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INTAROS Open Webinar, Arctic Science Summit Week, 2022-03-28

Pan-Arctic River Discharge Monitoring and Modelling

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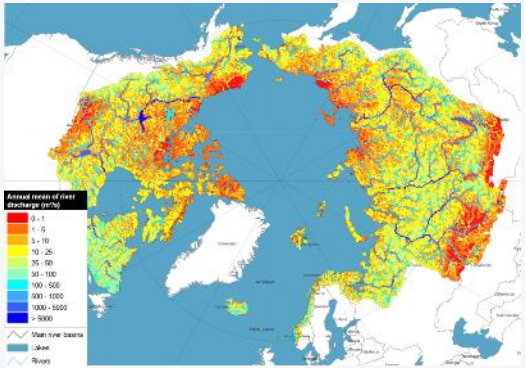
Arctic-HYCOS

- Hydrological monitoring in the Pan-arctic drainage basin of the Arctic Ocean (PADB)
- National hydrological services in Arctic countries
- Sweden/SMHI: development and operation of Arctic-HYPE pan-arctic hydrological model

WHOS – WMO Hydrological Observing System

- Arctic-HYCOS observations available in a common system (*not available at the start of INTAROS*)
- Assimilated in Arctic-HYPE pan-arctic hydrological model



Arctic-HYPE

- PADB setup of HYPE model
- Developed in collaboration with research groups in Canada and Russia (Arctic-HYPE modelling community)
- Open data:
  - historical analysis 1979-, 10 day forecasts
  - provided by OPENDAP server (thanks to INTAROS!)
- River ice, permafrost, non-contributing areas, sparse observation network (>40% un-gauged areas)

H2020 INTAROS

Integrated Arctic Observation Systems

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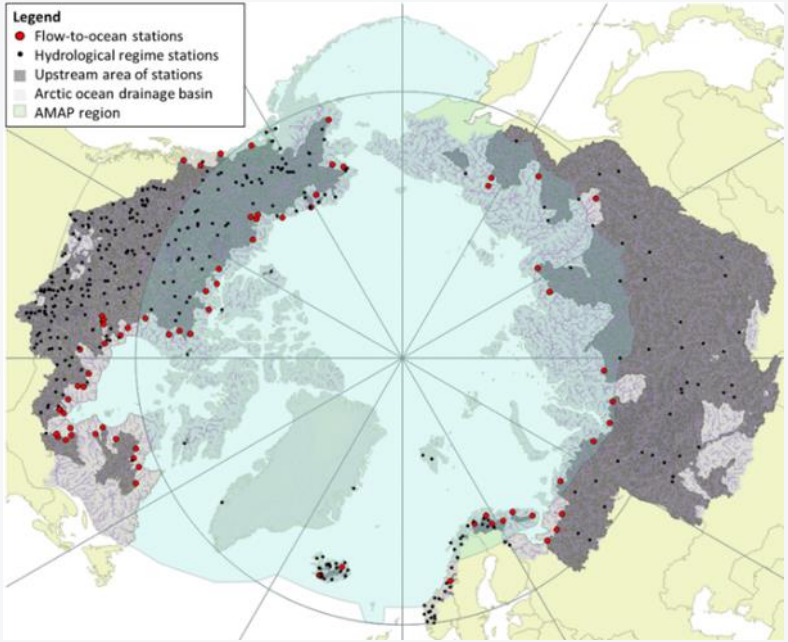


Assessment of Arctic-HYCOS observation system

+ Temporal (up to +100yrs) and spatial (~60%) coverage
+ Sustainable funding and organization
-/+ Partly poor (but improving) data access and latency time

Arctic hydrological modelling cases (WP6)

- Pan-arctic hydrological modelling (Arctic-HYCOS)
- Regional hydrological modelling in Yakutia (HYPE-ERAS)

