

Ambient Air Quality Near a Marcellus Shale Well Pad in Southwestern Pennsylvania

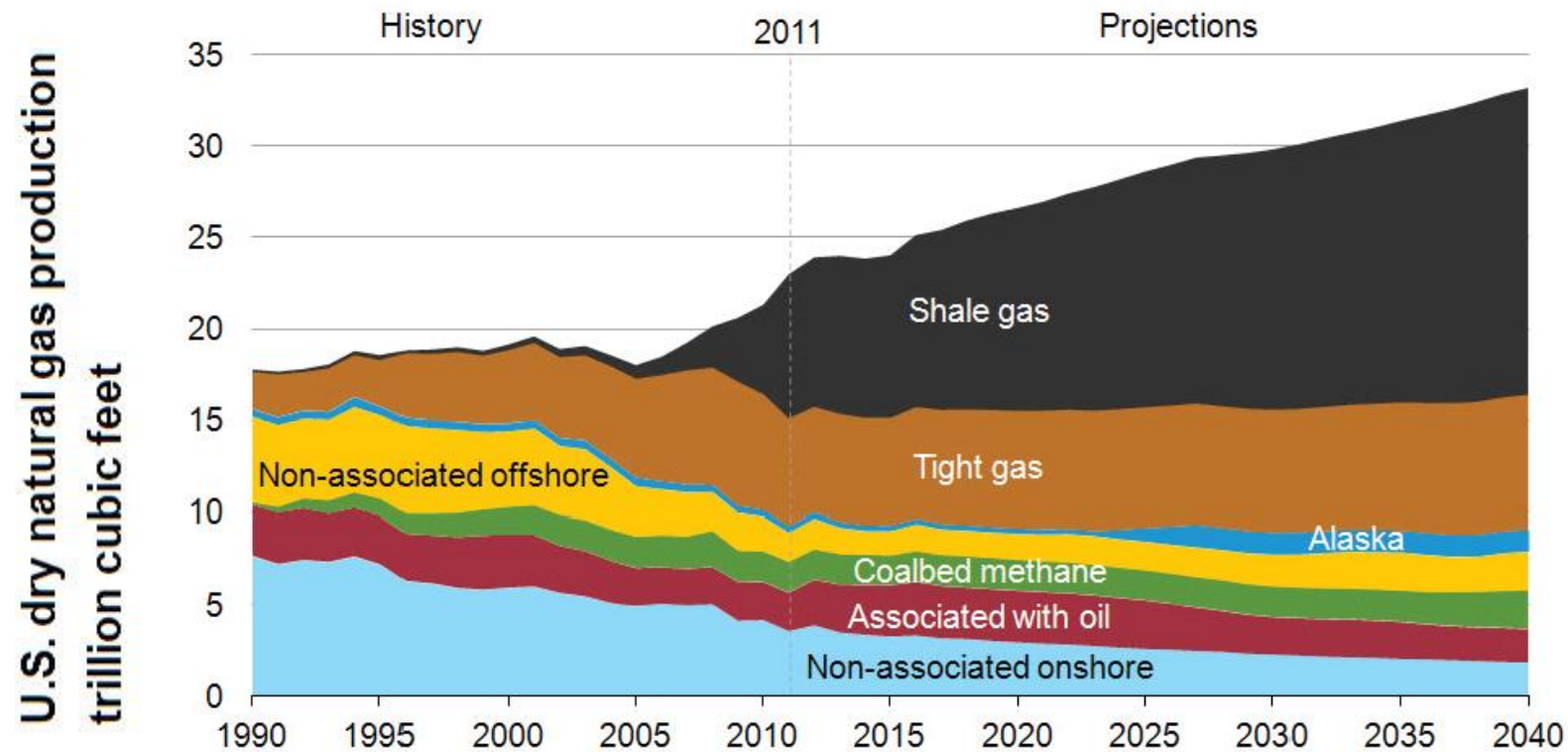
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Solutions for Today | Options for Tomorrow

Overall Project Objective

- To investigate and characterize the effect of shale gas well pad production activity on local air quality.

