Analysis of Earthview BluBird data acquired at Coterra's Remington site during CSU METEC single-blind controlled natural gas releases in January-February 2023

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(proprietary information)

Findings: Elevated CH4 concentrations were detected by the Earthview system during all of the METEC releases at the Remington site. Earthview's automated emission calculation translated these concentrations into elevated emission rates during two of the three test periods. Elevated emissions were not reported during one of the periods despite the elevated concentrations detected. This was due to a combination of wind direction issues and the releases taking place at pad locations that had not been previously defined as locations of potential emission sources.

1. Experiment Setting

METEC released natural gas on three days at the locations indicated in Figure 1: Jan. 31, 2023 (1/31) from 12:30 - 16:50 hours, Feb. 2, 2023 (2/2) from 10:13 - 16:49 hours, and Feb. 3, 2023 (2/3) from 09:52 - 13:29. The stated METEC release rates for the test period on 1/31 ranged from 4.7 - 24.2 kg/hr, from 2.0 - 14.3 kg/hr on 2/2 and from 2.4 - 19.3 kg/hr on 2/3.

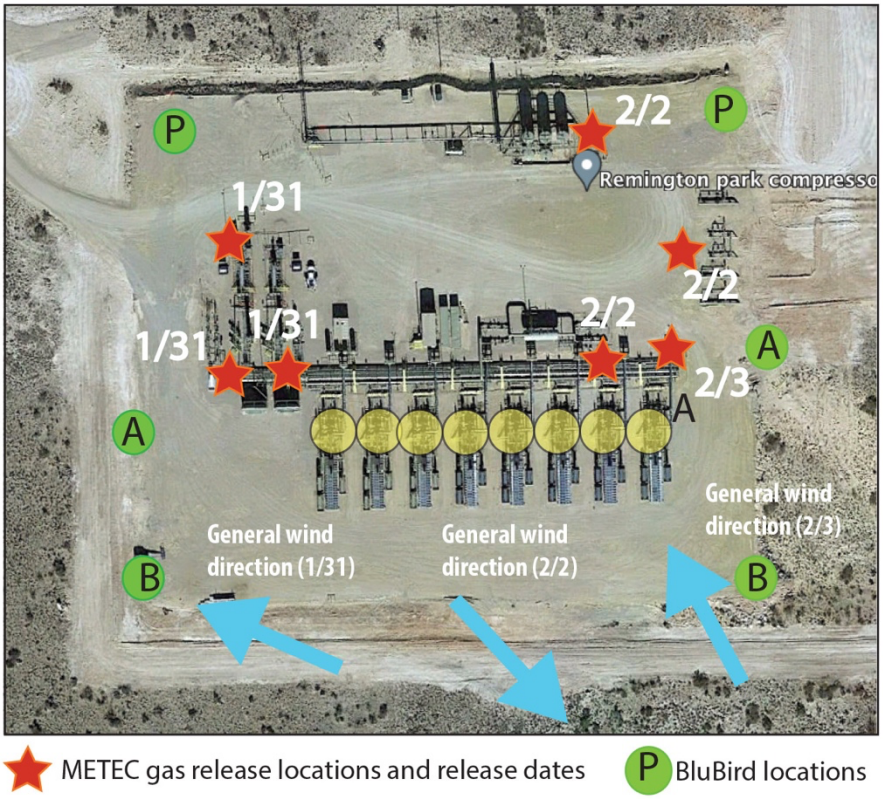

Figure 1. Remington pad configuration with BluBird node positions (green circles), potential emission source locations used for Earthview emissions calculations (yellow circles), and METEC release locations and times (red stars with dates in white). The blue arrows indicate the predominant wind directions during the release periods. The three BluBird nodes located on the east side of the site are referred to as the Remington East group and those on the west side are referred to as Remington West.

2. Wind Conditions

As shown in Figure 1 and in figures 2 and 3 below, winds during the release times were mainly from the east-northeast on 1/31; from the northwest on 2/2; and from the southeast on 2/3. Wind speeds were light to moderate (Figure 4). However, only one node (node A at Remington West) appeared to be reporting correctly during the 1/31 test period.

