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Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss
Numerical Prediction

ICON Info

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Improved precipitation, radiation, and temperature

Die Zusammenfassung auf Deutsch finden Sie auf Seite 2. / Le résumé en français se trouve à la page 3.

Summary

MeteoSwiss will introduce changes to the following components of its operational ICON model system: **ICON-CH1-EPS, ICON-CH2-EPS and KENDA-CH1.** The changes are planned for first quarter of 2026, the exact date will be announced in due time.

These changes address **known biases in precipitation, radiation, and temperature, and improve the handling of observational data.**

Users can expect the following changes to data quality:

- Reduced overestimation of very localised high precipitation rates in summer. – However, please note that although the new configuration reduces the local overestimation of high precipitation intensities, it does not substantially reduce the mean precipitation amounts over larger regions. Therefore, it will not significantly improve the overestimation of events such as, e.g., the warning level 4/5 event in late August 2025.
- More realistic radiation and sunshine duration in valleys.
- Improved temperature and humidity forecasts, particularly at night in valleys.
- Improved use of observations in data assimilation.

Users need to be aware of the following technical impacts of the changes:

- User actions required:
  - Take note that the definition of sunshine duration (DURSUN) will be updated.
- Optional user actions:
  - None.

Other technical changes

- Bug fix in the post-processing tool to interpolate to the Swiss coordinate system

For more details on the changes to the ICON model system and their impact on data quality, please refer to the relevant sections on pages 4 ff.

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Zusammenfassung

MeteoSchweiz wird Änderungen an den folgenden Komponenten seines operationellen ICON-Modellsystems einführen: **ICON-CH1-EPS, ICON-CH2-EPS und KENDA-CH1.** Die Änderungen sind für das erste Quartal 2026 vorgesehen, das genaue Datum wird zu gegebener Zeit bekannt gegeben.

Diese Änderungen verbessern **bekannte Schwächen bei Niederschlag, Strahlung und Temperatur und optimieren die Verarbeitung von Beobachtungsdaten.**

Die Nutzer können hinsichtlich der Datenqualität folgende Änderungen erwarten:

– Reduzierte Überschätzung sehr lokaler hoher Niederschlagsraten im Sommer. – Bitte beachten Sie jedoch, dass die neue Konfiguration zwar die lokale Überschätzung hoher Niederschlagsintensitäten reduziert, jedoch keine wesentliche Verringerung der mittleren Niederschlagsmengen über grössere Regionen bewirkt. Daher wird sie die Überschätzung von Ereignissen, wie beispielsweise dem Ereignis der Warnstufe 4/5 Ende August 2025, nicht wesentlich verringern.
– Realistischere Strahlung und Sonnenscheindauer in den Tälern.
– Verbesserte Temperatur- und Feuchtigkeitsvorhersagen, insbesondere nachts in Tälern.
– Verbesserte Nutzung von Beobachtungen in der Datenassimilation.

Die Nutzer müssen folgende technische Auswirkungen der Änderungen beachten:

– Erforderliche Massnahmen:
  – Beachten Sie, dass die Definition der Sonnenscheindauer (DURSUN) aktualisiert wird.
– Optionale Massnahmen:
  – Keine.

Weitere technische Änderungen

– Fehlerbehebung im Nachbearbeitungstool zur Interpolation auf das Schweizer Koordinatensystem

Weitere Einzelheiten zu den Änderungen am ICON-Modellsystem und deren Auswirkungen auf die Datenqualität finden Sie in den entsprechenden Abschnitten ab Seite 4.

Résumé

MétéoSuisse introduira des modifications dans les composants suivants de son système opérationnel ICON : **ICON-CH1-EPS, ICON-CH2-EPS et KENDA-CH1**. Les modifications sont prévues pour le premier trimestre 2026, la date exacte sera communiquée en temps utile.

