TECHNICAL REPORT

Inter Comparison of Indigenously Developed Photonic System AUM with CAAQM Systems at SG HALLI and KAVIKA Stations of KSPCB Bangalore

(May 29 – 30, 2019)

Submitted to

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by

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SCIENTIFIC AND INDUSTRIAL RESEARCH CENTRE

(GVP-SIRC)

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The following personnel contributed at various stages to the successful completion of the project.

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EXECUTIVE SUMMARY

In order to look at new and improved technologies for air pollution monitoring and the importance of supporting indigenous technologies for nation building, Prof. Rao Tatavarti of GVP-SIRC a DSIR recognised Centre of Research Excellence in Visakhapatnam made a detailed technical presentation at Karnataka State Pollution Control Board (KSPCB), Bangalore in October 2018; regarding the novel indigenously developed photonic system - AUM - for remote real time air pollution monitoring.

Following the clarion call from Honourable Prime Minister Prof. Tatavarti agreed to commercialize the system through a technology start-up company CATS Eco Systems Pvt. Ltd which was duly launched under the Start-up India Initiative.

During December 2018, the AUM Photonic System was successfully calibrated in collaboration with M/S EffecTech, UK - who are the global leaders in calibration of gases and instrument performance evaluation, with ISO 17025:2005 International Accreditation for Testing and Calibration.

After detailed discussions and deliberations between KSPCB team - led by the Chief Scientific Officer, Dr. B.R. Balagangadhar, and the GVP-SIRC / CATS Eco Systems Pvt Ltd team led by Prof. Rao Tatavarti, it was decided to conduct an inter-comparison study between the existing Continuous Ambient Air Quality Monitoring (CAAQM) stations at Bangalore and the indigenously developed Photonic System, AUM - over a suitable time period so that one can arrive at appropriate scientific conclusions.

Keeping in view the challenging wide ranging differences in the technologies for an inter comparison study (*i.e.*, technical aspects covering the underlying principles of sensing of the suite of sensors in the CAAQMS vis-à-vis the single photonic system, the respective time responses, sensitivities and accuracies of the suite of sensors vis-à-vis the photonic system, the differences in the sampling rates of CAAQMS vis-à-vis the photonic system) it was decided to bring the data from different systems on to a common sampling interval to arrive at meaningful scientific conclusions. Thus the data from the indigenous single photonic system AUM - *capable of real time remote monitoring of various air quality parameters based on the underlying principles of back scattering of light with data streaming at a very high sampling frequency of 10kHz (i.e., 10,000 samples per second or a sampling interval of 0.0001 sec)* - were reconciled in terms of sampling rates with the existing CAAQM systems (having a suite of sensors) from M/S Environment SA, France located at SG HALLI and M/S Eco Tech, Australia located at KAVIKA, having sampling intervals of 900*sec* and 300*sec* respectively.

This report details the inter-comparisons study between the novel indigenously developed photonic system, AUM and the conventional imported Continuous Ambient Air Quality Monitoring (CAAQM) systems which are currently being used by the Central Pollution Control Board and the various State Pollution Control Boards in India. The present study specifically looks at the results obtained by the indigenously developed photonic system (AUM) developed by Prof Rao Tatavarti and the two spatially separated (~6 *km* in the North –South direction) different systems in use at the Karnataka State Pollution Control Board (KSPCB) Bangalore stations at SG Halli (procured from M/S Environment SA, France) and at Karnataka Vidyut Karkhane (KAVIKA) (procured from M/S Eco Tech, Australia).

The inter-comparison study was conducted during May 29^{th} – 30^{th}, 2019. The study was made by locating the portable photonic system close (at approximately 1m horizontal distance and at about the same height to the intake of the Environment SA and at approximately 1m in horizontal direction and approximately 1m in the vertical direction to the intake of the Eco Tech System) to the CAAQM systems at SG Halli and KAVIKA respectively.

The existing SG Hallli System (from M/S Environment SA, France) was configured to record air quality parameters (CO (*mg/m*^{3}) , NO (*μg/m*^{3}), NO2 (*μg/m*^{3}), NO_x(*μg/m*^{3}), SO_2(*μg/m*^{3}), SR (Solar Radiation) (*watts/m*^{2}), Wind Speed (*m/s*) , Wind Direction (*deg*) and Particulate Matter PM10 (*μg/m*^{3}) at 900 *sec* time interval.

The KAVIKA system was configured to record air quality parameters (CO (*mg/m*^{3}) , NH_3 (*μg/m*^{3}) NO (*μg/m*^{3}), NO2 (*μg/m*^{3}) , NO_x(*μg/m*^{3}), O_3 (*μg/m*^{3}), SO_2(*μg/m*^{3}), SR (Solar Radiation) (*watts/m*^{2}), Wind Speed (*m/s*) , Wind Direction (*deg*), Benzene (*μg/m*^{3}), Toluene (*μg/m*^{3}), Ei-Benzene (*μg/m*^{3}) , o-Xylene (*μg/m*^{3}), p-Xylene (*μg/m*^{3}), Temperature (^{o}*C*), Relative Humidity RH (%), and Particulate Matter PM_{10} (*μg/m*^{3}) and $PM_{2.5}$ (*μg/m*^{3}) at 300*sec* time interval.

The wireless data from the Photonic System, AUM were down sampled at the rate of approx. 150*Hz* or at a time interval of 0.0064516 *sec* and the backscatter characteristics of light (*i.e.*, the back scattered light position $\{x, y\}$ and the back scattered light intensity {*sum*}) were recorded at 150*Hz*.. A sophisticated state of art methodology determines the individual air pollution parameters from the back scatter characteristics based on new science utilizing indigenously developed machine learning and deep learning algorithms.

Given the complexities of comparing different systems during a duration of 2 *hours* (120 *min*) it became imperative to reconcile the data from the indigenous Photonic System AUM *with 1.12 million data points* as a function of time, with the data from the imported systems from M/S Environment SA, France *with 8 data points* as function of time and from M/S Eco Tech, Australia *with 16 data points* as a function of time). Therefore, it was decided that the photonic system data would be further down sampled (averaged) to make appropriate comparisons. Therefore, while comparing with data from SG HALLI Station (Environment SA System) the AUM data was averaged to 15-*min* sampling, and while comparing the data from KAVIKA station (Eco Tech System) the AUM data was averaged to 5-*minute* sampling.

Based on the inter-comparison study, the following conclusions are drawn:

- *During the study period, the values of the air quality parameters from CAAQMS stations at SGHALLI and KAVIKA spatially separated by about 6kms were different, as is to be expected.*

- *The values of air quality parameters from the AUM photonic system were comparable to the conventional systems at SG HALLI and KAVIKA stations procured from M/S Environment SA, France and M/S Eco Tech, Australia.*

- *The indigenous photonic system AUM, can be effectively calibrated with any of the standard conventional systems to arrive at all the air quality parameters simultaneously at a much cheaper cost.*

- *As AUM yields higher sampling rates of data with high accuracy and sensitivity, in addition to having multifarious advantages of being portable, low power system with no logistical requirements for setting up the system; the WHO roadmap set for 2020 - to increase the spatio-temporal sampling of air quality parameters effectively across the world - can be achieved by the indigenously developed photonic system, AUM in a cost effective optimal way.*

PREAMBLE

In order to look at new and improved technologies for air pollution monitoring and the importance of supporting indigenous technologies for nation building. Prof. Rao Tatavarti of GVP-SIRC a DSIR recognised Centre of Research Excellence in Visakhapatnam made a detailed technical presentation at Karnataka State Pollution Control Board (KSPCB), Bangalore in October 2018; regarding the novel indigenously developed photonic system - AUM - for remote real time air pollution monitoring.

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After detailed discussions and deliberations between KSPCB team - led by the Chief Scientific Officer, Dr. B.R. Balagangadhar, and the GVP-SIRC / CATS Eco Systems Pvt Ltd team led by Prof. Rao Tatavarti, it was decided to conduct an inter-comparison study between the existing Continuous Ambient Air Quality Monitoring (CAAQM) stations at Bangalore and the indigenously developed Photonic System, AUM - over a suitable time period so that one can arrive at appropriate scientific conclusions.

Ambient Air Quality Monitoring – Standards and Limitations

Air quality monitoring requires proper selection of pollutants, selection of locations, frequency and duration of sampling, sampling techniques, infrastructural facilities, man power and operation and maintenance. The areas selected for monitoring are based on high traffic density, industrial growth, human population and its distribution, emission source, public complaints, the land use pattern etc. The criteria pollutants measured are Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Sulphur dioxide (SO2), Oxides of Nitrogen (NOx), and Carbon Monoxide (CO) etc. Therefore, the ambient air quality monitoring network involves measurement of a number of air pollutants at different locations in the country. The basis for a network design is the pollution source and the pollutants present. As per the CPCB Guidelines and the Indian Gazette Notification

NATIONAL AMBIENT AIR QUALITY STANDARDS (2009)

Pollutants	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)	
Sulphur Dioxide (SO_2), µg/m³	Annual * 24 Hours **	50 80	20 80	-Improved West and Gaeke Method -Ultraviolet Fluorescence
Nitrogen Dioxide (NO_2), µg/m³	Annual * 24 Hours **	40 80	30 80	-Jacob & Hochheiser modified ($NaOH$-$NaAsO_2$) Method -Gas Phase Chemiluminescence
Particulate Matter (Size less than 10µm) or PM_{10}, µg/m³	Annual * 24 Hours **	60 100	60 100	-Gravimetric -TEOM -Beta attenuation
Particulate Matter (Size less than 2.5µm) or $PM_{2.5}$, µg/m³	Annual * 24 Hours **	40 60	40 60	-Gravimetric -TEOM -Beta attenuation
Ozone (O_3) µg/m³	8 Hours * 1 Hour **	100 180	100 180	-UV Photometric -Chemiluminescence -Chemical Method
Lead (Pb) µg/m³	Annual * 24 Hours **	0.50 1.0	0.50 1.0	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper -ED-XRF using Teflon filter
Carbon Monoxide(CO), mg/m³	8 Hours ** 1 Hour **	02 04	02 04	-Non dispersive Infrared (NDIR) Spectroscopy
Ammonia (NH_3), µg/m³	Annual * 24 Hours **	100 400	100 400	-Chemiluminescence -Indophenol method
Benzene (C_6H_6), µg/m³	Annual *	05	05	-Gas Chromatography (GC) based continuous analyzer -Adsorption and desorption followed by GC analysis
Benzo(a)Pyrene (BaP) Particulate phase only, ng/m³	Annual *	01	01	-Solvent extraction followed by HPLC/GC analysis
Arsenic (As), ng/m³	Annual *	06	06	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper
Nickel (Ni), ng/m³	Annual *	20	20	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper

* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

NOTE: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigations.

dated November 18, 2009, the National Ambient Air Quality Standards were issued as shown in the table above.

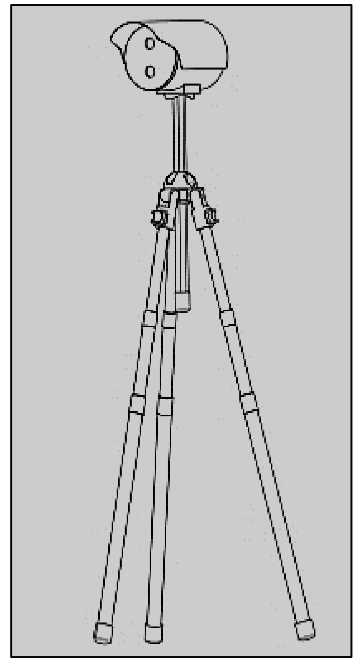
Typically, the air quality measurements are made using a suite of different instruments employing a widely varying methods and mechanisms, leading to a complex integration of different biases and limitations of the sensors *per se*. This typically can result in complexities in understanding and interpreting the data. Therefore, appropriate guidelines were drawn by regulatory authorities and issued to various ambient air quality monitoring agencies across the world. The Indian guidelines were issued by CPCB under the aegis of the Ministry of Environment and Forests.

The pernicious fact regarding the plausible biases in measurements across stations is very much appreciated by the CPCB, India and other regulatory authorities around the world and therefore a caveat was issued to users that the ambient air quality data monitored by different personnel and different instruments can result in biases of the measurements and therefore are only to be considered as indicative but not absolute values.

Against this back drop KSPCB suggested that we make an inter comparison study of the existing technologies used by CPCB with the novel indigenously developed photonic system AUM, *so as conclude whether the indigenously developed AUM system can be used for ambient air quality monitoring in lieu of the conventional imported systems.*

INDIGENOUS PHOTONIC SYSTEM FOR REAL TIME REMOTE MONITORING OF AIR QUALITY, AUM

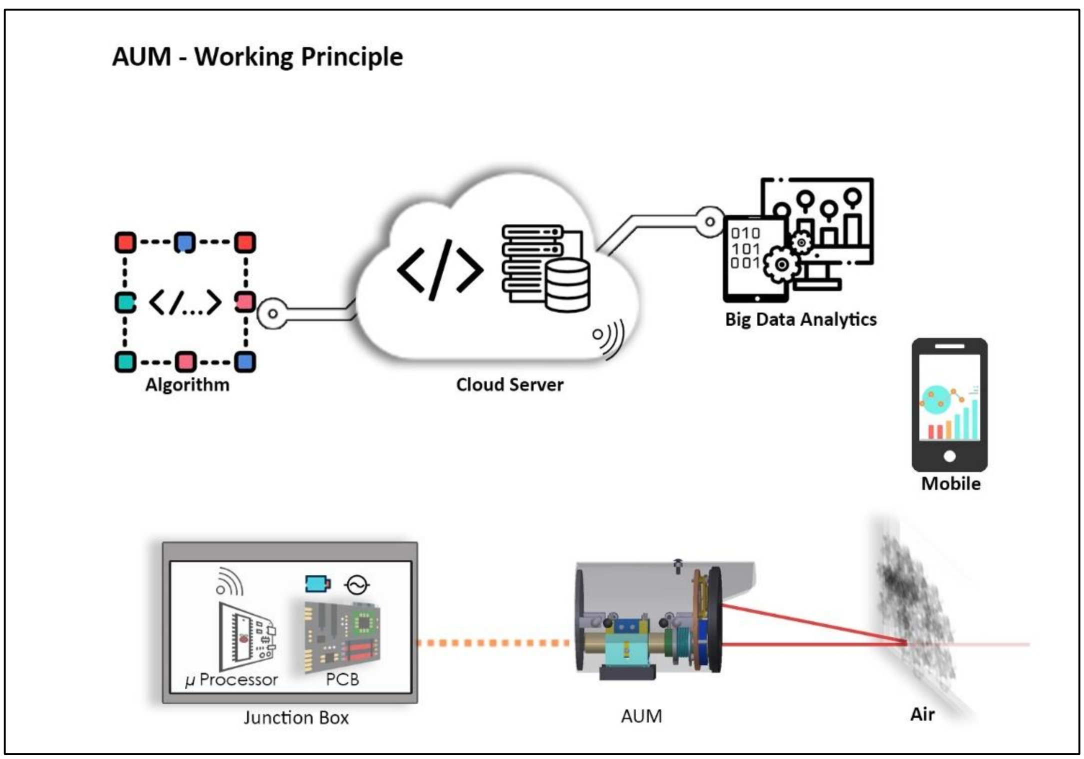
Conventional air pollution monitoring at a single location involves measurements by a suite of sensors having different technologies from different manufacturers - integrated and housed in a rather bulky shipping container. The monitoring of air pollution at a single location with the disparate sensors of varying sensitivities, accuracies and temporal responses, not only poses significant challenges in data acquisition and assimilation, but also, involves significantly high costs in order to arrive at digestible information for researchers, policy makers as well as the common public.



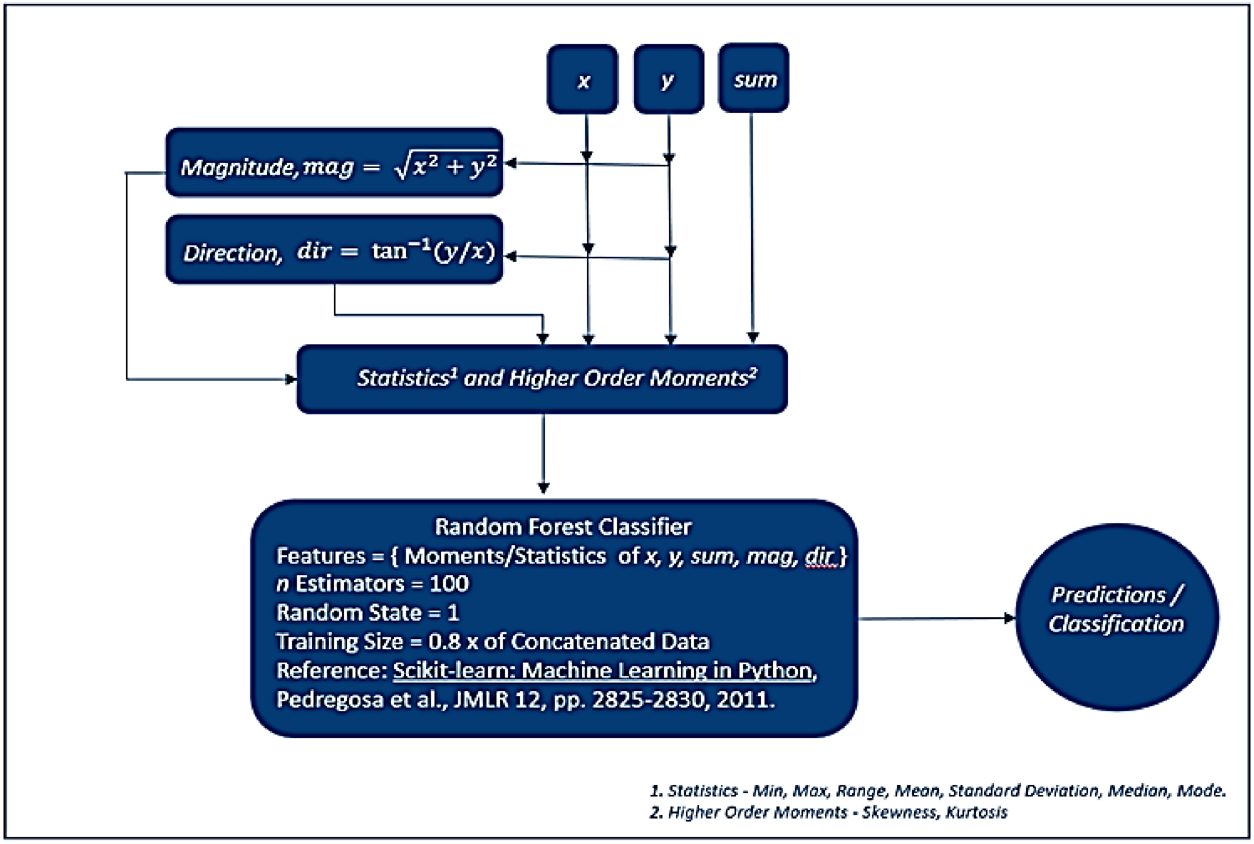
Against this backdrop, we designed and developed a compact photonic system capable of remote real time monitoring of various air pollutants in situ - either at a particular location or across a spatial domain of interest. The photonic system was designed and developed using COTS (commercially-off-the-shelf) technologies, making it significantly cheaper for wider deployment, in sync with the WHO's roadmap.

The uniqueness and novelty of the system lies in its ability to innovatively apply the concepts of laser back scattering, artificial intelligence and machine (deep) learning to identify, classify and quantify various air pollutants simultaneously. The photonic system was extensively evaluated in the laboratory as well as in the field, and was found to be good; yielding air quality estimates at very high sampling frequencies with high sensitivity and accuracy. The system is now ready for commercialization.

The system records the back scatter characteristics of light (position and the intensity of back scattered light from molecules in the volume of air) A schematic of the working principle of AUM is shown below.



The data from the Photonic System AUM were down sampled through wireless at the rate of 155*Hz* or at a time interval of 0.0064516 *sec* and the backscatter characteristics of light (*i.e.*, the backscattered light's position (x, y) and the back scattered light intensity (*sum*) were recorded at 155*Hz*..



From the three *unique* observations of backscattered light, the magnitude and direction of the backscattered lights positional vector is calculated at each instant. Thereafter, various statistical estimates (7 estimates – *mean, variance, minimum, maximum, range, skewness, kurtosis*) of the five independent back scatter characteristics are computed and those are input to machine learning models to arrive at the various air quality parameters in engineering units. Thus ay any instant of time 35 statistic values of the backscatter characteristics are used to determine the various air quality parameters. An innovative state of art methodology determines the individual air pollution parameters from the back scatter characteristics based on new science developed in conjunction with machine learning and deep learning algorithms. Annexure 1 issued separately show cases the 35 statistical parameters at different temporal averages.

INTER COMPARISON TRIALS AT KSPCB STATIONS @ SGHALLI AND KAVIKA - MAY 29-30, 2019

The inter comparison trials were conducted to conclude whether the novel indigenously developed photonic system, AUM can be deployed as an alternative to the conventional imported Continuous Ambient Air Quality Monitoring (CAAQM) systems which are currently being used by the Central Pollution Control Board and the various state pollution control boards in India. The present study specifically looks at the results obtained by the indigenously developed photonic system (AUM) developed by Prof Rao Tatavarti and the two spatially separated (~6 *km* in the North –South direction) different systems in use at the Karnataka State Pollution Control Board (KSPCB) Bangalore stations at SG Halli (procured from M/S Environment SA, France) and at Karnataka Vidyut Karkhane (KAVIKA) (procured from M/S Eco Tech, Australia).

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The KAVIKA system was configured to record air quality parameters (CO (*mg/m^3*) , NH_3 (*µg/m^3*) NO (*µg/m^3*), NO2 (*µg/m^3*) , NO_x(*µg/m^3*), O_3 (*µg/m^3*), SO_2(*µg/m^3*), SR (Solar Radiation) (*watts/m^2*), Wind Speed (*m/s*) , Wind Direction (*deg*), Benzene (*µg/m^3*), Toluene (*µg/m^3*), Ei-Benzene (*µg/m^3*) , o-Xylene (*µg/m^3*), p-Xylene (*µg/m^3*), Temperature (^{o}*C*), Relative Humidity RH (%), and Particulate Matter PM_{10} (*µg/m^3*) and $PM_{2.5}$ (*µg/m^3*) at 300*sec* time intervals.

Given the complexities of comparing different systems during a duration of 2 *hours* and 1.5 *hours* (120 *min* and 90 *min*) it became imperative to reconcile the data from the indigenous Photonic System AUM *with 1.12 million data* points as a function of time, with the data from the imported systems from M/S Environment SA, France *with 8 data points* as function of time and from M/S Eco Tech, Australia *with 16 data points* as a function of time).

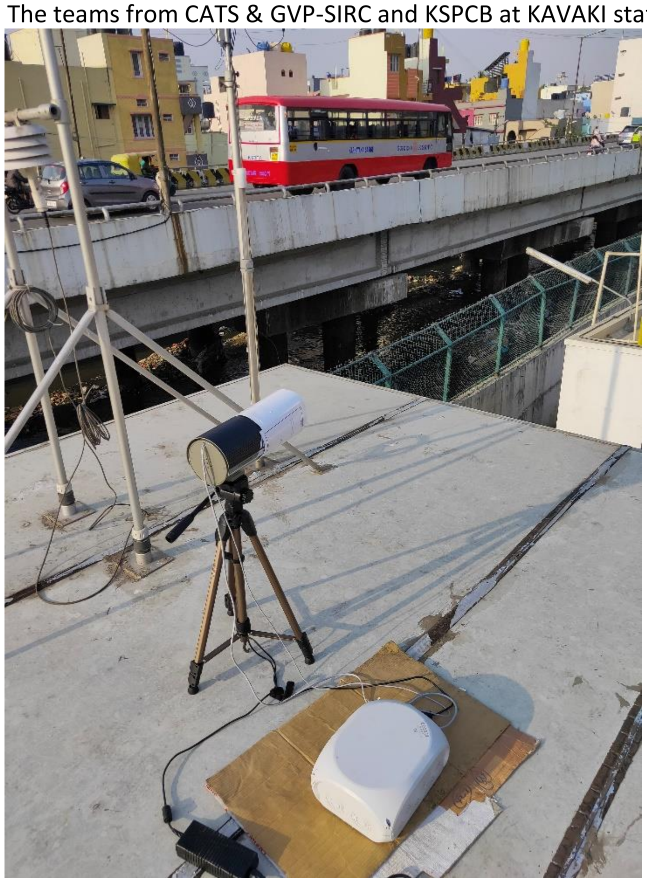
Therefore, it was decided that the photonic system data would be further down sampled (averaged) to make appropriate comparisons. Therefore, while comparing with data from SG HALLI Station (Environment SA System) the AUM data was averaged to 15-*minute* sampling, and while comparing the data from KAVIKA station (Eco Tech System) the AUM data was averaged to 5-*min* sampling.

The CATS team was led by Prof Rao Tatavarti of GVP-SIRC and Prof P. Arulmozhivarman of VIT University, whereas the KSPCB team was led by Dr. B.R. Balagangadhar and Ms. Madura.

The indigenously developed Photonic System, AUM collocated with the CAAQMS at SGHALLI

Teams from CATS / GVP-SIRC and KSPCB at SGHALLI Station

The teams from CATS & GVP-SIRC and KSPCB at KAVAKI station



AUM system located along with CAAQMS, KAVAKI

The team leads Prof. Rao Tatavarti and Dr B.R. Balagangadhar at KAVIKA station.

FIELD TRIALS – DATA FROM SG HALLI STATION FROM M/S ENVIRONMENT SA CAAQM SYSTEM

SG HALLI –Data (@15 *min*) from Environment SA CAAQMS – May 29, 2019

Time (HH:MM)	NO_SGH *µg/m³*	NO_2_SGH *µg/m³*	NO_X_SGH *µg/m³*	SO_2_SGH *µg/m³*	CO_SGH *mg/m³*	PM_{10} *µg/m³*	WS_SGH *m/s*	WD_SGH *degree*	SR_SGH *W/m²*
10:00	3.66	10.78	14.44	3.58	0.99	12.33	2.28	202.62	593.76
10:15	2.98	9.17	12.15	3.25	0.56	50.52	1.24	268.27	633.46
10:30	1.76	7.44	9.05	3.62	0.81	76.90	2.08	141.46	448.42
10:45	2.26	7.92	10.18	3.45	0.66	80.60	1.74	223.23	314.86
11:00	2.83	10.26	13.09	3.56	0.60	81.33	2.32	242.32	638.45
11:15	2.85	8.48	11.33	3.24	0.52	40.66	2.22	189.17	738.09
11:30	4.42	10.21	14.64	3.55	0.60	20.33	2.31	199.62	717.73
11:45	4.04	10.65	14.69	4.82	0.62	10.16	2.32	183.08	709.34
12:00	2.25	7.95	10.20	4.99	0.44	34.27	2.32	175.03	726.51
12:15	2.85	8.21	11.05	5.16	0.52	58.25	2.31	172.92	723.54
12:30	2.94	10.62	13.56	5.29	0.59	76.77	2.30	165.91	722.44
12:45	4.01	11.57	15.58	5.04	0.54	76.52	2.31	164.52	718.91
13:00	3.97	10.07	14.04	4.48	0.46	42.95	2.30	162.46	729.65
13:15	3.21	9.94	13.15	4.34	0.55	32.89	2.30	156.00	724.59
13:30	0.74	6.80	7.22	3.46	0.56	58.95	2.30	153.14	677.83
13:45	2.94	8.85	11.80	3.70	0.59	141.72	2.30	144.86	651.28
14:00	1.47	6.46	7.81	4.20	0.55	273.38	2.29	150.50	674.69
14:15	2.11	7.38	9.48	3.40	0.50	165.84	2.29	146.69	682.46
14:30	1.96	8.11	10.08	3.61	0.54	113.55	2.30	142.42	698.54
14:45	2.74	8.45	11.18	2.54	0.44	59.67	2.29	143.67	670.28

Field Trials – Data from KAVIKA Station from M/S Eco Tech CAAQM System

KAVIKA –Data (@5 *min*) from Eco Tech CAAQMS - May 29, 2019

Time	CO *mg/m³*	O_3 *µg/m³*	NO *µg/m³*	NO_2 *µg/m³*	NOx *µg/m³*	NH_3 *µg/m³*	SO_2 *µg/m³*	$PM_{2.5}$ *µg/m³*	PM_{10} *µg/m³*	Benzene *µg/m³*	Toluene *µg/m³*	p- Xylene *µg/m³*	o- Xylene *µg/m³*	Ei- Benzene *µg/m³*	Temp *°C*	RH *%*	WS *m/s*	WD *degree*	BP *mmHg*
15:25	0.55	72.43	6.65	31.01	37.65	19.63	1.04	48	125	0.93	2.06	2.94	0.06	0	32.71	39.09	1.57	268.84	715.68
15:30	0.58	72.56	8.89	29.02	37.91	17.96	1.04	48	125	0.93	2.06	2.94	0.07	0	32.71	39.31	2.44	274.97	715.68
15:35	0.53	77.35	6.13	27.74	33.88	21.72	1.01	48	125	0.84	1.95	2.93	0.31	0	32.63	40.16	2.41	256.19	715.61
15:40	0.37	74.06	5.83	21.79	27.62	22.17	0.99	48	125	0.84	1.95	2.93	0.31	0	32.72	39.85	2.37	238.09	715.58
15:45	0.41	58.91	4.98	22.31	27.29	20.16	0.98	48	125	0.84	1.96	2.95	0.32	0.02	32.73	39.53	2.16	251.67	715.58
15:50	0.43	58.87	4.45	23.04	27.49	19.52	0.94	48	125	0.91	2.39	3.44	0.47	0.62	32.74	39.87	2.08	273.27	715.54
15:55	0.48	57.24	5.25	25.38	30.63	17.82	0.9	58	82	0.91	2.39	3.44	0.47	0.62	32.83	39.81	2.29	289.26	715.48
16:00	0.52	62.45	7.88	28.61	36.49	14.55	0.91	58	82	0.91	2.38	3.22	0.47	0.62	32.88	39.38	2.08	273.51	715.45
16:05	0.5	65.73	3.66	25.11	28.77	21.23	0.9	58	82	0.85	2.27	0.13	0.46	0.57	32.77	39.41	1.8	253.93	715.43
16:10	0.45	63.34	5.32	27.2	32.53	18.91	0.92	58	82	0.85	2.27	0.13	0.46	0.57	32.7	39.79	2.23	263.51	715.3
16:15	0.43	61.21	4.75	28.02	32.77	19.82	0.91	58	82	0.85	2.25	0.33	0.46	0.57	32.73	40.19	1.74	289.31	715.24
16:20	0.49	55.55	8.31	30.48	38.79	15.64	0.92	58	82	0.84	1.97	3.08	0.42	0.58	32.86	39.79	2.09	277.8	715.22
16:25	0.56	53.22	8.1	32.95	41.05	16.73	0.96	58	82	0.84	1.97	3.08	0.42	0.58	33	39.55	1.67	286.02	715.22
16:30	0.64	52.46	8.36	34.94	43.3	20.67	0.97	58	82	0.84	1.98	3.07	0.42	0.58	32.94	39.5	2.19	267.84	715.17
16:35	0.62	55.46	7.84	33.1	40.94	23.17	0.97	58	82	0.8	2.04	2.99	0.38	0.57	32.91	39.16	1.29	269.76	715.17
16:40	0.6	55.73	9.29	36.06	45.35	19.51	0.96	58	82	0.8	2.04	2.99	0.38	0.57	33.15	38.94	1.53	291.32	715.15

