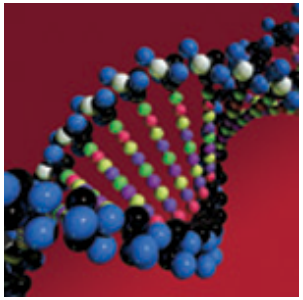
Mesoscale Model Interface Program
MMIF



Chris Emery
ENVIRON Corporation

Bret Anderson
EPA Region 7

June 25, 2009

ENVIRON

Introduction

- An “MCIP-like” direct meteorology-CALPUFF interface program has been considered for several years
  - First discussed at EPA’s 8th Conference on Air Quality Modeling in September 2005
  - Offers advantage of minimizing alterations to prognostic meteorological fields
  - Many find this approach preferable
- EPA OAQPS, regional offices, and FLMs have sponsored the development of MMIF
  - Use for regulatory applications
  - Brings a higher level of consistency to the review process
  - Other organizations and projects could benefit from use of single-purpose direct converter

Introduction

- EPA developed a prototype MM5 re-reformatting tool
  - “BARF” (Anderson, 2008)
  - Based on ENVIRON’s MM5CAMx and EPA’s MCIP
- ENVIRON was tasked to thoroughly review, update, and test the prototype:
  - Re-write in Fortran 90 with dynamic memory allocation
  - Organize into highly modular structure, in-code documentation
  - Expand to include WRF/ARW
  - Ensure bug-free and sufficient quality for regulatory review and public distribution
  - Conduct limited preliminary testing with MM5 and WRF datasets
  - The product of this work is MMIF version 1.0
    - Not considered: “Bret’s ever-evolving reformatter” (BEER)

MMIF

- Processes MM5 and WRF geophysical and meteorological output fields
- Diagnoses certain CALPUFF-required parameters that are not directly available from MM5 or WRF
- Offers option to pass through PBL heights or diagnose them from other variables
- Produces CALPUFF inputs for any sub-domain (horizontal or vertical)
- Compiles and run on both Windows and Unix/Linux platforms
- MMIF does not:
  - Generate any cloud information
  - Perform interpolation to different map projections or resolution

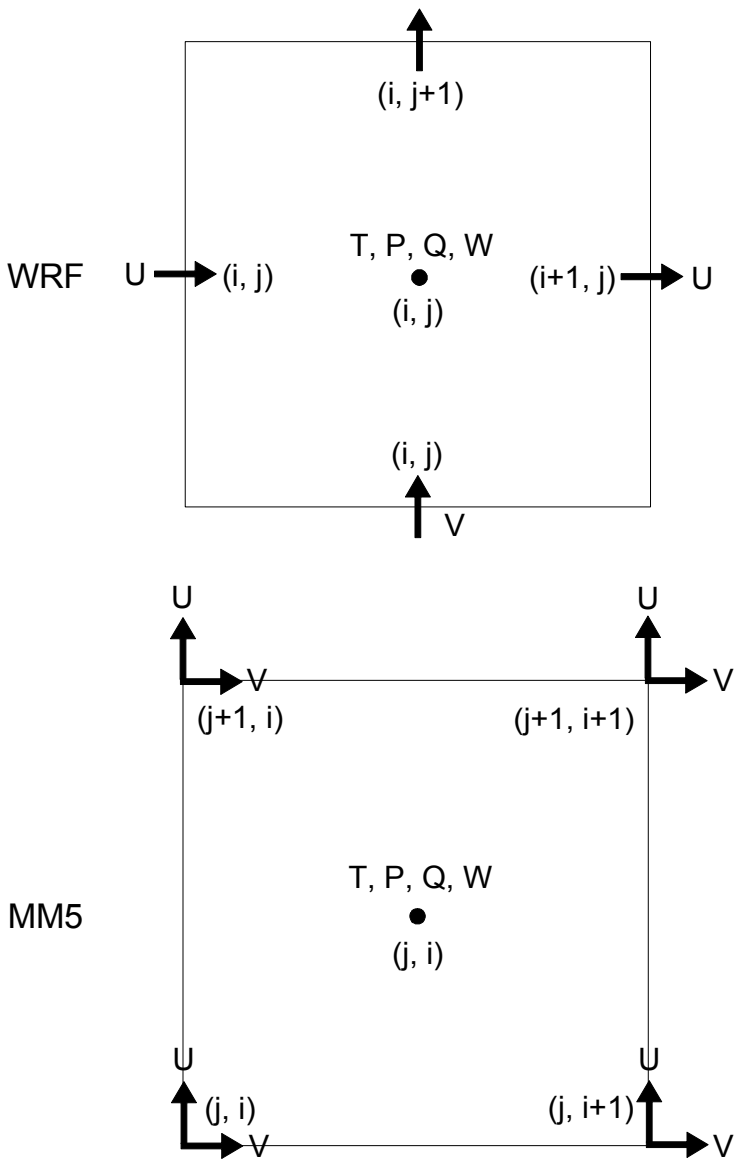
MMIF

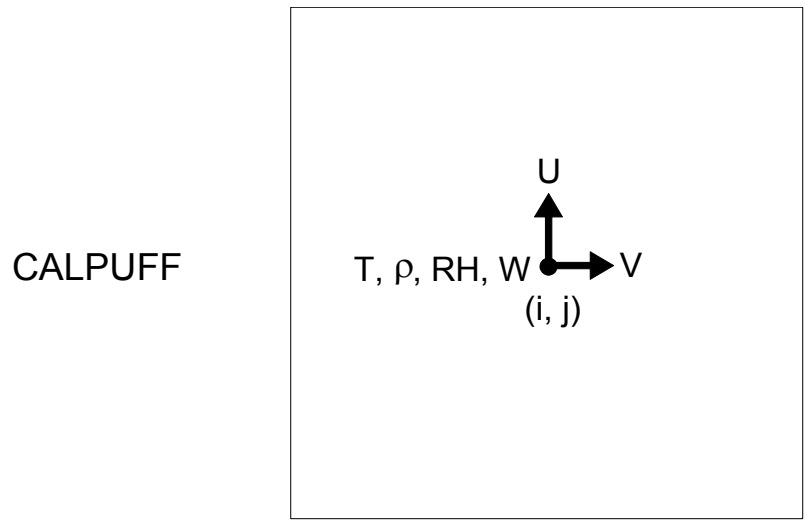
- Simple text-based user control file
- MMIF writes CALPUFF-ready input files equivalent to:
  - CALMET “NOOBS” option (all obs sites = 0)
  - CALGRID option (3-D fields of wind components and temperature)
- MMIF optionally writes projection/grid data for input to CALPUFF control file

