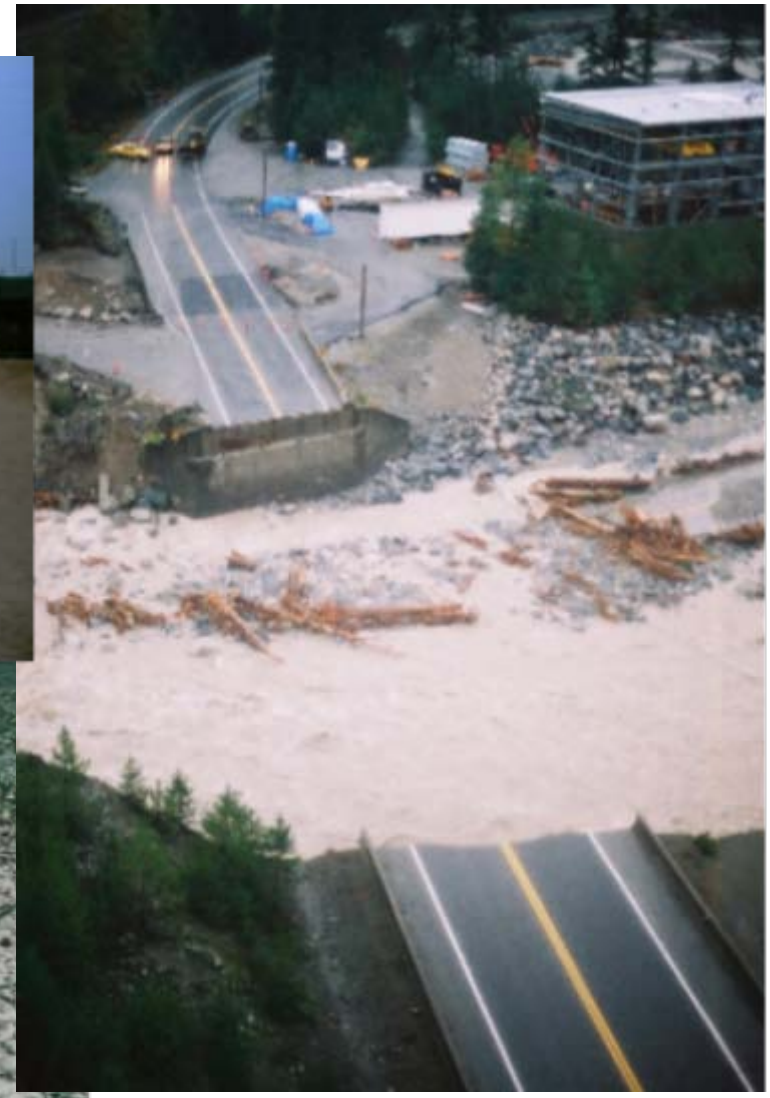
PRECIPITATION EXTREMES: BOTH WET AND DRY

Ronald Stewart
University of Manitoba

IMPACTS OF EXTREMES



And many others

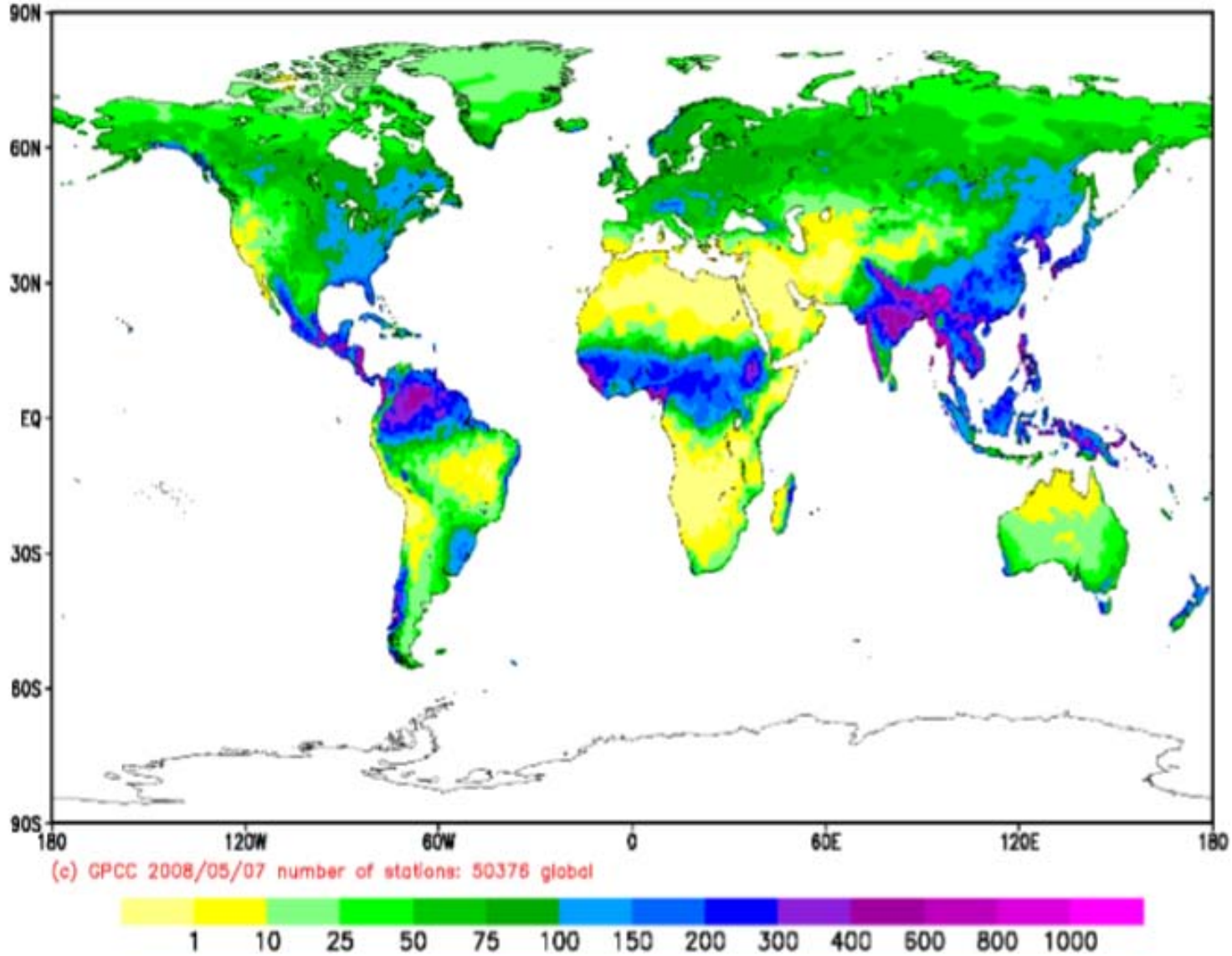
OBJECTIVE

- To examine some of the basics of extreme precipitation
- To illustrate that wet and dry regions can occur in close proximity
- To briefly consider some of the implications

STRUCTURE

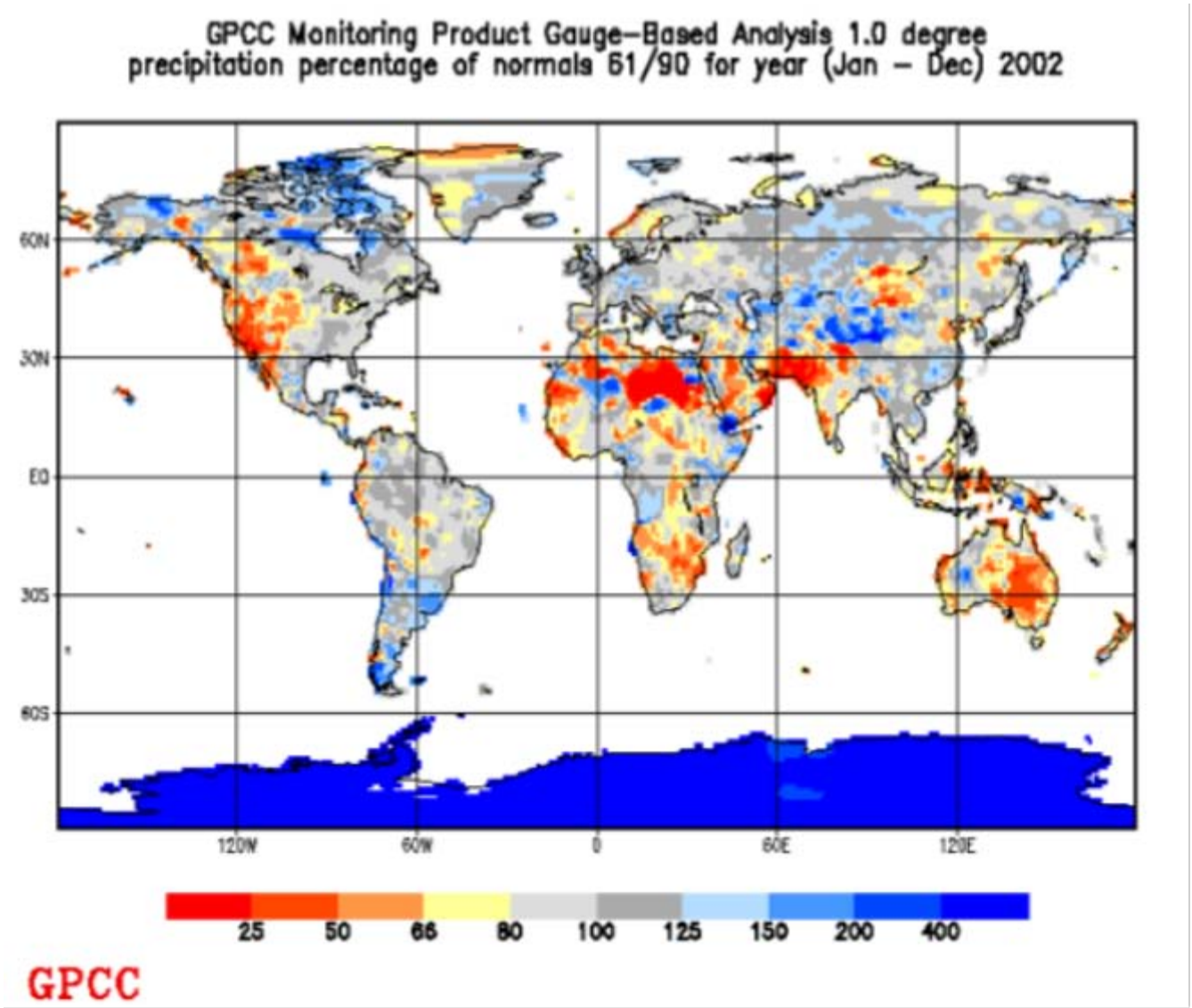
- Global climate
- Drought features
- Reducing precipitation
- Heavy precipitation - drought interactions
- Implications
- Future conditions
- Concluding remarks

JULY 10-YEAR PRECIPITATION



mm per month

2002


GPCC Monitoring Product Gauge-Based Analysis 1.0 degree
precipitation percentage of normals 61/90 for year (Jan – Dec) 2002
60N
30N
EQ
30S
60S
120W
60W
0
60E
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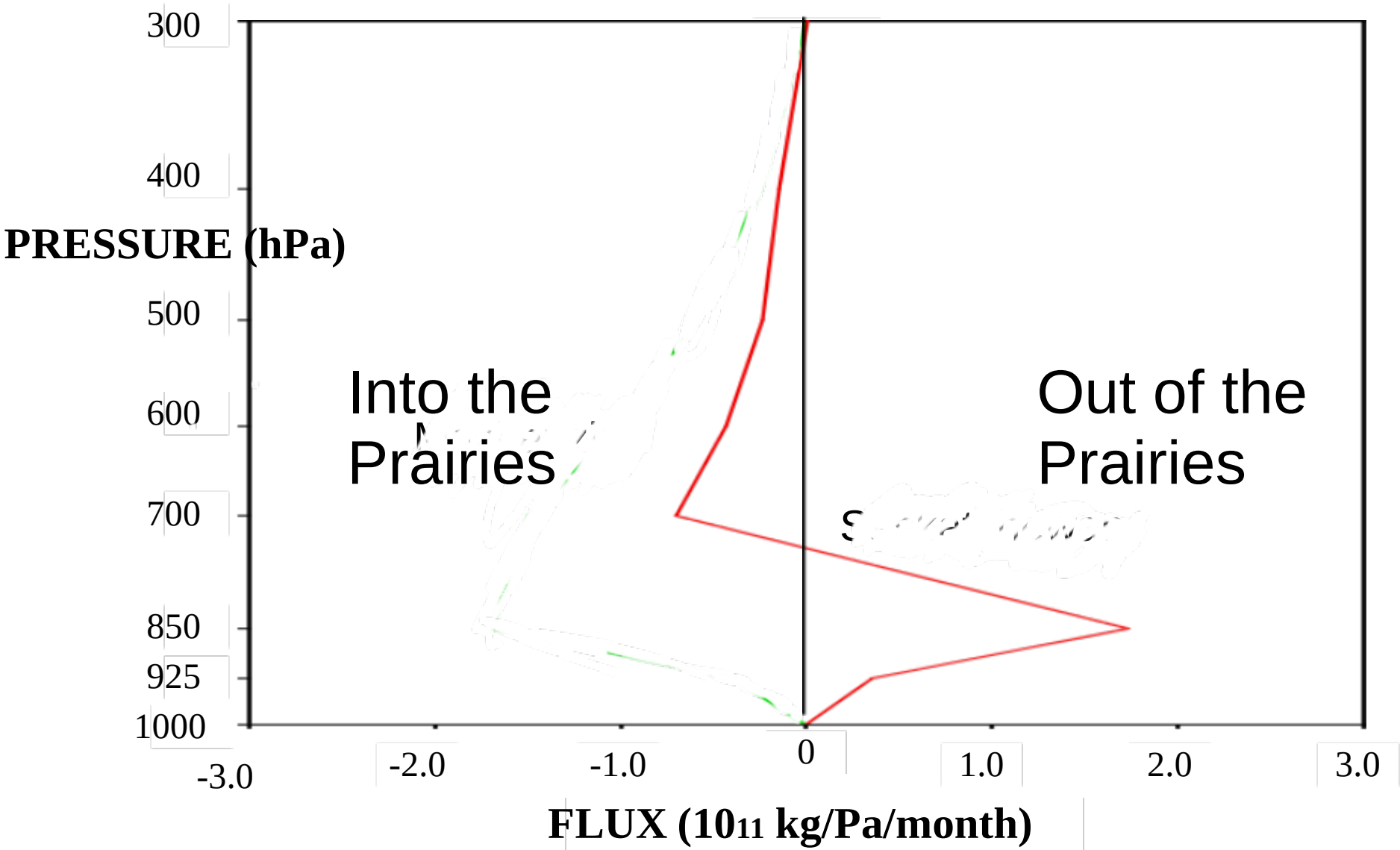
25
50
66
80
100
125
150
200
400
GPCC

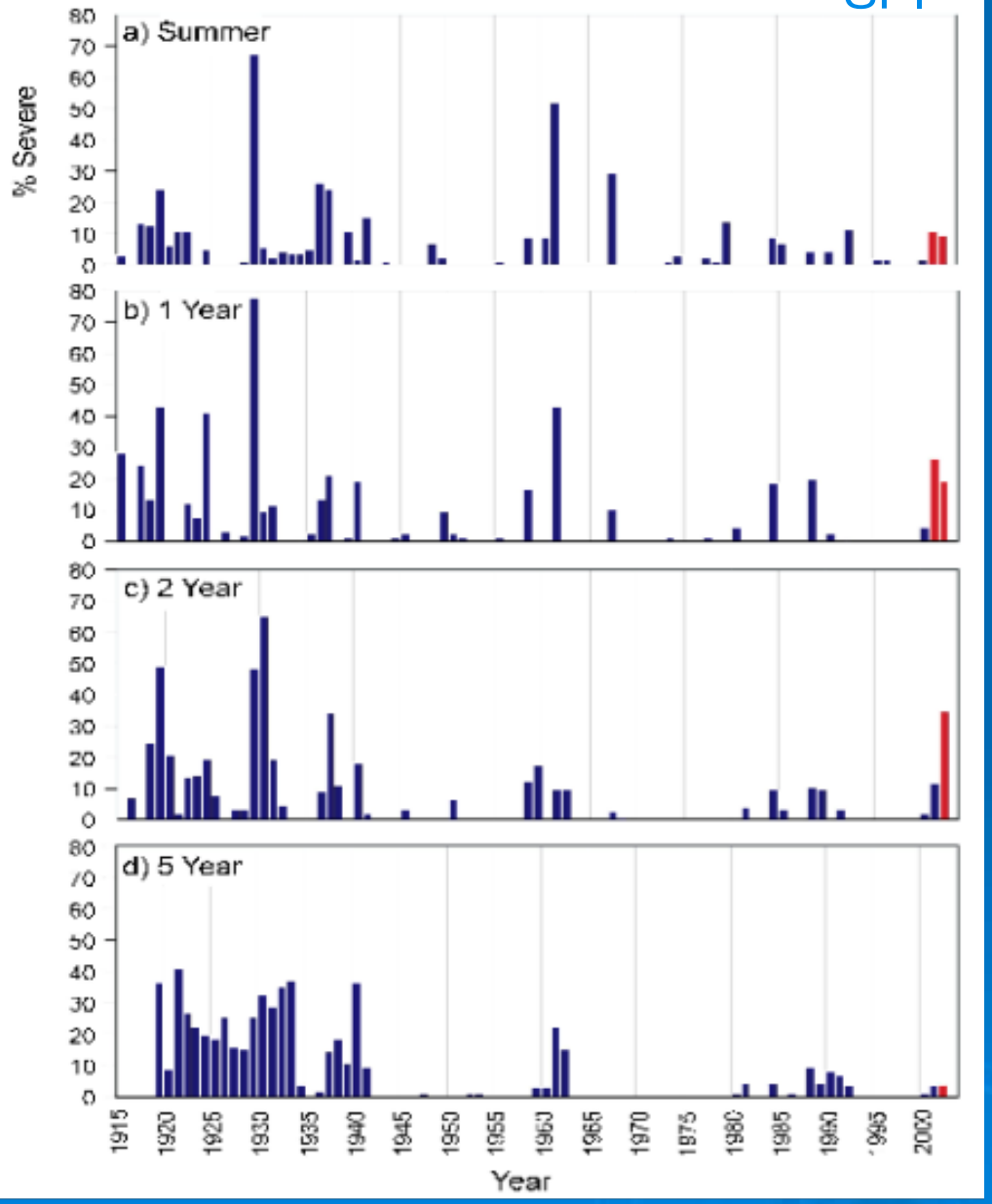

The Canadian
Prairies

VERTICAL MOISTURE PROFILE

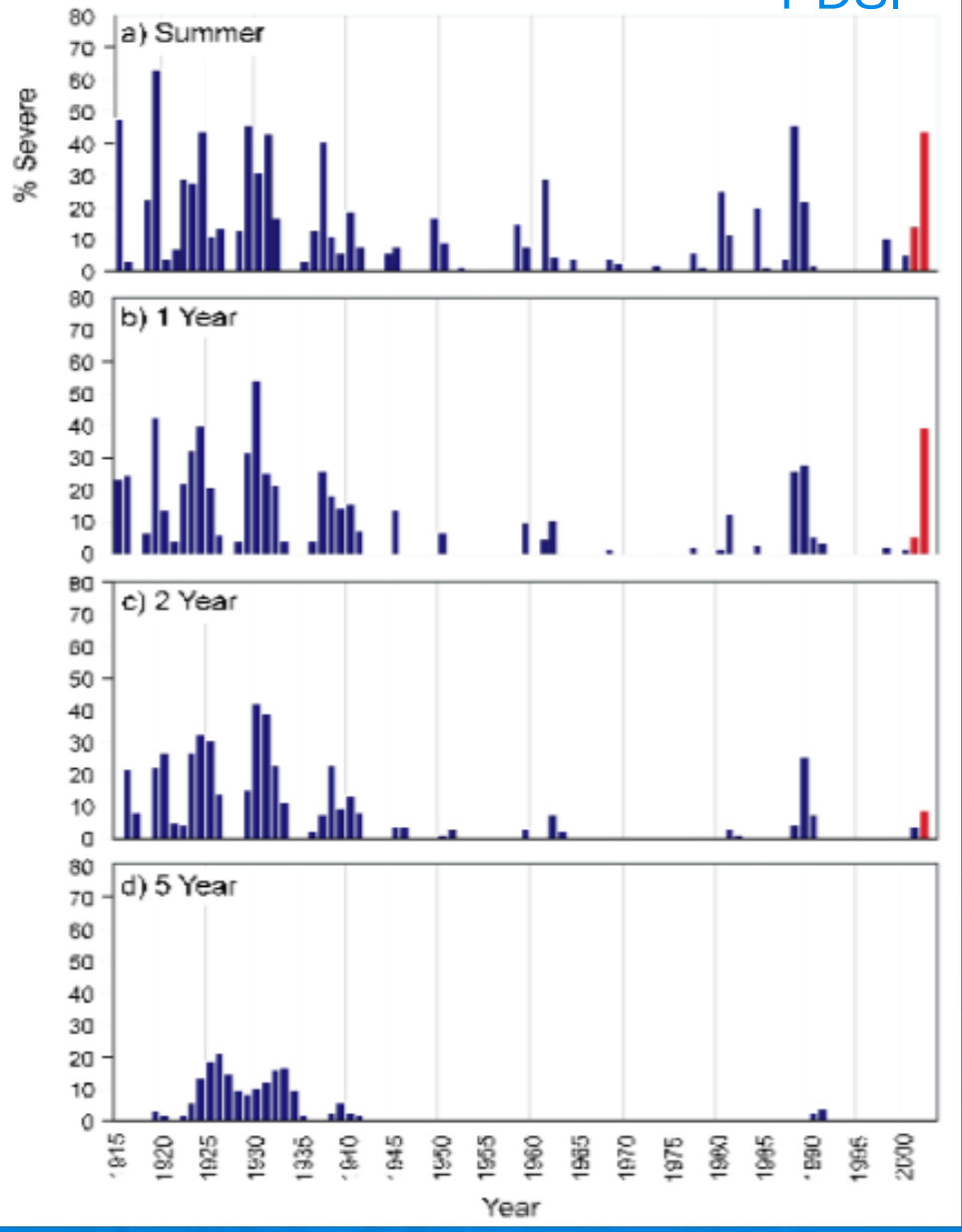


Drought Occurrence – Southern Prairies (1915-2002)

