The extremely warm summer 2018 in Sweden - set in a historical context

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Synoptic situation - 500 hPa pressure

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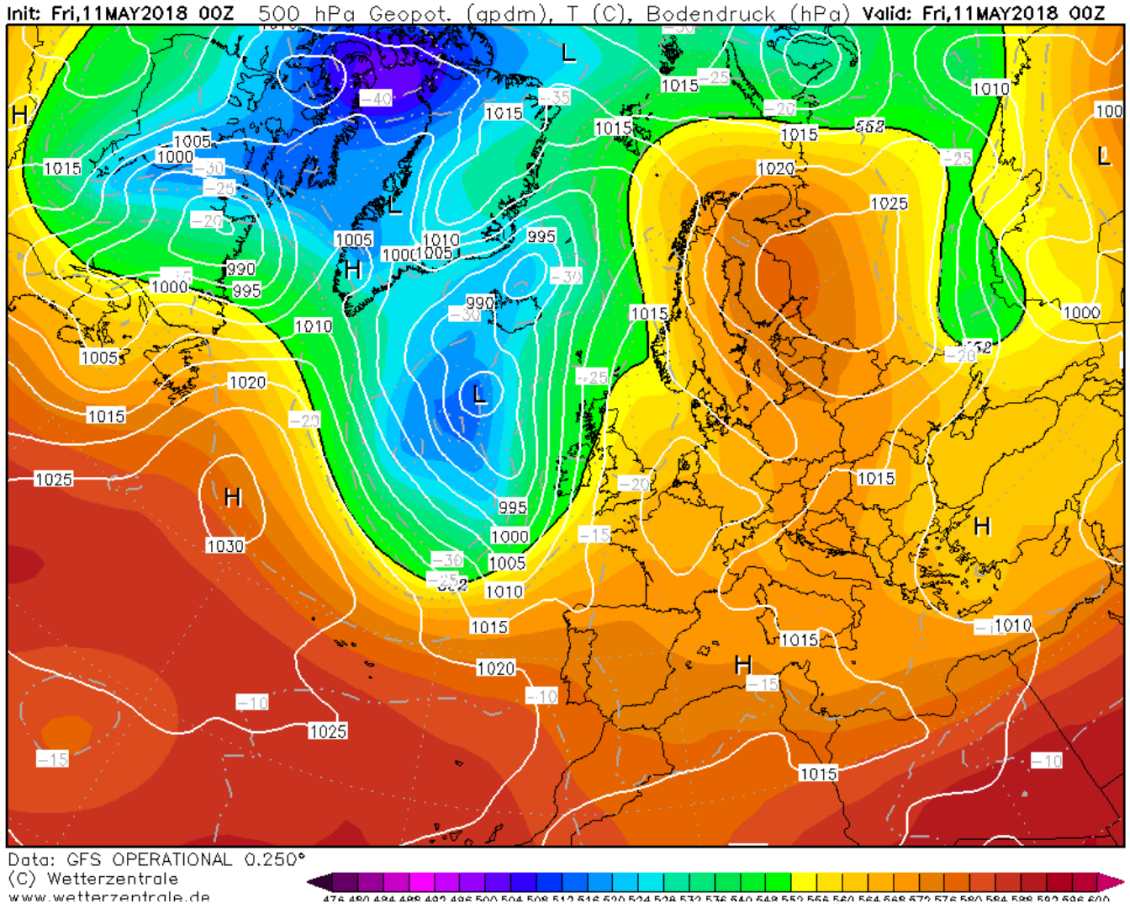
Example 11. May 2018



- Two long lasting blocking situations over Northern Europa
  - May 6 weeks
  - July 4 weeks
- Reduced cloudiness, high temperatures, and little/no precipitation

Data - Analysis

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Data

model ensemble	members	RCP		period
CMIP5	78/15	8.5	monthly/daily	1950 - 2100
CanSISE	50	8.5	daily	1950 - 2100
EC-EARTH	16	8.5	daily	1860 - 2100
EC-EARTH-LENS	SSP5858.5	daily	1970 - 2018	
MPI-GE	100	4.5	monthly	1860 - 2099

observations		
E-OBS v19	daily	1950 - 2018
SMHI Stockholm temperature series	daily	1756 - 2018
spatially averaged temperature time series for Sweden	daily	1860 - 2018

