Commission for Air Quality Management in NCR and Adjoining Areas (CAQM), Jawahar Vyapar Bhavan, New Delhi, 4 Oct 2024, 12:00

RIHN Aakash Project: atmospheric observations of $PM_{2.5}$ and other air pollutants in the north-west India

RIHN Aakash Project Leader: Prabir K. PATRA* (2023-2024), S. HAYASHIDA (2019-2022)

An interdisciplinary study toward clean air, public health, and sustainable agriculture: *case of crop residue burning in north-western India*

…acknowledging contributions from all the project members, in Japan, India and several other countries

Research Institute for Humanity and Nature 総合地球環境学研究所

JAMSTEC 国立研究開発法人 海洋研究開発機構 Japan Agency for Marine-Earth Science and Technology

Kharif Rice Paddy Stubble

Crop Residue Burning (CRB)

Human Health & Sustainability

(bottom-up) Structure and goals of Aakash Project

Revised from: S. Hayashida

Field surveys

WG1a: Field survey on cultural and socio-economic background of rural Punjab
農村社会の文化的・社会経済的背景の把握

WG1b: Crop diversification, soil conservation & GHGs
作物の多様化・土壌の保全. GHGs

WG1c: Ex-situ management of rice straw & husk
稲わらのバイオエネルギー利用など

WG1
Sustainable agriculture
持続可能な農業

WG2
Clean air
清浄な空気

WG3
Health
健康

1 2 3

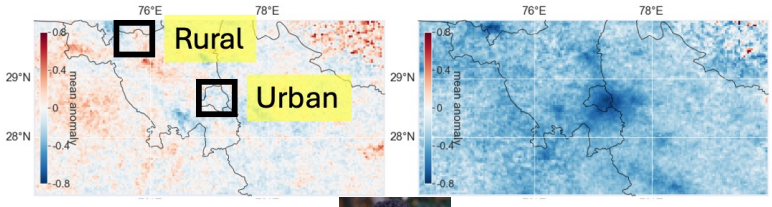
Behavioural changes among community, stakeholders and government policy
社会・ステークホールダー行政機関の行動変容

Atmospheric Science and Remote Sensing
モデルとリモートセンシング

Epidemiology and Public Health
疫学と公衆衛生

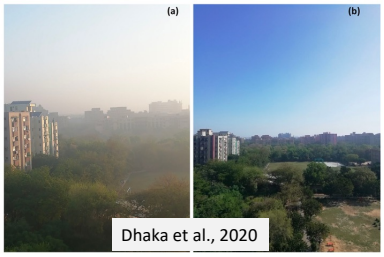
Funding per year : 50 mil Yen / ~30 lacs

COVID-19 : the positives and negatives out of the Pandemic

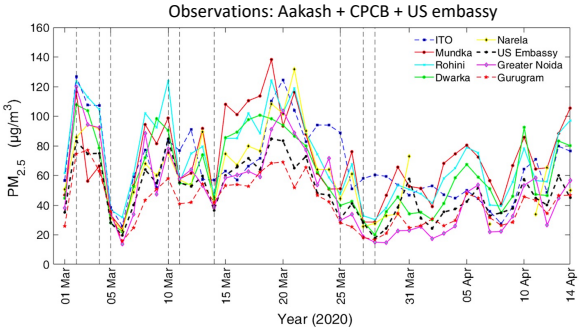


(a) BAU (b) Phase 1

Misra et al., 2021



Observations: Aakash + CPCB + US embassy

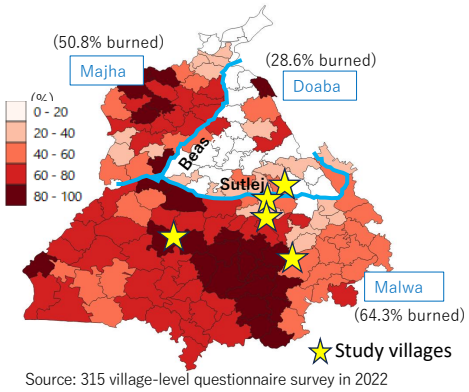


The downside of COVID-19 for our project:

1. We could not exchange between the researchers on both sides for 2 whole years (2020 and 2021)
2. Some of the exchanges started slowly by late 2022, e.g., the CUPI-G measurements
3. Due to lack of progress on research, we could not follow-up with any formalities, including communicating with CAQM and other govt. agencies in India or Japan

3

(WG1a) Regional differences in terms of burning



Source: 315 village-level questionnaire survey in 2022

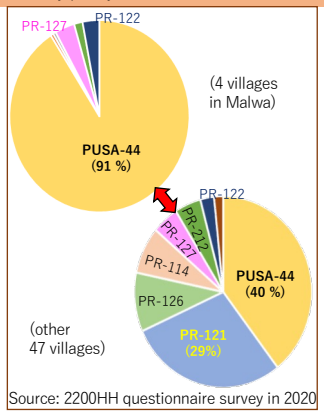
From questionnaire surveys and field surveys