MMIF Output Fields

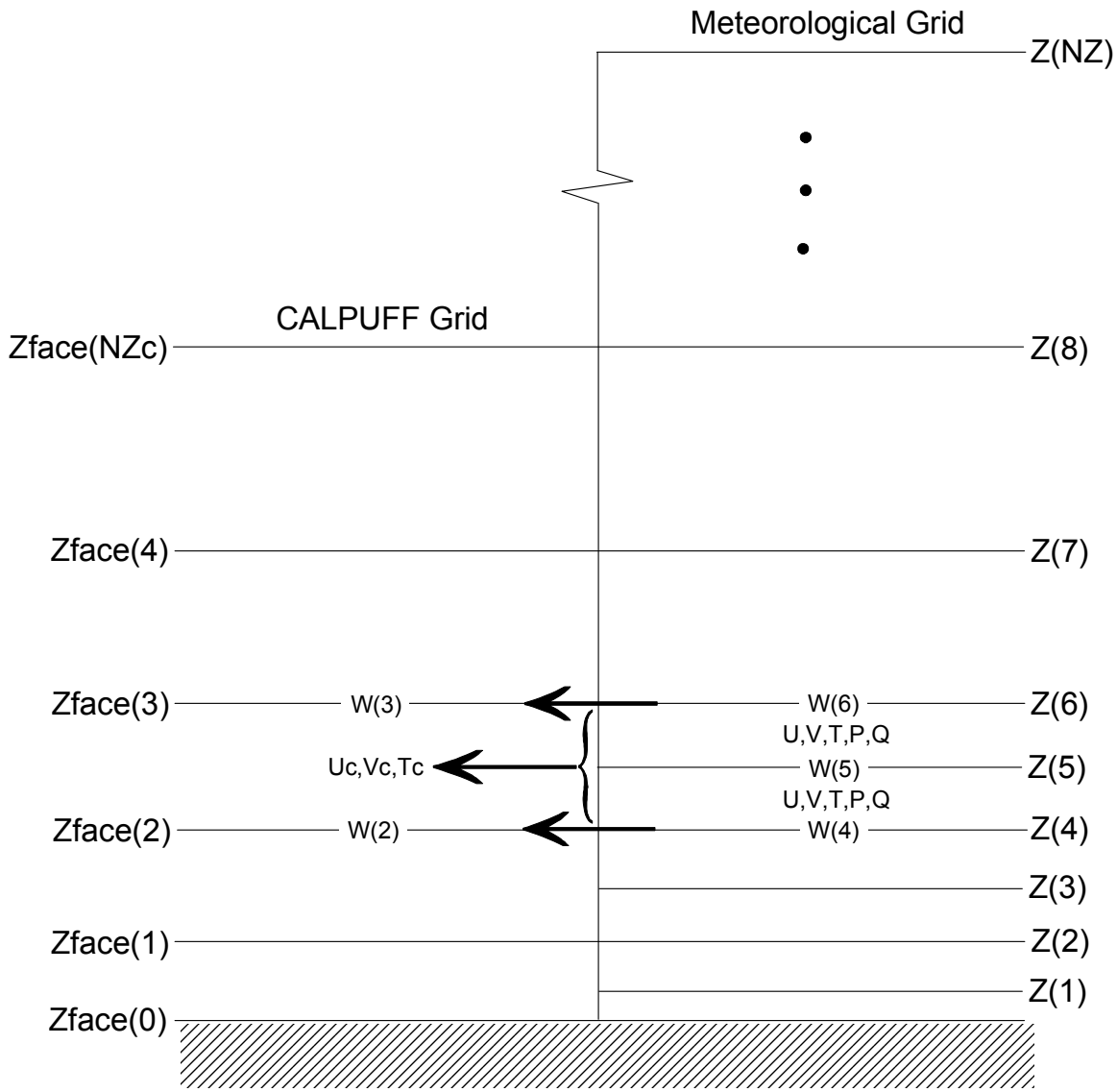
- Time-invariant fields
  - 2-D surface roughness length, m (Z0);
  - 2-D landuse code, dimensionless (ILANDU);
  - 2-D topographic elevation, m (ELEV);
  - 2-D leaf area index, dimensionless (XLAI).
- Time-variant fields
  - 3-D U-component (west-east) scalar wind, m/s (U-LEV);
  - 3-D V-component (south-north) scalar wind, m/s (V-LEV);
  - 3-D W-component (vertical) scalar wind, m/s (WFACE);
  - 3-D temperature, K (T-LEV);
  - 2-D PG stability, dimensionless (IPGT);
  - 2-D surface friction velocity scale, m/s (USTAR);
  - 2-D PBL depth, m (ZI);
  - 2-D Monin-Obukhov length, m (EL);
  - 2-D convective velocity scale, m/s (WSTAR);
  - 2-D rainfall rate, mm/hr (RMM);
  - 2-D surface temperature, K (TEMPK);
  - 2-D density, kg/m3 (RHO);
  - 2-D surface solar flux, W/m2 (QSW);
  - 2-D relative humidity, % (IRH);
  - 2-D precipitation code, dimensionless (IPCODE).