Data - Analysis

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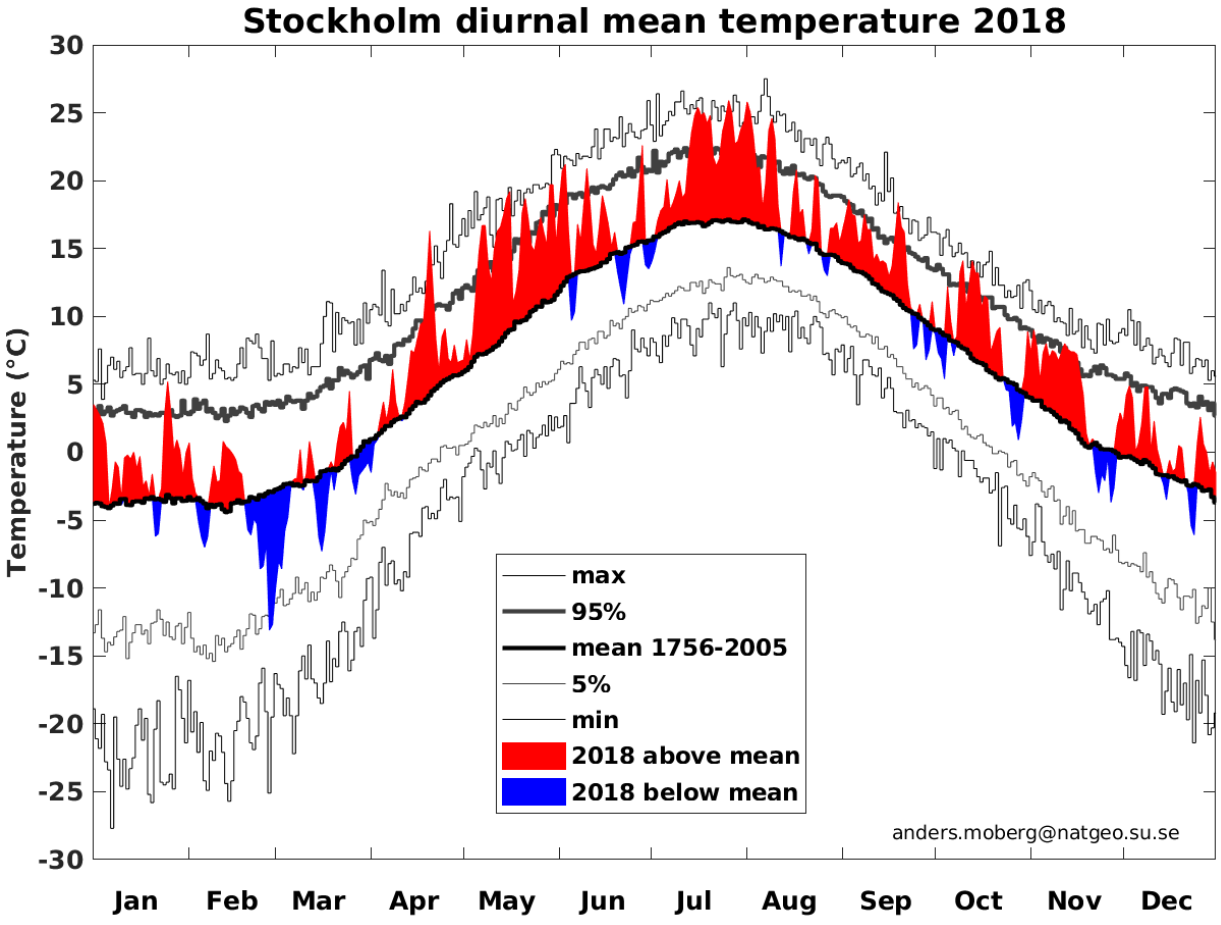
Variables

mean temperature (daily, monthly), maximum temperature (daily)

Heat indices

- total number of warm days per year (totWarmD)
- maximum number of consecutive warm days per year (max_conWarmD)
- number of heat events (tot_event) (an event is defined as minimum 3 consecutive days of Tmax $>$ threshold) (not shown here)
- Heat Wave Magnitude Index (HWMI, Russo et al. 2014) (not shown here)
- Warm Spell Duration Index (WSDI, Orlowsky and Seneviratne, 2011) (not shown here)

Diurnal mean temperatures in Stockholm 2018



For each day the anomaly with respect to the 250-year climatological mean for 1756-2005 is displayed in red (warm) or blue (cold). The diagram also shows the warmest and coldest diurnal mean temperature for each calendar day recorded within the 1756-2005 period as well as the corresponding 5th and 95th percentiles.

