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College of Engineering

The Big Picture:
Why Become an Engineer?

EEL 3003
Introduction to Electrical Engineering
Summer Semseter, 2013

Instructor: Dr. Michael Frank

Why do you want to become an engineer?

- To increase your employability?
- To earn a decent income?
- Because you enjoy solving engineering problems?

Those are all pretty good reasons, but…

- *I think there are some better ones.*

Let me tell you what I think is one of the best reasons to want to become an engineer…

The world needs engineers!

There's always a need for engineers to design & develop new products/processes/structures to help…

- Improve people's quality of life
- Improve public health, safety, longevity
- Provide scientists with new tools to explore the world around us (& the broader universe)
  - and increase our knowledge & understanding of our world & our relationship to it

But also…

The world <u>especially</u> needs really good, dedicated engineers <u>right now</u>!

Because:

- We're at a *critical point* in the development of human civilization right now (your lifetime).
  - Our expanding development & consumption of resources is running up against limits on the levels that are long-term sustainable
    - Est. already 50% over sustainable consumption!
- If we don't figure out clever ways to expand or circumvent those limits, *we're in trouble*
  - Risk of resource overshoot & economic collapse

What are the limits?

Factors that threaten our civilization:

- Limits on key resources:
  - Fresh water, arable land, cheap oil, *etc.*
- Blowback from environmental damage:
  - Increased greenhouse gases → global warming
    - More droughts, more severe storms, sea level rise
  - Ocean acidification, runoff, dead zones
  - Reduced biodiversity, increased extinction rates
    - From environmental damage: clearcutting forests, climate change, overharvesting of natural resources

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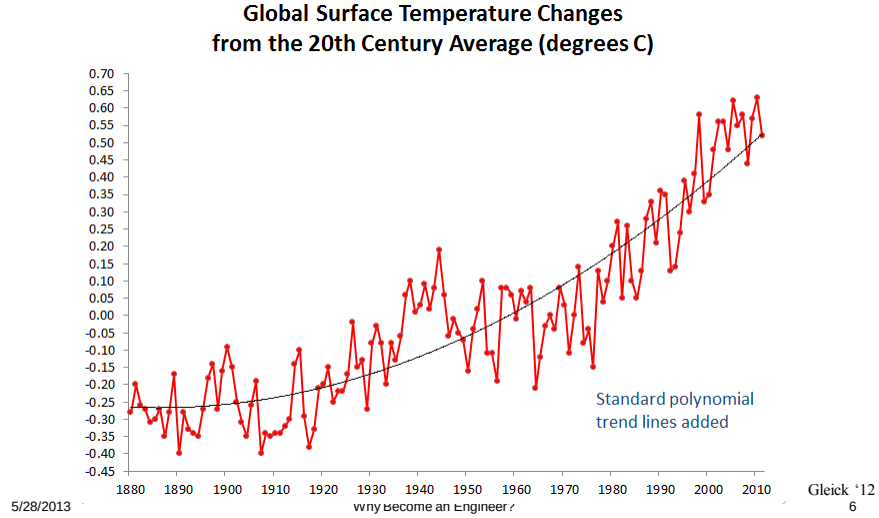
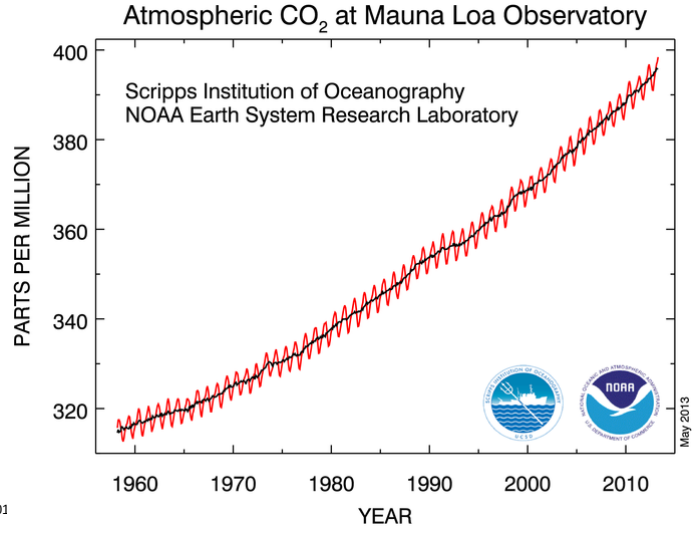
Warming of last 130 years



