Water quality in urbanized alpine catchments of Central Asia – what happens after the ice?

SCIWAI *and CARAWAN** Consortium (See abstract EGU2020-802). Correspondence to
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Photo: Ulken Almaty River, May and August 2019. Distance between 2 points is approximately 60 km

***Solutions for Clean Water in Central Asia: What Happens After the Ice? UKRI GCRF Strategic Fund. 2018-2020. **Characterising and Predicting Water Availability, Quality and Hazards in the Glacier-fed Catchments. UKRI GCRF Network Fund. 2018-2020. Led by Prof. Maria Shahgedanova and Prof. Andrew Wade.**

<u>Glaciers are retreating in the mountains of Central Asia and this will affect water availability. Other important questions are about impacts of diminishing cryosphere on water quality including</u>

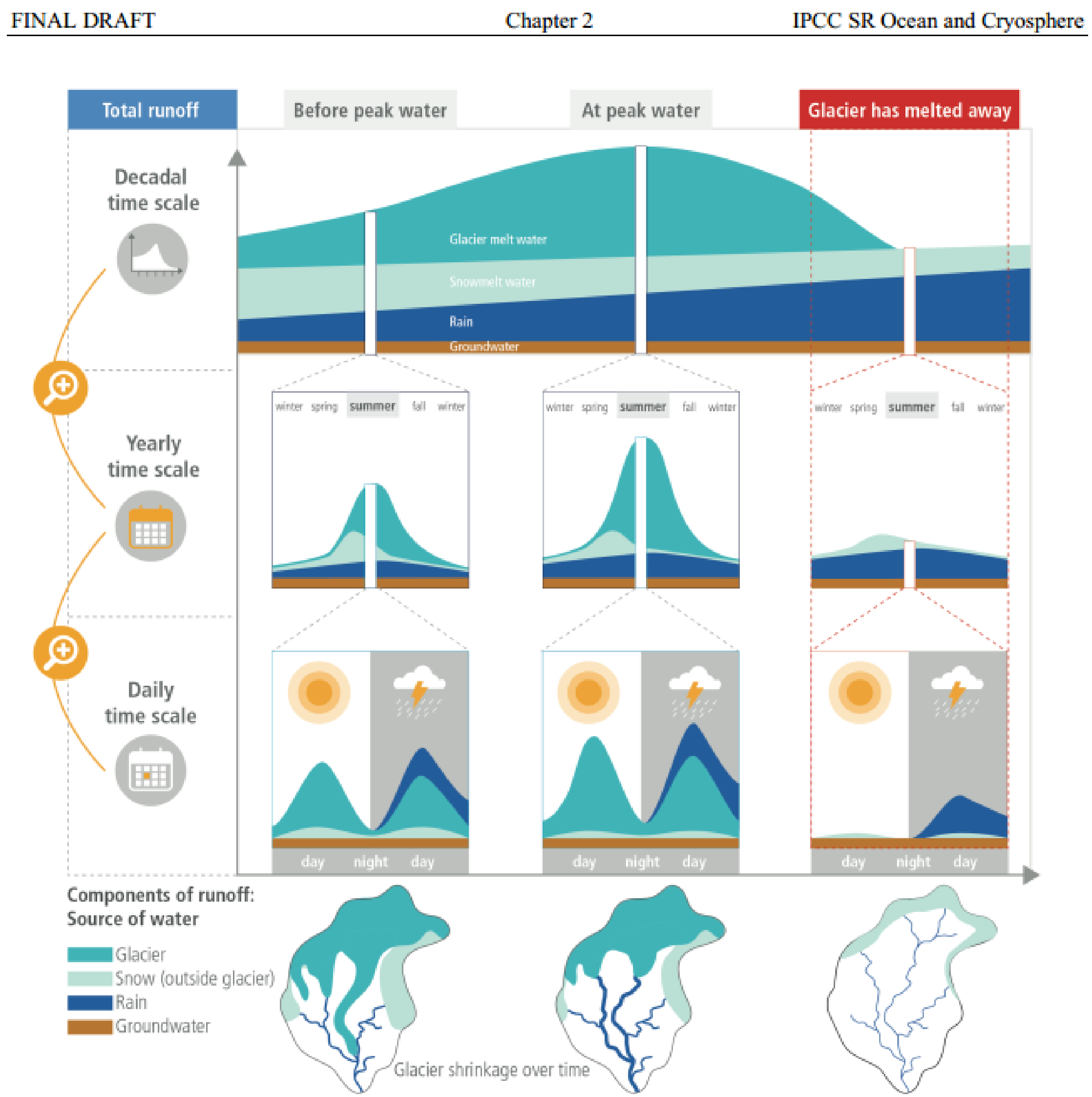
- ***Dilution** and downstream **water quality***
- ***Legacy pollutant release** from glaciers and bedrock weathering*
- ***Groundwater** quality*
- *Water quality in **reservoirs***

The New York Times

Learning With: 'Glaciers Are Retreating. Millions Rely on Their Water.'

