Observed redistribution of precipitation types toward more heavy showers in Northern Eurasia

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Introduction

Considerable threat to society under the observed global climate change comes from the changes precipitation characteristics. In the Northern Eurasia, increasing precipitation intensities and occurrence of heavy rain events, changes in the duration of wet and dry spells affect country national economies by modulating streamflow and water availability, causing local devastating flashfloods or large-scale deluges. A close careful look onto the structural changes in precipitation is required for understanding the observed tendencies and estimating future changes. Whereas in the climate models a distinguishing between stratiform and convective precipitation is straightforward as they are simulated as different variables, separating these precipitation types in real world is challenging and requiring an analysis of supplementary weather parameters.

In this study, long-term changes of convective and stratiform precipitation in Northern Eurasia for the last five decades are estimated. Different types of precipitation are separated according to its genesis using routine meteorological observations on precipitation, weather conditions, and morphological cloud types for the 1966–2016 period.

Fig.1

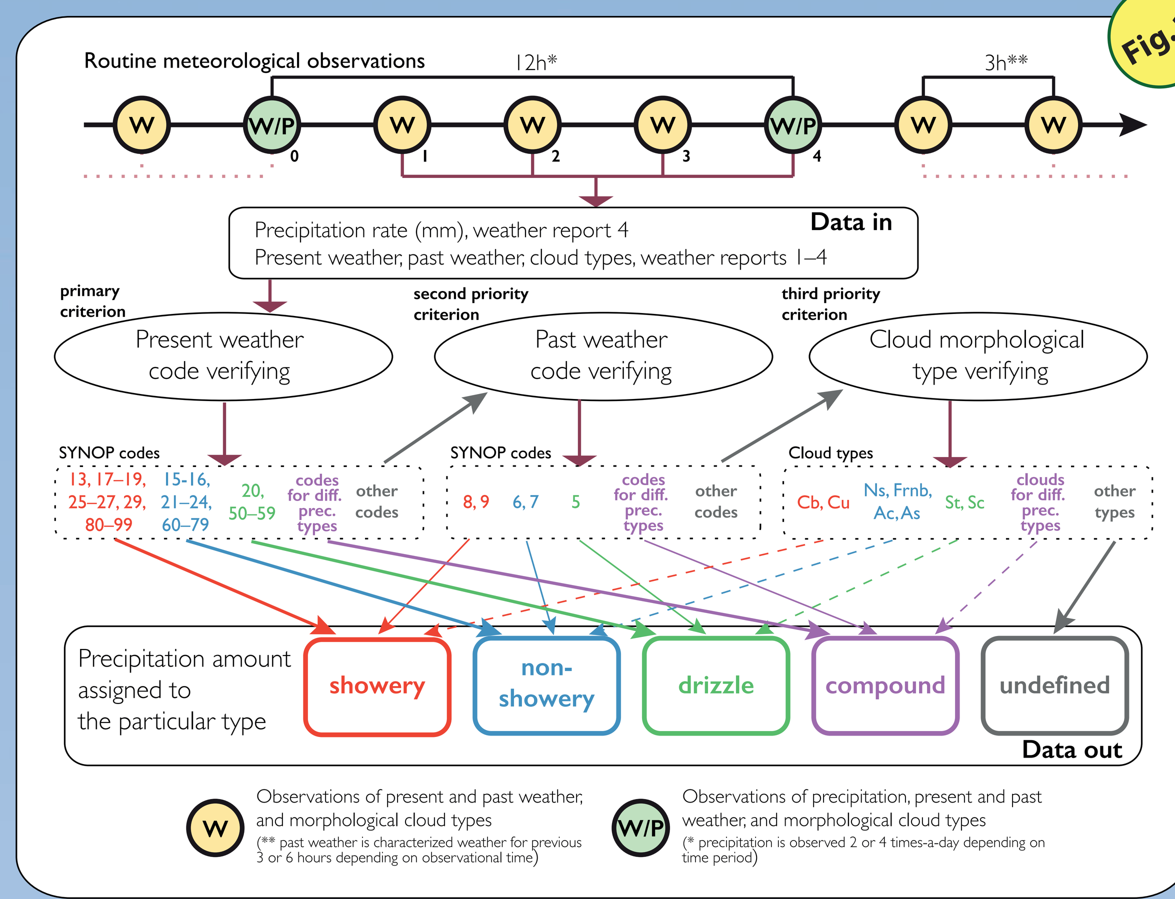

Figure 1. The scheme for separating precipitation types given routine meteorological observations on precipitation, present and past weather, and cloud morphological type.

