

WRAP Alaska Modeling for Regional Haze at Class I Areas

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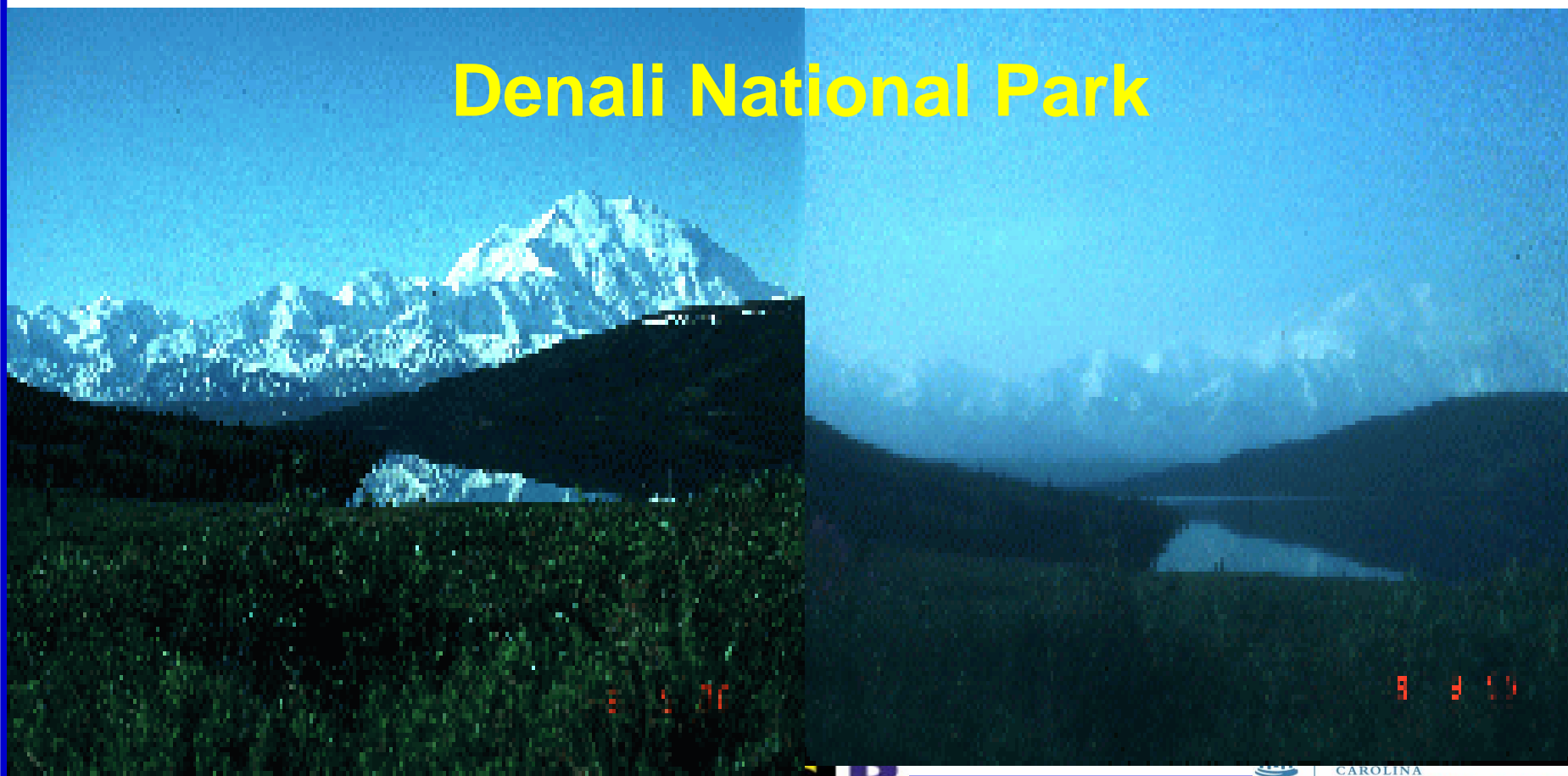
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University of North Dakota

Alaska Regional Haze Technical Analysis Meeting
April 26-28, 2005
Anchorage, Alaska

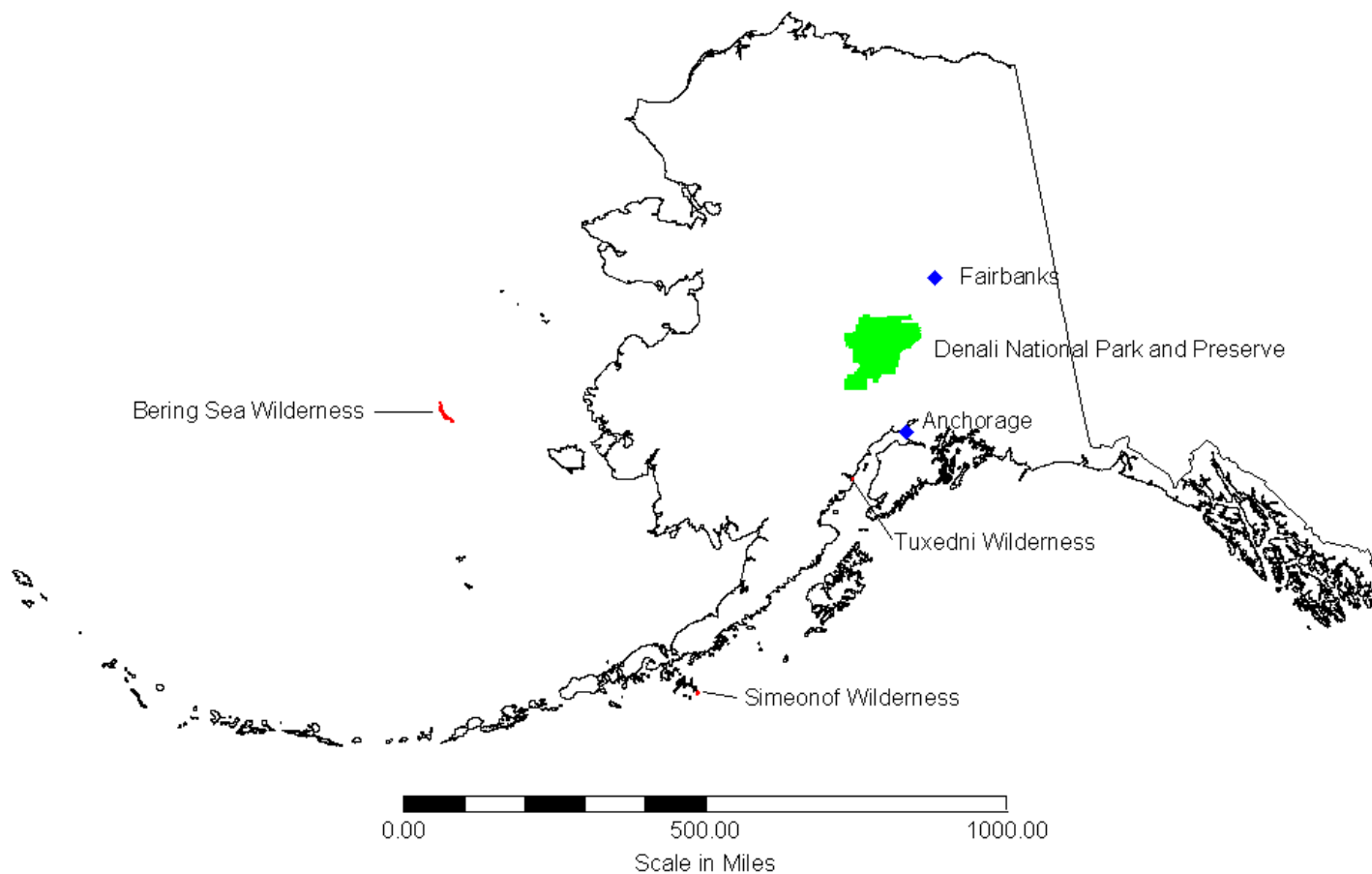
Why Visibility Class I areas

- Scenic Beauty
- Air Quality Benefits
- Indicator of Other Adverse Environmental Impacts

Denali National Park



Four Class I Areas in Alaska



- Denali National Park and Preserve
 - > 6 million acres in central Alaska; Elevations from 800 ft to 20,320 ft (Mt. McKinley); DENA1 IMPROVE monitor 125 km northwest of Mt. McKinley (i.e., closer to Fairbanks)
- Tuxedni Wilderness Area
 - Northwest edge of the Cook inlet southeast of Anchorage; TUXE1 IMPROVE site 1 km inland
- Simeonof Wilderness
 - Aleutian Islands ~93 km southeast of mainland Alaska; SIME1 IMPROVE site is ~95 km northwest of the Simeonof Wilderness Area
- Bering Sea Wilderness Area
 - 81,340 acres ~375 km east of mainland Alaska; Very remote, no nearby IMPROVE sites (SIME1 most representative)