Ces modifications permettront de corriger **des biais connus en matière de précipitations, de rayonnement et de température et améliorent le traitement des données d'observation.**

Les utilisateurs peuvent s'attendre aux changements de qualité de données suivants :

- Réduction de la surestimation des de précipitations élevées très localisées en été. – Toutefois, veuillez noter que, bien que la nouvelle configuration réduise la surestimation locale des intensités de précipitations élevées, elle ne réduit pas de manière substantielle les quantités moyennes de précipitations dans des régions plus vastes. Elle n'améliorera donc pas de manière significative la surestimation d'événements tels que, par exemple, l'événement de niveau d'alerte 4/5 survenu fin août 2025.
- Rayonnement et durée d'ensoleillement plus réalistes dans les vallées.
- Amélioration des prévisions de température et d'humidité, en particulier la nuit dans les vallées.
- Utilisation affinée des observations dans l'assimilation des données.

Les utilisateurs doivent tenir compte des conséquences techniques suivantes :

- Actions requises :
  - Veuillez noter que la définition de la durée d'ensoleillement (DURSUN) sera mise à jour.
- Actions facultatives :
  - Aucune.

Autres modifications techniques

- Correction d'un bug dans l'outil de post-traitement permettant l'interpolation vers le système de coordonnées suisse

Pour plus de détails sur les changements apportés au système de modélisation ICON et leur impact sur la qualité des données, veuillez-vous reporter aux sections correspondantes à partir de la page 4.

In detail: Changes and their impact on data quality

The figures can be found at the end of the document.

Calibration of the single-moment cloud microphysics scheme to reduce local overestimation of high precipitation intensities

The currently operational versions of ICON-CH1-EPS and ICON-CH2-EPS overestimate the frequency of high-intensity precipitation (precipitation > 5 mm/h) events, in particular during convective situations. To address this issue, the following changes will be introduced:

- The saturation adjustment scheme now accounts for the supersaturation occurring in convective updrafts. In the new model formulation, the permitted supersaturation increases linearly with local updraft velocity, allowing 1% supersaturation for every 2 m/s of updraft speed. Additionally, the maximum supersaturation is constrained by the ratio of cloud liquid water to specific humidity (QC / QV), ensuring that initial cloud formation still occurs at saturation.
- Currently the assumed drop size distribution (DSD) for rain is calibrated towards larger droplets to prevent excessive below-cloud evaporation of light rain. After the update, the shape of the DSD will depend on the local specific rainwater content (QR), and the shift in DSD will only be applied for light-to-moderate QR.
- The efficiency of the snow-to-graupel conversion by riming is reduced.
- The terminal fall velocity of snow is slightly reduced.

The changes outlined above substantially reduce local convective maxima in rain showers and thunderstorms. Snapshots of ICON-CH1-EPS and ICON-CH2-EPS forecasts illustrate this change (Fig. 1). Surface verification with SwissMetNet stations over an extended convective period demonstrates that the frequency bias for precipitation exceeding 5 mm/h is reduced, although high-intensity events are still overestimated (Fig. 2). Please note that measurements of high precipitation events using pluviometers are associated with considerable uncertainty.

The changes in the cloud microphysics calibration will lead to a slight deterioration in the prediction of intense winter precipitation (> 5 mm/h), particularly in cases where it was already underestimated by the previous configuration (not shown). Finally, note that although the new configuration reduces local overestimation of high precipitation intensities, it does *not* lead to a systematic and strong reduction of the mean precipitation amounts over larger regions (e.g., large-scale river catchments). However, experiments indicate that the ensemble spread of convective precipitation in summer is slightly reduced (not shown).

Activation of slope correction and shading of shortwave radiation by terrain

In mountainous terrain, the surface energy balance is strongly influenced by the local and surrounding topography. In the ICON model, the grid cells at the surface are oriented tangential to the Earth's sphere, and the employed radiation scheme only accounts for vertical fluxes within atmospheric columns. As a result, topographic influences on the surface energy balance must be additionally parameterized. However, until now, the operational model configuration did not consider how terrain features act on the surface radiative balance, resulting in an overestimation of global radiation and sunshine duration in Alpine valleys. With the new release, a correction will be activated that incorporates the slope dependency of direct-beam shortwave radiation (*slope correction*) and the shading effect from nearby mountains (*orographic shading*).

The change significantly reduces the overestimation of global radiation and sunshine duration in Alpine valleys, as shown in the surface verification (Fig. 3). The reduction in the bias is most substantial in winter, and evident across all seasons (not shown). Additionally, the standard deviation of the error for both global radiation and sunshine duration is reduced, which indicates a reduction in the spatiotemporal error structure of the model. Furthermore, the daytime warm bias in Alpine valleys during winter is also reduced (Fig. 4a). Other regions, particularly the Swiss Plateau, are virtually unaffected by this change.

