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Daily precipitation in a changing climate: lessons learnt from Swiss national climate change scenario initiatives

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Introduction

Fundamental changes in the hydrological cycle are expected in a future warmer climate. This is of particular relevance for the Alpine region, as a source and reservoir of several major rivers in Europe and being prone to extreme events such as floodings. For Switzerland, the recent CH2011 probabilistic multi-model assessment based on the ENSEMBLES climate model matrix projects summer mean precipitation to significantly decrease by the end of this century. In winter and in the transition seasons, the models simulate both increases and/or decreases in mean precipitation (Fig. 1). While in this recent scenario assessment seasonal mean changes were considered solely, some of the multifaceted characteristics of precipitation (changes) remained unanswered, such as changes in the temporal structure, precipitation type and (extreme) rain intensity.

Precipitation scenarios of seasonal means

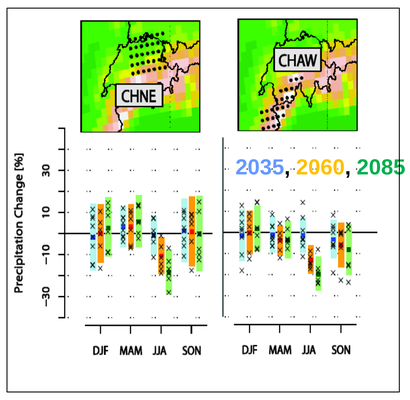
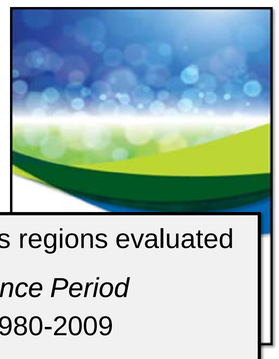


***Fig. 1**: Seasonal mean total precipitation changes wrt 1980-2009. The bars correspond to the 95% confidence interval derived from a multi-model combination algorithm.*

CH2011 (2011)



5 Swiss regions evaluated

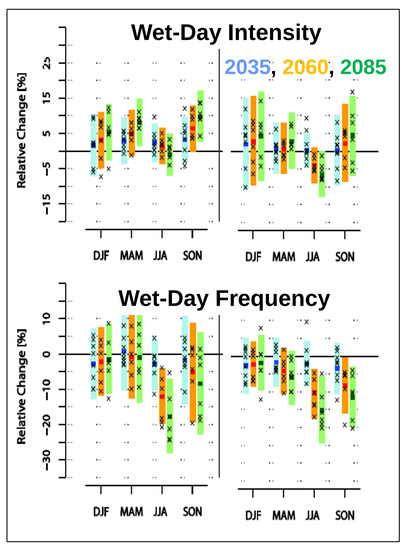
Reference Period
- 1980-2009

Scenario Periods
- 2020-2049 (“2035”)
- 2045-2074 (“2060”)
- 2070-2099 (“2085”)

Based on **ENSEMBLES** RCM projections

Uncertainty Assessment with **multi-model combination** algorithm of Buser et al. (2009)

Changes in Intensity and Frequency



- Summer drying over Switzerland due to a decrease in wet-day frequency
- Intensification north of the Alps in spring/fall
- No common sign of change during winter
- South of Switzerland tendency for winter precipitation intensification (not shown)

***Fig. 2**: Multi-model projections of intensity and frequency changes for two CH2011 regions. The bars correspond to the 95% confidence interval derived with a multi-model combination algorithm.*

Summer Drying at the end of the century

Changes in Precipitation Type

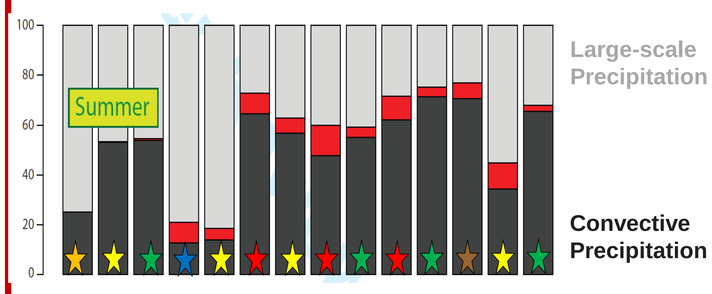


***Fig. 3**: Fraction of precipitation types in 14 simulations. The red (blue) colored part represents the additional portion to which the convective (large-scale) fraction will increase as simulated for a future climate. The star symbols at the bottom of the bars indicate the type of employed convective parameterization scheme.*

- Future summer precipitation expected to be more composed of convective precipitation at the expense of large-scale precipitation
- Model spread in convective fraction only partly explained by choice of convective parameterization scheme