MMIF Grid Processing

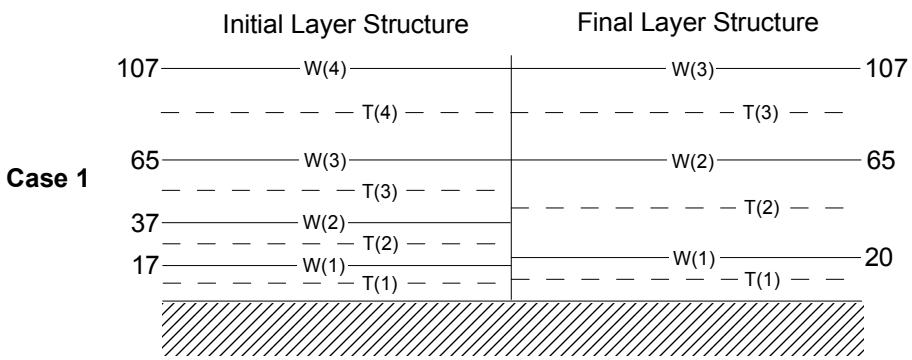


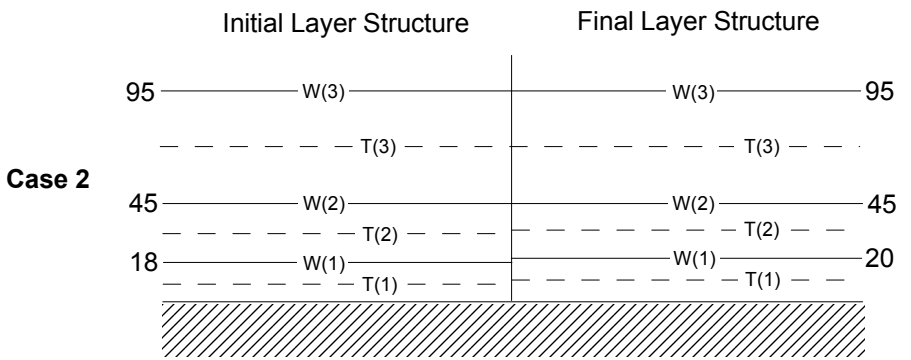


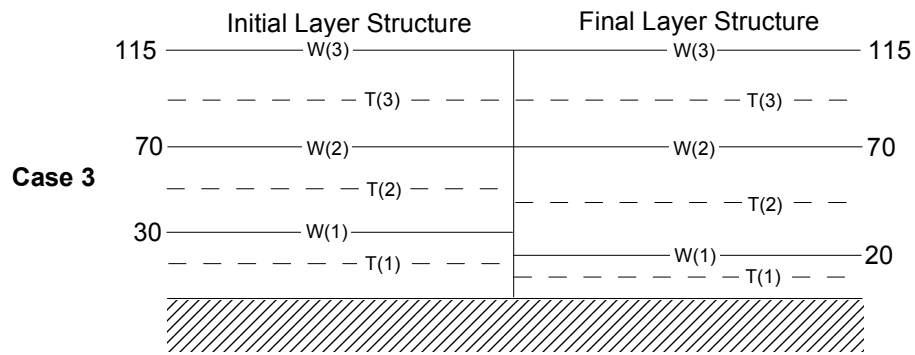
MMIF Grid Processing

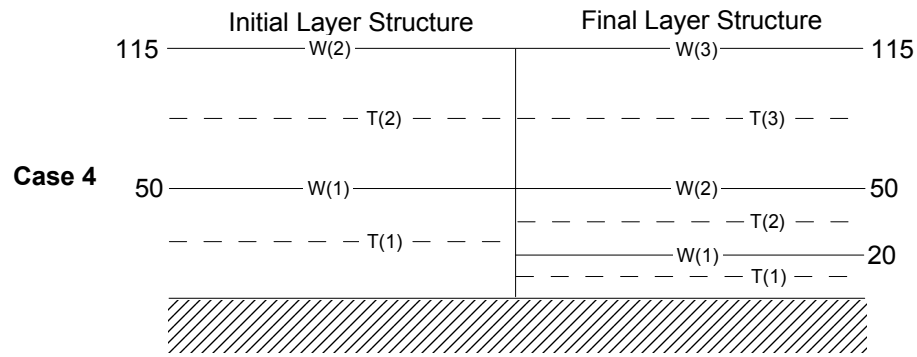


MMIF Grid Processing









MMIF Surface Characteristics

- MMIF outputs static 2-D roughness, landuse code, topographic elevation and LAI
  - All but LAI and WRF surface roughness passed through
- MMIF assumes MM5/WRF use standard 24-category USGS landcover
  - Any other dataset stops MMIF with an error
  - LAI and WRF roughness assigned to 24-cat USGS code according to USFS BlueSky/RAINS modeling system (MM52GEO program)

PBL Parameters

- MMIF uses MM5/WRF surface layer parameters and layer 1 met fields to calculate:
  - 2-D density, RH, Monin-Obukhov length (L) and convective velocity scale (W*) using Louis (1979)
  - 2-D 10-meter winds (if not available) and temperature
  - PBL depth
    - Pass through or
    - Optional re-diagnosis:
      - Bulk Richardson approach of Vogelezang and Holtslag (1996) using the Louis (1979) surface parameters
      - Methodology of Gryning and Batchvarova (2003) varies critical Richardson number for over-water PBL height

PG Stability Class

- PG vs. turbulence-based dispersion:
  - IWAQM Phase II guidance recommends PG stability for long range transport analyses
  - EPA Model Clearinghouse reaffirmed PG approach in early 2006
  - Several algorithms inside CALPUFF are dependent upon PG stability
- CALMET calculates PG stability using Turner (1970) method, 2 ways:
  - Observation-based (ceiling height/cloud cover from surface obs)
  - "NOOBS" method (ceiling height/cloud cover from MM5 data)
- MMIF provides 2 PG options that don't need clouds:
  - SRDT method, Supplement C to the Guideline on Air Quality Models (EPA, 1993)
    - Based on wind speed, solar radiation, and "Delta-T"
    - From the Meteorological Processor for Regulatory Models (MPRM)
  - Golder (1972) method
    - Function of Monin-Obukhov length and surface roughness
    - From the AERMOD LTOPG subroutine

MMIF Run Control

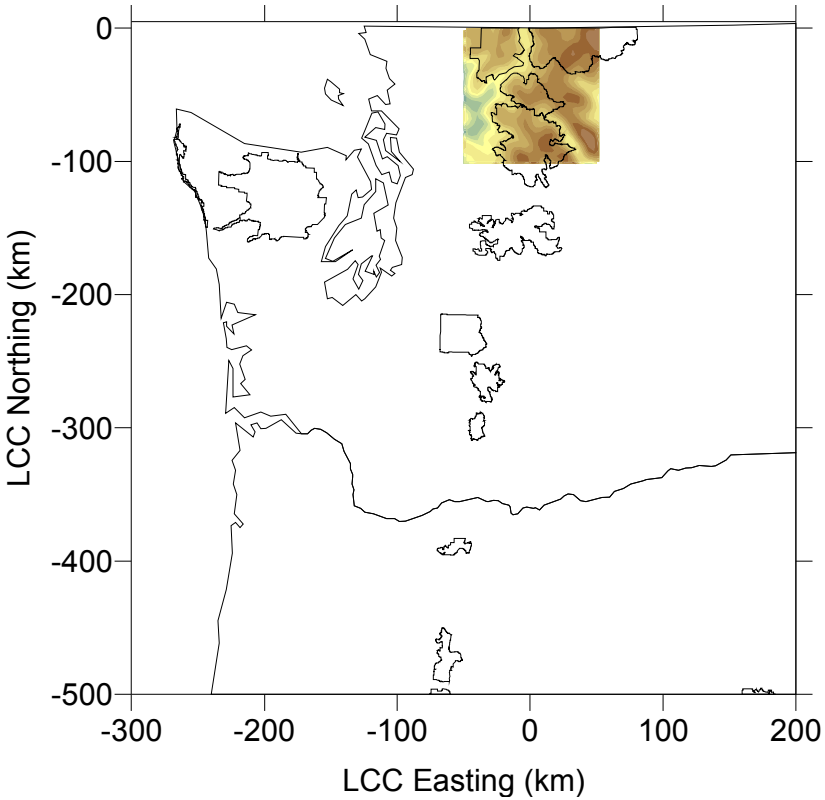
- Simple text file
  - Easy to script, limited options
  - Drives and handles like MM5CAMx (but better gas mileage)

```
MM5 or WRF?         |MM5
Start Extracting    |2006 05 29 01
Stop  Extracting    |2006 05 30 00
Output Time Zone    |-6
P-G Calc Method     |1
Re-calc PBL Depth? |F
Min, Max PBL Depth |50.0 3000.0
I-range to Extract |0 0
J-range to Extract |0 0
Num Output Layers  |21
Layer Mapping       |1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,19,21,23,25
Useful Info File    |test_mm5.info.txt
Output Filename     |test_mm5.met
Num MM5/WRF Files  |2
/dquad9c/aacog/mm5/2006mm5_4km.run4/2006-05-28/MMOUT_DOMAIN4_01
/dquad9c/aacog/mm5/2006mm5_4km.run4/2006-05-28/MMOUT_DOMAIN4_02
```

