The influence of the external parameters on river runoff in the INM RAS – MSU land surface model

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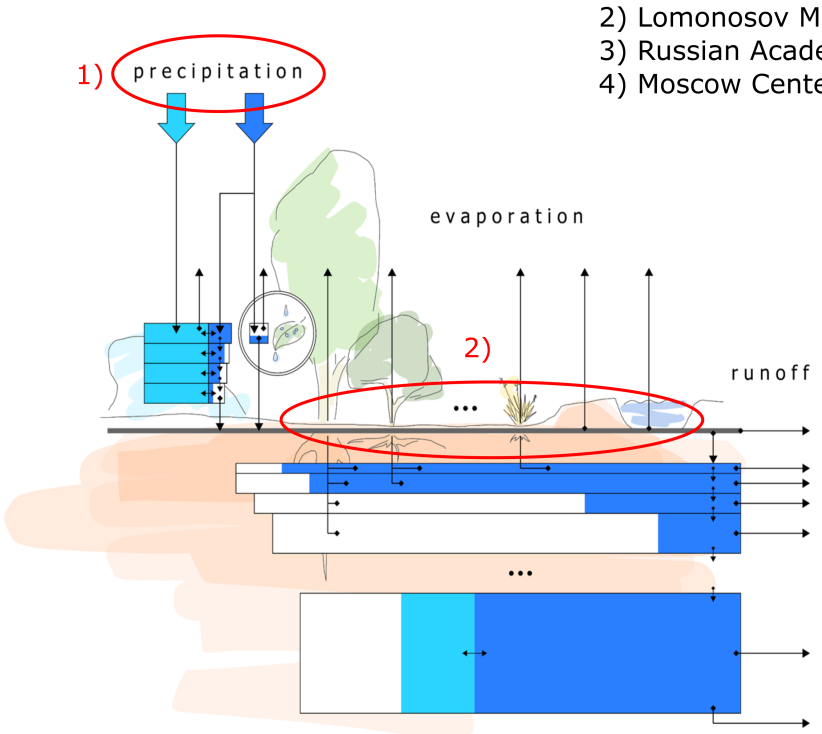

figure 1. Scheme of water balance in cell of INM RAS - MSU land surface model

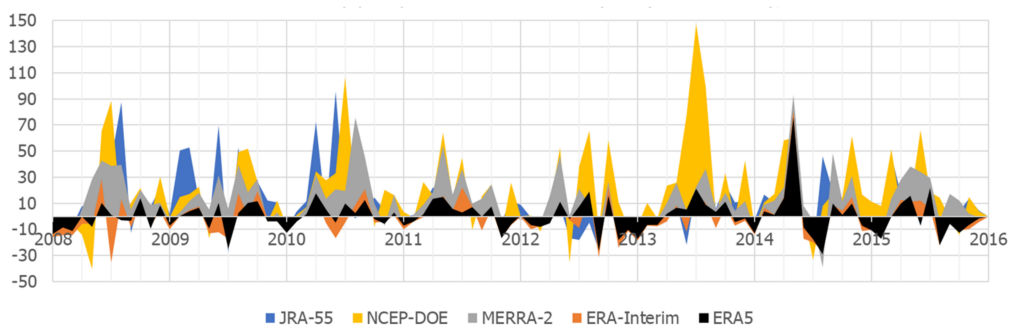

figure 2. Error of monthly precipitation sums in reanalysis (st. Ust-Tsilma, mm)

evaporation $E = \rho \frac{q - q_{surf}}{r_a}$; transpiration $E_T = \rho \frac{q - q_{surf}}{r_a + r_s}$