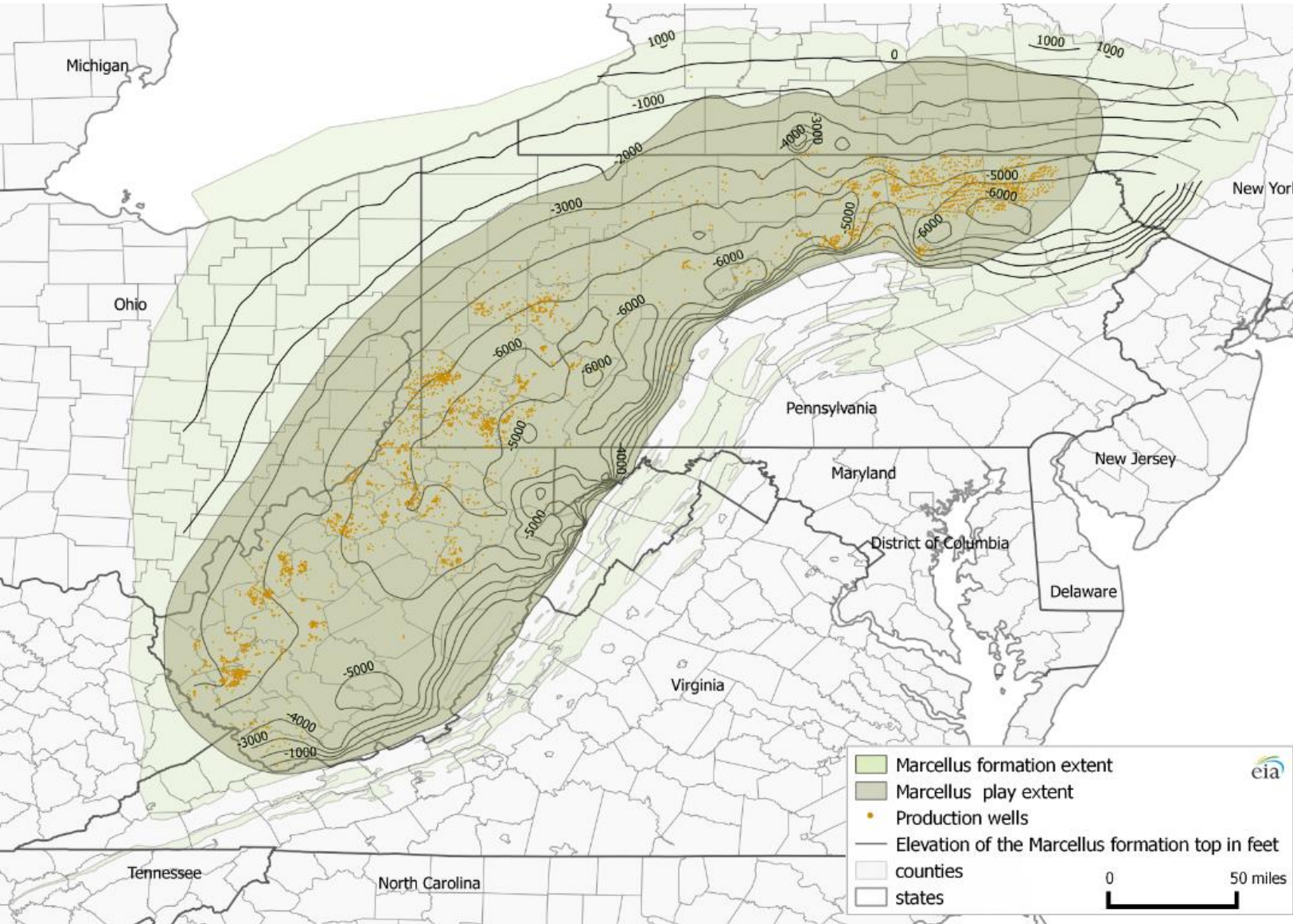


Outline

- Marcellus Shale Information
- Case Study Background
- Methods
- Results
- Discussions

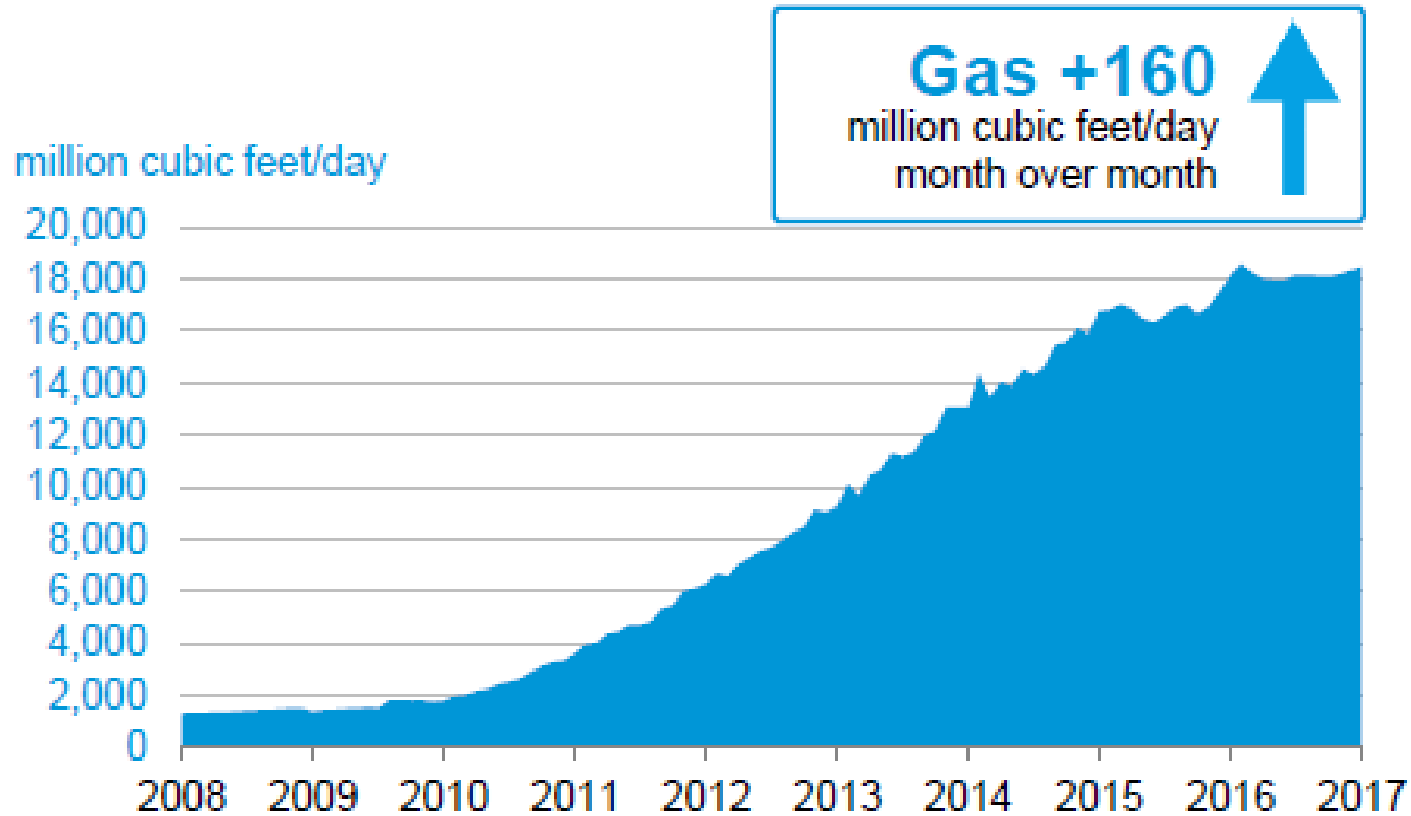
Marcellus Shale

Structure map of the Marcellus formation



- Focuses on 5 states
- Provides more than 35% of shale gas production in the U.S.
- The Marcellus is about 1 mile below the surface

