WRAP Alaska Modeling for Regional Haze at Class I Areas

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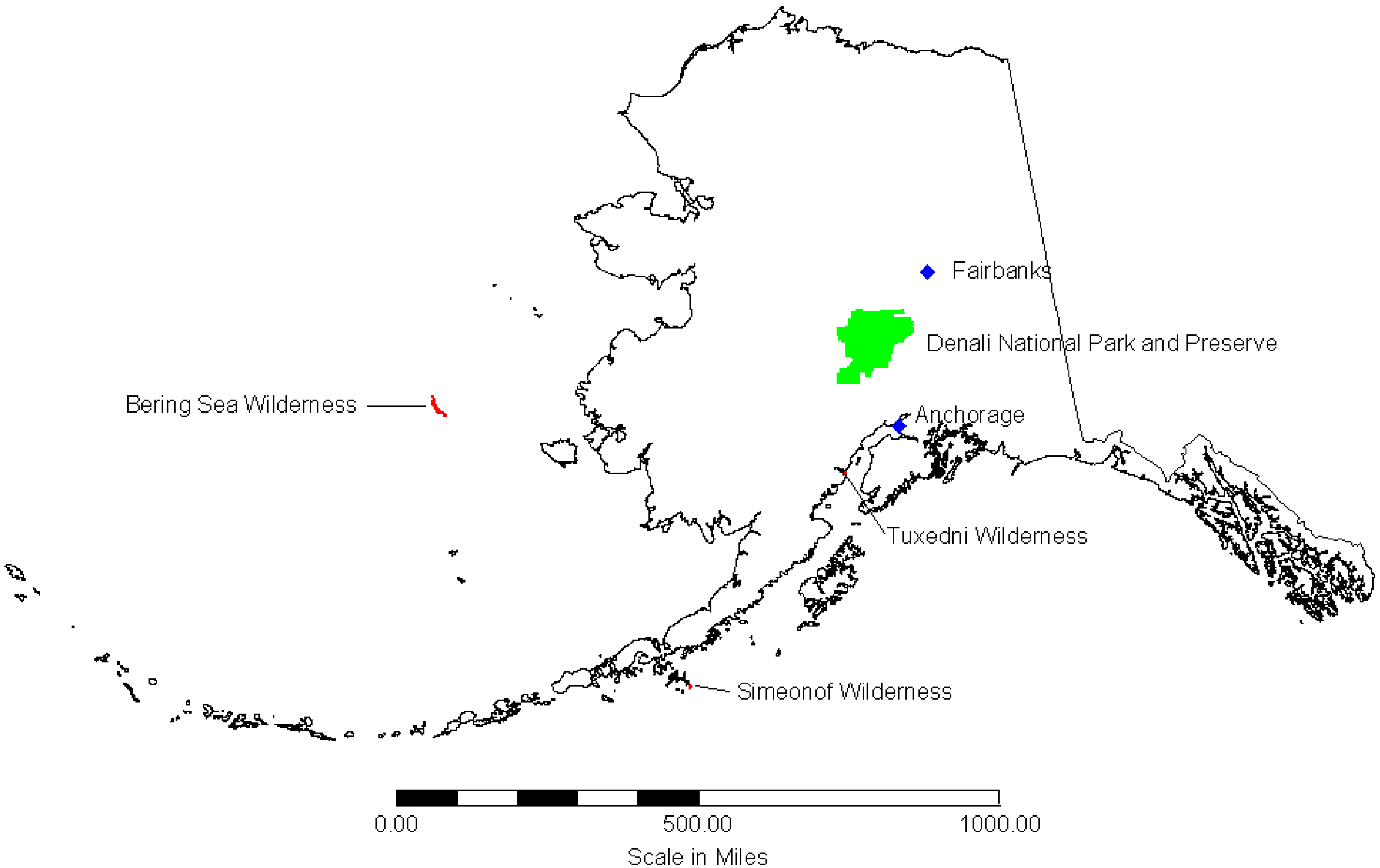
Why Visibility Class I areas

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

Four Class I Areas in Alaska

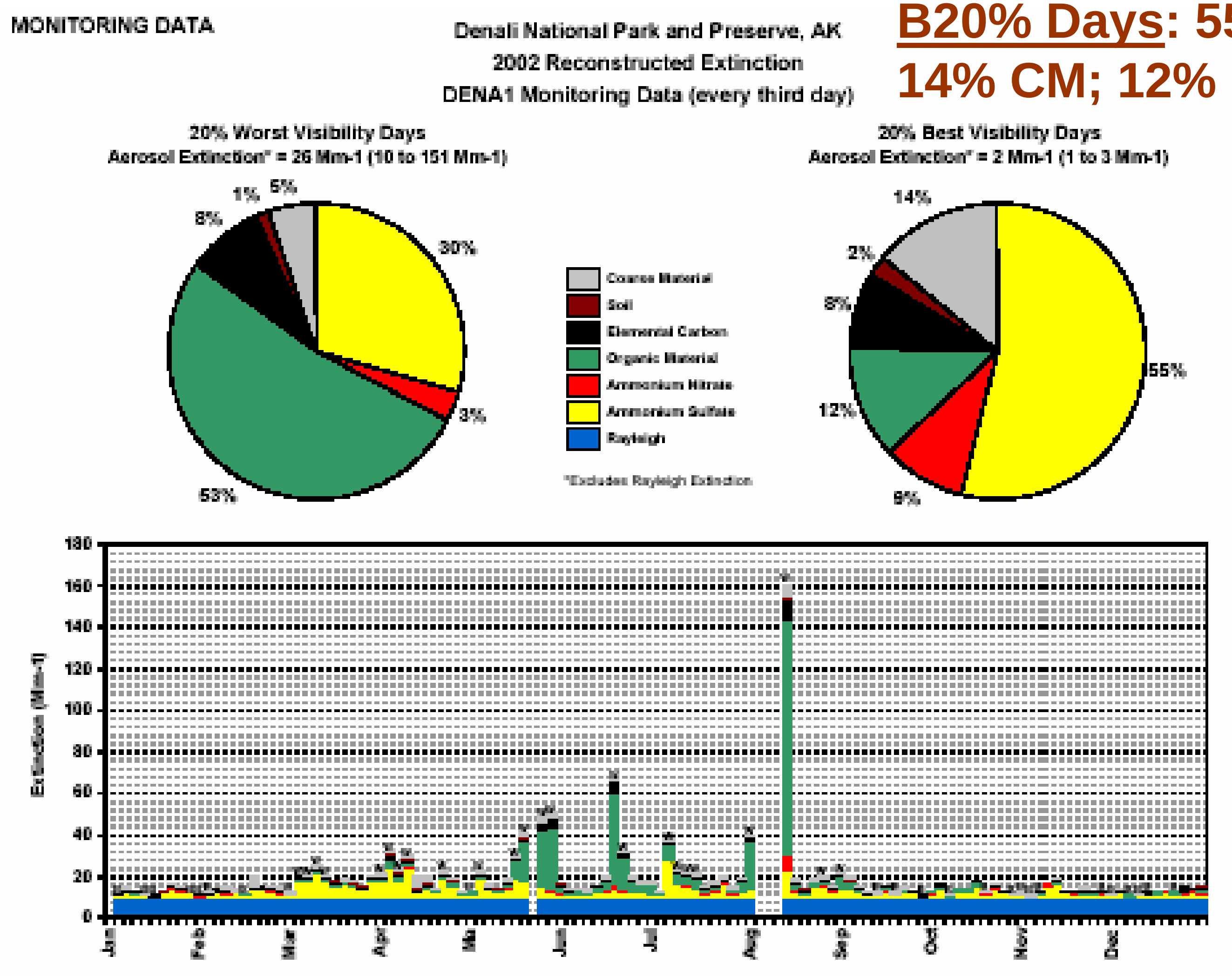


- Denali National Park and Preserve
  - > 6 million acres in central Alaska; Elevations from 800 ft to 20,320 ft (Mt. McKinley); DENA1 IMPROVE monitor 125 km northwest of Mt. McKinley (i.e., closer to Fairbanks)
- Tuxedni Wilderness Area
  - Northwest edge of the Cook inlet southeast of Anchorage; TUXE1 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)

