

Mg⁺ in the Upper Atmosphere of Mars

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Introduction

- NASA's MAVEN (Mars Atmosphere and Volatile Evolution Mission) satellite entered Mars' orbit in 2014.
- The goal of this mission is to determine how the loss of atmospheric species from the Martian atmosphere to space has led to changes in the Martian climate over time.
- The satellite uses an Imaging UltraViolet Spectrograph (IUVS) to image the distribution of various atmospheric species within the Martian atmosphere, including Mg⁺ ions.
- The long lifetime of Mg⁺ ions means they can be used to investigate dynamical processes in the upper atmosphere.
- Mg⁺ ions enter the upper atmosphere via meteoric ablation and the chemistry of the resulting species is summarised in the following scheme that was proposed by Plane et al. (2018).

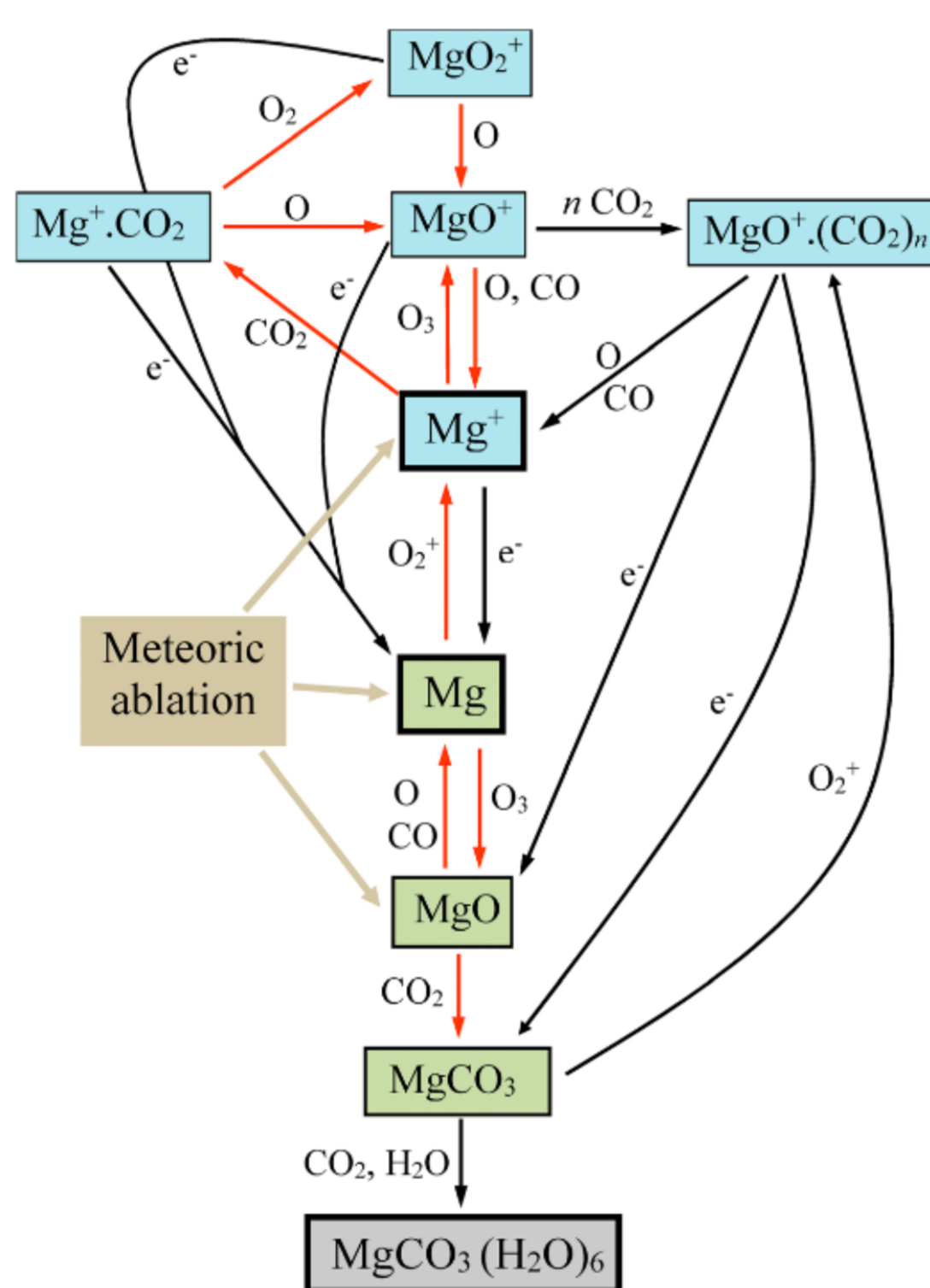


Diagram copied from Plane et al. (2018)