Marcellus Region Natural Gas Production

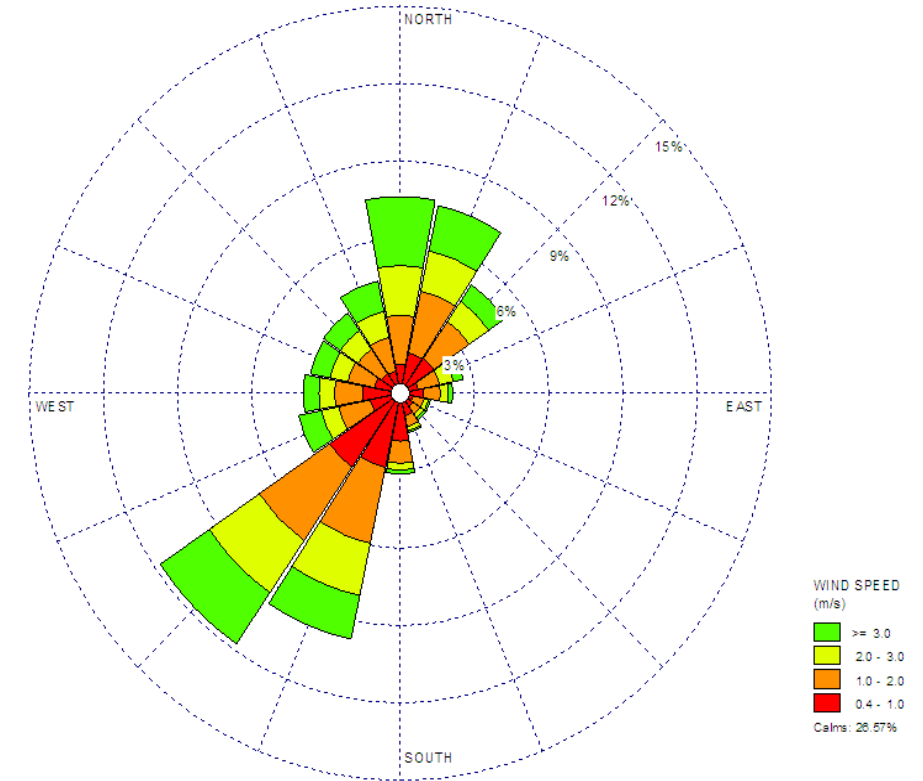
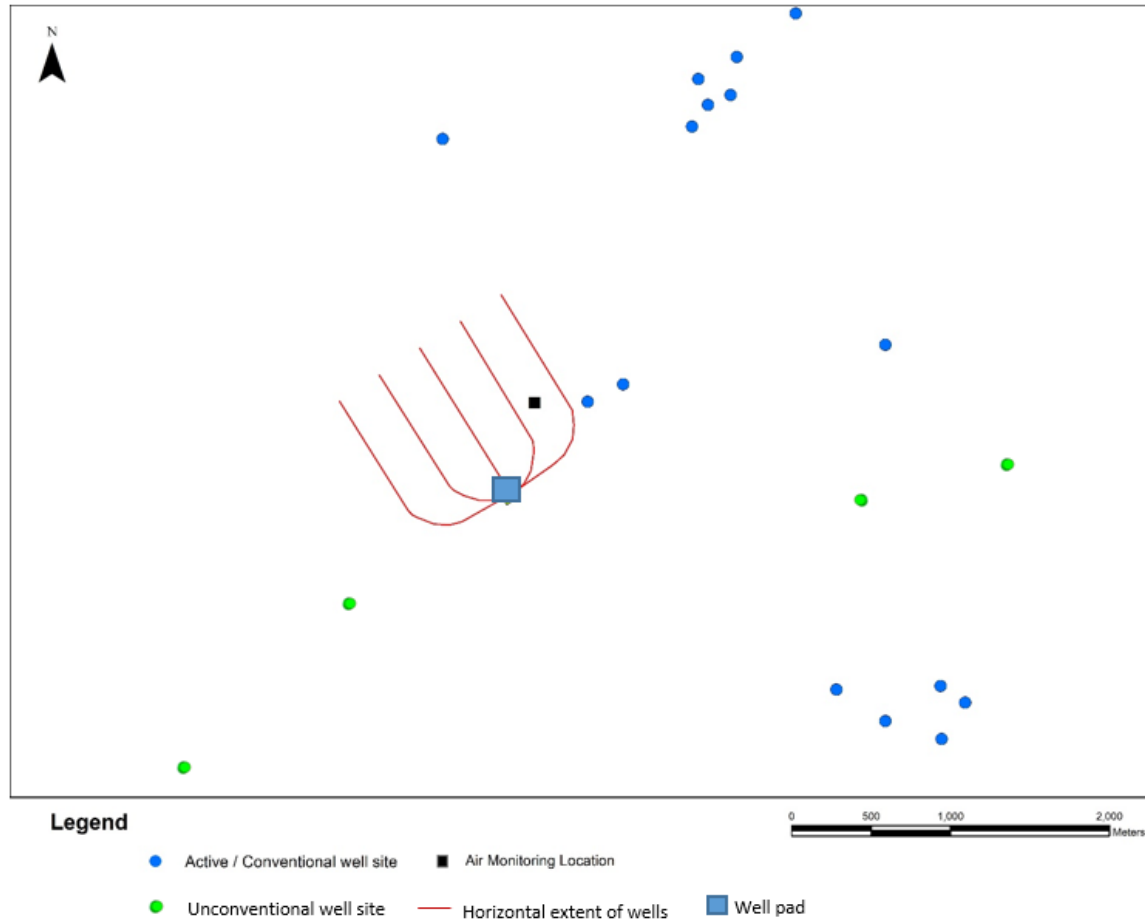


