Soil Moisture Analysis and Seasonal Forecast of Drought

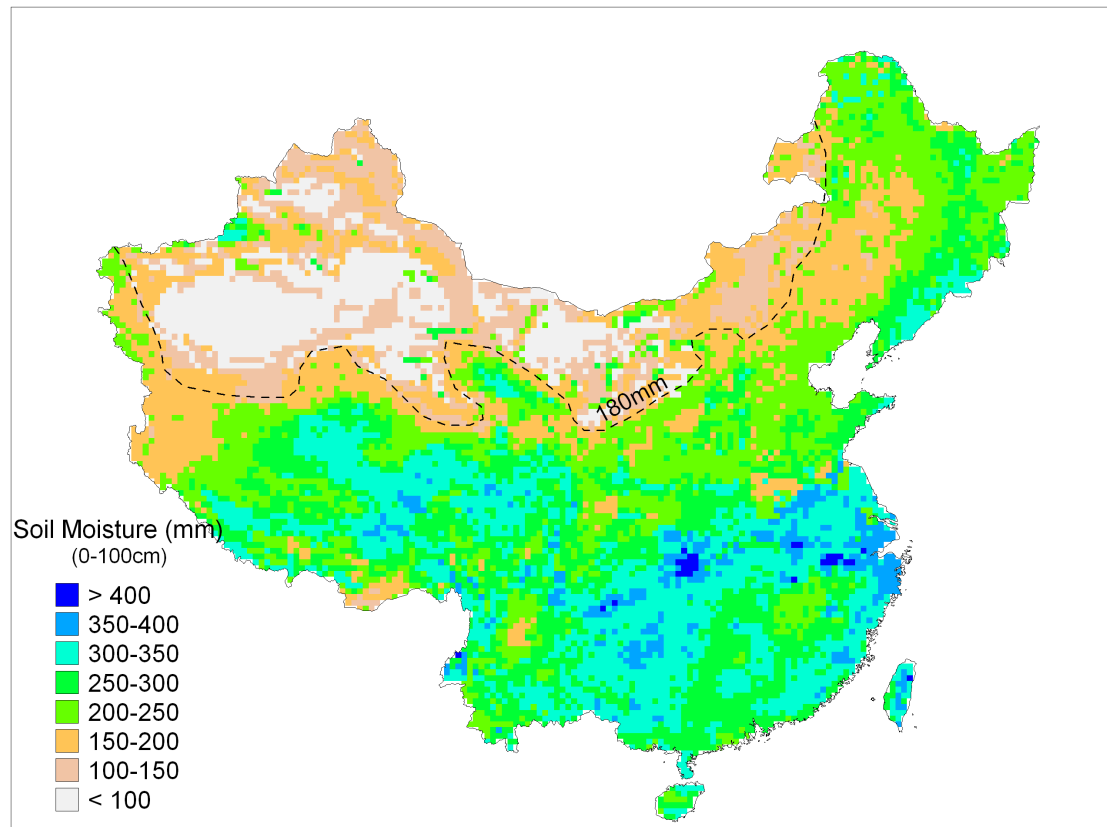Charles Lin[1], Lei Wen, Rabah Aider, Jacques Derome and Hai Lin

McGill University

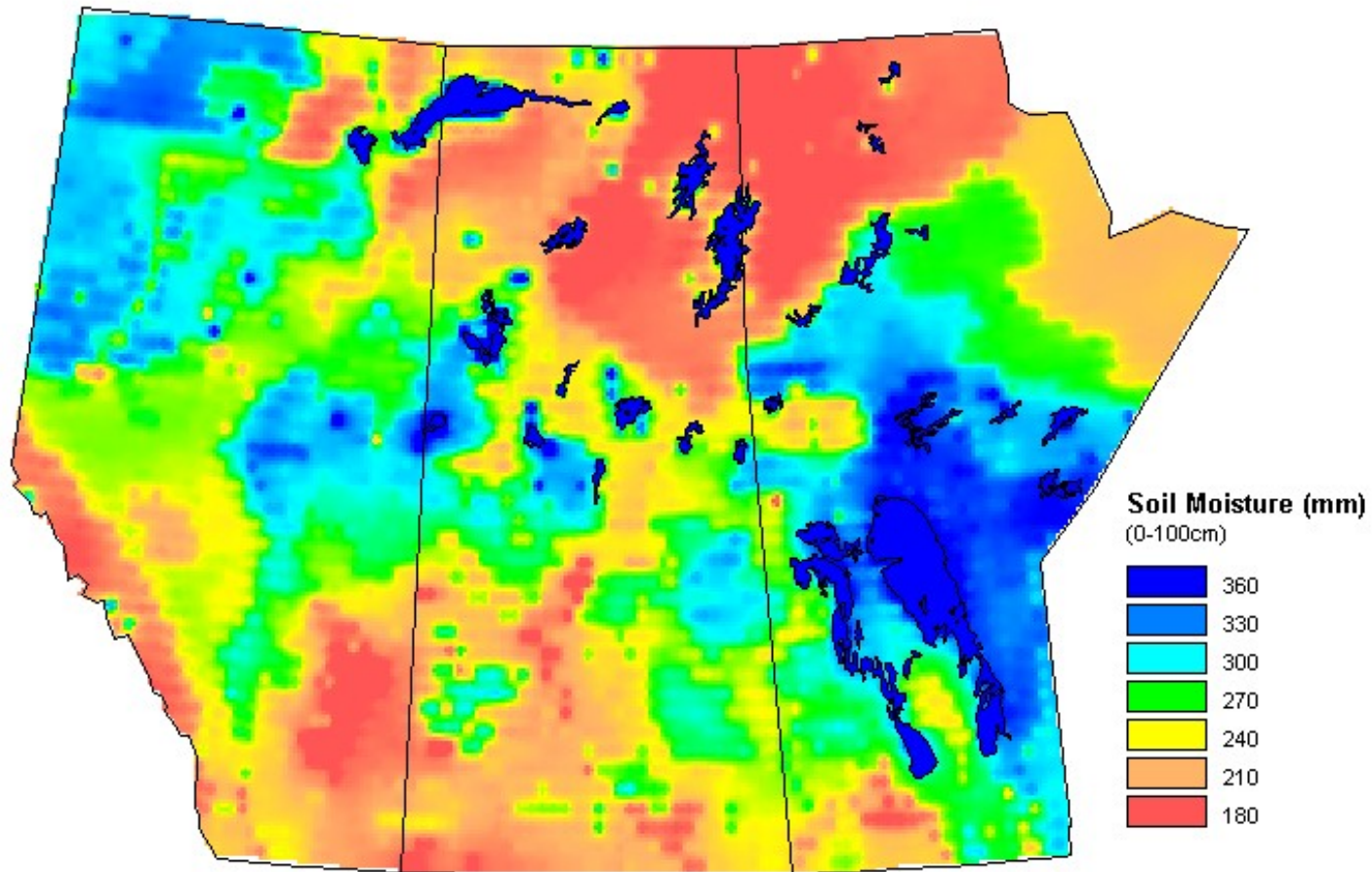[1]Currently at Environment Canada

Objectives

- To produce a soil moisture climatology
  - Land surface schemes VIC, CLASS in stand-alone mode
  - Methodology verification over China
  - Applications over Liard Basin (MAGS) and Prairies
- To examine seasonal forecast of drought
  - HFP2 model output (AGCM3/CLASS) from Canadian CLIVAR (1969-2003)

