The Hong Kong Polytechnic University
香港理工大學

Tropospheric ozone trend in Hong Kong during 1994-2018: the role of emission and climate change in subtropical Asia

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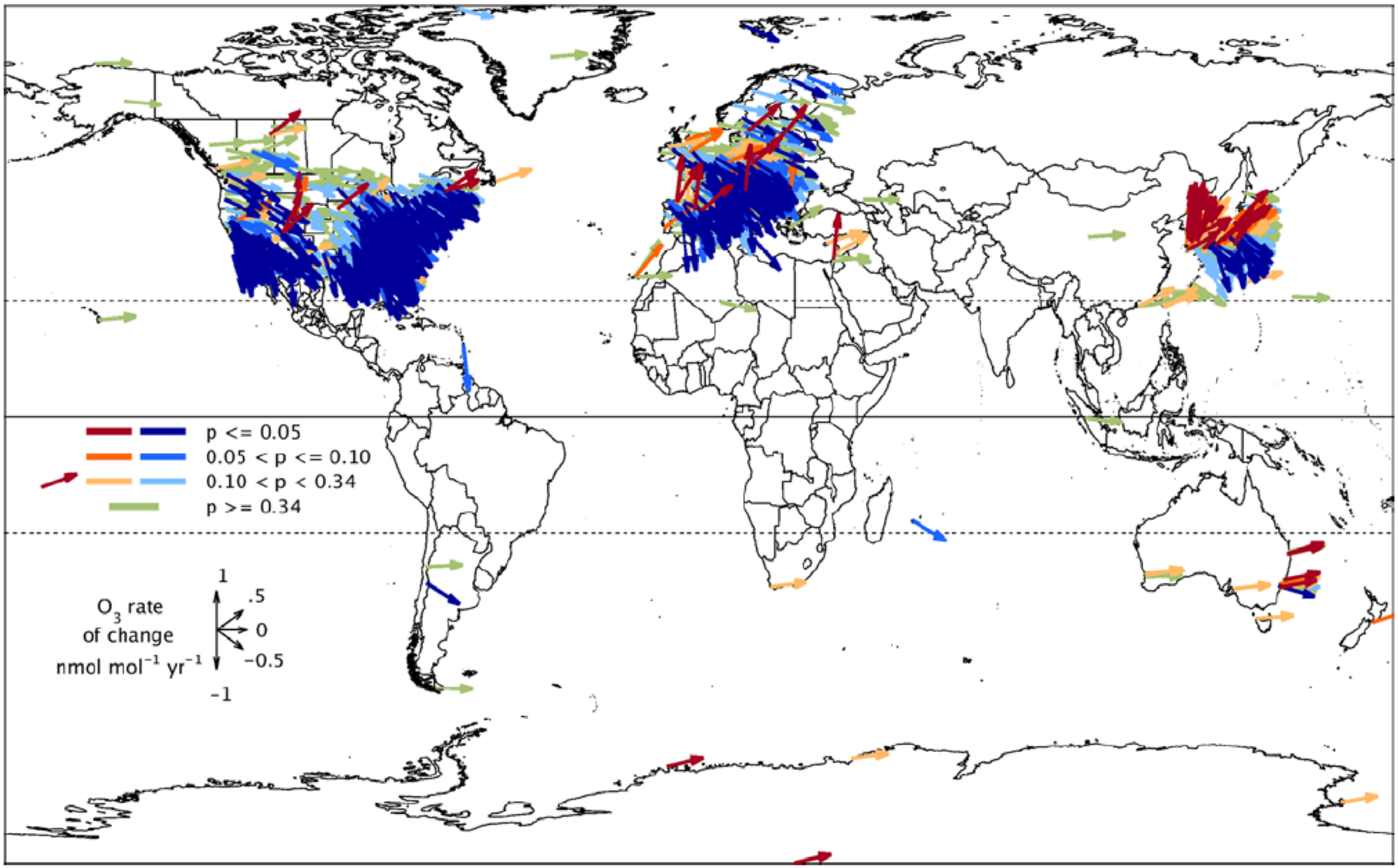
Content

- **Introduction**
  - measurements in Hong Kong
- **Analysis of long-term ozone trend**
  - climate vs. emission
- **A new research initiative**

Importance of Tropospheric Ozone

- **Main source of OH radicals**
- **Greenhouse gas**
- **Pollutant at ground level**
- **No long-term ozone data prior to the early 1990s in southern and eastern China**

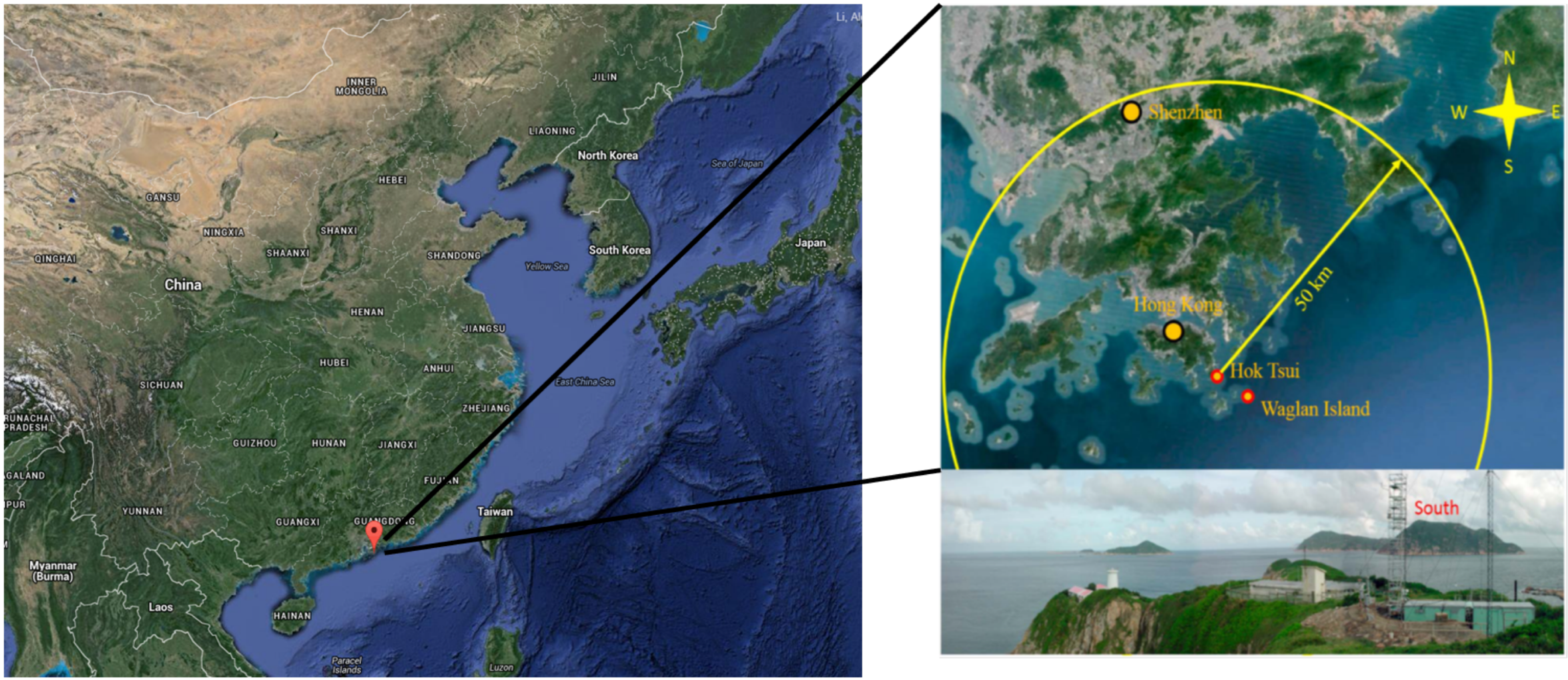
Also limited long-term data in Southeast Asia



2000–2014 trends of daytime average ozone (ppb yr^{-1}) at 1784 non-urban sites in June–July–August.

