Research of spatial-temporal dynamics of forest fires in Eastern Siberia

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Abstract – The spatial-temporal dynamics of forest fires for last five years in latitudinal range 40-74 degrees of the northern latitude are analyzed with using the data of the radiometer AVHRR/NOAA. It was shown that forest fires are observed from May till September, basically during three summer months with a maximum of the activity during the second half of summer. On a phase of a maximum of an 11-years cycle of solar activity the tendency of displacement of forest fires to the north is observed. This situation may be explained by latitudinal displacement of trajectories of the Atlantic cyclones on a phase of a maximum of solar activity.

Keywords: forest fires, remote sensing, solar activity, cloudiness.

1. INTRODUCTION

Basically, the degree of fire danger of forest depends on amount of an atmospheric precipitation, temperature and thunderstorm activity. Cloudiness can indirectly serve as a parameter of thunderstorm activity. Atmospheric precipitation in the north of the Asian continent, as a whole, is determined by moisture carrying from Northern Atlantic and Arctic Ocean seas by cyclones. The humidity content of cyclones of Arctic Ocean seas penetrating into a lower reaches of Lena River considerably goes down at passage of the Mid-Siberian plateau determining orography of the region between Yenisei and Lena rivers. The general trend of the annual precipitation variations for last 50 years has negative character.

It is known that the changes of atmosphere circulation investigated during several centuries are connected to a level of solar activity (Morozova, 2000). The variations of circulation are observed both during an 11-years cycle of solar activity, and on shorter time periods. Many authors mark change of atmospheric pressure near a ground surface and heights of geopotential surfaces after geomagnetic disturbances or the solar flashes accompanying with splashes of solar cosmic rays (Morozova, 2000). The same is shown by observations over change of a cloudiness and amount of lightnings during Forbush-decreasing of intensity of galactic cosmic rays and flashes of solar cosmic rays (Solovyev, 2003a).

The historical data (Abrosov, 1962) testify that during epoch of increased solar activity the pressure in area of maximum is increasing and in high latitudes is decreasing, this is a result of displacement of cyclones trajectories a poleward. The results which confirm the dependence of paths of cyclones in northeast Atlantic and Europe from a phase of a solar cycle are presented in (Tinsley, 1988). During an epoch of a solar maximum the "northern" way of the Atlantic cyclones is shifting to the south while the "southern" way is shifting to the north, and the amplitude of variations is approximately 10 degrees of latitudes. The author of work (Abrosov, 1962) furnish proofs that the basic features of structure of atmospheric circulation in Northern Asia up to 140th east meridian also are moving to the north during the increased solar activity, and during an epoch of weak solar activity has more southern placement. The latitudinal dependence of variations of total solar radiation in an 11-years cycle of solar activity is explained in work (Veretenenko, 1977) by latitudinal displacement of cyclones trajectories.

The purpose of the given work is research of spatial-temporal picture of distribution of a cloudy cover and forest fires in the Northern Asia.

2. DATA & METHODS

Since 1995 in Institute of Cosmophysical Research and Aeronomy SB RAS the direct reception of the data from NOAA satellites and research on data of remote sensing are conducted. In institute the system of operative monitoring of flood, forest fires, cloudiness and man-caused pollution zones is organized on the satellite data (Solovyev, 2000b; Solovyev, 1997c; Solovyev, 2002d).

In the given article the results of processing of the NOAA satellite data received in 1998-2003 are presented. Cloudiness was considered for 1998-2000, and forest fires - for 1998-2003. The monthly average data and annual average data have been used for the analysis of the spatial-temporal picture of distribution of a cloudiness and forest fires.

For research of a picture of distribution of forest fires the territory of Yakutia has been divided into three latitudinal zones: "southern" (56°-62°), "central" (62°-68°) and "northern" (68°-72°). Forest fires were detected on NOAA satellite data by the automated algorithm (Abushenko, 1999).

The cloudiness was estimated for three latitudinal zones (a "southern" zone - 56°-40 °, the "central" zone - 56°-66 °, "northern" zone - 66°-74 °) within the region of reception of station. Cloudiness on the satellite images was determined by standard algorithms as recommended by NOAA. For every latitudinal zone the cloudiness was estimated as percent of the square of zone.

3. RESULTS & DISCUSSIONS

For all three chosen latitudinal zones (Fig. 1a) the cloudiness is minimal in July. The cloudiness decreasing is observed from April till July, and from August till October cloudiness grows.

Value of the relation of cloudiness in the central zone to northern and southern zones increases during 1998-2000 years (Fig. 2a). It corresponds to representations about change of cloudiness in Europe depending on solar activity (Tinsley, 1988; Svensmark, 1997). The period 1998-2000 corresponds to the increased solar activity.

Fires in Yakutia are observed from May till September, basically during three summer months with a maximum in

second half of summer in July (Fig. 1b). The greatest amount of forest fires is observed in July and in August. The seasonal variation corresponds to the results of the (Sherbakov, 1979). The unusually big amount of forest fires in the second half of summer (for example, in 2003) is explained the dried out underbrush and this situation usually appears when during this period the amount of precipitation is small. It corresponds to cloudiness decrease in our observations.