Observational Statistics @ SG Halli and KAVIKA Stations: CAAQMS *vs* AUM

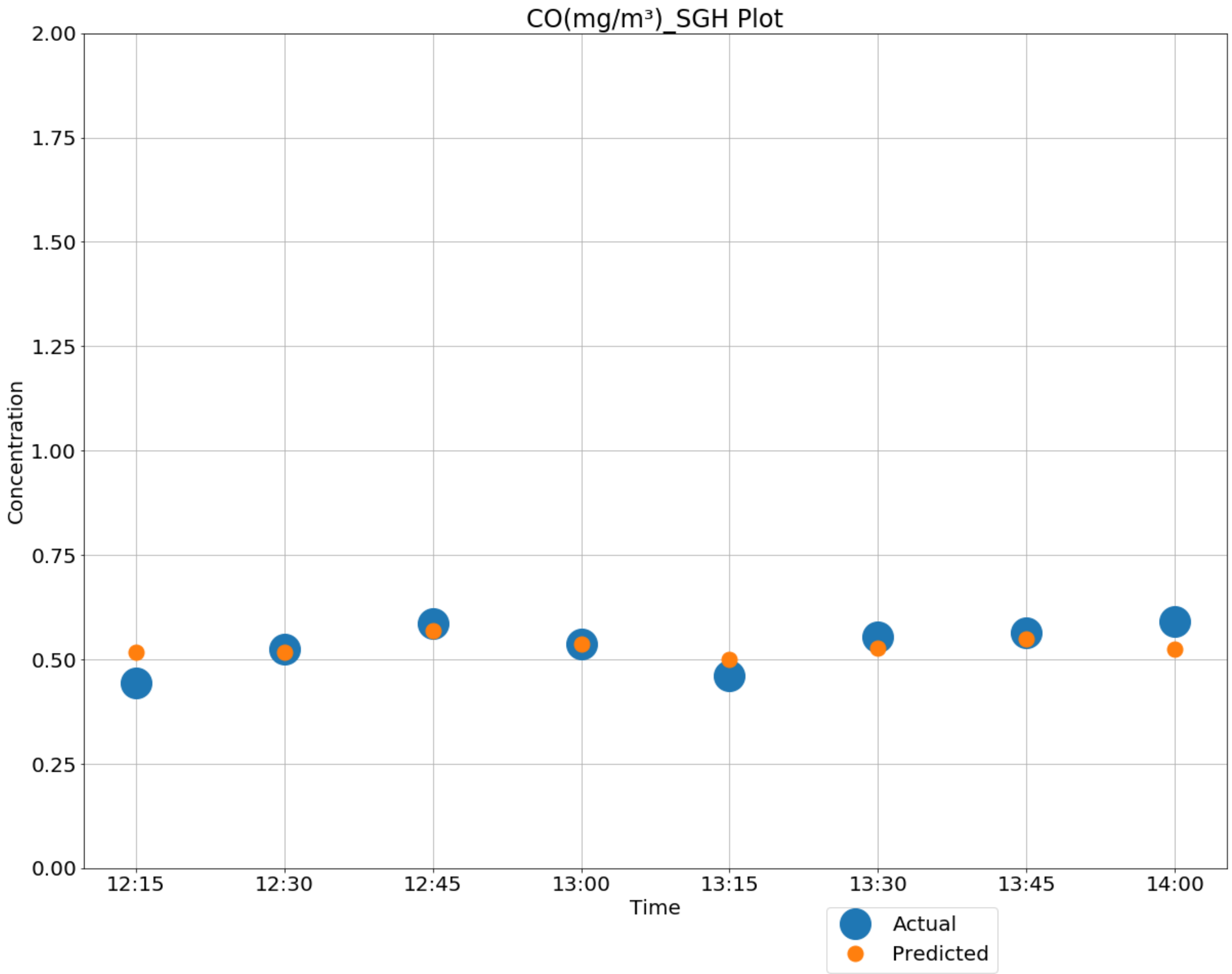
Location	CAAQMS	Duration	Parameters observed	Sampling Interval (*sec*)	Data Points
SG HALLI	*Environment S.A France*	120 *min*	11	900	8
	AUM	120 min	35	0.000645	~1.12 million
KAVIKA	*Eco Tech Australia*	90 *min*	15	300	16
	AUM	90 *min*	35	0.000645	~0.84 Million

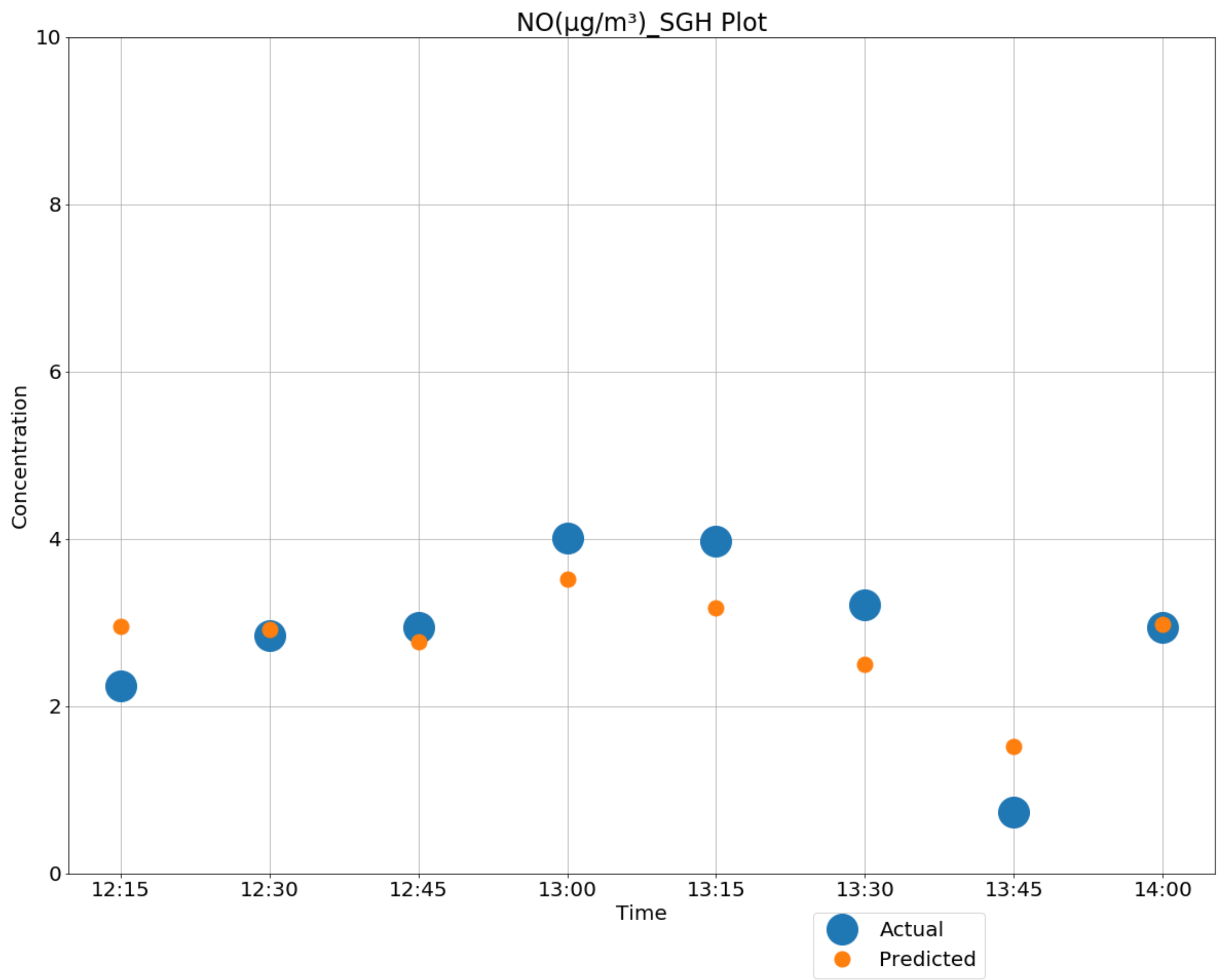
SG HALLI Inter Comparison Study

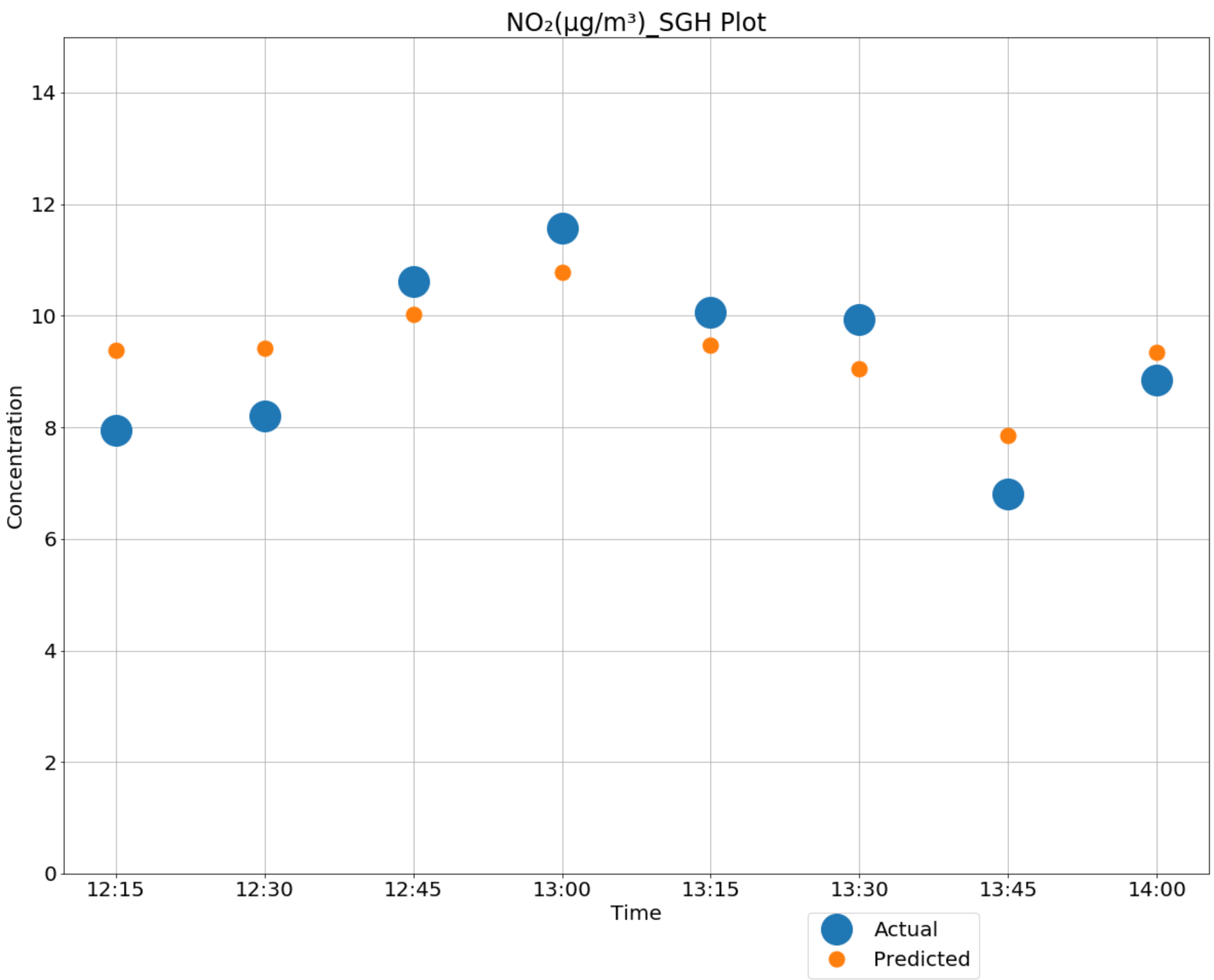
SGHALLI Inter Comparison Study - Air Quality Parameters from Environment SA CAAQMS *vs* CATS Photonic System, AUM

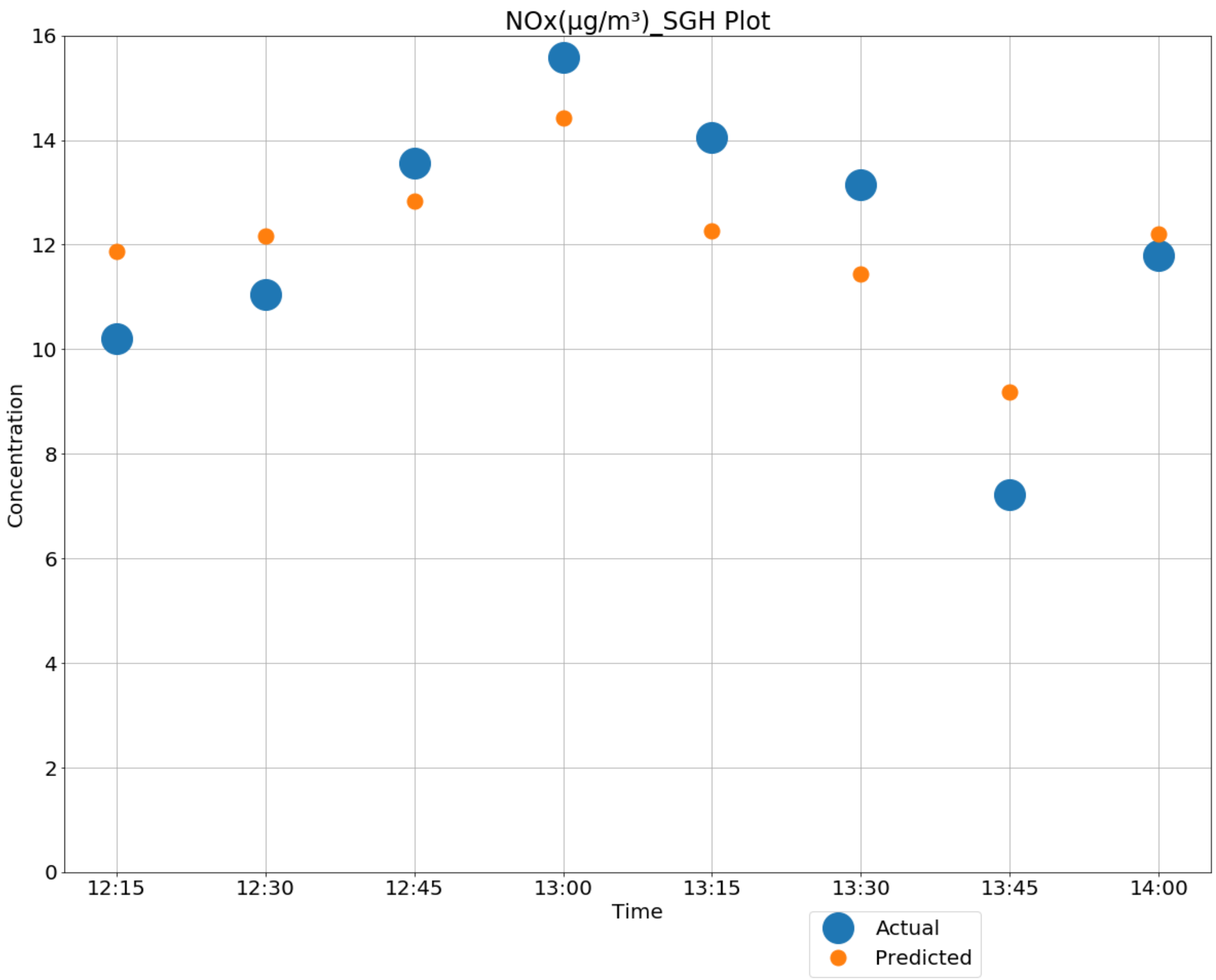
SNO	PARAMETER / SYSTEM	NO_SGH *µg/m³*	NO2_SGH *µg/m³*	NOX_SGH *µg/m³*	SO2_SGH *µg/m³*	CO_SGH *mg/m³*	PM10 *µg/m³*	WS_SGH *m/s*	WD_SGH *degree*	SR_SGH *W/m²*
1	Environment SA CAAQMS	2.25	7.95	10.2		4.99	34.27	2.32	175.03	726.51
	CATS Photonic System, AUM	2.9609	9.3856	11.8732	4.5019	0.51746	54.979	2.3005	160.9091	711.0383
2	Environment SA CAAQMS	2.85	8.21	11.05	5.16	0.524	58.25	2.31	172.92	723.54
	CATS Photonic System, AUM	2.9179	9.4198	12.1738	4.4227	0.51805	53.7937	2.3009	160.7814	712.9669
3	Environment SA CAAQMS	2.94	10.62	13.56	5.29	0.586	76.77	2.3	165.91	722.44
	CATS Photonic System, AUM	2.7772	10.0313	12.8398	4.9261	0.56905	71.3557	2.3009	163.7417	715.1139
4	Environment SA CAAQMS	4.01	11.57	15.58	5.04	0.537	76.52	2.31	164.52	718.91
	CATS Photonic System, AUM	3.5169	10.7798	14.4254	4.8113	0.5382	71.6324	2.3068	163.1116	717.8542
5	Environment SA CAAQMS	3.97	10.07	14.04	4.48	0.461	42.95	2.3	162.46	729.65
	CATS Photonic System, AUM	3.181	9.4711	12.2544	4.4428	0.50079	51.0034	2.3005	160.8854	715.7592
6	Environment SA CAAQMS	3.21	9.94	13.15	4.34	0.554	32.89	2.3	156	724.59
	CATS Photonic System, AUM	2.4988	9.0576	11.437	4.3202	0.52722	57.1029	2.3002	159.6012	706.192
7	Environment SA CAAQMS	0.74	6.8	7.22	3.46	0.564	58.95	2.3	153.14	677.83
	CATS Photonic System, AUM	1.5234	7.8498	9.1758	3.8617	0.5494	59.7137	2.3001	156.3531	691.5983
8	Environment SA CAAQMS	2.94	8.85	11.8	3.7	0.591	141.72	2.3	144.86	651.28
	CATS Photonic System, AUM	2.9853	9.3462	12.2028	4.499	0.5243	55.8079	2.3012	160.8916	711.1975

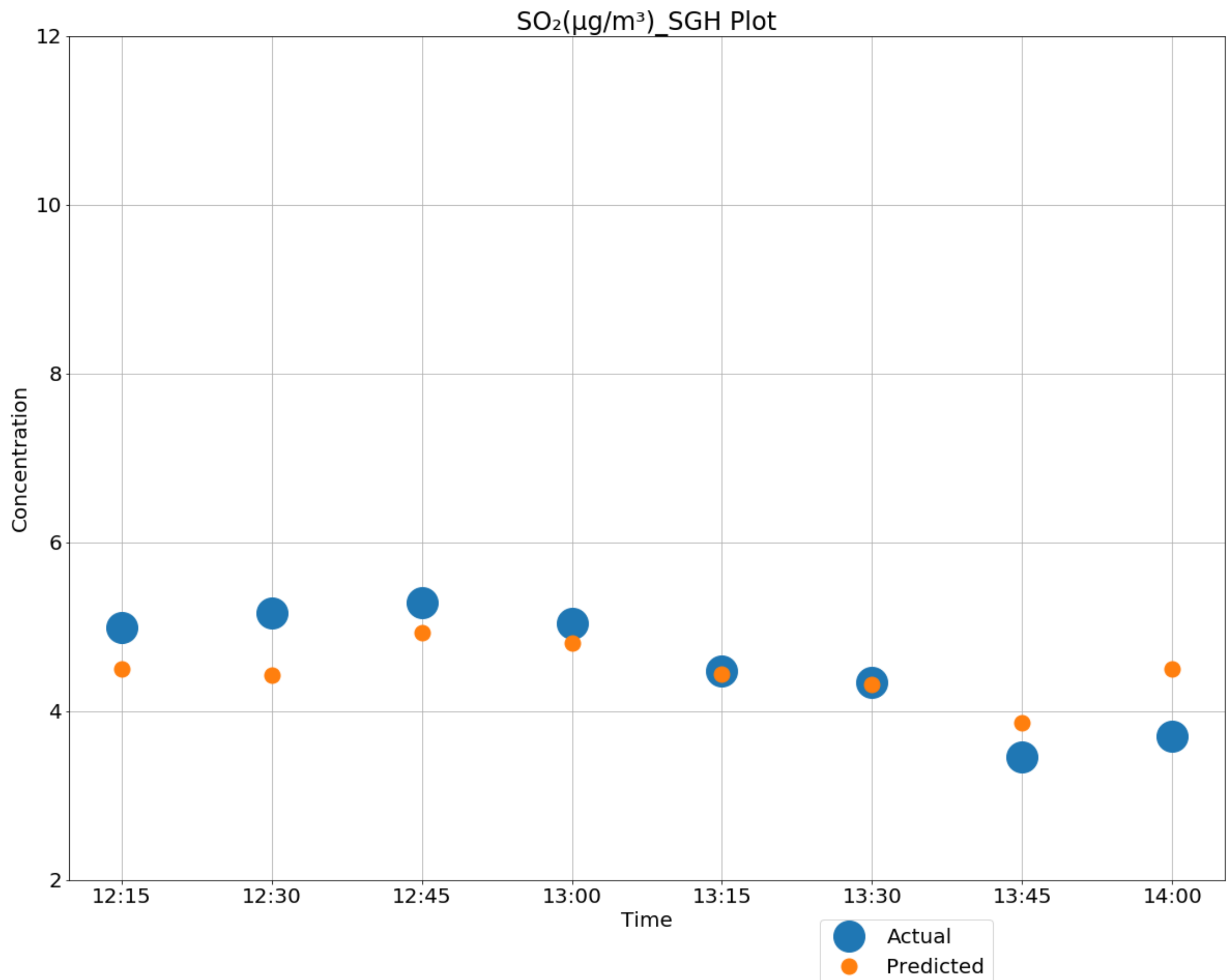
NOTE: *The following plots show the values obtained from **CAAQMS (**termed as **Actual)** and **AUM (**termed as **Predicted)** based on the inter comparison study.*

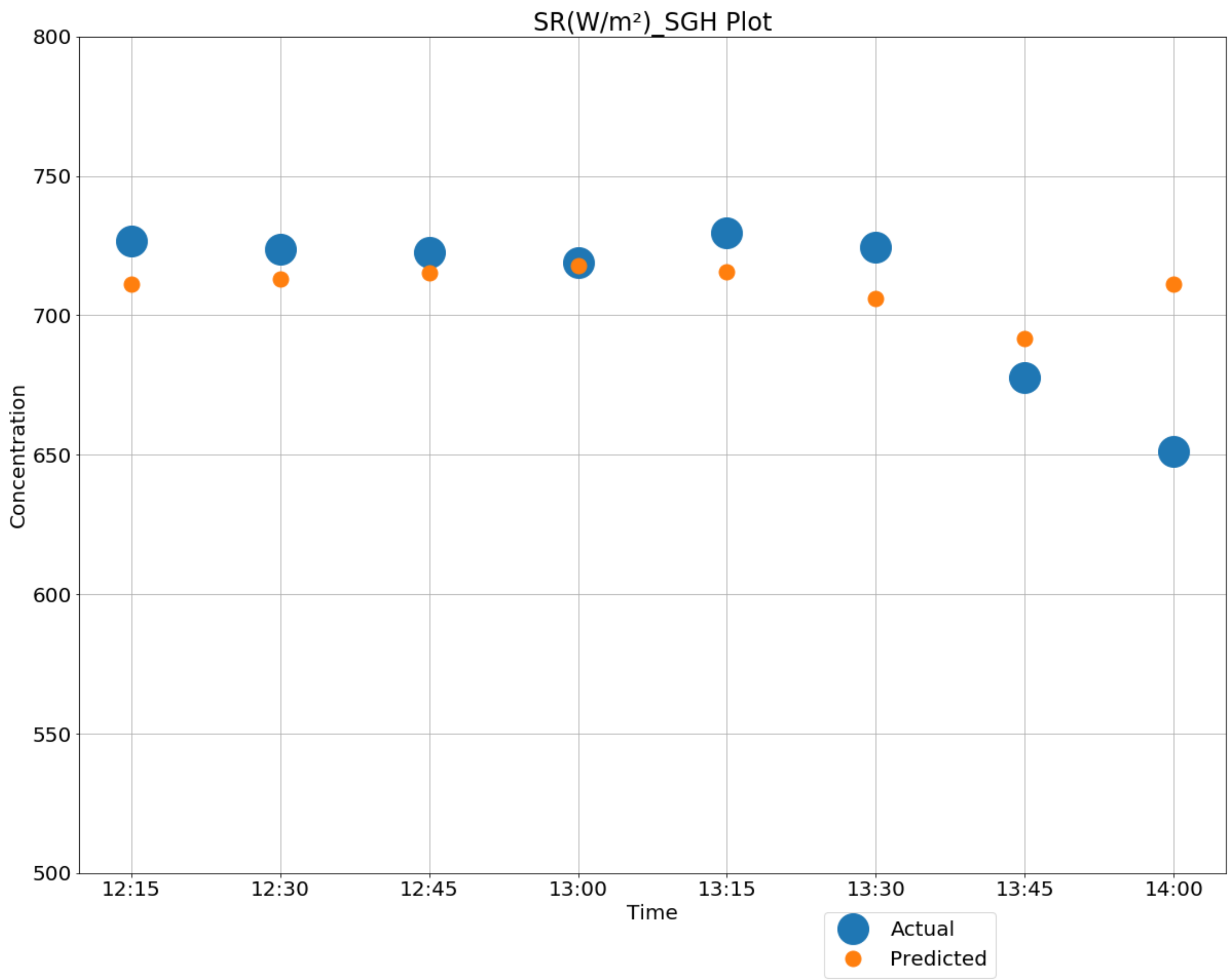

CO(mg/m³)_SGH Plot
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Concentration
12:15
12:30
12:45
13:00
13:15
13:30
13:45
14:00
Time
Actual
Predicted

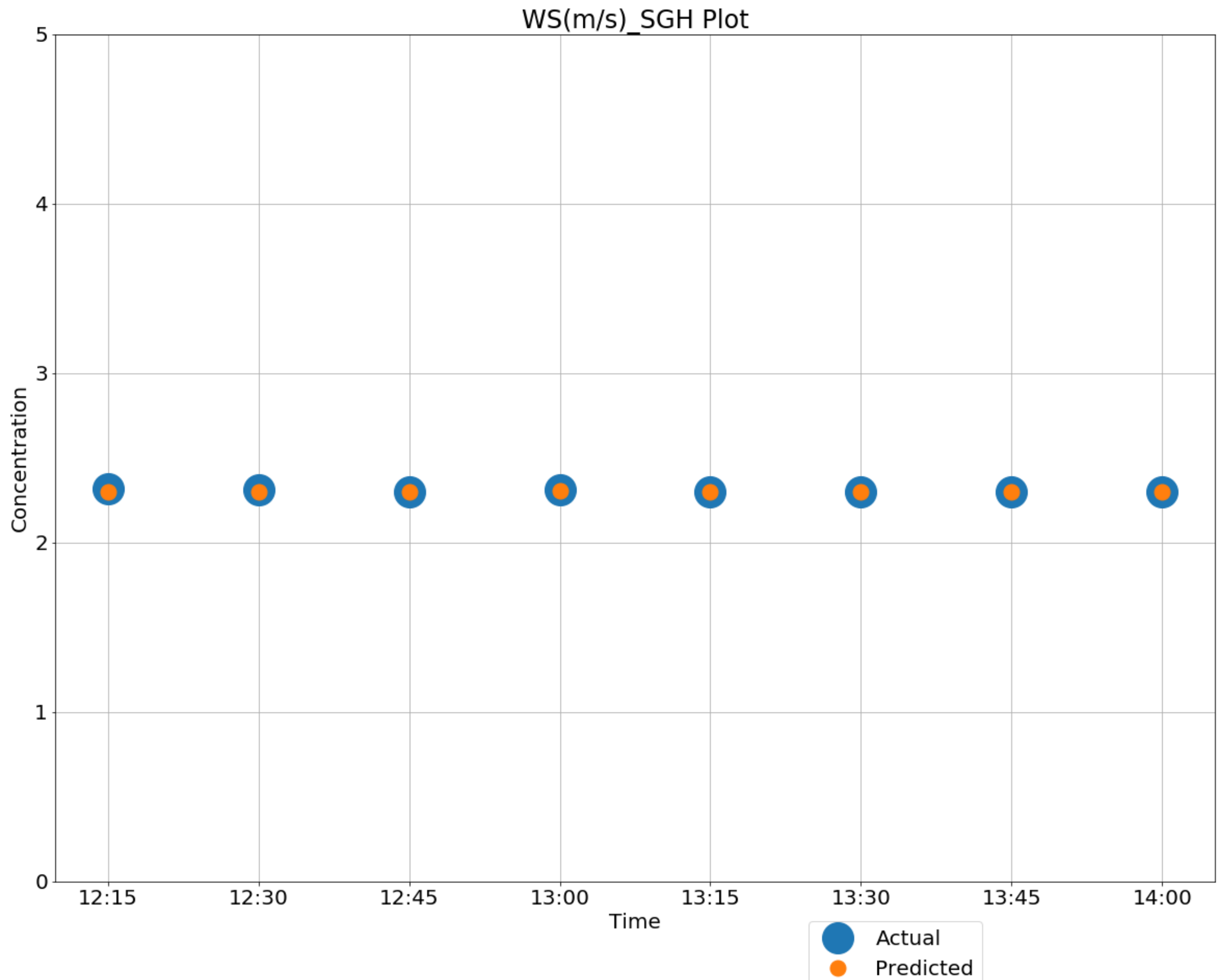

NO(µg/m³)_SGH Plot
10
8
6
4
2
0
Concentration
12:15
12:30
12:45
13:00
13:15
13:30
13:45
14:00
Time
Actual
Predicted

