



NO_x Emissions Reduction and Rebound in China Due to the COVID-19 Crisis

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KNMI

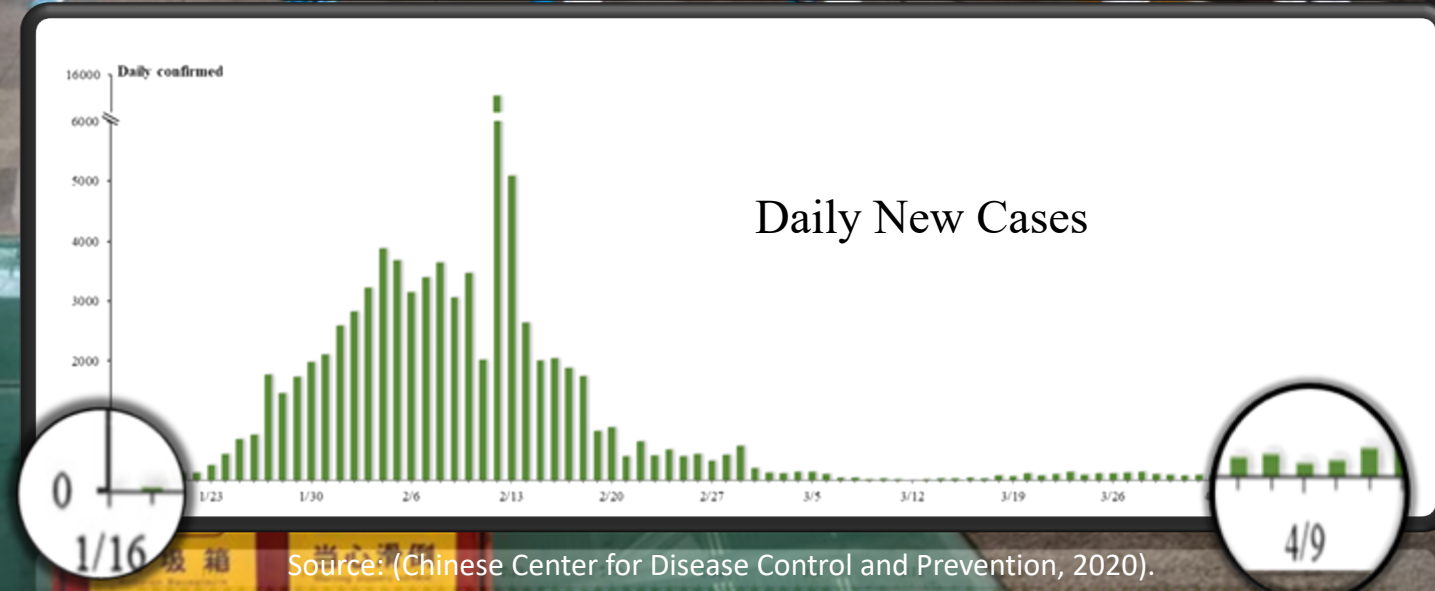
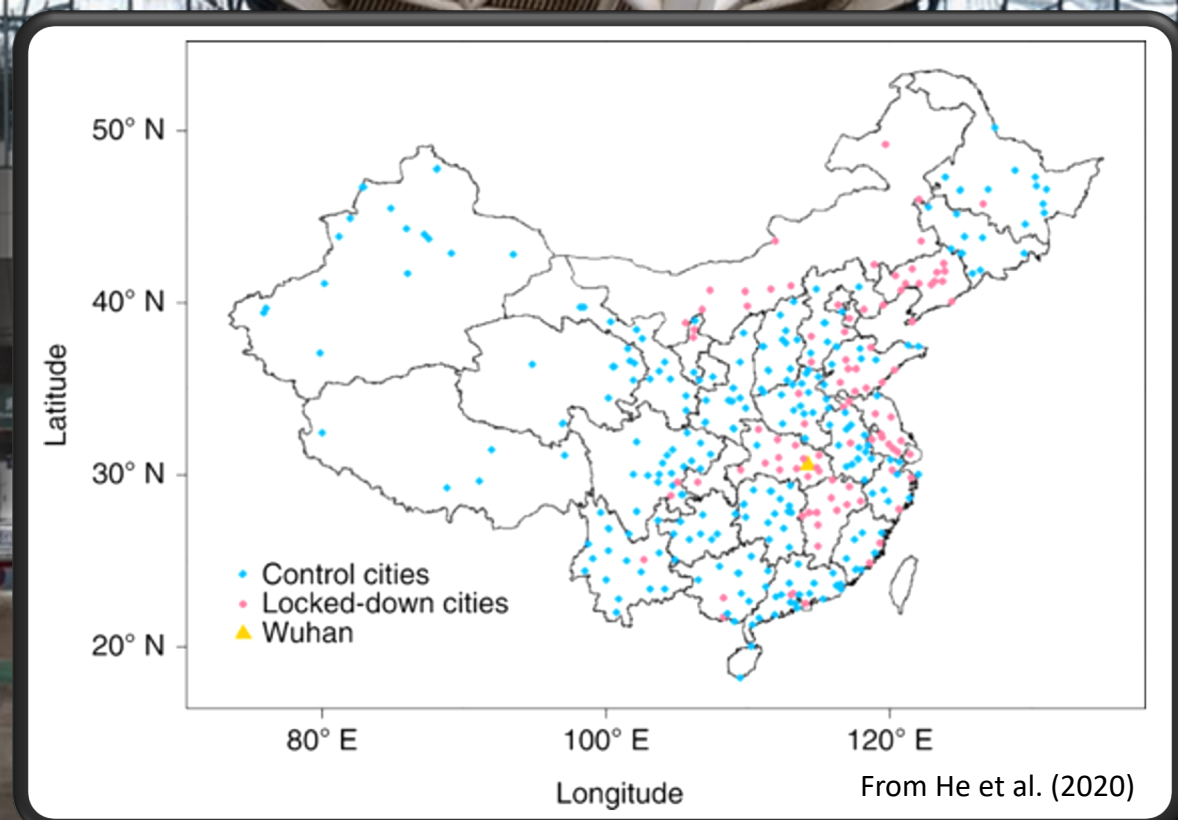
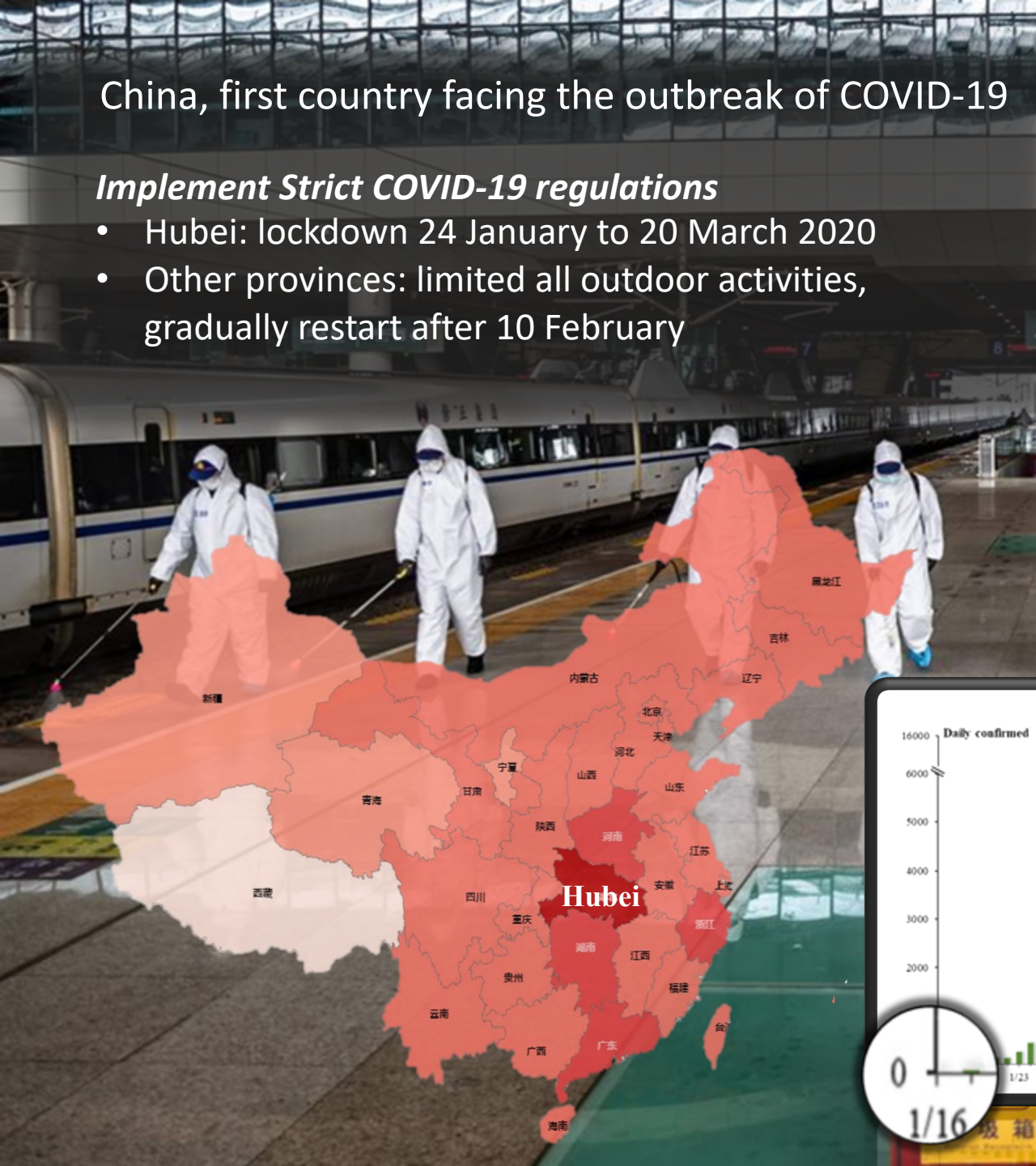
AMIGO workshop

