DRI Workshop-2007

Raddatz,R.L, 2005. Moisture recycling on the Canadian Prairies for summer droughts and pluvials from 1997 to 2003. *Agricultural and Forest Meteorology*, 131, 13-26.

Given that regional evapotranspiration:

(1) Affects the availability of convective energy (CAPE).

(2) Affects the availability of water vapour mass.

(3) Spatial discontinuities in vegetation and/or soil moisture can induce mesoscale thermal circulations (land-land breezes) that initiate moist deep convection.

(4) Plant available moisture in the root zone has a considerably longer memory than the anomalous weather pattern that produced initial dry or wet perturbations in precipitation.

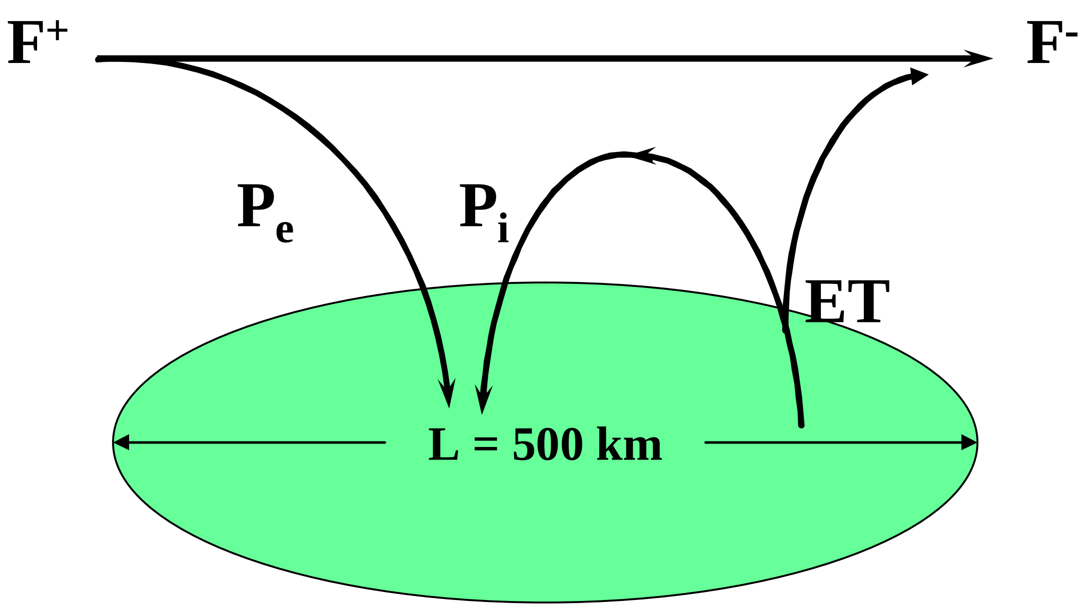
Hypothesis:

Summer dry periods (meteorological droughts) and summer wet periods (pluvials) are perpetuated by moisture and energy feedbacks from the surface water and energy budgets to the atmospheric water balance?

Sparse vegetation and dry soil limit evapotranspiration (latent heat flux). Less than usual amounts of water vapor in the atmospheric boundary layer reduce the availability of water vapour and potential energy – necessary, though not sufficient ingredients, for the generation of convective rain fall.

Lush vegetation and wet soil allow evapotranspiration (latent heat flux) to occur near the potential rate, thereby, maximizing the availability of water vapour and potential energy.

Atmospheric Water Balance



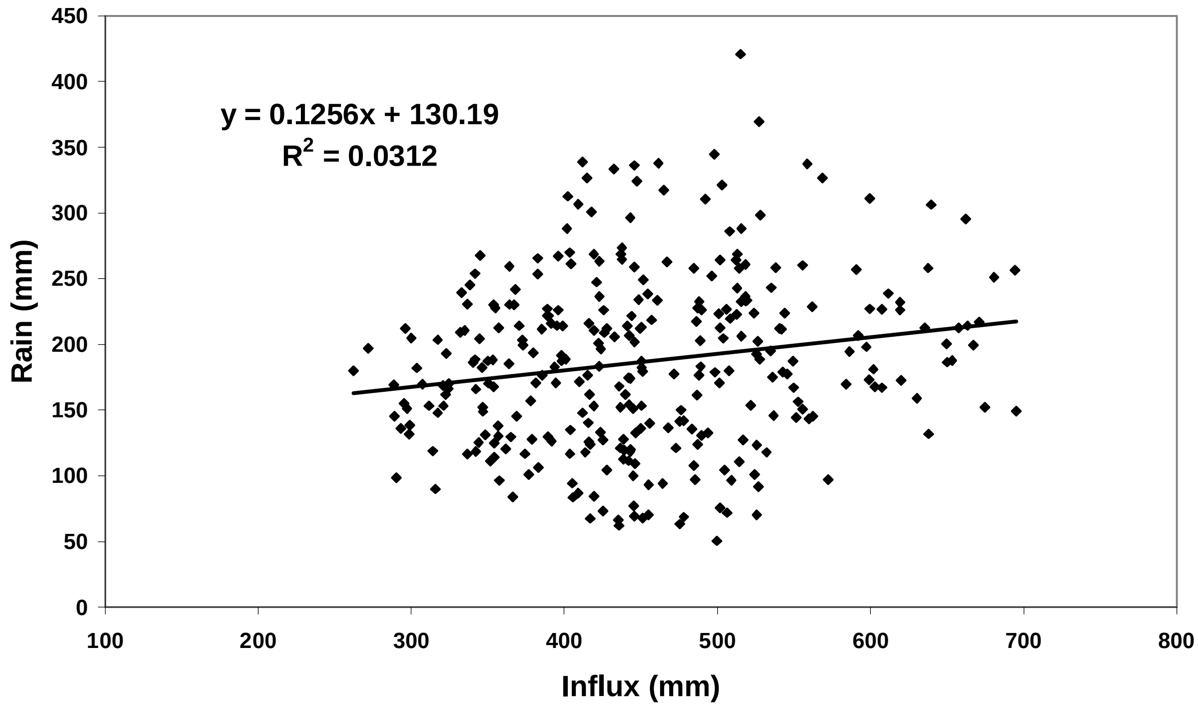
F^+ = horizontal influx of water vapour
F^- = horizontal efflux of water vapour
P_e = rainfall from external moisture
ET = evapotranspiration
P_i = rainfall from internal moisture
L = scale length of area

