Agenda

Ministry of Environment
National Institute of Environmental Research

Science Team Telecon

KORUS-AQ publications

Final Science Report Chapter Updates

Publications

Ministry of Environment
National Institute of Environmental Research

Going forward, here are a few requirements that will help us to keep track of science team progress and ensure consistency among the published findings:

1) **Anyone in the draft stage of manuscript writing should email their title and full author list to Jim Crawford. We will keep the list updated and shared at each monthly webex.**
2) **Authors are highly encouraged to present a summary of their analysis and findings during a monthly webex before submitting the paper.**
3) **Authors should also identify the target journal for their paper. We have not yet decided on whether a special issue will be commissioned, but this information may help us to decide whether to have a special issue or allow our papers to span many journals.**
4) **Double check to be sure that the most recent data is being used in your analysis (e.g., LARGE-APS size distribution data for DC-8 was updated today).**
5) **KORUS-AQ data doi's will become available in the near future. Please these doi's to reference the data used in your paper.**
6) **Intercomparison analyses of measurements are underway and will be presented in a future webex. If you are using variables measured by multiple groups, please be aware of and prepare to cite intercomparison results.**

Elementa-Special Feature

The KORUS-AQ Leadership has agreed to support a subset of papers to be submitted as a Special Feature to Elementa (https://www.elementascience.org/about/)

These papers would represent high-level overviews of the campaign and the major questions posed in the Final Science Synthesis Report

This is a preliminary list of paper topics and the team members taking primary responsibility:

1) **Campaign Overview (Crawford and KORUS-AQ leads)**
2) **Meteorological Overview (Peterson)**
3) **Detailed Analysis of Olympic Park Observations and the Factors Controlling Air Quality (Gangwoong and Meehye Lee, possibly multiple papers) – Taehwa should be contrasted when possible**
4) **Ozone Photochemical Production and Sensitivity (Schroeder) (suggest to add complementary paper from Yujin Oak)**
5) **Aerosol Synthesis and Overview (LARGE Team)**
6) **VOC Source Apportionment (Simpson) (suggest to add a contribution from Jung-Hun for the emissions work)**
7) **Multi-model assessment of Air Quality during the campaign (Park and Emmons)**
8) **Remote Sensing: Insights and Future Expectations in the context of KORUS-AQ (Jhoon Kim and Jay Al-Saadi) – possibly multiple papers**

Deadline for paper submissions: 31 May 2019

Publications (1)

Authors	Title	Journal	Status
Hwajin Kim, Qi Zhang, Jongbae Heo	Influence of Intense secondary aerosol formation and long range transport on aerosol chemistry and properties in the Seoul Metropolitan Area during spring time: Results from KORUS-AQ	Atmospheric Chemistry and Physics	Published
Najin Kim, Minsu Park, Seong Soo Yum, Jong Sung Park, Hye Jung Shin, Joon Young Ahn	Impact of urban aerosol properties on cloud condensation nuclei (CCN) activity during the KORUS-AQ field campaign	Atmospheric Environment	Published
W. Hu, D.A. Day, P. Campuzano-Jost, B.A. Nault, T. Park, T. Lee, P. Croteau, M.R. Canagaratna, J.T. Jayne, D.R. Worsnop, J.L. Jimenez	Evaluation of the new capture vaporizer for Aerosol Mass Spectrometers (AMS): Elemental composition and source apportionment of organic aerosols (OA).	ACS Earth Space Chemistry	Published
W. Hu, D.A. Day, P. Campuzano-Jost, B.A. Nault, T. Park, T. Lee, P. Croteau, M.R. Canagaratna, J.T. Jayne, D.R. Worsnop, J.L. Jimenez	Evaluation of the new capture vaporizer for Aerosol Mass Spectrometers: characterization of organic aerosol mass spectra	Aerosol Science and Technology	Published
Wenfu Tang, A. F. Arellano, J. P. DiGangi, Yonghoon Choi, G. S. Diskin, et al.,	Evaluating High-Resolution Forecasts of Atmospheric CO and CO2 from a Global Prediction System during KORUS-AQ Field Campaign	Atmospheric Chemistry and Physics	Published
Wenfu Tang, L. K. Emmons, A. F. Arellano Jr., B. Gaubert, C. Knote, S. Tilmes, R. R. Buchholz, et al.	Source Contributions to Carbon Monoxide Concentrations during KORUS-AQ based on CAM-chem Model Applications	JGR-Atmospheres	Published
Huang, M., J. Crawford, G. Diskin, J. Santanello, S. Kumar, S. Pusede, M. Parrington, and G. Carmichael	Modeling Regional Pollution Transport Events During KORUS-AQ: Progress and Challenges in Improving Representation of Land-Atmosphere Feedbacks	JGR-Atmospheres	Published
Seungshik Park, Geun-Hye Yu, and Sangil Lee	Optical absorption characteristics of brown carbon aerosols during the KORUS-AQ campaign at an urban site	Atmospheric Res.	Published

Publications (2)

Authors	Title	Journal	Status
Hyungkwan Lim, Myungje Choi, Mijin Kim, Jhoon Kim, Sujung Go, and Seoyoung Lee	Intercomparing the Aerosol Optical Depth using the Geostationary Satellite Sensors (AHI, GOCI and MI) from Yonsei AErosol Retrieval (YAER) Algorithm	J. Korean Earth Sci. Soc.	Published
Dan Goldberg, et al.	A top-down assessment using OMI NO2 suggests an underestimate in the NOx emissions inventory in Seoul, South Korea, during KORUS-AQ	ACP	Published
Paul Romer, P. Wooldridge, J. Crounse, M. Kim, P. Wennberg, J. Dibb, E. Scheuer, D. Blake, et al.,	Constraints on aerosol nitrate photolysis as a potential source of HONO and NOx	ES&T	Published
B. A. Nault, P. Campuzano-Jost, D. A. Day, J. C. Schroder, et al.	Secondary Organic Aerosol Production from Local Emissions Dominates the Organic Aerosol Budget over Seoul, South Korea, during KORUS-AQ	Atmospheric Chemistry and Physics	Published
Kara Lamb, et al.	Estimating Source Region Influences on Black Carbon abundance, microphysics, and radiative effect observed over South Korea	JGR-Atmospheres	Published
E. Lennartson, J. Wang, J. Gu, L. C. Garcia, C. Ge, M. Gao, M. Choi, P. Saide, G. Carmichael, J. Kim, and S. Janz	Diurnal variation of aerosol optical depth and PM2.5 in South Korea: a synthesis from AERONET, satellite (GOCI), KORUS-AQ observation, and the WRF-Chem model	ACP	Published
Min-Suk Bae, J. J. Schauer, Taehyoung Lee, Ju-Hee Jeong, Yoo-Keun Kim, Chul-Un Ro, Sang-Keun Song, Zang-Ho Shon	Relationship between reactive oxygen species and water-soluble organic compounds: Time-resolved benzene carboxylic acids measurement in the coastal area during the KORUS-AQ campaign	Environmental Pollution	Published

Publications (3)

