How much methane came out of that hole in Siberia?

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Siberia has explosion holes in it that **smell like methane**, and there are **newly found bubbles of methane in the Arctic Ocean**. As a result, journalists are contacting me assuming that the Arctic Methane Apocalypse has begun. However, as a climate scientist I remain much more concerned about the fossil fuel industry than I am about Arctic methane. Short answer: It would take about 20,000,000 such eruptions within a few years to generate the standard Arctic Methane Apocalypse that people have been talking about. Here's where that statement comes from:

How much methane emission is "a lot"? The yardstick here comes from Natalie Shakhova, an Arctic methane oceanographer and modeler at the University of Fairbanks. She proposed that **50 Gton of methane** (a gigaton is 10^{15} grams) might erupt from the Arctic on a short time scale **Shakhova (2010)**. Let's call this a "Shakhova" event. There would be significant short-term climate disruption from a Shakhova event, with economic consequences explored by Whiteman et al **Whiteman et al (2013)**. The **radiative forcing right after the release** would be similar to that from fossil fuel CO_2 by the end of the century, but subsiding quickly rather than continuing to grow as business-as-usual CO_2 does.

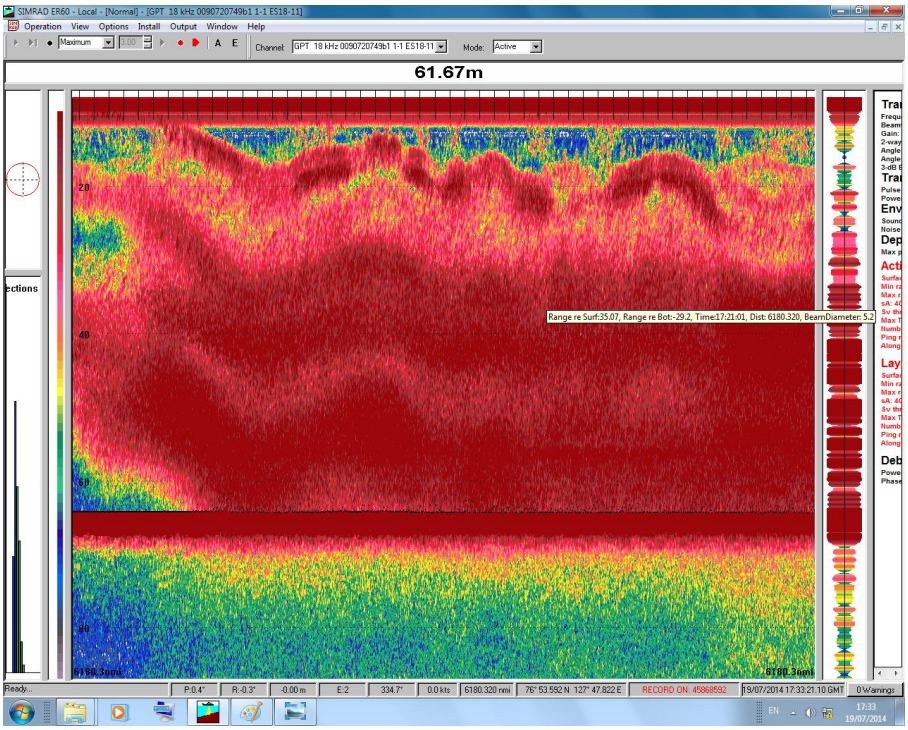
I and **others** have been skeptical of the possibility that so much methane could escape from the Arctic so quickly, given the century to millennial time scale of warming the permafrost and ocean sediments, and point out that if the carbon is released slowly, the climate impacts will be **small**. But now that explosion holes are being found in Siberia, the question is

How much methane came out of that hole in Siberia? The hole is about 80 meters in diameter and 60-100 meters deep.

It's hard to say exactly how much methane did this, because perhaps the crater allowed methane to be released from the surrounding soil. There may be emissions in the future from permafrost melting laterally from the sides of the hole. But for a start let's assume that the volume of the hole is the same as the volume of the original, now escaped, bubble. Gases are compressible, so we need to know what its pressure was. The deeper in the Earth it was, the higher the pressure, but if we are concerned about gas whose release might be triggered by climate warming, we should look for pockets that come close to the surface. Deep pockets might take thousands of years for surface warming to reach. The mass of a solid cap ten meters thick would increase the pressure underneath it to about four atmospheres, plus there may have been some overpressure. Let's assume a pressure of ten atmospheres (enough to hold up the atmosphere plus about 30 meters of rock).

If the bubble was pure methane, it would have contained about … wait for it … **0.000003 Gtons of methane**. In other words, building a Shakhova event from these explosions would take approximately **20,000,000 explosions**, all within a few years, or else the climate impact of the methane would be muted by the lifetime effect.

What about the bubbles of methane they just found in the Arctic ocean? There were **reports** this summer of a new expedition to the Siberian margin, documenting vast plumes of methane bubbles rising from sediments ~500 meters water depth.



It is certainly believable that warming ocean waters could trigger an increase in methane emissions to the atmosphere, and that the time scale for changing ocean temperatures can be fast due to circulation changes (we are seeing the same thing in the Antarctic). But the time scale for heat to diffuse into the sediment, where methane hydrate can be found, should be slow, like that for permafrost on land or slower. More importantly, the atmospheric methane flux from the Arctic Ocean is really small (extrapolating estimates from **Kort et al 2012**), even compared with emissions from the Arctic land surface, which is itself only a few percent of global emissions (dominated by human sources and tropical wetlands).

In conclusion, despite recent explosions suggesting the contrary, I still feel that the future of Earth's climate in this century and beyond will be determined mostly by the fossil fuel industry, and not by Arctic methane. We should keep our eyes on the ball.

References

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