The use of VIC soil moisture in drought monitoring and forecasting in Canada and China

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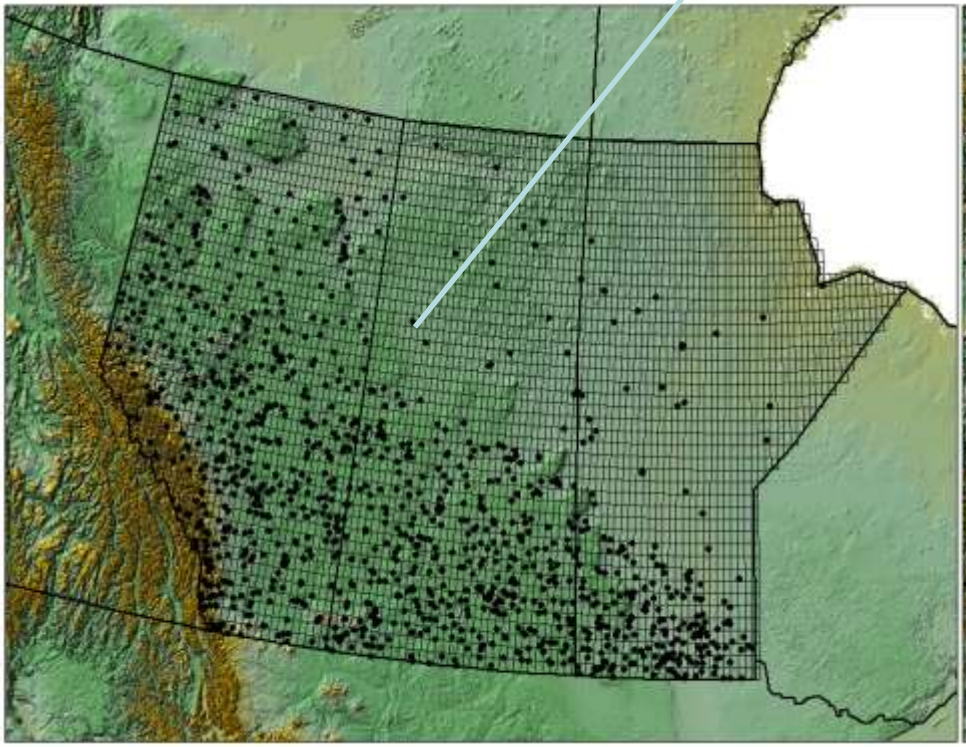
VIC prairie/China soil moisture modeling

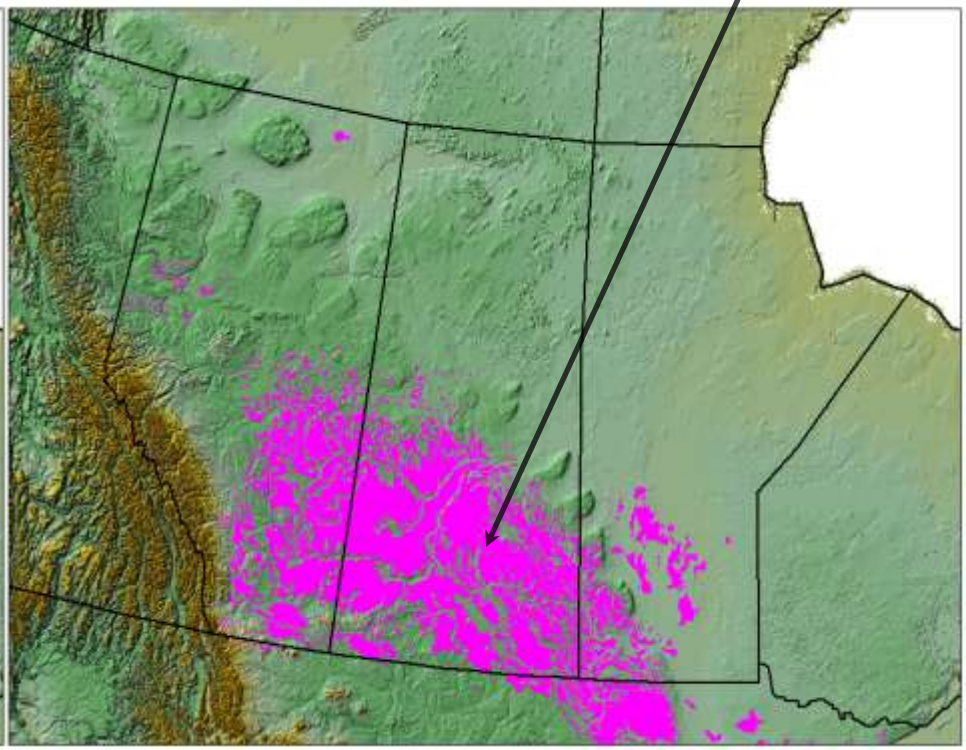
- three soil layers (0-20 cm, 20-100 cm, 0-100 cm)

  0.25 ° x 0.25 ° (prairie) / 30 km X 30 km (China), daily time step
- starting on 1 January, 1950, real-time forecasting with a lead time up to 35-day
- meteorological forcing: 1,167 (prairie) / 634 (China) stations + operational Canadian GEM forecast + operational 40-number super ensemble forecast + operational CMC ensemble seasonal forecast
- VIC soil moisture + its 60-yr climatology (1950-2009) →calculating a soil moisture index SMAPI (Soil Moisture Anomaly Percentage Index)
- Real-time VIC soil moisture is updated daily at present; prairie SMAPI results are publicly accessible online (http://www.meteo.mcgill.ca/~leiwen/vic/prairies/)

1. Wu et al., Thirty-five year (1971-2005) simulation of daily soil moisture using the Variable Infiltration Capacity model over China. Atmosphere-Ocean 45, 37-45, 2007
2. Wen at al. Reconstructing sixty year (1950-2009) daily soil moisture over the Canadian Prairies using the Variable Infiltration Capacity model, 2010

1,167 met stations (black dot) on the Prairies





4393 grid points, 0.25 ° x 0.25 °

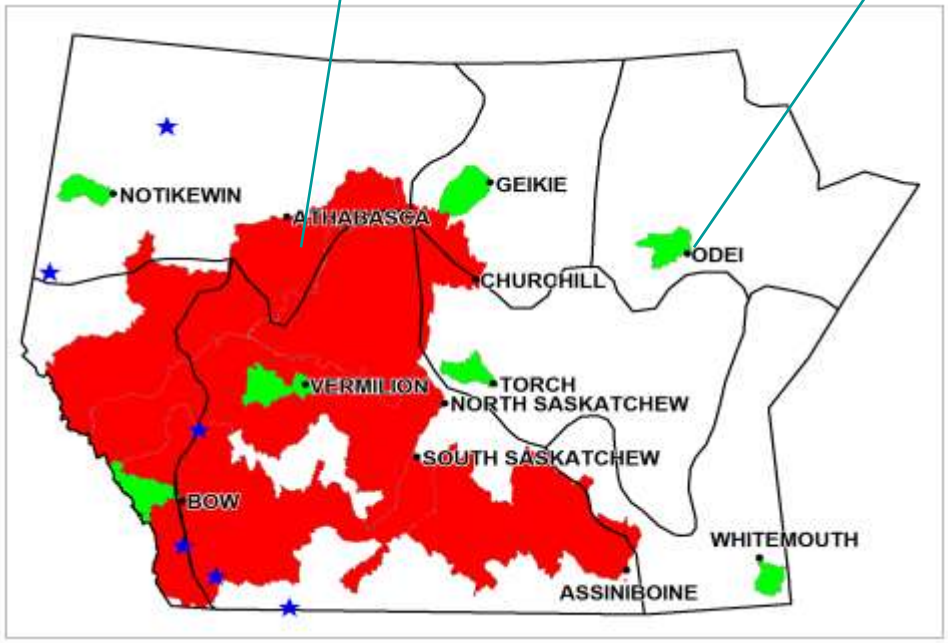
Prairies simulation domain

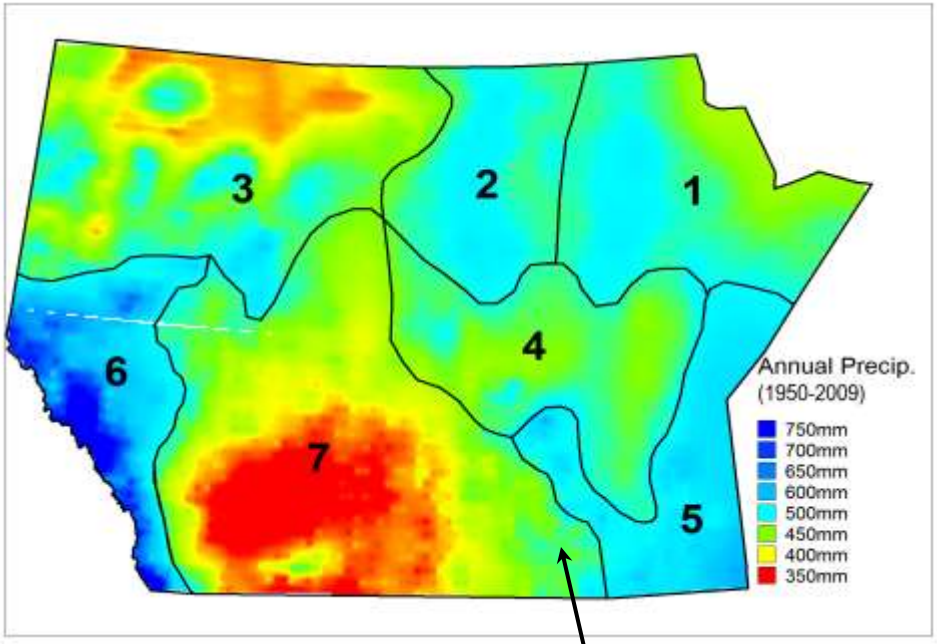
Flat terrain and non-contributing drainage areas, which brings challenges to hydrological modeling