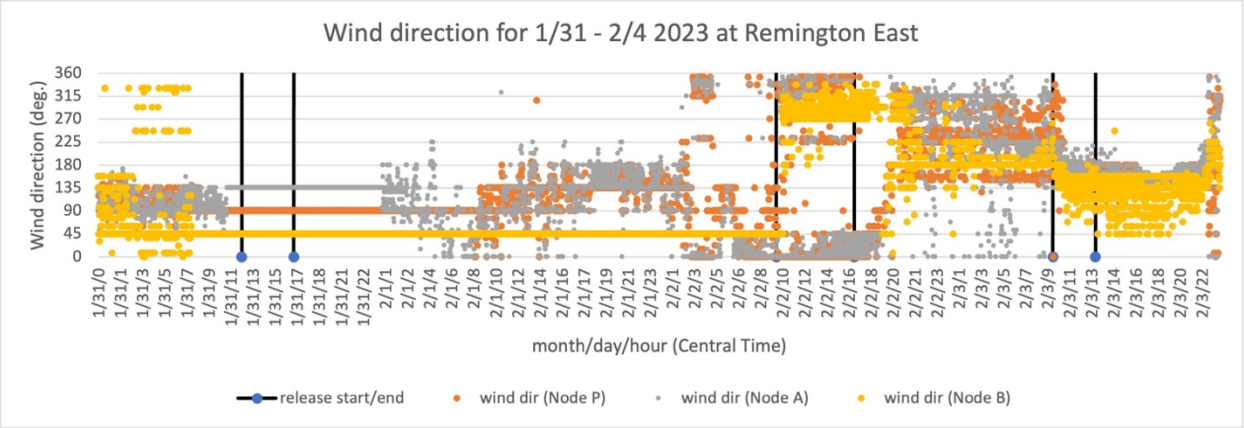

Figure 2. Wind directions reported by BluBird nodes on the east side of the site ("Remington East").

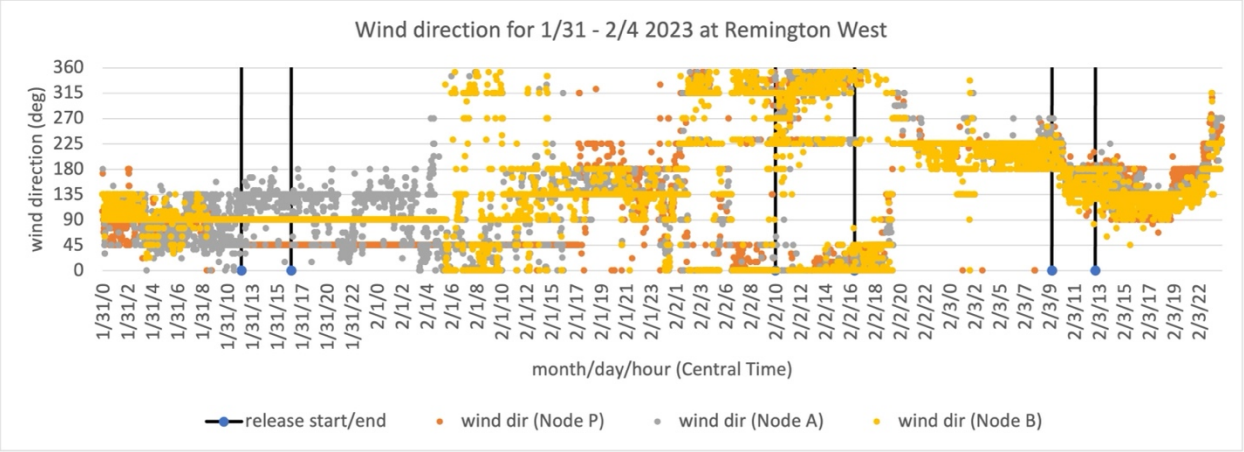

Figure 3. Wind directions reported by BluBird nodes on the west side of the site ("Remington West").

