CACS Jan'23 - Mar'24

Center For Atmospheric And Climate Sciences (IoE)

An Initiative of IIT Madras

OUR

GOALS

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Uniting Science for Environmental Insights:

CACS deciphers chemical processes in the atmosphere and biosphere through interdisciplinary research. Our investigations span climate, ocean, and atmospheric systems, probing interactions vital to life and climate. With lab experiments, field work, and models, we uncover the impact of pollution on health, climate, and ecosystems.
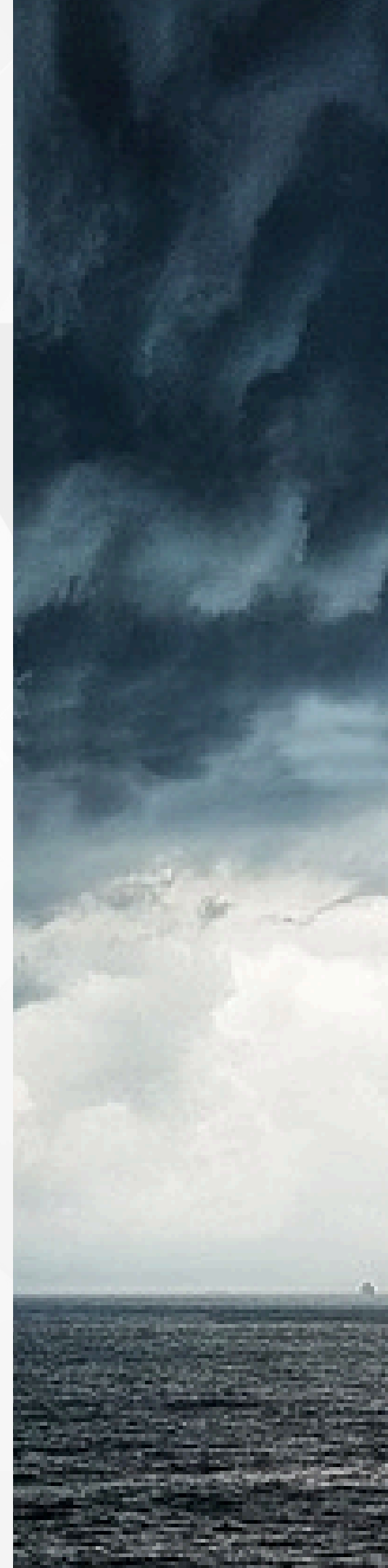
INTRODUCTION
MEMBERS :

- Dr. Sachin S. Gunthe (Civil Engineering) P.I.
- Dr. Anindita Sahoo (Humanities and Social Sciences)
- Dr. Anubhab Roy (Applied Mechanics)
- Dr. Chakravarthy Balaji (Mechanical Engineering)
- Dr. Chandan Sarangi (Civil Engineering)
- Dr. Krishna Malakar (Humanities and Social Sciences)
- Dr. Rajakumar Balla (Chemistry)
- Dr. R. Ravi Krishna (Chemical Engineering)
- Dr. S. M. Shiva Nagendra (Civil Engineering)

FORGING AHEAD :
VISION FOR HIGH-IMPACT RESEARCH

• We intend to publish high-quality peer review papers in coming years in extremely high impact journals (so far we have published 10 papers including in NPJ Climate and Atmospheric Sciences).

• We planned to develop the methods and model parameterizations for the improvements of the climate models, which will essentially help in reducing the climate uncertainly particularly focusing on Indian climate system, which is very unique and complex to understand.

• We are also intending to have a start up related to the use of the VOC measurements in several industries.

• We have the top class research collaborations with Harvard University, Max Planck Institute, Georgia Tech, and University of Manchester and wish to take this collaboration forward in terms of faculty and student exchange depending upon the funding scenario.

• We are in the midst of organizing a field measurement campaign on a grand scale in collaboration with esteemed international partners.

• We have had the privilege of hosting numerous distinguished visitors spanning various disciplines within climate change and social sciences(in alignment with the objectives outlined in our proposal).

