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Comment on "A cometary origin for atmospheric martian methane" by Fries *et al.*, 2016

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Comment

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Reports of transient plumes of martian atmospheric methane (Mumma *et al.*, 2009; Webster *et al.*, 2015) have led to suggestions of biologic or abiotic surface sources. Schuerger *et al.* (2012) examined the production of methane near the surface from interplanetary dust particles. They found this mechanism was capable of yielding the background value of methane, but could not reproduce plume densities by bolide, airburst or other meteor impact process. Fries *et al.* (2016) draw on the work of Schuerger *et al.* (2012) and propose that the methane plumes are sourced instead from intense meteor showers with conversion at high altitudes.

The Fries *et al.* (2016) methane (CH_4) production mechanism creates a scaling relationship between meteor shower deposition and plume mass, giving 8×10^8 and 2×10^8 kg of meteoric material for the plumes of 45 and 10 ppbv of CH_4, respectively (Mumma *et al.*, 2009; Webster *et al.*, 2015). While Zahnle *et al.* (2011) indicated that these values overestimate the abundance of CH_4 by an order of magnitude, we show that even the lowest value (2×10^7 kg for the 10 ppbv plume) is in excess of any observed or predicted fluences by several orders of magnitude.

First, we compare the Fries *et al.* (2016) values to the global flux of interplanetary dust particles on Earth, which is estimated to be between 5×10^3 and 3×10^5 kg/day (Plane, 2012). The fluence of meteoric material at Earth is not strongly increased by meteor showers (Grebowsky *et al.*, 1998) and this is indicative that meteor showers do not in general deliver significantly more material than the sporadic background. As Mars has three times less surface area, Fries *et al.* (2016) therefore requires a normal meteor shower to deliver 180 times more material than the upper limit of Earth's total daily fluence. Fries *et al.* (2016) suggest that Comet C/2007 H2 Skiff's meteor shower is correlated with a high-altitude dust plume (Sánchez-Lavega *et al.*, 2015), although there can be no constraint on CH_4 as no measurements were made at the time. Model predictions of Skiff's meteor shower do not provide a fluence or particle size, as these quantities are unconstrained by previous observations. Moreover, Skiff is unlikely to be able to deliver 2×10^7 kg/day as recent work (Crismani *et al.*, 2016) has shown that its fluence cannot exceed 10^3 kg/day.

Next, we compare the Fries *et al.* (2016) values to the observed mass fluence during the close encounter of comet C/2014 A1 (Siding Spring), determined to be ~1.6×10^4 kg over the planet (Schneider *et al.*, 2015). Comet Siding Spring's dust stream was likely atypically dense, as the nucleus passed within 1.4×10^5 km of Mars, and Mars subsequently passed through the comet's relatively fresh debris stream. (Note that Fries *et al.* (2016) mention the comet Siding Spring case in the supplementary material, but do not use the observed fluence of Schneider *et al.* (2015) or full particle size distribution (Kelley *et al.*, 2014)). Therefore, the fluence of the largest observed meteor shower at any planet was still three orders of magnitude less than necessary to explain any CH_4 plume by the method of Fries *et al.* (2016).

Finally, we consider other observational consequences of a meteoric deposition of 10^7 kg. This amount of material entering the atmosphere of Mars at relative orbital velocity (35 km/s for comet Skiff) would carry an equivalent energy of 6×10^{15} J. Using a model of cometary deposition derived from Yelle *et al.* (2014), we create a scaling between meteoric deposition and thermospheric temperature increase and find, to first order, that a deposition of 10^7 kg would increase the thermosphere by 3×10^3 K. Therefore meteoric deposition of the required magnitude of Fries *et al.* (2016) has readily observable consequences in the form of increased spacecraft drag (Zurek *et al.*, 2015) and enhanced thermospheric emissions (Jain *et al.*, 2015), neither of which have been observed at the time of meteor showers.

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Additional Information

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