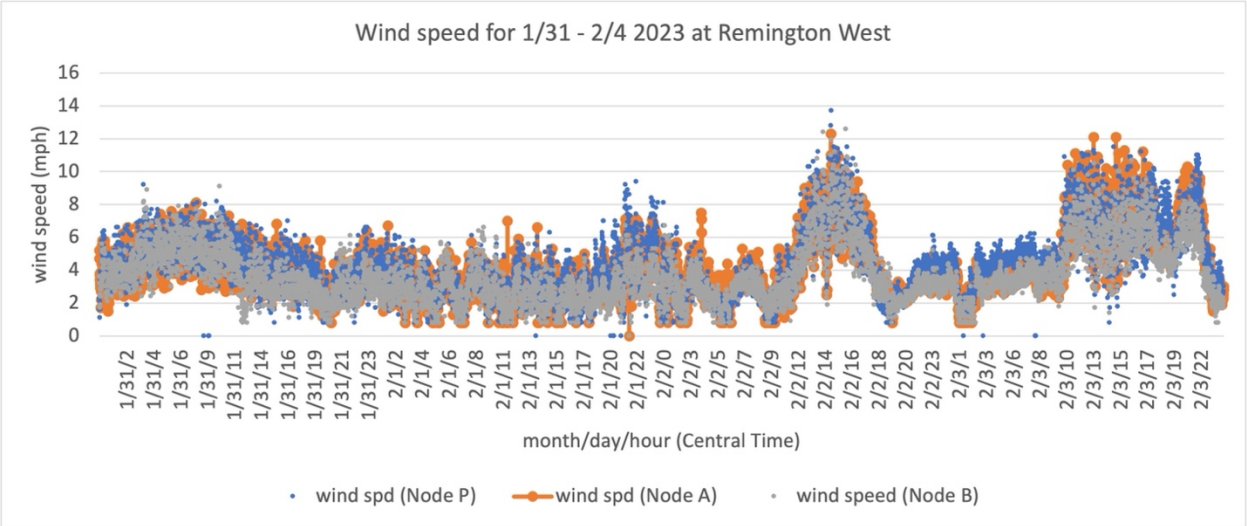

Figure 4. Wind speed reported by Remington West BluBird nodes.

3. BluBird-Measured CH4 Concentrations

CH4 concentrations reported in real-time by the BluBird system for the test periods are shown below (figures 5 and 6), along with indicators of the specific METEC release periods. During the 1/31 gas release period, BluBird nodes P and A on the west side of the site reported elevated concentrations (Figure 6). On 2/2, concentrations were high at nodes A and B on the east side of the site (Figure 5), while on 2/3, concentrations increased a relatively small but still significant amount at node P on the west side of the site (Figure 6). These increases at the particular nodes are consistent with wind direction.

