TEXAS Geosciences

Jackson School of Geosciences
Research Traineeship Experience (RTX)

2023 Participant Abstracts

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Urban Heat Islands and its Comparison to Neural Tube Defects

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The Urban Heat Island effect is defined as an urban area having higher than average surface temperatures than its rural and non-urban surroundings. The infrastructure of urban settings causes the increased retention of heat, causing the heat island effect. This phenomenon will lead to an increase in heat related symptoms such as stroke, hyperthermia, heat exhaustion, and heat cramps. Research has further shown that excess heat can affect mothers who are pregnant and thus affect their infants' growth through neural tube defects. Neural tube defects or NTDs are anomalies that occur when the neural tube does not close properly during its formation. The neural tube is responsible for forming the early brain and spine, and develops very early in pregnancy. The two most common NTDs are Spina Bifida (a spinal cord defect in which some of the vertebrae are not completely closed) and Anencephaly (a brain defect causing an open brain and lack of skull vault).

The first part of the project focused on showing a U.S. wide comparison between heat and the prevalence of NTDs. Spina Bifida and Anencephaly prevalence data per 100,000 live births for 5 year periods was acquired from the CDC EPH Tracking system. The data was then graphed to see the pattern and to capture any outlying states that had differing patterns of growth. This data was then compared to 2m temperature data from ERA5 for the same consecutive 5 periods of time to see any pattern between states with a higher average temperature and NTDs, and states with a higher average change in temperature and NTDs. There was no distinct pattern found between high temperatures or high changes in temperatures and NTDs. Neural tube defects also seemed to have no pattern throughout time, not increasing nor decreasing. The second part of the project focused on specific states and counties, going to a more urban scale. Arizona and California were determined to be "mixed" states with both high and low average temperatures, and two counties from each were selected and their NTD prevalence was compared against each other. One county was determined to have UHI qualities such as high average heat, high population, and highly developed imperviousness. Maricopa and Cocoino from Arizona were selected with Maricopa being the UHI representative. Fresno and San Luis Obispo from California were selected with Fresno being the UHI representative. Then, Arizona and California were compared as whole states. The same was done for "cold"/low average temperature and "hot"/high average temperature states Wyoming and Florida respectively. The conclusions proved to be inconclusive as most of the states and counties with lower average temperatures seemed to have higher prevalence of both NTDs. This could be due to inconsistencies in the NTD data provided by the CDC. Therefore, future research will be done with more reliable sources of NTD data and will also spread outside of the U.S. to countries that have variable rates of folic acid deficiency and air temperature. Another angle that can be explored is the comparison of NTDs to heat experienced by a person, which takes into consideration other factors such as humidity, wind, etc. instead of just air temperature.

Developing an Index to Understand Large-scale Rainfall Patterns in Southeast Texas

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Historically, hurricanes and tropical storms have caused floods in the southeast Texas region, affecting millions of people, a disproportionate number of whom are underprivileged. Consequently, we propose an index to diagnose meteorological drivers and rainfall patterns that can cause significant flooding in this region as part of the DOE-funded Southeast Texas Urban Integrated Field Laboratory (SETX-IFL) project. This method entails examining total daily precipitation simulations from 1950 to 2014 in order to better understand the occurrence of consecutive multi-day precipitation events that can contribute to flooding. This includes determining the number of consecutive days with at least 1mm, 5mm, 10mm, and 15mm of daily precipitation and identifying these events, defined as at least two consecutive days of precipitation at the thresholds covering at least 50% of the studied area. Additionally, days that met the criteria were analyzed more extensively to better understand the regional precipitation patterns. The results indicate that the 1mm and 5mm thresholds are ideal for capturing most region-wide rainfall events driven mainly by maritime winds. In comparison, the 10mm and 15mm thresholds aided in identifying large-scale events such as Hurricane Cindy, Tropical Storm Allison, and Hurricane Ike. This implies that this proposed index can provide valuable insight into the small- and large-scale rainfall events responsible for most flooding events. The proposed index can help improve our insight into past large-scale rainfall events responsible for most flooding events and future rainfall events in the southeast Texas region.

