UINTA BASIN WINTER OZONE MODEL PERFORMANCE FOR THE UTAH BUREAU OF LAND MANAGEMENT'S AIR RESOURCE MANAGEMENT STRATEGY (ARMS) MODELING STUDY

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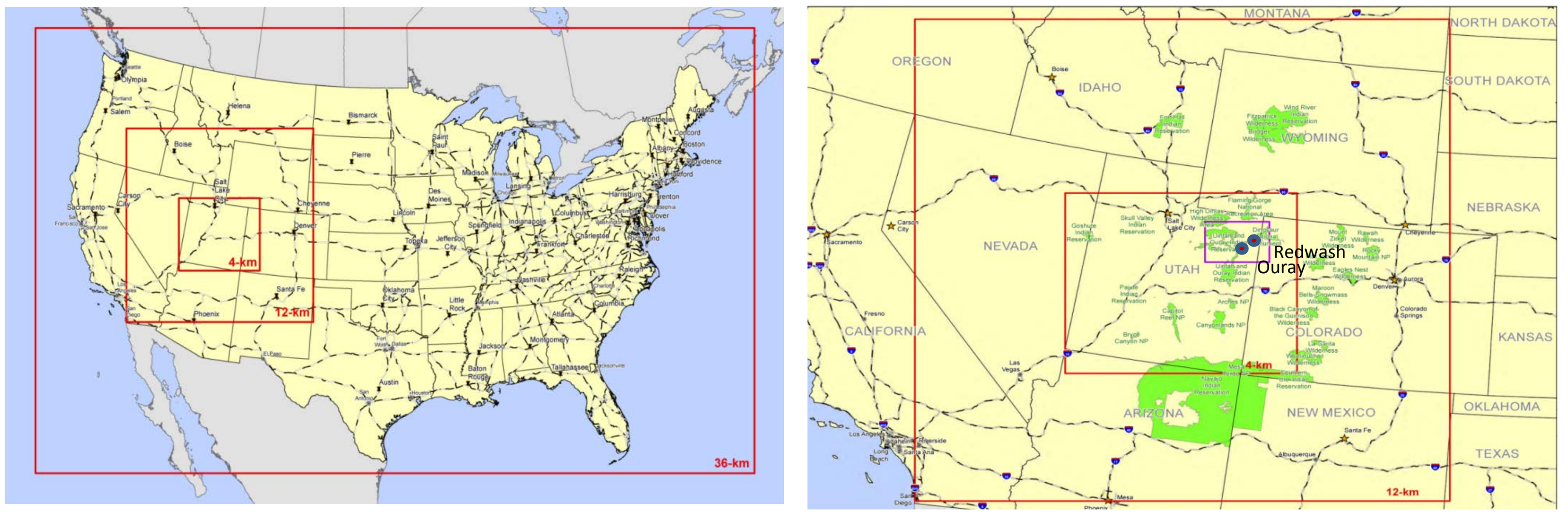
INTRODUCTION

The Bureau of Land Management (BLM), Utah State Office, conducted air quality modeling for the Uinta Basin to develop a landscape-scale Air Resource Management Strategy (ARMS). The Uinta Basin in northeastern Utah is an area with oil and gas extraction and production activities that are projected to continue into the foreseeable future. Elevated ozone levels have been measured during winter in the Uinta Basin since monitoring began in 2009. The ability for models to reproduce winter ozone formation is critical to the assessment and determination of suitable control strategies (Taylor, C et al. 2014), and similar modeling studies demonstrate the substantial challenges associated with modeling winter ozone formation.

For this study, care was taken to develop model inputs and select model options in consideration of characteristics that are necessary for winter ozone formation. Specifically,

- A robust gridded meteorological dataset that reproduces: strong and persistent cold pool temperature inversions, low wind speeds, and surface snow cover;
- A high-resolution, temporally and spatially accurate oil and gas emissions inventory; and use of improved snow albedo values and in-line photolysis rate calculations.

