8th Annual NOAA-CREST Symposium

June 5-6

2013

Climate & Extreme Weather Impacts On Urban Coastal Communities

The City College of the City University of New York

Table of Contents

TECHNICAL SESSION I: EXTREME EVENTS IN URBAN COASTAL COMMUNITIES

Tropical Moisture Exports and Extreme Rainfall

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Extreme floods are often due to large scale atmospheric moisture transport from tropical regions. We use a Tropical Moisture Export data set developed by Knippertz and Wernli using ERA-Interim reanalysis to explore how the 4 major sources of tropical moisture export they identify determine extreme rainfall in the Northeastern United States. The distribution of tracks from each source and the moisture release in the Northeast are mapped. The associated atmospheric circulation patterns are also explored. A preliminary model that relates the track origin, and circulation patterns to the extreme rainfall is developed and tested. The results indicate directions for potential predictability and also downscaling of extreme precipitation from climate models considering a key mechanism associated with the transport and delivery of such storms to the region.

Extreme Weather Forecasting – Coastal Urban Ecosystems

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The research presented here is directed towards determining aerosol particle size distributions (PSD) and land cover land use (LCLU) effects on precipitation for the coastal urban environment of New York City (NYC). Urban environments influence precipitation via alteration of dynamic effects and aerosol ingestion. This research aims to improve precipitation forecasts in complex urban environments. The Regional Atmospheric Modeling System (RAMS) was used to simulate July 2007 summer precipitation scenarios for NYC. Aerosol PSD from NASA's Aerosol Robotic Network (AERONET) were processed and ingested directly into RAMS to represent cloud condensation nuclei (CCN) and giant CCN (GCCN). NYC was represented by high resolution land data acquired from the National Land Cover Database (NLCD). An ensemble of eight numerical simulations was configured. The first two runs were month long runs for July 2007, the first with constant PSD values, and the second with PSD updates. The third and fourth runs mirrored the first two simulations for a “No-City” case. Four more runs addressed one day precipitation events under City and No-City and various PSD conditions. Model results suggest that LCLU provides the dominate forcing for urban precipitation; affecting precipitation rates, rainfall amounts, and spatial precipitation patterns. PSD then acts to modify cloud physics. Results indicate that precipitation forecasting is significantly improved with ingestion of observed PSD and assimilation of LCLU.

Improving Storm Surge Forecasts and Adapting Our Urban Coasts

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Hurricane Sandy caused the highest coastal water elevations in the history of New York City and the urban coasts of northern New Jersey. Seawater flooded electrical and transportation infrastructure, and brought deep water and severe damage to some areas. Here, I will highlight the storm surge forecasts that were provided as part of the New York Harbor Observing and Prediction System (http://Stevens.edu/NYHOPS). Forecasts of the peak flood levels posted Saturday at 6:00 AM, 2.5 days before the maximum surge arrived, were within 5% along the open coasts of NJ/NY, low by 25% for the lower Hudson River, the Battery, and NY/NJ Harbor regions, and low by 10% for Long Island Sound. A more accurate hindcast will be presented with errors generally below 5% everywhere, and experimental results will be used to demonstrate what physical factors were behind the high flood levels. Plans for improving the accuracy and usability of future forecasts will be discussed. Ideas to mitigate damage from the Sandy's of the future will be presented as well.

Evaluating Impacts of Climate Change and Hurricanes on Secondary Production in Coastal Embayments

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Accumulating evidence suggests that warming global temperatures negatively influence the growth and survival of coastal estuarine fauna that contribute to a $3 billion New Jersey fishery. Coastal storms especially hurricanes may have similar effects on the relationship between first year growth and recruitment of valuable species. We present preliminary findings on: 1) the effects of rising temperature on overwintering, bioenergetics and secondary production of weakfish (*Cynoscion regalis*) in Delaware Bay; 2) the fate and transport of toxic substances in the Passaic River estuary food-web that can serve as a baseline for detecting storm-induced impacts; and 3) a framework for comparing pre- and post-hurricane influences on the secondary production of selected species in coastal nurseries. Storm surge from Hurricane Sandy, for example, has resulted in strong erosive forcing and a large pulse of sea water and sediment, both of different chemistry, intruding landward, an event that has undoubtedly stressed coastal ecosystems already stressed by other anthropogenic activities. The critical role of tidal salt marshes and their production of finfish and shellfish, for example, may be compromised by hurricane induced changes in marsh topography and hydroperiod that, in turn, influence access to the marsh surface for feeding and refuge, exchange of materials and the vigor of dominant marsh flora. The same sites and collections methods introduced in 1999 in Delaware Bay and 2010 in the Passaic River estuary will be used to assess storm-induced impacts on habitat quality, and the quality of animals produced at the end of the first growing season.

Preparation, Response, and Recovery – Early Lessons from Hurricane Sandy and New York City: From Climate Non-Stationarity to Policy Non-Stationarity

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The objective of this paper is to examine and explain the significance of the response to Hurricane Sandy with respect to policy transitions. Hurricane Sandy was a highly impactful extreme event. The implication of the event could potentially extend significantly beyond the deaths, injuries, and damages caused. The paper analyzes the development of climate adaptation and resilience strategies in New York City over the past ten years and more specifically since Hurricane Sandy. The results of the paper illustrate how the City of New York has begun a process of rebuilding and recovery that will potentially foster a new type of climate policy and associated changes in urban resiliency to extreme events. In the paper, this new policy approach is detailed and analytical frames for evaluating this potential transition and larger scale transformation are presented.

Assessing the Ecological Impacts of Hurricane Sandy on the New Jersey Shorelines: Recovery and Resilience

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The objective of this study was to evaluate the ecological disturbance of the North Jersey shorelines following Hurricane Sandy. The latter brought large amounts of seawater to brackish systems. This anomaly of a large volume of water of different chemistry intruding landward has undoubtedly stressed a coastal ecosystem that was already stressed by various anthropogenic activities such as increased population density and construction. While the quantification of these stresses is challenging, it becomes extremely difficult in the presence of major but infrequent stressors such as hurricanes. Therefore, it was important to evaluate how such an extreme stressor modifies the short- and long-term self-organized processes of the ecosystem.

To better understand the resilience and recovery of the coastline, site-specific measurements were carried out in three different ecosystems: Sand beaches, wetland, and estuary residential areas. The sampling transects were set across sand inland beaches in which flooding persisted for up to one week after the end of the storm. In each ecosystem, measurements of pore water were acquired, and analyzed for nutrients, metals, and salinity. In some cases, the model MARUN, a finite element model for density-dependent flow in variably-saturated media was used to interpret the results. Preliminary findings suggest that the concentrations of heavy metals in pore water increased by three folds due to the storm, and the salinity of the inland system returned to brackish water in approximately 2 months.

TECHNICAL SESSION IIA: CLIMATE VULNERABILITY & ASSESSMENT, MITIGATION AND ADAPTATION

Winter climate extremes over the northeast United States and teleconnections with large-scale climate variability

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The linear correlations between 17 extreme climate indices that are based on winter daily precipitation, maximum temperature and minimum temperature over the northeast United States and 3 dominant large-scale climate variability: North Atlantic Oscillation (NAO), Pacific-North American pattern (PNA), and El Niño–Southern Oscillation (ENSO) are analyzed during the time period 1950-1999. Over the coastal region, the PNA and ENSO have significant positive correlations with the winter extreme precipitation, while the NAO has negative correlations with the winter extreme precipitation over north part but positive correlations over south part. For the temperature extremes, the NAO has significant positive correlations with the temperature extremes over almost the whole region, and the PNA and ENSO have significant positive correlations with the temperature extremes over north part but negative correlations over south part. The mechanisms behind these teleconnections are analyzed by applying composite analysis to the sea level pressure, moisture flux, relative humidity, wind, and omega fields. This study contributes to better understanding of the changes and variability of winter climate extremes over the northeast U.S., and helps to provide more accurate projection of future climate extremes to the decision-makers and inter-discipline researchers who are interested in the climate extreme impacts on urban coastal communities.

Vulnerability to Extreme Heat in New York City

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Background: Exposure to high ambient temperature and extreme heat is increasingly recognized as an important environmental health hazard. Understanding which populations are most vulnerable is informative for public health preparedness.

Aims: To determine what characteristics increase susceptibility to mortality on days of high temperature and extreme heat and examine how these susceptibility factors have changed over time.

Methods: We performed a case-only analysis of mortality records (from non-external causes) in New York City (NYC) during the period 1978 – 2009. After restricting to warm months (May – September), there were a total of 754,185 cases. Results: During the period 1999-2009, compared to other warm season days, deaths on extremely hot days were more likely from cardiovascular disease (CVD) (odds ratio (OR) = 1.10, 95% confidence interval (CI), 1.02 – 1.17) and more likely to occur at home (OR = 1.24, 95% CI, 1.12 – 1.38). The excess of deaths at home on hot days was seen in all time periods. The proportion of deaths that were among those 85 years and older was increased during the periods 1978-88 and 1989-99 (OR = 1.10, 95% CI, 1.02 – 1.18), but not in the most recent time period.

Conclusions: Our findings suggest greater susceptibility to heat related mortality among those with cardiovascular disease. The association of at home deaths with extreme heat could reflect heat exposure at home, social isolation, or some combination of these factors. Further analyses will examine spatial and additional demographic risk factors to help target interventions at the most vulnerable.

Integrated climate adaptation among livestock smallholders in the Gandaki River Basin, Nepal

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Climate change affects multiple aspects of livelihood for smallholder farmers and herders in Nepal. Weather extremes result in animal stress, insufficient animal feed, and promotion of livestock diseases. In order to build the resilience of vulnerable populations to climate variability and change, both physical and socioeconomic aspects of the linkage between climate and livelihood need to be better understood. With USAID funding, we are using remote sensing to better quantify the distribution of precipitation extremes in Nepal. Preliminary work shows that the TRMM precipitation product represents seasonal and geographic variability in precipitation reasonably well compared to available station observations. Remote sensing is therefore promising for quantifying climate hazards at fine spatial and temporal scales in Nepal, potentially in near real time. Field surveys are being undertaken to determine which aspects of climate variability are of most concern to livelihoods in order to guide further science and policy work. Three climate adaptation demonstration sites have been established in districts representing different elevations in the Gandaki River Basin, Nepal. Two types of irrigation system have been successfully installed in plots at all three districts for a comparison study. Forage seeds have been sown under each irrigation system to study their yields and contributions to soil and water conservation. The demonstration sites include a rainwater harvesting system using plastic ponds, kitchen gardening plots, and composting for nutrient recycling. The demonstration sites will be nuclei for complete resource centers and foci for community involvement in the research and development of climate resilience solutions.

Health Exposure, Socio-Economic Vulnerability, and Infrastructure at Risk to Current and Projected Coastal Flooding in New York City

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Sea-level rise throughout the 21st century will result in increased flood exposure as current flood levels are achieved more frequently and new flood levels result in more widespread inundation. To increase the resiliency of coastal communities and allow populations to respond and recover to these hazards, it is important to develop a place-based understanding of how storm surge exposure, impacts, and community vulnerability will change over time. This work uses a GIS-based methodology to develop and map a composite health exposure and infrastructure vulnerability index for New York City populations exposed to the current and predicted 100-year flood to assess overall flood risk at the intersection of exposure and vulnerability.

Both the physical and socio-economic impacts of flooding events are often unevenly distributed, with socially vulnerable groups most likely to experience a disproportionate share of the detrimental effects. When both physical and socio-economic vulnerability are present in combination, the risk to populations is exacerbated. The combination of social vulnerability, critical infrastructure at risk, and exposure to hazard provides a metric to rank neighborhood risk to flood hazards through an overall vulnerability index that characterizes site-specific levels of risk to flood hazard. Preliminary results show that future sea-level rise will increase the risk of the 100-year flood, particularly under scenarios of potential population growth and distribution in the coastal and near-coastal zones.

On the Changes of the Hydrological Balance of Caribbean Lakes – Modeling and Observations

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The Enriquillo and Sumatra are saltwater lakes located in a rift valley that is a former marine strait created around 1 million years ago when the water level fell and the strait was filled in by river sediments, they are the largest lakes in the Dominican Republic and Haiti, respectively, with Lake Enriquillo being the lowest point in the Caribbean. The lakes, part of the Enriquillo closed water basin in the southwestern region of the island of La Hispaniola, have been experiencing dramatic changes in total lake-surface area coverage during the period 1980-2012. The size of the lakes was determined using remote sensing images (NASA-LANDSAT) analyzed with geographic information system (GIS) at different times during the available record. The size calculation for Lake Enriquillo shows a lake surface area of approximately 276 km^2 in 1984 that gradually decreased to 172 km^2 in 1996. After a period of fluctuations between 1996 and 2001, the surface area of the lake reaches its lowest point in 2004, at 165 km^2. Beginning in 2004, the recent growth of the lake begins and reaches its 1984 size in 2006. Based on surface area measurement for December 2009, the lake size is 333 km^2, 17% larger than in 1984 and almost double than in 2004. Sumatra sizes at both ends of the record are 115.96 km^2 in 1984 and 134.26 km^2 in 2011, an overall 15.8% increase in 27 years. Because the lakes are mostly latitudinally restricted by topography, most of the size changes occur on the southeastern side of Lake Enriquillo, with some growth on the western tip. Determining the causes of lake surface area changes is of extreme importance due to the environmental, social, and economic consequences. The goal of this study is to quantify the changing water balance in these lakes using satellite and ground observations and regional atmospheric modeling. Analyses of environmental variables in the region reflect a hydrological unbalance of the lakes due to changing regional hydro-climatic conditions. Historical data show precipitation, land surface temperature and humidity, and sea surface temperature (SST), increasing all over the past decades. Salinity levels have also been decreasing by more than 30% from baseline levels. We hypothesized that the increases in SSTs may be leading to increases in regional moisture content which leads to decreases in evaporation capacity from the lakes, and simultaneously to increases in fresh water production in the neighboring sierras. A network of rain and fog gauges along the high sierras reflects growing cloud montane forests, with significant increase in water production. Results from a high-resolution mesoscale atmospheric modeling clearly reflect increases in the amount of liquid water content in the vertical column as function of changing regional climate conditions.

TECHNICAL SESSION IIB: COASTAL WATER QUALITY AND ASSESSMENT

CREST Long Island Coastal Observatory- a Resource for Regional Observations and Evaluations of Satellite Ocean color Data Processing

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The CREST Long Island Coastal Observatory (LISCO), in western Long Island Sound off Northport has been in operation for over two years. It provides continuous radiometric observations of coastal waters both for processing as local data records of ocean color and for comparison and validation of evolving satellite observations. Thus, as the processing schemes (NASA-OBPG & NOAA-IDPS) for Ocean Color data of VIIRS sensor continue to evolve, monitoring the validity and assessments of the VIIRS ocean color product are necessary especially for coastal waters to evaluate their consistency and utility as long term data records. As part of the Ocean Color Aerosol Robotic Network (AERONET-OC) which is designed to support long-term satellite ocean color investigations through cross-site multi-spectral radiometric measurements using the automated CIMEL radiometer, LISCO expands those observational capabilities with continuous monitoring as well as, uniquely, for the LISCO site, additional assessment of the polarized and un-polarized hyper-spectral properties of coastal waters. The talk will describe the information on IOPs and water constituent retrievals obtainable from LISCO's observational suite, as well as discuss its role for validation of satellite observations, in conjunction with other Aeronet coastal sites, and examine concerns which remain with satellite observations of coastal waters for the production of reliable data records for climate applications.

