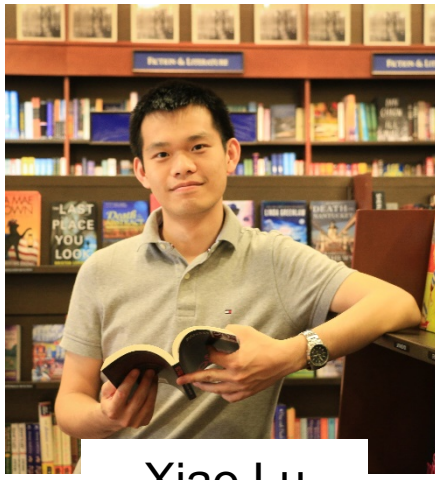
Tropospheric Ozone Assessment Report Phase II (TOAR II)
East Asia Focus Working Group (EAWG)



Xiao Lu
Harvard U.

Ke Li
Harvard U.

Tatsuya Nagashima
NIES of Japan

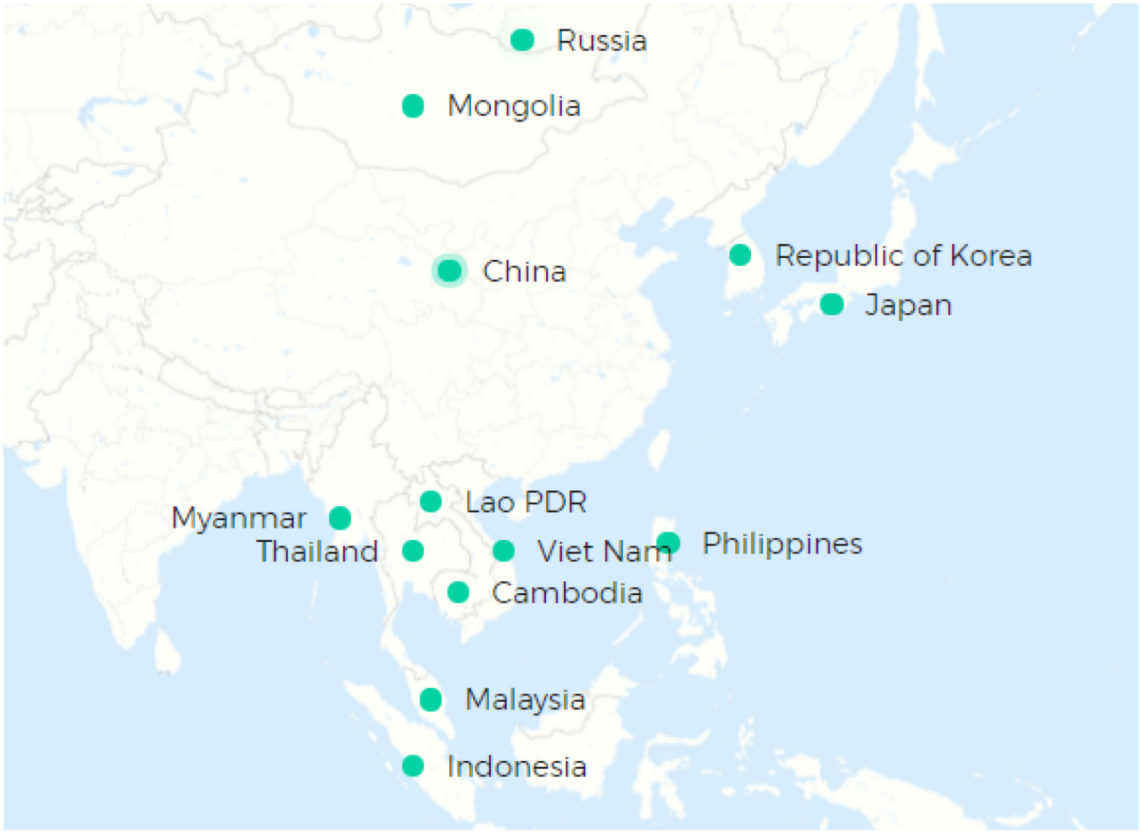
Ja-Ho Koo
Yonsei U.

