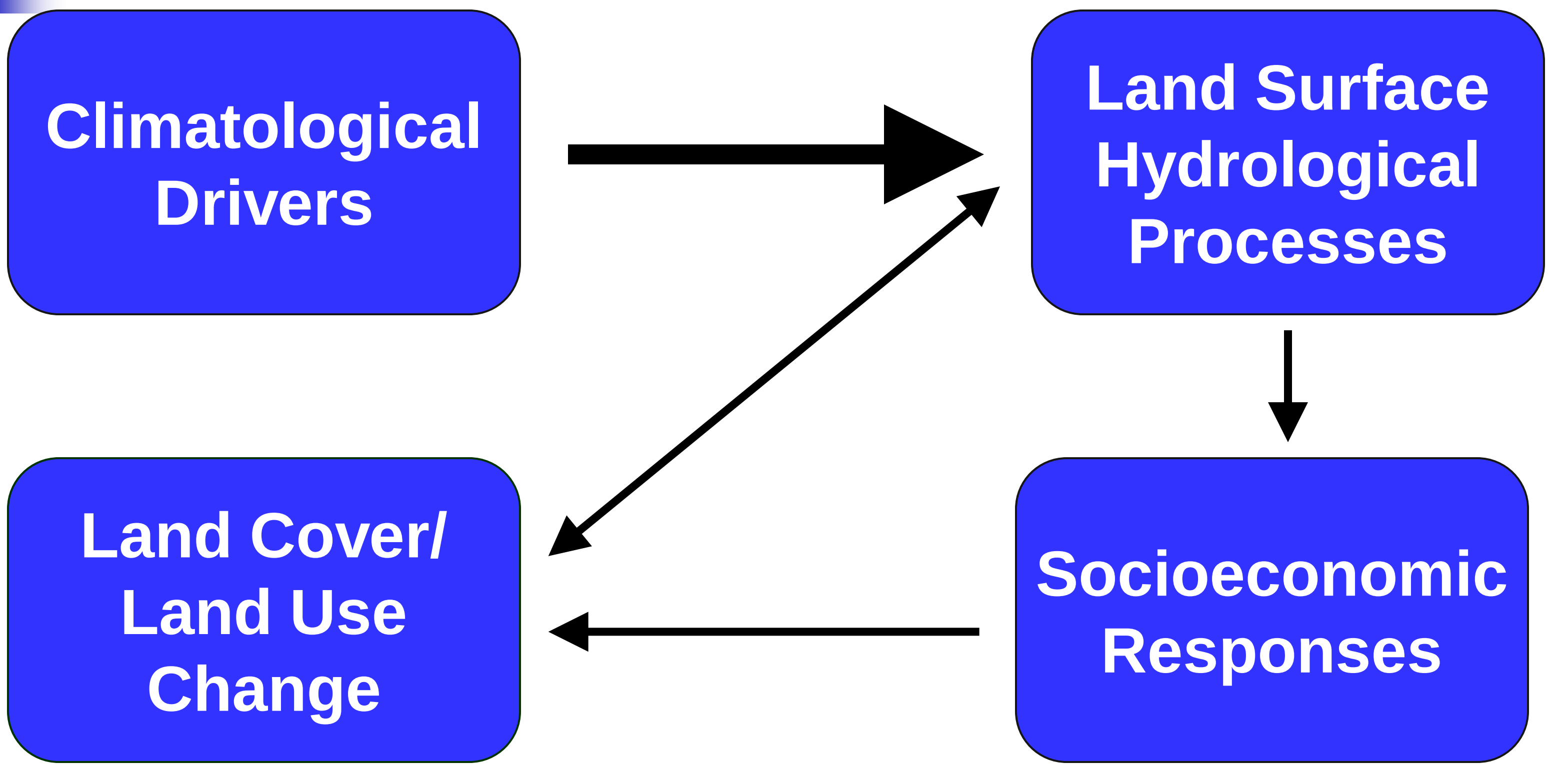
Image from NASA LCLUC website: http://lcluc.umd.edu/images/Regional_Initiatives/NEESPI3-large.jpg

Conceptualization of the Effects of Climate and LCLUC on Hydrological Processes



NEESPI STUDY AREA

LCLUC in NEESPI: Interactions with climate and hydrology

- 5 projects
  - Eshleman (UMCES), Townsend, Holko *et al.*
  - Aizen (UI) *et al.*
  - Saatchi (UCLA) *et al.*
  - Shiklomanov (UNH) *et al.*
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Small

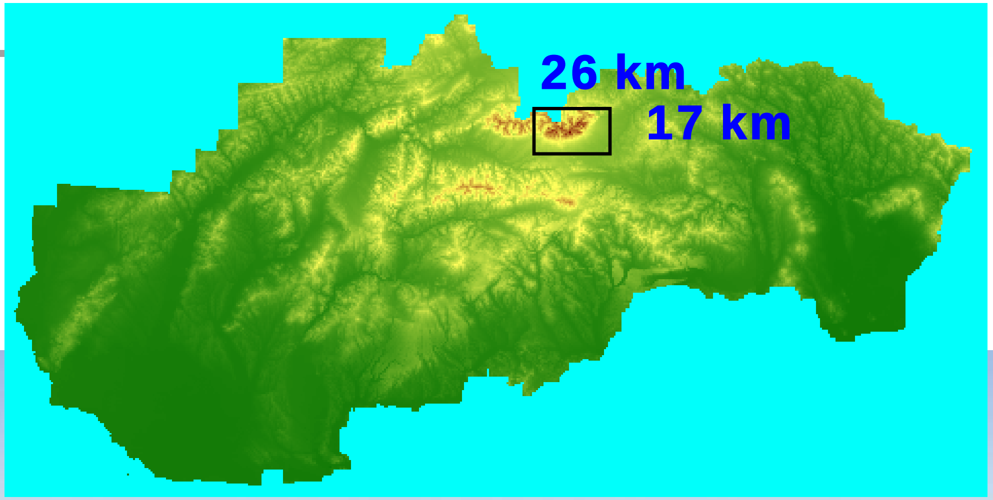
Spatial scale

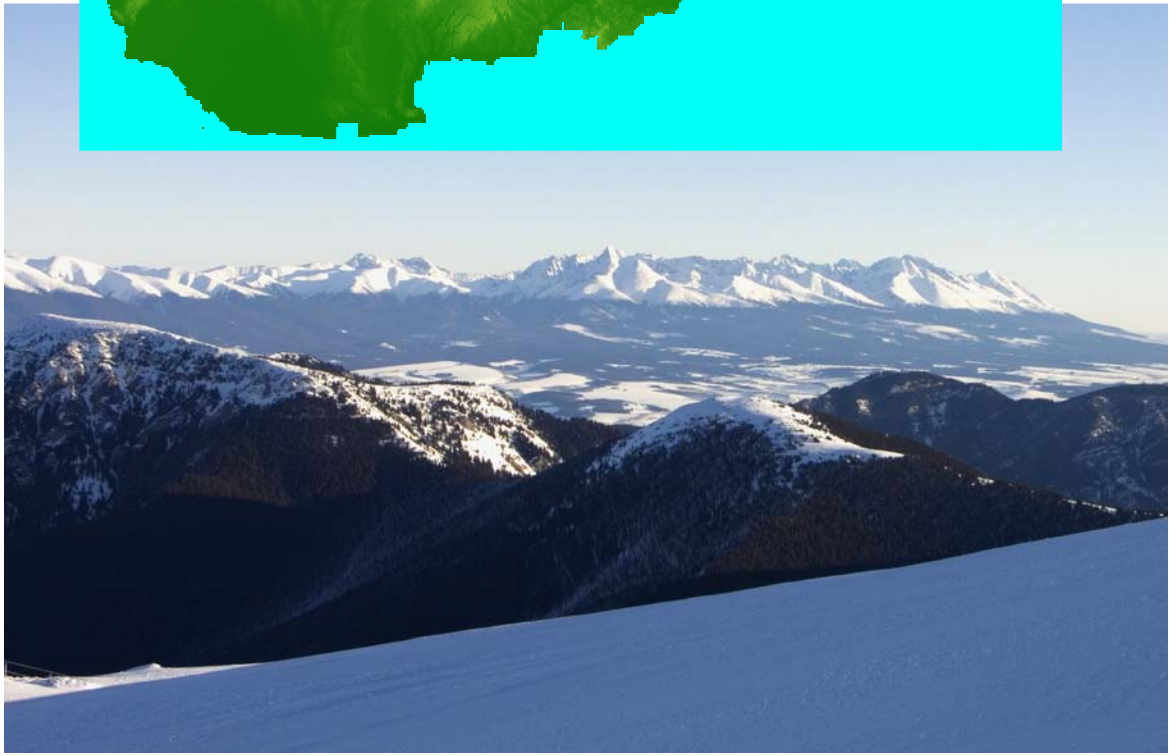
Large

Exacerbation of flooding in Carpathian Mountains due to deforestation

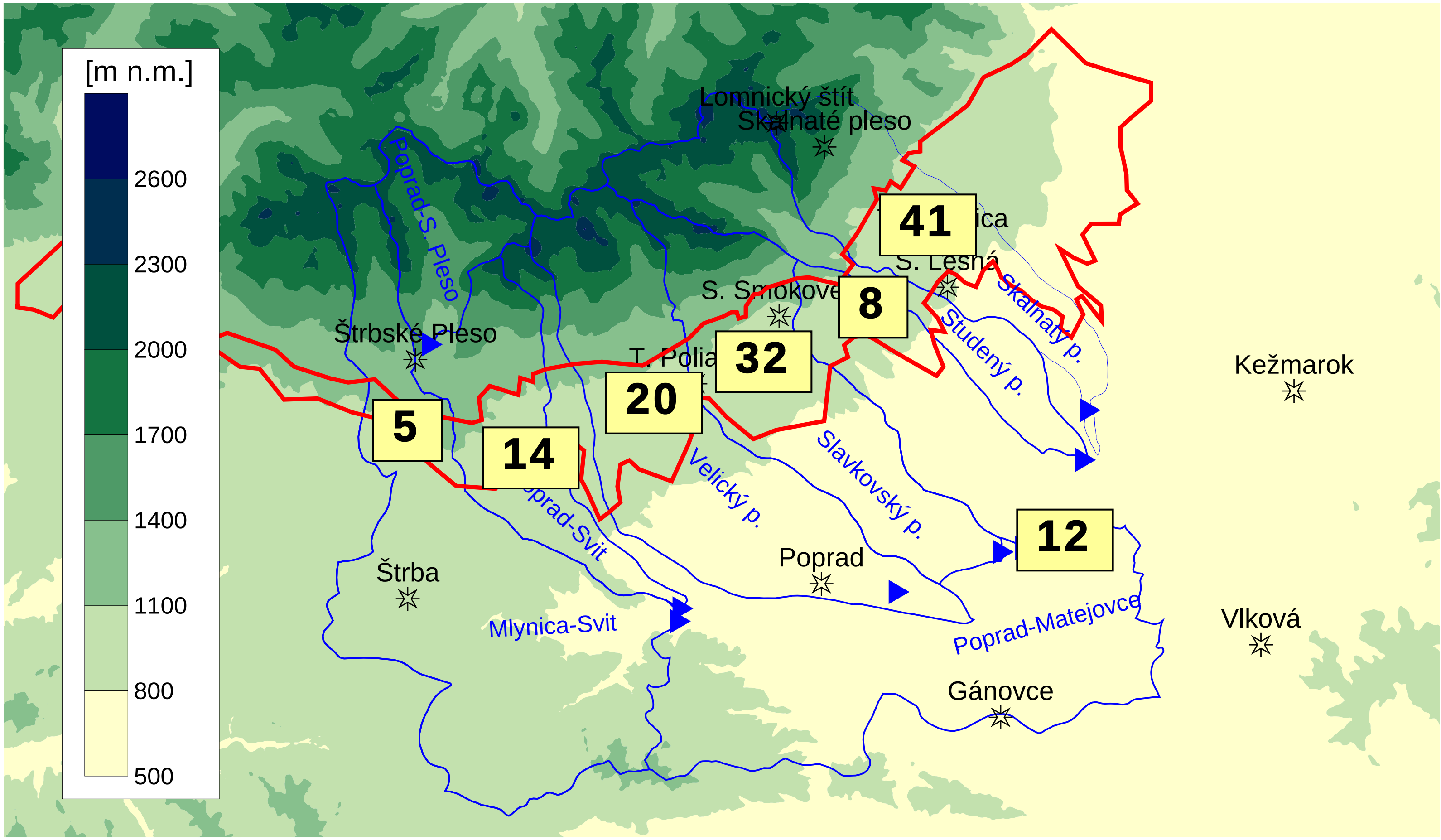
- Comparative analysis of data from small gaged catchments in High Tatras
- Complements research in Appalachian Mountains
- Took advantage of November 2004 blowdown of ~60 km^2 of conifer forest
- Established a good collaboration with L. Holko (Inst. Hydrology, SAS)

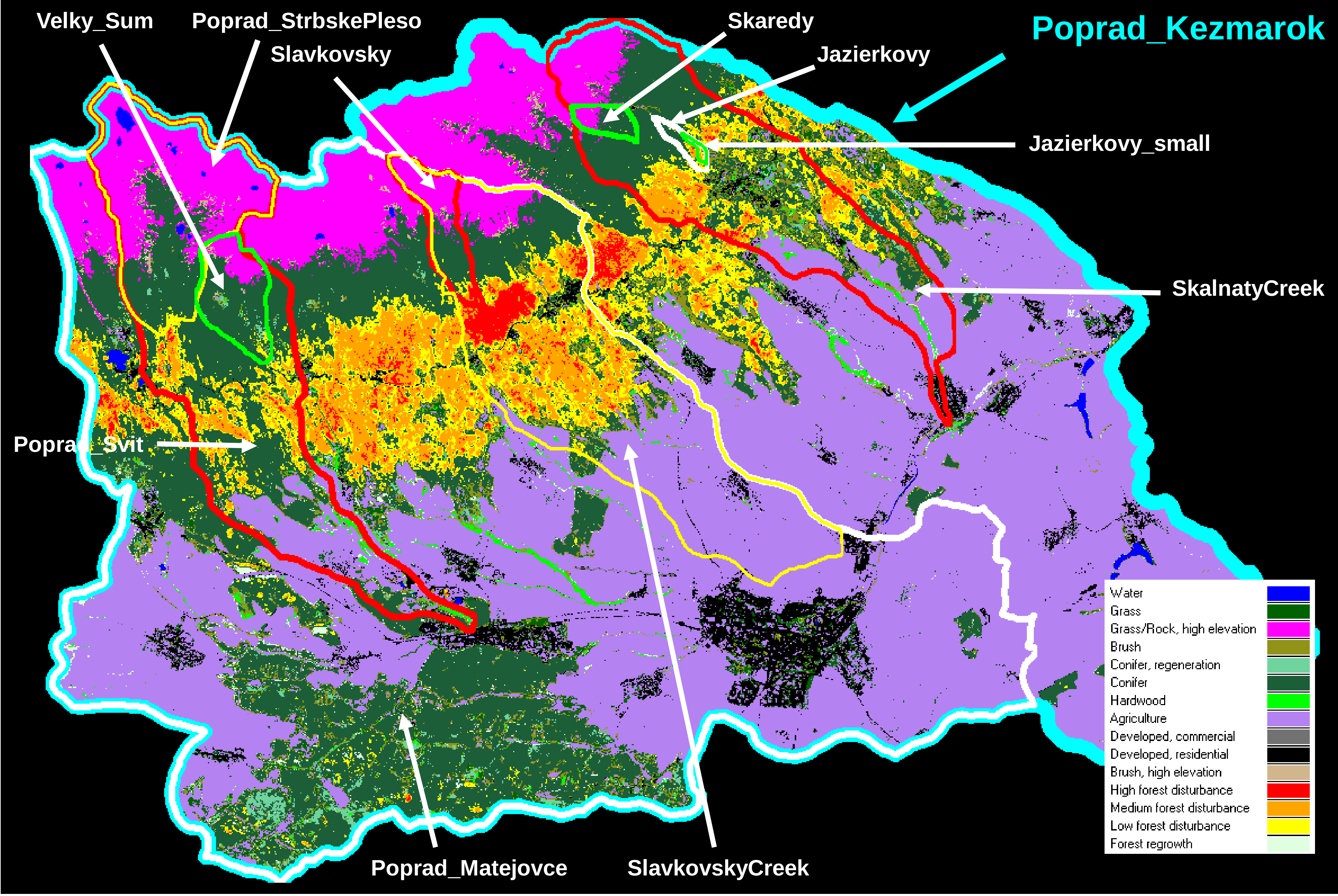
The High Tatra Mts. (341 km^2)– the highest part of the Carpathians (241000 km^2)





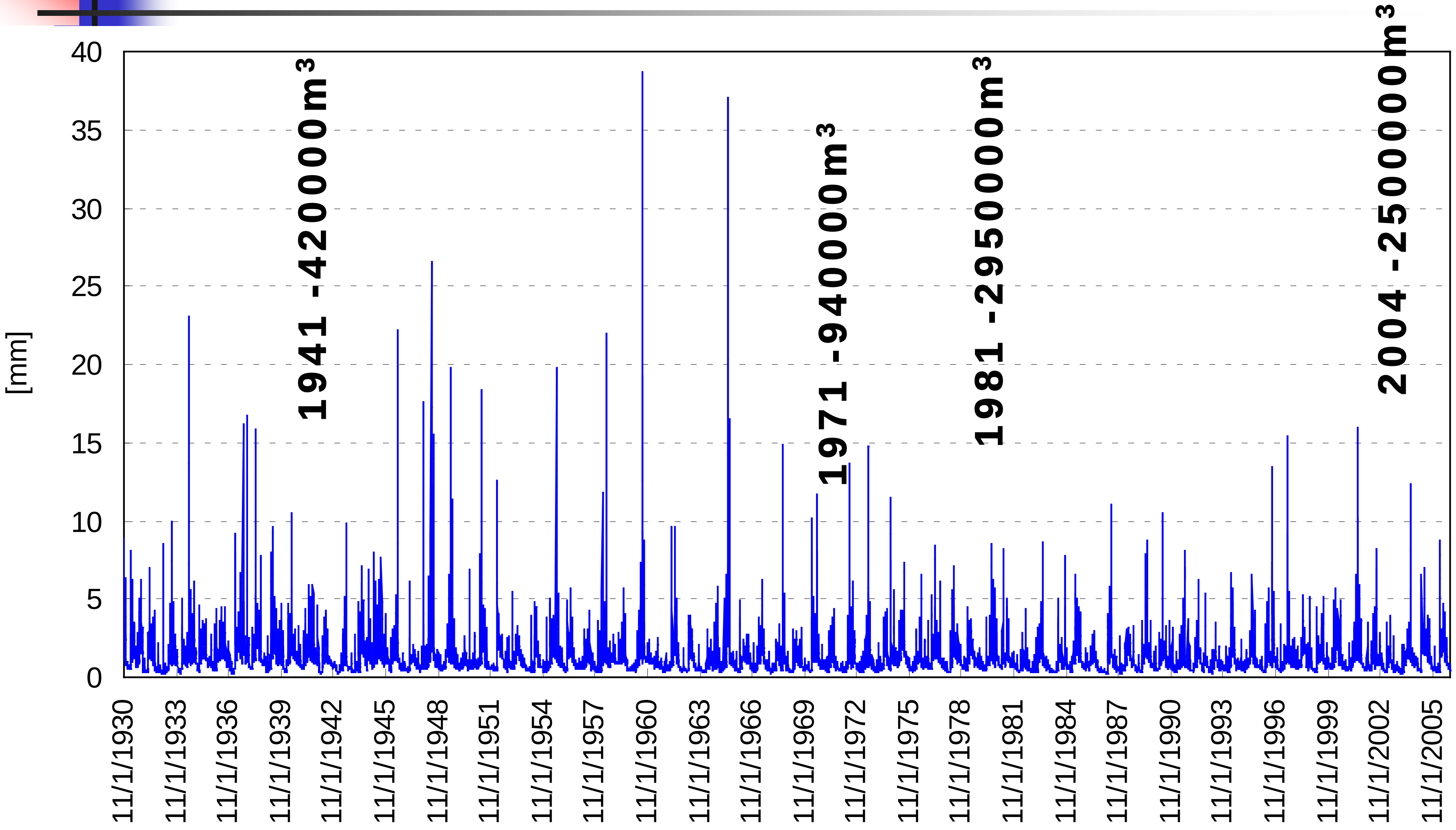
Subcatchments, precipitation stations, windfall area