Gaudel et al., 2018

HK PolyU measured surface ozone and CO since 1994 at coastal site in Hong Kong

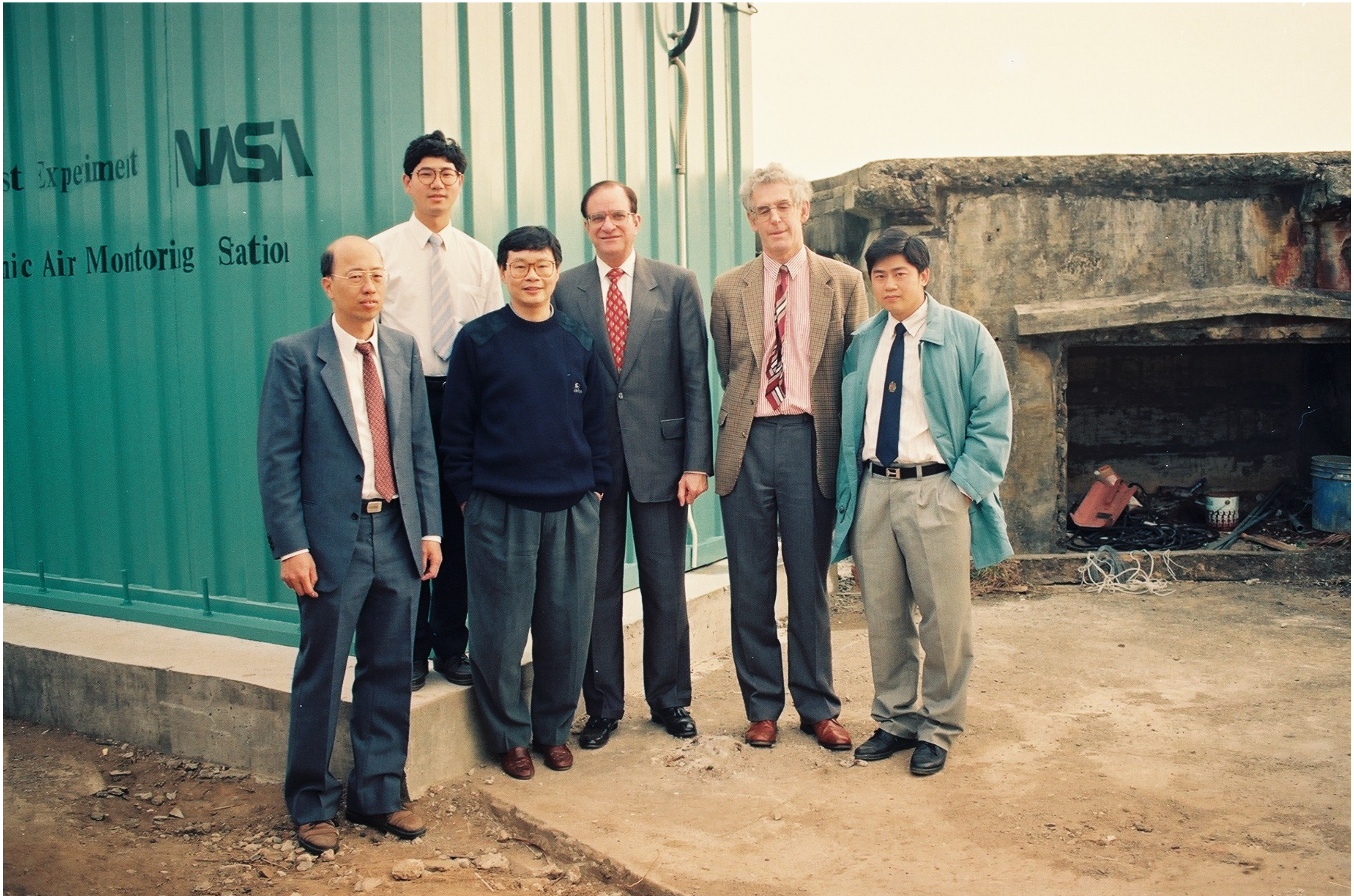


The site before

One container initially (1993)

Two containers since 1995

Some key people involved in setting up the station



Some key people involved in setting up the station

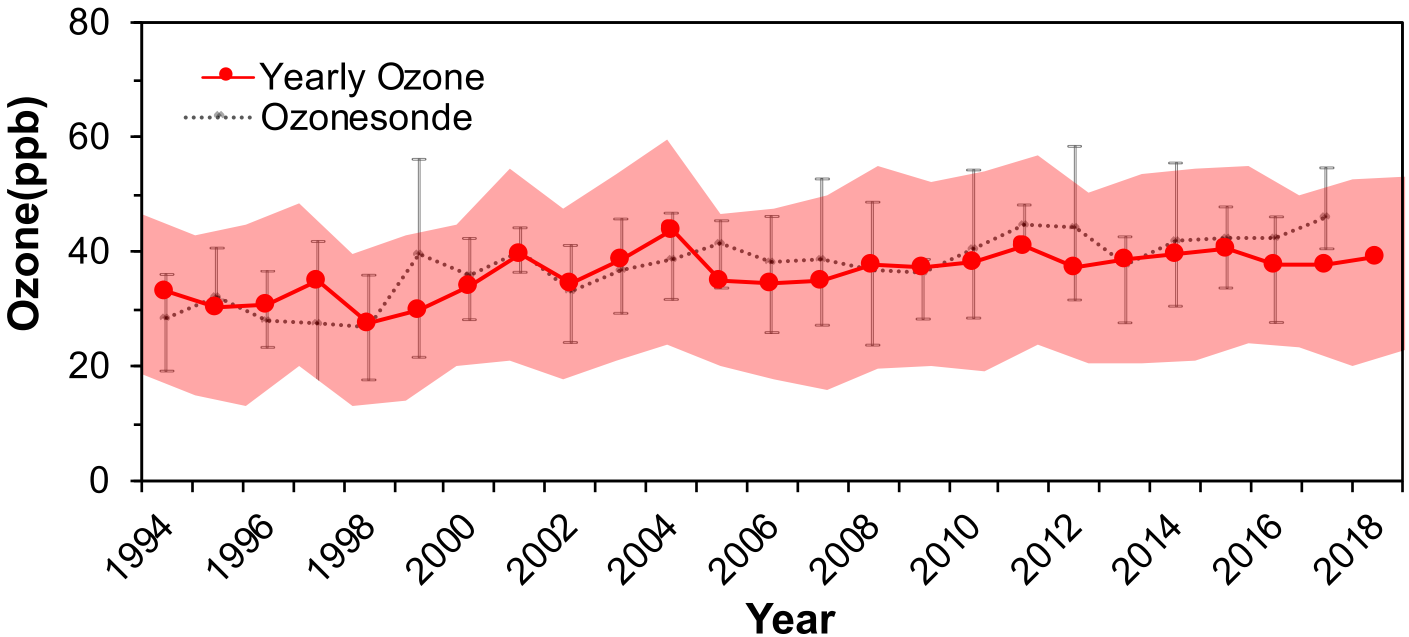
NASA DC 8 research aircraft stationed at Kai Tak Airport during PEM-WEST B (Feb 1994)

NASA DC 8 research aircraft stationed at Chek Lap Kok Airport during TRACE-P (Feb 2001)

