Simulation of the observed climate extremes trends during 1901–2010 with INMCM5

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Introduction

- Extreme climate and weather events have a great influence on society and natural systems.
- The magnitude and frequency of these events alter under changing climate.
- To predict future extremes changes it is important to be able to simulate observed ones.
- Global climate models can be used to simulate extreme events and trends of their altering.
- In the present work we asses the ability of the INM RAS climate model to simulate observed extreme events trends.

Data

- Climate extremes trends are studied on the basis of ten historical runs with the up-to-date INM RAS climate model (INMCM5) [1].
- The runs covering 1850–2014 years are made under the scenario proposed for the Coupled Model Intercomparison Project Phase 6 (CMIP6) [2].
- Developed by ECMWF ERA-20C [3] and CERA-20C [4] reanalyses are taken as observational data.
- These reanalyses were chosen because they are state-of-the-art and completely cover the XX century.
- The reanalyses data comes in gridded form and is available in INMCM5 resolution $2^\circ \times 1.5^\circ$.

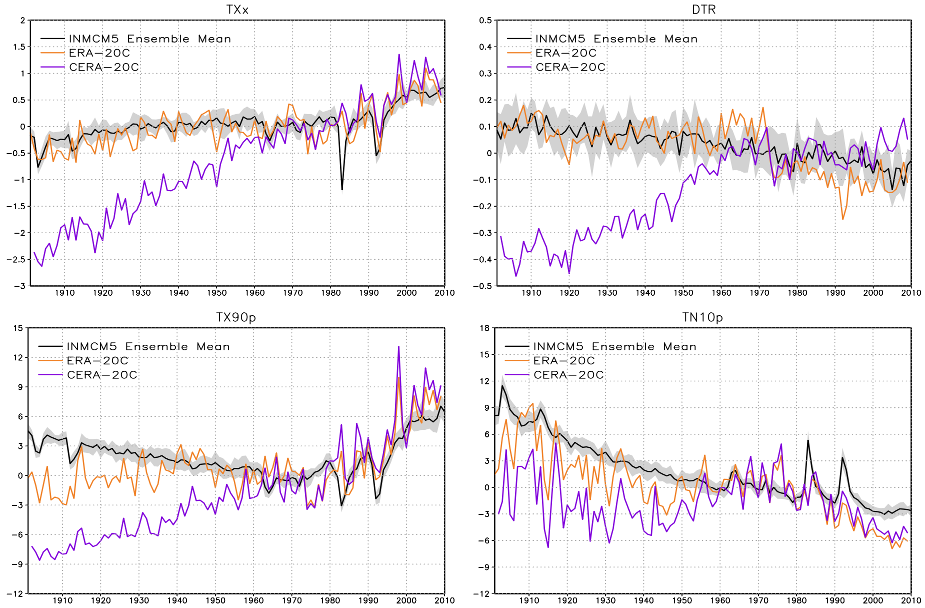
Method

- In our study 27 indices developed by ETCCDI [5] are used as quantitative measure of climate extremes events.
- These indices are calculated in order to estimate their trends simulation by the INM RAS climate model.
- Both land-averaged and pointwise trends are studied.
- Land-averaged trends are obtained by subtracting averaged index value for the base period 1961–1990.
- Pointwise trends are obtained by comparing indices averaged over two time intervals (1960–1974 and 1995–2009). Two-sided Mann–Whitney test is used to examine whether this change is significant or not.
- The test is applied independently for each node of the spatial grid. The sample is formed by the index values at this point for the selected period of years.

Results representation

- For the INMCM5 data the ensemble mean is plotted with black solid line and gray shading indicates 1 standard deviation within the ensemble.
- The average index value for 1961–1990 period is subtracted to normalize each trend.
- Spatial distributions show colored filling only where the results are statistically significant. The significance level is chosen as 1% for the temperature extreme indices and as 5% for the precipitation ones.

Temperature extremes trends



- Trends of the maximum daily maximum temperature (TXx, °C), diurnal temperature range (DTR, °C), percentage of warm days (TX90p) and cold nights (TN10p) calculated with INMCM5, ERA–20C and CERA–20C data are shown on the graphs above.

