Paleoclimatological context and reference level of the 2°C and 1.5°C Paris Agreement long-term temperature limits

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Background

- At the Paris climate conference (COP21) on 12 December 2015, 195 countries adopted by consensus a universal, legally binding global climate deal, which came into force 4 November 2016
- As of November 2017, a total of 169 Parties have ratified the climate deal.

However

- The treaty does not include further definition of the term "*above pre-industrial levels*".
- This is noteworthy, because pre-industrial climate has undergone significant natural fluctuations.

This presentation aims to establish:

(a) which baseline definitions have been put forward in previous works on global climate targets?
(b) discuss these baselines in the context of pre-industrial paleoclimate variability, and
(c) evaluate the suitability of different baseline definitions

The Baseline Origins

The two-degree climate change target was first formulated by the economist **William Nordhaus** in 1975 and refined in 1977:
As a first approximation, it seems reasonable to argue that the climatic effects of carbon dioxide should be kept within the normal range of long-term climatic variation. According to most sources the range of variation between distinct climatic regimes is in the order of ±5°C, and at the present time the global climate is at the high end of this range. If there were global temperatures more than 2 or 3°C above the current average temperature, this would take the climate outside of the range of observations which have been made over the last several hundred thousand years.

The next attempt to define the baseline for the climate limit was undertaken in 1995 by the **German Advisory Council for Global Change** (Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen, WBGU)
The first principle, preservation of Creation in its present form, is presented within this scenario in the form of a tolerable "temperature window". This window is derived from the range of fluctuation for the Earth's mean temperature in the late Quaternary period. This geological epoch has shaped our present-day environment, with the lowest temperatures occurring in the last ice age (mean minimum around 10.4°C) and the highest temperatures during the last interglacial period (mean maximum around 16.1°C). If this temperature range is exceeded in either direction, dramatic changes in the composition and function of today's ecosystems can be expected. If we extend the tolerance range by a further 0.5°C at either end, then the tolerable temperature window extends from 9.9°C to 16.6°C. Today's global mean temperature is around 15.3°C, which means that the temperature span to the tolerable maximum is currently only 1.3°C.

In 2014 the **World Bank** published the report "*Turn Down the Heat*" which was prepared by the Potsdam Institute for Climate Impact Research (PIK) and the Berlin-based climate think-

tank Climate Analytics (World Bank, 2014). The report states that temperatures at the time of publishing were 0.8°C "above pre-industrial levels", **defined through an 1850-1900** base period. Temperatures are averaged over 20 years to eliminate year-to-year variations and uncertainties in the data.

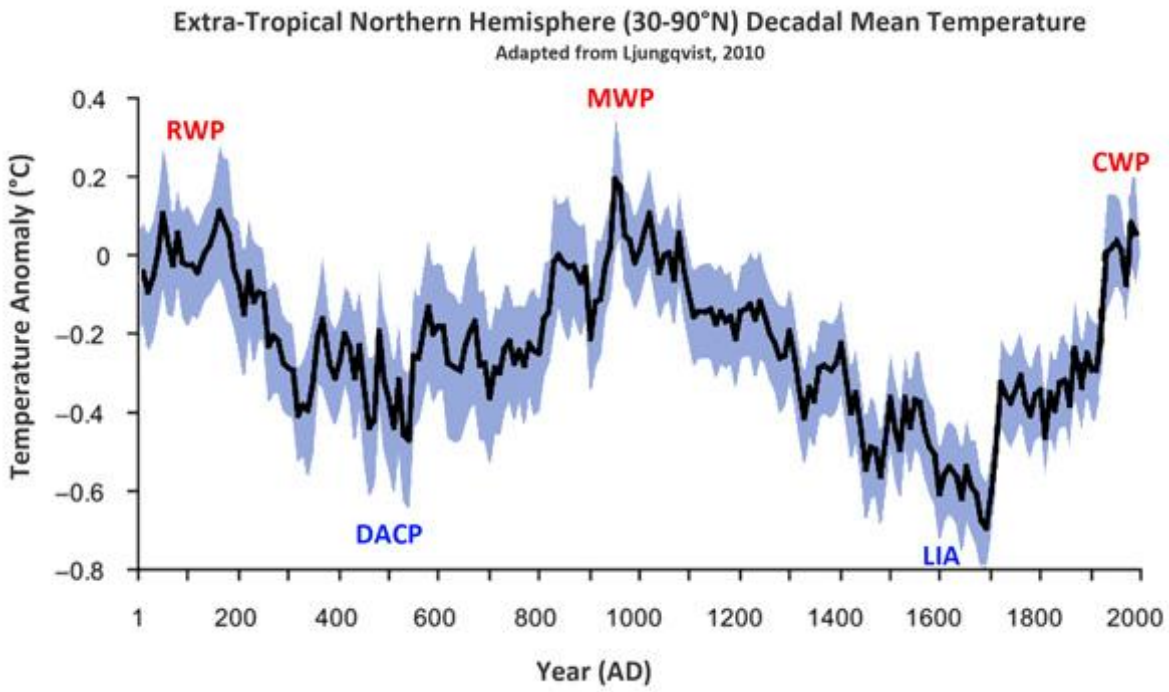
In a report from 2015, the **United Nations Framework Convention on Climate Change** (UNFCCC) cites the IPCC who reported an increase of 0.85°C since 1880 which UNFCCC (2015) considers "*a good approximation for pre-industrial levels*".

