Decadal dynamics of Arctic continental water cycle in the framework of MONARCH-A

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INTRODUCTION

High latitude regions are predicted to suffer much greater warming than lower latitudes as a result of climate change. This will cause drastic changes in the carbon and water balance of the region, with associated large effects on snow cover, soil freeze-thaw periods, soil moisture, permafrost, growing season, land cover, greenhouse gas fluxes and albedo.

Few research programs grew up to study arctic climate such as the MONARCH-A FP7 European project (MONitoring and Assessing Regional Climate change in High latitudes and the Arctic). Its main objective is to generate a dedicated information package tailored to a subset of multidisciplinary essential climate variables and their mutual forcing and feedback mechanisms associated with changes in terrestrial carbon and water fluxes, sea level and ocean circulation and the marine carbon cycle in the high latitude Arctic regions.

MONARCH-A : Program description

The Nansen Environmental and Remote Sensing Center (NERSC) co-ordinates and manages the MONARCH-A project. The Project Coordinator is Research Director Prof. Dr. J.A. Johannessen.

WP 1: Changes in terrestrial carbon and water fluxes (S. Quegan, USFD)
WP 2: Changes in sea level and ocean circulation (D. Stammer, UHAM)
WP 3: Changes in marine carbon cycle (T. Johannessen, UiB)
WP 4: Synthesis and Interaction with the Scientific Community.(J.A. Johannessen, NERSC)
WP 5: Management (J.A. Johannessen, NERSC)

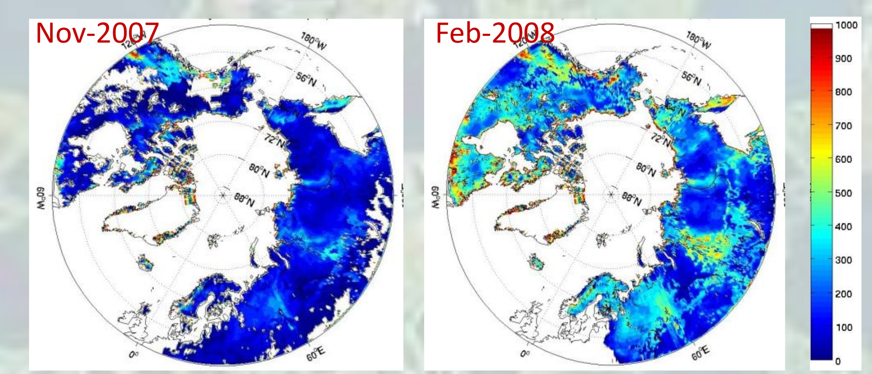
WP 1.1 Decadal change in snow properties.
WP 1.2 The decadal dynamics of high latitude water bodies
WP 1.3 Decadal changes in permafrost location and depth
WP 1.4 Land cover and fire and their representation in models
WP 1.5 Reanalysis of the water and carbon balances of the major high-latitude catchments and their link to climate

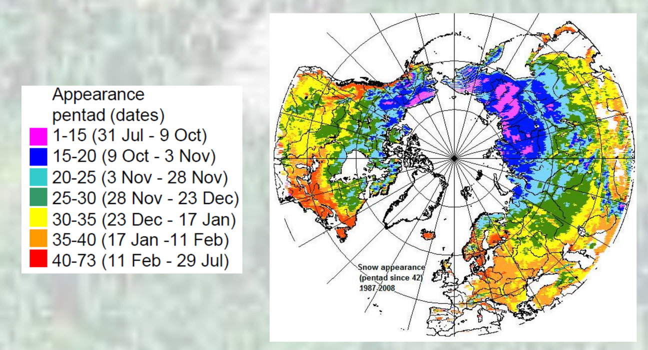
=> 9 deliverables in WP 1.1 and WP 1.2 from LEGOS/CNRS

Snow extent, snow depth, dates of start and end of the snow season, and snow water equivalent

⇒ Time series by pentads and months from 1989 to 2009
⇒ Global (over 50°N) on EASE-grid ML (25km²)