Fig.2

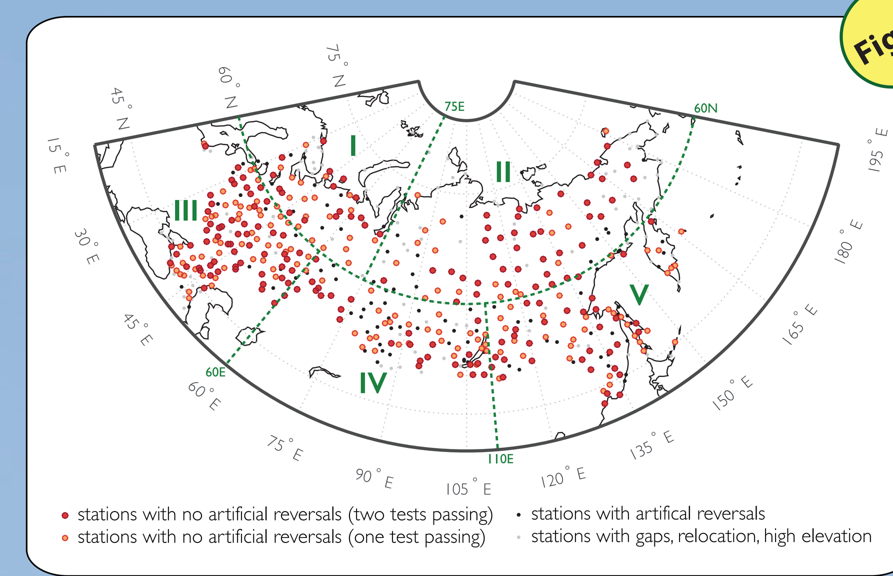

Figure 2. Weather station location

Fig.3

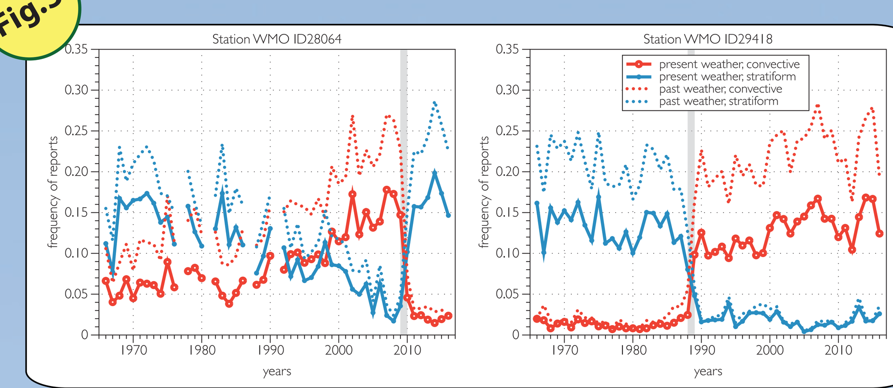

Figure 3. Examples of excluded stations