VIC calibration and validation

5 additional validation catchments in **red**

7 calibration catchments in **green**;





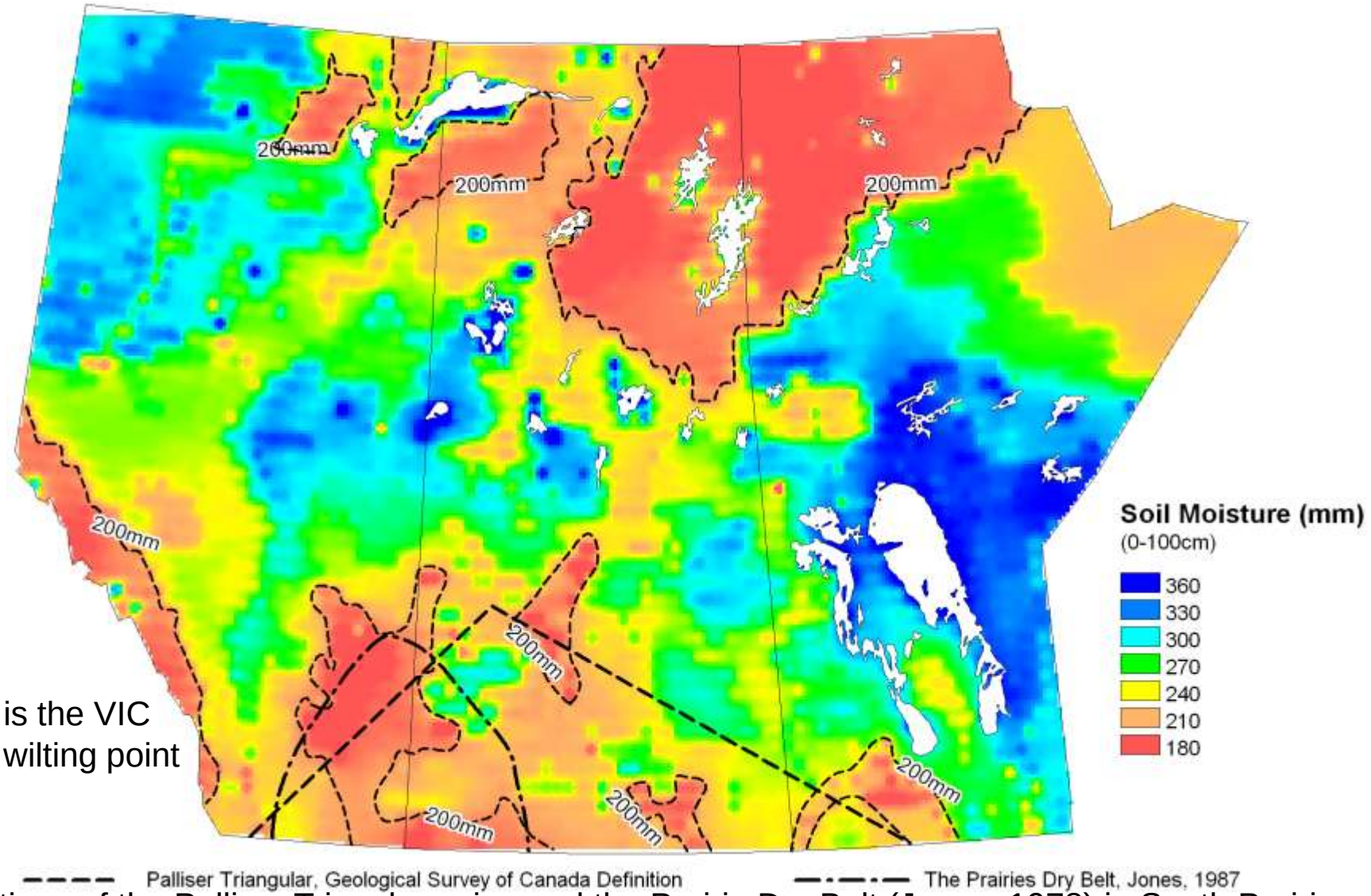
- We calibrate the six VIC user-calibrated hydrological parameters using observed daily hydrographs at the outlets of each of the 7 calibration catchments.
- The validation of the calibrated VIC over the Prairies involves the following three parts.

1. First, we validate VIC using observed daily hydrographs from the same 7 calibration catchments taken over different periods than for calibration.
2. Second, we further validate VIC using observed daily hydrographs from 5 additional catchments.
3. Third, we compare simulated soil moisture anomalies with *in situ* observations from 6 Alberta sites.

We define 7 VIC simulation regions over the Prairies, which is based on the annual precipitation of 1950-2009

VIC soil moisture

60-yr (1950-2009) average of soil moisture (top 1-m) over the Prairies
with the 200 mm soil moisture contour, showing modeled very dry areas

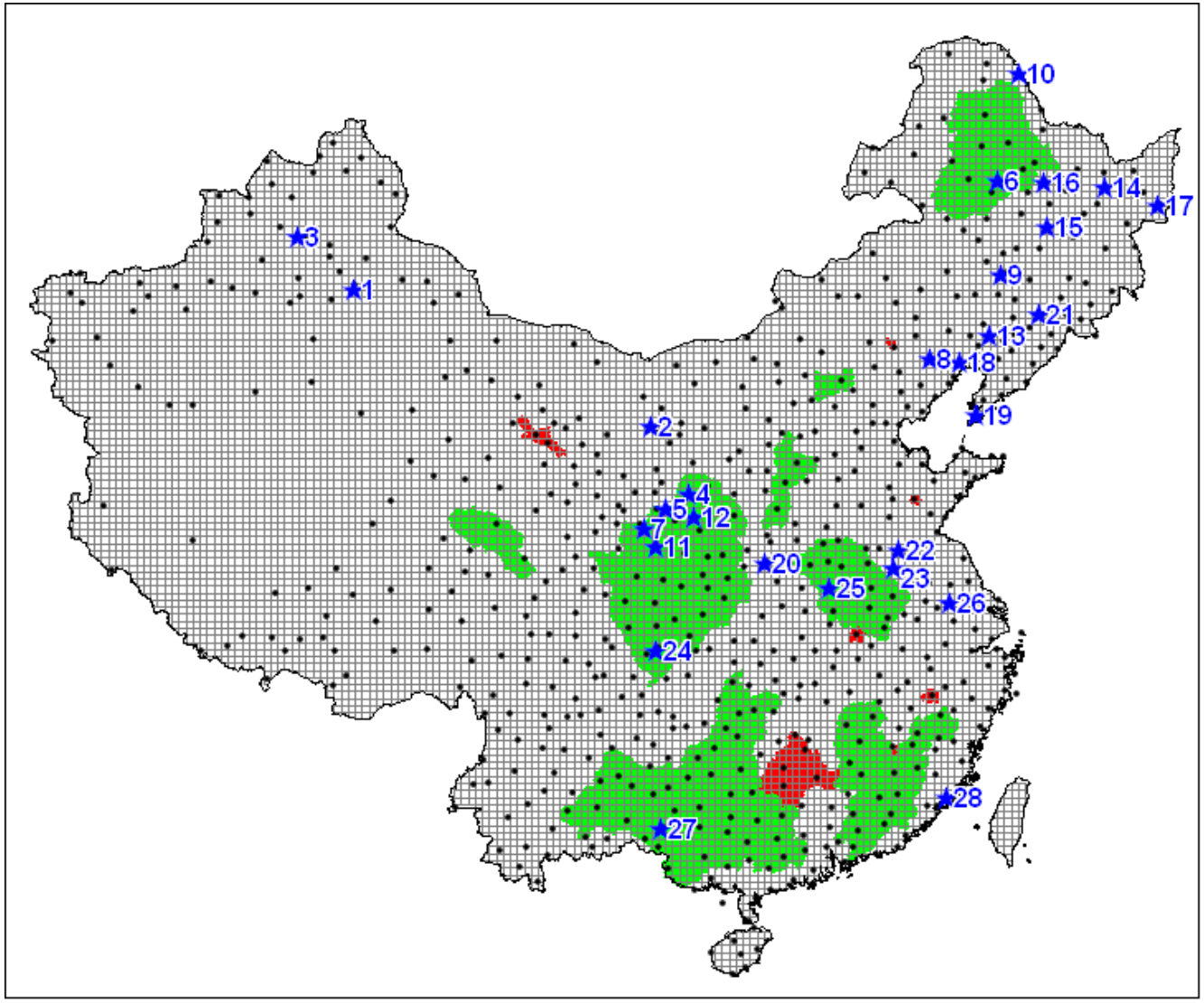


200 mm is the VIC average wilting point

Identifications of the Palliser Triangle region and the Prairie Dry Belt (Jones, 1978) in South Prairies.

