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Comparison of climate time series produced by General Circulation Models and by observed data on a global scale

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1. Abstract

Outputs of General Circulation Models (GCMs) for precipitation are compared with time series produced from observations. Comparison is made on global and hemispheric spatial scale and on annual time scale. Various time periods are examined, distinguishing periods before and after publishing of model outputs. Historical climate time series are compared with the outputs of GCMs for the 20th century and those for the A1B, B1 and A2 emission scenarios for the 21st century. Several indices are examined, i.e. the estimated means, variances, Hurst parameters, cross-correlations etc.

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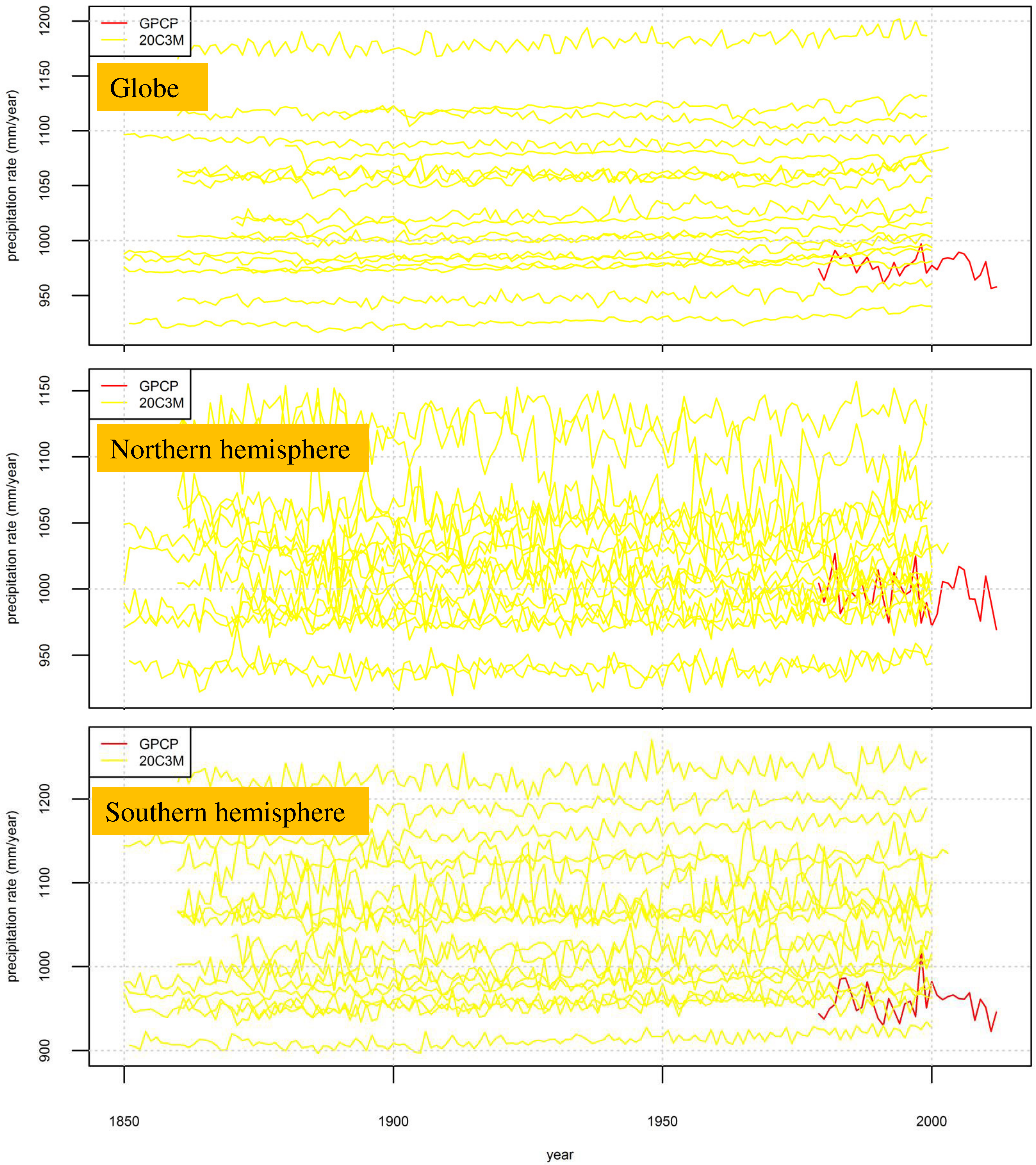
2. Introduction