SPI



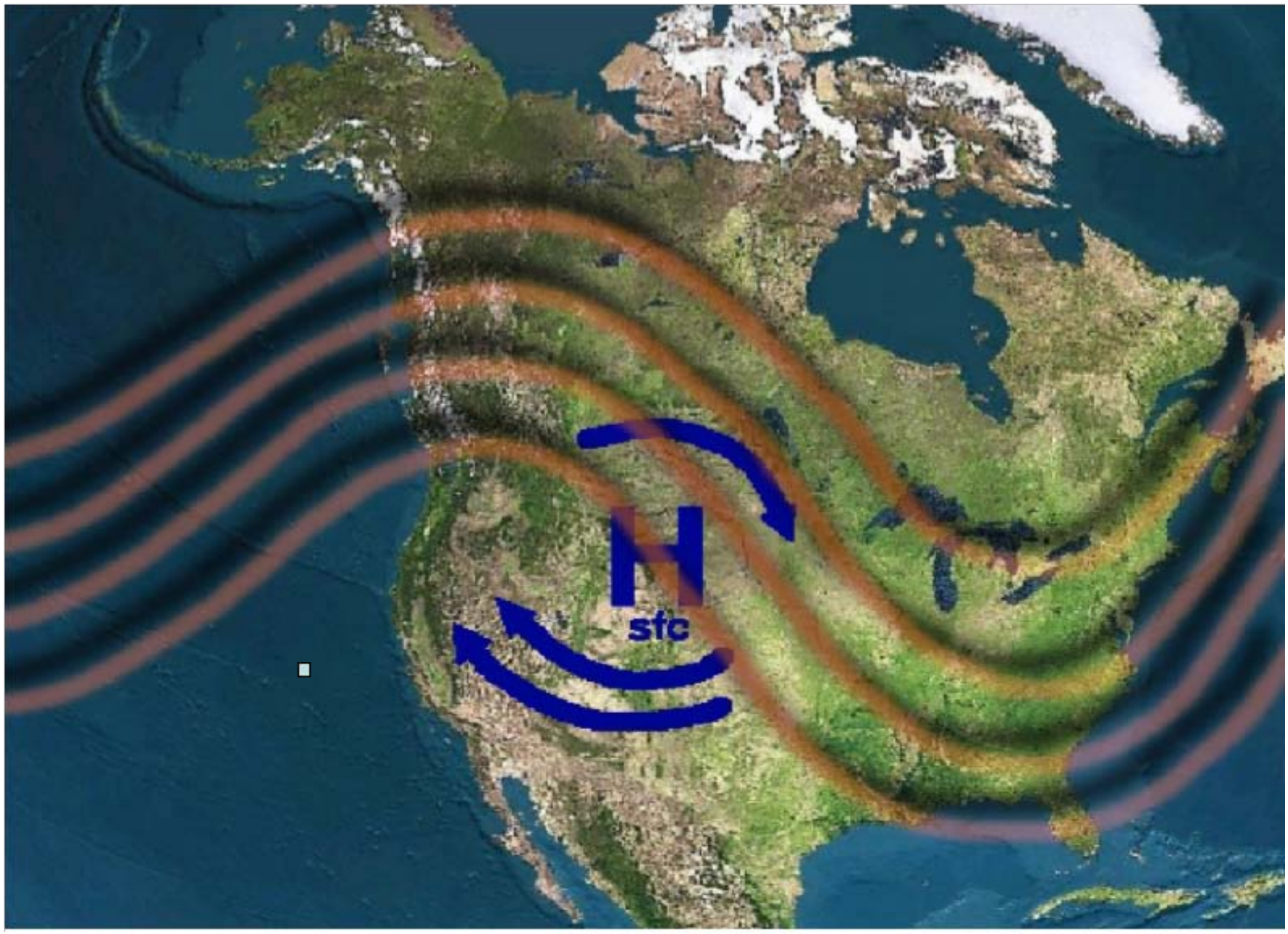
PDSI



Droughts in Canada

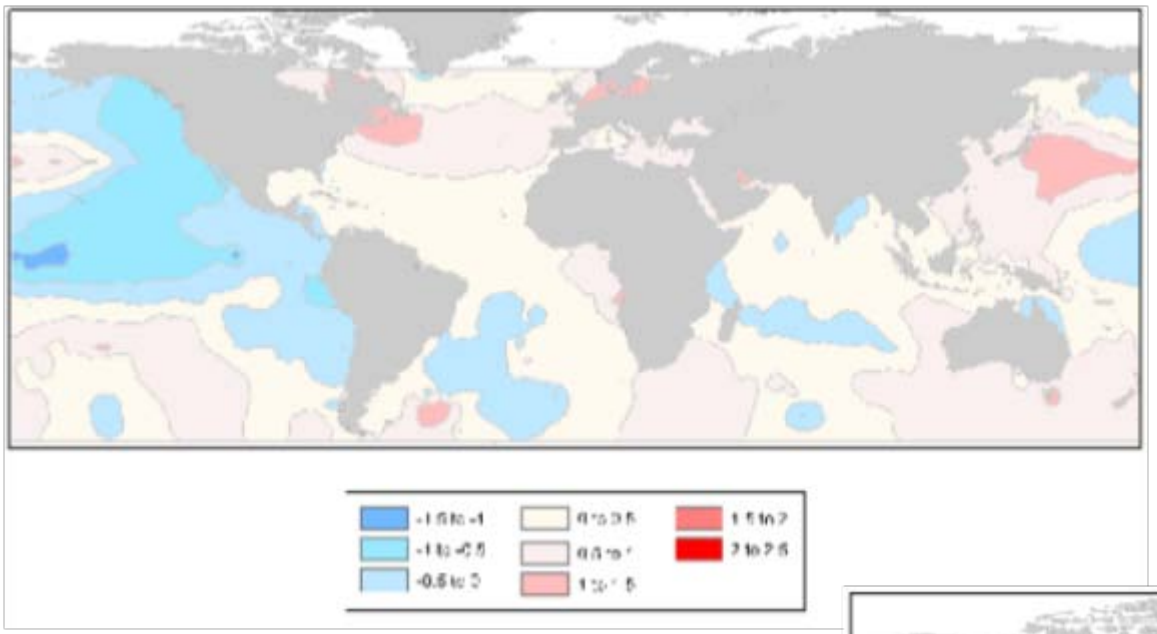
1999-2005 is a recent example

COMMON VIEW …



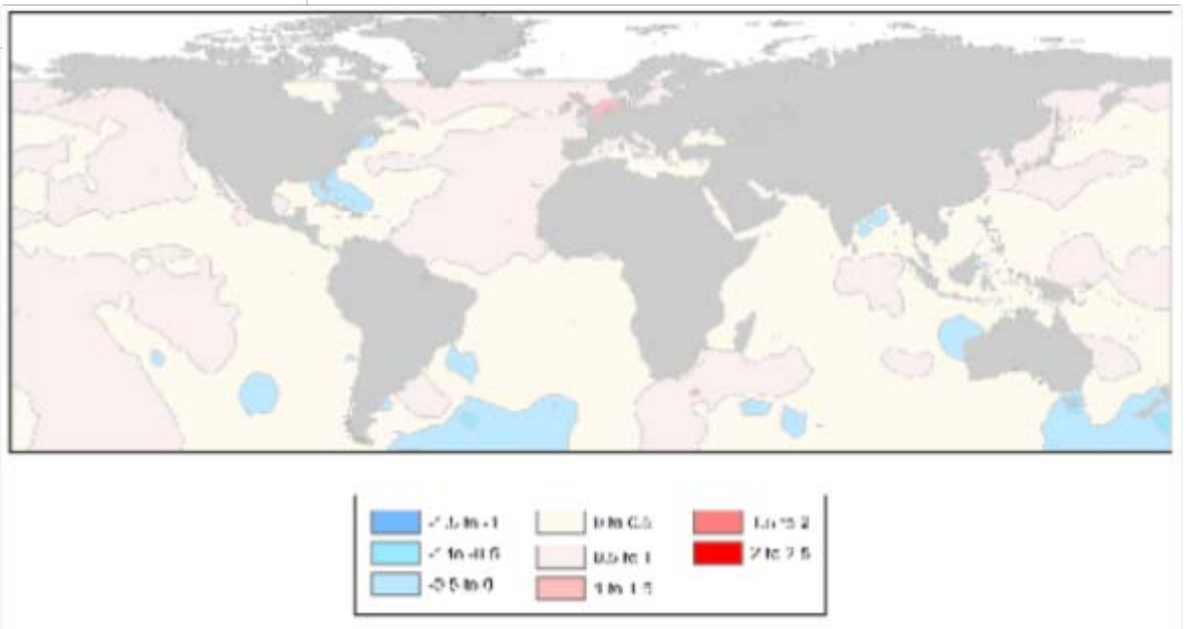
SST Anomalies

1999

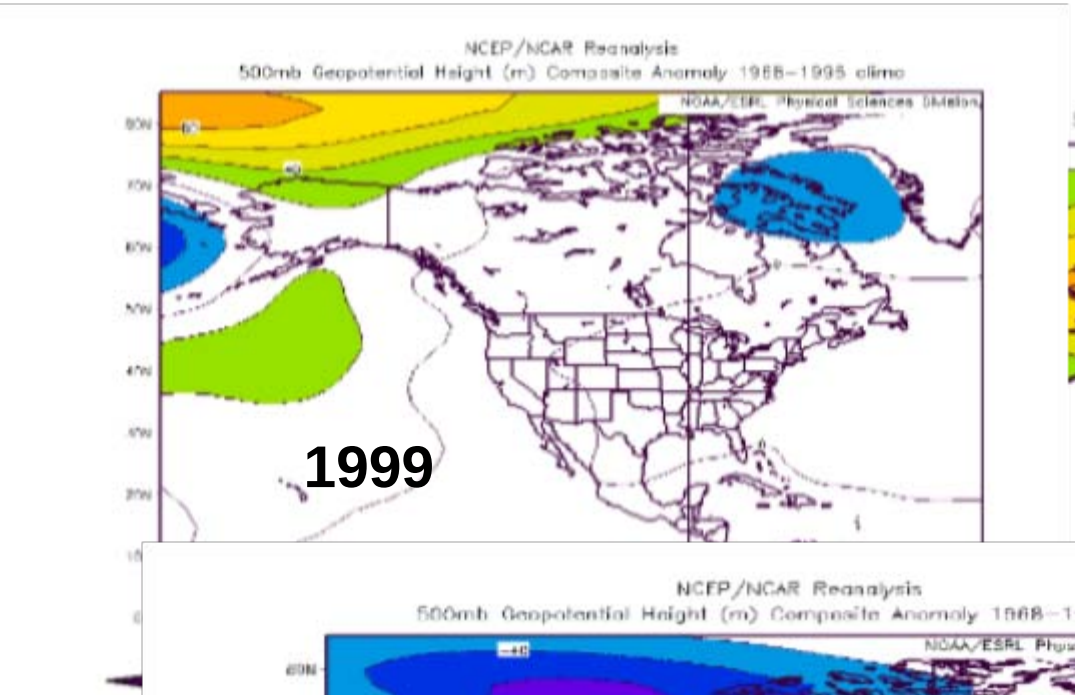


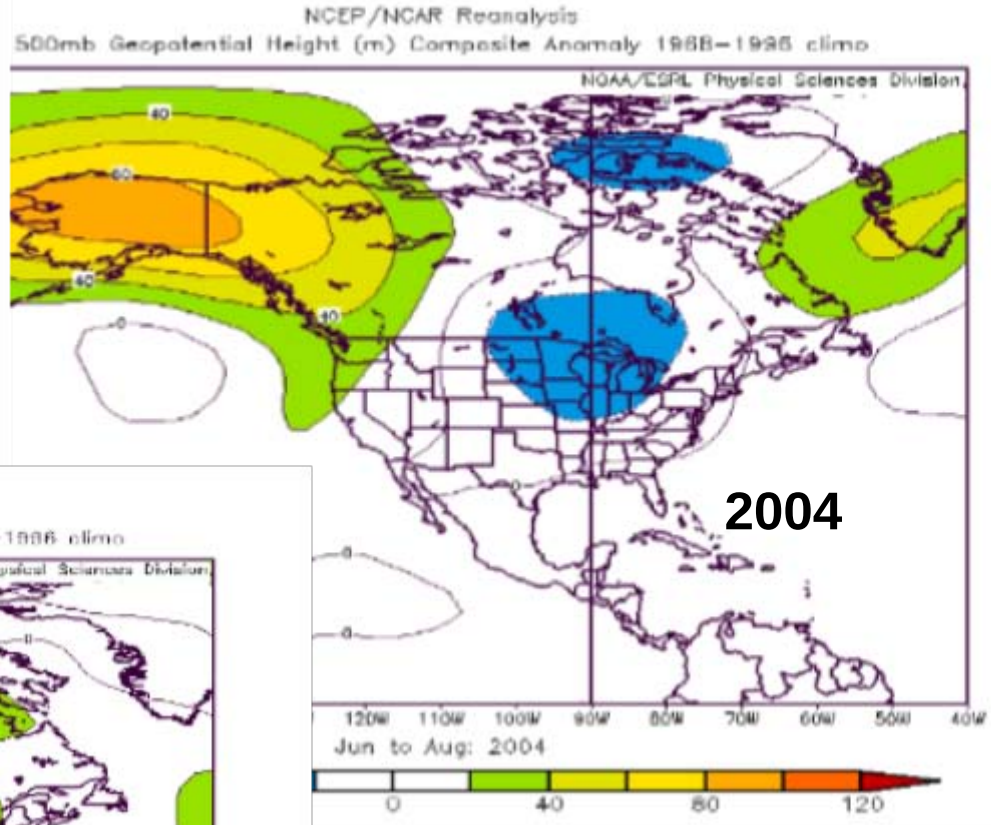
SST Annual Anomalies

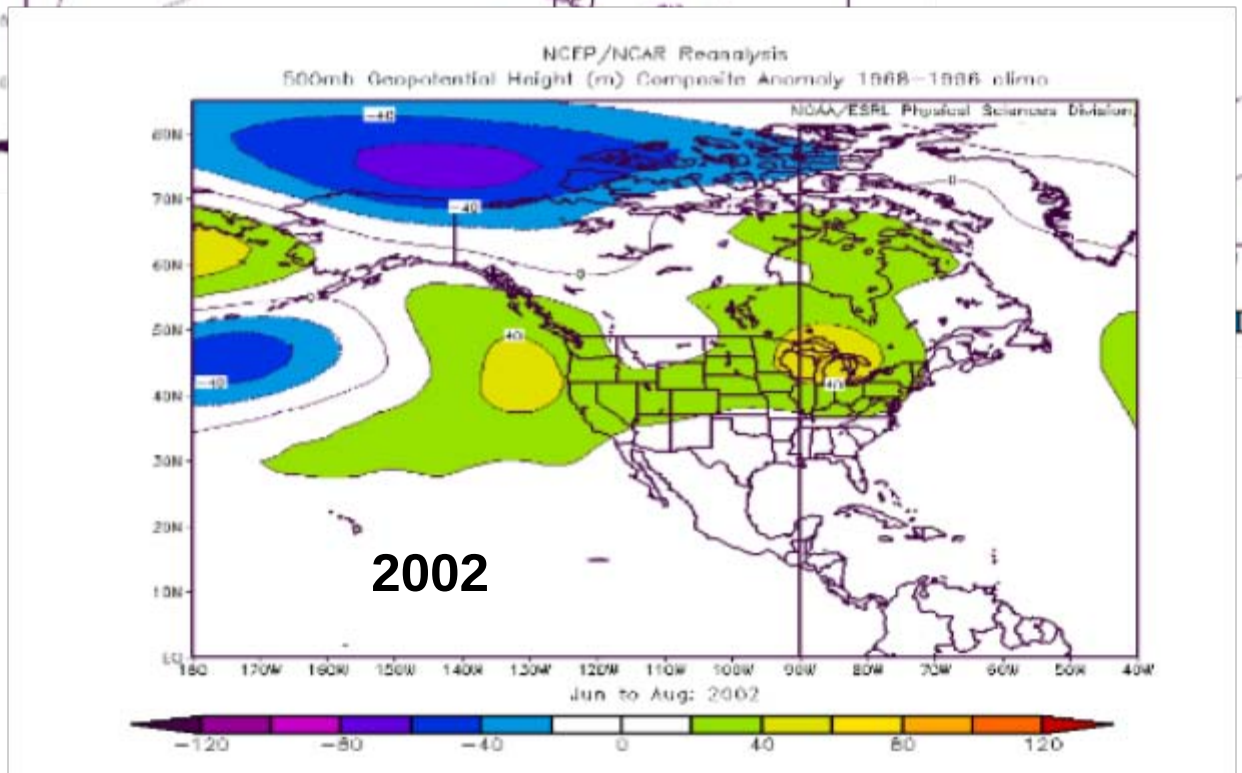
2004



CONTINENTAL SCALE PATTERNS



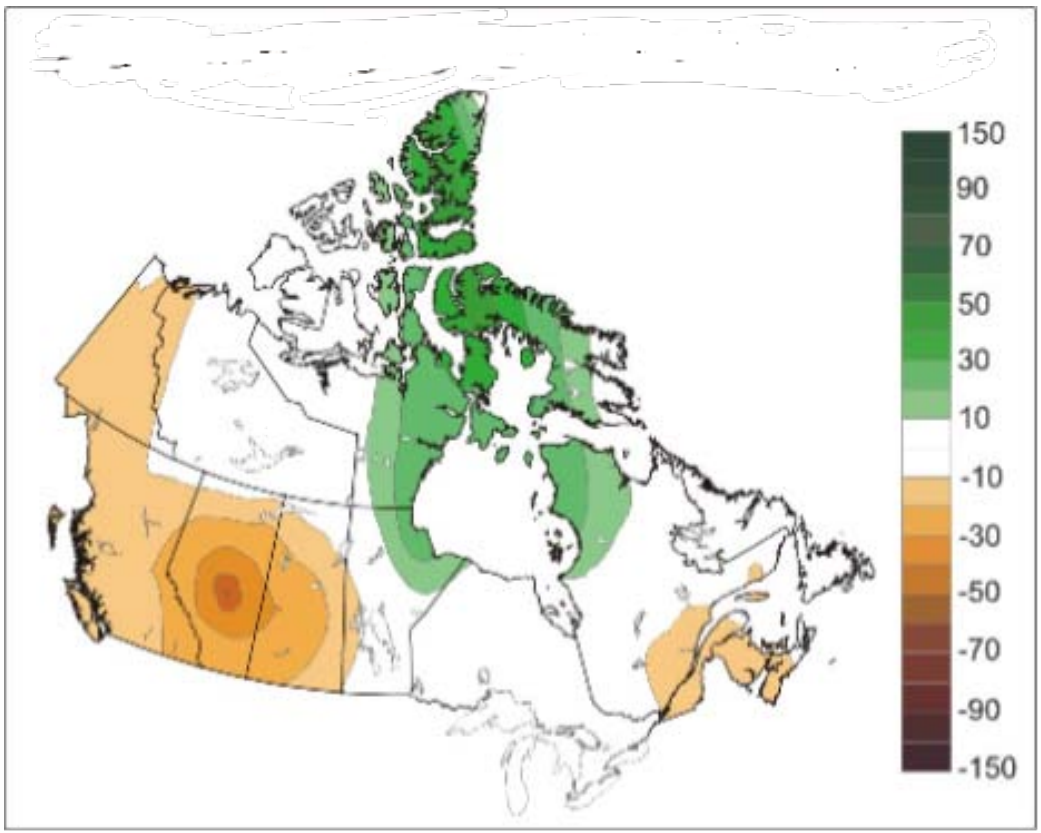




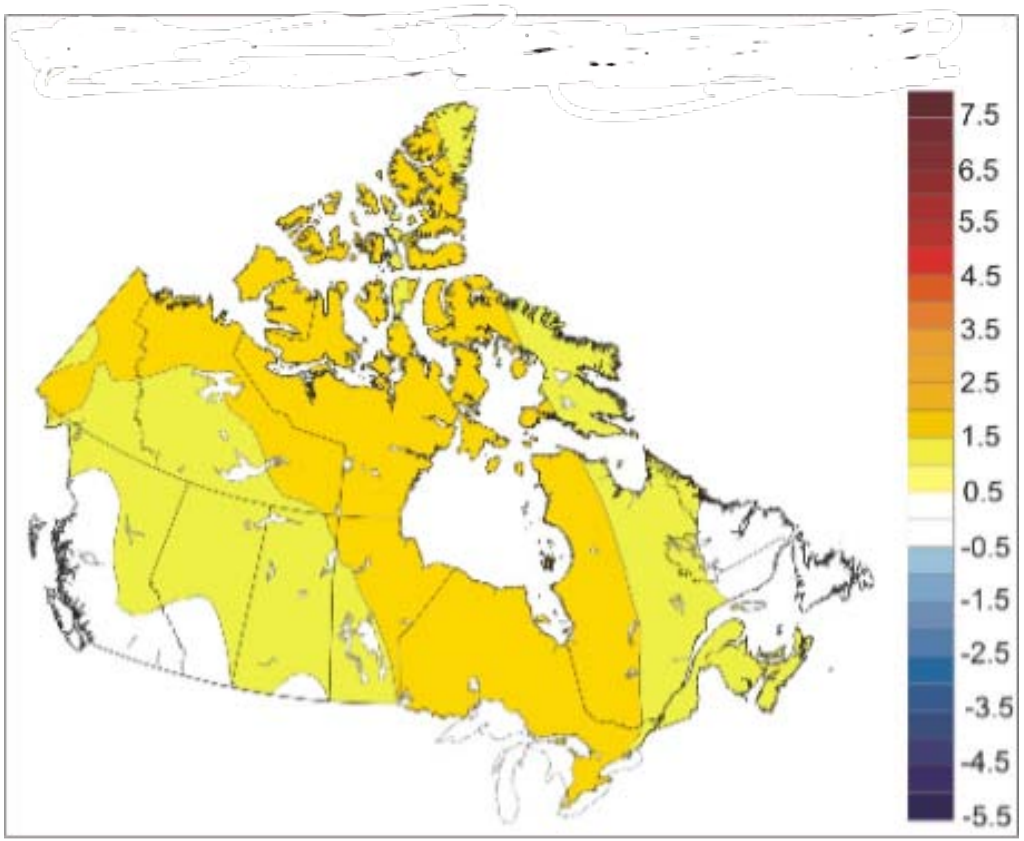
Summer 500 mb

Drought … Not Too Hot

Precipitation