Nov. 2020

China, first country facing the outbreak of COVID-19

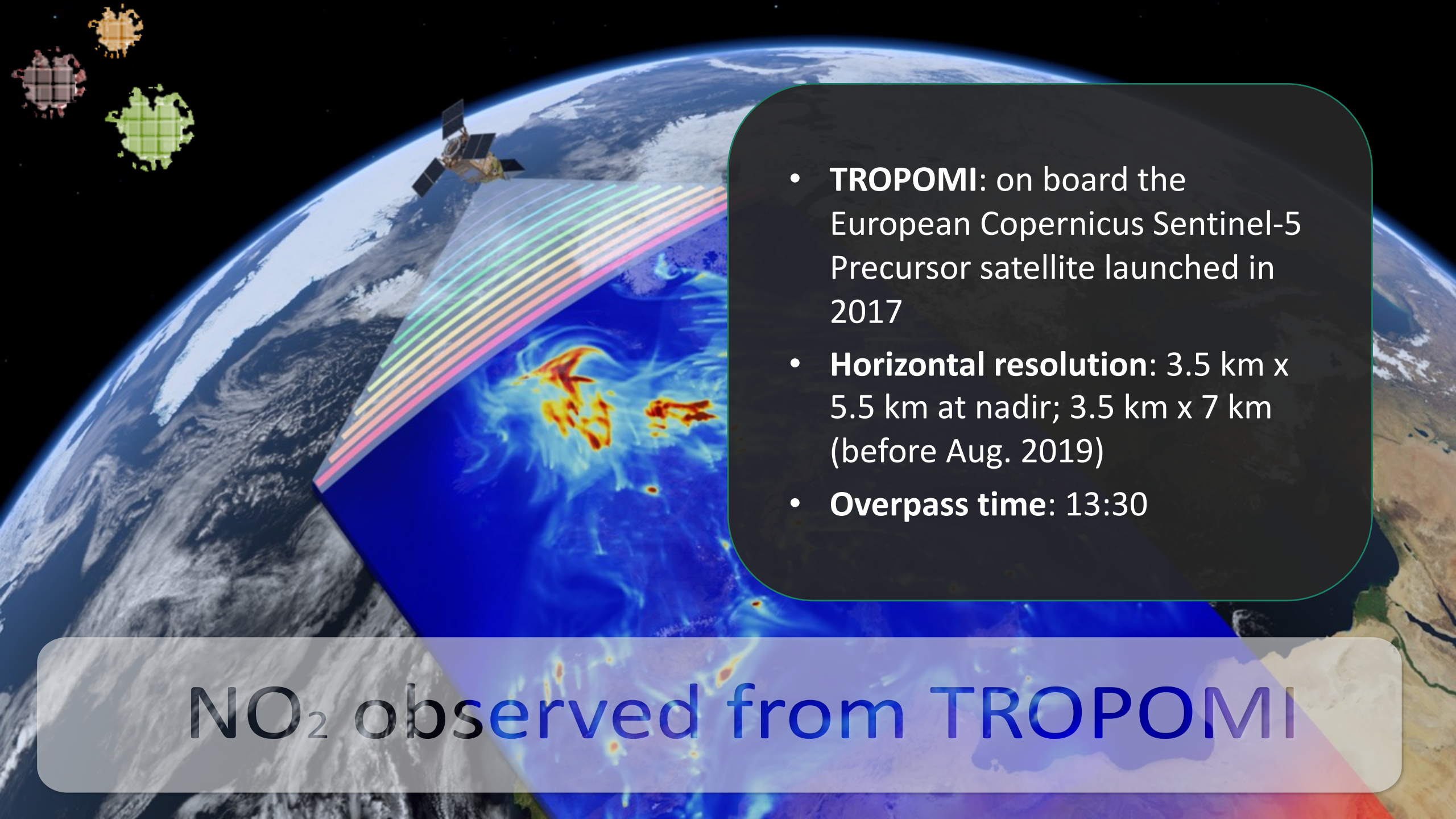
Implement Strict COVID-19 regulations

- Hubei: lockdown 24 January to 20 March 2020
- Other provinces: limited all outdoor activities, gradually restart after 10 February



Source: (Chinese Center for Disease Control and Prevention, 2020).