MMIF Preliminary Testing

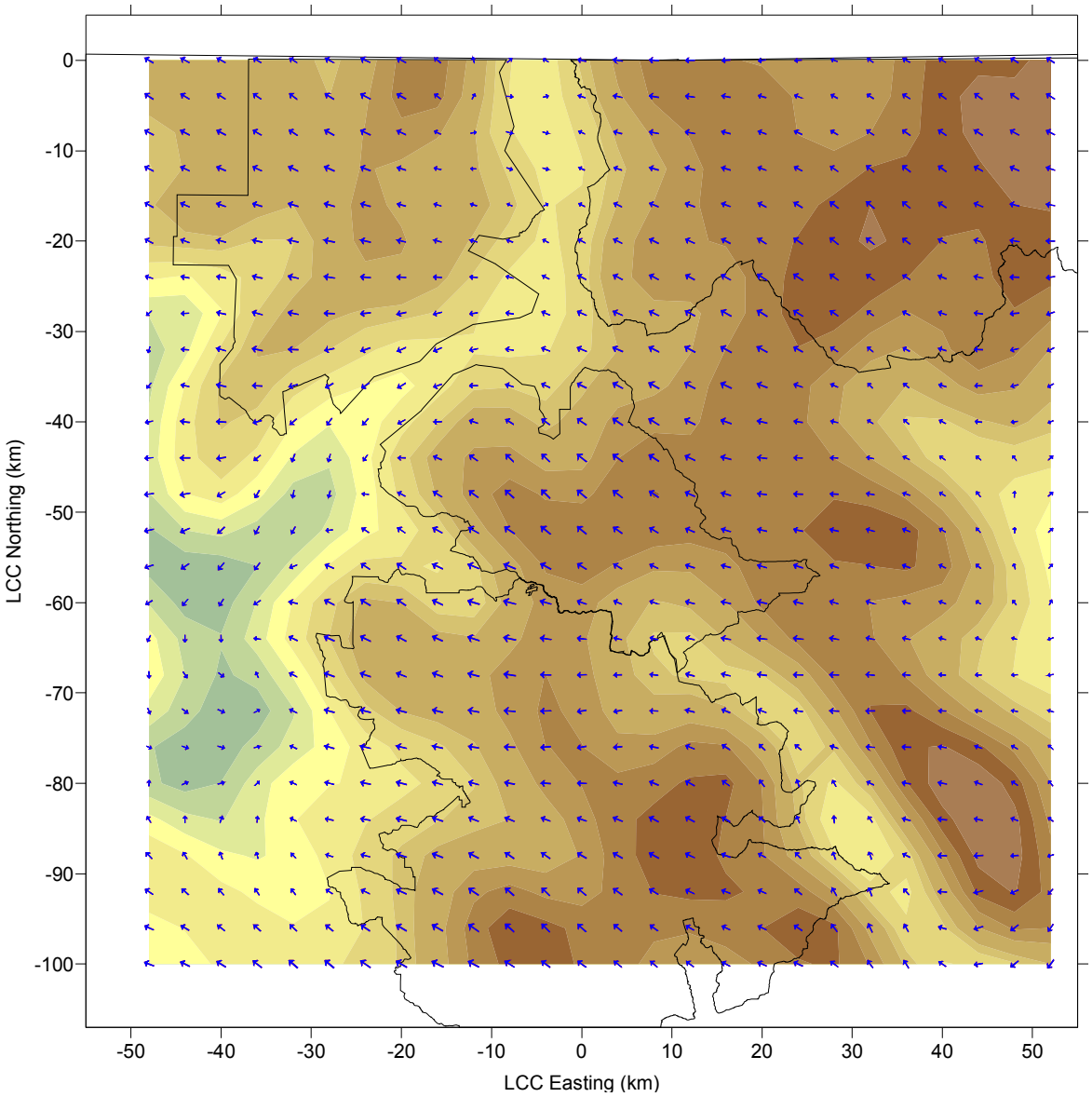
- 3 datasets on various Lambert grids:
  - MM5 version 3-6-3: 4 km domain from UW
    - 163×124×37 points over WA, OR, and ID
    - January 1, 2005
  - WRF version 2.2: 10 km domain from UA Fairbanks
    - 235×136×43 points over the northern half of AK
    - July 12, 2004
  - WRF version 3.0.1.1: 0.6 km domain from 3TIER, Inc.
    - 91×82×31 points over eastern WY
    - April 25, 1999
- Tested/compared on both Linux and Windows versions
- MMIF compared to CALMM5/CALWRF + CALMET where possible
  - Graphical comparison using SURFER

UW MM5



MM5 Layers (partial)	MM5 Half-Sigma Level	MMIF ZFACE (m)
23	.5800	3874
22	.6200	
21	.6600	
20	.6950	
19	.7250	2369
18	.7550	
17	.7850	
16	.8150	
15	.8450	1317
14	.8700	
13	.8900	
12	.9050	753
11	.9150	
10	.9250	
9	.9350	
8	.9450	445
7	.9550	
6	.9650	294
5	.9750	
4	.9825	146
3	.9875	109
2	.9925	73
1	.9975	20

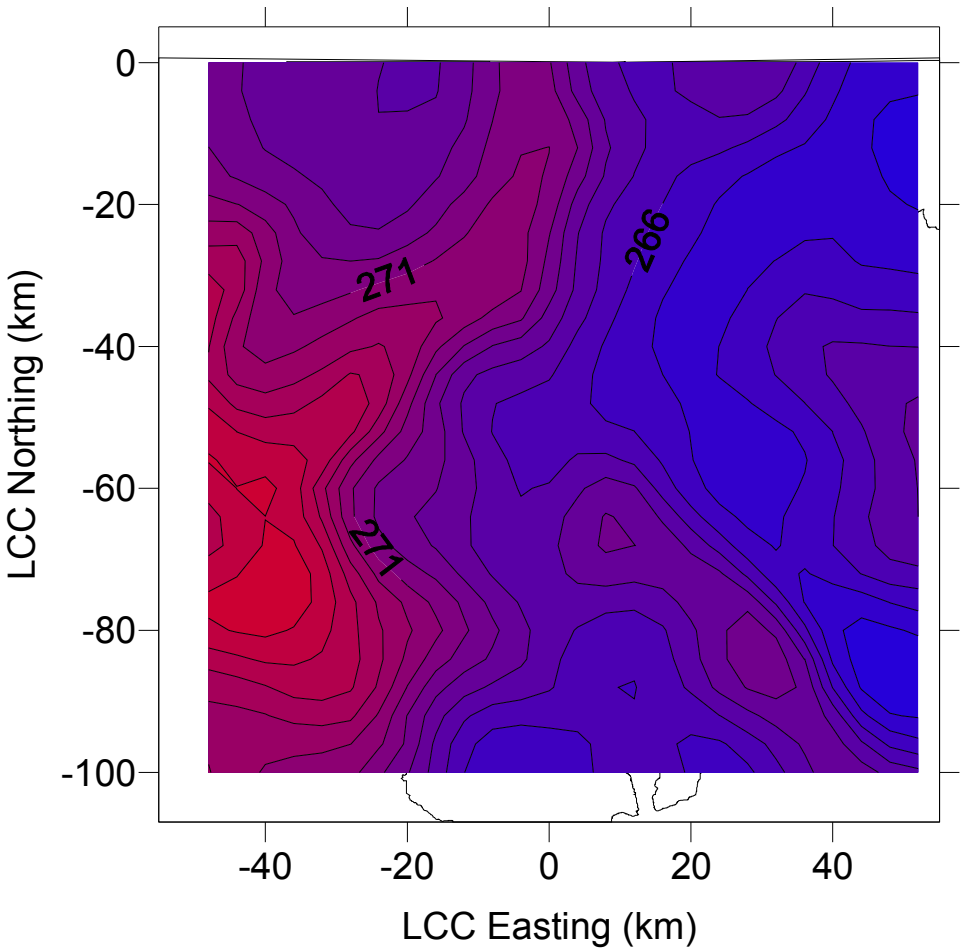
UW MM5
10-m Winds from MMIF vs. CALMM5/CALMET

