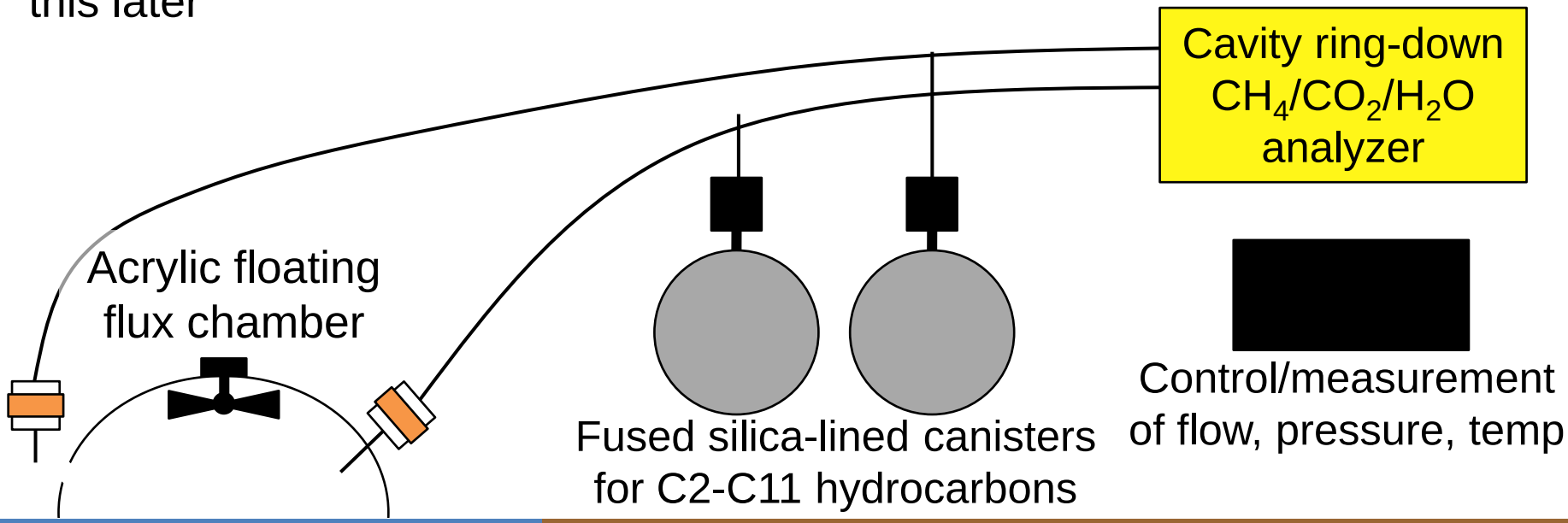
Produced Water Emissions Research Summary

