WeeklyNote

2019.12.05

張慕琪

AGU PUBLICATIONS

JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE

10.1002/2016JD025724

Bias correction and downscaling of future RCM precipitation projections using a MOS-Analog technique

M. Turco[1,2], M. C. Llasat[1], S. Herrera[3], and J. M. Gutiérrez[4]

[1]Department of Applied Physics, University of Barcelona (UB), Barcelona, Spain, [2]Barcelona Supercomputing Center (BSC), Barcelona, Spain, [3]Meteorology Group, Department of Applied Mathematics and Computer Science, Universidad de Cantabria, Santander, Spain, [4]Meteorology Group, Instituto de Física de Cantabria, CSIC-Universidad de Cantabria, Santander, Spain

Introduction

降水变量是对于很多领域都具有重要的研究意义的变量，例如农业、水文，特别是对包含了极端事件的应用或气候变化来讲。

降尺度方法可以提高降水变量的空间尺度精度。

然而，降尺度后的模型依旧有较大的偏差；对此，模式输出统计(Model Output Statistics)方法使用的最为广泛。

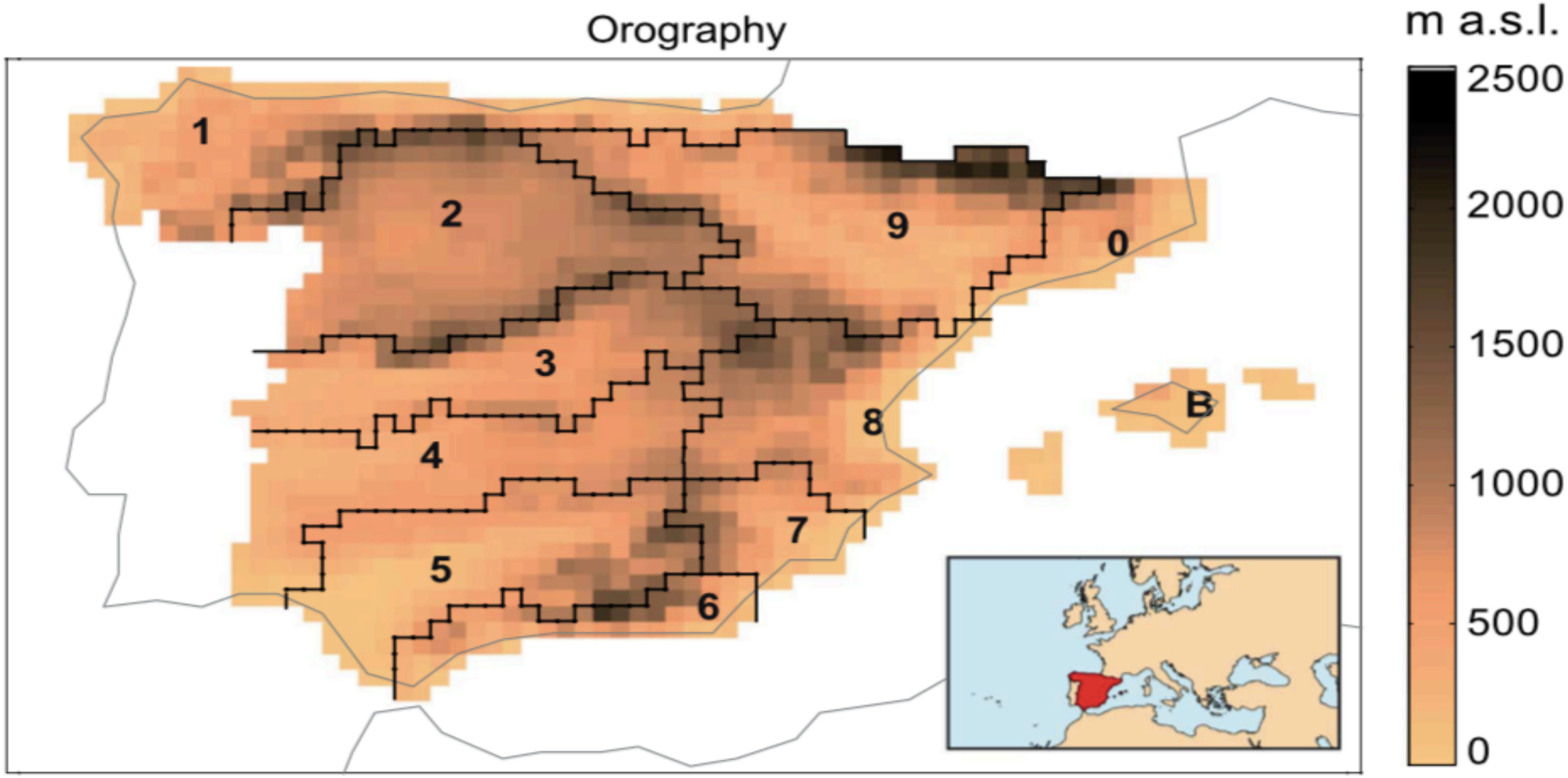
Introduction

Climate Change Studies

MOS-Analog

- distribution-wise
  - 修正方程由观测和模拟的分布决定（即包含了分位数映射的偏差校正）
  - 1）QQM改变了掩饰的气候变化信号
  - 2）QQM无法矫正由于模型在大尺度环流上产生的误差
  - 3）由于RCM输出和观测具有不同的分辨率，QQM是低效率的
- event-wise
  - 使用模拟和观测间的空间相似性
  - 1）概念上更简单且成本低
  - 2）可以重现预报因子和预报量间的非线性关系
  - 3）可以真实的再现空间上的降水特征
  - 但无法模拟未观测到(unobserved)的天气特征

Method



地形复杂且多样；

由于处于不同气候地区，因此其气候变化大。

（EAR40驱动的RCM模拟可以捕捉到该地区不同流域的年循环）

Figure 1. Topography of Spanish Iberian Peninsula and the Balearic Islands as represented by Spain02 at 0.2° × 0.2°, showing the main river basins: (0) Catalana, (1) Norte, (2) Duero, (3) Tajo, (4) Guadiana, (5) Guadalquivir, (6) Sur, (7) Segura, (8) Levante, (9) Ebro, and (B) Baleares. The inset shows a geographical map at larger scale.