VIC and CLASS in stand-alone mode

Poster by Lei Wen

- VIC at 30 km x 30 km resolution over China from 1971 to 2005

- Calibration and validation using hydrographs and *in-situ* soil moisture measurements

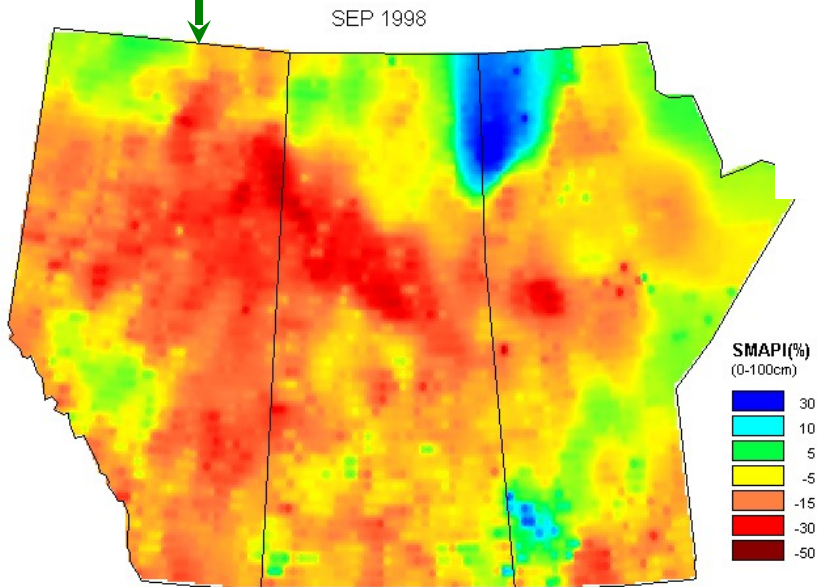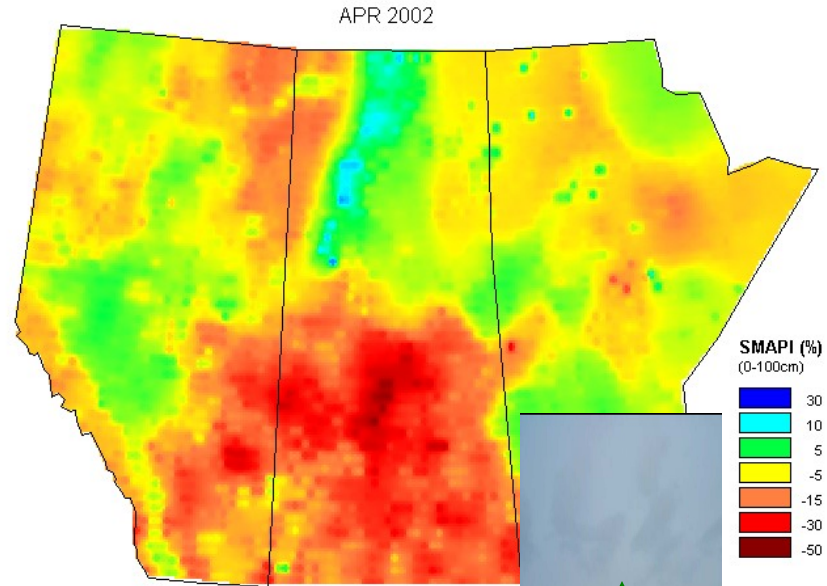- Produce a 35-yr soil moisture climatology for the top 1-m layer

Wu et al. (2007)

- Run VIC at 0.25^o x 0.25^o over Canadian Parries from 1950 to 2005

- Produce a 56-yr soil moisture climatology for the top 1-m layer

Soil Moisture (mm)
(0-100cm)

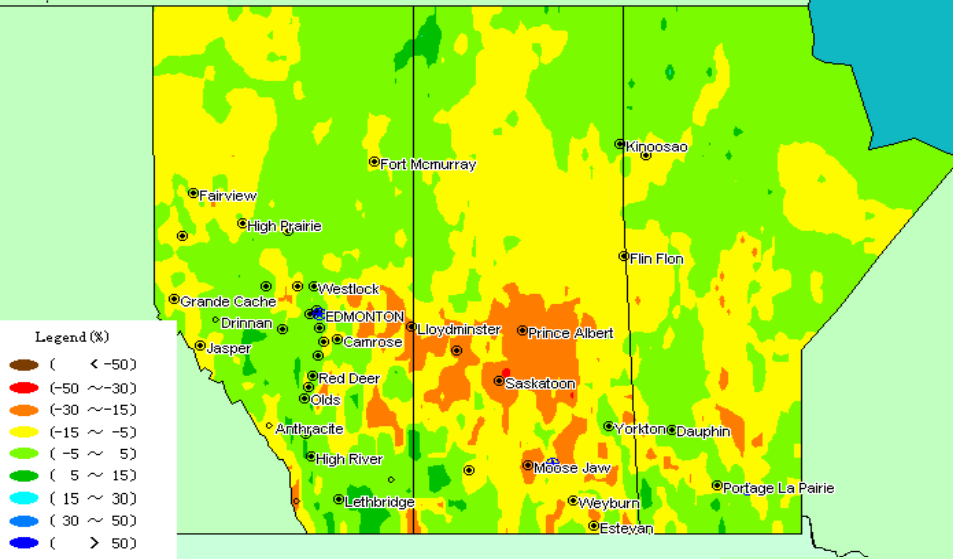|	
■	360
■	330
■	300
■	270
■	240
■	210
■	180