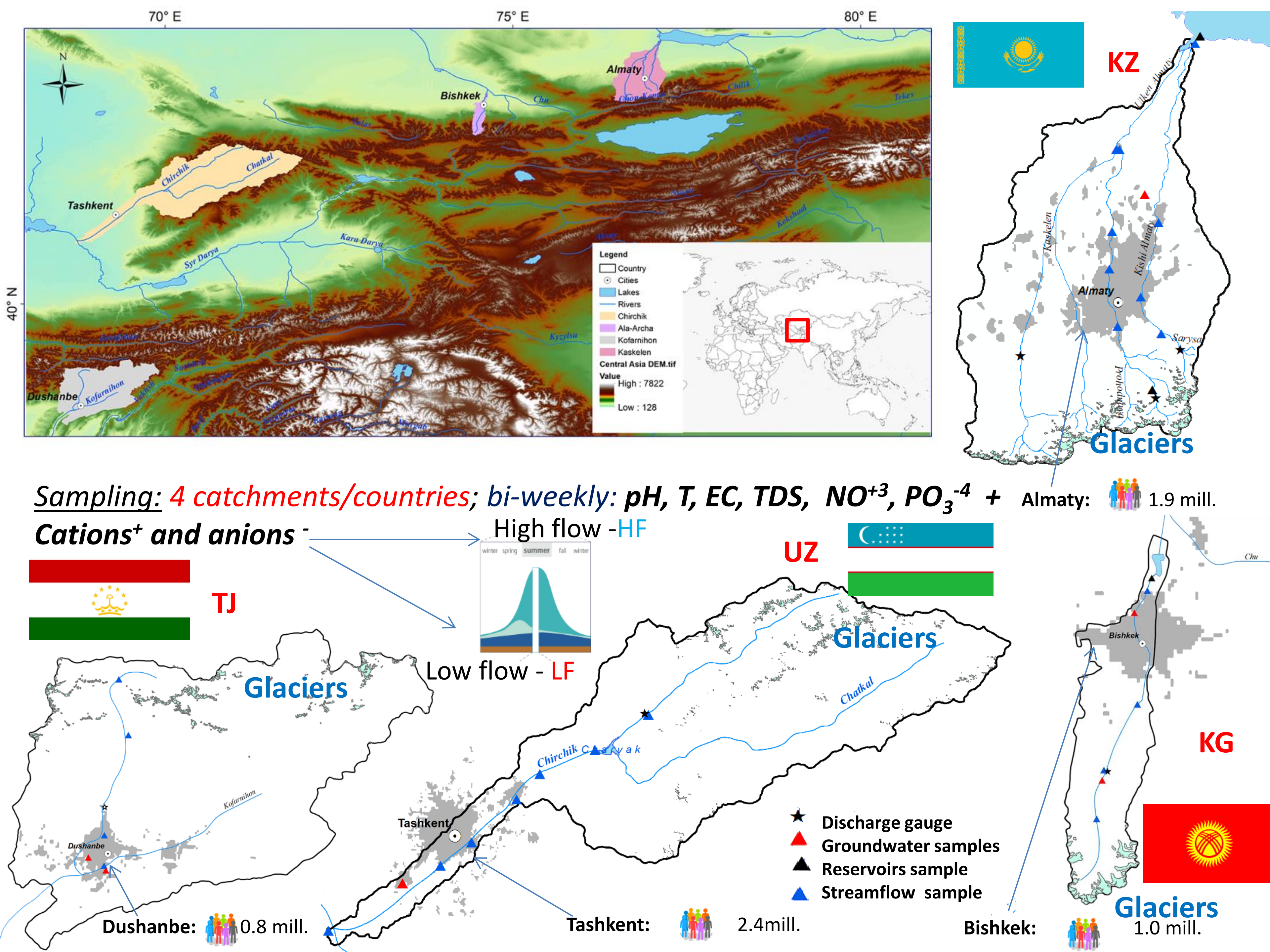
By Jeremy Engle

Jan. 23, 2019



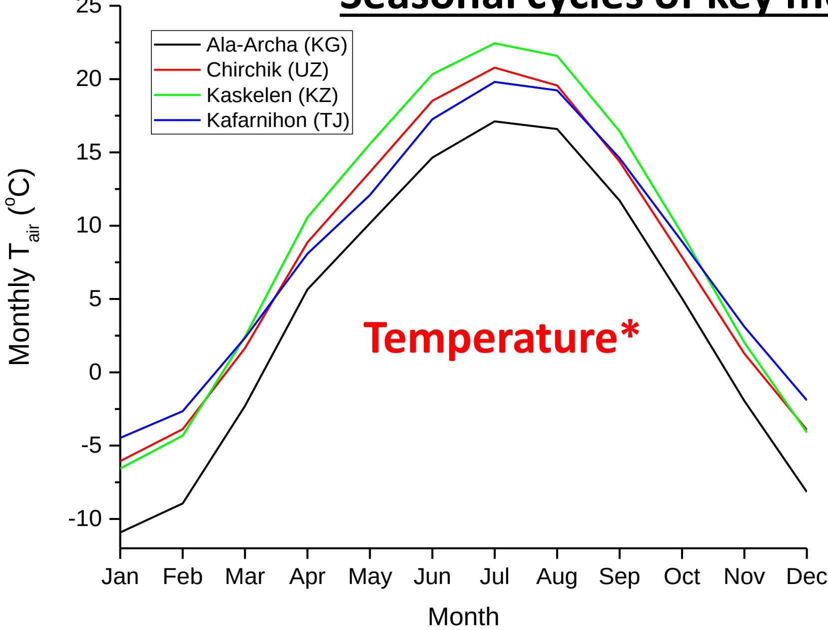
Hock et. al 2019 IPCC report Chapter 2. . 'High Mountain Areas',

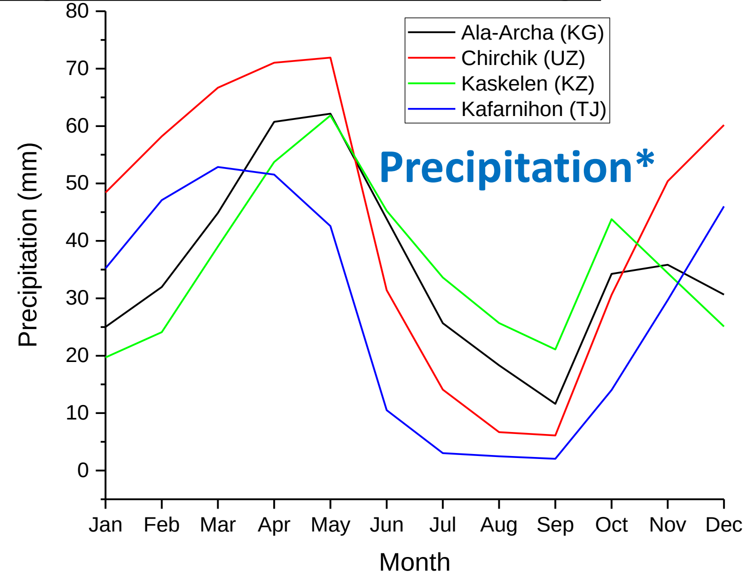
https://www.nytimes.com/interactive/2019/04/17/climate/melting-glaciers-globally.html

