Winter Ozone Analyses in Wyoming's Upper Green River Basin (UGRB)

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WDEQ-AQD Team

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  - Cara Keslar, *Monitoring*
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- Emissions Inventory
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- Compliance
  - Jennifer Frazier, *Jonah Interagency Office*
  - Brandi O'Brien, *Pinedale Anticline Project Office*

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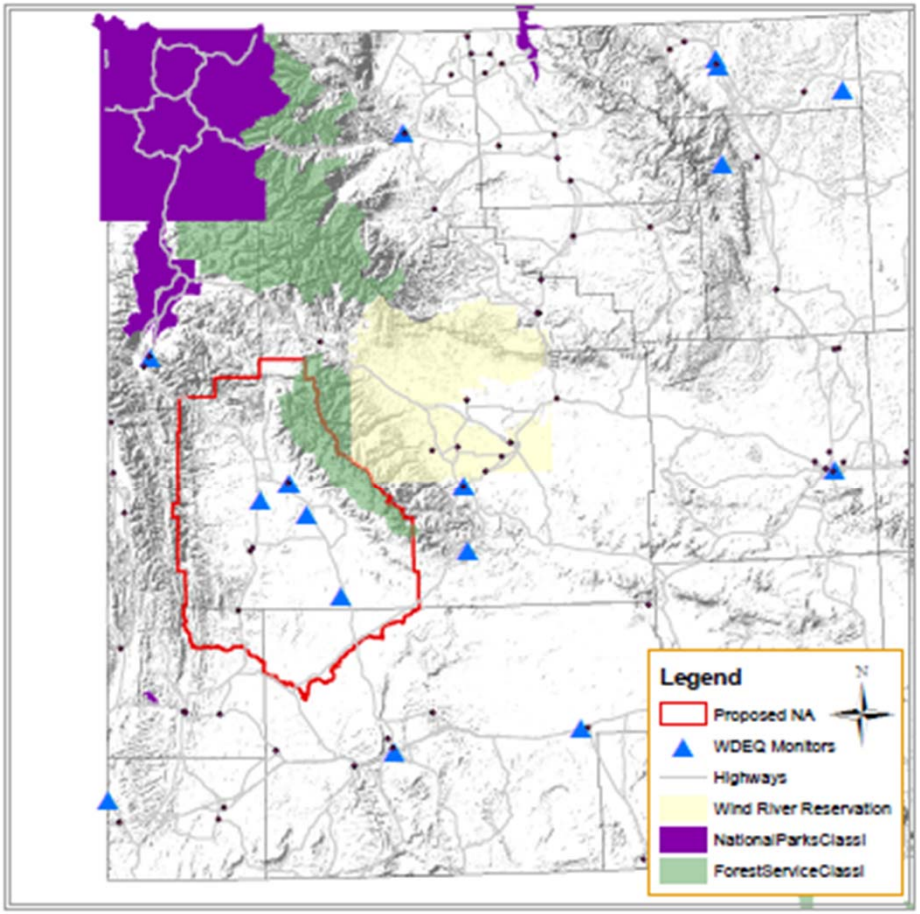
Objective

