Inhomogeneities in bias-corrected precipitation time-series over Russia

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Introduction

During XX century in USSR there was several serious changes in precipitation observational procedure (Groisman P.Y., 1991). So, in precipitation time series, obtained from observational network of USSR, there are **inhomogeneties**, which (plus gaps and outliers in data) complicate and distort trend analysis.

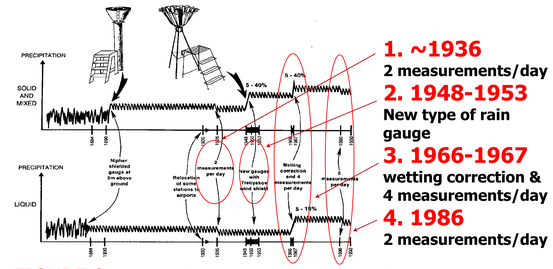

FIGURE 0 History of systematic changes in the precipitation network over USSR (from Groisman P.Y., 1991, Fig. 1)

Bias-corrected precipitation data

Bias-corrected monthly precipitation sums dataset was published in 2015 by the Voeikov Main Geophysical Observatory (VMGO) and World Data Center B (Obninsk, Russia): http://meteo.ru/data.
The developed in VMGO correction algorithm accounts all known measurement rain gauge biases over USSR (WMO. Report №74). Correction procedure use regression model and metadata about station location and environmental conditions (Bogdanova E.G. et al., 2002)
Bias-corrected dataset (monthly sums) includes 456 stations over Russia for time period *1936-2010*.

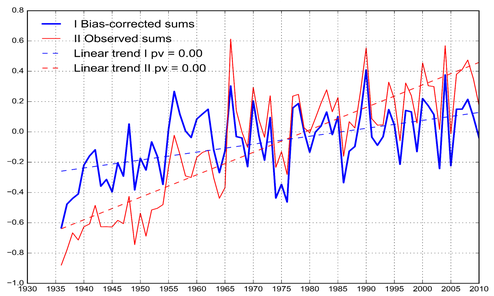

FIGURE 1 Normalized anomalies of annual sums over all Russia for bias-corrected and observed precipitation datasets

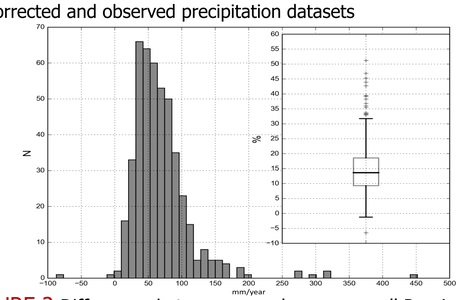

FIGURE 2 Differences between annual sums over all Russia (LTMs) of bias-corrected and observed precipitation datasets

Homogeinety tests: info

Three homogeneity tests (Htests) were applied to detect the step-wise shift in the mean (a break) of annual precipitation sums time series over Russia (following Winjgaard J.B. et al., 2003):
A. the standard normal homogeneity test (Alexandersson H., 1986)
B. the Pettitt test (Pettitt A.N., 1979)
C. the Buishand range test (Buishand T.A., 1982)

The tests were used to determine shift year in time series of precipitation annual sums

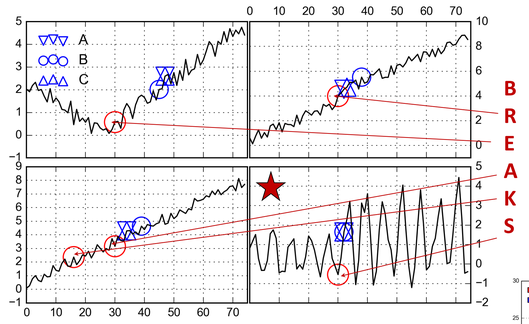

FIGURE 3 Test cases of inhomogeneity detection

Homogeneity tests: results

1. The more Htests are used, the more number of time series looks like homogeneous.
2. Pettit range test (B - Circle) indicates shifts more often then another used Htests;
3. The main time periods, when shifts were indicated:
   I. 1950-1955 – type of rain gauge change;
   II.1965-1970 – wetting correction;
   III.1975-1980 – ? natural changes ?
4. Bias-corrected dataset has less inhomogeneities: for them Htests determine up to 50% less significant breaks then for observed sums;

Results in graphics

Number of Htests, determined at the same year shift on 5% significance level

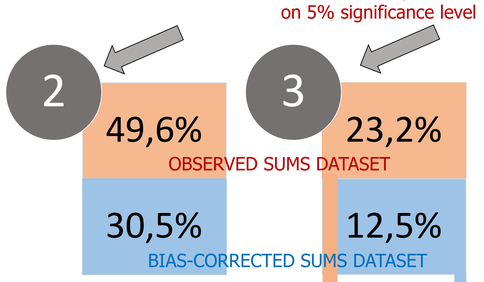

FIGURE 4 Percent of time series in datasets with detected homogeneity breaks on 5% significance level