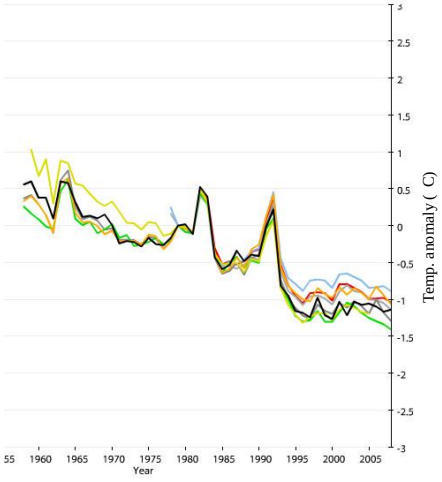
Gleick '12

Carbon dioxide concentrations over the last half-century



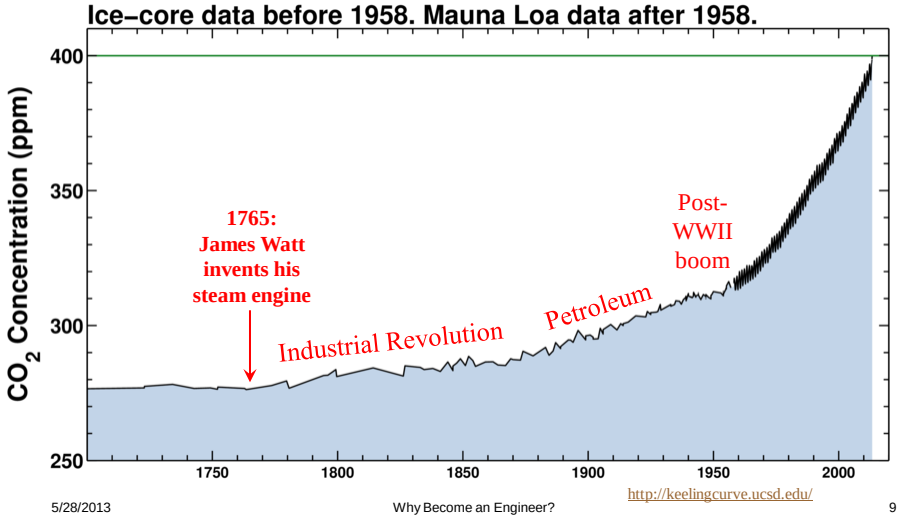
Stratospheric Temperature Falling → Signature of Greenhouse Gas Blanket

Apart from laboratory studies and computer simulations, we know that the surface warming is caused by greenhouse gases because the temperature of the *upper* atmosphere is actually falling, as we would expect if increased GHG concentration at lower altitudes is reducing IR emission from the lower atmosphere into the upper atmosphere. Direct satellite measurements of IR emissions also confirm this reduction.



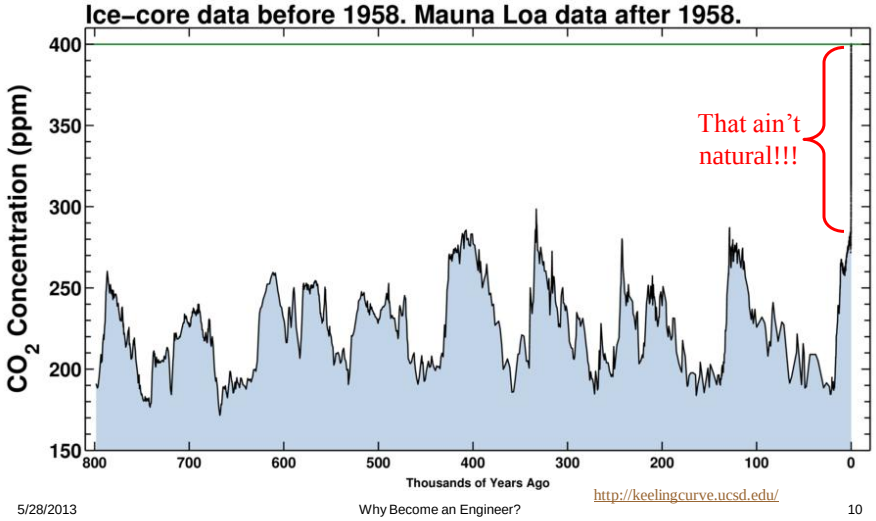
Source: NOAA

Looking back a little farther at CO_2 levels… (last 300 years)



