Cold Region Studies in CEOP (CRS)

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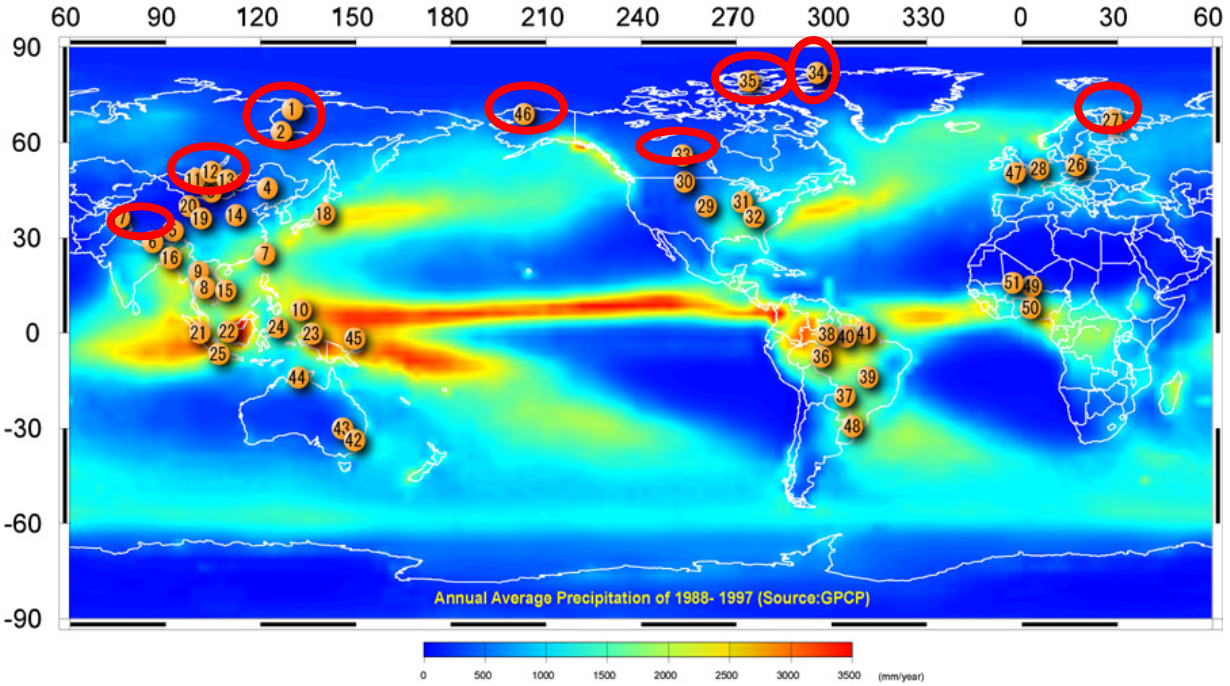
Four Overall Collaboration Topics

1. Convergence of observation and data integration
2. Long-term variation of snow distribution in northern regions and Its Impact on atmospheric circulation
3. Water and energy budgets (WEBs)
4. High mountain hydrology Including glaciers



Sites with annual average temperature below 0 ℃

1. Convergence of Observation and Data Integration

Targets:

- Reference site/basin network in cryosphere
- Integrated satellite/in-situ products in cold regions

Strategy:

- Sophistically integrated in-situ observation (super site) including isotope, new sites (location, number, standard)
- Common metadata, data quality check, archiving system, and data policy
- Integrated satellite products and validation by in-situ data: snow, snowfall, soil moisture, canopy snow, vegetation
- Integrated satellite products and validation by in-situ data: snow, snowfall, soil moisture, canopy snow, vegetation
- Long-term, comprehensive, high-quality observation at different spatial scales (regional-point) in Northern Eurasia
- Precipitation data applying various methods

2. Long-term Variation of Snow Distribution in the Northern High Latitude Region and Its Impacts on Atmospheric Circulation

Targets:

- Seasonal and Inter-annual variation of hydrological conditions

Strategy: (Research based on long-term data)

- Long-term snow (SWE) and soil moisture by the SSM/I: product, validation, impact analysis concerning atmosphere and hydrology
- Model analysis and inter-comparison
- Land surface model improvement for regional climate modeling: better inclusion of frozen ground including permafrost

3. Water and Energy Budgets (WEBs)

(Research for CEOP2 period)

Targets:

- Intercomparison among the large rivers flowing to Arctic ocean, such as *Lena, Obi, Yenisey, and Mackenzie*
- Impacts of the WEB variation on atmospheric circulation

Strategy:

- Data integration
- Atmosphere-land interaction land processes: snow, permafrost, soil moisture, vegetation, fluxes, land water.
- Predictability Improvement of GCMs coupled with LDAS
- Down-scaling and A-L coupled DAS
- Large Arctic draining River Runoff and its change
  <Existing project: IPY Arctic-HYDRA>
- Stable isotope budget

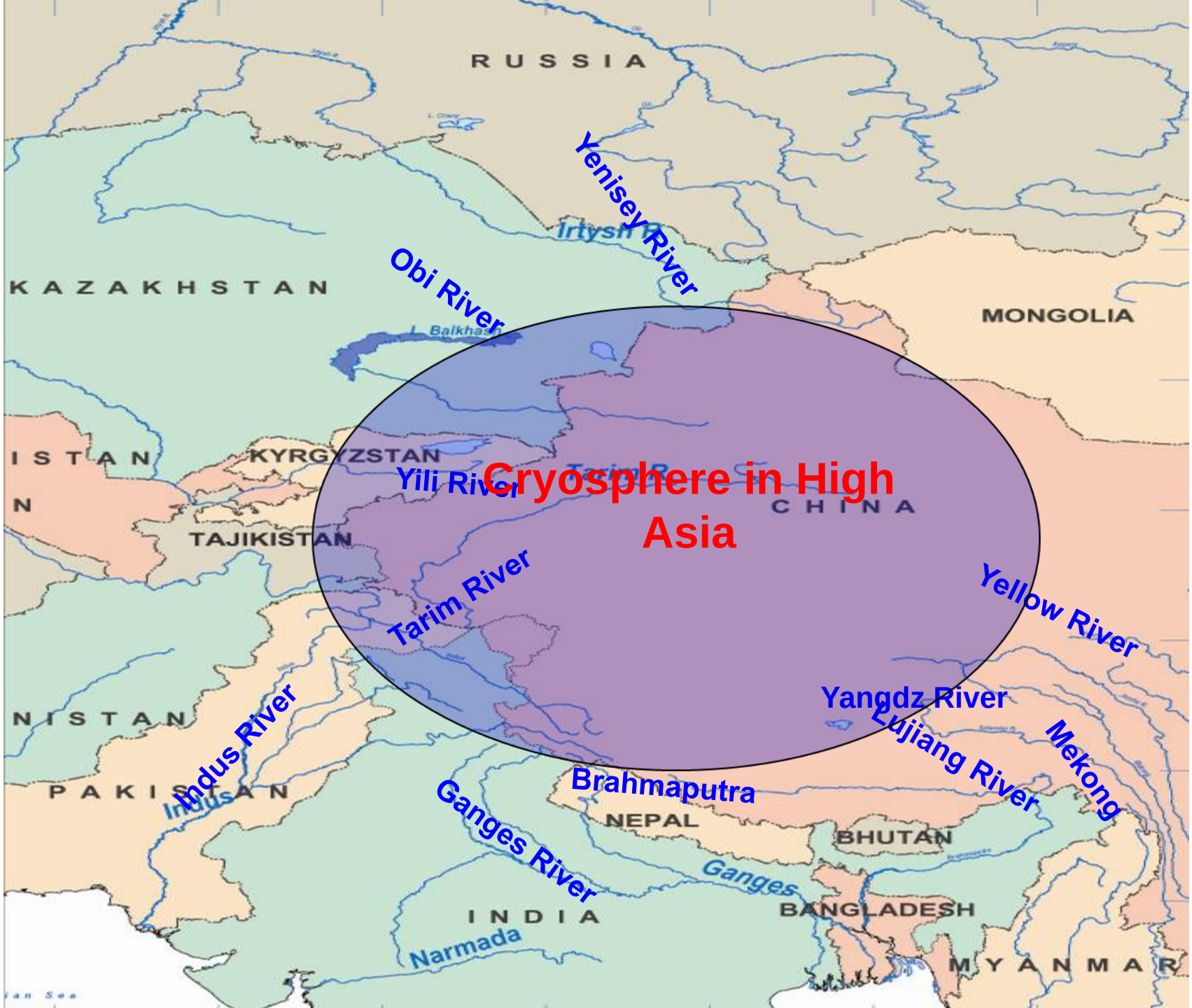
4. High Mountain Hydrology Including Glaciers

Targets:

- From process study to application to water resources management

Strategy:

- Enhanced collaborative research in reference basins
- Intercomparison of impacts of climate change on water resources
- Cooperation with “Semi-arid region study”
  - Planned Project: IHACY- International High Asia Cryosphere Year, CliC related project, China core.


RUSSIA
Yenisey River
Irtysh R.
Obi River
KAZAKHSTAN
MONGOLIA
L. Balkhash
ISTAN
KYRGYZSTAN
Yili River
Cryosphere in High Asia
N
CHINA
TAJIKISTAN
Tarim River
Yellow River
Yangdz River
NISTAN
Lujiang River
Mekong
Indus River
Brahmaputra
PAKISTAN
Indus R.
Ganges River
NEPAL
BHUTAN
Ganges
BANGLADESH
INDIA
Narmada
MYANMAR

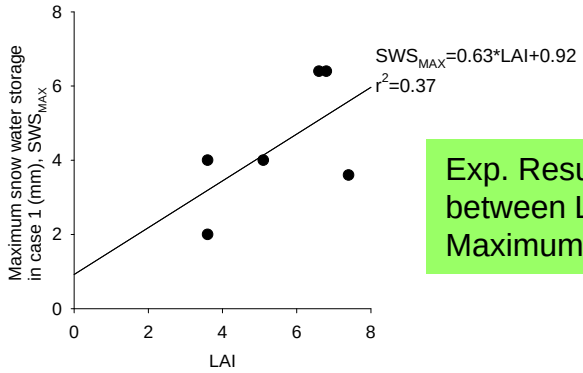
Several NEW RESULTS

Water and Energy Budgets (WEBs) (1)

Parametarization of canopy snow, model simulation.

