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Covid-19 imprints on the short- and long-lived chemical species in the troposphere

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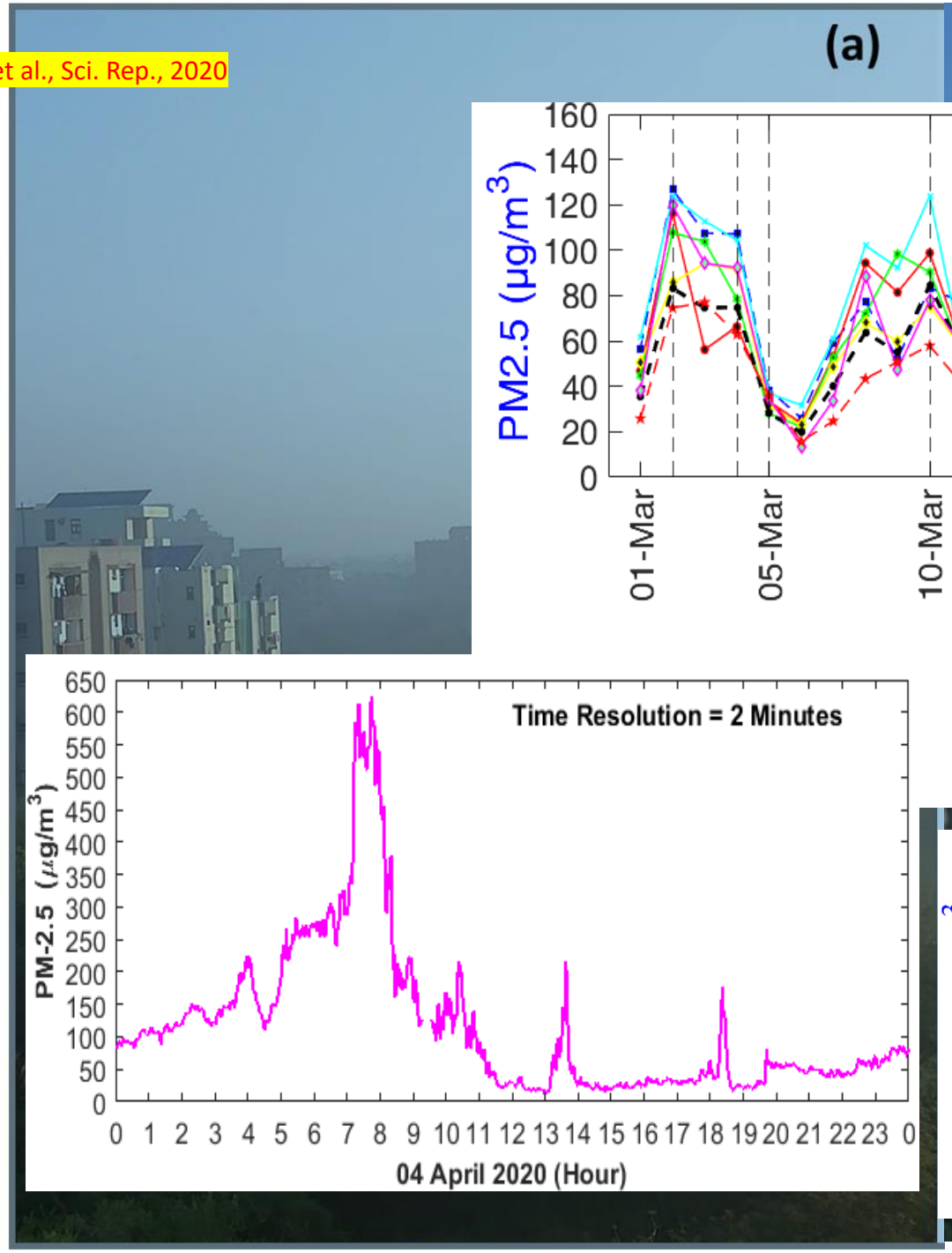
Introduction

- Covid-19 pandemic has produced large impact on our lifestyle and industrial activity since the late February 2020
- The primary (NO_2) and secondary (PM2.5) air pollution species, as observed from the satellites, showed large decreases over different parts of the globe depending on the timing of lockdowns
- We have analysed time series observations in one of most polluted city (New Delhi) and its neighbourhood for understanding the effects of lockdown on the air pollution and tropospheric radiation budget

