EU Life + MONIMET: Climate change indicators and vulnerability of boreal zone applying innovative observation and modeling techniques

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The increased temperature in the boreal region has extended the growing season. Especially the spring recovery of photosynthesis has the potential to start earlier, which increases the net uptake of CO2. In the autumn, on the other hand, higher temperatures increase soil respiration (CO2 emission). This has been shown to be significant during the warm late autumns, when low light levels cannot anymore maintain high photosynthesis levels. During the summer, the changing climate may increase the carbon uptake due to enhanced gross primary production (GPP). However, net uptake may also be reduced as a result of increased respiration or if excess heat and droughts reduce GPP. The drier and warmer conditions are also suggested to increase the frequency of forest fires. In addition to meteorological factors, carbon sinks are enhanced by the direct influence of higher CO2 levels (CO2 fertilization) and increasing nitrogen availability (atmospheric deposition and mineralization in the soil).
In MONIMET project, flux measurements by Eddy Covariance (EC) technique at six Finnish forest sites with the longest time series spanning over 15 years are used. In order to study the influence of climate change, these results are up-scaled in time and space. For this, modelling techniques are implemented at various scales (process models, land surface/biosphere models, global transport models), as well as the inversion technique based on tall-tower measurements of background concentrations. The use of web cameras are also investigated in upscaling and monitoring ecosystem processes. Image colour information provides a useful and cost-efficient way to monitor leaf onset and snow cover from broad areas, and they can be used as proxies and indicators of spring timing, for example. In addition, ecosystem behaviour can be monitored with earth observation satellites, which provide global data on various environmental variables.
Moreover, in MONIMET, an extensive network of web-cam phenological observation sites in Finland is implemented. The data is used to assess the indicators produced with the models. Finally, the models are run with climate scenario data, and consequently the impact of the climate change on land surface can be observed in terms of climate change indicators.

The main results of the project are to estimate vulnerability of boreal forest ecosystems to climate change impacts in the future, and to assess uncertainties due to measurements, climate models and ecosystem models. Results we aim to achieve can be listed as below
1. A harmonized webcam network for monitoring the seasonal cycle in
boreal ecosystem carbon exchange
2. Demonstration of the mapping of climate indicators in boreal forest zone
3. Demonstration of vulnerability assessment for Finnish municipalities
to climate change effects in boreal forest
4. Calibrated soil-vegetation-atmosphere model parametrisations for the
boreal zone
5. Estimates of the uncertainty of the results

In this paper we will present achievements on the objectives listed above.

Keywords: Climate change, Camera network, Vulnerability

Urbanization and its impact on local environment: An assessment based on historical baselines of land use/ land cover and future scenarios

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Land use or land cover modification is a primary contributing factor of changing local environment and land surface temperature. The evolving process of urbanization is a dominant demographic trend and significant component of land conversion, resulting in changes in urban climate and urban ecology. One of the most challenges for the decision makers is to find a suitable solution to keep a balance between urbanization level and urban climate and eco-environmental systems. Natural surface in the Hue City, Vietnam has been greatly replaced by engineering constructions to meet the requirement of rapid population growth in the past decades. This study focuses to generate maps of spatiotemporal eco-environmental vulnerability for different land use or land cover change scenarios based on historical baselines of land cover retrieved from Landsat satellite data in the years 1975, 1989, 2003, and 2014. The series maps of eco-environmental vulnerability with differential future scenarios of land use or land cover changes are then simulated to provide references for planers. Results demonstrate that urbanization magnitude has a significant effect on the local environmental and urban climatic conditions.

Keywords: Urbanization, Eco-environment, Landsat data, Land use or Land cover

Urbanization and its impact on local environment: An assessment based on historical baselines of land use/ land cover and future scenarios

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Land use or land cover modification is a primary contributing factor of changing local environment and land surface temperature. The evolving process of urbanization is a dominant demographic trend and significant component of land conversion, resulting in changes in urban climate and urban ecology. One of the most challenges for the decision makers is to find a suitable solution to keep a balance between urbanization level and urban climate and eco-environmental systems. Natural surface in the Hue City, Vietnam has been greatly replaced by engineering constructions to meet the requirement of rapid population growth in the past decades. This study focuses to generate maps of spatiotemporal eco-environmental vulnerability for different land use or land cover change scenarios based on historical baselines of land cover retrieved from Landsat satellite data in the years 1975, 1989, 2003, and 2014. The series maps of eco-environmental vulnerability with differential future scenarios of land use or land cover changes are then simulated to provide references for planers. Results demonstrate that urbanization magnitude has a significant effect on the local environmental and urban climatic conditions.