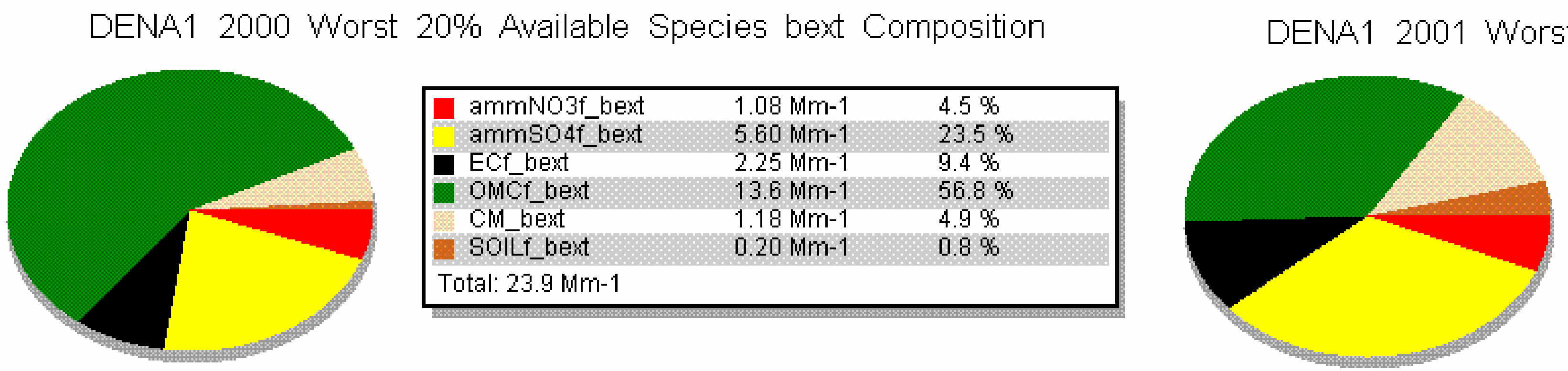
Denali National Park -- 2002

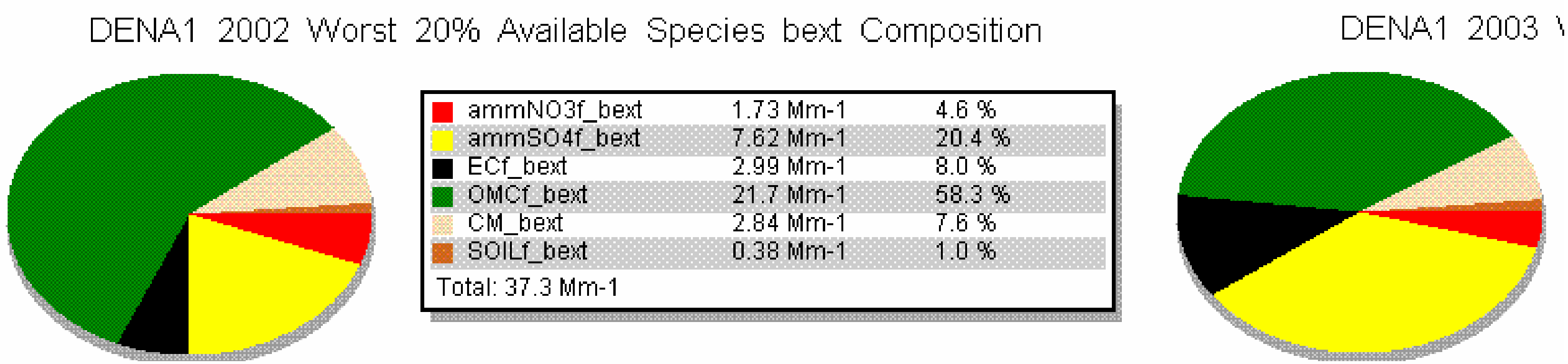
W20% days: 53% OC; 30% SO4; 8% EC

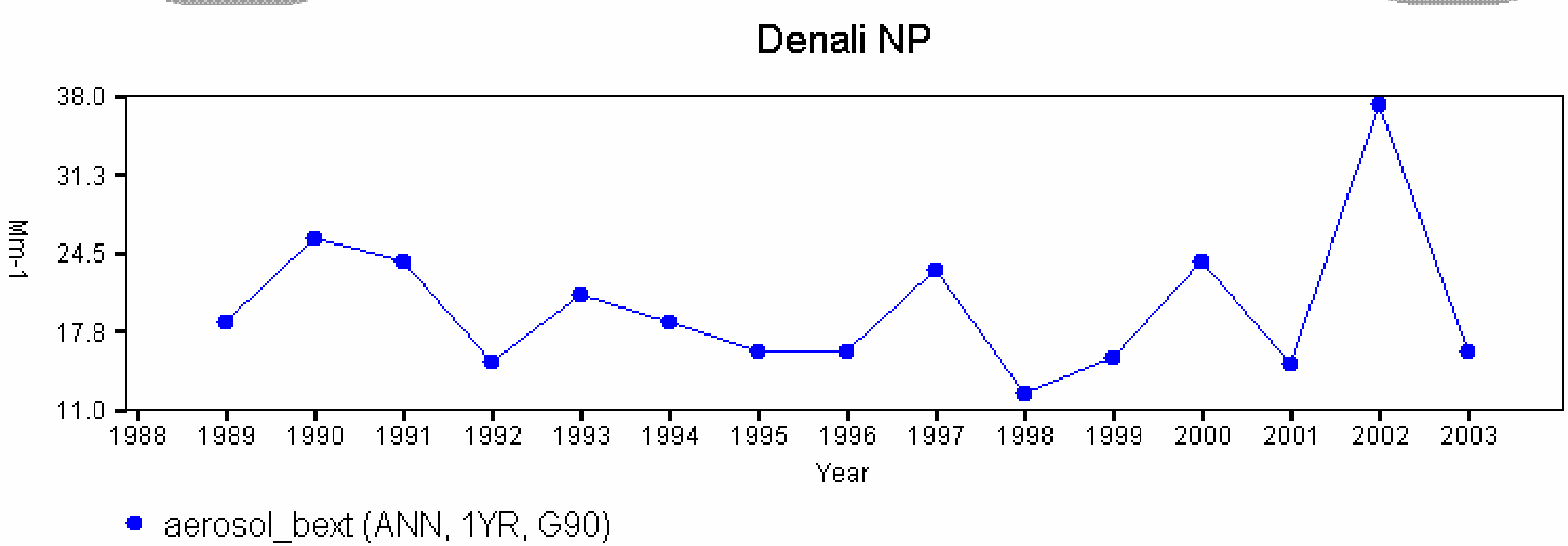
B20% Days: 55% SO4; 14% CM; 12% OC



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


DENA1 2000 Worst 20% Available Species bext 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

