SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2017
Project Title:	Small-scale severe weather events: Downscaling using Harmonie
Computer Project Account:	spnlster
Principal Investigator(s):	Andreas Sterl
Affiliation:	KNMI (Royal Netherlands Meteorological Institute) P.O. Box 201 3730 AE De Bilt Netherlands
Name of ECMWF scientist(s) collaborating to the project (if applicable)	n/a
Start date of the project:	13 April 2016
Expected end date:	31 December 2019

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)	25000000	25000000	25000000	0
Data storage capacity	(Gbytes)	15,000	0	15,000	0

Summary of project objectives

(10 lines max)

The non-hydrostatic Harmonie model is used in climate mode (HCLIM) to downscale climate model results. This offers the possibility to investigate the effect of climate change on small-scale phenomena like convective rainfall and wind gusts. This is not only relevant from a scientific point of view, but has many applications. For example, wind turbines suffer from night-time low level jets that are not represented well in current climate models, and convective events are only parameterized.

Summary of problems encountered (if any)

(20 lines max)

As reported in last year's report, an earlier 10-year run had to be repeated due to a bug in the surface scheme. This re-run could be finished in 2017 using the remaining budget plus KNMI-internal resources.

The next step is to run ten years with boundary values taken form a CMIP6-run with EC-Earth. Due to problems with setting up EC-Earth, such a run could not be performed yet. Current expectation is that the run will be done in late summer. Running Harmonie will start immediately thereafter.

Summary of results of the current year (from July of previous year to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

Model stet-up

The aim of this project is to dynamically downscale climate model output using the non-hydrostatic Harmonie Climate (HCLIM). The model has a horizontal resolution of 2.5 km, and the model domain covers western Europe (e.g., see Fig. 1).

As explained in the "problems" section above, a first 10-years run had to be discarded. A re-run has been performed for the 10 years 2000-2009. This period conforms to the requirements of Euro-CORDEX. Consequently, this run is part of the Euro-CORDEX Flagship Pilot Study (FPS). The domain used for this run is slightly different from that used in the earlier run (compare present Fig. 1 with Fig. 1 of last year's report). A further change is that Harmonie is not driven directly from ERA-Interim, but that the meso-scale model RACMO is used as an intermediate step. This was done because direct ERA-Interim forcing lead to problems at the boundaries. Especially, the western parts (|Ireland, southern France) experienced too less precipitation.

Soil Moisture

As the earlier run had to be discarded because of problems with soil moisture, we first checked the development of this variable. The left panel of Figure 1 shows the linear trend of total soil moisture content over the ten-year period of the run. Large parts of continental north-western Europe get a bit drier, while southern Europe and the Brtish Isles get wetter. As Fig. 2 shows, the trend is superimposed on a large interannual variability. The right panel of Fig. 1 displays the linear trend of precipitation. Clearly, the large-scale patterns of soil-moisture change and precipitation change are the same. Therefore, the former can be explained by the latter, making us confident that the surface module of Harmonie now works correctly and does not introduce artificial trends.

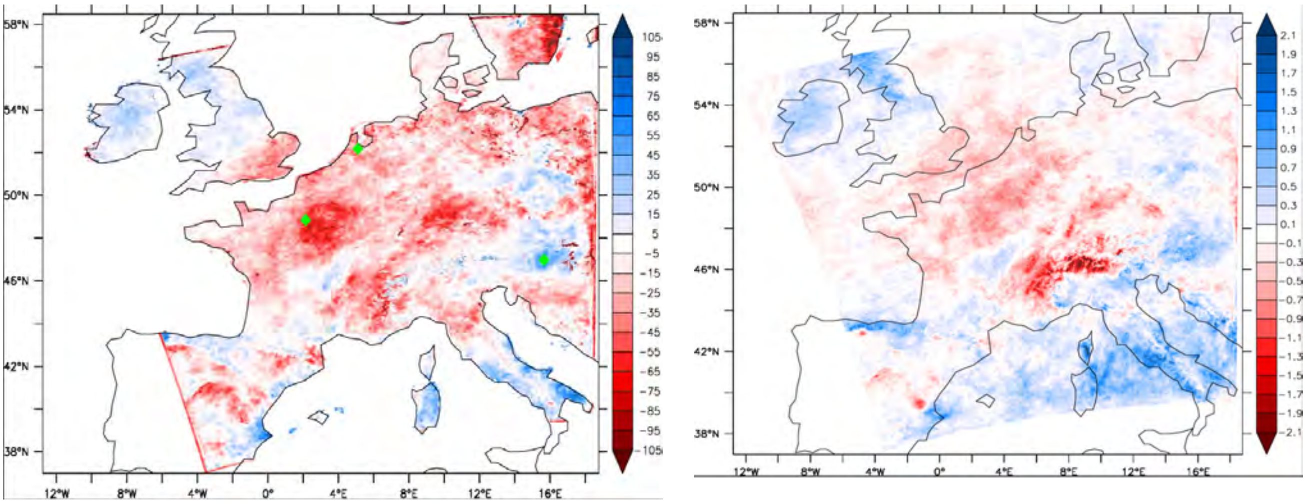

Figure 1: Linear trends in soil moisture (left, in kg m^{-2}/(10ys)) and precipitation (right, in mm d^{-1}/(10ys). The green diamonds in the left panel denote the positions for which time series are shown in Fig. 2.

