Abstract Book

Three Day Online International Conference on

Aerosol, Air Quality, Climate Change and Impact on Water Resources and Livelihoods in the Greater Himalayas

(This International Conference is organised as a part of celebration of Golden Jubilee Commemoration Year of DST)

Organized by

Aryabhatta Research Institute of Observational Sciences (ARIES)
An autonomous institute under the Department of Science and Technology, Govt. of India), Nainital, Uttarakhand

In Collaboration with

Department of Physics
Hemvati Nandan Bahuguna Garhwal University (A Central University)
Srinagar, Pauri Garhwal, Uttarakhand

Venue
Aryabhatta Research Institute of Observational Sciences (ARIES)

Dates

14th -16th September, 2020

Conference Themes

Atmospheric Aerosols, Aerosol Chemistry, Air Pollution

Growing air pollution over Indo-Gangetic Plains and Himalayan Glaciers, Network Measurements

Climate change impacts on Himalayan Glacier and Monsoon over the Himalayas

Source apportionment in Indo-Gangetic Plain and Gangetic Himalayan Region

Winter/Summer Crop burning and impact on Himalayan Resource

Extreme Events (Dust Storms, Cloud Burst, Rainfall, earthquakes)

Coupling of Ocean-Land and Himalayan

Application of geospatial Techniques

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Invited and Keynote Speakers

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Prof. S. N. Tripathi (Invited: IIT, Kanpur)
Prof. Ram Sagar (Invited: IIA, Bangalore)
Prof. Neeraj Rastogi (Invited: PRL, India)
Prof. Shubha Verma (Invited, IIT Kharaghpur)
Prof. V. Vinoj (Invited, IIT Bhuwneshwar)
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Prof. Nikolaos Mihalopoulos (Invited, NOA, Greece)
Prof. Kirpa Ram (Invited, BHU, India)
Prof. Philip Hopke (Invited, USA)
Professor Harish Chandra Nainwal (Invited, HNBGU, India)
Prof Arnico Panday (Keynote Speakers, Nepal)
Professor Daniel Rosenfeld (Keynote Speakers, ISRAEL)
Prof. V. Faye McNeill (Keynote Speakers, Columbia University)
Prof Dimitris G Kaskaoutis (Invited, NOA Greece)
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Aerosols, and air quality across the Greater Himalayas: The Emerging Regional Understanding and Priorities for the Next Decade

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The past decade has seen an unprecedented volume of research and peer reviewed publications on aerosols, air quality and climate change as well as their impacts on water resources and livelihoods across the entire Greater Himalayas. Gradually, enough puzzle pieces are falling into place to enable us to glimpse the complex interconnected system at a regional scale. The first half of this keynote address will summarize our current understanding of atmospheric change across the broader region, assessing how well we know what we know, and identifying large gaps and research questions. The second half will discuss priorities for the decade ahead, discussing not just research priorities, but also institutions and Trans boundary cooperation that will be required to improve regional understanding and to reduce the impacts on water resources and livelihoods.

Multiphase Atmospheric Chemistry: From the molecular to the regional and global scales

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Multiphase chemistry in atmospheric clouds and aerosol particles is a major source of organic and inorganic atmospheric particulate matter, and also has a profound influence on gas-phase composition and precipitation chemistry. Despite considerable progress, mechanistic understanding of some key aqueous atmospheric processes is still lacking, and their representation is incomplete in most regional and global models. I will present an overview of aqueous chemical processes in the atmosphere, highlighting recent developments and critical uncertainties. I will also discuss my group's efforts in characterizing these processes in the laboratory and improving their representation in atmospheric chemistry models.

Aerosol effects on microstructure and precipitation of deep convective clouds with a focus at the Himalaya foothills

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Air pollution and dust particles can invigorate deep convective clouds and induce more intense precipitation and lightning by several pathways. By nucleating larger number of smaller cloud droplets, the aerosols slow down the coalescence of cloud droplets into raindrops, thus delaying the precipitation initiation until the clouds grow to above the freezing level, where the cloud water freezes into ice hydrometeors which melt into heavy downpours while electrifying the clouds. Heavy air pollution can absorb the solar radiation and heat the polluted air on expense of surface heating. This process can suppress convective clouds that form by surface heating, but trigger heavy storms and floods when the heated air layer is lifted orographically at the foothills. Aircraft measurements of aerosol and clouds during the CAIPEEX campaign at the Himalaya foothills documented the predominance of elements of these processes there.

Observational facilities in the field of atmospheric science at ARIES

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The Aryabhatta Research Institute of Observational Sciences (acronym ARIES) started research activities in the field of atmospheric science and climate change about 2 decades ago. It has installed a battery of modern instruments at Manora Peak, a strategically important location in the central Himalayan region, for in situ measurements of various physical and chemical properties of aerosols and trace gases. Recent addition in this has been successful installation of a unique 206.5 MHz ST radar facility. The ARIES has also established both national and international collaborations in these fields. On this historic occasion of Golden Jubilee celebrations of the DST, its contribution to the growth of climate change and atmospheric science studies at ARIES will be highlighted in the presentation.

Tipping elements approach for forecasting onset and withdrawal of Indian Summer Monsoon: climate change and air quality impacts

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The Indian summer monsoon is the season of rain caused by a seasonal reverse in winds direction and a change in pressure distribution. Although rainy season happens annually, the time of monsoon season's onset and withdrawal vary within a month from year to year. Such variability strongly affects life and property of more than a billion people in India, especially those living in the rural area and working in the agricultural sector, which employs 70% of the population. The forecasting of climate phenomena on a seasonal scale is a challenge mostly because there is no recent historical precedent for such changing in the climate. Thus, to overcome this challenge, the unique long-term forecast of monsoon onset and withdrawal had been developed for central India[1] - the most exposed and rural part of central India, where, before, monsoon forecasting has never been made. The new approach relies upon the two recently discovered feature of monsoon. First, at the onset of monsoon, some atmospheric variables (in particular, in near-surface air temperature, relative humidity) pass a critical threshold. There is a similar feature at monsoon withdrawal. Second, there are two tipping elements in the spatial organization of monsoon, which were revealed by the phenomenon of critical growth of fluctuations[2]. The first tipping element appears in the area of the Eastern Ghats (EG). The second is in North Pakistan (NP). The regularities between the Tipping Elements allow predicting the upcoming monsoon onset and withdrawal for 40 and 70 days in advance, respectively. The forecast relies on the analysis of near-surface air temperature, and relative humidity from both the ERA-40 and NCEP/NCAR re-analyzes. The results of retrospective tests [1951-2015] show 73 % success for monsoon onset and 84 % for withdrawal[1]. Significantly, that forecasts of future monsoons showed to be successful already five years in a row (2016-2020)[3]. The new methodology offers three key advances of monsoon forecasting: (i) predicting monsoon timing in central India where prediction has never been made, (ii) predicting the date of the upcoming monsoon onset for 40 days in advance, that is unprecedently early; (iii) forecasting withdrawal date for 70 days in advance, that is a new kind of extraordinary early forecast and the only one available in India. Moreover, it accounts for the conditions of Climate Change and also air quality, it offers a perspective on the regional monsoon forecast.

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[1]Stolbova, V., E. Surovyatkina, B. Bookhagen, and J. Kurths (2016): Tipping elements of the Indian monsoon: Prediction of onset and withdrawal. Geophys. Res. Lett., 43, 1–9

[2]*Surovyatkina E.D., Kravtsov Yu. A. and Kurths Ju., Fluctuation growth and saturation in nonlinear oscillators on the threshold of bifurcation of spontaneous symmetry breaking (2005), Phys. Rev. E, 72, 046125, https://doi.org/10.1103/PhysRevE.72.046125*

[3] *https://www.pik-potsdam.de/services/infodesk/forecasting-indian-monsoon*

Source Apportionment in the Indo-Gangetic Plain and Trans-boundary Pollution

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In this presentation, the source apportionments of airborne particulate matter across the Indo-Gangetic Plain that have been recently published will be reviewed. Although this is a area with high airborne particulate matter concentrations, there have not been long term collections of particle composition data except in Dhaka where apportionments and trends have been explored for more than 20 years. Multiple episodic studies have been conducted in Delhi and Kanpur, India and Lahore, Pakistan, but there are no systematic, long term studies in either India or Pakistan. Traffic, secondary inorganic species largely from coal-fired power plants, and dust are major contributors to the measured PM concentrations. In addition, the widespread burning of agricultural fields after the crops have been harvested leads to a significant contribution of biomass burning aerosol to the PM mass values from November to April each year. Additionally, there are contributions from biomass burning for heating and cooking in urban areas. The biomass burning aerosol is then transported across political boundaries. Ommi et al. (2016) determined that biomass burning contributions during winters in Rajshahi, Bangladesh were substantially higher than in Dhaka, Khulna, or Chittagong. Multiple techniques identified Northern India and Nepal as the main source area responsible for the increased biomass burning concentration difference at Rajshahi compared to the other 3 cities. Recent work by Rahman et al. (2020) has observed similar findings for major contributions to biomass burning particles in Dhaka.

Atmospheric aerosols over the Himalayas: types, sources and transport dynamics

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The Himalayan range and Tibetan plateau have been recognized as very vulnerable areas to aerosols, although their relative low abundance over these high-elevated terrains, which however, play a serious role in the regional climate, monsoon circulation, atmospheric dynamics and hydrology. Himalayas are highly affected by anthropogenic aerosols uplifted from the polluted Indo-Gangetic Plains (IGP), dust from the Thar Desert as well as from other distant sources like southwest Asia and Taklimakan desert, local emissions from biomass and biofuel burning for heating purposes. Nowadays, central, west and East Indian Himalayas, as well as the Nepali Himalayas, have been extensively studied in view of aerosol optical and physical properties, updraft dynamics from the plains, aerosol radiative impact on solar radiation and clouds, while studies dealing with carbonaceous aerosols, BC sources and chemical composition have become increasingly available during the last years. In this presentation, basic aerosol optical and physical properties at sites in the central-west Himalayan region will be analyzed, mostly regarding their seasonality, sources and types. The specific role of the IGP in the Himalayan aerosols will be underlined and dynamic processes regarding the emission and propagation of dust storms from the Thar Desert will be discussed. Apart from the natural and anthropogenic emission sources, boundary-layer dynamics and changes in the mixing-layer height are especially important for the aerosol loading and physico-chemical properties over the Himalayas, as they strongly modify the relative contribution between local and transported aerosols. Especially during the pre-monsoon season, the position and dynamics of the Intertropical discontinuity plays a major role for the dust accumulation over the Himalayan foothills, as well as in its vertical distribution and influence.

Direct and indirect radiative forcing and the significance of the aerosol measurements from Nainital, a high altitude location, in the Central Gangetic Himalayan Region

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The natural and anthropogenic atmospheric aerosols, play an important and complex role in the regional/global climate system via scattering and absorption of incoming solar radiation (i.e. direct effect) and also by modifying the cloud microphysical properties (i.e. indirect effects). Although, some very significant studies have been carried out in recent years that attempted to quantify the impact of various aerosol types on the overall radiative forcing contextual to regional climate system, it still remains one of the major uncertainties in the climate change assessment. Therefore, the precise measurements on various physico-chemical and radiative properties of aerosols are required to reduce this uncertainty, especially over oceans and high-altitude sites where the aerosols are relatively sparse. It is in this context, the aerosol studies from the high altitude locations like Nainital in the central Gangetic Himalayan region have attained a very significant importance, as the remote and sparsely populated regions over this part of Himalaya provide the much essential background aerosol information. The **A**ryabhatta **R**esearch **I**nstitute of observational scienc**ES** (ARIES), at Nainital, has been systematically carrying out these much needed aerosols measurements since 2002. Many important studies have come out based on the ARIES dataset alone ever since. The author aims to provide an overview of these results and the present status of the aerosol research in ARIES followed by the possible future directions in a presentation during the conference.

PM-Induced Oxidative potential with particle chemical composition and sources: results from long-term measurements in Athens, Greece

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PM-induced oxidative stress has been proposed as a primary mechanism in the initiation of adverse health effects, but there is no well-established association between the composition, the mechanism and the sources of aerosol oxidative potential (OP), and most of the reported results include only short time periods of sampling. This study covers a three-year sampling period (2016-2019), using low and high-volume samplers, resulting in the collection of fine aerosol samples on a 12-h and 24-h basis, to assess the impact of aerosol sources on OP, at Thissio site, in the centre of Athens city. An innovative semi-automated system was used for the determination of PM water soluble oxidative potential, through the Dithiothreitol (DTT) assay method. The currently studied site (Athens, Greece – urban background) is of great interest as it is affected by both regional aerosol transportation and intense local emissions, mainly during winter-time when the use of wood burning for domestic heating dominates. Fine aerosol water soluble OP presents maximum values during the coldest months of the year, due to the intense biomass burning for heating purposes. Furthermore, during winter, the multiple regression analysis revealed that the toxicity of aerosols is significantly associated with low volatility organic aerosol (LV-OOA) (71 ± 10 pmol min^{-1} μg^{-1}), biomass burning organic aerosol (BBOA) (28 ± 7 pmol min^{-1} μg^{-1}) and hydrocarbon-like organic aerosol (HOA) (17 ± 4 pmol min^{-1} μg^{-1}), highlighting the significant impact of combustion, both as primary and secondary product emission. Finally, the measured water soluble OP is satisfactorily reconstructed on a seasonal basis, using the calculated relative toxicities of the aforementioned studied chemical parameters that explain about 68% of fine aerosol DTT activity. The results of the current study emphasize the need to systematically investigate the induction of reactive oxygen species from different aerosol components.

Fog in the Indo-Gangetic Plain: The critical roles of subsidence and baroclinic activity

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Dense and widespread winter fog in the Indo-Gangetic Plain (IGP) causes a significant reduction in visibility and worsened air pollution. Despite extensive observations, the key processes in the formation and maintenance of fog are not yet clear. Here we elucidate the critical role the extensive and deep subsidence in the region plays in the maintenance of stable stratification and turbulence, which are essential for fog formation. Observations and reanalysis data show that the sudden decline of the cloud cover in the region around 1996-97, most likely caused by reduced activity of western disturbances, and increased availability of surface water due to rising irrigation, resulted in substantial abrupt changes in the dynamics and thermodynamics of the boundary layer to favour fog formation.

Studies of aerosols, ozone, and clouds from sky radiometer: Algorithms and observation results

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A ground-based sky radiometer, which can observe spectral direct irradiance and sky radiances, has a long history of aerosol observation. The use of this instrument is expanding to study water vapor, ozone, and clouds as well. As part of it, ozone and cloud retrieval methods have been developed by the author. In the presentation, the ozone and cloud retrieval algorithms will be introduced first. Comparison of sky radiometer retrieved ozone and cloud properties (cloud optical thickness and cloud-particle effective radius) with data of other platforms will be shown, and the rooms for further improvement will be discussed. Secondly, analyses of multi-year and multi-sites data of sky radiometer observed within Japan will be presented to show the optical characteristics and radiative effects of aerosols of different origins.

Atmospheric aerosols pathways and processes: IGP-Central Himalayas-Glacier

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India has reasons to be concerned about climate change since vast population of it depends on climate-sensitive resources like water, agriculture and forestry for livelihood. The recession of Himalayan Glaciers has an adverse impact on water availability, and precipitation-aerosol interplay possibly on decrease in rainfall and increase flooding in certain parts. These are threat to food security and causes die back of natural ecosystem including species that sustain the livelihood of rural households, and also implications on coastal system due to sea level rise and increased in extreme events. In addition to this, achievement of flagship national development goals linked with other systems such as habitats, health, energy, and infrastructure investments are also adversely affected due to Climate Change and Himalayan ecosystem.

So, we scientific community, with a first step forward of generating assessment report by MoES for India, based upon IPCC's set of formulas, can further plan local to regional scale science for the *Third pole* that would deliver benefits to vulnerable population in India to the impacts of climate change. In the present invited talk, I would attempt to highlight the ground-based research over IGP-Himalayan Foothills-Glacier linkages, done in recent years by Finnish Meteorological Institute, Finland in collaboration of our key partners in India. The core question could be, why there is no closure study simultaneous over belt of IGP and blanket of Himalayas ranging from west to east and adjoin Glaciers to assess the outflows and transport pathways with a comprehensive assessment of air-masses horizontally and vertically, boundary layer dynamics and snow deposition of *Atmospheric Aerosols*.

Vertical distribution of light-absorbing particles in glacier snow of the Sunderdhunga Valley, Northern India

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The absorption of short-wave radiation is one of the dominating energy sources for melting snow and ice, especially in the Himalaya. Light-absorption in snow is largely dependent on the surface albedo, which is mainly regulated by the snow grain size, as well as the presence of light-absorbing particles (LAP). The Central Himalayas is a region that has been recognized as an area where LAP deposition onto snow surfaces is higher compared to other parts of the Himalaya. Yet, it remains as a regions where measurements of LAP in glacier snow are scarce. Here we present measurements of LAP constituents from two glaciers in the Sunderdhunga valley, Uttarkhand, India. Snow pits were sampled in the post-monsoon period of 2016, and the LAP exhibit a large vertical distribution in the different snow layers. Across the pits, however, there are similarities in the depositional pattern, with a very distinct LAP layer interleaved between visually lighter snow below and above this dark layer. The dark layer is most probably a result of intense melting occurring during the summer months of 2016. Although our data is limited in spatial and temporal scale we propose that our values presented in this study are useful for large scale assessments of the radiation impact LAP in snow across the Himalaya. At the same time, our results demonstrate the complexity that can exist on a small scale due to the complex terrain existing in the glacier valley.

Brown Carbon Aerosols Characteristics over the Indo-Gangetic Plain

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Light absorbing organic carbon, also termed as "Brown Carbon" (BrC), absorbs light efficiently in the near UV (300 to 400 nm) to the visible region. The BrC originates from a variety of sources including biomass burning and fossil-fuel burning, and can be of both primary and/or secondary origin. The BrC has several important climatic effects e.g., global models estimate that light absorption by BrC in different regions around the world may be about 27–70% of that by black carbon. The BrC also has a semi-direct effect by causing significant warming/heating of cloud water/snow that leads to evaporation/dispersion of clouds/snow. The Indo-Gangetic Plain (IGP) receives emission from a variety of sources including post-harvest agricultural-waste burning and combustion of fossil-fuel in vehicles, industries, and thermal power plants. These emissions can reach to higher Himalaya under the favorable meteorological conditions and affect the cryosphere. This talk shall discuss the BrC characteristics over the IGP and its possible implications to Himalayan environment.