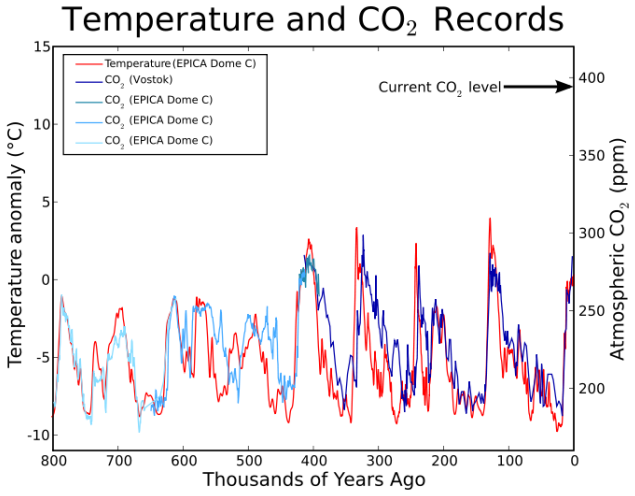
http://keelingcurve.ucsd.edu/

0.8 Million Years' Worth of Data on Atmospheric CO_2 Variations



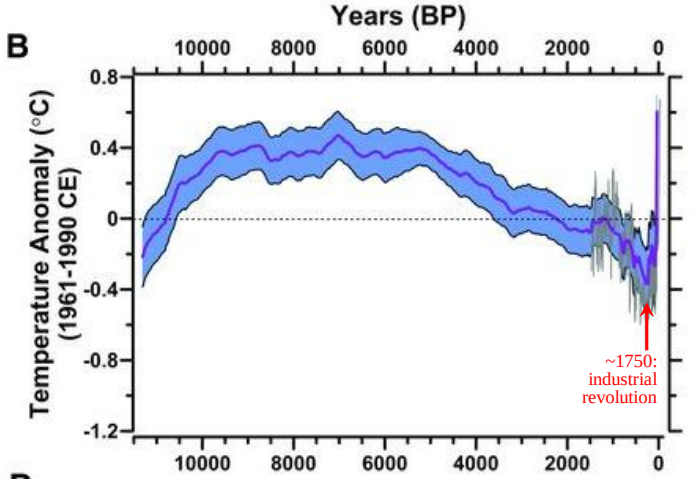
http://keelingcurve.ucsd.edu/

0.8 Million Years' Worth of Data on Temperature / CO_2 Correlations



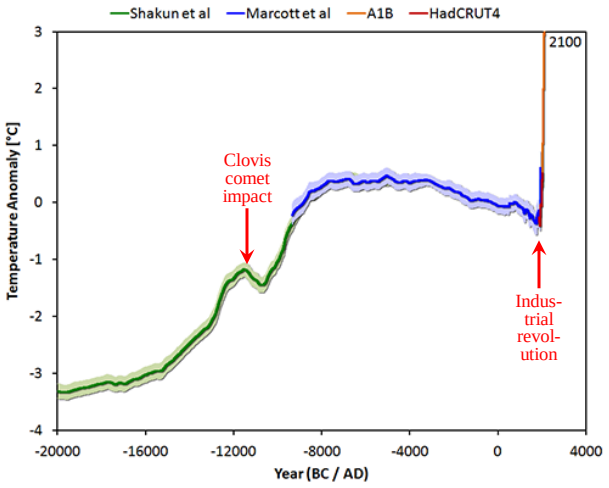
 http://en.wikipedia.org/wiki/File:Co2-temperature-plot.svg