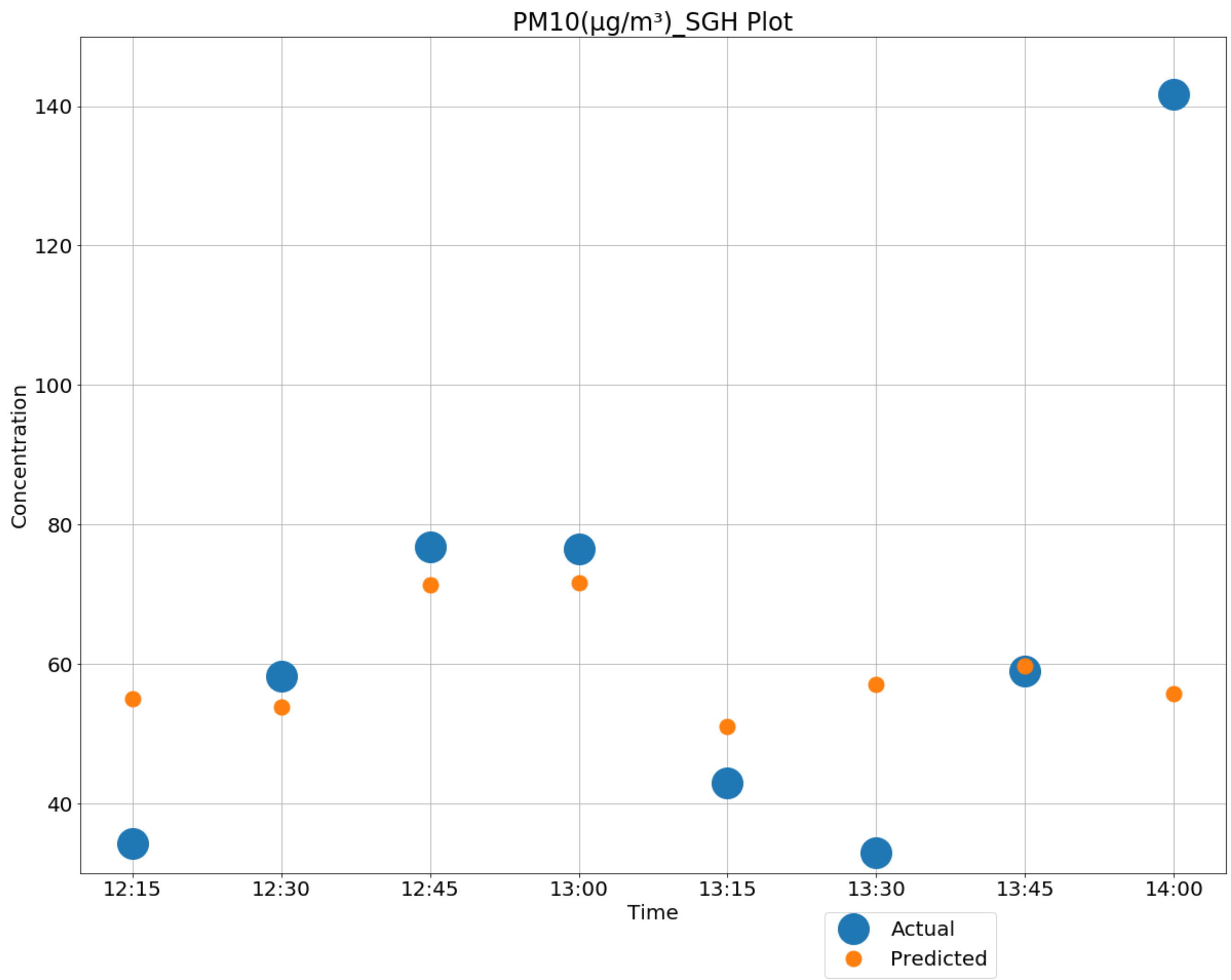

NO₂(µg/m³)_SGH Plot
14
12
10
8
6
4
2
0
Concentration
12:15
12:30
12:45
13:00
13:15
13:30
13:45
14:00
Time
Actual
Predicted

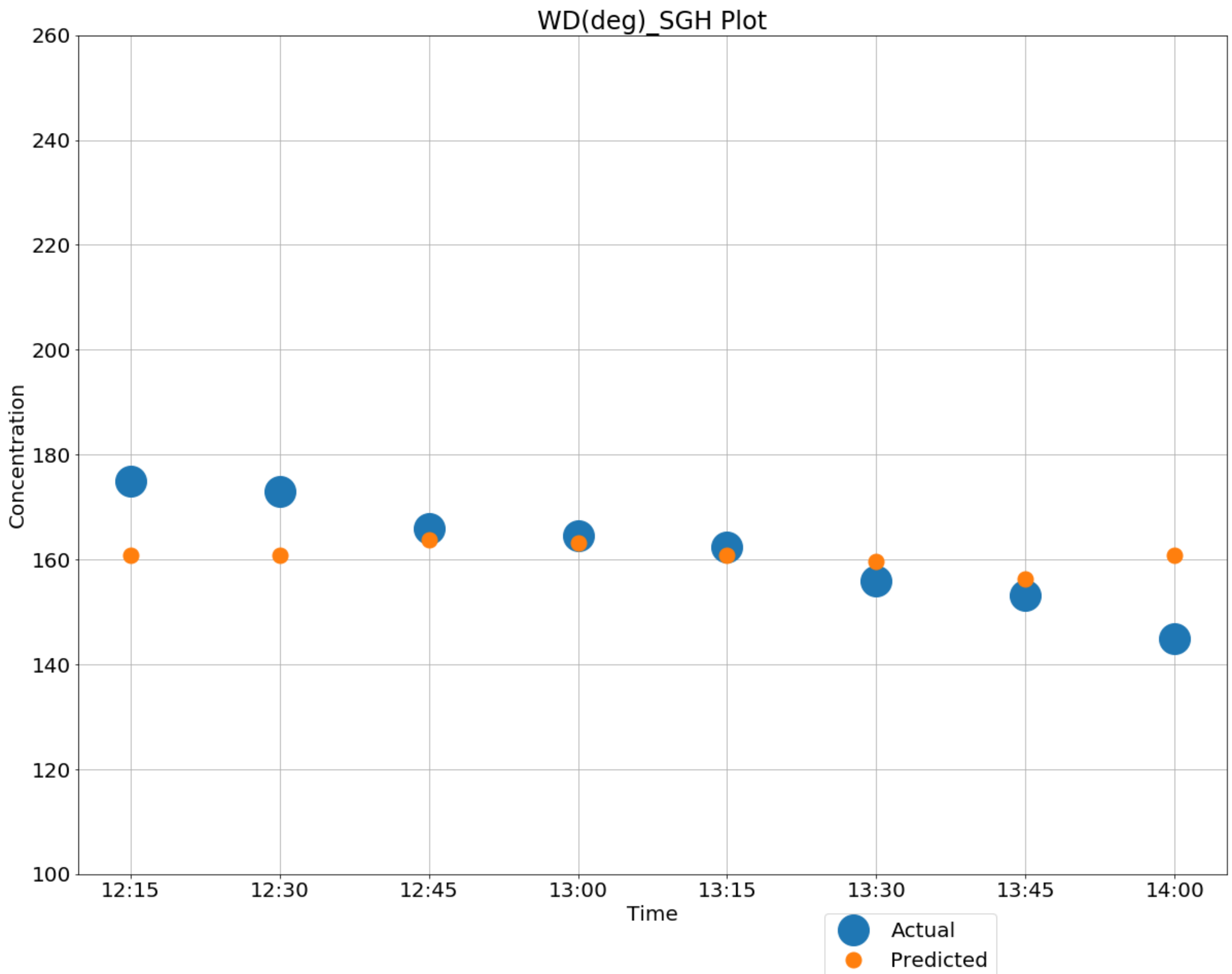

NOx(µg/m³)_SGH Plot
16
14
12
10
8
6
4
2
0
Concentration
12:15
12:30
12:45
13:00
13:15
13:30
13:45
14:00
Time
Actual
Predicted


SO₂(µg/m³)_SGH Plot
Concentration
Time
12
10
8
6
4
2
12:15
12:30
12:45
13:00
13:15
13:30
13:45
14:00
Actual
Predicted

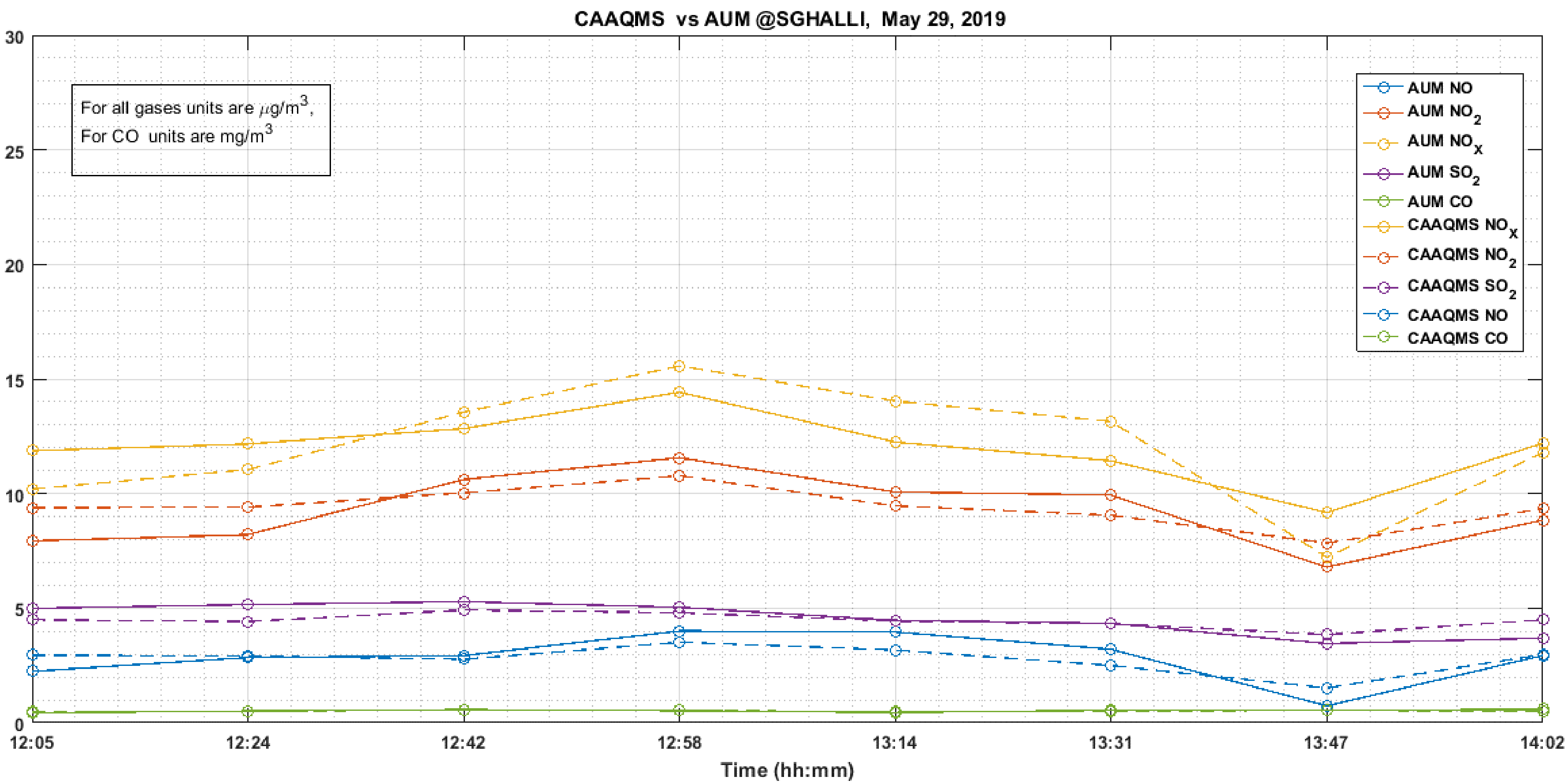

SR(W/m²)_SGH Plot
800
750
700
650
600
550
500
Concentration
12:15
12:30
12:45
13:00
13:15
13:30
13:45
14:00
Time
Actual
Predicted


WS(m/s)_SGH Plot
Concentration
0
1
2
3
4
5
12:15
12:30
12:45
13:00
13:15
13:30
13:45
14:00
Time
Actual
Predicted

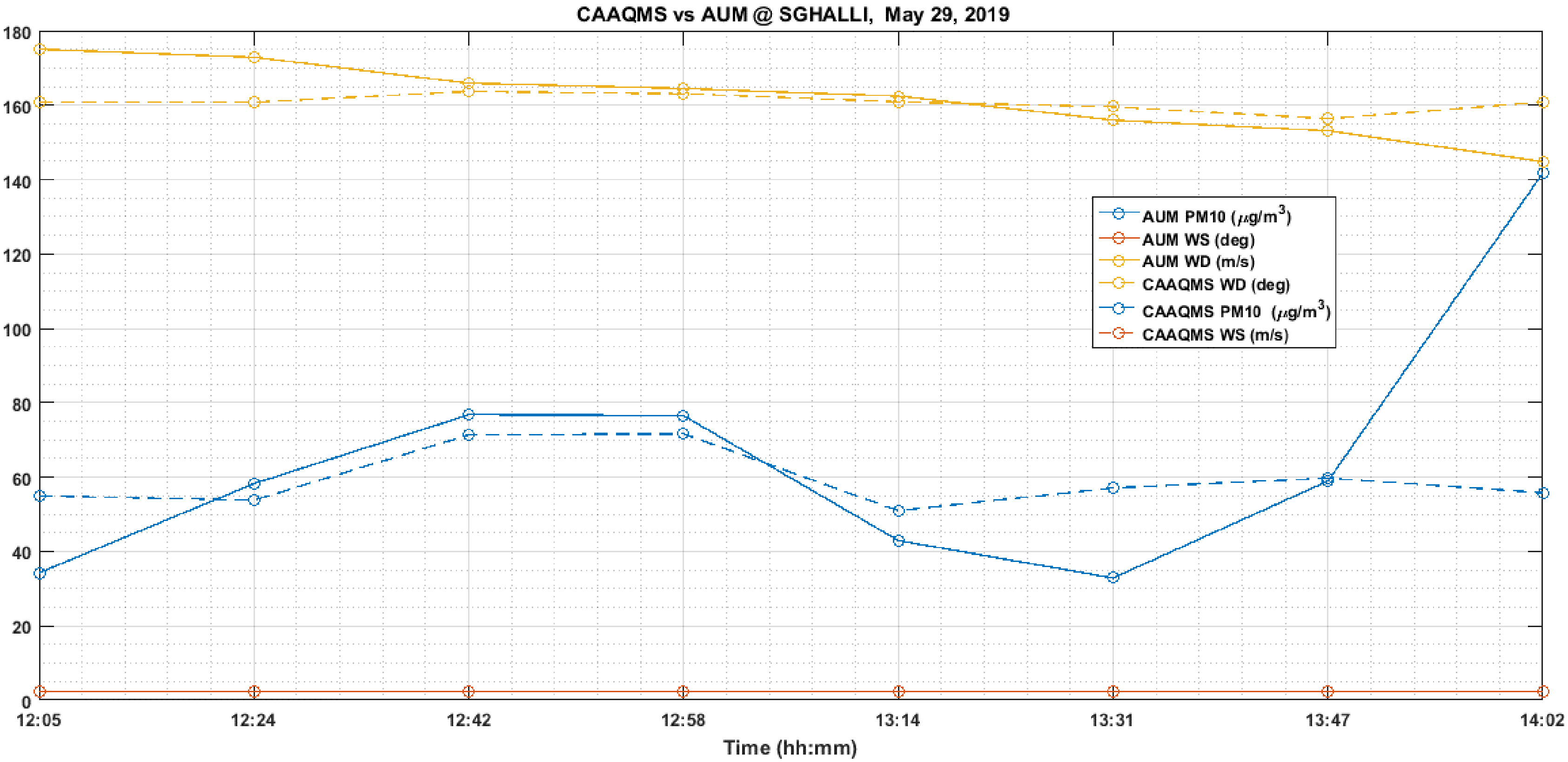

PM10(µg/m³)_SGH Plot
Concentration
140
120
100
80
60
40
12:15
12:30
12:45
13:00
13:15
13:30
13:45
14:00
Time
Actual
Predicted



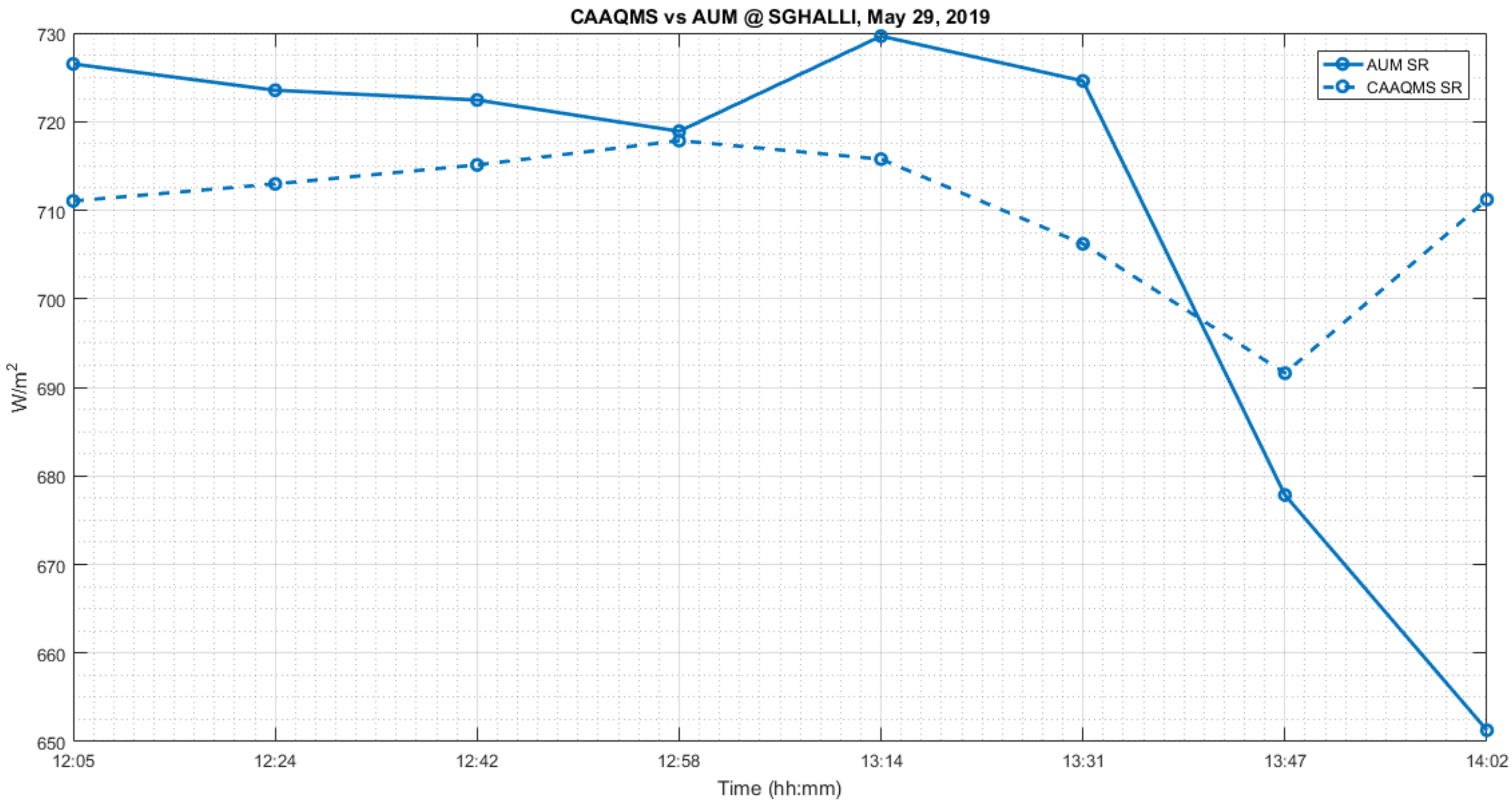
WD(deg)_SGH Plot
260
240
220
200
180
160
140
120
100
Concentration
12:15
12:30
12:45
13:00
13:15
13:30
13:45
14:00
Time
Actual
Predicted



CAAQMS vs AUM @SGHALLI, May 29, 2019
For all gases units are μg/m3,
For CO units are mg/m3
AUM NO
AUM NO2
AUM NOx
AUM SO2
AUM CO
CAAQMS NOx
CAAQMS NO2
CAAQMS SO2
CAAQMS NO
CAAQMS CO
30
25
20
15
10
5
0
12:05
12:24
12:42
12:58
13:14
13:31
13:47
14:02
Time (hh:mm)



CAAQMS vs AUM @ SGHALLI, May 29, 2019
180
160
140
120
100
80
60
40
20
0
AUM PM10 ($\mu g/m^3$)
AUM WS (deg)
AUM WD (m/s)
CAAQMS WD (deg)
CAAQMS PM10 ($\mu g/m^3$)
CAAQMS WS (m/s)
12:05
12:24
12:42
12:58
13:14
13:31
13:47
14:02
Time (hh:mm)


CAAQMS vs AUM @ SGHALLI, May 29, 2019
AUM SR
CAAQMS SR
W/m2
730
720
710
700
690
680
670
660
650
12:05
12:24
12:42
12:58
13:14
13:31
13:47
14:02
Time (hh:mm)

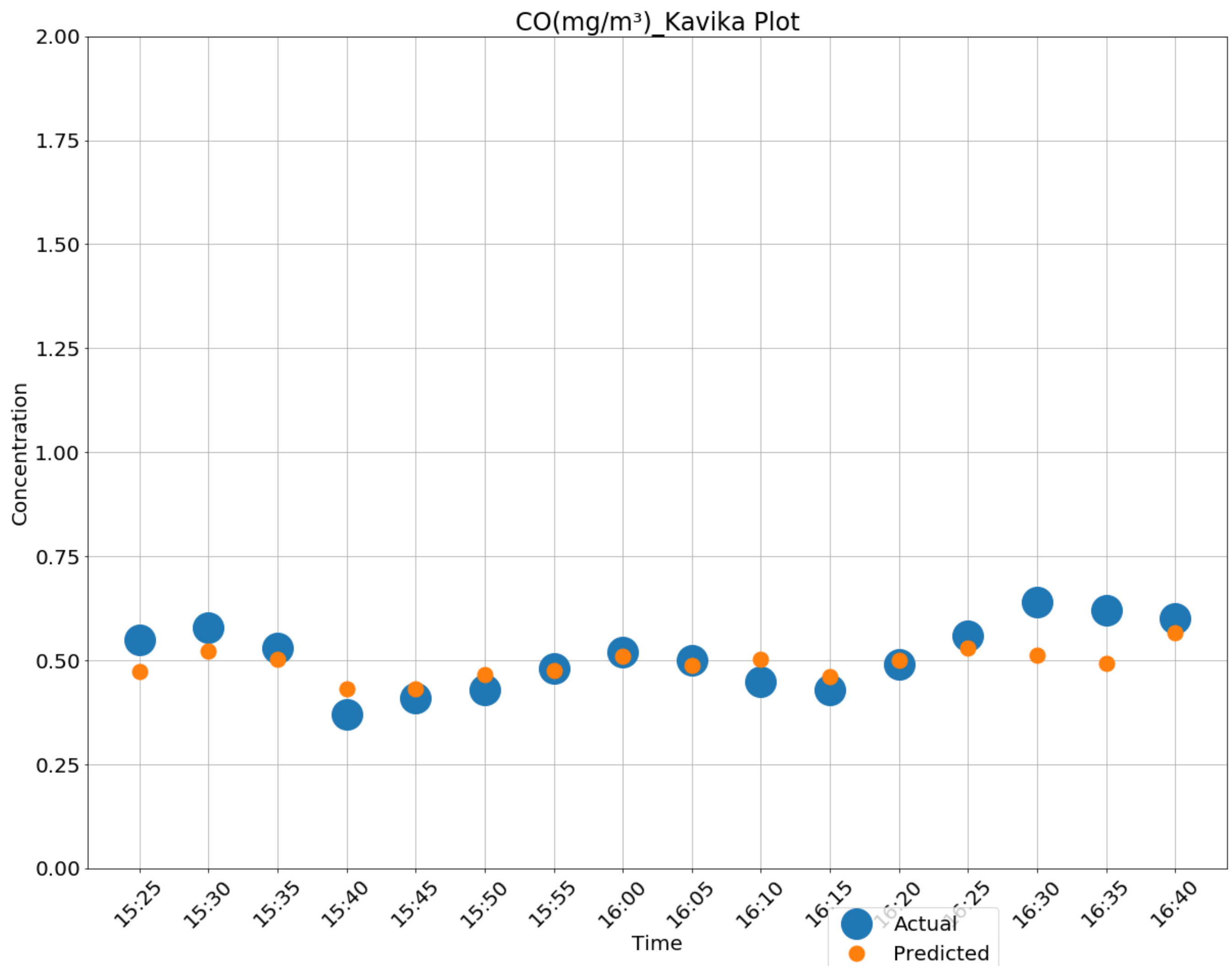
KAVIKA Inter Comparison Study

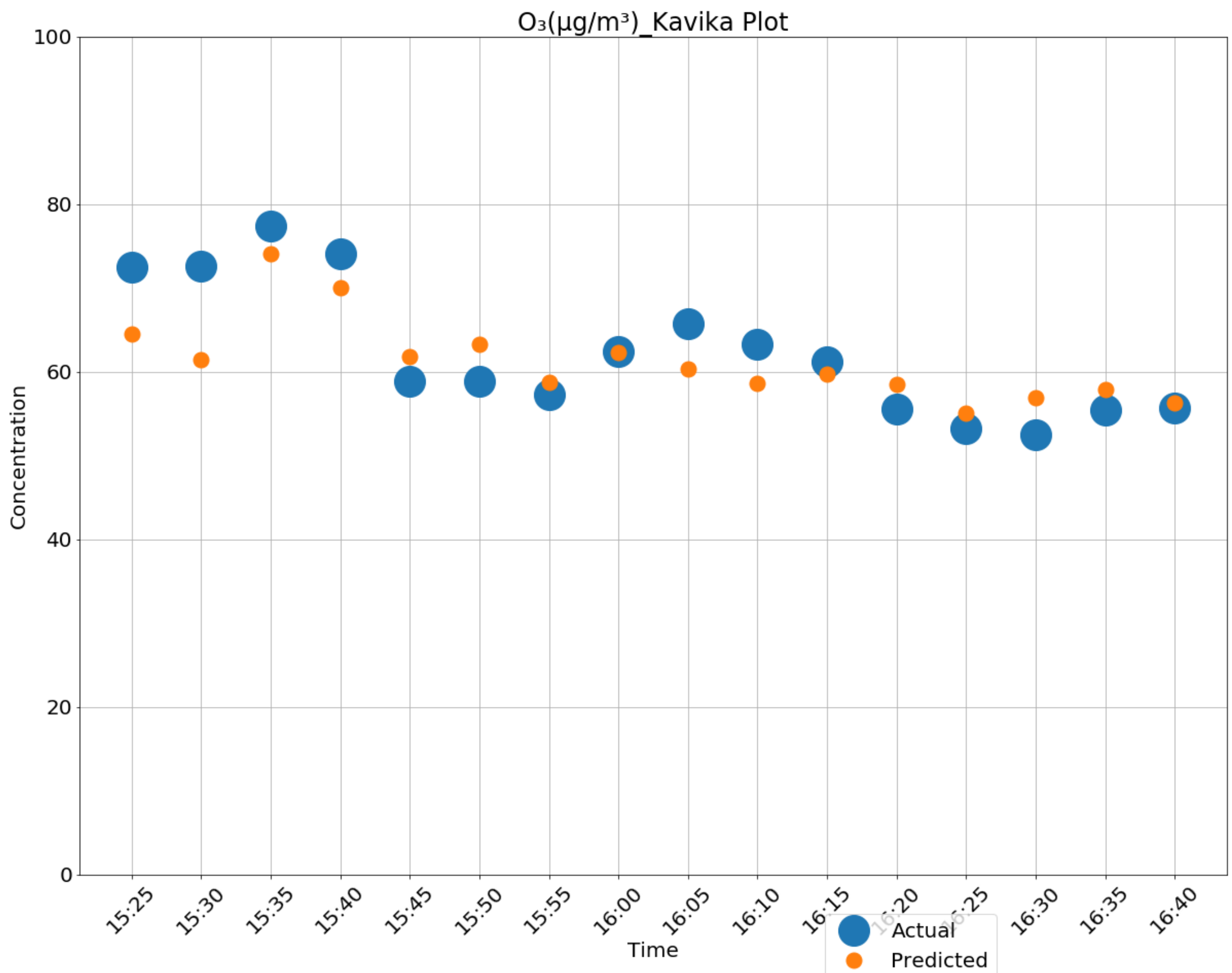
KAVIKA Inter Comparison Study: Air Quality Parameters from Eco Tech CAAQMS *vs* CATS Photonic System, AUM