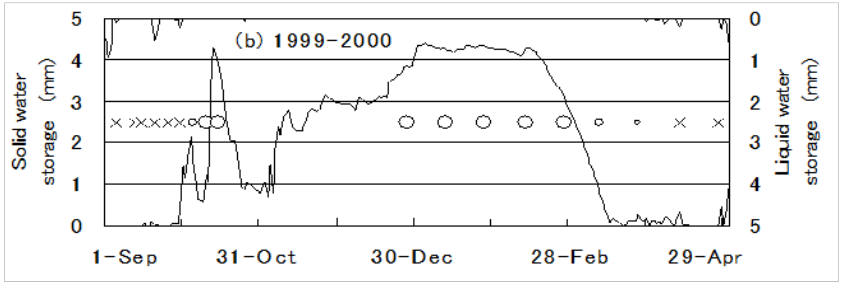
Experiment in Cold Environmental Room (NIED)

Field observation

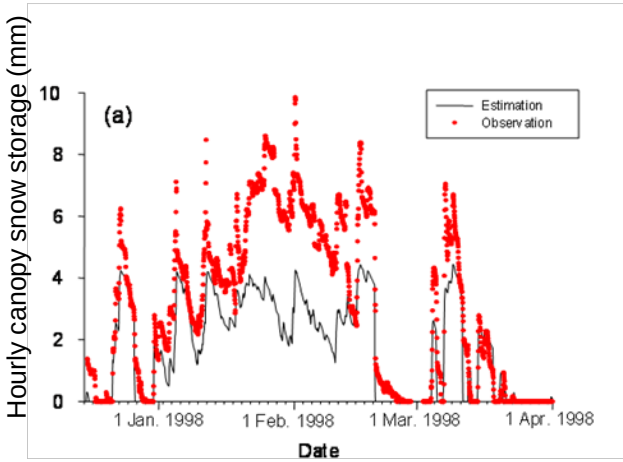


Exp. Results: Relation between LAI and Maximum crown storage

Inclusion of crown snow in land surface model and simulation



Simulation result of CSNOW model compared with observation for Sapporo, 1997/98.



Simulation of crown snow using 2LM(Yamazaki)for Yakutsk condition.
X and ○ show the relative amount of snow on crown (Eye obs.)

Water and Energy budget (2)
Budget study by drainage model simulation

Objective: Reproduce the long-term changes in WEBs, and recent abrupt changes in Northern Eurasia, applying land hydrological model through integration of various elements. Existing land model(2LM) will be changed to Integrated Land Surface Model in 2008.

Hydrometeorological station data, CEOP data, Topography map, Satellite data, Surface condition, Global data-sets

<Input>
Atmosphere
Vegetation
Soil

Land model

2LM
(Yamazaki)

Evaporation
Runoff
Soil moisture
Active layer
Snow cover
Etc.

Channel routing network
Flood
River freezing

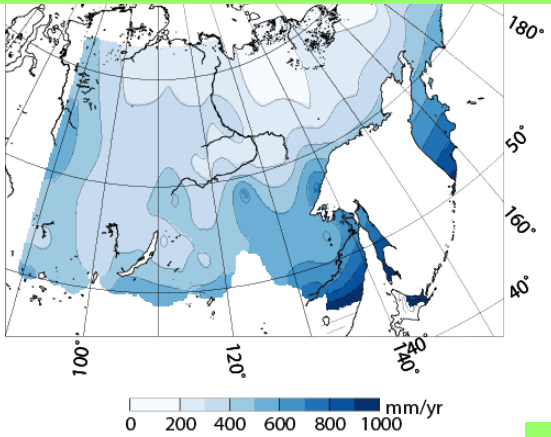
Runoff model

River runoff

Verification

Precipitation

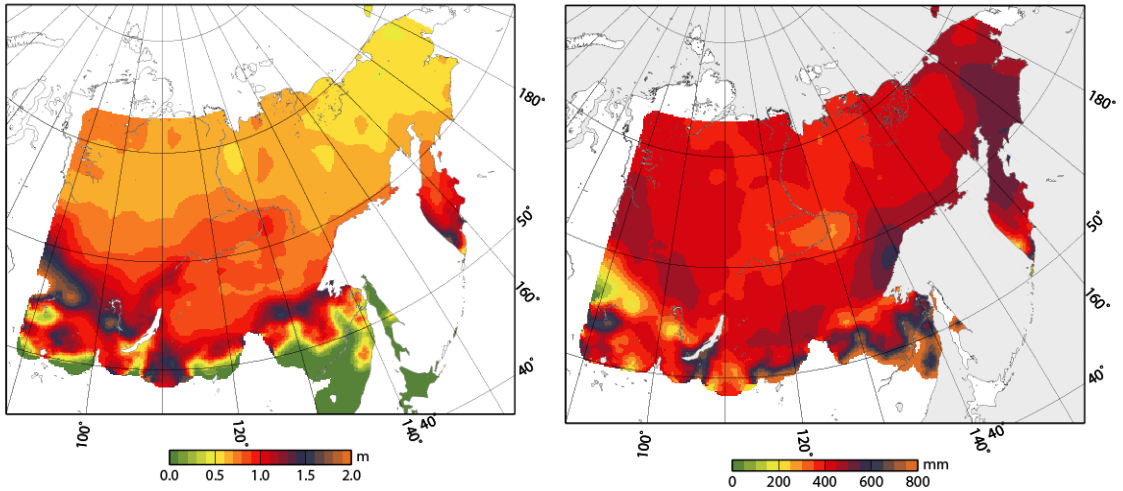
Input data: Grid data of mean annual precipitation (1986-2004)



July

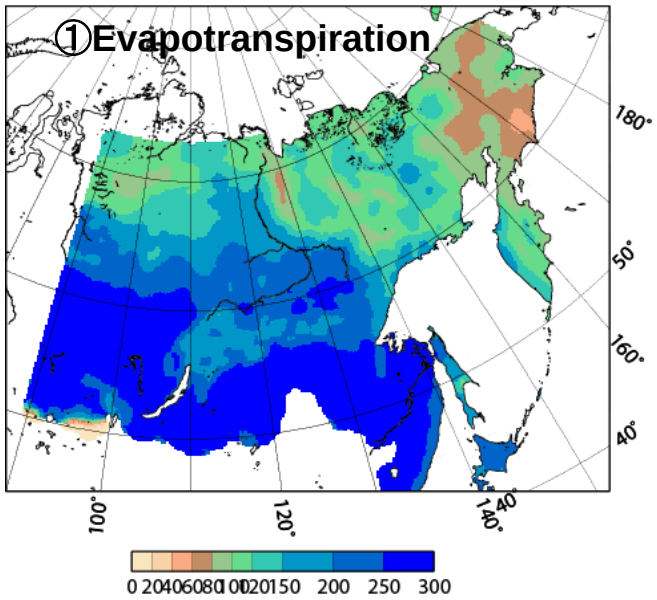
Results for July 20,2002.

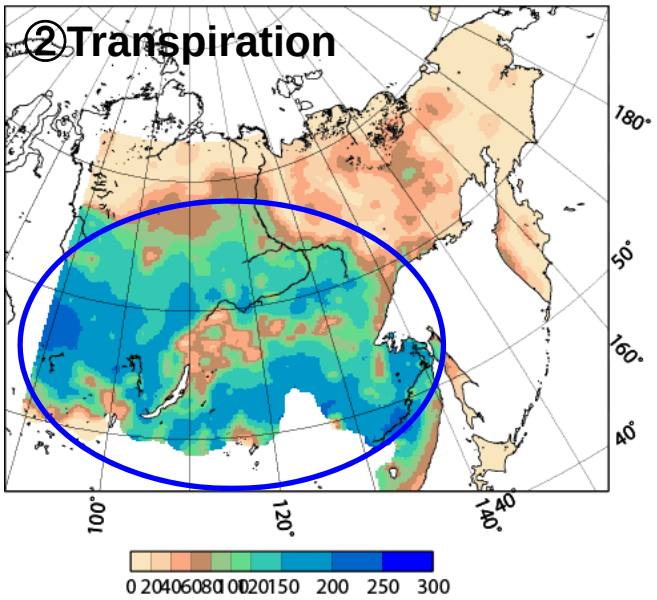
July 20, 2002



Simulation results of thawed depth (left) and soil moisture(0-3m) (right)