1. ENSEMBLES RCM Data set

EU-funded project ENSEMBLES是欧洲各个国家共同合作，覆盖整个欧洲的数据集

2. Observed Data

高分辨率的Spain02(0.2◦ × 0.2◦, 20 km × 20 km approximately)data set

Method

1. MOS-Analog downscaling

1）对于每个由GCM驱动的RCM模拟的降水数值A(t)，通过两个数据的欧几里得距离，可以获得t’时刻，由ERA40驱动的RCM模拟的降水数值B(t’)；

2）同样，在t’时刻得到的观测降水数值b(t’)被作为降尺度的数据分配给由GCM驱动的RCM。

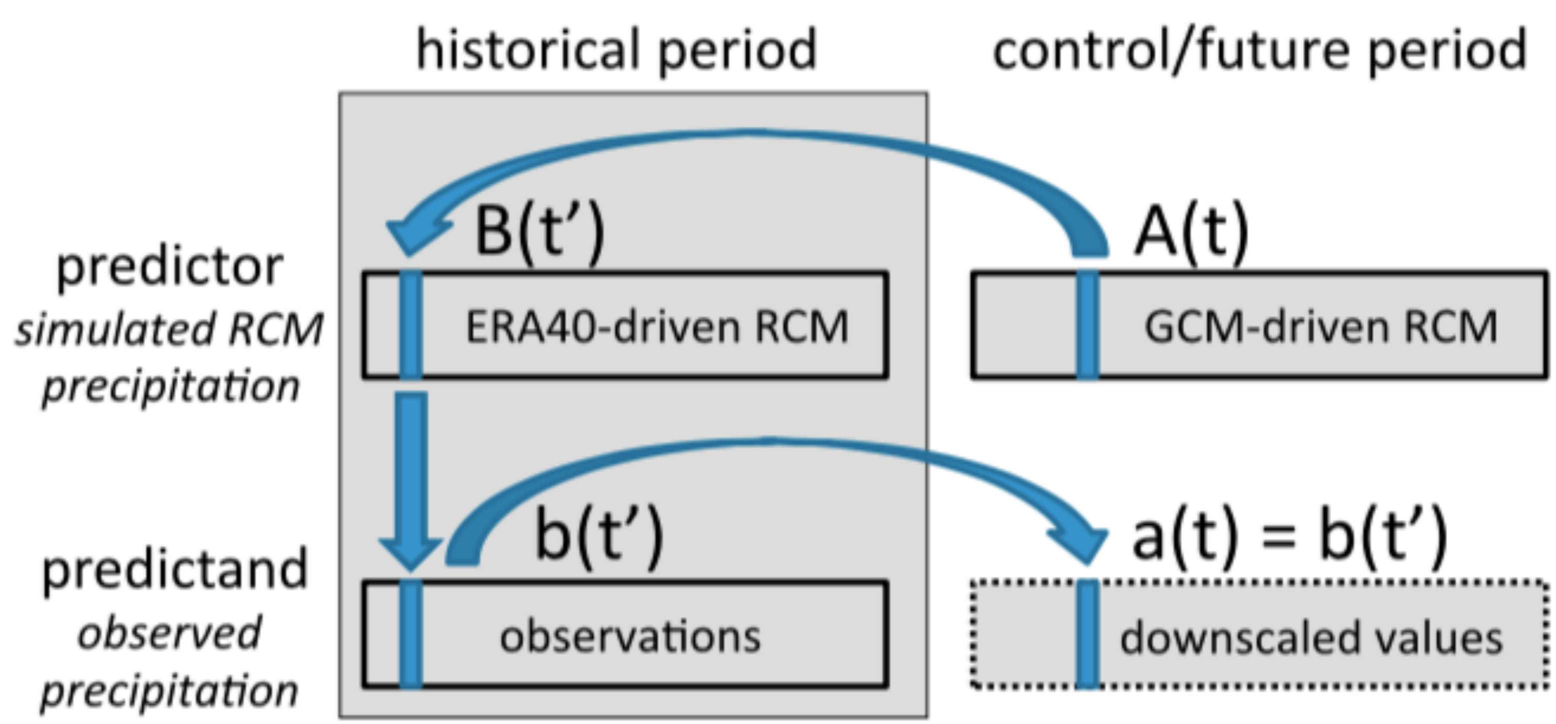


Figure 2. Schematic illustration of the MOS-Analog method (adapted from *Fernandez and Saenz* [2003]). See the text for details.

值得注意的是，该方法仅能生成在历史数据中观察到的值，因此该限制可能会影响其在未来气候变化模拟中的泛化能力，尤其是一些极端值。

Method

2. Quantile Mapping Method：QQM

该方法默认观测和模拟的降水强度分布近似为gamma分布；

为了可以和MOS-Analog方法具有可比性，传递函数由ERA40驱动的模拟进行调整，并将其运用于在20C3M（历史）和未来A1B情境下校准GCM驱动的模拟：

$$X^*_{\mathrm{GCM}} = F^{-1}_{\mathrm{Obs}}(F_{\mathrm{ERA40}}(X_{\mathrm{GCM}}))$$

X_{GCM}和X_{GCM}^*为原始的GCM驱动的模拟和被矫正过后的GCM模拟值，F_{Obs}和F_{ERA40}为满足Gamma分布的观测和由ERA40驱动的模拟

Method

3．Comparison Measures

使用三种方法来评估MOS-Analog方法的能力:

1）同时比较观测和模拟数据在Table 2中不同变量的表现;

Table 2. Climatic Mean and Extreme ETCCDI Indices for Precipitation Used in This Work (See Also http://etccdi.pacificclimate.org)

Label	Description	Units
PRCPTOT	Total precipitation	mm
R1	Number of day with precipitation over 1 mm/d	days
SDII	Mean precipitation amount on a wet day (>1 mm)	mm