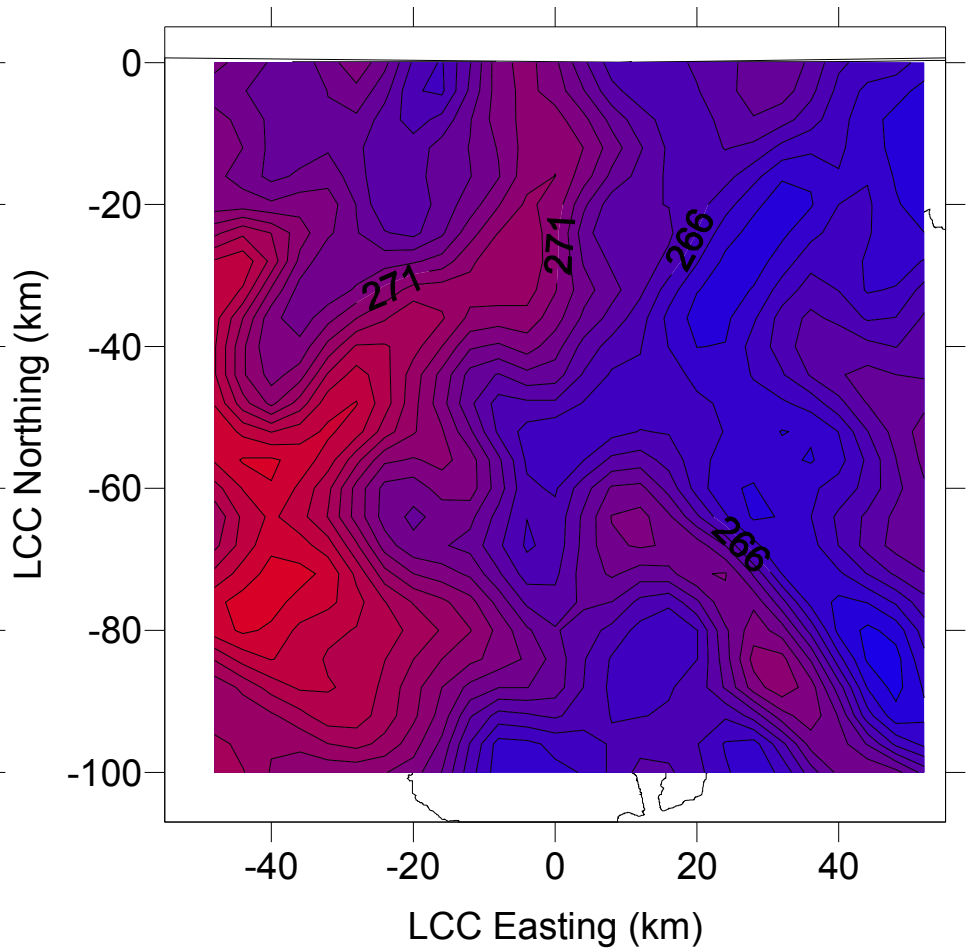


UW MM5

CALMET 10-m Temp

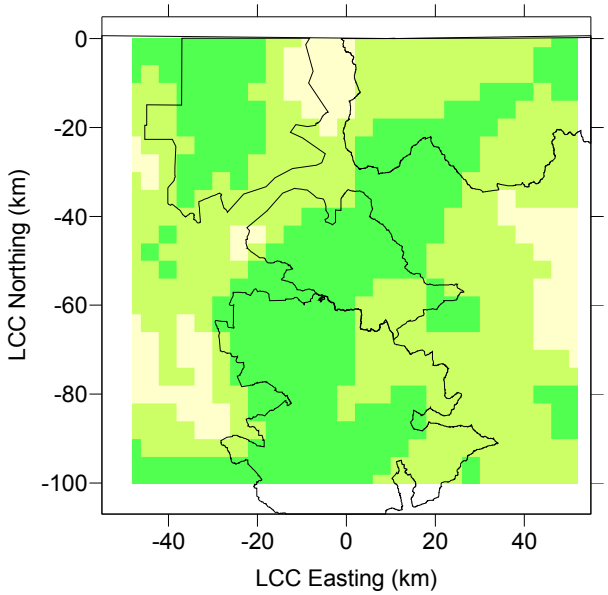
MMIF 10-m Temp





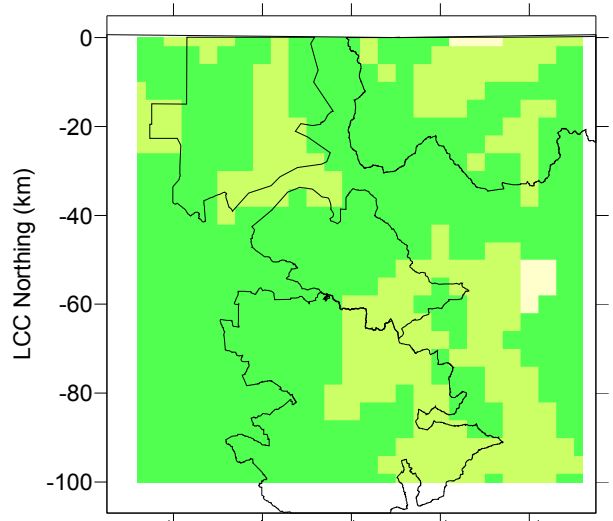
UW MM5

CALMET PG

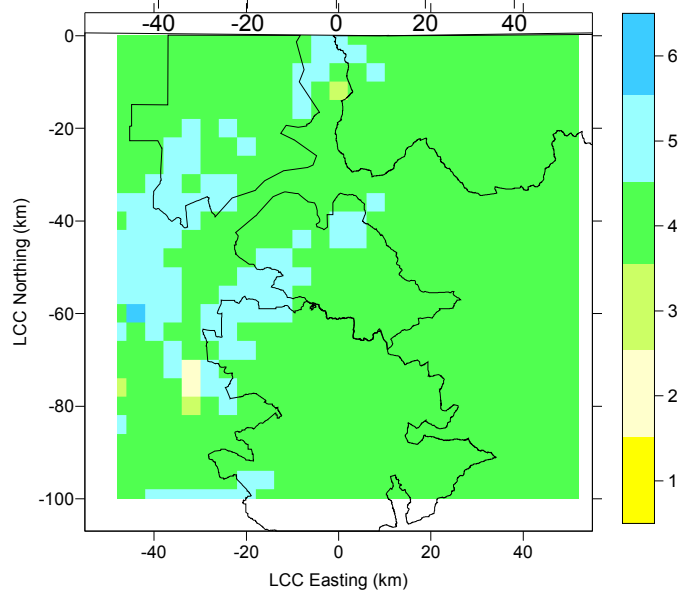


MMIF PG

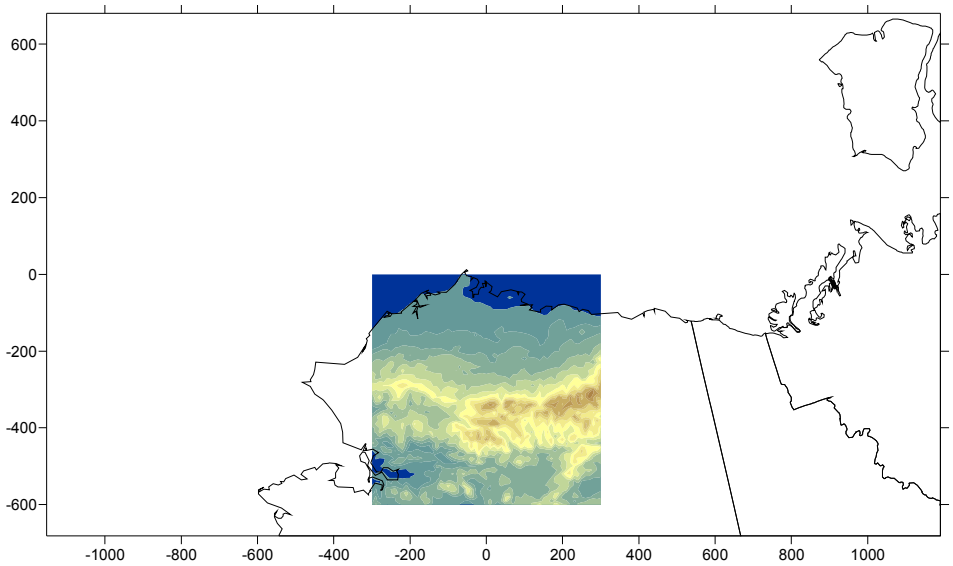
SRDT



LTOPG

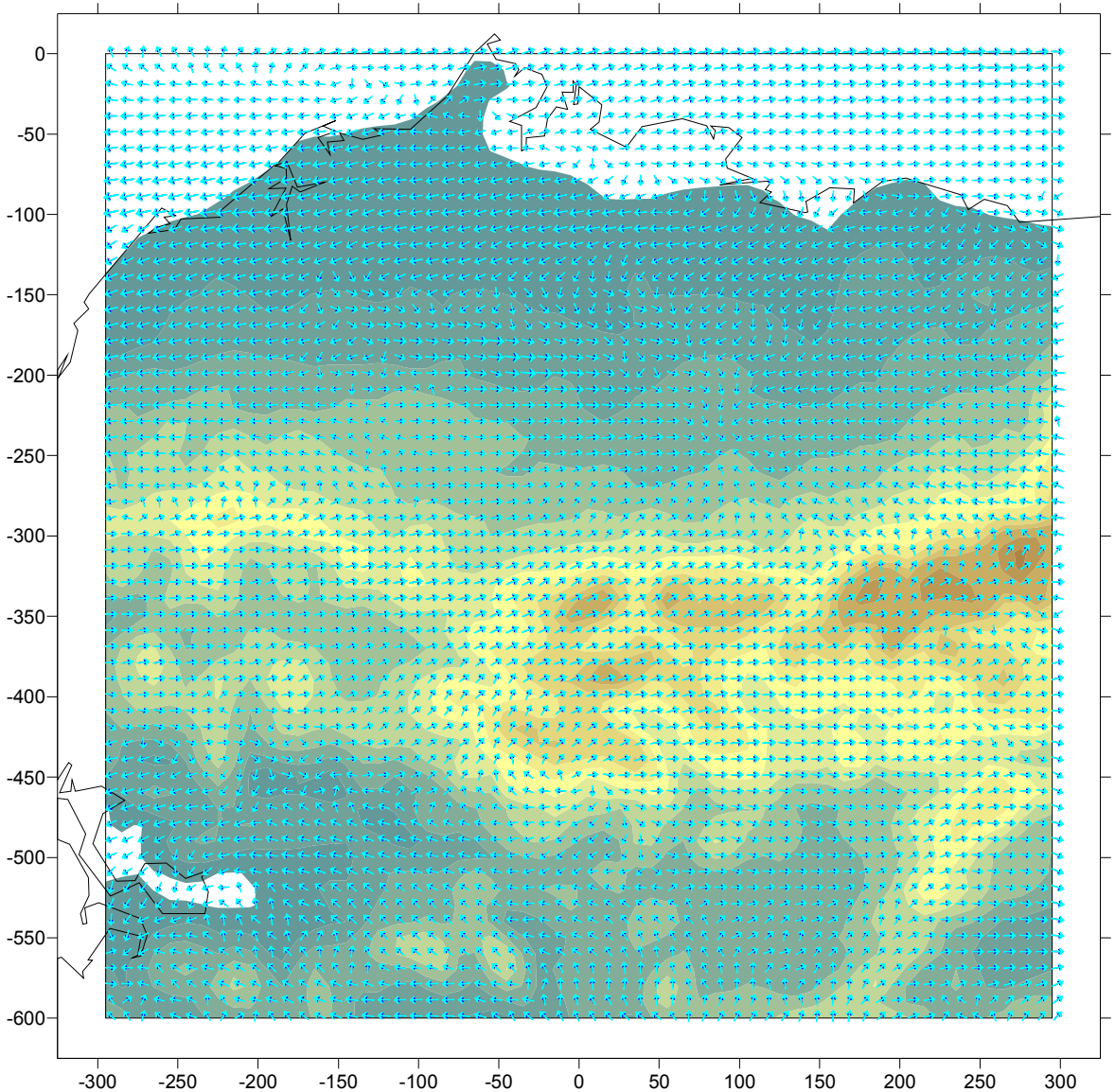


UAF WRFv2