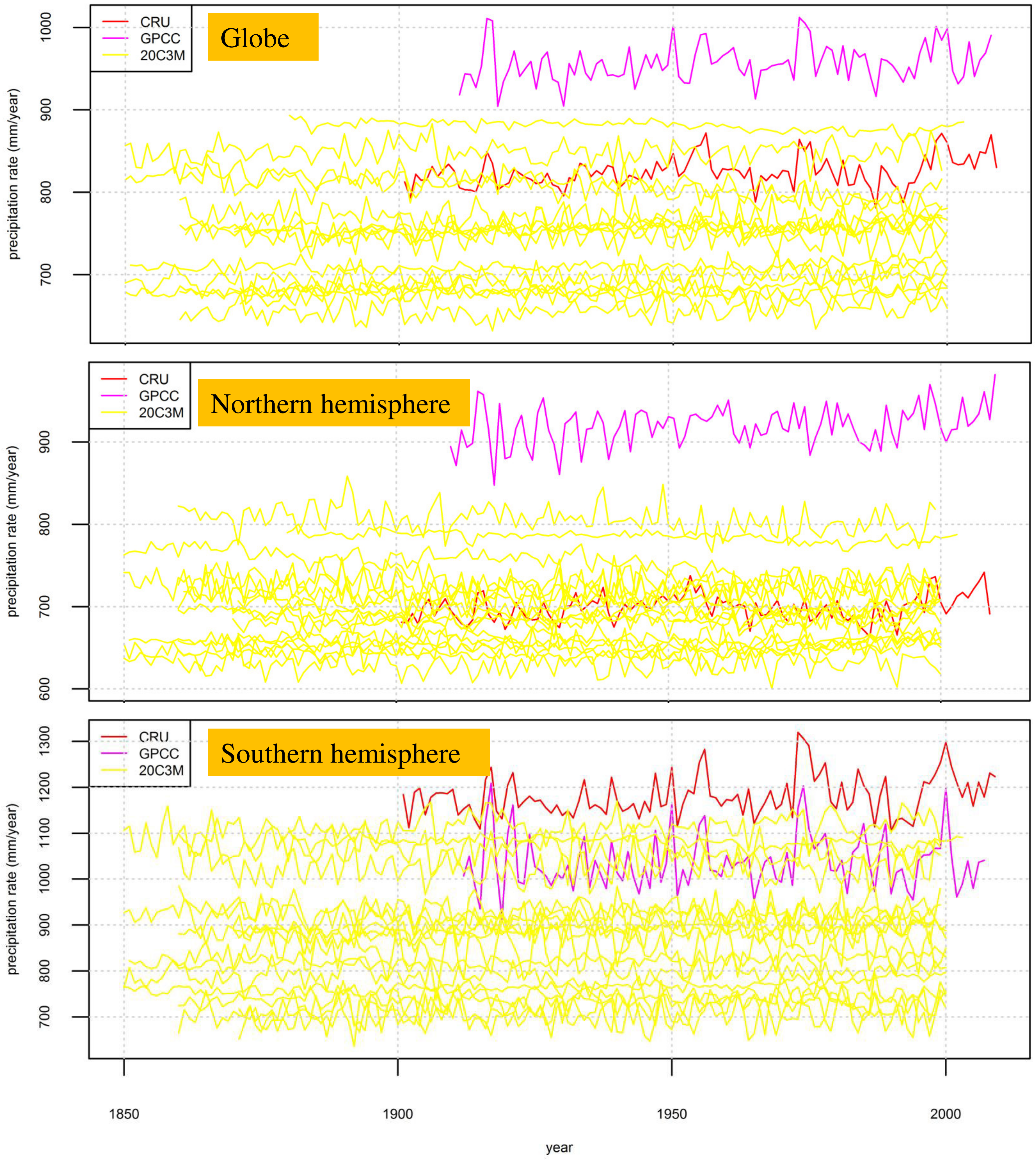
- Precipitation data at the annual time scale are compared to output of GCMs for the 20C3M, A1B, B1, A2 scenarios (Hegerl et al. 2003; IPCC 2000; IPCC 2007; IPCC-TGCIA 1999; Leggett et al. 1992).
- We examine:
  - land and land combined with sea regions;
  - the Southern, the Northern Hemisphere and the globe.
- The precipitation data sets are the GPCP Version 2.2 (Adler et al. 2003), the CRU TS3.10 .01 (Harris et al. 2013) and the GPCC Version 6.0 (Schneider et al. 2011).
- The GCM outputs for the IPCC Fourth Assessment Report (AR4) (IPCC 2007) are used for the comparison.
- Data and their integration on the above regions were obtained from the KNMI Climate Explorer web site (climexp.knmi.nl).
- The Hurst parameter, the standard deviation, the linear trend and the cross-correlation for corresponding time periods are estimated and compared.
- Previous similar studies have been performed for smaller regions e.g. Anagnostopoulos et al. (2010), Koutsoyiannis et al. (2008). It was shown that the GCMs for the 20C3M scenario failed to reproduce the past climate.
- Here almost 10 years after the preparation of the AR4, the predictions of the A1B, B1, A2 scenarios are compared to the obtained data sets in addition to the comparison with the 20C3M scenario.