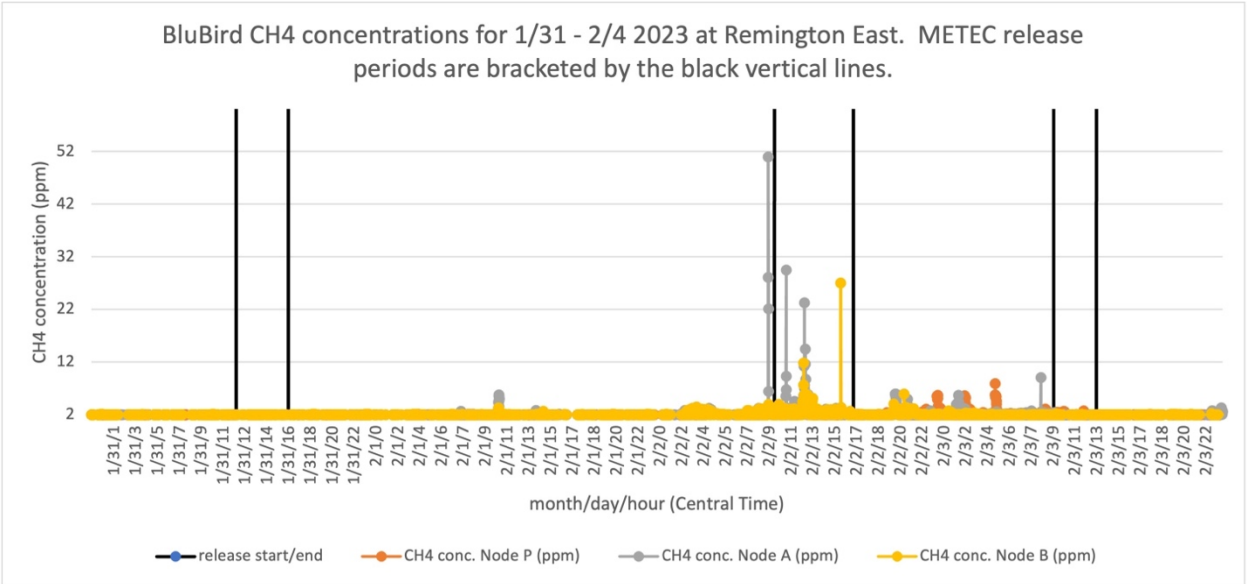

Figure 5. Methane concentrations reported by BluBird units located along the east side of the Remington site. The METEC release periods are indicated by the black vertical lines. The data show elevated concentrations during the release period on Feb. 2, coincident with winds from the northwest.

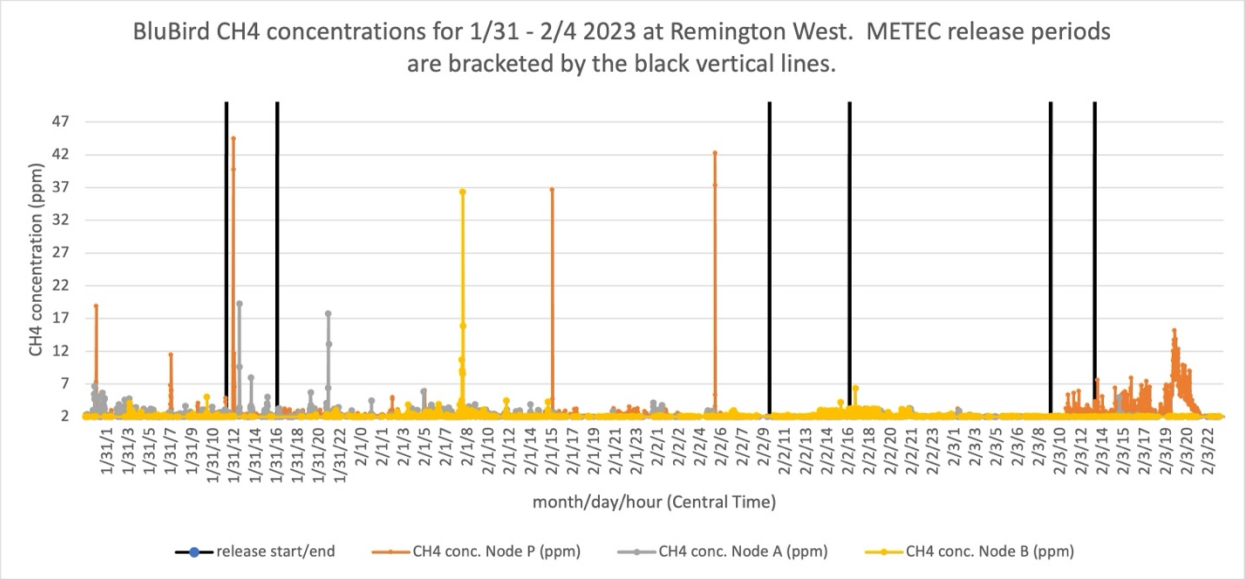

Figure 6. Methane concentrations reported by BluBird units located along the west side of the Remington site. The METEC release periods are indicated by the black vertical lines. The data show elevated concentrations during the release period on Jan. 31, coincident with winds from the east-northeast, and lower but still well above background concentrations on Feb. 3, with winds from the east.

4. Estimated Emission Rates Using Standard and Revised Methods

The real-time CH4 emission rates calculated by Earthview's standard method are given in Figure 7, along with indicators showing the METEC release periods. Emission rates that significantly higher than background are present during two of the three release periods (as well as at other times).