- **TROPOMI:** on board the European Copernicus Sentinel-5 Precursor satellite launched in 2017
- **Horizontal resolution:** 3.5 km x 5.5 km at nadir; 3.5 km x 7 km (before Aug. 2019)
- **Overpass time:** 13:30

NO₂ observed from TROPOMI

Days relative to the 2020 Chinese New Year

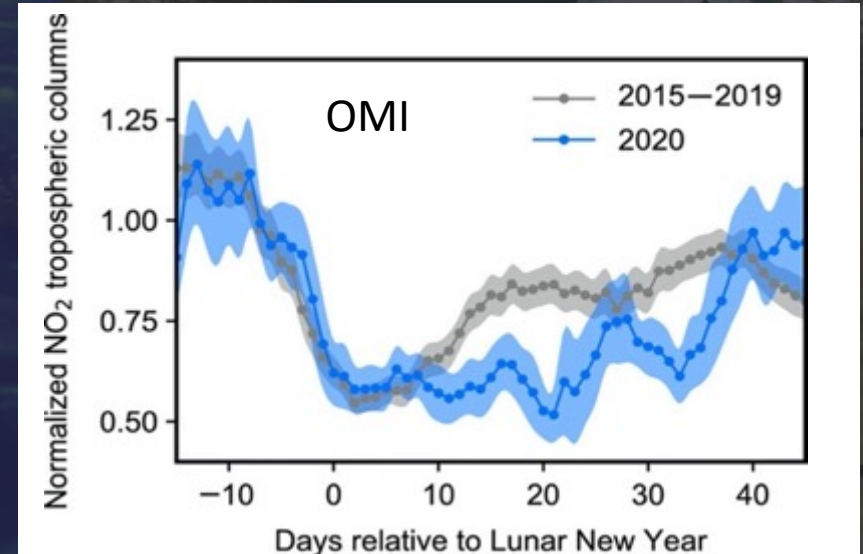
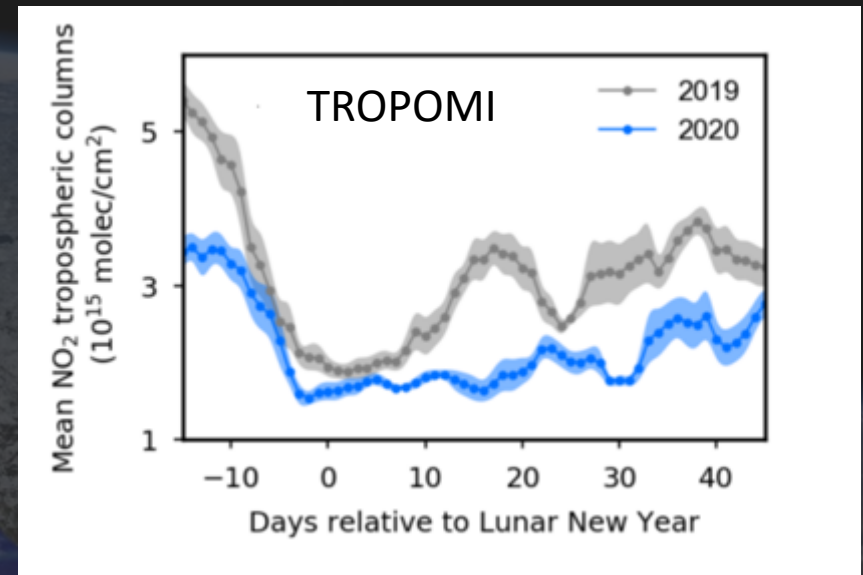
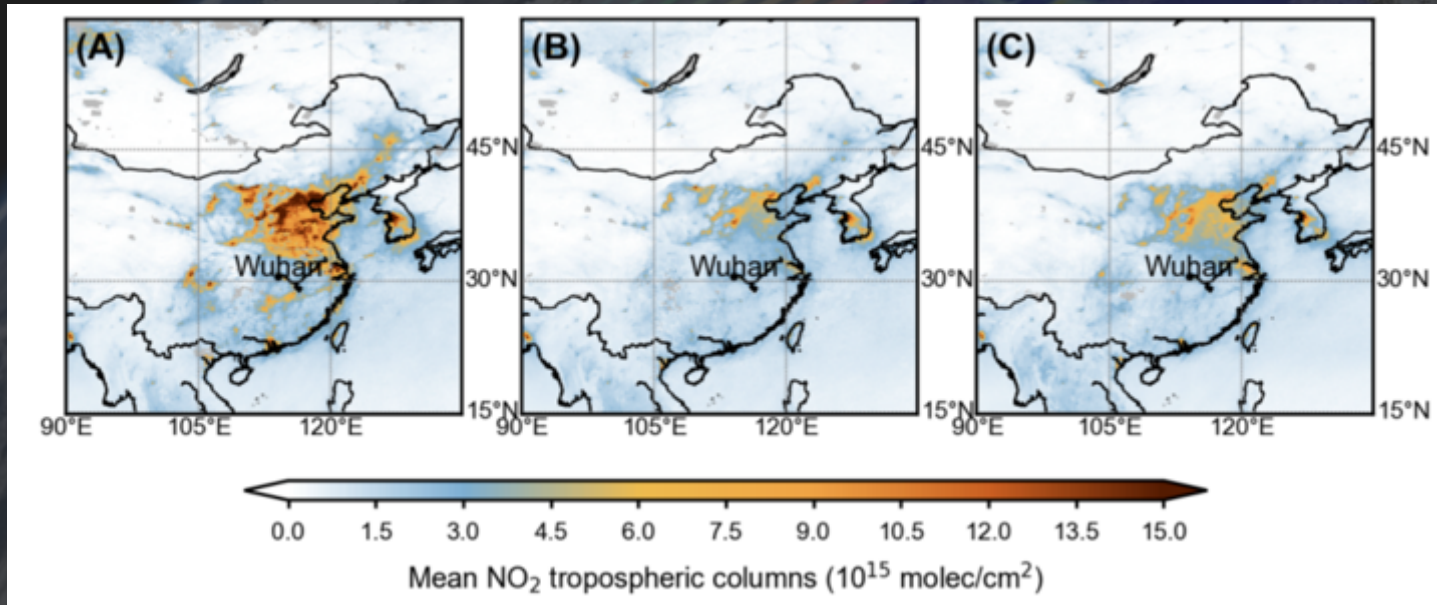
(A) -20 to -1



