Policy, Economics and Technology Actions to Reduce CO_2 in the Atmosphere

(Direct Capture from Atmosphere,"Geo-engineering" Excepted)

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CCUS Student Week

Colorado School of Mines

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Today's Relevant Numbers (10/15/2018)

Daily CO_2

- October 12, 2018: 405.66 ppm
- October 12, 2017: 403.56 ppm

Average pre-industrial world ('interglacials'): 280 - 290 ppm

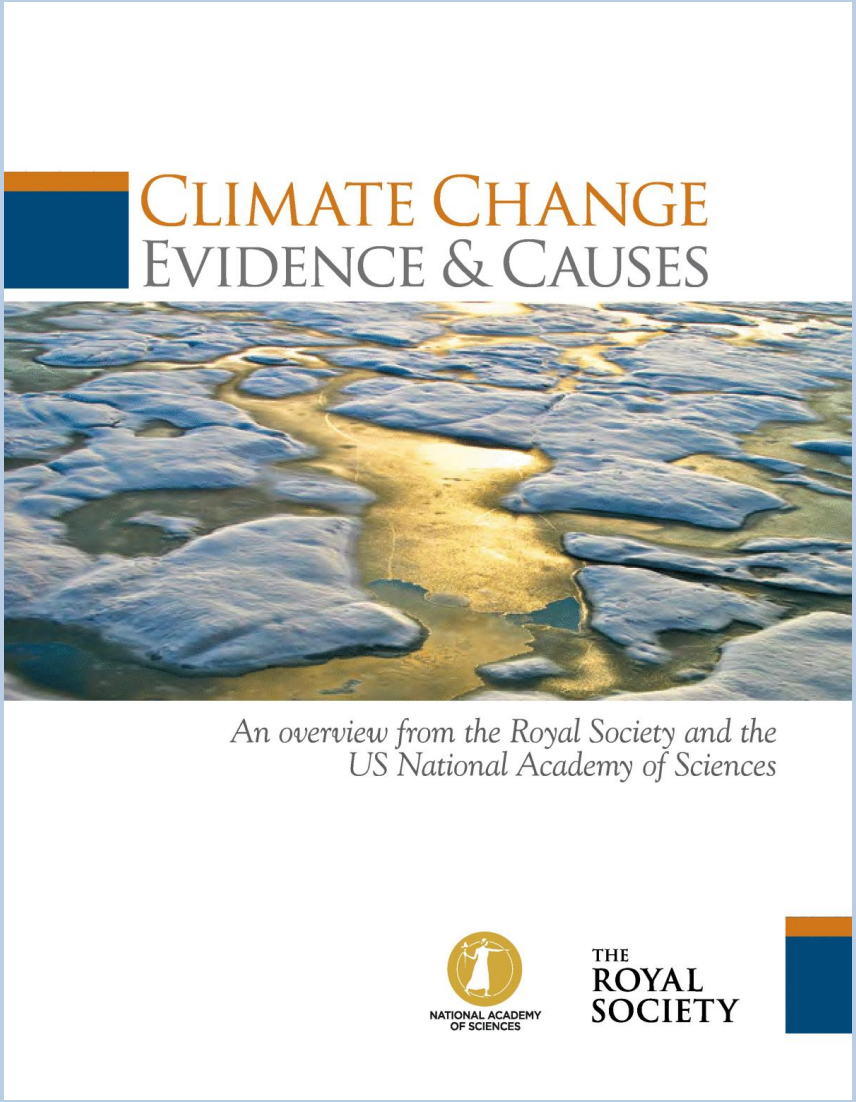
- **5**th Warmest Aug. since 1880: 2018

Why We Got Here

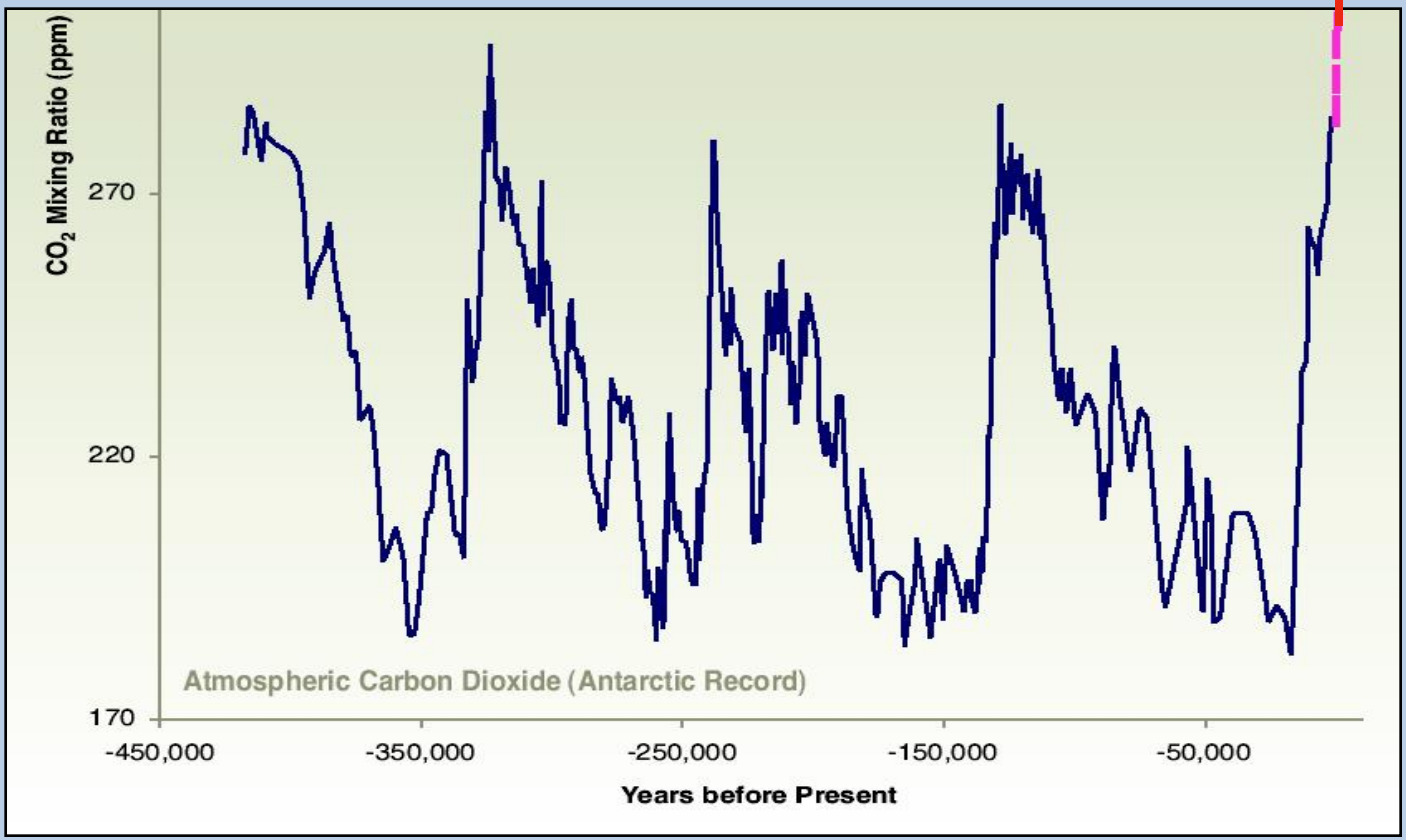
Comprehensive Reference (Feb. 2014) on <u>The Problem</u>

This book deals with Evidence and Causes

We (even more so YOU) need to find the SOLUTIONS



CO_2 Concentration (ppm) Changes on Geological Time Scale – 450,000 years - till TODAY https://www.co2.earth/



The Paris Goals (COP 21, 2015), and amended in Marrakech (2016), Bonn (2017), Soul (2018)

A finite planetary carbon budget that achieves a 50% chance of limiting warming to less than 1.5^{o} C by 2100

Ultimate temperature increase below 2^{o}C and then reduce to 1.5^{o} C by 2100 (there is a lag built in)

To meet those two goals, global CO_2 emissions must peak by 2020!