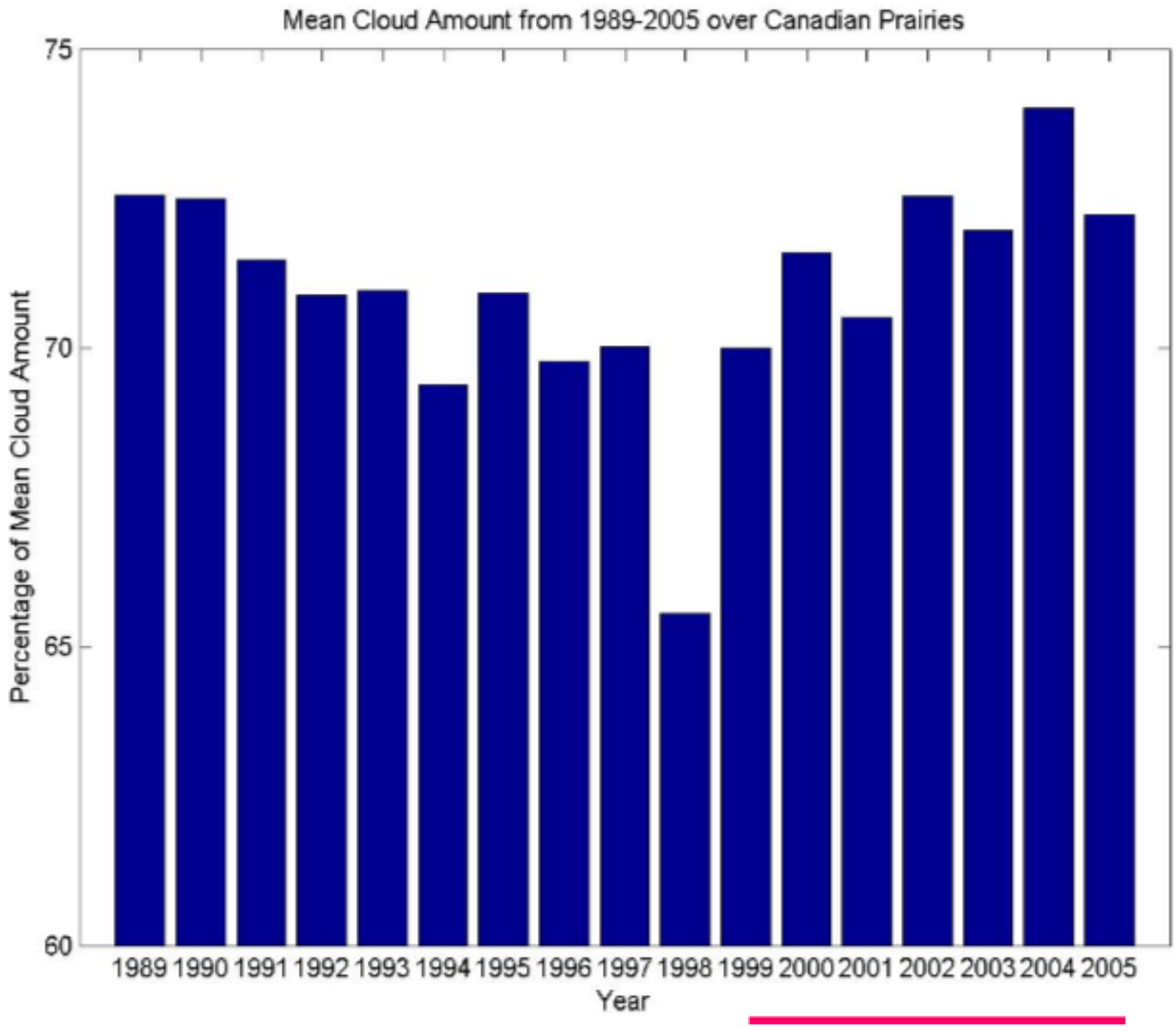


Temperature

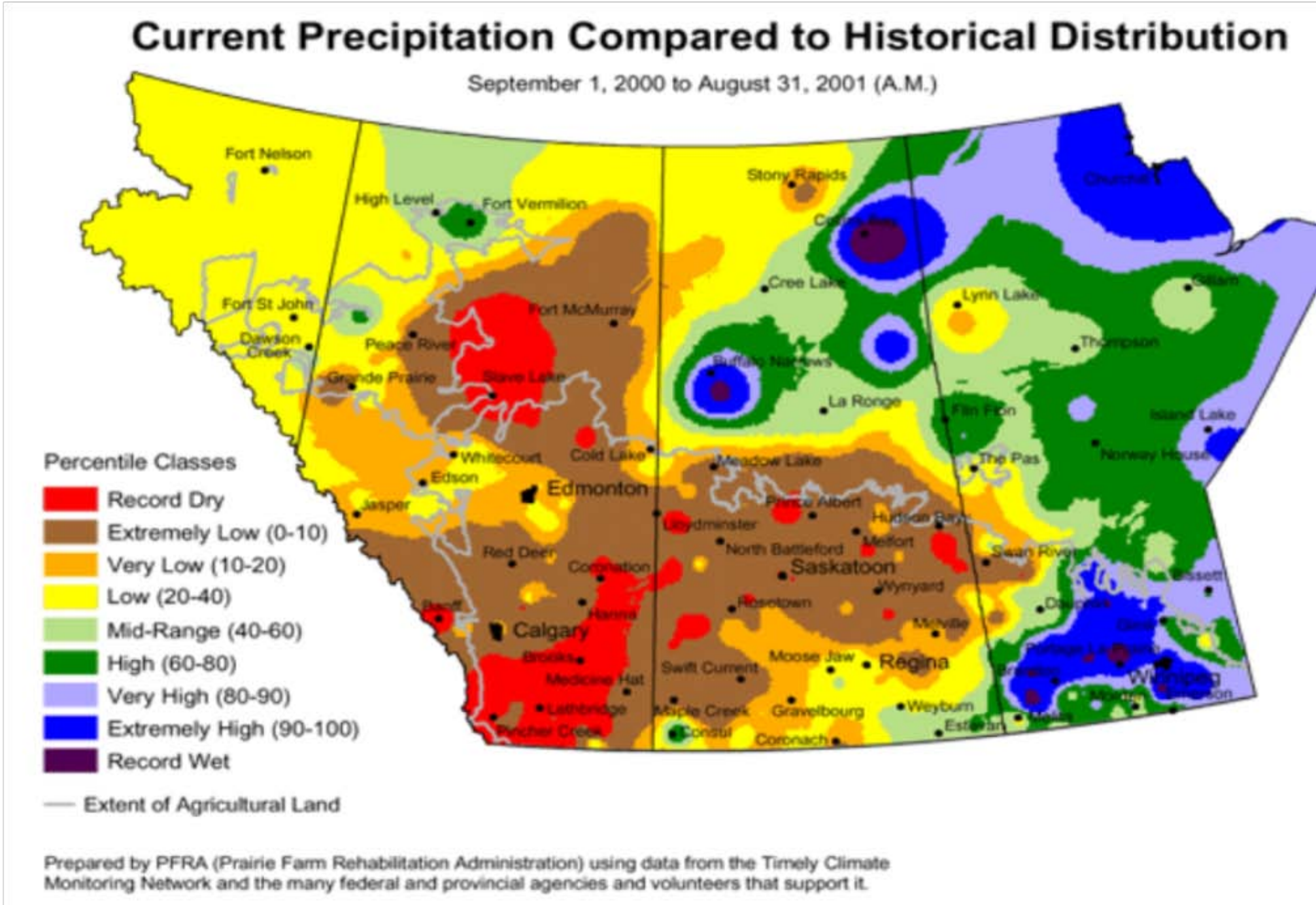


Summers of 2000, 2001 and 2002

CLOUD AMOUNT

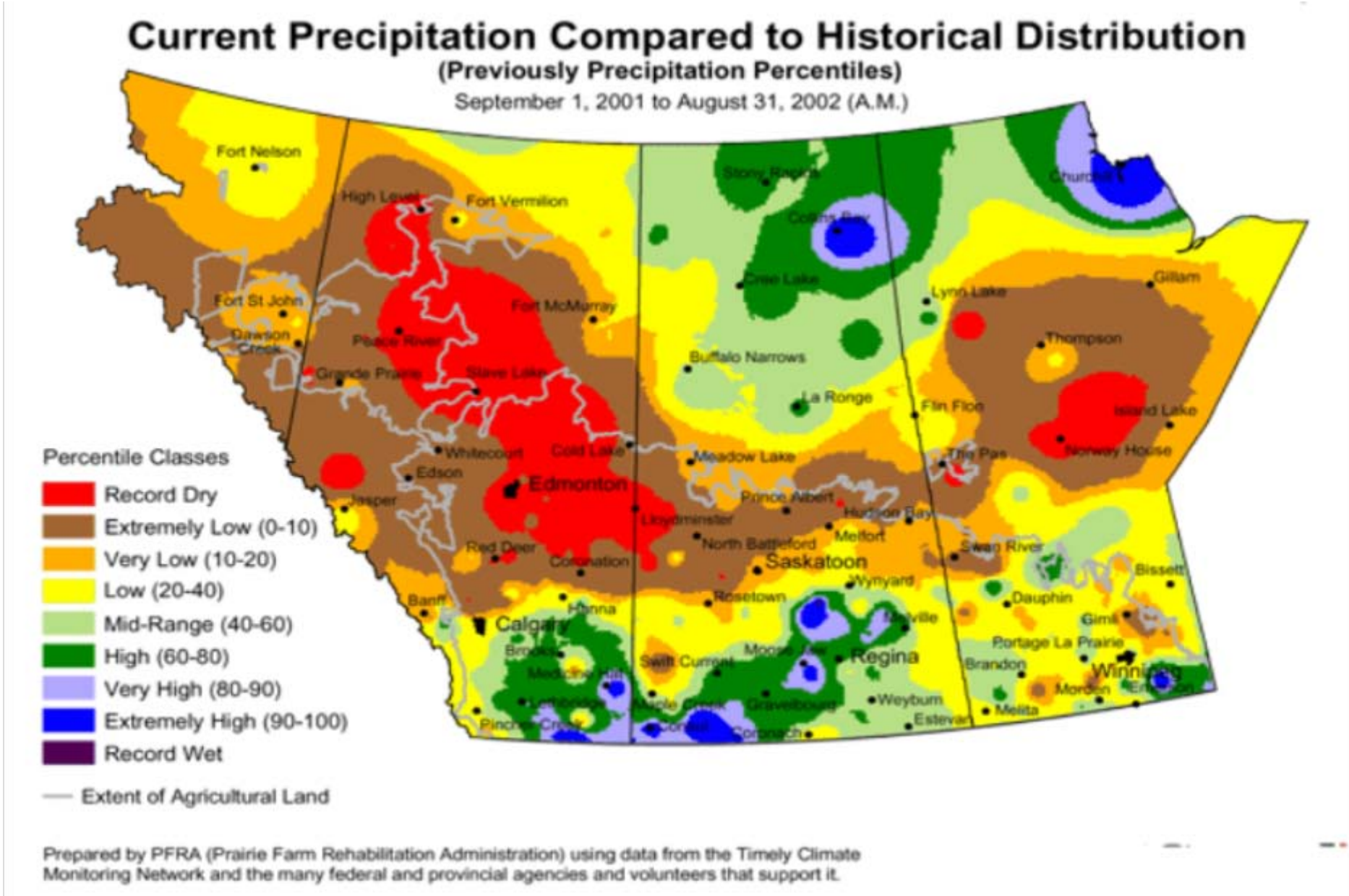


2001



Prepared by PFRA (Prairie Farm Rehabilitation Administration) using data from the Timely Climate Monitoring Network and the many federal and provincial agencies and volunteers that support it.

CANADIAN PRAIRIES
2002



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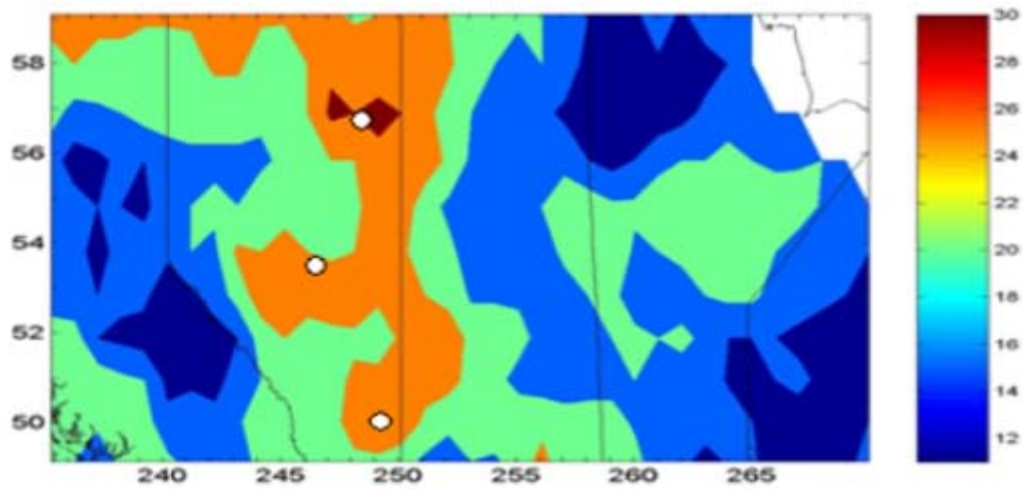
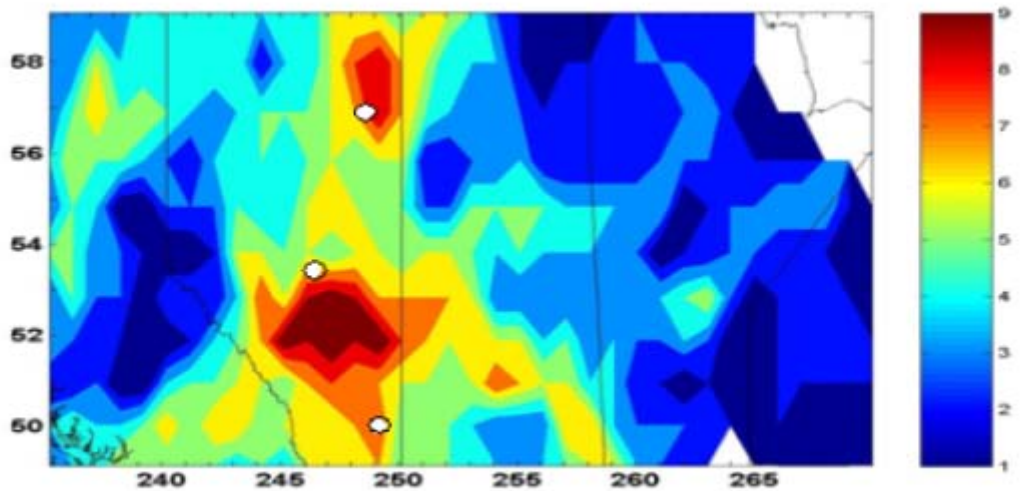
MONTHS EXPERIENCING DROUGHT