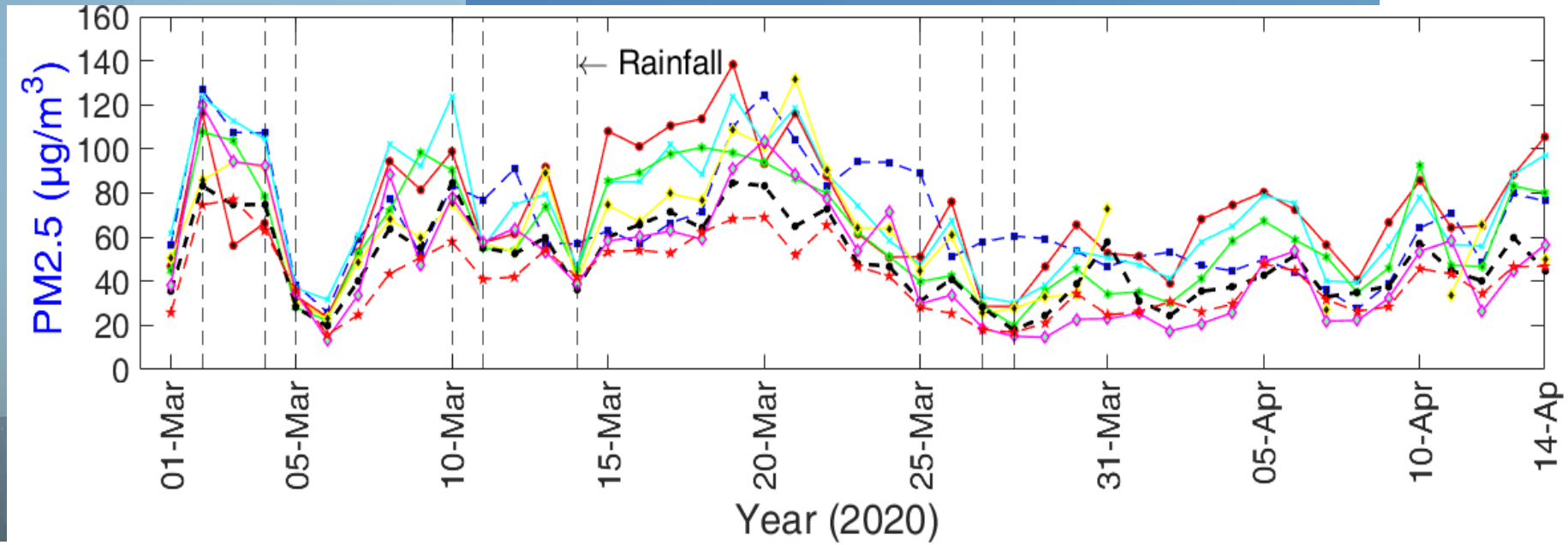
- Considering the present level of the fossil fuel CO_2 (FF-CO_2) emissions (about 10 PgC yr^{-1}), a 10% reduction of the global emission results in a decrease of about 0.5 ppm in global mean CO_2 growth rate
  - the global mean CO_2 growth rate is about 2 ppm per year with a large interannual variability (up to 70%) due to the biosphere-climate feedbacks (e.g., Patra et al., 2005)
  - this situation poses a different challenge for the satellite and surface measurements to detect the Covid-19 effect on CO_2 concentrations
- We have taken a different approach to detect a 30% reduction in China FF-CO2 emissions during Feb-Mar 2020 using inventory emission scenarios and model simulations