Marc Mansfield, Huy Tran, and Seth Lyman

Utah State University
Bingham Entrepreneurship & Energy Research Center

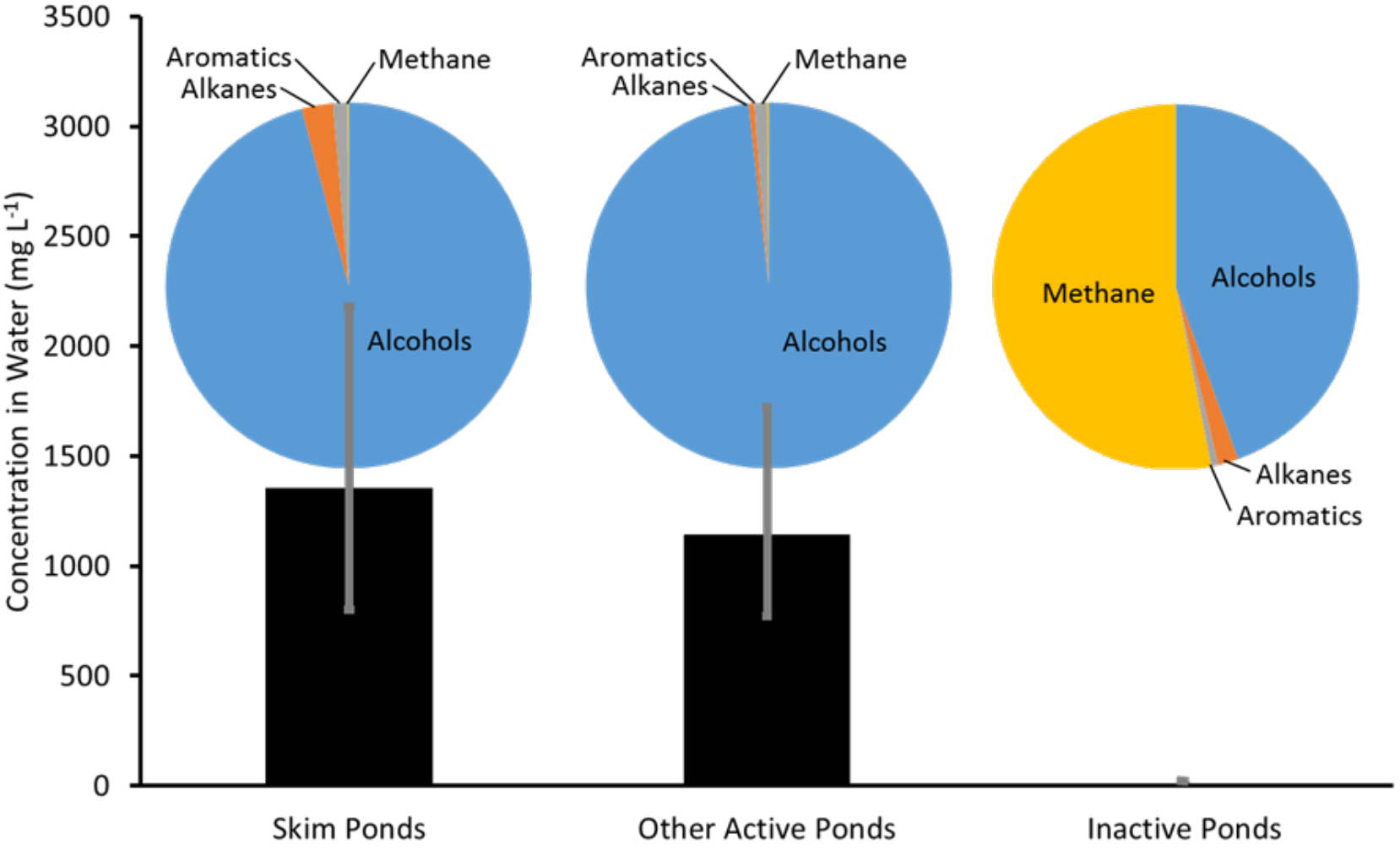
Measurement Techniques: Flux Chamber

- ~225 hour-long measurements in Uinta Basin and Wyoming at 10 facilities (facilities in Basin account for 25% of total Basin pond area)
- Evidence exists that chamber is biased low in high winds. More about this later

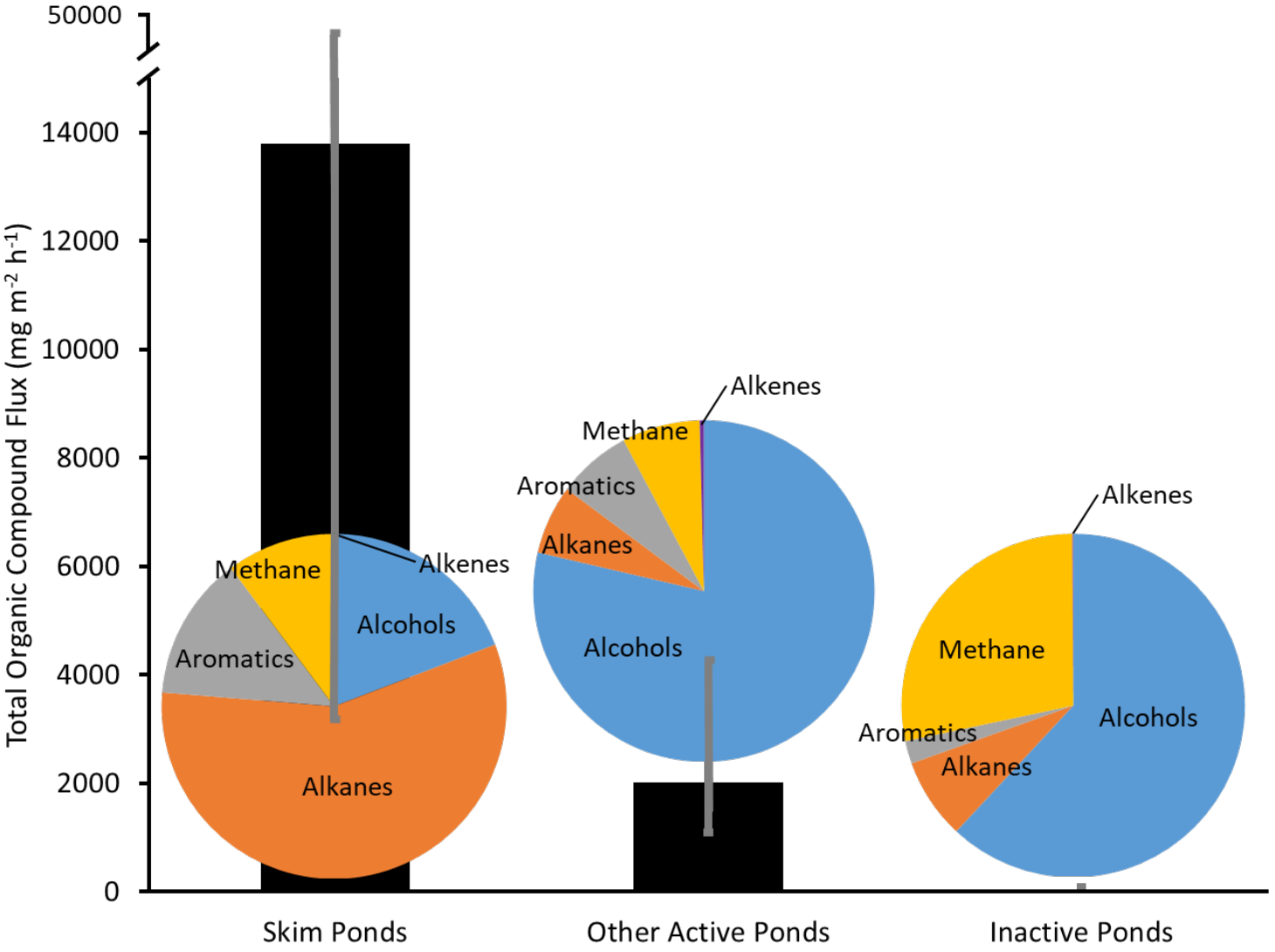


$$\text{Flux} = \frac{(\text{Conc}_{in} - \text{Conc}_{out})}{\text{Surface area}} \times \text{Flow Rate}$$