- Define Soil Moisture Anomaly Percentage Index (SMAPI)

$$SMAPI = \frac{\theta - \bar{\theta}}{\bar{\theta}} \times 100\%$$

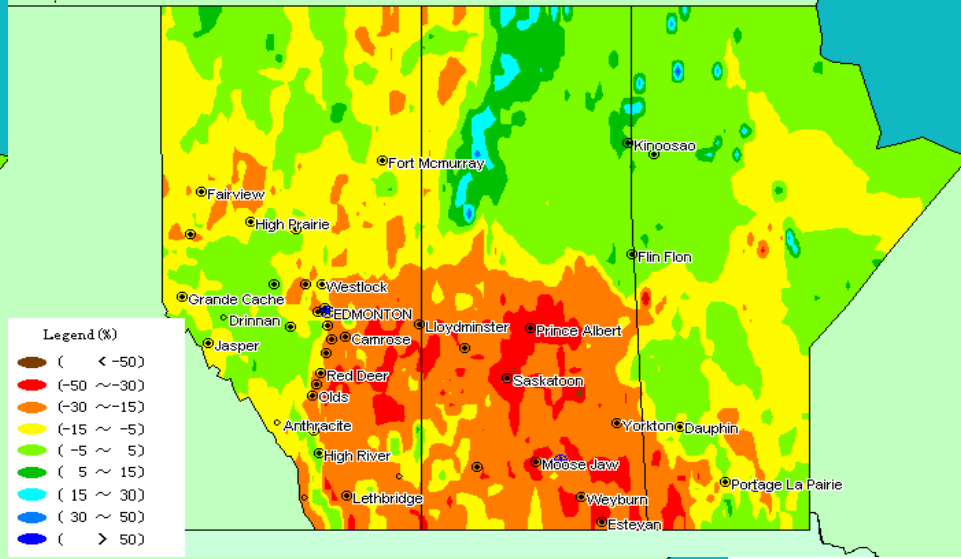- Results available via DRI website (www.meteo.mcgill.ca/~leiwen/vic/prairie)
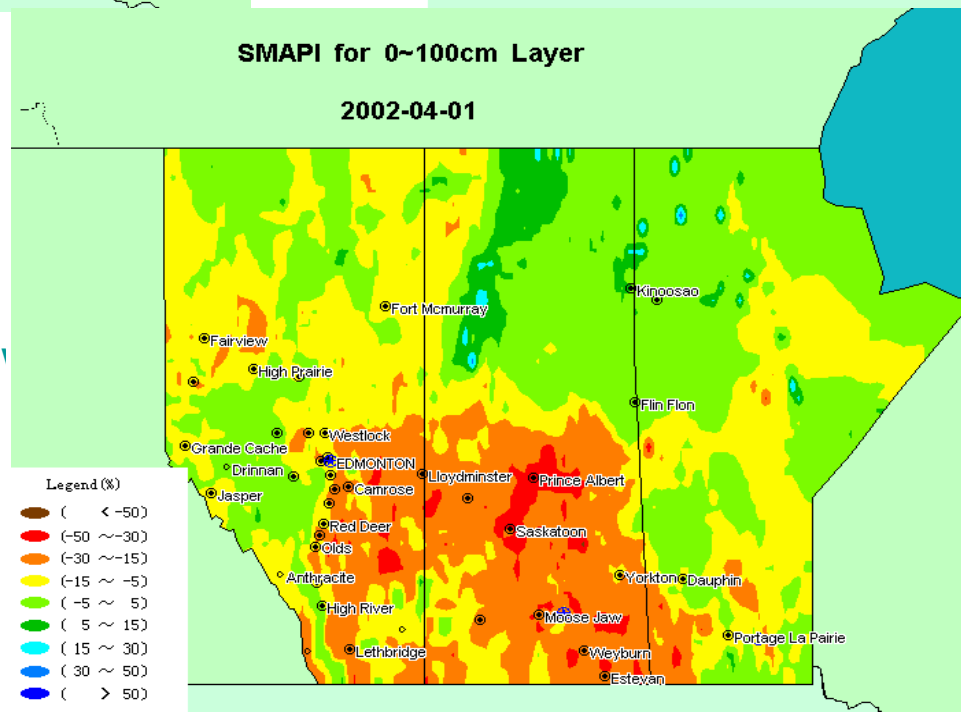
SMAPI for 0~20cm Layer
2002-04-01

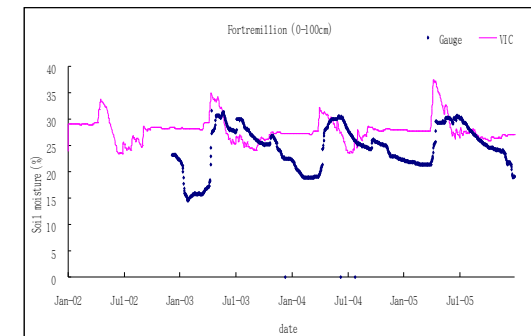SMAPI for 20~100cm Layer
2002-04-01

SMAPI for 0~100cm Layer
2002-04-01

Daily soil moisture index (SMAPI) for 1 April, 2002
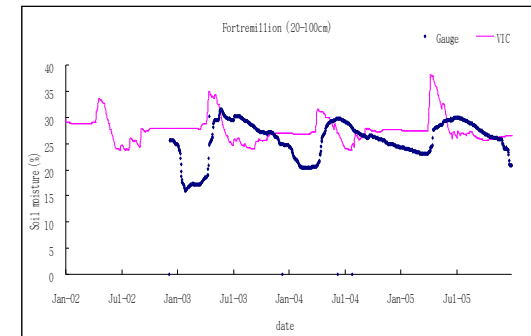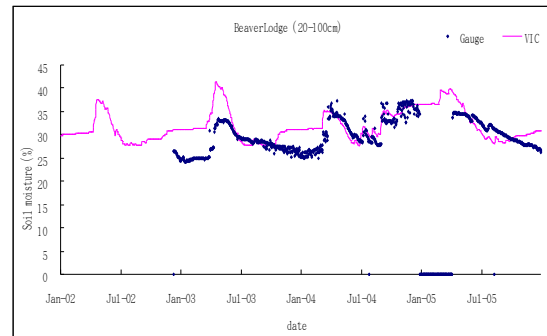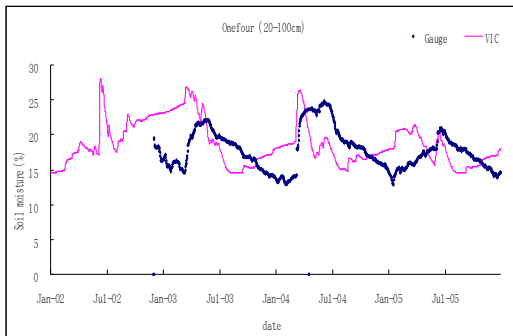
http://www.meteo.mcgill.ca/~lei