• CACS has recently initiated the Interdisciplinary Dual Degree (IDDD) Program in Atmospheric and Climate Sciences. We aim to further enhance enrollment in this program and are strategically planning outreach activities to engage prospective students.

VISIBLE OUTPUTS - CONFERENCES

DR. SACHIN S. GUNTHE

S.No	Name	Place	Conference
1.	Aishwarya Singh	IASTA Conference 2023, Mumbai, India	(Conference oral presentation) CLOUD-FORMING POTENTIAL OF ANTHROPOGENIC SULFATE AEROSOLS: INSIGHTS FROM SO2 EMISSIONS OF A COAL-FIRED POWER PLANT IN INDIA DURING THE COVID LOCKDOWN.
		AGU Fall Meeting 2022, Chicago, USA	Conference poster) High cloud forming potential of anthropogenic sulfate aerosols arising from SO2 emissions of a coal-fired power plant during relatively cleaner conditions of Covid lockdown in India. (Conference poster) Mass based Hygroscopicity ofAtmospheric aerosols from a high-altitude site in India using precision-based Quartz Crystal Microbalance (QCM) technique. (Conference oral presentation) Characteristic Aerosol Properties during Monsoon and COVID Lockdown under Cleaner Conditions: Source Apportionment and Chemical Properties from a High-Altitude site in India.

VISIBLE OUTPUTS - CONFERENCES
DR. SACHIN S. GUNTHE

S.No	Name	Place	Conference
2.	M. Chakradhar Reddy	London UK	Chakradhar Reddy, Basudev Swain, Nidhi A., Pengfei Liu, Amit Sharma, Marco Vountas, Sachin S Gunthe. "Spatio-temporal variability of atmospheric mercury over India by using ground-based observations and GEOS-Chem model simulations" in 2nd Regional GEOS-Chem Europe User's Meeting, University College London, London, United Kingdom, 14-18, August 2023.
3.	Nidhi L. Anchan	Malaga, Spain	Anchan. N.L., Swain. B., Sharma. A., Malasani. C.R., Chandrasekharan. A., Kumar U., Ojha. N., Liu. P., Vountas. M., Gunthe. S.S.,(2023), "Seasonal variation of Aerosol Optical Depth over India under futuristic climate scenarios: An implication of Carbonaceous Aerosols", (2.06-24) presented a poster at European Aerosol Conference 2023, 3-8 Sep.
		Mumbai, India	Anchan. N.L., Swain. B., Sharma. A., Malasani. C.R., Chandrasekharan. A., Kumar U., Ojha. N., Liu. P., Vountas. M., Gunthe. S.S.,(2023), "Decadal trend of Aerosol Optical Depth over India under futuristic climate scenarios: An implication of Carbonaceous Aerosols", (Abstract: T7030) presented a lightening talk and poster at Indian Aerosol Science and Technology Association (IASTA) 2023, 12-14 Dec.

VISIBLE OUTPUTS - PUBLICATIONS

DR. SACHIN S. GUNTHE

S.No	Name	Place	Publications
1.	Aishwarya Singh	IIT-Madras	Vaishya, A., Raj, S. S., Singh, A., Sivakumar, S., Ojha, N., ... & Gunthe, S. S. (2023). Black carbon over tropical Indian coast during the COVID-19 lockdown: inconspicuous role of coastal meteorology. Environmental Science and Pollution Research, 30(15), 44773-44781. Salim, R., Singh, A., Kalkura, K.N., Gopinath, A.K., Raj, S.S., KA, R., Krishna, R.R. and Gunthe, S.S., 2023. Investigating the applicability of a global average calibration line for ambient size-resolved Cloud Condensation Nuclei (CCN) measurements: A technical note. Journal of Atmospheric and Oceanic Technology, 40(6), pp.661-667. Singh, A., Raj, S. S., Panda, U., Kommula, S. M., Jose, C., ... & Gunthe, S. S. (2023). Rapid growth and high cloud-forming potential of anthropogenic sulfate aerosol in a thermal power plant plume during COVID lockdown in India. npj Climate and Atmospheric Science, 6(1), 109.

