Report as of FY2006 for 2006AK51B: "Investigation of Streamflow Response to Seasonal Snowcover Change in the Yukon River"

Publications

- Other Publications:
  - Yang, D., Yukon River Streamflow Response to Seasonal Snowcover Changes, American Water Resource Association Alaska Annual Meeting, Fairbanks, April 3-5, 2007.
  - Yang. D., Streamflow response to seasonal snowcover change over the large northern rivers, American Geophysical Union Fall Meeting, San Francisco, December, 2006.
- unclassified:
  - Yang, D., Challenges in understanding arctic hydrology system changes,Asia CliC Workshop, Yokohama, Japan, May 17-19, 2007.

Report Follows

Investigation of Streamflow Response to Seasonal Snowcover Change in Yukon River

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1. Background

The Yukon River is one of the largest rivers in the northern regions. It contributes 203 km^3 per year freshwater to the Bering Sea. Hydrologic conditions and its changes of the Yukon River significantly affect regional biologic and ecologic systems. Unlike other large northern rivers, the Yukon has received less research attention. The USGS produced a report in 2000 to document the major hydrologic patterns with the basin. Studies found that large parts of southern Canada and the Yukon Territories have experienced reduced runoff. Snowcover is one of the critical land memory processes that significantly affect atmosphere, hydrology and ecosystems in the high latitude regions. Snowcover melt and associated floods are the most important hydrologic event of the year in the northern river basins. Studies show that snowmelt has started early over the recent decades in the northern regions of Canada, Alaska and Siberia associated with warming in winter and spring seasons. This change in the melt pattern may indicate a hydrologic regime shift over the high latitudes. Due to insufficient investigation and lack of long-term records, our current understanding of Yukon River hydrology and climate changes, particularly large-scale snowmelt processes and their interaction with climatic change and variation, is incomplete. This limits our capability of documenting past change and predict future change over this largest watershed in Alaska.

We recently applied the weekly snowcover data in large Siberian watersheds (Lena, Yenisei and Ob rivers) and identified a close association of the runoff to snowcover extent changes during the spring melt period. Our initial analyses of snowcover and streamflow data in Alaska also show a strong correlation of monthly runoff with snowcover extent during early summer season. These encouraging results clearly indicate the potential of using the weekly snowcover information to improve snowmelt runoff modeling and prediction in the high latitude regions. This research project continues our effort in the Yukon River with a focus on analyzing basin and sub-basin snowmelt processes.

2. Study Objective

This research will use the weekly NOAA snowcover extent data to study the streamflow hydrology in the Yukon River. The focus of this research is to examine the streamflow response to snowcover extent change during the spring melt season. The overall objective of this research is to determine the potential of using remotely sensed snowcover information to improve our capability of snowmelt runoff modeling and forecasting over large northern river basins. The major work of this research project includes:

A. *Generation and analysis of weekly snowcover extent and runoff time-series*
B. *Examination of streamflow response to snowcover extent change*
C. *Cross-validation of results*

3. Summary of Activities

During 2006, we have developed snow cover, climate and streamflow datasets over the Yukon River. We have complied temperature, precipitation, snowcover, and streamflow data for the sub-basins within the watershed. On the basis of these data, we have generated weekly basin snowcover, temperature, precipitation and streamflow time-series. We also defined basin temperature and precipitation regimes (Figs. 1-2), and calculated the basin-mean snowcover extent and SWE (Figs. 3-4) over the river for the entire AVHRR and SSMI records.

These weekly data clearly show the seasonal changes of snowcover, such as the weekly snowcover climatology, dates of snowcover formation/disappearance and duration of snowcover/snow-free days, and rates of snowcover change during the accumulation and melt seasons. They also show the interannual variations (i.e. the range of maximum and minimum values. The weekly snow cover, temperature and precipitation data allow us to explore the compatibility between winter snowfall and snowcover data. The maximum SWE over a basin is usually less than winter snowfall due to snow sublimation. Comparisons of basin winter snowfall and SWE accumulation show that maximum SWE is generally less than winter snowfall accumulation in most winter during 1988-2001, except for a few years when SWE was greater than total snowfall.

We found a negative relationship between basin temperature and snow cover extent. When basin mean temperature stays around $–20^oC$, basin snow cover percent varies between 80% and 100%. When temperature is about $–10^oC$, snow percent ranges from 30% to 100%. When temperature close to 0^oC, snow cover percent varies from very low (close to snow free) to very high (100% snow cover). We also found a negative relationship between temperature and SWE. The maximum SWE in Yukon basin is around 120mm, and this can occur for temperatures from $–35^oC$ to $–7^oC$. The SWE at 0^oC varies from 0mm to 100mm. Basin snow free (SWE = 0mm) when basin temperatures are around 7^oC.