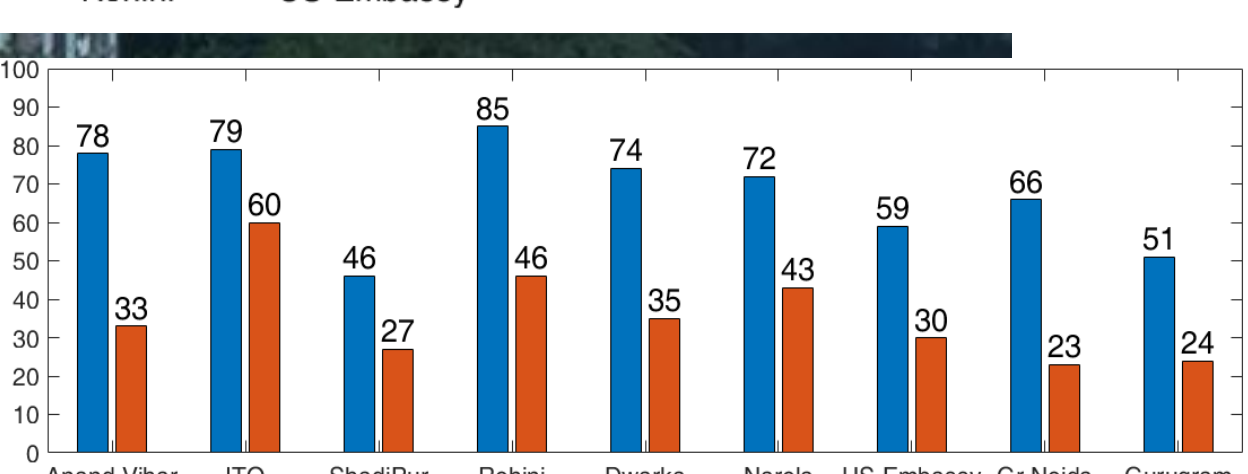
Dhaka et al., Sci. Rep., 2020



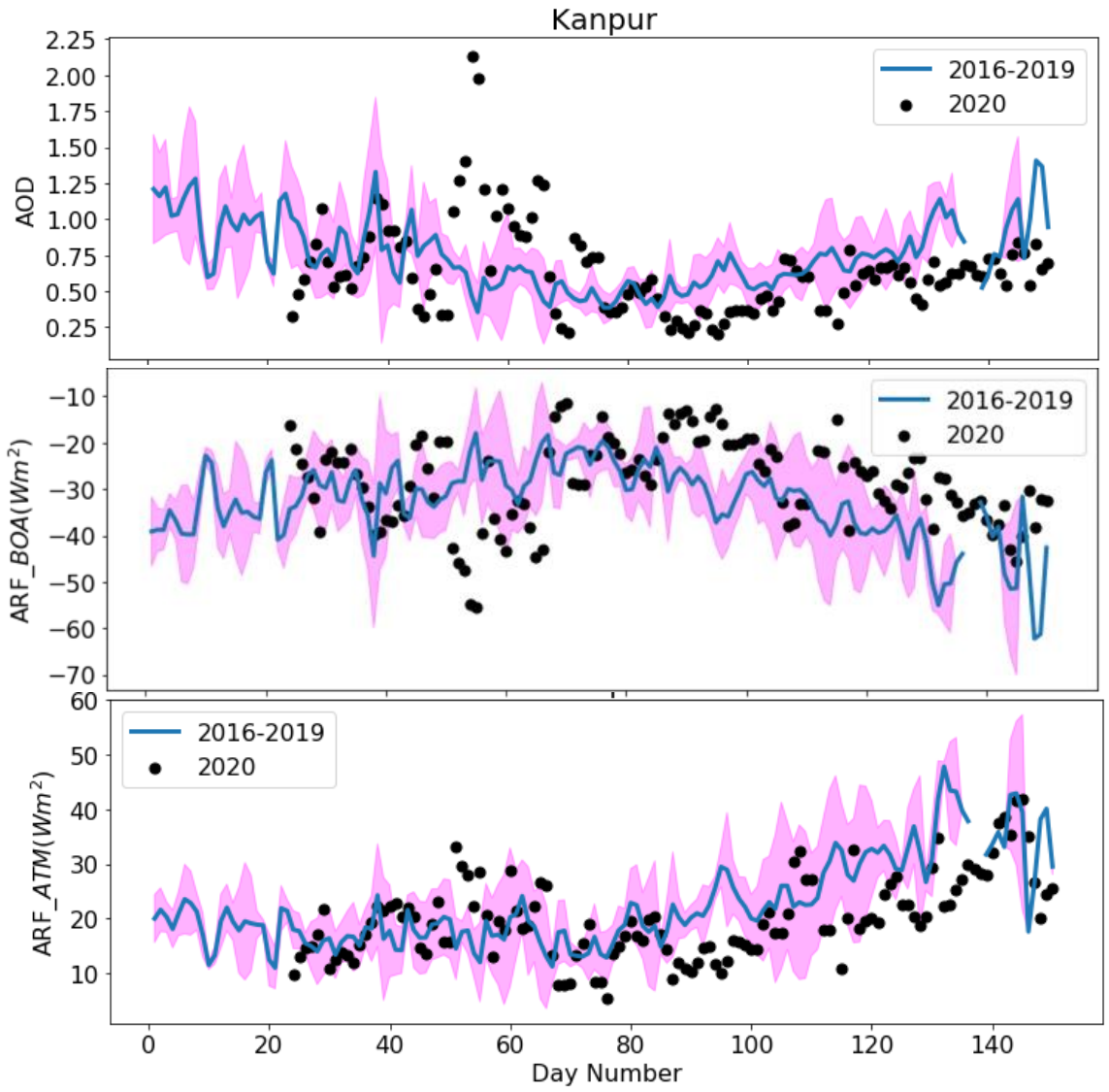
(a)

(b)





Q1. Impact of Covid-19 on the Earth's radiation budget



Kanpur, India AERONET site:
2016-2019: Average of 4 years (blue line; shaded 1-**σ** standard deviations)

Time series of daily mean aerosol optical depth (AOD) at 440nm.

Time series of 24 hours mean aerosol radiative forcing at the bottom of the atmosphere (BOA).