VISIBLE OUTPUTS - PUBLICATIONS
DR. SACHIN S. GUNTHE

S.No	Name	Place	Publications
2.	Ankit Patel	IIT-Madras	M. Soni, R. Sander, L.K. Sahu, D. Taraborrelli, P. Liu, A. Patel, I.A. Girach, A. Pozzer, S.S. Gunthe, N. Ojha. Comprehensive multiphase chlorine chemistry in the box model CAABA/MECCA: implications for atmospheric oxidative capacity, Atmos. Chem. Phys., 23 (2023), pp. 15165-15180, 10.5194/acp-23-15165-2023. M.A. Aswini, S. Tiwari, U. Singh, S. Kurian, A. Patel, S.S. Gunthe, A. Kumar. Aeolian dust and sea salt in marine aerosols over the Arabian Sea during the southwest monsoon: sources and spatial variability. ACS Earth Space Chem., 6 (4) (2022), pp. 1044-1058, 10.1021/acsearthspacechem.1c00400.
3.	Rizana Salim	IIT-Madras	Salim, R., Singh, A., Kalkura, K.N., Gopinath, A.K., Raj, S.S., KA, R., Krishna, R.R. and Gunthe, S.S., 2023. Investigating the applicability of a global average calibration line for ambient size-resolved Cloud Condensation Nuclei (CCN) measurements: A technical note. Journal of Atmospheric and Oceanic Technology, 40(6), pp.661-667.

VISIBLE OUTPUTS - PUBLICATIONS

DR. SACHIN S. GUNTHE

S.No	Name	Place	Publications
4.	Emil Varghese	IIT-Madras	Kaushik A, Gupta P, Kumar A, Saha M, Varghese E, Shukla G, Suresh K, Gunthe SS. Identification and physico-chemical characterization of microplastics in marine aerosols over the northeast Arabian Sea. Sci Total Environ. 2024 Feb 20;912:168705. doi: 10.1016/j.scitotenv.2023.168705. Epub 2023 Nov 23. PMID: 38000750. Varghese E, Krishnamoorthy S, Patel A, Hredhya TK, Kumari K, Bhattacharya BK, Kundu SS, Goswami J, Yadav S, Verma RS, Ravikrishna R, Gunthe SS. Relationship between fungal bioaerosols and biotic stress on crops – A case study on wheat rust fungi. Journal of Plant Diseases and Protection (Accepted on 16 January, 2024). Varghese E, Krishnamoorthy S, Patel A, Hredhya TK, Kumari K, Bhattacharya BK, Kundu SS, Goswami J, Yadav S, Verma RS, Ravikrishna R, Gunthe SS (2022). Size-resolved genomic characterization of fungal bioaerosols with emphasis on the diversity and dispersion of pathogenic fungi affecting crops and plants. American Geophysical Union Fall Meeting 2022, Chicago, USA, Dec 12-16, 2022 (i-poster published).

VISIBLE OUTPUTS - PUBLICATIONS

DR. ANINDITA SAHOO

Publications

Sahoo, A. & Roshni R. (in press). Review of the book Individuality in Language change by L Anthonissen. Sociolinguistic Studies. (a book which will be published soon)

VISIBLE OUTPUTS - PUBLICATIONS

DR. ANUBHAB ROY

S.No	Publications
1.	Instability of a thin film of chemotactic active suspension N Murugan, A Roy Journal of Fluid Mechanics 955, A11, 2023
2.	Pair trajectories of uncharged conducting spheres in an electric field N Thiruvenkadam, P Patra, V Kadaba Puttanna, A Roy Physics of Fluids, 2023
3.	Wind-generated waves on a water layer of finite depth Y Kadam, R Patibandla, A Roy Journal of Fluid Mechanics 967, A12, 2023
4.	Orientation of finite Reynolds number anisotropic particles settling in turbulence A Roy, S Kramel, U Menon, GA Voth, DL Koch Journal of Non-Newtonian Fluid Mechanics 318, 105048, 2023
5.	Collision efficiency of like-charged spheres settling in a quiescent environment P Patra, DL Koch, A Roy Journal of Fluid Mechanics 968, A22, 2023