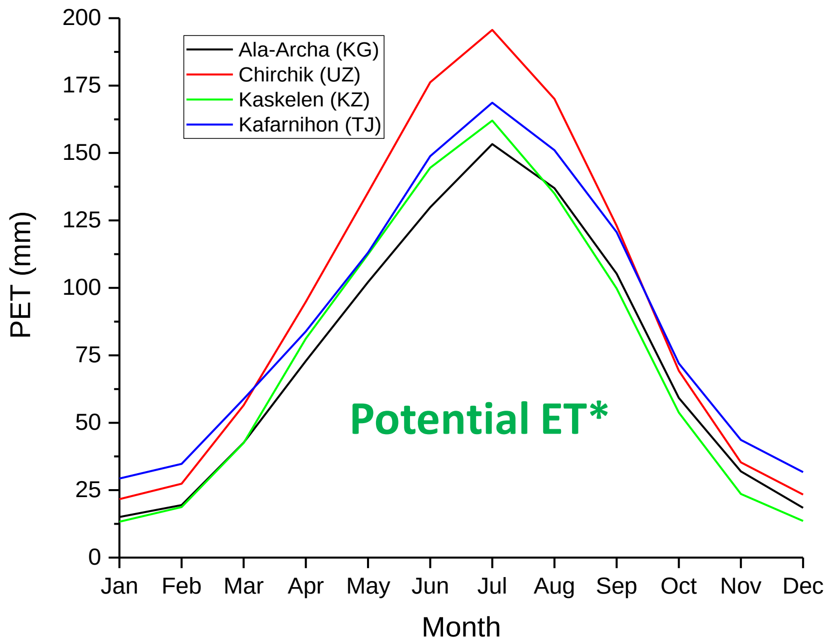


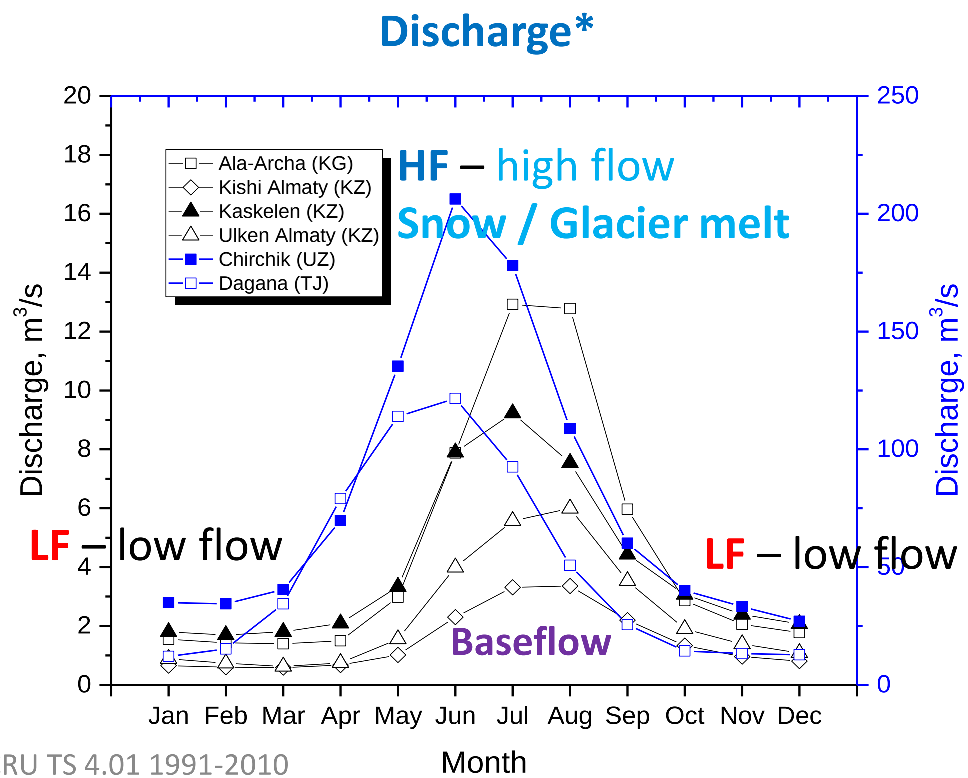
70° E
75° E
80° E
40° N
N
Almaty
Bishkek
Tashkent
Dushanbe
Chu
Chilik
Tekes
Chatkal
Chirchik
Syr Darya
Kara Darya
Kofarnihon
Kyzylsu
Legend
Country
Cities
Lakes
Rivers
Chirchik
Ala-Archa
Kofarnihon
Kaskelen
Central Asia DEM.tif
Value
High : 7822
Low : 128
KZ
Kaskelen
Kishi Almaty
Ulken Almaty
Sarysay
Almaty
Glaciers
Sampling: 4 catchments/countries; bi-weekly: pH, T, EC, TDS, NO+3, PO3-4 +
Cations+ and anions -
Almaty: 1.9 mill.
High flow -HF
winter spring summer fall winter
Low flow - LF
UZ
TJ
Glaciers
Glaciers
Chatkal
Chirchik
Charvak
Kofarnihon
Dushanbe
Tashkent
Chu
Bishkek
KG
Discharge gauge
Groundwater samples
Reservoirs sample
Streamflow sample
Glaciers
Dushanbe: 0.8 mill.
Tashkent: 2.4mill.
Bishkek: 1.0 mill.

Seasonal cycles of key meteorological variables and discharge







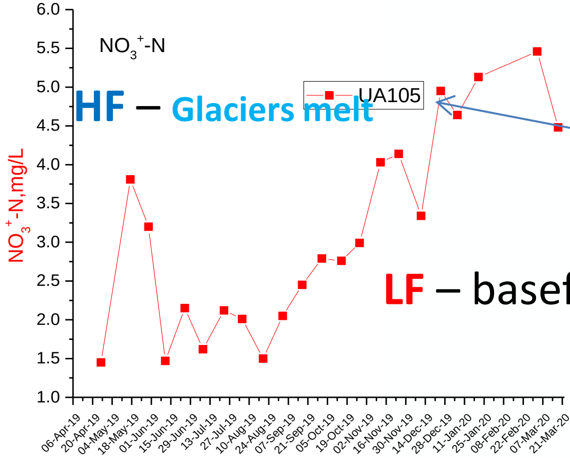


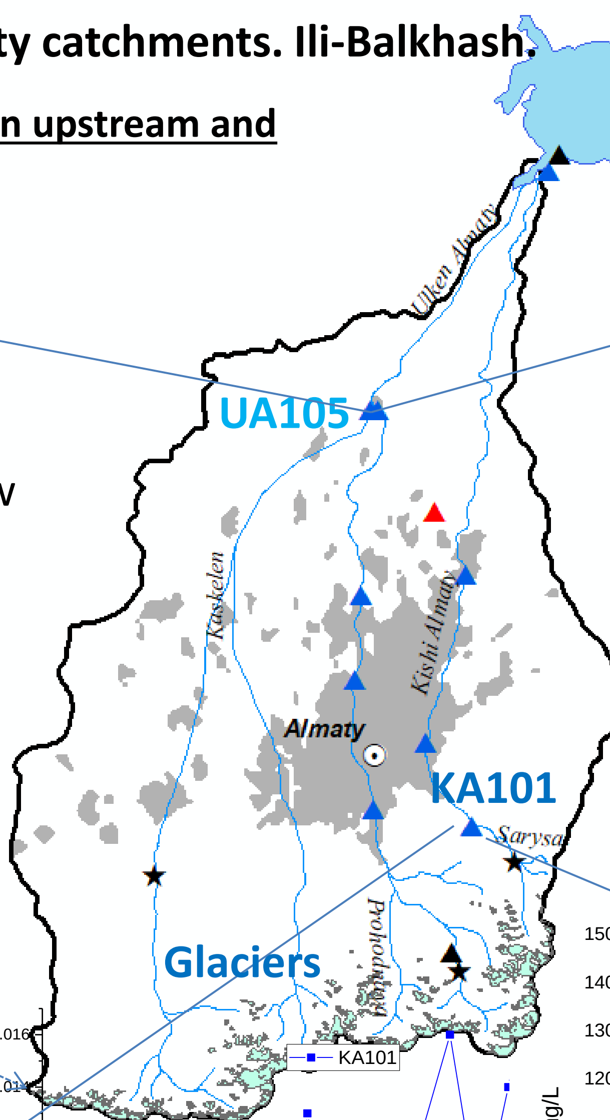
*CRU TS 4.01 1991-2010

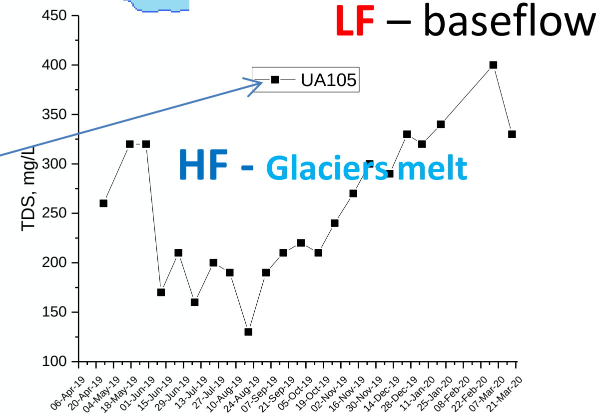
Kazakhstan: Kishi and Ulken Almaty catchments. Ili-Balkhash.

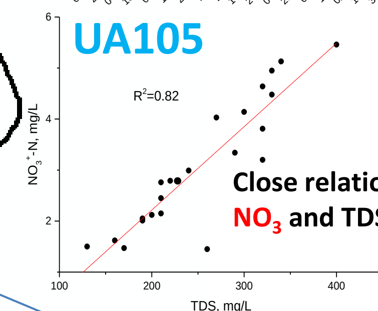
KZ

Nutrients and total dissolved solids in upstream and downstream parts:



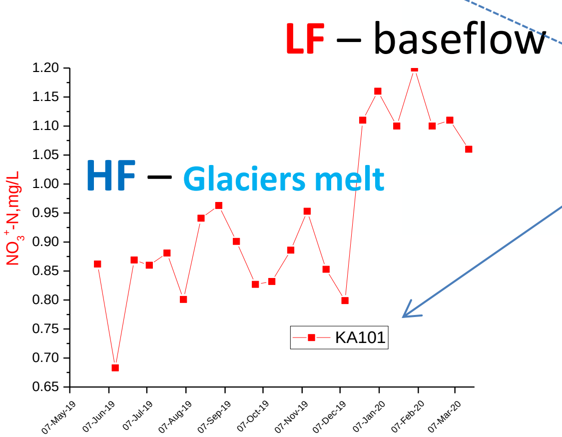


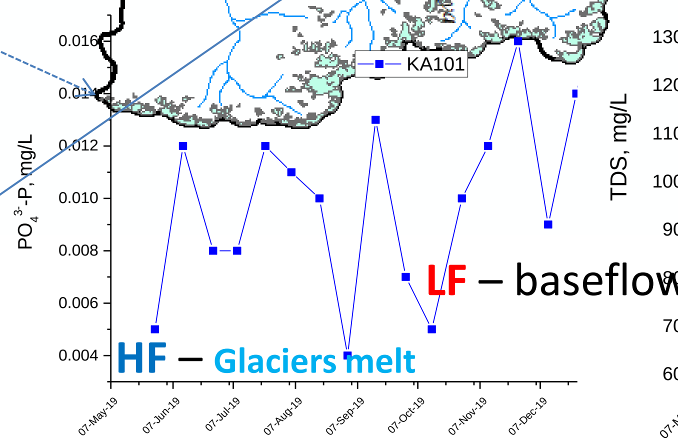


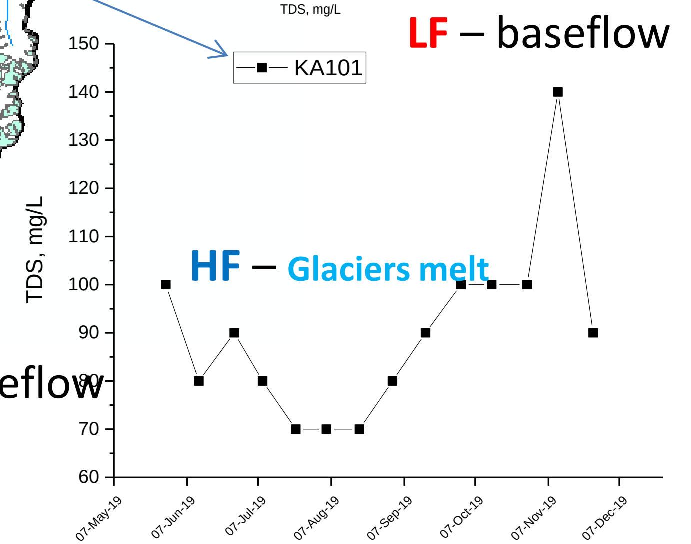


Close relationships between NO_3 and TDS and Flow?!

- The glacier melt dilution effect is clearly seen and its more pronounced downstream for NO_3 and TDS
- PO_4 is low in both periods (shown only upstream)

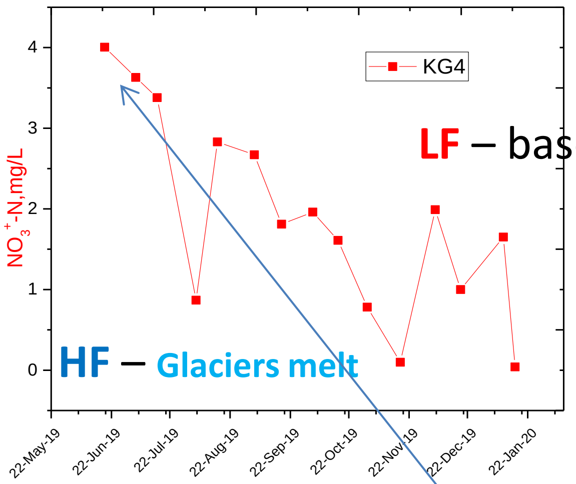


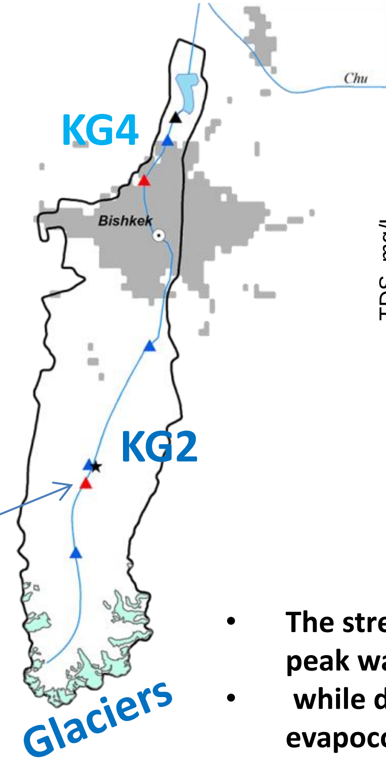


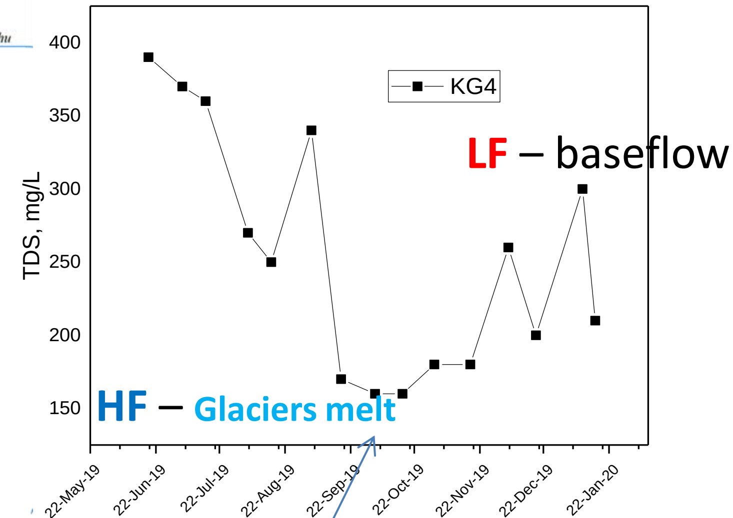


Nutrients and total dissolved solids in upstream and downstream :

