Implementation of Albedo from Melting Snow into WRF

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Cold Season 2-m Temperature Bias

- Significant Warm or Cold Model Bias in some regions at some time
- Why?
- How to reduce Bias?
- Source of Model Errors: Synoptic scale, Local scale (e.g., Surface Fluxes, Surface Albedo, Land Properties) etc.
- Unified Noah LSM

A Method for Warm Bias Reduction

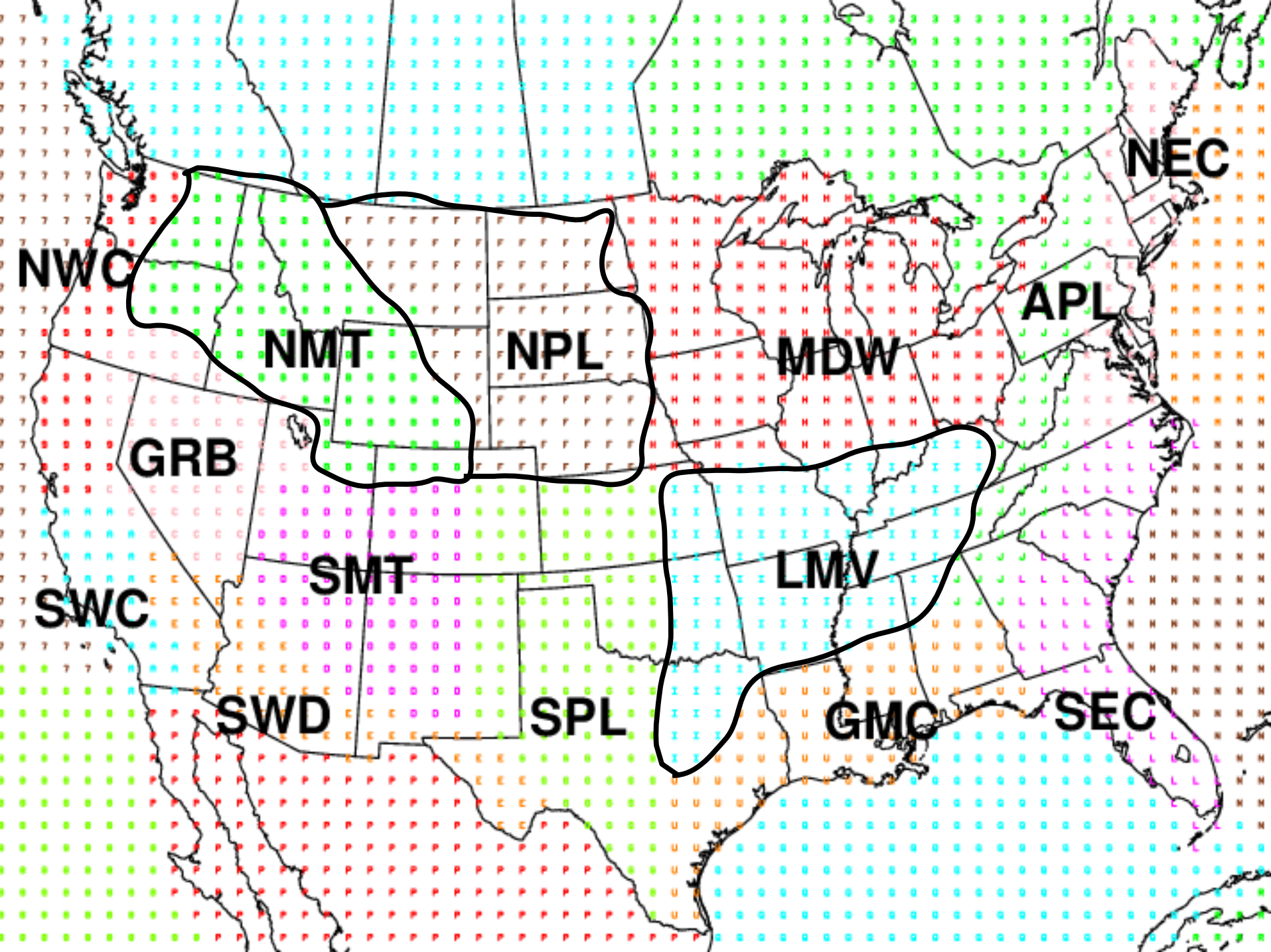
- An option in Noah LSM: Zilitinkevich's Thermal Roughness Length