Temporally-Resolved Observations of Hurricanes, Tropical Cyclones and Severe Storms using Repeat-Pass Radiometry from 6U CubeSat Constellations

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Global observations of clouds and precipitation are essential to improve monitoring and prediction of hurricanes, tropical cyclones and severe storms with substantial impacts on human life and property. For example, severe storms, tropical cyclones and hurricanes have caused more than 722 Billion USD of damage from 1980-2016 in the U.S. alone. To understand processes in clouds that lead to rain, snow, sleet and hail, global observations with rapid revisit times are essential. To this end, sensors on geostationary satellites have substantially improved weather prediction by providing visible and infrared measurements on the 5- to 10-minute time scale. However, to improve understanding of cloud and ice processes leading to the onset of precipitation on a global basis requires nanosatellite constellations using repeat-pass radiometry capable of penetrating into the storm to perform temporally-resolved observations of the radiative effects of scattering from cloud particles and hydrometeors.

At the same time, the use of nanosatellites to enable rapid access to space has grown exponentially in the past 3-5 years. In particular, CubeSats were introduced in 1999 as an educational satellite platform consisting of one or more units "U" of 10 cm cubes. CubeSats were originally used as teaching tools and for demonstration of space technology. However, rapid maturation of commercially-available nanosatellite technology and fast "fly-learn-refly" cycles have allowed CubeSats to produce high-value science, including remote sensing of the Earth's environment. As of the end of 2015, more than 425 CubeSats had been launched by 36 countries. More than 80% of all science-focused CubeSats have been launched from 2012 to 2016. The rapid development cycles of CubeSats of 2-3 years from funding to readiness to launch afford opportunities for rapid adoption of new technology. CubeSats typically benefit from low-cost launches as secondary payloads on missions of opportunity, e.g., free non-commercial U.S. launches provided by NASA's CubeSat Launch Initiative.

Nanosatellite constellations can provide rapid revisit times, including for sensing dynamic processes in the Earth’ s atmosphere, including temperature, humidity, precipitation and cloud properties. An example is the Temporal Experiment for Storms and Tropical Systems (TEMPEST) mission concept. TEMPEST consists of a constellation of 5 identical 6U CubeSats measuring at 5 millimeter-wave frequencies with 5-minute temporal sampling to observe time-resolved severe storms and their transition to precipitation. 6U CubeSats are chosen due to their substantial margins on mass, power, satellite-to-ground communications and radiometer calibration capability. To achieve such a constellation requires (1) precision inter-satellite instrument calibration among the 6U CubeSats in the constellation and (2) orbital drag maneuvers to control the relative positions of 6U CubeSats in the constellation to achieve the required temporal spacing between successive observations.

Currently, the TEMPEST Technology Demonstration (TEMPEST-D) mission is under development to raise the TRL of the instrument and key satellite systems as well as to demonstrate the observational capabilities required to achieve such a 6U CubeSat constellation. A partnership among Colorado State University (Lead Institution), NASA/Caltech Jet Propulsion Laboratory and Blue Canyon Technologies,

TEMPEST-D will provide observations at five millimeter-wave frequencies from 89 to 183 GHz using a single compact instrument that is well suited for 6U CubeSats. The TEMPEST-D project started in August 2015 and passed CDR in July 2016, with planned delivery of the complete 6U CubeSat in Q3 of 2017. TEMPEST-D will be integrated by Nanoracks for launch to the International Space Station on a commercial resupply service (NASA ELaNa-23) in Q2 or Q3 of 2018, with deployment soon thereafter into a 400-km orbit with 51.6° inclination for a 90-day mission following on-orbit commissioning.

Keywords: Hurricanes, Tropical Cyclones and Severe Storms, CubeSats, Nanosatellites, Satellite Constellations, Microwave radiometry, Temporally-resolved observations

A study on the development of the Coexistence Index of Environment and Man for zoning Baekdudaegan mountain range in South Korea as a biosphere reserve

