evolution of scores with forecast range

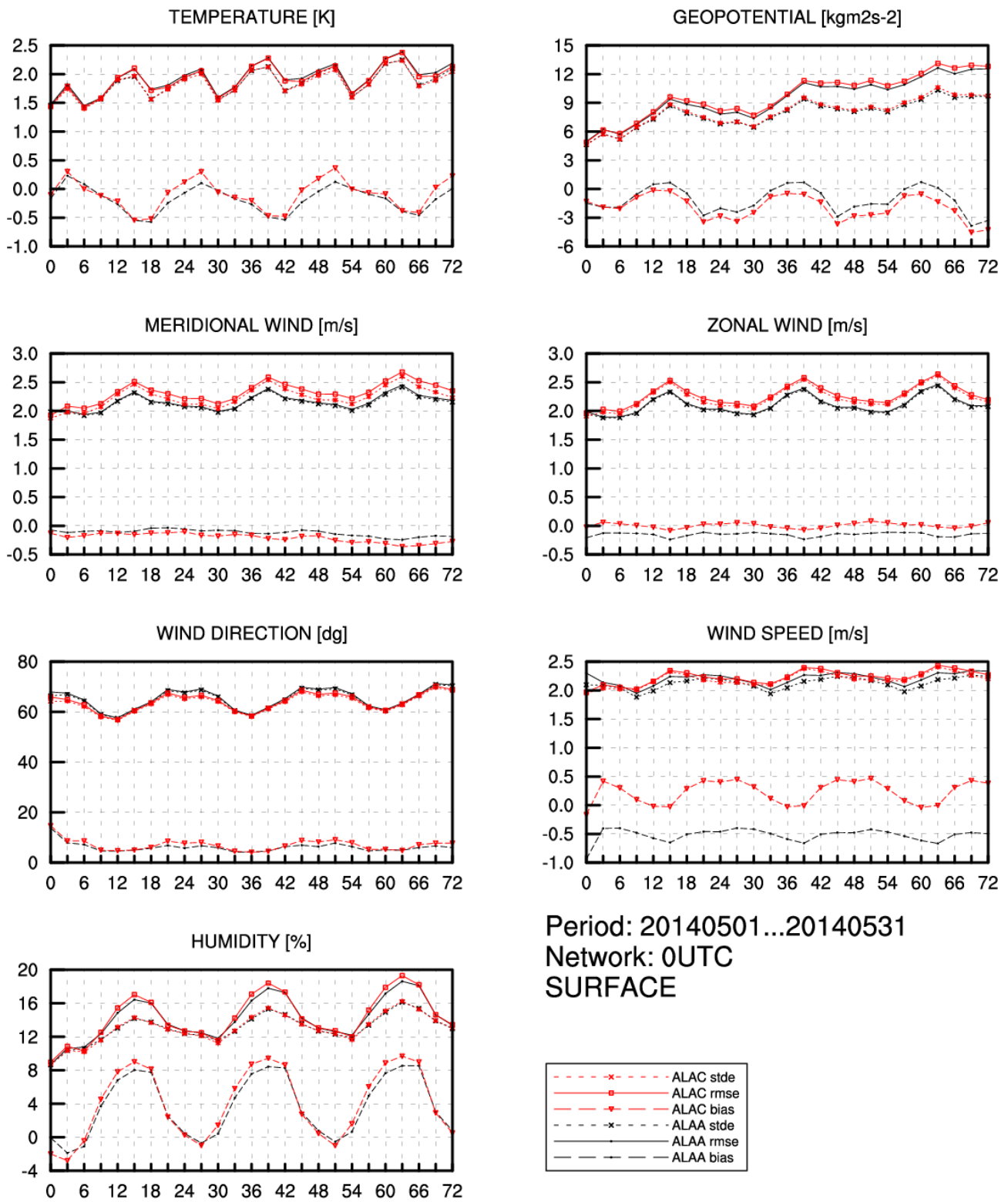


Figure 41. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for ALARO0 baseline (black) and experiment with ALARO0 baseline and 73 levels and QXRTGH=1.6 (red) for May 2014.