Environmental Stressors Driving Relative Sea Level Rise of River Delta Systems

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Changes in coastal storm risk and shoreline migration are tied to both sea level rise and changes in local land level. Many cities and communities built on river deltas are particularly sensitive to coastalland subsidence. Here, we present a global, empirically derived projection of river delta systems at riskof future relative sea level rise based on a new database of environmental risk indicators. Indicatorsinclude measures of environmental impact from both the upstream river basin and the local coastalzone, such as population density, urban development, and water engineering, as well as land cover. Allindicators are hypothesized to have a significant level of direct or indirect control on the local rate ofrelative sea level rise, commonly through changes in sediment delivery and deposition on the deltaplain. Indicators are statistically weighted based on observed rates of relative sea level rise in theliterature. We find regional differences in the dominant sources of sea level rise risk. In Southeast Asia, the coastal zones with large deltaic megacities dominate basin source risks, while broadly developed river basins in East Asia and parts of Europe contribute strongly to sea level rise risk in those regions. Statistical clustering analysis of the environmental indicators across all deltas suggests there are several different modes of environmental stress that face communities living on the world's deltas.

Ocean Color Observations and Their Applications to Climate Studies

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Polarized light in the oceans carries intrinsic information that can be utilized to estimate the optical and microphysical properties of the oceanic hydrosols. It is especially sensitive to the scattering coefficient, which cannot be retrieved from the total light reflectance used in current ocean color remote sensing algorithms. Based on extensive simulations using the vectoria radiative transfer program RayXP, the attenuation-to-absorption ratio (c/a), from which b is readily computed, is shown to be closely related to the Degree of Linear Polarization (DoLP). The relationship is investigated for the upwelling polarized light for several wavelengths in the visible part of the spectrum, for a complete set of viewing geometries, and for varying water compositions. A large dataset of Stokes components is collected for various water compositions, measured in the field with a hyper-spectral and multi-angular polarimeter for validation purposes.

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A Bidirectional Reflectance Distribution Correction Model for the Retrieval of Water Leaving Radiance Data in Coastal Waters

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Water-leaving radiances, retrieved from in situ or satellite measurements, need to be corrected for the bidirectional properties of the measured light in order to standardize the data and make them comparable with each other. Bidirectional reflectance correction algorithms specifically tuned for typical coastal waters and other case 2 conditions are particularly needed to improve the overall quality of those data. In order to analyze the bidirectional reflectance distribution function (BRDF) of case 2 waters, a dataset of typical remote sensing reflectances was generated through radiative transfer simulations for a large range of viewing and illumination geometries. Based on this simulated dataset, a case 2 water focused remote sensing reflectance model is proposed to correct above-water and satellite water-leaving radiance data for bidirectional effects. The proposed model is first validated with a one year time series of in situ above-water measurements acquired by collocated multispectral and hyperspectral radiometers, which have different viewing geometries installed at the Long Island Sound Coastal Observatory (LISCO). Match-ups and intercomparisons performed on these concurrent measurements show that the proposed algorithm in LISCO (case 2) waters outperforms the standard operational algorithm (optimized for case 1 conditions) at all wavelengths. LISCO's time series data have also been used to evaluate improvements in match-up comparisons of Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data when the proposed BRDF correction is used in lieu of the current algorithm. It is shown that the discrepancies between coincident in-situ sea-based and satellite data decreased by 3.15% with the use of the proposed algorithm.

Hyperspectral Remote Sensing of Tropical Coastal Environments: the use of HICO data to derive water quality parameters in southwestern Puerto Rico

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Remote sensing characterization of coral reef areas and other benthic communities is a challenging task due to the exponential attenuation of the water column and the temporal and spatial variability of water optical properties. Profiles of inherent/apparent water optical properties (IOPs/AOPs) and near surface biogeochemical properties are being measured to assess the temporal and spatial variability of these parameters in southwestern Puerto Rico and to develop retrieval algorithms using the International Space Station's Hyperspectral Imager of the Coastal Ocean (HICO) data. Bio-optical sampling in both Case 1 and Case 2 waters of Guanica Bay and La Parguera was conducted on September 20 and 26, October 23, and November 29, 2012, and on January 25, 2013 to measure AOPs and IOPs and collect water samples for the analysis of Chl-a, TSS, and CDOM. The field sampling effort of this task is in collaboration with the Caribbean Coastal Ocean Observing System (CariCOOS), which is part of NOAA's IOOS. Since September 2012 four cloud-free HICO passes have been obtained (September 20 and 24 and November 29, 2012 and February 22, 2013). The two dates with coincident cloud-free images and field sampling are being used for algorithm development. Atmospheric correction of these images using a cloud-shadow correction scheme is in progress. High sediment runoff from episodic rainfall events have been observed to dramatically increase turbidity and chlorophyll contents in these waters for up to two weeks after the events. The impact of these transient events on corals and other benthic organisms is presently unknown.

NASA Future Ocean Color Satellite Missions and Applications to Studies of Extreme Weather Events and Impacts on Urban Coastal Ecosystems

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NASA has demonstrated the value of science-quality Earth observations in a wide range of practical application areas, including Climate, Water Resources, Ecological Forecasting, Disasters, Oceans, Human Health and Air Quality [1]. With advanced global remote sensing capabilities that include global hyper-spectral imaging, extended spectral coverage to the UV and SWIR, and improved spatial coverage, NASA's future ocean color missions are expected to provide high quality observations that, over the long-term, will contribute to an extended time series of records on inland, coastal, and ocean ecosystems—all which have substantial value beyond basic science and research. Here we discuss the new capabilities afforded by NASA's Decadal Survey mission GEO-CAPE (Geostationary for Coastal and Air Pollution Events) [2] and the Climate Initiative mission PACE (Pre- Aerosol, Clouds and ocean Ecosystem) [3], and how they could potentially advance research and applications related to extreme weather events and impacts on urban coastal ecosystems. Measurements from these future ocean color missions will provide a unique capability to help understand changes that affect our ecosystem services; implement science-based management strategies of coastal, marine and inland aquatic resources; and support assessments, policy analyses, and design approaches to planning adaptation and responses to impacts of climate change [3].

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http://dsm.gsfc.nasa.gov/pace_documentation/PACE_SDT_Report_V8_9-04-2012-2.pdf

Comparison of Coastal Inundation from Hurricane Sandy and Past Tropical Storms along New Jersey's East Coast

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Vulnerabilities of coastal flooding and the need for storm-surge protection was recently exposed by Hurricane Sandy's landfall on NJ's coast at Atlantic City in late October 2012. This study is a comparative analysis and evaluation of topographic data and sea surface levels from tide gauges for tropical storms along the coast. The results are useful to evaluate the geospatial information required for coastal protection and for new insight on predicting the extent of coastal zone inundation. Analysis of dune deformation pre- and post Hurricane Sandy, from high spatial resolution topographic mapping, will provide new insight on coastal dune engineering and beach protection and most importantly design and construction of civil and infrastructure projects need to incorporate geodetic datum shifts to accommodate sea level change.

Polarimetric remote sensing for the retrieval of optical properties of the ocean

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Polarized light in the oceans carries intrinsic information that can be utilized to estimate the optical and microphysical properties of the oceanic hydrosols. It is especially sensitive to the scattering coefficient, which cannot be retrieved from the total light reflectance used in current ocean color remote sensing algorithms. Based on extensive simulations using the vectoria radiative transfer program RayXP, the attenuation-to-absorption ratio (c/a), from which b is readily computed, is shown to be closely related to the Degree of Linear Polarization (DoLP). The relationship is investigated for the upwelling polarized light for several wavelengths in the visible part of the spectrum, for a complete set of viewing geometries, and for varying water compositions. A large dataset of Stokes components is collected for various water compositions, measured in the field with a hyper-spectral and multi-angular polarimeter for validation purposes.

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Seasonal variation of ocean inherent optical properties and chlorophyll concentration

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Using a dataset consisting of 9000 reflectance spectra simulated using HYDROLIGHT for all observable natural water conditions, we have developed three neural networks (NN) working in parallel to model the inverse problem for both oceanic and coastal waters. These NNs are used to relate the remote sensing reflectance at available MODIS visible wavelengths (412, 443, 488, 531, 547 and 667nm) to the phytoplankton (a_{ph}), non-phytoplankton particulate (a_{dm}), dissolved (a_g) absorption and particulate backscattering (b_{bp}) coefficients at 443nm. These reflectance derived parameters ($a_{ph}(443)$, $a_{dm}(443)$, $a_g(443)$, $b_{bp}(443)$) are then combined with the measured reflectance values and used as input to a fourth NN, to derive chlorophyll concentration ([Chl]). Unlike the previously developed networks that where trained based on a synthetic dataset and tested on the NASA bio-Optical Marine Algorithm Dataset (NOMAD), this network was trained and tested solely on the NOMAD. This algorithm is then used to process the current daily global MODIS mission data. The processed data are then averaged by season and are used to present the global seasonal distributions and variations for each IOP as well as [Chl].

Imaging of underwater targets with polarimetric camera

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Underwater imaging is challenging because of the significant attenuation of light due to absorption by water and suspended/dissolved matter and scattering by water and suspended particulates which results in rapid blurring and degradation of an image. Using polarization properties of light is one of the options for improving image quality. Some living and manmade objects in water have partially polarized surfaces, whose properties can be advantageous in the context of target camouflage or, conversely, for easier detection and thus are of significant scientific and technical interest.
The results shown in this presentation correspond to measurements carried out on a polarized target in open ocean (Curacao) and coastal (NY Bight) waters. The target is in the shape of a square subdivided into smaller squares. Each of these smaller squares is a polarizing film with different polarization orientations or transmission coefficients, which was placed on a highly reflective mirror. The target was imaged under water with green-band full-Stokes polarimetric video camera and measurements of each Stokes vector components were collected as a function of the Sun's azimuth angles. These measurements were then compared with the modeled image of the target using radiative transfer code for the atmosphere-ocean system combined with the simple imaging model.
It is shown that even in the case of clear water the impact of the water body on the polarized underwater image is very significant and retrieval of target polarization characteristics from the image can be extremely challenging. Algorithm for the retrieval of the target properties from the camera image is proposed.

Impacts of Land Cover Land Use (LCLU) and Aerosol PSD Variation on Precipitation in a Coastal Urban Environment Using Cloud-Resol

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The research presented here is directed towards determining aerosol particle size distributions (PSD) and land cover land use (LCLU) effects on precipitation for the coastal urban environment of New York City (NYC). Urban environments influence precipitation via alteration of dynamic effects and aerosol ingestion. This research aims to improve precipitation forecasts in complex urban environments. The Regional Atmospheric Modeling System (RAMS) was used to simulate July 2007 summer precipitation scenarios for NYC. Aerosol PSD from NASA's Aerosol Robotic Network (AERONET) were processed and ingested directly into RAMS to represent cloud condensation nuclei (CCN) and giant CCN (GCCN). NYC was represented by high resolution land data acquired from the National Land Cover Database (NLCD). An ensemble of eight numerical simulations was configured. The first two runs were month long runs for July 2007, the first with constant PSD values, and the second with PSD updates. The third and fourth runs mirrored the first two simulations for a “No-City” case. Four more runs addressed one day precipitation events under City and No-City and various PSD conditions. Model results suggest that LCLU provides the dominate forcing for urban precipitation; affecting precipitation rates, rainfall amounts, and spatial precipitation patterns. PSD then acts to modify cloud physics. Results indicate that precipitation forecasting is significantly improved with ingestion of observed PSD and assimilation of LCLU.

Flow Behaviors under Surface Shear and Velocity Conditions

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Flows with free surfaces are commonly encountered in the nature and engineering applications. We investigate behaviors of flows generated by velocity and shear stress boundary conditions at water surfaces. First, analysis is made for a steady flow between two horizontal infinite plates, and it indicates that the solution for the flow driven by velocity condition at the top plate is exactly same as that by shearing condition. Then, an analytical solution is derived for an impulsively started flow initiated by a constant shear stress on a surface using Laplace transform, and it is shown that the flow is distinct from that caused by suddenly applying a velocity on it. At last, numerical solutions of cavity flows are made and they indeed confirm the conclusions drawn by the analyses; surface velocity and stress conditions lead to same results if one only considers steady state flows, whereas they produce flows with distinct velocity profiles if one simulates them as unsteady flows. These conclusions suggest that the conditions at water surfaces should be selected with discretion in studying flows with surfaces such as those in rivers and oceans.

Downscaling Of SMOS Data Using NDVI, Elevation, and Sand Fraction

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CREST REU Scholar
Dugwon Seo and Dr. Tarendra Lakhankar
CREST Mentors

Surface soil moisture information at high spatial resolution is necessary for better forecasting and understanding of various hydrological, meteorological and ecological models. Microwave remote sensing systems show great potential in retrieving soil moisture information on daily basis. However, major limitations using passive microwave systems are due to lower spatial resolution. Accurate fine-scale soil moisture observations are needed at a consistent basis to be used for local and regional scale models. In the absence of consistent high resolution soil moisture datasets, downscaling procedures enable to convert coarse resolution surface soil moisture estimates to high and liable resolution soil moisture estimates. Surface soil moisture distributions and dynamics depend greatly on vegetation (NDVI), topographic (EL), and sand (SF) features. The downscaling algorithm is based on the understanding of each of these physical parameter (NDVI, EL, and SF) and coarse remote sensing data and how they impact soil moisture retrievals. Results suggest that not all physical parameter (NDVI, El, and SF) affect surface soil moisture equally, since every region has its own soil composition. Unhealthy vegetation can be due to high sand fraction or seasonal change, or vice versa.

TECHINCAL SESSION III: SCIENCE OF CLIMATE AND CLIMATE CHANGE

Do we know how storms will change in a climate warming?

