Towards flood assessment over Northern Eurasia using multiscale climate modeling system

Elena Stafeeva, Igor Shkolnik
(stafeeva@main.mgo.rssi.ru)
Voeikov Main Geophysical Observatory, Saint-Petersburg, Russia

Introduction

The evidence of modeling projections of climate change impacts on extreme hydrological events is important for water resources and flood assessment by decision-makers. Climate projections provided by global and regional climate modeling systems (GCM/RCM) usually feed the impact models. However, challenges in representing dangerous hydrological events over the river catchments suggest that decisions must be made depending on the degree of realism of mean and extreme runoff simulation by an RCM at daily (hourly) resolution.

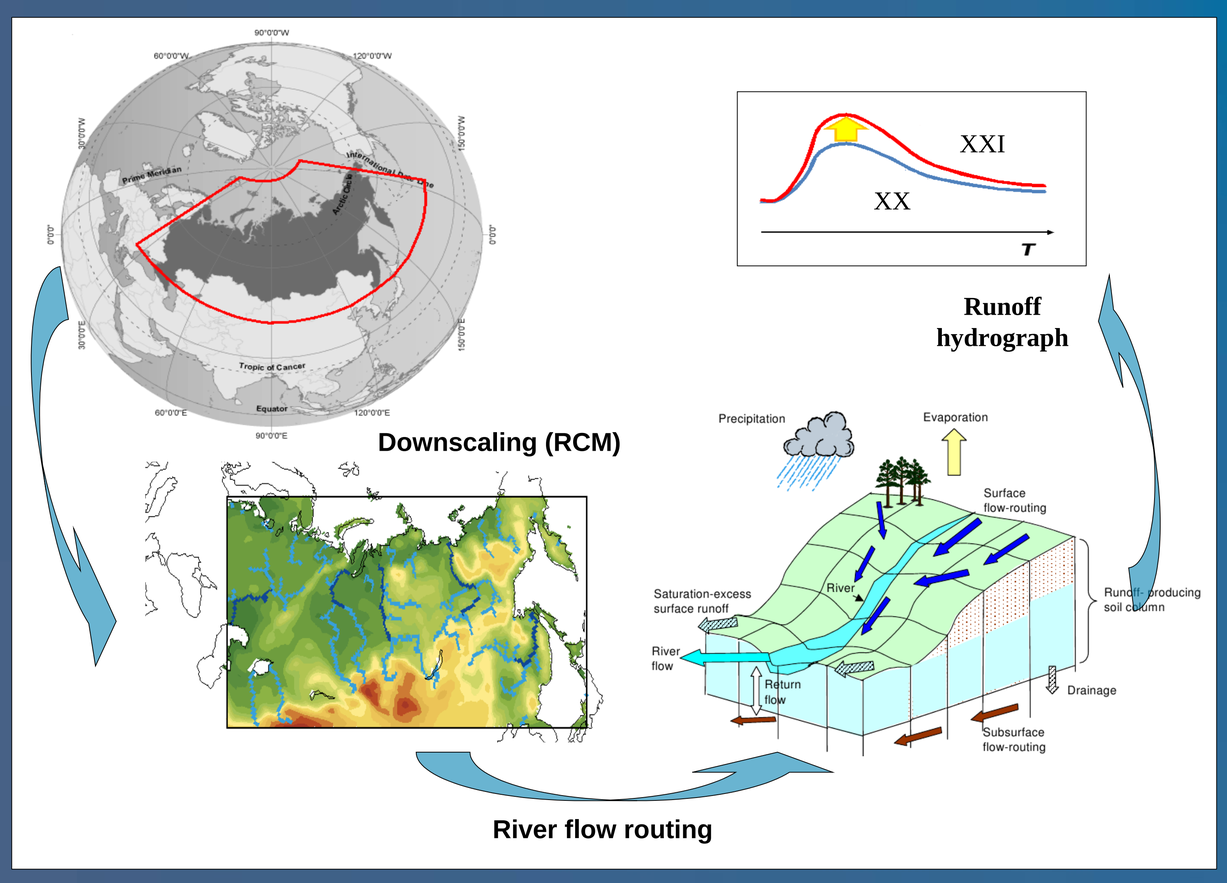


Fig.1 VMGO climate models system: global, regional, local

River flow routing model (RivRout)

Accurate description of water transport via river channels is important for flood prediction. In this study the river flow routing model (**RivRout**) has been developed and applied to 20 years (1981-2000) MGO RCM daily runoff simulation for northern Eurasia driven by the reanalysis ERA-40.

Given an RCM simulated runoff, the river flow routing model can compute flow and volume of water everywhere across watersheds. The simulation of river flow consists of: surface runoff and groundwater flow which are outputs from RCM and the inflow from neighbouring upstream cells (Fig. 2). The scheme uses Manning's equation to determine the river flow velocity, which depends on the amount of streamflow in the river channels.