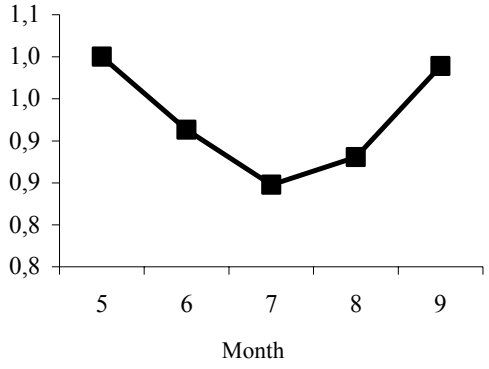
On Fig. 3 the distribution of forest fires for 1955-2003 is presented. From 1998 till 2000 smooth reduction of the area of forest fires in Yakutia is observed. The minimum of forest fire activity has fallen on 2000. Further, within two years the sharp increase of the area of forest fires is observed. If to consider a trend for all 6-years period of satellite observations the increase of forest fires is observed, and the greatest increase is observed in central latitudinal zone, and the least in northern latitudinal zone.

With 1998 till 2003 year the tendency of displacement of forest fires to the central zone (Fig. 2b) is observed. On Fig. 4 the summary map of forest fires for 1998-2003 is presented. The absence of fires in a northwest part of Yakutia and their small number in the western part is observed. It can be explained by humidity of the climate and small population density in these regions. The map of forest fire distribution well coincides with a map of an atmospheric precipitation. The regions of high concentration of fires coincide with regions with the average annual amount of precipitations less than 250-200 mm (The Atlas of Agriculture of Yakutia, 1989). On the other hand the regions with high concentration of forest fires coincide with zones of the increased population density. Thus the man-caused activity of people considerably influences on the amount of forest fires too.

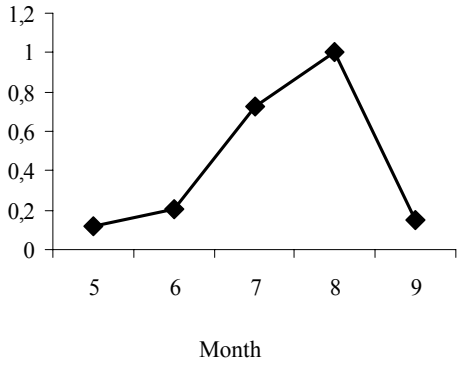
The retrospective analysis of numerous cuts of trunks of the overmature larches leads to conclusion the forest fires - are widespread phenomenon in Yakutia with the certain periodicity. On separate tested old trees (their ages are up to 300 years) the action up to tens of fires was marked, these fires are occurred in 10 or 22 years (Timofeev, 1994). According to data of the "Avialesokhrana" about fires in Yakutia for last 50 years the approximately 20-years periodical variations are observed (Fig. 3).

The analysis of a long-term variations of annual temperature for the period of supervisions from 1947 to 1995 testifies to downturn of temperature from the middle of the fortieth years up to the end of the 50's - the beginning of the 60's. The warming which has followed after began in a southern part of researched region. Next the warming has extended over northern areas. During all this period the waves of heat and a cold by duration from 4 till 8 years on a background of more significant changes of temperature duration on the average 10-12 years (Semiletov, 1998) were marked. As a whole for all period of observations the expressed positive trend in a long-term course of temperature of air is marked.

The general trend in a long-term course of the annual sums of precipitations for last 50 years is negative. The temperature of air correlates with an 11-years cycle of solar activity (Morozova, 2000). The thunderstorm activity anticorrelates with an 11-years cycle of solar activity (Mullayarov, 1997). The humidity and cloudiness in the northern hemisphere also anticorrelate with a solar activity. However, in local scale the behavior of the humidity and clouds depend on a latitude and orography of terrain, and is being determined by change of trajectories of atmospheric cyclones and anticyclones. Therefore the picture of the fire hazard on the selected geographical area changes in complex manner during solar cycles.

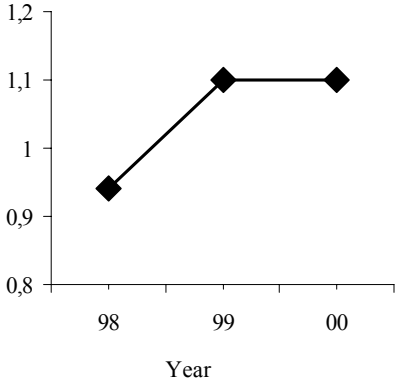


(a)



(b)

Figure 1. The seasonal variations of cloudiness (a) and the area covered with the forest fires (b) in Yakutia during the period May-September, normalize for maximum.



