SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year

2016

Project Title:

COSMO NWP meteorological test suite

Computer Project Account:

SPITRASP

Principal Investigator(s):

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Name of ECMWF scientist(s) collaborating to the project
(if applicable)

Umberto Modigliani and his staff

Start date of the project:

2016

Expected end date:

2018

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	1000000	279098.49	5000000	4848411.04
Data storage capacity	(Gbytes)	180	90	1000	400

This template is available at:
http://www.ecmwf.int/en/computing/access-computing-facilities/forms

Summary of project objectives

(10 lines max)

The aim of the COSMO NWP Meteorological Test Suite Special Project is to employ the software environment built on the ECMWF platform during the SPITRASP project (2013-2015) for carefully-controlled and rigorous testing (including calculation of verification statistics) for any COSMO model test-version. NWP COSMO benefits from the evaluation of new model versions prior to consideration for operational implementation (official version) according to source code management procedure. This procedure facilitates the decision whether the upgrade of a model test version to a new release is possible and gives the possibility to evaluate the impact that all implemented numerical or physical processes advances bring to convection permitting model resolutions. This type of designated testing also provides the research community with baselines against which the impacts of new techniques can be evaluated on a larger spatial and temporal domain.

Summary of problems encountered (if any)

(20 lines max)

- With regards to the running and maintaining of the test suite, we encontered problems with access permission for stop/start pending jobs (always to be performed through communication with ECMWF personnel).
- Problems with permissions read/write resulted since the installation of VERSUS patch 4.2 (August 2015).

Summary of results of the current year (from July of previous year to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

The platform previously developed as part of the NWP Meteorological Test Suite project represents a well-defined framework to test present and future versions of the COSMO model for their forecasting performance. This tool will be employed to perform tests that will upgrade a model test-version to a new release. The test suite addresses only the statistical quality of a COSMO version - in this case version 5.03 (5.3) - in comparison with the previous one - version 5.01 (5.1). The statistical measures are defined within the task itself. The verification task concerns both the type of scores to be used as well as the array of parameters (850 hPa relative humidity, precipitation, 2m temperature and so on). The comparison of the model versions for validation was carried out on a common domain. The new version of the model is considered validated or accepted if the set of verification results show a positive impact on the common domain or if the results are neutral.

1. Model Set-up

Starting with version 5.03 (5.3) of the COSMO model, tests were performed on the Cray HPC available, using ECMWF computer resources both for numerical simulations and for archiving procedures. Billing units were provided by the members as part of the SPITRASP special project previously registered.

Version 5.03 (5.3) of the COSMO model (7km horizontal resolution) was implemented on the Cray HPC following the procedure presented in the Final Report of the respective priority task. Version 5.01 (5.1) was previously implemented for evaluation against COSMO version 5.0, on the IBM HPC. For both model versions, the int2lm 2.0 version was used for the interpolation of initial and lateral boundary conditions provided by the ECMWF IFS system.

The directory structure and the archiving procedures for version 5.03 (5.3) of the COSMO model (new) followed the ones used for the previous versions. On completion of the testing procedure, model outputs were transferred to the machine with the installed VERSUS software for the statistical analysis. The model output obtained from the numerical experiments is locally stored in the ECFS system.

For both model versions, the integration domain used for calculation covers the COSMO countries and a good part of European Russia (in figure 1), as follows:

- 751x511 = 383761 grid points
- 40 vertical levels
- rotated coordinates:
  - pol latitude = 40
  - pol longitude = -170
- coordinates of the lowest left corner
  - start latitude = -16.125
  - start longitude = -15.75

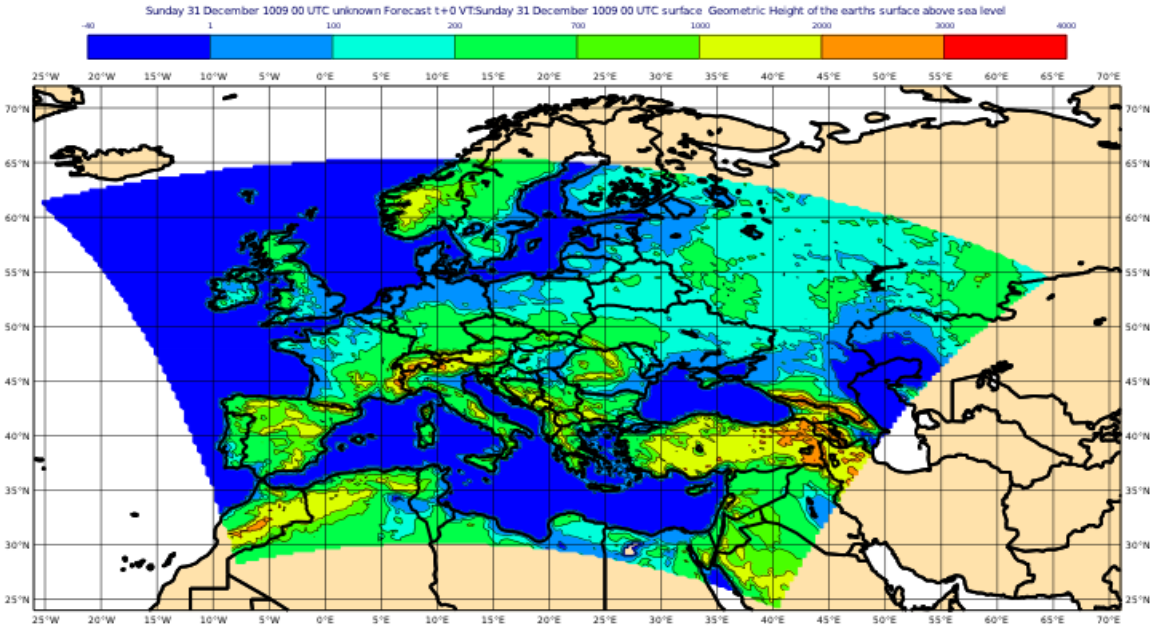


Fig. 1 Integration domain for the COSMO model used for the current test.

The ***cost of the suite*** in the present configurations is specified in table 1. Note that COSMO-5.01 (5.1) was run on IBM, while COSMO-5.03 (5.3) was run on Cray, with different queuing systems, processors, etc.

Table 1. Cost of the suite in the present configurations.