Diurnal mean temperatures in Stockholm 2018

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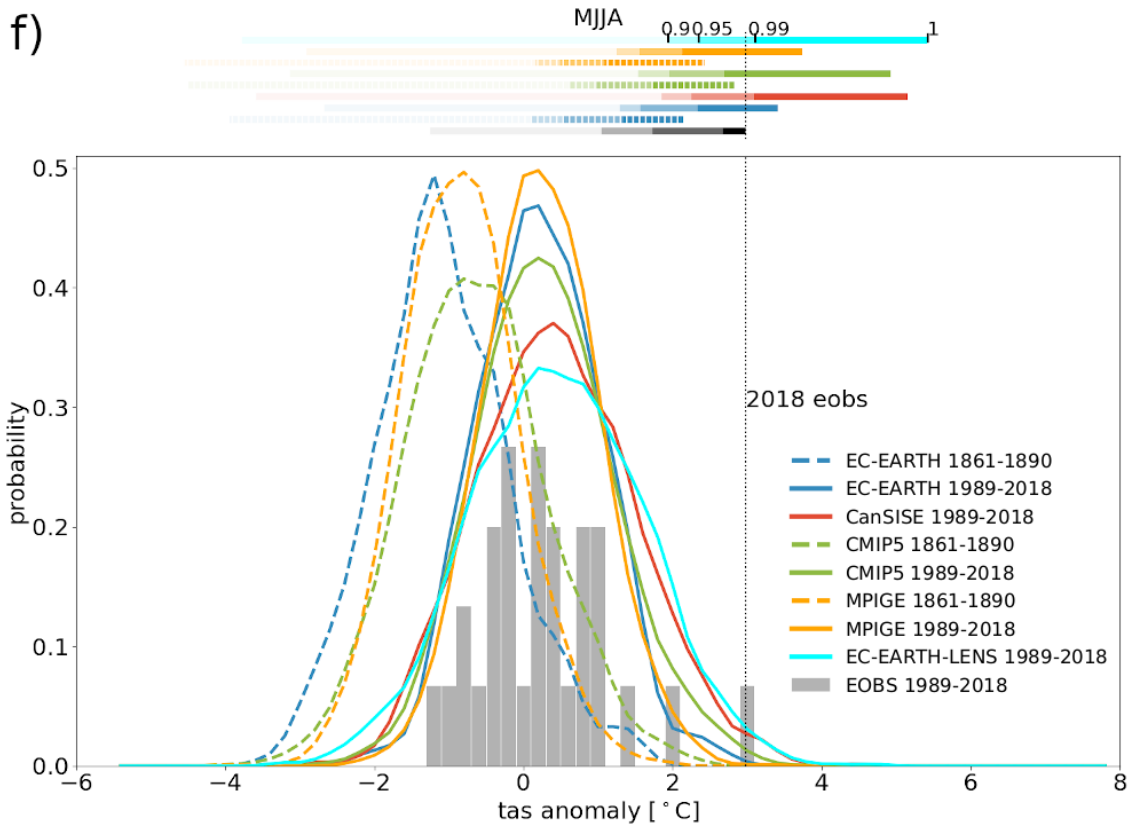
- Mean MJJA temperature in Stockholm in 2018 was 17.8°C, which is 3.0K above the mean for 1998-2017 or 4.0K above the 1756-1900 mean.
- The figure clearly shows that the extended summer, ranging from May to mid August, yielded a large number of days with temperatures by far exceeding the long-term mean.
- Episodes of relatively colder conditions in June can be seen in the Stockholm record as illustrated by blue downward facing spikes.
- For MJJA more than 35% of the days were above the long-term climatological 95th percentile calculated for each day (upper grey line in the figure).
- Only one additional year exceeds the 95th percentile with 20% of the days in a full May-August season.

Temperature annomaly vs. 1981 - 2010



Probability distributions for monthly average temperature anomalies, calculated for 1861-1890 (dashed) and 1989-2018 (solid) against 1981-2010 for Southern half of Sweden, for May to August months pooled. The upper part the panel shows the .9, .95, .99, and 1 percentile for each distribution. Ensemble distributions are a kernel density fit, whereas the histogram for EOBS is based on actual data. The observed year 2018 is indicated by the dotted black line.

