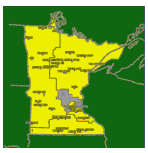
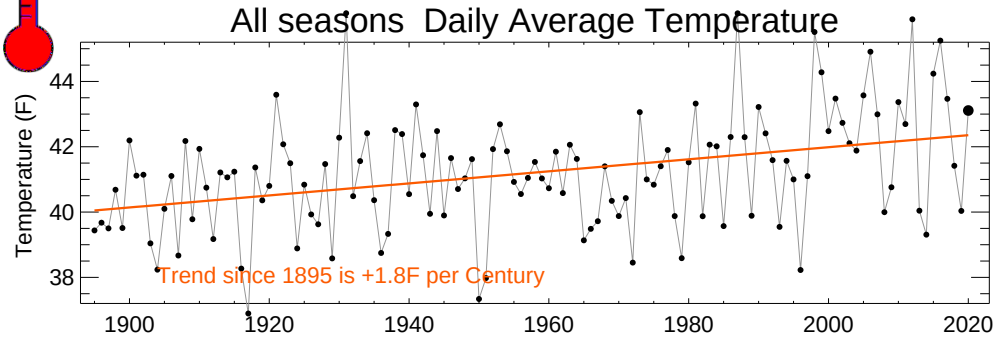
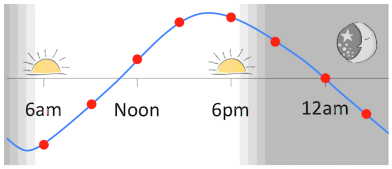
Atmospheric Surface Temperature