- Production increased to approximately **18.0 Bcf/d** in 2016

U.S. Energy Information Administration, 2016

Case Study Background

Air Monitoring at Washington County Well Pad



Case Study Background

NETL's Mobile Air Monitoring Laboratory



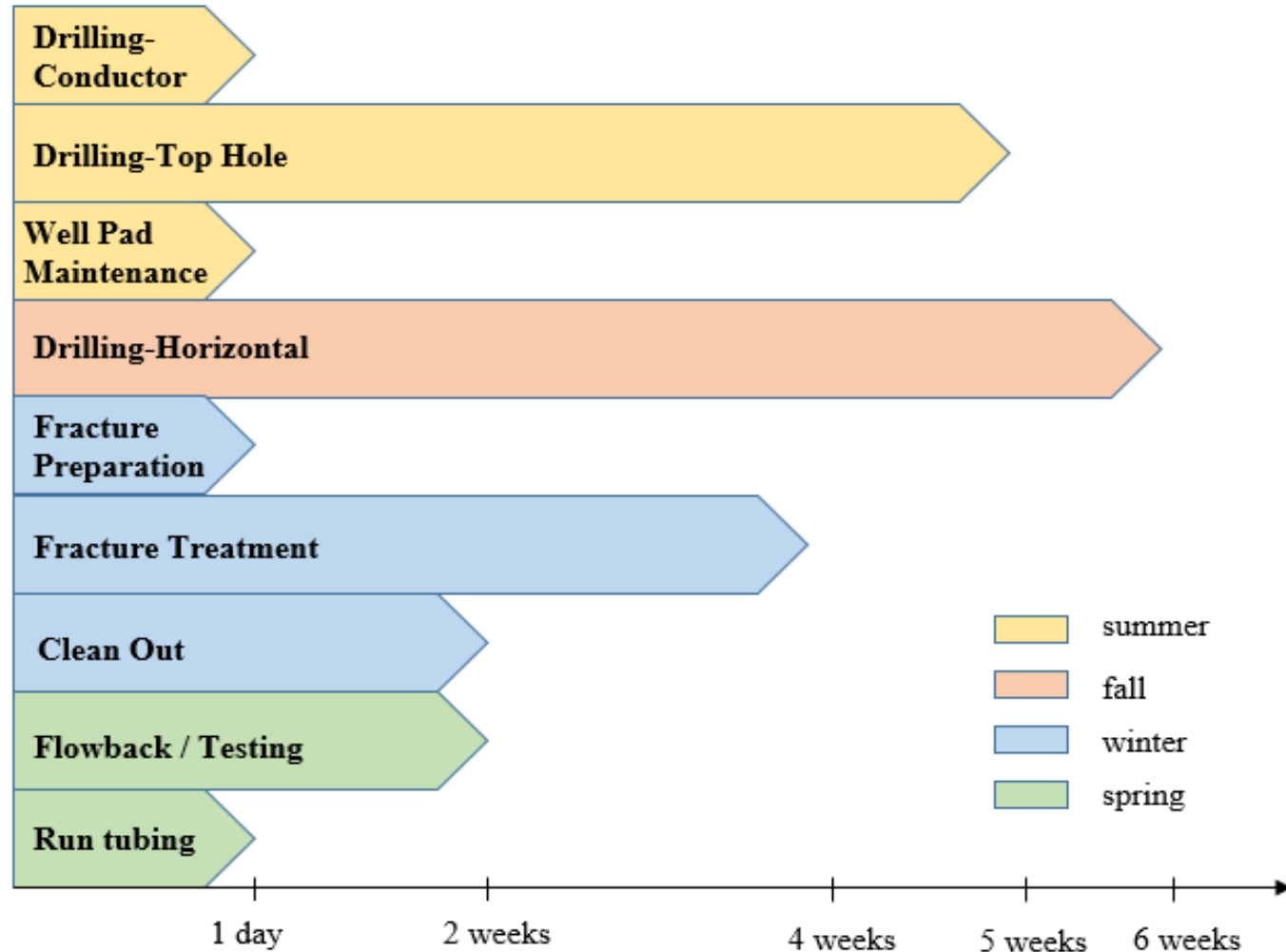
Continuously measures ambient concentrations of methane, VOCs, NOx, Ozone, Particulate Matter, as well as meteorological parameters



- Satellite Link for Remote, Unattended Operation
- Requires Electric Power (line or generator)

Case Study Background

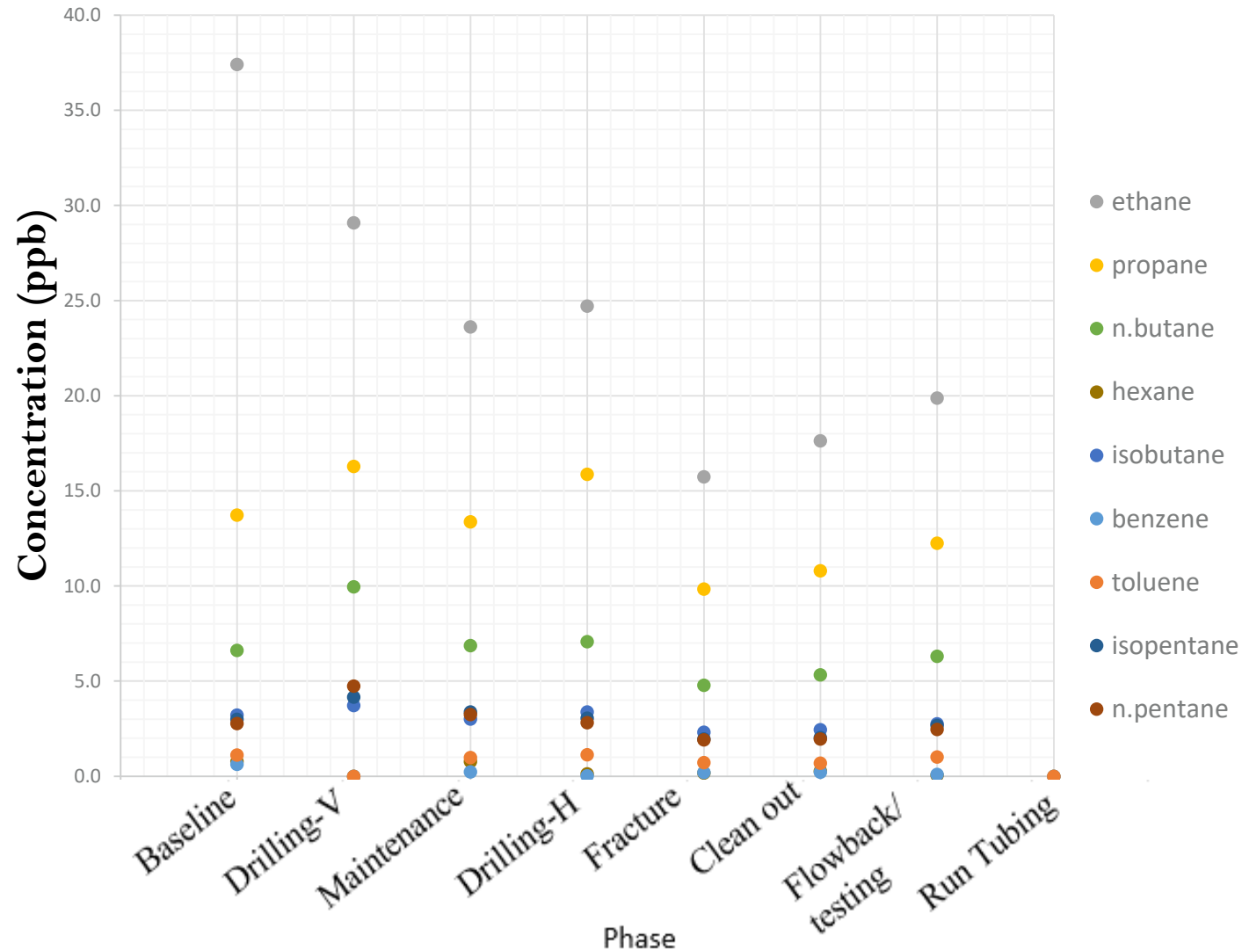
Unconventional Natural Gas Production Process Activity Diagram



