1. Motivation

- Global km-scale climate models allow us to study the climate system with unprecedented local detail.
- However, there are novel challenges for data output, storage and usability of global simulations at a grid spacing of 10 km or below.
- In the course of analysing a km-scale simulation, we find ***strange wave-like patterns*** in extreme precipitation fields.

Definitely a surprise - but do they stem from too low screen resolution, a model bug or from an unexpected glitch in the data handling?

2. Simulations

- We employ a 30-year simulation of the fully coupled global climate model ICON under the high emission scenario SSP3-7.0 covering 2020 - 2049 (nextGEMS; Segura et al., 2025)
- Natively, ICON is run with a grid spacing of about 10 km on an icosahedral-triangular grid

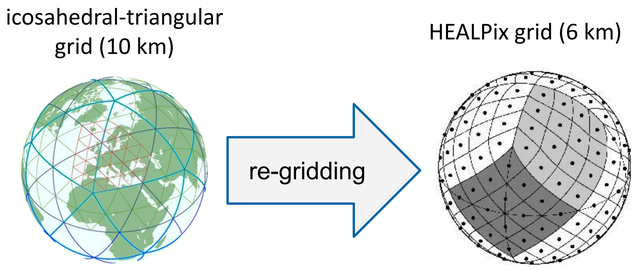

***Figure**: Schematic representation of the re-gridding process, which is implemented in the outputting procedure of the ICON workflow.*

3. Re-gridding

- Due to the immense amount of global data at 10 km resolution, the ICON simulations are stored on the so-called HEALPix grid (Górski et al., 2005) for easier handling by users.
- The HEALPix is a gridded representation of a sphere, characterized by equal area and iso-latitude. Further, it offers a hierarchy of spatial resolutions ("zoom levels") enabling easy and fast calculations on the desired resolution.
- These HEALPix resolutions are at fixed, discrete zoom levels.
- The native 10 km ICON grid is remapped via nearest neighbour to the closest finer HEALPix zoom level of about 6 km.

4. Analyzing extreme precipitation

- We analyze extreme hourly precipitation for a separate scientific study (Brunner et al., 2025).
- We calculate 10-year return levels of hourly precipitation extracting the annual maxima of the 30-year simulation at each grid cell and fitting a Generalized Extreme Value distribution.

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Output regridding can lead to Moiré pattern in km-scale global climate model data from ICON

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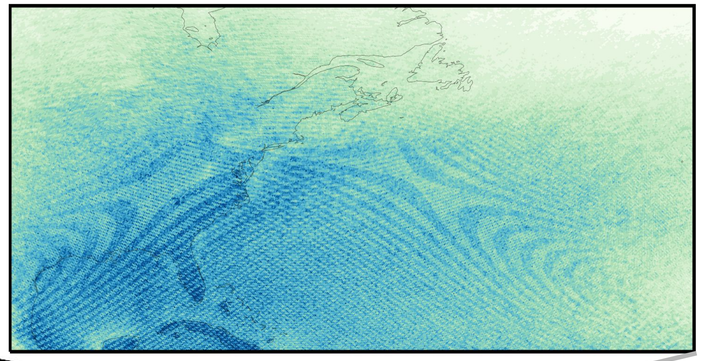
5. An unexpected re-gridding glitch

- We find **wave-like Moiré patterns** in rare precipitation extremes, such as the 10-year return level of hourly precipitation, but not in more moderate extremes such as the annual maximum daily precipitation nor in any temperature-related extremes.
- This is caused by the **interaction of the two grids** within the remapping process from the 10 km to the finer 6 km grid which we confirmed by remapping grid properties such as the cell area.
- To avoid the pattern, die ICON output could be remapped to an even higher resolved zoom level with an oversampling of at least 2. However, this would lead (at least temporarily) to a huge increase in the data volume.
  Alternatively, other (slower) remapping approaches such as conservative could be used.