VISIBLE OUTPUTS - PUBLICATIONS

DR. ANUBHAB ROY

S.No	Publications
6.	Surface and internal gravity waves on a viscous liquid layer: initial-value problems R Patibandla, S Basak, R Dasgupta, A Roy International Journal of Multiphase Flow, 104592, 2023
7.	Penetrative and Marangoni convection in a fluid film over a phase boundary Darish Jeswin Dhas, Srikanth Toppaladoddi and Anubhab Roy Journal of Fluid Mechanics 977, A34, 2023
8.	Irregular dependence on Stokes number and non-ergodic transport of heavy inertial particles in steady laminar flows AVS Nath, A Roy, S Ravichandran, R Govindarajan Phys. Rev. Fluids 9, 014302, 2024
9.	The merger of co-rotating vortices in dusty flows S Shuai, A Roy, MH Kasbaoui Journal of Fluid Mechanics (accepted), 2024

VISIBLE OUTPUTS - PUBLICATIONS
DR. CHAKRAVARTHY BALAJI

Publications

- P. Yaswanth, B. Arul Malar Kannan, V. M. Bindhu, Balaji Narasimhan, C Balaji, "Evaluation of Remote Sensing Rainfall Products, Bias Correction and Temporal Disaggregation Approaches, for Improved Accuracy in Hydrologic Simulations", Water Resources Management, Volume 37, pages 3069–3092, (2023).

- Book - Fine-Tuning Extreme Rainfall Predictions: A Machine Learning Approach - Sandeep Chinta, Harish Baki, C. Balaji & Balaji Srinivasan, 2023.

- Book – "The Joy of Teaching 2.0"

VISIBLE OUTPUTS - PUBLICATIONS
DR. CHAKRAVARTHY BALAJI

About the Book (Fine-Tuning Extreme Rainfall Predictions)

This book presents primarily the results of in-house research of the authors in the fields of numerical weather prediction, extreme events, and machine learning. The focus of the book is on improving the accuracy of short-range predictions for extreme rainfall events in India, such as monsoons and cyclones, which can cause significant damage. The accuracy of any numerical weather prediction model depends on both the representation of atmospheric physics and the initial conditions. This book traces a step-by-step approach to calibrating model parameters that critically influence the outcomes using machine learning and enhancing initial conditions through data assimilation. The book also provides a beginner friendly introduction to the basics of numerical weather prediction. It delves into advanced techniques, such as Sobol sensitivity analysis, adaptive surrogate modeling-based calibration, and hybrid ensemble-variational data assimilation.

Python codes for the algorithms are included in the text, making it a valuable resource for researchers in the field. The methodology proposed in this book can be adapted to other meteorological events and related fields like turbulence modeling, hydrology, agricultural meteorology, and, with modifications, to any general problem in science and engineering concerning large-scale computations of boundary and initial value problems.

VISIBLE OUTPUTS - PUBLICATIONS
DR. CHAKRAVARTHY BALAJI

About the Book (The Joy of Teaching 2.0)

Teaching and learning are as old as civilization. The inventions of the printing press and computers have been watersheds in the history of the development of teaching. AI-powered tools like ChatGPT have brought both challenges and opportunities to education. The teacher of today is expected to not only teach more but also "teach more clearly and insightfully" than what is available on the Internet or elsewhere. This book is an attempt to place teaching in the contemporary context and examine ways of making it a real joy. Many of the ideas advocated in this book are based on the author's experience of teaching bright young minds for nearly three decades. This new edition has an exclusive section on the Joy of writing.

VISIBLE OUTPUTS - PUBLICATIONS
DR. CHANDAN SARANGI

S.No	Publications
1.	https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2022EF003266
2.	https://www.nature.com/articles/s41612-023-00443-x

VISIBLE OUTPUTS - PUBLICATIONS
DR. KRISHNA MALAKAR

S.No	Publications
1.	Shah, A., & Malakar, K. (2024). Climate-change-induced risk mapping of the Indian Himalayan districts using the latest IPCC framework. International Journal of Disaster Risk Reduction, 104283. https://doi.org/10.1016/j.ijdrr.2024.104283