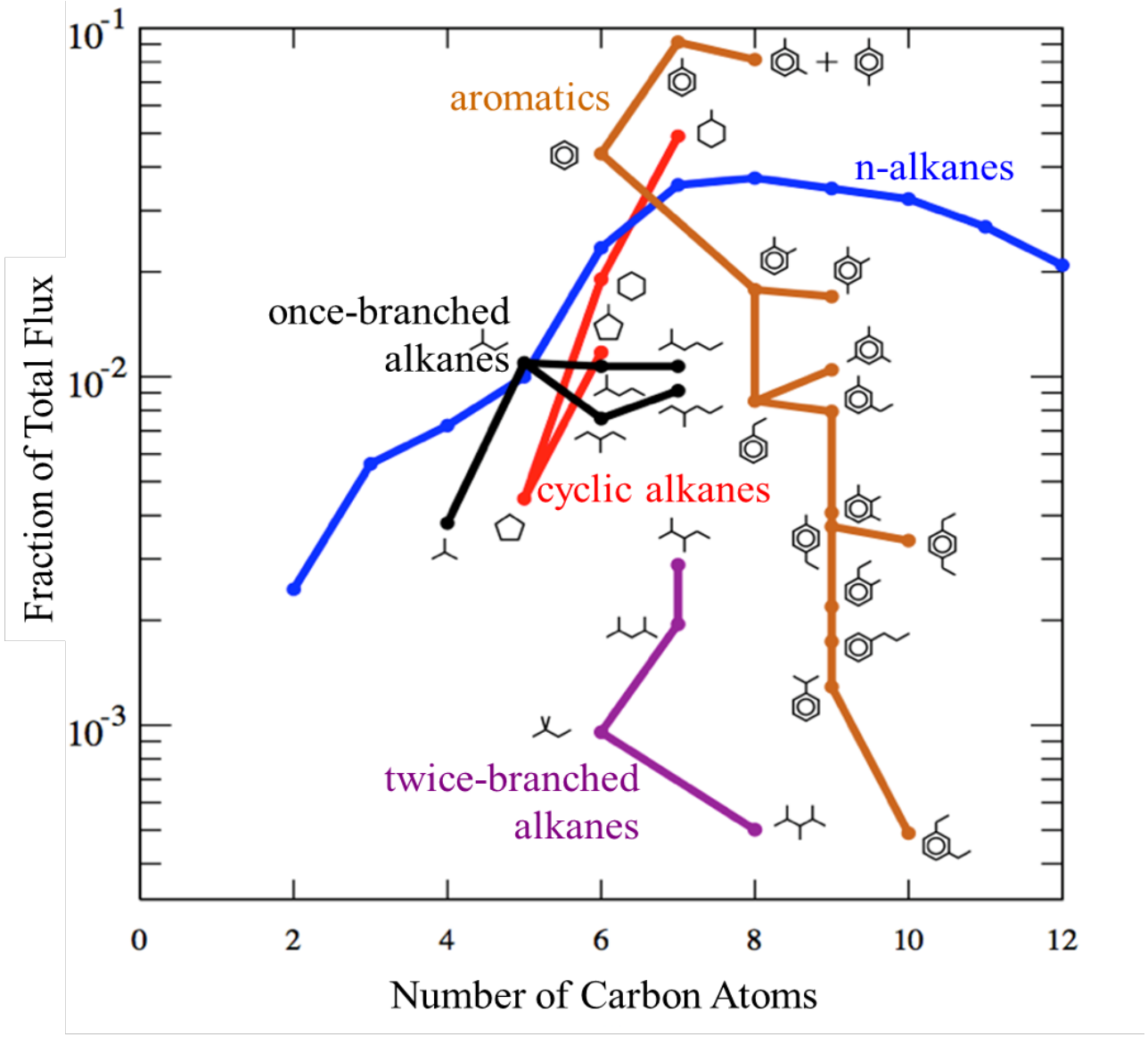
Water Composition



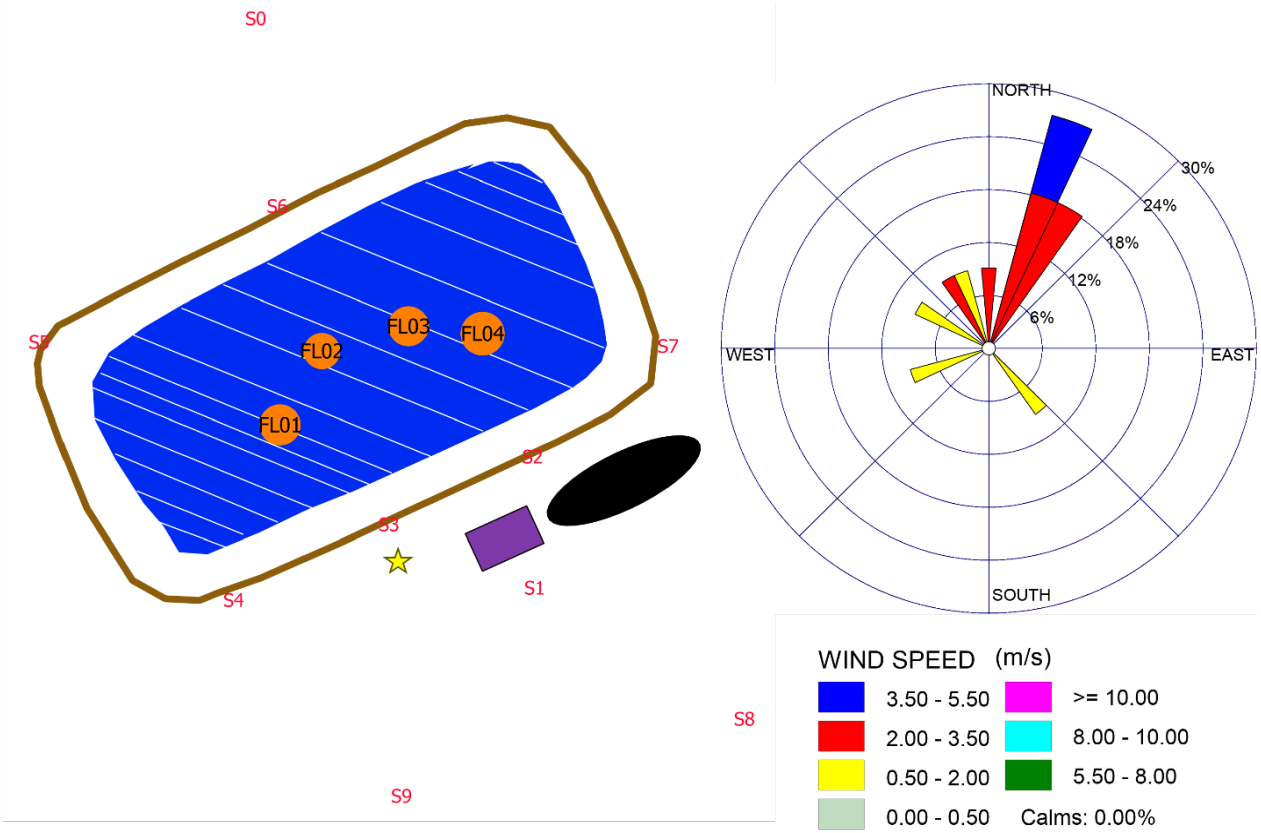
Emission Flux Composition



Emission Flux Composition



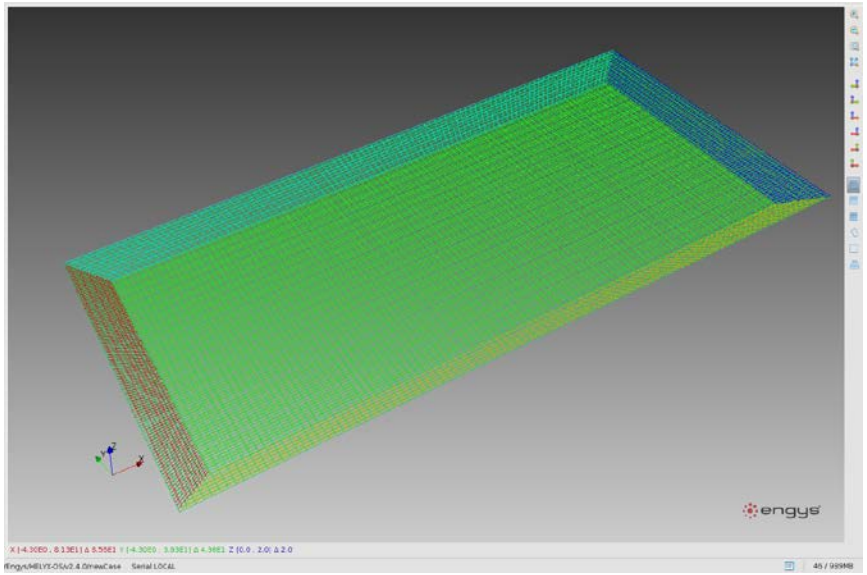