Kyrgyzstan: Ala-Archa River - KG





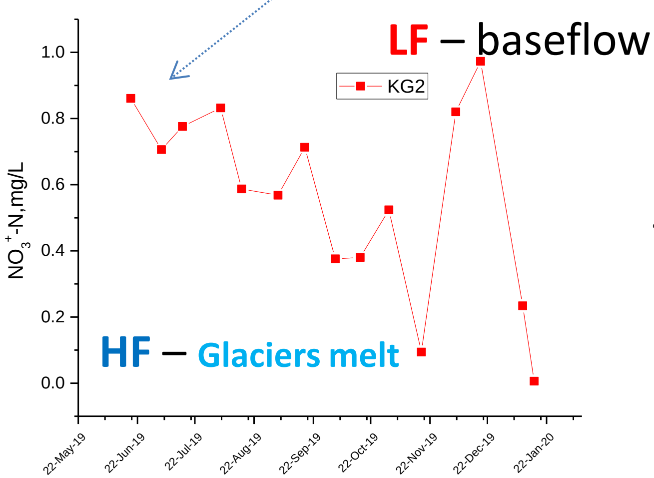


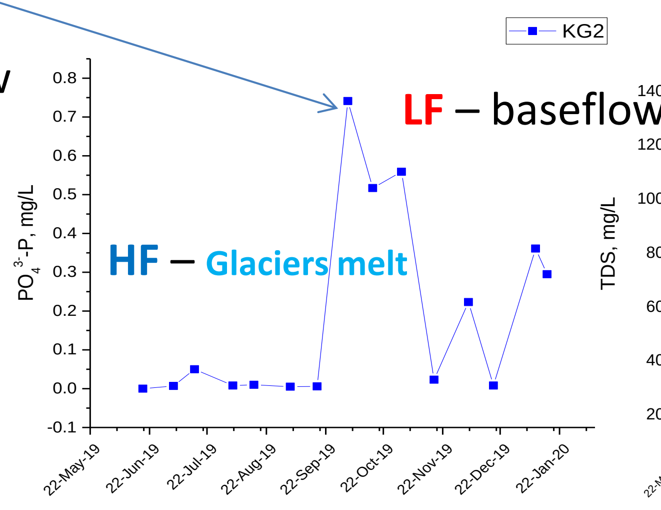
- The glacier melt seem s to bring NO_3

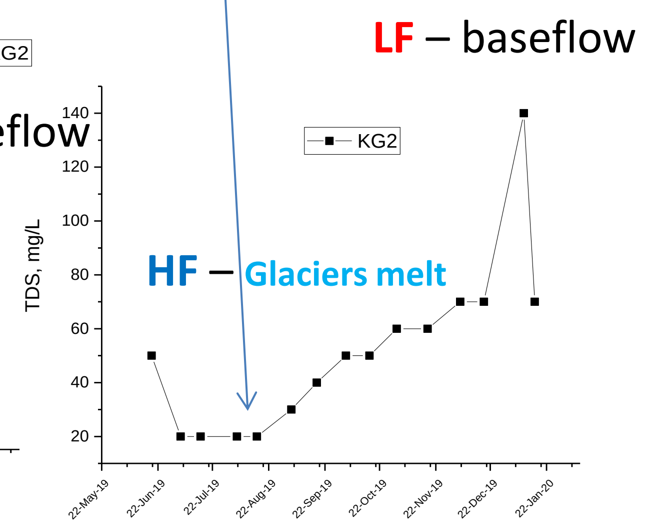
As nitrate concentration decline on downstream site towards the end of melt period

- PO_4 has spikes in early autumn first noted in GW upstream

- The stream water is very diluted upstream esp. during peak water
- while downstream TDS drops in early autumn evapoconcentration is less?

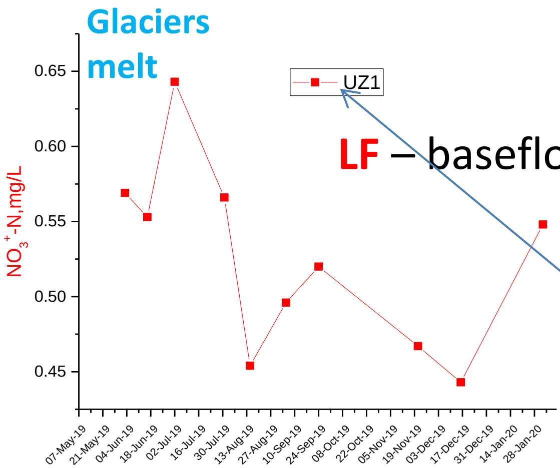




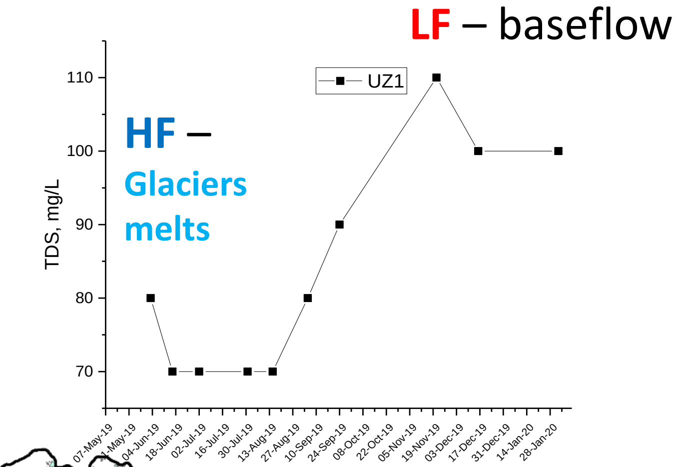


Uzbekistan. Pskem-Chirchik River - tributary of Syr-Darya River - UZ.

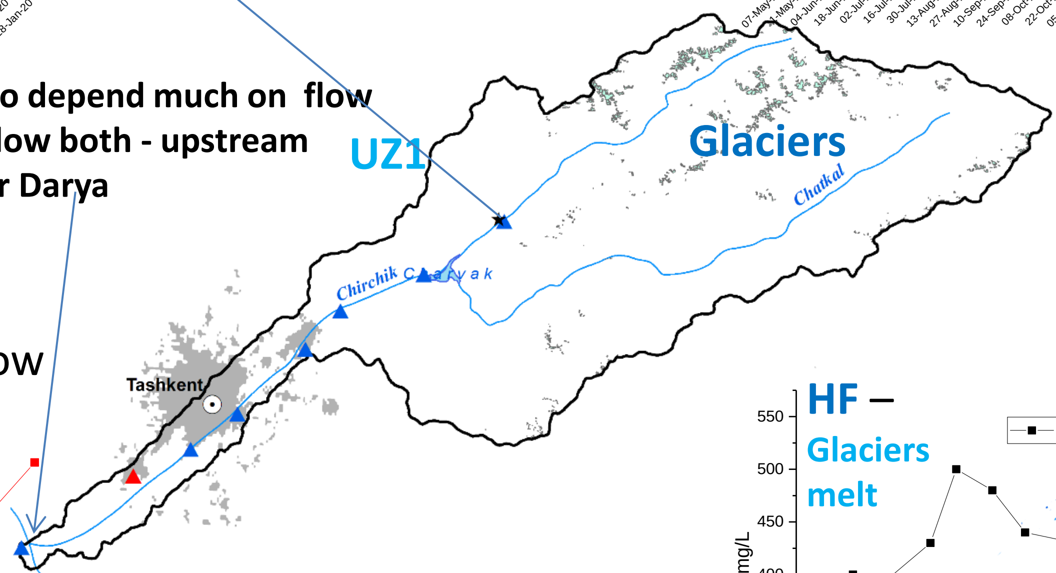
HF – Nutrients and total dissolved solids in upstream and downstream :

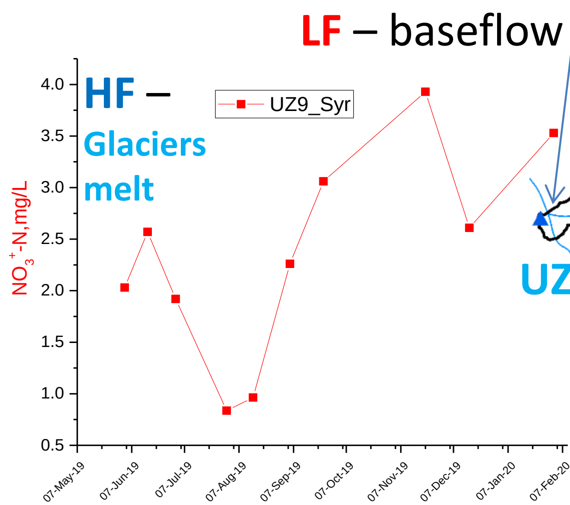


upstream – Pskem River

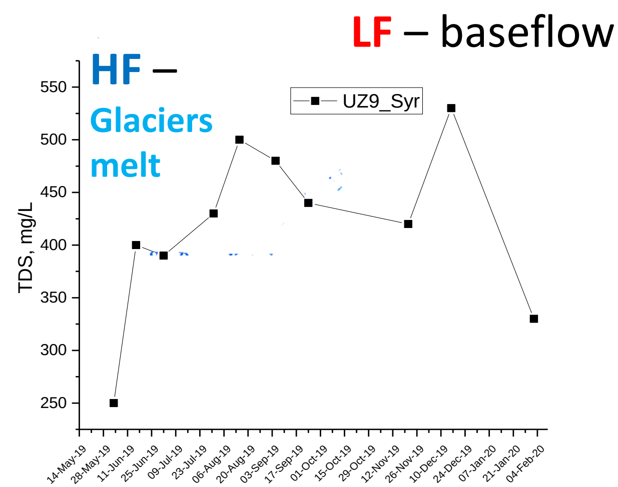


- NO_3 and TDS do not seem to depend much on flow
- Nitrate concentrations are low both - upstream and at the outlet – inflow to Syr Darya



