

American Geophysical Union + Chinese Academy of Sciences

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I was privileged to give one of the keynote talks at the first joint meeting of the American Geophysical Union (AGU) and the Chinese Academy of Sciences (CAS). The meeting was timely and propitious. Both of these nations and the world as a whole need increased cooperation between the United States and China, cooperation in science and technology, cooperation based on facts and mutual interests, cooperation upon which the future of young people and other life on the planet depend.

All the charts and my talk are available on my web site as a [Recent Presentation](#). My talk is provided by the notes attached to each chart; I have edited these descriptions for clarity. Please feel free to use these charts in your classes or any other educational efforts – you do not need to ask my permission. I have also included back-up charts not shown during my talk.

My talk was nominally about atmospheric aerosols, the portion of the climate story that is poorly defined, in contrast to the greenhouse gas portion. However, we must look at the broad climate picture to appreciate the importance of aerosols. Global warming accelerated markedly in the past several years (see Chart 13). What is driving that acceleration? I suggest that at least a portion of the increased warming rate is probably because growth of atmospheric aerosols is no longer keeping pace with growth of greenhouse gases.

Indeed, global aerosol forcing of climate may have stabilized or even decreased slightly during the past several years, because of efforts to reduce air pollution in parts of the world such as China. However, as I emphasized in *Storms of My Grandchildren*, the high precision global measurements needed to define changes in aerosol climate forcing, especially the effect of aerosols on clouds, are not being made.

Historically, aerosol cooling has partially offset greenhouse gas warming. Aerosols have a direct cooling effect by reflecting sunlight. Increasing aerosols also have an indirect cooling effect by altering the brightness and lifetime of clouds. The indirect effect arises because some aerosols serve as cloud condensation nuclei, so they can alter cloud particle size and thus the brightness and lifetime of clouds.

The direct aerosol forcing is sensitive to small amounts of aerosol absorption. The indirect effect via aerosol and cloud interactions is complex. Computer modeling helps develop understanding of the processes, but quantitative evaluation can only be achieved via global satellite observations of aerosol and cloud microphysics to extremely high precision. Specifically, the polarization of sunlight reflected by the clouds and aerosols must be measured with an accuracy of 0.1 percent. The ability to achieve such accuracy has been demonstrated in studies of the veil of smog that shrouds the planet Venus, but the United States has been remarkably resistant to proposals to make polarization measurements of Earth to that accuracy, as will be recounted in detail in *Sophie's Planet*.

There are other reasons, besides interpretation of accelerating global warming, for measuring global aerosol properties very accurately. Human-made aerosols are carried by the winds and deposited on land and ocean surfaces almost globally. These aerosols contain nutrients such as nitrogen, phosphorous and iron, which, together with increasing atmospheric CO₂, fertilize Earth's biosphere (see Charts 10 and 11). We have suggested that this fertilization effect is at least partly responsible for increased uptake of fossil fuel carbon during the past three decades, compared with the preceding three decades (see Charts 8 and 9). If this interpretation is correct, we can anticipate that continuing efforts to reduce particulate air pollution, which is essential for the sake of human health, will lead to an upsurge of atmospheric CO₂. Again, precise global satellite measurement of aerosols is needed, in coordination with surface data and modeling.

Still another reason to monitor and understand aerosol climate effects relates to the likelihood that the world will overshoot the safe level of atmospheric CO₂. Indeed, Chart 21 implies that we have already overshoot the level of CO₂ that will be safe on the long-term. Because of the time required to draw down atmospheric CO₂, even with aggressive phase-out of fossil fuels (see Charts 51 and 52), it may prove essential to take steps to alter Earth's energy imbalance and the rate of ice melt, if the loss of coastal cities is to be averted.

We are not at a point to recommend such actions, but there is a real danger that such a point may be reached, especially if phase-out of fossil fuels as our principal energy source is not achieved soon. Most large cities are located on coastlines (see Chart 23), China has several hundred million people living near sea level (Chart 24), and much of global infrastructure is on coastlines.

One of the oldest proposals for solar radiation management (SRM), popularized by Russian climatologist Mikhail Budyko, is to mimic the effect of volcanoes by injecting SO₂ gas into the stratosphere. This would form aerosols that reflect sunlight, cooling Earth. Because the aerosols fall out on a time scale of about a year, they require continual replenishment, and thus this purposeful intervention with climate can be terminated easily, if it is found to have undesirable effects.

Focused objectives of SRM might be achieved via the latitude of SO₂ injection. Stratospheric aerosols tend to move toward the poles, where they descend and are “washed out” of the atmosphere. Thus we are carrying out climate simulations for four idealized distributions of stratospheric aerosols: (1) globally uniform, (2) Southern Hemisphere, (3) Southern Ocean and Antarctica, and (4) Antarctica (see Chart 33). Aerosol properties and amount correspond to those in the year after the Pinatubo eruption. The most interesting result is for case (3), which has aerosols over the Southern Ocean and Antarctica. This leads to large cooling of the internal ocean along the coast of Antarctica at the depths where ice sheets are presently melting rapidly (see Chart 35). The ocean temperature response is the mirror opposite to the warming at depth (and surface cooling) found in observations and in our simulations for increasing greenhouse gases (see our [Ice Melt, Sea Level Rise & Superstorms paper](#)).