Fig.4

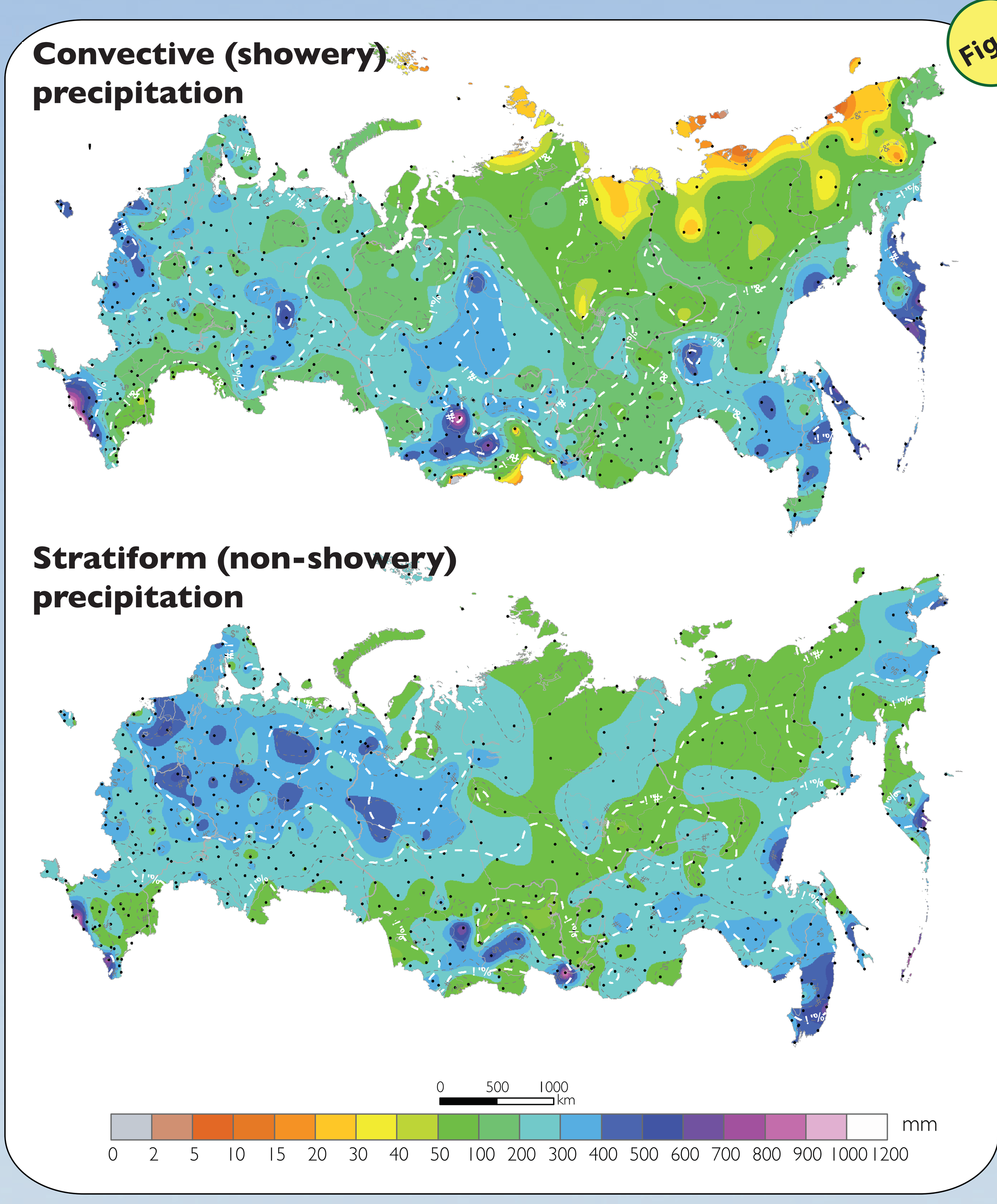

Figure 4. The climatology of annual rate (colorscale) and frequency (white dashed curves) of showery and non-showery precipitation.

