



Improved health co-benefits of ozone and nitrogen oxides upon China's integrated air quality control policies during 2015-2019

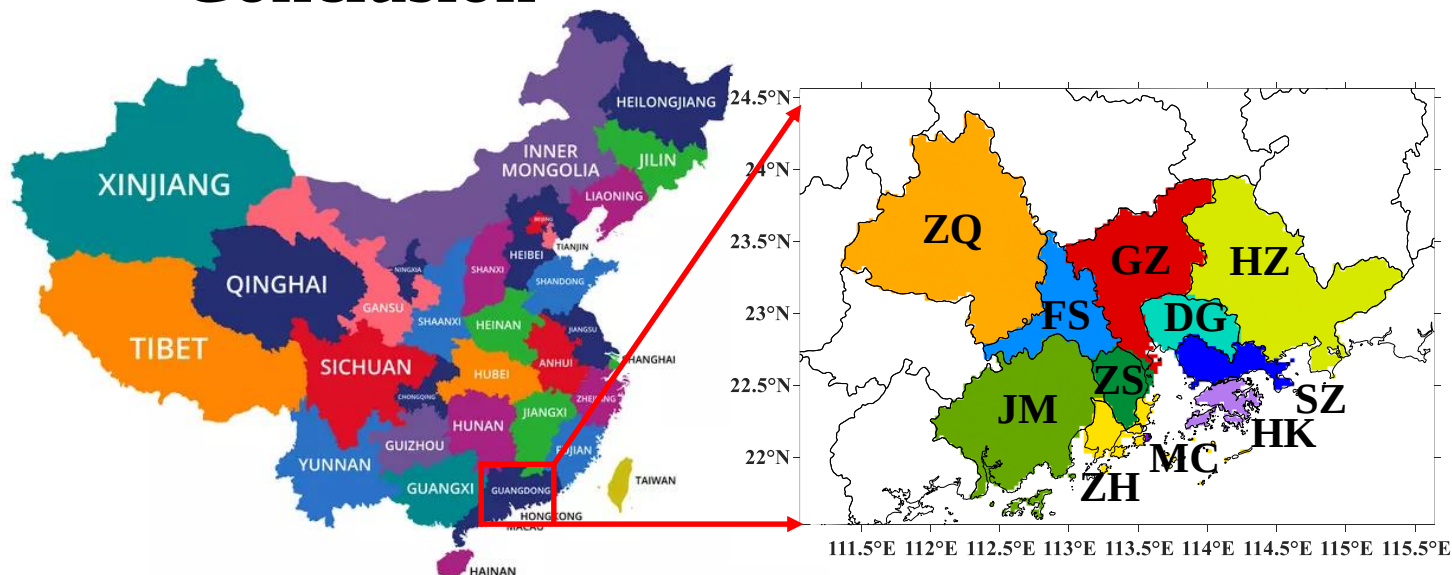
Xuguo Zhang, Jimmy C. H. Fung*, Alexis K. H. Lau, Md Shakhaoat Hossain, Peter K. K. Louie, and Wei (Wayne) Huang

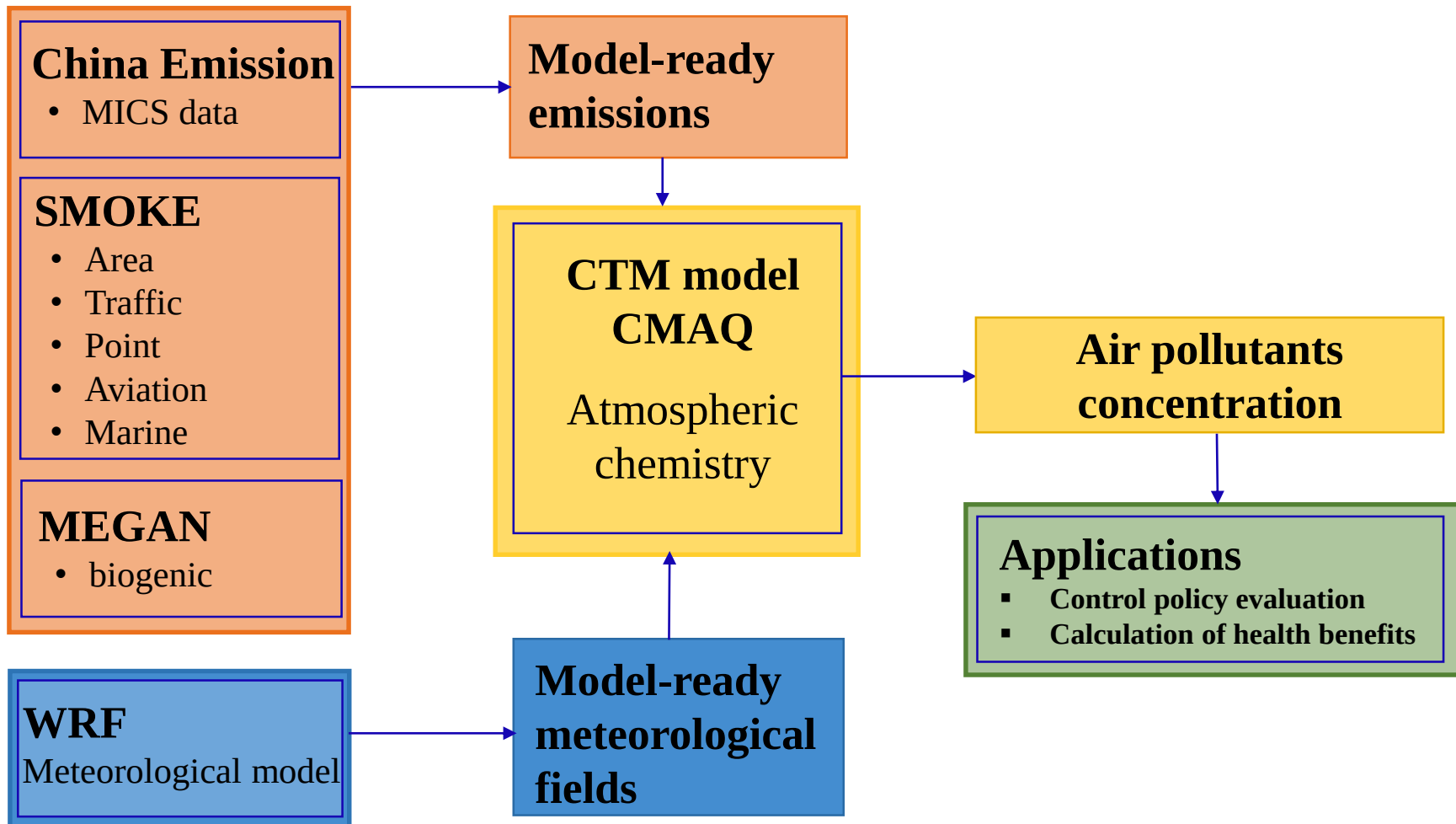
**Division of Environment and Sustainability
Department of Mathematics**