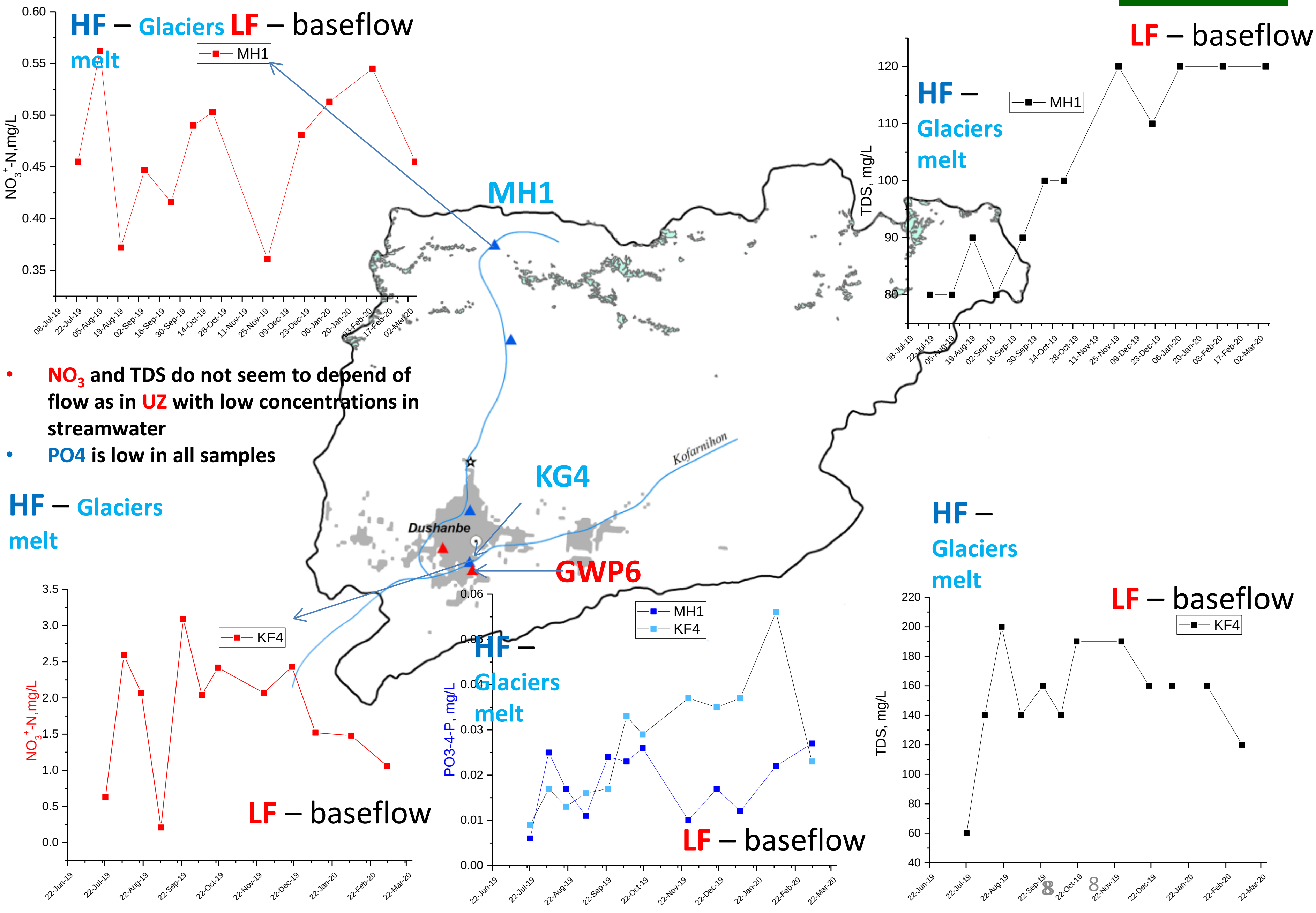


downstream - Chirchik River



Tajikistan: Varzob and Kafarnihon Rivers - Amu-Darya tributaries - TJ

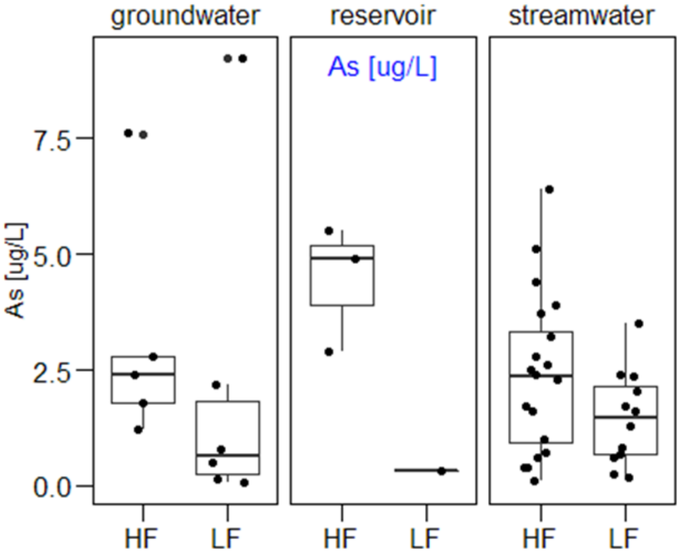
Nutrients and total dissolved solids in upstream and downstream :

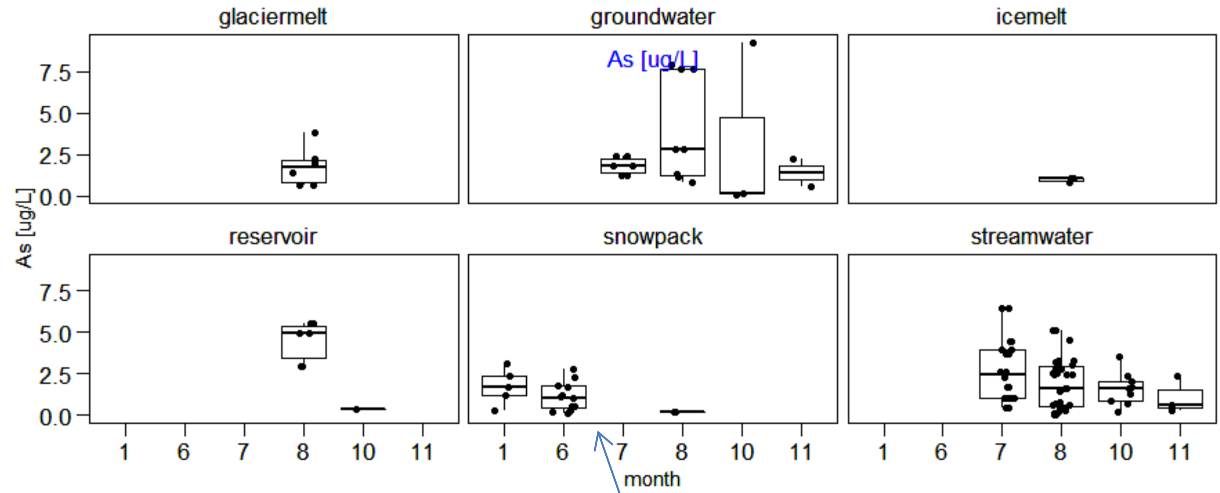


- NO_3 and TDS do not seem to depend of flow as in UZ with low concentrations in streamwater
- PO4 is low in all samples