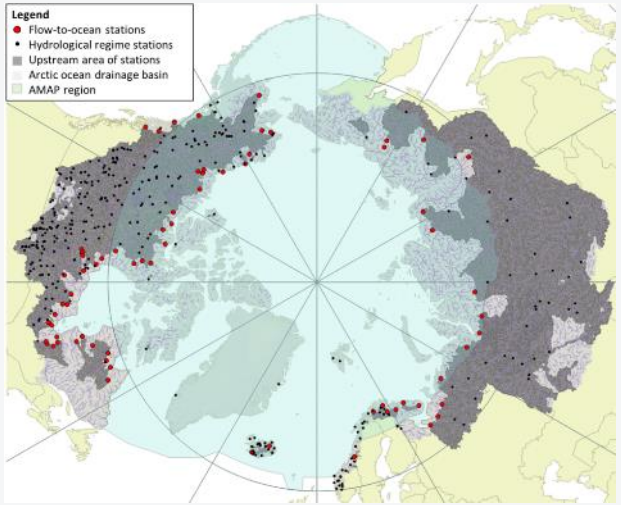
Arctic-HYPE: Hydrological Modelling and Prediction for Arctic-HYCOS

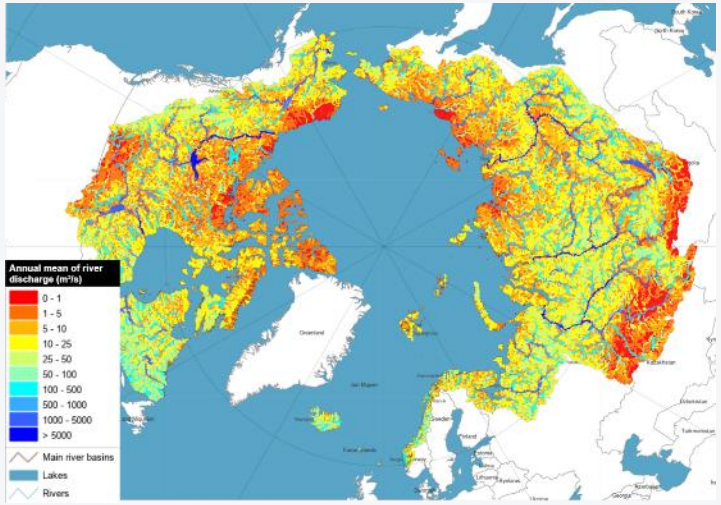
Aim:

- Contribute to monitoring of river flow to Arctic Ocean and changes in arctic hydrological regimes (ungaged flow ~40% Pan-arctic drainage basin)

Arctic-HYPE

- $25 \cdot 10^6$ km^2 pan-arctic drainage basin
- ~33000 sub-basins (mean ~800 km^2)
- Forcing 1979-present (HydroGFD; Berg et al, 2017)
- Analyses and forecast (1-10 days) assimilating Arctic-HYCOS data

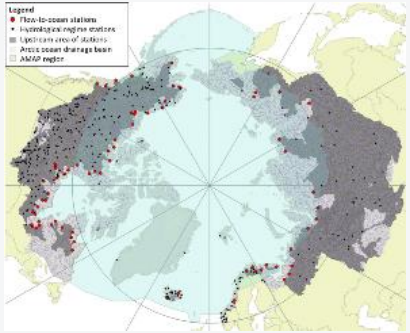




https://hypeweb.smhi.se/explore-water/geographical-domains/#arctichype

iAOS / WHOS integrated observation systems

Arctic-HYCOS observations



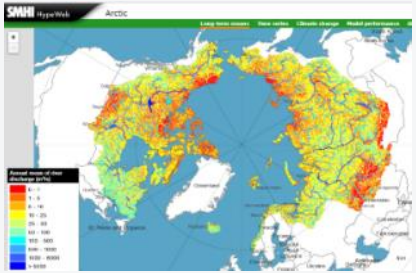
GRDC and National data services

provisional/archive data

Multiple interfaces

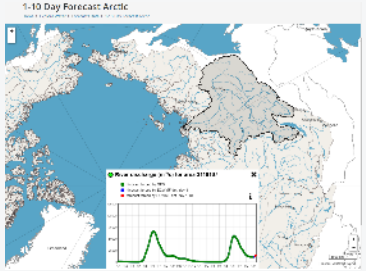
Dissemination through web-pages and ftp sites

Arctic-HYPE model



Status before INTAROS / WMO WHOS

- Multiple interfaces for each provider and variable
- Uncertainty of data update/versions
- Variability in data and metadata format