INT2LM for COSMO-5.01 (5.1) on IBM	*INT2LM COSMO-5.03 (5.3) on Cray*
about 81.5 BU per run (takes ~ 8 min)	about 40 BU per run (takes ~ 6 min)
total_tasks = 64 and nodes = 1	**EC_total_tasks = 24 and EC_nodes = 1**
COSMO-5.01 (5.1) on IBM	*COSMO-5.03 (5.3) on Cray*
about ~ 2284 BU per run (takes ~ 28 min)	about 3600 BU per run (takes ~ 28 min)
total_tasks = 512 and nodes = 8	**EC_total_tasks = 480 and EC_nodes = 20**

2. Model Output Verification Set-up

As for previous versions of the COSMO model, the verification was performed with grid-to-point comparisons. This technique allows to compare gridded surface and upper-air model data to point observations. 3600 selected stations situated in an area covering -25/24/65/65 (W/S/E/N) were used for the data the stratification. Previously registered suspect observation values for each parameter were included in order to exclude forecast-observation greater than a specific limit. This process was perfomed in order to eliminate errors connected with observations.

The new model version was registered with the version number COSMO-5.03 (5.3), in order to follow the evolution of model versions/tests. Two models were taken into account: 5.01 (5.1) - operational and 5.03 (5.3) - new test version. The models have the same grid characteristics but a different model id: process ID 102 for the operational version and process ID 103 for the test version.

Similarly to previous model versions, four front-ends (FE) are registered for the new test version 5.03 (5.3) of the model. These were created separately for precipitation, cloud cover, upper air data and surface parameters due to the different interpolation methods used for each parameter.

Due to the large size of the files containing the forecast data, which would slow down the VERSUS system, the original grib model outputs were split in hourly files, using the wgrib facility. This action was performed before the uploading phase.

The verification modules for the current test are presented below:

- BIAS and RMSE for surface continuous parameters (2mT, Dew Point T, WindSp, TCC, MSLP);
- ETS, FBI, Performance diagrams for precipitation (6h, 12h, 24h) for selected thresholds (greater than 0.2, 0.4, 0.6, 0.8, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 25, 30);
- BIAS, MAE, RMSE for upper air verification of T, RH, WindSp for selected pressure levels (250., 500., 700., 850., 925., 1000.).

For the model output verification, the following steps were performed:

- Configuration of all standard surface and upper air verification tests
- Execution of above mentioned verifications in a batch mode
- Configuration of Cross model verification: interactively and batch mode
- Configuration of related graphics
- Analysis of scores in numerical format

3. Verification Results and Statistical Analysis Graphs

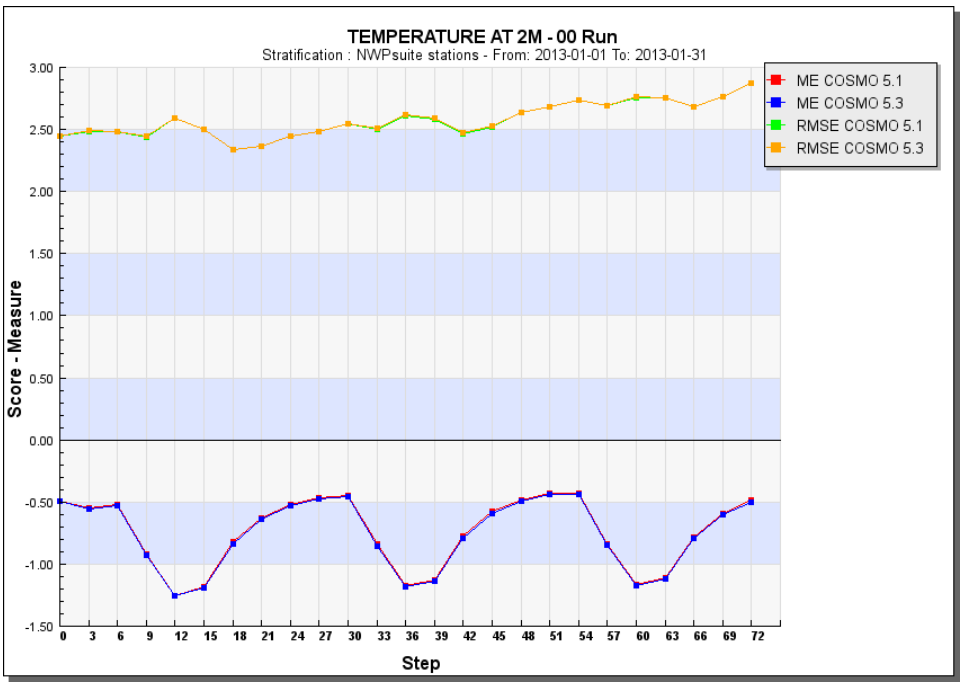
The verifications for the two model versions were performed for the months of January and July 2013. The statistical results for surface and upper air parameters obtained through the VERSUS system are presented below in figures 2 – 22. Overall, the statistics of the two versions of the model are quite similar, with some differences:

- **2m temperature** differences for the winter season are insignificant; both models underestimate values forecasted for the entire period, with a profound daily cycle of the errors (figure 2a). For the summer period again both models exhibit a tendency to underestimate T2m values during the day and overestimate during the night. However, looking at the numerical differences (figure 2), the forecast of COSMO-5.03 (5.3) is slightly worsened compared to that of COSMO-5.01 (5.1) for most of the day in the winter period while slightly improved or neutral for almost all timesteps for the summer one. It has to be noted however that the difference of the statistical scores (right pane) is marginal (apparent in the 3rd decimal place).

- For **mean sea level pressure**, both model versions exhibit the same behaviour during both periods analysed, mainly overestimation and increasing RMSE with forecast lead time, especially in winter. As in the case of the previous parameters analysed, the model shows no improvement for the winter period. However, again for the summer period, COSMO-5.03 (5.3) displays a small improvement, while the amplitude of errors is slightly reduced during most of the forecast intervals (figure 3).
- With respect to **10 meter wind speed**, mean error values for the winter period are worsened in version 5.03 (5.3) but this is not noticeable in the summer period. Overal the comparison of scores shows neutral impact resulting from the introduction of new version (figure 4).
- For the forecast of **precipitation (6h and 24h accumulation periods)**, the statistics of both model versions are very similar (overestimation in small thresholds [>1mm] but underestimation of precipitation amounts for higher thresholds [<5mm], higher FAR and lower POD with increasing threshold) with some insignificant differences mainly associated with False Alarm Rate score (figures 5 - 6).
- The scores for the forecast of **upper air parameters (relative humidity, temperature and wind speed)** also show similar behaviour for both (figures 7 - 8). The numerical difference of scores was also calculated. Temperature comparison of ME and RMSE for the two model versions gave insignificant differences (lower than 0.02 degrees). The outcome from Wind Speed performance comparison is similar, while for the winter period a slight negative impact from the 5.03 (5.3) implementation in the higher atmospheric levels (>500mb) is indicated. Similarly for RH, the differences were minimal with no steady inclination towards either of the two versions.