3. 20C3M scenario for the land and sea regions



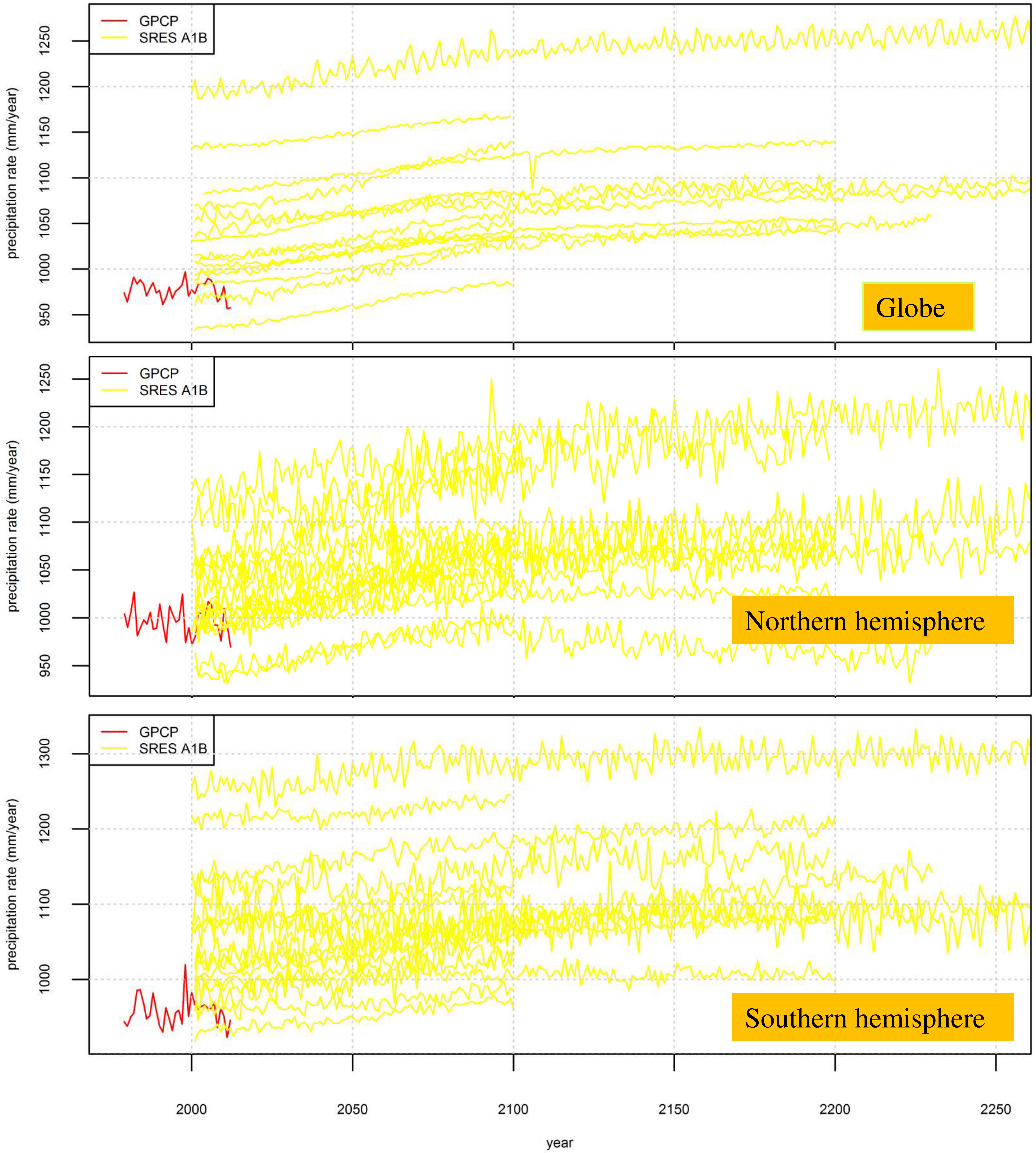
The Figures represent the annual precipitation rate per year. Notice the difference between the observed data (GPCP data set) and the GCM in terms of their means and standard deviations.