Results

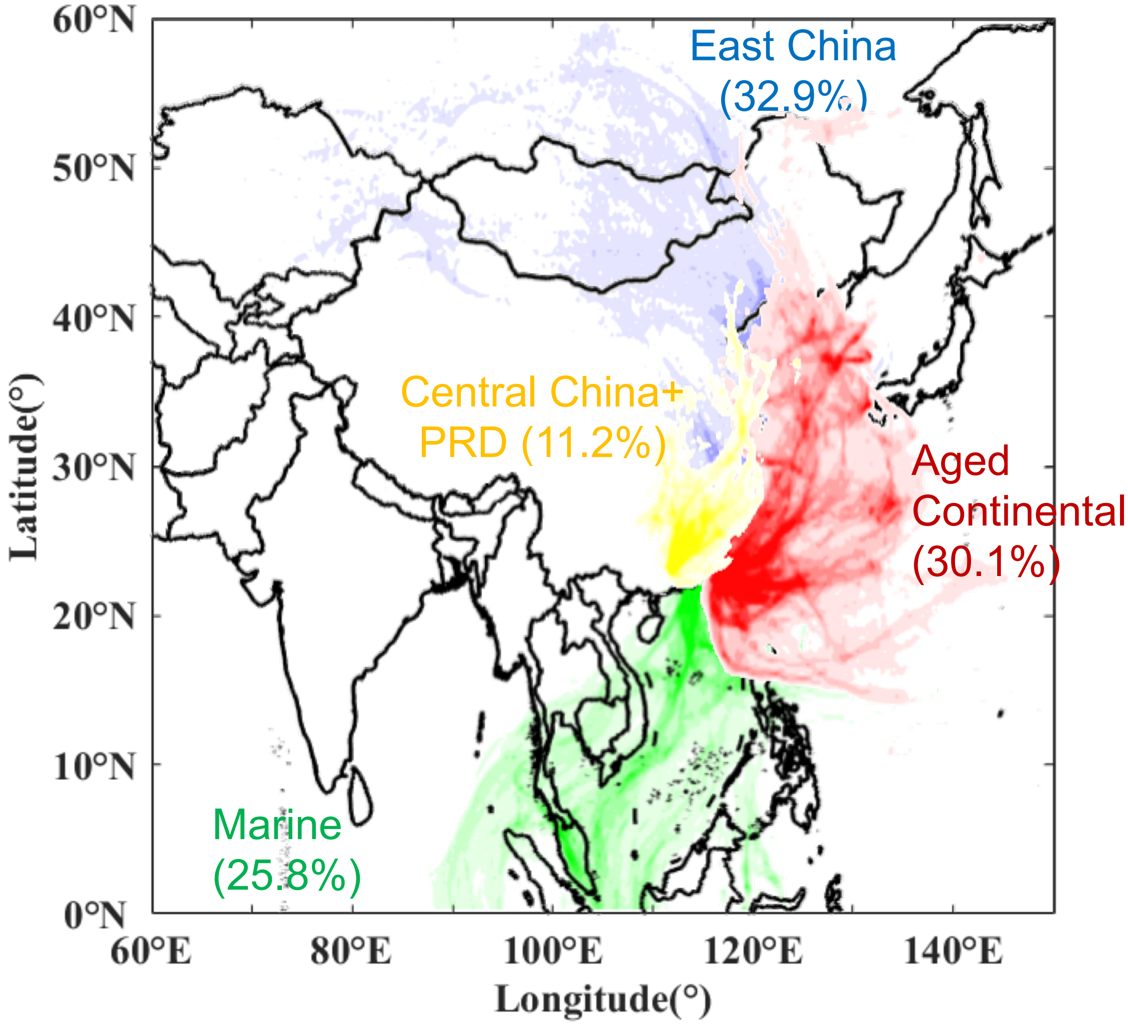
- Ozone trend in 1994-2018 in the overall and in different air masses
  - focus on the large increase in maritime ozone
- Satellite-observed ozone precursors in SE Asia
- Large-scale meteorology in SE Asia
- Impact of changes in summer climate on marine ozone (using WRF-Chem model)

Yearly mean ozone mixing ratios at Hok Tsui (HT) in 1994-2018

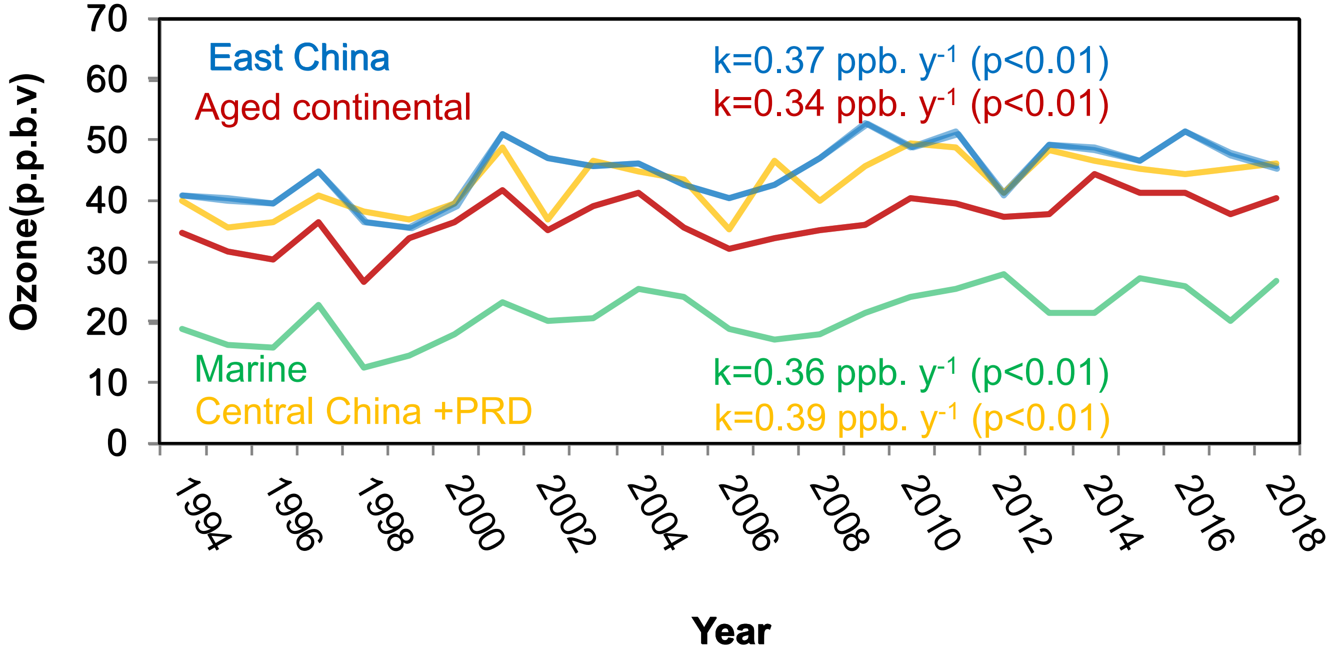


- An upward trend at rate of 0.35 ppb year^{-1}(yr^{-1}) ($p<0.01$)
- Ozonesonde (0- km) during 1994-2017 in Hong Kong increased by 0.59 ppb yr^{-1} ($p<0.01$)