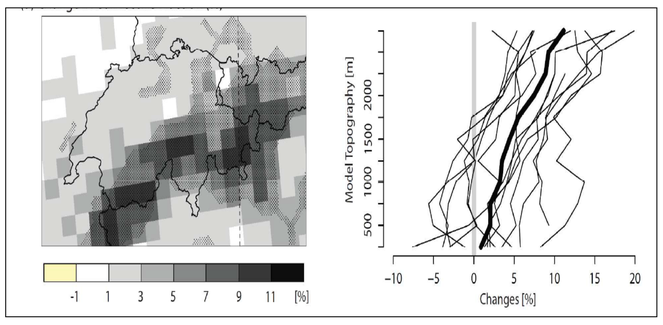


***Fig. 4**: Summer change in convective fraction (%) in the multi-model mean over Switzerland (left). Hatched areas indicate regions where at least 75% of the models agree on the mean signal. Right-hand panel illustrates the changes as a function of the topography for all ENSEMBLES models.*

- Elevation-dependent response in parameterized precipitation types (used as proxies for potential rain-type changes)
- Over the Alps increase in convective fraction by up to 10%

Changes in Dry and Wet Spells

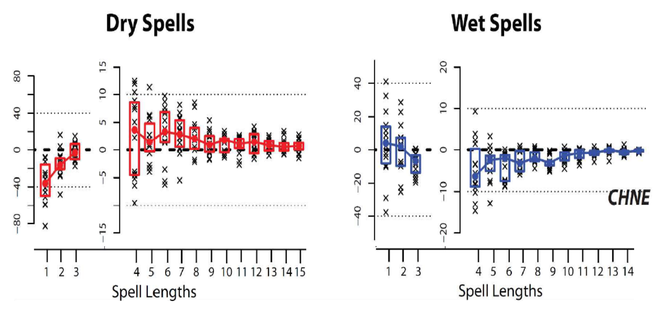


***Fig. 5**: Changes in modeled dry and wet spells over the regions CHNE and CHAW. The changes reflect differences in the number of spells over the whole 30-year period (2085 vs. 1980-2009). Crosses mark individual model chains, the box the interquartile range of the multi-model ensemble.*

- Increase in dry days (Fig. 2) enhance likelihood of multi-day dry spells at the expsense of multi-day wet spells
- Augmented risk for meteorological summer droughts

Changes in Extreme Preciptiation

Changes in return values

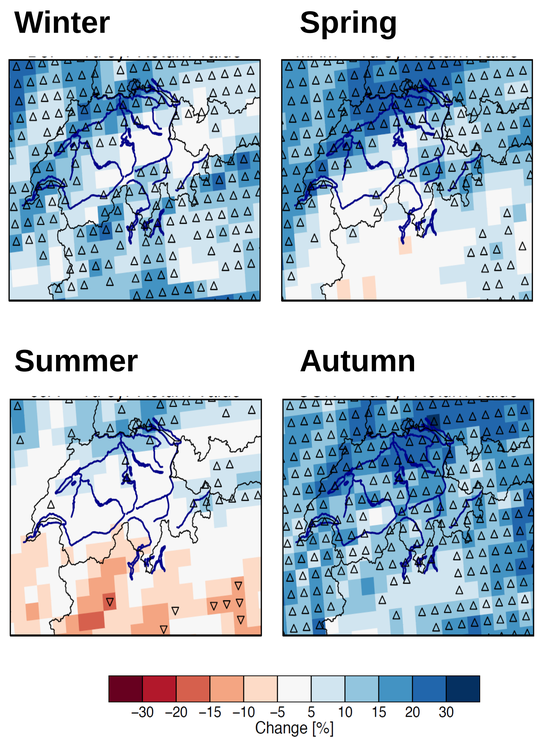


***Fig. 6**: Ensemble median change signals (2070-99 wrt 1970-99, in %) over Switzerland for the 1-day return values of extreme precipitation with a return period of 5 years. Triangles indicate climate model grid boxes at which 8 out of 10 RCMs agree on the sign of change. Extreme indices are estimated using a block maxima approach (GEV) based on seasonal maxima from each considered year in the reference period.*

- Extreme daylong precipitation events projected to intensify over Switzerland with robust signals in all seasons except summer. For high-alpine areas large inter-model spread found.
- Projections show substantial increases (up to 20%) of return values for precipitation extremes with return periods between 2 and 100 years.
- Changes in extremes do not scale with changes in mean precipitation or with wet-day frequency changes

Conclusions

The presented results inform on the multifaceted precipitation changes relevant for a number of sectors connected to the water cycle. The qualitatively different behavior between changes in extremes and intensity and changes in the mean highlights the complexity of projecting precipitation change over Switzerland. The results here give rise to further discussion and research. Changes in wet-day frequency and intensity could help adjusting calibrated weather generators. Likewise, information on precipitation-type shifts could be used to modify conditional resampling techniques in a climate change context.
This study was limited in the number of independent model projections. Ideally, the analysis should be repeated at the advent of the new CORDEX suite.

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