Denali National Park -- 2002

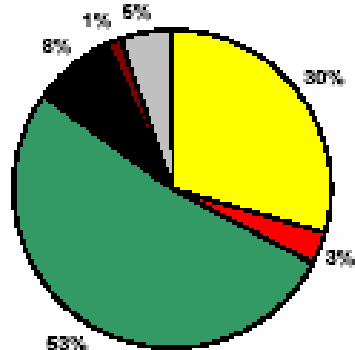
W20% days: 53% OC; 30% SO4; 8% EC

B20% Days: 55% SO4; 14% CM; 12% OC

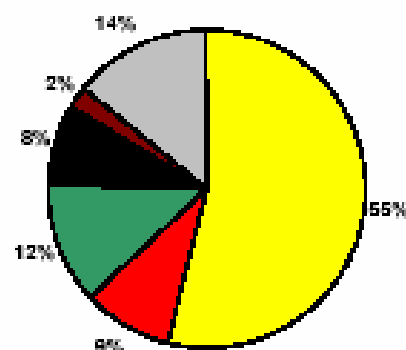
MONITORING DATA

Denali National Park and Preserve, AK
 2002 Reconstructed Extinction
 DENA1 Monitoring Data (every third day)

20% Worst Visibility Days
 Aerosol Extinction* = 26 Mm⁻¹ (10 to 151 Mm⁻¹)



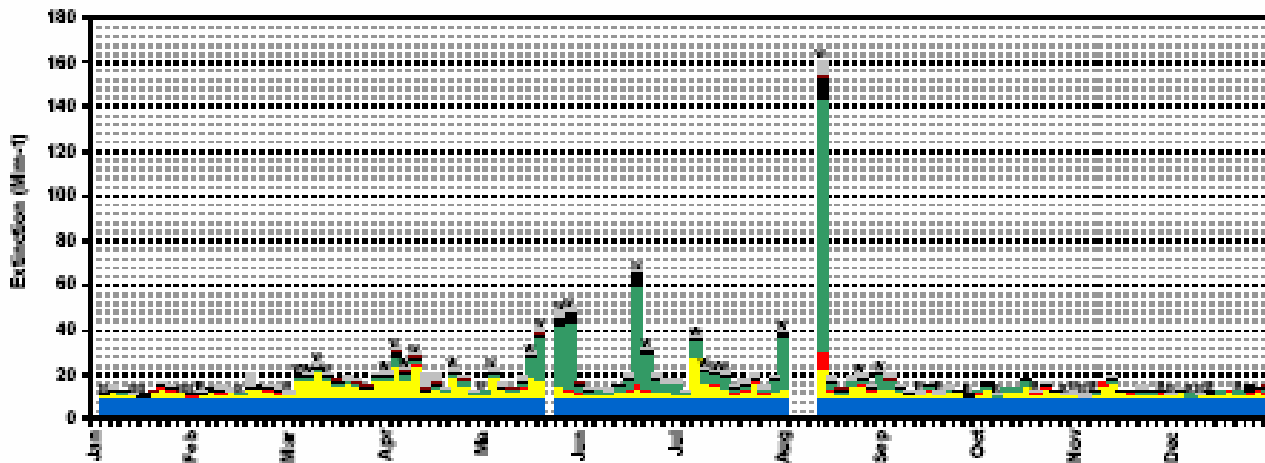
20% Best Visibility Days
 Aerosol Extinction* = 2 Mm⁻¹ (1 to 3 Mm⁻¹)



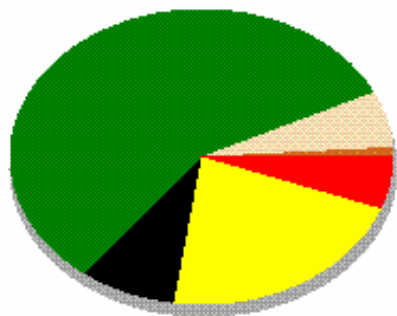
- Coarse Material
- Soil
- Elemental Carbon
- Organic Material
- Ammonium Nitrate
- Ammonium Sulfate
- Rayleigh

*Excludes Rayleigh Extinction

W20% days look like dominated by fire impacts (high EC/OC)

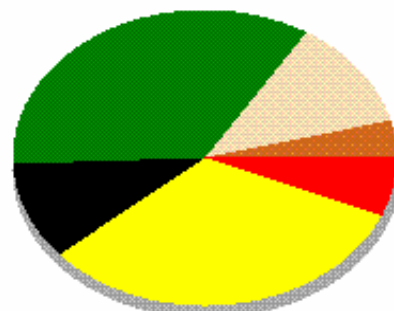


DENA1 2000 Worst 20% Available Species best Composition

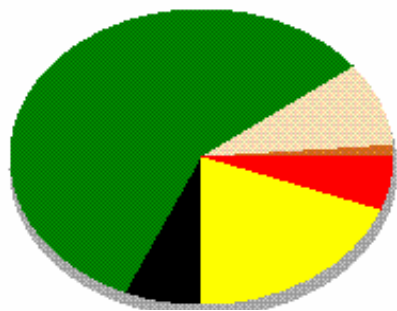


ammNO3f_bext	1.08 Mm-1	4.5 %
ammSO4f_bext	5.60 Mm-1	23.5 %
ECf_bext	2.25 Mm-1	9.4 %
OMCf_bext	13.6 Mm-1	56.8 %
CM_bext	1.18 Mm-1	4.9 %
SOILf_bext	0.20 Mm-1	0.8 %
Total: 23.9 Mm-1		

DENA1 2001 Worst

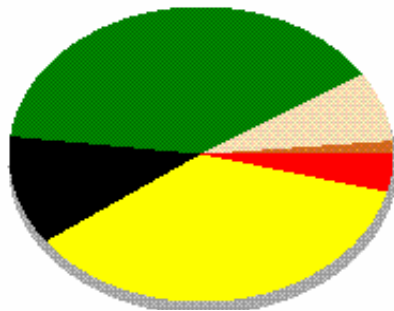


DENA1 2002 Worst 20% Available Species best Composition

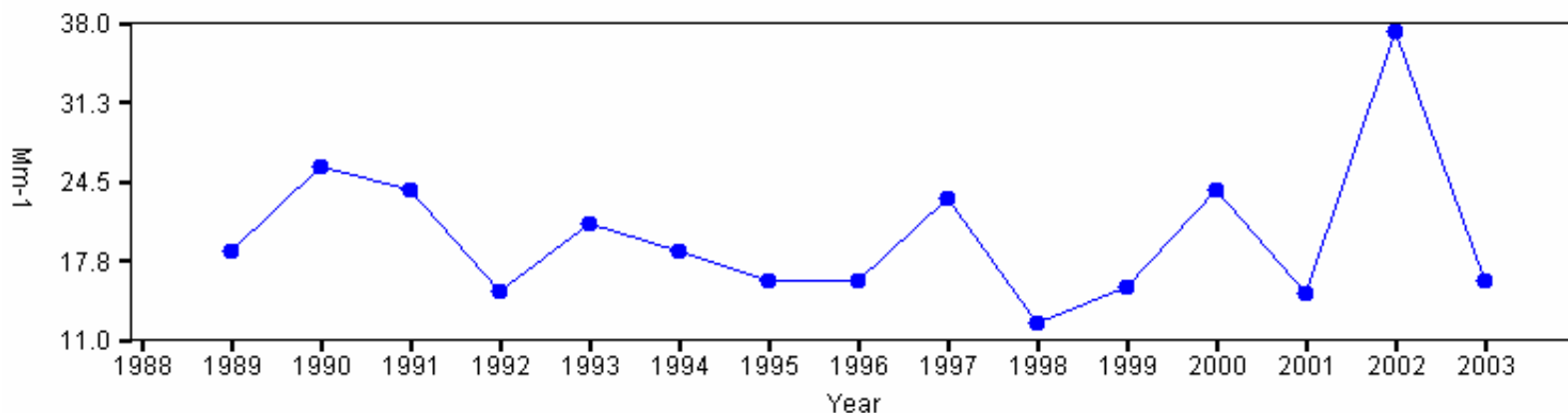


ammNO3f_bext	1.73 Mm-1	4.6 %
ammSO4f_bext	7.62 Mm-1	20.4 %
ECf_bext	2.99 Mm-1	8.0 %
OMCf_bext	21.7 Mm-1	58.3 %
CM_bext	2.84 Mm-1	7.6 %
SOILf_bext	0.38 Mm-1	1.0 %
Total: 37.3 Mm-1		

DENA1 2003 \



Denali NP



• aerosol_bext (ANN, 1YR, G90)