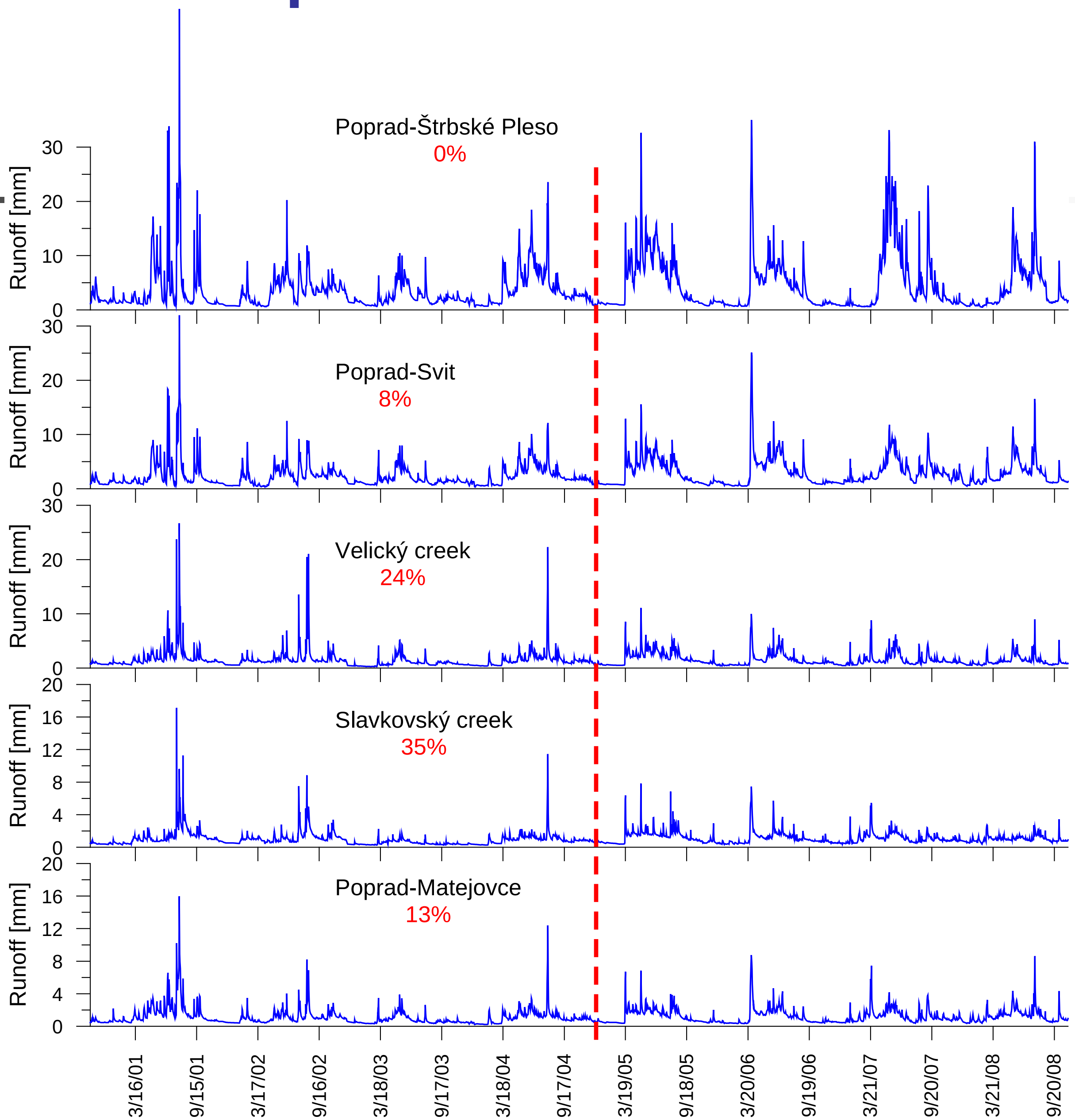


Classification of forest damage between 2003-2005 for the Slovakian High Tatras study area. Non-conifer areas retain their original land cover categories.

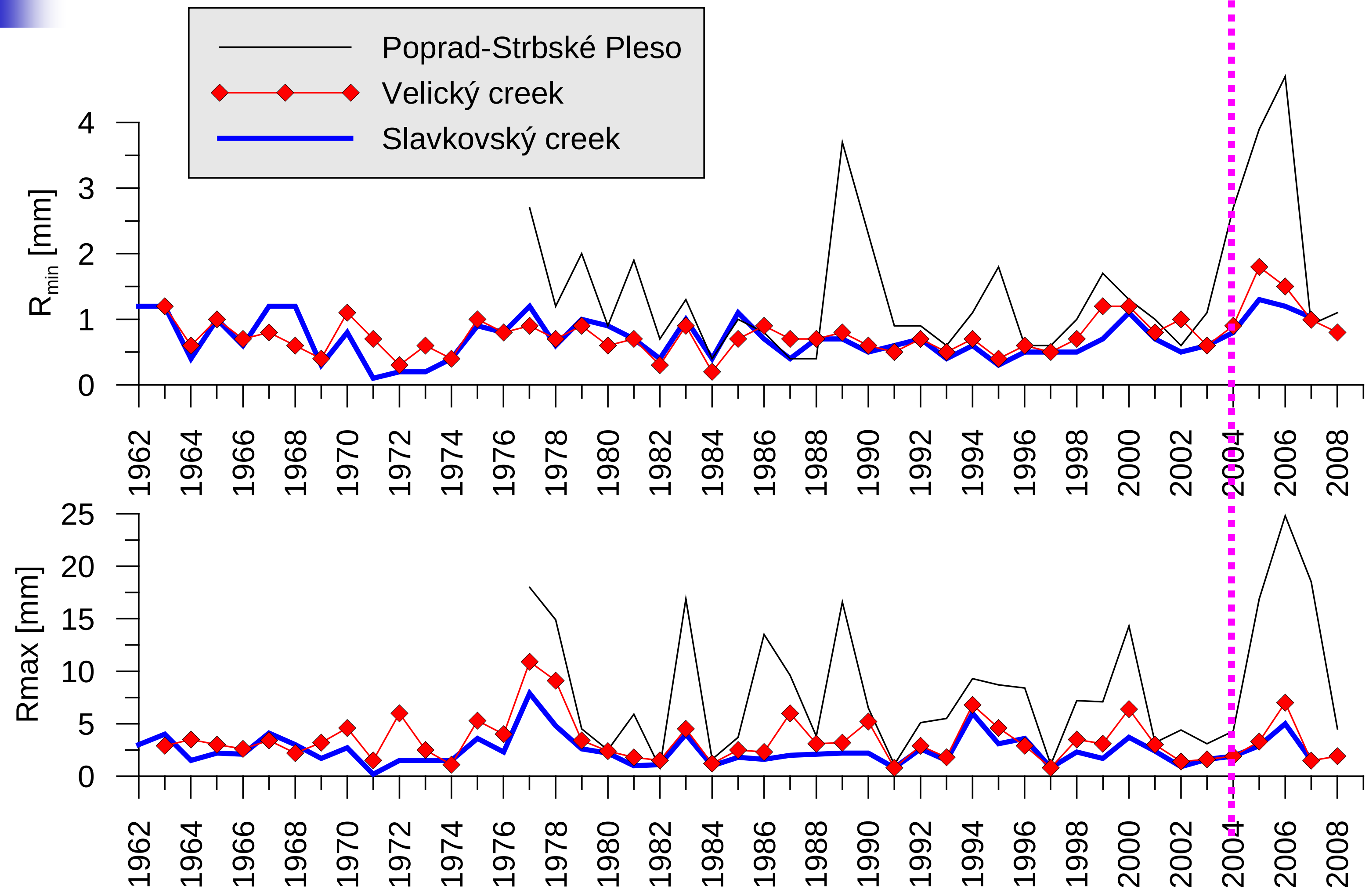
Discharges (Poprad river) and windfalls



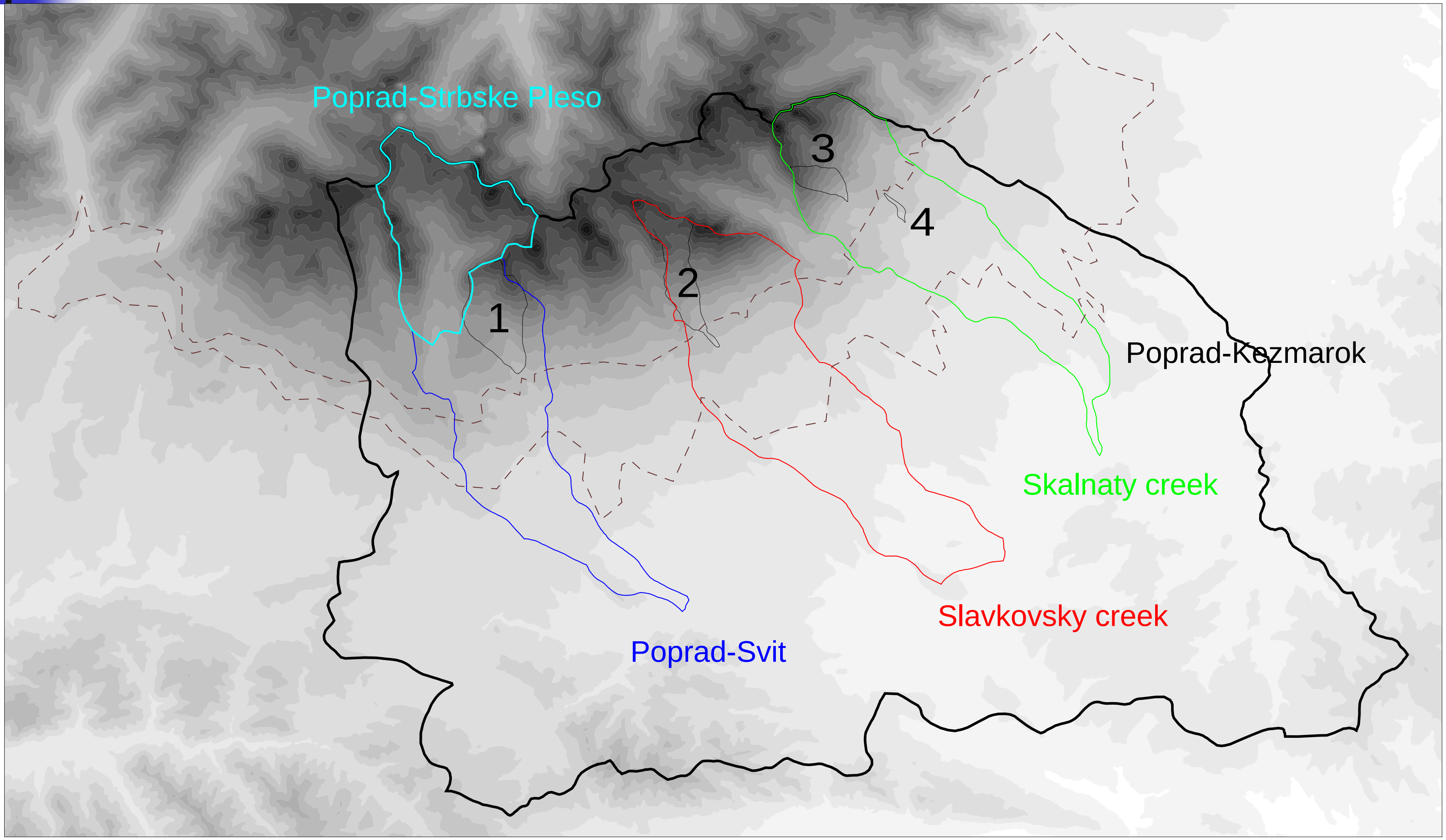
Pre- and post-windfall discharges



April – minimum and maximum daily runoff

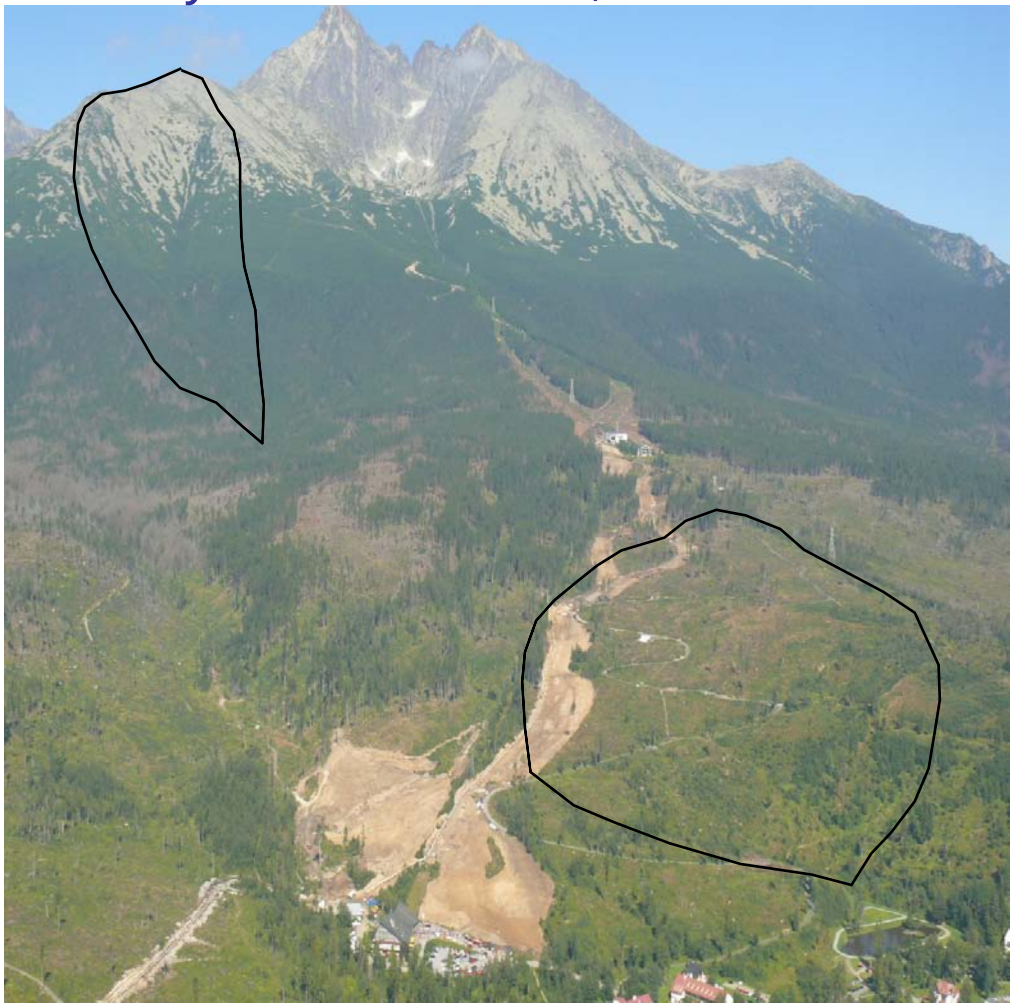


New small gaged (& nested) subcatchments

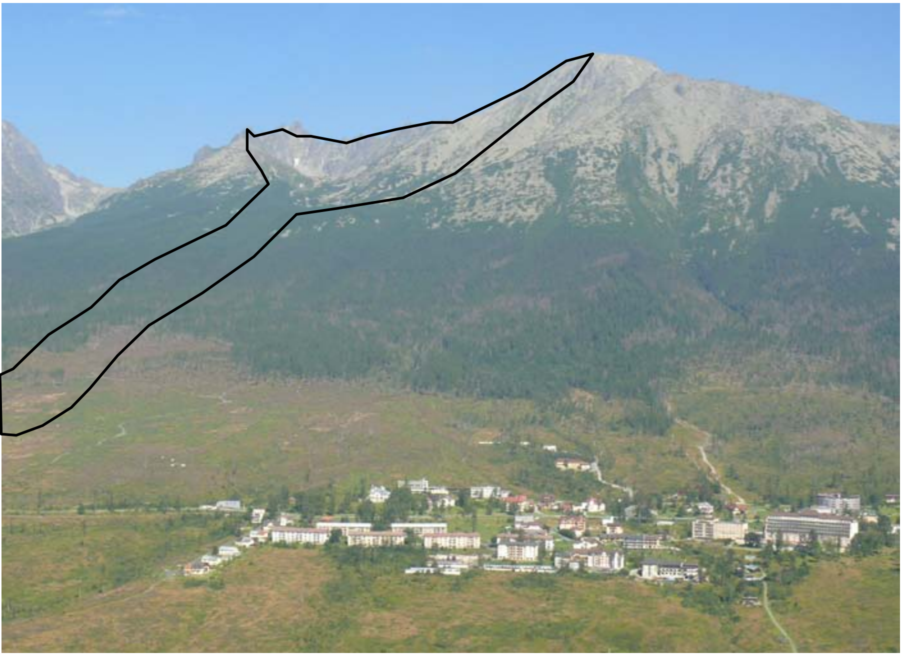


Veľký Šum - 4.6 km², 1592 m a.s.l.

Škaredý creek - 1.1 km², 1564 m a.s.l.



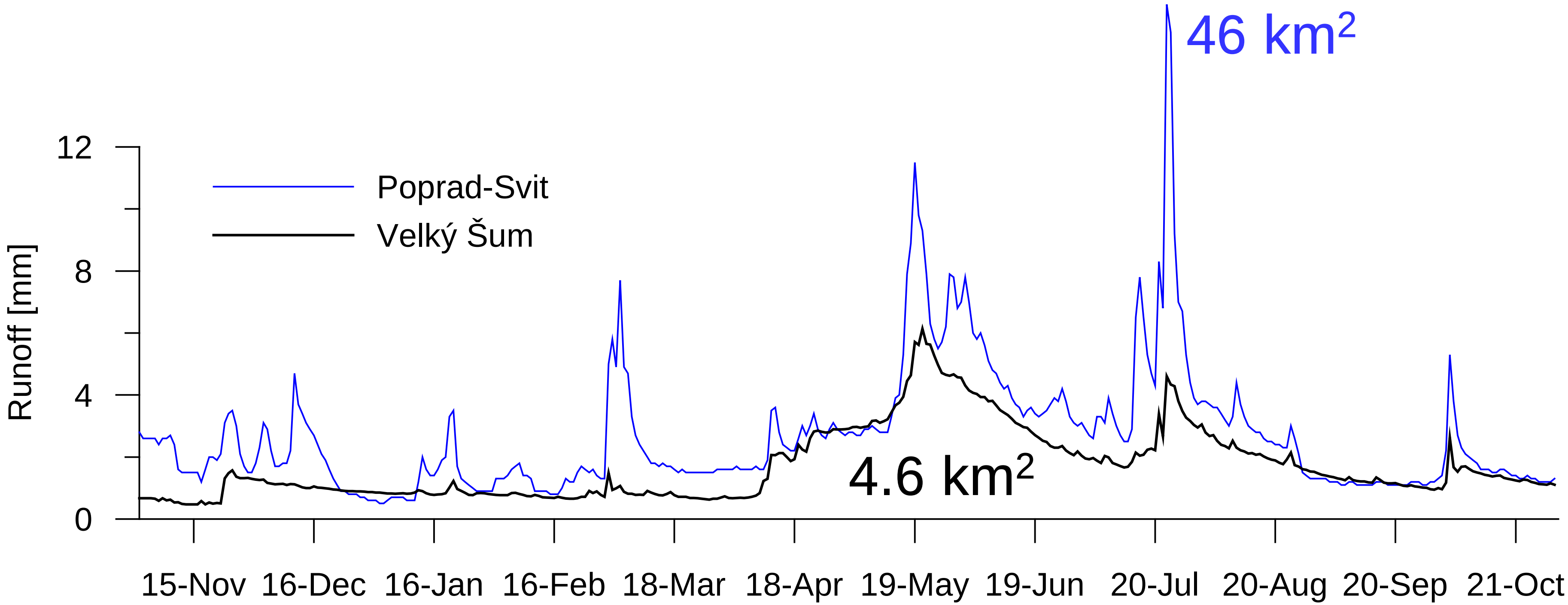
Jazierkový creek - 0.7 km², 1041 m a.s.l.