(a)

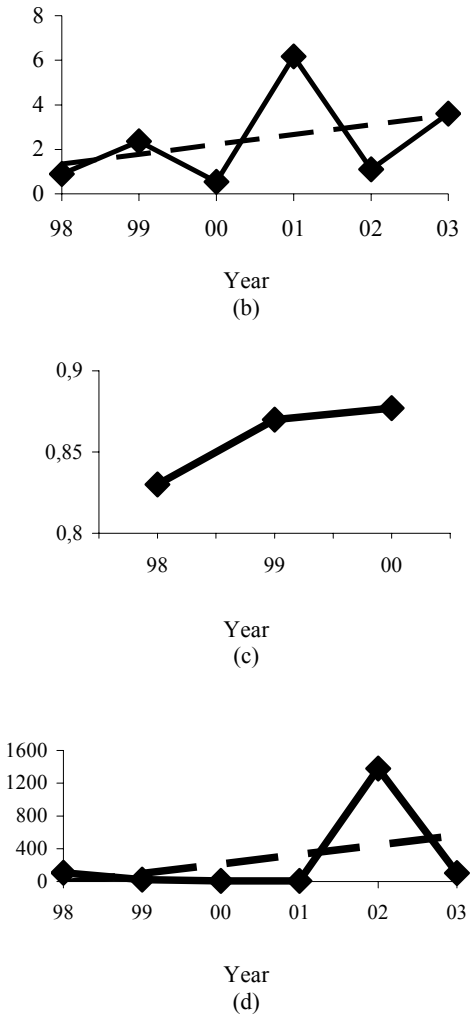


Figure 2. The relations between cloudiness of three latitudinal zones and the similar relations for area covered by fires: (a) – the relation of cloudiness of the central zone to a southern zone; (b) – the relation of the fires area of the central zone to southern zone; (c) – the relation of cloudiness of the central zone to northern zone; (d) – the relation of the fires area of the central zone to northern zone.

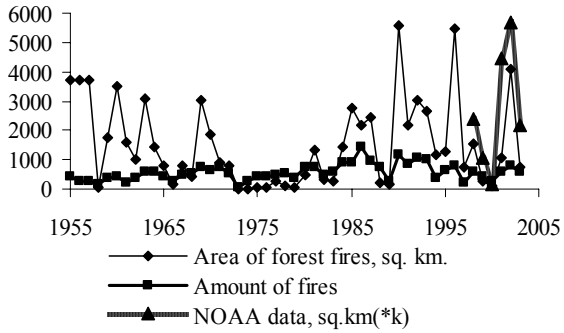


Figure 3. Annual variation of forest fires for 1955-2003.

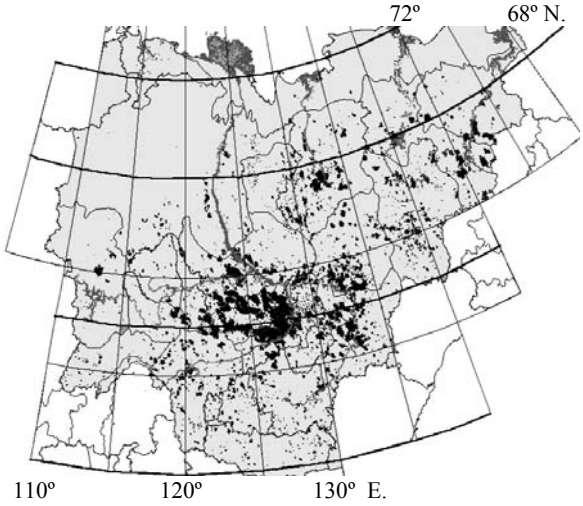


Figure 4. Map of distribution of forest fires detected from NOAA satellites for 1998 – 2003.

4. CONCLUSIONS

The amount and the areas of forest fires are conditioned mainly by the quantity of thunderstorms, by the temperature and by the humidity of the second half of summer. These parameters depend, in the certain degree, from solar activity which is determined by latitude of a place of observation. The latitudinal dependence of the cloudiness dynamics can be explained by displacement of trajectories of the Atlantic cyclones determining weather from Europe up to 140 meridians in Northern Asia and by the places of origin of regional cyclones.

The cloudiness above Yakutia goes down from May till August and from August till September increase. The forest fires in Yakutia are occurring from May till September, basically for three summer months with maximum in second half of summer. The presence of a variation with the period of more than five years is marked.

According to satellite data during 1998-2003 the general displacements of cloudiness and forest fires in latitudinal direction are observed. That is probably caused by displacement of a trajectory of the Atlantic cyclones which determine cloudiness and precipitations on the most part of Yakutia.

The absence of forest fires in a northwest part of Yakutia and the small amount of fires in the western part can be explained by concerning increased humidity in these regions and by small population density there. The map of forest fire distribution well coincides with a map of an atmospheric precipitation. The regions of high concentration of fires coincide with regions with the average annual amount of precipitations less than 250-200 mm. On the other hand the regions with high concentration of forest fires coincide with zones of the increased population density. Thus in our opinion the man-caused activity of people considerably influences on the amount of forest fires too.

It is necessary to note also, that the received data testify that the standard structure of ecological monitoring at studying northern geosystems should be added by new elements (by technologies of remote sensing and so on).

These elements are focused on researches of the forest fires, and demand the development of special hardware-software means.

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