And, gross emissions decline trajectory must follow this trajectory:

Now (2018): 37 $GtCO_2$/yr

2020: 40

2030: 24

2040: 14

2050: 5

5th UN - IPCC Report

Soul, South Korea,
October 8th, 2018

http://report.ipcc.ch/sr15/pdf/sr15_headline statements.pdf

1. Key findings

1. Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate (*high confidence*).

2. Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long term changes in the climate system, such as sea level rise (*high confidence*).

3. There will be more hot extremes in most inhabited regions (*high confidence*), heavy precipitation in several regions (*medium confidence*), and the probability of drought and precipitation deficits in some regions (*medium confidence*).

4. Avoiding overshoot and reliance on future largescale deployment of carbon dioxide removal (CDR) can only be achieved if global CO2 emissions start to decline well before 2030 (*high confidence*).

Science Magazine summary of Soul, Korea, IPCC Report, Oct. 8th, 2018

Overshooting 1.5°C will be disastrous. For example, with 1.5°C of warming, sea levels are projected to rise 26 to 77 centimeters by 2100; going to 2°C adds another 10 centimeters, which would affect an additional 10 million people living in coastal regions.

Plants, insects, animals, and marine life will all be pushed farther out of current geographic ranges with 2°C of warming. Coral reefs are projected to decline 70% to 90% at 1.5°C, but at 2°C, 99% of reefs would be ravaged. Storms, flooding, and drought would exact an even higher toll.

The panel says keeping warming to 1.5°C is technically feasible, but the emissions cuts pledged so far by the nations that signed the Paris agreement fall far short of what's needed. To hit and keep that 1.5°C target, net anthropogenic CO_2 emissions must come down 45% from 2010 levels by 2030 and reach net zero around 2050.

One bright spot is renewable energy. "There [has been] exponential growth in the last 5 years in solar, wind, and batteries that is significantly changing electricity systems around the world," Peter Newman, a sustainability scientist at Curtin University in Bentley, Australia, said during the Sunday briefing. But efforts to reduce emissions are lagging in freight, aviation, shipping, and in industry, he said.

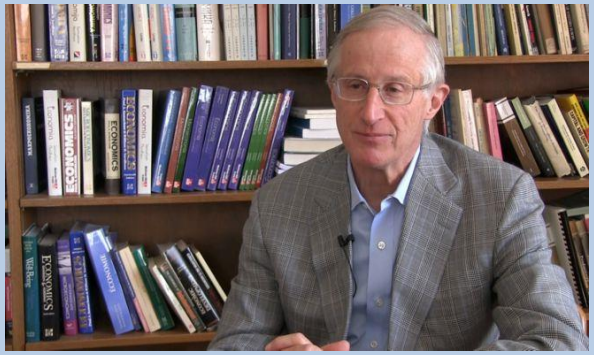
Because forests capture and sequester carbon, reforestation could help reduce net emissions. But forest loss is still outpacing reforestation globally.

Other strategies to sequester carbon have yet to live up to their promise, Newman says. The report notes that one proposed approach, bioenergy with carbon capture, in which trees or other crops are grown on vast plantations, then burned in power plants that capture carbon emissions and store them underground, could encroach on agricultural land and undermine food security.

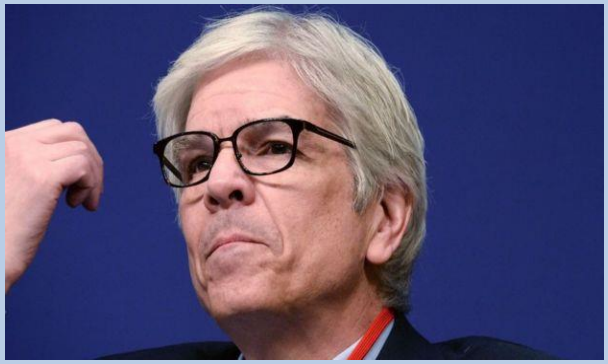
Meanwhile, coal's share of global electricity must be cut from 37% today to no more than 2% by 2050, the report says. Technologically, economically, and politically the challenge is immense, "indicative both of the scale of the challenge and the resistance [the effort will] face," notes Shindell, who also contributed to the report.