	CO mg/m^3	O_3 µg/m^3	NO µg/m^3	NO_2 µg/m^3	NOx µg/m^3	NH_3 µg/m^3	SO_2 µg/m^3	PM 2.5 µg/m^3	PM 10 µg/m^3	Benzene µg/m^3	Toluene µg/m^3	p- Xylene µg/m^3	o- Xylene µg/m^3	Ei- Benzene µg/m^3	Temp °C	RH %	WS m/s	WD degree	BP mmHg
E	0.55	72.43	6.65	31.01	37.65	19.63	1.04	48	125	0.930	2.060	2.940	0.060	0.000	32.710	39.090	1.570	268.840	715.680
C	0.4736	64.5459	6.5429	27.028	33.8661	19.6766	0.959	52.5	105.65	0.851	2.066	2.325	0.374	0.274	32.844	39.616	2.040	266.587	715.450
E	0.58	72.56	8.89	29.02	37.91	17.96	1.04	48	125	0.930	2.060	2.940	0.070	0.000	32.710	39.310	2.440	274.970	715.680
C	0.522	61.445	7.0784	28.7567	36.7241	18.4785	0.9557	53.5	101.35	0.846	2.060	2.439	0.386	0.325	32.895	39.452	1.938	268.365	715.397
E	0.53	77.35	6.13	27.74	33.88	21.72	1.01	48	125	0.840	1.950	2.930	0.310	0.000	32.630	40.160	2.410	256.190	715.610
C	0.5034	74.0875	6.0166	26.4488	32.4758	20.6761	0.9936	48.7	121.99	0.854	2.007	2.990	0.330	0.039	32.687	39.976	2.346	255.295	715.593
E	0.37	74.06	5.83	21.79	27.62	22.17	0.99	48	125	0.840	1.950	2.930	0.310	0.000	32.720	39.850	2.370	238.090	715.580
C	0.4315	70.0654	5.8551	23.8973	29.7337	20.258	0.9817	49.2	119.84	0.843	1.991	2.902	0.338	0.077	32.737	39.824	2.304	249.589	715.553
E	0.41	58.91	4.98	22.31	27.29	20.16	0.98	48	125	0.840	1.960	2.950	0.320	0.020	32.730	39.530	2.160	251.670	715.580
C	0.432	61.8064	5.3171	24.1953	29.4558	19.9362	0.9659	49.9	116.83	0.848	2.018	2.861	0.348	0.122	32.739	39.680	2.173	257.884	715.552
E	0.43	58.87	4.45	23.04	27.49	19.52	0.94	48	125	0.910	2.390	3.440	0.470	0.620	32.740	39.870	2.080	273.270	715.540
C	0.467	63.2598	5.6123	25.6867	31.5109	19.5737	0.9772	51.5	109.95	0.850	2.023	2.874	0.362	0.195	32.746	39.888	2.289	259.427	715.542
E	0.48	57.24	5.25	25.38	30.63	17.82	0.9	58	82	0.910	2.390	3.440	0.470	0.620	32.830	39.810	2.290	289.260	715.480
C	0.4749	58.7464	5.3761	25.9944	31.3094	18.3549	0.909	57	86.3	0.894	2.360	3.030	0.455	0.558	32.803	39.870	2.213	282.823	715.472
E	0.52	62.45	7.88	28.61	36.49	14.55	0.91	58	82	0.910	2.380	3.220	0.470	0.620	32.880	39.380	2.080	273.510	715.450
C	0.5098	62.3229	7.0312	27.8904	34.7057	15.9686	0.9149	56.8	87.16	0.901	2.337	3.078	0.457	0.544	32.844	39.565	2.101	273.902	715.458
E	0.5	65.73	3.66	25.11	28.77	21.23	0.9	58	82	0.850	2.270	0.130	0.460	0.570	32.770	39.410	1.800	253.930	715.430
C	0.4886	60.3955	6.2079	28.5263	33.9953	17.6524	0.9167	57.2	85.44	0.888	2.286	2.807	0.445	0.539	32.837	39.781	1.939	283.176	715.363
E	0.45	63.34	5.32	27.2	32.53	18.91	0.92	58	82	0.850	2.270	0.130	0.460	0.570	32.700	39.790	2.230	263.510	715.300
C	0.5037	58.6324	6.9012	29.2122	35.4387	17.9859	0.9294	57.1	85.87	0.881	2.245	2.612	0.428	0.538	32.872	39.691	1.921	283.578	715.330
E	0.43	61.21	4.75	28.02	32.77	19.82	0.91	58	82	0.850	2.250	0.330	0.460	0.570	32.730	40.190	1.740	289.310	715.240
C	0.4602	59.6813	5.7618	28.5465	34.4132	19.0047	0.911	57.9	82.43	0.865	2.267	1.293	0.453	0.573	32.805	39.983	1.764	288.451	715.263
E	0.49	55.55	8.31	30.48	38.79	15.64	0.92	58	82	0.840	1.970	3.080	0.420	0.580	32.860	39.790	2.090	277.800	715.220
C	0.4992	58.4844	6.9053	29.5122	36.6054	18.4751	0.9353	57.9	82.43	0.851	2.123	2.009	0.425	0.566	32.860	39.748	1.720	288.003	715.245
E	0.56	53.22	8.1	32.95	41.05	16.73	0.96	58	82	0.840	1.970	3.080	0.420	0.580	33.000	39.550	1.670	286.020	715.220
C	0.5295	55.0153	7.8024	31.8849	40.0834	17.7078	0.9581	57.7	83.29	0.838	1.998	2.544	0.405	0.550	32.966	39.577	1.705	285.504	715.228
E	0.64	52.46	8.36	34.94	43.3	20.67	0.97	58	82	0.840	1.980	3.070	0.420	0.580	32.940	39.500	2.190	267.840	715.170
C	0.5122	56.8818	6.5702	31.6191	38.2961	18.8593	0.9577	57.6	83.72	0.839	2.020	2.136	0.400	0.559	32.902	39.763	1.712	286.577	715.225
E	0.62	55.46	7.84	33.1	40.94	23.17	0.97	58	82	0.800	2.040	2.990	0.380	0.570	32.910	39.160	1.290	269.760	715.170
C	0.4925	57.8964	7.5703	31.9876	39.1538	18.7183	0.948	57.6	83.72	0.829	2.054	2.081	0.413	0.570	32.976	39.519	1.709	286.871	715.227
E	0.6	55.73	9.29	36.06	45.35	19.51	0.96	58	82	0.800	2.040	2.990	0.380	0.570	33.150	38.940	1.530	291.320	715.150
C	0.5676	56.3243	8.5871	33.8833	42.5141	19.0018	0.9588	57.7	83.29	0.817	2.033	2.878	0.397	0.558	33.071	39.182	1.617	287.720	715.194

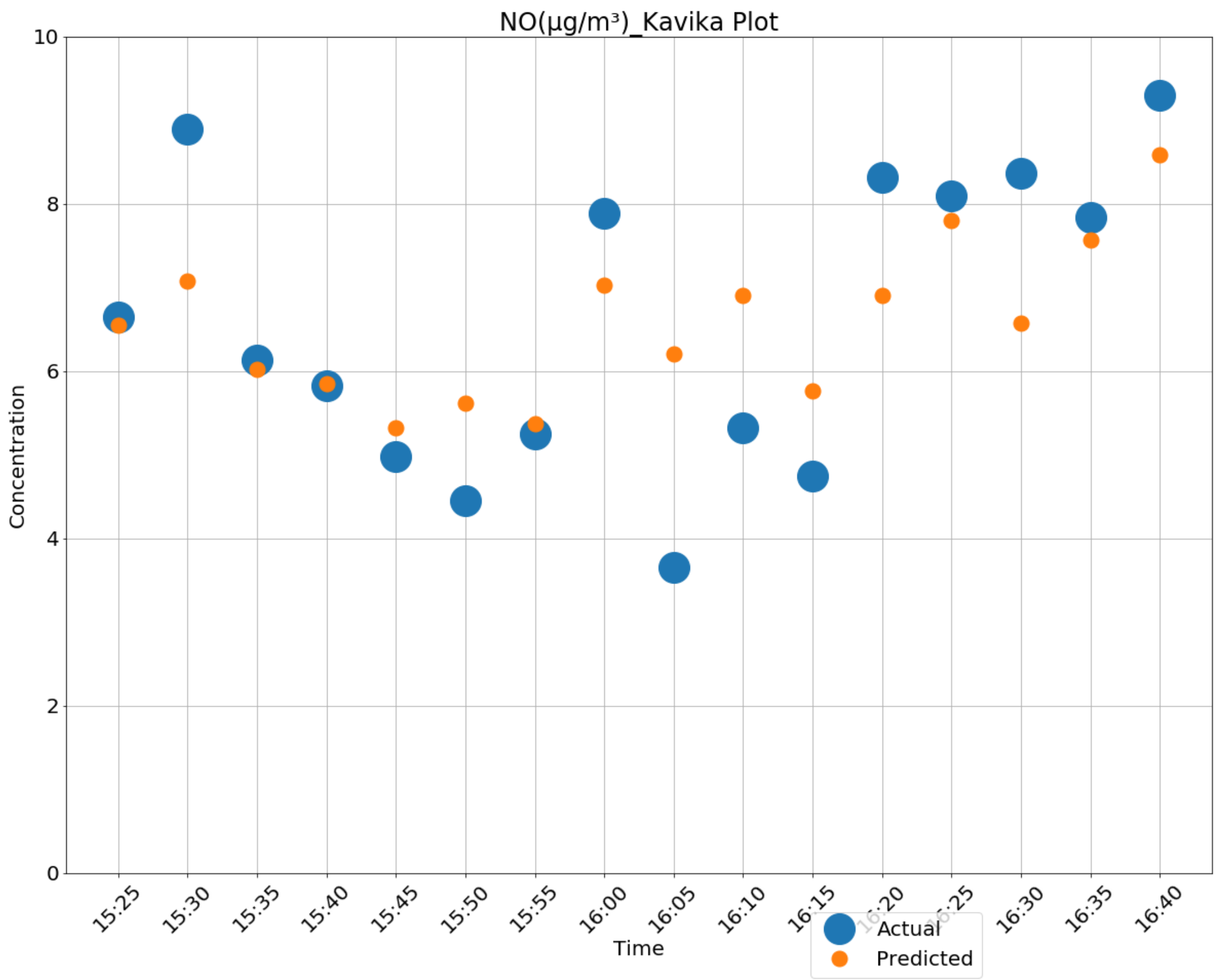
E - Eco Tech CAAQMS
C - CATS Photonic System, AUM

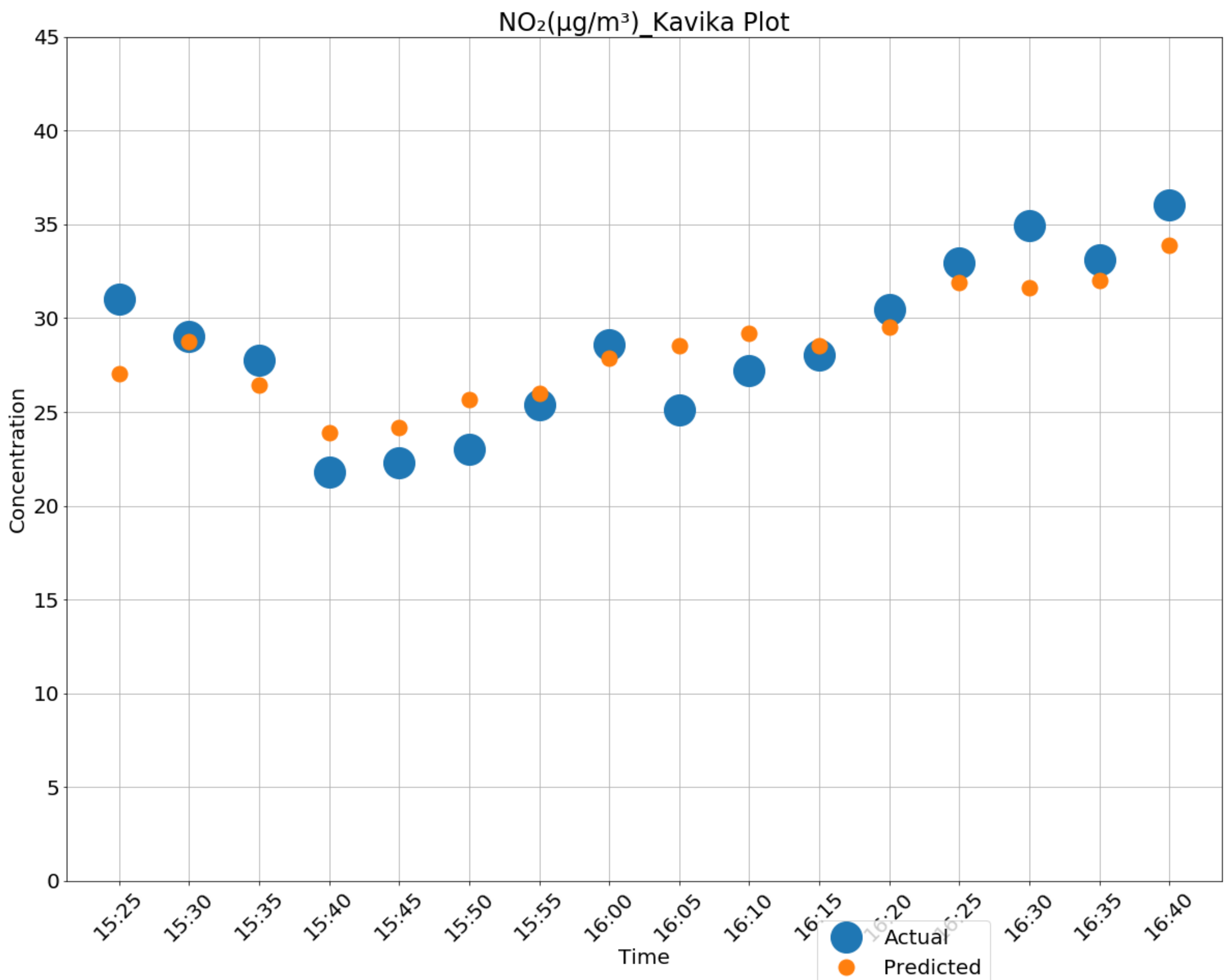
NOTE: *The following plots show the values obtained from* ***CAAQMS (****termed as* ***Actual)*** *and* ***AUM (****termed as* ***Predicted)*** *based on the inter comparison study.*

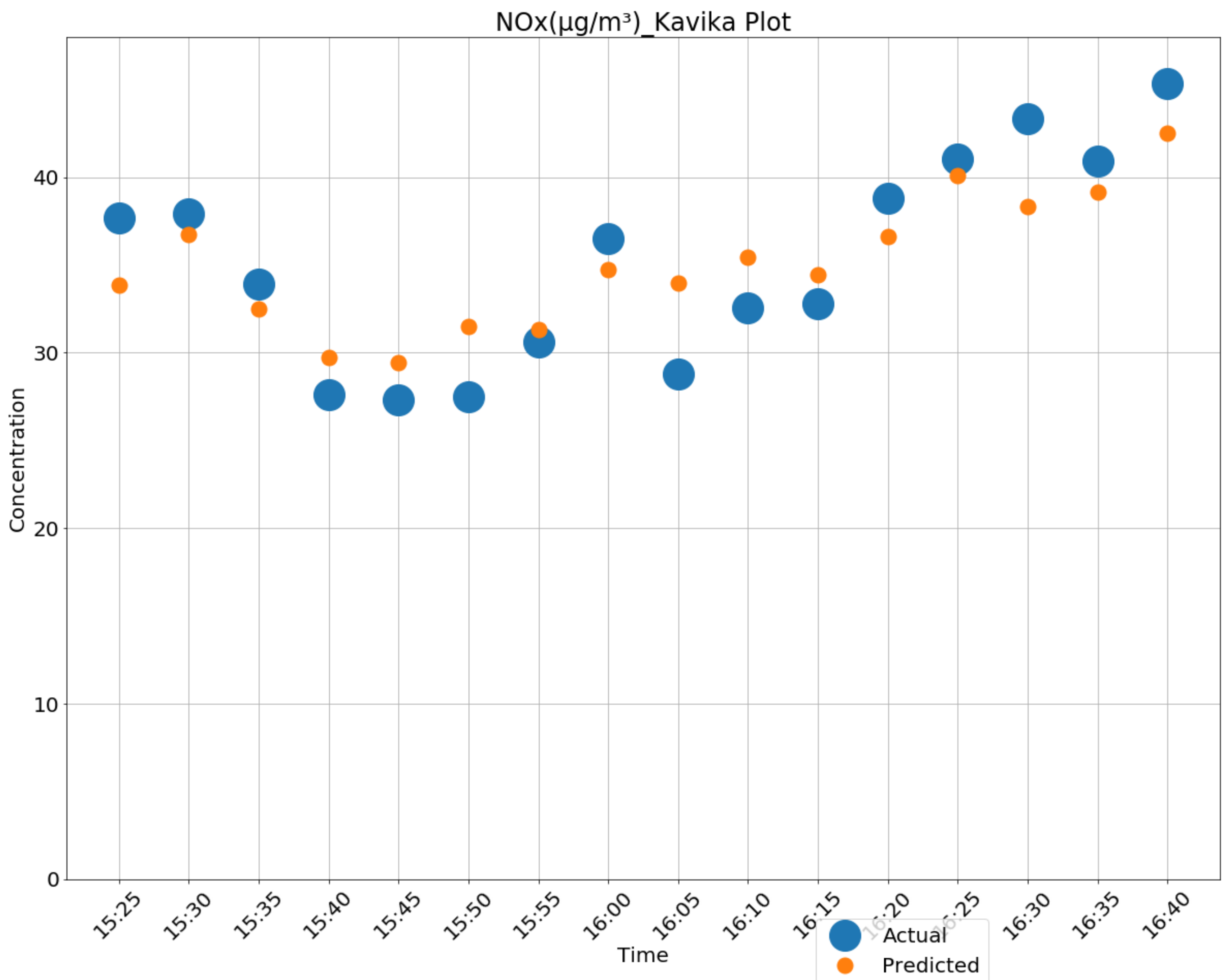

CO(mg/m³)_Kavika Plot
Concentration
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted

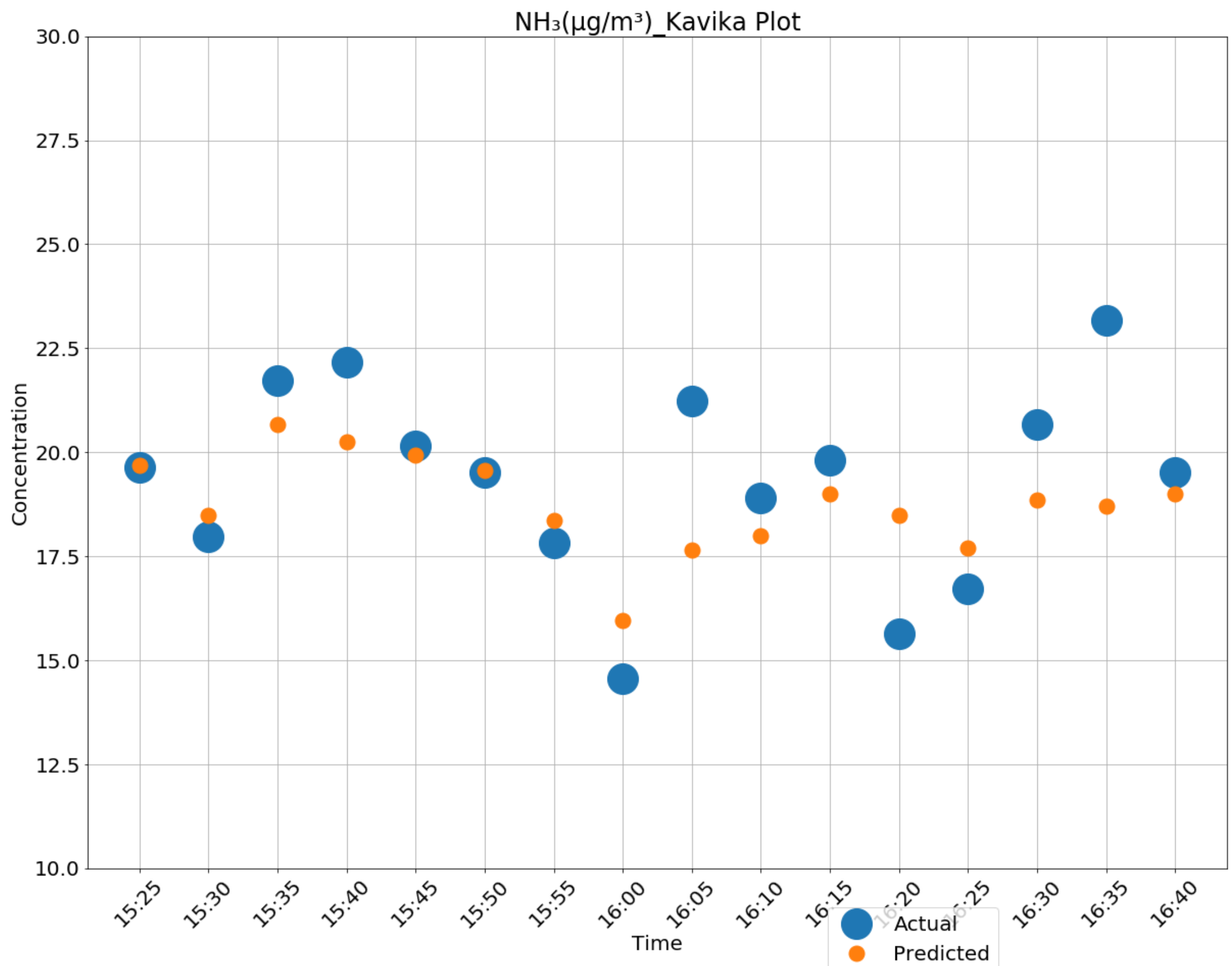


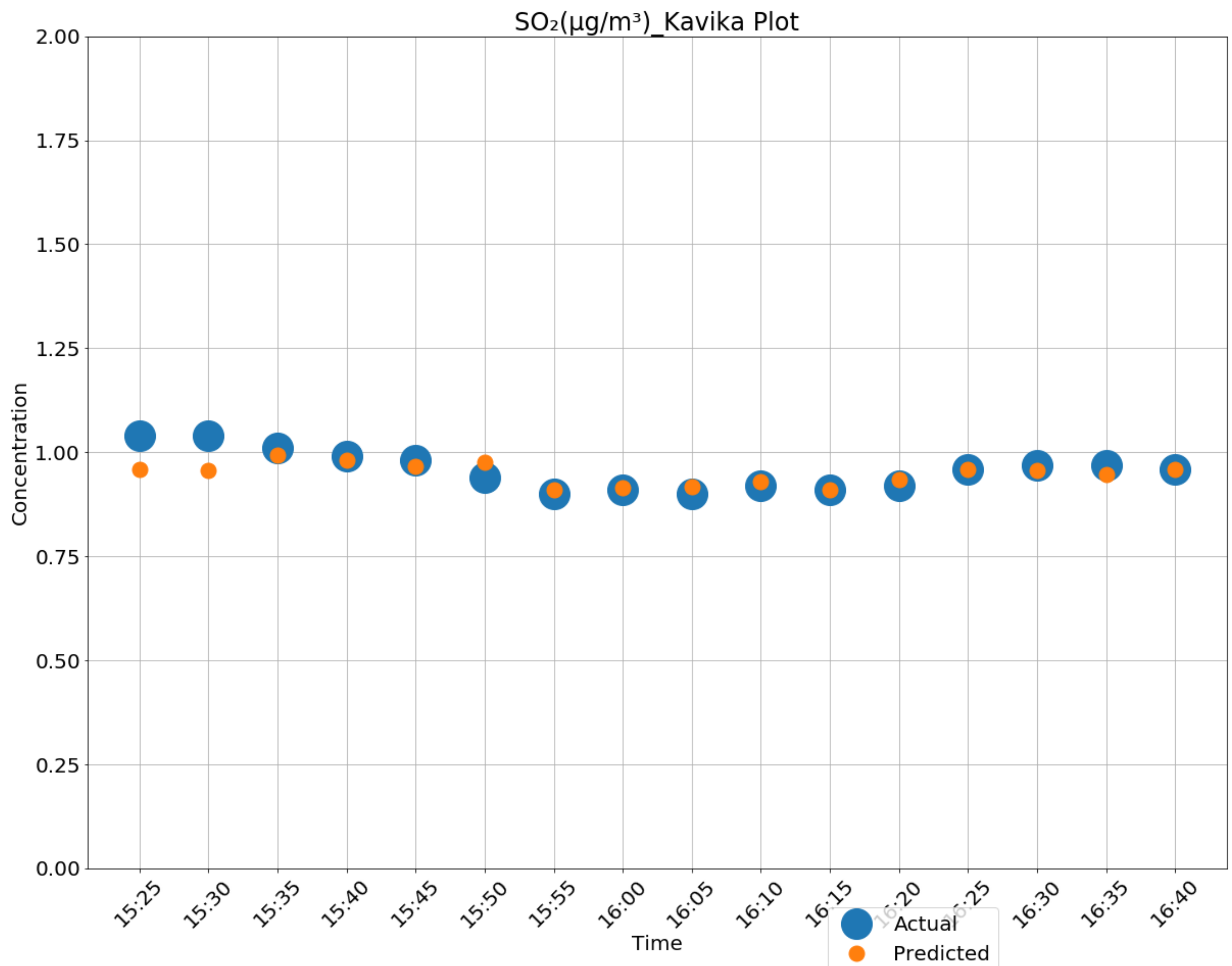
O₃(µg/m³)_Kavika Plot
Concentration
Time
0
20
40
60
80
100
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Actual
Predicted


NO(µg/m³)_Kavika Plot
Concentration
Time
10
8
6
4
2
0
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Actual
Predicted

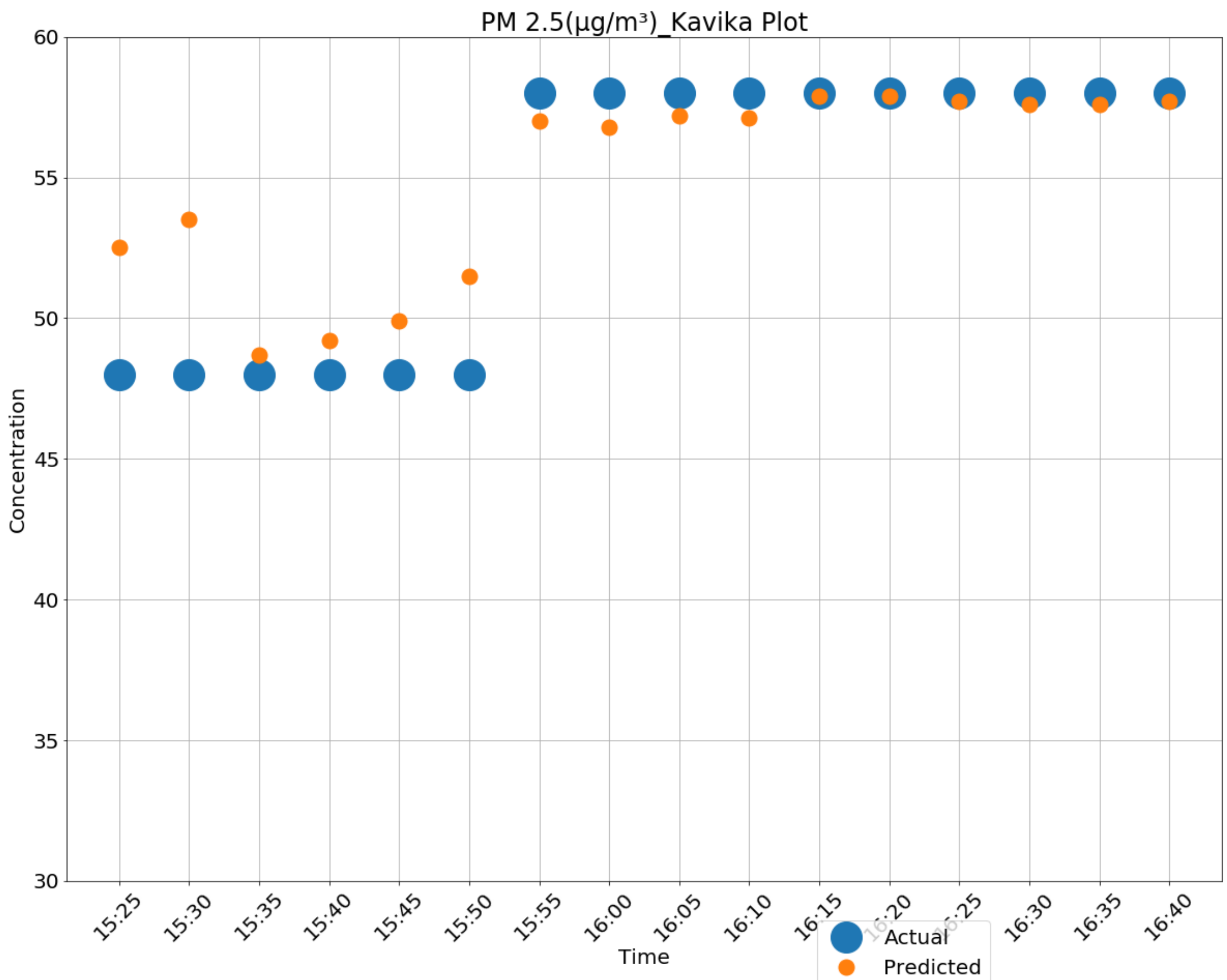

NO2(µg/m³)_Kavika Plot
45
40
35
30
25
20
15
10
5
0
Concentration
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted


NOx(µg/m³)_Kavika Plot
Concentration
0
10
20
30
40
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted

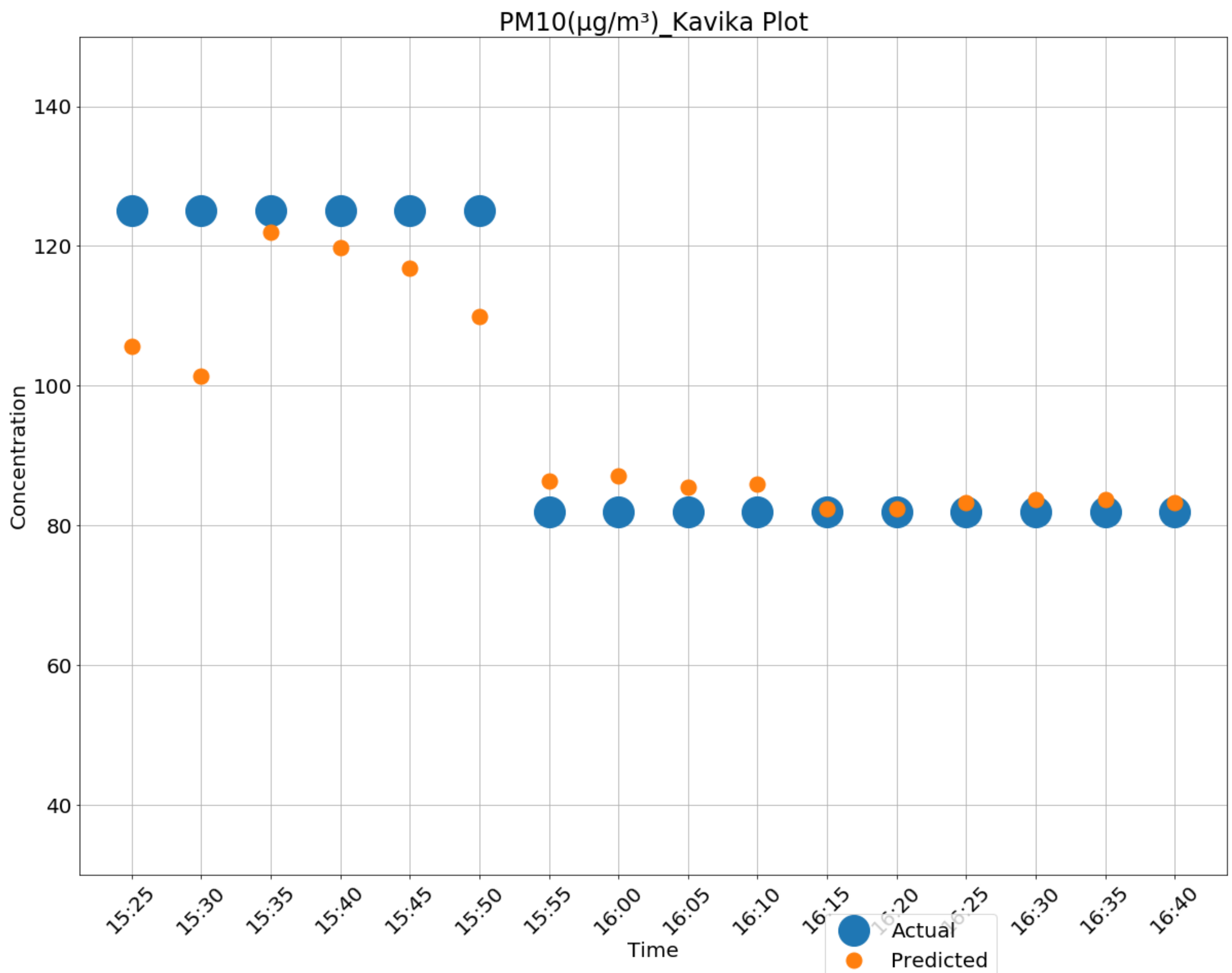

NH₃(μg/m³)_Kavika Plot
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
Concentration
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted

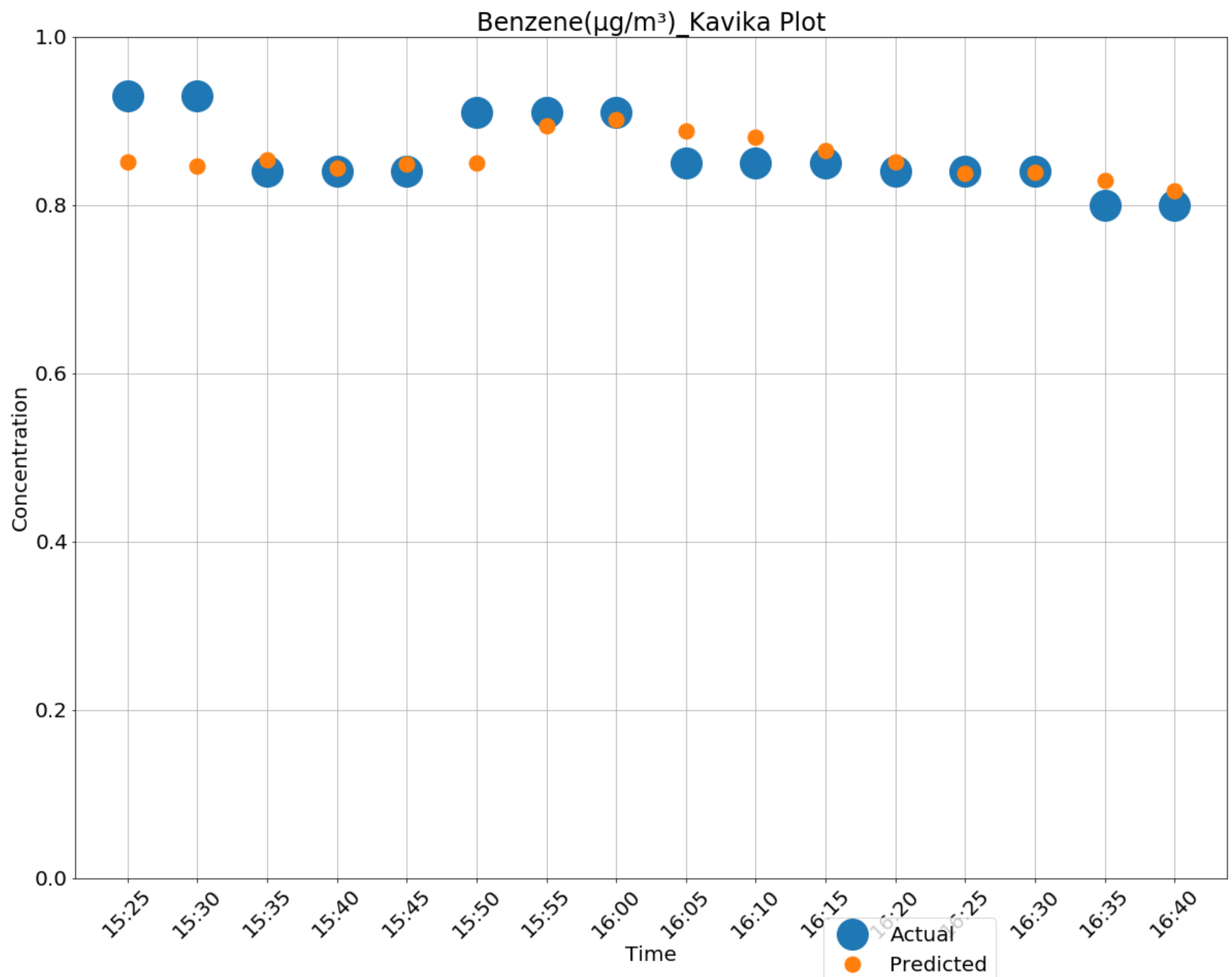


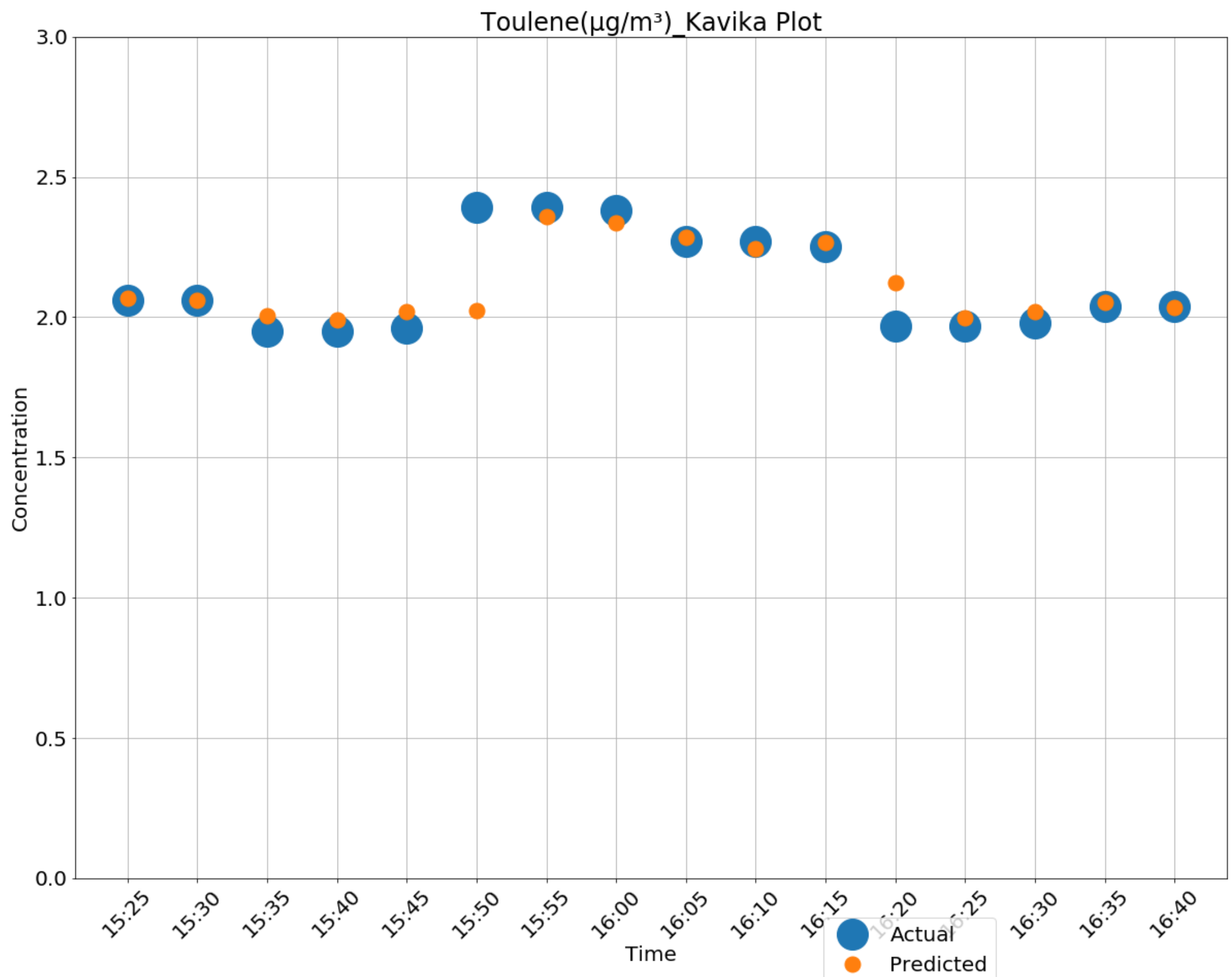
SO₂(µg/m³)_Kavika Plot
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Concentration
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted

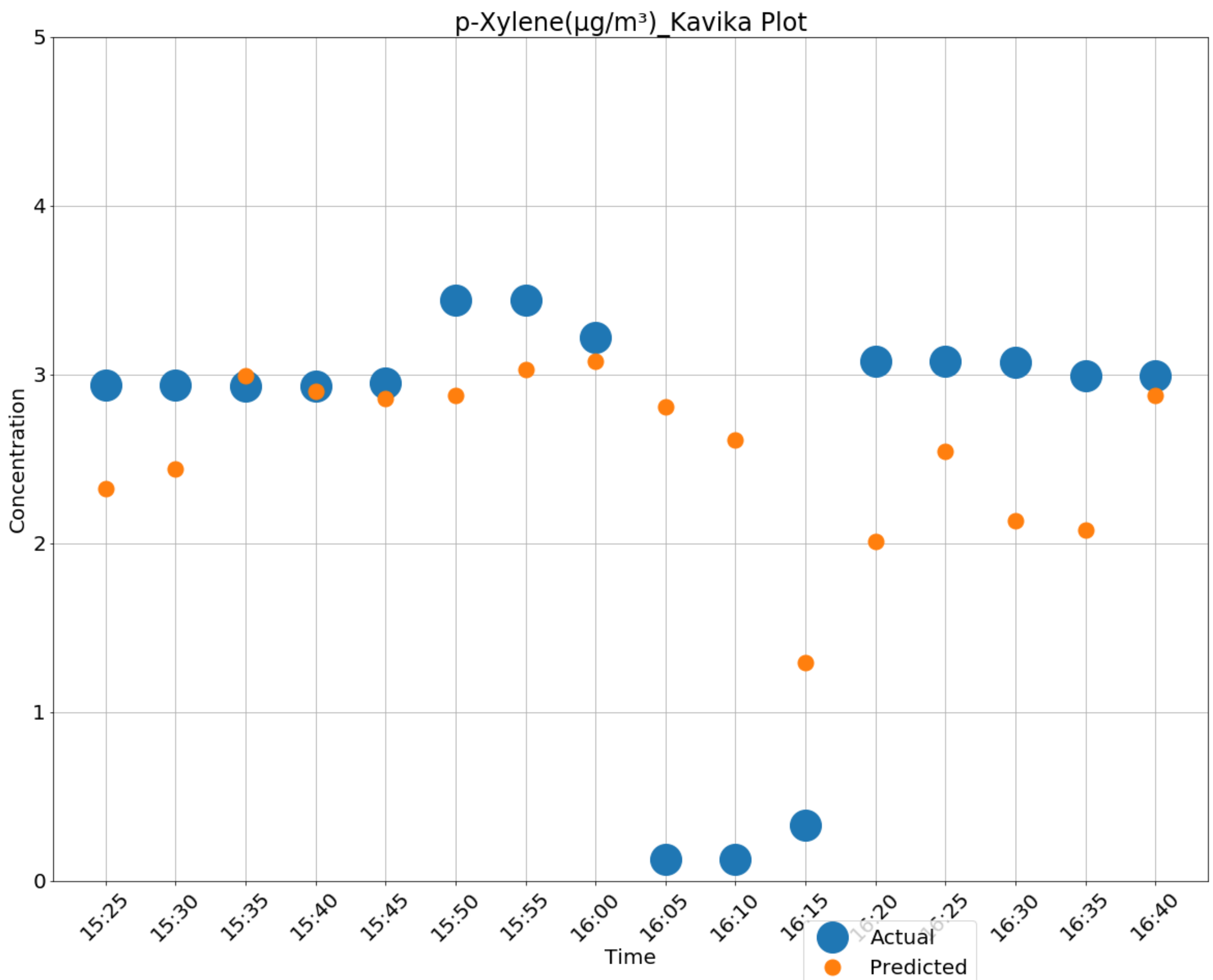


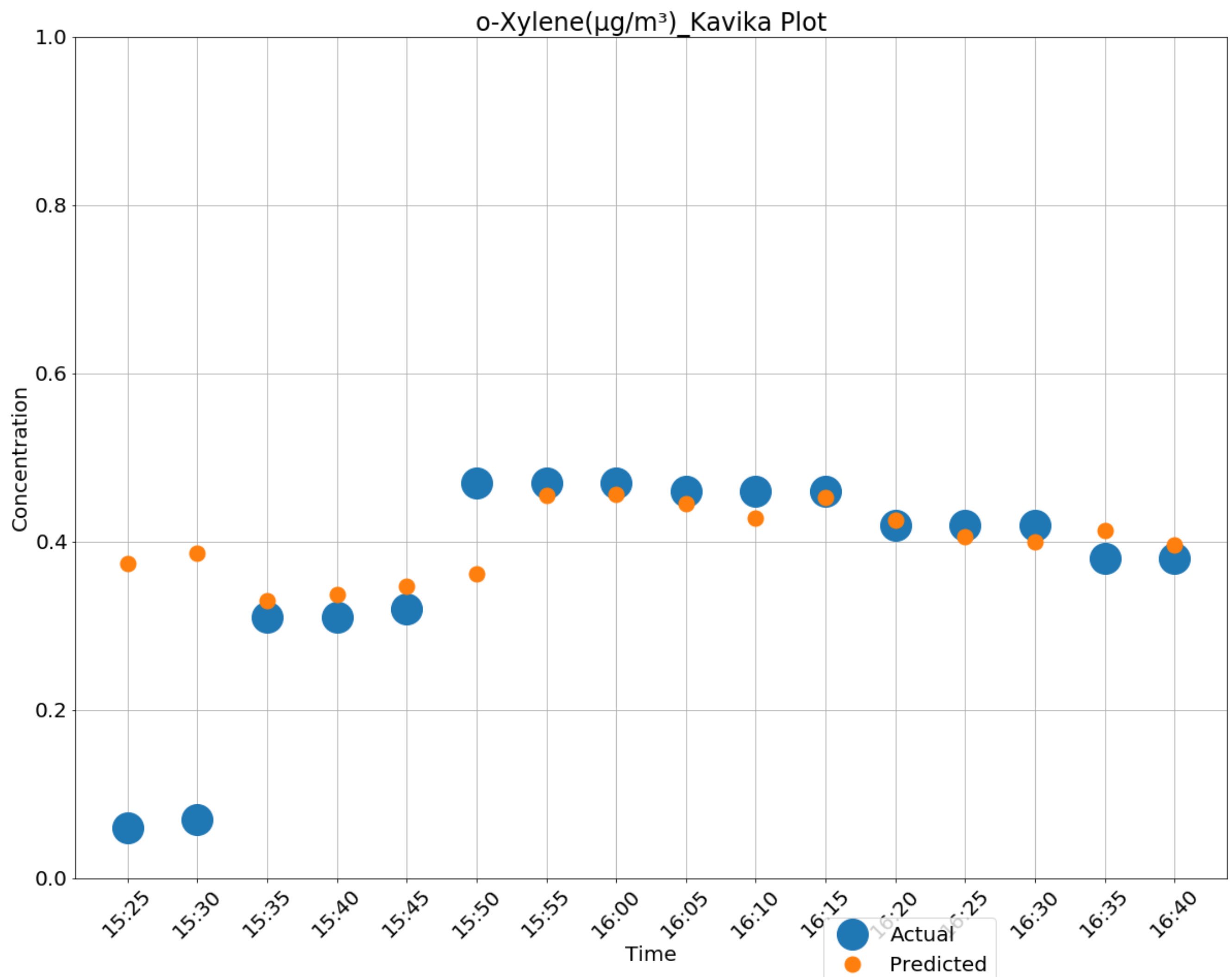
PM 2.5(µg/m³)_Kavika Plot
60
55
50
45
40
35
30
Concentration
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted

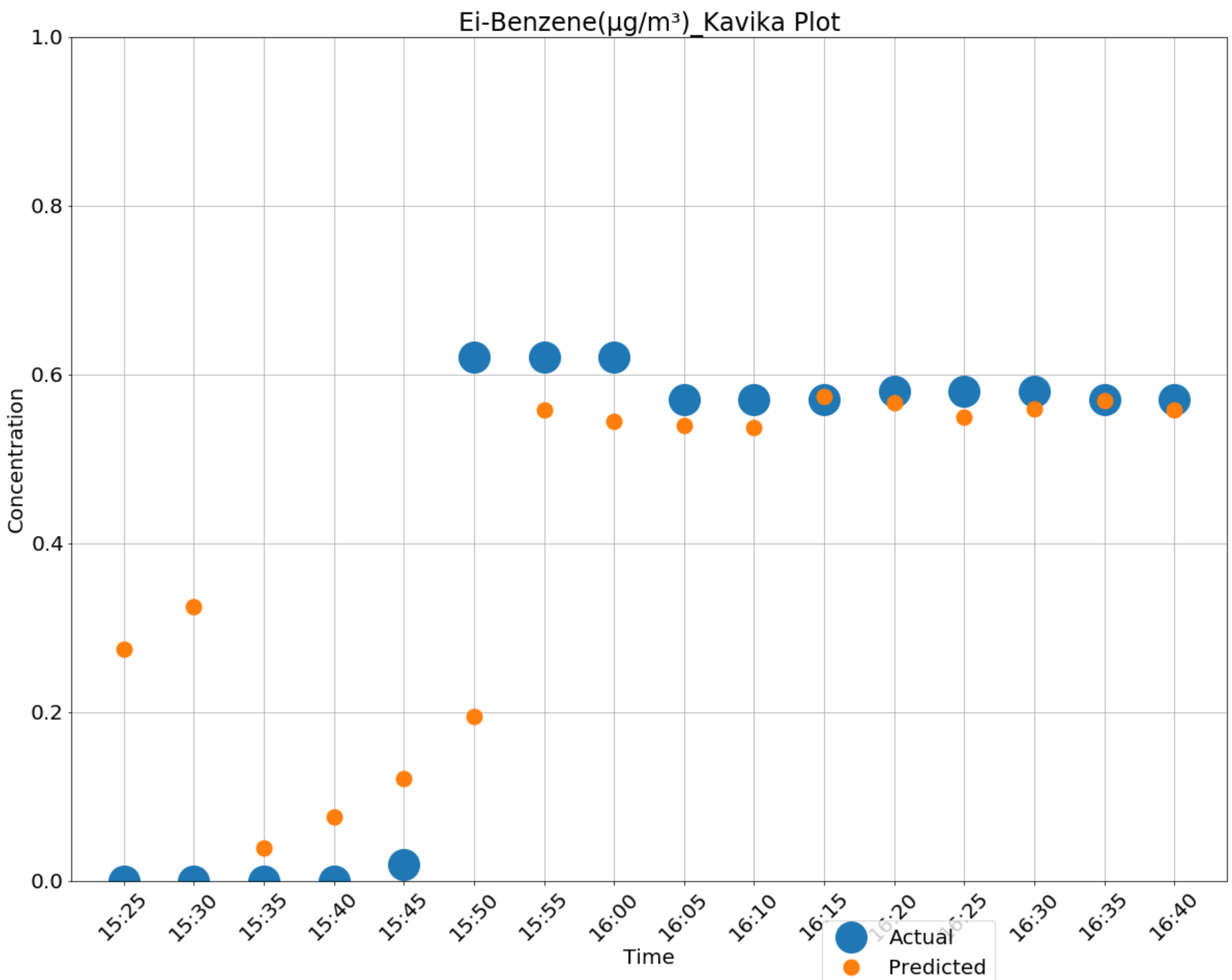

PM10(µg/m³)_Kavika Plot
Concentration
Time
140
120
100
80
60
40
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Actual
Predicted

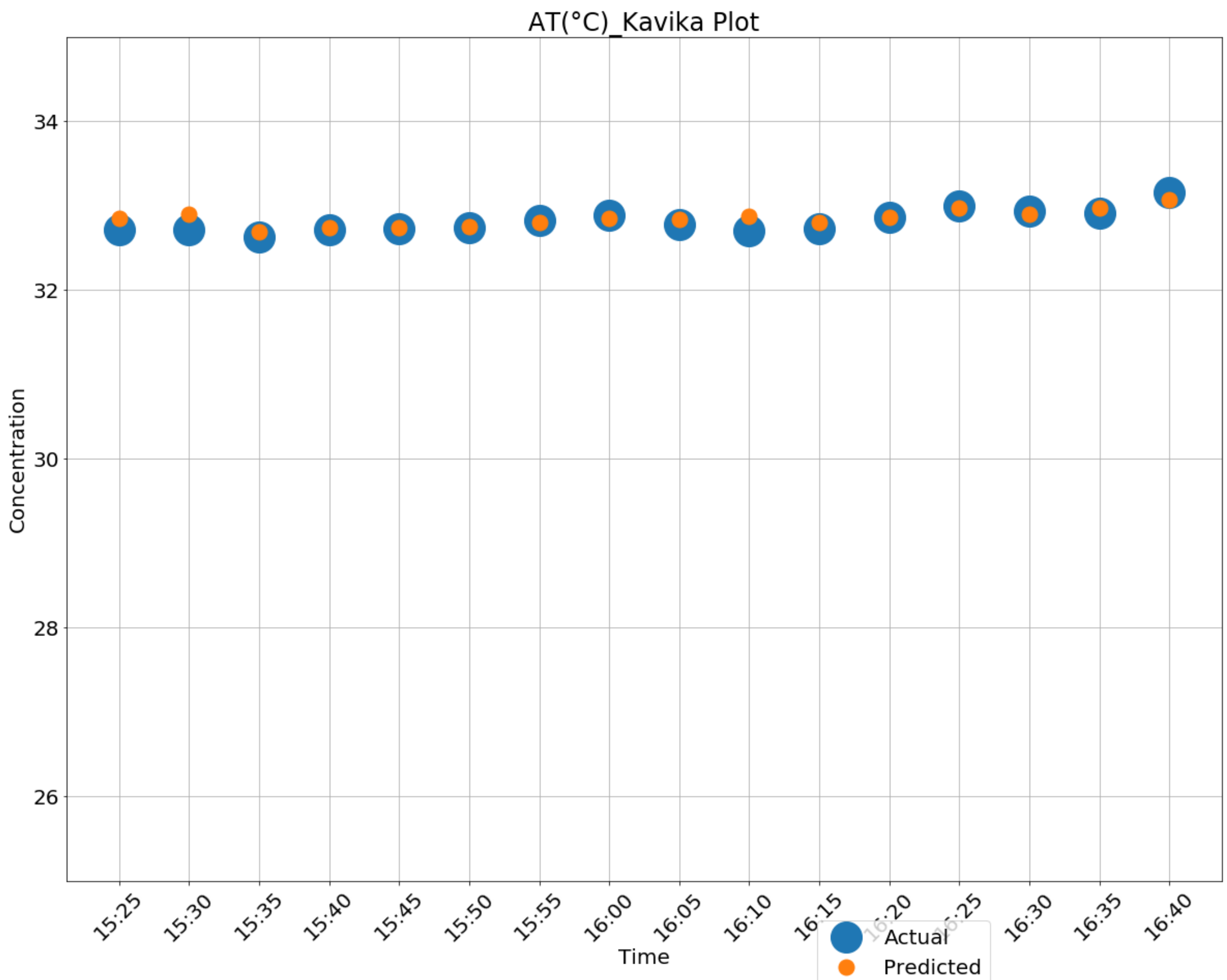

Benzene(µg/m³)_Kavika Plot
Concentration
0.0
0.2
0.4
0.6
0.8
1.0
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted


Toulene(µg/m³)_Kavika Plot
Concentration
3.0
2.5
2.0
1.5
1.0
0.5
0.0
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted

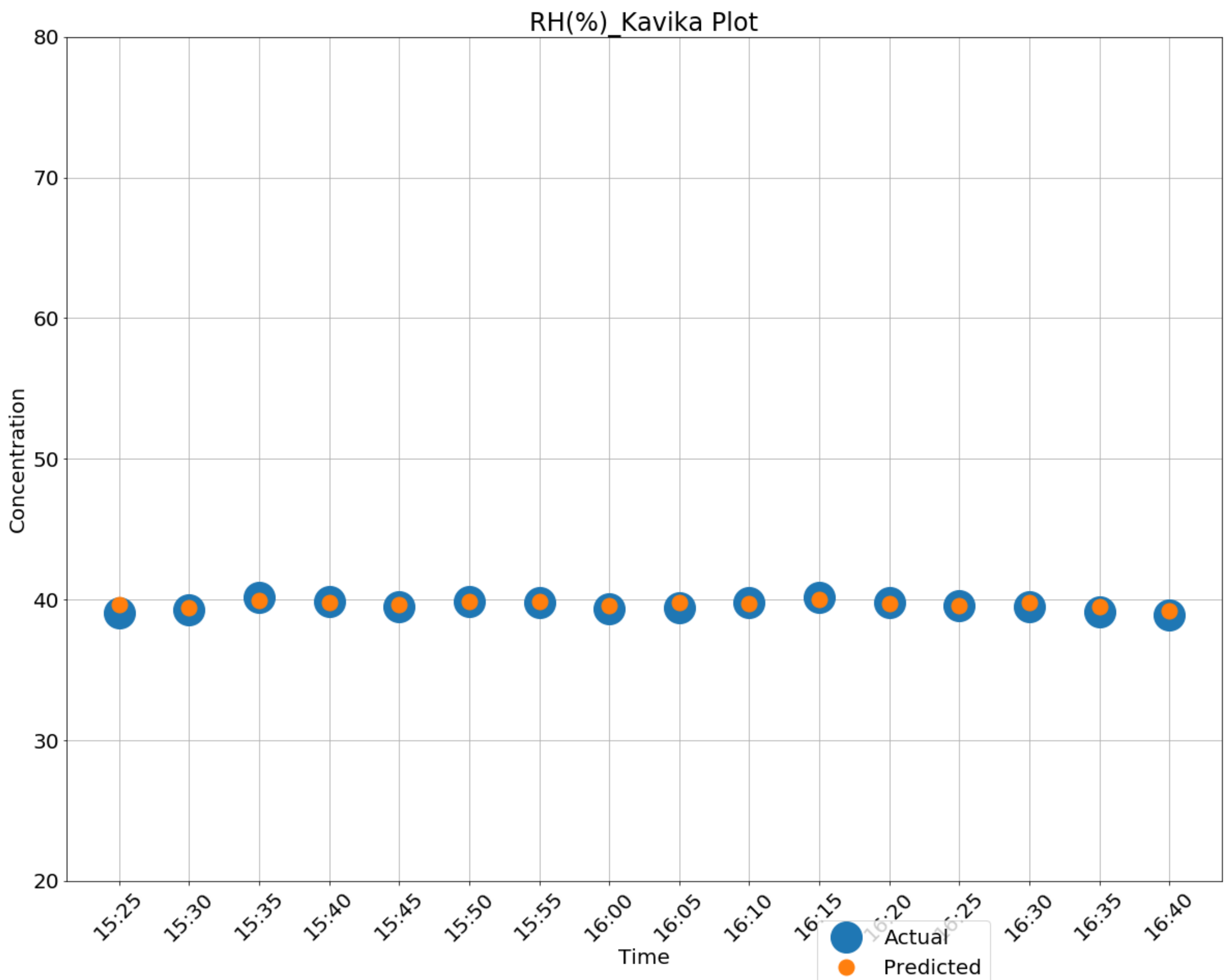

p-Xylene(µg/m³)_Kavika Plot
Concentration
0
1
2
3
4
5
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted


o-Xylene(µg/m³)_Kavika Plot
1.0
0.8
0.6
0.4
0.2
0.0
Concentration
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted

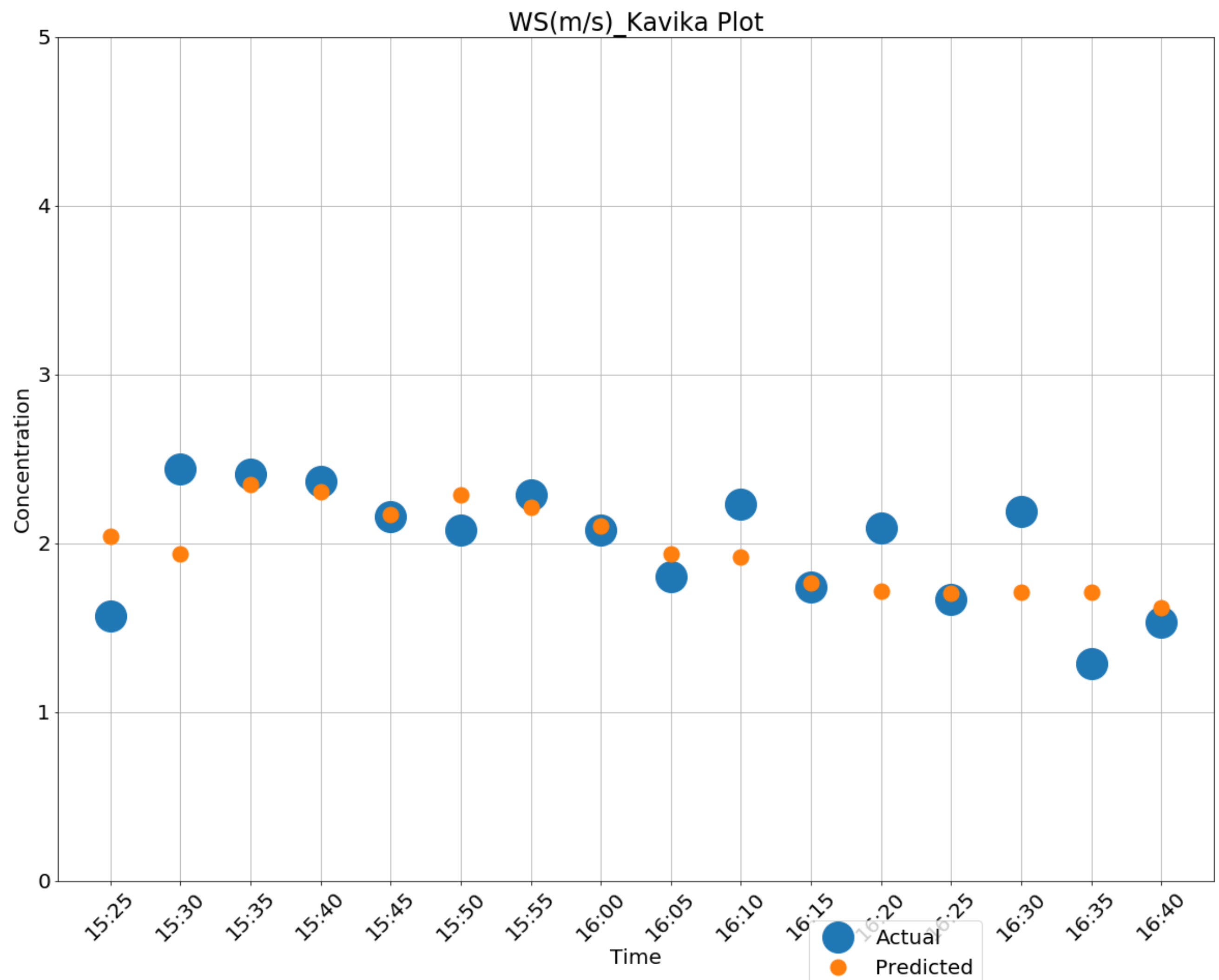

Ei-Benzene(µg/m³)_Kavika Plot
1.0
0.8
0.6
0.4
0.2
0.0
Concentration
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted

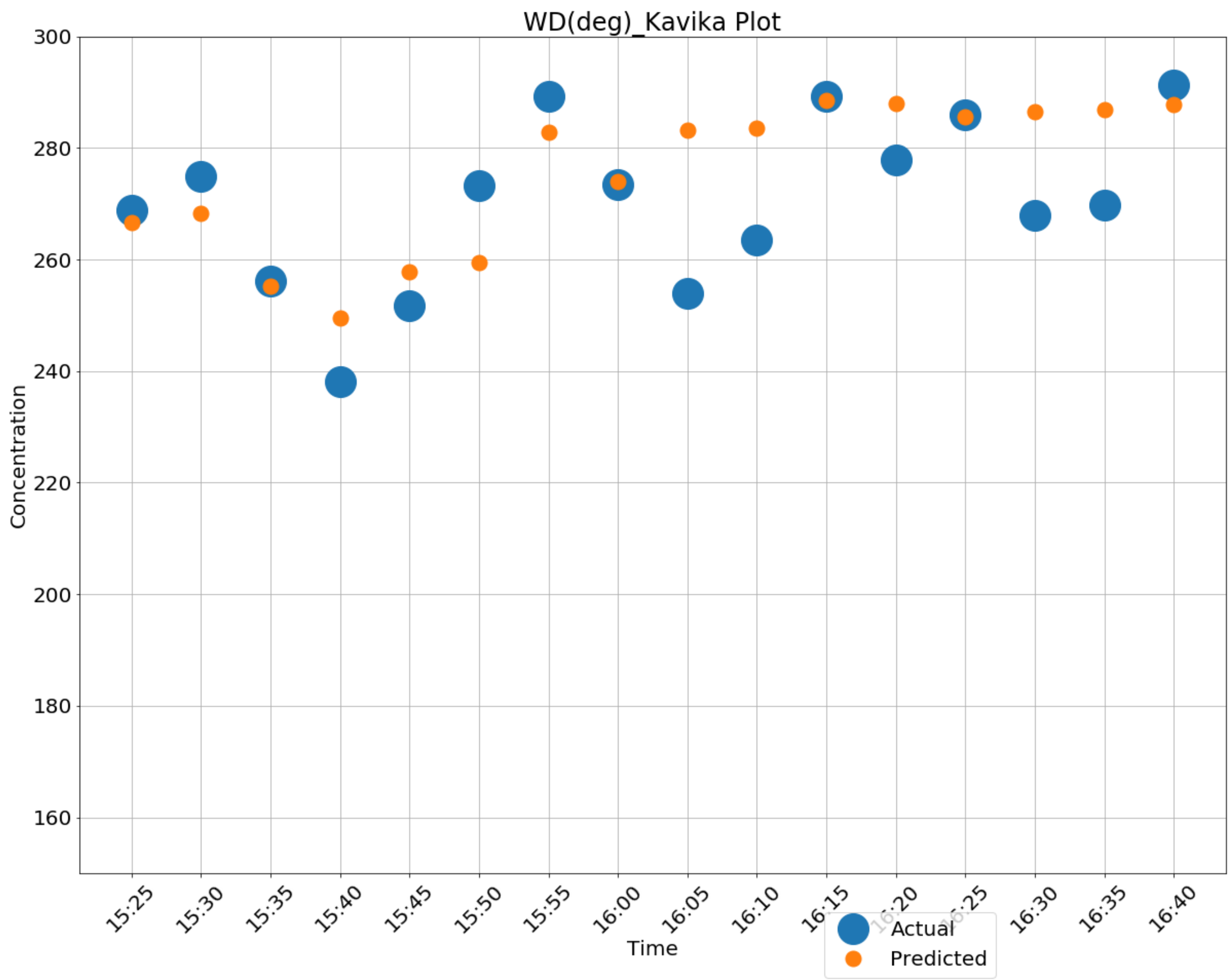


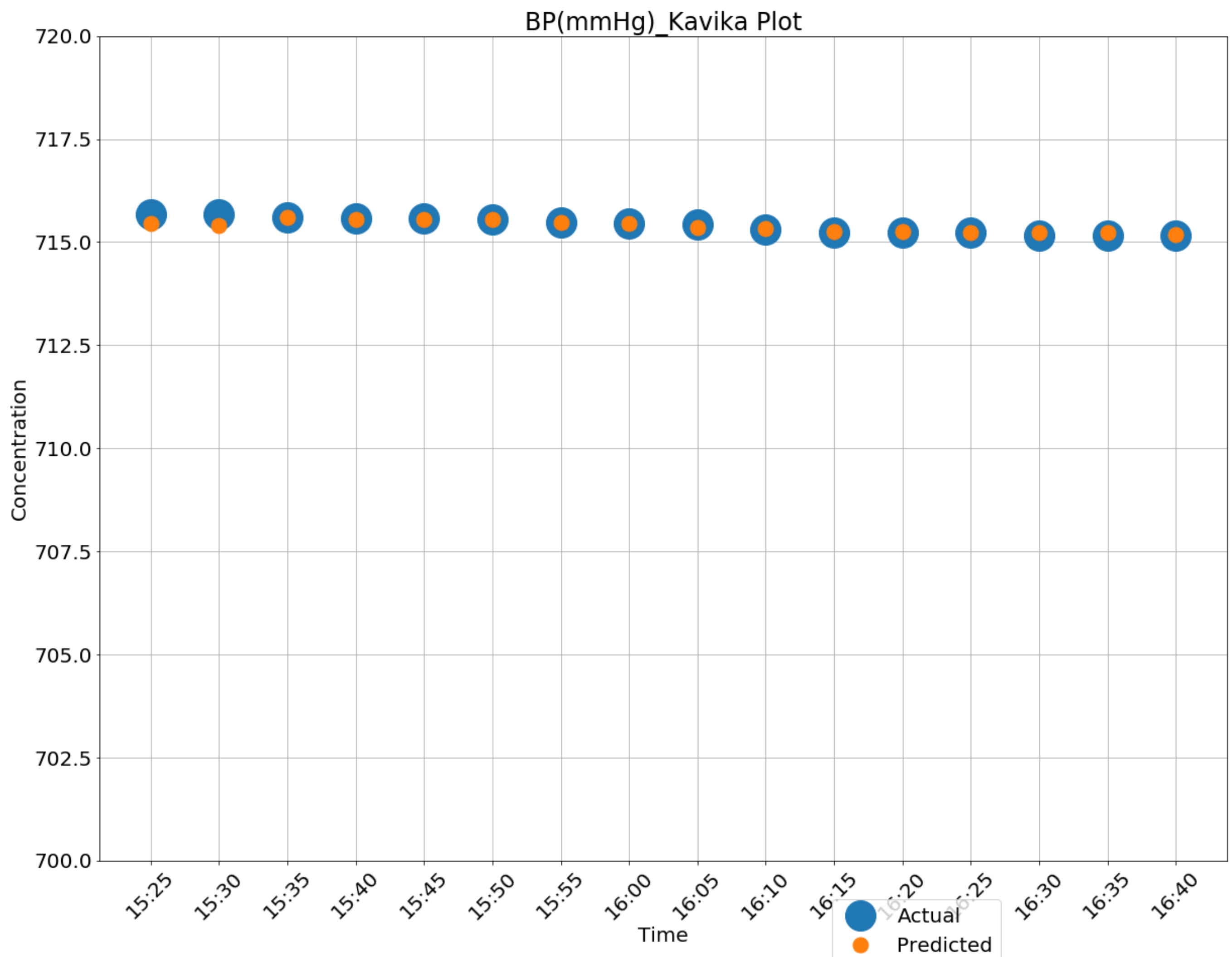
AT(°C)_Kavika Plot
Concentration
34
32
30
28
26
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted

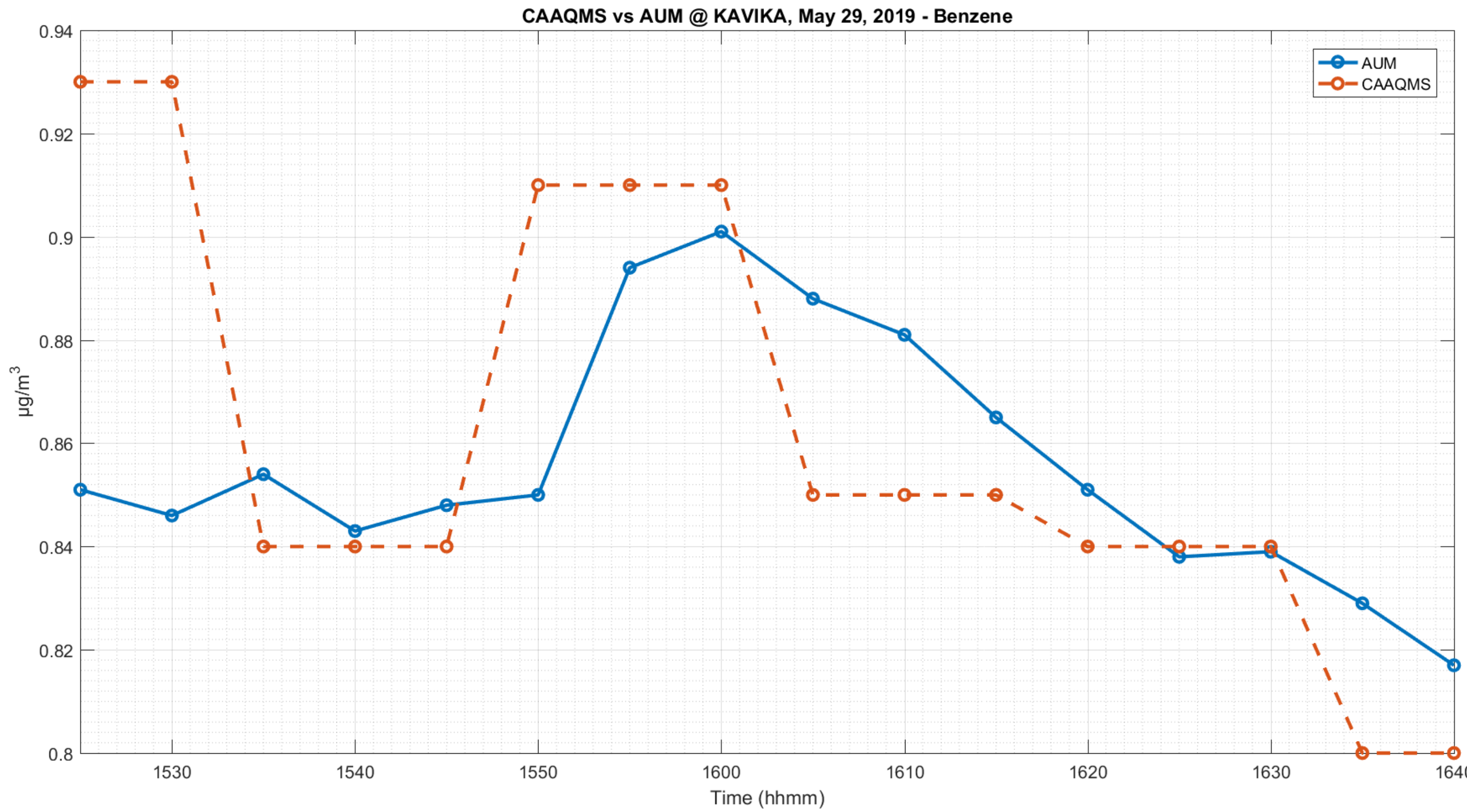


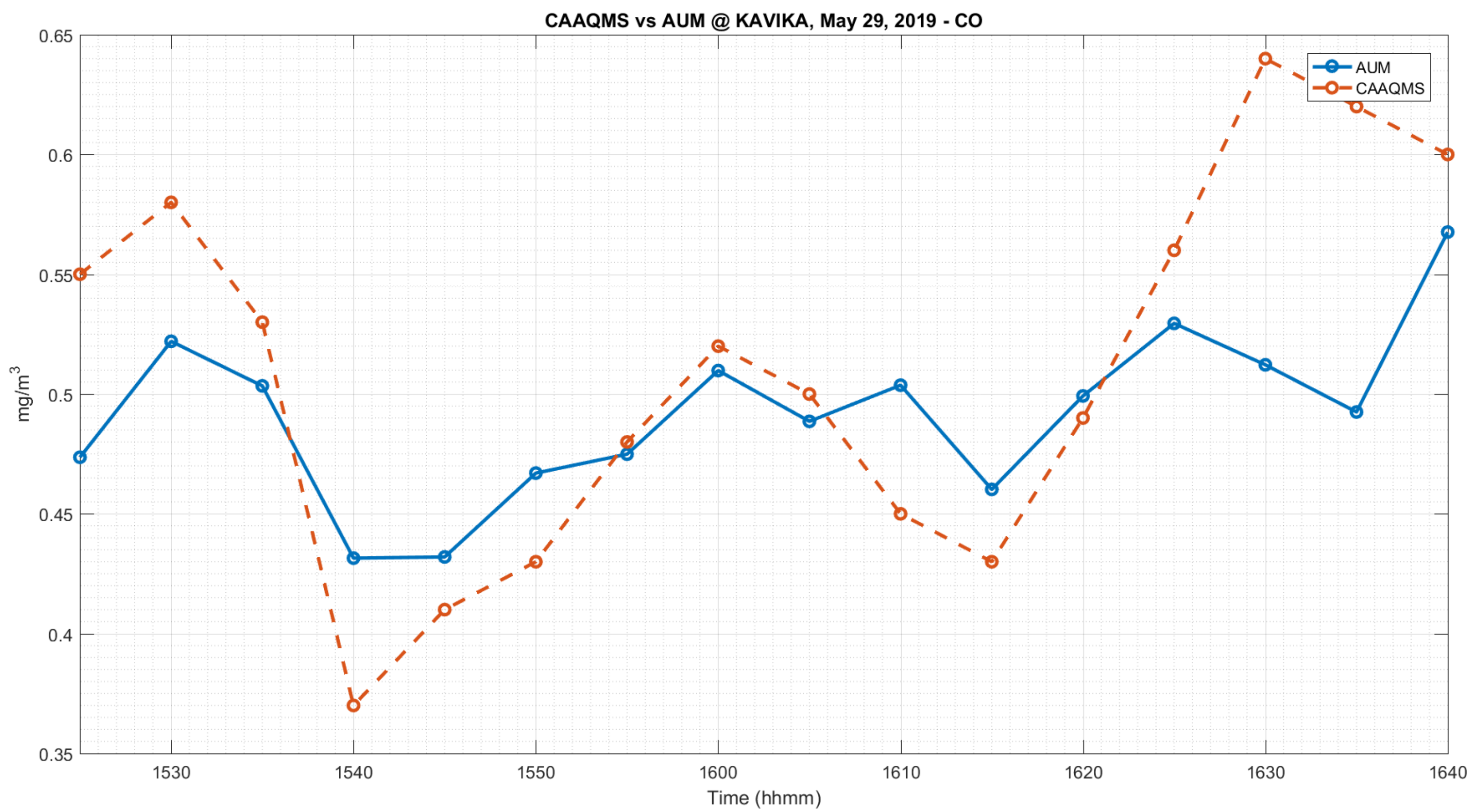
RH(%)_Kavika Plot
80
70
60
50
40
30
20
Concentration
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted


WS(m/s)_Kavika Plot
Concentration
5
4
3
2
1
0
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Time
Actual
Predicted

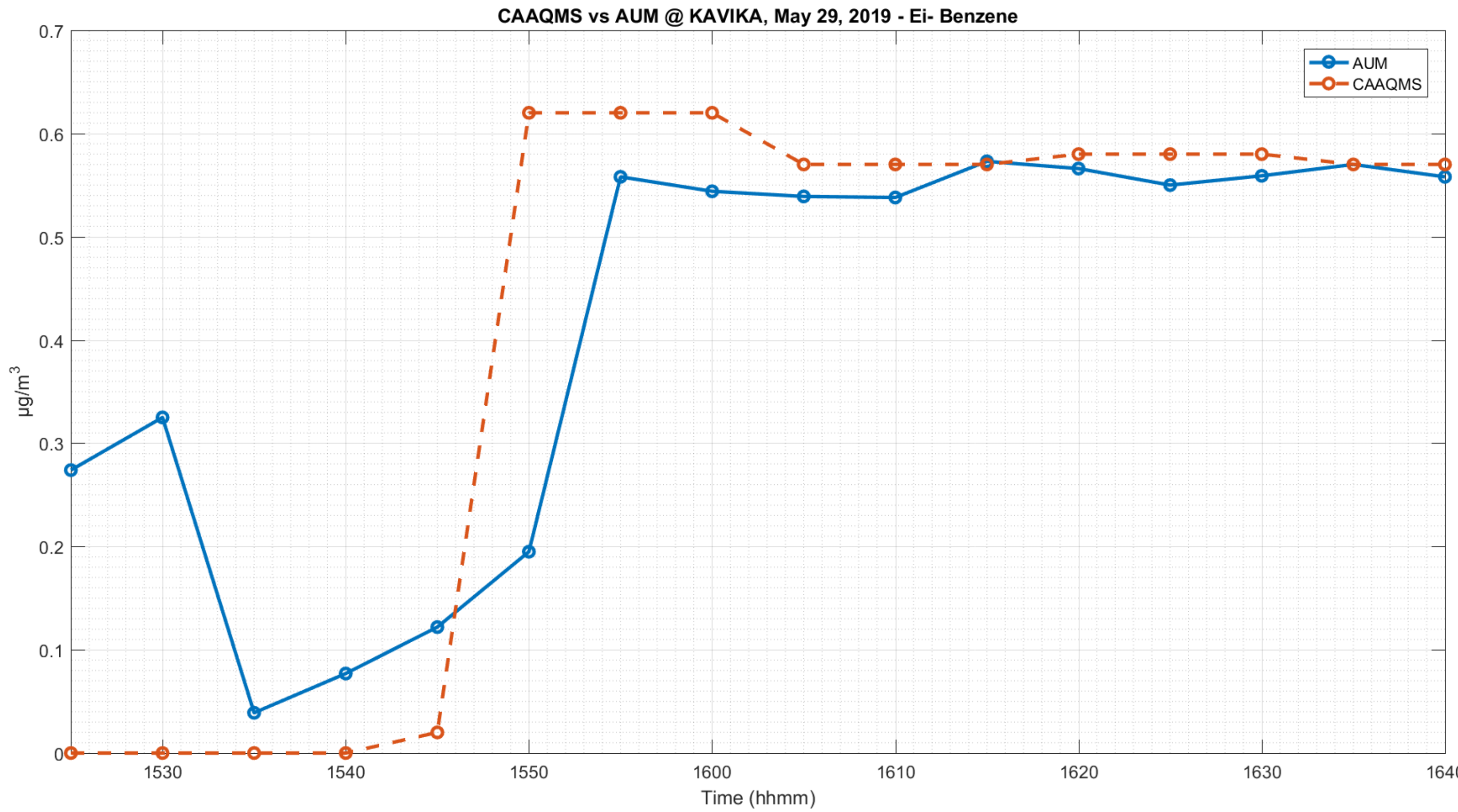

WD(deg)_Kavika Plot
Concentration
300
280
260
240
220
200
180
160
Time
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
Actual
Predicted

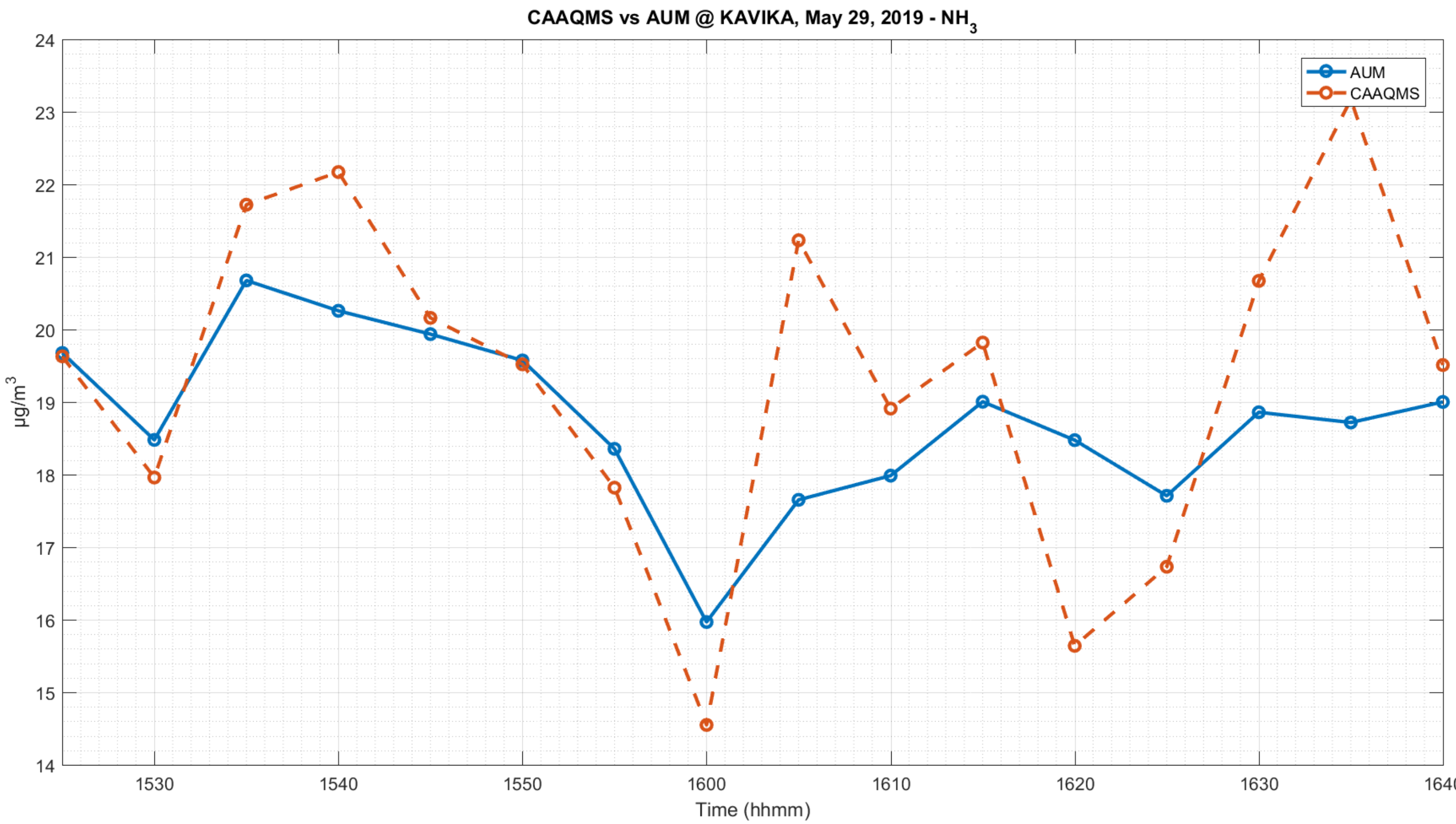

BP(mmHg)_Kavika Plot
Concentration
720.0
717.5
715.0
712.5
710.0
707.5
705.0
702.5
700.0
15:25
15:30
15:35
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:30
16:35
16:40
Time
Actual
Predicted

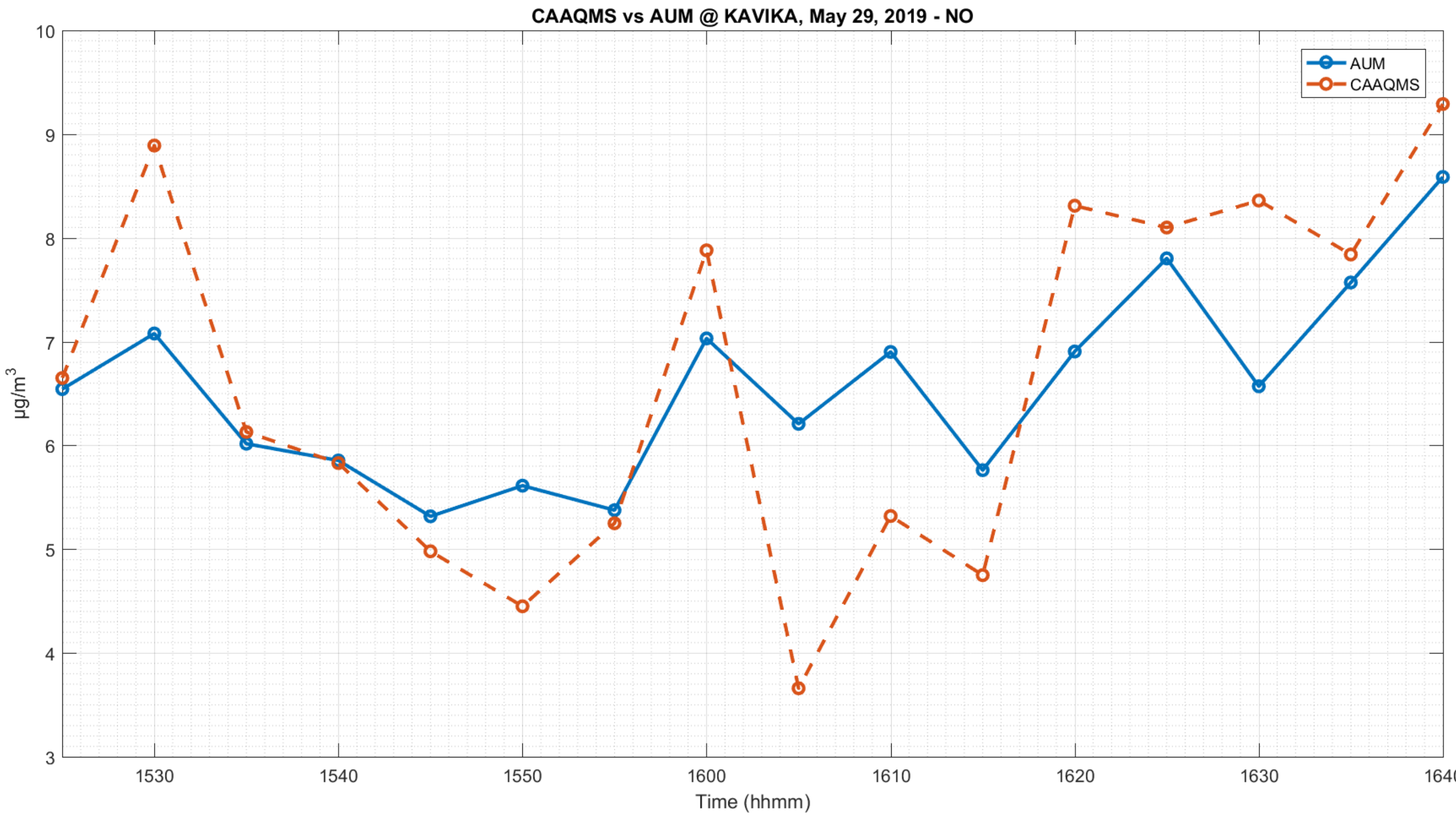

CAAQMS vs AUM @ KAVIKA, May 29, 2019 - Benzene
AUM
CAAQMS
µg/m3
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8
1530
1540
1550
1600
1610
1620
1630
1640
Time (hhmm)

