Changes in Arctic Atmospheric Chemistry Linked to Ocean Sea Ice Changes

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A forty-year record of ozone measurements at the NOAA Barrow, Alaska Observatory reveals a dramatic change in the annually reoccurring spring depletion of boundary layer ozone (Oltmans et al., 2012). This naturally occurring phenomenon has been greatly enhanced during March over the last two decades due to the changing character of Arctic sea ice. The frequency of the depletion events (defined as ozone mixing ratios <10 ppb) in March has increased by 85% in the second half of the 40-year record compared to the first half. The ozone loss is closely tied to the photochemical reaction with halogens, primarily bromine, whose source are ocean sea water. The activation of bromine takes place through the influence of reactions on snow and ice crystals over the vast Arctic sea ice. In the past, spring ice was primarily ice that had survived the previous or multiple summers (multiyear ice). Now spring ice is dominated by ice that formed during the previous winter (annual ice), which with its more numerous leads is much more conducive than the sturdier multiyear ice for promoting the production of the reactive bromine species implicated in boundary layer ozone depletion. This change in the oxidizing characteristics of the atmosphere may have important implications for the closely related chemical cycle involving mercury. Coincident with the ozone depletion events are events that deplete atmospheric gaseous elemental mercury (GEM) and convert it into a form of mercury that can be deposited to the sea ice surface and the surrounding snow covered tundra regions. It is this converted form of mercury that can be incorporated into the Arctic food chain involving both sea life and terrestrial animals.

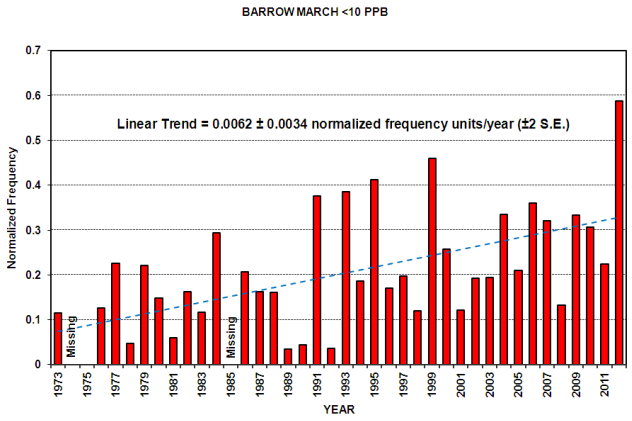

Figure 1. The normalized frequency of hourly average ozone values <10 ppb for the month of March of each year from 1973-2012. The linear trend and two standard error limits for the normalized frequency are 0.0062 ± 0.0034.

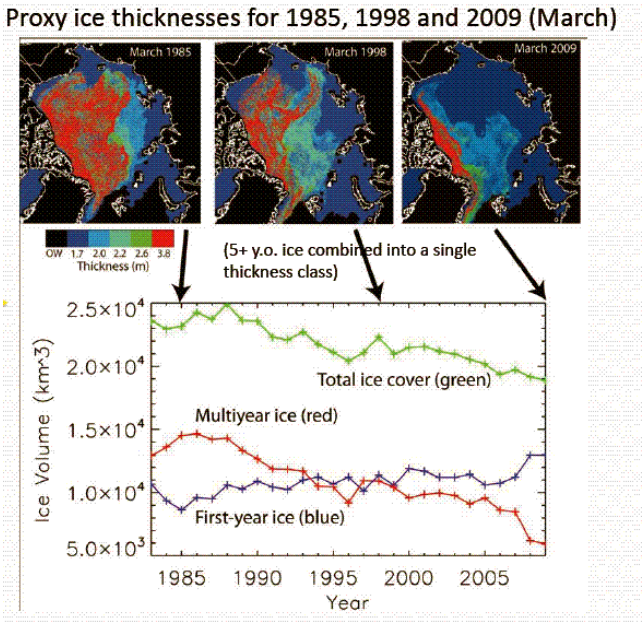

Figure 2. Changes in Arctic sea ice characteristics from M. Tschudi et al.,"Trends and Patterns in Sea Ice Age Distributions within the Arctic Basin and Their Implications for Changes in Ice Thickness and Albedo" presented at the State of the Arctic Conference, March 2010, Miami, Florida.