Weeks 1 and 2: Bootcamp Weeks

These past two weeks have been great! The first week I was pretty nervous coming in. I was worried that I wouldn't pick up on things quickly enough, but the Boulder REU laid the solar and space physics concepts out super clearly. The lectures and labs were really engaging, and I learned a lot. There are definitely people from that week who I plan to reach out to in the future to talk to about their work and about their journey in getting to where they are now. The IDL tutorials were a super helpful introduction since I was only familiar with Python up to that point. Everyone in the MACH and BSA programs were kind and eager to learn and help others learn, which was a fantastic environment to be in! I read a dissertation that gave a lot of good information about atmospheric loss in the ionosphere, and probed the role of a magnetic field in atmospheric loss, which felt very MACH to me! Overall, this week made me excited about what was to come.

The second week Laura supplied us with a long plasma physics lesson, an IDL tutorial, and some additional readings. The plasma physics lesson was more advanced than what I've learned in my classes so far, but I enjoyed being able to expand my knowledge. I liked seeing bits of all different types of physics I know mixed together, from relativity to physics 2 concepts. Although I'm still working on putting all of the pieces together, it's really cool to see how relatively simple physics concepts can create such complex phenomena. The IDL tutorial definitely taught me a few very essential IDL skills. Although it was frustrating to troubleshoot, it was super satisfying to get things working, and made me feel like I was learning a new skill. Before this week I didn't really know anything about the ionosphere and wasn't sure what I'd think about it, but after doing a bit of reading about it I'm finding it way more fascinating than I thought that I would! The practical applications of radio waves in the ionosphere combined with the complex physics of the plasma and aurora and atmospheric loss make me super excited to dive more into the science. It's truly amazing how much can occur in just one layer of the atmosphere. This week has made me start to feel like a real scientist and like I can tackle research this summer!

Week 3

This week I got started on my project! I compared the dataset of substorm start times in the paper "Nightside auroral zone and polar cap ion outflow as a function of substorm size and phase" to the various datasets in the SuperMAG database. We were hoping that the magnetometer data would match the Gordan-Wilson dataset since it's able to cover a larger range of times than Polar did with imaging, but I found that the matches were very poor. It was more shocking that the GW dataset didn't all show up in the Kan Liou dataset since they used the same instrument on Polar, and GW used Liou's work to make their start times. This upcoming week will be spent trying to determine why the GW dataset doesn't show up in Liou's. Even though this was not the result we were hoping for, we learned something new and found more questions to investigate. That's what research is all about, and it feels good to be making progress already. I

also met with Chris this week to set up Unix which is a bit daunting, but I know that it is well worth it to learn and will be fine once I become more familiar with it.

I definitely felt a good bit of imposter syndrome this week. Even though I was just comparing lists of substorm start times, I was concerned that I'd do something incorrectly and be judged for it. Despite this, I was able to do everything well and progress with the project. This has helped to somewhat dispel my imposter syndrome by just trying things and having them turn out successfully. I'm excited to see what next week will bring!

Week 4

This week was relatively calm. I spent Monday and Tuesday looking through Polar UVI images of substorm onsets that Gordon-Wilson and Liou agreed on, onsets only on the Gordon-Wilson list, and onsets only on the Liou list. I was trying to determine why some substorms were rejected from either list in order to find which list was 'better'. I was not able to identify any patterns as to how the substorms were chosen, so Lynn decided that I will analyze the ion outflow for all 5 lists to determine how the definition of onset affects the results. I've been waiting for Niloufar to set me the code to do this, so in the meantime I've been learning how to use Unix. I also put together my elevator pitch and the 5 minute presentation for professional development next week.

Week 5

Much of this week involved trying to resolve technical issues with my UNH account. This was something that I didn't have much control over, so while I was waiting for that to be done I worked on my 5 minute presentation which I think went well! Doing this presentation aided in my understanding of my project, and taught me how to effectively communicate the science that I'm doing. Once my account was fixed I was able to run the initial epoch analysis for the Wilson substorm list. Our results needed some adjusting to better compare to the Wilson study, and I sent the results of that to Lynn this morning. I am running the analysis now for all 5 substorm lists that I'm looking at, which will take several days. It's a bit intimidating to run code that takes that long because I'm afraid of accidentally messing it up and having to restart, but it's also exciting to be looking at such large quantities of data. I'm also working on an analysis of just the large substorms from the Wilson list in order to see how that affects our comparison.