Nobel Prizes in Economics, 2018

Prof Nordhaus, of Yale University, was the first person to create a model that described the **interplay between the economy and the climate**, the academy said. In the work of William Nordhaus these spill-overs are the negative consequences of climate change. He developed an integrated method for looking at economic activity, and its environmental consequences and for evaluating responses to it, such as carbon taxes, an approach he has advocated.



Professor Romer, of New York University's Stern School of Business has focused on the positive side-effects of technological change. He argued that innovators often don't get all the benefit of what they do, so market economies left to their own devices tend not generate enough new ideas.



Addressing this shortfall, Roemer suggests, requires for well-designed government action to stimulate more innovation, such as subsides for research and development.

So, Let us Look at

How do we get there? – 2020-2030

Johan Rockstrom et al., Stockholm Resiliency Center

- Eliminate fossil-fuel subsidies (currently at $500 billion/yr) by 2020, perhaps much more (by International Monetary Fund calculations)
- Moratorium on new coal-based energy development
- Better carbon management on farms and civil society overall
- Improved energy efficiency by 40-50% by 2030
- Implement a carbon price, starting at $50/ton now and rise to $400/ton by mid-century
- By mid-century, expect that coal will have left the energy industry
- Some cities (e.g. Copenhagen and Hamburg, will be fossil fuel free by 2050)
- Expect Phase Out of internal combustion engines by 2030 in Norway, Sweden, Denmark, Germany and the Netherlands (may take till 2040)

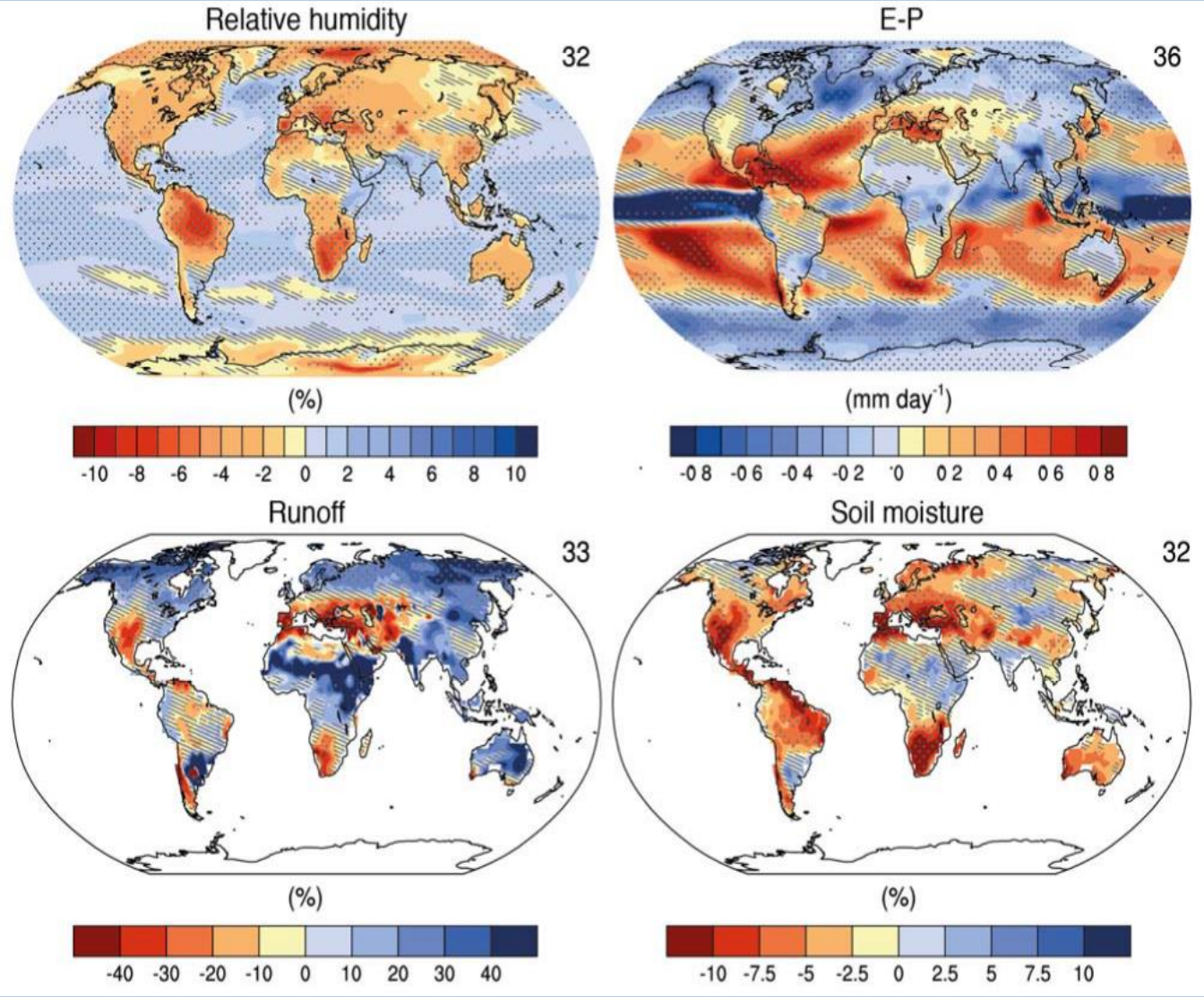
Drawdown
The Most Comprehensive Plan Ever Proposed to Reverse Global Warming