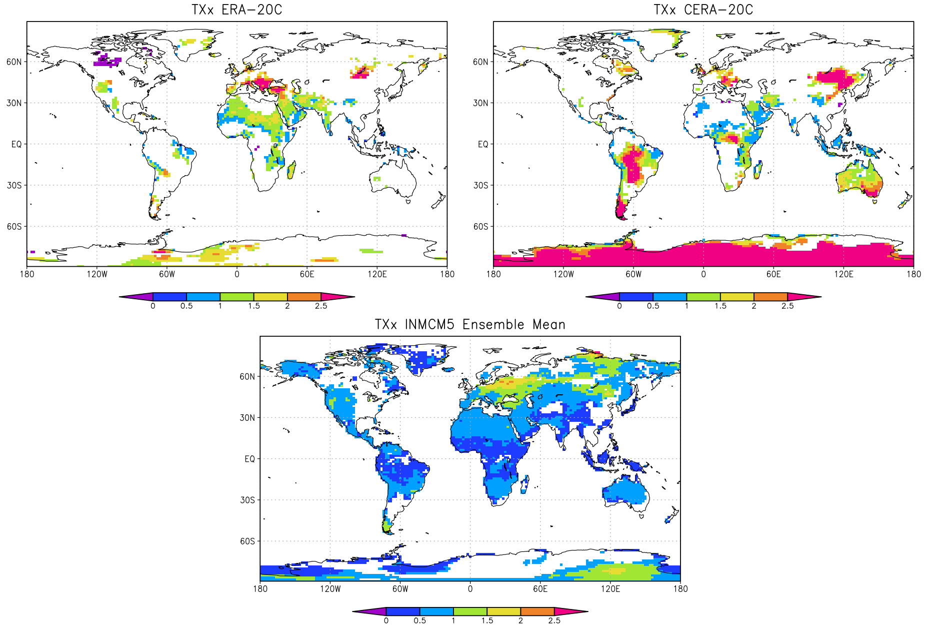
- From the second part of XX century trends obtained from different sources are in good agreement for all considered indices except DTR.

- For DTR both INMCM5 and ERA–20C shows slow decrease during the whole considered time interval, but CERA–20C demonstrate confident increase with it’s slight slow-down from the second part of XX century.

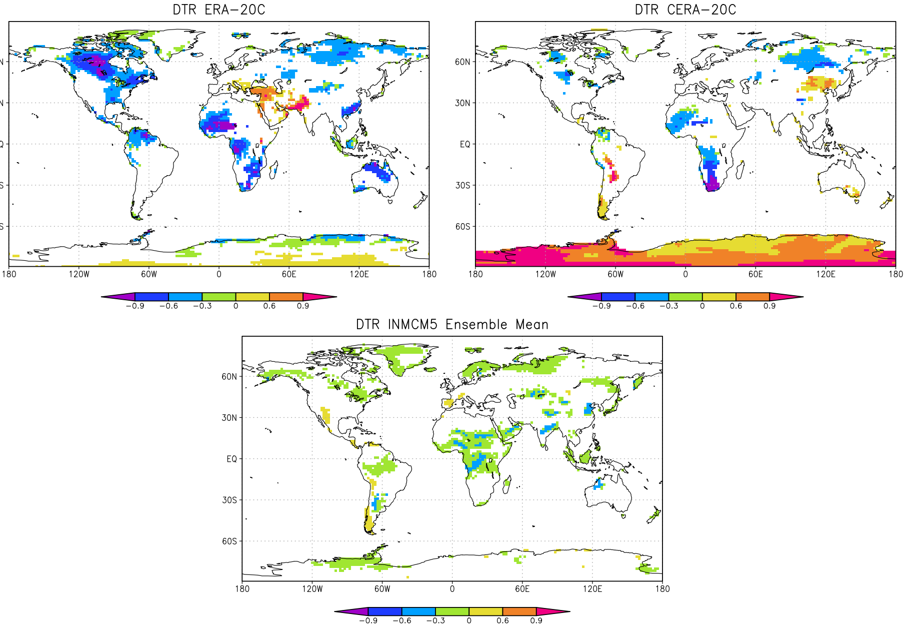
- In the first part of XX century CERA–20C trends for TXx, DTR, TX90p greatly vary from INMCM5 and even from ERA–20C.

