Assessment of CALMET Performance Using In-Situ Data in a Complex Meteorological Environment

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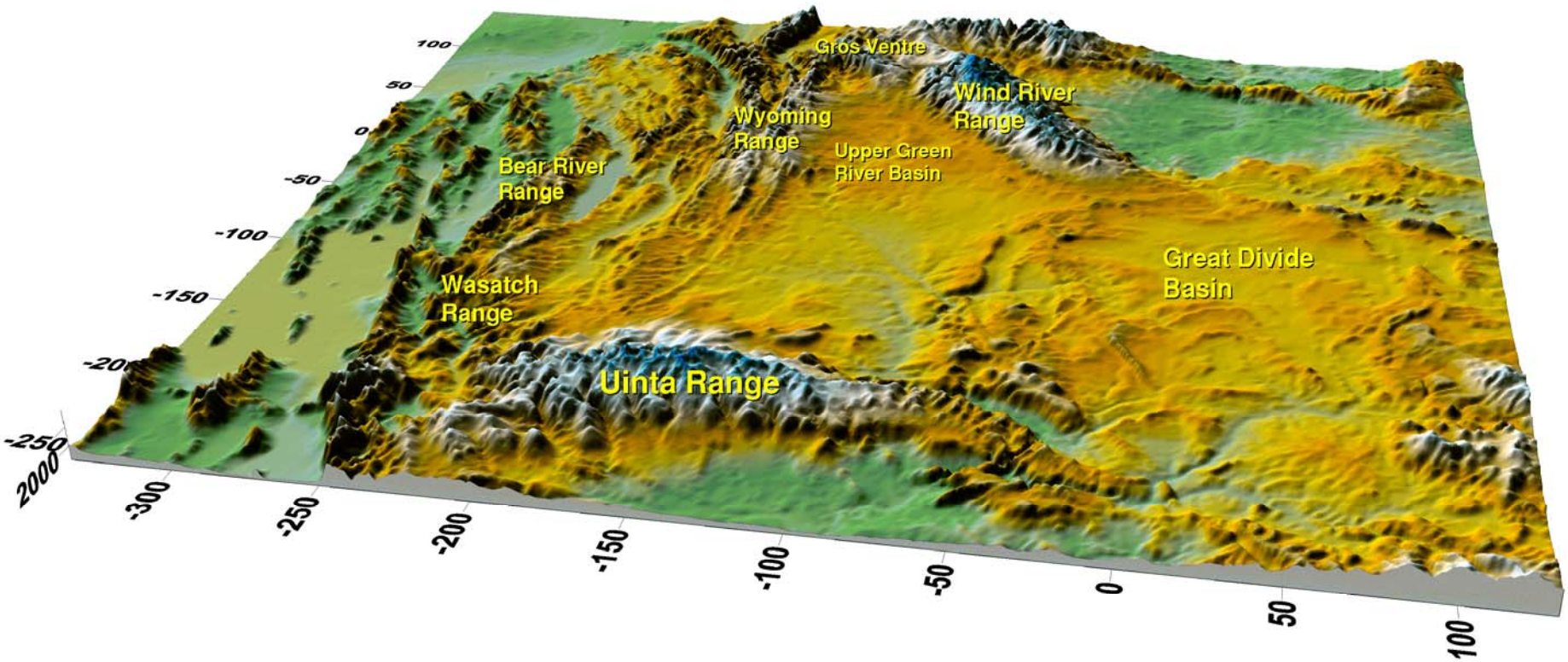
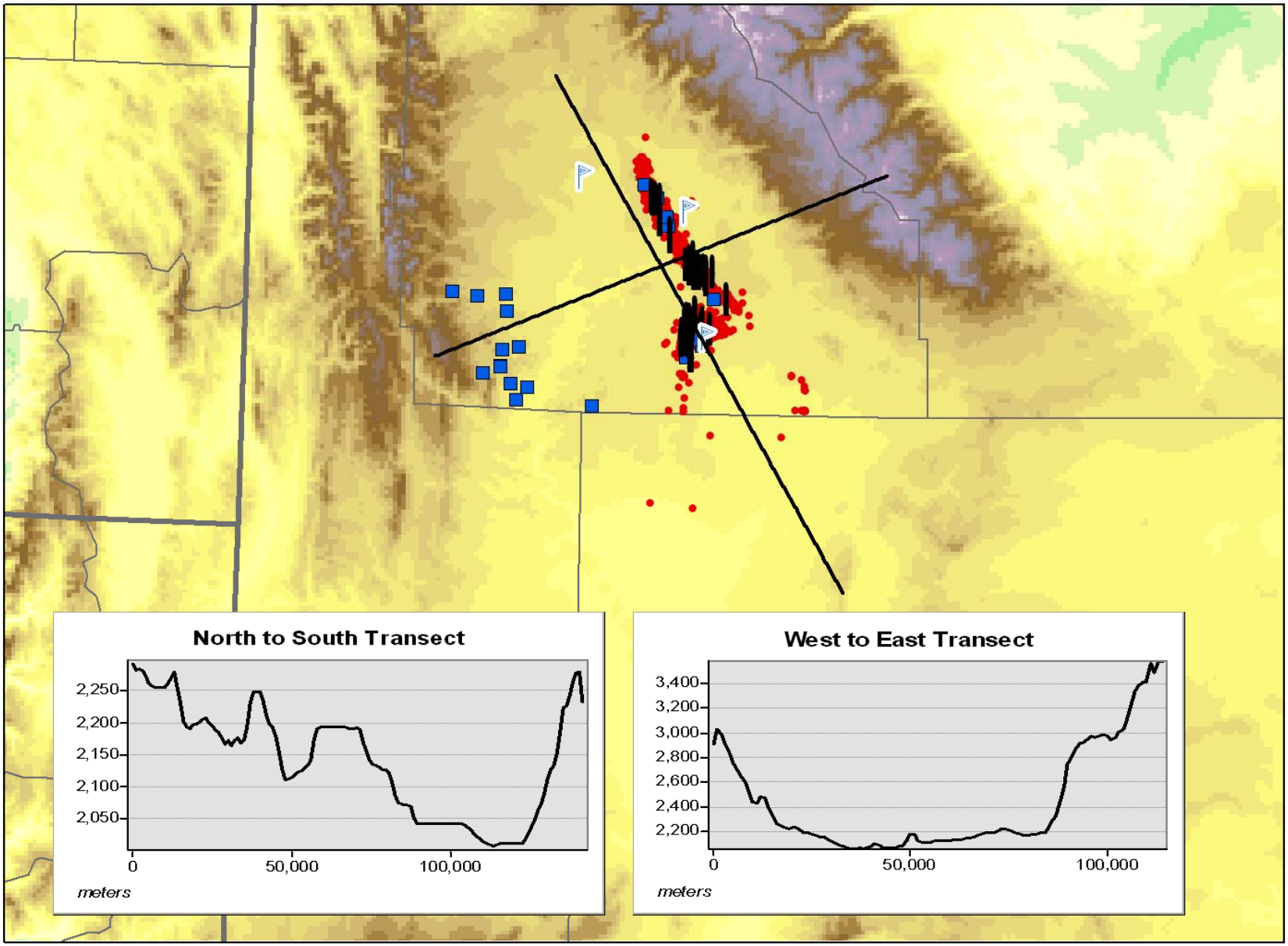
Background

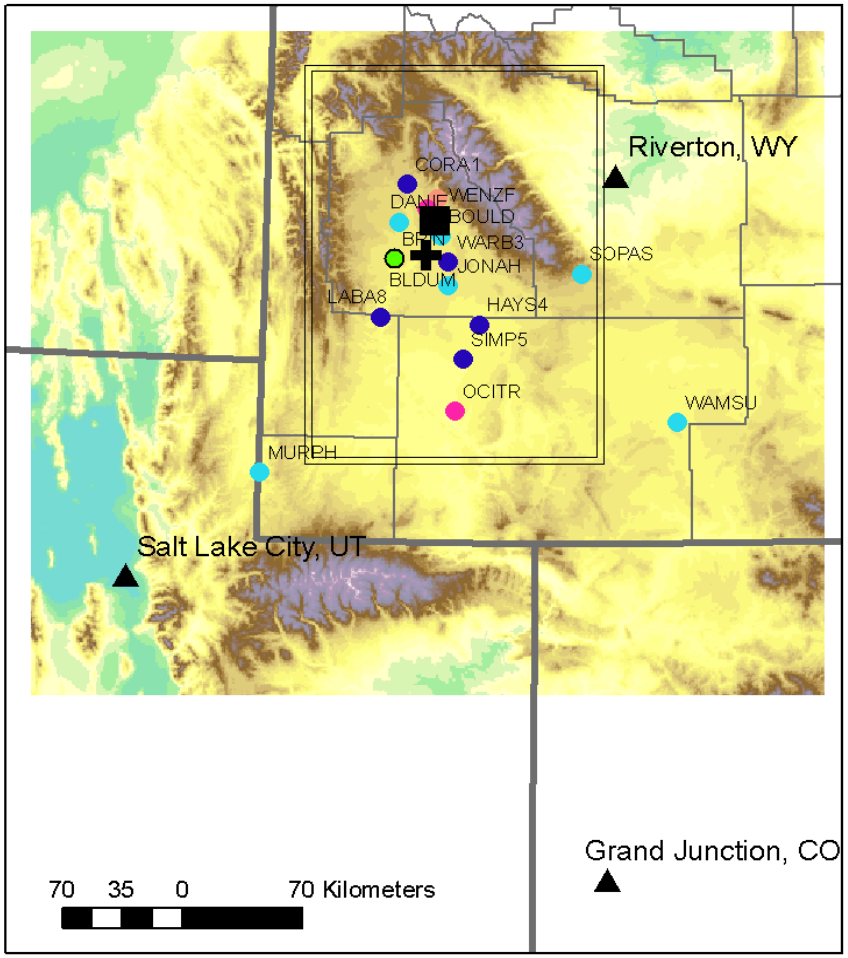
- State of Wyoming performed field studies in 2008 to assess high winter ozone in Sublette Co.
  - (Upper Green River Basin)
- Winter ozone depends on certain physical parameters:
  - High pressure system (clear skies, low winds)
  - Snow cover (stabilizes atmosphere, increases photolysis)
  - Low mixing heights
- Combined with:
  - Continuous NOx and VOC sources
  - Complex terrain (recirculation and blocking)
- Leads to winter ozone