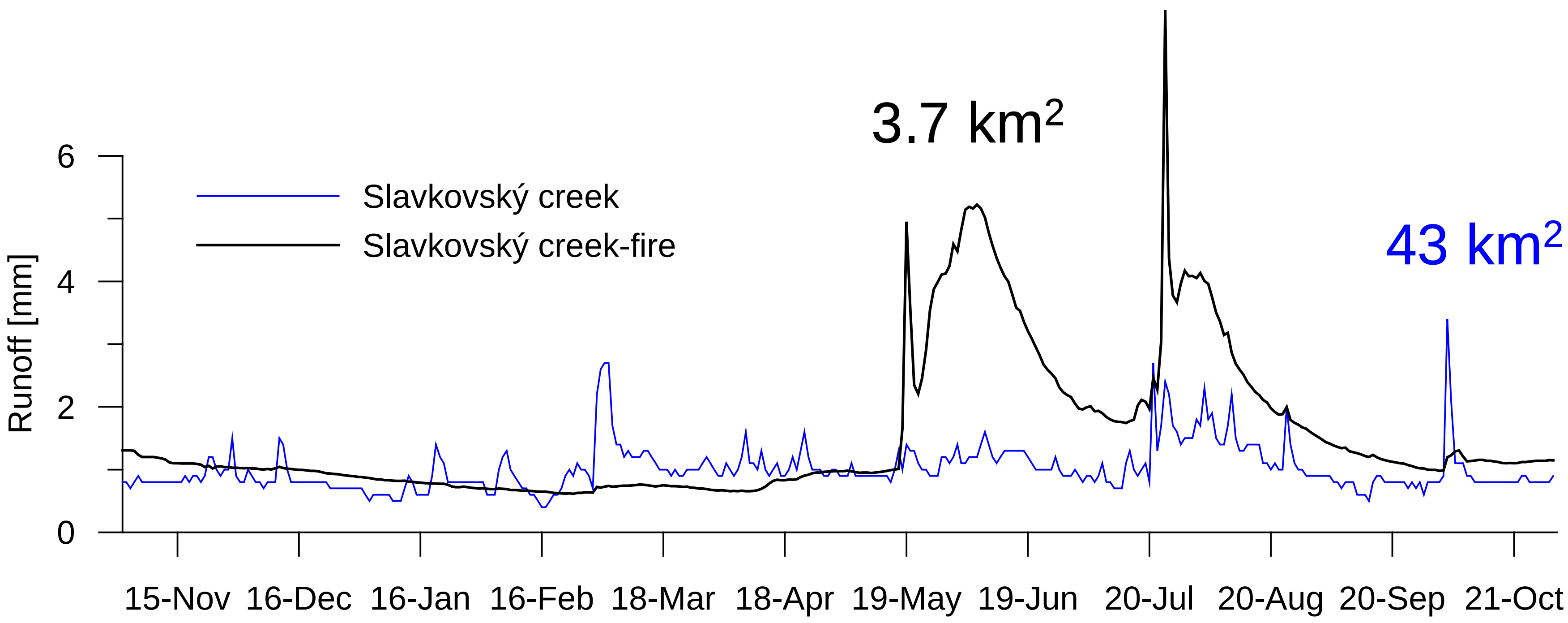
Slavkovský c.-fire - 3.7 km², 1759 m a.s.l.

Photos P. Fleischer 2008

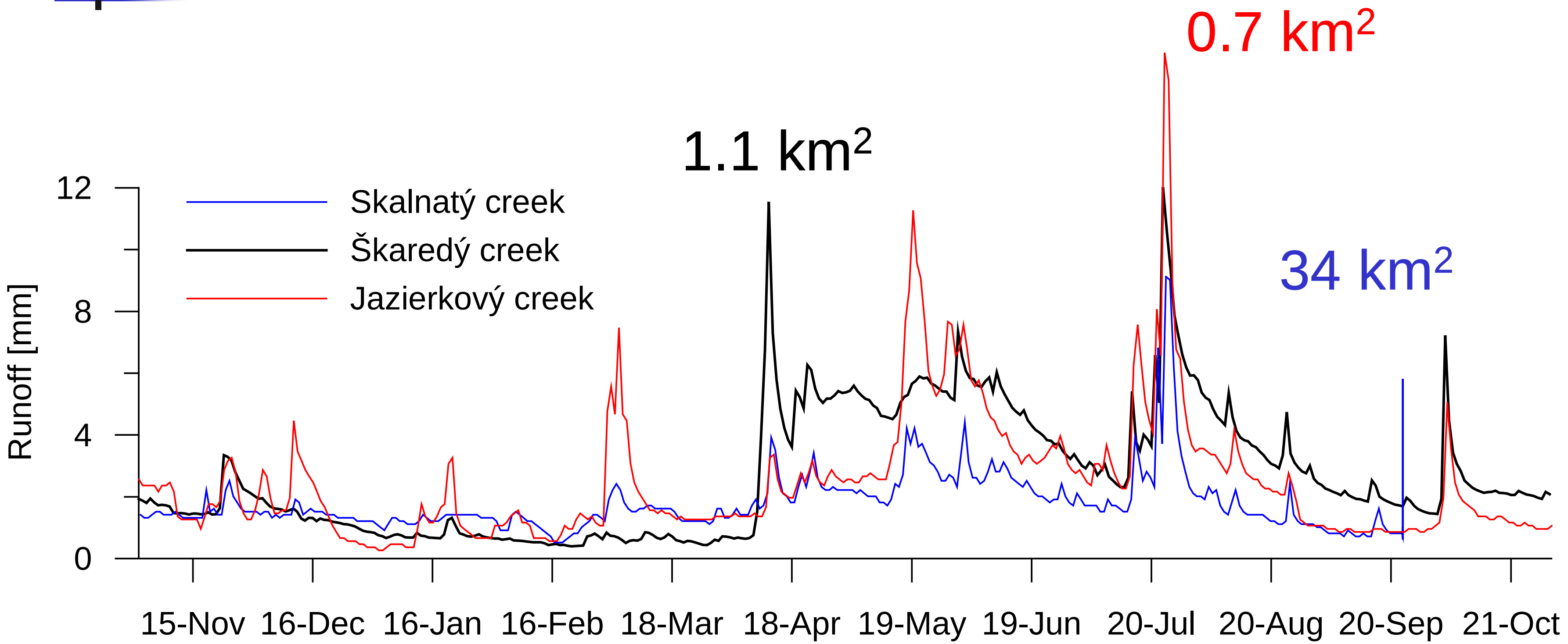
Comparison of discharges in the nested catchments (2008)



Comparison of discharges in the nested catchments (2008)

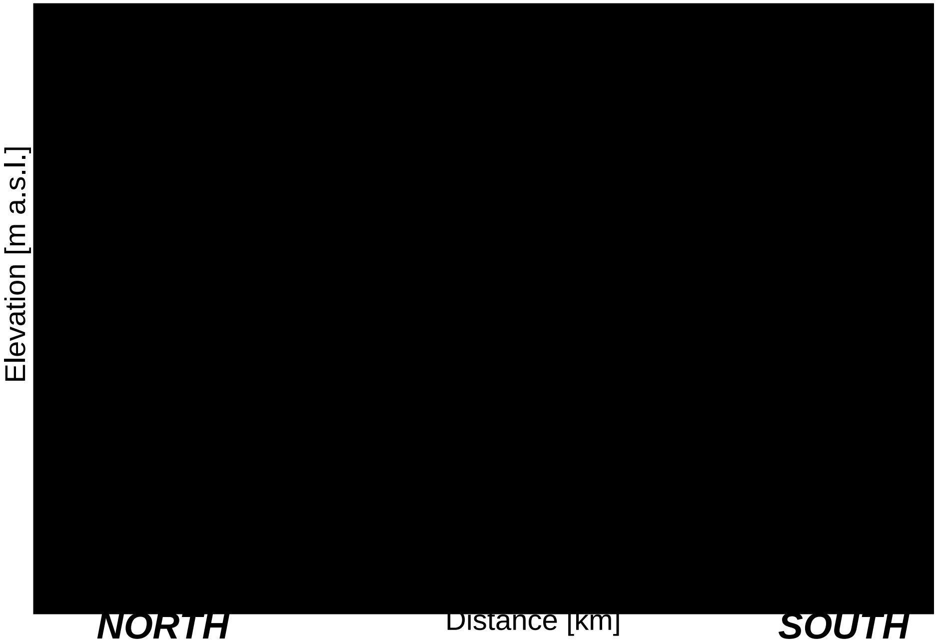


Comparison of discharges in the nested catchments (2008)



Complicating Factors

Elevation & annual P

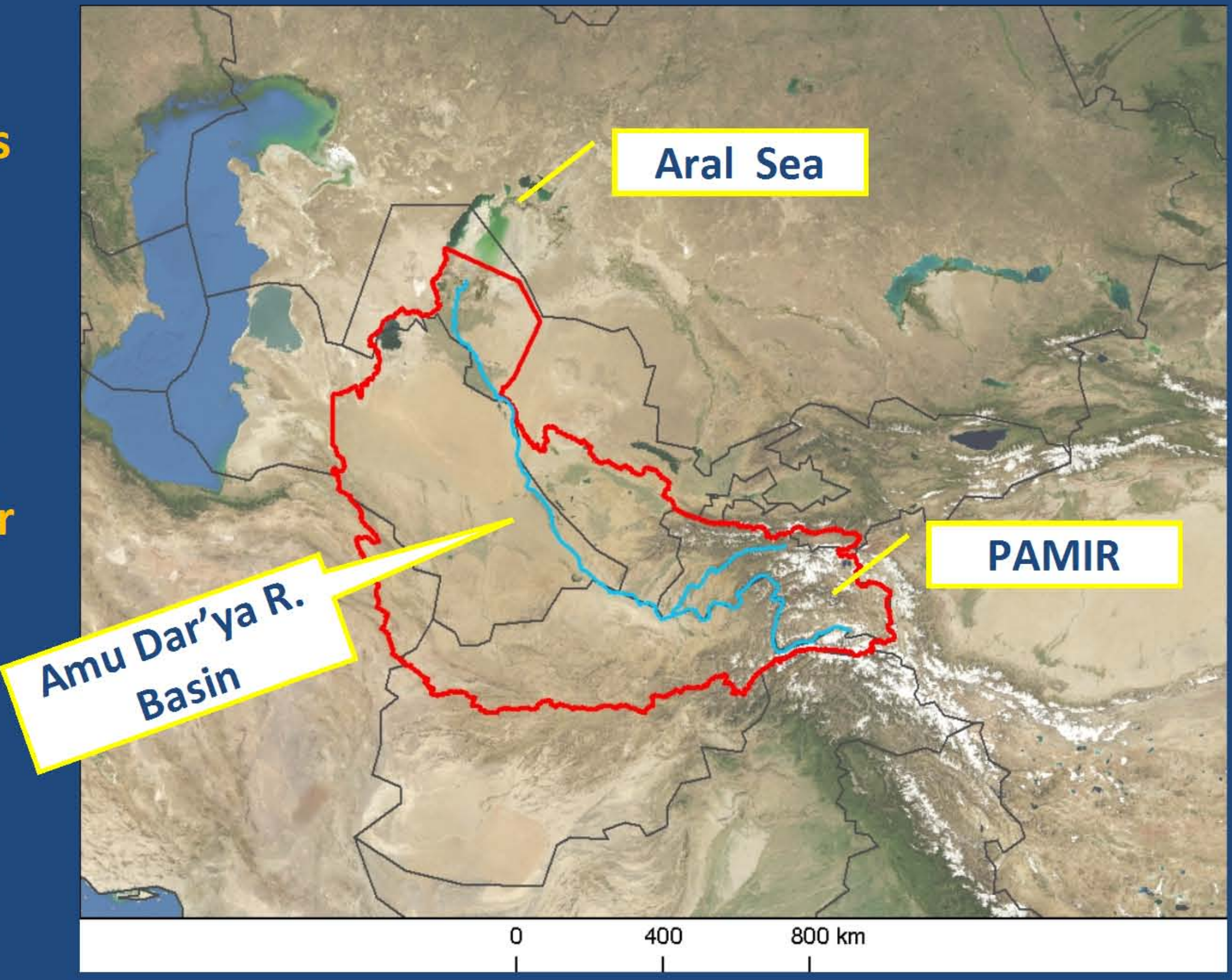


Variability in surficial geology (moraine deposits)

Molnár and Pacl, 1988

Diagnosis of changes in alpine water storages and land surface degradation in Pamir mountains and Amu Dar'ya River basin

The goal of this project is to simulate and predict the dynamics and feedbacks of a half-century of changes in seasonal snow/ glaciers/ water resources and their effects on land degradation in the Amu Dar'ya River basin.



Objectives for the 2nd year

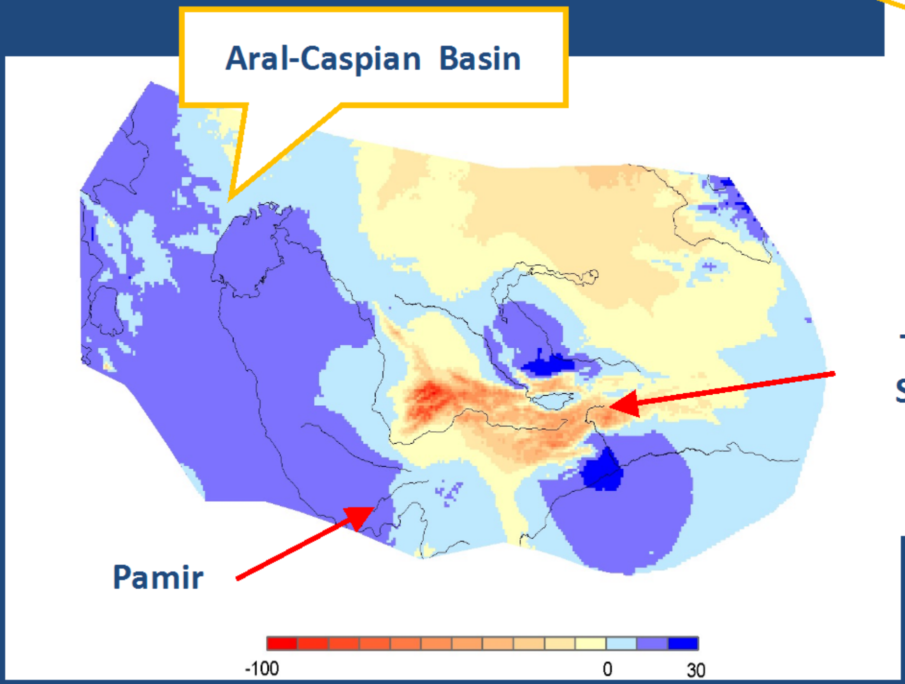
Evaluate changes in

- Climate
- Seasonal snow cover
- Glacier's area and volume
- Snow/glacier runoff
- Effect of changing water resources on irrigated lands

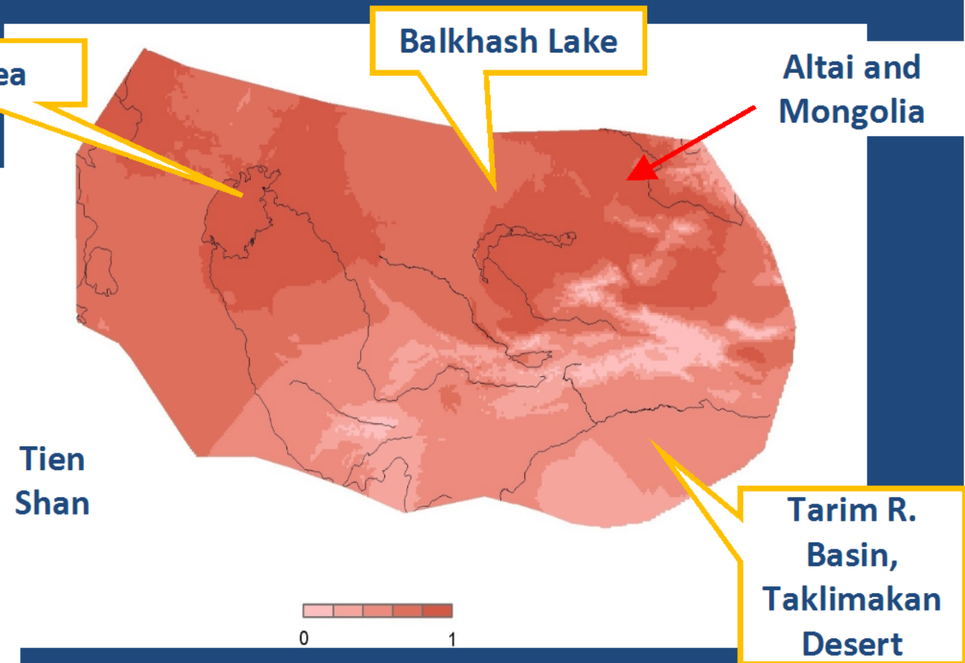
in Amu Dar'ya River basin in the last 30 to 100 years

Climate Change

Over 60 years observational data analysis from 250 stations of central Asia (Kazakhstan, Turkmenistan, Kyrgyzstan, Uzbekistan, Tajikistan, Xinjiang , Mongolia)



Differences in 30-year averages of annual precipitation (dP_{an}= $aveP_{an1973-2008}$ – $aveP_{an1942-1972}$) .