Discussion of the Baselines

The field of paleoclimatology has made major progress over the past decades.
Modern studies have provided high-resolution climate reconstructions based on sophisticated paleontological, isotope and geochemical methods. In the following we will be reviewing the upper and lower limits of pre-industrial natural temperature change and compare these to the ranges defined in the above-mentioned papers and reports on the climate goal.

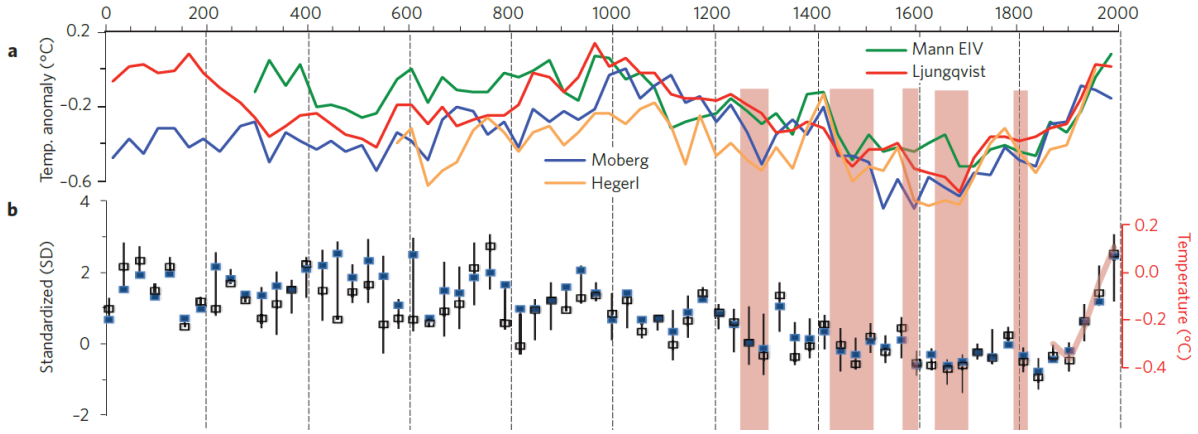
Global temperature reconstruction by Ljungqvist 2010

RWP: Roman Warm Period. MWP: Middle Ages Warm Period. CWP: Current Warm Period.
DACP: Dark Ages Cold Period LIA: Little Ice Age