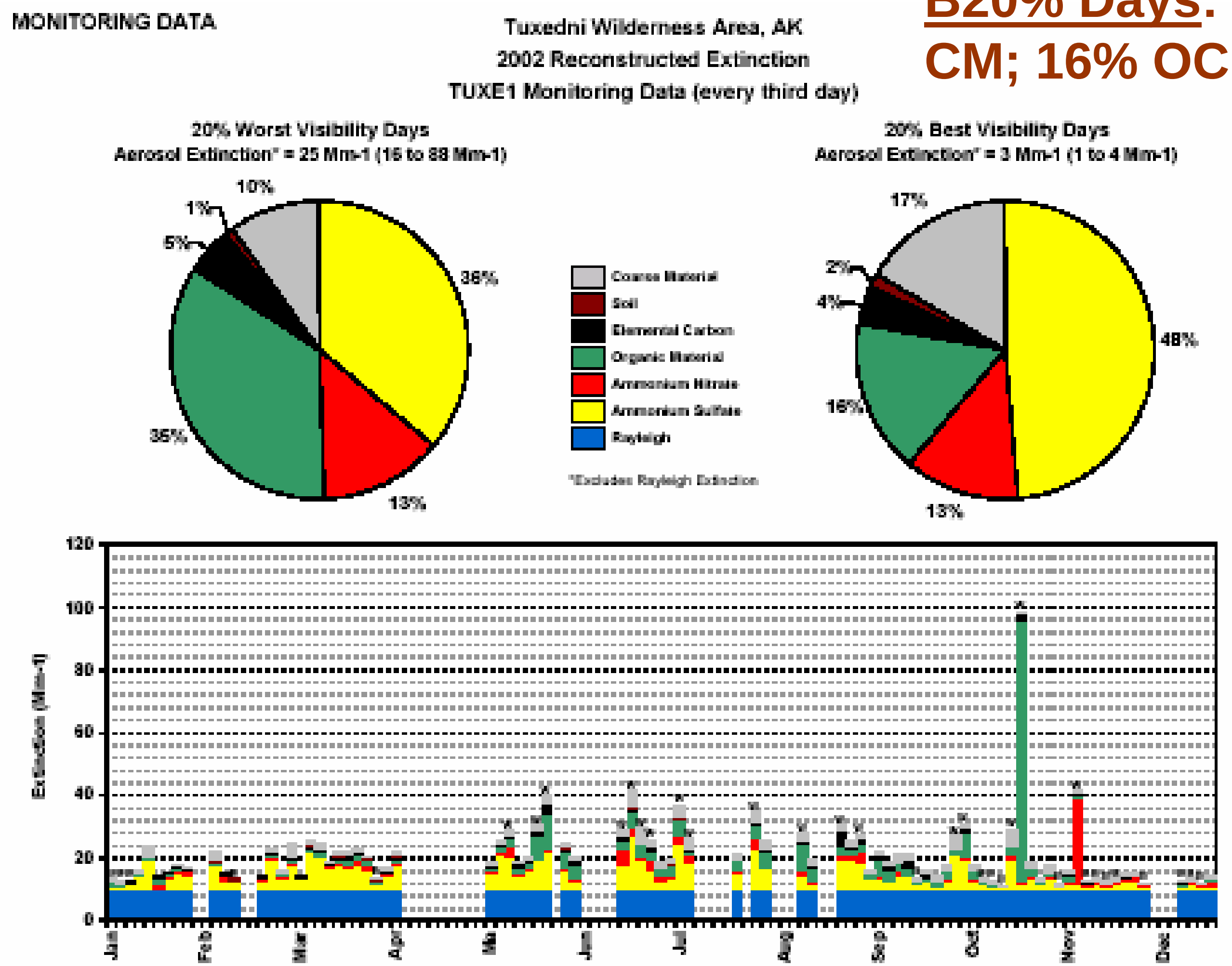

DENA1 2002 Worst 20% Available Species bext Composition
ammNO3f_bext 1.73 Mm-1 4.6 %
ammSO4f_bext 7.62 Mm-1 20.4 %
ECf_bext 2.99 Mm-1 8.0 %
OMCf_bext 21.7 Mm-1 58.3 %
CM_bext 2.84 Mm-1 7.6 %
SOILf_bext 0.38 Mm-1 1.0 %
Total: 37.3 Mm-1
DENA1 2003


Denali NP
38.0
31.3
24.5
17.8
11.0
Mm-1
1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
Year
aerosol_bext (ANN, 1YR, G90)

Tuxedni Wilderness Area

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

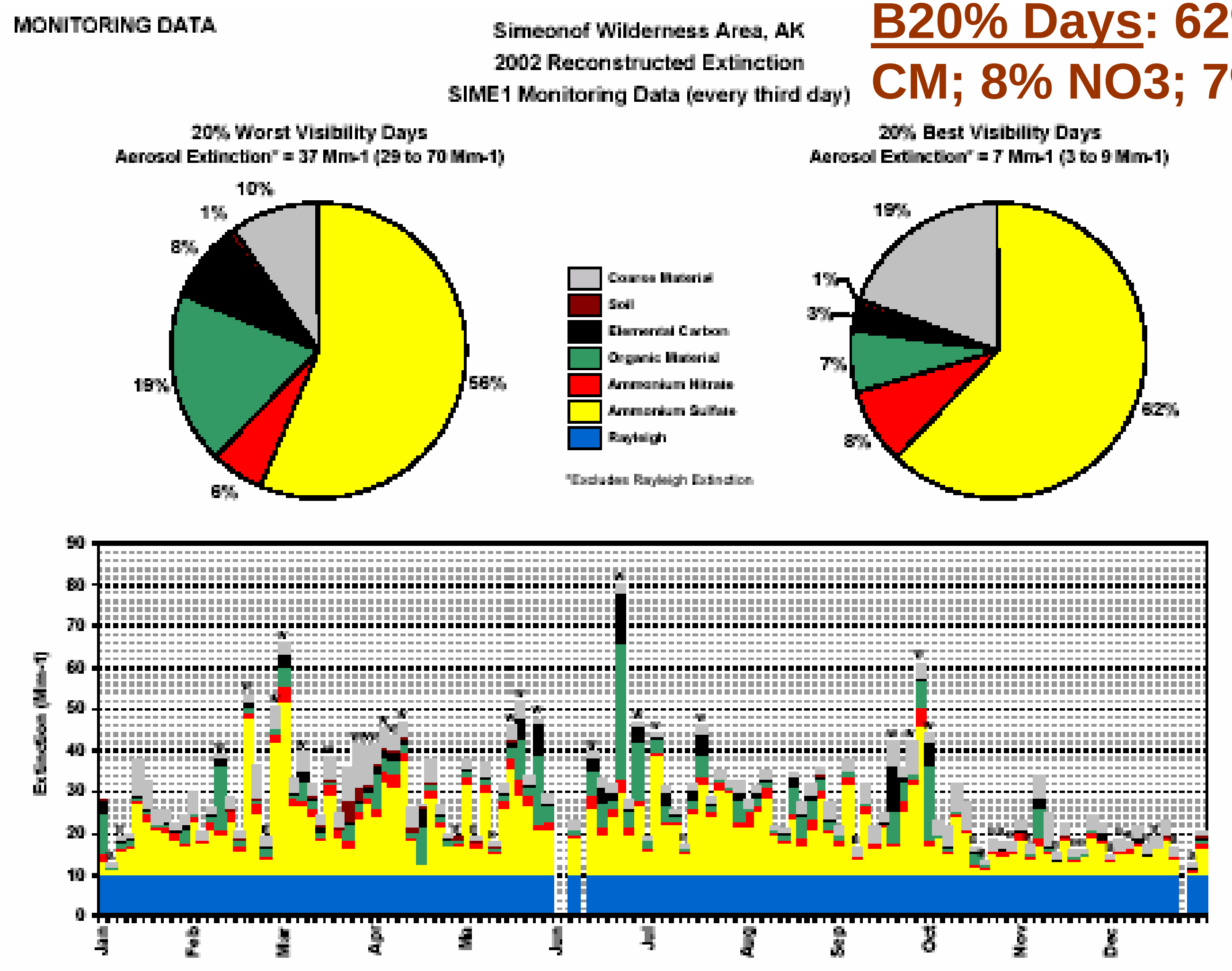
B20% Days: 48% SO4; 17% CM; 16% OC; 13% NO3