Four major types of air masses

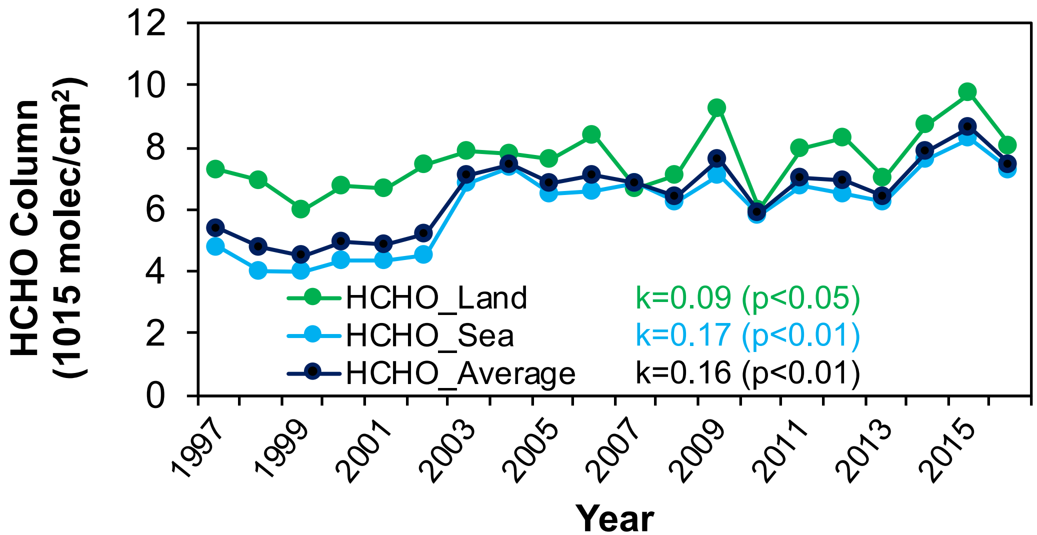


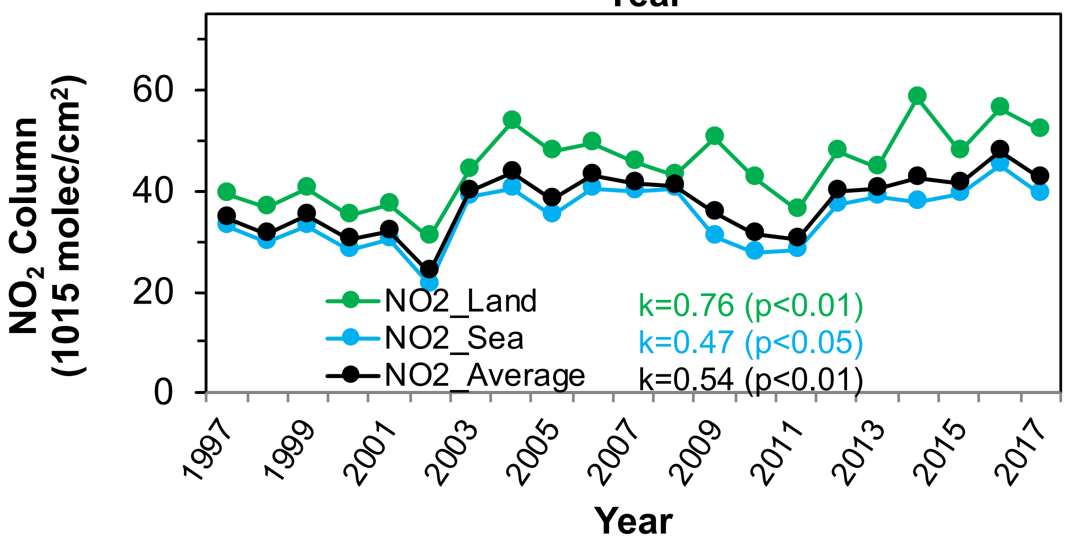
Surface ozone in the four air-mass groups

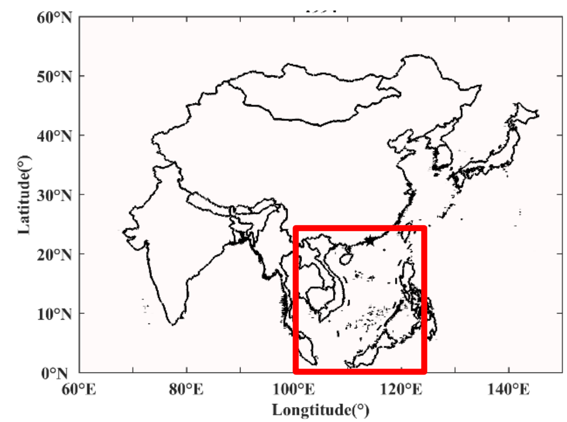


- Ozone increased in all four major air masses
- Largest rate (relative rate) of increase in marine air

Long-term changes in ozone precursors





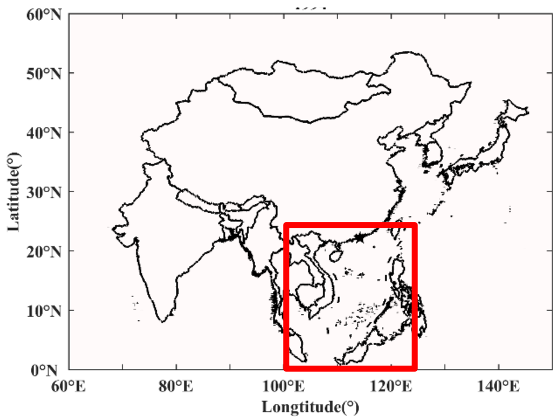


The data shown are average values in the red box (0 - 25˚ N; 100˚ E-120˚ E)

- Rising emissions in NOx and VOCs in Southeast Asia

- NO2 : OMI (http://www.temis.nl/airpollution/no2.html)
- HCHO: GOME (1997–2002), SCIAMACHY 2003-2004 and OMI (after 2004) http://h2co.aeronomie.be/