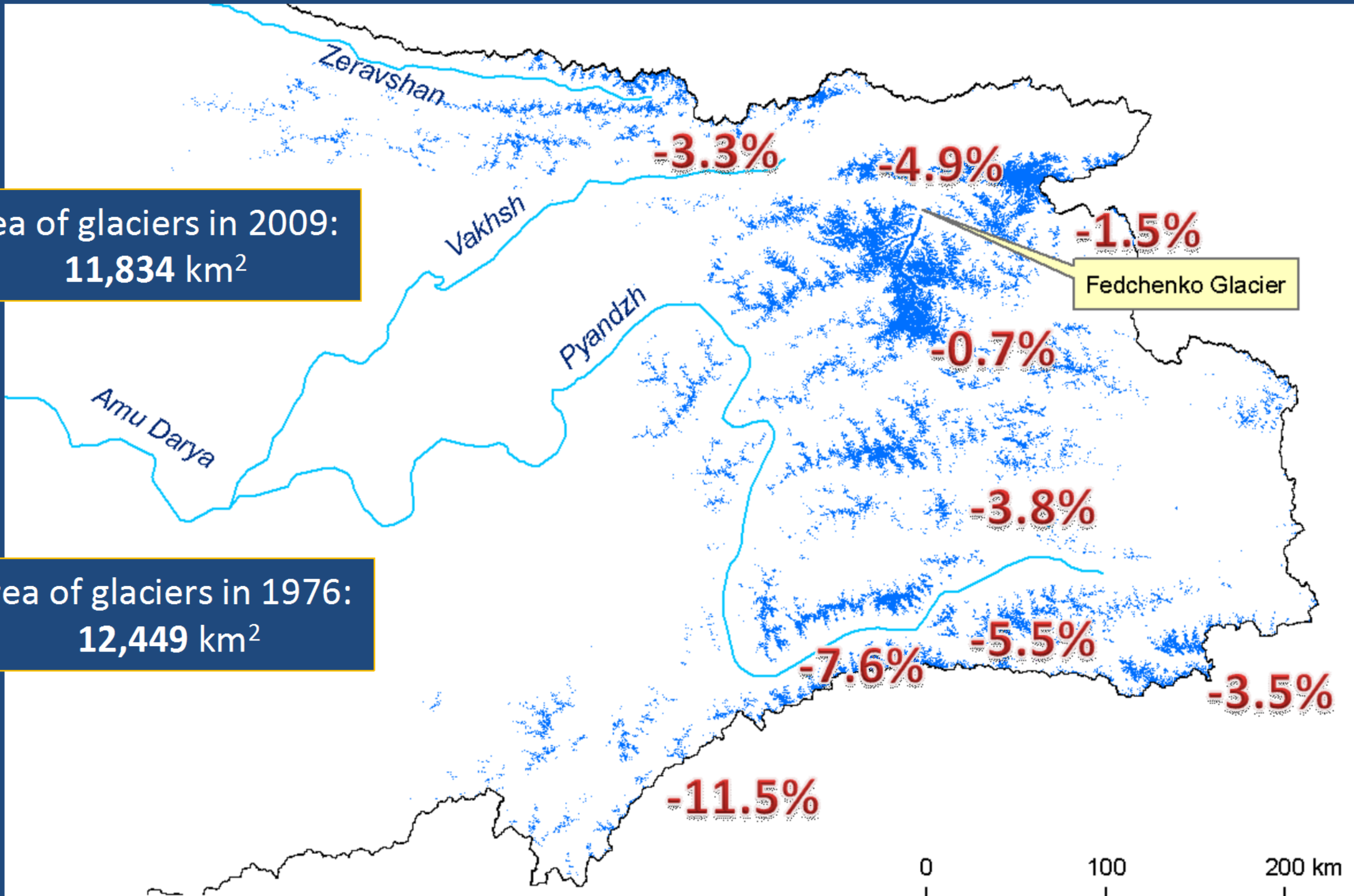


Differences in 30-year averages of annual mean air temperatures (dT_{an} = $aveT_{an1973-1942}$ – $aveT_{an1942-2008}$)

Glacier area loss in Amu Dar'ya R. basin

area of glaciers in 2009:
11,834 km^2

area of glaciers in 1976:
12,449 km^2



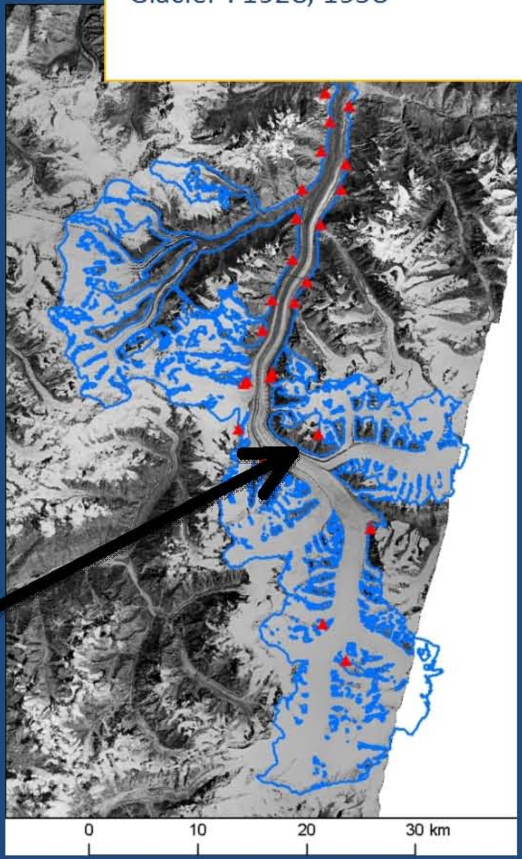
2009 GPS field work on Fedchenko glacier

Fedchenko Glacier representative for the Pamir glacier thickness and ice volume change measurements

GPS survey of:

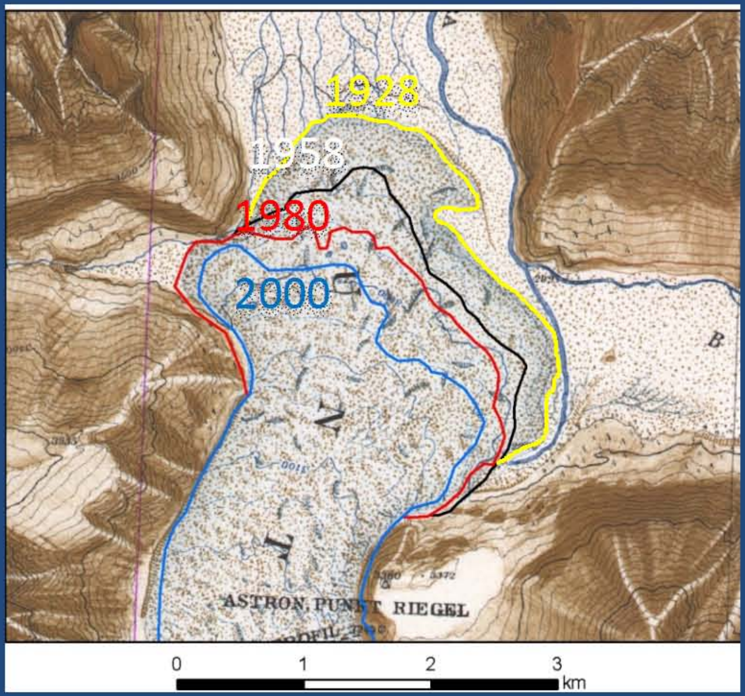
- benchmarks established in 1928 and 1958
- 23 km of surface profiles at elevations 3800-5200m
- Surface velocity and glacier thickness measurements

Bench marks on the Fedchenko Glacier : 1928, 1958

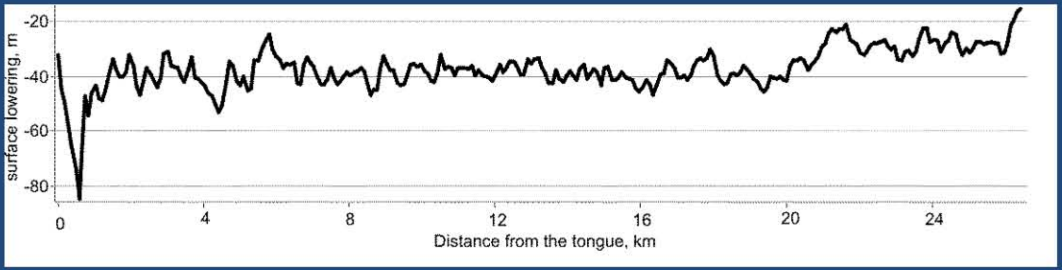


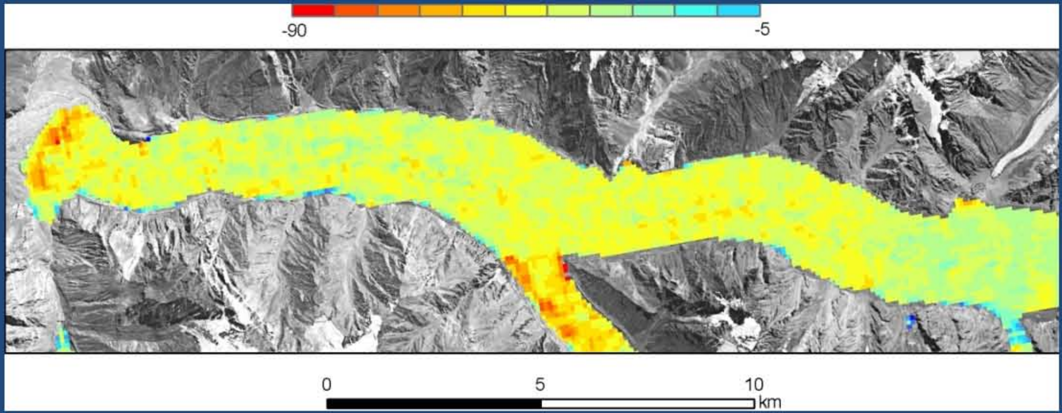
Fedchenko glacier changes 1928-2009

Termini retreat
(map by Finsterwalder 1928)



Surface lowering





From 1928 to 2000 the termini retreat was 1.1 km.

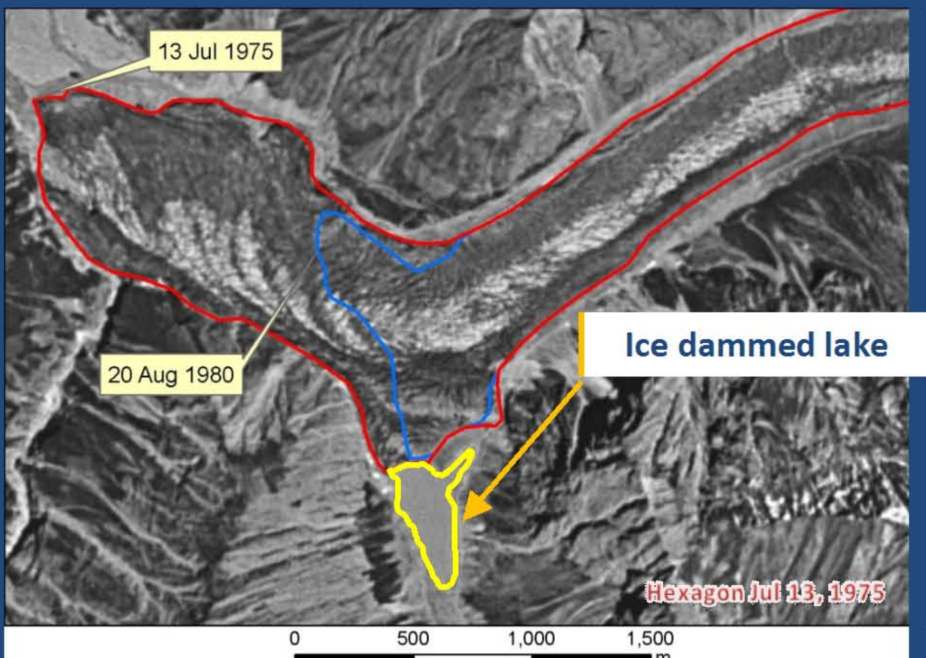
From 1958 to 2009 the termini retreat was 755 m, area loss was only 2 km^2 (total area 714 km^2)

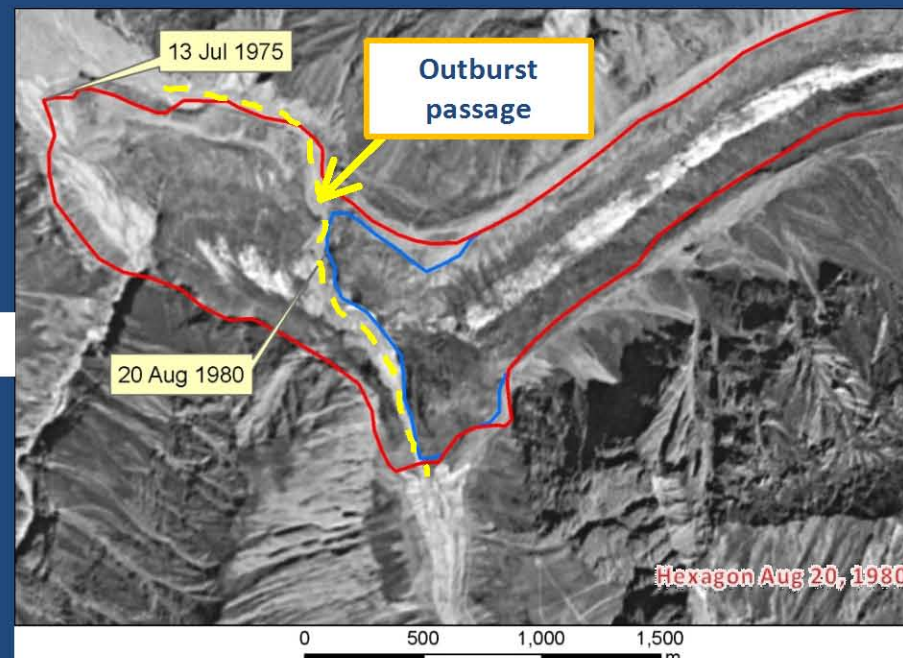
The surface melted much faster and lowered up to 90 m on the glacier tongue area at 2,896 m a.s.l. and 40 m at elevation of 4,000 m.

Pamir surging glaciers

There are 215 glaciers with unstable dynamics, 51 surging glaciers

Medvezhiy glacier surge in 1974 (west from Fedchenko)





Other documented surges were in 1963, 1988 and 2001

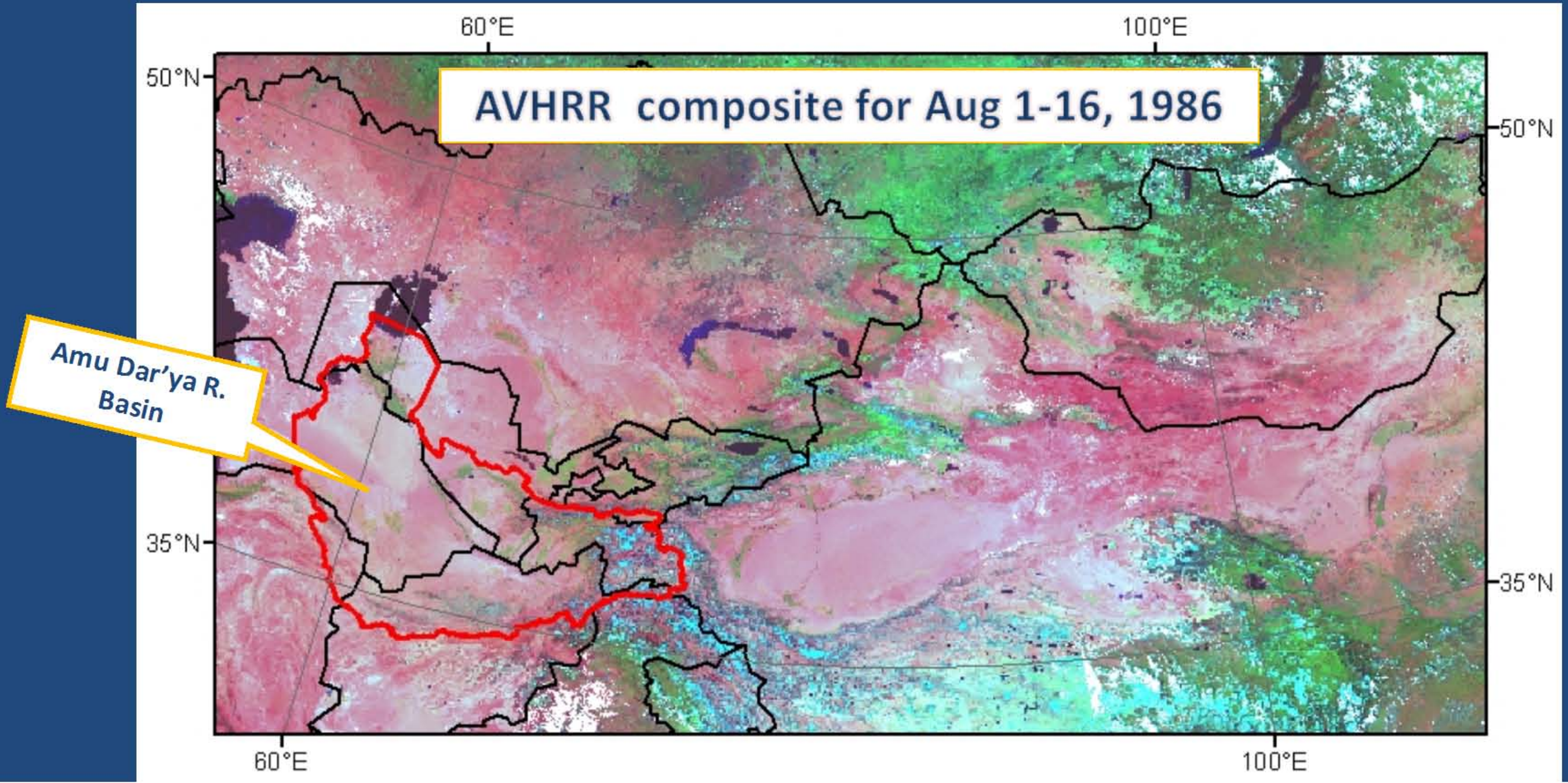
Climate change increase instability of glacier systems and increase number of catastrophic lake outbursts

New 1980-2009 AVHRR , 1km/16-day product for central Asia

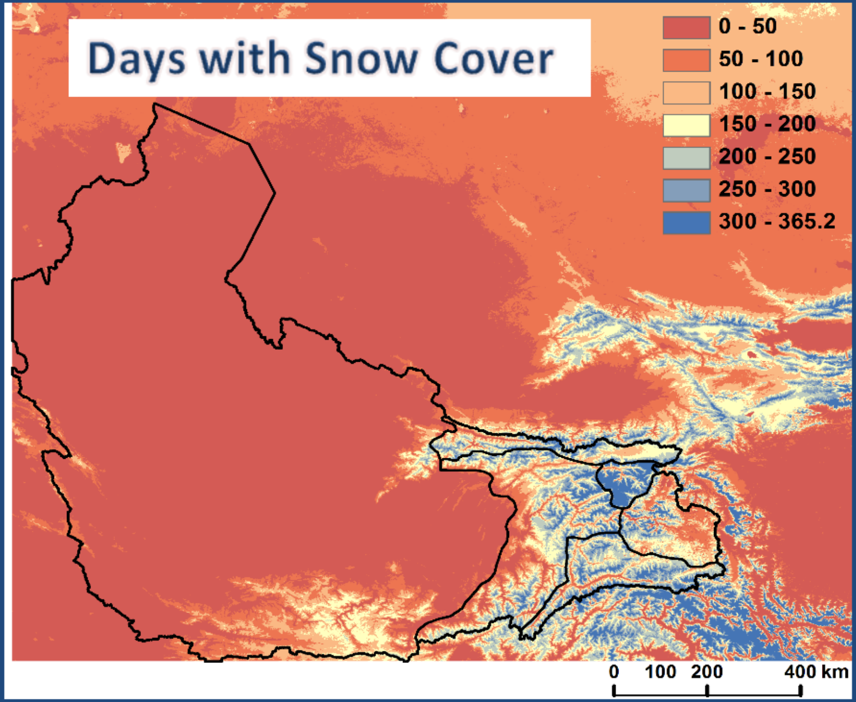
The baseline SAPS (*Latifovic et al.,* 2005) output:

- TOA VIS and NIR reflectance,
- TOA band4 and band5 temperature brightness,
- mask of cloud, clear sky, cloud shadow, snow/ice

→ Snow cover product
NDVI product

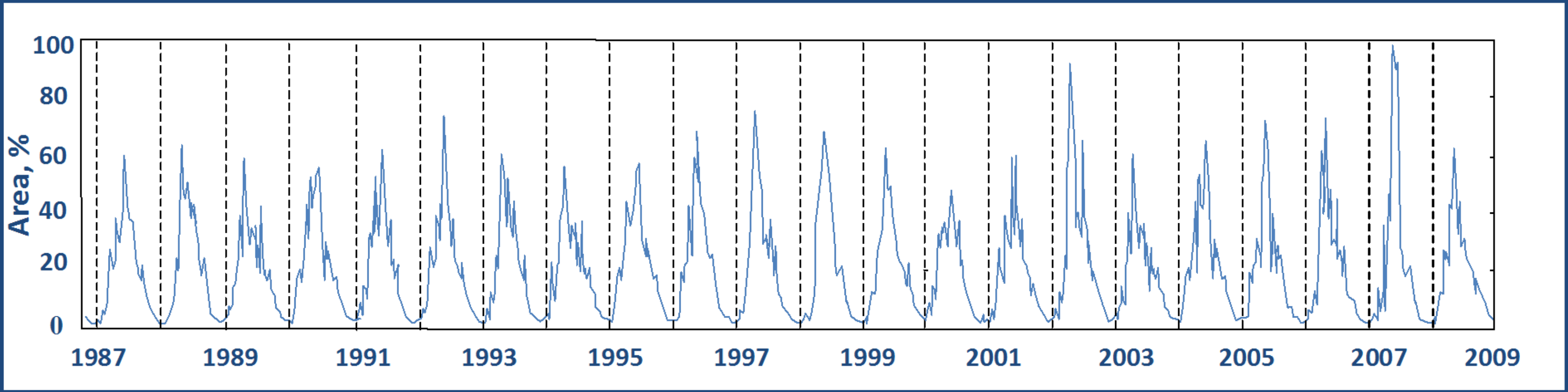


Snow Cover (AVHRR and MODIS) 1987-2009



- Snow cover appearance 9 days later at the end of November and disappearance 14 days later at the end of May at elevations over 3000 m
- Significant positive trend 1.4% yr in snow cover extend has revealed only in the last 10 years.

