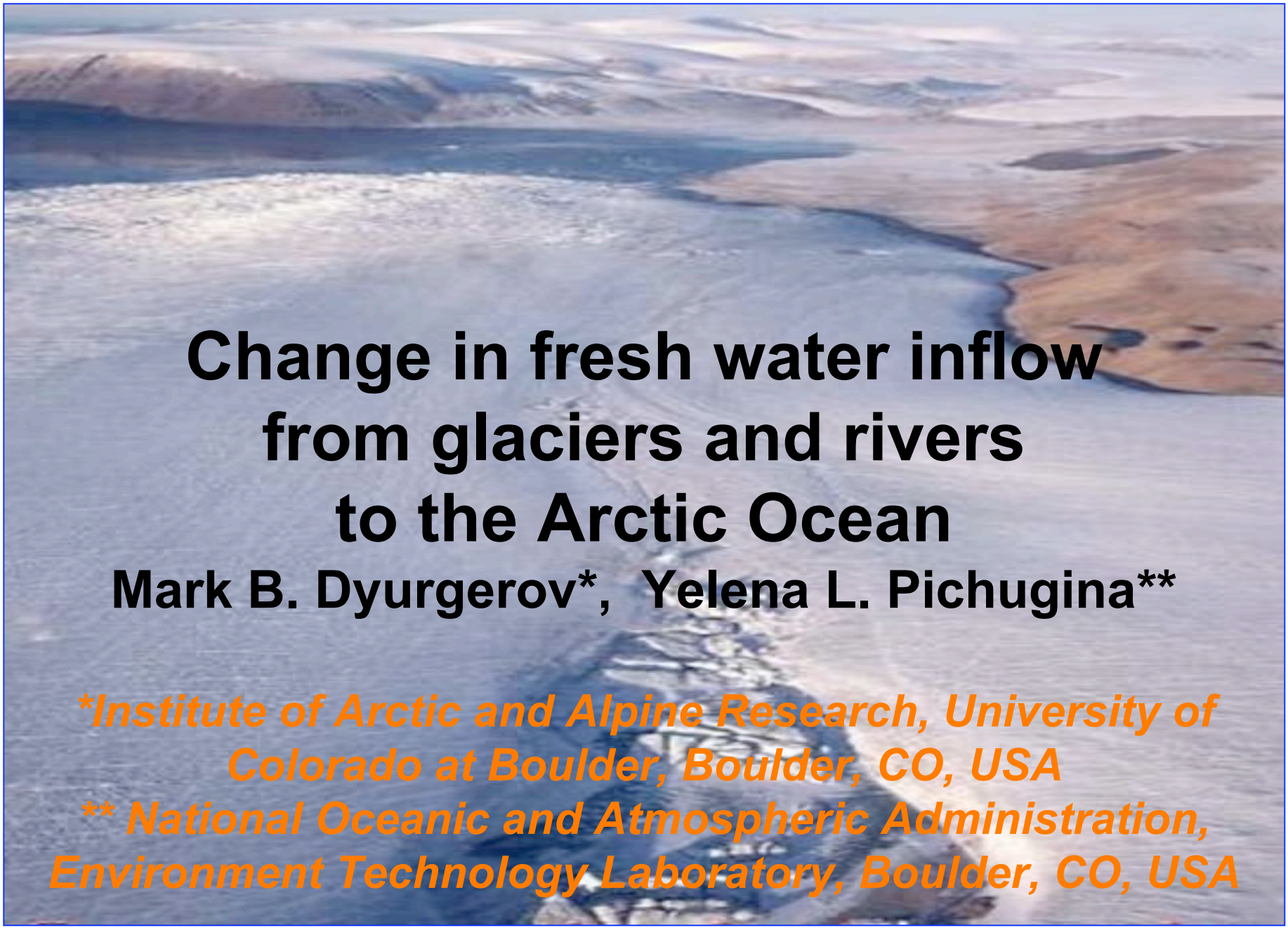

# Change in fresh water inflow from glaciers and rivers to the Arctic Ocean

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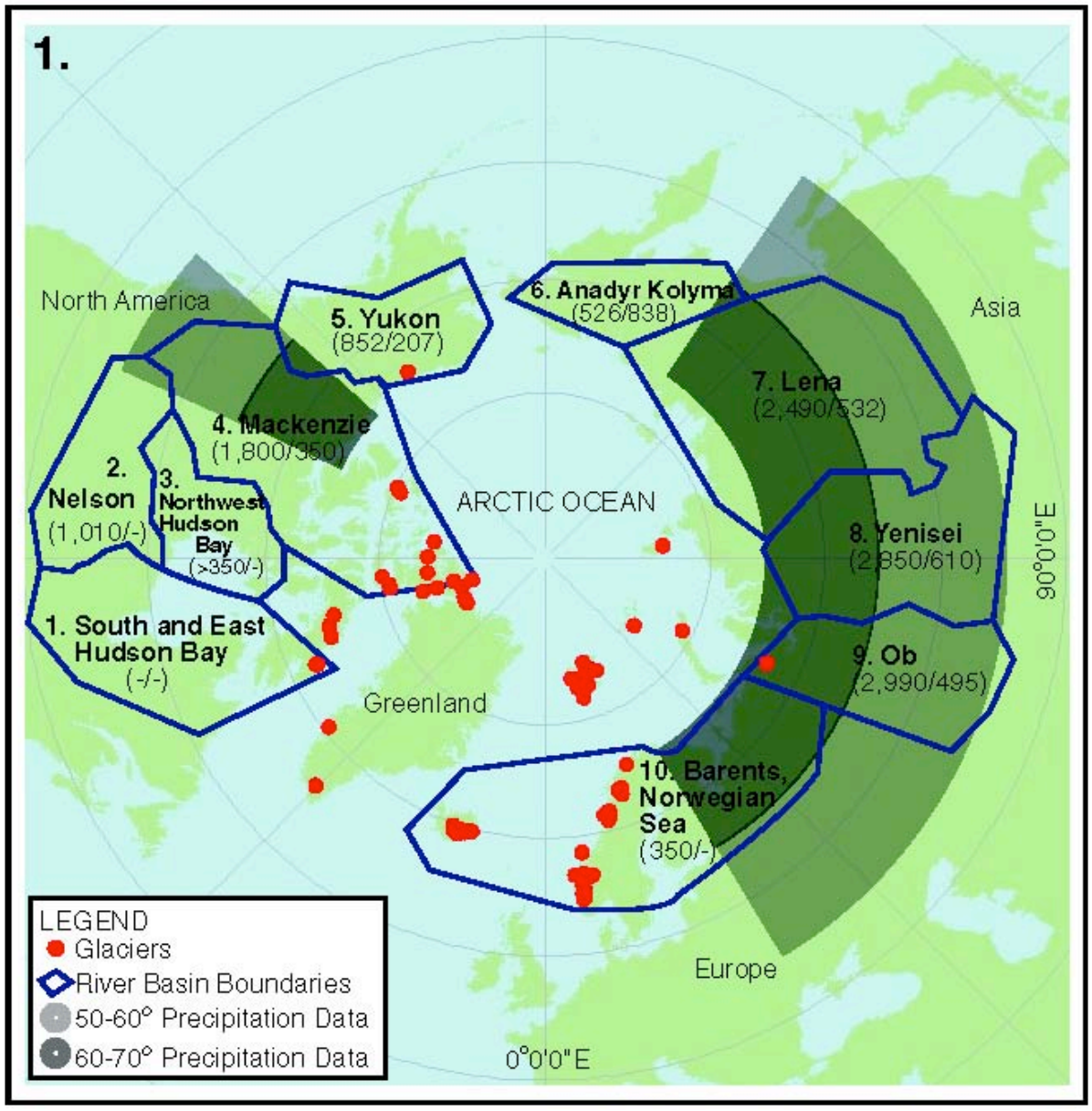
## The Problem

Discharge data measured from large river basins in the pan-Arctic, may not provide an integrative measure of freshwater inflow to the Arctic Ocean (AOc), because these data include only a small fraction of net glacier inflow to the AOc. The main glacier area in the Arctic region has never been gauged. We have noticed and showed here that the glacier net inflow to the AOc, specifically the net glacier volume loss, has been substantial part of seasonal fresh water inflow to the AOc, and has increased since the end of 20th century.




Map of pan-Arctic river basins (basins are numbered from 1 to 10), benchmark glaciers, and precipitation data zones. Numbers in parentheses indicate basin area in 1000 km2, and discharge in km3/year, respectively (Lammers and Shiklomanov, 2001; Hulme, 1999). Note, basin 10 does not included in calculations of river discharge and glacier melt-water production in order to reduce overlapping between gauged and ungauged data.