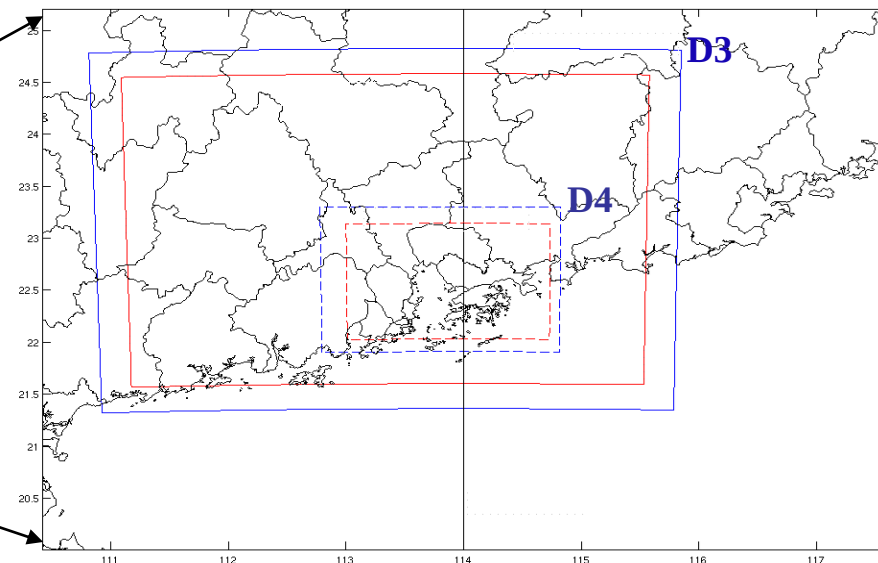
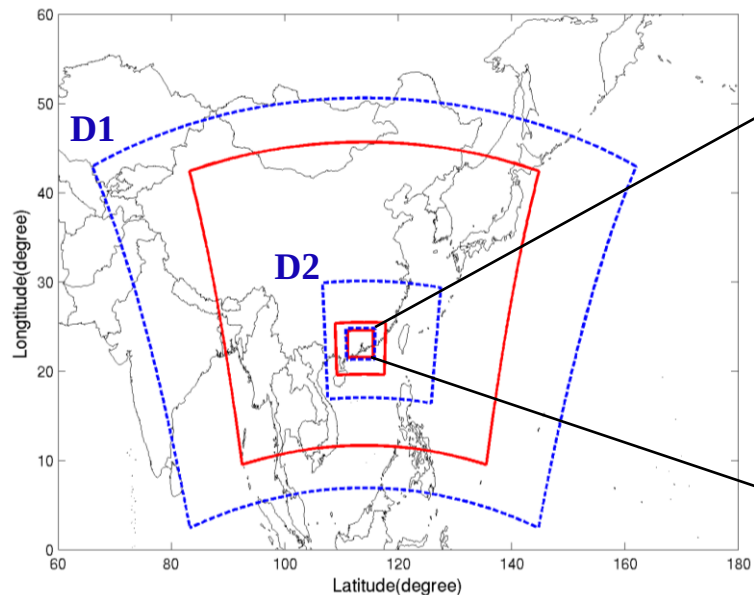
Outline

- Introduction
 - Air quality modeling system and Scenario setting
- Improved health co-benefits of the two-pollutant
- Conclusion



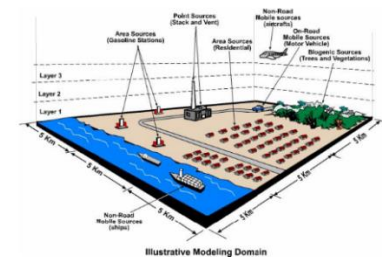


- Larger **WRF domain** could minimize the boundary effects of meteorological parameters on **CMAQ grid**.



