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 2017

Project Title: **COSMO NWP meteorological test suite**

Computer Project Account: SPITRASP

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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)	7500000 (5000000 + 2500000 additional)	7405026.18 (99%)	5000000	6572.75
Data storage capacity	(Gbytes)	1000	700	1000	310

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)

Due to slightly larger costs of the suite on the new Cray platform and the introduction of the COSMO-2.8km runs, additional computing resources were requested from ECMWF in August.

Due to the new requirements of storing also data from two additional COSMO-2.8km model versions, the disk space of the VERSUS virtual machine was increased from 400 GB to 2 TB.

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

The platform previously developed as part of the NWP Meteorological Test Suite project constitutes a well-defined framework to test present and future versions of the COSMO model for their forecasting performance. This tool is 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 versions 5.04a and 5.04e respectively, both in comparison with the previous main version 5.03. 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 and wind speed, 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. Previous tests were only performed for the 7 km horizontal resolution of the COSMO model. Starting from version 5.04a of the COSMO model, the 2.8km horizontal resolution of the model will also be tested using the NWP Suite. For this purpose, the operational 5.03 version of the model was also integrated at both resolutions in order to be used for the verification.

Versions 5.04a and subsequent version 5.04e of the COSMO model (7km and 2.8km horizontal resolution), as well as version 5.03 (2.8km resolution) were implemented following the procedure presented in the Final Report of the respective priority task. Version 5.03 (7km resolution) had been previously implemented for evaluation against COSMO version 5.01. An additional test was performed with the comparison of the same latest COSMO version (5.04e) against the official version (5.03) but with soil field for both model versions initialized from the COSMO-ICON global model instead of the IFS (ECMWF) as has happened with all the previous tests until now. The int2lm 2.0 version was used for the interpolation of initial and lateral boundary conditions for all tests.

The directory structure and the archiving procedures for the new COSMO-5.04a and 5.04e models followed the ones used for the previous versions model versions tested on this platform. After completion of the testing procedure, model outputs are transferred to the machine with the installed VERSUS software in order to perform the statistical analysis. The model output obtained from the experiments is locally stored in the ECFS system. The domain characteristics can be seen in Figure 1.

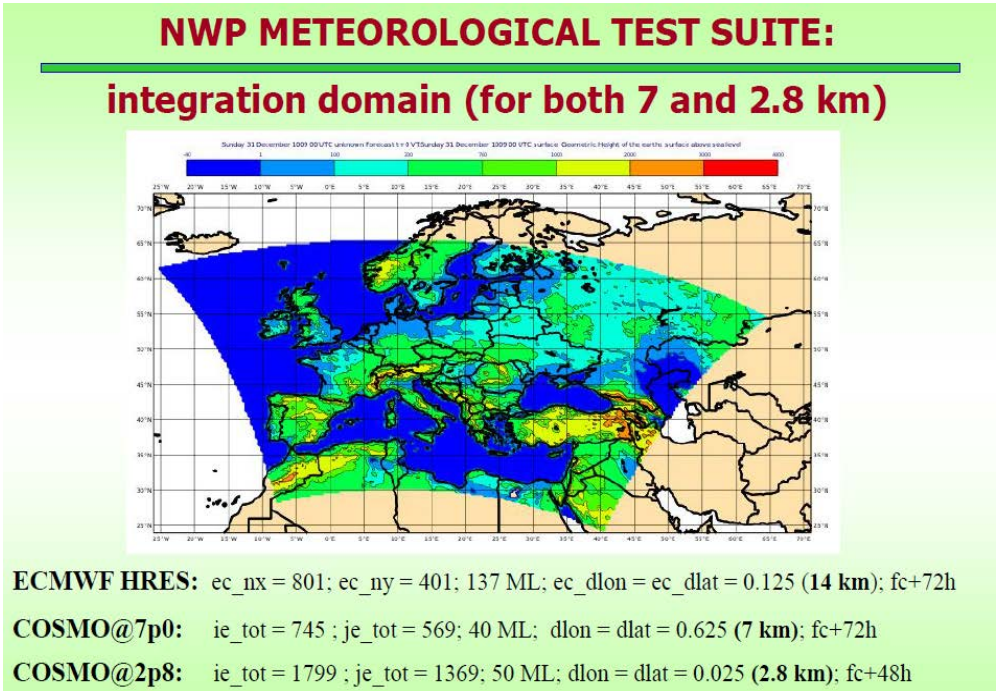


Fig. 1 Integration domain and domain characteristics for the COSMO model used for the current test.