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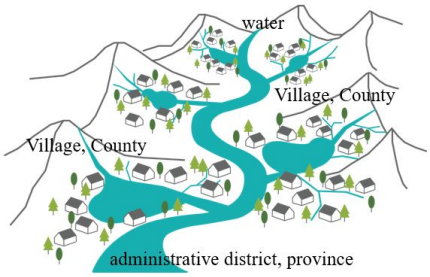
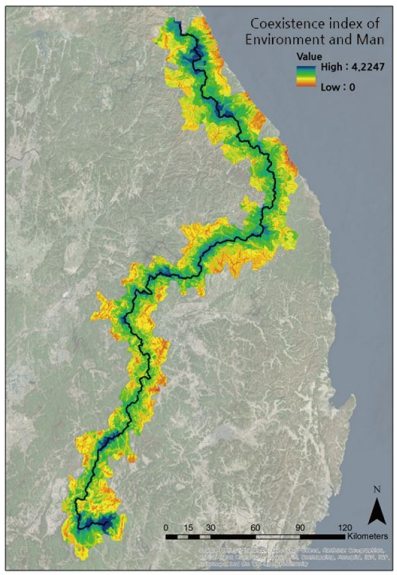
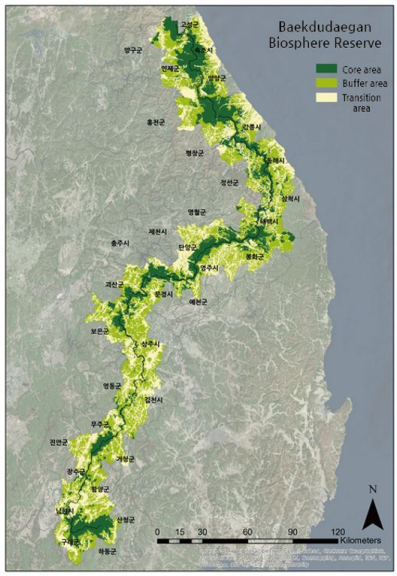
Baekdudaegan Mountain Range(BDDG) in Korea is both a symbolic ecological area with diverse flora and fauna and a unique geographical system. Reflecting the saying “Mountain ranges divide streams, but streams do not cross mountain ranges”, BDDG has constituted an administrated district of Korean territory. However, BDDG was heavily damaged by human activity from 1970s, during economic Korea’s development period. BDDR was designated by Korean government as a protected area, and many challenges remain for local residents due to strict laws around the area. In this research, considering local human and nature resources, we applied the biosphere reserve(BR) of UNESCO’s Man and the Biosphere Programme. The BR consists of core, buffer and transition areas and pursues the interacting of man and nature, aiming for harmonious life. Therefore, taking a long-term view, we concentrated on development of BR index for efficient conservation of BDDG. Firstly, we established the BR index related to the protected area by reviewing laws and policies from Germany, Japan and South Korea. The collected data were reclassified through an analysis of the frequency of each indicator. Secondly, the nine contents of the final Index were constituted as “elevation,” “slope,” and “watershed” as physical indicators; “ecological naturalness,” “crown density,” and “forest ages” as ecological indicators; and “land-cover,” “protected area,” and “resident population” as management indicators. Applying the concepts of BR, 9 thematic maps were generated based on a score from 1 to 3 points for each indicator. Thirdly, an index map was created by overlying nine maps, and the AHP (Analytical Hierarchy Process) method was conducted by relevant experts to reflect BDDG’s conditions and reality. The coexistence of the Index of Environment and Man(IEM) was developed by weighting the results of the AHP Method on the Index map. Finally, the BR zonings were designated by IEM through natural breaks classification of Jenks in ESRI ArcGIS. The significance of results was determined by area. Firstly, most of core area (IEM: 4.2247–1.93) was “protected area” as designated by the law. Secondly, “ecological naturalness” in ecological value of buffer area (1.92–1.6) was high, as in the core area. Thirdly, “resident population” in management indicators effected the transition area (1.59–0). In summary, areas with high natural value were conserved as the core and buffer area, while the transition area was a residential area where excellent nature resources abound. The research aims at exploring the coexistence of nature and humans in BDDG from the perspective of long-term conservation. Through the application of BR, BDDG was found to be a potential area and a living area for residents who conserve precious natural resources. Many BRs hope to become area where humans live in harmony with nature. In particular, the participation of residents is essential in zoning transition areas to maximize the effects of BR, and a lot of research on this topic using various methods is needed.

Keywords: Biosphere Reserve, Baekdudaegan mountain ranges, BR index, Coexistence Index of Environmental and Man, Protected area





Applying Coexistence index of Environment and Man



Zoning for Baekdudaegan Biosphere Reserve

Enhancing Disaster Risk Reduction Capabilities with Multifrequency, Multi-polarization, Very high-Resolution SAR Information

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The potential for wideband active/passive microwave satellite data could open a new era in water resources management as microwave signatures see through clouds (i.e., all-weather) and operate diurnally. Harris Corporation has led the development of a new instrument that provides co-aligned radiometric data at X-, K-, and Ka- bands and SAR data at X- and two Ku- bands for operational mapping of snow water equivalent. In this presentation, we will outline the concept and provide experimental results from airborne field trials in 2017.