Tuxedni Wilderness Area

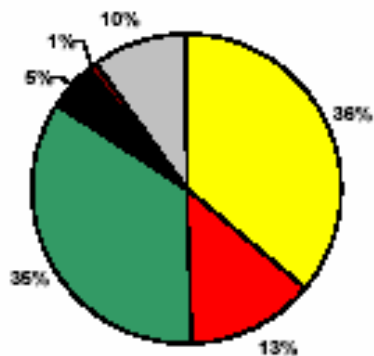
W20% days: 36% SO₄; 35% OC; 13% NO₃; 10% CM

B20% Days: 48% SO₄; 17% CM; 16% OC; 13% NO₃

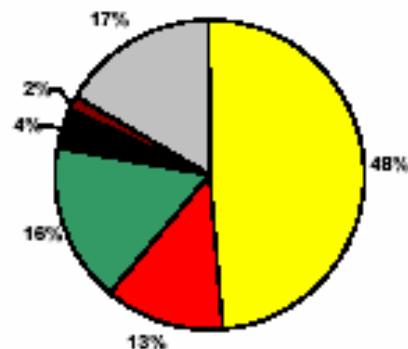
MONITORING DATA

Tuxedni Wilderness Area, AK
2002 Reconstructed Extinction
TUXE1 Monitoring Data (every third day)

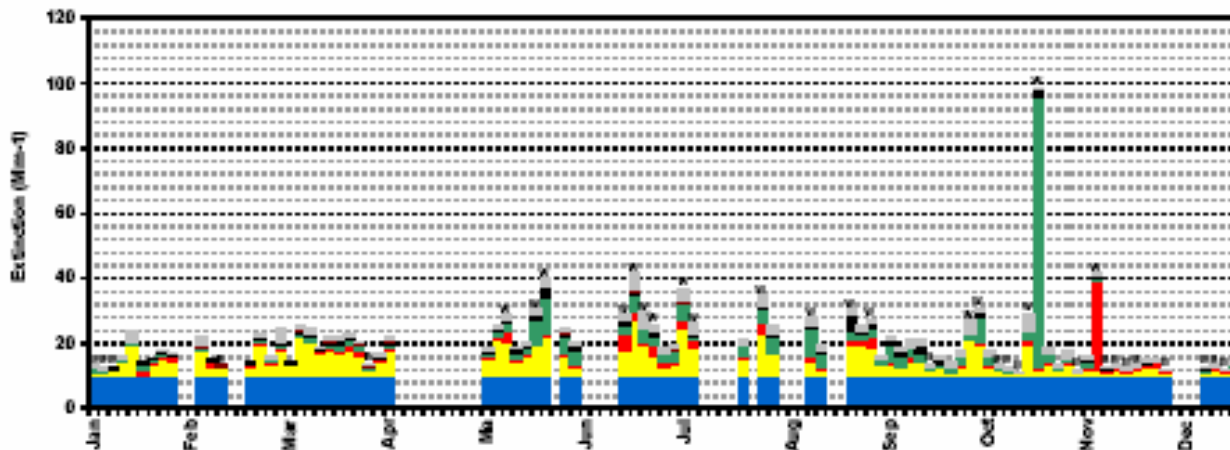
20% Worst Visibility Days
Aerosol Extinction* = 25 Mm⁻¹ (16 to 88 Mm⁻¹)



20% Best Visibility Days
Aerosol Extinction* = 3 Mm⁻¹ (1 to 4 Mm⁻¹)



*Excludes Rayleigh Extinction



Simeonof Wilderness Area

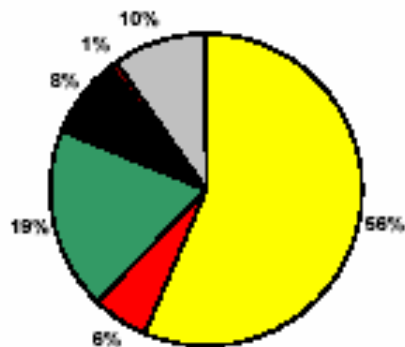
MONITORING DATA

Simeonof Wilderness Area, AK
 2002 Reconstructed Extinction
 SIME1 Monitoring Data (every third day)

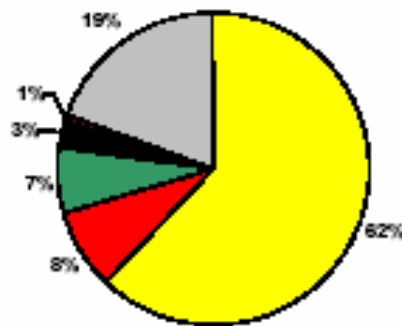
W20% days: 56% SO₄; 19% OC; 13%; 10% CM; 8% EC

B20% Days: 62% SO₄; 19% CM; 8% NO₃; 7% OC

20% Worst Visibility Days
 Aerosol Extinction* = 37 Mm⁻¹ (29 to 70 Mm⁻¹)



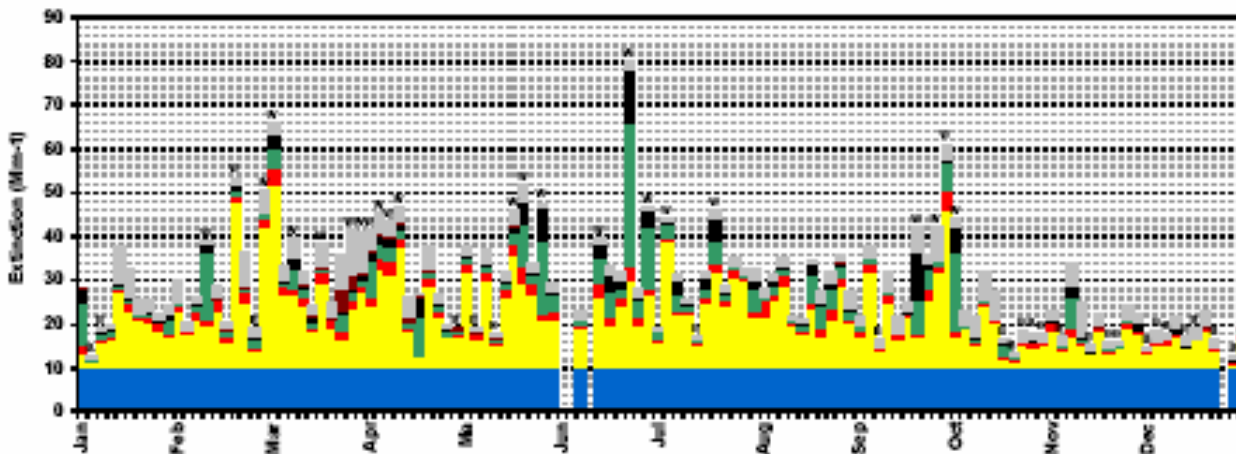
20% Best Visibility Days
 Aerosol Extinction* = 7 Mm⁻¹ (3 to 9 Mm⁻¹)



Legend:
 Coarse Material (Grey)
 Soil (Red)
 Elemental Carbon (Black)
 Organic Material (Green)
 Ammonium Nitrate (Red)
 Ammonium Sulfate (Yellow)
 Rayleigh (Blue)