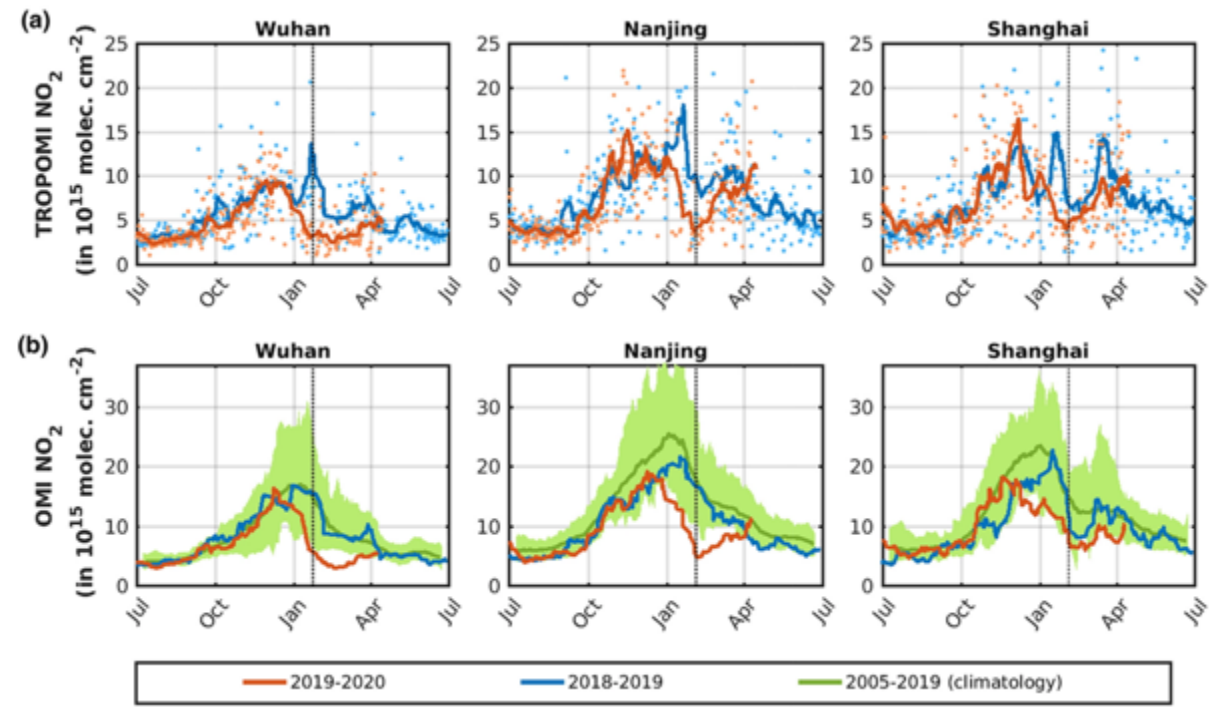
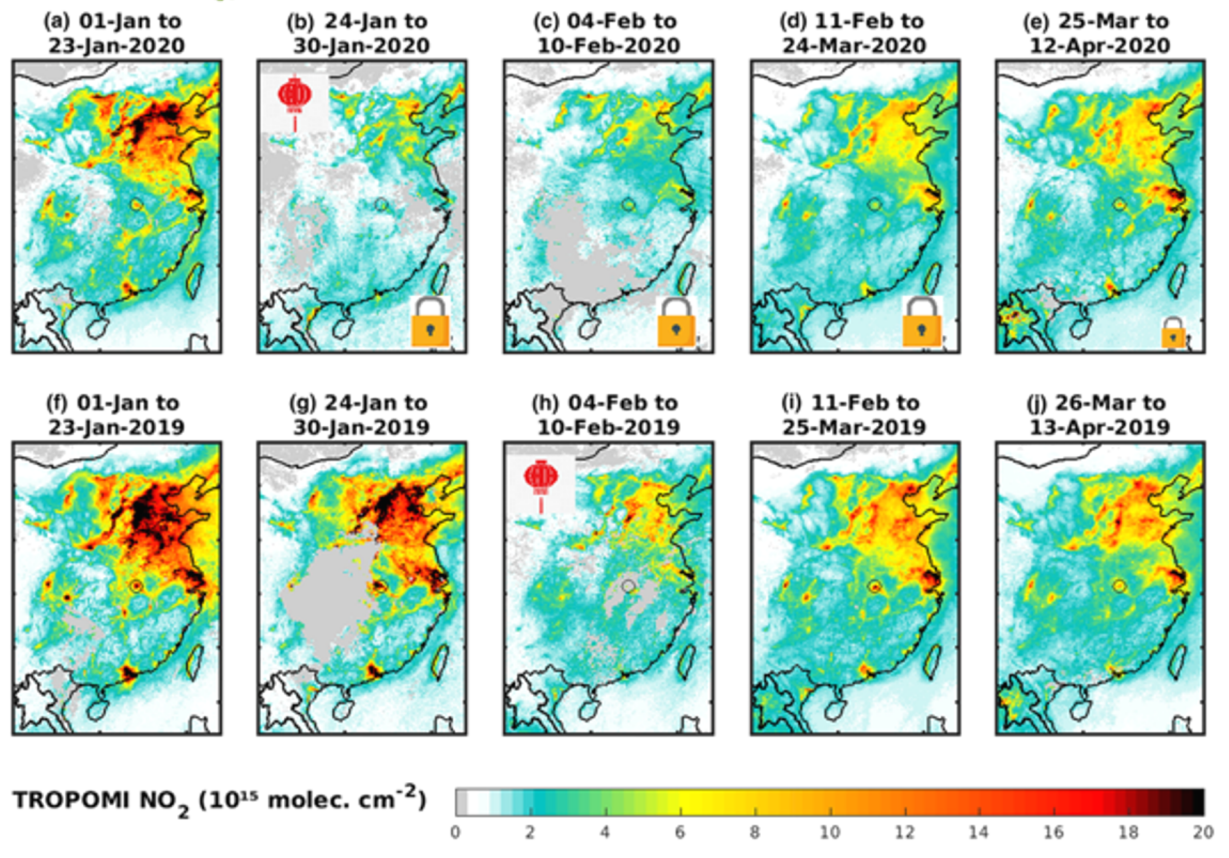
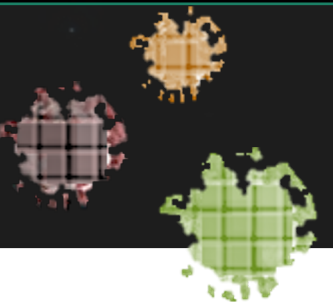
(B) 0 to 19