Keywords: SAR, Water Resources

Adaptation responses to increasing drought frequency

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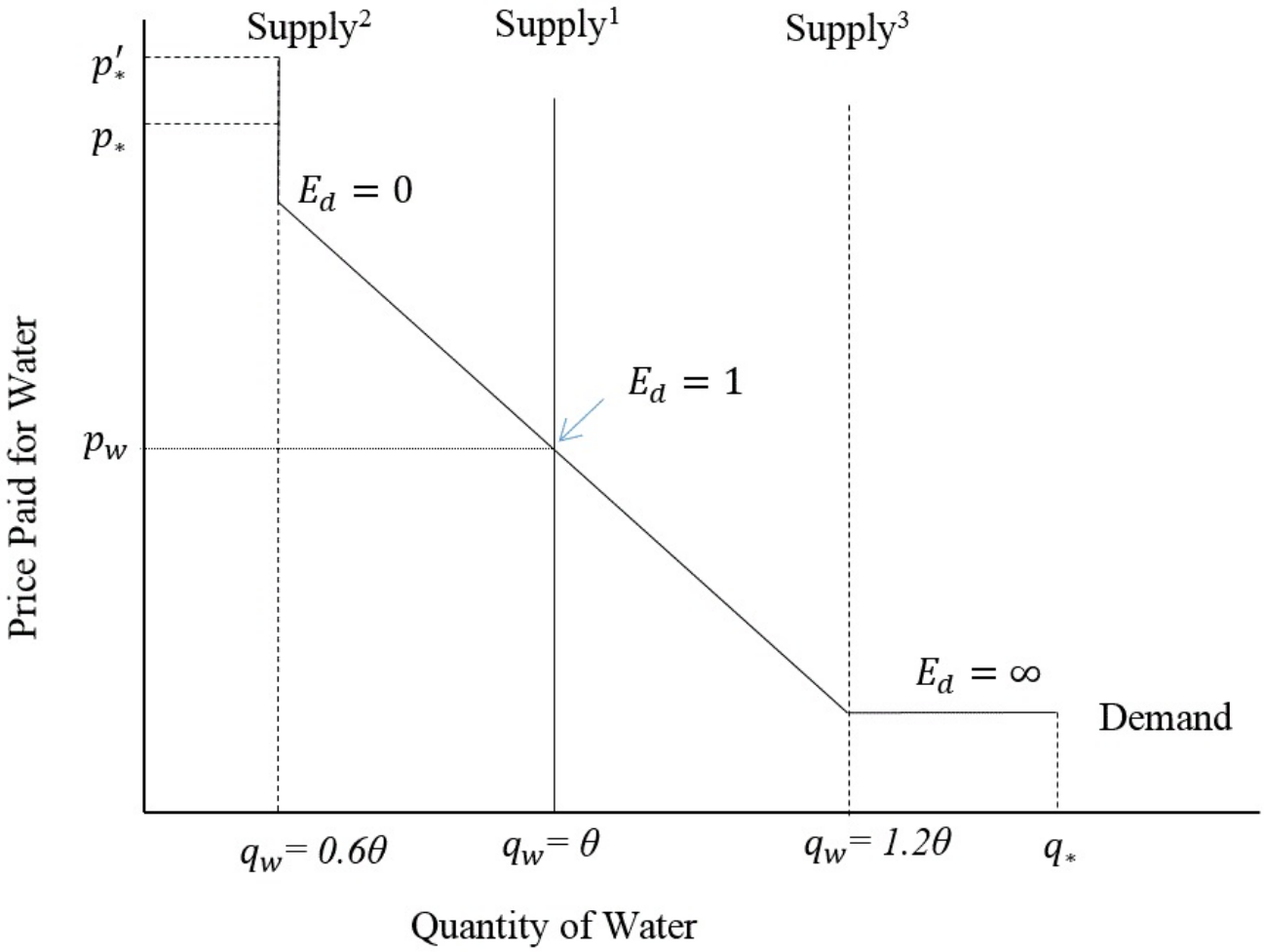
Using state contingent analysis we discuss how and why irrigators adapt to alternative water supply signals. This analysis approach helps to illustrate how and why producers currently use state-general and state-allocable inputs to adapt and respond to known and possible future climatic alternative natures. Focusing on the timing of water allocations, we explore inherent differences in the demand for water by two key irrigation sectors: annual and perennial producers which in Australia have allowed a significant degree of risk-minimisation during droughts. In the absence of land constraints, producers also had a capacity to respond to positive state outcomes and achieve super-normal profits. In the future, however, the probability of positive state outcomes is uncertain; production systems may need to adapt to minimise losses and/or achieve positive returns under altered water supply conditions that may arise as a consequence of more frequent drought states. As such, producers must assess whether altering current input/output choice sets in response to possible future climate states will enhance their long-run competitive advantage for both expected new normal and extreme water supply outcomes. Further, policy supporting agricultural sector climate change resilience must avoid poorly-designed strategies that increase producer vulnerability in the face of drought.
Our analysis explores the reliability of alternative water property right bundles and how reduced allocations across time influence alternative responses by producers. We then extend our analysis to explore how management strategies could adapt to two possible future drier state types: i) where an average reduction in water supply is experienced; and ii) where the frequency of droughts increase (Figure 1). The combination of these findings are subsequently used to discuss the role water reform policy has to deal with current and future climate scenarios. We argue current policy strategies could drive producers to more homogeneous production systems over time, which ultimately entail risky adaptation options under future water supply availability or increased drought frequency scenarios. Lastly, our analysis has shown the flexibility of applying SCA toward examining uncertainty surrounding future states of nature under climate change.

