Cumulonimbus clouds and thunderstorms in summer over Russia: Changes during 1966-2010

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Recent studies show the increase of the forest fires risk in Northern Eurasia regions under expected climate changes [Mokhov et al., 2006; Mokhov and Chernokulsky, 2010; Groisman et al., 2012]. Significant part (about 15-20%) of forest fires is initiated by lightning. Here, we assess the changes in the occurrence of Cumulonimbus clouds (CbO) and thunderstorms (ThO) in summer over Russia from routine 3-hourly synoptic observations on meteorological stations during 1966-2010 [Chernokulsky et al., 2011].

We found that total cloud fraction in summer has a positive trend over Russia as a whole (about 2-4%/decade) due to an increase of CbO with an occurrence of high-level cloudiness (cirrus form). However, changes of low cloud fraction (cumuli and strati) vary significantly from station to station. The CbO has positive trend up to 6-8%/decade for many Russian stations (Fig. 1). Other low-level cloud types (Cumulus, Nimbostratus and Stratus) display domination of negative values for trends (3-5%/decade for cumuli and 1-3%/decade for strati) with minor regional exceptions. In particular, an increase of the occurrence for stratus clouds is noted over the coastal regions of the Far East (about 4-7%/decade). In general, the occurrence of convective clouds tends to increase with more intensive cumuli, the occurrence of stratiform clouds tends to decrease.

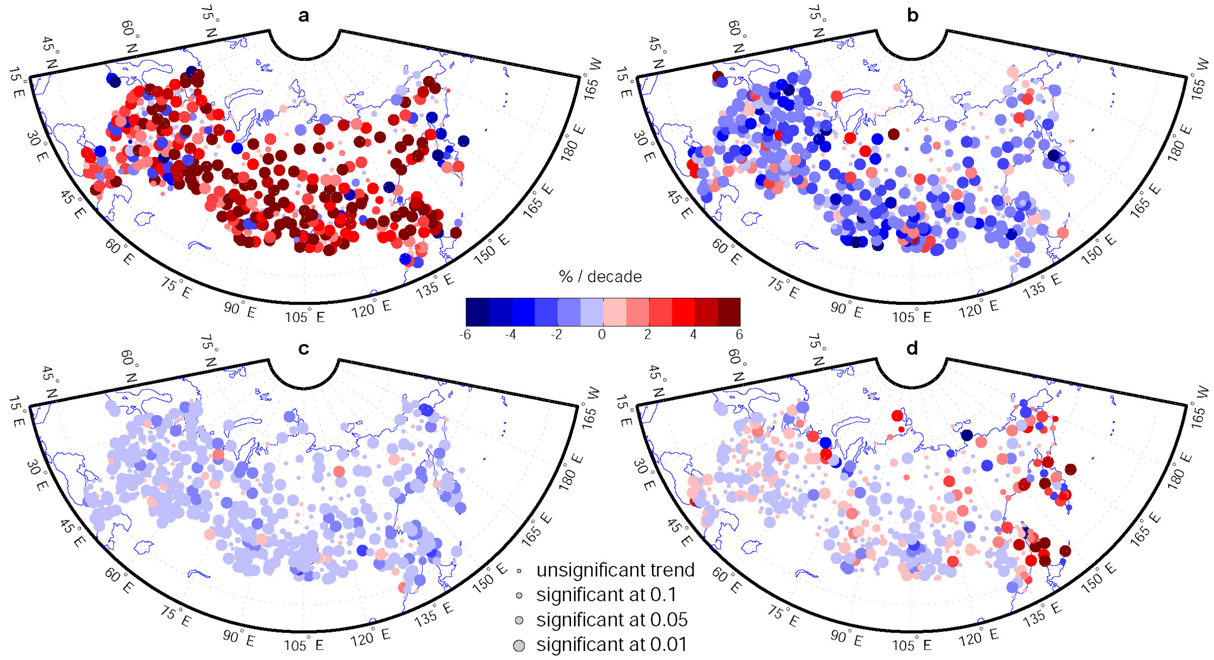

Figure 1. Trends of the occurrence of reports with Cumulonimbus clouds (a), Cumulus clouds (b), Nimbostratus clouds (c) and Stratus clouds (d) in summer during 1966-2010.

An increase of CbO can lead to an increase of the thunderstorm events occurrence (ThO). Coefficient of linear regression r of ThO to CbO in summer varies between 0.1 to 0.3 (with the maximum over Caucasus and south of Ural) (Fig.2a). Coefficient r is maximal in July-January (Fig.2b) (up to 0.45 for the entire Caucasus region). An increase of r from the first period (1966-1987) to the second one (1989-2010) is revealed. Moreover, statistical significance of r is increased from the first period to the second one as well. This comes from the change in sign for ThO trends (from negative to positive, except Caucasus with positive trend for both periods) (Fig. 3).