Methods: Data Collection

Measurement	Unit	Time resolution	Instrument	Measurement technique
VOCs (52 compounds, U.S. EPA PAMS Spectra VOC calibration standard, Linde Specialty Gases, Stewartsville, NJ)	ppb	1 hr	Perkin Elmer Ozone Precursor Analyzer	GC-FID with thermal desorption
Ozone, NO _x , SO ₂	ppb	1 min	Teledyne-API Gas Analyzers	UV absorption, Chemiluminescence, UV fluorescence
Methane* and Carbon Isotopes** in Methane, CO ₂ * and Carbon Isotopes** in CO ₂	* ppm ** per mil	1 sec	Picarro G2201-i	Cavity ring-down spectrometry
PM ₁₀ and PM _{2.5}	µg/m ³	1 hr	Thermo Fisher TEOM 1405DF	Microbalance
Meteorological Parameters: wind speed and direction, temperature, relative humidity, barometric pressure, rainfall, and solar intensity	various	1 min	Davis Instruments Vantage Pro2 Plus	Various

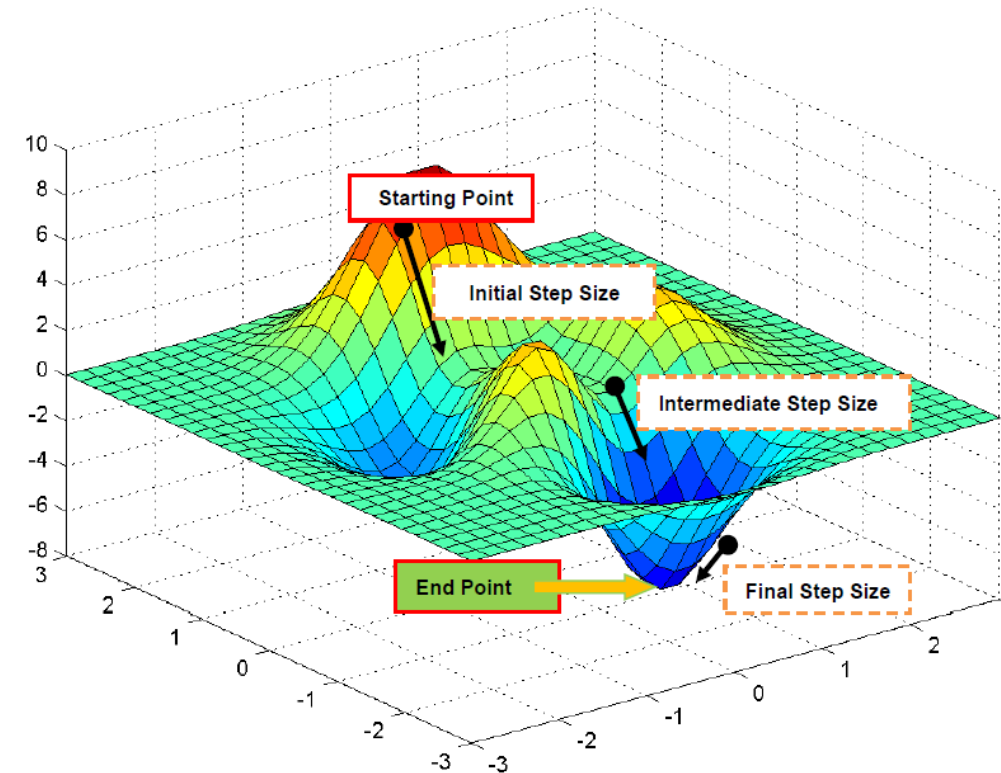
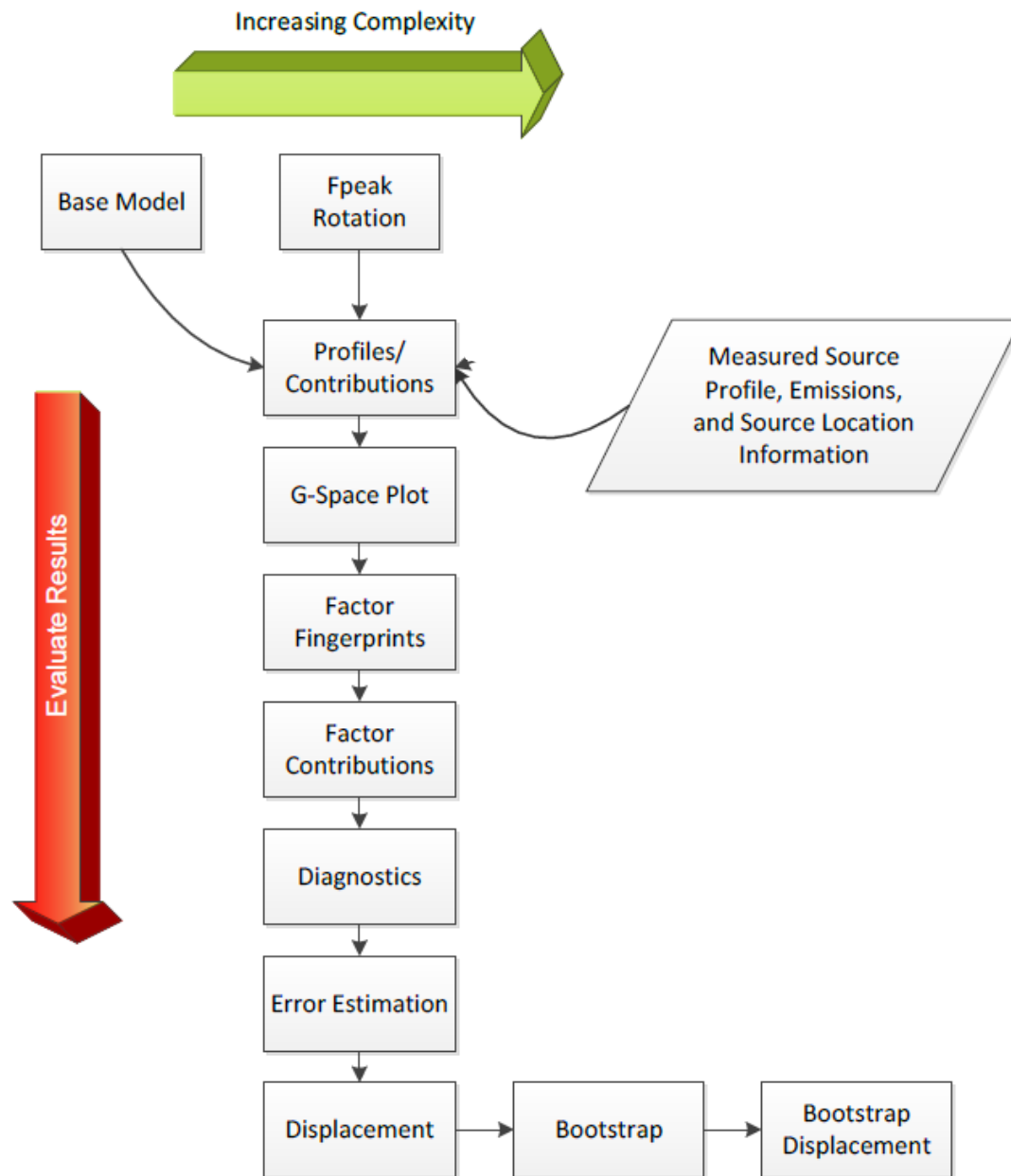
Methods: Data Collection