Authors	Title	Journal	Status
K. Miyazaki, T. Sekiya, D. Fu, K. Bowman, S. Kulawik, K. Sudo, T. Walker, Y. Kanaya, M. Takigawa, K. Ogochi, H. Eskes, F. Boersam, B. Gaubert, J. Barre, and L. Emmons, and the KORUS-AQ team	Balance of emission and dynamical controls on ozone during the Korea-United States Air Quality campaign from multiconstituent satellite data assimilation	JGR-Atmospheres	Published
Mark F. Lunt, Sunyoung Park, Shanlan Li, Stephan Henne, Alistair J. Manning, Anita L. Ganesan, Isobel J. Simpson, et al.	Continued emissions of the ozone-depleting substance carbon tetrachloride from East Asia	GRL	Published
Herman, Jay, Elena Spinei, Alan Fried, Jhoon Kim, Jae Kim, Woogyung Kim, Alexander Cede, Nader Abuhassan, and Michal Segal-Rozenhaimer	NO2 and HCHO Measurements in Korea from 2012 to 2016 from Pandora spectrometer Instruments	AMT	Published
Spinei, E., A. Whitehill, A. Fried, M. Tiefengraber, T. Knepp, S. Herndon, j. R. Herman, M. Miller, N. Abuhassan, A. Cede, D. Richter, J. Walega, J. Crawford, J. Szykman, L. Valin, D. Williams, R. Long, R. Swap, Y. Lee, N. Nowak, and B. Pochje	The first evaluation of formaldehyde column observations by improved Pandora spectrometers during the KORUS-AQ field study	AMT	Published
Jinkyul Choi, Rokjin J. Park, Hyung-Min Lee, Seungun Lee, Duseong S. Jo, Jaein I. Jeong, Daven Henze, Jung-Hun Woo, Soo-Jin Ban, et al.	Impacts of local vs. trans-boundary emissions from different sectors on PM2.5 exposure in South Korea during the KORUS-AQ campaign	Atmospheric Environment	Published
Seoyoung Lee, Jhoon Kim, Myungje Choi, Jaemin Hong, Hyungkwang Lim, Tom Eck, Brent Holben, Joon-Young Ahn, Jeongsoo Kim, Ja-Ho Koo	Analysis of long-range transboundary transport (LRTT) effect on Korean aerosol pollution during the KORUS-AQ campaign	Atmospheric Environment	Submitted
J. Sullivan , T. McGee , R. Stauffer, A. M. Thompson, A. Weinheimer , C. Knote , S. Janz, A. Wisthaler, et al.	Taehwa Research Forest: A receptor site for severe pollution events in Korea during 2016	ACP	Under Review

Publications (4)

Authors	Title	Journal	Status
Yeseul Cho, Ja-Ho Koo, et al.	Spatiotemporal properties of O3 and NO2 in the Seoul Metropolitan Area: comparison among total column, vertical profile, and surface patterns	TBD	In prep
Sang Seo Park, et al.	Temporal variation of total ozone without its variations at surface and stratosphere	TBD	In prep
Eric Heim, et al.	Asian Dust Observed during KORUS-AQ Facilitates the Uptake and Incorporation of Soluble Pollutants during Transport to S. Korea; The Hwangsa Anthropogenic Model	TBD	In prep
Myungje Choi et al.	Validation, comparison, and integration of GOCI, AHI, MODIS, MISR, and VIIRS aerosol optical depth over East Asia during 2016 KORUS-AQ campaign	TBD	In prep
Myungje Choi, Seoyoung Lee, et al.	Assessment of 3-D aerosol distribution for long-range transport and local emission using GOCI and ground, airborne, and satellite lidar measurement during 2016 KORUS-AQ	TBD	In prep
Heesung Chong, Seoyoung Lee, et al.	High resolution remote sensing of SO2 and HCHO from the GeoTASO instrument during KORUS-AQ: PCA-based vertical column retrievals	TBD	In prep
Heesung Chong, et al.	Surface NO2 volume mixing ratio estimated from total column observations of Pandora spectrometer during KORUS-AQ	TBD	In prep
Sujung Go, et al.	Imaginary part of refractive index derived from UV-MFRSR in Seoul, and implications for retrieving UV Aerosol Optical Properties for GEMS measurements	Remote Sensing of Environment	In prep
Hyungkwan Lim, et al.	Aerosol loading height retrieval from AHI using spatiotemporal variability during KORUS AQ	TBD	In prep

Publications (5)

Authors	Title	Journal	Status
B. A. Nault, P. Campuzano-Jost, D. A. Day, J. C. Schroder, D. R. Blake, M. R. Canagaratna, J. A. de Gouw, F. Flocke, A. Fried, J. B. Gilman, T. F. Hanisco, L. G. Huey, et al.	Quantification of the Rapid Photochemical Secondary Organic Aerosol Production Observed across Megacities around the World	Nature Geosciences or PNAS	In prep
B. A. Nault, P. Campuzano-Jost, D.A. Day, W. W. Hu, B. B. Palm, J. C. Schroder, R. Bahreini, H. Bian, M. Chin, S. L. Clegg, P. Colarco, J. Crounse, J. A. de Gouw, J. Dibb, M. J. Kim, et al.	Global Survey of Submicron Aerosol Acidity (pH)	Nature Geosciences or PNAS	In prep
W. Hu, P. Campuzano-Jost, D. A. Day, B. A. Nault, T. Park, T. Lee, A. Pajunoja, A. Virtanen, P. Croteau, M. R. Canagaratna, J. T. Jayne, D. R. Worsnop, J. L. Jimenez	Size distributions and ambient quantifications for organic aerosol (OA) in aerosol mass spectrometer (AMS) instruments with the new capture vaporizer (CV)	Journal of Aerosol Science	In prep
D. Jeong, R. Seco, D. Gu, Y. Lee, B. Nault, C. Knote, T. Mcgee, J. Sullivan, J. L. Jimenez, P. Campuzano-Jost, D. Blake, D. Sanchez, A. Guenther, D. Tanner, G. Huey, R. Long, B. E. Anderson, S. R. Hall, Y.-J. Lee, D. Kim, J.-Y. Ahn, A. Wisthaler, and S. Kim	Integration of Airborne and Ground Observations of Nitryl Chloride in the Seoul Metropolitan Area and Its Impact on the Regional Oxidation Capacity During the KORUS-AQ 2016 Field Campaign	TBD	In prep
D. Sanchez, R. Seco, D. Gu, A. Guenther, D. Jeong, J. Mak, Y.-J. Lee, D. Kim, D. Blake, S. Herndon, D. Jeong, T. Mcgee, and S. Kim	OH Reactivity Budget Analysis at the Taehwa Research Forest During KORUS-AQ 2016	TBD	In prep

Publications (6)

Authors	Title	Journal	Status
Yujin Ok, Rokjin J. Park, D. Blake, W. Brune, A. Weinheimer, A. Fried, J. Crawford, and J. Schroeder	Evaluation of simulated VOCs during the KORUS-AQ campaign and their effect on ozone production in Korea	TBD	In prep
Hyeonmin M. Kim, Rokjin J. Park, Jaein I. Jeong, Daun Jeong, Saewung Kim, and Seogju Cho	Effect of nitryl chloride chemistry on oxidation capacity in East Asia	TBD	In prep
Hyung-Min Lee, Rokjin Park, Hyeong-Ahn Kwon	Top-down estimate of isoprene emissions in East Asia using inverse modeling: implication of satellite retrievals from GOME-2 and OMI formaldehyde with KORUS-AQ aircraft observations	TBD	In prep
Changmin Cho, J. St. Clair, G. Wolfe, Jin Liao, Sukhan Jung, Dae il Kang, Jinsoo Choi, Myung-Hwan Shin, Jinsoo Park, T. Hanisco, Kyung-Eun Min	Top-down estimation of volatile organic compounds (VOCs) emission rates in petrochemical complex using airborne in-situ formaldehyde (HCHO) observation	Atmospheric Environment or ACP	In prep
Minsu Park, Najin Kim, Seong Soo Yum, Lee Thornhill, Bruce Anderson, Dong-Su Kim, Hyun-Jae Kim, Ha-Eun Jeon, Yun-Seo Park, Sang-Bo Lee	On the submicron aerosol distributions and CCN activity in and around the Korean Peninsula measured onboard the NASA DC-8 research aircraft during the KORUS-AQ field campaign	TBD	In prep
Jin Liao, T. Hanisco, G. Wolfe, J. St. Clair, J. Jimenez, P. Campuzano-Jost, B. Nault, A. Fried, et al.	Towards a satellite-in situ hybrid proxy for organic aerosol abundance	ACP	In prep

