Assessment of apportionment and measured streamflows as possible drought indicators.

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Drought Research Initiative

- The Drought Research Initiative (DRI) receives funding support from the Canadian Foundation for Climate and Atmospheric Research (CFCAS) to research the 1999-2005 drought: one of the worst natural disasters that Canada has ever suffered.

- The main objectives of DRI are:
  - Characterize the physical features of the drought
  - Improve the understanding of processes and feedbacks governing the formation, evolution, cessation and structure of the drought
  - Assess and contribute to reducing uncertainties in the prediction of drought
- Additional objectives are:
  - Compare the similarities and differences of current drought to previous droughts and those in other regions
  - Apply our progress to address critical issues of importance to society

Streamflow: a complex and important indicator of drought

- It represents the runoff generation over the upstream area which can be a large area in some cases.
- The streamflow at a point is affected by the amount of water drawn off upstream for irrigation and the amount that is retained in wetlands, sloughs and reservoirs.
- It is a visible manifestation of the “dryness” of an area for the public.

Objectives of Streamflow Analysis

- To assess the applicability of streamflow as a drought indicator
- To explore the impact of the 1999-2004/5 drought upon streamflow

Prairie Complications

- Streamflow is highly regulated and may not reflect unaltered conditions

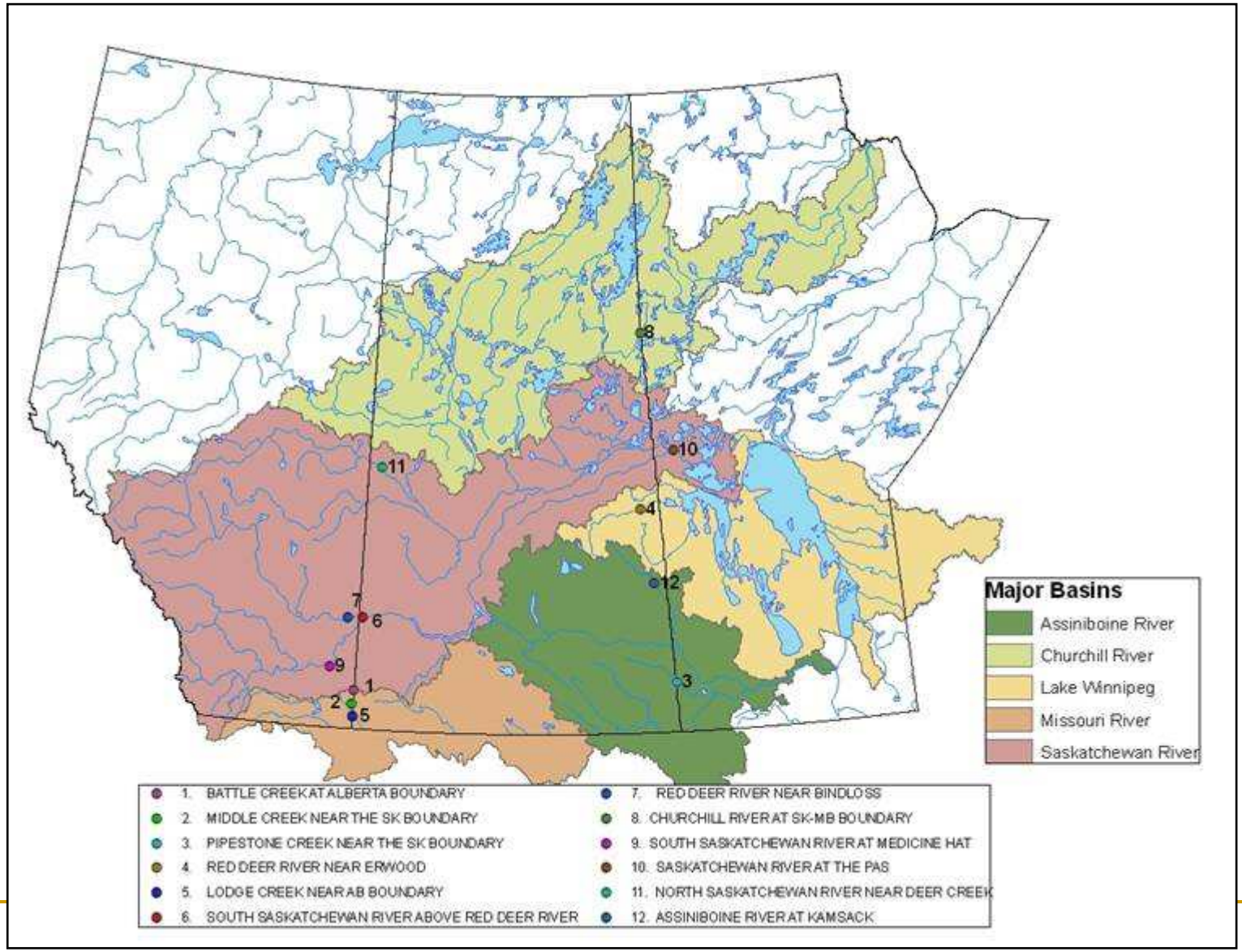
- Prairie streamflow comes from the melt of mountain snowpack while the prairie contribution may be more ephemeral.