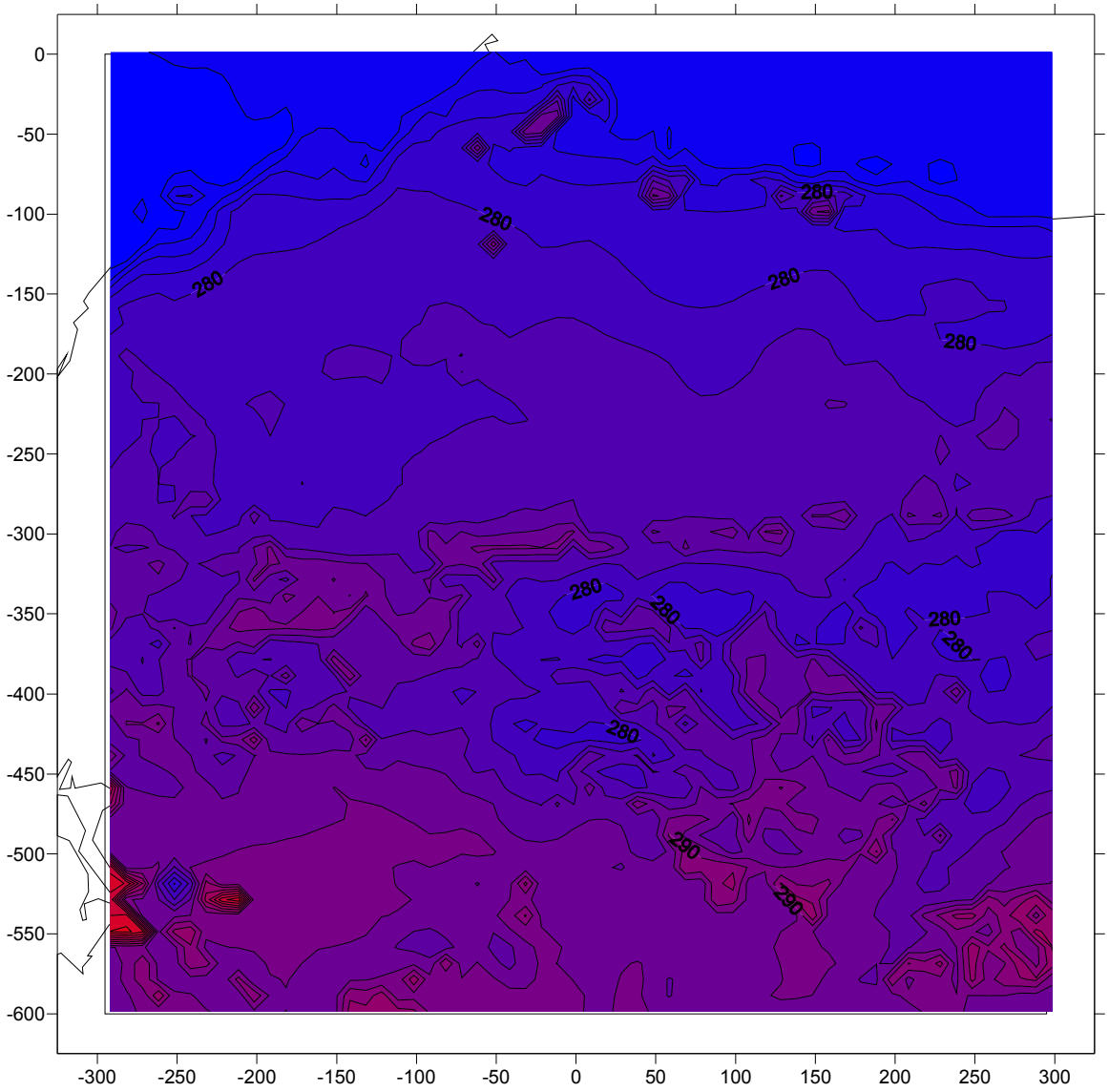


WRF Layers (partial)	WRF Half-Sigma Level	MMIF ZFACE (m)
26	0.548	4331
25	0.577	
24	0.607	
23	0.637	
22	0.668	
21	0.696	2712
20	0.724	
19	0.75	
18	0.775	
17	0.799	
16	0.821	1527
15	0.842	
14	0.861	
13	0.875	1016
12	0.885	
11	0.895	
10	0.905	
9	0.915	691
8	0.925	
7	0.935	532
6	0.945	
5	0.955	376
4	0.965	
3	0.975	223
2	0.985	148
1	0.995	74
		20

