Consortium

for

Small-Scale Modelling

Technical Report No. 54

Numerical Weather Prediction Meteorological Test Suite: S24icon202504 vs S24icon202410

November 2026

DOI: 10.5676/DWD_pub/nwv/cosmo-tr_54

www.cosmo-model.org

Editor: Massimo Milelli, CIMA Foundation

Numerical Weather Prediction Meteorological Test Suite: S24icon202504 vs S24icon202410

E. Minguzzi[1], ***S. Gabrian***[2], ***F. Fundel***[3],

U. Schaettler[3], ***C. Gebhardt***[3], ***D. Rieger***[3],

M. Bogdan[2], ***A. Iriza-Burca***[2]

[1]***ARPA Emilia Romagna (ARPAE)***

[2]***Administraţia Naţională de Meteorologie (NMA)***

[3]***Deutscher Wetterdienst (DWD)***

Contents

1 TECHNICAL SPECIFICATIONS **3**

1.1 Configuration of ICON-LAM experiments 5

2 MODEL OUTPUT VERIFICATION **7**

2.1 Characteristics of FFV2 on ECS: 8

3 VERIFICATION RESULTS **9**

4 EVALUATION/ RECOMMENDATIONS **11**

5 ANNEX I: Graphs for Surface Parameters: All Models **13**

6 ANNEX II: Graphs for Precipitation **16**

7 ANNEX III: Graphs for Upper Air Parameters **18**

8 Annex IV: Configuration of ICON versions **21**

1 TECHNICAL SPECIFICATIONS

The ICON Numerical Weather Prediction Test Suite is run with resources from a dedicated ECMWF Special Project. This continues the activities started in the previous three special projects, therefore ensuring the usage of a homogeneous verification platform for all versions of ICON model. This is meant as a benchmark in order to evaluate new versions of the model against existing operational ones prior to their recommendation for official duty, as well as a final check to identify possible flaws in the new model release. The use of a standardized testing and verification approach also eases the comparison of corresponding model versions (operational against new), and helps assessing the impact of new features introduced in the code. The set-up and configuration of the tests is focused on minimising initial and lateral boundary conditions effects; data assimilation system is also switched off, in order to point out the changes due to the model itself. Through this approach, performance of new model versions can be thoroughly tested, with an emphasis on newly introduced code developments.

ECMWF computer resources were used for simulation and for archiving purposes, through billing units provided by the members as part of the SPITRASP special project “ICON Numerical Weather Prediction Test Suite" approved for 2024-2026. Table 1 presents a summary of the resources allocated and used for NWP Test Suite activities.

		Previous year		**Current year**	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	7,500,000	2,871,000	7,500,000	0
Data storage capacity	(Gbytes)	6,000	75,000	6,000	37,000

Table 1: ECMWF special project SPITRASP allocated and required resources.

The activities performed during the project were dedicated to running and evaluating the performance of the ICON-LAM model with the numerical weather prediction test suite running on the Atos HPC. These activities include:

→ Implementation and running the ICON-LAM model on the Atos system (model configuration and integration, processing of model output for production of feedback files)

→ Update and running of the MEC system for production of feedback files

→ Update and running of the FFV2 (previously Rfdbk) package dedicated to the calculation of statistical scores.



Figure 1: Integration domain for the ICON-LAM model at 2.5km horizontal resolution.

ICON v2024.10 was used as a benchmark to evaluate **ICON v2025.04**. The directory structure and archiving procedures for all model versions follow the ones used for the previous implementations. For ICON-LAM, DWD ICON Tools version 2.6.0 was employed for the interpolation of initial and lateral boundary conditions. Model output was stored in grib2 format, to avoid problems encountered for the previous hindcast tests.

The ICON NWP Test Suite follows the implementation previously employed for the COSMO Test Suite, adapted for the Atos machine and tailored to the ICON-LAM model. The design of the experiments is similar to the one used in the previous reports. The experiments are carried out for the same one-month periods, one in winter (December 2021) and one in summer (July 2021). For each simulation, the model is run in "hindcast" mode, forced with analysed boundary conditions. This type of simulation results in a continuous 31 day forecast. For implementation reasons, the forecast is restarted every 5 days, without interfering with the continuity of the simulations.

The main simulation settings of all the experiments are:

- horizontal resolution: 2.5 km (R2B10; 1,997,000 cells); integration domain shown in Figure 1
- vertical resolution: 65 levels
- time step 24"
- initial and lateral boundary conditions from ECMWF HRES analysis; since analysis data are only available at 6 hours intervals, short term (1-5 hours) forecasts are used to fill the gaps.
- soil variables initialized from ICON-EU, while the soil is free to evolve during the simulation

- SST and sea ice fields updated every 24 hours from IFS analysis.

1.1 Configuration of ICON-LAM experiments

Two model versions were employed for the present tests: **ICON version 2024.10** and version **2025.04**. Based on these two model versions, this report describes three ICON-LAM experiments (see table 1), as follows:

→ S24icon202410: this experiment has already been described in detail in the previous NWP Test Suite report, and includes updated namelists (according to the model version), new soil IC form ICON-EU and slightly smaller domain in the SE corner (same as presented in the previous report). IFS atmospheric boundary conditions are hourly and the "Top Boundary Nudging" option has been activated. As a result, synoptic scale circulation over Europe is expected to follow more closely ECMWF analysis. Climatological concentrations of trace gases take into account changes in atmosphere composition in the last decades, which has a small effect on the description of radiative exchanges.

→ S24icon202504: the configuration of the suite is the same as in the reference experiment (S24icon202410), but a new version of the ICON model (2025.04) has been used. This new version includes several bug fixes and new options for physical parameterisations. The most important change affects the treatment of microphysics processes.

Previous ICON versions run at convection-permitting resolution (2 km) often produced extremely high localised peaks of convective precipitation: this did not affect the overall performance of the model, but made it difficult to use forecasts for severe weather warnings and hydrological applications. Almost every partner of the COSMO consortium has experienced this problem; however, this was particularly troublesome over complex orography and in the Mediterranean area, during summer months. A dedicated working group was formed, and ICON version 2025.04 includes a new microphysics formulation, that successfully mitigates the problem.

Figures 2 and 3 show an example of how ICON v2025.04 effectively reduces the excesses of localized precipitation that were often predicted by previous model versions; the exemplification is done for a reduced area of the integration domain empoyed in the present experiments. Another change in the configuration of the S24icon202504 experiment is the activation of the module for urban parametrisation "terra-urb". This module is the result of a multi-year development activity within the COSMO consortium. After extensive testing, it is now sufficiently reliable to be included in the default ICON configuration. Differences with respect to the previous model versions are expected to affect surface temperatures in urban areas, but changes in surface wind and precipitations are also possible.

Table 2 summarize the setup of the most recent NWP-TS experiments and Table 3 lists the most important differences in namelist keywords between experiments S24icon202504 vs S24icon202410.

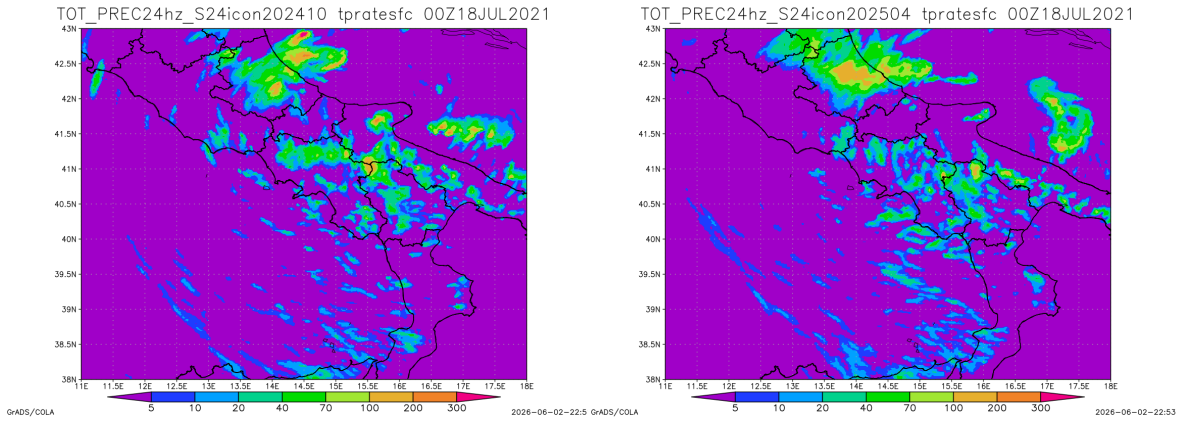


Figure 2: NWP-TS, 24h precipitation for 17/07/2021 in Southern Italy: experiment S24icon202410 (left; max grid point 527 mm), experiment S24icon202504 (right; max grid point 172 mm).

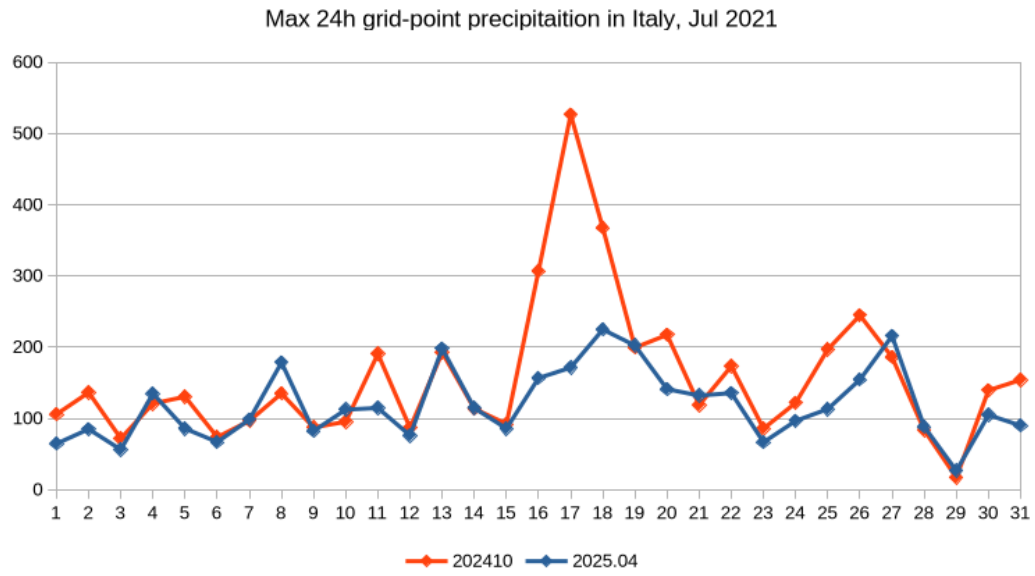


Figure 3: NWP-TS, 24h precipitation in Italy in July 2021, max grid point values: experiment S24icon202410 (red), and S24icon202504 (blue).