Publications (7)

Authors	Title	Journal	Status
KORUS-AQ Leadership	KORUS-AQ Overview Paper	Elementa	In prep
David Peterson, et al.	Meteorology Influencing Pollution Regimes and Transport during KORUS-AQ	Elementa	In prep
Gangwoong Lee, Meehye Lee et al.	Detailed Analysis of Olympic Park Observations and the Factors Controlling Air Quality (possibly multiple papers)	Elementa	In prep
Carolyn Jordan, Andreas Beyersdorf, LARGE group, et al.	Overview of aerosol observations and controlling factors during KORUS-AQ	Elementa	In prep
Jason Schroeder, et al.	Observation-based Modeling of Ozone Chemistry in the Seoul Metropolitan Area During the Korea-United States Air Quality Study (KORUS-AQ)	Elementa	In prep
Yujin Ok, et al.	Evaluation of simulated O3 production efficiency during the KORUS-AQ campaign: Implications for anthropogenic NOx emissions in Korea	Elementa	suggested
Isobel Simpson, et al.	Characterization and source apportionment of VOCs in the Seoul Metropolitan Area	Elementa	In prep
Jung-Hun et al.	Updated emissions inventory for KORUS-AQ	Elementa	suggested
Rokjin Park, Louisa Emmons, KORUS-AQ modelers	Integrated model assessment of the KORUS-AQ period (possibly multiple papers?)	Elementa	In prep
Jhoon Kim, Jay Al-Saadi, et al.	Remote Sensing: Insights and Future Expectations in the context of KORUS-AQ	Elementa	In prep

KORUS-AQ modeling plans – Feb 2019 (particularly to address Transport questions)

- Rokjin Park (SNU): GEOS-Chem nested simulations with 0.2 x 0.33 for East Asia and possibly a few adjoint simulation to quantify source contributions.
- Louisa Emmons (NCAR): CAM-chem at 0.47x0.63, with tagged NOx/O3 to estimate local vs outside contributions to ozone.
- Gabriele Pfister (NCAR): WRF-Chem (same configuration as WRF-Tracer forecasts, 15km and 3km resolutions).
- Meng Gao (U.Iowa): WRF-Chem with same configuration as the forecasts (20km for domain 1 and 4km for domain 2). We plan to do emission perturbation of the Seoul area, and probably source perturbation, also.
- Cheol-hee Kim: Will re-run WRF-Chem with V5 emissions, but will not be able to re-do source-receptor analysis.

Update from the Emissions group

Emission inventories: Update to KORUS emission inventories
(J.-H. Woo)
- Collaborative with KORUS-AQ modelers (Emmons, Park, Carmichael)
- Modeling groups are helping to evaluate the latest emissions (V5)

Modeling: Evaluation of ozone production efficiency of GEOS-Chem
(R. Park)
- Comparison with observation-constrained values
- Insight into NO_x emission in Korea during KORUS-AQ

Published papers: Miyazaki et al., Balance of emission and dynamical controls on ozone during KORUS-AQ from multi-constituent satellite data assimilation, JGR

Goldberg et al., A top-down assessment using OMI NO_2 suggests an underestimate in the NO_x emissions inventory in Seoul, South Korea during KORUS-AQ, ACP

Papers in progress: Simpson et al., Characterization and sources of VOCs in the Seoul region during KORUS-AQ
- To be submitted to Elementa in May

Core question: How well do KORUS-AQ observations support current emission estimates (e.g., NO_x, VOCs, SO_2, NH_3) by magnitude and sector?

RSSR Question 4

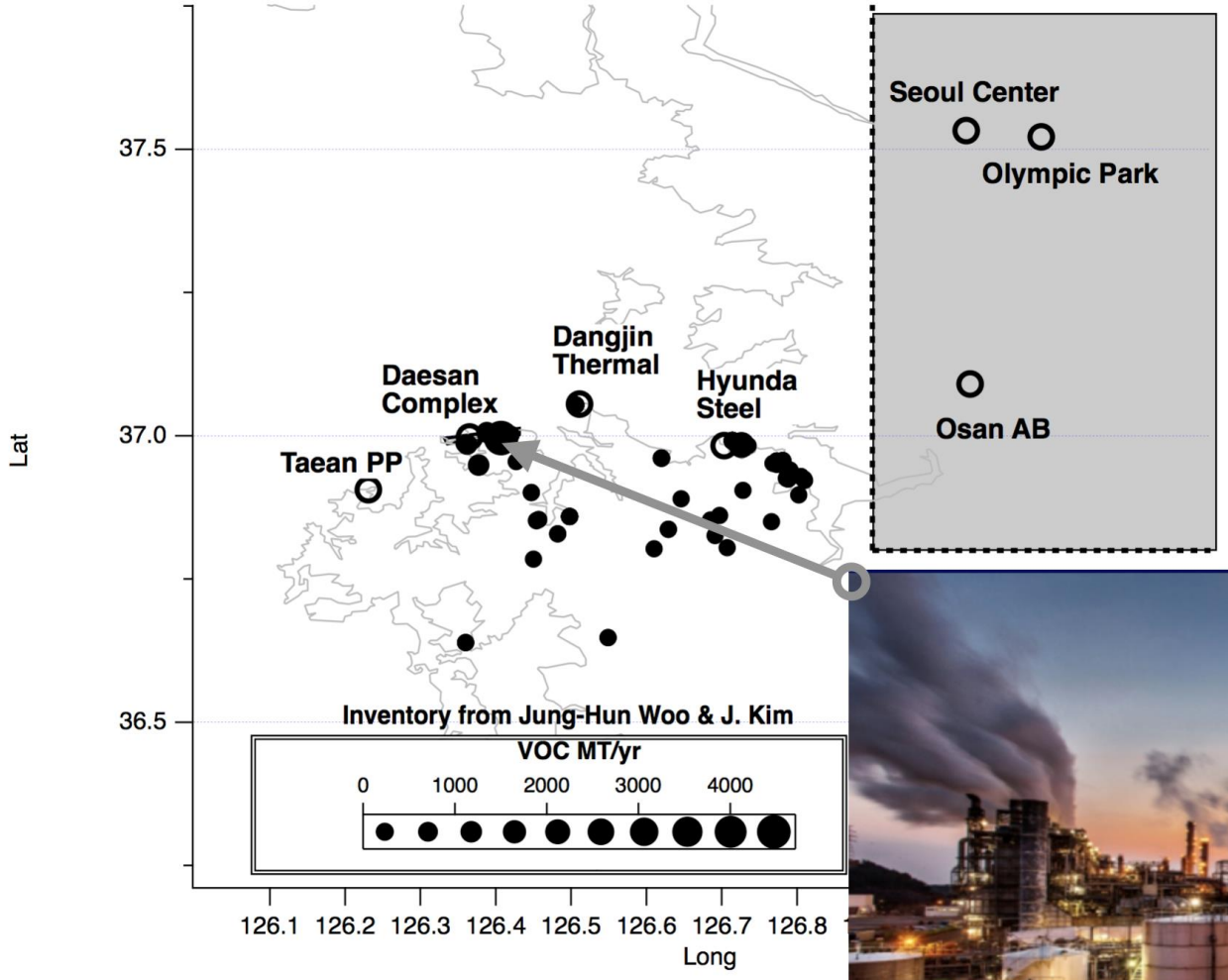
How significant is the impact of the large point sources along the west coast to the air quality of SMA temporally and spatially?