Fig.5

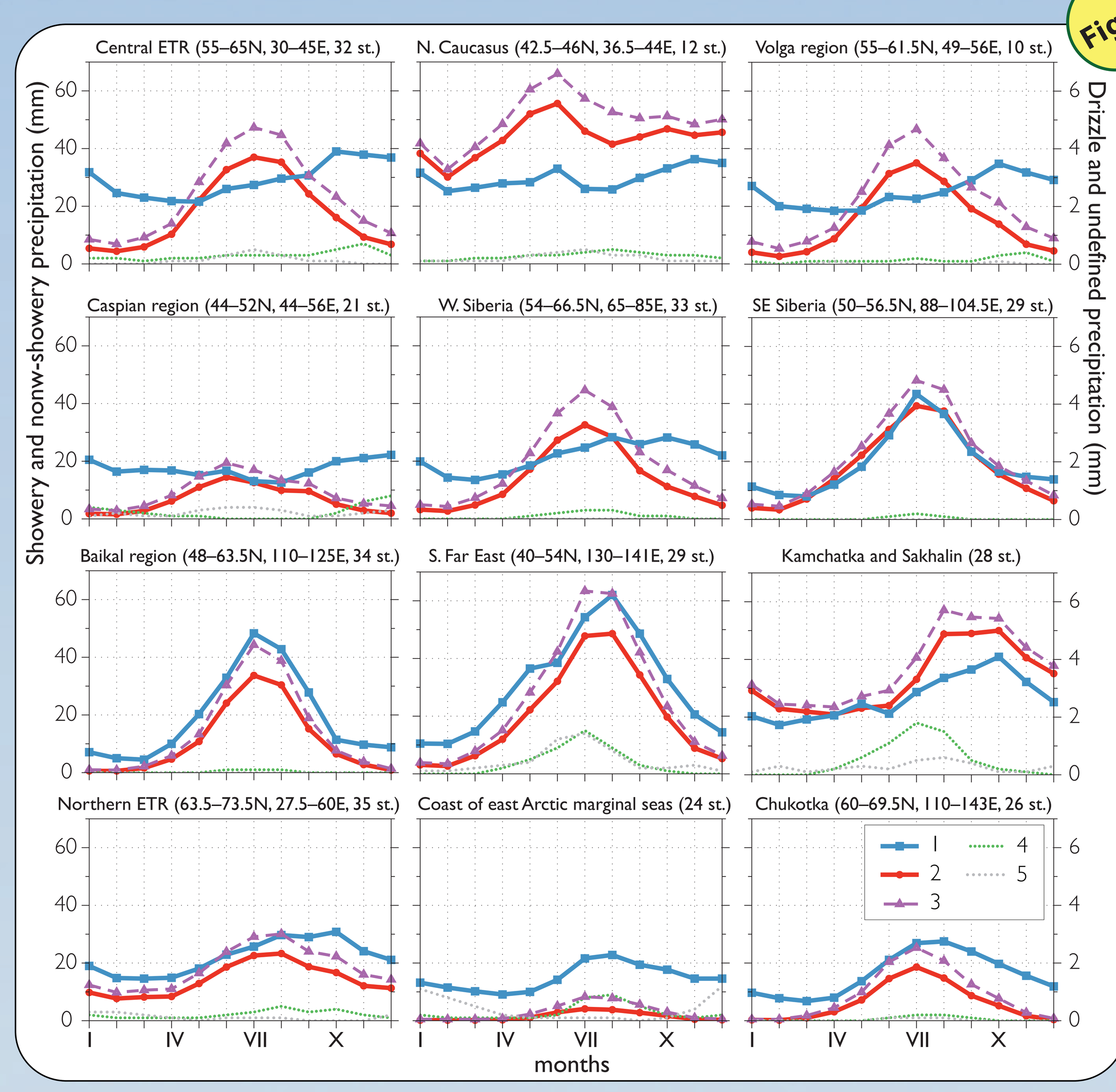

Figure 5 Annual cycle of monthly sum (mm/month) of non-showery (1), showery (2), showery+compound (3), drizzle (4), and undefined (5) precipitation in different parts of Russia.