4. 20C3M scenario for the land regions



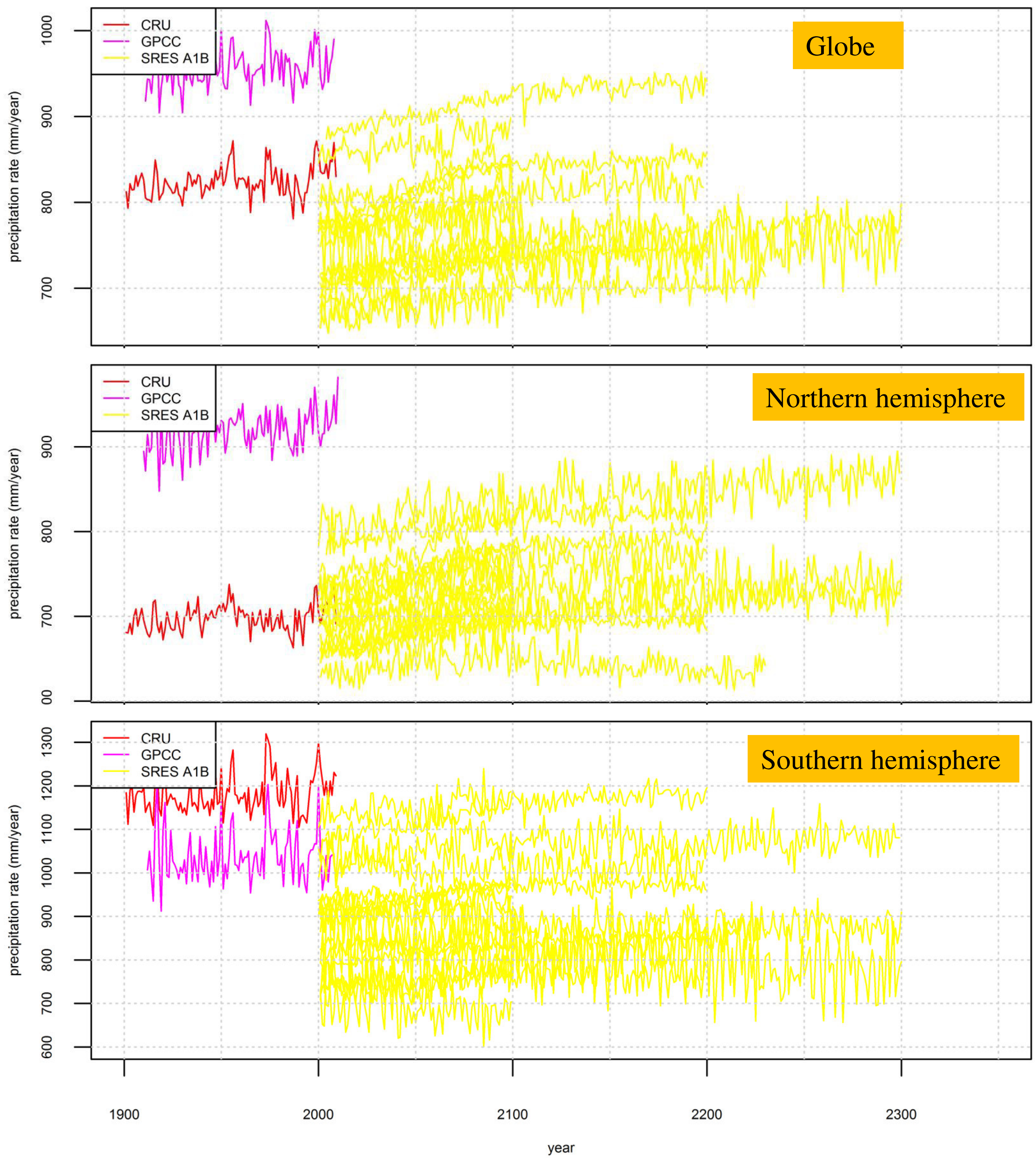
The Figures represent the annual precipitation rate per year. Notice the difference between the observed data (CRU and GPCC data set) and the GCM in terms of their means and standard deviations. Notice also the difference in the means of CRU and GPCC data sets.