$Z_{OT} = Z_{OM} \exp \{ - k*C*Re^{1/2}\}$

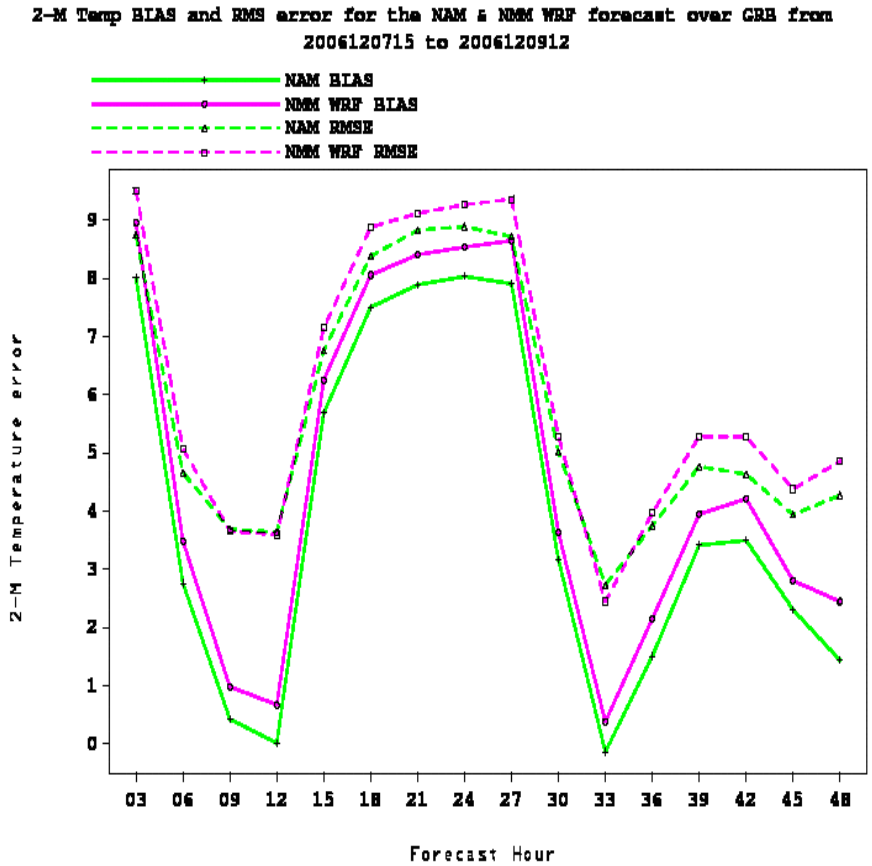
C = Constant in present ARW

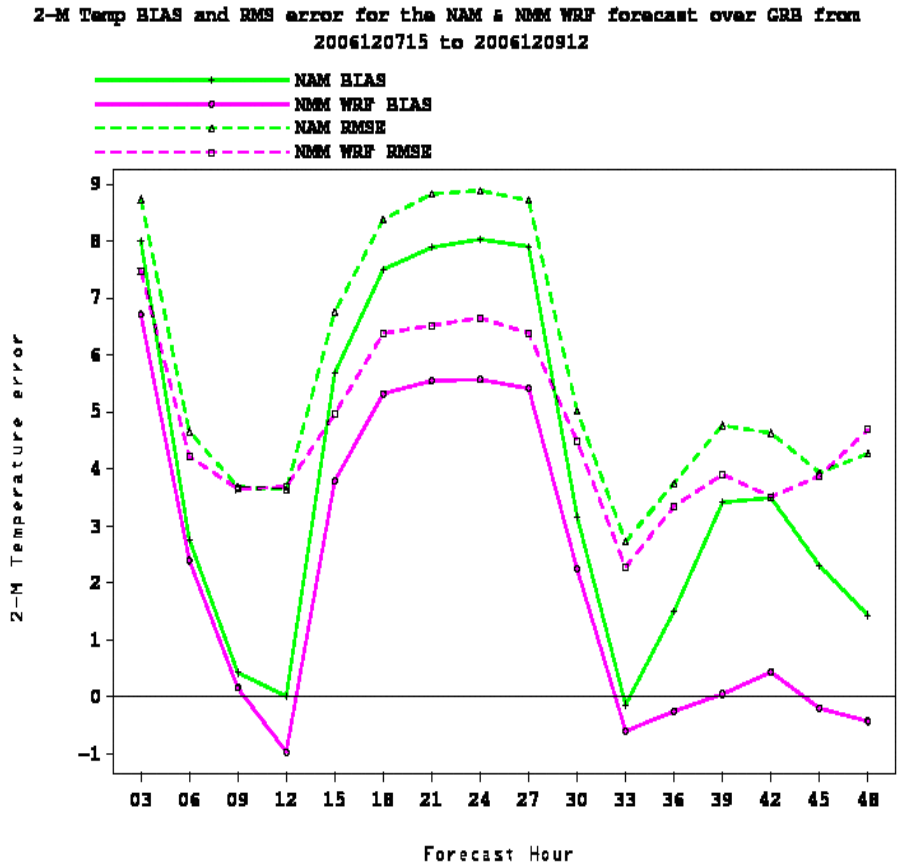
$C = Constant*\{1 + C_{max}*(R_{ib}/R_{ic})^{2}\}$

for stable regime in new NMM


NEC
NWC
APL
NMT
NPL
MDW
GRB
SMT
LMV
SWC
SWD
SPL
GMC
SEC

GRB


2-M Temp BIAS and RMS error for the NAM & NMM WRF forecast over GRB from 2006120715 to 2006120912
NAM BIAS
NMM WRF BIAS
NAM RMSE
NMM WRF RMSE
2-M Temperature error
Forecast Hour


2-M Temp BIAS and RMS error for the NAM & NMM WRF forecast over GRB from 2006120715 to 2006120912
NAM BIAS
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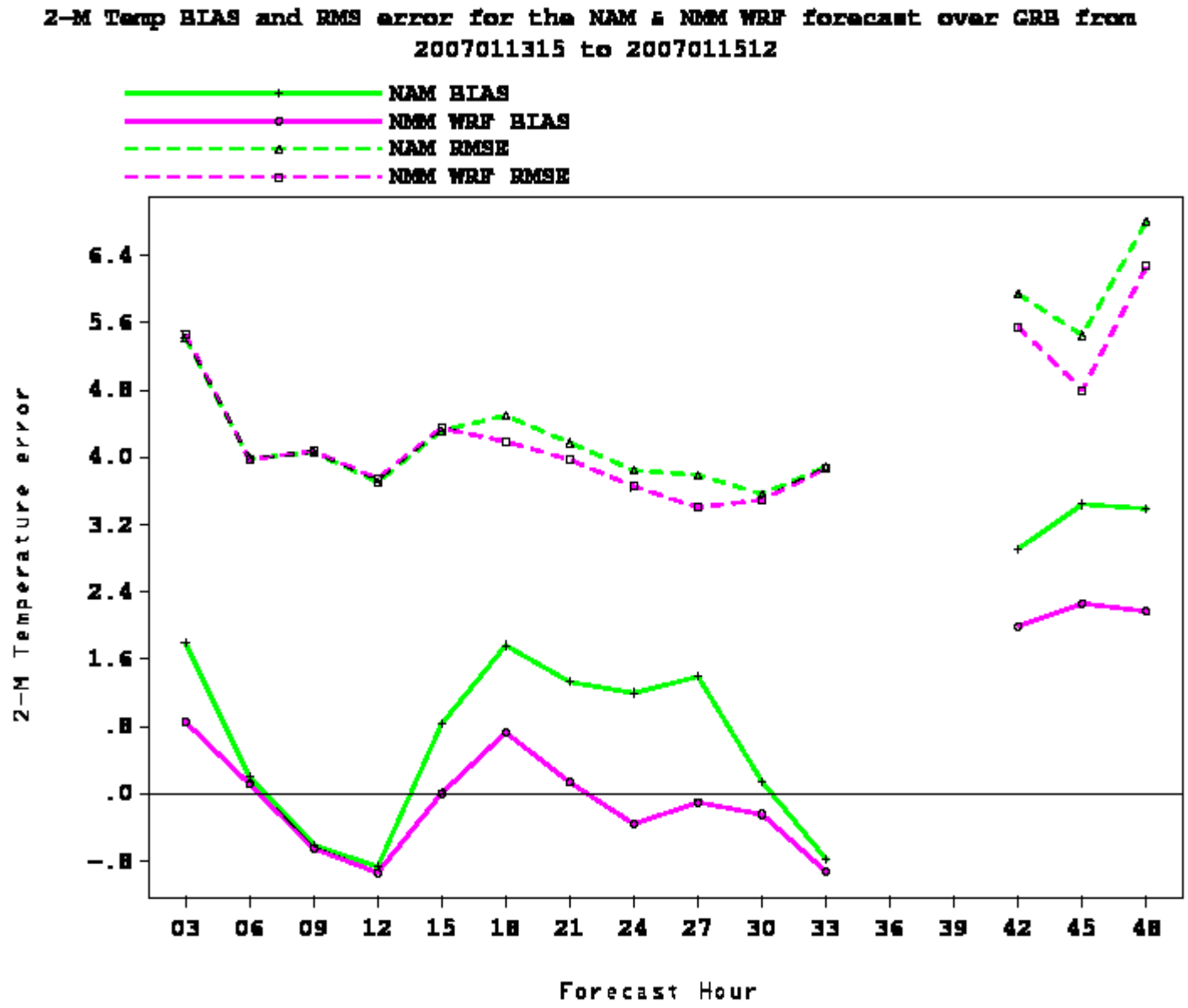
NMM WRF RMSE
2-M Temperature error
Forecast Hour

