Closing water budgets of the three great Siberian River Basins

*Pavel Shabanov[1], Ambroise Dufour[1], Olga Zolina[2], Sergey Gulev[1], Martin Wegmann[3]

1. Shirshov Institute of Oceanology, Russian Academy of Sciences, 2. Institut des Géosciences de l’ Environnement, Université Grenoble Alpes, 3. World Meteorological Organisation, Geneva

The basins of the three great Siberian rivers –Ob, Yenisei, Lena –have come under scrutiny as symptomatic of the effects of Arctic amplification on regional water cycles. As the air moistens, Zhang et al. (2013) report more vapour convergence and greater discharges into the Arctic Ocean. The thawing permafrost is also extremely relevant. However, the warming signal can display counterintuitive patterns (Wegmann et al., 2018) and the consequences on moisture fluxes are not straightforward (Dufour et al., 2016).

This study draws on several reanalyses including ERA-5 (Hersbach et al., 2019). The discharge data before 1999 comes from the Global Runoff Data Centre (GRDC, 2014) and from the Arctic Great River Observatory (Shiklomanov et al., 2018) hitherto. We also consider an intermediate product : river discharge from the Global Flood Awareness System at 0.1° resolution (GloFAS v2.1). This is the output of the HTESSEL land model and LISFLOOD river routing model, run at 0.1° resolution.

We replicate the significant moisture convergence trend found in Zhang et al., 2013 for the extended 1948-2018 period. However, the trend breaks down for the shorter 1979-2018 time windows and in other reanalyses except MERRA-2 over 1980-2018. The discharge observations summed over the mouths of all three rivers are significantly increasing in the long run but not during the satellite era. The initial findings appear sensitive to the starting and ending points of the study period. We believe part of the explanation is to be found in warm Arctic - cold Siberia pattern (Wegmann et al., 2018). The weak increasing trend in convergence and discharge is not driven by a straightforward global warming trend. Rather, it is the consequence of atmospheric variability which is inherently more noisy than thermodynamical signals.

Nearly all reanalyses exhibit significant negative net precipitation trend over the satellite era with the exception of NCEP NCAR R1 and MERRA-2. Further analysis indicates that these trends are due to a decrease in precipitation rather than an increase in evaporation. The decrease in precipitation occurred mainly in summer and is absent in the Global Precipitation Climatology Project. The conflicting trends between convergence and net precipitation indicate a severe unbalance of moisture budgets over Siberia. The GloFAS product also displays a decreasing net precipitation trend - a consequence of the HTESSEL land model being forced by reanalysis precipitation fields.

Over the Siberian river basins, there are weak long-term increasing trends of moisture convergence and river discharge. The reanalyses show perplexing negative precipitation trends in contradiction with the increasing/constant moisture transport. The causes of either tendencies are likely atmospheric variability and strong analysis increments.

Zhang, X., He, J., Zhang, J., Polyakov, I., Gerdes, R., Inoue, J., & Wu, P. (2013). Enhanced poleward moisture transport and amplified northern high-latitude wetting trend. Nature Climate Change, 3(1), 47.

Dufour, A., Zolina, O., & Gulev, S. K. (2016). Atmospheric moisture transport to the Arctic: Assessment of reanalyses and analysis of transport components. Journal of Climate, 29(14), 5061-5081.
Wegmann, M., Orsolini, Y., & Zolina, O. (2018). Warm Arctic –cold Siberia: comparing the recent and the early 20th-century Arctic warmings. Environmental Research Letters, 13(2), 025009.
Hersbach, H., Bell, B., Berrisford, P., Horányi, A., Sabater, J. M., Nicolas, J., ... & Dee, D. (2019). Global reanalysis: goodbye ERA-Interim, hello ERA5. ECMWF Newsl, 159, 17-24.
GRDC (2014): Global Freshwater Fluxes into the World Oceans / Online provided by Global Runoff Data Centre. 2014 ed. Koblenz: Federal Institute of Hydrology (BfG), 2014.
Shiklomanov, A.I., R.M. Holmes, J.W. McClelland, S.E. Tank, and R.G.M. Spencer. 2018. Arctic Great Rivers Observatory. Discharge Dataset, Version 20191228. https://www.arcticrivers.org/data
GloFAS v2.1, 2019-11-05, DOI: 10.24381/cds.a4fdd6b9

Keywords: water cycle, moisture transfer, reanalysis data

