REMOTE SENSING BASED STUDY ON VEGETATION DYNAMICS IN DRYLANDS OF KAZAKHSTAN

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Vorwort des Herausgebers

Die Reihe „Erdsicht – Einblicke in geographische und geoinformationstechnische Arbeitsweisen“ soll Forschungsergebnisse und Arbeiten im Bereich der Erdsystemforschung vorstellen. Die Betrachtung der Erde als System ist als Inhalt heutiger und zukünftiger Geowissenschaftlicher Gemeinschaftsforschung dringend gefordert. Die Herausforderungen liegen zum einen in der Erforschung der vielfältigen Interaktionen zwischen den verschiedenen Teilbereichen des Systems Erde. Hierzu zählen Wechselwirkungen zwischen fester Erde und Atmosphäre, zwischen der Landoberfläche und der Hydrosphäre oder zwischen Biosphäre, Hydrosphäre und Atmosphäre. Der Mensch steht dabei mit seinen zentralen Nutzungsansprüchen (Ernährung – landwirtschaftliche Nutzung – Ressourcennutzung) im Mittelpunkt eines vielfach vernetzten Erdsystems. Der Mensch verändert Landschaften und Atmosphäre und greift somit in alle Skalenbereiche des Erdsystems ein. Insofern müssen diese Veränderungen beobachtet und bewertet werden, damit Konzepte für ein nachhaltiges Erdsystemmanagement auf den unterschiedlichen Raum- und Zeitskalen entwickelt werden können. Die neuen Geoinformationstechniken (Geostatistik; Geographische Informationssysteme – GIS; luft- und Satellitengestützte Fernerkundungssysteme – Remote Sensing) helfen dabei, das System Erde zu beobachten und zu begreifen. Ohne diese Technik ist eine ganzheitliche Betrachtung der Erde und eine flächenhafte Bereitstellung von Informationen über das Erdsystem nicht möglich.

Die vorliegende Studie von Dr. Pavel Propastin beschäftigt sich mit der Landschaftsdegradation in Kasachstan unter besonderer Berücksichtigung der veränderten politischen Bedingungen, die seit den 90er Jahren eine abnehmende Beeinflussung der Ökosysteme zur Folge hatten. Dr. Propastin benutzt zur Bewertung der Landschaftsveränderung insbesondere NDVI-Zeitreihen des Sensors NOAA-AVHRR, die bis 1984 zurückreichen und eine hohe zeitliche Auflösung bis in unseren aktuellen Betrachtungsraum liefern. Diese Arbeit ist ein gutes Beispiel für die Anwendung der Fernerkundung zur Bewertung von Desertifikation und Weidepotenzial in semiariden Gebieten. Inhaltlicher Schwerpunkt ist die Trennung von klimatisch bedingter Veränderung und anthropogen bedingter Veränderung in den Landschaftsräumen Kasachstans. Diese Fragestellung ist im Rahmen der „Global-Change-Forschung“ von großer Bedeutung, um die zukünftige Belastung der Naturräume in Relation zu po-

tenziellen globalen Veränderungen (Niederschlags-, Temperaturveränderung) und zusätzlichen menschlichen Einfluss zu bewerten.
Dr. Propastin stellt geeignete Methoden zur langfristigen Bewertung von Landschaftsräumen vor und bildet einen flächendeckenden Datensatz. Seine Ergebnisse belegen eine grundsätzliche Trennung des menschlichen Einflusses von klimatisch bedingten Einflüssen. Die von Dr. Propastin erarbeitete Methode ist zudem auf die weiteren Regionen Zentralasiens übertragbar und somit von überregionaler Bedeutung.
Seine Studie erscheint zudem im so genannten „Internationalen Jahr der Wüsten und der Desertifikation“ (United Nations Convention to Combat Desertification CCD) und stellt einen wichtigen Beitrag zur Trockengebietsforschung in Zentralasien da.

Göttingen, Juni 2007
Martin Kappas

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Introduction

Problem description

From currently published studies it is known that the vegetation on the surface of the Earth is rapidly changing. Change is occurring to the phenology, the distribution of vegetation on the earth surface and to the annual dynamics of photosynthetic activity (Kowabata et al., 2001; Reed et al., 1994). The change of vegetation cover is both naturally and anthropogenically influenced. This change has direct implications for human society as well as for the earth system, since the processes occurring in the vegetation cover are tightly coupled to the processes occurring in other components of this system such as meteorological, hydrological and biogeochemical. Thus, understanding the causes of vegetation variability and measurement of vegetation responses to natural and anthropogenic influences are of great scientific importance.