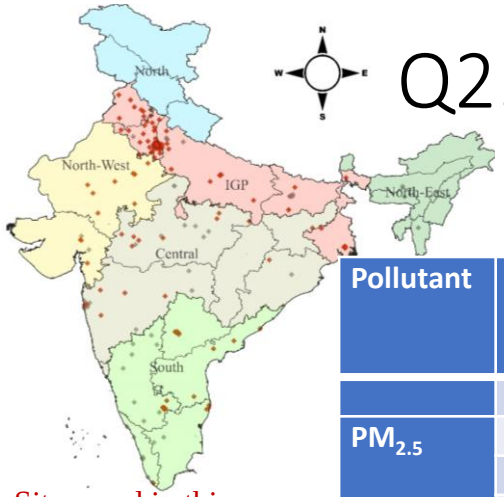
Time series of 24 hours mean atmospheric forcing (Atmospheric forcing is calculated as)

$$F_{ATM.} = F_{TOA} - F_{BOA}$$

Khatri et al., Unpublished
DATA: AERONET, IIT-Kanpur

Singh et al., Env. Pollut., 2020

Q2. Impacts of Covid-19 air pollution and human health



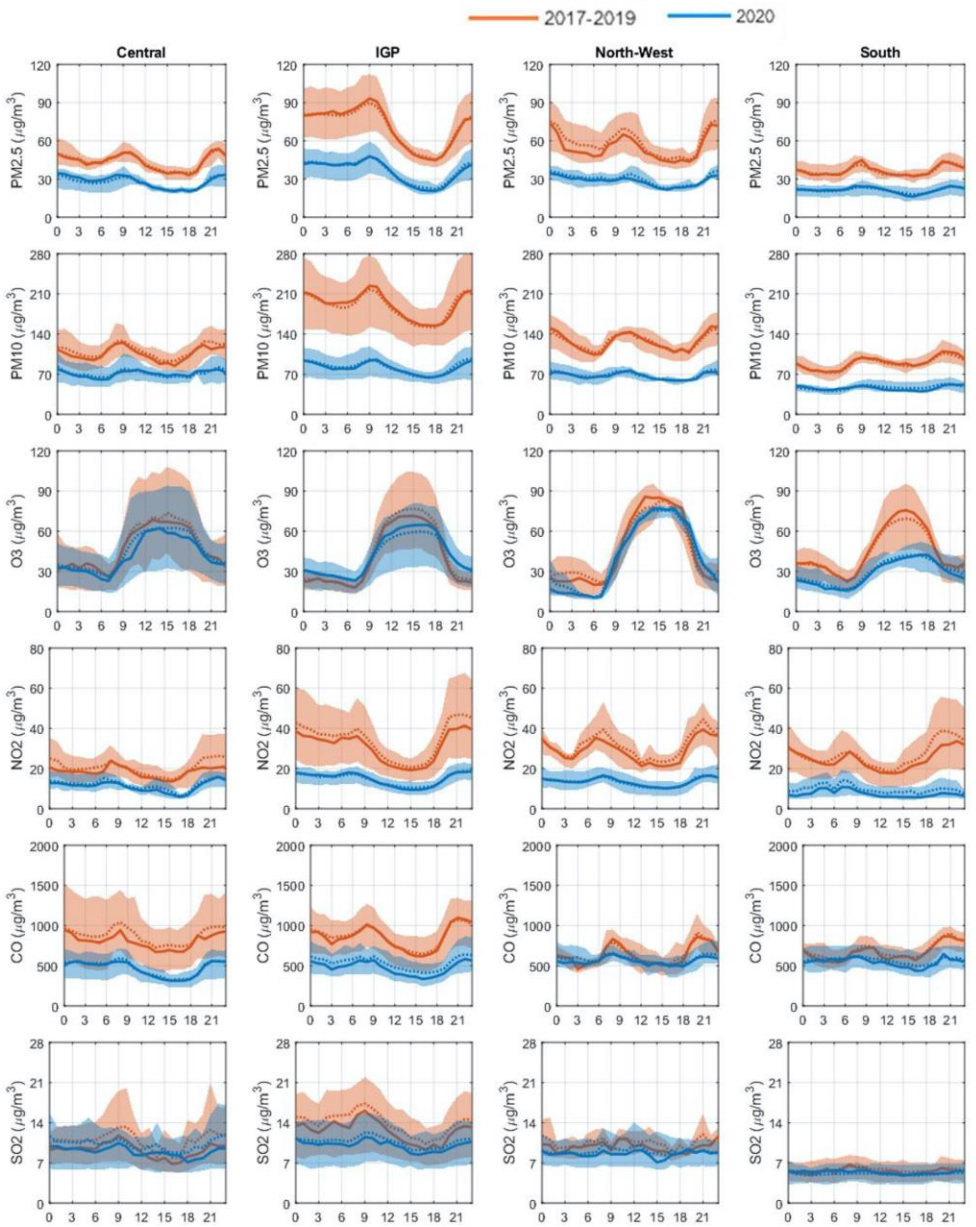
Sites used in this study are highlighted in red colour