Malwa region is;

- Less landholdings→ higher yield varieties → longer growing duration→ less time after harvest?
- Need to observe on machinery availability and skilled labour availability among different socio-cultural groups based on castes

Data in : Asada & Vatta. (2022)

households by paddy varieties in Kharif season (%)



Source: 2200HH questionnaire survey in 2020

Rice is not the traditional crop of Punjab - constraint to only some districts of north west region of state and predominantly rainfed. During 1960-61, the total area of Punjab under paddy was ***0.23 million hectares***. The total production in the former year was 0.34 million tons with the average ***yield of 15 quintals per hectare***.

Adoption of semi dwarf high yielding paddy varieties along with production technologies have made Punjab 'The Rice Bowl of India'. During 2012-13 the area of Punjab covered by the paddy had reached to ***2.8 million hectares*** and productivity of ***60 quintals per hectare***.

As the water table of Punjab is falling by up to 3 feet per year, the production of Rice is being more challenging and drastic in the state. More than 95 percent of the cultivated area of the state is irrigated of which most of the irrigation is done with tubewells, pumping more than 56 billion litres of water every year for rice production.

Consumption of rice is as minimum as 0.2 kg per capita per month in the state of Punjab

(Jaspreet Singh, Head Grower at GoodLeaf Farms)

4

(WG3) Awareness of air pollution in Punjab: progress in the analysis of surveys

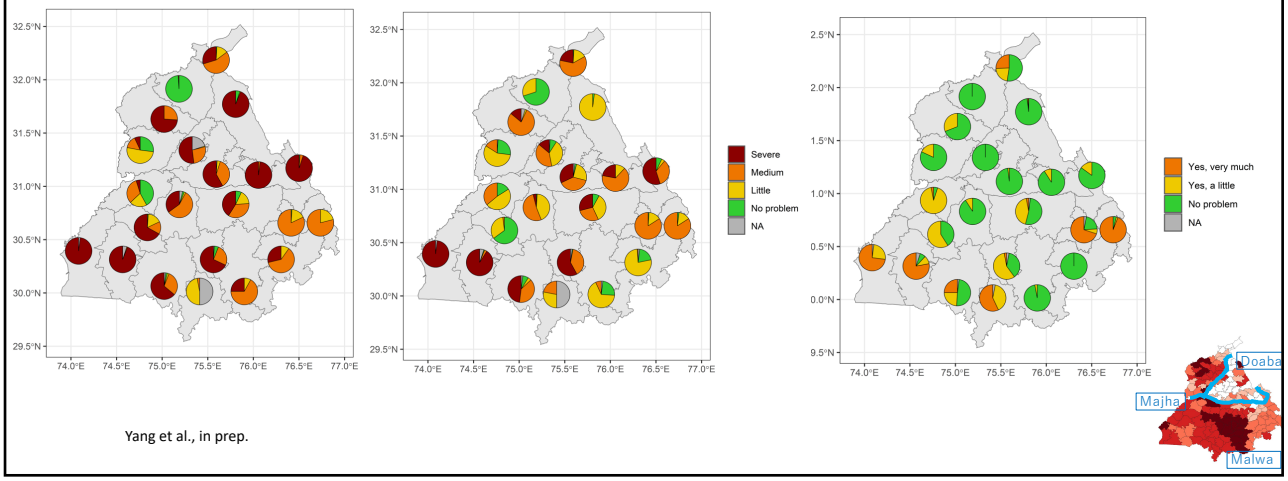
- Survey area: 22 districts of the state of Punjab
- Time period: 2020 Aug. to 2021 Jan.
- Subjects: 2202 households (50 Households/Village)

Respondents:
M:F =2196 : 6
Mean Age 50.8

About air pollution in **Delhi**

About air pollution in **Punjab**

Do you think smoke from stubble burning affects you and your family's health?



Yang et al., in prep.

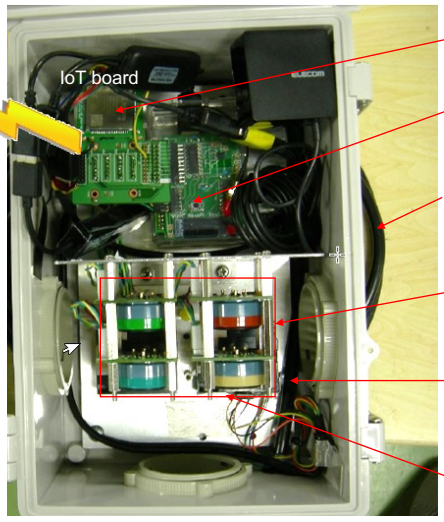
5

CUPI-G The instrument for PM2.5 and pollutant gases specially designed for the Aakash project

