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NASA Astrobiology Early Career Collaboration Award Report**

I traveled to the University of California, Santa Cruz (UCSC) to work with faculty from the Other Worlds Laboratory as well as visiting planetary scientists during their annual Exoplanet Summer Program. My goal in attending was to learn about building a theoretical model to describe cloud chemistry in exoplanet atmospheres by engaging with experts in planetary formation, climate, photochemistry, and geochemistry.

My research focuses particularly on sub-Neptunes, exoplanets between the size of Earth and Neptune. These planets have characteristics of both terrestrial and gaseous worlds, and their bulk densities can be described by a multitude of interior structures simultaneously [1-4]. Such interiors range from cool, habitable water worlds, to scorching magma worlds. To constrain the interior and surface conditions, we can use the composition of the observable upper atmosphere and retrace its evolution. As the James Webb Space Telescope observes more sub-Neptunes, a new “Missing Ammonia” mystery has emerged. While theoretical models previously predicted ammonia (NH_3) to be abundant in sub-Neptune atmospheres, it has not been detected to date [5-10]. This molecule has been proposed as a key indicator of atmospheric depth and the presence of water or magma oceans [11]. Thus, understanding its evolution through the atmosphere is crucial to discerning a sub-Neptune’s true nature. I aim to investigate this mystery by modeling NH_3 dissolution and aqueous chemistry within water clouds.

The workshop held daily talks from attendees, providing me an opportunity to present my own preliminary results to approximately sixty attendees from around the world. I listened to talks across a wide range of subfields, including mission development, laboratory experiments, and theoretical approaches to understand exoplanet formation, evolution, climate, and interior/surface conditions. I particularly remember talks from Morgan Sidel (California Institute of Technology) on how atmospheric escape can help distinguish between different sub-Neptune interiors, and Dr. Kazumasa Ohno (National Astronomical Observatory of Japan) on what a planet’s current volatile inventory can infer about its formation. I immensely benefited from conversations with Dr. Joshua Krissansen-Totten (University of Washington), Dr. Nick Wogan (NASA Ames Research Center), Dr. Artyom Aguichine (UCSC), and Dr. Xi Zhang (UCSC) regarding the development of my model. We discussed how to couple photochemical and geochemical principles, build realistic adiabats or pressure-temperature profiles in the deep interior, and the potential for sulfur chemistry in this model. As this is a theoretical approach that can be sensitive to model assumptions, we also discussed reliable ways to benchmark this model to ensure the results are physical.

As a result of this workshop, I refined my oral presentation skills, connected with other graduate students in my field, and worked with seasoned planetary scientists. I believe these collaborations will shape the trajectory of my Ph.D. career, and the insight I gained will remain with me throughout my future projects. I am grateful to the NASA Astrobiology Program for the opportunity, and I recommend that other early-career scientists apply for the NASA Early Career Collaboration Award.

Figures

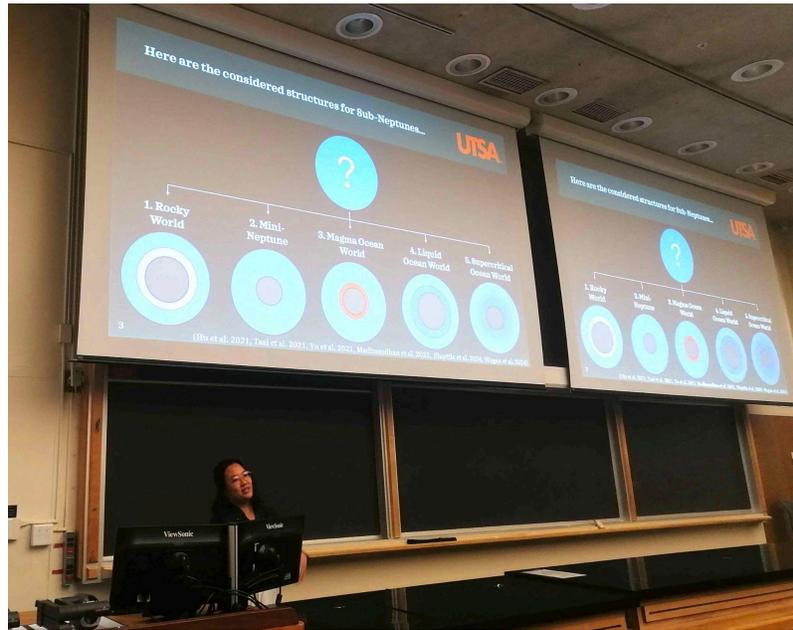


Figure 1. Presenting preliminary results regarding NH_3 chemistry in sub-Neptune atmospheres to attendees of the Exoplanet Summer Program at the Other Worlds Laboratory.

References

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