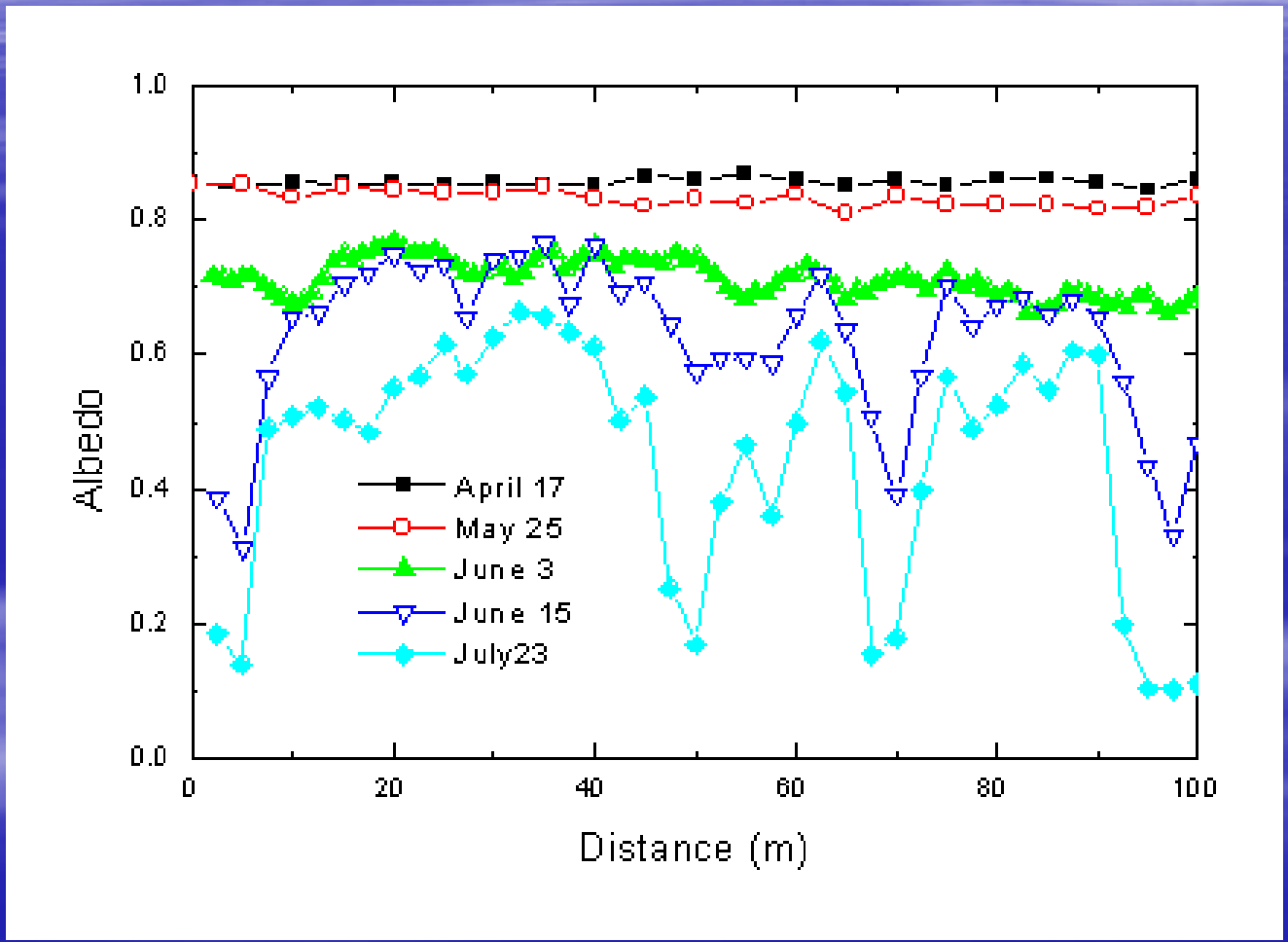
GRB


2-M Temp BIAS and RMS error for the NAM & NMM WRF forecast over GRB from 2007011315 to 2007011512
NAM BIAS
NMM WRF BIAS
NAM RMSE
NMM WRF RMSE
2-M Temperature error
6.4
5.6
4.8
4.0
3.2
2.4
1.6
.8
.0
-.8
03
06
09
12
15
18
21
24
27
30
33
36
39
42
45
48
Forecast Hour

