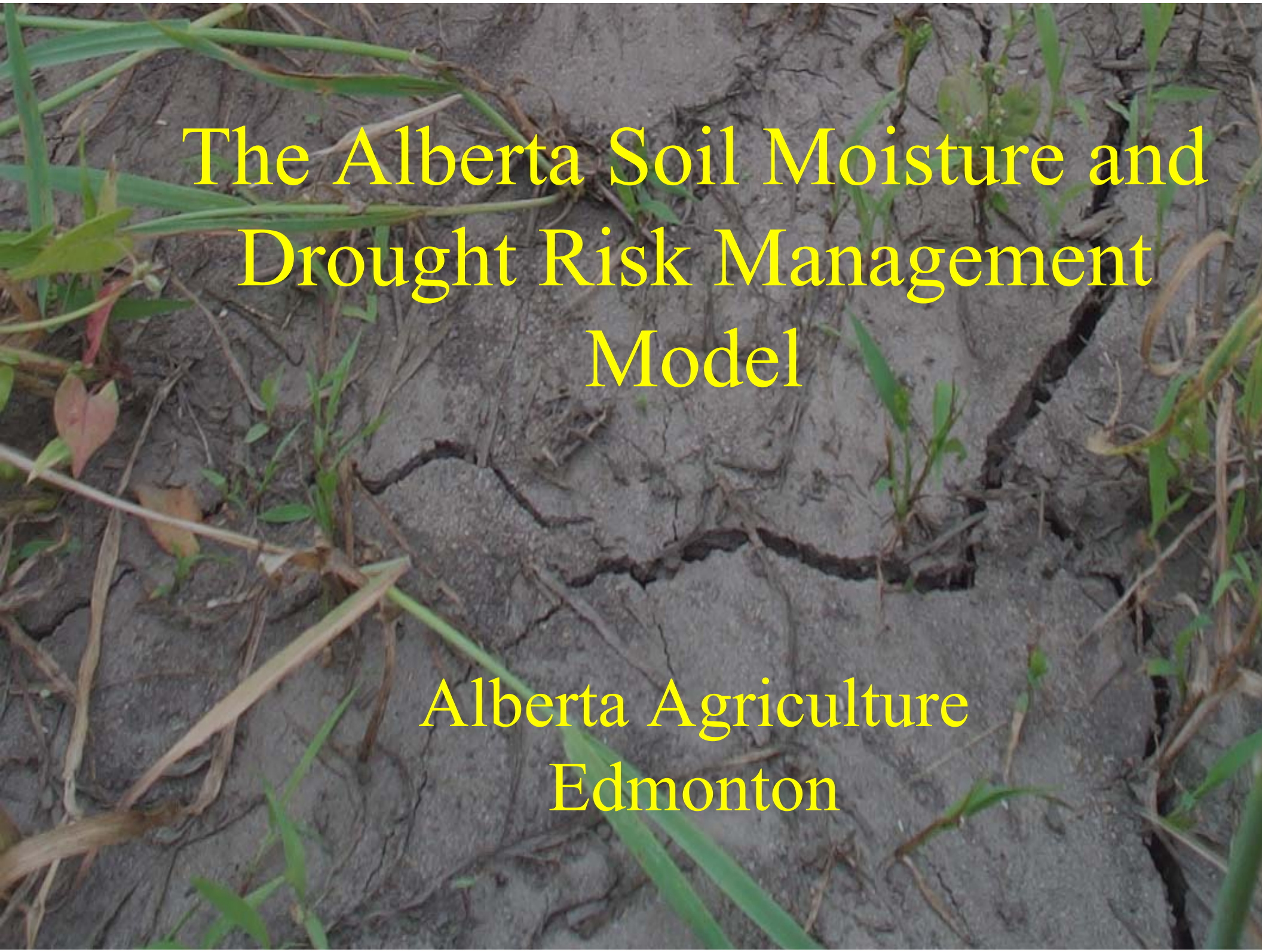


The Alberta Soil Moisture and Drought Risk Management Model

Alberta Agriculture
Edmonton

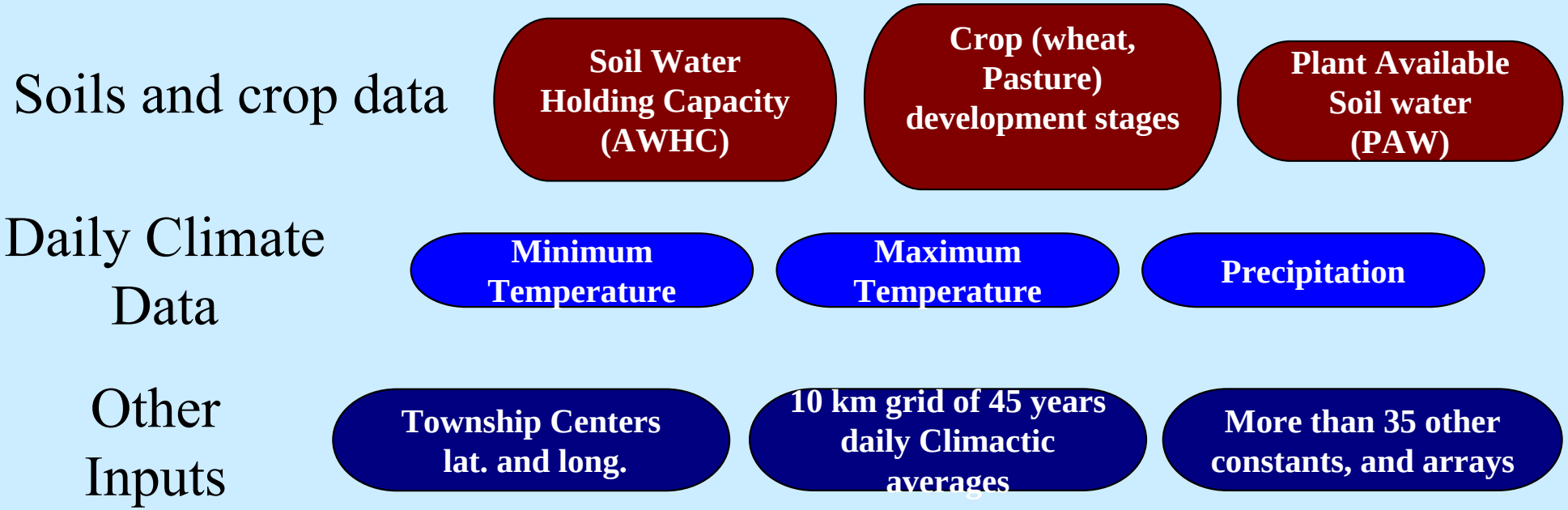
Model History:

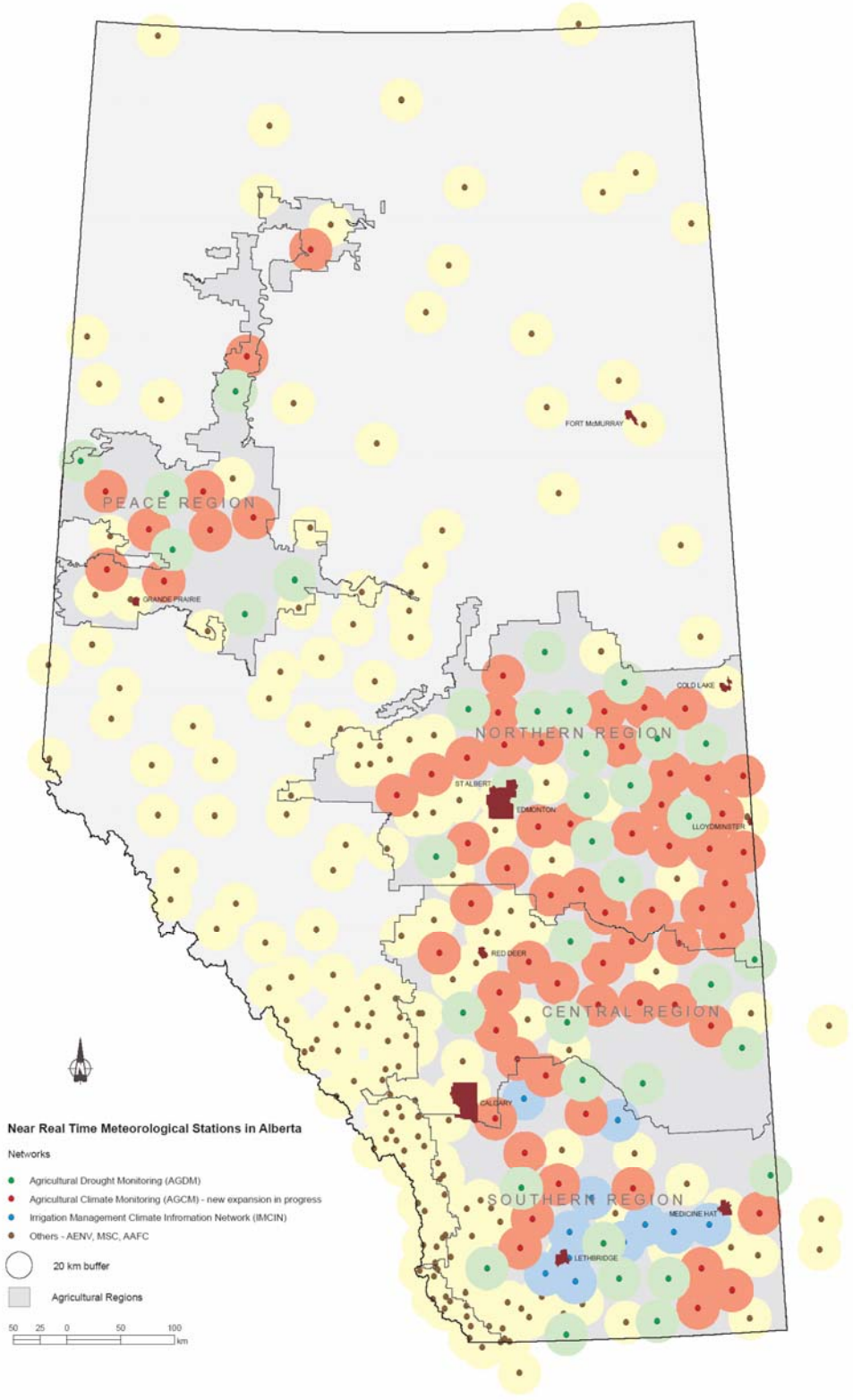
- Initiated in early 1990's -through funding from the Nat Christie Foundation
- Primary FORTRAN development (1992-1995) by:
  - **Dr. Wolé Akinremi and Dr. Sean McGinn**
  - **Dr. Allan Bar**
- Fortran to SAS conversion: **Keith Toogood**
- Testing, enhancements and validation: **Ralph Wright, Dr. Zahid Qureshi**

