Dedicated to
broadening participation
in the geosciences
“Understanding the complex, changing planet on which we live, how it supports life, and how human activities affect its ability to do so in the future is one of the greatest intellectual challenges facing humanity. It is also one of the most important for society as it seeks to achieve prosperity and sustainability.”

- National Research Council
Earth, Wind, Sea, and Sky

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The next generation of scientific leaders will serve an increasingly diverse nation and be part of an increasingly multicultural society. Nowhere is this truer than in the geosciences, where we face the challenge of contributing to an equitable and sustainable future for all communities.

These challenges are profound and demand the full scope of human ingenuity including a diversity of people and approaches. Research shows that diverse groups design more innovative solutions to problems and bring a higher level of critical analysis to decisions. In the context of the geosciences, greater diversity also means welcoming indigenous approaches to learning and knowing about Earth.

Greater diversity in the geosciences is necessary to ensure that all communities will benefit from new approaches to dealing with a planet under stress. This need is especially compelling for minority communities who often bear a disproportionate share of the impacts of human interaction with the planet. Due to the fact that scientific priorities are determined through the competition of ideas in a peer-review process, consideration of every community’s priorities requires that qualified participants from each group are involved in the process.

Given the demographic changes underway in the U.S. (by 2050, for example, white and Euro-Americans will make up less than 50% of the U.S. population) as well as the historic homogeneity of the geosciences (only 2% of the geoscience PhDs earned between 1973 and 2002 went to Latinos or African Americans), the need for greater diversity is self-evident: without a more inclusive geoscience workforce, there simply will not be enough geoscientists.

Significant Opportunities in Atmospheric Research and Science (SOARS) and Research Experience in Solid Earth Science for Students (RESESS) are dedicated to ensuring that the next generation of geoscientists both reflect and serve an increasingly diverse nation and multicultural world.

SOARS has extended educational opportunities to college and university students from diverse backgrounds for 12 years. In 2005, the National Science Foundation’s program of Opportunities for Enhancing Diversity in the Geosciences funded a new program to partner with the SOARS program. RESESS extends the SOARS model of research, multi-dimensional mentoring, and a supportive learning community into the fields of geophysics and geology.

It is an opportune time for SOARS and RESESS to partner. Driven by the overarching need to envision a sustainable future for our planet and its inhabitants, research in the geosciences is becoming more interdisciplinary and collaborative. By combining the SOARS and RESESS learning communities, we will develop a new generation of leaders who will thrive in an increasingly complex scientific culture that requires broad knowledge of the geosciences as well as expertise in a specific discipline.

With support from multiple mentors and peers, each year our protégés embark upon a summer of scientific investigation, personal growth and professional development. Our combination of hands-on research, practice in scientific communication, and leadership training prepares our protégés to contribute to future scientific endeavors. SOARS and RESESS protégés can participate in up to four summers of research, receive funding for professional conference travel, and apply for supplemental funding for undergraduate and graduate programs. Through these efforts, SOARS and RESESS seek to create the next generation of leaders in the geosciences whose investigative expertise is complemented by strong leadership and communication skills.

This edition of Earth, Wind, Sea, and Sky highlights the work of the talented SOARS and RESESS protégés. Their research includes many aspects of the Earth system, from understanding how El Niño influences wind-generated power on American Indian lands. Their commitment to serving society influenced the choice of some other topics including improving our understanding of hurricanes, describing the economic choices inherent in farmed fishing, examining the temporal and spatial patterns of urban air pollution, and improving urban flood forecasting with radar-derived precipitation measurements.

We hope that in these abstracts you will see both the dedication our protégés bring to serving all communities, as well as the strong scientific abilities and diverse perspectives they contribute to geoscience. To learn more about these talented students or the SOARS and RESESS programs, please visit both web sites: www.soars.ucar.edu and www.unavco.org/resess.