R20	Number of days with precipitation over 20 mm/d	days
RX1DAY	Maximum precipitation in 1 day	mm
CDD	Consecutive dry days (<1 mm)	days
CWD	Consecutive wet days (>1 mm)	days

Method

3．Comparison Measures

2）为了评估该方法对年循环特征的捕捉，对Fig1中不同流域的月尺度（1971-2000）的表现进行评估；

3）对该方法在关于保留RCMs中气候变化信号方面的表现进行评估，并和经典的偏差校正方法（QQM）进行比较。

Results

Table 1. RCM Simulations Produced in the ENSEMBLES Project Used in This Study With the Corresponding Driving GCM[a]

Number - Acronym	RCM	Driving GCM	Reference
1 - CNRM[b]	ALADIN	ARPEGE	*Radu et al.* [2008]
2 - DMI[b]	HIRHAM	ARPEGE	*Christensen et al.* [2008]
3 - DMI-BCM	HIRHAM	BCM	*Christensen et al.* [2008]
4 - DMI-ECHAM5	HIRHAM	ECHAM5-r3	*Christensen et al.* [2008]
5 - ICTP[b]	RegCM3	ECHAM5-r3	*Pal et al.* [2007]
6 - KNMI[b]	RACMO	ECHAM5-r3	*Van Meijgaard et al.* [2008]
7 - HC[b]	HadRM3Q0	HadCM3Q0	*Haugen and Haakensatd* [2006]
8 - MPI[b]	M-REMO	ECHAM5-r3	*Jacob* [2001]
9 - SMHI[b]	RCA	ECHAM5-r3	*Samuelsson et al.* [2011]
10 - SMHI-BCM	RCA	BCM	*Samuelsson et al.* [2011]

[a]The numbers are used to facilitate the reading of the Taylor diagrams presented later (see section 4).

[b]The best performing models in this region according to previous studies [*Herrera et al.*, 2010; *Turco et al.*, 2013].