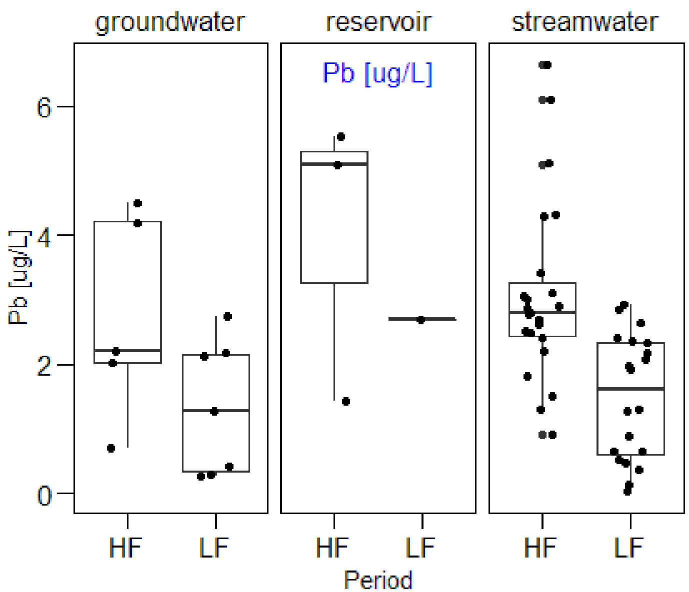
There is some evidence of elevated PTEs (such as As, Pb shown here) in HF period compared to LF

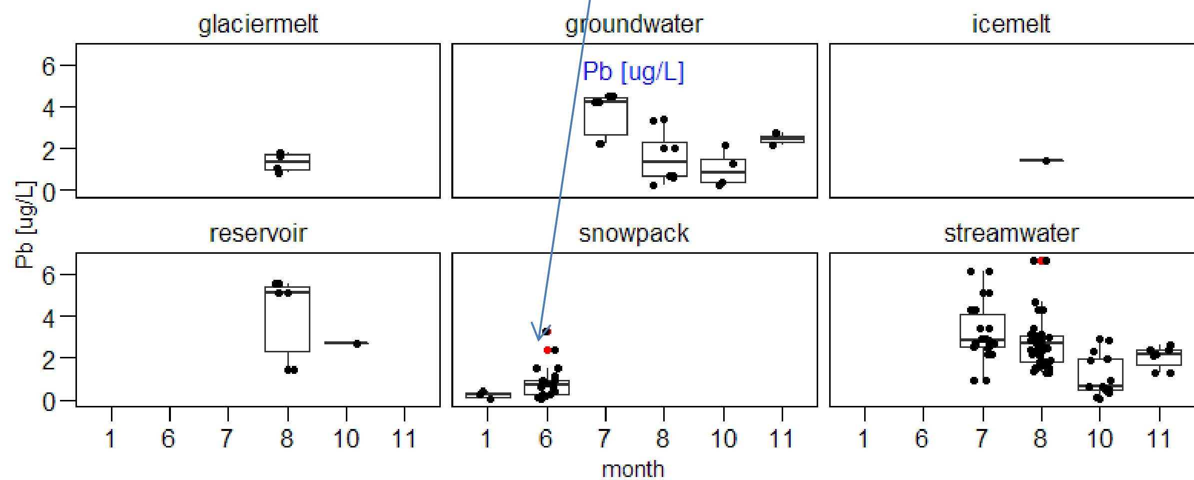
'Legacy pollutants'? also registered for Cu and Zn (not shown)





This can be traced to glacier melt and contaminated snowpack (data for cryosphere samples for KZ and KG). January snowpack – Almaty city. June snowpack – Tuyuksu glacier, KZ. August snowpack – KG glaciers.

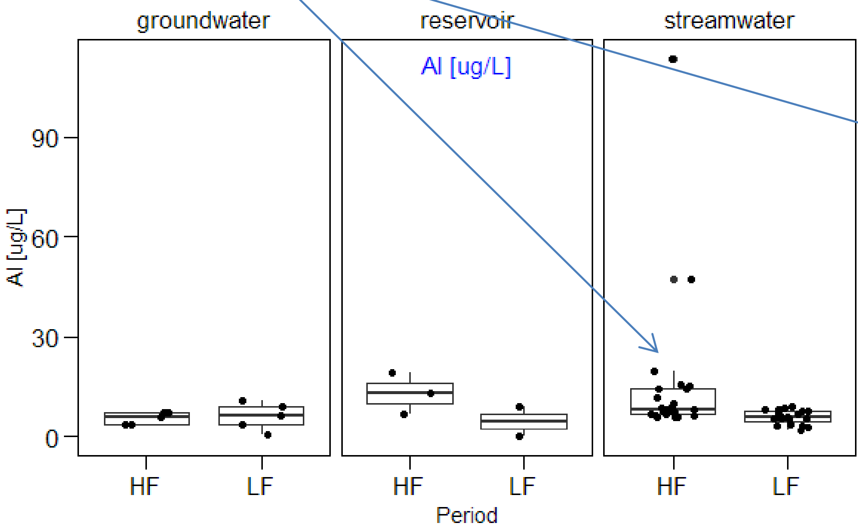


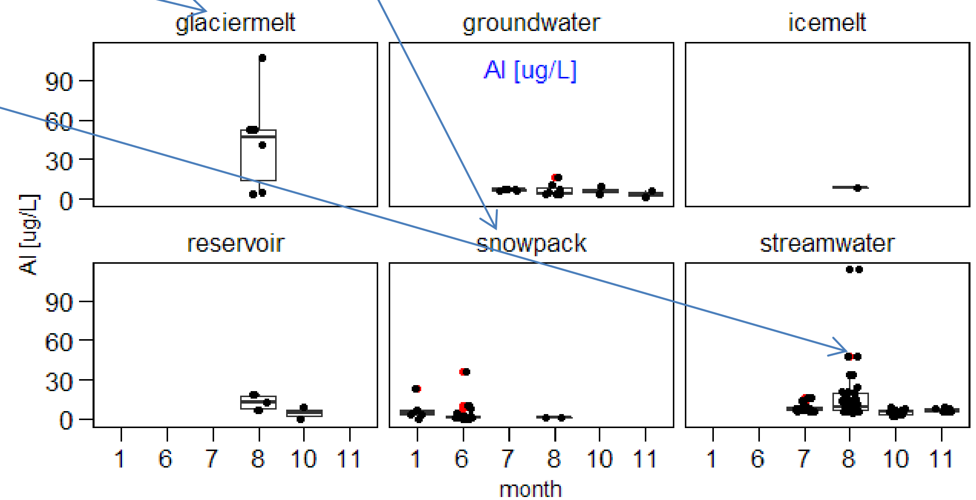


All PTEs are within regulatory standards set by WHO for drinking water (data across all sites)

‘Legacy pollutants’?