Experiment ID	Completed by	Icon version	Simulation periods	Namelist	Soil IC + domain	Top bound. nudging	BC frequency
S23icon2023	11/05/2023 17/05/2023	2.6.5.1	Jul 2021 Dec 2021	265-2023	ICON-EU	No	3 hours
S23icon202410	22/12/2024 10/12/2024	2024.10	Jul 2021 Dec 2021	2024	ICON-EU	No	3 hours
S24icon202410	31/01/2025 04/02/2025	2024.10	Jul 2021 Dec 2021	2024	ICON-EU	Yes	1 hour
S24icon202504	20/07/2025 13/07/2025	2025.04-1	Jul 2021 Dec 2021	2025	ICON-EU	Yes	1 hour

Table 2: Summary for the main features of the most recent ICON-LAM experiments.

Namelist	Key	Version 2025.04	Version 2024.10
New microphysics setup			
NWP_TUNING_NML	TUNE_SUPSAT_LIMFAC	2	N/A
NWP_PHY_NML	LVARIABLE_RAIN_N0	T	N/A
NWP_TUNING_NML	TUNE_ZCSG	0.25	0
NWP_TUNING_NML	TUNE_VOSNOW	20	-1
Activation of urban module			
LND_NML	LTERRA_URB	T	F
Other modifications			
NWP_PHY_NML	ITYPE_SATPRES_COEFFS	2	N/A
NWP_PHY_NML	ITHERMO_WATER	1	0
NWP_PHY_NML	ITYPE_DISSIP_HEAT	1	N/A
NWP_TUNING_NML	TUNE_SGSCliFAC	0.5	N/A
NWP_TUNING_NML	TUNE_GRZDC_OFFSET	0.1	N/A
NWP_TUNING_NML	ITUNE_VIS_DIAG	2	N/A
NWP_TUNING_NML	TUNE_BOX_ICE	5.E-2	N/A
TURBDIFF_NML	IMODE_SNOWSMOT	2	1
TURBDIFF_NML	IMODE_TKEMINI	1	N/A
LND_NML	ITYPE_OSKIN_WARM	0	N/A

Table 3: List of the most important namelist changes between ICON versions 202410 and 202504.

2 MODEL OUTPUT VERIFICATION

The Model Equivalent Calculator (MEC) software for the production of Feedback Files and verification scripts based on the R package FFV2 implemented on the ATOS system were employed for Model output Verification, as follows:

→ production of feedback-files using MEC (performed on the **Atos HPC machine**; employs part of the available billing units;

→ production of model output verification based on feedback-files using the FFV2 (performed on the **ECS** interface);

→ additionally, conversion of observations from bufr to netcdf format (using bufr2netcdf) can also be performed on the **ECS** interface, using the **bufr2netcdf** utility.

The Feedback files used in the verification procedure are produced by MEC and contain all information regarding observations and their usage in the data assimilation system. They are ingested in FFV2, which then employs them to compute the verification scores. The production of Feedback files and verification procedures are based on observations data sets available from the MARS database and converted from bufr to NetCDF format locally.

Characteristics and requirements of the MEC processing chain on Atos:

→ pre-processing of model output files stored on ECFS: model output files stored as grib2 files containing 24 time steps each are split into hourly or three hourly files; separate files are obtained for accumulated parameters;

→ preparation of input files required by MEC: constant files, model grid file description, forecast files, observations

→ set -up of MEC namelist file and run scripts

→ production of feedback-files using MEC

The costs for producing a month of feedback files for one model configurations (including pre-processing of model output files) is around 125 000BUs. The total resources for MEC and FFV2 used for this project is 540 803 BUs.

2.1 Characteristics of FFV2 on ECS:

An objective model output verification is performed based on grid-to-point comparisons that enable a correspondence between gridded surface and upper-air model data to point observations, similar to the previous VERSUS verification procedures employed in the past to evaluate COSMO and ICON model versions. Around 3200 stations are employed for the stratification (see Figure 4). Suspect observation values were previously included in the verification test in order to minimize errors introduced from the observations.

Due to the specifications of the verification system for hindcast runs (single run), +24 hours lead time is shifted to 0. Statistical scores were computed for each period of interest, taking into account all observations available in the integration domain. However, results can be further on obtained for different station stratifications or subdomains, depending on developer and user requirements.

The current verification modules for testing the ICON models include surface continuous parameters, precipitation verification (6h and 12h) and upper air verification (TEMP based), as follows:

→ 2m temperature (T2M), 2m dew point (TD2m), 10 meter wind speed (FF), total cloud cover (N), surface pressure (PS): mean error (ME), root mean square error (RMSE), mean absolute error (MAE), standard deviation (SD), R2, TCC (tendency correlation), LEN (number of observations used), OMEAN and FMEAN (observed and forecast mean), etc.;

→ precipitation 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): probability of detection (POD), false alarm rate (FAR), equitable threat score (ETS), frequency bias (FBI), Performance diagrams, etc.

→ upper air temperature (T), relative humidity (RH) and wind speed (FF) for selected pressure levels (250., 500., 700., 850., 925., 1000.): BIAS, MAE, RMSE, SD, etc.

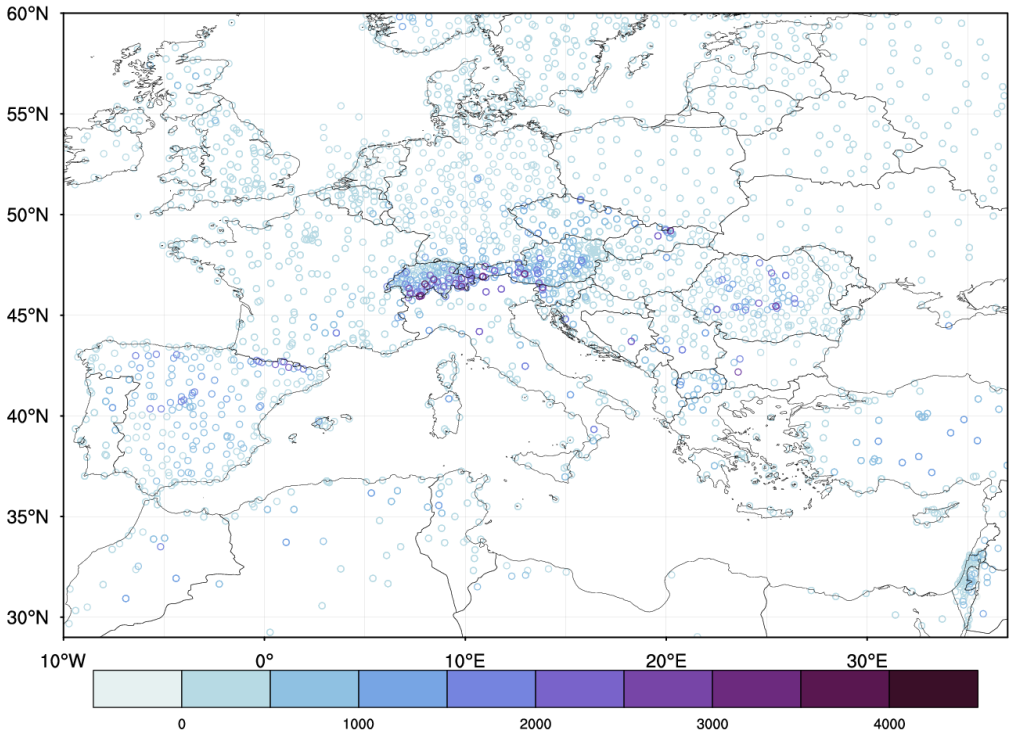


Figure 4: Overview of meteorological observations used for the verification.

3 VERIFICATION RESULTS

The verification results presented in the following section (figures 3-12) are a sample of the derived statistics, with a complete overview of all the statistical analysis (graphs and numbers) available at:http://www.cosmo-model.org/shiny/users/fdbk/

Note: Verification was performed taking into account all configurations of the analysed models. This allowed for a full comparison between all configurations, but additional comparisons to the ones presented below are also available.

The statistical results obtained through the R-based FFV2 verification system for all model configurations are presented in Annex I for surface parameters, Annex II for precipitation and Annex III for upper air parameters. A summary of the main findings is given below.

Note: Due to the specifications of the verification system for hindcast runs (single run), +24 hours lead time is shifted to 0.

Continuous Surface Parameters (Figs. 4-7)

→ With respect to **2m temperature (figure 5)** the differences are **insignificant** with respect to RMSE for both seasons for both model implementations. For ME during the

summer period, there is a clear general tendency of both model versions to overestimate temperature values for the entire day, which is **lower with S24icon202410 version**. Differences between the two model versions are more significant during the night and early morning, **in favour of S24icon202410**.