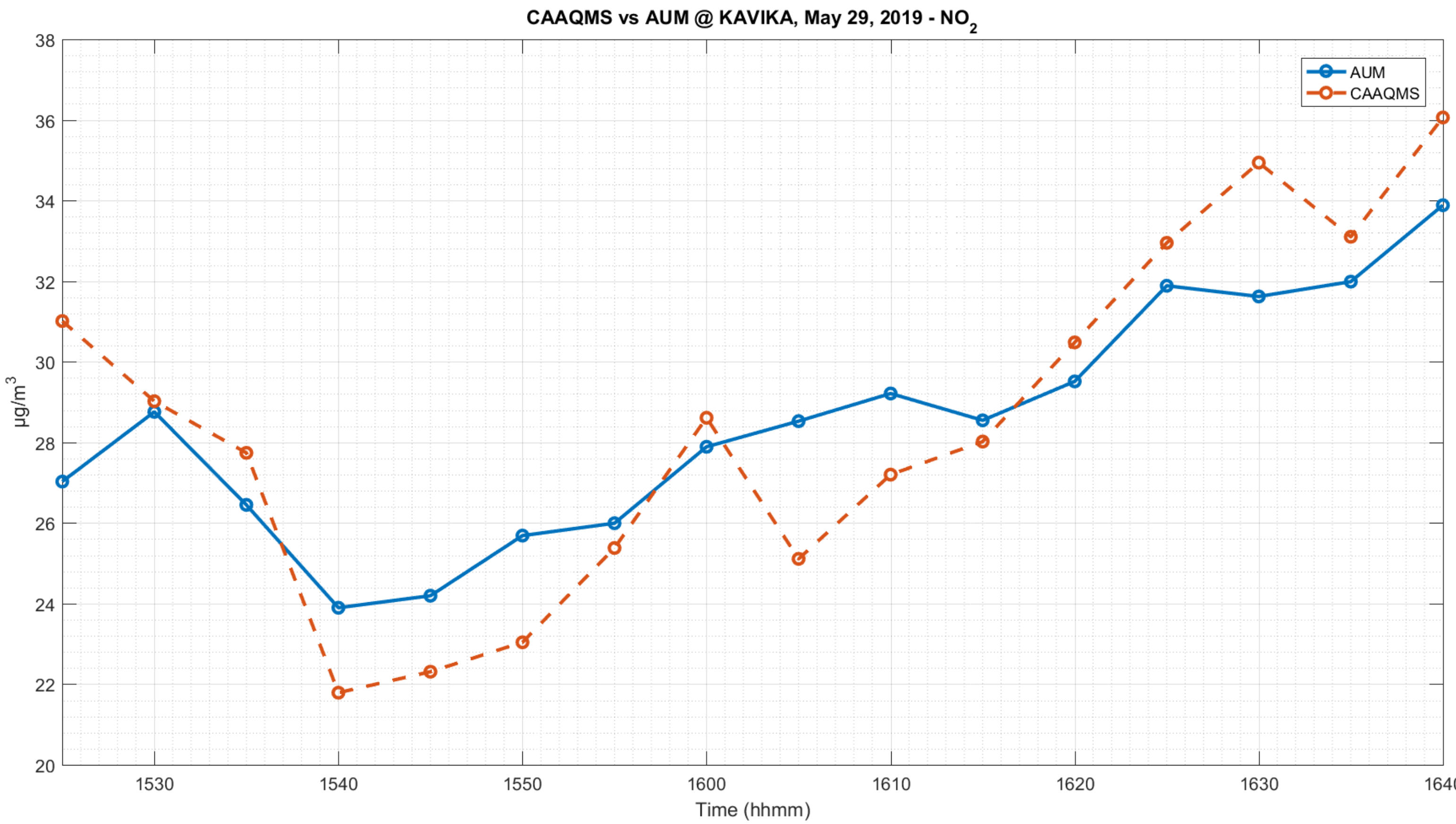


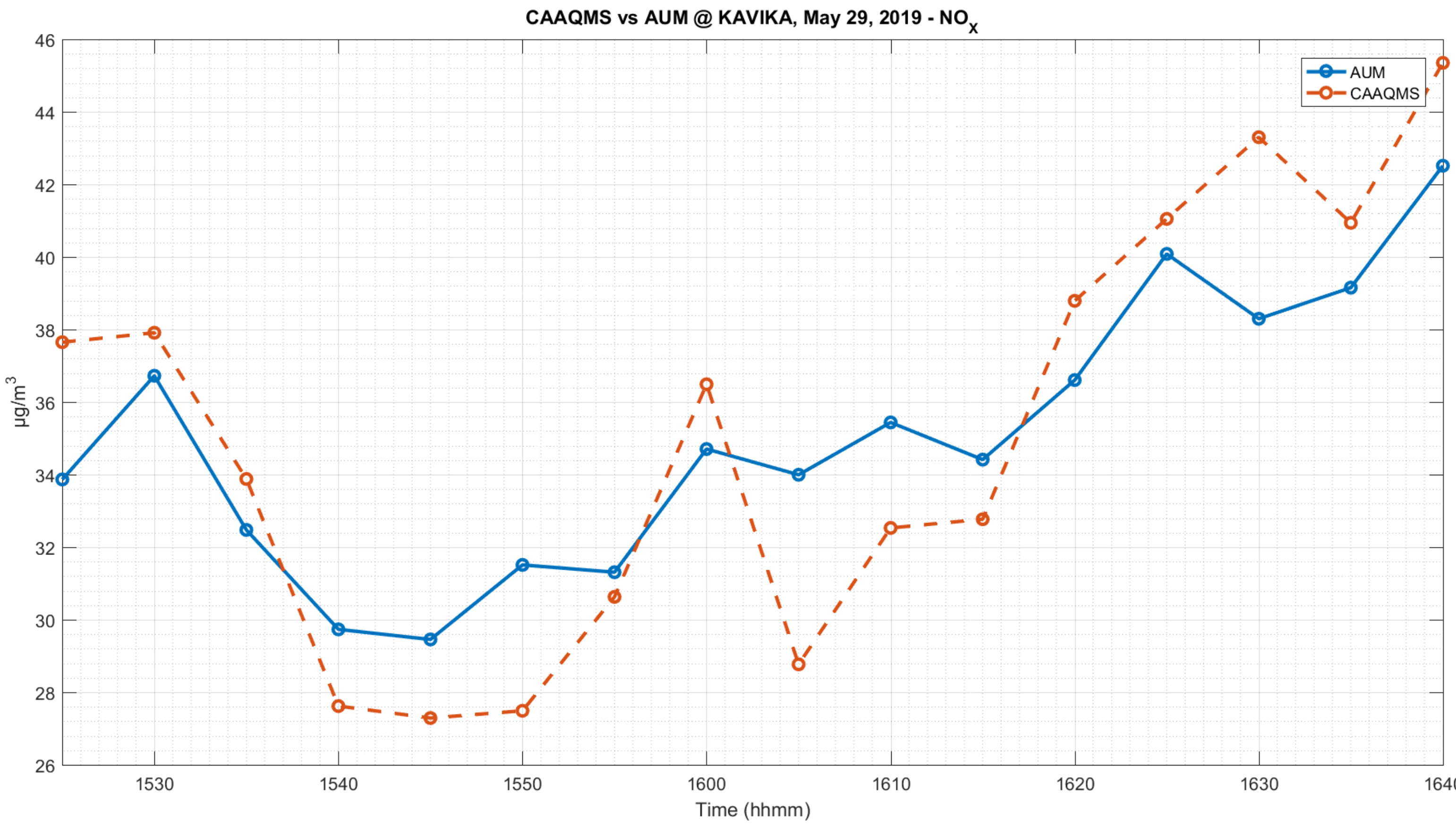
CAAQMS vs AUM @ KAVIKA, May 29, 2019 - CO
AUM
CAAQMS
mg/m3
0.65
0.6
0.55
0.5
0.45
0.4
0.35
1530
1540
1550
1600
1610
1620
1630
1640
Time (hhmm)

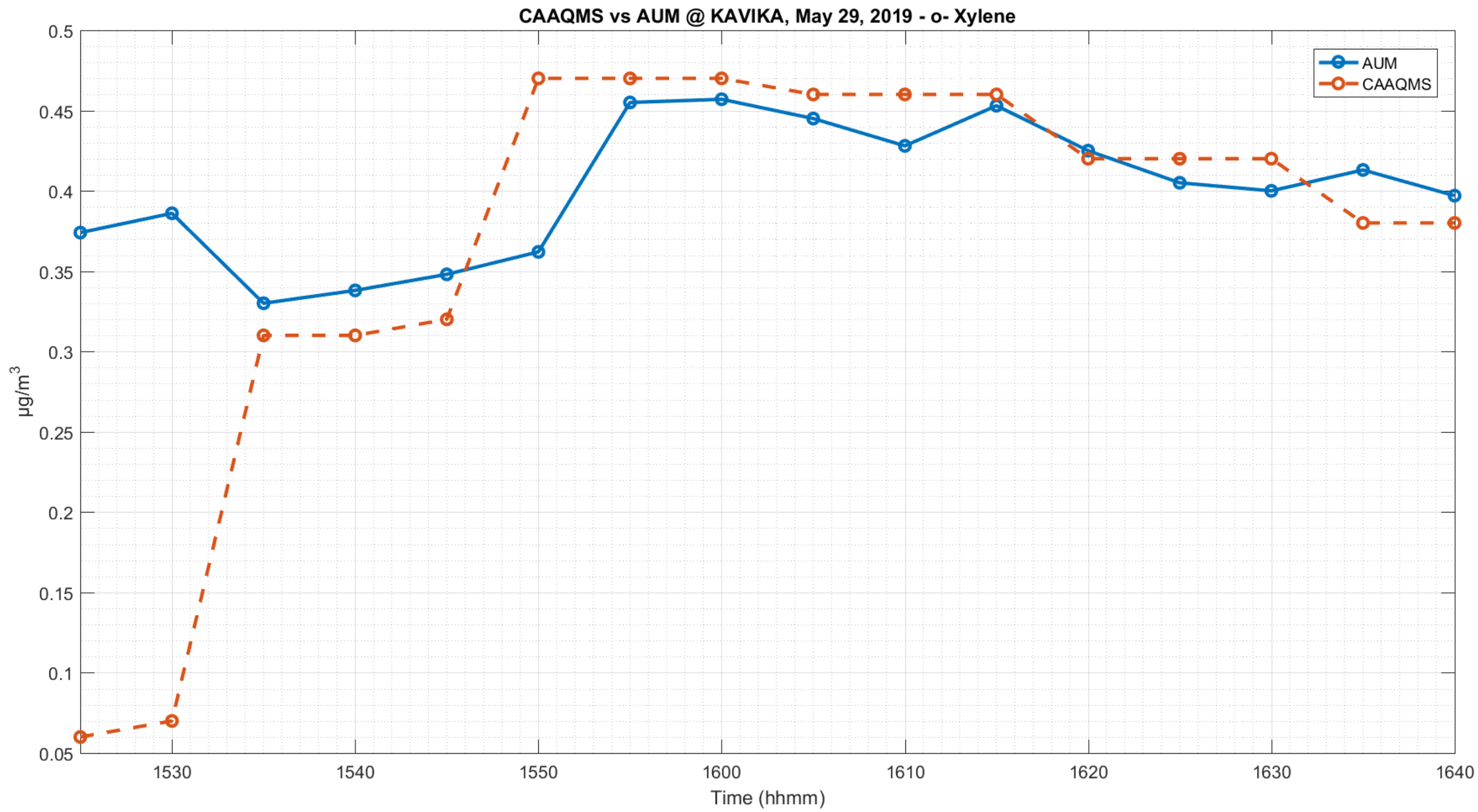

CAAQMS vs AUM @ KAVIKA, May 29, 2019 - Ei- Benzene
AUM
CAAQMS
μg/m3
Time (hhmm)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1530
1540
1550
1600
1610
1620
1630
1640

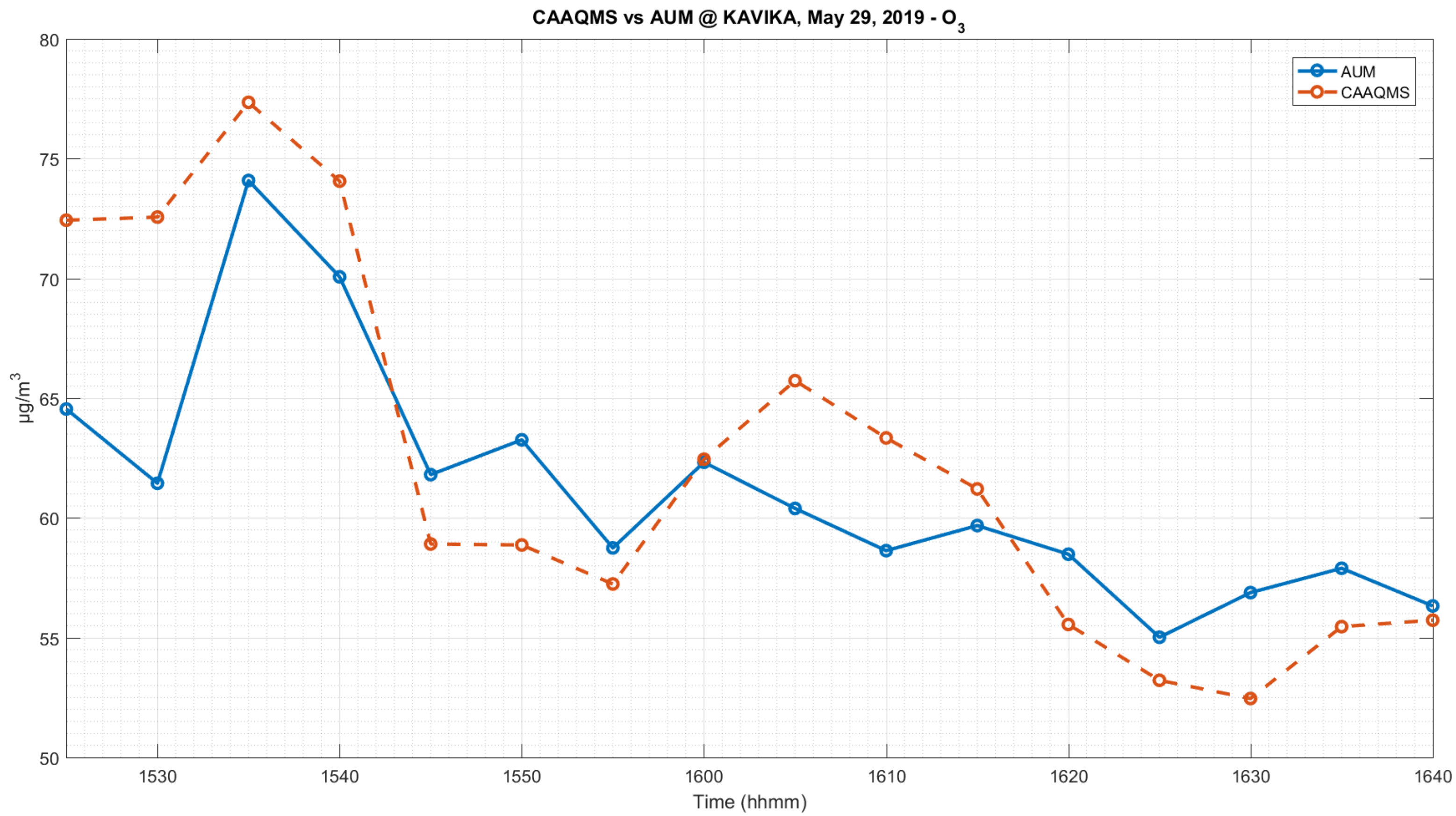

CAAQMS vs AUM @ KAVIKA, May 29, 2019 - NH3
AUM
CAAQMS
μg/m3
Time (hhmm)
24
23
22
21
20
19
18
17
16
15
14
1530
1540
1550
1600
1610
1620
1630
1640

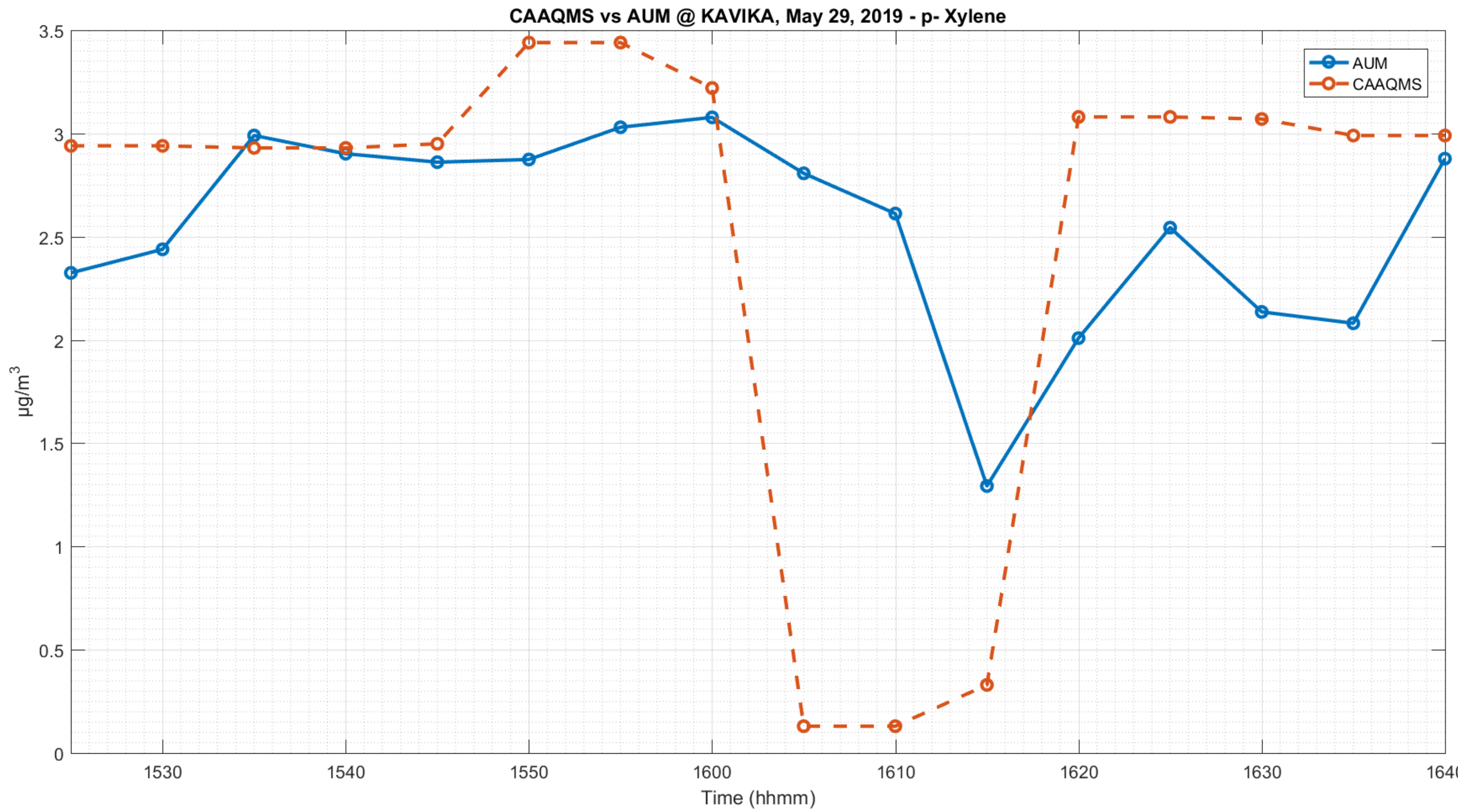

CAAQMS vs AUM @ KAVIKA, May 29, 2019 - NO
AUM
CAAQMS
μg/m3
Time (hhmm)
10
9
8
7
6
5
4
3
1530
1540
1550
1600
1610
1620
1630
1640


CAAQMS vs AUM @ KAVIKA, May 29, 2019 - NO2
AUM
CAAQMS
µg/m3
Time (hhmm)
38
36
34
32
30
28
26
24
22
20
1530
1540
1550
1600
1610
1620
1630
1640

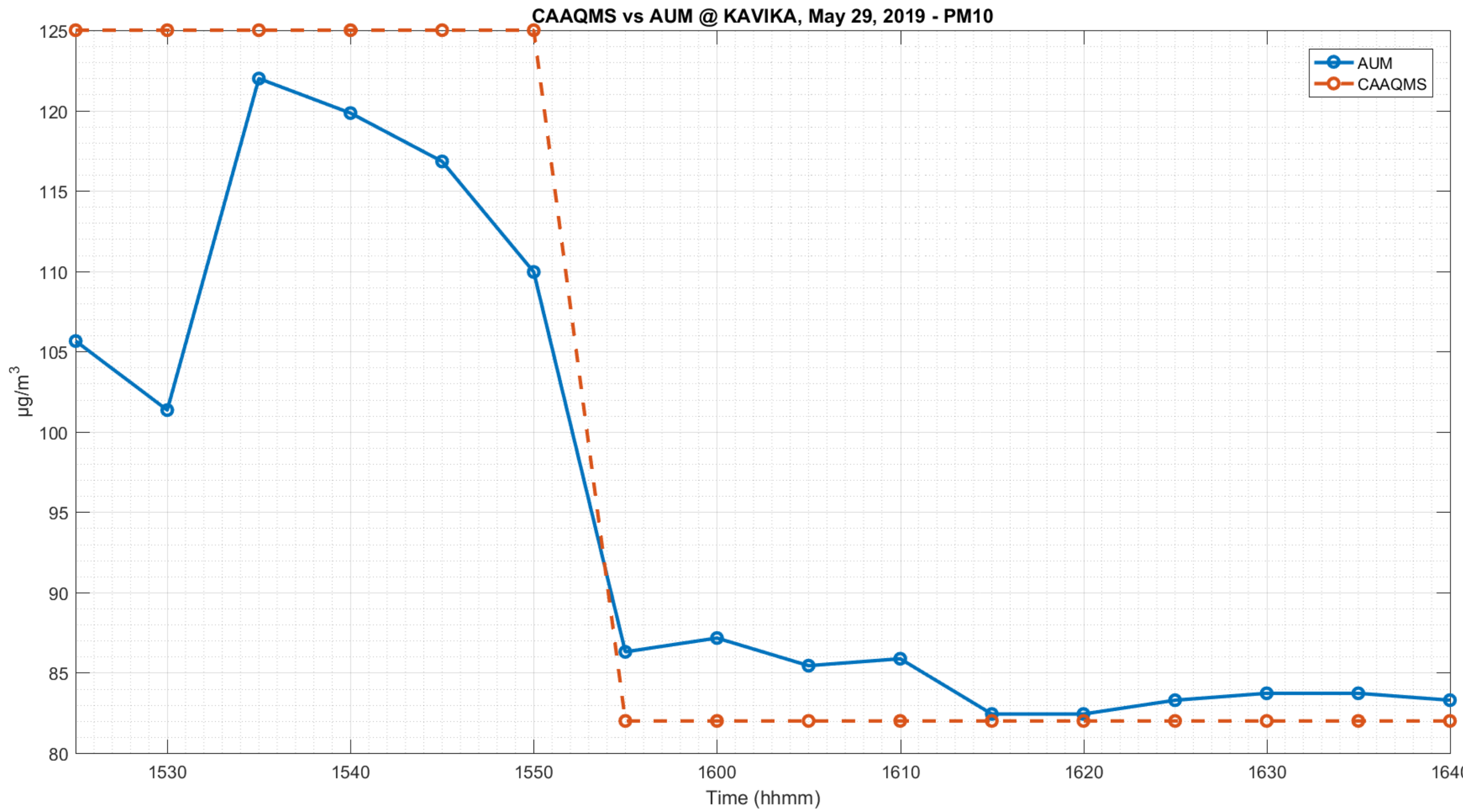

CAAQMS vs AUM @ KAVIKA, May 29, 2019 - NOX
AUM
CAAQMS
μg/m3
Time (hhmm)
46
44
42
40
38
36
34
32
30
28
26
1530
1540
1550
1600
1610
1620
1630
1640


CAAQMS vs AUM @ KAVIKA, May 29, 2019 - o- Xylene
AUM
CAAQMS
µg/m3
Time (hhmm)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
1530
1540
1550
1600
1610
1620
1630
1640

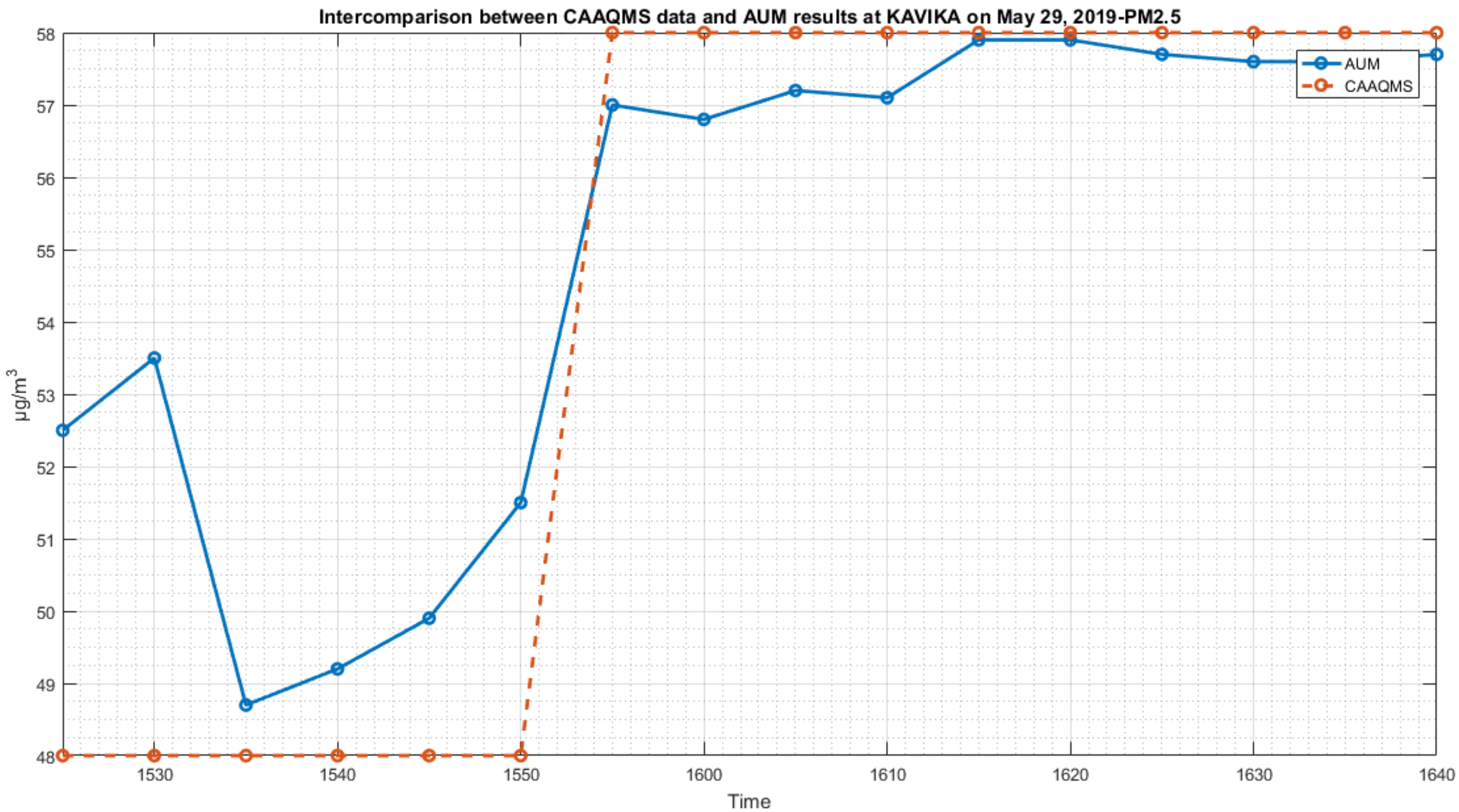

CAAQMS vs AUM @ KAVIKA, May 29, 2019 - O3
AUM
CAAQMS
µg/m3
Time (hhmm)
80
75
70
65
60
55
50
1530
1540
1550
1600
1610
1620
1630
1640