Evolution of scores with forecast range

Period: 20140101...20140131 Network: OUTC
 RELATIVE_HUMIDITY (BIAS)

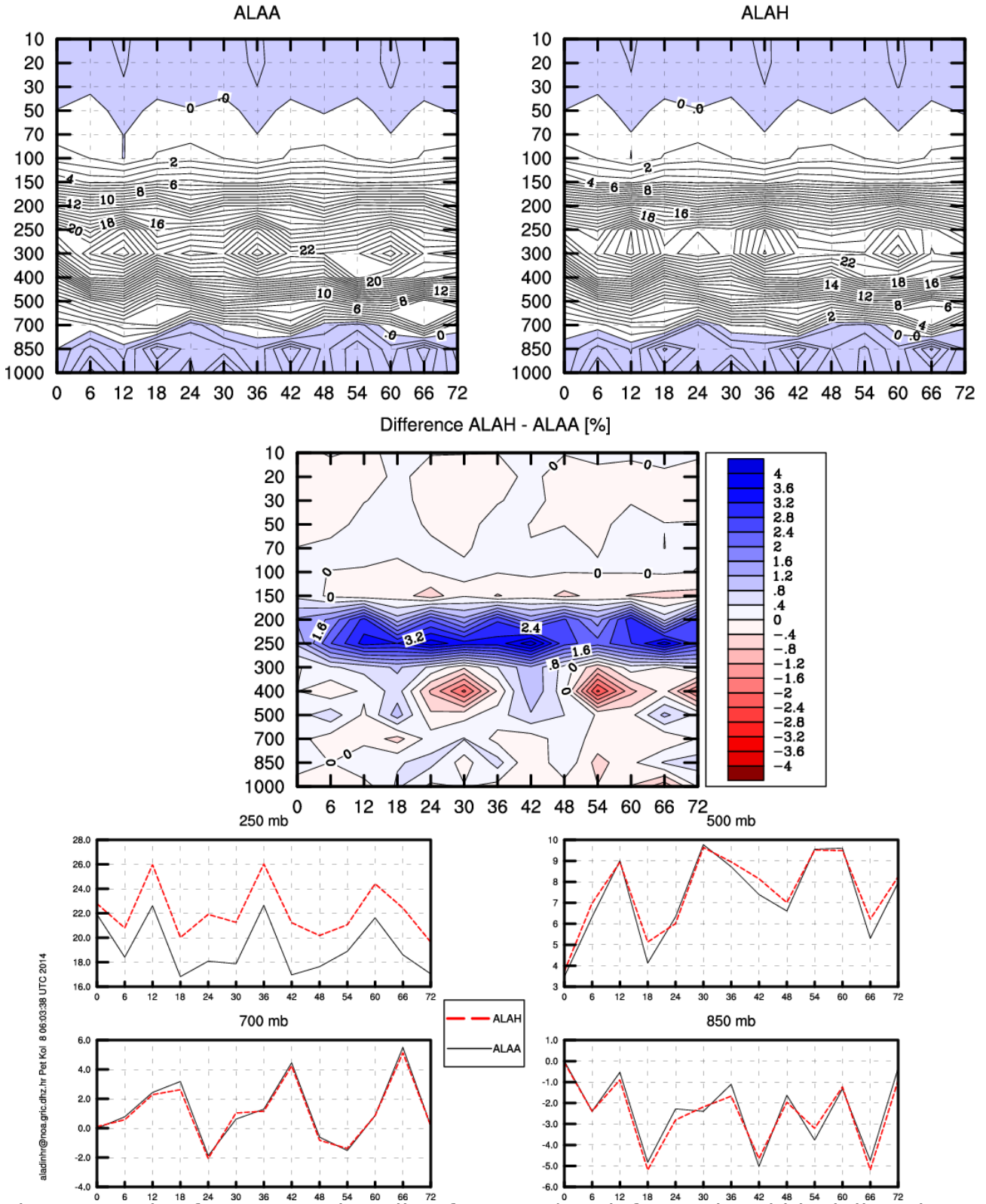


Figure 42. Bias for ALAR00 baseline forecast (top left panel and black lines in bottom panels) and experiment with 73 levels and QXRTGH=3.5 (top right panel and red lines in bottom panels) for January 2014.

aladinhr@noaa.gov; Pet Kol 8 06:03:38 UTC 2014

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 GEOPOTENTIAL (RMSE)