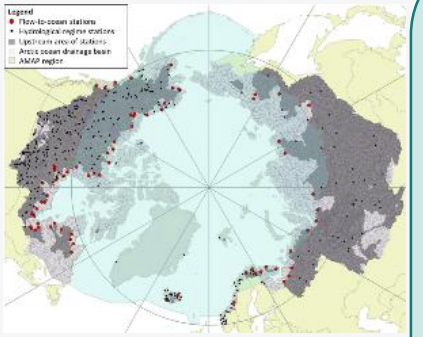


Model output without observations
Interactive web-site
Limited interoperability

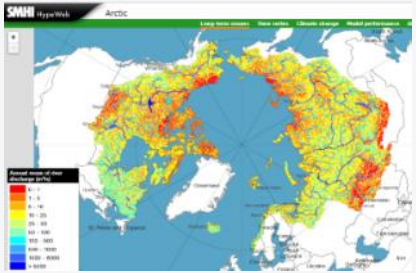
https://hypeweb.smhi.se/explore-water/forecasts/short-medium-range-forecast-artic/

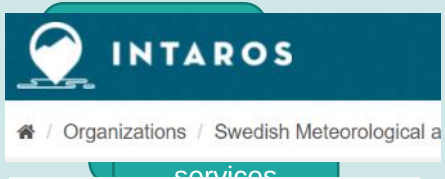
iAOS / WHOS integrated observation systems

Arctic-HYCOS observations



Arctic-HYPE model

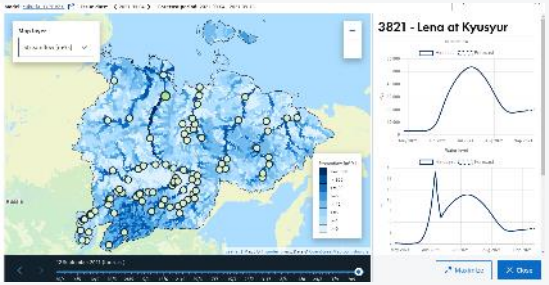




INTAROS iAOS / WMO WHOS

- Single interface to different data providers
- Linking to original data provider (latest data version)
- Conforming data and metadata format

Model dissemination by OPENDAP server
User services combining model and observations



Hydrology, Permafrost and resilience in East Russian Arctic and Sub-Arctic (HYPE-ERAS)

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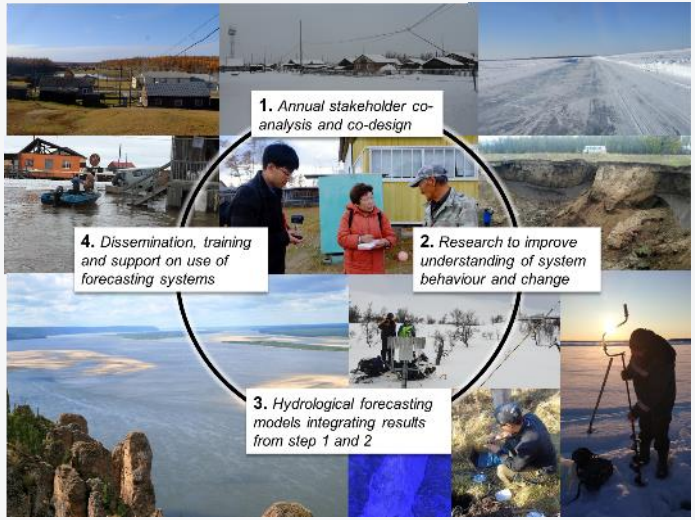
Environmental change ⇔ Societal challenges



Republic of Sakha (Yakutia), Russia

Study area and project partners from Sweden, Russia, and Japan

HYPE-ERAS research themes

- Water in Yakutian life
- Where water comes from
- New flood hazard knowledge
- Permafrost landscape change
- Roads on thinner ice
- Understanding climate change
- Hydrological modelling and forecasting

https://hype-eras.org

HYPE - Hydrological Predictions for the Environment model (Lindström et al, 2010)