Nakayama et al., 2017; doi: 10.1080/02786826.2017.1375078

Data transmission to Cloud server Every day

Via mobile network



SIM card board

Raspberry Pi A+ (CPU)

GPS antenna

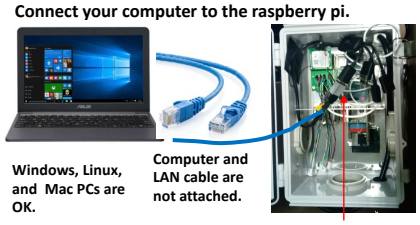
Electro-chemical sensors Alphasense UK Corp.
CO, Ox, NO_2, NO

Temperature & Humidity sensors

PM2.5 sensor

Cost : @$2,000 (@300,000 yen)

Connect your computer to the raspberry pi.



Windows, Linux, and Mac PCs are OK.

Computer and LAN cable are not attached.

LAN-USB adaptor (attached)

$PM_{2.5}$ range: 10～600μg/m^3
Temperature range: －10～100° C
Relative Humidity: 10～95％

Price: 50,000円

www.sibata.co.jp/item/080990-002

Sep. 2023
Yamasaki-san
Mangaraj-san
Kojima-san

CUPI-G

6

WG2 =>> WG3 : Aakash (CUPI-G) measurement networks in 2022 & 2023

Existing Indian measurement networks

SAFAR-India (http://safar.tropmet.res.in)

Central Pollution Control Board: CPCB (India)

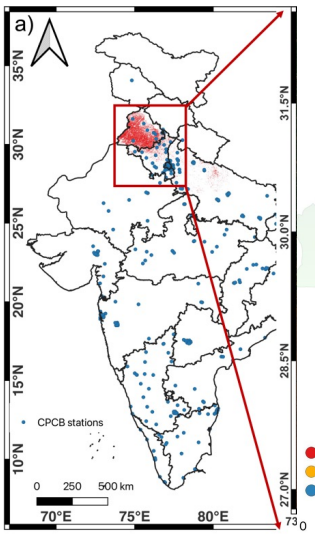
US Embassy (BAM*), JP Embassy…

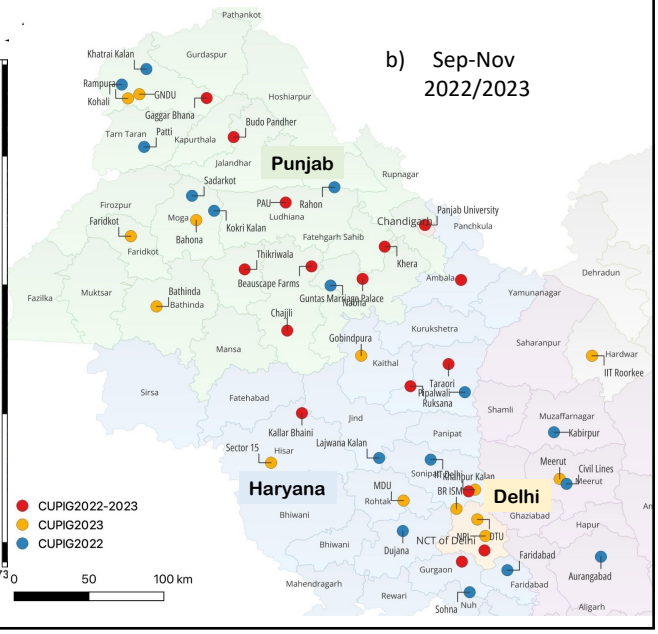
https://aakash-rihn.org

Singh et al., Sci. Rep, 2023:

T. Singh, Y. Matsumi, T. Nakayama, S. Hayashida, P. K. Patra, N. Yasutomi, M. Kajino, K. Yamaji, P. Khatri, M. Takigawa, H. Araki, Y. Kurogi, M. Kuji, K. Muramatsu, R. Imasu, A. Ananda, A. A. Arbain, R. Khaiwal, S. Bhardwaj, S. Kumar, Sa. Mor, S. K. Dhaka, A. P. Dimri, A. Sharma, N. Singh, M. S. Bhatti, R. Yadav, K. Vatta, Su. Mor

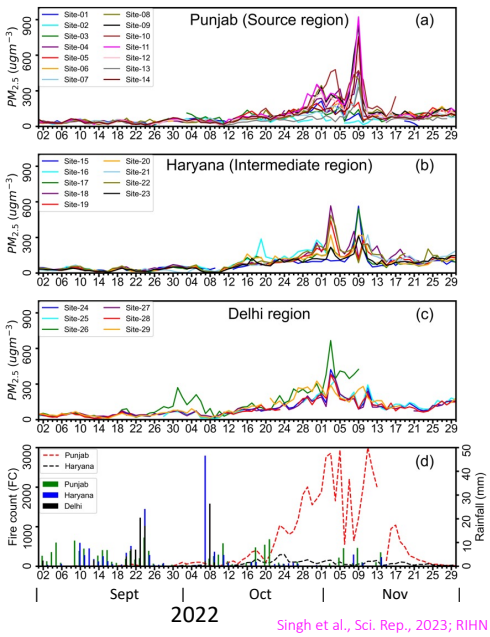
(updated for 2023 CRB campaign)