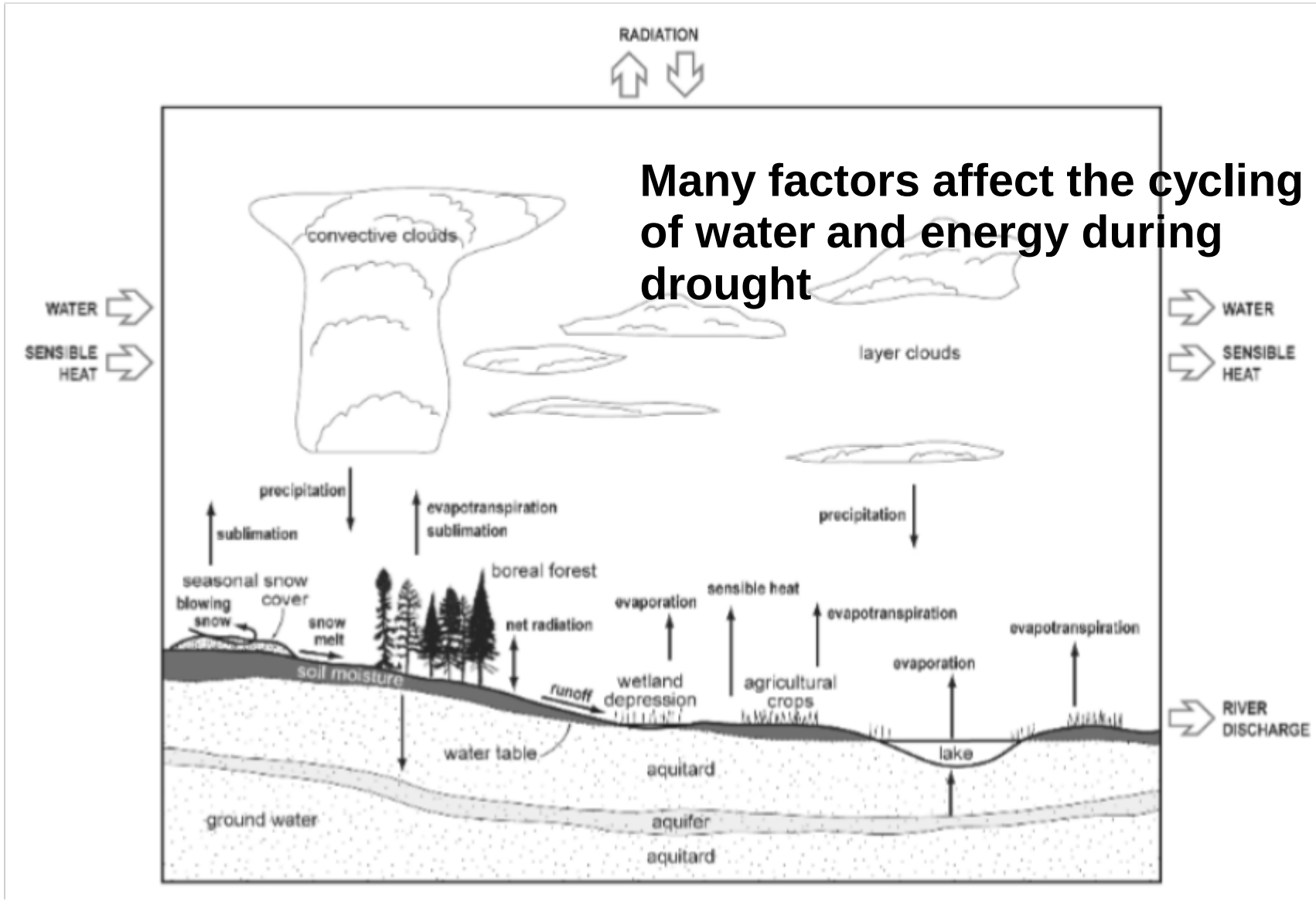
September 1999 – December 2004

SPI ≤ - 0.5



SPI ≤ - 1.5

WATER AND ENERGY CYCLING



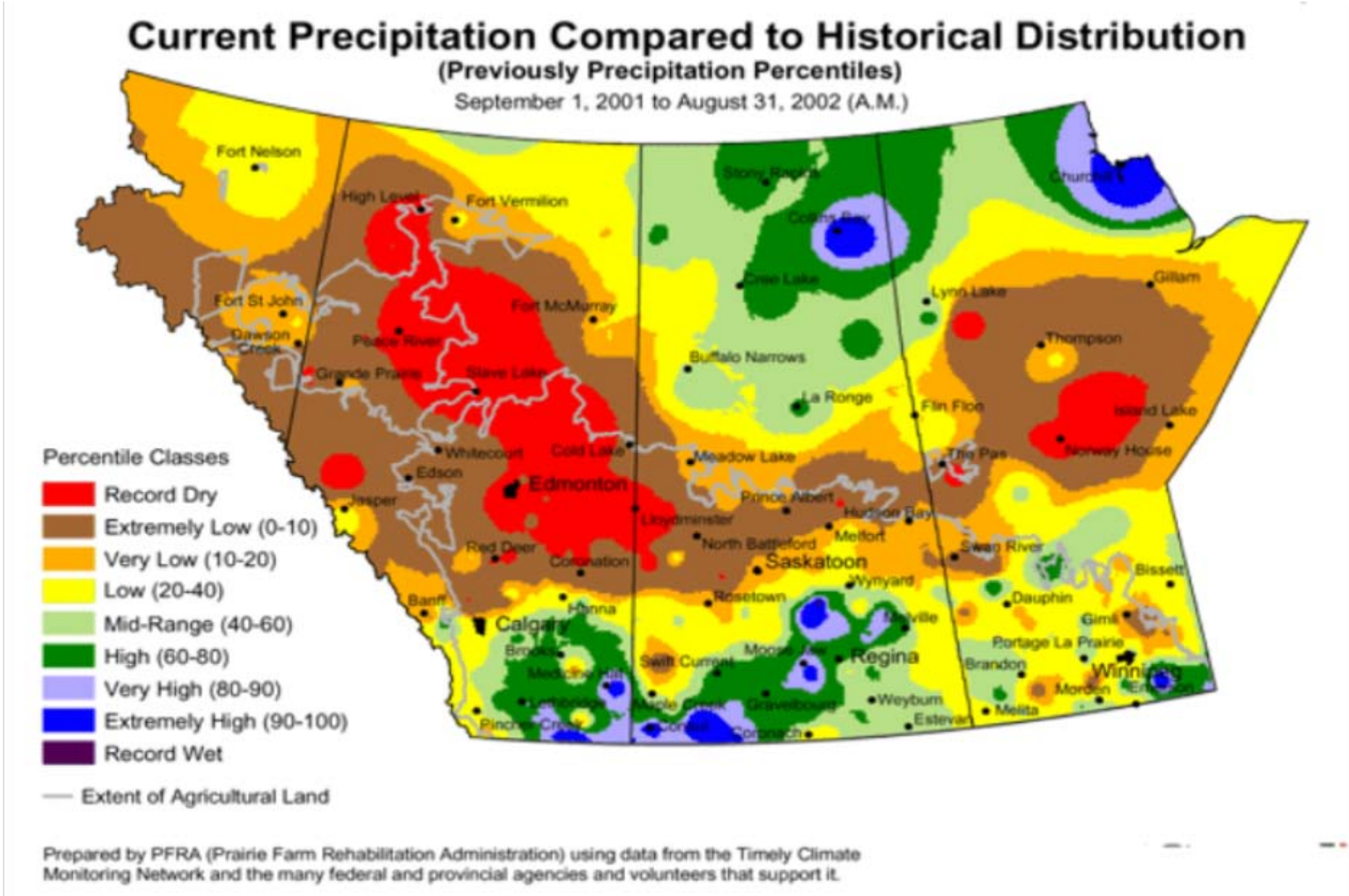
PRECIPITATION REDUCTION

There are many means of reducing precipitation.

Large scales
Storm track alteration
Reduced and altered types of clouds
Aerosol effects
High cloud bases and large sub-cloud precipitation loss
Altered surface evaporation
...

How did each/all of the factors act to reduce precipitation?

CANADIAN PRAIRIES
2002



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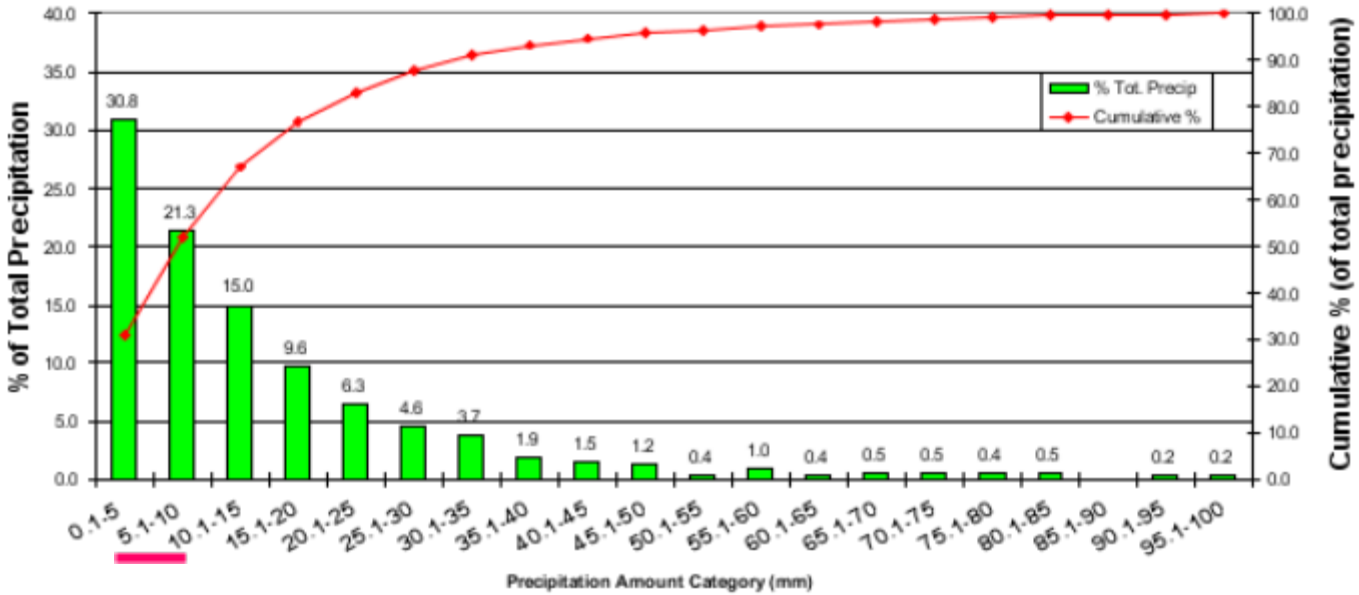
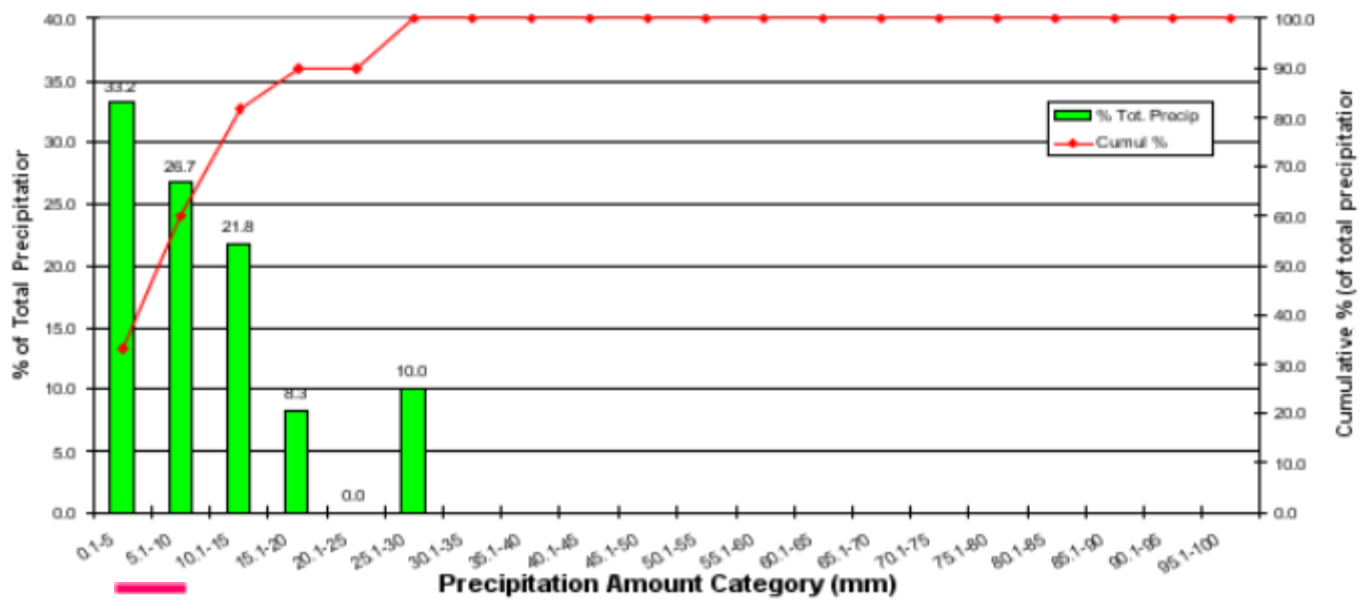
Daily Precipitation Amounts



Low precipitation event:
< 10 mm

<u>Climatology</u>
Low precipitation events: 52% of total



<u>Sub-drought 2001-2002</u>
Low precipitation events: 60% of total

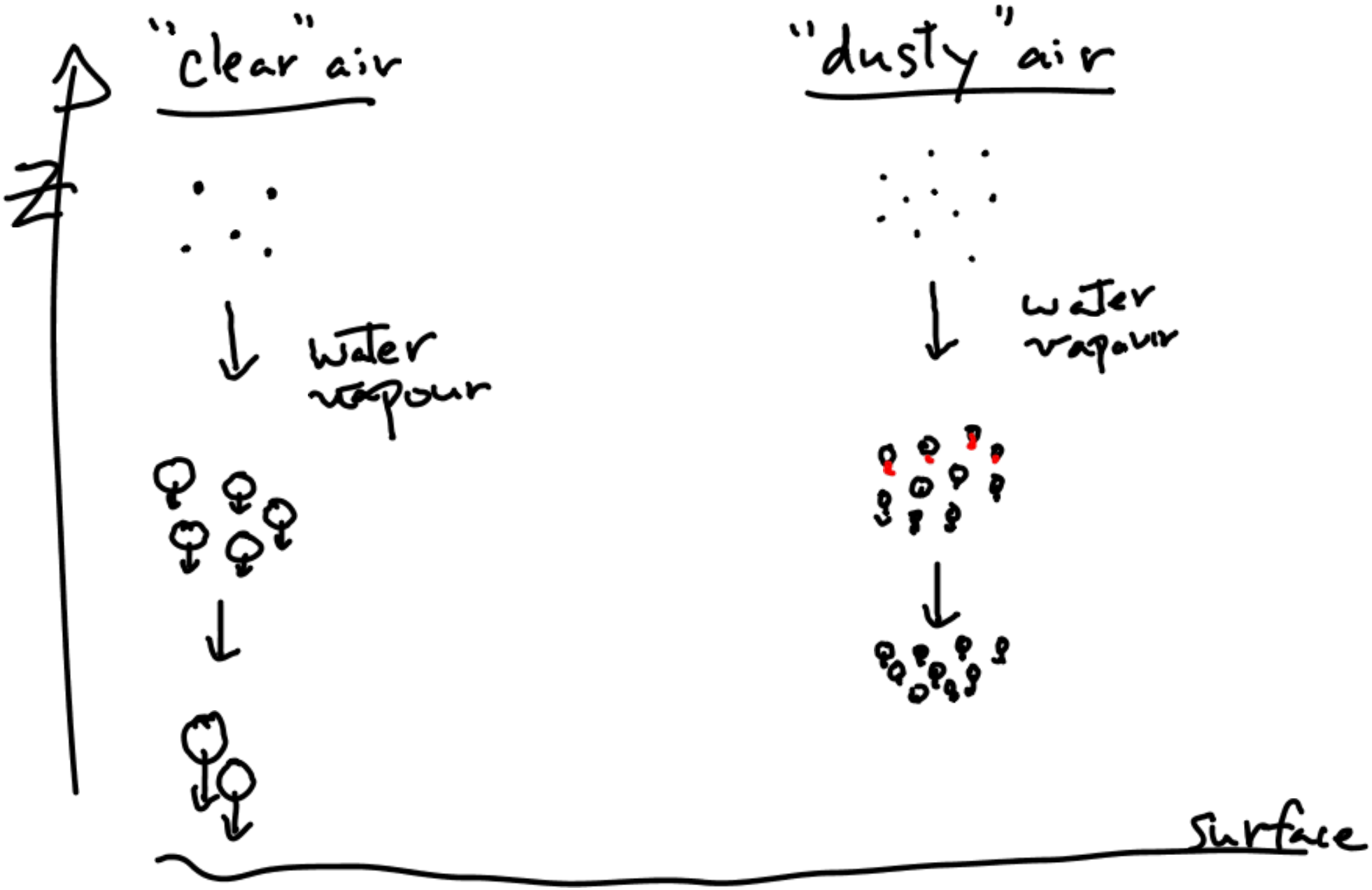
VIRGA

Courtesy of Barrie Bonsal

DUSTSTORMS AND FOREST FIRES

32 major dust storms in Saskatchewan in 2002

AEROSOLS AND PRECIPITATION



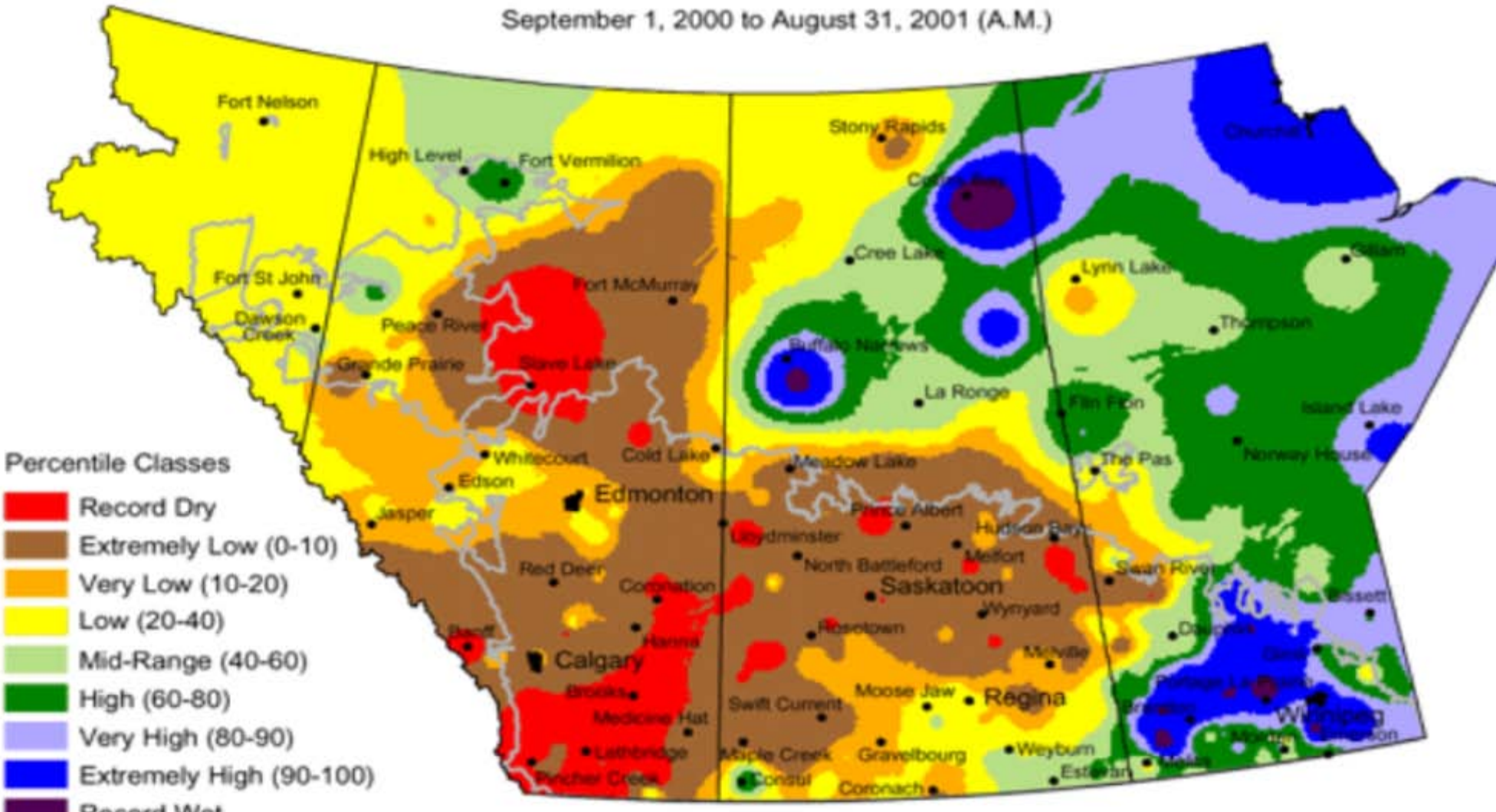
PHYSICS OF ‘EDGES’

- Did processes acting near 'edges' act to perpetuate and/or eliminate the drought?

- Vegetation feedbacks
- Albedo feedbacks
- Atmospheric circulations
- ...

Current Precipitation Compared to Historical Distribution

September 1, 2000 to August 31, 2001 (A.M.)