Annual snow covered area variability in Amu Dar'ya River basin 1 km 8 days resolution validated by surface observational snow data (1986-1991) from NSDC).

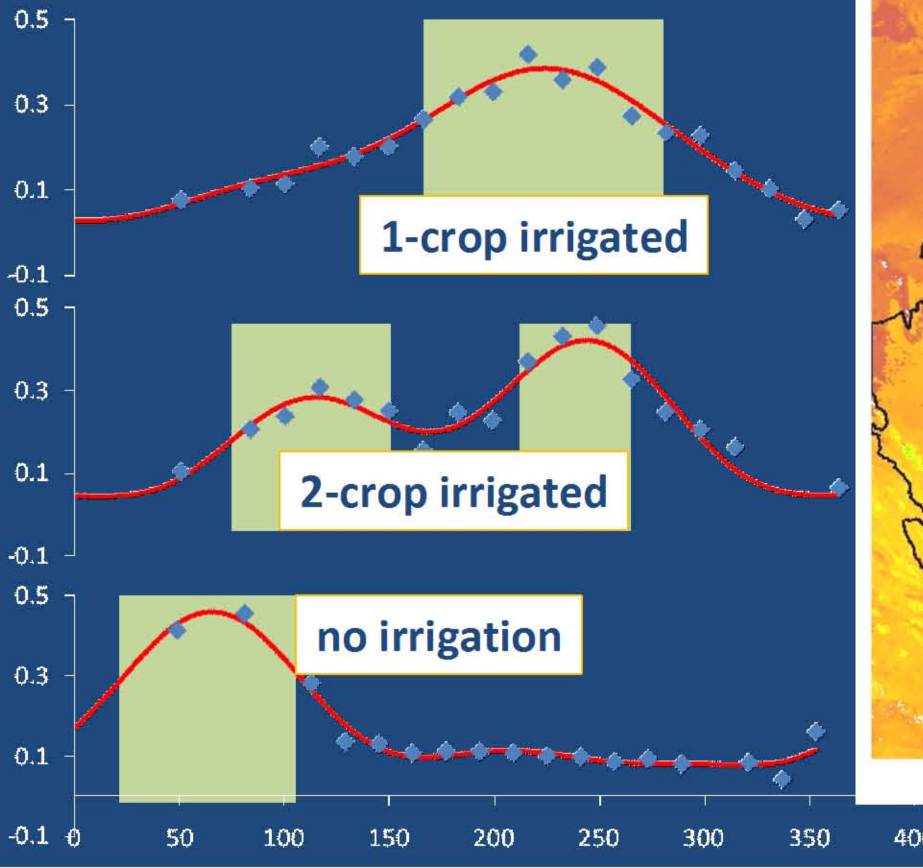


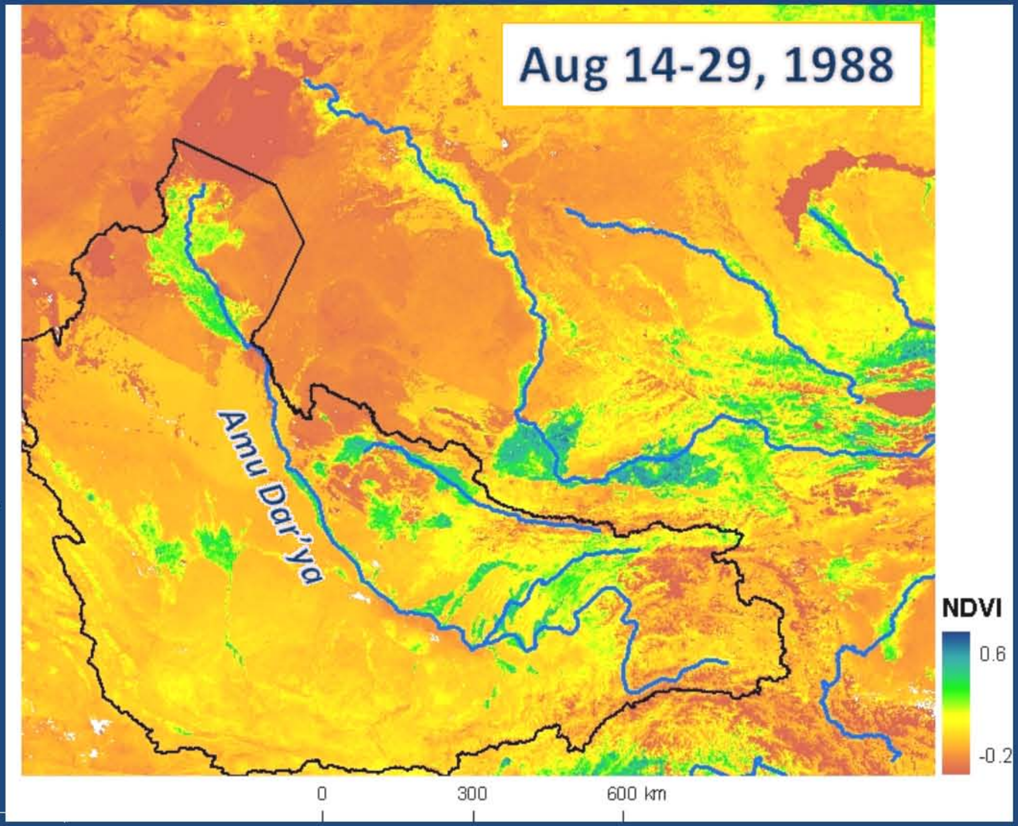
Irrigated lands in Amu Dar'ya R. Basin

Q: Climate -> Water Resources -> Irrigation

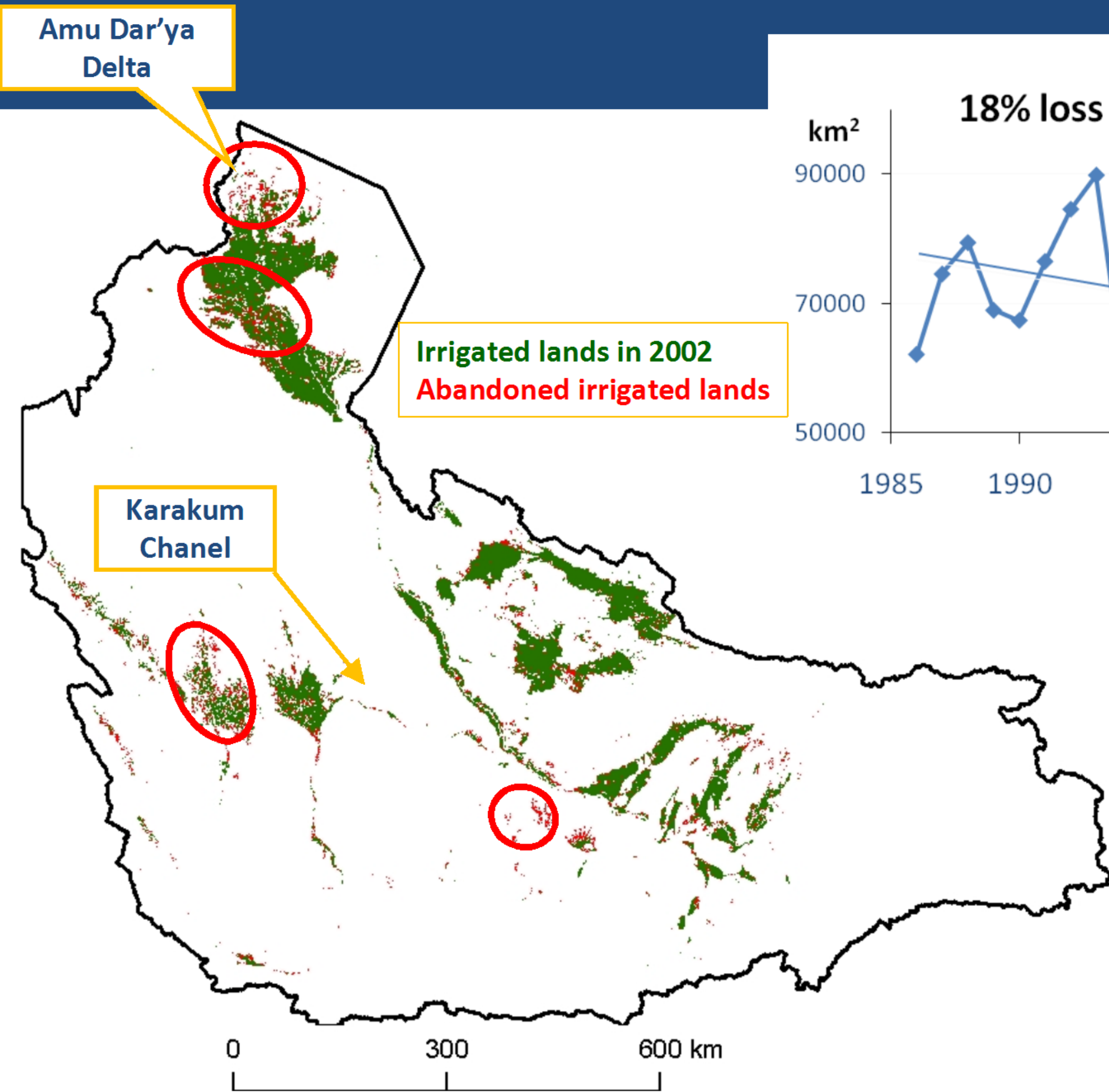
Approach: Land Surface Phenology to estimate area/intensity of irrigation

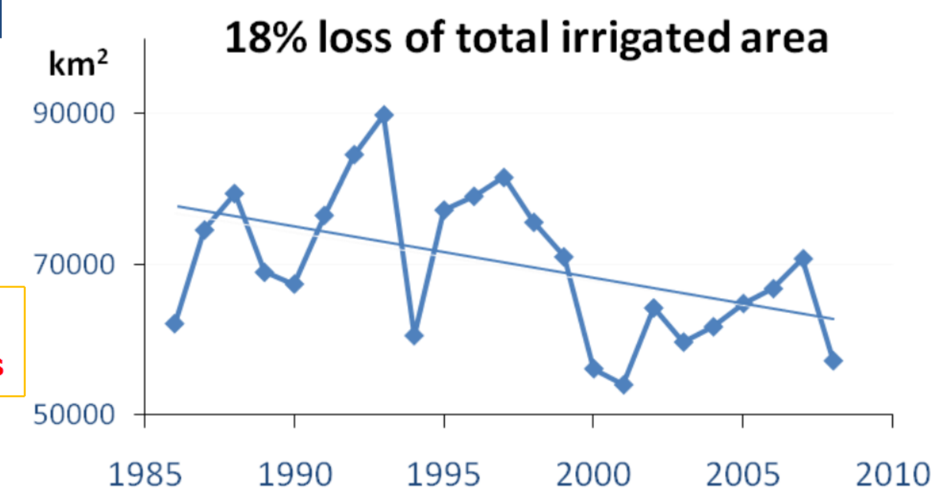
1 km/16-day NDVI -> FFT gap filling (HANTS) -> date(s) of NDVI peak(s) -> 1 or 2 crops irrigated area





Loss of Irrigated lands 1986-2008

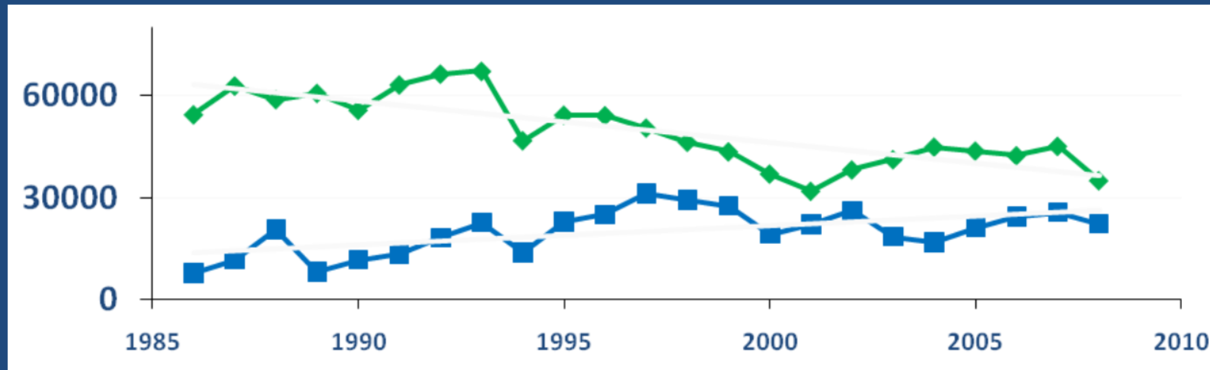


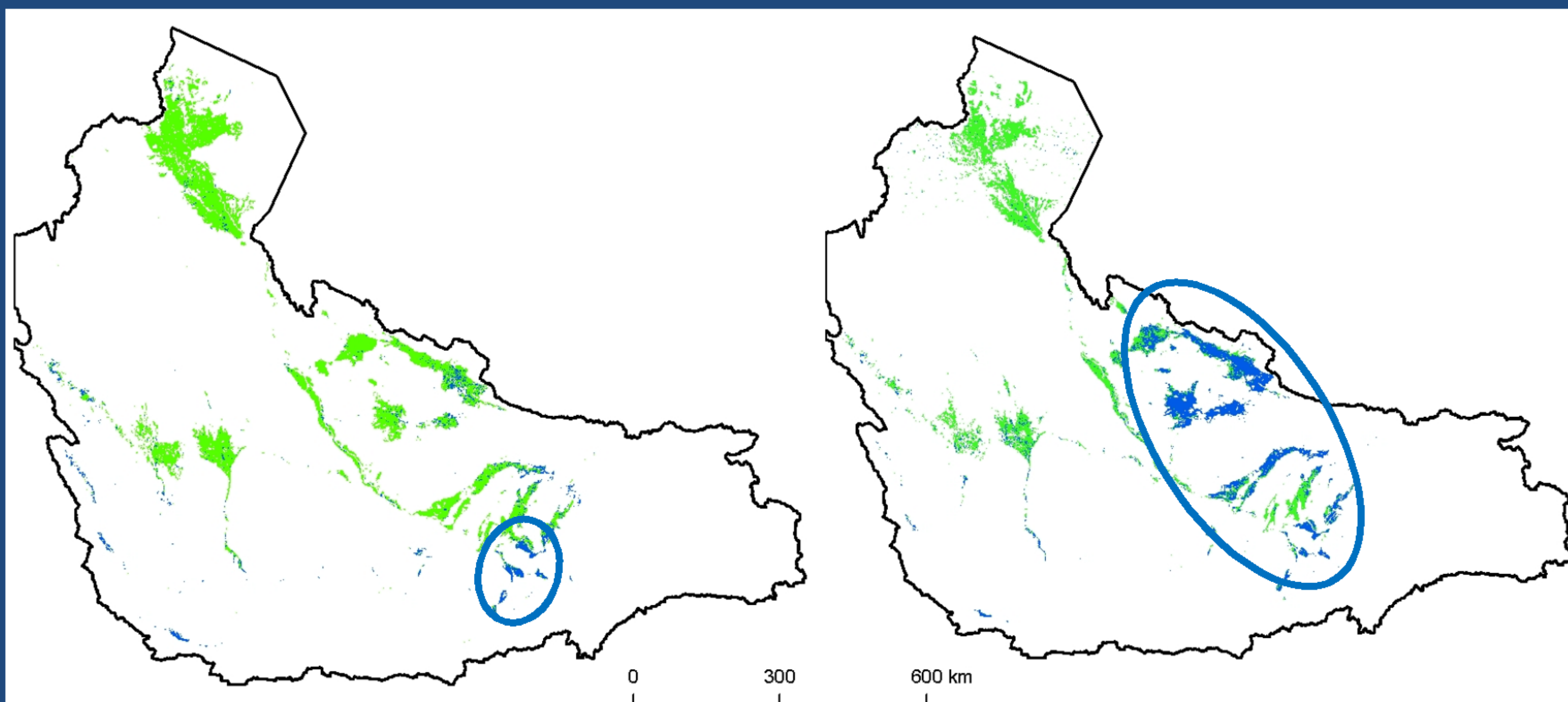


Strong intra-annual variations due to droughts and available water for irrigation

Long term ? trend due to land degradation

Switch from 1 crop to 2 crops per year





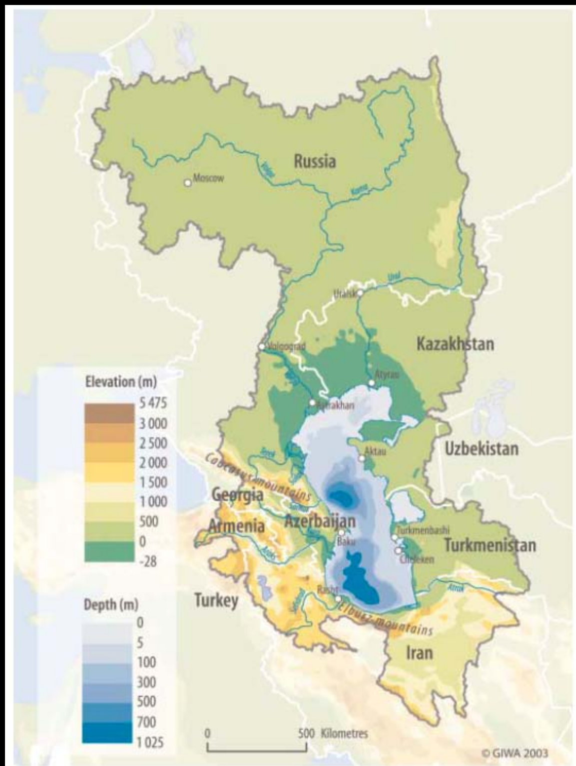
Significant increase in irrigation intensity at mountain foothills where water is abundant

Towards an Integrative and Sustainable Science Program for Caspian Sea Environment

Sassan S. Saatchi
Senior Scientist
UCLA/Institute of Environment
NASA/JPL
California Institute of Technology

Collaborators:
Qiang Fu, UCLA/Geography Dept. (PhD Student)
Ali Nouri, UCLA/Institute of Environment (Postdoc)
Soleiman Mohamadi, Gilan University, Iran
Dara Entekhabi, MIT
Babak Hedjazi, University of Geneva

Caspian Sea Environment



The Caspian Sea basin is rich with diverse aquatic, avian and terrestrial wildlife, and has a variety of ecosystems with unique and fragile **hydrological** and **ecological** characteristics.

1. Largest land-locked body of water on earth
2. Caspian drainage basin is ~ 3.5 Million km2 (world’s largest watershed, and annual runoff) with 130 rivers flowing into the sea with Volga contributes 80% of runoff.
3. Being a closed body and large basin, the system can filter high frequency water budget and is a good indicator of interdecadal and long term climate change
4. Being a closed system hydrological and biogeochemical processes are intimately linked (water, energy, resources) Any changes in land impacts the hydrology and ecosystem & vise versa.
5. The basin is diverse in ecosystems, natural habitats, large river systems, major wetlands with high level species endemism and diversity.
6. Caspian has drastic sea level change due to climate and hydrological processes.