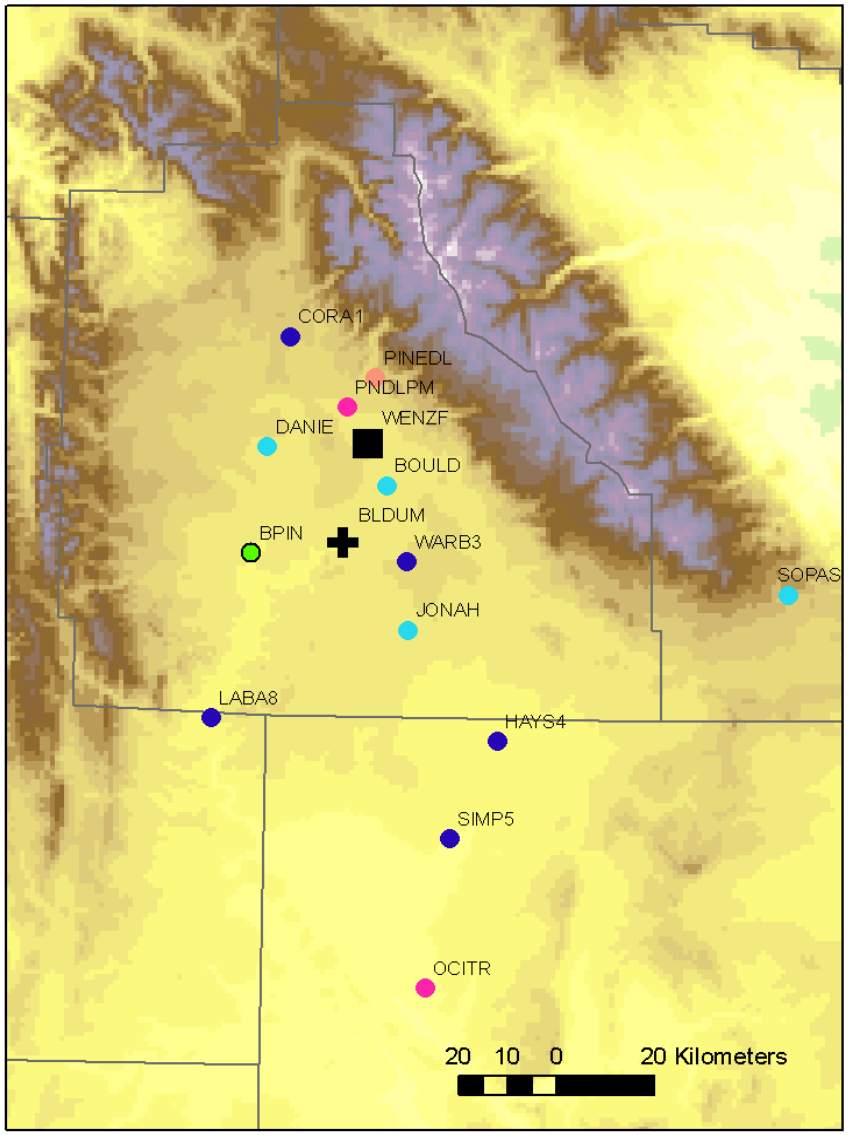

Gros Ventre
Wind River Range
Wyoming Range
Upper Green River Basin
Bear River Range
Great Divide Basin
Wasatch Range
Uinta Range
100
50
0
-50
-100
-150
-250
2000
-300
-250
-200
-150
-100
-50
0
50
100


North to South Transect
2,250
2,200
2,150
2,100
2,050
0
50,000
100,000
meters
West to East Transect
3,400
3,200
3,000
2,800
2,600
2,400
2,200
0
50,000
100,000
meters

CALMET (v5.8) Phase I Inputs

- 1 km horizontal resolution
- nx = 464, ny = 400, nz = 14
- 20 km RUC hourly analysis fields (not forecast fields)
- SODAR (up to 250 m) + RUC data = UP1.DAT
- Up to 4x daily sonde releases = UP2.DAT
- Mesonet provides surface coverage (19 sites) = SURF.DAT





Legend

- CASTNET
- MESONET
- SRF MET/AQ
- SUPPLEMENTAL
- NWS SRF MET
- SODAR/SRF MET
- SONDE/SRF MET AQ
- NWS UPPER AIR

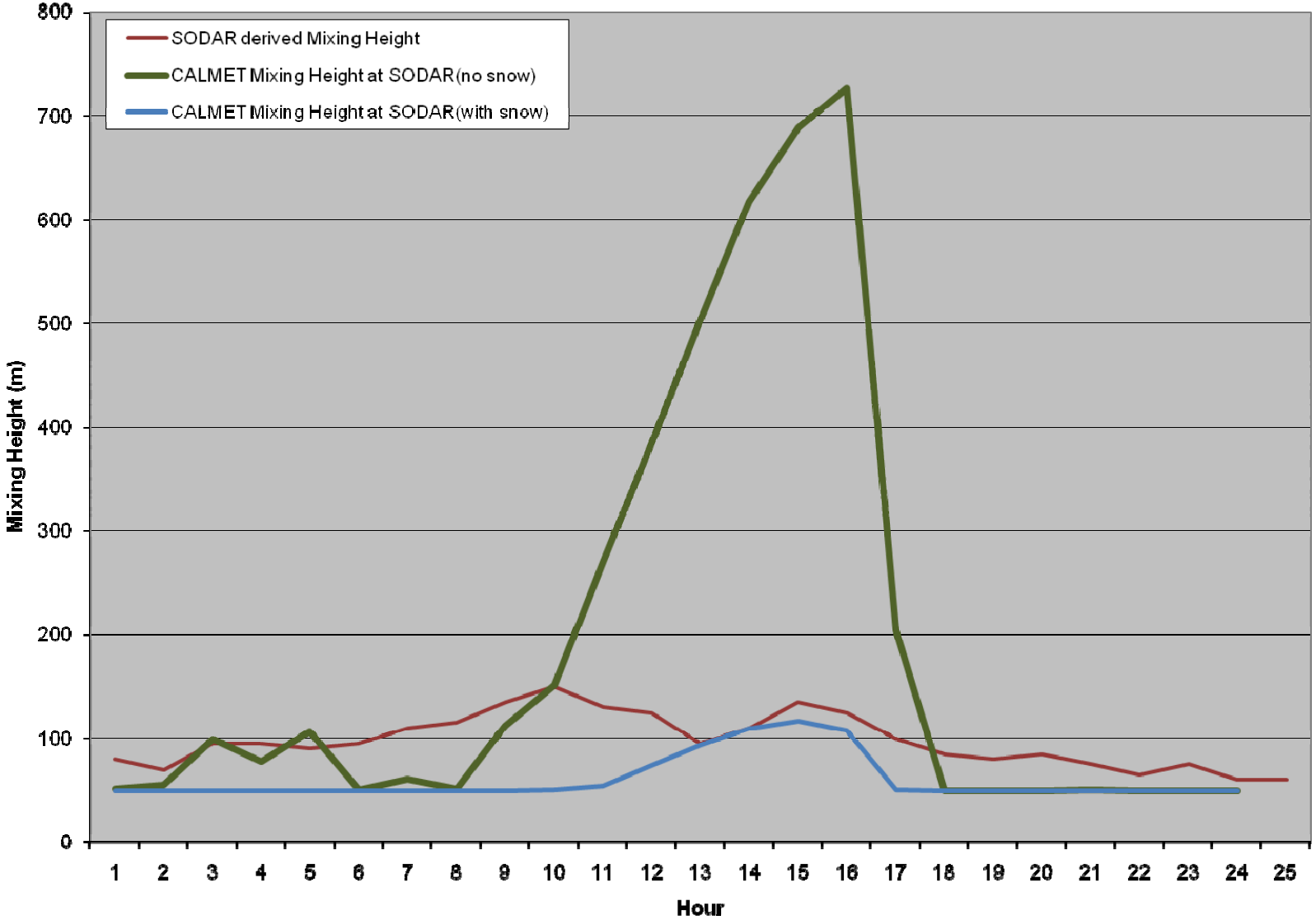
More CALMET Input

- Run with MREG=1 and user-defined settings:
  - TERRAD = 15 km
  - R1,R2 = 4 km
  - RMAX1,RMAX2 = 20 km