$r_a = (C_u C_\theta u)^{-1}$

derived from parametrization of atmosphere surface layer

$r_s = f(\text{vegetation type, LAI, PAR, } \dots)$

derived from parametrization of plant biophysics

figure 3. Concept of resistances for turbulent fluxes

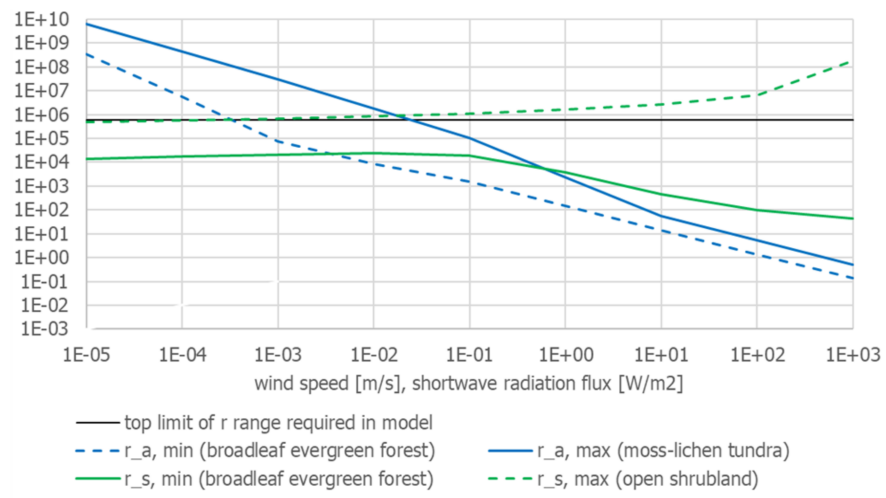

figure 4. Scales of r_a and r_s, s/m

Chosen external parameters (figure 1):
1) Precipitations – from reanalysis, values are inaccurate
2) Areas of various land surface types – there are no unified data

Problem :
Evaluation of influence of choice of sources of data 1) and 2) on the river runoff (for the cases of Severnaya Dvina, Ob and Kolyma rivers)

1. Precipitations (reanalysis)

We made a comparison of monthly sums of precipitation for 2008-2015 according to 23 weather stations in Sev. Dvina basin and nearby (corrected*) and according to modern global reanalyses. All reanalyses show an overestimation of precipitation. By the lowest degree – ERA5, which errors are close to random (figure 2).
The properties of the ERA5 error series were confirmed for majority of plain terrain weather stations in the basins of the studied rivers (mountain stations are not representative to comparison with coarse grid cells of reanalysis)

2. Land cover map

The distribution of land surface types determines the value of the cell-average parameters (figure 3):
r_a – aerodynamic resistance, s/m
r_s – stomatal resistance, s/m
beta – max plant roots depth, m
LAI – leaf area index, m^2/m^2

Chosen land cover maps:
Basic : Wilson & Henderson-Sellers, 1985 [1] – composition of maps from 1950-1970 on a grid 1.5 × 2°. Have many inaccuracies
Alternative : USGS GLCC v2.0 (Global Land Cover Characterization), 2000 [2] – map was made using k-means clustering for monthly NDVI maximums in 1992-93 (AVHRR shooting, resolution 1 km). It was selected because uses the same surface type classification as the model uses

For all 3 rivers, the observed changes in runoff with changing the map occur almost entirely due to changes changes of evaporation from wet leafs (mainly due to changes of r_a; contributions of changes of beta and LAI stay unclear, but they are exactly not so significant). This also leads to shift of date of snow cover disappearance on about half-decade forward (r_a occurs in heat flux equation). Interesting, that noticeable changes in transpiration (main component of total evapotranspiration from river basins covered by plants) was not fixed.

On figure 4 Lines r_a are plotted for conditions when it is maximum (stable stratification). Lines r_s, on the contrary, for conditions when it is minimal (absence of stress factors). Here r_a is a function ONLY of wind speed and r_s is a function ONLY for radiation. Two lines for each r are plotted for the most contrasting types of vegetation and represent the range of values that is provided only by changing vegetation types

So, it happens because r_s exceeds r_a by several orders of magnitude (figure 3), and absence of changes of r_s during change of map leads to blocking of transpiration changes

Results

1) At least at plains of Russia, the ERA5 reanalysis is the best among the others by precipitation reproduction. Monthly precipitation sums are reproduced with an error close to random

2) For enough large river basins (covered by plants or not), a low sensitivity of runoff to changes in the map of land surface types can be expected – even in the case of imprecise map (case of the Ob also show moderate changes of runoff, although it is debatable)

3) At wind speeds > about 1 m/s, the stomatal resistance is always higher than the aerodynamic by several orders of magnitude. We can recommended to choose the second between the improvement of the parameterizations of the atmosphere surface layer and plant biophysics for increasing of accuracy of the models of the active layer

The work is partially supported by RFBR, grant 20-05-00773

[1] Wilson M F and Henderson-Sellers A 1985 A global archive of land cover and soils data for use in general circulation climate models *Journal of Climatology* **5 2** 119–43
[2] Loveland T R et al 2000 Development of a global land cover characteristics database and IGBP DISCover from 1 km AVHRR data International *Journal of Remote Sensing* **21 6–7** 1303–30