Developing and Analyzing ASTER Digital Elevation Models to Monitor Elevation Change of Glaciers in Greenland

Brooklyn Douglass, Alexandra Stephens, Ginny Catania, Kevin Shionalyn

A complete record of the surface elevation for the Greenland Ice Sheet (GrIS) is crucial to understanding the period in which many marine-terminating glaciers began to retreat (late 1990s-present). Surface velocity and terminus change records for GrIS outlet glaciers are publicly available and ubiquitous, however surface elevation change, particularly in the time period of retreat onset, is lacking. Since the GrIS is now contributing the largest land-ice mass to sea level rise, it is imperative to understand ice sheet evolution over the satellite era in order to correctly model its future. NASA's Terra satellite, launched in 1999, contains the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument, which takes stereo images and is used to create digital elevation models (DEMs). However, due to sensor jitter, these DEMs have elevation

errors of around ±20 m. Using the MicMac ASTER (MMASTER) pipeline (Girod et al., 2017), and updates to this pipeline for application to GrIS outlet glaciers, we are able to reduce this error and produce a series of DEMs over Central West Greenland glaciers with accuracies of <10 m. We use these DEMs to examine the spatio-temporal variability in elevation change over glaciers that have experienced heterogeneity in outlet glacier change. We compute the frontal force for glaciers and how this has changed over time in order to model the expected velocity response. By comparing the modeled velocity response to retreat to the observed velocity response, we can examine the mechanisms responsible for ongoing glacier retreat.

Understanding the Methods Used to Analyze the Dripping Rates at Inner Space Caverns

Enrique Morales, Nicola Tisato

Inner Space Caverns, also known as Laubach Cave, is a large public cavern near Georgetown, Texas. As part of a larger effort to understand the complexities of this cave, a study was conducted to understand the methods used to analyze the dripping rates of the cave. To understand the variability of the dripping rates, lab experiments were conducted with three (3) sensors that tracked the amount of water droplets dispensed. The 3 sensors used were an optical sensor, webcam-based sensor, and a data logger. The optical sensor is a light sensor that is directly attached to the water source. When a droplet passes through the light, the sensor counts one droplet. The webcam-based sensor is run by a MATLAB code that takes the standard deviation between the frames collected, makes a threshold value, counts a droplet when the threshold is passed, and saves the data and current frame every five (5) minutes. The data logger is the actual instrument that is put into the cave. The data logger utilizes a glass plate on top of a sensor that picks up vibrations and records the intensity of the vibrations created as the corresponding number of droplets. Analyzing the data from the lab experiments showed that the data logger was inaccurate, counting 90% of the total drops during the 1st day experiment and between 130-150% of the total drops during the 2nd day-long and 3 day-long experiment. Due to the fact that the lab experiment was conducted using a data logger that was previously in the cave, the previous data that was collected from the cave is inaccurate. In order to continue properly studying the cave in the future, the sensors in the cave should be removed and corrected. Correcting the sensors will ensure that the true relationship between the dripping rates/calcite precipitation and rainfall is accurately portrayed. This will help with climate models and the understanding of speleothem growth.

Identifying Hyperfresh Craters

Erick Herrera, Caitlin Moeller, Doug Hemingway

Space weathering is a poorly understood phenomenon involving solar wind and micrometeoroid impacts that cause changes to the spectral properties of the surfaces of airless bodies like the Moon. Space weathering is thought to play a central role in the formation of a unique class of optical anomalies on the Moon known as lunar swirls. Lunar swirls are characterized by alternating bright and dark markings and are believed to occur only where strong crustal magnetic fields deflect the incoming solar wind ions, shielding parts of the surface from their effects. Hemingway et al. (2015) used Clementine multispectral imagery to identify spectral characteristics that distinguish swirls, and therefore solar wind-related weathering, from other types of optical maturity of lunar soils. Hemingway et al. (2015) suggested that all craters should begin with spectral properties that depend only on the local composition but will develop distinct characteristics over time depending on their level of exposure to the solar wind. Determination of the relationship between the ages and spectral characteristics of a variety of craters, with varying degrees of magnetic shielding, could lead to valuable insights into the timescales over which these various space weathering processes operate. Because large rocks in a crater's ejecta blanket tend to disintegrate into finer regolith over time, Rock Abundance can be used as a proxy for absolute age (Ghent et al., 2014). The Lunar Reconnaissance Orbiter's (LRO) instrument Diviner measures lunar surface temperatures, which can be used to estimate Rock Abundance (RA) using discrepancies in temperature between warm rocks and cool regolith (Ghent et al., 2014). Unfortunately, the geographic registration differs slightly between the Clementine and Diviner datasets, so a lateral correction is required before the two datasets can be compared. I identified the latitudinal and longitudinal shift between Diviner and Clementine data at several locations across the lunar surface which can be used to shift the two datasets into a common geographic reference frame. This sets the stage for further comparison between data sets with the goal of assigning an absolute age to a variety of craters in and around lunar swirls, which should help to constrain the timescales associated with solar wind versus micrometeoroid-driven weathering.