Fig.6

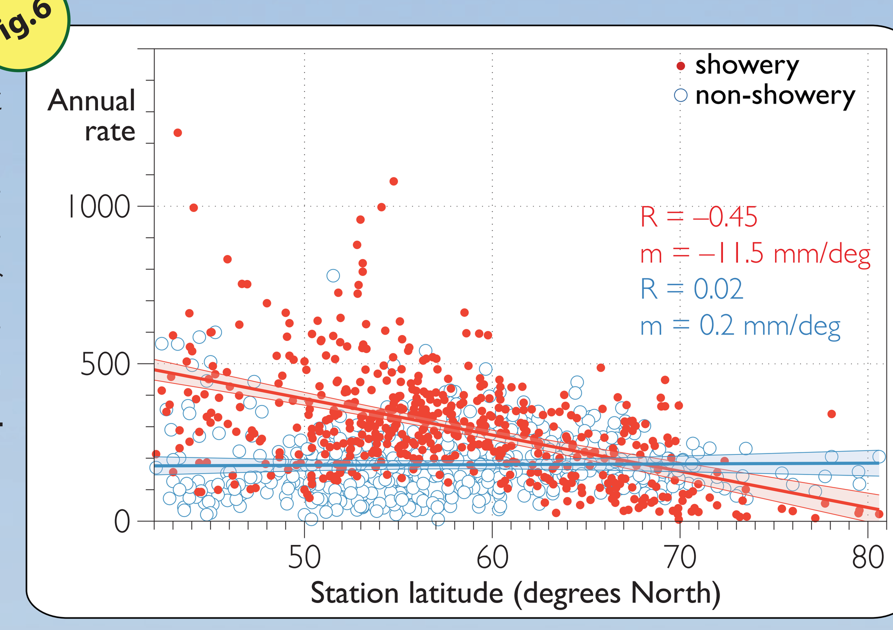

Figure 6. Scatter plot for precipitation annual rate and station latitude. Correlation (R) and linear regression (m) coefficients are also shown.

Figure 7. Mann-Kendall correlation coefficient between detrended time-series of summer P_{Conv} (a), P_{Strat} (b), $P95_{Conv}$ (c), $P95_{Strat}$ (d), and frequency of CAPE>100 J kg^{-1} in summer (from ERA-Interim data

