Global Changes of seasonal extremes and mean from precipitation daily climate model data

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Summary

We use data from the Essence project, in which a 17-member ensemble of climate change simulations in response to the SRES A1b scenario has been carried out using the ECHAM5/MPI-OM climate model. The large size of the dataset gives the opportunity to detect with high statistical confidence the variability of climate extremes and means. Daily precipitation data are used to calculate the seasonal precipitation maximum and the seasonal mean. The data are split into three time periods of 25 years. Within each set of 25 years the data are tested for dependence to make sure that they are i.i.d. The seasonal peaks are modelled by using the Generalized Extreme Values (GEV) distribution, while empirical distributions are used to study changes of the seasonal precipitation mean. Results indicate that over most of the world precipitation maxima are increasing in the future. Seasonal means behave differently. In many regions they are not increasing and are not significantly correlated with the seasonal peaks.

Introduction

Changes in extreme weather and climate events have significant impacts and are among the most serious challenges to society in coping with a changing climate *CCSP* [2008]. Indeed, "confidence has increased that some extremes will become more frequent, more widespread and/or more intense during the 21st century" *IPCC* [2007]. As a result, the demand for information services on weather and climate extremes is growing. The sustainability of economic development and living conditions depends on our ability to manage the risks associated with extreme events. By using a 17-member ensemble of daily precipitation output in response to the SRES A1b scenario from the ECHAM5/MPI-OM climate model (for details see *Sterl et al.* [2008]), we demostrate that the future behavior of 100-years return levels of seasonal precipitation maxima differs significantly from that of the seasonal precipitation means.

The block maxima approach and the empirical distribution

To study changes in seasonal precipitation means we use the empirical didtribution, while the generalized extreme value (GEV) distribution is used to model seasonal precipitation maxima. According to the extremal types theorem [*Coles*, 2001] the GEV provides a model for the distribution of block maxima. The data are split into six period of 25 years and then divided into blocks of equal length of one season. The GEV is fitted to the set of 17(ensemnles)*25(seasonal peaks) of block maxima, and the empirical distribution is used for the set of 17(ensembles)*25(seasonal mean). The GEV fit is done by using the Maximum-Likelihood fitting implemented in the R package ismev (http://cran.r-project.org/web/packages/ismev/index.html).

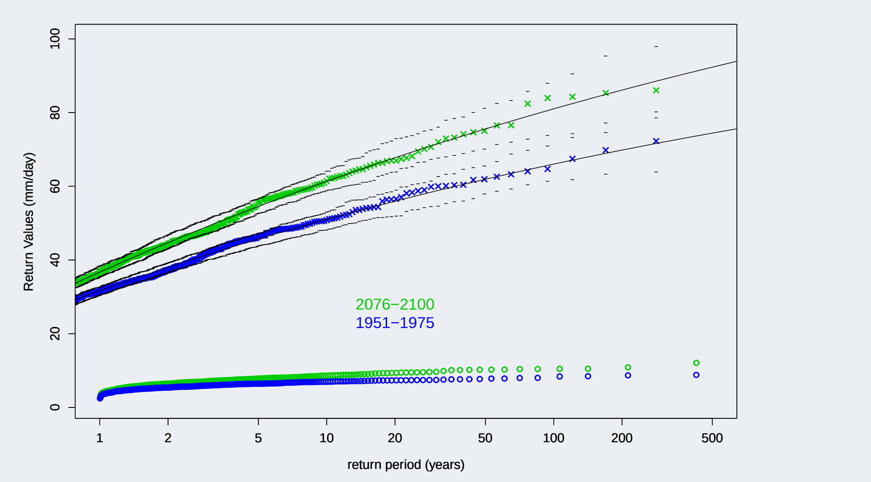

Figure: 1) Return level plot at grid point (44W,20S)