Methods: Receptor Modeling

Positive Matrix Factorization (PMF)

- Mathematical approaches for quantifying the contribution of sources to samples based on the composition or fingerprints of the sources.
- Goal: Determining the contribution of each identified stage source to ambient air pollutants' concentrations
 - EPA PMF 5.0



Methods: Receptor Modeling

Decision parameters:

- Factor solution fingerprints
- Factor profile contributions
- Error estimation results
- Hourly peak concentrations of pollutants

MODEL 1

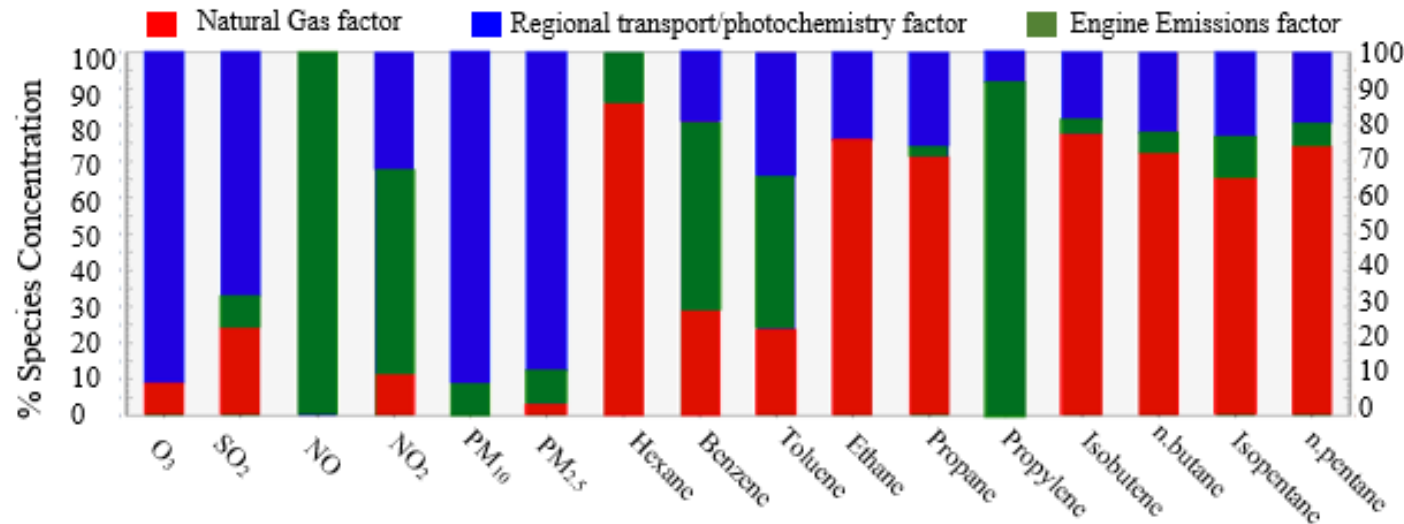
Prior to well pad constructions

MODEL 2

drilling, hydraulic fracturing, flowback, and
production activity

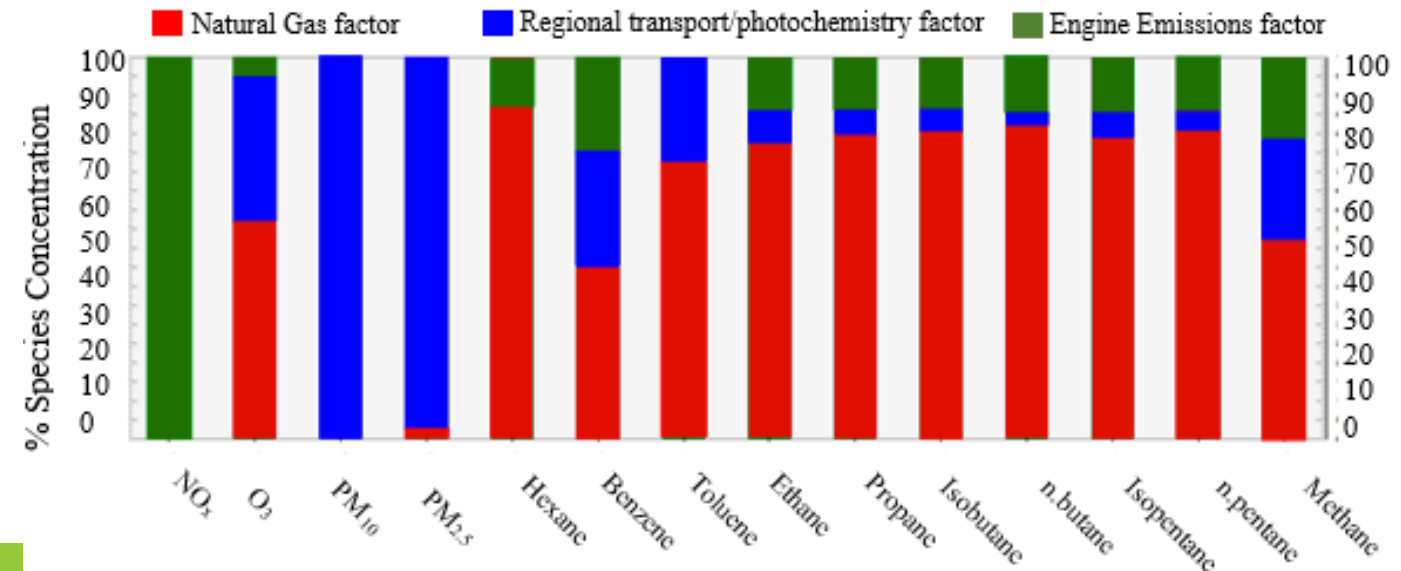
Results

3-Factor Solutions



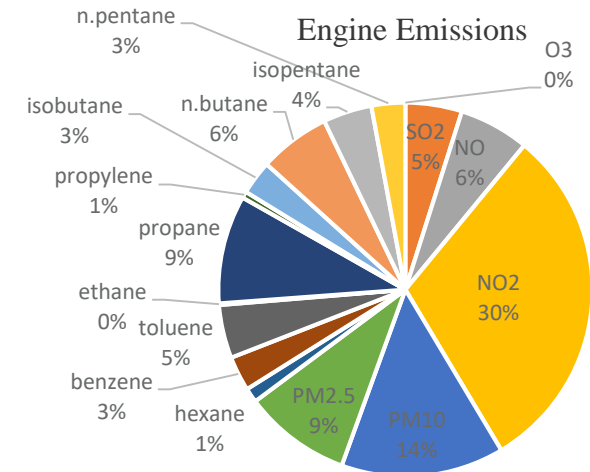
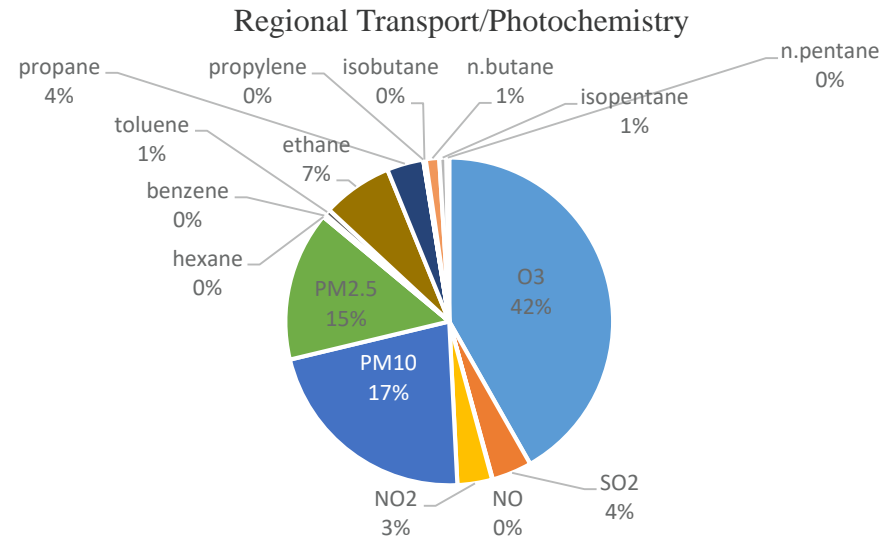
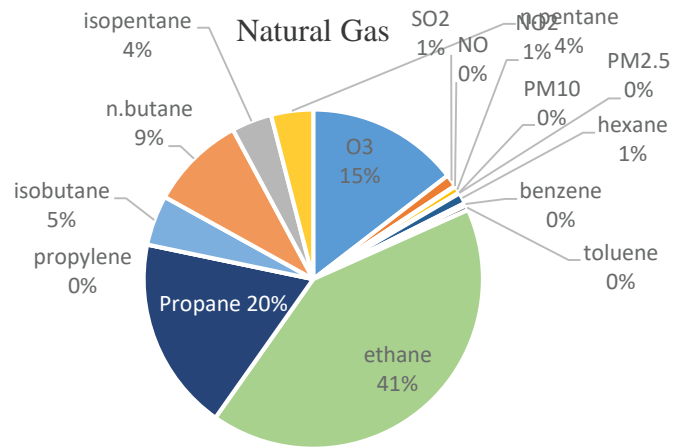
← For Baseline Monitoring Period, $F_{\text{peak}}=1$

For Drilling through Production Monitoring Period, $F_{\text{peak}}=1 \rightarrow$

