NASA Science Mission Directorate
Research Opportunities in Space and Earth Sciences – 2012
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A.47 Development and Testing of Potential Indicators for the National Climate Assessment

NASA is a major contributor to global climate and related environmental assessment activities, such as the Intergovernmental Panel on Climate Change (IPCC), Climate Assessments and the World Meteorological Organization/United Nations Environment Programme (WMO/UNEP) Ozone Assessment Reports. NASA has made a similarly significant contribution to the U.S. National Climate Assessment (NCA), a central component of the 2012-2022 U.S. Global Change Research Program's Strategic Plan, and intends to continue supporting the NCA.

Indicators are anticipated to be an important component of future NCAs. These indicators are intended to provide a clear and concise way of communicating to the NCA audiences about not only status and trends of physical drivers of the climate system, but also the ecological and socioeconomic impacts, vulnerabilities, and responses to those drivers. This program aims to enhance NASA's participation in future NCAs by encouraging the development and testing of potential indicators that address the needs expressed in the NCA vision for a national system of indicators. Such indicators will draw significantly, but not necessarily exclusively, from NASA-produced data and/or modeling products. Given the multiple audiences of the NCA, the targeted indicators are expected to be useful to those who will be drawing on the NCA to make decisions related to impacts, adaptation, vulnerability, and mitigation associated with climate and global change (e.g., Federal agencies engaged in place- based or sector-based decision-making).

This program will support 14 projects with a total funding of approximately $2.5M for a period of 18 months, although some projects have shorter periods of performance. NASA will evaluate the need of future climate indicator solicitations as these projects near completion.

William Emanuel/Pacific Northwest National Laboratory
Land Cover Indicators for U.S. National Climate Assessments

The proposed project will assemble NASA remote sensing data products to provide a pilot land cover indicator for the U.S. National Climate Assessment (NCA). A land cover indicator for the NCA will track changes in land cover due to human activities and as a result of climate change, making it a synthetic indicator of influences on climate, climate change impacts, and the consequences of adaptation or mitigation measures involving land management. The project will combine moderate resolution (MODIS) land cover data products with higher resolution (Landsat) data. Land cover maps will serve as an important component of the indicator, but charts depicting attributes such as composition by land cover class, statistical indicators of landscape characteristics such as fragmentation, and tabular data summaries are all indispensable for communicating the status and trends of U.S. land cover to planners, decision makers, and a variety of stakeholders relying on NCA products. We will combine these representations of land cover at national, regional, and state scales. We will investigate the error and uncertainty imposed by combining remote sensing data at multiple spatial resolutions, and in the case of Landsat data at irregular temporal intervals, and incorporate measures of uncertainty into land cover indicators. We expect to visualize the land cover indicator in a spatially nested manor from the national to NCA regions to individual states within a region. Charts and tabular data will correspond to the spatial units of adjacent maps and aggregate accordingly.

The project will develop several prototype land cover indicators based on remote sensing data. We will interact with those involved directly in the NCA (e.g., the Federal Advisory Committee), users within Agencies and other institutions, and stakeholders (e.g., through NCAnet) to evaluate the utility of alternative prototypes. Adopting the most promising aspects of different prototypes, the project will develop a pilot indicator and provide access by the general public through the Web. We expect experience with this pilot indicator to provide clearer definition of the requirements of a land cover indicator for the NCA, the best uses of remote sensing data in meeting those requirements, and the basis for further indicator development involving remote sensing data.

Mark Flanner/University of Michigan

Cryosphere Radiative Forcing: An Indicator of Climate Feedback and Environmental Change

The objective of this proposal is to produce, maintain, and publicize a global, time-varying observational dataset of cryosphere radiative forcing (CRF). This metric of the cryosphere describes its instantaneous influence on Earth's top-of-atmosphere (TOA) solar energy budget. Because TOA energy fluxes fundamentally drive global climate, changes in CRF over time provide a quantitative measure of the amplifying effect of cryospheric evolution on climate change. CRF also provides a concise indication of the vulnerability or resiliency of the cryosphere to evolving climate and allows cryospheric evolution to be compared, in consistent terms, with direct anthropogenic forcings and feedbacks associated with other environmental changes. CRF depends not only on coverage of seasonal snow, glaciers and sea-ice, but also on local insolation, cloud cover, snow and ice properties (e.g., thickness and morphology), and the nature of the snow-free surface. CRF therefore incorporates climate-relevant features of the cryosphere, such as the muted influence of snow on albedo of conifer forests and the amplified influence of sea-ice changes that occur during the summer solstice season, whereas such features are lost in common metrics of snow and sea-ice extent.