Photo source: Alberta Irrigation Projects Association and bigfoto.com

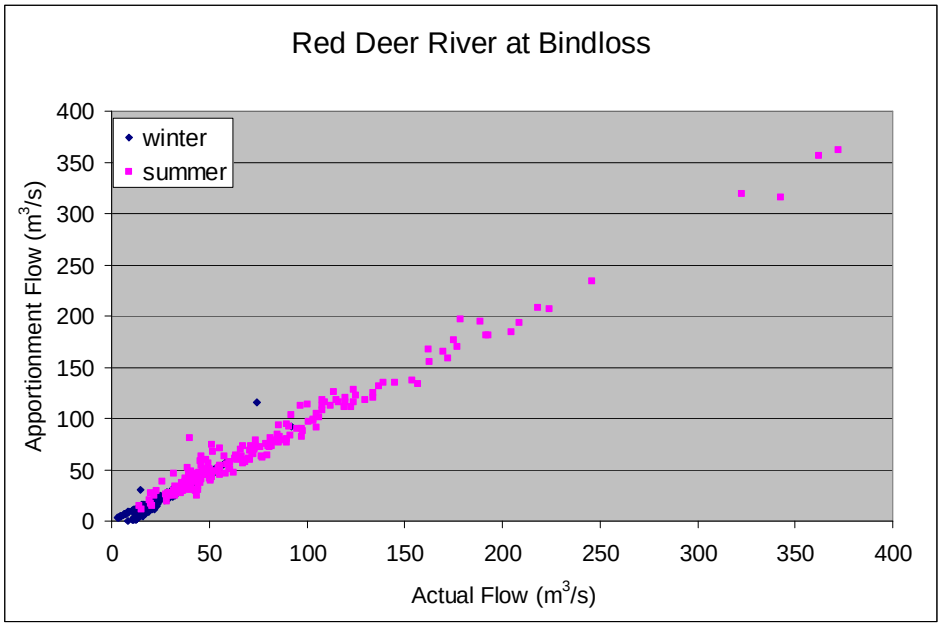
Data

- Monthly actual and apportionment flows were obtained from Environment Canada
  - Apportionment flows are estimates of the amount of water that would have flowed across the border if there had been no human activity (irrigation, reservoirs, municipalities, etc).
  - Are used in water management thus of interest to see how they address drought
- Stations located on the AB-SK and SK-MB borders
- Data period was 1977-2007 for major rivers and 1985-2007 for smaller rivers