Our ongoing efforts focus on examination of streamflow response to snowcover extent and SWE changes, and cross-validation of results. We are using bias-corrected precipitation data to compare with SSM/I and *in-situ* snowcover data over the Yukon basin and sub-basins. We also examine snowcover extent changes and variations over time, including trend analysis, in order to identify extreme snowcover cases and investigate their association with climate conditions. We are generating weekly discharge time-series from the daily streamflow data collected at different locations within the watersheds, and analyzing them to define the seasonal runoff changes. These include weekly runoff regime, rates of streamflow in the snowmelt season and peak flow. We will also examine the spatial and temporal changes in streamflow, including extremes and trends.

Fig 1. Weekly temperature over the Yukon river

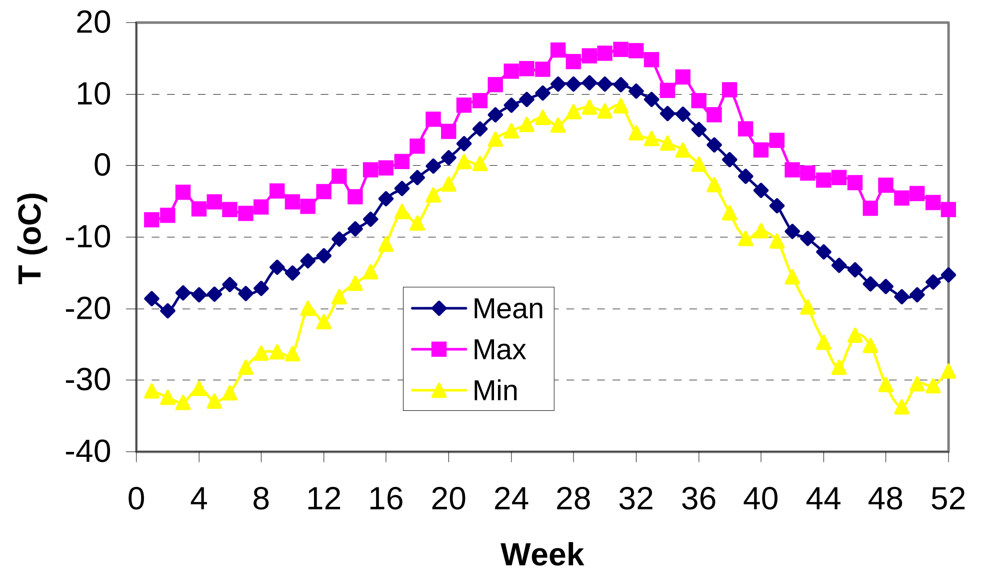
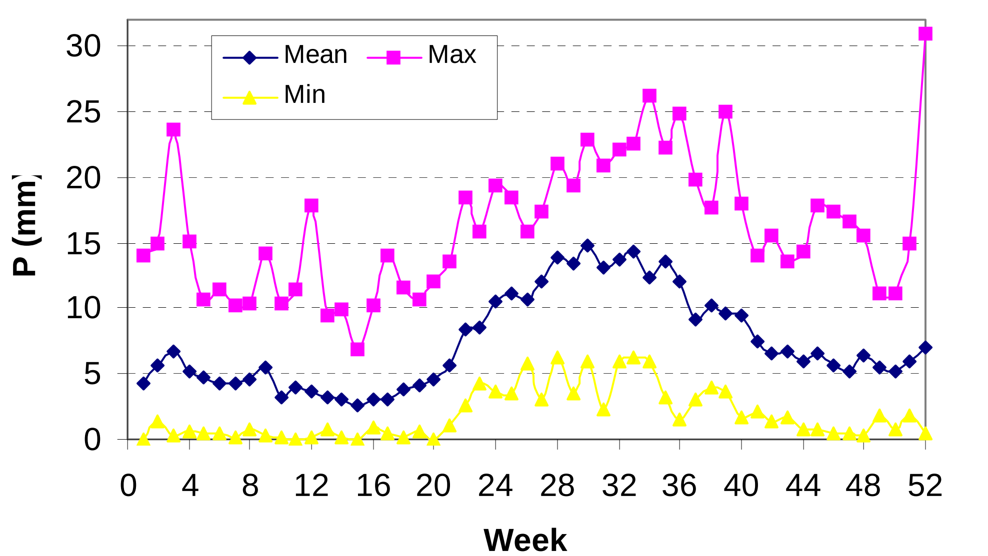