Figure 1 shows the return level plots of precipitation peaks and seasonal means calculated for the season SON at grid point 44W, 20S. The blue and green colors are related to the periods 1951-1975 and 2076-2100, respectively. The crosses represent the seasonal peaks, while the open circle are related to the seasonal means. The black lines represent the results of the GEV fits and the dashed black lines are the level of confidence at 95%. In our global results we show the 100-years return levels, the precipitation value corresponding to a return period of 100 years (see fig. 1)

Results

Fig. 2 shows the differences of 100 years return levels for seasonal means and extremes for three periods: period-1=(2001:2025), period-2=(2051:2075), period-3=(2076:2100) with respect to the first period (1951:1976). The colorbar is in mm/day and represents precipitation anomalies with respect to the reference period (1951:1975).

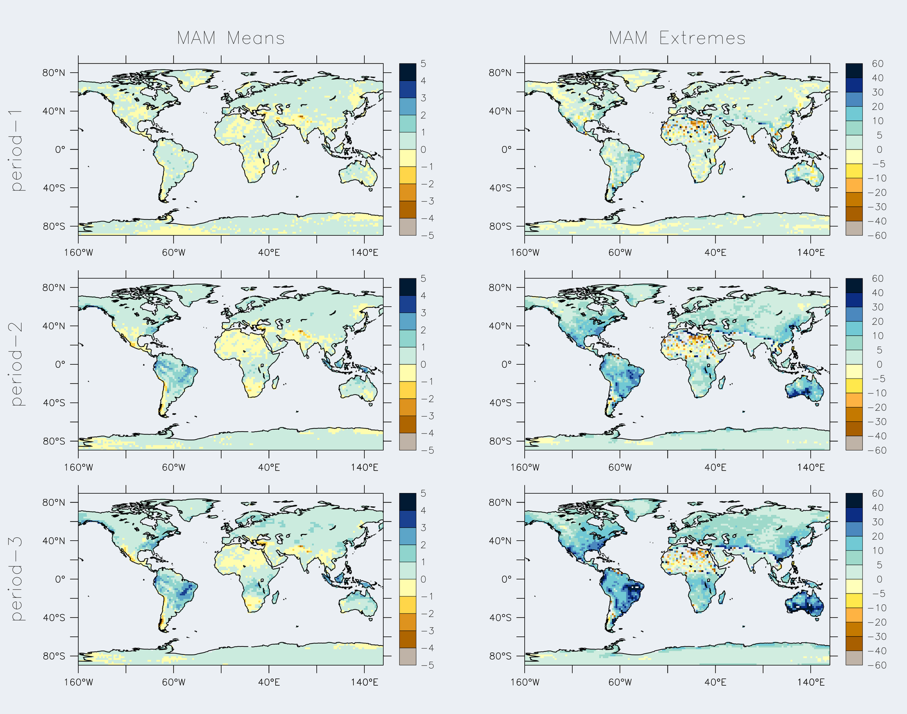

Figure: 2a) 100 years return level differences.