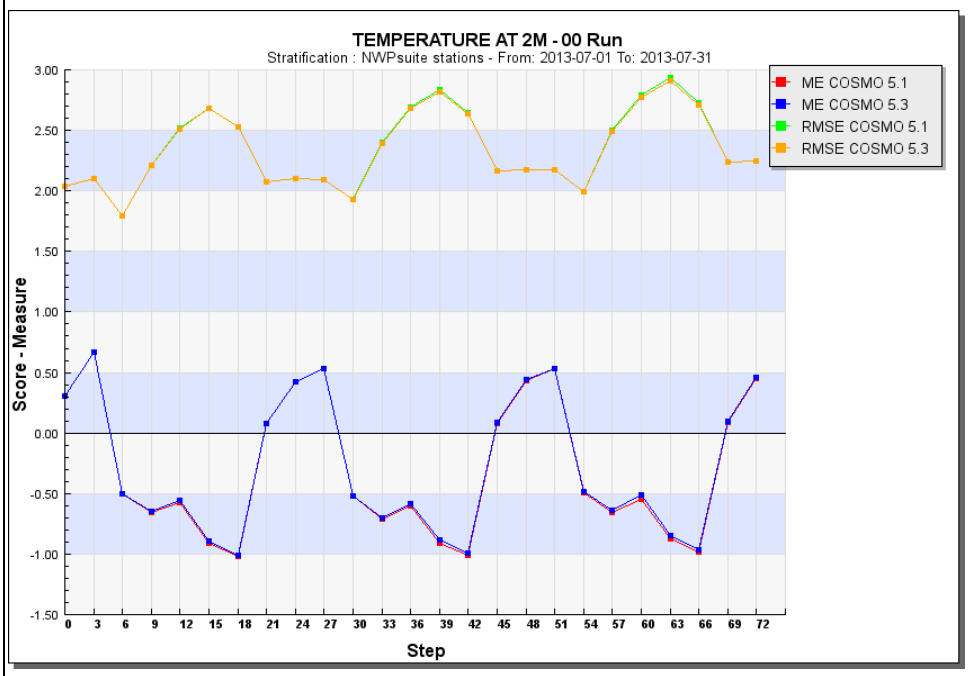
The graphics included in the present report are a selection from the full range of statistical scores obtained for the comparison of COSMO-5.03 (5.3) versus COSMO-5.01 (5.1). The entire set of results can be retrieved from the VERSUS system at the ECMWF.

It is important to be noted that any marginal differences in the comparison of the weather parameter values, could be attributed to the different architecture and compilers of the systems (Cray HPC and IBM HPC) that the two COSMO model versions were implemented.



2mT	winter		
ME	5.3	5.1	
0	-0.494	-0.494	0.001
3	-0.559	-0.551	-0.008
6	-0.533	-0.522	-0.012
9	-0.929	-0.920	-0.009
12	-1.258	-1.251	-0.007
15	-1.191	-1.184	-0.006
18	-0.833	-0.824	-0.010
21	-0.643	-0.633	-0.010
24	-0.530	-0.518	-0.012
27	-0.475	-0.463	-0.012
30	-0.458	-0.445	-0.014
33	-0.853	-0.842	-0.011
36	-1.184	-1.176	-0.008
39	-1.134	-1.127	-0.008
42	-0.788	-0.779	-0.010
45	-0.590	-0.579	-0.011
48	-0.492	-0.480	-0.011
51	-0.441	-0.430	-0.011
54	-0.442	-0.431	-0.012
57	-0.844	-0.835	-0.010
60	-1.173	-1.167	-0.006
63	-1.116	-1.111	-0.006
66	-0.792	-0.783	-0.009
69	-0.599	-0.589	-0.010
72	-0.498	-0.488	-0.010
RMSE	5.3	5.1	
0	2.445	2.445	-0.001
3	2.490	2.484	-0.006
6	2.484	2.481	-0.003
9	2.443	2.437	-0.006
12	2.596	2.589	-0.007
15	2.505	2.501	-0.004
18	2.340	2.336	-0.004
21	2.366	2.363	-0.003
24	2.447	2.445	-0.002
27	2.484	2.483	-0.001
30	2.550	2.549	-0.001
33	2.509	2.503	-0.005
36	2.616	2.610	-0.006
39	2.591	2.586	-0.004
42	2.470	2.466	-0.004
45	2.526	2.521	-0.005
48	2.635	2.634	-0.001
51	2.685	2.684	-0.001
54	2.740	2.739	-0.001
57	2.692	2.688	-0.004
60	2.760	2.755	-0.004
63	2.759	2.758	-0.001
66	2.679	2.679	0.000
69	2.762	2.761	-0.001
72	2.876	2.876	0.000

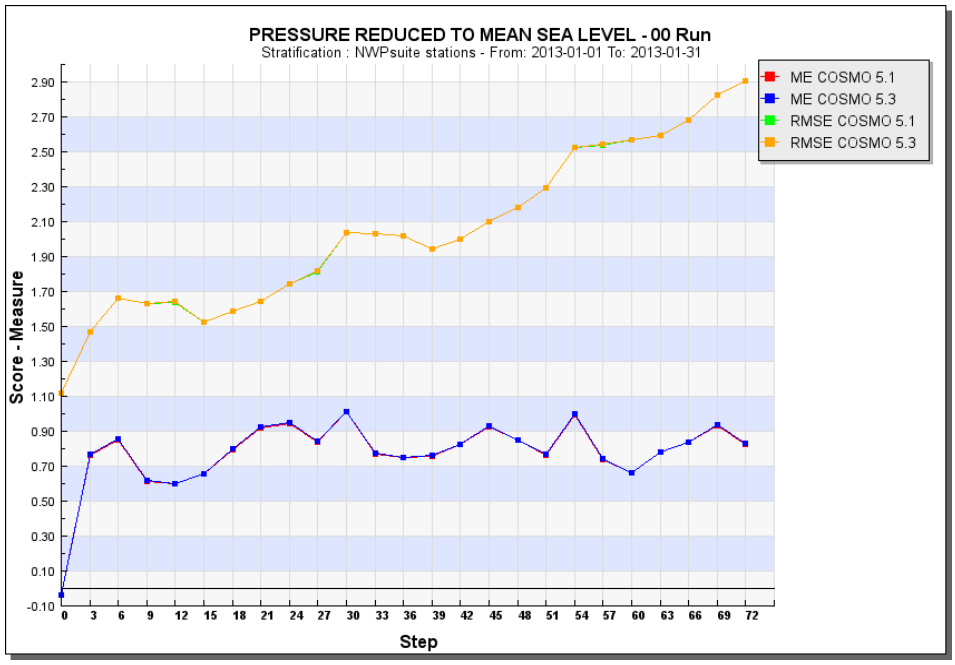
(a)