China 30-km VIC modeling domain with 10,458 points

624 meteorological stations (•)
28 sites with *in situ* soil moisture measurements (blue stars)

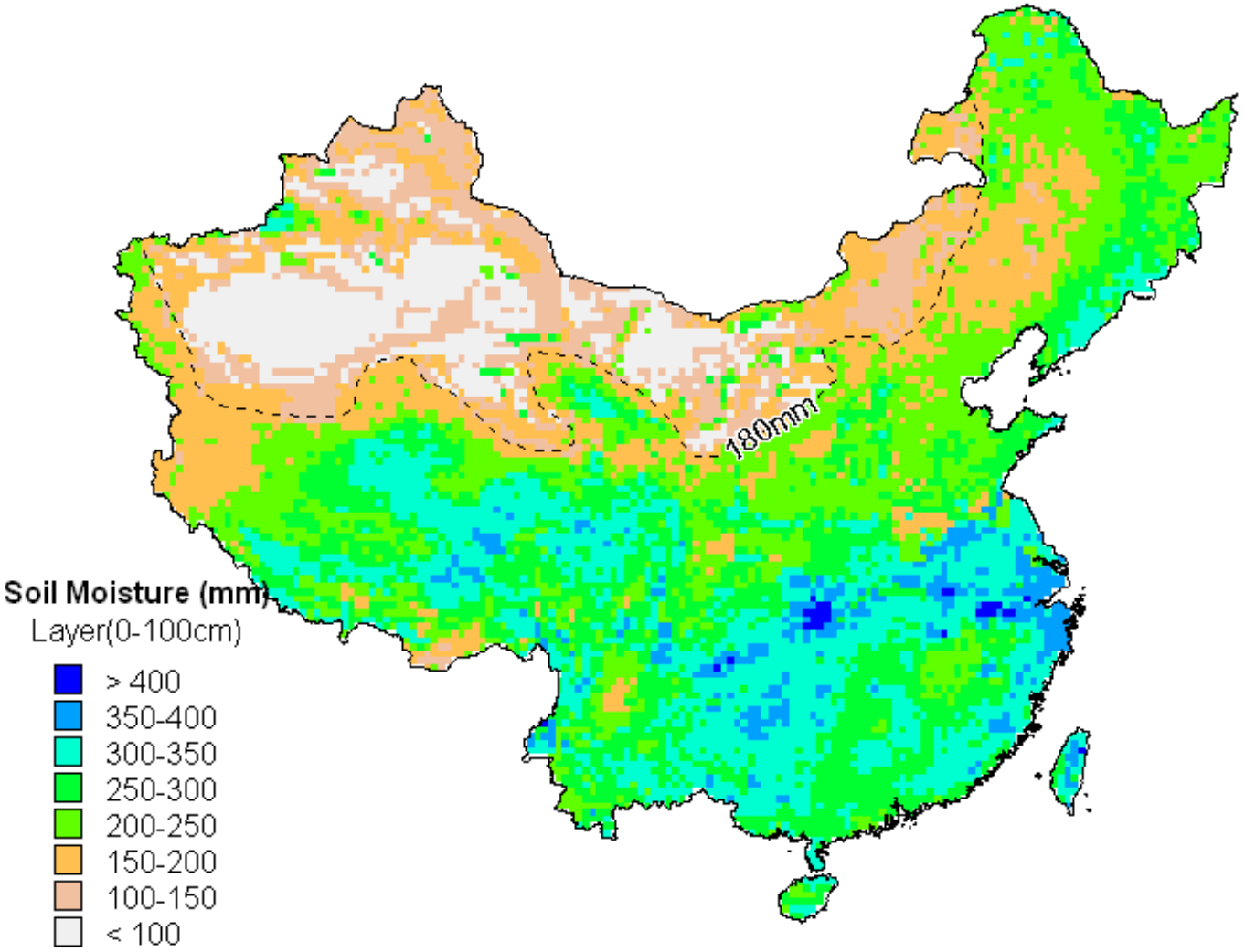


- 35 calibration and validation catchments (green; 190 to 351,530 km^2)
- 8 additional validation catchments (red; 1,230 to 10,010 km^2)

VIC soil moisture

60-yr (1950-2009) average of soil moisture (top 1-m) over China
with the 180 mm soil moisture contour, showing modeled very dry areas

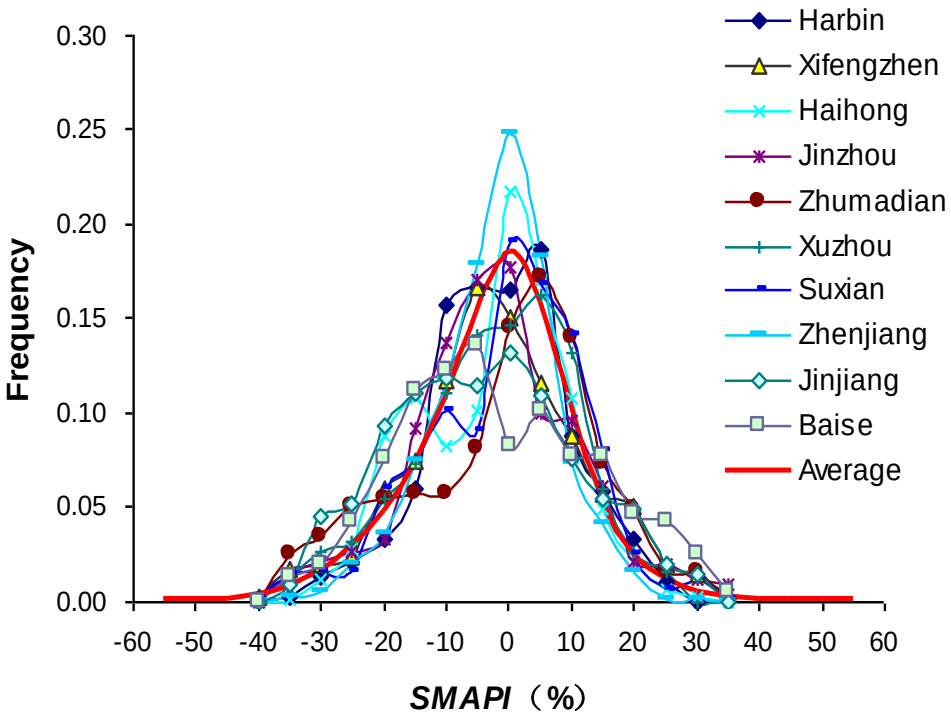
- Climatology compares qualitatively well with charts of dry/wet zones from Office of State Flood Control and Drought Relief Headquarters of China



Soil Moisture Anomaly Percentage Index (SMAPI)