Model overview

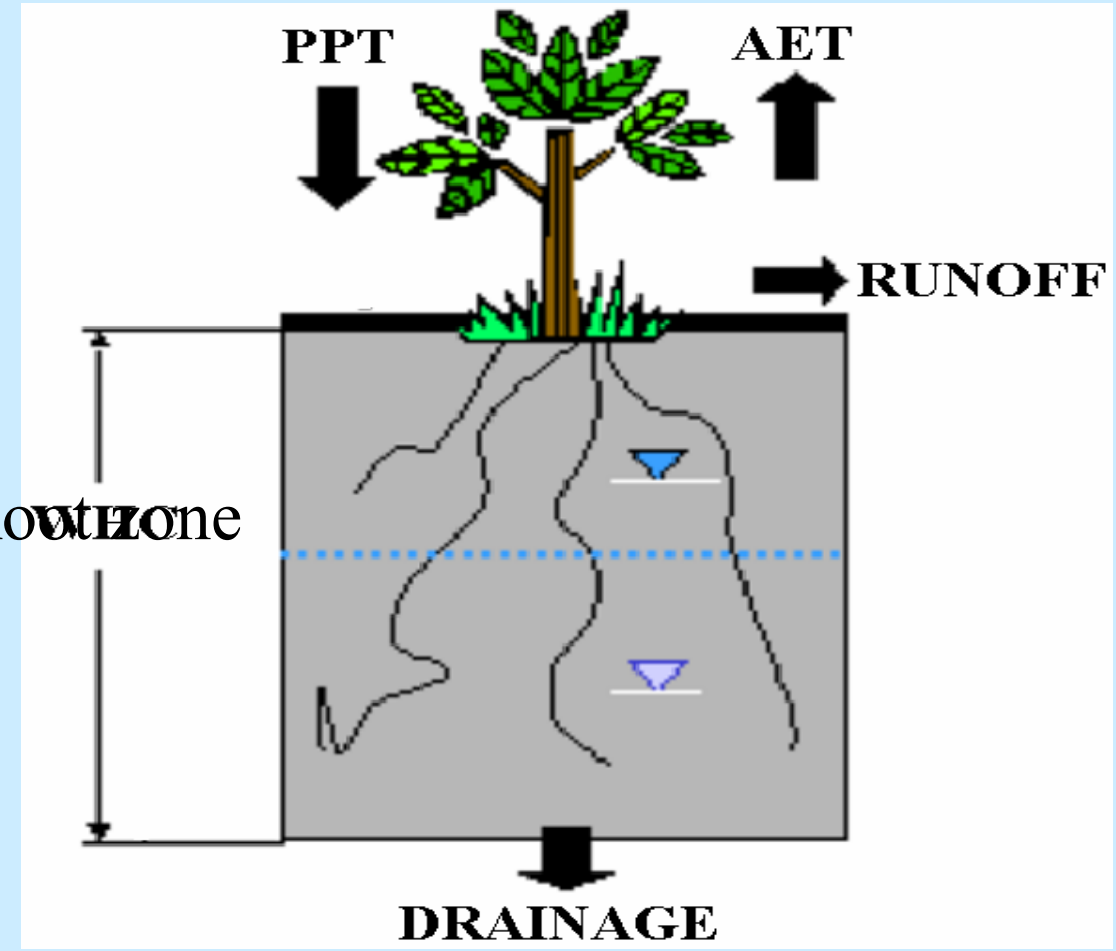
Based upon the Versatile Soil Moisture Budget (Baier and Robertson (1966)

- Relatively simple and operational!
- Medium textured soil with four layers, each 300 mm thick
- Computes soil moisture, ET, drought indices, etc… for 4418 Townships




PEACE REGION
NORTHERN REGION
CENTRAL REGION
SOUTHERN REGION
FORT McMURRAY
GRANDE PRAIRIE
COLD LAKE
ST ALBERT
EDMONTON
LLOYDMINSTER
RED DEER
CALGARY
MEDICINE HAT
LETHBRIDGE
N
Near Real Time Meteorological Stations in Alberta
Networks
Agricultural Drought Monitoring (AGDM)
Agricultural Climate Monitoring (AGCM) - new expansion in progress
Irrigation Management Climate Information Network (IMCIN)
Others - AENV, MSC, AAFC
20 km buffer
Agricultural Regions
50 25 0 50 100
km

A simplified root zone water balance accounting for soil water interring, leaving and remaining within the root zone



Root zone soil water balance

$$\theta_i = (\theta_{i-1} + ppt_{i-1}) - (snoBlo_{i-1} + Ro_{i-1} + subl_{i-1} + leach_{i-1} + AET_{i-1})$$

θ_i = **Today's soil moisture at the beginning of the day, mm**

θ_{i-1} = **Available soil moisture at the beginning of previous day,mm**

ppt_{i-1} = **24-hour total precipitation at the end of previous day, mm**

Ro_{i-1} = **Water lost due to runoff, mm**

$snoBlo_{i-1}$ = **24-hour snow blown out of snow pack previous day, mm**

$leach_{i-1}$ = **Water lost below rooting zone, mm**

AET_{i-1} = **Water used by plants at the end of previous day, mm**

$subl$ = **sublimation of snow pack**

Soil water balance

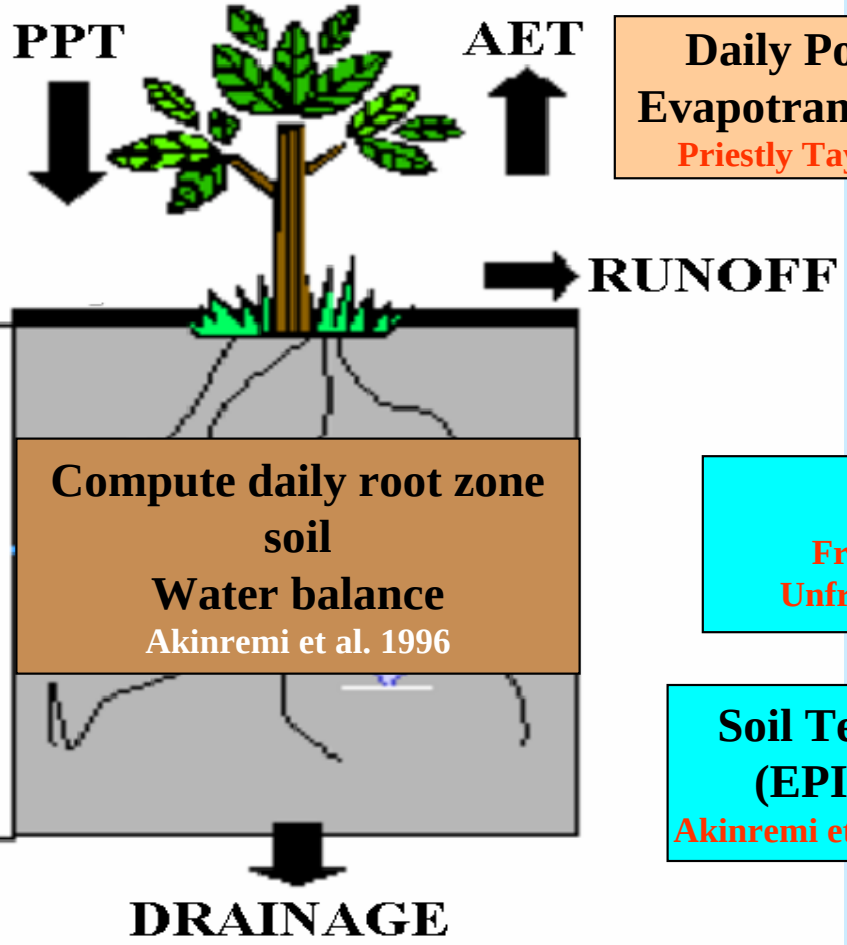
(by township)

Seeding Date
Bair et al. 1979

Crop Stage
Bair et al. 1979

Harvest Date
Akinremi et al. 1996

Precipitation
Rain or Snow?
(Wright)



Daily Potential Evapotranspiration
Priestly Taylor 1972

Actual Evapotranspiration
Bair et al. 1979

Saturated Flow
Adapted from
Ritchie and Otter 1985

Unsaturated Flow
Adapted from
Ritchie and Otter 1985

Compute daily root zone soil Water balance
Akinremi et al. 1996

Runoff
Frozen: Ash et al. 1992
Unfrozen: USDA SCS 1972

Soil Temp. (EPIC)
Akinremi et al. 1996

Snow Melt
McKay 1964
Modified by Wright

Effective Precipitation (Ppt_e)

- The amount of precipitation available for soil moisture storage and plant use

$$Ppt_e = ppt - snoBlo - RO - subl - leach$$

Where:

ppt	=	precipitation
snoBlo	=	snow blown off of field = 0.7*ppt
RO	=	runoff from field
subl	=	sublimation of snow pack
leach	=	leaching of soil water below 120 cm

Precipitation (ppt)
Rain or Snow?