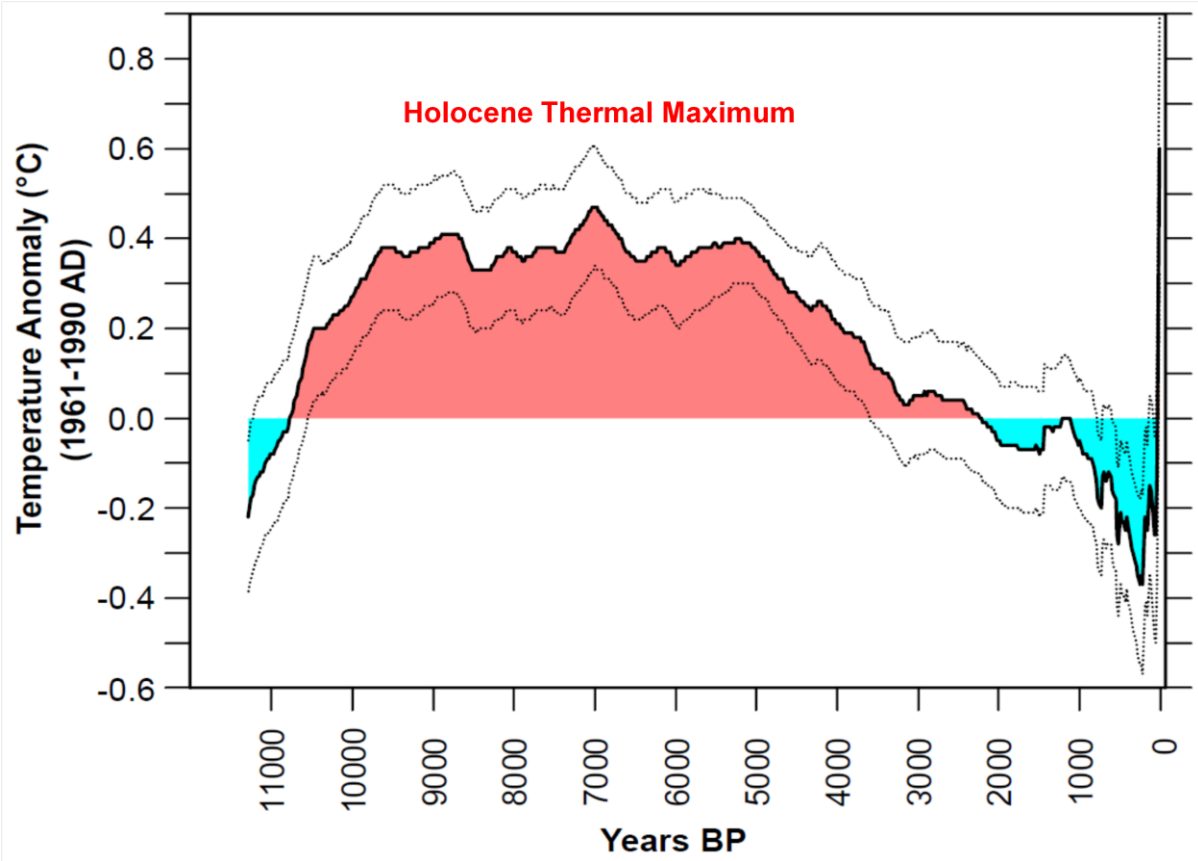
Ref: http://www.co2science.org/education/reports/prudentpath/ch1.php
"Continental-scale temperature variability during the past two millennia) PAGES 2k Consortium *Nature Geoscience* 6, 339–346 (2013) doi:10.1038/ngeo1797

In this paper the different estimates of climate variation are plotted and their error bars are shown