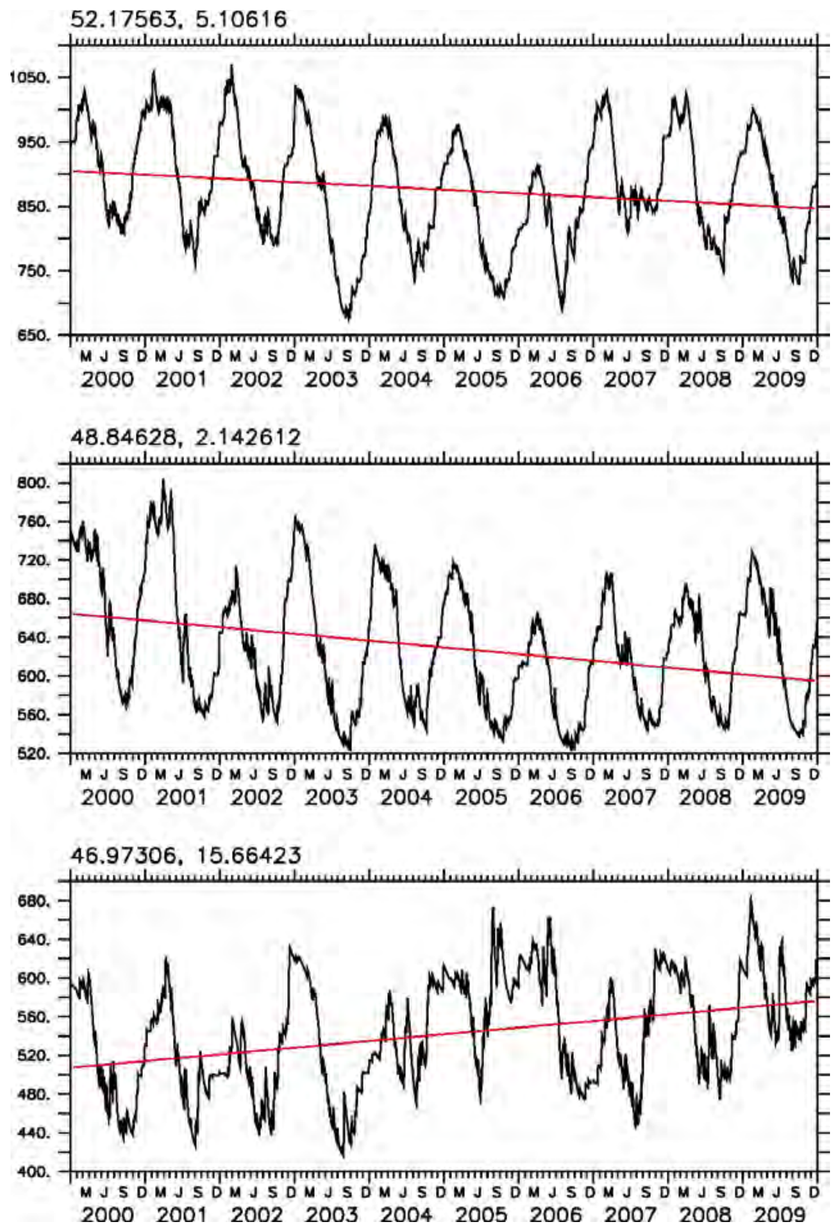

Figure 2: Time series of soil moisture at the three locations marked in Fig. 1. Monthly values in black, linear trend as a red line.

Temperature and precipitation

Temperature and precipitation have been compared to E-OBS, a gridded observation-based data set (Haylock et al., 2008; JGR, doi:10.1029/2008JD10201), on a seasonal basis (see Appendix). The main findings are

- Temperatures in Harmonie are generally too low. Exceptions are southern France and northern Italy, which are slightly too warm in summer.
- Mean precipitation is too high in winter and spring, and too low in summer.
- Maximum precipitation is higher in the model than in the observations.

Fig. 3 compares the cumulative hourly precipitation as observed at weather station De Bilt (central Netherlands) with the corresponding grid-point values from Harmonie for three different years. As can be seen, modelled and observed rainfall amounts and the timing of rainfall events are in good correspondence. An exception is the summer of 2005, when the observed rainfall amount is much higher than the modelled one. The model misses some events with a high amount of rain.

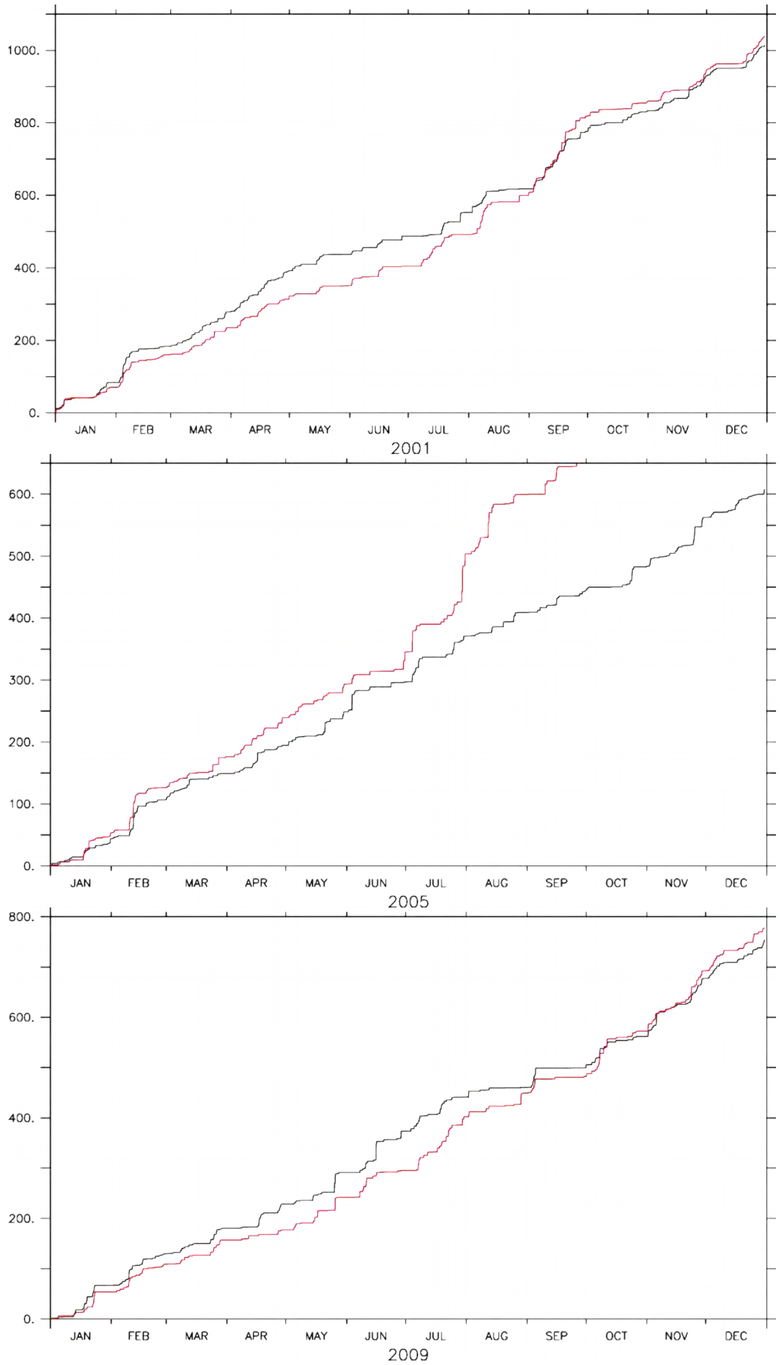

Figure 3: Cumulative rainfall amount as measured at weather station De Bilt in 2001, 2005, and 2009 (red) and respective grid-point values from Harmonie (black).