Long-term changes in meteorology



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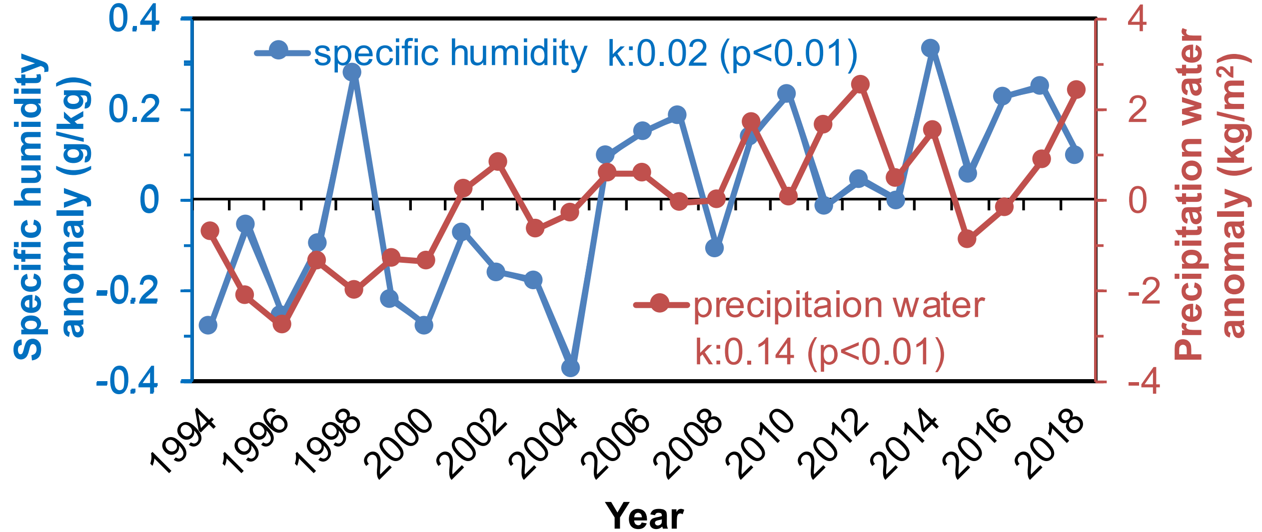
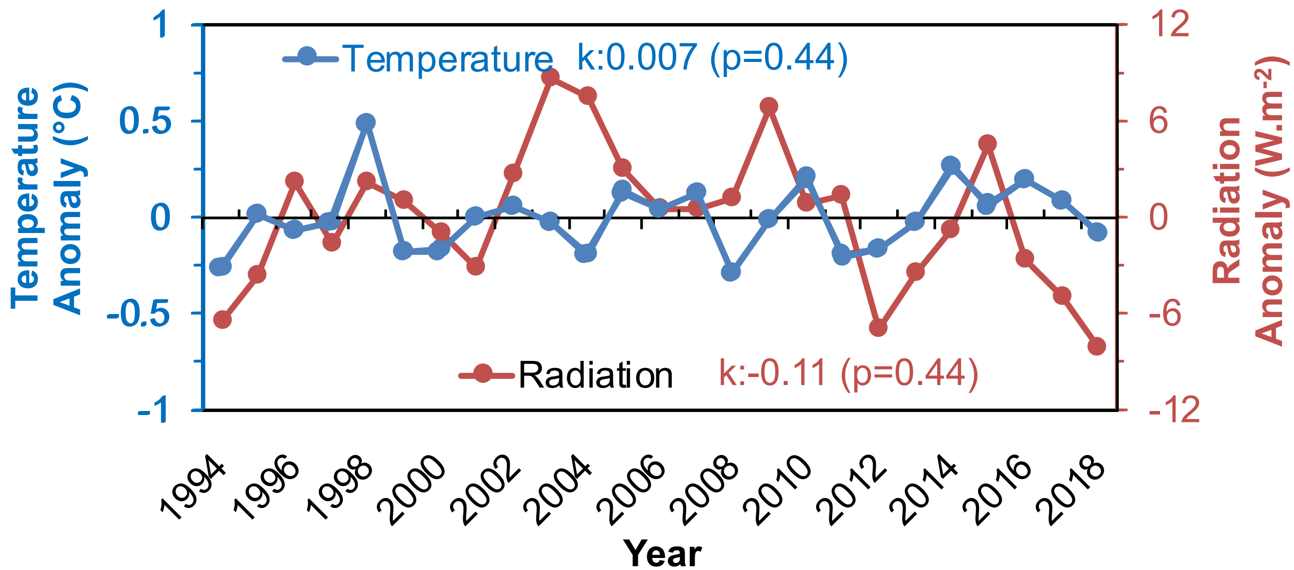
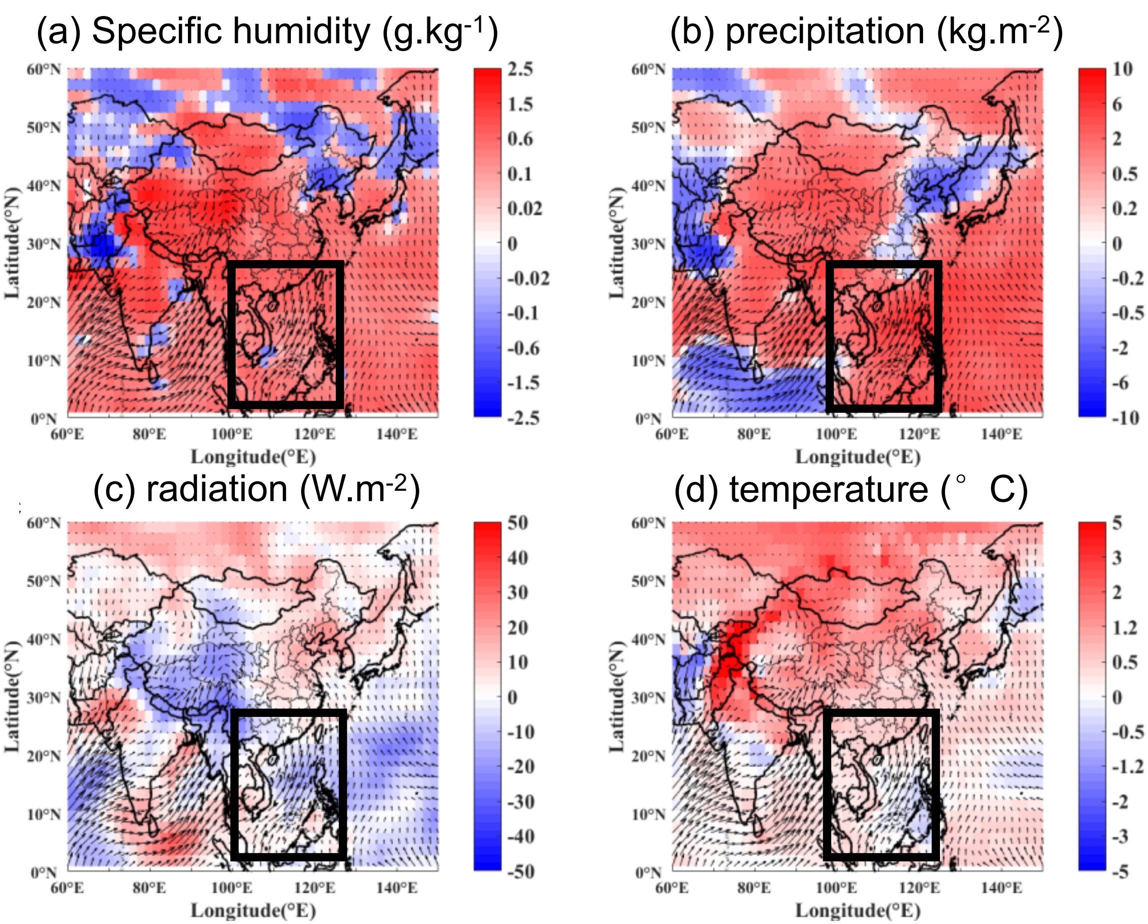