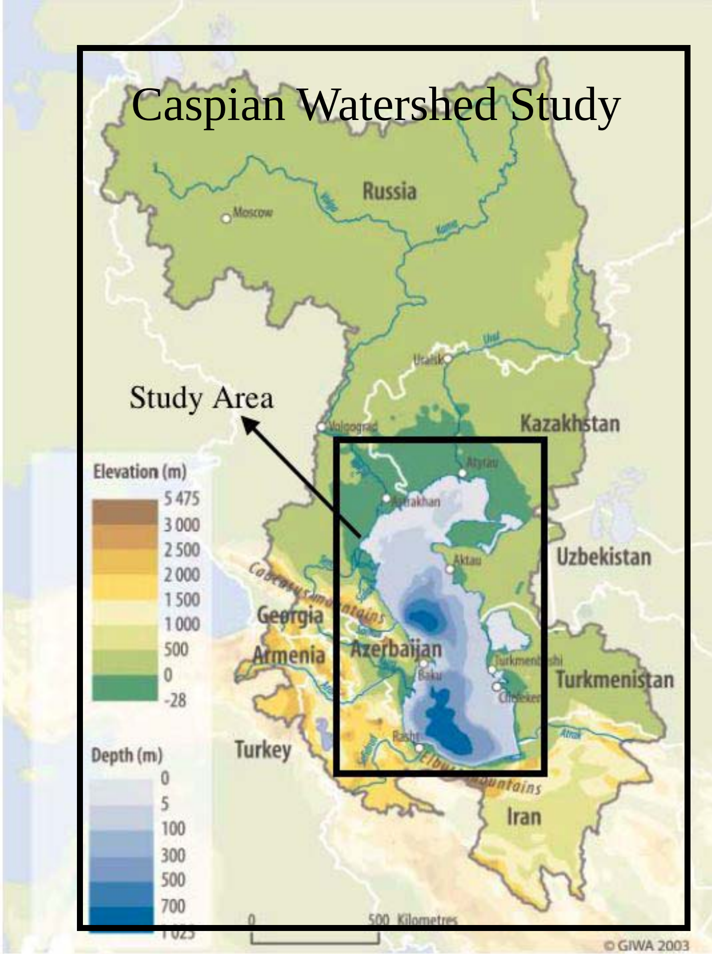
Caspian Sea Environment
Proposal Objectives

Fundamental Questions:

1. How does Caspian Sea Function as an entity (e.g. hydrological & Ecological system)?
2. To what extent human developments (past, present, future) impacts the environment?
3. What is the interaction of Caspian Sea Region with regional and global Climate?

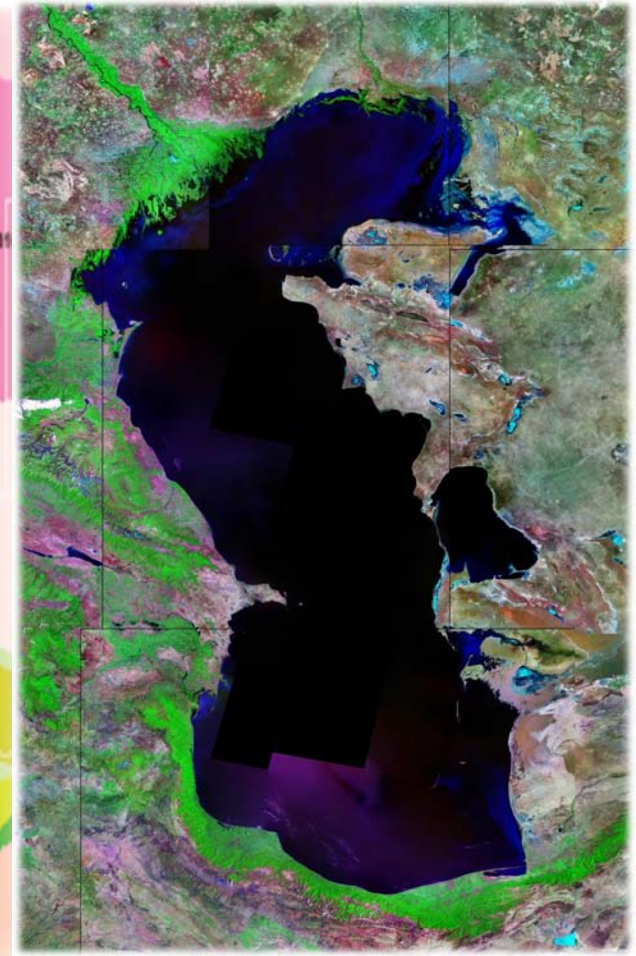
Specific Science Questions:

1. What is the impact of human induced changes of land, sea and coast on Caspian Hydrological and Ecosystem Function?
2. How does regional and global climate change and variability impact the Caspian ecosystem?
3. How can regional development be sustained along with the Caspian conservation of resources and nature?



Study Area

Caspian Ecosystems



Landsat ETM circa 2000

Caucasus mixed forests

Caspian Hyrcanian forests

Pontic steppe

Azerbaijan shrub steppe

Central Asian northern desert

Central Asian southern desert

Phase I

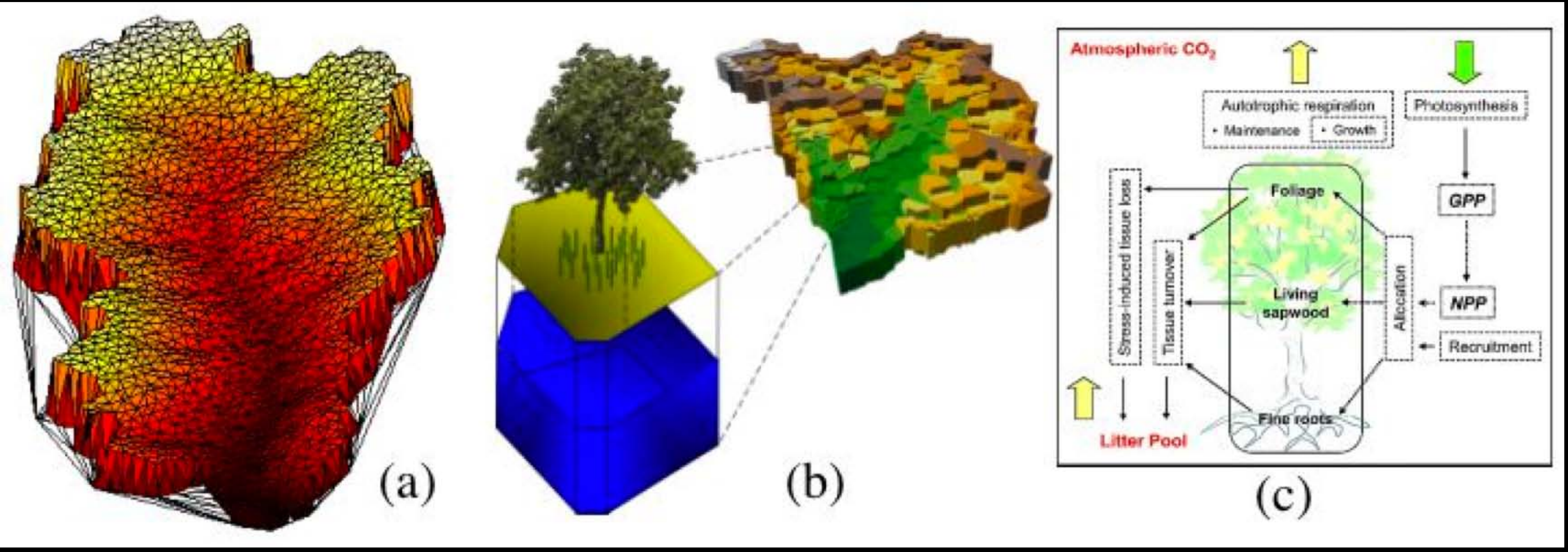
Assessment of impacts of land cover
Land use change on Caspian Sea
Watershed hydrology

integrated remote-sensing and modeling system & training

1. watershed and water resource health,
2. spatial and temporal variability in regional water fluxes
3. potential change in groundwater recharge/resources,
4. potential change in evaporative flux
5. potential change in surface water runoff (retention basin loss),
6. potential impact of increased urbanization
7. Identify gaps in potential data and information requirements
8. Identify stakeholders and human factors through a series of metrics

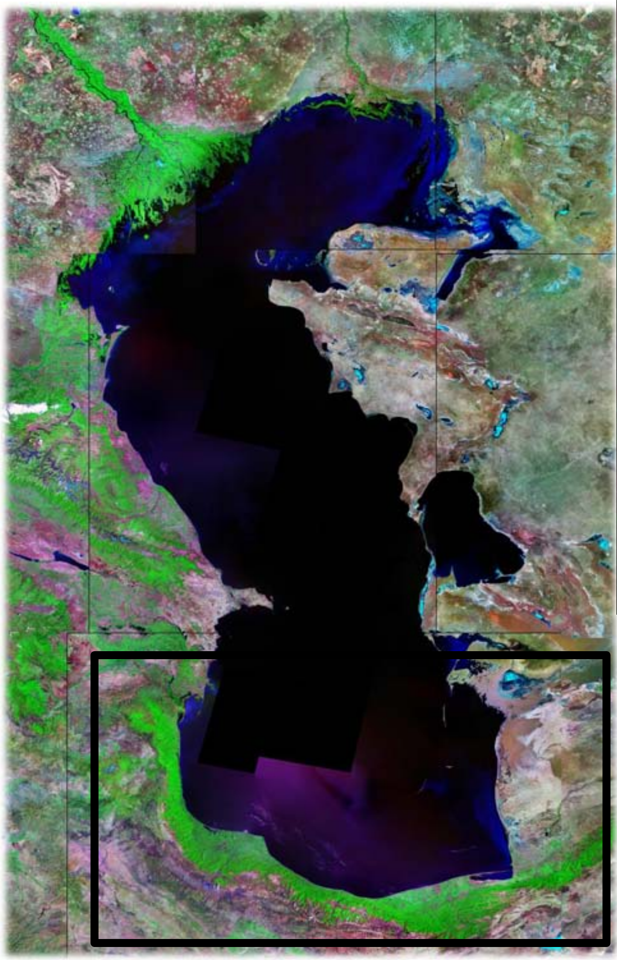
Phase II
Simulations of Caspian Hydrology

Use of geographically distributed model to model the closed basin hydrology to capture linkages and possible feedbacks between land hydrology, synoptic atmospheric circulations, and physical and biological limnology of the Caspian Sea and its watershed.

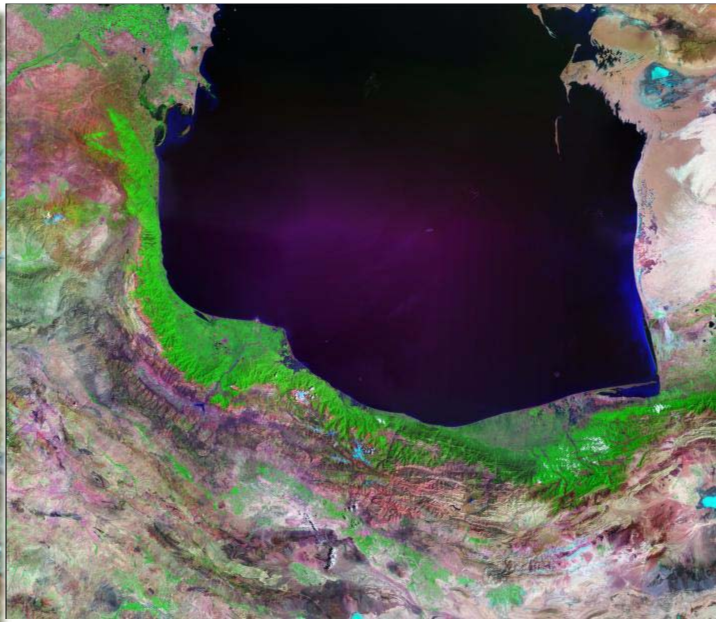


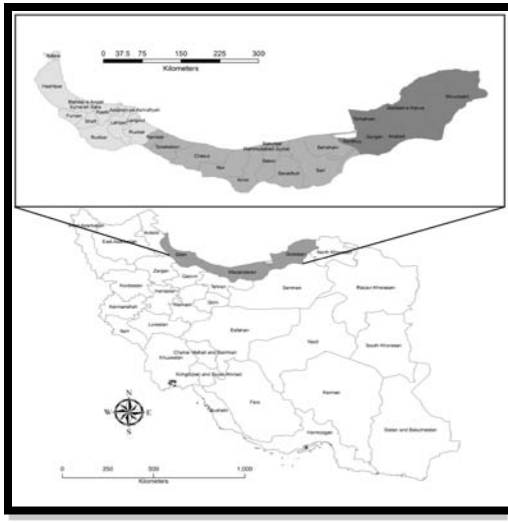
The over schematic of the tRIBS-VEGGIE architecture: a) Example of a TIN representation of topography within the distributed (spatial) watershed model, b) an unstructured grid cell representation of the model with water, energy and biospheric processes, and c) A conceptual diagram of carbon fluxes simulated by the model (Ivanov et al., 2008a).

LAND USE AND LAND COVER CLASSIFICATION AND CHANGE DETECTION OF THE CASPIAN SEA BASIN



Landsat ETM circa 2000



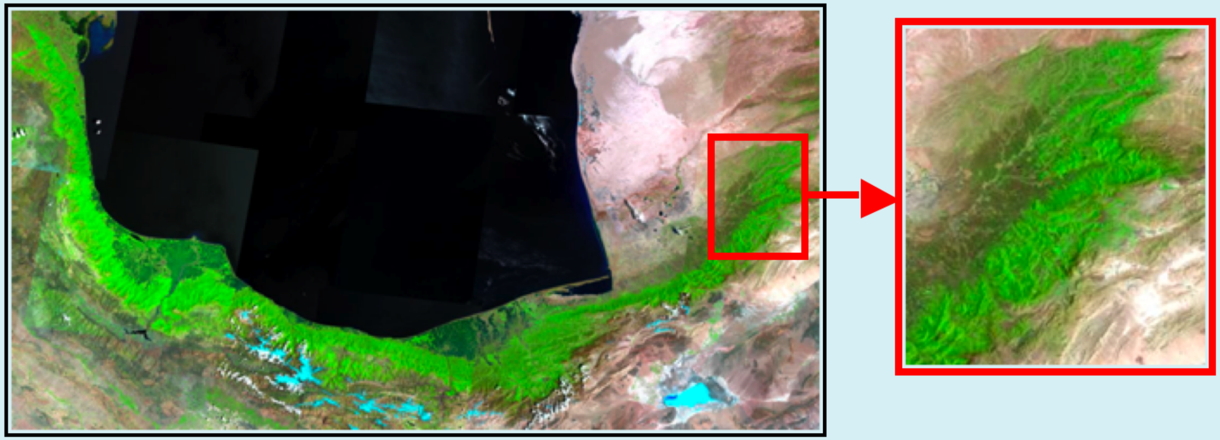


The forests of southern Caspian region in Iran is considered the remnants of Hyrcanian vegetation zone within the Euro-Siberian region and is considered the largest forest patch within the Caspian Sea basin.

The vegetation zone is a green belt stretching over the northern slopes of Alborz Mountains stretching from southern Turkmenistan from the east to southern Azerbaijan in the west

Changes of Forest Cover Observed by Landsat

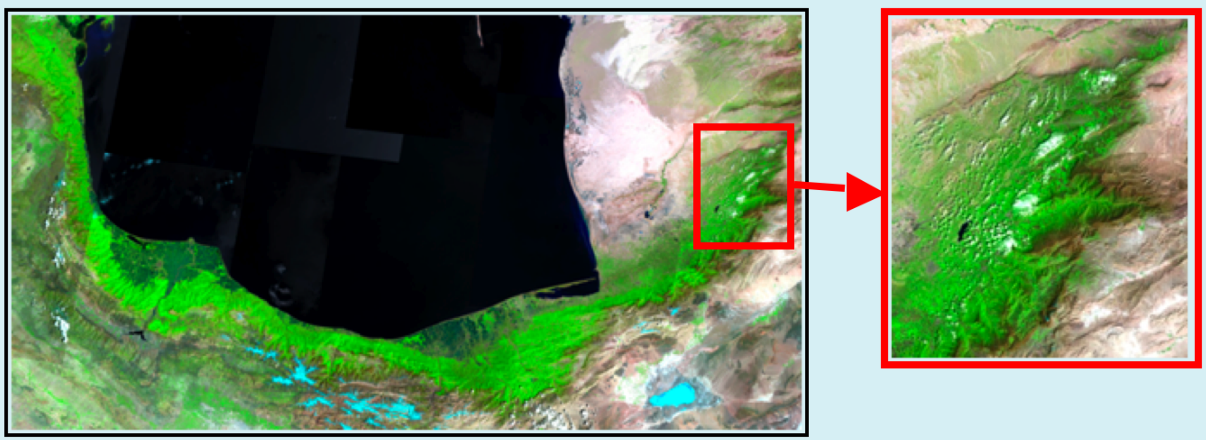
Caspian Sea Forest Belt in the 1990s (LandSat TM, band 543)



- Caspian forest in 1963 was 3,420,487 ha. In 1980, total area reduced to 1,900,000 ha,

Current estimate is 1,,800,000

Caspian Sea Forest Belt in the 2000s (LandSat ETM $^{+}$, band 543)



- 975,000 cubic meters of forests of Gilan are burnt every year.

- Average biomass reduction from 300 tons/ha to 100

Summary

- Deforestation and land cover and land use change are extensive in particular in southern Caspian region with areas of forests being replaced by urban and agricultural land.

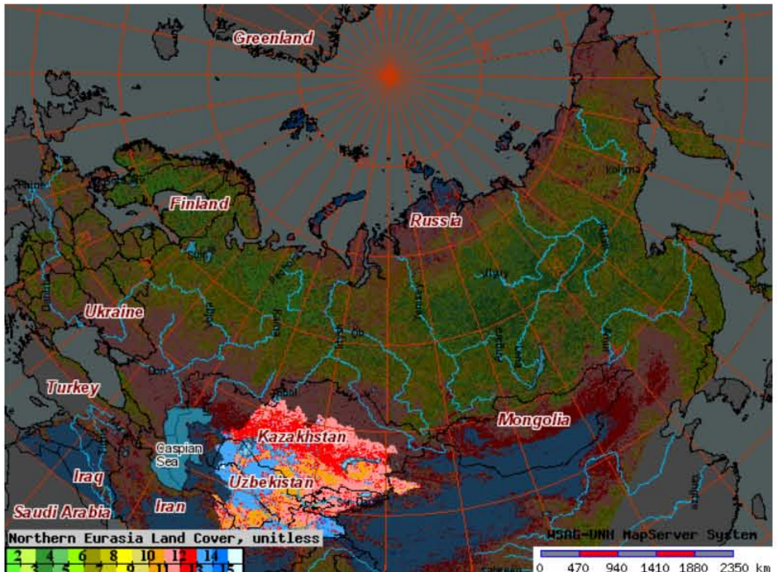
- We have processed MODIS data over about 10 years and analyzing it to quantify LCLUC over the entire Caspian Sea Basin from 2000-2010.

- Surface parameterization for spatial hydrological model has been completed. We are submitting our second phase proposal to develop the model and examine the impact of land use and climate over the basin.