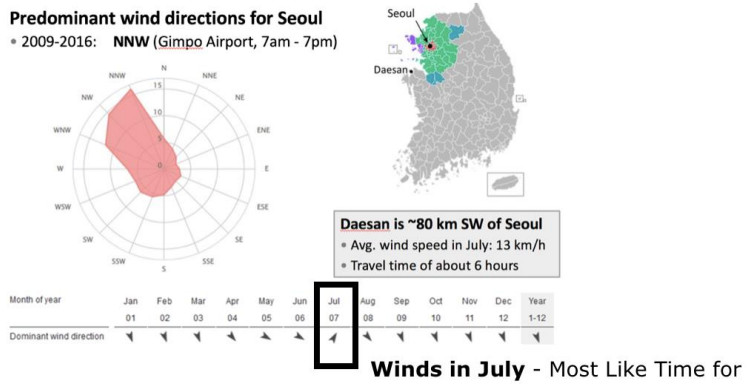
Summary Finding Last Workshop:

Point source impacts appears to be stronger in the southern portion of the SMA, but further verification of emissions are needed to improve the quantification of these impacts and translate them into contributions to fine particle pollution and ozone.

For toxic substances, attention needs to be given to the health and safety of workers and populations in closer proximity to the facilities production these emissions

Very Large VOC Emission Sources on Korea's West Coast only Several Hours Transport Time from Seoul Metropolitan Area





Winds in July - Most Like Time for Daesan Emissions To SMA

Daesan Complex

18 Plants

3.9 million m²

Produces > 1 million tons ethene/year

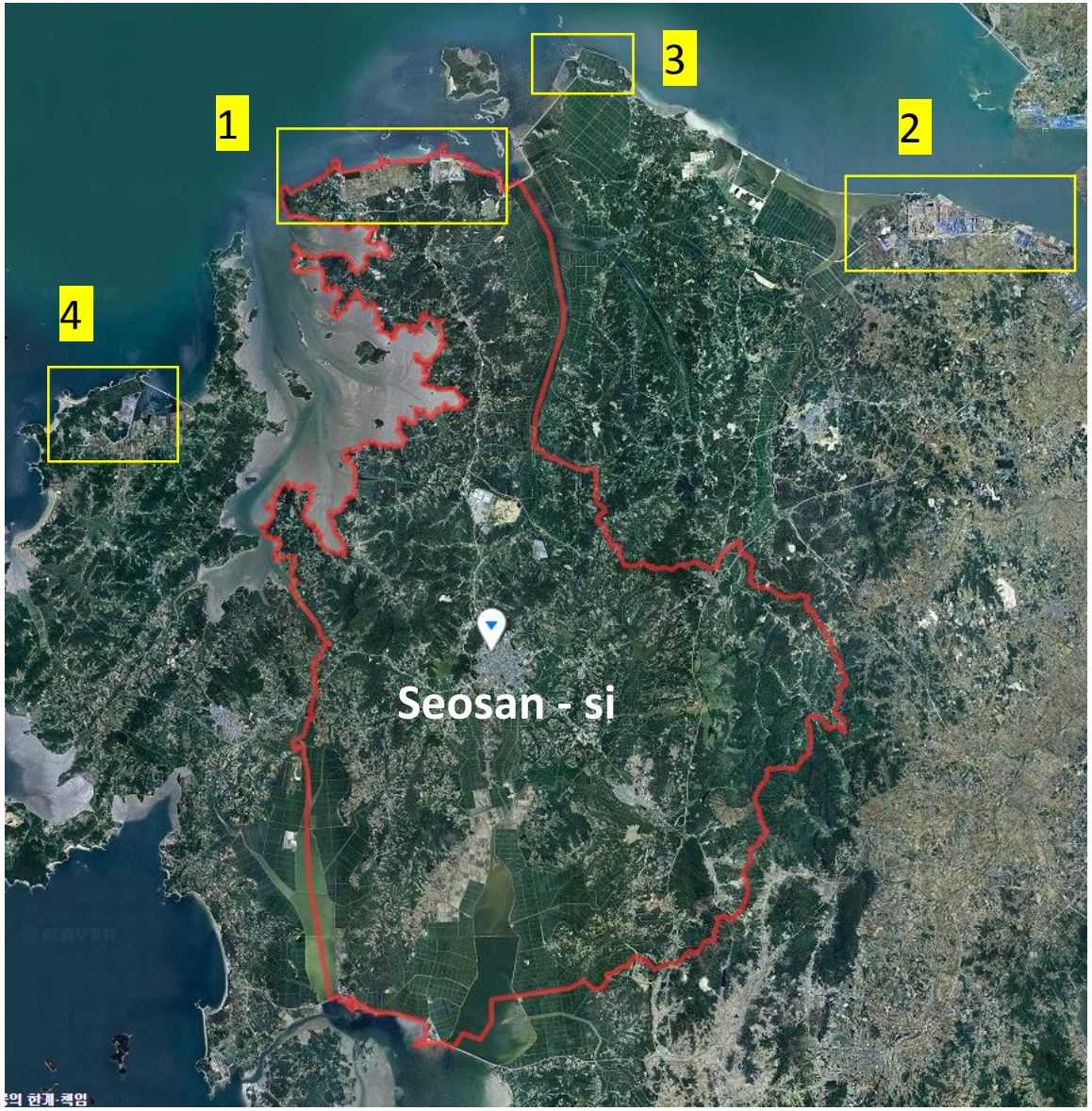
1. Daesan Industrial Complex (Seosan-si)