Great magnitude changes in vegetation activity result from the contemporary global warming of the earth climate leading to redistribution of precipitation and temperatures on the earth surface (IPCC, 2001). Most of these changes are observed in the high latitudes of North America and Eurasia and associated with an increase in vegetation activity due to prolongation of the growing season caused by temperature rise, particularly throughout the spring months. Rapid increase of CO_2 content in the atmosphere is reported to be a driving force of this phenomenon. Changes in vegetation activity can also result from a variety of other environmental factors, such as desiccation and droughts, El Nino-Southern Oscillation (ENSO) (Anyamba et al, 2001; Gutmann et al, 2000) or human activities (e. g. land-use). Inter-annual changes associated with a decrease of vegetation activity are observed in wide areas of Australia, South and Central Africa, South America and in some regions of Asia. Causes of diminishing vegetation activity are the increasing dryness of the climate in these regions and inadequate human influence.

The consequences of the contemporary climate change have been observed in all regions of the Earth but the most devastated consequences are to be expected in the ecosystems of low stability to internal forces. Such ecosystems are presented in drylands and cover more than 30 % of the terrestial surface. On the one hand, the natural environment of the drylands is highly vulnerable and fragile, variations of climate conditions here are the highest among all terrestrial ecosystems and that is

why any unwise action of people in resources development can lead to a disturbance of equilibrium in nature, and accelerates processes of land degradation and desertification. On the other hand, drylands are densely populated and extensive used for agricultural production.

There is a great demand for a better understanding of nature of climate impacts on the drylands as a whole system and on the vegetation cover as an important component of this ecosystem at all scales from global to regional and local. This understanding requires detailed investigations on the vegetation response to climate factors. On the one hand, knowledge of this response holds the potential for discrimination of threatened areas and forecasting of damage grade by drought events. On the other hand, this knowledge subsequently improves planning of protection arrangements. Another benefit is associated with forecasting of regional agricultural yields for drought years which improves planning for food supply for times of food scarcity.

The hot debate about the concept of dryland dynamic has its roots in the specific features of dry lands, namely high variability of climatic conditions and high dependence of ecosystem dynamics in dry lands on this variability. According to this, it is not surprising, that this debate is accompanied by the debate about equilibrium or non-equilibrium of the dry land ecosystems. Detection of vegetation cover change in drylands and understanding of its causes and consequences depend on the point of view in the equilibrium concept (Sillivan & Rohde, 2002; Herrmann & Hutchinson, 2005; Vetter, 2005; Robinson et al., 2002).

According to the equilibrium concept, the dry lands are believed to have only a weak mechanism of internal regulation which, consequently, enables a weak resistance to external factors such as climatic perturbations including drought and desiccation hazards, fire and human activities. Therefore, it seems likely that any trend in ecosystem conditions may be highly dependent on the trends in various climatic factors, mainly, precipitation and temperature. In order to identify changes that are attributed alone to human influence, this climatic component must be identified and removed from the evident ecosystem changes (Evans & Geerken, 2004; Li et al., 2004). Thus, an evaluation and monitoring of land performance may begin with an investigation of climatic factors dynamics and their changes over monitoring time and resilience and resistance of the ecosystem to these changes. After that, when this task is solved, one can look at ecosystem changes that are caused by anthropogenic impact.

In the last two decades, capabilities for monitoring global and regional environmental phenomena were significantly improved. The dryland theory shifted to characterizing and understanding external forcing as possible explanations for ecosystem variability. Studies of relationships between satellite derived vegetation index, NDVI, and climatic data have shown that most ecosystem variability in dry regions is directly dependent on rainfall variability (Tucker & Nicholson, 1999; Anyamba & Tucker, 2005; Olsson et al., 2005; Xiao & Moody, 2004). It is primarily caused by changes in rainfall patterns, which leads to change in biomass production, that climate change will affect land degradation and desertification. Changes in rainfall can be controlled by regional or global processes such as global circulation changes related to patterns of sea-surface temperature or El Nino Southern Oscillation (Young & Harris, 2005; Gurgel & Ferreira, 2003; Verdin et al., 1999; Anyamba & Tucker, 2001). The dynamics of ecosystem in dry lands are essentially driven by climatic variability. Deficits in rainfall, especially during drought and desiccation events, seriously reduce biomass and vegetation cover. This can give a start to process of land degradation, if the ecosystem resources are used with the same intensity degree as during wet years. The developing degradation disrupts ecological and social patterns and can hinder an ecosystem recovery after the climatic hazards. However, it does not always follow that climatic hazards will give rise to desertification in every case. Much depends on the resource management (Herrmann & Hutchinson, 2005).

Objectives and aims of the study

This thesis was not only focused on a monitoring vegetation conditions and climate in a dry region of Kazakhstan but also on discrimination between climatic and anthropogenic forces in the complex of dryland dynamics. The work tried to find out what the proportion between them is and how they influence the dynamic and changes of ecosystems in the study region over the last two decades of the 20th century. On the one hand, the large size of the study region (approximately 3°*3° latitude/longitude) reveals problems caused by a significant heterogeneity of its surface features through a large quantity of landscape types. On the other hand, it achieved advantages for a discussion of the final results: a variety of ecosystems exhibited a broad spectrum of influence proportions between climatic factors and