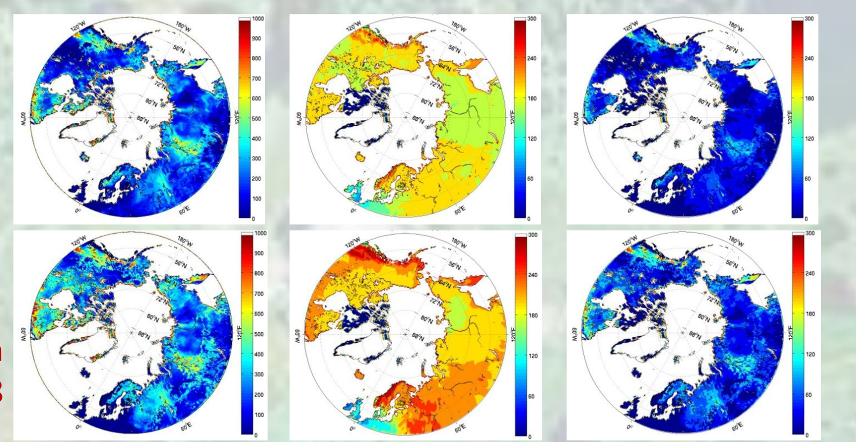
Snow depth (mm)
Combination of static and dynamic algorithm
+ Brightness Temperature pentads at 37 and 19 Ghz (SSMI-NSIDC)
+ Ground Temperature averaged pentads over the period 1983-1994 (ISBA)
+ Surface Air Temperature pentads (NCEP)





Date of star of the snow season
Average (1987-2008) dates (in pentads since pentad 42, July 29) of snow appearance.

Snow water equivalent
+ Snow Depth
+ Snow density from ISBA averaged pentads over the 1987-2008 period

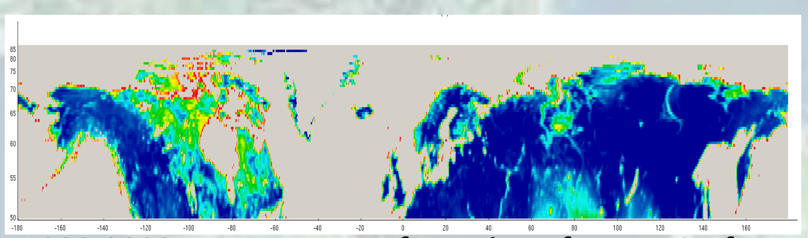


Depth (mm) *Density (kg/m³)* *Water equivalent(mm)*

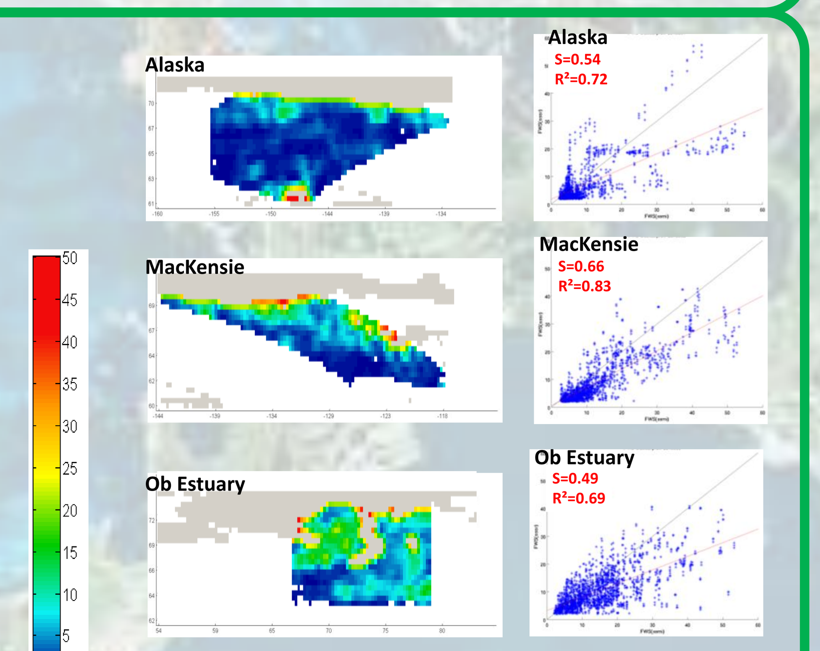
Global (North of 50°N latitude) summer monthly fields of surface water extent from SSMI