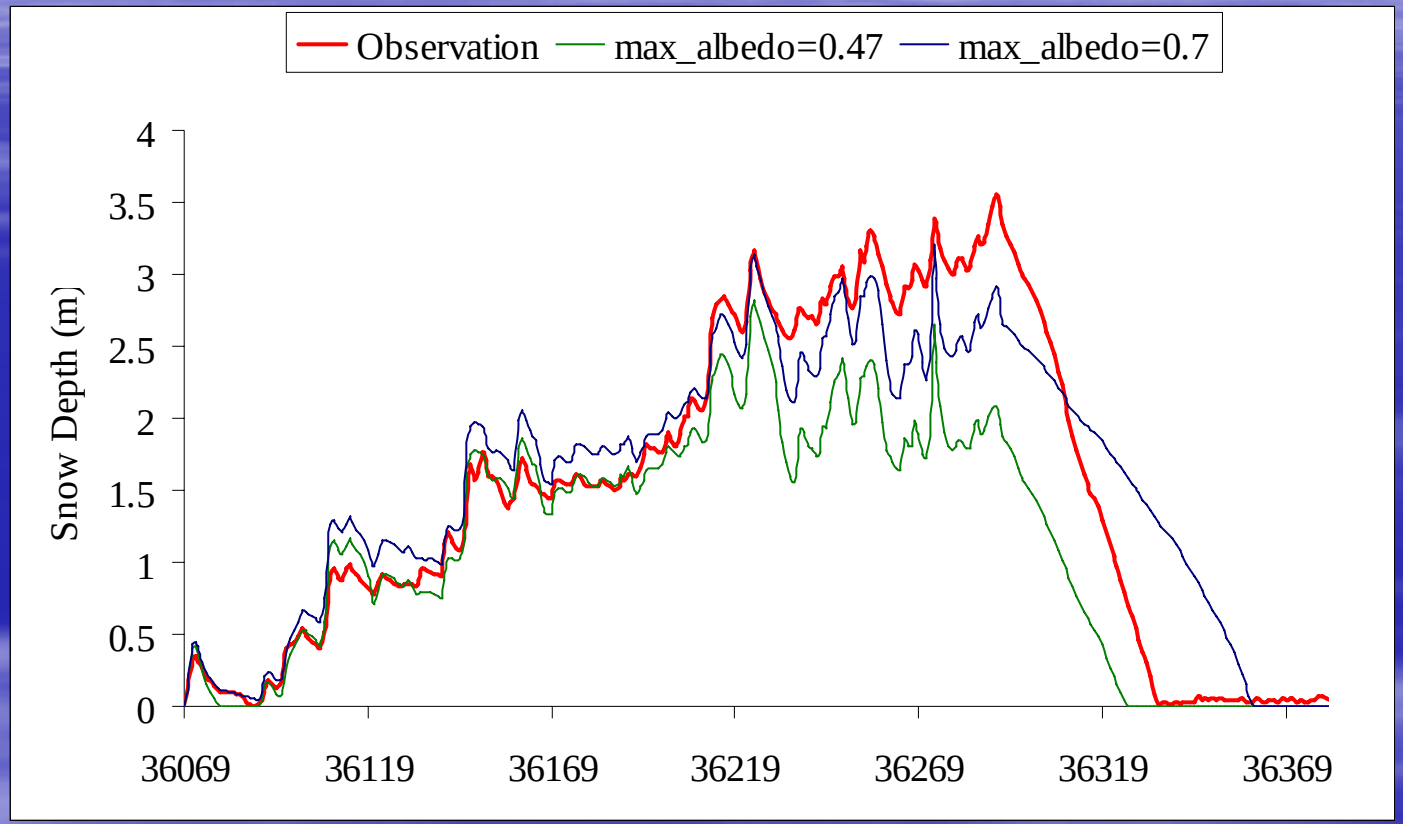
A Method for Cold Bias Reduction

- To Parameterize the Albedo for Melting Snow

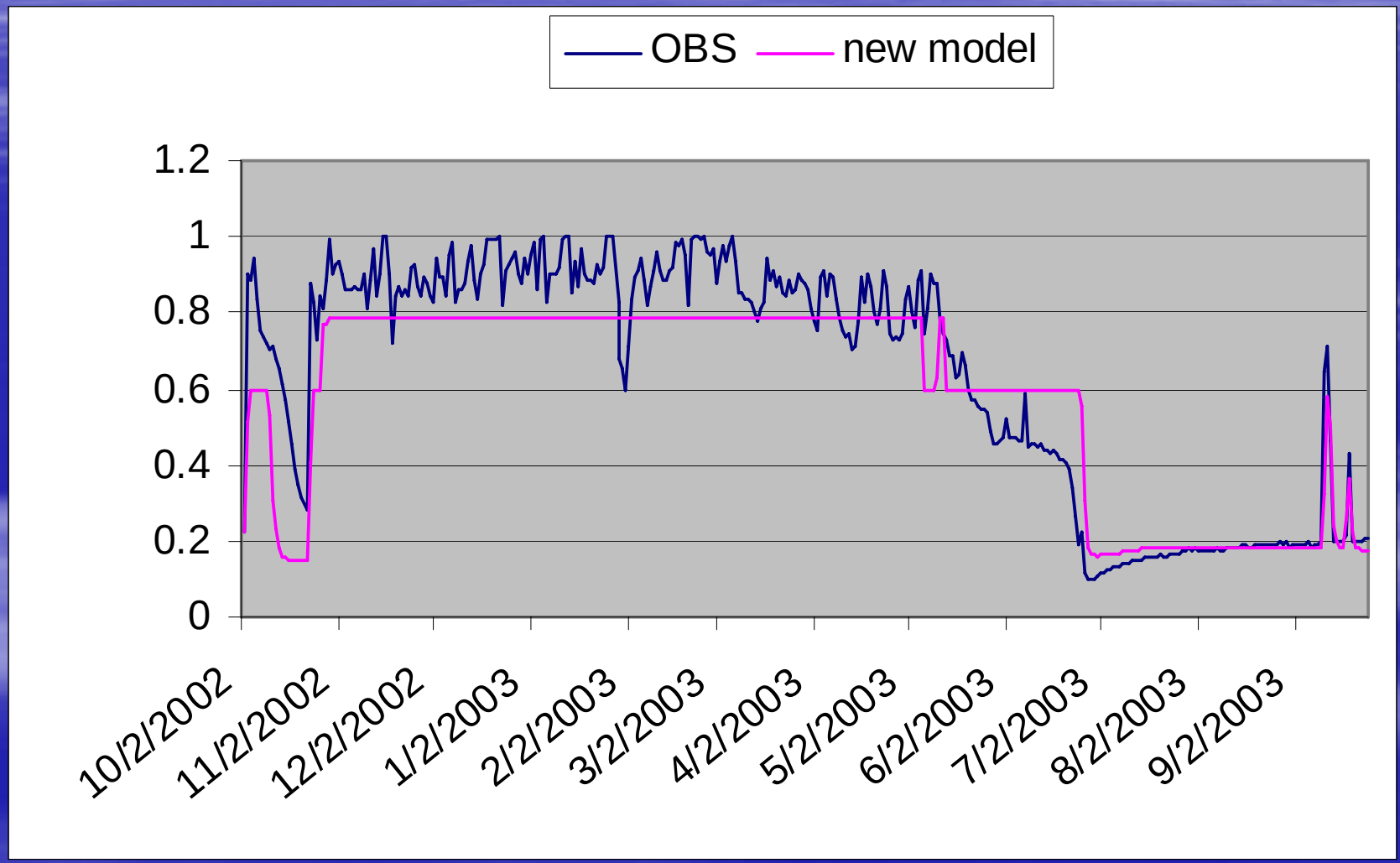
Observed spatial and temporal variability of albedo along a line of Instruments during the melt season (Arctic Field Experiment)



