

Report
International Workshop on
“Modeling Atmospheric-Oceanic Processes for Weather
and Climate Extremes” [MAPEX 2019]

A rapid increase in the frequency of extreme weather events has been seen over India and rest of the world in recent decades. Countries in Asia are witnessing increasing number of extreme weather events such as typhoons, cyclones and threat of exacerbating these events (due to warming climate) on mankind are looming large. These events, such as the recent floods over Kerala and Tamil Nadu, drought in Assam and extreme rainfall in Mumbai etc. are causing huge damages to the properties and results in loss of lives. Hence such extreme weather events are a threat to the well- being of the society. Also, they pose a threat to the economy of the country in terms of damages to public and private infrastructure. An important step in short-term mitigation of the weather extremes is that we should be able to reliably predict such events well in advance. The prediction of tropical weather is a challenge due to the inherent uncertainty of the atmosphere and especially the extremes due to the gaps in the proper understanding of the processes involved.

With this vision in mind, the International Workshop on ‘Modeling Atmospheric – Oceanic Processes for Weather and Climate Extremes’ (MAPEX 2019) was organized by Centre for Atmospheric Sciences (CAS) of Indian Institute of Technology Delhi (IIT Delhi) in collaboration with the Asian Network on Climate Science and Technology (ANCST) during 28-29 March 2019. The workshop was hosted by IIT Delhi. MAPEX 2019 is a key activity of the Special Topic Group on "Atmosphere - Ocean Interactions" of ANCST.

The workshop brought together both academic and operational researchers to facilitate an understanding of the operational needs and determination of focus on research of the immediate challenges of predicting extreme weather events. Leading experts from India and abroad delivered talks in the workshop sharing

knowledge on current status of research in extremes in tropical climate particularly in Asia.

MAPEX 2019 received overwhelming response especially from the research students and early career scientists. A total of around 100 abstracts were received out of which 67 were selected for oral and poster presentations. There were 42 poster presentations and about 25 oral presentations. The submitted papers were received from several countries (Indonesia, Malaysia, Singapore, Bangladesh, Thailand, China Saudi Arabia and Japan).

The main themes of the workshop were to address the challenges in operational forecasts of extreme weather events with a focus on Atmospheric-Oceanic Processes.



Opening Ceremony; Lighting of ceremonial lamp

From left to right: Dr. Vimlesh Pant, Prof. Manju Mohan, Dr. M. Rajeevan (Secretary, Ministry of Earth Sciences), Prof. M. Balakrishnan (Deputy Director S&P; IIT Delhi) Prof. V. Ramgopal Rao (Director, IIT Delhi)

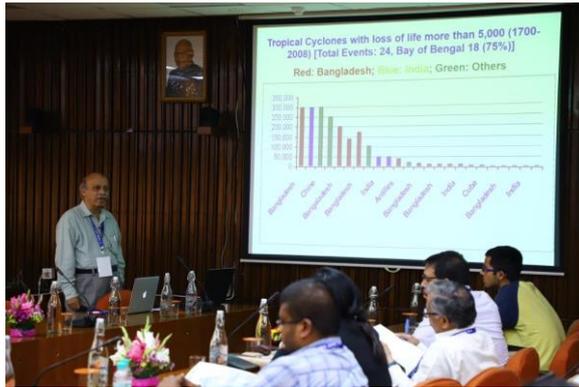


From left to right: Prof. M. Balakrishnan, Prof. V. Ramgopal Rao, Dr. M. Rajeevan, Prof. Manju Mohan



Session in progress

The first session of the first day of the workshop (28 March 2019) was based on challenges in operational forecasts of extreme weather events. Prof U C Mohanty (IIT Bhubaneswar), who was the keynote speaker of the session, presented an assessment of observations and predictions of extreme weather events over India viz., tropical cyclones over Bay of Bengal, severe thunderstorm and lightning.