Parameter	Value
Projection	Lamber-Conformal
Alpha	250°N
Beta	40°N
X center	114°E
Y center	28.5°N

Domain	Geographical coverage	WRF grid (km)	CMAQ grid (km)	Resolution (km)
D1	China and Japan	7641 x 4968	4914 x 3726	27
D2	Southeast China	2007 x 1467	882 x 666	9
D3	Guangdong	516 x 390	456 x 330	3
D4	Hong Kong	214 x 163	179 x 125	1

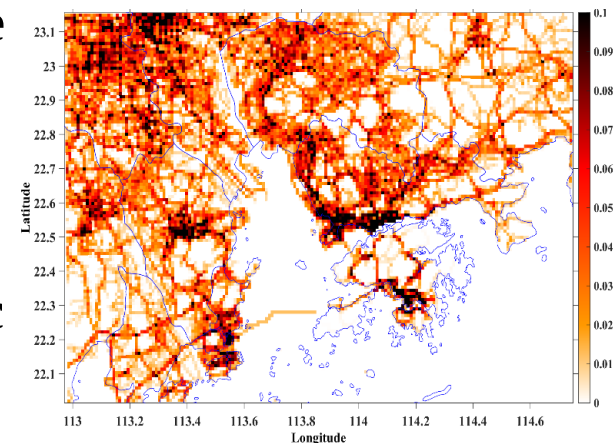


Emissions data are processed in **two separate approaches**:
Bottom up for D3 and D4, with resolutions of 1 & 3 km:

- **HK**: annual emission amounts of 2015 for Hong Kong was provided by the HK EPD;
- **PRD**: working closely with Prof. Allen Zheng from Jinan University.
- Emissions from marine vessels and shipping lines have been updated by using real time global AIS data in 2015.
- **The MICS emission inventory** projected to 2015 have been applied for D1 and D2.

For biogenic emissions, emission factors from satellite information were used in the MEGAN model to allocate isoprene, monoterpene, and other biogenic volatile organic compounds (BVOCs).

Work with Prof. Lo, H. K. in Civil, HKUST



Traffic emission intensity. Unit: g/s.



2015

- **Base case (2015)**
- 2015EI (HK&PRD EZ), MICS data (Non-PRD), 2015 AIS-marine (China).

2015EI

2020S1

- **S1: Short-term Scenario (2020)**
- On the basis of the year 2015, implementing the **short-term measures** (HK) and **13th Five-year-plan controls** (PRD EZ and Non-PRD)

Controls
on China

2020S2

- **S2: Further Controls on Transportation & Power in PRD**
- On the basis of S1, **Electrifying public buses** (oil to electric, gas to electric).
- Upgrading the emission **standard (Euro 6)**.
- Thermal power plants upgraded to use **LNG**.

Controls
on PRD

2020S3

- **S3: Further Controls on Industry & Area in PRD**
- On the basis of S2, **double the energy efficacy** for area and industrial sources in PRD.

Controls
on PRD

2020S4

- **S4: Impact due to Super-regional Control Measures outside PRD**
- Sectoral control measures in S2 and S3 for the Non-PRD areas.

Controls
on super-
regional

Note: **Pearl River Delta (PRD)** region includes the PRD Economic Zone (**PRD EZ**) and the **HK** region.



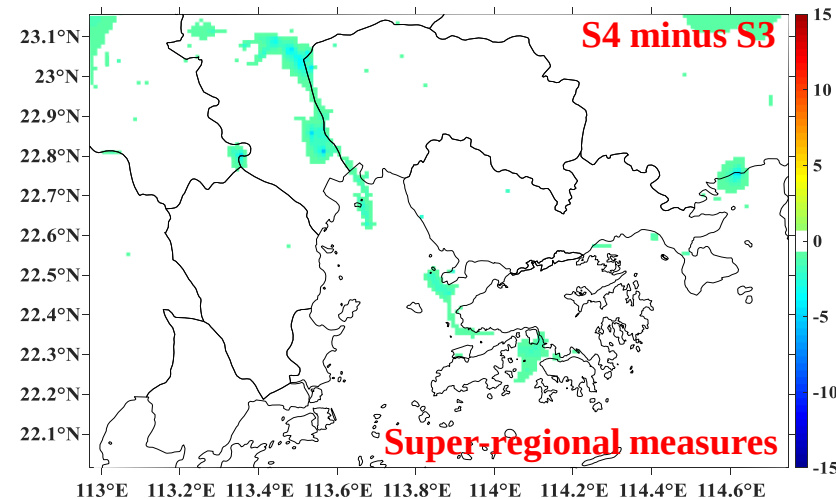
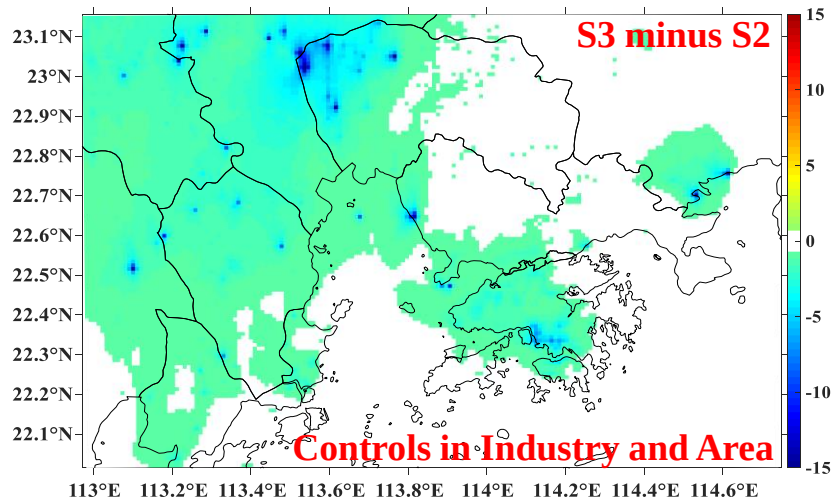
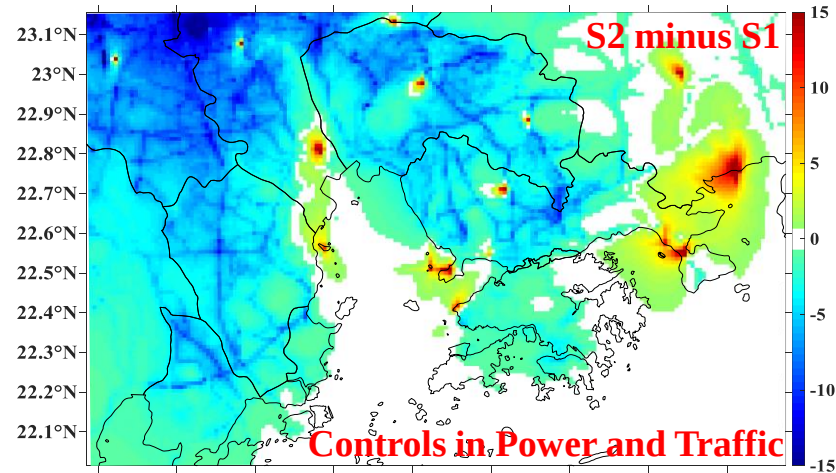
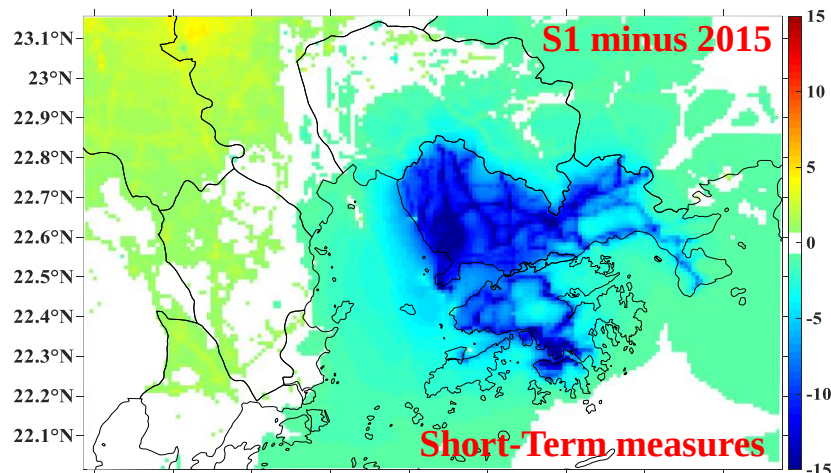
$$\%AR(O_3) = [\exp(\beta(O_3) \times C(O_3)) - 1] \times 100\%$$