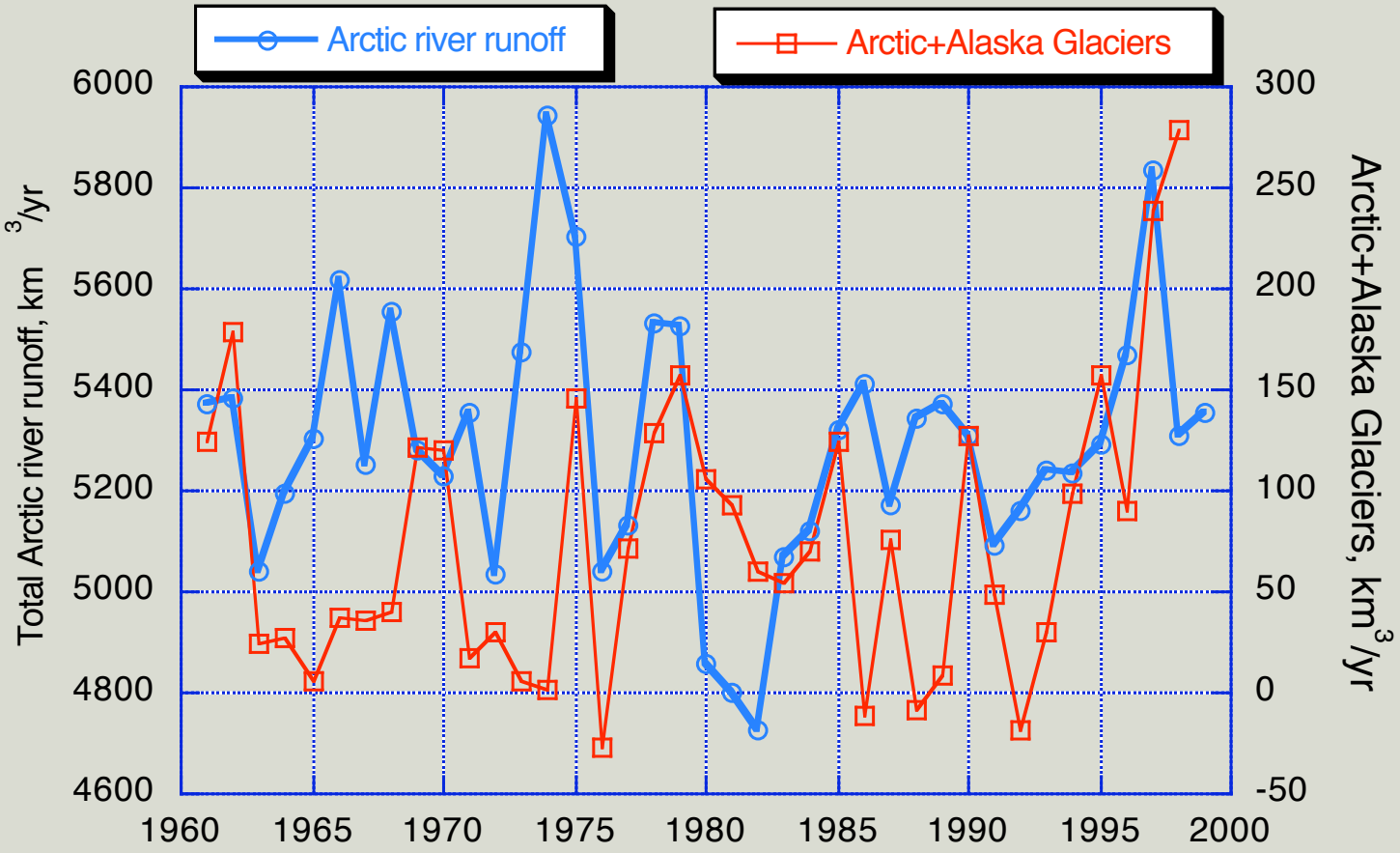



Fig.2 Annual net inflow from pan-Arctic rivers and glaciers not including Greenland ice sheet