VISIBLE OUTPUTS - WORKSHOPS

DR. SACHIN S. GUNTHE

S.No	Name	Place	Workshop
1.	Ankit Patel	Innsbruck, Austria	Attended workshop in Hands-On PTR-MS instrument
2.	Emil Varghese	Munnar, Kerala	National Workshop on Atmospheric Aerosol Measurements and Modeling over India: Past decade, Current status and Challenges ahead, hosted by Centre for Atmospheric and Climate Sciences, IIT Madras

VISIBLE OUTPUTS - AWARDS
DR. SACHIN S. GUNTHE

S.No	Name	Awards
1.	Aishwarya Singh	• Prime Minister's Research Fellowship (PMRF) for doctoral research • International Immersion Experience (IIE) award by Global Engagement Office, IIT Madras • AGU Student Travel Grant Award for attending the AGU Fall Meeting 2022, Chicago, USA

VISIBLE OUTPUTS - AWARDS
DR. SACHIN S. GUNTHE

S.No	Name	Place	Awards
2.	Emil Varghese	EAC 2023, Malaga, Spain	Best Poster Award: E.Varghese, S. Krishnamoorthy, R.S.Verma, R. Ravikrishna, A.E. Valsan, V.R. Despres, S.S. Gunthe (2023) Molecular characterization of bioaerosols over a tropical marine region. European Aerosol Conference (EAC 2023) 3-8 Sept
3.	Nidhi L. Anchan	IIT-Madras	Received a fully funded PhD opportunity in Energy, Environment & Chemical Engineering Division of McKelvey School of Engineering at Washington University at St Louis, USA.
4.	Rizana Salim	University of California, Irvine	Fulbright-Kalam Climate Doctoral Research Fellowship

VISIBLE OUTPUTS - AWARDS

DR. ANUBHAB ROY

Name	Awards
Pijush Patra	" The role of particle-flow interactions in cloud microphysics " **Institute Research Award for PhD (2023-24)**

VISIBLE OUTPUTS - ACHIEVEMENT

Name	Achievement
Amar Krishna Gopinath	The research work of Amar Krishna Gopinath et al. published in the prestigious Journal of Geophysical Research: Atmospheres on behalf of the American Geophysical Union, ranks in the top 10% of downloaded papers within its first 12 months of publication. This fantastic achievement is a testament to the recognition and celebration of their work within the community. Complex Interplay Between Organic and Secondary Inorganic Aerosols With Ambient Relative Humidity Implicates the Aerosol Liquid Water Content Over India During Wintertime

VISIBLE OUTPUTS - INTERNATIONAL RECOGNITIONS

DR. ANUBHAB ROY

S.No	Specifics
1.	Laboratoire de Physique, ENS de Lyon, France
2.	IUSTI, Aix Marseille Université, Marseille
3.	Laboratoire de Mécanique des Fluides et d'Acoustiquec (LMFA) at University of Lyon
4.	International Research Network (IRN) Hydrobio - CNRS meeting and 11th Conference of the International Marangoni Association, Bordeaux, France
5.	Toulouse Institute of Fluid Mechanics (IMFT), Toulouse, France
6.	EUROMECH colloquium on Suspension Flows and Rheology in Nice, France
7.	76th Annual Meeting of the Division of Fluid Dynamics, American Physical Society, Washington DC, USA
8.	With Prof. Yohei Onuki (RIAM Kyushu University, Japan) on "Triadic resonant instability of internal gravity waves in a stratified shear flow", 300,000 JPY

INVITED TALKS

S.No	Name	Talks
1.	Dr. Anindita Sahoo	**"Linguistics in Industry"-"International Conference on Multidisciplinary Research and Innovation: Enhancing Industry- Academia Interface"**. Organized by Ethiraj College for Women, Chennai.
2.	Dr. Chakravarthy Balaji	Title of the lecture, **"The Science of climate change", Institute for Climate Change Studies (ICCS),** Kottayam, Kerala. 2nd November 2023
3.	Dr. Chandan Sarangi	Invited talk at Mumbai during IASTA 2023 on **"CMIP5 MODELS INCLUDING AEROSOL INDIRECT EFFECT PERFORMS BETTER IN SIMULATING THE TRENDS IN EXTREME RAINFALL OVER INDIA".**

Prof. Sachin S. Gunthe have been recognized as an influential & highly-cited researcher by Scientific Journal Nature.

https://www.nature.com/articles/d41586-023-03913-7

Dr. Anubhab Roy was appointed as a **CNRS** (the French National Centre for Scientific Research) Visiting Professor at Laboratories de Physique, ENS de Lyon, France, for the year 2023.