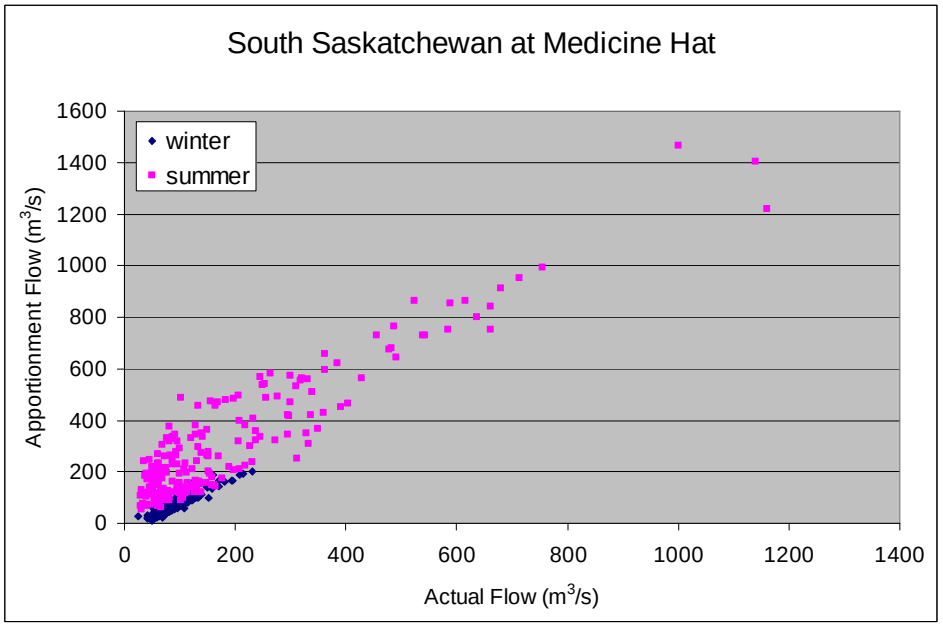
Stations


Major Basins
Assiniboine River
Churchill River
Lake Winnipeg
Missouri River
Saskatchewan River
1. BATTLE CREEK AT ALBERTA BOUNDARY
2. MIDDLE CREEK NEAR THE SK BOUNDARY
3. PIPESTONE CREEK NEAR THE SK BOUNDARY
4. RED DEER RIVER NEAR ERWOOD
5. LODGE CREEK NEAR AB BOUNDARY
6. SOUTH SASKATCHEWAN RIVER ABOVE RED DEER RIVER
7. RED DEER RIVER NEAR BINDLOSS
8. CHURCHILL RIVER AT SK-MB BOUNDARY
9. SOUTH SASKATCHEWAN RIVER AT MEDICINE HAT
10. SASKATCHEWAN RIVER AT THE PAS
11. NORTH SASKATCHEWAN RIVER NEAR DEER CREEK
12. ASSINIBOINE RIVER AT KAMSACK

Actual vs. Apportionment



Small differences between apportionment flow and measured streamflow.



Large differences between apportionment flow and measured streamflow.

Methodology

- Employed the threshold technique to characterise hydrologic drought
  - Based upon work by Yevjevich (1967)
- Threshold level employed was the 10th percentile of monthly stream flow

Variables:

- Q_z= threshold level
- t_i= start of drought
- d_i= drought duration
- v_i= deficit volume of drought (severity)
- v_i/d_i= average deficit flow (intensity)

