LAND DEGRADATION SURVEILLANCE OF DRYLANDS IN CHINA

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List of Principal Investigators (PIs)

Topic Nr.	PIs	Title
32396_1	*Prof. Joachim Hill,* *Dr. Xiaosong Li*	***Retrieval of vegetation and soil properties using multi-source optical remote sensing in drylands***
32396_2	*Dr. Gabriel del Barrio,* *Prof. Zhihai Gao*	***Advanced remote sensing methods for land degradation assessment by coupling vegetation productivity and climate in drylands***

EXECUTIVE SUMMARY

Land degradation is a process by which the land productive capacity declines or even is completely lost under the influence of natural forces and human activities. The scope of land degradation has become global in the last decades, which compromises sustainable land management and threatens the safety of food production. Assessment and monitoring of land degradation based on Earth Observation make the most accepted scientific basis for controlling land degradation. Objectives:(1)To develop methods of vegetation & soil bio-physical variables(PV/NPV fractional cover, NPP, Soil organic matter and soil texture) retrieval based on satellite data in drylands, at local and regional scale;(2)To enhance, benchmark and validate two novel approaches to land degradation surveillance by remote sensing: a two-dimensional implementation of Rain Use Efficiency (2dRUE), and a Moisture-responded Net Primary Productivity (MNPP).(3)To use the said approaches to map land degradation in a study area defined by the Potential Extent of Desertification in China(PEDC). This is a delimitation of UNCCD-affected areas in terms of drylands within China.Methods:(1)Vegetation PV/NPV fractional cover, NPP estimation in drylands: Aiming to retrieve the PV/NPV fractional cover in arid regions, the non-linear mixture method will be applied in order to improve the spectral mixture models for PV/NPV fractional cover estimation based on field measured spectra and hyperspectral satellite data Proba-1. High spatial resolution (GF-1 and UAV) and field survey data would be used as reference data for validation. For NPP estimation, some key parameters in CASA model, including the FPAR and the light use efficiency, will be optimized to promote the accuracy of NPP estimation.(2)Soil organic matter and texture(sand, silt and clay) estimation in drylands: Parametric or non-parametric regression models will be studied to establish a good relationship between soil proprieties and soil spectra, and the model would be applied to PROBA-1, Sentinel-2 and GF-1 data. The influence of spectral, spatial resolution and the presence of vegetation cover on soil proprieties retrieval would be analyzed.(3) 2dRUE for land degradation assessment: Input data for this method are time series of a remotely sensed vegetation density parameter (typically, NDVI or NPP), corresponding climate fields, and a land use/land cover map. Both assessment of land states of ecological maturity, and monitoring of land productivity trends, are performed on this data set for the study period. The former are computed after a graphical representation of RUE against aridity index. The latter are derived from a stepwise regression analysis. (4) MNPP method for land degradation assessment: A MNPPmethod for identifying areas of land degradation based on the change of annual NPP and MNPP over time and MI will be developed. Method of severity assessment of Land degradation will be studied on the basis of modelling of relative benchmarks of pixel-based land degradation. Deliverables: The deliverables will be scientific outputs in terms of peer reviewed journal publications, PhD and MSc theses and data sets in terms of datasets, map and assessment system for land degradation. Availability of funding to run the project: During the 4 years research, several funding projects are being undertaken by the team members. They will support the joint researches of proposed the Dragon 4 cooperation project and the progress reporting in the annual symposium.

ABSTRACT 32396_1: "Retrieval of vegetation and soil properties using multi-source optical remote sensing in drylands"