Simulation of black carbon and other aerosol species over the Hindukush Himalayan region and their impact on glaciers

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Indian Institute of Technology Kharagpur

Aerosols are particles in the atmosphere known to impact Earth's climate directly as well as indirectly. Aerosols tend to scatter or absorb insolation and thus affect the radiation budget likewise. Another impact due to aerosols exists in the cryosphere by altering the ablation rate of ice and snow. Deposited aerosol over snow enhances absorption of solar radiation, darkens the upper mixing layers of the snowpack, thereby reducing the snow albedo and leads to accelerated melting of snow. The Himalayan region has been exposed to particulate pollution and deposition of BC, as reported in observational studies at high-altitude Himalayan stations. In a recent study, the spatial mapping of black carbon (BC) aerosol distribution over the Hindukush-Himalayan region led to identifying a hot-spot zone located around Manora Peak. Among glaciers over this zone, BC concentration in the snow (> 60 µg kg-1) and BC-induced snow albedo reduction (~5 %) were estimated explicitly being high during the pre-monsoon for Pindari, Poting, Chorabari, and Gangotri glaciers (which are major sources of freshwater for the Indian subcontinent). Since aerosol species (e.g., BC, dust, sulfate, organic carbon) in general enhances the absorption of the solar radiation relative to the pure snow, it is necessary to evaluate the transport and amount of deposition in the snow of abundant aerosol species in addition to that of BC. This evaluation, therefore, necessitates the spatial mapping of aerosol species, sources of their transport, and compare the relative snow albedo reduction due to deposited aerosol species with that due to BC. The present study will focus on presenting the simulated distribution of BC and other aerosol species' impact over Hindu Kush Himalayan sites, including their sources and implications on glacier runoff.

Trace gases studies over the Central Himalayas and surrounding regions

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Demand for economic growth is leading to enhancement of air pollution in the developing countries. This is becoming important in the tropical regions, where intense solar radiation and greater amounts of water vapour make these regions most active photo-chemically. It is now known that higher concentrations of ozone and some other pollutants have deteriorating health impact on living beings and reduce vegetation growth. Despite this tropical Asia, particularly South Asia, is still not well studied. The monsoon system, over this region, is one of the largest regional climate phenomena and has major influence on the redistribution of trace species, even at the greater distances and altitudes. In view of this, an observational facility was setup at a high-altitude site (ARIES, Nainital, 29.4N, 79.5E; 1950 m) in the central Himalayas for ground-based measurements of trace gases (ozone, CO, NO_y, CH_4, SO_2, and NMHCs) and aerosols as well as balloon-borne observations of ozone and meteorological parameters. This talk will brief upon these observations in addition to the modelling efforts and satellite data analysis over this mountainous region.

Aerosol loading over the Indo-Gangetic Plains and its link to changing climate and land use over the Thar Desert and Rajasthan

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The rapid pace of economic development over the Indian region has led to significant increase in annual mean aerosol loading especially over the Indo-Gangetic Plains. However, during certain times of the year, the mineral dust or more generally the dust aerosols forms the major component of the composite aerosol column loading. These natural aerosols leads to significant deterioration of air quality and also modifies the surface energy balance regionally with implication to regional weather and hence climate. A seasonal analysis based on both ground and satellite measurements show that dust loading has declined over the Indian region by as much as 10 to 20%. This decline is attributed to the increased (decreased) rainfall (winds) regionally and large scale changes to land use and land cover (LULC). For instance, the croplands over the Rajasthan region increased by as much as 13%. More details on these aspects will be discussed.

Can elevated dust layers explain the altitudinal heterogeneity in snowmelt trends over western Himalayas ?

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High-mountain Asia (HMA) is commonly known as the third pole of Earth, however, the snow cover and glacier mass is reducing at an unprecedented rate in recent decades. While, climate change has been believed to be the primary reason for these reducing trends, light-absorbing particles (LAPs), mainly dust and black carbon, can also significantly impact the heterogeneity in snowmelt and regional water availability within HMA. In this talk, I will discuss the significance of dust deposition on snow albedo reduction and snowmelt over Himalayas. Westerly-driven, long-range transportation of dust particles via elevated aerosol layers (EALs) is a persistent phenomenon during spring and summer over the Indian subcontinent. During the snow accumulation season EALs transport ~100-1000 $\mu g/m^3$ of dust to the snow-covered slopes Himalayas. Using unique satellite estimates of snow albedo changes due to these impurities, I will demonstrate robust physical association between the EALs and aerosol-induced snow darkening over Himalayas. Further, results from fully coupled chemistry Weather Research and Forecasting (WRF-Chem) regional model simulations will also be discussed to reinforce the satellite observations. Results reveal that LAPs can induce high magnitudes of snow albedo reduction (4 %–8 %) in pre-monsoon seasons, which eventually leads to a snow-mediated radiative forcing of ~ 30–50 W m^{-2} at surface. Consequently, the western Himalayas hold the most vulnerable glaciers and mountain snowpack to LAP impacts within HMA. More interestingly, a distinct elevation signature is found in dust- and black carbon-induced snow darkening over Himalayas in both observations and simulations. Specifically, the influence of dust on snow darkening is greater than that of black carbon above 4000 m. Thus, these findings suggest a discernable role of dust in the spatial heterogeneity of observed snowmelt and snowline trends over HMA and implicate an increasing contribution of dust to snowmelt as the snow line rises under future warming.

Climate Change and changing behaviour of water resources in different river streams of the Himalaya

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The world mountains especially the Himalayan Region are supposed to be the early indicators of Climate Change in terms of snow melting and seasonal flow of water in different streams. The changing seasonal flow pattern throughout the year indirectly indicates implications of different levels of climate change. The changes in water resources have a variety of impacts on land use and other economic activities of the people in the downslope regions. The present study therefore takes into account field study based results from the five different basins representing the Indian Himalayan Region, i.e., Sindh (J&K), Parbati (HP), Dhauliganga (UK), Ranganandi (AP) and Imphal (MN). The study concludes by suggesting some of the mitigating measures so as to upkeep the livelihood options of the local communities being adversely affected by scarce and erratic behaviour of water resources in the Himalaya.

Climatological aspects of Himalayan region: An emphasis to the transport of pollutants

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Himalayan ecosystem is very sensitive to the any change in the atmospheric variables such as temperature, moisture and rainfall. It has witnessed a number of extreme weather events in past few decades which is a matter of great concern. Increasing anthropogenic pressure is one of the causes giving rise to global temperature and affecting Himalayan region as well. Model analysis shows that western Himalayan region is going to see the rise of 4-6^0 C in the temperature by the end of this century. In addition, Himalayan region is also affected seasonally by the continental as well as long range transport of pollutants which is found to show an adverse impact on the glaciers. Here, an attempt is made to understand the influence of long range transport of predominant aerosol type, mainly dust, during spring/summer, using the ground and satellite based information.

Aerosol-Lightning association in humid, semi-humid and arid regions over Northern India

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Association between aerosol and lightning is still not well defined and matter of debate. Aerosols have found to enhance as well as suppress the convection process and influences the lightning activity accordingly. The relationship between satellite measured aerosol index and atmospheric lightning over northern India (700E-960E) is investigated using long term data from 2005 to 2014. Data has considered from TRMM for lightning (LIS) and precipitation (3A12, V-7 and 3B43, V-7 sensor), and OMI and MODIS for, respectively, aerosol index (AI) and relative humidity. To better understand the changing relationships from humid to arid regions, the inter-annual variability of pre-monsoon seasons and monsoon seasonal data for 3 sub-regions of approximately equal area: Northeast (humid region), Northwest (arid region) and Central (semi-humid region) have been separated and analyzed. During pre-monsoon months of March-April-May, lightning was found to decrease for humid as well as arid regions. For this season, aerosol index shows negative correlation with lightning over the humid region and insignificant correlation over the arid region. It is found that during monsoon season and humid region, lightning activity is increasing along with increasing in aerosol index, while, for the same season, arid region showed decrease in lightning although aerosol index increased. For this season, however, season representative cloud fraction, deep convection, and precipitation were enhanced for over both the region. These findings suggest that a sufficient cloud fraction and deep convection drives lightning frequency over the region. Same but moderate results have been found for semi-arid region.

Nitrogenous aerosols in Himalayas: concentration, sources and implications

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Nitrogen is an important component in the environment and its compounds act as a limiting nutrients for plants growth and survival. However, an increase in concentration and deposition of nitrogenous aerosols has triggered numerous problems including eutrophication, acidification and even change in biodiversity. Once released into the atmosphere, they can be transported over a long distance. Himalayas are comparatively pristine and least impacted by local anthropogenic emission. Nonetheless, it is threatened for fragile environment and the ecosystem therein. To date, study of nitrogenous aerosols in Himalayas is still deficit. Given its importance in ecological and environmental sustainability, further investigation of nitrogenous aerosols is must. In this study, atmospheric aerosol samples were collected during summer and winter in 2013-2014 at southern side of eastern Himalayas. We provide the first comprehensive data for total nitrogen (TN) and its isotopic ratio (δ15N), major ions, water soluble total nitrogen (WSTN), water soluble inorganic nitrogen (WSIN) and organic nitrogen (ON) over Himalayas. Our results clearly demonstrate seasonal variation of concentration of nitrogenous aerosols and δ15N, which are approximately twice in winter compared to summer. The results from δ15N, statistical analysis, satellite data and HYSPLIT model indicates the major contribution of transported biomass burning (BB) emissions from North-West of India, East Pakistan and Nepal. This highlights the emissions over South Asia can have strong influence on the aerosol chemistry and abundance of chemical species over Himalayas via long-range transport, which might have impact on Himalayan ecosystem via their deposition.

Physio-chemical Impact over Outdoor Solar Photovoltaic by Atmospheric Aerosols Absorption and Deposition

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Natural atmospheric airborne aerosols or commonly dust exhibit a wide range of sizes from nanometres to few micrometres with different size and configuration. It is composed of both organic and chemical composition and significantly affect air quality index with much destruction in the environment and human livelihood. In recent times it has been observed that Solar rooftop PV has gained huge popularity and has been installed throughout India to priorities and encourage sustainable green energy generation. As per standard test condition, a photovoltaic cell operates with [15-25] % efficiency under adverse physical condition i.e. temperature, irradiance, humidity, etc. A recent study shows that atmospheric particulate matter (PM) i.e. dust outbreak and free aerosols deposition over the encapsulate surface of Solar PV modules possesses serious threat in power generation and optimization capability of Solar PV in turn drastically reduces the power output and efficiency. Moreover, it has also been responsible for alteration in physiochemical properties of PV after long exposure. In this work, an effort has been made to present a synopsis of aerosol observations, source inventories, characterization, energy metrology and the theoretical understanding required to enable an assessment of radiative forcing from aerosols. An investigation has been made over aerosol science more precisely aerosol chemistry to study its typical chemical properties, estimate unique potential impact, assess the influence over solar panel feasibility, sensitivity and transmittance.

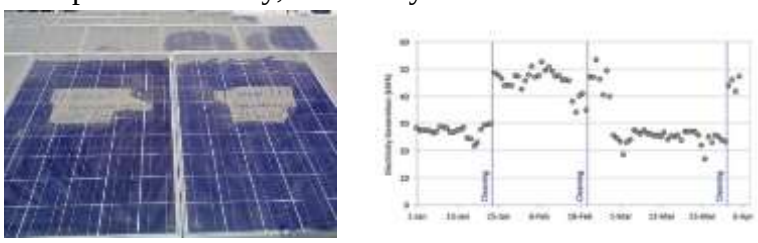

Figure 1. (A) Partially cleaned solar panels representing accumulation of PM for 28 days and (B) the change in measured solar energy production after several solar panel cleanings.

Relative estimation of air pollution tolerance of plants from Polluted and non-polluted forest area of Jhansi city in Bundelkhand region

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In recent era, biodiversity of plants is now become an eco-sustainable tool for monitoring and mitigation of air pollution. The present study aimed to compare the impact of pollutants i.e. particulate matter (PM), SO_2, NO_2 released from different pollution sources (e.g. vehicles, stone crushers, mining etc.) on some biochemical (i.e. heavy metals, chlorophyll a, chlorophyll b total chlorophyll and carotenoids) parameters of common plant species, growing at four different sites emphasizing different pollution sources and a control site of Jhansi City, Bundelkhand region. Results revealed that the site facing towards stone crushers shows significant ($p < 0.05$) decrease in chlorophyll contents and carotenoids values followed by mining and vehicular pollution. Present study indicates a heavy pollution load on the forest area present in and around the Jhansi city, Bundelkhand region. Some Tolerant plants (Lantana camara, Carissa carandus, Gentiana chirayita, Prosopis juliflora, Azadiracta indica, Butea monosperma, Holoptelia integrifloia) find their suitability for plantation in ecologically sensitive regions, having implications for forest ecosystem restoration.

Ecological Assessment of Water Quality of Betwa River in Jhansi District

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Jhansi is situated in Central part of India of Bundelkhand region of Uttar Pradesh, India. Betwa is the main river in Jhansi which is also a tributary of river Yamuna. The present investigation was carried out on Betwa River for the assessment of water quality. The sampling locations were chosen carefully in order to get maximum representation of the diverse eco-hydrological environments within the river system. The water samples were analyzed for various physicochemical and microbial parameters such as pH, EC, TSS, TS,TDS, total hardness, Ca, Mg , alkalinity, acidity, Cl, DO, BOD, free CO2, temperature and MPN. Results showed that the water of Betwa River was alkaline in nature with higher concentration of cations. Nitrates, phosphates and heavy metals are significant in the water which can be attributed due to high rate of decomposition and anthropogenic pressure. Higher BOD, COD, Turbidity and low DO level in water is due to abundance of animated life and the microbial activity, which result in the depletion of the dissolved oxygen. Therefore, results revealed that the river water is polluted due to sewage, domestic wastes and industrial effluents of many big and small enterprises with various types of organic compounds and heavy metals deterioted to human health and aquatic organism.

Neutral Induced Low Frequency Electrostatic Waves in Magnetized Dusty Plasma

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The role of neutral in a partially ionized collisional dusty plasma for the ionosphere has been analyzed. The dispersion relation for the electrostatic wave using electron, ions, dust particles, and neutrals has been derived, in the presence of strong collision among these constituents. The continuity and momentum equation has been solved by assuming that the perturbed electron and ion density varies almost similar to the perturbed plasma potential. The dust perturbation has been obtained by considering the charge neutrality of first order. These perturb quantities are the input for the dispersion relation. The instability condition is found to be depending upon the neutral scale length. The Electrostatic wave propagates almost perpendicular to the neutral wind direction. The simulated frequency is depend upon the thermal velocity of the neutrals, gyro frequency of ions, collision frequency between dust and ions, and collision frequency between dust and neutrals. The real as well as imaginary part of the wave frequency is depending upon the neutral scale length which also set the condition for the instability to occur at ionospheric altitude.

Spatio temporal Analysis of Glacial Lakes in the Jhelum basin, Kashmir Himalayas, India

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Changes in glacial lakes and the consequences of these changes, particularly on the development of water resources and management of glacial lake outburst flood (GLOF) risk, has become one of the challenges in the sustainable development of high mountain areas in the context of global warming. However, current knowledge about the distribution and recent changes in glacial lakes within the Jhelum basin is still limited. This paper presents the findings of a study on the distribution of, and area changes in glacial lakes in the Jhelum basin. Data on the number of glacial lakes and their area was generated for the years 2001, 2010 and 2017 using Landsat satellite images. The glacial lake inventory generated for the year 2017 revealed the total number of 322 glacial lakes with a total area of 22 .11 Km^2 and average size of 0.006 km^2 in the study area. The number of glacial lakes increased consistently over the study period from 267 in 2001 to 322 in 2017, an overall growth rate of 20.5%. The area of glacial lakes also increased from 19.31 Km^2 in 2001 to 22.11 Km 2 in 2017, a growth rate of 14.5%. A large number of glacial lakes in the inventory are small in size ($\leq$ 0.001 km^2. The glacial lake area between 0.10-1.0 km^2 has increased from 12.23 Km^2 to 13.42 Km^2 from 2010 to 2017. The total area has increased by 1.19 Km^2 ±0.012 for lakes with area greater than 0.01 Km^2 and less than 1.0 Km^2 and 0.25±0.012 Km^2 for those glacial lakes greater than 1.0 Km^2. The processes of glacial lake change were very complex, consisting of self-expansion, new formation and the disappearance of glacial lakes. From 2001 to 2017, the number of newly formed glacial lakes was greater than the number that disappeared. More than 78% of lake expansions consisted of the growth of existing glacial lakes over two spans of time. Thus newly formed lakes are not biggest contribution to the lake expansion in the Kashmir Himalaya. All the glacial lakes were located between 2700 m and 4500 m a.s.l. with a simple normal distribution. The majority of glacial lakes were distributed in an altitudinal zone from 3800 m to 4300 m accounting for more than 68% and 54% of all glacial lakes in quantity and area respectively. The rapidly expanded glacial lakes should be selected as potential lakes at high risk for GLOF to monitor and observe continuously.

Keywords: *Glacial lakes; Spatio-temporal-analysis; Landsat Imagery; Jhelum basin*

Glacier Retreat Analysis in the Context of Climate change impact over the Alaknanda basin

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This study explores the Glacier retreat footprints and hazardous zones in the context of the climate change impacts over the central Himalayan region. The motivation of the study is to evaluate the spatio-temporal changes in glacier area, volume and shift of the snout positions due to snow/glacier melt during the period 1968-2017. The analysis of LISS-IV and merged LISS-IV satellite imagery of different time frames (1968, 1990 and 2017) with SAR and SRTM DEM are used to observe the spatial and temporal changes in glacier extent. Considering the glacier receding trends in Indian Himalaya, this study also aim to identify the common drifts in glacier area to measure the fluctuation in the glacier ice velocity. High resolution SAR images are used to study the glacier velocity for ablation months during the year 2017 and emphasis to estimate the ice flow intensity and its phase information. Excessive climatic variations/perturbations impact the snow accumulations in the glacier region which causes downward drift on glacier ice to the ablation regions. Linear trends of MOD11A2 land surface temperature product were obtained and temperature variability has been analysed during 2002-2018. Temporal variation of climatic parameter (i.e. temperature) over the basin has shown the increasing trend. This shows significant warming over the basin in different seasons and a significant negative trend in snow cover area is observed. Results indicate the possible impact of increase temperature on snow cover especially in the low lying mountainous regions. The derived information may further use to analyse the climate change footprints such as snowline movement, snow volume change and glacier mass balance etc. This study developed the understanding of climate change impacts on the Alaknanda basin by analysing the basin characteristics and the degree of glaciations.

The relation between aerosol optical depth and lightning over hilly region: Uttarakhand India

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In this study, we are presenting the climatology of lightning flash rate (LFR) and aerosol optical depth (AOD) over the Uttarakhand, a hilly region of India for the first time. Lightning data (1995-2014) is collected from Lightning Imaging Sensor (LIS) and Optical Transient Detector (OTP) boarded on Tropical Rainfall Measuring Mission (TRMM) and AOD at 550 nm data (2000-2014) from Moderate Resolution Imaging Spectro-radiometer (MODIS). The dependency of lightning flash rates is also investigated from thermodynamic parameters such as convective available potential energy (CAPE), surface air temperature, vertical velocity, cloud top temperature, vegetation cover, and terrain slope. These thermodynamic parameters used to understand the convective activity over Uttarakhand including the foothills of Central Himalaya. The lightning flash rate shows a higher correlation with AOD, CAPE, and vertical velocity. Time series show a similar trend of variation for CAPE and AOD with the flash counts. The increasing AOD in pre-monsoon season leads to higher flash counts over this region. Possible sources of aerosols that cause an increase in lightning activities are identified from the classification of aerosol on the basis of the characteristic values of AOD and AE. Anthropogenic sources have a significant contribution to the aerosol concentration over this region. Further results and outcomes will be discussed in detail during the presentation.