- For TN10p all sources during the 1901–2010 show steady decrease with some sharp increases corresponding to volcanic eruptions. For this index INMCM5 demonstrates fast decrease in the first half and moderate decrease from the second half of XX century. In contrast ERA–20C and CERA–20C show medium decrease in the first half and fast from the second half of XX century.

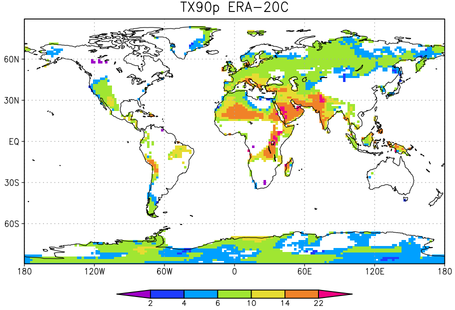
TXx (°C) changes from 1960–1974 to 1995–2009

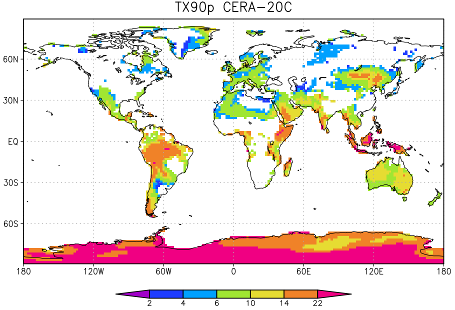


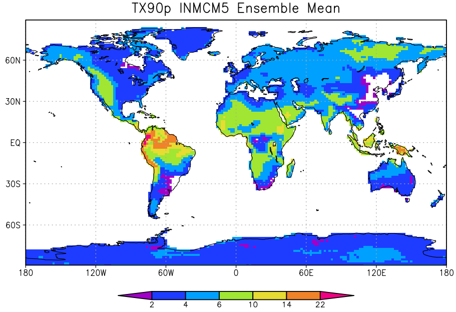
DTR (°C) changes from 1960–1974 to 1995–2009



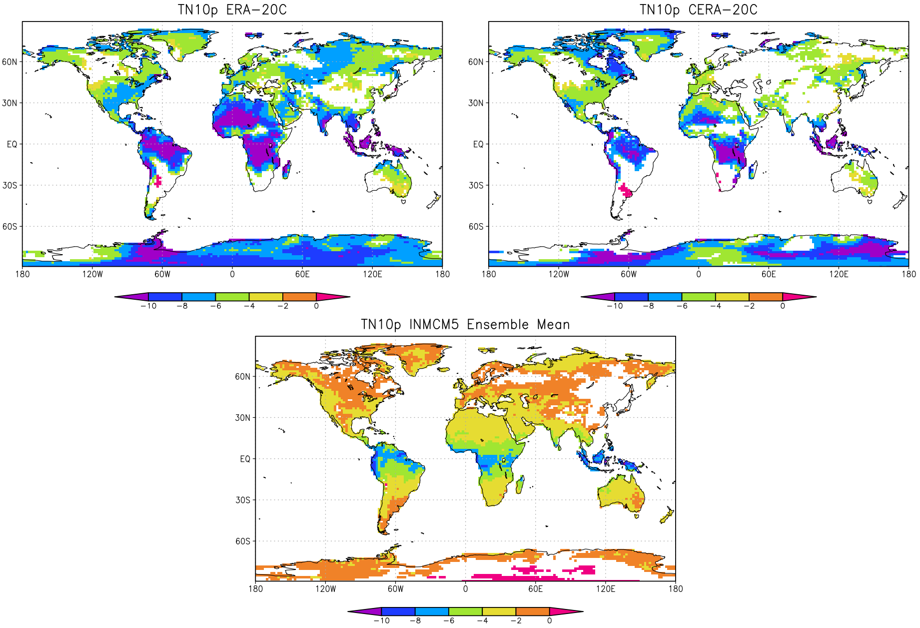
TX90p (%) changes from 1960–1974 to 1995–2009