Inversed-modeling: Case study



Inverse dispersion models:

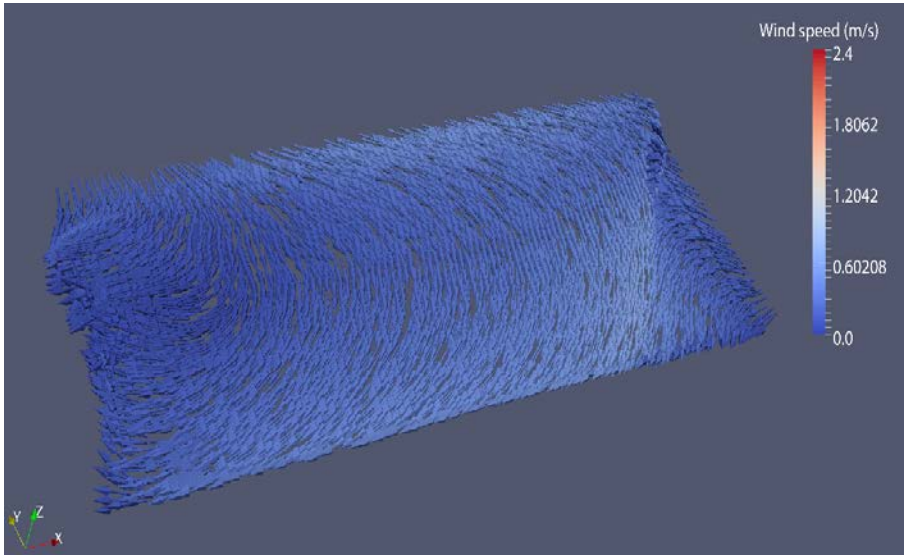
- Utilized models: EPA regulatory **AERMOD** and the Heavy Gas dispersion model for Steady-state (HEGADAS-S).