Temperature annomaly vs. 1981 - 2010

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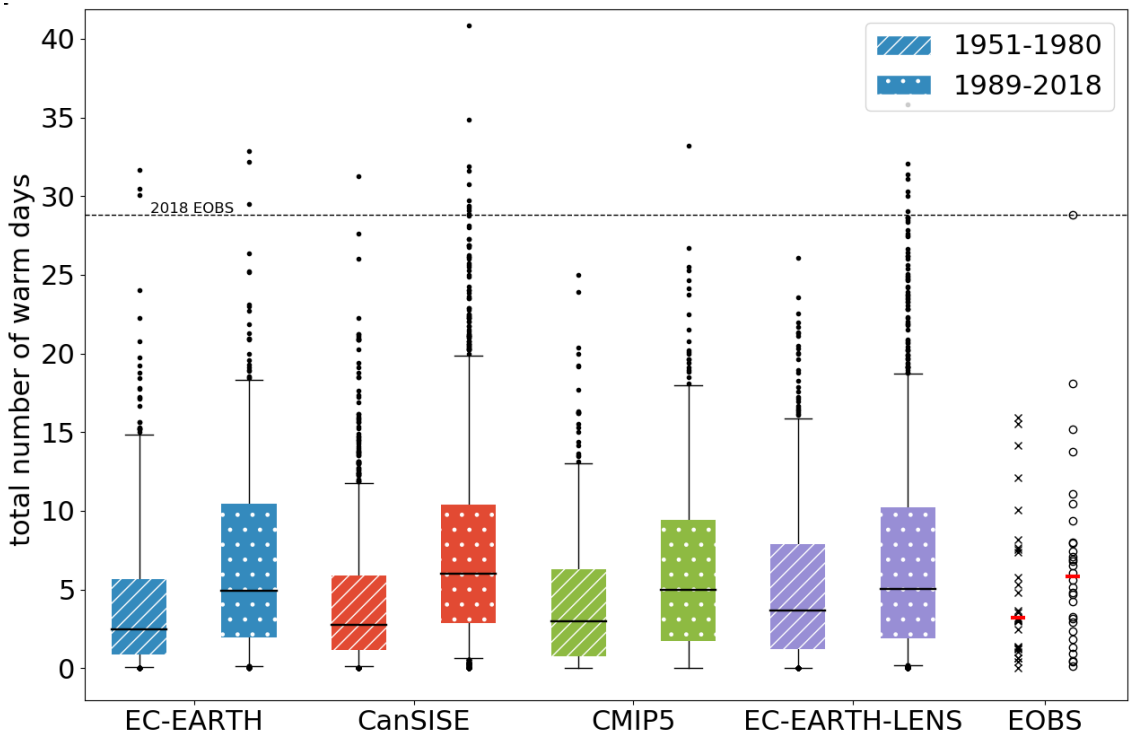
- pdfs of the May and July illustrate the rarity of the weather situation in 2018 in Southern Sweden (not shown) as 2018 sets the most extreme mark of the observations for the last decade.
- The pooled MJJA distributions (Figure 2), show 2018 as the most extreme summer in Southern Sweden in the past 30 years according to the E-OBS data set.
- The spread of all five GCM ensembles include summers as warm (or as cold) as any individual observed summer during the 1989-2018 period.
- May 2018 is warmer than all of the 100 simulated May months in the MPI-GE for Southern Sweden.

Total number of warm days



Total number of warm days (totWarmD) for the period 1951-1980 (dashed) and 1989-2018 (dotted) for 4 models (x axis), calculated from MJJA months and averaged over Southern Sweden. All model members are pooled into one box. The number of days for 2018 as derived from E-OBS is indicated by the horizontal dashed line.

Total number of warm days

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- 28 warm days (totWarmD) are found for Southern Sweden in MJJA 2018 according to E-OBS.
- This puts MJJA 2018 on the extreme end and well above any other years.
- Comparing the observations for 1989-2018 with 1951-1980, the distribution has widened at the same time as the mean and median (red mark) has been shifted towards more warm days.
- Model ensembles agree on that, with CanSISE showing the strongest change signal between the two periods.
- All models indicate an increase, indicated by a shift of the 95th percentile (upper whisker), and by larger absolute maxima.

