The Earth's Climate at Deep Minima of the Solar Activity

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Some Cases of the Earth’s Climate Change on the Centennial Time Scale
8-9 century
Collapse of Maya Civilization

- Series of draughts (associated with the shift of ITCZ to South)
- Loss of climate stability leads to widespread dislocation, war
- Leads to depopulation, population migration, never recovered
The tree rings record in the Khangai Mountains of Mongolia (Pederson, 2014) revealed that Central Mongolia was wettest and warmest in 1211 – 1225, the exact time of the Great Mongol empire rise of Genghis Khan.
Year without summer: quiet Sun or Tambora?

Byron & Mary Shelley (Frankenstein) in Switzerland

Alexander Pushkin in Sankt Petersburg
20th century minimum

Scott Expedition, 1910-13, the coldest winter in Antarctica (-77F)

April 1912, Titanic
“extreme and prolonged low sunspot-number regime reversed the dearth of southern icebergs in the North Atlantic” (E. N. Lawrence, Weather, 2000)

No snow in S. Petersburg this winter 2019-2020

2014 N. America cold wave
Solar Cause of these and others Climate Changes?
Centennial Gleissberg Cycle (CGC)

90-110 year quasi-periodic modulation of 11-year cycle of sunspots

CGC recorded in 450 AD - 1450 AD (auroras)—Feynman & Fougere (1988), Ruzmaikin et al. (2006)

CGC recorded in $^{10}$Be, $^{14}$C — Beer et al. (2007), Ogurtsov et al. (2013), Usoskin (2013)
CGC in TSI Wavelet

11-year cycle scale

centennial scale

CGC Mode (80-110 yrs)

TSI from www.lasp/SORCE
CGC Minima

- Auroral Minima in (450 - 1450) record
- Beginning of 18th century (1710 - 1720 end of MM)
- Beginning of 19th century (1800 - 1820, Dalton min)
- Beginning of 20th century (1900 - 1920, Gleissberg, Feynman-Crooker min)
- Beginning of 21st century (2006 - ?, Silverman min)
North Hemisphere Temperature & TSI

Data: TSI Krivova et al. (2007)
Tem. NH Mann et al. (1999) detrended for CO₂ rise

Centennial modes

Cross Correlation of TSI and the Earth’s Temperature
19th century CGC minimum in T Land

Temperature data from Berkley Earth Project, Rohde et al. (2013)
Climate pattern associated with CGC
Climate Patterns associated with solar variability

11-year cycle

North Atlantic Oscillation (NAO), related to NAM

CGC

Pacific North American (PNA)
Maps for 1850-1999:
(a) TSI,
(b) Tcentennial mode
(c) PNA index

Reconstructed by Trouet and Taylor (2010)
Conclusions

✧ CGC minima influenced the Earth’s climate.

✧ The temperature response to CGC is phase delayed by about 10-20 yrs

✧ PNA is a major climate pattern associated with CGC

✧ The quiet Sun strongly influences the Earth’s climate on long time scales.