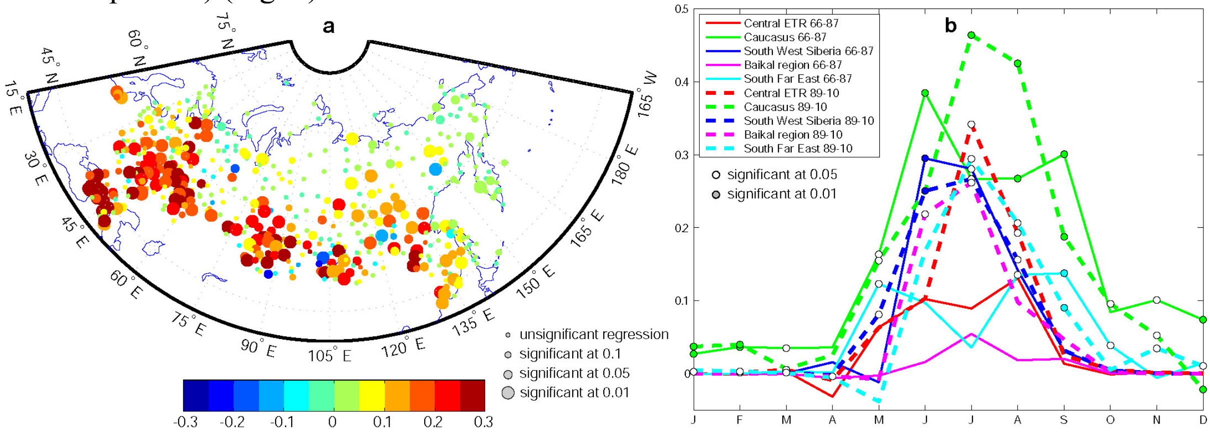

Figure 2. Coefficient of linear regression *r* for the occurrence of days with thunderstorms to the occurrence of days with Cumulonimbus clouds: spatial distribution for r in summer for the period 1966-2010 (a) and annual cycles for two 22-years periods (1966-1987 and 1989-2010) (b) for: 1. Central region of the European part of Russia (50N-60N, 30E-60E), 2. Caucasus region (40N-50N, 35E-50E), 3. South-west of Siberia (50N-60N, 65E-95E), 4. Baikal region (50N-60N, 105E-120E), and 5. South of the Far East (40N-55N, 125E-140E).

In general, cloudiness changes over Russia during last decades point to an increase of the fire ignition risk in summer. This tendency together with an increase of weather-associated fire indices should lead to more fire-hazardous regional climate in Northern Eurasia.

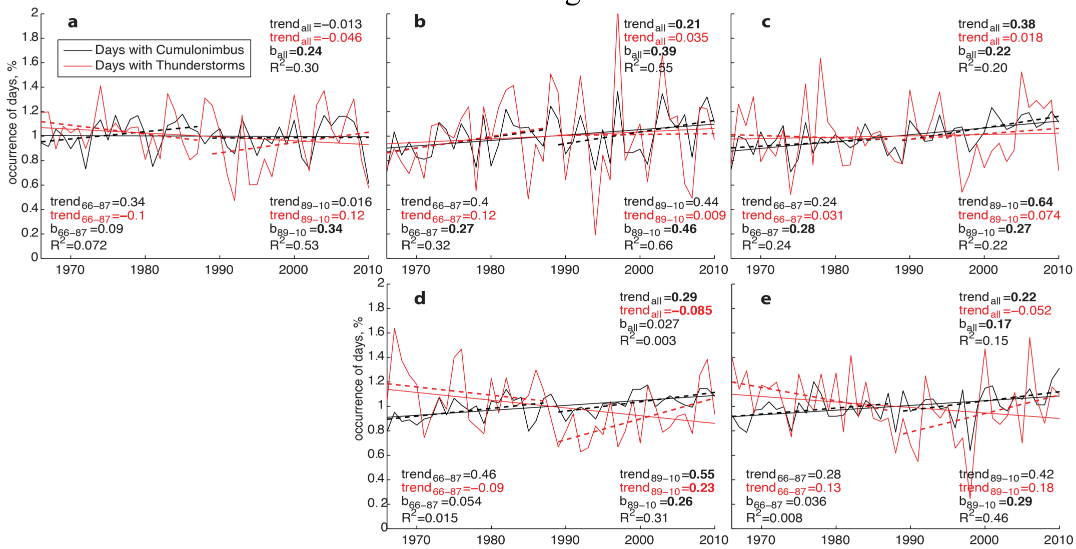

Figure 3. Interannual variations in the number of days in July with CbO and ThO for different regions (see caption to Fig.2). Coefficients of CbO and ThO trends, coefficient of linear regression of ThO to CbO and corresponding coefficient of determination are displayed (bold font corresponds to 0.05 confidence level).

References

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