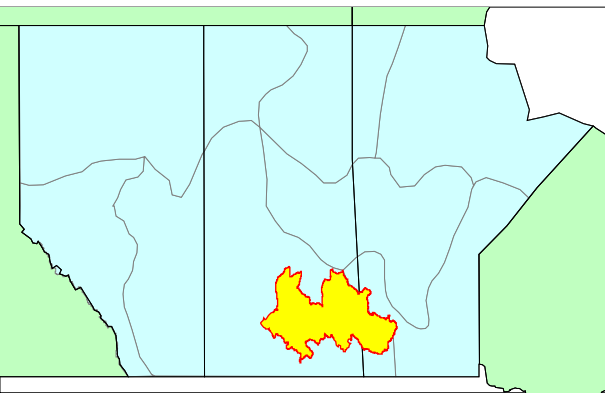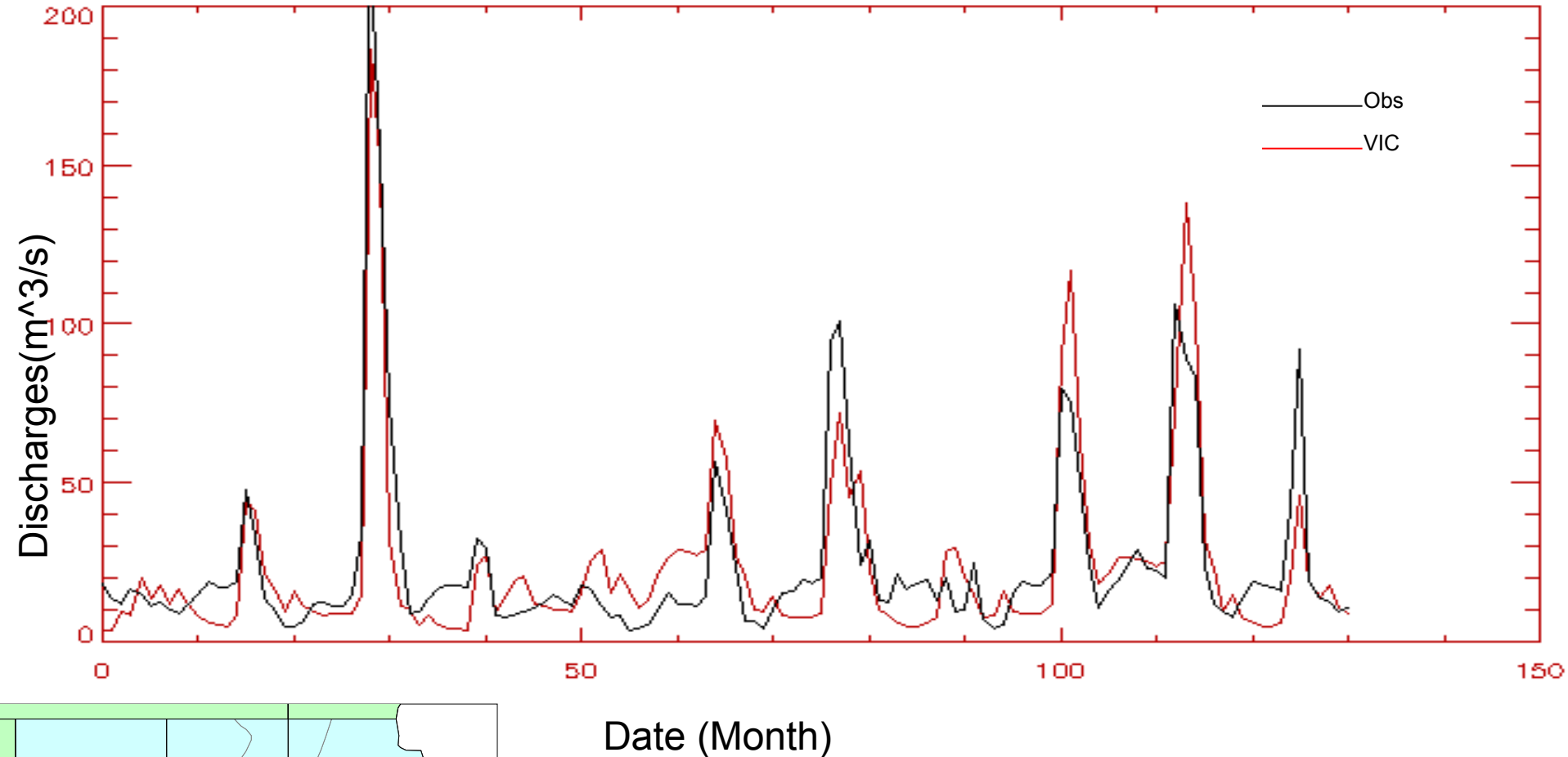Can be used to reconstruct the Prairie drought history

- Comparison of VIC soil moisture with *in situ* observations at 3 depths (0-20, 20-100, 0-100 cm) at 3 sites in Alberta
- Note this is validation and not calibration
- This is a comparison of a point measurement versus a 625 km2 grid average

Validation

(example)

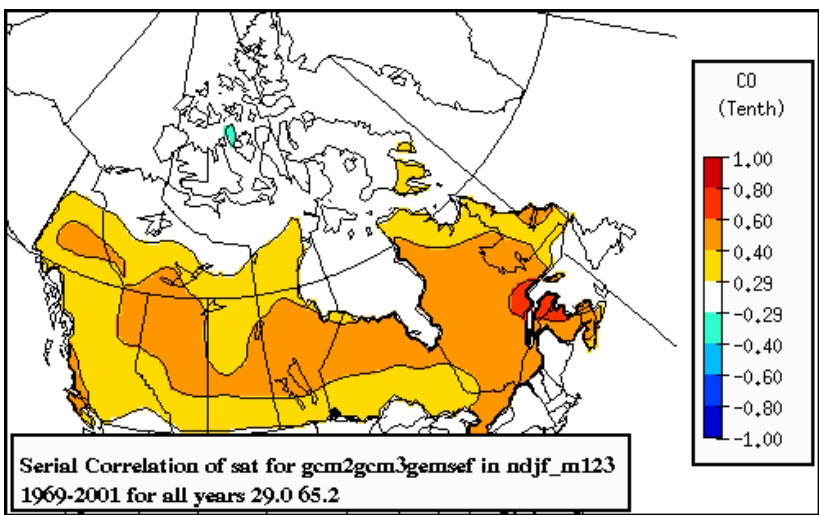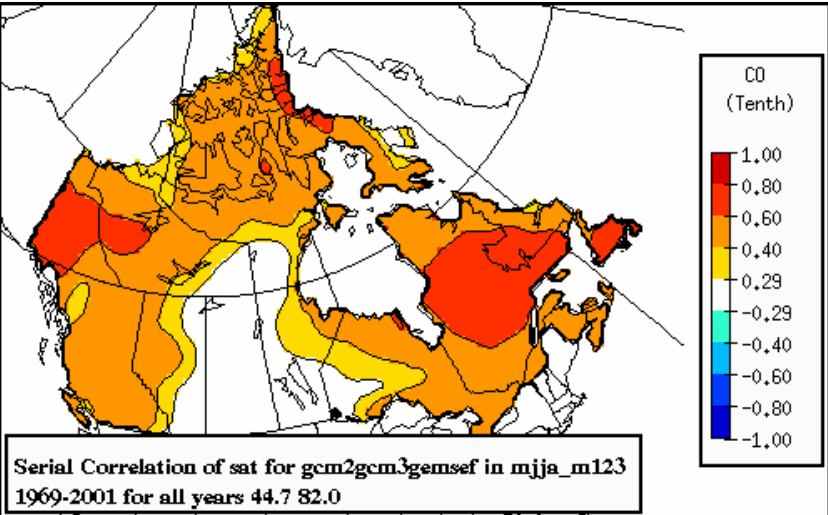| River Name	Period	Err. (%)	Nash (day)	Nash (Mon)
ASSINIBOINE	1977-1987	-5.4	0.62	0.77

