Development and Use of an Ozone Regression Model to Predict and Evaluate Ozone in the UGRB

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

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UGRB Non-Attainment Area

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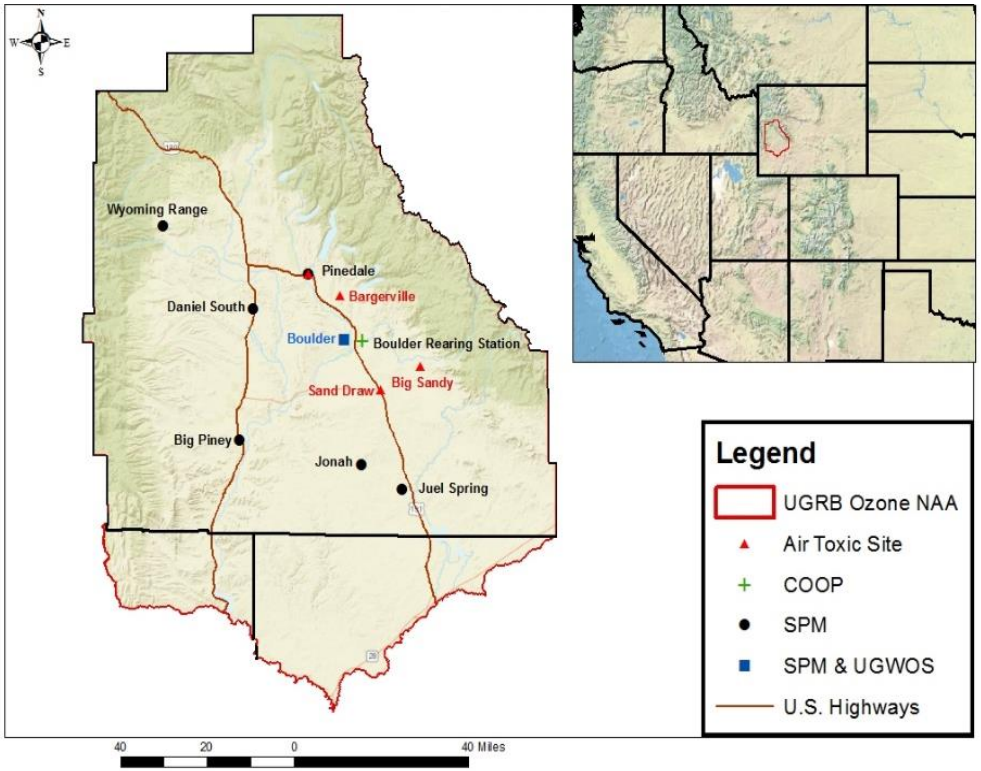

- Entered marginal non-attainment status in July of 2012
- Region of intense fossil fuel extraction
- Prone to strong thermal inversions and persistent snow cover
  - Produces ozone (O_3) exceedances in the winter season
- Yearly field studies (UGWOS) starting in 2007 to help understand and predict winter O_3 formation in this area
- WDEQ-AQD forecasts for O_3 in UGRB everyday from January - March

Previous Modeling Explored

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Multiple studies have been commissioned by the WDEQ-AQD:

- EPA's OZIPR photochemical box modeling
- 3-dimensional photochemical grid modeling (CAMx & CMAQ)

Box Modeling

- Results found that optimum VOC/NO_x ratios for winter O_3 formation in southwestern Wyoming are higher than typical summer events
- Representation of chemistry was capable of generating O_3 concentrations consistent with observed values
- But lack of spatial treatment (emissions/emission sources) and meteorology limits real-time predictability