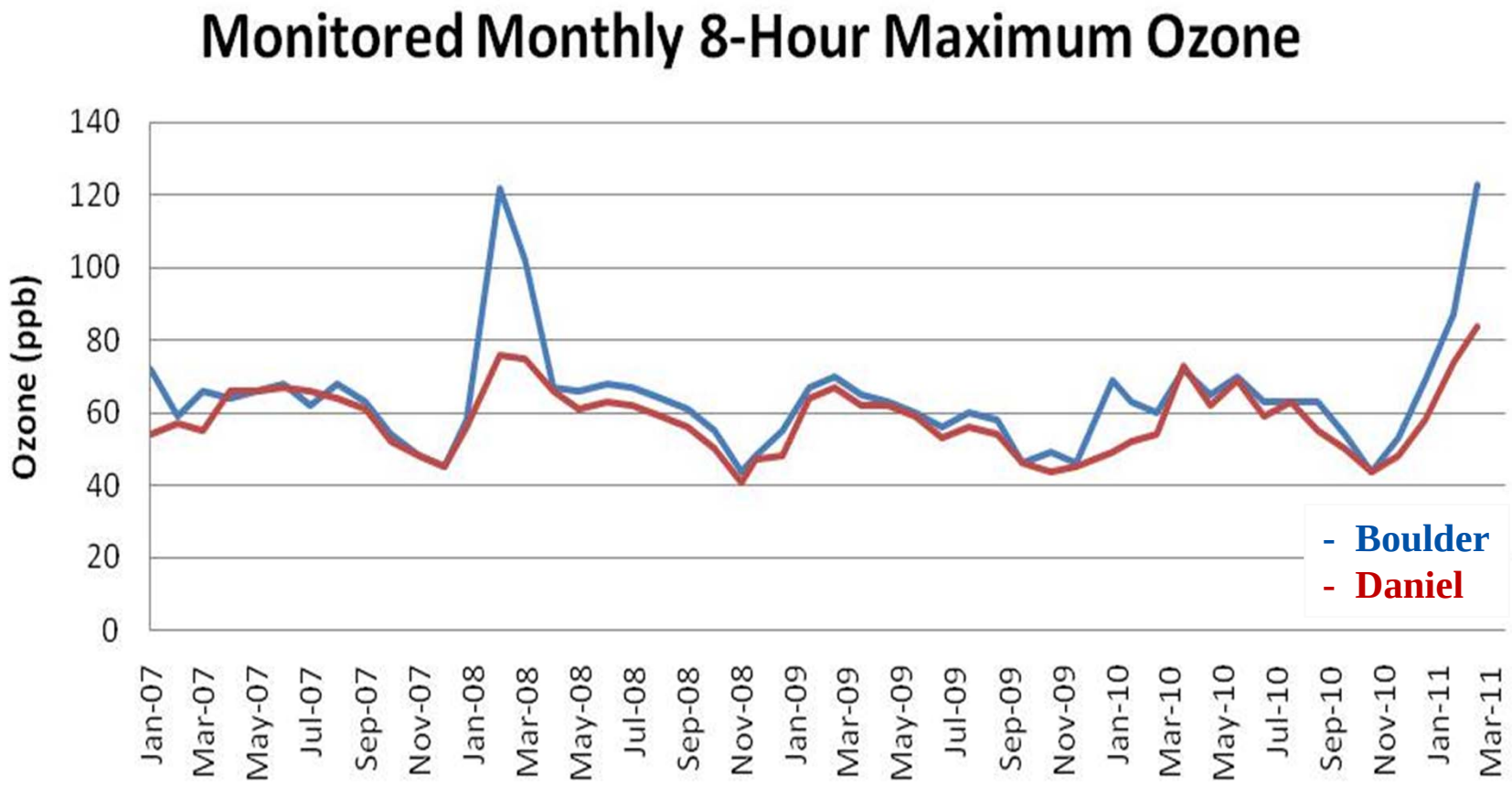
Develop defensible and robust model for the evaluation of episodic winter ozone in the Upper Green River Basin.

Proposed Ozone Nonattainment Area



- Ozone NAA Recommendation and supporting Documentation Submitted to EPA March 2009
- Sublette County and Portions of Lincoln and Sweetwater Counties

Daniel & Boulder
8-Hour Monthly Maximum Ozone
January 2007 – March 2011



Considerations

- Pending ozone standard revision
- Schedule
- Cost

Argonne NL Box Model of 2006 Winter Ozone Episode in Southwest Wyoming

(Funded by BP, December 2007)

- Ambient data analysis
- VOC canister sample analysis
- Box model sensitivity runs
  - Indicated that VOC reductions may be the best approach for reducing ozone

- Recommendations
  - Collecting additional VOC canister samples
  - Looking at diurnal profiles of VOCs to better understand the role of VOCs in winter ozone formation

Conceptual Model of Winter Episodes in Southwest Wyoming (January 2010)

- Compilation and analyses of air quality, emissions and meteorological data
- Describes key characteristics of winter ozone episodes in Upper Green River Basin
- Included 2008 Winter Ozone Box Model Study

Conceptual Model: 2008 Winter Ozone Box Model Study

- EPA's OZIPR Photochemical Box Model
- Base Case formulated using observed meteorological data and trace gas composition data (morning precursor data collected at Jonah monitoring site)
- CB05 Chemical mechanism

Conceptual Model and 2008 Winter Ozone Box Model (continued)