$$\%AR(NO_2) = [\exp(\beta(NO_2) \times C(NO_2)) - 1] \times 100\%$$

$$\%AR_{photochemical} = \%AR(O_3) + \%AR(NO_2)$$

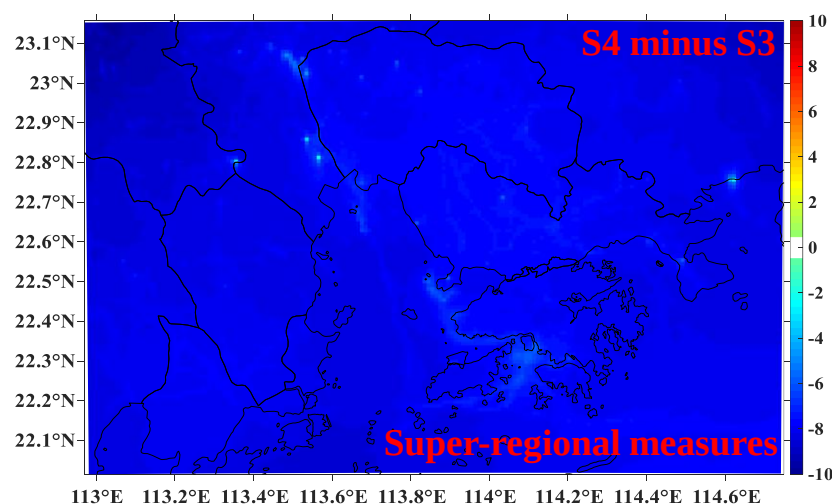
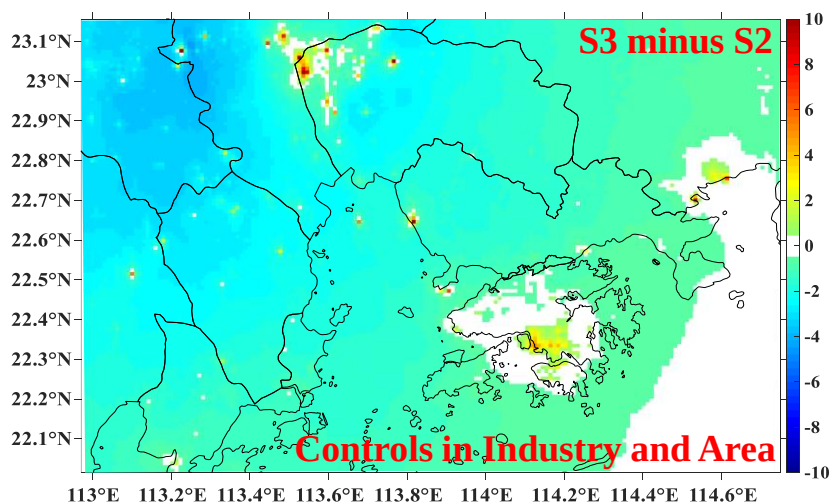
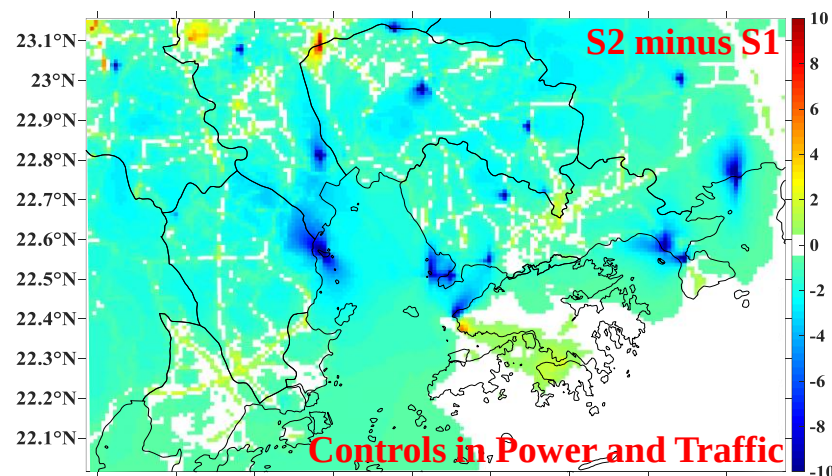
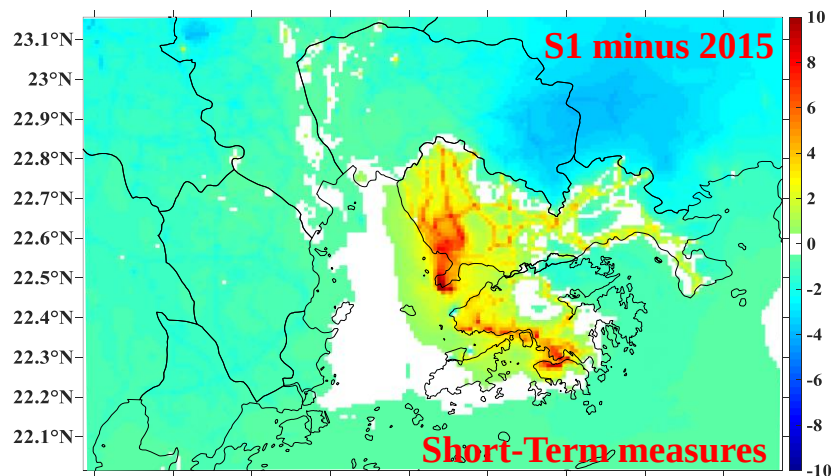
- **Percentage Additional Risk (%AR):** the added health risks due to **emergent hospital admissions** for **cardiovascular and respiratory** diseases attributing to the exposure of the air pollution.
- C represents the 3-hour moving **averaged concentrations** of the respective pollutants in the unit of $\mu\text{g}/\text{m}^3$.
- β is the **measured regression coefficient** associated with each pollutant.