Simeonof Wilderness Area

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

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

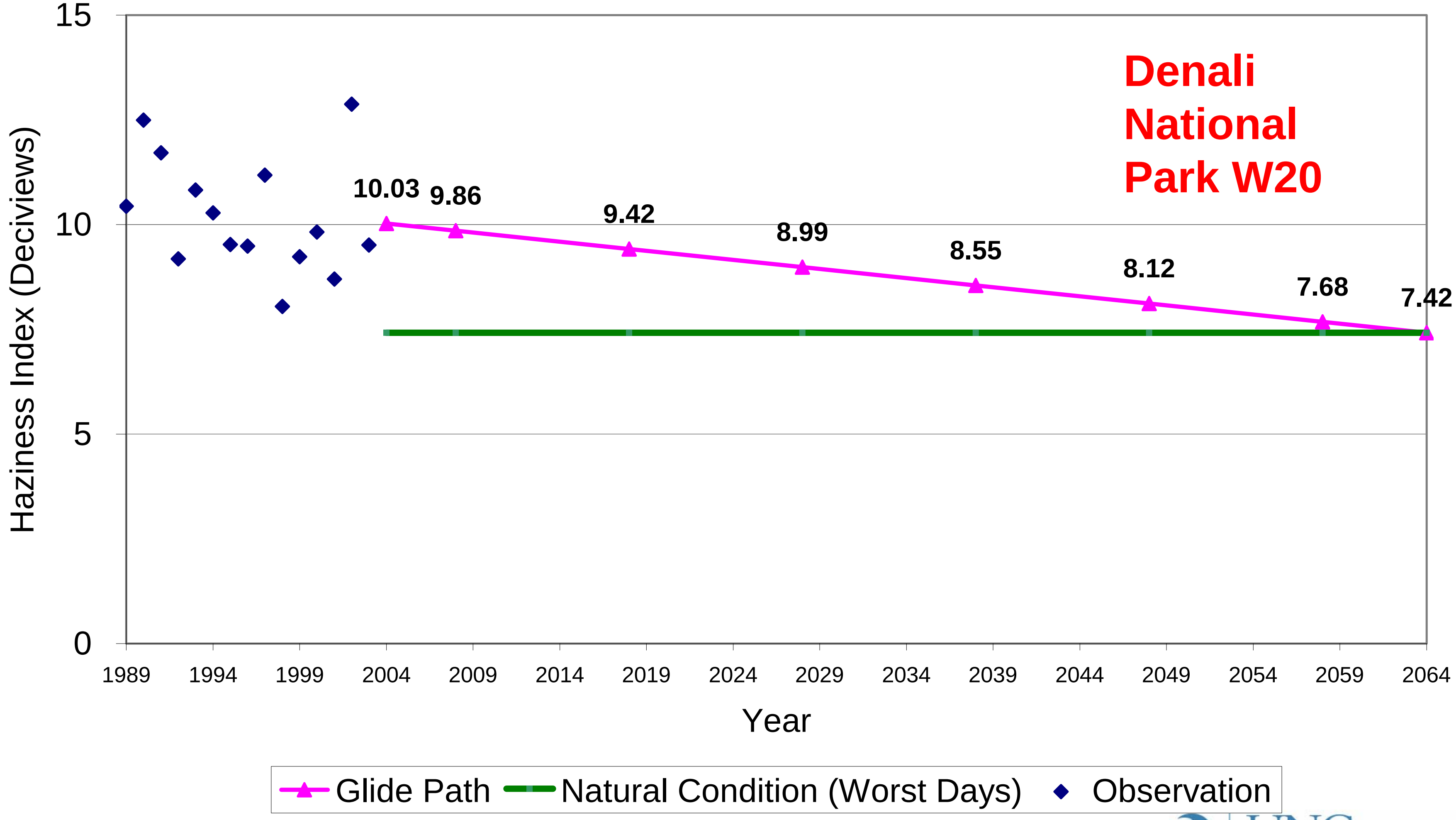


Also represents Bering Sea

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



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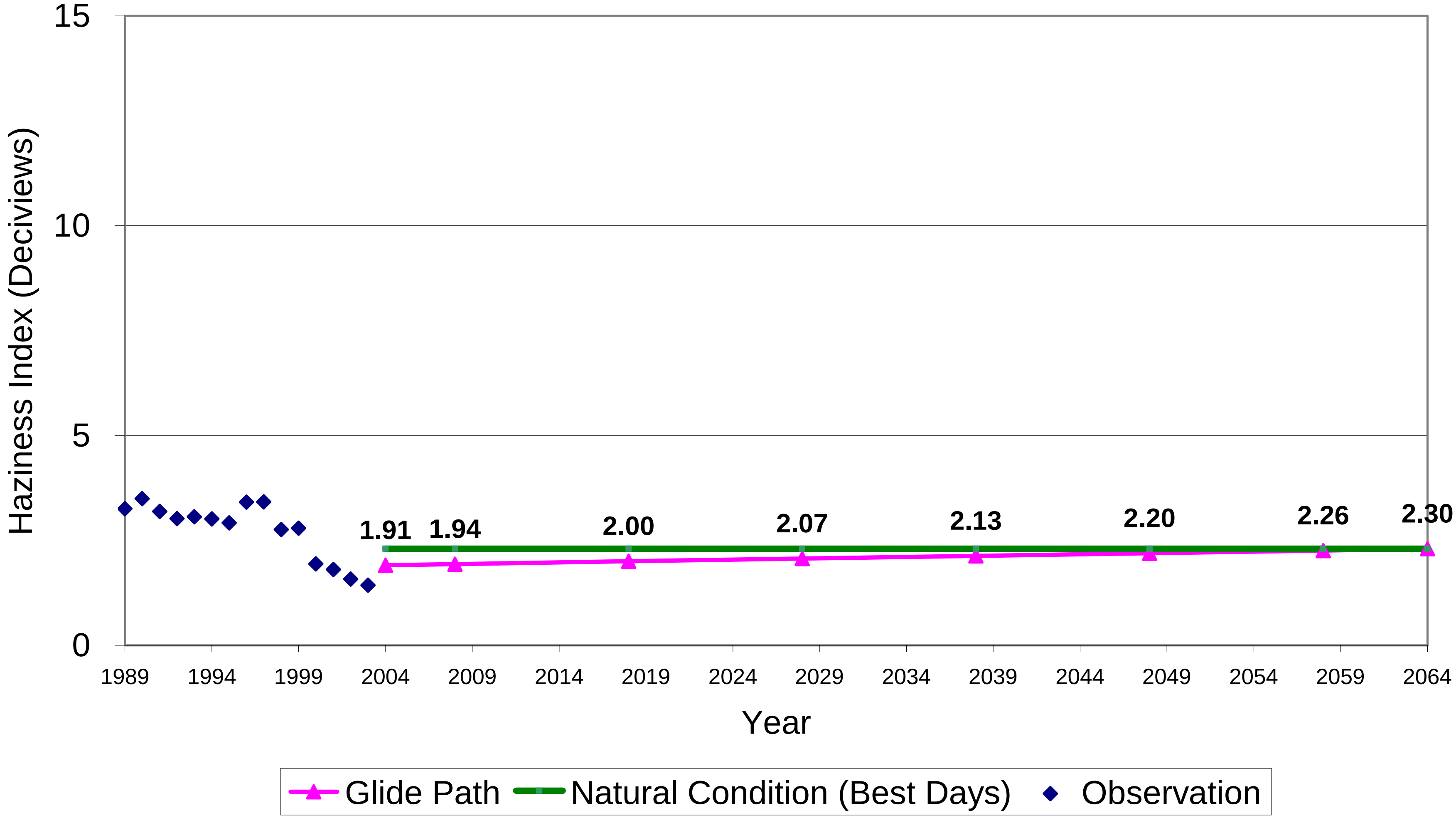
Denali National Park Best 20% Days (B20)
Current 5-Year Average for B20 Days (1.91 dv) lower than EPA default natural conditions for best days (2.30 dv)