During winter, the behaviour of the two model versions is different. S24icon202410 shows a constant underestimation during the entire daily cycle, especially during the warm hours. For S24icon202504, this behaviour is visible during the day, when **model errors are lower than for S24icon202410**. During the nighttime an overestimation of temperature values is visible from S24icon202504. In general, this behaviour is also visible from the time Series verification results presented in **figure 6**. Analysis of the time series results also shows that, in general, **S24202504 is warmer than S24202410**, for both seasons, which could be due to the activation of the urban module in version S24202504 (as supported also by independent evaluations from the urban module).

→ Results for **2m Dew Point Temperature (figure 7)** also show **insignificant** differences with respect to RMSE for both seasons for both model implementations. The general tendency of both model versions is of underestimation of forecasted values for this parameter. With regards to ME values, there is a **slight improvement from S24icon202504**, especially during night time. Similar to results for T2M, **S24202504 is warmer than S24202410** with regards to TD2M, again especially during nighttime. Although this behaviour is observed for both seasons, the differences between the two configurations and seasons are less visible than for T2M.

→ NWP test statistical results for **10m Wind Speed (Fig. 8)** show no significant differences between the two model versions, except for some **small reduction of ME values from S24icon202504** during the evening.

→ **Surface Pressure (Fig. 9)** exhibits no visible differences between the model implementations in terms of RMSE. This behaviour is valid for both seasons. In terms of ME, the behaviour of the models is similar. Both models show an overestimation during the summer period and general overestimation during winter. During summer, **model errors are visibly lower for S24icon202410**, while during winter there is a **slight improvement from S24icon202504**.

Dichotomic Parameters (Figs. 10-12)

→ **Total Could Cover (Fig. 10)** TCC is a parameter that exhibits no significant differences between the model implementations with respect to RMSE for both seasons. For ME during the summer period, there is a clear general tendency of both model versions to overestimate total cloud cover values for the entire day (as was the case for T2M), which is **lower with version S24icon202504**. During **winter,the behaviour of the two model versions is also similar**, with overestimation **during the morning and night**, with a **slight improvement from S24icon202504**. In contrast, there is a visible underestimation during the warm hours (day/afternoon), with MEC values **in favour of S24icon202410**. Statistical results for this parameter also suggest that **S24202504 generally forecasts less clouds compared to S24202410**, independent of the season.

→ **6h Precipitation (Fig. 11)** Regarding the forecast of 6h precipitation, the statistics for the two model versions are very similar. Some **very small improvements from S24icon202410** are seen for the summer season, with slightly higher POD and smaller

FAR for the higher thresholds (> 5mm/6h, > 10mm/6h). Overall however, there are **no significant differences** in favour of either implementation, for both seasons.

→ **12h Precipitation (Fig. 12)** The statistical plots are very similar as the ones calculated for the 6h precipitation, with **no significant differences** among the models as described above.

Upper Air Parameters (Figs. 13-15)

→ **Upper Air Temperature (Fig. 13)** For the summer period, there is a **better performance from S24icon202410** for the lower atmosphere, while for the middle and upper atmosphere, score values are generally **in favour of S24icon202504**. Differences between the two model implementations are more visible in the lower atmosphere, while for the middle and upper atmosphere they are generally more significant in terms of ME. For the summer period, the behaviour of the two models is **reversed**. That is, differences are more visible in the middle and upper atmosphere atmosphere, while for the lower atmosphere they are generally more significant in terms of ME. For the warm season, for the lower atmosphere, score values are generally **in favour of S24icon202504**. For the middle and upper atmosphere, **lower ME values from S24icon202504** are contrasted by **lower RMSE and MAE values from S24icon202410**.

→ **Upper Air Relative Humidity (Fig. 14)** Forecast performance for both models shows no significant differences for the lower atmosphere, for both seasons. More visible differences are displayed for the upper atmosphere, **with a generally better performance from S24icon202504**.

→ **Upper Air Wind Speed (Fig. 15)** While there is no significant result in favour of either model for the analysed periods with regards to upper air wind speed, some **larger amplitude of errors are displayed by both models** during the warm season at 300hPA and by **S24icon202504 during winter at 850hPa**.

4 EVALUATION/ RECOMMENDATIONS

The Statistical scores do not show overall significant differences in favour of one model. Based on the mixed results obtained from the evaluation of **ICON v2025.04 (new)** against v2024.10 (operational), it is recommended to **keep the current operational version (v2024.10) as a reference** for the evaluation of the next model version (v2026.04) and investigate this further on.
Contributors:

→ Run the test suite for S24icon202410 and S24icon202504 (E. Minguzzi)

→ Perform model evaluation with MEC/FFV2 for S24icon202410 and S24icon202504 (A. Iriza-Burcă, S. Gabrian)

→ MEC and Rfdbk support and debugging (F. Fundel)

→ Evaluation report for the SMC (E. Minguzzi, U. Schattler, C. Gebhardt, D. Rieger, A. Iriza-Burca)

List of publications/reports from the project with complete references

- E. Minguzzi - *"NWP-TS: summary of Icon experiments at 31/08/2025"*,27th COSMO General Meeting, Basel, Switzerland, 14-18 September 2025
- F. Gofa – *"Verification in COSMO consortium"*, COSMO Newsletter, No. 24, July 2025
- M. Milelli and colleagues – *"WG S/I: news about our activities"*,27th COSMO General Meeting, Basel, Switzerland, 14-18 September 2025

5 ANNEX I: Graphs for Surface Parameters: All Models

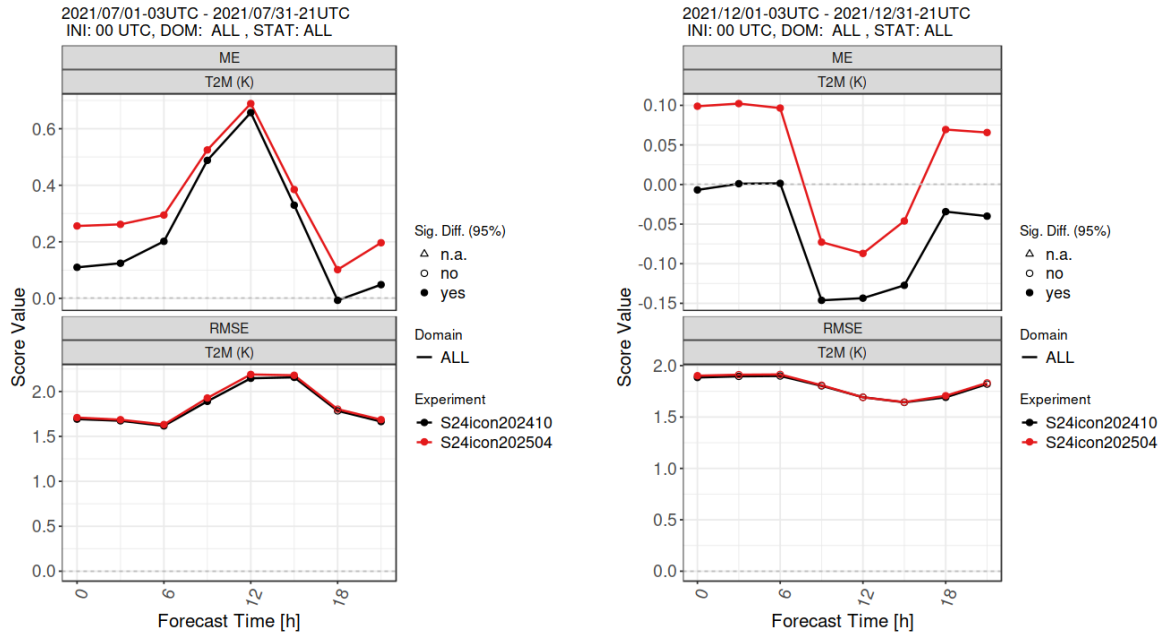


Figure 5: **2-meter temperature** verification results for July 2021 (left) and December 2021 (right): **S24icon202410** (black) and **S24icon202504** (red). **ME (top) and RMSE (bottom)** are shown for different forecast times (0h to 18h).

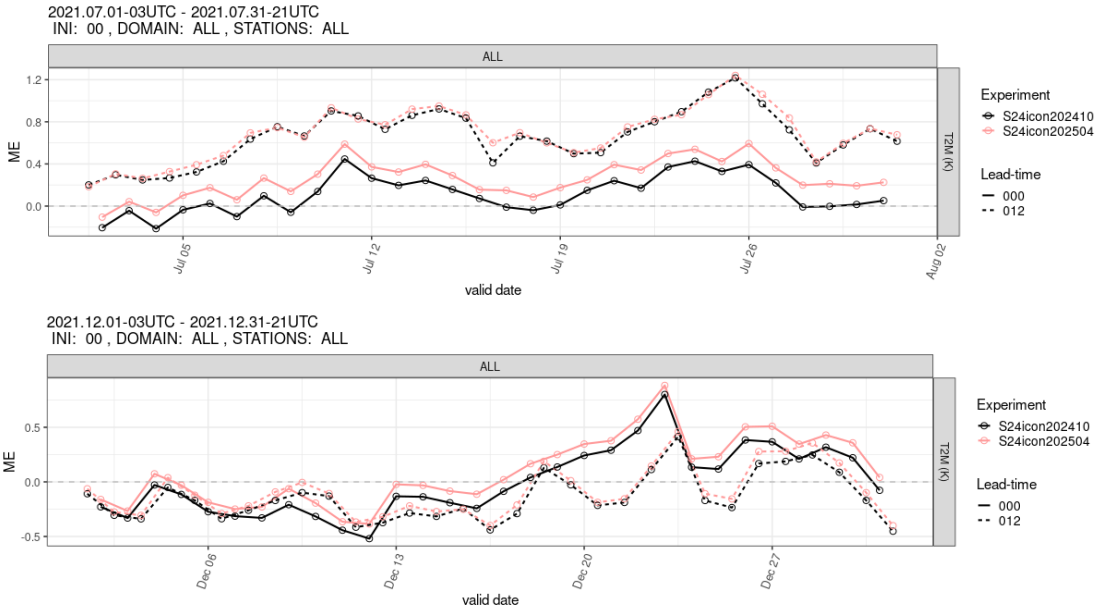


Figure 6: **2-meter temperature Time Series** verification results **(ME)** for July 2021 (a) and December 2021 (b): **S24icon202410** (black) and **S24icon202504** (red). +00/24 hours (black) and +12 hours (pink).