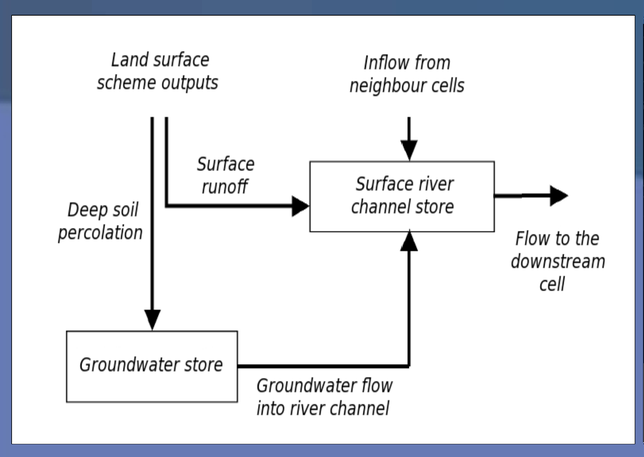


Fig. 2 River flow routing scheme (Lucas-Picher, 2010)

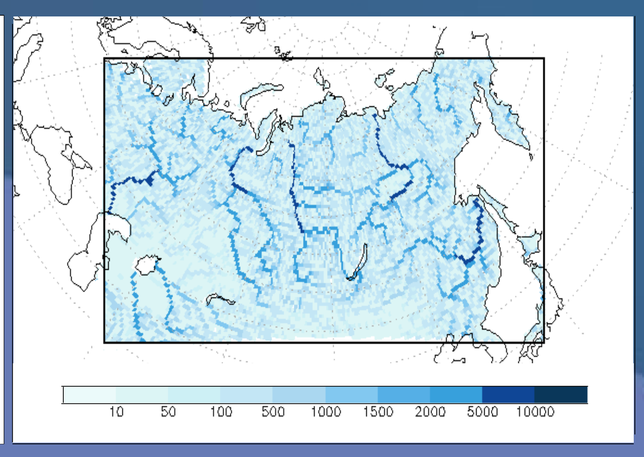


Fig. 3 Simulated river network for the watersheds covered by RCM

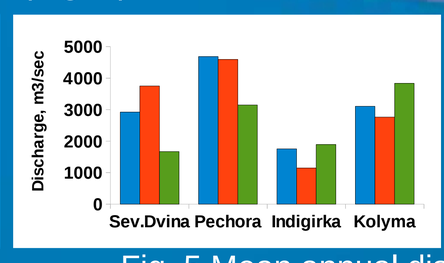
For each grid cell there is information about flow direction. There are eight possible directions. We use the database of flow directions with the resolution 0.5°x0.5° from the Goethe University Frankfurt.

The river width (Fig. 3) is obtained using a geomorphological relationship between annual mean discharge passing through at river section and river width. Estimates of annual mean discharge are obtained using flow direction data and global runoff dataset [Cogley].

RivRout validation

For the validation of RivRout we used discharge data from the GRDC (Germany) for the largest watersheds (Fig. 4) of the Northern Eurasia.

Fig. 4 Location of watersheds



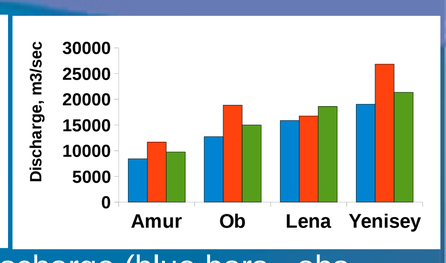


Fig. 5 Mean annual discharge (blue bars - obs, red bars - model, green bars - reanalysis CFS)

Annual discharge (Fig. 5) is calculated with different accuracy. Values of discharge for the half of watersheds are close to observations. The most significant disagreements with observations can be found in Ob and Yenisey watersheds because of overestimation of precipitation in the model over this watersheds.