If ppt is snow, then a snow coefficient blows 30% of ppt off of the soil surface

Model interprets ppt as snow if:

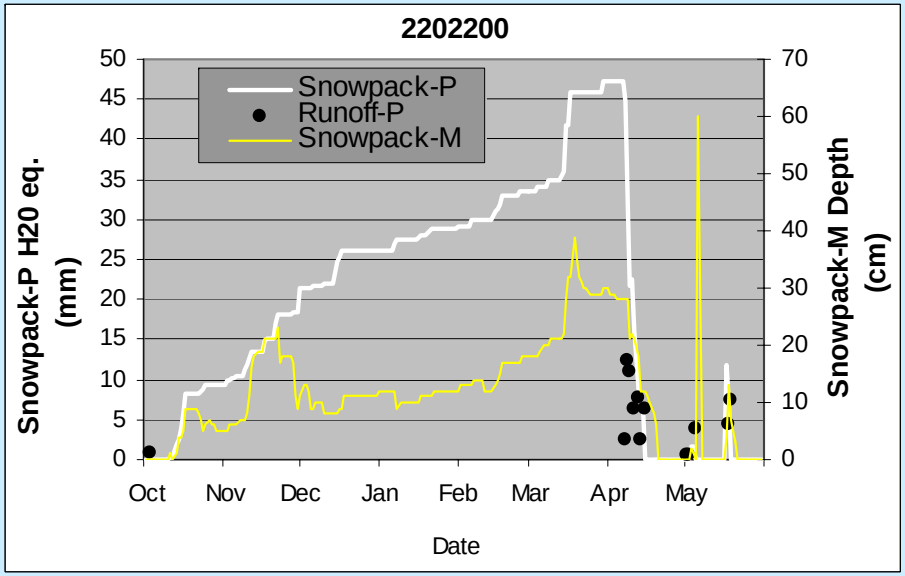
mean daily temperatures are <= 2 °C

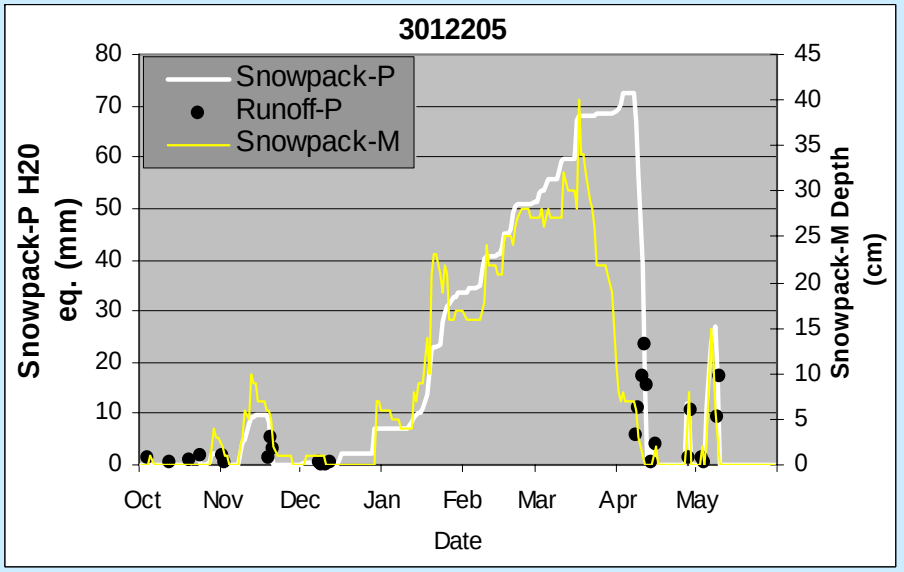
Ppt_e = ppt – snoBlo – Subl – RO - leach

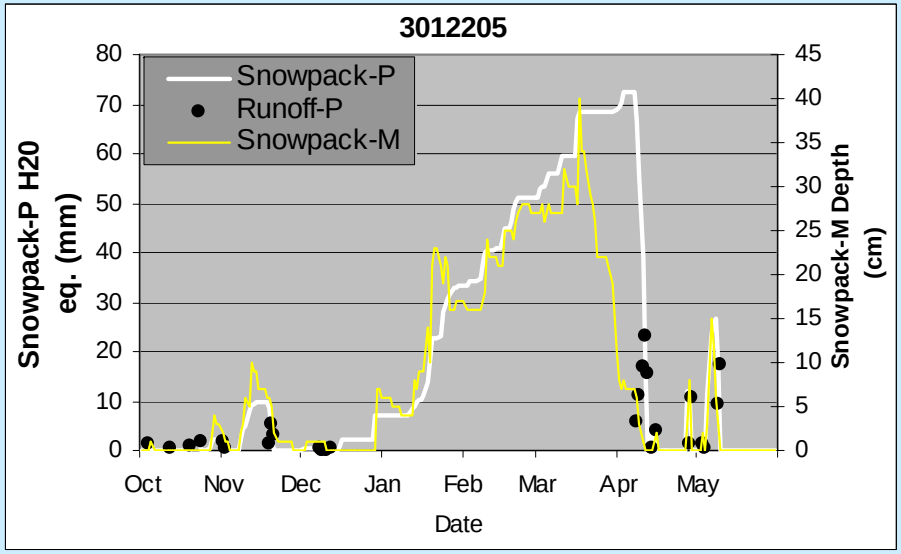
Modification to McKay (1964) Snow Melt-Temperature Curves

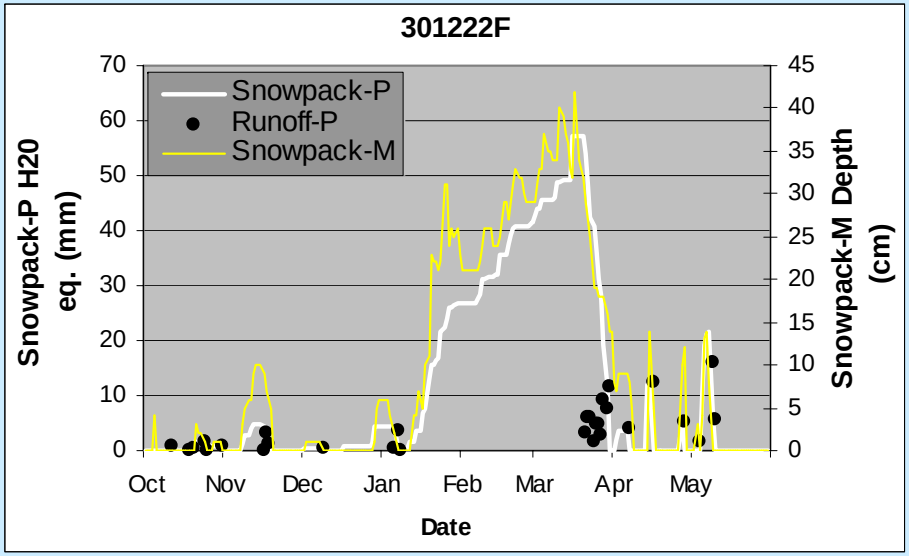
- Used Snow melt runoff data from Field Scale catchments
- 14 Site years of data across 11 sites
  - Snow pack measurements
  - Runoff measurements
- Brute force attack to adjust Mckay
- Verified against EC snow pack data (Boolean)

Performance of Snow Melt Routine Vs EC Snow **depth** data









snow pack and snow melt

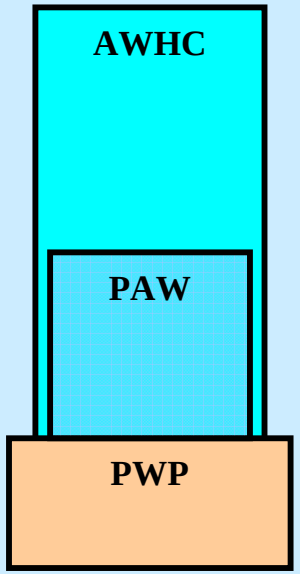
Runoff on Frozen soils

Snow Melt and/or Rain

Ash et al, 1992

Computed using PAW and AWHC in first soil layer

$$Runoff = \text{surface water} \times \frac{PAW_1}{AWHC_1}$$



Where:

Surface water = **rain** + **snow melt drainage** out of the snow pack

Rain = precipitation if:
mean temperature is > 2 °C

Effective Precipitation

$$Ppt_e = ppt - snoBlo - Subl - RO - leach$$

Computing Curve Numbers When Soil Water Content is < FC

For each soil layer (i= 1 to 4)

$$cnpd = cnpd + \left(\frac{PAW_i}{AWHC_i} \times Wf_i \right)$$

Next soil layer (i)

$$cn = 63 + cnpd(91.5 - 80)$$

Depth Weighting Factors

wf(1) = 0.953

wf(2) = 0.0595

wf(3) = 0.00372

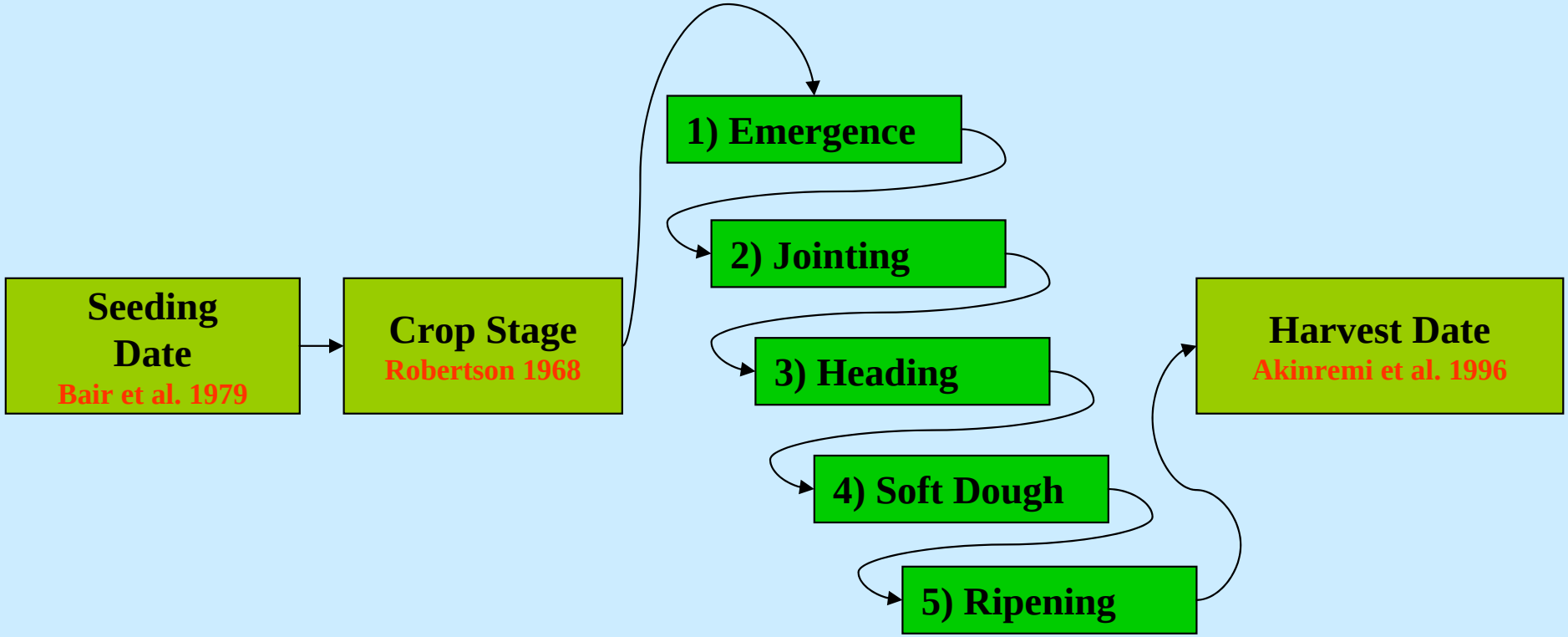
wf(4) = 0.000232

As cn ↑ runoff potential ↑

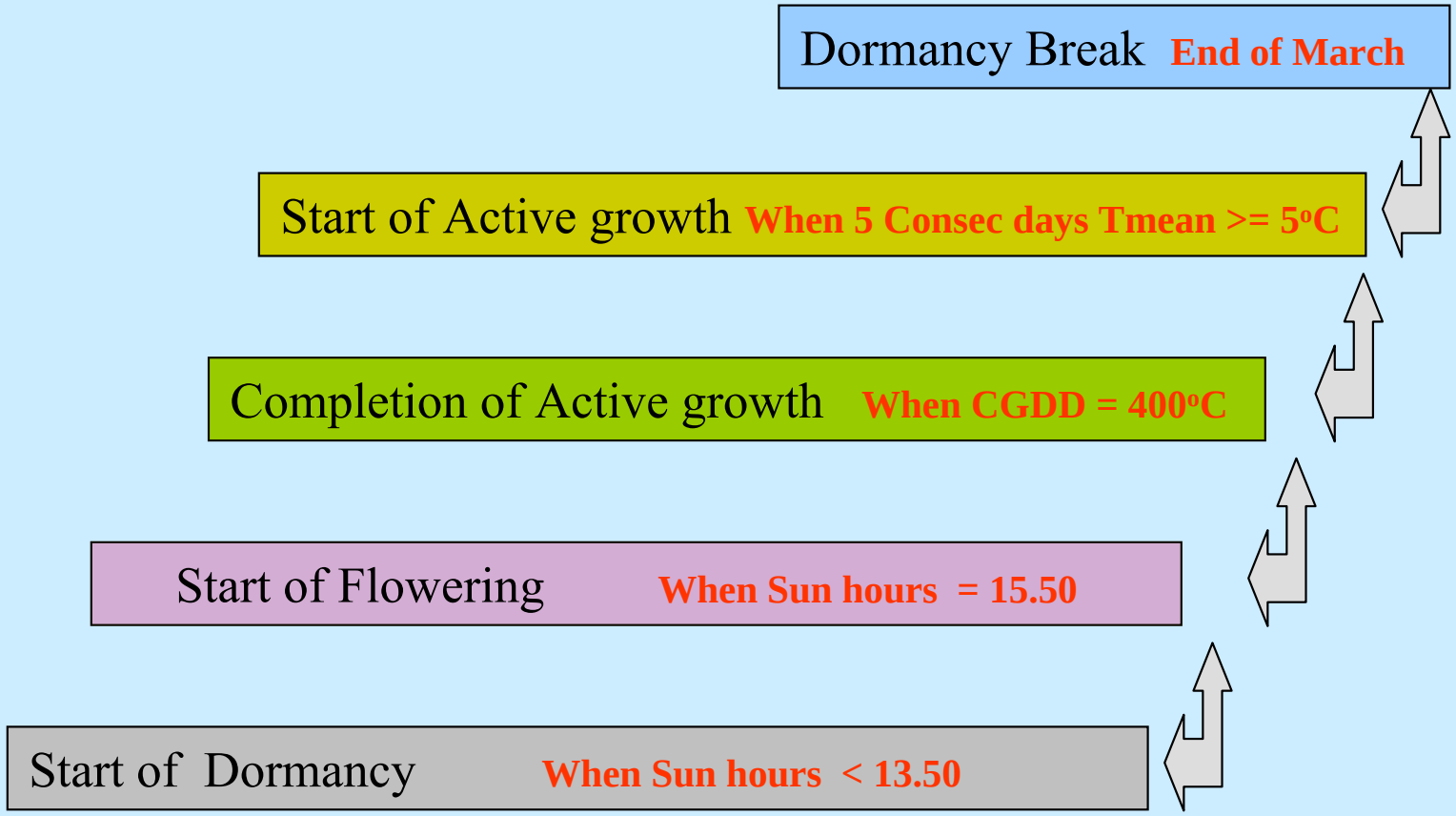
Effective Precipitation

$$Ppt_e = ppt - snoBlo - Subl - RO - leach$$

Wheat crop development stages



Pasture Growth Stages



Potential Evapotranspiration
(PET)

$$PET = \alpha\left(\frac{\delta}{\delta+\gamma}\right)R_n - G$$ (Priestly and Taylor, 1972)

Where:

$\propto$ = PT constant

$R_n = f(Latitude, Julian\ day)$

$\delta = f(Mean\ Temperature)$

$\gamma = f(Mean\ Temperature)$

Actual Evapotranspiration (AET)

Computations for each soil layer (i= layer)

$$AET_i = f\left(\frac{PAW_i}{AWHC_i} \times \text{Drying Curve}_i \times COF_i \times PET\right)$$

Where:

Drying Curve	=	ratio of AET/PET as a function of PAW/AWHC
COF	=	crop root extraction coefficients whose value is dependant on crop stage and water content
PET	=	potential evapotranspiration

Crop Coefficients (COF)

Crop Stage	Soil Layer (cm)			
	0-30	**30-60**	**60-90**	**90-120**
Emergence	0.50	0.05	0.01	0.01
Jointing	0.55	0.10	0.02	0.01
Heading	0.75	0.20	0.10	0.05
Soft Dough	0.80	0.25	0.15	0.05
Ripening	0.80	0.25	0.15	0.05