- From 2015 to 2020, a significant **NO_x reduction for SZ, HK**, focusing on the Traffic sector.
- The controls in the **Power and Traffic** lead to **increases in the Power sector, mainly due to the increased power generation for electrifying the traffic.**
- The **Super-regional controls** present little impact for NO₂, indicating the characteristics of a **short lifetime of NO₂**, affected more **by local sources**.



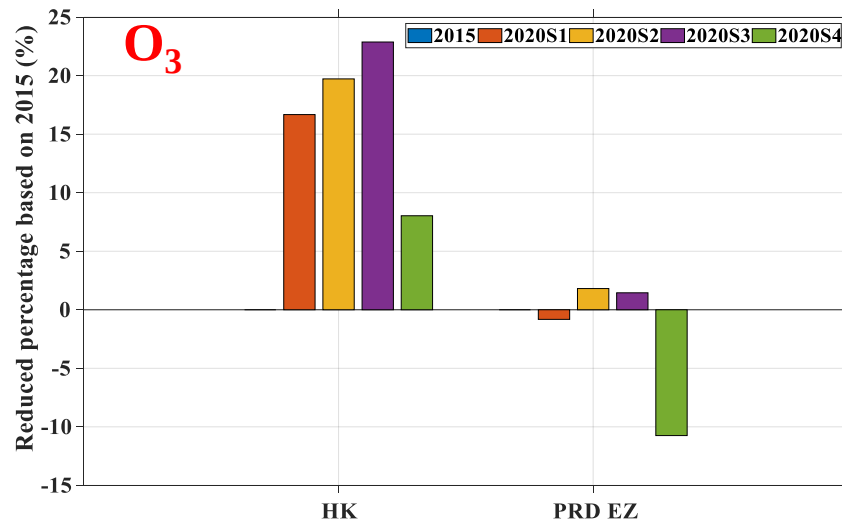
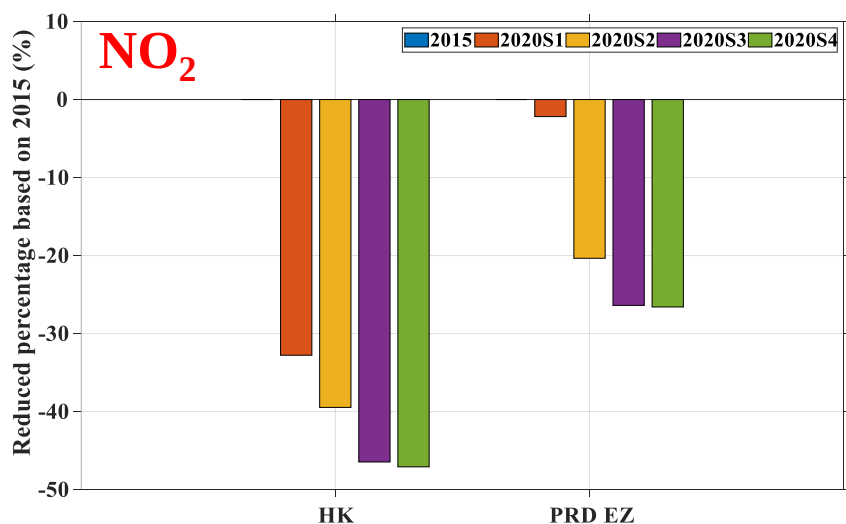


- From 2015 to 2020, NO_x decreased, **less titration**, so O_3 **increased** in Shenzhen and HK
- S2 minus S1: The O_3 reduction mainly due to the increased NO_x from power plant. **Have titration** in O_3 .
- The **Super-regional controls** lead to clear and significant O_3 reduction due to less regional and super-regional transport.