Results （Mean value of 1986-2004）





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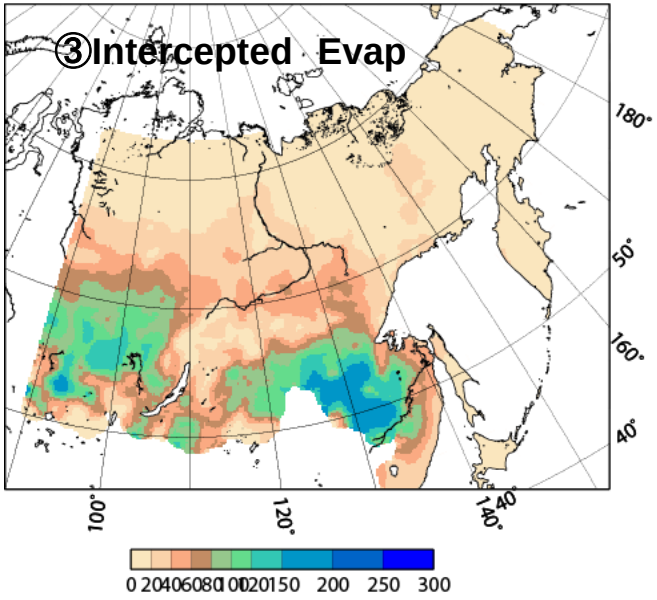
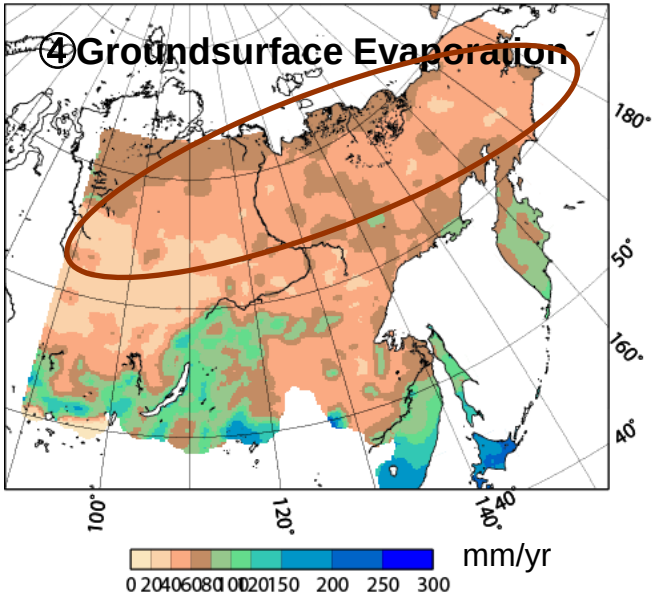




Taiga～ ②

Tundra～④

Future plans for 4 collaboration topics

1. Convergence of Observation and Data Integration.
2. Long-term Variation of Snow Distribution in the Northern Latitude Region and Its Impact on Atmospheric Circulation.
3. Water and Energy Budgets (WEBs).
4. High Mountain Hydrology Including Glacier.

(1) Topic 1 : Consideration and integration of cold region sites of new CEOP2 reference sites.

(2) Topic 2: Data archive and data-set formation of snow cover and frozen ground for Asian regions. Application of CEOP data for interaction studies.

(Recommended at Asia-CliC Workshop, 2007 and 2nd Asia-CliC Symposium, 2007. Works are being done bit slowly)

(3) Topic 3: Application of land hydrological model to all Siberian rivers based on long-term data for understanding the hydrological intensification (run-off increase).

(4) Topic 4: Gathering information, data and analysis results within the activities of the glacier group of Asia-CliC and CliC.

Issues in Cold Region Hydro-climate

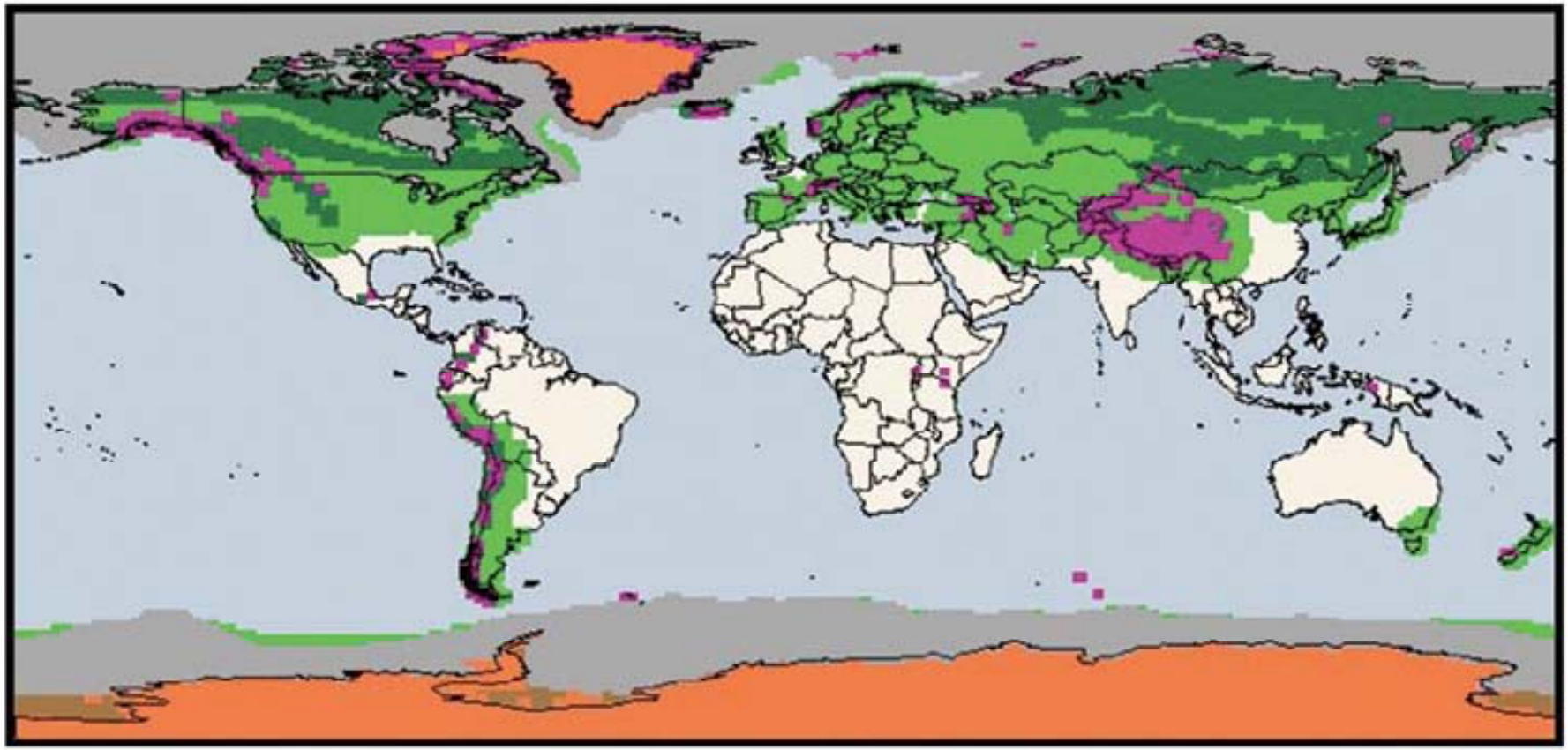
Daqing Yang

CliC International Project Office
Norwegian Polar Institute
Tromso, Norway

Climate and Cryosphere

...a core project of the World Climate Research Programme

Global Cryosphere by Type



Cold rivers and lakes

Glacier

Ice Sheets

Ice Shelves

Sea Ice

Permafrost

Snow Cover

CPA1. The Terrestrial cryosphere and hydrometeorology of cold regions

Central questions:

- What will be the magnitudes, patterns and rates of change in terrestrial cryosphere regimes on seasonal to century time scales? What will be the associated changes in the water cycle?
- What is the role of terrestrial cryospheric processes in the spatial and temporal variability of the water, energy and carbon cycle of cold climate regions, and how can they be parameterized in models?
- What are the interactions and feedback between the terrestrial cryosphere and atmosphere/ocean systems and current climates, its variability and future change?

Outputs: (solid precip, snow, lake- and river-ice, glaciers, permafrost, frozen ground)

- **Spatial-temporal variability**
- **Changes in the cryosphere and water cycle**
- **Observations and data**
- **Modelling**

Cold climate hydrology is a key component of CPA1 – CliC/GEWEX/CLIVAR all have contributions to understanding cold climate regions

Issues in Cold Region Hydro-climate

- Cold regions/Arctic precipitation
- Human impact on hydrology change
  - Dams / reservoirs regulations
  - Water use (mining, oil/gas, irrigation, and municipal activities)
- River thermal regime and change
  - River ice (CliC Theme 1 – T Prowse/SHI)
  - Water temperature (ICARP–II, CliC)
- RS snow (SCE/SWE) data and validation
  - Basin SCE/SWE vs. discharge
  - Basin SWE vs. snowfall
- Sediment flux and budget
  - Boulder workshop