Global Temperatures last 11,000 years

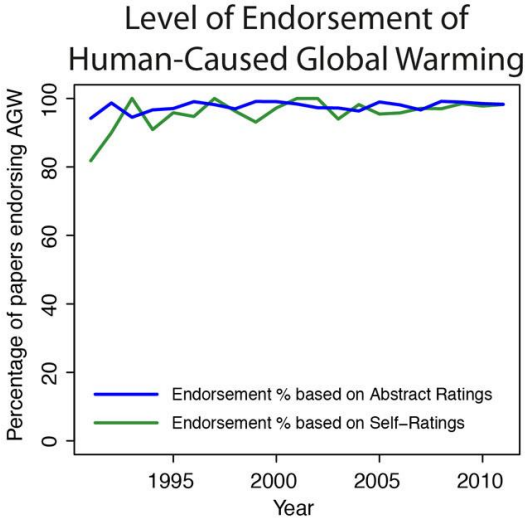


Marcott *et al.* 2013

20,000 B.C. to 2,100 A.D. (projected)

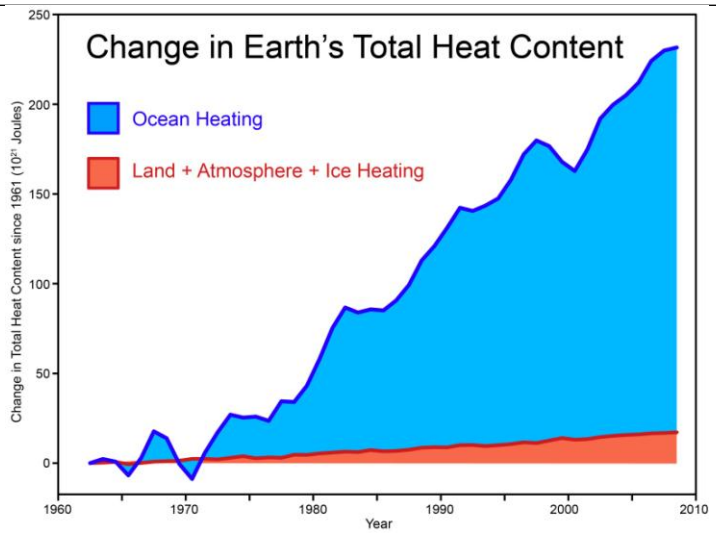


Clear consensus in peer-reviewed literature: We are causing global warming



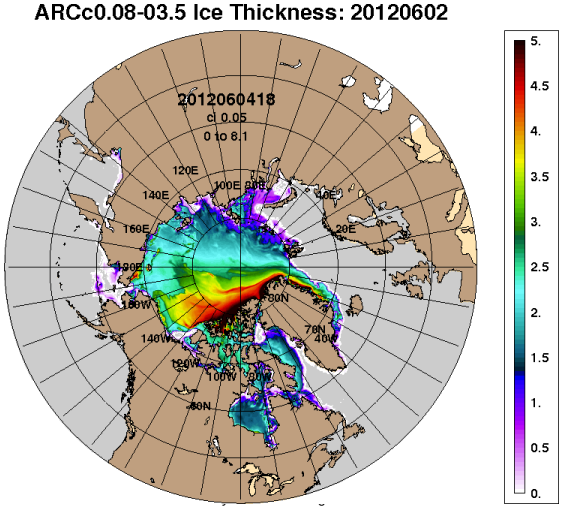
SkepticalScience.com

Most of the heat goes into the ocean…



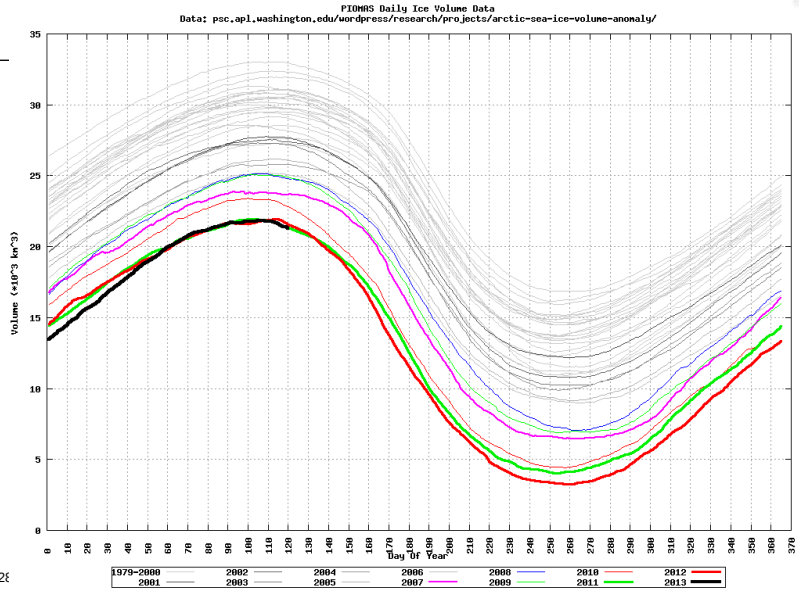
Gleick '12

Arctic Sea Ice – Last 12 Months



http://www7320.nrlssc.navy.mil/hycomARC/arctic.html

Arctic Sea Ice Volume



http://meteomodel.pl/index.php/arcticice

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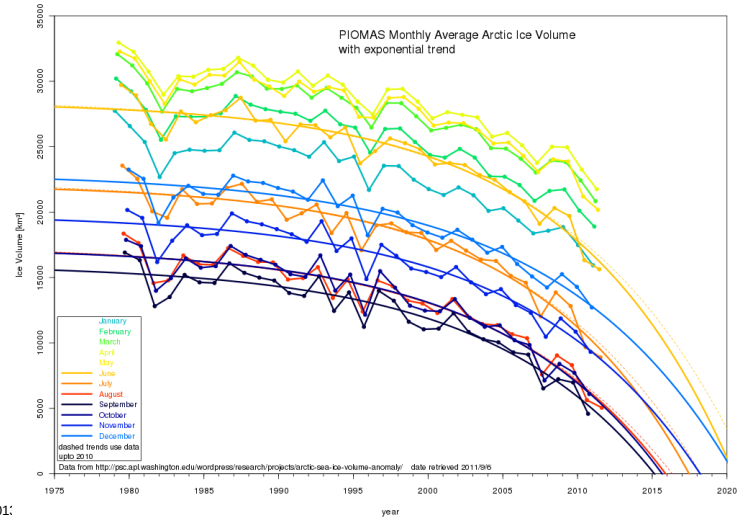
An Ice-Free Arctic Ocean by 2020?



Why is Sea Ice Important?

Its melting doesn't affect sea level, but…

- Remember your thermodynamics:
  - Specific heat capacity of water c = 4 J/g/K.
  - Latent heat *of fusion* of water H_f = **334** J/g !
- ∴The heat absorbed by ice when melting is enough to raise the temperature of the same amount of already-melted water by $\Delta T = H_f/c$ = 83.5 C !
  - So, what happens to ocean temps. when sea ice is gone?
    - Melting the 20,000 km^3 of peak Arctic sea ice absorbs as much heat as warming top 1 m of the ***entire world ocean*** by ~8.3 F!
- Also, ice reflects sunlight, open ocean absorbs it
  - Less ice cover → more summer heating of Arctic waters

What are the dangers from global warming?

- Medium-term risks (next several decades)
  - Increased impacts from more extreme weather
    - More floods, droughts, heat waves, more severe hurricanes, *etc.*
  - Food insecurity - Risk of devastating famines!
    - Context: Increasing world population, limits on land/fresh water
    - Chaotic climate → Increased chance of widespread crop failures
    - Consequences such as: Mass starvation, civil unrest, regional/world war
- Long-term risks (~100+ yrs.)
  - Large areas of Earth become uninhabitable by humans
    - Wet-bulb temps. exceed survivable limits part of year
- Very-long-term risks (100s/1,000s of years):
  - Greenland/Antarctica ice sheets melt completely, sea level rises >200′
  - Anaerobic bacteria in rotting oceans poison atmosphere w. H_2S gas
    - Most land animal species would go extinct, like in P-Tr event

