

Precipitation and Its Future Changes in the Greater Alpine Region: High-resolution Bias-adjusted Versus Dynamically Downscaled Datasets

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Datasets

◆ Temporal resolution: daily

Reference observational data:

- ◆ **SPARTACUS**: Austria, 1km [1]
- ◆ **RhiresD**: Switzerland, 2km [2]
- ◆ **EURO4M-APGD**: Alps, 5 km [3]
- ◆ **E-OBS**: Europe, 0.1° [4]

Model data:

- ◆ **OeKS15**: Austria, 1 km, an ensemble of 13 simulations statistically downscaled from **EURO-CORDEX** using bias adjustment (reference dataset: SPARTACUS) [5]
- ◆ **CH2018**: Switzerland, 2 km, an ensemble of 21 simulations statistically downscaled from **EURO-CORDEX** using bias adjustment (reference dataset: RhiresD) [6]
- ◆ **CORDEX-FPS**: greater Alpine region, ~3 km, an ensemble of 22 (evaluation) and 18 (historical/future; RCP8.5) dynamically downscaled, convection-permitting simulations, nested within intermediate ~12 km convection-parameterizing RCMs [7,8,9]

References

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- [5] Chimani et al., 2016: <https://doi.org/10.60669/wgxm-4927>
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- [7] Coppola et al., 2020: <https://doi.org/10.1007/s00382-018-4521-8>
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Do the **statistically downscaled, bias-adjusted models** yield results consistent with **dynamically downscaled, convection-permitting models** despite being much less complex? Does **dynamical downscaling** provide a more reliable representation of physical processes than **bias adjustment**? Do the different downscaling methods produce the same climate change signal?

Evaluation (2000-2009)