We will derive CRF by extending techniques recently applied by the PI to determine CRF and albedo feedback during 1979-2008. We will incorporate NASA remote sensing retrievals of surface reflectance, snow presence, sea-ice concentration, cloud cover, and cloud optical thickness with radiative transfer modeling. We will employ retrievals of land surface albedo when sky conditions permit, and utilize mircrowave retrievals of snow cover under cloudy skies to produce spatially-complete datasets. Our technique combines retrievals of sea-ice concentration with measurements of age-dependent, seasonally-evolving sea-ice albedo. We will produce near real-time estimates of CRF using regular releases of MODIS data and preliminary sea-ice concentrations provided daily by the National Snow and Ice Data Center (NSIDC). Global, gridded land snow CRF will be provided at native 0.5 arc-minute resolution, produced every 8 days, and sea-ice CRF on 25 km equal area grids at daily resolution. We will also provide merged land and sea-ice data on regular 0.5 degree grids at monthly resolution to facilitate easier data analysis and visualization. Data released to the public will include gridded uncertainty estimates and flags indicating the derivation technique. The methods we propose are transparent, generalized, and will accommodate new NASA measurements such as those from VIIRS.

Global, hemispheric, and continental averages of CRF will serve as concise indicators of the cryospheric state, and timeseries of these data, normalized to temperature change, will indicate the strength of albedo feedback. These indicators will therefore serve as important input for the U.S. National Climate Assessment and other assessments such as IPCC reports. Data produced for this project will be available through University of Michigan and NSIDC websites, allowing users to explore other applications of the data including its potential as a leading indicator of seasonal climate. Finally, funding for this project will support two early career scientists.

Rong Fu/The University of Texas at Austin
Improving Assessment of Regional Climate Change in Supporting of Regional Resilience to Extreme Climate Events Over the US Southern Great Plains

Flash droughts refer to those droughts that intensify rapidly in spring and summer, coupled with strong increase of summer extreme temperatures, such as those that occurred over Texas in 2011 and the Great Plains in 2012. Climate models failed to predict these flash droughts in 2011 and 2012 and are ambiguous in projecting their future changes, largely because of models' weakness in predicting summer rainfall and soil moisture feedbacks. By contrast, climate models are more reliable in simulating changes of large-scale circulation and warming of temperatures during winter and spring seasons. Thus, we propose to develop and test a physical climate indicator of the risk of flash droughts in summer by using the large-scale circulation and land surface conditions in winter and spring based on observed relationships between these conditions and their underlying physical mechanisms established by previous observations and numerical model simulations.

The proposed flash drought indicator (IFDW) will be developed and tested using NASA Modern Era Retropsective-Analysis for Research (MERRA), North American Land Data

Assimilation (NLDAS) products, the Coupled Model Inter-comparison Project Phases 5 (CMIP5) models and a suite of satellite datasets. IFDW will be mapped in a way similar to drought severity index shown at National Integrated Drought Information Center (NIDIS) with additional information about uncertainty, past and future probability distributions of IFDW.

The proposed IFDW has several advantages over the available drought indices that simply track local drought condition in past, present and future:

a. It mitigates the weakness of current climate models in predicting future summer droughts and takes advantage of the models strength and our understanding of the mechanisms that control flash droughts;
b. It provides actionable drought risk information for stakeholders before droughts become fully developed in current climate,
c. It links future increase of temperatures in winter and spring to risk of flash droughts in summer. Such a link would make the projected changes of the flash droughts more intuitive and compelling to high-level decision makers and public.

This investigation team consists of an experienced climate-drought researcher, a young postdoctoral researcher specialized in applying climate science to support decision making and a leader of state water resource planner with strong track recording of working together previously. The development and communication of the IFDW will be guided by strong expertise in communicating drought information to stakeholders from the beginning to the end of this proposed project.

Simon Hook/Jet Propulsion Laboratory
Inland Water Temperature: An Ideal Indicator for the National Climate Assessment

NASA is a significant contributor to the U.S. National Climate Assessment (NCA), which is a central component of the 2012-2022 U.S. Global Change Research Program Strategic Plan. The NCA has identified the need for indicators that provide a clear, concise way of communicating to NCA audiences about not only the status and trends of physical drivers of the climate system, but also the ecological and socioeconomic impacts, vulnerabilities, and responses to those drivers.