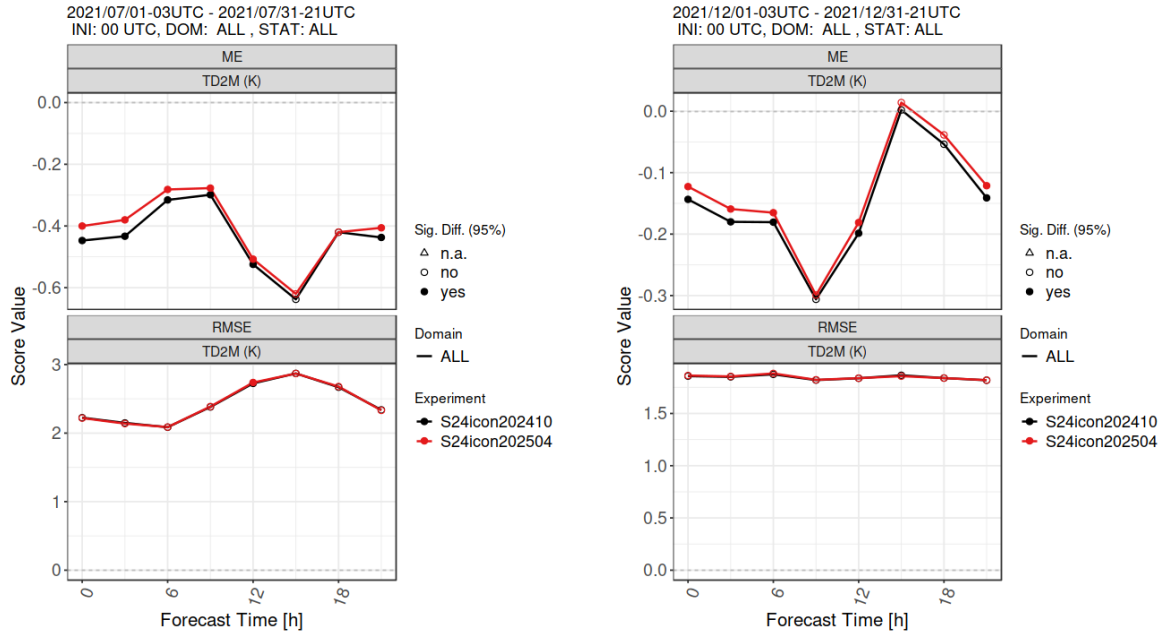


Figure 7: 2-meter dew point temperature verification results for July 2021 (left) and December 2021 (right): **S24icon202410** (black) and **S24icon202504** (red), **ME (top) and RMSE (bottom)** are shown for different forecast times (0h to 18h).

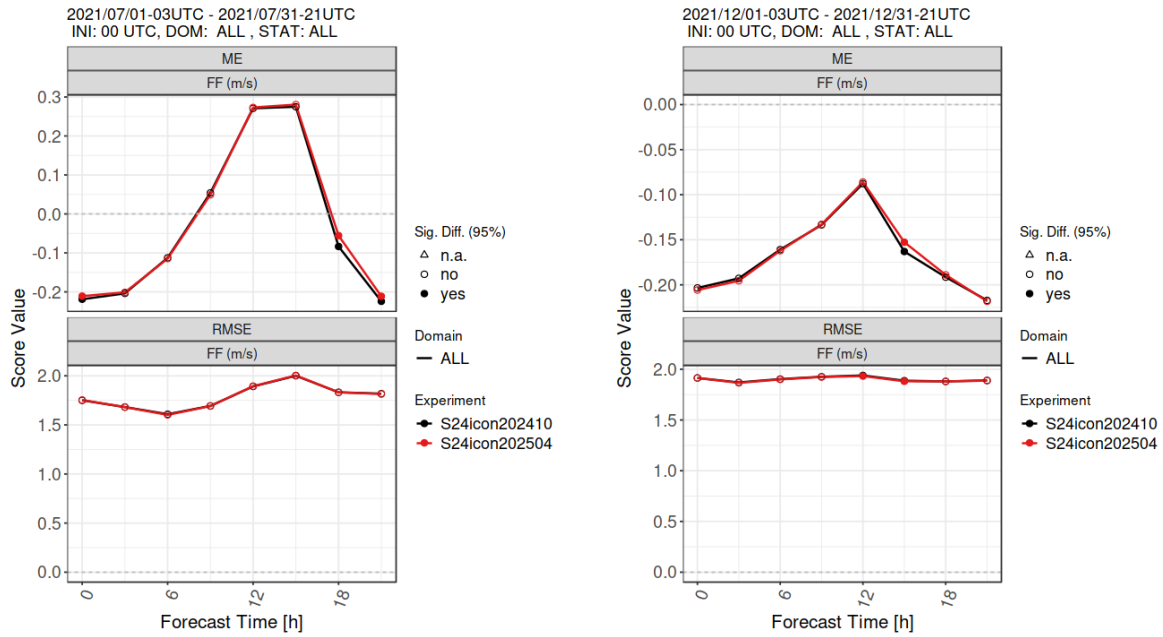


Figure 8: 10-meter wind speed verification results for July 2021 (left) and December 2021 (right): **S24icon202410** (black) and **S24icon202504** (red). **ME (top) and RMSE (bottom)** are shown for different forecast times (0h to 18h).

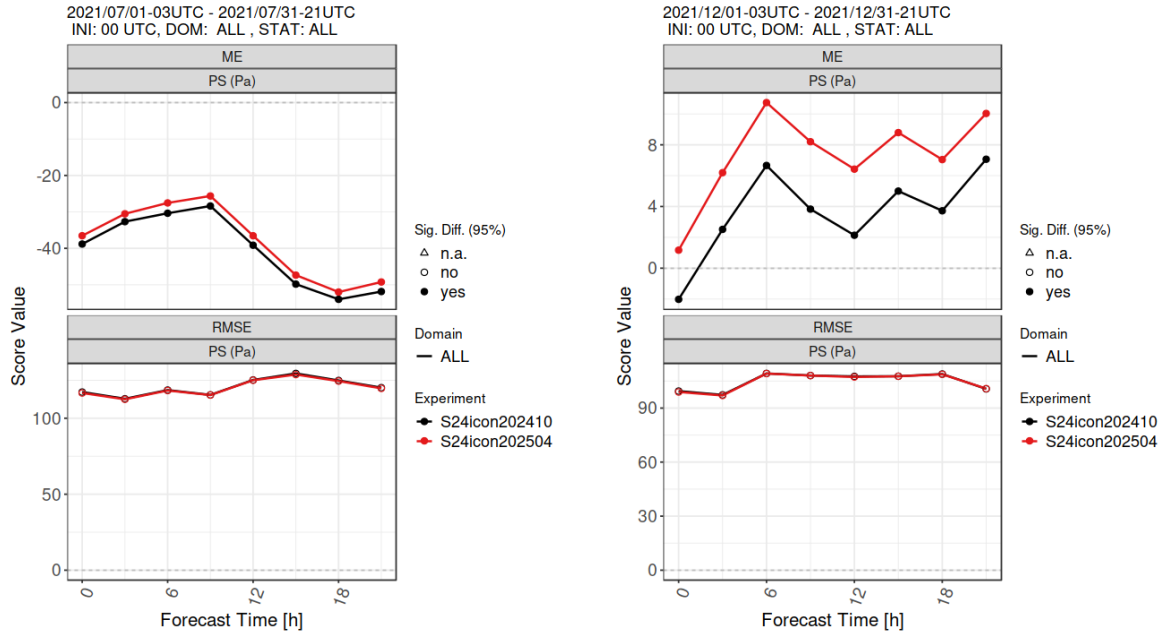


Figure 9: Surface pressure verification results for July 2021 (left) and December 2021 (right): **S24icon202410** (black) and **S24icon202504** (red).**ME (top) and RMSE (bottom)** are shown for different forecast times (0h to 18h).