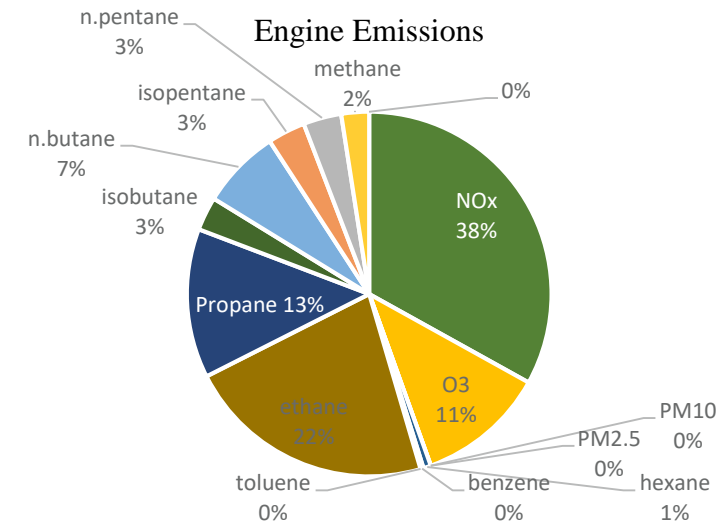
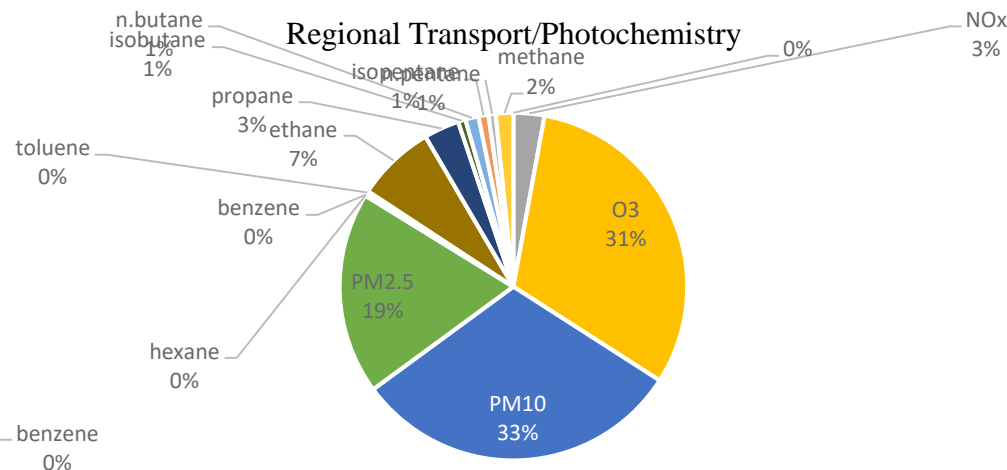
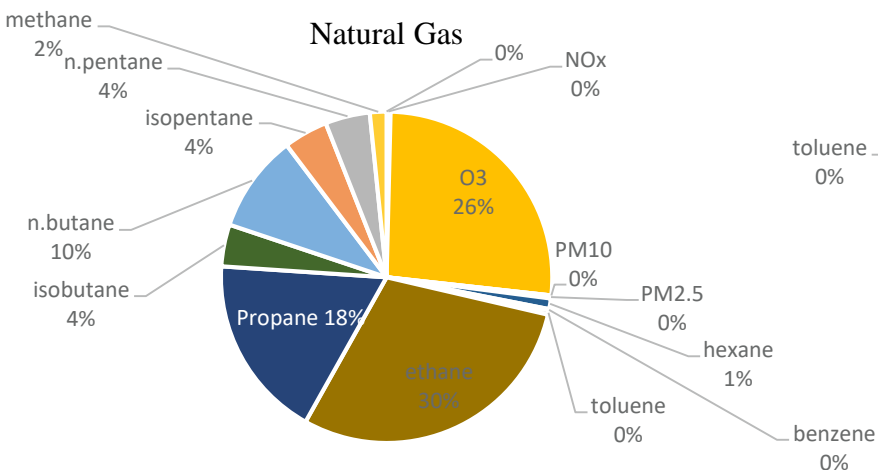


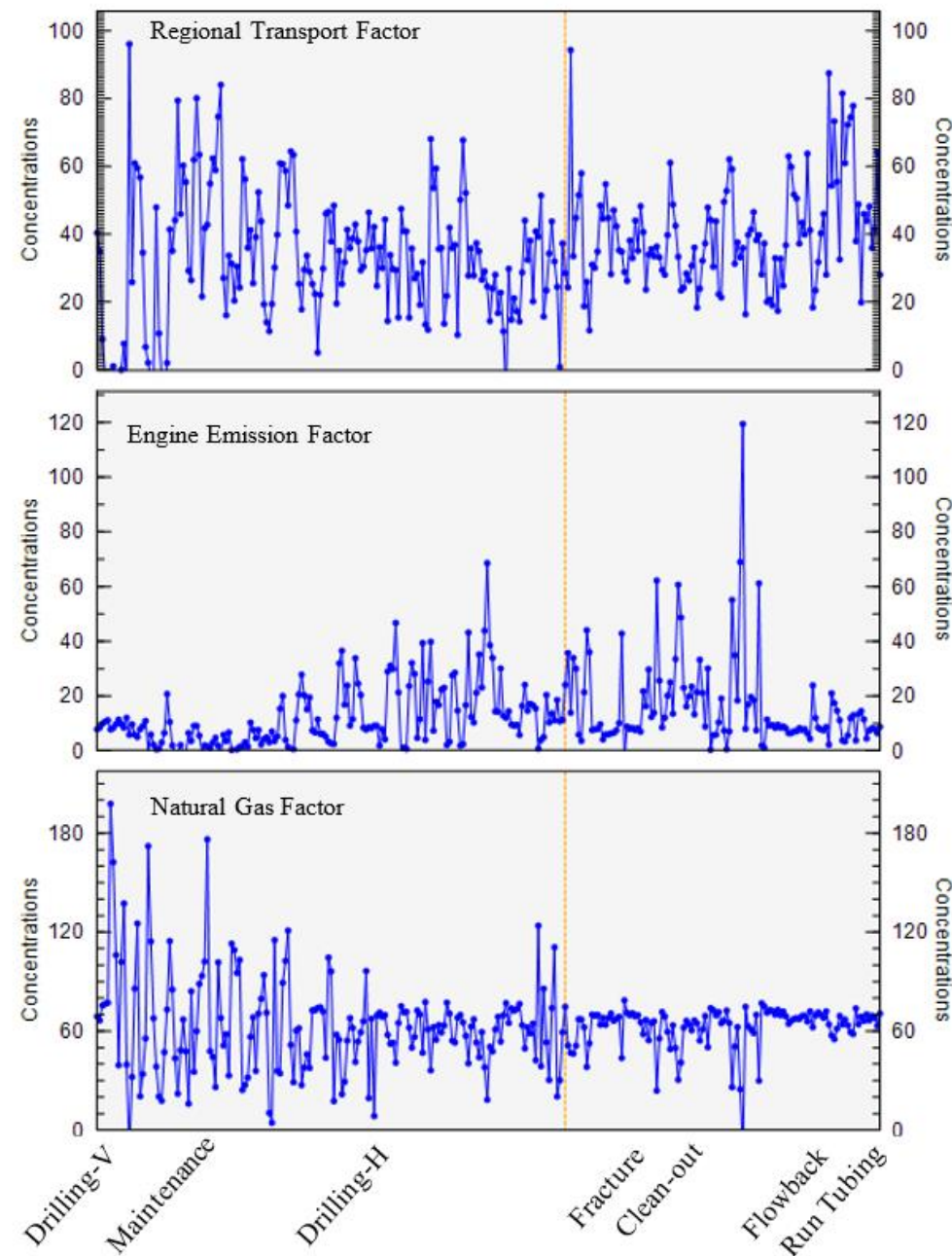
Results: Factor Contributions

Baseline PMF



Drilling through Production PMF





Conclusion

- Vertical drilling and maintenance stages → the *natural gas* factor
 - horizontal drilling phase → *natural gas* factor
- An increasing contribution over time → the *engine emission* factor
 - The peak concentration → clean-out stage
- Vertical drilling, horizontal drilling and flowback → the *regional transport/photochemistry* factor
 - High variability

QUESTIONS?

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