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Remote sensing assessment of the feedbacks between climatic, environmental and societal changes in Siberia over 30 years: the CLASSIQUE project
Remote sensing assessment of the feedbacks between climatic, environmental and societal changes in Siberia over 30 years: the CLASSIQUE project

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SCIENTIFIC OBJECTIVES

The CLASSIQUE French research project is focused on the impacts of climate change in Siberia, with a special attention to land cover evolution, forest vulnerability and permafrost reduction. It mobilizes climatologists, hydrologists, agronomists, demographers and specialists of scientific mediation in a trans-disciplinary effort to better quantify (1) future changes of climate and vegetation properties in Siberia; (2) the consecutive evolution of the agricultural potential of the region; (3) the demographic and societal effects of these changes; and (4) the interactions and feedbacks induced.

METHODOLOGY

This chosen approach aims to develop integrated models able to predict the evolutions of land cover and hydrology and the links with the Russian population. To predict the future impacts of climate change on Siberian ecosystems, the two French vegetation models (ISBA and ORCHIDEE land surface models) will be used and various datasets will be developed for their validation on the past thirty years and identify possible trends. A large interest is devoted to remote sensing archives which provide surface monitoring and spatial integrated variables on the last thirty years. Various satellite products are gathered and developed at different scales to assess land surface variables like, land cover / land use changes, albedo, surface temperature, fire and vegetation dynamics as well as soil moisture, wetlands, snow cover, freezing and thawing periods, etc. Preliminary products developed and satellite database status are presented.

LAND COVER MAPPING & CHANGE

Various land cover products have been compared on the Yakutskian region (Sakha republic) and some discrepancies have been highlighted. The products registered at 5km scale area: GLC2000 (SPOT/VGT, Bartholomé et al., 2005) for the Year 2000, GlobCover (ISBA, MERSI, Avina et al., 2008), MODIS (version MOD12Q1, Fried et al., 2002) for 2005.

In terms of legends comparison, GlobCover and GLC2000 contain more classes than MODIS with sometimes no correspondence between classes. As examples, the class “bare-areas” don’t exist in MODIS classification but class “Swampland” is not found in GLC2000 and GlobCover classifications. There is a rather good agreement between GlobCover and GLC2000 maps but not with MODIS.

Indeed, on MODIS map, shrubs cover almost all the region of Sakha and Needeleik deciduous trees cover only a part of the south. It is the opposite in GLC2000 and GlobCover where Needeleik deciduous trees and grass in general, cover most of the region. In the extreme north of the region, GlobCover and GLC2000 maps present some discrepancies. Grasslands appear in GlobCover (and MODIS) but not in GLC2000. As GlobCover and MODIS cover the same period of time, these differences may reveal vegetation changes in the extreme north of the Sakha region.

URBANIZATION EVOLUTION ON YAKUTSK REGION

Urban land cover change modeling from 1992 to 2011 made with Landsat 5 TM series: growth of Yakutsk city and emergence of suburbanization dynamics mostly on allotment gardens

REMOTE SENSING DEVELOPMENTS

VEGETATION PHENOLOGY

The analysis of optical reflectance seasonal variations allows to estimate the timing of the vegetation phenology (greening up and senescence dates) and its evolution over the last 30 years. The SPOT/VGT and NOAA-AVHRR instruments have been used for that purpose.

Remote sensing greening up dates (Day of the year), calculated over times series of reflectances from AVHRR Pathfinder and SPOT-VGT S10 data, averaged over the Siberian region (50°N-72°N, 45°E-120°E).

At spring, reflectances evolve following snow cover melting and foliation. Special care was given to separate snowmelt effect from foliation. More than SPOT-VGT, this was performed by using a combination of middle infrared and near infrared reflectances which makes the distinction easier than using the NDVI.

On NOAA-AVHRR, a NDVI threshold approach was calibrated using SPOT-VGT results on the common years.

SNOW COVER

Two satellite-derived snow water equivalent (SWE) products have been validated by in situ observations from former Soviet Union snow network. The FMI GLOBSNOW product outperforms the LEGOS product in bias. At the same time, the temporal correlations in situ observations are very low. LEGOS product reproduces well the temporal variation of SWE while it is strongly biased compared to in situ observations on Siberian territory.

Also, although SWE and snow depth (SNOLD) are strongly related, SWE signal is more noisy and no agreement was found between ENVISAT and SWE, with same regional patterns.

HYDROLOGY WETLANDS REGIME

The ratio of water loss (water level into lakes/wetlands or loss by evaporation) in increasing for northern Western Siberia climate change or anthropogenic impact?

Need for assessment of hydrological role of wetlands

Although SWE signal is more noisy, there is a good agreement between ENVISAT and SMOS, with same regional patterns.

FROM RADAR ALTIMETRY (ENVISAT)

Type 1: Small permanent flooding (low peak) and well pronounced drying/wintering

Type 2: High permanent flooding with insignificant drying

Type 3: Medium permanent flooding with two peaks and well pronounced drying

FROM MICROWAVE RADIOMETRY (SMOS)

Fraction of wet zones from SMOS (Winter 2010)

For a few remote areas where in situ data are not available, the maps were compared with MODIS surface reflectance (2005), which contain the limits of MODIS permafrost (220K is the limit for MODIS)