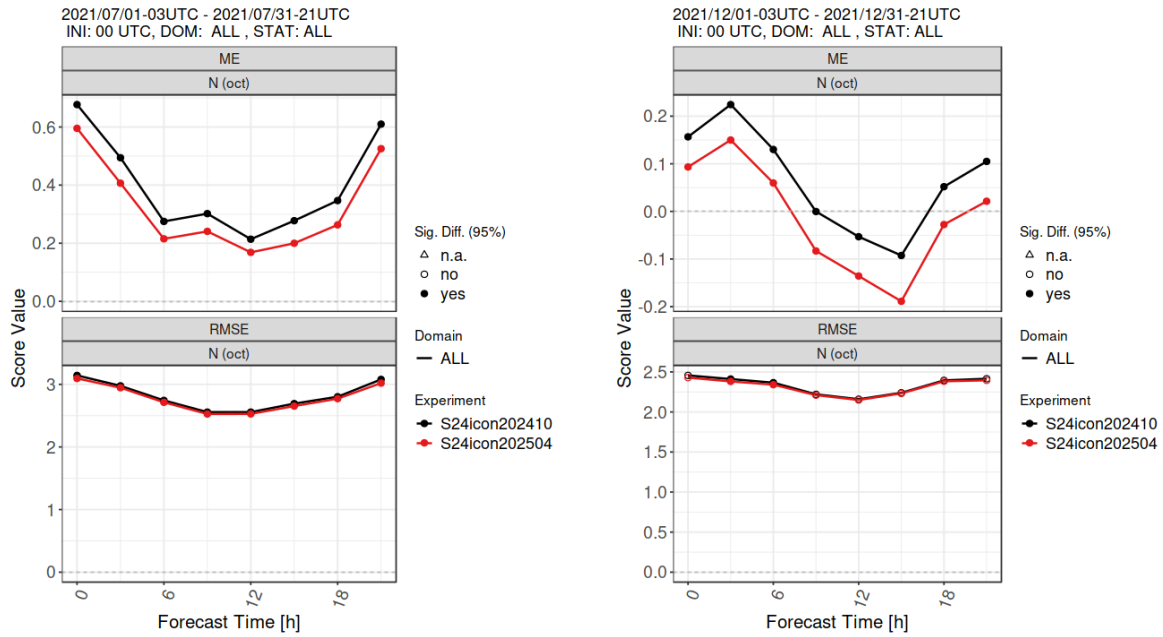
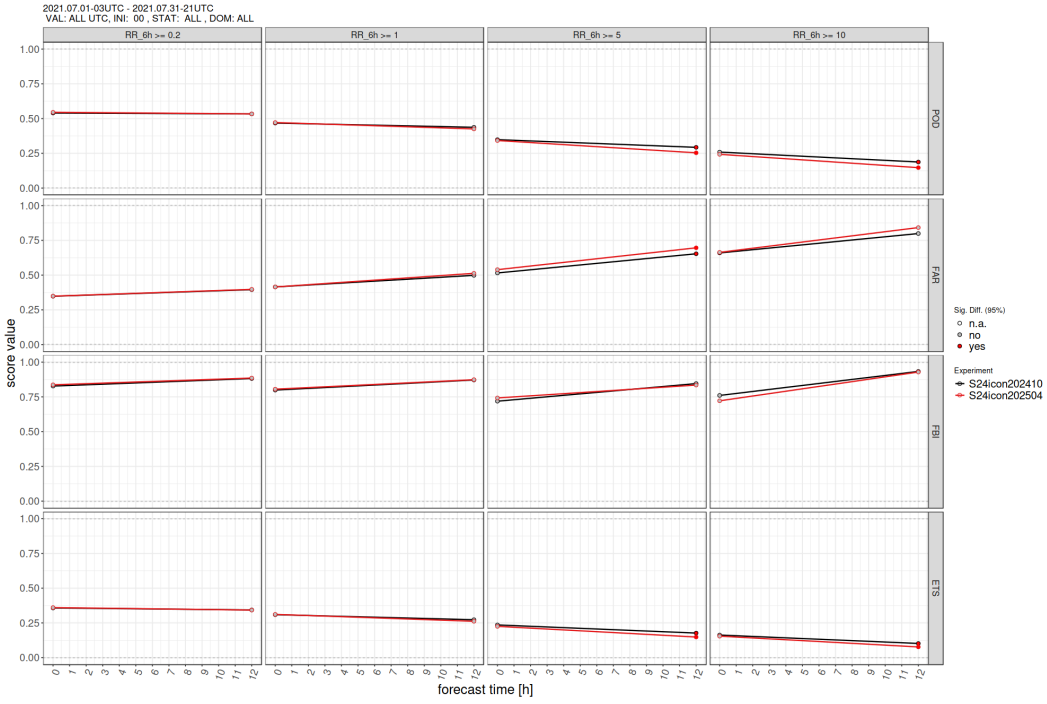
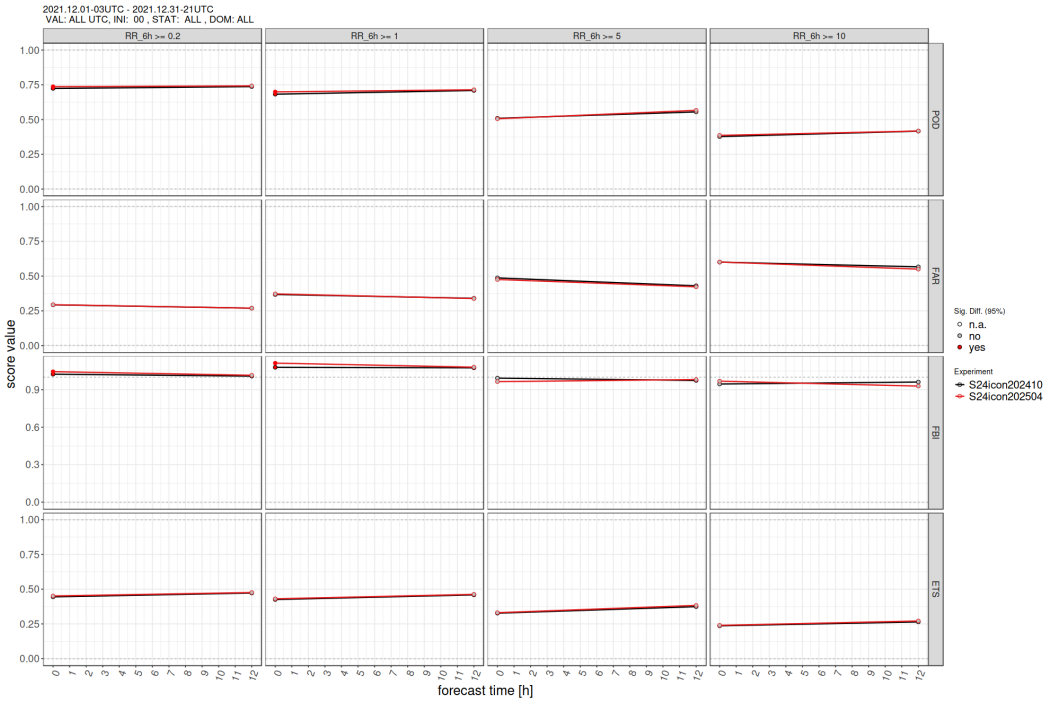


Figure 10: Total cloud cover verification results for July 2021 (left) and December 2021 (right): **S24icon202410** (black) and **S24icon202504** (red). **ME (top) and RMSE (bottom)** are shown for different forecast times (0h to 18h).

6 ANNEX II: Graphs for Precipitation

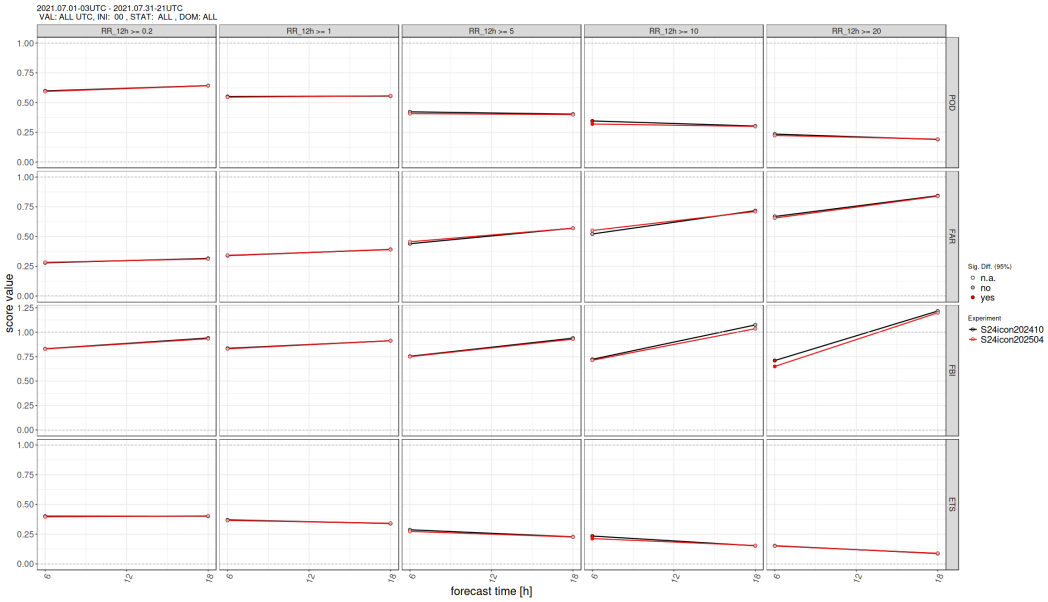


(a)

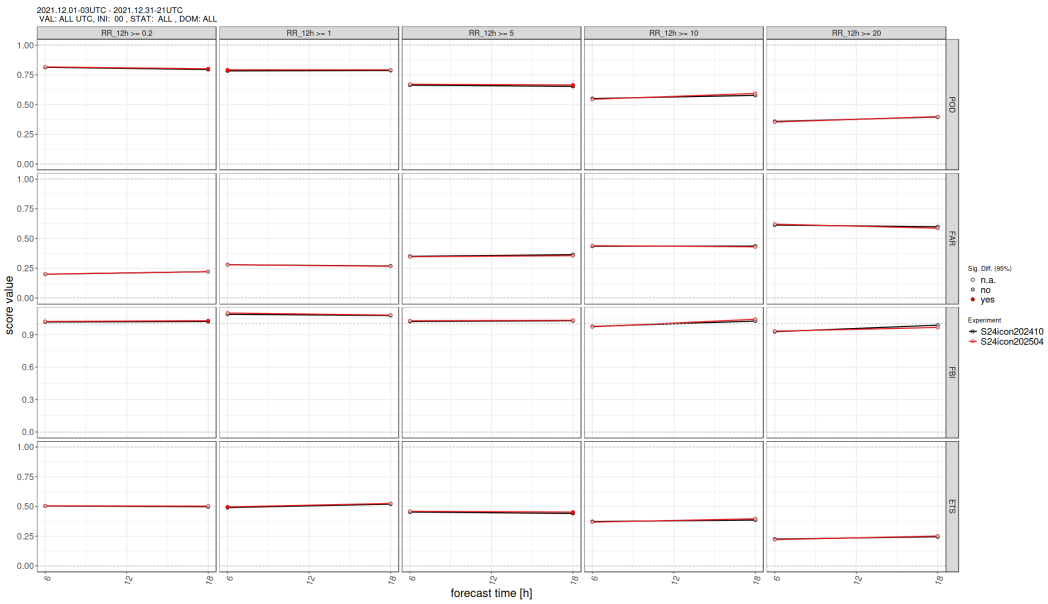


(b)

Figure 11: RR_6h verification results for July 2021 (a) and December 2021 (b): **S24icon202410** (black) and **S24icon202504** (red). POD, FAR, FBI and ETS (top to bottom). Thresholds 0.2, 1, 5, 10mm (left to right).