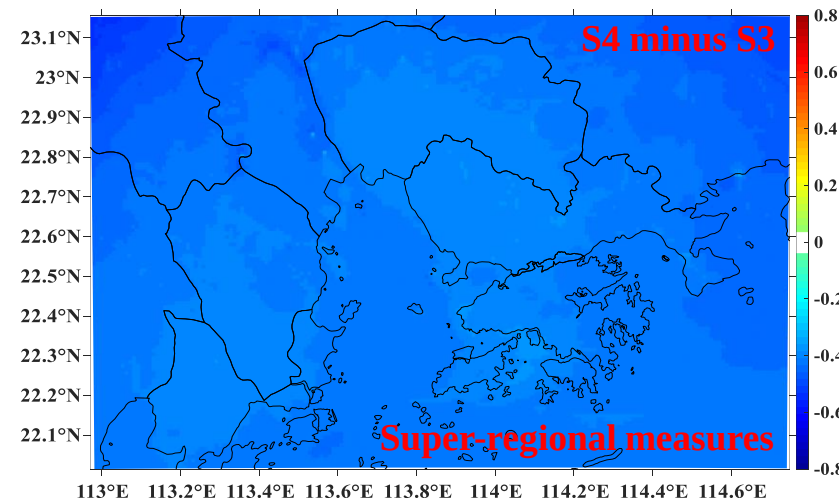
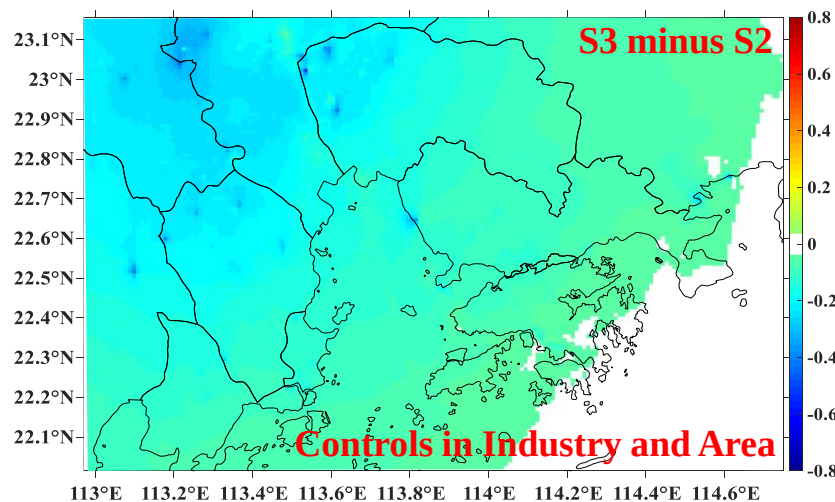
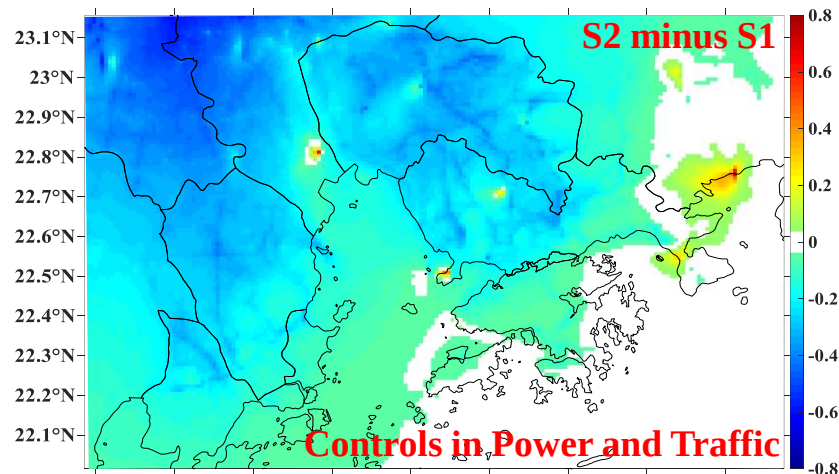
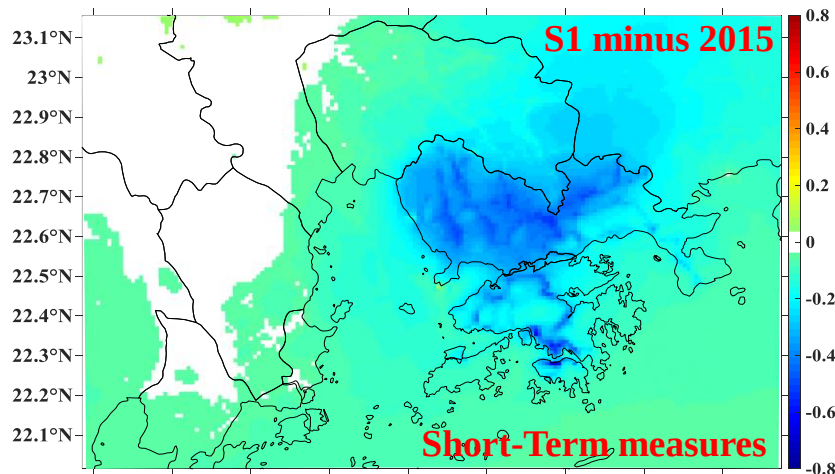




- **Clear NO_2 drop** in both HK and PRD EZ regions.
- **The drops in NO_2** in the HK region lead to less NO_x -titration effect, so O_3 penalties were observed, illustrating its characteristic of the **VOC-limited** O_3 formation regime.
- Roughly 7% O_3 increase in HK relevant to 2015, more O_3 has been transported into HK. less NO_x .
- Simultaneously controlling VOC and NO_x will make HK O_3 decrease, and PRD O_3 decrease larger.