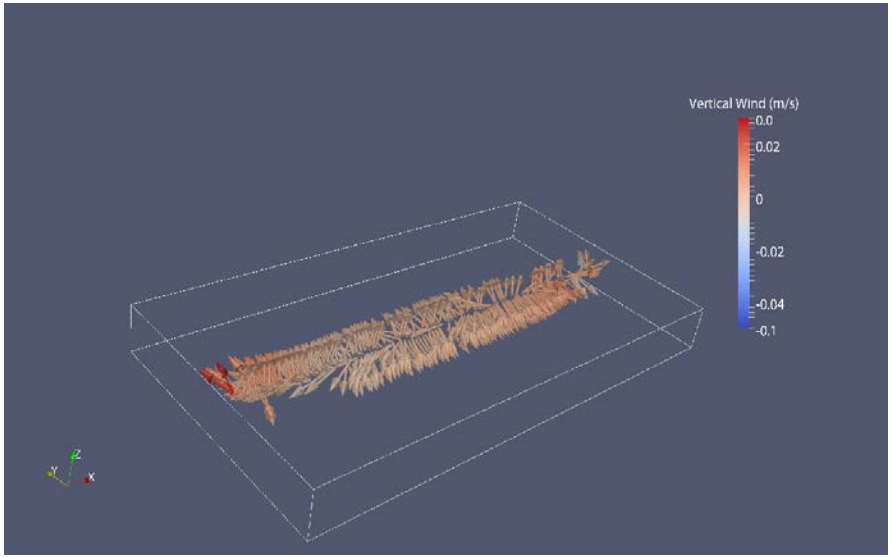
Inversed-modeling: Wind complexities



Fluid dynamic model suggests:

- wind speeds at water level significantly differ from wind speed at 6 m above ground level
- emission rate is not uniform at every point over pond's surface. Emissions are mainly released from up-wind part of the pond.

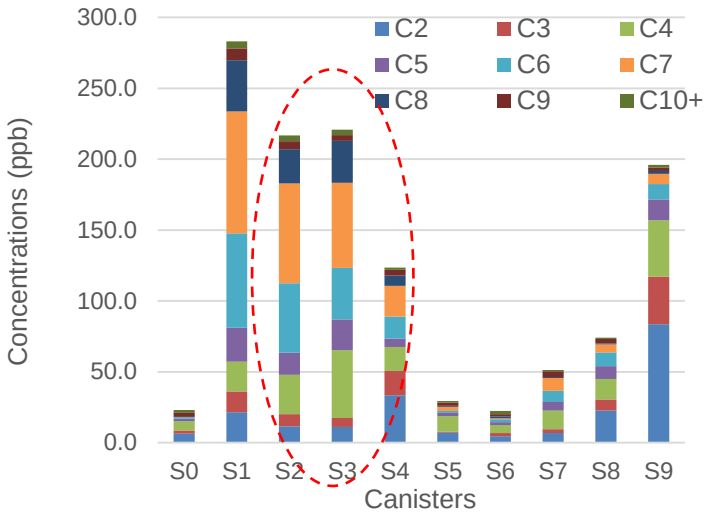




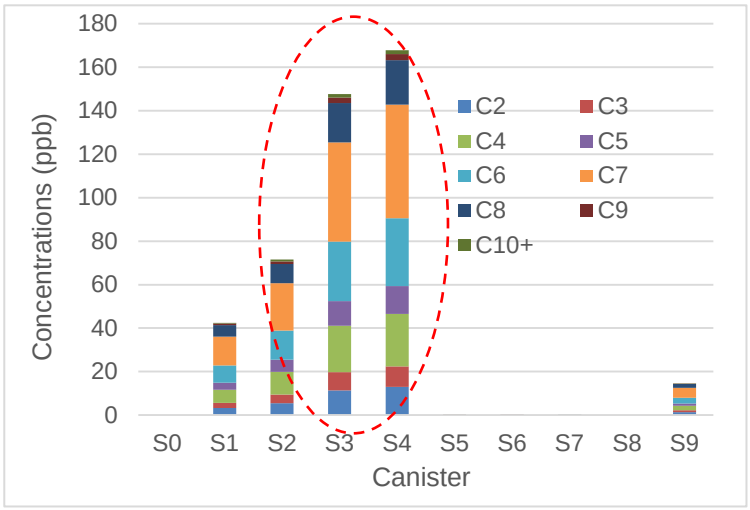
Inversed-modeling: Results vary with techniques used

Comparisons of NMHC concentration distributions (excluding alcohols)

