SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2026……
Project Title:	Coupled climate simulations using the ICON model ……
Computer Project Account:	SPDEKHAI……
Principal Investigator(s):	Pavel Khain…… ……
Affiliation:	Israel Meteorological Service ……
Name of ECMWF scientist(s) collaborating to the project (if applicable)	…… ……
Start date of the project:	1.1.2024……
Expected end date:	31.12.2026……

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)	303M	301.4M	233M	45.9M
Data storage capacity	(Gbytes)	630,000	300,000	630,000	100,000

Summary of project objectives (10 lines max)

Generally, the project goal is to advance climate-modelling focusing on coupled atmosphere-ocean simulations. The main objectives are: (1) Performing climate uncoupled simulations for the years 1980-2100 using the ICON model at a resolution of 12 km over the Mediterranean region and at a resolution of 2.5 km over the East Mediterranean; (2) Performing a 1000-year global simulation with ICON-Seamless (coupled configuration) with a horizontal resolution of about 80 km in the atmosphere and 40 km in the ocean; (3) Performing several research simulations on past periods of the ICON/NEMO coupled system with the aim of calibrating and adapting it to future coupled climate runs, both for the Mediterranean and European setups.

Summary of problems encountered (10 lines max)

During the first 2.5 years of the project (2024-2026) we have made a significant progress. In relation to objective (1), we have performed climate uncoupled simulations for the years 1980-2100 using the ICON model at resolutions of 12 km over the Mediterranean and South-East Europe region and 2.5 km over the East Mediterranean. Although the simulations were beneficial, we encountered minor problems both technical and scientific. The technical ones were related to rare bugs in ICON output when running the model on ATOS using the intel compiler with Open-MP. The scientific ones were related to rare unphysically strong precipitation values in specific grid points in local convective situations. After significant effort, we were able to solve these two problems, and performed the simulations again. This time the results were highly beneficial, and allowed us to perform a comprehensive analysis of the climate projection over the East Mediterranean, which was highly valuable for decisions related to prevention and adaptation at governmental and private sectors. In relation to objective (3), we encountered technical difficulties to couple ICON to NEMO-MED ocean model. Although we got significant support from MEDCORDEX community, the coupled model was crashing due to numerical instability near the strait of Gibraltar. Therefore, with the help of DWD colleagues, we are now working on coupling ICON to a different ocean model, ICON-O, over the Mediterranean.

Summary of plans for the continuation of the project (10 lines max)

The plans remained similar. In relation to objective (1), during the last half year of the project, we plan to perform a climate run (scenario ssp245) with 12km and 2.5km resolutions, driven by MPI-ESM-HR. In parallel, we plan to continue the work on ICON - ICON-O regional coupling, aiming to reproduce the historical evolution correctly, both in the atmosphere and the sea.

List of publications/reports from the project with complete references

1. Geyer, B., Campanale, A., Churiulin, E., Feldmann, H., Goergen, K., Hagemann, S., Ho-Hagemann, H. T. M., Karadan, M. M., Keuler, K., Khain, P., Lawand, D., Ludwig, P., Maurer, V., Petrov, S., Poll, S., Purr, C., Russo, E., Schubert-Frisius, M., Schulz, J.-P., Singh, S., Steger, C., Truhetz, H., and Will, A. (2026). Optimisation of ICON-CLM for the EURO-CORDEX domain: developments, sensitivities, tuning, Geosci. Model Dev., 19, 5439–5490, https://doi.org/10.5194/gmd-19-5439-2026, 2026.
2. P. Khain, A. Givati, Bughici T., Y. Levi, A. Zipori and Y. Yosef: “Simulating climate with ICON model at high resolution”, Annual Conference for Science and the Environment 2026, Jerusalem, Israel.
3. P. Khain, A. Givati, Bughici T., Y. Levi: “Climate modelling at high resolution”, Weizmann Institute of Science, 11.12.2025.
4. Bughici T., P. Khain, Y. Levi and A. Givati: “Sensitivity of Near-Surface Temperature Trends in ICON-CLM to Soil Parameterization over the Eastern Mediterranean”, ICCARUS 2026, DWD Headquarters in Offenbach, Germany.
5. Uzan, L., E. Vadislavsky, P. Khain, M. Cohen, I. Carmona and Y. Levi “Calibration of ICON-CLM in the East Mediterranean region”, the ICCARUS (4-8.3.2024), DWD Headquarters in Offenbach, Germany.
6. Vadislavsky E. and P. Khain: “Coupling ICON-CLM to NEMO-MED over the Mediterranean”, the ICCARUS (4-8.3.2024), DWD Headquarters in Offenbach, Germany.
7. Vadislavsky E., P. Khain, L. Uzan, Y. Levi and A. Givati: “Coupling ICON-LAM to NEMO-MED at IMS”, the 8th Med-CORDEX workshop (14-16.5.2024), Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) in Rome, Italy.
8. Uzan, L., Vadislavsky, E., Carmona, I., Khain, P., Cohen, M., Chalfine, L., and Naor, R. (2023). Climate model calibration and simulations plan: status report for the Climate Center Committee, Report No. 1. Israel Meteorological Service.
9. Uzan, L., Vadislavsky, E., Carmona, I., Muskatel, H., Levy, Y., Khain, P., Cohen, M., Zheleznov, A., Chalfine, L., Rosen, U., and Naor, R. (2024). Climate model calibration and simulations plan: status report for the Climate Center Committee, Report No. 2. Israel Meteorological Service.