5. A1B scenario for the land and sea regions



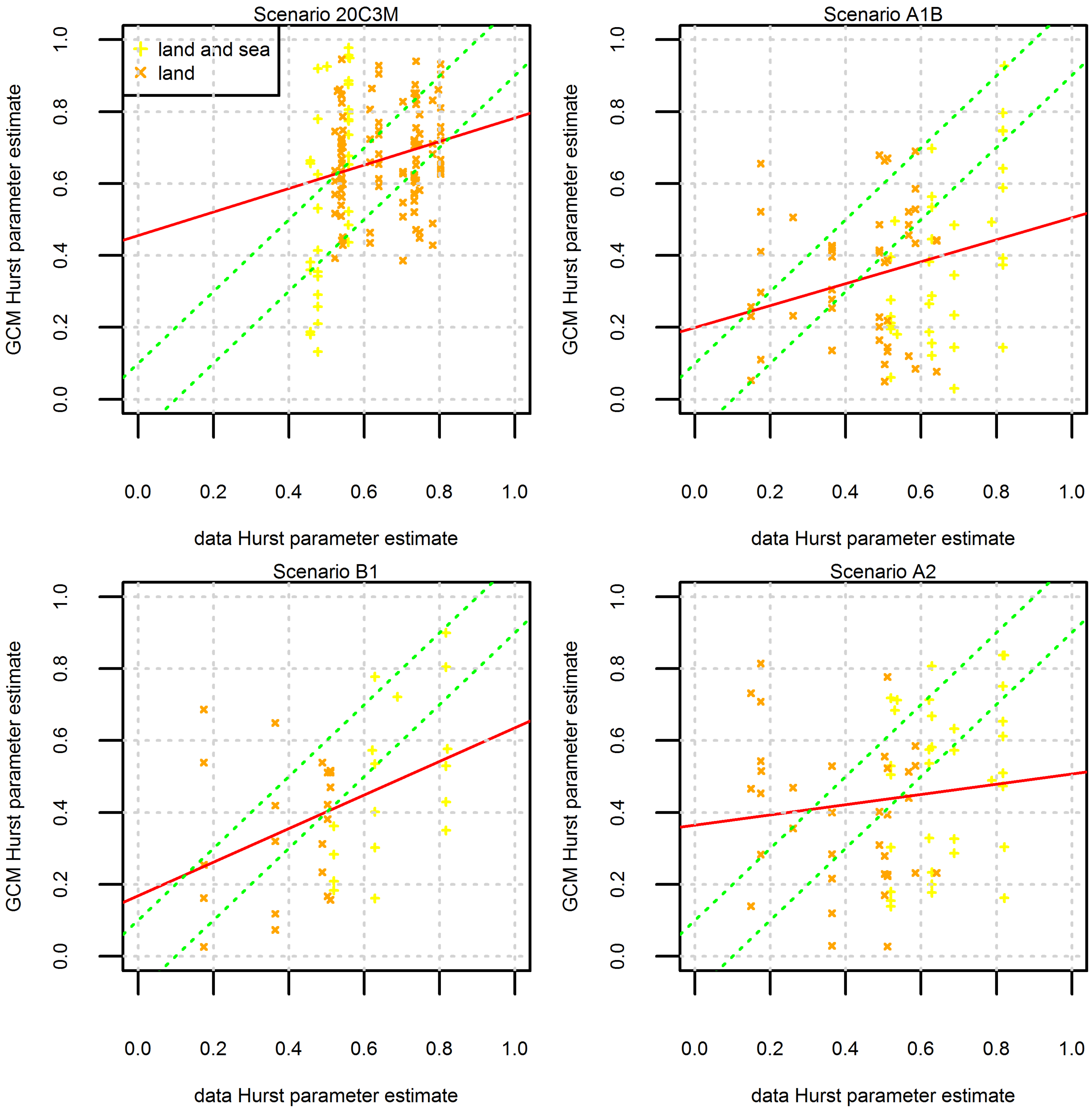
The Figures represent the annual precipitation rate per year. Notice the difference between the observed data (GPCP data set) and the GCM in terms of their means and standard deviations. Notice also that the GCMs predicted increase of the precipitation, which has not been verified by the data.