Sincerely,
Dr. Susan C. Eriksson
Director, RESESS
Director of Education and Outreach, UNAVCO
Dr. Rajul E. Pandya
Director and Principal Investigator, SOARS
Associate Director for Diversity in Education and Outreach, UCAR
Radar and surface measurements of boundary layer convergence zones

While boundary layer convergence zones (BLCZs), which are areas of low-level convergence of air at the surface, influence daily weather, their specific effects on wind, temperature, moisture, and thunderstorm formation are not well known. In order to address this problem, BLCZs that occurred in the 2002 International H2O Project (IHOP) field campaign were documented and analyzed using a variety of data sets consisting of temperature, wind direction and speed, and moisture values from nearby surface stations as well as measurements of Doppler velocity, radar reflectivity, and a new radar-derived field called refractivity, which provided the horizontal distribution of moisture at the surface. The velocity, reflectivity, and refractivity fields came from the S-band Dual Polarization Doppler Radar (S-Pol); the moisture, temperature, wind direction, and wind speed came from the surface stations at Verles (VERL), Rustytank (RUST), Lincolns (LINC), and Playhouse (PLAY). The objective of this study was to acquire a better characterization of BLCZs by analyzing data from various sources. The preliminary results indicated similarities in the data between radar fields and surface stations, similarities between the four surface stations, and both similarities and differences between cases documented. With a better characterization of BLCZs, environmental events such as changes in temperature, wind, and moisture as well as thunderstorm development may be better forecasted in the future.
Ozone profiles obtained from the Central Equatorial Pacific Experiment (CEPEX) campaign in 1993 show near-zero ozone levels in the upper tropical troposphere. Ozone chemical destruction and undiluted vertical transport into the upper troposphere were thought to be the causes of the low ozone values found. Questions surfaced as to whether the correct value for the background current measurement was used in the ozone concentration calculations. In this study, three different sensing solutions, including the solution used during that campaign, were tested in the electrochemical cell of the ozonesonde in order to determine the background current generated by the cell as a function of ozone concentration. Different ozone amounts were used to determine the background current as a function of ozone concentration. Linear regression of the background current measurements was used to determine a new background correction for the CEPEX raw data. These reprocessed data no longer showed near-zero ozone levels in the upper troposphere and no longer required significant chemical ozone loss in the upper troposphere or undiluted transport from the surface for their explanation.
A comparison of large-scale influences on tropical cyclogenesis in the Eastern Pacific

In a given hurricane season, several tropical disturbances propagate across environments favorable for development; however, only a few disturbances actually strengthen into tropical cyclones. The lack of a consolidated theory on tropical cyclogenesis makes it difficult for forecasters to predict a storm’s development. Previous studies have approached this problem by comparing large-scale influences on storms that developed into tropical cyclones and on those that did not. This study used a similar approach to characterize the environmental influences on cyclogenesis in the 2005 Eastern Pacific Hurricane season. Data for each storm were taken from the NCEP/NCAR Final Analysis model and analyzed over a 48-hour period during the development stage. The non-developing storms were selected based on certain atmospheric parameters that resembled the developing storms prior to cyclogenesis. Composites and spatial averaging were used to compare 12 developing storms and 11 non-developing storms during this season. The results showed that the environments of the developing storms had large regions of increased moisture above the boundary layer and greater temperatures in the upper troposphere. Regions of increased potential vorticity penetrated deeper into the troposphere for the developing storms. Lastly, the storms that developed were in environments with relatively strong wind shear to the south of the vortex. The results suggest that the moisture, temperature, and wind shear fields preceded development, while the vorticity fields were more of an indicator of development. Identifying these large-scale characteristics as possible determining influences can lead to a better understanding of tropical cyclogenesis.
Radar rainfall verification in Geographic Information Systems (GIS): A step toward improving short-term flash flood forecasting