The forecast period of each daily run is 72 hours for the 7km resolution and 48 hours for the 2.8km resolution, on one daily cycle based on the 00UTC initializing data. Simulations were performed for one month in summer (July 2013) and one month in the winter season (January 2013), 2 months in total for each model version. The initial and lateral boundary data are provided by the ECMWF IFS system.

The ***cost of the suite*** in the present configurations is specified in tables 1 and 2. All model versions were run on Cray, with the same queuing systems and processors.

Table 1 Cost of the suite in the present configurations for the 7km resolution (on Cray).

COSMO-7km		
INT2LM COSMO-5.03 (5.3)	*INT2LM COSMO-5.04a*	*INT2LM COSMO-5.04e*
about 40 BU per run (~ 6min)	about 43 BU per run (~ 5min 30sec)	about 40 BU per run (~ 6min)
EC_total_tasks=24, EC_nodes=1	**EC_total_tasks=36, EC_nodes=1**	**EC_total_tasks=24, EC_nodes=1**
COSMO-5.03 (5.3)	*COSMO-5.04a*	*COSMO-5.04e*
about 3600 BU per run (~ 28min)	about 2993 BU per run (~ 15min 28sec)	about 4100 BU per run (~ 21min)
EC_total_tasks=480, EC_nodes=20	**EC_total_tasks=720, EC_nodes=20**	**EC_total_tasks=720, EC_nodes=20**

Table 2 Cost of the suite in the present configurations for the 2.8km resolution (on Cray).

COSMO-2.8km		
INT2LM for COSMO-7km to COSMO-2.8km		
about 278 BU per run (~ 864 sec)		
COSMO-5.03 (5.3)	*COSMO-5.04a*	*COSMO-5.04e*
about 38417 BU per run (~ 6616 sec)	about 35682 BU per run (~ 6145 sec)	about 37000 BU per run (~ 6300 sec)
EC_total_tasks=1296, EC_nodes=36	**EC_total_tasks=1296, EC_nodes=36**	**EC_total_tasks=1296, EC_nodes=36**

2. MODEL OUTPUT VERIFICATION

The verification was performed with grid-to-point comparisons in order to compare gridded surface and upper-air model data to point observations. The selected stations are situated in an area covering -25/24/65/65 (W/S/E/N) and are around **3600** for this stratification. Suspect observations values had been already created for each parameter (forecast-observation greater than a specific limit were excluded) and included in the verification test in order to eliminate errors that are connected with observations. For version 5.04e of the model, verifications were also carried out for a smaller stratification, which contained only **198** German stations.

The new model versions were registered with the version number (COSMO-5.04a and COSMO-5.04e) and resolution for the 2.8km model (COSMO-5.03-2p8, COSMO-5.04a-2p8 and COSMO-5.04e-2p8), in order to follow the evolution of model versions/tests. For the present tests, two model versions were evaluated separately:

- new test version (5.04a) against operational 5.03 (5.3)
- new test version (5.04e) against operational 5.03 (5.3)

All models have the same grid characteristics but they were each assigned a different model id: 103 (COSMO 5.03–7km), 104 (COSMO 5.03–2.8km), 105 (COSMO 5.04a–7km), 106 (COSMO 5.04a–2.8km), 107 (COSMO 5.04e–7km), 108 (COSMO 5.04e–2.8km).

Similarly to the previous COSMO-5.03 (5.3) version, 4 front-ends (FE) are also registered separately for each new test versions and each resolution (in total 20 FEs). These were created separately due to the different interpolation methods used in each case: three separate FEs for precipitation, cloud cover and other parameters and a separate FE for the upper air data, for each model version and resolution. Given the large size of the forecast data (especially for the 2.8km model), original grib model outputs were split in smaller files before the uploading phase, using the **wgrib** facility, in order to speed up the latter.

The verification modules for the current tests are the following:

- **surface continuous parameters** (2mT, Dew Point T, WindSp, TCC, MSLP): BIAS, RMSE – up to 72 hours anticipation for COSMO-7km, up to 48 hours anticipation for COSMO-2.8km;
- **precipitation verification** (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): ETS, FBI, Performance diagrams – up to 72 hours anticipation for COSMO-7km, up to 48 hours anticipation for COSMO-2.8km;
- **upper air verification** - T, RH, WindSp for selected pressure levels (250., 500., 700., 850., 925., 1000.): BIAS, MAE, RMSE – up to 72 hours anticipation for COSMO-7km, up to 30 hours anticipation for COSMO-2.8km.