Results

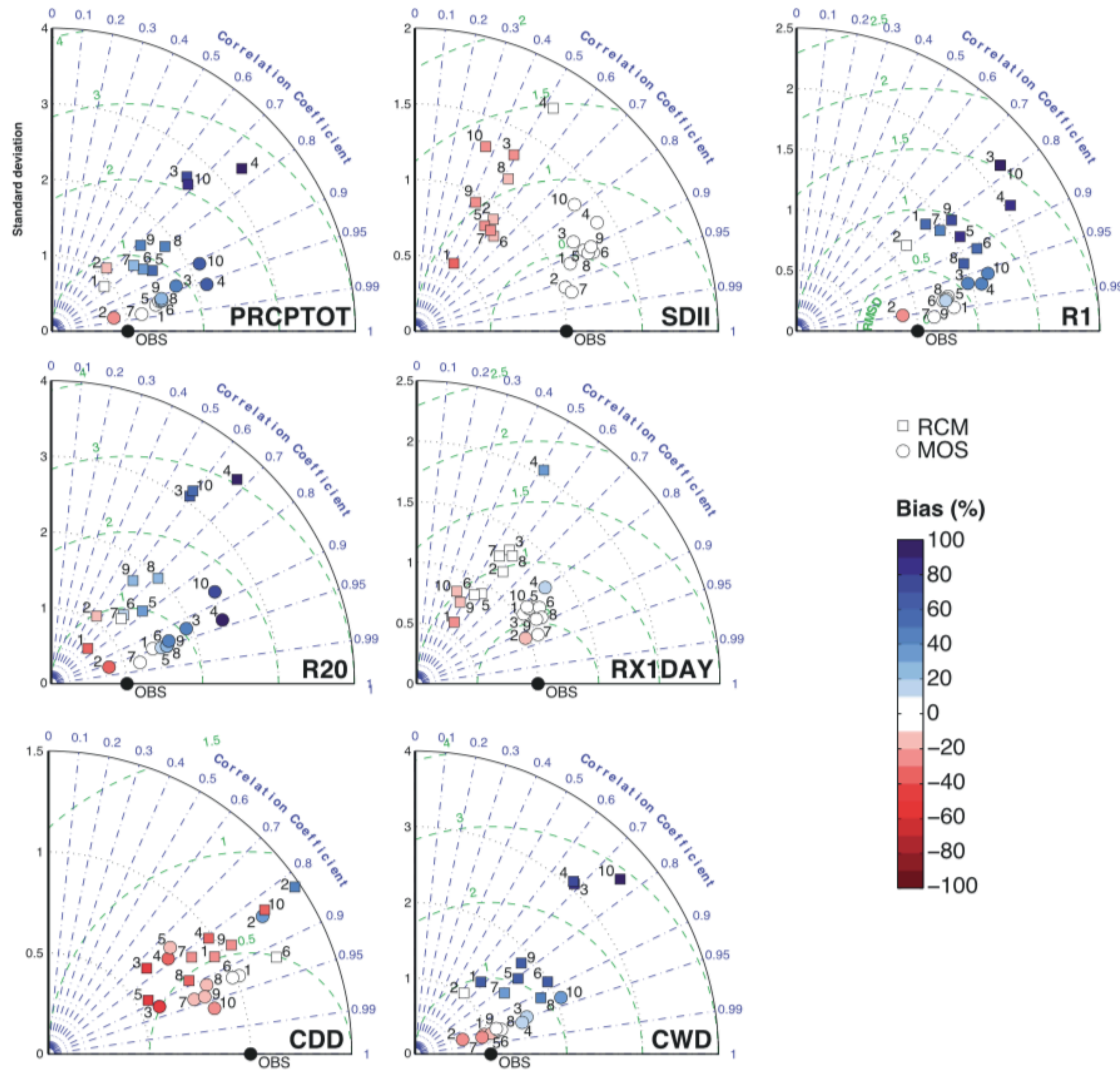


Figure 4. Taylor diagrams for the GCM-driven RCMs for different ETCCDI indices (Table 2). The squares and the dots with the numbers indicate, respectively, the model output (as referred on Table 1) and the MOS-Analog applied to this model.

Results

Table 1. RCM Simulations Produced in the ENSEMBLES Project Used in This Study With the Corresponding Driving GCM[a]

Number - Acronym	RCM	Driving GCM	Reference
1 - CNRM[b]	ALADIN	ARPEGE	*Radu et al.* [2008]
2 - DMI[b]	HIRHAM	ARPEGE	*Christensen et al.* [2008]
3 - DMI-BCM	HIRHAM	BCM	*Christensen et al.* [2008]
4 - DMI-ECHAM5	HIRHAM	ECHAM5-r3	*Christensen et al.* [2008]
5 - ICTP[b]	RegCM3	ECHAM5-r3	*Pal et al.* [2007]
6 - KNMI[b]	RACMO	ECHAM5-r3	*Van Meijgaard et al.* [2008]
7 - HC[b]	HadRM3Q0	HadCM3Q0	*Haugen and Haakensatd* [2006]
8 - MPI[b]	M-REMO	ECHAM5-r3	*Jacob* [2001]
9 - SMHI[b]	RCA	ECHAM5-r3	*Samuelsson et al.* [2011]
10 - SMHI-BCM	RCA	BCM	*Samuelsson et al.* [2011]

[a]The numbers are used to facilitate the reading of the Taylor diagrams presented later (see section 4).