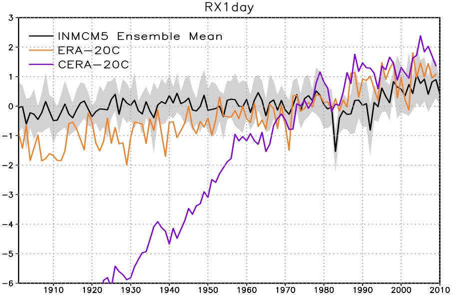


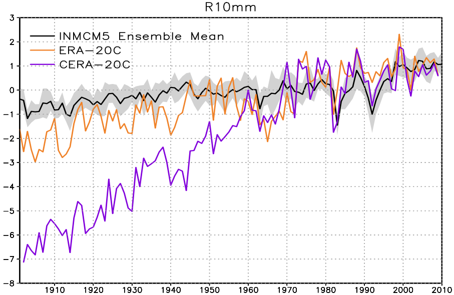
TN10p (%) changes from 1960–1974 to 1995–2009

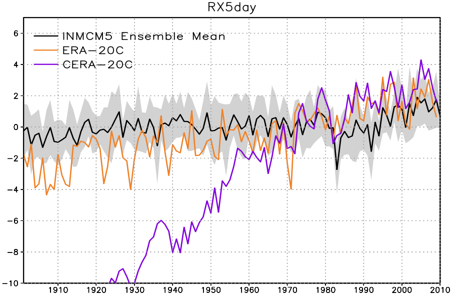


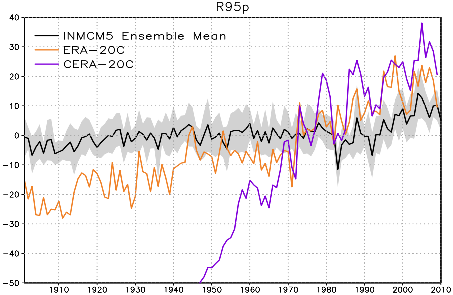
- For all considered temperature indices their changes in INMCM5 are spatially distributed over large areas, whereas reanalyses have quite local changes. Accordingly absolute changes in INMCM5 are less than in reanalyses data.
- The extremal changes in INMCM5 indices are mostly located in same regions where reanalyses extrema are.
- For diurnal temperature range INMCM5 simulate the insignificant areas in good agreement with reanalyses.
- For indices based on maximal daily temperature there are differences in ERA–20C and CERA–20C results in Amazon Basin, Australia, East and Southeast Asia.