*Excludes Rayleigh Extinction

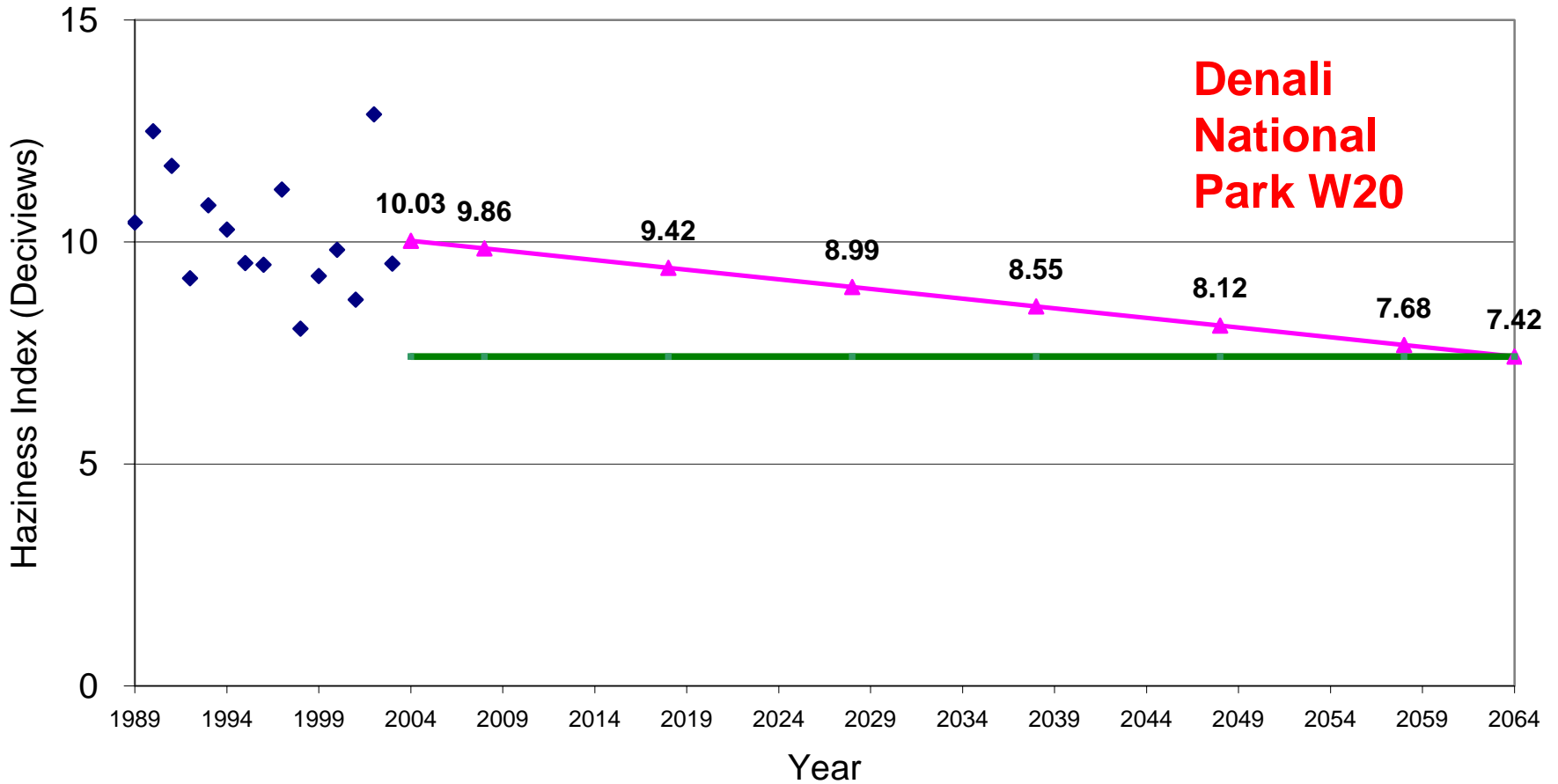
Also represents Bering Sea



Regional Haze Rule Requirements (1)

- Protection of visibility at the 156 “mandatory Federal Class I areas” (Sections 169A&B of CAA)
- Visibility goal of “natural conditions” (no man-made impairment) by 2064
- Reasonable progress goals for improving visibility at Class I areas are as follows:
 - **Improve visibility for the Worst 20% days**
 - **No degradation in visibility for the Best 20% days**
- First visibility SIP due December 17, 2007 to demonstrate visibility progress in 2018 toward natural conditions – progress demonstrated using air quality simulation models plus WOE

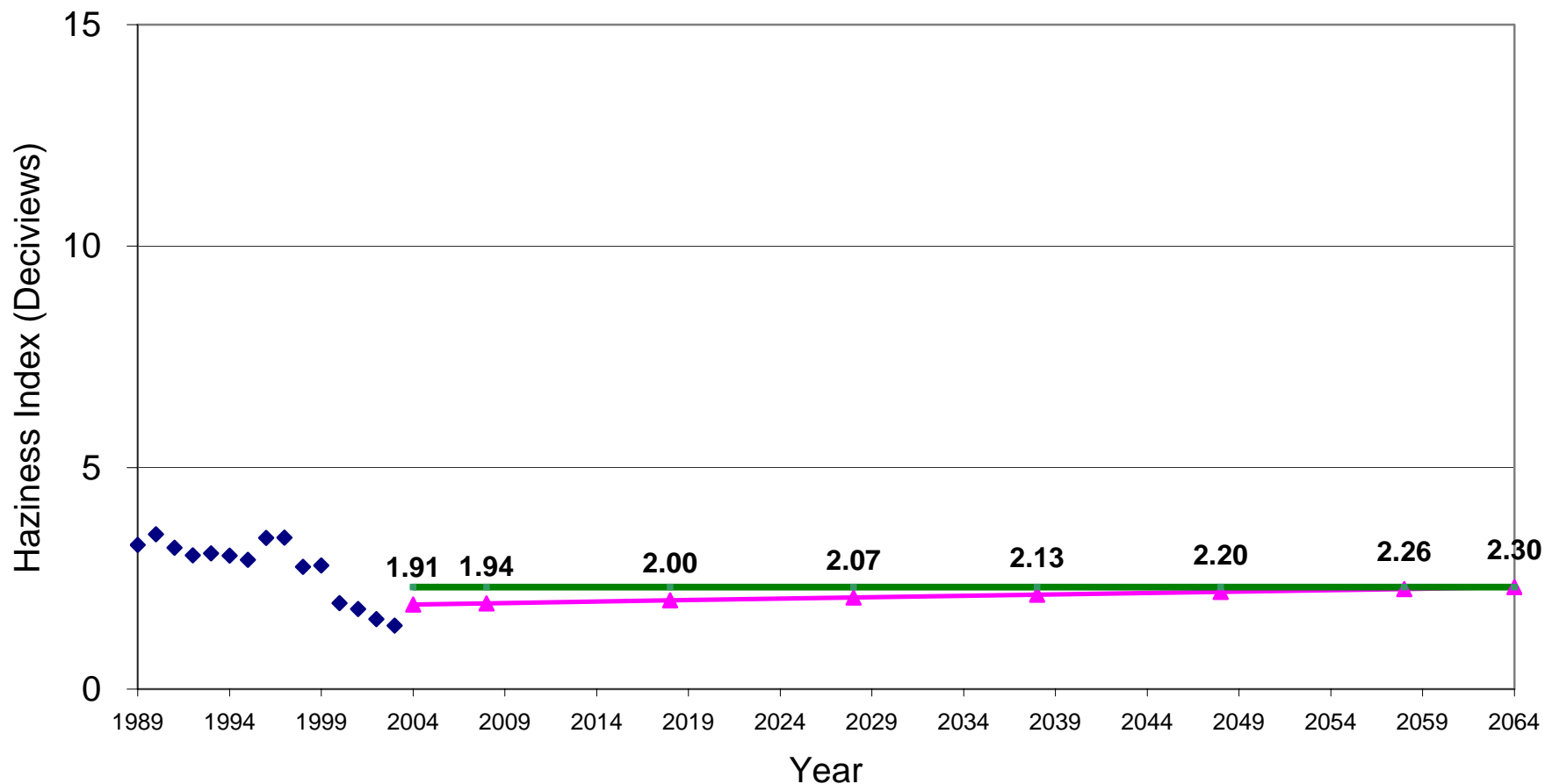
Linear Glide Path to Natural Conditions in 2064 for Worst 20% Days Observed 5-Year (1999-2003) Visibility Worst 20% Days = 10.03 dv Linear Glide Path Target at 2018 = 9.42 dv Need 0.61 dv Reduction by 2018 to Meet Target



▲ Glide Path — Natural Condition (Worst Days) ◆ Observation

Denali National Park Best 20% Days (B20)

