**Harvard University · Environmental Science and Engineering · Personal Statement · Daniel Varon**

I first encountered the science of atmospheric modelling as a research assistant in Professor Shaun Lovejoy's climate physics group at McGill. In a series of publications, Professor Lovejoy had characterized the scale-dependent variability of atmospheric temperature fields, and demonstrated that at time scales of about ten days and thirty years, fluctuations in these fields undergo sudden transitions. Up to ten days, temperature fluctuations increase in magnitude with scale, while at time scales between ten days and thirty years, they decrease; finally, at scales longer than thirty years, temperature variability starts to rise again [1]. My project was to determine the extent to which general circulation models (GCMs) reproduce this behaviour. Over the course of two years, I conducted a series of fluctuation analyses characterizing temperature variability in the simulation outputs of four different GCMs. This research yielded a publication in the peer-reviewed journal *Earth System Dynamics*, in which we show that the GCMs we studied do not produce high enough multicentennial temperature variability in pre-industrial scenarios, and postulate that this might be because they lack certain slow climate processes like, for example, land ice.

Studying previous geophysical models made for a good introduction to atmospheric science, but my goal now is to get involved in the production of original simulations. Although my past research has been in climate dynamics, in graduate school I would like to focus my efforts on atmospheric chemistry modelling. I am especially interested in Professor Daniel Jacob's research—particularly his work on chemical-transport modelling for species from commercial sources (*e.g.*, mercury and ammonia emissions)—because of its impactful connection to human and environmental health. The ideal thesis project for me would be one that examines the interplay between chemical-transport models and satellite remote-sensing systems. In Professor Jacob's group, I would look forward to studying questions as to how atmospheric models can inform and be informed by interpretations of data retrieved from space-based optical systems.

Since my work with Professor Lovejoy, I have contributed to several other research projects. In 2013, I took a position as a summer research assistant in Professor Tracy Webb's astrophysics group at McGill. Professor Webb's research has recently been focused on a galaxy supercluster called RCS 2319+00. This object constitutes a rare astrophysical laboratory, because while the time scale associated with the formation of superclusters is approximately the age of the universe, RCS2319+00 is forming at redshift $z \sim 0.9$, meaning it is nearly eight billion years ahead of its time. I could not resist the opportunity to study such an exceptional system, and eagerly accepted the challenge of mapping its distribution of starburst galaxies. In Professor Webb's group, I ran Monte Carlo simulations in tandem with a matching algorithm to determine cluster membership in a catalogue of more than 200,000 galaxies, and used an infrared galaxy template to estimate star formation rates. Ultimately, I identified thirty-eight starburst galaxies producing a total of $\sim 1.1 \times 10^4$ solar masses per year in the redshift range of RCS2319+00, six of which appear to reside in the cores of the supercluster. This was somewhat surprising, since many processes are thought to suppress star formation in the core environment [2]. We concluded that not enough time had elapsed for these processes to take effect, and used this reasoning to place a lower bound of $\sim 1 \times 10^9$ years on their characteristic time scales. I defended this work as my Honours Research Thesis and presented it with a poster at the 2014 Canadian Undergraduate Physics Conference in Kingston, Ontario.

After graduating from McGill, I wanted to gain work experience in applied science. To that end, I took a research support position in the medical physics department at Montréal's Jewish General Hospital, where I have contributed to two projects—one in radiation oncology and one in urology. The latter is a study of patients who have had artificial urinary sphincters implanted as treatment for incontinence. My role has been to develop a database detailing treatment histories and outcomes, which will be used to search for correlations between previous treatments, pre-operative urodynamic studies, and post-operative outcome. In contrast, my radiation oncology project is a study of how the volume variability of pelvic organs correlates to toxicity in the outcome of radiation therapy for prostate cancer. (This type of treatment takes place over several weeks, during which time the fluctuating bladder and rectum can become mistakenly irradiated.) My job is to estimate daily organ volumes for a collection of past patients by using cone-beam computed tomography scans (low-resolution scans taken daily to align the prostate with its position in the dose plan) to produce 3D contours of the bladder, rectum, and prostate.

All of my research projects to date have required me to manipulate large datasets, and in doing so I have become skilled in statistical methods, graphical representations of data, and several programming languages (particularly Python and Mathematica). My research has also given me opportunities to communicate science through posters, presentations, and written reports. I have even experienced the peer-review publication process. In contrast, my course work has provided me with ample training in theory; I have taken twenty-six physics and mathematics courses (including six at the graduate level) on subjects ranging from thermal physics to string theory. I now wish to strengthen my research foundations in modelling and experiment; I want to produce data, not just analyze it. Basically, I am seeking a research project that integrates theory, observation, and simulation with the objective of gaining new insights on Earth engineering technology. At Harvard, Professor Jacob's atmospheric chemistry modelling group offers many such opportunities. Given the chance, I would look forward to contributing to this group's research activities in graduate school.

Thank you for your consideration.

Daniel Varon
December 15th, 2014

[1] Lovejoy, S. et al. 2013. *Extreme Events and Natural Hazards*, 231-54. doi:10.1029/2011GM001087.
[2] Taranu, D. S. et al. 2014. *MNRAS* 443 (3), 1934. doi:10.1093/mnras/stu389.