European Principal Investigator	***Chinese Principal Investigator***
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The quantitative assessment and evaluation of ecosystem functions and services and the associated trade-offs require monitoring spatially explicit parameters that can serve as proxies for important vegetation and soil properties. These important variables also serve as indicators for land degradation and desertification processes in dryland areas. Earth observation satellites in the optical domain enable the retrieval and monitoring of key vegetation and soil characteristics mandatory in dryland research. Already existing and forthcoming optical satellite scheduled by Europe and China, such as Sentinel 2A/B, GF-1/4/5 etc., will provide large data streams which can be employed for grassland degradation monitoring and assessment. The expected large data volumes require enhanced automated processing techniques that are accurate, robust,fast and temporally consistent. However, owing to the specific conditions of dryland ecosystems, the retrieval of vegetation and soil properties from satellite remote sensing present significant challenges.
Firstly, total vegetation fractional cover is sparse, and non-photosynthetic vegetation (NPV) usually accounts for a substantial proportion. Therefore, approaches based on simple vegetation indices such as the NDVI are unable to provide unbiased estimates of photosynthetic (PV) and non-photosynthetic vegetation cover on variable soil backgrounds. At the same time, mapping of soil properties is often hampered by the presence of PV and NPV cover, while being already limited by the spectral and spatial resolution of images acquired with operational earth observation systems. Therefore, the retrieval of enhanced vegetation and soil indicators is mandatory for improving the assessment and monitoring of land degradation processes across different spatial and temporal scales. The use of multi-source optical remote sensing data provided by Europe and China offers new and exciting possibilities for an operational dryland monitoring approach. This is the primary objective of the proposed study.
Under the support of Dragon 4, the following key activities would be focused:
(1) Vegetation PV/NPV fractional cover, NPP estimation in drylands
Both vegetation cover and NPP have been recognized as the most effective indicator of land degradation. Aiming to retrieve the PV/NPV fractional cover in drylands, the non-linear mixture effects would be investigated firstly in order to identify the best spectral mixture models for PV/NPV fractional cover estimation, based on field spectra and hyperspectral satellite data provided by GF-5. Then, upscaling techniques would be developed to generalize the field and hyperspectral information to multi-spectral data with different spectral and spatial resolutions such as Sentinel 2A/B. High spatial resolution (GF-1 and UAV) and field survey data would be used as reference data for validation. For NPP estimation, some key parameters in the CASA model, including the Fraction of Absorbed Photosynthetically Active Radiation fPAR and the light use efficiency (LUE), must also be derived from the satellite data.
(2) Soil organic matter and texture(sand, silt and clay) estimation in drylands
Soil properties represent the long-term status of land degradation, since they do not change as rapidly as the vegetation indicators. Based on soil samples, different calibration methods for spectroscopy-based regression models (parametric or non-parametric) will be studied to establish a robust relationship of high quality between soil properties and laboratory spectra. The model will be applied to GF-5, Sentinel 2A/B and GF-1/4 data. The performance of satellite data with a spatial resolution higher than 30m will be investigated thoroughly for the mapping soil properties. In particular, the influence of spectral and spatial resolution as well as the presence of vegetation cover on the accuracy of estimated soil properties will be analyzed in depth.
(3) Consequence of vegetation degradation on soil organic carbon stocks in drylands
Task 3 will contribute to enhance the understanding of the impact of land degradation on soil organic carbon stocks (SOC). Supported by the derived vegetation characteristics with Sentinel 2A/B and GF-1/4(task 1), the soil organic matter (SOM) will be estimated at regional scale considering the vegetation cover as well as the reduction of SOC due to land degradation. This will be achieved by selecting typical vegetation samples along a gradient of increasing degradation levels, while establishing a relationship between PV/NPV difference and soil organic carbon stocks.

ABSTRACT 32396_2: "Advanced remote sensing methods for land degradation assessment by coupling vegetation productivity and climate in drylands"

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Land degradation is a process by which the land productive capacity declines or even is completely lost under the influence of natural forces and human activities. The scope of land degradation has become global in the last decades, which compromises sustainable land management and threatens the safety of food production, especially in the poverty-stricken areas of developing countries. Post-hoc mitigation approaches are expensive and often ineffective. Therefore early warning systems based on Earth Observation make the most accepted scientific basis for controlling land degradation.

This proposal aims at detecting land degradation in dry lands at a regional scale. It involves the use of geomatic methods on remotely sensed data and other geospatial databases, to develop a repeatable system that can support policy-making and the reporting to UNCCD. This aim frames the following concrete objectives:
Objective:
(1)To enhance, benchmark and validate two novel approaches to land degradation surveillance by remote sensing: a two-dimensional implementation of Rain Use Efficiency (2dRUE), and a Moisture-responded Net Primary Productivity (MNPP).
(2)To use the said approaches to map land degradation in a study area defined by the Potential Extent of Desertification in China. This is a delimitation of UNCCD-affected areas in terms of drylands within China.
Methods:
(1)2dRUE for land degradation assessment: RUE is a ratio of NPP and precipitation. The monthly NPP and precipitation data for PEDC (2004-2018) and test areas (2009-2018) will be applied for computation of monthly and annual RUE at the above mentioned two scales. Input data for this method are time series of a remotely sensed vegetation density parameter (typically, NDVI or NPP), corresponding climate fields, and a land use/land cover map. Both assessment of land states of ecological maturity, and monitoring of land productivity trends, are performed on this data set for the study period. The former are computed after a graphical representation of RUE against aridity index. The latter are derived from a stepwise regression analysis.
(2)MNPP method for land degradation assessment: A MNPP method for identifying areas of land degradation based on the change of annual NPP and MNPP over time and MI will be developed. Method of severity assessment of Land degradation will be studied on the basis of modelling of relative benchmarks of pixel-based land degradation.
Deliverables:
(1) A dataset for land degradation assessment.
(2) A systematic framework for land degradation assessment based on remote sensing at regional scale.
(3) Land degradation status maps in PEDC, and associated protocols for its update over time
(4) Published research papers, and mid-term and final report.
(5) Dissertations of two MS students and Ph.D. students.
Availability of funding to run the project:
During the 4 years research, two funding projects, sponsored by National Science and Technology Major Project (No. 21-Y30B05-9001-13/15) and National Natural Science Foundation of China (NSFC)(No. 41571421), are being undertaking by the Chinese team members. They will support the normal progressing of the Dragon 4 cooperation and the participating of the annual symposium.