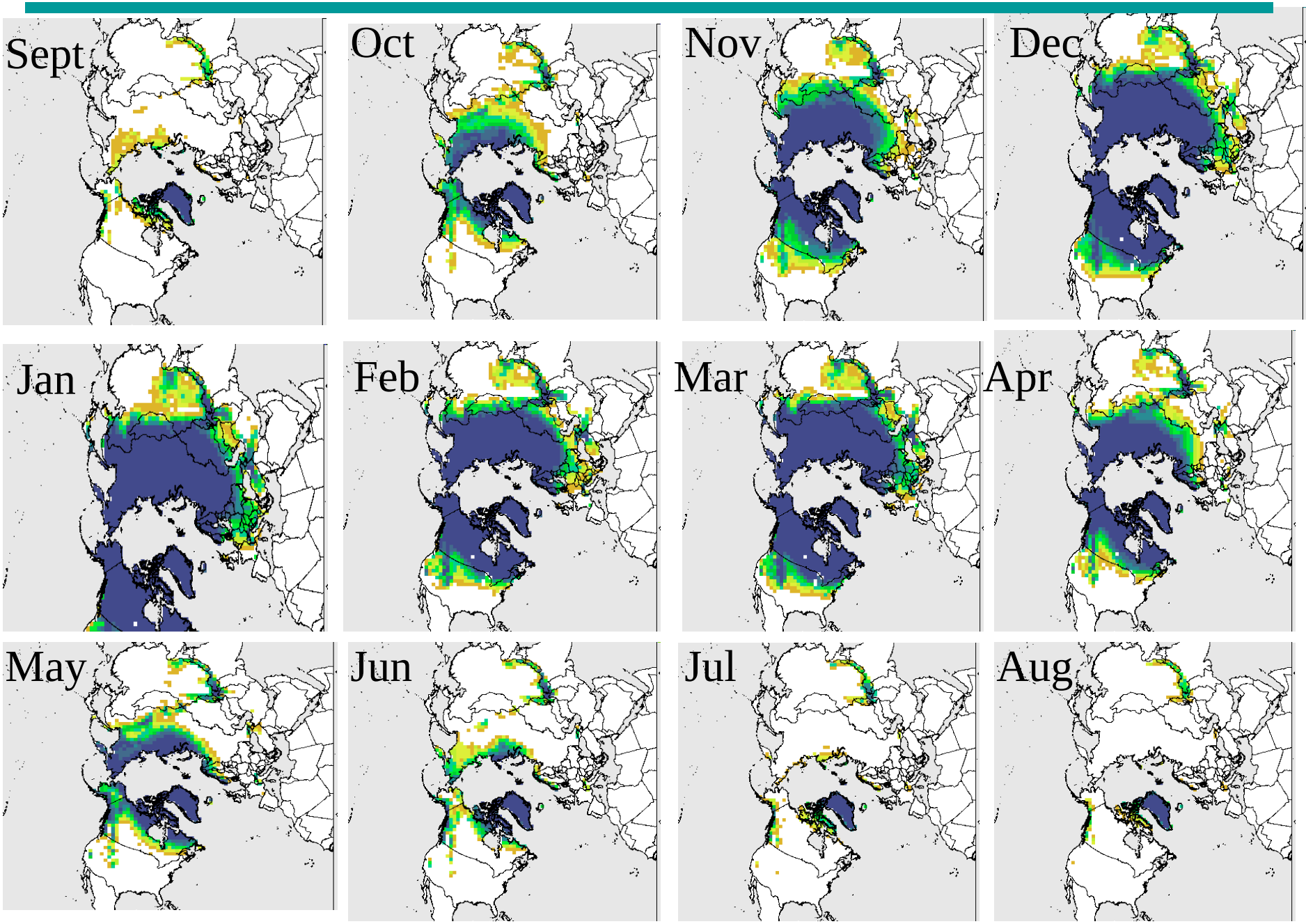
Cold Region/Arctic Precipitation Issues

- *Operational networks – our knowledge base*
  - *Decline of the networks in the northern regions, including Siberia, Alaska and N. Canada*
  - *Few stations in the mountain regions*
  - *How to sustain and improve the operational networks*

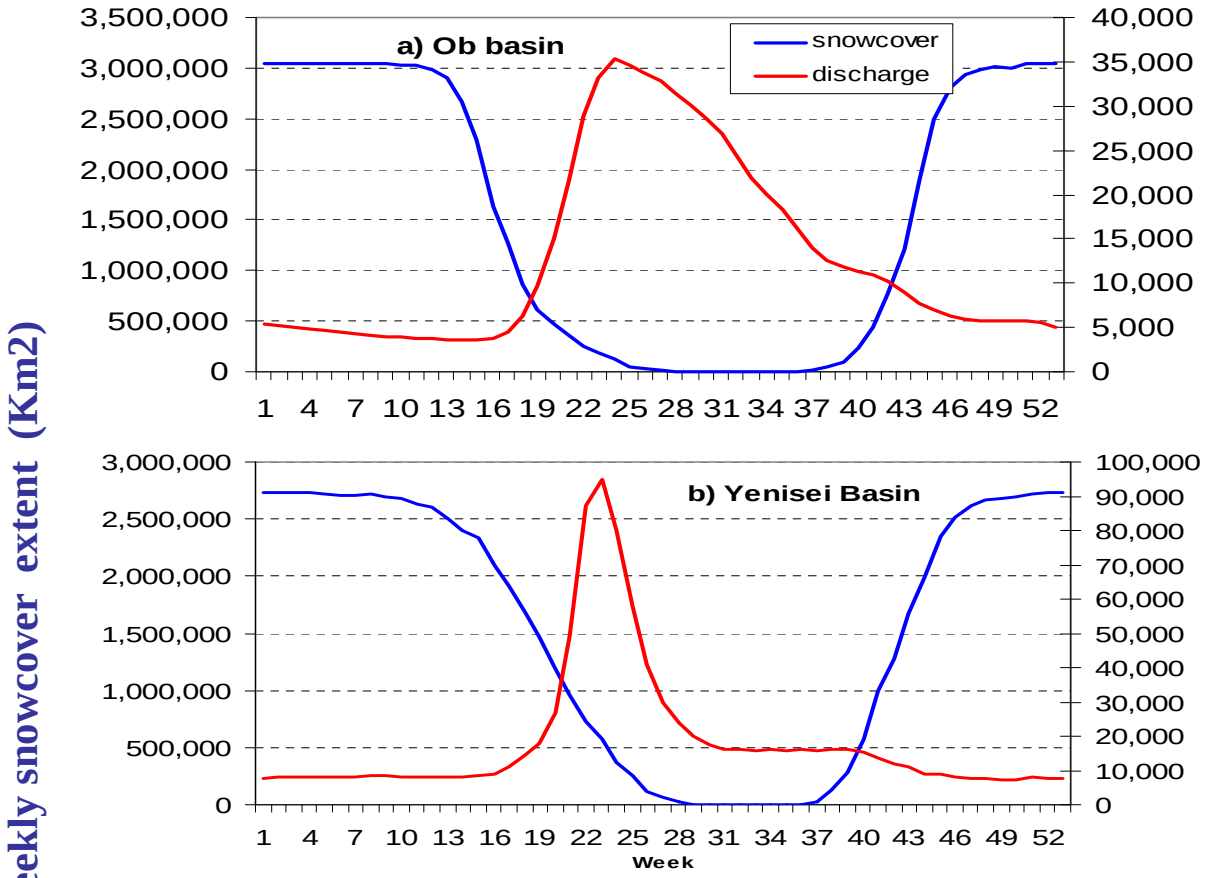
- *Data quality and compatibility across national boundaries*
  - *Large biases in gauge measurements of solid precipitation*
  - *Incompatibility of precipitation data due to difference in instruments and methods of data processing*
  - *Difficulties to determine precipitation changes in the northern regions*

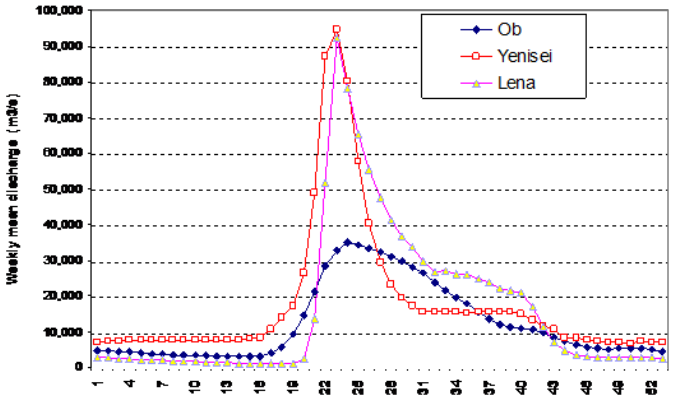
- *Validation of precip data, including satellite and reanalysis products and fused products at high latitudes.*

Snow Cover : NOAA Monthly Snowcover Extent, 1966-99 / Rutgers Univ.