- Outcomes & Recommendations
  - Photochemical mechanisms are capable of simulating observed high ozone
    - When limited vertical mixing and high UV albedo associated with snow cover taken into account
  - Conditions from early February through mid March should be modeled
  - Meteorological modeling should be conducted at 4 km or higher resolution
  - Accurate speciated and spatially & temporally resolved emissions inventory
- Noted that:
  - A Box model grossly simplifies spatial variability in emissions and meteorology
  - Lack of spatial treatment in the box model can lead to misleading conclusions concerning the relative impact of VOC vs. NOx emission reductions

Meteorological Modeling: Development of High-Resolution 3-Dimensional Wind Fields using CALMET (August 2009)

- February 1 through March 31, 2008
- 20-km RUC, surface & upper air observations from Upper Green River Winter Ozone Study 2008, NWS surface data, daily snow cover data from the National Hydrologic Remote Sensing Center
- Extensive meteorological model performance evaluation performed
  - Excellent model performance
- Used in Technical Support Document for Proposed Nonattainment Area Boundary (March 2009)

CALGRID Ozone Modeling Analyses (June 2010)

- Capitalized on CALMET wind field
- 5 full-scale runs for February 18-24, 2008
- Numerous sensitivity and diagnostic analyses

Ozone Technical Forum (OTF)

http://deq.state.wy.us/aqd/Ozone%20Technical%20Forum.asp

- Information sharing opportunity among members of scientific community
  - Winter ozone formation
  - Winter ozone modeling
- Meetings held December 2009 & September 2010

Ozone Technical Advisory Group (TAG)

- External advisory group consisting of regulatory agencies, academics, citizens and industry
- Formed May 2010 as an OTF recommendation
- TAG subgroups
  - Reactivity
  - Box modeling (non-PGM modeling including CALPUFF)
  - Meteorological Modeling
  - Photochemical Grid Modeling
  - Climatology

Winter Monitoring in Support of Modeling – Spatial Distribution of Ozone, Meteorology, Precursors

- Used for conceptual model, wind field development, model performance
- Mesonet Stations
  - 3 meter with wind speed, direction, temp, RH
  - 2B ozone
  - 5-9 locations continuous during winter
- Aircraft:
  - Ozone and $PM_{2.5}$
  - A.M. & P.M. flights during intensive periods
- Speciated VOC's
  - At regulatory ozone stations
  - TO-15 and TO-11
  - 3 hour samples during intensive periods

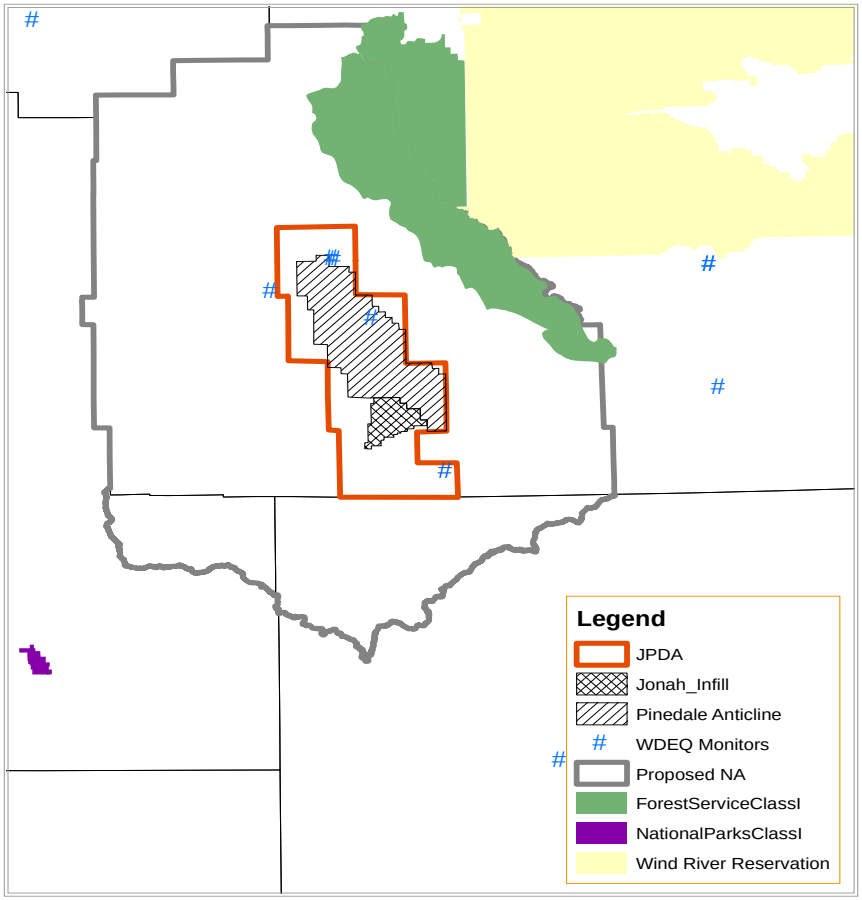
Winter Monitoring in Support of Modeling - Vertical Profiling of Ozone, Meteorology, Precursors