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It is now common to hear the confident assertion that storms in a warmer climate will be stronger and more dangerous. The usual justifications for this are: a warmer atmosphere can hold more water vapor so precipitation will increase proportionately or the climate models say so. But do we really know how storms will change in a warming climate? To answer this question we have to know the answer to three other questions: (1) what is the current day distribution of storm strengths, (2) what causes the rarer stronger storms and (3) how are weak and strong storms coupled to the general circulation? The difficulty is that the answers to these questions and the title question cannot really be separated. Instead we need to to provide partial answers to the first three questions before developing a comprehensive answer to all of them together. (1) Although storm statistics have been collected for more than a century with particularly strong storms identified in the records, these statistics apply mostly to northern hemisphere, midlatitude land areas – there has not actually been a global survey of storm strength. Moreover these statistics are collected at fixed locations so there is little information about the evolution of storm strengths in the moving frame of the storm itself, which prevents elucidating their effect on the general circulation. For instance, a storm that is weak when it reaches a weather station might have been stronger earlier in its life. With the advent of a global satellite observing system, we are finally beginning such surveys. Early results will be presented. (2) The factors leading to strong midlatitude storms have received a lot of attention but the focus has been on large-scale dynamics and a little on precipitation because measurements were available. The study of the causes of severe midlatitude storms is incomplete however, especially concerning the role of cloud radiative effects. The focus in the tropics is almost exclusively on hurricanes and typhoons but not on their precursors or on other types of strong storms. Again new observations have become available but have not yet been used to their fullest. Some early hints from new observations are shown. (3) We can tell that weak and strong storms produce different amounts of atmospheric heating but we have not yet worked out whether there are other differences regarding their importance to the atmospheric general circulation. For instance, which storm-strength categories contribute most to the energy and water exchanges in the climate? This question is a chicken-and-egg question in that we do not know whether stronger general circulations produce stronger or weaker storms or the reverse. Long enough records now exist to compare and contrast weaker and stronger circulations and the weaker and stronger storms they encompass. So answers could be obtained by an approach that will be outlined. The current answer to the title question should be “we don’t know”.

Use of Satellite Tools to Monitor and Predict "Super Storm" Sandy 2012 – Current and Emerging Products

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From a meteorological perspective, "Super Storm" Sandy was a "perfect storm" in terms of the convergence of several synoptic features which phased together along the mid-Atlantic coastline to create record low-pressure, a huge wind field with corresponding storm surge and copious amounts of precipitation in some areas, including record snowfall. The two features that phased – Hurricane Sandy moving northward along the Atlantic seaboard, and a strong mid-latitude winter season type disturbance – alone would have caused significant weather and disruptions in the area. But the combined impacts of Sandy to the public were nearly unthinkable for this region in terms loss of life, property damage, economic loss, and coastal flooding and erosion. Sandy caused over 250 deaths and upwards of $70 billion in damage and economic loss during its trek from the Caribbean northward to the mid-Atlantic and Northeastern United States.

The forecast predictions by the major numerical weather centers in the United States and in Europe were generally very good, with models such as NOAA's GFS and ECMWF's model forecasting Sandy several days in advance. Satellite data play an important role in the initialization of these models. Additionally, satellite data and derived products are vital to national and regional forecasters who are responsible for issuing warnings to the public. For example, satellite imagery aid the National Hurricane Center fixing the storm center and storm intensity trends. Water vapor and precipitation estimates from satellite aid in the assessing the location, duration and trends in where the heaviest precipitation is occurring, especially when the system is offshore and out of radar range. Other products such as ocean surface heat content and ocean surface winds also play a vital role to the forecasters. The purpose of this paper is to illustrate many of the products that were available during Sandy, and introduce proxy products from upcoming satellite missions that will demonstrate the future capabilities.

Climate Services from the New Generation of NOAA Operational Satellites

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The world is currently facing many damaging and large scale problems: Earth population is growing faster than food production; Land's fresh water & soil fertility have been over-exploited; Demands for more food are growing fast putting further constraints on Earth resources; Warmer climate is anticipated to intensify weather hazards; More intensive and larger area droughts are suppose to increase agricultural losses; Food security is expected to become jeopardized considerably. In order to sustain the Earth, produce more food and protect the environment we have to monitor areas and intensity of climate limitations; predict weather hazards and their impacts; provide advanced detection of droughts; minimize agricultural losses; develop adaptation strategies for agriculture and environment, introduce new technologies to avoid Earth destruction without deterioration of human life. All of these goals require strong and comprehensive climate and weather assessments for advanced predictions of their impacts on economies and society. STAR has developed such services using 33 year observations form NOAA operational environmental satellites. They include an early detection of drought and monitoring drought area, intensity, duration, origination and impacts, prediction of fire risk, moisture and thermal stress, assessment of vegetation health (VH), use of VH for monitoring and prediction of crop yield and for early detection of malaria risk, intensity of the disease and affected area etc. This information for 192 world countries and 4,000 administrative regions is delivered every week to the NOAA WEB (http://orbit.nesdis.noaa.gov/smcd/emcb/vci), which is attended by 3,000-5,000 every month. The climate services will be improved considerably with observations from the new generation of operational polar-orbiting satellites. The first one, called Suomi NPP (S-NPP), is currently in space providing high quality global daily data with 375 m spatial resolution due to the new Visible Infrared Imager Radiometer Suite (VIIRS) sensor.

Trends in Intense Precipitation Over Land: Observations and Climate Models

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Precipitation events are expected to become substantially more intense under global warming, but few global comparisons of observations and climate model simulations are available to constrain predictions of future changes. We present a systematic comparison of changes in annual-maximum daily precipitation in station observations between weather stations (archived in GHCN-Daily) and the suite of global climate models contributing to the fifth phase of the Coupled Model Inter-comparison Project (CMIP5). We use both parametric and non-parametric tests to quantify the strength of trends in intense precipitation in observations and models, taking care to sample both in comparable ways. We find that both observations and models show generally increasing trends in intense precipitation since 1850, although annual-maximum daily precipitation has increased faster in the observations than in most of the CMIP5 models. We expect our findings help inform assessments of precipitation-related hazards such as flooding.

Climate Change and Urban Systems: Mapping the mobilization of pollutants due to flooding from sea level rise and its potential Public Health and Other Societal Impacts

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Due to anthropogenic impact on the environment, pollutants are constantly being added to local soil, surface waters, and groundwater systems. According to climate change predictions, altered patterns of precipitation and sea level rise are expected to increase the frequency and intensity of floods in many regions of the world (Ahern, et al., 2005). This study utilizes Geographic Information Science (GISc), Remote Sensing (RS) imagery and hydrological and elevation models. The main objective of the research is to identify risk areas for natural hazards, i.e. flooding, impacting coastal cities due to climate change, determine the extent to which existing contaminants can mobilize and effect human health, in order to minimize and mitigate any resultant negative health impacts in the future.

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Cloud Effects of Extratropical Cyclones and Regions of Storminess

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Dry dynamics of synoptic scale weather are theoretically well developed and understood. Clouds and moisture however have uncertain effects which are now able to be studied using composites of reanalysis with satellite cloud and precipitation products. A novel approach to tracking cyclones and their areas of influence has been developed (Bauer *et al.* 2012). Incoherent statistics of this dataset are presented here. We propose using this dataset with satellite precipitation and cloud products to study the life of these cyclones. Which cyclones are most effectively transporting heat and mass poleward is of particular interest. Use of composites will allow a Lagrangian tracking of properties over the lifetime of the storm. Observing changes in water vapor absorbed or lost (precipitation) and cloud radiative heating will help understand the role of moisture in storm development and lifetime. To understand the role clouds play in the climate process, regime identification has been proven effective at identifying unique "weather states" (Jakob and Tselioudis 2003). We propose using these techniques in combination with Lagrangian tracking to identify regimes of cyclone types and investigate the influence of separate components of the governing physics.

Urban Heat Island Mitigation: Strategies

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In this paper we will take a close look at the water - energy feedback loop. We will generate a more detailed analysis of well known Energy/Water relationships such as power plant water use and wastewater treatment plant energy use. We will also approach hitherto unanalyzed water energy feedback loops such as urban storm water management and energy use as well as summertime urban peak load energy use and associated water consumption.

Current research suggests that vegetative surfaces can have significant impact on ambient urban temperatures and on urban storm water volumes. Our research will examine the performance of green infrastructure in urban environments. Rainwater gardens, green roofs that lower energy consumption and vegetation plantings can provide multiple benefits such as lowering temperatures during heat waves and passively managing storm water.

A scenario approach will be utilized to investigate a range of viable retrofitting options within our target area, the northwest Brooklyn neighborhoods of Red Hook, Gowanus, and Park Slope, which comprise the area served by Brooklyn Community Board 6. The findings of the study will be mapped to understand the spatial patterns within the community board in need of improvement. The focus of our scenario work will be on understanding how green infrastructure can impact energy and water consumption while understanding the social benefits that positively impact the community. In conclusion, this analysis will provide a practical approach to characterizing the costs and benefits of green infrastructure retrofits at neighborhood and urban scales.

Impacts of Climate Changes on the Caribbean Low Level Jet and the Mid-Summer Drought

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The Intra-Americas Region (IAR) is sensitive to climate changes and contains fragile ecosystems. It has also been shown that these changes not only have local impacts, but also are significantly linked to climate and weather conditions in North and South America and other surrounding areas. However, the mechanisms that drive the varying climate trends in this area have yet to be fully characterized. Previous research has studied the drivers that potentially contribute to the complexity and variability of climate in this region. Among them are the Caribbean Low Level Jet (CLLJ) and other regional and global phenomena that play a key role in controlling and modulating local climate changes. This research will focus on the role of the CLLJ, identified as a 925-hPa zonal wind region, which demonstrates correlations between SSTs, moisture transport and vertical wind shear during peak hurricane season. However, these studies have indicated that the dynamics of the CLLJ itself need to be further investigated. In order to understand the CLLJ and climate dynamics, historical climate trends in the IAR will be investigated with an emphasis on the vertical structure components of the Planetary Boundary Layer. The methodology used for the study presented here includes analysis of historical climate trends in the IAR using surface station data, large-scale vertical gridded atmospheric data, and SSTs datasets. This analysis leads to the characterization of the mechanisms involved in the CLLJ dynamic circulation, its influence on the MSD, and observed changes of key climatic variables.

Impact of Climate Change on Reservoir Eco-hydrodynamics

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Warming of water temperature causes thermal stratification in lakes and reservoirs, which is an important characteristic of heat transfer dynamics. Under the impact of climate change, a coupled hydrological and hydrothermal model is applied to New York City drinking water reservoirs to simulate the changes in thermal characteristics. Again, the potential future climate change may lead to changes in the timing and quantity of streamflow, which has large effect on reservoir water quality. In order to evaluate the reservoir water quality (particularly, turbidity level) under future climate change, a two dimensional reservoir turbidity transport model is applied to estimate the effects of hydro-climatology on turbidity transport as result of differences in reservoir thermal structure during seasonal events. Results suggest that under future scenarios, the average annual streamflow is increased by 5% and 7%, which results in an annual increase in reservoir turbidity by 3% and 5% for the future period of 2046-2065 and 2081-2100. Further, a simple ice model driven by air temperature and wind speed is attempted to hindcast the ice phenology in New York City drinking water reservoirs. These results obtained from coupling of hydrologic models and Global Circulation Model projections, will be useful to inform the water managers to formulate future guidelines to mitigate the potential impact of climate change and preserve reservoir ecosystems and its water resources.

How do hydrologic indicators respond to climate change?

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Recent works have indicated that climate change in the northeastern United States is already being observed in the form of shorter winters, higher annual average air temperature, and more frequent extreme heat and precipitation events. These changes could have profound effects on aquatic ecosystems, and the implications of such changes are less understood. The objective of this study is to examine how future changes in precipitation and temperature translate into changes in streamflow using a physically based semi-distributed model, and subsequently how changes in streamflow could potentially impact stream ecology. Streamflow parameters were examined in a New York City water supply watershed for changes from model simulated baseline conditions to future climate scenarios (2081-2100) for ecologically relevant factors of streamflow using the Indicators of Hydrologic Alterations tool. Results indicate that earlier snowmelt and reduced snowpack advance the timing and increase the magnitude of discharge in the winter and early spring (Nov-Mar) and greatly decrease monthly streamflow later in the spring in April. Both the rise and fall rates of the hydrograph will increase resulting in increased flashiness and flow reversals primarily due to increased pulses during winter seasons. These shifts in timing of peak flows, changes in seasonal flow regimes, and changes in the magnitudes of low flow can all influence aquatic organisms and have the potential to impact stream ecology.

Probability density estimation for information-based measures of long term global forecasting accuracy

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Measures of accuracy not only provide a way to evaluate the performance of one long-term forecast model against others, they help diagnose specific problems with a forecast. Such problems may show up in local regions or during specific time periods and can be identified using information based measures. These measures are advantageous, in part because the measured quantity is directly interpretable and they tend to be a more stringent measure of forecast quality. The weather observation is interpreted as an informational signal with a certain bit rate, given by the terms of entropy. A good forecast has a low bit rate and a perfect forecast reduces the bit rate to zero, since the observation tells us no new information. To calculate the bit rate of a forecast, we must first compute the entropy, which is derived from the probability density of a forecasted value. Since forecasts can be run with varying initialization parameters, an ensemble of forecasts is derived from a sampling of the space of initialization parameters. Here we focus on global observations of temperature and precipitation from the NCEP Climate Forecast System Version 2 (CFSv2) model ensemble. We use a a normal distribution approximation and a Kernel Density Estimator (KDE) to generate a probability distribution of the ensemble estimates. In addition, for the forecast modeling to be valuable, it should provide information not readily available from historic observations (climatology), so we compare the forecast density estimates to estimates of past observations. Finally, we note that there are biases in the long term forecast model which are easily removed. We examine these biases and test how removing them improves the information gain of the forecast ensemble.

TECHNICAL SESSION IVA: RAIN, SNOW AND COASTAL FLOOD HAZARDS

Case Study of Torrential Rain and Flood in the Merrimack River Valley in May 2006

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The Merrimack River flooding event during the 3rd week of May 2006 was a flooding event that the region had not seen for nearly 70 years. This once in a generation type event was the result of a lot of Atlantic Ocean moisture being deposited over the Merrimack Valley from northeastern Massachusetts north to central New Hampshire. Over the course of a six day span from the 12th to the 18th of May 2006; upwards of a foot of rain fell over the river valley, with the majority of those amounts falling on the 13th and 14th.The days prior to the flooding event and during the event, the North Atlantic Oscillation (NAO) was experiencing a well-established negative value. During this period, the combination of a strong anti-cyclone north of a strong cyclone makes up a Rex Block in the eastern third of the North American continent. These two pressure centers positively reinforce each other and take days to break down. In this flooding event it took about a week for the atmosphere to finally get itself in gear and move these features. The Weather Research and Forecasting model (WRF) was run over the region and successfully produced the substantial amounts of water that fell over Southern and Central New England. Experiments with various domains, grid sizes, physics parameterization schemes and choices of global model driving data were tested for this torrential rain case. The WRF faithfully reproduced continuous heavy rainfall over the Merrimack Valley. The model simulated and diagnosed a SE-NW corridor of deep moist air with a tropical nature that transports moisture from the Atlantic Ocean to New England coast to fuel the torrential rain in the Merrimack River Valley.