Minnesota



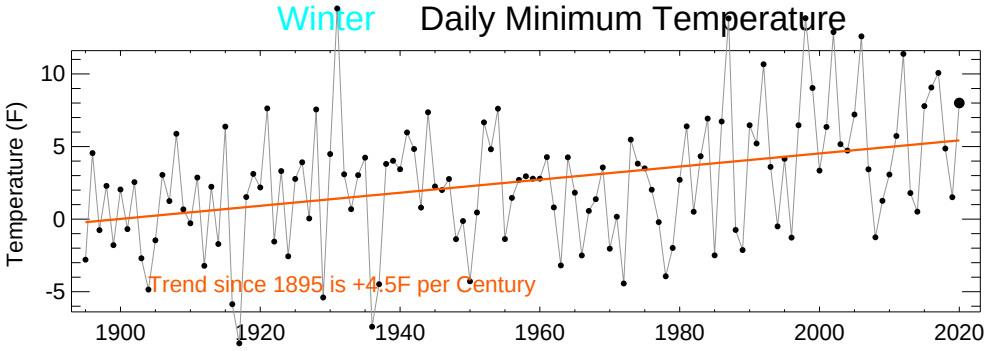
All seasons Daily Average Temperature

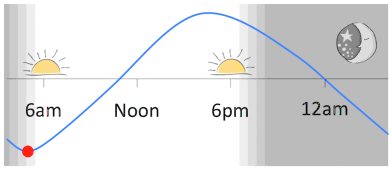




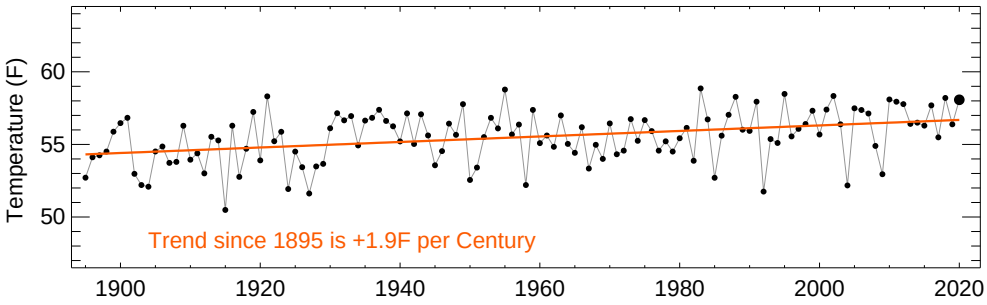
Daily temperature cycle

Winter Daily Minimum Temperature

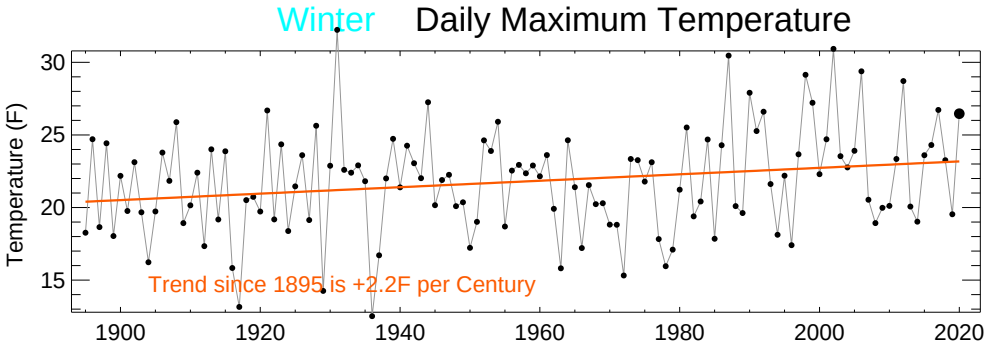


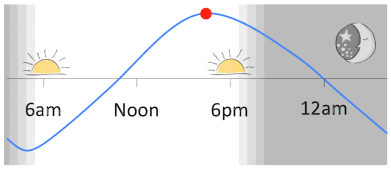


Summer Daily Minimum Temperature

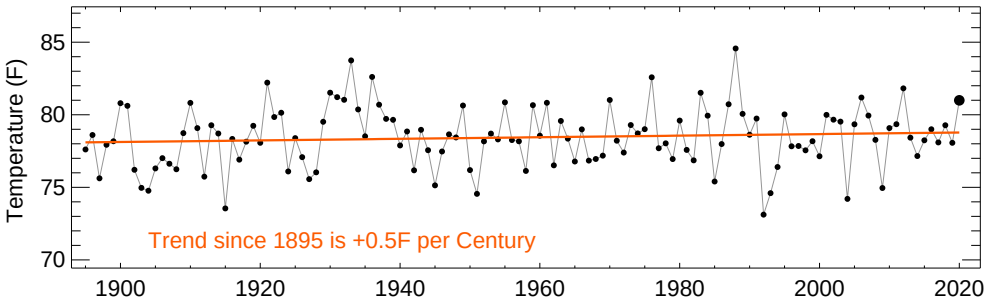


Winter Daily Maximum Temperature

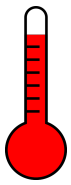




Summer Daily Maximum Temperature



Atmospheric Surface Temperatures (T_s)



Shown are the trends for atmospheric surface temperature for each of the 50 United States. The source is NOAA/NCDC (USHCN v2.5) bias-adjusted annual average values, daily maximum/minimum values. They are taken from the file: ftp://ftp.ncdc.noaa.gov/pub/data/ushcn/v2.5/ushcn.tavg.latest.FLs.52j.tar.gz
For some years, especially early in the 20th century, the archived values are estimated from surrounding stations. We include these estimated values in our trend plots. See Menne et al. 2009.

Daily average trends: The red dots on daily cycle image (opposite side) indicate times of measurement – once every 3 hours. These 8 values are then averaged to get a daily mean. However, daily averages from early years sometimes only measured 3 times per day.

Daily minimum trends: A single measurement of the minimum temperature usually at night just before sunrise.

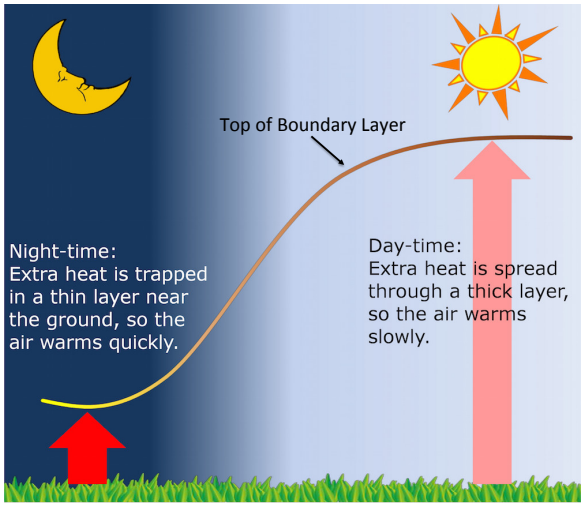
Daily maximum trends: A single measurement of the maximum temperature usually in the late afternoon.

Why are nights warming faster than days?

Humans live and play in the boundary layer, the lowest layer of the atmosphere. Here the air is well mixed and separated from the atmosphere above. At night this layer is very thin (hundreds of feet), whereas during the day it grows, thickens, up to ½ mile, and includes many more air molecules.

The build-up of carbon dioxide (CO_2) in the atmosphere from human emissions reduces the amount of radiation released into space, which increases both the nighttime and daytime temperatures. However, at night there is a much smaller volume of air that gets warmed, so the extra energy added to the climate system from CO_2 leads to a greater warming at night than during the day. (figure and text adapted from Davy et al. 2016).

Implications: We all know that during the day plants convert atmospheric CO_2 to oxygen (O_2) by photosynthesis. But during the night, when photosynthesis is off, plants respire; they use atmospheric O_2 and convert it to water and CO_2 which is released to the atmosphere. A recent paper by Anderegg et al. (2015) suggests that rising nighttime temperatures in the tropics accelerates plant respiration. The concern is that carbon stored in world's forests may be vulnerable to future nighttime warming and be released to atmosphere as CO_2. Scientists are studying whether plants may become more vulnerable to disease, insects and drought because of the reduced carbon storage.



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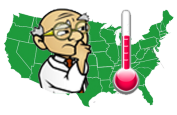

References

Anderegg et al. Tropical nighttime warming as a dominant driver of variability in the terrestrial carbon sink. *Proceedings of the National Academy of Sciences* Dec 2015, 112 (51) 15591-15596; DOI: 10.1073/pnas.1521479112

Davy, Richard, et al. Diurnal asymmetry to the observed global warming, *International Journal of Climatology* (2016). DOI: 10.1002/joc.4688

Menne, M.J., C.N. Williams, and R.S. Vose, 2009: The United States Historical Climatology Network monthly temperature data, Version 2. *Bulletin of the American Meteorological Society*, 90, 993-1007.

Levitus, S., et al. (2012), World ocean heat content and thermosteric sea level change (0–2000 m), 1955–2010, *Geophys. Res. Lett.,* 39, L10603, doi:10.1029/2012GL051106.