Precipitation extremes trends



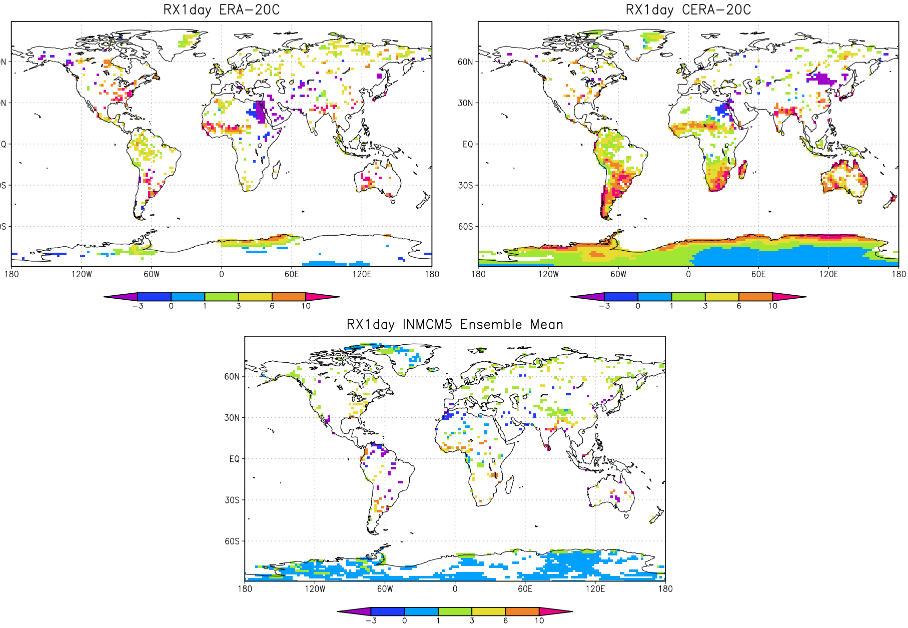




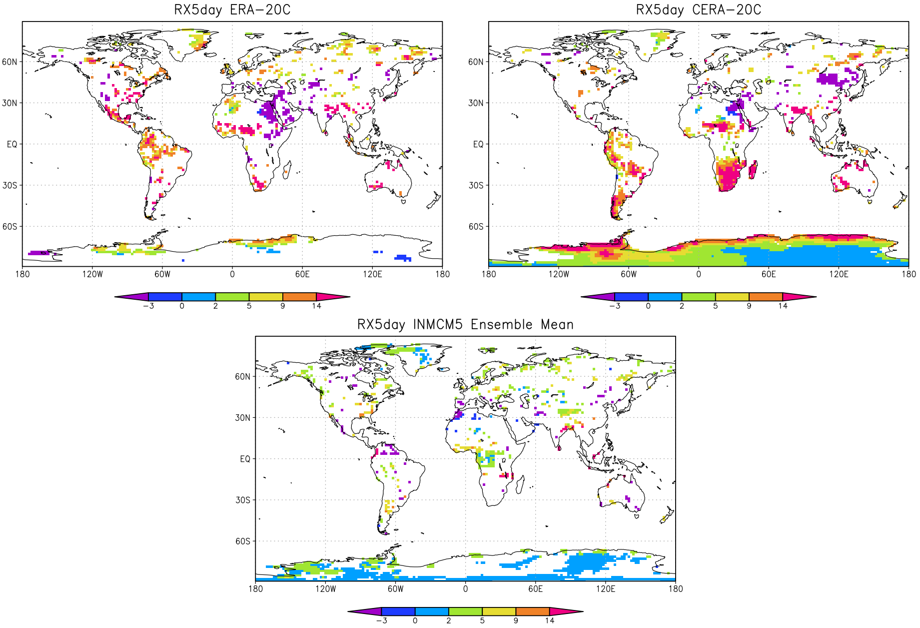


- Trends of the maximum 1 and 5 day precipitation (RX1day and RX5day, mm), count of heavy precipitation days (R10mm), precipitation amount on very wet days (R95p, mm) calculated with INMCM5, ERA–20C and CERA–20C data are shown on the graphs above.
- For all indices CERA–20C shows rapid growth until 1960–1970. After 1970 CERA–20C demonstrates the same increase rate as ERA–20C.
- Changes in R10mm from all three data sources are in good agreement since 1970. The INMCM5 shows constant slow increase rate over the whole period. ERA–20C has a little bigger, but also constant rate.
- Indices RX1day and RX5day have very similar behavior. INMCM5 indicates no changes in them until 1970 and after 1970 there is slow increase in agreement with ERA–20C and CERA–20C.
- For very wet days precipitation amount both reanalyses demonstrate faster growth rate than INMCM5.

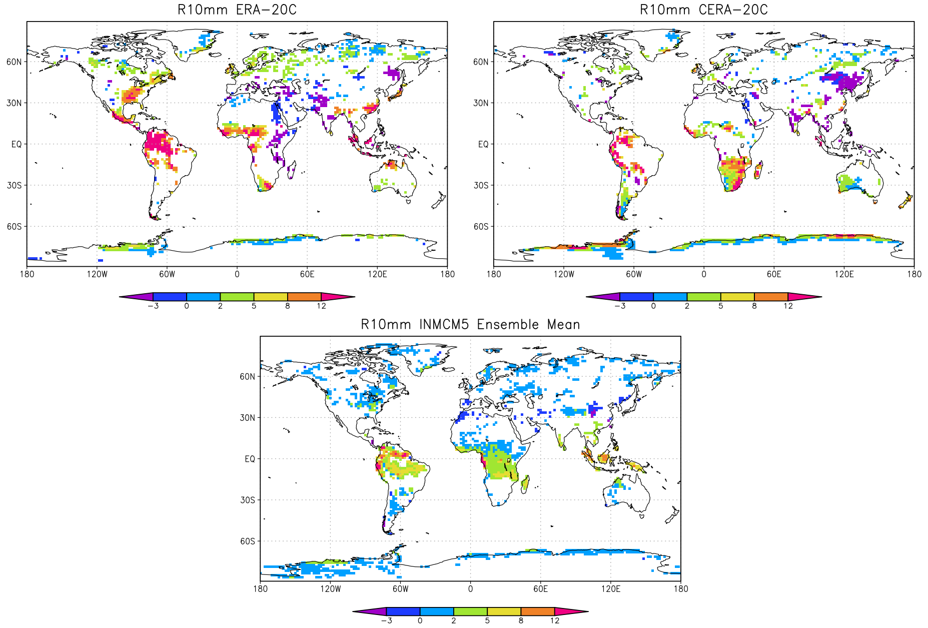
RX1day (mm) changes from 1960–1974 to 1995–2009