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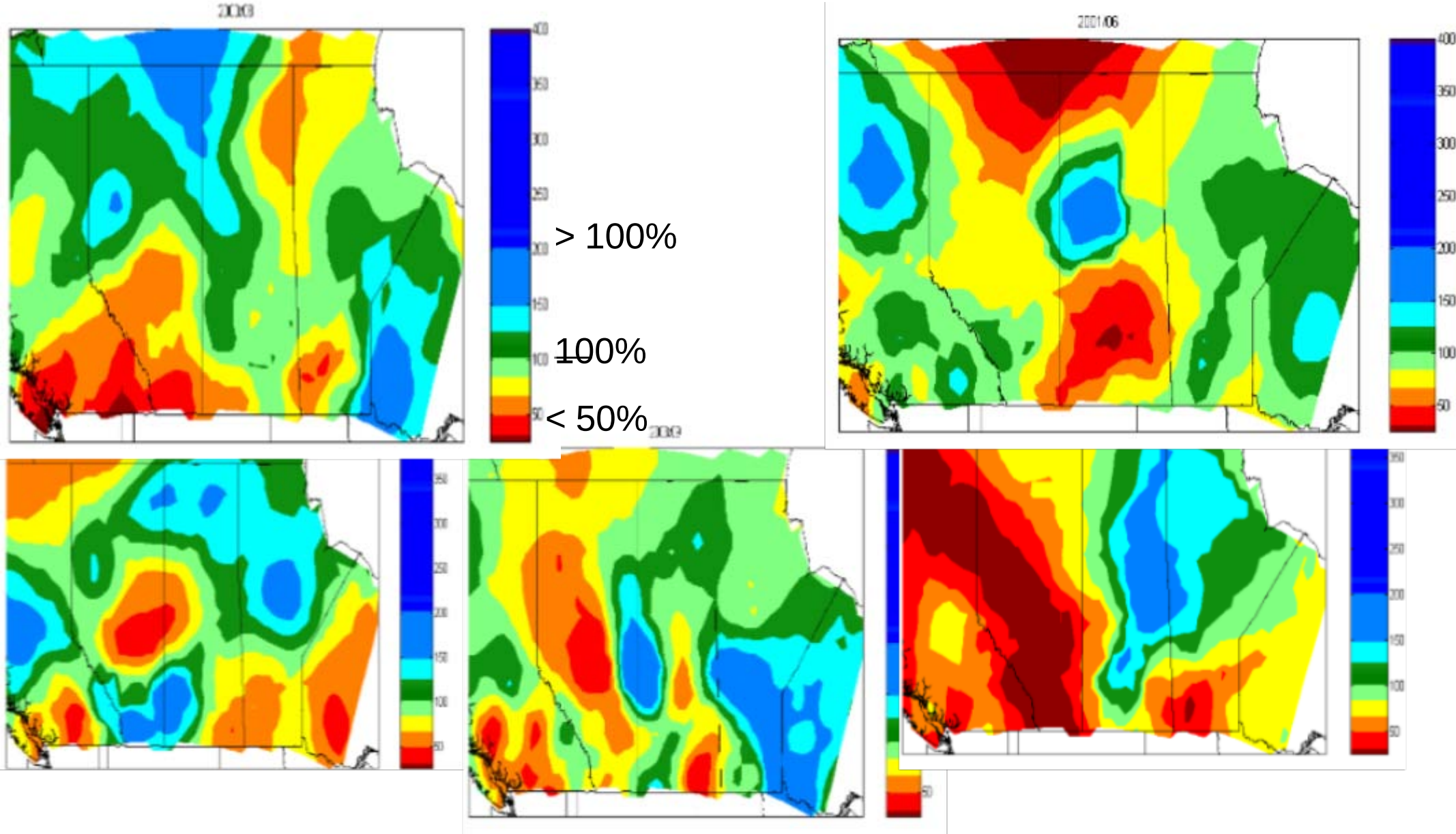
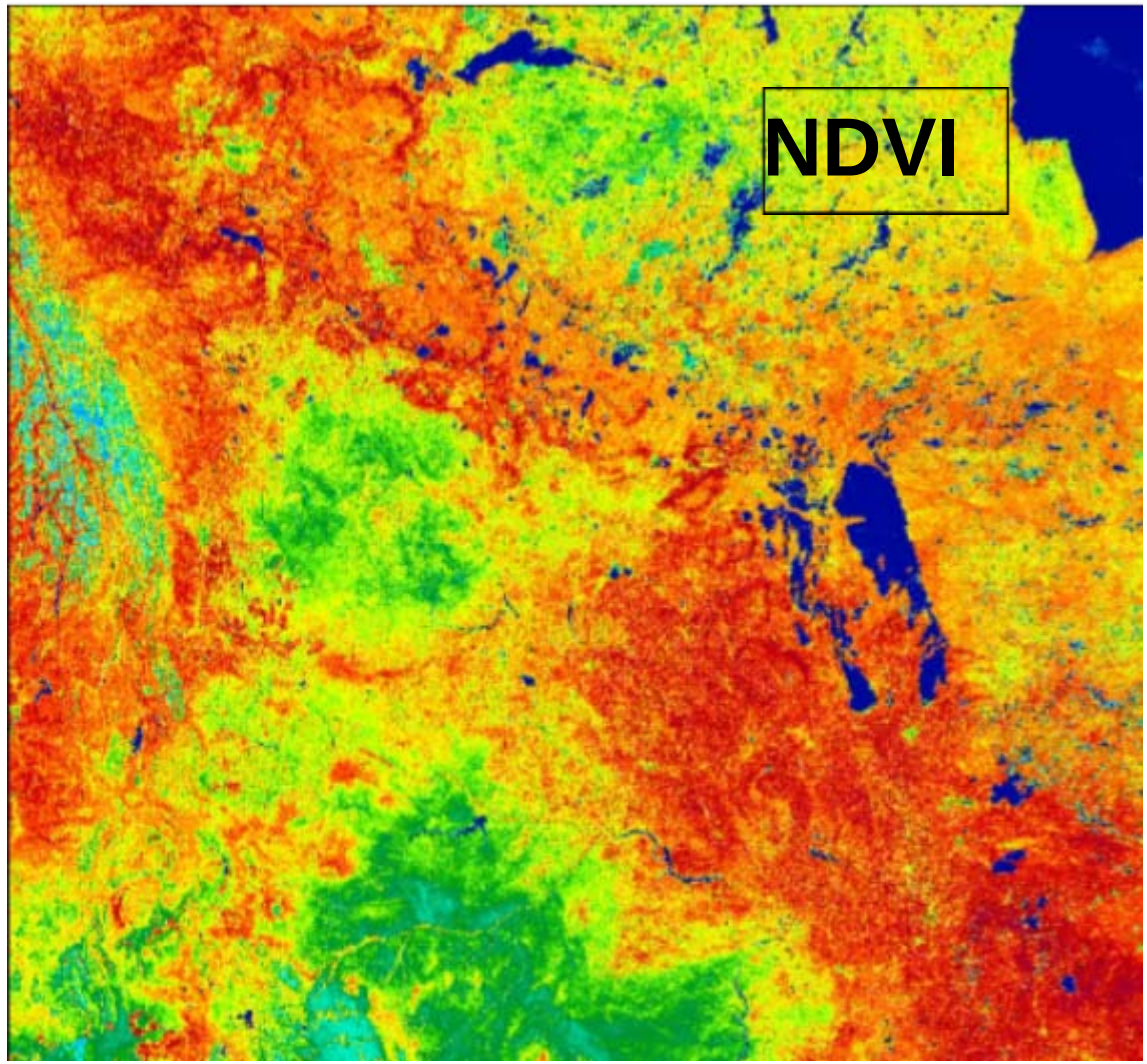
MONTHLY-SCALE PRECIPITATION GRADIENTS During 1999-2005 Drought

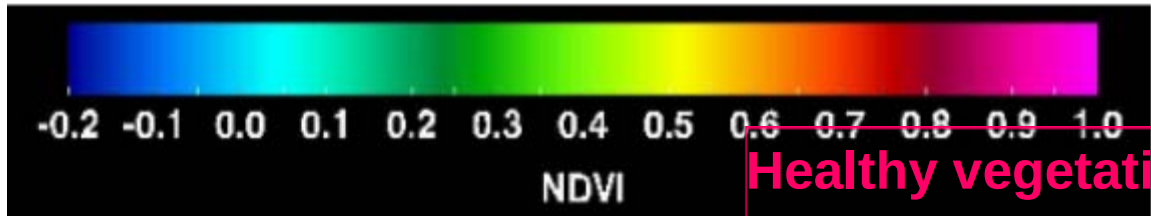


VEGETATION



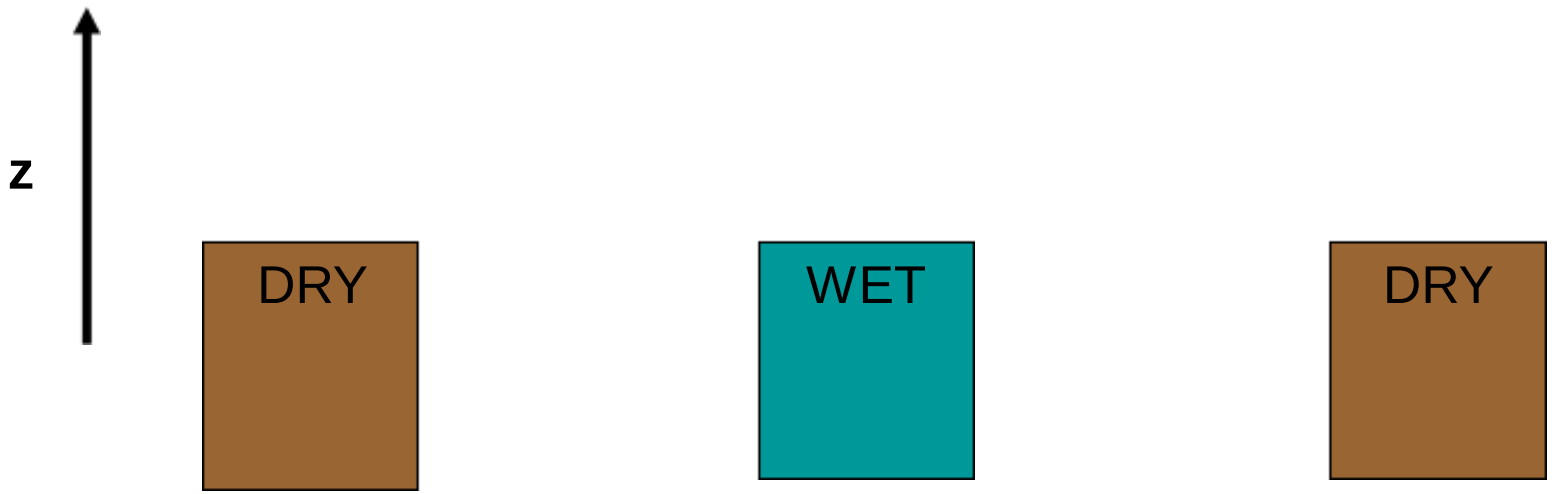
July 11-20, 2002

NDVI: Normalized Difference Vegetation Index

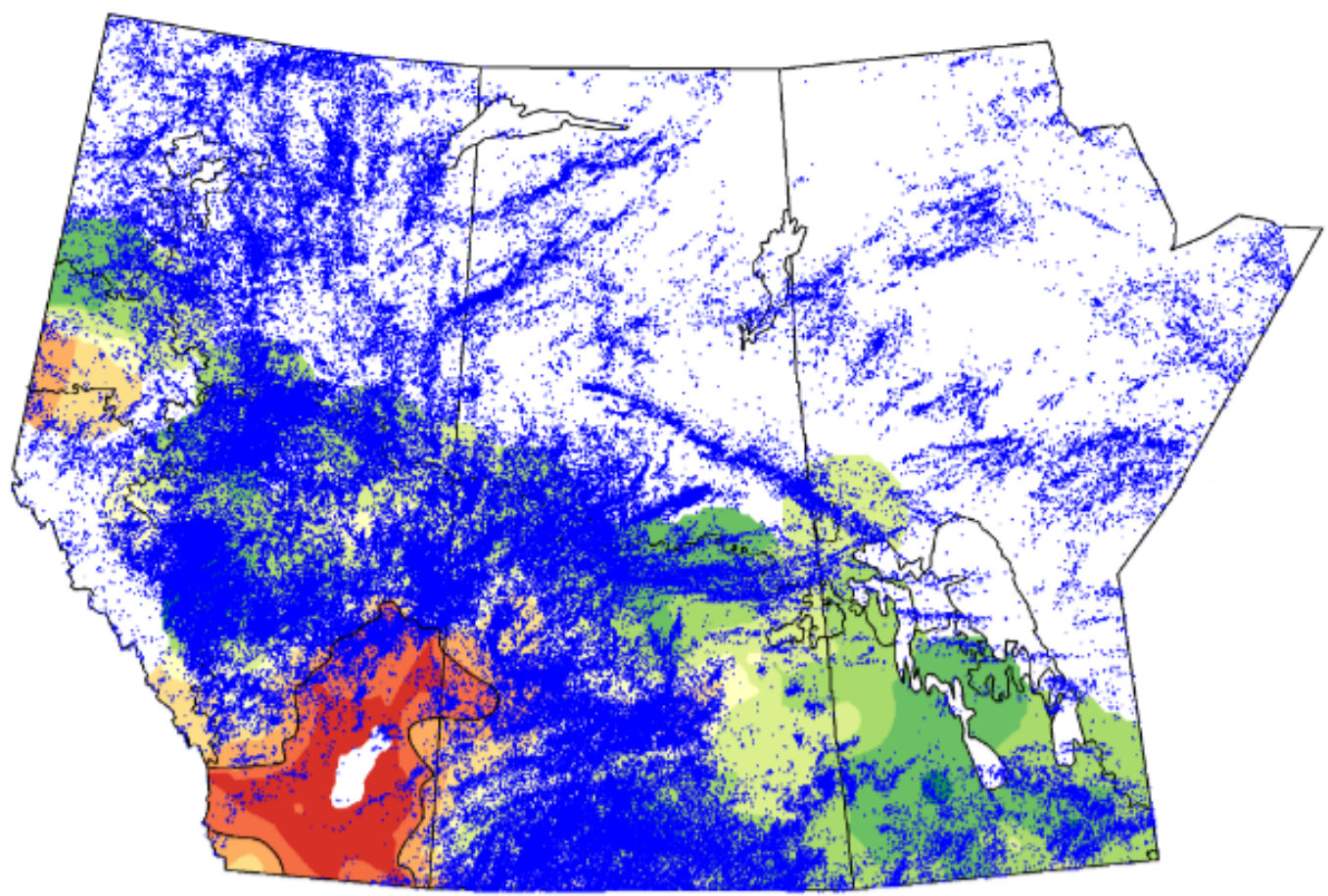


INTERACTING WET AND DRY REGIONS?

- **Did adjacent regions interact in a significant manner to perpetuate their attributes?**



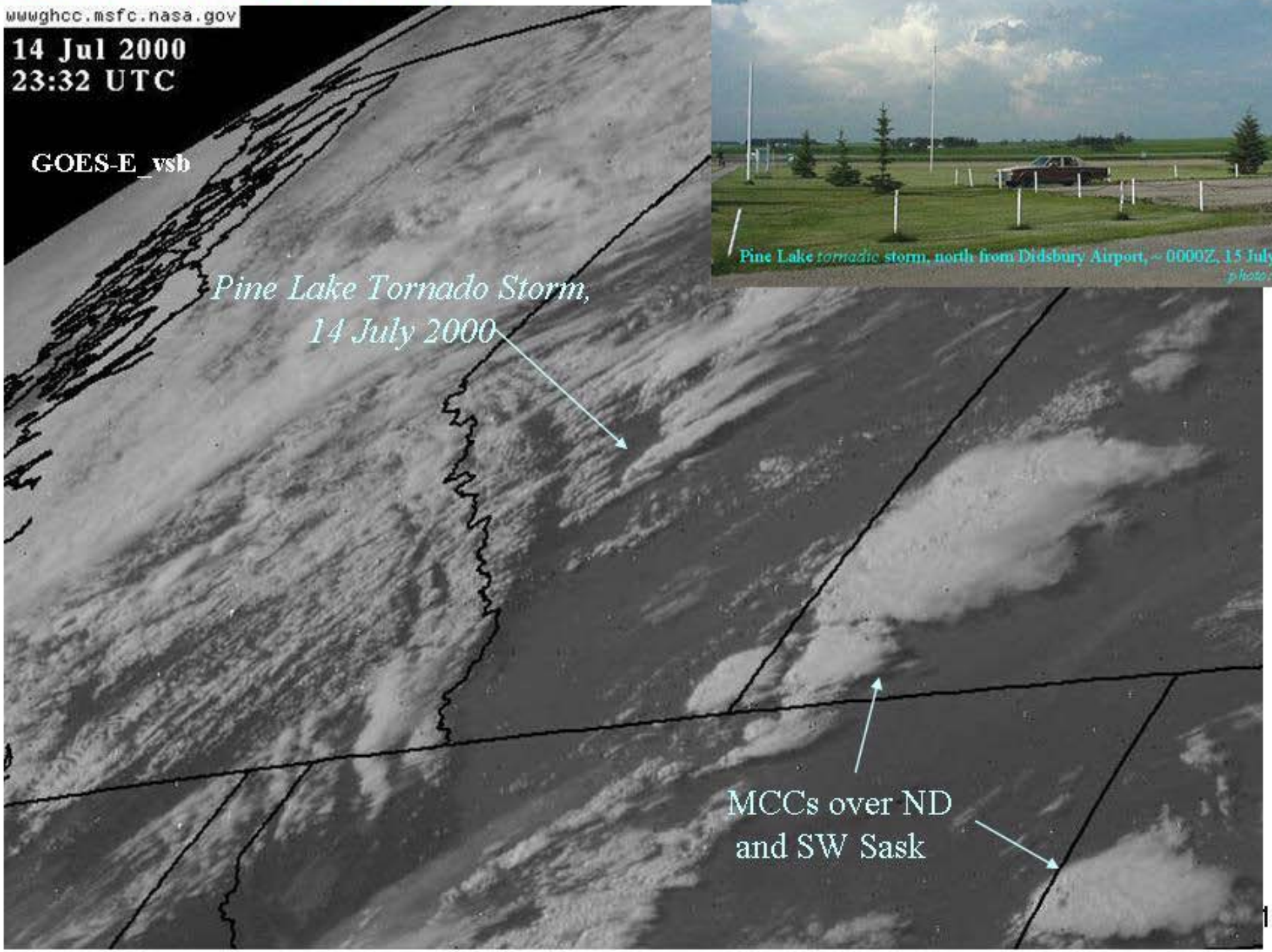
LIGHTNING AND SOIL MOISTURE



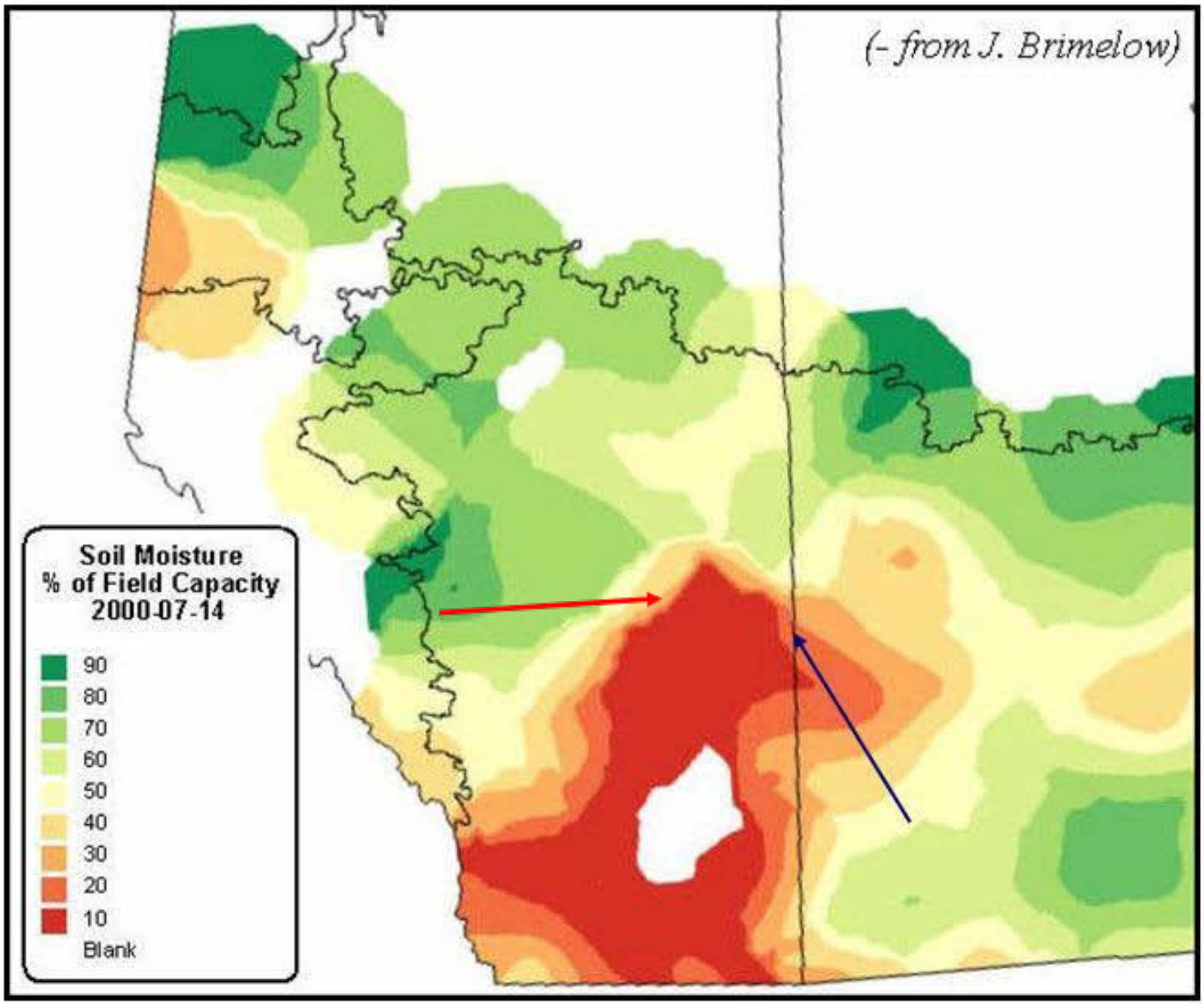
Summer of 2000 Lightning

July 2000 (entire month of lightning strikes and average soil moisture) first green shading > 60%
first pinkish <50% ... the orange/red colors are soil moistures (plant available water) much below 50% ... deep reds are in the 25-30% PAW range