Optical and radiative characteristics of different aerosol species over the Indo-Gangetic Basin: Implication to Himalayan Climate

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The Indo-Gangetic Basin (IGB) in north India is considered to be one of the global hotspots of enhanced aerosol loading, which usually composed of the complex combination of various anthropogenic and natural emissions and have distinct seasonal features. Due to combined effects of the IGB topography and the Himalayan orography, aerosols over the IGB region are lifted up quite often and found to be extended up to the Himalayan foothills. In the present study, the optical and radiative characteristics of water-soluble (sulphate: SO_4 and nitrate: NO_3) and carbonaceous aerosol species (organic carbon: OC and elemental carbon: EC), extracted from $PM_{2.5}$ samples were investigated at a representative megacity over the Indo-Gangetic Basin (IGB) during 2012. The aerosol optical depth (AOD) at 500 nm for SO_4, NO_3, EC and OC was found to be contributing ~36%, 20%, 27% and 9%, respectively in the total AOD value (0.61±0.18) during the entire study period. Further, single scattering albedo (SSA) for SO_4 and NO_3 was found to be highest, which suggests their scattering nature. On the other hand, EC, being the highly absorbing species, was found to show the lowest SSA, which was estimated to have the highest warming (~70%) to the total atmospheric warming. Being fine particulates, the carbonaceous aerosols are found to be transported and impacted the Himalayan foothills, which will be discussed in detail.

ET estimation using simplified surface energy Balance Index using Landsat 8 imagery

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Evapotranspiration (ET) is an important hydrological variable for better irrigation management, water budgeting, and runoff estimation which should be estimated as precisely as possible both in space and time. However, most of the available crop-coefficient based ET computation methods provide point-scale estimates which need upscaling to apply at the catchment or command area scale. This study evaluates the applicability of the Simplified Surface Energy Balance Index (S-SEBI) method to estimate the spatially distributed daily ET in the Kangsabati reservoir command in eastern India considering the crop coefficient based Hargreaves-Samani method as the benchmark. The study is based on two major crops of paddy and potato in the Rabi season of 2015 at 100 surveyed ground truth locations in the selected command area having different crop growth stages, and using the site-specific Landsat-8 images on three cloud-free dates. The study reveals that the S-SEBI based ET estimates are well-comparable with that of the benchmark model. The S-SEBI method shows improved ET estimates during the crop development stage characterized by higher canopy cover than that during the initial crop development stage with lesser canopy cover that traps less radiation. Therefore, the crop coefficient based method could be advantageous at point-scale with adequate data availability conditions, whereas the S-SEBI method could be used in data-scarce areas to estimate the spatially distributed ET values.

Rainfall Variability Analysis and its Impact on Farming Systems in the Northern Mountainous Regions of India

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Climate change has become a burning issue worldwide. High variability and change in climatic conditions have manifested several adverse implications on nature and society. This study analyzes rainfall variability in the northern mountainous region of India and its impact on farming systems. Rainfall data from 1846 to 2006 were gathered from the Indian Institute of Tropical Meteorology (IITM), Pune, Maharashtra. The 170 years rainfall data of all the three states – Uttarakhand, Himachal Pradesh, and Jammu and Kashmir were averaged and analyzed as average annual rainfall, average monthly rainfall, average decadal rainfall, season-wise average decadal rainfall, average decadal monthly rainfall, average decadal minimum, maximum, and mean value of rainfall, and season wise minimum, maximum, and mean value of rainfall. Data on changing farming systems were gathered through case studies and collection from the secondary sources. This study shows that rainfall variability – seasonal and temporal, is very high in this region. During the recent period, rainfall has decreased substantially along with high temporal and seasonal variations. This has resulted in changing farming systems in the Himalaya.

Variability of air quality and aerosol over Indian region during 2003-2012

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Understanding the effect of atmospheric aerosols on climate and environment is still the critical issue to be dealt by science community. Aerosols are produced from both, natural and anthropogenic emissions and these sources are well understood to affect the air quality, human health and radiation budget. The Indo-Gangetic basin is one of the biggest and most populated regions in the world and the studies over IG-basin using satellite and ground based data show strong seasonal variability of aerosol optical depth (AOD) with maximum loading during pre-monsoon (summer) season. In this article, decadal (2003-2012) variability of aerosol optical depth (AOD) derived from AERONET measurements over Kanpur are analyzed. Results indicate that AOD is found to be maximum during 2003 and minimum in 2012. The aerosol size distribution (ASD) exhibits increase in the radius and decrease in width of distribution. It shows enhancement during 2003 and 2010 and diminished values during 2004, 2007, 2009 and 2011. The ASD are found to peak during summer season (pre-monsoon) throughout 2003-2012 only except the years 2008 and 2011. Moreover for the years 2008 and 2011 ASD showed peak value during a monsoon month (July). Changes in the spectrum of ASD are explained in terms of surface temperature and precipitation. Air pollutants such as Nitrogen dioxide, carbon mono-oxide, carbon dioxide are also analyzed and their association on ozone depletion has been discussed.

Thickness and volume estimation of Indian Himalayan Glaciers using field based geophysical techniques – A brief review

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Like many worldwide glaciers, the Himalayan glaciers also shrinking rapidly leading to adverse impacts on downstream areas. The most recent estimate of global glacier change indicates a mass loss rate of 259 ± 28 Gt y^{-1} between 2003 and 2009, with global runoff from glaciers exceeding 1,350 km^3 y^{-1}. Previous studies indicate that the glaciers in the Ganges, Indus, and Brahmaputra Rivers basins of the Himalaya are currently losing 24 ± 2 Gt y^{-1} of ice. However, the volume of Himalayan glaciers is still highly uncertain due to lack of reliable ice thickness data. It varies between 2955 to 4737 km^3 based on different statistical scaling and numerical methods. Ice thickness of glacier is not only prerequisite parameter in volume estimation but also significant in ascertaining the glacier dynamics. Himalayan glaciers alone provide water to 1.4 billion people. Under the ongoing global warming, changes in volume of Himalayan glaciers will alter the downstream discharge and thus affect the human population that depends on them. Therefore, suitable understanding of existing glacier ice volume is important for water management and future planning. In recent years certain models have been developed to bridge this gap and used for estimation of spatial distribution of ice thickness. Such models incorporate remote sensing data and calibrated against limited field data. More recently, a consensus on glacier ice thickness and thus volume has been made using these models. In Indian parts of Himalaya, only ~11 glaciers out of 9575 (as per Geological Survey of India glacier inventory) have been explored for field based ice thickness which is insignificant in view of its vast extent. In 03 glaciers namely Dunagiri and Tipra (central Himalaya) and Zemu (eastern Himalaya) the ice thickness was measured by geophysical resistivity method while in others the Ground Penetrating Radar (GPR) survey was used. Detailed GPR survey was carried out only in two glaciers (Dokriani & Chhota Shigri). All the other glaciers have only sporadic point measurements. This may be one the reason that only two glaciers of Indian Himalaya have considered for comparison and calibration of widely used numerical models. During 2016, we have estimated ice thickness of Satopanth glacier in Alaknanda Basin, Central Himalaya, using GPR. It was the first attempt of thickness measurement using GPR in Upper Alaknanda Basin. The ice thickness ranges between 38±3.5 to 50±3.5 m near the glacier terminus and 98±7 to 112±7 m at the end of ablation zone using 20 and 16 MHz frequency antenna respectively. We have surveyed a total length of ~3 km by GPR profiling along and across the glacier with maximum profile length of 450 m. In this paper, we are providing a brief review of the available thickness measurements in Indian Himalaya glaciers. We also suggest that in order to estimate the volume of glacier stored water; one representative glacier should be selected for GPR survey in each Himalayan river basin. Though the field based observations are challenging in Himalaya not because of rough terrain, harsh weather conditions and financial constraints but also due to extensive debris over the glaciers

and malfunctioning of the instrument itself during the surveys. Furthermore, relatively less debris covered glaciers and lower frequency GPR antennas shall play a crucial role in field based ice thickness calculation.

Impact of lockdown due to COVID-19 outbreak on air quality over Uttarakhand, Environment of Himalaya

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COVID-19 outbreak (worldwide pandemic) has emerged as curse socially while beneficial for nature. In this study, we analyse the effect of lockdown on air quality of five crucial cities of Uttarakhand (i.e. Dehradun, Haridwar, Kashipur, Rudrapur and Haldwani). The variation in concentration of air pollutants (PM_{10}, SO_2, and NO_2) has been analyzed during two phases, pre-lockdown (January- March 2020), and lockdown (April-June 2020). The average reduction on PM_{10}, SO_2, and NO_2 concentration has been evaluated 29%, 47% and 37% respectively as compare to the regular trend in pre-lockdown phase. A quantitative study of Air Quality Index (AQI) shows a shifting from poor to satisfactory level. The range of reduction has been found 31%-61% (compare to 2019) over different sites of Uttarakhand. In addition the maximum decrease in air pollutant (PM_{10}, SO_2, and NO_2) observed for Haridwar (50%, 82% and 65%), while minimum for Haldwani (17%, 16% and 26%) respectively during lockdown phase with respect to year 2019. Our observations and results indicate that air quality is significantly improved during lockdown and would be adopted as a climatic policy to healing nature.

Study of PM2.5 distribution, it's relation with metrological parameters

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Urbanization has facilitated the human life. However, on the flip side has invited a lot of adversity on the human lives. Air pollution is one the major concerns and enhanced levels finer air pollutants - particularly $PM_{2.5}$ makes the situation rather more critical. Presently, the analysis of distribution of $PM_{2.5}$ on different temporal scales - monthly, daily and diurnal over a period of two years (2016 and 2017) have been carried for Near Capital Territory (NCT)/Delhi region. The seasonal variations are quite evident. The maximum concentration of $PM_{2.5}$ is observed in winters than in summers and least during monsoon months. The diurnal variation also shows strong dependence on the seasonal conditions. The winter months (November, December and January) shows higher concentration of $PM_{2.5}$ during the daytime compared to the night time. The summer and monsoon months (May, June, July, August and September) shows almost equivalent concentrations during daytime and night time. The April and October shows similar trend as of winter months, however with lower magnitude of concentration. The effect of monsoons and metrological parameters has been also analysed. The precipitation (rainfall due monsoons) lowers the levels of $PM_{2.5}$ concentration. The $PM_{2.5}$ concentration is positively and negatively co-related with the wind speed and temperature. The AQI is good during the months of July and August and in the winter months is quite unhealthy. The exceedence factor (EF) of $PM_{2.5}$ suggests that NCT/Delhi was critically polluted during both the years.

Keywords: Particulate matter, Air Quality Index, Meteorological parameters, Control measures

Black carbon over a high altitude central Himalayan Glacier: Variability, transport, and radiative impacts

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Light absorbing impurities like black carbon (BC) aerosols have the potential to warm the remote Glaciers of Himalaya. Estimations of accurate ambient BC concentration and radiative forcing is nearly impossible without in situ observations. Long term ambient BC measurements spanning from May to October has been carried out at Satopanth Glacier (4000 m, amsl) of central Himalaya during the year 2019. BC varied from 8.12 ngm^{-3} to 450.29 ngm^{-3} during the entire period of observation. Monthly averaged BC values shows highest concentration during May (280.80±78.55 ngm^{-3}) and least in August (117.64±72.47 ngm^{-3}). Trend shows ambient BC decreases from Premonsoon to monsoon attributed to limited long range transport and rapid wet scavenging processes. High rate of BC influx during Premonsoon and post monsoon are attributed to transport from polluted IGP region, wild fires at slope of mountains and vehicular emissions at semi urban sites located at valley region of Glacier. Higher brown carbon influx is attributed to biomass burning, especially wood burning during intense forest fires at slopes of mountains. Total BC direct forcing and heating rates from atmospheric and surface darkening is significantly high during Premonsoon, indicating a warming and possible disruption of natural snow cycle over Glacier location.

Source apportionment of carbonaceous aerosols

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Carbonaceous aerosols from both natural and anthropogenic sources constitute a significant part of atmospheric aerosols and are responsible for the largest fraction of the light absorption with main sources the industrial emissions, traffic and biomass burning .Black carbon (BC) strongly absorb the solar radiation from ultraviolet (UV) to near infrared, being the most efficient absorber among the atmospheric aerosols. On the other hand some organic carbon (OC) absorbs strongly in UV and some of OC (well known as brown carbon, BrC) also absorb in visible spectrum. However, the issues related to BrC are still under discussion due to the scarcity of BrC related measurements and its highly variable chemical composition and optical properties, including large uncertainties in the assessment of radiative forcing. Therefore, elucidating the optical properties and sources of carbonaceous aerosols and especially those of BrC is of paramount importance for constraining current radiative transfer model.

Black Carbon emissions from residential biomass burning for different fuels and burning conditions: A biomass burning experiment

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A survey for the biomass burning experiment had been carried in and around the location of Tripura University campus. Approximately up to 5 km area has been covered in all directions of the university campus during the survey which included the visit of almost 100 individual houses. During the survey, villagers reported that there are seasonal variations in usage of biomass sources depending on the availability of sources during a particular season. Based on the survey, collection of the most dominating biofuels/ biomass sources in different seasons has been done. A biomass burning experiment has been conducted at the Department of Physics. We have tested total of 12 samples including Rubber, Akashi, Arjun, Jack fruit, Mango, Gamahi, Teak, Guava, and Blackberry woods, Bamboo sticks, dry coconut shell, dry leaves, and dry branches. Each collected sample was burned under the flaming and smoldering conditions in the present experiment. This burning experiment had been conducted under control environment in a closed room. Significant spectral properties of BC have been observed during the two main burning phases (flaming and smoldering). A homemade chulla/chamber was used to burn biofuels/biomass sources. Each day, two different experiments were conducted under two different conditions (flaming and smoldering) using same source. During morning hours (10:00-11:00 am IST), first experiment was conducted with flaming condition and on the same day, after reaching the BC concentration values to normal value, second experiment was conducted during late evening hours (06:00-07:00 pm IST) with smoldering condition. The BC produced during the burning period has been measured by using a 7- channel Aethalometer. The measurement of BC concentration has been performed at three different time periods, which were classified as pre burning period, burning period, and post burning period. An increase in BC concentration has been noticed during the burning period for each source. The large variations in the BC concentrations were observed from the starting to the end of the burning period for each sample. From the measured BC concentration, AAE values were determined at 880nm for various biofuels under both the Flaming and Smoldering conditions. In this study, a range of ÃŽÂ± value from 1.20 to 2.37 has been determined when sources burnt under flaming condition and when sources burnt under smoldering condition; AAE values are found to be 1.59 to 2.33. More details will be presented.

Passive measurement of Indoor Radon Thoron concentration in Ghuttu Window, Tehri Garhwal

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Radon-222 is a radioactive noble gas that is an intermediate product of the Uranium-238 decay series. It is formed by the alpha decay of Radium having a half-life 3.81 days. Radon gas is present in all types of rock and soil because all of them are made up of minerals having radium in traces. When the ambient aerosol particle attaches to the decay product of the radon (218Po, 214Pb, 214Bi, and 214 Po) radon progeny rich aerosol is formed. Radon progeny rich aerosol is the main source of natural radiation dose. These aerosol reaches the respiratory tract through inhalation and are deposited there. By the Inhalation of short-lived decay products of the radon and thoron, these progenies are deposited to the airways of the lung and can cause damage to the soft tissue of the lungs. Radon concentration varies with Uranium contents present in the soil and lithology of the area. from soil, radon reaches to the atmosphere by the exhalation process. The exhalation rate is highly dependent on the geology and the presence of tectonic faults. The radiation hazard strongly depends on the radon exhalation rate from the soil. In the present study, samples were collected from the dwellings of Ghuttu window region of Tehri Garhwal District of Uttarakhand. The measurement is carried out by using the passive Pinhole Dosimeter (LR-115 plastic track detectors). Seasonal Indoor Radon and Thoron concentration in a different type of Dwelling, with different ventilation conditions, are measured. The indoor radon concentrations were found very high. During summer, the radon concentration varies from 21.31 Bq/m3 to 119.45 Bq/m3, and thoron varies from 7.65 Bq/m3 to 189.29 Bq/m3 during the rainy season it ranges from 11.91 Bq/m3 to 297.92 Bq/m3 for radon and between 5.88 Bq/m3 to 251.96 Bq/m3 for thoron. For winter season radon varies 34.20 Bq/m3 to 174.16 Bq/m3 and thoron varies between 16.17 Bq/m3 to 201.96 Bq/m3. The interesting results obtained from this study will be discussed during the conference. Key Word:- Radon, Uranium, Radium, Aerosol, Dosimeter.

HALF-DECADAL TREND OF PARTICULATE MATTER OVER DIFFERENT MICRO ENVRIONMENTS IN PUNE, INDIA

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The half decadal trend of PM_{10} and $PM_{2.5}$ mass concentrations obtained from the air quality monitoring stations established at nine different micro - environments of Pune, India is analyzed (for the period 2014 to 2018). Amongst these environments the PM_{10} concentrations showed a significant decreasing trend at all locations (Except Katraj: an urban complex area). However, the $PM_{2.5}$ concentrations showed an increasing trend in majority of the locations within the city. Two locations viz. Pashan (green environment) and Manjri (close to agricultural land) showed a decreasing trend of $PM_{2.5}$ concentrations with a decrease of 4.2% and 6% respectively. The highest half decadal increase of $PM_{2.5}$ concentrations of 38 % is observed at Bhosari (a location in the proximity of industries in Pune). The half decadal trend of meteorological parameters like temperature, wind speed and relative humidity also were analyzed. Temperature and wind speed did not show any significant trend during the period (Wind speed showed increase at certain environments in the city, which is not very significant). On analysing the half decade trend of PM_{10} and $PM_{2.5}$ it was found that at certain locations there was an increasing trend during some seasons and decreasing in the other localities. The highest increasing trend of both PM_{10} and $PM_{2.5}$ is observed in the urban locality of Katraj in the winter season. On a whole it is observed that the coarser particles show a declining trend whereas the finer particles show increasing trend over the time span of 5 years which can be attributed to the increasing anthropogenic emissions.