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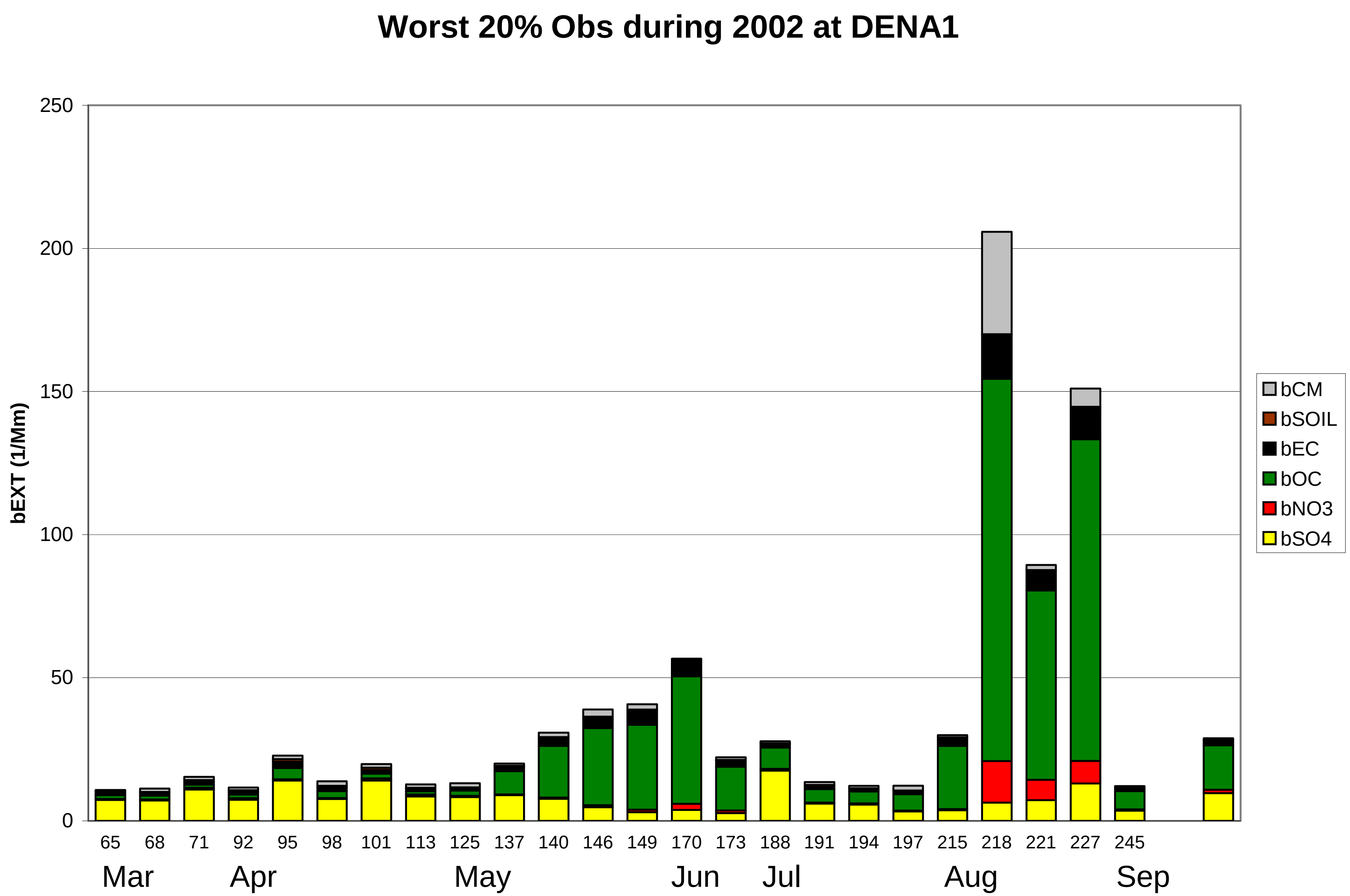
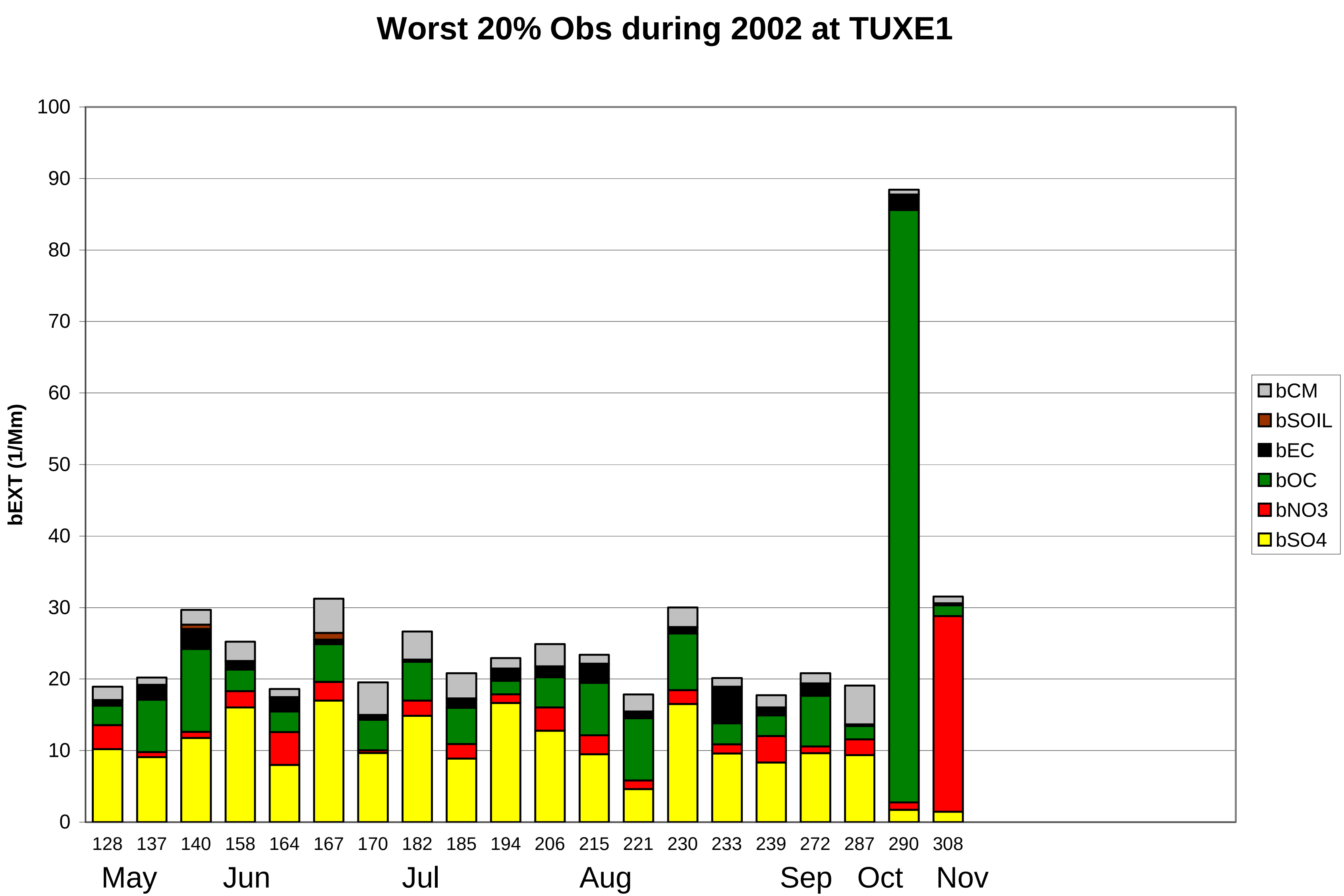
Denali National Park – Worst 20% Days during 2002