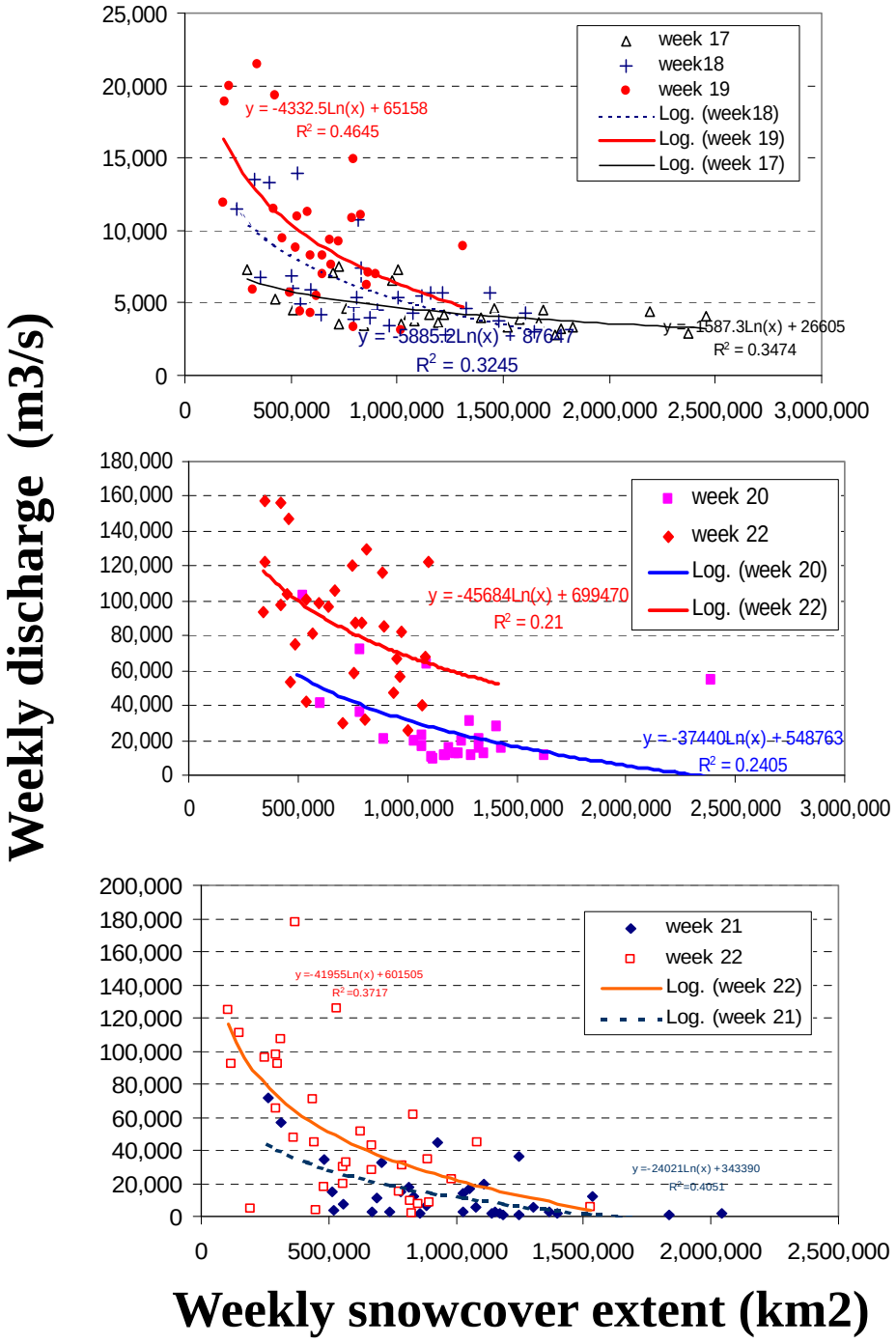


Weekly mean basin snowcover & discharge over Siberian large watersheds, 1966-99.





Weekly relation of discharge vs. snowcover extent

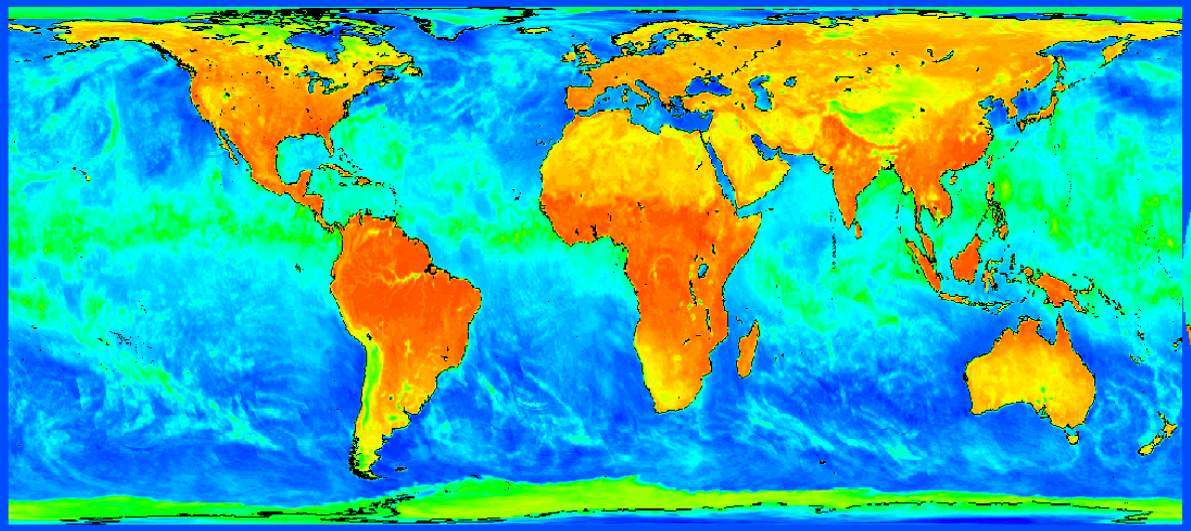


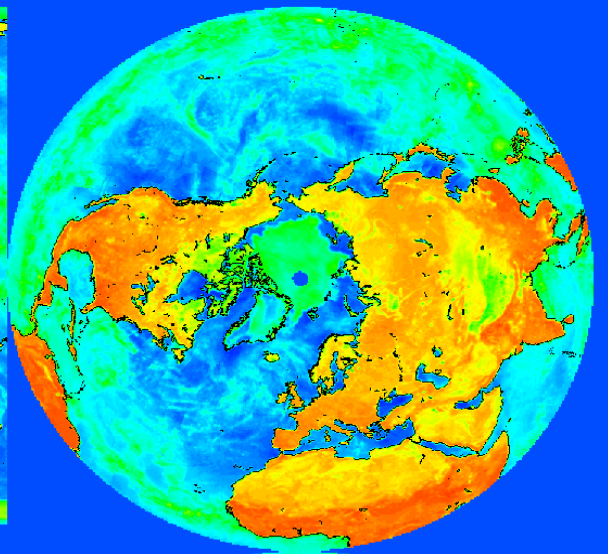
Ob River, Weeks 17-19

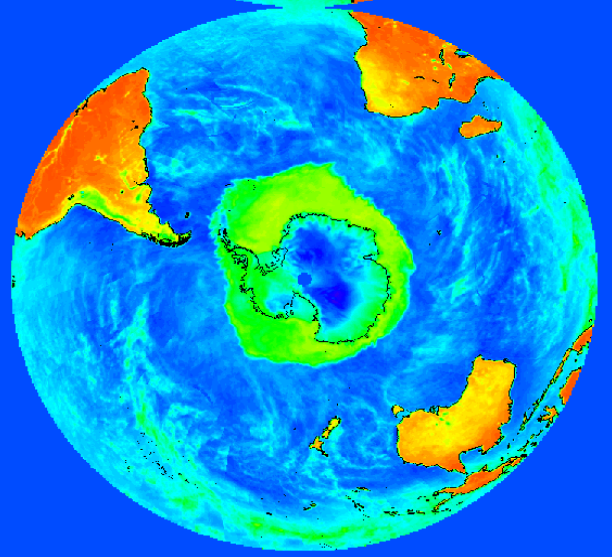
Yenisei River, Weeks 20-22

Lena River, Weeks 21-22

SWE Dataset







SMMR, SSM/I & AMSR-E Brightness Temperatures 1978-2007

EASE-Grid

(Equal-Area Scalable Earth Grid)

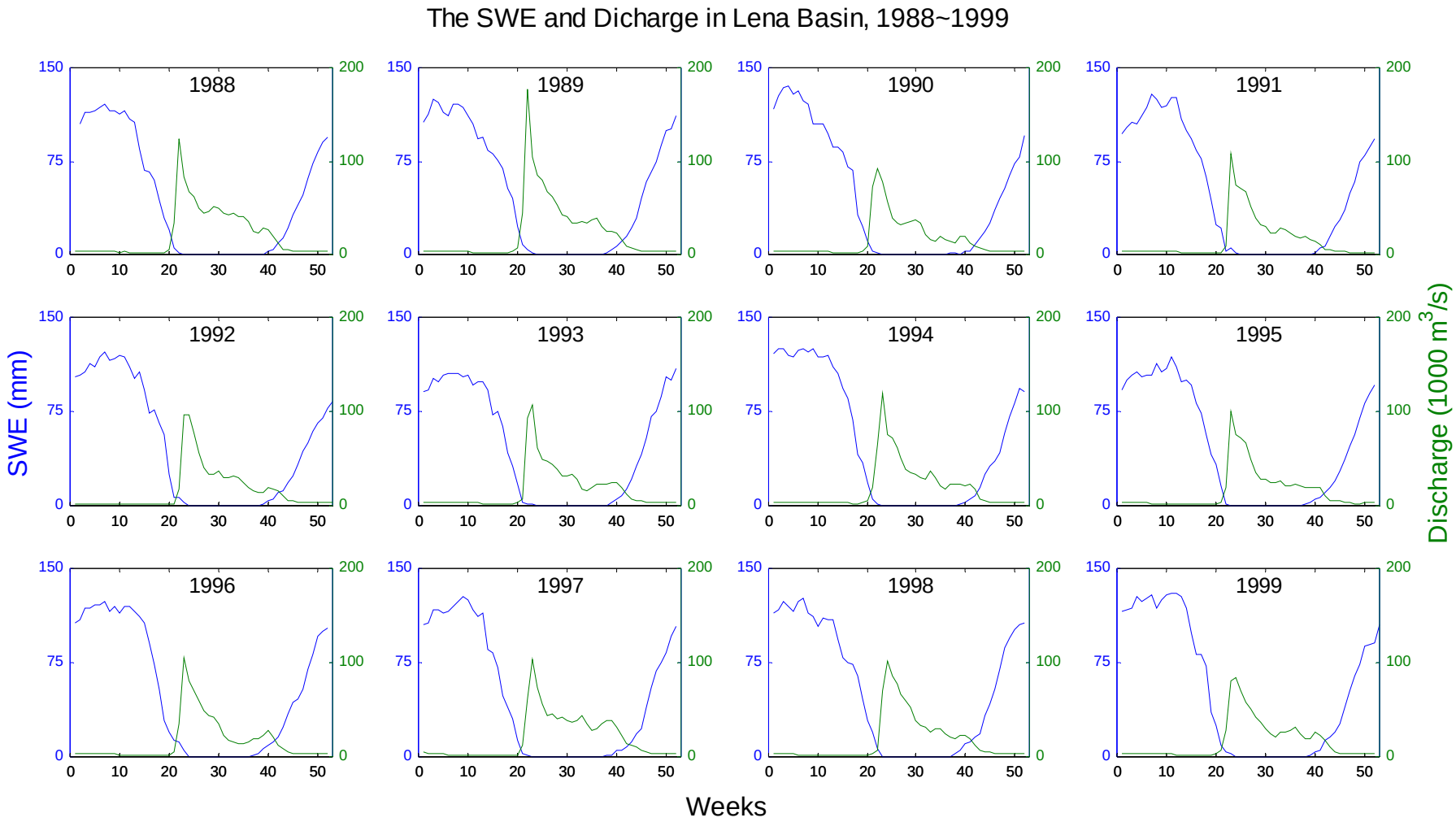
Full Global, North and South Hem. Projections

$$SWE\ (mm) = 4.77\ (\ (TB\_19H - 6.0) - (TB\_37H - 1.0\ )\ )$$

TB_19H and TB_37H are horizontally-polarized SSM/I brightness temperatures (K) at 19 and 37 GHz, respectively.

