

PROCESSING OF MULTI-TEMPORAL SATELLITE DATA FOR LOCUST MASS BREEDING CONTROL IN THE WEST SIBERIA

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ABSTRACT:

The problem of locust mass breeding in Russia became more and more urgent. Last outbreaks of a locust in the West Siberia, Kazakhstan and the Caucasus have evoked considerable interest of scientists to remote sensing methods of locust numbers control and forecast. A few physical parameters determine the life cycle of the locust: temperature and humidity of the soil and air, green biomass volume, soil type. Modern remote sensing has potential ability to retrieve these parameters. Some of these parameters, mostly vegetation index, are successfully used for locust control, for example, in North Africa. Wide range of sensors can be used for locust control. Long range of locust mass breeding (years) demands heritage satellite systems. At the moment only NOAA(AVHRR) plus EOS(MODIS) meets these requirements. South part of the West Siberia was analysed for vegetation index change in connection with locust spreading. Multi-temporal analysis was done on three levels: year, season and day to day. First was multi-year range of observations. Vegetation index change from 1981 to 2005 was compiled. Years with vegetation index minimum conform to maximum of locust numbers. Vegetation index changes in time like sinusoid with a period about 10 years. Meteorological observations did not show any periodical processes for the first view. Long term air temperature analysis indicates the growth at 4 degree in last 150 years. The sine shape of vegetation index looks like solar activity curve. Another type of analysis was done in year cycle. Vegetation index change for 30 test sites in 2005 was calculated. Ten days MODIS composite images were used for NDVI retrieving. Two field campaigns were done in 2005 for verification. Daily monitoring on the base of MODIS data was applied to Madagascar test site, April 2002 locust mass breeding. Future multi-temporal data analysis will include surface temperature, heat fluxes on the soil surface, soil humidity. For soil and DTM research ASTER, Landsat and SRTM data will be included.

1. INTRODUCTION

The problem of locust mass breeding in Russia became more and more urgent. Last outbreaks of a locust in the West Siberia, Kazakhstan and the Caucasus have evoked considerable interest of scientists to remote sensing methods of locust numbers control and forecast. A few physical parameters determine the life cycle of the locust: temperature and humidity of the soil and air, green biomass volume, soil type. Modern remote sensing has potential ability to retrieve these parameters. Some of these parameters, mostly vegetation index, are successfully used for locust control, for example, in North Africa, Australia (Bryceson, 1990, Despland, Rosenberg and Simpson, 2004, Hamilton and Bryceson, 1993, Tucker, Hielkema and Roffey, 1985).

The main aim of our research is application of satellite data for monitoring and in future forecast of locust mass breeding in West Siberia.

The south of West Siberia is one of the main agricultural areas of Russia. The area has continental climate with cold winter and dry hot summer. Year mean temperature is about 3.5 °C, annual precipitation is about 350 mm whereof about 100 mm is snow. Steppe landscapes are widely spread. Most of the land is plugged and the farming is based on grain-crops. Local test site located on the border Russia/Kazakhstan area, in Novosibirsk region. Test site landscapes are representative for wide agricultural are in south part of West Siberia.

A few types of locust are founded in West Siberia: Italian locust (*Calliptamus italicus*), Morocco locust (*Doclostaurus maroccanus*) and Asian locust (*Locusta migratoria migratoria*). The most dangerous is Italian locust. More than 4 million ha was affected by locust in Kazakhstan and West Siberia in 1999. Locust density was reached to 150 per square metre.

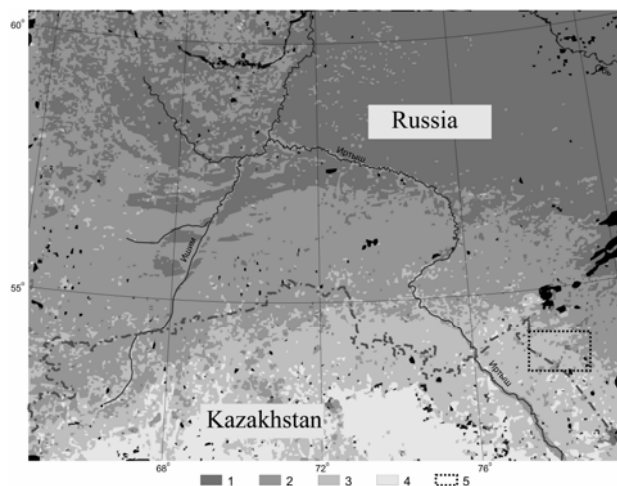


Figure 1. Test site location. Zones: 1-taiga, 2-semi-taiga, 3-steppe, 4-semi-desert, 5-test site.

