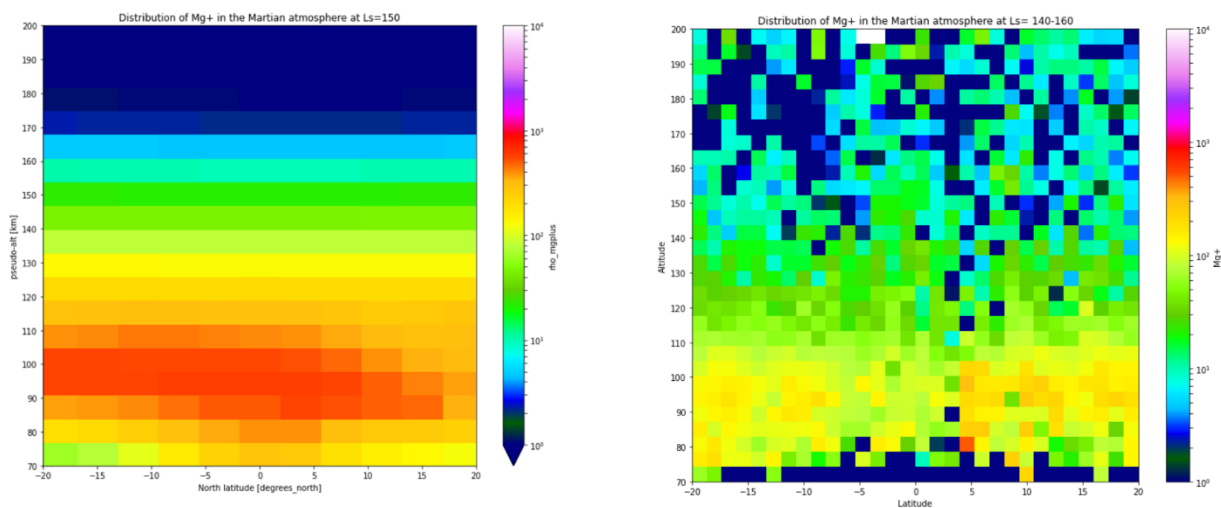


Laidlaw Scholarship Research Project Report: Summer 2020

Name:	Caitlin Gough
University:	University of Leeds
Faculty:	EPS
Title of Scholarship Project:	'The Upper Atmosphere of Mars.'

Outline of Research:

At the start of my research project, I focused on learning how to code using Python and how to create Jupyter Notebooks. Once I had got to grips with how to handle and graph large datasets using Jupyter, I started to analyse data from the LMD model of the Martian atmosphere. Using Python, I created plots to study diurnal and latitudinal trends, studying the differences between the Northern and Southern Hemisphere seasons, considering the aphelion and perihelion points in Mars' orbit. I produced plots to show how: temperature; zonal, meridional, and vertical winds; and the abundances of Mg/Mg+, electrons and dust vary as a function of altitude and latitude. After reading a research paper discussing meteoric ablation and the comet C/2013 A1 (also known as 'Siding Spring') by Crismani *et al.* (2018), I created a series of plots to represent the effect the close passing of this comet had on the distribution of Mg+ in the Martian atmosphere. After analysing model data, I began to study Imaging UltraViolet Spectrometer (IUVS) measurements from the MAVEN satellite; this allowed for comparison to evaluate if there is agreement between LMD predictions and MAVEN measurements.



These two graphs plot the distribution of Mg+ in the Martian atmosphere at Ls≈150°. This is just one example of a comparative figure that can be used to evaluate the agreement between the LMD model (left) and MAVEN IUVS measurements (right). This

particular figure shows that the model predicts a concentration of Mg⁺ larger than the IUVS measurements by an approximate scale factor of 10, suggesting either the need for a scaling factor in the model or a gap in our knowledge of the chemistry/dynamics.

How is the research work you have been undertaking impactful?

Throughout the summer, I had weekly meetings with Professor Plane's research group, giving me the opportunity to present my work and hence network with academics within the School of Chemistry. These meetings allowed me to collaborate with one of the group's PhD students; one of the figures I produced that looked at the presence of dust in the Martian atmosphere simulated in the LMD model was specifically relevant to his area of research. My work highlighted a potential disagreement between the LMD model and IUVS data. The comparison between model predictions and satellite measurements is vitally important to our understanding of the chemistry of Mars' atmosphere. Towards the end of my research period, I collaborated with a fourth-year undergraduate student from California State University; we worked on analysing and graphing data from MAVEN's IUVS instrument. This work led to me being involved in a zoom meeting with Professor John Plane, Professor Dan Marsh and Dr Wuhu Feng with whom I had been working throughout the summer as well as, Dr Matteo Crismani (a professor at California State), Robert Tyo (the fourth-year undergraduate mentioned above) and Professor Nick Schneider (the principle investigator of the Imaging UltraViolet Spectrometer on MAVEN). My work plotting LMD data using Jupyter Notebooks proved to be important when considering this comparison of LMD and IUVS data.

What impact has conducting research had on your degree course and university experience?

This period of research has significantly deepened my understanding of atmospheric and planetary science, as well as solidifying my first-year physical chemistry content. I feel that, through this experience, I have also gained a new appreciation for the inherent interdisciplinary nature of my course; my research project looked at the presence of inorganic ions in the upper atmosphere of Mars using chemistry to understand these observations utilising methods from other fields, including: computer science, mathematics, and physics. As part of my research, I read academic papers that contained chemistry that far surpassed the level of my undergraduate course. I spent a large amount of time over the summer annotating and doing extra research into concepts I had not yet studied in my degree. I have now found many of these topics are relevant to my second-year work and I have really benefitted not only from this exposure to more advanced theory, but from the process of working with and understanding academic journals. I was also invited by a member of Professor Plane's group to attend additional lectures held for the academics studying physical chemistry at the University of Leeds; this has allowed me to explore areas of physical chemistry outside that of my research area.

What leadership skills do you believe you have gained from the research period?

I have developed many communication skills throughout this period of research, this was perhaps shaped by the COVID-19 pandemic which meant that my work with both Professor Plane's group and academics in the United States had to be carried out via zoom. Through the weekly meetings with Professor Plane's group, I had the opportunity to present my work to both PhD students and academics who were much more experienced than myself, this definitely developed my confidence when presenting. This new-found confidence in my ability to lead has also presented itself in other areas of my study, for example in my new role as a PAL mentor, where I teach first-year students. I have also found that I now naturally take on leadership roles in group-work activities associated with my degree. Working with an undergraduate from California State University gave me a different experience of leadership than that of working in Professor Plane's group. I had the opportunity to work with someone who had a more similar background to myself. This allowed for a more equal and collaborative approach, working together on understanding the structure of the large datasets we were studying. I have also taken part in many Laidlaw networking events where I have enjoyed not only discussing the results of my own research but learning about the findings of other scholars from around the world.

What are your future career or educational plans?

After completing my master's degree in chemistry, I hope to do a PhD in Atmospheric and Planetary science at the University of Leeds, before going onto a career of research as a professor.

Signature of Scholar



Signature of Project Leader