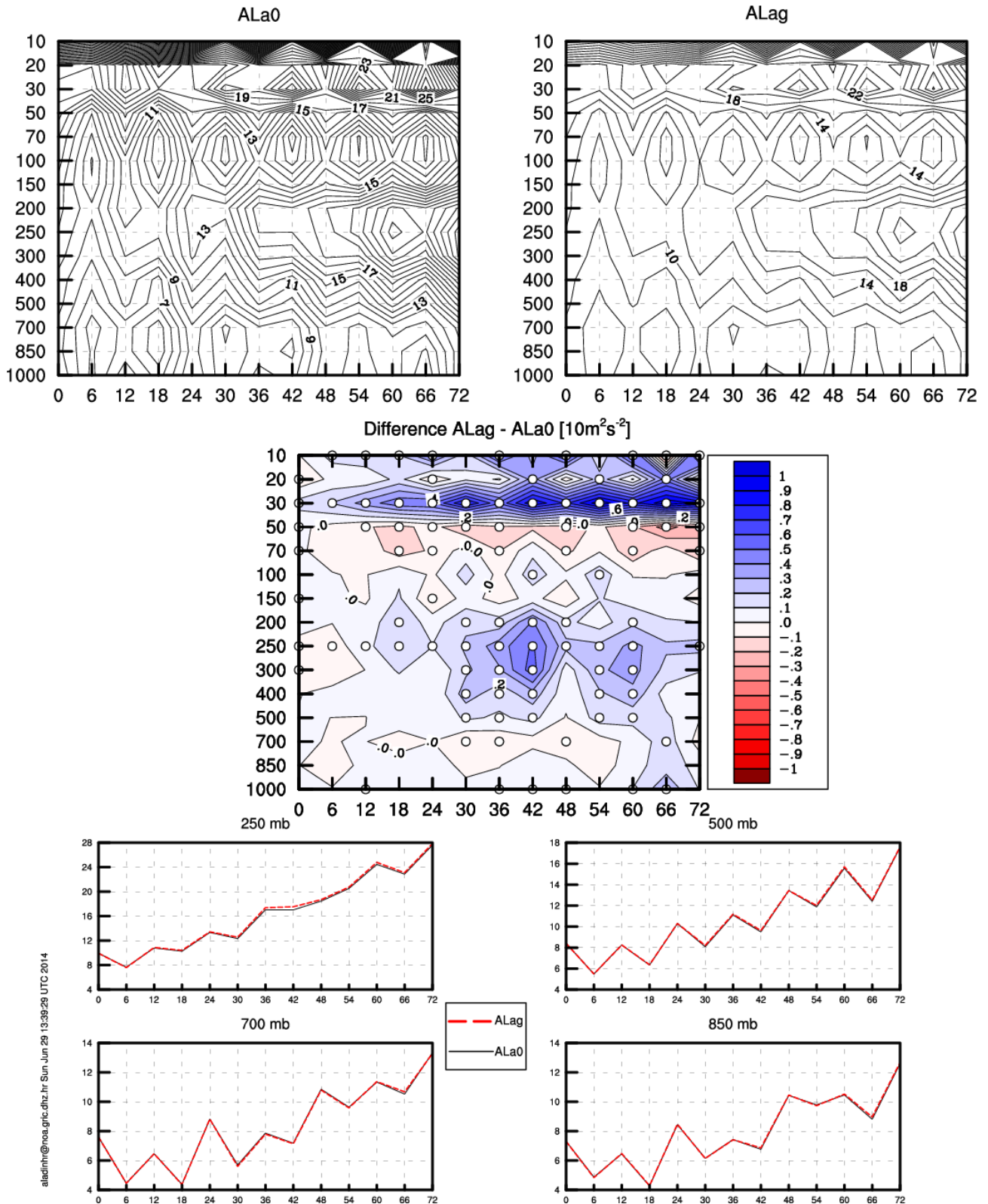


Figure 43. Root mean square error for ALARO0 baseline forecast (top left panel and black lines in bottom panels) and experiment with LAPRXPK=F, LREGETA=F (top right panel and red lines in bottom panels) for May 2014.