Keywords: drought adaptation, water user behaviour, state contingent modeling



The possible influence of climate variability and fishing activity on the annual fishing conditions of Grey mullet *(Mugil cephalus* L.) in the Taiwan Strait

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The Grey mullet (*Mugil cephalus* L.) is a cosmopolitan species that is distributed in tropical and temperate zones at latitudes 42˚N–42˚S (Thomson 1963). It is one of the most important commercial species of fish in the coastal fisheries of Taiwan. A cohort analysis was performed to estimate the population number and instantaneous rate of fishing mortality by age of Grey mullet in the Taiwan Strait (TS) in 1958–2004. Since 1986, annual catches considerably dropped and continually remained at an extremely low level during the period despite the high fishing intensity. The population number of Grey mullet aged > 4 y has declined since 1986 and decreased to 20 000 individuals in 2004, constituting only 0.01% of the maximum level in 1981. The Grey mullet stock probably lost the reproductive potential because of severe recruitment overfishing since 1960s. Overexploitation of the Grey mullet stock reduced its spawning biomass to age 3–4-y groups, and environmental changes during the past 2 decades have likely driven the stock to consecutive years of poor recruitment and its current low level in the TS. Based on a long-term variability of sea surface temperature (SST) in the TS, it implied that variations of SST in winter caused by climate variability and climate change have a major role in affecting the abundance and migration behavior of Grey mullet in the TS.
The long-term unique long-term (1967–2009) records of catch per unit effort (CPUE) of Grey mullet in the TS was further used to investigate the influences of multi-timescale climatic indices on the annual catch of grey mullet. The CPUE of Grey mullet showed fairly good correspondence with the annual PDO index (R^2 =0.82, $p<0.01$). The PDO may play a role in affecting the migration of grey mullet, but increases in SSTs may be a main reason for the decreased catches after 1980.
This study is to estimate exploitable biomass and recruitment of grey mullet stock in the Taiwan Strait. Cohort analysis was employed to estimate population number and the instantaneous rate of fishing mortality (F) by age for 1958-2004. The population number of grey mullet in the Taiwan Strait decreased from late 1960s to early 1970s due to the high instantaneous rates of fishing mortality in 1960s. Since 1986, annual catches sharply dropped and continuously remained at a very low level these years despite of the high fishing intensity, which indicates that overfishing has existed since 1960s. The population number of age group over age 4 has decreased since 1986 and reduced to be 20 thousand individuals in 2004, which is only 1/100 of the maximum level of 2 million individuals in 1981. It seems that the grey mullet stock has lost the reproductive ability due to the severe recruitment overfishing.

Keywords: Grey mullet, Climate change, Pacific Decadal Oscillation, Cohort analysis, Wavelet analysis

Simulated Impacts of Afforestation in East China on Climate Modulated by Ocean Variability