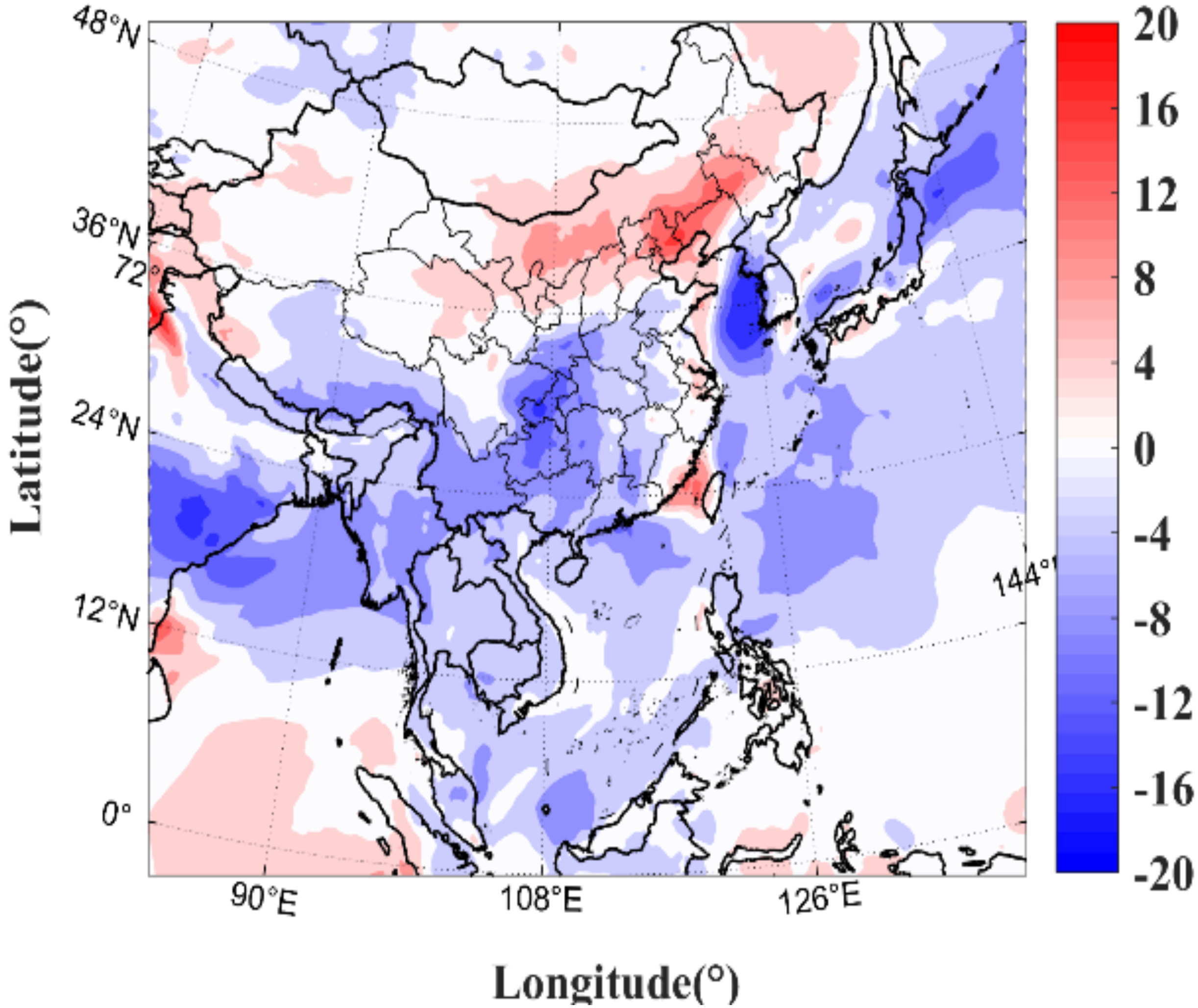


NCEP/NCAR reanalysis (https://rda.ucar.edu/datasets/ds090.0/)

The spatial difference in met. parameters between July in 2016-18 and 1994-96



WRF-Chem simulated summer ozone difference due to meteorology (2016-18 minus 1994-96)



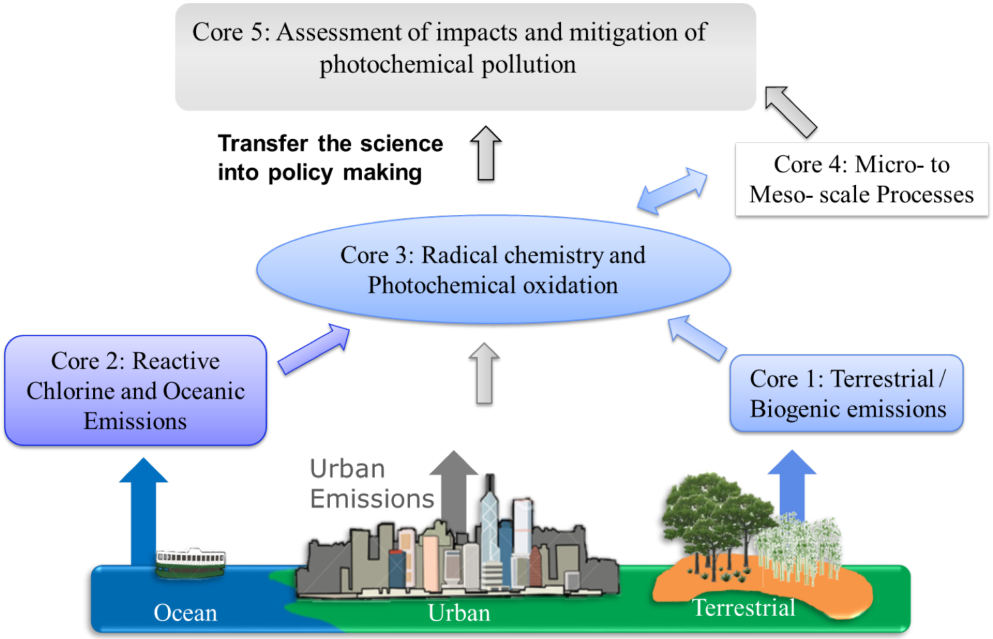
- Weather conditions in July 2016-2018 actually reduced ozone levels in Southeast Asia and southern China relative to July 1994-96

Summary

- Overall increasing trend in surface and PBL O_3;
- East China outflow: the increase stopped in the recent decade;
- Maritime air: continued and faster increase;
- Recent summer weather conditions counteracted the impact of increasing emissions from Southeast Asia and shipping activities.
- Need to continue the long-term observations
  - levelling off/decrease in Northeast Asia's outflow?
  - future changes in maritime air from tropical/subtropical Asia?
  - implications on mitigation of ground-level ozone

Photochemical air pollution in highly urbanized subtropical regions

- from micro environ. to urban-terrestrial-oceanic interactions



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A New Theme-based project of HK Research Grants Council (2018-2022, HK$33.33M, ~US$4.3 M)