  Based on domain and input data characteristics
- Default settings except for:
  - ITPROG = 2
  - MNMDAV = 5 grid cells

    Based on sensitivity and verification analyses
    - MNMDAV smooths mixing height field
- Not all collected data used as input:
  - Sonde releases (temperature) and estimated mixing heights used for validation

February 20, 2008

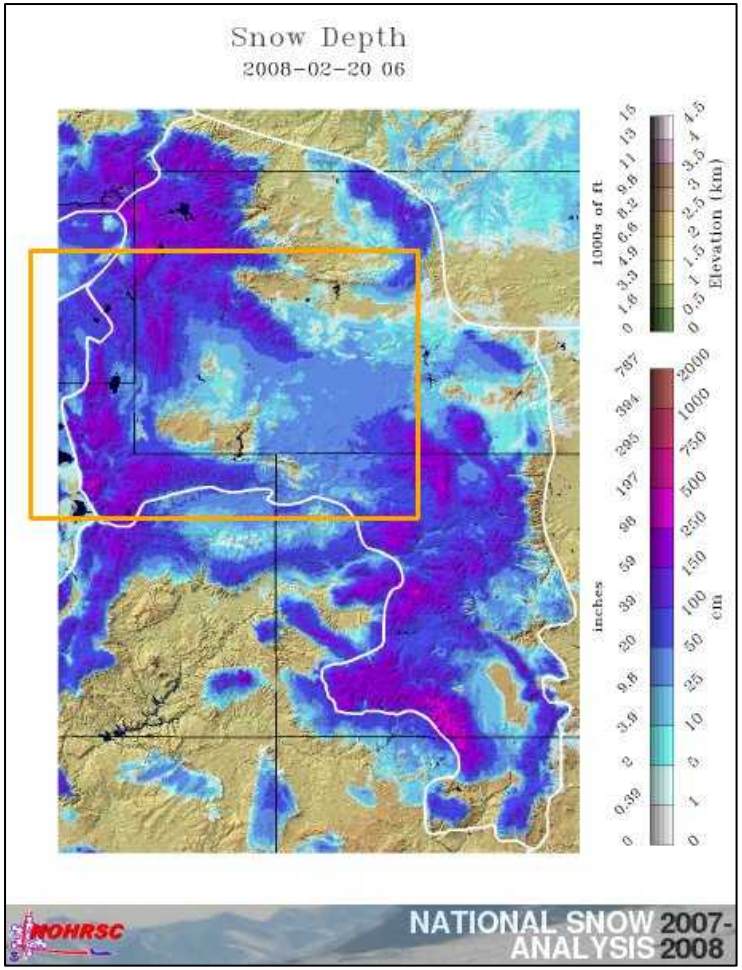


TRC

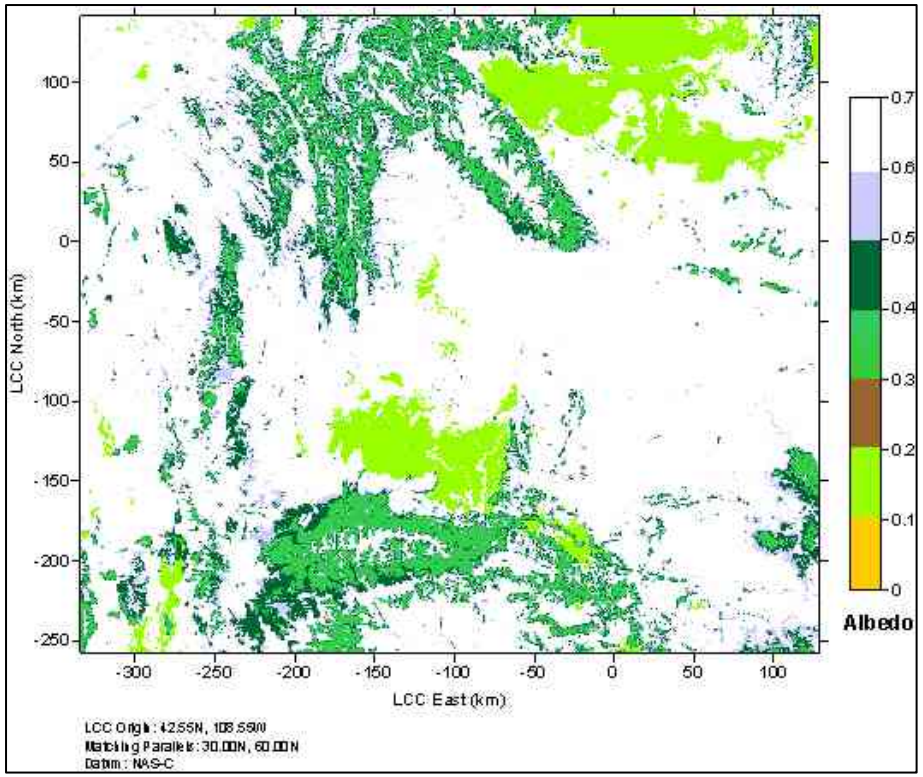
GEO.DAT Enhancement

- Based on above, snow is a proven critical component to boundary layer energy budget in CALMET
- Downloaded daily 1 km gridded snow cover data (from National Operational Hydrologic Remote Sensing Center)
- If grid cell covered > 50% with snow
  - (α, B_0,z_0) modified to AERMET winter values (for the dominant land use category)
  - else modify to AERMET late fall values (for the dominant land use category)
- Result is a GEO.DAT file for each day to reflect that day's snow cover