H_2S or SO_2? Modeling of Martian sulfur degassing processes using MAGEC

Jesse Do, Lucia Bellino, Chenguang Sun

High concentrations of SO_2 in the form of sulfate minerals dominate the Martian surface despite the absence of free oxygen in the atmosphere. This abundance of sulfate minerals is attributed to the degassing of sulfur during heavy volcanic activity in the Late Noachian and Hesperian Periods, which may have contributed to the Greenhouse effect in the atmosphere of early Mars that would

have allowed liquid water to exist on the surface. In volcanic eruptions, sulfur degasses in the oxidized form of SO_2 or as a reduced state in the form of H_2S. While early Mars conditions were reduced, oxidized sulfates have been observed in abundance on the Martian surface. If early Mars had reduced conditions, then we would expect H_2S to dominate the sulfur degassing process. To investigate this process, we simulated Martian degassing processes using different magma compositions and pressures relevant to the Martian mantle at the iron-wüstite mineral buffer using the Magma And Gas Equilibrium Calculator (MAGEC). Our results found that H_2S concentrations dominate the degassing process, with even S_2 concentrations found to be higher than SO_2. Due to a time constraint of this RTX program, we were only able to investigate one temperature and oxidation condition for this degassing process. Additionally, a new version of MAGEC was under development during the time of these experiments, but we only had the option to use the first version of the program. Based on the models under these tested conditions, degassed H_2S was significantly higher than SO_2, while SO_2 was even lower than the amount of S_2 degassed in volcanic eruptions. To align with sulfate observations on the Martian surface, we hypothesize that sulfide deposits were chemically altered to form sulfates from contact with liquid surface water.

Groundwater and Topography Interaction on Early Mars

Jhovanni Loeza, Eric Hiatt, Marc Hesse

Current groundwater models often rely on the Dupuit-Boussinesq (DB) approximation for groundwater flow in an unconfined aquifer. This approximation is attractive due to its ease in implementation; however, several underlying assumptions produce inaccurate results under specific conditions, such as when groundwater tables interact with sloping topography. The Martian area of Arabia Terra is compelling because it is one of the few regions on Mars that records a depositional environment, thought to be produced by groundwater and topography interactions. This region is pivotal to understanding the interconnected relationship between Mars climate and the perturbation of the groundwater table due to recharge events. However, modeling this relationship is difficult due to the inaccuracies in the DB approximation regarding topography and groundwater interaction. Work by E. Bresciani produced an extended solution to more accurately simulate groundwater interaction on hillslopes where the DB approximations may become inaccurate. To analyze the accuracy of this solution in a physical setting, we developed Hele-Shaw flow cells to examine the effects of new parameters detailed by Bresciani. The tanks were built using acrylic sheets cut to 5-, 10-, and 15-degree topographic hill slopes with an initial depth to aquifer height of 5cm. A gap spacing of 0.5mm between the two sheets of acrylic was achieved by 3d printing spacers to be adhered between the sheets. A peristaltic pump was used with a perforated tube to produce varying rainfall recharge from 100 to 200ml/min evenly across the cells. We conducted parameter sweeps across recharge rates, hillslope angles, and depth to the base of aquifer. After collecting and processing the data using Adobe Photoshop and Matlab, we produced 121

different flowrate and slope dependent water table/seepage data points to be analyzed and compared with the DB and Bresciani extended solutions. This data will enable current Mars groundwater models to more accurately constrain movement of the Martian groundwater table as it was forced by climatic oscillations and will enable us to better constrain paleoclimate on early Mars.