Acknowledgement

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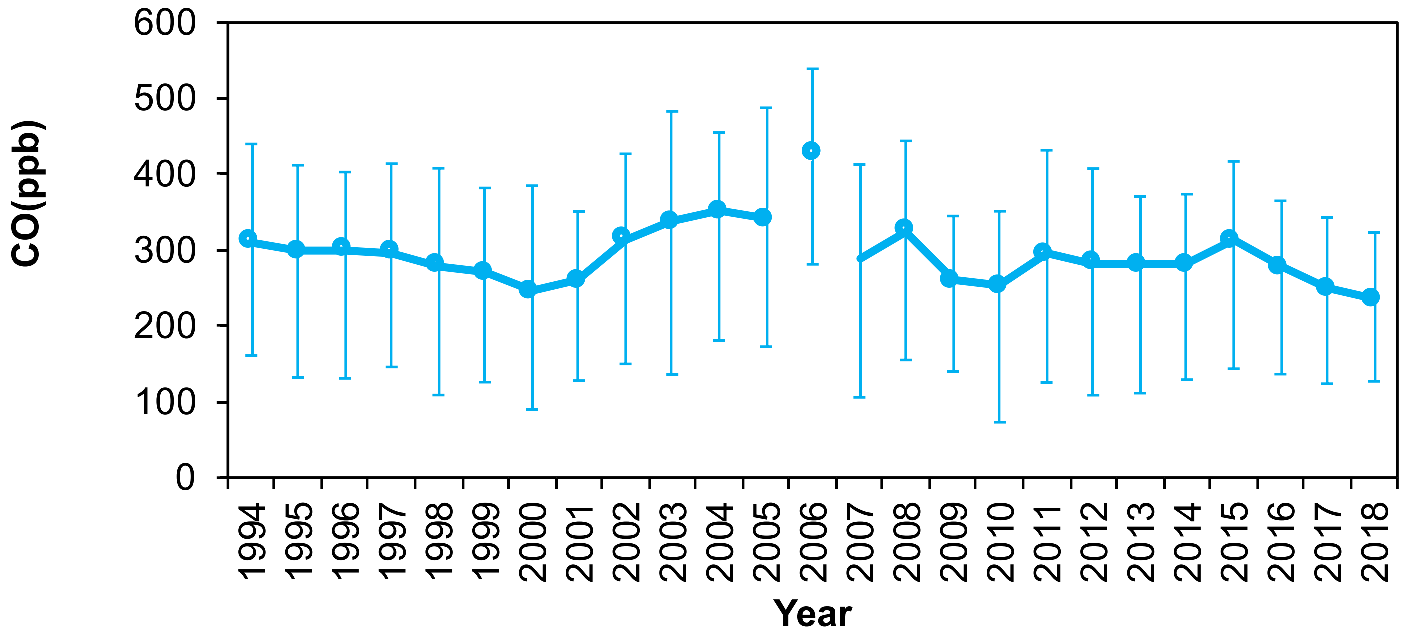
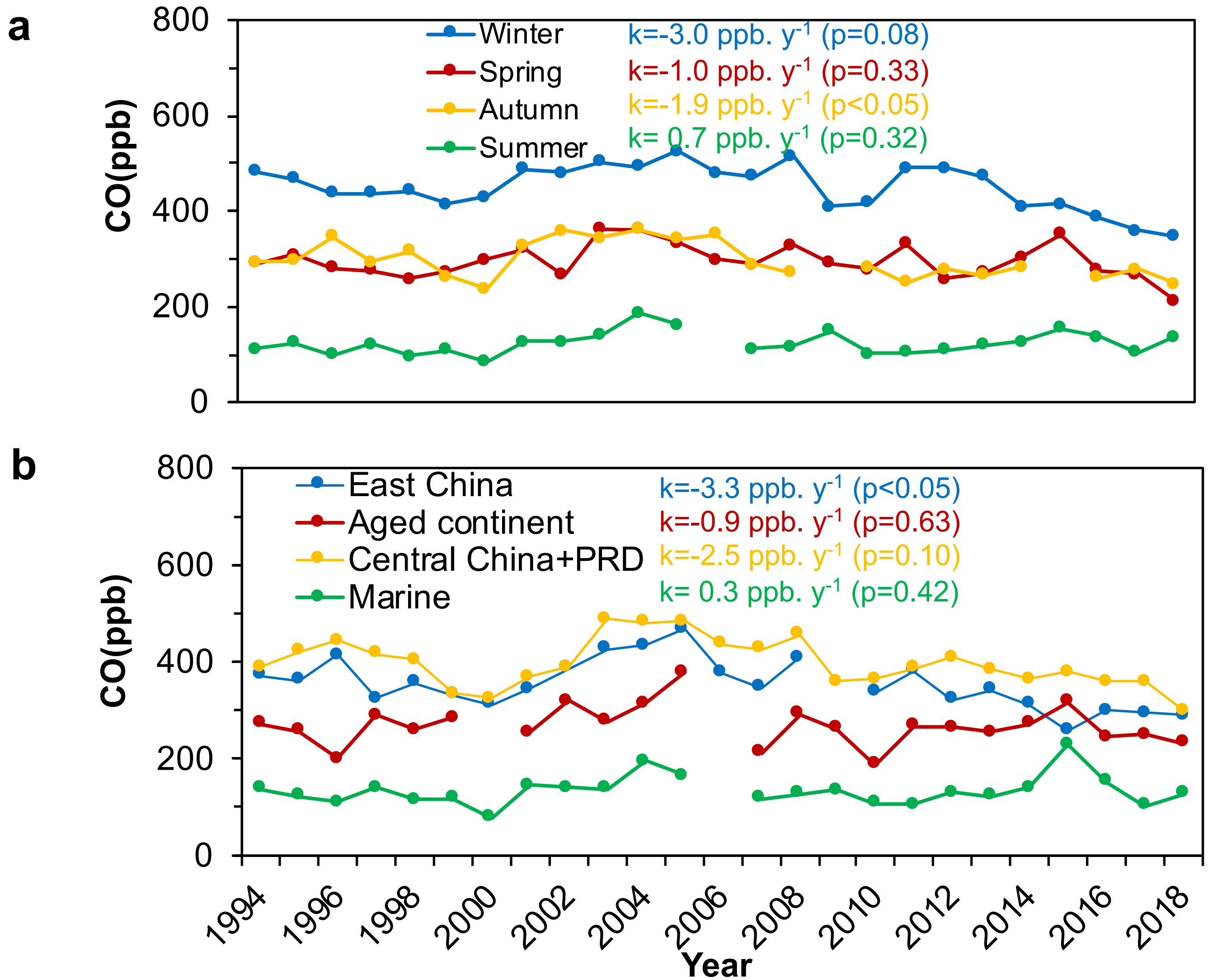
- Long-term monitoring supported by PolyU
- Data analysis supported by the Hong Kong Research Grants Council (PolyU 153042/15E and T24-504/17-N)


View from Mt Tai Mo Shan to the southwest
Thank You!

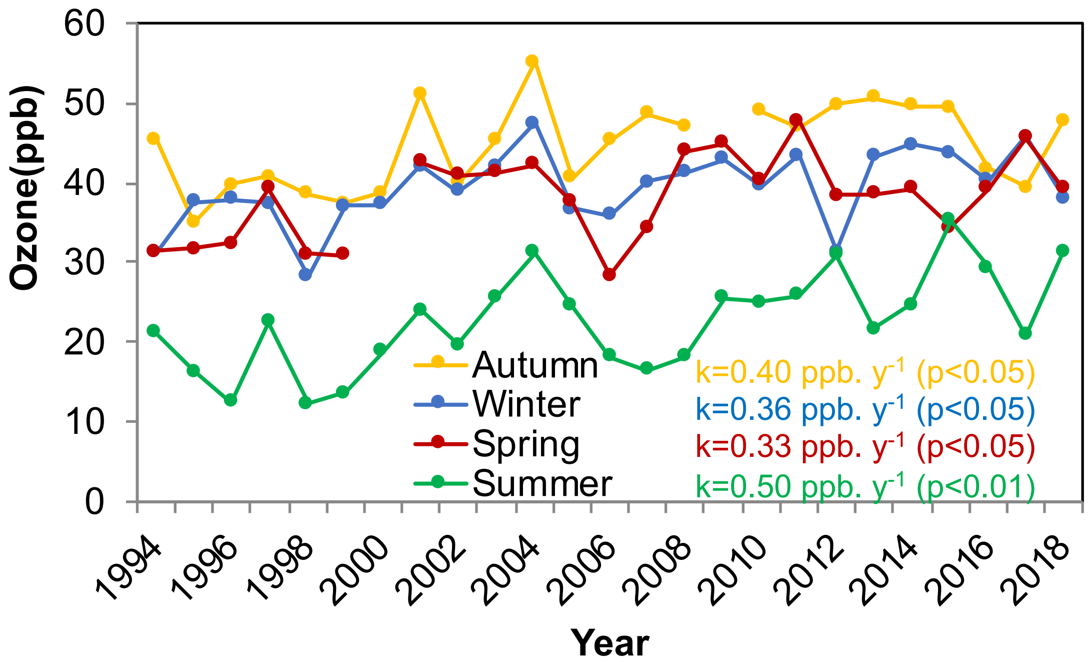
Long-term CO trend and variability : Yearly mean CO mixing ratios at HT