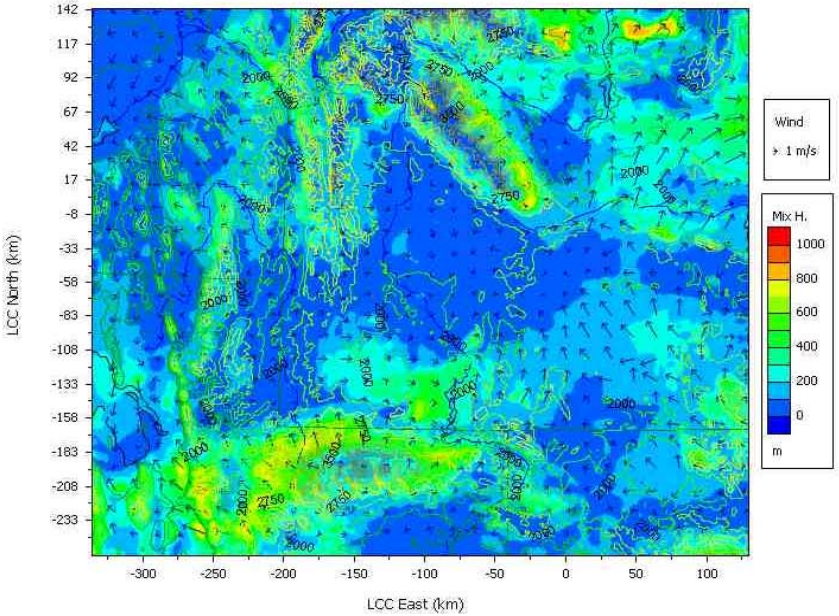
Measured Snow Depth
February 20, 2008



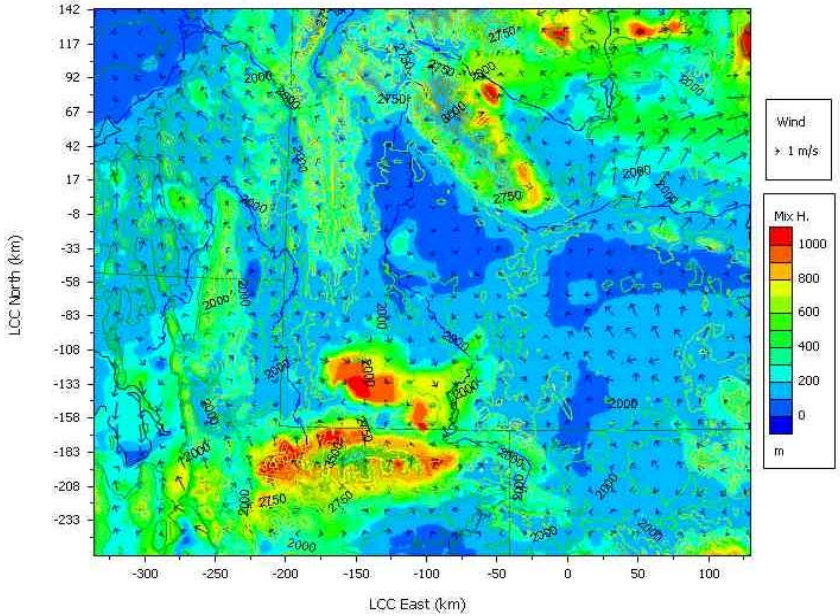
Corresponding CALMET
Albedo with Snow



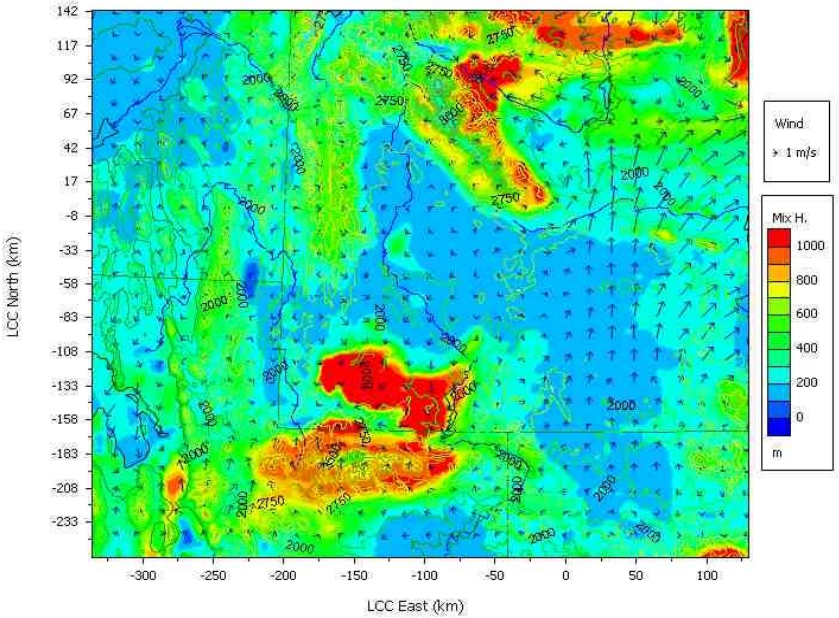
Feb 20, 2008 10:00 MST



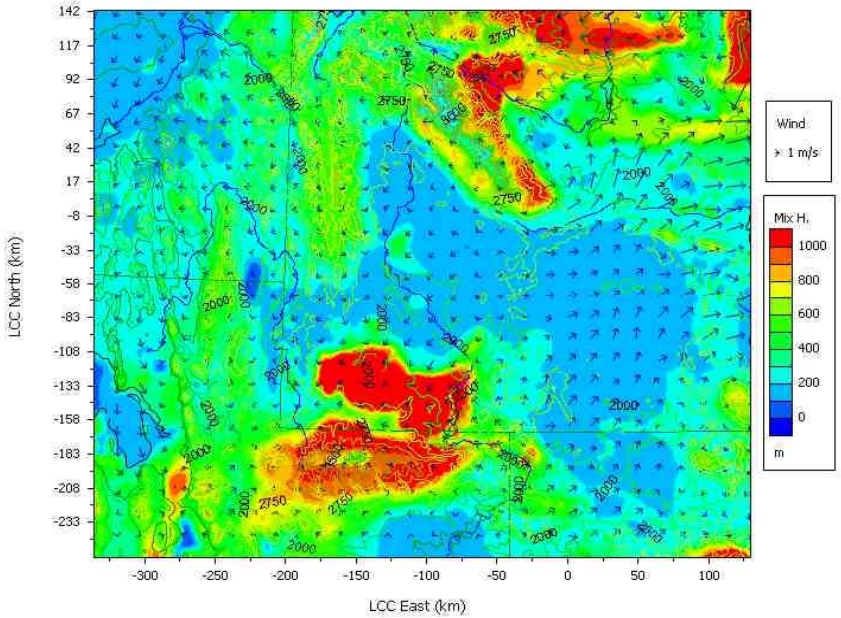
Feb 20, 2008 12:00 MST

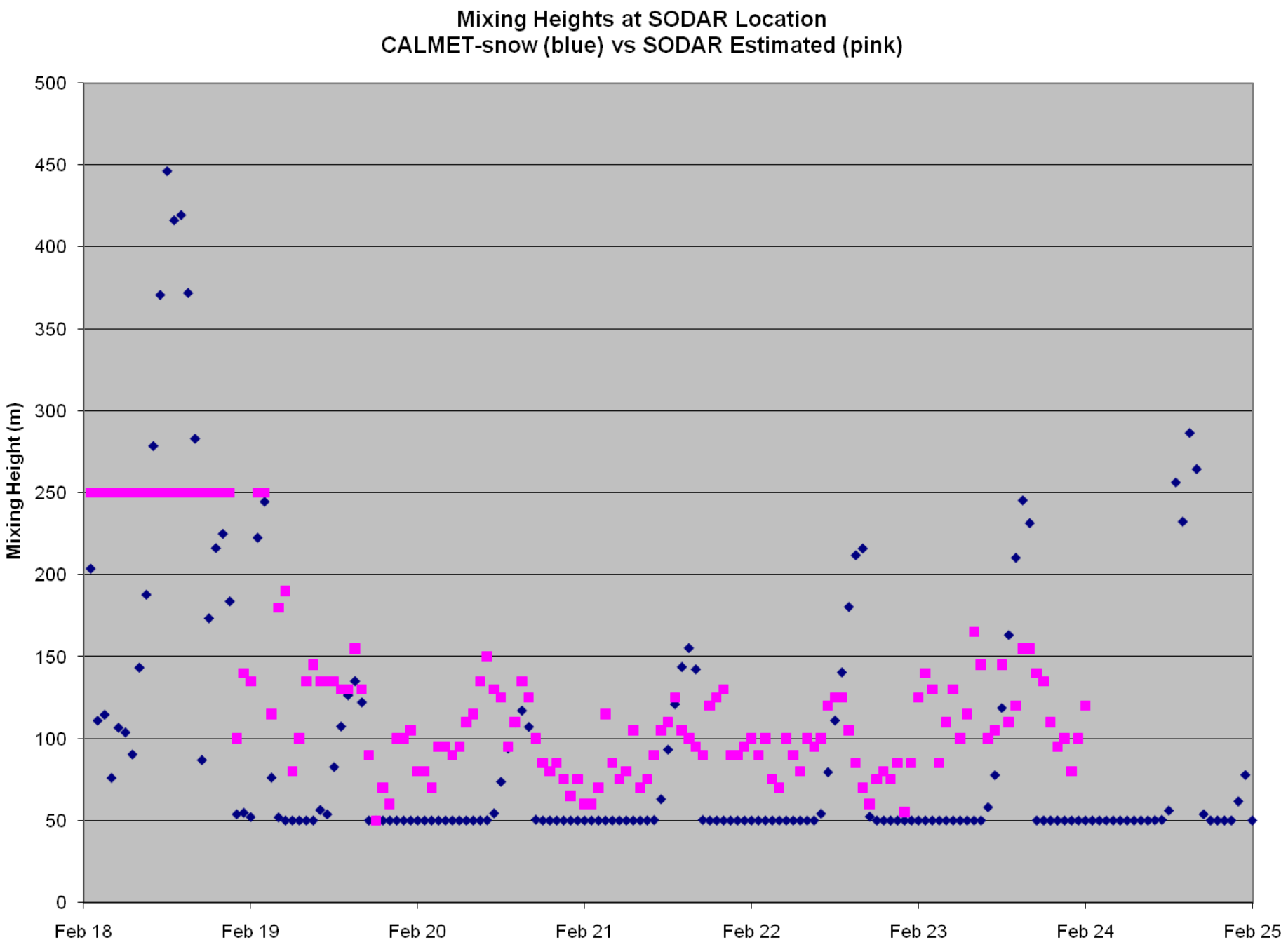