We will use existing thermal infrared satellite data in conjunction with in situ measurements to produce water temperatures for all the large inland water bodies in North America to be used as an indicator for the NCA. Recent studies have revealed significant warming of inland waters throughout the world. The observed rate of warming is - in many cases - greater than that of the ambient air temperature. These rapid, unprecedented changes in inland water temperatures have profound implications for lake hydrodynamics, productivity, and biotic communities. Scientists are just beginning to understand the global extent, regional patterns, physical mechanisms, and ecological consequences of lake warming. We will assemble and synthesize records of lake temperature from both in situ and remote sensing data sources to understand the interactions between lake hydrodynamics and ecology throughout the full water column.

These synthesized records of lake temperature are ideal for communicating the state of the climate to the public, decision makers, and academia. Our synthesized product will directly support multiple sections of the 2013 National Climate Assessment report, providing information on the scientific basis for climate change as well as how different sectors and geographic regions are being affected by climate change. Information on how large inland water body temperatures are changing cuts across the different regions and sectors and will help enable a more integrated understanding of the changes that are taking place.

As part of our earlier studies we have collected the thermal infrared satellite data from those satellite sensors that provide long-term and frequent spaceborne thermal infrared measurements of inland waters including ATSR, AVHRR, and MODIS and used these to examine trends in water surface temperature for approximately 100 of the largest inland water bodies in the world. The primary objectives of this work are (1) Extend the temperature time-series to all of the North American inland water bodies that are sufficiently large to be studied using 1km resolution satellite data for the last 3 decades; (2) relate changes in the thermal behavior of the water bodies to changes in surface air temperature data; (3) compare the regional trends in water surface temperature derived from these observations to those in the CMIP5/IPCC model simulations/projections; (4) predict future changes in inland water body surface temperatures based on comparisons with the models and (5) summarize the data using ecologically relevant indicators that are meaningful to the general public, and make it available for the National Climate Assessment writing teams.

We have the necessary remote sensing datasets in-house and collaborate with a broad network of scientists who collect in situ lake temperature measurements. The satellite-based datasets include the entire archive for MODIS, ATSR and AVHRR over N. America. Our AVHRR archive includes the 4-km Global Area Coverage (GAC) and 1-km Local Area Coverage (LAC) data. We have developed a consistent processing methodology specifically for deriving the surface temperature of inland waters that will allow the entire long-term data record to be processed in a consistent manner (including error analysis) and have developed a set of automated calibration and validation sites to verify the satellite data and surface temperature retrievals.

Paul Houser/George Mason University
Water Cycle Intensification Indicator (WCI)

The most significant climate change impacts are shifts in the distribution of precipitation and evaporation, and the exacerbation of extreme hydrologic events. Therefore, we propose to develop and test potentially spatially- and temporally-scalable Water Cycle intensification Indicators (WCI) using NASA observations and model reanalyses in support of the National

Climate Assessment (NCA). The WCI will summarize how climate changes result in stronger or more extreme water cycling over the nation. The final composite WCIwill be a monthly, vertically integrated gridded composite of primary water cycle trends and extremes, integrated and weighted through water balance concepts. The WCI will provide baselines and future projections to compare options about how society can best address water issues, and will provide the water sector with sources and perspectives of data not otherwise available. By providing a key set of indicators on the water cycle consequences of climate change of direct relevance to a broad set of stakeholders, and actively increasing the pool of assessment-capable scientists by involving a recently graduated postdoctoral fellow, the proposal is directly relevant to the NASA-ROSES A.47 solicitation.

Integral to this effort will be participation in NASA's Indicator System Team (IST), which will help to coordinate and align the WCI with the NCA national indicator strategic vision, and to identify complementary resources and alternate products. To this end, the PI (Houser) proposes to help coordinate this team by submitting an application for IST Leader. By closely coordinating with and participating with the NCA indicator efforts, and conducting regular IST communications, the IST leader will provide management and direction to help align IST with the NCA indicator vision. The PI's long association and leadership of NASA, intergovernmental, and related climate programs give him a unique ability to serve in this role and enable value-added coordination that will optimize NASA's contribution to the NCA indicator effort.