Prof U C Mohanty



Dr. A K Mitra

Prof. Mohanty discussed that the Hurricane Weather Research and Forecasting (HWRF) model system achieved significant improvement in track prediction, occurrence of thunderstorms over the basin because of the higher model resolutions, improved physics and representation of large-scale synoptic condition and other features. Inclusion of satellite data assimilation, impact of Doppler radar reflectivity and radar position also shows an improvement in forecast.

Dr Muhammad Firdaus Ammar Bin Abdullah of Malaysian Meteorological Department presented city scale forecasting of extreme rainfall events over Kuala Lumpur, Malaysia. He presented a case study of an extreme rainfall event which was analyzed using WRF-1km model along with which impact of terrain in shaping the synoptic factors, Mixed Rossby-gravity waves at 200 HPa were also analysed. Dr Ammar bin Abdullah also stressed the need for an improved systematic observation network in the study region for improving the forecast of extreme events.

Aspects of seamless modeling system for weather/climate were elaborated by Dr A K Mitra from NCMRWF. He discussed how NCMRWF aims to have a seamless model framework across all the processes from sub - seasonal to seasonal scale to adapt to climate variability and presented a case study of Dust storm of Agra on 3 May 2018 which was well captured by NCMRWF after incorporation of regional data assimilation in the model. Dr. Manish Modani of The Weather Company, IBM talked about the numerical weather prediction at IBM/The weather company which incorporates data assimilation from variety of observations, including

satellite, conventional (METARs, SYNOPs, cell-phone pressures, radiosondes), and radar. The forecast output has numerous applications like consumer, aviation, energy demand and insurance applications.



Dr M F Ammar Bin Abdullah

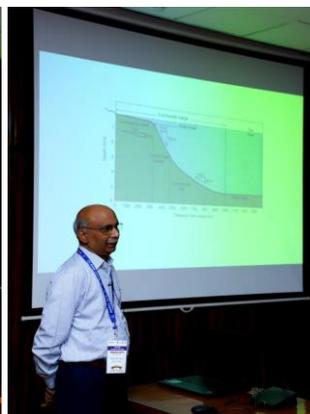


Dr. Manish Modani

The next session was about Mechanisms, drivers and feedbacks in Atmospheric – Oceanic Processes leading to extremes. The keynote speaker, Prof A Chandrasekar of Indian Institute of Space Science and Technology Thiruvananthapuram, presented a case study of 4Dvar assimilation in WRF Model for simulating 350 mm rainfall in Uttarakhand during June 2013 and concluded that 4DVAR allows the observations to be distributed over a period of time and is consistently better all along picking right amount of intensity and can be used in extreme rainfall events.



Prof A Chandrasekar



Prof A D Rao



Prof Ashok Karumuri

The second keynote speaker, Prof. A D Rao (CAS IIT Delhi), talked about the storm surges associated with cyclonic wind stress and related inundation particularly in Indian coast. He discussed the importance of Inflow angle of cyclone and correct onshore topography in correct prediction of storm surges. Dr S Sijkumar (SPL-VSCC) presented a case study of Ockhi cyclone and talked about the influence of Atmospheric waves on the cyclogenesis of Ockhi. Outgoing longwave radiation from satellite data showed an eastward propagation while shortwaves were

mostly westwards. He observed periodicity of temperature and Zonal winds observed prior to formation of cyclone and discussed that mixed Rossby-gravity waves (MRG) can converge to transform into cyclonic disturbances. Numerical simulation was proposed to further examine the transition of MRG to TD waves. Prof Ashok Karumuri from University of Hyderabad examined the heavy rainfall event in Chennai, 2015 and revealed that strong/Warmer SST were observed in Bay of Bengal in N-E Monsoon season along with El-Nino in Tropical Pacific. He explained that ENSO is positively correlated to NE Monsoon bringing more rainfall. Rainfall decreases if El Nino signal or ENSO signal is removed. Realistic SST improves the prediction. He concluded that SST had more effect on Chennai rainfall along with effects of urbanization related LULC changes which was captured in sensitivity experiments carried out with the WRF model.



