Multiple climatic regimes in transitional seasons

Mokhov I.I.

A.M. Obukhov Institute of Atmospheric Physics RAS
Lomonosov Moscow State University
mokhov@ifaran.ru

During last decades an increase in climatic variability is detected. In particular, very extreme was spring in Russian regions in 2017 with very warm March and cold air outbreaks in May (and even in June). In the last 5 years (2012-2016), the number of hazardous meteorological events in Russian regions has been almost three times more than for 1998-2002 (http://www.meteorf.ru/). Analysis of intraseasonal variability of surface air temperature from long-term observations reveals multimodal features in probability density functions (PDF), in particular for transitional (spring, autumn) seasons (Agayan and Mokhov, 1989; Mokhov and Semenov, 1997; Mokhov et al., 1998).

In (Mokhov and Semenov, 1997), an analysis of bimodal features of PDF for intra-seasonal variations of surface air temperature using a stochastic energy balance model and daily data from long-term (since the end of the 19th century) observations at many Eurasian meteorological stations was performed. The PDF polymodality can be formed by different processes. In particular, the formation of the PDF bimodality can be related to the nonlinear temperature dependence of surface albedo near the snow boundaries.

Mokhov and Semenov (1997) used the energy balance equation

$$C\partial T/\partial t = F_S - F_T - \mathrm{div}\, F + w(t)$$

in terms of a zonal surface temperature T(φ). Here: $F_S = QS(1-\alpha(T))$, QS - insolation, α – albedo, $F_T = A + BT$ - outgoing long-wave radiation (A, B – constants), *C* - parameter characterizing the heat capacity of the climatic system, div $F = \gamma(T-T_H)$ – meridional heat influx, T_H – hemispheric mean temperature, γ – parameter characterizing the meridional heat transfer, w(t) - Gaussian random source, φ - latitude. In general, the efficiency of meridional heat transfer (and parameter γ) depends on climatic conditions (Vasyuta et al., 1988; Rind and Chandler, 1991).

Albedo α is considered as a function of temperature T, antisymmetric relative to Ts = 0^oC - temperature of snow/ice cover boundary

$$\alpha(T) = \alpha_o - (1/2)\Delta\alpha f(T-T_s),$$

where parameter Δα characterizes change of albedo at the snow/ice cover boundary.

According to (Mokhov and Semenov, 1997) the PDF for temperature anomalies has three extremes, including two maxima and minimum near Ts, if

$$T^* > T^o,$$

where $T^* = (1/2)QS\Delta\alpha/(B+\gamma)$, $T^o = (df/dT)^{-1}$. In (Mokhov and Semenov, 1997) using analytic parametrization of the albedo, analytical expressions are obtained for the PDF maxima position ΔT relative to Ts = 0^oC

$$\Delta T^2 = T^{*2} - T^{o2}.$$

The sensitivity of ΔT to the climate (temperature) change can be estimated from the next expression

$$\Delta T d\Delta T/dT = T^* dT^*/dT - T^o dT^o/dT.$$

In particular, the decrease of Δα under warming (dT > 0) contributes to a decrease of ΔT. Decrease (or increase) of climate anomalies near 0^oC with snow/ice cover variations depends also on changes of the efficiency of meridional heat transfer.

This work was carried out within the framework of RFBR projects and RAS programs.

References

Agayan G.M. and I.I. Mokhov (1989) Quasistatiomary autumn atmospheric regimes of the Northern Hemisphere during the period of the FGGE. *Izvestiya, Atmos. Oceanic Phys.*, **25**, 851-855.

Mokhov I.I., Semenov V.A., 1997: Bimodality of the probability density functions of subseasonal variations in surface air temperature. *Izvestiya, Atmos. Oceanic Phys.*, **33**, 702-708.

Mokhov I.I., V.K. Petukhov and V.A. Semenov (1998) Multiple intraseasonal temperature regimes modelling of trends of the Earth’s climate variability characteristics. *Izvestiya, Atmos. Oceanic Phys.*, **34**, 163-171.

Rind D. and M. Chandler (1991) Increased ocean heat transports and warmer climate. *J. Geophys. Res.*, **96**(D4), 7437-7461.

Vasyuta Yu.B., I.I. Mokhov and V.K. Petukhov (1988) Sensitivity of low-parametric climate models to variations of characteristics of meridional heat flux. *Izvestiya, Atmos. Oceanic Phys.*, **24**, 85-92.