William Koshak/Marshall Space Flight Center
Indicators Derived From TRMM/LIS Satellite Lightning Observations

Lightning observations from the Tropical Rainfall Measuring Mission (TRMM) satellite Lightning Imaging Sensor (LIS) will be used to obtain important lightning-based indicators for the National Climate Assessment (NCA). This effort complements and expands upon a NCA effort already in progress by the PI (Koshak) that employs national ground-based lightning detection network data to track various characteristics of cloud-to-ground (CG) lightning, and its impacts. Because LIS observations provide total lightning (i.e., both CGs and cloud flashes) extending back to 1997, our proposed effort will provide a more comprehensive assessment of the coevolution of global temperature, lightning, and adverse lightning-caused impacts on the US. According to a conservative estimate in the literature, a 40 Â± 14 % increase in total lightning is anticipated per 1 degree C average land wet-bulb temperature change. Moreover, increasing global temperatures have the potential to produce not only more thunderstorms, but more intense thunderstorms across the US. Total lightning observations provided by TRMM/LIS are well-suited to observe these fluctuations across the southern half of the country (the southeastern portion of which contains the most lightning in the US). In addition, lightning nitrogen oxides (LNOx) indirectly influences our climate since it controls the concentration of ozone and hydroxyl radicals in the atmosphere, and since it is the most important source of nitrogen oxides in the upper troposphere. In turn, the distribution of ozone forcing can have a substantial influence on regional rainfall patterns.

The LIS-based indicators that we will monitor and trend include the Lightning Frequency Indicator (LFI) and the Lightning NOx Indicator (LNI). The LNI depends on flash frequency, flash area, and flash brightness; increases in any of these three variables imply an increase in LNOx production. The information provided by the LNI will be augmented using detailed regional estimates of LNOx obtained from the NASA MSFC Lightning Nitrogen Oxides Model (LNOM) data archive. The application of these key indicators in this proposed effort represents a high priority to the NCA and is a low hanging fruit.□

We will also monitor/trend two additional indicators that are derived by combining national CG lightning data with rainfall measurements from the national radar mosaic. The first indicator is the Intense Convection Indicator (ICI). By definition, we say that intense convection occurs whenever the product of total rainfall (in millimeters) and total number of CG strokes exceed a certain threshold for a specified grid cell and period. It allows us to monitor, by proxy, the evolution of the number of intense thunderstorms that are often, but not necessarily, accompanied by floods, hailstones, and tornados. The second indicator is the Dry Lightning Indicator (DLI). It is computed for each grid cell and period by dividing the total number of CG strokes by the rainfall amount (when the rainfall amount is below a specified value). Since dry lightning (i.e., CG lightning accompanied by little or no rainfall) is important to wildfire ignition, the trending of the DLI will be of value to decision makers in the Forestry sector.

Kyle McDonald/The City College of New York
Development of Integrated Land Surface Water State Indicators for Climate Assessment

The transition of the landscape between predominantly frozen and non-frozen conditions in seasonally frozen environments impacts climate, hydrological, ecological and biogeochemical processes profoundly. This abrupt transition occurs each year over roughly 50 million km2 of the Earth's terrestrial surface at high northern latitudes. Major landscape processes closely linked to freeze/thaw (FT) state include timing and spatial dynamics of seasonal snowmelt and associated soil thaw and release of nutrients in plant available form, runoff generation and flooding, ice breakup in large rivers and lakes, timing and length of vegetation growing season and associated productivity and trace gas exchange. The timing of seasonal thawing and snowmelt in spring also coincides with the onset of the growing season and influences boreal ecosystem sink activity for atmospheric CO2. Water and energy cycles are strongly linked in seasonally frozen environments.

A warming of the terrestrial summer in the Arctic correlates with a lengthening of the snow-free season due to changes in the energy fluxes. Changes snowmelt dynamics in freeze-thaw dominated basins will create powerful terrestrial amplification to warming Arctic regions.

Accurate characterization of seasonal freeze/thaw transition timing coupled with accompanying characterization of snowpack water content, surface inundation, and radiation balance give the potential for an unambiguous indication of climate change.

We propose the development of a set of climate indicators built upon remote sensing measures of surface water state variables: Landscape freeze/thaw (FT), Snow Water Equivalent (SWE), Surface inundation fraction (Fw), and radiative flux. Combined, these state variables provide unique insight into linkages and feedbacks in terrestrial energy, water and carbon cycles and allow examination to the response of the integrated system to climate drivers.

This effort will provide the first observationally-based assessment of its kind, between surface water state and climate, based on remote sensing datasets across basin to continental scales. The indicators we will derive will be determined directly from remote sensing datasets assembled under our Team's prior and on-going NASA research and coupled with datasets available from NASA archives.