Hydrological models and flash flood warning systems are largely dependent on accurate precipitation inputs. In the Colorado Front Range, estimation of rainfall has been problematic due to the varying intensity and spatial distribution of the precipitation fields. The goal of this project was to conduct a Geographic Information Systems-based spatial analysis and verification of the radar-derived precipitation. Rain gauge measurements were used for correcting radar rainfall estimates over a 24-hour period for convective and stratiform precipitation events over the Denver Urban Drainage and Flood Control District. Two methods were tested for correcting radar-derived precipitation: 1) mean difference between recorded gauge values and the radar measurements and 2) mean difference of the inverse distance weighted (IDW) interpolated gauge values and the radar measurements. An overall comparison of radar and gauge measurements for the two rain events showed that the radar produced more spatially accurate precipitation estimates during a convective event. The IDW interpolated precipitation method was found more appropriate for regional scale verification. The methodology developed in this study provides a framework for spatial rainfall verification, which can aid in automated correction of radar rainfall estimates. This can assist flood control and emergency managers in mitigating and responding to flash flood events.
Quasi-biennial oscillation (QBO) effect on the diurnal tide in the Whole Atmosphere Community Climate Model (WACCM)

Solar tides are thermally driven perturbations excited throughout the atmosphere that vary with local time and season; however not all sources of tidal variability are known. The Quasi-biennial Oscillation (QBO) is an oscillation in the stratospheric zonal winds near the equator with a 27.7-month cycle through which solar tides propagate. This research examined the QBO effects on diurnal solar tides using a model of the entire atmosphere called the Whole Atmosphere Community Climate Model (WACCM). Representative observational data of the QBO were inserted into WACCM to see if the QBO is a source of diurnal solar tidal variability. Hourly fields from three simulations for April were used to assess solar tidal variability with distinct stratospheric winds over the equator: control (no QBO), QBO winds from the east, and QBO winds from the west. These results were sorted and binned according to local time at each latitude and altitude. This process produced monthly averaged meridional winds as a function of local time for April. A harmonic decomposition was performed to determine the diurnal means, amplitudes, and phases of the three simulations. A comparison of the diurnal mean and amplitude revealed that the diurnal mean was not measurably affected by the QBO, but the QBO produced a 20 meter second$^{-1}$ difference in the diurnal amplitude. The latter result was highly significant, indicating that the QBO is a source of solar tidal variation in WACCM. In addition, this research further evaluates the performance of WACCM and provides insight into the underlying physical processes that govern tidal variability in the upper atmosphere.
Developing a C++ interface for netCDF-4

The network Common Data Form (netCDF) was created by Unidata at the University Corporation for Atmospheric Research to simplify data access and sharing in the atmospheric science community. Even though the current full release of netCDF known as netCDF-3 has proven to be successful, increasing data complexity and user demands have necessitated a new release of netCDF with improved functionality and the ability to store user-defined data types. With this need in mind, Unidata created netCDF-4, which features all the functionality of netCDF-3 as well as more flexible ways to add data and better support for custom data structures. This implementation adopts simplified aspects of another more complex data model known as HDF5. At present netCDF-4 interfaces exist for C and Fortran, however none exists for C++. This project’s aim was to design and partially implement a C++ interface for netCDF-4. The netCDF-4 C++ interface was implemented as a thin layer on top of the netCDF-4 C interface; its design allows all the functionality of a full C++ implementation of the interface. When fully implemented, the netCDF-4 C++ interface will allow data providers and developers with a preference for C++ to take advantage of the new features netCDF-4 offers for creating portable, self-describing datasets.
Characteristics of sea surface temperatures (SSTs) between 23°C and 24°C west of the Galápagos Islands

Previous research showed that low-level wind flow over the Galápagos Islands was decoupled from higher-level winds during some of the time periods used. By looking at wind profiler data, researchers noticed that the decoupling of the winds occurred when sea surface temperatures (SSTs) were cooler than 23°C, while during the coupled wind flow cases SSTs were warmer than 24°C. This research focused on six Tropical Atmosphere Ocean project (TAO) buoys, which provided SSTs collected from January 1994 to September 2003. The TAO buoys were used to look at characteristics of SSTs that were in the range of 23°C to 24°C west of the Galápagos Islands. The total count of SST measurements between 23°C and 24°C depended on three conditions. The first condition was whether it was observed during the cold season, warm season or in between. The second condition that affected the range of SSTs was whether it was during El Niño, La Niña, or normal periods. Finally, the location of the TAO buoys affected whether the SST values were in the range of 23°C to 24°C. SSTs between 23°C and 24°C were less frequent at the 2° N buoys, during strong El Niño periods, and in the middle of cold and warm seasons.
Observations and assessment of outer rainband tornadoes spawned by Hurricane Katrina