TOAR tropospheric ozone assessment report Phase II

March 10, 2021

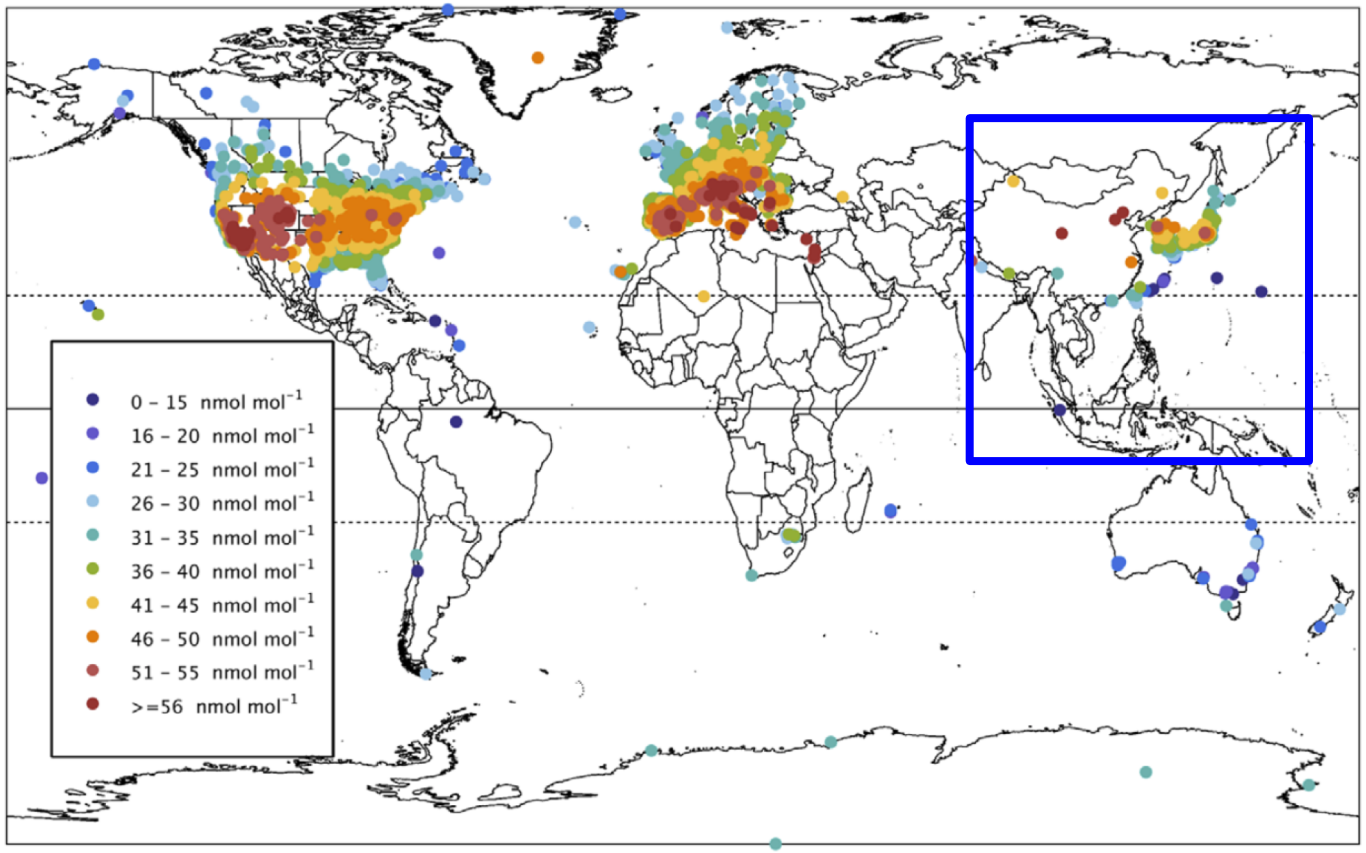
TOAR-II EAWG Motivation: ozone over EA was not well characterized in TOAR I

The East Asia region



https://www.eanet.asia/

JJA daytime average ozone, 2010-2014, TOAR I



[Gaudel et al., 2018, Elementa]

TOAR-II EAWG Challenges and priorities in ozone study over East Asia

Data collections

- Surface/free tropospheric ozone observations are still sparse, some data are out there but not publically accessible.
- Auxiliary/supporting data (precursor measurements, meteorological parameters/emission inventory, etc.) are poorly collected or shared.

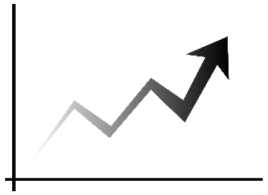
Ozone trend attributions and global impacts

- Ozone trends in East Asia are not well understood, models fail to capture the trends and disagree with each other on the trend attributions.
- Global impacts of ozone change in East Asia need to be re-evaluated.

TOAR-II EAWG Goals

Goal 1: Construction of the EAO3 database

- Ozone measurements from surface to free troposphere.
- Auxiliary data, including in-situ meteorological data, ozone precursor and aerosol measurements, gridded anthropogenic and natural emissions, geographic data, etc.



Goal 2: Quantification of factors driving EA ozone trends

- Quantify climatic and chemical factors driving EA ozone trends over East Asia, reconciling the results from different methods (statistics/CTMs/ML) using the same (similar) data source in EAO3 database.

Goal 3: Quantification of global influences of EA ozone and precursors

- Quantify the influences of East Asia ozone and precursor outflow on intercontinental ozone transport, the global ozone budget, and radiative forcing.

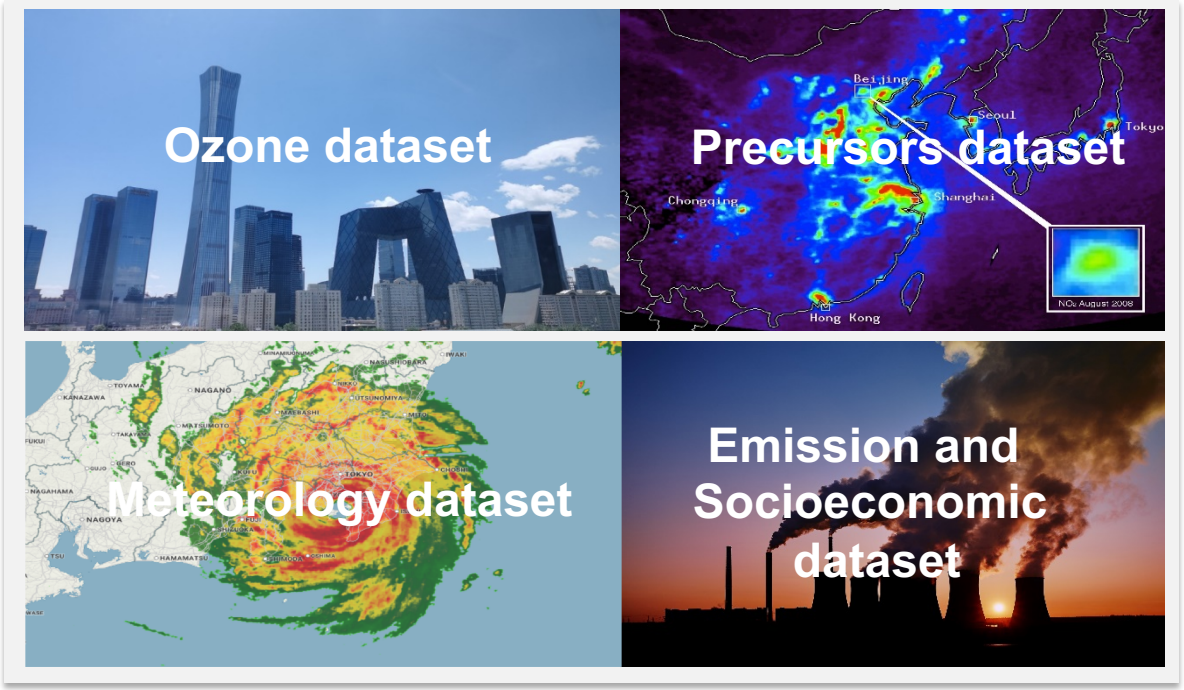
TOAR-II EAWG Goal 1: Construction of the EAO3 database

