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The Cryosphere Imperative: Why Paris 2015 Must Succeed

Summary:
The earth's cryosphere – regions of snow and ice – is approaching thresholds that may tip the balance between successfully addressing climate change; or slipping into a cascade of catastrophic and near-irreversible global impacts that begin with the cryosphere. This "cryosphere imperative" for immediate mitigation provides an increasingly sharp scientific reality, one underestimated by both policymakers and the general public.

Minimizing high-risk cryosphere changes demands much higher levels of ambition for greenhouse gas emission reductions in the Paris 2015 agreement, which will set commitments through 2030. Absent such ambition, and especially if current emission levels continue, avoiding rapid deterioration of snow and ice regions and associated global climate destabilization may become close to impossible and at a minimum, extremely costly to global economies to reverse. Adaptation to the levels of projected climate disruption may not be possible without massive migration and other changes to human centers of population and infrastructure that will carry enormous economic and human costs.

Elements of the "Cryosphere Imperative":
Parts of the Arctic, Antarctica and mountain regions already have warmed two-three times faster than the rest of the planet. The very nature of ice makes this warming more important than elsewhere: the difference between -1° and +1°C is the difference between frozen, stable ice and water. If this rate of cryosphere temperature rise continues, projected from 4° to 10°C (7° to 18°F) for the major cryosphere regions by 2100 under different emissions scenarios, impacts will occur all over the globe: sea level rise, permafrost melt that could release substantial additional greenhouse gases, loss of snow and ice that otherwise cool the planet by reflecting the sun's rays. The major risks within this "cryosphere imperative" include:

Irreversible, inevitable sea-level rise: Current melting of land glaciers and polar ice sheets (Greenland and Antarctica), plus warming oceans will raise sea levels by 1-1.4 meters (1-4 feet) in the next 85 years. Halting this level of flooding likely is no longer humanly possible. Warming to date now appears to have destabilized the West Antarctic Ice Shelf (WAIS) and Greenland, setting in motion irreversible ice sheet loss as cold meltwater sinks and brings warmer ocean water to the base, a conveyor belts that stops only when all ice is gone. Loss of the WAIS could add an additional 1-2 feet in sea-level rise already by 2100.

Loss of land glaciers and water resources: Nearly all land glaciers and seasonal snow cover across the globe are thinning or retreating, and many of these contribute to water supplies for drinking and crops. This melt will peak globally around 2070, along with associated flood risk from rapid melting, then slow as these glaciers completely disappear.

Polar ocean acidification: The Arctic Ocean, near-Arctic waters and Southern Ocean around Antarctica provide the world's richest fisheries, but these cold waters are more vulnerable to acidification that weakens the entire food chain, beginning with krill. Scientists already see damage from this more acid water, caused by increased CO2 in the atmosphere.

Loss of Arctic sea ice: Summer sea ice will disappear in the Arctic Ocean sometime in the next few decades. Preventing this loss is almost certainly no longer possible unless CO2 emissions stabilize within the next decade. Regardless of when the first ice-free summer occurs, sea-ice extent has already decreased to less than half its pre-industrial levels. The accompanying loss of reflective surface, together with earlier springtime loss of reflective snow cover at high latitudes and in mountain regions, feeds back to higher overall levels of cryosphere warming, speeding additional melting of ice sheets, glaciers and not least, thawing of permafrost and seabed hydrates.

Permafrost and Shallow seabed thaw: Massive methane release and collapsing shallow Arctic hydrates is the non-linear "answer" from nature, reinforcing human-induced greenhouse gas emissions by triggered releases of CO2 and methane from huge natural pools. The probability of risk is hard to judge, but signs exist that it may happen in coming years or decades. Avoiding large releases of methane from the East Siberian Arctic Sea appears difficult-to-impossible without reducing global CO2 emissions dramatically.

Destabilization of Antarctica: There is increasing evidence that at carbon dioxide concentrations of 400-850ppm in the past, Antarctica was in what scientists term an unstable "Icehouse" phase. Like an old-time icehouse, the entire continent including East Antarctica would partially melt and then re-glaciate, with sea level up to 22 meters higher than today. We passed 400 ppm in 2013, and if our emissions continue at current rates will pass 450ppm by 2030 and 850ppm by 2100. Above 850ppm, Antarctica in the past was entirely deglaciated, with sea level 60 meters (180 ft) higher than today – but such high levels of CO2 have not existed for nearly 50 million years.

Mitigating and Slowing Cryosphere Destabilization:
Such cryosphere thresholds bring a new imperative to aggressive mitigation in the Paris 2015 agreement, as well as pre-2020 actions. A cryosphere-based response will entail far more aggressive commitments than any nation has yet publicly made.

Some of these changes, such as loss of West Antarctic ice sheets, will take hundreds or even thousands of years to occur. Others, like release of methane from seabed hydrates, could drastically accelerate warming in the very near-term. All however could irrevocably be set into motion already in this next UNFCCC commitment period. Some clearly already have begun: sea ice loss, land glacier reductions, sea level rise and polar ocean acidification already are very well documented as well underway.

The only way to slow and minimize these changes, and keep associated risks to human communities to manageable levels, is to bring CO2 emissions down to the lowest possible levels in the next 15 years. Reductions in so-called anthropogenic short-lived climate pollutants, especially black carbon and methane, can contribute to slowing the rate of some of these cryosphere changes, especially for black carbon-emitting sectors near the Arctic and Himalayas; but the backbone of risk reduction must be CO2 reductions well within the next commitment period of 2020-30.

Stabilization at a global mean temperature of 2°C (which means 5-6°C in the cryosphere) and 450ppm actually represents a rather high level of risk for unstoppable cryosphere feedbacks, and should be considered a maximum based on our current understanding of those risks. However, because of the risk of irreversible processes being set into motion already at current greenhouse gas levels, the most prudent long-term course for climate stabilization is first, to minimize new emissions to the maximum extent possible; and restrict time spent above 400ppm, with an ultimate goal to bring down CO2 levels safely below 400ppm as soon as possible.