While it is common for tornadoes to occur in conjunction with land-falling tropical cyclones (TCs), characteristics of the hurricane-spawned tornadoes themselves remain poorly documented. This study (i) documented and described supercells embedded within the outer rainbands of Hurricane Katrina (2005) and (ii) compared Katrina’s supercell storms to past studies containing documented hurricane-spawned tornadoes. Radar reflectivity and velocity data collected on 29 August 2005 by WSR-88D Next Generation Weather Radar (NEXRAD) instruments in Slidell, Louisiana, and Mobile, Alabama, were used to track the supercells. Atmospheric soundings from 29 August 2005 showed that environmental conditions were comparable to those in previous hurricane-spawned tornado studies. Twenty-three storms from 0300 UTC–0900 UTC were tracked, and single-Doppler radar analyses examined characteristics such as shear and rotational velocity. Storms were initially classified as mesocyclonic or non-mesocyclonic, and were then classified as tornadic if winds reached 18 meters second$^{-1}$ (F0 intensity) at any time during their duration. Because tornadoes are not resolvable several kilometers from the radar, the intensity of the mesocyclone was used to infer the occurrence of a tornado. Eighteen of Katrina’s supercells were classified as tornadic, three reached mesocyclone strength but never reached F0 intensity, and two storms never reached mesocyclone criteria. Remarkably, the majority of the supercells formed over the Gulf of Mexico and not over land, which contrasts with previous studies. Furthermore, the ground-relative speeds of these tornadic mesocyclone winds in the outer rainbands can reach strong Category 4 intensities despite sustained winds in Katrina only reaching Category 3 at landfall.
The El Niño Southern Oscillation (ENSO) is a well-known source of inter-annual climate variability for both precipitation and temperature in the northern Great Plains. The northern Great Plains also have the largest wind resource in the United States. With the continued growth of wind energy, ENSO’s effect on wind speed needs to be examined because of our current lack of understanding about how wind speeds are affected by inter-annual variability. After having previously established that a teleconnection to ENSO exists, we set out to quantify the uncertainty in this relationship with this study. Our method used the sign test and resampling of hourly airport wind speed measurements for the past half-century at four airports in both North Dakota and South Dakota. Airport data were useful in this case because they have very long and continuous measurements of hourly wind speed. With these data, we were able to show that ENSO did have an effect on wind speeds as well as on wind power. The warm phase of El Niño, in particular, was correlated with the largest reductions in wind speed in South Dakota. In North Dakota, it was the cold phase that produced the largest reduction in wind power. The largest differences occurred in April, while the smallest differences occurred in July. It is our hope that this method will also be a useful tool for wind farm developers across the country to more accurately assess the value of their site based on limited in situ data.
Comparison analysis of CHAMP radio occultations to the model forecasts: 2005 hurricane season

This project uses a new data source, Radio Occultation (RO), to verify hurricane forecasts. RO uses Global Positioning System (GPS) receiving satellites to accurately measure vertical profiles of the atmosphere with unprecedented global coverage. This global coverage provides new data in areas surrounding hurricanes, and those data can be used to verify model hurricane forecasts. This investigation primarily focused on the Global Forecasting System (GFS) model. To verify the GFS forecasts, the GFS output parameters of temperature, pressure, and water vapor pressure were converted into refractivity, which is the basic parameter measured by RO. A mean absolute value of the fractional errors was then used to compare the RO-measured refractivity and the GFS refractivity. This specific type of mean allowed a comparison between grid domains of different resolutions and the vertical structure of the atmosphere. The comparisons of the vertical structures from both the observed and modeled datasets were calculated for the cases with and without tropical cyclones. This study further analyzed cases with tropical cyclones and correlated the GFS output error to the errors in the predicted track and intensity. Comparing the two refractivities for all the storms for the 2005 Atlantic and East Pacific hurricane season showed consistent error in the GFS output. The analysis revealed that the GFS error was larger closer to the cores of the tropical cyclones. Further analysis of individual layers will allow a better understanding of which layers have the most impact on the errors found in the GFS model compared to the RO. These results suggest that including RO data in GFS models may improve the GFS forecast output.
The modification of a carbon monoxide instrument for improved sensitivity