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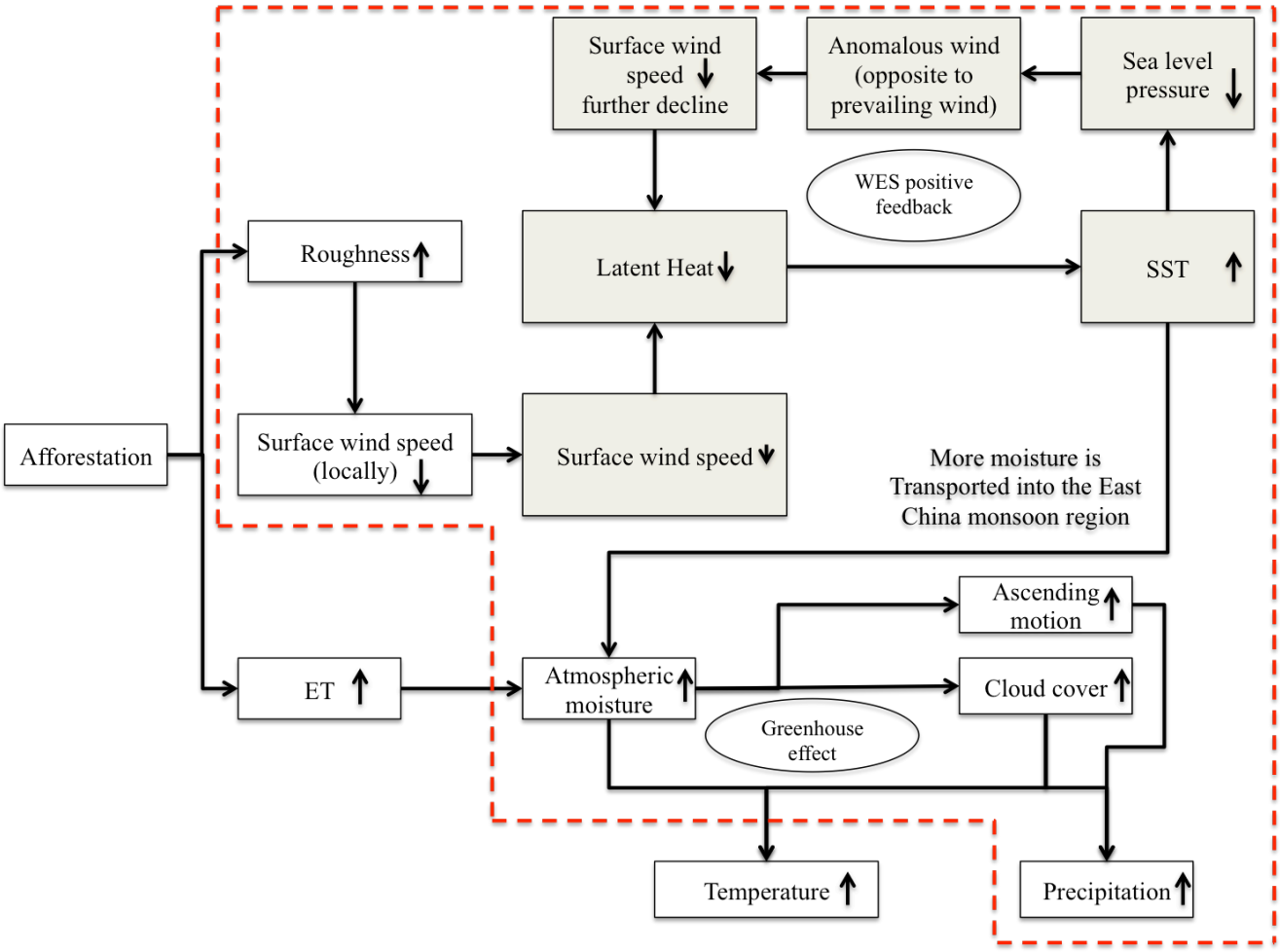
Using the fully coupled climate model, NCAR CCSM3.5-DGVM, this work examines the effects of afforestation in East China on climate and the role of ocean variability in modulating with these land-atmosphere interactions.

In response to afforestation, the local surface air temperature significantly decreases in summer and increases in winter. The summer cooling is due to enhanced evapotranspiration. The winter warming is caused by a decrease in surface albedo, and in the presence of ocean variability, this warming is enhanced by the trapping of longwave radiation by additional moisture and clouds.

With the ocean variability, the response of the hydrologic cycle to afforestation is amplified. More water vapor transport in East China and form more cloud and precipitation especially in winter and pre-monsoon season.

Keywords: Afforestation, Ocean variability, WES feedback



Ecological risk assessment of island exploitation based on relative risk model

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Keywords: Island, Risk Assessment, Relative Risk Model, Human Exploitation Activity

A comparison of individual exposure, perception, and acceptable levels of $PM_{2.5}$ with air pollution policy objectives in China