Prediction of Coastal Flooding at Residence Zones and Transportation Infrastructure at the East Bank of Delaware Bay in Sea-Level Rise Conditions

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Catastrophic flooding associated with sea-level rise and change of hurricane patterns has put the northeastern coastal regions of the U.S. at a greater risk. In this paper, we predict coastal flooding at the east bank of Delaware Bay and analyze the resulting impact on residents and transportation infrastructure. The three-dimensional coastal ocean model FVCOM coupled with a two-dimensional shallow water model is used to simulate hydrodynamic flooding from coastal ocean water with fine-resolution meshes, and a topography-based hydrological method is applied to estimate inland flooding due to precipitation. The entire flooded areas with a range of storm intensity and sea-level rise are thus determined. The future populations in the study region years are predicted using an economic-demographic model. With the aid of ArcGIS, detailed analysis of affected population and transportation systems including highway networks, railroads, and bridges is presented for all of the flood scenarios. It is concluded that sea-level rise will lead to a substantial increase in vulnerability of residents and transportation infrastructure to storm floods, and such a flood tends to affect more population in Cape May County but more transportation facilities in Cumberland County, New Jersey.

CREST-SAFE: A Long Term Field Campaign Experiment for Snow Using Microwave Remote Sensing

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The CREST-Snow Analysis and Field Experiment (CREST-SAFE) is being carried out for winter seasons (2011-2013) at the research site of the National Weather Service office, Caribou ME, USA. In this ground experiment, dual polarized microwave (37 and 89 GHz) observations are conducted continuously from the time of snow onset to snow melt off along with detailed synchronous observations of snowpack physical properties. The objective of this long term field experiment is to improve our understanding of the effect of changing snow characteristics (grain size, density, temperature) under various meteorological conditions on the microwave emission of snow and hence to improve retrievals of snow cover properties from satellite observations in the microwave spectral range. In this presentation, we give an overview of the field experiment and of routinely automatic and manually measured datasets including: microwave observations, meteorological observations (air temperature, snow skin-temperature, humidity, wind speed and direction, cloud cover, precipitation, incoming and outgoing radiations), and snow physical parameter from snow pit at different depth (snow depth, grain size, shape, hardness, and density). We also present the analysis of microwave observations collected during the two years of experiment along with observations of the snowpack properties. Seasonal changes of the snow pack physical properties were simulated with the SNTHERM model whereas to simulate the snowpack emission in the microwave we have used the HUT (Helsinki University of Technology) snow emission model. The analysis of microwave observations has revealed a large difference in the microwave brightness temperature over fresh and aged snow pack even under the same snow depth. This suggests a substantial impact of other physical parameters on the microwave emission of snow as snow grain size and density that need to be investigated.

A Short-Term Rainfall Prediction Algorithm

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An algorithm for predicting one to two hours in advance the spatial distribution of rainfall rate is introduced in this work. The suggested algorithm uses radar rainfall data to predict the rainfall field. The algorithm predicts first the most likely rainy areas and then predicts the expected amount of rainfall rate in each rainy pixel. The algorithm identifies the rainy cloud cells and determines the cloud motion vector of each cell. The motion vector is used to advect the rainy area and to identify the potential predictors. The potential predictors are the previous observations of reflectivity located in a neighborhood region with center on a predicted pixel. The forward selection algorithm is used to eliminate irrelevant pixels and determine the best predictors for each region. Rainfall prediction is derived after evaluating the empirical models over the persistence and advected rainy pixels. The weather research and forecasting (WRF) model was used to compare the performance of the proposed algorithm. Prediction errors of the proposed algorithm for a single storm were smaller than the forecast from the WRF model, which indicates that the proposed algorithm is a potential tool to predict rainfall spatial variability at short time interval. Further, research is required to confirm that the new model outperform the WRF model. Although, radar reflectivity is used to illustrate the performance of the algorithm, an extension to satellite rainfall data is a straightforward implementation.

Towards Developing a Global Inundation/Flood Monitoring System Using ATMS

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The objective of this study is to develop an operational global flood monitoring system using NPP-ATMS microwave brightness temperature (BT) measurements. The operational tool is based on a microwave-based soil wetness index (SWI). Swath-wise BTs of ATMS 89 GHz and 23 GHz channels are routinely downloaded from NOAA's CLASS. Each swath data is remapped to a regular grid of 35 km by 35 km using the nearest neighborhood technique to produce daily global brightness temperature maps. Global values of SWI are calculated using the difference in BT between the 89 and 23 GHz channels. Using these daily SWI values, we implemented the Robust Satellite Techniques (RST) method, following Temimi et al., 2007, 2011, to calculate the Soil Wetness Variational Index (SWVI) which is dependent on the mean and standard deviation of SWIs of the same months of the previous years. These SWVI values are influenced by surface coverage variations. That capability helps to capture wet areas (inundation, flooding or very wetsurface). Snow/ice on the ground were masked out using a threshold-based approach proposedby Kongoli et al., 2006. The developed tool was also adapted to AMSU data to investigate timeseries of inundation records across the globe. The obtained maps were verified against historical flood events in Australia and other parts of the world.

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Assimilating merged remote sensing and ground based snowpack information for runoff simulation using hydrological models

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Stream flow estimation and flood prediction influenced by snow melting processes have been studied for the past couple of decades because of their destruction potential, money losses and demises. It has been observed that snow, that was very stationary during its seasons, now is variable in shorter time-scales (daily and hourly) and rapid snowmelt can contribute or been the cause of floods. Therefore, good estimates of snowpack properties on ground are necessary in order to have an accurate prediction of these destructive events. The snow thermal model (SNTHERM) is a 1-dimensional model that analyzes the snowpack properties given the climatological conditions of a particular area. Gridded data from both, in-situ meteorological observations and remote sensing data will be produced using interpolation methods; thus, snow water equivalent (SWE) and snowmelt estimations can be obtained.

The soil and water assessment tool (SWAT) is a hydrological model capable of predicting runoff quantity and quality of a watershed given its main physical and hydrological properties. The results from SNTHERM will be used as an input for SWAT in order to have simulated runoff under snowmelt conditions. This project attempts to improve the river discharge estimation considering both,

excess rainfall runoff and the snow melting process. Obtaining a better estimation of the snowpack properties and evolution is expected. A coupled use of SNTHERM and SWAT based on meteorological in situ and remote sensed data will improve the temporal and spatial resolution of the snowpack characterization and river discharge estimations, and thus flood prediction.

Sensitivity of WRF Downscaled Precipitation and Maximum Temperatures in the Northeast Corridor
Session: Climate Vulnerability & Assessment, Mitigation and Adaptation

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Understanding the effects of low resolution forcings such as Land-cover and topography on climate is an integral part of predicting conditions in the future of the Northeast Corridor (NEC). Specifically of interest is how energy consumption is affected by regional climate trends. Electric demand in the NEC is directly connected to temperature variability for space heating and cooling of buildings. Energy consumption from buildings can represent up to 20% of the total energy consumption in the NEC. Moreover, the peak demand is driven by extreme climate events such as heat waves, while changes in precipitation might affect the water supply of power plants. This work presents a sensitivity study of high resolution (4km) regional climate modeling (WRF) downscaled in the Northeast Corridor using the NCEP-NCAR Reanalysis Project as input to a set of cumulus parametrization and micro-physics schemes with the aim of validating the model for simulations of future climate (2013-2100).
It is shown that precipitation is very sensitive to cumulus parametrization schemes, with the Kain-Fritsch scheme providing the best representation of the original forcing's precipitation and comparing well with gridded ground observations (PRISM), while no improvements were found by alternating micro-physics parametrization schemes. Moreover, acceptable results for maximum temperature were found, with the model underestimating PRISM temperatures by less than 10% in average for the region.

An auto-calibration procedure applied to the surface runoff component of the GOES-PRWEB operational algorithm

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The objective of this research project is to calibrate and validate the surface runoff component of the GOES-PRWEB algorithm. GOES-PRWEB is an algorithm implemented in Matlab™, which computes the components of the daily water and energy balance for Puerto Rico. To estimate the surface runoff, the algorithm uses the NRCS-Runoff Curve Number method equation. In this equation the input parameters are the curve number (*CN*) and the rainfall (*P*). *CN* represents a proportion of rainfall converted to runoff and the rainfall (*P*) is obtained from NOAA's AHPS website.

The Rio Guanajibo Basin in Puerto Rico was selected as a prototype watershed for developing the methodology. To evaluate preliminary errors, monthly comparisons were made with data from 2010, 2011 and 2012. Comparisons included: GOES-PRWEB (estimated) runoff vs. direct runoff from stream gauges (observed), estimated recharge vs. observed base flow and estimated runoff plus recharge vs. observed total streamflow. Results show, in several cases, an overestimation in the runoff and an underestimation in the aquifer recharge by the algorithm, which tended to cancel out the error in the total stream flow result. Nevertheless, there were some significant errors in the total stream flow during some months. These errors in total stream flow may indicate errors in the radar-derived rainfall or possibly in the evapotranspiration or soil moisture.

Future work will include application of the methodology to all gauged stations in PR, extrapolation of the results to un-gauged areas, validation of the calibrated algorithm with data from 2009, and implementation of a radar-rainfall correction procedure in operational mode (i.e., auto-calibration).

Improvement of Microwave Emission Model using Long Term Field Experiment

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Microwave remote sensing has shown great potential in estimating snowpack properties such as: snow depth and Snow Water Equivalent (SWE). However, other snow properties like density, wetness and grain size, which are variable in space and time, largely impact the microwave signal scattering, still need to be investigated and understood. With winters getting shorter and spring arriving 10-15 days earlier than it did 20 years ago, there is a high need to accurately understand the effect of changing snow characteristics (wetness, grain size and density) under various meteorological conditions on the microwave emission of snow. Specifically, information about the volume and temporal distribution of the snow wetness is important for predicting snowmelt run-off and flash floods caused by rapid snowmelt. Simultaneously, for wet snow, microwave retrievals appear to be problematic. However, better characterization of snow physical parameters like wetness can provide deeper insight to improve retrievals of snow cover properties from satellite observations in the microwave spectral range.

This study is focused on the development of a new method to estimate snow wetness (liquid water content) based on snow grain size and temperature; with the objective of assimilating the wetness on microwave emission models. Furthermore, this study concentrates on increasing the accuracy of the models during the melting and refreezing period. This research, will also discuss new instrumentation that will be develop and tested for accurate estimation of snow wetness through the winter season.

Aerosol-Cloud Interaction at City University of City College of New York using Ground Based Remote Sensing Systems

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The interaction between aerosol particles and cloud plays an important role in studies of climate radiation. In particular, it is generally assumed that increases in aerosol loading results in higher concentration of cloud condensation nuclei which ultimately lead to increase cloud droplet number concentration and smaller cloud droplets effective radius. Extensive studies of aerosol-cloud interaction have been attempted with the satellite remote sensing. However, it is a challenge to directly measure such aerosol cloud interactions from satellites since simultaneous retrievals of aerosol loadings and cloud properties such as cloud optical depth (COD) and droplet effective radius (Reff) are impossible at the same regions Therefore, efforts at quantifying these effects are limited to statistical trend studied over large domains. In this paper, direct ground based method is used to assess the Aerosol-Cloud Interaction at City College of New York (CCNY) based on the synergistic measurements by using microwave radiometer (MWR), multi filter rotating shadow band radiometer (MFRSR), light detection and ranging (LIDAR) systems, and Santa Barbara Discrete Ordinate Radiative Transfer (SBDART) model. The SBDART model is used to create the look-up-table for atmospheric transmittance which will then be used with MWR and MFRSR data. MFRSR provides transmittance, MWR gives liquid water path (LWP) and LIDAR offers aerosol extinction below cloud base. A method of iterative inversion algorithm is developed to obtain the COD and Reff. Finally, simultaneous aerosol extinction and Reff are acquired to evaluate the correlation between them. In doing this, the diffuse transmission must be calibrated and methods to assess errors in the Langley regressions are illustrated. Finally, preliminary results observed at CCNY-site will be presented.

Using Land Surface Microwave Emissivities to Detect Snow on Different Surface Types

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The sensitivity of passive microwave satellite observations to different land surface types and the presence/absence of snow are evaluated for the Northern Hemisphere. Surface microwave *effective emissivities* are derived from SSM/I observations by removing the contributions of the cloud and atmosphere and then separating out the surface temperature variations using ancillary atmospheric, cloud and surface data. The effect of presence of snow, the variation of land types, and temperature on the emissivities have been examined by observing the temporal and spatial variability of these measurements between 19 and 85 GHz over the Northern Hemisphere. The time-anomaly of differences between effective emissivity at 19V and 85V enabled the constant effects of land surface vegetation properties to be removed, leaving only the snow signal. The resulting 12-year signal combined with skin temperature data can detect the existence of snow cover over the Northern Hemisphere on daily basis. The results of this method compared with the operational NOAA weekly snow cover maps agrees at 90% of locations and times. Almost half of the disagreements may be caused by the space-time resolution differences of the microwave and operational snow cover determinations. Investigation of specific cases shows that the differences may be explained evolution of snow emissivities associated with freeze-melt-refreeze cycles and precipitation (snowfall). These results compared with the NOAA IMS, Canadian Meteorological Centre and the (MODIS) snowcover data agree within 82% and (92%).

TECHNICAL SESSION IVB: ATMOSPHERE AND AIR QUALITY

Stratospheric Aerosol and Gas Experiment (SAGE III) on the ISS

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After nine years in storage, a Stratospheric Aerosol and Gas Experiment III (SAGE III) instrument, a nearly-identical copy of one that flew on a Russian Meteor 3M spacecraft between December 2001 and March 2006, is now scheduled for flight aboard the International Space Station (ISS) in early 2015. SAGE III uses a grating spectrometer that measures ultraviolet/visible energy during spacecraft sun and moon rises and sets, plus scans the Earth's horizon on the sun side of the orbit. Observing from the International Space Station (ISS) SAGE III will provide near-global, long-term measurements of key components of the Earth's atmosphere critical to understanding atmospheric radiative and chemical processes, and climate change. Important measurements include the vertical distribution of aerosols and ozone from the mid-to-upper troposphere through the lower mesosphere. In addition, SAGE III will provide stratospheric and mesospheric measurements of temperature and such trace gases as water vapor and nitrogen dioxide. SAGE III-ISS will be among the early NASA payloads sent into space on a commercial launch vehicle known as the SpaceX F9/Dragon. Started in 2002 by Elon Musk, founder of PayPal and Zip2 Corporation, SpaceX has developed launch vehicles, established a launch manifest and is funded by NASA to demonstrate delivery and return of instruments and supplies to the space station. SAGE III-ISS will be the first instrument to measure the composition of the middle and lower atmosphere from the space station.