Tuxedni Wilderness Area – Worst 20% Days during 2002



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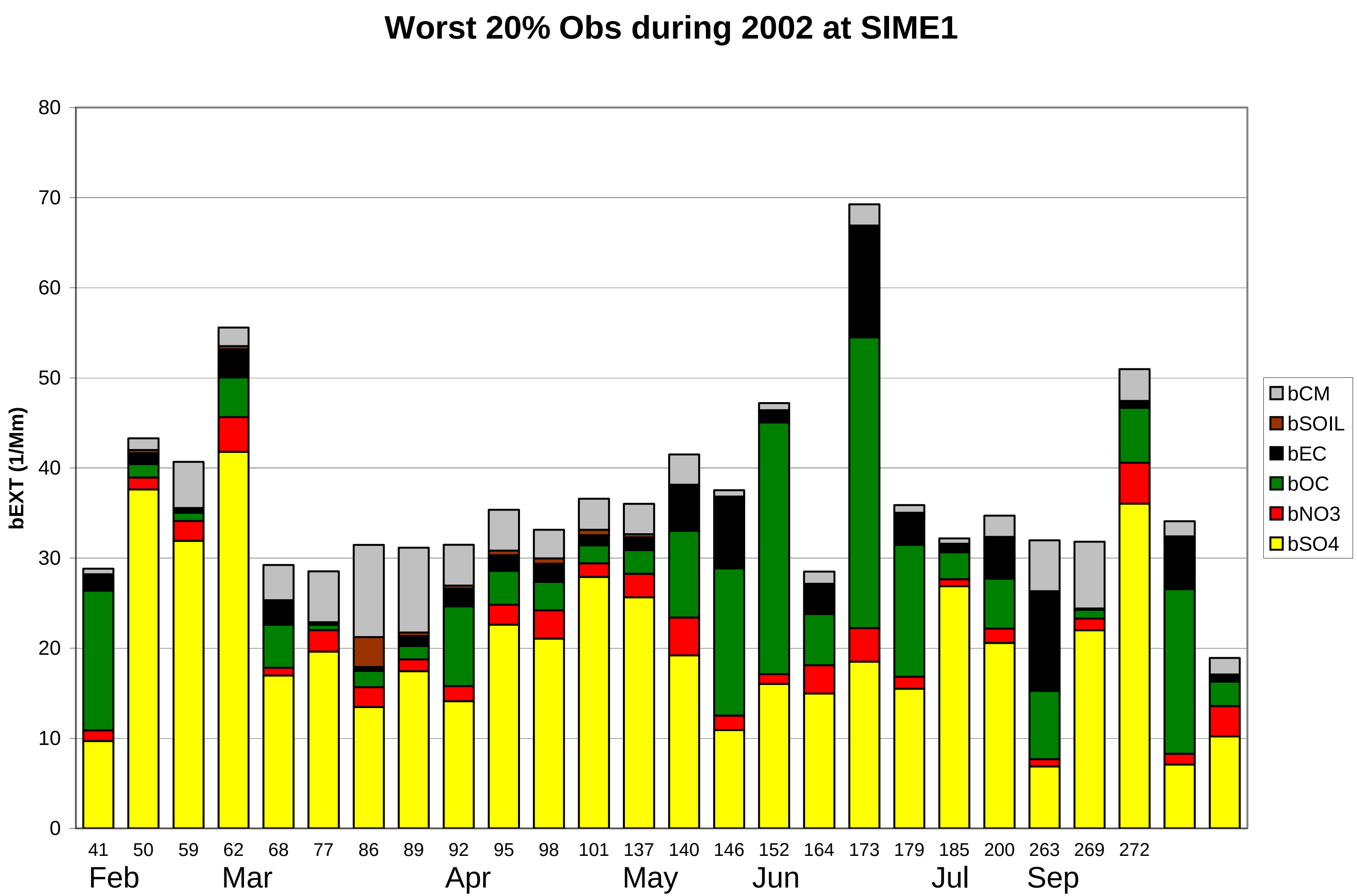
Simenof Wilderness Area – Worst 20% Days during 2002



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 (SOx, NOx, PM and VOC)
  – For most sources, SO4 and NO3 will be primary pollutants of interest (i.e., SOx and NOx 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

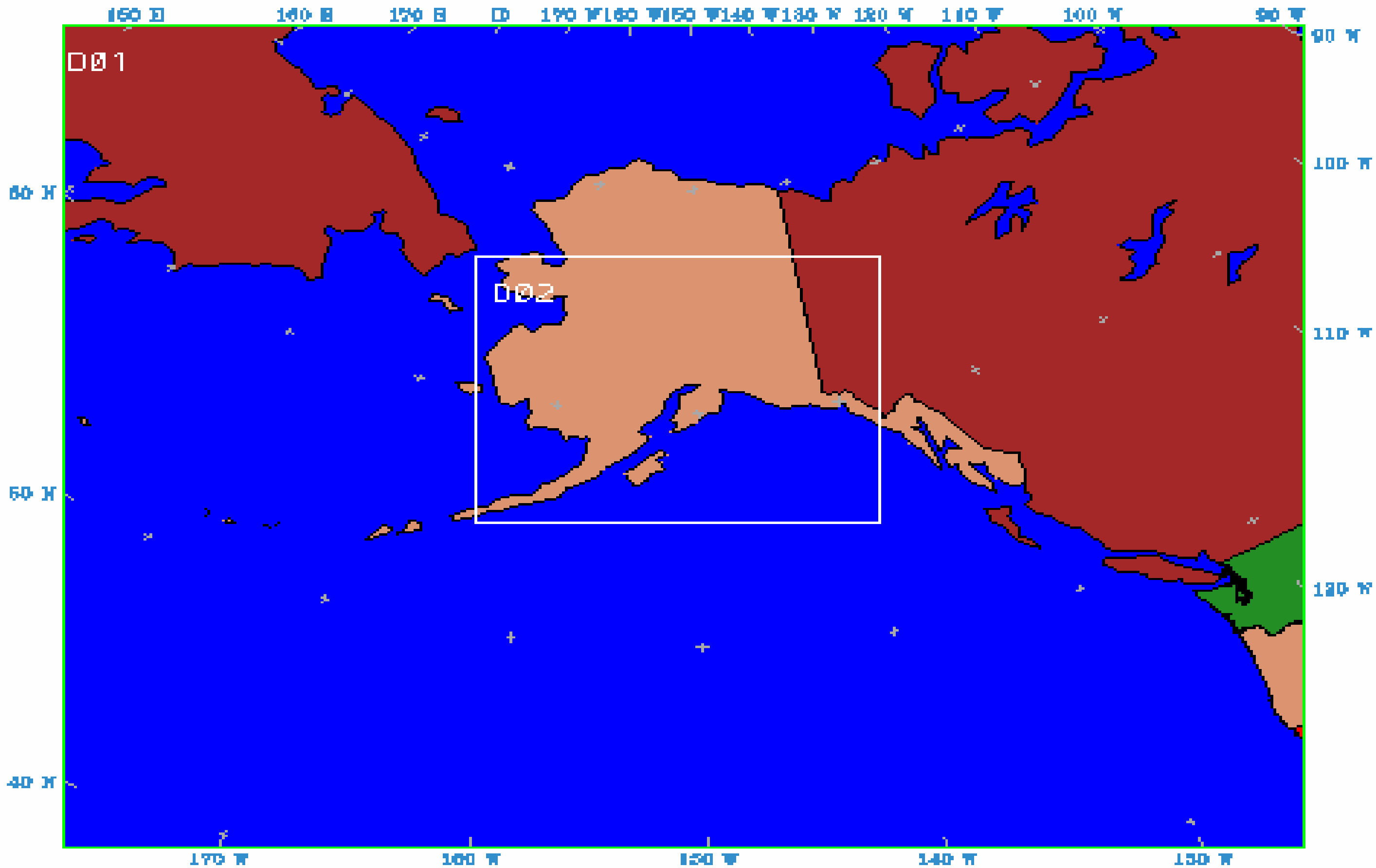
- **Dark, cold, and very dry in winter**
- **Interactions between sea ice and the air not well understood. Sea ice breakup and formation.**
- **In the dark, ice and snow undergo strong radiative cooling, which can set up a strong temperature inversion near the surface**
  - This creates an extremely 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