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 GEOPOTENTIAL (RMSE)

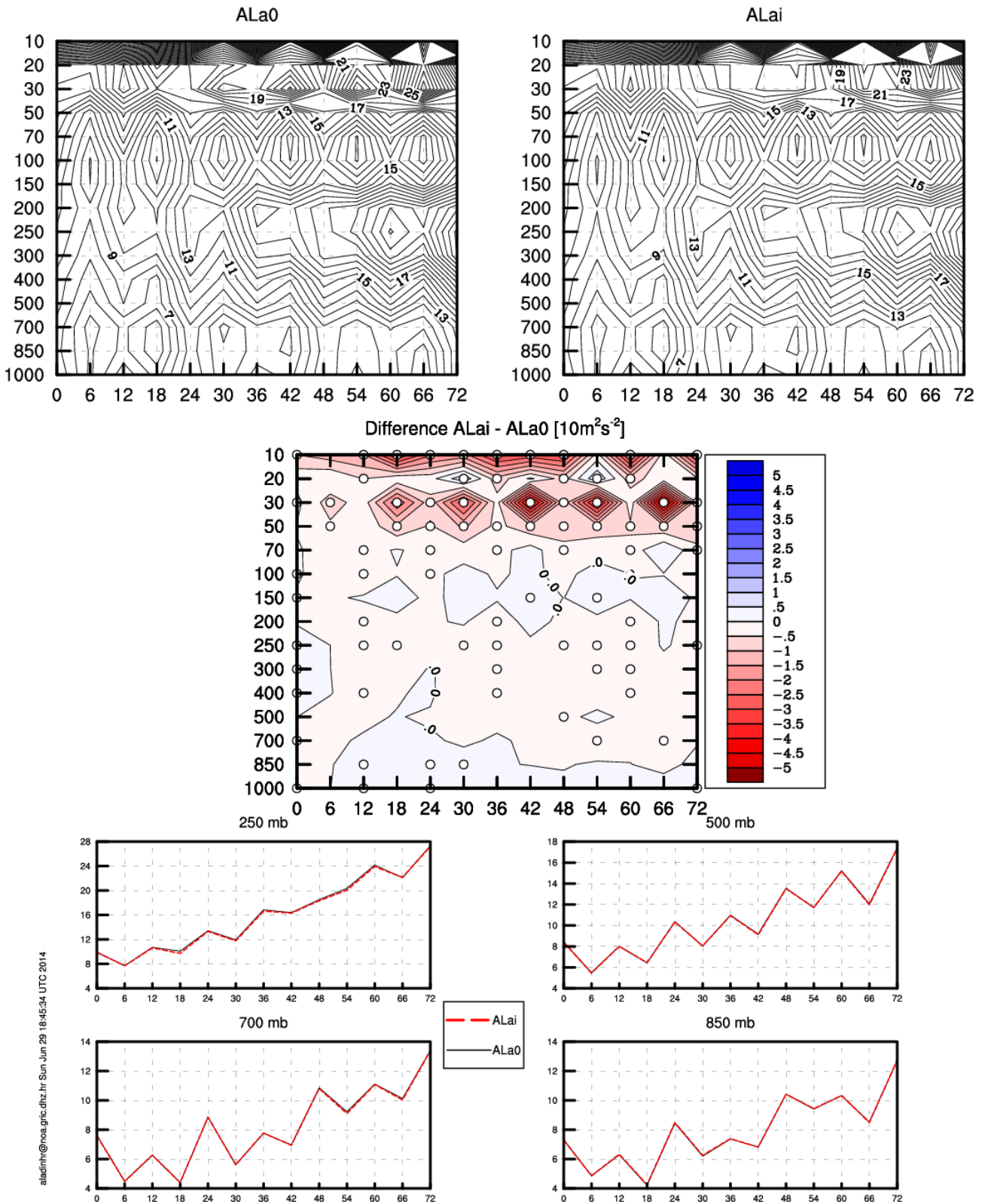


Figure 44. Root mean square error for ALARO0 baseline forecast (top left panel and black lines in bottom panels) and experiment with vertical finite elements (top right panel and red lines in bottom panels) for May 2014.