7

Daily-mean $PM_{2.5}$ variations in Punjab, Haryana and Delhi

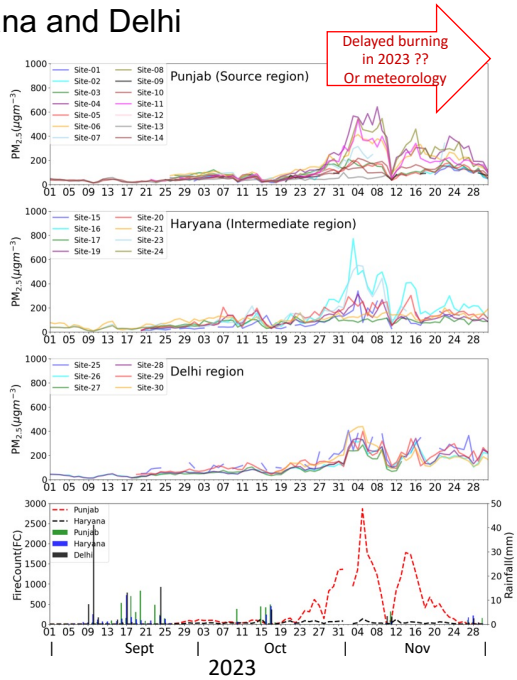


Measurements of September are homogeneous over the region – all sites showing similar $PM_{2.5}$ values.

A check for the the CUPI-Gs stability !

After mid-October, large variations over the source region is observed

Toward the end of November, regional sites show consistent behaviour



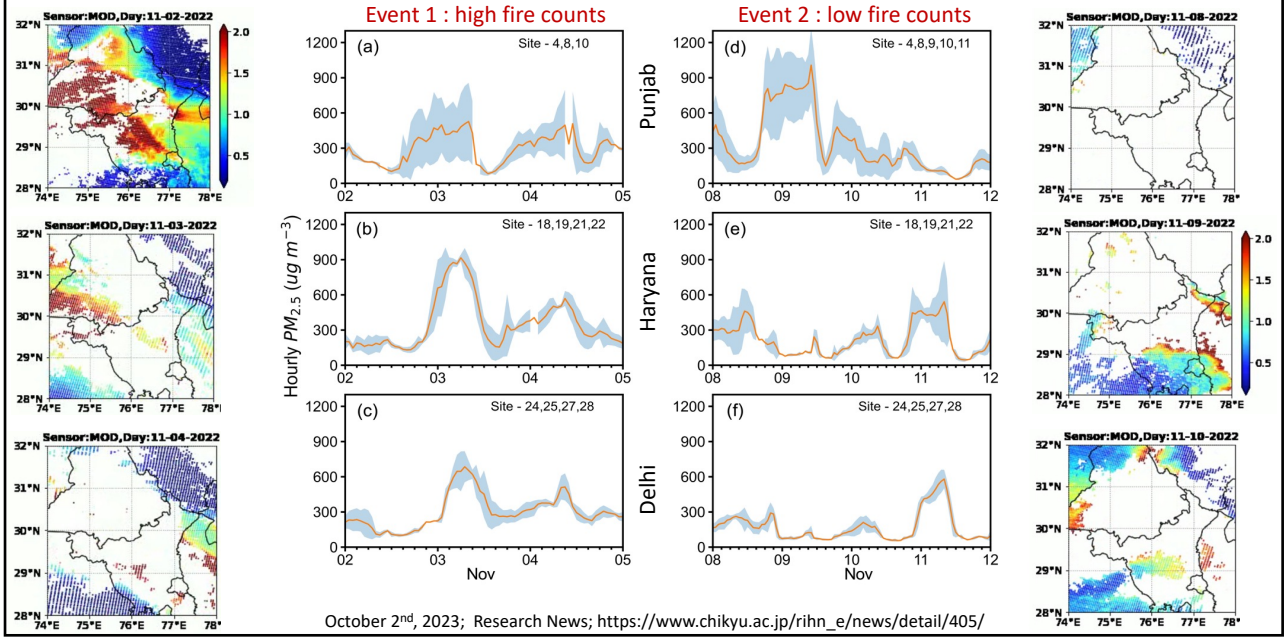
Singh et al., Sci. Rep., 2023; RIHN Press release