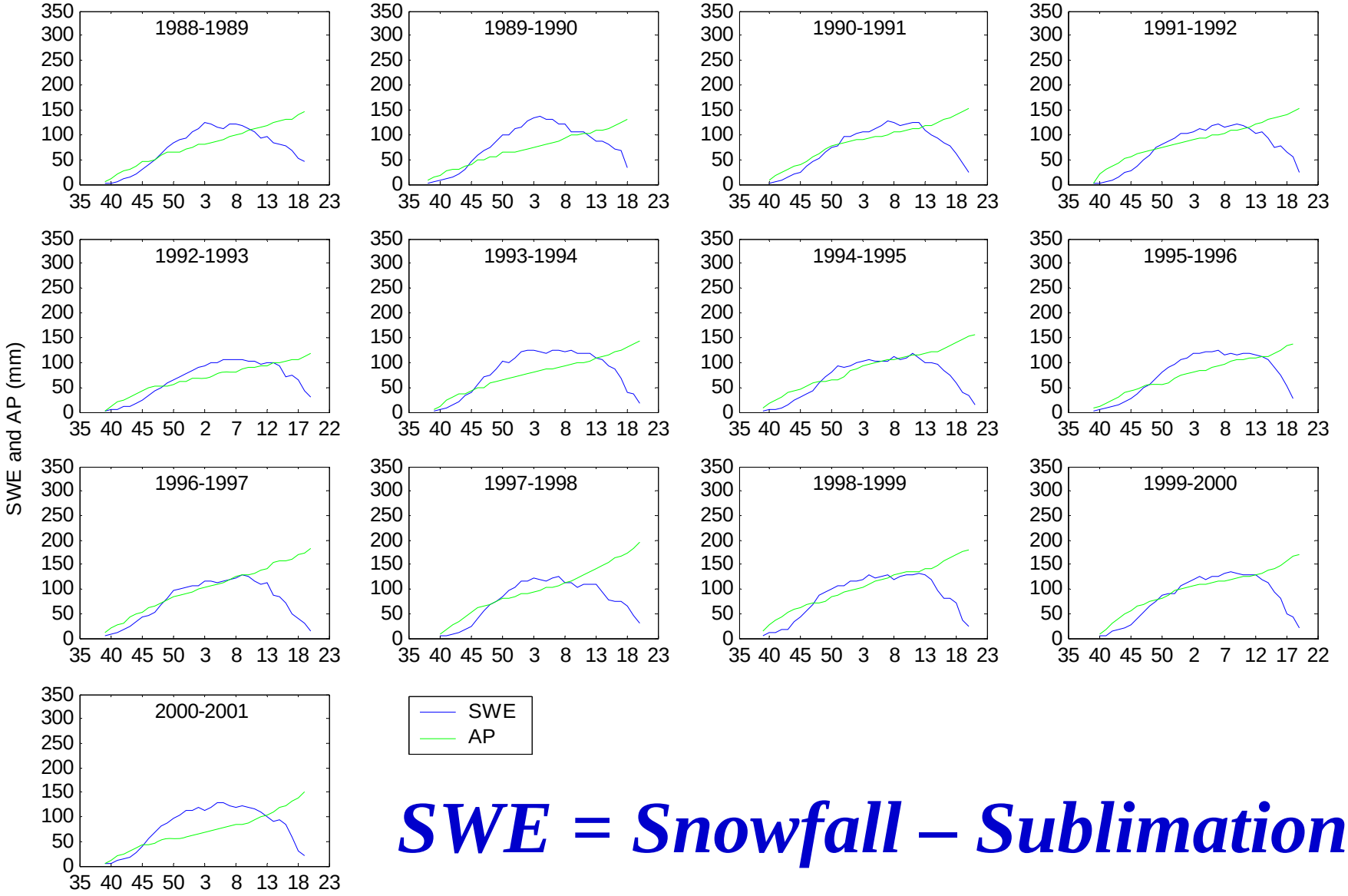
http://nsidc.org

Basin SWE (mm) vs. weekly discharge (m3/s), Lena R., 1988-99



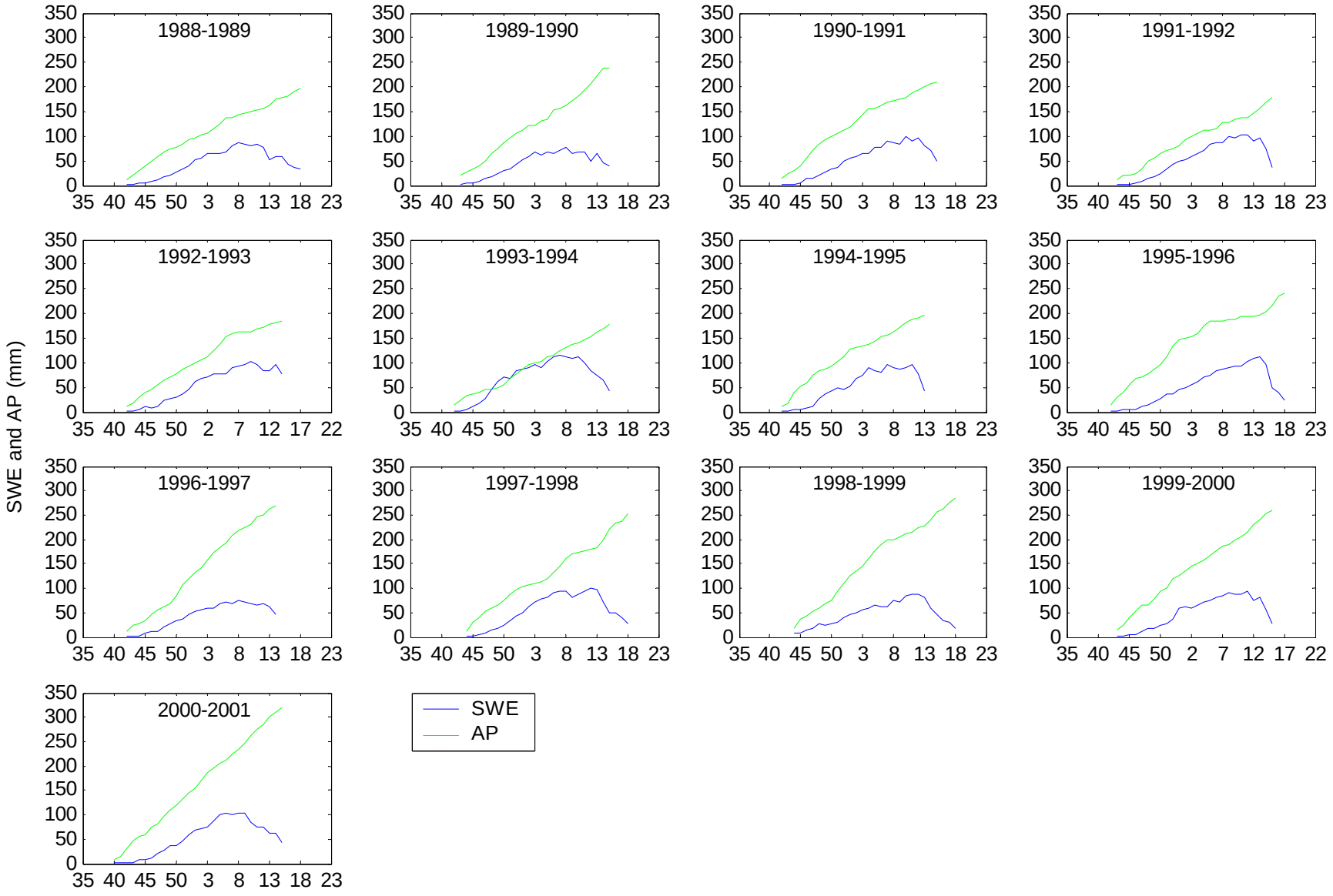
Streamflow = SWE – ET?

Basin SWE vs. Winter Precip (mm), Lena R., 1988-01



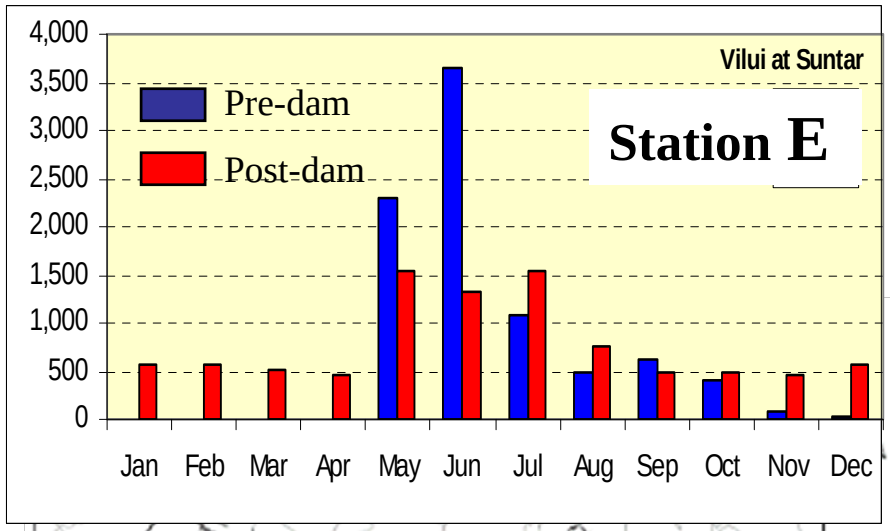
SWE = Snowfall – Sublimation?