2mT	summer		
ME	5.3	5.1	
0	0.302	0.301	0.000
3	0.668	0.667	-0.001
6	-0.503	-0.506	0.004
9	-0.647	-0.654	0.007
12	-0.560	-0.574	0.014
15	-0.897	-0.908	0.011
18	-1.006	-1.016	0.010
21	0.081	0.078	-0.004
24	0.425	0.424	-0.002
27	0.530	0.529	-0.001
30	-0.519	-0.524	0.005
33	-0.699	-0.713	0.014
36	-0.586	-0.605	0.019
39	-0.884	-0.906	0.022
42	-0.992	-1.006	0.014
45	0.087	0.080	-0.008
48	0.440	0.435	-0.005
51	0.537	0.537	0.000
54	-0.486	-0.495	0.009
57	-0.635	-0.655	0.020
60	-0.514	-0.549	0.035
63	-0.844	-0.873	0.029
66	-0.962	-0.978	0.016
69	0.100	0.088	-0.012
72	0.455	0.450	-0.005
RMSE	5.3	5.1	
0	2.040	2.040	0.000
3	2.099	2.098	-0.001
6	1.789	1.791	0.001
9	2.211	2.211	0.000
12	2.511	2.515	0.004
15	2.682	2.684	0.003
18	2.524	2.528	0.004
21	2.078	2.077	-0.001
24	2.101	2.101	0.000
27	2.097	2.096	-0.001
30	1.927	1.928	0.001
33	2.397	2.404	0.008
36	2.681	2.687	0.006
39	2.816	2.833	0.018
42	2.636	2.645	0.010
45	2.164	2.167	0.003
48	2.175	2.176	0.000
51	2.172	2.171	-0.001
54	1.992	1.996	0.004
57	2.491	2.503	0.013
60	2.771	2.791	0.020
63	2.913	2.932	0.019
66	2.710	2.724	0.015
69	2.233	2.238	0.005
72	2.247	2.249	0.002

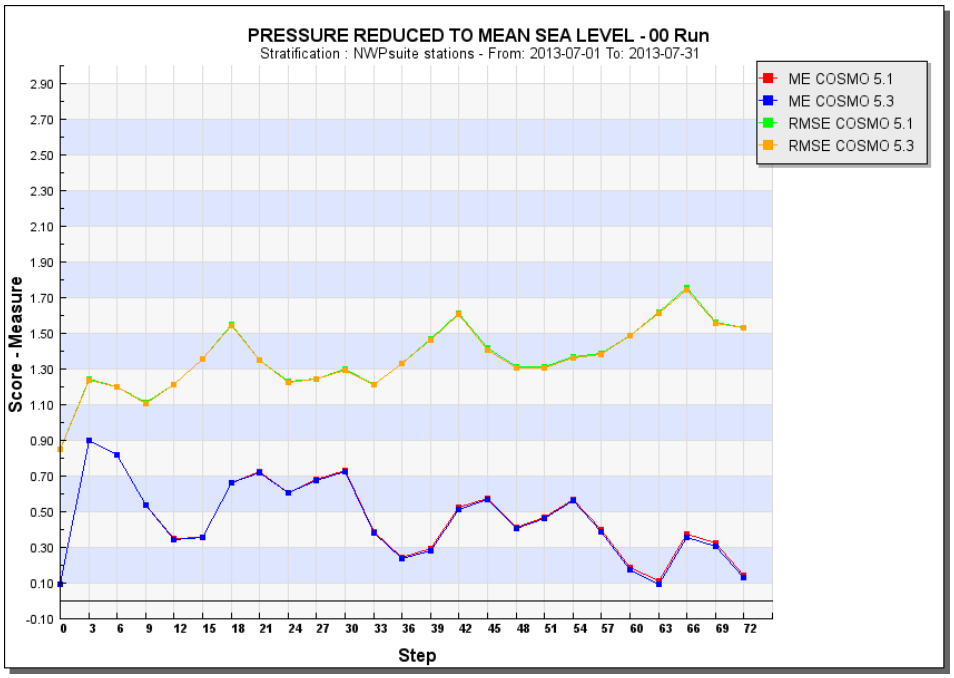
(b)

Fig. 2 2m Temperature verification results (00UTC run) – COSMO-5.01 (5.1) and COSMO-5.03 (5.3) mean error (ME) and root mean square error (RMSE) for: (a) January 2013 (b) July 2013. Numerical scores and differences on the right pane. Colors indicate: **red** - worsening, **green** - improvement, yellow - neutral.



MSLP	winter		
ME	5.3	5.1	
0	-0.036	-0.036	0.000
3	0.767	0.765	-0.002
6	0.855	0.853	-0.003
9	0.618	0.615	-0.003
12	0.601	0.599	-0.002
15	0.658	0.656	-0.002
18	0.798	0.796	-0.002
21	0.923	0.920	-0.003
24	0.949	0.946	-0.004
27	0.843	0.840	-0.004
30	1.014	1.011	-0.003
33	0.773	0.770	-0.003
36	0.749	0.747	-0.002
39	0.761	0.759	-0.002
42	0.827	0.826	-0.002
45	0.930	0.928	-0.002
48	0.851	0.848	-0.003
51	0.768	0.765	-0.003
54	0.997	0.994	-0.003
57	0.741	0.737	-0.004
60	0.665	0.661	-0.004
63	0.784	0.780	-0.004
66	0.839	0.836	-0.003
69	0.935	0.932	-0.004
72	0.831	0.827	-0.004
RMSE	5.3	5.1	
0	1.117	1.117	0.000
3	1.468	1.467	-0.001
6	1.665	1.664	-0.001
9	1.633	1.632	-0.001
12	1.641	1.641	-0.001
15	1.526	1.526	-0.001
18	1.588	1.587	-0.001
21	1.643	1.642	-0.001
24	1.744	1.742	-0.001
27	1.816	1.816	-0.001
30	2.038	2.038	-0.001
33	2.029	2.029	0.000
36	2.018	2.018	-0.001
39	1.945	1.944	-0.001
42	2.001	2.000	-0.001
45	2.098	2.097	-0.001
48	2.181	2.180	0.000
51	2.295	2.295	0.000
54	2.527	2.527	-0.001
57	2.541	2.540	0.000
60	2.568	2.568	0.000
63	2.593	2.594	0.001
66	2.680	2.681	0.002
69	2.827	2.827	0.000
72	2.904	2.904	0.000

