PHENOLOGY RESEARCH AND OBSERVATIONS OF SOUTHWEST ECOSYSTEMS SYMPOSIUM (PROSE)

U.S.A. National Phenology Network (USA-NPN) &
Southwest U.S. Region, American Society of Photogrammetry & Remote Sensing (SW-ASPRS)

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University of Arizona, Tucson, AZ

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PHENOLOGY, ECOLOGY, AND ECOSYSTEM FUNCTION: COMBINING MULTIPLE OBSERVATIONS USING SIMPLE MODELS

Phenology is an expression of ecological synchrony, a key indicator of climatic change and an important control of land atmosphere exchange and other ecosystem services. Metrics to track phenology are varied and often different techniques are used to answer research questions in ecology. As we begin to organize data on Phenology from disparate sources we are challenged to extract information from a range of measurement platforms. One method to combine multiple data types is to fuse data with models using data assimilation techniques. I will present some initial findings using flux observations, sap flow and remote sensing measurements to constrain simple models and highlight some of the opportunities presented by combining multiple phenology indicators into models

BIO

David Moore is a broadly trained plant ecologist and ecosystem scientist. His research centers on the changing role of forests in the carbon cycle and the controls of carbon use and allocation in plants and ecosystems. His research uses a broad range of observation types from ground measurements to satellite remote sensing and focuses of time series of ecosystem processes and the timings of transitions between ecosystem states both seasonally and interannually. After receiving his undergraduate degree in Botany at University College Dublin, David worked for the National Parks and Wildlife Service in Ireland, carrying out biological inventories of the stoney beaches of the Irish coast. He received his PhD from the University of Illinois working primarily at the Duke Forest Free Air Carbon dioxide Enrichment experiment in Chapel Hill, NC. In 2006/07 David was a postdoctoral researcher in Boulder, CO at the Co-operative Institute for Research in Environmental Science (CIRES). During that time he worked both at the University of Colorado and the National Center for Atmospheric Research (NCAR) where he worked on integrating data from an eddy flux tower into an ecosystem model and also on the Airborne Carbon in the Mountain Experiment. He took a faculty position at King's College London in 2007 until 2011 and served as a visiting scientist to the Data Products group at the National Ecological Observatory Network in 2010/2011 before joining the School of Natural Resources and Environment at the University of Arizona in 2011.

ABSTRACTS OF PRESENTED PAPERS

(LISTED ALPHABETICALLY BY FIRST AUTHOR)

LONG-TERM REPRODUCTIVE PHENOLOGY IN THE CHIHUAHUAN DESERT LINKING LEGACY AND CONTEMPORARY DATASETS

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Arid and semi-arid regions of the southwestern USA are especially sensitive to changes in temperature as well as drought frequency and intensity. Phenology is an integrated and salient indicator of plant responses to climate change. We examine an 18-year dataset of monthly observations of reproductive phenology for three species of perennial grasses (*Bouteloua eriopoda*, *Sporobolus flexuosus*, and *Muhlenbergia porteri*) and one deciduous shrub (*Prosopis glandulosa*) on the Jornada Basin Long Term Ecological Research (LTER) site in southern New Mexico, USA. We compare and contrast timing and duration of flower and fruit production for the three grass species with the co-existing shrub that has historically displaced grasses in this system (*P. glandulosa*). We examined field observations of reproductive phenology made monthly along two 75-m x 1-m belt transects to yield counts of individual plants in each of five phenophases: (1) dormant, (2) leaf-out with no reproductive structures, and producing (3) flowers, (4) seeds, or (5) fruits for each species/site combination. The appearance of first fruit for grasses occurred consistently in August or September, although the number of plants producing fruit was highly variable from year to year. *P. glandulosa* demonstrated remarkable synchrony in the production of first leaves (in April), flowers (in May), and fruit (in June) across four sites. The appearance of first fruit and peak fruit production was most often in the same month for *P. glandulosa* and *S. flexuosus*. The time from first to peak fruit production in *B. eriopoda* was one month at two sites and in the same month at a third, suggesting local variability in rainfall or soil moisture dynamics may play a role in peak fruit production. To bridge LTER monthly data on reproductive phenology with phenology observations at finer temporal resolutions, we are performing a cross-walk of monthly LTER observations with observations using NPN protocols conducted weekly and pheno-cam greenness indices captured daily. We present our study design as an expansion to the Jornada LTER phenology study protocol that could be extended to other sites within the LTER network to facilitate improved predictions regarding plant responses to changes in climate.