We will report these variables, their seasonal and interannual variability and multi-year trends as appropriate to each indicator. Applying multivariate analysis, we will investigate and report correlations between the measures and associated variability and trends in the correlations. We will extend this effort to assess large drainage basins in the Arctic (Yukon and McKenzie Rivers), wherein local water balance fluxes will be united with riverine transport, discharge and heat flux, and validation using monitored river discharge and temperature from USGS and Canadian sources.

Jianhua Qian/University of Massachusetts Lowell
Frequency of Winter Weather Regimes in the US Northeast as an Indicator for National Climate Assessment

The NASA Modern-Era Retrospective analysis for Research and Application (MERRA) data will be used for a long-term daily weather typing (WT) analysis for the US Northeast (NE). The focus of the WT analysis is on the frequency of the east coast winter weather regimes, especially the extreme northeasters (nor'easters), which affect many socio-economic sectors in the region. The frequency of specific weather regimes (WT index) can be used for weather hazard risk assessment and energy usage assessment.

The seasonal mean climate in the east coast of US is determined by the frequency, position and intensity of various weather regimes. We will use an automated k-means clustering method to analyze the daily data of MERRA reanalysis from 1979-present to check the variability and change in the WT index. The Intergovernmental Panel of Climate Change (IPCC) reported that global warming is more dramatic in higher latitudes than in the tropics, which therefore acts to not only increase absolute moisture in the atmosphere but also reduce atmospheric baroclinicity in terms of the equator-pole temperature gradient. Consequently, the location of storm tracks (which depends on the temperature gradient), both the east coastal storm track to the northwest of the Gulf Stream and the frontal storm track across the mid-latitude of North American Continent, could also be changed. Accordingly, this would induce change of climate zones and the timing of season. The proposed study will analyze these WT variability and change and their impacts in the cold season (October-April).

The variability and change of weather regimes directly impact people's daily lives, especially in the natural hazard risk management in the metropolitan areas on the east coast of US. Nor'easter is one type of extreme weather regime that frequently affects this region. The proposed study of WT analysis by using the MERRA reanalysis data will produce information on the frequency of the weather regimes, especially the extreme ones, in NE as an indicator for NCA.

Daily energy usage is found to be dependent on weather (clouds, temperature, etc.). The daily weather regimes obtained in this study will be compared to the daily energy usage data (currently available) to study the weather and climate impacts on the energy industry. Averaged daily energy usage corresponding to each weather types will be analyzed by composite analyses. Long-term variability and change in energy usage will also be examined by using the WT index.

Alex Ruane/NASA Goddard Institute for Space Studies
The Agricultural Productivity Indicator Analysis System (APIAS): Tracking the Agricultural Impacts of Climate Variability and Change

The National Climate Assessment will benefit from an indicator directly assessing and tracking the effects of climate change and climate variability on US agriculture, a critical sector of the US economy and global food system that is uniquely susceptible to climate impacts. While policymakers are working to manage associated risks, long-term planning is hindered by the high number of confounding stresses that affect reported agricultural production each year. The proposed research will use NASA models and missions to produce the Agricultural Productivity Indicator Analysis System (APIAS), consisting of a high resolution gridded crop model (parallel DSSAT, or pDSSAT) driven by a coordinated set of observed and constructed climate normals:

Climate Normal A (Observations): The previous 30 growing years of daily climate using a bias-corrected version of the NASA Modern-Era Retrospective-Analysis for Research and Applications (MERRA). Output from a pDSSAT simulation output driven by this climate normal forms the core indicator of simulated crop production. Analysis allows the previous year to be placed in the context of the current climate normal and enables examination of regional performance and climate-induced trends.

Climate Normal B (Smoothed Observations): The previous 30 growing years of daily climate smoothed to remove sub-seasonal climate variability and extreme events but maintaining mean radiation, mean temperatures, and seasonal rainfall totals. By comparing this indicator to the indicator above we can determine the effects of sub-seasonal climate variability and extremes in comparison to the signal of mean climate change and major modes of interannual variability.

Climate Normal Set C (GCM Scenarios): A subset of climate scenarios generated by combining observations with changes projected by CMIP5 climate models to represent the preceding 30-year climatology and the upcoming 30-year climatology. A comparison of these indicators (and the trend between the two periods) to the observed record places recent agricultural events and trends in the context of past and near-future climates, allowing an assessment of the changing probabilities of events and the performance of climate model projections against the observed trends.