doi.org/10.1002/2017JE005510

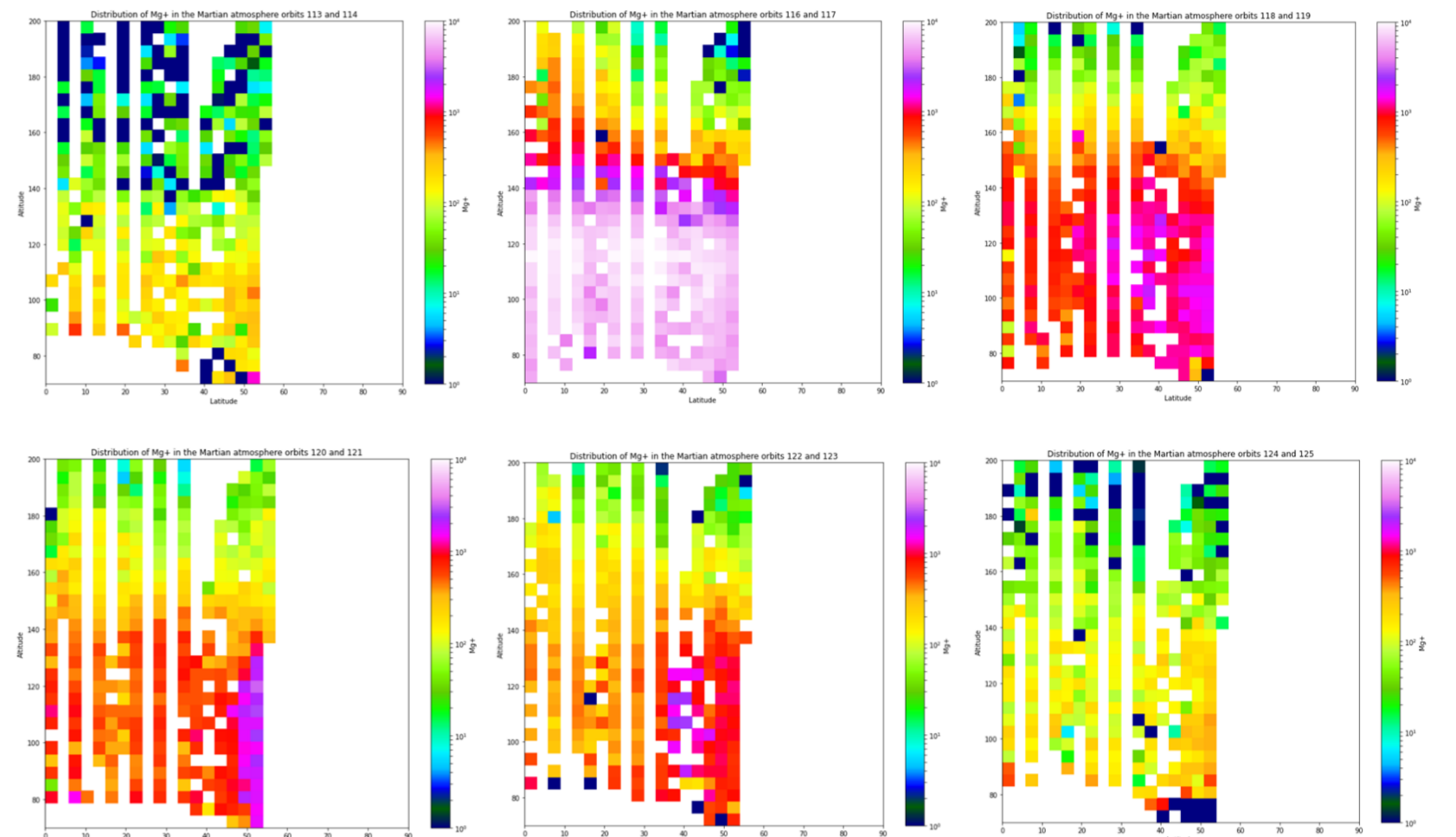
Project Aims

- IUVS data from the MAVEN satellite was analysed with particular interest in the effect of comet C/2013 A1, also known as 'Siding Spring'.
- These observations were then to be compared to Laboratoire de Météorologie Dynamique (LMD) Mars Global Circulation Model (GCM) outputs in order to better understand the chemistry and dynamics of the Martian upper atmosphere.

Research Methodology

- Throughout this project, Python code was written in Jupyter Notebooks to analyse both LMD Mars GCM predictions and MAVEN observational data.
- Comparative figures were made in order to evaluate the agreement between the model predictions and experimental data.
- At the University of Leeds, the LMD Mars GCM has been installed and runs on the Advanced Research Computer (ARC4). Large multi-dimensional data sets from MAVEN were also stored on ARC4.