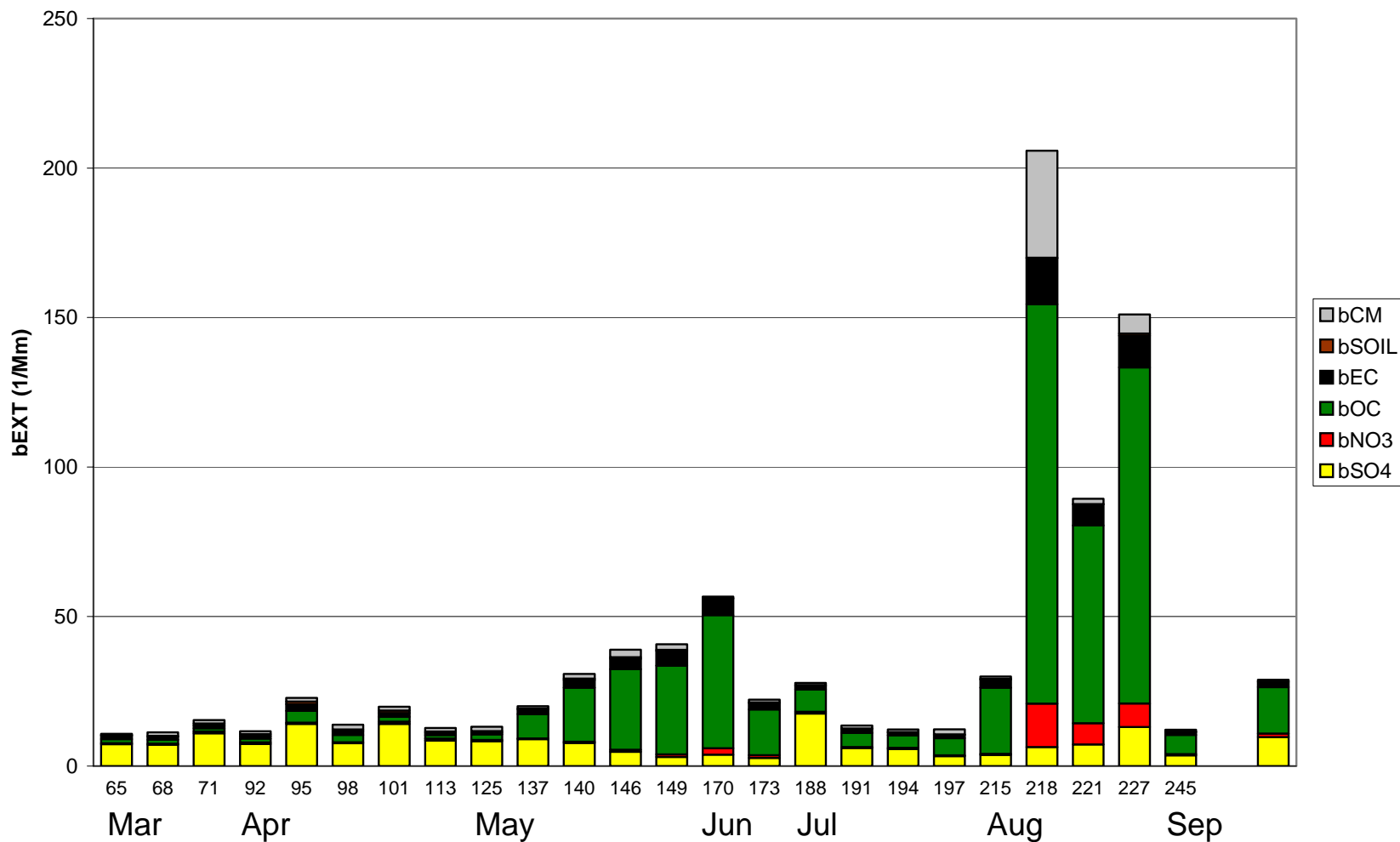
Current 5-Year Average for B20 Days (1.91 dv) lower than EPA default natural conditions for best days (2.30 dv)



◆ Observation ▲ Glide Path — Natural Condition (Best Days)

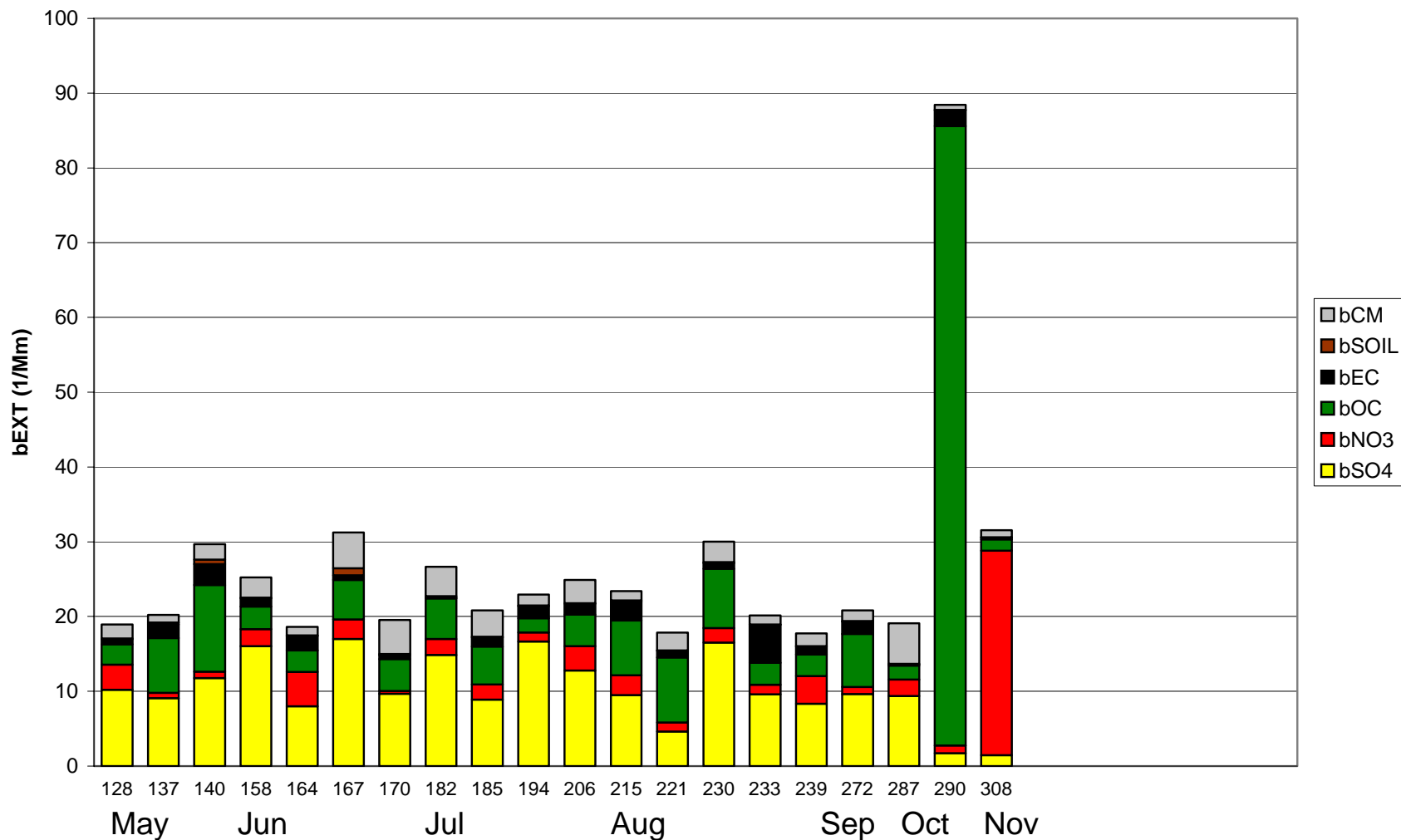
Denali National Park – Worst 20% Days during 2002

Worst 20% Obs during 2002 at DENA1



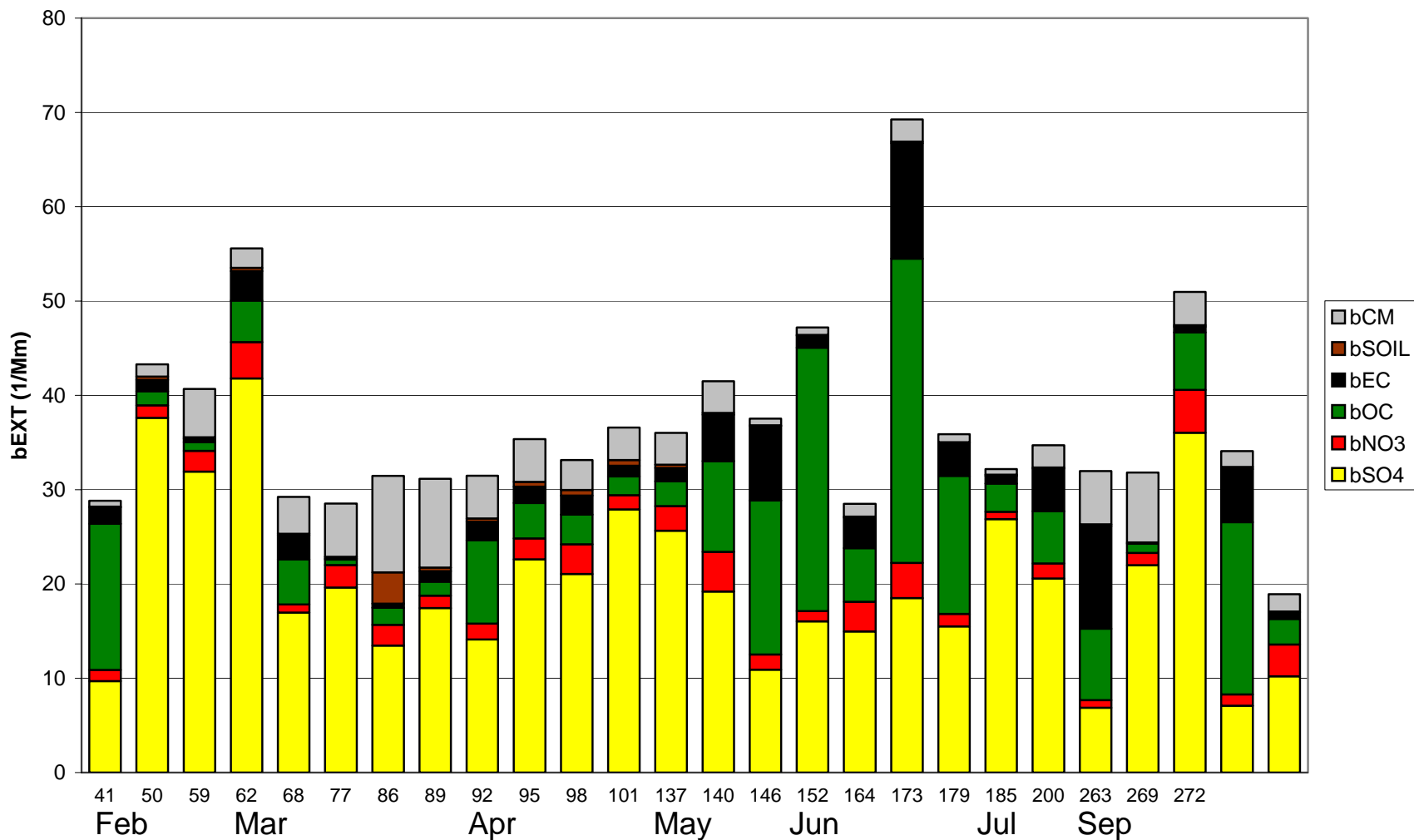
Tuxedni Wilderness Area – Worst 20% Days during 2002