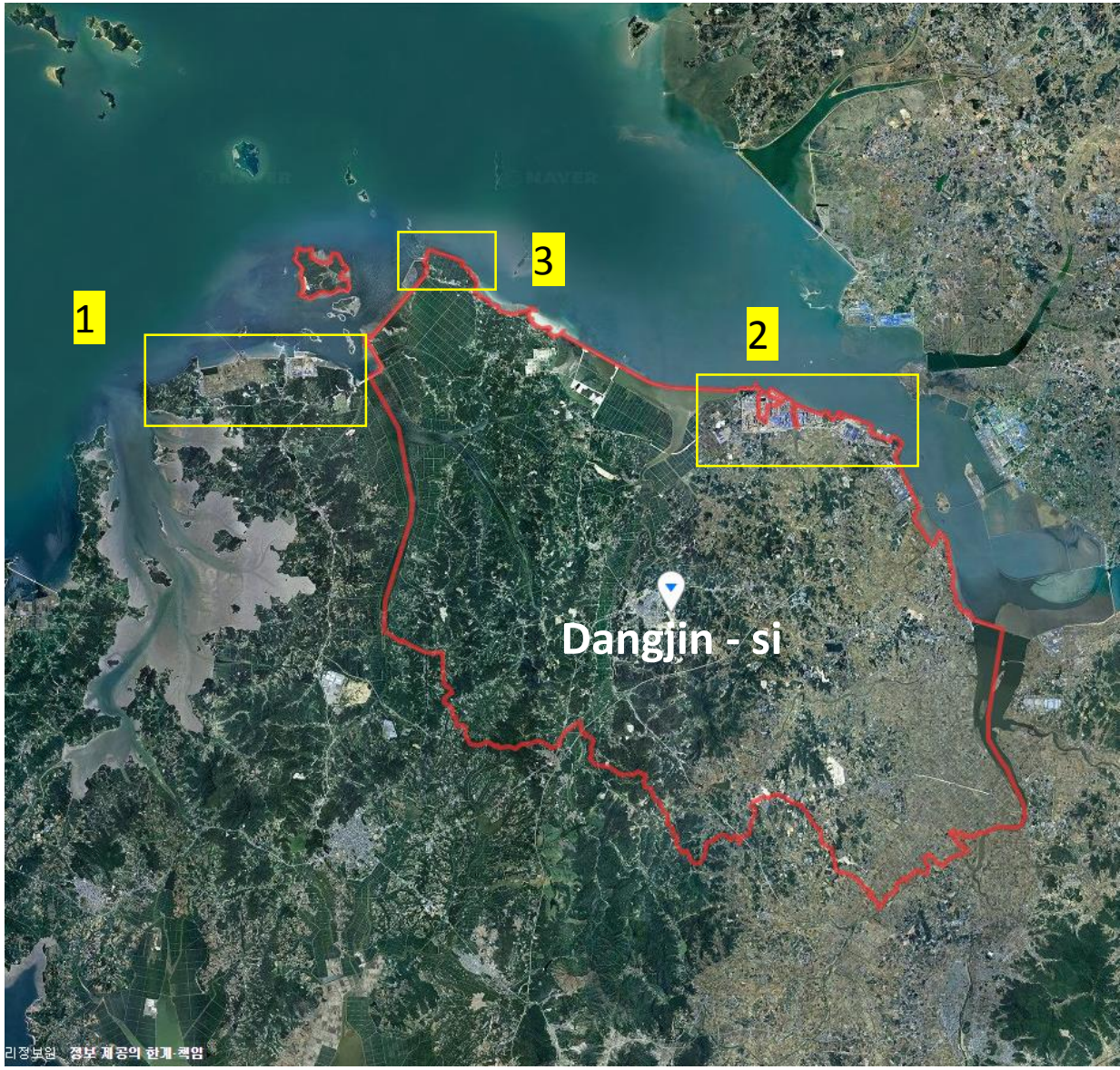
2. Hyundai Steel (Dangjin-si)

3. Dangjin power plant (Dangjin-si)

4. Taean power plant (Taean-gun)

From Professor Jung Hun Woo & Jinseok – Feb. 2019





New Inventory - Seosan From Professor Jung Hun Woo & Jinseok – Feb. 2019

Industrial Sector	TIER 1 Sector	TIER 2 Sector	metric ton/yr	SAPRC species					Chemical Species (HCHO and Precursors)				
									HCHO	ETHE	0.29*OLE1	0.05*OLE2	0.12*OLE1
	area		VOC	ETHE	HCHO	OLE1	OLE2	CH2O	Ethene	propene	1,3 butadi	1-Butene	
v	Industrial Processes	Chemical Manufacturing: SIC 28	1,778	243	-	440	129	-	243	128	6	53	
v	Industrial Processes	Food and Kindred Products: SIC 20	2	0	0	0	0	0	0	0	0	0	
v	Industrial Processes	Mineral Processes: SIC 32	0	0	-	0	0	-	0	0	0	0	
	Miscellaneous Area Sources	Agriculture Production - Crops	234	5	-	23	18	-	5	7	1	3	
	Miscellaneous Area Sources	Other Combustion	170	25	7	10	7	7	25	3	0	1	
v	Mobile Sources	Off-highway Vehicle Diesel	97	21	9	8	2	9	21	2	0	1	
	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	23	6	-	4	1	-	6	1	0	1	
v	Mobile Sources	Marine Vessels, Commercial	94	16	5	11	8	5	16	3	0	1	
v	Solvent Utilization	Surface Coating	1,730	5	-	16	99	-	5	5	5	2	
v	Solvent Utilization	Degreasing	361	1	-	3	21	-	1	1	1	0	
	Solvent Utilization	Dry Cleaning	70	1	-	1	6	-	1	0	0	0	
	Solvent Utilization	Graphic Arts	15	-	-	-	0	-	-	-	0	-	
	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Con	449	5	-	8	39	-	5	2	2	1	
	Solvent Utilization	Miscellaneous Non-industrial: Commercial	64	1	-	1	6	-	1	0	0	0	
	Stationary Source Fuel Combustion	Residential	17	6	0	1	1	0	6	0	0	0	
v	Stationary Source Fuel Combustion	Industrial	28	12	-	2	1	-	12	1	0	0	
	Stationary Source Fuel Combustion	Commercial/Institutional	2	0	0	0	0	0	0	0	0	0	
	Stationary Source Fuel Combustion	Total Area Source Fuel Combustion	0	0	0	0	0	0	0	0	0	0	
v	Storage and Transport	Petroleum and Petroleum Product Storage	138	-	-	18	5	-	-	5	0	2	
	Waste Disposal, Treatment, and Recover	Open Burning	52	22	-	3	2	-	22	1	0	0	
	Waste Disposal, Treatment, and Recover	Wastewater Treatment	0	0	0	0	0	0	0	0	0	0	
		SUM	5,325	366	21	551	343	21	366	160	17	66	
	mobile	metric ton/yr	VOC	ETHE	HCHO	OLE1	OLE2	CH2O	Ethene	propene	1,3 butadi	1-Butene	
	Mobile Sources	Passenger Car	51	14	0	10	2	0	14	3	0	1	
	Mobile Sources	Van	2	1	0	0	0	0	1	0	0	0	
	Mobile Sources	Bus	14	3	1	1	1	1	3	0	0	0	
	Mobile Sources	Truck	68	23	18	3	0	18	23	1	0	0	
	Mobile Sources	Towing and rescue cars	1	0	0	0	0	0	0	0	0	0	
	Mobile Sources	RV	9	2	1	1	0	1	2	0	0	0	
	Mobile Sources	Taxi	0	0	0	0	0	0	0	0	0	0	
	Mobile Sources	Highway Vehicles - Gasoline	16	4	-	3	0	-	4	1	0	0	
		SUM	161	46	21	18	4	21	46	5	0	2	
	point	metric ton/yr	VOC	ETHE	HCHO	OLE1	OLE2	CH2O	Ethene	propene	1,3 butadi	1-Butene	
	Stationary Source Fuel Combustion	Industrial	16	6	-	1	0	-	6	0	0	0	
v	Industrial Process	Oil and Gas Production: SIC 13	7,544	641	106	419	570	106	641	121	29	50	
v	Stationary Source Fuel Combustion	Electric Utility	0	0	0	0	0	0	0	0	0	0	
v	Industrial Process	Chemical Manufacturing	8,194	1,120	-	2,028	594	-	1,120	588	30	243	
v	Industrial Processes	Petroleum Refining: SIC 29	8	-	-	1	0	-	-	0	0	0	
v	Storage and Transport	Petroleum and Petroleum Product Storage	1,015	-	-	134	40	-	-	39	2	16	
v	Waste Disposal, Treatment, and Recover	On-site Incineration	384	160	-	25	12	-	160	7	1	3	
		SUM	17,161	1,927	106	2,608	1,216	106	1,927	756	61	313	

metric ton/yr	VOC	CH2O	Ethene	propene	1,3 butadie	1-Butene	Sum
Industrial Complex	21,390	120	2,225	901	74	373	3,693