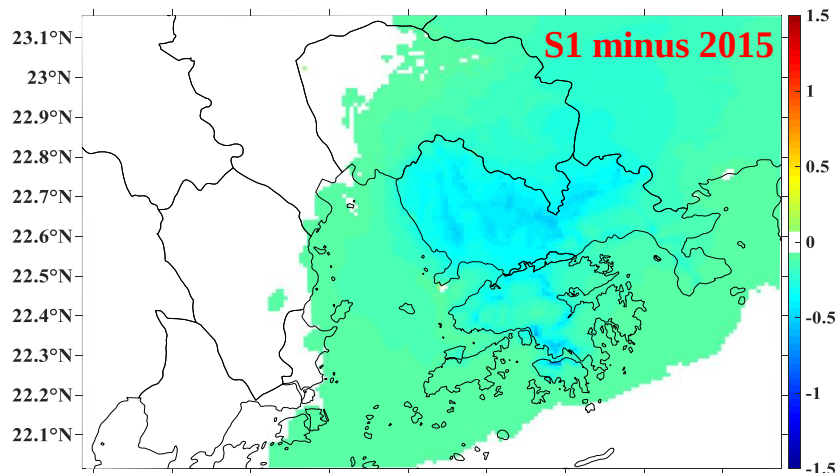


- The **short-term measures** lead to the considerable **improvement** for **Shenzhen and HK**.
- The controls in **Power and Traffic** lead to **health improvement for most parts of the domain**, except the AR in the Power sector is increasing.
- Both of the controls in the **Industry, Area & the Super-regional measures** show the **improving health impact** at a considerable rate.

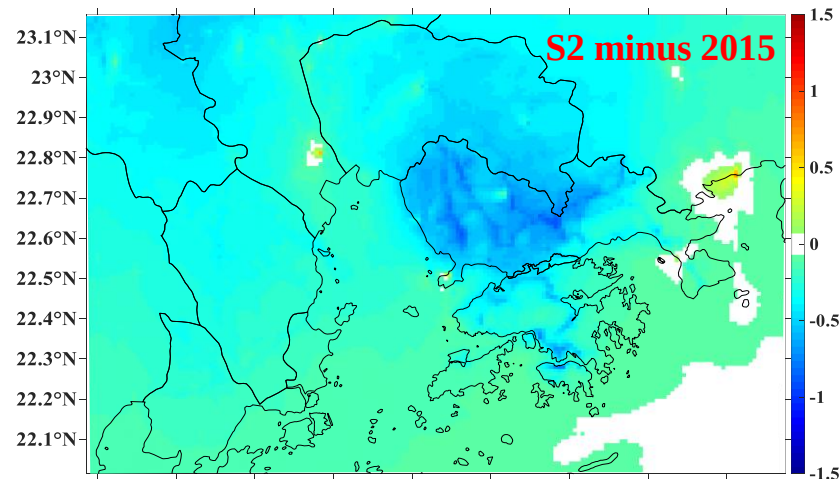




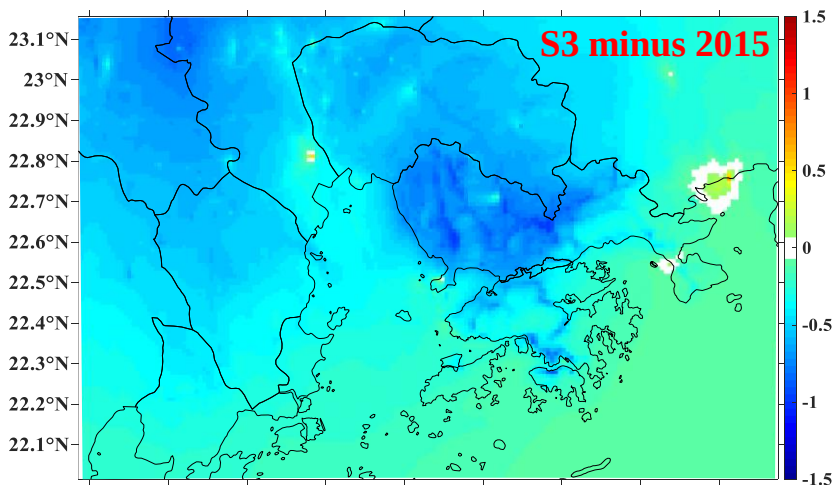
- **The short-term measures** lead to the considerable improvement in SZ, HK for overall photochemical AR.
- The controls in **Power and Traffic** lead to health improvement for most parts of the domain, except the AR in the Power sector is increased a little.
- Both of the controls in the **Industry, Area & the Super-regional measures** show a clear **improved health impact**.