UNH Water Systems Analysis Group NASA LCLUC projects

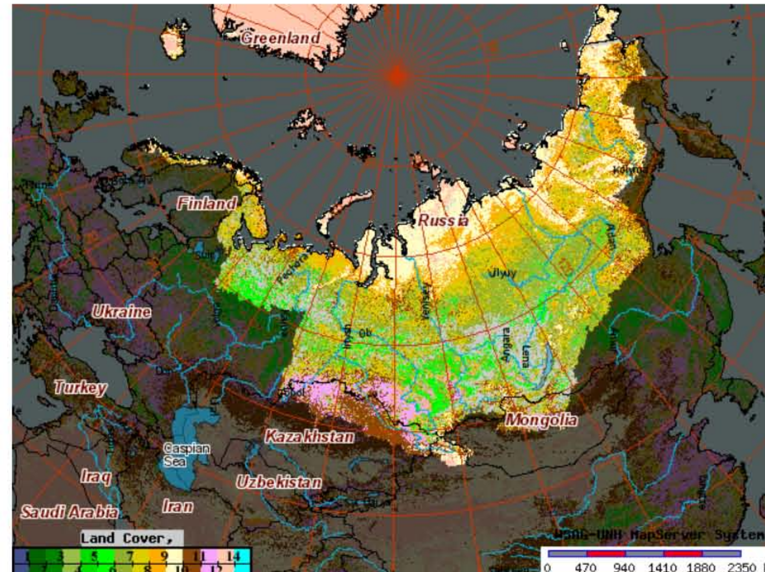
Contributions of changes in land use/land cover, water use, and climate to the hydrological cycle across the Central Asian States

Alexander I. Shiklomanov *et al.*



Role of land cover and land use change in hydrology of Eurasian pan-Arctic

Richard B. Lammers *et al.*

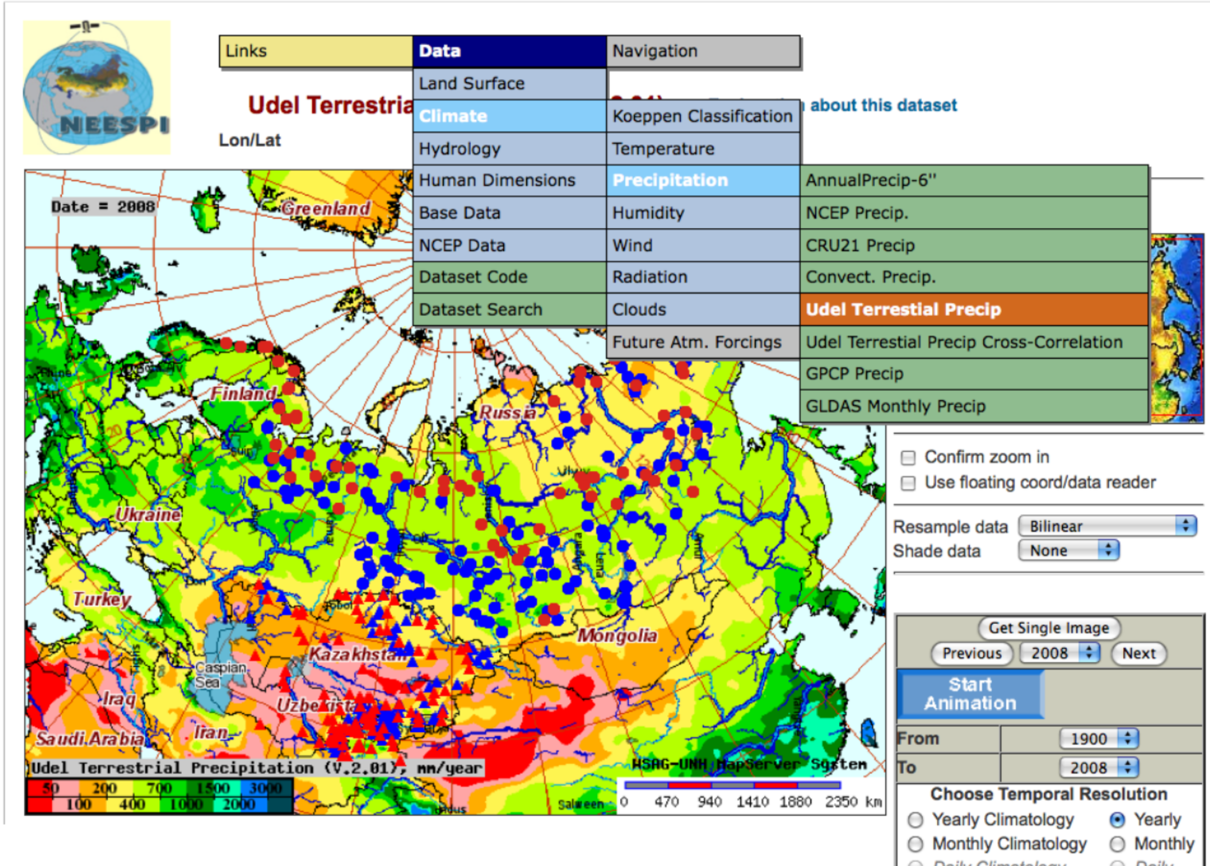


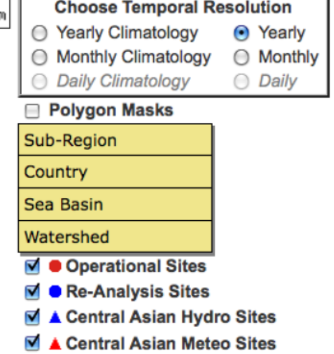
UNH DOMAINS IN NEESPI

Cross project themes

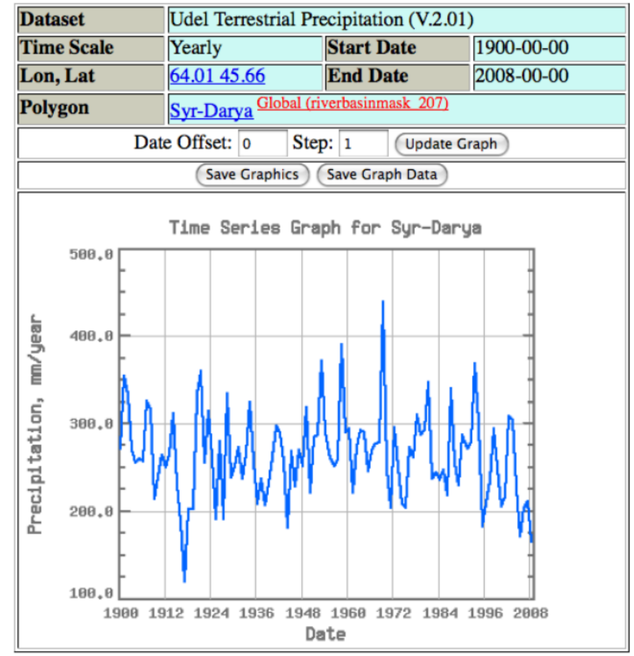
- Data consolidation and harmonization
- Analysis of water cycle components and impacts
- Future projections

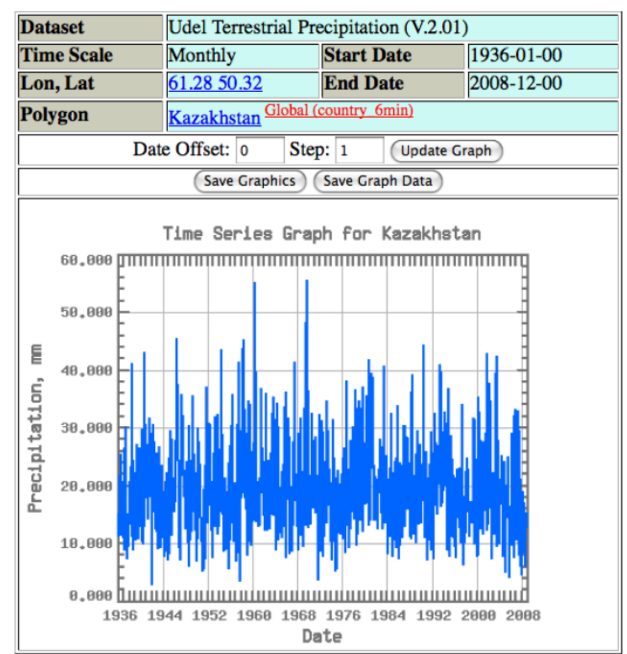
UNH NEESPI Website for Water System Studies





Examples of data interrogation





Primary components

Remote sensing data	Data visualization
Ground observations	Data analysis
Modeled data	New layer creation

Website unveiling May 2010. Now available by request.

Hydrological station data for Central Asia

▲ River monitoring
▲ Water use monitoring

An example of a new dataset on UNH NEESPI website

Distribution of river monitoring stations (with data) by country

Country	Number of stations: Monthly river discharge, м^3/s	Number of stations: Annual discharge , м^3/s	Number of stations: Water use
Kazakhstan	383	383	11
Kyrgystan	167	169	3
Tajikistan	128	128	4
Turkmenistan	24	25	6
Uzbekistan	133	133	10
Total	835	838	34

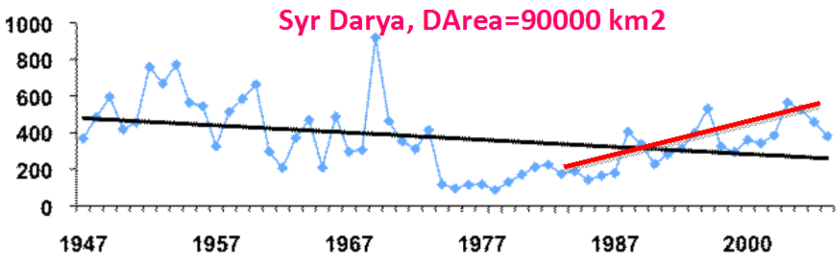
Length of hydrological records by country

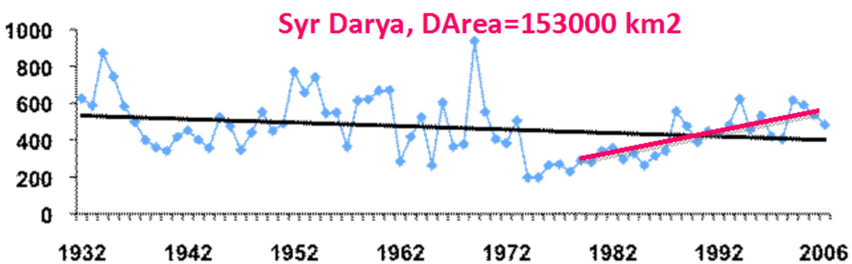
Country	Mean Monthly Discharge, m^3/s		Mean Annual Discharge, m^3/s		Water Use	
	First Year	Last Year	First Year	Last Year	First Year	Last Year
Kazakhstan	1930	2006	1930	2006	1981	2005
Kirgistan	1910	2006	1910	2006	1981	1990
Tadjikostan	1929	2008	1929	2008	1981	1990
Turkmenistan	1936	1985	1930	1991	1981	1990
Uzbekistan	1913	2006	1913	2006	1981	1990

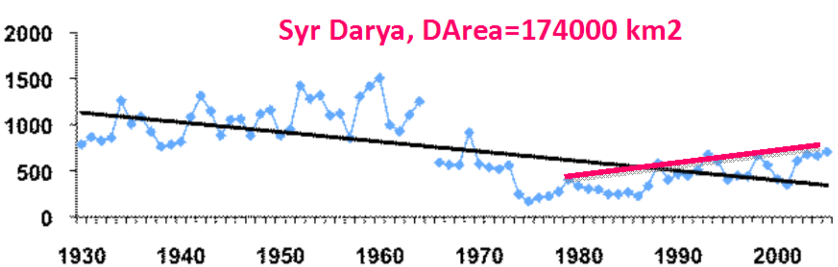
Website unveiling May 2010
Now available by request

Analysis of water cycle components and impacts – Syr Darya R.

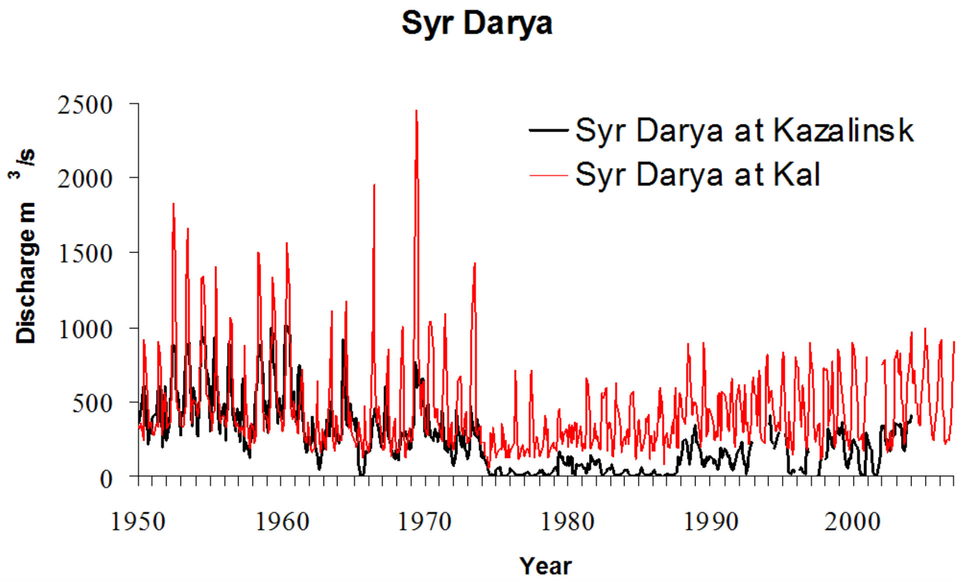
Annual discharge

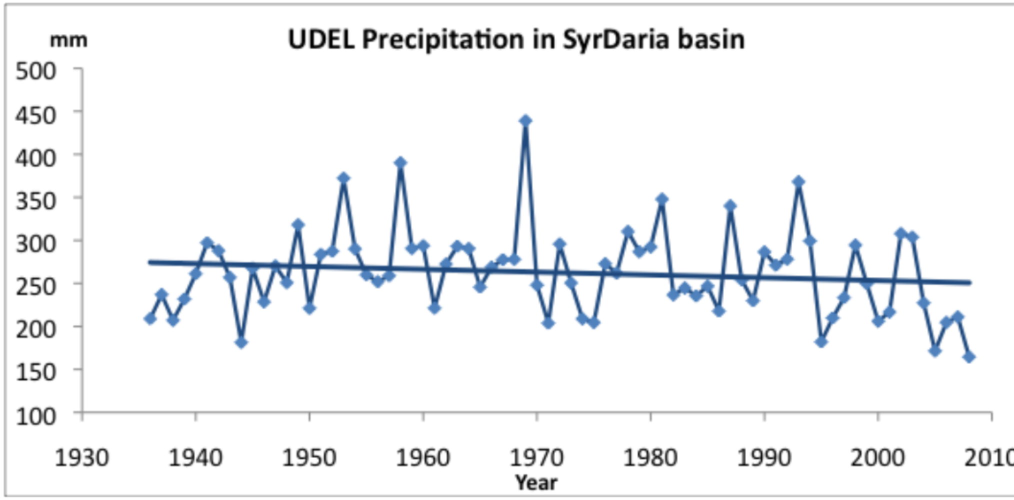






Monthly discharge





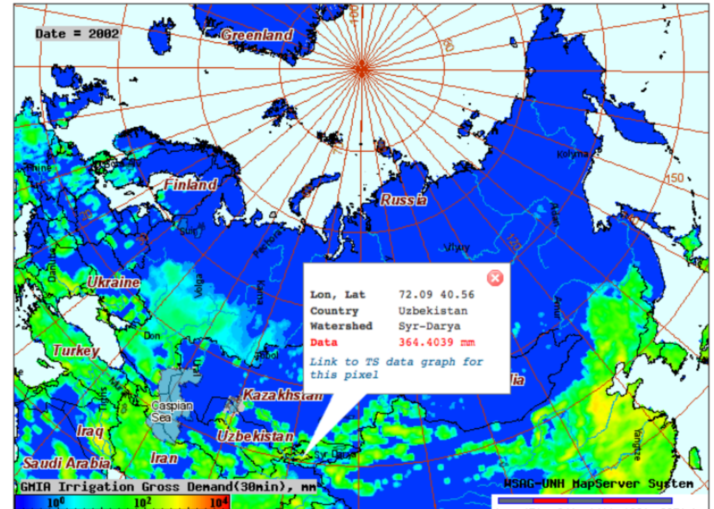
Recent Syr Darya R.: 1) increased glacier and snow field melt at high elevations discharge increases; 2) decline in human water use; and 3) increasing precipitation (but not all data sets show this)

Irrigation time-series analysis

UNH Gridded Irrigation Area time-series for Northern Eurasia using Global Irrigated Area Map (1-km resolution derived from remote sensing data) and historical census data from FAO.

Using UNH hydrological model (WBMplus) we evaluated annual water demand for irrigation over the long-term period

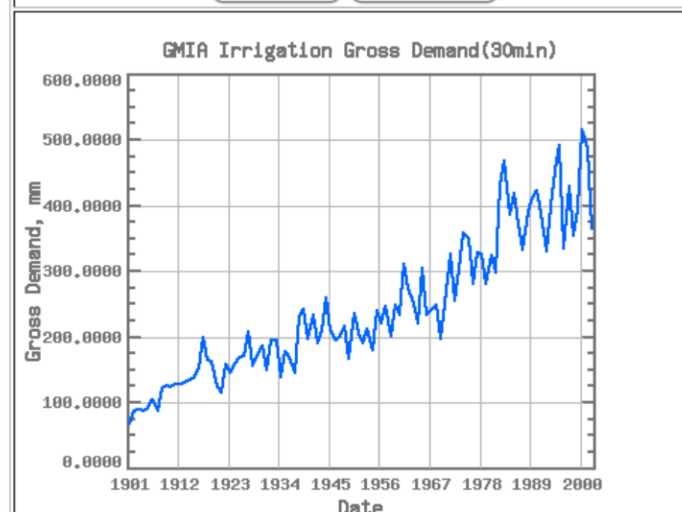
- Identify regions with ground water mining



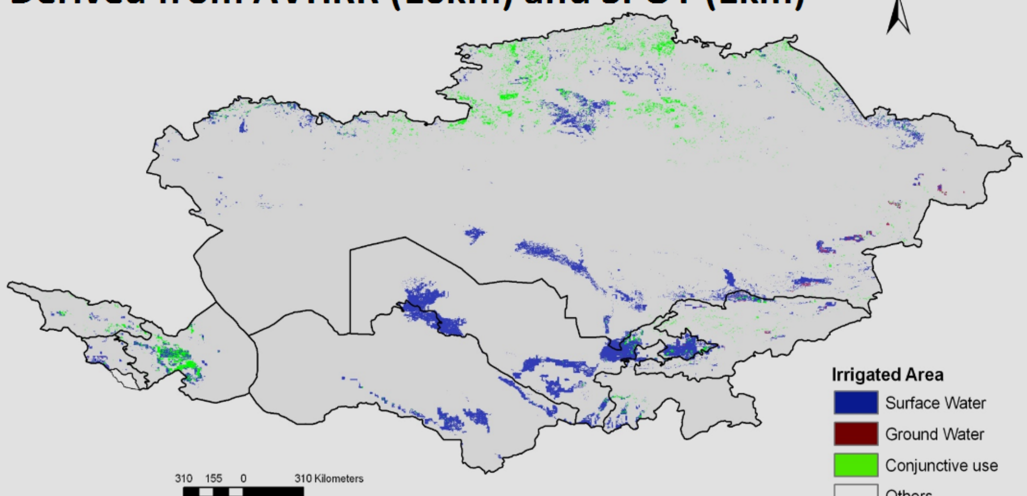
Dataset	GMIA Irrigation Gross Demand(30min)		
Time Scale	Yearly	Start Date	1901-00-00
Lon, Lat	72.10 40.56	End Date	2002-00-00
Polygons	Not Available		