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 GEOPOTENTIAL (RMSE)

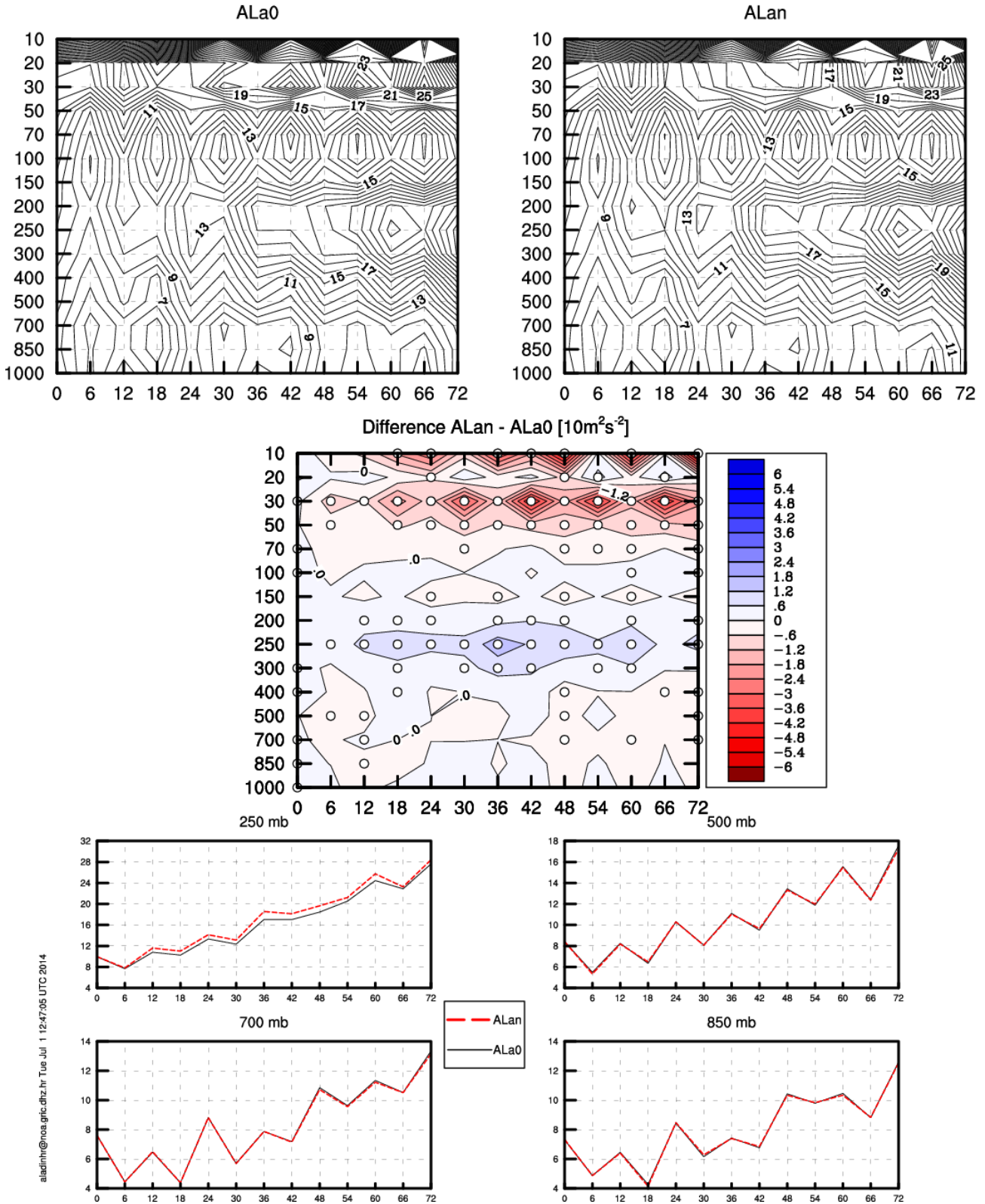
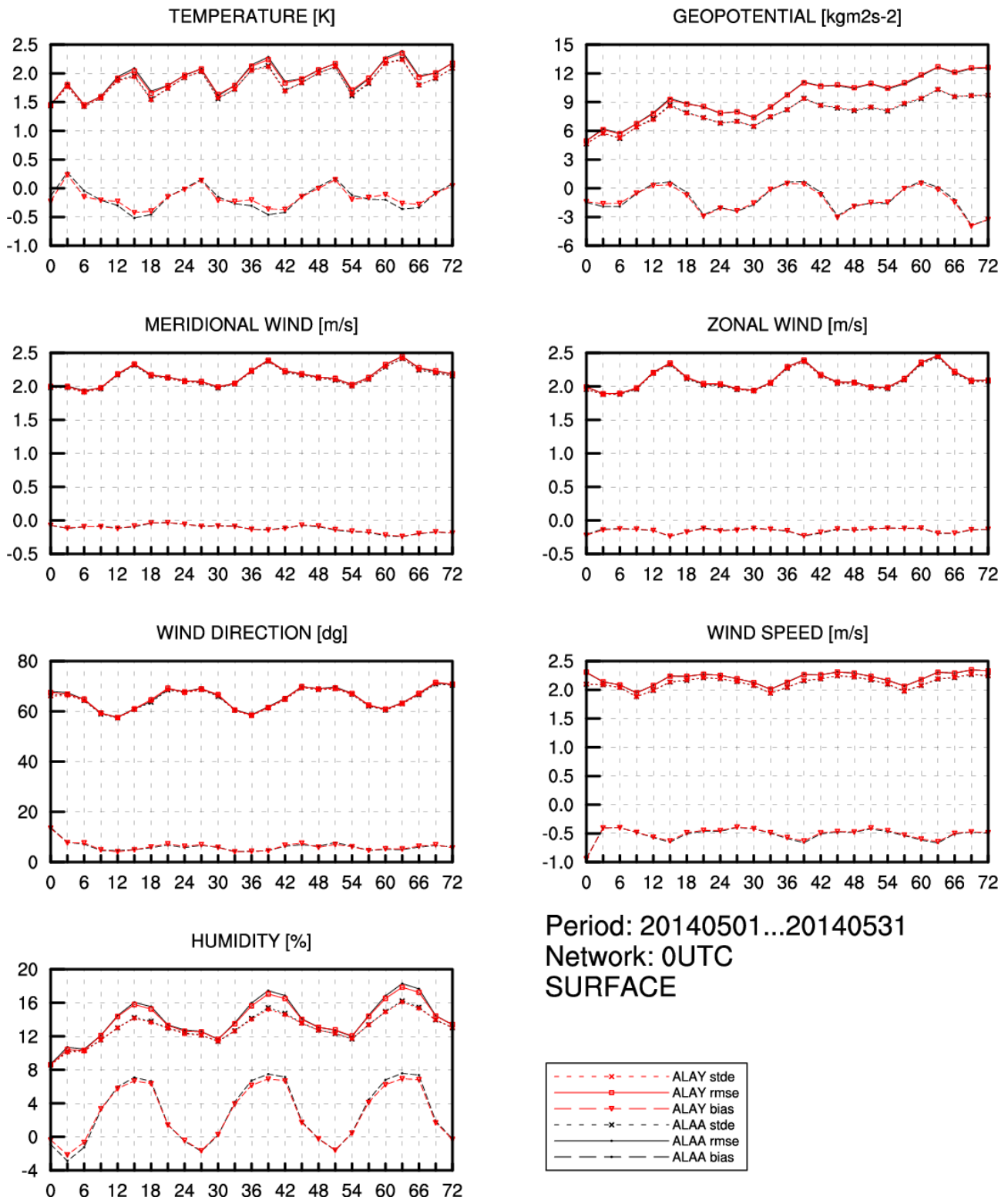