Various types of satellite data were tested for locust mass breeding monitoring: surface temperature, vegetation index, and soil humidity. At the moment the vegetation index looks the most promising parameter.

2. DATA

2.1 Satellite data

MODIS and AVHRR satellite data were used for vegetation index retrieving. Archive AVHRR monthly reflectance data for band 1 and 2 were downloaded. AVHRR data have time range since 1981 till 1998. MODIS/TERRA monthly reflectance data from 1999 were also selected. 8-day composite of MODIS bands 1 and 2 reflectance were involved in processing for 2005 year season. Daily MODIS bands 1 and 2 reflectance was used for daily monitoring.

2.2 Ground data

Ground meteorological data were used in data analysis. Two field campaigns were done for locust counting.

3. METHOD

NDVI was retrieved on the base of reflectance in bands 1 and 2 both AVHRR and MODIS data (McGinnis, Tarpley, 1985). Then mean values of NDVI were calculated for test site area. Mean values were used for time-series analysis of NDVI data.

4. RESULTS

Results of NDVI analysis in relation with locust extension will be presented on three levels: year level, seasonal level and daily monitoring.

4.1 Year monitoring

Test site for year level monitoring located in relatively large area: 53-55 N, 76-79 E. Year level monitoring indicates that vegetation index changes in time like sinusoid with a period about 10 years (fig. 2). Years with vegetation index minimum

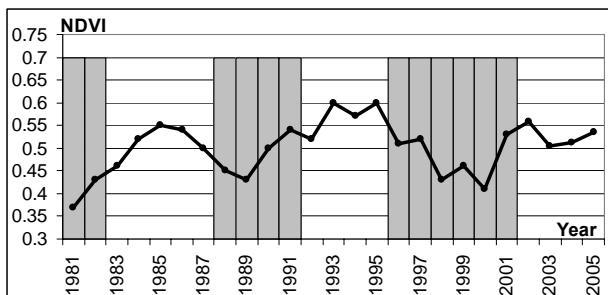


Figure 2. Vegetation index, monthly mean - August 1981-2000 – AVHRR, 2001-2005 – MODIS
Columns indicate periods of locust mass breeding.

conform to maximum of locust numbers. Meteorological observations did not show any periodical processes for the first view (fig. 3, 4).

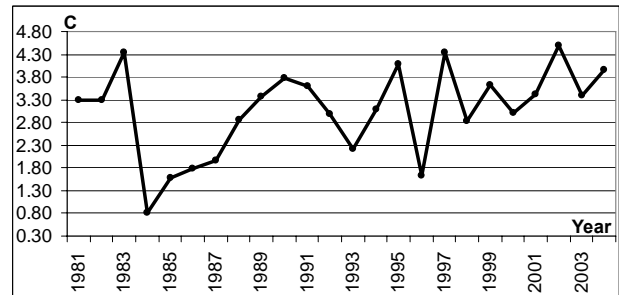


Figure 3. Mean year temperature.

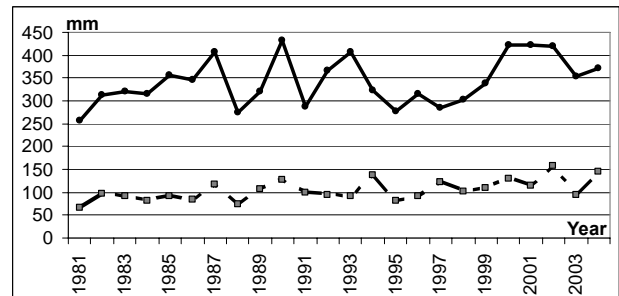


Figure 4. Mean year precipitation – solid line, snow - dash line.