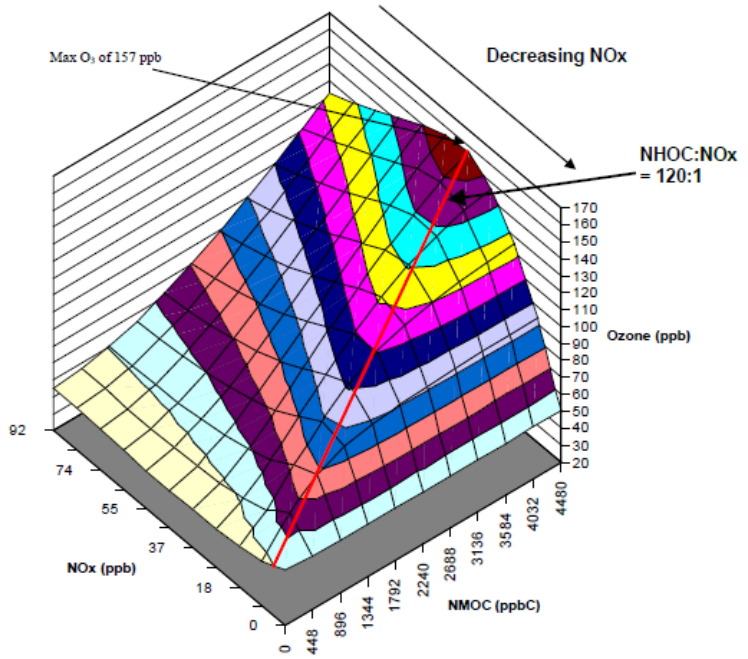

Figure 2-6. Base case 1-hr ozone response surface (EKMA diagram) showing NMOC and NOx-sensitive regions on either side of a "ridge line" at NMOC/NOx ratio of about 120.

Previous Modeling Explored

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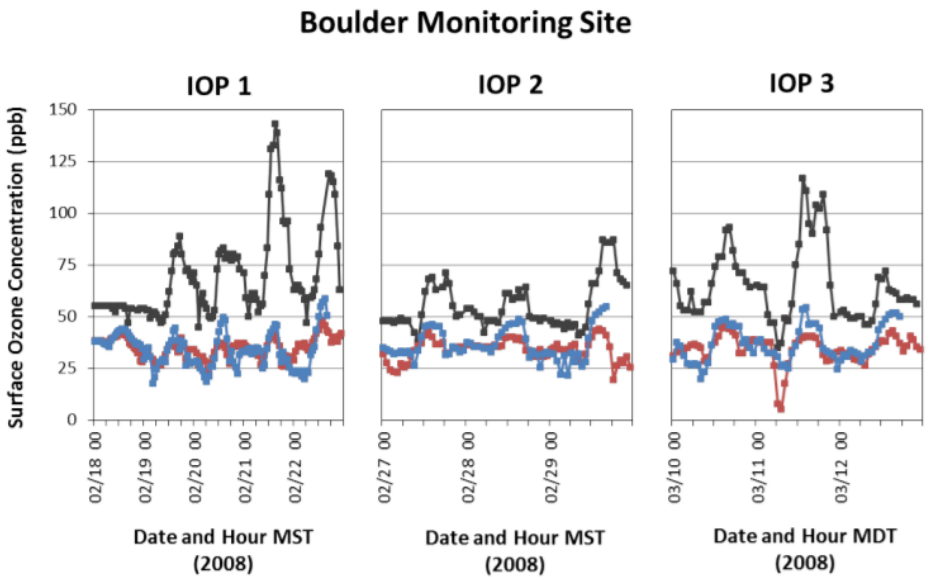
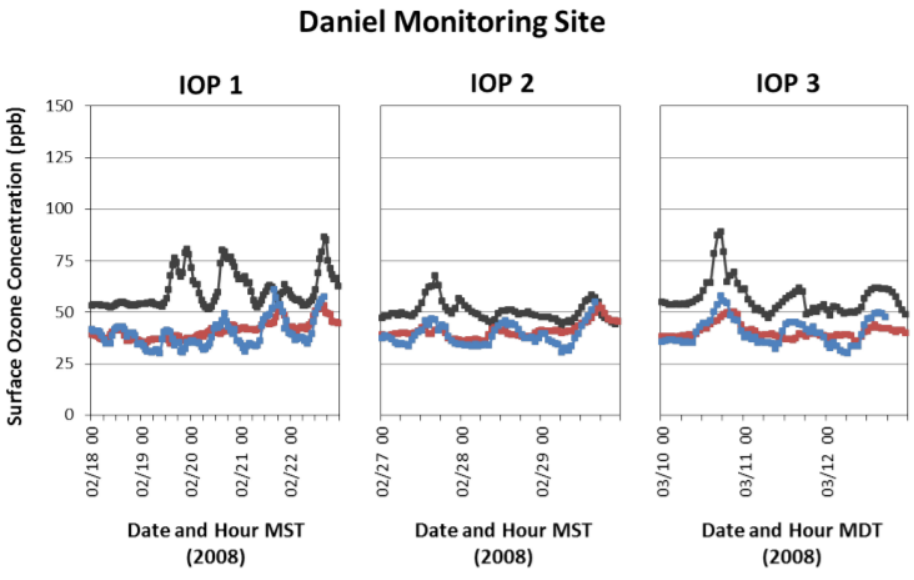
3-Dimensional Photochemical Grid Model Results