New Inventory - Dangin From Professor Jung Hun Woo & Jinseok – Feb. 2019

Industrial Sector	TIER 1 Sector	TIER 2 Sector	metric ton/yr	SAPRC species				Chemical Species (HCHO and Precursors)				
								HCHO	ETHE	0.29*OLE1	0.05*OLE2	0.12*OLE1
	area		VOC	ETHE	HCHO	OLE1	OLE2	CH2O	Ethene	propene	1,3 butadiene	1-Butene
v	Industrial Processes	Food and Kindred Products: SIC 20	1	0	0	0	0	0	0	0	0	0
v	Industrial Processes	Primary Metal Production: SIC 33	122	17	-	30	9	-	17	9	0	4
v	Industrial Processes	Mineral Processes: SIC 32	1	0	-	0	0	-	0	0	0	0
	Miscellaneous Area Sources	Agriculture Production - Crops	341	7	-	33	26	-	7	10	1	4
	Miscellaneous Area Sources	Other Combustion	198	29	8	12	8	8	29	4	0	1
v	Mobile Sources	Off-highway Vehicle Diesel	88	19	8	8	1	8	19	2	0	1
	Mobile Sources	Off-highway Vehicle Gasoline, 2-Stroke	20	5	-	4	1	-	5	1	0	0
	Mobile Sources	Marine Vessels, Commercial	69	11	4	8	6	4	11	2	0	1
v	Solvent Utilization	Surface Coating	1,547	4	-	14	88	-	4	4	4	2
v	Solvent Utilization	Degreasing	161	0	-	2	9	-	0	0	0	0
	Solvent Utilization	Dry Cleaning	49	1	-	1	4	-	1	0	0	0
	Solvent Utilization	Graphic Arts	8	-	-	-	0	-	-	-	0	-
	Solvent Utilization	Miscellaneous Non-industrial: Consumer and Co	436	5	-	8	38	-	5	2	2	1
	Solvent Utilization	Miscellaneous Non-industrial: Commercial	5	0	-	0	0	-	0	0	0	0
	Stationary Source Fuel Combustion	Residential	17	5	0	1	1	0	5	0	0	0
v	Stationary Source Fuel Combustion	Industrial	176	73	-	11	5	-	73	3	0	1
	Stationary Source Fuel Combustion	Commercial/Institutional	7	1	0	0	1	0	1	0	0	0
	Stationary Source Fuel Combustion	Total Area Source Fuel Combustion	0	0	0	0	0	0	0	0	0	0
v	Storage and Transport	Petroleum and Petroleum Product Storage	128	-	-	17	5	-	-	5	0	2
	Waste Disposal, Treatment, and Recovery	Open Burning	50	21	-	3	2	-	21	1	0	0
	Waste Disposal, Treatment, and Recovery	Landfills	120	10	2	7	9	2	10	2	0	1
	Waste Disposal, Treatment, and Recovery	Wastewater Treatment	0	0	0	0	0	0	0	0	0	0
		SUM	3,544	208	22	159	213	22	208	46	11	19
	mobile	metric ton/yr	VOC	ETHE	HCHO	OLE1	OLE2	CH2O	Ethene	propene	1,3 butadiene	1-Butene
	Mobile Sources	Passenger Car	62	17	0	12	2	0	17	3	0	1
	Mobile Sources	Van	3	1	0	0	0	0	1	0	0	0
	Mobile Sources	Bus	14	3	2	1	1	2	3	0	0	0
	Mobile Sources	Truck	111	38	30	5	1	30	38	1	0	1
	Mobile Sources	Towing and rescue cars	2	1	1	0	0	1	1	0	0	0
	Mobile Sources	RV	11	2	1	1	0	1	2	0	0	0
	Mobile Sources	Taxi	0	0	0	0	0	0	0	0	0	0
	Mobile Sources	Highway Vehicles - Gasoline	15	4	-	3	0	-	4	1	0	0
		SUM	219	65	33	22	4	33	65	6	0	3
	point	metric ton/yr	VOC	ETHE	HCHO	OLE1	OLE2	CH2O	Ethene	propene	1,3 butadiene	1-Butene
	Stationary Source Fuel Combustion	Industrial	111	46	-	7	3	-	46	2	0	1
v	Industrial Processes	Primary Metal Production: SIC 33	4,249	581	-	1,052	308	-	581	305	15	126
v	Stationary Source Fuel Combustion	Electric Utility	522	24	39	32	19	39	24	9	1	4
v	Waste Disposal, Treatment, and Recovery	On-site Incineration	151	63	-	10	5	-	63	3	0	1
		SUM	5,033	714	39	1,100	335	39	714	319	17	132

metric ton/yr	VOC	CH2O	Ethene	propene	1,3 butadie	1-Butene	Sum
Industrial Complex	7,326	50	840	345	23	143	1,401

Major Focus – Comparisons of VOC Measurements With Emission Inventories

- **Mass Balance Approach -** Seokhan Jeong, Kyung Min & Blake Group
- **Estimates using Formaldehyde Production Rates in Downwind Plumes** – Changmin Cho, Kyung Min, Blake Group, et al.
- **Fast Time Response Measurements as Proxy for WAS VOCS** – Wennberg, et. al.
- **Further Analysis by Mass Balance Approach** – Fried et al.

Secondary Focus – Comparisons of CH_2O Measurements & Precursors With Emission Inventories

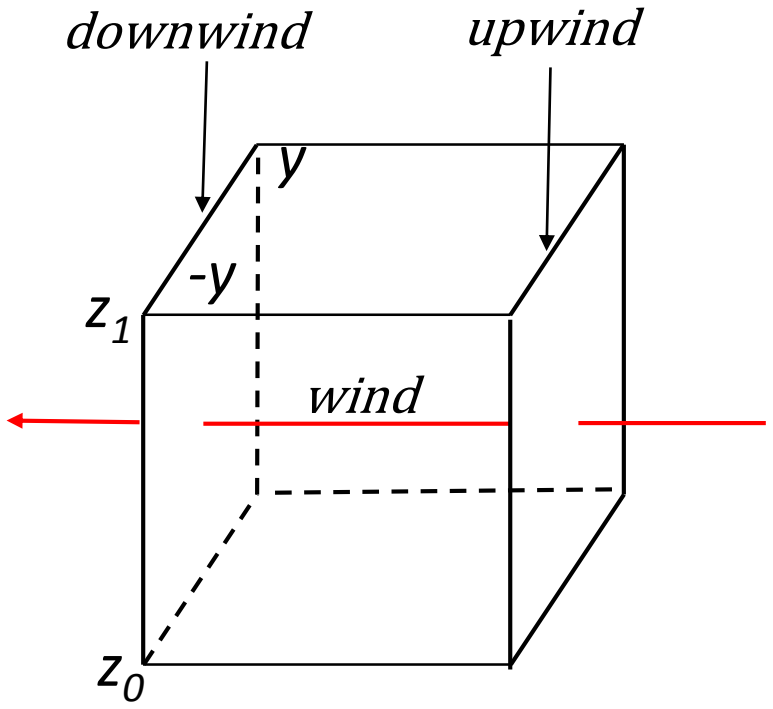
- Mass Balance Approach Using Wennberg AHNs to Remove CH_2O Production Over Daesan to Derive Emission Fluxes