Week 6

I'm writing this log a little bit late, whoops! During week 6 I ran the ion outflow analysis for all 5 lists. During this time I learned some new Unix commands that allow me to run code without having to worry about the virtual machine randomly disconnecting, which I've realized is a necessity when running code that takes more than an hour. We realized there was a bug in the code that was affecting how some of the data was binned, and Niloufar was able to identify and correct the bug, and expand the time after substorm onset that we looked at. I reran the analysis with the new code for all 5 lists and got results that seemed more reasonable. Even though it can

be inconvenient to run into bugs, especially when it takes so long to correct and rerun the code, I was able to learn something from it. The bug wasn't noticeable unless you really understood the nature of the data that I'm working with, but Chris pointed it out and I learned how to identify an error like that myself. I can't believe that we're already 6 weeks through, the time has been flying!

Week 7

This was a pretty busy week, especially with the holiday. At the beginning of the week, I created histograms showing the distribution of Kp and DST index values for the large and small substorms in the Wilson onset list, which was surprisingly difficult to format correctly since I did it in excel. On Wednesday we decided to change the axis of our analysis and split it up into 4 quadrants instead of just day and night, so I reran the analysis for all 5 datasets. I reran it twice to get the plots in both linear and logarithmic scales so that we could determine which was most useful. I also ran code that pulled the Kp and AE index values for the 4 datasets that did not include them. The way the code formats the csv file it produces with the indices is not useful at all, especially since the Kp values need to be divided by a factor of 10, so there is quite a bit of time that goes into reformatting the file. There appear to be a few uncharacteristically high flux bins, so Niloufar edited the code so that it produces a file with a list of the outlier data points that I have to check by hand to confirm whether they are real, or if it's 'bad' data. She discovered a bug in the code that was excluding some of the data points, so I will need to rerun the analysis again to produce the correct summary plots. Going through all of them by hand is extremely tedious, especially since there are so many of them. Even though it's super important to ensure that I'm using good data, it is not my favorite part of research so far.

What is super exciting, however, is that I'm working on an AGU abstract! This is my first time writing any sort of abstract and (hopefully) presenting my work at a conference, so I'm both nervous and excited. It definitely invokes a feeling of imposter syndrome, but I have to remind myself that if Lynn didn't think my project was worthy of an AGU abstract then she wouldn't encourage it.

Week 8

After rerunning the analysis for all lists, I divided the Wilson list into large and small substorms using a Kp index of 2 as the cutoff value. Even though only about 11 substorms switched from one list to another in the way that we divided the list, the plots looked extremely different from the plots produced for Wilson's large and small substorms. This means that there are a few large substorms dominating the average, so we need to work with more data to get an accurate average. We decided to expand our time range from 3 months to 2 years and see what happens. We decided that we wanted to filter out storm-time substorms, so we added DST to the code that pulls Kp and AE indices. Anything that has a DST less than -20 is during a storm, so I filtered those substorms out of the data and divided them into large and small substorms. At the end of this week, I've run the analysis for large substorms for the Kan Liou list.

Week 9

This week was just full of technical difficulties! The analysis takes 18+ hours to run for each substorm list, and has been running all the way until the last month of data and then crashing. I have no idea why it's doing this, and it's hard to troubleshoot since it takes the code so long to run. Everyone is at COSPAR in Greece this week, so I've had time to just go through and organize all of the data while running everything. I've also edited my AGU abstract and think it looks good to submit, but I'm going to wait to see how the analysis for the longer time period looks. The BSA REU invited William and I to present with them at their final presentations next week, which is exciting and unexpected! I decided that I'll do a 20 minute presentation with them, but not the poster session. I don't think that I could put together a quality poster in 2 days, so I decided that it's best to just do one of the presentations well rather than have 2 mediocre presentations.

Week 10

I can't believe this is my last week in MACH SUR! I spent this week running the superposed epoch analysis for as many of the lists as possible and plotting the parts of the analysis it actually ran. I also presented with the Boulder REU on Thursday, and it went much better than I had anticipated! Everyone had such positive feedback, and there were a few people that came up to me after the presentation to talk more about it. I also feel incredibly lucky that so many of my friends, mentors, and peers came to watch. This was my first time giving a real research presentation, so it was great practice for when I present with MACH. It was also a great feeling to be surrounded by my peers who are just as passionate about science and enthusiastic about everyone's research.

Overall, I'm so grateful for this experience. I truly feel like I learned more in these 10 weeks than I did in 10 months in my previous research. I almost didn't apply for this internship because I convinced myself that I wouldn't get any internships this summer, but I'm so glad that I applied with one minute to spare. I applied to MACH SUR because I'm interested in all areas of astronomy related to planets, but I wasn't sure how interesting a project about the Earth would be. I was pleasantly surprised by how much there is to learn about our home planet, and by how fascinating the science and research behind it is! I came into this internship not knowing if I was cut out for research, but I'm coming out of it with the confidence that I can have a successful career in this field with the technical skills to back it up.