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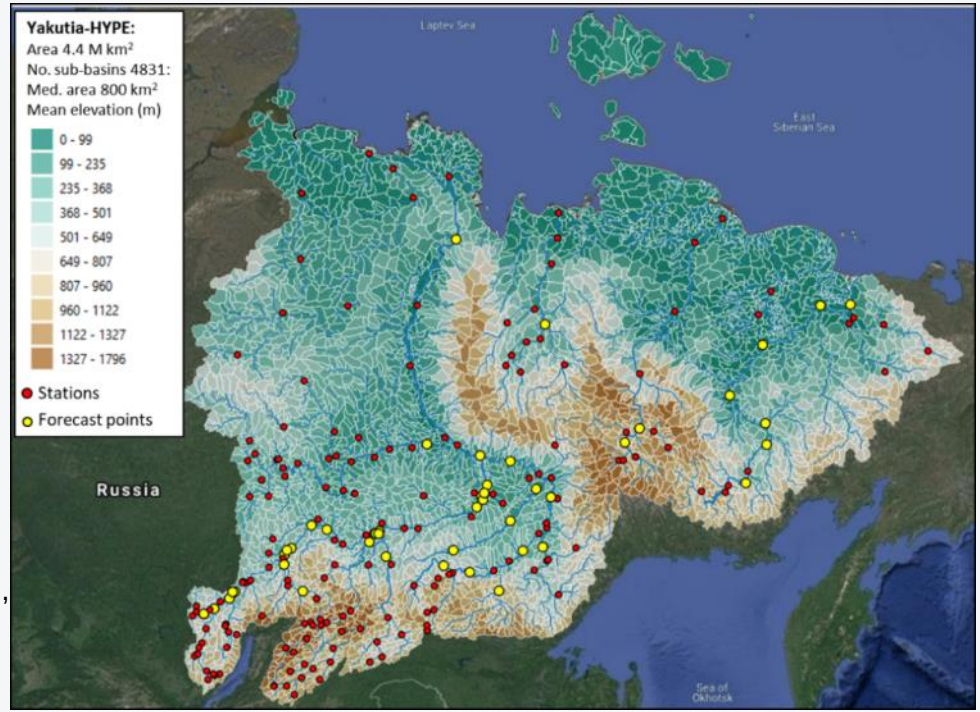
Yakutia-HYPE: a local adaption of Pan-arctic and World-wide HYPE models

(Arheimer et al, 2020; http://hypeweb.smhi.se)

- Semi-distributed hydrological model
- Water balance in snow, soil, glaciers, lakes, river network
- Lake and River ice growth/melt and breakup
- Water level prediction by transforming simulated discharge using empirical rating-curves
- Simplified frozen soil impact on infiltration and runoff (not permafrost model)
- Yakutia-HYPE setup:
  - ~4800 sub-basins with 60 sub-classes for different combinations of soil and landcover types
  - Meteo-input: Hydro-GFD (bias-corrected ERA5+ECMWF forecast, Berg et al, 2018/2020)

- Co-developed by SMHI and MPI
- ~120 discharge and water level gauging station for calibration, evaluation and assimilation



Forecast production chain and dissemination

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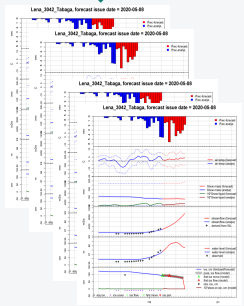
Metorological hindcast and forecast

Hydrological model hindcast and forecast

River and ice Data collection

Satellite images



Detailed data at forecast points

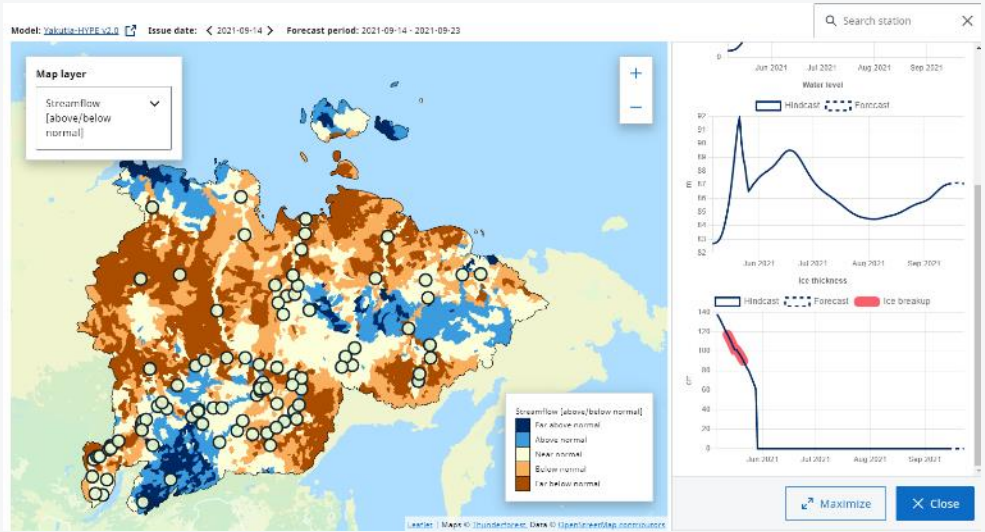
Web service

Forecast expert interpretation

Public

Stakeholder

HYPE-ERAS - River ice breakup and flood forecast system



https://www.smhi.se/forskning/forskningsnyheter/islossningsprognos-for-floden-lena-ovantat-saker-pa-forsta-forsoket-1.160406