[b]The best performing models in this region according to previous studies [*Herrera et al.*, 2010; *Turco et al.*, 2013].

Results

1. MOS-Analog 方法可以显著提升每个指数上RCM的结果（相关系数和标准差均和观测相当）；
2. 在误差方面，MOS-Analog降尺度方法可以提升RCM的偏差和均方根误差；
3. 最重要的是，该方法明显降低了对降水频率的高估。

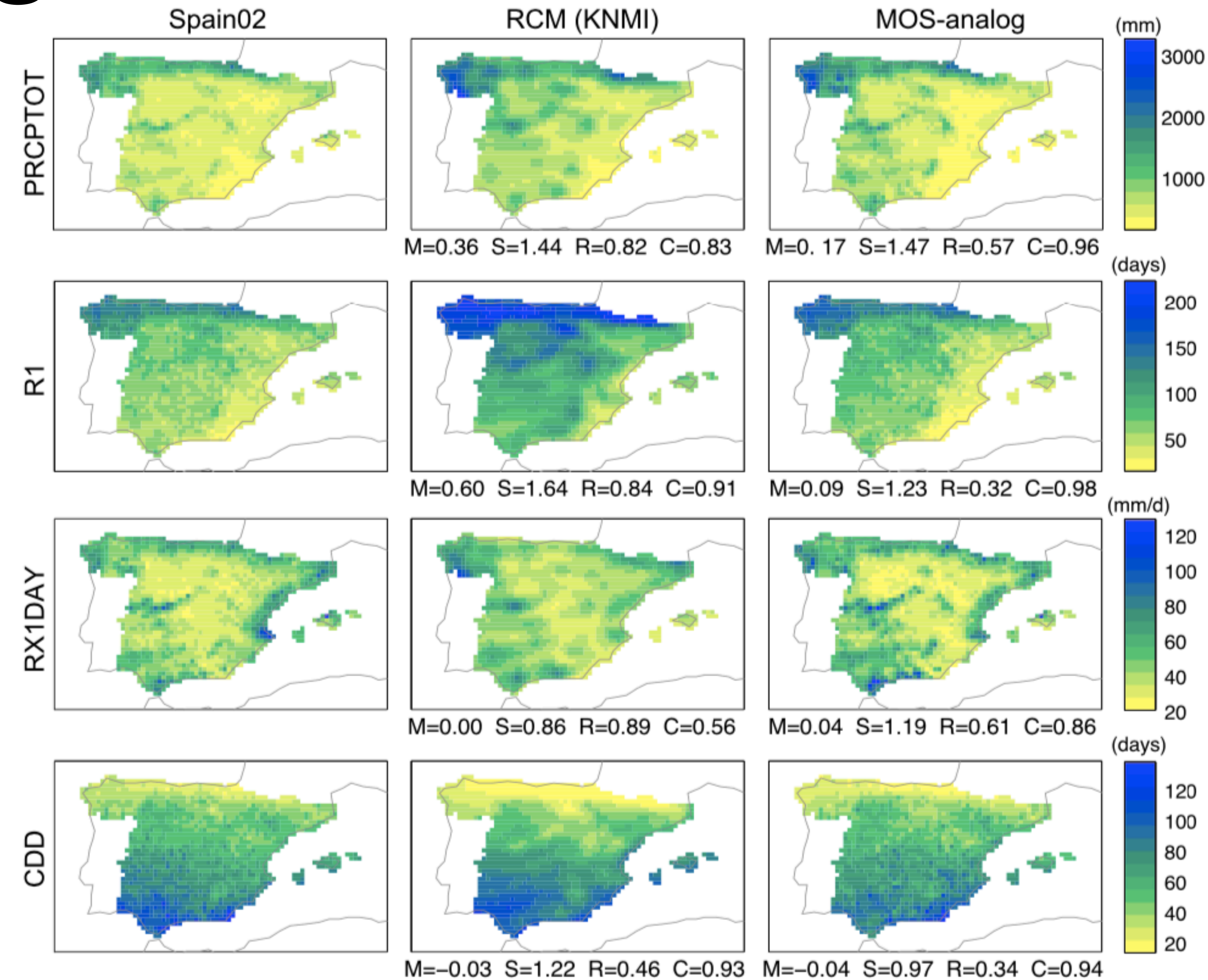


Figure 3. Spatial distribution of the observed (left column) Spain02, (middle column) RCM, and (right column) MOS-Analog mean values (averaged over the baseline period 1971–2000) for some of the precipitation indices shown in Table 2. The spatial validation scores for the RCM and MOS-Analog simulated values are given below the corresponding panels: mean error *M* (in % with respect to the observed mean); the relative standard deviation *S*; the centered root-mean-square *R*; and the correlation *C*.