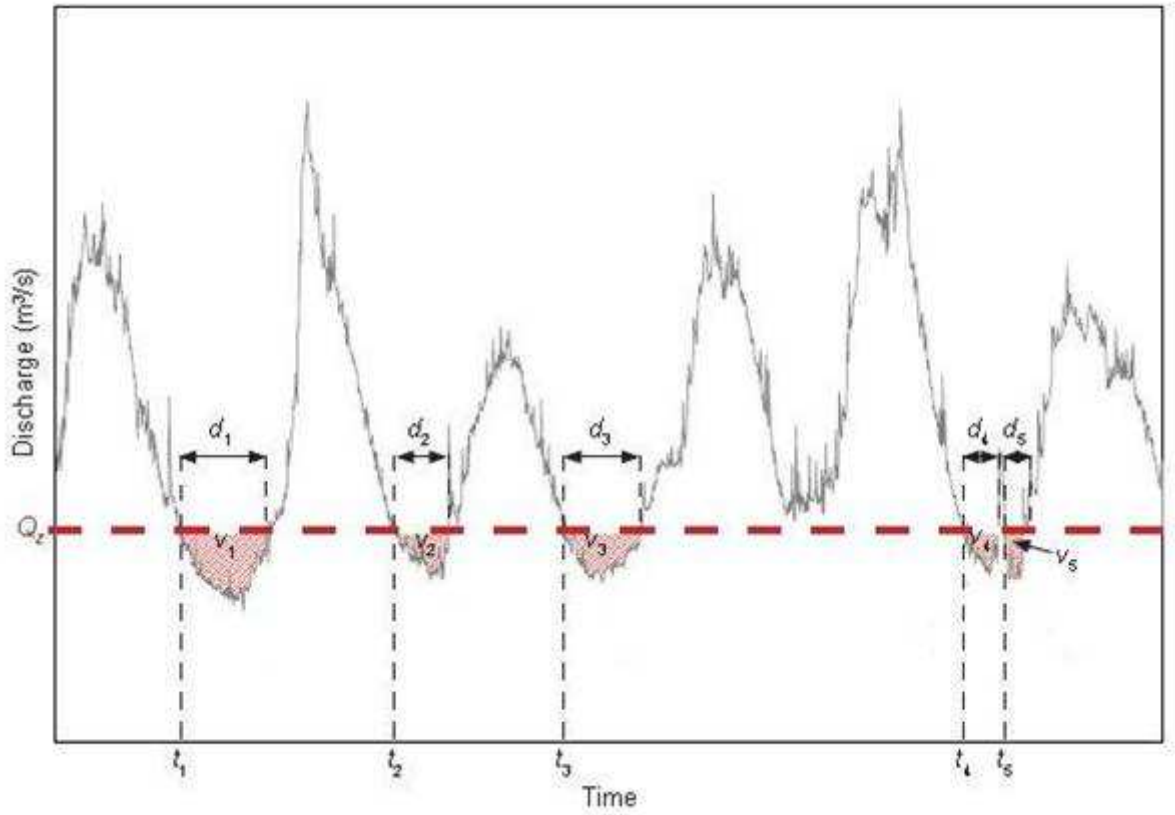