Pollutant	Region	# of Stations	Avg. conc. (2017-2019)	Avg. conc. (2020)	*National Ambient AQS***
			(µg/m^3)	(µg/m^3)	(µg/m^3)
$PM_{2.5}$	Central	9	43	26	40–60 (An, 24h)
	IGP	80	70	37	
	North-West	13	61	31	
	South	19	38	21	
PM_{10}	Central	14	109	74	60–100 (An,24h)
	IGP	63	186	82	
	North-West	11	128	68	
	South	12	91	47	
O_3	Central	9	54	44	100–180 (8h,1h)
	IGP	65	41	41	
	North-West	12	43	40	
	South	14	43	31	
NO_2	Central	10	21	13	40–80 (An, 24h)
	IGP	57	33	15	
	North-West	10	32	14	
	South	16	27	14	
CO	Central	9	868	489	2–4x10^3 (8h, 1h)
	IGP	60	854	544	
	North-West	13	651	582	
	South	14	696	565	
SO_2	Central	7	11	12	50–80 (An,24h)
	IGP	58	14	11	
	North-West	9	11	10	
	South	16	6	5	

Air pollutant change during the lockdown (25/3 – 03/5 2020) ?

National AAQ vs WHO standards

**http://www.arthapedia.in/index.php?title=Ambient_Air_Quality_Standards_in_India



Tracking fossil-fuel CO_2 signal due to Covid-19 in Earth's atmosphere

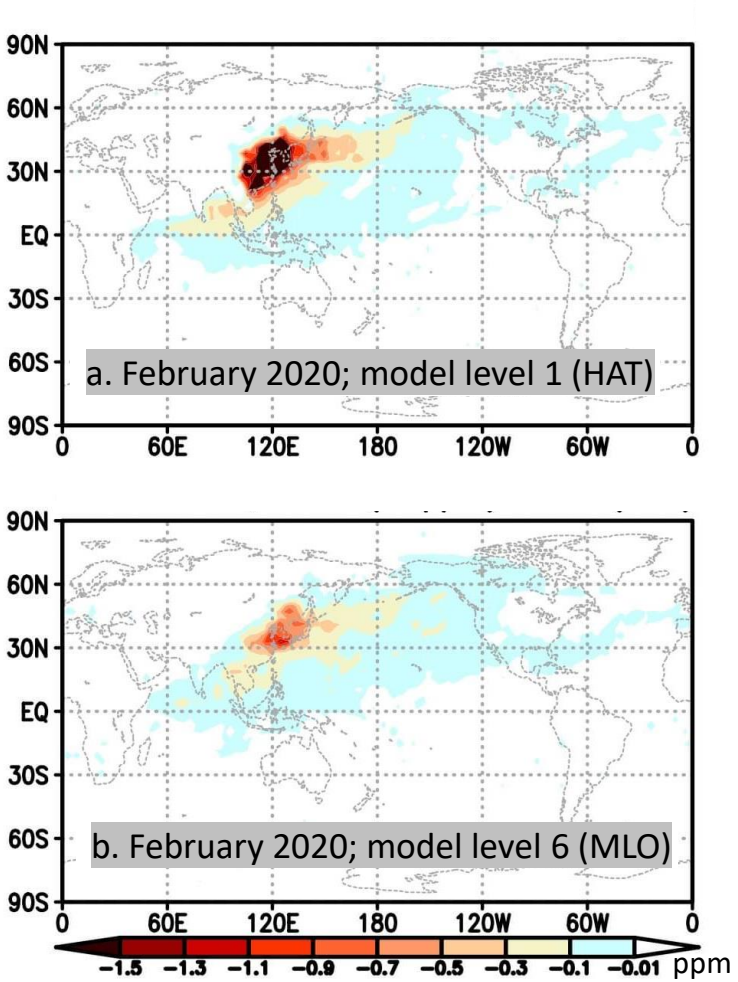
by P. K. Patra

MIROC4-ACTM simulated CO_2 RSD differences (Covid19-Control) for a 30% emission reductions in China for Feb 2020

