Air quality modeling to solve the mystery of high wintertime ozone

Ravan Ahmadov

- ✓ It is important to model the high wintertime ozone events by air quality models in order to understand, predict and mitigate wintertime ozone pollution events.

- ✓ Air quality models were unable to predict or reproduce the high wintertime O_3 episodes in the US (Wyoming and Utah) observed in recent years.

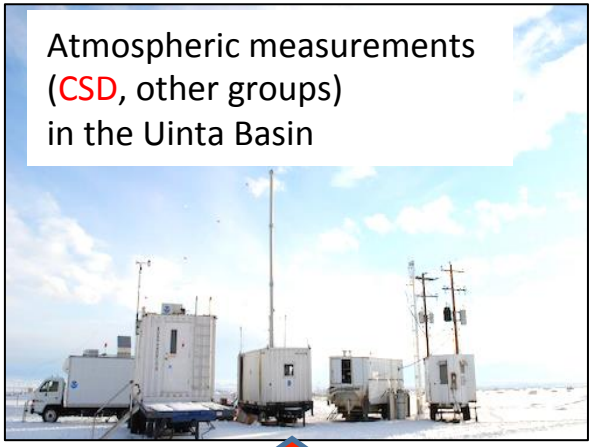
- ✓ Main challenges for modeling such pollution episodes: complex terrain and meteorology, snow effect of chemistry, deposition and photolysis fluxes and poorly constrained oil and natural gas emissions.

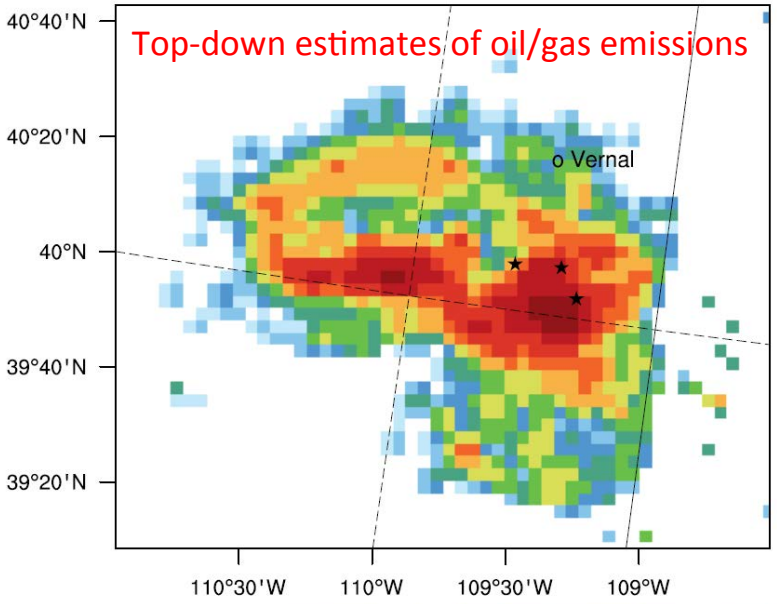
- ✓ We targeted the wintertime ozone pollution events by leveraging off the CSD's measurements and the regional air quality model (Weather Research and Forecasting coupled to Chemistry) capabilities.

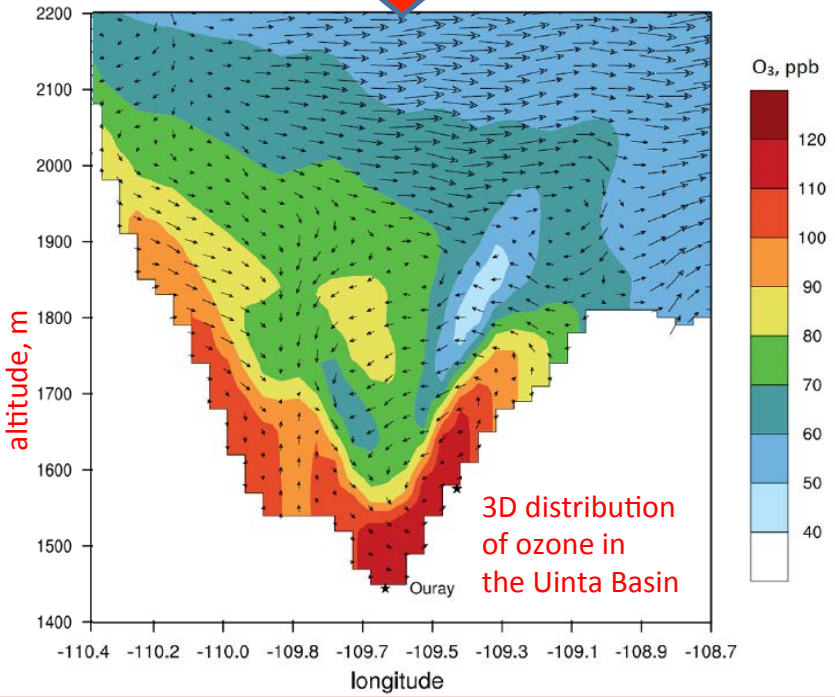
Uinta Basin, 2013
Photo by S.Sandberg

Air quality modeling framework (emissions, transport, chemistry and evaluation) developed at CSD

