Total solar radiation in the Arctic from 1950s to present time: observations at Russian drifting and stationary stations

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The goal of the work presented here is to estimate the variability of the total solar radiation in the Russian Arctic from the mid-1950s to the present time. We present the results of the joint analysis of monthly and annual sums of the total solar radiation (TSR) measured at the stationary stations (SS) and at the drifting "North Pole" stations (NP) in the Arctic Basin. At the NP stations the observations cover the period from 1954 to 1991 as well as 2007 and 2009. The variability of the coordinates and time results in the statistical heterogeneity of the time series of data collected at the NP stations. To obtain homogeneous series of data for the moving platforms, we used a normalization approach based on the calculation and analysis of the relative anomalies of investigated parameters. Initially, we have used this approach for the analysis and comparison of the total ozone data received on different moving platforms (NP and research vessels) in 2003 – 2008 [1]. The same statistical approach can be successfully applied to the analysis of other characteristics of the atmosphere, as shown here for the case of total solar radiation (TSR).

Normalization of the TSR data

Relative anomalies of the monthly sums of the TSR were calculated according to the formula:

$$K_{Qi} = (Q_i - Q_{av.,\,i})/Q_{av.,\,i} \qquad (1)$$

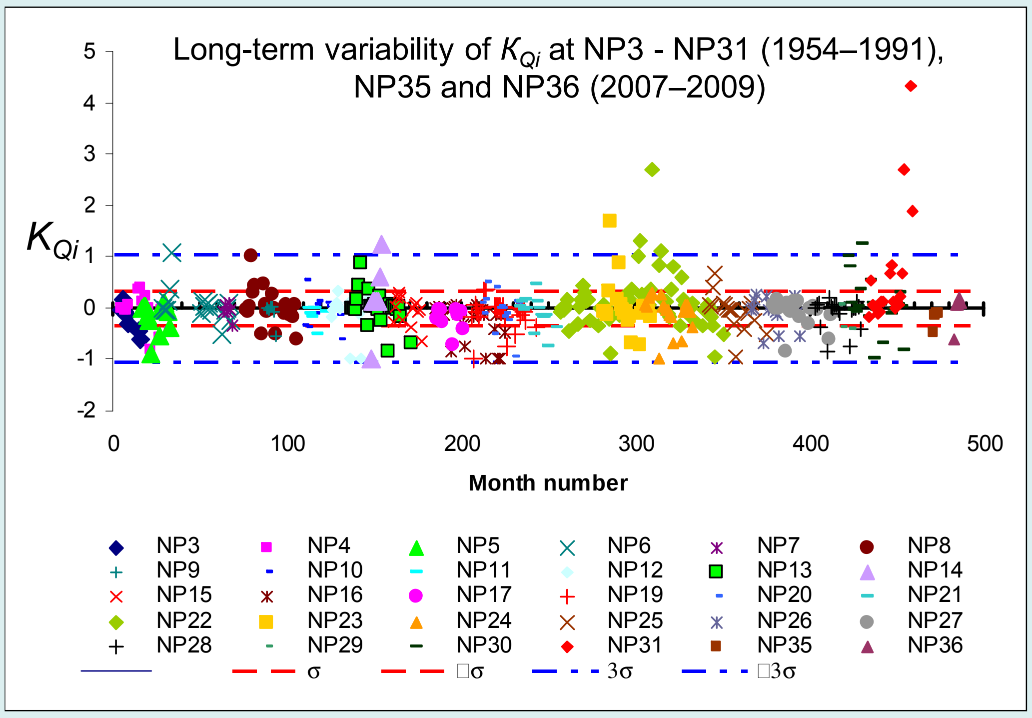
Q_i – monthly sum of the TSR for *i*-th month at the drifting station of interest;
$Q_{av.,\,i}$ – mean monthly sum of the TSR for the *i*-th month averaged for all drifting stations (from NP-3 to NP-36) during the whole period of observations (norm);
K_{Qi} – relative anomaly of TSR for the *i*-th month at the drifting station of interest.

Table 1.

The calculated "norms" for the monthly sums of the TSR, *Qav, i* (MJ/м^2), their standard deviations, σ, and quantity of values, n, on which averaging was made

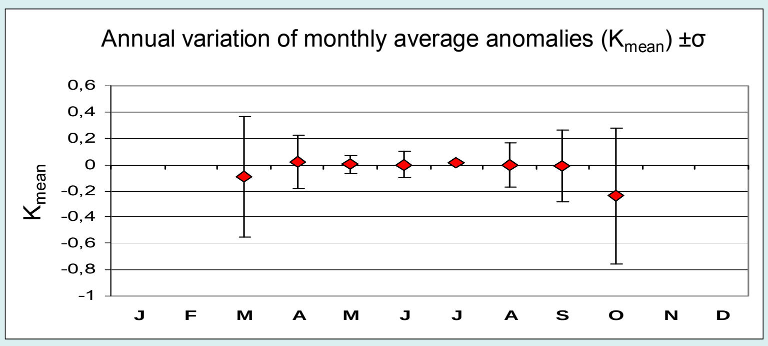
Month	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
$Q_{av,i}$	71	365	684	773	613	364	122	16
σ	40	54	47	80	62	61	34	14
n	60	49	62	65	71	70	69	52

Normalization allows to assess the long-term variability of TSR



The first datum point (month № 5) corresponds to May, 1954. Dotted straight lines specify borders of confidential intervals ±*σ* and ±3*σ*. Small number of months when K_{Qi} is more than 3*σ* above average confirms the applicability of the normalization approach and points out years with unusual deviations in the field of TSR [2].