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

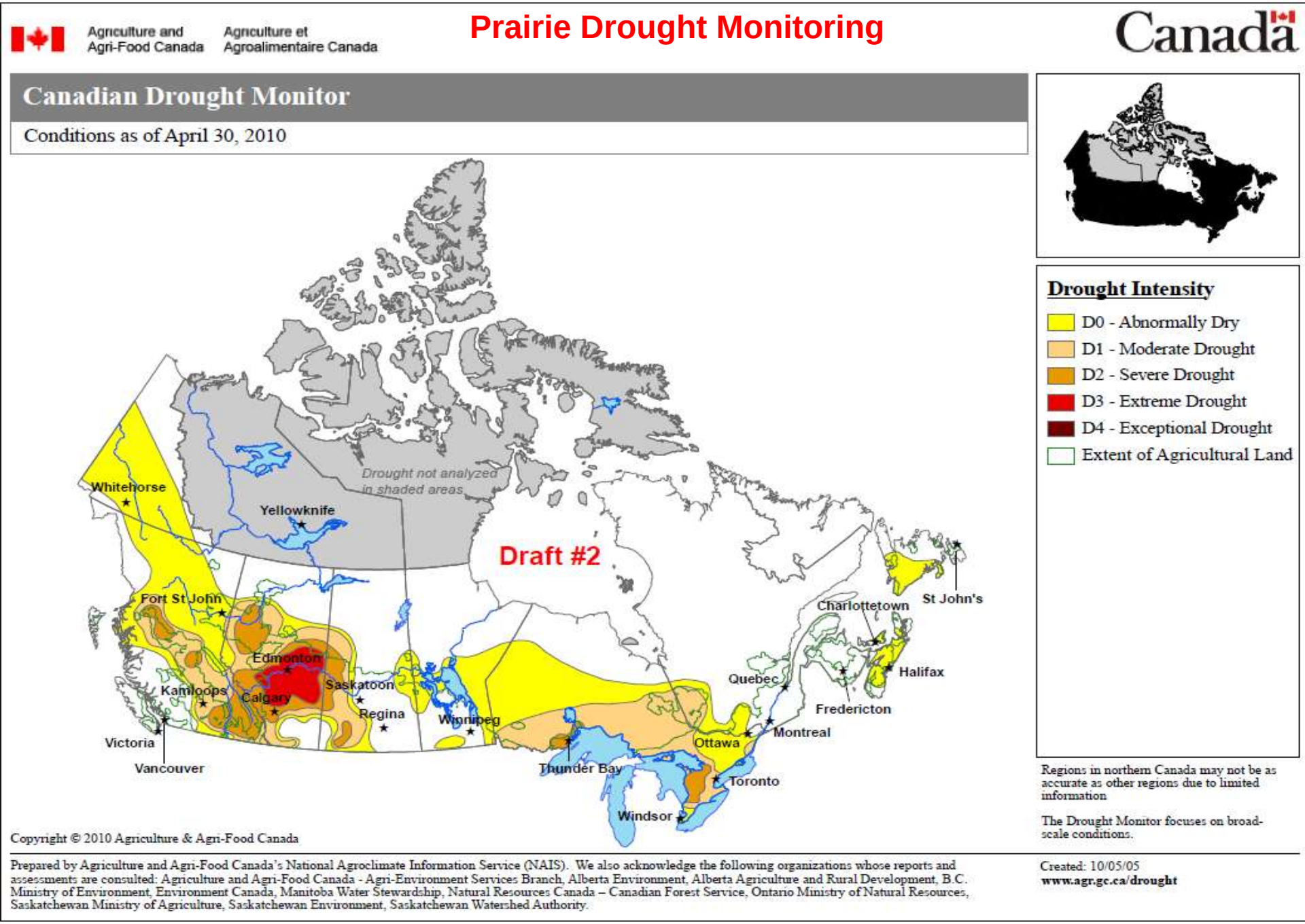
- The soil moisture climatology reflects local characteristics and mirrors the hydro-meteorological phenomena of a region
- Applying the concept of relative soil wetness for measuring drought severity (posting processing soil moisture)
- Keyantash and Dracup, BAMS, 2002 (second highest ranking among the five evaluated indices for agricultural drought)



Drought classifications based on SMAPI

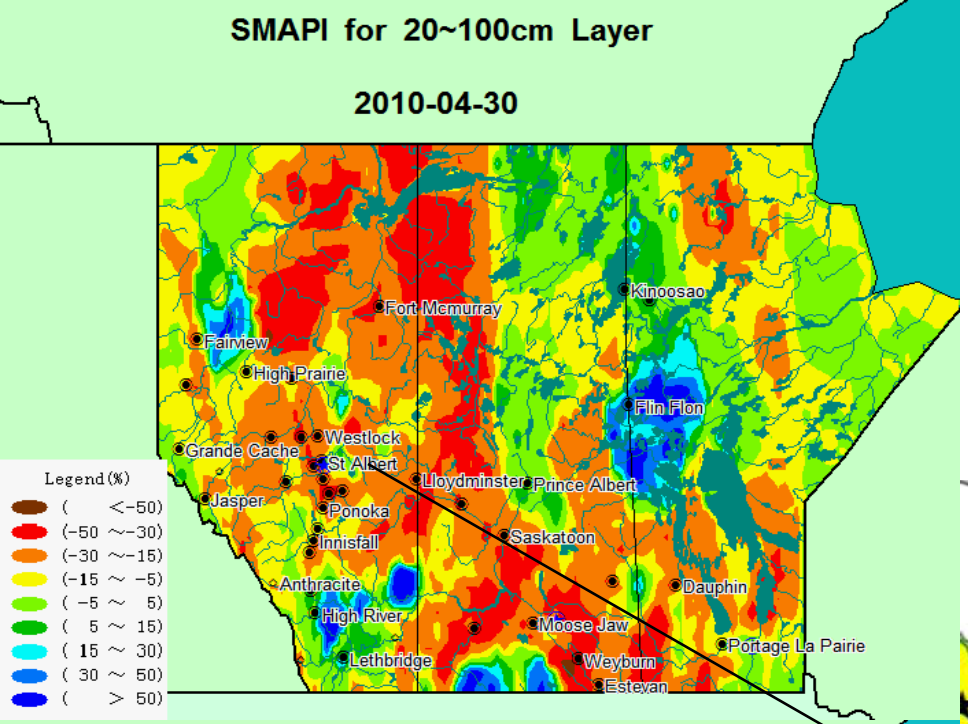
Category	SMAPI	Average Frequency
extreme drought	≤ -50%	0.005
severe drought	-50% to -30%	0.020
moderate drought	-30% to -15%	0.100
mild drought	-15% to -5%	0.200
near normal	-5% to 5%	0.350
slightly wet	5% to 15%	0.200
moderately wet	15% to 30%	0.100
very wet	30% to 50%	0.020
extremely wet	> 50%	0.005