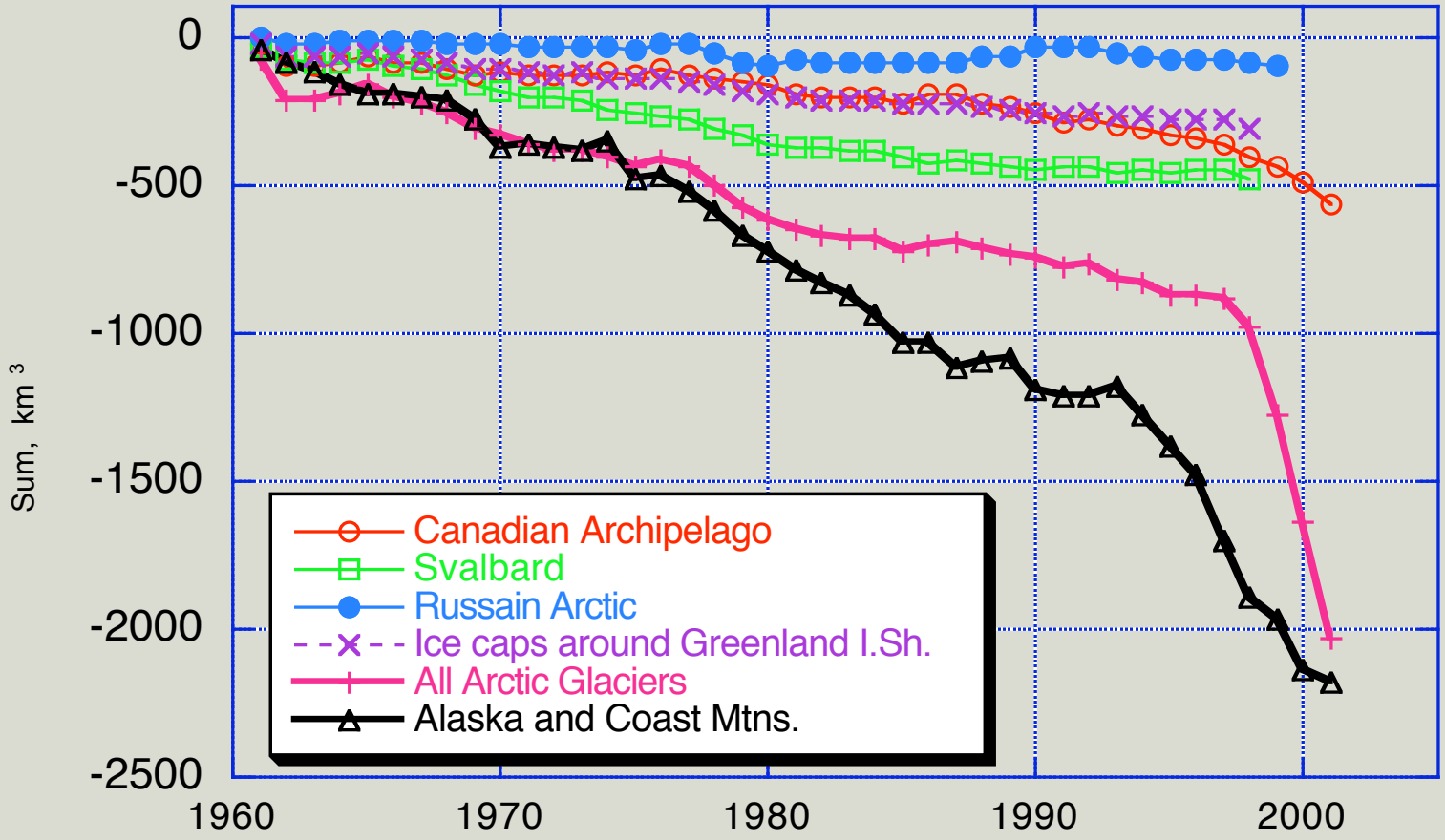



Fig. 3 Glacier volume losses in the pan-Arctic region

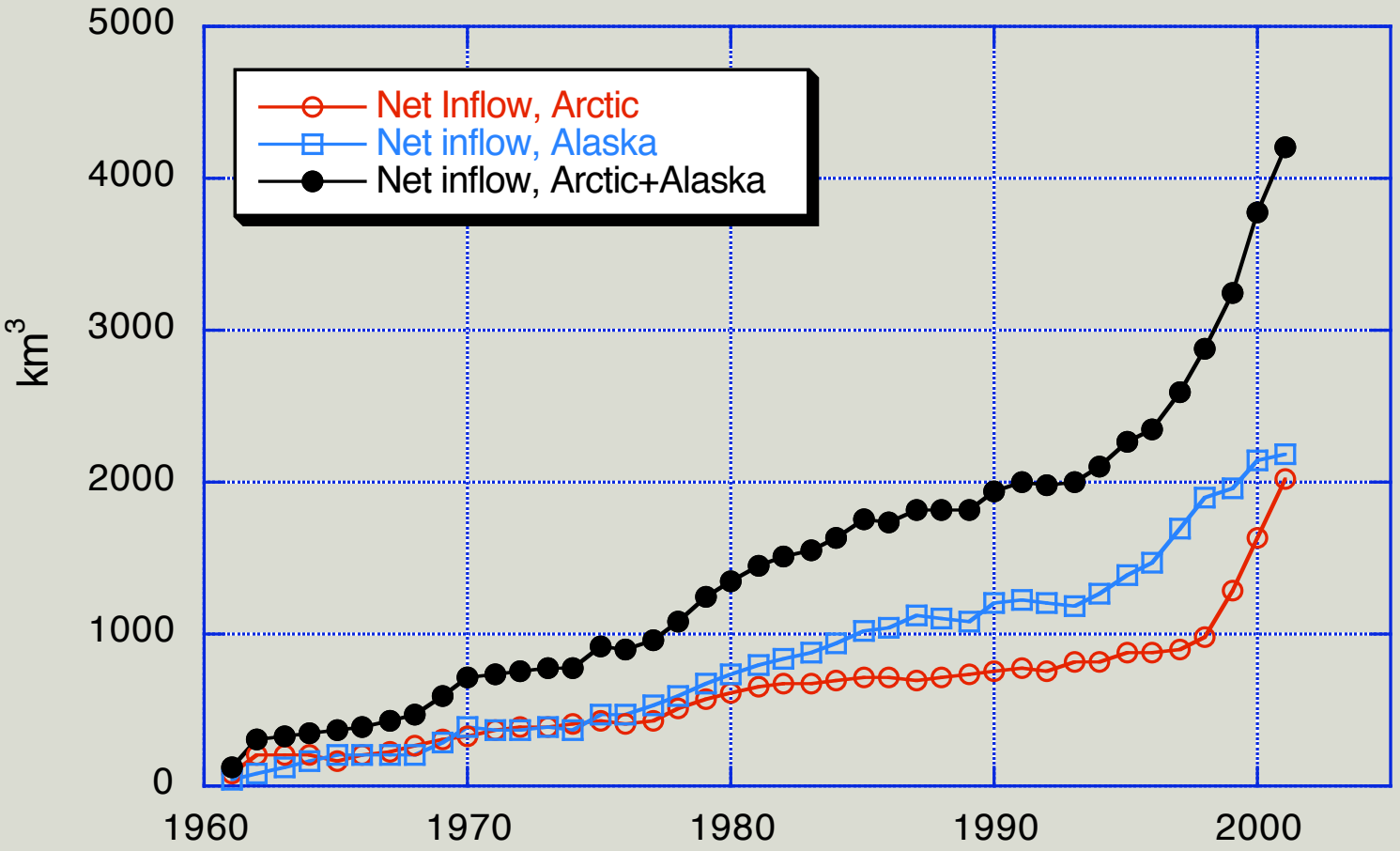



Fig. 4 Net fresh water inflow from glaciers

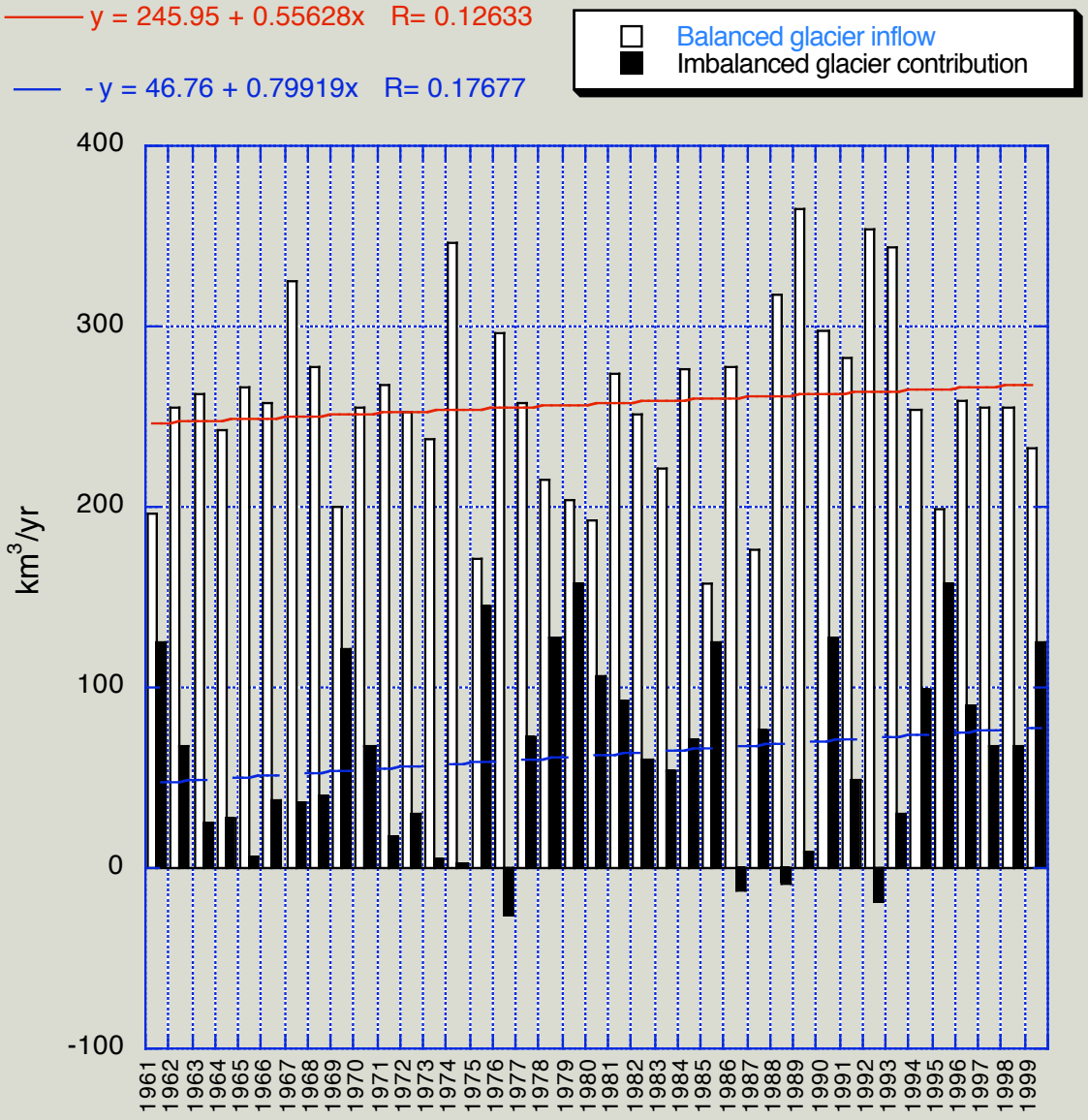



Fig. 5 Two components of glacier melt-water contribution to the Arctic Ocean: 1. “balanced” (equal to annual precipitation at a glacier surface); 2. imbalanced (equal to glacier annual/summer mass losses, mass balance).