6. A1B scenario for the land regions



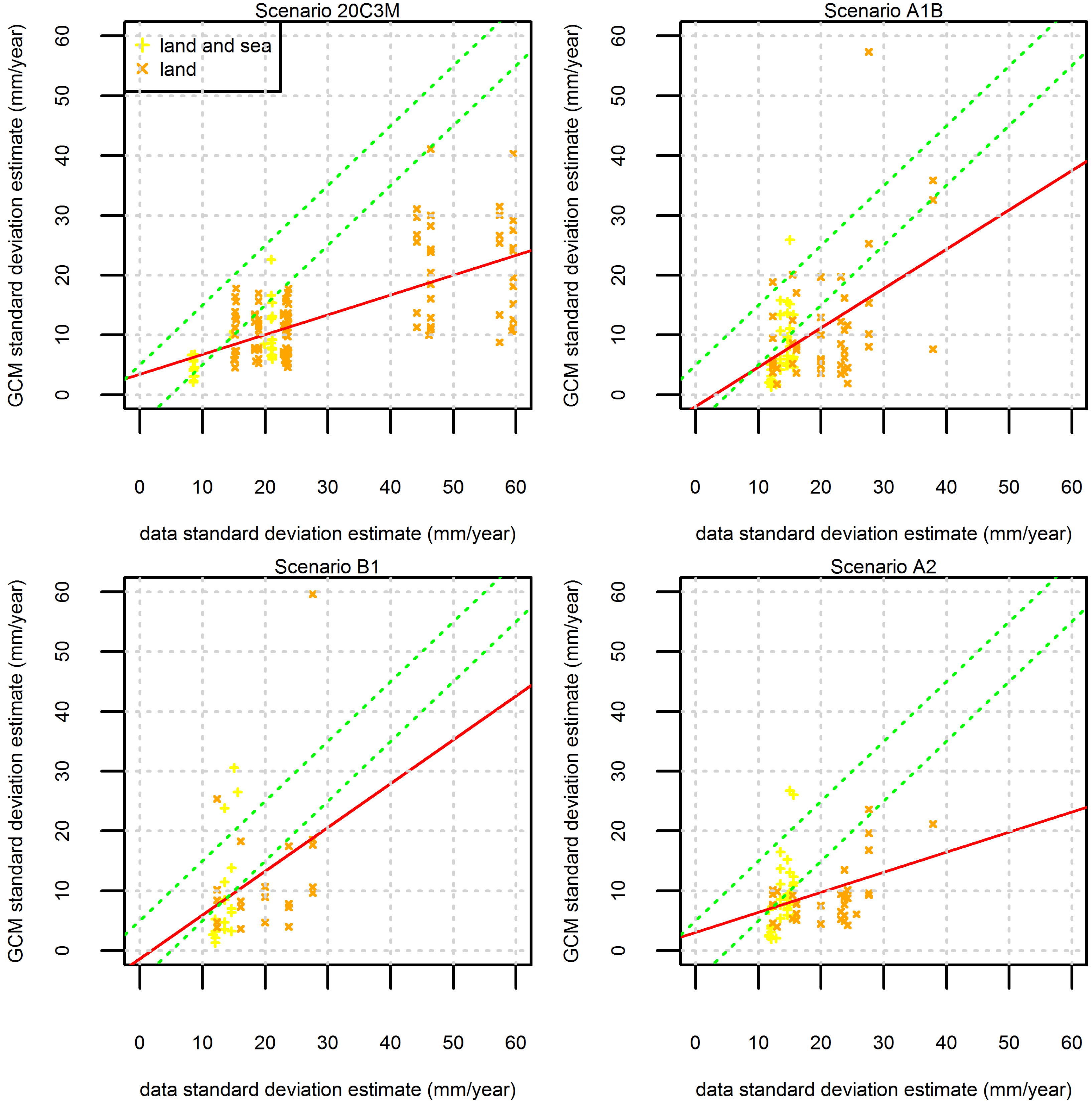
The Figures represent the annual precipitation rate per year. Notice the difference between the observed data (CRU and GPCC data sets) and the GCM in terms of their means and standard deviations. Notice also that the GCMs predicted increase of the precipitation, which has not been verified by the data except in GPCC data for the Northern Hemisphere.