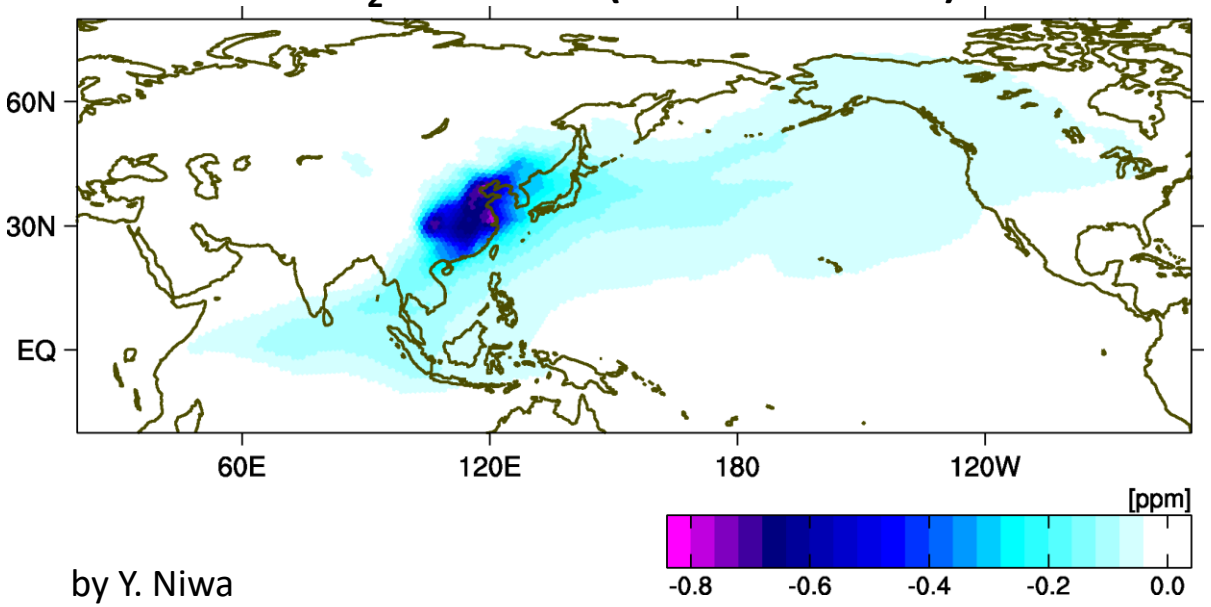
RSD: residual standard deviation (time series – fitted line)

The model simulation at horizontal resolution of ~2.8°x2.8°

RSD difference (Covid19-Control)



XCO_2 difference (Covid19-Control)



by Y. Niwa

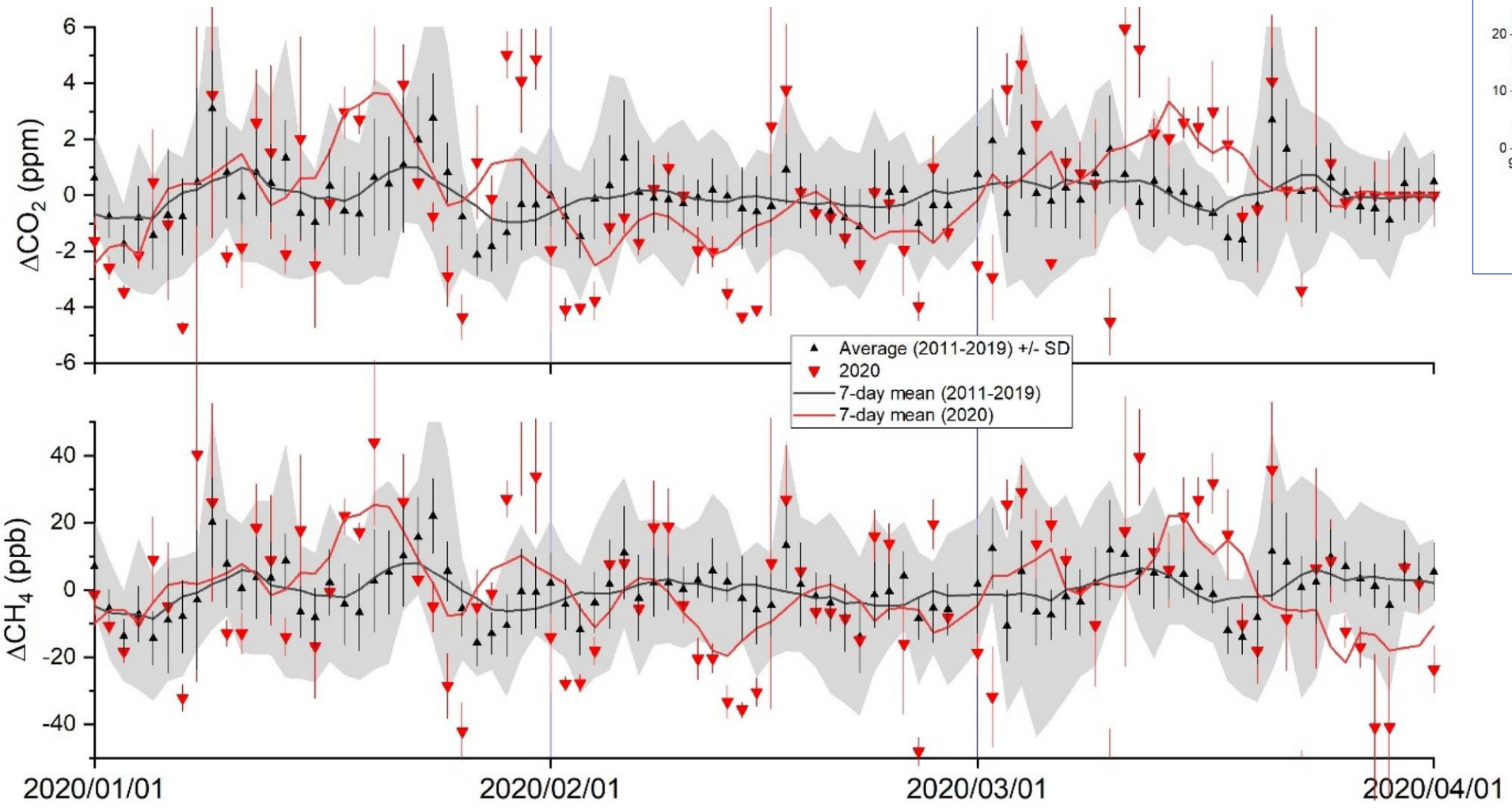
NICAM-TM simulated XCO_2 differences (Covid19-Control) for a 30% emission reductions in China for Feb 2020