Date (Month)

Note: Assiniboine drains an area of 269,838 km², in which 39% (105,237 km2) are non-contributing drainage areas

- Comparison of simulated soil moisture from a hydrologically modified version of CLASS with *in situ* observations at four sites in China

- Can run CLASS over Prairies if the seven atmospheric forcing fields are available
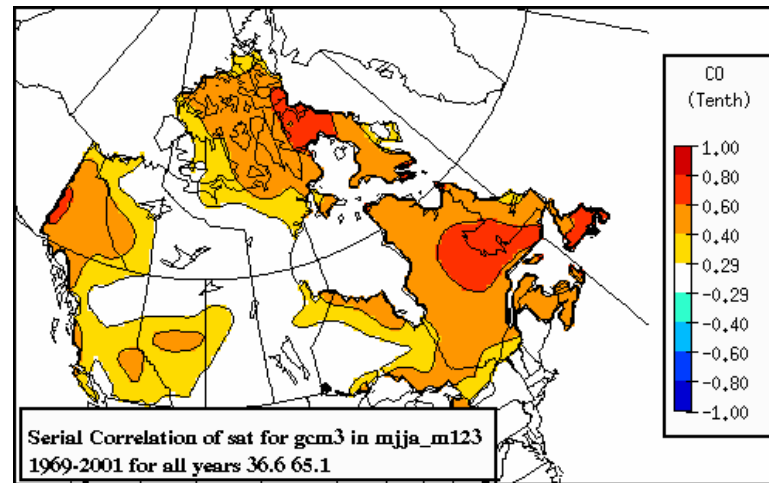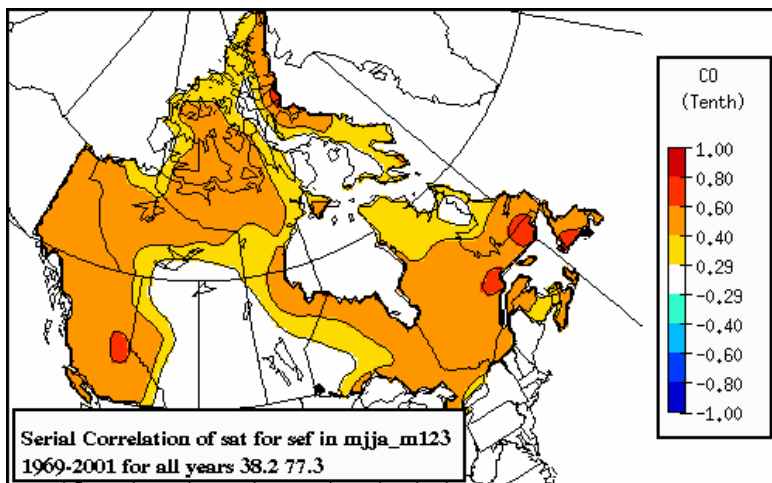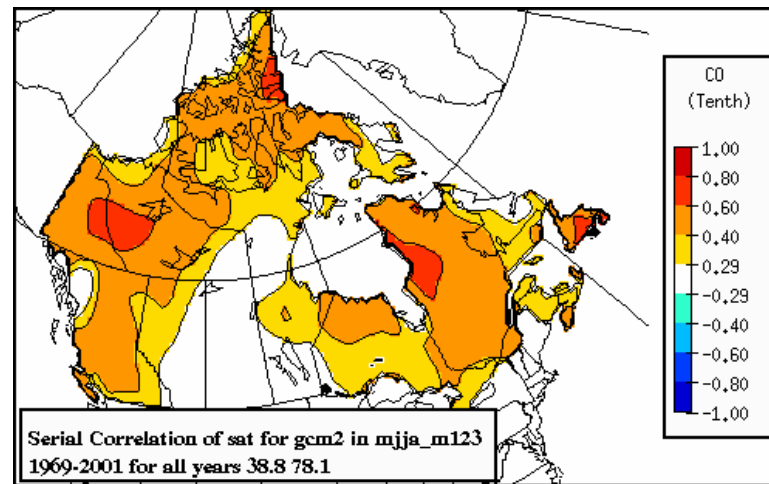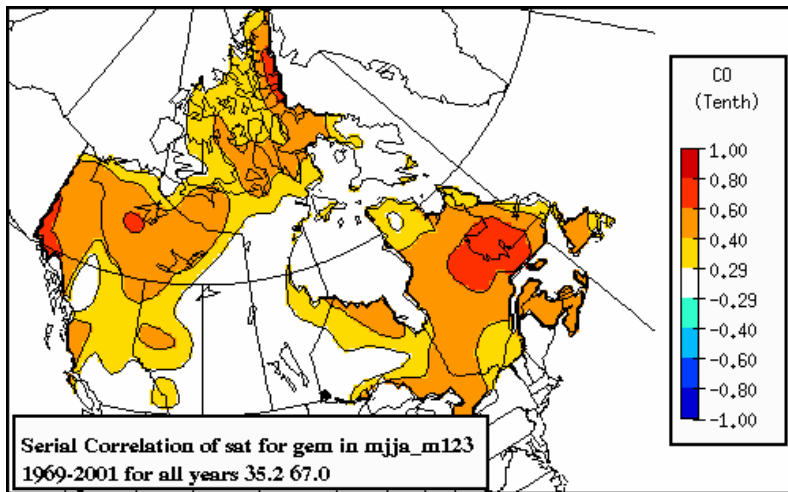