Worst 20% Obs during 2002 at TUXE1



Simenof Wilderness Area – Worst 20% Days during 2002

Worst 20% Obs during 2002 at SIME1



Regional Haze Rule Requirements (2)

- **Section 169A of the Regional Haze Rule:**

- Each implementation plan must contain measures necessary to make reasonable progress toward meeting the national visibility goal, including...
 - (1) ...each major stationary source (in existence in 1977, but not in operation in 1962) which **may reasonably be anticipated to cause or contribute to any impairment of visibility** in any Class I area shall procure, install and operate the **best available retrofit technology – BART**

Regional Haze Rule Requirements (3)

- **Section 169B of the Regional Haze Rule:**
 - As part of the Reasonable Progress SIP should include a regional control strategy for all point sources
 - Alaska will need to evaluate the need for a point source control strategy for all point sources in Alaska

Proposed RHR Guidelines for BART

- Two modeling roles in EPA's May 2004 proposed BART Rule (Final Rule delayed to June 15, 2005):
 1. **Does a potential BART-eligible source contribute to visibility impairment at a Class I area**
 - Visibility impacts of > 0.5 deciview (dV)
 2. **What is degree of visibility improvement at Class I areas due to BART controls**
- Once a facility is BART-eligible, then all visibility precursor species must be considered (SO_x, NO_x, PM and VOC)
 - For most sources, SO₄ and NO₃ will be primary pollutants of interest (i.e., SO_x and NO_x emissions)
- Court decisions imply must trace visibility impacts at Class I areas back to individual source

Overview of Alaska Modeling

- MM5 meteorological modeling 45/15 km
 - What meteorological modeling skill can we obtain for Alaska?
- CALMET/CALPUFF Dispersion Modeling
 - Limited emissions information (not all sources)
 - Anchorage, Fairbanks and Juneau
 - Major Point Sources
 - Mobile sources (on-road, some non-road (railroads))
 - Preliminary Modeling to examine source/receptor relationships, local impacts and test ability to perform air quality modeling in Alaska
 - Are modeling results reasonable?
 - Not full-scale quantitative evaluation

WRAP Alaska Modeling

- **MM5 modeling to support regional haze modeling for year 2002**
- **The State of Alaska is working to develop a statewide emissions inventory**
- **Premature to do photochemical modeling with 3-D photochemical grid models (e.g., CMAQ and CAMx) as is being done in lower 48 states**
- **MM5 will supply meteorological fields to CALPUFF**
 - **Will use for BART modeling and as part of the 2007 SIP**

Challenges for Met Modeling of Alaska

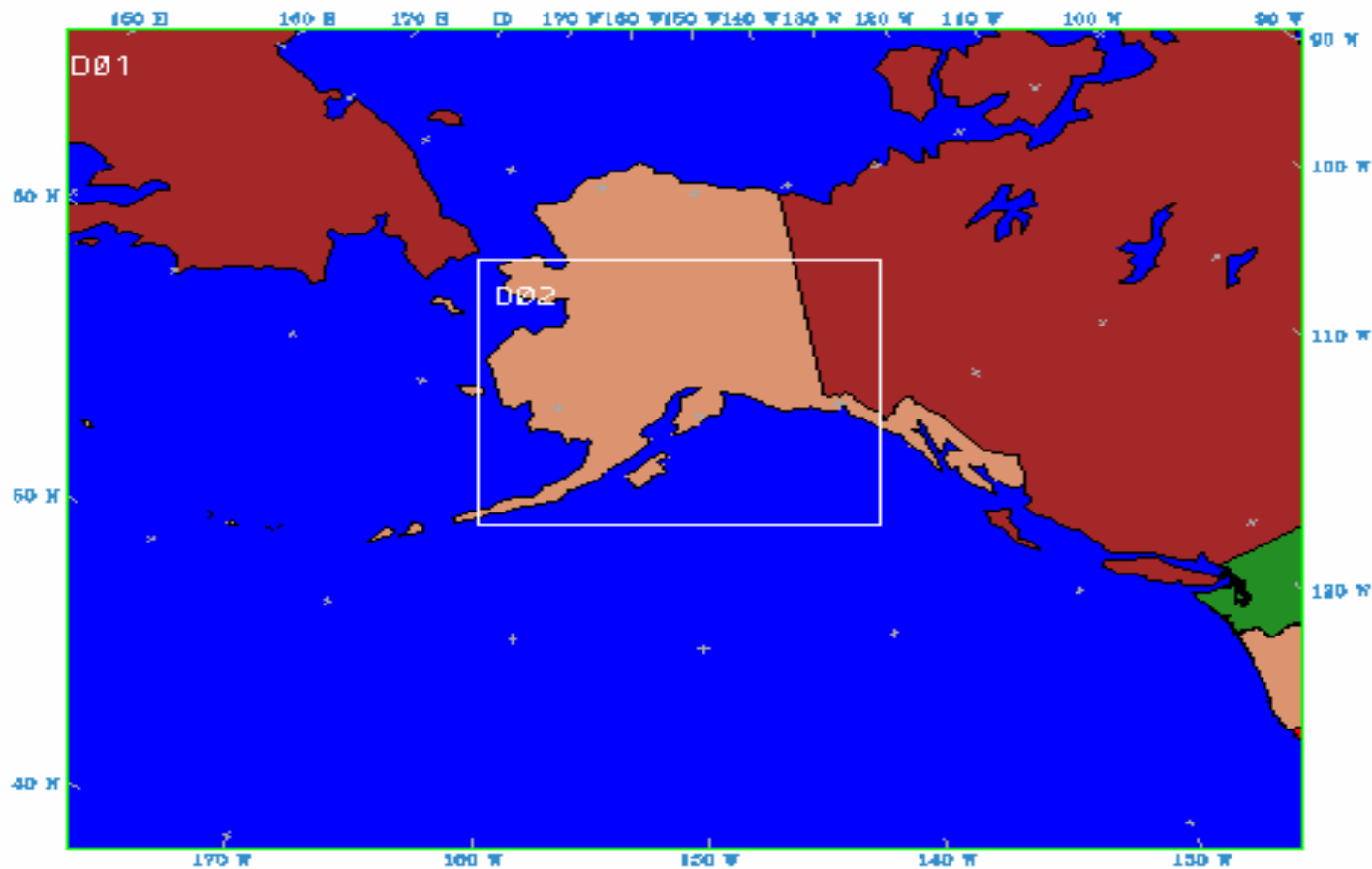
- Dark, cold, and very dry in winter
- Interactions between sea ice and the air not well understood. Sea ice breakup and formation.
- In the dark, ice and snow undergo strong radiative cooling, which can set up a strong temperature inversion near the surface
 - This creates an extremely stable boundary layer which can decouple from the flow aloft.
 - It is therefore possible to have air masses with different origins and properties superimposed in the vertical.
- **MM5 does not simulate boundary layer inversions well**

Challenges for Met Modeling of Alaska

(concluded)

- **The MM5 modeled temperature fields are very sensitive to the cloud field; some Arctic clouds have unusual properties.**
 - diamond dust
 - multiple layers of thin cloud
 - convective plumes over gaps in sea ice
- **Alaska is so cold in winter that the some of the physical assumptions underpinning MM5 parameterizations of moist processes may no longer be valid. POLAR option.**
- **Harsh conditions mean observing network is sparse.**