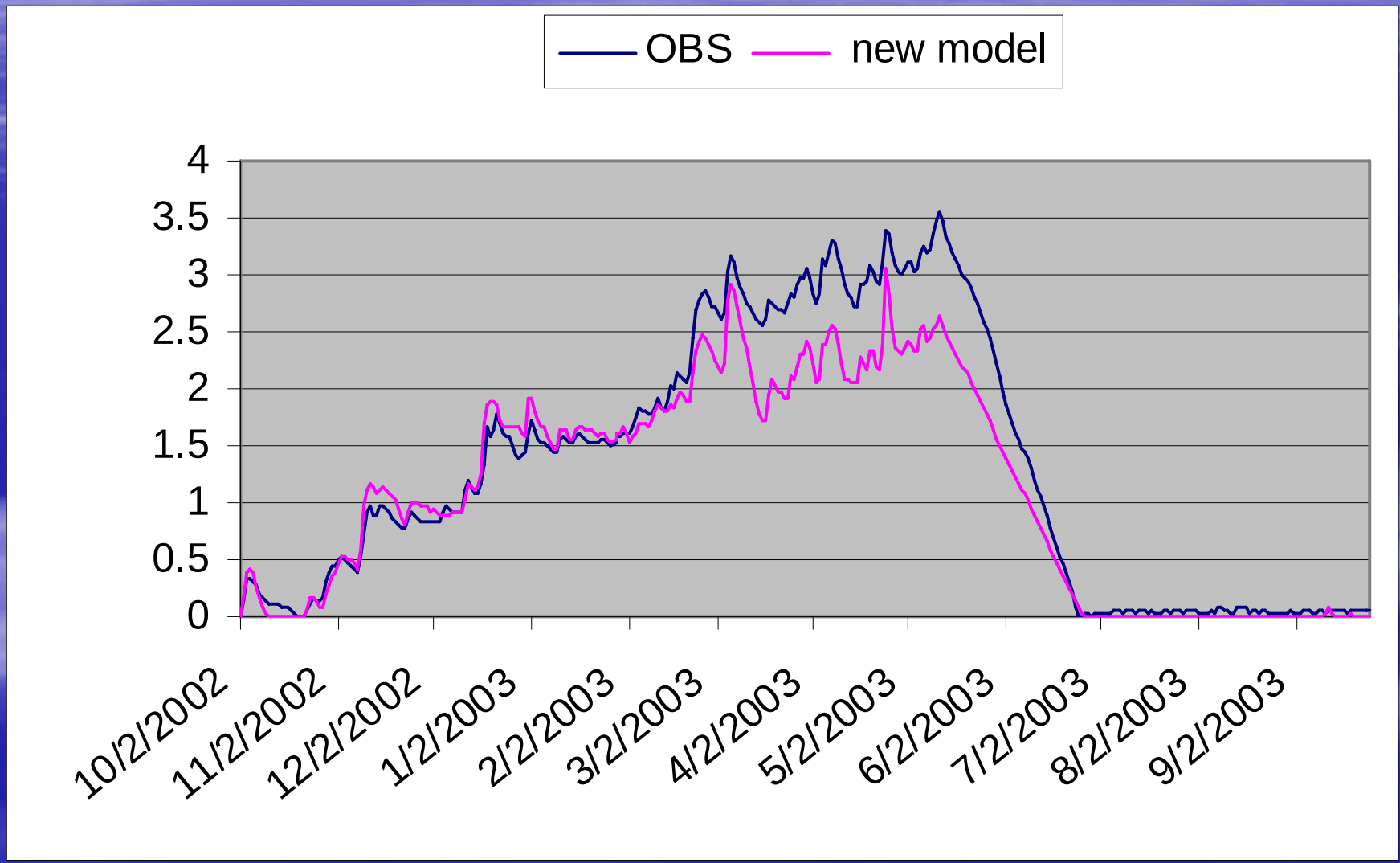
Noah LSM 2.7.1
1-D Model


Observation
max_albedo=0.47
max_albedo=0.7
Snow Depth (m)
4
3.5
3
2.5
2
1.5
1
0.5
0
36069
36119
36169
36219
36269
36319
36369

Albedo (max_albedo=0.79; melting max_albedo=0.79*75%)



Snow Depth (m) (max_albedo=0.79 & melting max_albedo=0.79*75%)



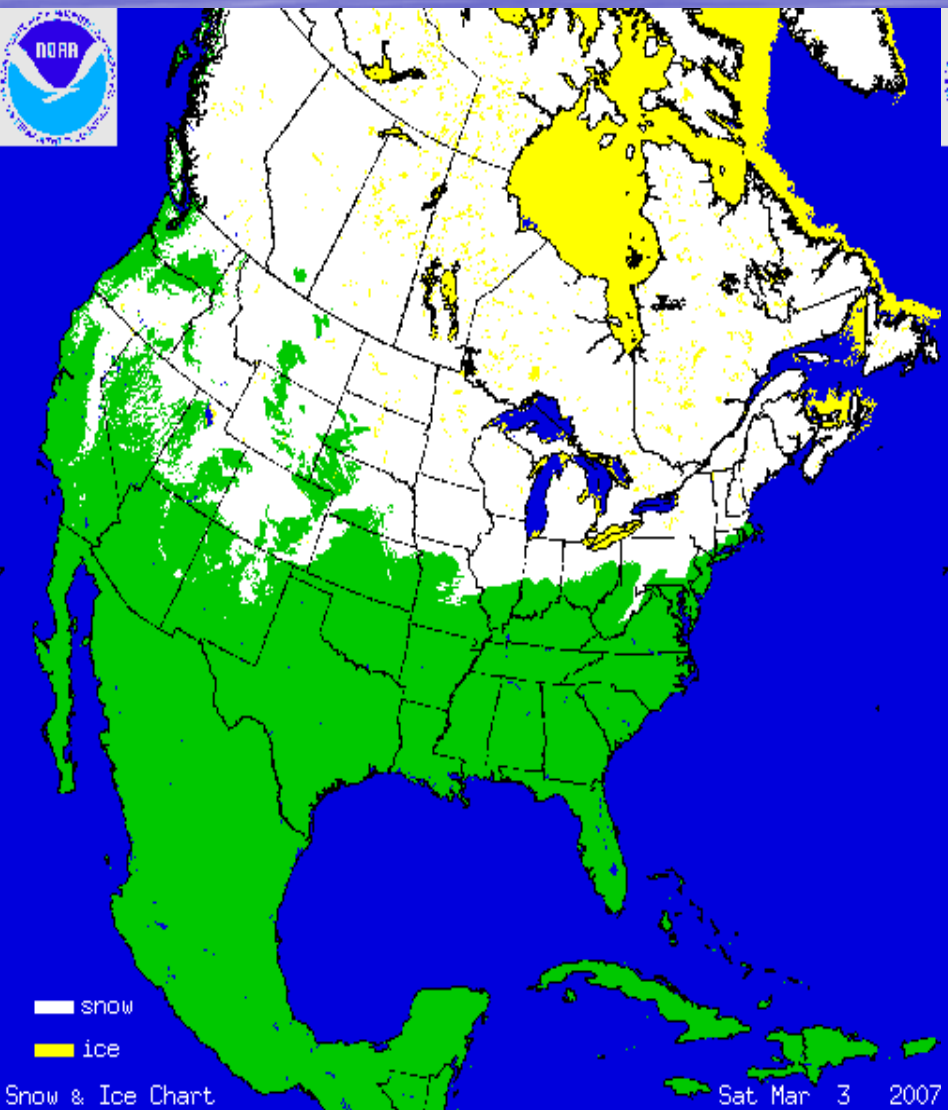
Reduced max_albedo to 0.75% of Original Value during Melting Period

- Better agreement between the model output and ground observation of snow depth & time for complete melting

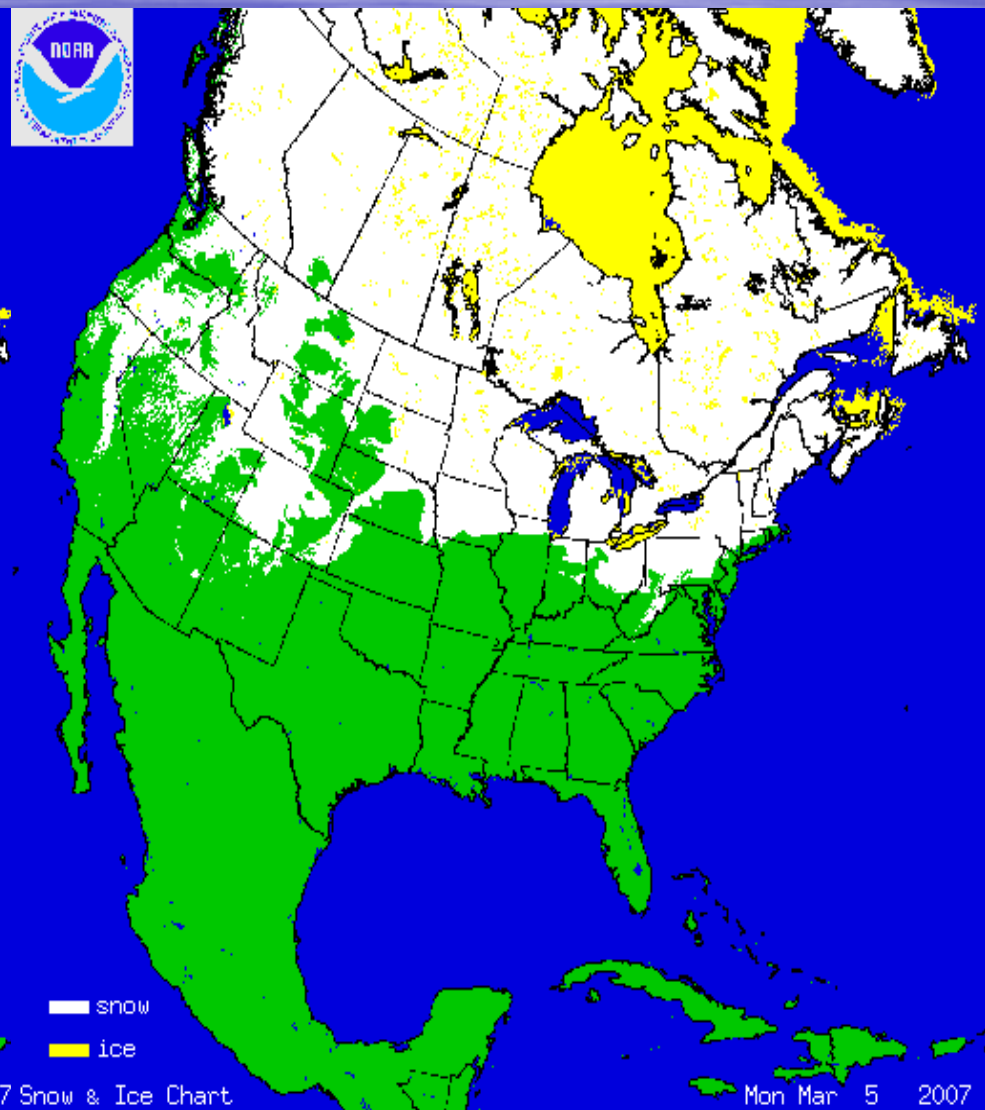
Implementation of Melting Snow Albedo to WRF for March 3, 2007 case