CHANGES IN SPRING AND SUMMER FLOWERING SEASON DURATION ACROSS AN ELEVATION GRADIENT

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Recent investigations of plant phenology have focused not only on the start of season or particular phenological events, but also the length of the growing season. The duration of the season has important implications for food availability, water and nutrient cycling, carbon sequestration, and bird and insect demography. The lengthening of the growing season expected for most locales and the potential shortening of the season in other ecosystems under global warming is likely to have wide-ranging consequences. We explored the duration of spring and

summer flowering seasons across an elevation gradient ranging from desert scrub to pine forest in southeastern Arizona. Approximately 15% of plant species evaluated showed a trend toward a shorter spring season; these species occurred almost exclusively at low elevations. The shorter season was due, in most cases, to a later start to the spring season. Nearly 25% of species evaluated showed a significant change in the duration of the summer season. At low elevations, the trend was almost exclusively in the direction of a decrease in the length of the season, and defined by the end of the summer season occurring sooner. At high elevations, the trends were toward a lengthening of the season, resulting from a progressively later end of the season. This study will highlight how the overall length of season is controlled by different climatic mechanisms at the beginning and end of the seasons.

A Remote Sensing Approach to Drought Monitoring to Inform Range Management at the Hopi Tribe and Navajo Nation

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The Hopi Tribe and Navajo Nation are situated in the northeastern corner of Arizona in the lower Colorado River basin. For more than a decade, the area has faced extensive and persistent drought conditions that have impacted vegetation communities and local water resources while exacerbating soil erosion. Moreover, the droughts threaten ecosystem services, agriculture, and livestock production activities, and make this region sensitive to interannual climate variability and change. The purpose of this research is to employ remote sensing data to monitor drought and inform management and decision-making. A drought assessment framework is being developed that integrates land cover, climate, and topographical data with land surface remote sensing time series data. The main goal of this framework is to better understand the existing seasonal and inter-annual relationships between climate variability and vegetation dynamics. Land surface Normalized Difference Vegetation Index time series data derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) from 2001 to present were analyzed to characterize the seasonal phenology and interannual vegetation response to environmental factors, with an emphasis on different vegetation communities. Satellite-derived land surface phenology shows significant relationships in response to elevation gradients, temperature, and precipitation. This change is more prominent at intermediate elevations.

Response of Urban and Non-Urban Land-Cover in Semi-Arid Ecosystem to Summer Precipitation Variability

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Vegetation response to precipitation variability is an important climate-ecosystem-hydrology feedback. Anthropogenic impacts coupled by changes in seasonal and annual precipitation patterns can have a dramatic and large spatial effect on ecosystem structure and functioning, especially in water limited environments. While the natural Sonoran desert is water limited, Phoenix metropolitan area is constantly being irrigated to support human activities. The aim of this research is to study how urban areas differ from their natural surroundings ecosystems in their phenology and response to summer water inputs. Rain use efficiency (RUE), inter-annual and intra-annual vegetation phenology and above-ground net primary production (ANPP) of the

two land cover types and their response to summer precipitation have been analyzed. In addition, a soil water balance model is used to simulate the Horton index as a measure land cover response to climate variability. Results show that the urban environment has a year round constant, high productivity with high variability in RUE. The desert has lower productivity and responds strongly to summer water. Furthermore, the desert ecosystem convergences towards H=1 and RUE ~ 133 MJ/M2*hour mm-1. Based on the RUE and ANPP it was calculated that 295 mm of water input are necessary to sustain the urban tree biomass. Unlike natural ecosystems, urban areas RUE do not converges to a common maximum value, suggesting that inter annual variability in hydrological partitioning over urban and desert land-cover is consisted with the water use efficiency concept.