Wen et al. (2007)

HFP2 Seasonal Forecast (AGCM3/CLASS, 1969-2003)

Poster by Rabah Aider

Correlation with observations for seasonal forecast of Surface Air Temperature for 4 seasons (4 models - GEM, SEF, GCM2, GCM3)

CO (Tenth)
1.00
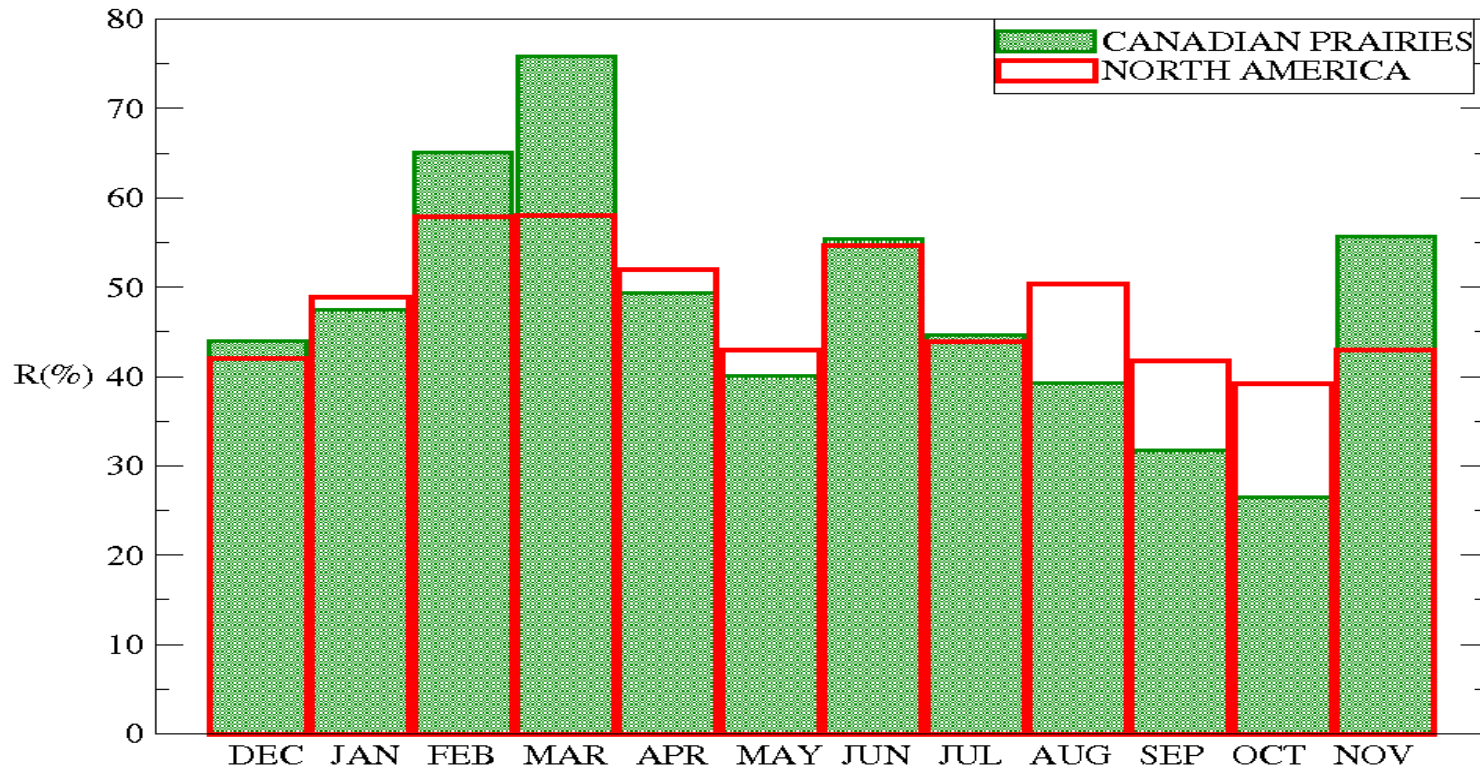0.80
0.60
0.40
0.29
-0.29
-0.40
-0.60
-0.80
-1.00

Serial Correlation of sat for gcm2gcm3gemsef in fmam_m123
1969-2001 for all years 52.9 98.4

CO (Tenth)
1.00
0.80
0.60
0.40
0.29
-0.29
-0.40
-0.60
-0.80
-1.00

Serial Correlation of sat for gcm2gcm3gemsef in ason_m123
1969-2001 for all years 33.3 67.1

CO (Tenth)
1.00
0.80
0.60
0.40
0.29
-0.29
-0.40
-0.60
-0.80
-1.00

Serial Correlation of sat for gcm2gcm3gemsef in mjja_m123
1969-2001 for all years 44.7 82.0

CO (Tenth)
1.00
0.80
0.60
0.40
0.29
-0.29
-0.40
-0.60
-0.80
-1.00

Serial Correlation of sat for gcm2gcm3gemsef in ndjf_m123
1969-2001 for all years 29.0 65.2

MJJA seasonal forecast of Surface Air Temperature by each of 4 models (GEM, SEF, GCM2, GCM3)

Serial Correlation of sat for gem in mjja_m123
1969-2001 for all years 35.2 67.0

Serial Correlation of sat for gcm2 in mjja_m123
1969-2001 for all years 38.8 78.1

Serial Correlation of sat for sef in mjja_m123
1969-2001 for all years 38.2 77.3

Serial Correlation of sat for gcm3 in mjja_m123
1969-2001 for all years 36.6 65.1

Correlation of mean monthly forecast of 500 mb height through the annual cycle
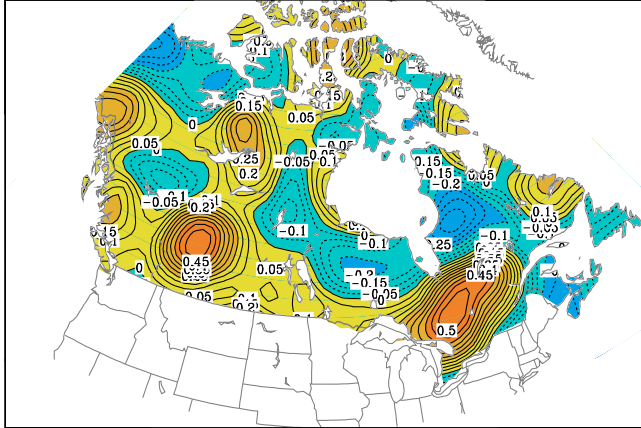