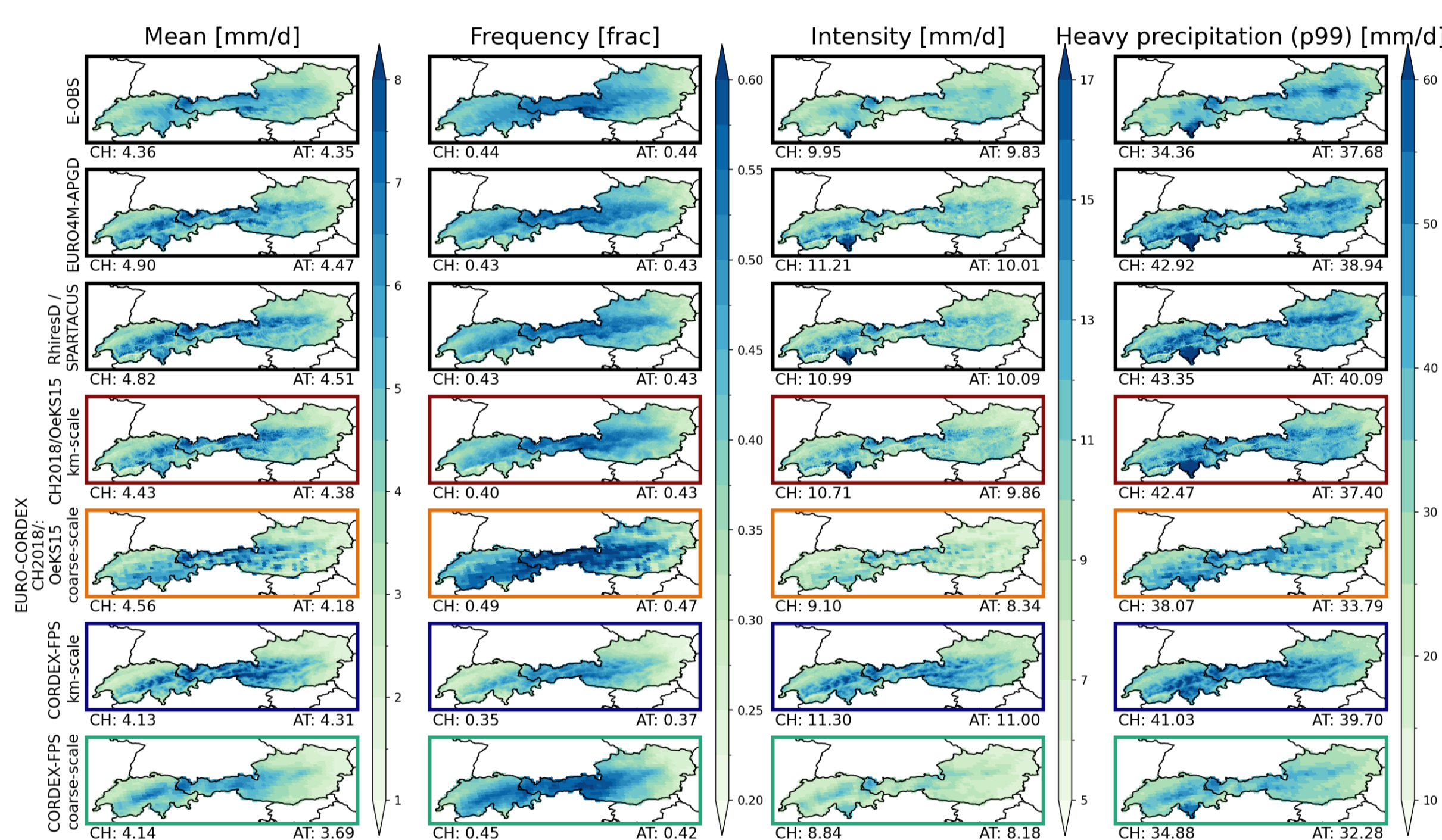


Figure 1: Summer (JJA) daily precipitation metrics of gridded observational products and medians of all model ensembles. The numbers below the axes indicate the spatial mean of the plotted precipitation fields over Switzerland and Austria. The frame colors correspond to the line color of the same datasets in other figures.

- ◆ Both types of km-scale datasets improve daily precipitation statistics with respect to coarser, convection-parameterizing models, and they produce similar spatial means over large areas
- ◆ **Dynamically downscaled models** are too wet at high elevations, overestimating all observational datasets and other model ensembles
- ◆ **Statistically downscaled, bias-adjusted datasets**, by construction, resemble their reference observational dataset. As a result they create implausibly small spread, especially at high elevations

