Field Research During a Pandemic

On July 3, 2019 we knew we had a novel dataset. We had spent 26 hours gathering data around the total solar eclipse from Andacollo, Chile. We saw very distinct atmospheric



Figure 1: 2019 MTSGC eclipse team.

gravity wave signals just after totality. As the team of five Montana students and staff mused about finding the first eclipse-driven stratospheric gravity waves, we also began discussion of replicating these measurements with the next eclipse seventeen months later— also in Chile. How could we pass up such a unique opportunity?

Even though the December 14, 2020 eclipse was further south than the 2019 eclipse, it was moving west to east and across the Andes just like in 2019. So began the brainstorming. On the five-hour drive from La Serena back to the Santiago International Airport, we devised four specific areas if interest for further research: our core objectives. Once back in Montana though, our first order of business became getting more participants for the next field campaign. Our 2019 crew was

exhausted after working 40 hours with minimal naps planned into the schedule. Second order of business was expanding measurements across the path of totality. "What if we put teams at four launch sites, evenly spaced from the west coast of Chile to the east coast of Argentina?" we thought, and so the journey began . . .

December 9, 2019 the Montana eclipse team was spending the week at the AGU conference presenting results from the 2019 field campaign. As is expected, the networking at such conferences is always a highlight. It was here that we met Kathleen McNamara from Oklahoma State University and talked about our respective ballooning projects. We exchanged contact information to continue discussions regarding possible collaboration.

By January 8, 2020 the NASA and NSF EPSCoR programs began exchanging emails regarding possible funding avenues for us to propose a



Figure 2: Pre-COVID conference, AGU Dec 2019. Left to right: Tom Colligan, MTSGC, Jennifer Fowler, MTSGC, Cass Runyon, SCSGC, Jaylene Naylor, University of Montana.

2020 total solar eclipse field campaign. On January 17, 2020 we had put together a proposal and submitted it through the NSF Division of Atmospheric and Geospace Sciences (AGS). By March 11, 2020 the funding had been awarded. Our teams are: Montana Space Grant Consortium, University of Idaho, Oklahoma State University, and University of Kentucky. NSF funded the bulk of the proposal while NASA space grant consortia funded the student's time through competitive summer internship programs. Everything was in place and we were

ready to begin an epic science adventure. But March 2020 also signaled the advent of another inauspicious event, the first confirmed COVID-19 cases in the United States.

The gist of our grant proposal is this: train six to eight students from each participating state through the summer of 2020 to properly conduct a 24-hour balloonborne field campaign and ready data analysis software to quickly ascertain results. The proposal included plans to have all participants spend a week training together in Montana early in the summer. Along with the rest of the world we started making alternative plans, most of which relied on Zoom. Starting in late May 2020 we held weekly all-team Zoom meetings and trainings, weekly small-team meetings based on research topic, and weekly balloon launches.



Figure 3: Summer training included weekly launches with some occurring simultaneously across the country. Left to right: Montana, Kentucky, Idaho (with the university president), and Oklahoma.



Figure 4: All-teams Zoom meeting, summer 2020.

By August 2020 the countries of Chile and Argentina had closed their borders. All forty participants were getting nervous that our hours of training would be for naught, but the Montana flight director, Carl Spangrude, figured it did not hurt to make an inquiry with the Chilean Consulate. Our team was instructed to present the Consulate with a list of all potential participants' passport numbers and a deadline of early September was set. This brought additional complications as new US passports were being processed slowly and some students did not yet have a number. By mid-September, the Consulate told us we were too early in applying and to resubmit our list in October.

By October 2020 amidst resurgent COVID cases in the US, slow speed of passport processing services, and the possibility of an additional 14-day quarantine in Chile (meaning almost 21 days in country to conduct the field campaign), our list of 40 participants was down to 17. Along with going to only one country, we cut our launch sites down to two (from four) and increased the length of the campaign from 24 hours to 48 hours. Based on these conditions, we resubmitted the necessary paperwork to the Consulate and worked on logistics such as housing, vehicle rentals, and acquiring helium. Housing was settled after an exhaustive search for places we could launch directly from as well as stay isolated in, with final destinations in Toltén and Villarrica. Helium was secured with the tremendous help of Jorge Carrasco of the Universidad de Magallanes. Jorge worked with two companies as well as various pickup and drop off locations to make sure we could get the 26 K tanks of helium (13 per site) needed for the field campaign. This also meant we needed to rent four pickup trucks to transport the helium and two minivans to transport people and personal luggage. October was also the month we reached out to the DGAC (FAA equivalent) to coordinate our launch schedule.