By measuring vertical fluxes of carbon monoxide (CO), the amount of air pollutants that originate from local versus transported anthropogenic and biogenic sources can be traced. This study focused on improving the sensitivity of a commonly used instrument utilizing the fluorescence properties of CO molecules in the vacuum ultraviolet (VUV) range. The instrument can measure atmospheric CO mixing ratios and determine vertical fluxes of CO. To improve its performance, the instrument’s flow cell was modified and applied with a highly absorptive copper oxide (CuO) coating. After the coating of the flow cell, measurements of CO mixing ratios at dew points of 5°C, 10°C, and 15°C were made with the modified instrument and compared to measurements made with the original instrument. Measurements at different dew points were made in order to check the effect of water interference on the instrument.

Comparative evaluations of the different configurations of the instrument were based on its sensitivity to CO and on the signal-to-noise ratio. The sensitivity to CO of the modified instrument was determined to be about two times higher than the sensitivity to CO of the original instrument. However, large numbers of noise photons caused the signal-to-noise ratio of the modified instrument to be significantly lower than the signal-to-noise ratio of the original instrument. To decrease the number of noise photons, future work will be completed in which another layer of CuO coating will be applied to better absorb VUV light.
Correlating atmospheric water vapor and hurricane development

Research has indicated that there may be a relationship between water vapor and hurricane development; however, traditional methods of measuring water vapor lack the accuracy necessary to make direct correlations. In this study, water vapor data was obtained using the Global Positioning System (GPS). GPS water vapor measurements from areas near the point of landfall of hurricanes that occurred between 2003 and 2005 were obtained and correlated to other hurricane elements such as wind speed and pressure. Findings indicated a direct relationship between the amount of water vapor in the atmosphere and hurricane intensity. Correlation coefficients for atmospheric water vapor and wind speed of tropical cyclones were computed. Coefficients for water vapor and cyclone pressure, and water vapor and atmospheric pressure, were also computed. The absolute values of all coefficients were greater than 0.5. In addition, findings strongly suggested that cyclone intensity decreased without adequate water vapor in areas surrounding the storms. Only one hurricane out of 21 increased in intensity after landfall, and the water vapor measurement from this area was the highest of all readings. The correlation between cyclone intensity and water vapor was not consistent throughout the storm eye. The southeast and northwest quadrants had higher correlation coefficients than the other quadrants. Further understanding of water vapor and its role in hurricane development would likely aid in improving tropical cyclone models and forecasts.
The impact of megacities on the emission of nitrogen dioxide using GOME and SCIAMACHY data

Continuous satellite measurements now offer the opportunity to compare nitrogen dioxide (NO₂) concentrations to variables such as anthropogenic sources. Decadal population and NO₂ trends were analyzed for 14 regions by use of population data records from Columbia University and NO₂ column data from the Global Ozone Monitoring Experiment (GOME) and the Scanning Imaging Absorption Spectrometer for Atmospheric CHartography (SCIAMACHY) instruments. A number of noteworthy trends were present in the time series, the most important being that despite population increases in many regions around the world, NO₂ decreases were present in all regions of study except for Beijing and a selected Pacific Ocean region. An increase in NO₂ of 14.9% was present over the selected Pacific Ocean region. This increase may have been due to influences from surrounding regions. However, further research of this region is essential to determine a definite cause. NO₂ increased 72% per decade over China and this change is likely related to increases in energy consumption of 149% per decade and other industrial activities in China, at the same time the population increased at 9.5% per decade. These trends indicate that population growth and increasing energy consumption and industrial activity are correlated, and without effective limitations on energy consumption and industrial activity, pollutants in the atmosphere will continue to increase.
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Assessing the prospects for employment in an expansion of U.S. aquaculture