GOES-R ABI Sounding Algorithm Development: "ABI+PHS" Approach and Processing of Cloudy Observations

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The Advanced Baseline Imager (ABI) is the primary instrument on GOES-R satellite for imaging Earth's weather and is now scheduled for flight in 2015. It will be able to view the Earth with 16 spectral bands (from infrared to visible) and has very high temporal and spatial resolution (up to 30 sec refreshing rate and 0.5 km footprint, respectively, depending on the operational mode). However, the vertical resolution of the retrieved products from "ABI only" atmospheric states (temperature and water vapor profiles) are poor in comparison with hyperspectral instruments. An "ABI+PHS" approach is under development at Hampton University to improve the accuracy of ABI retrievals by using information obtained from the Polar Hyperspectral Satellite (PHS). Results of algorithm validation on actual radiances obtained during Joint Airborne Validation Experiment (JAIVEx) and other validation campaigns are presented. Another direction of HU GOES-R activity is to enhance ABI sounding algorithms with the ability to retrieve atmospheric profiles under all-sky conditions (i.e. clear and cloudy observations). The Dual Physical-Statistical Regression Algorithm developed as a collaboration between HU and University of Wisconsin allows one to obtain cloud characteristics (i.e., cloud top pressure, temperature, and effective cloud amount) and atmospheric retrievals below broken or semi-transparent cloud levels. The potential accuracy of the method is estimated from actual radiances in comparison to retrievals with GDAS and ECMWF analyses, as well as in-situ radiosonde observations.

FPGA Programming for Real Time Analysis of LIDAR Systems

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Pulsed Lidar systems employing fiber laser operate at low energy per pulse. As a result, pulse repetition frequency (PRF) is increased to obtain high signal to noise ratio (SNR). Increasing the PRF makes real time analysis using only a data acquisition card and software such as MATLAB nearly impossible, because the time between pulses is very small for processing backscattered signals. Field Programmable Gate Arrays (FPGAs) offer a great solution for real time analysis as backscattered signals can be processed on a hardware level. FPGA does not only help process backscattered signals during the limited time between pulses, but also helps to reduce the amount of data transferred from the data acquisition card to the system (usually a PC). Data transfer reduction is achieved by accumulating power spectra of received signals (frequency domain) instead of continuously transferring time domain signals. In this study, FPGA was programmed to process backscattered signals for an all-fiber Coherent Doppler Lidar (CDL) system for wind sensing that operates at 20 kHz. Two signal processing techniques were developed and programmed into the FPGA that allowed for obtaining vertical wind measurements for up to 3 km. The first technique allows for accumulating power spectra of time gated backscattered signals, whereas the second technique enabled us to accumulate autocorrelation of the in-phase and quadrature (I-Q) de-modulated backscattered signals.

Limb Scattering Radiative Transfer Model Development in Support of the Ozone Mapping and Profiler Suite (OMPS) Limb Profiler Mission

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The Gauss-Seidel Limb Scattering (GSLS) radiative transfer (RT) model has been tested through comparison with several other limb RT models, including the Siro, MCC++, CDIPI, LIMBTRAN, and SASKTRAN. To address deficiencies in the GSLS radiance calculations revealed in earlier comparisons, several recent changes have been added that improve the accuracy and flexibility of the GSLS model, including:

1. Introduction of variable atmospheric and surface properties along the limb line of sight.
2. Improved treatment of the variation of the extinction coefficient within atmospheric layers.
3. Re-introduction of the ability to simulate vector (polarized) radiances.
4. Addition of the ability to model multiple aerosol types within the model atmosphere.

These model improvements are verified by comparison to standard radiance tables, demonstrating significant improvement in cases for which previous versions of the model performed poorly. The GSLS model is imbedded in the retrieval algorithm used to process data from the Ozone Mapping and Profiler Suite (OMPS) Limb Profiler, which was recently launched on the Suomi NPP satellite. The significance of the GSLS RT model improvements for the OMPS LP retrievals will be illustrated by several examples.

Noise Reduction in Lidar Signals Using Interval-Thresholded Empirical Mode Decomposition

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Lidar is an active remote sensing technique which relies on having enough signal-to-noise ratio to measure individually scattered photons from a laser pulse against solar and electronic background noise signals at high spatial and temporal resolutions. Noise reduction techniques including spatial or temporal averages, moving averages, Savitzky-Golay filtering, and wavelet-based denoising have been applied previously to reduce the effects of statistical noise on derived data. However, these methods suffer from significant drawbacks that can degrade measurement resolution,corrupt or remove physical information, or improperly fit functions to the signal. Empirical Mode Decomposition (EMD) serves as a method of signal decomposition producing Intrinsic Mode Functions (IMFs) empirically derived from the signal that represent frequency components. This presentation applies a recently developed EMD-based thresholding technique modified to account for the continuous nature of IMFs to lidar signals[5]. The presented EMD-based methods improve SNR by between 54.2–81.9% over a noisy modeled signal and between 24.2–44.7% for a measured 532 nm lidar signal. RMSE for EMD techniques is shown to be between 0.09–0.125 for EMD techniques compared to 0.181–0.195 shown by wavelet methods when comparing the denoised signal to the original modeled signal. EMD-based methods also better correlate to undenoised profiles of extinction coefficients with comparable-to-better relative errors compared to wavelet-based techniques. For space-based missions and meteorological models using instrument-derived data where instrument size and weight become increasingly cost-prohibitive and relatively small statistical errors can lead to significant numerical instabilities, the application of accurate noise reduction methods offers potential cost-saving and resolution-increasing benefits.

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Aerosol Chemical Composition in the Mid-Atlantic Region: Assimilation with Aerosol LIDAR to Provide Insight into Aerosol Sources and Processes

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Extensive measurements of aerosol chemical composition are to be carried out at a near-coastal urban site in the Mid-Atlantic (Baltimore, MD). The measurements will include analysis of both organic components and inorganic ions (Na+, NH4+, K+, Ca2+, Mg2+, Cl-, NO3-, SO42-) sampled in near-real-time with a Particle-into-liquid sampler (PILS). The systems will be deployed to measure continuously on timescales of 10-20 min for weeks-to-months, and across multiple seasons. Elastic, Raman and Doppler *li*ght *d*etection and *r*anging (LIDAR) measurements provide high resolution information on the altitude dependence of troposphere aerosols, water vapor, and wind. A primary motivation of the work is the coupling of detailed, time-resolved chemical composition measurements with the intensive and extensive aerosol parameters (e.g. attenuated backscatter, extinction, aerosol optical depth, Angstrom coefficient, etc.) from lidar profiles, satellites, and ground based PM2.5 instruments. This work will enable the examination of the effect of radiative forcing of aerosols in the Mid-Atlantic region as a function of air mass composition, hygroscopicity, and relative humidity (RH). An overall goal of the work is the characterization of aerosol properties under predominantly anthropogenic, biogenic, and marine influences. This will also include a seasonal analysis of the coupling and impacts of the boundary layer on aerosol chemical composition

Tropospheric Temperature Measurements Using the Hampton University Raman Lidar

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Hampton University-based rotational Raman (RR) lidar measurements of temperature were calibrated during the special Ground-Based Remote Atmospheric Sensing Program (GRASP) campaign, which was conducted from the HU campus. The April 18-30, 2012, HU lidar temperature calibrations consisted of comparisons of simultaneous pure RR lidar measurements of laser light backscattered by atmospheric nitrogen and oxygen molecules in two difference narrow-band spectral regions, centered around 354.20 nm and 353.35 nm, with reference temperature profiles from radiosondes. The resulting lidar calibration coefficients were used to convert the lidar signals into tropospheric temperatures. The radiosondes were launched from the campus of HU, site of the RR lidar, and from the NASA Langley Research Center, located approximately 10 km to the North of the HU campus. The 354.20 nm spectral region corresponds to low rotational Raman quantum numbers, where backscattered light decreases with tropospheric temperature. The 353.35 nm spectral region corresponds to high quantum numbers, where the backscattered light increases with temperature. The resulting tropospheric lidar temperature profiles are presented. The profiles were found to agree with the radiosondes to within 3 degrees Celsius.

Tropical Atlantic Atmospheric Retrievals from the Infrared Atmospheric Sounder Interferometer (IASI) during the Aerosol and Ocean Science Expeditions (AEROSE)

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The benefit of global satellite retrieved atmospheric profiles for weather analysis/forecast operations has been continually increasing- since the first successful temperature profile retrievals were achieved with the Satellite Infrared Spectrometer (SIRS) aboard NIMBUS-3 in 1969. Since oceans cover 70% of Earth's surface, satellite soundings are most important for understanding different global atmospheric phenomena. The tropical Atlantic Ocean is a region of significant meteorological and oceanographic interest in terms of atmospheric chemistry and mesoscale-to-synoptic scale dynamic and thermodynamic phenomena. Passive and active remote sensing instruments onboard geostationary and polar orbiting satellites are providing global data, but the unique dynamic and thermodynamic nature of advected Saharan and sub-Saharan air masses over maritime environments provide a unique challenge for the interpretation of these remote sensed profile data. As a consequence, oceanic research missions are necessary for validation of satellite remote sensors using in-situ measurements. In this study, Infrared Atmospheric Sounding Interferometer (IASI) retrievals are compared to data collected during the Aerosol and Ocean Science Expeditions (AEROSE) field campaigns. The methods and data being used to obtain retrievals are discussed.

Initial Results Obtained from a Differential Absorption Lidar (DIAL) to Measure Tropospheric Ozone in Maryland

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The Tropospheric Ozone Lidar Network (TOLNet) is an interagency research initiative for ground-based ozone and aerosol lidar profiling, recently established for air quality applications/studies and to serve the GEOstationary Coastal and Air Pollution Events (GEO-CAPE) mission. UMBC Atmospheric Lidar Group is participating in the TOLNet initiative in conjunction with the NASA Goddard Space Flight Center (GSFC) in the construction of an ozone Differential Absorption Lidar (DIAL) system. Ozone DIAL profiles will provide vertical and temporal information about ozone in the daytime PBL, the nighttime residual layer, and the evolution of the controlling atmospheric dynamics with time scales as short as a few minutes. The objectives of this initiative are to (1) provide high temporal and vertical resolution measurements of ozone and aerosols at a few sites from near surface to upper troposphere for air-quality/photochemical model and satellite retrieval validation; (2) Exploit synergies with EV-I/TEMPO, DISCOVER-AQ, GEO-CAPE, and existing networks, including regulatory surface monitors and thermodynamic profilers, to advance understanding of processes controlling regional air quality and chemistry; (3) develop recommendations for lowering the cost and improving the robustness of such systems to better enable their possible use in the future national networks to address the needs of NASA, NOAA, EPA and state and local air quality management programs.

The DIAL method exploits the difference in signal returned between a strongly absorbing “on” channel and a weakly absorbing “off” channel to obtain the ozone number density. To obtain these specific wavelengths, Raman cells were manufactured to enhance Stimulated Raman Scattering (SRS) in a Raman-active media. With the knowledge of the ozone absorption coefficient at these two wavelengths, the vertical number density can then be derived. Preliminary results will be discussed.

Analysis of Evolution of Nabro Eruption using the CALIPSO Data and HYSPLIT Backtrajectory Model

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Nabro in Eritrea, Ethiopia, Africa (13.37°N, 41.70°E) erupted on June 13, 2011 generating volcanic (stratospheric) aerosol that lasted in the atmosphere for several months with ash plumes seen between 11 and 15 km. The Nabro eruption is well known as an important source of stratospheric aerosol in 2011 around the world because it ejected significant levels of SO_2 into the atmosphere, and it was clearly observable by multiple monitoring stations and satellites around the globe including CALIPSO (Sawamura, 2012). We have studied the evolution of Nabro eruption and the transportation of aerosol throughout the world between 13 and 30 June 2011 using CALIPSO level 2 data and the HYSPLIT backtrajectory model. The closest CALIPSO overpasses to the back trajectories confirm that a short time after the eruption (3-10 days) the aerosol was transported into Europe and then Asia until about 20 days later when stratospheric aerosol arrived over the United States. Using CALIPSO level 2 data, the stratospheric aerosol was observed for several months over Nabro's location. The optical and micro-physical characteristics of these aerosols and their transport pathway will be investigated during this ongoing study.

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Mid-IR Quantum Cascade Laser for LIDAR Application

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Introduction

LIght Detection and Ranging (LIDAR) instruments have proved to be powerful for atmospheric research and environmental monitoring [1]. LIDAR systems are used to build atmospheric profiles by collecting the backscatter signal from molecules and particles in the atmosphere. A LIDAR system consists of a transmitter which generates a pulsed signal at a specific wavelength, a receiver to collect the backscatter signal, and a computer system which digitizes the signal as a function of time or range [2]. The wavelength chosen for the transmitter depends on what you want to see in the atmosphere. To see the backscatter signal from the larger particles, a longer wavelength should be used and vice versa. Choosing a wavelength in the mid infrared (MIR) band would be beneficial for detecting aerosols and characterizing cloud drop size below the cloud [3].

Feasibility Study

The drawback of a MIR LIDAR system is the low signal to noise ratio (SNR). This is due to a low backscatter in the MIR band (3 µm – 8 µm) compared to the visible (380 nm – 750 nm) since SNR is inversely proportional to wavelength. Based on SNR estimates we explored the viability of a Mid-IR QCL LIDAR, including calibration issues. The measurement sensitivity typically depends on the amount of light that is backscattered, collected, and focused onto the detector. This is dictated primarily by the backscatter coefficient of the scattering source. Typical LIDAR systems detect elastic backscattering from atmospheric molecules (Rayleigh scattering) and aerosol particles (particle or Mie scattering). In the mid-IR elastic backscattering is dominated by coarse mode particulate scattering because of the $1/\lambda^4$ wavelength dependence of Rayleigh scattering. Particle backscatter efficiencies depend strongly on the atmospheric density of aerosols ($1/\lambda^2$); however, in the MIR, backscatter efficiencies tend to be very small. In order to improve the low SNR, averaging pulses over time helps reduce the noise and therefore increases our SNR. Figure 1a shows the SNR values of the potential LIDAR system, where an SNR of approximately .4 (should be 1) at 1km can be achieved for MIR channel (4.55 um) on a clear day after 30 minute averaging. Figure 1b shows the SNR of the system when looking at clouds, where the SNR is improved by more than a factor of ten for one minute averaging.