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

During the last year (30.6.2025-30.6.2026) we have focused on three topics: (1) Solving technical problem related to rare bugs in ICON output when running the model on ATOS using the intel compiler with Open-MP, and a scientific problem related to rare unphysically strong precipitation values in specific grid points in local convective situations; (2) Performing corrected climate uncoupled SSP5-8.5 projections for the years 1980-2100 using the ICON model at resolutions of 12 km over the Mediterranean and South-East Europe region and 2.5 km over the East Mediterranean driven by MPI-ESM-HR and ECEARTH3-VEG GCMs, analyse the results and publish climatological reports; and (3) With the help of DWD colleagues, we are trying to implement ICON coupling with ICON-O ocean model on ATOS, first in global (default) and the in regional configuration. The plan here remained unchanged, i.e. performing several research simulations on past periods of the ICON/ICON-O coupled system with the aim of calibrating and adapting it to future coupled climate runs for the Mediterranean setup.

Below we describe several results related to the second topic mentioned above, namely the results of the tuned 1980-2100 climate simulations using 2.5 km resolution (driven by 12 km resolution). The simulations performance analysis was performed by our colleagues Dr. Yitzhak Yosef (IMS), Dr. Theodor Bughici (IMS), Dr. Assaf Zipori (IMS) and Dr. Noam Halfon (IMS), and led by IMS director Dr Amir Givati.

One of the main goals of the previous simulations was to tune ICON in order to increase the frequency of weak and moderate precipitation while reducing the overestimation of very intense precipitation events. After a comprehensive analysis, we significantly reduced the intercept parameter of the raindrop size distribution, resulting in an increase in light and moderate precipitation. At the same time, we increased the supersaturation remainder in the saturation adjustment under conditions of strong updrafts, which substantially reduced the overestimation of precipitation during intense convective events.

The spatial distribution of the multi-year mean precipitation is shown in Figure 1. This analysis indicates that the tuned ICON 2.5km-resolution simulation nicely reproduces the annual precipitation over Israel. Particularly, it improves the coastal precipitation mechanisms and reproduces the enhancement of precipitation over the inner coastal plain. However, the sharp southward precipitation gradient remains too weak, the orographic enhancement is underestimated, and the rain-shadow effect is only weakly represented. Furthermore, ICON exhibits a slight overestimation over both arid and non-arid regions.