PHENOLOGICAL SYNCHRONY AND SEASONAL NICHE BREADTH OF MIGRATORY BIRDS ON THE LOWER COLORADO RIVER

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Predicting global species distributions for conservation requires detailed knowledge of habitat requirements based on niche dimensions, a challenge for migratory species with biogeographically complex life cycles. Annual survival for millions of songbirds requires successful migration involving en route stopover sites. To select high quality stopover habitats, birds may rely on valid cues of food availability such as phenological synchronies between vegetation and invertebrate prey. We tested predictions of the Phenological Synchrony and Seasonal Niche Breadth Hypotheses to examine relationships between migrant abundance, vegetation phenology, foraging substrates, niche breadth, and drought during spring migration along the lower Colorado River in southwest USA. The temporal distribution of migrant abundance and proportional foraging substrate use closely tracked flowering of willow and mesquite species. Peak migrant abundance coincided with narrowest niche breadth and a phenologically synchronized habitat shift from willow to mesquite. The slope of the correlation between migrant abundance and tree flowering was greater and niche breadth was broader in years with increasingly severe drought. Continued aridification of the southwest could severely disrupt trophic phenological synchronies. The capacity of migratory species to adjust will depend on phenotypic plasticity and how future changes exceed the historic range of variability.

IDENTIFYING SPATIAL AND TEMPORAL STRUCTURE TO SCALE UP CARBON DIOXIDE FLUXES IN DRYLANDS

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The development of spatially-distributed models of carbon dioxide flux using remote sensing data is a rapidly evolving avenue of research. Validation of these models requires linking remote sensing data to ground measurements of carbon dioxide exchange, generally collected by eddy covariance towers. In dryland environments, this link is complicated by spatial heterogeneity in land cover and temporal variability in vegetation activity and soil moisture. Our study considers the relationship between vegetation indices and carbon flux at a shrub-dominated site in central New Mexico. We find that vegetation greenness is highly variable throughout the study area—indicating spatial heterogeneity in land cover—and that the region near the tower is not strongly

correlated to tower fluxes. In order to better understand that spatial heterogeneity, we compare trends both in MODIS and Landsat imagery. We then examine the connections between regions of higher correlation and the tower area for patterns in space and time associated with vegetation distribution, phenology and soil moisture. We determine that the variability in the vertical distribution of soil moisture identifies the relationship between vegetation greenness and carbon uptake via photosynthesis. By applying finer-resolution remote sensing data, we classify particular regions that have similar vegetation structure to the tower area, and thus are appropriate areas for scaling the tower flux measurements.

REMOTE SENSING PHENOLOGY FOR INVASIONS: A CHALLENGE AND AN OPPORTUNITY

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The most problematic invasive plant species alter ecosystem structure, function, and/or disturbance regimes, often by exhibiting phenology distinct from the native ecosystems they are invading. While distinct phenologies may present opportunities for mapping via remote sensing, heterogeneous precipitation patterns in drylands confound efforts to map invasions based on phenology. We examined 94 cloud-freeLandsat TM scenes over 11 years to identify the optimal dates for discriminating between *Pennisetum ciliare* (buffelgrass) and uninvaded areas on the south slope of the Santa Catalina Mountains. We used ground observations, aerial photography, and AVIRIS to create a high spatial resolution map of *P. ciliare* in 2003. We calculated principal components transforms and normalized band ratios for each cloud-free scene as well as the slope of each variable between each sequential date to characterize relative change. We used Random Forests to create predictive models of *P. ciliare* cover and measured variable importance for each model. Models had good performance overall (R2=0.83). Three of the four most important variables were tied to a single date (8-14-2007) and eight of the ten most important variables were tied to the summer monsoon. The landscape bracketing the 8-14-2007 date was characterized by low baseline greenness followed by rapid greenup and senescence than uninvaded areas. Moreover, the landscape exhibited a synchronized greenup and senescence pattern that lacked in other monsoon TM series (e.g., May-September, 2003, and June-August, 2006). Our results indicate that *P. ciliare* phenology is distinct from native phenology and that landscape-scale synchronization occurs (albeit infrequently), enabling limited opportunities for mapping on a landscape scale with moderate resolution multispectral sensors such as Landsat TM.