Mean Precipitation Efficiencies 1997-2003

Fraction of average horizontal water vapour flux over the area that falls as rain – indicates the relative frequency with which moisture, convective available potential energy (CAPE), and lift come together, and convert water vapour to rain.

Area	**Period Mean**
Drought	**29 %**
Normal	**46 %**
Pluvial	**73 %**

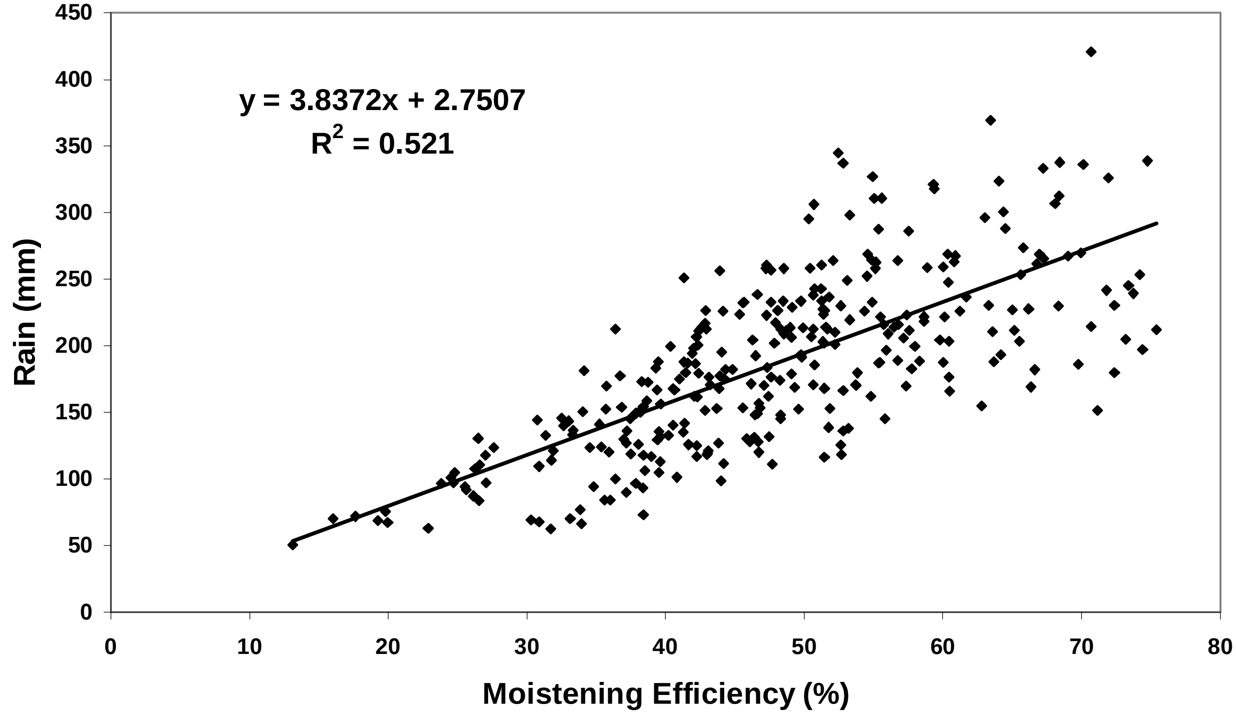
Summer rainfall not correlated to influx of moisture to Prairies