Fig.7

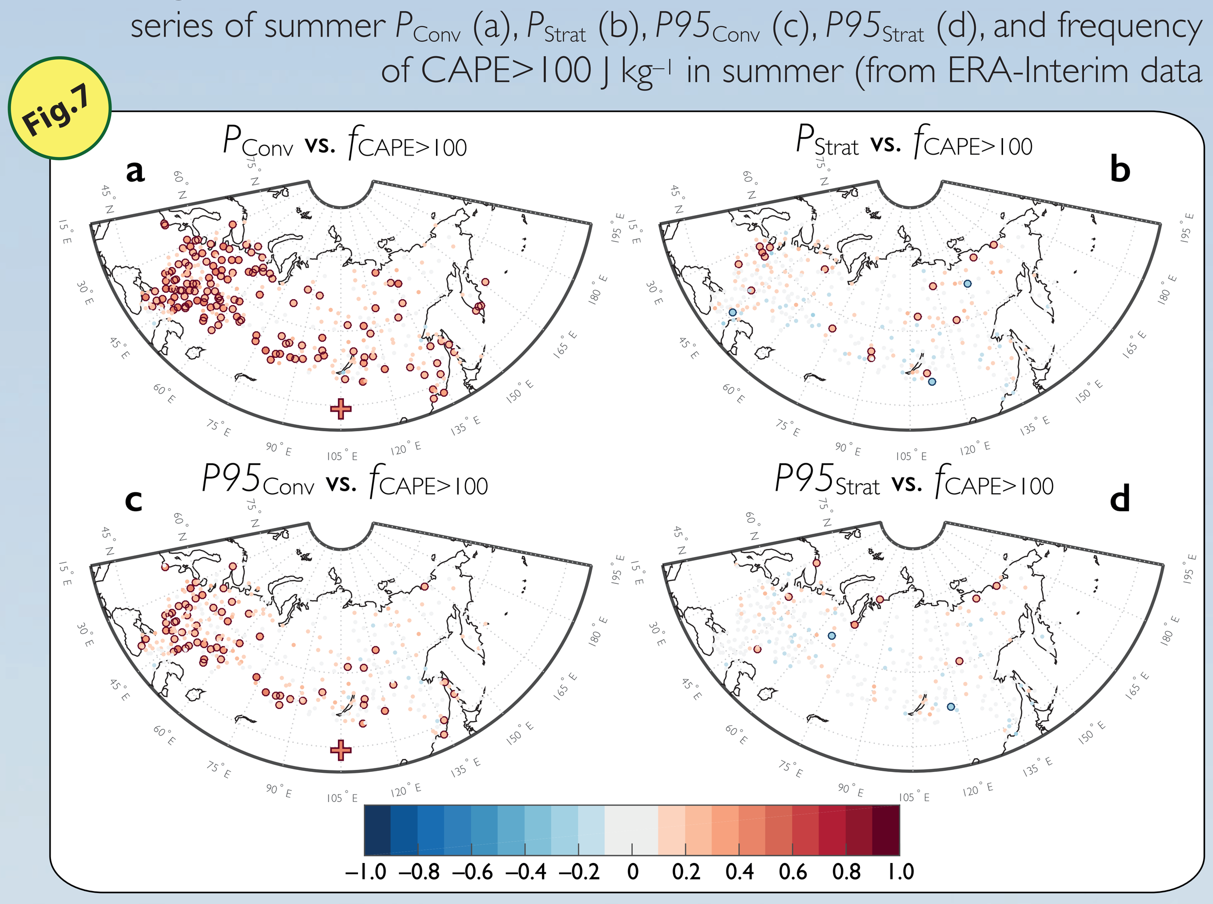

Fig.8

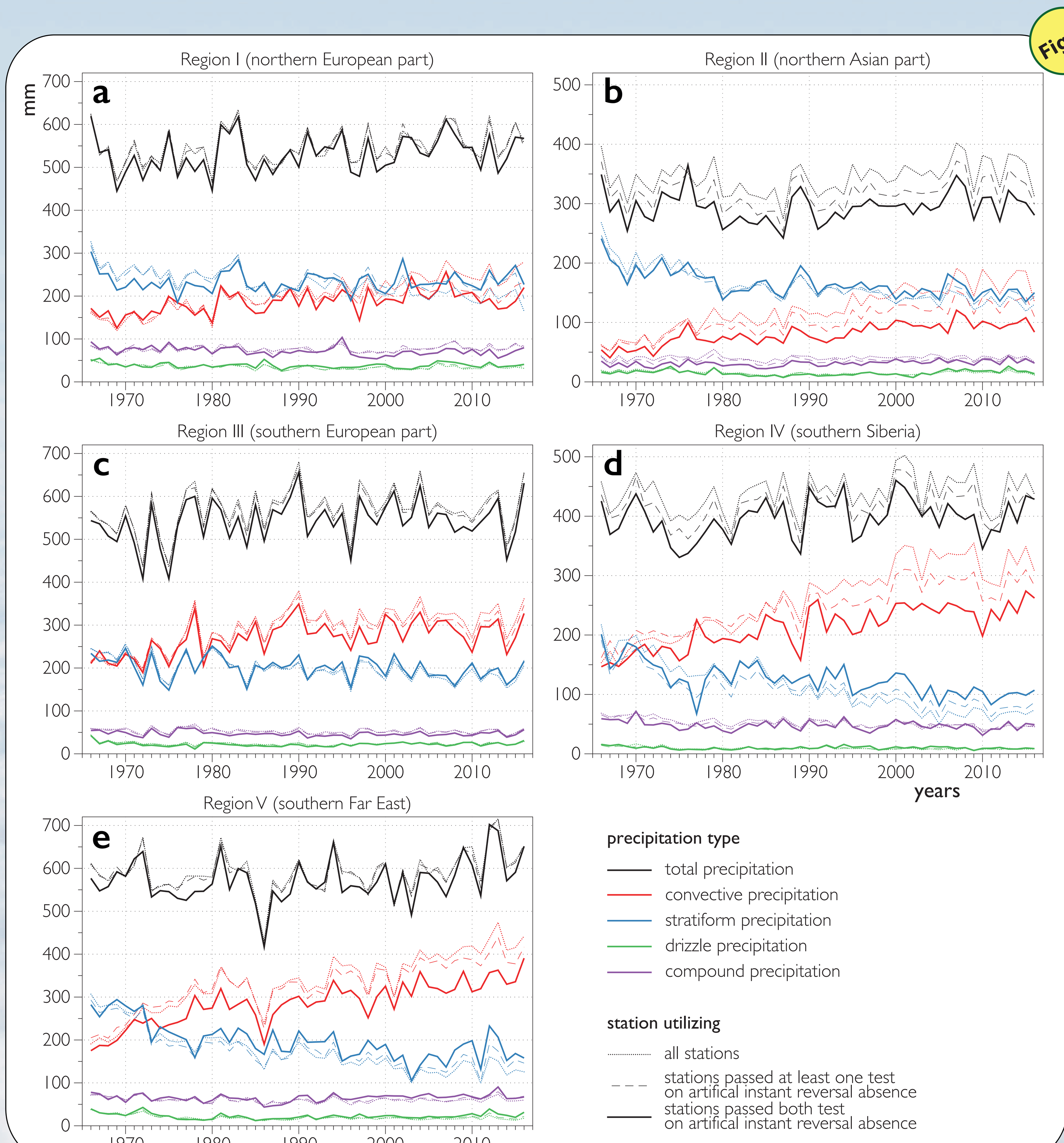

Figure 8. Interannual variations of annual precipitation totals aggregated for five regions (see Fig.2 for details). Black, red, blue, green, and magenta colors denote total, convective, stratiform, drizzle, and compound precipitation totals, respectively. Solid (dashed) lines stand for the result of aggregation of stations that passed both tests (only one test) on artificial instant reversal absence; dotted lines display variations with all stations utilizing.