Feb 20, 2008 14:00 MST



Feb 20, 2008 16:00 MST

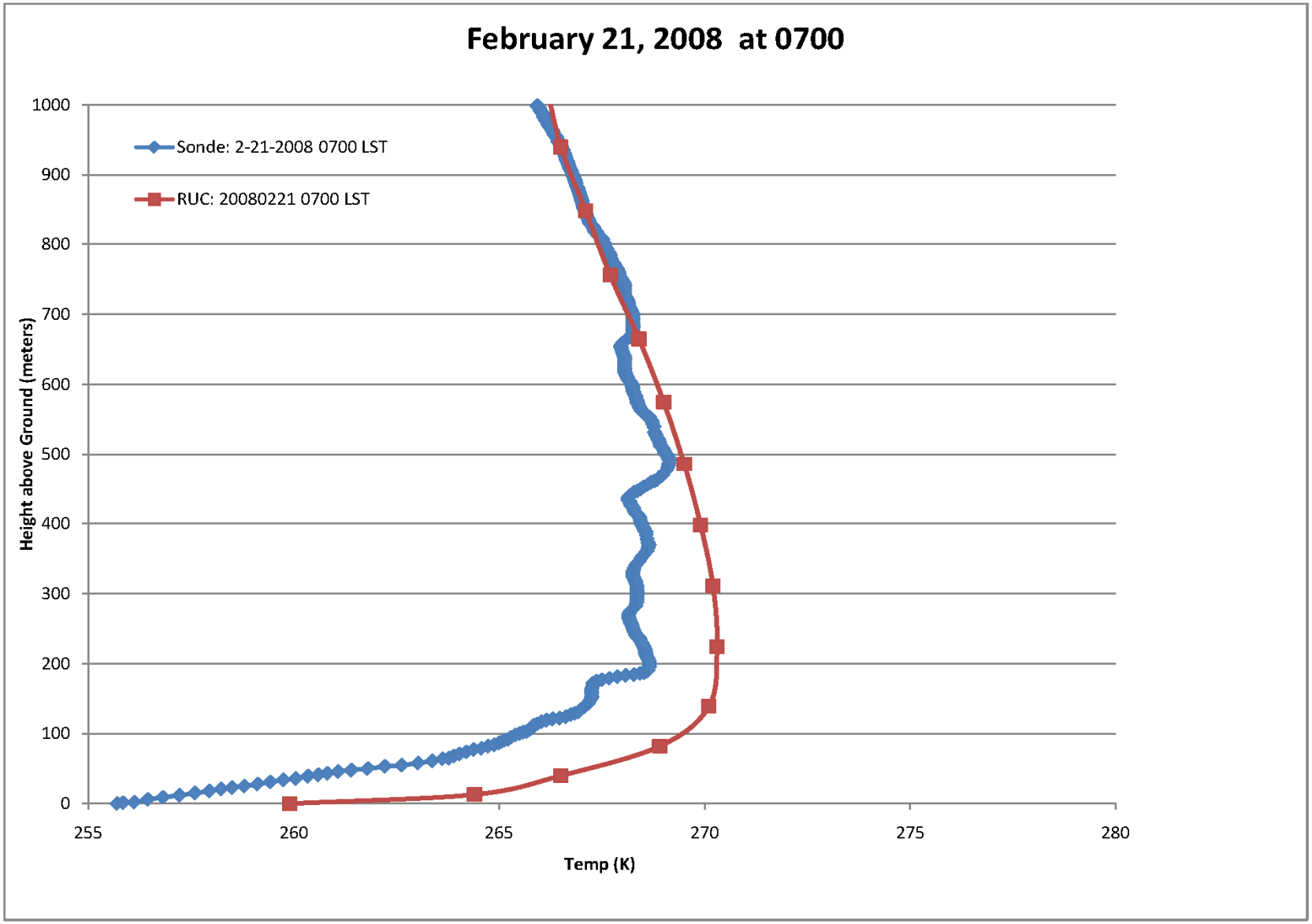


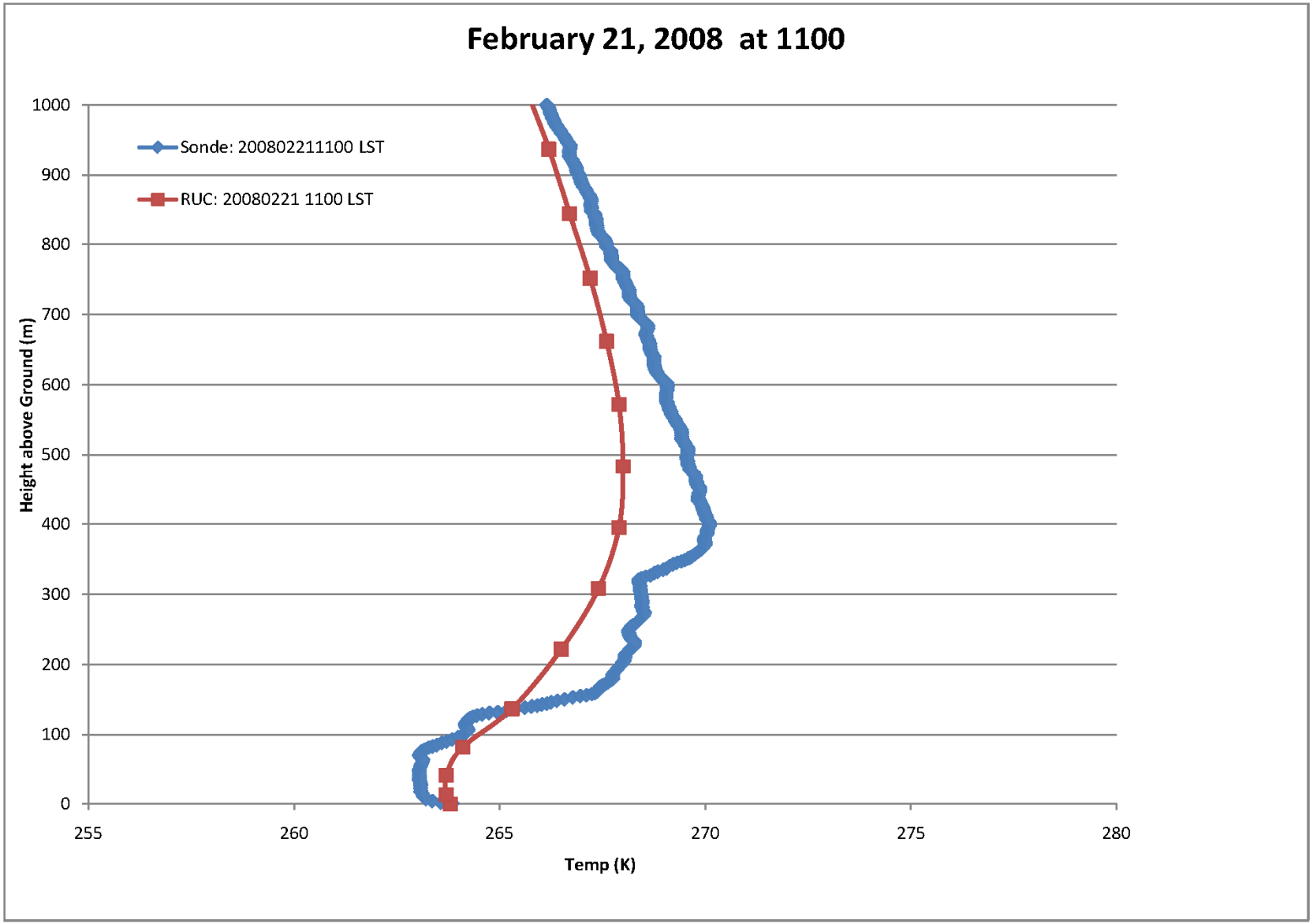

Mixing Heights at SODAR Location
CALMET-snow (blue) vs SODAR Estimated (pink)
Mixing Height (m)
500
450
400
350
300
250
200
150
100
50
0
Feb 18
Feb 19
Feb 20
Feb 21
Feb 22
Feb 23
Feb 24
Feb 25