List of publications/reports from the project with complete references

- HCLIM38h1: A convection permitting climate model for Western Europe (Hylke de Vries, Bert van Ulft, Erik van Meijgaard, Geert Lenderink and Andreas Sterl; KNMI, De Bilt, Netherlands, June 19, 2018)

Summary of plans for the continuation of the project

(10 lines max)

The basic idea of the project is to have three 10-years runs: (i) actual present climate, i.e., driven by ERA-Interim, (ii) model present climate (driven by EC-Earth), and (iii) future model climate. Run (i) has been finished. Run (ii) will be performed later this year (2018), when the *historical* CMIP6 run with EC-Earth is finished. Work on comparing the ERA-Interim driven run (run (i)) with the EC-Earth driven one (run (ii)) will start directly thereafter. The EC-Earth driven run for the future (run (iii)) is to follow in the first half of 2019.

Appendix 1: HCLIM38h1: A convection permitting climate model for Western Europe (Hylke de Vries, Bert van Ulft, Erik van Meijgaard, Geert Lenderink and Andreas Sterl. KNMI, De Bilt, Netherlands, June 19, 2018)

HCLIM38h1: A convection permitting climate model for Western Europe

Hylke de Vries, Bert van Ulft, Erik van Meijgaard, Geert Lenderink and Andreas Sterl
KNMI, de Bilt, Netherlands

June 19, 2018

1 Abstract - Introduction

This document describes some first results of a decadal integration (period 1999-2009) with the Harmonie model in climate mode (HCLIM38 for short). HCLIM38 is run nested in the RACMO regional climate model, which is fed by boundaries from ERA-Interim. This simulation over western and central Europe, is part of the Cordex-FPS project, where a number of different convection permitting models (horizontal resolution $\sim$ 2.5 km) is used over Europe for a common period and (overlapping) domains. The first results (i.e., the cross-model evaluation of a number of cases and months) have been recently submitted. Another investigation in which the performance of the driving regional climate model is contrasted to the CPM is under way. In this document, we compare the direct model output to gridded observations of 2-meter temperature and daily precipitation. Focus will be on seasonal averages and the typical amplitude of the variations on daily time-scale.

2 Data and Methods

For the observations we use E-OBS v14.0 gridded data (0.25 degree grid resolution). HCLIM model output (hourly, 2.5km resolution) has been first converted to daily values, which is the same time-resolution as E-OBS. Data has then been remapped to the E-OBS grid using 4nn-distance weighted averaging (i.e. cdo -remapdis) and further statistics are derived from these regridded daily model data. The same holds for the RACMO data (daily, 12km) that has been used. We have carried out some tests with performing the regridding afterward, i.e., after performing the statistics. This influences the variance plots only slightly. Variables that have been considered are 2m-temperature and precipitation. For 2m-temperature we have corrected the final (interpolated) results for elevation differences between model and observation. This is done using the adiabatic lapse rate of -6.5 degree Celsius per km and the topography differences between gridded E-OBS and interpolated model-orography.

3 Results

For 2m-temperature we display a matrix of panels for each season. In this matrix we show the multi-year seasonal average of monthly-mean values of the daily-mean, daily-max and daily-min temperatures. In addition, the bottom row of panels shows the multi-year seasonal average of monthly-standard deviation of daily-mean temperature (a measure of the variability on daily time-scale). For precipitation the same matrix-approach is used, but we show patterns of the multi-year seasonal average of monthly-mean and monthly-max of the daily-precipitation-sum. For precipitation we measure the variability on the daily time-scale using the monthly standard deviation of daily precipitation sums.

Temperature Temperatures in winter are generally (slightly) too low compared to E-OBS, mountainous regions in particular. This holds both for HCLIM and the driving model RACMO. Over the low-lying areas, the negative bias is about 1 degree. Both min and max temperatures are also too cold, yet the typical temperature variability is rather good (bottom panels). In spring the results are very similar, yet daily-minima have a larger negative bias (too few clouds?). Temperature variability is quite good. The negative bias in daily-mean temperature (almost) disappears in summer, or at least is much smaller than in the other seasons. Southern France and Italy get too warm, especially in the daily-max temperatures, and is accompanied with an overestimation of the temperature variability. For the driving model RACMO this positive bias in daily-max is not seen (except over Sardinia, close to the simulation edge), yet in that model the daily-min temperatures are too warm. This implies that the diurnal temperature range is too small in Racmo and too large in HCLIM. Autumn is probably the best season in both models, with the smallest biases and approximately correct variability.

Precipitation Precipitation in HCLIM is, if we ignore the mountainous regions, a bit too high on average (top panels) in winter and spring, and too low in summer. Autumn is quite good. The extremely strong underestimation in the "direct-HCLIM" runs (not using RACMO as intermediate model), is not seen, except at the very edges, particularly in the very south-west corner of the domain. Especially in summer the mean precip in HCLIM has a negative bias, yet, the monthly-max values are clearly higher. In the monthly-max there is also the largest difference between HCLIM and RACMO, where HCLIM produces more precipitation than RACMO. In conclusion, in HCLIM the intensities will be higher, despite the overall negative bias in summer.