8

AODs by Pradeep Khatri

(WG2) Uniqueness of Aakash/CUPI-G measurments

Singh et al., 2023

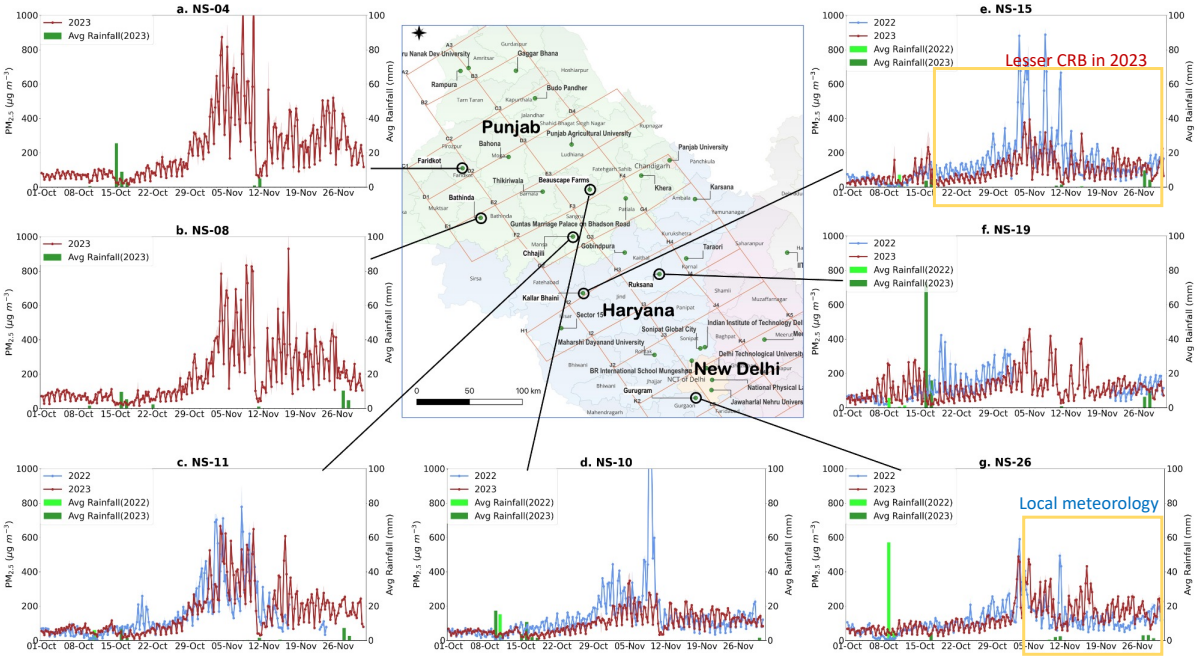


October 2nd, 2023; Research News; https://www.chikyu.ac.jp/rihn_e/news/detail/405/

9

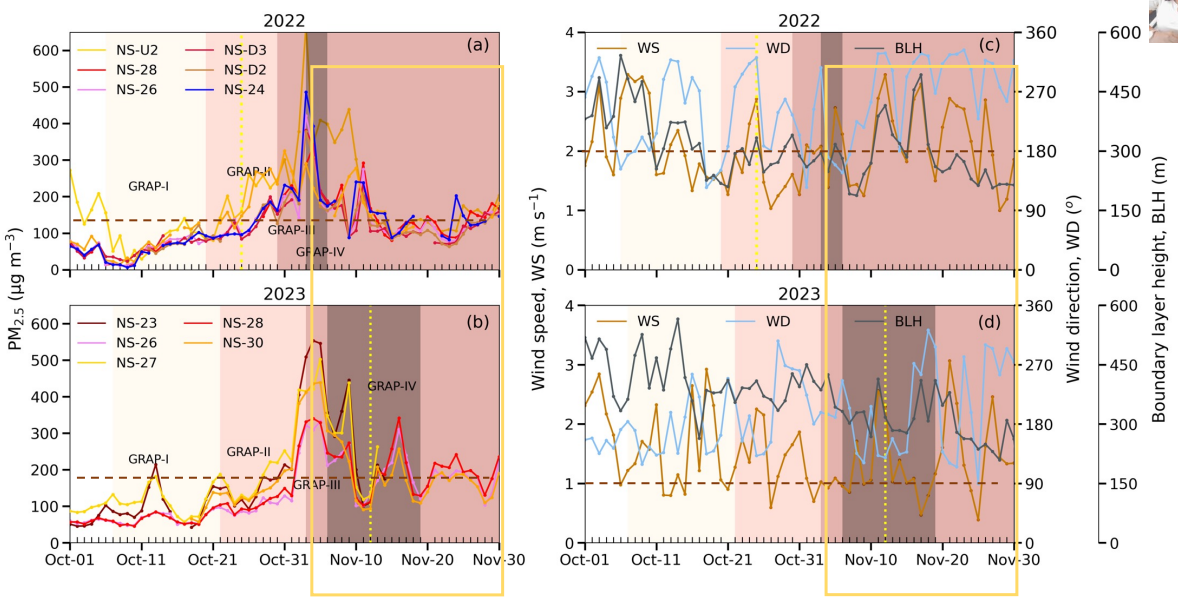
Spatial and Temporal Variabilities in Hourly Mean $PM_{2.5}$