Algorithm from ***Fily et al. [2003]***
+ Brightness Temperature at 37 GHz for horizontal and vertical polarization
+ Emissivity (***Prigent et al. [1998]***)
+ Constants (***Fily et al. [2003]***)

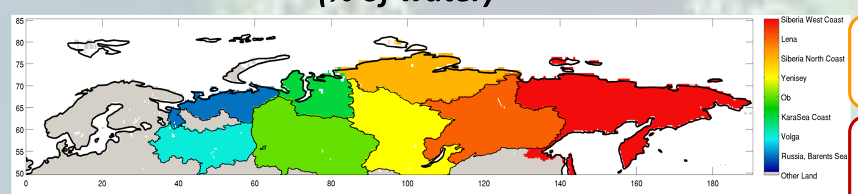
=> time series for 1989-2009
=> Percentage of the pixel covered by water



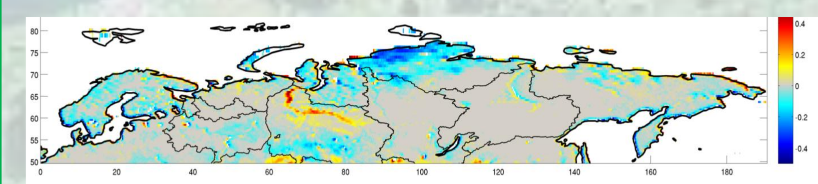
1989-2009 August mean of Fraction of Water Surface (% of water)



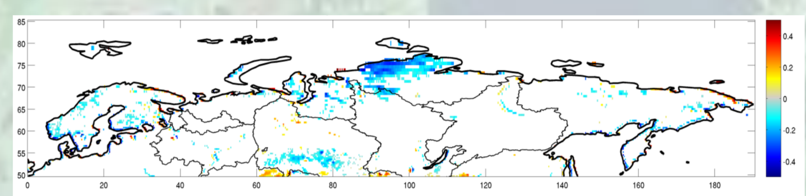
ASAR/FWS summer 2007 *Scatterplots for 2007-2009*



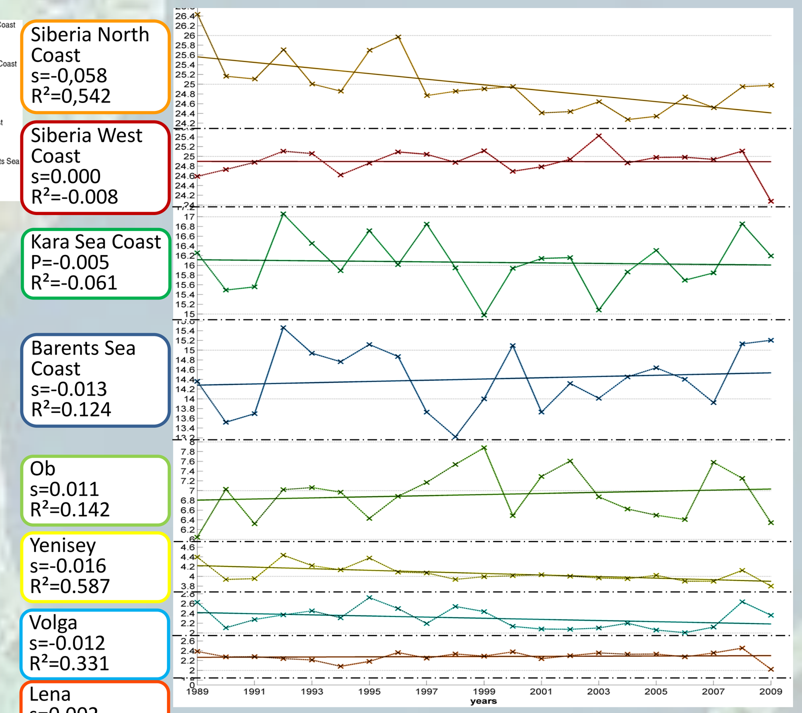
Major Russian basins (HydroSHEDS)