Help to maximize data sources

Guide data portal, credit attributions, copyright handling, web service?

EAO3 database

TOAR II database



(Candidate data are listed in Table A1 in the proposal)

Ozone dataset

- Ozone from the surface to tropopause (ozonesonde/lidar, aircraft, satellite), providing full pictures of ozone over EA.

Precursors dataset

- NO_x, CO, VOCs, PANs, $PM_{2.5}$ from site observations, field campaigns, and satellite observations, supporting study on ozone chemistry, model validation, etc.

Meteorology dataset

- In situ observations of meteorological parameters, supporting O_3-meteorology relationship studies and modeling activities.

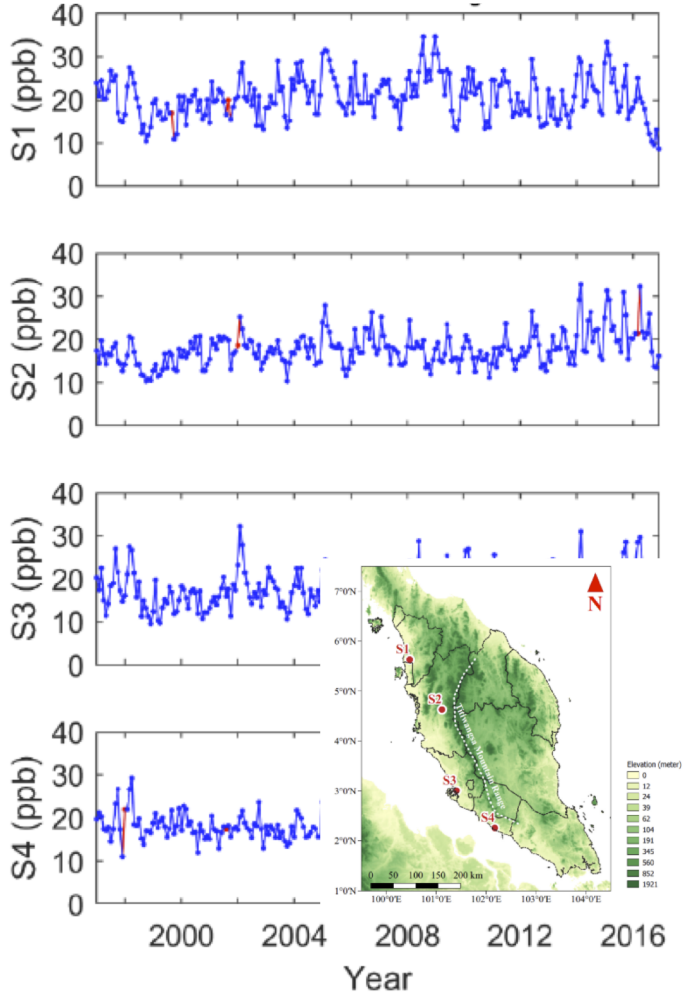
Emission dataset

- Include anthropogenic and natural emissions for supporting modeling (CTM/statistical/ML) activities.

TOAR-II EAWG Goal 1: Construction of the EAO3 database

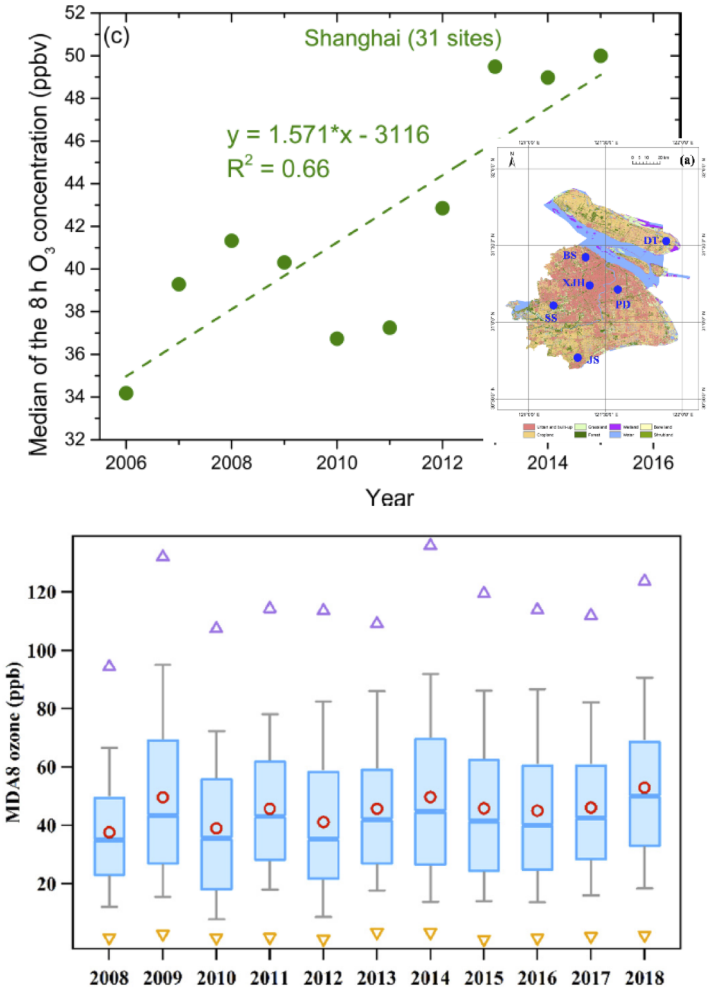
Examples of EA ozone measurements not included in the nationwide monitoring network (Table A1)