Snow Maps

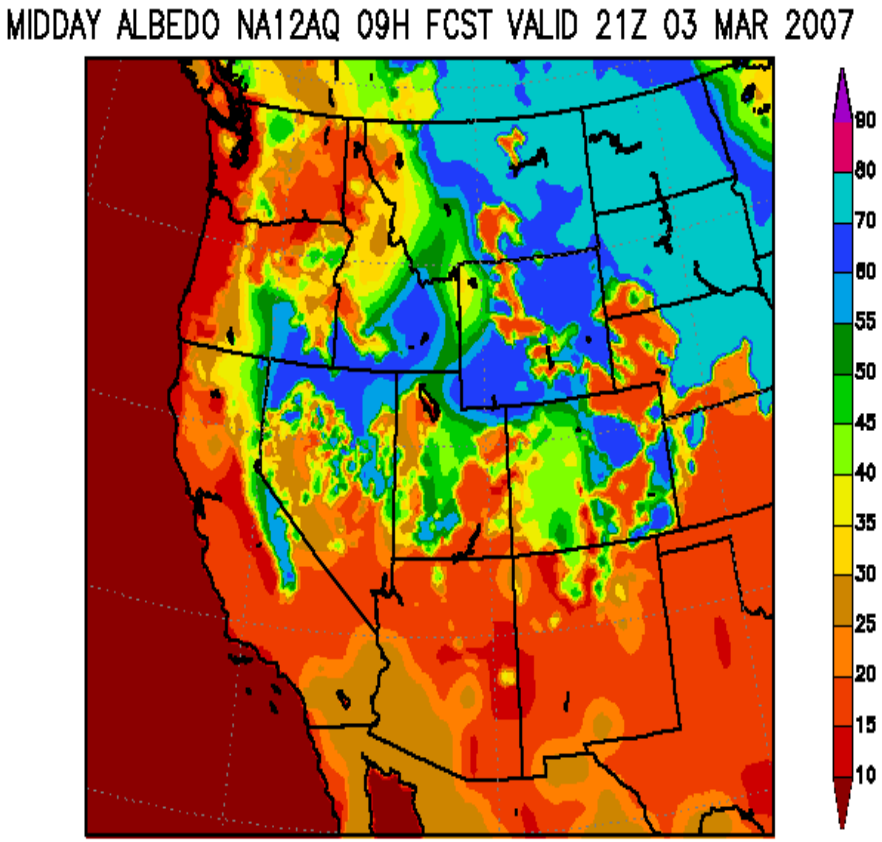
March 3, 2007



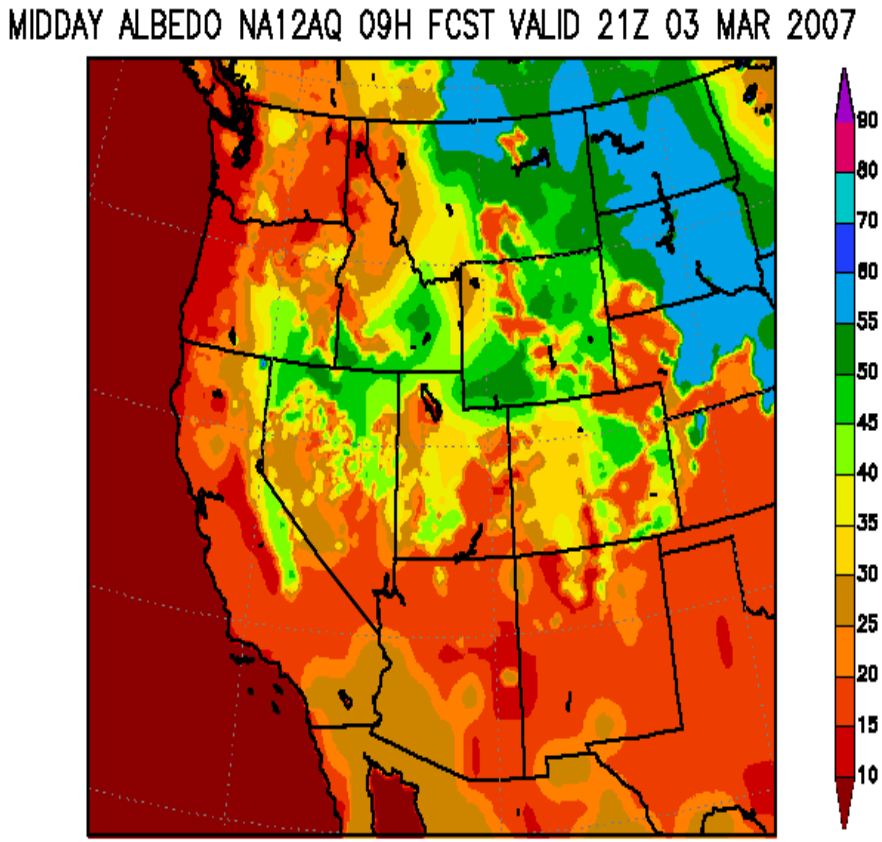
March 5, 2007



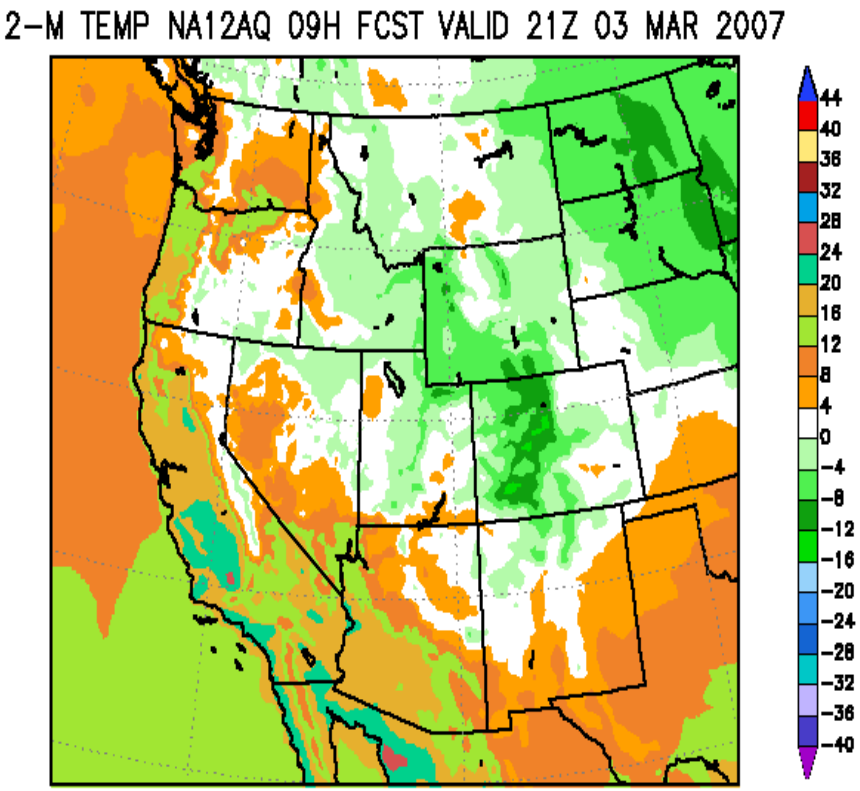
Control Run



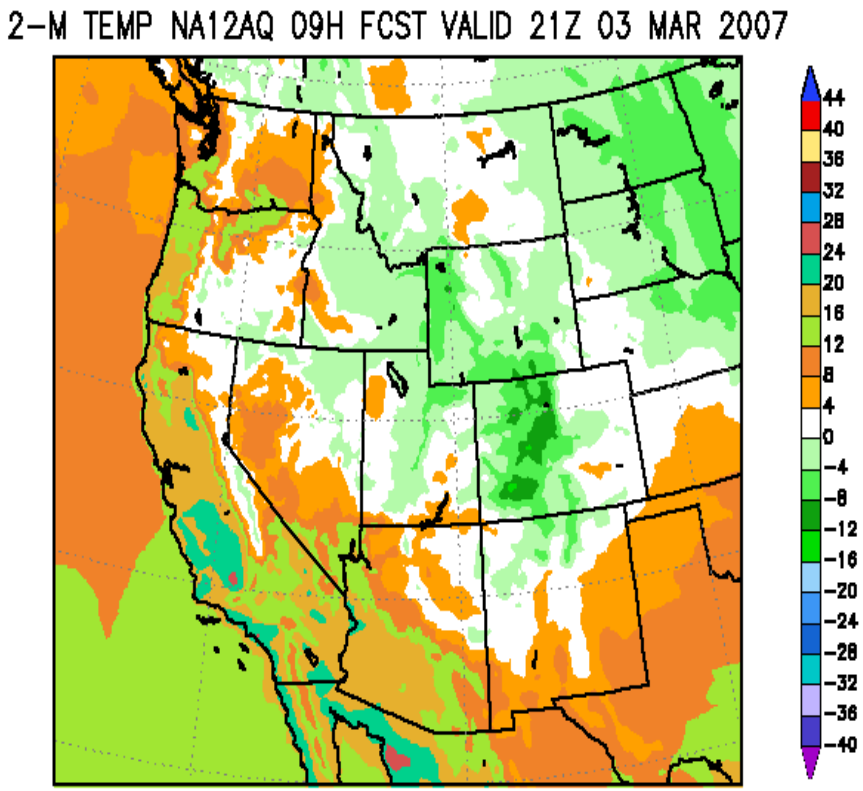
Melting Snow Albedo Run

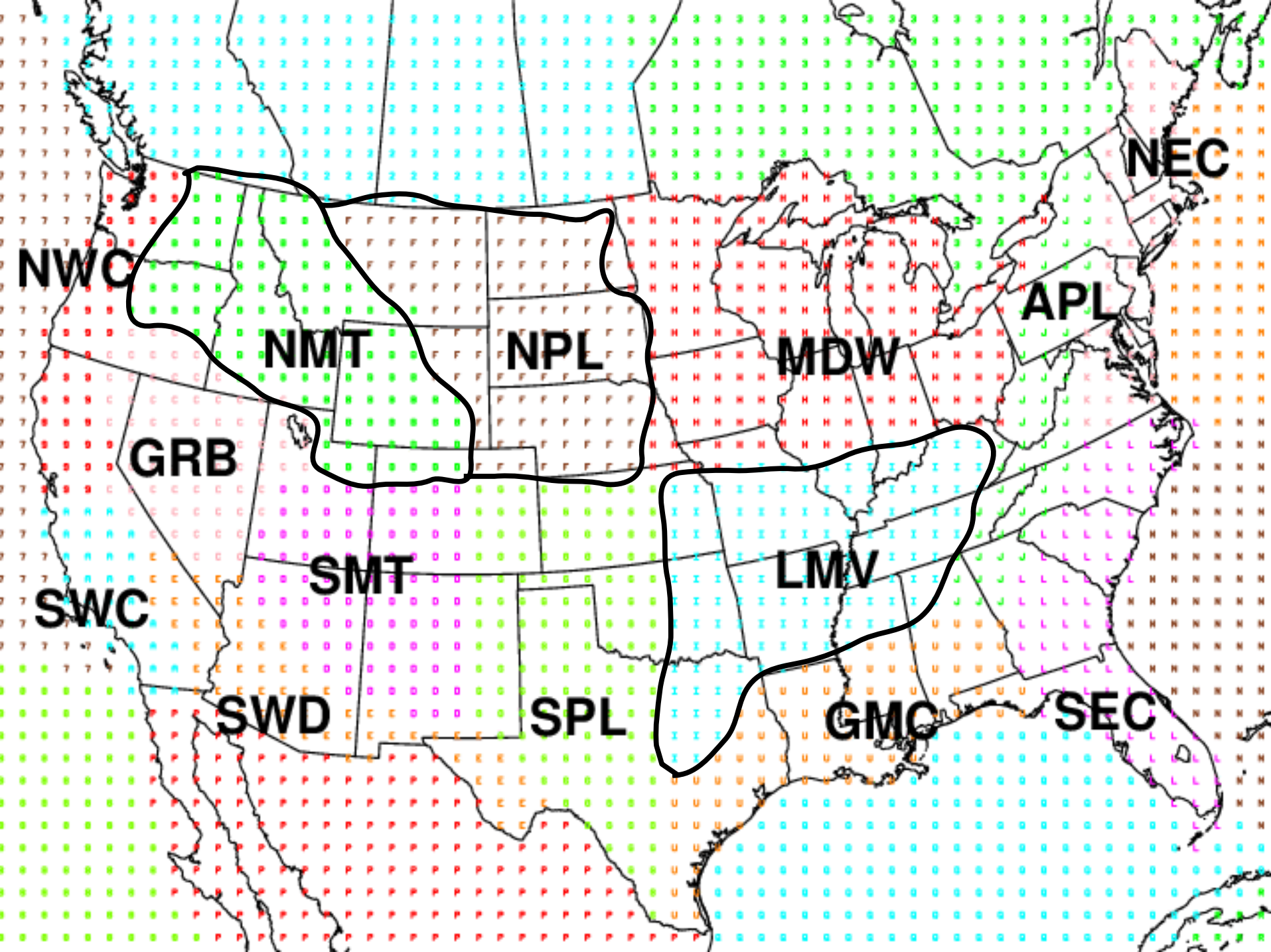