500 mb GZ Temporal Correlation NCEP-HFP2

Precipitation anomaly of seasonal forecast for JJA 2001-02 (4 models – GCM2, GCM3, GEM, SEF; significance not determined)
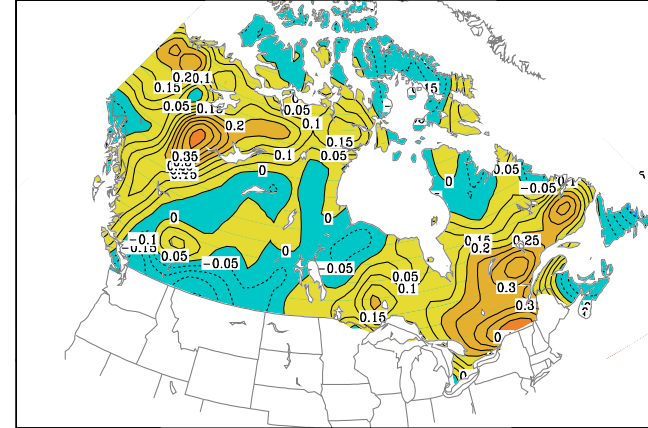
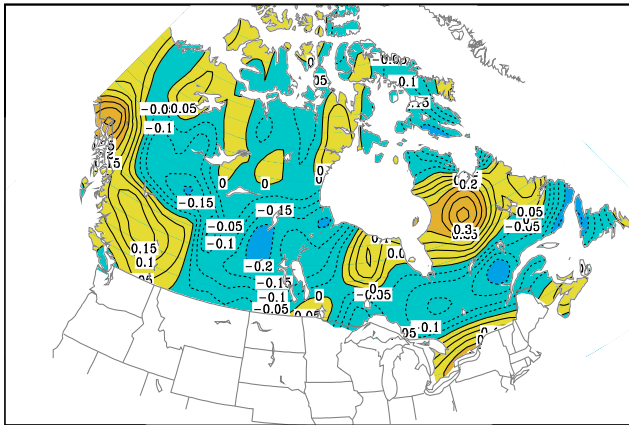## GCM2

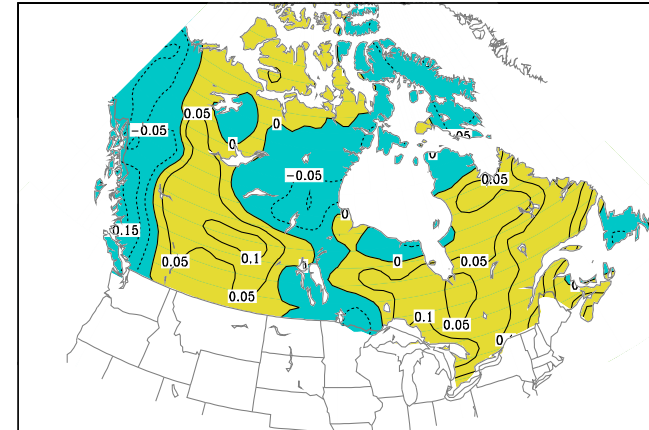
JJA 2001-02 anomaly

GEM

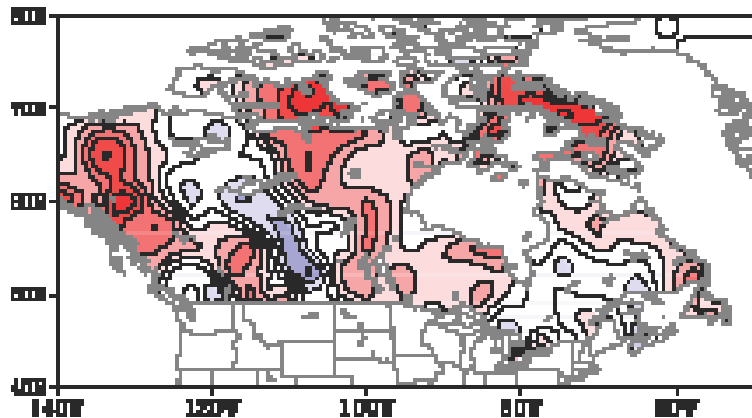
JJA 2001-02 anomaly

GCM3
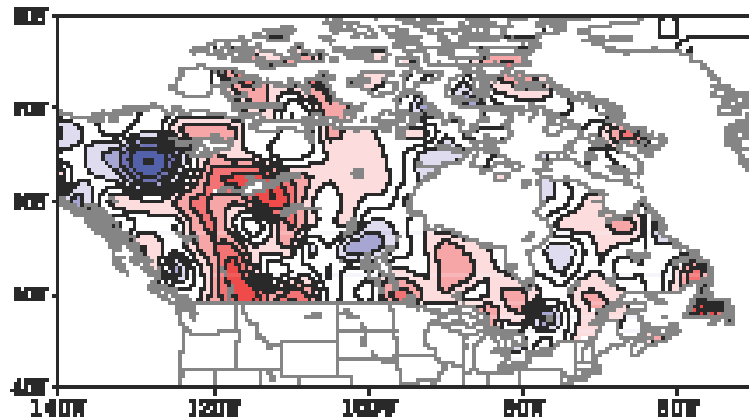

JJA 2001-02 anomaly

SEF

JJA 2001-02 anomaly

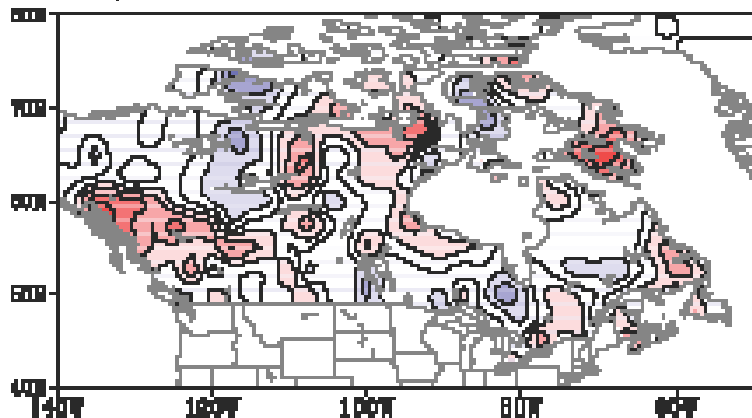Correlation for seasonal forecasts of Precipitation for 4 seasons (4 models -
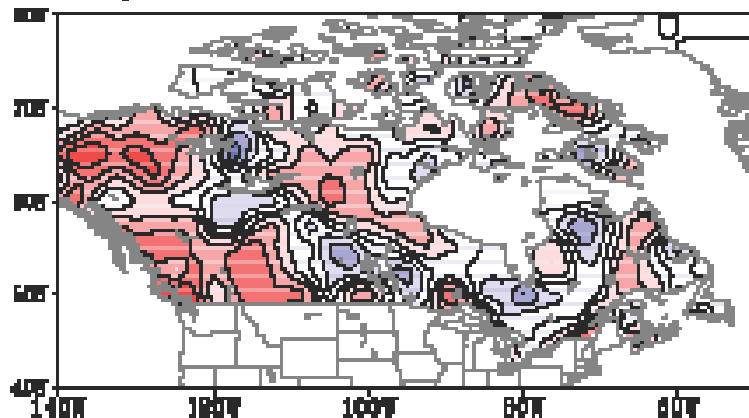GCM2/GCM3/GEM/SEF)