20-year surface ozone in Malaysia



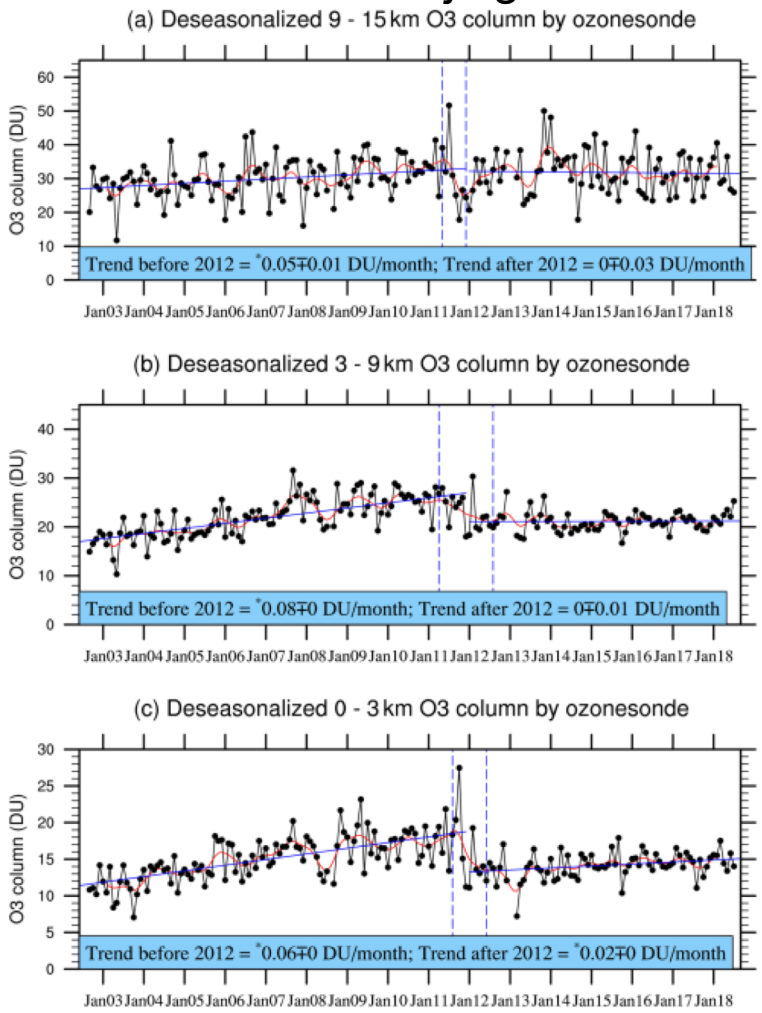
[Ahamad et al. 2020]

15-year surface ozone in Shanghai/Guangzhou



[Xu et al. 2019; Yin et al., 2019]