APIAS' open and transparent framework will 1) enable an investigation of direct climate impacts on the production of major commodities at county, regional, and state levels; 2) identify hot spots for proactive adaptation; 3) elucidate uncertainties in agriculture and climate models for a wide variety of stakeholders, policymakers, and end-users; and 4) provide a firm basis for climate impact and attribution analyses in the agricultural sector.

Steven Running/University of Montana

Translating EOS Datasets Into National Ecosystem Biophysical Indicators

In 2007, while on the IGBP Science Committee, I originated the idea of building what became the IGBP Climate Change Index as a means to translate the raw scientific data into a more palatable and accurate but simplified metric for the public and policy makers. In the last 5 years I have spend alot of time thinking about how best to do this. Concurrently I have been evaluating what variables are both of climate significance, as a forcing or an impact, and how good are the datasets that represent each one. I think since NASA is the leader of developing new biophysical geospatial datasets, that we should prototype national indicator maps, and see how well they are accepted by the larger National Assessment community. So I propose to use some of our existing MODIS land datasets to build test maps. I have found maps of biophysical data are most easily interpreted when they are a relative anomaly, or departure from normal rather than some absolute measure in awkward or unfamiliar units. A well built anomaly map would implicitly define normal as the 0 point, with departures above or below normal that are deemed significant colored in clearly opposing colors. The width of the 0 point implies non-significant variability.

So I propose to use the ongoing 12+ year MODIS record to build anomaly maps in identical format for annual:

Spectral vegetation index anomaly, NDVI or EVI

LAI

NPP

Evapotranspiration

Growing season length

Snowcover duration

% forest disturbed by fire, insect epidemics or other mortality

It is important to evaluate each year, and each pixel on the basis of what would be normal. Now that we have 12yr of MODIS record we can compute a 12 average for each pixel/variable, then in forward processing measure the current year against this normal. The audience then can easily understand if the current year is above or below average for each metric.

Scott Sheridan/Kent State University
Development of a Water Clarity Index for the Southeastern U.S. as a Climate Indicator

Coastal ecosystems of the Southeastern United States are sensitive and inherently linked to acute and long-term perturbations in climate. This is evident in the environmental responses to various weather-related events that affect the region such as heat waves, cold air outbreaks, tropical cyclones, and other heavy precipitation events. These phenomena affect many aspects of water quality across the Gulf, including transport, rapid cooling, eutrophication, and resuspension in shallows such as Florida Bay, and land gain/loss along the Louisiana coast. Of remotely sensed variables, water clarity, as measured by the light diffuse attenuation coefficient (Kd), can be considered to be one of the most fundamental indicators of ecosystem health. However, although Kd is available from existing satellite ocean color products, there is a lack of effective means to interpret and use it at synoptic coastal scales, especially on how to link it to climate variability. Hence, the proposed objectives of this research are:

1) To develop a multi-decadal indicator of water clarity (Kd index) for the coastal waters of the Gulf of Mexico and Florida's Atlantic coast,

2) To assess how high frequency (daily- weekly) perturbations and long-term changes in atmospheric conditions (circulation patterns, weather types, and precipitation events) are associated with variability in the Kd index , and

3) To develop an empirical-based moving estimate of water clarity and light stressed conditions for purposes of tracking and monitoring critical changes in coastal regions and assessing impacts on light-sensitive species (corals, seagrass).

Moderate resolution (1-km) ocean color data from SeaWiFS (1997 - 2010), MODIS/Aqua (2002 - present), and Coastal Zone Color Scanner (1978-1986) will be used to derive validated Kd data products, from which the water clarity index will be derived for each of several pre-defined coastal regions. Atmospheric circulation patterns, defined through synoptic climatological methods, weather type classifications, and historical precipitation records will all be used as metrics of climate change and variability within the region.

Research currently in progress is being conducted to establish associations between dominant synoptic weather patterns and ocean color around South Florida. The development of the relationship between water clarity along the Southeastern US coast and atmospheric conditions over the period of available data is expected to show both short-term fluctuations as well as long-term trends. These connections will provide an understanding of where the Kd-climate relationship is strongest to isolate areas in the Southeast sector where historical and future changes in light conditions would likely result in substantial impacts to light-sensitive species (corals, seagrass). They will also aid in the tracking and monitoring of light stress thresholds and exceedance over defined limits applicable to both the science and management end user communities as well as provide a meaningful indicator for assessing climate impacts on the coastal environment.