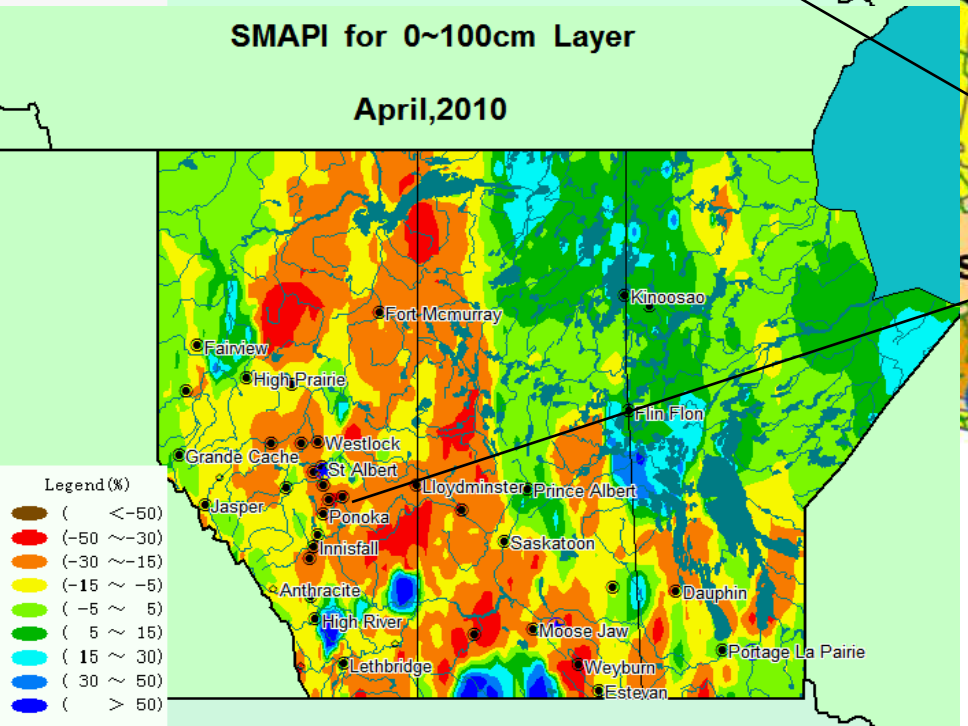
Prairie Drought Monitoring

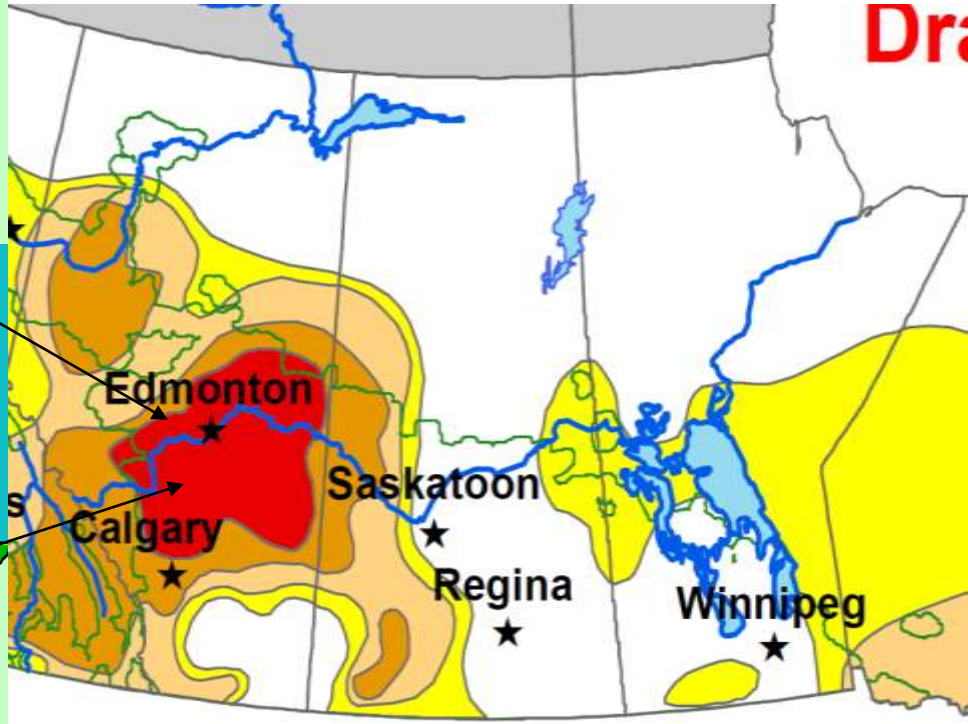


NADM from Richard Rieger, Agriculture and Agri-Food Canada

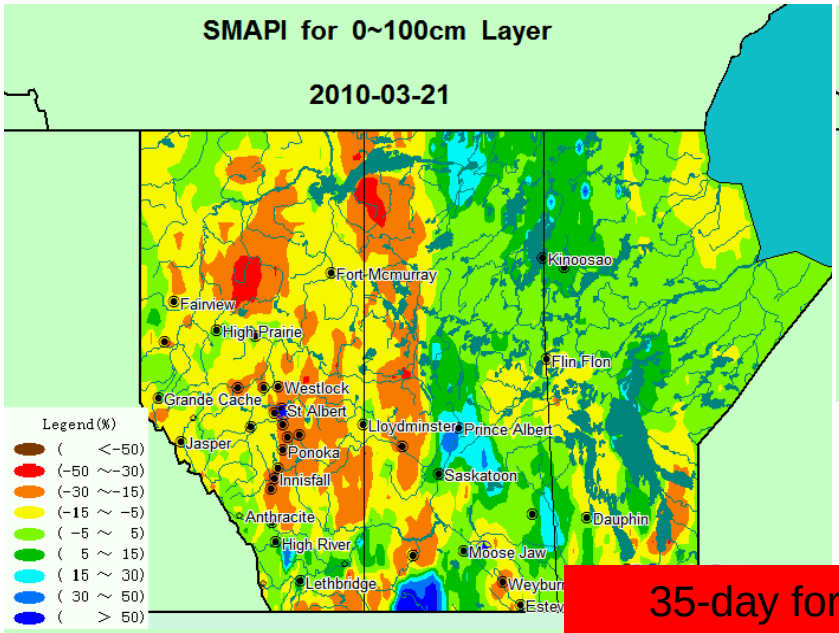
VIC Drought Monitoring
(zoom in)

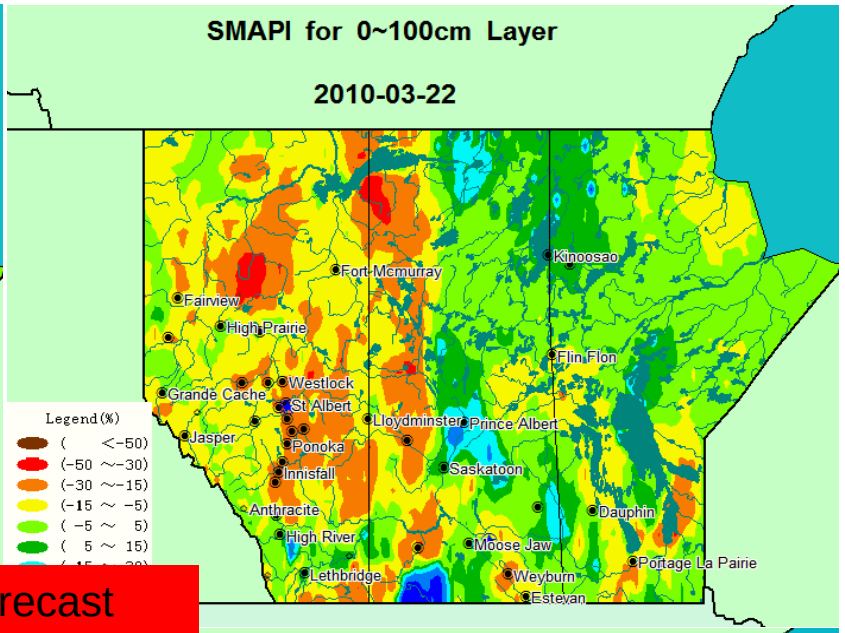




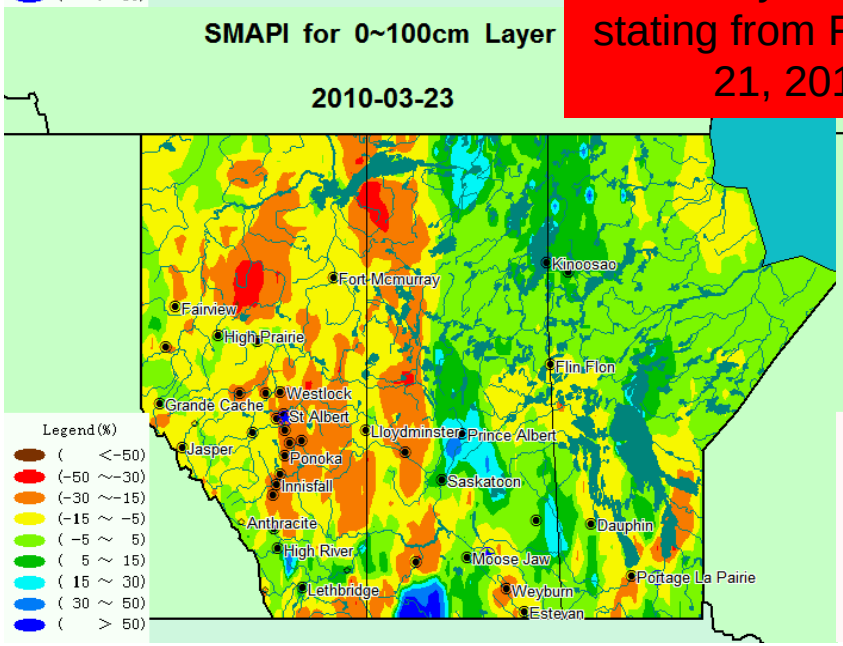


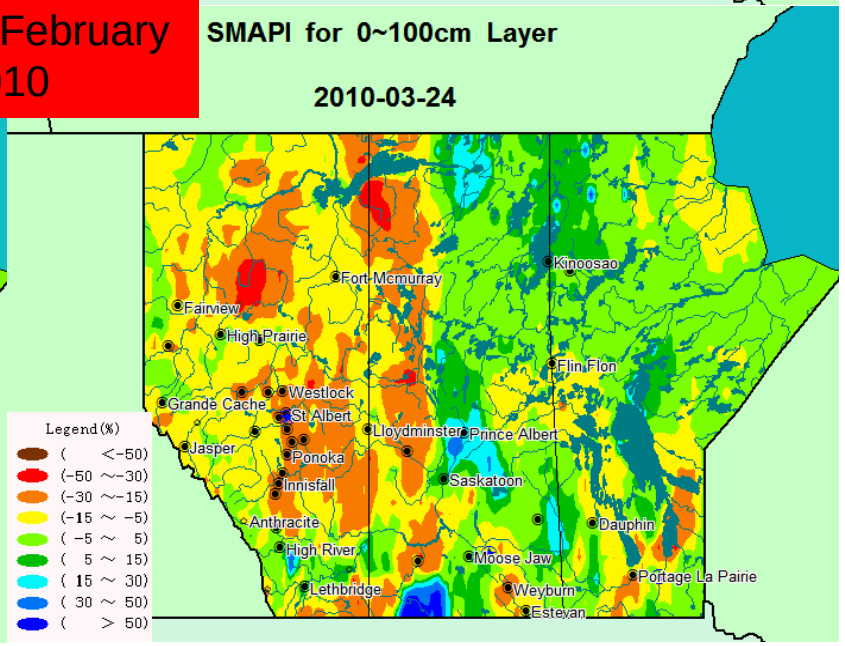
Real-time VIC Prairie Drought Forecasting