Date Offset: 0 Step: 1 Update Graph

Save Graphics Save Graph Data

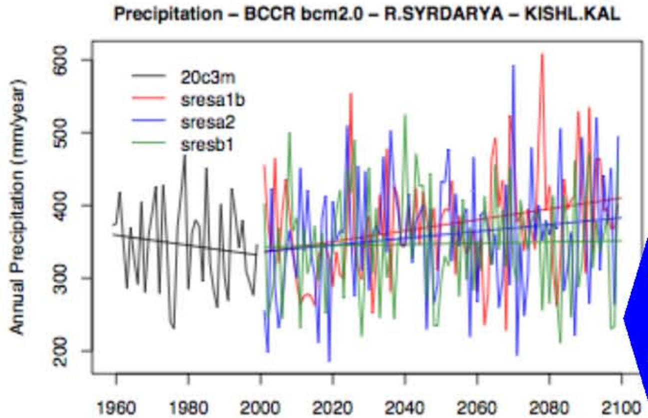


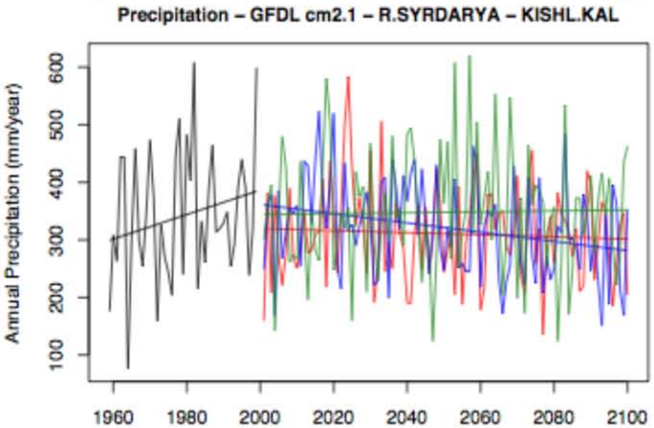
Irrigated Area Map of Central Asia
Derived from AVHRR (10km) and SPOT (1km)

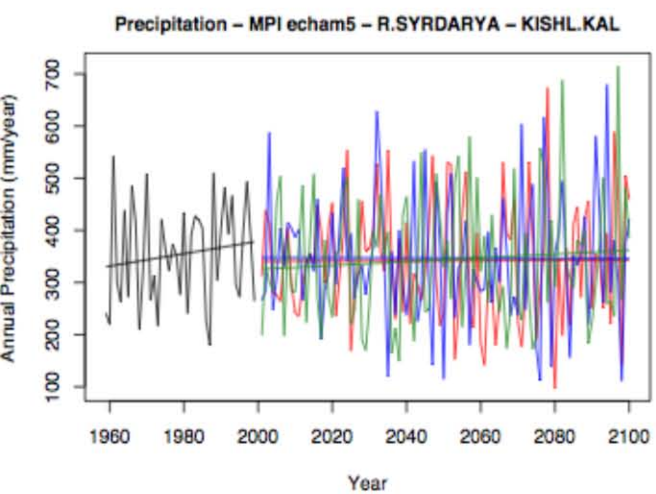


Irrigation water demand in the Syr Daria basin continues to increase

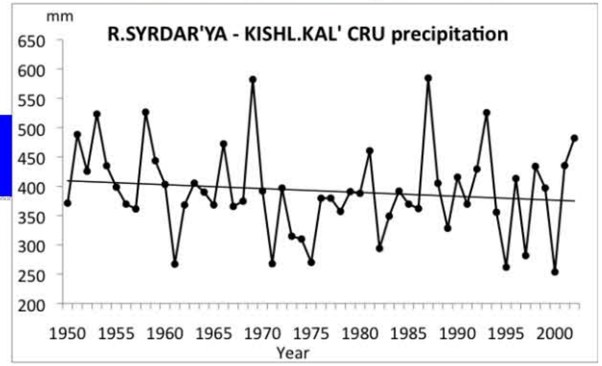
Future GCM precipitation projections for Central Asia

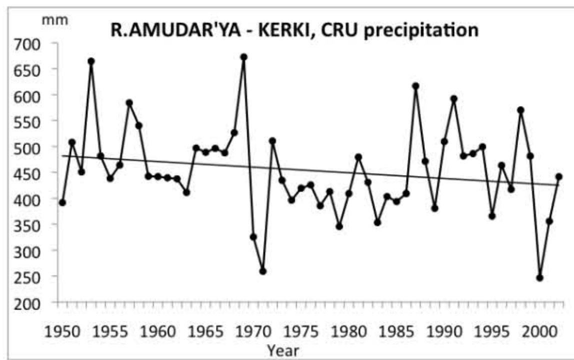


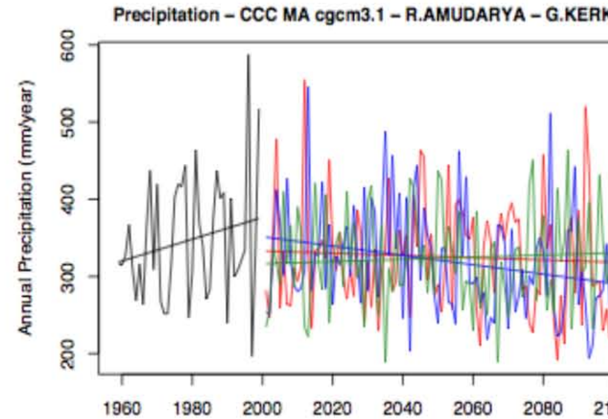


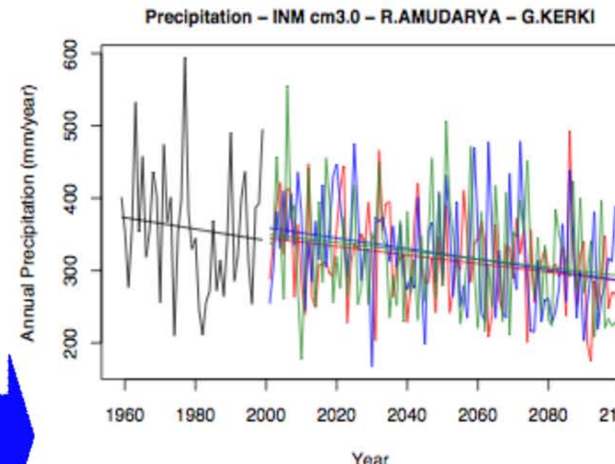


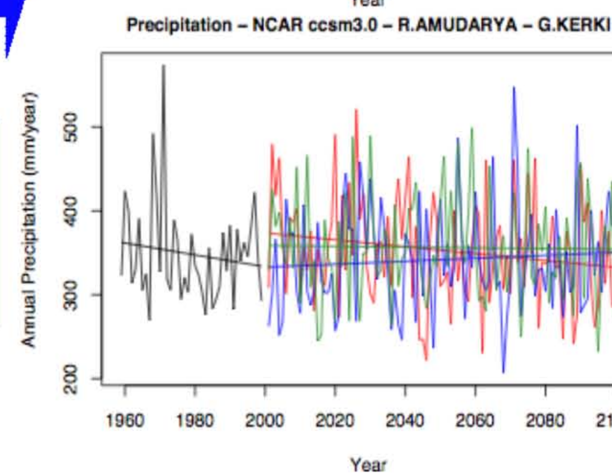
Observed Precipitation







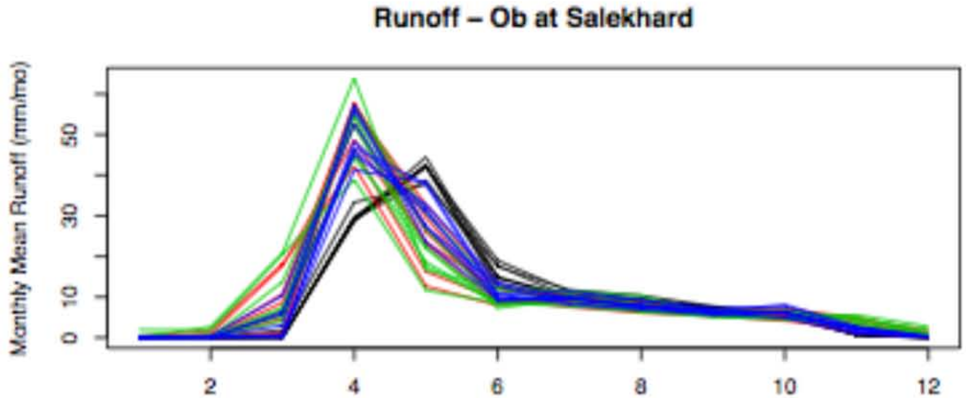


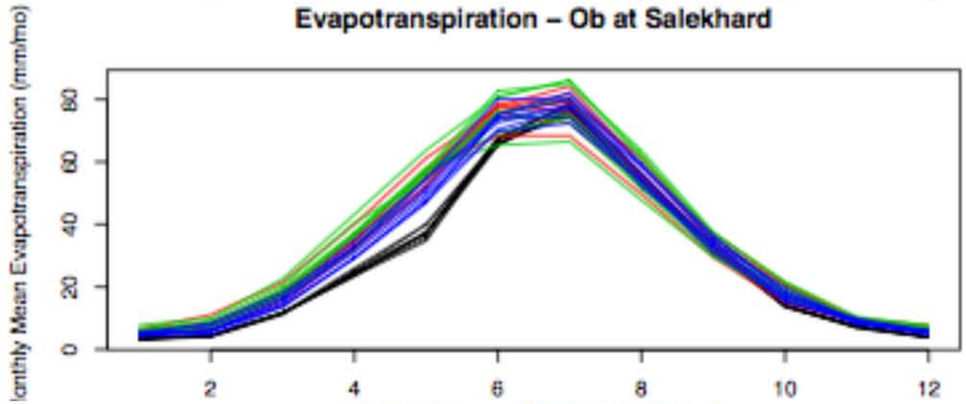


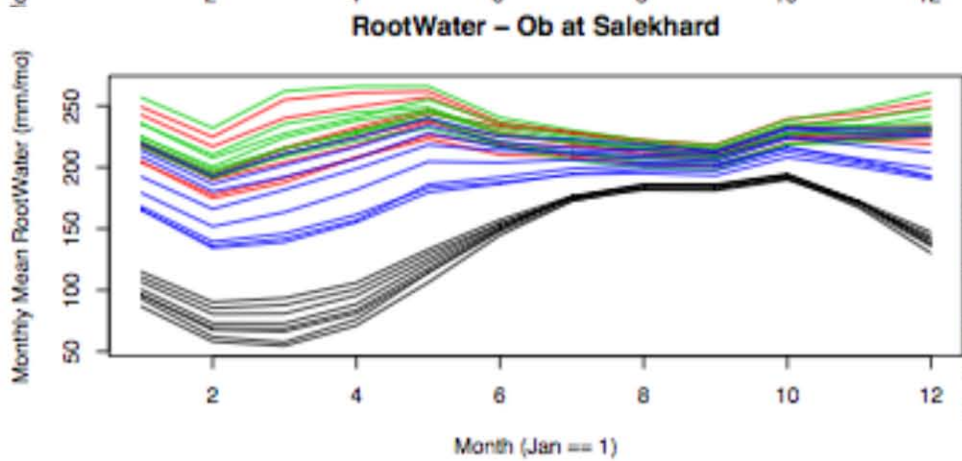
GCMs have wide variability for both 20th C and future simulations.

- Most downscaling methods will not change this trend.

UNH Model Experiments

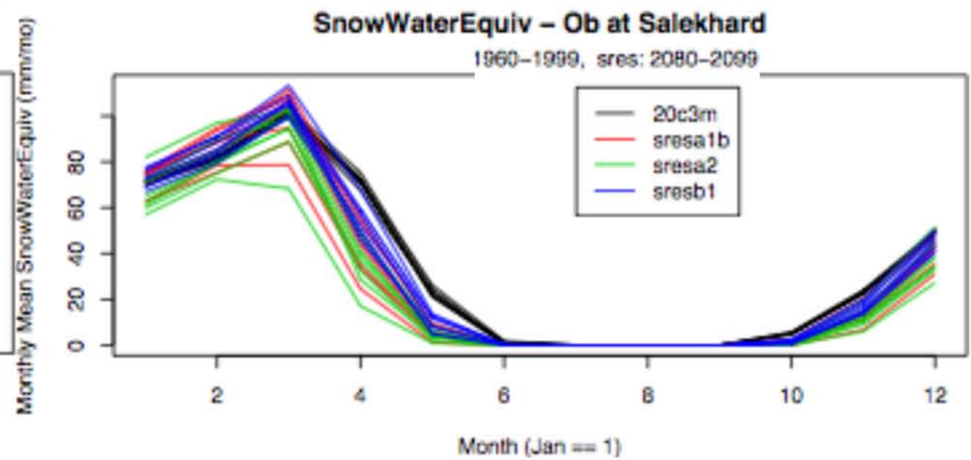




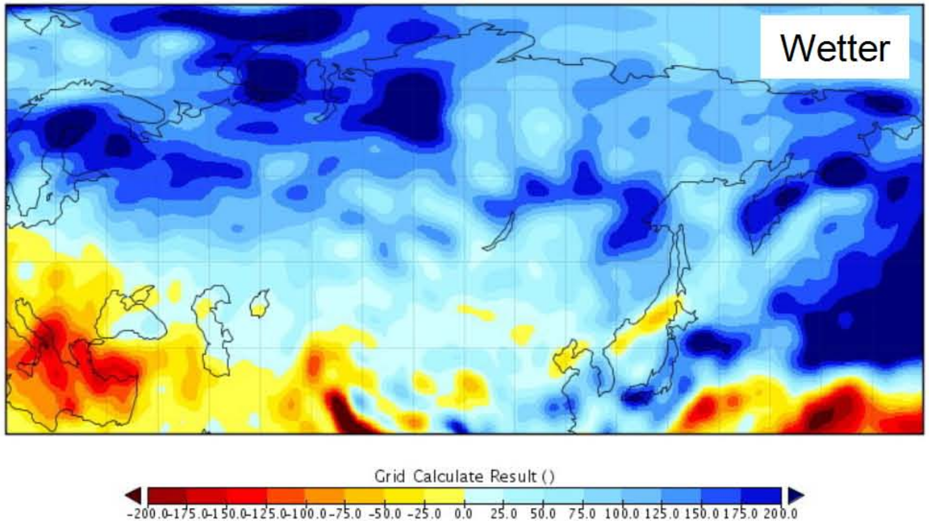


PWBM simulations (cold regions)

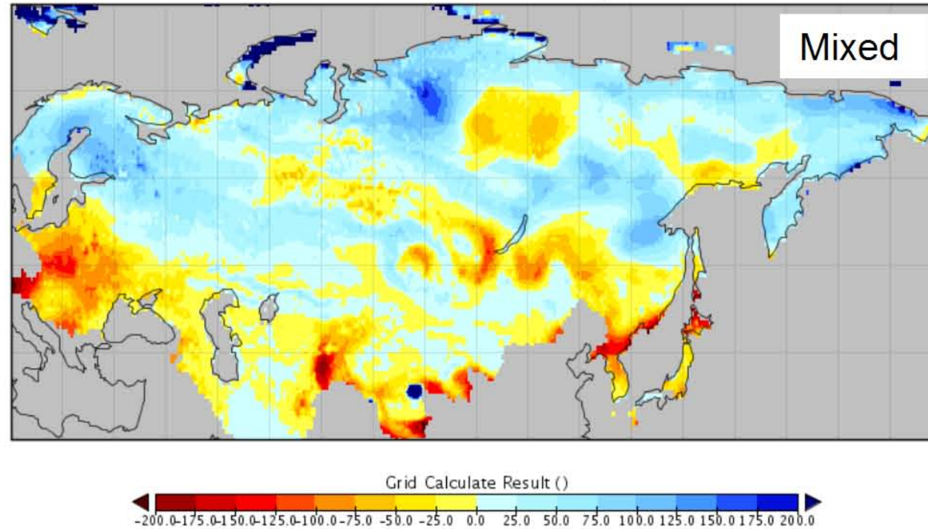
- Runoff shift, peak higher, annual discharge is increasing
- 8 different models from 6 different countries show remarkable consistencies
- Evapotranspiration is going up
- More water in the soil
- Less snow in the spring & shorter period with snow



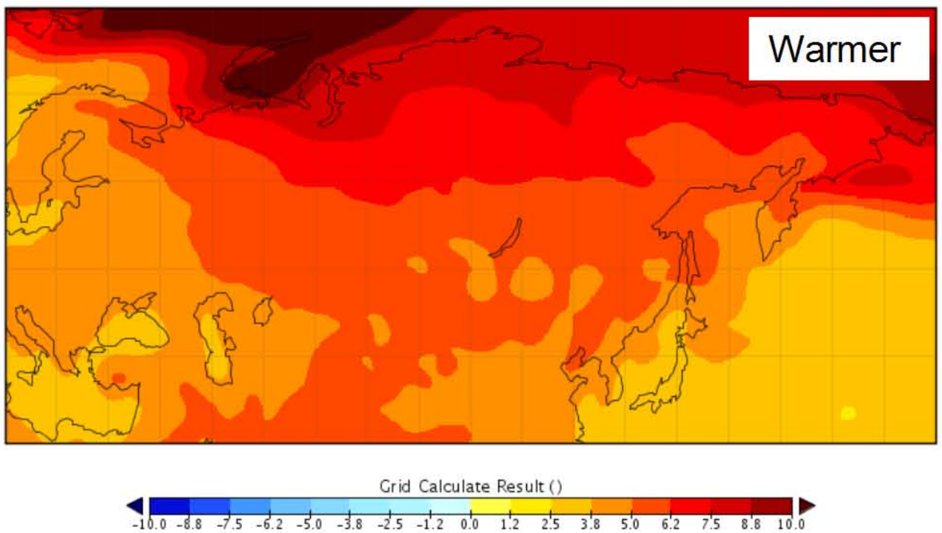
Annual Precipitation Change



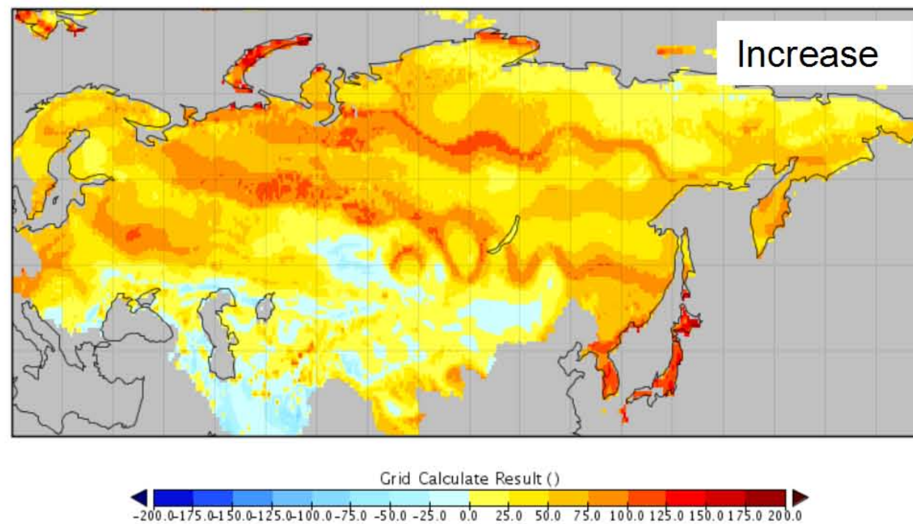
Annual Runoff Change



Annual Air Temperature Change



Annual Evapotranspiration Change



ECHAM5 A1b - Differences (2080-2100) - (1961-2001)

- Climate drivers (left panels) show consistent change over the region
- Complex interactions in the hydrologic cycle make sign of resultant runoff change (upper right panel) uncertain

Summary

Data consolidation and harmonization

- We show how we have integrated multidisciplinary data streams from multiple projects spanning several domains. This has proven to be a powerful analysis tool for researchers and students

Analysis of water cycle components and impacts

- We have made historical analysis of changes in water cycle components, land cover and water use across NEESPI region. Climate plays major role in most regions of NEESPI

Future projections

- We have analyzed IPCC scenarios from different AO GCMs and found a wide variability in precipitation projections for the region
- Results of simulations with UNH water balance models using different AO GCMs climate projections show more consistent changes in hydrology
- Preliminary projections of future water balance show wetter climate and higher runoff for most NEESPI region except Central Asia and Southern Europe where it is opposite.