Maximum number of consecutive warm days (max_conWarmD)

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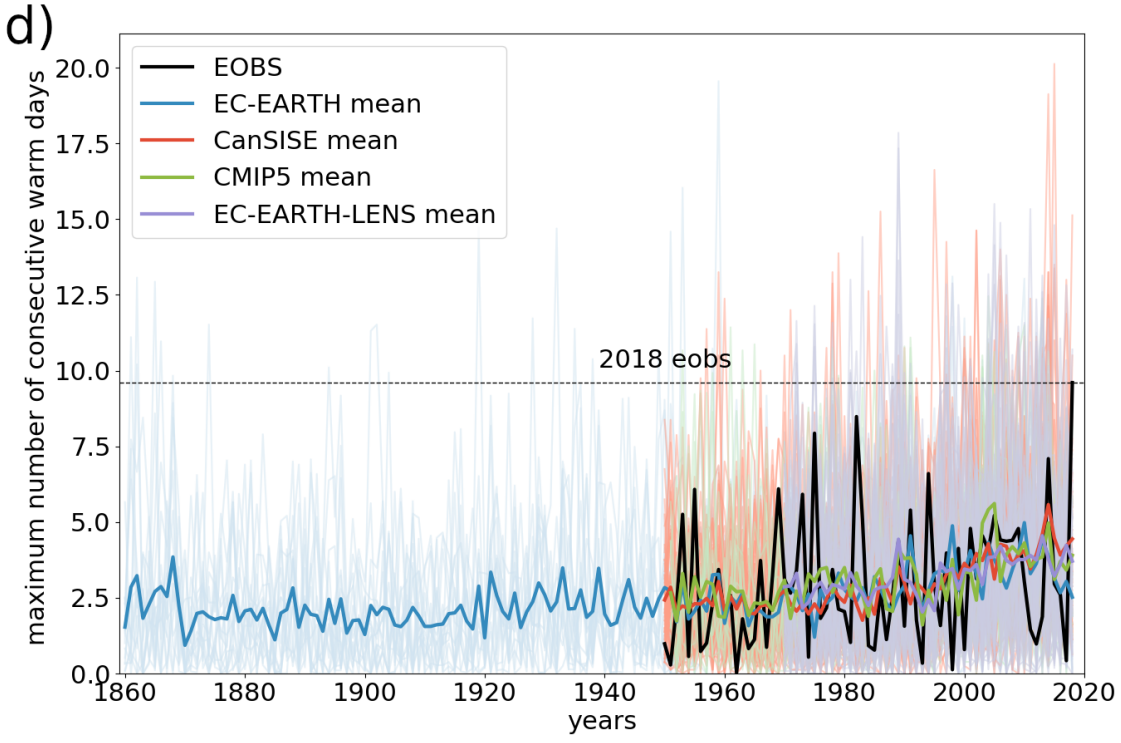

Time series for each ensemble member (thin lines) and ensemble means (bold lines) for max_conWarmD. The number of days for 2018 as derived from E-OBS is indicated by the horizontal dashed line.

Maximum number of consecutive warm days (max_conWarmD)

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- The observed variability from E-OBS (black solid line) lies within the variability of all simulations.
- 2018 does not stand out as being among the most extreme summers in the period.
- The sharp peaks for the single ensemble members indicate high year to year variability of max_conWarmD for each member.
- Referring to the long time series of EC-EARTH, the warming signal starting at the last decades of the 20th century is clearly visible, as it is for all four ensembles.
- Summer 2018 value is passed much more often in recent years than in earlier times, shifting the summer 2018 event towards the centre of the distributions.

Summary

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- The results show that the degree of rarity of the summer is very different depending on which measure is investigated.
- The monthly mean temperature for May and the number of warm days above the 95th percentile in MJJA are examples for which 2018 is the most extreme summer observed so far.
- an example of how results may be different depending on definition, we note that in case of not counting May as a summer month, focusing on the more commonly used generic three-month JJA summer, summer 2018 was not as remarkable. In particular, in light of the large ensembles such a particular warm JJA summer is found in single members of all assessed climate model ensembles even in pre-industrial climate.
- Anomalies in indices, as those observed in 2018 occur less than once in 20 in all ensembles. For some indices, the anomalies are even more rare and do not occur more frequently than once in 100.

Summary

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Full analysis will be found in an article submitted last week to ESD with the title "The extremely warm summer 2018 in Sweden - set in a historical context". A link to the discussion paper will be provided as soon as available.