WRAP Alaska 45 km and 15 km MM5 Domains



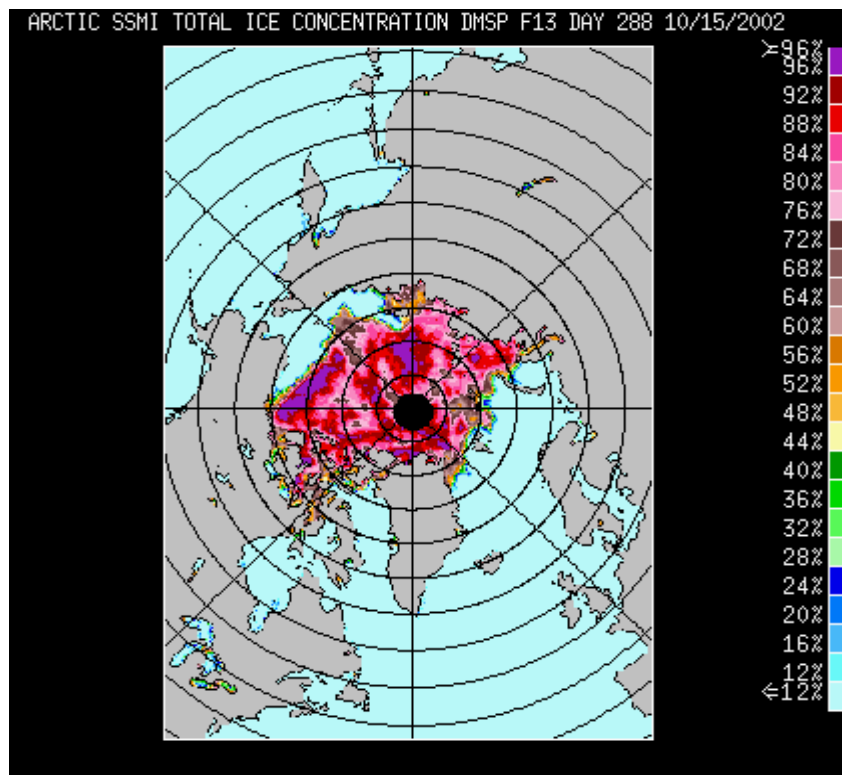
Background on MM5 Configuration for 2002 Annual Run

- WRAP MM5 configuration based on work of the Mesoscale Modeling and Applications Group at the University of Alaska Fairbanks
- The UAF Group has extensive experience with operational numerical weather prediction in high latitudes using MM5
- We started with their setup and performed sensitivity tests to find optimal configuration to support air quality modeling
 - Acknowledge contributions of Dr. Jeff Tilley

Treatment of Sea Ice

- **When modeling a full year over the Alaska domain, have to account for the annual cycle of sea ice.**
 - **Sea ice forms part of the atmosphere's lower boundary. Grows in spatial extent during fall and winter, and retreats during the spring.**
- **MM5 diagnoses sea ice fraction in a grid cell using the sea surface temperature; this option must be used during the winter months.**
- **Use of the sea ice option requires the use of the 5-layer land surface scheme. Less detailed than OSU, worse during summer.**

Timing of Sea Ice Switch On/Off



- **October 13, 2002: sea ice on**
- **May 30, 2002: sea ice off**

- Gridded sea ice concentrations from passive microwave sounders
- Data from NASA GSFC National Snow and Ice Data Center

Method for Evaluating Alaska MM5 2002 Annual 45/15 km Run

For both grids, examined:

- **Surface statistics for wind, temperature, and humidity**
-Subdomain definitions?
- **Upper air soundings of temperature, dew point, and winds**
(not shown in this presentation)
- **Precipitation**
-Gridded observations at $2.5^\circ \times 2.5^\circ$ resolution

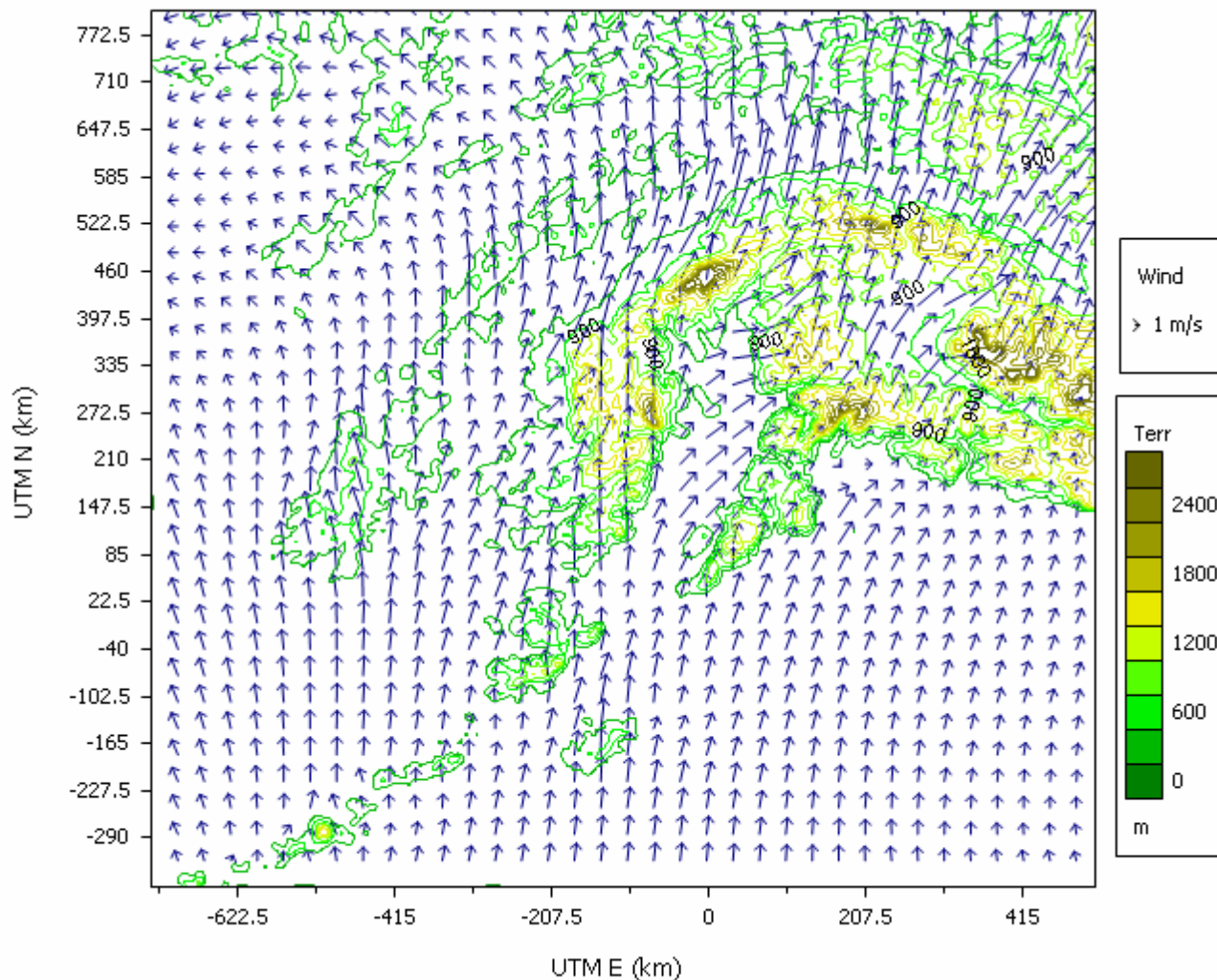
and compare with observations.