Passive measurement of Indoor Radon Thoron concentration in Ghuttu Window, Tehri Garhwal

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Radon-222 is a radioactive noble gas that is an intermediate product of the Uranium-238 decay series. It is formed by the alpha decay of Radium having a half-life 3.81 days. Radon gas is present in all types of rock and soil because all of them are made up of minerals having radium in traces. When the ambient aerosol particle attaches to the decay product of the radon (218Po, 214Pb, 214Bi, and 214 Po) radon progeny rich aerosol is formed. Radon progeny rich aerosol is the main source of natural radiation dose. These aerosol reaches the respiratory tract through inhalation and are deposited there. By the Inhalation of short-lived decay products of the radon and thoron, these progenies are deposited to the airways of the lung and can cause damage to the soft tissue of the lungs. Radon concentration varies with Uranium contents present in the soil and lithology of the area. from soil, radon reaches to the atmosphere by the exhalation process. The exhalation rate is highly dependent on the geology and the presence of tectonic faults. The radiation hazard strongly depends on the radon exhalation rate from the soil. In the present study, samples were collected from the dwellings of Ghuttu window region of Tehri Garhwal District of Uttarakhand. The measurement is carried out by using the passive Pinhole Dosimeter (LR-115 plastic track detectors). Seasonal Indoor Radon and Thoron concentration in a different type of Dwelling, with different ventilation conditions, are measured. The indoor radon concentrations were found very high. During summer, the radon concentration varies from 21.31 Bq/m3 to 119.45 Bq/m3, and thoron varies from 7.65 Bq/m3 to 189.29 Bq/m3 during the rainy season it ranges from 11.91 Bq/m3 to 297.92 Bq/m3 for radon and between 5.88 Bq/m3 to 251.96 Bq/m3 for thoron. For winter season radon varies 34.20 Bq/m3 to 174.16 Bq/m3 and thoron varies between 16.17 Bq/m3 to 201.96 Bq/m3. The interesting results obtained from this study will be discussed during the conference. Key Word:- Radon, Uranium, Radium, Aerosol, Dosimeter.

Dominance of Biogenic Emissions in Aerosol-CCN Activation under Limited Anthropogenic Emissions over Eastern Himalaya, India

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The present study is an attempt to investigate the role of biogenic aerosols in cloud condensation nuclei (CCN) activation in absence or limited anthropogenic emissions over a high altitude site, Darjeeling (27.01˚N, 88.15˚ E, 2200 m asl) at eastern Himalaya in India. The ceasing of anthropogenic activities during the lockdown due to pandemic COVID-19 provided us a unique opportunity to study the impact of biogenic emissions. The sampling site in Darjeeling is highly influenced by the biogenic emissions from the huge coniferous forest covers, which normally gets suppressed under the anthropogenic emissions during normal period. We sampled condensation nuclei (CN) and cloud condensation nuclei (CCN) during lockdown period (April-May 2020) and compared with the normal period (April-May 2018). The limited or absence of anthropogenic emissions reduced the mean CN concentration by 53% during the lockdown period (3245±846 cm-3) compared to the normal period (6194±3248 cm^{-3}). CN over eastern Himalaya is mainly contributed by the locally generated fossil fuel and biomass burning emissions related to tourist activities as well as long-range transport from distant source regions like central and western IGP and Nepal. The absence of anthropogenic emissions all over the country reduced the CN during the lockdown period. However, an increase of mean CCN concentration (lockdown: 2209±550 cm^{-3}; normal 1926±915 cm^{-3}) by 15 % was observed. Activation Ratio (AR; CCN to CN ratio) during lockdown was enhanced to a large extent (from 0.30 in normal period to 0.68 in lockdown) indicating much higher solubility of aerosols during lockdown. Another interesting result was the high rise in secondary organic aerosols (SOA) during the lockdown period that could be associated and coupled with the high increase in CCN and AR. We observed that SOC was strongly correlated with the AR during the lockdown period and such correlation was moderate during the normal period. Absence of anthropogenic emissions reduced the emissions of NO and in turn enhanced the formation of O_3. Much higher surface O_3 during the lockdown (due to very low NO) could better promote the formation of secondary OC (SOC) through the photochemical oxidation of biogenic volatile organic compounds (BVOCs) emitted from Himalayan coniferous forest cover. SOC during the lockdown (7.6±3.5 µg m^{-3}) was double of that in normal period (3.8±1.4 µg m^{-3}). Such high SOC was found to effectively contribute in aerosol-CCN activation. The present study shows the importance of Himalayan coniferous forest cover in significantly contributing to cloud microphysics. Keywords: CCN, SOC, Lockdown, Eastern Himalaya

Leaf physiognomy decodes the Miocene monsoon intensification

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Monsoon circulation is a planetary scale phenomenon, however, our knowledge regarding its dynamics is still incomplete due to its complex nature and different external forcing factors. The Asian Monsoon System (AMS) is considered as the strongest monsoon system on earth and consists of three sub-systems i.e. the East Asia (EAM), South Asia (SAM) and Western North Pacific monsoons (WNPM). The ASM is complex system because of its relationship with major orographic features such as the Himalaya and Tibetan Plateau. Based on the terrestrial and marine archives it has been argued that the onset and intensification of the SAM to a near-modern state occurred during the Miocene, while modelling and other terrestrial proxies point to a much earlier origin for the proto-EAM and proto-SAM. The dicot angiosperm leaves provide a good indication of prevailing climatic conditions as a result of key adaptations in their leaf structure/ physiognomy. Here we use climate leaf analysis multivariate program (CLAMP) to decode the Lower (~13–11 Ma) and Middle (9.5–6.8 Ma) Siwalik climate signal inherent in the physiognomy of fossil leaves. The reconstructed climate data indicates that the Middle Siwalik was warmer and wetter than the Lower Siwalik, particularly in the cooler part the year. The leaf physiognomy of Lower and Middle Siwalik assemblages is indistinguishable to that of the modern leaf assemblages, which are influenced by today's SAM climate. This indicates that the SAM, was already well established as an independent sub-system during the late middle Miocene (~13–11 Ma) and has changed only a little from the perspective of leaf adaptations since then. The monsoon intensity index indicates an intensified monsoon during the late Miocene (9.5–6.8 Ma), a finding endorsed by other proxies.

Polluted aerosols escalating heating over the Indo-Gangetic plane for over a decade

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Since ages Indian atmosphere remain dusty and polluted due to agricultural practices especially over Indo Gangetic plains (IGP). However the role of aerosols in heating of the atmosphere remain ambiguous. This study utilizes 10 years of CALIPSO aerosol datasets (2007-2017) for different types of aerosols specially focusing on the polluted continental aerosols over IGP region, India. The seasonal variations of polluted continental/smoke (PCS) aerosols and associated changes in the heating rate and the radiative forcing are studied over the IGP region. We find that PCS aerosols escalate heating over the IGP region in comparison to other aerosols during winter season.

Characterization of carbonaceous aerosols in eastern part of the central IGP: Seasonal variability and source apportionment

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Black Carbon (BC) mass concentration within the planetary atmospheric boundary layer was measured at Gorakhpur, a semi-urban city located in eastern part of the central Indo-Gangetic Plain (IGP). The present study aims to access temporal variation of BC aerosols over a different time scales due to seasonal changes in the emission sources, boundary-layer dynamics and changeable meteorological conditions of this region. The annual-mean BC concentration at 880 nm is observed to be 12.6±8.2 μg m^{-3} in the range of 0.03 – 58.6 μg m^{-3}. Winter season is characterized by extremely high BC concentration of 19.5±15.8 μg m^{-3} comparable to those seen in urban environments of IGP region, dropping off to 4.6±3.4 μg m^{-3} during the monsoon. In the period of study, spectral dependence of absorption coefficient reveals that dominant source of BC is biomass burning during post monsoon season while there is mixed contribution from biomass, bio-fuel burning and fossil fuel combustion in other seasons. Diurnal variation in the absorption angstrom exponent indicates that the morning and evening peaks are contributed by the biomass combustion with values above threshold of 1.3. However, angstrom exponent values are found low during noon time of pre-monsoon and monsoon season, suggesting fossil fuel contribution. Concentration weighted trajectory (CWT) analysis reveals that the potential sources for the carbonaceous aerosols and pollutants are due to local emissions within the urban environment and transported smoke from agricultural residue burning in North-West India during post monsoon. The high BC during winter is mostly associated with the advection from West and North-West side of the station, while during monsoon the air mass pattern is constricted to the oceanic region making BC aloft due to local pollution only.

Simulation of NOX and ozone during lightning event in pre-monsoon season by WRF-Chem

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Lightning is one of the main sources of nitrogen oxide (NOx) in the troposphere. Reactive NOx, play an important role in the chemistry at troposphere. It affects the concentration of ozone in the atmosphere, which is an important greenhouse gas. WRF-Chem model has been used to simulate lightning temporal and spatial distributions before, during, and after thunderstorm during pre-monsoon season over North-East India. The main goal of the study is to evaluate the influence of NOx by lightning source strength on the distribution of ozone in the troposphere. The domain with spatial resolution of 27 km by covering most of the north-east part of India and some part of Bay of Bengal, where lightning is frequent during pre-monsoon. The simulation has been run for 16th May to 25th May 2009 with/without lightning module. This study utilizes Emissions Database for Global Atmospheric Research (EDGAR), Fire Inventory from NCAR (FINN) and Model of Emissions of Gases and Aerosols from Nature (MEGAN) for anthropogenic, fire and biogenic emissions. The aerosol model chosen is Modal Aerosol Dynamic Model/Secondary Organic Aerosol Module (MADE-SORGAM). The simulation outputs reveal that the surface concentration of NOx is found to be increased significantly after the lightning event. The magnitude of NOx and ozone is much higher with lightning module than without lightning module for higher affected areas. It is observed that surface ozone concentration is also changing with NOx concentration and there is a improved correlation between the models simulated NOx and O_3 against satellite observations. The model was able to successfully simulate high and low lightning dominant regions in terms of ozone concentrations.

Quantification of fractional aerosol iron solubility over the coastal Arabian Sea

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The role and significance of Iron (Fe) as a limiting nutrient in controlling primary productivity and thus, to global climate is well known [1, 2, 3, 4] Atmospheric deposition is one of the major pathway for Fe supply to coastal and remote Ocean surface [4]. The water-soluble fraction (of total aerosol Fe), often called bioavailable Fe is readily available for microbes and their quantification is of utmost importance. Here, we report on a new method for the measurement of Fe in water-soluble fraction of aerosol collected at a coastal location in the Eastern Arabian Sea. We have compared our soluble Fe measurements with those measured using High-Resolution-ICP-MS (HR-ICP-MS). A total of 31 and 23 PM2.5 samples were collected during summer (March-May, 2018) and winter (December, 2018-February, 2019) months respectively using a high-volume sampler with a PM2.5 inlet. Post sampling, all samples were leached using deionized water and Fe was measured in the water extract (WS-Fe) using Dionex ICS-5000, Ion chromatography as well as HR-ICP-MS. We also measured total Fe and Al in acid digested (HF +HNO3; [5]) aerosol samples using ICP-OES and estimated mineral dust concentration using Al [6]. We analysed WS-Fe in 37 samples (17 from summer and 20 from winter) using IC and HR-ICP-MS and a significant correlation (r = 0.97) observed between them with all data found within 5 % variability validating the measurement of Ion Chromatograph. Using the measured Fe concentration, we quantified temporal variation in fractional Fe solubility (WS-Fe (%)) over the study region. Our seasonal data show higher fractional solubility for Fe (19.35±19.01%) with large variability during winter compared to summer month (10.49±8.94%). Conspicuously, we observed high dust during winter compared to summer, in contrast to dust measured at other sites over India [5]. The enhanced Fe solubility during winter may be attributed to increased anthropogenic emissions during winter which is evident from high sulphate concentration observed during this period. In addition, highly processed mineral dust via long range transport can also add to enhanced Fe solubility during winter months.

Key Words: Mineral Dust, Iron Solubility, Nutrient, Ion chromatograph, Arabian Sea

Investigation of heavy rainfall characteristics over central Himalaya: A case study using field observation and numerical modeling

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Mountainous regions of the central Indian Himalaya are prone to Indian summer monsoon seasonal very heavy rainfall induced vagaries. In spite of few space based observations and modeling of such rainfall events over the Himalayan region, there are significant lacunas in the field-observations of extreme to heavy rainfall events and numerical modelling studies highlighting roles of cumulus and cloud micro-physical parameterisations. To address these knowledge gaps, this study aims to analyse the observed heavy rainfall characteristics during 16-20 July, 2014 (daily total precipitations are 100.8, 77.8, 307.7, 127.4, 48.9 mm) at a central Himalayan location in the Uttarakhand state of India (i.e. Kosi-Katarmal, Almora, 29.639N, 79.622E, 1213 m above sea level). The hourly, 3-hourly and 6-hourly cumulative heavy rainfall events are used for evaluating the WRF-ARW model sensitivity using six numbers of available cumulus and cloud micro-physical parameterisations each for three nested domains having spatial integration scale of 9, 3, and 1 km. Therefore, a total of 36 model experiments are carried out. The monsoon seasonal 1 min precipitation observations using a Disdrometer (OTT, Parsivel2) at the Kosi-Katarmal, Almora, are categorized as per the World Meteorological Organisation specified rainfall type, i. e. heavy drizzle with rain (Hdr) and heavy rain (Hr). The rainfall intensity, reflectivity, and particle number are analyzed. It is noted that Hr accounted for ~12% of total rainfall having maximum rainfall intensity of 39.4 mm/hour with average reflectivity of 35.1 dBz. However, maxima of reflectivity = 53.4 dBz could be rarely observed, and might be linked with sever meso-scale convective systems during monsoon. The 3-dimensional reflectivity—intensity—particle number plots for Hdr category of precipitation indicates a clear two regime structure of precipitation distribution, where intensity and reflectivity are related to each other through an exponential law. The two regimes of precipitation could be distinguished at reflectivity ~ 22.5 dBz. The WRF-ARW model sensitivity is assessed using the dichotomous forecast skills, i.e. correlation coefficient (cc), probability of detection (pod), threat score (Ts), false alarm rate (Far), and accuracy (Ac) associated to an event during hourly, 3-hourly and 6-hourly rainfall at Kosi-Katarmal and model simulations over three domains for each experiment. Finally, a cumulative index (CI), was estimated for each experiment. The event is defined as any value > 1.0 in the standardised anomaly of the observation. The final values of all the statistical scores are estimated from a contingency table of 'Hit' and 'Miss'. The best model performance is noted for the combination of Betts-Miller-Janjic cumulus and Kessler cloud microphysics parameterisations during 6-hourly prediction over domain-2 and 3, i.e. when the model spatial integrating scale is finest (3x3 and 1x1 km). The CI scores for both the experiments are noted to be 0.66. Interestingly it is noted that the performance of the combination of Betts-Miller-Janjic cumulus and Kessler cloud microphysics parameterisations increases with domain resolutions, i.e. 9 to 3 to 1 km, for 3-hourly (CI = 0.09, 0.24, 0.55) and 6-hourly rainfalls (CI = 0.06, 0.66, 0.66), and not for 1-hourly rainfall.

Assessment of radionuclides distribution and radiological hazards in soil sample of Himalayan region

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Natural radioactivity is prevalent in the earth's environment and exists in several geological formations such as air, water, soils, rocks and plants. The present work reports the distribution and exposure of radionuclides i.e. Radium (226Ra), thorium (232Th) and potassium (40K) in the soil of Himalayan region of Uttarakhand, India. The soil samples collected from the different villages of Almora district on the basis of previous experiments performed and analysed using NaI(Tl) gamma ray spectrometry. The average concentration of 226Ra, 232Th and 40K were 48, 45 and 2049 Bq/kg. These values are higher than their global average values. Their exposure was estimated in terms of hazard index, absorbed dose and annual effective dose. The average value of external and internal h-index was 0.73 and 0.86, respectively. The external and internal health hazard index average value was found less than unity. While the average value of absorbed dose was 135 nGyh-1 which is higher than the global average. The total indoor effective dose was found to vary from 0.55 mSvy-1 to 0.91 mSvy-1 with an average value of 0.66 mSvy-1. The total outdoor effective dose was found to vary from 0.14 mSvy-1 to 0.23 mSvy-1 with an average value of 0.17 mSvy-1. These results were correlated with exhalation, emanation from the soil and previous studies.

Keywords: Radionuclides, Health hazard, Absorbed dose, Effective dose

Aerosol-Lightning association in humid, semi-humid and arid regions over Northern India

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Association between aerosol and lightning is still not well defined and matter of debate. Aerosols have found to enhance as well as suppress the convection process and influences the lightning activity accordingly. The relationship between satellite measured aerosol index and atmospheric lightning over northern India (700E-960E) is investigated using long term data from 2005 to 2014. Data has considered from TRMM for lightning (LIS) and precipitation (3A12, V-7 and 3B43, V-7 sensor), and OMI and MODIS for, respectively, aerosol index (AI) and relative humidity. To better understand the changing relationships from humid to arid regions, the inter-annual variability of pre-monsoon seasons and monsoon seasonal data for 3 sub-regions of approximately equal area: Northeast (humid region), Northwest (arid region) and Central (semi-humid region) have been separated and analyzed. During pre-monsoon months of March-April-May, lightning is found to decrease for humid as well as arid regions. For this season, aerosol index shows negative correlation with lightning over the humid region and insignificant correlation over the arid region. It is found that during monsoon season and humid region, lightning activity is increasing along with increasing in aerosol index, while, for the same season, arid region showed decrease in lightning although aerosol index increased. For this season, however, season representative cloud fraction, deep convection, and precipitation were enhanced for over both the region. These findings suggest that a sufficient cloud fraction and deep convection drives lightning frequency over the region. Same but moderate results have been found for semi-arid region.