Time Series of Observed (black), CAMx (red) and CMAQ (blue) Ozone Concentrations at Boulder During the Three IOPs



Time Series of Observed (black), CAMx (red) and CMAQ (blue) Ozone Concentrations at Daniel During the Three IOPs

- Under-prediction of observed O_3 concentrations by both CAMx and CMAQ

Statistical Approach:
Ozone Regression Modeling

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All statistical regression models have the same basic format:

$$O_{3x} = \left[\sum_{k=1}^{n}(c_k V_k)\right] + C$$

Where:

- O_{3x} designates the O_3 concentration on day x as predicted by the model
- C is a constant
- $c_k V_k$ represents the pairs of weighting coefficients and predictor variables

Boulder-8 Model Development

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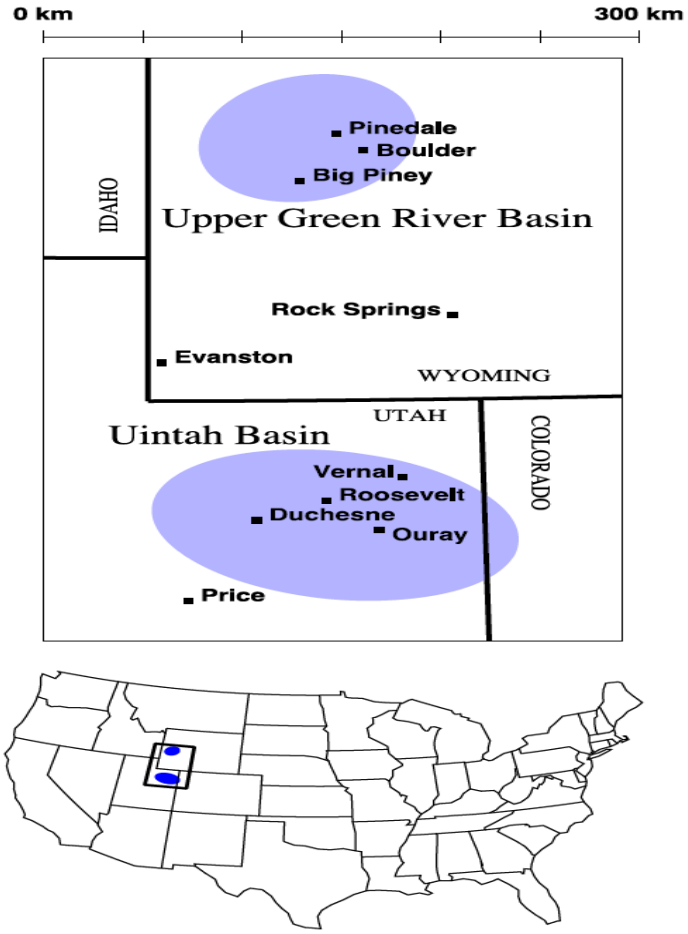
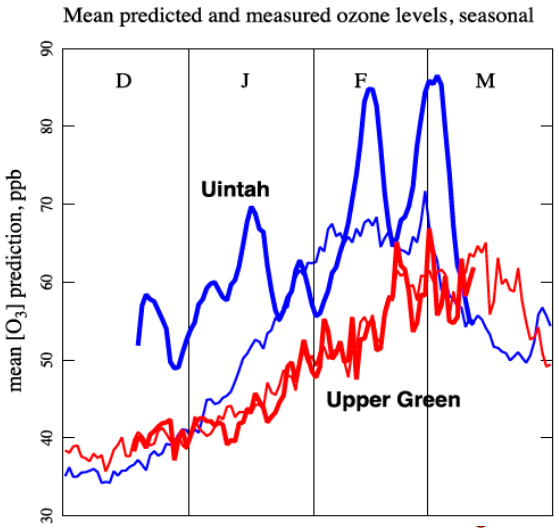


Figures from Mansfield et al., 2013 - Statistical analysis of winter ozone events