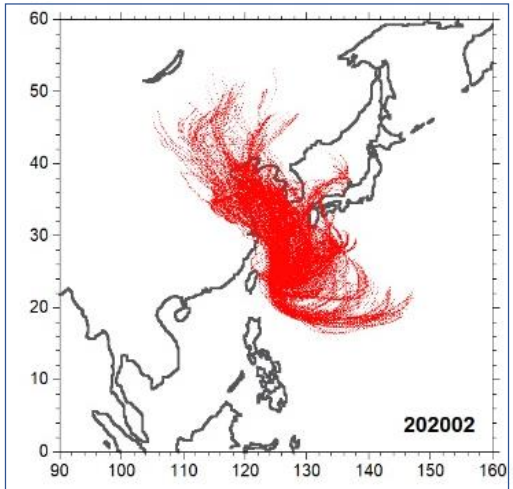
The model simulation is run at horizontal resolution of ~112 x 112 km, which is much larger than the satellite footprints ~3 x 3 km

Some signals of about 1 ppm would be present in the GOSAT and OCO-2, if the background could be defined

Tohjima et al., 2020

Detection of Covid-19 signal in CO_2 measurments





Hateruma, Japan
(24.05°N, 123.80°E)

The site makes continuous CO_2 and CH_4 since 1996 at sub-hourly time intervals

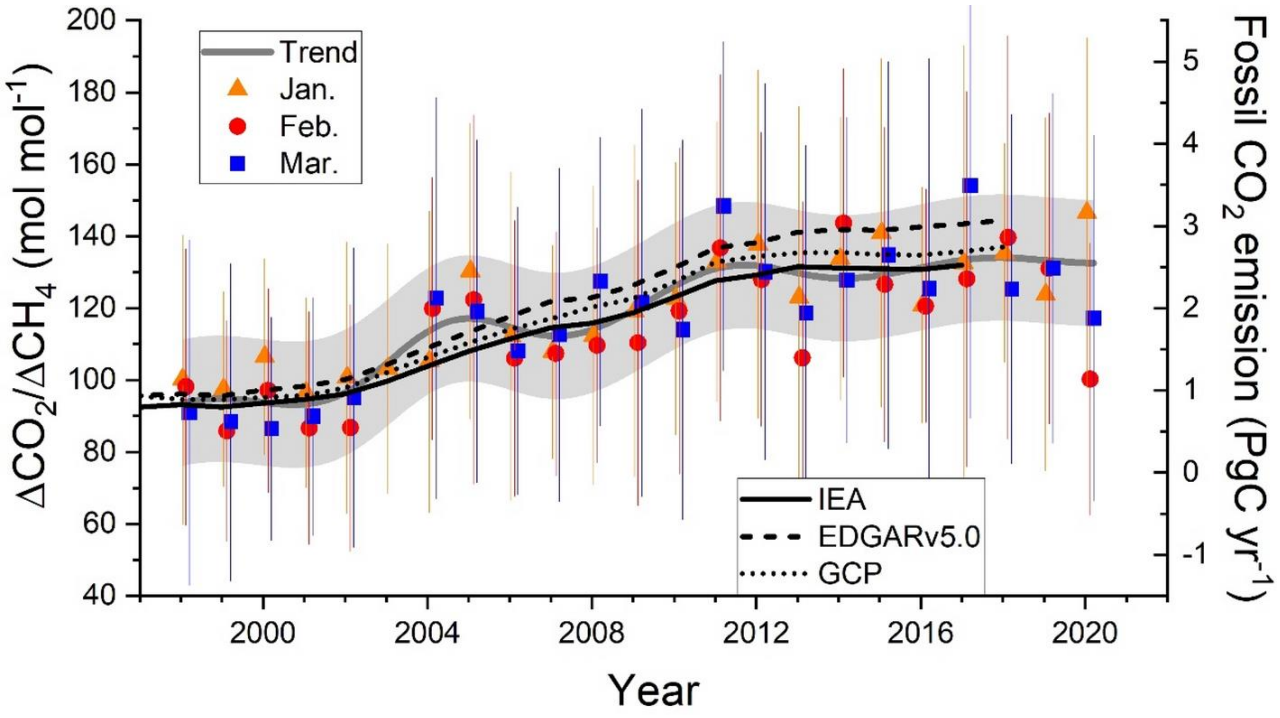
Measurement accuracy are :
~0.1 ppm for CO_2
~5 ppb for CH_4