Soil Moisture and Storms



Soil Moisture for *Pine Lake Tornado* Storm

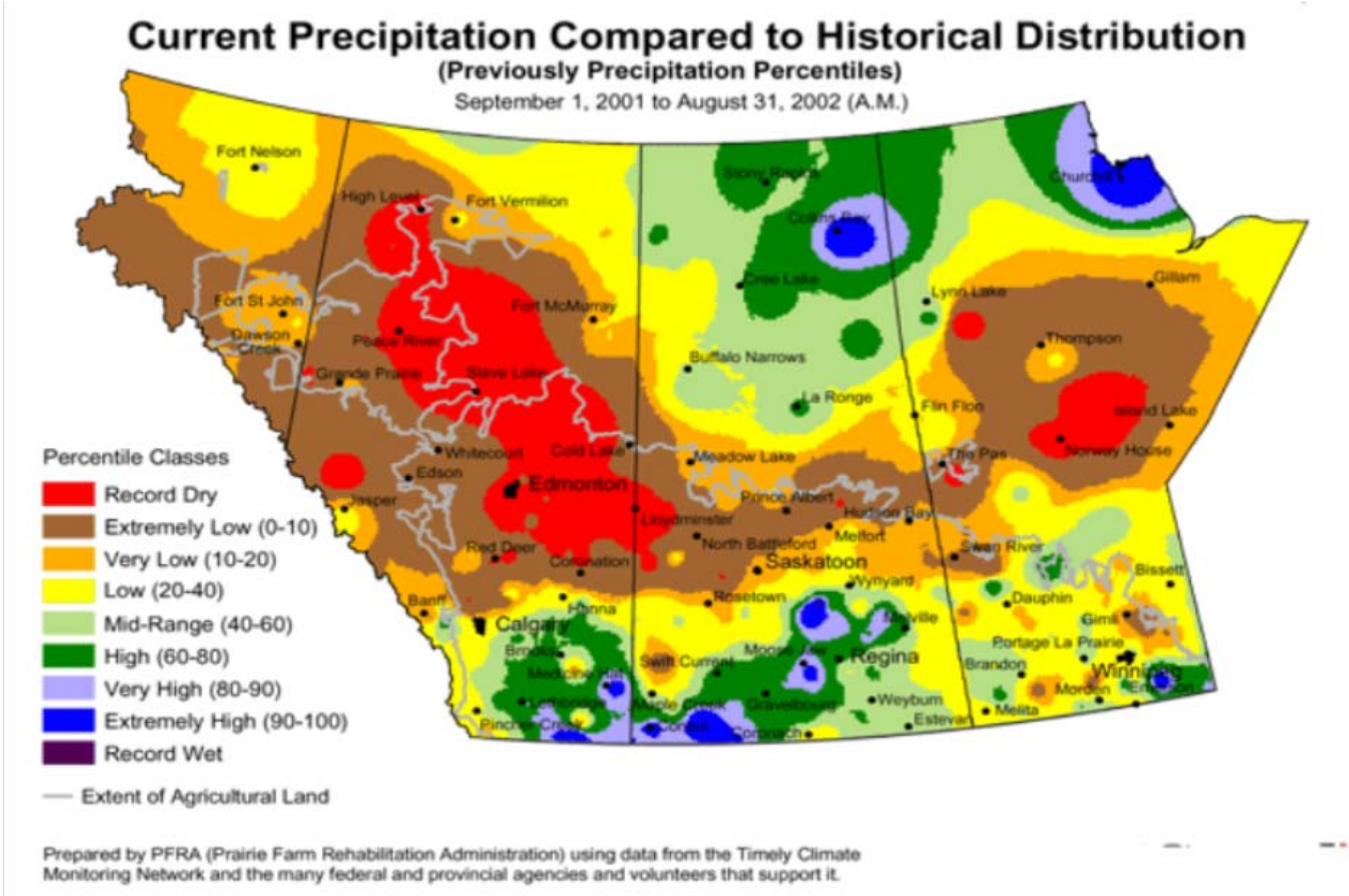


BREAK POINTS

- Major changes in drought features

- Specific examples
  - June 2002
  - spring 2005
  - ...

CANADIAN PRAIRIES
2002



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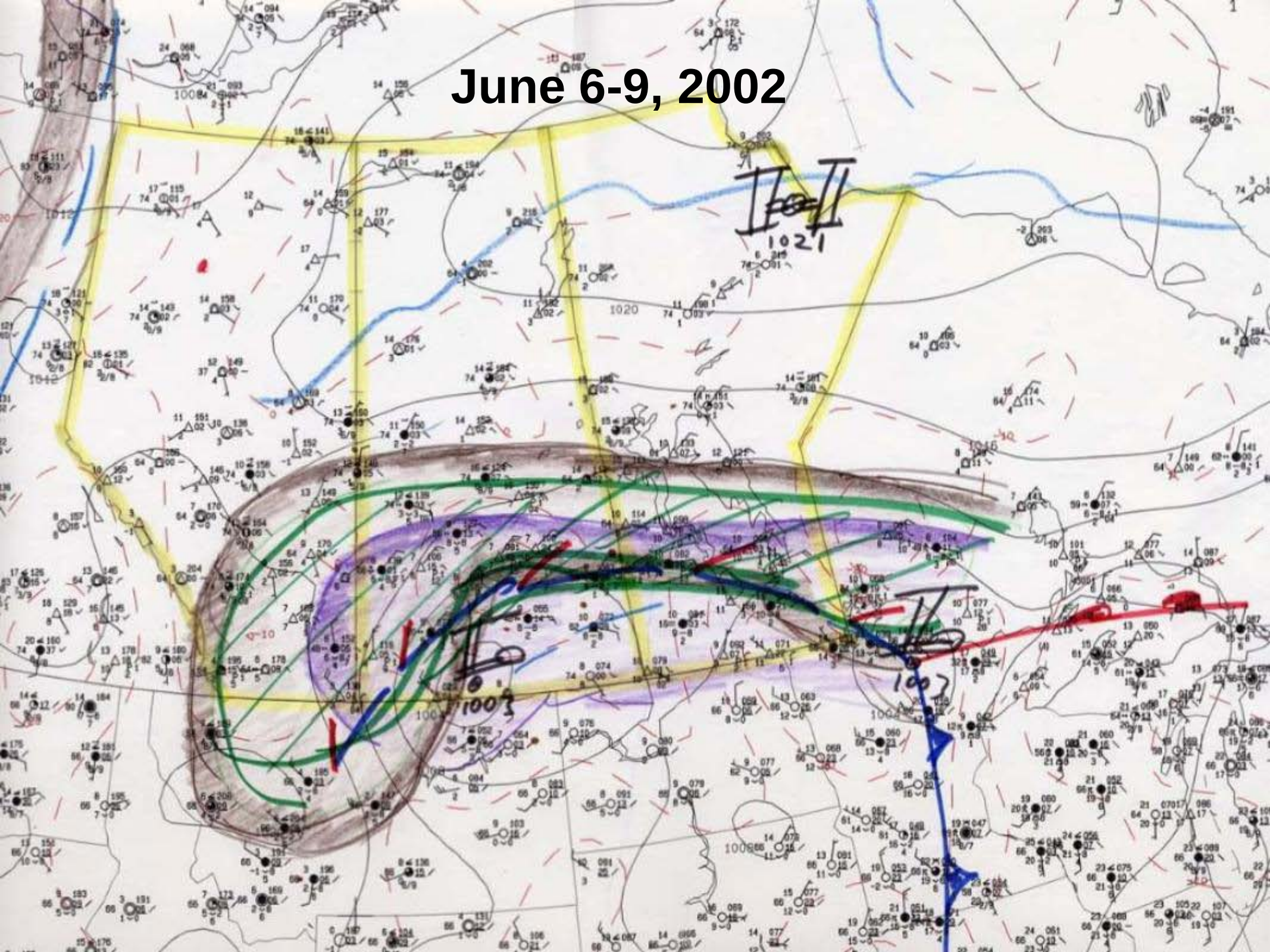
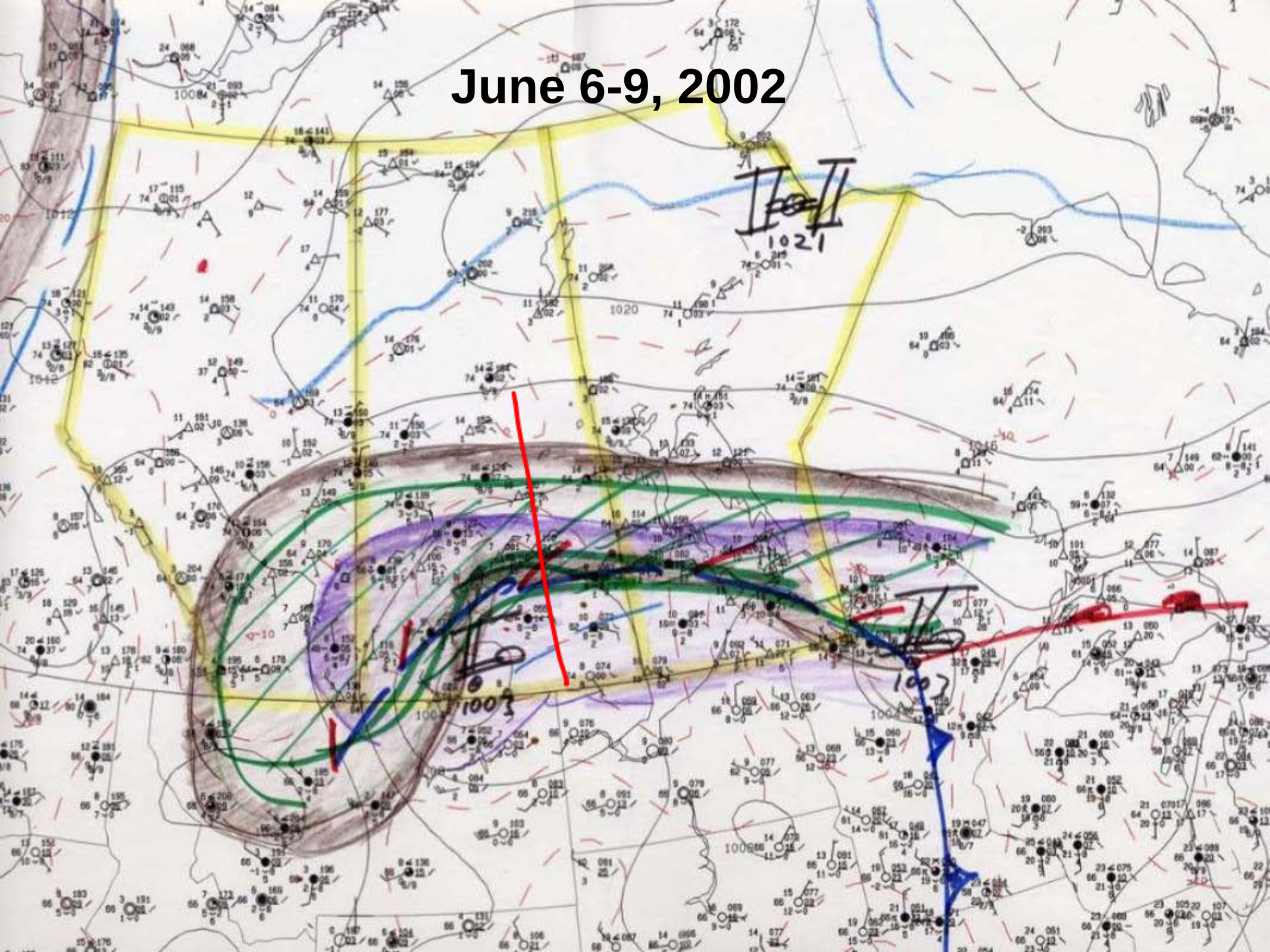
Dry in April 2002 ...


June 6-9, 2002
1021
1020
1007
1008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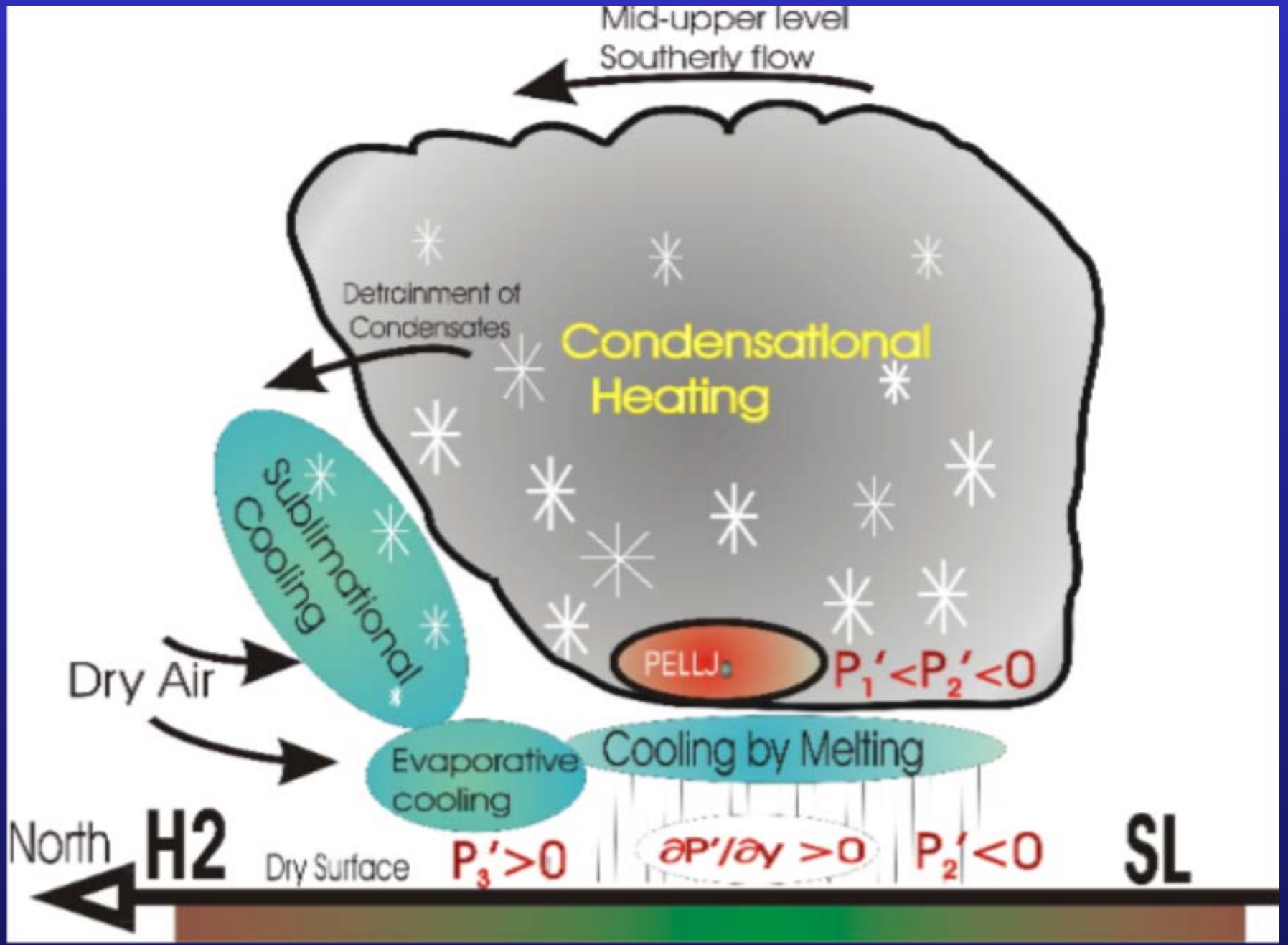
1008