The United States imports 60 percent of its seafood, leading to a $7 billion seafood trade deficit. To mitigate this deficit, the National Oceanographic and Atmospheric Administration (NOAA), a branch of the U.S. Department of Commerce, has promoted the expansion of U.S. production of seafood by aquaculture. NOAA projects that the future expansion of a U.S. aquaculture industry could produce as much as $5 billion in annual sales. NOAA claims that one of the benefits of this expansion would be an increase in employment from 180,000 to 600,000 people (100,000 indirect jobs and 500,000 direct jobs). Sources of these estimates and the assumptions upon which they are based are unclear, however. The Marine Aquaculture Task Force (MATF), an independent scientific panel, has been skeptical of NOAA’s employment estimates, claiming that its sources of information are weak and based upon dubious assumptions. If NOAA has exaggerated its employment projections, then the benefits from an expansion of U.S. aquaculture production would not be as large as projected. My study examined published estimates of labor productivity from the domestic and foreign aquaculture of a variety of species, and projected the potential increase in employment associated with a $5 billion aquaculture industry, as proposed by NOAA. Results showed that employment estimates range from only 40,000 to 128,000 direct jobs by 2025 as a consequence of the proposed expansion. Consequently, NOAA may have overestimated its employment projections—possibly by as much as 170 percent, implying that NOAA’s employment estimate requires further research or adjustment.
Aerosols are particles in the atmosphere that are responsible for many chemical reactions and play a key role in light reflection. However, even though aerosols are well known, the formation of aerosols is still unclear. The Chemical Emission, Loss, Transformation and Interactions within Canopies second campaign (CELTIC-II) is looking at the different factors that go into the makeup of aerosols. One of the key focuses of this study was to look at the concentration of sulfuric acid and the hydroxyl radical (OH) because of their involvement in aerosol formation. Sulfuric acid is one of the key components to aerosol formation. Because of its low vapor pressure, sulfuric acid in the gas phase rapidly condenses to form particles. Any gaseous sulfate that is found in the atmosphere must have been formed recently by chemical reactions. OH is the atmosphere’s primary oxidant and plays many roles in the chemistry of the environment, one being a necessary chemical for sulfuric acid formation in the gas phase. This study looked at the concentration of sulfuric acid and OH in the atmosphere at Niwot Ridge Colorado for four weeks during the summer of 2006 using Selected Ion Chemical Ionization Mass Spectrometry (SICIMS), a technique that is able to measure as low as 30 to 40 parts per quadrillionths by volume (ppqv). During days of high sun, SICIMS measured concentrations of sulfuric acid from 5x10^6 to 25x10^6 molecule cm^-3 and concentrations of OH around 0.6x10^6 molecule cm^-3. These data will be used in a test model of aerosol formation.
Extreme dust events can play a significant role in altering Earth’s radiative balance by lofting considerable amounts of mineral aerosols into the atmosphere. This study investigated the meteorological conditions that have led to the initiation of mineral dust events in the Chihuahuan desert region of the United States and Mexico. This research is a continuation of work by Rivera et al. (2005) that focused on characterizing dust sources in the Chihuahuan desert region by analyzing satellite remote sensing data. Back trajectory, residence time analyses, and weather map information were used to investigate the conditions that led to these events and to the potentially long-range transport of the dust across the U.S. Results from the National Oceanic and Atmospheric Administration’s Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) back-trajectory analyses suggested wind speeds near 10 meters second\(^{-1}\) occurred during events, which were higher than speeds observed during calm periods. Weather maps showed patterns of low pressure systems over the area of New Mexico and the Texas Panhandle suggesting that our dust events could be influenced by the formation of cyclones and fronts. Residence time calculations and source contribution function suggested similar large scale wind patterns from the southwest during dust events, consistent with dust transport as observed from satellite imagery and cyclonic wind patterns seen in the weather maps.
Assessing the precision of Global Positioning System (GPS) radio occultation