EFFECTS OF LAND USE DYNAMICS AND ENVIRONMENTAL TRENDS ON THE TIMING AND MAGNITUDE OF PHENOLOGICAL STAGES IN ARID AGRO-ECOSYSTEMS OF NORTHWESTERN MEXICO

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Examining how key environmental factors control and trigger phenological cycles will improve our understandings of vegetation responses and dynamics for different land cover types in arid ecosystems. La Costa de Hermosillo (LCH) is an arid agro-ecosystem located in central-eastern Sonora, Mexico where the overexploitation of resources (primarily groundwater), resulted in the

abandonment of large expanses of agricultural lands. To address the ecological degradation posed by these abandonments, current governmental policies subsidize restoration efforts in order to rehabilitate these areas. In this study, we assess the effect of land cover types and key climatic factors and restoration treatments on three phenometrics (two timing and one greenness). We extracted and processed 16-day NDVI time series data from the Moderate-resolution Imaging Spectroradiometer (MODIS) between 2000 and 2010 for LCH to derive the phenometrics for each year using TIMESAT software. We also used climatic variables (seasonal precipitation and temperature) and thematic land cover maps, to assess the impact on phenological response. We constructed a Multiple Linear Regression (MLR) model using six land cover types to elucidate the most influential climatic factors that drive phenology. We also analyzed the difference in the phenological response among land cover types. Based on our findings, we identified that timing and greenness vary among land cover types as a consequence of the differences in vegetation structure and plant species. We also derived general phenological models based on the environmental variables that significantly explained vegetation responses for each of the land cover types. The use of remote sensing based data and methodologies constitutes an efficient way to assess the most adequate management practices (such as restoration methods applied to abandoned fields).

Mapping Landscape Phenology Preference of Yellow-billed Cuckoo with AVHRR Data

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The yellow-billed cuckoo (*Coccycus americanus occidentalis*) is a neo-tropical migrant bird that travels north from South America into the southwestern United States during the summer to nest. In Arizona, favored riparian forest and woodland nesting habitat has declined in recent decades, due primarily to human activities and the prolonged drought conditions. As a result, western yellow-billed cuckoos have been petitioned for possible listing under the Endangered Species Act. In this study, we map yellow billed cuckoo habitat in the state of Arizona using the temporal greenness dynamics of the landscape, or the landscape phenology. Landscape phenometrics were derived from Advanced Very High Resolution Radiometer (AVHRR) satellite Normalized Difference Vegetation Index (NDVI) composite data using Fourier harmonic analysis. Applying Fourier analysis to the waveform composed of the 26 annual composite NDVI values produces phenometrics related to the overall vegetation amount, variability and timing. Field data on Cuckoo presence were obtained from 1998 surveys conducted by Northern Arizona University, the Arizona Game and Fish Department (AGFD) and the U.S. Geological Survey. To focus the research within probable landscapes, an AGFD vegetation map (derived from the Arizona GAP program) was used to extract polygons of riparian vegetation and cottonwood-willow riparian vegetation. To create the models, we coupled the satellite phenometrics with field data of cuckoo presence or absence and with points sampling the entirety of mapped riparian and cottonwood-willow vegetation types. Statistical tests reveal that locations with cuckoos present are landscapes with greenness that is significantly more variable and that peaks significantly later than locations in average riparian vegetation, average cottonwood-willow vegetation, or with cuckoos absent. Models developed from the 1998 parameters and applied to 1999 data were effective at predicting cuckoo presence for survey locations visited in 1999, with up to 64 percent of cuckoos located in the highest preference class.

