# Analysis of the added value of increased spatial resolution in a region of complex orography: a comparison with CORDEX simulations

SMART ECOMOUNTAINS

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## Abstract

This study investigates **the benefit of increasing the spatial resolution** in a **high mountain region** of special interest in **southeastern Iberian Peninsula (IP)**, Sierra Nevada (SN). The analysis was based on comparing precipitation outputs from a **20-year convection permitting (CP) climate simulation** with precipitation datasets from different sources. **SN** was selected because it **serves as an excellent mountain landscape** for studying **the effects of climate change** on ecosystems, which is mainly due to:

- Geographic location: SN is a **semi-arid mountainous region** located in the Baetic System; an alpine mountain range extended across the S-SE of the IP.
- Close to the sea, SN is home of the highest peaks in the IP**, Veleta at 3394 m and Mulhacén at 3478 m**. This results in a **significant altitudinal gradient** in this area.
- Due to its geomorphological singularity, SN was designated as a **Biosphere Reserve (1986), Nature Reserve (1989), and National Park (1999).**

## Methodology

**DATA:** Precipitation from different sources were used in order to see **the effect of the increase in resolution**:

1. Reference datasets: observational products from different sources and spatial resolution were collected:
   - Gridded products result of interpolating precipitation from weather stations: **AEMET-GRID** (5km spatial resolution) and **REDIAM-GRID** (100 m spatial resolution).
   - Hybrid products result of combining satellite imagery and in-situ station data: **CHIRPS** (~6km spatial resolution).
   - Precipitation from satellite estimates: **CMORPH** (~8 km spatial resolution).
2. Euro-CORDEX simulations: An ensemble of 9 climate simulation from 0.11-Euro-CORDEX (~12.5km spatial resolution) driven by ERA-Interim datasets was also used to compare the effect of the increased resolution.
3. Convection permitting (CP) simulations completed with the Weather Research and Forecasting (WRF) model v4.3.3: WRF was selected to complete a climate simulation from 2001 to 2020 with a model configuration based on one-way two domains (see Fig. 1).
4. Lateral boundary conditions of the WRF CP simulation: ERA5 (~31km spatial resolution).

**MODEL EVALUATION AND ASSESSMENT OF ADDED VALUE:** The comparison was carried out in terms of annual precipitation and mean frequency and intensity of heavy precipitation (pr > 10 mm/day) on an annual and June-July-August-September-October-November (JJASON) basis.

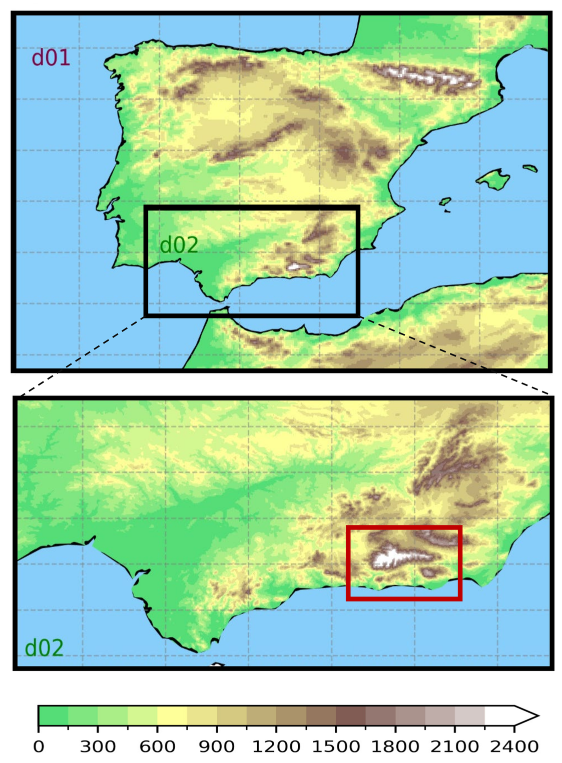


**Fig 1.** The domain configuration employed in this study. The d01 domain covers the IP at 5 km of spatial resolution and d02 is centered over Andalusia (1 km). With a red box the study region is displayed in d02.