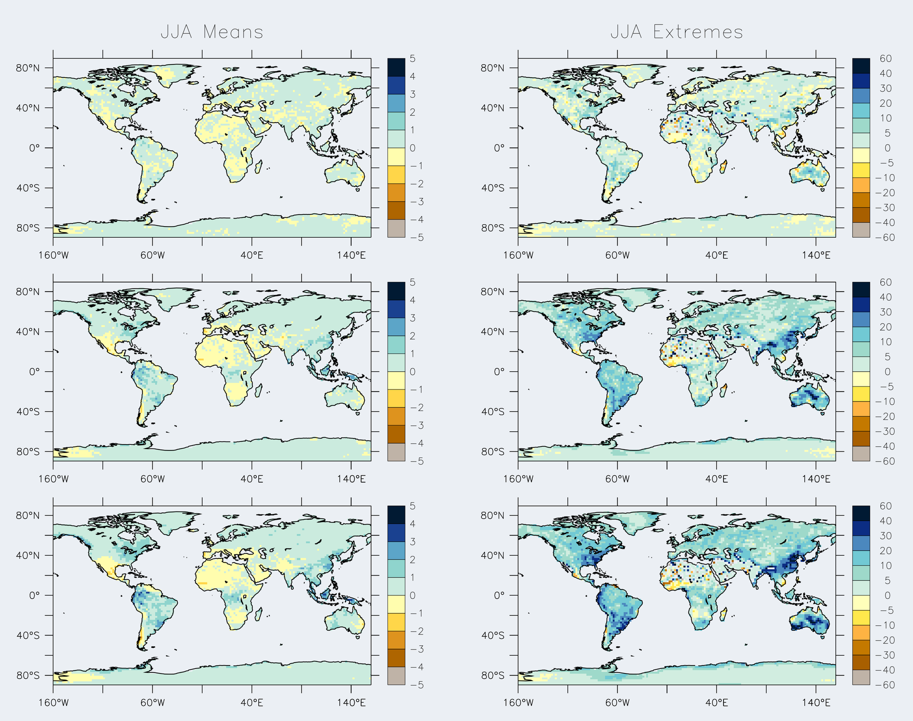

Figure: 2b)

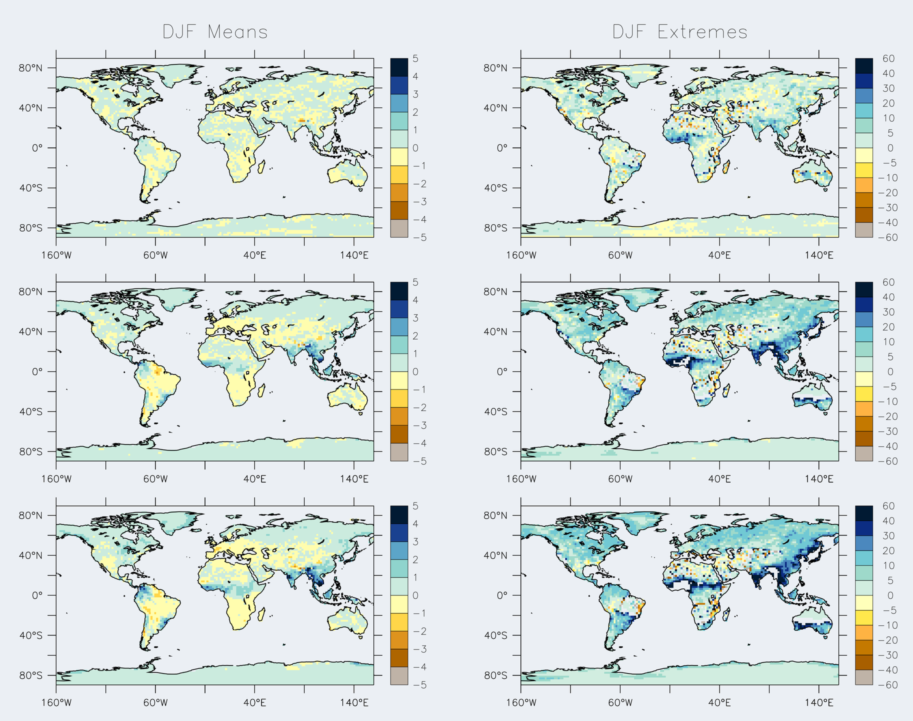

Figure: 2c)