Contamination assessment of potentially toxic heavy metals in road dust deposited in different types of urban environment over Dehradun city, Garhwal Himalaya

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In present study road dust samples have been taken from 30 representative locations from different types of land-use viz. residential, commercial, national highways and silent zone to assess the concentration and contamination level of some potentially toxic heavy metals over Dehradun city, Uttarakhand, India. Concentrations of Fe, Mn, Zn, Cu, Pb, Cd, Cr, and Ni were determined by acid digetion method followed by inductively coupled plasma-mass spectrometry (ICP-MS). The mean concentrations of Fe, Mn, Zn, Cu, Pb, Cd, Cr, and Ni in the road dust samples over the study area were ranged from 7620-18900 mg kg-1, 237.69-558.99 mg kg-1, 86.07-336.66 mg kg-1, 34.23-243.33 mg kg-1, 37.08-356.43 mg kg-1, 0.702-14.304 mg kg-1, 12.84-79.4 mg kg-1 and 9.006-73.23 mg kg-1 respectively. Decreasing order of mean concentration for heavy metals is as follows Fe> Mn>Zn>Pb>Cu>Cr>Ni>Cd. The contamination level of Zn, Cd, and Pb were classified under very high contamination category for most of the locations. Mn, Cu and Ni were classified under Moderate contamination category and Fe and Cr were found Low contamination category at all locations over the study area. The decreasing order of degree of contamination level in different land-use type are Commercial > Residential > National Highways> Silent Zone. The pollution load index (PLI) found higher than 1 in all monitored 30 locations which shows the detritions in quality of road dust over Dehradun city. Pollution load found highest in commercial locations and lowest in silent zones. Zn, Cu, Cd, Cr and Ni show positive correlation with each other indicating same source origin which could be anthropogenic sources mainly vehicular sources. A significant positive correlation found between Fe and Mn revealing same origin of source which could be natural lactogenic sources. Keywords: Heavy metals, road dust, contamination factor, pollution load index

Variation of Major Air Pollutant in Megacity Mumbai

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The aim of this study is to determine the diurnal, daily and monthly variation in particulate Matter (PM_{10} And $PM_{2.5}$), surface ozone (O_3) ,carbon monoxide (CO) and nitrogen dioxide (NO_2) with meteorological parameters over coastal city Mumbai (19.070N,72.870E) for a period January 2016 to December 2018 using SAFAR which is Network of the ground-based continuous air quality monitoring stations. During June to September months which is monsoon season concentration of these major pollutants was lowest due to washout effect of monsoonal rain and highest monthly concentrations found in November to February months. The amplitude of diurnal variation PM10, $PM_{2.5}$, CO, O_3 and NO_2 was least in the monsoon months (June to September) and the diurnal pattern was weak. It has been found that on diurnal scale concentration of PM_{10} and $PM_{2.5}$ higher during the morning hours thereafter it reduces and concentration of O3 starts to increase from 10 hr. and shows a peak at 12 to 15hr and thereafter it decreases slowly, the diurnal pattern CO and NO_2 is different from O_3. The annual concentration PM_{10} $PM_{2.5}$ O_3 CO and NO_2 during 2016-2018 are observed in the range of 99-103 µg/m³, 59 -69 µg/m³ ,34 – 35ppb, .0.67-0.77 ppm, 21 -23ppb respectively. The coastal meteorology play important role in variation of PM_{10}, $PM_{2.5}$, CO, O_3 and NO_2.

Aerosols Optical Depth during Fire events in Uttarakhand State Using Satellite Observations

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Forest fires of high magnitude occurred during May, 2019 over the mid and southern plain forest regions of Uttarakhand. The Suomi NPP/VIIRS corrected reflectance true colour imagery shows a large amount of smoke over and around the region of study. The MODIS satellite aerosols optical depth (AOD) data at 550nm over land has been used for the analysis of daily and monthly variation in aerosols during these fire events of 2019. The AOD values with maximum of 1.8 (0.5 mean) is found during the first week of forest fires, while towards the end of the month, high AOD reaching up to 2 can also be seen. The corresponding high angstrom exponent (1.8) reveals the presence and dominance of fine particles in the southern plain with some pixels of mixed size range. Active Lidar CALIOP on board CALIPSO data is further analysed to see the vertical profiling of the emitted smoke and mixed particles. The maximum extinction due to particles was limited to the 2 km (altitude), while the elevated smokes reaching up to the altitude of 4 to 5 km has been detected.

New Particle Formation and Growth to Climate-relevant Aerosols at a High Altitude Site in the Western Himalaya – Ranichauri

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New particle formation (NPF) influences the Earth's radiative budget when the newly formed particles grow to climate-relevant sizes. This study presents the analysis of 21-months of continuous aerosol size distribution measurements in a high altitude western Himalayan environment - Ranichauri and provide observational evidence that the newly formed particles grow to cloud condensation nuclei (CCN)-active sizes (i.e. 50-100 nm in diameter). Out of total 55 NPF events, 38 (66%) events occurred in the pre-monsoon season (March-May). NPF events were classified into those with and without pollution influence as polluted and clean, respectively, using black carbon data. The air mass age was also analysed based on the ratio of number concentration of Aitken to accumulation mode aerosols, indicated that NPF occurred in the relatively cleaner air masses reaching the site. The median formation rate of 10 nm particles and particle growth rates for clean events were three-fold and two-fold, respectively, higher than polluted events. In this study, the first estimates of the survival probability of newly formed particles to 50 nm and 100 nm size, which was not attempted for an Indian environment previously is presented. The survival probability to 50 nm particles ranged from 44 to 98%, with a mean and standard deviation of 82 ± 18%. On average, ~60% of the particles surviving to 50 nm survived to 100 nm, making the overall survival probability of 100 nm to 53 ± 31%. These findings highlight the coadjutant effects of interactions between clean and polluted conditions for NPF and growth in a high altitude environment of India.

Air Pollution during 2016 Diwali Festival by the Firecrackers Burning over Suburban site of Agra

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Short-term measurements of PM1 , trace gases (SO2 and NO2) and heavy metals during Diwali festival were studied at Suburban site of Agra. In the present study, PM1 level was recorded extremely high (240 μg/m ^{3} , which is 4 times higher than the NAAQS limit for PM2.5 (60 μg/m^3)). SO2 (32 ppb) and NO 2 (48 ppb) were also found higher than prescribed limit of National Ambient Air Quality Standards (NAAQS, SO2 = 31 ppb and NO2 = 43 ppb). The mass concentration of 8 heavy metals (Mn, Fe, Zn, Cu, Ba, Pb, Ni and Cd) was 1.3, 4.0, 1.1, 1.9, 3.7, 1.6, 1.4 and 1.5 times higher during Diwali day than the normal days. The results indicate that firework episodes during Diwali festival affected the ambient air quality adversely due to emission and accumulation of PM_1, SO2 , NO2 and heavy metals.

Monthly PM_{10} concentration pattern over Delhi: A Remote Sensing Perspective

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In recent years, rapid urbanization and industrial growth have increased the ground level PM_{10} concentration over the Delhi region. Previous studies have already proved its association with numerous health issues such as respiratory and cardiovascular diseases. There are some limitations of ground-based monitoring that can be solved by using satellite-based remote sensing datasets. Ground-level PM_{10} concentration and its variability over time and space depend on several anthropogenic and meteorological factors. Thus Monthly time series analysis of PM_{10} can provide a better understanding of the distribution of the ground-level PM_{10} concentration, which can be very helpful in policy-making and better management. In this study, the monthly PM_{10} level is computed for the Delhi region using the Landsat 8 Operational Land Imager (OLI) dataset from January 2014 to December 2018. The area average of PM10 over the study region is produced monthly, seasonally, and annually. January and April's months show the Maximum and minimum concentration, respectively. Seasonally, winter reflects the maximum and pre-monsoon the minimum PM_{10} level over Delhi. The average level is observed at about 84µg/m3. Annually, 2016 represents the highest average concentration and 2014 the lowest. The presence of tiny particulates plays a crucial role in modifying and regulating the earth's climate and air quality. Hence, the research aims to highlight the current scenario of air quality and its impact.

Keywords: PM_{10}, AOT, Delhi, Landsat 8

Characteristics of extreme rainfall events during the southwest monsoon period and their association with global climate indices

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The characteristics of extreme rainfall events over India during the southwest monsoon period and their linkage with global climate indices were investigated in the present study. Daily rainfall data were taken from APHRODITE products and Sea Surface Temperature (SST) from Hadley Centre. Extreme events and associated floods lead to major hydrological disasters. The cause of floods may be due to topographic features of the region as well as the frequency of occurrence of high-intensity rainfall. Most of the South Asian regions are vulnerable to extreme rainfall events and such events are adversely affecting the flora and fauna, also making large scale damages to the livelihood and economy of the region. In the present study, the characteristics of extreme rainfall events during the southwest monsoon season are analysed for duration of 65 years (1951-2015). Here we attempted to explore the Spatio-temporal features and heterogeneity of these extreme events at a finer resolution. We also elucidated the linear trend of these extreme rain events on the spatial domain and found that extreme rainfall is decreasing over north central Indian and south-western coastal belts. An increase in the frequency and amount of rainfall from extreme rain events is observed in the western coastal belts between 16 to 20 N and central Indian regions. The linear trends of extremes are showing differences from the trends of mean rainfall patterns. The statistical method based on 99thpercentile (>99p) is used for identifying areas of extreme rainfall. The spatial and temporal variations of extreme precipitation events and their percentage contributions are also examined over these regions. In addition to the spatial trends, we analysed the relationship of various climate indices (Nino3.4, Modoki, DMI, PDO, AMO, and AZM) with the mean and extreme rainfalls. Most of the indices show a significant inverse relationship with mean and extreme rainfall. The areas of the level of significance are comparatively smaller in the extreme rainfall cases. The AMO shows a positive correlation in the peninsular and northern regions. Similarly, AZM also shows a positive correlation in the southwest peninsular India and north-eastern regions.

Chemistry and dynamics of reactive trace gases over India

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Reactive trace gases (e.g. O_3, CO, NOx, etc.), despite of smaller atmospheric abundances, profoundly impact the air quality and climate. Chemistry and dynamics of trace gases over developing Indian region is closely linked with stronger biogenic and anthropogenic emissions plus moist tropical conditions. Here, we investigate the regional and seasonal distributions of trace gases over India using the Copernicus Atmosphere Monitoring Service (CAMS) model reanalysis. O_3 as well as precursors show considerably higher mixing ratios over the densely populated Indo-Gangetic plain (IGP) (e.g. O_3 = 40–90 ppbv, NO_2 = 13–30 ppbv). To investigate the relative effects of chemistry versus meteorological conditions, photochemical box modelling is being performed over urban environments of western India and IGP. Box model captures noontime O3 build up and reveals a significant enhancement of about a 100 ppbv O_3 in the urban outflows. Additionally, high amounts of several secondary organic and inorganic products are simulated. Initial results revealed the significant influence of meteorological variations (solar irradiance and boundary layer dynamics) in driving high ozone pollution, besides non-linear chemistry. Detailed analyses of the contrast in air chemistry between western India versus IGP is under progress through sensitivity simulations.

Significance of volatile organic compounds, oxides of nitrogen and carbon monoxide in surface ozone formation at Dayalbagh, Agra

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The atmospheric chemistry and health implications of pollutants are important scientific concerns. The present study deals with the concentration and diurnal variations of (VOCs) mainly BTEX and formaldehyde, ($NOx=NO+NO_2$), (CO) and (O_3) at Dayalbagh Agra during August -November 2019. Surface O_3, CO and NOx concentration were recorded by continuously operating online trace gas analyzer. BTEX were analyzed by using MS/FID and HCHO by colorimetric method. The average concentration of NOx, O_3 and CO were recorded 5.14, 41.1 and 513 ppb, respectively. The average concentration of BTEX and HCHO were 74.5 and 11.3 µg/m3, respectively. Diurnal pattern of VOCs, NOx and CO are highly influenced by vehicular traffic and photochemical oxidation. O3 showed maximum value in afternoon due to the photochemical generation from its precursors. Among BTEX xylene has the highest ozone formation potential.

Assessment of climate model simulated rainfall pattern based on satellite-derived estimates over the Indian Region

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The objective of this study is to evaluate the rainfall pattern from Coupled Model Inter-comparison Project Phase 5 (CMIP5) based on satellite-derived rainfall products Tropical Rainfall Measuring Mission (TRMM) over the Indian Region, with special focus on daily monsoon season (JJAS) rainfall. In this connection, JJAS daily rainfall data from five best defined global climate models (GCMs) that participated in CMIP5 archive along with its multi-model mean (MMM) have been utilized to investigate the rainfall pattern in terms of contour map and time series under the Representative Concentration Pathway 4.5 (RCP4.5) and Representative Concentration Pathway 8.5 (RCP8.5) both during 2006 to 2018. On the other hand, TRMM rainfall data has also been extracted and plotted in terms of contour map and time series during the reference time period to compare the JJAS rainfall pattern with the CMIP5 models whether the GCMs are able to capture rainfall data reasonably well compared to satellite-derived estimates or not under different warming scenarios over this region? Based on the assessment, it is noted that CMIP5 models are able to simulate daily mean monsoon season rainfall during JJAS, however, it underestimates the rainfall intensity at daily scale. The outcomes presented here might be useful for assessing the reliability of CMIP5 models to project the rainfall pattern in near future under the various forcing scenarios over the Indian Region.

Ozone Variations in Central Himalayan Valley: Seasonal Changes and Impact of Biomass-Burning

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Ground-level ozone (O_3) affects human health and vegetation adversely, besides playing key role in the air chemistry. Doon valley of the Himalayas has experienced an unprecedented growth in the anthropogenic activities leading to enhanced emissions and poor air quality. Air pollution in the valley is aggravated due to trapping of the emissions and photo-chemically processed air by the surrounding complex terrain. In this scenario, we have been conducting ground-based O_3 measurements employing a photometric UV analyzer at the Graphic Era (77.99° E, 30.27° N, 600 m above mean sea level) for more than 500 days since April 2018. During the study period, noontime average O_3 has been observed in the range of 6–95 ppbv with highest levels during spring / pre-monsoon and a secondary enhancement during the post-monsoon. Maximum Daily 8-hour O_3 (MDA8) index is estimated to exceed the WHO standard on 24% and 28% of days of observations during 2018 and 2019 respectively. Analysis of fire observations from MODIS satellite and wind patterns shows that significant O_3 enhancements in spring (May 2018 and 2019) were linked with regional-scale biomass burning. Impacts of fires were however weaker during post-monsoon due to seasonal change in wind circulation. Our measurements show a very good agreement with variations simulated by the CAMS global model (r = ~0.8), however, model typically overestimated the magnitude. The findings highlight the role of regional processes and seasonal changes in controlling O_3 in this central Himalayan valley.

Radon Exhalation rate of soil and indoor radon concentration of various places in Champawat Region of Kumaun Himalaya, India using Active and Passive Technique

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Soil being the most important source, affects the radon gas levels in the human environment. It depends not only on the uranium and thorium content in the minerals present in the soil but also on the chemical and physical properties of the soil profile. Humans beings constantly and continuously affected by exposer to ionizing radiation, emitted from naturally occurring radioactive elements present in the Earth's crust and atmosphere. The concentration of these radioactive elements varies from place to place, depending on local geology and geography condition. Radon is an inert gas that act as a source of ionizing radiation contributes a large proportion of the radiation dose received by the world's population emanated through the radioactive minerals present in the soil. Radon exhaled from the soil accumulates in a closed environment and accounts for 55% of the inhaled dose. Scintillation and SSNTD based monitoring have been utilized for the measurement of radon and thoron exhalation rates in soil samples and indoor air from the Champawat region of Kumaun Himalayan respectively. The Rn222 mass exhalation rate in the soil samples varied from 3.52 mBq kg-1 h-1 to 109.30 mBq kg-1 h-1 with an average of 47.16 mBq kg-1 h-1. The surface exhalation rate of Rn220 in the soil samples ranges from 2.23 Bq m-2 s-1 level to 12.73 Bq m-2 s-1 with an average of 7.49 Bq m-2 s-1. The Rn222 concentration in indoor air was found from 36.56 Bqm-3 to 200 Bqm-3 and Rn220 concentration varied from 35.56 Bqm-3 to 167.78 Bqm-3 in the respective areas. Keywords: Radon, Thoron, Exhalation rate, Soil, Smart RnDuo, Pinhole Dosimeter References: 1. Ramola, R., & Choubey, V. (2003). Measurement of radon exhalation rate from soil samples of Garhwal Himalaya, India. Journal of Radioanalytical and Nuclear Chemistry, 256(2), 219-223. 2. Choubey, V. M., & Ramola, R. C. (1997). Correlation between geology and radon levels in groundwater, soil and indoor air in Bhilangana Valley, Garhwal Himalaya, India. Environmental Geology, 32(4), 258-262. 3. Kakati, R. K. (2014). Radon exhalation rate of soil and indoor radon concentration of various places of Karbi Anglong District of Assam. Journal of Applied physics, 6(4), 13-16.

Impact of attached and unattached fraction of radon and thoron's daughter elements and its Seasonal variability in the presence of atmospheric aerosol in the Main Boundary Thrust Region of Garhwal Himalaya Region

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In the present study, it was estimated to measure the radon, thoron and their progeny concentration through passive detector technique in the Main Boundary Thrust Region of Garhwal Himalaya. For the measurement of attached and unattached progeny concentration, LR-115 type-II deposition-based Wire-mesh capped sensor consisting of (DTPS/DRPS) and direct deposition based DTPS/DRPS sensors were used respectively. We took 65 samples in and around the Main Boundary Thrust Region which consists of over 10 villages. In these samples, we estimated the dose conversion factor and finally we estimated the annual effective dose due to radon and thoron. The results obtained will be well explained in the full length paper. This study is important from health risk point of view due to its epidemiological perspective.

Perception of climate change and its impacts on the livelihood of Gaddis residing in Bharmour, Chamba (Himachal Pradesh)

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A transhumant community of the western Himalaya follows vertical migration along with their sheep and goats. Their movement patterns are guided by the prevailing climatic conditions and hence they are keen observers of the same. On way they are dependent on natural resource that not only sustain them but also the livestock. Recent climatic changes are impacting their livelihood. It is with this background that the present study was conducted to study the perception of climate change on the Gaddis and its effect on their livelihood. The study was carried out in the Bharmour block of district Chamba, Himachal Pradesh that is argued to be the original seat of the community. A total of 100 individuals from 3 villages were selected for the study and the data on- awareness regarding the term "climate change", and its indicators were collected through semi-structured questionnaires, focus group discussion, and Participatory Rural Appraisal (PRA). The study revealed that only 78% of the respondents (n=100) were aware of the technical term "climate change" while all knew of it in the colloquial form. A total of 10 climate change indicators were reported by them. Out of these 10, decrease in snowfall (81%) and increase in temperature (66%) were the most perceived indicators while range shift of species (38%) and declining availability of water (33%) were the least perceived indicators. Gaddis reported that these changes are impacting their livelihood such as with regards to decreasing fodder availability, reduced water resources along their migratory routes. The study concludes that Gaddis perceive changing climatic conditions that has bearing on their livelihood both with regards to subsistence cropping and migration.

Keywords: Agriculture, Climate, Gaddi, Livelihood, Transhumance

Covid -19 Janta Curfew: Lucky turn of fate for air pollution in India

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Covid-19 a vicious virus originated from China in late December 2019 which affected the global population abruptly. Till date social distancing is the only method to break off the transmission. Worldwide lock-down in different phases were imposed in order to break the chain of transmission. Government of India has initiated sudden preventive measures against spreading of Covid-19 pandemic by imposing the restriction in movement of people on 22nd March 2020. 1.3 Billion people obeyed the curfew as a result of which all the sectors came to rest. In this paper impact of Janta curfew on the environmental air during initial phase of pandemic Covid-19 in 23 major Indian cities were investigated. As a result significant reduction in the aerosols concentration, on an average AQI (-30.78%), PM_{10} (-32.96%) and $PM_{2.5}$ (-34.54%) were measured in 23 major Indian cities. Overall despite adverse socio economic impact this epidemiology has caused positive impact on air quality due to shut down of anthropogenic activities countrywide.