- Used for conceptual model, met and PGM model development
- Tall tower
  - 73 m – measured at 3, 25, 50, 73 m
  - Ozone, NO_x, CH_4, NMHC, Wind speed, direction, temp.
  - Continuous during winter
  - Downwind of Jonah Field
- Tethered balloon
  - 100 m – measured at 3, 33, 67,100 m
  - Ozone, NO_x, CH_4, NMHC, speciated VOC's (grab samples)
  - Deployed daily during intensive periods
  - In Pinedale Anticline Field
- Mini-SODAR
  - Up to 250 m – typical mixing height <100 m
  - Continuous during winter
- Rawinsondes/ozone sondes
  - 3-4 sondes daily during intensive periods

Winter Monitoring in Support of Modeling Precursor monitoring

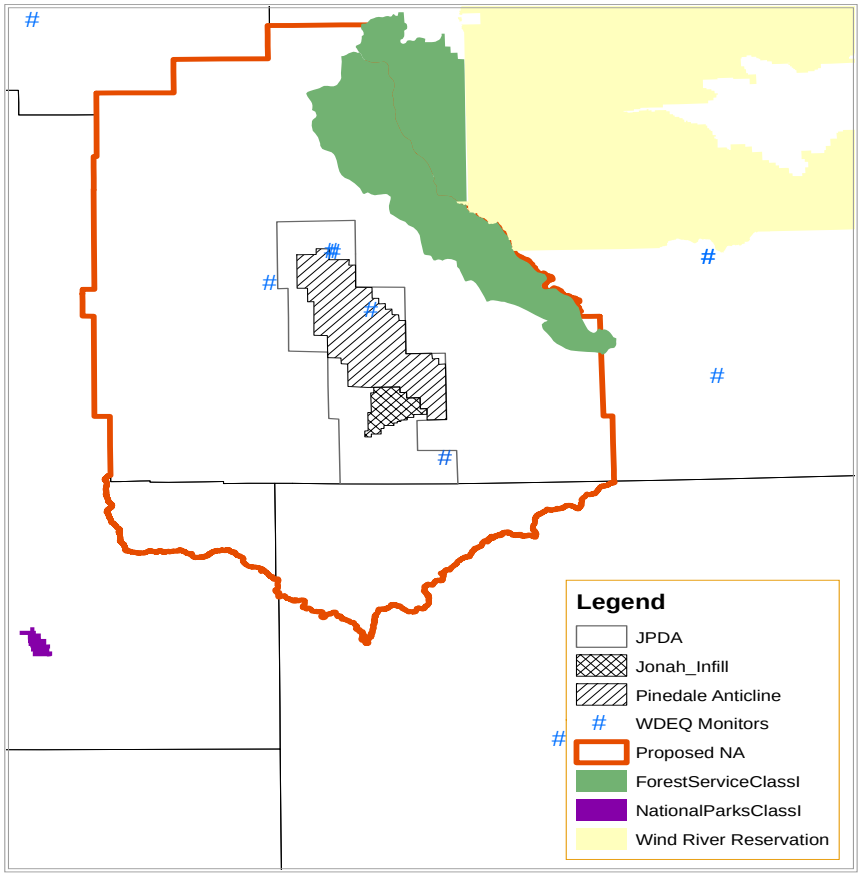
- CH_4/ Non-Methane Hydrocarbons
  - Continuous year-round at 1 site
  - Can trigger 3-hour canister samples when NMHC reaches predetermined level
- NO_{xy} (continuous)
  - Photolytic trace NO_2 since 2011
  - Speciated NO_y :2009, 2011
- HONO and formaldehyde (continuous)
  - 2010 and 2011; 1-min. resolved
- CO
  - Canisters 2008
- Speciated PM
  - Similar to STN site – 24 hour average
  - 1-in-3 sampling for 2011; 20 extra days in Feb.- March
- Upper Green Winter Ozone Study (2007-2011)
  http://deq.state.wy.us/aqd/Upper%20Green%20Winter%20Ozone%20Study.asp