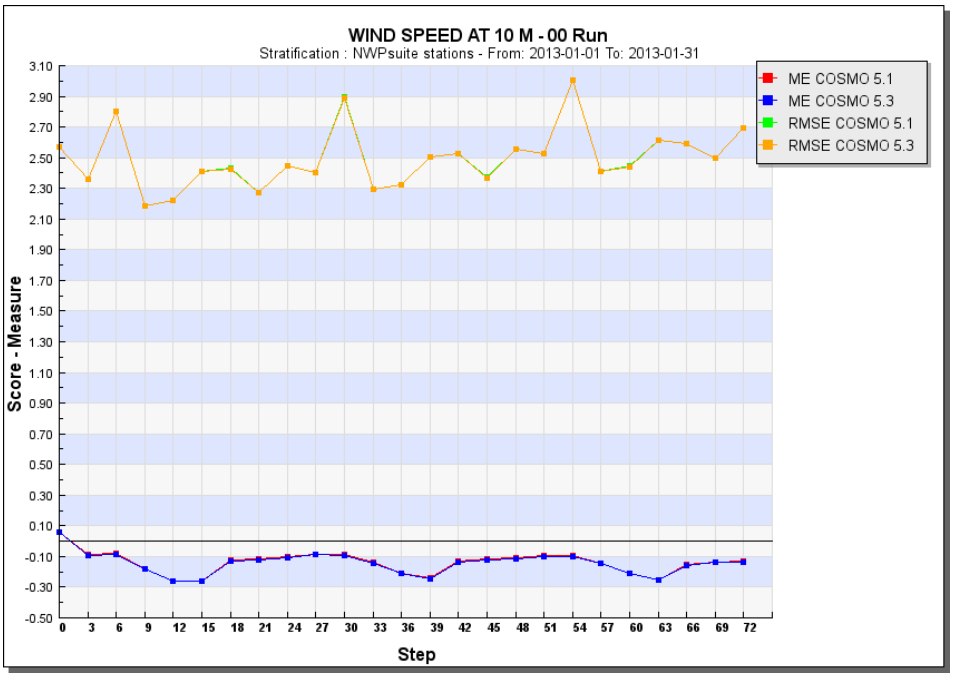
(a)



MSLP	summer		
ME	5.3	5.1	
0	0.091	0.091	0.000
3	0.900	0.900	0.000
6	0.817	0.818	0.001
9	0.537	0.539	0.002
12	0.346	0.349	0.003
15	0.354	0.358	0.004
18	0.661	0.666	0.005
21	0.720	0.724	0.004
24	0.604	0.608	0.004
27	0.677	0.681	0.004
30	0.725	0.731	0.005
33	0.380	0.386	0.006
36	0.238	0.247	0.008
39	0.283	0.293	0.011
42	0.515	0.527	0.012
45	0.567	0.577	0.010
48	0.405	0.412	0.007
51	0.463	0.466	0.003
54	0.563	0.568	0.005
57	0.388	0.399	0.011
60	0.177	0.190	0.013
63	0.095	0.112	0.017
66	0.357	0.376	0.019
69	0.306	0.325	0.019
72	0.129	0.147	0.018
RMSE	5.3	5.1	
0	0.853	0.853	0.000
3	1.240	1.241	0.000
6	1.199	1.200	0.001
9	1.109	1.110	0.001
12	1.214	1.215	0.001
15	1.357	1.358	0.001
18	1.544	1.547	0.003
21	1.349	1.351	0.002
24	1.226	1.229	0.002
27	1.241	1.243	0.002
30	1.296	1.299	0.003
33	1.212	1.215	0.002
36	1.328	1.332	0.004
39	1.463	1.467	0.004
42	1.607	1.614	0.007
45	1.409	1.416	0.007
48	1.308	1.313	0.005
51	1.308	1.311	0.003
54	1.365	1.369	0.004
57	1.381	1.385	0.004
60	1.486	1.490	0.004
63	1.614	1.618	0.004
66	1.746	1.755	0.010
69	1.554	1.562	0.008
72	1.530	1.534	0.004

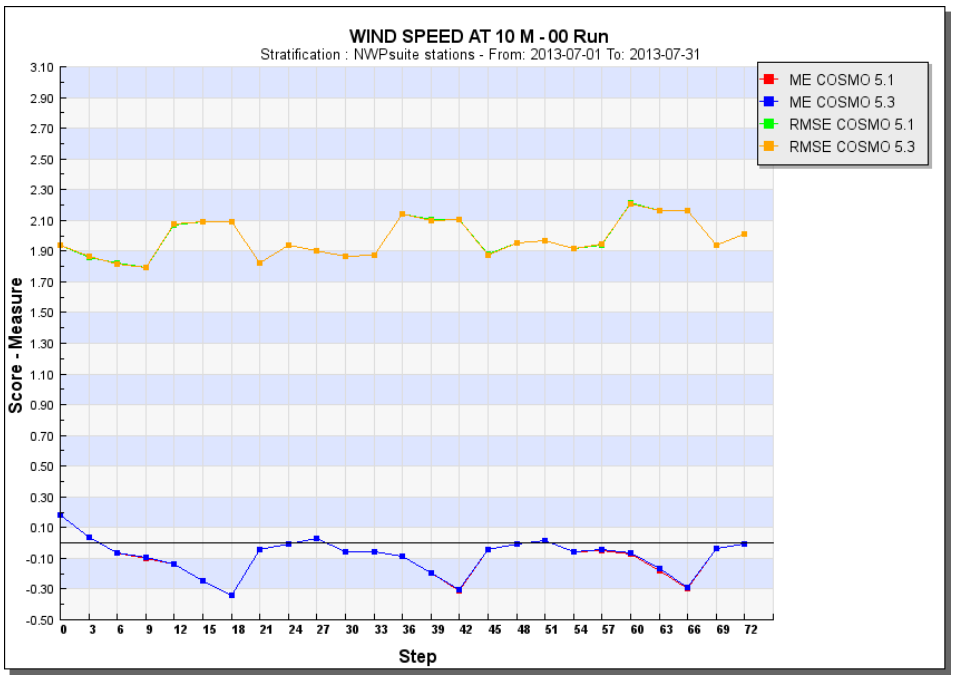
(b)

Fig. 3 Pressure reduced to mean sea level verification results (00UTC run) – COSMO-5.01 (5.1) and COSMO-5.03 (5.3) ME and RMSE for: (a) January 2013 (b) July 2013. Numerical scores and differences on the right pane. Colors indicate: **red** - worsening, **green** - improvement, yellow - neutral.