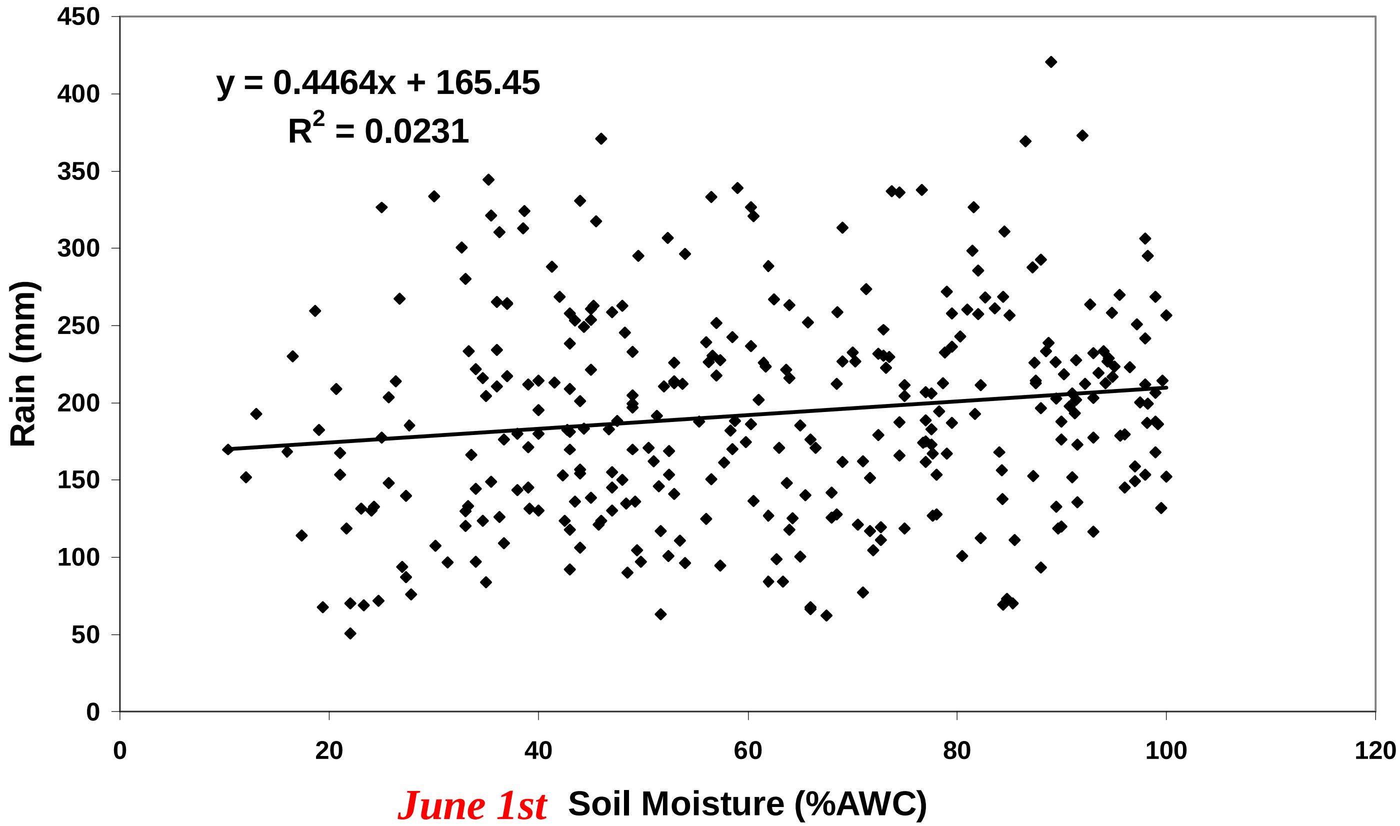
Suggests that there is generally sufficient moisture advected into the Canadian Prairies to produce the observed rainfall amounts. Thus, it is the other primary ingredients that are required for rainfall, lift & CAPE, that are scarce during droughts, but plentiful during pluvials.

Moistening Efficiency M = ET* L / F

Fraction of average horizontal water vapour flux over the area attributable to evapotranspiration within the area.



There is an intra-summer feedback between evapotranspiration and rainfall, and thus, evapotranspiration plays a role in the occurrence of dry, normal and wet periods.



The intra-summer feedback between evapotranspiration and rainfall does not extend to an inter-seasonal influence from spring to summer. (Note: Evapotranspiration is limited by soil moisture)

Mean Recycling Ratios 1997-2003

Fraction of average rainfall over the area attributable to evapotranspiration within the area.

Area	**Period Mean**
Drought	**16 %**
Normal	**21 %**
Pluvial	**24 %**

Clear differences in the mean recycling ratios for drought, normal rainfall and pluvial areas indicate that recycled moisture, attributable to evapotranspiration,was a factor in determining whether an area had a dry, normal or wet summer .