IIT Madras pioneers in setting up Integrated Proton Transfer Reaction Mass Spectrometer (PTR-MS) for Advancements in Atmospheric Chemistry and Aerosol Science.

This online measurement facility will enable frontier research in atmospheric chemistry and aerosol science by providing high resolution long term chemical characterization of ambient air in urban environment, high altitude site in the southern India and other campaigns.

GALLERY
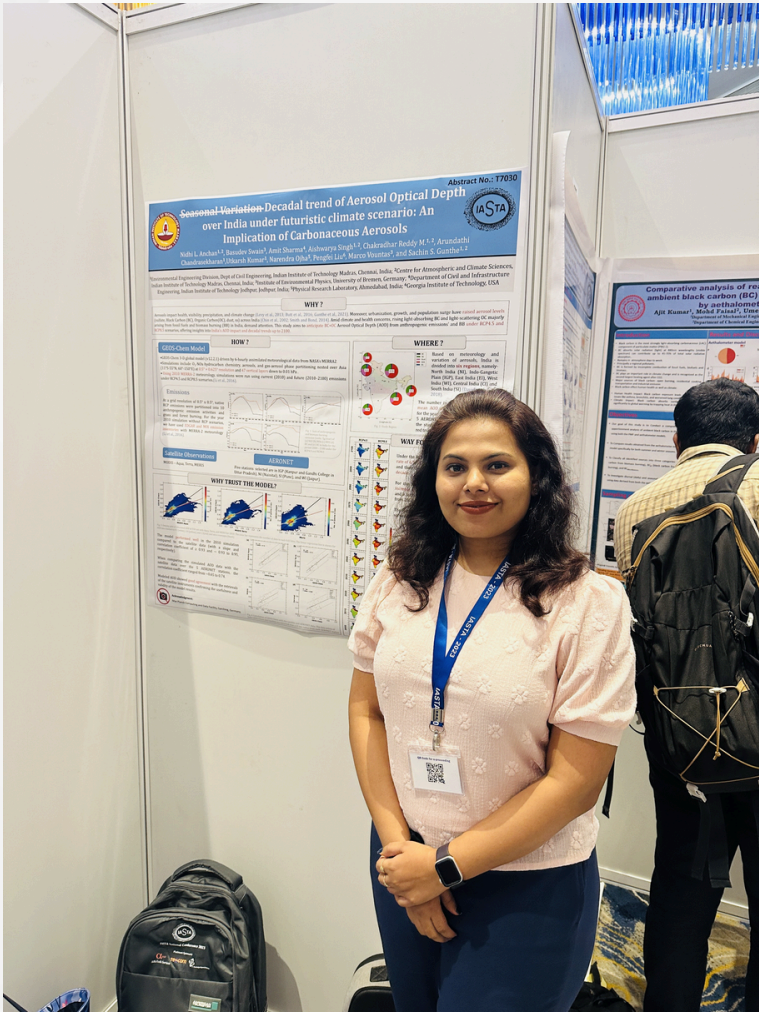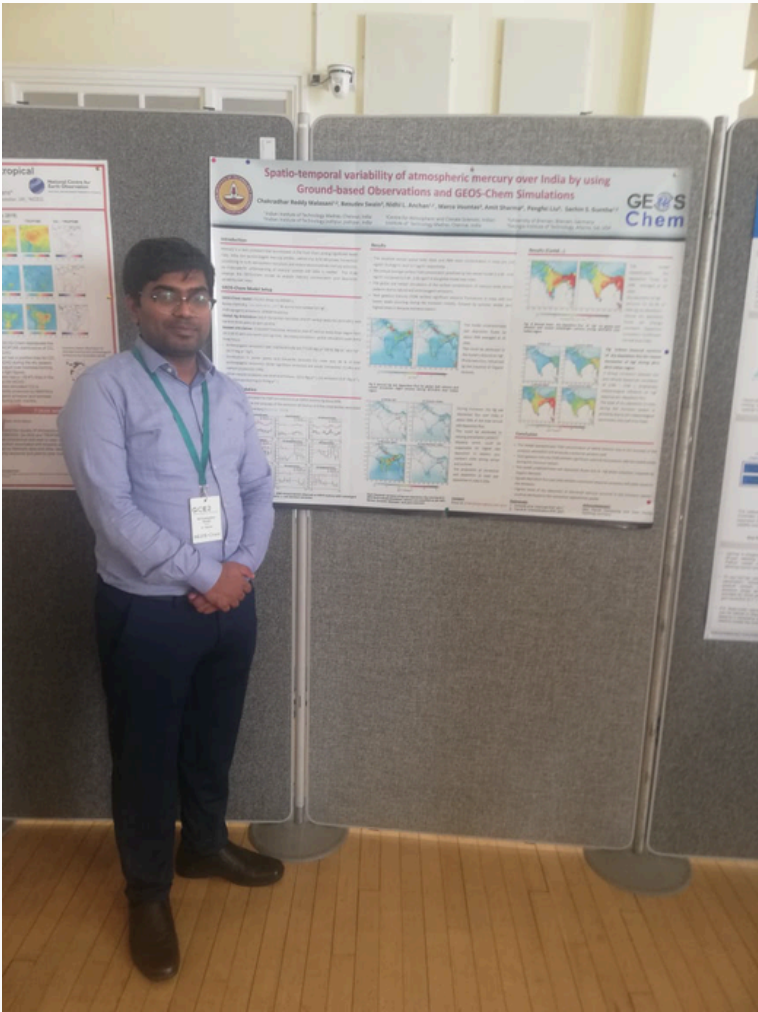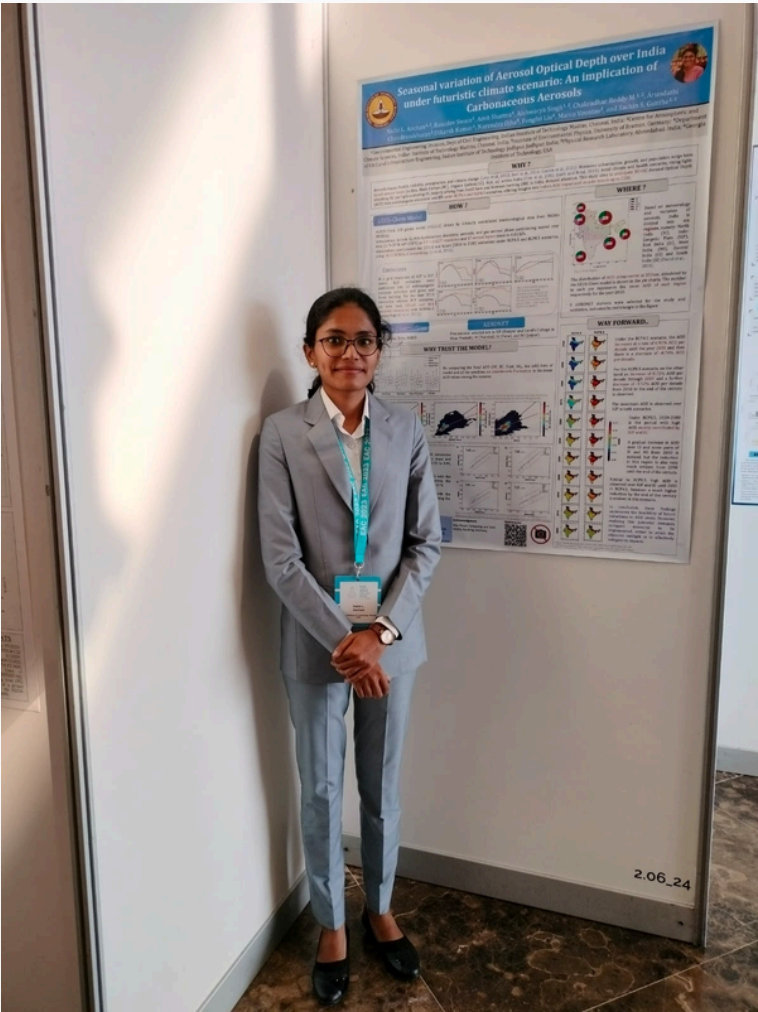
THE PAPERS FROM INDIAN RESEARCHERS THAT ARE SHAPING SCIENCE