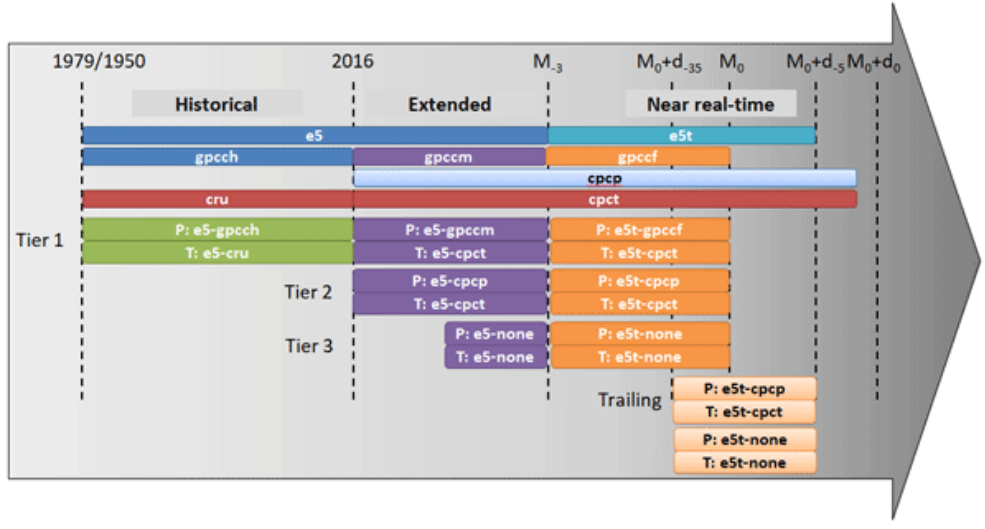
HYPE-ERAS is funded by FORMAS, RFBR and JST through the Belmont Forum Collaborative Research Action: Resilience in the Rapidly Changing Arctic

https://hype-eras.org/forecasts

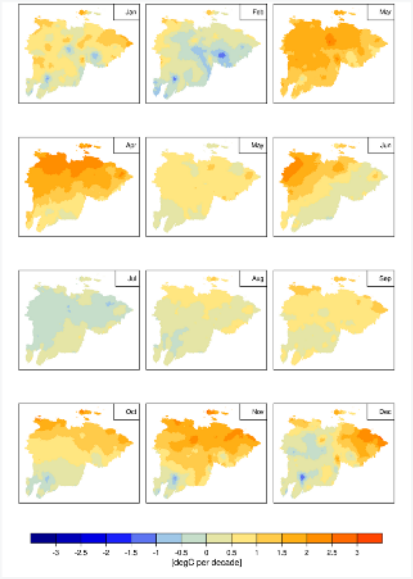
HydroGFD3.0 (Hydrological Global Forcing Data): a 25 km global precipitation and temperature data set updated in near-real time

Berg *et al*, Earth Syst. Sci. Data, 13, 1531–1545, 2021
https://doi.org/10.5194/essd-13-1531-2021

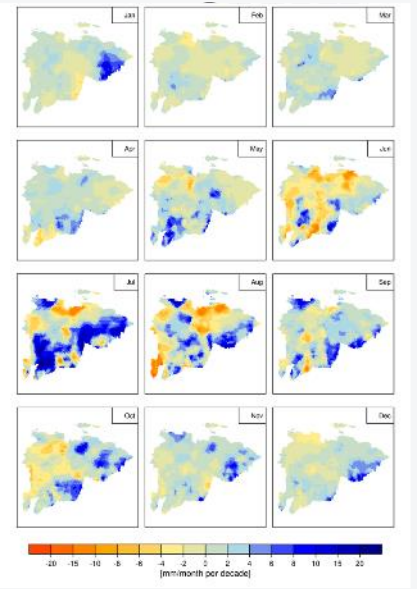
ERA5 re-analysis corrected by different P and T obs
Time period: 1950 –> near real time
Temporal/spatial resolution: daily/25km