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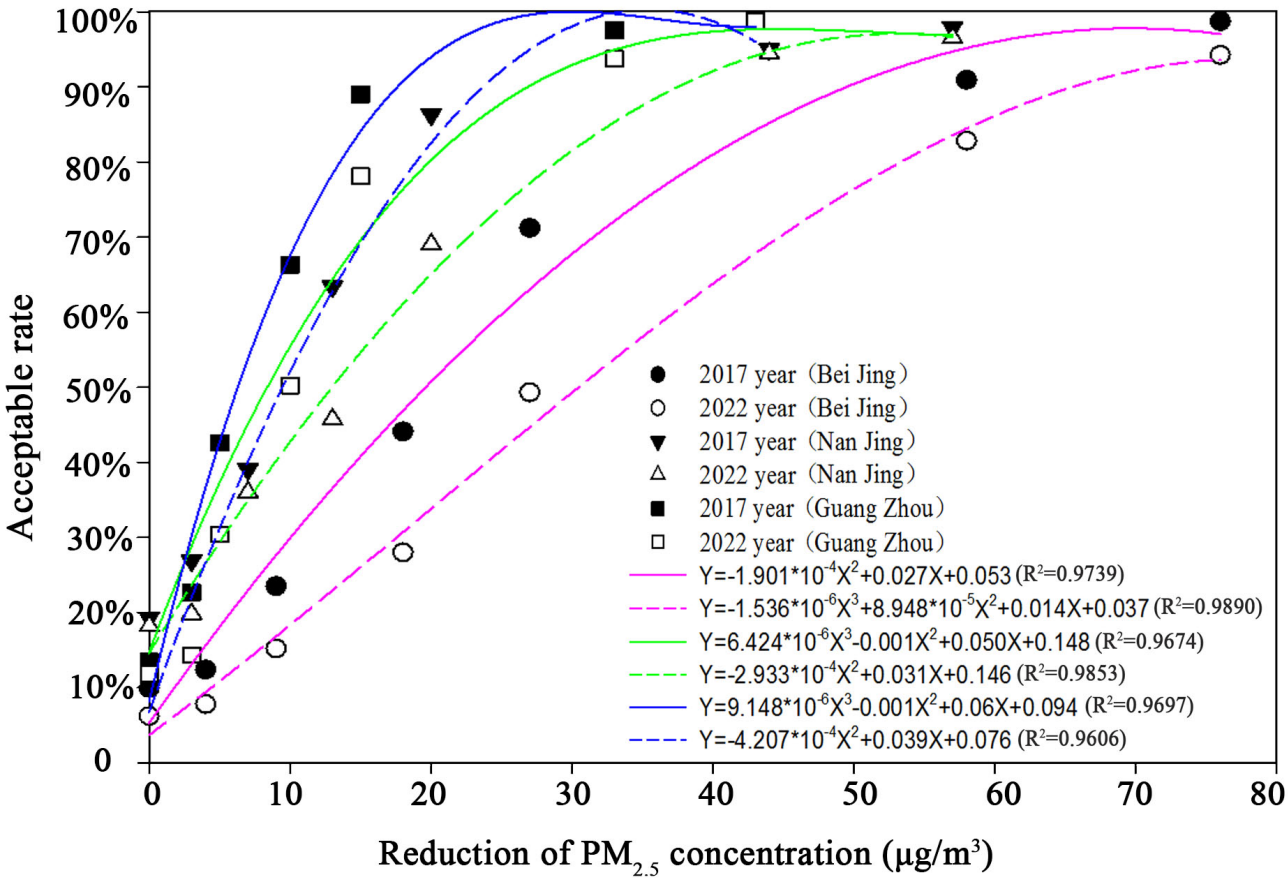
In order to explore the public perception of air pollution andevaluate what constitutes public acceptable concentrations of fine particulate matter (PM2.5), questionnaire surveys were conducted separately in three representative cities, Beijing, Nanjing, and Guangzhou in China.The multi-city results demonstrated great differencesin public risk perception.The public perception of the health effects of air pollution (*Effect*) and familiarity with it (*Familiarity*) were significantly higher in the winter than in the summer. Moreover *Effect* and *Familiarity* during severe haze dayswere significantly higher than during typical days.The public perception of trust in the government (*Trust*) was consistent regardless of seasonal and weather conditions. Exposure to severe haze pollution and experiencing harms from it were key factors influencing public willingness to take action in response to haze.These results implied that individual levels of exposure correlate quite closely with risk perception and acceptance of PM2.5. However, there remains a crucial gap between public acceptable risk levels (PARL) of air pollution and the policy objectives of the Action Planon Prevention and Control of Air Pollution. Thus, the results of this study may act as a strong reference for policymakers to develop more effective measures to combat air pollution.

Keywords: Air pollution, Risk perception, PM2.5 exposure, Preventative action, Environment Management



Integrating remote sensing and in-situ data to delineate vulnerable groundwater recharge areas in urban cities of Taiwan

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Stream sediments are transported from mountainous regions to lower terrains before their deposition in the coastal alluvial plains. Since stream gradient and potential groundwater recharge are relatively high in upper stream of alluvial systems, it is critical to develop conservation policies to delineate and protect the vulnerable groundwater recharge areas (VGRAs) for sustainable management of surface and groundwater resources. Even though VGRAs are relatively small in Taiwan, human activities have gradually spread over the VGRAs as a result of urbanization. To address the critical issues about VGRAs linking to urbanization, three cities in the western plains of Taiwan are chosen, including Taichung, Jiayi, and Tainan cities, as study areas. This study integrates remote sensing data and in-situ geologic drilling to delineate the VGRAs in both regional and local scales. Drilled hydrogeological frameworks are implemented with auxiliary soil moisture and land cover derived from MODIS and Landsat images as indicators. Preliminary results show that in-situ groundwater quality and quantity data in delineated VGRAs conform the characteristic of groundwater recharge. Findings of this study provide a possible solution to protect the human-natural system in developing urban and alluvial plains.