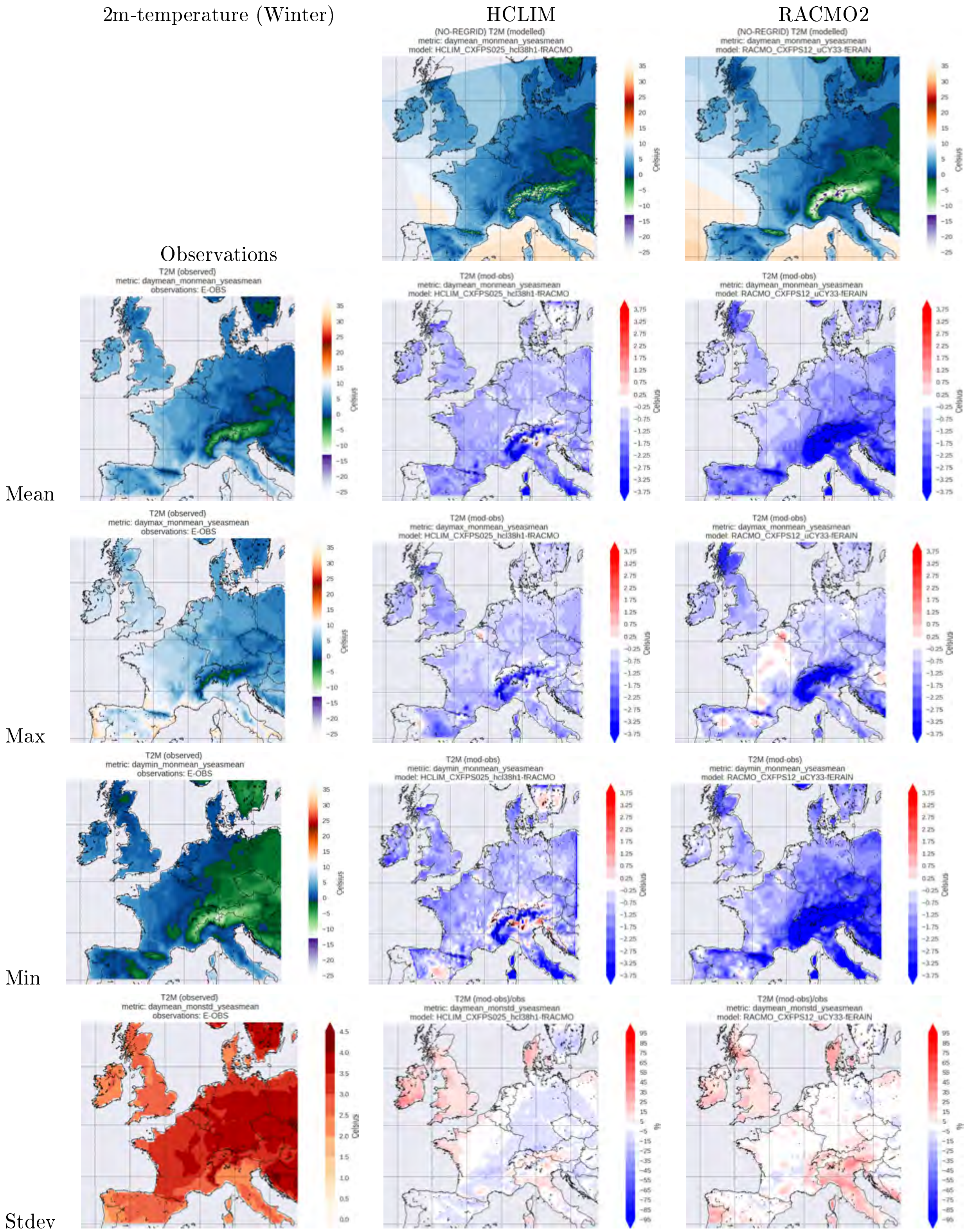

Figure 1: T2M Winter. Top row: Model native-grid seasonal averages. Left: HCLIM; right: RACMO. Left column: Observations top-bottom: daymean, daymax, daymin and monthly sd based on daily mean. The remaining panels show the model-obs absolute and relative differences for the fields on the left. Temperature is corrected for height-differences.