Please note that the definitions of existing output fields for surface radiative fluxes do *not* change. That is made possible since the corrections to the direct-beam shortwave radiation at the surface are only applied after the respective variables have been saved for output. Output fields that include orographic shading correction, but exclude slope correction, may be provided in the future depending on demand. Unlike the current output fields for surface radiative fluxes, the sunshine duration diagnostic in the ICON model and its corresponding output field (DURSUN) will be affected by this change.

Reduction of vertical turbulent mixing over sloped terrain

Currently, ICON-CH1-EPS and ICON-CH2-EPS exhibit a distinct near-surface warm bias in Alpine valleys, especially at night and during the colder months. To mitigate this warm bias, a new option is activated that reduces both the near-surface minimum vertical diffusion coefficient and the laminar transfer resistance depending on the local terrain slope. This adjustment limits vertical turbulent mixing near the surface and enhances nocturnal cooling via atmosphere-surface heat exchange (sensible cooling) over sloped terrain.

Activating this change results in a substantial reduction of the nocturnal warm bias in Alpine valleys, and a reduction in the bias of 2 m relative humidity (Fig. 4). In addition, the standard deviation of the 2 m temperature error is slightly reduced in Alpine valleys (not shown). While the new configuration also slightly improves the scores over the Swiss Plateau (now shown), a slight deterioration is found at Alpine mountain stations, where the change causes a slight increase in the already existing cold and moist bias (Fig. 5).

Various improvements in the handling of observations within the KENDA-CH1 data assimilation cycle

The following modifications are implemented in the KENDA-CH1 data assimilation cycle:

– Artificial relative humidity saturation adjustment: The threshold for setting observations values to saturation has been revised. Previously, relative humidity values above 96% were artificially set to 100%, suggesting saturation. This adjustment is removed, ensuring that only fully saturated conditions are treated as such.

– Height assignment for surface stations without pressure measurements: Surface stations that do not provide direct measurements of surface pressure are now assigned the model surface pressure at the nearest grid point. This pressure information is significantly more accurate than the previously used information deduced from the height using a standard atmosphere.

- Exclusion of high-altitude SYNOP stations: Observations from stations located above 3000 meters above sea level are now excluded from assimilation since those high-altitude measurements show increased uncertainty and variability.
- Exclusion of sub-hourly SYNOP station data: Sub-hourly observations from SYNOP stations are now discarded because they don’t provide benefit to the quality of the analysis.
- New LETKF version: A new version of the LETKF code is introduced. This updated version includes code optimizations and new developments preparing MeteoSwiss' KENDA cycle for further planned releases.

Figures:

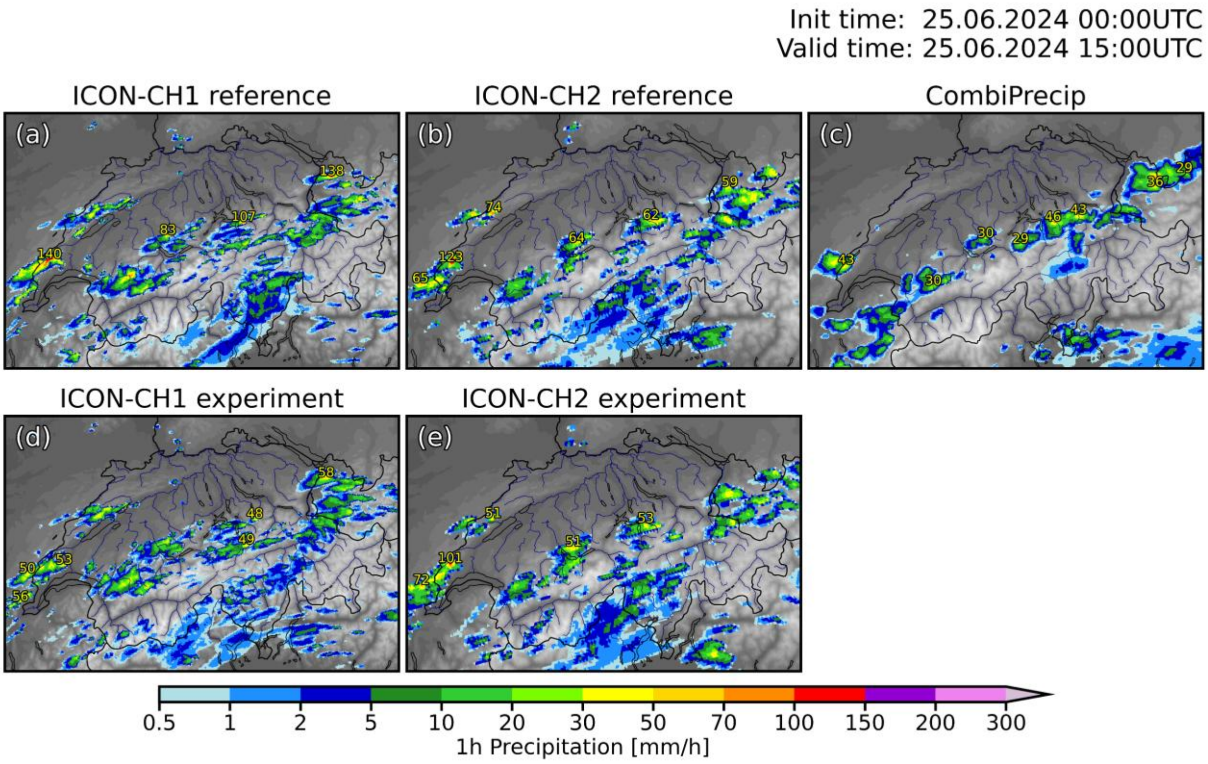

Figure 1: Snapshot of hourly precipitation from ICON-CH1-EPS and ICON-CH2-EPS control forecasts with the previous configuration (a, b) in comparison to the new configuration (d, e) and the rain-gauge corrected radar product CombiPrecip (c). The values of local maxima are indicated with yellow numbers.