(C) 20 to 39

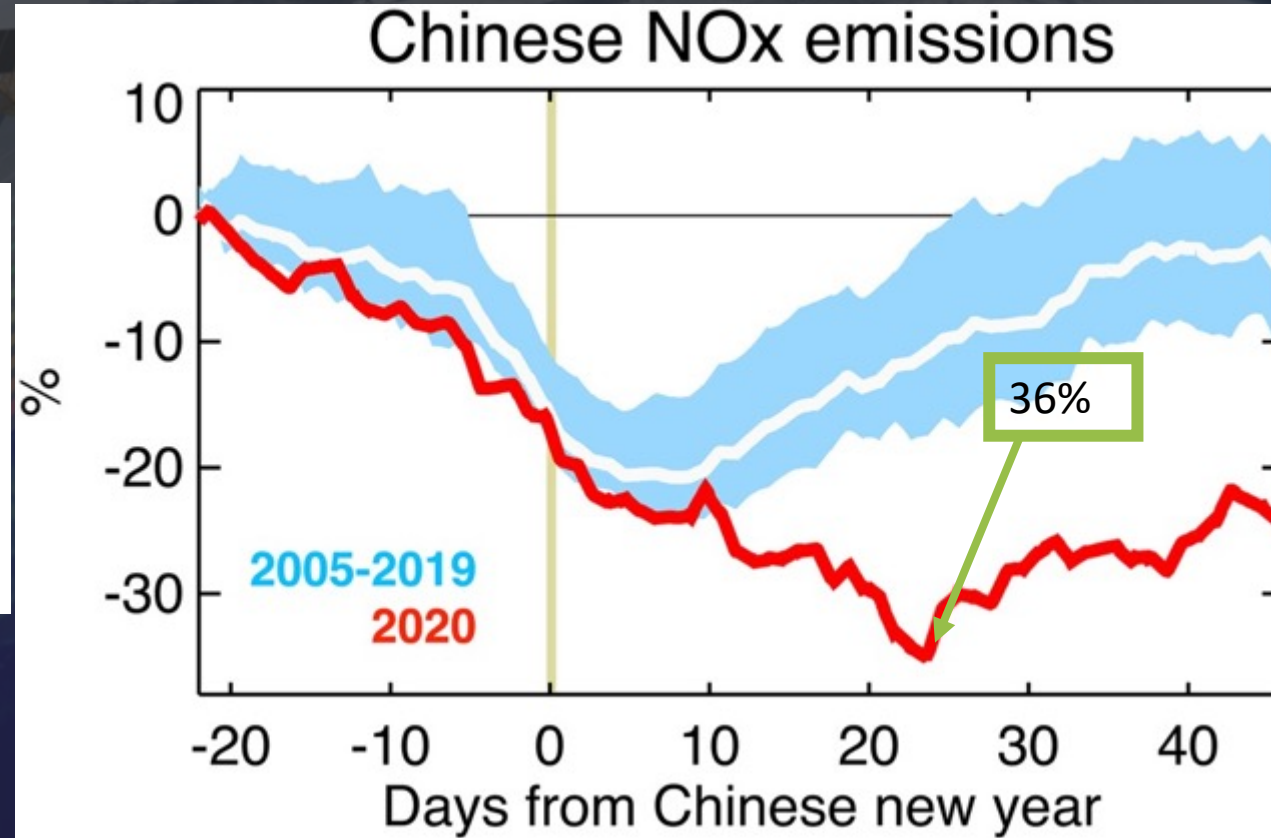
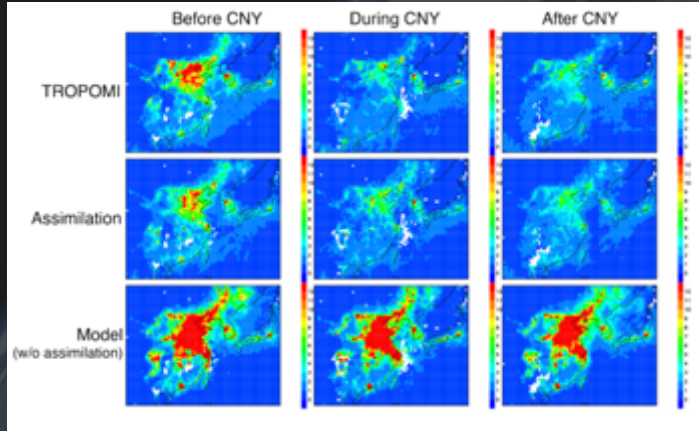


Liu et al. (Sci. Adv.) show that Satellite measurements show about 50% drop in tropospheric nitrogen dioxide vertical column densities from (C) to (A). OMI observations show that the decline in 2020 is $21 \pm 5\%$ larger after the CNY than that from 2015 to 2019.



Bauwens et al. (GRL) conclude that Satellite NO₂ data show substantial decreases by 40% on average over Chinese cities due to lockdown measures against the coronavirus outbreak