Fig 2. Weekly precipitation in Yukon river



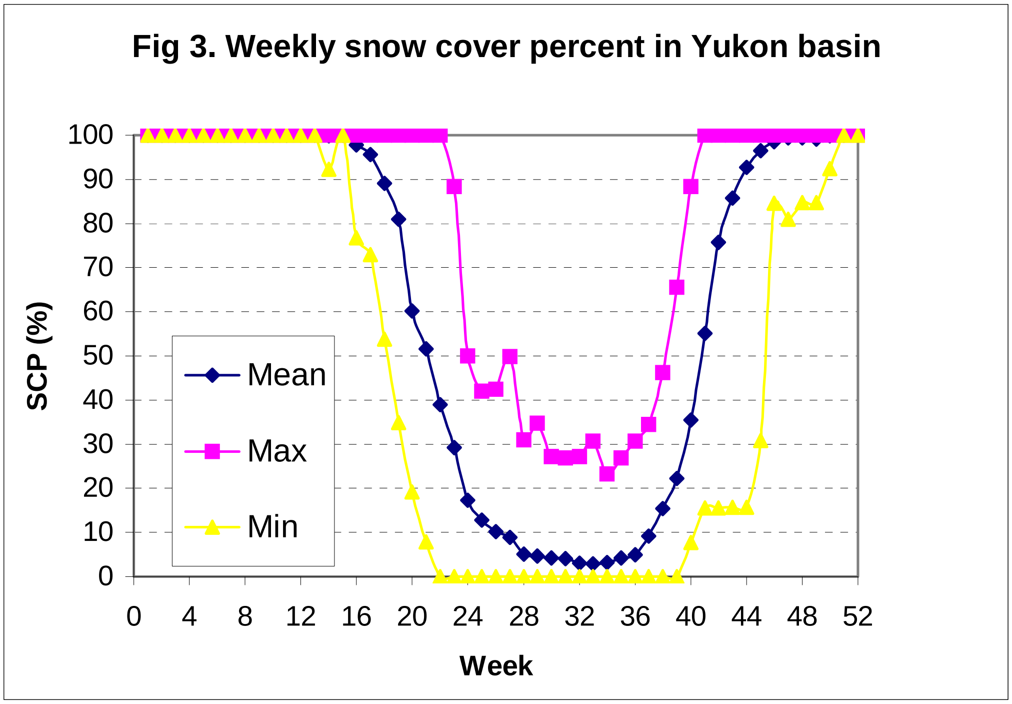


Fig 3. Weekly snow cover percent in Yukon basin
SCP (%)
100
90
80
70
60
50
40
30
20
10
0
0
4
8
12
16
20
24
28
32
36
40
44
48
52
Week
Mean
Max
Min

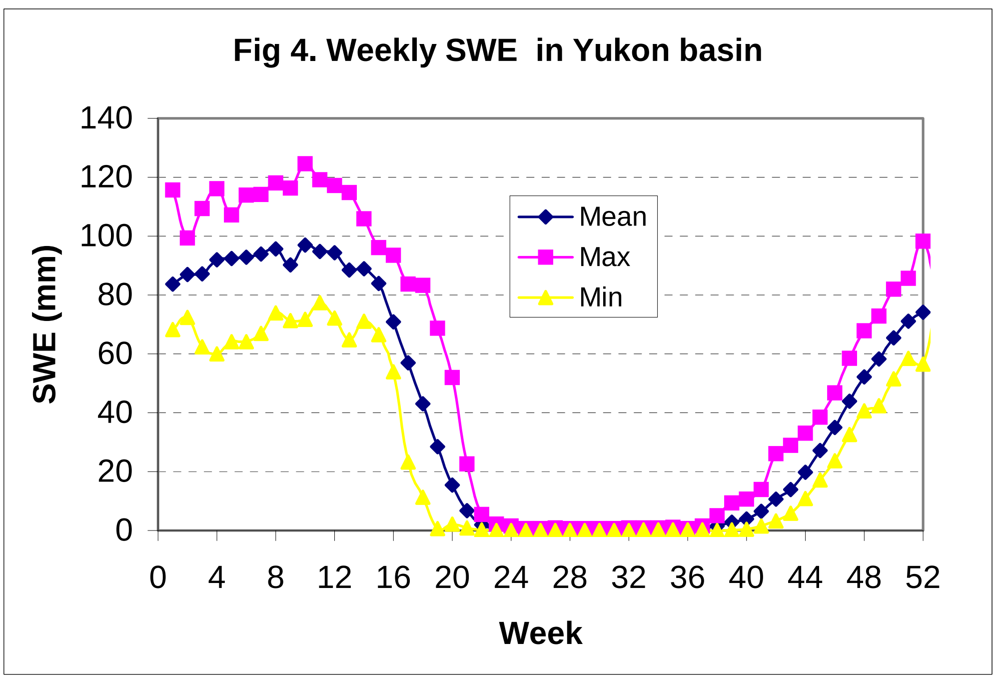


Fig 4. Weekly SWE in Yukon basin
SWE (mm)
140
120
100
80
60
40
20
0
0
4
8
12
16
20
24
28
32
36
40
44
48
52
Week
Mean
Max
Min