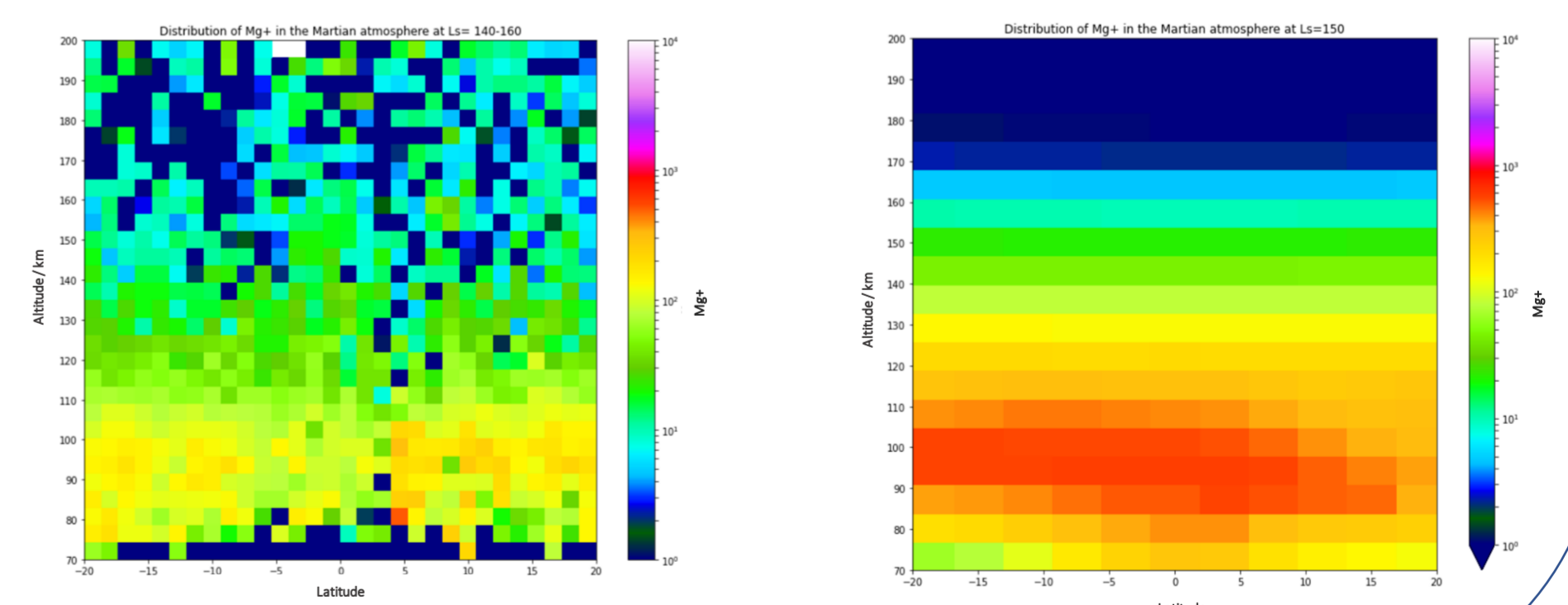
IUVS Analysis – Siding Spring



- On the 19th of October 2014, comet C/2013 A1, also known as 'Siding Spring' had a close encounter with Mars. During this meteor shower, meteoric ablation occurred between 105 and 120km where, amongst other species, Mg⁺ was deposited.
- The above figure plots IUVS data for orbits 113 to 125 in order to show the change in Mg⁺ throughout the course of the meteor shower.
- There is no data for orbit 115 as the MAVEN satellite was in protective mode in order to avoid damage.
- This figure shows the increase in Mg⁺ in the upper atmosphere after orbit 115, as a result of increased meteoric ablation, before the return to a state similar to that shown in orbits 113 and 114.
- This event also led to an increase in the concentration of neutral Mg above the IUVS detectable threshold, allowing the processes that control its distribution to be explored.

MAVEN / LMD Comparison

- The following comparative figure shows the distribution of Mg⁺ in the Martian atmosphere found experimentally (left) and predicted by the LMD model (right) at Ls ≈ 150°.
- On observation, the LMD model output appears to be larger than the IUVS measurements by an approximate scale factor of 10.
- The IUVS data also suggests the presence of Mg⁺ at higher altitudes than the model predicts.



Conclusion

- Comparing the outputs from global models with experimental data is important for validating the current understanding of both the chemistry and dynamics of the atmosphere.
- Disagreements between the LMD Mars GCM predictions and IUVS data, with respect to the concentration of Mg⁺, suggest that either a scaling factor needs to be applied to the model or that there is some gap in our understanding of the planet's atmospheric chemistry.
- Disagreements with respect to the altitude at which Mg⁺ is found suggest the presence of additional dynamic factors that need to be taken into account in the model predictions.