Areas at Risk of Water Insecurity and Biodiversity Loss

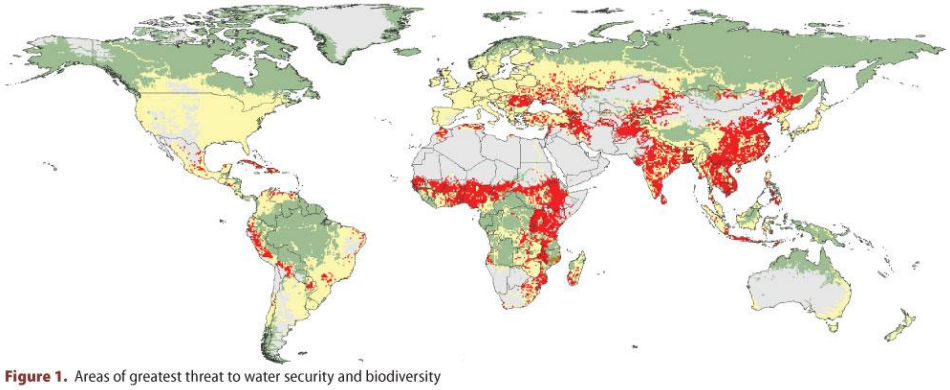
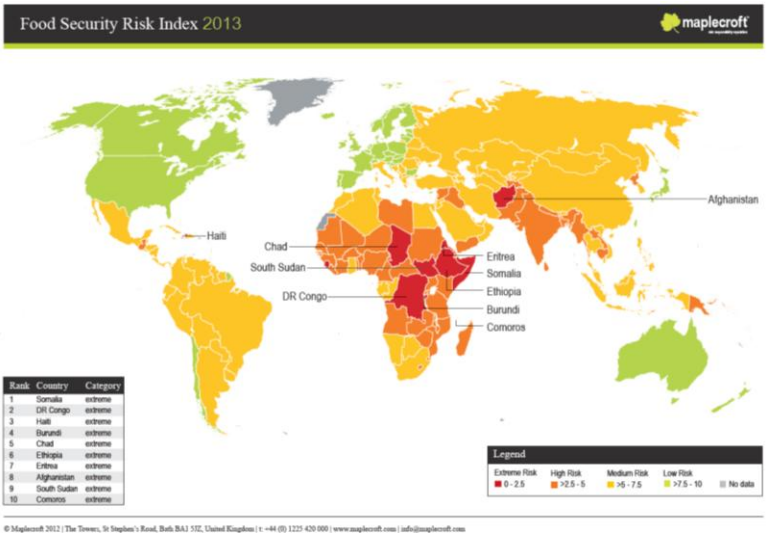


Figure 1. Areas of greatest threat to water security and biodiversity

Biodiversity threat:	*Low*	*High*	*Low*	*High*
Human water scarcity threat:	*Low*	*Low*	*High*	*High*

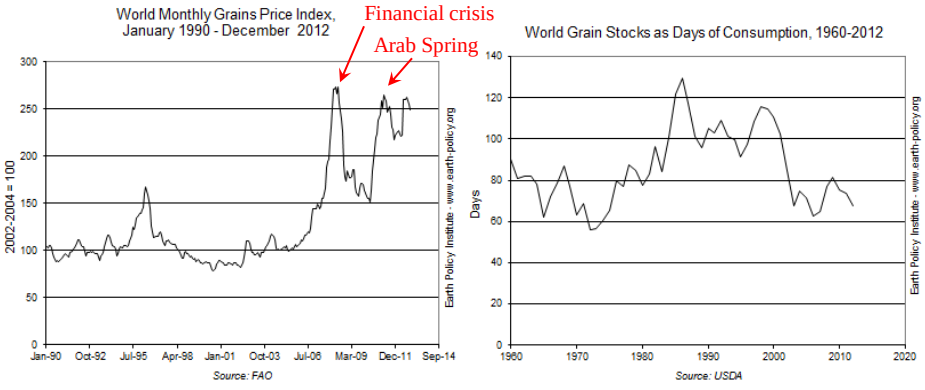
Source: Vörösmarty et al., 2010

Regional Food Insecurity Today



Rank	Country	Category
1	Somalia	extreme
2	DR Congo	extreme
3	Haiti	extreme
4	Burundi	extreme
5	Chad	extreme
6	Ethiopia	extreme
7	Eritrea	extreme
8	Afghanistan	extreme
9	South Sudan	extreme
10	Comoros	extreme

Some Early Signs of Global Food Insecurity?