WindSp	winter		
ME	5.3	5.1	
0	0.062	0.062	0.000
3	-0.090	-0.087	-0.003
6	-0.087	-0.082	-0.005
9	-0.181	-0.178	-0.003
12	-0.263	-0.260	-0.003
15	-0.260	-0.258	-0.002
18	-0.130	-0.125	-0.004
21	-0.120	-0.117	-0.003
24	-0.105	-0.101	-0.004
27	-0.089	-0.086	-0.003
30	-0.094	-0.089	-0.005
33	-0.142	-0.139	-0.003
36	-0.212	-0.209	-0.003
39	-0.243	-0.239	-0.004
42	-0.134	-0.130	-0.004
45	-0.122	-0.116	-0.006
48	-0.114	-0.110	-0.004
51	-0.097	-0.094	-0.003
54	-0.102	-0.096	-0.006
57	-0.144	-0.141	-0.003
60	-0.213	-0.209	-0.004
63	-0.255	-0.251	-0.004
66	-0.155	-0.149	-0.006
69	-0.141	-0.136	-0.004
72	-0.135	-0.130	-0.004
RMSE	5.3	5.1	
0	2.571	2.571	0.000
3	2.358	2.358	0.000
6	2.799	2.801	0.002
9	2.188	2.189	0.001
12	2.222	2.224	0.002
15	2.411	2.411	0.000
18	2.426	2.429	0.002
21	2.275	2.274	0.000
24	2.445	2.446	0.000
27	2.403	2.404	0.001
30	2.891	2.893	0.003
33	2.295	2.294	0.000
36	2.326	2.327	0.001
39	2.503	2.504	0.001
42	2.523	2.524	0.001
45	2.370	2.374	0.003
48	2.553	2.555	0.001
51	2.525	2.526	0.001
54	3.006	3.006	0.001
57	2.411	2.411	0.001
60	2.441	2.445	0.004
63	2.616	2.615	-0.001
66	2.589	2.590	0.001
69	2.498	2.497	-0.001
72	2.694	2.695	0.000

(a)



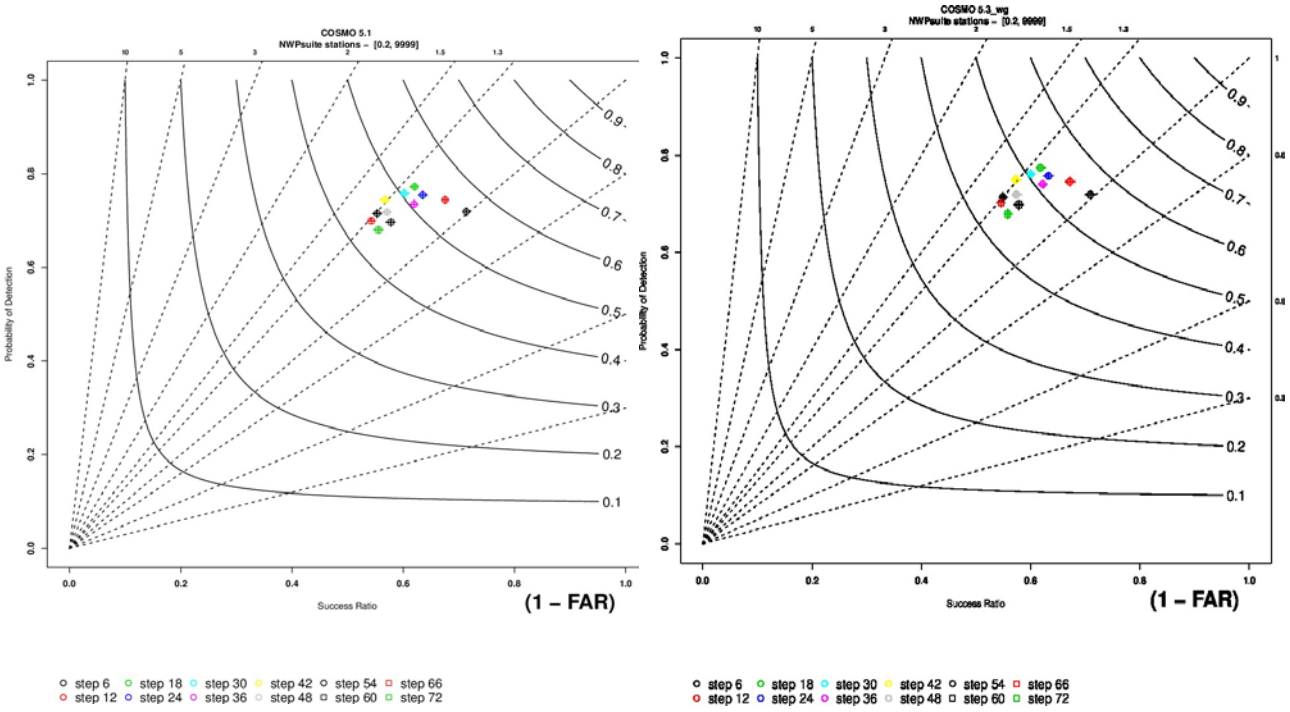
WindSp summer

ME	5.3	5.1	
0	0.182	0.182	0.000
3	0.036	0.036	0.000
6	-0.063	-0.063	0.000
9	-0.096	-0.099	0.002
12	-0.135	-0.137	0.003
15	-0.245	-0.247	0.002
18	-0.344	-0.343	0.000
21	-0.044	-0.046	0.002
24	-0.004	-0.006	0.002
27	0.030	0.029	-0.001
30	-0.055	-0.056	0.000
33	-0.057	-0.060	0.003
36	-0.086	-0.087	0.001
39	-0.192	-0.195	0.003
42	-0.307	-0.309	0.002
45	-0.040	-0.041	0.001
48	-0.006	-0.007	0.001
51	0.015	0.015	0.000
54	-0.058	-0.057	-0.001
57	-0.046	-0.050	0.004
60	-0.067	-0.070	0.002
63	-0.169	-0.178	0.008
66	-0.292	-0.295	0.003
69	-0.039	-0.036	-0.002
72	-0.006	-0.003	-0.003