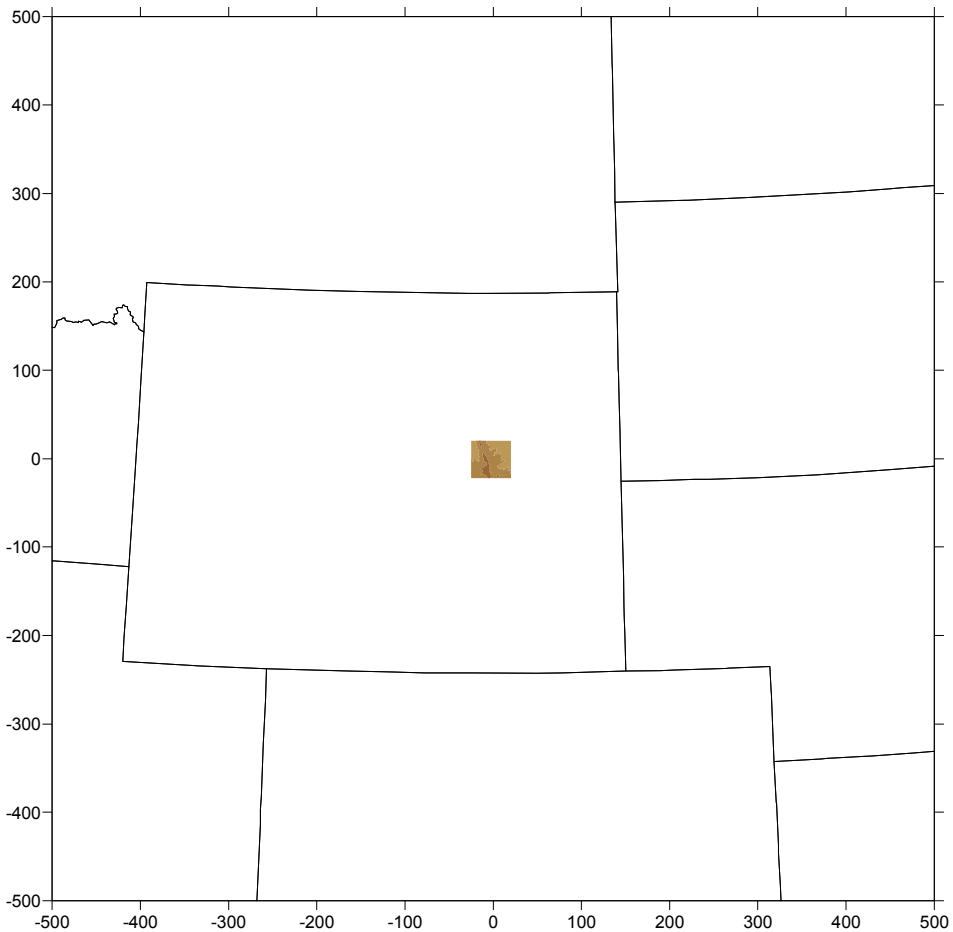
UAF WRFv2
Winds on Linux vs. Windows



UAF WRFv2
Temperature on Linux vs. Windows

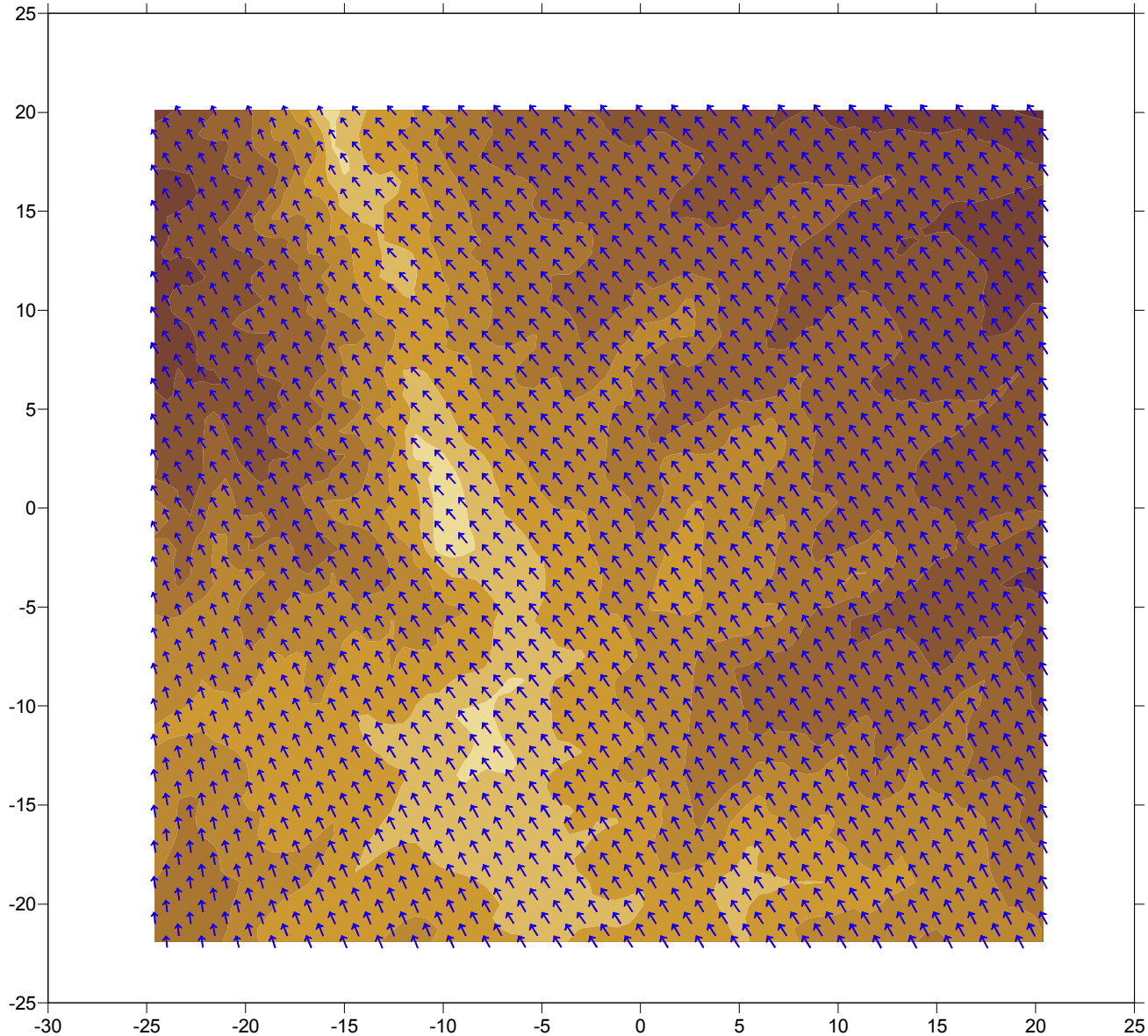


3TIER WRFv3



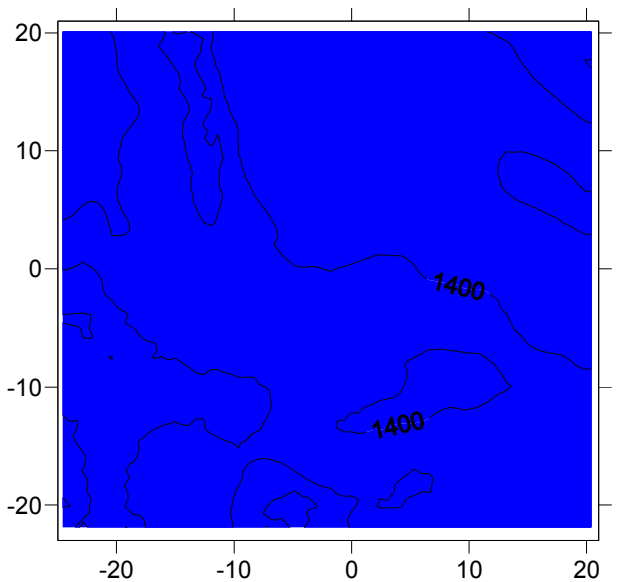
WRF Layer (partial)	WRF Half-Sigma Level	MMIF ZFACE (m)
17	0.5730	4363
16	0.6175	
15	0.6595	3334
14	0.6990	
13	0.7355	
12	0.7695	2155
11	0.8010	
10	0.8300	1557
9	0.8565	
8	0.8805	1082
7	0.9025	
6	0.9230	706
5	0.9415	
4	0.9580	401
3	0.9730	271
2	0.9865	159
1	0.9965	55
		20

3TIER WRFv3
