MCCC 2024 Annual Report

**Methane:** Methane is a potent greenhouse gas, and global warming since the 1800s from methane is equivalent to 67% of the global warming attributed to carbon dioxide. Of concern is the acceleration of atmospheric methane over the past twenty years, coincident with the development of shale gas extraction (Hydraulic Fracturing or Fracking). While Maryland has banned fracking, export of liquid natural gas (LNG) through the Cove Point facility is occurring.

Methane production in enhanced with eutrophication, as measured by Dr. Laura Lapham, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory. Nutrient enrichments generate organic matter that is decomposed in sediments and this eutrophication leads to methane production. Methane is released from Chesapeake Bay sediments, particularly during storm events. These storm events fluxes are not currently considered in the Maryland Greenhouse Gas inventory.

**Anaerobic digestion for dairy manure:** Animal waste technologies are being evaluated by Dr. Stephanie Lansing, University of Maryland, Department of Environmental Science and Technology. Dr. Lansing has determined that dairy cattle manure is particularly well suited for anaerobic digestion which produces energy (biogas) and compost (odorless, nutrient-rich). The Maryland Department of Agriculture has an Animal Waste Technology Fund which can aid in the adoption of anaerobic digestion. Anaerobic digestors can also be used for food waste, which is a large percent of municipal solid waste. The concentration of dairy cattle in Maryland is in Washington and Frederick Counties. The greatest benefit of anaerobic digestion is the removal of methane, a particularly potent greenhouse gas.

**Methane release from restored wetlands:** Methane emissions from restored wetlands are being assessed by Dr. Stephanie Yarwood, University of Maryland, Department of Environmental Science and Technology. Dr. Yarwood has measured significant methane emissions from restored marshes on Maryland’s Eastern Shore. While the hydrology and vegetation can be restored rather quickly, methane emissions persist for decades after the restoration occurs. Dr. Yarwood also found that various amendments to enhance revegetation like biosolids, hay, manure and wood chips, these amendments can actually serve to accentuate the methane emission rates. Clearly, research into wetland restoration methods to avoid long term methane emissions is needed.

BOESCH contribution:

Apropos to hydrogen fuel discussion at the March STWG meeting, [Sun et al. (2014)](https://pubs.acs.org/doi/10.1021/acs.est.3c09030) in *Environmental Science and Technology* reexamined previous life cycle assessments of hydrogen pathways to better account for all climate warming emissions and impacts over time. These include both blue (natural gas with carbon capture) and green (renewable-based electrolysis) hydrogen pathways. They found the climate benefits greatly depend on the amount hydrogen and methane emissions, as well as CO2 emissions, and in some cases the climate benefits are negative. Both the international [Institute of Energy Economics and Financial Analysis](https://ieefa.org/resources/blue-hydrogen-not-clean-not-low-carbon-not-solution) and the Takoma Park-based [Institute for Energy and Environmental Research](https://ieer.org/wp/wp-content/uploads/2024/01/What-Good-is-Hydrogen-IEER-report-for-Just-Solutions-January-2024.pdf) also recently released assessments critical of the carbon emissions reductions resulting from the use of blue hydrogen because of incidental emissions of both methane and hydrogen. These did not specifically address the process of catalytic decarbonizing of methane to produce hydrogen without relying on carbon capture and storage that Jonah Erlebacher described to the STWG. However, any methane leakages upstream and hydrogen leakages downstream would be of significance in any life cycle analysis.

Regarding these upstream methane emissions, [Sherwin et al. (2014)](https://www.nature.com/articles/s41586-024-07117-5) analyzed one million airborne measurements of methane from oil and gas systems to produced emissions inventories for six U.S. regions (one of those was the Marcellus Shale region of Pennsylvania). Estimated emissions range from 0.75% of natural gas production in a high-productivity, gas rich region to 9.6% in a rapidly expanding, oil-focused region. The average for the six regions is 2.95%, roughly three times the rate assumed in EPA national emissions inventories. Midstream facilities, including pipelines, contribute 18–57% of estimated regional methane emissions.

**Tracing sources of atmospheric methane using clumped isotopes**

**Mojhgan A. Haghnegahdara, Jiayang Sun, Nicole Hultquista, Nora D. Hamovit, Nami Kitchen, John Eiler, Shuhei Ono, Stephanie A. Yarwood, Alan J. Kaufman, Russell R. Dickerson, Amaury Bouyon, Cédric Magen, and James Farquhar**

In the Baltimore-Washington area, methane, a strong greenhouse gas, comes from a variety of sources. Some of it comes from cities and natural gas operations, but a surprising amount is blown in from large pig farms down south, especially in North Carolina. Weather patterns, like winds from the west and southwest, blow methane from both urban areas and farms.

Methane is much more potent than carbon dioxide when it comes to trapping heat in the atmosphere, even though it doesn’t last as long. This means that every bit of methane adds to global warming, and with farming emissions potentially playing a bigger role than we thought, it’s something we need to pay close attention to. If we don’t address these emissions, especially from agriculture, it could have a big impact on the environment in the near future.