A Comparative Analysis of Earthquake Stress Tensors in Japan: Michael's Inverse Method vs. Kostrov Summation for the Years 2019-2020

Jorge Garcia, Huiwen Sun, Thorsten Becker, Daniel Trugman

Understanding stress distribution in seismic regions is crucial for comprehending earthquake mechanisms and assessing potential seismic hazards. To have a deeper understanding of the regional deformation and stress conditions, this poster presents a temporal analysis on the stress states in Japan during 2019 and 2020. This is done by performing the Michael stress inversion on regional focal mechanism data obtained from Uchide et al. (2022)[1]. The orientation of the principal stress axes are extracted and visualized for comparison across the years.

This information is significant for the past and present tectonics of the study region, which would be significant for seismic hazard mitigation strategies in regions like Japan. Examining the temporal evolution of stress states in Japan though the stress inversions of focal mechanisms enhances the comprehension of complex stress patterns governing earthquake occurrences, facilitating accurate seismic hazard assessments, and improving the resilience of vulnerable communities in seismic regions worldwide.

Basin-wide Changes Reflected by Linked Geochronology and Geochemistry of Two Stratigraphic Sections Within the Early Cretaceous Rocas Verdes Basin, Patagonia

Julia Daniel, Jacqueline Epperson, Matthew Malkowski

Understanding the causal mechanisms for physical and environmental change in sedimentary basins is necessary to link the sedimentary record to local versus global events in Earth's past. Moreover, constraining the timing of these changes in sedimentary records further aids our understanding of how a basin evolves and why. This investigation focuses on the late Jurassic to early Cretaceous Rocas Verdes Basin (RVB) in the southernmost Andes, where previous studies and field observations have documented substantial changes in depositional environments. In this study, we aim to better reconstruct the depositional conditions of the RVB by evaluating new geochemical and geochronological data from mudstones of the Zapata Formation in southern Chile. New

results are correlated with previously characterized age-equivalent stratigraphy of the Rio Mayer Formation further North in Argentina. Sampled sections of the Zapata Formation were selected based on its inferred paleogeographic position, which represents a deeper and less restricted portion of the basin relative to the Rio Mayer Formation. We conducted whole-rock geochemical analyses of 30 samples from the Zapata Formation. We then correlated lithological and geochemical records of the Zapata and Rio Mayer Formations using measured stratigraphic sections, chemostratigraphy, and geochronology. Sections in both study areas show a relatively abrupt increase in Ca wt %, reflecting CaCO3 deposition. This transition is accompanied by the introduction of abundant bioturbation and a lithologic shift from black carbonaceous shale to gray calcareous mudstone indicating a correlatable basin-wide change. This stratigraphic transition also shows a similar increasing trend in Mn concentration and a decrease in concentrations of redox sensitive metals, U and Cr. While the absolute concentrations differ between the Zapata and Rio Mayer formations, they follow similar trends suggesting basin-driven changes with subtle differences in chemical depositional environments. Significant depositional changes in both records supports the hypothesis of an early Cretaceous ocean oxygenation of the RVB. Future work will introduce new zircon U-Pb age data from ash beds within the Zapata Formation and TOC to further constrain timing and assess accuracy of this correlation.

Are We Doing Enough?: an Evaluation of Environmental Justice Screening Methods used to Identify Carbon Storage Sites

Keira Boehle, Ramon Gil-Equi

CCS is a viable mitigator for climate change and a positive addition to communities environmentally and economically. However, this is only true if done with the Environmental Justice (EJ) of the communities of injection and/or capture sites in mind. Recently, with the rise of global networks and communication of environmental injustices, EJ has become a higher priority with energy project developers. Without community permission of development, projects are stalled because of laws like the National Environmental Policy Act and the Safe Drinking Water Act. This research examines the societal risks of CCS project locations, particularly in Louisiana Parishes Ascension and St. Martin. To do this, many CCS developers use EJ screening tools to compare communities on the state or national level. Do these EJ Screening tools help CCS developers enough to foster EJ in communities? I believe the outcome of this research will prove the need for community engagement to really understand what the true burdens of a community are to make sure that they get proper compensation. The methodology used was to simulate an EJ analysis of potential CCS sites by using the typical EJ Screening tools used by CCS developers: Department of Energy's Energy Justice Mapping Tool DAC Reporter (DOE DAC Reporter), Climate and EJ

Screening Tool (CEJST)), and the Bureau of Economic Geology's (BEG) EJ Screening Map. Methods used to try and find out more about the true burdens of a community were to look at the parish's local newspapers and government Facebook pages. I tried to gather my own data by reaching out to parish government employees who would be involved in CCS development. As of writing this I have had no responses. Although more research is needed to fully represent community burdens from CCS development, this investigation reveals no true consolidation of available community data leaving room for future surveying.