- Adopted a statistical analysis approach similar to the methods introduced by Mansfield and Hall, 2013
  - Developed O_3 quadratic regression models for Uintah Basin of Utah and the UGRB of Wyoming
  - Used limited data points in UGRB (mainly Boulder)
  - Predictor variables used in the Boulder model include:
    - lapse rate
    - snow depth
    - solar angle
    - temperature
    - inversion persistence
    - surface wind speed
    - relative humidity
    - barometric pressure



UGRB-11 Model Development

Modifications to Mansfield and Hall Methodology

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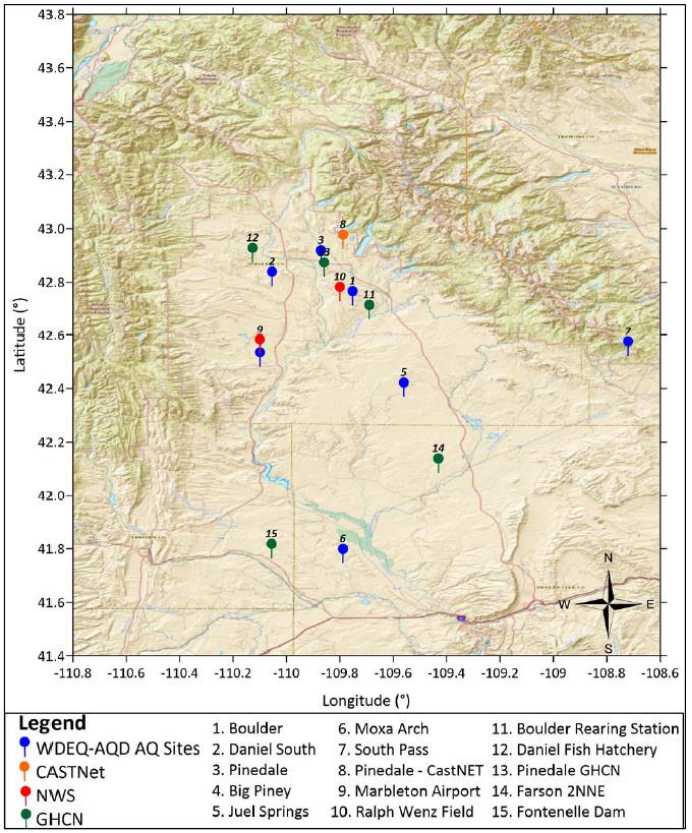
- Meteorological data a combination of:
  - WDEQ-AQD's ambient monitoring station network
  - Individual mesonet stations
- Basin-wide averages, maximum, minimums, and totals of predictor variables taken into account
- Utilize a combination of 11 independent predictor variables
  - lapse rate
  - snow depth
  - solar angle
  - basin-wide average temperature
  - inversion persistence
  - basin-wide average surface wind speed
  - relative humidity
  - barometric pressure
  - basin-wide average ΔT (2m to 10m)
  - basin-wide average solar insolation – cloudiness
  - basin-wide average total ultra-violet radiation - albedo