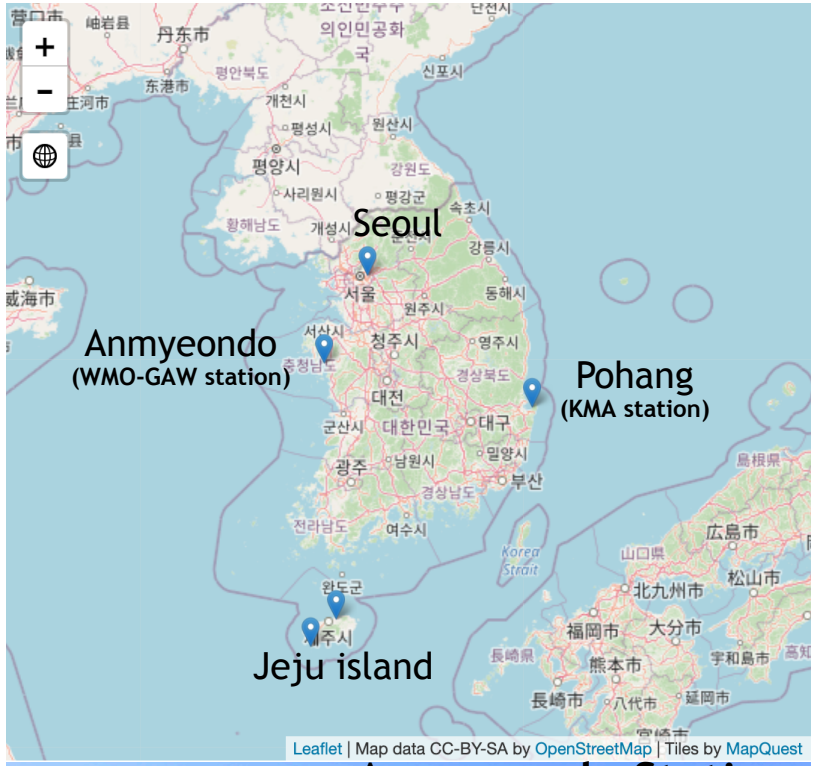
15-year tropospheric ozone in Beijing

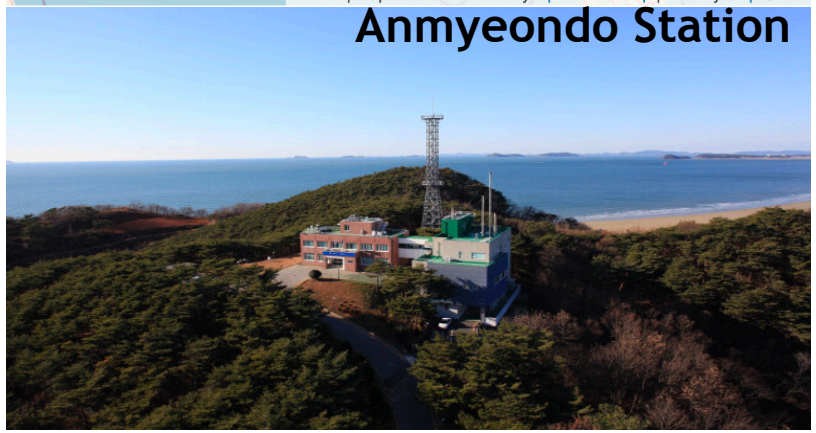


[Zhang et al., 2020]

TOAR-II EAWG Goal 1: Construction of the EAO3 database

Highlight: ozonesonde measurement plan in South Korea





Plan 2021 at Anmyeondo

- JUL-AUG: ~30 launches for the pre-ACCLIP and GEMS validation
  (ACCLIP: Asian Summer Monsoon Chemical and Climate Impact Project by NCAR and NASA)
- SEP-OCT: ~20 launches for the domestic monitoring with NIER
  (NIER: National Institute of Environmental Research, Korea)
- OCT: preliminary results will be presented in the Quadrennial Ozone Symposium (**QOS**). **3-9 October** **(qos2021.yonsei.ac.kr)**

Plan 2022 at Anmyeondo

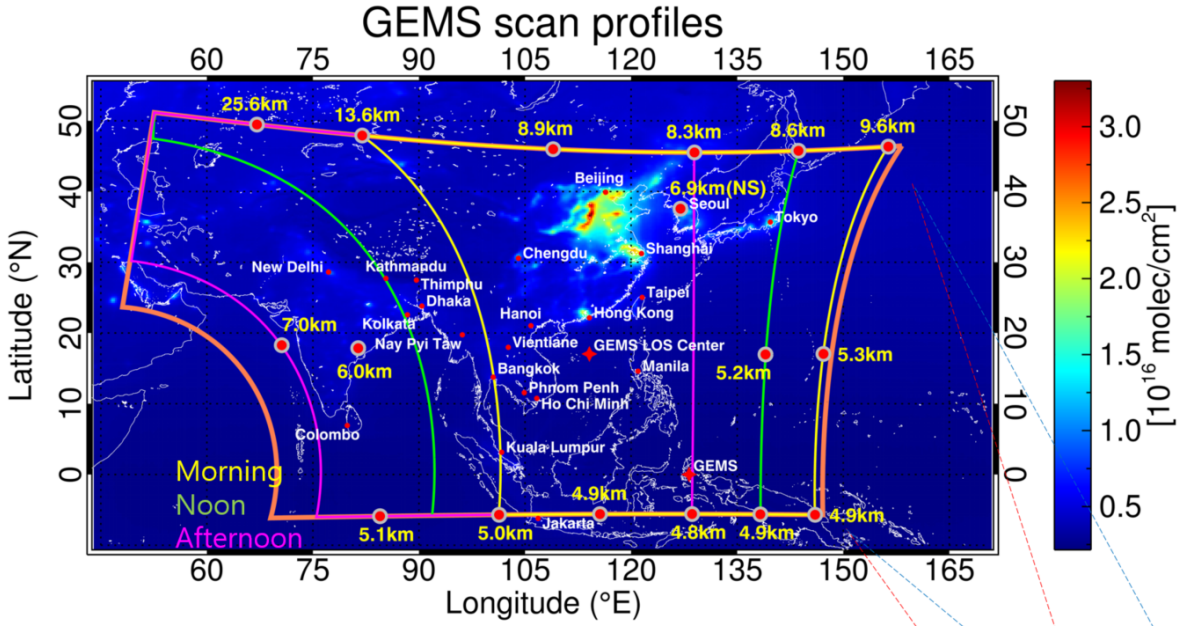
- MAY-JUN: ~20 launches for the domestic monitoring with NIER
  (comparison to the findings during the Korea-US Air Quality campaign, KORUS-AQ, in 2016)
- JUL-AUG: ~30 launches for the main ACCLIP and GEMS validation

Plan at Pohang

- Launching about every week since 1995.

TOAR-II EAWG Goal 1: Construction of the EAO3 database

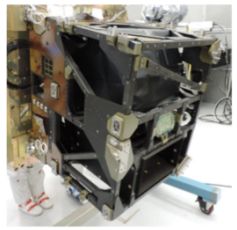
Highlight: Geostationary Environment Monitoring Spectrometer (GEMS)

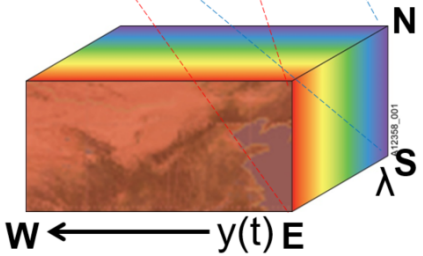


2048 N-S x 695 E-W
x 8 times/day
= 11,386,880 spectra/day

x 20 products

Kim et al. (BAMS, 2020)