Mangaraj et al., in revision



10

$PM_{2.5}$ Levels Amidst Policy Interventions in Delhi-NCR

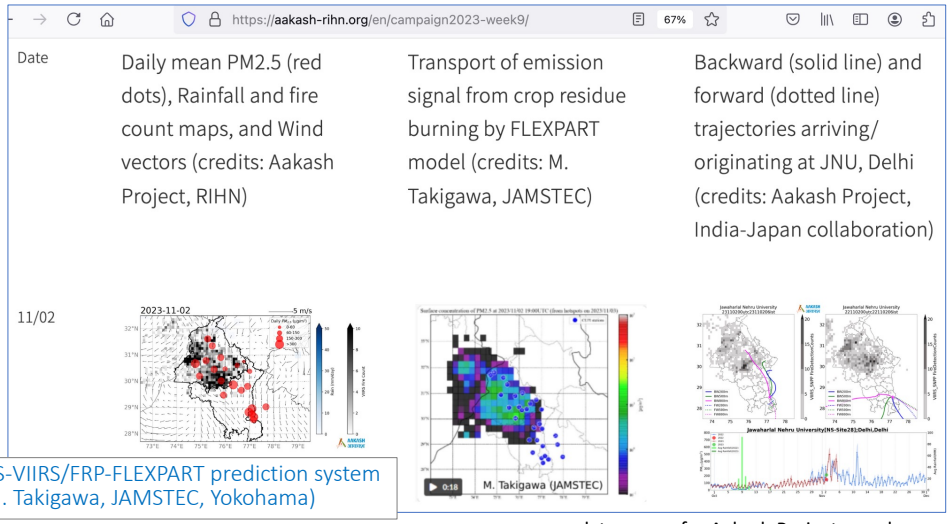


Drop in $PM_{2.5}$ emissions attributable to → GRAP restrictions, but detailed understanding is lacking

Mangaraj et al., in revision

11

How do we link meteorology with air pollution: near real-time analysis



NCEP/GFS-VIIRS/FRP-FLEXPART prediction system (M. Takigawa, JAMSTEC, Yokohama)

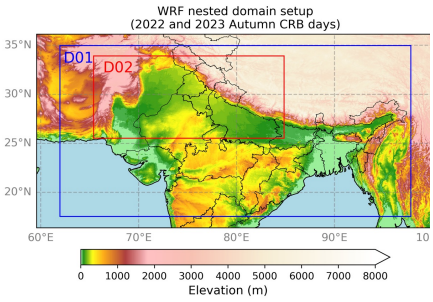
CUPI-G, 2024, near real-time: https://aakash-rihn.org/en/data-set2/

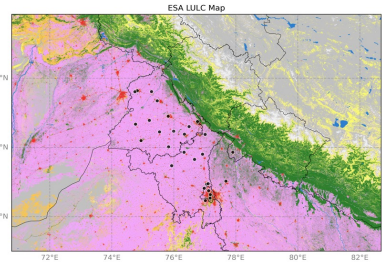
… a data server for Aakash Project members : https://aakash-rihn.org/en/data-set

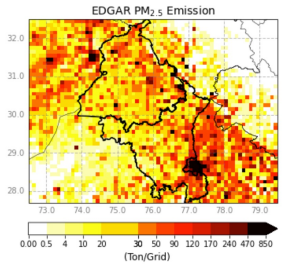
12

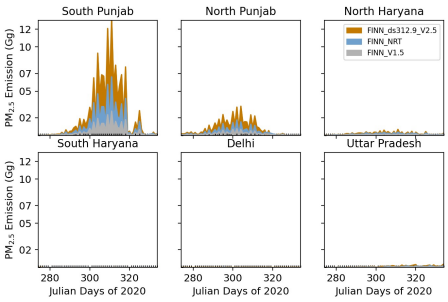
WRF-Chem model setup and regional characteristics

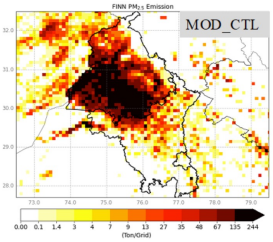
- 84% areas of Punjab and Haryana are croplands
- Dense network of CUPI observation are placed to measure the surface $PM_{2.5}$ levels.