MODEL DOMAINS AND KEY MONITORING SITES



MODELING OVERVIEW

The PGM system consisted of the following components:

- Meteorology: Weather Research and Forecasting (WRF v3.4) model (Craig, K. et al, 2013)
- Emissions: enhanced oil and gas emissions are spatially and temporally resolved with Sparse Matrix Operator Kernel Emissions (SMOKE v3.0) (Taylor, C. et al., 2013)
- Air Quality Model results are shown for both the:
  - Comprehensive Air Quality Model with extensions (CAMx, v5.4) – 36-km one way nesting and 12/4-km two way nesting
  - Community Multiscale Air Quality Model (CMAQ, v5.0 with snow albedo patch) – one way nesting

WINTER OZONE MODEL PERFORMANCE

TIME SERIES COMPARISONS

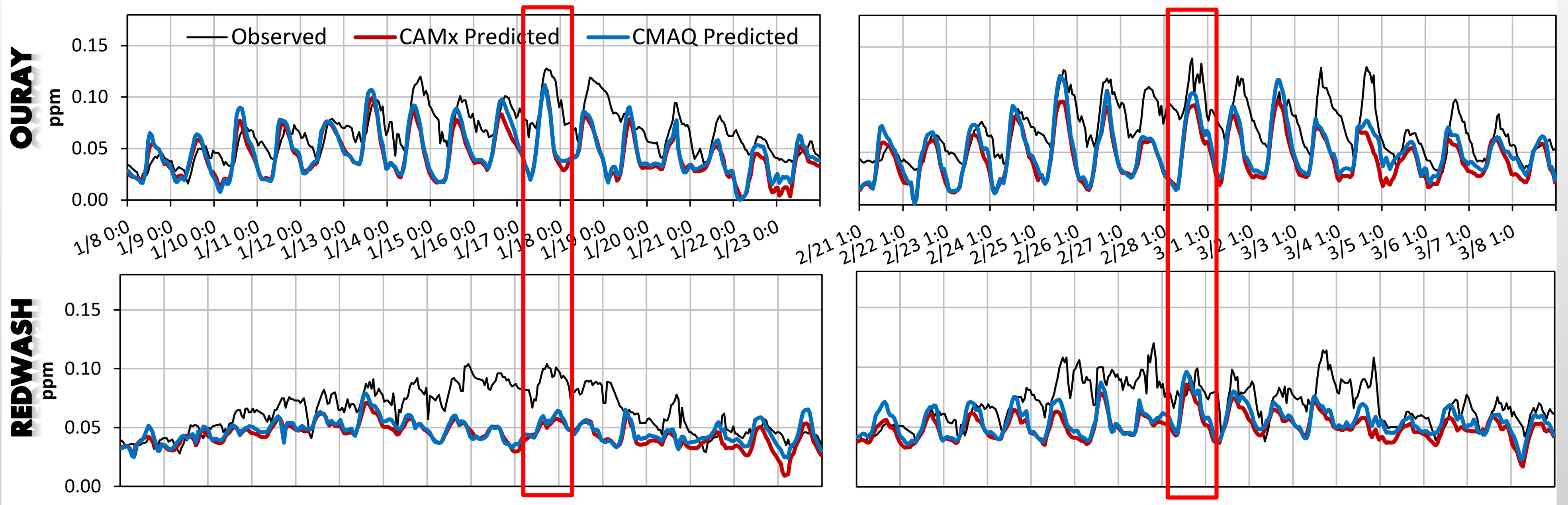


Figure 1: Time series of monitored and modeled ozone concentrations in January, 2010 (left column) and February-March, 2010 (right column) at Ouray (top row) and Redwash (bottom row).

