**Summertime hailstorms over Switzerland in surrogate climate change simulations**

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### Motivation and objectives
- Summer hailstorms over Switzerland cause considerable damage to the property, crops, real estate, etc.
- Future climate changes over Switzerland can be considerable (up to 5 °C surface warming towards 2100, RCP8.5).
- Climate change can potentially make summer hailstorms more harmful by enhancing their intensity, frequency, footprints. It is essential to be able to foresee possible changes for planning adaptation measures.
- Summer hailstorms over Switzerland can be simulated by using a mesoscale model at high resolution, e.g. WRF.
- Surrogate climate change approach - a convenient and simple method of imitating the climate change can be applied to these simulations. While oversimplified, it can help to reveal trends in hailstorm characteristics.

### Simulation settings
- Domain settings:
  - 2 km horizontal resolution,
  - 414 x 375 latlon grid,
  - 2 km horizontal resolution,
  - 35 vertical levels, upper boundary: 50 hPa
- Forcing data: ECMWF analysis, 1/8", 6-hourly.
- No cumulus parameterization.
- Noah land-surface model.
  - Microphysics: Morrison double-moment scheme (with explicit hail)
- APWA-diagnostics package for WRF (Creighton et al. 2014)
  - HAILCAST-1D hail model
- Surrogate climate change simulations (Schär et al. 1996): adding artificial biases to air temperature and humidity for simulating changed climate conditions.
  - MPI-ESM-LR, MPI-ESM-MR: among the least biased models.
  - Mean RH decrease in lower troposphere up to 10-15% (last-saturation-temperature constraint, Sherwood et al. 2010)
- Simulations: Unbiased control run + 2 surrogate climate change cases with homogenous +5 °C temperature bias:
  - Mean freezing level increase, km
  - No cumulus parameterization.
- Strong warming in lower troposphere, stratospheric cooling.
  - Mean RH decrease in lower troposphere up to 10-15% (last-saturation-temperature constraint, Sherwood et al. 2010)
- Simulations: Unbiased control run + 2 surrogate climate change cases with homogenous +5 °C temperature bias:
  - "unbiased": unchanged air RH (following Clausius-Clapeyron), -10%RH case: 10% decrease of the RH.
- Changes in the mean daily maximum MU CAPE 0-180 mb, J/kg
- Changes in the atmospheric conditions

### Changes in hailstorm characteristics
- Changes of hailstorm characteristics
- Summed hailstorms are much more frequent in the surrogate CC conditions. Main spatial patterns remain unchanged (“holes” - internal variability).

### Summary
- Simple uniform air temperature and relative humidity biases were used to roughly simulate the future climate conditions.
- More frequent hailstorms, covering larger surfaces and producing larger hailstones were simulated in CC conditions (relative to an unbiased JJA2012 run).
- Future work: more realistic climate-change biases. Pseudo-Global Warming?