RMSE	5.3	5.1	
0	1.938	1.938	0.000
3	1.863	1.862	0.000
6	1.819	1.819	0.001
9	1.796	1.797	0.000
12	2.074	2.073	-0.001
15	2.092	2.093	0.000
18	2.090	2.089	-0.001
21	1.824	1.825	0.001
24	1.938	1.938	0.000
27	1.900	1.899	-0.001
30	1.869	1.869	0.000
33	1.877	1.875	-0.002
36	2.140	2.141	0.000
39	2.099	2.103	0.004
42	2.105	2.106	0.001
45	1.877	1.879	0.002
48	1.952	1.956	0.004
51	1.965	1.965	0.001
54	1.914	1.914	0.001
57	1.945	1.942	-0.003
60	2.211	2.211	0.001
63	2.160	2.161	0.001
66	2.167	2.166	-0.001
69	1.935	1.938	0.002
72	2.009	2.010	0.001

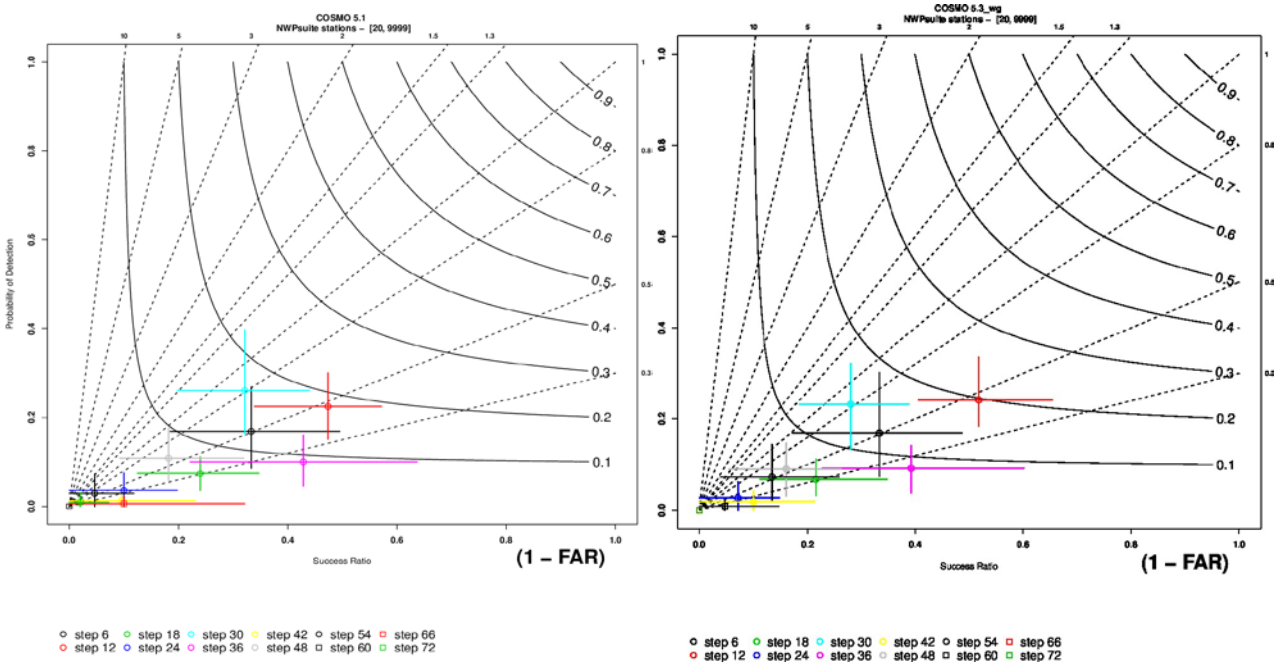
(b)

Fig. 4 Wind Speed at 10 m verification results (00UTC run) – COSMO-5.01 (5.1) and COSMO-5.03 (5.3) ME and RMSE for: (a) January 2013 (b) July 2013, Numerical scores and differences on the right pane. Colors indicate: **red** - worsening, **green** - improvement, **yellow** - neutral.



a) (b)

Fig. 5 6h precipitation > 0.2mm verification results (00UTC run) – January 2013, PD for: (a) COSMO-5.01 (5.1) (b) COSMO-5.03 (5.3)



(a) (b)

Fig. 6 6h precipitation > 20mm verification results (00UTC run) – July 2013, PD for:
(a) COSMO 5.1 (b) COSMO 5.3