Figure 45. Root mean square error for ALARO0 baseline forecast (top left panel and black lines in bottom panels) and experiment with more intensive numerical horizontal diffusion RRDXTAU=123 (top right panel and red lines in bottom panels) for May 2014.

Evolution of scores with forecast range



aladinhr@noa.gric.dhz.hr Wed Sep 3 06:40:42 UTC 2014

Figure 46. Standard deviation (short dash), root mean square error (full line) and bias (long dash) for ALARO0 baseline (black) and experiment with ALARO0 baseline and cycling of prognostic cloud water and ice, rain and snow and convective variables TVFI=0.16, SCLESPS=3066., RPHIO=12500 (red) for May 2014.

Evolution of scores with forecast range

Period: 20140501...20140531 Network: 0UTC
 RELATIVE_HUMIDITY (RMSE)

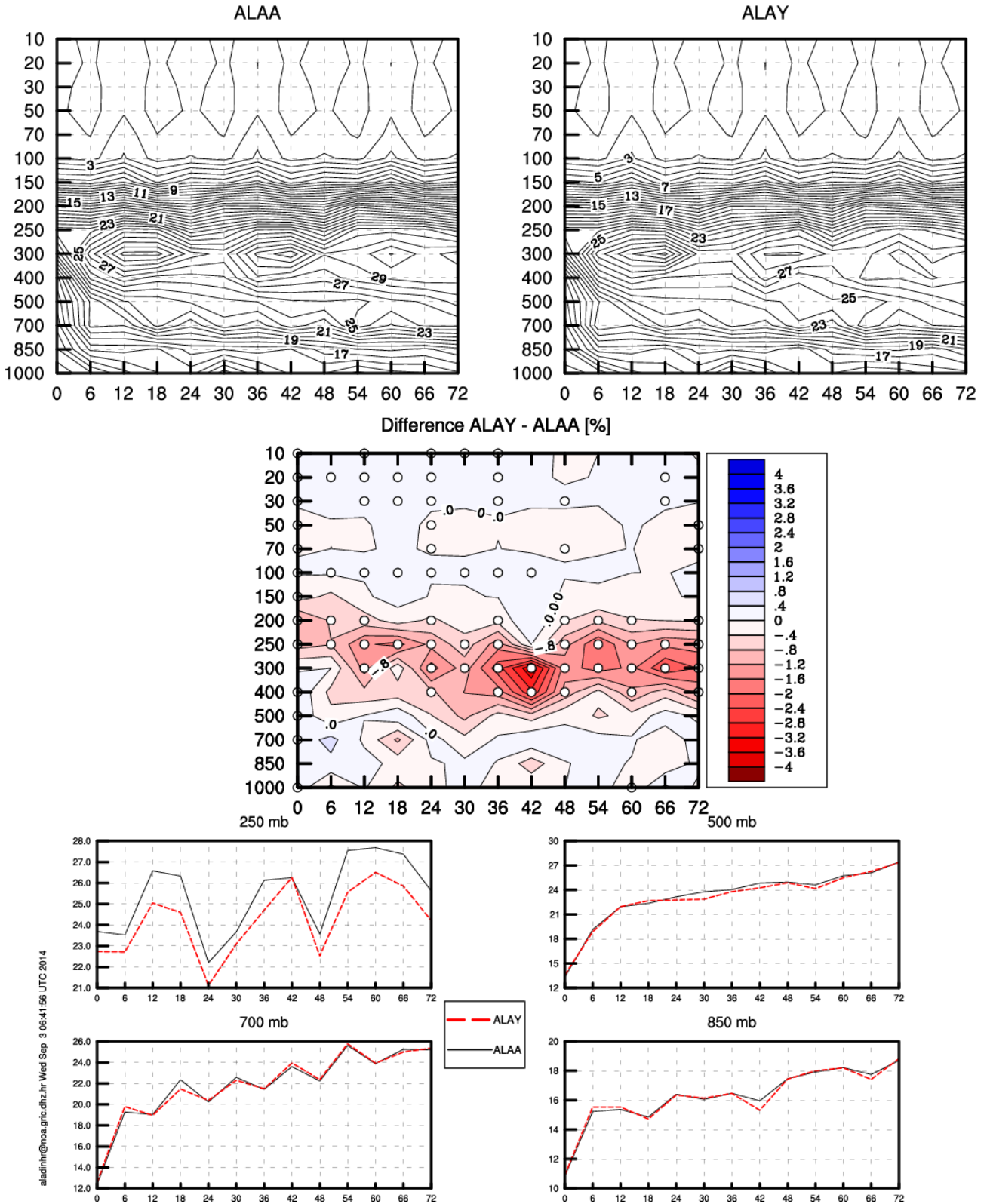


Figure 47. Root mean square error for ALARO0 baseline forecast (top left panel and black lines in bottom panels) and experiment with Initial files with cycling of TKE, prognostic condensates and convective variables, TVFI=0.16, SCLESPS=3066., RPHIO=12500 (top right panel and red lines in bottom panels) for May 2014.