35-day forecast stating from February 21, 2010





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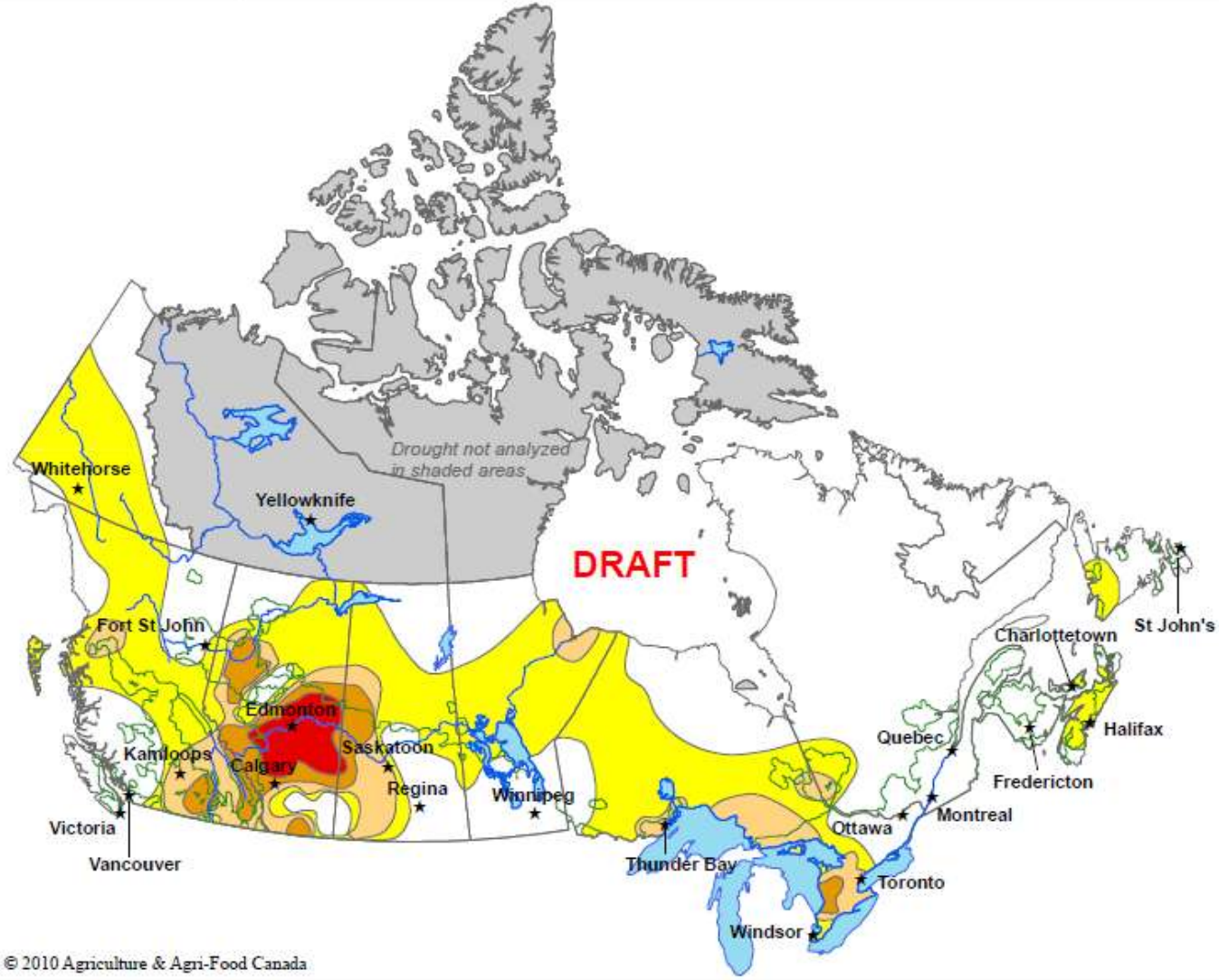
Canada

Canadian Drought Monitor

Conditions as of March 31, 2010



Drought Intensity

- D0 - Abnormally Dry
- D1 - Moderate Drought
- D2 - Severe Drought
- D3 - Extreme Drought
- D4 - Exceptional Drought
- Extent of Agricultural Land

Regions in northern Canada may not be as accurate as other regions due to limited information

The Drought Monitor focuses on broad-scale conditions.

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Prepared by Agriculture and Agri-Food Canada's National Agroclimate Information Service (NAIS). We also acknowledge the following organizations whose reports and assessments are consulted: Agriculture and Agri-Food Canada - Agri-Environment Services Branch, Alberta Environment, Alberta Agriculture and Rural Development, B.C. Ministry of Environment, Environment Canada, Manitoba Water Stewardship, Natural Resources Canada – Canadian Forest Service, Ontario Ministry of Natural Resources, Saskatchewan Ministry of Agriculture, Saskatchewan Environment, Saskatchewan Watershed Authority.

Created: 04/06/10

www.agr.gc.ca/drought

Monitoring and forecasting 2009 Winnipeg Spring flood

The province has activated ...

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Red River flooding

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The province has activated the Red River Floodway. Officials had said the flood diversion channel wouldn't be used until all of the ice was off the Red River near the floodway gates south of Winnipeg, but water levels inside the city were just getting too high.

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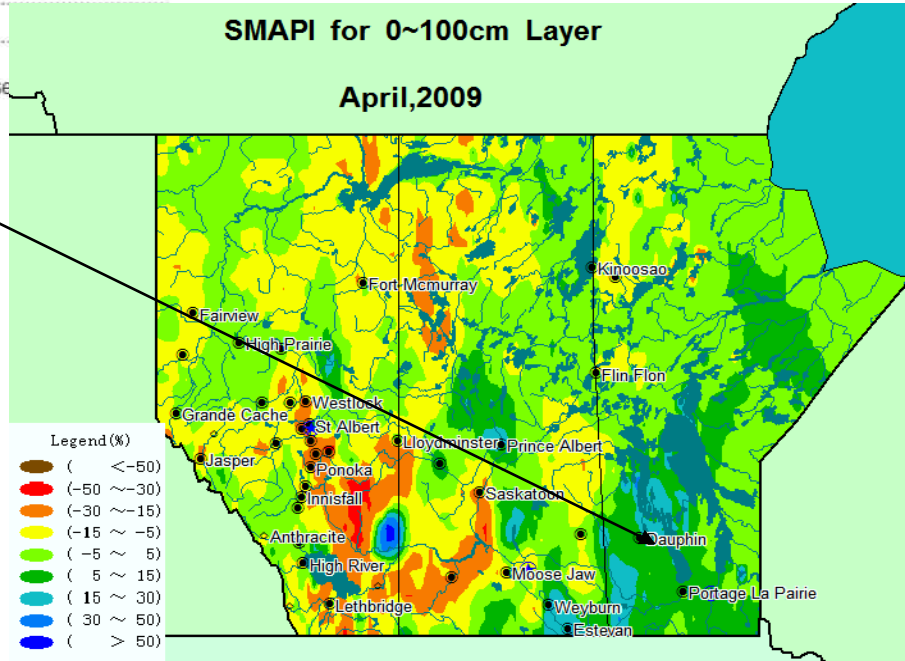
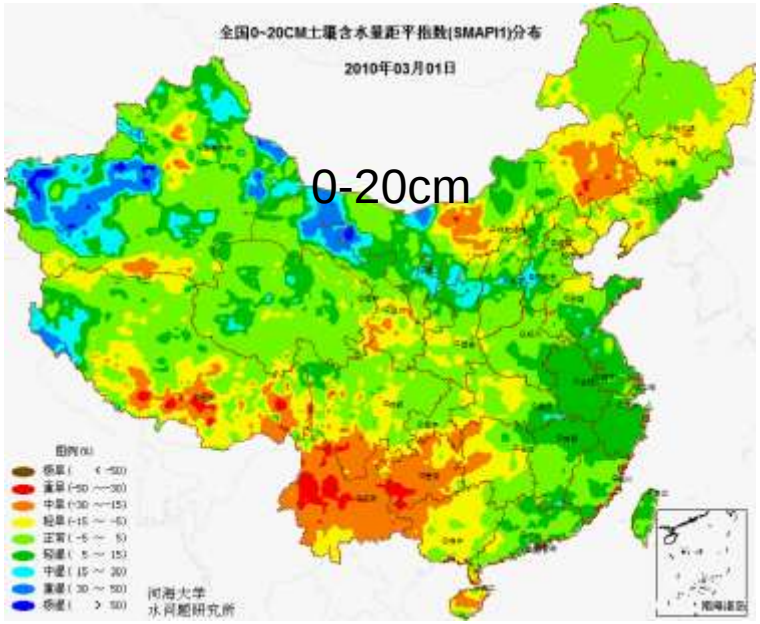
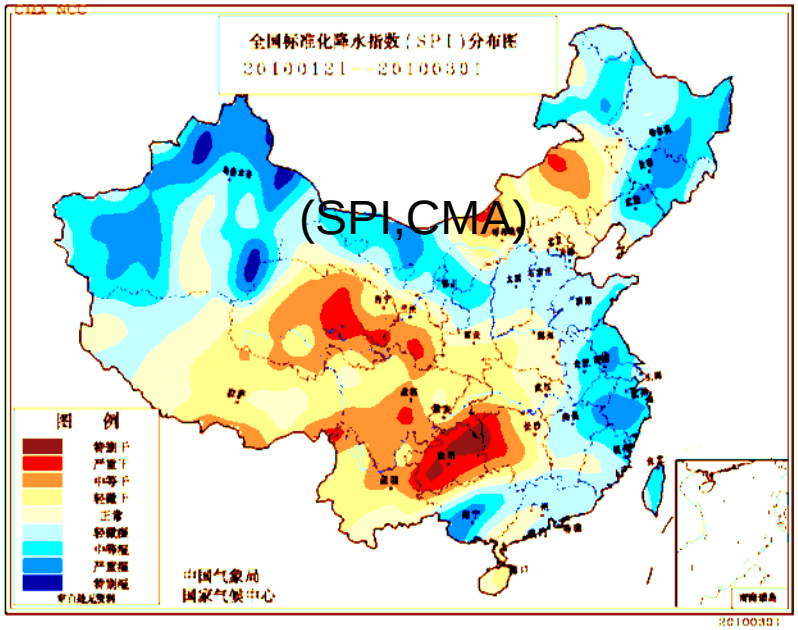
Wed Apr 8, 4:25 PM