If crop stage > 3 and soil layer is 2, 3 or 4

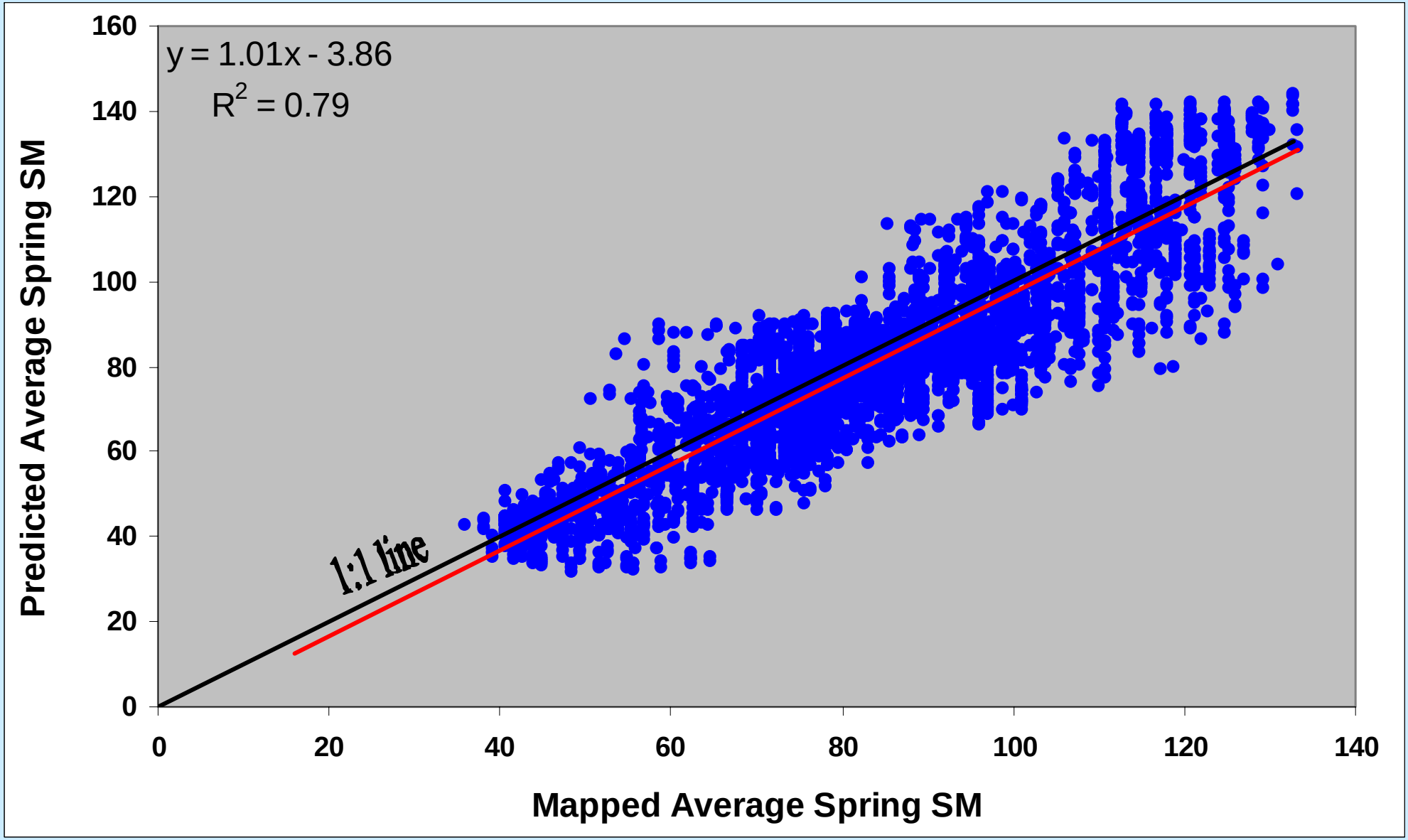
$$\mathbf{COF}_{(layer)} = \mathbf{COF}_{(layer)} + \mathbf{COF}_{(layer)} * \mathbf{COF}_{(layer\ -1)} * (1\text{-PAW/AWHC})$$

$$AET_i = f\left(\frac{PAW_i}{AWHC_i} \times Drying\ Curve_i \times PET \times \boldsymbol{COF_i}\right)$$