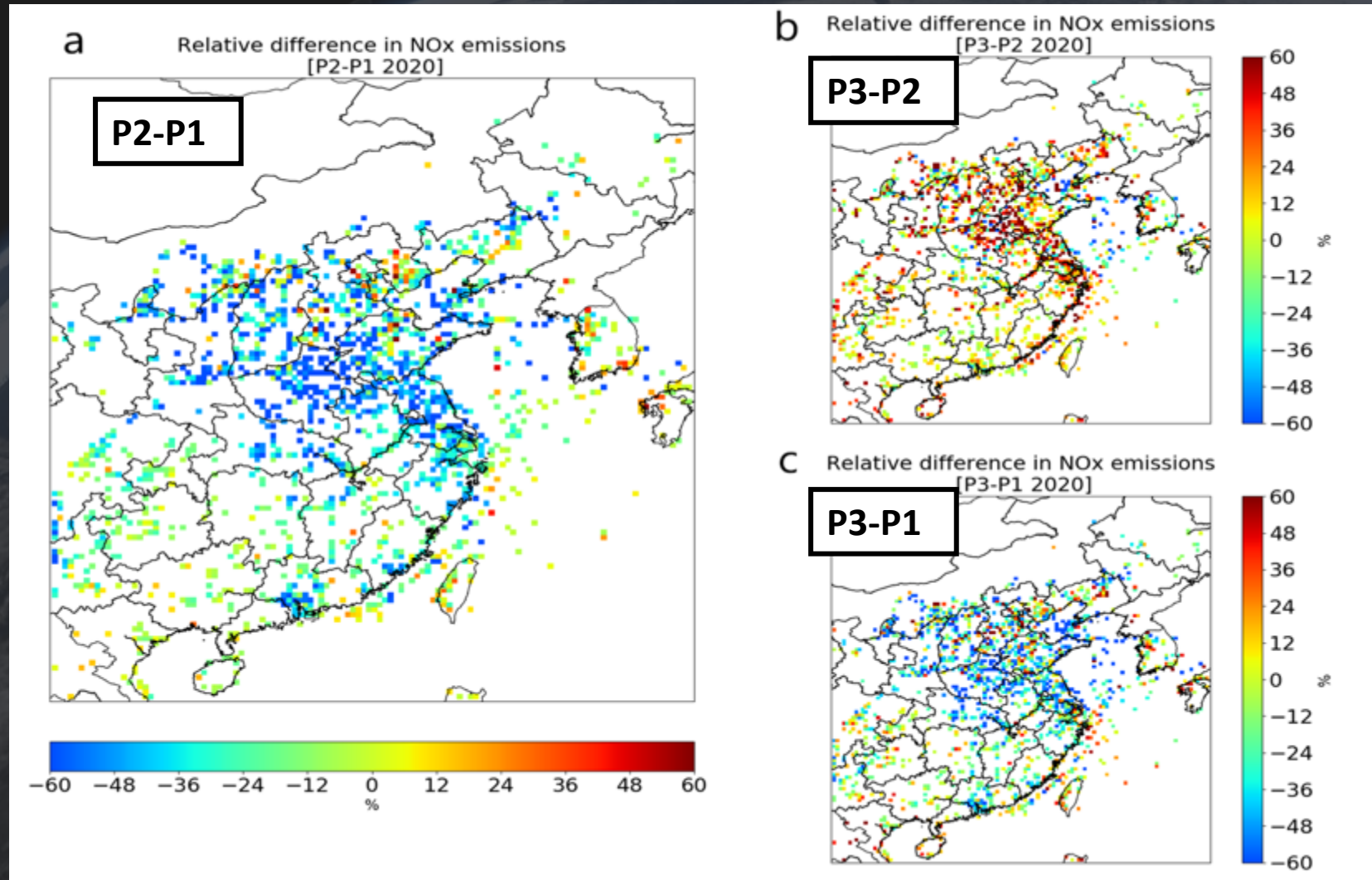
Satellite-derived NOx emissions



NOx emissions from advanced emission inversion method from satellite observations

The relative emission changes derived using two instruments (TROPOMI and OMI) are consistent at country scale (Miyazaki et al., GRL)

Satellite-derived NO_x emissions



NO_x emissions from DECSO (Ding et al., GRL):

- strong decrease with few exceptions
- Over Ocean:
 - Shanghai- Guangzhou: Decrease by 25% in P2
 - Increase with 18% in P3

Bohai Sea and Yellow sea:

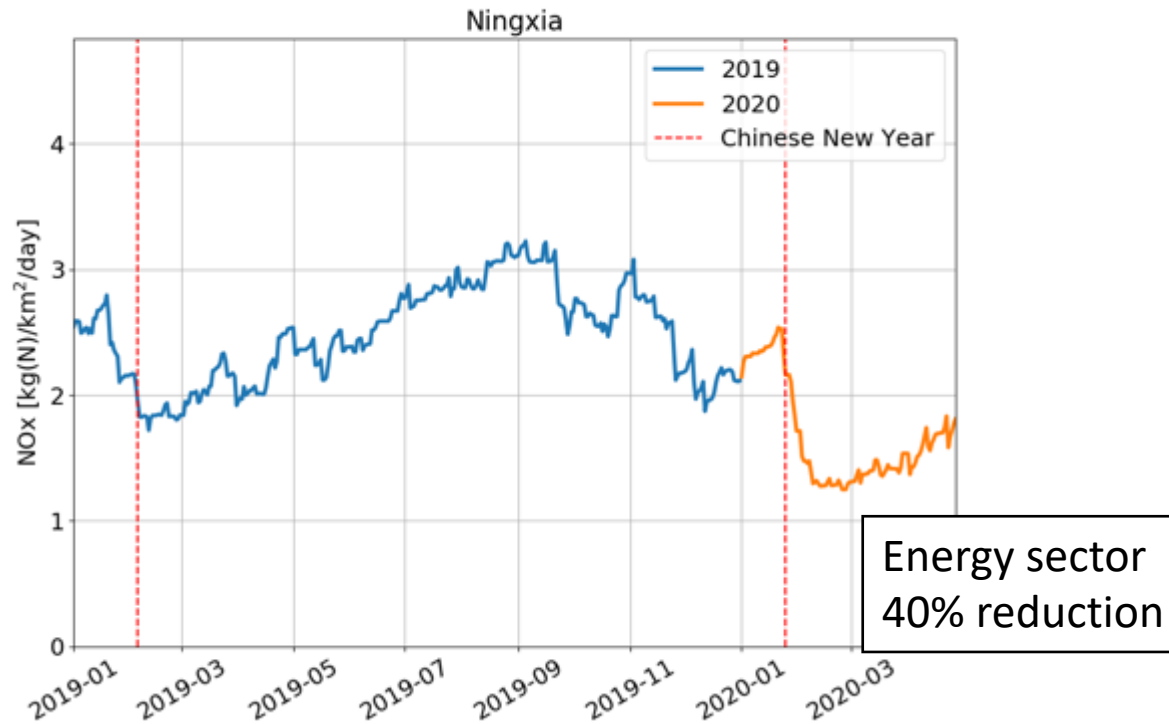
- Reduce by 41% in P2
- Continuing decreasing by 6% in P3