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

- Registration of the models
- Configuration of FEs and data ingestion
- Configuration of all standard surface and upper air verification tests
- Execution of the 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

As previously mentioned, the verifications for all model versions were performed for the months of January and July 2013. Some of the statistical results that were obtained through the VERSUS system (surface and upper air) are presented in figures 2 – 5 for the 7km model version and the 2.8km version.

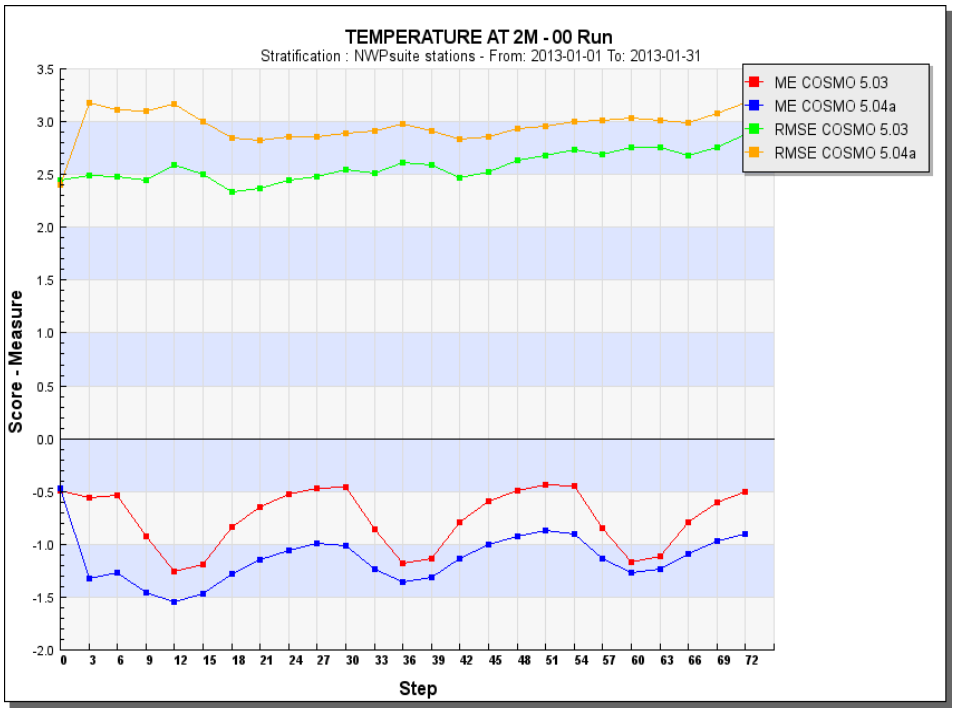
2m temperature differences for the winter season are significant, with an increase of RMSE by ~0.3-06 degrees in almost all time steps after the implementation of 5.04a model version and a higher underestimation of 2mT. This behavior is less obvious in summer season while both models underestimate temperature the warm hours of the day and slightly overestimate during night while exhibiting a profound daily cycle of the errors for both seasons (figure 2). The results are similar with both resolutions while the 7km version one is performing worse for both model versions (5.04a, 5.03) in comparison to the finer one.

For mean sea level pressure, both version 5.03 and 5.04a exhibit the same behavior during both periods analyzed, mainly overestimation of MSLP, especially in winter and also for this season an increase of error with lead time. COSMO 5.04a displays a small improvement with the coarser resolution in mean error for both seasons (figure 3).