SPATIAL COMPARISONS

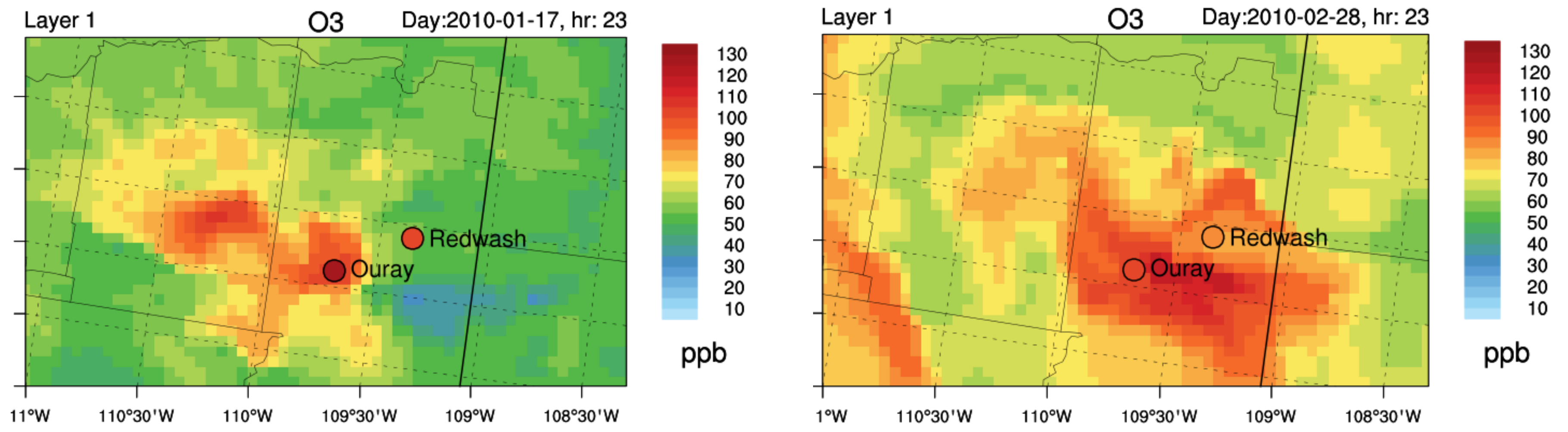


Figure 2: Spatial plots of CMAQ ozone concentrations in Uinta Basin on January 17, 2010 (left) and February 28, 2010 (right) at 4 pm local time.

VERTICAL PROFILES

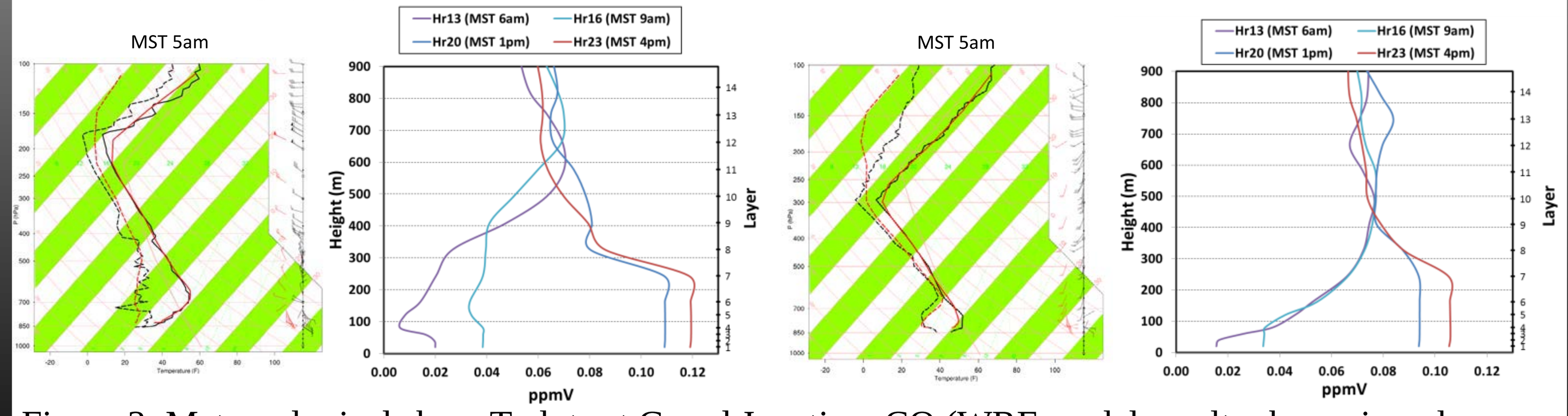
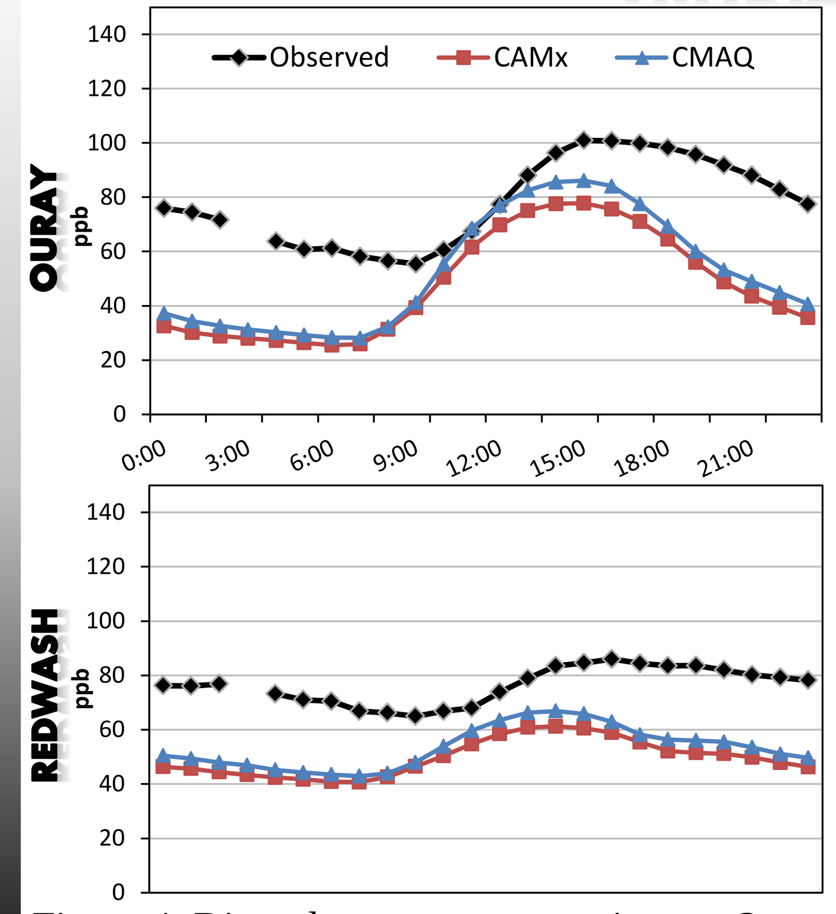