Winds from MMIF vs. CALWRF/CALMET



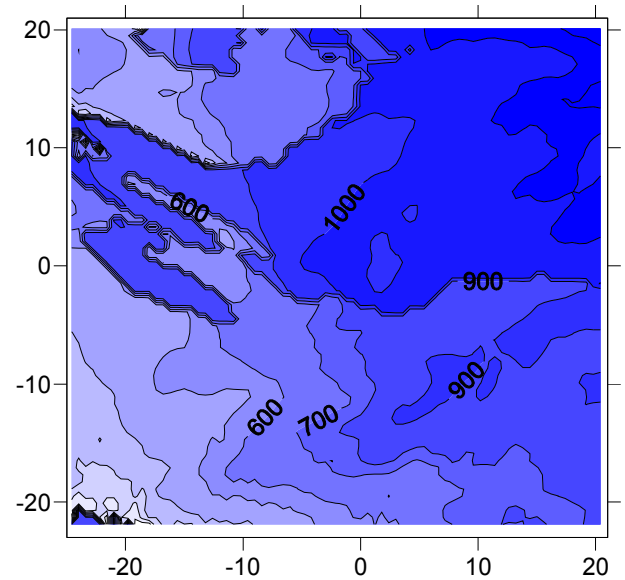
3TIER WRFv3

CALMET PBL

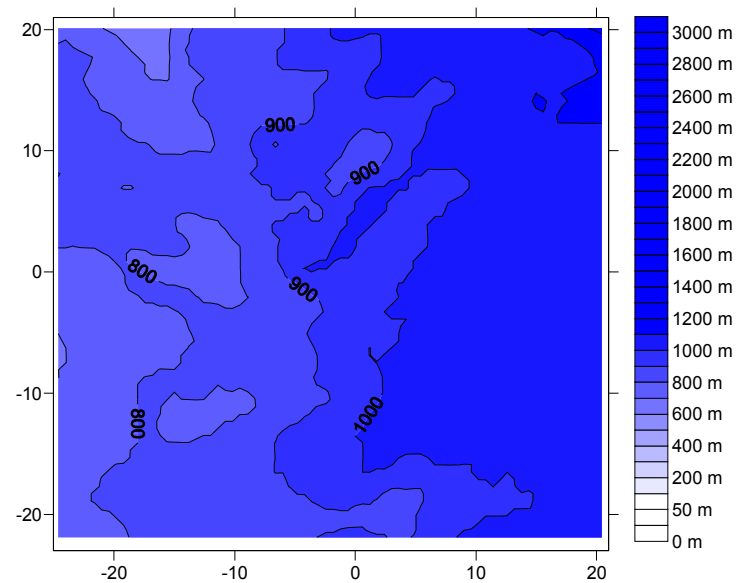


MMIF PBL

Pass-Through



Re-diagnosed



Summary

- Preliminary testing with MMIF:
  - Consistent results between Linux and Windows
  - Consistent results for winds between MMIF and CALMET
  - Similar results for temperature and precip between MMIF and CALMET
  - Different results for diagnosed values between MMIF and CALMET
    - PG stability
    - PBL depth