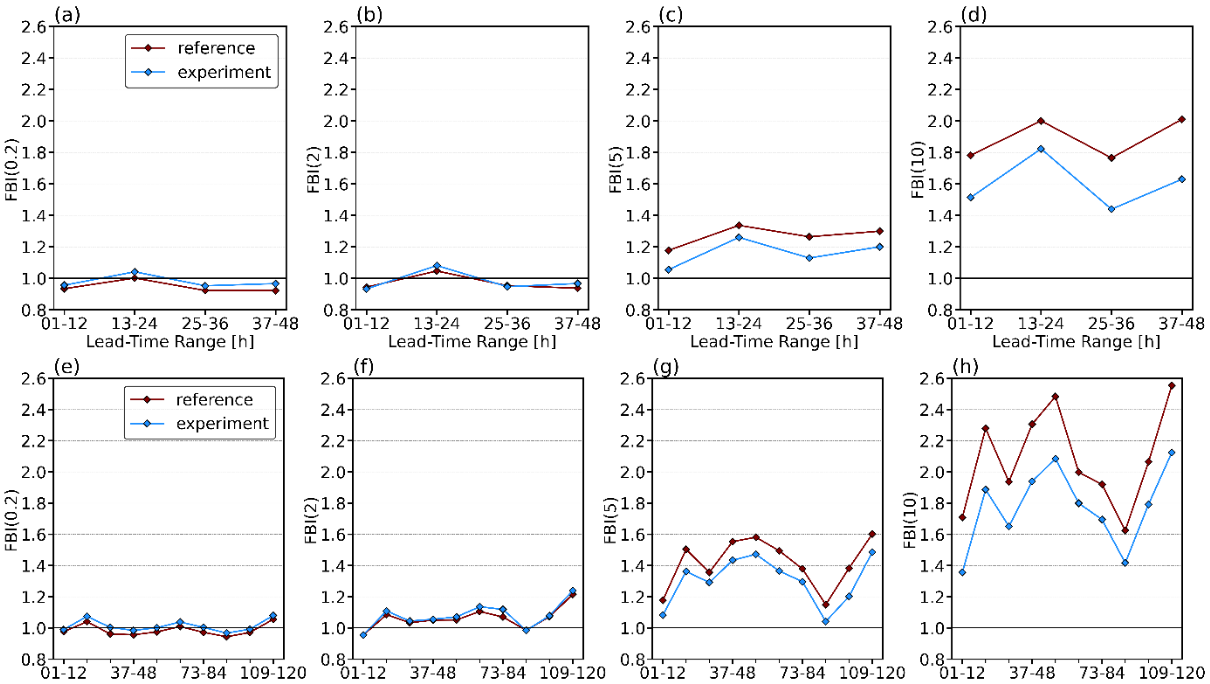

Figure 2: Frequency-bias (FBI) of hourly precipitation across a range of intensity thresholds (0.2, 2, 5, and 10 mm/h) computed at 156 SwissMetNet stations in Switzerland. The FBI is shown as a function of lead time for the reference run (red) and the experiment with the new configuration (blue). The top row (a-d) corresponds to the control run of ICON-CH1-EPS, while the bottom row (e-h) shows ICON-CH2-EPS. The verification covers the period 12.05.2024 00UTC – 15.07.2024 12UTC.

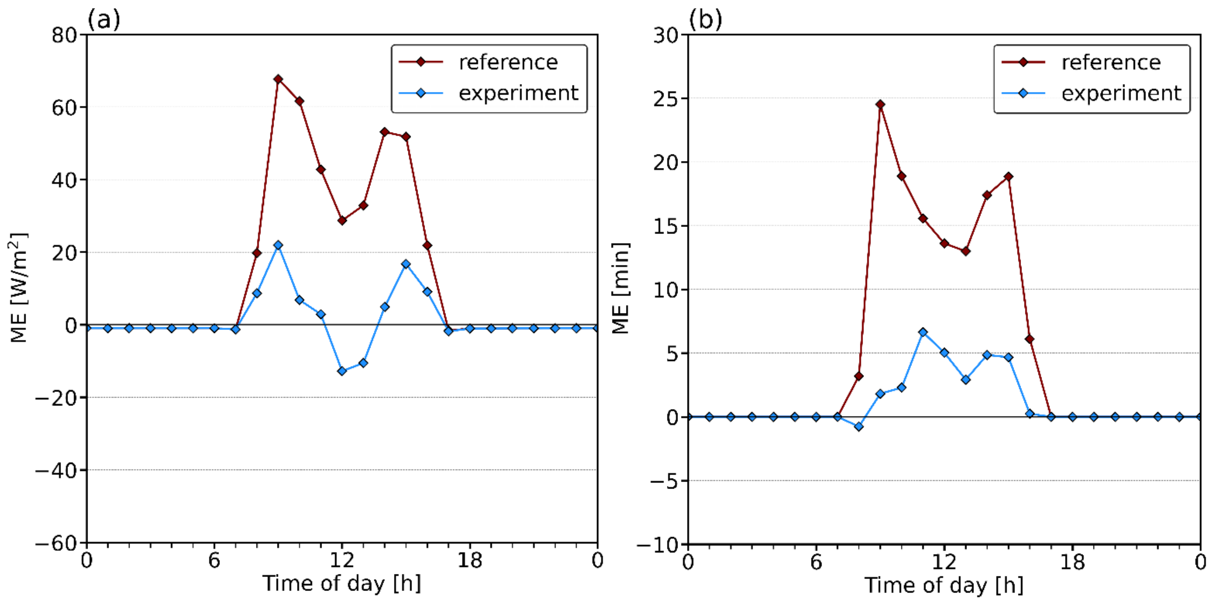

Figure 3: Diurnal cycle of mean error (ME) for global radiation (a) and sunshine duration (b) during a winter test period (19.01.2023 00 UTC – 31.01.2023 12 UTC), based on verification against 57 Alpine valley stations in Switzerland. The results compare the ICON-CH1-EPS control run from the reference setup (red) to the experiment using the new configuration that includes orographic shading (blue), for the lead-time range 13 – 24h.