P1: 3-23 January
before

P2: 8-28 February
during

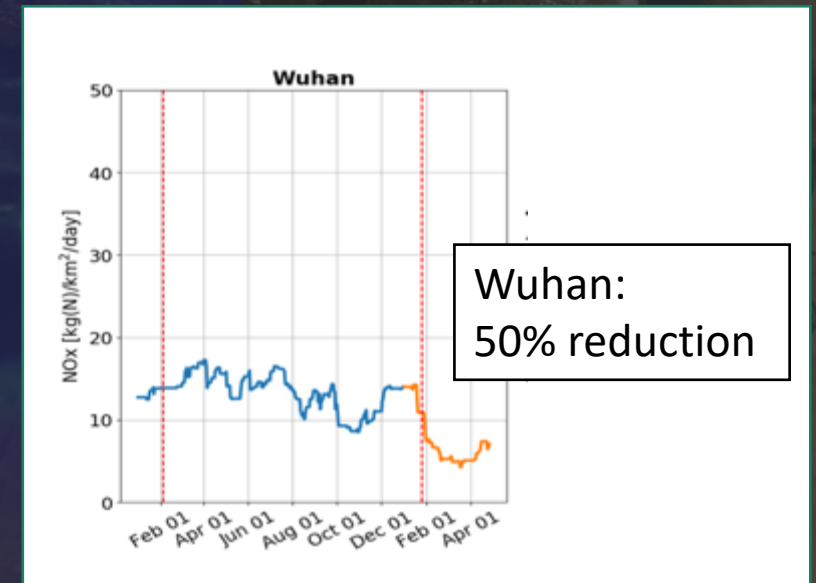
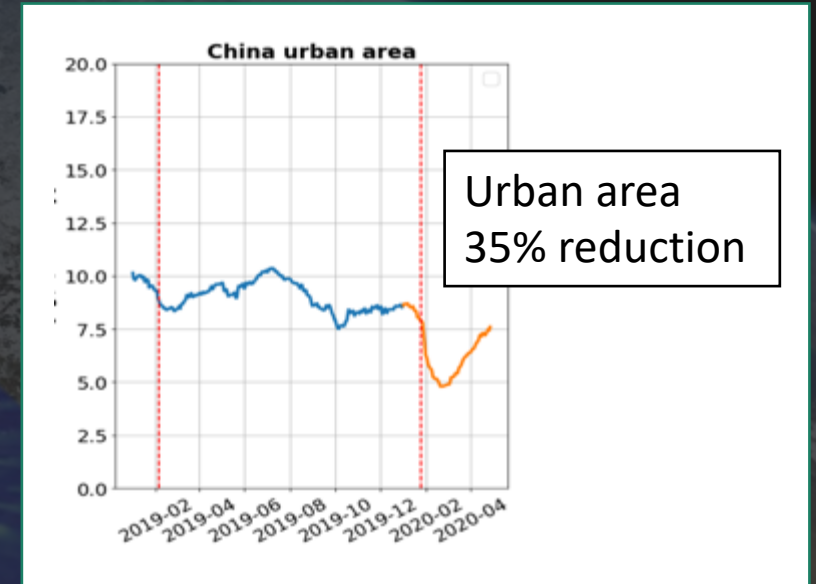
P3: 18 March to 7 April
after

Satellite-derived NOx emissions



Ningxia Province:

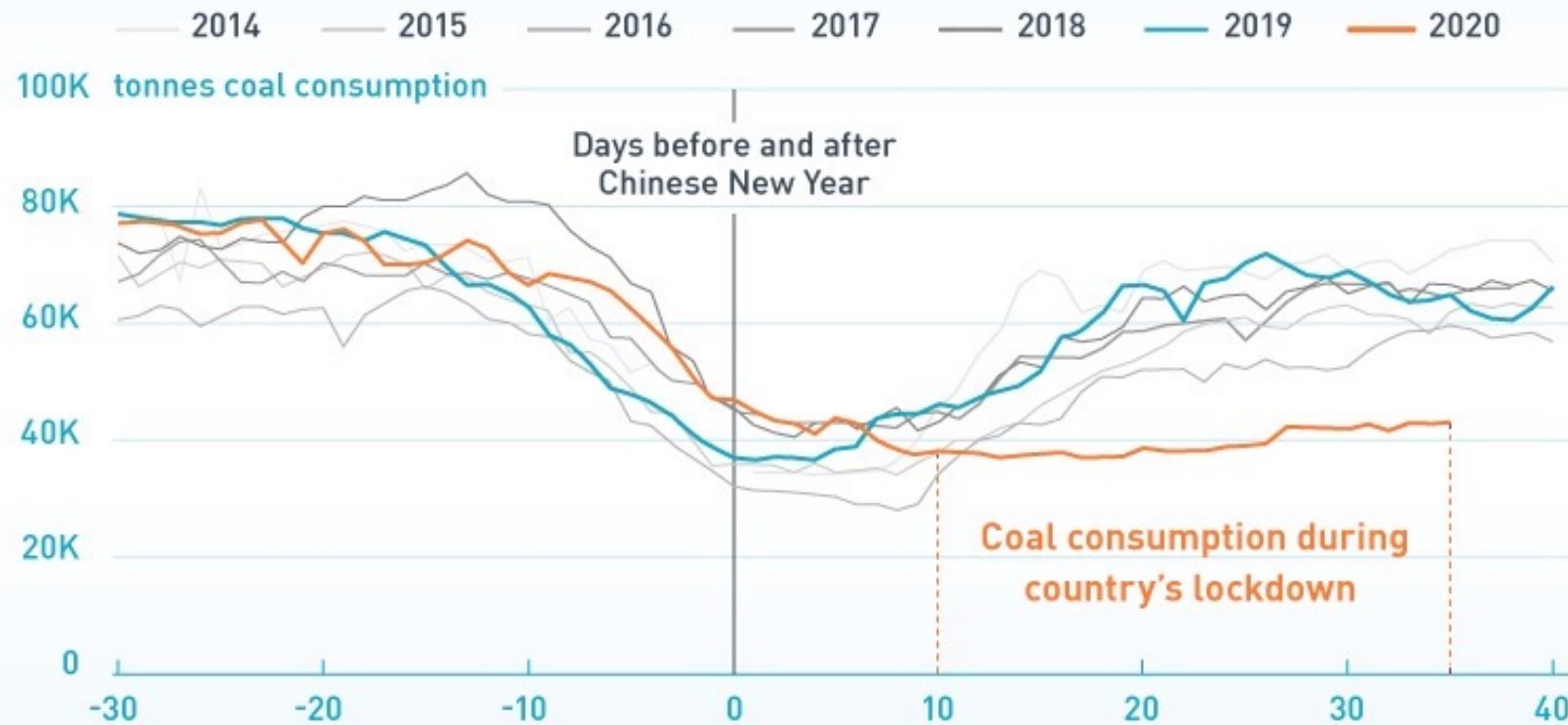
- 0.4% of the total population
- Coal production, electricity generation from coal power plants are in the top ten list.
- 80% of the generated energy for industry



Satellite-derived NOx emissions

CHINA'S COAL USE PLUMMETS

Consumption dropped 36% compared to the same period last year, as the coronavirus outbreak put much of the country on lockdown.