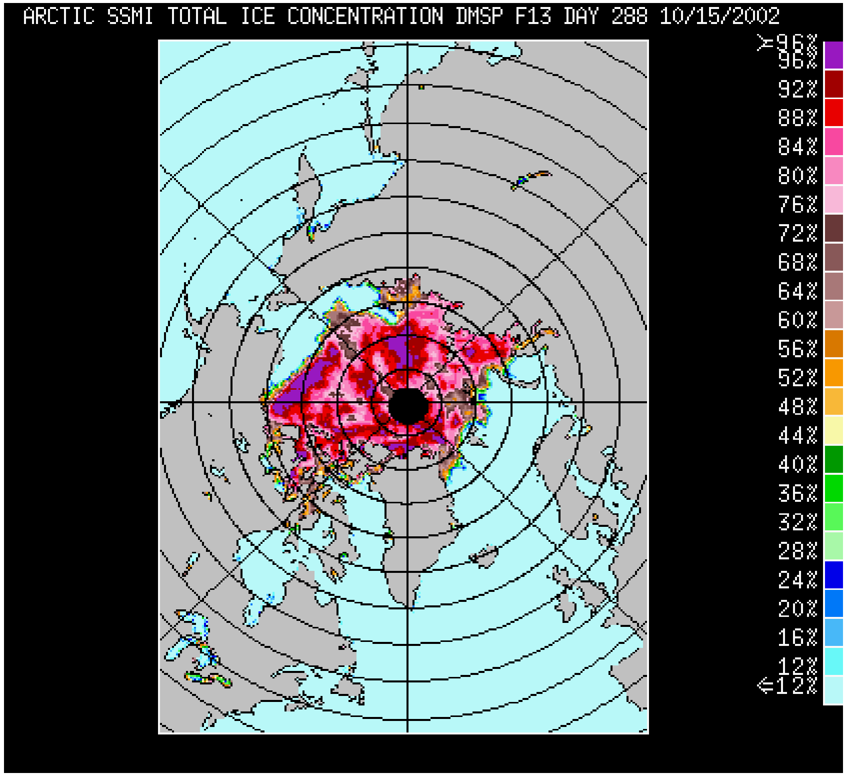
Background on MM5 Configuration for 2002 Annual Run

- 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 2.5º x 2.5º resolution**

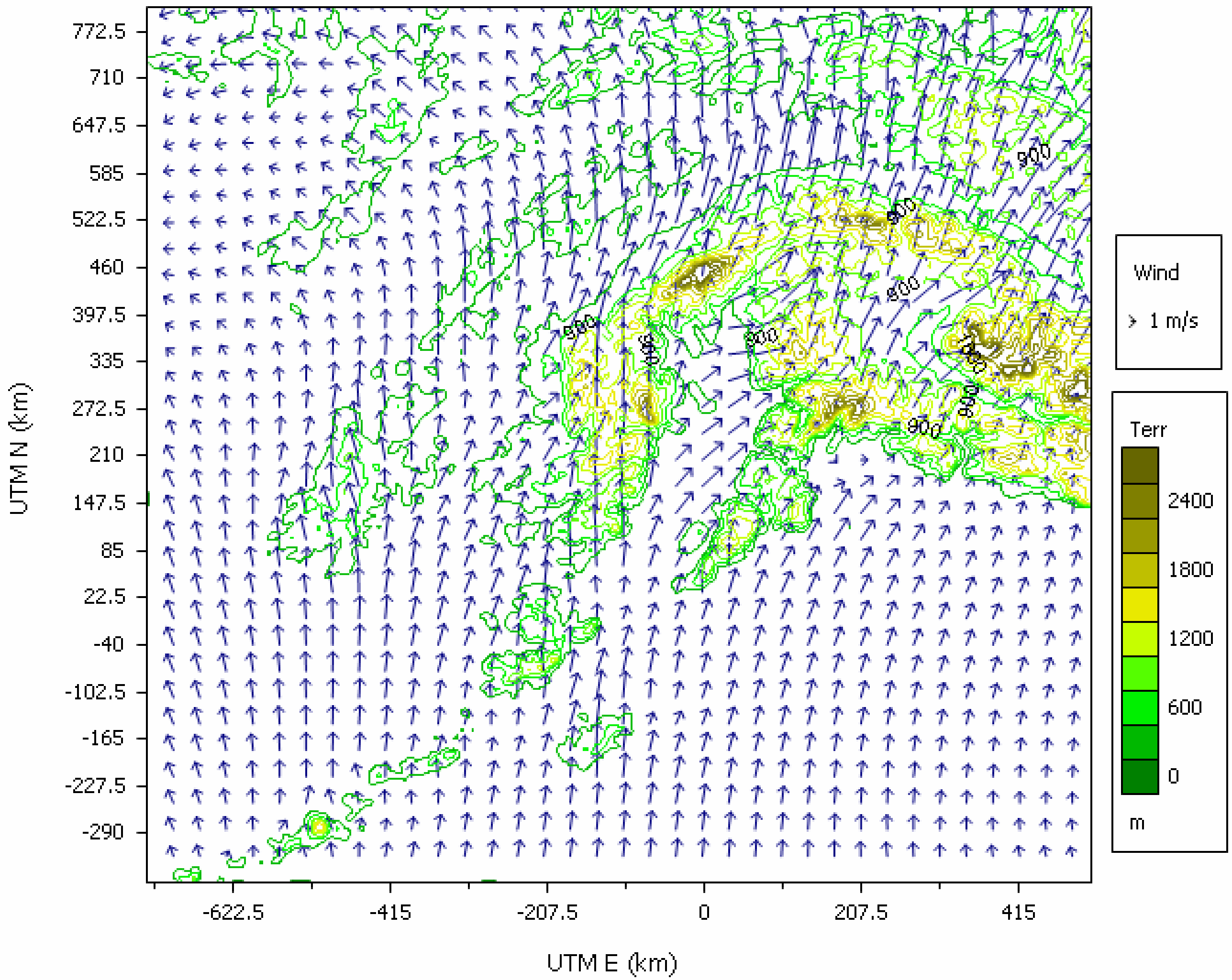
and compare with observations.