The only relation has been found – with sun spots numbers and solar radiation (fig. 5).

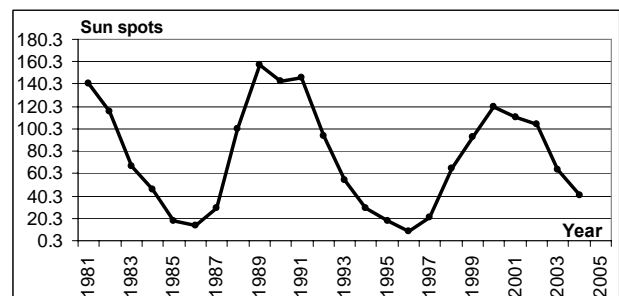


Figure 5. Sun spots numbers.

4.2 Seasonal monitoring

Seasonal monitoring was executed for smaller size test site. This test site has 30 test points. NDVI calculated for every 8 days during 2005 year vegetation season. Example for five test points is represented on figure 6. Two field campaigns was carried out

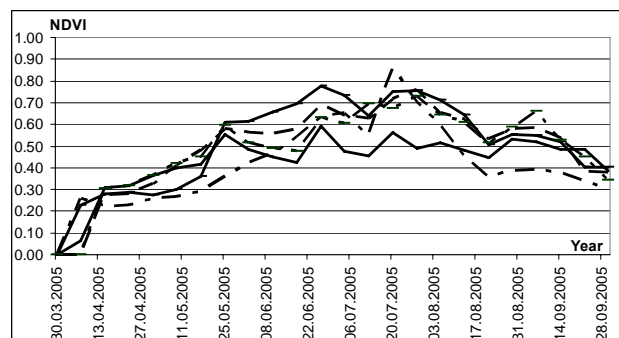


Figure 6. Vegetation index change on local test points in 2005. on test site in 2005 for locust counting. Probable correlation was established for NDVI and locust density (fig. 7).

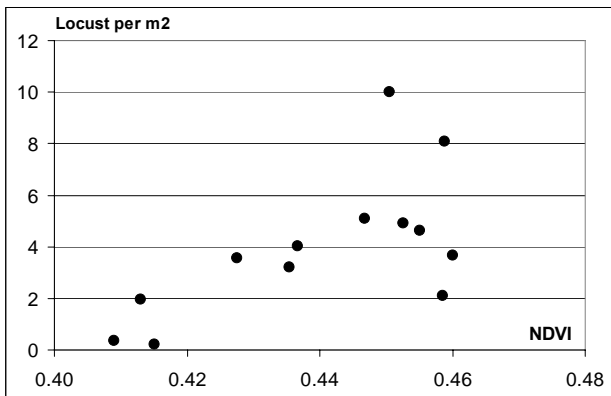


Figure 7. Average vegetation index and locust density in 2005.

4.3 Daily monitoring

Due to the luck of locust last years on the test site, we tried to test other areas affected by locust. One of the well recorded outbreak of locust took place in Madagascar in 2002 (Franc A., 2006). Test site is shown on figure 8.