Keywords: Covid-19, Janta Curfew, Air pollution, India

Identification and assessment of vulnerable indicators: a case study of north-western Himalaya, India

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The forests play a key role in preserving and maintaining the fragile Himalayan ecosystem. In addition, forest has been a primary livelihood source for the indigenous communities. They are also rich in biodiversity and are also known as green pearl in the Himalayan region. This life supporting system is under great stress and has become vulnerable due to increasing anthropogenic pressure and variety of disasters. The present study therefore assesses the forest vulnerability in Kinnaur district in Himachal Pradesh in terms of changing climate, hazards, anthropogenic activities using participatory approach, prioritization matrix survey, interviewing the communities and direct field observation, GPS surveys, field observation, secondary data sources, and Remote Sensing and Geographic Information System applications. Total 49.64 km2 area got affected and has become vulnerable due to landslides and soil erosion among forest and non-forest land use land cover classes. The most disastrous floods were experienced in 1993, 1995, 1997, 2000, 2005, 2007 and 2013. Climatic variability was also found high in the study area. In the construction of Tidong project, large numbers of trees were felled/damaged at dam site (at Lamber village) and powerhouse site of the project (near Rispa village). The area has been hit by earthquakes more than 28 times having magnitude of 4.0 and above. If alike climatic variability keeps on increasing in future, the geo-hazards and climatic hazards will also be increasing due to the impacts of climate change which collectively would cause a great loss to the forest resources in coming future.

Keywords: Forest vulnerability, hazards, climatic variability, Indian Himalaya

Source apportionment of PM10 in an urban industrial area using positive matrix factorization

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In this study, 64 daily PM_{10} aerosol samples were collected from an urban -industrial city Raipur, situated in eastern - central part of India, during February 2015 to May 2019. Samples were analyzed for the concentration of trace elements (Al, Ba, Ca, Co, Cr, As, Mn, Sb, Se, Sr, Cu, Fe, Ga, Mg, Ni, Ti, V, Pb, Zn), carbonaceous species (OC-EC) and ionic species (Na^+, NH_4^+, K^+,Cl^-, SO_4^{2-} and NO_3^-). Back trajectory air mass (HYSPLIT) analysis and positive matrix factorization (PMF) were employed for source identification and apportioning the contribution from possible sources. The average mass concentration of PM10 aerosols was found to be 137.28± 37.81 µg/m, with a range of 61.0-195.0 µg/m³ during sampling period. Strong seasonal variation was observed in PM10 concentration with maximum concentrations in winter (145.96 ± 31.37 µg/m³) than in summer (119.81 ± 46.63 µg/m³) and minimum in monsoon (89.12 ± 29.87 µg/m³). The PMF model identified five main sources; industrial sources (37.1 %), soil dust (26.6%), biomass burning (19.5%), vehicular emissions (15.7%), and secondary aerosols (1.0%) as major pollution sources in the city. The correlation analysis between meteorological factors and PM_{10} aerosols were also analysed and found to exhibit inverse relationship with wind speed (-0.22), precipitation (-0.12), temperature (-0.32) and humidity (0.32). The back trajectory analysis showed the influence of regional sources during the days of maximum concentrations.

Passive measurement of Indoor Radon Thoron concentration in Ghuttu Window, Tehri Garhwal

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Radon-222 is a radioactive noble gas that is an intermediate product of the Uranium-238 decay series. It is formed by the alpha decay of Radium having a half-life 3.81 days. Radon gas is present in all types of rock and soil because all of them are made up of minerals having radium in traces. When the ambient aerosol particle attaches to the decay product of the radon (218Po, 214Pb, 214Bi, and 214 Po) radon progeny rich aerosol is formed. Radon progeny rich aerosol is the main source of natural radiation dose. These aerosol reaches the respiratory tract through inhalation and are deposited there. By the Inhalation of short-lived decay products of the radon and thoron, these progenies are deposited to the airways of the lung and can cause damage to the soft tissue of the lungs. Radon concentration varies with Uranium contents present in the soil and lithology of the area. from soil, radon reaches to the atmosphere by the exhalation process. The exhalation rate is highly dependent on the geology and the presence of tectonic faults. The radiation hazard strongly depends on the radon exhalation rate from the soil. In the present study, samples were collected from the dwellings of Ghuttu window region of Tehri Garhwal District of Uttarakhand. The measurement is carried out by using the passive Pinhole Dosimeter (LR-115 plastic track detectors). Seasonal Indoor Radon and Thoron concentration in a different type of Dwelling, with different ventilation conditions, are measured. The indoor radon concentrations were found very high. During summer, the radon concentration varies from 21.31 Bq/m3 to 119.45 Bq/m3, and thoron varies from 7.65 Bq/m3 to 189.29 Bq/m3 during the rainy season it ranges from 11.91 Bq/m3 to 297.92 Bq/m3 for radon and between 5.88 Bq/m3 to 251.96 Bq/m3 for thoron. For winter season radon varies 34.20 Bq/m3 to 174.16 Bq/m3 and thoron varies between 16.17 Bq/m3 to 201.96 Bq/m3. The interesting results obtained from this study will be discussed during the conference.

Key Word: Radon, Uranium, Radium, Aerosol, Dosimeter.

Characterization of a Regional Dust Storm using RAMAN Lidar over the Western Indian Region

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The present study characterizes a regional dust storm (DS) that occurred on 5th May 2016 over Ahmedabad (23.1° N, 72.7° E, 55 m amsl) located in west India using Raman Lidar (RL) and complemented by satellite observations. The Moderate Resolution Imaging Spectroradiometer (MODIS) corrected reflectance images confirm the presence of dust layer over Ahmedabad. The horizontal visibility sharply decreases to below 1 km on DS day. A back trajectory analysis indicates the origin of dust loaded air masses mostly from the Arabian Peninsula and Middle East towards the receptor site. The diurnal variation of RL aerosols backscatter at 355 nm and 532 nm exhibited elevated dust loading from the surface to 3 km on the dusty day compared to the dust-free day (i.e. 29 April 2016). Highest aerosol optical depth (AOD ~ 2.2 and 0.85) values are noticeable from the RL and MODIS on the DS day due to intense dust loading compared to the dust-free day. Two-fold increase in the ultraviolet aerosol index (UVAI ~ 3) magnitude is observed on the DS day compared to the dust-free day (UVAI ~ 1.4). Further, we have characterized the regional DS using the RL linear depolarization ratio and lidar ratios which showed the dominance of Saharan dust and dust mixture during DS. Therefore, this study has substantial implications for understanding the regional DS over the western Indian region.

Simulation of particulate matter over mega-cities of India : Preliminary results of a sensitivity study

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With the advent of COVID-19 strong control measures had been taken (by applying lock-down) which significantly affected the vehicular, industrial, and other outdoor activities resulting in reduced air pollution. We have calculated percentage change of pollutants during lockdown from observation and implemented a percent reduction for different pollutants in line of that in emission inventory. We have simulated PM2.5 (particulate matter of aerodynamic radius less than 2.5 micron) over India at 12 Km horizontal resolution using WRF-Chem (Weather and Research Forecast model) version 3.9.1 during 25th Mar 2020 - 12th Apr 2020. Two different sets of meteorology: FNL with a horizontal resolution of 1 degree, and IITMGEFS with a horizontal resolution of 12 Km have been utilized for comparison. Model outputs were evaluated with the observation data from SAFAR1 (System of Air Quality Forecasting and Research) observational network over four cities: Delhi, Ahmedabad, Mumbai and Pune. Model simulation utilising the reduced emission well captures the observed reduction and pattern of PM2.5 concentration. Site to site comparison indicates possibility of stepwise implementation of lockdown across different areas.

Diurnal and seasonal variations in some Non-methane Hydrocarbons (NMHCs) over Nainital: The central Himalayan site

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Non methane Hydrocarbons (NMHCs) are primary air pollutants in the atmosphere that have their negative impact on the atmospheric environment and human health. They also play an important role in tropospheric chemistry and are important precursors for the tropospheric ozone and secondary organic aerosols. Despite this, there are limited continuous and systematic observations of NMHCs over India, particularly over the Himalayan regions. In this reference, for the first time, online observations of 14 different NMHCs are initiated at ARIES (29.39oN, 79.45oE, 1958 m amsl), a high-altitude site at Nainital in the central Himalayan region since December 2016. Here we present diurnal and seasonal variations in NMHCs. Two different profiles of diurnal patterns, one with noon time higher values (in n-butane, i-butane and m,p-xylene) and other with bi-model variations (in other NMHCs) are seen. Both kinds of variations show significance of photochemistry and convective boundary layer respectively. Some of NMHCs showed consistent seasonal variations with winter time high and some autumn time high. We observed that alkanes show higher values in all seasons except in autumn. Aromatics show dominance over other NMHCs in autumn. We have compared these results with an IGP representative site (Kathgodam) observed results where relative higher levels are observed. We have also set up a photochemical box model (NCAR MM) to study the ozone variations and role of different NMHCs species in its variations. Further details of observational analysis and model studies will be presented.

Kinetic study of Oxidation of Organic compounds

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A study of mechanism of organic reactions is not only a satisfying intellectual preshit, it has a bearing on synthetic and industrial organic chemistry as well. Chemist gain information's about chemical reactions with the help of chemical kinetics and related techniques. The oxidation of organic compounds and recent analysis techniques for analysing and interpreting the organic reactions is correlation analysis. The effect of structure of the oxidant and reductant and of solvent on the oxidation of several reactions like alcohols, aldehydes, amines, etc byhalochromates are to be investigated and suitable mechanism will be discussed. Correlation analysis which possess the amazing ability to predict the effect of a structure on reactivity , find enormous applications in the areas relevant to the present day problems and needs of the society and the country. It is widely used in the field of synthetic organic chemistry, medicinal chemistry, pharmacology, polymer chemistry, bioorganic chemistry, etc. In environmental science, correlation analysis is handy in determining the quality of water and waste matter. Key words: oxidation, correlation analysis

Disperencies in monitoring environmental parameters in construction projects: A case of National Highway-57

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The state of Uttarakhand is one fastest developing hill state in the Indian Himalayan Region (IHR). These developments include constructional activities of hotels, cutting of hills for new houses, by passes and bridges etc. The all-weather road and a railway line have been a dream project of the state and central government and is currently the largest in Uttarakhand and Garhwal region is one of the fragile parts of IHR. These development works comes at a cost of manpower rather than heavy yellow vehicles and this manpower is always in direct contact to air contaminants and hazards, thus leading to an issue of public health where the affected one is not even financially capable to availing high end treatments. And with some naïve environmental laws in India regarding construction activities, the situation becomes even worse. For the present study, an informal closed end interview was done with the people working in the road widening project in Uttarakhand from Rishikesh to Badrinath (NH-58) which included labours, helpers, machine operator etc. Their perspective on awareness for their health and environmental equity was documented and examined and the Personal Protective Equipment (PPEs) provided to them and its usage pattern was examined. The results gave a clear judgement of lack of policy intervention for large development projects and the fortune of the health of the workers being a part of such project. A generalized risk factor analysis have been generated from the inputs provided. A general suggestion for enhancements in the current policy have been done to benefit the weaker section so as to develop a standard living condition for them and at the same time, avoiding the risk of operational unsafety.

Enhancement of aerosol loading over the sensitive the Hindu Kush Himalayan (HKH) region

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Recent studies are more focusing on burden of increasing aerosols over the Hindu Kush Himalayan (HKH) region. Depending upon their composition, aerosols scatter and absorb the incoming solar radiation. However, due to lack of ground based data, the region has been less explored in view of long-term aerosol studies, its impact on the radiation budget and atmospheric heating rates. The present work reported about the increasing aerosol burden over sensitive HKH region using ground and space based data.

Validation of MERRA-2 and AIRS cloud fractional data with ground based observation over IAO-Hanle

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Cloud fraction or could coverage is one of the important parameters to examine the quality of clear sky during day and night. There are various methods to determine the clear sky and IAO-Hanle has been observing (visually) the cloud data (in octa) since 1997 for every one hour during day and night. The present work reported about the validation of such visual observation using MERRA-2 and AIRS data during 1997-2019.

A study of airborne pollens in Srinagar valley of Garhwal Himalaya

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The atmosphere surrounding us has many biological and non-biological materials. Biological materials in the atmosphere are pollen grains, fungal spores, bacteria, viruses, plant and animal parts. The present study was conducted for one year (May 2019 to April 2019) to understand the pollen types and their concentration in the atmosphere of Srinagar valley (HNBGU Chauras Campus). Sampling was done by Digital Rotorod pollen and air particle collector and spectra prepared for monthly occurrence of pollen types. The dominant pollen types identified belonged to Asteraceae (33.23 %) followed by grass type (26.6 %). Other types of pollen identified in the air belonged to Amaranthus/Chenopodium type, Betula/Casurina type, Mangifera indica, members of family Arecaceae, Bombacaceae, Cannabinaceae, Myrtaceae, Pinaceae, Ulmaceae etc. and some pteridophytic spores. The pollen which could not be identified were categorized under unidentified group. The study of the meteorological parameters like rainfall, temperature, wind velocity, wind direction, relative humidity etc. affect the concentration of these pollen counts. Statistically, of these factors rainfall showed the highest correlation with the pollen counts (p-value <0.05).

Keywords: Atmosphere, pollen types, pollen spectra, meteorological data, Garhwal Himalaya.

Shifting of apple belts to higher elevations due to climate change and impact on livelihood security in Kullu Valley Himachal Pradesh

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Livelihood security intended to a living status of any individual at regional as well as global level. In India, Jamu-Kashmir, Himachal Pradesh, and Uttarakhand are the core area of apple production. Climatic change as well as extreme conditions of Indian Himalaya is the key factor for changes in the soil ecosystem. The warming temperature of the selected region has changed the flowering pattern of apple crops, which has affected farming patterns in the selected region. The decline in snowfall and rainfall has also lead to water scarcity and melting of glaciers in Himachal Pradesh which in turn affecting the biodiversity of higher altitudinal area of Himachal Pradesh. The present study was carried out in apple orchards of Kullu- Manali, Himachal Pradesh, India. The study was conducted at three studied locations on the basis of their altitude. To meet out with the objective study sites were selected at the altitudinal gap of 600 m above mean sea level. First study was done near Kullu market Seobag (1200 m amsl), then Khaknal (1800 m amsl), and then Palchan (2400 m amsl). The seasonal and altitudinal variations have been studied herein. The results findings showed that apple crop is favouring the higher elevations. There was significant effect of altitude on apple farming.

Keywords: Apple farming, Altitudinal variation, Warmer temperature, Livelihood Security, Indian Himalayan Region

Radiative implications of severe dust storms over the Indian region

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Dust is one of the most important constituents of atmospheric aerosol, contributing nearly 75% of the total global aerosol mass burden and plays a vital role in the Earth's radiation budget, hydrologic cycle, Indian Summer Monsoon (ISM). Dust storms are the major source of dust aerosol and often occur over arid and desert regions during the dry season. The present study is focused to examine the radiative impact of two severe dust storm occurred in pre-monsoon season of 2018 (i.e. first: 17 May and second: 14 June 2018) over the Indian region (particularly over the Northern Indian Region) and adjacent oceanic region using a synergistic approach of insitu, satellite and modeling measurements. The in situ and satellite observations found a higher value of aerosol optical depth (i.e. AOD, up to 2.4) and aerosol index (i.e. AI, up to 4), which was more prominence on 14th June 2018 suggesting that the second dust storm was more intense than first one. The Dust Regional Atmospheric Model (DREAM8b) also showed a good agreement with satellite retrievals with a higher value of surface dust concentration in the range of 320–640 μgm^{-3}. An enhancement in outgoing longwave radiation is found in the range of 20 – 50 wm-2 on monthly as well as seasonally basis which caused significant atmospheric heating (2.69 K day^{-1} on 17 May 2018 and 1.85 K day^{-1} on 14 June 2018). The present study will be helpful to reduce the uncertainty in global radiative forcing and hence climate change also.

Probing lower atmospheric dynamics during rainstorm using ARIES Stratosphere Troposphere Radar

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Rainstorm are usually associated with the intense deep convection in the atmosphere. These events are critical for the transport of mass and momentum flux, heat and moisture throughout the upper tropopshere and lower stratosphere region. VHF radars with their wind profiling capability with high temporal and vertical resolution provides in depth study of these events. These events occur frequently over Himalayan foothills, however due to lack of observational network over this complex terrain, a comprehensive study still lacks over the nature of these events over this region. Recently a wind profiler Stratosphere Troposphere radar operating at VHF frequency of 206.5 MHz has been installed in meteorologically sensitive subtropical region (29.4oN,79.5o E) at high altitude site (~1.8 km amsl)at Aryabhatta Research Institute of Observational Sciences(ARIES) in Nainital located in Himalayan foothills. Using the capability of VHF radars detect echoes from clear air and both precipitation an intense deep convection event has been observed during regular operation. Using the reanalysis dataset from NCEP/NCAR and MERRA-2 it has been speculated that it was induced due to moisture carried by the western disturbance. Moisture in the mid - troposphere coupled with the orographic lift led to vigorous updrafts and downdrafts of magnitude reaching up to 16 m/s. Updrafts found to be extending well beyond the tropopause into the lower stratosphere region. A clear demarcation between updrafts and downdrafts region was established during the mature phase of the event due to veering of the wind which also led to the tilting of the updraft cores. During the event the exchange of the vertical mass flux between upper troposphere and lower stratosphere has also been estimated. The study holds importance as it is the first ever attempt to study these rainstorm events through wind profiling features with ST Radar over this region.

A Review on Effects of Forest Fires on Air Quality with Special Reference to Uttarakhand

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Forests are considered to be valuable natural resource of vegetation and wealth along with the habitat for animals, birds, insects etc. and play important role in the environment affecting the climatic conditions of the neighbouring regions. However, these forests are very occasionally affected by forest fires, the causes of which may be natural or anthropogenic. Natural causes include high temperature and dryness during summer months, wind speed and direction. Sometimes forest fires may occur due to lightning but loss is limited due to subsequent rain. Global studies reveal that most of the forest fires are caused by human activities. The air quality of the region hit by forest fires is deteriorated due to the emission of various gases and toxins such as CO2 CO, CH4, NO, NO2, VOCs, etc. along with particulate matter and soot etc. The carbon content stored in the vegetation is released into the atmosphere in just few hours of burning that significantly increases the CO2 level contributing to global warming whereas the incomplete combustion results in formation of poisonous CO. The world had been hit by major forest fires in the past. Those were studied by various workers to estimate the damage and to take precautionary actions in future to lessen it. The state of Uttarakhand of northern India, lying in the Great Himalayan Region, has nearly 45% of its total area covered with forest including 4969 sq. km. very dense forest, 12,884sq. km. of moderately dense forest and 6,444 sq. km. open forest. Forest fires in Uttarakhand have been a regular feature. Since the formation of the state in 2000, more than 44,518 hectares of forest has been lost to fire which has affected the state's climate as well as the health of its residents. This paper reviews the effects of forest fires on the climatic condition, air quality etc. of the region after the major forest fire occurrences around the world. In addition, it also presents the history of forest fires in Uttarakhand region and their after effects. Finally, the protective/precautionary measures taken by the concerned authorities to minimize the damage in terms of environment and economy of the region along with human health are discussed.