Atmospheric measurements (CSD, other groups) in the Uinta Basin







The state of the art fully coupled air quality model: WRF-Chem

Full simulation of meteorology, tracer transport, atmospheric chemistry, photolysis, removal processes in high spatial resolution

Oil and natural gas sector emissions for the Uinta Basin used in the model

Emission datasets	Source	Methane (tons/year)	Non methane VOCs (tons/year)	NO_x (tons/year)
Bottom-up	EPA National Emission Inventory (NEI-2011)	100,279	101,184	16,448
Top-down	Based on the measurements	482,130	184,511	4,158

Ahmadov et al. (2015), ACP

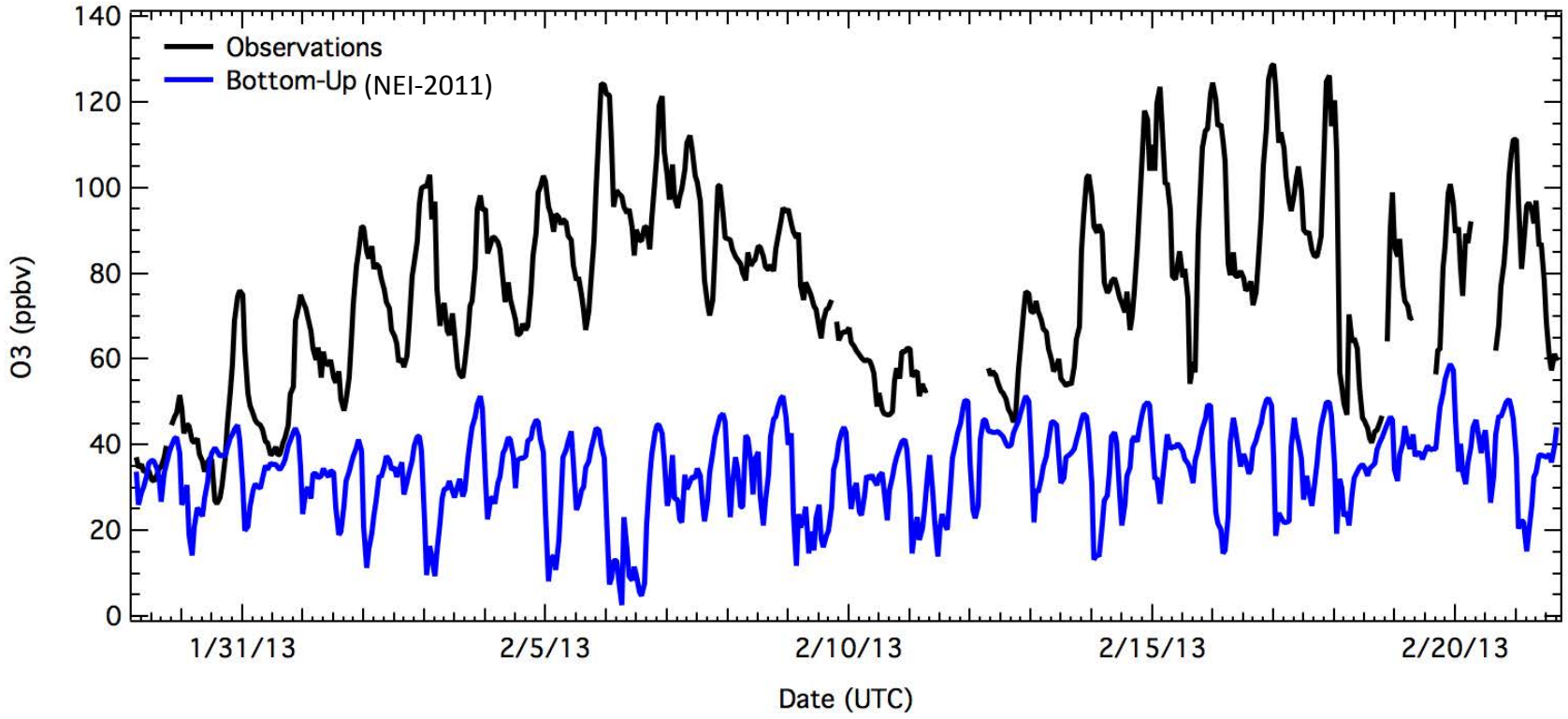
- ✓ Total top-down based methane flux estimate is from *Karion et al., 2013* (M. Trainer's talk)
- ✓ Total methane and other VOC emissions in NEI-2011 are lower by a factor of 4.8 and 1.8 than in the top-down estimates respectively!
- ✓ Conversely, NO_x emissions are 4 times higher in the NEI-2011 inventory!

Implications for air quality regulations, climate and air quality studies!