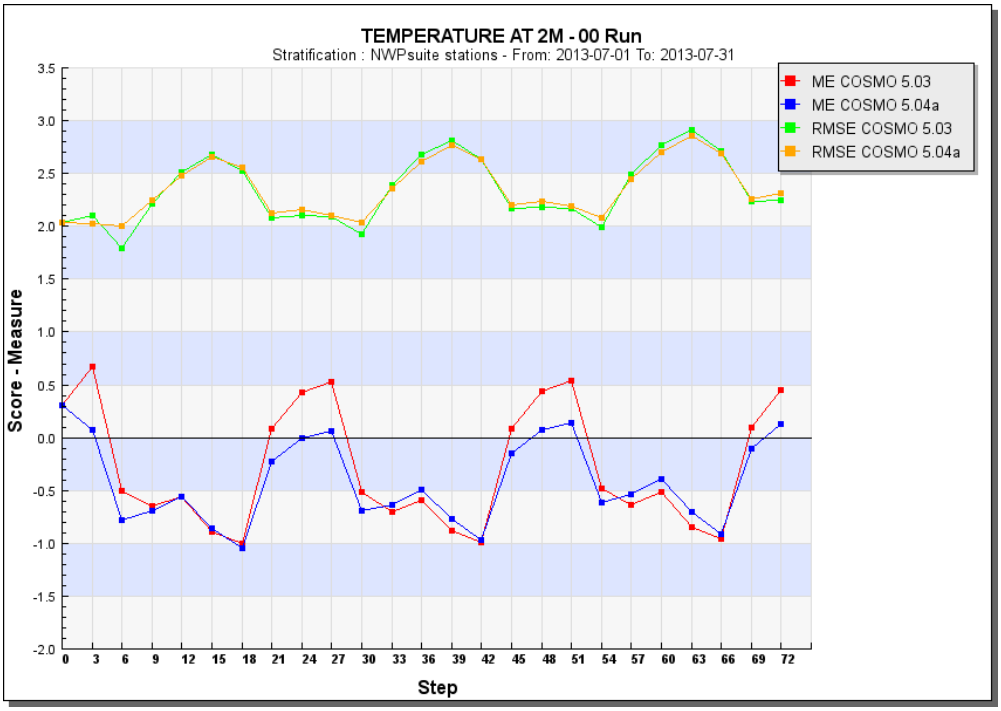
For the forecast of precipitation (6h accumulation periods), the statistics of model versions 5.03 and 5.04a are very similar (overestimation in small thresholds [>1mm] but underestimation of precipitation amounts for higher thresholds [<5mm], higher FAR and lower POD with increasing threshold) with some insignificant differences mainly associated with False Alarm Rate score (figure 4). In deail, with model version 5.04a FAR is slightly reduced for higher thresholds and POD is increased while the BIAS (underestimation) remains steady. The overall performance of the higher resolution version is better that the coarser one for both versions (5.03, 5.04a).

The scores for the forecast of upper air parameters (relative humidity, temperature and wind speed) for version 5.04e comparative to version 5.03 show similar behavior for both models and main differnces are observed close to the surface, with quite similar values of indices for higher pressure levels .

Relative Humidity exhibits no significant differences between the two versions. For winter period there is small reduction in the errors with 5.04e version close to surface for both resolutions. Values of RH are underestimated the warm hours and underestimated during night hours during winter period while for the summer there is an overestimation almost for all levels that is more obvious close to surface with version 5.04e of the model. For the higher resolution configuration, scores are slightly worsened for some time steps, but due to the graphical representation this cannot be quantified (figure 5).