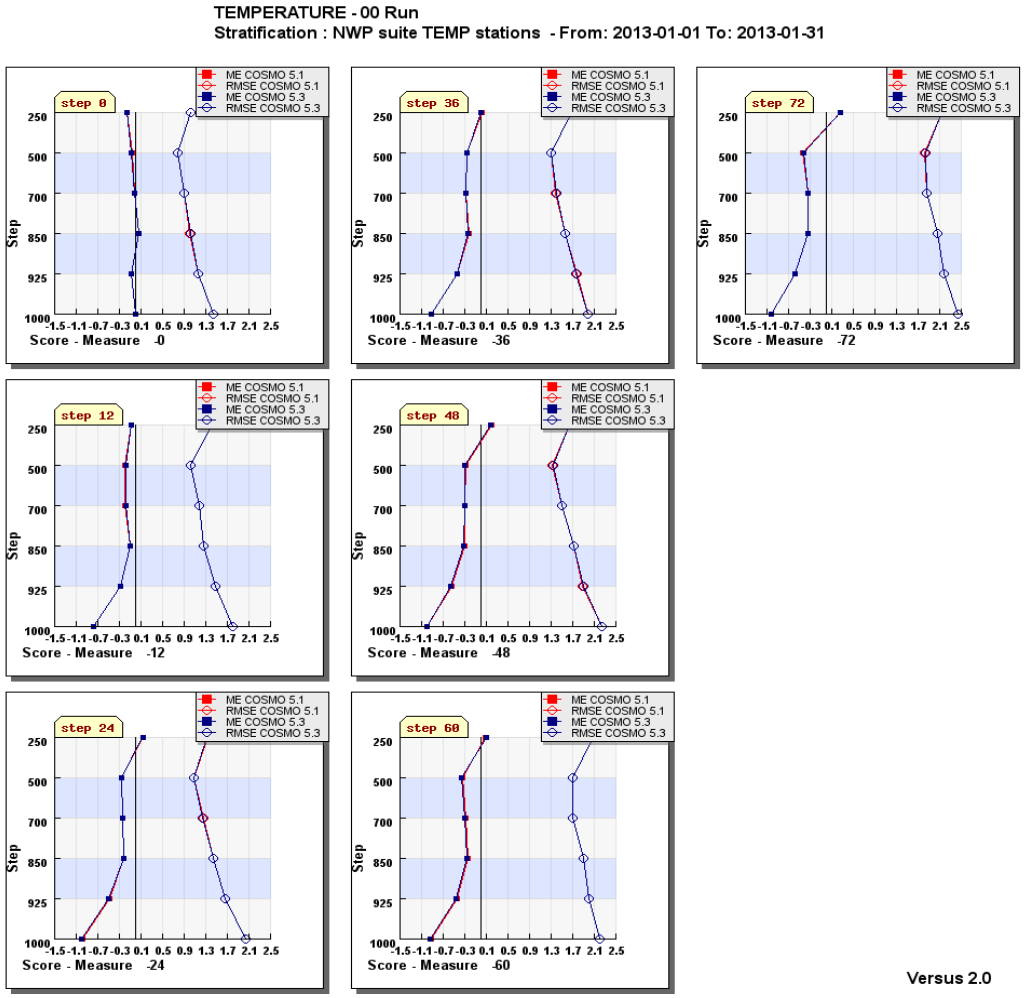


Fig. 7 Upper air verification for January 2013: Temperature COSMO 5.1 (red) / COSMO 5.3 (blue)

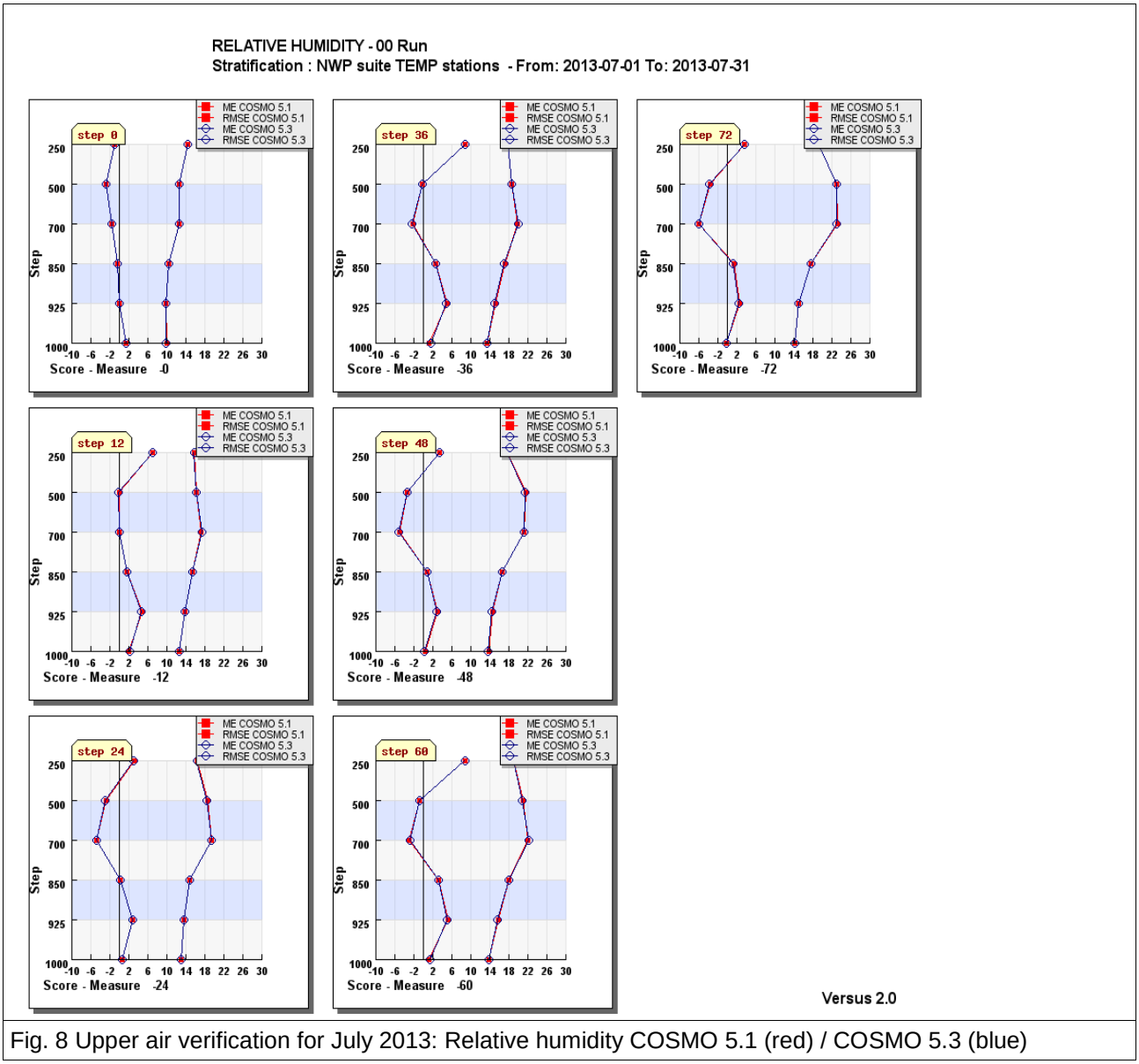


Fig. 8 Upper air verification for July 2013: Relative humidity COSMO 5.1 (red) / COSMO 5.3 (blue)

List of publications/reports from the project with complete references

A. MONTANI, A. IRIZA, M. BOGDAN, A. CELOZZI, R. DUMITRACHE, F. GOFA - "Numerical Weather Prediction Meteorological Test Suite": COSMO 5.3 vs. 5.1, COSMO-Model Report, December 2015, http://cosmo-model.org/content/model/documentation/NWPSuiteReports/cosmo v5.3-vs-5.1.pdf

The detailed report regarding the comparison of the COSMO-5.01 (5.1) versus COSMO-5.03 (5.3) versions using this platform was submitted to the COSMO Steering Committee.

Summary of plans for the continuation of the project

(10 lines max)

At present, the tests for a new version (5.04a) of the COSMO model are undergoing. For this version, the model will be tested both at 7km and 2.8km horizontal resolution. For this purpose, tests for COSMO-5.03 (5.3) at 2.8km horizontal rezolution will also have to be performed, in order to provide an operational version against which the new model (5.04a) can be tested.

Activities (including use of resources) will also be carried out in the second part of the year, when another release of the COSMO model is anticipated.

- Maintenance of the Test Suite
- Future versions of the COSMO model and future VERSUS relreases need to be installed as soon as they are available
- Performing model evaluation for the next versions of the model.