PHENOLOGY AS A TOOL FOR SCIENCE, MANAGEMENT AND EDUCATION IN A CHANGING ENVIRONMENT: THE USA NATIONAL PHENOLOGY NETWORK

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The USA National Phenology Network (USA-NPN; www.usanpn.org), established in 2007, is a national science and monitoring initiative focused on phenology as a tool to understand how plants, animals and landscapes respond to climatic variability and change. Core functions of the National Coordinating Office (NCO) of USA-NPN are to provide a national information management system including databases, develop and implement internationally standardized phenology monitoring protocols, create partnerships with a variety of organizations including field stations for implementation, facilitate research and the development of decision support tools, and promote education and outreach activities related to phenology and climate change. This presentation will describe programs, tools and materials developed by USA-NPN to facilitate science, management and education related to phenology of plants, animals and landscapes within protected areas at local, regional and national scales. Example tools and materials include databases, user interfaces, web services, support materials for partnership development, communication, education and outreach. Particular emphasis will be placed on the on-line integrated animal and plant monitoring program, Nature's Notebook, which provides standardized protocols for phenological status monitoring and data management for over 500 animal and plant species.

ABSTRACTS OF PRESENTED POSTERS
(LISTED ALPHABETICALLY BY FIRST AUTHOR)

VIP DATA EXPLORER: A TOOL FOR EXPLORING 30 YEARS OF VEGETATION INDEX AND PHENOLOGY OBSERVATIONS

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Continuous acquisition of global satellite imagery over the years has contributed to the creation of long term data records from AVHRR, MODIS, TM, SPOT-VGT and other sensors. These records account for 30+ years, as these archives grow, they become invaluable tools for environmental, resources management, and climate studies dealing with trends and changes from local, regional to global scale. In this project, the Vegetation Index and Phenology Lab (VIPLab) is processing 30 years of daily global surface reflectance data into an Earth Science Data Record of Vegetation Index and Phenology metrics. Data from AVHRR (N07,N09,N11 and N14) and MODIS (AQUA and TERRA collection 5) for the periods 1981-1999 and 2000-2010, at CMG resolution were processed into one seamless and sensor independent data record using various filtering, continuity and gap filling techniques (Tsend-Ayush et al., AGU 2011, Rivera-Camacho et al, AGU 2011). An interactive online tool (VIP Data Explorer) was developed to support the visualization, qualitative and quantitative exploration, distribution, and documentation of these records using a simple web 2.0 interface. The VIP Data explorer (http://vip.arizona.edu/viplab_data_explorer) can display any combination of multi temporal and multi source data, enable the quickly exploration and cross comparison of the various levels of processing of this data. It uses the Google Earth (GE) model and was developed using the GE API for images rendering, manipulation and geolocation. These ESDRs records can be quickly animated in this environment and explored for visual trends and anomalies detection. Additionally the tool enables extracting and visualizing any land pixel time series while showing the different levels of processing it went through. User can explore this ESDR database within this data explorer GUI environment, and any desired data can be placed into a dynamic "cart" to be ordered and downloaded later.

ESTIMATING LARGE-SCALE EVAPOTRANSPIRATION IN ARID AND SEMI-ARID SYSTEMS

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A common goal for water resource managers is to ensure long-term water sustainability for increasing human populations in the arid and semi-arid southwestern United States. Measuring evapotranspiration (ET) at watershed or river-reach scales is required to estimate how much water can be apportioned for human needs while maintaining healthy riparian vegetation and wildlife. ET measurements are often made on local scales, but scaling up to larger river-reaches has been problematic due to spatial and temporal variability. Satellite data, however, provide spatially distributed remote sensing products that account for seasonal climate and vegetation variability. We used Moderate Resolution Imaging Spectrometer (MODIS) products to create an empirical ET model calibrated by three riparian-influenced and two upland, water-limited flux

tower sites by correlating MODIS Enhanced Vegetation Index (EVI) values and MODIS nighttime land surface temperatures (Ts) to measured flux tower ET. Results showed that combining all sites introduced bias, so we developed separate models to estimate riparian and upland ET. While EVI and Ts were the main drivers for ET in riparian sites, precipitation replaced Ts as the secondary driver of ET in upland sites. A multiple linear regression approach adequately estimated upland ET (r2 = 0.77). Future research includes applying our empirical models to large river-reaches across the southwestern United States. Total annual ET can be estimated at river-reach or watershed scales provided that each region is classified appropriately. This approach improves accuracy of ET estimates at large scales and provides timely estimates because MODIS and flux tower networks collect continuous data.