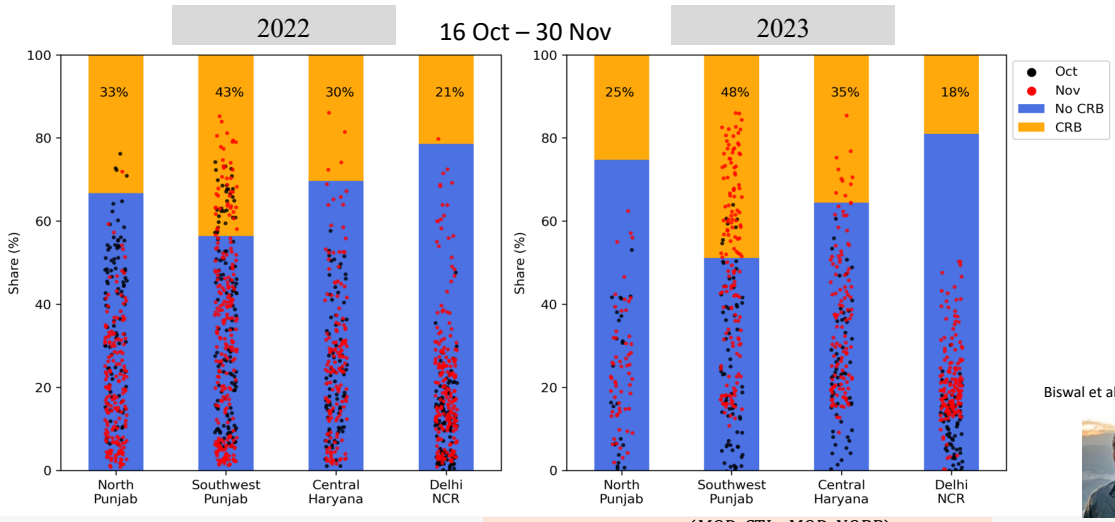


D01 is 27 × 27 km and D02 is 9 × 9 km resolution
Chem_Opt: 301, GOCART coupled with RACM-KPP
Meterology: driven by ERA5
Anthropogenic emission: EDGAR-v6
Biomass burning: FINN NRT-v1
Biogenic emission: MEGAN
DMS: GOCART
Duration: 15-OCT to 30-NOV for 2022 and 2023

Modellers: Biswal, Bisht, Takigawa, et al.

13

Fractions of $PM_{2.5}$ share due to CRB by regions (WRF-Chem)



Biswal et al., in prep.

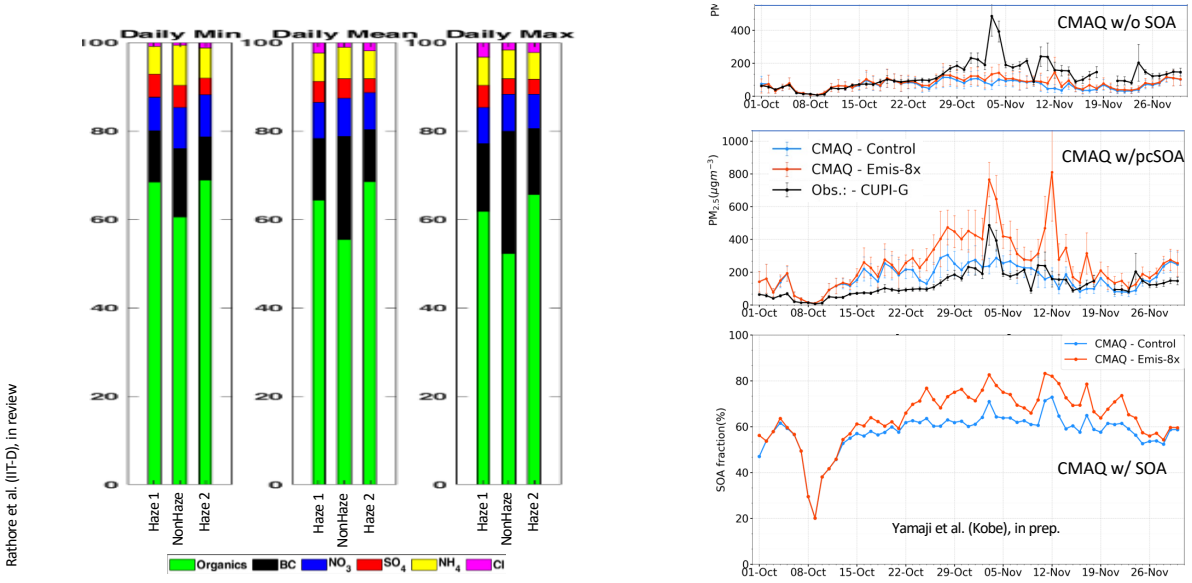
Method to calculate CRB share (%)

$$\text{BB Share (\%)} = \left(\frac{MOD\_CTL - MOD\_NOBB}{MOD\_CTL}\right) \times 100$$