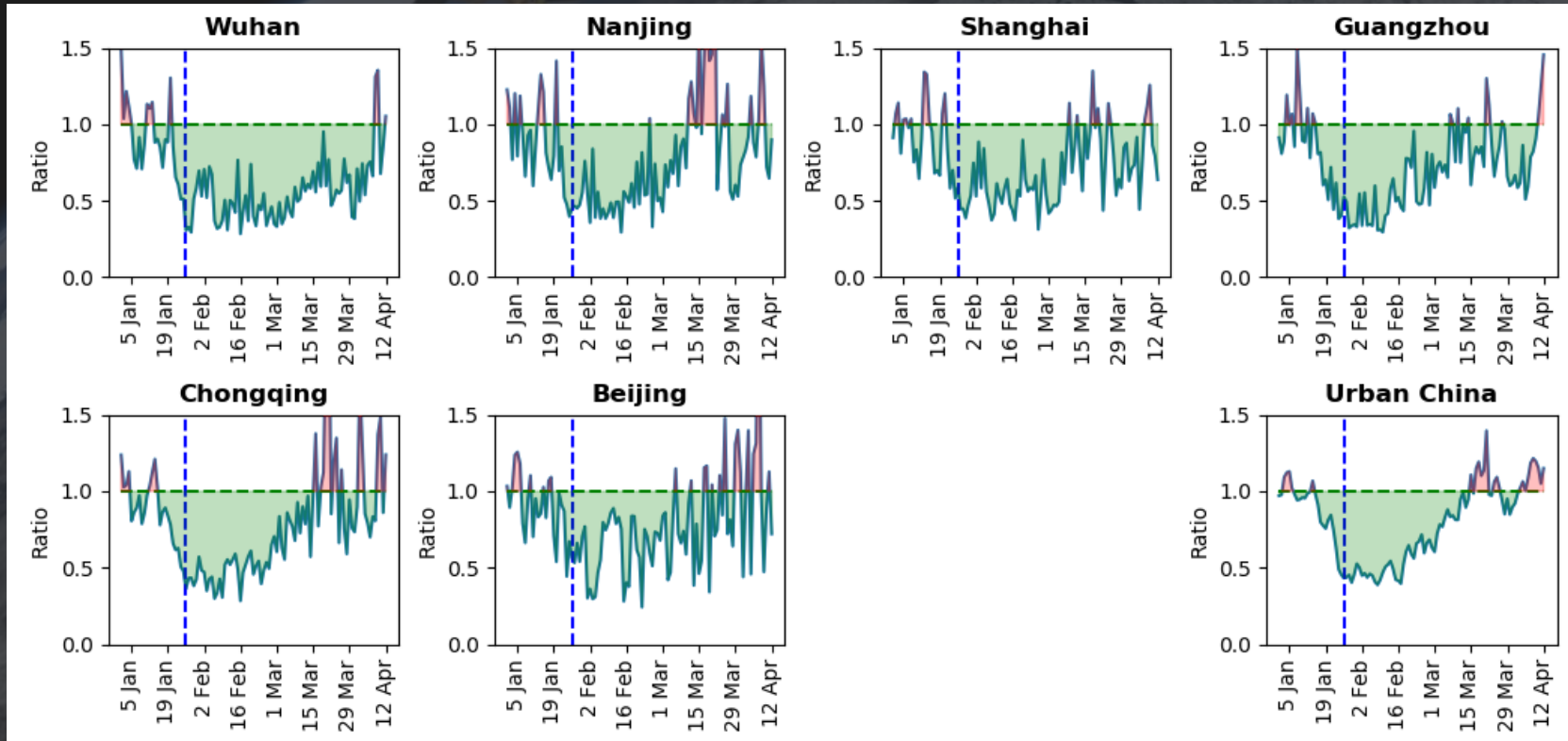


Source: CREA/WIND / Graphic: Jason Kwok, CNN



Concentration reduction

in-situ measurement vs ensemble forecast (business-as-usual)



- Green areas show the reduction,
- Red areas show the increase.
- Most cities: reductions start around the Chinese new year (blue line) and end in March
- Wuhan: reduction ends in April
- 36 selected most populated cities: average concentration reduction is 41%, and averaged emission reduction is 35%

The ratio between in-situ measured NO₂ and the modelled NO₂ from 1 January to 12 April 2020



Conclusions

Due to the lockdown measures:

- Emission reductions for cities are ranging from 20% to 50%.
- The emissions reduction of the energy sector is about 40%.
- For maritime transport, the reductions are about 25 to 40% depending on the region.

The reductions in both emissions and concentrations show a similar timeline consisting of a sharp reduction around the Spring festival and a slow recovery from mid-February to mid-March.



References:

Bauwens, M. S. Compernelle, T. Stavrakou, J.-F. Müller, J. van Gent, H. Eskes, P. F. Levelt, R. van der A, J. P. Veefkind, J. Vlietinck, H. Yu, C. Zehner: Impact of coronavirus outbreak on NO₂ pollution assessed using TROPOMI and OMI observations. *Geophysical Research Letters*, <https://doi.org/10.1029/2020GL087978>, 2020. <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020GL087978>

Liu, F., A. Page, S. A. Strode, Y. Yoshida, S. Choi, B. Zheng, L. N. Lamsal, C. Li, N. A. Krotkov, H. Eskes, R. van der A, P. Veefkind, P. F. Levelt, O. P. Hauser, J. Joiner: Abrupt decline in tropospheric nitrogen dioxide over China after the outbreak of COVID-19. *Science Advances*, <https://doi.org/10.1126/sciadv.abc2992>, 2020. <https://advances.sciencemag.org/content/6/28/eabc2992>

He, G., Pan, Y. & Tanaka, T. The short-term impacts of COVID-19 lockdown on urban air pollution in China. *Nat Sustain* (2020). <https://doi.org/10.1038/s41893-020-0581-y>
<https://www.nature.com/articles/s41893-020-0581-y>

Miyazaki, K., K. Bowman, T. Sekiya, Z. Jiang, X. Chen, H. Eskes, M. Ru, Y. Zhang and D. Shindell: Air Quality Response in China Linked to the 2019 Novel Coronavirus (COVID-19) Lockdown. *Geophysical Research Letters*, 47, <https://doi.org/10.1029/2020GL089252>

Ding, J., van der A, R. J., Eskes, H. J., Mijling, B., Stavrakou, T., van Geffen, J. H. G. M., et al. (2020). NO_x emissions reduction and rebound in China due to the COVID-19 crisis. *Geophysical Research Letters*, 46, e2020GL089912. <https://doi.org/10.1029/2020GL089912>