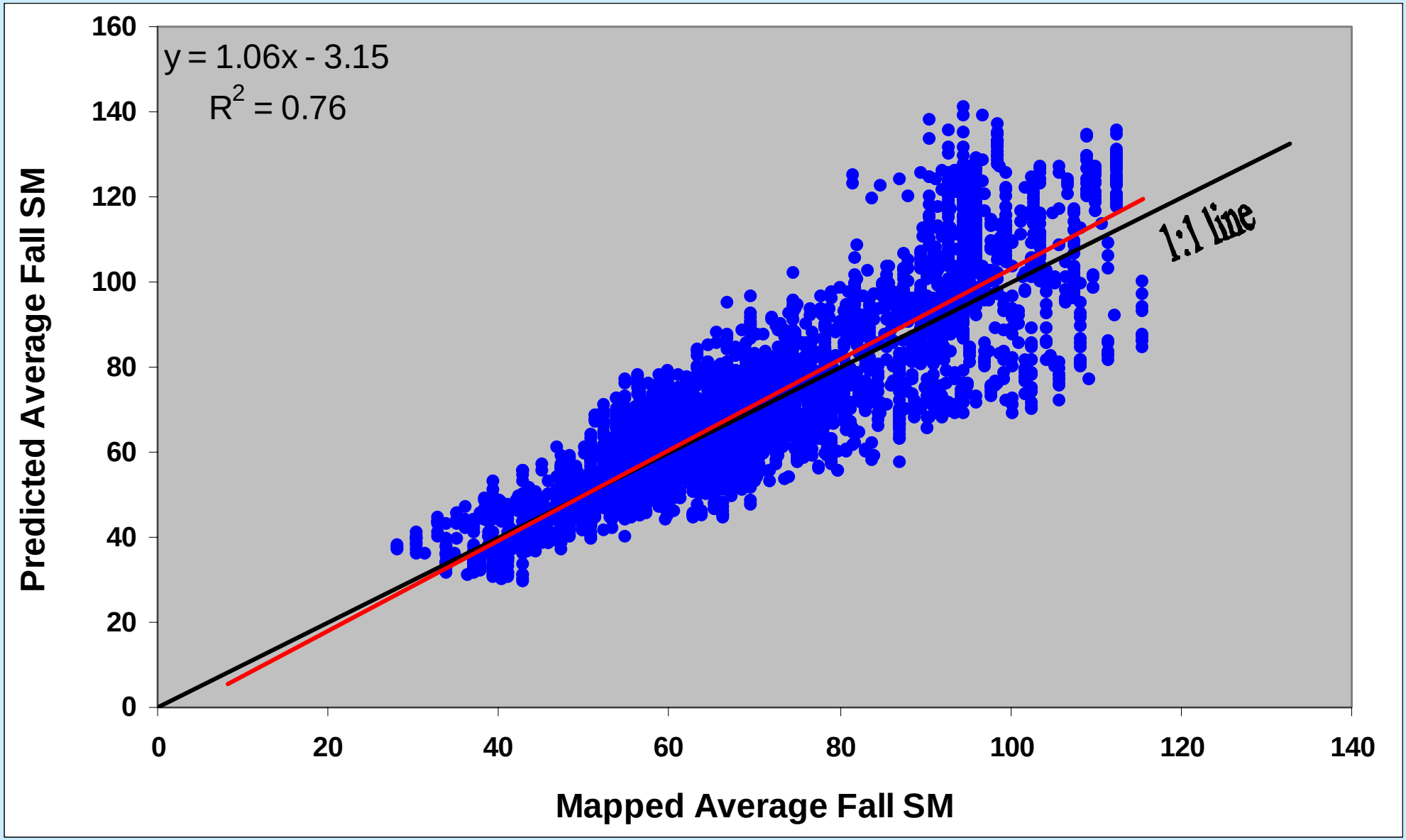
Validation and Testing

- Spring and fall soil moisture maps are produced annually, as far back as 1982

Average Spring Soil Moisture



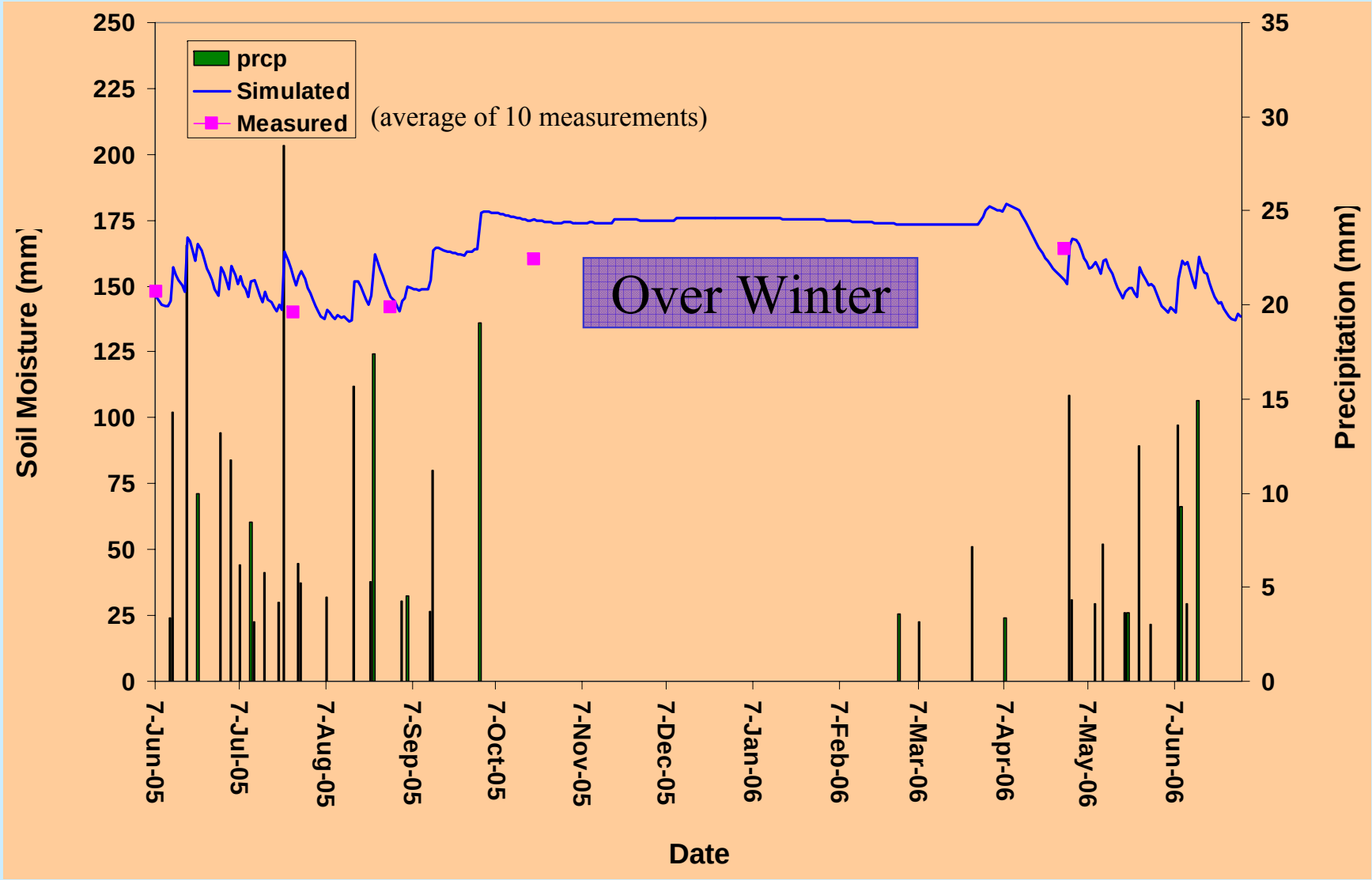
Average Fall Soil Moisture



Modeling Soil Moisture in Pasture fields

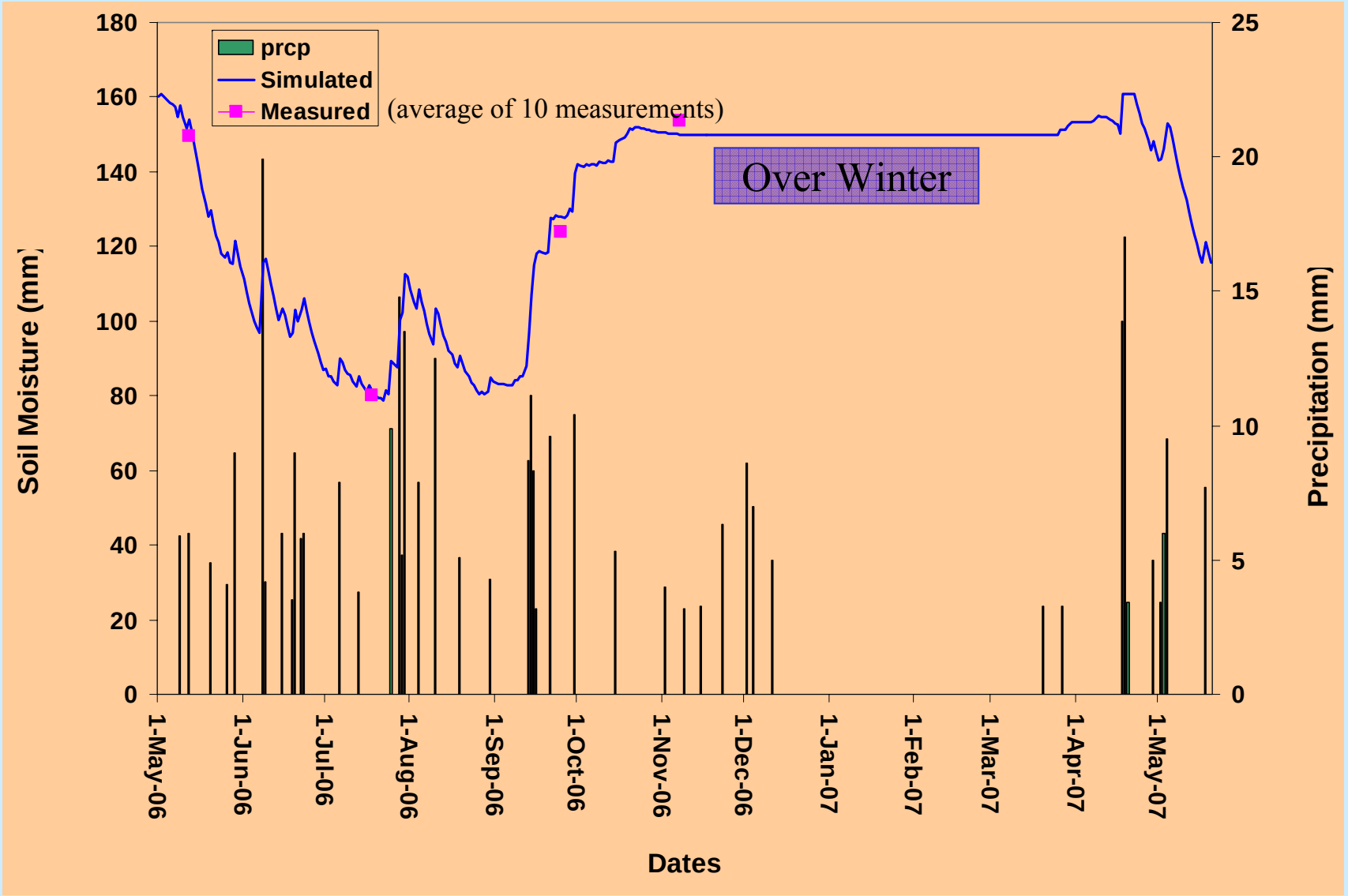
Model Validation on Pasture fields Near Two Hills

(5 km from Station)



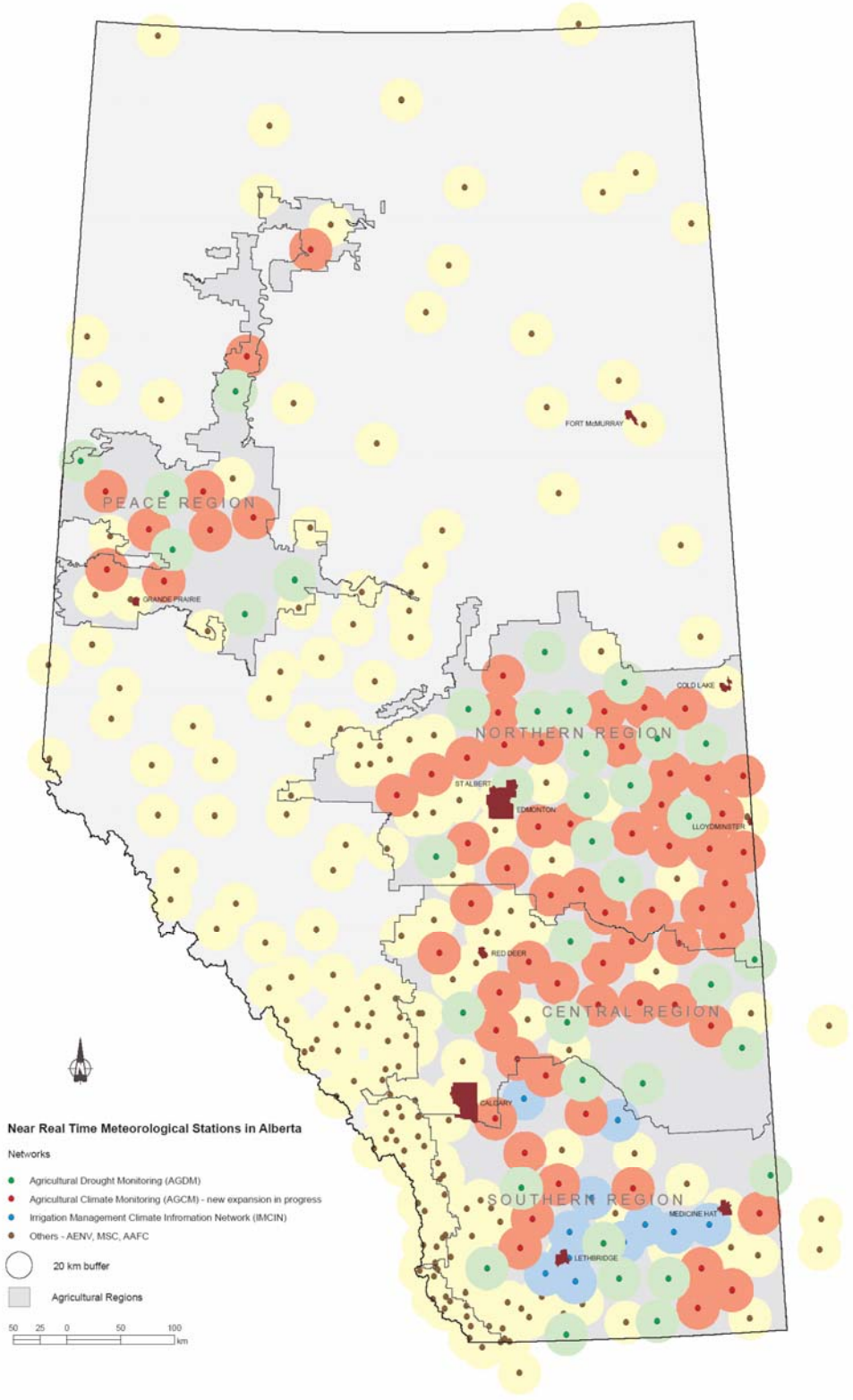
Model Validation on Pasture fields Near Killiam

At Killiam AGDM station



Model testing and validation at AGDM stations

- Weather stations are outfitted with soil moisture sensors at three depths (Theta Probe ML2X) from Delta-T Device Ltd. and temperature sensors.