Observed and modeled ozone time series at the Horse Pool site, 2013

Multi-day buildup of surface O_3 during the stagnation episodes

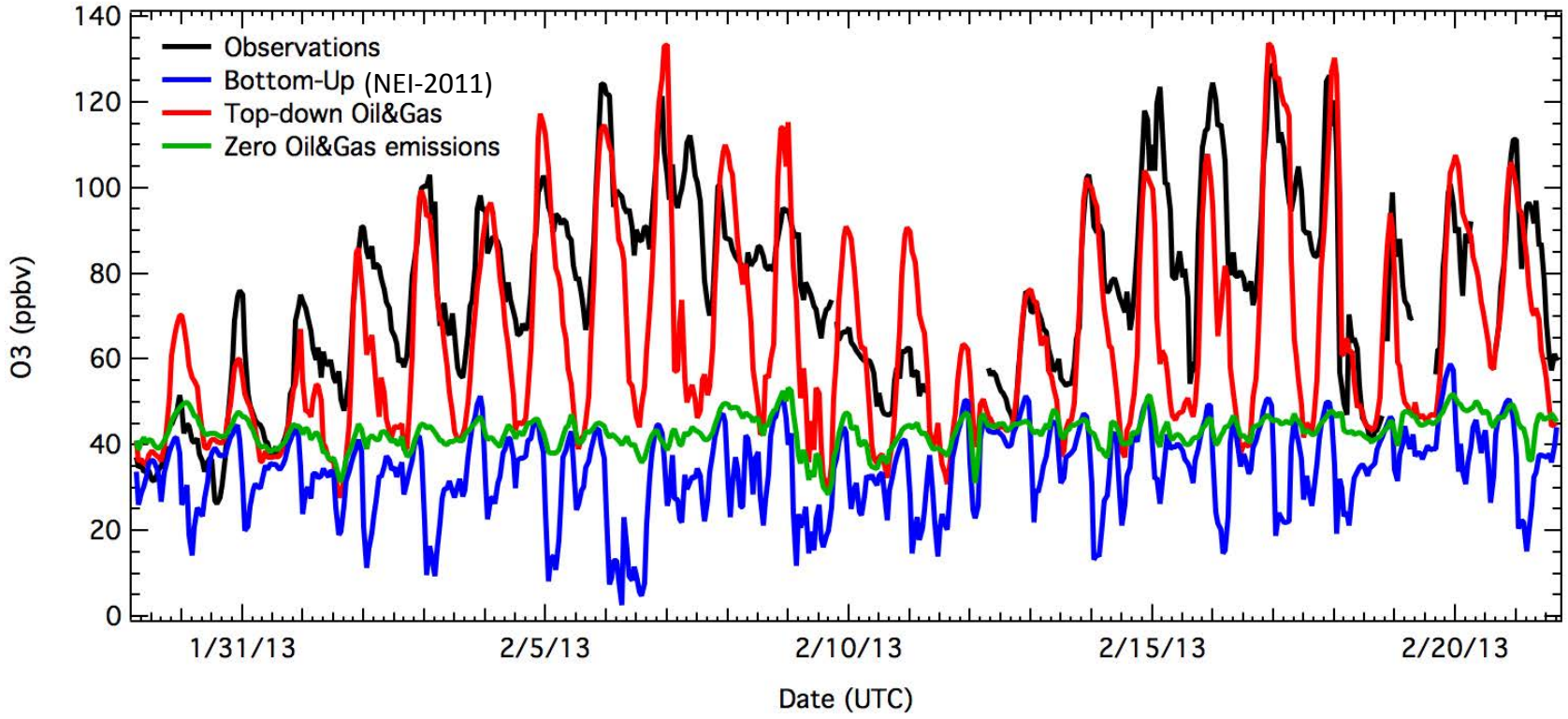
The model using the EPA emissions fail to reproduce the observed high O_3 levels!



Ahmadov et al. (2015), ACP

Observed and modeled ozone time series at the Horse Pool site, 2013

Only the top-down emission case can explain the high ozone levels!
The high ozone in the Uinta Basin is driven mostly by the oil/gas emissions!



Ahmadov et al. (2015), ACP

Main findings and future applications of this study

- The emission inventories for methane and ozone precursors for the oil/gas sector can be significantly improved by using the top-down emission estimates. Implications for climate and air quality modeling, environmental regulations!
- We identified and quantified the contribution of major processes and mechanisms that drive high wintertime ozone in the Uinta Basin. Our sensitivity simulations show reducing the VOC emissions (especially aromatics) would be an efficient way to mitigate wintertime O_3 problem in the Uinta Basin.
- Synergy between high quality measurements, the WRF-Chem model capabilities in CSD and collaboration with other NOAA and CU Boulder researchers have played a key role in the success of this study.
- Next step is to extend this framework to other shale basins in the US.
- Stakeholders: States, EPA, Bureau of Land Management, other state and federal agencies, and the energy industry

More details in the poster 4-5