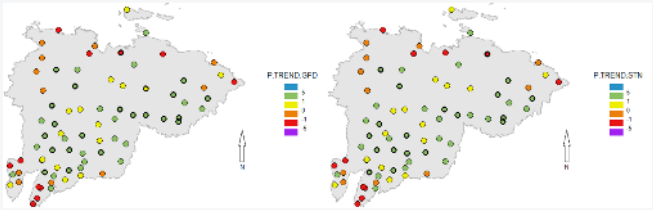


Trends in 2m air temperature: 1991-2020



Trends in precipitation: 1991-2020





Trends in annual precipitation (mm/yr), 1980-2019
Stations with significant trends marked by thick line

Relation between snow and seasonal characteristics of hydrological change (spatially and temporally)

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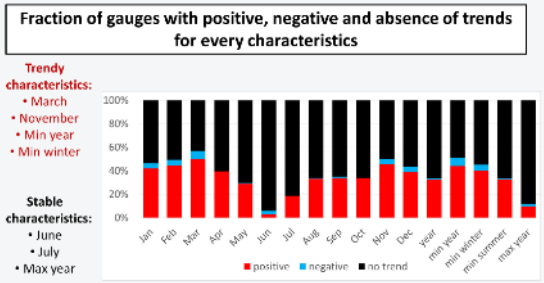
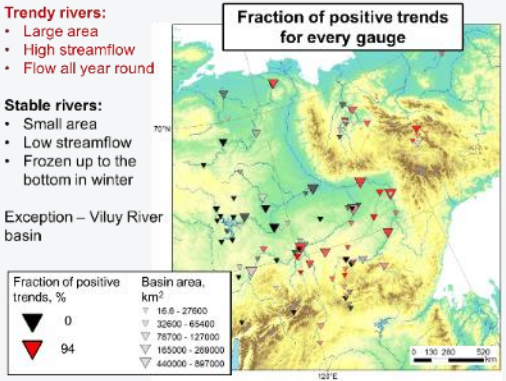
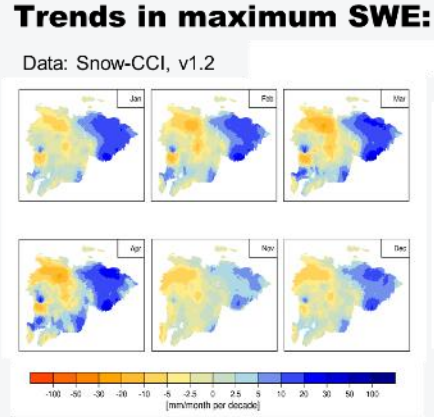
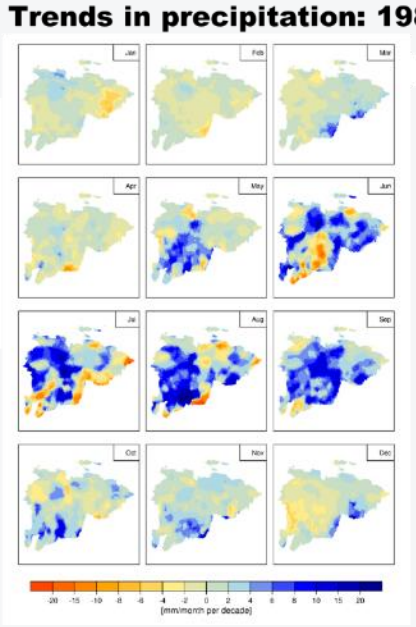
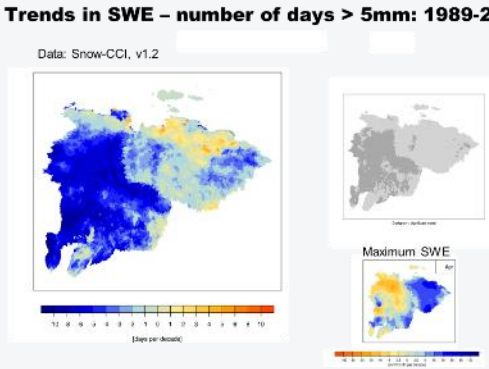