Figure 3: Meteorological skew-T plots at Grand Junction, CO (WRF model results shown in red and measurements in black) and vertical profiles of CMAQ ozone concentrations at Ouray on January 17, 2010 (left) and February 28, 2010 (right).

DIURNAL PATTERNS



Ozone concentrations are averaged for each hour of the day during two periods of elevated ozone concentrations to evaluate diurnal patterns. Modeled and monitored concentrations at Ouray and Redwash are plotted in Figure 4. When comparing modeled diurnal patterns with monitored diurnal patterns:

- Modeled nighttime concentrations are substantially lower than measurements
- Modeled ozone production starts earlier and reaches a maximum earlier in the day
- Modeled peak ozone declines much more rapidly than measurements

The difference between daily minimum and maximum concentrations is larger at Ouray than Redwash for both modeled and monitored values.

Figure 4: Diurnal ozone concentrations at Ouray (top) and Redwash (bottom) during January 12-20, 2010 and February 23, 2010 through March 7, 2010.

FINDINGS

- As shown in Figure 1, both CMAQ and CAMx reproduce periods of elevated ozone concentrations during winter in the Uinta Basin and perform best at Ouray where the highest ozone concentrations were monitored in 2010. Both models tend to under-predict afternoon and nighttime concentrations (Figure 4).
- While both models under-predict peak ozone concentrations (Figure 1), CMAQ results tend to reproduce the timing and magnitude of observed peak concentrations better than CAMx.
- CMAQ has a lower mean normalized bias and error (-18 and 22, respectively) than CAMx (-25 and 27, respectively) when compared to monitors in the 4-km domain.
- The modeled extent of elevated ozone differs between events (Figure 2), although the model may not accurately reproduce concentrations at Redwash (Figure 1). The peak concentrations are predicted to occur in the vicinity of Ouray for all events analyzed, which is consistent with monitoring studies conducted in 2011.
- During periods of elevated ozone concentrations at the surface in the Uinta Basin, vertical profiles of ozone (Figure 3) and precursors (not shown) indicate the presence of a strong inversion throughout the day with a boundary layer height of ~200 to 300 meters above ground level. These findings are consistent with modeled and measured morning upper air soundings at Grand Junction, Colorado.
- While the models' appear to be able to reproduce the onset of conditions that lead to elevated ozone events (Figure 1) and characterize inversion and stagnation periods throughout the duration of the events (Figures 1 and 3), improvement of the models' nighttime chemistry may improve peak daytime performance during winter (Figure 4).