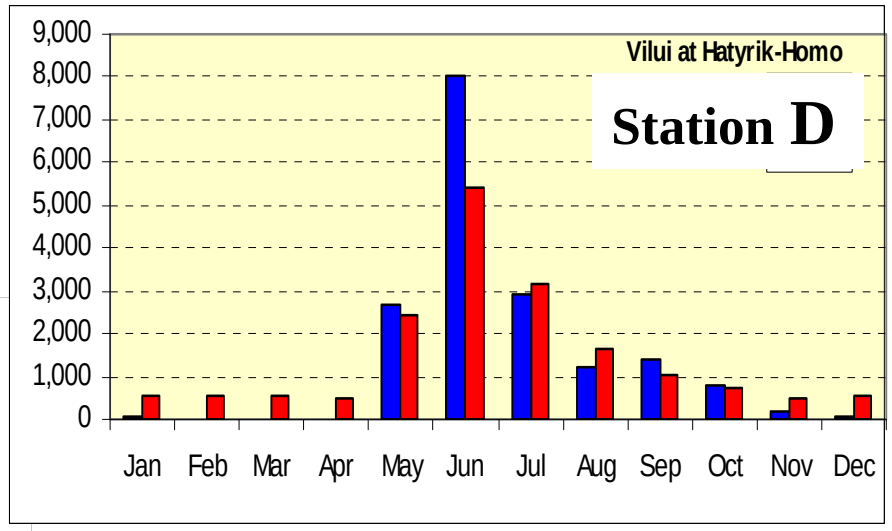
Basin SWE vs. Winter Precip (mm), Ob R., 1988-01

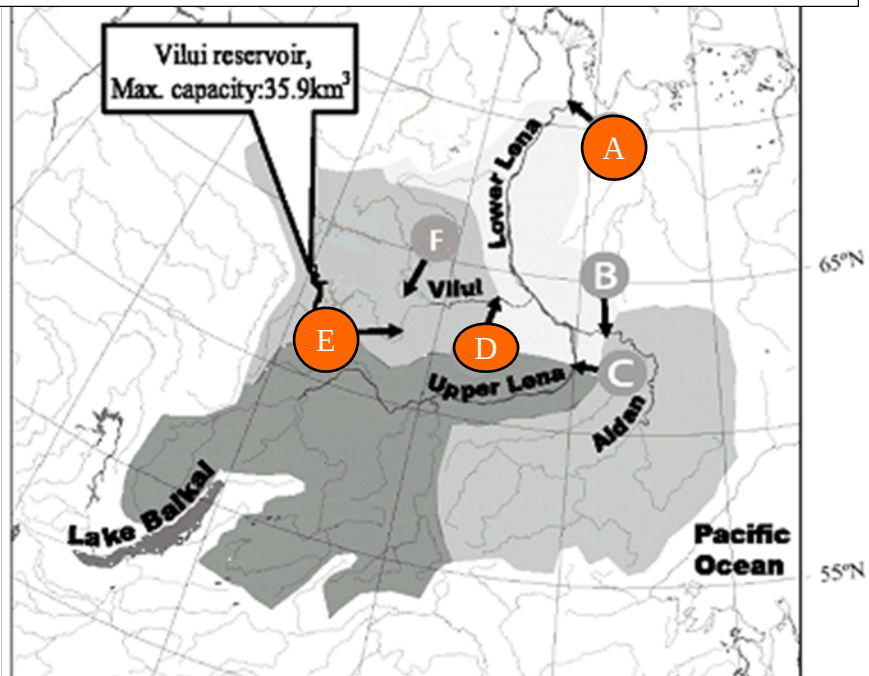


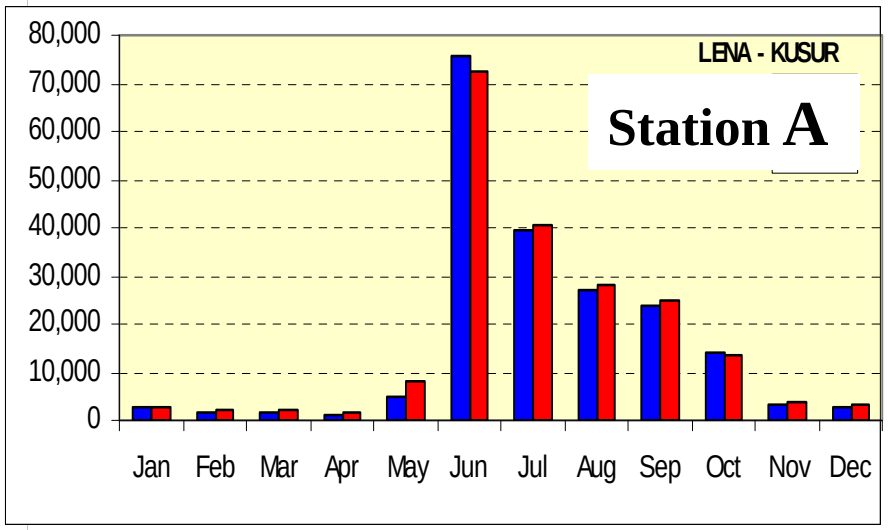
Dam Regulation and Impact:

Monthly mean discharge for pre-dam (1942-67) and post-dam (1968-90) periods at stations E, D and A

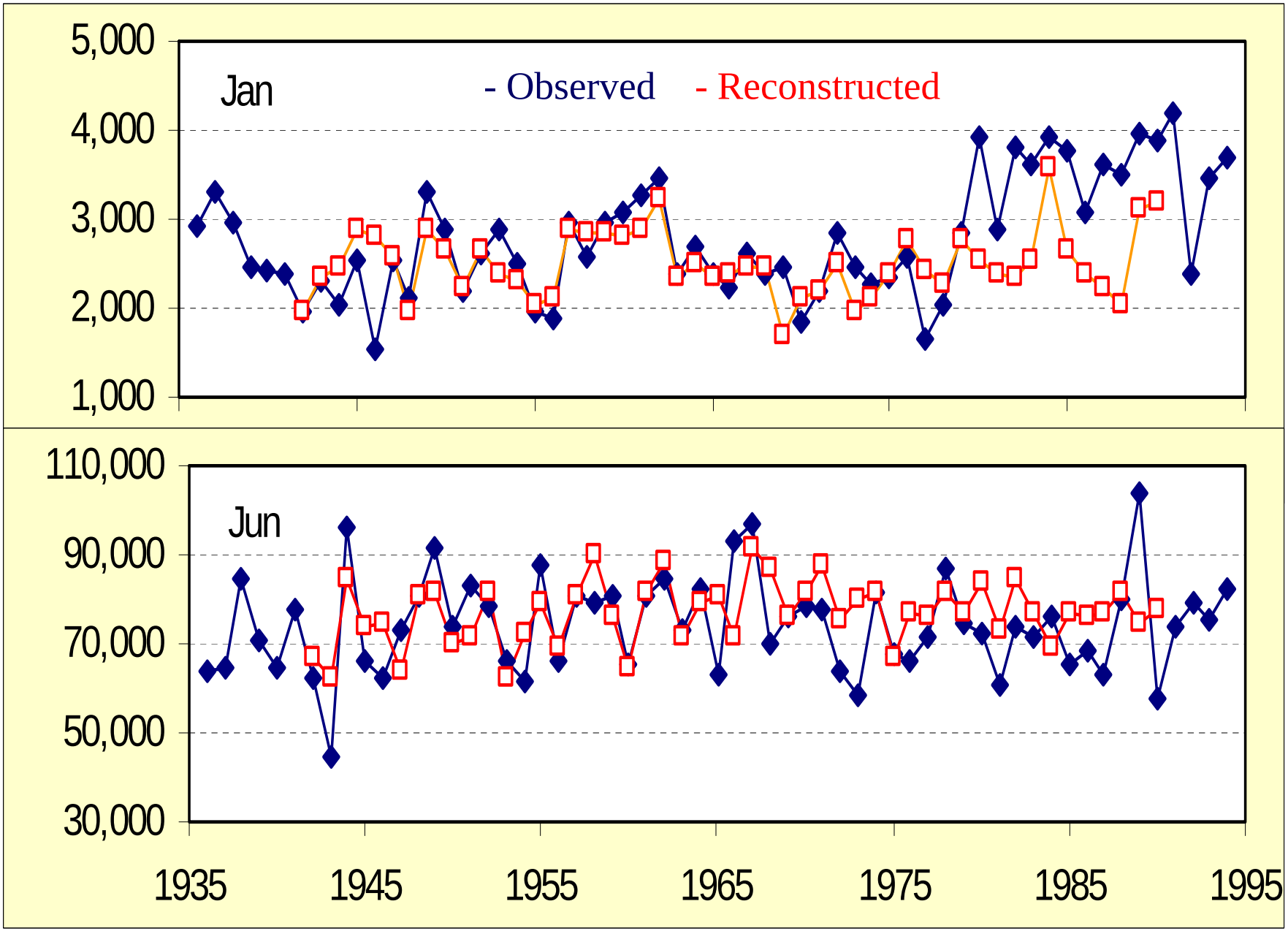








Comparison between observed and reconstructed monthly discharge at the Lena basin outlet, 1942-90