Met Stations Utilized in UGRB-11 Model



UGRB-11 Model Performance

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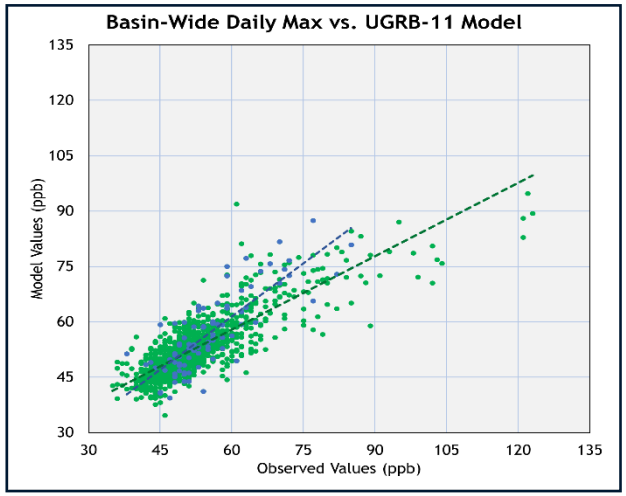
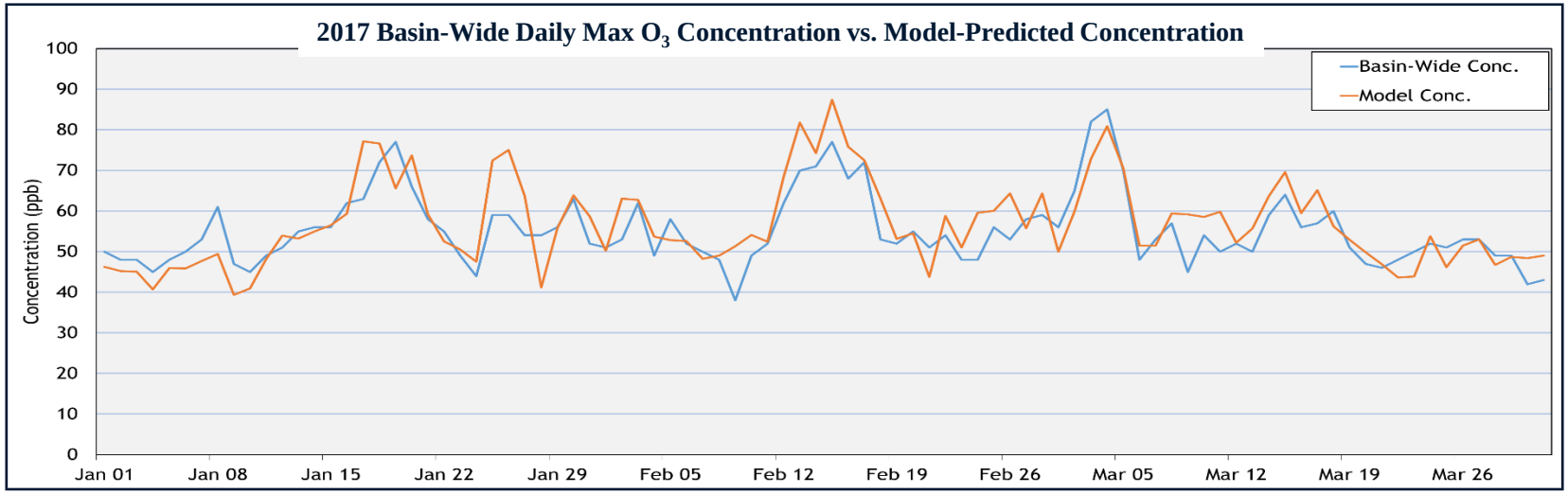


- UGRB-11 model had a correlation (R^2 value) of 0.66 for data collected from January – March for 2005 - 2017
- UGRB-11 model had an average absolute error of ~ 4 ppb for the 2017 season



Forecasting Assistance

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- UGRB-11 model will be used for operational forecasting during the 2018 winter O_3 season
- Fluctuation between the observed and modeled O_3 values serves as reminder that the regression model is primarily to be used as a guidance **tool**
  - Model top predictor variables:
    1. Basin-wide average surface wind speed
    2. Solar angle
    3. Basin-wide average total UV radiation
    4. Barometric pressure
    5. Snow depth
  - Experience top predictor variables:
    1. Snow depth
    2. Basin-wide average surface wind speed
    3. Inversion
    4. Basin-wide average total UV radiation
- Predictor variables provide air quality forecasters direction regarding the atmospheric conditions that are most responsible for elevated O_3 levels

WDEQ Ozone Prediction Model

Forecast Date: 3/4/2017

Enter Forecast Parameters

	GFS	NAM-WRF	
Surface Temperature	-1.63		°C
Surface Relative Humidity	70.5		%
Daytime Surface Wind Speed	5.07		knots
Surface Pressure (msl)	1015		mb
700 mb Temperature	1.1		°C
700 mb Elevation	2966		meters
Number of days Inversion has been in place	2		days
Daily average cloud cover	0		Enter (0-10)
Average Snow Depth	20.75		inches

Morning Delta-Temperature	1.02	°C

Predicted Ozone Concentration (ppb) 77.1

Basin Temp (°C)	BT	-1.63
Lapse Rate(K/km)	LR	-3.45
Inversion Day Count (#)	CDI	2
ΔTemp(°C)	DT	1.02
Wind Speed (m/s)	WS	2.61
Relative Humidity (%)	RH	70.50
Total Daily Solar Radiation(W/m2)	SR	5109
UV Radiation(W/m2)	UV	498
Zenith Solar Angle (°)	SA	49.96
Snow Depth(in)	SD	20.75
Barometric Pressure (bar)	BP	0.779

Questions?

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Contact Information

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