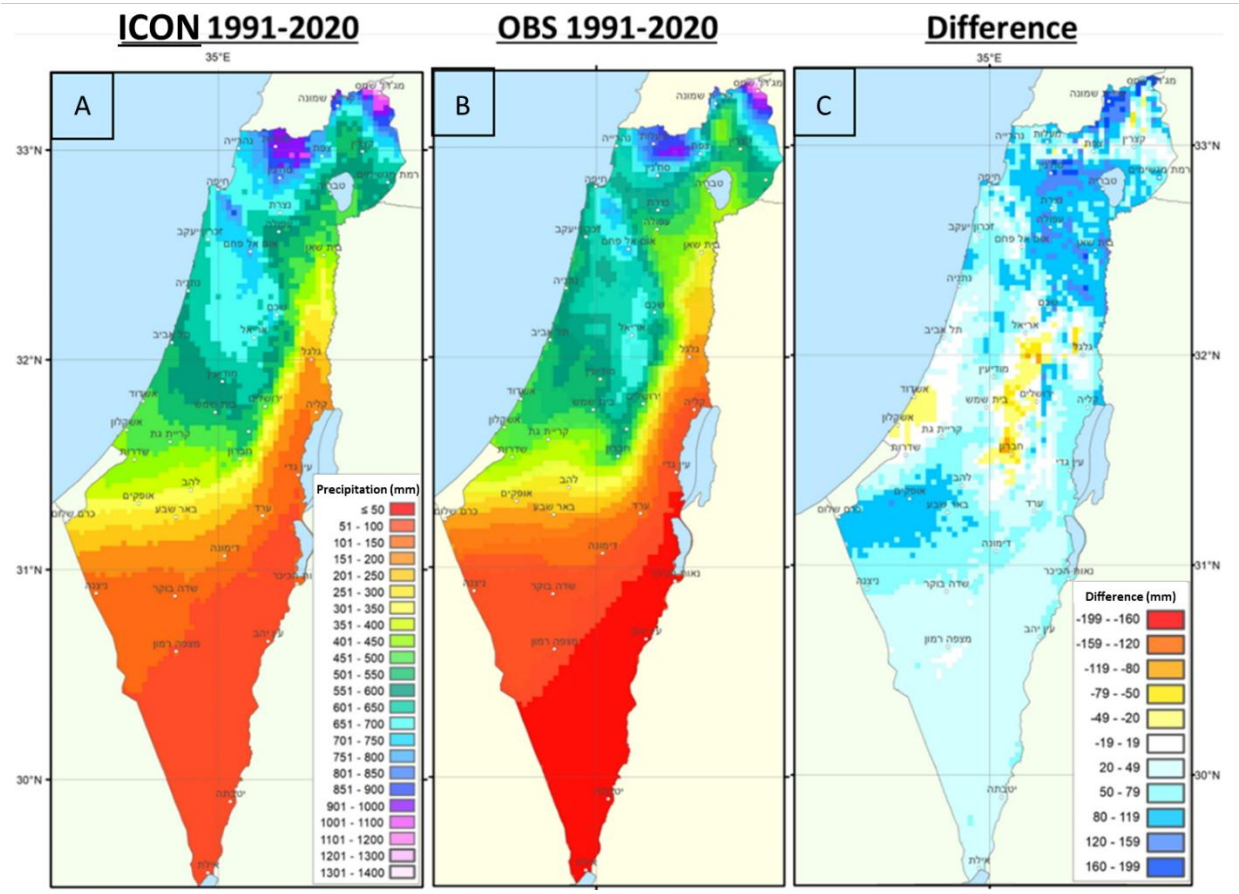

Fig 1. Annual mean (over 1980-2020) precipitation in (A) ICON 2.5km driven by ICON 12km driven by MPI-ESM-HR tuned 1-moment scheme, (B) same in observations (rain gauges), and (C) difference model minus observations.

The most significant improvement in the tuned 2.5 km ICON configuration was in the representation of precipitation intensities. Figure 2 shows 10-minutes precipitation intensity return periods at various stations. At each station, the return periods were calculated after the highest 10-minutes event was identified or each year, and the distribution of yearly peaks was constructed. One can see that precipitation intensities in ICON 2.5km after tuning (green) match the observations (black), significantly improving previous results (blue).