Extreme hourly precipitation: 10-year return levels (mm/h)

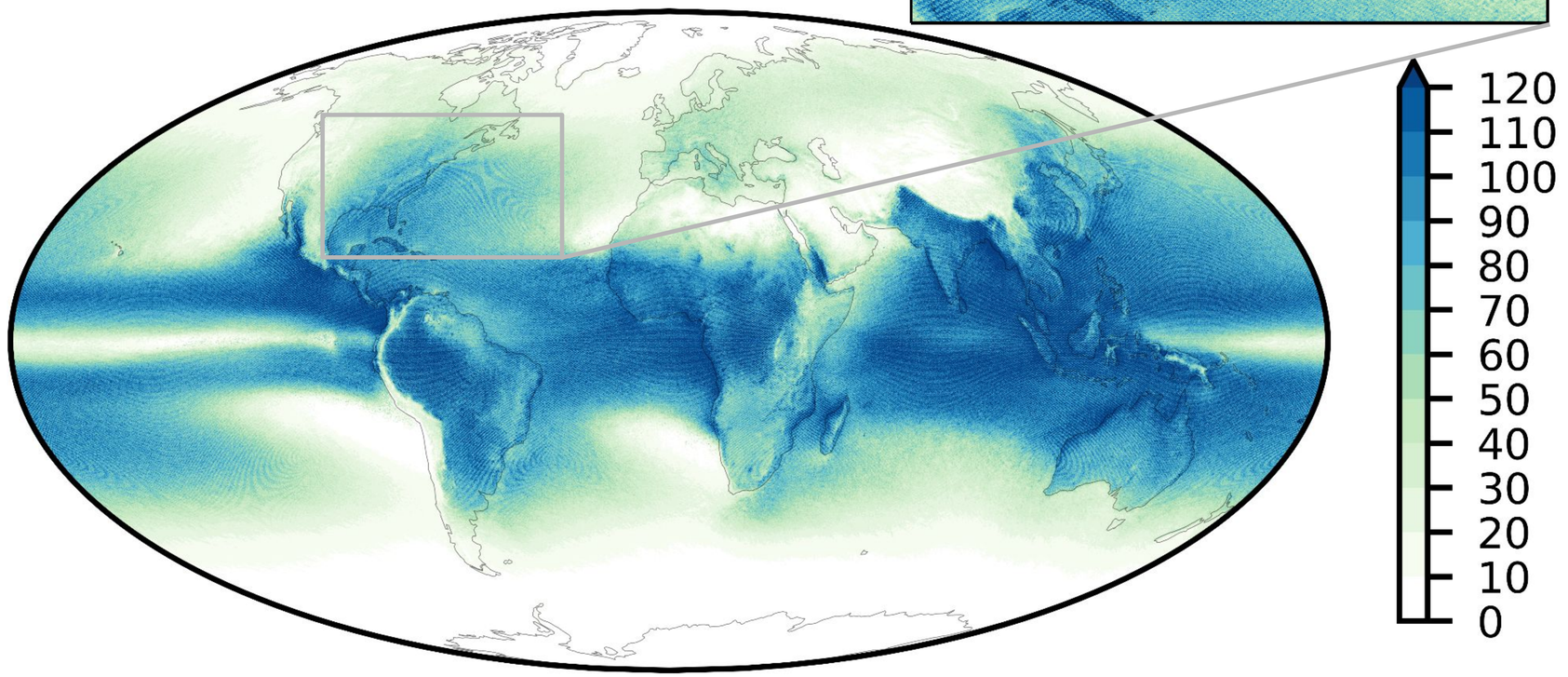


***Figure**: 10-year return levels of hourly precipitation for the ICON simulation (2020 - 2049; SSP3-7.0)*

6. References

Brunner, L., Poschlod, B., Dutra, E., Fischer, E., Martius, O., Sillmann, J. (2025, submitted): A global perspective on the spatial representation of climate extremes from km-scale models. Submitted to Environ. Res. Lett.

Gorski, K. M. et al. (2005): HEALPix—A Framework for high resolution discretization, and fast analysis of data distributed on the sphere. Astrophys. J., 622, 759–771.

Segura et al. (2025, preprint). nextGEMS: entering the era of kilometer-scale Earth system modeling, https://doi.org/10.5194/egusphere-2025-509