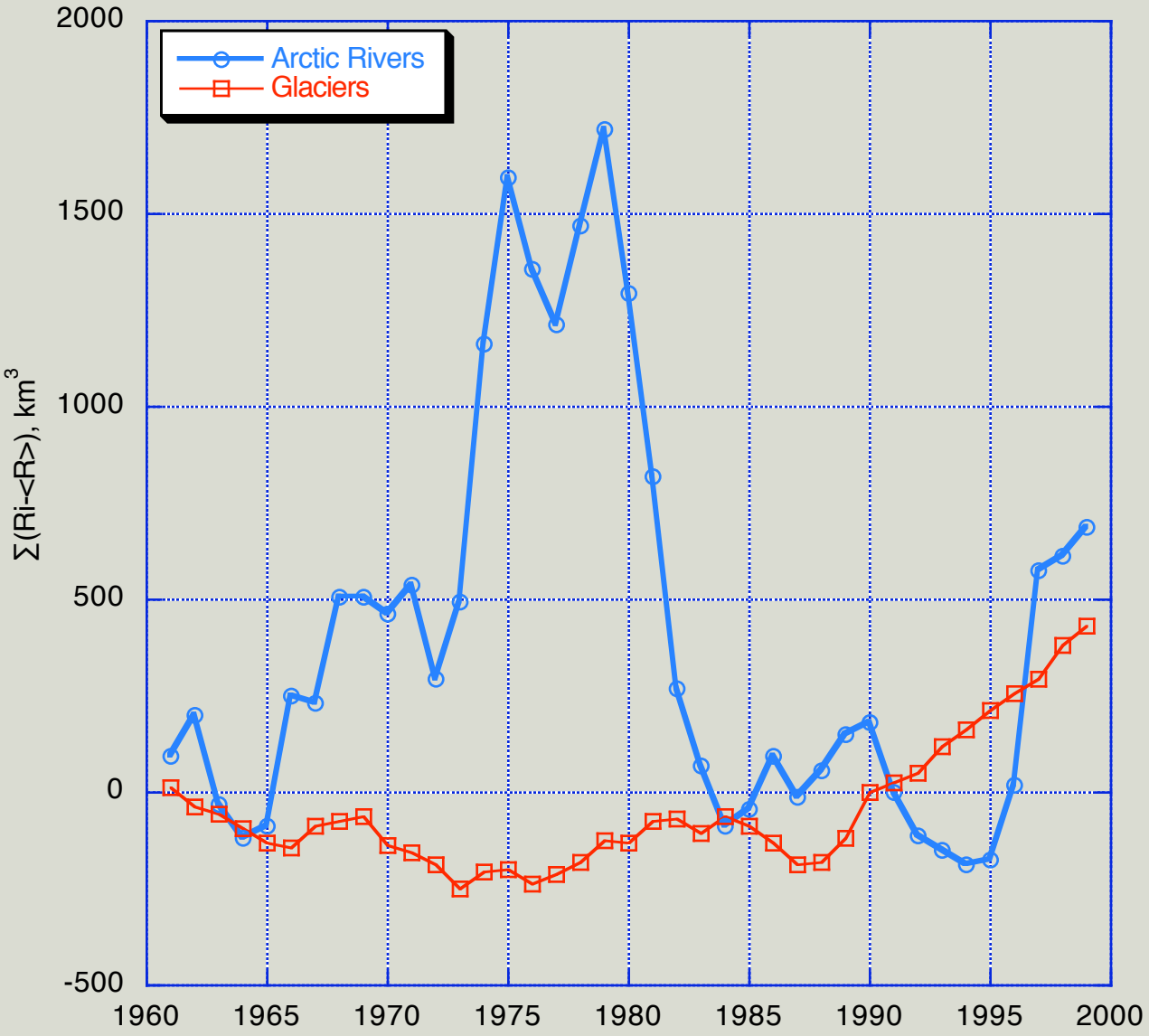



Fig. 6 Change in River and Glacier runoff to the AOc; cumulative departures from reference period 1961-1990.