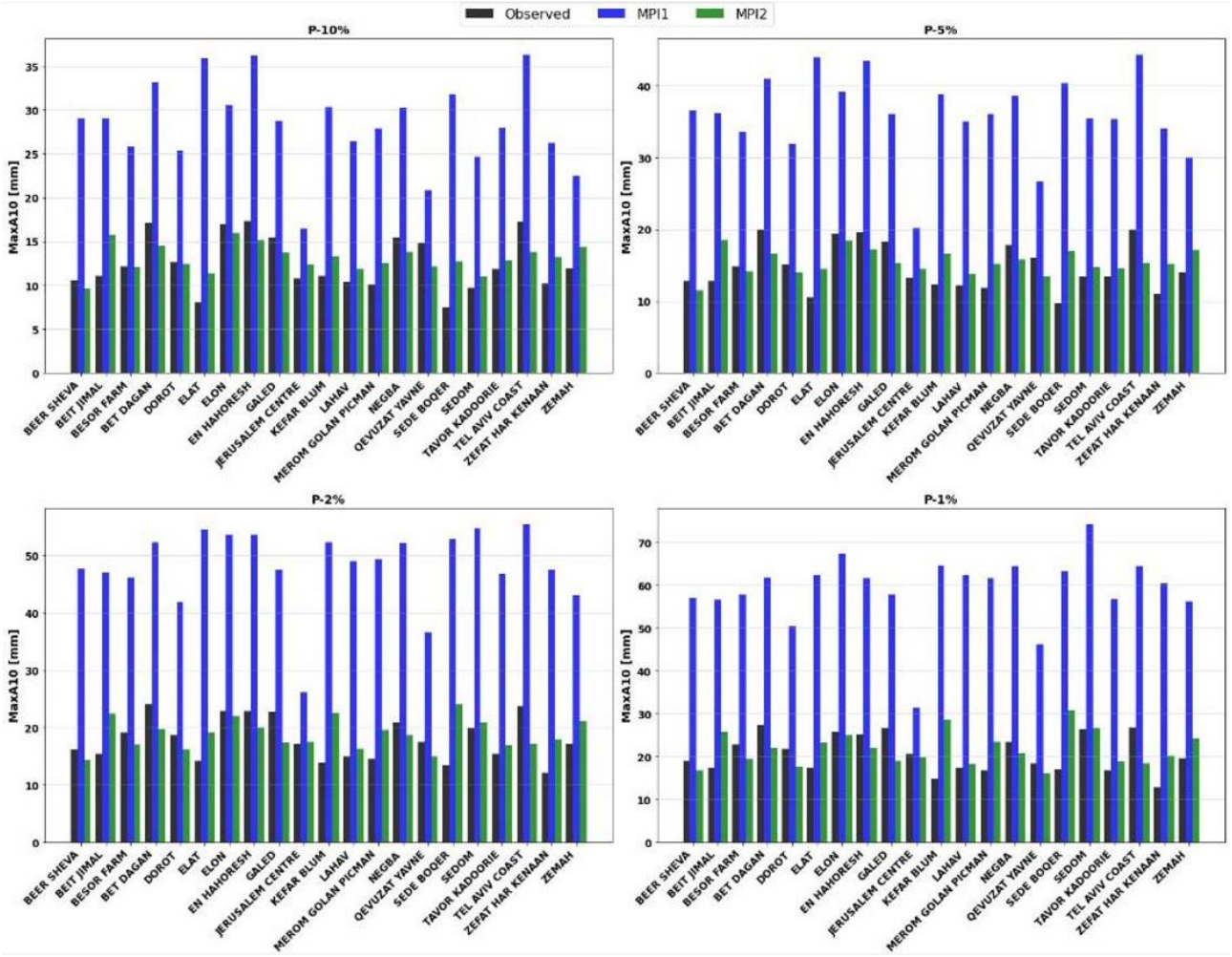

Fig 2. 10-minutes precipitation intensity return periods at various stations: one event per 10 years (upper left), one event per 20 years (upper right), one event per 50 years (lower left), one event per 100 years (lower right). Precipitation intensities in observations are in black, in ICON 2.5km previous version (before tuning) are in blue, and ICON 2.5km new version (after tuning) are in green.

Additional results and reports are available on IMS website https://ims.gov.il/en/node/230.

During the last half year of the project, the goal is to perform a climate run (scenario ssp245) with 12km and 2.5km resolutions, driven by MPI-ESM-HR. In parallel, we plan to continue the work on ICON - ICON-O regional coupling, aiming to reproduce the historical evolution correctly, both in the atmosphere and the sea.