Planktonic Foraminifera Extinction Behavior Between the Pliocene to Present Day

Catherine Layfield, Adam Woodhouse, Chris Lowery, Anshuman Swain

Each species of planktonic foraminifera has a unique extinction pattern. Because these single celled organisms have an abundant fossil record, it is possible to compare early Pliocene extinctions with late Holocene extinctions. Having these records available is crucial to understanding how foraminifera responded to catastrophic climate events, like the Pleistocene epoch ice age that happened ~2.7 million years ago. Being able to identify evolutionary patterns after these climate events allows scientists to gain a clearer picture of the ever-changing process that is evolution. For this study, 39 planktonic foraminifera species that have extinction dates within the last 5.3 million years were sifted out from the largest planktonic foraminifera database, Triton. First, the ecogroup, morphogroup, speciation, and extinction data was extracted from Triton using the statistical coding platform, R. After saving this data to a master document, R was used to create 53 100,000-year long time bins to easily organize the species' occurrence data. Then, the occurrence and time bin data were conglomerated into a single .csv file for each species. R was used to plot each species total occurrences, occurrences during extinction along the falling limb, smooth data of the falling limb, and the inflection points where the extinction slope experienced the most dramatic change in occurrences. These plots emitted new data in R including extinction slope, length of decline after inflection, length of falling limb, and the inflection point. A positive correlation between length of falling limb and extinction occurred, implying species with a more recent extinction date took longer to go extinct. This result persisted when plotting extinction vs length of decline after the inflection point. Additionally, most short falling limbs occurred before the Pleistocene ice age. These results suggest that major climate events have a positive impact on planktonic foraminifera's adaptation evolution.

Up and Over: How Do Rivers Climb Mountains? Constraining groundwater's role in forming crater lake inlets on early Mars.

Paola Avina, Eric Hiatt, & Marc Hesse

Early in its history, Mars resembled present-day Earth in many ways, with surface water, river systems, lakes, and possibly even an ocean. However, over the past 4 billion years, the planet has become desolate and dry. We have evidence of Mars' former terrestrial-like hydrologic conditions through geomorphological clues that have persisted. Light layered deposits and integrated fluvial systems provide a comparison and offer clear evidence of liquid water presence on Mars' surface. During the period when Mars had surface water, the planet experienced a higher rate of crater formation. These newly formed craters interacted with the hydrosphere, resulting in the creation of impact crater lakes. One prominent characteristic of these crater lakes was the presence of an inlet valley that crossed the elevated rim. Such features should not be observed because rivers typically flow around elevated terrains such as mountains unless aided by tectonic processes. Without plate tectonics on Mars, this raises the question of why the river systems would cut through the crater rim instead of going around it.. The specific process through which impact craters with initially elevated rims were breached by inlets remains unclear. With the help of the Open Basin Lakes catalog developed by Goudge et al. (2016), we were able to locate these lakes on Mars. Using elevation models we differentiate between inlets and outlets by finding elevation of each, knowing that inlets have a higher elevation. From the outside of these impact craters to the inside in order to find our directional angle in a consistent manner. In ArcGIS Pro, we researched over 200 impact craters to see a connection with groundwater maps with these river systems. Using distance and directional tools, we were able to find the degree angle at which these inlets entered these impact craters. Although some were heavily eroded and affected by other craters which we were unable to map, more than half were placed in a rose diagram to see the distribution. Our results show how these fluvial systems are related to the topographic gradient. With our results, my mentors will be focusing more on these inlet vallies using underground water models to find the correlation in gradient directions and valley orientations.