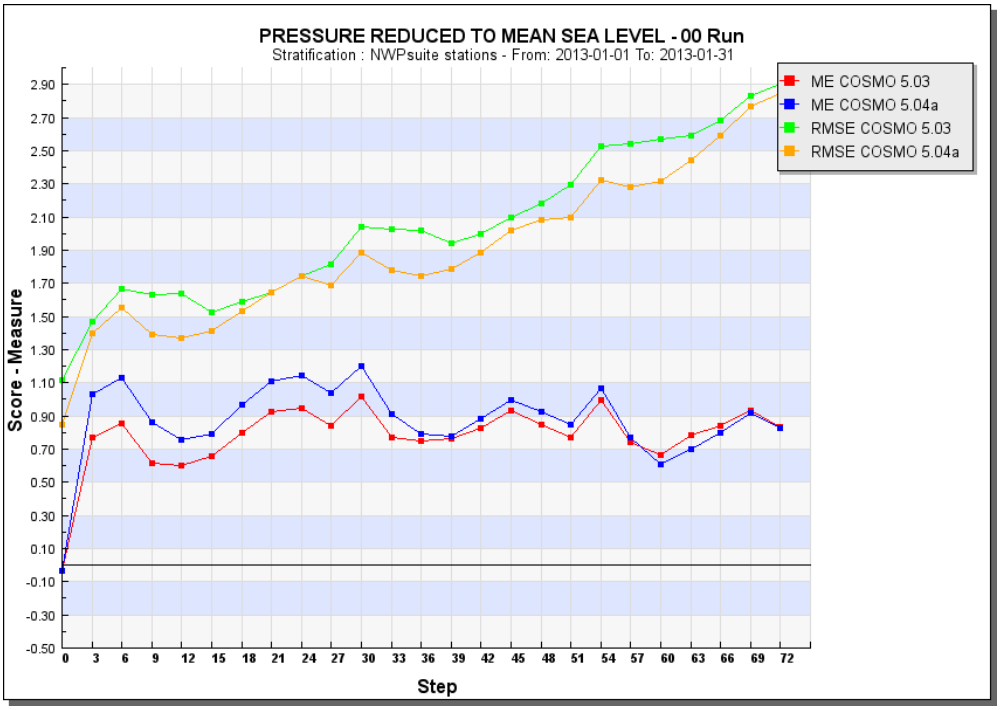


a)

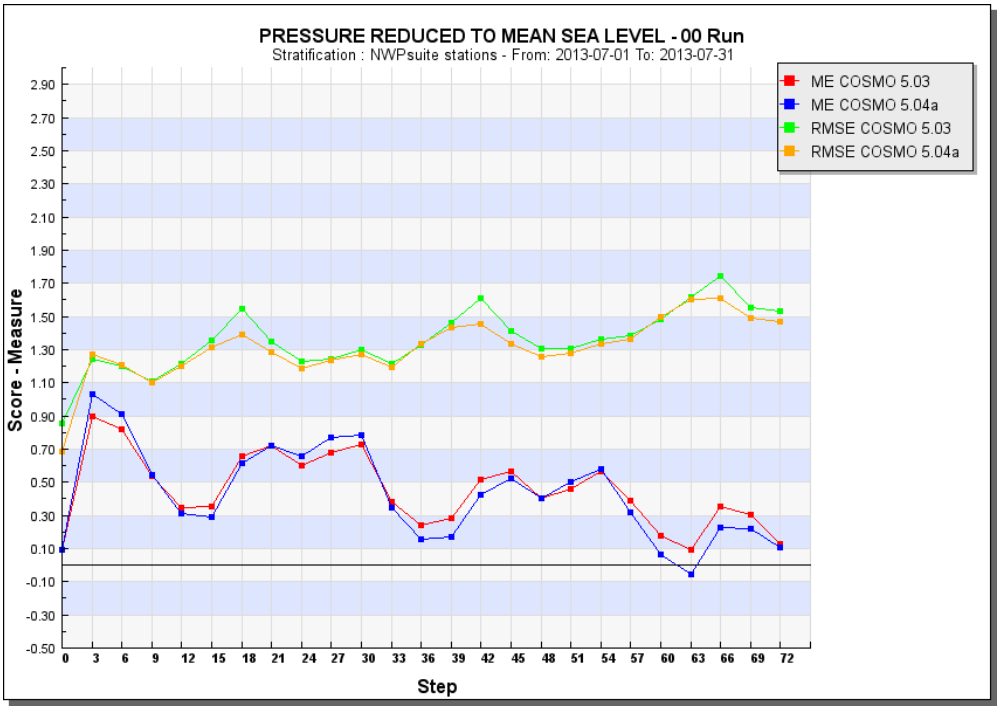


b)

Fig. 2 COSMO-7km Temperature at 2m verification results (00UTC run) - COSMO 5.04a and COSMO 5.03 mean error (ME) and root mean square error (RMSE) for: (a) January 2013 (b) July 2013



a)



b)

Fig. 3 COSMO-7km Pressure reduced to mean sea level verification results (00UTC run) - COSMO 5.04a and COSMO 5.03 (5.3) mean error (ME) and root mean square error (RMSE) for: (a) January 2013 (b) July 2013