Results

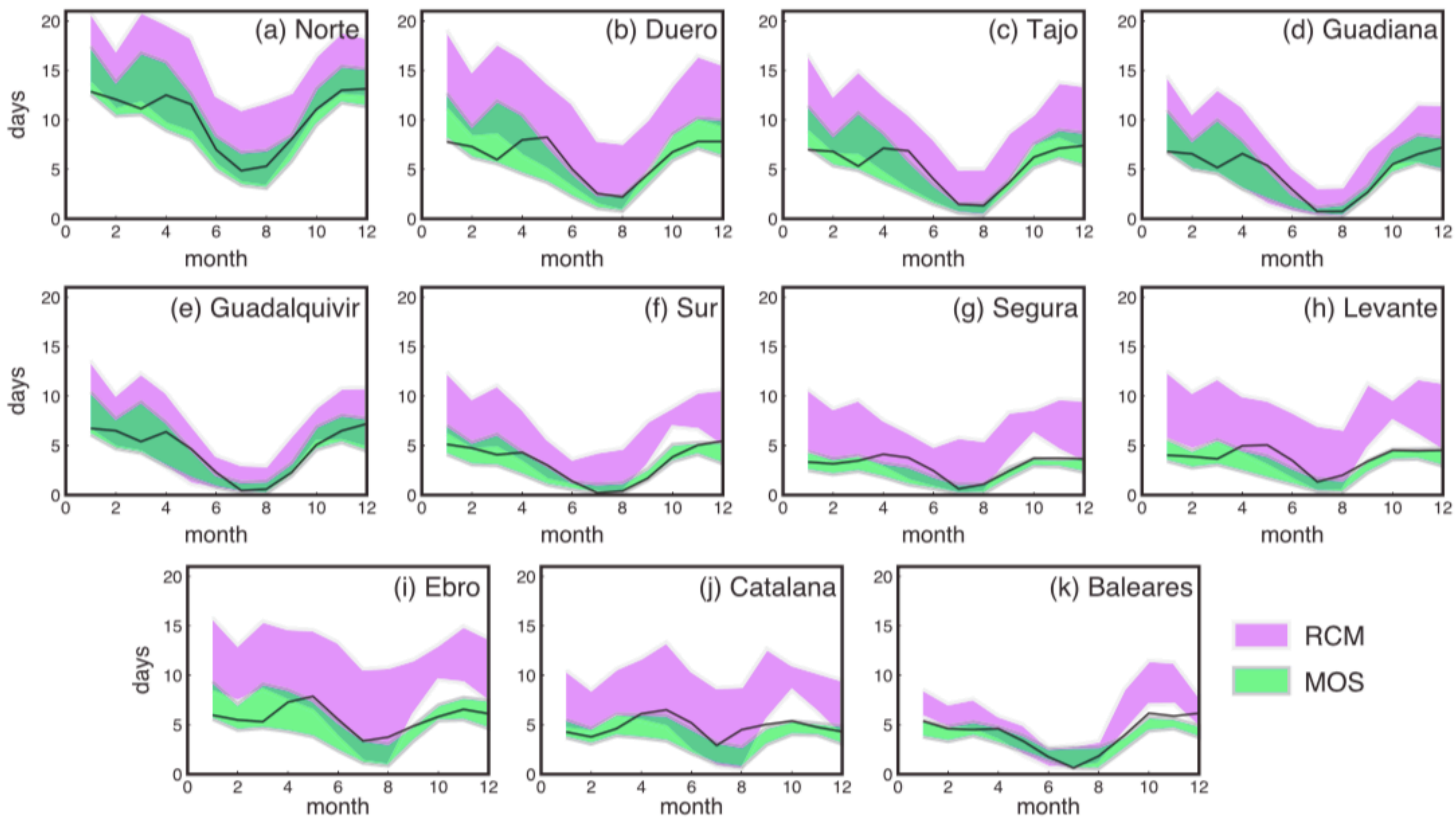


Figure 5. Seasonal cycle of the spatially averaged *R*1 index (in days) for each river basin (according to Figure 1). The black line represents the observed (Spain02) climatology. The violet-shaded band spans the values for the RCMs, while the green one spans the respective MOS downscaled values.