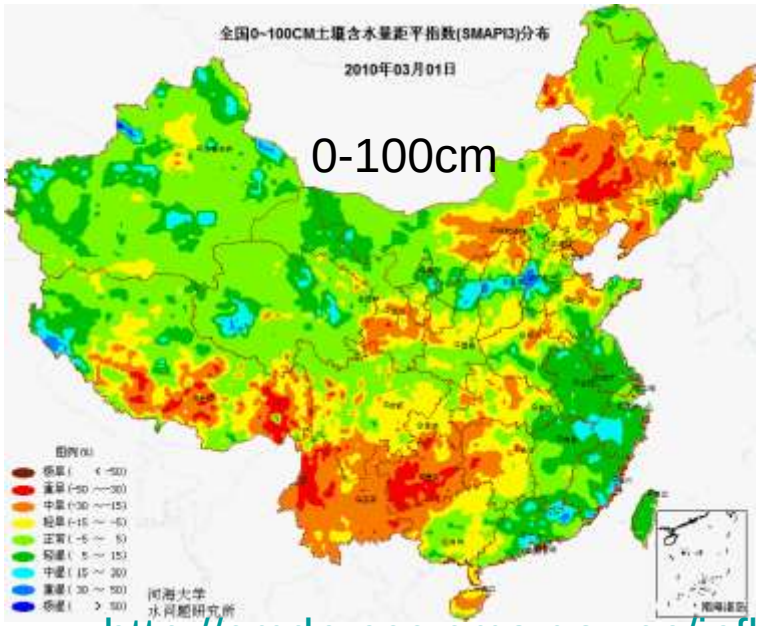


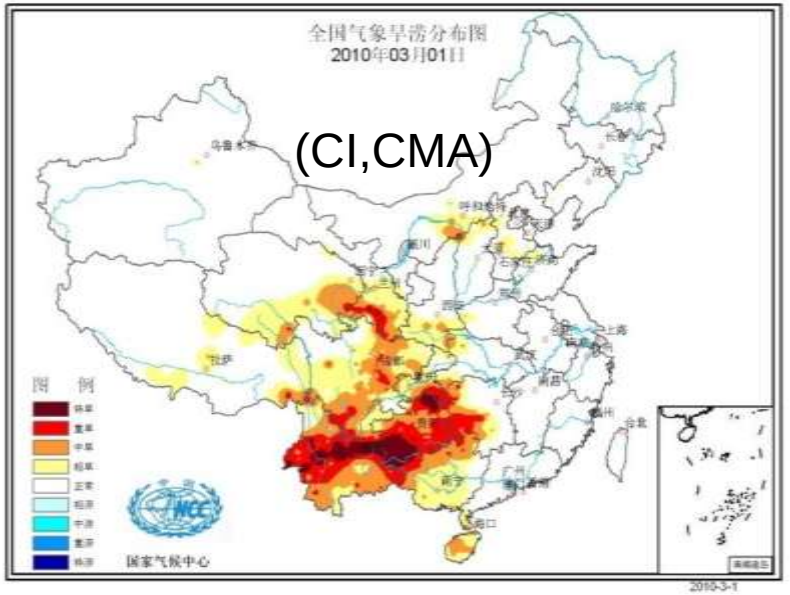
2010 South-west China Drought

China Drought monitoring, Mar. 1, 2010



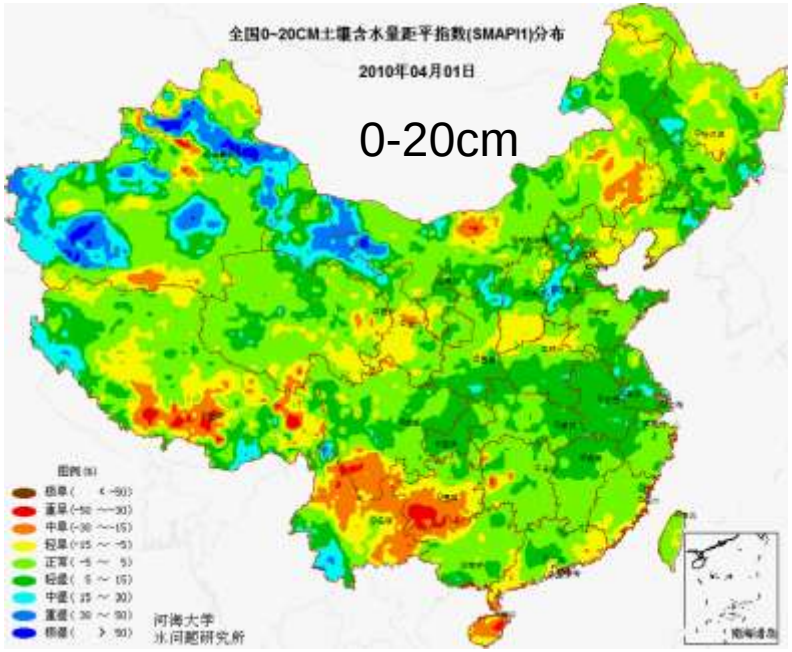


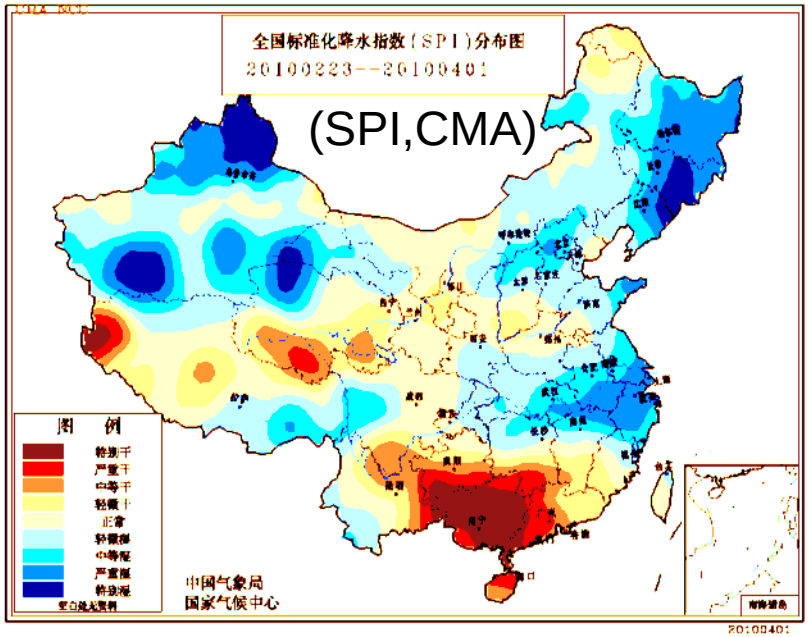


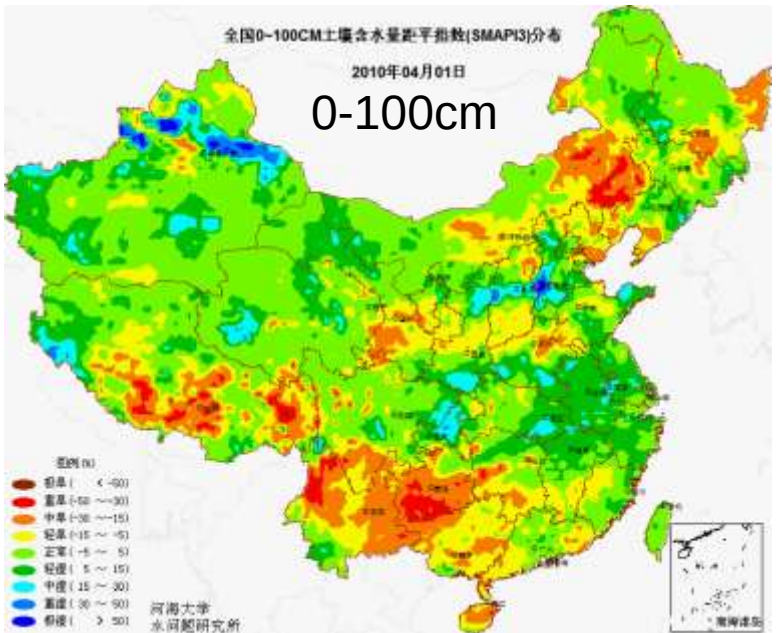


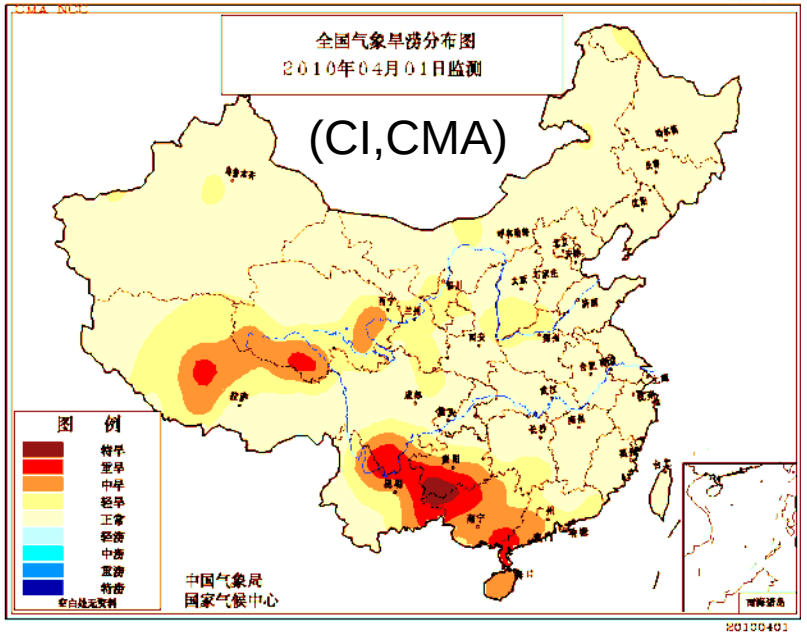
http://cmdp.ncc.cma.gov.cn/influ/dust.php?dateStr=2010-4#calendar

China Drought monitoring, Apr. 1, 2010