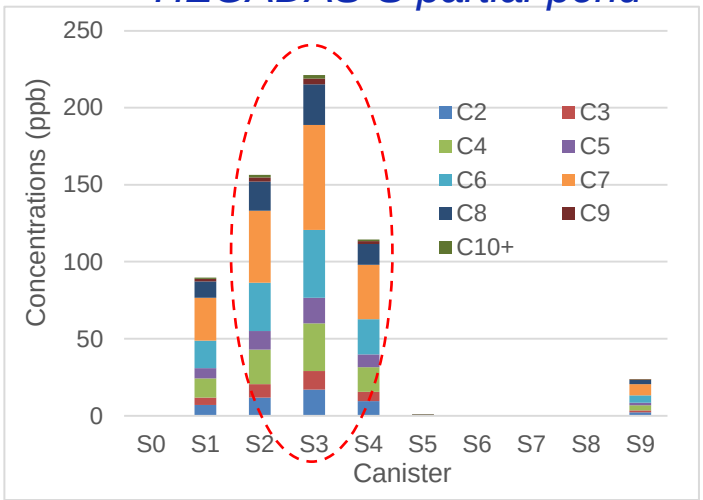
Canister measurements



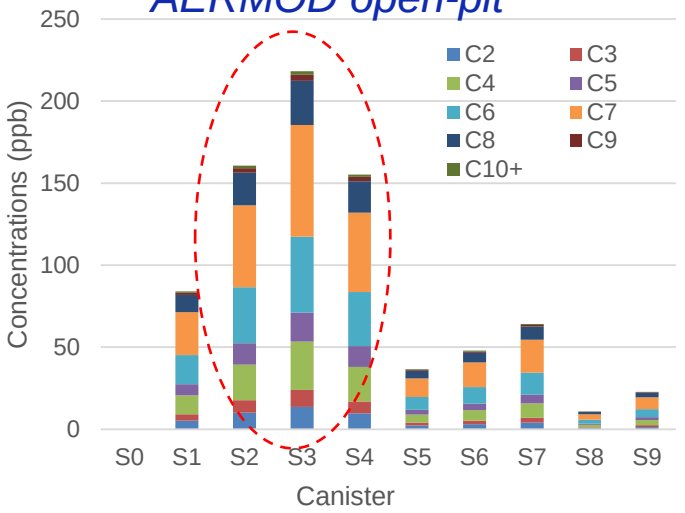
HEGADAS-S full-pond



HEGADAS-S partial-pond



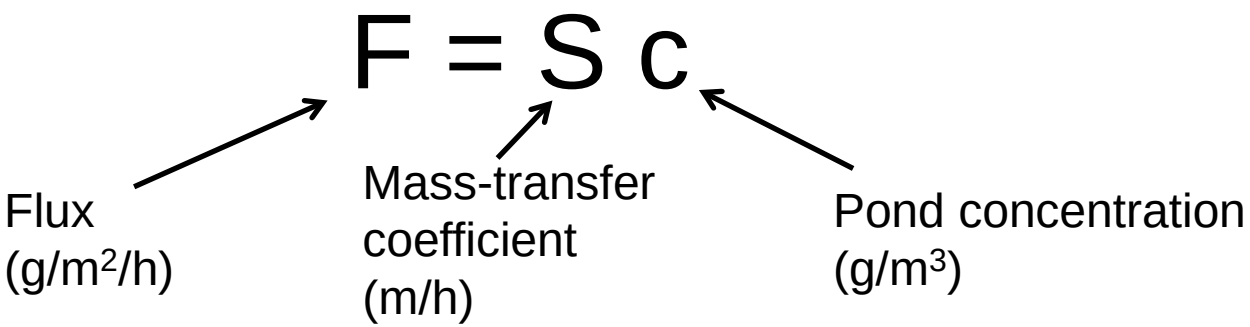
AERMOD open-pit



Inversed-modeling consistently overestimate flux-chamber measurements

Measurement Campaign	Means of estimation	Alkanes	Alkenes	Aromatics	Alcohols	Total NMHC
April 2015 (Landfarm)	FLUX	287.5	4.6	83.8	2.4	378.3
	FLUX-C	The developed wind correction factors are not applicable for air-soil exchange interface				
	AERM	2891.0	0.4	1068.8	29.6	3990
	HEGA	2690.4	0.8	1027.1	11.1	3729
Apr2016 (Pond)	FLUX	34.0	0.0	60.4	201.5	296
	FLUX-C	37.9	0.0	67.1	659.6	765
	AERM-1	714.8	1.3	628.1	312.8	1657
	HEGA-1	Was not performed due to calm and strongly variate wind				
	AERM-2	525.1	16.0	490.6	2658.2	3690
	HEGA-2	149.6	6.2	142.9	866.3	1165
	AERM-3	659.7	26.8	748.6	1729.3	3164
	HEGA-3	495.1	15.1	388.4	1148.4	2047
Jul2016 (Pond)	FLUX	24.4	0.0	67.6	108.8	201
	FLUX-C	46.0	0.1	123.3	545.6	715
	AERM-1	261.7	4.2	265.8	1327.0	1859
	HEGA-1	114.9	1.5	143.3	686.3	946
	AERM-2	417.4	3.9	1063.7	1935.8	3421
	HEGA-2	160.8	0.8	424.0	728.8	1314
Geometric means of ratios	**HEGA/FLUX-C**	**5.3**	**2.7**	**3.6**	**1.8**	**2.5**
	AERM/FLUX-C	**11.5**	**5.2**	**7.5**	**2.8**	**4.2**
	HEGA/AERM	**0.5**	**0.5**	**0.5**	**0.4**	**0.5**