Geomorphology and Landforms in Changme Khangpu Basin, North Sikkim, India

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Glaciers in the different region of the Himalaya behave in a different manner corresponding to the factors such as valley morphology, shape, size, aspect and slope, precipitation and temperature pattern etc. However, there is large number of glaciers which retreated fast, and some with reduction in retreat rate and are constant during the same period of observations. The present study provided the topographical control over the glacier's response in Changme Khangpu basin and the landforms associated with the glacier environment. This study includes data from field and remote sensing techniques using the datasets like- Landsat TM, ETM+, and OLI images, Sentinel-2 and ASTER DEM. The results shows that in general the glaciers over the Himalaya lies above 3500 m a.s.l and in the Sikkim Himalaya (i.e. Changme Khangpu basin) glaciers elevation ranges is between 4000 m and 6000 m. In total, 58 glaciers were identified with the area between 0.28 and 22.54 km2. The geomorphic processes have carved out the landscape of this basin and the concentrations of rock-falls are generally prevalent in the extreme north and south of the basin. Changme basin has dominant glacial processes active in the region in the northern parts, while the presence of braided channels, gullies, river terraces, bar deposits has proven the fluvial processes in the other half of the region.

Statistical analysis of seasonal variation of solar radiation and meteorological parameters in Himalayan region

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The present study aims to determine the analysis of available satellite-derived data (https://power.larc.nasa.gov) of solar radiation and meteorological parameters (temperature and relative humidity) data at the National Aeronautics and Space Administration (NASA) for three main places, namely – Gopeshwar (30.40^{o}N, 79.31^{o}E), Nainital (29.38^{o}N, 79.46^{o}E) and Pithoragarh (29.58^{o} N, 80.21^{o}E) in Uttarakhand. The seasonal average data of solar radiation and meteorological parameters recorded for a period of six years from 2013-2018 for the present investigation. Three statistical treatments (standard deviation, kurtosis and skewness) were performed to check the accuracy of data. A trend analysis of the maximum and minimum seasonal average data of global solar radiation, temperature and relative humidity. The highest global solar radiation recorded as 11.23 kWh/m^2 (autumn) for the Nainital location and the lowest global solar radiation recorded as 4.80 kWh/m^2 (winter) for Gopeshwar location. The results shows increases in trends and anomalous behavior that may be considered as a result of the effect of climate change and climate variability. Investigation of data indicated that Nainital location obtains an ample amount of global solar radiation, indicating the strong potential for the use of solar energy. Through this type of study observed that the climatic conditions for any particular site.

Key words: Solar radiation, Climate change, statistical parameters, metrological parameters.

Variabilities in ozone over the Himalayan atmosphere: Role of precursors, meteorology, and dynamics

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Ozone is one of the most important trace gases in our atmosphere that is both beneficial and harmful to living beings. Stratospheric ozone protects us from harmful UV radiations while its higher concentrations in the troposphere adversely affect human health, agricultural productivity and air-quality. Some of the ozone precursor gases like NOx and NMHCs play a critical role, via photochemistry, in determining ozone production and loss. In addition, meteorology and dynamics also play an important role in ozone variabilities. In view of this, observations of ozone vertical distributions are being made at ARIES, a high-altitude site in the central Himalayas. This region is also influenced by the stratosphere troposphere transport processes and associated with frequent tropopause folding. Here, the effect of regional emissions and dynamics on ozone profile will be discussed based on the ozonesonde observations. We have observed very frequent tropopause folding over this region during winter and spring which causes episodes of ozone enhancement in the Himalayan troposphere. Regional emissions of ozone precursor from surrounding regions further adding higher ozone in the Himalaya. Since, the frequency of ozonesonde launch is limited that adds significant temporal voids in between data. To mitigate the observation voids, we have also initiated the activities to utilize Indian geostationary satellites. Here, we will also discuss the potential of INSAT–3D to produce high spatio–temporal ozone profiles over the Indian regions, which surely leads to better understanding of ozone chemistry and successive improvements in numerical weather predictions over India.

Light Absorption Properties of Atmospheric Black Carbon over the Garhwal Himalayas and its Foothills

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Light absorption properties of atmospheric aerosols have gained specific attention in recent years because of its negative effects on climate and the environment. In the present study, Black Carbon (BC) and aerosol absorption properties at seven wavelengths (370, 470, 520, 590, 660, 880, and 950 nm) were studied over the five sites in the transect of the Garhwal Himalayas and its foothills during the summer and winter season of the year 2014-2016. Altitudes of the study sites are 250m (S1-IGP, site1-neighboring Indo-Gangetic Plain site), 680m (S2-FH, site2-foothills of lesser Himalayan site), 2000m (S3-LH, site3-lesser Himalayan site), 1200m (S4-LH, site4-lesser Himalayan site), and 2600m asl (S5-GH, site5-Greater Himalayan site). BC mass concentration was observed to be in the range of 4.29-10.38 µg m-3 during the summer season, while 2.23-22.01 µg m-3 during the winter season. Aerosol absorption at S1-IGP, S2-FH, and S3-LH was stronger in the winter season than in the summer season. In contrast, aerosol absorption at S5-GH was stronger in the summer season. At all the study sites, Angström exponent (α) was observed to be high during the winter season as compared with the summer season, which suggested the higher influence of biomass burning source during the winter. Moreover, filter-loading or compensation parameter (k), which is considered as a proxy for the determination of the local/fresh and transported/aged particles, were utilized in the present study. Except at S3-LH, at all the study site's compensation parameter was observed to be higher during the summer season as compared to the winter season. A high value of the compensation parameter is considered to be an indication of freshly emitted local BC particles. In contrast, low value of the compensation parameter during the winter season suggested the major influence of transported aged BC particles.

A Statistical and Comparative Study of PM_{10} in Major Cities of Uttarakhand

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We have investigated the status of air quality parameter particulate matter (PM_{10}) in some major cities of Uttarakhand, namely Dehradun, Haridwar, Haldwani, Kashipur and Rudrapur during 2012-2018. The numbers of vehicles have drastically increased in these cities during last five years and causing more pollution. A large amount of particulate matter is generated as a result of vehicular emissions heavy amount of construction work carried out in the sake of development and many other anthropogenic activities. Here, an attempt is made to analyze the growth in the level of respirable suspended particulate matter (RSPM) commonly known as PM_{10} during 2012-2016 in the afore-mentioned cities in Uttarakhand, which is an important parameter to study the ambient air quality. Monthly, seasonal as well as annual variations of this pollutant are studied and it found that the concentrations of the pollutant are high in winter and pre monsoon season as compared to the post monsoon and monsoon seasons. The observed PM_{10}concentration was 2-3 times higher than the prescribed limits fixed by the Central Pollution Control Board (CPCB) New Delhi, India. A detailed statistical analysis has also been carried out on the basis of monthly average values of the PM_{10}.

Keywords: Particulate Matter (PM_{10}), Statistical Analysis and Air Quality Index (AQI).

Influence of annual prescribed burning on shrub stratum at Chilla forest rage, Rajaji Tiger reserve Uttarakhand, India

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Prescribed fire helps in the restoration of forest ecosystems and plant communities. It not only removes the flammable fuel load but also helps in preparing the seedbed on the forest floor. The present study was designed to investigate the effect of prescribed fire on shrubs composition and species richness in Chilla forest range (Rajaji Tiger Reserve India). A burnt site, where prescribed burning has been applied by forest officials and another site of similar environmental and microclimatic conditions was taken as unburnt for comparative study. 15 quadrates of (10 m x 10 m) were laid down randomly on each study site and studied for frequency %, density, IVI and the other diversity measures. The burnt site attained maximum density of shrubs i.e. 4780 plants ha^{-1} whereas, in unburnt site, it was 4306.7 plants ha^{-1}. Among all shrubs *Sida cardifolia* (386.7 plants ha^{-1}) and *Ricinus communis* (333.3 plants ha^{-1}) was dominated shrub in burnt site and unburnt site respectively. The contiguous distribution pattern was observed by maximum shrubs following the random. The diversity measures indicated that both sites were progressive in species richness and dominance of the shrub community structure. Prescribed fire affects the shrub composition in an adjustable manner as the low intensity burning reflects its intermediate response in germination and seed establishment.

Keywords: Prescribed fire, species composition, Density, Richness

Assessment of Water Quality of High Altitude Snow-Fed Lake (Hemkund) Using Water Quality Index (WQI) and Benthic Macro-invertebrate Based Biotic Index

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The present study deals with the water quality of high altitude snow-Fed lake Hemkund in the Indian Himalayan Region. Hemkund is a sacred lake and remains covered with snow for six months (November to March). It is frequently visited by Sikh pilgrims every year during May to October when the ice cover melts. Three sites (S1 least visited section; S2 frequently visited/bathing activities; S3 at the out let) were sampled in the months of June, August and October for the collection of water samples and benthic macroinvertebrate following standard methodology during 2018-19. Nineteen physicochemical parameters viz. Water temperature, pH, total dissolved solids, dissolved oxygen (DO), biological oxygen demand (BOD), free carbon dioxide (CO_2), hardness, total alkalinity, calcium, magnesium, sulphate, phosphate, chloride, salinity and nitrate were analyzed. Benthic macro invertebrate samples were collected from each site at the depth of 15 to 40 cm from the littoral zone. Water quality index (WQI) calculated from the parameters indicated good water quality while the benthic macro invertebrate based index Biological Monitoring Working Party (BMWP) indicated moderate to good water quality. Apart from this low DO; high BOD, chloride, free CO_2 were recorded at S2 along with the decline in relative abundance of sensitive macro invertebrate depicting anthropogenic pressure. The present study provides the base line data on the status of Hemkund lake which is facing anthropogenic as well as climate change threat. Further, the study will help the decision makers to formulate conservational measure of the sacred lake.

Keywords: Snow-Fed Lake; Hemkund; WQI; benthic macroinvertebrates; BMWP

Comparative study of Forenoon and Afternoon aerosol optical properties and radiative forcing over Varanasi

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There are different ways in which aerosols effects the Earth's climate. Aerosols absorb and scatter radiations in the atmosphere and modify the regional heat budget. The effect on radiative balance is quantified in terms of aerosol radiative forcing. However, aerosols still remains an uncertain aspect in the atmospheric science research. Aerosol optical properties and radiative forcing is an important input for global climate models. In the present study, we analysed the optical properties of aerosols as obtained by Multi Wavelength Solar Radiometer (MWR), OPAC simulated aerosol optical properties, modelled Aerosol Radiative Forcing and Heating Rate for pre-monsoon season of 2016 at Varanasi (25.30 N, 83.00 E, 176 m asl), India. The location is a representative Central Indo-Gangetic Plains (IGP) station in ISRO-ARFI Network. Aerosol optical properties for clear sky days were computed with the help of OPAC model for forenoon and afternoon sessions, separately. The OPAC model is iterated such that the generated spectral aerosol optical depth (AOD) falls within 5% of the observed spectral MWR-AOD. Finally, the radiation model (SBDART) was used to derive aerosol radiative forcing (ARF) for forenoon and afternoon sessions. Preliminary results show 28.7% increase in TOA, while 10.3% decrease at the surface and resulting 7.9% decrease in net atmospheric forcing during afternoon, as compared to forenoon period. Computed heating rate for forenoon is found to be as 2.20 ± 0.5 K/day, which was 7.9% lesser (2.04 ± 0.6 K/day) during afternoon. Results suggest significant differences in aerosol optical behaviour during forenoon and afternoon.

Impact of Anthropogenic Disturbances on Water Springs inside Van Panchayat Forest in Uttarakhand

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In this study the community forest (*van panchayats*) area of 98 villages in 6 districts of Uttarakhand were surveyed for assessing the impact of anthropogenic disturbances and changing climate on community forest water springs. In the entire study, a total of 490 sample plots were laid. We collected data of water springs, lopping, cutting, fuel-wood collection, grass collection, blousing and fire signs inside Van Panchayat forests. In each quadrate identification of trees species, shrub species, grazing signs, lopping signs, fire signs, animal trails, dung/ hoof marks, grass cutting signs were recorded. The signs of heavy grazing/ brousing were recorded in 80% of the sample plots, the sign of fuel wood collection were recorded in 65.9% of the sampled quadrates. The sign of forest fires on stem of trees were observed in 15.3% of the sampled quadrates and noticeably all these quadrates were in low and mid altitude (1000-2000 mts.) forest dominated mostly by *Pinus roxburgii*. This clearly indicates the huge anthropogenic pressure in the community forests. The pressure is mainly because of high consumption of wood from Van Panchayat forest. In this study total 138 springs were studied in ninety-eight (N=98) villages during our survey. Of these five (N=5) villages were having two (N=2) springs per village which were perennial. In the forty-four (N=44) villages there were single springs of perennial nature. In one (N=1) village, there were two springs (N=2) which remain active only for nine (N=9) months. It was found that among the observed springs about only 39.93% were perennial, 47.8% of springs only give water till nine months, and 13.7% springs provide water for six (N=6) months only. 61.5% of springs have shrieked in total discharge days by 90-150 days annually. We also analyzed the rate of discharge of springs, and perception of local population about reduction in spring discharge pattern in last four decades.

Keywords: *van panchayat,* fuel-wood, springs, anthropogenic disturbances, grazing, brousing.

Understanding the sources of airborne fine and coarse particulates in Varanasi, India

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Size-segregated particulate-bound organic, inorganic and metal species were analyzed in Varanasi to understand airborne particulate chemistry and associated sources. Near-real time size-segregated particulates samples were collected in an urban environment using Anderson cascade impactor. Fine particulates ($PM_{2.1}$)

were found enriched in water-soluble organic carbon (18%) and water-soluble ions with dominance of secondary inorganic aerosols (20%). This clearly indicates secondary nature of $PM_{2.1}$ while the coarse mode ($PM_{>2.1}$) fraction was mainly metal enriched, mostly of crustal origin. The fine particulate acidity was predominantly neutralized by NH_4^+ whereas, Ca^{2+} and Mg^{2+} -based neutralization were dominant in $PM_{>2.1}$. The n-alkanes molecular distribution showed C_{max} at C_{23} ($PM_{2.1}$) and C_{18} ($PM_{>2.1}$) with weak dominance of odd numbered alkanes. Levoglucosan to galacosan ratio indicate emissions from hardwood and agricultural crop residues burning. An advance receptor model was used to identify the sources of fine and coarse particulates considering several inorganic and organic markers. We note that secondary aerosols and biomass burning emissions (40%) primarily contribute to $PM_{2.1}$ while crustal emissions, secondary aerosols and biomass burning emissions contribute to $PM_{>2.1}$.

Keywords: Secondary aerosols, Biomass burning, n-Alkanes, Fatty acids, Phthalates.

Water harvesting initiative for an astronomical site in Central Himalayas

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Rapid urbanization, infrastructure development and rise in tourism activities accompanied with improper waste management are contaminating as well as depleting pristine water resources in Himalayas. Implementation of water harvesting techniques in Himalayas will have long range benefits in saving the stressed ecosystems supporting human life. An initiative for water harvesting at a fast emerging astronomical site of Devasthal (29o 21'N, 79o 41'E, 2.45 km amsl) in Central Himalayas is planned to supplement existing water resources. Devasthal astronomical observatory is well known for its geographical location and accommodates few telescopes with their associated infrastructure. Further development of site is planned with various upcoming astronomical and atmospheric instruments in near future which will constrain the existing sole ground water resource at site. Though site receives sufficient rainfall but most of the water runs off and goes unutilized due to steep slopes and absence of natural barriers. A scheme of roof top rain water harvesting system utilizing one of the astronomical building is discussed in the paper to sustain present and future water requirements. A drive towards self-reliance is planned by augmenting more water harvesting techniques at site to meet growing demands and support emergency conditions.

Insights from intensive long-term observations of carbon aerosols and trace gases at the Central Himalayas

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Himalayas are home to one of the most exotic ecosystems yet it faces severe threat due to its proximity with highly polluted Indo-Gangetic Plain. Despite this, comprehensive study of carbonaceous aerosols, one of the major air pollutants is still inexistent here. For bridging this gap, we present here simultaneous observations (2014-2017) of organic carbon (OC), elemental carbon (EC) and multiwavelength absorption coefficients over a high-altitude site (Nainital, 29.4^{o}N, 79.5^{o}E, 1958 m a.m.s.l) in the central Himalayas. The results show the first diurnal variations with a unimodal pattern in both OC, EC, and absorption coefficient. Such diurnal pattern is in contrast to the bimodal pattern observed at any continental polluted site. Clear seasonal variations in OC and EC were seen with a primary maximum during spring and a secondary maximum in autumn/winter. We have used concentration weighted trajectory (CWT) assisted analysis along with high OC/EC ratios and show that the biomass burning in northern India is one of the major sources for the springtime maximum even at this high-altitude site. Poor correlation between boundary layer height and OC-EC shows that the influence of local sources is most prominent during winter. The higher temporal resolution of online measurements reveals that swiftly varying meteorological parameters change the OC-EC concentrations at diurnal scales. It is also shown that the atmospheric radiative forcing during afternoon is about 70% higher than the forenoon one.

Investigation of changes in Annual Precipitation cycle of the Jammu and Kashmir union-territory of North West Himalayan Region

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The Northwest Himalayan (NWH) region has one of the most unique geophysical significance along with a very complex interaction between atmospheric and topographical properties. The precipitation pattern over the NWH region is mostly controlled by the two major atmospheric circulations: one is the Indian summer monsoon (ISM) which lasts from June to September and the other one is Western disturbances occurring during the winter season activated from December to March. But the distribution pattern and intensity of precipitation is different for all the states and Union territories of NWH, where the orographic arrangement of each of the states plays a vital role in the precipitation distribution pattern. Focussing on the Union Territory of Jammu and Kashmir, the present study will focus on the precipitation trend and pattern in the last 40 years (1979-2019) using the ERA-5 reanalysis datasets. ERA-5, the fifth-generation datasets, The European Centre for Medium Weather Forecasts has been released based on their consistent performances over a regional scale. They are also quite better in terms of spatial resolution compared to other reanalysis dataset products. Based on the performance evaluation of them over the hydro-climatic regime of the Indian Subcontinent, it has been investigated that ERA-5 outperforms the other reanalysis products for the monsoon season precipitation in India. Now its performance is also evaluated in the present work over the complex terrain of NWH at a finer regional scale.