Fig.9

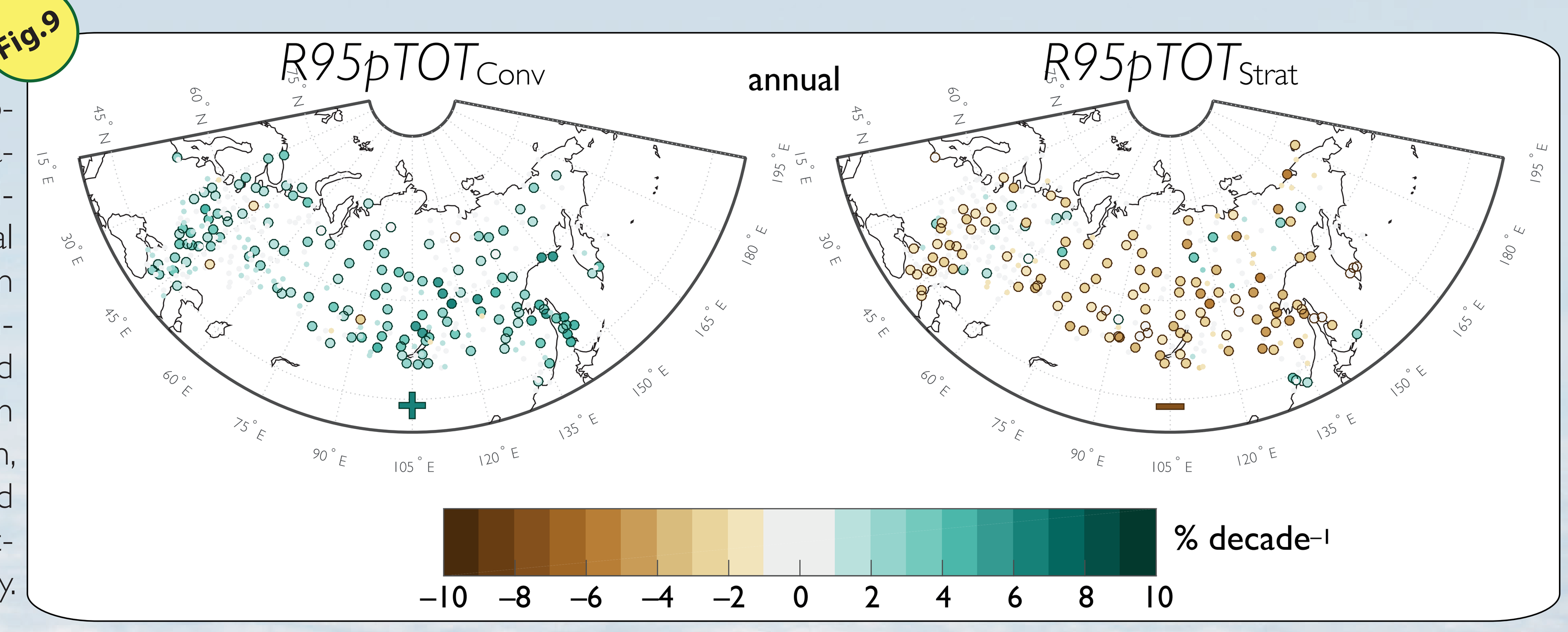

Figure 9. Trends (obtained with non-parametric Theil-Sen estimator) for annual values of contribution of heavy (95th percentile) convective and stratiform precipitation to total precipitation, $R95pTOT_{Conv}$ and $R95pTOT_{Strat}$, respectively.

Conclusions

From initial 538 stations, the main analysis is performed for 326 stations that have no gaps and meet criteria on the artificial discontinuity absence in the data. Moderate increase of total precipitation during the analyzed period is accompanied with a relatively strong growth of convective precipitation and a concurrent decrease of stratiform precipitation. Convective and stratiform precipitation totals, precipitation intensity and heavy precipitation sums depict major changes in summer, while relative contribution of the two precipitation types to the total precipitation (including contribution of heavy rain events) show strongest trends in transition seasons. A contribution of heavy convective showers to total precipitation increases with statistically significant trend of 1–2 % decade^{-1} in vast NE regions reaching 5 % decade^{-1} at a number stations. The largest increase is found over the southern Far East region mostly because of positive changes of convective precipitation intensity with linear trend of more than 1 mm day^{-1} decade^{-1} implying 13.8% increase per 1 °C warming. In general, stratiform precipitation decreases over the majority of NE regions in all seasons except for winter. This decrease happens at slower rates in comparison to the convective precipitation changes. The overall changes of precipitation character over the majority of NE regions are characterized by a redistribution of precipitation types toward more heavy showers.

Chernokulsky A.V., Kozlov F.A., Zolina O.G., Bulygina O.N., Mokhov I.I., Semenov V.A. Observed changes in convective and stratiform precipitation in Northern Eurasia over the last five decades // Environmental Research Letters, 2019, V.4, No.4, P. 045001. DOI: 10.1088/1748-9326/aafb82.

Chernokulsky A.V., Kozlov F.A., Zolina O.G., Bulygina O.N., Semenov V.A. Climatology of precipitation of different genesis in Northern Eurasia // Russian Meteorology and Hydrology. 2018. V.43. N.7. P.425–435. DOI: 10.3103/S1068373918070014.

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