## Results

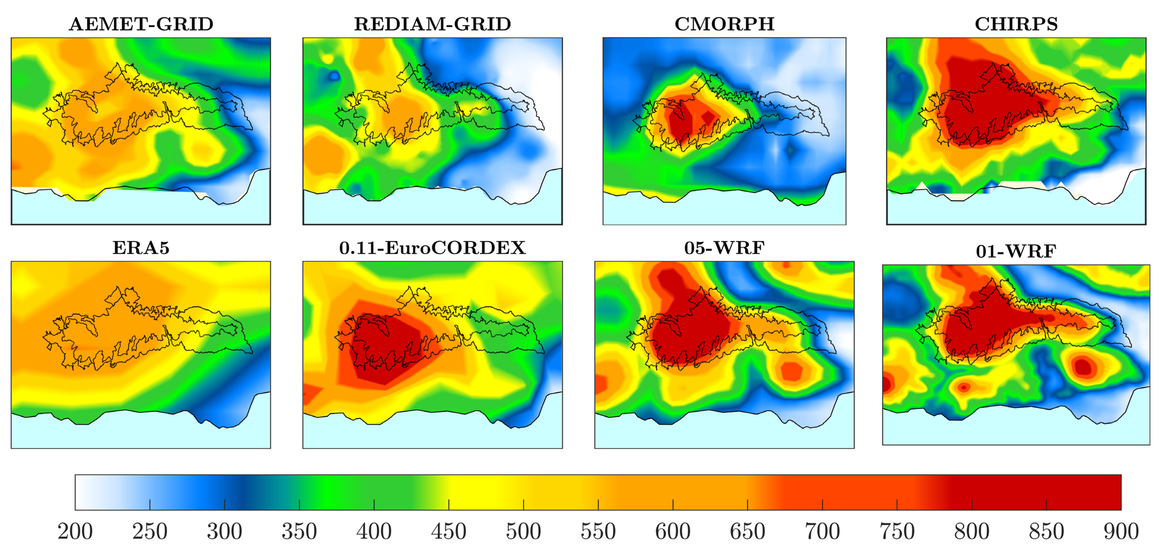


**Fig. 2** Mean annual precipitation in SN. In the first row, observations (AEMET-GRID, REDIAM-GRIM, CMORPH, and CHIRPS) are shown. The second row displays the results for the lateral boundary conditions (ERA5), the ensemble mean of 9 Euro-CORDEX simulations (0.11-EuroCORDEX), and CP climate simulations using WRF at 1 and 5 km spatial resolutions (05-WRF and 01-WRF, respectively).

**Table 1** Spatial mean (expressed in mm/year) of the annual accumulated precipitation of the grid points within the Sierra Nevada region as well as the maximum value (in mm/year) of the annual accumulated precipitation.

| | MEAN | MAX |
|---|---|---|
| AEMET-GRID | 501.66 | 621.64 |
| REDIAM-GRID | 424.21 | 611.52 |
| CMORPH | 527.70 | 1314.50 |
| CHIRPS | 798.85 | 1262.20 |
| ERA5 | 561.60 | 654.85 |
| Euro-CORDEX | 631.80 | 1120.70 |
| 05-WRF | 735.70 | 1794.50 |
| 01-WRF | 791.17 | 1739.10 |