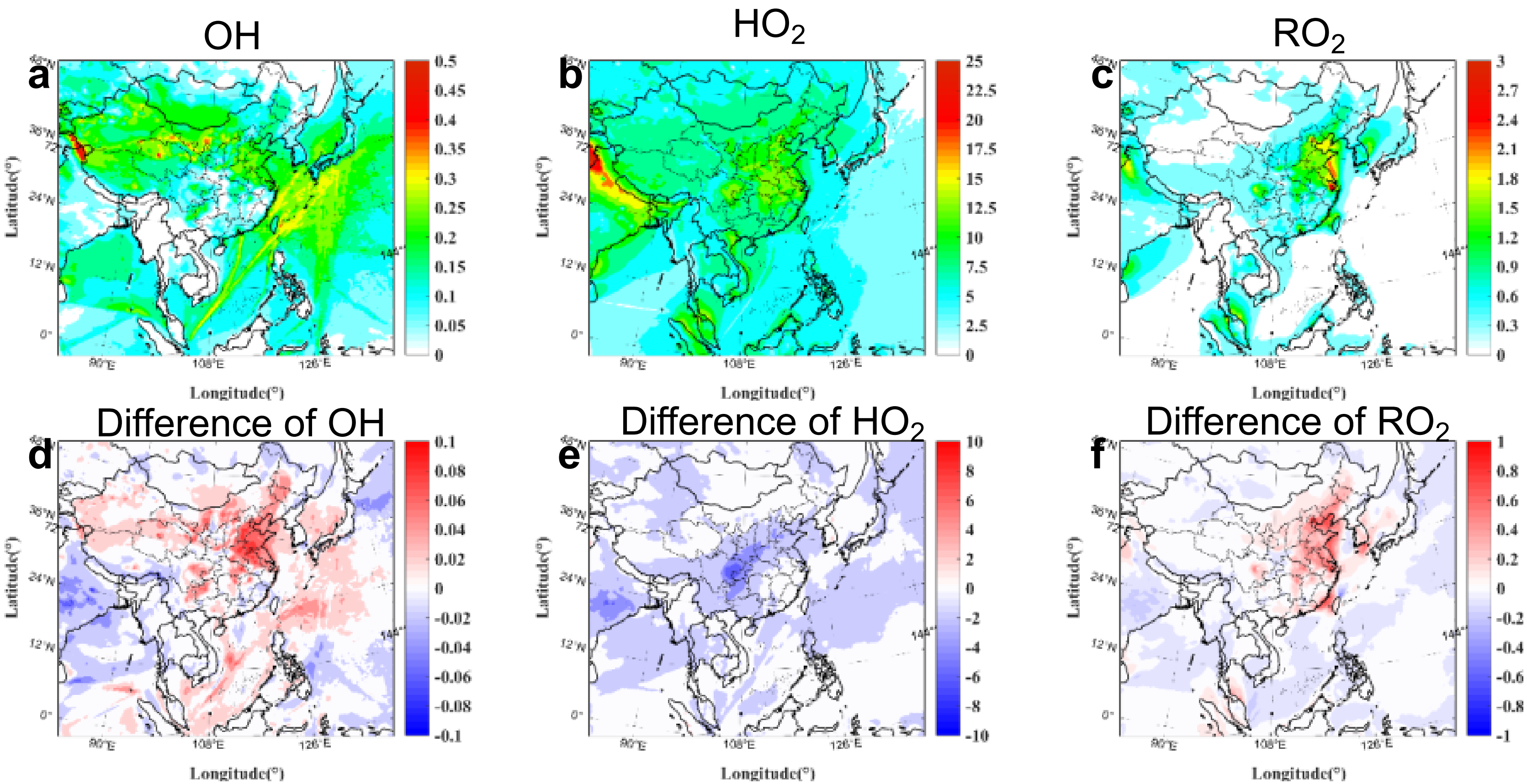
Trend in (a)seasonal and (b)air-mass segregated CO during 1994-2018



Trend in seasonal O_3 during 1994-2018



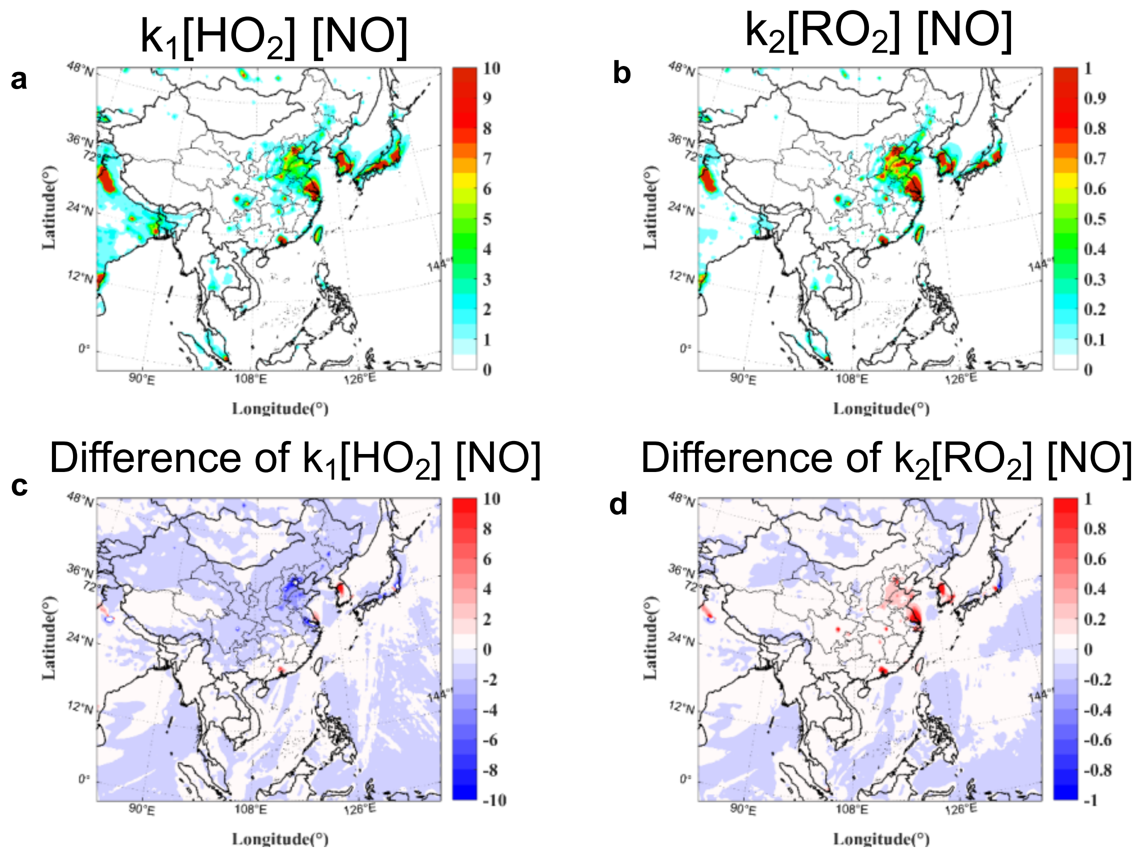
Simulated spatial distribution of RO_X



(a)(b) (c) values in July 2016-18 (Unit: ppt)

(e) (f) (g) difference between respective values in July 1994-96 and July 2016-18 with 2016 emission (Unit: ppt)

Simulated spatial distribution of ozone production



(a (b) values in July 2016-18 (Unit: ppb. h^{-1})

(c)(d) difference between the respective values in July 2016-18 and 1994-96

Long-term measurement of O_3

- O_3 by absorption of 254 nm (Thermo model 49, 49 and 49i)
- Multi-point calibration (5 points) twice a year
- Every 6 months, calibrated with a EPD transfer standard model 49iPS which is referenced to the EPD Primary Standard SR34

Long-term measurements of CO

- CO by absorption of Infra-red light (with gas filter Thermo model 48 and Teledyne API Model 300EU after March 2006)
- Internal heated catalyst to convert CO to CO_2 for background correction (especially water vapour)
- Multi-point calibration (5 points) is conducted twice a year or as required
- Scott-Marrin gas cylinder (NIST traceable) with 150 ppm CO gas as the calibration gas