ESTIMATING AGRICULTURAL WATER CONSUMPTION OVER AN ARID REGION USING REMOTE SENSING

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Evapotranspiration (ET), the sum of evaporation from soil surface and transpiration from plants, is a major component of the hydrological cycle and energy transport between the biosphere, atmosphere and hydrosphere. Quantifying ET is critical for water resources management, especially in arid regions where limited water resources are. Traditional methods for ET estimations are time consuming, expensive and point based. Remote sensing can estimate ET as a residual of the energy balance, thus reduces the need for ground data while providing information on critical hydrological components such as vegetation, soil, and topographic data. Furthermore, it provides regional coverage and information on the spatial and temporal variability of actual consumption. Focusing on the Central Arizona Project Long Term Ecological Research (CAP-LTER) area, the main objectives of this paper are to estimate water use by the agriculture sector and determine the sector sensitivity to drought. A remote sensing based algorithm has been developed for mapping spatially distributed ET over the CAP-LTER area. Two sets of Landsat 5 TM images were used to estimate daily and seasonal actual ET under drought and wet conditions. Model performance evaluation showed the model seasonal estimations under-predict by 1-16%. Results show natural desert has evaporation of 5-6 mm/day with high variation between drought and wet years, while active agriculture can reach to over 15 mm/day with low variation due to constant irrigation to maximize yield. Considering only the fields identified as active in both years were compared, preliminary results suggest the agriculture sector total water consumption was 59.35x106 m3 and 67.0 x106 m3 for 2000 (drought) and 2008 (wet), respectively. Statistical analysis of values distribution between years, coupled with the difference in precipitation shows no significant difference between years; thus implying the agriculture sector as a whole may not be drought sensitive.

VEGETATION PHENOLOGY AND INTENSITY ALONG AN EPHEMERAL DESERT RIVER AS A FUNCTION OF CLIMATE AND RIVER FLOWS, 2000 -2010

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The San Pedro River, located in the Sonoran and Chihuahuan Deserts, is one of the most biologically diverse ecosystems in the Rocky Mountains of the southwestern United States.

Riparian vegetation dynamics related to the changes in length of seasons may affect the life and migration of many wildlife species. Vegetation density is related to river flows, depth to groundwater, air temperature and precipitation, which vary year to year. MODIS products (Enhanced Vegetation Index (EVI) and Normalized Difference Vegetation Index (NDVI)) were used to monitor riparian vegetation dynamics during an 11-year period (2000-2010) to examine the impacts of climatic and hydrologic variables on the onset of greenness, senescence, and maximum vegetation density. Data of temperature, rainfall and water flows were extracted from Parameter- elevation Regressions on Independent Slopes Model (PRISM) and gages data. The phenology profiles from time series data and relationships between the vegetation index and temperature not only show changes in length of seasons but also allow us to identify how vegetation responds to moisture stress in the riparian areas of the San Pedro River. By using remote sensing dataset over San Pedro River basin, we can assess the response of vegetation to different biophysical variables in the spatial and temporal domains. Our short-term efforts will continue and focused in the quantification of this response across the basin using field-observed measurements that can help us to validate our results.