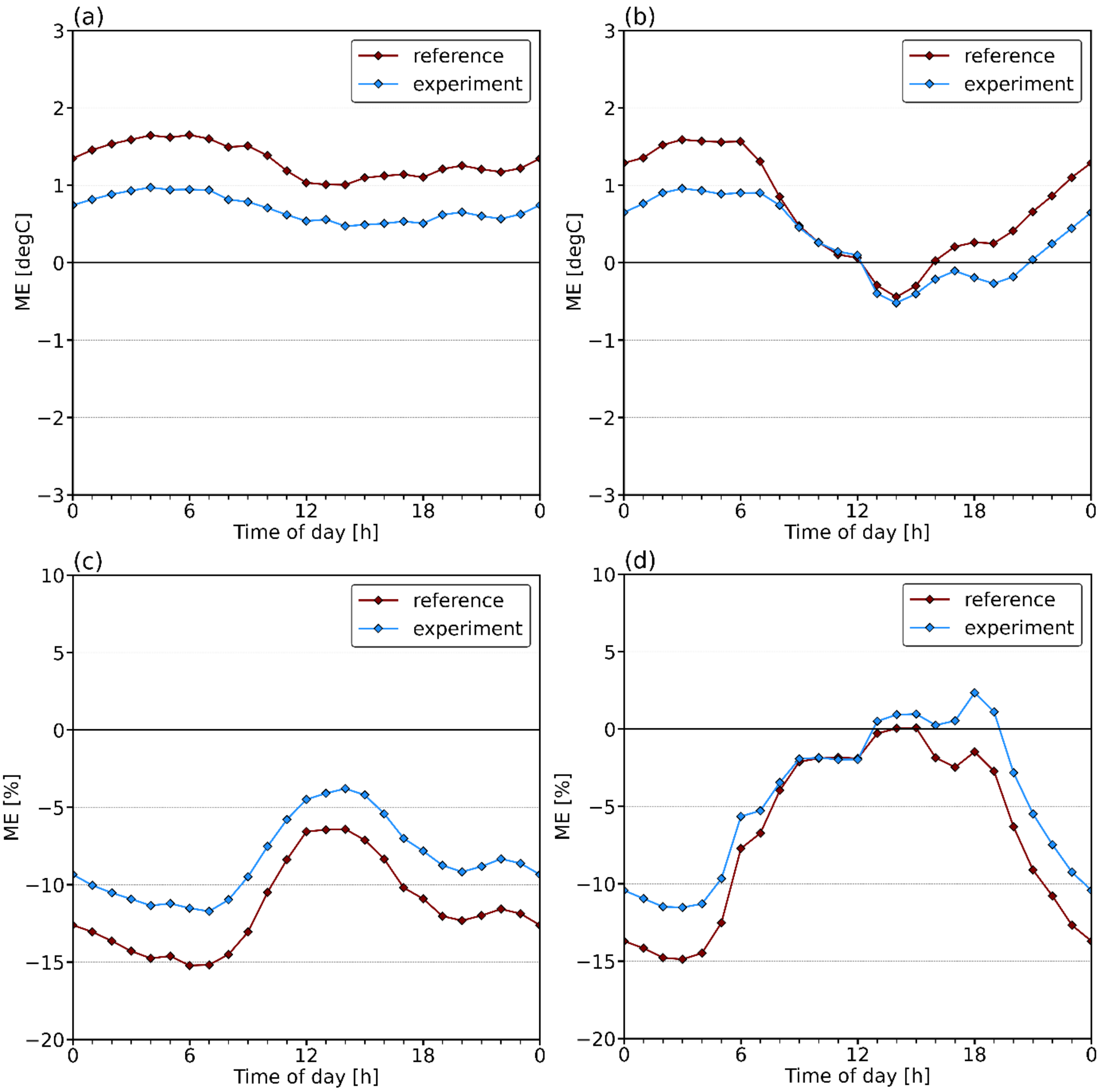

Figure 4: Diurnal cycle of mean error (ME) for 2 m temperature (a) and 2 m relative humidity (c) during a winter test period (03.01.2023 00UTC – 17.01.2023 12UTC), based on verification against 57 Alpine valley stations in Switzerland. The results compare the ICON-CH1-EPS control run from the reference setup (red) to the experiment with the new configuration (blue) for the lead-time range 13 – 24h. (b) and (d) show the same variables as (a) and (c), respectively, but for a summer test period (01.06.2024 00UTC – 14.06.2024 12UTC).