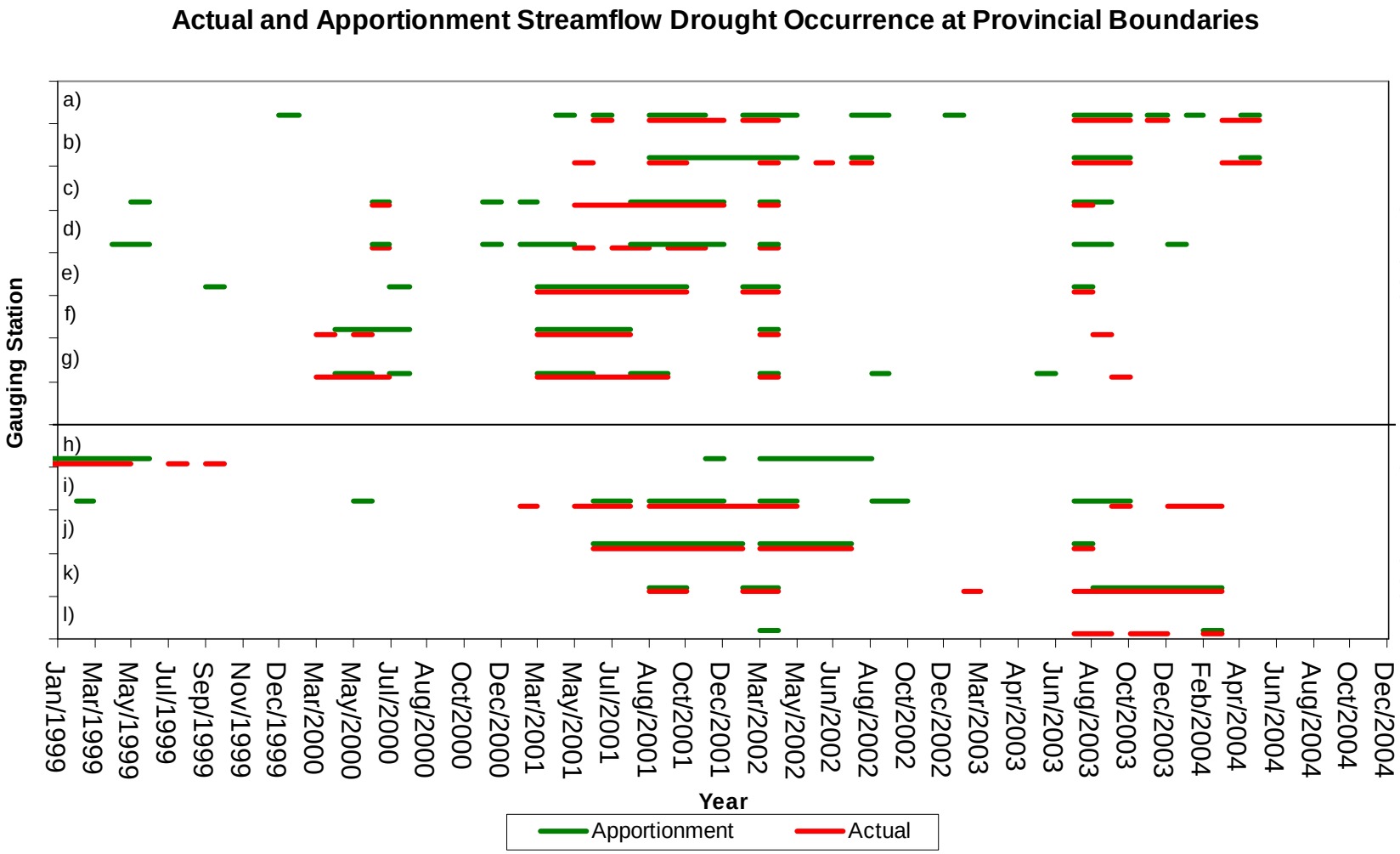