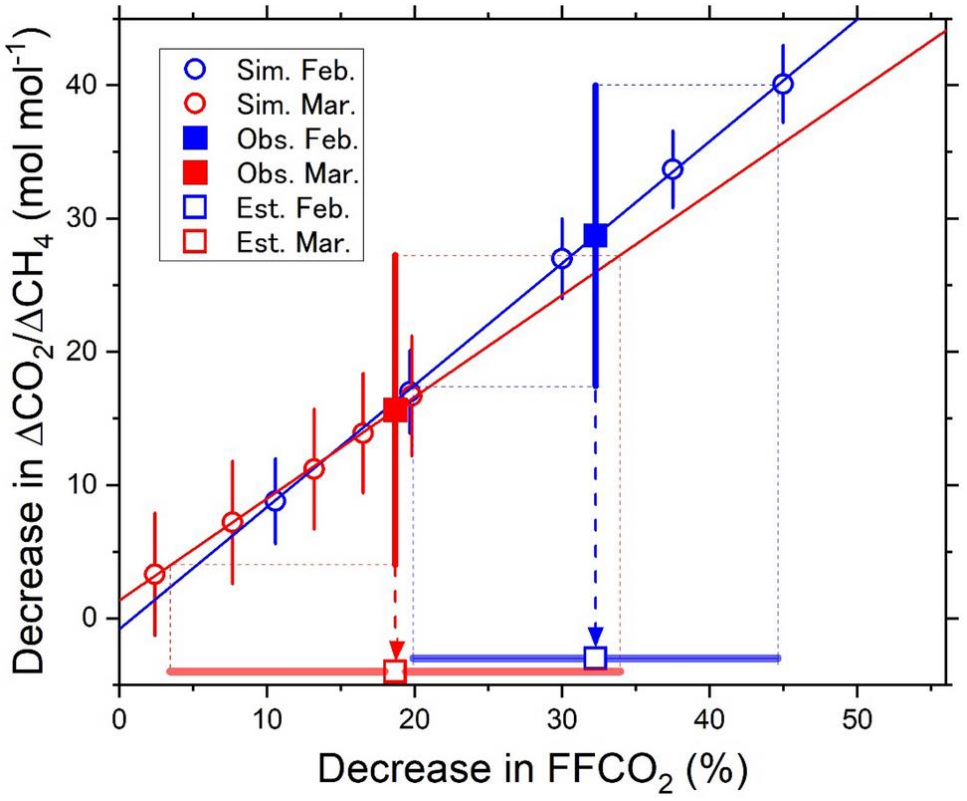
Tohjima et al., 2020

Tohjima et al., 2020

Monthly average $\Delta CO_2/\Delta CH_4$ ratios and FF-CO_2 for Jan-Feb-Mar

High-quality, high-time resolution and long-term observations at Hateruma helps us to validate the model for FF-CO_2 emission change (1998-2019)





The NICAM-TM simulations using severity of confinement data (Le Quéré et al., 2020) helps to estimate 2020 emission reduction from China

Conclusions

- We have analysed the effect of Covid-19 on the short-lived air pollutants and long-lived greenouse gases near the earth's surface
- The short-lived air pollutants, except for O_3, show immediate decrease in concentration following Covid-19 related socioeconomic restrictions
- While the detection of mean concentration changes were challenging for both CO_2 and CH_4, we are able to detect changes in the ratio of their synoptic variabilities
- Our results suggest high-quality long-term surface observations without data gaps are indispensable for accurately tracking emission mitigation policies

Thank you

Questions, comments and suggestions