Arctic heat waves – a risk assessment

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A record-breaking heatwave affected the European continent in summer 2003.

The anomaly is 3°C larger than 1961-1990 mean, which is a $5.4\sigma$ excess.

Return value w.r.t 1990–2002 climatology: $\tau=46000$y (with lowest value of 9000y)

A 50% increase in $\sigma$ increases the probability by a factor of 150 => Large sensitivity to var change!

We are in a changing variability regime!

Prudence simulations show that the 03 event can Occur every second year at the end of the century.
Arctic zonal temperature anomalies
(within 60°-90°N latitudinal zone)

- Winter, summer, and annual anomalies, 1881-2003 period
- All linear trends significant at the 0.01 level
- (available from CDIAC, Lugina et al. 2003, updated)

Courtesy P. Groisman
Northern Hemisphere temperature anomalies

- Winter, summer, and annual anomalies, 1881-2003 period
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Courtesy P. Groisman
Surface air temperature change: 1954 - 2003

- Winter (DJF) - °C
- Spring (MAM) - °C
- Summer (JJA) - °C
- Autumn (SON) - °C

ΔT_s
HISTORICAL TEMPERATURE RECORDS

QUALITY CHECKED ARCTIC STATIONS FOR CLIMATE STUDIES

Svalbard lufthavn

$T_M$ 1912-2006 (Nordli & Kohler 2004; met.no rep.series)
Hetebølger på Svalbard?

- Temperaturserien indikerer svært moderate endringer variabilitet & ekstremer
- Energikrevende smelteprosess begrenser positive utslag
- Lengden på smeltesesongen vil være en mer følsom indikator
- $\tau = \# \text{ dager } T > 0\, ^\circ\text{C} (4\text{d på rad})$
- Kun månedsverdier tilgjengelig -> rekonstruerer daglige data vha splines
Melt season length 1912 - 2006

Middel 1912-2006: 105d
Trend 1912-2006: 1,5d/dek

Reasonable reconstruction

Which processes matter?
\[ \tau = \alpha + \beta_1 T_{nh}^{NH-temp} + \beta_2 PC2^S_{summer-NAO} + \beta_3 PC2^W_{previous-winter-EOF2} + \varepsilon \]

EOFs (1766-present) - Casty et al (2007), ClimDyn
Modeling of excesses

\[ Z = \tau - \mu(t) \]

Time varying threshold to meet stationarity requirements, mean \( u = 111 \).

General Pareto Distribution (GPD)

\[
Pr(Z \leq z \mid Z > 0) = H(z) = 1 - \left( 1 + \frac{\xi z}{\sigma} \right)^{-\frac{1}{\xi}}
\]
Scatterplot of $z$

GPD median + quartiles

100 y return value

Global mean temperature anomaly

Deviations from 1961 - 1990
Should polar bears be worried?

They probably should 😞