Figure modified from Flieg et al (2006)

Results

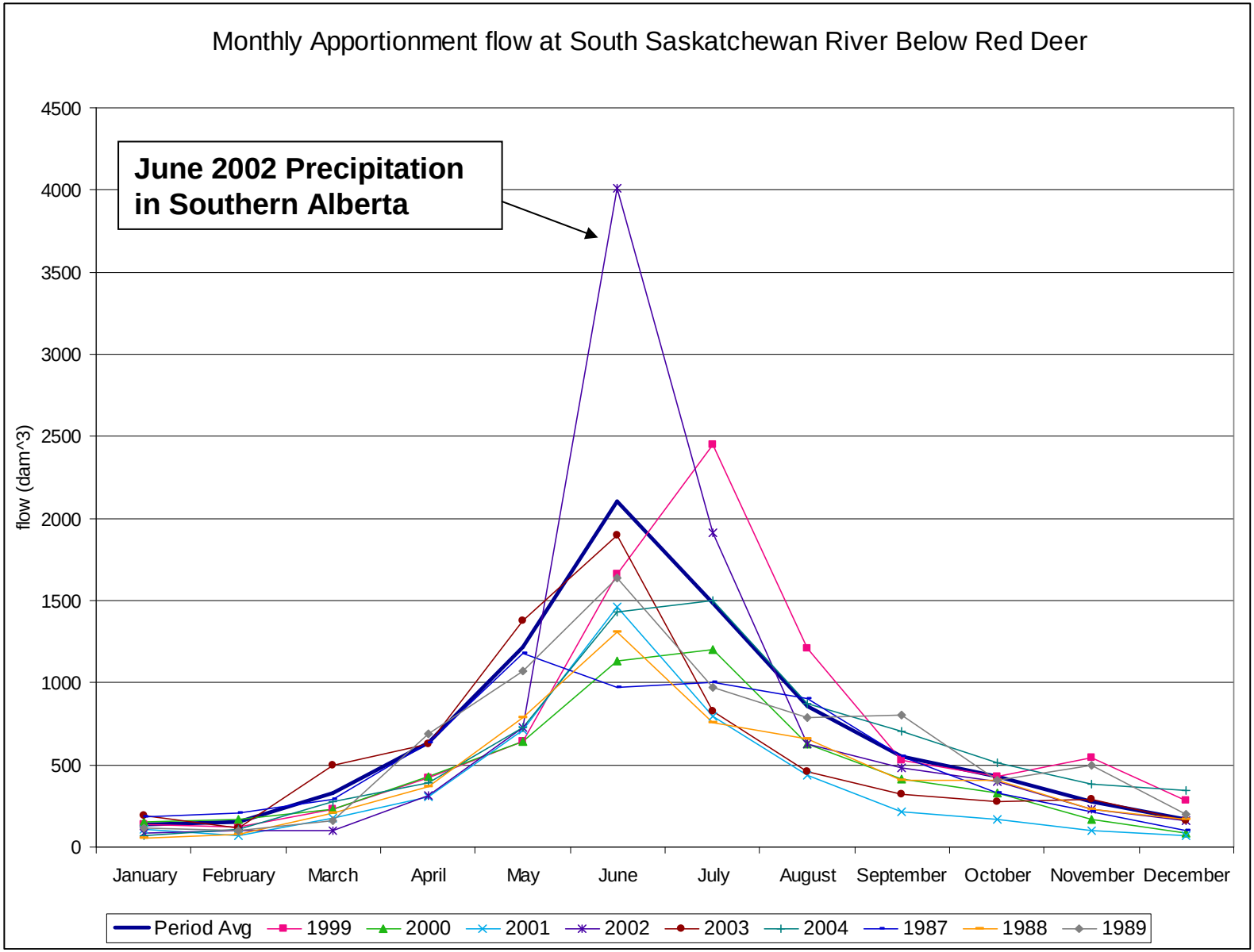


Gauging Stations: a) North Saskatchewan at Border, b) Red Deer at Bindloss, c) South Saskatchewan below Red Deer, d) South Saskatchewan at Medicine Hat, e) Battle Creek at Border, f) Lodge Creek at Border, g) Middle Creek at Border, h) Churchill River at the Border, i) Saskatchewan at The Pas, j) Red Deer near Erwood, k) Assiniboine at Kamsack and l) Pipestone Creek.

Most severe drought events

Station	Total Months below Q10*	Max. consecutive months below Q10*	Start date of max consecutive period below Q10*	Deficit Volume ($m^{3)*}$
North Sask. at A-S border	13/ 10	4/3	Sept 2001/ Sept 2001	4,819,392/6,432,903
Red Deer River at Bindloss	11/13	3/8	Aug 2003/ Sept 2001	2,931,552/3,400,940
South Sask. below Red Deer River	11/12	8/5	May 2001/ Aug 2001	8,825,376/15,332,151
South Sask at Medicine Hat	7/16	2/5	Oct 2001/Aug 2001	3,646,944 /14,016,767
Battle Creek	11/12	8/8	Mar 2001/Mar 2001	15,652/19,496
Middle Creek	13/11	7/3	Mar 2001/Mar 2001	2028/2,123
Lodge Creek	10/10	5/5	Mar 2001/Mar 2001	673/2,642
Churchill River	2/7	1/6	Sept 1999/Mar 2002	900,000/2,615,903
Saskatchewan River at The Pas	16/15	8/4	Sept 2001/Sept 2001	57,049,920/32,552,424
Red Deer River (near Erwood)	14/14	8/8	Jun 2001/Jun 2001	309,121/275,813
Assiniboine River at Kamsack	13/11	8 /7	Aug 2003/ Sept 2003	73,815/35, 606
Pipestone Creek	5/ 3	2/1	Aug 2003/Mar 2004	608/5,545
Median	11/11.5	6/5	Jun 2001/Aug 2001	
*Actual/Apportionment				

Effect of Severe Rainfall Event



Conclusions

- Apportionment and actual stream flows using the threshold method do provide a reasonable indicator of drought conditions.
- Small basins respond more quickly to drought than larger basins which suggests that streamflow in these basins is more susceptible to drought.
- Apportionment flows generally reflected the progress of the actual streamflow drought along the Alberta/ Saskatchewan and Saskatchewan/Manitoba borders during the 1999/2004 drought although some significant deviations occurred at specific stations.
- Severe apportionment drought periods generally lag behind severe actual drought periods
- While small rain events do not have a measurable impact on the flows, larger-scale, heavy rain events can result in significant increases in flows that can last for as long as a month.

Questions?

References

- Yevjevich, V. An objective approach to definitions and investigations of continental hydrologic droughts, Hydrology Papers 23, Colorado State University, Fort Collins, USA, 1967.
- A. K. Fleig, L. M. Tallaksen, H. Hisdal, and S. Demuth. 2006. A global evaluation of streamflow drought characteristics. Hydrol. Earth Syst. Sci. Discuss.: 18