WRAP Alaska 2002 MM5 Summary

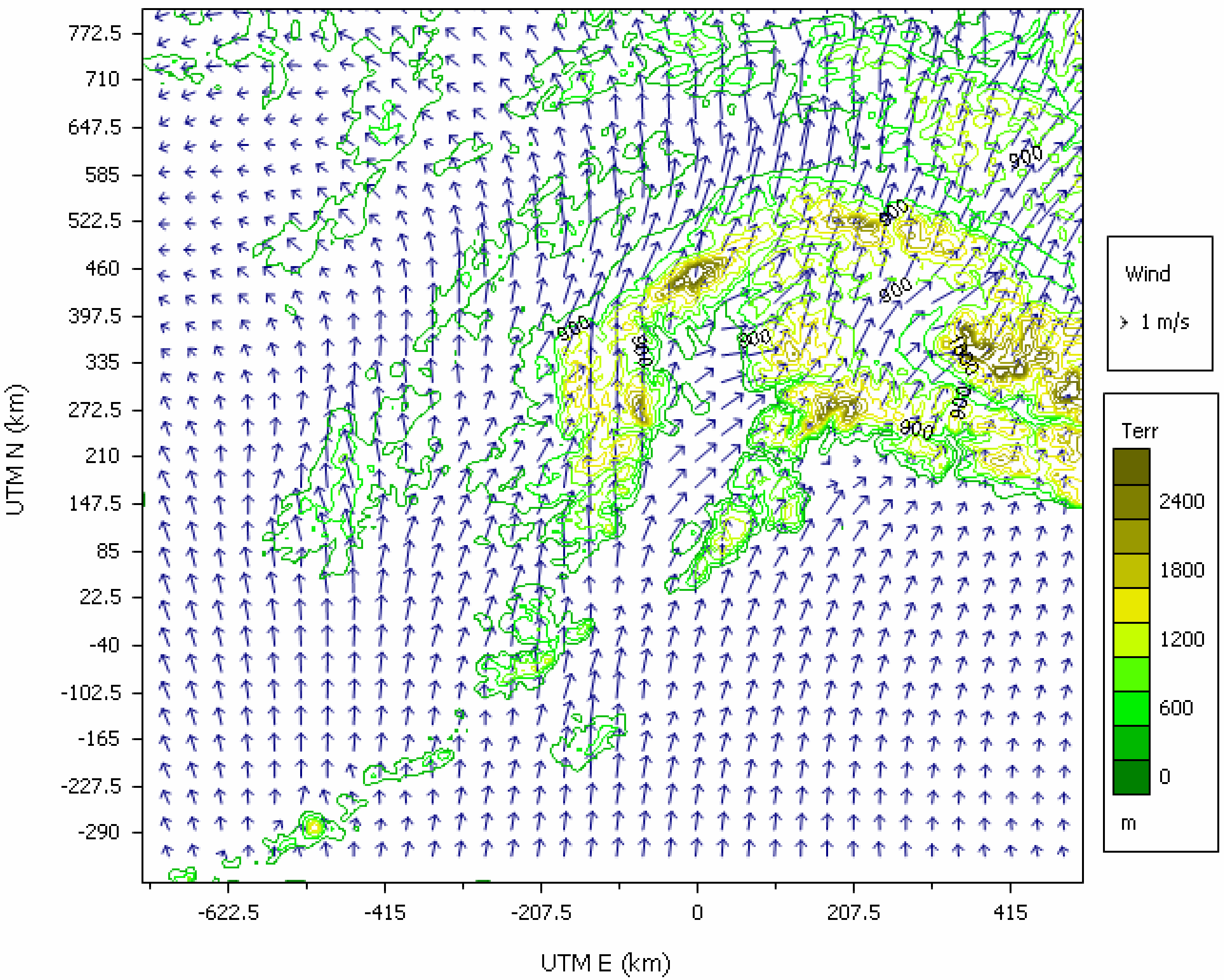
- 2002 Annual Run completed, report in preparation
  - Performance not as good as typically seen in mid-latitudes
    - Surface meteorological performance poor for temperature, good for humidity and variable for winds
    - Upper-air performance indicates difficulty of MM5 to properly characterize inversions
- 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

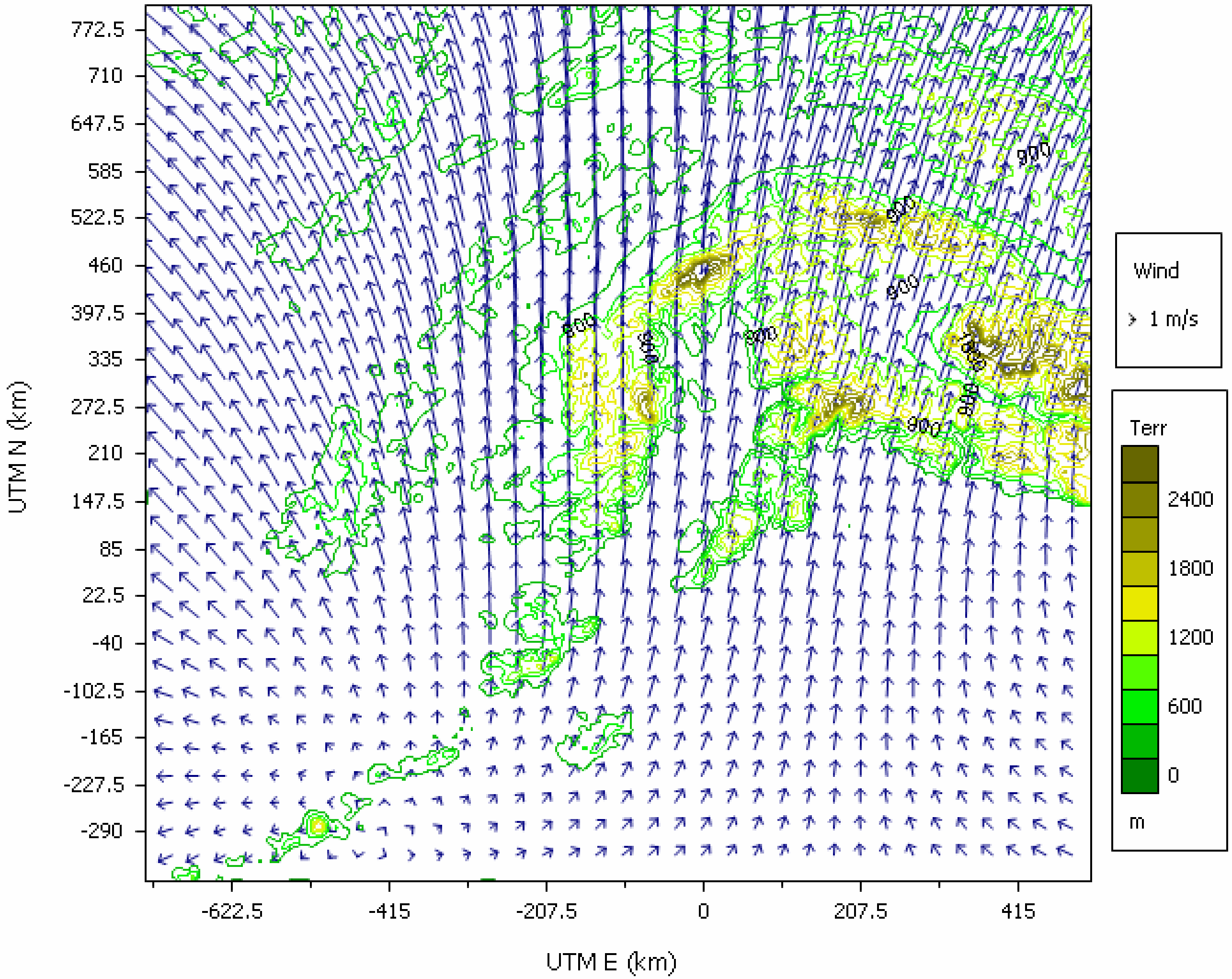
CALMET/MM5 Surface (10m AGL) Wind Field July 3, 2002 @ 00 GMT



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, PM2.5 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