Conclusion

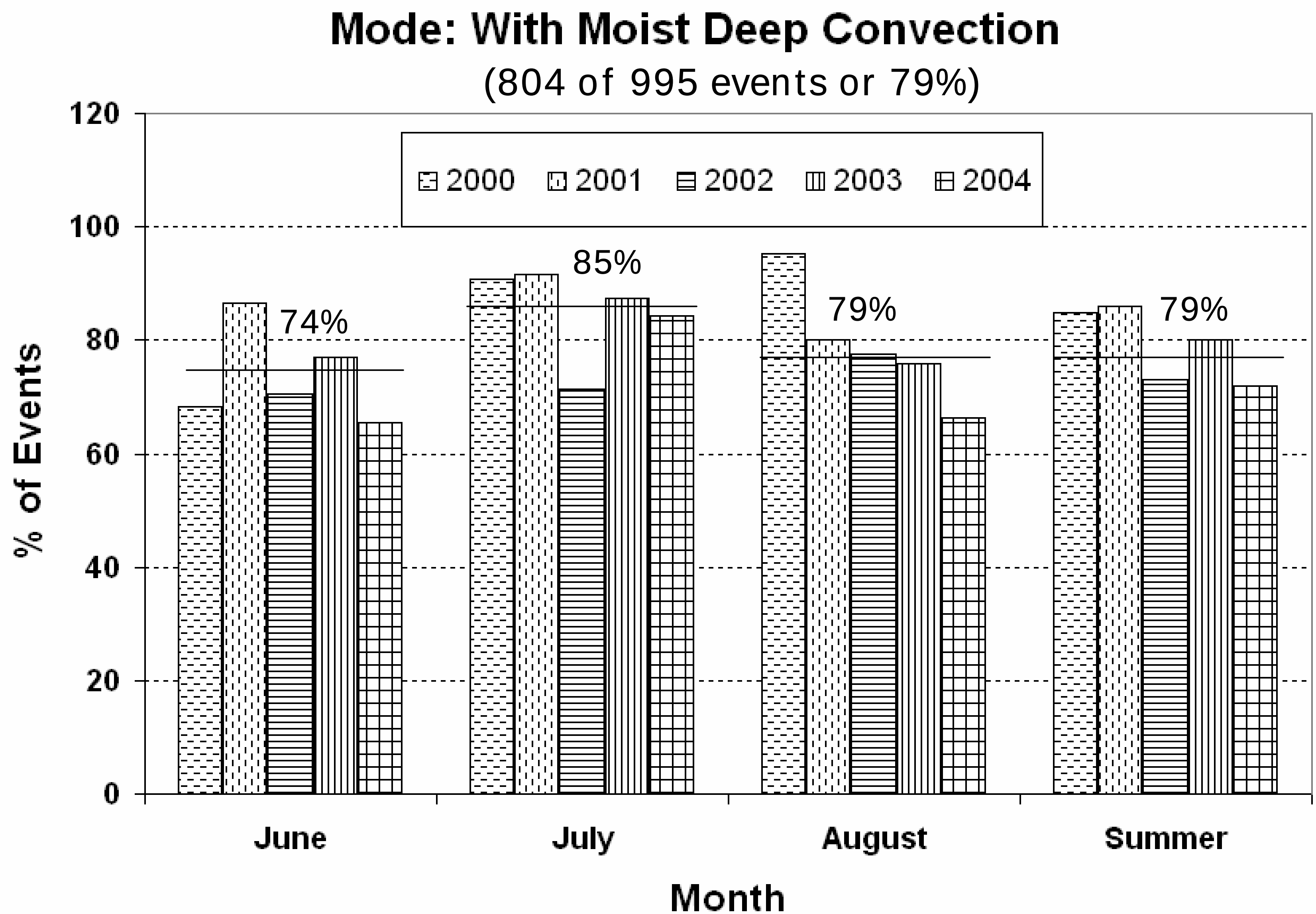
For the agricultural region of the Canadian Prairies, dry and wet areas during the summers of 1997-2004 were perpetuated by moisture and energy feedbacks from the surface water & energy budgets to the atmospheric water balance.

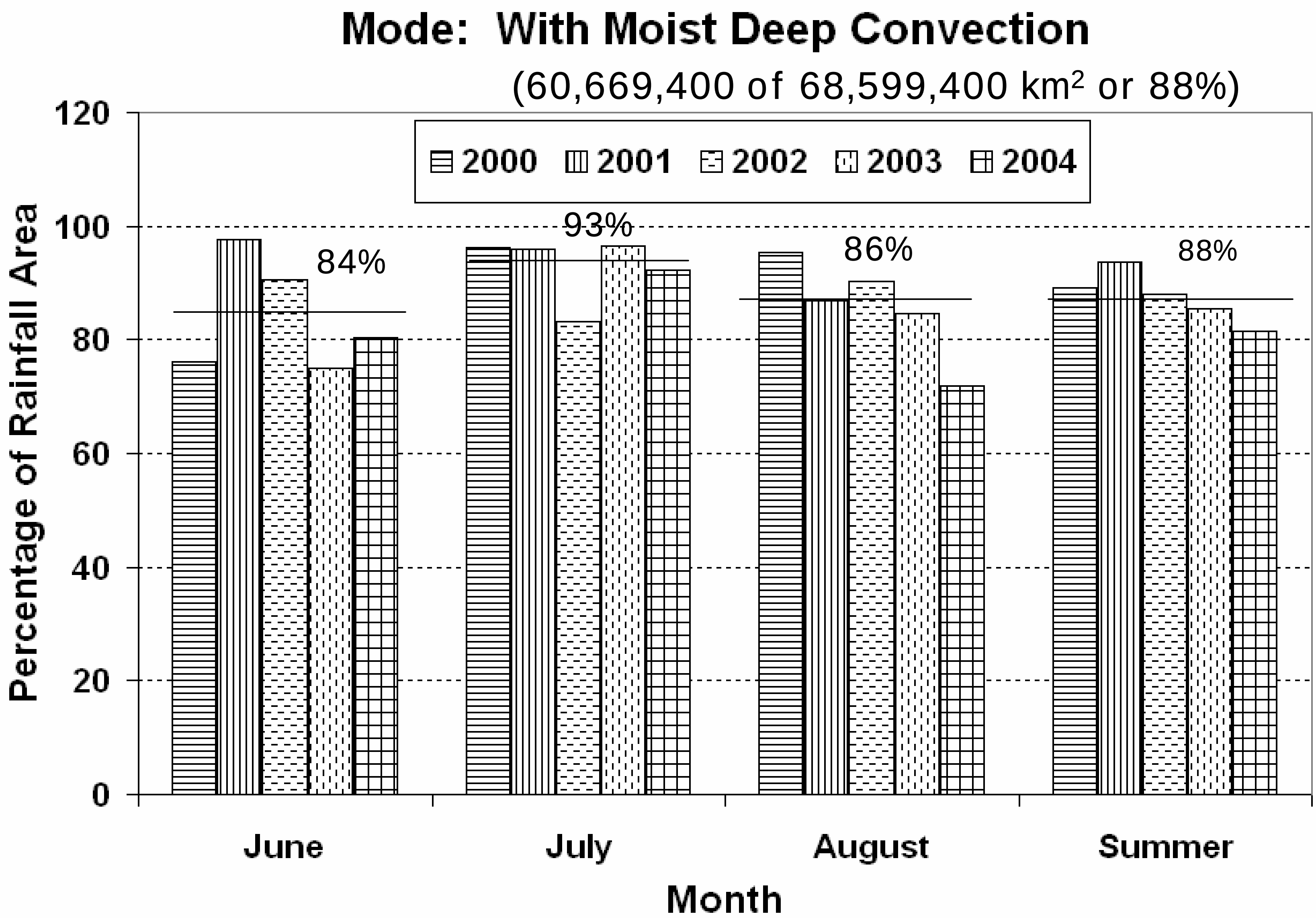
Raddatz, R.L. and J. M. Hanesiak, 2007. Significant Summer Rainfall in the Canadian Prairies: Modes and Mechanisms 2000 – 2004