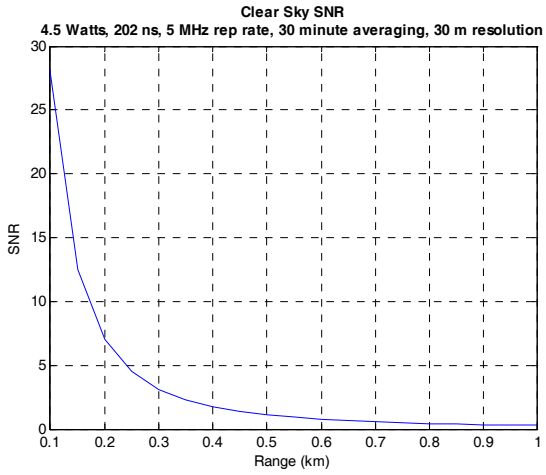

Figure 1a Aerosol Detection with 30 minute

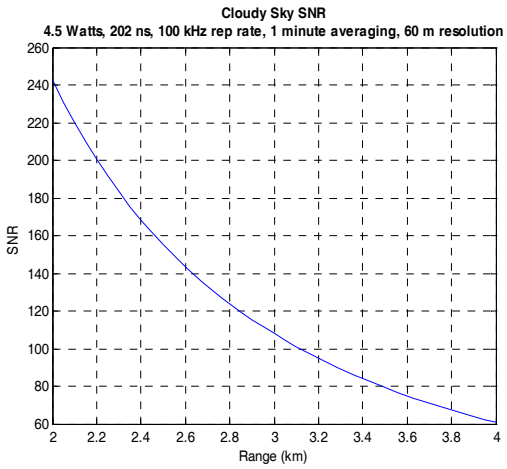

Figure 1b Cloud Detection with 1 minute averaging

Objectives

At CCNY, we are building a MIR LIDAR to improve and better understand the atmospheric profile. By using the Mid-IR LIDAR data along with the visible (VIS) LIDAR data, it would make it possible to separate the fine from the coarse aerosols which is critical in interpreting anthropogenic aerosol sources. Further, using both data sets will help in characterizing aerosol-cloud interaction and cloud drop size below the cloud. Backscatter data in the VIS, NIR (near IR), and MIR (mid IR) is able to distinguish these modes much better than backscatter measurements in the VIS and NIR only.

Prototype Design

The MIR LIDAR is being designed to be mobile; therefore our system is small and compact to make it portable. Figure 2, below, shows our current system configuration. This LIDAR is capable of running anywhere with power available since the entire system is situated on a cart for easy transportation. We are able to take data at any angle, making our LIDAR functional for many applications. Our transmitter is a Quantum-Cascade laser (QCL) with a wavelength of 4.55 microns, a pulse width of 202 ns and a peak power of 4.5 W. We chose a QCL at that wavelength since it falls within an atmospheric window (wavelengths at which electromagnetic radiation can transmit through the atmosphere to the surface), see figure 3. Quantum-Cascade lasers are particularly suitable in this wavelength range, as they offer several Watts of pulsed optical power, while retaining a good far field pattern as required for laser remote sensing techniques in atmospheric research. Our receiver is an f/5 Newtonian telescope with a 10 inch primary mirror. Our data is collected using a detector with a spectral range of approximately 2.5 – 5 µm and a spectral response, D*, of 9.25×10^{10}. Once signal is collected, it is digitized using a 12 bit Gage digitizer and then analyzed using LabVIEW and MATLAB. At 100 KHz repetition rate, our system range is 1.5 km with 60 m resolution.

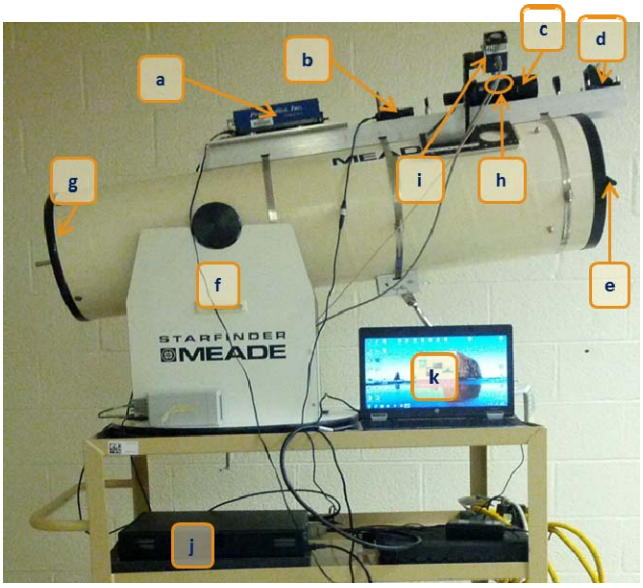

Figure 2 CCNY MIR LIDAR
a) QCL laser
b) Green laser beam finder
c) Laser beam expander
d) Folding mirror
e) Output mirror
f) Newtonian telescope
g) 10” primary mirror
h) Relay lens
i) MCT detector
j) Digitizer
k) CPU

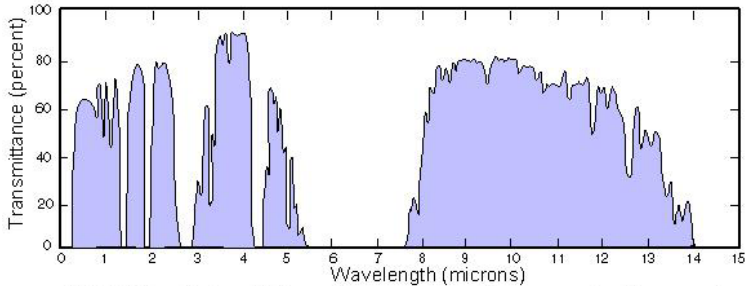

Figure 3 Atmospheric Transmittance

Preliminary Results

Currently, we are working on the final calibrations of our LIDAR system. We have so far collected hard target signal from distances up to 800 meters away. Figure 4 shows examples of backscatter signal off buildings 90 - 250 meters away. These figures average the signal 256 times to increase the SNR. In the left plot of figure 4 a clear signal can be seen from a building 275 meters away. The plot to the right shows a signal coming from a building 90 meters and another 150 meters away. However, based on the SNR calculations above, we will probably need to average over 30 minutes to see a signal from aerosol particles.

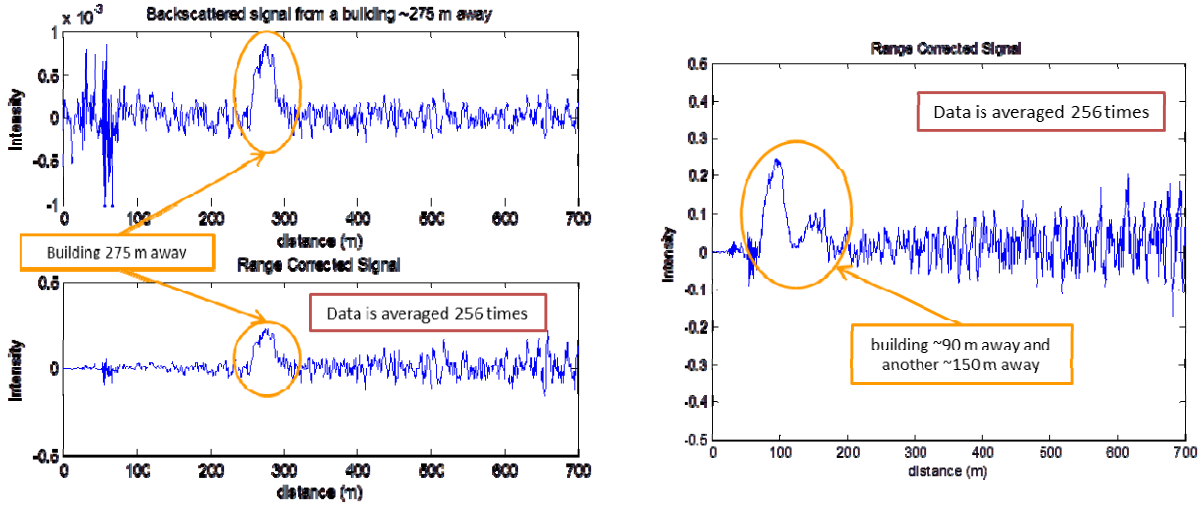

Figure 4 Preliminary Results

Future Work

Our next crucial step to complete our system is to improve detector alignment. To do this, we plan on redesigning the layout of our detector by replacing our relay lens with a folding mirror and adding a xyz stage for the detector. Once we have better alignment we hope to start picking aerosol and cloud signal. With a working system, we can then consider revising it with a remote controlled Newtonian telescope for easy angle adjustments or coming up with a design to thermo-manage our system giving us the possibilities of running our system at lower temperatures.

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Design and Optimization of a 1.5µm All-fiber Autonomous Scanning Coherence Doppler Lidar for Wind Profiling Application

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An all-fiber Coherence Doppler Lidar (CDL) using wavelength of 1.5µm has many advantages: it is eye-safe, low cost due to the used of optical components from the telecommunication industry and its reliability for various environmental conditions. The purpose of this research is to design and optimize a state-of-the-art autonomously scanning, heterodyne detection based CDL system for wind speed and direction determination, and aerosols profiling applications. The main components of the system are: laser source, Accousto-optic modulator, Fiber amplifier, Optical circulator, Optical antenna, Balanced detector, Motor controller and FPGA based signal pre-processor. The system deploys a 20KHz pulse repetition rate transmitter and the backscattered signals are sampled at 400MHz using an A/D converter on the FPGA board. The FPGA is programmed to generate and accumulate real time periodograms representing average power spectra of the Doppler shifted echo from a series of more than 60 time delayed range gates, where each range gate is 48 meters. These accumulated periodograms are sent to a host computer using a high speed bus for further data processing. Both vertical and horizontal wind speed can be measured up to a range of 3Km under nominal aerosol loading and atmospheric turbulence conditions. To obtain a representation of the horizontal wind speed, the motor controller and the signal pre-processor are synchronized to sample the atmosphere at three different angles: zenith and +/-20º from zenith. These measurements are used to reconstruct a 3D vector to estimate and represent both vertical and horizontal wind speeds, and aerosol profile.

Lidar Ratio Auto-Determination Based on Joint Initial Lidar Ratio and Initial Scattering Ratio Variations and AERONET AOD

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At the UPRM Atmospheric Research Laboratory, the backscatter-power data received from the Lidar equipment is processed and used to determine various atmospheric parameters, such as the fundamental aerosol backscatter coefficient, aerosol extinction coefficient, aerosol optical depth (AOD), aerosol size distribution (ASD), water vapor mixing ratio (WVMR), etc. Determination of the Lidar ratio is fundamental in the usage of equations leading to the calculations of these important atmospheric parameters. There have been multiple methods devised for the Lidar ratio determination including combining Mie and Raman scattering data if available. In this work, the Lidar ratio is determined for the three fundamental Lidar wavelengths of 355, 532, and 1064nms without the usage of the Raman channel, using AERONET AOD data. The approach in the past involved incrementing an initial Lidar ratio assumption until the error in AOD calculated by Lidar and obtained from AERONET approached zero or an acceptable value. In the present work, the initial backscatter ratio is incremented from an initial value in a nested fashion while initial lidar ratio is being incremented. At every joint variations the AOD error due to the difference of Lidar and AERONET results is obtained. A final Lidar ratio is accepted when the error has converged to a minimum value.

Keywords: Lidar Ratio, AERONET, Mie and Ramen Scattering

Using Model Forecasts to relate satellite AOD to surface PM2.5

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Retrieving Surface PM2.5 from satellite is very important for Air Quality applications and due to local meteorology and inhomogeneous aerosols, simple satellite AOD is not sufficient. Extra information can be obtained from using air quality models to provide a realistic ratio between satellite AOD and surface PM2.5. Currently, the IDEA product makes use of the GEOS CHEM product but this global product has 2.5 deg resolutions. Use of regional Community Air Quality Model (CMAQ) at 12km resolution can improve performance by including more realistic emissions. GEOS-CHEM PM2.5 / AOD ratios can be obtained on a yearly average where as CMAQ data is at 12km resolution and is available every hour. Since the EPA standard is for a 24 hour average PM2.5 estimator, we look primarily at 24 hr averages which are to be correlated to polar orbiting satellites at 1800 UTC. Different Seasonal and RH conditions are be explored. We note that the GEOS CHEM results have much less structure than the CMAQ which accounts better for local emission sources. Significant differences in the magnitude are present. CMAQ slopes are in much better statistical agreement with results between satellites and field measurements. When comparing results for different seasons, we note that the qualitative differences are fairly low although clear quantitative differences are observed. There seems to be a larger PM2.5 to AOD ratio near more coastal areas in general which may be a function of different aerosol types.

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Investigating the Effects of Aerosols on Clouds and Convection

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Aerosol particles play a significant role in the global climate system. Their influence extend to cloud formation where they act as cloud concentration nuclei (CCN) , attenuation of radiation, and recent studies suggest they can either intensify or moderate precipitation. Although they play a considerable role in climate prediction, aerosol effects, especially the indirect effect on clouds, are not well known. For this reason, scientists are constantly trying to gain a better insight into aerosol interactions. My research aims to contribute to current understanding by investigating the different types of aerosols over continental Africa and the Atlantic Ocean.

In this study, several convective cloud cases over Africa and the surrounding oceans were extracted from CloudSat data, one of NASA's experimental satellites. Using the NOAA HYSPLIT Air Parcel Trajectory Model, the convective cloud particles were traced back to a certain source location that would determine how that particular cloud is polluted. Three source locations were determined: Sahara, Tropical Africa, and the Atlantic Ocean. Saharan dust particles polluted the convective cloud particles that were traced back to the Sahara, particles that were traced back to Tropical Africa were polluted by biomass burning, and sea spray polluted the particles traced back to the Atlantic. Using a contour frequency altitude diagram, I was able to determine which convective case was associated with each aerosol type, and further investigate its convective properties.

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TECHNICAL SESSION VA: REMOTE SENSING AND MONITORING OF EXTREME EVENTS

Transport of Asian Dust to the Mid-Atlantic United States: Lidar, satellite observations and $PM_{2.5}$ speciation.

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Strong surface winds during late winter and spring in Central and East Asia are known to uplift soil from the Gobi and Taklimakan deserts into the free atmosphere. This coupled with global circulation, favors the long range transport of dust across the Pacific and into the United States (U.S.), potentially impacting air quality in the planetary boundary layer (PBL). Collocated NASA A-train observations were used to track the transport of dust across the Pacific and North American continent, and provide 3-D structure of Asian dust (horizontal scale and vertical thickness of dust aerosol layers, and particle size). Elastic lidar (532 and 1064 nm) measurements at the University of Maryland, Baltimore County (39.25°N, 76.70°N) were carried out to monitor the intrusion of Asian dust into PBL in the metropolitan Baltimore-Washington area. Columnar aerosol optical properties and vertical aerosol extinction retrieved from lidar measurements allows quantification of aerosol concentrations below the PBL where it affected ground-based $PM_{2.5}$ measurements. Monitoring data from the $PM_{2.5}$ chemical speciation trends network (STN) and the Interagency Monitoring and Protected Visual Environment (IMPROVE) aerosol monitoring network were used to examine the elemental soil components (e.g. Al, Ca, Fe, Si and Ti) and estimate the $PM_{2.5}$ mass increment associated with the Asian dust.