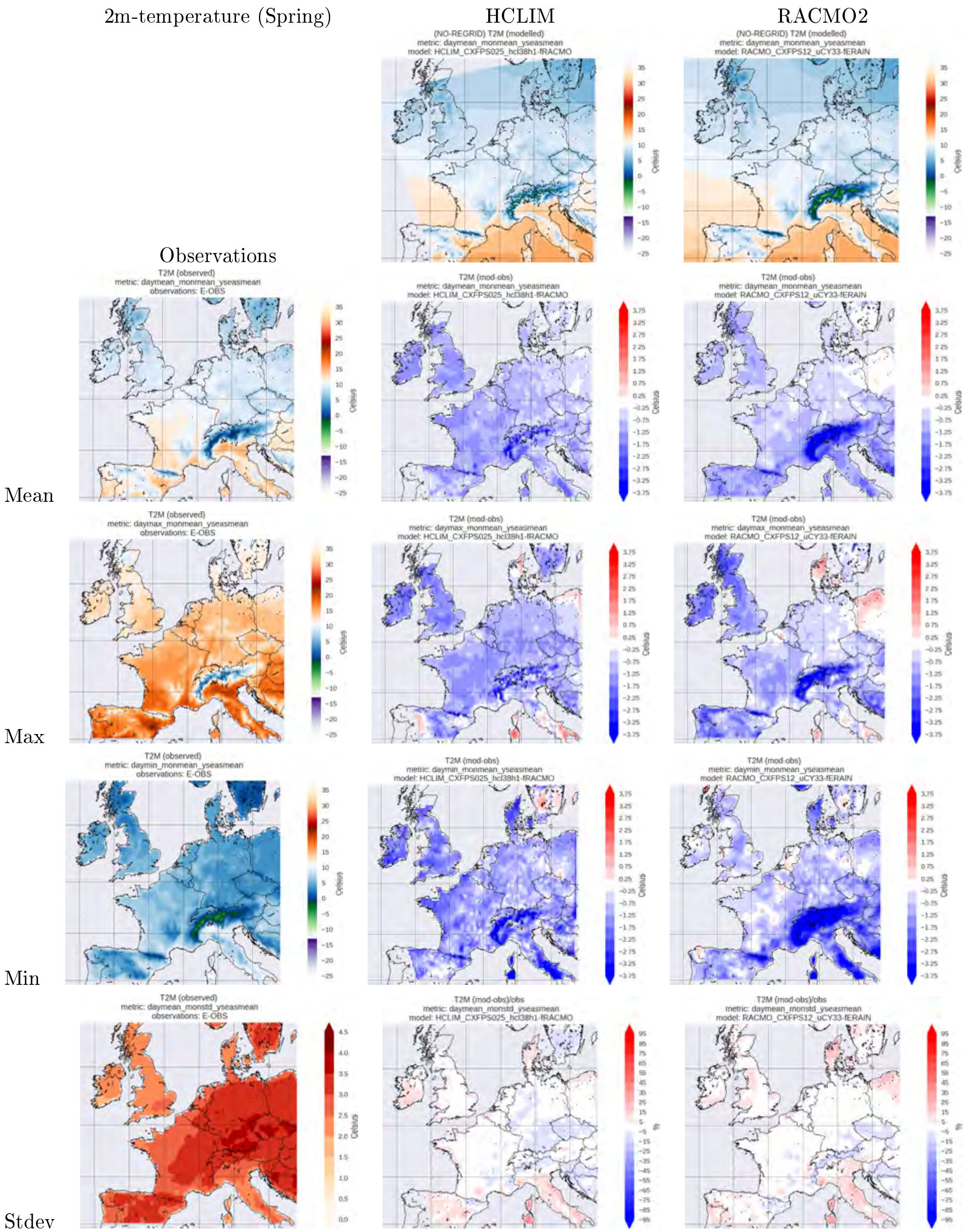

Figure 2: T2M Spring.

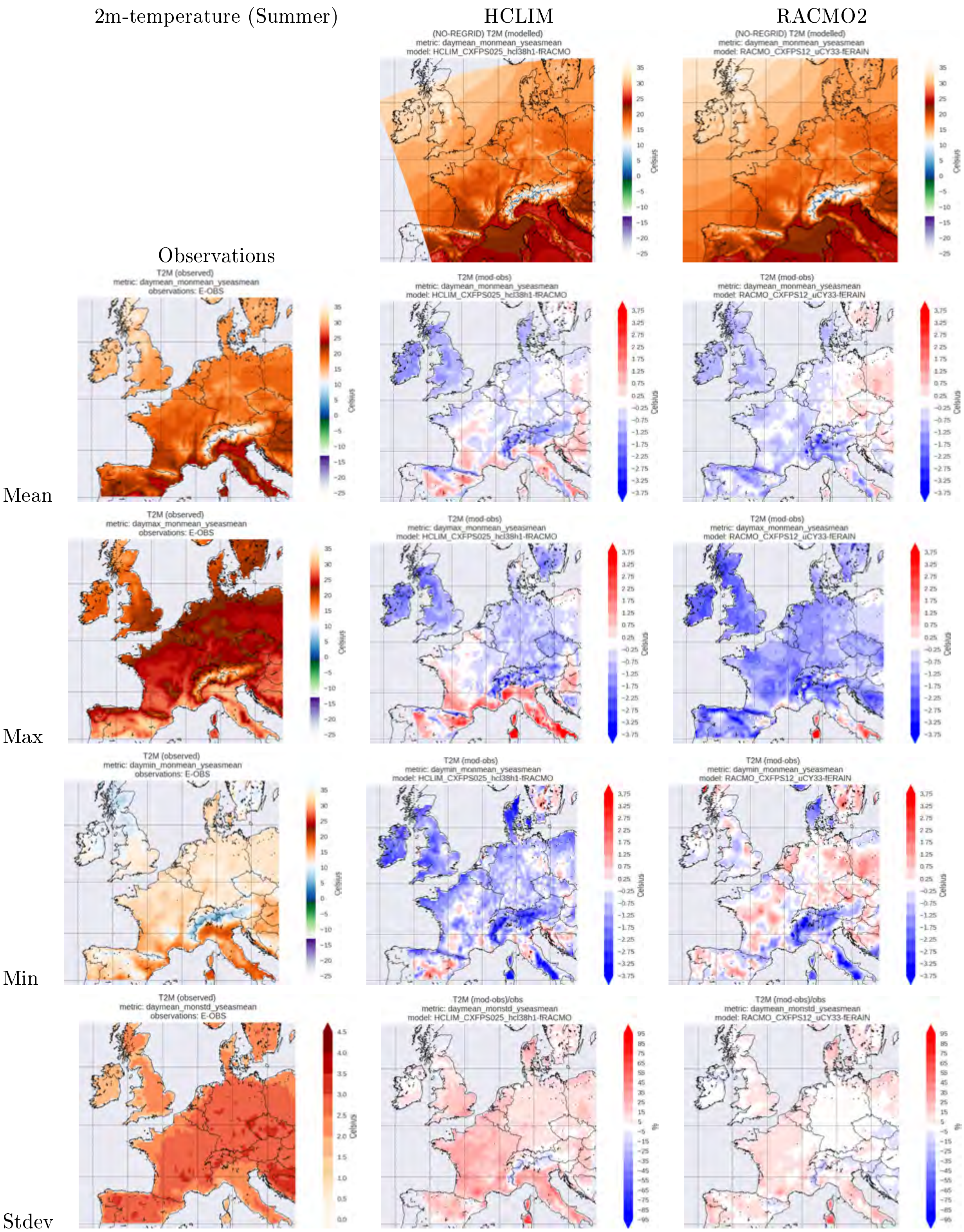

Figure 3: T2M Summer.

