Arctic Methane: Can the Top-down and Bottom-up Views of its Budget Be Reconciled?

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Warming in the Arctic has proceeded faster than any region on Earth. Our current understanding of Arctic biogeochemistry implies that changes in terrestrial fluxes of carbon can be expected as the Arctic warms. Vast stores of organic carbon are thought to be frozen in Arctic soils, as much as 1,700 billion tonnes of carbon, several times the amount emitted by fossil fuel use to date. If mobilized to the atmosphere, this carbon would have significant impacts on global climate, especially if emitted as methane (CH_4), a potent greenhouse gas.

NOAA/ESRL, Environment Canada, and other agencies have collected observations of greenhouse gases in the Arctic and the rest of the world for at least several decades. Analysis of these data does not currently support significantly changed Arctic emissions of CH_4. However, it is difficult to detect changes in Arctic emissions because of transport from lower latitudes and large inter-annual variability. Modeling/assimilation systems can help untangle the Arctic budget and trends of greenhouse gases. On the other hand, they are dependent on assumptions about underlying prior fluxes and wetland distributions, as well as possible transport model biases, leading to significant uncertainties.

In this presentation, we will discuss our current understanding of the Arctic carbon budget from both top-down and bottom-up approaches. In particular, we show that current atmospheric inversions agree well on the Artic CH_4 budget. On the other hand bottom-up process models vary widely in their predictions of emissions from Arctic wetlands, with some models predicting emissions that are too large to be accommodated by the budget implied by global atmospheric network observations. In addition, large emissions from the shallow Arctic ocean have been proposed, and we show that these emissions are inconsistent with atmospheric observations.

We will also discuss the sensitivity of the current atmospheric network to what may well be small, gradual increases in emissions over time by considering whether seasonal processes indicated by field ecology studies, such as spring ice-out of Arctic wetlands, can be identified in atmospheric network observations. Finally, we will briefly discuss an ongoing project to use flux observations as constraints in atmospheric models by using remote sensing data to go from hectare scales represented by flux measurements to regional scales that can be simulated by atmospheric models.

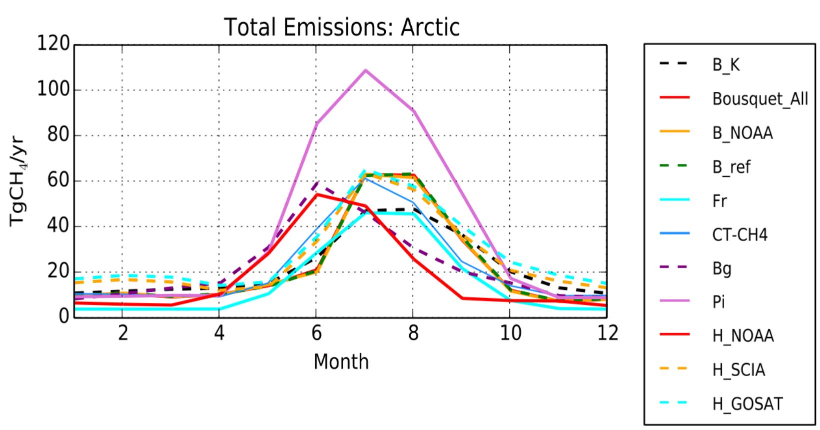

Figure 1. The average seasonal cycle of Arctic CH_4 emissions for 10 inversions. The shaded area is the estimated uncertainty for the CT-CH4 inversion. Dashed lines indicate inversions that are constrained by space-based data.