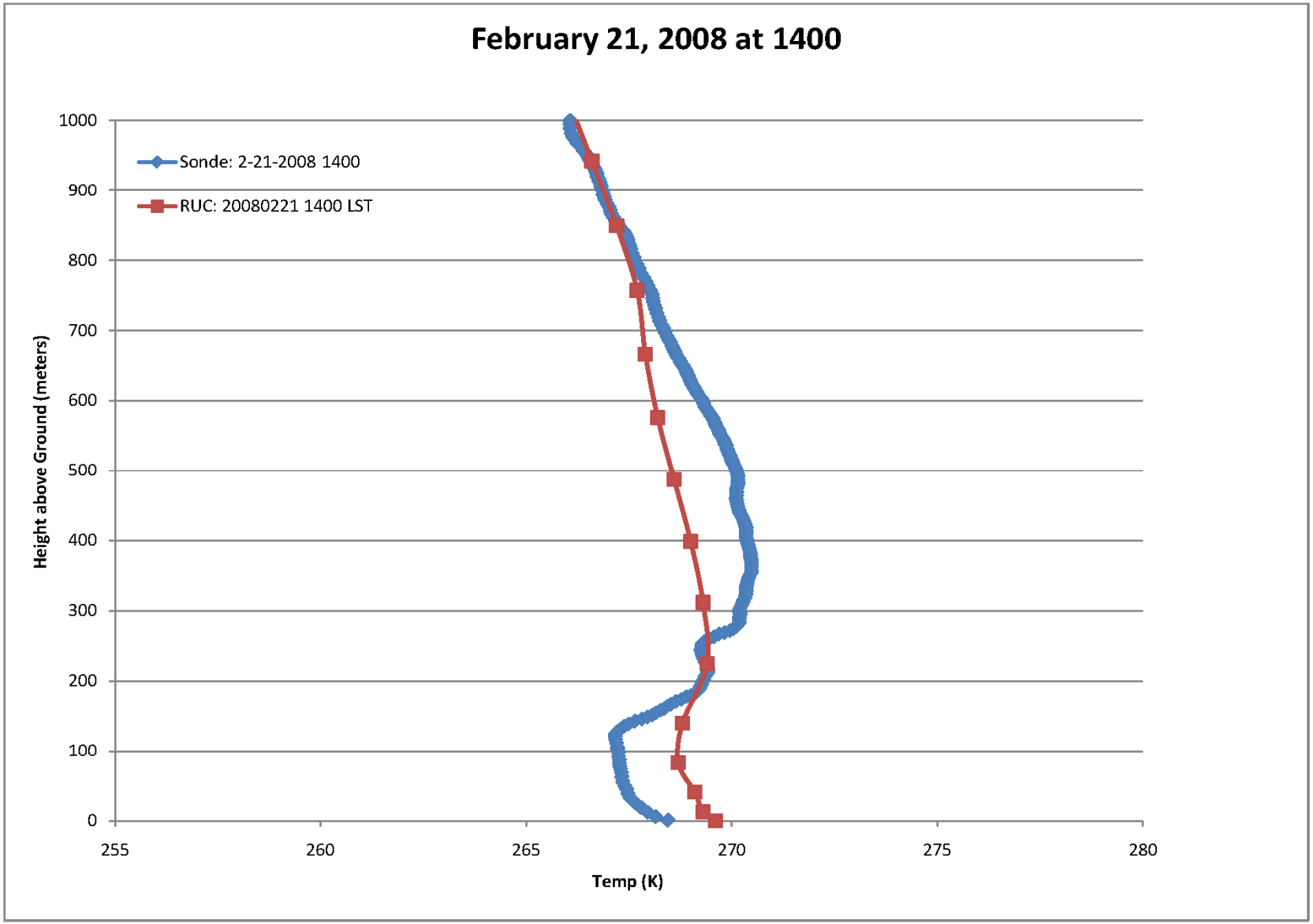
Validations con't

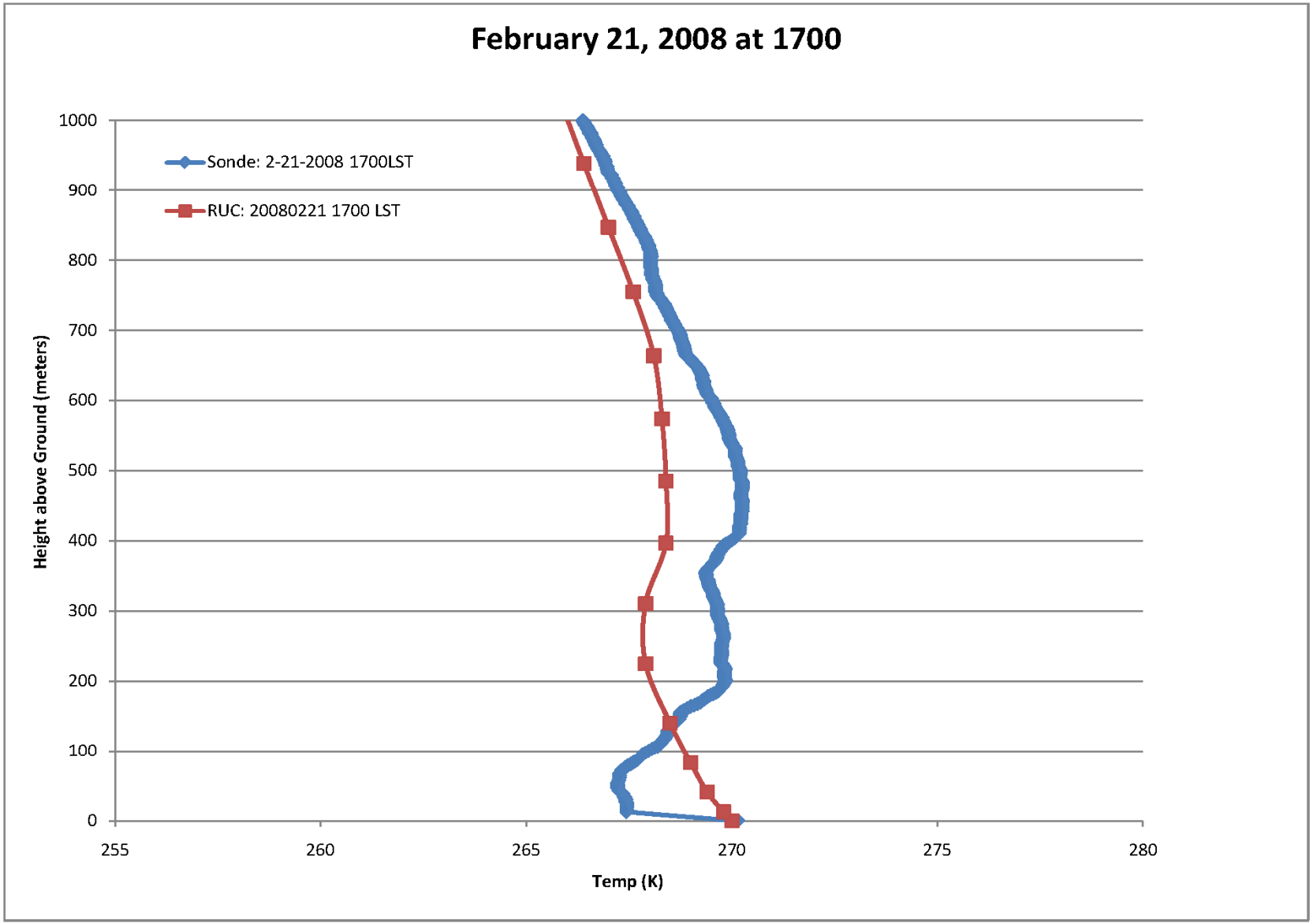
- Explicit snow cover provides CALMET a more complete energy budget
- More confidence in Basin-wide mixing height field

- Now, look at vertical temperature from sonde
  - Used through the ITPROG setting
  - ITPROG =0 uses UP.DAT data
  - ITPROG=2 uses hourly prognostic profiles (gridded)
- Compared sonde vs. RUC temperature profile


February 21, 2008 at 0700
Sonde: 2-21-2008 0700 LST
RUC: 20080221 0700 LST
Height above Ground (meters)
1000
900
800
700
600
500
400
300
200
100
0
255
260
265
270
275
280
Temp (K)


February 21, 2008 at 1100
Sonde: 200802211100 LST
RUC: 20080221 1100 LST
Height above Ground (m)
1000
900
800
700
600
500
400
300
200
100
0
255
260
265
270
275
280
Temp (K)


February 21, 2008 at 1400
Sonde: 2-21-2008 1400
RUC: 20080221 1400 LST
Height above Ground (meters)
1000
900
800
700
600
500
400
300
200
100
0
255
260
265
270
275
280
Temp (K)


February 21, 2008 at 1700
Sonde: 2-21-2008 1700LST
RUC: 20080221 1700 LST
Height above Ground (meters)
1000
900
800
700
600
500
400
300
200
100
0
255
260
265
270
275
280
Temp (K)

Validations con't

- Comparisons conducted for all soundings during the week with similar results
- Based on above, recommend using ITPROG =2 for this analysis
  - RUC data provides better spatial (20 km) and temporal (hourly) resolution than quasi-periodic sonde or widely spaced, 2x daily NWS data
  - Good, representative vertical temperature data increases confidence in CALMET stability and kinematic effects domain-wide

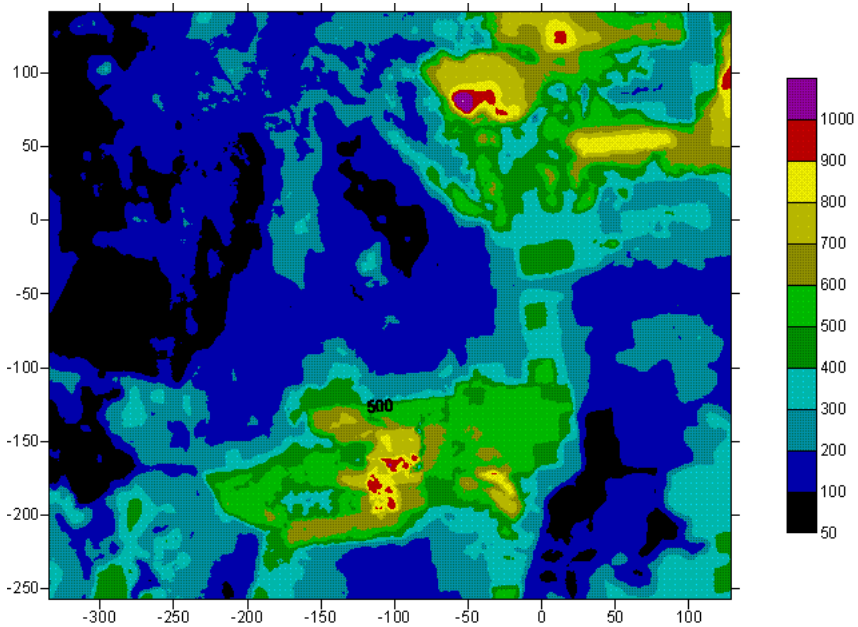
Additional Studies

- Common comments:
  - **Domain-scale versus local scale lapse rates…**
  - **Diagnostic models are not constrained by physics like prognostic models…**