Being separated from Ladakh, the Jammu and Kashmir union territory has its own meteorological, geophysical, socio-economic significance. The orographic arrangements of J&K are quite different from that of Ladakh and thus the seasonal, annual, and decadal precipitation pattern as well. The annual cycle of Jammu and Kashmir has been experienced a large shift from 1979 to 2019. The decadal analysis has been performed over the newly formed Jammu and Kashmir Union territory of the northwest Himalayan Region using the ECMWF ERA 5 reanalysis datasets. The maximum rainfall has been observed in the month of July in the decade of 1989-1999 and the minimum has been observed in the month of October for the decade 1999-2009. The all-over precipitation is quite lower for the decade of 1999-2009 and the most significant change has been seen over the month of March in which a gradually decreasing trend has been observed. From the spatial plots of mean seasonal precipitation, a higher concentration of precipitation is visible over Srinagar and the Kashmir valley region in the season of DJF, MAM, and ON. The monsoon period or JJAS period of rainfall, being influenced by the arrival of the South-eastern monsoon winds, provides a large amount of orographic precipitation over the state of Uttarakhand and Himachal Pradesh, but the deficit of moisture is one of the obstacles for the monsoonal rainfall in the Valley of Kashmir. The maximum rainfall occurs in this area is influenced by the Western Disturbances. Considering the trend analysis of the 40 years of seasonal rainfall

pattern in Jammu and Kashmir, it can be seen that a drastic change of precipitation has been taken place in the season of ON and MAM, rather the rainfall pattern is comparatively more consistent over the area in the season of JJAS and DJF but a significant shift of peak towards the early months is observed from the annual cycle figures. Results obtained from the present study are encouraging and would be helpful in understanding the state level investigation seasonal precipitation dynamics over the NWH region.

Statistical modeling of particulate matter using ANN techniques over Indo Gangetic Plain using satellite AOD and meteorological parameters

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Air quality affects our health, the liveability of our cities and towns, and our environment. Air pollution, particularly from anthropological activity has a momentous impact on human health and the economy. There are various policy level intrusions and learning from Global benchmarking that can help India improving its deteriorating air quality in cities especially the highly-dense IGP cities that come in news during post-October periods every year. The present study focusses on the correlation patterns of AOD 550 land and the ground PM concentrations in the select five cities of the IGP region. The ground data for the year 2017 has been obtained from the CPCB AQM stations of these five cities and the Satellite observed Aerosol Optical Depths (AOD-550) from the MODIS Level-II 3K, 0.55 μm has been retrieved and matched to the overpass local time. The weather parameters like WD, WS RH, and Temp at an hourly interval were obtained from the micro-met stations installed at in-situ AQM stations. Statistical tools Multiple linear regression (MLR) and Multi-Layer Perceptron (MLP) have been incorporated for the comparative analysis. The prediction capabilities of the MLP model surpassed the MLR in all regions over India. Both the models represent a significant relationship with r =0.35 to 0.45 for MLR and 0.7 to 0.8 for MLP, whereas in most of the cities MLP was found a best-suited model for the comparison of satellite base AOD with ground data. The MLP analysis for Kanpur PM2.5 shows the correlation coefficient r=0.899 and RMSE, MAE are 0.208, 0.043 whereas the least has been found at Kolkata due to its coastal impact as confirmed. This study confirms that local meteorological influences play a vital role in the diffusion of PM concentration in these spatially different cities. Given that the coarser number of monitoring stations and its high installation and maintenance costs envisages the scope of Geospatial Tools i.e., Remote Sensing products from indigenous (ISRO) or global platforms (ESA, JAXA, NASA) to be actively used for estimating Air quality and management plans for the dense Indian cities that are devoid of in-situ AQM's.

Keywords: ***Air Pollution, Indo-Gangetic Plain; Satellite Observation; AOD; PM_{10}; Statistical Analysis; Met Parameters; Artificial Intelligence***

Real-Time Measurements of $PM_{2.5}$ Oxidative Potential using Dithiothreitol (DTT) Assay in Agra during the COVID-19 lockdown period

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The COVID-19 outbreak has shown some positive impacts on the natural environment. The lockdown events have reduced air pollution levels by approximately 20% across 27 countries due to the reduction in major anthropogenic activities. Oxidative potential (OP) of PM2.5 was a selected indicator to link the aerosol exposure to its adverse health effects. Samples collected before (Feb - Mar) and during (Apr - May) lockdown period of 2020 were measured by using dithiothreitol (DTT) assay, at a residential, urban background site in Agra, India. The result showed that the average drop in PM2.5 mass concentration was 45.4% during lockdown. The volume- and mass-based dithiothreitol (DTTv and DTTm) activities of PM2.5 were significantly lower in lockdown period by 24.3%. The average DTTv was 0.014, 0.0064 nmolmin-1 m-3 and average DTTm was 6.18, 11.42 pmolmin-1 μg-1 before and during lockdown respectively. The results showed mean value of nine metals during lockdown period followed the order: Al > Zn > Pb > Mn > Cu > Cr > Ni > Cd > Ba.

Solar energy assessment in the Himalayan region during the Covid-19 lockdown using Earth Observation technologies

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The Covid-19 lockdown led to a reduction in the aerosol levels around the World leading to a clearer sky for the solar irradiance to reach the surface of the Earth. In this analysis, INSAT-3D AOD data was used to monitor the aerosol levels of the region following the use of MODIS 5-year climatology to analyze the aerosol pattern during the lockdown period. Solar irradiance was estimated using a fast radiative transfer model in conjuction with multi-poly regression analysis using CAMS AOD and BSRN data as input to train the model for clear sky condition. This has impacted the aerosol content of the atmosphere across the globe leading to a notably clearer skies around the world. India entered a nation-wide lockdown starting from 24 March 2020 so as to contain the spread of the global pandemic. The period saw a drop in the aerosol levels across the country. The study was performed for the region of Nainital and it was found that there was a significant reduction in the AOD values obtained from INSAT-3D in late March and early April as compared to the MODIS 5-year aerosol climatology. An average increase in GHI and DNI were found to be 2% and 4%, respectively with a maximum increase of 4% and 10%, respectively.

Seasonal behaviour of Aerosol Optical Depth and Black Carbon in the northwestern and Central Himalayan regions, India

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The present study is focussed on ground based measurements of Aerosol Optical Depth (AOD) and Black Carbon (BC) over Katarmal-Almora (Uttarakhand) and Mohal-Kullu (Himachal Pradesh) during July 2019 to June 2020. Average AOD values were 0.34 during winter (November-January), and 0.39 during summer (March-June) at Katarmal, while during the same seasons these values stood to be 0.28 and 0.36 at Mohal, respectively. The aerosol loading was observed to be high during summer period due to long-range transportation of aerosol particles by air mass and also due to frequent forest fire events. On the other hand, the annual average BC concentration was observed to be 0.461 ± 0.025 μg m^{-3} at Katarmal while this value at Mohal was 1.607 ± 0.126 μg m^{-3}. Diurnal variation of BC showed a gradual build up in the morning hours between 6 AM to 10 AM IST and in the evening from 7 PM to 10 PM IST, while low concentration was observed during day and night time. BC concentration was increased approximately two times during morning and evening hours compared to afternoon and night hours at Katarmal, and these values remained about three times more than Mohal. Seasonal variations of BC showed high concentration during winter dry season associated with the air masses primarily coming from the Indo-Gangetic Plain and minimum during monsoon season due to heavy precipitation at both the sites. In addition, the values of AOD and BC concentration over Kosi-Katarmal, Almora and Mohal-Kullu have also been compared with those reported from the selected locations in India.

Ambient air quality and Black carbon (BC) behaviour in pre- and during COVID -19 at Kosi- Katarmal, Uttarakhand

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COVID-19 is a huge tragedy all over the world communities. The defensive and protective plan includes self-isolation, work from home, social distancing, home quarantine, and lockdown. This lockdown strategy is strongly adopted by the government, non-functioning, business trade centres and industrial units. The present study gives the status of ambient air quality and black carbon (BC) in pre- and during COVID -19 at Katarmal, Uttarakhand. Particulate matter (TSP, PM_{10} and $PM_{2.5}$) are inhalable particles, with diameter generally less than 100 micrometres. The air quality index (AQI) in period of Pre – lockdown found to be 34.5 and fall in Light Air Pollution (LAP) category while during lockdown it stood to be 20.5 and falls under Clean Air (CA) category respectively. The highest rate decrease for TSP with 55% followed by PM_{10} with 50% in Almora. The main contributing sources are vehicular emissions, forest fire, deforestation and while external sources included air masses loading with fine aerosols from the polluted regions. During lockdown period, human activities restricted to their homes and results in reduced pollution or particulate matter emissions.

Keywords: COVID -19, lockdown, particulate matter, black carbon, Himalaya, pollution sources, air quality index.

Characteristics of atmospheric aerosols and their nature over Varanasi region

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Atmospheric aerosol plays crucial role in the Earth's radiation budget and and climate studies. The present study reports the variability of the physical and optical properties of columnar aerosol over Varanasi (25.2°N, 82.9°E), located in middle of the Indo-Gangetic Basin for year 2018. The study is carried out using MICROTOPS-II for measuring AOD and two high volume samplers ($PM_{2.5}$ and PM_{10}) for measurement of both coarse and fine particulates. AOD was found to be enhanced during pre-monsoon and winter season. $PM_{2.5}$ particles were found to be dominant during winters whereas PM_{10} were dominant during pre-monsoon season. A large variation in aerosol optical depth and Ångström exponent indicate towards highly turbid atmospheric environment with significant heterogeneity in aerosol sources, types and optical properties.

Trend analysis of Ozone and NO_x in Indo-Gangetic Plain

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Increasing levels of surface O_3 in India particularly in Indo-Gangetic Plain (IGP) is considered as a major issue as it is posing a threat to climate change, human health and crop yield. In view of the issue of increasing levels of surface O_3 in India, the present study was carried out over a suburban site of IGP to determine the trend of O_3 and its important precursor nitrogen oxides (NO_x) over the period 2010-15. The study focuses on the overall characteristic of annual, monthly, diurnal and hourly variations of surface O_3. The mean concentration of O_3 during the study period was 32.5 ± 12.0 ppb. Annual mean O_3 values have shown an increment of 23.3 % from 2010 to 2015. Similarly, NO_x levels were observed to be increased by 30.2 % over the study period. O_3 levels at the study site showed a significant increasing trend of 0.7 ppb/yr. The observed O_3 trend was analyzed in terms of changes in NO_x levels and meteorological parameters. No significant difference in meteorological parameters was observed during 2010-15, however, NO_x levels have shown an increasing trend of 0.9 ppb/yr. In addition to trend analysis two case studies were conducted during dust storm and crop-residue burning activities to examine their influence on O_3 levels. During dust event a significant reduction in the mean O_3 levels (6.1 %) were observed while an enhancement of 15.1 % during crop-residue burning activities was observed.

Variability of lower atmosphere thermodynamics and its association with lightning flash rate over Himalayan region

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The temporal variation of thermo dynamical parameters and lightning flash rate density has been observed over northwest (NW) Himalayan region (30-38 ºN, 72-80 ºE) and northeast (NE) Himalayan region (21-29 ºN and 86-94 ºE) for the period of (1998-2014) and results are presented in this paper. Thermodynamics of lower atmosphere especially atmospheric boundary layer (ABL) plays a major role for transporting energy in the form of heat and moisture for the generation of lightning activity. The western part of Himalayan region receives maximum lightning flashes (~ 80 flashes km^{-2} yr^{-1}) during the month of June and July whereas the NE part of Himalayan region experiences maximum flashes (~ 65 flashes km^{-2} yr^{-1}) during the months of March-May. This part of Himalayan region receives rain during these months, though orography and wind circulation plays a major role for the formation of lightning over this region. Also the presence of heat, moisture, strong updraft and resulting development of precipitation are active in the sufficient intensity for lightning discharge. Wind also plays a major role in this region, for convection and orographic lifting. During the period of March-May winds are westerly (from hilly region) and throughout the year it is southerly (from land), which give additional effect on convection. After November onwards the climate of this region become dry and cold also it gets very less flashes almost ~1-2 flashes km^{-2} yr^{-1} during November to February. Along with the thermodynamic parameters aerosols over this region plays a major role for the formation of high lightning flash rate over these two parts of Himalayan region.

Evaluation of WRF (3.8.1) model for meteorology over central Himalaya

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The weather research forecast (WRF) model is evaluated over the highly complex mountainous topography of central Himalaya. WRF simulations reveal higher variability in meteorology as compared to the ERA Interim reanalysis. Owing to higher resolution, simulated temporal evolution of meteorological profiles is seen to be in agreement with the balloon-borne measurements with stronger correlations aloft (r = 0.44–0.92), than those in the lower troposphere (r = 0.27–0.48). Our study shows that the model at finer grid resolution significantly reduces the biases in simulated meteorology.

Study of regional and synoptic transportation of $PM_{2.5}$ during the COVID 19

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This study deals with the variability and dynamics associated with the concentration of fine particulate matter ($PM_{2.5}$) over central Himalayan region (Manora Peak) before and during lockdown period of COVID 19. The lock-down situation served as a natural laboratory to understand the short and long range transport phenomena in a naturally controlled environment. It also provided true representation of the background level at a remote Himalayan site which is away from any significant anthropogenic activity. The $PM_{2.5}$ concentration decreased remarkably to about 10 µg/m^3 (in March) during first lock-down as compared to before lockdown situation (about 20-25 µg/m^3) and the values in previous years (23 µg/m^3, 2018; 21 µg/m^3 , 2019). The significant diurnal variation of $PM_{2.5}$ shows the association with meteorological parameters (wind speed, incoming solar radiation, rain etc). A noon time peak (22-50 µg/m^3) is observed on all clear sky days and may be attributed to the transport of pollutants along with the slope winds. The trajectories analysis confirmed the major contribution from regional sources, as air masses transported from the nearby sites e.g., foothill Indo-Gangetic plain, while sudden enhancements of $PM_{2.5}$ (up to 350 µg/m^3) are associated to long range transport from western arid desert region of India and Arab countries.

Size distribution of organic and elemental carbon during the winter season in Delhi, India

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Sources, formation, and growth mechanism of the aerosol particles can be understood by the analysis of size distribution. However, the size distributions of organic and elemental carbon have been much less studied as compared to other different chemical species. Therefore, a study was carried out to investigate the variation in the concentration and the size distribution of organic carbon (OC) and elemental carbon (EC) measured in the residential area of Delhi, India. Size segregated aerosol samples were collected by cascade impactor in four different size fractions (>10 Ã‚µm; 10-2.5 Ã‚µm; 2.5-1.0 Ã‚µm; <1.0Ã‚µm) during the winter season. The OC and EC concentration was measured by DRI 2001 thermal/optical carbon analyzer. Among the four different size fractions, the highest concentration of OC and EC was observed in PM1 size fraction. Particle size distribution shows a unimodal peak of OC and EC at <1.0 Ã‚µm in the fine size range of aerosol particles. A decreasing trend in the OC and EC concentration was observed with an increase in the diameter of aerosol particles. The percentage contribution of OC and EC were ranged between 18 to 21% and 7 to 9%, respectively. The OC/EC ratio of >2.0 with the higher ratio in larger size fraction of particulate matter. In addition to this, the increasing trends in the OC/EC ratio were observed with a trend increase in the diameter of aerosol particles. The increasing concentration of OC and EC can adversely affect the atmospheric properties and health of the people. Therefore, efforts should be made to control OC and EC pollution. Keywords: Aerosol; Elemental Carbon; Organic Carbon; Size Distribution

Variation of Major Air Pollutant in Megacity Mumbai

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The aim of this study is to determine the diurnal, daily and monthly variation in particulate Matter (PM_{10} And $PM_{2.5}$), surface ozone (O_3) ,carbon monoxide (CO) and nitrogen dioxide (NO_2) with meteorological parameters over coastal city Mumbai (19.070N,72.870E) for a period January 2016 to December 2018 using SAFAR which is Network of the ground-based continuous air quality monitoring stations. During June to September months which is monsoon season concentration of these major pollutants was lowest due to washout effect of monsoonal rain and highest monthly concentrations found in November to February months. The amplitude of diurnal variation PM_{10}, $PM_{2.5}$, CO, O_3 and NO_2 was least in the monsoon months (June to September) and the diurnal pattern was weak. It has been found that on diurnal scale concentration of PM_{10} and $PM_{2.5}$ higher during the morning hours thereafter it reduces and concentration of O_3 starts to increase from 10 hr. and shows a peak at 12 to 15hr and thereafter it decreases slowly, the diurnal pattern CO and NO_2 is different from O_3. The annual concentration PM_{10}, $PM_{2.5}$, O_3 CO and NO_2 during 2016-2018 are observed in the range of 99-103 µg/m³, 59 -69 µg/m³ ,34 – 35ppb, .0.67-0.77 ppm, 21 -23ppb respectively. The coastal meteorology play important role in variation of PM_{10}, $PM_{2.5}$, CO, O_3 and NO_2.

Investigation of atmospheric aerosols over semi-urban and urban areas in Eastern Indo-Gangetic Plain: seasonal variability and source apportionment using PMF

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The study investigates the chemical composition and source of aerosol origin at a semi-urban (Kharagpur–Kgp) and urban (Kolkata–Kol) region during the period February 2015 to January 2016 and September 2010 to August 2011 respectively. Major water-soluble inorganic aerosols (WSII) were determined using Ion chromatography and carbonaceous aerosols (CA) using OC–EC analyser. A multivariate factor analysis Positive Matrix Factorization (PMF) was used in resolving source of aerosols at the study locations. Seasonal analysis of WSII at Kgp and Kol indicated relative dominance of calcium at both the places followed by sodium, chloride, and magnesium ions. Non-sea salt potassium (nss–K^+), a biomass burning tracer was found higher at Kol than at Kgp. Sum of secondary aerosols sulphate (SO_4^{2-}), nitrate (NO_3^-) and ammonium (NH_4^+) was higher at Kol than Kgp with relative concentration of SO_4^{2-} being higher than NO_3^- at Kgp which was vice-versa at Kol. Examination of carbonaceous aerosols showed three times higher concentration of organic carbon (OC) than elemental carbon (EC) with monthly mean of OC/EC ratio > 2, indicating likely formation of secondary organic carbon formation. Seasonal influence of biomass burning inferred from nss–K^+ (OC/EC) ratio relationship indicated dissimilarity in seasonality of biomass burning at Kgp (Kol). PMF resolved sources for Kgp constituted of secondary aerosol emissions, biomass burning, fugitive dust, marine aerosols, crustal dust and emissions from brick kilns while for Kol factors constituted of burning of waste, resuspended paved road dust, coal combustion, sea spray aerosols, vehicular emissions and biomass burning.

Air Quality in Kathmandu

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Air pollution is the major problem for developed and developing countries. As which leads to the chronic exposure to diseases like lung, heart and so on. So, we measured main 3 urban places of the Kathmandu for the quality and which got more values than provided by the WHO standards.

Climate change: Impact on livelihood of Changpas

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SKUAST-K

Climate change affects ecology of Himalayas. This in turn affects vegetation, pastureland, and feed availability to livestock species living in this region. Nutritional deficiency affects health and production of livestock and hence livelihood of traditional livestock farmers: Changpas.