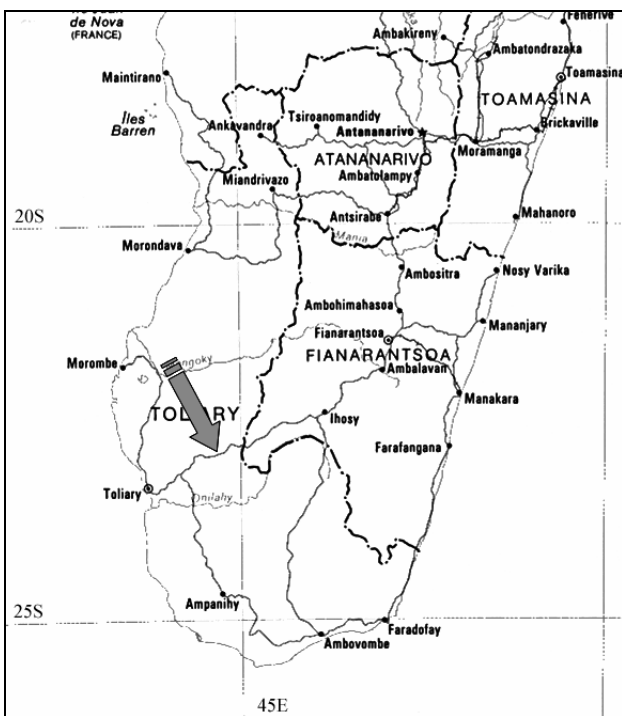


Figure 8. Test site in Madagascar.

Daily vegetation index was retrieved for month period from 1 till 30 April 2002. Only two images from month time-series are shown on figures 9 and 10. Vegetation index indicates significant reduction from day to day. Ground truth data confirm decrease of vegetation and locust mass breeding.

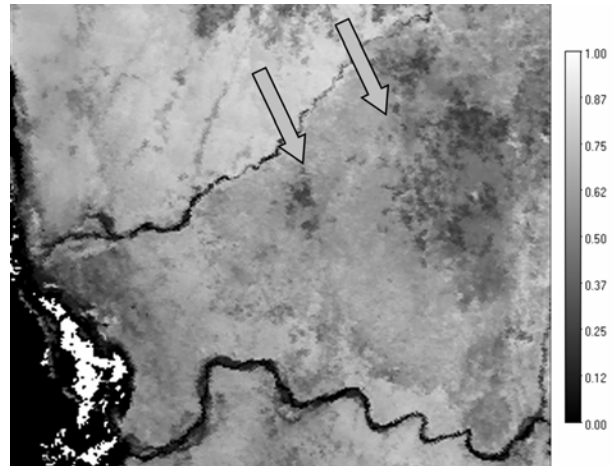


Figure 9. NDVI 25 April 2002 in Madagascar. Arrows indicate locust outbreak area.

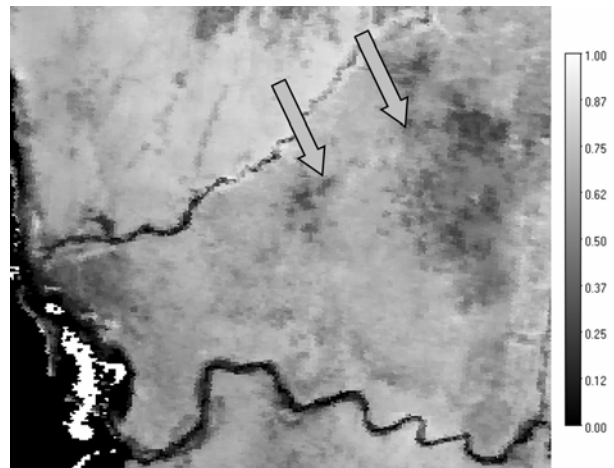


Figure 10. NDVI 26 April 2002 in Madagascar. Arrows indicate locust outbreak area.

5. DISCUSSION

First results of NDVI data application for locust mass breeding look promising. Very interesting results were obtained on year and daily level. Future researches will concentrate on the relation of NDVI with precipitation and air temperature. Land surface temperature time-series analysis will be done. More complex researches like surface heat fluxes analysis, surface thermal inertia retrieving also will carry out. Soil humidity data also require precise analysis.

6. CONCLUSION

The results of multi-temporal satellite NDVI data on the year level:

- 1) Vegetation index in the south part of the West Siberia is changed periodically;
- 2) The period is about 11 year;
- 3) Locust mass breeding is coincided with minimum values of vegetation index;
- 4) Remote sensing could be used for locust mass breeding forecast on year level.

Seasonal level monitoring did not show clear results yet. Daily level monitoring looks more promising:

- 1) Vegetation index indicates locust mass breeding;
- 2) Rapid drop of the vegetation index points to locust mass breeding area;
- 3) Remote sensing could be used for locust mass breeding monitoring in real time.

7. ACKNOWLEDGEMENTS

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