Emissions Inventory in Support of Modeling



- Emissions Inventories in the Upper Green River Basin are an evolving process
- 2004 Annual Inventory included 8 sources and 7 pollutants for sources within the Jonah Pinedale Development Area (JPDA)

Emissions Inventory in Support of Modeling (continued)



- Now: Annual & Winter Inventories (higher temporal resolution) for entire Proposed Nonattainment Area
- 14 Sources, 25 Pollutants

Emissions Inventory in Support of Modeling (continued)

- Inventory enhancements for 2008 ozone modeling (2008 Winter inventory for oil and gas sources within Sublette County for February 1 through March 31, 2008)
  - Flashing emissions from gas wells updated using equations derived from ProMax;
  - Flashing Emissions for oil wells updated using field specific VOC and HAP emission factors;
  - Flaring emissions for NOx and CO calculated;
  - Formaldehyde emissions estimated based on per-well emission factor;
  - Truck loading and fugitive emissions calculated based on information provided by operators in the Annual 2008 Emission Inventories;
  - Venting and blowdown emissions estimated and temporally and spatially resolved;
  - Drill rig emissions temporally and spatially resolved;
  - Speciation (where unreported) estimated based on EPA's Emissions Modeling Clearinghouse Speciation methodology/data or ProMax flash simulations;
  - Stack parameters (velocity, diameter, temperature and stack height) were developed for tanks, pneumatic pumps, dehy units, engines, process heaters, fugitives, truck loading, venting and blowdowns, other completion events and mobile sources.

Reactivity Study

- Evaluate ozone formation for UGRB measured conditions
  - Assess the relative impacts/contribution of individual VOCs to ozone formation
  - Derive a reactivity scale for UGRB conditions
    - Derive box model to represent UGRB episodic conditions to conduct reactivity calculations
    - Adapt SAPRC-07 for calculating VOC reactivities for the low temperatures of the UGRB episodes
    - Calculate the incremental reactivities of the individual VOCs measured during UGRB episodes
    - Sensitivity studies to determine the effects of uncertainties on the ozone and incremental results

Analysis of VOC and NOx Concentration Fields in the UGRB using CALPUFF

- February 19-24, 2008 time
- Evaluate degree of pollutant mixing in the vertical near large NOx sources
- Evaluate whether NOx emissions are (and remain) stratified in vertical layers nearby and downwind of buoyant NOx sources under different atmospheric stability regimes
- Evaluate spatial variability of VOC/NOx ratios in the UGRB

WRF Meteorological Modeling for Ozone Impact Analyses

- 2008 Annual run at 36 km/12 km resolution to align with WestJump modeling domains
- February and March 2008 down to 1.33 km resolution with finest domain centered on the UGRB

Photochemical Grid Modeling

- All modeling conducted in conformance with EPA's air quality and emissions model performance guidance
- Focus on February 1 through March 31, 2008
- Includes CAMx and CMAQ model performance evaluation
- Model domains align with WRF domains
- Vertical grid structure may be informed by UGWOS 2011 Monitoring data, CALPUFF study
- Datasets include updated 2008 winter oil and gas emissions inventory and other regional inventories as necessary, February and March 2008 WRF simulations, regional ambient monitoring data

Photochemical Grid Modeling (continued)

- Model Performance Evaluation
  - Operational model performance metrics and graphics
  - Diagnostic evaluations may include:
    - Model sensitivity experiments, such as changes in vertical diffusivity, comparing contributions of background ozone in CAMx and CMAQ, and a comparison of indicator ratios between the models and to the data
    - Process analysis such as 3-dimensional process analysis output of the integrated reaction rates
    - Source Apportionment

Photochemical Grid Modeling (continued)

- Final model selection will be based on which of the two models is determined to best enable us to meet our objective
- February 1 through March 31, 2008 typical and future episodes
  - February 1 through March 31, 2008 Typical
  - February 1 through March 31, 2008 Future Year #1 (OTB)
  - February 1 through March 31, 2008 Future Year #1 Control
    - May be iterative
  - February 1 through March 31, 2008 Future Year #2
- Tasks may be repeated for other areas of the state and/or other time periods, depending on future needs of WDEQ-AQD

Photochemical Grid Modeling (continued)

- PGM RFP Available by request from:

  A&I Procurement Section
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