PEACE REGION
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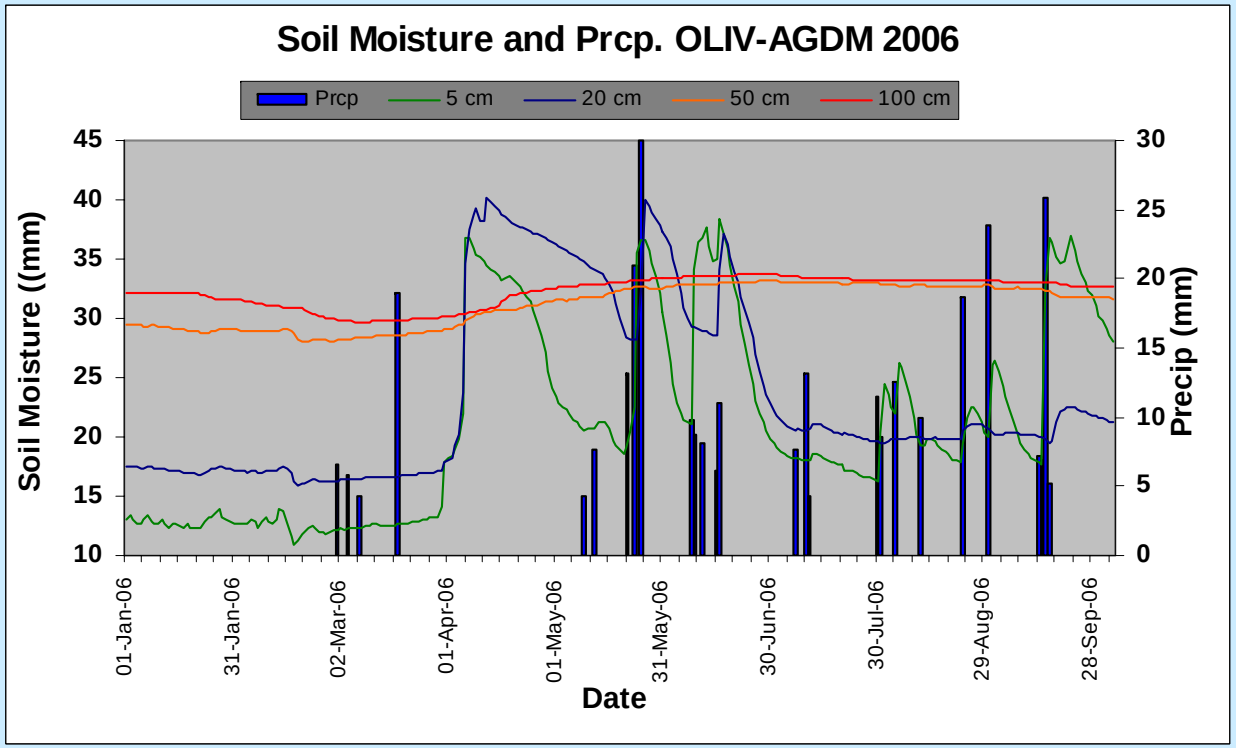
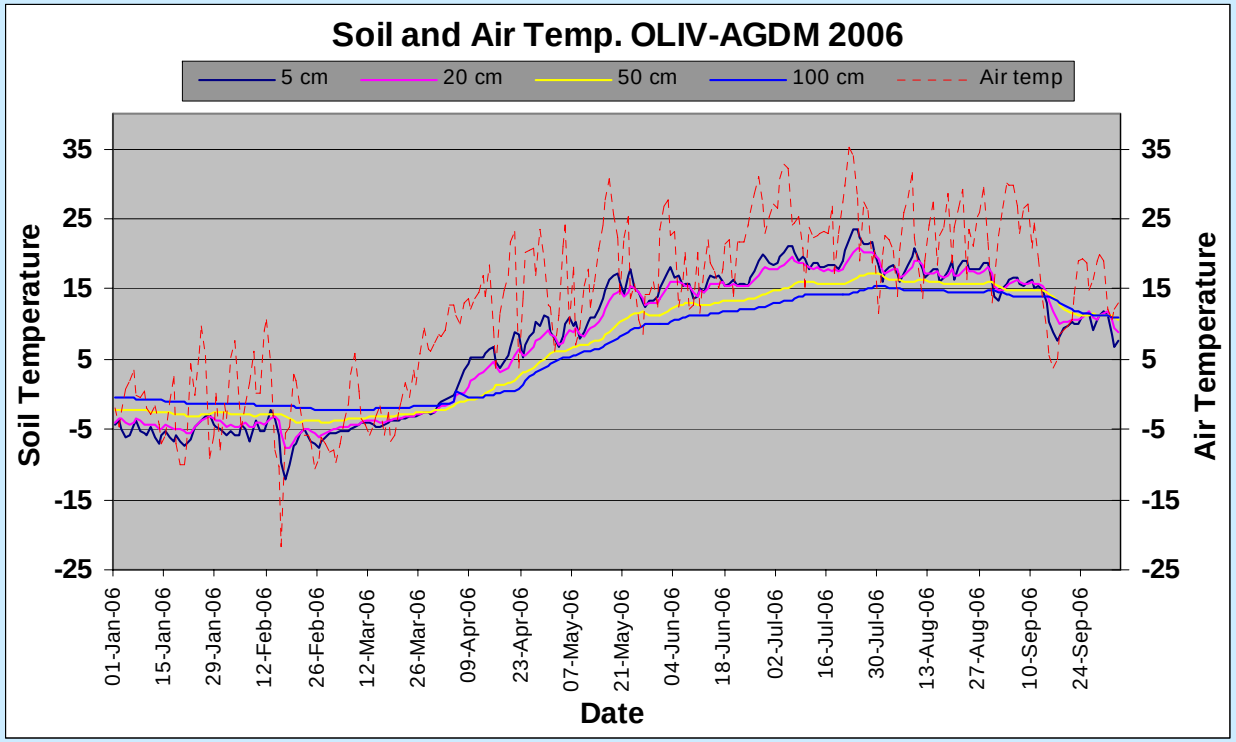
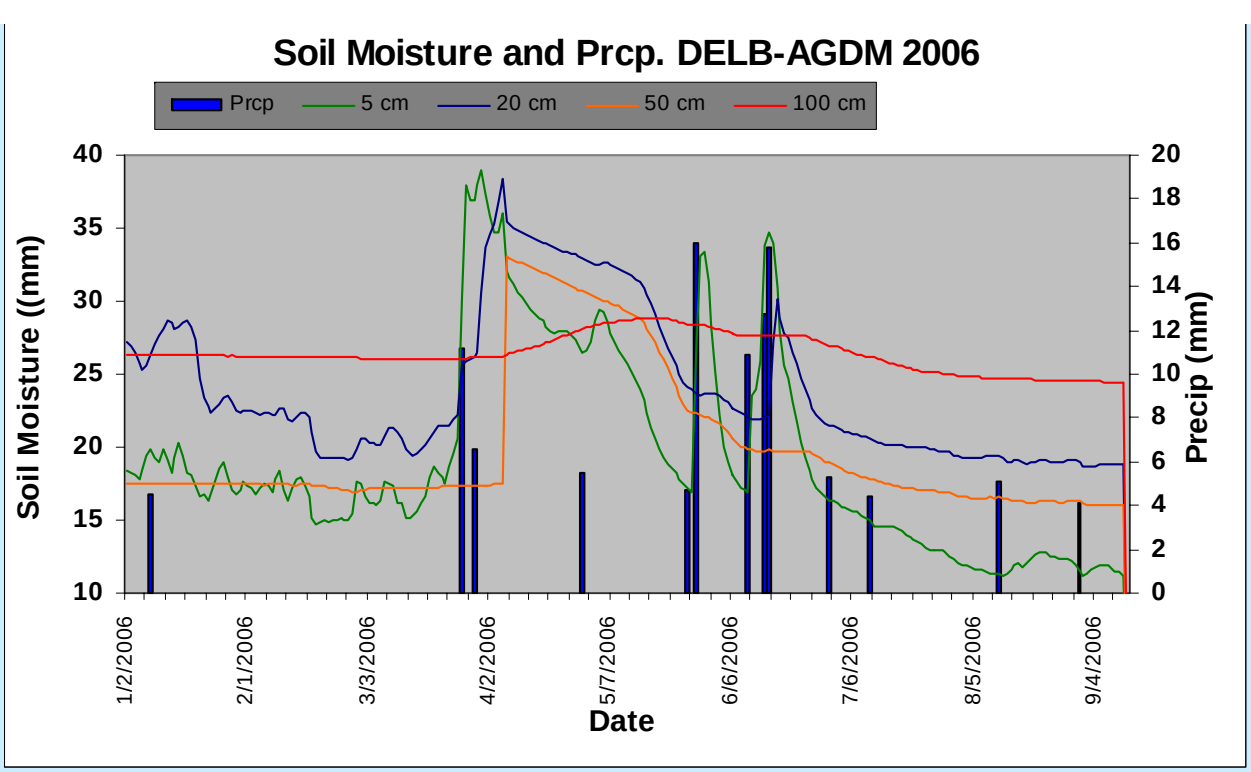
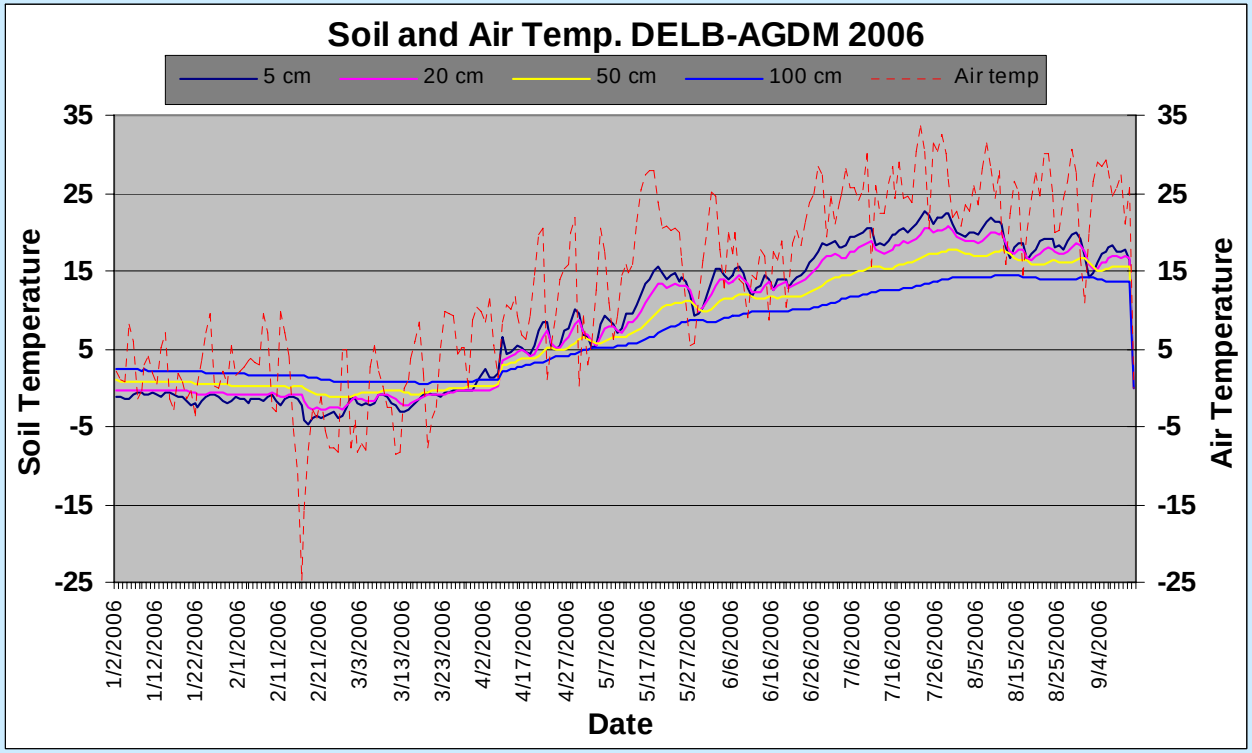
km