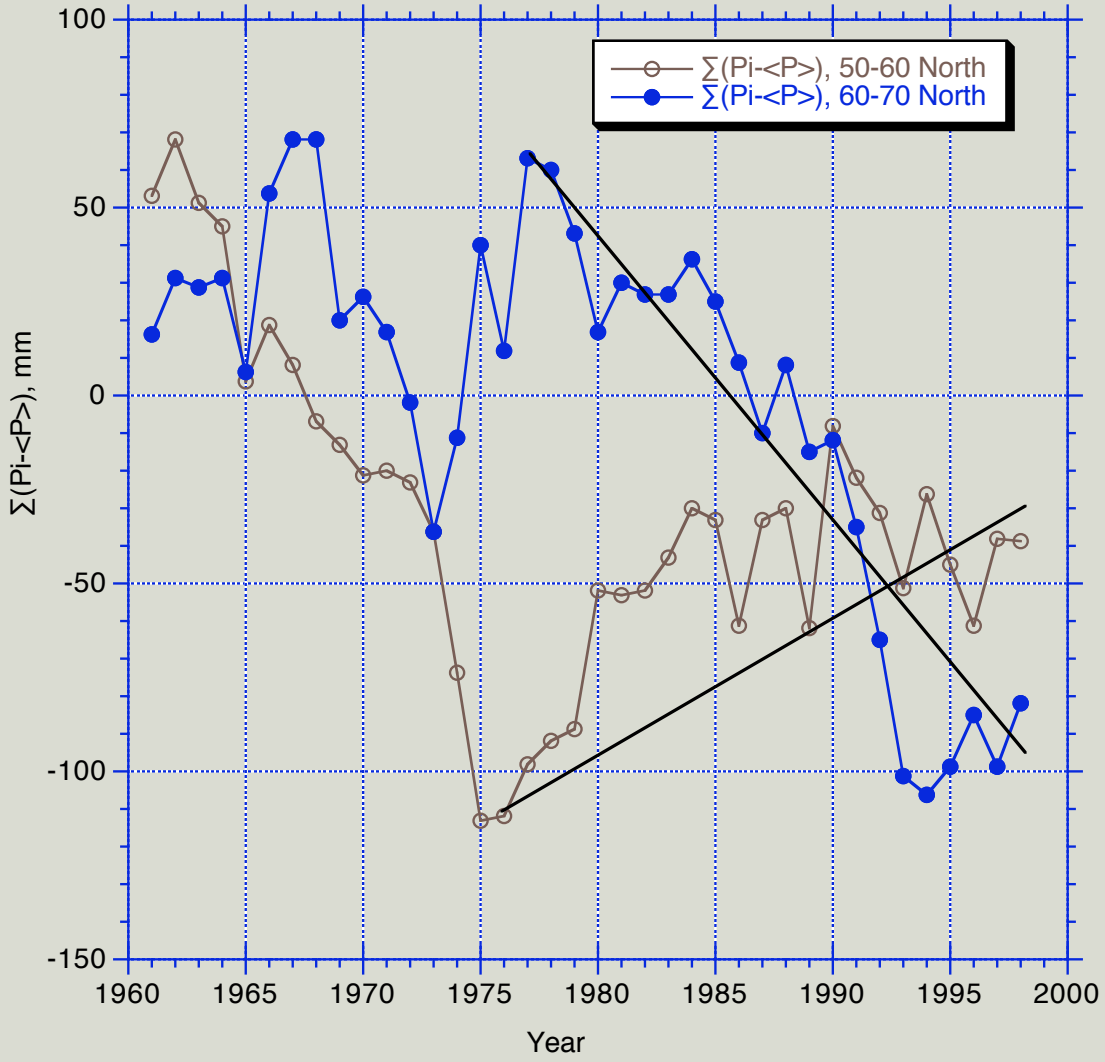
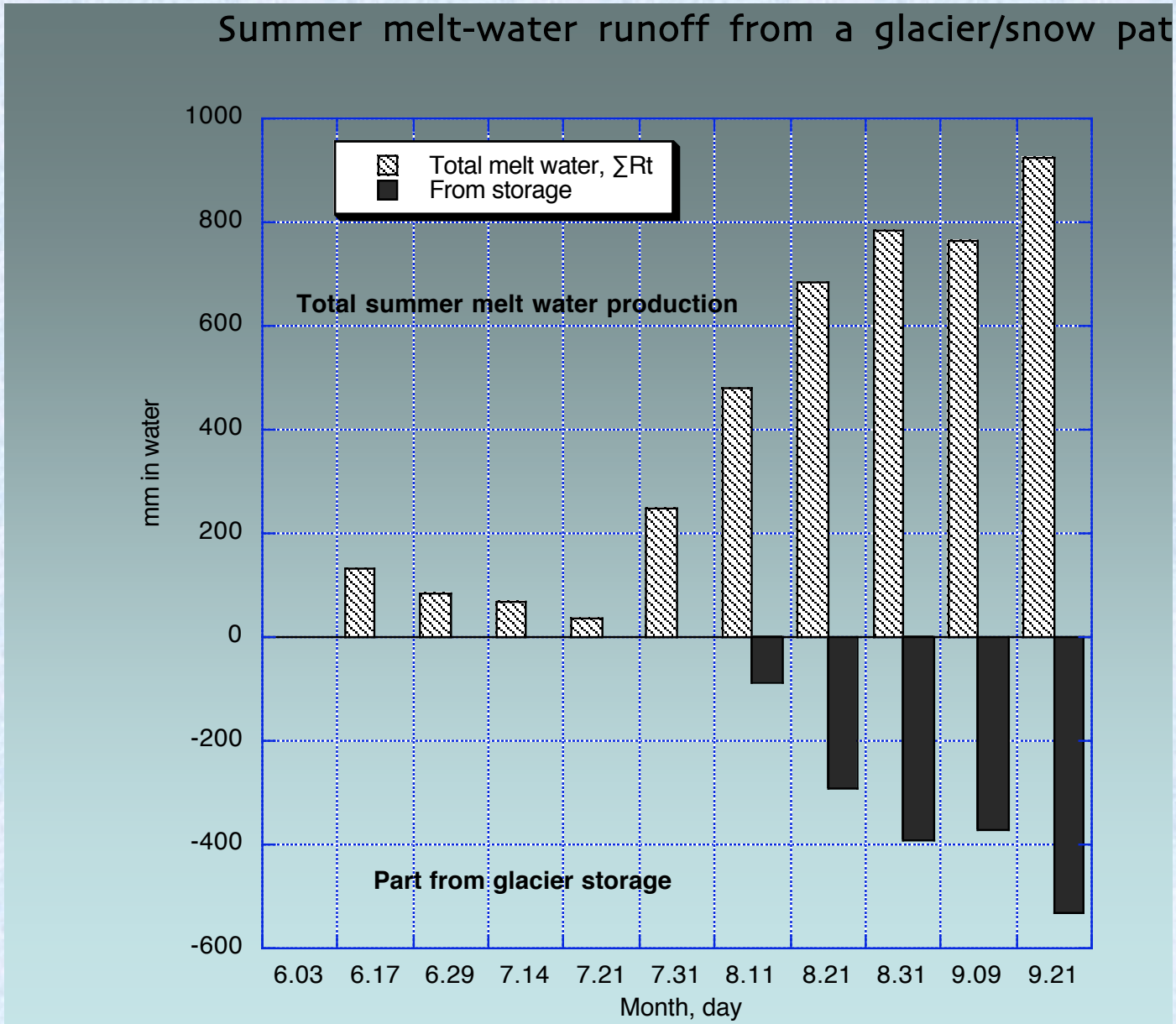