We are not suggesting such aerosol experiments in the real world. SRM seems appropriate only as a last resort, if we are unable to achieve phasedown of fossil fuel emissions and atmospheric CO₂ levels, and if unacceptable consequences such as loss of coastal cities seem to be in the offing. Even if aerosols were confined to the Southern Ocean and Antarctic region, they likely would affect some populated areas such as New Zealand. The aerosols might also have undesirable effects such as ozone depletion. The principal effect of such studies should be a redoubling of efforts to phase down CO₂ emissions.

There is breaking news on the efforts to minimize human-made climate change. First, in remarkably good news, Citizens Climate Lobby (CCL) is reporting that Canada plans to adopt carbon fee & dividend, beginning in January 2019; I copy the press release from CCL below. Second, the Supreme Court of the United States has ordered a temporary administrative stay in the Juliana v. United States case while it considers the federal government’s most recent writ of mandamus petition. The OCT attorney’s filed their response to the Supreme Court on 22 October and requested the Court to allow the trial to proceed. We are awaiting the Supreme Court’s response.

If the CCL and OCT efforts bear fruit, especially in the United States, it becomes plausible to imagine that global CO₂ emissions could begin a real decreasing trend within a few years. The climate simulations in [Young People’s Burden](#) show that global warming can be kept less than +1.5°C, if phasedown of emissions begins in 2021 (Charts 51 and 52).

Ultimately the fate of the planet and the future of young people, their offspring, and other life on Earth depends upon cooperation between the United States and China. If these nations agree to a rising carbon fee, it could be made near global (Charts 43 and 44). Cooperation should extend to technology, because the crucial requirement for deep decarbonization is carbon-free electricity generation.

CCL Press Release follows:



Canadian Prime Minister Justin Trudeau announces Canada’s carbon pricing policy.

Canada adopts carbon fee and dividend to rein in climate change

WASHINGTON, D.C., Oct. 23, 2018 — Carbon fee and dividend, the solution to tackle climate change proposed by Citizens’ Climate Lobby, has emerged as the default policy in Canada to price carbon and reduce the greenhouse gas emissions contributing to global warming.

Beginning in 2019, Canada’s federal policy will put a rising fee on carbon emissions and return the revenue directly to Canadians. The federal policy is a backstop to cover the four provinces that have not initiated their own carbon-pricing policies. Nearly half of Canadians live in these provinces.

“For years, CCL grassroots lobbyists have pressed both the U.S. and the Canadian governments to enact carbon fee and dividend to bring heat-trapping emissions under control,” said Mark Reynolds, Executive Director of Citizens’ Climate Lobby. “We’re thrilled that Canada is taking the lead with this policy, and we hope their decision will inspire the U.S. Congress to take similar action.”

The policy announced today by Canadian Prime Minister Justin Trudeau applies a tax on carbon starting at \$20 per ton in 2019, rising \$10 per ton annually until it reaches \$50 per ton in 2022. Residents and businesses in Ontario, Saskatchewan, Manitoba and New Brunswick, the four provinces subject to the federal tax, will receive rebate checks that will exceed the amount of the carbon tax paid by the average family.

Trudeau summed up the problem simply in today’s announcement: “It is free to pollute, so we have too much pollution.” He presented the solution simply too, saying, “Starting next year, it will no longer be free to pollute anywhere in Canada. We are going to place a price on the pollution that causes climate change from coast to coast to coast. We’re also going to help Canadians adjust to this new reality.”

He stated that a family of four would receive \$307 with their tax return this spring. That will more than double to \$718 by 2022. Using one province as an example, Trudeau said, “Eight in 10 Ontario families will get back more than they pay.” The policy also includes extra support for small, rural and remote Canadian communities. Trudeau emphasized that “every nickel” of the carbon pricing revenue would be returned to Canadians.

Since its inception in 2010, [CCL Canada](#) has lobbied relentlessly for Ottawa to adopt carbon fee and dividend, over the years holding 793 meetings with members of Parliament and generating thousands of letters to the editor and op-eds in support of the policy.

“We’re the little lobby that could,” said Cathy Orlando, CCL’s International Outreach Manager based in Sudbury, Ontario. “Our patience and persistence has been rewarded with an effective program that puts Canada on the path to meeting its global obligation on climate change. Today’s announcement is also an affirmation of CCL’s approach to engaging government with an attitude of appreciation, respect and being nonpartisan.”

Earlier this month, CCL Canada held its 5th annual conference, sending 55 citizen lobbyists to Parliament Hill to meet with MPs. Throughout the 36 CCL chapters in Canada, volunteers also met with staff in the local offices of members of Parliament.

“The recent report from the IPCC warned us that we have little more than a decade to get our act together and take unprecedented actions to avert catastrophic climate change,” said Reynolds. “Carbon fee and dividend is one of those unprecedented actions that not only reduces our risk, but also protects our economy by putting money in people’s pockets.”

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Citizens’ Climate Lobby is a nonprofit, nonpartisan, grassroots advocacy organization focused on national policies to address climate change. With nearly 500 active chapters across the world, our volunteers work to generate the political will necessary for passage of our [Carbon Fee and Dividend proposal](#).