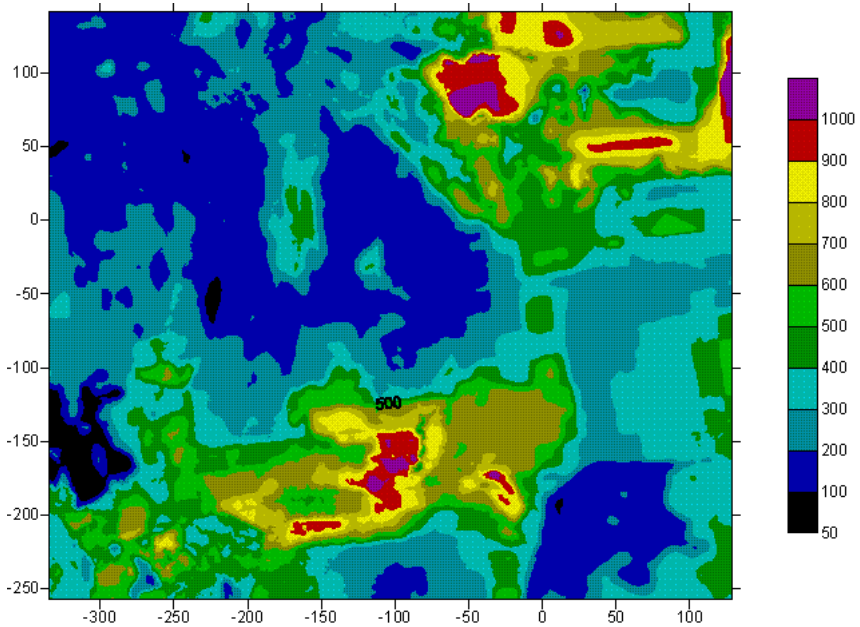
- The use of local scale lapse rates has been the recommended default in CALMET version 6, option had to be removed in version 5.8
  - Version 6 generally produces higher values, less of a difference within the Basin

February 21, 2008 noon mixing heights

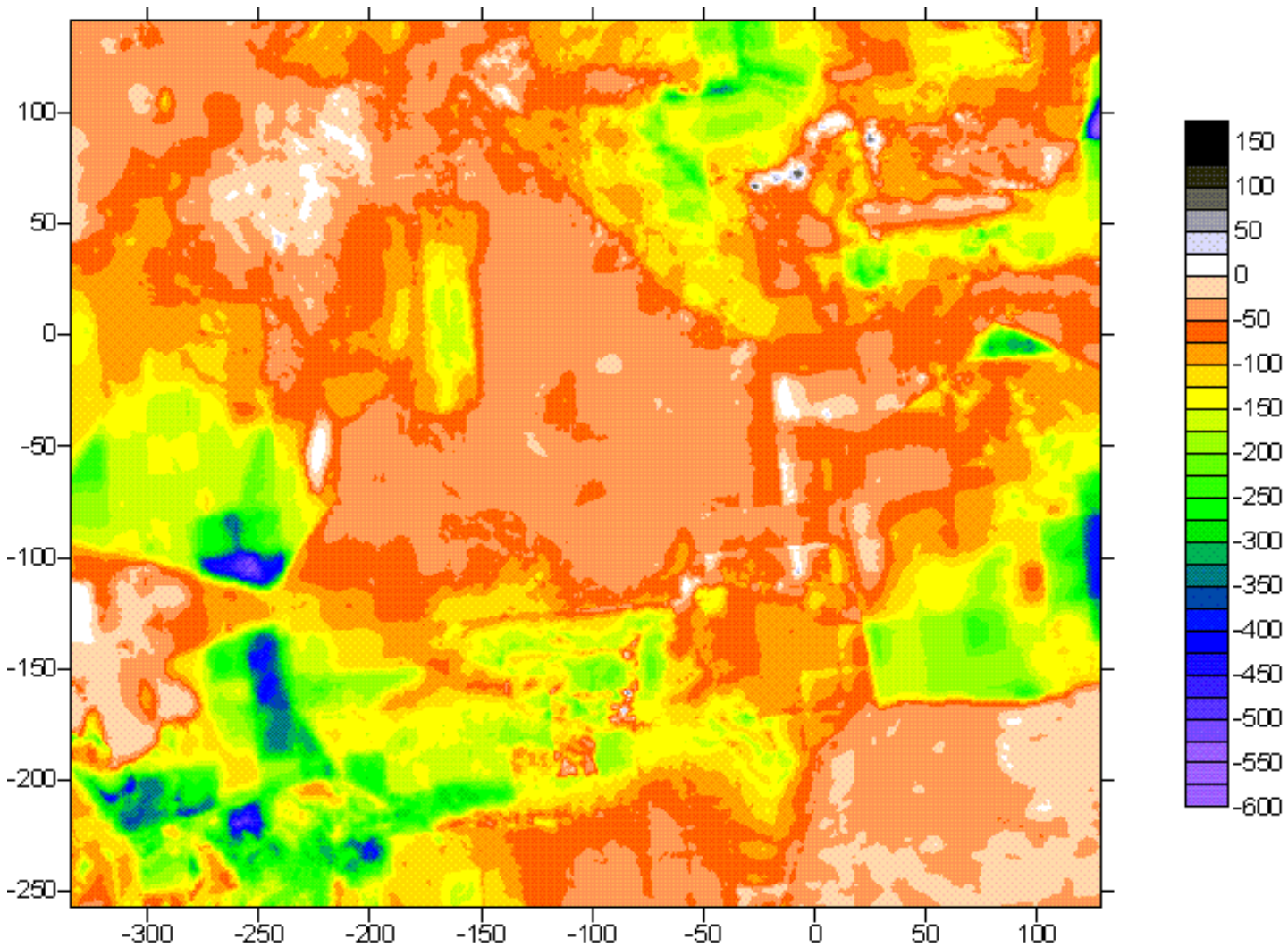
Version 5.8



Version 6



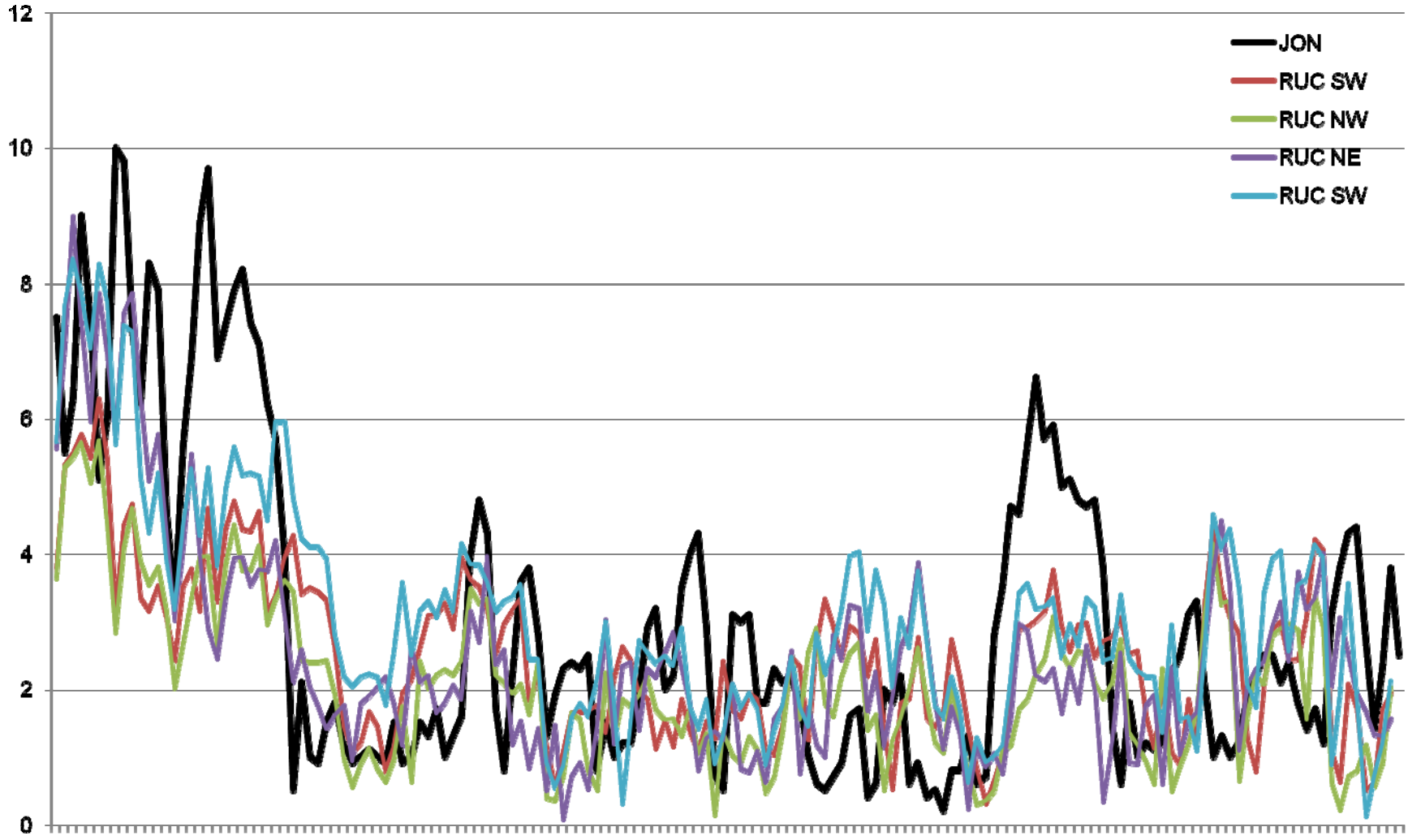
February 21, 2008 noon mixing heights (version 5.8 – version 6)