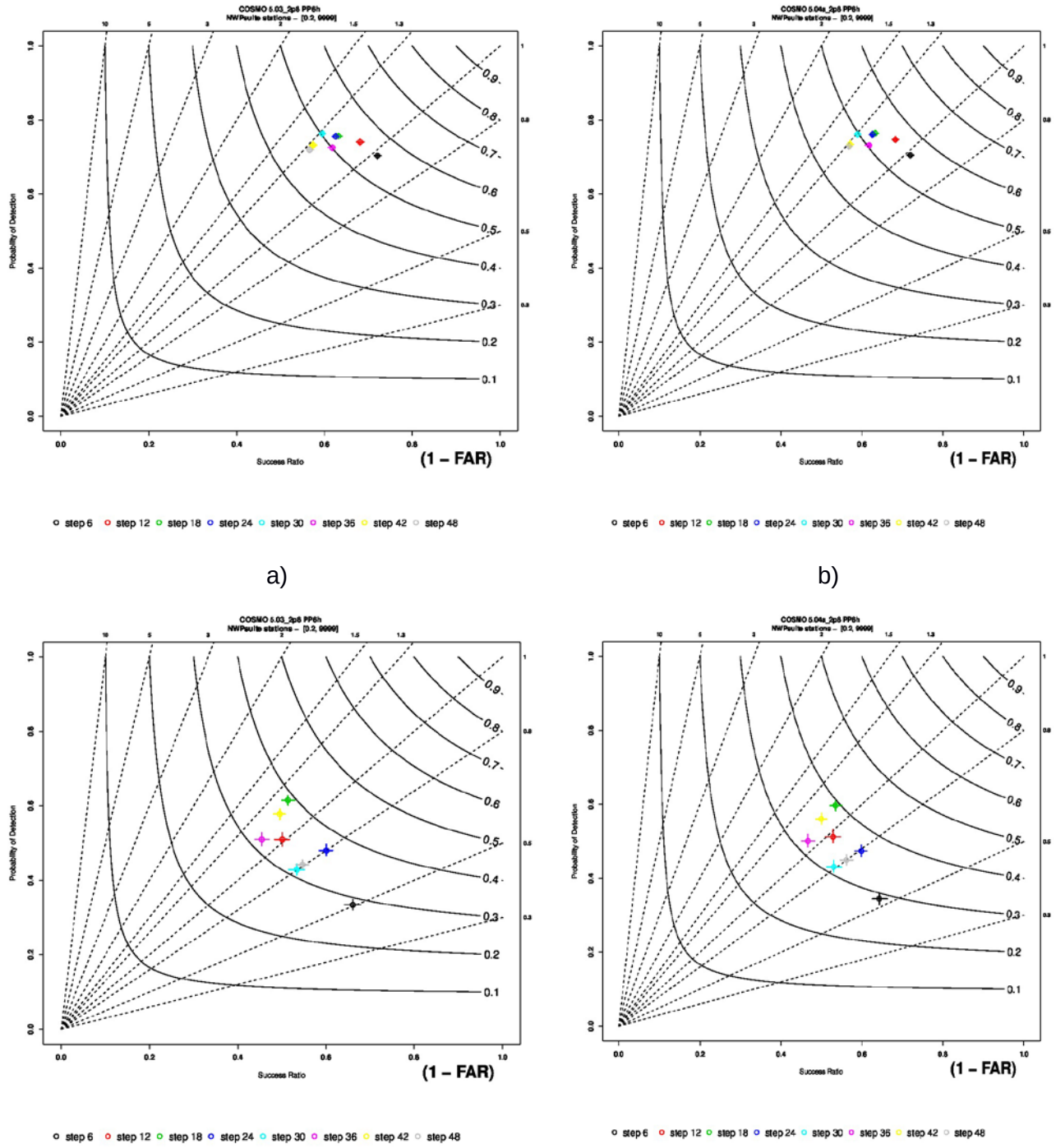
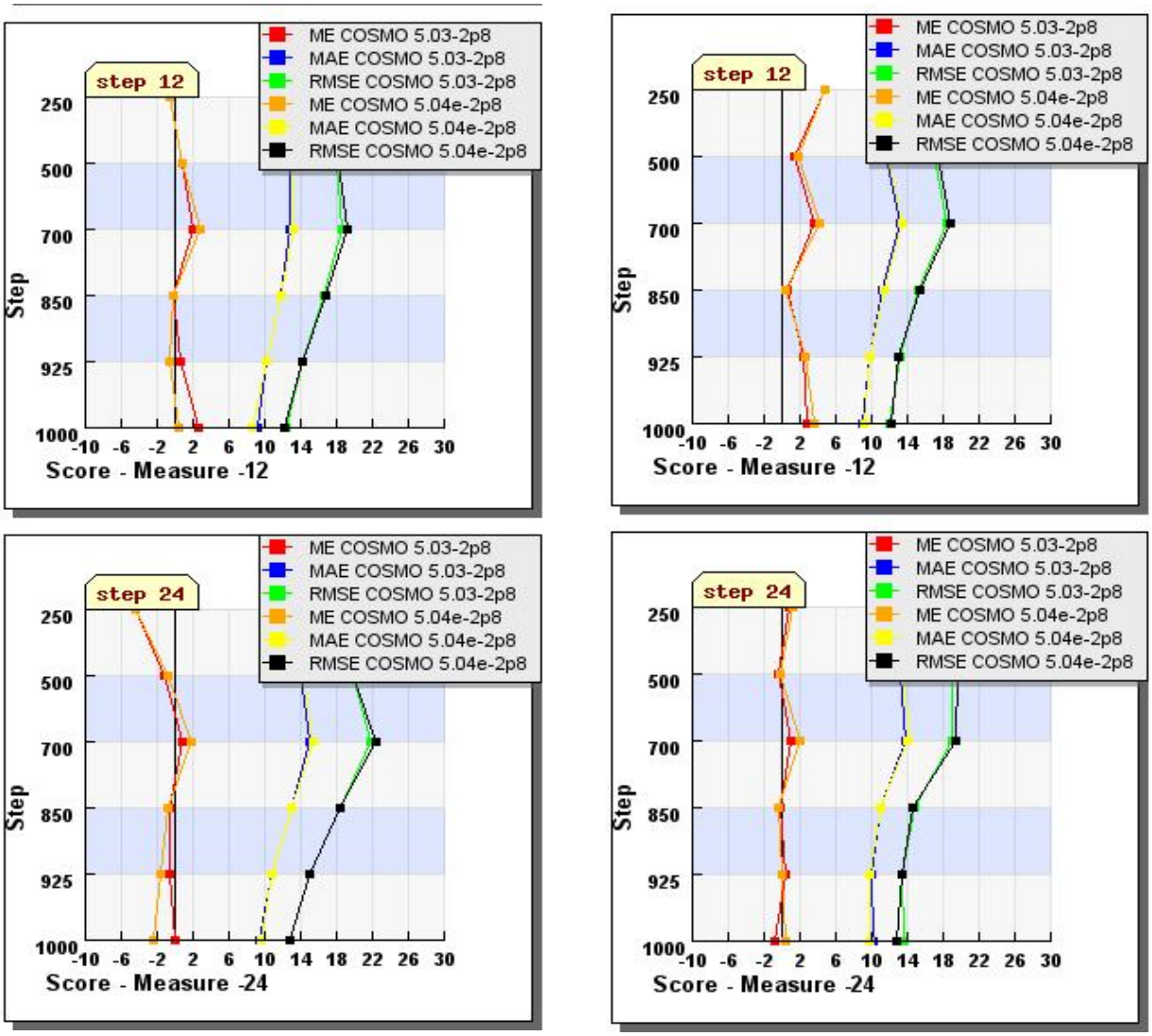