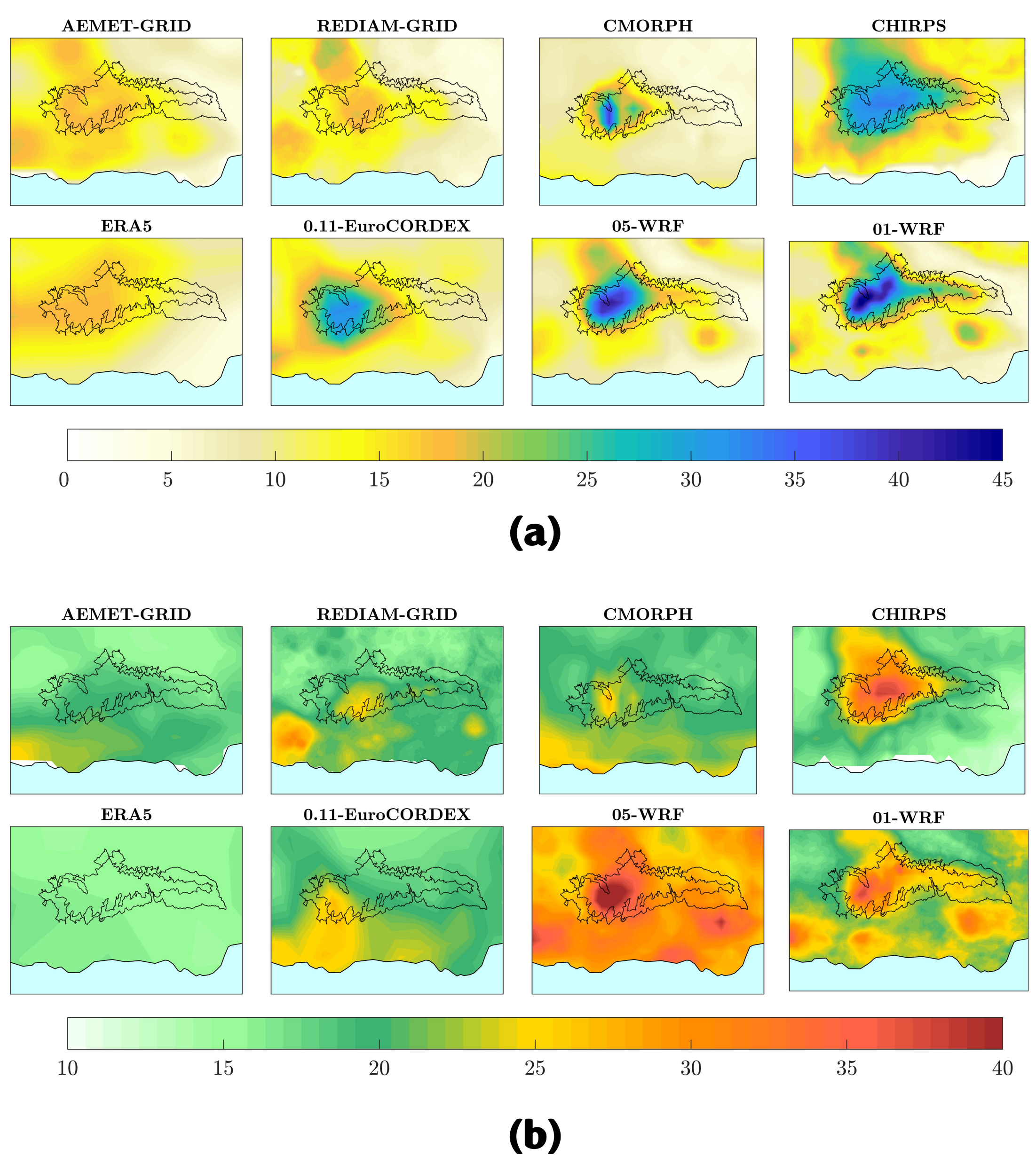


**Fig. 3** Extreme values on an annual basis. The mean of days with heavy precipitation (pr > 10 mm) is shown in (a), and its mean intensity expressed in mm/day is shown in (b). The nature reserve and national park are represented with black lines in all panels.