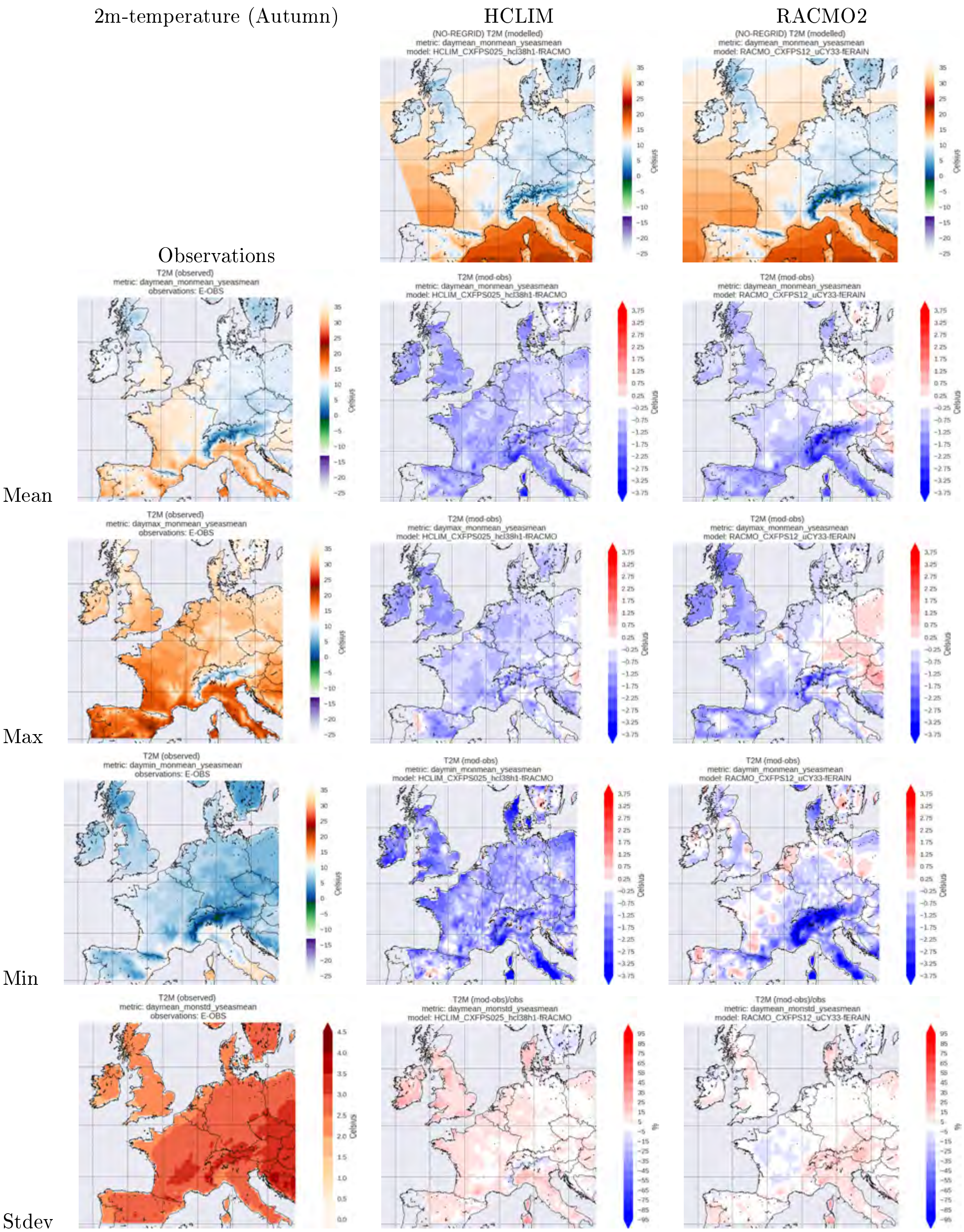

Figure 4: T2M Autumn.

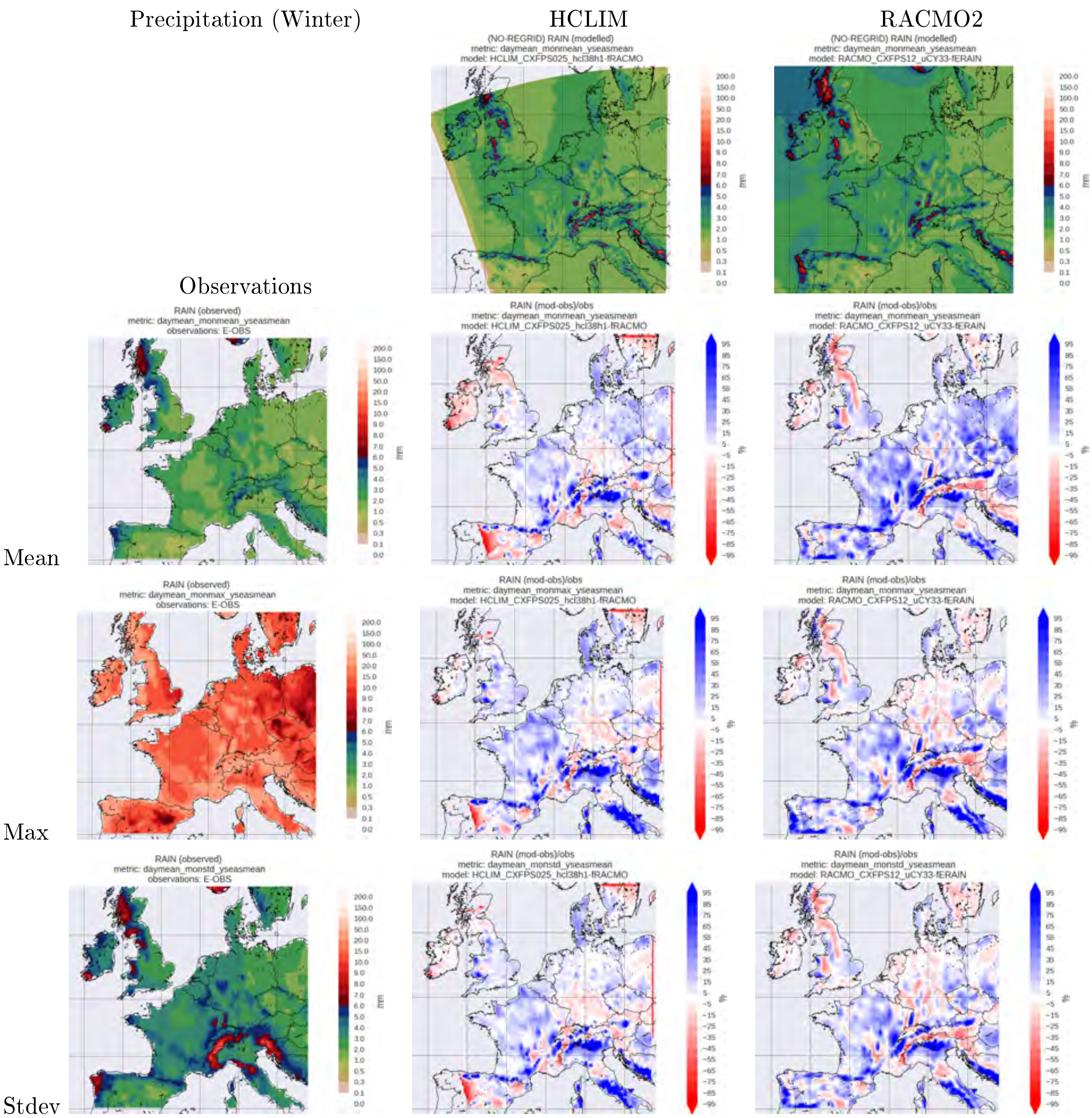

Figure 5: RAIN Winter.