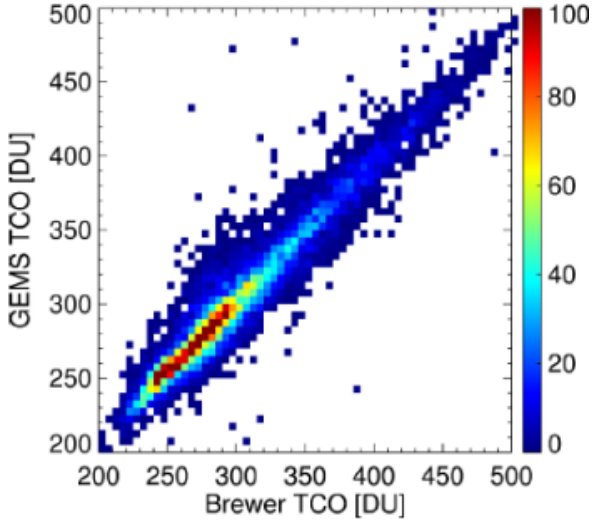




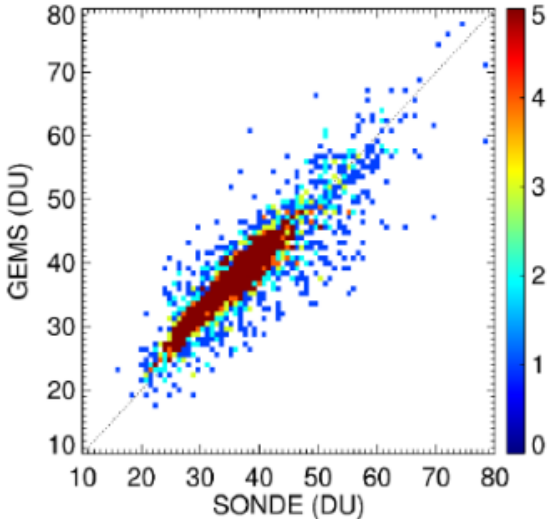
Inter-comparison

(Courtesy of Jae-Hwan Kim, Pusan national Univ.)

Total column ozone (TCO)
X: Brewer obs. Y: pre-GEMS
(2004-2008)



Ozone profile
X: ozonesonde obs. Y: pre-GEMS
(2005-2006)



Time table:

- Spring 2021: Total column ozone data will be released.
- Spring 2022: Tropospheric ozone and ozone profiles will be released.

GEMS

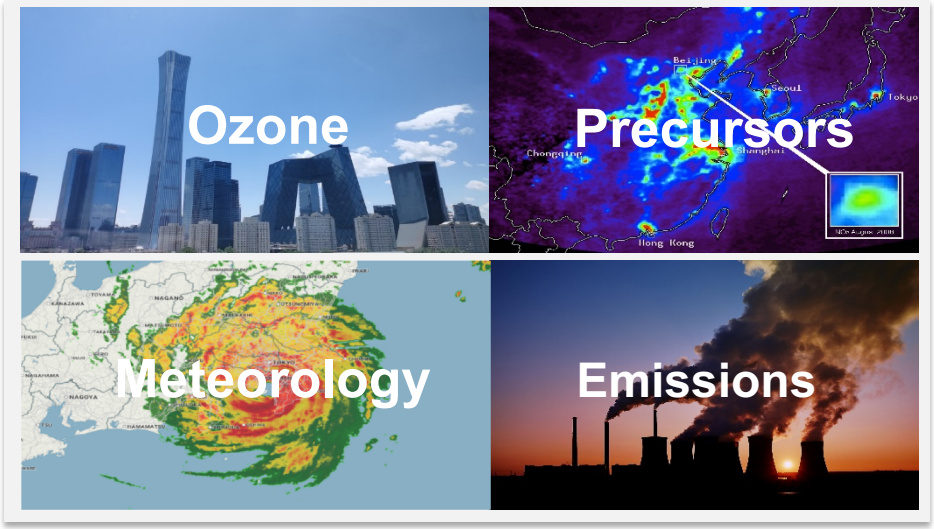
National Institute of Environmental Research

TOAR-II EAWG Goal 2: Quantification of factors driving EA ozone trends

Key questions to be answered:

- What causes the model biases/discrepancies in capturing short-term/long-term ozone trends over EA?
- What are the relative contributions of chemical vs. climatic factors to ozone trends? Can we reconcile the results from different methods?

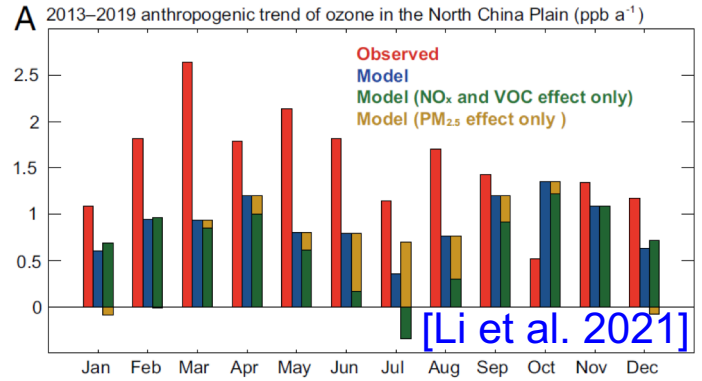
EAO3 database



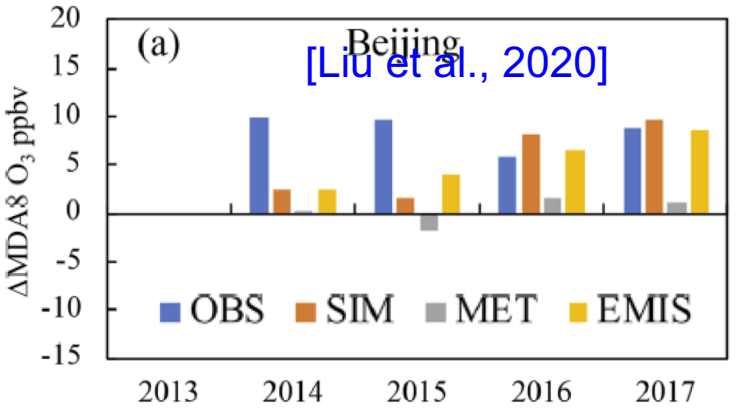
Different modeling tools

- Statistical models
- Machine learning methods
- Chemical model simulations

O_3 trend attributions



[Li et al. 2021]



[Liu et al., 2020]

TOAR-II EAWG Goal 3: Quantification of global influences of EA O_3 and precursors

Key questions to be answered:

- What are the short-term and long-term contributions of EA emissions to air quality downwind, global ozone budgets, and radiative forcing?