Additional Studies con't

- **Diagnostic models are not constrained by physics…**
  - CALMET ran with prognostic model output (RUC) + observations (carefully added)
  - Coarser scale models cannot always capture local scale, low wind speed, stable conditions properly
  - The UGWOS database provides high resolution observations, which are necessary for this analysis

Jonah and RUC Ground Level Wind Speed (Feb. 18-24)



Jonah and RUC Ground Level Wind Direction (Feb. 18-24)

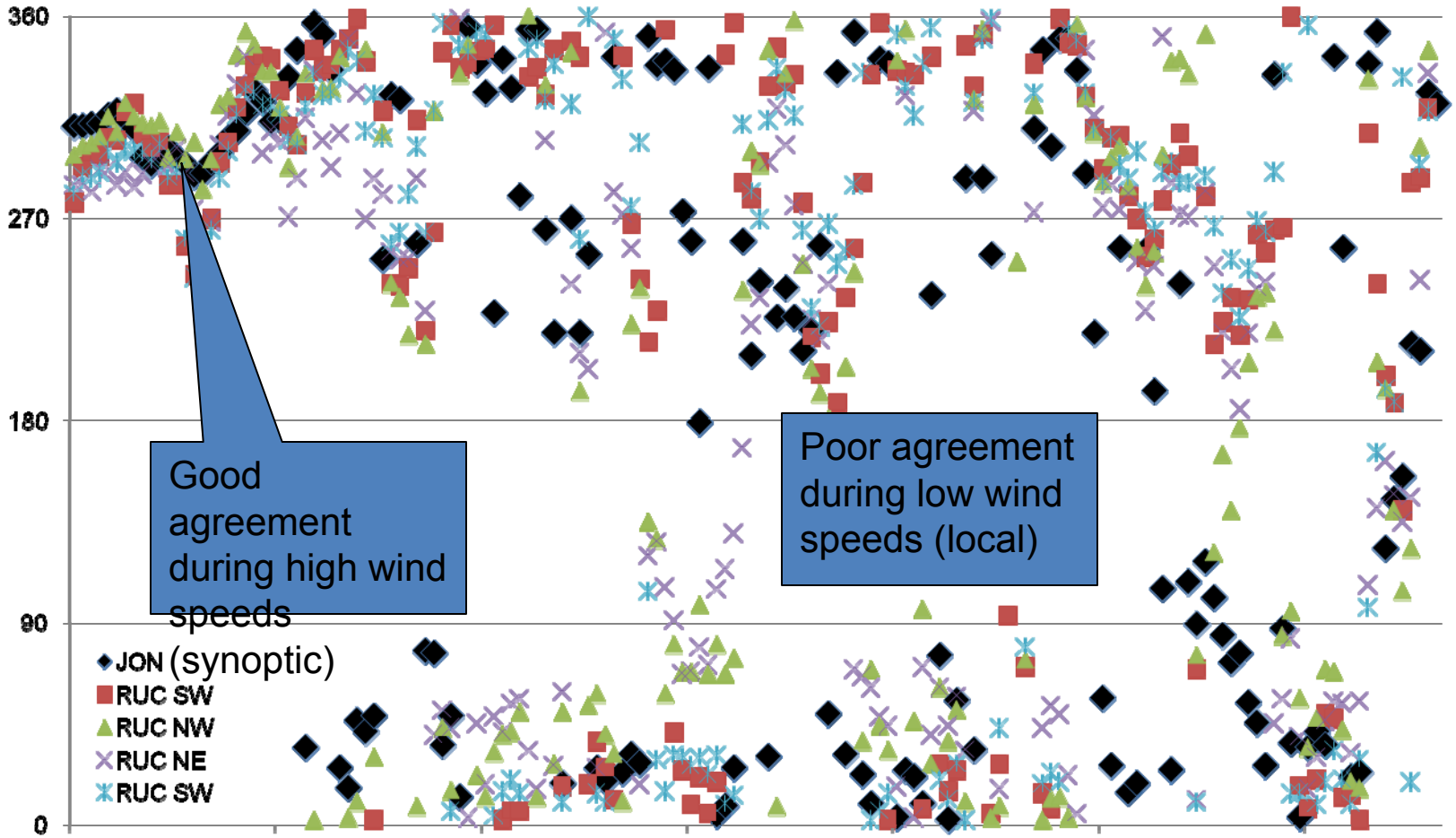
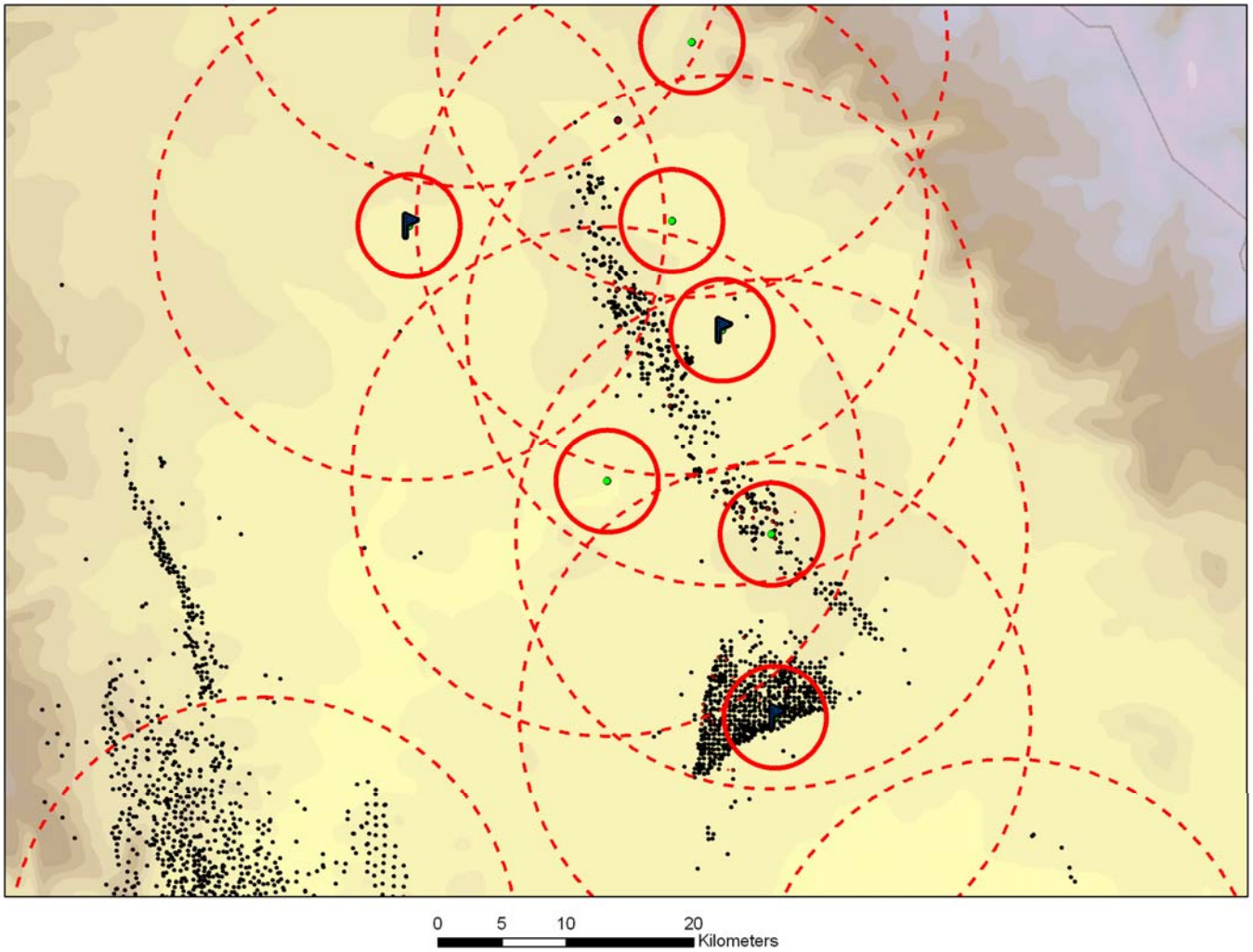


Illustration of R-values, Sources and Monitor Locations



Conclusions

- CALMET is a flexible model that:
  - Can easily incorporate non-standard data (SODAR, sonde data)
  - Can easily incorporate high resolution prognostic data (RUC,MM5)
  - Can easily incorporate high resolution terrain and land use data (snow cover, land cover)
  - Utilize existing model upgrades (e.g., version 6)
  - Blend and diagnose domain-wide atmospheric conditions specifically for air quality impacts

Questions?

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Ken Rairigh, P.E. (State of Wyoming),
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Alfred Klausmann, CCM (TRC)

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