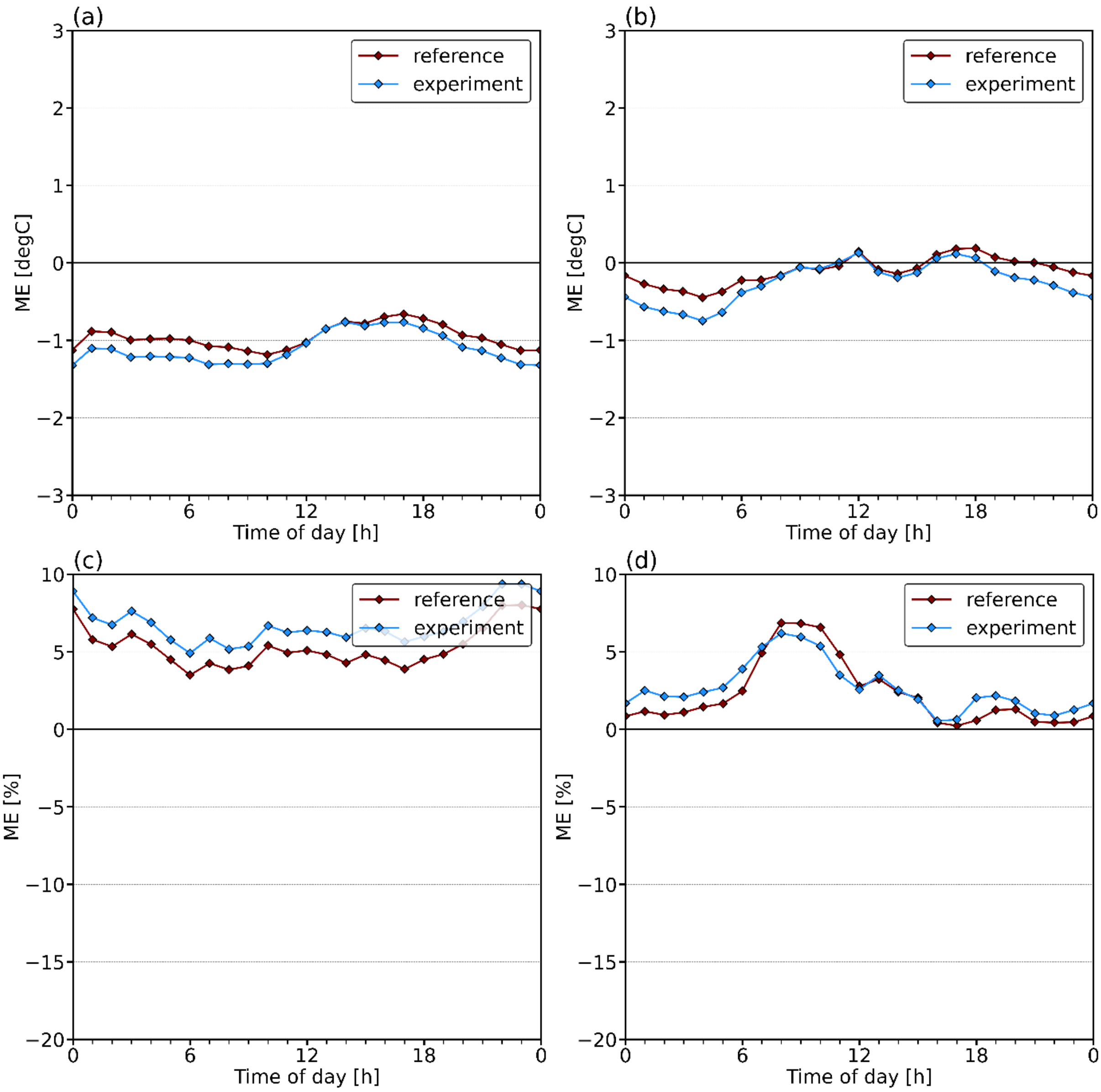

Figure 5: Same as Figure 4 but for 20 stations located on Alpine mountains in Switzerland.

Other Technical Changes

A bug was corrected in the post-processing tool to interpolate the output to the Swiss coordinate system (LV03 / LV95). Because of this change the point considered as nearest neighbour might be different as compared to the previous cycle for some locations. The effect of this change is not noticeable in the seasonal verification and is expected to be smaller compared to the effect of the meteorological changes introduced in the ICON model for all applications