Storm- and cloud-scale feedbacks



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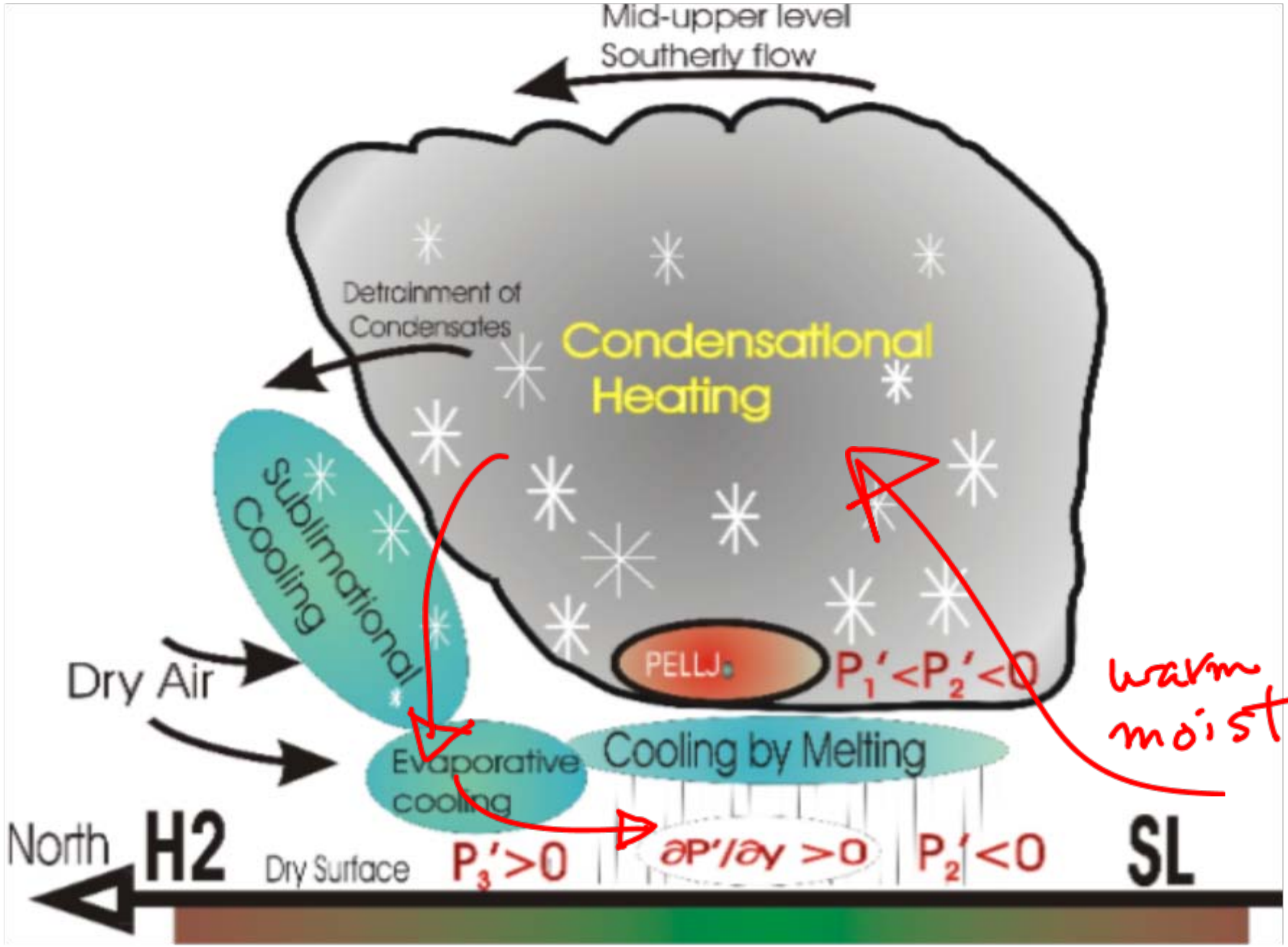
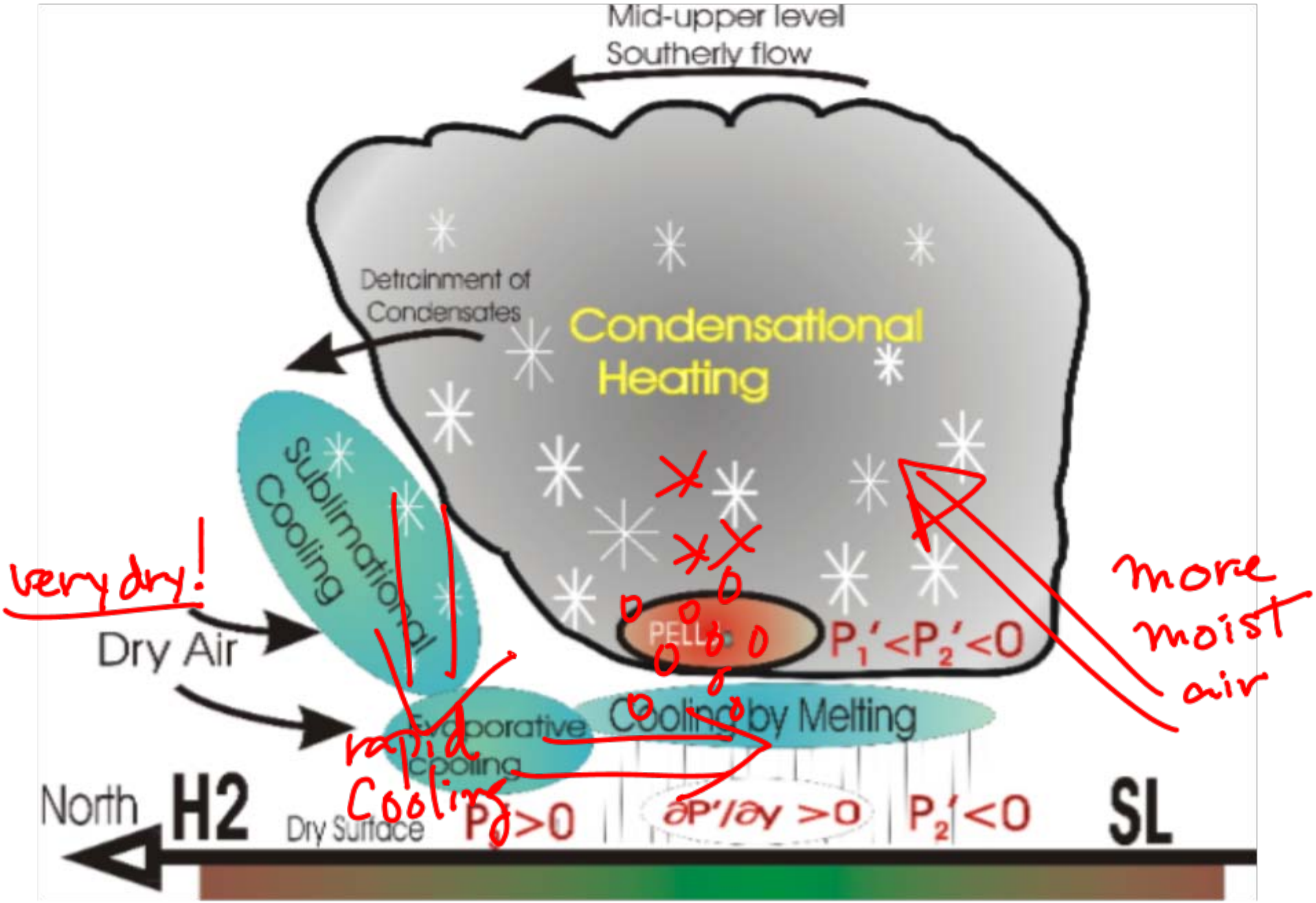
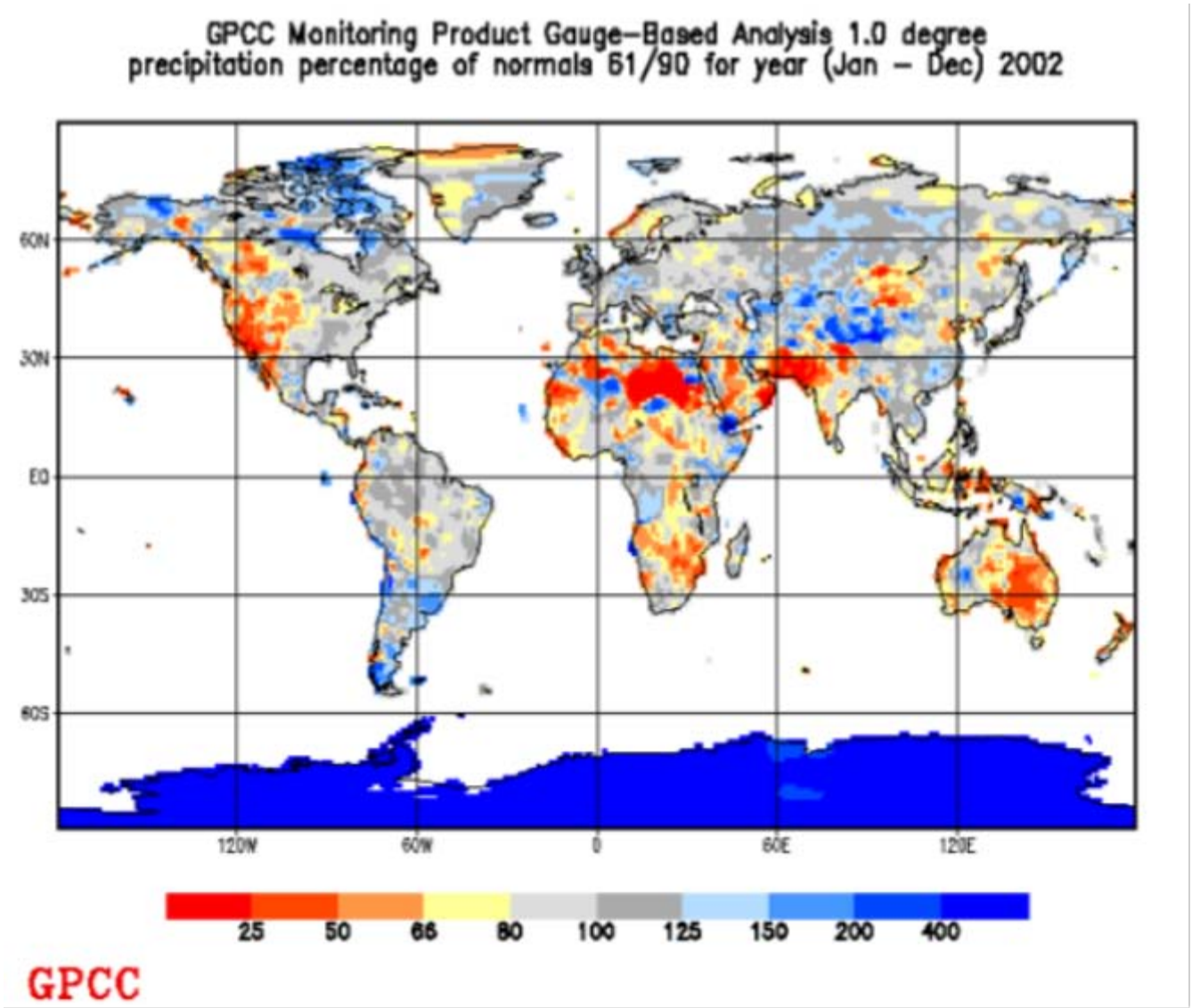


Storm- and cloud-scale feedbacks



2002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30N
EQ
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125
150
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400
GPCC


St. Jean de Baptiste, Manitoba
July 2005

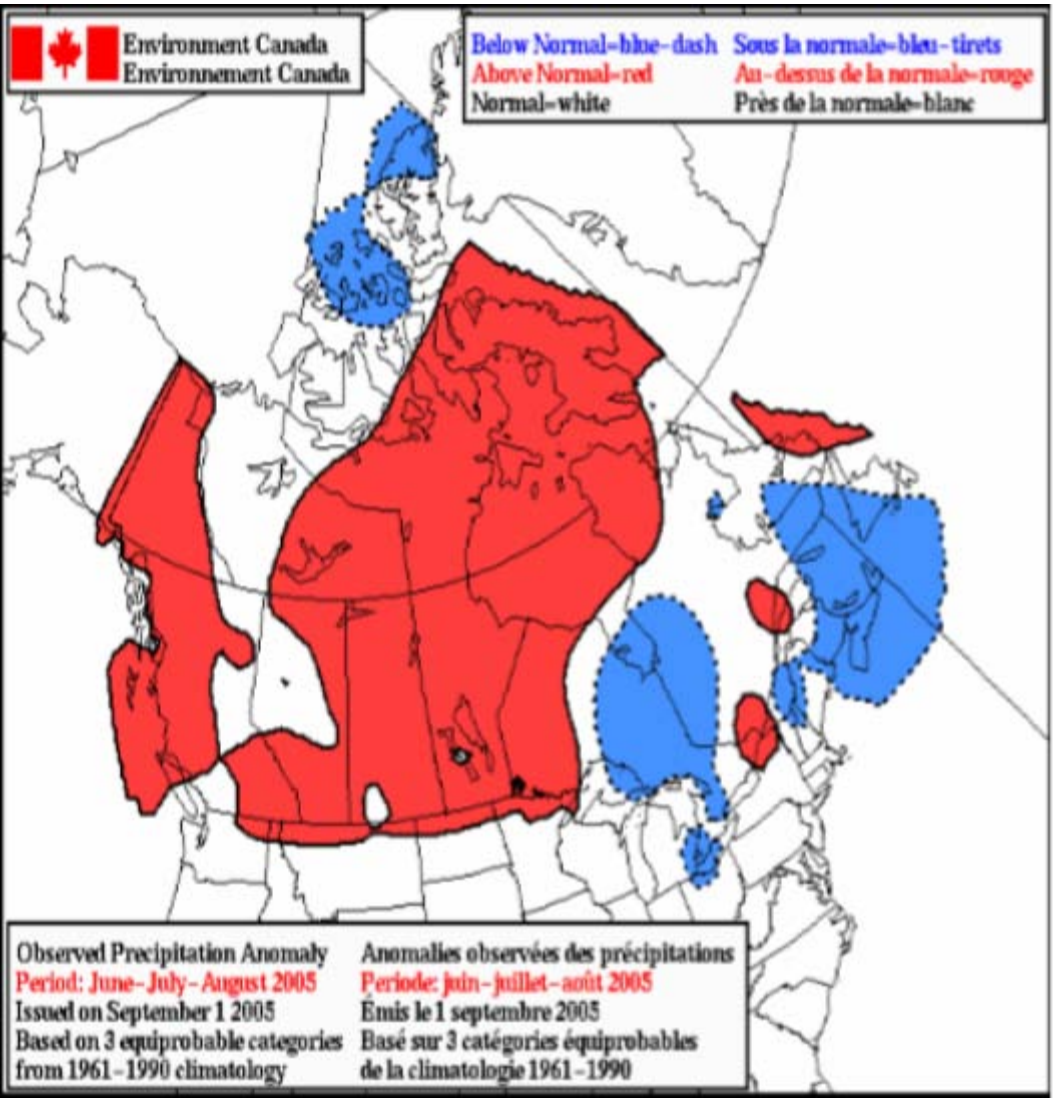
IMPLICATIONS

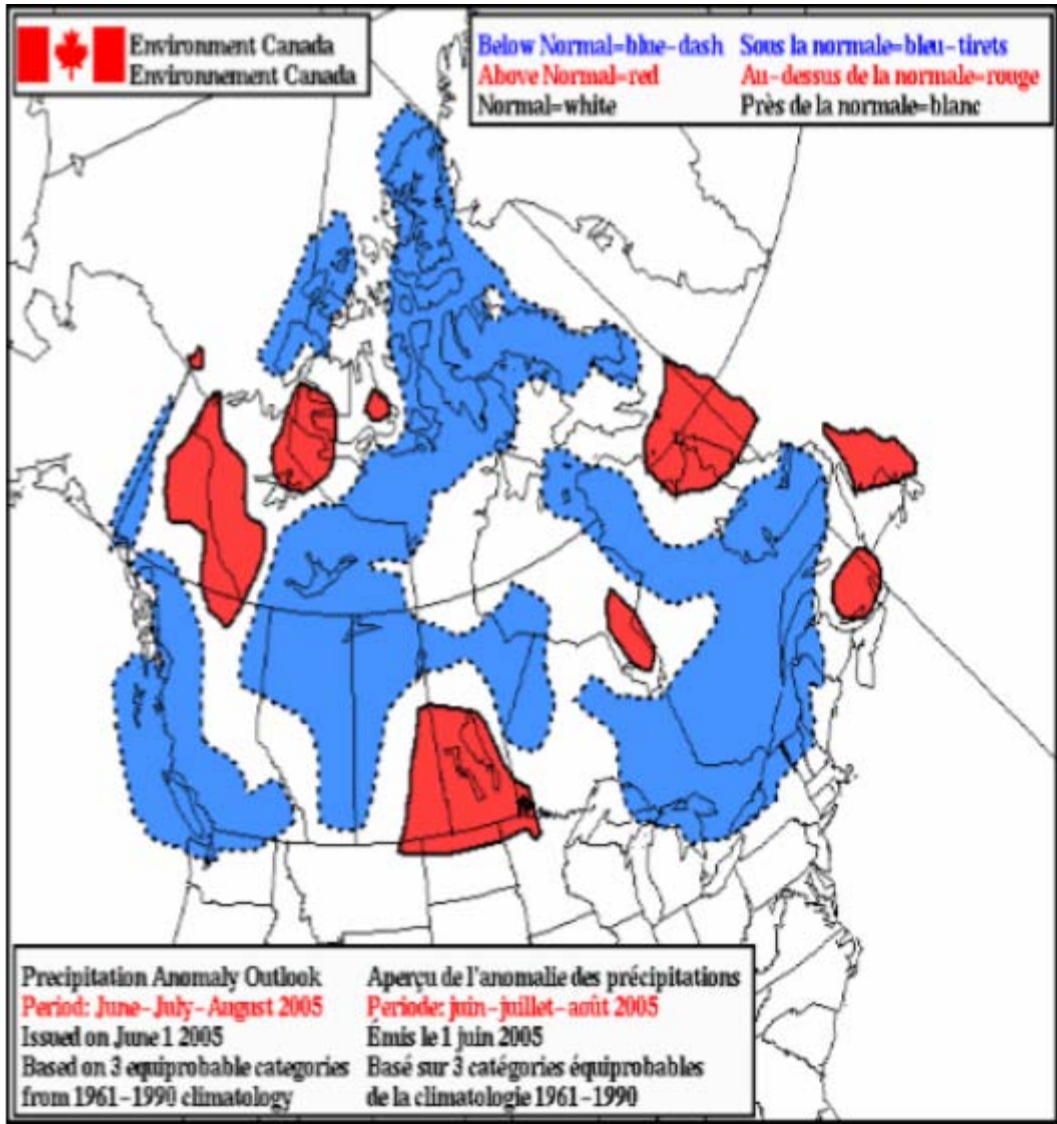
The focus has been on a few issues from a particular drought.

There are implications for:

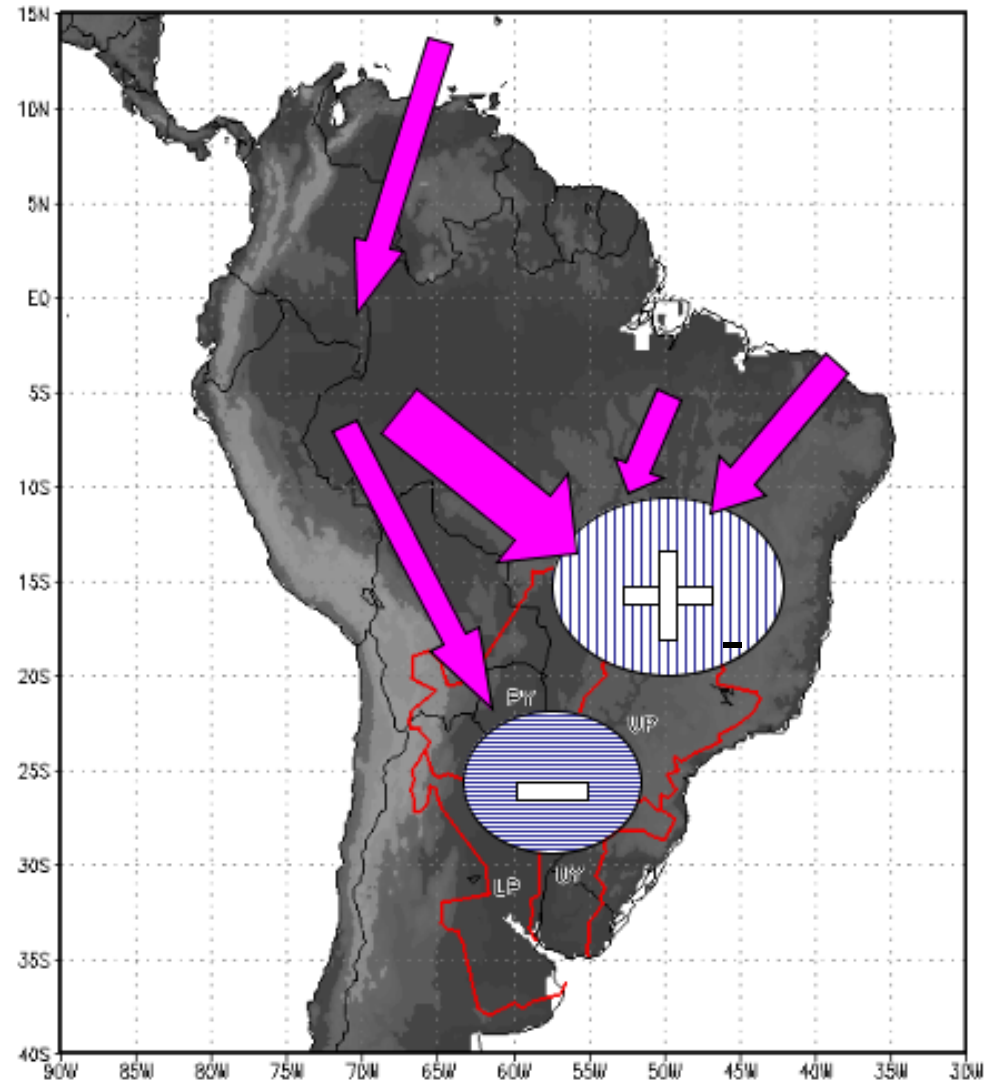
- Prediction
- Other droughts
- ...