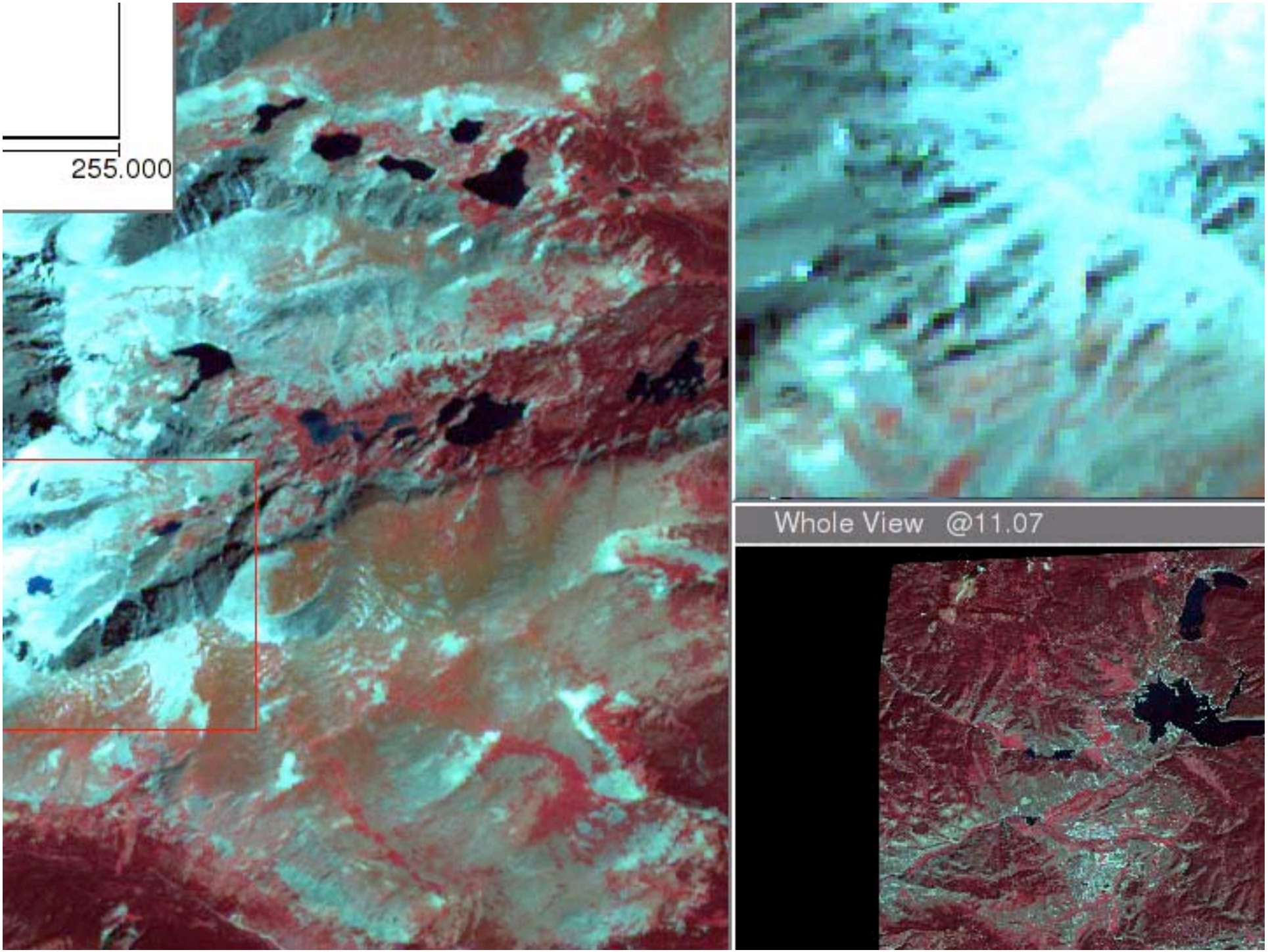

Fig.7 Annual precipitation changes through time in watersheds of 9 large pan-Arctic basins. Data is in two latitude belts: 50-60˚N and 60-70˚N, between 117˚ 30' – 127˚ 30'West and 32˚ 30' – 142˚ 30' East (Hulme, 1999). Calculations are made as the cumulative departures from average values from the 1961-90 reference period.

# Results and Conclusions

- Pan–Arctic region provides an opportunity to study water inflow to the Arctic Ocean from continents (river runoff) and glacier runoff from Arctic archipelagoes separately (Fig.2,Fig.6).
- Annual river runoff from continents exceeds substantially annual glacier runoff but glaciers are the main contributors to the change in ocean level (Fig. 2).
- Main components of inflow from glaciers to the AOc are: balanced inflow (Fig.5), which is equal to annual precipitation and the runoff from the ice storage (Fig. 4 and Fig. 5), which is the direct impact to mass and level change in the AOc.
- River inflow to the AOc shows large change in time due to change in precipitation rate (Fig. 6, Fig. 7). Water inflow from glaciers shows steadily increases since the end of 1980th (Fig. 6) and associates with the climate warming in the pan-Arctic region. Comparisons of these components show the increases from the end of 1980s (Fig. 6).
- An increases in river runoff is due to increases in annual precipitation rate in 50-70 North latitudes (Fig.7); increases in glacier component presumably associates with the increases in air temperature (Serreze et al., 2000; number of publications).




Two main components of a glacier or snow patch runoff with negative mass balance;dry and warm climate conditions (release from storage has started first decade of August)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