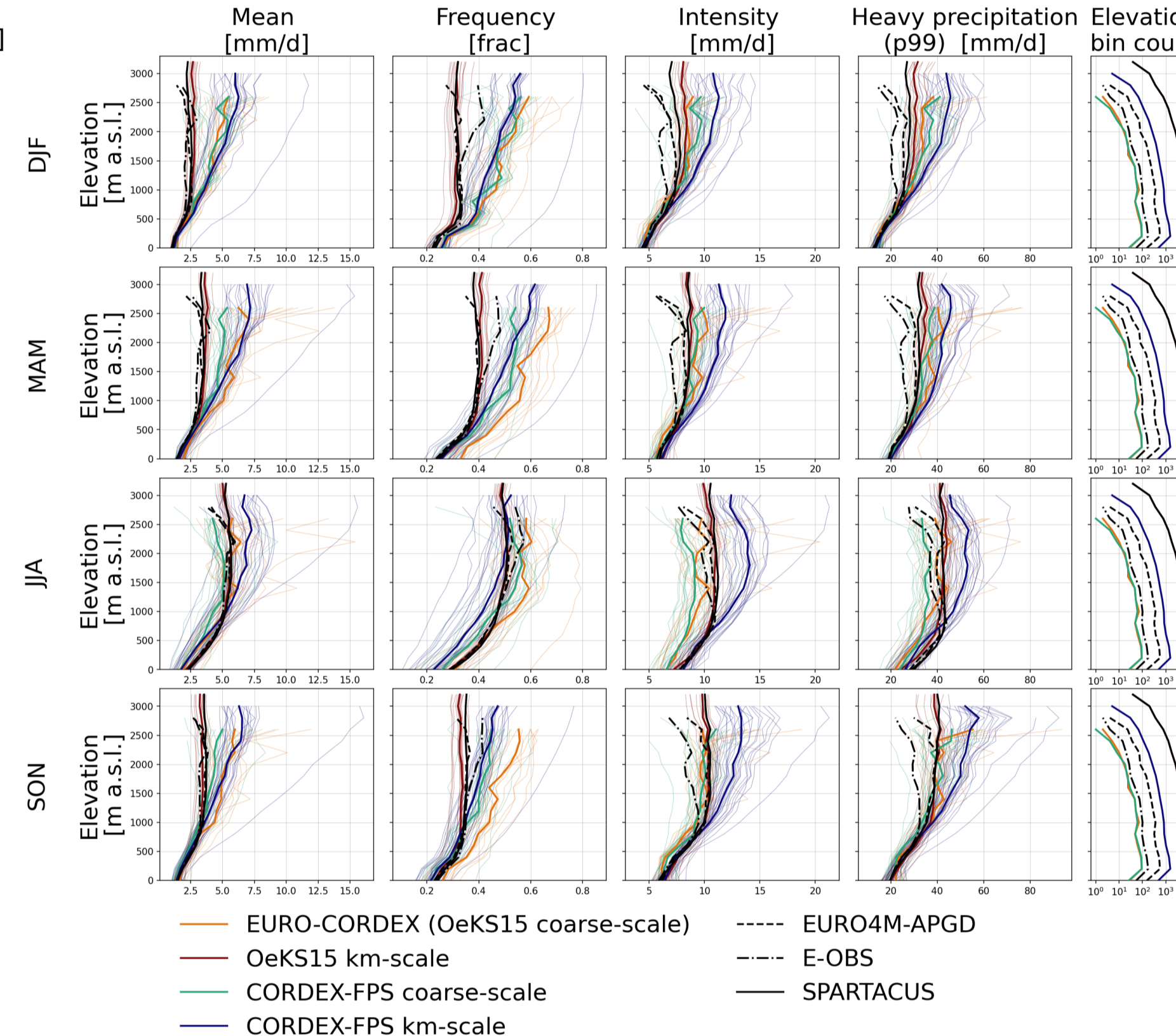


Figure 2: Elevation dependence of observations and all model ensembles over Austria (bins of 200m). Thin lines denote individual models, whereas thick lines represent ensemble medians. The km-scale OeKS and SPARTACUS bin counts overlap fully since the datasets share a grid and therefore also the orography.

Climate change signal (1996-2005 vs. 2090-2099; RCP8.5)