Keywords: vulnerable groundwater recharge, geologic drilling, soil moisture, land cover

Application of Ecological Suitability Assessment Method in Functional Zoning, Protection and Utilization Planning of Uninhabited Islands

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This paper introduced the ecological suitability assessment method, originally from land use research, into the functional zoning, protection and utilization planning of uninhabited islands. This study established the ecological suitability evaluation index system, using Danmenshan Island as an example. Based on the index system and its calculation results, a map overlapping operation was conducted using GIS software, in order to set up a quantitative method for the land use of Danmenshan Island. This quantitative method, which introduced the ecological suitability assessment concepts, could be transfer to other uninhabited islands, assisting their decision-making and planning strategies.

Keywords: ecological suitability, functional zoning, uninhabited islands

Comparison of sap flux density of a tree and a palm species and their responses to changing urban environments

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Urban greening strategy has been proposed to mitigate air pollution and provide significant ecosystem services. One method to assist in planning strategies for water management in an urban setting is to study tree water use and its response to environments of different tree species. We measured sap flux density (J_s) of a tree (*Tabebuia argentea*) and a palm (*Ptychosperma macarthurii*) species in a roof garden by using Granier' s thermal dissipation method. The daytime and nighttime J_s were analyzed under rain-free and rainy conditions. The results showed that with high vapor pressure deficits (*VPD*), diurnal pattern of J_s in palms was higher than that in trees . In addition, in both rain-free and rainy conditions, palms have faster response of daytime J_s to *VPD* as compared to trees, suggesting their more sensitivity to changes in the evaporative demands. At night, trees and palms have no response to *VPD*, yet the nighttime fluxes were significant, ranging 18-23% and 20-25% of the daily sum J_s in trees and palms, respectively. The results implied that trees will have the better ability to tolerate climate change impacts such as droughts than palms due to its slower responses to the environments. In other words, trees use water more conservatively than palms. However, the impacts may not be too severe because of their mechanism to recharge the stem water storage as seen from significant nocturnal J_s. Thus, trees should be preferred to plant in an urban setting than palms because they would be less affected by changing from the environment. In addition, we suggest that maintaining trees water use by appropriate irrigation and selecting trees for planting with suitable species are the keys to maximise urban greening benefits.

Keywords: urban greening, water management, sap flux density, vapor pressure deficit, Tabebuia argentea, Ptychosperma macarthurii

Comparison of stand transpiration in a palm and a tree species and its variation with weather conditions in Bangkok

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Global warming is a significant and ongoing problem to our planet as it induces drought, flood, and climate change and also affects biodiversity. Many countries in certain regions may suffer from increased intensity and frequency of drought events. Urbanization is another emerging issue and can intensify the global warming due to dense population and activities driving carbon dioxide emission. Therefore, urban greening has been imposed in many cities to mitigate such adverse effects. The severe droughts will influence tree water use and potentially affect the performance of urban trees. To explore selectively planting drought-tolerant trees that use water conservatively will lead to efficient urban water management. Here, we studied water use of a palm species (*Ptychosperma macarthurii*) and a tree species (*Tabebuia argentea*) in a roof garden, using the heat dissipation method to measure their sap flux density (J_s). We found that palms had higher sap flux density (the product of J_s and sapwood area) compared to trees in both rainy and rain-free conditions. Sap flux density in palms had exponentially saturated pattern with vapor pressure deficit (VPD), representing atmospheric demand, in both conditions, suggesting stomatal sensitivity at high VPD. However, variations of sap flux density in trees with VPD were different under rainy and rain-free conditions. Trees sap flux density in rain-free condition had exponentially saturated pattern whereas that in rainy conditions followed a linear function because of non-limiting water availability. Our results indicated that trees closed their stomata at a slower rate and had lower stand transpiration rate than palms (0.59 ±0.13 mm day^{-1} *versus* 2.01 ±0.31 mm day^{-1}, respectively). Thus, when trees and palms suffer from drought, palms will potentially dry out faster than trees. Additionally, we derived a simple model using daily sap flux density to estimate monthly and annual sums of water use. Overall, palms stand transpiration rate had 3.4-times higher than trees in our site. This study provides quantitative insights into tree and palm water use characteristics which will strongly benefit water management policy, particularly when the planet face severe drought in the future.

Keywords: stand transpiration, Ptychosperma macarthurii, Tabebuia argentea, vapor pressure deficit, water management, urban greening