https://www.nature.com/articles/ngeo1797

Global sea surface temperature reconstruction by Marcott et al. 2013



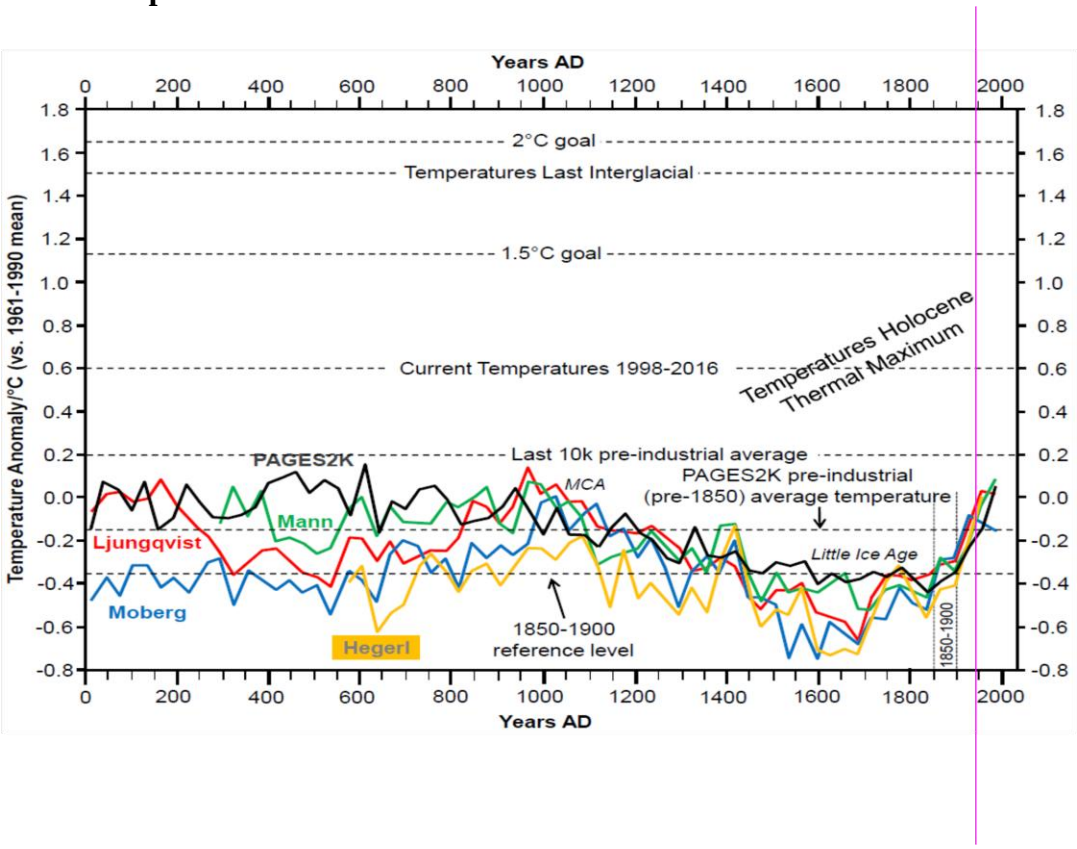
Marcott et al. (2013) published a Holocene global sea surface temperature reconstruction from 73 globally distributed records. The resulting curve showed the Holocene Thermal Maximum (HTM) to be 0.4°C warmer than the average period 1961-1990.

The authors concluded that modern global mean temperature have not yet exceeded the warmest temperatures of the HTM.

The Little Ice Age is the coldest phase of the entire Holocene and there does not represent a good baseline

Suitability of Baselines

Global temperature levels



Conclusion

- Pre-industrial temperatures have undergone marked natural variations at every possible time-scale.
- Definition of an 1850-1900 “pre-industrial” reference level is therefore simplistic and does not do justice to the significant natural dynamics of the pre-industrial temperature development.
- The choice of a baseline near the lower extreme of a variable parameter is uncommon in science.
- An average over a longer pre-industrial interval capturing several natural temperature fluctuations appears more adequate.
- Suitable averaging time windows may be e.g. the last 1000 years, 2000 years or 10,000 years, always excluding the last 150 years due to anthropogenic influence.
- The temperature level reached during the interval 1940-1970 may serve as a better reference level as it appears to roughly correspond to the average pre-industrial temperature of the past two millennia,
- Honouring the findings and guidance of the IPCC AR5, it needs to be made clearer in the climate limit narrative that part of the 0.8°C warming that has already occurred with regards to the 1850–1900 mean is of natural origin, representing the expected

temperature rebound after the unusually cold Little Ice Age. Furthermore, the climate limits need to be systematically compared to peak temperatures of key pre-industrial natural warm phases. Temperature reconstructions indicate that pre-industrial temperatures of the past 10,000 years have repeatedly reached a similar or even higher intensity as present-day climate.

Notes from Discussion. This talk was not suggesting that the temperature anomaly scales be shifted from the plotted temperatures nor that the 1.5 and 2 degree agreed goals be modified.
i) The argument is that a baseline should be the Pages2K preindustrial average temperature which was exceeded around 1923, and not the 1850 low point which in itself was abnormal.

ii) The second part of the meeting related to ongoing research of the Medieval Climate Anomaly and publication of the work is restricted.

Ref: https://www.frontiersin.org/articles/10.3389/feart.2017.00104/full