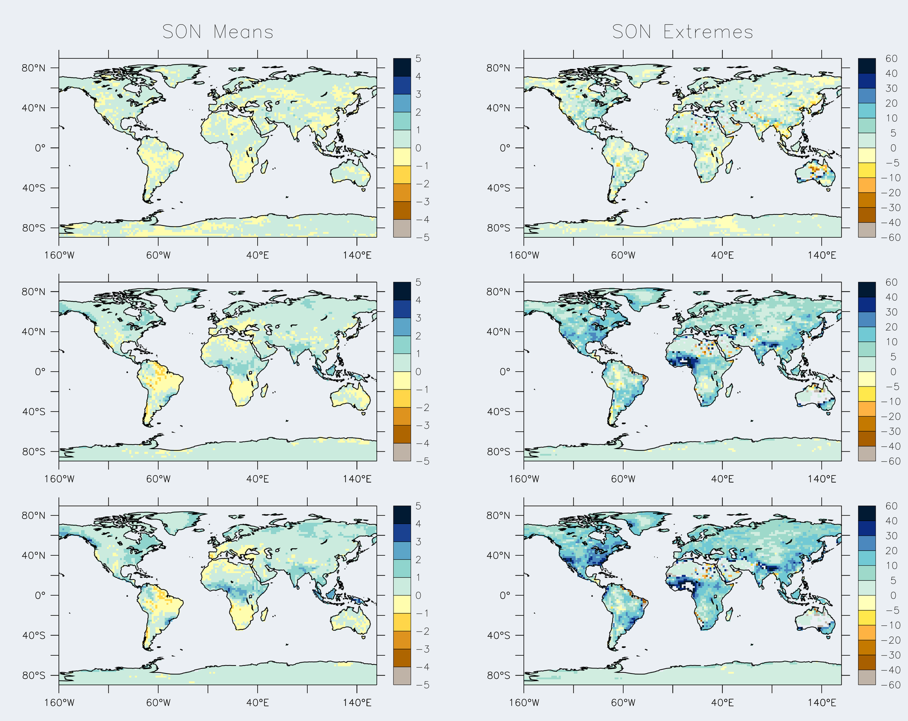

Figure: 2d)

The extremes are increasing nearly everywhere. The change in seasonal mean precipitation is small or negative in 45^oS - 45^oN, whereas the magnitude of extreme precipitation is strongly increasing in the same zonal band, except for the North of Africa where we have decreasing of the mean and low mixed changings of the extremes. Elsewhere, particularly on the second and the third periods studied, and throughout each season, both mean and extreme precipitation are increasing. The values of the anomaly of 100 years seasonal mean return periods do not 2 mm/day in the extratropical region. In the same region the increase of the 100 years seasonal peaks is higher. There is no clear correlation between the change of seasonal means and peaks. This is because the probability distributions of daily precipitation from past to future are not only shifting, but their scale and skewness parameters are also changing. Looking to patterns it seems that during spring-summer seasons the dry areas (see Northen Africa JJA), are becoming drier, while in fall-winter seasons wet areas are becoming wetter (see JJA Northen Latin America). Furthermore, changes in the period 2001-2025 have the same pattern as those in the later periods, but lower magnitude.

Conclusion

The seasonal precipitations peaks are increasing over the entire Globe for each season. Increases in the intensity of precipitation extremes exceed those for mean precipitation nearly everywhere. Extreme precipitation decrease or increase lowly only in a small fraction of tropical-subtropical area where seasonal mean precipitation decreases. The increase in the last two studied periods is higher then in the past and the maximum changes in the Northern and Southern hempispheres are recorded in boreal (DJF) and austral (JJA) winter, respectively. From past to future the spatial patterns are the same with dry areas becoming drier and wet areas becoming wetter. This is a preliminary analisys of our model precipitation output. Next we will assess the significance of the changes found. Furhtermore, we will try to find relations between chagnes in extremes and means, respectively.

Some References

1. CCSP (2008) http://downloads.climatescience.gov/sap/sap3-3/sap3-3-final-all.pdf; 2. IPCC 2007, Solomon et al. (2007), Climate Change 2007, The Physical Science Basis. *Cambridge University*. 3. Coles, S. (2001),An introduction to statistical modeling of extreme values,*Springer, London.*. 4.Sterl, A. et.al.(2008),When can we expect extremely high surface temperature?,*Geophys. Res. Lett.*,.