1. remarkable;
2. smaller uncertainty;
3. MOS-Analog校正了RCMs对降水的高估情况；
4. 再现了降水变量的季节循环特征。

1. 地中海盆地一年有两个极大值，第一个极大值在秋季，第二个在春季；
2. 其他类型的盆地，最大值出现在冬季，最小值出现在夏季。

Results

2011-2100

1. MOS和QQM两种方法各有千秋；
2. MOS和QQM方法都要和ENS比较？

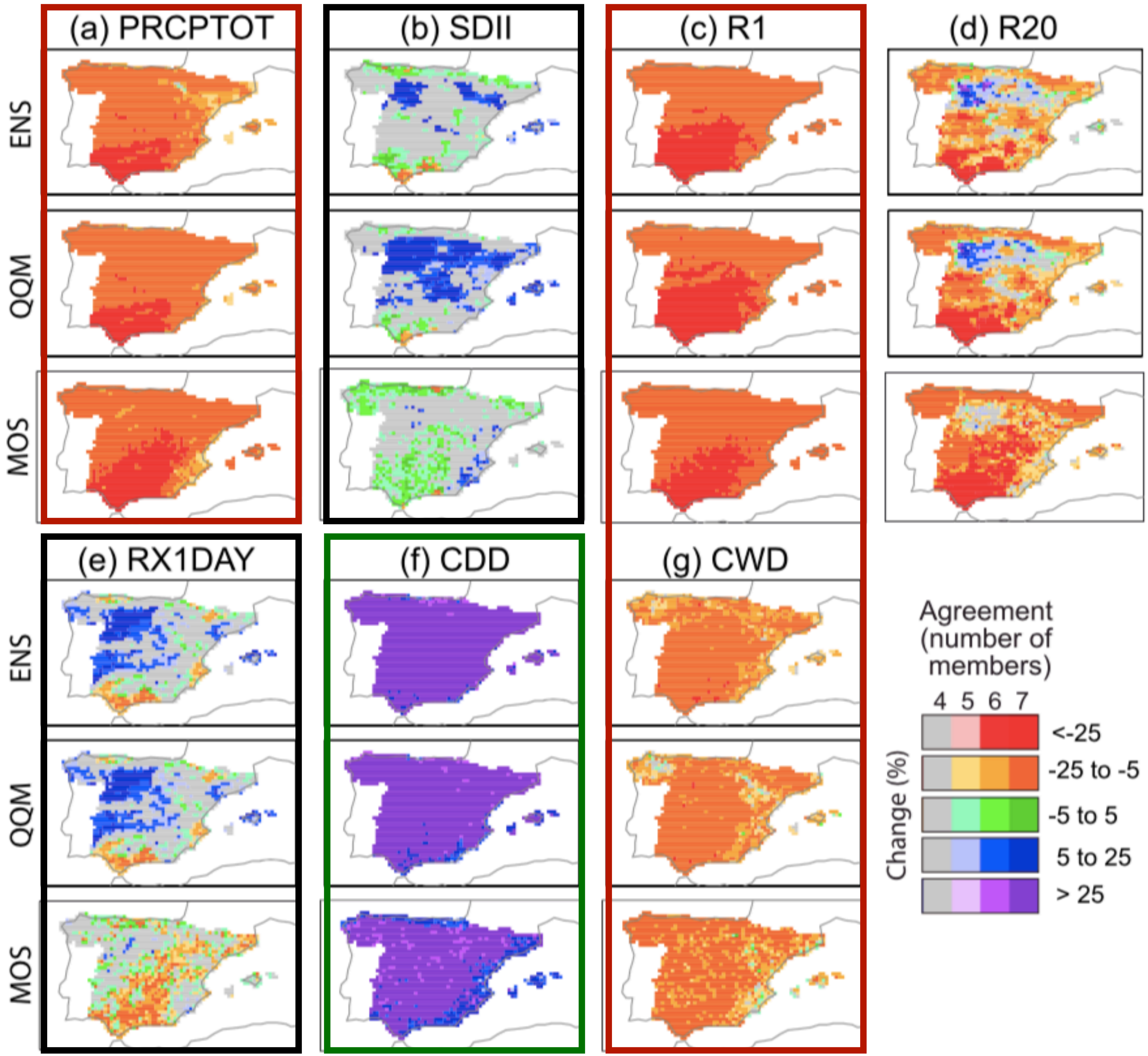


Figure 7. Future climate change signals (expressed as percentage of change with regard the baseline control period 1971 – 2000) for the period 2071 – 2100 for the precipitation indices shown in Table 2. The different rows correspond to the results for to the seven-member ensemble (ENS), the quantile mapping bias correction method (QQM), and the MOS-Analog downscaling method. The color saturation level shows the percentage agreement in the direction of change among the ensemble members.