FWS July trend over 1989-2009 (% of water)



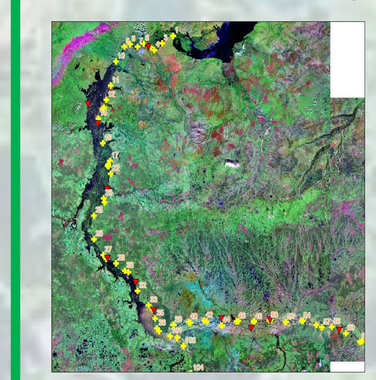
FWS July significant trend over 1989-2009



FWS July trend per basin

Water level variations over the large Arctic rivers and lakes from satellite altimeters

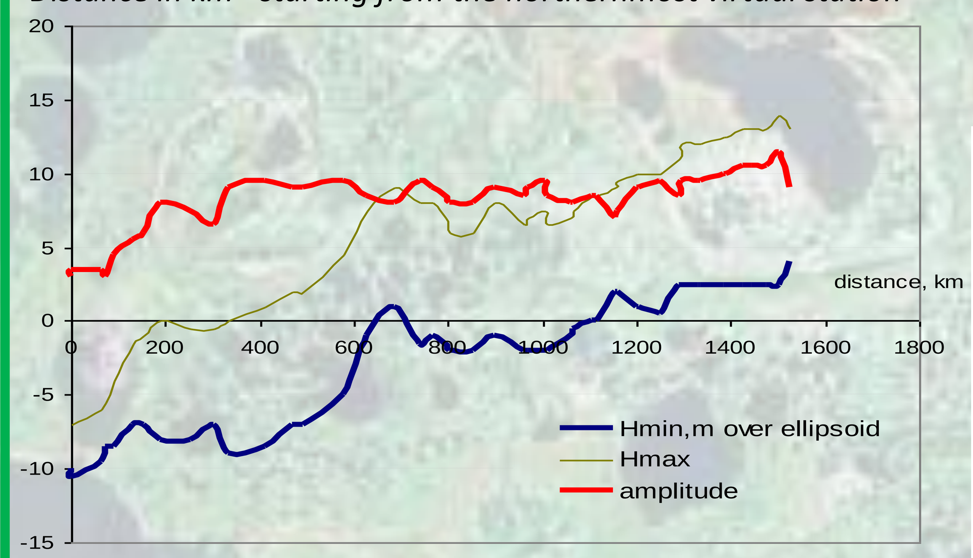
Over Rivers: exemple for Ob



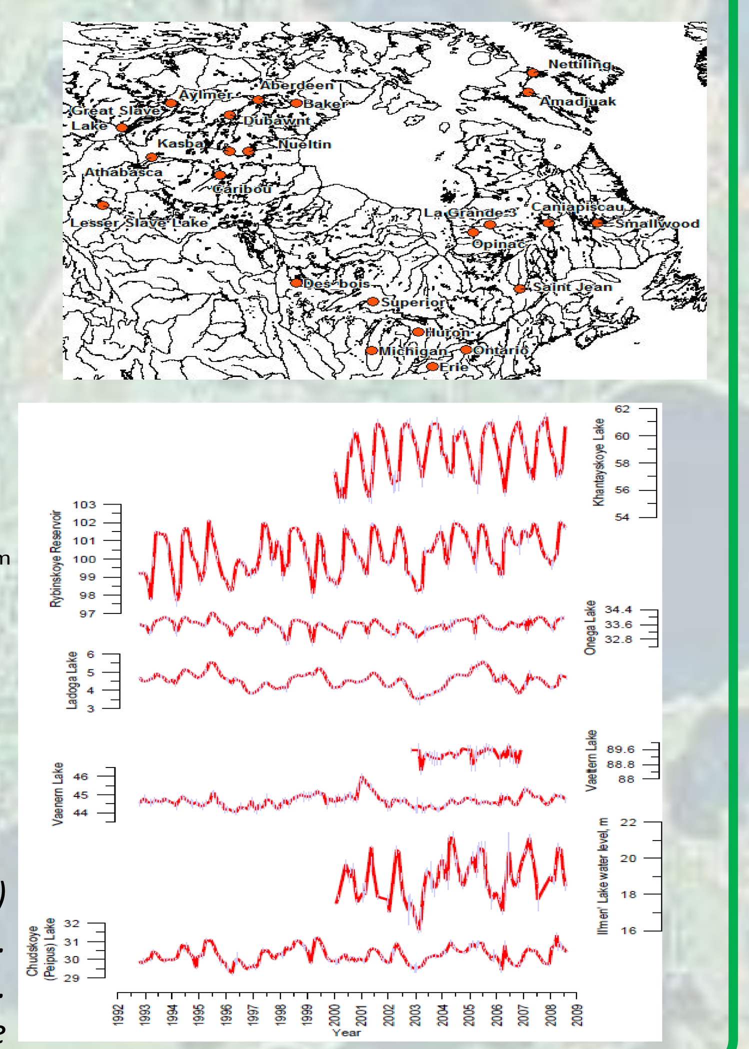
Input to the preparation of AltiKa satellite altimetry mission

58 virtual stations

Water level *(m, over ellipsoid); Averaged data for 2002-2009 maximal and minimal values, and seasonal amplitude. Distance in km - starting from the northernmost virtual station*