EAO3 database

Chemical (global) model simulations

EA ozone influences on:

- Downwind air quality
- Global ozone budgets
- Ozone radiative forcing

TOAR-II EAWG Team: 14 members from 7 countries/regions

Surface measurement; Ozonesonde; Satellite; Model

China: Meng Gao (Hong Kong Baptist University)
Jianlin Hu (Nanjing University of Information Science and Technology)
Keding Lu (Peking University)
Xiaobin Xu (China)
Likun Xue (Shandong University)

Japan: Junichi Kurokawa (Asian Center for Air Pollution Research)
Keiichi Sato (Asian Center for Air Pollution Research)
Seiji Sugata (National Institute for Environmental Studies)

South Korea: Juseon Bak (Pusan National University)
Dongwon Lee (National Institute of Environmental Research)
Mee-Hye Lee (Korea University)
Joowan Kim (Kongju National University)

USA: Yuqiang Zhang (Duke University)

Malaysia: Mohd Talib Latif (Universiti Kebangsaan Malaysia)

Thailand: Kasemsan Manomaiphiboon (King Mongkut's University of Technology Thonburi)

Vietnam: Nguyen Tran Huong Giang (Da Lat University)

TOAR-II EA WG Expected outcome

- **The EAO3 database for supporting ozone research over East Asia.**

- **A research article introducing the EAO3 database and overviewing the ozone and precursor levels/variations over East Asia.**
- **A research article quantifying factors driving ozone trends over East Asia from different approaches.**
- **A research article quantifying global influences of East Asian ozone and precursors.**

TOAR-II EAWG Connections to the TOAR II and other WGs

Statistics Working Group

- Guide trend calculations

Share observations/model results and interpretations

TOAR tropospheric ozone assessment report Phase II

- Update EA ozone trends;
- Estimate global influences

- Guide data analyses and interpretation

East Asia Focus Working Group

ACM Working Group

South Asia Working Group

OPT Working Group

etc.

Help to maximize data sources

Guide data portal and web service?

TOAR II database

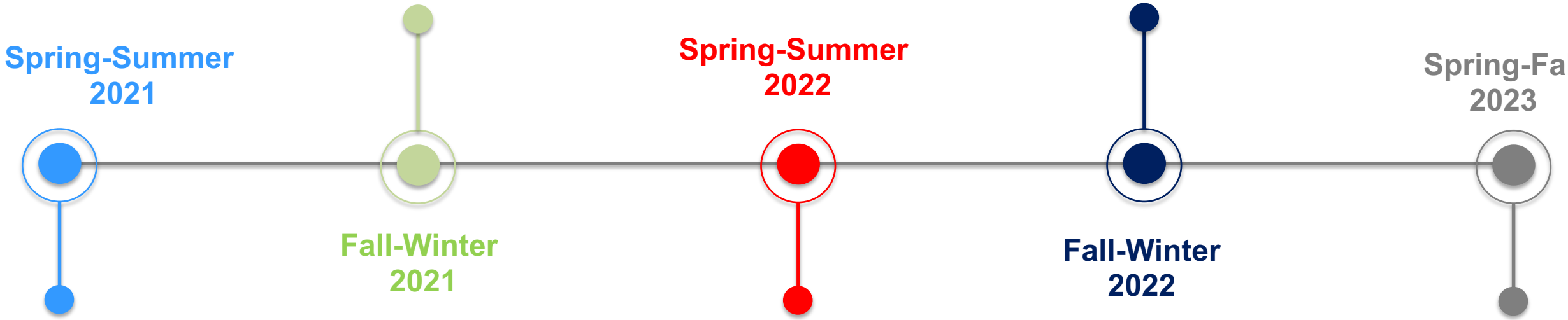
EAO3 database

Benefit future ozone study over East Asia!

TOAR-II EAWG Roadmap

- Collect and compile the EAO3 dataset.
- Discuss the Statistical/ML/CTMs setup.

- Complete CTM simulations for ozone trend attribution.
- Compare the results from different approaches for ozone trend drivers.
- Conduct CTM simulations to quantify the impacts of EA ozone.



- EAWG Kick-off meetings.
- Outline EAO3 dataset categories.
- Reach out and invite research groups who would be interested in providing ozone and auxiliary data or joining modeling activities.