Results

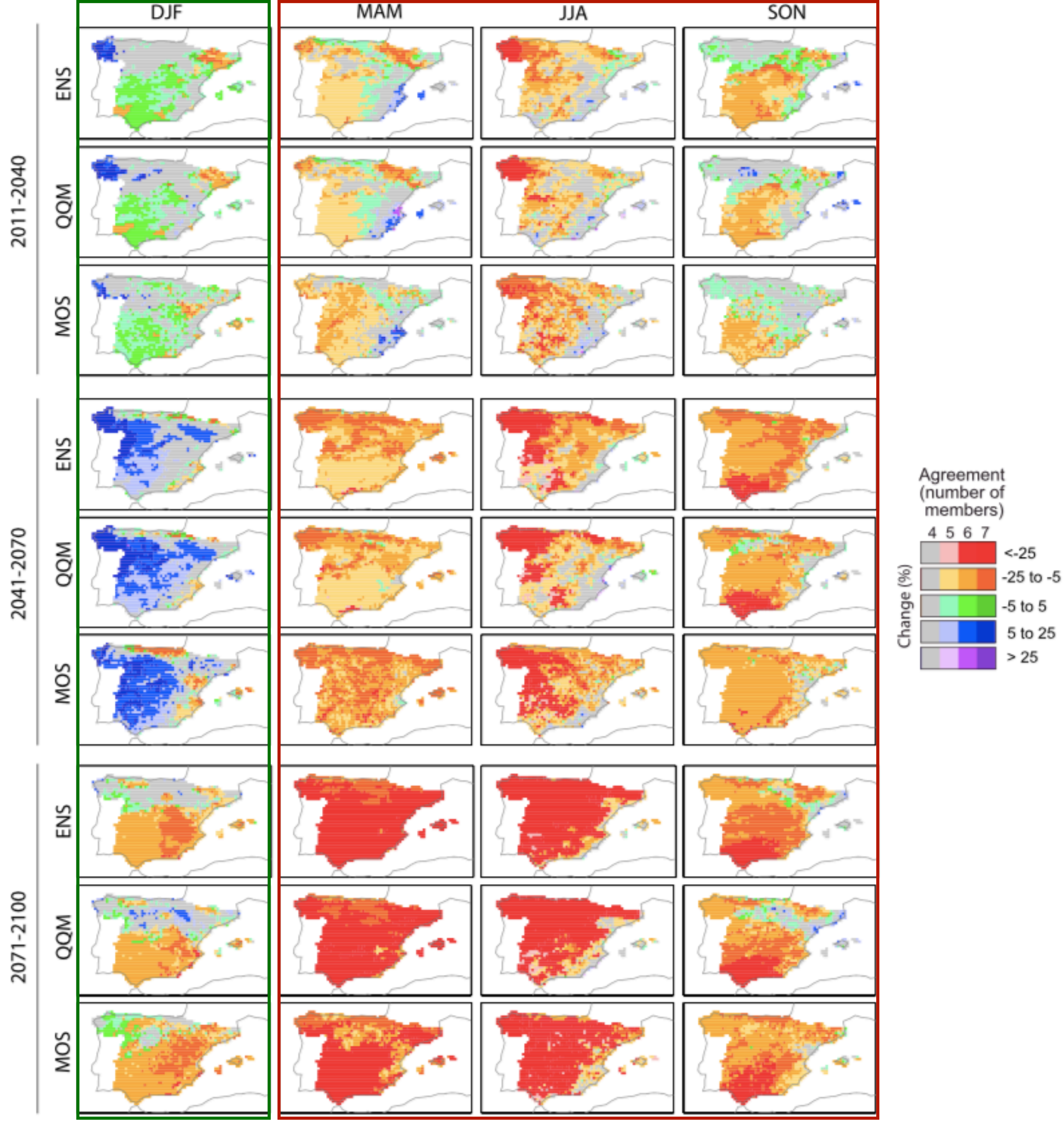


Figure 8. Seasonal changes of the precipitation index *PRCPTOT* for different future periods (2011–2040, 2041–2070, 2071–2100). Values for MOS-Analog (MOS), the quantile mapping bias correction method (QQM), and RCMs (ENS) are expressed in percentage of change between the baseline (1971–2000) and future periods. The color saturation level shows the percentage agreement in the direction of change among the ensembles.

Conclusions

1. MOS-Analog方法明显改进了RCM原始输出的偏差；对于未来，各个变量的变化非常一致，并且具有空间上的一致性；本文的模型结果为地中海地区不断增加的干旱提供了一定可信度；
2. RCM的气候变化信号通过基于分布的分位数映射方法得到了普遍保留，而MOS-Analog方法同样也保留了其气候变化信号；
3. 在获得更好的原始模型前，偏差校正方法依旧是一个临时解决方案。

谢谢