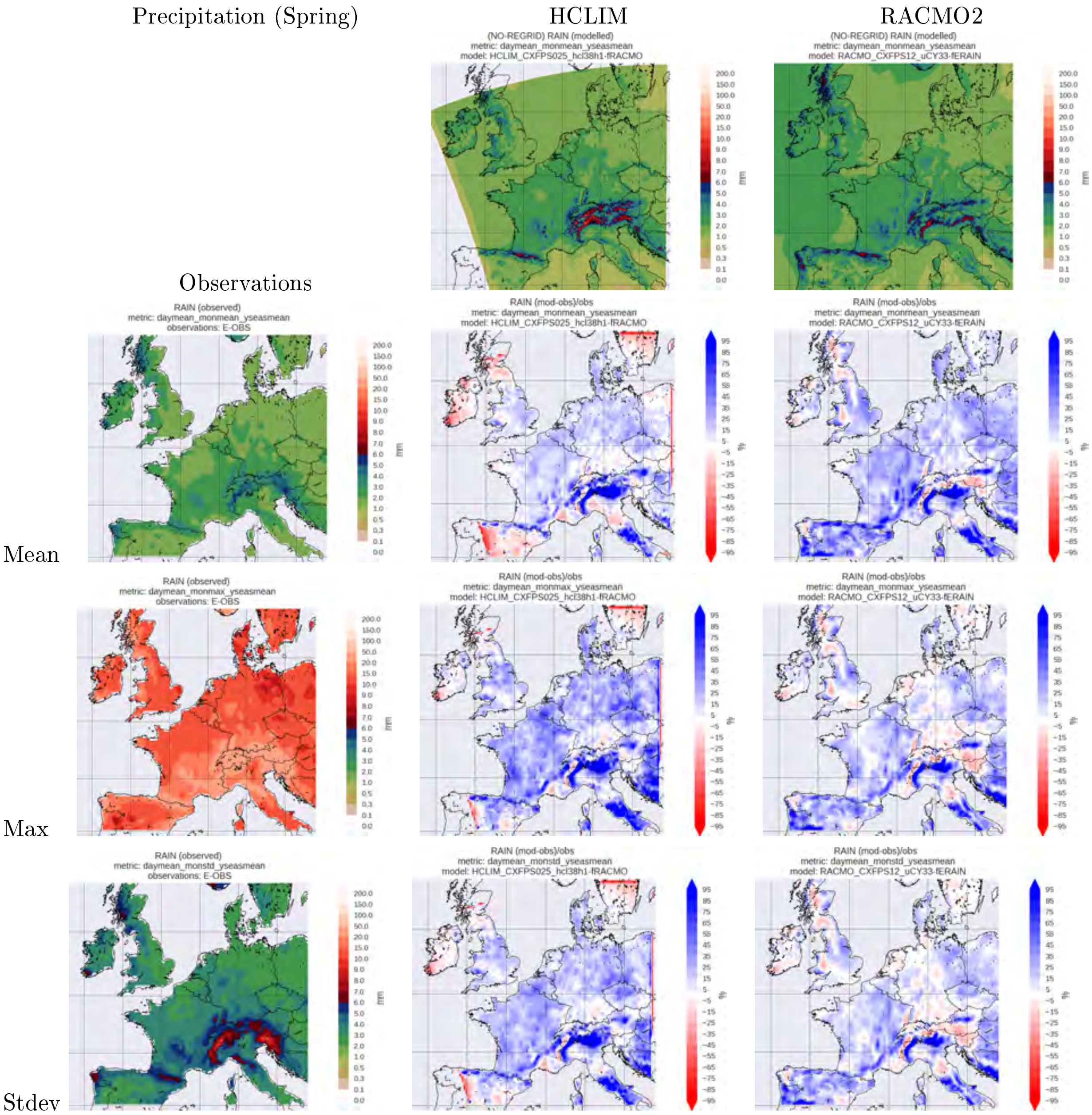

Figure 6: RAIN Spring.