Over Lakes



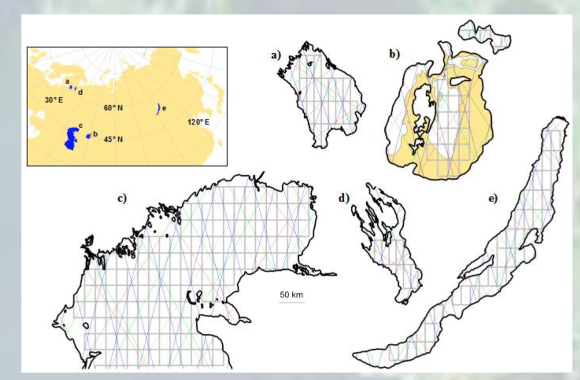
Water level variability (m, above geoid) of the Eurasian lakes and reservoirs. Red line - mean values, light blue bars -standard deviation. All Y axis on this figure have the same vertical scale

Timing of freeze/thaw periods over rivers and lakes from combination of SSMI and altimeter

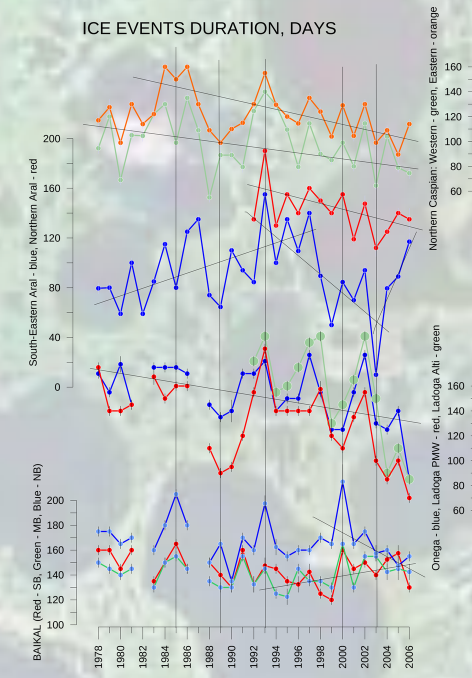
River ice: in situ and satellite data

Methodology on Ob river
- 24 hydrological stations daily data (2001-2011)
- 96 ENVISAT virtual stations (2002-2011)