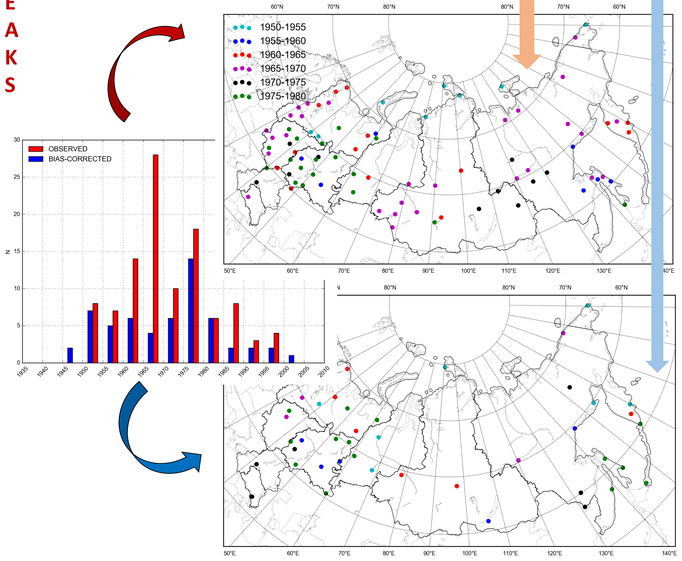

FIGURE 5 Histogram of detected shifts in two datasets (red – observed sums, blue – bias-corrected sums) and spatial distribution of breaks (legend same). All three Htests showed breaks on 5% significance level (Figure 4 right column)

Results

Bias-corrected precipitation dataset, prepared in VMGO, has higher quality then wide-spread dataset of observed precipitation sums: it has much less breaks and all well known precipitation measurement biases (change of rain gauge type, wetting correction, wind influence) are minimized. Undoubtedly, bias-corrected dataset is very useful for water cycle researches over Russia.

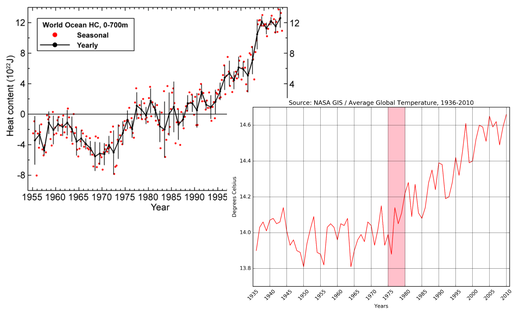

FIGURE 6 Global temperature & ocean heat content time series

Discussion

Breaks during period 1975-1980 could not be explained with changes in USSR observational routines. So, they have natural or unknown reasons. Global temperature and ocean heat contents variability point for natural genesis of that signal (Figure 6) – after 1975 step-wise shift could be easily indicated. On the other hand only 18 from 456 stations over all Russia showed significant breaks in that period. If it was a response to the global changes in climate system, it is hard to link it with some spatial patterns and geographical regions.
For bias-corrected dataset there could be another explanation: the MVGO model uses wind data for correction procedures. Wind measurement procedure was significantly changed in 1970-s. So, it could generate additional uncertainties in precipitation time series.

Conclusions

Despite the procedure of correction, the bias-corrected precipitation dataset, developed in VMGO and distributed by «WDC-B» (Obninsk, Russia), still includes some artifact breaks and shifts, associated with changes in measurement routines in time series.
There is no doubt, that it is preferable to use VMGO bias-corrected dataset for analysis of climate and hydrological cycle during XX century.
It is recommended to check time series from the dataset for homogeneity.
The simplest way to avoid homogeneity problem is to use data subset 1966-2010.

The described differences between observed and bias-corrected datasets show, that corrected sums almost always higher then observed sums (Groisman P.Y. et al., 2014). The additions could reach 30-50% even for annual values! Especially it is critical for northern regions, where the part of solid precipitation form in annual sum is high.

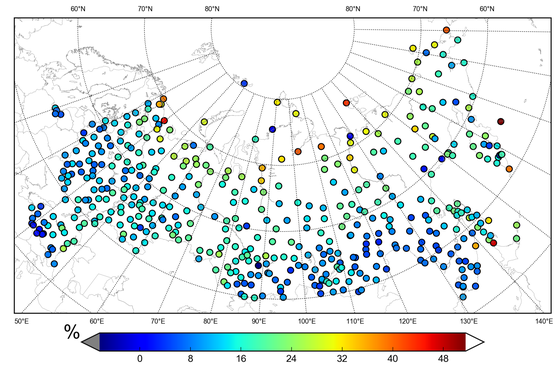

FIGURE 7 Spatial distribution over Russia of differences between long-term means of annual sums from bias-corrected and observed precipitation datasets

Acknowledgments

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