Soil Moisture and Prcp. OLIV-AGDM 2006
Prcp
5 cm
20 cm
50 cm
100 cm
Soil Moisture ((mm)
Precip (mm)
45
40
35
30
25
20
15
10
30
25
20
15
10
5
0
01-Jan-06
31-Jan-06
02-Mar-06
01-Apr-06
01-May-06
31-May-06
30-Jun-06
30-Jul-06
29-Aug-06
28-Sep-06
Date


Soil and Air Temp. OLIV-AGDM 2006
5 cm
20 cm
50 cm
100 cm
Air temp
Soil Temperature
Air Temperature
35
25
15
5
-5
-15
-25
01-Jan-06
15-Jan-06
29-Jan-06
12-Feb-06
26-Feb-06
12-Mar-06
26-Mar-06
09-Apr-06
23-Apr-06
07-May-06
21-May-06
04-Jun-06
18-Jun-06
02-Jul-06
16-Jul-06
30-Jul-06
13-Aug-06
27-Aug-06
10-Sep-06
24-Sep-06
Date

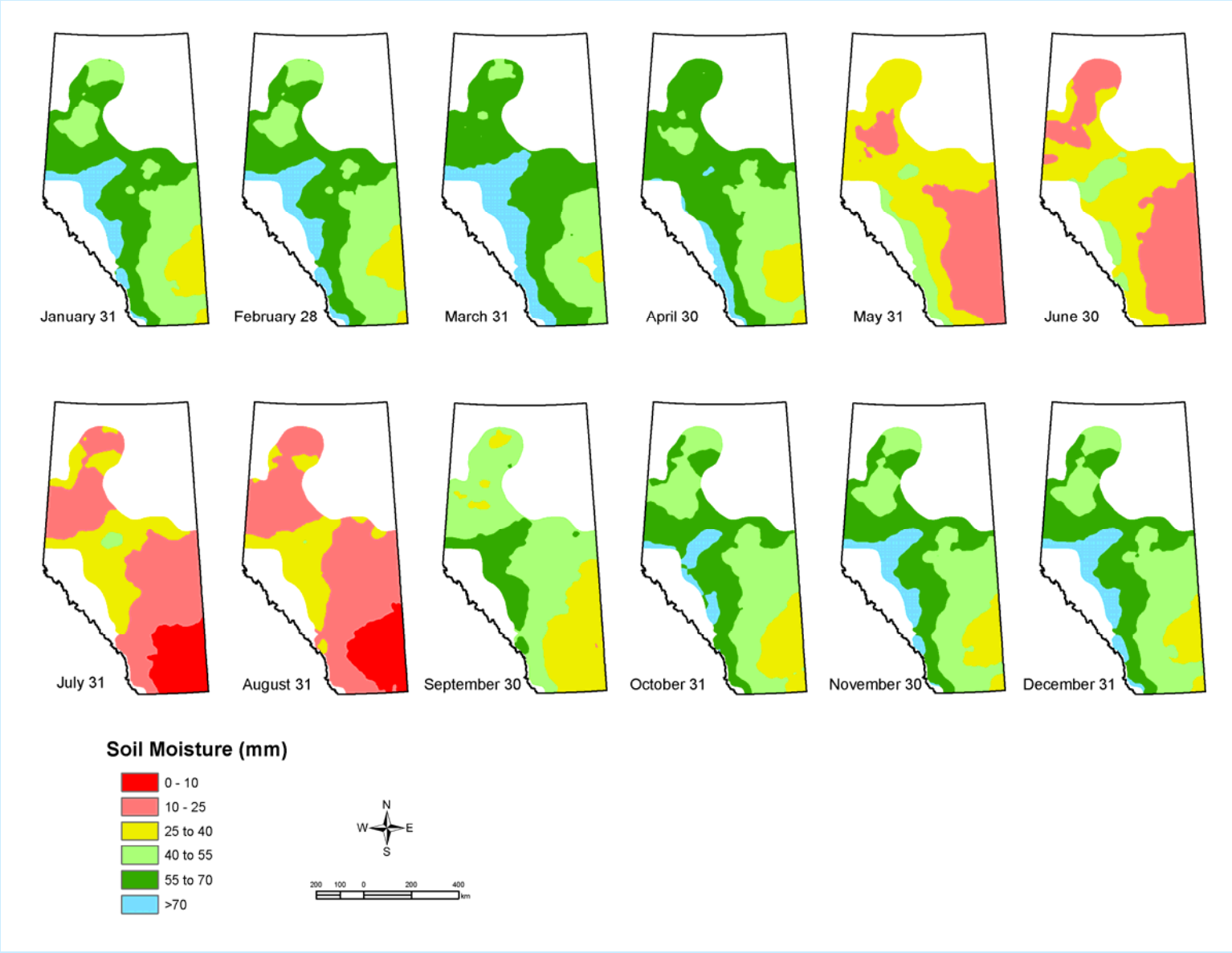

Soil Moisture and Prcp. DELB-AGDM 2006
Prcp
5 cm
20 cm
50 cm
100 cm
Soil Moisture ((mm)
Precip (mm)
Date
1/2/2006
2/1/2006
3/3/2006
4/2/2006
5/7/2006
6/6/2006
7/6/2006
8/5/2006
9/4/2006


Soil and Air Temp. DELB-AGDM 2006
5 cm
20 cm
50 cm
100 cm
Air temp
Soil Temperature
Air Temperature
Date
1/2/2006
1/12/2006
1/22/2006
2/1/2006
2/11/2006
2/21/2006
3/3/2006
3/13/2006
3/23/2006
4/2/2006
4/17/2006
4/27/2006
5/7/2006
5/17/2006
5/27/2006
6/6/2006
6/16/2006
6/26/2006
7/6/2006
7/16/2006
7/26/2006
8/5/2006
8/15/2006
8/25/2006
9/4/2006

USE of Model Soil Moisture outputs

- Regular reports and maps to ADRMC and briefings to policy makers.
- Regular crop reports.
- ACIS web sites (maps). http://www1.agric.gov.ab.ca/
- AFSC moisture deficiency insurance program
- Requests from
  - Consulting Companies
  - farmers

Average Pasture Soil Moisture as Plant Available Water to 60 cm Depth



Thank You!

Questions?