7. Hurst parameter comparison



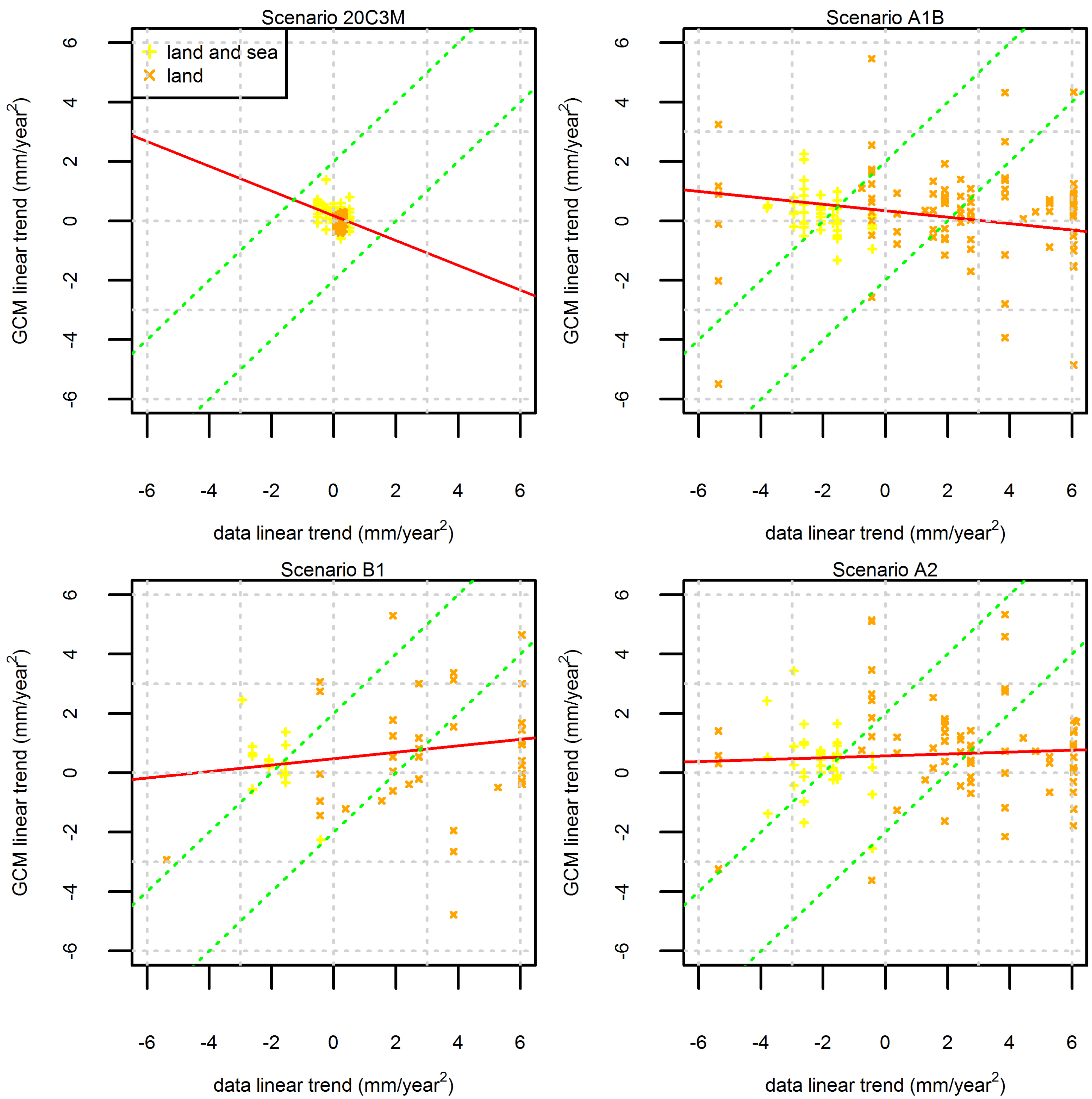
Green lines indicate differences between Hurst parameter estimates up to 0.2. Almost half of the models are out of this range.