From Lebedeva & Gustafsson, 2021
https://doi.org/10.3390/w13192747

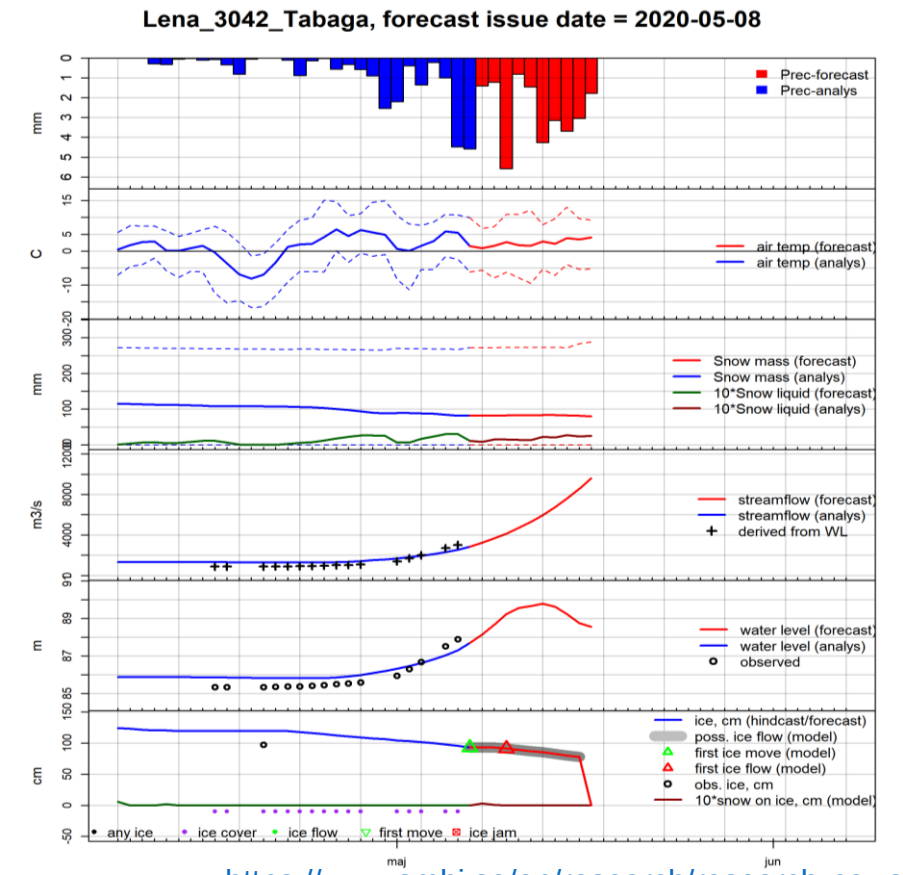






Snow CCI Phase 1 manuscript in preparation

River ice breakup in Yakutsk 2020-05-11/12



Forecast for Lena river at Tabaga issued 2020-05-08 (Friday) predicting first ice flow during period 8th – 11th of May (red triangle)

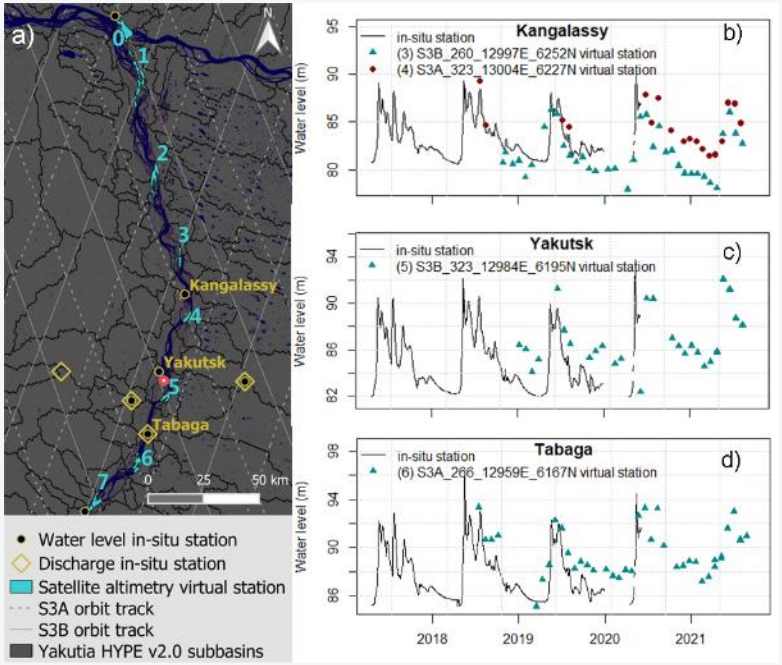
First ice flow was observed 2020-05-10

Please note:
The ”bump” in the water level is a result of a transition in the **rating curve parameters** from ice to ice free conditions