Mass-Transfer Law



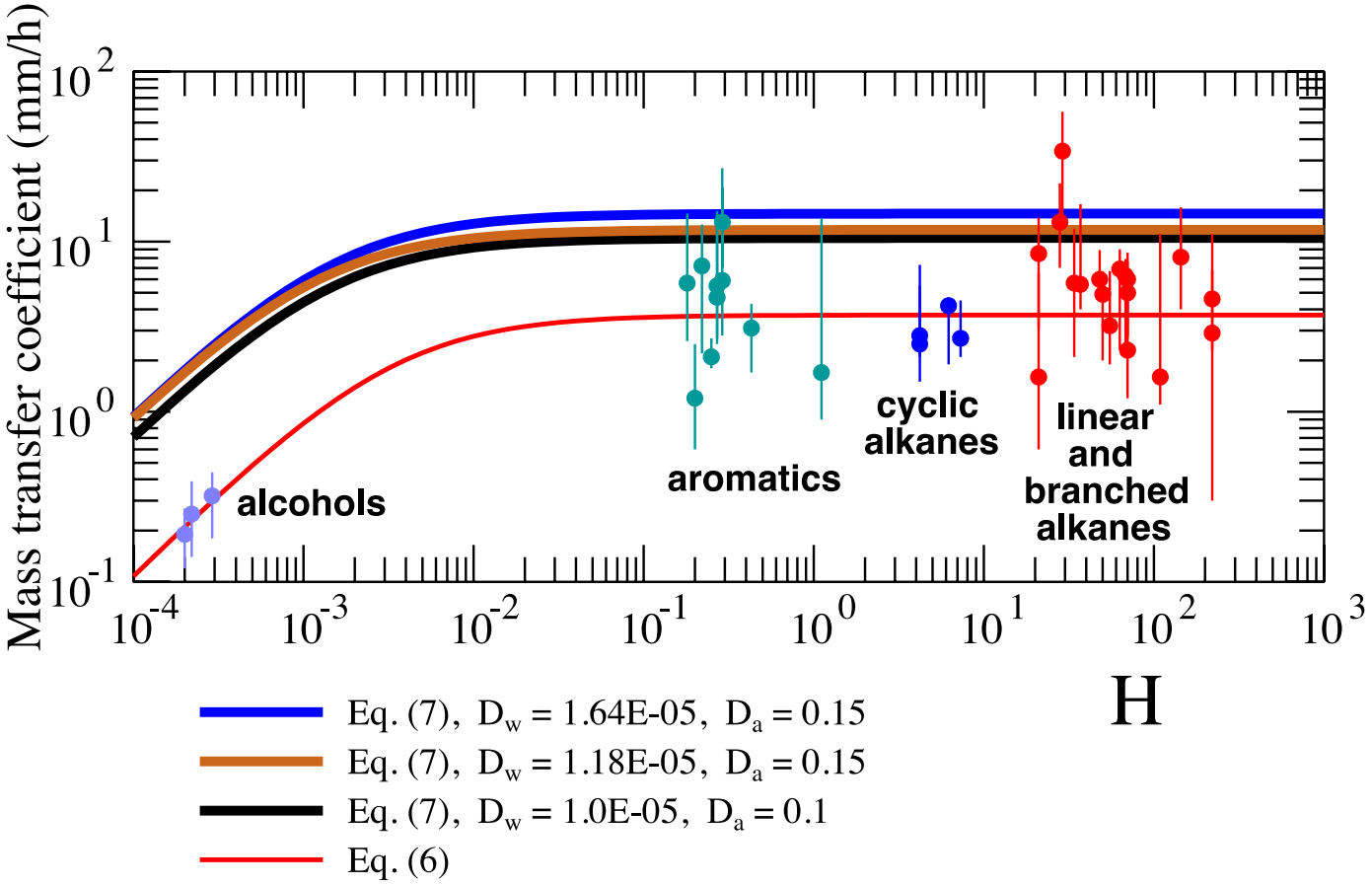
Proportionality between flux and concentration.

S may depend on:

temperature, wind speed, salinity,
nature of compound

WATER-9

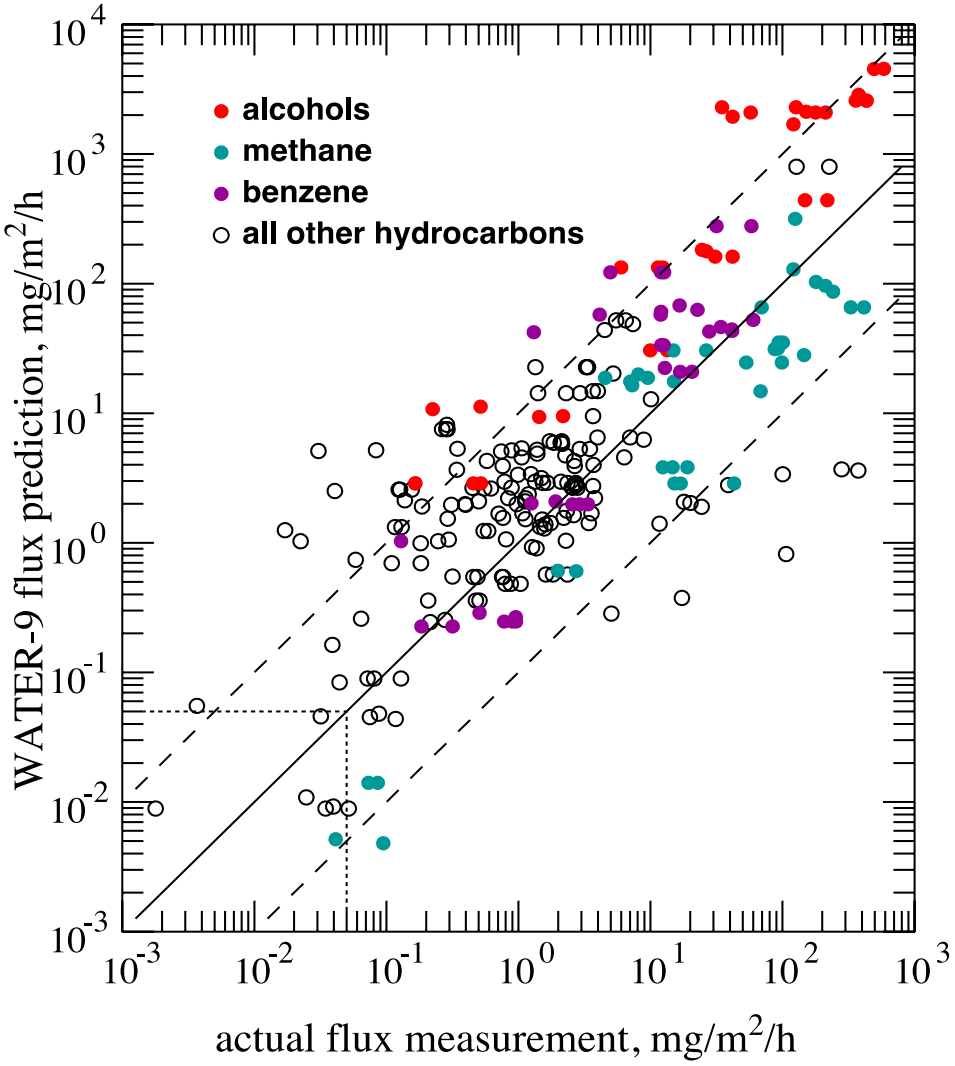
Semi-empirical algorithm for estimating S (H = Henry's law coefficient, it anti-correlates with solubility.)