There have been previous theoretical, experimental, and comparison studies to determine the precision of Global Positioning System (GPS) radio occultation (RO), but the current stage of the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) satellites presents a unique opportunity to determine the precision using collocated soundings. The collocated soundings from the COSMIC Data Analysis and Archive Center (CCDAC) were constrained on latitude bands as well as local time and scintillation index and the standard deviations of the soundings were calculated for a specific height grid. This study showed the consistency of the tropopause in different regions and established that the occultations were not affected by the tropopause. This was concluded by viewing the high precision of a parameter, PPMT, which stands for “precision parameter for middle troposphere” by region. Larger PPMT values (implying lower precision) were observed for the southern hemisphere for GPS RO soundings that were separated by 200 and 300 km and related to significant refractivity variations due to active weather systems on both the mesoscale and synoptic scale. The precision of the refractivity determined in this study of collocated GPS RO less than 1 km apart is 0.02%, which for temperature is approximately 0.05°C. The precision of a typical radiosonde system is on the order of 0.5°C or higher, therefore, the GPS RO is one order of magnitude more precise than the radiosonde. With such a precision and spatial coverage, GPS RO is currently the best technique for climate analysis as well as weather prediction.
Understanding local wind circulations over White Sands Missile Range

This study built a local wind-field climatology and analyzed the resulting wind patterns at White Sands Missile Range (WSMR) in southern New Mexico. Mesoscale circulations in mountain-valley desert regions have been previously studied in several regions of the Intermountain West, none of which included WSMR. Hourly surface mesonet (SAMS) data were collected at 13 stations across WSMR over five years from 2001 through 2005. The months and hours of approximate minimum and maximum temperature, along with a few intermediate times, were selected to analyze local mesoscale wind behaviors. These data were visualized in the form of wind roses, which plot wind speed, direction and frequency. Wind roses were plotted on a terrain map at the data locations for the analysis of topographic effects on wind circulations. This analysis showed that mesoscale patterns of upslope and downslope flows, as well as up-valley and down-valley flows occurred, depending on the season of the year and hour within the diurnal cycle. Additionally, the analysis showed that significant variations occurred across the different stations, depending on their locations on the valley floor or mountain slopes. The results of this study enhance the understanding of local wind patterns in desert valley regions in general. This finding has great importance because of today’s rapid growth of human population in these regions.
Effect of the Gulf of Mexico’s mixed layer depth on hurricane intensity in the warming environment

Due to the effect of mixed layer ocean depth in the Gulf of Mexico on hurricane intensity, it is important to understand how global warming will affect the ocean and how this change will in turn affect hurricane intensity. We ran the Advanced Research Workshop Weather Research and Forecast (ARW) model for Hurricane Katrina with the Gulf of Mexico’s mixed layer depth distribution specified, and we compared the results to actual events to determine the accuracy of the model for its use in future predictions; then we reran the model adjusted for projected sea surface temperatures (SSTs) for the year 2100 due to global warming. The analysis showed that, due to the higher water temperature, the intensity of the hurricane started to increase more quickly in the beginning of the run which altered its track, causing it to cross over a deeper part of the mixed layer’s warm core rings (WCRs). This movement helped it to maintain its peak intensity for a longer period of time than in the present-day simulation. This preliminary analysis demonstrates the importance of including the depth of the mixed layer when forecasting and simulating hurricanes, and implies that global warming may increase the intensity of hurricanes in the Gulf of Mexico.
One major pollutant of concern in the Mexico City metropolitan area (MCMA) is tropospheric ozone. It is a secondary pollutant that damages local vegetation and the human respiratory system. Ozone is formed in the atmosphere by nitrogen oxides (NOx) and volatile organic compounds (VOCs), but it is unclear which of these two is the limiting reactant. Finding the limiting reactant would allow legislators to take proper measures to control ozone concentrations. The weekend effects of ozone, NOx, and carbon monoxide (CO, which is an indicator for VOCs) were analyzed from 1986-2003. It was found that though there was a definite normal weekend effect for NOx and CO, there was no consistent weekend effect for ozone. This finding made it difficult to pinpoint the limiting reactant of ozone formation. The CO/NOx ratio was then calculated to study possible correlations with ozone concentration. There was a positive and almost linear relationship between ozone concentration and the CO/NOx ratio. This relationship means that as CO or VOCs increased, ozone concentrations increased as well. Next, bivariate correlations were performed and they gave a good and positive relationship for the CO/NOx ratio and ozone concentrations. However, there was no clear relationship between ozone concentration and particulate matter less than 10 micrometers in size, and ozone and sulfur dioxide. Finally, the calculated ozone sensitivity coefficient showed that in the MCMA, ozone concentrations were usually VOC sensitive. This result clarifies the limiting reactant of ozone formation and shows that limiting VOCs would cut down on tropospheric ozone concentrations.
Modeling of vertical deformation associated with the 1931 Mach earthquake, Pakistan