Then in mid-October we heard from Elizabeth Isaman of the U.S. Embassy in Santiago. She offered to help us move the paperwork along. By October 22nd we received an update from Elizabeth:

- Per the revised (Chilean) guidance from the weekend, everyone will need a PCR test within 72 hours of arrival but will NOT need a second test upon arrival. This should make the arrival easier.
- Each person on the trip will need to go to the Chilean consulate to give fingerprints and get their Salvoconducto. They are not able to do it remotely.

On October 23rd we got news that the Chilean Ministry of Science had approved our project and the Ministry of Foreign Affairs was



Figure 5: Montana Team packing and tying knots for payload to balloon attachment.

requesting information to pass to the regional Consulates for our Salvoconductos. This all meant... *We Are Going to Chile!!!*



Figure 6: Idaho team in front of the Chilean Consulate to pick up their Salvoconductos, San Francisco, CA, Dec 2, one day after Montana's visit.

Maybe going to Chile ... We still needed our respective universities and colleges to approve spending of travel funds for this trip. Spangrude took the lead in putting together a document of COVID protocols that each participant would follow. Additionally, we needed to make sure everyone could get COVID tests and results within 72 hours of arrival in Chile and that everyone had at least \$30,000 of coverage in travel insurance. Next we needed to go to our regional Consulate for our Salvoconductos within 10 days of arriving in



Figure 7: Montana team at the Missoula International airport Dec 7.

Figure 8: Meeting up with the Idaho team in Miami.

Chile and book our airline reservations. By November 14th we had everything in place and started packing. Each piece of luggage needed to be less than 50 lbs. (research balloons are *heavy*). Packing took six hours. Self-quarantining started November 23rd in our home states.

December 5th and 6th were our COVID tests. Fingers crossed that everyone would pass. December 7th found all 17 team members healthy and at the airports ready to leave the US. Teams met in Miami for our 8-hour international flight arriving in Santiago, Chile December 8th at 8:30 am. Next was getting through customs and processing paperwork to accept our COVID tests. Once out of the airport doors, we were eventually picked up for transportation to the rental vehicle lot (Who drives standard? Anyone? Anyone?). Once we unloaded all the bags, the team sat in the sun while one-by-one, each vehicle's paperwork was completed in a single-room building with just enough space for the attendant and a customer. Once a key was produced, the vans and trucks would be inspected by an employee and one of our team members (noting the locations of tire jacks and fire extinguishers) and repacked with cargo and drivers.

At last, the hotel. After about 30 hours we could finally take off our masks once in our hotel rooms. Time in the rooms was short however, as we had our Chilean COVID tests to take, helium delivery to confirm, and groceries to buy.



Figure 9: Left - waiting for rental cars (note: keep sunscreen handy). Right – students "waiting" patiently to check into the hotel.



Figure 10: Sorting, repacking, and tying more knots.

December 9th was the day to sort and repack all our equipment based on field site as well as go over final details of launch procedures, schedules, etc. Some logistics included



Figure 11: **Left** - reviewing logistic details for both sites. **Right** - Applying for travel paperwork with our fantastic translator Maria Yepez.



Figure 12: Gravity waves appearing in the clouds.

December 10th was travel day to the Villarrica site while the Toltén team stayed in Santiago to finish final exams for Oklahoma State University students. Along the drive, gravity waves were spotted in the clouds giving the team motivation for measurements.



Figure 13: Second stop on drive to Toltén to check our paperwork.



December 11th began with the Toltén team's departure from Santiago for their 8-hour drive. Meanwhile the Villarrica team went to pick up helium that had been delivered to Toltén.

December 12th was the day to setup and test equipment, get food for the field campaign, and tie up any last-minute logistics. This day was also the last chance before the field campaign began for the University of Idaho students to study for their final exams beginning December 14th. For the Villarrica team, this meant going to the local coffee shop to find available Wifi. The nice thing about being with a team of STEM

Figure 14: Helium pickup by Villarrica team. Wif

majors is the study groups that form to help teammates get through exams regardless of institution.



Figure 15: Left - UI student Lauren Perla studying for finals with Middle - personalized coffee. Right - Spend enough time at a coffee shop and they get to know you.



Figure 16: Left - Preparing the Lufft surface weather station for measurements in Toltén. Right - Dinner at the Villarrica site. Students made many meals during the campaign.

December 13th, 2020, 1:06pm Chilean local time hourly launches began.