Paul Hawken, Ed. Penguin © 2017

Ranking of solutions by potential impact	Atmospheric CO_2 reduction, Gt	Primary effects
1. Refrigeration	90	Recover refrig. gases (HFC, CFC)
2. Wind turbines (onshore)	85	2.9c/kwh vs. 3.8 c/kwh for NG
3. Reduced food waste	71	35% food is discarded (in high-income places)
4. Plant rich diet	66	Reduce cows; they "emit" gas
5. Tropical forests	61	Reforestation
6. Educating girls	60	Edu. women yields fewer children
7. Family planning	60	10x increase by 2027
8. Solar farms	37	

There are 80 solutions categories in total in this evaluation. There is NO MENTION of the use of CO_2 in enhanced oil recovery!

Humidity and Soil Moisture – IPCC 5th Assessment



Emissions, Climate Change and Conflict

Climate change in the Fertile Crescent and implications of the recent Syrian drought; Colin P. Kelley[a],[1], Shahrzad Mohtadi[b], Mark A. Cane[c], Richard Seager[c], Yochanan Kushnir[c];

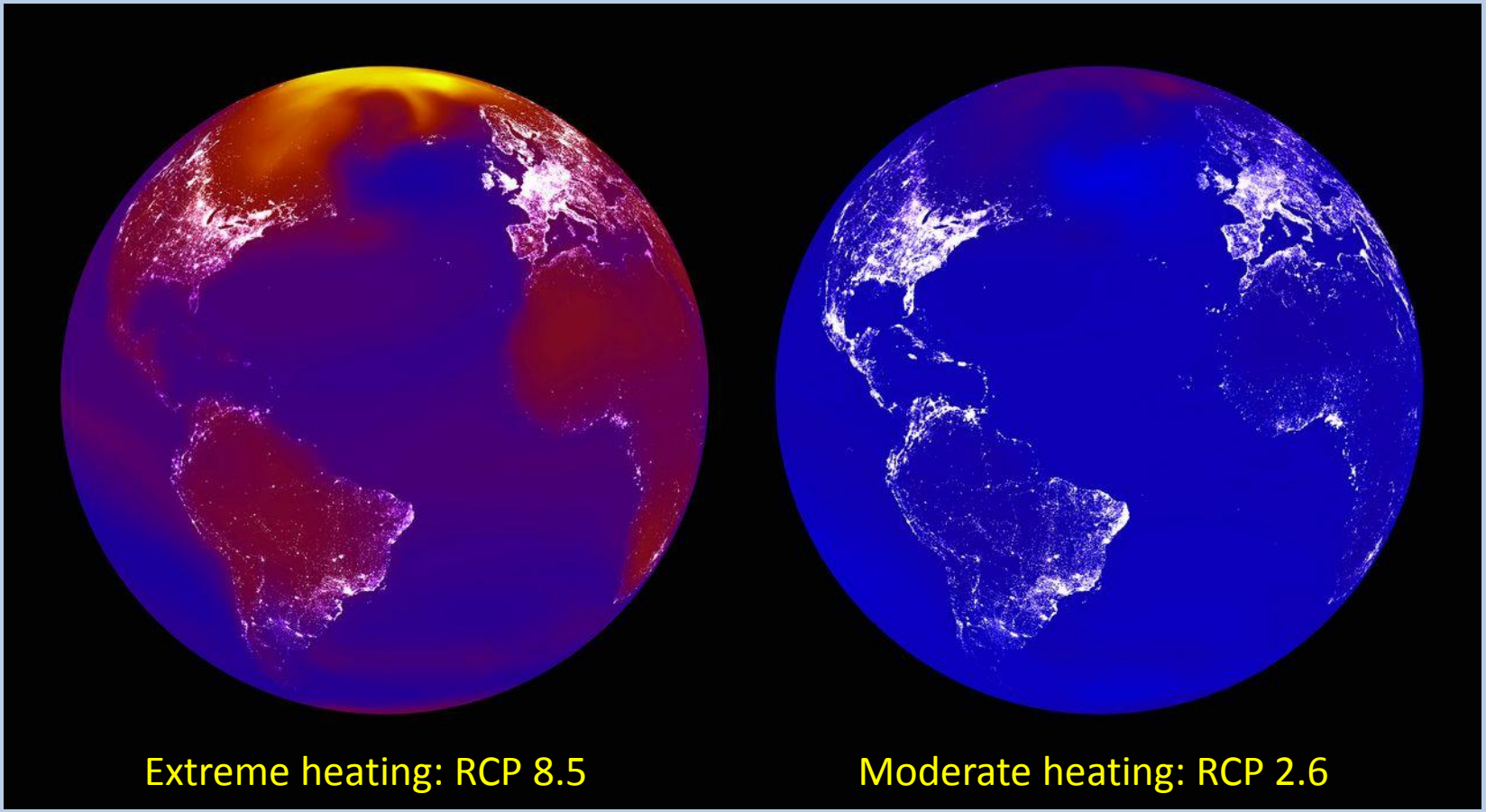
Proceedings, US National Academy of Sciences, vol. 112 no. 11
> Colin P. Kelley, 3241–3246, doi: 10.1073/pnas.1421533112

There is evidence that the 2007–2010 drought contributed to the conflict in Syria

It was the worst drought in the instrumental record, causing widespread crop failure and a mass migration of farming families to urban centers. Century-long observed trends in precipitation, temperature, and sea-level pressure, supported by climate model results, strongly suggest that **anthropogenic forcing has increased the probability of severe and persistent droughts in this region, and made the occurrence of a 3-year drought as severe as that of 2007–2010 2 to 3 times more likely than by natural variability alone.** We conclude that human influences on the climate system are implicated in the current Syrian conflict.

Two Possible Futures

For how climate might change and how those changes are likely to affect humanity, based on recent empirical findings



Tamma A. Carleton, and Solomon M. Hsiang Science 2016;353:aad9837. Sept. 2016

Representative Concentration Pathways: describe four possible climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come. The four RCPs are named after possible ranges of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 W/m^2, respectively).

Conclusions

"Where to From Here"

1. Climate drives global shifts in economic activity and conflicts
2. More frequent "expensive" events (e.g. hurricanes, sea level rise and mega-droughts)
3. Policies should, of course, be enacted to drive emissions reductions, and
4. Changing practices to be done NOW: (a) energy production and use, (b) food production, (c) land use, (d) education (for girls), (e) urban infrastructure upgrade, (f) transportation, materials. Future "living buildings", ocean farming, …

We are facing opportunities and challenge far more essential than at the start of the "Space Race" in the late 1950s through 1970s onwards. Space race now is getting a bit off-track ("space defense force"), let's get back to the excitement, creativity and investments of the original space race, now focused on a climate change control race.