WRAP Alaska 2002 MM5 Summary

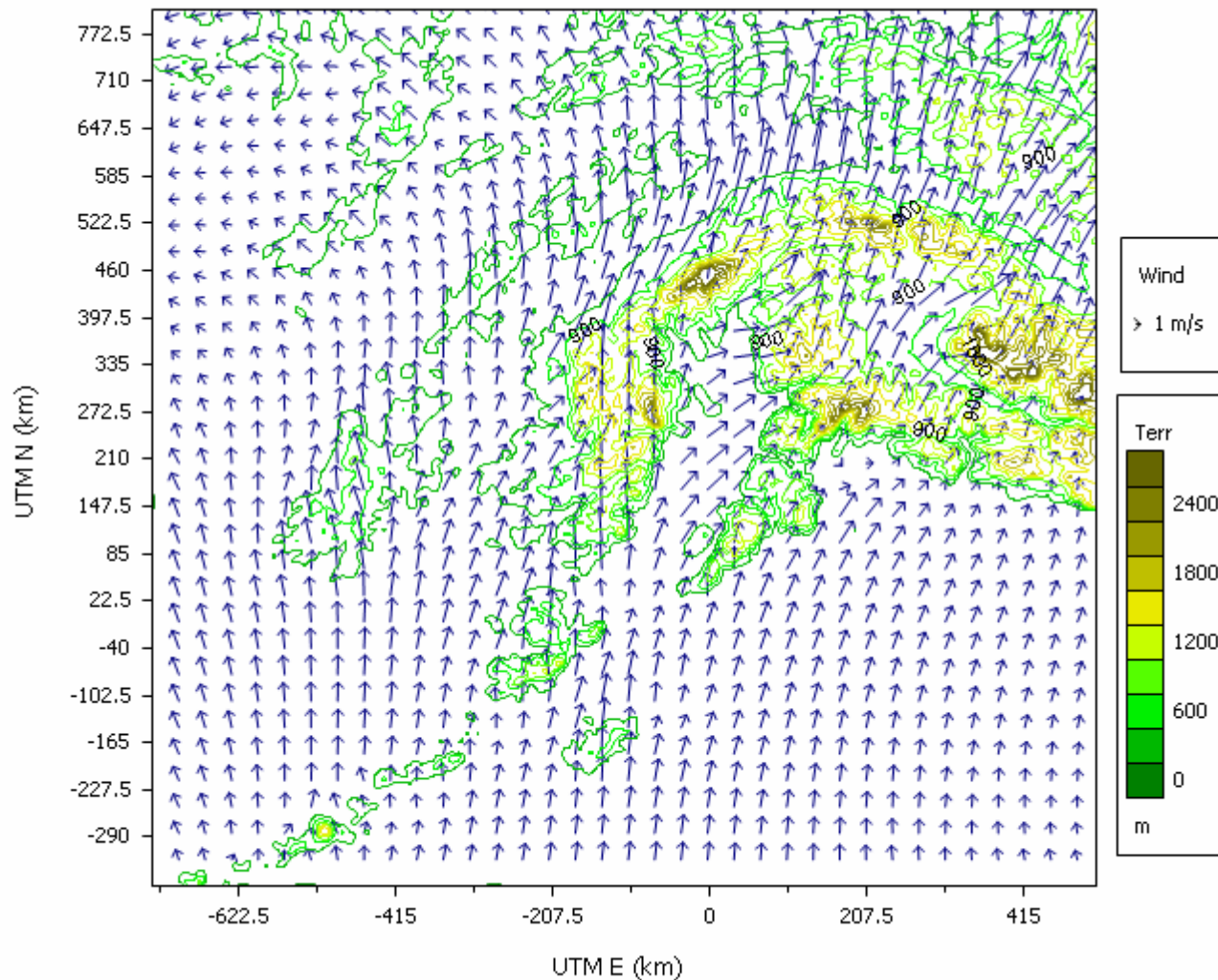
- 2002 Annual Run completed, report in preparation
 - Performance not as good as typically seen in mid-latitudes
 - Surface meteorological performance poor for temperature, good for humidity and variable for winds
 - Upper-air performance indicates difficulty of MM5 to properly characterize inversions
- Subregional MM5 performance evaluation suggests performance better in southern than northern part of State
- Details on Alaska MM5 model performance can be found at:

http://pah.cert.ucr.edu/aqm/308/meetings/March_2005/03-08_09-05.SF_CA/Alaska_Mar8-9_2005.ppt

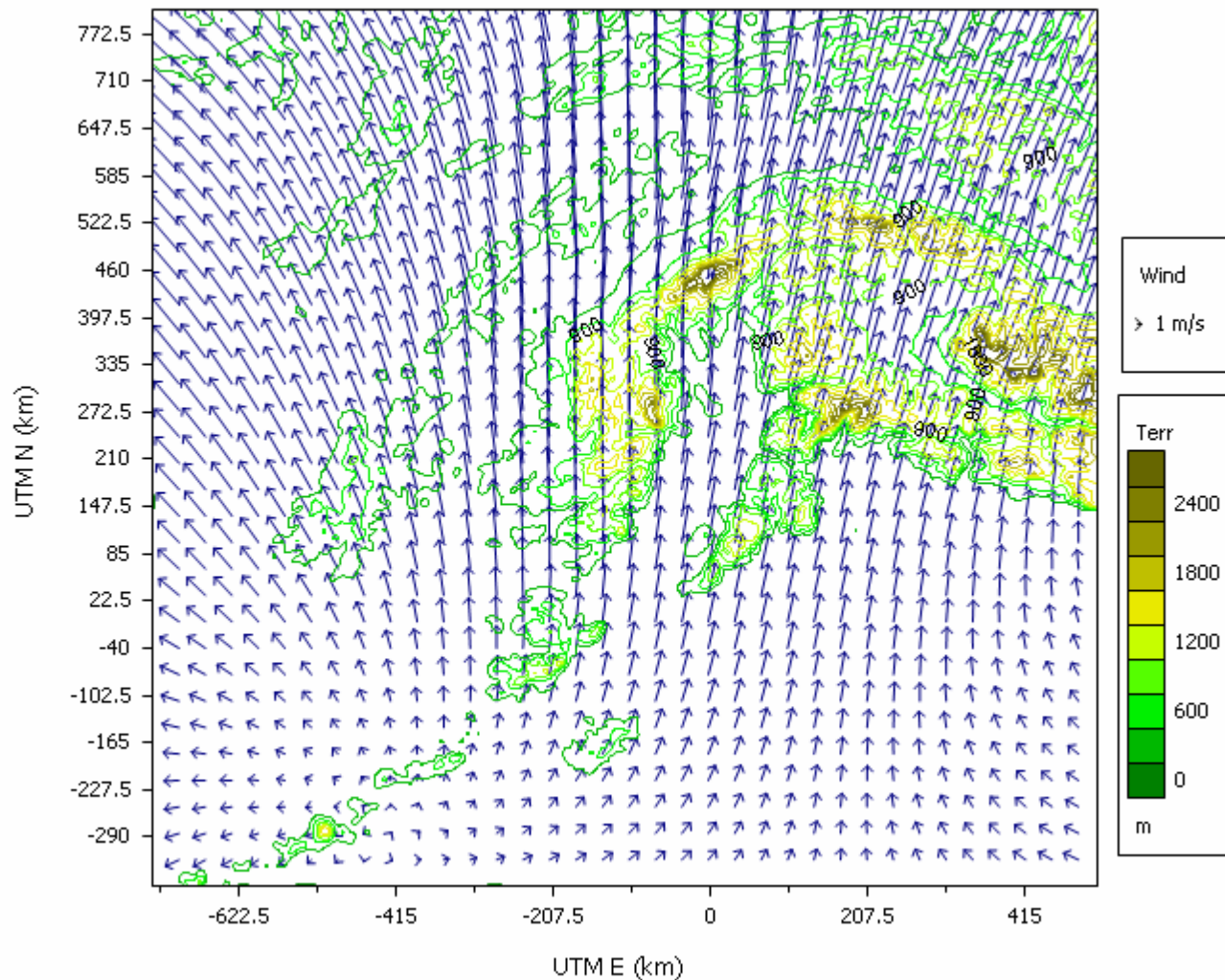
CALMET/MM5 Surface (10m AGL) Wind Field July 3, 2002 @ 00 GMT



CALMET/MM5 Surface (10m AGL) Wind Field July 3, 2002 @ 20 GMT



CALMET/MM5 Aloft (1850 m AGL) Wind Field July 3, 2002 @ 20 GMT



Alaska Air Quality Modeling (1)

- Emissions Inventory from Sierra Research
 - On-Road, Non-Road and Area sources for three major greater cities (Anchorage, Fairbanks and Juneau)
 - Major point sources across Alaska
- CALMET modeling at 5 km
 - Hourly MM5 data at 15 km
 - Operate using MM5Only flag

Alaska Air Quality Modeling (2)

- CALPUFF Modeling
 - Sulfate (SO₄), Nitrate (NO₃), Primary PM (EC, OC, PM_{2.5} and CM)
 - Qualitative Evaluation Only
 - Don't have all sources
 - Currently no fires – Under development, draft Alaska fires available
 - Focus on SO₄ and NO₃
- Will need to roll fraction of 2004 Alaska funding into 2005
- Will form basis for BART and point source modeling requirements

Alaska Air Quality Modeling (3)

- Perform 2002 CALPUFF modeling to get PM and visibility impacts at Class I Areas by major source category:
 - On-Road Mobile
 - Airport
 - Port
 - Railroad
 - Other Non-Road Mobile
 - Point
- Evaluate for Reasonableness
- WRAP RMC 2005 Work Plan contains Task 6 to perform BART Modeling, including Alaska
- Will try to address other point sources in Alaska using similar approach

Alaska Air Quality Modeling (4)

- Next Steps – (1) Finish 2004 Work Elements
 - CALMET/CALPUFF Modeling to Assess Source Contributions at Class I Areas
 - Assess ability to perform meteorological and air quality modeling in Alaska
 - Document in final reports and post to WRAP RMC Alaska Webpage (in development)
- Next Steps – (2) 2005 Work Elements
 - Modeling of potential BART-eligible sources using CALPUFF plus potentially other point sources in Alaska