Blue, tan, black: Temperature modulation.

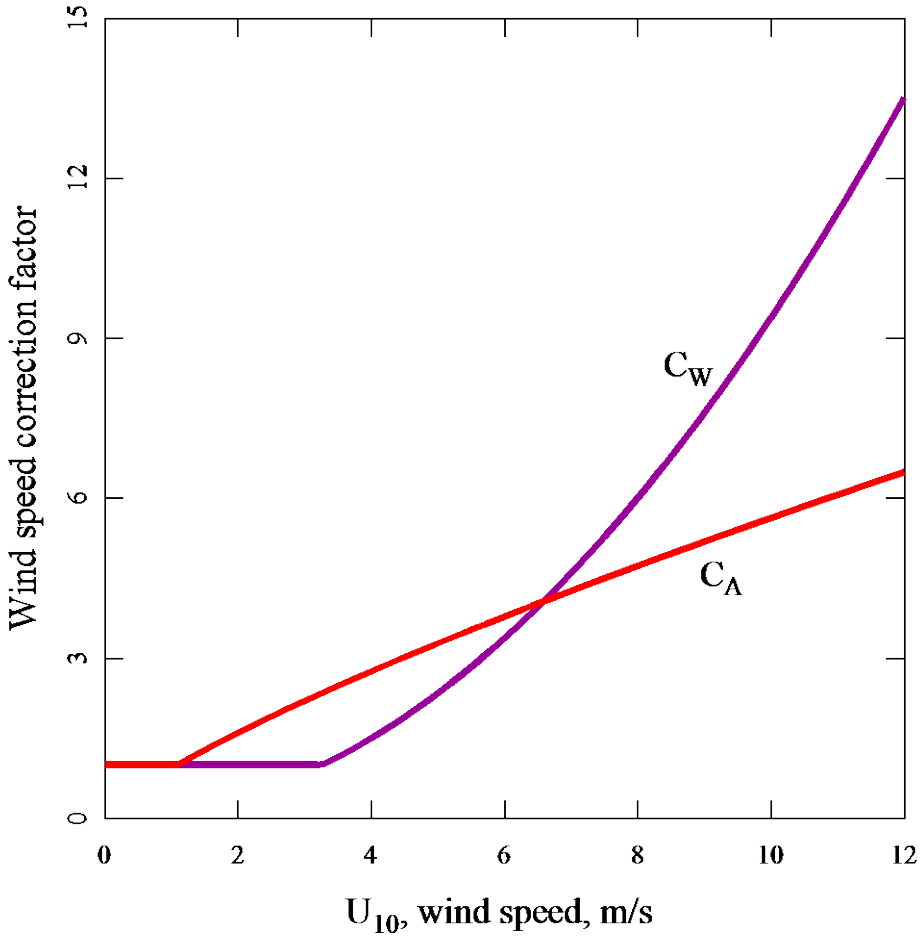
Salinity modulation is about 30% to 50% in H.

WATER-9 prediction of flux chamber results.



Accurate to within about 1 order of magnitude over a range of about 5 orders.

Wind Speed Correction



Based on WATER-9

Basin-wide scale up

Table 3. Estimated total annual emissions from all produced water ponds in the Uinta Basin, tonne/yr. Bootstrapped means are shown, and upper and lower 95% confidence intervals are shown in parentheses. Confidence intervals reflect natural variability in measurements from the pond types indicated rather than measurement uncertainty.

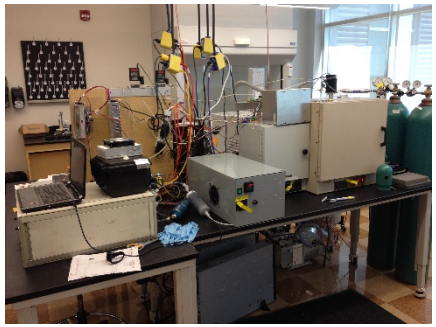
Tonnes yr^{-1}	Skim ponds	Other active ponds	Inactive ponds	Total
Methane	201 (32,830)	444 (263,853)	69 (27,201)	714 (323,1885)
Carbon dioxide	88 (48,175)	2014 (1425,2887)	15544 (10761,22947)	17646 (12234,26008)
Alkanes	1128 (217,4384)	394 (254,620)	18 (1,96)	1541 (472,5101)
Alkenes	0 (0,0)	24 (3,98)	0 (0,1)	24 (3,100)
Aromatics	267 (53,1043)	422 (245,743)	5 (1,19)	694 (299,1805)
Alcohols	379 (142,713)	4704 (2428,10617)	150 (84,337)	5233 (2653,11667)
Non-methane organics	1773 (412,6141)	5546 (2968,11952)	174 (86,458)	7494 (3466,18552)

Acknowledgements

Funding Provided By

- U.S. Department of Energy/Research Partnership to Secure Energy for America (Contract No. 12122-15)
- Bureau of Land Management (Cooperative Agreement No. L13AC00292)
- Uintah Impact Mitigation Special Service District
- GSI, Inc./State of Wyoming
- Utah State and Institutional Trust Lands Administration

Thank You




binghamresearch.usu.edu