Harry Stern/University of Washington, Seattle

The Timing of Arctic Sea Ice Advance and Retreat as an Indicator of Ice-Dependent Marine Mammal Habitat

The Arctic is widely recognized as the front line of climate change. The Arctic sea-ice cover is shrinking and thinning, with total disappearance of summer sea ice projected to occur in a matter of decades. These changes are already impacting ice-dependent marine mammals, which depend on the sea-ice cover as an integral part of their existence.

We propose to use daily sea-ice concentration data (generated by the NASA Team algorithm from satellite passive microwave instruments) to develop and test potential indicators of changes in Arctic marine mammal habitat based on the timing of sea-ice retreat in spring and advance in fall. The steps of the method are: (1) Define a region. (2) Calculate the daily sea-ice area (km2) in the region (1979-present). (3) Select a sea-ice area threshold (km2) roughly halfway between the summer minimum and winter maximum over a baseline period. (4) Pick off the date each spring when the sea-ice area drops below the threshold, and the date each fall when the sea-ice area rises above the threshold. The result is two time series for each region: the date of spring transition each year, and the date of fall transition each year. The spring and fall sea-ice transition dates derived in this manner go back in time more than 30 years. We will focus on regions that are biologically important to Arctic marine mammals such as the North Water polynya, narwhal summering and wintering grounds in Baffin Bay, walrus habitat in the Chukchi and Bering seas, key polar bear habitat, and shallow continental shelf regions.

As part of developing our timing indicators, we will conduct two ecological case studies, one involving the migration of beluga whales from the north coast of Alaska to the Bering Sea in fall, and one involving the dates when polar bears in Baffin Bay arrive on land in the spring and return to the sea ice in the fall.

We will use output from several Global Climate Models (GCMs) that participate in the Coupled Model Intercomparison Project Phase 5 (CMIP5), in preparation for the IPCC Fifth Assessment Report, to compute our sea-ice indicators and assess the future impact on Arctic marine mammals over the next several decades.

Our sea-ice timing indicators will be useful to many groups of people, such as wildlife managers, indigenous hunters, shipping companies, fishermen, cruise-ship operators, oil and gas exploration companies, sea-ice researchers, and marine mammal biologists. We will make our indicators broadly available. The indicators possess all the proposed qualities of physical indicators set forth in a recent National Climate Assessment report, and the sea-ice data on which the indicators are based are certain to be available long into the future. The data products we produce will be archived at the National Snow and Ice Data Center (NSIDC) Distributed Active Archive Center (DAAC).

The involvement of a graduate student in this project meets NASA's objective of increasing the pool of assessment-capable early career scientists, and the project builds on our current and previous NASA-funded work.

Daniel Tong/George Mason University
Development and Testing of a Dust Indicator for Climate Assessment in the Western United States

Dust activity is an important indicator to regional climate change. The Dust Bowl in the 1930s was the largest natural catastrophe in the North America history, caused by extended drought and poor land management. Although the severity and duration of the 1930s drought was exceptional, reconstructed paleo-climatic records show that the central U.S. plains have experienced severe droughts about once or twice a century over the past 400 years. Dust record is hence an integral component of the national climate assessment. The objectives of this proposed work are: 1) to develop a climate-quality indicator of local windblown dust storms in the U.S.; 2) to test and validate the dust indicator data using NASA satellite dust detection and model products; and 3) to assess the status and long-term trends in the dust indicator at local, regional and national levels.

We propose to develop and test a 30-year dust activity indicator for the western United States and to fully participate in the NASA indicator system team initiative. For the arid and semi-arid regions of the western United States, we have developed a novel approach to identify local windblown dust events through routine ambient aerosol monitoring. This proposed work will use the dust identification algorithm from Tong et al. (Atmos. Chem. Phys., 2012) to develop a dust storm dataset (dust indicator), and rely on satellite dust detection and model dust prediction as independent data sources to test, cross-check and validate the dust indicator. The proposed work consists of three major research activities, indicator development, satellite-based validation, and model-based validation. The first one is to develop a dust indicator dataset using the IMPROVE ground observations and the dust identification algorithm. The output of this step will be tested using either satellite dust data or GOCART dust model prediction, depending on the results of cloud screening and other constraints of the satellite products.