Heavily cited research from Indian scientists is making an impact in a variety of fields. **By Michael Eisenstein**

India was the world's third-most-prolific publisher of research papers in 2022, but it was ranked only 153rd for the number of citations it received per paper. Indeed, in 2020, about 30% of papers from India were not cited at all, compared with 20% in both the United States and China. These trends are mirrored in many other low- and middle-income countries whose researchers struggle to get published in high-impact journals.

But despite this challenging publishing environment, some Indian scientists have produced influential, highly cited studies in a number of fields in the past few years. Here *Nature* highlights several of these key areas of research that have the potential to improve public health and quality of life both domestically and globally.

Strategies to reduce air pollution

Many parts of India have highly polluted air. The University of Chicago's Air Quality Life Index ranks India as the second-most-polluted nation in the world in terms of air quality, behind only Bangladesh, and refers to Delhi as "the most polluted city in the world".

To improve India's air quality, researchers must first develop a deeper understanding of the sources of this pollution and how it interacts with weather systems. Sachin Gunthe, who studies aerosols at the Indian Institute of Technology Madras, based in Chennai, has published a series of highly cited papers exploring the composition, formation and distribution of airborne pollutants. In particular, he has studied particulate matter that has a diameter of 2.5 micrometres or less ($PM_{2.5}$), which can create visible haze and wreak havoc on human health, contributing to more than one million deaths a year in India alone.

In 2020, Gunthe teamed up with Narendra Ojha at the Physical Research Laboratory in Ahmedabad and his colleagues to investigate seasonal patterns of $PM_{2.5}$ production and windborne distribution[1]. Using simulations based on meteorological data, they determined that the sources of pollution change considerably over just a few months. In October, following the monsoon season, most $PM_{2.5}$ originates from burning biomass in wildfires, agriculture and household stoves, and creates pollution that spreads across northwest India to Delhi and other cities (see page S25). By December, most $PM_{2.5}$ arises from industrial and fossil-fuel sources in cities, where it is trapped and accumulates because of the relatively stagnant winter wind patterns. This work shows that strategies to control pollution must address seasonally changing conditions.

Gunthe then collaborated with researchers including Pengfei Liu at the Georgia Institute of Technology in Atlanta to take a deeper dive into Delhi's air-pollution crisis. In a 2021 publication, they traced the origins of Delhi's haze to the behaviour of a particularly small category of airborne particles measuring less than one micrometre[2]. They subsequently showed that in high humidity, this particulate matter interacts with ammonia and chlorine in the air, forming bigger particles that contribute to worse visibility and heightened health risk.

A follow-up study in 2022 found a feedback loop in which condensation from high water content in the air reduces the dispersal of particulate matter[3]. This leads to worse pollution and higher humidity, exacerbating the problem. On the basis of these results, the authors proposed a two-pronged intervention to reduce both ammonia emissions, from agriculture and fossil-fuel use, and chlorine production, which is a consequence of plastic burning and e-waste disposal in particular.

Electrodes for a hydrogen economy

One of the most exciting routes from fossil-fuel dependency is the 'hydrogen economy', in which energy-rich hydrogen is efficiently extracted from a cheap and abundant fuel source: water. Earlier this year, the Indian government announced its intention to build the country's production capacity to at least 5 million tonnes of hydrogen a year by 2030, with the goal of ultimately making the country energy independent and an exporter of 'green hydrogen' to other major economies.

One promising strategy is to use electrochemical water-splitting systems in which

THANK YOU