Each field site was staffed by a mix of students from different institutions. We knew from summer training that each student was qualified to take measurements with the equipment we had brought with us. We did not need to stick with the summer teams divided by state. We also knew the students had treated each other as teammates from day one with little competitive instinct for their school. This was a completely collaborative effort. So, while the Chilean teams were collecting data day and night, team members from University of Kentucky, University of Idaho, University of Montana, and Oklahoma State University conducted data analysis in the US, also working through very long shifts.



Figure 17: Villarrica day shift.



Figure 19: The Toltén team prepares a balloon before the eclipse.



Figure 18: Villarrica night shift.



Figure 20: UI student Sebastian Garcia does some outreach by explaining the real-time data being collected in Spanish.

Day and night shifts were arranged to maintain data consistency, allow staff to get sleep, and keep everyone fed throughout the 48 hours of the campaign. This meant setting up "mission control", ground stations for receiving data, and the balloon fill area, where personnel could comfortably work while also allowing the other shift to sleep. While students were conducting the launches, the PIs were uploading data to the data repository for the US students to continue analysis. The PIs were also in constant contact with each other between the launch sites to help problem solve issues such as frequency interference between other airborne radiosondes not associated with our group. When you have not had much sleep, scheduling frequency configurations takes a whole team.



Figure 21: Villarrica night launch.



Figure 22: Toltén launch before the eclipse.

Meanwhile, back in the US ...



Figure 23: Students conducting data analysis at the University of Idaho both virtually and in person.



Figure 24: UI student Alex Chambers analyzing gravity waves.



Figure 26: UI graduate student, Jackie Martinez-Alvarez and UI undergraduate student, Leah Davidson analyzing gravity waves.



Figure 25: University of Montana student Graham Moss comparing weather model runs against the data.



Figure 27: The analysis team worked as long as the launch teams.

Of course, there was an eclipse ...



Figure 28: Eclipse from Toltén. Photo credit: Jamey Jacob



Figure 29: Eclipse from Toltén. Photo credit: Jamey Jacob



Figure 30: Villarrica team in their eclipse glasses.



We "experienced" the eclipse more than we actually saw the eclipse, but this did not "dampen" our enthusiasm.

Figure 31: Launches continued even through the down pours. The Villarrica team had to occasionally dump the water from the tarp protecting the ground data-receiving stations.

December 15th, 2020, 1:06pm Chilean local time hourly launches conclude.



Figure 32: Last launch in Toltén.

Launch 50 888 g Form You made it! Congrats! - Nightowls

Figure 33: Note on the data recording form from the night shift in Toltén.

The last data set was completed about 3:00 pm Chilean time. POP THE CHAMPAGNE! After savoring those bubblies for 10 minutes, we needed to get packed up to leave early the next morning. By the evening of December 15th, we were happy to watch the sunset and further savor the successful work we had completed. Each field site took time to see sights before dinner (Figures 27 and 28). December 16th was the reunion of the whole team, with the Villarrica site joining Toltén to drop off helium and fix a flat tire (nothing like starting a day with a tire blow out) before beginning the long drive back to Santiago. Our 8-hour drive turned into 10 hours due to traffic. After a few hours, our 6-vehicle caravan we had started in was completely scattered, but we all made it back to Santiago safely and some Idaho students even took exams that night.

Our plane departed Chile at 11:30 pm December 17th. We got a late check out from the hotel first scheduled for 3:00 pm. It seemed we had plenty of time to re-sort and repack equipment, get showers, eat, and get on the plane. But alas, the best laid plans . . . it took days to figure out how to pay for the helium and it came down to going to the Santiago office to make the payment the day of our departing flight. This task took several hours and our hotel allowed us to push check out back to 5:00 pm. Next we just needed to get the rental vehicles back to the airport by 7:00 pm- *no problem*. . . Did we mention how bad traffic is in Santiago? We got all six rental vehicles returned by 8:00 pm. From there we needed to head straight to check in for our flights, check equipment, and make it through passport control to give up our exit paperwork. Once at our gate we all spread out to search for our last chance at souvenirs and food in Chile.

December 18th - - - Home. We landed in Miami, went through US customs and border control then met up for a final team debrief before each state headed to their gate for the final flights home. This was indeed an adventure and a scientific endeavor not to be soon forgotten. Stay tuned for the results of our data analysis . . .



Figure 34: On the black-sand shores of Lake Villarrica.



Figure 35: Pacific Ocean near Toltén.



Figure 36: They may be exhausted but data analysis continues even in the airport.



Figure 37: Whole team before we left each other for our respective homes.