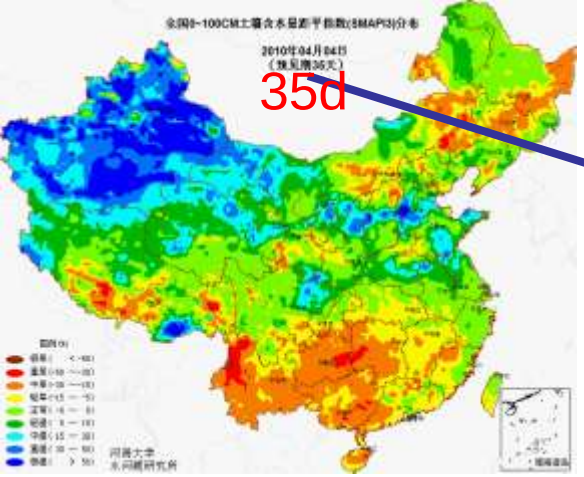


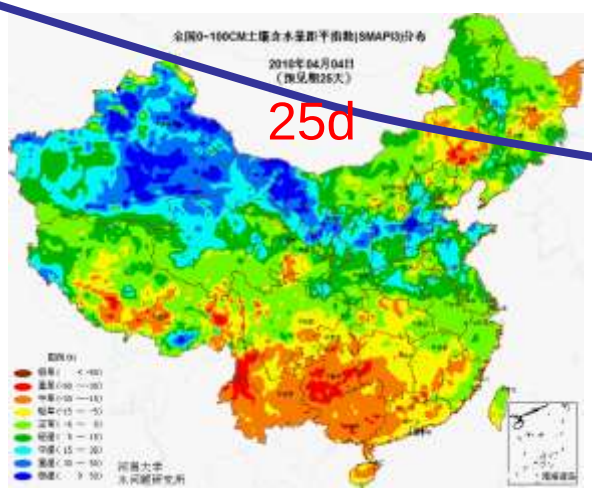


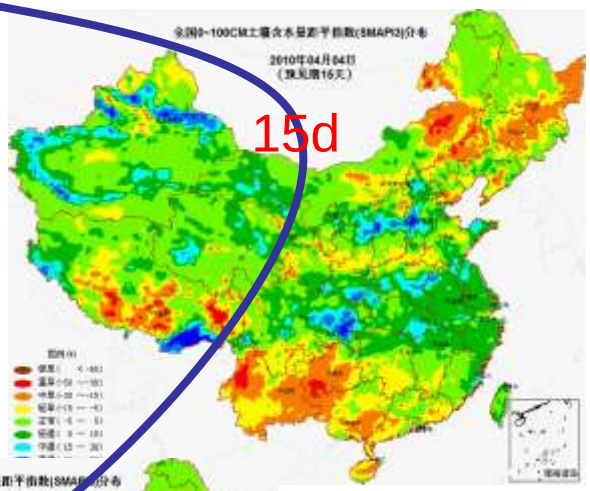


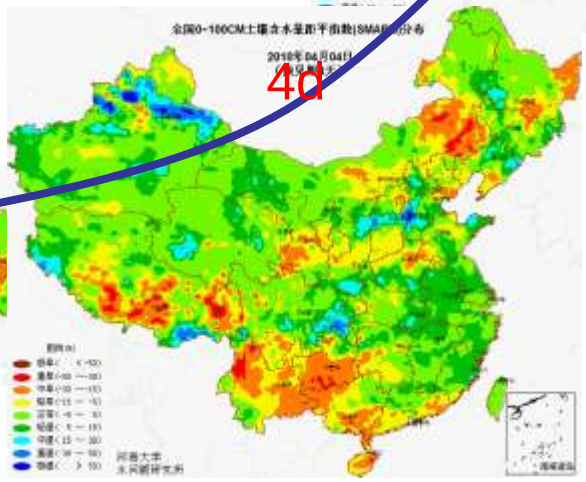
Real-time China drought forecast

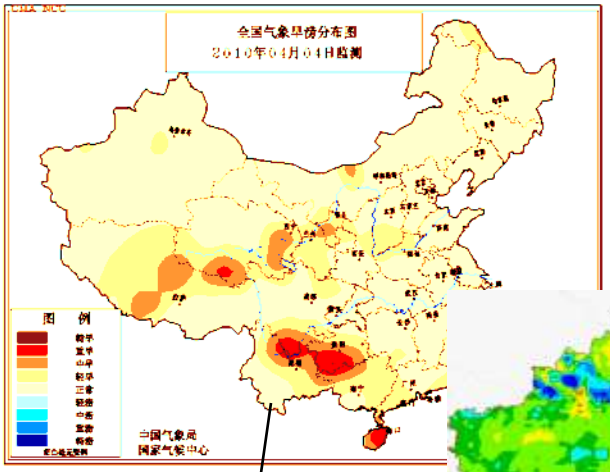
Forecast verifying on April 4, 2010 with different lead time







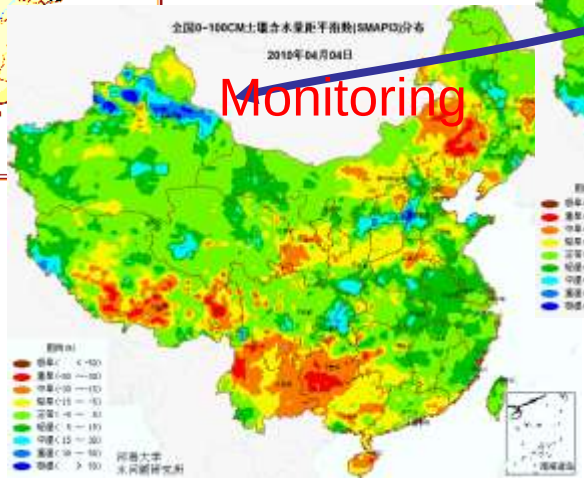




Monitoring

(Drought Monitor,

China Meteorology Administration



Thanks very much !
Merci beaucoup !