The Kirthar Range in western Pakistan is the result of east-west compression caused by the indentation of the Indian Plate into the Eurasian Plate. The 1931 Mw 7.3 Mach earthquake resulted in 65 cm of local uplift on a leveling line through the Bolan Pass in the northern Kirthar Range. Previous studies modeled the fault as an east-dipping blind thrust with a top depth of 4 km and a bottom depth of 35 km, yet geologic cross-sections illustrated a blind wedge thrust system verging to the east with a horizontal décollement at 8 km. Extensive simulations of slip on this inferred structure suggested that this subsurface geometry could not be responsible for the slip in the Mach earthquake. A west-dipping thrust was also considered a viable fault, as it was geologically capable of producing the anticlinal fold seen at the Bolan Pass. Forward elastic-modeling methods applied to the west-dipping thrust showed that the earthquake could not have occurred on a simple fault of this form either. A new approach, merging the wedge and west-dipping geometries may ultimately explain what happened in the 1931 earthquake sequence. Understanding fault constraints in Bolan Pass will give insight into correlations between the Mach earthquake and other seismic events during the 1930s.
Continental breakup on the East African Rift

Although the East African Rift (EAR) is often cited as the premier example of incipient rifting, the size and often times inaccessibility of the rift have limited the analysis and interpretation for accurate determination of the physical processes controlling the deformation of the Earth’s crust. Existing geodetic data are wholly inadequate to address the direction and distribution of extensional strain along and across this incipient plate boundary zone. A new five-year project with three Global Positioning System (GPS) campaigns (in years 1, 3, and 5) distributed across Tanzania will help us obtain interpretable results with a total extension rate across the EAR on the order of 5 millimeters year\(^{-1}\). GPS measurements in the EAR are critical to finally establish the kinematic framework of rifting. New GPS measurements spanning the Western and Eastern rifts in Tanzania, combined with the distant data on the surrounding plates, will provide the kinematics of deformation across and along the length of the EAR. In particular, they will allow us to test and further refine the counter-clockwise rotation model of the Tanzanian craton suggested by the very scarce geodetic data currently available. GPS measurements will also provide strain distribution across and along the Western and Eastern rifts. In addition to horizontal motions, GPS measurements will provide vertical displacements, critical to test for present-day uplift of the African plateau predicted from the African Superplume upwelling. Using the GAMIT/GLOBK suite of GPS processing software, we present a new, preliminary determination of the horizontal velocities in the EAR at Tanzanian latitudes.
A new approach to Global Positioning System (GPS) multipath visualization

Multipath is a condition where the transmitted radio signal is reflected by physical features or structures, creating multiple reflections of the same signal arriving at the receiver at different times. The result is degradation in signal strength of the transmitted signal from the satellite to the Global Positioning System (GPS) antenna. Multipath occurs when transmitted signals do not go directly to the GPS antenna, but rather arrive from different parts of the environment. These additional reflected signals cause distortion of the direct signal to GPS antennas, but proper positioning can minimize multipath error. Reception of bounced signals at the antenna causes erroneous data from the GPS receiver, which results in inaccurate measurement of position. The GPS receiver has trouble distinguishing between reflected signals and direct signals, and that is one of the problems multipath produces. To minimize the multipath error, positioning the GPS antenna from a location that is less susceptible to multipath can help the receiver accept amplified signals. Furthermore, a MATLAB simulation was developed previously that predicts multipath based on site analysis data to generate the plot of vectors on a Digital Terrain Model (DTM). This work produces a three-dimensional plot of ray paths when signals are being transmitted from a satellite. This ray path visualization enables a user to properly position a GPS antenna to minimize the multipath error.
Sitting (L to R): Marco Orozco, Luna Marie Rodríguez Manzanet


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