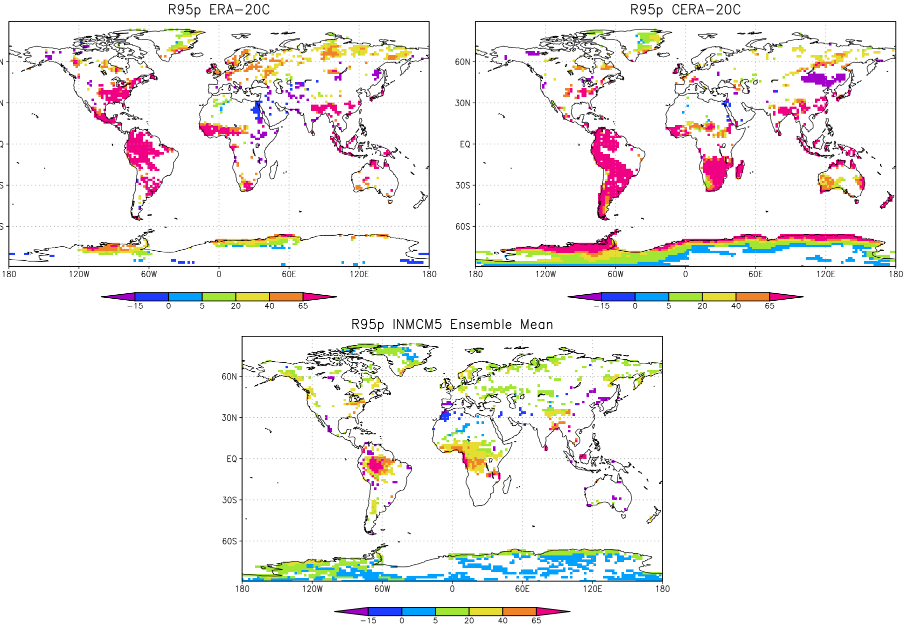
RX5day (mm) changes from 1960–1974 to 1995–2009



R10mm (days) changes from 1960–1974 to 1995–2009



R95p (mm) changes from 1960–1974 to 1995–2009



- Precipitation indices characterize by considerably greater variance than the temperature ones. Even with significance level fixed on 5% the locations of significant changes are scattered across land.
- Precipitation amount during very wet days (R95p) dramatically increased in South America and South Africa in both reanalyses, but INMCM5 shows only moderate changes in these regions.
- Distribution of precipitation indices in Africa varies between reanalyses and the model. Precipitation in INMCM5 is concentrated in Equatorial Africa, while reanalyses indicate that it is located in Western and Southern Africa.
- It worth noticing that neither ERA–20C nor CERA–20C assimilate observed precipitation. So these reanalyses cannot be considered as reliable source of precipitation data.

Conclusion

- For the 1960–2010 period INMCM5 land-averaged indices changes are in agreement with both reanalyses.
- For the whole considered time interval there is a good agreement between INMCM5 and ERA–20C in temperature indices trends.
- The regions with extremal changes in temperature indices have similar locations in INMCM5 and reanalyses.
- INMCM5 indicates changes with smaller magnitude over larger areas comparing to reanalyses.
- ERA–20C and CERA–20C demonstrate rather different behavior in land-averaged trends before 1960. Also spatial distribution of the changes differ in such regions as Amazon Basin, Australia, East and Southeast Asia.

References

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