CH2O
Ethene
Propene
1,3- Butadiene
1-Butene

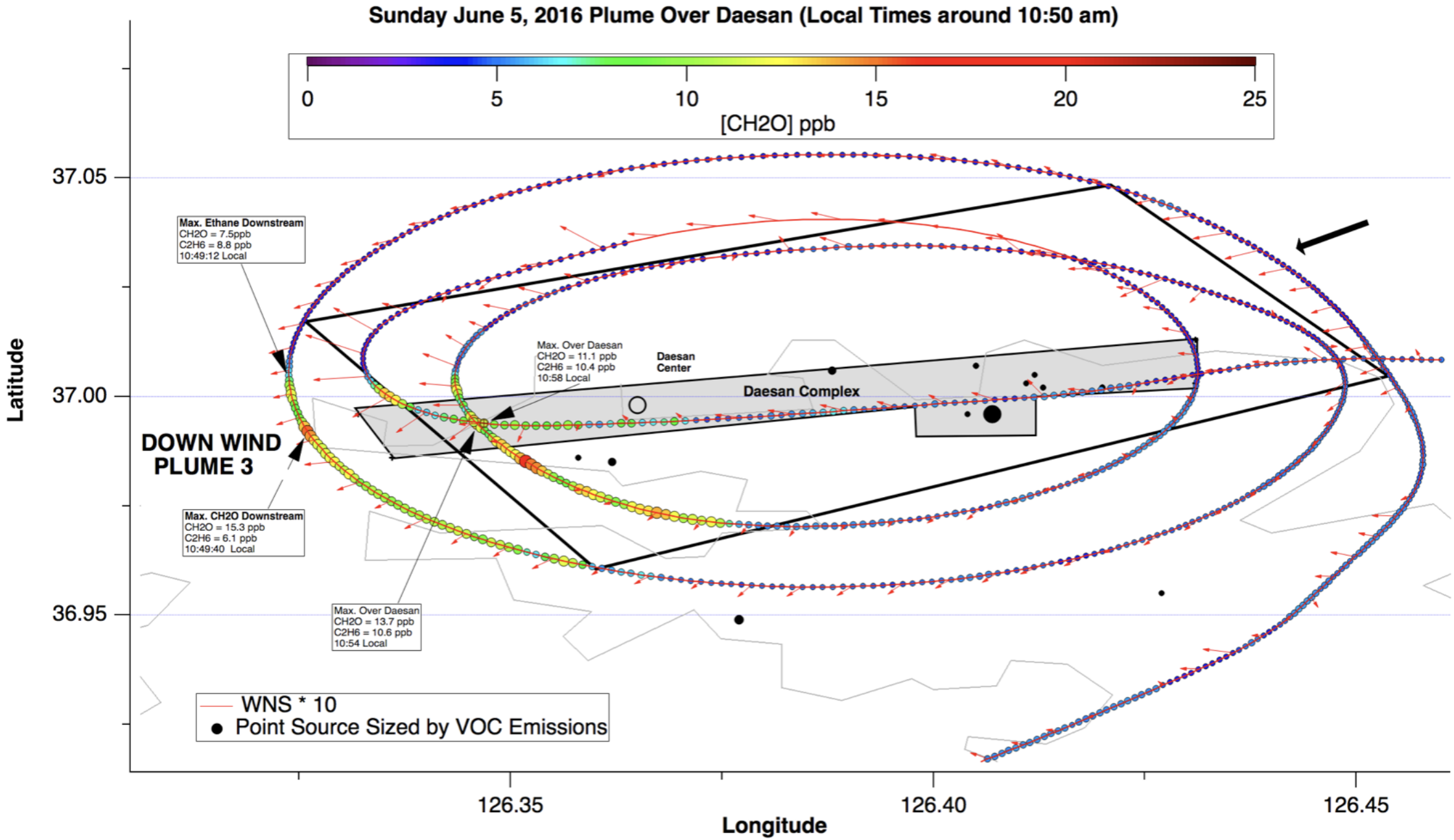
Mass balance approach – S. Jeong, K. Min, Blake Group

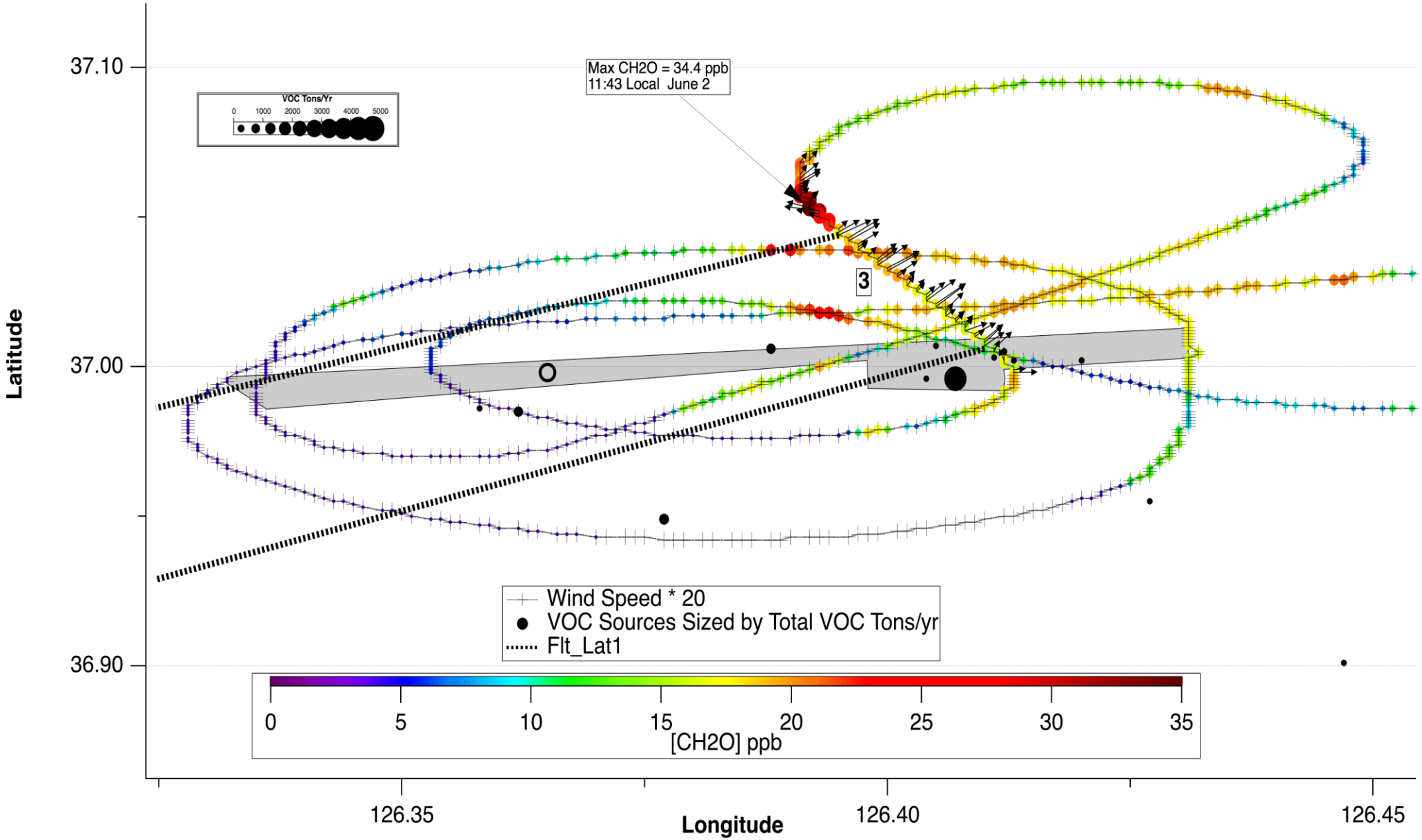
[Peischl.J et al., 2015]
[White et al., 1976]