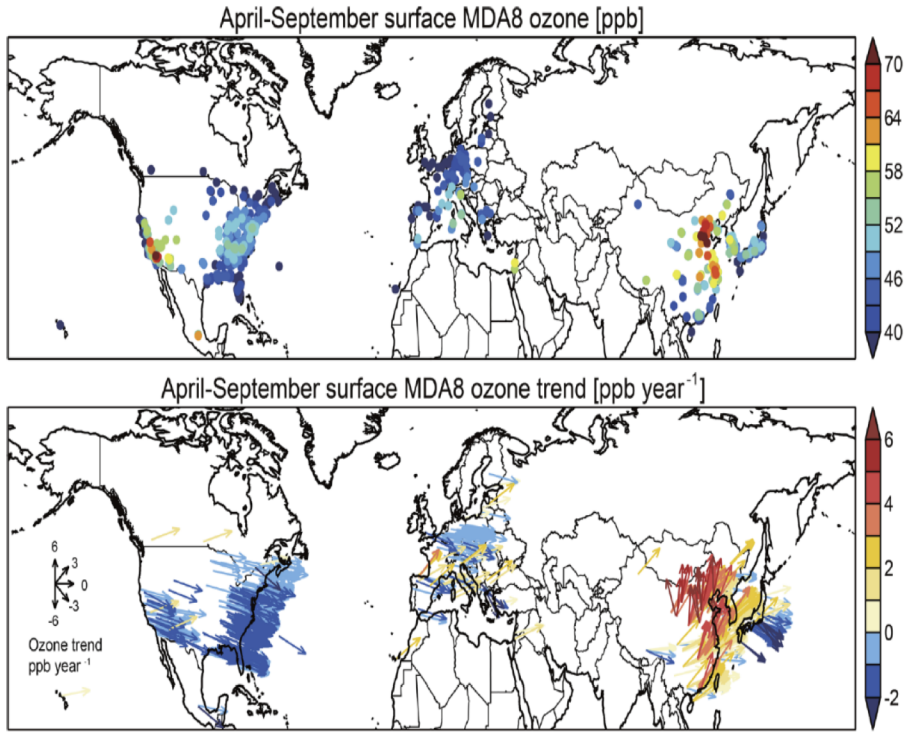
- Complete and release the EAO3 dataset.
- Conduct and complete statistical analyses for ozone trend attributions.
- Conduct CTM simulations for ozone trend attribution.

- Wrap up results and prepare for publication.
- Summit for publication by 1 September, 2023

Back-up slides

TOAR-II EAWG Motivation: EA is the current hotspot of ozone research

High and rising EA ozone levels

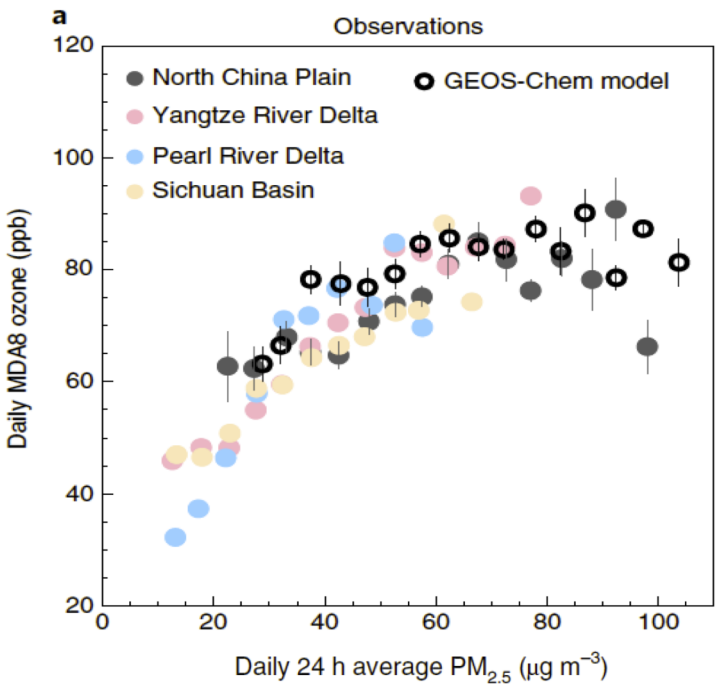


China: 2013-2019; Others (TOAR I) : 2010-2014

China has the highest ozone levels and fastest short-term increasing rates

[Lu et al. 2018, ESTL]

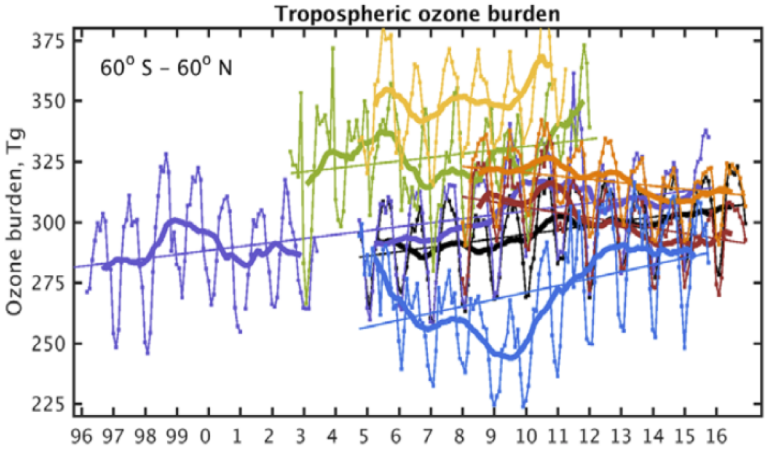
"Unique" and complex precursor-O_3-$PM_{2.5}$ chemistry



Suppression of O_3 in high $PM_{2.5}$ conditions over China

[Li et al. 2019, Nature Geoscience]

Global influences



	change, Tg yr^{-1}	p-value
Black: OMI/MLS	0.95 +/- 0.55	0.00
Brown: IASI-FORLI	-1.01 +/- 1.17	0.09
Orange: IASI-SOFRID	-0.73 +/- 0.81	0.08
Purple: GOME/OMI	0.82 +/- 0.35	0.00
Blue: OMI-RAL	1.02 +/- 0.79	0.01
Green: SCIAMACHY	1.33 +/- 1.04	0.01
Yellow: TES		

Global O_3 burden increases

⇅

EA O_3 increases

[Gaudel et al. 2018, Elementa]