Control Run



Melting Snow Albedo Run

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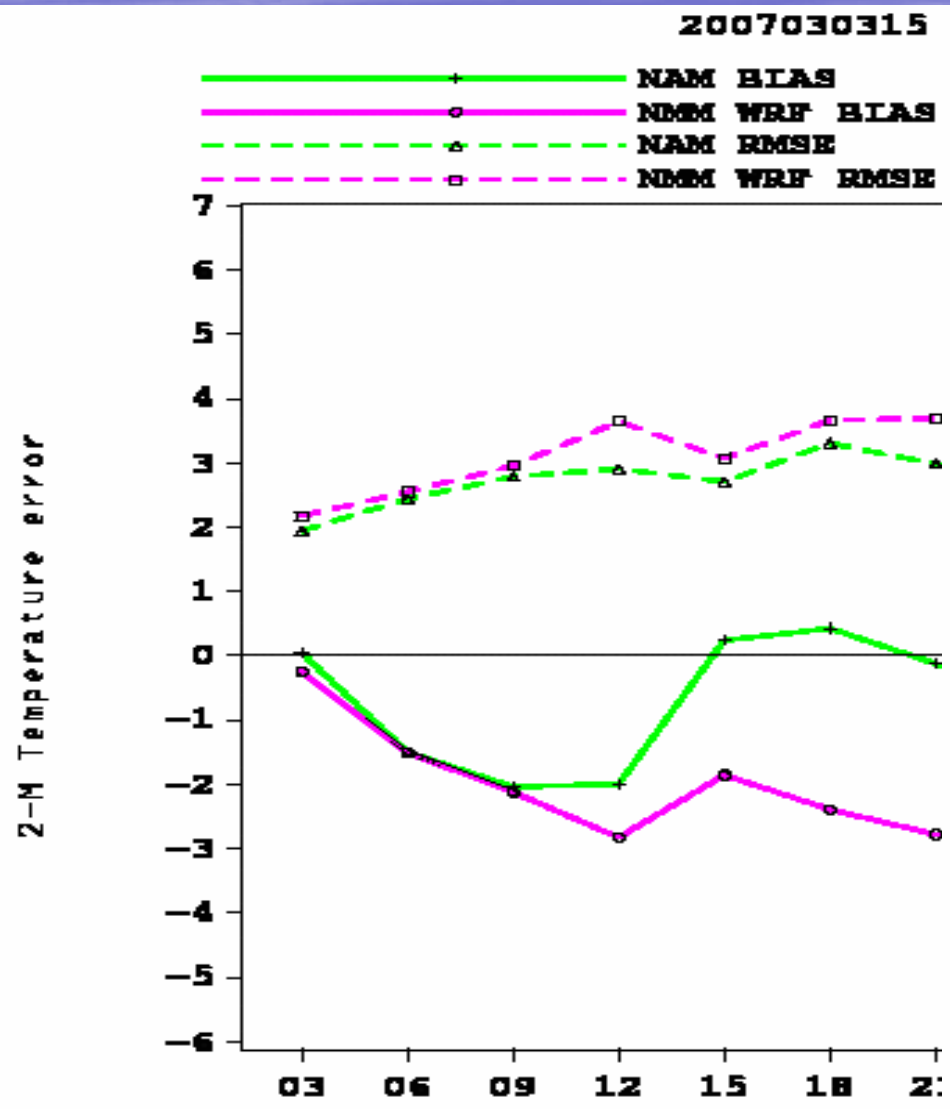
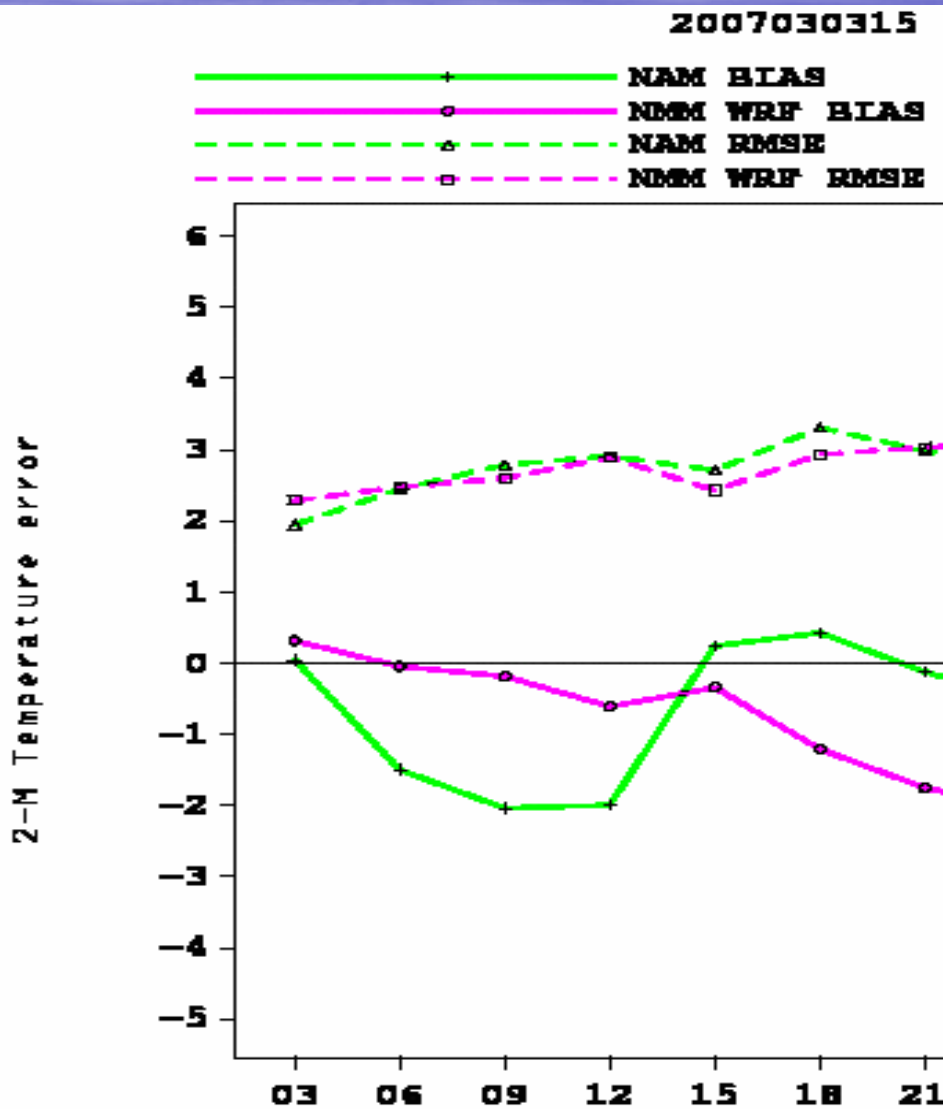
2-m Temperature Bias and RMS Error

Control Run



Melting Albedo Run



Summary

- 2 preliminary schemes to reduce warm or cold bias of 2-m temperature during cold seasons
- Reduce warm bias by modifying Thermal Roughness Length calculation
- Reduce cold bias by considering Albedo of Melting Snow
- Just few lines of code changes are needed in the Unified Noah LSM
- Applicable to Global WRF, Climate Model & Data Assimilation