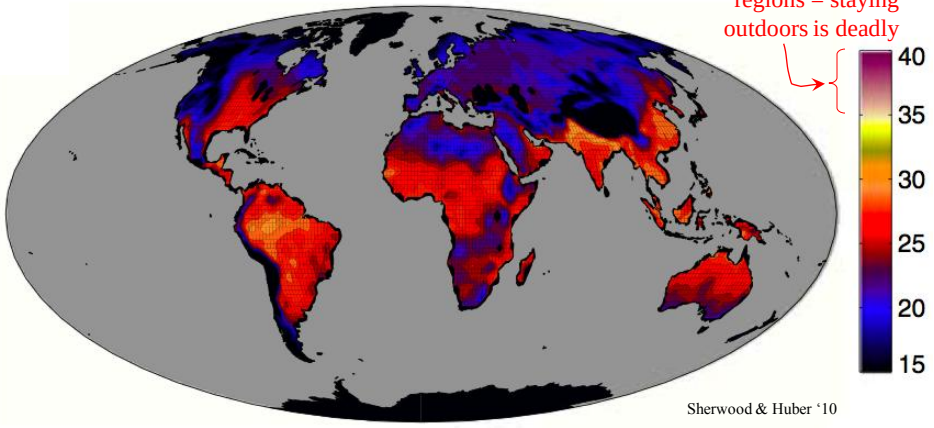


Larsen '13

Annual Peak Wet-Bulb Temperature Around the World Today

Human body overheats if the wet-bulb temp. (which includes maximum evaporative cooling) exceeds ~35 C = 95 F.

White/lavender regions = staying outdoors is deadly

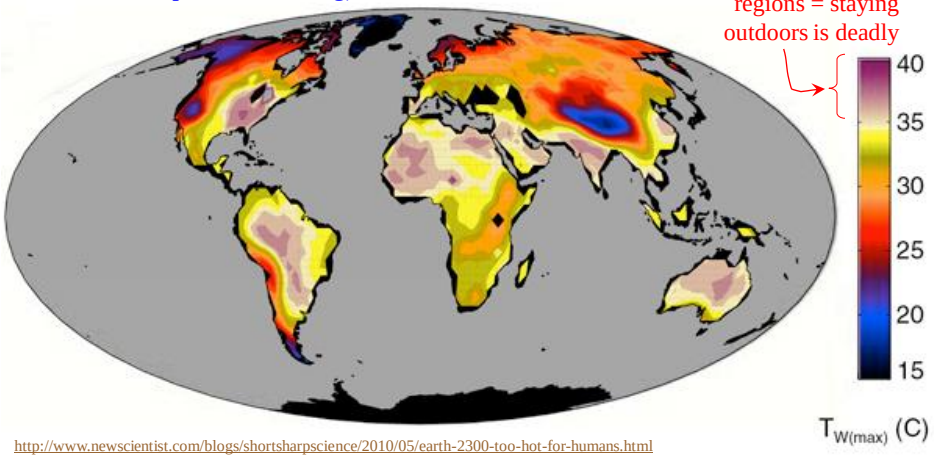


Sherwood & Huber '10

Projected Peak Wet-Bulb Temperatures under +12 C of Global Warming

Human body overheats if the wet-bulb temp. (which includes maximum evaporative cooling) exceeds ~35 C = 95 F.

White/lavender regions = staying outdoors is deadly



http://www.newscientist.com/blogs/shortsharpscience/2010/05/earth-2300-too-hot-for-humans.html

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What can you do, as an engineer, to help humanity mitigate these risks?

- Help to design & develop products, processes, and structures in areas such as the following:
  - New energy technologies, new fuels, new engines
    - To help reduce our dependence on fossil fuels
  - More efficient/resilient food production methods
  - New public/private infrastructure, *e.g.*:
    - Delivery infrastructures for new energy technologies
    - Structures to aid survival in extreme weather events
  - Geoengineering techniques
    - Ways to cool the Earth, moderate weather/climate?

Conclusion

- Our modern civilization faces major challenges to its continued prosperity & well-being in the 21st century
- Becoming an engineer (and a *good* one!) is thus not just a matter of personal/practical expediency…
- *You* could be the one who invents key technologies or leads development of infrastructure projects that:
  - Improve global energy security / food security
  - Help people mitigate or adapt to increasingly extreme weather events, rising sea levels, ecological damage *etc.*
- *The world needs you to pitch in & work hard to become the very best engineer that you can be.*