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CONSTRAINING THE MSL-SAM METHANE DETECTED SOURCE LOCATION THROUGH MARS REGIONAL ATMOSPHERIC MODELING SYSTEM (MRAMS)

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Abstract

The detection of methane by SAM instrument [1] has garnered significant attention. There are many major unresolved questions regarding this detection: 1) Where is the release location? 2) How spatially extensive is the release? 3) For how long is methane released? In an effort to better address the potential mixing and remaining questions, atmospheric circulation studies of Gale Crater were performed with MRAMS mesoscale model, ideally suited for this investigation. The model was focused on rover locations using nested grids with a spacing of 330 meters on the innermost grid that is centered over the detection site. In order to characterize seasonal mixing changes throughout the Martian year, simulations were conducted at Ls0, 90, 180 and 270. The rise in methane concentration was reported to start around Ls336, peaked shortly after Ls82, and then dropped to background prior to Ls103. The aim of this work is to establish the amount of mixing during all seasons and to test whether methane releases inside or outside of Gale crater are consistent with SAM observations.

1. Experiment configuration

Four different scenarios were considered for this research: punctual methane release inside Gale crater (scenario 1#), punctual METHANE release outside -100km NW- crater (scenario 2#), continuous METHANE release outside -100km NW- crater (scenario 3#) and continuous methane release inside crater (scenario 4#). In the punctual releases scenarios (1#, 2#), experiments were designed injecting four tracers into the model to simulate the transport of methane and to understand the mixing of air inside and outside the crater. Tracer #1 mimics methane release and the other three tracers are placed in different elevations (vertical discriminator), due to the three dimensional nature of mixing and transport. In this two first scenarios, tracer #2 is placed from 200 to 500 meters AGL inside Gale crater, tracer #3 from 500 to 2,000 meters AGL inside Gale crater, and tracer #4 elsewhere (outside and above Gale crater, see Figure 1). In the continuous release scenarios (3# and 4#) just one tracer (methane continuous release) was considered and MRAMS code was modified to do so mimicking different clathrates emissions [4]. In all scenarios, the release is assumed to take place near the season when the rise of concentration was first noted (Ls336). This is a transitional time at Gale Crater, when the flushing winds are giving way to a rapid mixing scenario but slower compared to Ls270.

2. Results

As expected [2, 3], Ls270 was shown to be a faster mixing season when air within and outside the crater was well mixed by strong, flushing, northerly flow and large amplitude breaking mountain waves: air flowing downslope (buoyancy and dynamical forcing) at night penetrate all the way to the surface. In the experiments, all inside mass is gone from crater after just 10 hours. At other seasons only ~50% of inside mass stays in crater after 10 hours and simulations indicate that the air flowing down the crater rims does not easily make it to the crater floor. Instead, the air encounters very cold and stable air pooled in the bottom of the crater, which forces the air to glide right over the colder, more dense air below. Thus, the mixing of near surface crater air with the external environment in these seasons is potentially rapid but slower than Ls270. Atmospheric circulation is strongly 3-D, not just 2-D, so in order to constrain a source air mass location is important to take into account vertical motion instead of just horizontal wind speed and direction. Timescale of mixing in MRAMS model is on the order of 1 sol regardless of season, much faster than previously estimated. Duration of methane peak observed by SAM is ~100 sols (assuming no high frequency variations). In the scenario 2# (punctual methane release outside Gale crater), methane arriving rover location from outside crater is diluted by approx. 6 orders of magnitude after just 12 hours (Figure 2). Therefore, either there is a continuous release inside the crater (more likely) to counteract mixing, or the methane is widely distributed so that mixing doesn't matter, or a local release outside the crater have to be continuous and very large magnitude (unlikely). Continuous release experiments (scenarios 3# and 4#) are being performed both inside and outside the crater. The calculations of methane fluxes are being performed mimicking clathrates emissions at different depths and formed from a gas phase containing 90%, 50% and 10% of methane [4]. Preliminary results of scenario 3# show that timing for SAM measurements is important due to the mixing (increases and drops) of methane inside crater (Fig. 4) and can be seen here:https://data.boulder.swri.edu/jpla/EPSC17/CH4_Ls270_AGL_14M.gif. Scenario 4# experiment is being performed.

3. Figures

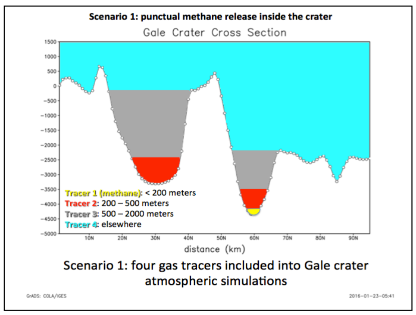

Figure 1: Tracers configuration for scenario 1#. Note tracer 1 is outside the crater in scenario 2#

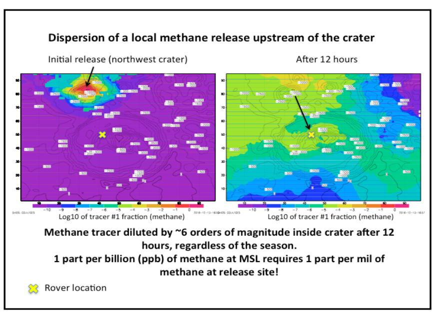

Figure 2: ***Punctual*** methane released outside crater is diluted by approx. 6 orders of magnitude after just 12 hours when arriving to rover location

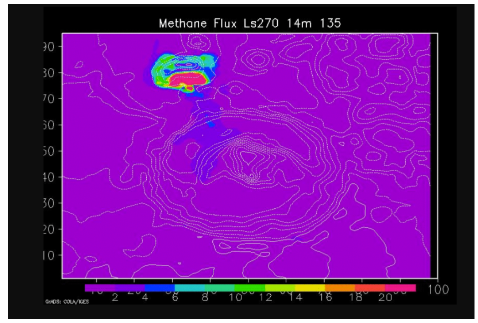

Figure 3: Scenario 3#: methane ***continuous*** release outside crater. Some methane make it to the rover location during nighttime.

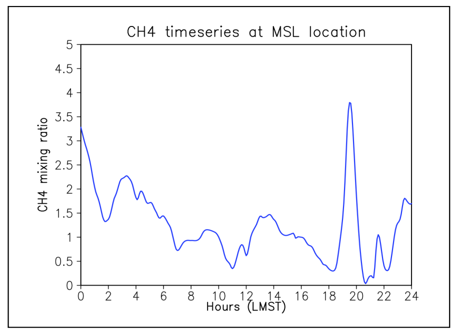

Figure 4: Methane time series at rover location for scenario 3#. Although methane ***continuous*** release is outside crater, some methane make it to the rover location due to atmospheric circulation, so timing of SAM measurements is critical. Nighttime (dynamic) downslope flows entering through north crater rim (moreover at ~1800-2000LMST in the seven sols that methane is releasing in the simulation) have an impact into the methane levels.

References

[1] Webster et al. Science, 2015 [2] Pla-Garcia et al, Icarus 2016. [3] Rafkin et al., Icarus, 2016 [4] Gloesener et al. 6th MAMO conference, 2017