Using Coral To Reconstruct Ancient Climates

Bradley Ibarra, Robert Domeyko, Dr. Judson Partin

The El Nino-Southern Oscillation (ENSO) is a climate phenomenon that occurs every 2-7 years, affects billions worldwide, and it is uncertain how ENSO will respond to a warming climate. In order to assess the computer models that project future climate and future ENSO, we compare these models run under past conditions to records of past climate. In our study, we are generating records of past climate from ancient corals collected in Vanuatu, an island nation in the western tropical Pacific. Corals record sea surface temperature and salinity where they grow, and thus they

are proxies for past oceanic conditions. Using a computer numerically controlled (CNC) drill, we mill mm scale sub-samples of coral powder for geochemical analysis: strontium-to-calcium ratio (Sr/Ca) and stable oxygen isotopic composition (δ18O). Sr/Ca is a proxy for sea surface temperature, and δ18O is a proxy for temperature and salinity. Temperature and salinity changes in Vanuatu track changes in ENSO. Therefore, coral records of Sr/Ca and δ18O from Vanuatu that grew thousands of years ago are records of past ENSO. These records of ancient ENSO are compared to the climate model output to assess model performance, thus aiding our ability to understand ENSO variability in a warmer future.

Reconstructing Fire using Macroscopic Charcoal Abundances in Pliocene Flviolacustrine Sediments in the Teruel Basin, Spain

Maya Smith, Nicole Czwakiel, Daniel Breecker

Mediterranean-type climates (MTCs) have long been of interest to scientists due to high biodiversity and unusual precipitation regime. MTCs are unique in that precipitation mostly occurs during the winter (in some locations spring and fall months) and the summers are typically dry. On the Iberian Peninsula the MTC may have developed during the Pliocene when pollen records showed a gradual shift from mostly subtropical vegetation to dominance of drought tolerant taxa during global cooling. Projected future climate changes pose a risk as winter climatic shift from subtropical to MTCs can give us more insight into the future climate and ecosystems of the Mediterranean Basin.

Paleoclimate studies can provide insight into how global warming might affect the Iberian climate. Charcoal records can be useful indicators of fire regimes along with pollen and hydroclimate proxies might help us understand climate-ecosystem relationships. Here we present charcoal abundances over the Mid-Pliocene -Early Pleistocene period in samples of fluvial and lacustrine sediments retrieved from the Villabla Alta section, Teruel Basin, in the Iberian Peninsula. We found that there is a gradual increase in the charcoal count leading up to the M2 glaciation 3.3 million years ago which suggests increasing fire activity during this time. As a result, we hypothesize that an increase in charcoal counts coinciding with global cooling could indicate decreased summer rainfall, consistent with long-term vegetation change and our own unpublished paleosol carbonate oxygen isotope data. It is also possible that global cooling resulted in an increase in Iberian winter rainfall, denser vegetation, more fuel, and thus greater fire activity, but it is not clear that woody vegetation density was winter rainfall-limited at this time. Therefore, we favor the interpretation that intensified summer drought increased east-central Iberian fire activity during Pliocene global cooling at approximately the same time that drought-tolerant vegetation was gradually replacing subtropical ecosystems.

Greenland Glacier Data Aggregation for Time Series Analysis: Error and Velocity Data

Jonathan A. Ruepong, Clifton T Terwilliger

Mentors: Ginny Catania, Kevin Shionalyn

The retreat of glaciers in Greenland is a fact, but the exact reasons and values are unknown. Kevin Shionalyn has implemented a machine learning model that attempts to model and predict the movement of glaciers. However, their data, and thus their model, is limited to only 4 glaciers in Greenland. Whilst their model can predict the seasonality of glacier movement, the model fails to predict the finer details; likely due to the limitation of data. To remedy this, the model simply needs data for more glaciers. Our project is to aid in the collection of said data. More specifically, determine which glaciers in Greenland have good bed data, and sample the velocity data from 2000 to present for said glaciers using existing satellite data. To sample the satellite data, a buffer was drawn around the terminus line equal to four times the thickness of the glaciers. The underlying satellite was then cropped by the buffer, and values were taken from the cropped data. Out of 278 glaciers, 47 glaciers were found to be outside of 2 standard deviations away from the median error, and an additional 6 had no underlying data. Left with 223 glaciers that had acceptable bed data, the velocity values were sampled using similar buffers. As a result of this project, it has been determined that 223 glaciers in Greenland have good bed data, and a time series for the velocity of every glacier has been constructed.