Monitoring and Detecting Arctic Greenhouse Gas Budgets: The Importance of Long-term Surface Observations and the Role of CarbonTracker-CH_4

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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 and about equal to known coal reserves. If mobilized to the atmosphere, this carbon would have significant impacts on global climate, especially if emitted as CH_4. A recent study suggests that permafrost carbon climate feedbacks have had profound impacts on past climate, possibly driving the Paleocene-Eocene Thermal Maximum 55 Million years ago. Model studies project that by the middle of the 21st Century, the Arctic will be a net source of carbon to the atmosphere.

NOAA/ESRL, Environment Canada, and other agencies have collected observations of greenhouse gases (GHG) in the Arctic and the rest of the world for at least several decades. Analysis of this data does not currently support increased Arctic emissions of CO_2 or CH_4. However, it is difficult to detect changes in Arctic emissions because of transport from lower latitudes and high inter-annual variability. Arctic surface emissions are also especially difficult to detect from space, and current satellite platforms do not provide useful information about GHG budgets in the lower Arctic troposphere. Modeling/assimilation systems, such as NOAA's new CarbonTracker-CH_4 system can help untangle the Arctic budget and trends of GHGs. CarbonTracker-CH_4 has shown success in simulating the inter-annual variability of Arctic fluxes, and it is able to distinguish Siberian fluxes from Boreal North American fluxes.

We address the plausibility of monitoring the Arctic GHG emission trends. How large would Arctic emission trends have to be before they could be identified in network observations? What spatial information could be recovered? How would the spatial density of observations affect our ability to perceive and attribute trends in Arctic emissions? Could emission have already been increasing during the close of the 20th Century? Trends in emissions need to be large before they can be discerned in network observations; our calculations show that emissions of methane must increase by at least 5TgCH_4/yr to be seen in a 10-year observational record. Long-term surface observations of GHGs are crucial to monitoring the fate the vast and currently frozen Arctic soil carbon reservoir.

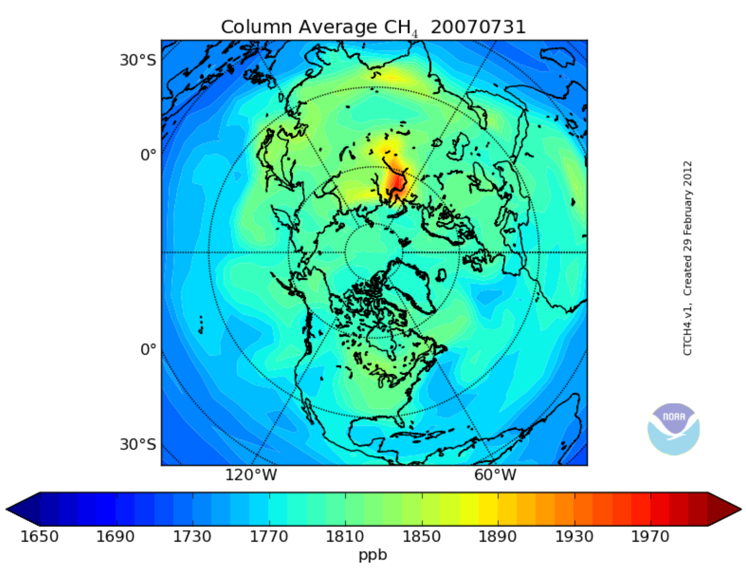

Figure 1. Daily average of the pressure-weighted mean mole fraction of methane simulated by CarbonTracker-CH_4. Units are nanomoles of CH_4 per mole of dry air (nmol mol-1), and the values are given by the color scale depicted under the graphic. Gradients in CH_4 concentration are due to exchange between the atmosphere and the earth surface, including fossil fuel emissions, emissions from agriculture and waste, wildfire emissions, and emissions from wetlands.