**State of polar climate in 2023**

**Ming-Hu DING, Xin WANG, Lin-Gen BIAN, Zhi-Na JIANG, Xiang LIN, Zhi-Feng QU, Jie SU, Sai WANG, Ting WEI, Xiao-Chun ZHAI, Dong-Qi ZHANG, Lei ZHANG, Wen-Qian ZHANG, Shou-Dong ZHAO, Kong-Ju ZHU**

**Ice Caps**

In 2023, global temperatures hit record highs, and the polar regions, especially the Arctic, took the brunt of it. The Arctic saw temperatures more than 2°C higher than average and had its hottest summer since 1979, causing massive wildfires in Canada, which made air pollution and greenhouse gas emissions even worse. Meanwhile, the Antarctic’s sea ice cover had the lowest levels ever recorded.

In the Antarctic, there were extreme melting events, including huge icebergs breaking off, like the A81 iceberg. The rise of greenhouse gas levels, including carbon dioxide and methane, keep rising in both polar regions. These high levels contributed to more extreme weather like heatwaves and heavy rainfall. Polar ice cap melting also means rising sea levels, which would impact the Maryland coast.

**Three decades of ocean warming impacts on marine ecosystems: A review and perspective Roberto M. Venegas, Jorge Acevedo, Eric A. Treml**

Over the past three decades, ocean warming has caused significant changes in marine ecosystems. These warming waters are affecting marine species in major ways. Some species, like adaptable or invasive ones, are thriving, while others, like coral reefs, marine mammals, and polar species, are struggling to survive.

The more sensitive species, which are often crucial to their ecosystems, are the ones impacted the most. Coral reefs are bleaching, fish are moving to new areas, and marine mammals are losing their habitats. The results have ultimately caused imbalances and disrupted the ecosystems.

If we don't protect these vulnerable species and manage the overpopulation of more adaptable ones, the ecosystem could collapse. We need to focus on global and local efforts to mitigate ocean warming or we risk losing vital marine biodiversity, which could have cascading effects on everything from food security to coastal protection.

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Over the past three decades, ocean warming has caused significant changes in marine ecosystems. Rising sea levels, shifts in ocean currents, and lower oxygen levels are all part of the picture, and these changes are affecting marine species in major ways. Some species, like adaptable or invasive ones, are thriving, while others, like coral reefs, marine mammals, and polar species, are struggling to survive.

This is bad news because the more sensitive species, which are often key to the ecosystem, are the ones being hit the hardest. Coral reefs are bleaching, fish are moving to new areas, and marine mammals are losing their habitats. The imbalance between species that are thriving and those that are suffering is disrupting the entire marine ecosystem.

And it gets worse: If we don't protect these vulnerable species and manage the overpopulation of more adaptable ones, the ecosystem could spiral out of control. The paper stresses that global and local efforts need to focus on both mitigating ocean warming and adapting to its impacts, or we risk losing vital marine biodiversity, which could have cascading effects on everything from food security to coastal protection.

[**https://www.chesapeake.org/stac/wp-content/uploads/2023/01/FINAL\_STAC-Report-Rising-Temps\_April.pdf**](https://www.chesapeake.org/stac/wp-content/uploads/2023/01/FINAL_STAC-Report-Rising-Temps_April.pdf)

Water temperatures in the streams and rivers of the Chesapeake Bay watershed have been rising over the past few decades, often faster than air temperatures. This increase is driven by changes in land use, with urban development playing a significant role. In areas with lots of concrete and other hard surfaces, rainfall runs off quickly and heats up before flowing into nearby streams, raising water temperatures. In contrast, forests and areas with natural vegetation help keep streams cooler by providing shade and allowing water to soak into the ground.

This warming is causing serious problems for aquatic life, especially for cold water species like brook trout, which need cooler water to survive. Warmer waters also contribute to other issues, like harmful algal blooms and lower oxygen levels, making life harder for many species. While some management practices, like planting trees along waterways, help reduce these impacts, other common practices, like stormwater ponds, can unintentionally make the problem worse by heating up the water even more.

To combat rising water temperatures, the report suggests that we need to focus on protecting natural areas and strategically managing urban and agricultural lands. By increasing tree cover and using land management practices that help cool the water, we can protect vulnerable species and improve the overall health of the watershed. It’s a reminder that how we use the land directly affects the health of our water systems.

**Acceleration of daily land temperature extremes and correlations with surface energy fluxes**

**Chris Huntingford, Peter M. Cox, Paul D.L. Ritchie, Joseph J. Clarke, Isobel M. Parry & Mark S. Williamson**

Extreme heat days are becoming more frequent and more intense, and they are getting hotter than the average daily warming we’re seeing globally. This trend is especially bad in places like North America. In some areas, like the northern mid-latitudes, the acceleration of extreme heat is being driven by drying soils and reduced evaporation.

The acceleration of extreme temperatures is going to keep intensifying through the end of the century. This means more severe heatwaves which poses serious risks for human health likely causing heat-related deaths to rise. It will also impact agriculture, with reduced crop yields, and will impact the carbon cycle by increasing carbon emissions from dried-out soils.

To make things worse, the causes of this extreme heat vary from region to region, meaning we need targeted, location-specific strategies to deal with it. If we don’t act, we are facing a future with more frequent and severe heatwaves, which could disrupt food security, damage ecosystems, and threaten millions of lives.