Hurtling Over Regional Observations of Extreme Weather Events while Forming Partnerships

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A network of ground based remote sensing instruments, ancillary observations and regional partnerships form an urban observatory that has been used to monitor weather events and to archive climate information. A focus will be given to extreme weather episodes. Vertical wind profiles recorded during both Irene and Sandy will be presented. In addition, observations during recent heat events have been used as case studies for model validation and have inspired partnerships regionally.

Cross Validation of Solar Radiation Using remote sensing equipment & GOES Satellite

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Researcher of UPRM NOAA-Crest Research Center
Computer Engineering student at UPRM

Multiple in-situ remote sensing sensors have been installed at UPRM for atmospheric characterizations. One such characterization is solar radiation validation of GOES-13 visible channel using Pyranometer and AERONET. GOES satellite passes over UPRM every 30 minutes with 1 Km resolution. In the cross validation, near similar wavelengths of different sensors have been used as well as near noon hour data acquisition from satellite to provide a close similarity with the data obtained from both AERONET and Pyranometer with zenith angle. The satellite wavelength range of interest is from 550 to 750 with 30 minute data intervals. The wavelength intervals are 300 to 1100 nm with 10 minute data intervals for the Pyranometer. The AERONET wavelength selected is 675 nm, which is the closest to the satellite wavelength of interest with data acquisition interval of 15 minutes. Data was acquired from satellite over three months with a frequency of one data per month and four data on the last month. AERONET and Pyranometer data were also of the same duration. The cross validation showed 19% error between GOES-13 and Pyranometer. The same satellite data was compared with Aerosol Optical Depth obtained by AERONET and the error was observed to be 12%. Results are shown in time series plots over several months.

Keywords: Solar radiation, GOES-13, pyranometer, AERONET, remote sensing

Microwave-based Snowfall Rate Estimation, Artificial Neural Network Approach

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An accurate estimate of snowfall is always a major challenge for water resources management communities. There are regions that either melted water from accumulated snow plays a major role in meeting freshwater demand or severity of winter snowfall creates major problems for transportation and energy supply, particularly for metropolitan areas such as New York City. Arguably, ground-based gauges and radar have been utilized to measure snowfall. Considering the sparse network or lack of spatial coverage of ground-based instruments, it is required to deploy satellite-based technologies without existing ground-based sensors limitations and errors. Sensitivity of high frequency microwave (MW) range of electromagnetic to ice particles and snowflakes lead us to use satellite-based MW brightness temperature (BT) to estimate snowfall rate. To meet the main objective of this study that is using satellite-retrieved microwave signals to improve capability of snowfall rate estimation from space, we are developing a multi-frequency algorithm based on an artificial neural network (ANN) system. The developed algorithm will estimate snowfall rate using microwave frequencies from the Advanced Microwave Sounding Unit (AMSU)-B. The preliminary results show that any combination of MW channels including mid and high frequency bands of 89, 150, and 183±7 GHz are more related to snowfall amount than the ones without this channel. These results also reveal the promising performance of the ANN-based models in the estimation of snowfall in higher latitude and mountainous regions with average correlation coefficient of ~ 0.50 for independent validation cases.

Improving hydrological modeling in NYC reservoir watersheds using remote sensing evapotranspiration and soil moisture products

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The main goal of this work is to demonstrate the efficacy of integrating remote sensing data to enhance the hydrology model GWLF that is employed by the NYC Department of Environmental Protection in the management of the City's water supply. The approach consists of integrating remote sensing products in the modeling of hydrological processes to complement the used in situ streamflow and precipitation measurements. A MODIS evapotranspiration product was used to calibrate and verify GWLF in the Cannonsville watershed. Three calibration scenarios were considered to introduce new calibration parameters, namely, soil water capacity, critical soil water content, and a potential evapotranspiration scale factor. The new calibration approaches result in better model performance in the simulation of evapotranspiration and similar performance in the prediction of streamflow. The calibration scenario that involves Priestley Taylor PET scale factor and soil water capacity showed better agreement between MODIS ET and model ET. Better agreement between microwave-based LPRM root zone soil moisture estimates and available water in the unsaturated zone within the watershed was also obtained after calibration with the MODIS ET product, with a RMSD equal to 0.159 (NS=0.41) compared to 0.171 (NS=0.32) under default calibration. Applying hypothetical temperature changes of 1, 2 and 3 oC in GWLF revealed higher sensitivity under the new calibration of streamflow to climate change in comparison with the previously used calibration. These results show the great potential of integrating remote sensing data in hydrological models for an accurate prediction of reservoir inflow, quality and quantity under climate variability and change.

Benthic Habitat Mapping for La Parguera Marine Reserve, Southwest Puerto Rico, using passive and active remote sensing data

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Coral ecosystems around the world, including those located in La Parguera Natural Reserve in southwestern Puerto Rico are among the most vulnerable in the world, because of the strong anthropogenic impacts and extreme weather events (i.e. hurricanes). The potential effects of climate change not only could affect the coastal and marine ecosystems, but also the communities that depend on these resources. Mapping marine habitats and associated species distributions is fundamental in determining the potential for protection, assisting in resource management and assessing impacts. Active and passive sensors are being used to overcome limitations of studying coral reefs present in optically deep waters. The fusion of these data sources coupled with *in situ* bio-optical data will provide information for image processing including atmospheric and water column corrections. The specific objectives of this project are: to evaluate bottom depth retrieval algorithms from passive sensors to a significant spatial resolution (4 meters) validated using bathymetric data from an active sensor; temporal variations of *in situ* inherent/apparent optical properties (IOP/AOP) and validation with image-derived AOP/IOP; establish an empirical correlation between LiDAR intensity image and bottom albedo from passive sensor and *in situ* bio-optical measurements; and develop a high resolution benthic habitat maps for La Parguera Reserve based on techniques that include supervised classification and feature extraction methods to evaluate marine communities and their distribution. The knowledge of these benthic habitats and their spatial distribution is vital for understanding complex coral reefs systems, assessing patterns, identifying area of habitat diversity and determining management strategies.

GOES Data to Estimate the Evolution of Effective Radius at Cloud Tops

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The evolution of the effective radius of convective cloud tops can be estimated by using a sequence of radiative properties of channels 2 (3.9 µm) and 4 (10.7 µm) from GOES. The reflection function represents the albedo of the medium that would be obtained from a directional reflectance measurement. It has been shown that there is a relationship between 3.9 µm reflectance and ice crystal size at cloud top. As the mean diameter of a cloud-top ice crystal distribution decreases, more solar radiation near 3.9 µm is reflected. The Lindsey and Grasso (2008) algorithm was adopted to compute the albedo. This algorithm uses the total radiance of channel 2, the solar irradiance, and the equivalent black body emitted by thermal radiation at 3.9 µm for a cloud at temperature T; and this temperature is estimated with cloud-top brightness temperature of channel 4, T_4. To estimate the albedo for channel 2 requires that $T_4 < 233°K$. Lindsey-Grasso's algorithm uses albedo, the solar zenith angle, scattering angle, and look up tables from radiate transfer to estimate the effective radius of convective cloud tops. A threshold brightness temperature from channel 4 was used to locate the pixels where the convective core can occur. Three stages of rainy pixels were identified: the new, persistent and dissipating rainy pixels. The effective radius was computed at each rainfall stage and the probability distribution was derived to characterize the rainy pixel stages. Rainy pixels were also observed through time to study their evolution.

Keywords: effective radius, drop size distribution, GOES, albedo, zenith and scattering angles.

Remote Sensing of Land Surface State Variables Controlling Biogeochemistry in Alaska

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Shifts in global climatic patterns have stronger effects in high-latitude regions, stressing the sensitivity of these regions to anthropogenic climate change. In particular, parameters like the freeze-thaw state of the landscape, the extent of inundated regions, and the distribution of temperature regimes are major constraints on the photoproductivity and land-atmosphere fluxes of energy, water, and carbon. Our approach consists in the analysis and synchronization of remote sensing datasets from microwave and optical sensors with in-situ measurements of surface variables from the Alaska Ecological Transect (ALECTRA) biophysical network and National Climate Data Center meteorological data. These data sets will serve as inputs for testing and validation of algorithmic, process-based models designed to generate classification maps detailing the spatial and temporal distribution of 4 principal variables: freeze-thaw state, soil moisture, inundation state, and surface temperature. Characterization of these state variables and their linkages to the carbon cycle is a chief scientific imperative of the Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) and the Soil Moisture Active-Passive (SMAP) mission, two initiatives led by NASA's Jet Propulsion Laboratory. CARVE's campaigns will supply detailed aircraft-based measurements to quantify carbon fluxes and carbon cycle-climate processes of regions in Alaska. SMAP will make global measurements of landscape freeze/thaw state, surface inundation, and surface temperature from an orbiting platform. In order to complement the validation efforts for these missions, these parameters will be derived from several remote sensing data and validated with ground references, in order to test their validity as indicators of biophysical conditions on the ground.

This study was supported and monitored by National Oceanic and Atmospheric Administration (NOAA) under Grant - CREST Grant # NA11SEC4810004.The statements contained within the manuscript/research article are not the opinions of the funding agency or the U.S. government, but reflect the author's opinions. Portions of this work were carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration.

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Random Forest LCLU Classification of Gulf Coast

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Development of human infrastructure alters natural ecosystems, indigenous species habitats and many natural processes. Societies have been experiencing a backlash effect from the environment. Infrastructure sectors in all parts of the world are at risk of falling under the strong effects of climate zone variation. The transportation, Communication (ICT), water resource and energy systems will now be stressed and tested by gradual transformations and extreme weather events. These drastic events may or may not be in the design considerations of a large portion of coastal civilizations around the world. With the use of historical field data and remote sensing technologies, these fluxes can be assessed and even projected. With the appropriate land use and classification, statistical models can be applied to help understand the processes that are developing in such regions. Remote sensing data sets available for this project include multi-date ALOS PALSAR and UAVSAR scenes spanning the complete gulf region; these include scenes from wet and dry seasons. Co-registration of these data with a DEM derived from SRTM will account for topographic variations within a classification scheme. Image composites will demonstrate the utility of multi-date acquisitions for examining changes in land cover across seasons and years. Research is focused on deriving indicators of Community Resiliency for human and natural systems to support an assessment of "infrastructure at risk" for coastal communities

ACKNOWLEDGEMENTS
All grants and fellowships awarded to the City College of New York, CUNY and Its NOAA Crest Program, (DOE) ESES Program, and Crossroads Initiative.
Mentorship: Dr. Kyle McDonald for aiding in the research and analysis process.
This work is supported by:
NOAA-CREST grant **#NA11SEC481000;** DOE (ESES) grant # : **P031M105066**

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Weather related impacts on Coastal Communities and Sustainable Strategies for Resiliency in New York City – Staten Island Case Study

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The importance of dealing with potentially severe climate impacts during the past 20 years (1993 to 2013) has become increasingly evident. In recent years, extreme temperatures, storm related disasters, and climate records have been occurring in countries around the world. The impacts of these patterns in New York City represent an opportunity to propose quantitative criteria to illustrate how vulnerable coastal communities may be to the damaging effects of extreme weather events and therefore provide a strategy for resilient coastal communities. A series of criteria, analyses, evaluations, and strategies of coastal edge damages have been designed to study the impacts that these extreme weather events have on the coastal community of Staten Island. This case study integrates typical variables of coastal communities and is serving as a learning tool for the consequences of weather related catastrophes and different vulnerability levels of communities in and around New York City. A preliminary conceptual weighted vulnerability index model and metrics to formulate an impact ranking system has been formulated. It produces results to test and comparatively evaluate the levels of resiliency and vulnerability of a given community of the proposed solutions under potential future climate and weather scenarios. Proposed index considers multiple vulnerability/resiliency levels relevant to coastal communities which include storm surge damages, building, energy and potable water infrastructures. The index is applied along the gradient coastal-inland transects using geospatial tools. This combination of factors and vision within the context of selected specific case studies using local coastal communities as learning experiences may help us to suggest specific solutions for possible sustainable reconstruction for a long term resilient future.

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Investigating the cause of the Lakes Enriquillo and Azui growth using Hydrological Modeling

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The concept of climate change has brought up the question of whether it is responsible for the unexpected growth of the lakes Enriquillo and Azeui located in Dominican Republic and Haiti. Both lakes have undergone a growth in their size and volume during the past 10 years since 2003. Almost 11 meters rise in water level surface has been observed while the volume of them is doubled.
The hydrologic modeling of the two watersheds encompass the lakes has been set up using SWAT (Soil and Water Assessment Tool) for years of 2003, 2004 and 2011. The atmospheric data consisting precipitation, temperature, wind speed, relative humidity, solar radiation are applied using the data gathered from the sensors implemented on the northern part of the lakes and the result of atmospheric downscaling model. Soil parameters gathered using the result of other studied done in different part of the Island and the information presented by FAO (2007). Land Cover map of the year 2003 is used for the simulation of the years 2003 and 2004 and some updates are considered for 2011.
The result of the modeling shows that the change in the pattern of atmospheric data and precipitation is not the only drive to add such huge amount of water to the Lakes and geological studies have to be considered as well. This research is to present the run-off values moving toward the lakes obtained from hydrologic modeling using the atmospheric data and their comparison with the actual volume changes of the lakes.

TECHNICAL SESSION VB: STORM, DROUGHT AND EXTREME WEATHER EVENTS

Heat Waves, Heat Islands & Global Warming, Oh My: LA's One Hot City

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Los Angeles is a warming subtropical coastal city. California has warmed 2^{o}F in the last 50 years, metro LA has warmed nearly twice that rate, over 5^{o}F in the last century. The changing urban land use has added substantially to heat fluxes, particularly during the warmer months. Recent studies found that heat waves are becoming more frequent and longer in duration. Increased temperatures and intense heat waves lead to greater energy and water demands, increased air pollution levels and elevated mortality rates. Future predictions show even greater heating. A thorough study of the city's heat island, including urban albedo, land use changes, heat wave morphology and coastal meteorology (sea breezes, inversions, synoptic scale circulations) is needed. Together with our CUNY-CREST partners and JPL collaborators, the California State University, Los Angeles team of faculty mentors and graduate student researchers plan to thoroughly investige the Los Angeles heat island(s), its diurnal characteristics, seasonality, and contributing factors (albedo, radiative fluxes, land use changes, urban and synoptic circulations, and Pacific Ocean influences). The team will investigate the relationships between urban heating, energy consumption, air pollution and heat stress. The role of sea breezes in alleviating coastal summer heating will be measured using the South Coast Air Quality Management District's meso-network of land use, wind and inversion data. From these sources and NOAA re-analyses data, a model of urban heating and wind circulation will be created. CSULA students will look at the most effective mitigation schemes for reducing urban heating.