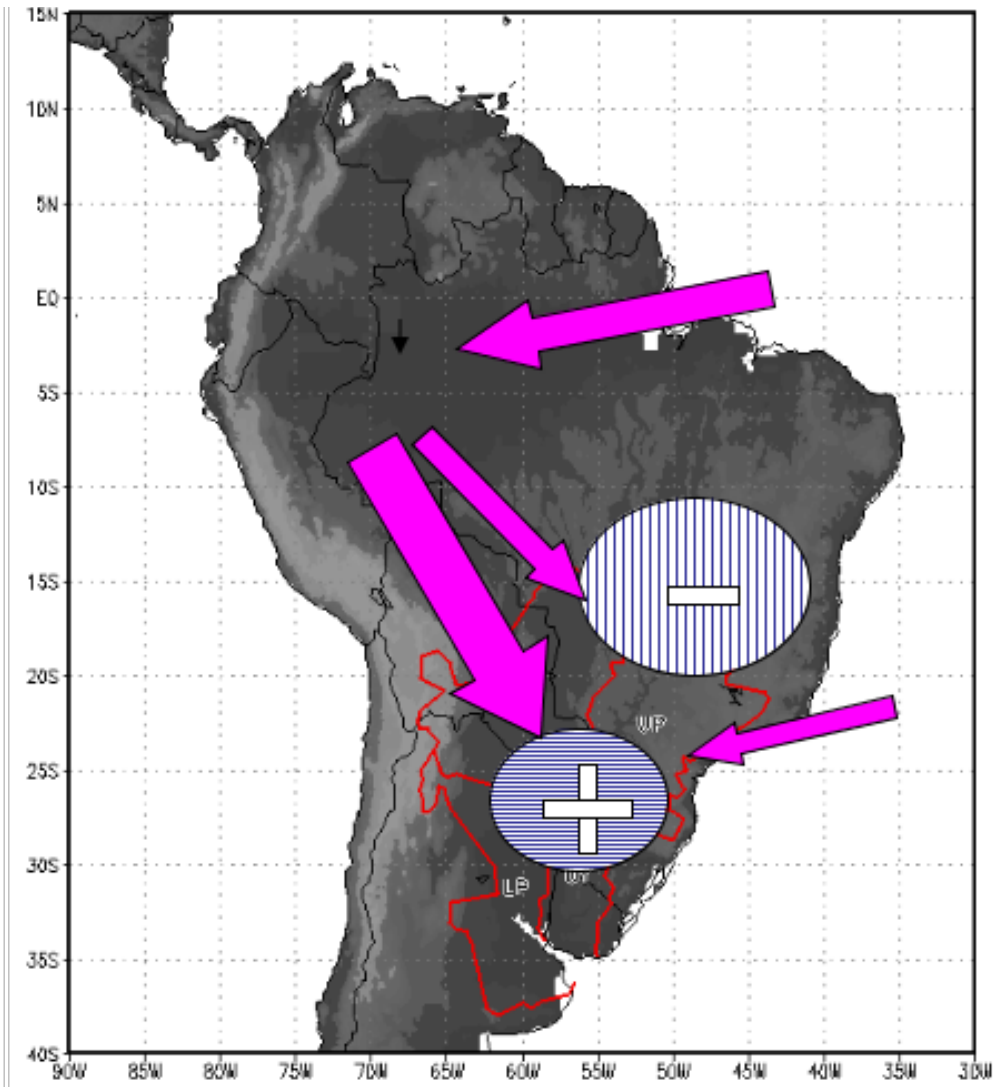
SEASONAL PREDICTIONS
Summer of 2005

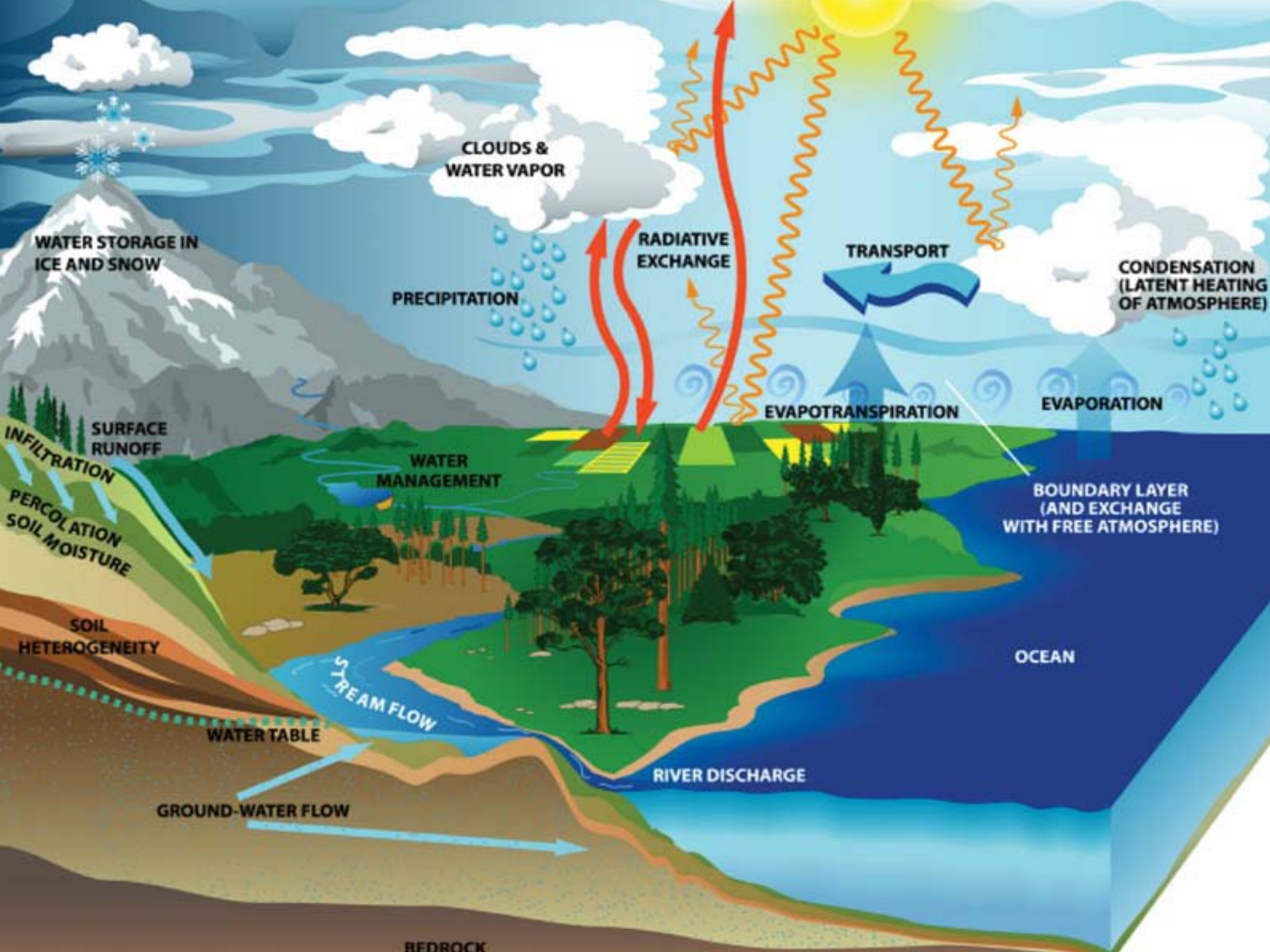




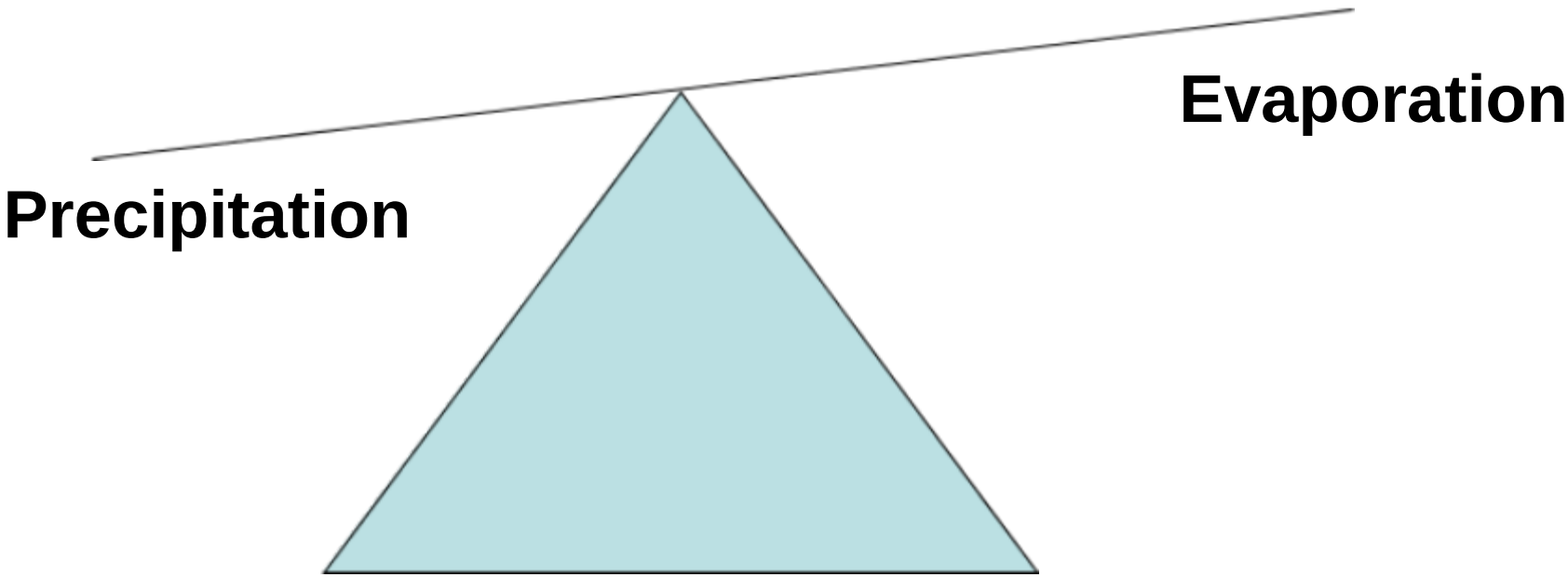
FLOW FIELDS AND PRECIPITATION ANOMALIES



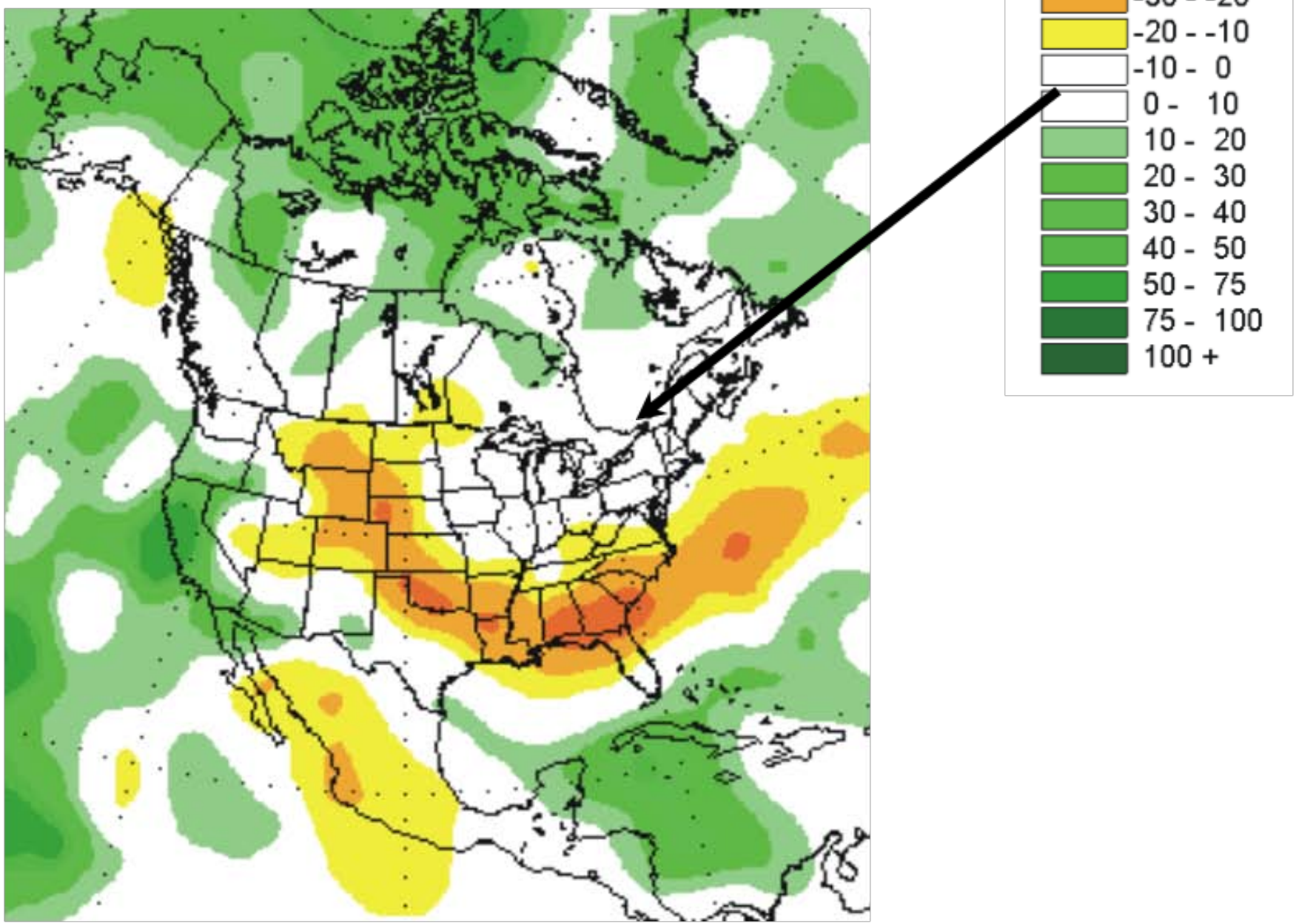



CLOUDS &
WATER VAPOR
WATER STORAGE IN
ICE AND SNOW
PRECIPITATION
RADIATIVE
EXCHANGE
TRANSPORT
CONDENSATION
(LATENT HEATING
OF ATMOSPHERE)
EVAPOTRANSPIRATION
EVAPORATION
SURFACE
RUNOFF
INFILTRATION
PERCOLATION
SOIL MOISTURE
WATER
MANAGEMENT
BOUNDARY LAYER
(AND EXCHANGE
WITH FREE ATMOSPHERE)
SOIL
HETEROGENEITY
OCEAN
STREAM FLOW
WATER TABLE
RIVER DISCHARGE
GROUND-WATER FLOW
BEDROCK

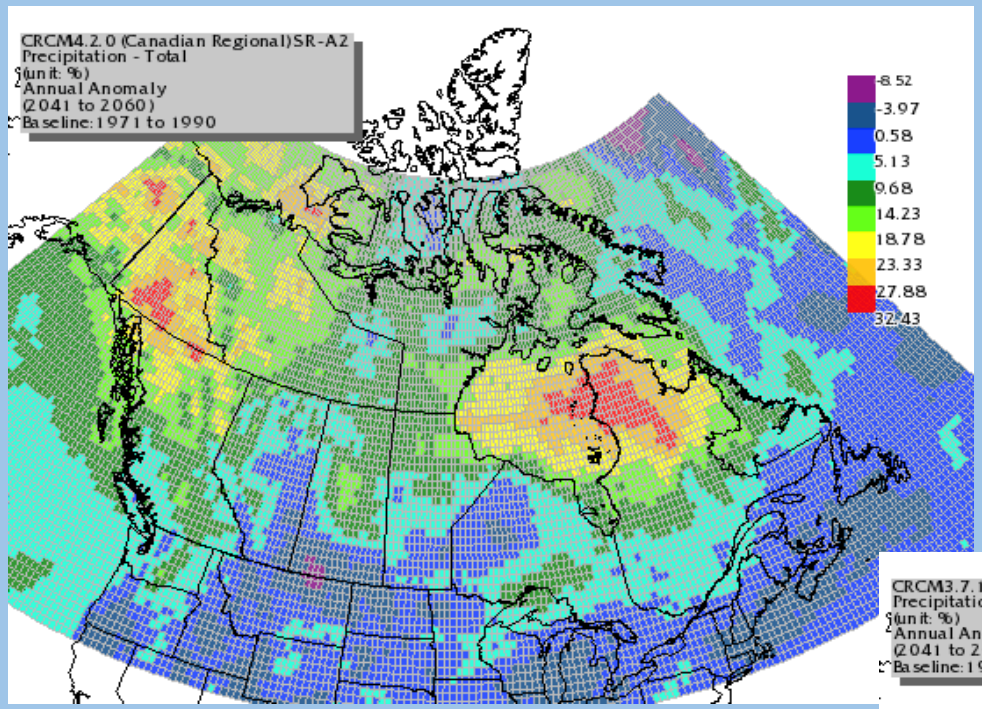
BALANCING OR NOT



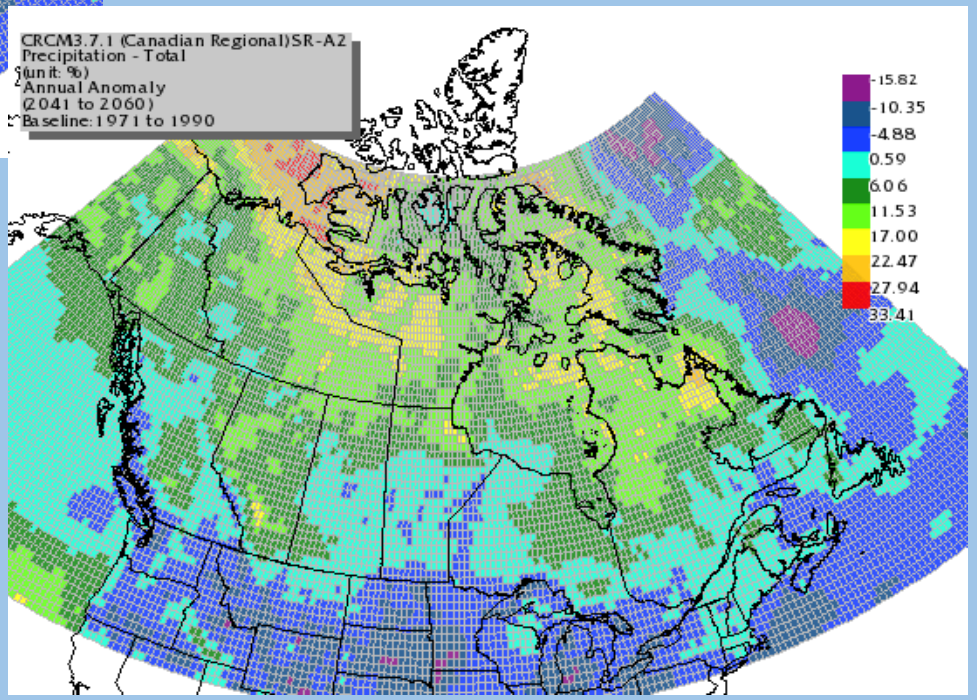
FUTURE PRECIPITATION?



Annual Precipitation Anomaly



4.2.0



3.7.1

IMPORTANCE OF SURFACE FEATURES

Less precipitation
Less evapotranspiration
Less precipitation

More precipitation
Greater evapotranspiration
More precipitation

IMPORTANCE OF SURFACE FEATURES

Less precipitation
Less evapotranspiration
Less precipitation

More precipitation
Greater evapotranspiration
More precipitation

Phenomenon[a] and direction of trend	Likelihood of a human contribution to observed trend[b]	AR4 basis for assessment	Current status
Warmer and fewer cold days and nights over most land areas	*Likely*[d]	Formal study	
Warmer and more frequent hot days and nights over most land areas	*Likely (nights)*[d]	Formal study	
Warm spells/heat waves. Frequency increases over most land areas	*More likely than not*[f]	Expert judgement	??
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*More likely than not*[f]	Expert judgement	Global precip and water vapour results
Area affected by droughts increases	*More likely than not*	Formal study	
Intense tropical cyclone activity increases	*More likely than not*[f]	Expert judgement	Supporting SST detection results
Increased incidence of extreme high sea level (excludes tsunamis)[g]	*More likely than not*[f,h]	Expert judgement	Formal study on waves

CONCLUSIONS

Extremes of a 'great deal' and 'very little' precipitation are inherent aspects of the climate system.

Some features of the 1999-2005 drought were expected but others were not.

Heavy and severe precipitation events sometimes occurred within and adjacent to the drought area.

The two types of extremes may at least sometimes 'feed onto each other'.

These results may be of wide applicability.

The future may hold more such extremes - the climate may become more variable although there is considerable uncertainty.


Thank you for your attention