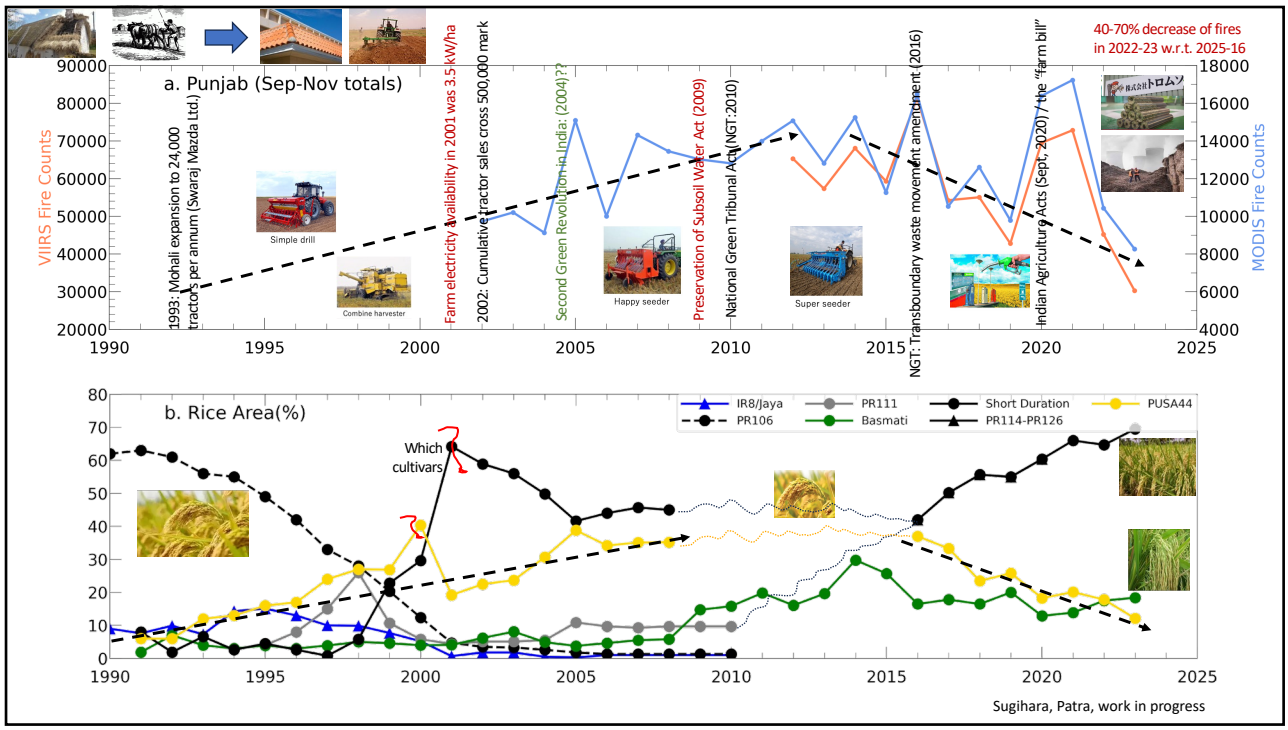
MOD_CTL = Anthopogenic emissions, Biomass burning emission; MOD_NOBB = Anthopogenic emissions, No biomass burning emisison

14

Testing hypothesis on secondary organic aerosols: WRF-CMAQ model (2022) & IIT-D Sonipat observations (2023)



15



16

Results from air pollutant observation campaigns in 2022/2023

- The 2022 observations identified pollution episodes in Delhi with clear impacts from rice stubble burning in Punjab, flowing over Haryana and other directions
- The 2023 observations showed less significant impacts directly. However, strategic new measurement locations capture the pollution outflows to Rajasthan
- Quantitative assessments of crop residue burning (CRB) on Delhi's air quality are ongoing, with chemistry-transport models
  - Sensitivity model simulations suggest 14-21% of $PM_{2.5}$ in Delhi-NCR was directly attributed to emissions from CRB in Punjab during Oct-Nov 2022, and that is about 18% in Oct-Nov 2023
  - Model simulation estimated the effect of CRB could be as much 40-50% of $PM_{2.5}$ for pollution episodes in Delhi-NCR under the favourable north-westerly winds conditions.
- Our observations reveal for the first time that $PM_{2.5}$ levels in some rural areas, where no previous measurements have been taken, are comparable or higher than those in major cities like Delhi
- Continuation of air quality network in rural areas of Punjab-Delhi region is crucial for protecting public health. Use of low-cost sensors are proven to be effective option

"हमें वायु प्रदूषण और ग्रीनहाउस गैस उत्सर्जन को एक साथ कम करने के बारे में बात करनी चाहिए। फसल अवशेष प्रबंधन इसका एक अच्छा उदाहरण हो सकता है।" **बी. सिवरामन | 23 Oct 2023** NEWSCLICK

17

"The Earth has enough resources for our need but not for our greed." – M.K. Gandhi

Solving a global issue together using local-regional studies

Thank you

18