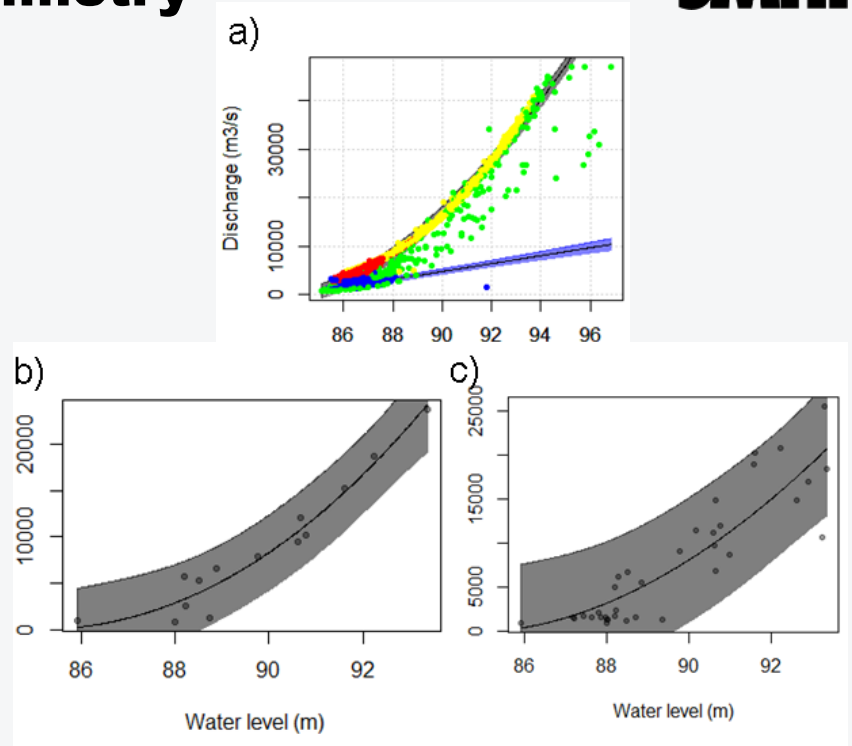
(ice jamming is not predicted by the model)

https://www.smhi.se/en/research/research-news/forecasts-of-river-ice-break-up-for-the-lena-river-unexpectedly-accurate-on-the-first-attempt-1.160535

River monitoring by Satellite altimetry



In situ and virtual stations for water level and discharge monitoring in the Lena River in central Yakutia



Rating curves for Lena river at Tabaga station using (a) in-situ discharge and in situ water level (b) in situ discharge and satellite altimetry water level, and (c) simulated discharge and satellite altimetry water level

Summary

- Arctic-HYCOS observation system:
  - river discharge data from major Arctic rivers
  - Represents ~60% of the pan-arctic drainage basin of the Arctic Ocean.
  - Well established and sustainable (national hydrological services NHS)
  - Partly FAIR through WMO, GRDC and NHS data services
  - Areas of improvement - interoperability and reusability

- Arctic-HYPE modelling case studies:
  - Pan-arctic: https://hypeweb.smhi.se/explore-water/forecasts/short-medium-range-forecast-artic/
  - Yakutia (paused): https://hype-eras.org/forecasts/

Arctic-HYCOS data sources

SMHI

National Hydrological Institutes / INTAROS

- https://catalog-intaros.nersc.no/dataset/arctic-hycos-hydrological-data

GRDC

- https://www.bafg.de/GRDC/EN/04_spcldtbss/41_ARDB/ardb_node.html;jsessionid=327E4AE8D7D5BFD76747335897DD4470.live11314

WMO

- https://hydrohub.wmo.int/en/projects/Arctic-HYCOS

Thank you!

Northern Research Basins Workshops & Symposium www.nrb23.se

August 26 2022 at www.cryosphere2022.is
August 2023 in Sweden

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