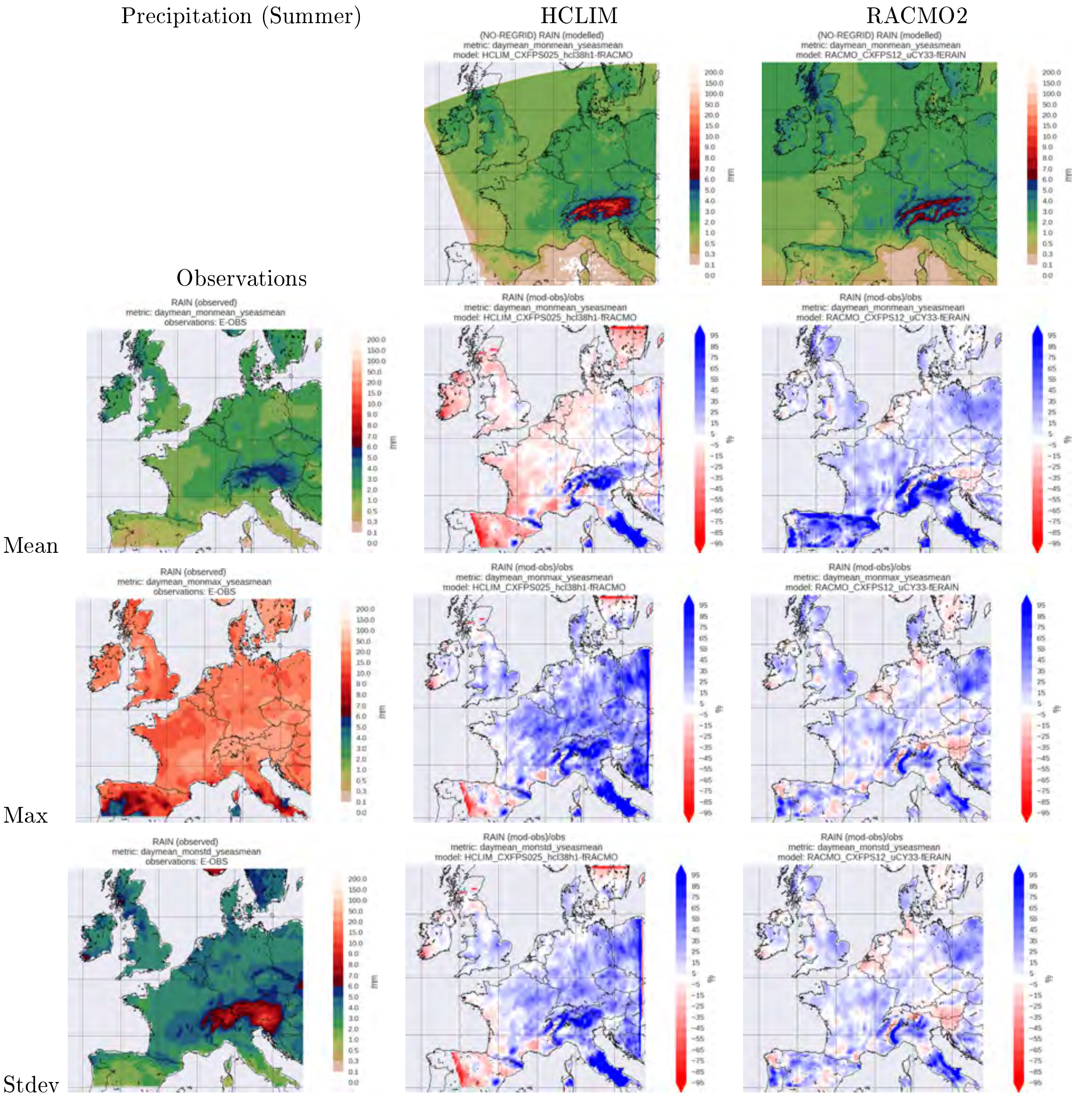

Figure 7: RAIN Summer.

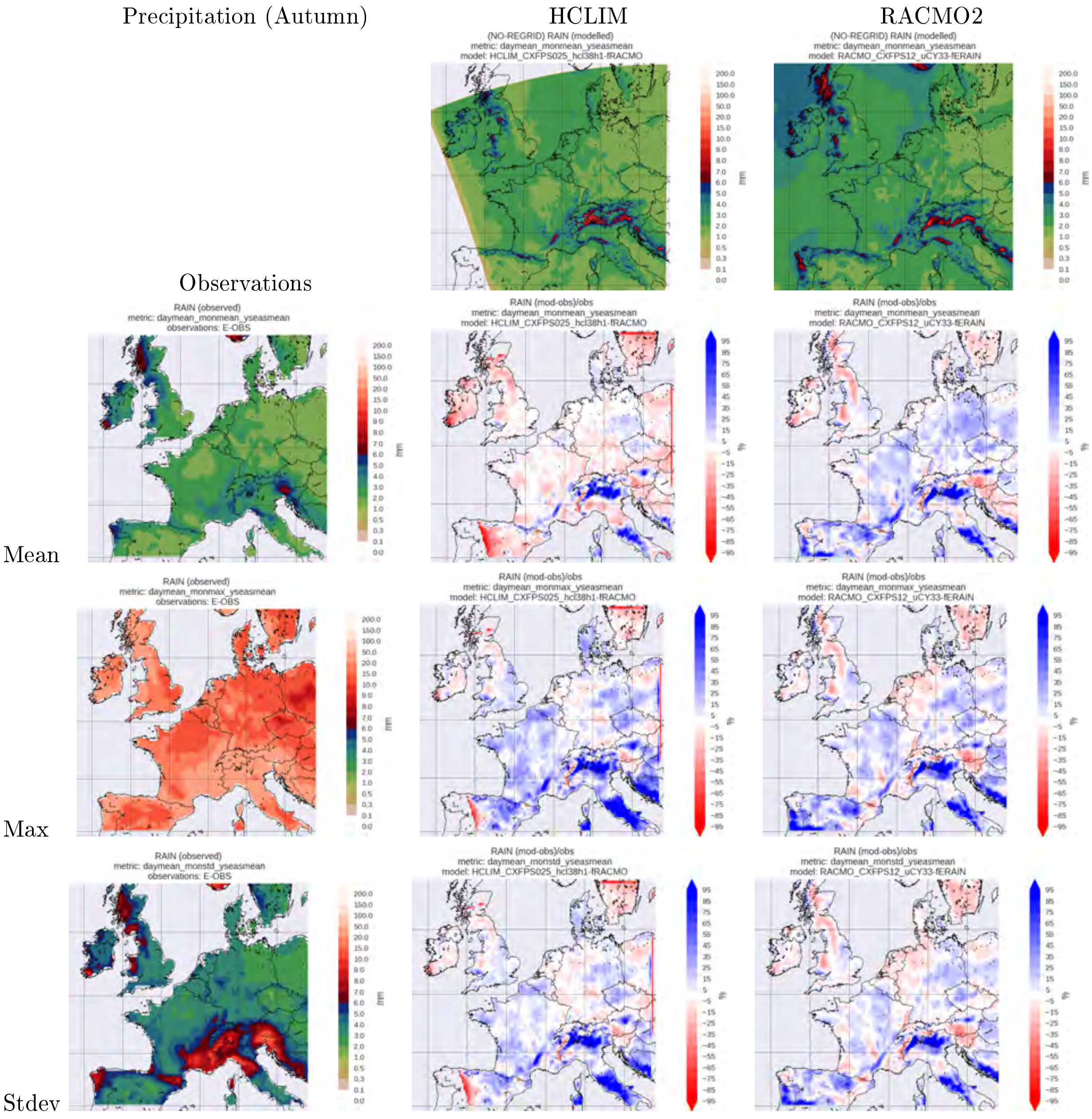

Figure 8: RAIN Autumn.