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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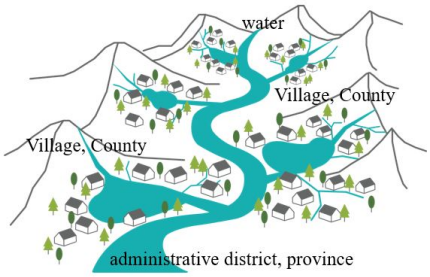
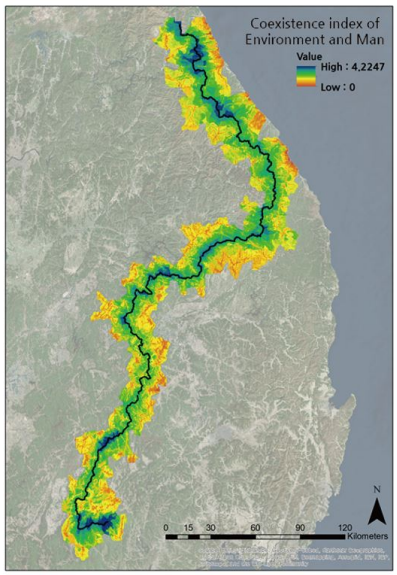
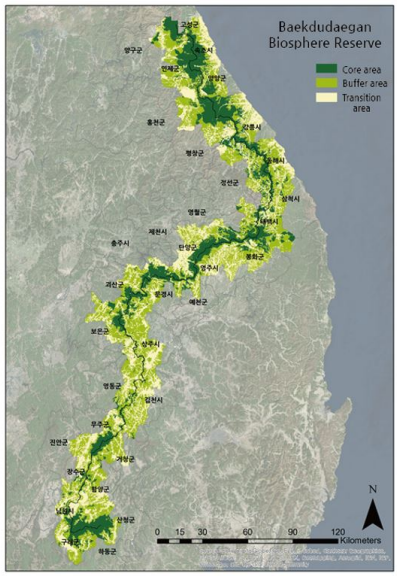
Baekdudaegan Mountain Range(BDDG) in Korea is both a symbolic ecological area with diverse flora and fauna and a unique geographical system. Reflecting the saying “Mountain ranges divide streams, but streams do not cross mountain ranges”, BDDG has constituted an administrated district of Korean territory. 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