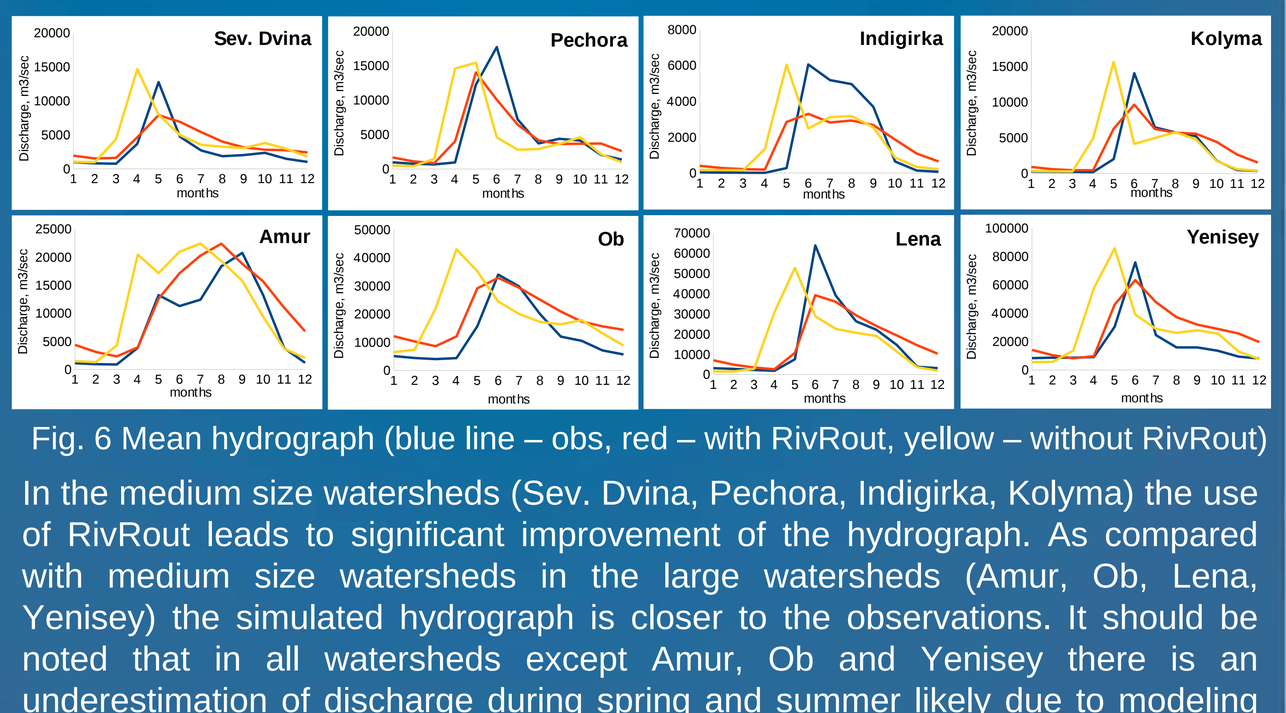


Fig. 6 Mean hydrograph (blue line – obs, red – with RivRout, yellow – without RivRout)

In the medium size watersheds (Sev. Dvina, Pechora, Indigirka, Kolyma) the use of RivRout leads to significant improvement of the hydrograph. As compared with medium size watersheds in the large watersheds (Amur, Ob, Lena, Yenisey) the simulated hydrograph is closer to the observations. It should be noted that in all watersheds except Amur, Ob and Yenisey there is an underestimation of discharge during spring and summer likely due to modeling underestimation of snow cover.

For the available period of observational data Fig. 6 shows correlation coefficients between the simulated and observed monthly mean discharge in the watersheds. As can be seen in the Fig. 6 the correlation coefficients tend to increase over all watersheds using RivRout (red bars) as compared with simulation without river routing scheme (yellow bars). Root mean square differences thereby between modeled and observed hydrographs decrease over all watersheds.

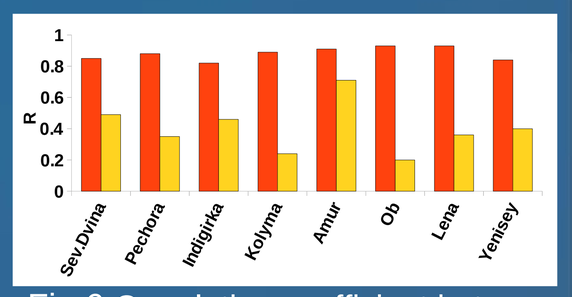


Fig.6 Correlation coefficient between simulated and observed hydrograph

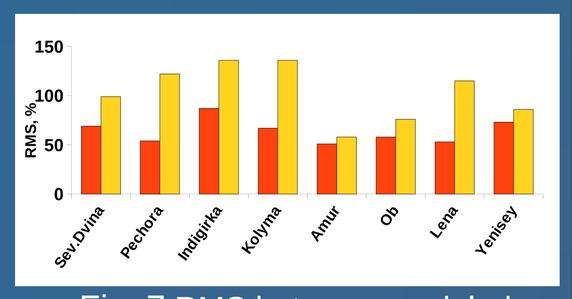


Fig. 7 RMS between modeled and observed hydrograph

For RivRout validation we used also the runoff from reanalysis CFS with spatial resolution 0.5x0.5. We made comparison between observations and simulated data (RCM driven ERA-40 and RivRout) and reanalysis CFS. Fig. 8 shows correlation coefficients of mean monthly anomalies of discharge between observations and reanalysis (green bars) and between observations and modeled discharge (red bars). In both cases results are in good agreement.

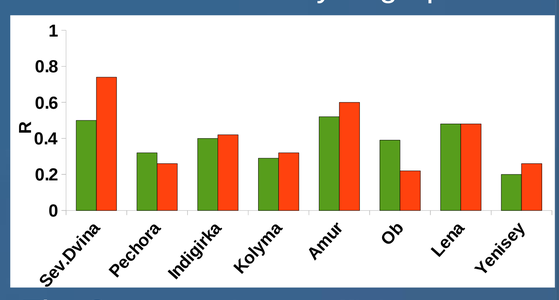


Fig. 8 Correlation coefficients mean monthly anomalies of discharge

Conclusion

- ✓ The validation of the developted coupled with RCM river flow routing scheme has been carried out
- ✓ The simulated daily river discharge estimates at the stations are in reasonable agreement with observations, notably in the plain regions
- ✓ The scheme is valid for use in the assessment of the expected flood changes under global warming across the watersheds of the Northern Eurasia.

Acknowledgments
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