$$E = v\cos(\alpha) \int_{z_0}^{z_1} \int_{-y}^{y} (X - X_{bg})\, dydz$$

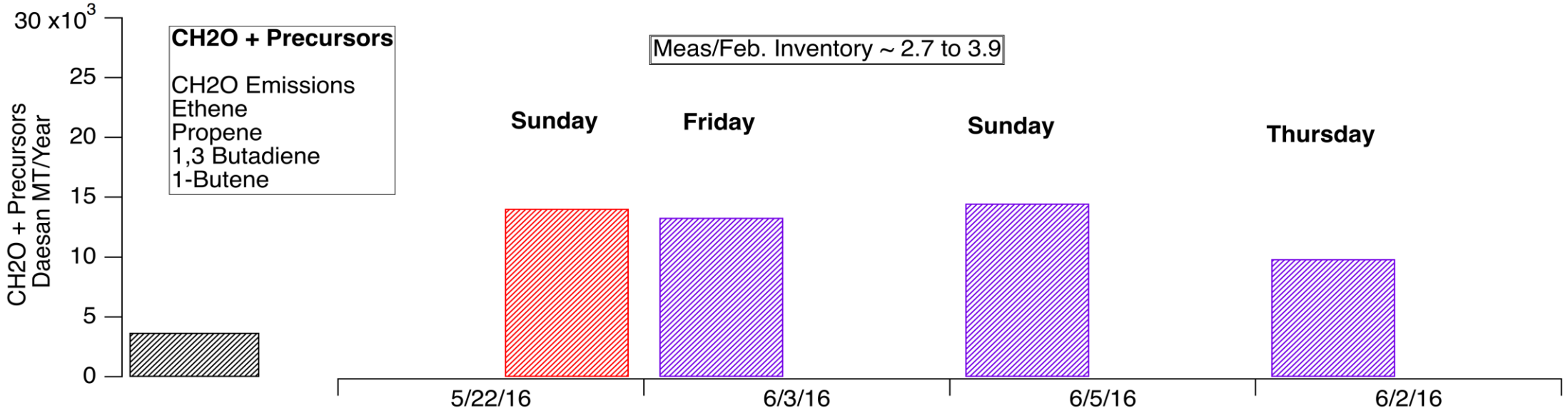


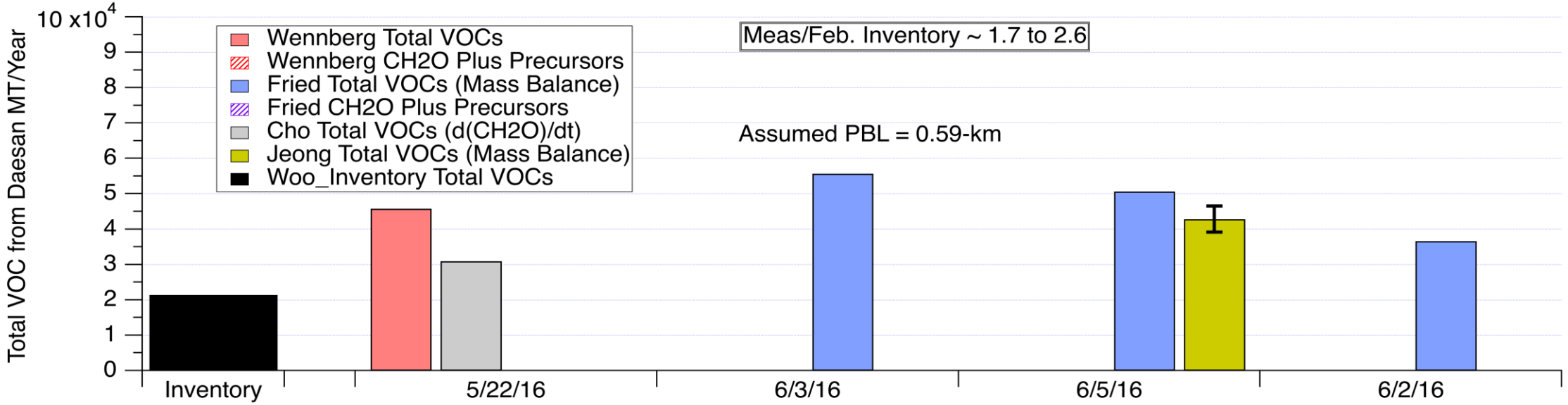
E : emission rates
v : wind velocity
α : angle between the vertical axes of downwind and main wind direction
z_0 *to* z_1 : planetary boundary layer depth
y to -y : sampling width
$X - X_{bg}$: the enhancement of VOCs


Sunday June 5, 2016 Plume Over Daesan (Local Times around 10:50 am)
0
5
10
15
20
25
[CH2O] ppb
37.05
37.00
36.95
Latitude
126.35
126.40
126.45
Longitude
Max. Ethane Downstream
CH2O = 7.5ppb
C2H6 = 8.8 ppb
10:49:12 Local
Max. Over Daesan
CH2O = 11.1 ppb
C2H6 = 10.4 ppb
10:58 Local
Daesan
Center
Daesan Complex
DOWN WIND
PLUME 3
Max. CH2O Downstream
CH2O = 15.3 ppb
C2H6 = 6.1 ppb
10:49:40 Local
Max. Over Daesan
CH2O = 13.7 ppb
C2H6 = 10.6 ppb
10:54 Local
WNS * 10
Point Source Sized by VOC Emissions


Max CH2O = 34.4 ppb
11:43 Local June 2
VOC Tons/Yr
0 1000 2000 3000 4000 5000
3
Wind Speed * 20
VOC Sources Sized by Total VOC Tons/yr
Flt_Lat1
0 5 10 15 20 25 30 35
[CH2O] ppb
37.10
37.00
36.90
Latitude
126.35
126.40
126.45
Longitude

Summary of Daesan Emissions & Comparisons with Feb. Inventory





Where Do We Stand on Emissions

- Validity in Extrapolating Measurement Snapshots to Yearly Flux Estimates (g/sec → MT/year) - Plume Persistence –
  STILL OPEN QUESTION

- Comparisons of Measurements to Appropriate Emissions Inventory (Daesan emissions only or entire region) –
  ADDRESSED

- Heterogeneity of Downstream Plumes from Multiple Sources –
  DOWNSTREAM PLUMES NOT USED

- Homogeneity of Emissions from a Given Facility –
  CONSISTENCY IN RESULTS - MAY NOT BE A PROBLEM

Where Do We Stand on Emissions

- **Flight Profiles not Designed for Source Flux Measurements**
  - Requires extensive vertical walls upstream & downstream for VOC vertical distributions
  - June 5, spiral near Daesan & inferred vertical mixing from fast chemical & thermodynamic meas.
  - Larger uncertainties for June 2 & 3

- **Evidence from Alkene-HNs Showing Importance of CH_2O Production (Lower Limit ~ 63%) Even Over Daesan. This Extends CH_2O Transport Footprint**

Where Do We Stand on Emissions

- Top Down Daesan VOC Estimates Factor ~ 1.2 to 2.6 Higher Than Feb Emission Inventory
- Working on Comparisons for Hyundai Steel, Dangjin Power Plant & Taean Power Plant
- Working on Error Bar Estimates for Top Down Inventories
- Possibilities of Year-Round Ground-Based Sampling?