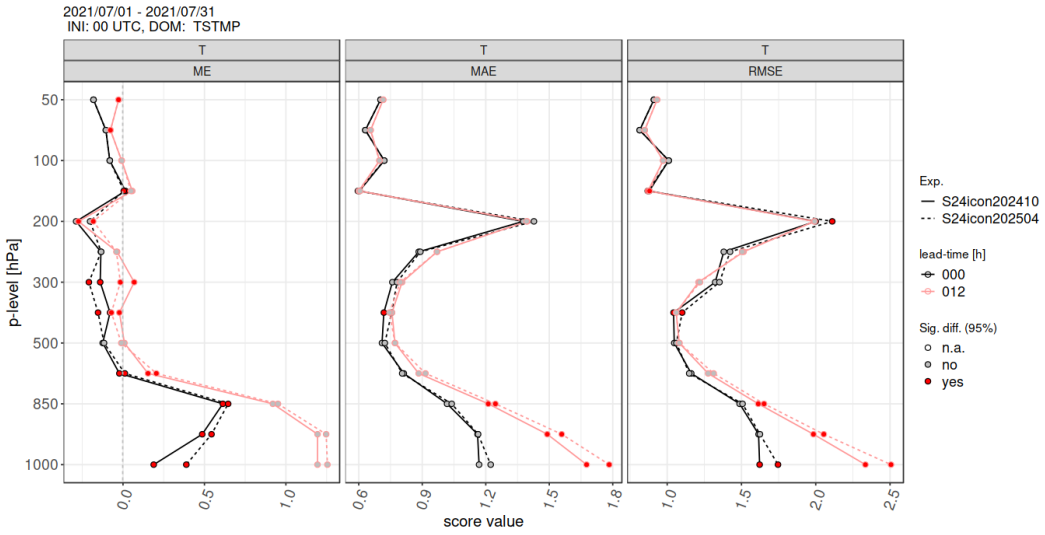
(a)



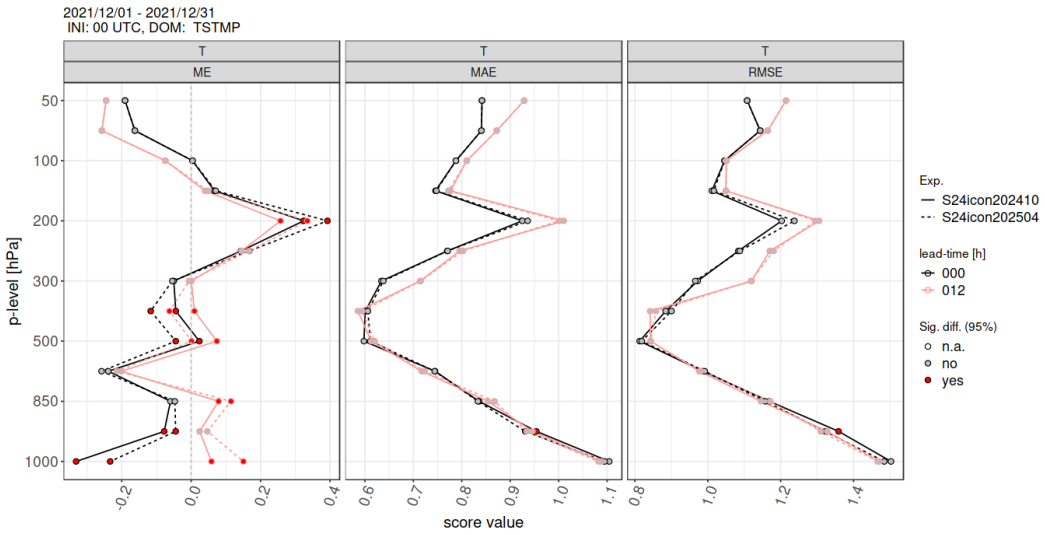
(b)

Figure 12: RR_12h verification results for July 2021 (a) and December 2021 (b): **S24icon202410** (black) and **S24icon202504** (red). POD, FAR, FBI and ETS (top to bottom). Thresholds 0.2, 1, 5, 10, 20mm (left to right).

7 ANNEX III: Graphs for Upper Air Parameters

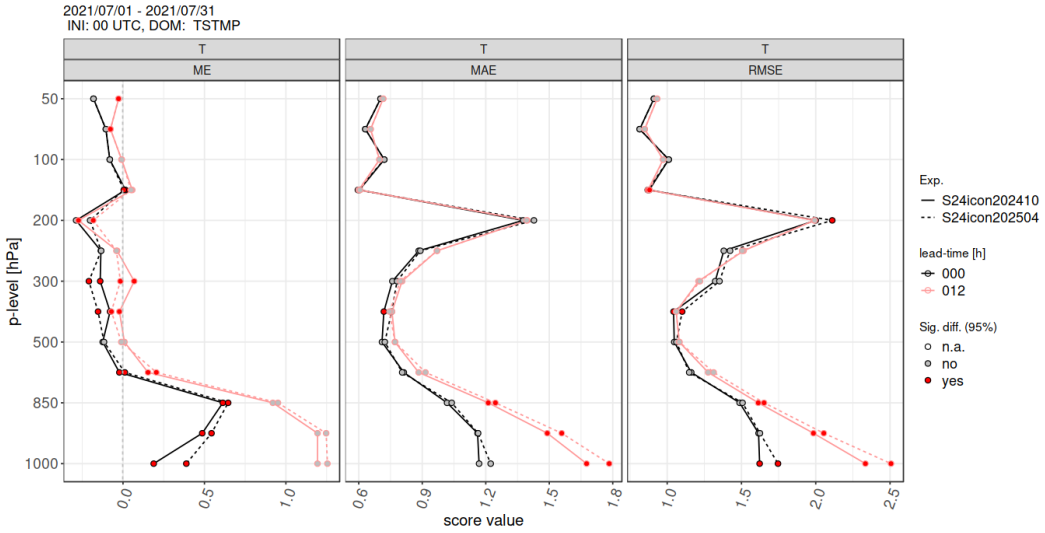


(a)

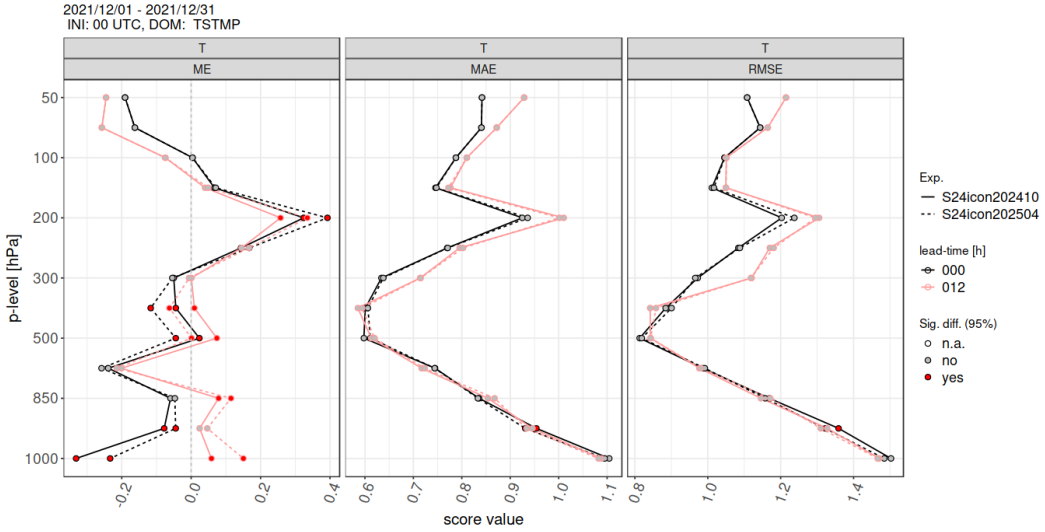


(b)

Figure 13: Upper Air Temperature verification results for July 2021 (a) and December 2021 (b) **S24icon202410** (solid) and **S24icon202504** (dashed). ME, MAE and RMSE (left to right). +00/24 hours (black) and +12 hours (pink).