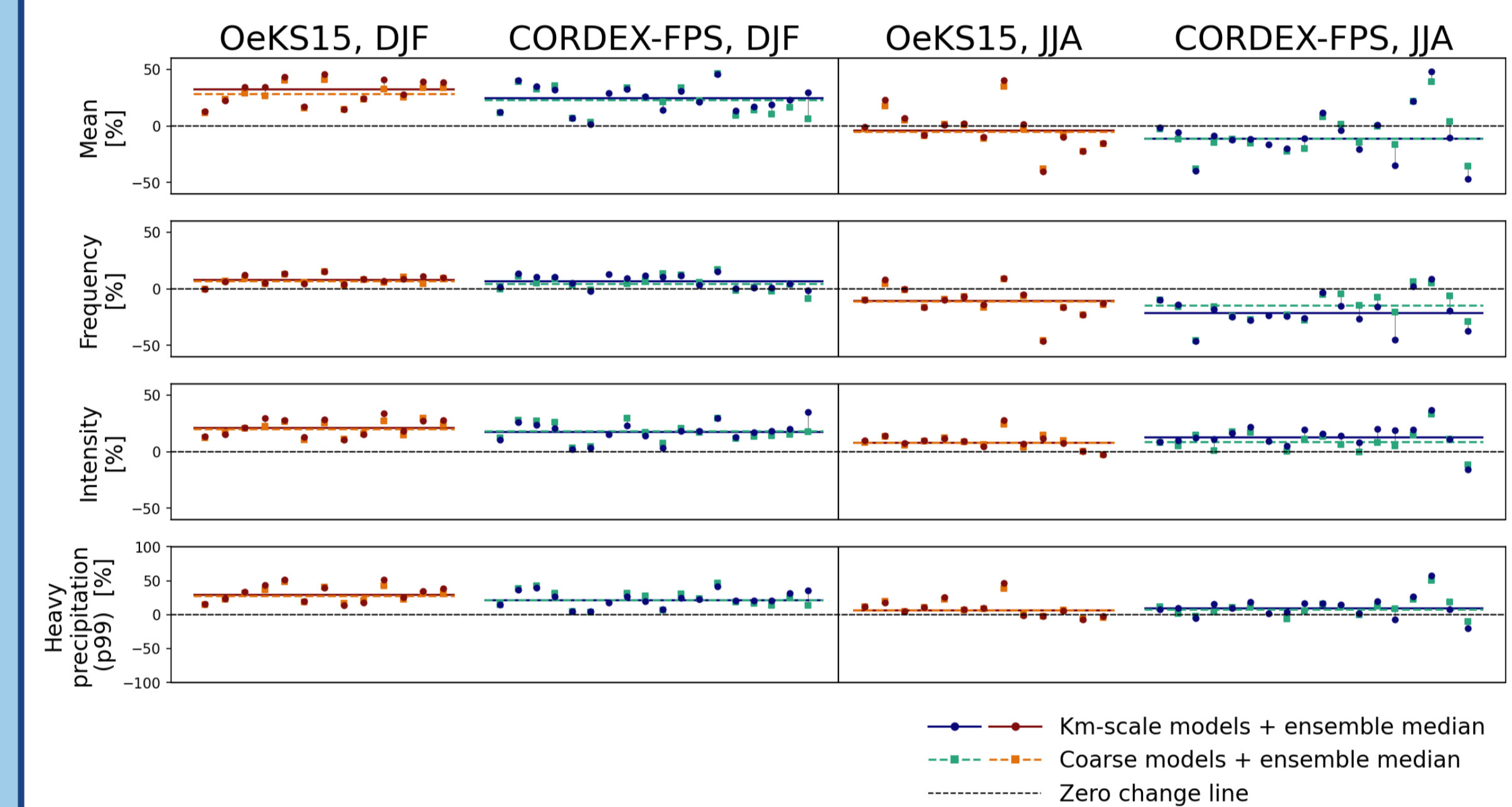
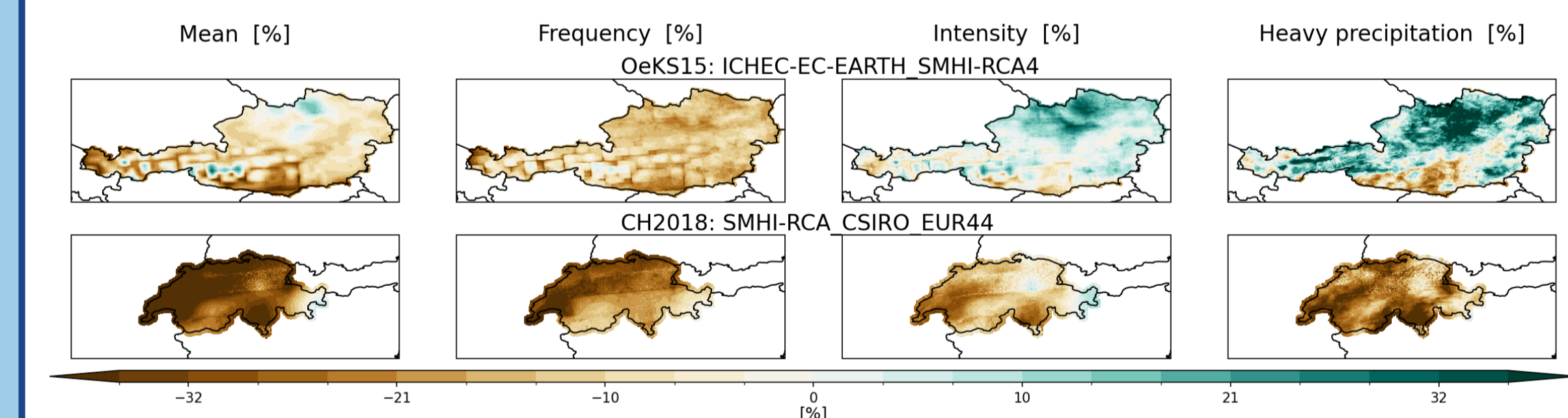


Figure 3: Spatial means of the climate change signal of all precipitation metrics over Austria in all models in winter (DJF; left) and summer (JJA; right). Each marker represents the spatial mean of a precipitation metric in one model. The km-scale models (circles) are connected to their parent coarse-scale models (squares) by vertical lines. The horizontal lines show the spatial mean of the corresponding ensemble medians, and the black dashed line represents the zero change line.



- ◆ Both types of km-scale datasets strongly inherit the climate change signal from their parent simulations
- ◆ **Bias adjustment** can give rise to spurious, unphysical spatial patterns, revealing the underlying coarse grid. This is not the case for **dynamically downscaled models**.

CONCLUSIONS:

Bias-adjusted and dynamically downscaled km-scale models can differ in how they represent various aspects of daily precipitation, both in the evaluation period and in the context of climate change. Each method has its own distinct advantages and disadvantages, and both types depend heavily on their parent models.