Calculated relative anomalies K_{mean} do not vary within a year



Average K_{mean} values were calculated according to Eq. (1). No values can be shown for November-February due to polar night. The maximum variability of K_{mean} is observed in March and October, which are the months with the least significant contribution to total annual radiation.

Tendencies of long-term variability of solar radiation in the Arctic Basin

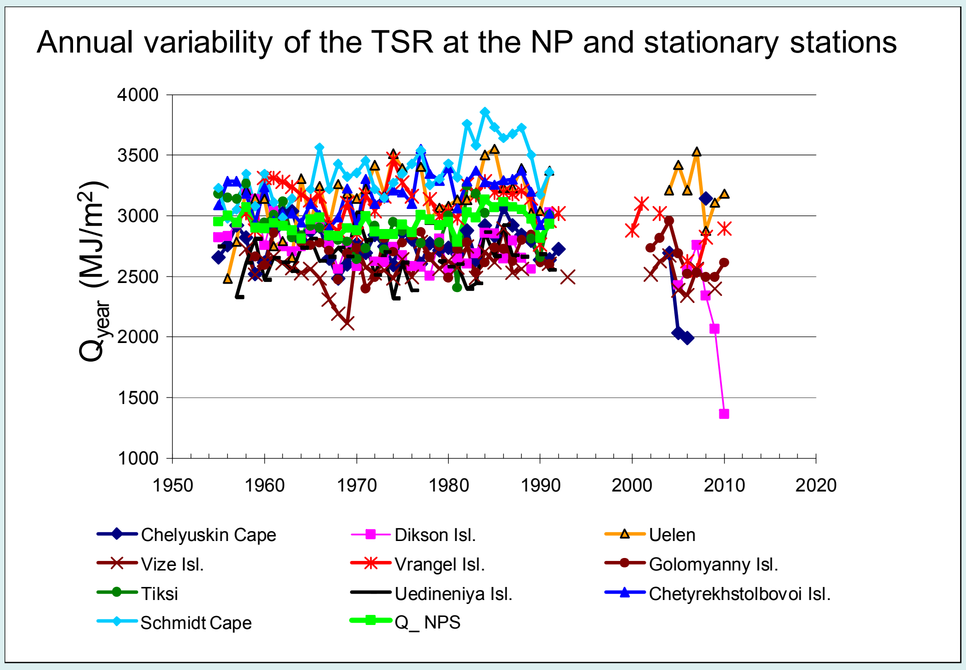
The values of monthly sums of the TSR (*Qi,r*) were recovered as follows:

$$Q_{i,r} = (1 + K_Q)\, Q_{av,\,i} \qquad (2)$$

K_Q –average relative anomaly for a year (arithmetic mean of all K_{Qi} values for a given year).
Recovered annual sum of the TSR ($Q_{year,r}$) is the sum of the *Qi,r* for the corresponding year:

$$Q_{year,r} = (1 + K_Q)\, Q_{av,\,year} \qquad (3)$$

where $Q_{av.year}$ – sum of $Q_{av,I}$ (see Table 1)
The annual sums of TSR recovered thus are free from influence of existential variability along a line of NP drift.
This normalization approach allowed us to compare the recovered TSR data at all drifting stations with the TSR observed at the stationary stations.



Thick green line (Q_NPS) shows annual variability of the recovered annual sums of the TSR at all drifting NP stations.

Conclusions

1. Normalization approach performed with the TSR values recorded on different moving platforms generates sets of data, which are comparable to each other and to the data collected at stationary stations.
2. Normalized TSR data obtained on moving platforms can be used for characterizing the radiation regime in the Arctic Basin.
3. In 1954 – 1991, there was no trend in TSR at all stations with a probable exception of Schmidt Cape (R^2=0.45; station closed since 1992).
4. In 1990s, observations at NP stations have been interrupted. At currently active stationary stations, the TSR values fit the pattern observed before 1991 and show no significant long-term trend. Only at Dikson Island, a yet unexplained anomaly is observed.

References

1. Rusina E.N., Genikhovich E.L. (2010) Method of analysis of total ozone data registered from moving platforms. //Proceedings of MGO. 2010. Vol. 562. P. 61–75. (In Russian)
2. Rusina E.N., Radionov V.F., Sibir E.E. (2011) On the possibility of the analysis of the data of observations of the total ozone and total solar radiation on moving platforms. // SPb.: AARI. 2011. p. 39–50. (In Russian)