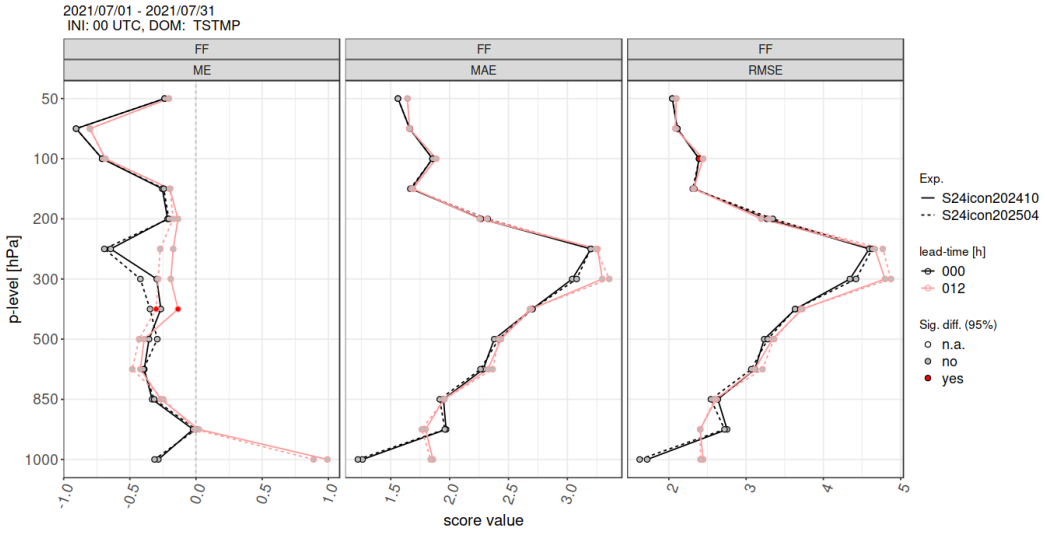


(a)

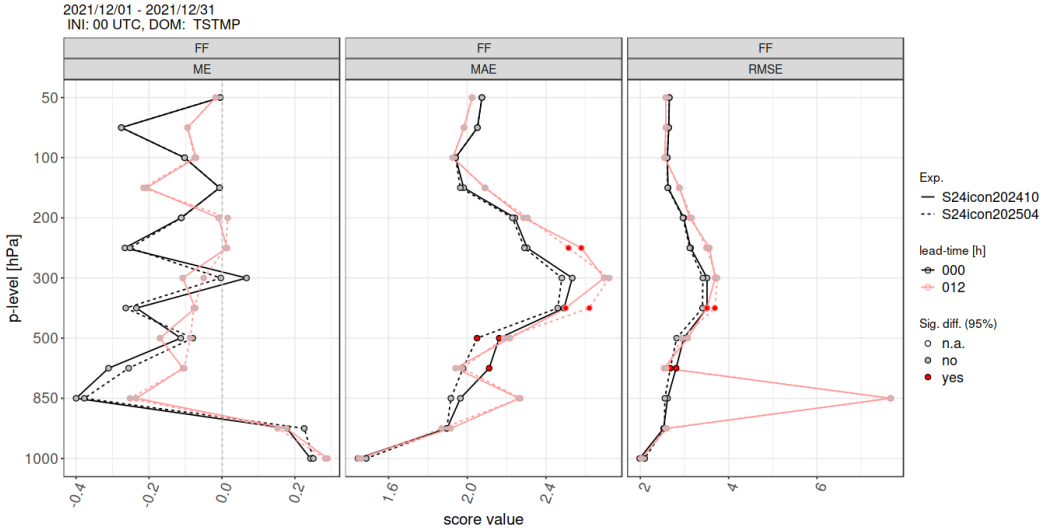


(b)

Figure 14: Upper Air Relative Humidity verification results for July 2021 (a) and December 2021 (b): **S24icon202410** (solid) and **S24icon202504** (dashed). ME, MAE and RMSE (left to right). +00/24 hours (black) and +12 hours (pink).



(a)



(b)

Figure 15: Upper Air Wind Speed verification results for July 2021 (a) and December 2021 (b): **S24icon202410** (solid) and **S24icon202504** (dashed). ME, MAE and RMSE (left to right). +00/24 hours (black) and +12 hours (pink).

8 Annex IV: Configuration of ICON versions

Changes to ICON versions are documented in the model Release Notes. They can be found on `https://dkrz.de` ⇒ RELEASE_NOTES.md.

2025.04: released on 06 May 2025
Version 2025.04 (doi.org/10.35089/WDCC/IconRelease2025.04)
Current version evaluated with the NWP Test Suite.

2024.10: released on 07 October 2024
Version 2024.10 (doi.org/10.35089/WDCC/IconRelease2024.10)
Previous version evaluated with the NWP Test Suite. Reference version in the present document.

2024.07: released on 11 July 2024
Version 2024.07 (doi.org/10.35089/WDCC/IconRelease2024.07)

2024.01-1: released on 04 March 2024
Version 2024.01 (doi.org/10.35089/WDCC/IconRelease01)

2.6.5.1: released for testing with the NWP Test Suite on 15 December 2022
Selective information regarding testing with the NWP Test Suite available at:
`https://www.ecmwf.int/en/research/emi-rd-projects/spitrasp-2021`

2.6.1: released on 09 April 2020; first version tested with the NWP Test Suite (against COSMO ver 5.08 and 5.06).
Results from NWP Test Suite evaluation available at:
`https://www.cosmo-model.org/content/tasks/workGroups/wg5/NWPSuiteReports.priv/cosmo_v5.8_vs_v5.6_vs_ico-v2.6.1.pdf`

List of COSMO Newsletters and Technical Reports

(available for download from the COSMO Website: www.cosmo-model.org)

COSMO Newsletters

No. 1: February 2001.

No. 2: February 2002.

No. 3: February 2003.

No. 4: February 2004.

No. 5: April 2005.

No. 6: July 2006.

No. 7: April 2008; Proceedings from the 8th COSMO General Meeting in Bucharest, 2006.

No. 8: September 2008; Proceedings from the 9th COSMO General Meeting in Athens, 2007.

No. 9: December 2008.

No. 10: March 2010.

No. 11: April 2011.

No. 12: April 2012.

No. 13: April 2013.

No. 15: July 2015.

No. 16: July 2016.

No. 17: July 2017.

No. 18: November 2018.

No. 19: October 2019.

No. 20: December 2020.

No. 21: May 2022.

No. 22: May 2023.

No. 23: May 2024.

No. 24: Jul 2025.

COSMO Technical Reports

No. 1: Dmitrii Mironov and Matthias Raschendorfer (2001):
Evaluation of Empirical Parameters of the New LM Surface-Layer Parameterization Scheme. Results from Numerical Experiments Including the Soil Moisture Analysis.

No. 2: Reinhold Schrodin and Erdmann Heise (2001):
The Multi-Layer Version of the DWD Soil Model TERRA_LM.

No. 3: Günther Doms (2001):
A Scheme for Monotonic Numerical Diffusion in the LM.

No. 4: Hans-Joachim Herzog, Ursula Schubert, Gerd Vogel, Adelheid Fiedler and Roswitha Kirchner (2002):
LLM — the High-Resolving Nonhydrostatic Simulation Model in the DWD-Project LITFASS.
Part I: Modelling Technique and Simulation Method.

No. 5: Jean-Marie Bettems (2002):
EUCOS Impact Study Using the Limited-Area Non-Hydrostatic NWP Model in Operational Use at MeteoSwiss.

No. 6: Heinz-Werner Bitzer and Jürgen Steppeler (2004):
Documentation of the Z-Coordinate Dynamical Core of LM.

No. 7: Hans-Joachim Herzog, Almut Gassmann (2005):
Lorenz- and Charney-Phillips vertical grid experimentation using a compressible nonhydrostatic toy-model relevant to the fast-mode part of the 'Lokal-Modell'.

No. 8: Chiara Marsigli, Andrea Montani, Tiziana Paccagnella, Davide Sacchetti, André Walser, Marco Arpagaus, Thomas Schumann (2005):
Evaluation of the Performance of the COSMO-LEPS System.

No. 9: Erdmann Heise, Bodo Ritter, Reinhold Schrodin (2006):
Operational Implementation of the Multilayer Soil Model.

No. 10: M.D. Tsyrulnikov (2007):
Is the particle filtering approach appropriate for meso-scale data assimilation ?

No. 11: Dmitrii V. Mironov (2008):
Parameterization of Lakes in Numerical Weather Prediction. Description of a Lake Model.

No. 12: Adriano Raspanti (2009):
COSMO Priority Project "VERification System Unified Survey" (VERSUS): Final Report.

No. 13: Chiara Marsigli (2009):
COSMO Priority Project "Short Range Ensemble Prediction System" (SREPS): Final Report.

No. 14: Michael Baldauf (2009):
COSMO Priority Project "Further Developments of the Runge-Kutta Time Integration Scheme" (RK): Final Report.

No. 15: Silke Dierer (2009):
COSMO Priority Project "Tackle deficiencies in quantitative precipitation forecast" (QPF): Final Report.

No. 16: Pierre Eckert (2009):
COSMO Priority Project "INTERP": Final Report.

No. 17: D. Leuenberger, M. Stoll and A. Roches (2010):
Description of some convective indices implemented in the COSMO model.

No. 18: Daniel Leuenberger (2010):
Statistical analysis of high-resolution COSMO Ensemble forecasts in view of Data Assimilation.

No. 19: A. Montani, D. Cesari, C. Marsigli, T. Paccagnella (2010):
Seven years of activity in the field of mesoscale ensemble forecasting by the COSMO–LEPS system: main achievements and open challenges.

No. 20: A. Roches, O. Fuhrer (2012):
Tracer module in the COSMO model.