Ice phenology for lakes and internal seas



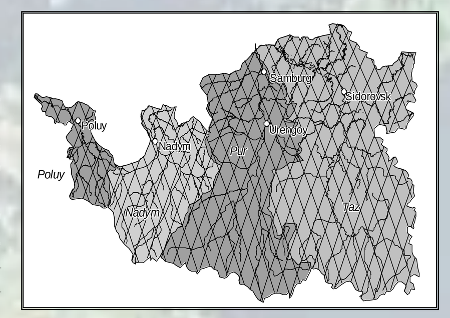
Ice phenology
- First ice
- Ice with polynyas
- Ice 100%
- Ice with polynyas, water on ice
- Beginning of ice break-up
- Open water

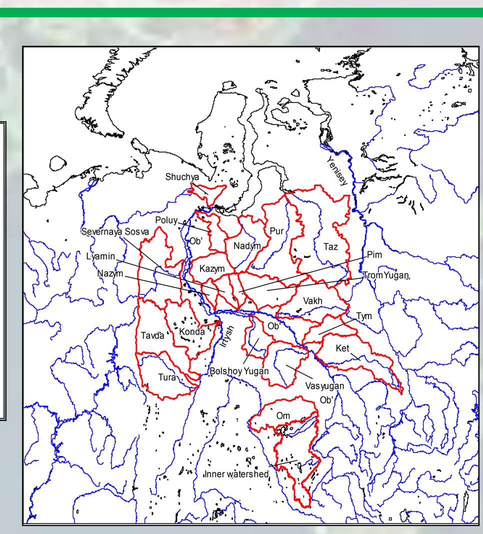


Seasonal and inter-annual variability of wet zones extent in Western Siberia from radar altimetry and their implication for hydrological modeling

Wet zones: 21 watershed of Ob' river

No	River name	Watershed area, km²	No	River name	Watershed area, km2
1	Taz	155666	12	Tym	30902
2	Vakh	76504	13	Ket	94828
3	Pur	103329	14	Vasyugan	63092
4	TromYugan	51820	15	Bolshoy Yugan	33366
5	Nadym	54152	16	Severnaya Sosva	91149
6	Poluy	19557	17	Konda	70592
7	Shuchya	11831	18	Tavda	86629
8	Kazym	34634	19	Tura	78385
9	Nazym	11169	20	Om	62734
10	Lyamin	15528	21	Inner watershed	115524
11	Pim	12055			

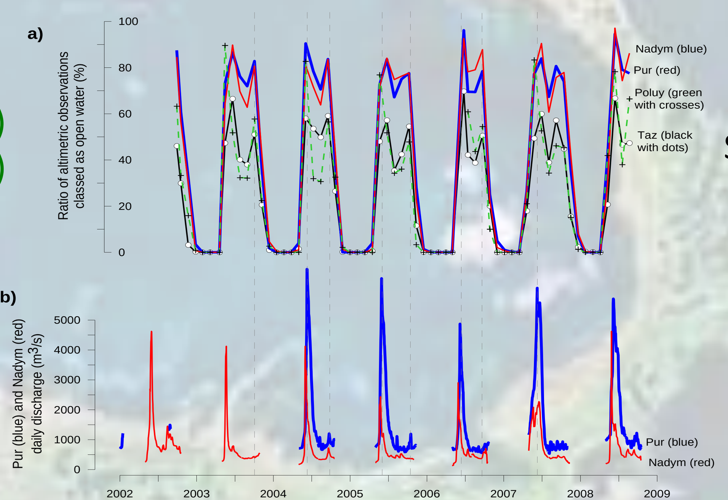




Wet zones: inter-annual variations

Wet zones extent (%) (PNPT)

Discharge (NP)



Significant variability from year to year.
Wet zones extent (%) similar in spring and autumn,
though in volume it is very different
=> need to study water level changes

OUTLOOKS

- Snow Water Equivalent are compared to models.
- Further correlation with river runoff will be made.
- Fields of surface water extent will be compared to other datasets and 20 years variability will be studied more deeply.
- SWE will be used to force the hydrological model for 3 watersheds of North-Western Siberia.

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