Fig. 4 COSMO-2.8km 6h precipitation > 0.2mm verification results (00UTC run), (1-FAR) for:
(a) COSMO 5.03 January 2013 (b) COSMO 5.04a January 2013 c) COSMO 5.03 July 2013 d) COSMO 5.04a July 2013



a) b)

Fig. 5 COSMO-2.8km Upper air verification for Relative Humidity (00 UTC), mean error (ME), mean absolute error (MAE) and root mean square error (RMSE) for 12 hours anticipation (top) and 24 hours anticipation (bottom): (a) January 2013 (b) July 2013

List of publications/reports from the project with complete references

1. A. MONTANI, **A. IRIZA,** M. BOGDAN, R. BOVE, R. DUMITRACHE, F. GOFA (contributors) - *"Numerical Weather Prediction Meteorological Test Suite": COSMO 5.04a vs. 5.03 (7km and 2.8km)*, COSMO-Model Report, August 2016

2. A. MONTANI, **A. IRIZA,** M. BOGDAN, R. DUMITRACHE, F. GOFA, R. BOVE (contributors) - *"Numerical Weather Prediction Meteorological Test Suite": COSMO 5.04e vs. 5.03 (7km and 2.8km)*, COSMO-Model Report, March 2017

Summary of plans for the continuation of the project

(10 lines max)

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 releases need to be installed as soon as they are available

Performing model evaluation for the next versions of the model.