Objective: What exactly is the nature of significant (> 10 mm in 24hrs) summer precipitation in the Canadian Prairie Provinces?

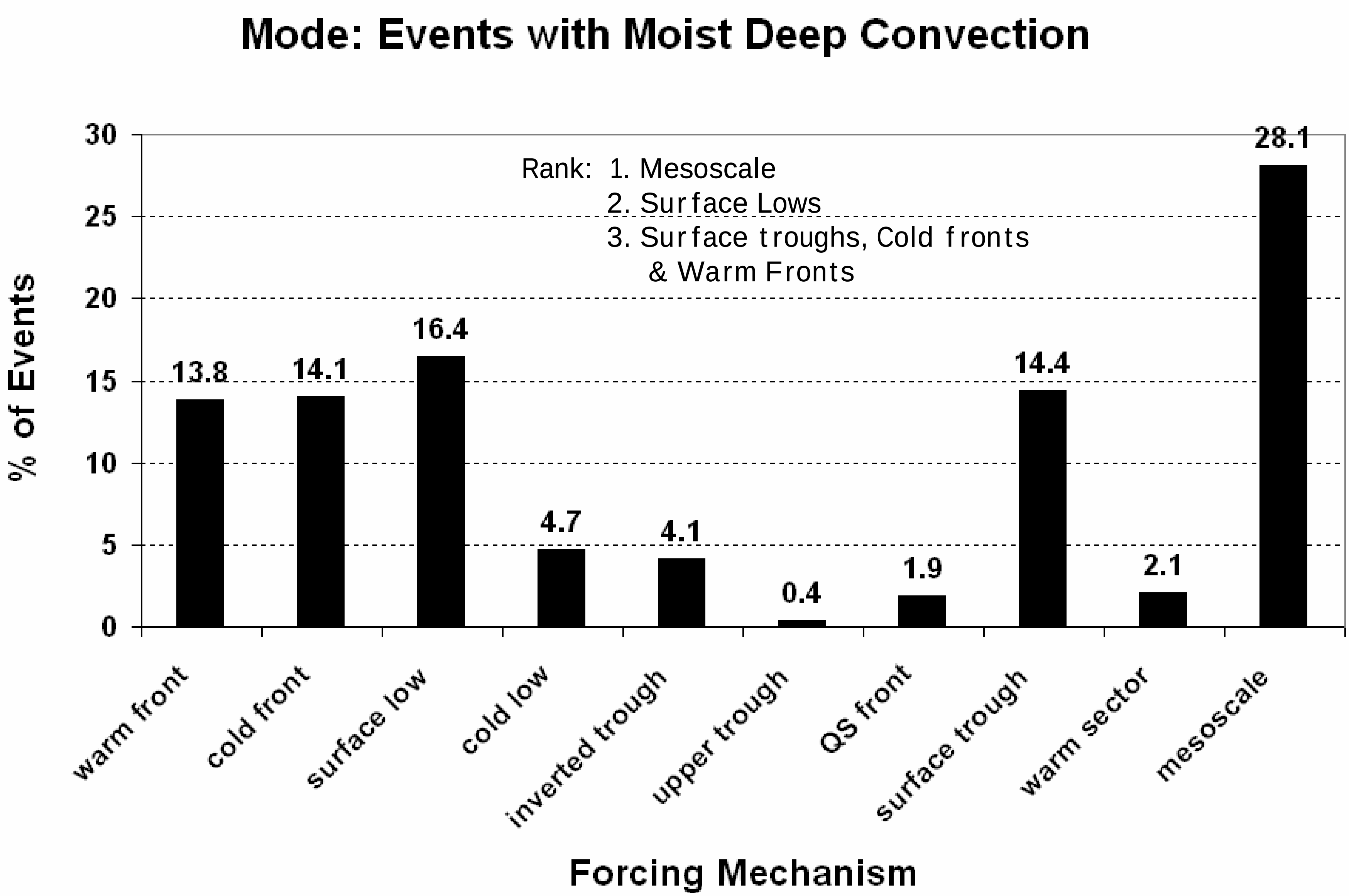
1. What is the relative frequency of significant rainfall events with moist deep convection (i.e., thunderstorms) versus events without convection?
2. What are the relative frequencies of the various synoptic and mesoscale forcing mechanisms that are responsible (i.e., that provide the lift) for the significant events with and without moist deep convection?
3. What are the relative areas effected by each of the two modes of rainfall, and by each of the forcing mechanisms?