a) MAM 4models lead=0

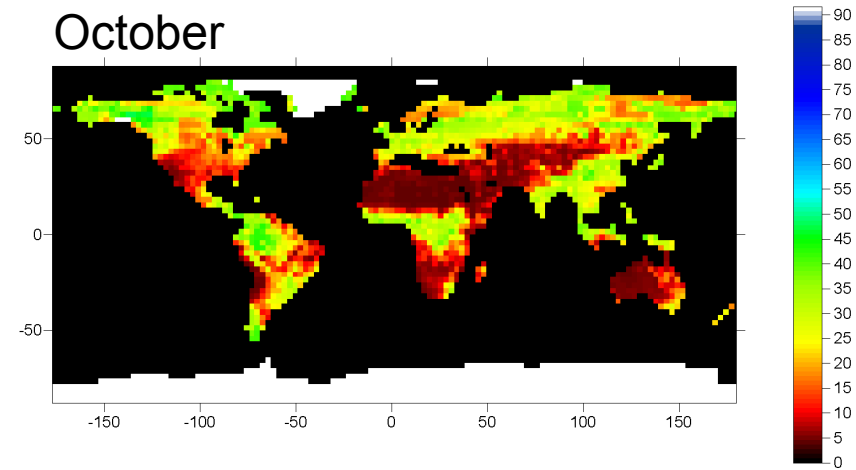b) JJA 4models lead=0

c) SON 4models lead=0

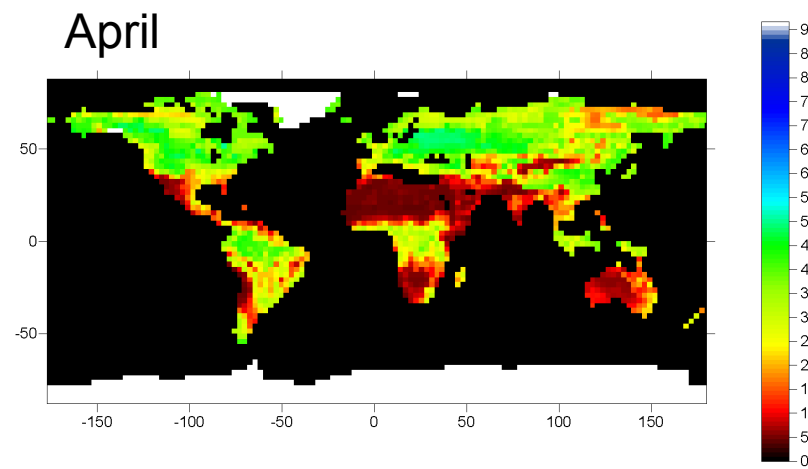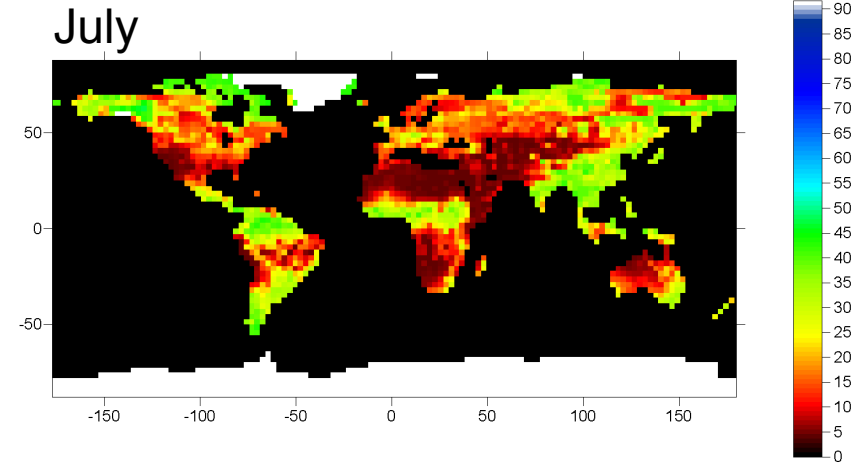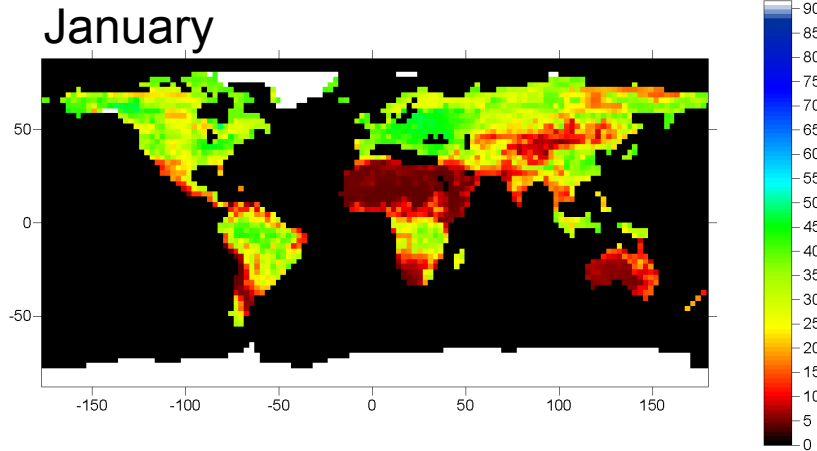d) DJF 4models lead=0

GCM3.1 simulation of soil moisture (1850-2000 climatology, top 10 cm of CLASS, T63; kg/m2)

January

July

April

October

www.cccma.bc.ec.gc.ca/data/cgcm3/cgcm3.shtml

Future Work

- Continue with soil moisture analysis using stand-alone models
  - VIC, MESH over Prairies
- Extend HFP seasonal forecasts past 2003
  - Focus on 1999-2005 drought
  - Initialization issues
    - Magnitude of GCM3/CLASS soil moisture anomalies
    - Sensitivity of GCM3/CLASS forecasts to initial soil moisture anomalies
    - Snowpack initialization?