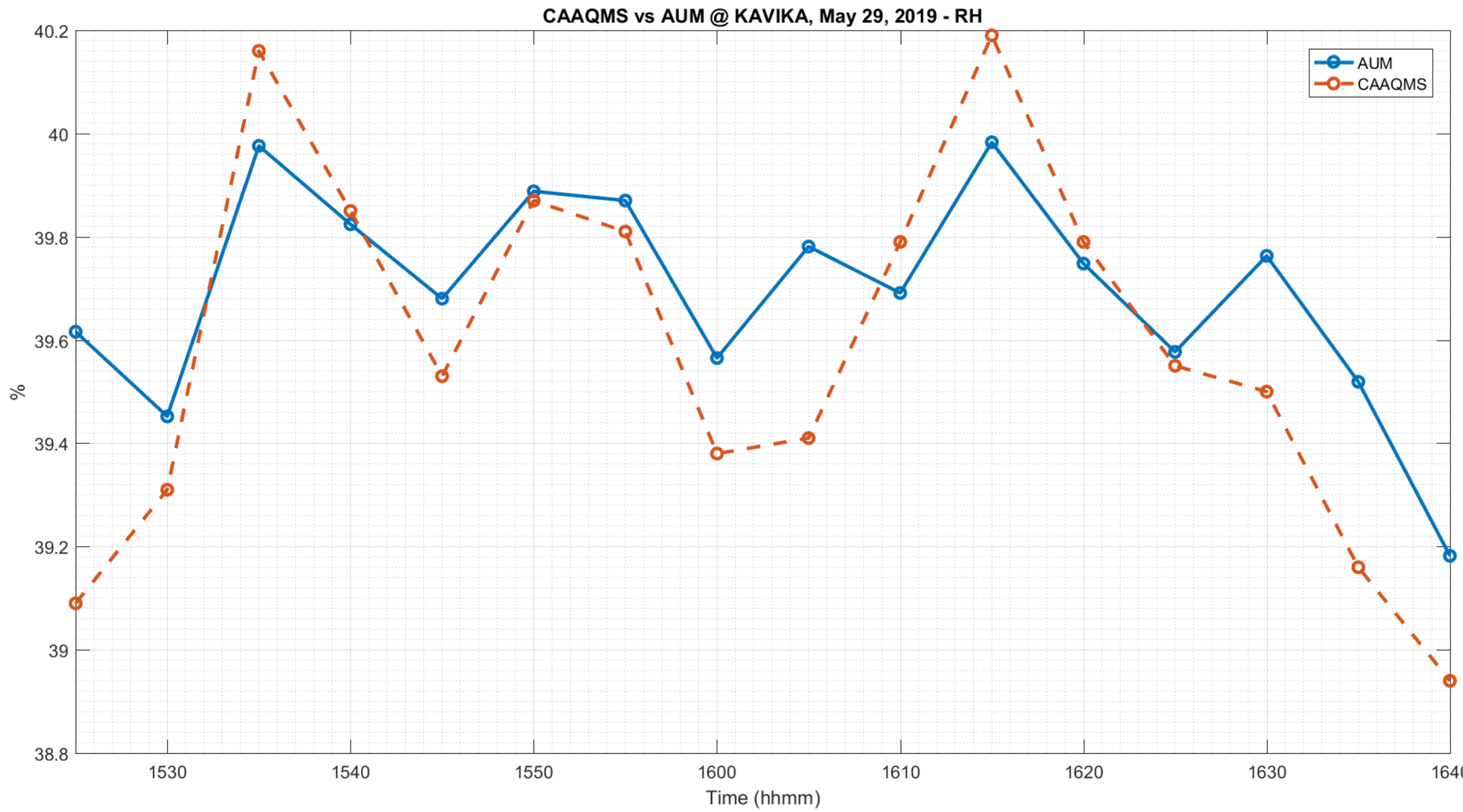
CAAQMS vs AUM @ KAVIKA, May 29, 2019 - p- Xylene
AUM
CAAQMS
µg/m^3
Time (hhmm)
3.5
3
2.5
2
1.5
1
0.5
0
1530
1540
1550
1600
1610
1620
1630
1640

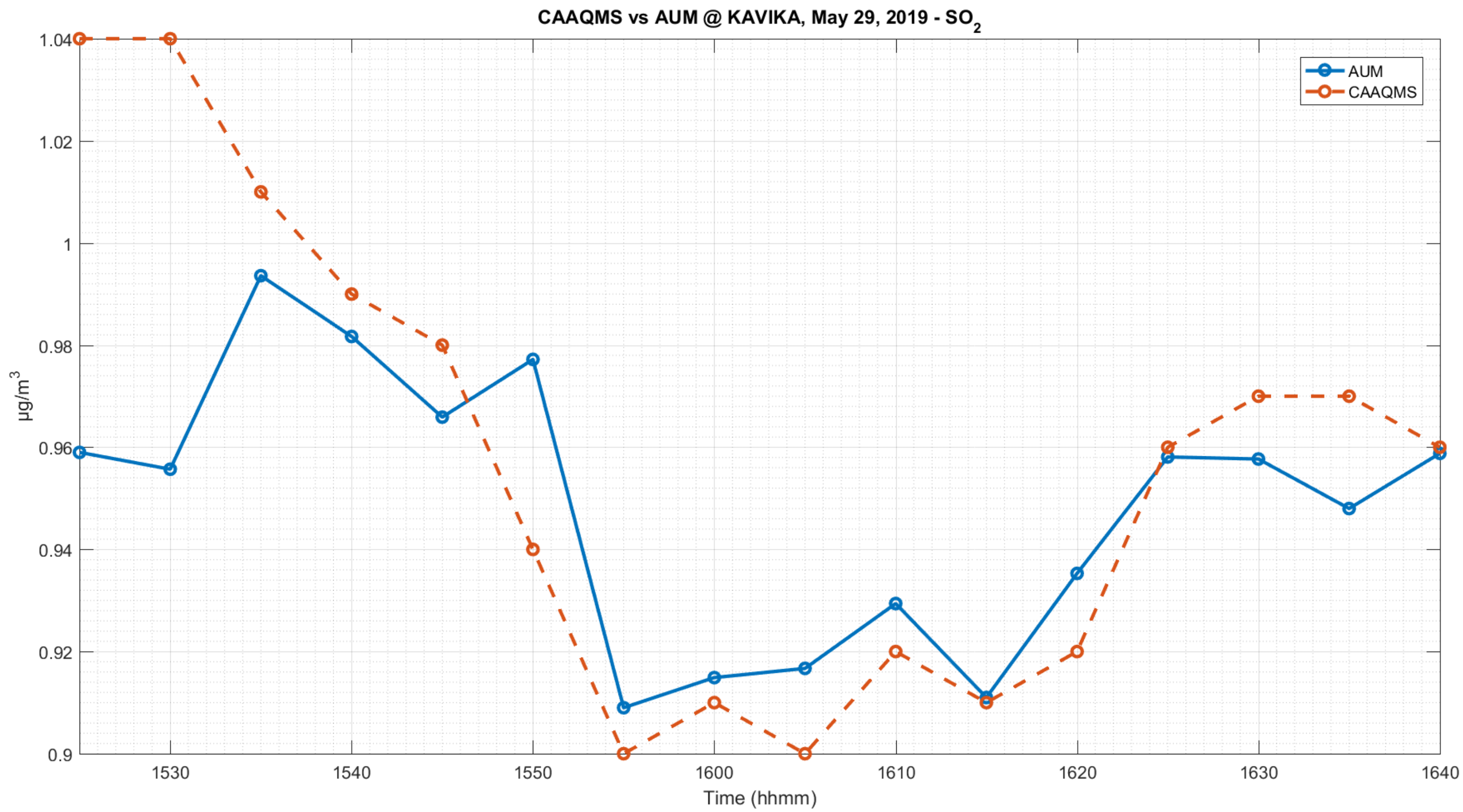


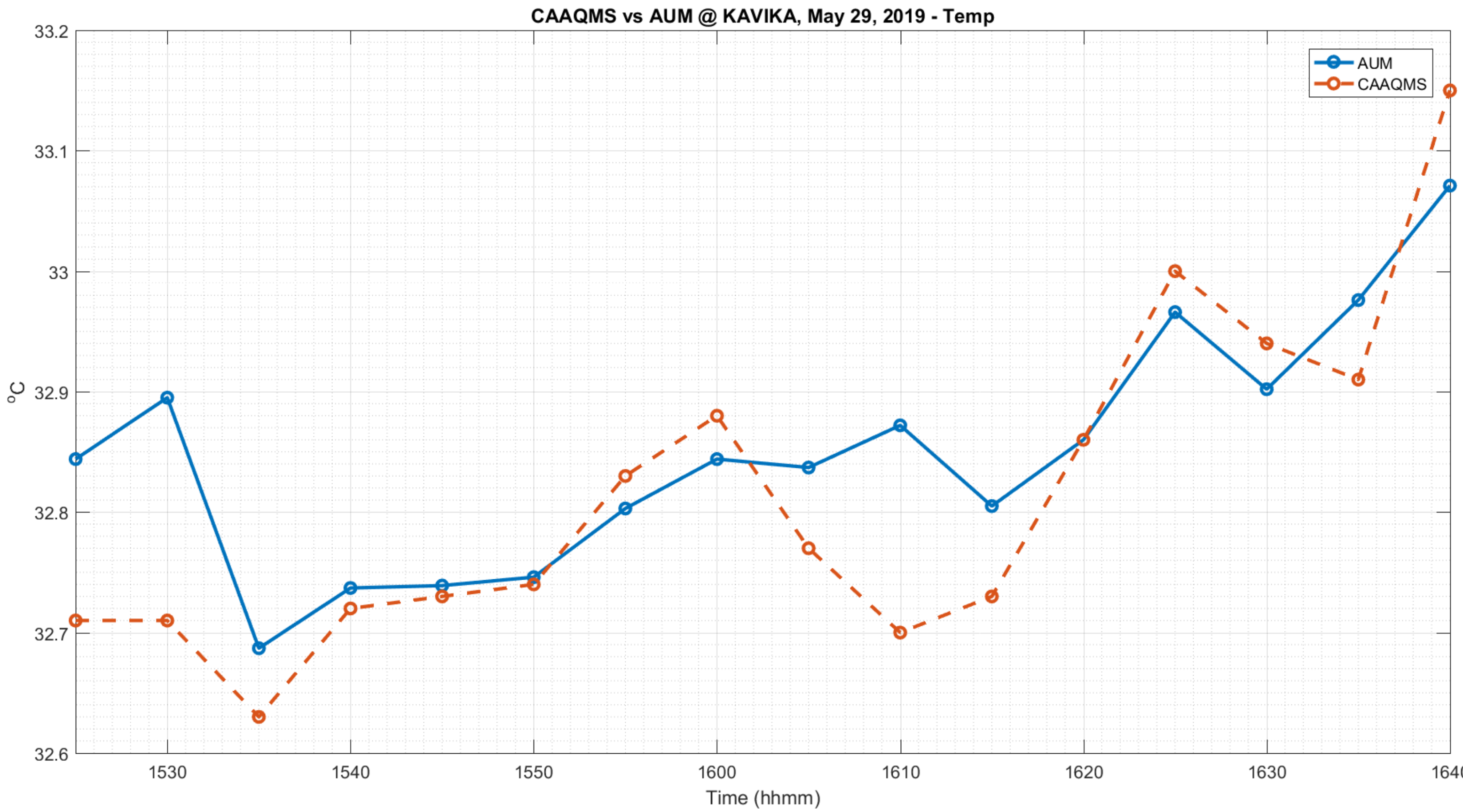
CAAQMS vs AUM @ KAVIKA, May 29, 2019 - PM10
AUM
CAAQMS
125
120
115
110
105
100
95
90
85
80
μg/m3
1530
1540
1550
1600
1610
1620
1630
1640
Time (hhmm)



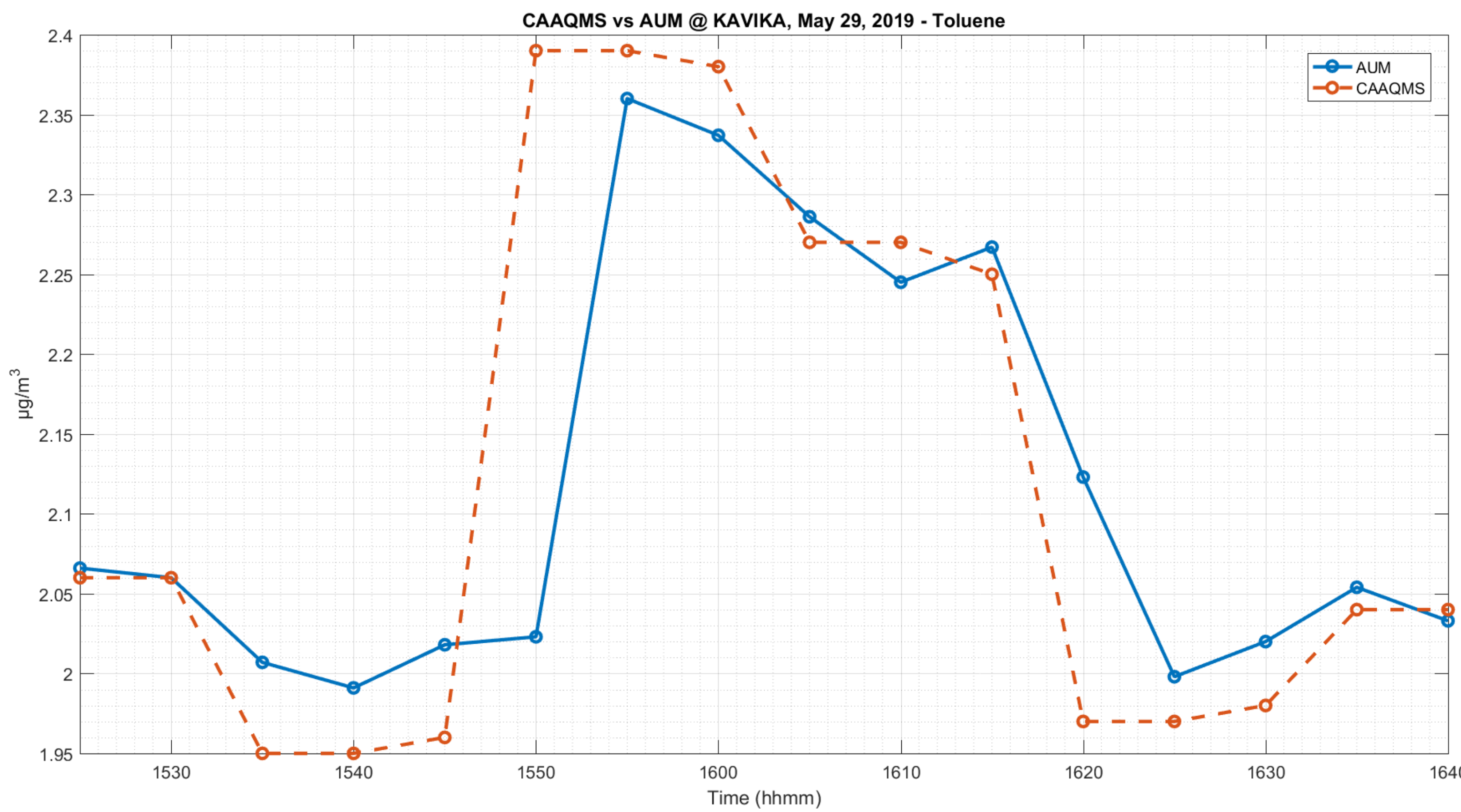
Intercomparison between CAAQMS data and AUM results at KAVIKA on May 29, 2019-PM2.5
AUM
CAAQMS
µg/m3
Time
58
57
56
55
54
53
52
51
50
49
48
1530
1540
1550
1600
1610
1620
1630
1640


CAAQMS vs AUM @ KAVIKA, May 29, 2019 - RH
AUM
CAAQMS
%
40.2
40
39.8
39.6
39.4
39.2
39
38.8
1530
1540
1550
1600
1610
1620
1630
1640
Time (hhmm)

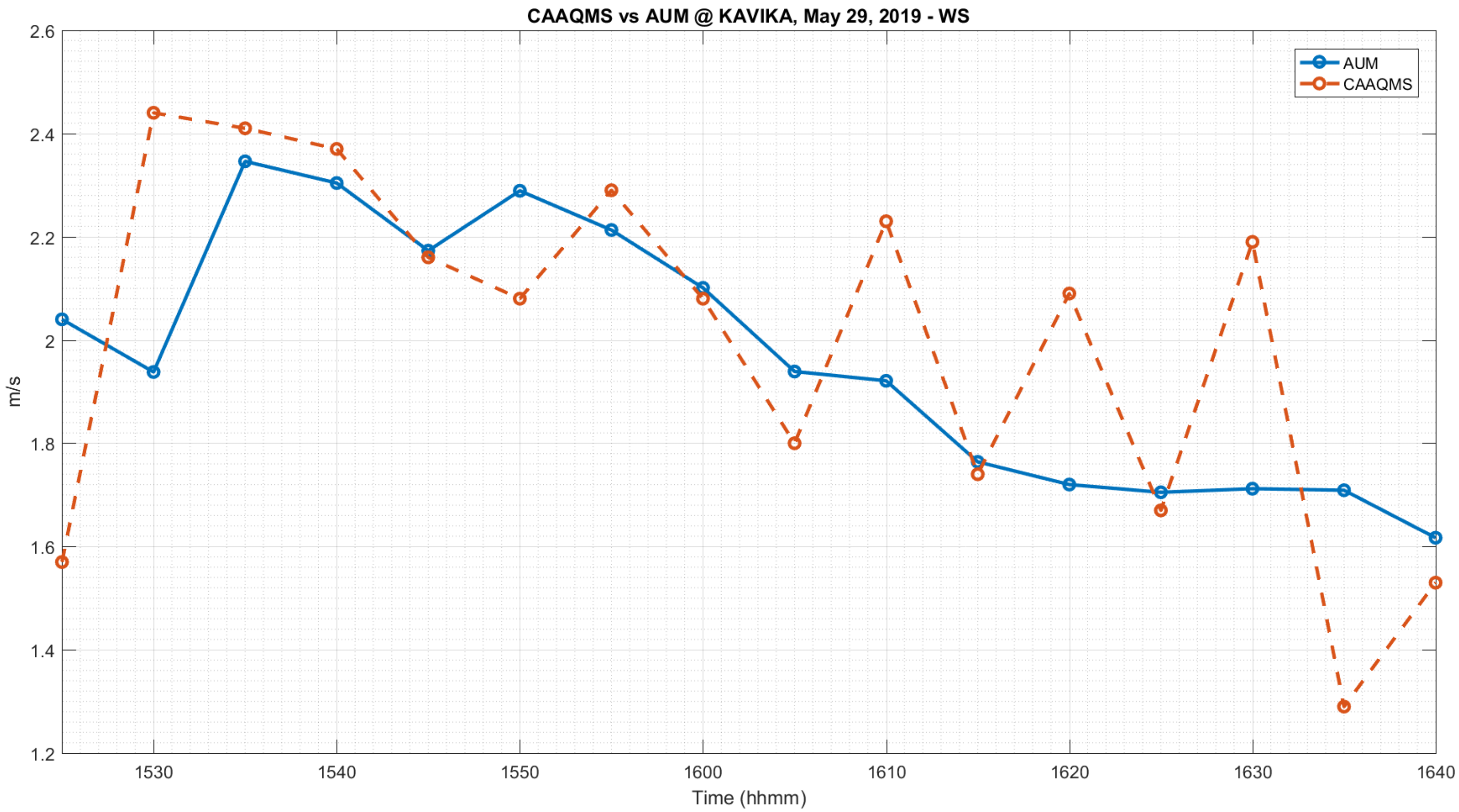

CAAQMS vs AUM @ KAVIKA, May 29, 2019 - SO2
AUM
CAAQMS
μg/m3
1.04
1.02
1
0.98
0.96
0.94
0.92
0.9
1530
1540
1550
1600
1610
1620
1630
1640
Time (hhmm)

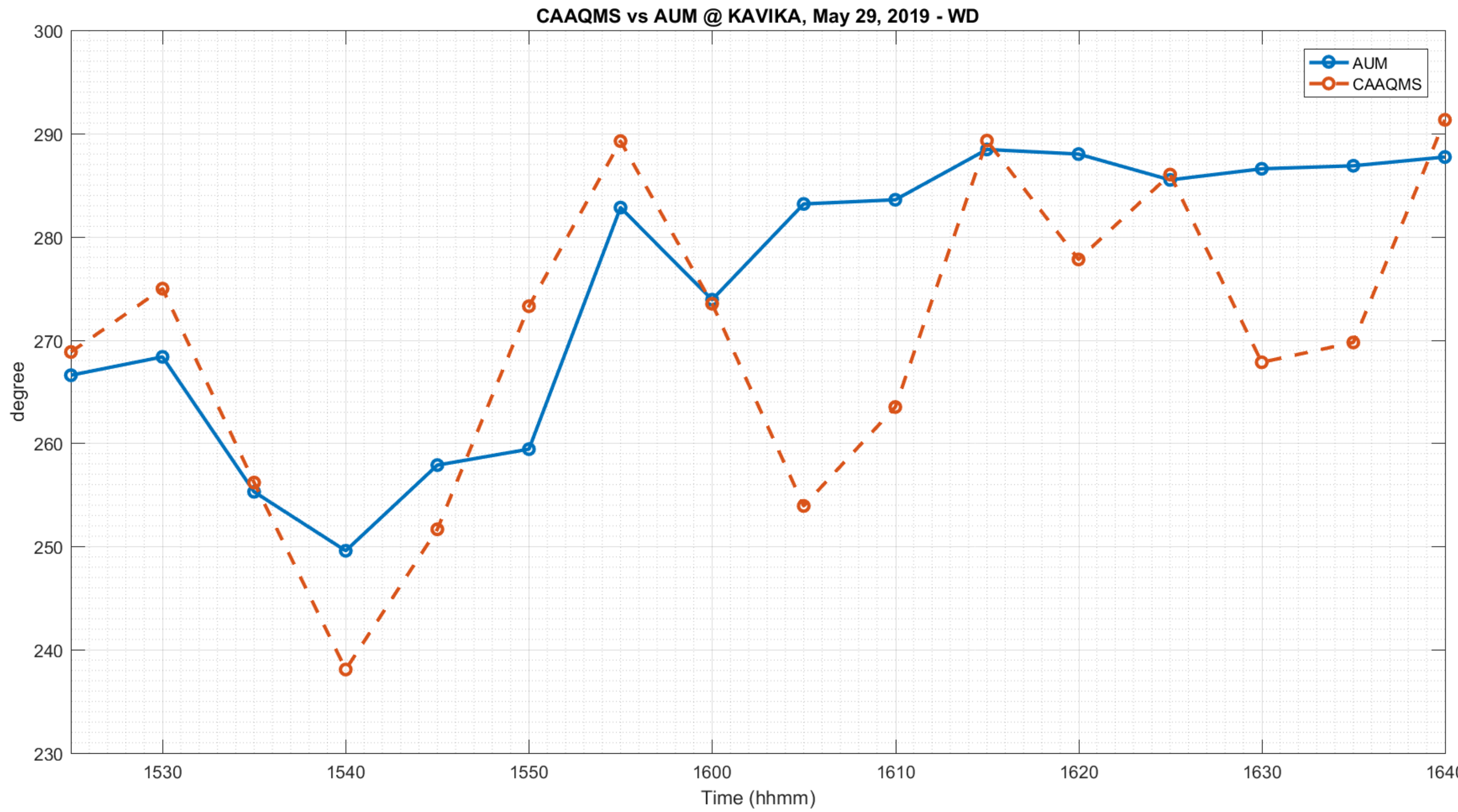


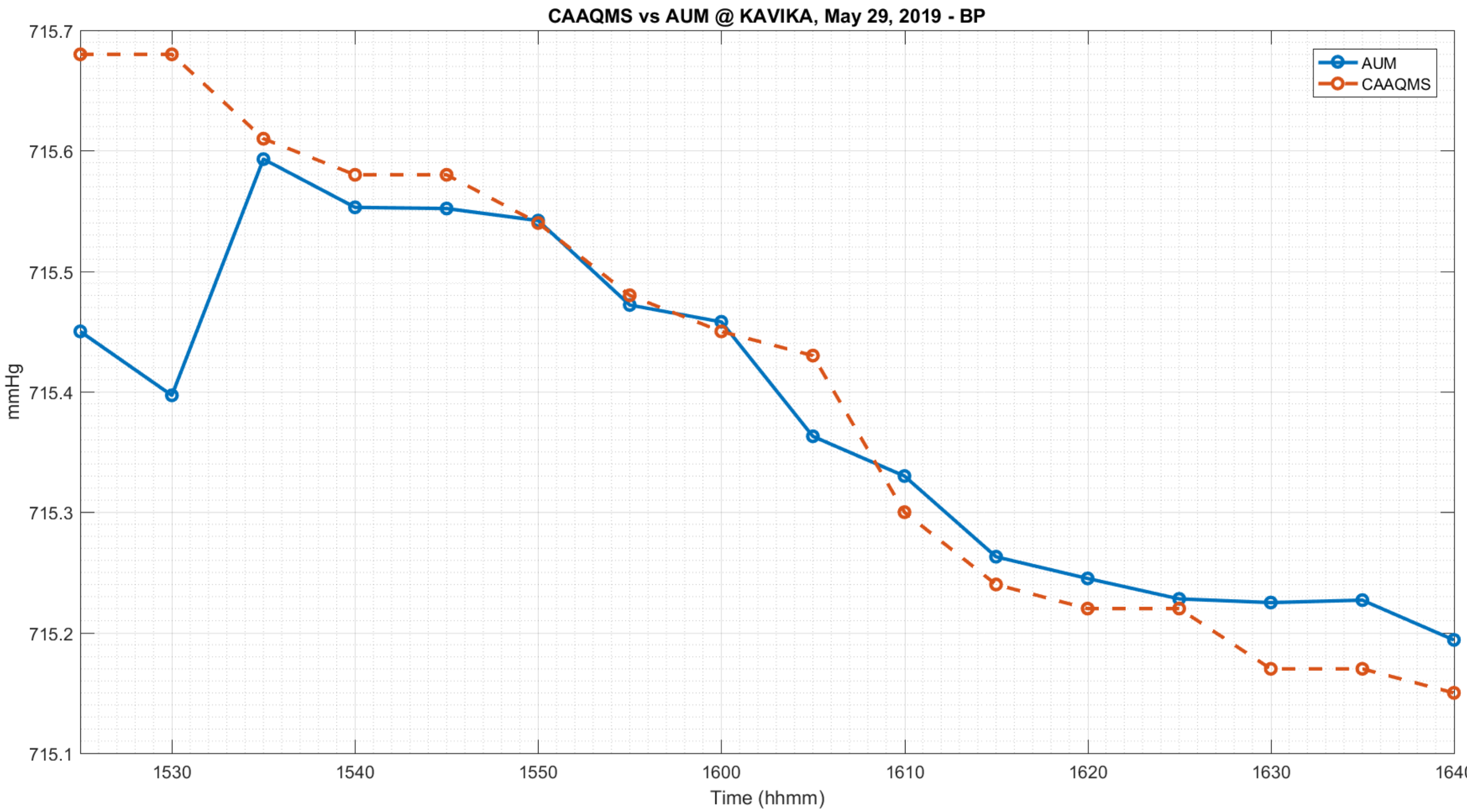
CAAQMS vs AUM @ KAVIKA, May 29, 2019 - Temp
AUM
CAAQMS
°C
33.2
33.1
33
32.9
32.8
32.7
32.6
1530
1540
1550
1600
1610
1620
1630
1640
Time (hhmm)



CAAQMS vs AUM @ KAVIKA, May 29, 2019 - Toluene
AUM
CAAQMS
μg/m3
2.4
2.35
2.3
2.25
2.2
2.15
2.1
2.05
2
1.95
1530
1540
1550
1600
1610
1620
1630
1640
Time (hhmm)


CAAQMS vs AUM @ KAVIKA, May 29, 2019 - WS
AUM
CAAQMS
m/s
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1530
1540
1550
1600
1610
1620
1630
1640
Time (hhmm)


CAAQMS vs AUM @ KAVIKA, May 29, 2019 - WD
AUM
CAAQMS
degree
300
290
280
270
260
250
240
230
1530
1540
1550
1600
1610
1620
1630
1640
Time (hhmm)



CAAQMS vs AUM @ KAVIKA, May 29, 2019 - BP
AUM
CAAQMS
715.7
715.6
715.5
715.4
715.3
715.2
715.1
mmHg
1530
1540
1550
1600
1610
1620
1630
1640
Time (hhmm)

Summary and Conclusions

Inter Comparisons at SG HALLI Station: Average values during study period

Parameter	Environment SA, France **CAAQMS**	CATS Eco Systems, India **AUM**	difference in value ***(CAAQMS ~ AUM)***
NO (*μg/m³*)	*2.86375*	*2.795175*	*0.068575*
NO_2 (*μg/m³*)	*9.25125*	*9.41765*	*0.1664*
NO_X (*μg/m³*)	*12.075*	*12.04778*	*0.02722*
SO_2 (*μg/m³*)	*4.5575*	*4.473213*	*0.084287*
CO (*mg/m³*)	*0.5325*	*0.530559*	*0.001941*
PM_{10} (*μg/m³*)	*65.29*	*59.42359*	*5.86641*
WS (*m/s*)	*2.305*	*2.301388*	*0.003612*
WD (*deg*)	*161.855*	*160.7844*	*1.0706*
SR (*W/m²*)	*709.3438*	*710.215*	*0.8712*

Inter Comparisons at KAVIKA Station: Average values during study period

Parameter	Eco Tech, Australia **CAAQMS**	CATS Eco Systems, India **AUM**	difference in value ***(CAAQMS ~ AUM)***
CO (*mg/m³*)	0.51	0.491731	0.018269
O_3 (*μg/m³*)	62.28563	61.22442	1.06121
NO (*μg/m³*)	6.605625	6.570994	0.034631
NO_2 (*μg/m³*)	28.5475	28.44186	0.10564
NO_X (*μg/m³*)	35.15375	35.01759	0.13616
NH_3 (*μg/m³*)	19.32563	18.77049	0.55514
SO_2 (*μg/m³*)	0.9575	0.94825	0.00925
$PM_{2.5}$ (*μg/m³*)	54.25	54.9875	0.7375
PM_{10} (*μg/m³*)	98.125	94.95375	3.17125
Benzene (*μg/m³*)	0.86125	0.855938	0.005312
Toluene (*μg/m³*)	2.120625	2.118	0.002625
p- Xylene (*μg/m³*)	2.536875	2.553688	0.016813
o- Xylene (*μg/m³*)	0.3675	0.401	0.0335
Ei- Benzene (*μg/m³*)	0.404375	0.411688	0.007313
Temperature (*°C*)	32.81313	32.849	0.03587
RH (*%*)	39.58313	39.69469	0.11156
WS (*m/s*)	1.99625	1.968188	1.40576
WD (*deg*)	270.3306	275.2345	1.814029
BP (*mmHg*)	715.4063	715.3808	0.00356

Based on the inter comparison studies at SG Halli and KAVIKA stations we therefore conclude that the AUM indigenous photonic system is well suited for continuous ambient air quality monitoring as per the guidelines and standards issued by CPCB, Ministry of Environment and Forests, Government of India.

The additional features of AUM system, *viz*. compact, portable, light weight, low power consumption, one system to monitor all air quality parameters simultaneously at very high sampling intervals with high accuracies and sensitivities make it more suitable and attractive for field applications in the real world compared to the existing conventional systems.