8. Standard deviation estimate comparison



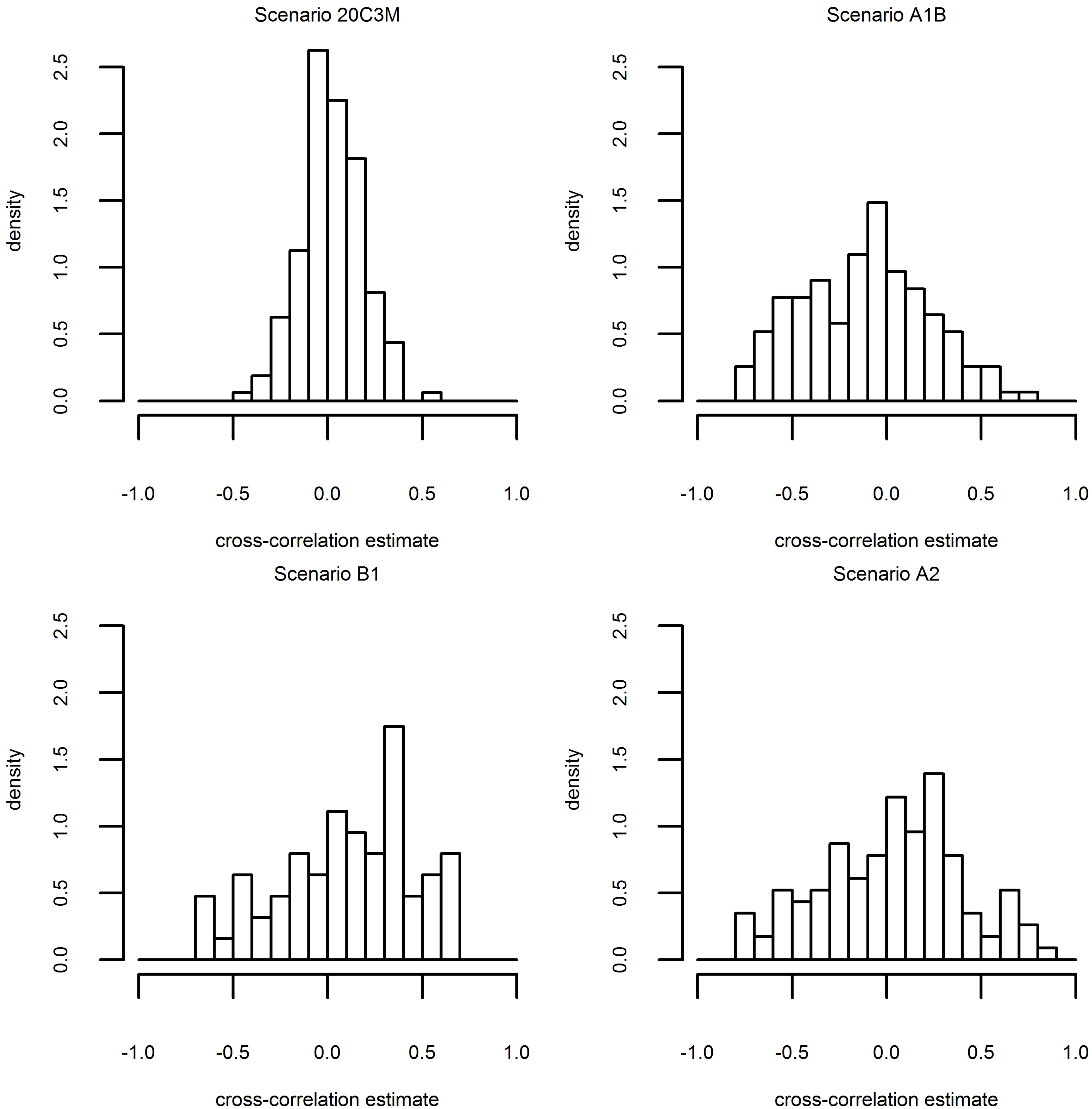
Green lines indicate differences between standard deviations estimates up to 10 mm/year. Almost 75% of the models are out of this range. Estimated standard deviations of models tend to be smaller.

9. Linear trend comparison



Green lines indicate differences between linear trend estimates up to 4 mm/year^2. The 20C3M scenario succeeded in representing the observed data, in which the trend is virtually 0. However almost 50% of the models for the A1B, B1, A2 scenarios are out of this range.

10. Cross-correlation estimate comparison



Cross-correlations for lag-zero estimates histograms between the annual values of the observed data sets and the outputs of GCMs. The cross-correlations for the 20C3M are concentrated around zero, whereas for the other models they are uniformly distributed in the whole domain.

11. Conclusions

- The GCMS do not reproduce:
  - the mean,
  - the standard deviation,
  - the Hurst parameter, and
  - the linear trend

  of the observed precipitation.
- The GCMS do not correlate adequately with the observed precipitation.
- Furthermore, there are discrepancies among the different data sets of global and hemispheric precipitation. In particular the estimated statistical parameters of the CRU and GPCC data sets (observed precipitation) have differences at the annual time scale. However, they correlate adequately as shown in the table below.

	Southern hemisphere		Northern hemisphere		Global	
	CRU	GPCC	CRU	GPCC	CRU	GPCC
Hurst parameter	0.75	0.53	0.76	0.56	0.83	0.61
Standard deviation (mm/year)	47.09	58.39	16.21	23.34	20.21	22.99
Linear trend (mm/year^2)	0.39	0.12	0.12	0.22	0.21	0.19
Cross-correlation	0.84		0.67		0.78	

12. References

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