The proposed work will extend our research capabilities to contribute developing new climate indicators that are especially aimed at needs of local environmental managers in the Southwestern communities. The success of this proposed project will create a practical dust indicator to inform local decision-makers in the Southwest of current status and trends of duct activity within their own jurisdiction and beyond through regionally coordinated mitigation and adaption planning. The proposed work will benefit the scientific community by providing a rigorously validated local dust dataset suitable for evaluating model prediction and validating satellite aerosol products. The long-term trends in the dust indicator will advance our knowledge of changes in an important climate variable.

The proposed work falls clearly within the areas delineated in the 2011 NASA Strategic Plan. It will develop and test a new climate indicator, by extensively utilizing NASA satellite and model data, for future national climate assessments. Outcomes from this work could be immediately integrated with other indicators in the NCA system to support the 2013 national climate assessment. The public and local/state government managers will benefit from the improved dust indicator information relevant to decision-making about climate change and air quality, so that the advances in Earth system sciences can be utilized at local governments to meet the challenges of climate and environmental change.

Stephanie Weber/Battelle Memorial Institute
Using NASA Earth Science Datasets for National Climate Assessment Indicators: Urban Impacts of Heat Waves Associated with Climate Change

This project will draw on NASA Earth science datasets and other physical and socioeconomic data to help urban governments assess: How vulnerable is our city's population to increasing heat waves associated with climate change?

Heat waves have been increasing globally in the past 5-10 years and are projected to continue increasing throughout the 21st century. The vulnerability of a city's population to heat waves reflects exposure to extreme heat events, sensitivity of the population to impacts, such as adverse health effects, and adaptive capacity to prepare for and respond to heat waves. Vulnerability can be assessed at the city level and also comparatively among different parts of a city. For example, some sub-populations are less resilient to heat waves than others, such as the elderly, the very young and the economically disadvantaged. In addition, vulnerability to heat waves is exacerbated by the non-climate stressor of urban heat islands (UHIs). As noted at the NCA Indicators Workshops, socially and economically vulnerable populations are especially at risk to the impacts of heat waves, due to increasing energy costs, air pollution, and heat-related illness and mortality.

The project team will engage urban stakeholders in a process to develop a set of vulnerability indicators that are focused on heat waves in urban areas. The objective of this proposed work is to elucidate for urban governments the degree to which heat waves are changing, the real-life impacts of heat waves on urban populations, and the effectiveness of adaptation actions to reduce urban temperatures. The proposed approach integrates physical, ecological, and socioeconomic information into a set of five related indicators that address vulnerability. Based on stakeholder engagement in a 1st pilot city, the indicator methodology will be finalized and then implemented for the 1st pilot city and a 2nd pilot city as a test of scale-up.

The project team will utilize the following datasets in the development of the heat wave indicators:

- Land surface temperature from Aqua/MODIS,

- Land cover from Terra and Aqua/MODIS, to delineate urban areas,

- NDVI from Aqua/MODIS, to assess greenness as a cooling mechanism,

- Socioeconomic datasets from NASA SEDAC, such as U.S. Census grids, to identify disadvantaged/vulnerable groups,

- National Weather Service (NWS) Heat Advisories/Warnings, to help define city context-specific heat waves,

- U.S. EPA's UHI Community Actions Database, to identify and test adaptation programs to boost resilience, and

- Urban ozone levels from U.S. EPA's Air Quality System.

The proposed set of 5 indicators includes:

Exposure indicators:

- Urban Heat Wave Indicator: Heat index degree days in a single summer for heat waves defined by NWS Heat Advisories and Watches/Warnings

- Urban Heat Island Indicator: Difference between average urban and rural LSTs during heat waves

- Air Quality Indicator: Daily 8-hr maximum metropolitan O3 values during heat waves

Sensitivity indicator:

- Urban Socioeconomic and Hotspot Indicator: Classification of sensitivity of census block groups based on socioeconomic census and urban greenness data

Adaptive capacity indicator:

- Urban Adaptation Effectiveness Indicator: Measured reductions in LST or increases in NDVI in neighborhoods related to UHI reduction measures

The scale for each indicator will be categories of equal intervals, which will reflect both absolute values and trends with reference to a baseline period. The proposed work demonstrates the value of NASA Earth science data for societal benefit in a scientifically rigorous manner; combines the social, ecological and physical aspects of climate change impacts and vulnerability; focuses on impacts that matter to people; highlights positive actions that can boost resiliency; and is grounded in stakeholder participation at the appropriate (urban) level.