While common perceptions prevail, objective answers to these questions are necessary to enhance the understanding of the meteorological processes responsible for summer rains, including droughts and pluvials, and they are a prerequisite to improving forecast skill

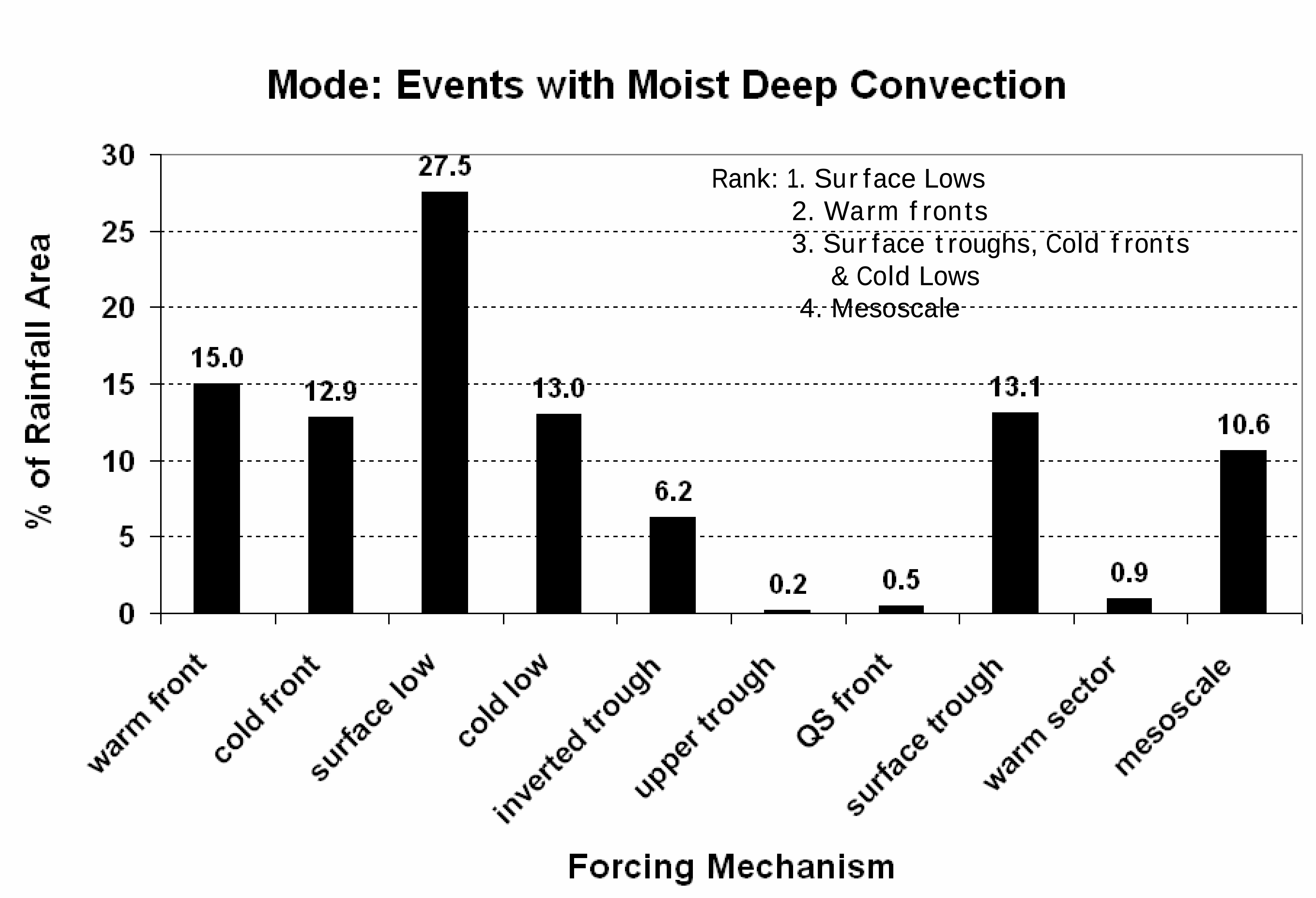

Mode: With Moist Deep Convection
(804 of 995 events or 79%)
2000
2001
2002
2003
2004
85%
74%
79%
79%
% of Events
0
20
40
60
80
100
120
June
July
August
Summer
Month