EVALUATION OF RECONSTRUCTED REMOTE SENSING TIME SERIES DATA

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Vegetation phenology is a proxy for studying vegetation states and carbon budget. It can be created by doing profiles with the remote sensing vegetation indices (NDVI, EVI, EVI2). Records of daily global satellite images are available from the last three decades, however, the presence of clouds, aerosols, variable viewing geometry and less than ideal processing techniques makes it difficult to obtain high quality data every time. For many areas the filtered data does not provide enough temporal coverage to enable adequate and thorough analysis and results in incomplete phenological profiles. In order to address the resulting gaps in these data records, various filling techniques were devised. The purpose of the gap filling is to accurately reconstruct the VI time series profile, while preserving as much of the original data to support accurate land surface vegetation characterization. In this research we devised a method based on finding the seasonally variable per-pixel optimum composite period, all remaining gaps are addressed by simple interpolation technique based on the Inverse Distance Weighting (IDW) approach. The method is further constrained by a moving window long term average to address biases that may result from over- or under-fitting. This method is used in support of the NASA MEASURES VIP project which aims at generating a 30+ year multi-sensor Vegetation Index and Phenology ESDRs. We then carried statistical analyses to determine the errors and uncertainties associated with this gap filling technique at and the derived phonological metrics and GPP as proxied by the summation of the VI profile.

FIRE, DUST, AND PHENOLOGY REMOTE SENSING

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I will present results from ongoing research to understand the effects of increased length of the annual wildfire season on the post-fire phenology of herbaceous vegetation, which drives the potential for increased wind erosion of soil in semiarid rangelands of the western USA. An increased length of the annual wildfire season is a prominent impact of climate change in this region, however effects on the current wind erosion regime are unknown, particularly in more northern landscapes such as the Great Basin that experience a strong seasonality in annual climate. When wildfires burn in the summer, there is the paradigm that soils are stabilized after fire by green-up of herbaceous vegetation, which generally occurs in the subsequent spring after the winter dormant season. An increased propensity for early-spring or late-fall wildfires might result in an insignificant increase in wind erosion, if post-fire green-up of herbaceous vegetation occurs relatively rapidly (e.g., prior to the winter dormant season). Conversely, surfaces might be prone to erosion over a much longer time period if herbaceous vegetation is slow to reemerge following wildfire. Furthermore, expensive post-fire seeding treatments are commonly conducted to promote the establishment of a desirable vegetation community, but effectiveness of these treatments for stabilizing soils is not well understood. Specific research questions I am addressing are: 1) For how long after fire do burned areas remain significant dust sources?; 2) Do seeding treatments increase rates of soil stabilization?; and 3) What will be the impact of the increased length of the wildfire season that is occurring with climate change? To examine these questions I am linking an existing long-term database of post-fire vegetation recovery for Great Basin landscapes developed by USGS scientists, with land surface phenology measurements made with archived, long-term MODIS and AVHRR satellite data, and a process-based wind erosion simulation model.

REMOTE SENSING DATA FUSION FOR ANALYSIS OF DRYLAND FOREST PHENOLOGY

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Semi-arid forests and woodlands are exceptionally sensitive to weather fluctuations. The higher temperatures and altered water regimes predicted by most climate change scenarios may dramatically change the species composition and extent of dryland forests in the western U.S. To anticipate the effect of future climate change on these ecosystems, it is necessary to establish a baseline of information about their current patterns of phenological behavior. The patchy land cover and variety of plant phenology states that characterize dryland landscapes hinder the necessary assessment of vegetation dynamics across a range of spatial and temporal scales. In this study we evaluate the use of a remote sensing fusion algorithm to merge 30 m Landsat-5 TM and 500 m MODIS nadir bidirectional reflectance distribution function (BRDF)-adjusted data for the purpose of tracking vegetation changes in dryland forest areas. We applied the spatial and temporal adaptive reflectance fusion method (STARFM) to produce a series of synthetic images spanning the 2006 growing season (February - November) over a central Arizona study site predominantly composed of dryland forest vegetation. We analyzed the differences in pattern and timing of the peak normalized difference vegetation index (NDVI) compared to the same metrics extracted from Landsat- and MODIS-only time series. The results indicate that the synthetic time-series captures spatial and temporal complexity that is not provided by the individual data sources: the 500 m MODIS data mask critical sub-pixel species and phenology variations, while the presence of a single clear-sky Landsat image from June through late September obscures summer vegetation dynamics.