The lack of elevated rates during the 1/31 release period is contrary to what would be expected given the concentration plot in Figure 6, where high concentrations were reported by nodes P and A on the west side of the site. The reason for this is suggested by the wind directions in figures 2 and 3, and explored further in Figure 8. During the 1/31 release period, only one of the 6 nodes (node A in Remington West) appears to be responding to changes in wind direction. Node P at Remington West reports that the winds are constant from the northeast (45 deg.), and since there are no indicated sources upwind in that direction, the processing software would treat the concentrations seen at node P as from an off-pad source. At node A however, wind directions appear to have been reporting correctly, but the wind directions when node A saw the elevated concentrations were during brief periods when the winds were from 45 to 60 degrees (Figure 8). Again, as indicated by the source locations in Figure 1, node A assumes that there are no potential emission sources upwind in that direction. During the remainder of the time, the winds are steady from 135 deg., which likely would have caused the gas plumes to be aligned in between nodes P and A and thus missed by both nodes.

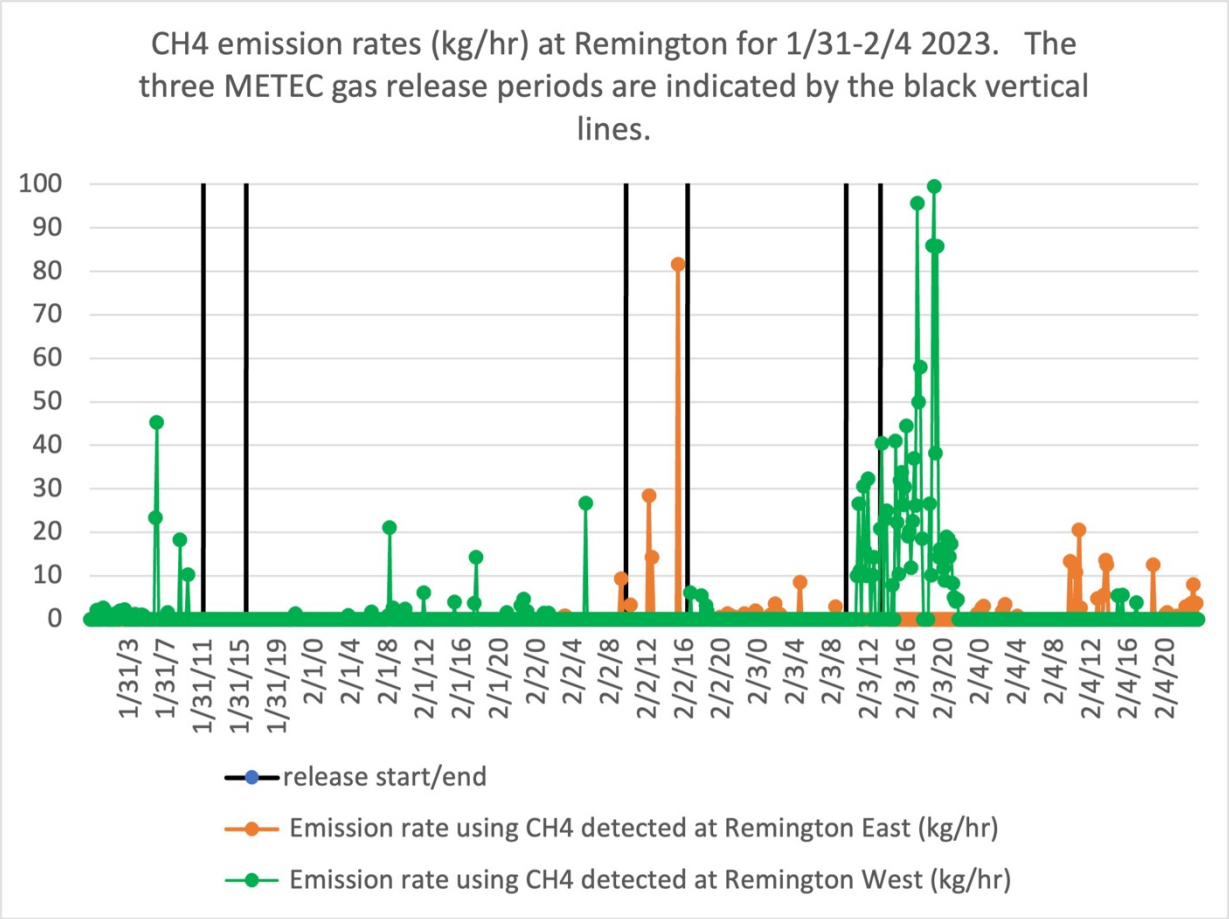

Figure 7. Earthview-calculated emission rates (kg/hr) for Jan. 31 - Feb. 4, 2023. The three METEC release periods are indicated.

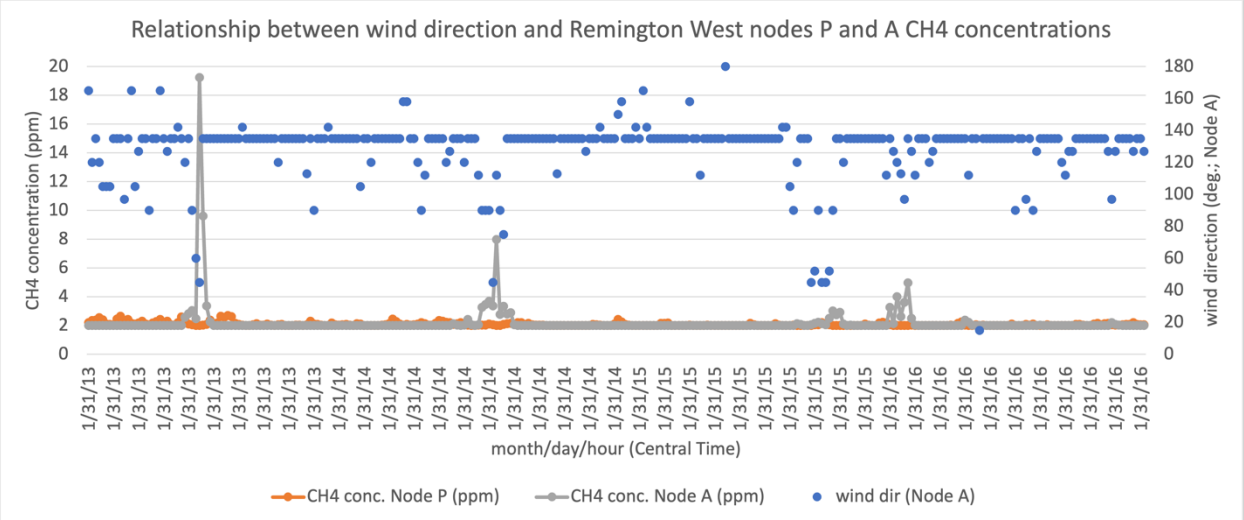

Figure 8. Wind direction (as reported by node A) and CH4 concentrations (reported by nodes P and A) at Remington West during a portion of the 1/31 METEC release period. Note that the spikes in

concentration at node A occur during brief periods when winds shift toward the northeast, aligning with the release source locations.

During the 1/31 release period, the standard Earthview method would have calculated emission rates ranging from 62 kg/hr to 25 kg/hr. Using an average of CH4 concentrations that were above background during that period (see the discussion in the Sir Barton 4 summary) would have yielded an emission rate for the event of around 20 kg/hr. For the 2/3 period, emission rates using the latter method are around 14 kg/hr versus the standard method's 25 to 40 kg/hr.

5. Conclusions

The data presented above show that elevated CH4 concentrations were detected during all of the METEC releases at the Remington site. Earthview's automated emission calculation system translated these concentrations into elevated emission rates during two of the three test periods, but likely failed to identify elevated emissions during the 1/31 period due to a combination of wind direction issues and the release locations in areas that had not been previously defined as locations of potential emission sources. Calculated emission rates were overestimated compared to the stated METEC release rates when using Earthview's standard method, but are more in line with METEC's rates when a revised rate calculation approach is used.