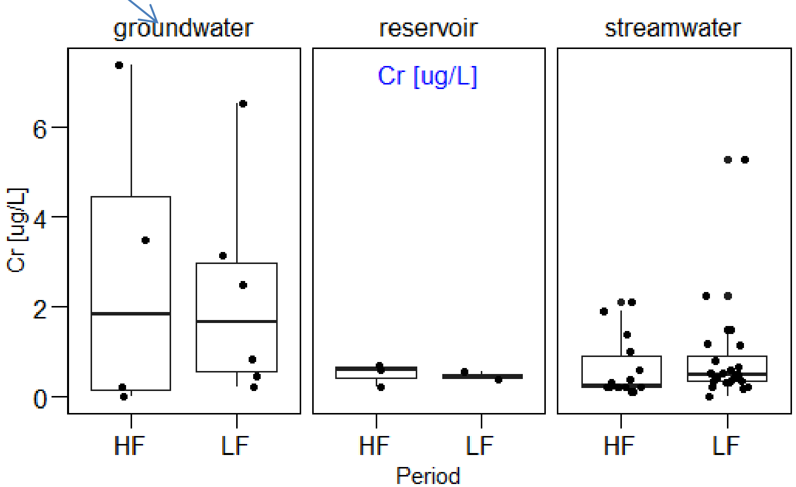
Al in HF period can be clearly traced to glacier melt and contaminated snowpack (KZ and KG only).

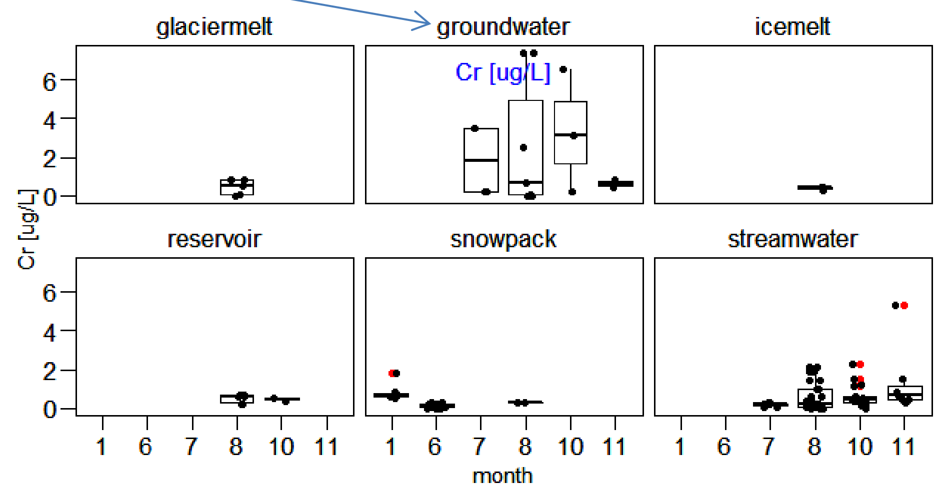




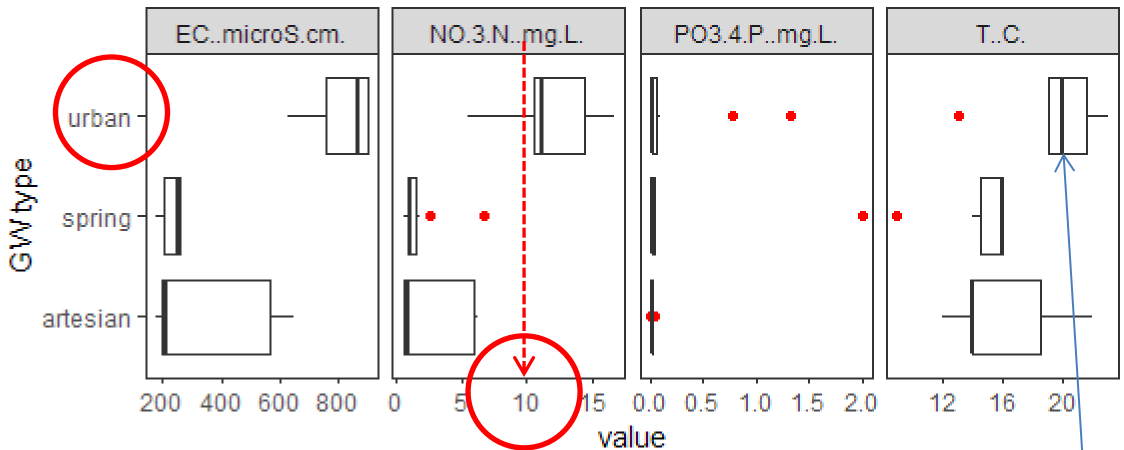
It is unclear what is the source of Al – mineral dust or pollutants from Almaty and Bishkek which are large cities located in close proximity to glaciers. January snowpack – Almaty city. June snowpack – Tuyuksu glacier, KZ. August snowpack – KG glaciers.

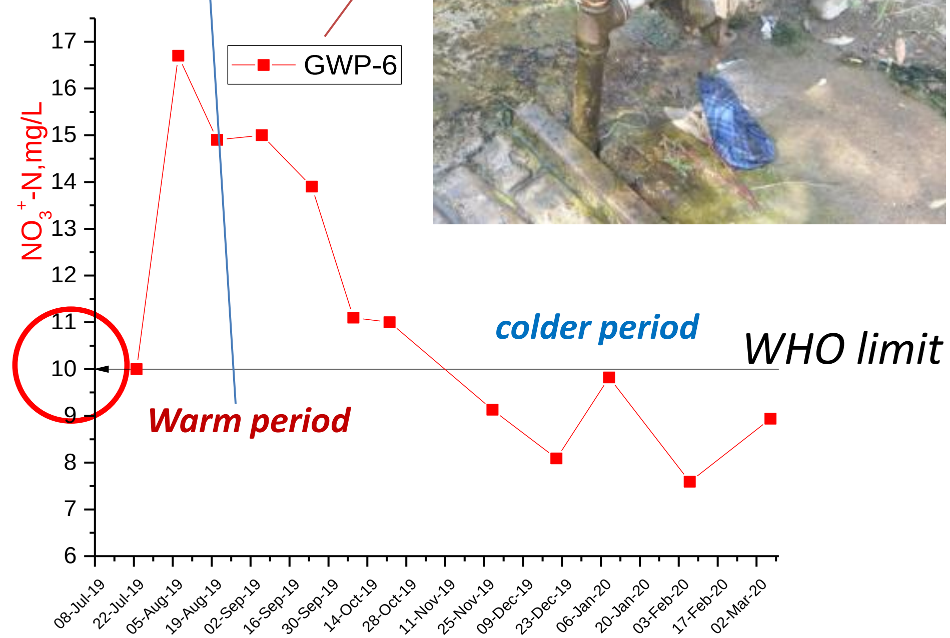
Higher Cr concentrations are found in GW compared to streamwater





Nutrients and Electrical Conductivity in different types of groundwater. Elevated Nitrate concentrations in urban groundwater.





- **Systematically high nitrate (higher than 10 ml L^{-1} of NO_3-N set by WHO was found urban groundwater samples in three countries – KG, UZ, TJ.**
- **Phosphate concentrations are very low**
- **The low nitrate concentrations in springs and artesian groundwater indicate that fecal contamination is a likely primary source of elevated nitrate concentrations in urban shallow ground water**

Conclusions

- *Overall **water in is clean** upstream and downstream*
- *There is indeed **contaminant leaching from snow and glacier melt** (e.g. Al)*
- *Glacier melt provides **dilution service to the downstream sections of the catchments.** This effect is more pronounced in smaller catchments where urban and agricultural areas are located closer to the glacierized areas (e.g. KZ – Almaty and KZ – Bishkek)*
- *Urban groundwater is contaminated by **nitrates** most probably by **urban sewage** – primary concern*