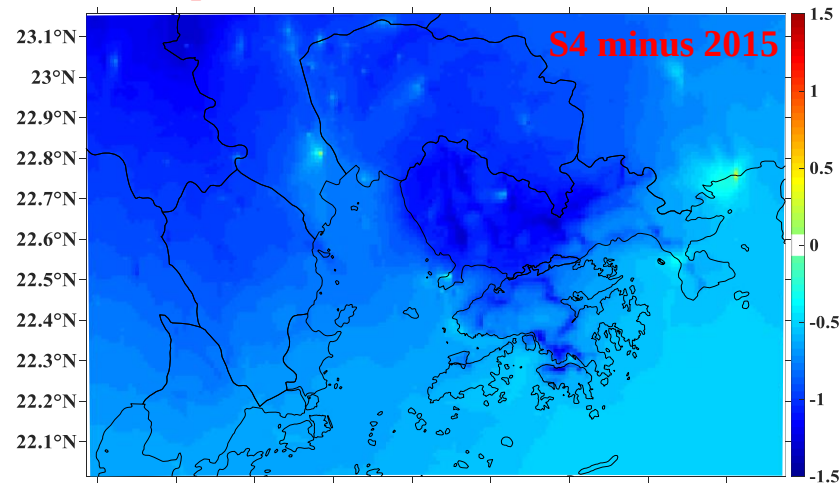
Up to Short-Term measures



Up to Controls in Power and Traffic

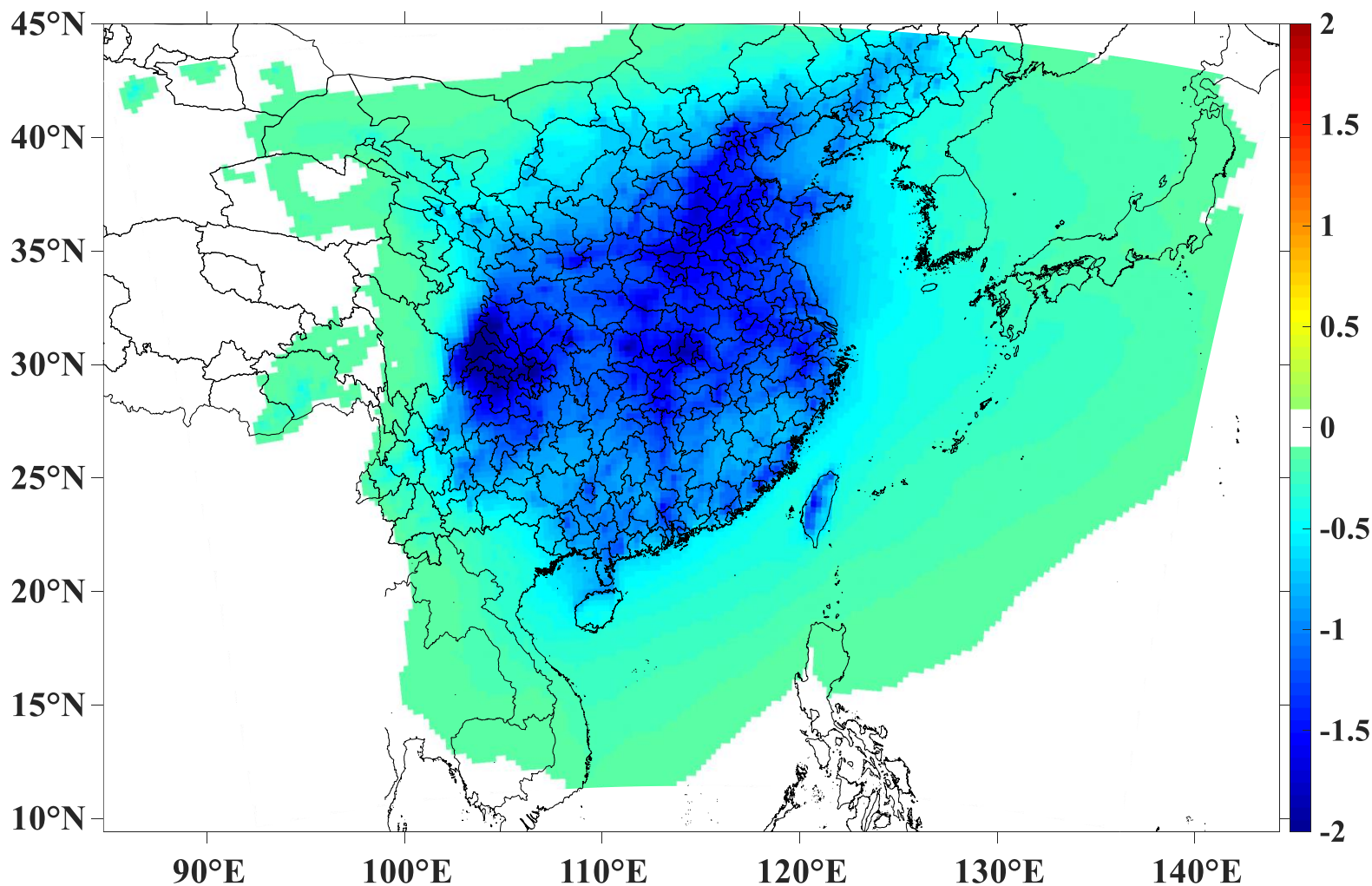


Up to Controls in Industry and Area



Up to Super-regional measures

- The **avoided ratio** of the health co-benefits could be **over 2%**, especially in northern China.



Up to Super-regional measures



- Demonstration of utilizing a **CMAQ** model to project **emission-concentration-health levels** to help the government make future control policy.
- Although the NO_x-titration effect triggered the O₃ rising, the **integral health co-benefits** had been **improving** for most parts of China, with a VOC-limited regime.
- **The short-term measures** lead to substantial health benefits for **Shenzhen and HK**.
- **The sectoral emission controls** demonstrate a considerable health improvement for **major PRD cities**.
- **Joint-national controls** confine the domain-wide health risks below the **safety line** in China.
- **Over 1.5-2%** of the emergency **hospital admissions** for the cardiovascular and the respiratory diseases **attributing to NO₂ and O₃** could be avoided due to national cooperation efforts in China.



THANK YOU

xzhangbg@connect.ust.hk



Acknowledgement