Classifying Extratropical Cyclone Extremes in the Northeast: A Probability Based Approach

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Wintertime extratropical cyclones deliver heavy precipitation and strong winds to the Northeastern United States, in some cases creating costly and devastating impacts. As the climate warms, monitoring the trends and variability of strong storms will be crucial. In order to benchmark current storms for comparison with future projections, this study creates a probability-based classification of northeastern extratropical cyclones. The cyclones are identified by applying a tracking algorithm to gridded reanalyses products.After identifying the storms, cyclone-local metrics of the storm's strengths are generated by area-averaging the sea level pressure gradients and near-surface wind speeds. Extreme value theory (EVT) is then applied to these metrics to generate estimated return periods based on the storm's strength. In addition to deriving return periods, this approach generates uncertainties levels, which estimate the robustness of the results. Since EVT based analyses of extratropical cyclones are rare, the current project serves as both a means to classify the storms and a chance to develop and test the methodology. Therefore, examples of the return period sensitivity to choices regarding the storm characteristics, strength metric and the cut-off used to define the distribution tail are shown. Then, for the set of return periods that is most general, a classification system based on return periods is defined. For storms classified as extreme, an analysis of the large scale atmospheric forcing is carried out using the vertical tilt between the surface and upper-level disturbance and the baroclinicity. Additionally, the relationship between these storms and the North Atlantic Oscillation is investigated.

Delaware Reservoirs' Drought Risk Assessment: A Paleo View

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The Delaware River provides half of New York City's drinking water, is a habitat for wild trout, American shad and the federally endangered dwarf wedge mussel. It has suffered four 100-year floods in the last seven years. A drought during the 1960s stands as a warning of the potential vulnerability of the New York City area to severe water shortages if a similar drought were to recur. The water releases from three New York City dams on the Delaware River's headwaters impact not only the reliability of the city's water supply, but also the potential impact of floods, and the quality of the aquatic habitat in the upper river. The goal of this work is to influence the Delaware River water release policies (FFMP/OST) to further benefit river habitat and fisheries without increasing New York City's drought risk, or the flood risk to down basin residents. The Delaware water release policies are constrained by the dictates of two US Supreme Court Decrees (1931 and 1954) and the need for unanimity among four states: New York, New Jersey, Pennsylvania, and Delaware -- and New York City. Coordination of their activities and the operation under the existing decrees is provided by the Delaware River Basin Commission (DRBC). Questions such as the probability of the system approaching drought state based on the current FFMP plan and the severity of the 1960s drought are addressed using long record paleo-reconstructions of flows. For this study, we developed reconstructed total annual flows (water year) for 3 reservoir inflows using regional tree rings going back upto 1754 (a total of 246 years). The reconstructed flows are used with a simple reservoir model to quantify droughts. We observe that the 1960s drought is by far the worst drought based on 246 years of simulations (since 1754). However, there are intermediate drought warning periods and proper adaptation would be sufficient during these periods. Modified release rules that aid thermal relief to wild trout in the upper Delaware can be explored without much stress to the system during most periods.

A Simple Web-Based Method for Scheduling Irrigation in Puerto Rico

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Over application of irrigation water can lead to the waste of water, energy, chemicals and money, and also may lead to the contamination of ground and surface waters. Over application of water can further lead to leaching of fertilizers past the root zone and water logging, resulting in lower crop yields. Under-application of irrigation water can lead to water stress with reduced crop yields and a loss of revenue to the grower. There are various approaches for scheduling irrigation. One approach is to supplement rainfall with enough irrigation so that the cumulative rainfall and irrigation, over a specific period of time matches the estimated potential evapotranspiration. Potential evapotranspiration (ET_c) can be estimated by the product of a crop coefficient (K_c) and the reference evapotranspiration (ET_o). In this study we present an approach based on applying irrigation to the crop to meet the crop water requirements derived from a remote sensing technique. Reference evapotranspiration is obtained from an operational water and energy balance algorithm (GOES-PREWEB) which produces a suite of hydro-climate variables on a daily basis for Puerto Rico. The algorithm produces daily estimates of the Penman-Monteith, Priestly-Taylor and Hargreaves-Samani reference evapotranspiration. The crop coefficient curve is constructed per the methodology recommended by the United Nations Food and Agriculture Organization (FAO). Daily rainfall can be obtained from radar (NEXRAD) if rain gauge data is not available for the farm. A detailed example is provided for a farm growing tomato in Juana Diaz, Puerto Rico. The approach is relatively simple and the near-real time data is available to any farmer in Puerto Rico with internet access.

Mapping Manhattan's Urban Heat Island

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CREST is part of a multi-institutional Consortium for Climate Risk on the Urban Northeast (CCRUN) which studies climate related impacts on the coastal cities of New York, Philadelphia, and Boston. The CREST contribution is looking at Health risks from the Urban Heat Island and air quality in partnership with the Columbia School of Public Health. Data is derived from a combination of CCNY's MesoNet system and a series of field campaigns. A series of mid-day field campaigns measure temperature and humidity at street level in Manhattan on fine scale. Anomalies can relate to local environment such as vegetation and buildings Normalization by daily variability allows local anomalies to be added to create an average anomaly map of Manhattan. Though sample size is not yet large enough for confidence at the 95% level, a pattern is emerging of warm and cool regions corresponding roughly to building height, and humidity patterns corresponding to proximity to large bodies of water. Some unexpected anomalies in this pattern will be investigated by a system of temporary instrument placements to map diurnal variations. A related effort models local variability seen in weather stations of the MesoNet system by linearly regressing local temperature anomalies against daily meteorological variables such as windspeed, humidity and cloud cover. The accuracy is greatly improved by including time lag data. It is not yet clear if the local regressions can be related to the local environment. If so, projected changes in climate may be used to project urban heat island effect.

Incorporation of SMOS soil moisture data on National Weather Service's Gridded Flood Guidance on Arkansas Red river basin

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Climate change and variability increases the probability of frequency, timing, intensity, and duration of flood events. After rainfall, soil moisture is the most important factor dictating flash flooding, since rainfall infiltration and runoff are based on the saturation of the soil. It is difficult to conduct ground-based measurements of soil moisture consistently and regionally. As such, soil moisture is often derived from models and agencies such as the National Weather Service (NWS) use proxy estimates of soil moisture at the surface in order support operational flood forecasting. In particular, a daily national map of Flash Flood Guidance (FFG) is produced that is based on surface soil moisture deficit and threshold runoff estimates. Improved flash flood forecasting requires accurate and high resolution soil surface information. The remote sensing observations of soil moisture can improve the flood forecasting accuracy. The Soil Moisture Active and Passive (SMAP) and Soil Moisture and Ocean Salinity (SMOS) satellites are two potential sources of remotely sensed soil moisture data. SMAP is a directed mission within the NASA Earth Systematic Mission Program and is planned to launch in 2015, while SMOS is a Living Planet Programme from the European Space Agency (ESA) and launched in 2009.

SMOS measures the microwave radiation emitted from the Earth's surface. SMAP has a similar mission and will use a combined radiometer and high-resolution synthetic aperture radar operating at L-band (1.20-1.41 GHz) to measure surface soil moisture directly. Microwave radiation at this wavelength offers relatively deeper penetration and has lower sensitivity to vegetation impacts. The main objective of this research is to evaluate the contribution of remote sensing technology to quantifiable improvements in flash flood applications.

This study is focused on adding a remote sensing component to the NWS FFG Algorithm. The current operational FFG algorithm applies the precipitation-based Antecedent Precipitation Index (API) and the NWS Hydrology Laboratory - Research Distributed Hydrologic Model (HL-RDHM) to counties across the USA, and when combined with Doppler radar and Multisensor Precipitation Estimation (MPE) data, supports the issuance of Flash Flood Warnings. HL-RDHM is under active and continual development at the National Oceanic and Atmospheric Administration's National Weather Service (NOAA/NWS), Office of Hydrologic Development (OHD) and is used at many River Forecast Centers (RFC) for stream flow, snow pack, and soil moisture modeling. The challenge of this study is employing the direct soil moisture data from SMAP and SMOS to replace the model-calculated soil moisture state which is based on the soil water balance in 4 km x 4 km Hydrologic Rainfall Analysis Project (HRAP) grid cells. In order to determine the value of the satellite data to NWS operations, the streamflow generated by HL-RDHM with and without soil moisture assimilation will be compared to USGS gauge data. Furthermore, we will apply the satellite-based soil moisture data with the FFG algorithm to evaluate how many hits, misses and false alarms are generated. As SMAP has not yet been launched, high resolution (10 km) SMAP test bed data will be used which contains soil moisture and temperature from an integration of a distributed (DEM-based) hydrological model. This study will evaluate the value of remote sensing data in constraining the state of the system for main-stem and flash flood forecasting.

History of winter storm tracks in the Northeast US recorded in the 20th Century Reanalysis Data

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The extra-tropical winter storms in the 20th century are revisited using 20th Century reanalysis (20CR). The 20CR is an atmospheric reanalysis data set with the sea level pressure observation assimilated, which spans from the present back to 1870s. In history, the extra-tropical winter storms passing near the Western North Atlantic have caused tremendous damage in the East coast USA, including floods and storm surges, as in the most recent event, Sandy. By taking a closer look at the past winter storms, we attempt to identify the characteristics of the most damaging winter storms in the East coast USA.

We compared the storm tracks detected from the sea level pressure field in the 20CR to those from the other state-of-art reanalysis products, ERA-interim and NCEP-R2, for the overlapping periods (1979-2010). This is in order to verify the performance of 20CR. We track the low pressure centers using two independent algorithms developed by the University of Reading and GISS. This is to verify the performance of the storm trackers. We find out that the tracks from different reanalysis data and different tracker algorithm agree moderately well to each other, in terms of track positions and duration. Also, track density, storm genesis density, as well as the storm lysis density show good agreement in their sensitivity to the various modes of climate variability.

Finally, we examine the consistency of the 20CR over time by comparing storm statistics during 30year intervals. This stage is important for examining long-term changes in storms and their relation to known modes of large-scale variability such as ENSO and the NAO.

Characterizing Temperature Variations Due to the Urban Heat Island for Climate Health Impacts in New York City

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The impact of climate and heat on human health has been the subject of much research. The urban heat island and increases in air temperature over all is a substantial threat to the health of New York City residences. Since cities feature a wide variety of urban settings and various neighborhoods have different physical responses to meteorological events, it is expected that the temperature response and resulting heat stress vary as well. Therefore, this research has been focusing on neighborhood-scale field campaigns to downscale temperature and air quality predictions from neighborhood to city scale in New York City. In order to assess the temperature variability at street level within a city during the hottest part of the day, mobile measurements are performed using a Vernier Labquest hand-held data acquisition attached to air temperature and relative humidity sensors. The data are used to develop model output statistics to downscale model forecasts of temperature and humidity. The main goal of this project is to develop neighborhood based temperature, air quality predictions and maps from the large scale measurements and predictions made by comparing the actual temperature sensed at the street level to weather station data. The weather stations are the National Weather Service (NWS) surface station at Central Park and volunteer surface station from CCNY's MetNet. This work was funded as part of the health component of the Consortium for Climate Risk in the Urban Northeast (CCRUN), a NOAA Regional Integrated Science Assessment (RISA) that includes universities from New York, Philadelphia, and Boston.

Spatial and Temporal Analyses of a Global Warming Reverse-Reaction Coastal-Cooling Along the California Coast

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Previous studies by Lebassi et al. (2009) analyzed summer surface June, July and August mean-monthly maximum air temperature trends between 1950-2005 for two California air basins: San Francisco Bay Area and South Coast Air Basin . The spatial distribution of the observed summer max temperatures showed a complex pattern in which cooling trends were found at low elevation coastal areas open to marine air penetration and warming trends at inland and high elevation coastal areas. The authors suggested that increased sea breeze activity was responsible for the observed coastal cooling. The current research focuses on the extreme monthly-average maximum air temperatures for the all of California to determine both the spatial variability of this effect and the most influential factors on coastal cooling.

Statistical analyses identify coastal cooling as far as 60 km from the coast and below 500 m MSL, consistent with the sea-breeze causal hypothesis. Cross-sections verify these assumptions, since the intensity of the cooling signal decreases significantly when inland-distance increases. In addition, two new coastal-cooling air basins were detected: San Luis Obispo Air Basin and San Diego Air Basin .

The high correlation of summer coastal and inland maximum temperatures with Pacific Decadal Oscillation (PDO) magnitude suggests that the summer coastal cooling could be modulated by this signal. Two factors exist that could induce the increased pressure gradient that generates the increased sea breeze activity: the temperature increases of inland areas, (a consequence of large-scale warming) and the cooling of SSTs (controlled by the PDO). Which mechanism has a stronger influence on coastal cooling is still unknown.

GOES-PRWE Water and Energy Balance Algorithm Automation

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GOES-PRWEB is an algorithm that requires different datasets, scattered among several servers. Currently a Python automation algorithm is used to obtain daily input for GOES-PRWEB, execute various MatLab™ scripts, and finally, upload the results to a server where they are accessible to the public. Although the process is automated, it is inefficient and improvements are needed. The automation should be configurable and reusable. To achieve this goal, a system based on a "Pipeline" design pattern is being developed, which provides the concept of a "stage" as a processing element, and allows for system flexibility to use multiple threads for execution.

The new system uses Java as its main language, making the system portable among various platforms. To date, we have been able to improve the running time, relative to the initial Python-based automation system, by 83%. Initially, to execute one pass of the automated system required 60 seconds, which has now been reduced to 10 seconds. The reduction in execution time is important when long-term simulations are being performed.

By using Java, it was possible to leverage portability and multithreading, offering an advantage over Python which does not support multiple threads. Also, by using the Pipeline design pattern, it allows the use of a configuration file to control which stages are to be executed and in which order, thereby enhancing the system flexibility. In addition to testing and finalizing the Java automation algorithm, future work will also include the development of web-tools (e.g., database, mapping and time series plotting) for the purpose of quickly and efficiently disseminating results to the public.

Improvements to the WRF Multilayer Urban Parameterization

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The Weather Research Forecast model (WRF) coupled with the Martilli multi-layer urban canopy scheme (BEP) and a building energy model (BEM) has been evaluated for the summer 2010 three-day heat wave in NYC. The urban parameterization considers direct (thermal and mechanical) urban effects on the PBL, while its building-energy module accounts for anthropogenic-heat exchange to and from buildings represented by high resolution (250 m) urban canopy parameters from the National Urban Database. The thermal and drag effects of buildings, represented in the WRF multilayer urban canopy model, better estimated surface temperatures and wind speeds over NYC. Improvements to the model have been implemented to reduce the error in the prediction of surface temperature and wind. Urban canopy parameters for the 5 boroughs at 250 meters are being obtained to have a better representation of the city's morphology. The addition of latent heat in urban areas would have a considerable impact on the surface temperature and possibly in the rain fall amounts when local storms are developed. A summer campaign has being planned to evaluate the model.

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