No. 21: Michael Baldauf (2013):
A new fast-waves solver for the Runge-Kutta dynamical core.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_21

No. 22: C. Marsigli, T. Diomede, A. Montani, T. Paccagnella, P. Louka, F. Gofa, A. Corigliano (2013):
The CONSENS Priority Project.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_22

No. 23: M. Baldauf, O. Fuhrer, M. J. Kurowski, G. de Morsier, M. Müllner, Z. P. Piotrowski, B. Rosa, P. L. Vitagliano, D. Wójcik, M. Ziemiański (2013):
The COSMO Priority Project 'Conservative Dynamical Core' Final Report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_23

No. 24: A. K. Miltenberger, A. Roches, S. Pfahl, H. Wernli (2014):
Online Trajectory Module in COSMO: a short user guide.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_24

No. 25: P. Khain, I. Carmona, A. Voudouri, E. Avgoustoglou, J.-M. Bettems, F. Grazzini (2015):
The Proof of the Parameters Calibration Method: CALMO Progress Report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_25

No. 26: D. Mironov, E. Machulskaya, B. Szintai, M. Raschendorfer, V. Perov, M. Chumakov, E. Avgoustoglou (2015):
The COSMO Priority Project 'UTCS' Final Report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_26

No. 27: J-M. Bettems (2015):
The COSMO Priority Project 'COLOBOC': Final Report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_27

No. 28: Ulrich Blahak (2016):
RADAR_MIE_LM and RADAR_MIELIB - Calculation of Radar Reflectivity from Model Output.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_28

No. 29: M. Tsyrulnikov and D. Gayfulin (2016):
A Stochastic Pattern Generator for ensemble applications.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_29

No. 30: D. Mironov and E. Machulskaya (2017):
A Turbulence Kinetic Energy – Scalar Variance Turbulence Parameterization Scheme.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_30

No. 31: P. Khain, I. Carmona, A. Voudouri, E. Avgoustoglou, J.-M. Bettems, F. Grazzini, P. Kaufmann (2017):
CALMO - Progress Report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_31

No. 32: A. Voudouri, P. Khain, I. Carmona, E. Avgoustoglou, J.M. Bettems, F. Grazzini, O. Bellprat, P. Kaufmann and E. Bucchignani (2017):
Calibration of COSMO Model, Priority Project CALMO Final report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_32

No. 33: N. Vela (2017):
VAST 2.0 - User Manual.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_33

No. 34: C. Marsigli, D. Alferov, M. Arpagaus, E. Astakhova, R. Bonanno, G. Duniec, C. Gebhardt, W. Interewicz, N. Loglisci, A. Mazur, V. Maurer, A. Montani, A. Walser (2018):
COsmo Towards Ensembles at the Km-scale IN Our countries (COTEKINO), Priority Project final report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_34

No. 35: G. Rivin, I. Rozinkina, E. Astakhova, A. Montani, D. Alferov, M. Arpagaus, D. Blinov, A. Bundel, M. Chumakov, P. Eckert, A. Euripides, J. Förstner, J. Helmert, E. Kazakova, A. Kirsanov, V. Kopeikin, E. Kukanova, D. Majewski, C. Marsigli, G. de Morsier, A. Muravev, T. Paccagnella, U. Schättler, C. Schraff, M. Shatunova, A. Shcherbakov, P. Steiner, M. Zaichenko (2018):
The COSMO Priority Project CORSO Final Report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_35

No. 36: A. Raspanti, A. Celozzi, A. Troisi, A. Vocino, R. Bove, F. Batignani (2018):
The COSMO Priority Project VERSUS2 Final Report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_36

No. 37: A. Bundel, F. Gofa, D. Alferov, E. Astakhova, P. Baumann, D. Boucouvala, U. Damrath, P. Eckert, A. Kirsanov, X. Lapillonne, J. Linkowska, C. Marsigli, A. Montani, A. Muraviev, E. Oberto, M.S. Tesini, N. Vela, A. Wyszogrodzki, M. Zaichenko, A. Walser (2019):
The COSMO Priority Project INSPECT Final Report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_37

No. 38: G. Rivin, I. Rozinkina, E. Astakhova, A. Montani, J-M. Bettems, D. Alferov, D. Blinov, P. Eckert, A. Euripides, J. Helmert, M.Shatunova (2019):
The COSMO Priority Project CORSO-A Final Report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_38

No. 39: C. Marsigli, D. Alferov, E. Astakhova, G. Duniec, D. Gayfulin, C. Gebhardt, W. Interewicz, N. Loglisci, F. Marcucci, A. Mazur, A. Montani, M. Tsyrulnikov, A. Walser

(2019):
Studying perturbations for the representation of modeling uncertainties in Ensemble development (SPRED Priority Project): Final Report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_39

No. 40: E. Bucchignani, P. Mercogliano, V. Garbero, M. Milelli, M. Varentsov, I. Rozinkina, G. Rivin, D. Blinov, A. Kirsanov, H. Wouters, J.-P. Schulz, U. Schättler (2019):
Analysis and Evaluation of TERRA_URB Scheme: PT AEVUS Final Report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_40

No. 41: X. Lapillonne, O. Fuhrer (2020):
Performance On Massively Parallel Architectures (POMPA): Final report.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_41

No. 42: E. Avgoustoglou, A. Voudouri, I Carmona, E. Bucchignani, Y. Levy, J. -M. Bettems (2020):
A methodology towards the hierarchy of COSMO parameter calibration tests via the domain sensitivity over the Mediterranean area.
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_42

No. 43: H. Muskatel, U. Blahak, P. Khain, A. Shtivelman, M. Raschendorfer, M. Kohler, D. Rieger, O. Fuhrer, X. Lapillonne, G. Rivin, N. Chubarova, M. Shatunova, A. Poliukhov, A. Kirsanov, T. Andreadis, S. Gruber (2021):
The COSMO Priority Project $T^2(RC)^2$: Testing and Tuning of Revised Cloud Radiation Coupling, Final Report
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_43

No. 44: M. Baldauf, D. Wojcik, F. Prill, D. Reinert, R. Dumitrache, A. Iriza, G. deMorsier, M. Shatunova, G. Zaengl, U. Schaettler (2021):
The COSMO Priority Project CDIC: Comparison of the dynamical cores of ICON and COSMO, Final Report
DOI: 10.5676/DWD_pub/nwv/cosmo-tr_44

No. 45 Marsigli C., Astakhova E. Duniec G., Fuezer L., Gayfulin D., Gebhardt C., Golino R., Heppelmann T., Interewicz W., Marcucci F., Mazur A., Sprengel M., Tsyrulnikov M., Walser A. (2022):
The COSMO Priority Project APSU: Final Report.

No. 46 A. Iriza-Burca, F. Gofa, D. Boucouvala, T. Andreadis, J. Linkowska, P. Khain, A. Shtivelman, F. Batignani, A. Pauling, A. Kirsanov, T. Gastaldo, B. Maco, M. Bogdan, F. Fundel (2022):
The COSMO Priority Project CARMA: Common Area with Rfdbk/MEC Application Final Report.

No. 47 A. Voudouri, E. Avgoustoglou, Y. Levy, I. Carmona, E. Bucchignani, J. M. Bettems (2022):
Calibration of COSMO Model, Priority Project CALMO-MAX: Final Report.

No. 48 D. Rieger et al. (2022):
The Priority Project C2I, Transition of COSMO to ICON - Final Report.

No. 49 E. Churiulin, M. Toelle, V. Kopeikin, M. Uebel, J. Helmert and J.-M. Bettems (2022):
The COSMO Priority Task VAINT: Vegetation Atmosphere INTeractions Report.

No. 50 F. Gofa, A. Bundel, M. S. Tesini, C. Marsigli, M. Hoff, D. Boucouvala, A. Mazur, J. Linkowska, G. Duniec, D. Cattani, B. Pasquier, A. Muraviev, E. Tatarinovich, Y. Khlestova, D. Zakharchenko (2023):
The COSMO Priority Project AWARE: Appraisal of "Challenging WeAther" FoREcasts Final Report.

No. 51 E. Russo, B. Geyer, R. Petrik, K. Keuler, M. Adinol, H. Feldmann, K. Goergen, A. Kerkweg, P. Khain, P. Ludwig, M. Mertens, P. Pothapakula, M. Raffa, B. Rockel, J.-P. Schulz, M. Sulis, H. Thi Minh Ho-Hagemann, H. Truhetz, L. Uzan, U. Voggenberger, C. Steger (2024):
CLM Community WG EVAL, COordinated PArameter Testing project 2 (COPAT2): COSMO-CLM 6.0 clm1 recommended model configuration.

No. 52 D. Boucouvala, J. Linkowska, J. Gehring, V. Garbero, A. Vocino E. Brainin, R. Dumitrache, A. Canessa (2025):
The COSMO priority Project ICON-COMFORT: (COMpetence in FORecasTing).

No. 53 H. Muskatel, D. Rieger, P. Khain, G. Zaengl, U. Blahak, M. Ahlgrimm, A. de Lozar, M. Koehler, Y. Levi, E. Avgoustoglou, K. Shpund, A. Seifert, D. Reinert, U. Schaettler, A. Givati, A. Khain (2026):
The COSMO Priority Project CAIIR: Clouds and Aerosols Improvements in ICON Radiation Scheme Final Report).

COSMO Technical Reports

Issues of the COSMO Technical Reports series are published by the *COnsortium for Small-scale MOdelling* at non-regular intervals. COSMO is a European group for numerical weather prediction with participating meteorological services from Germany (DWD, AWGeophys), Greece (HNMS), Italy (USAM, ARPA-SIMC, ARPA Piemonte), Switzerland (MeteoSwiss), Poland (IMGW), Romania (NMA) and Russia (RHM). The general goal is to develop, improve and maintain a non-hydrostatic limited area modelling system to be used for both operational and research applications by the members of COSMO. This system is initially based on the COSMO-Model (previously known as LM) of DWD with its corresponding data assimilation system.

The Technical Reports are intended

- for scientific contributions and a documentation of research activities,
- to present and discuss results obtained from the model system,
- to present and discuss verification results and interpretation methods,
- for a documentation of technical changes to the model system,
- to give an overview of new components of the model system.

The purpose of these reports is to communicate results, changes and progress related to the LM model system relatively fast within the COSMO consortium, and also to inform other NWP groups on our current research activities. In this way the discussion on a specific topic can be stimulated at an early stage. In order to publish a report very soon after the completion of the manuscript, we have decided to omit a thorough reviewing procedure and only a rough check is done by the editors and a third reviewer. We apologize for typographical and other errors or inconsistencies which may still be present.

At present, the Technical Reports are available for download from the COSMO web site (www.cosmo-model.org). If required, the member meteorological centres can produce hard-copies by their own for distribution within their service. All members of the consortium will be informed about new issues by email.

For any comments and questions, please contact the editor:

Massimo Milelli

massimo.milelli@cimafoundation.org