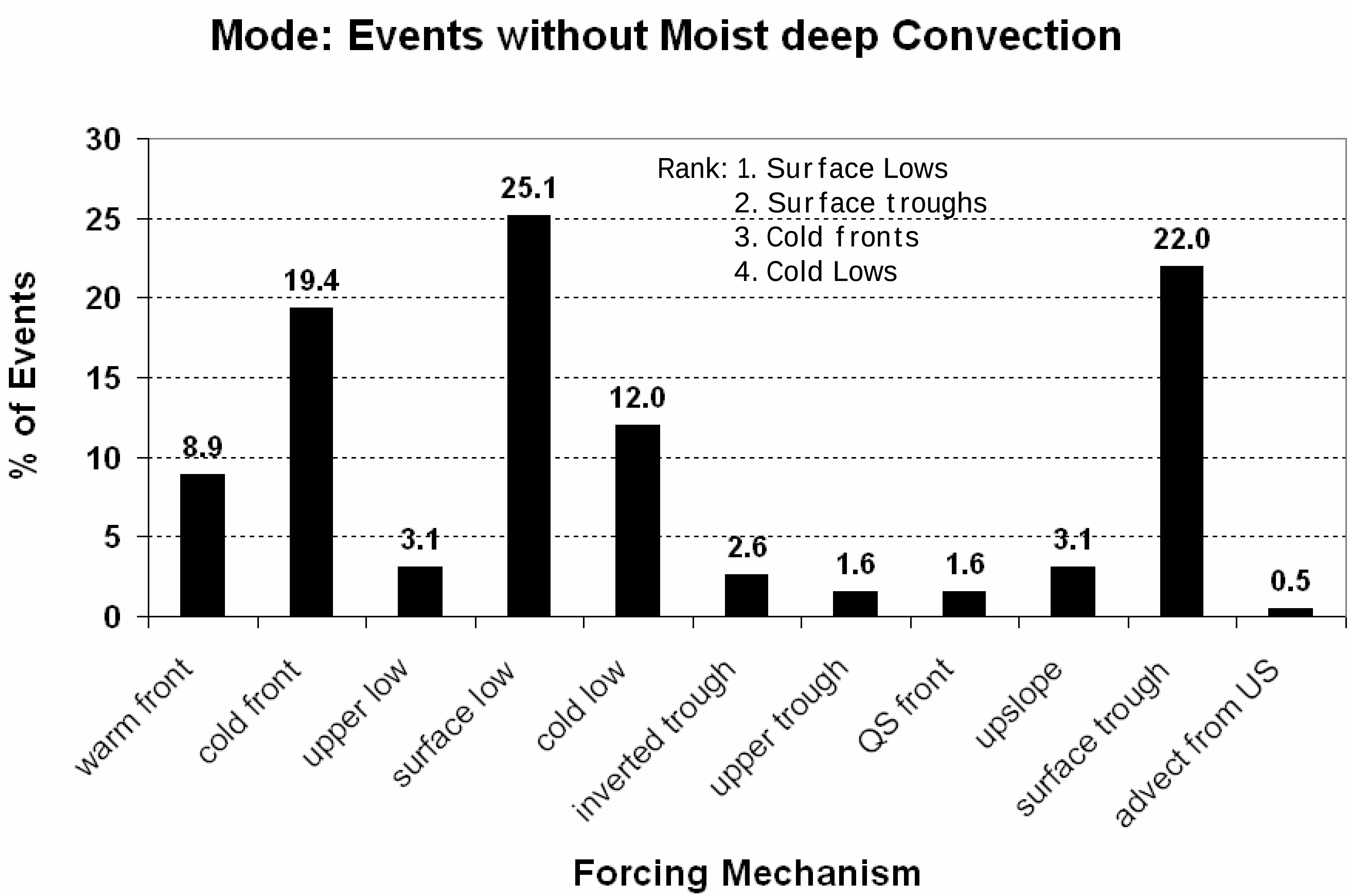


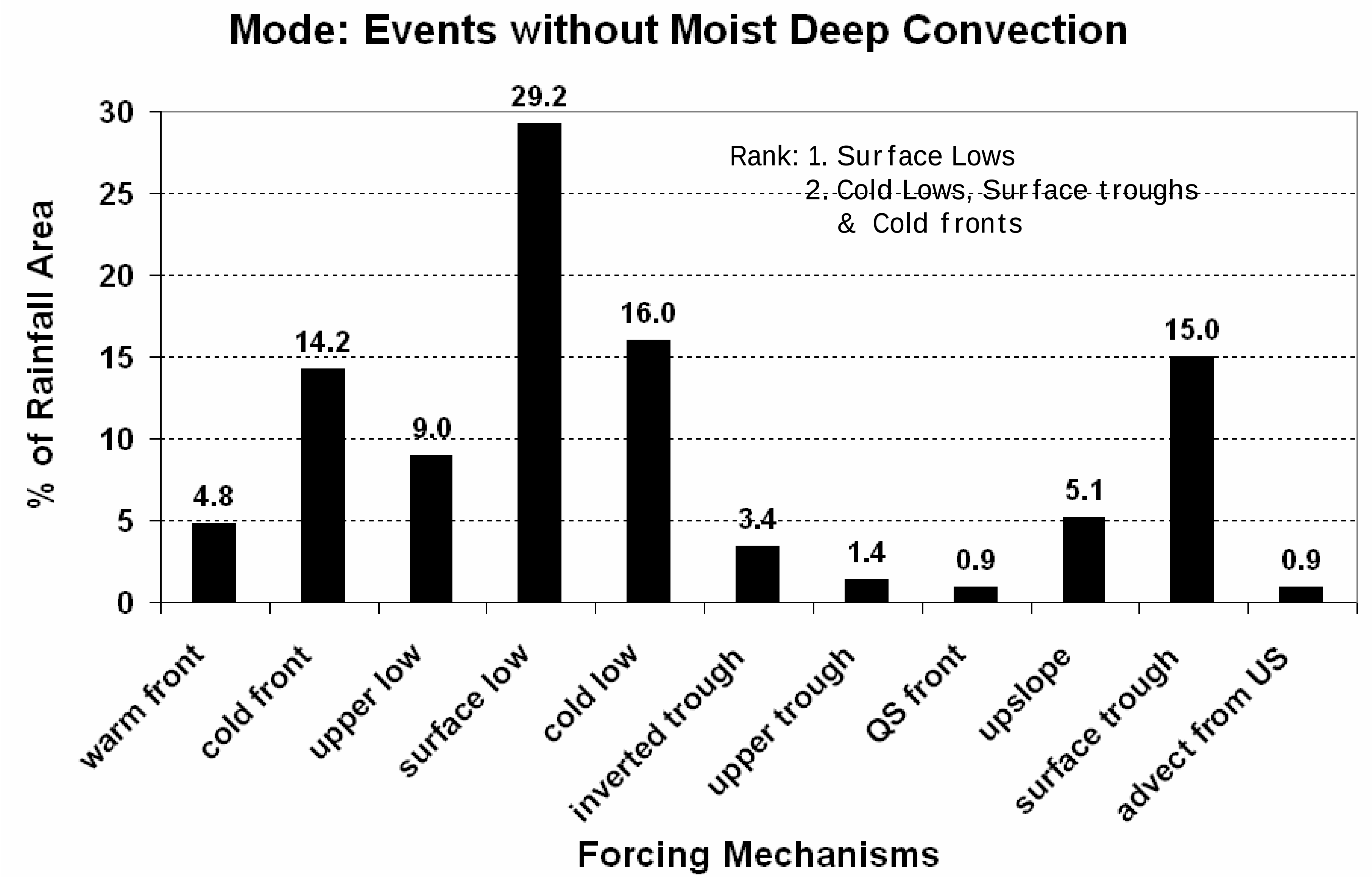
Mode: With Moist Deep Convection
(60,669,400 of 68,599,400 km2 or 88%)
2000
2001
2002
2003
2004
84%
93%
86%
88%
Percentage of Rainfall Area
120
100
80
60
40
20
0
June
July
August
Summer
Month



Mode: Events with Moist Deep Convection
Rank: 1. Mesoscale
2. Surface Lows
3. Surface troughs, Cold fronts
& Warm Fronts
% of Events
0
5
10
15
20
25
30
13.8
14.1
16.4
4.7
4.1
0.4
1.9
14.4
2.1
28.1
warm front
cold front
surface low
cold low
inverted trough
upper trough
QS front
surface trough
warm sector
mesoscale
Forcing Mechanism


Mode: Events with Moist Deep Convection
% of Rainfall Area
Forcing Mechanism
Rank: 1. Surface Lows
2. Warm fronts
3. Surface troughs, Cold fronts
& Cold Lows
4. Mesoscale
0
5
10
15
20
25
30
15.0
12.9
27.5
13.0
6.2
0.2
0.5
13.1
0.9
10.6
warm front
cold front
surface low
cold low
inverted trough
upper trough
QS front
surface trough
warm sector
mesoscale


Mode: Events without Moist deep Convection
Rank: 1. Surface Lows
2. Surface troughs
3. Cold fronts
4. Cold Lows
% of Events
30
25
20
15
10
5
0
8.9
19.4
3.1
25.1
12.0
2.6
1.6
1.6
3.1
22.0
0.5
warm front
cold front
upper low
surface low
cold low
inverted trough
upper trough
QS front
upslope
surface trough
advect from US
Forcing Mechanism



Mode: Events without Moist Deep Convection
Rank: 1. Surface Lows
2. Cold Lows, Surface troughs
& Cold fronts
% of Rainfall Area
30
25
20
15
10
5
0
4.8
14.2
9.0
29.2
16.0
3.4
1.4
0.9
5.1
15.0
0.9
warm front
cold front
upper low
surface low
cold low
inverted trough
upper trough
QS front
upslope
surface trough
advect from US
Forcing Mechanisms

Conclusions / Summary

- Moist deep convection (thunderstorms) occurred with ~79% of summer rainfall events (≥ 10 mm in 24h), and events with convection accounted for 88% of the total rain area.

- Synoptic forcing, particularly surface lows, were responsible for 72% of all summer rainfall events (≥ 10 mm in 24 h) with moist deep convection, and about 90% of this rainfall area.

- Many (~28%) summer rain events (≥ 10 mm in 24 h) with moist deep convection were forced by mesoscale mechanisms, but these events only account for 10-11% of the rainfall area.

- All events without convection, and thus the total rainfall area without convection, were due to synoptic scale forcing, in particular, surface lows.