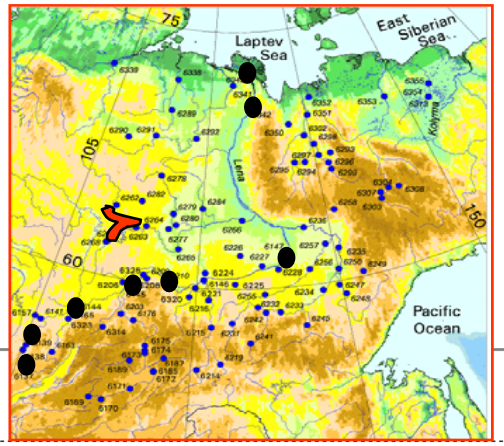
River Ice: Freeze-up and Break-up Dates

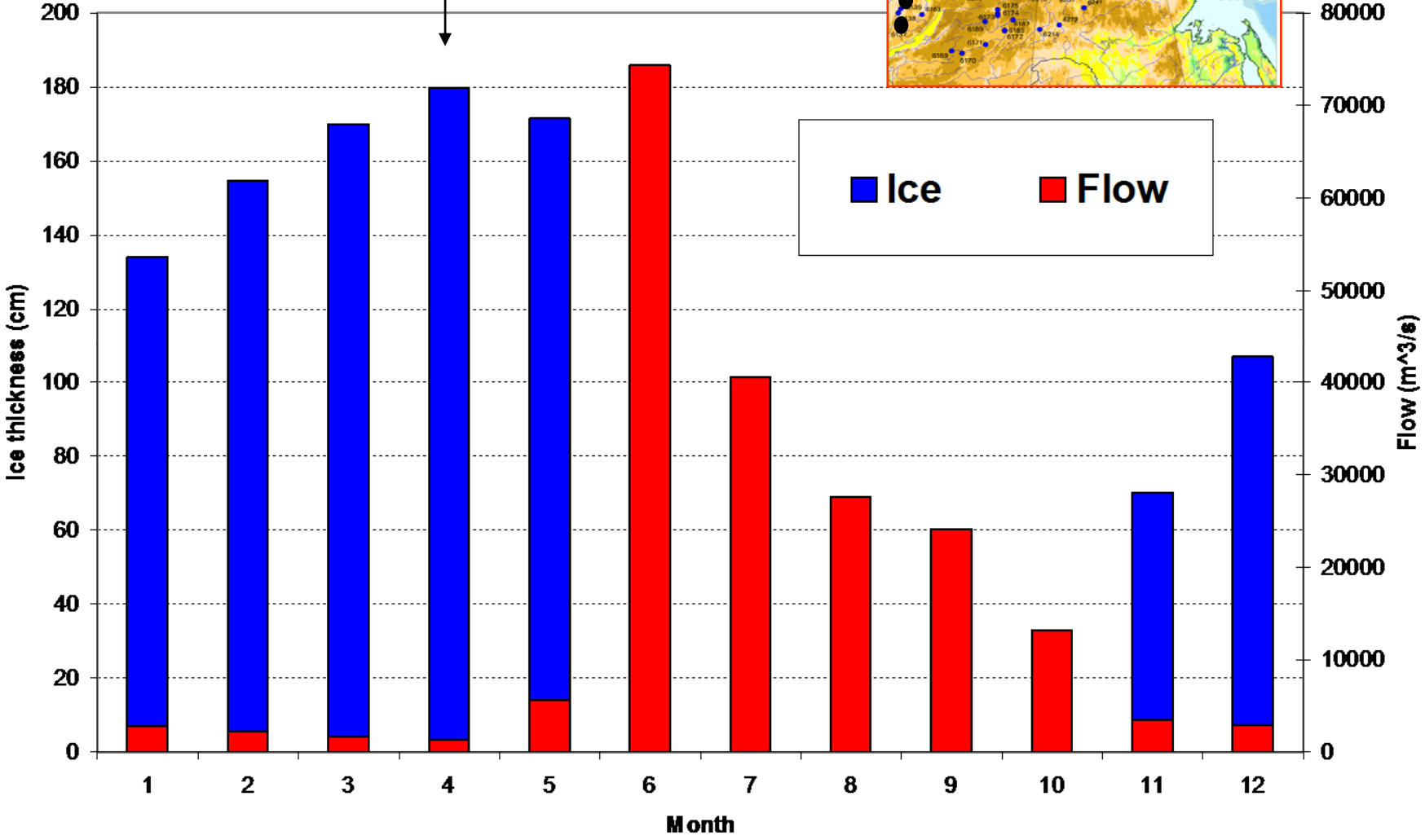
Freeze-up

Break-up

Max Ice

Min flow **Lena at Kusur**





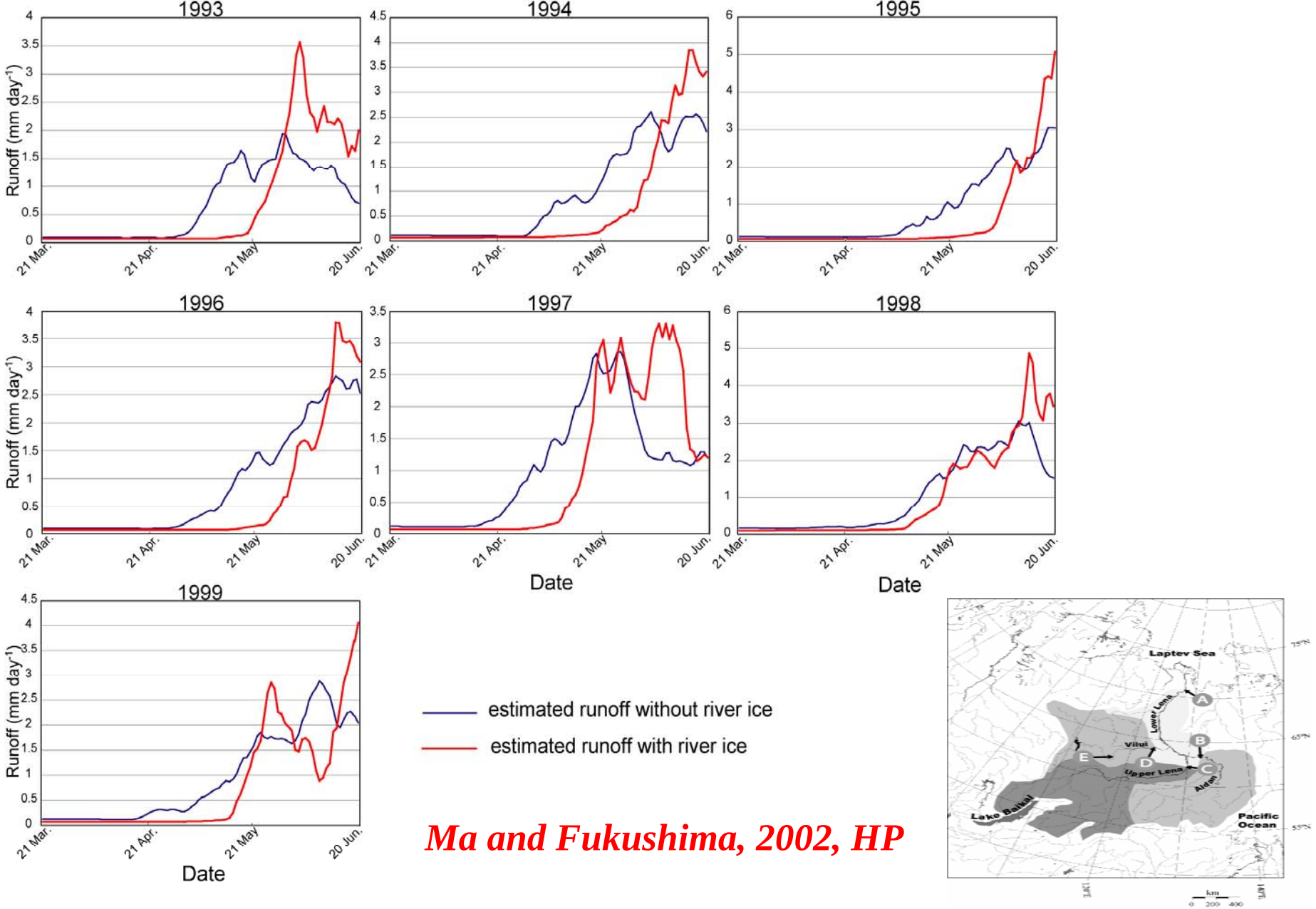


Fig. 4. Comparison of hydrographs simulated by the Ma and Fukushima (2002) model with and without river ice during 21 March -20 June at Tabaga on the Lena River from 1987 to 1999.

Sediment

SEDIBUD Workshop, Boulder, U.S.A.: Sediment Fluxes Budgets in Changing High-Latitude and High-Altitude Cold Environments, Sept 08

1. Joyce Glacier, Garwood Valley
2. Garwood Glacier, Garwood Valley

Argentina

3. Laguna Potrok Aike

Austria

4. Pasterze

Bulgaria

5. Musala area

Canada

6. Cape Bounty

Finland

7. Kidisjoki

Germany

8. Reintal

Greenland

9. Kangerlussuaq-Strømfjord
10. Mittivakkat glacier catchment
11. Zackenberg

Iceland

12. Botn í Dýrafirði
13. Reykjaströnd
14. Tindastóll
15. Fnjóskadalur-Bleiksmýrardalur
16. Hofsjökull, northern forefield
17. Austurdalur
18. Hrafnadalur
19. Orravatnsrústir

India

20. East Dabka Watershed (Kumaon Himalaya)

New Zealand

21. Douglas Glacier
22. Godley Valley
23. Unnamed Valley

Norway

24. Erdalen
25. Bødalen
26. Vinstradalen
27. Tana catchment
28. Dynamiskbekken (Svalbard)
29. Ebbaelva (Svalbard)
30. Hørbyeelva (Svalbard)
31. Kaffiøyra (Svalbard)
32. Scottelva (Svalbard)

Russia

33. Mezen

Sweden

34. Latnjavagge
35. Kärkevagge
36. Kårsavagge