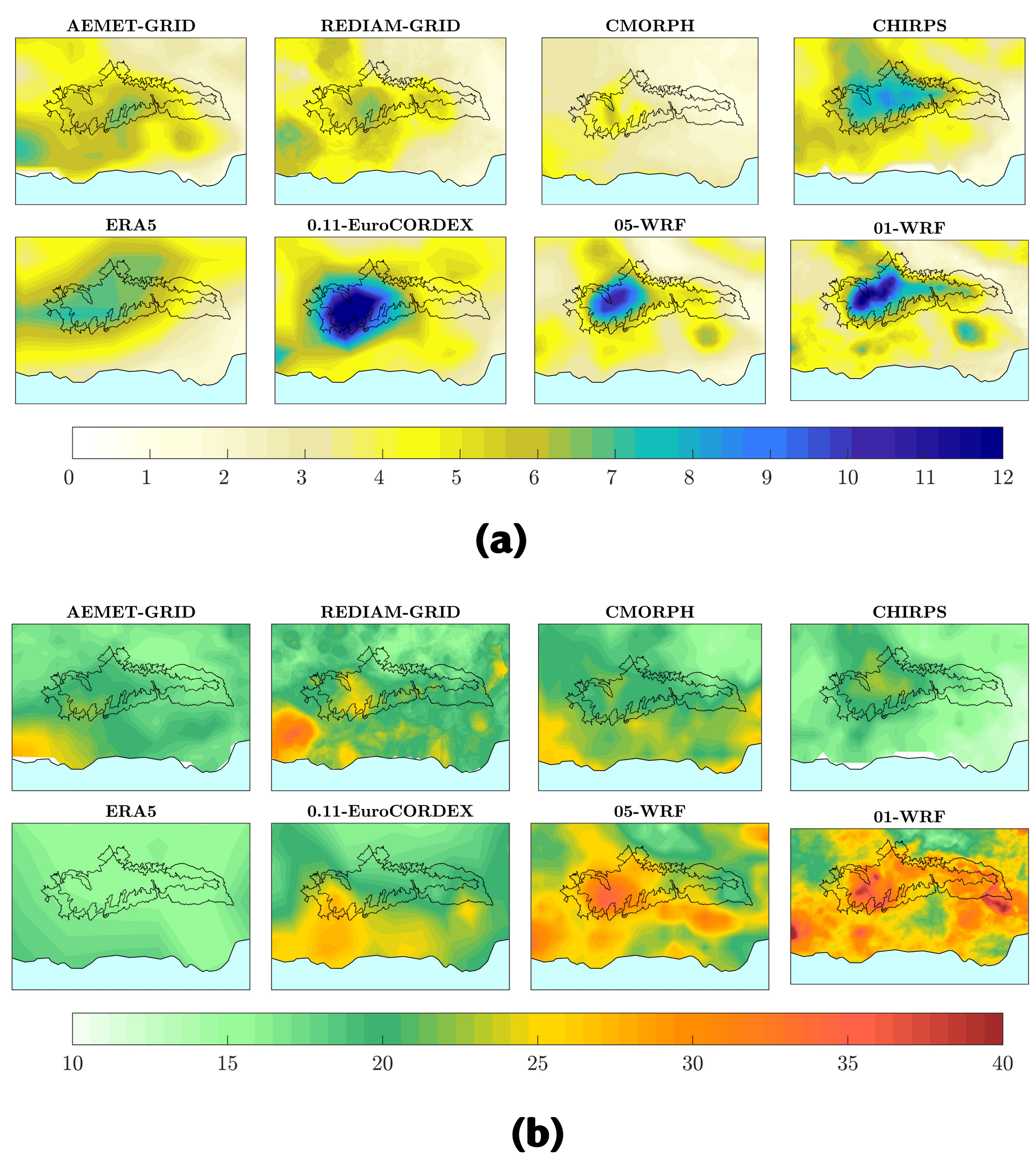


**Fig. 4** JJASON Extreme values. The mean of days with heavy precipitation (pr > 10 mm) is shown in (a), and its mean intensity expressed in mm/day is shown in (b). The nature reserve and national park are represented with black lines in all panels.

## Concluding Remarks

- The results showed that **there is a large uncertainty between the different observational databases in high mountains**. Thus, **WRF produces precipitation amounts that are more similar to satellite imagery products**, particularly in higher altitude regions (west of SN). The latter is especially true when comparing WRF and CHIRPS outputs.
- **Interpolated gridded products** such as AEMET-GRID and REDIAM-GRID **could present deficiencies in characterizing precipitation** since in this region there are fewer meteorological stations due to difficult access, thus worsening the interpolation results.
- The CP climate simulations (05-WRF and 01-WRF) seem to represent the spatial patterns of precipitation more adequately than the Euro-CORDEX ensemble, at least in terms of extreme values.
- Overall, **WRF performed well in representing precipitation in SN**, with similar results in both domains, though d01 exhibits a slightly higher overestimation. According to these findings, future research will be conducted using more specific value-added metrics to determine whether the resolution increase from 12 km to 5m and from 5km to 1 km generates additional value in this region.

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