Dr S Sijikumar



Dr. Ramesh Vellore

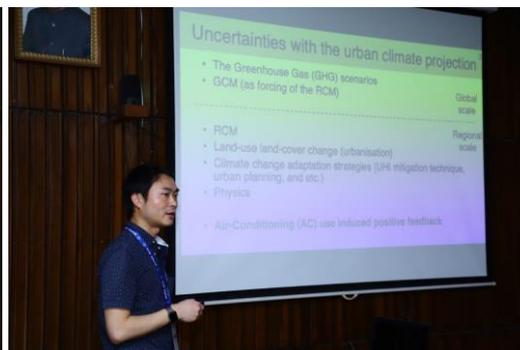
Dr Ramesh Vellore (IITM Pune) talked on large scale dynamics on Himalayan Precipitation Extremes. He discussed that NE India is experiencing larger number of extreme events of late and greater number of Monsoon break is expected in the future times. He observed that during the Monsoon break there is a slight southward shift to TEJ and there is a coupling of Siberian anti-cyclone and low troughs. Southern region of Brahmaputra River was found to be more affected by the orography while Northern region was affected by extra tropical synoptics.

The third and last session of day 1 of the workshop was on the role of environmental factors on extreme weather events. Keynote speaker of the session was Prof. Edwin Aldrian who is Vice Chair of IPCC Working Group I (The Physical Science Basis). Prof Aldrian described about climate and atmospheric variability and their impact to the maritime continent ocean climate interaction. He observed

that wetting (drying) trend in the rainfall amount was found over the northern (southern) part of the Indonesia. The wetting trends of several extreme precipitation indices were depicted in December-January-February (DJF) and March-April-May (MAM) seasons. However, a drying tendency was observed for June-July-August (JJA), September-October-November (SON) and MAM in the southern region of Indonesia. During El-Nino development period in JJA and SON, the entire Indonesian region is dominated by dry conditions. However, during SON a wet anomaly also appears over northern Sumatra, expanding eastward during DJF and MAM, creating wetter conditions in the west and drier in the east.



Prof. Edvin Aldrian



Dr. Yuya Takane

Next, Dr. Yuya Takane from National Institute of Advanced Industrial Science and Technology (AIST), Japan explored the importance of positive feedback in Urban Warming with regards to use of air-conditioning in megacities. Dr. Takane explained that to project urban climate, a downscaling technique is needed. Use of air-conditioning (AC) was found to be positive feedback to the urban temperature. It was pointed out that heat emission from use of AC increases linearly with the urban temperature, causing additional urban warming amounting up to approximately 20% of the increase in urban temperature in residential areas. Dr. Takane stressed that this feedback should not be neglected in future urban climate projections, mainly in hot cities with large usage of AC. The next speaker, Dr. Bala Subrahmanyam (SPL-VSSC, Thiruvananthapuram) presented performance evaluation of COSMO (Consortium for Small-scale Modelling), a regional numerical weather prediction (NWP) model, during the passage of OCKHI cyclonic storm over the Arabian Sea. Dr. Subrahmanyam noted that formation of deep depression in Comorin Sea and its intensification into cyclonic storm ranging from severe to very severe was evident from the COSMO model simulations. However,

rapid intensification of OCKHI was unexpected and not captured well by the model.



Dr. Bala Subrahmanyam



Dr. Hari Prasad Dasari

Dr. Hari Prasad Dasari from King Abdullah University of Science and Technology, Saudi Arabia, demonstrated an investigation of the Planetary Boundary Layer (PBL) height characteristics and its variability at different time scales over the Arabian Peninsula (AP) based on high-resolution assimilative Weather Research and Forecasting (WRF) regional simulations. He observed that during El-Nino, the Red sea convergence zone moves northward leading to occurrence of heavy rainfall in the northern region. He concluded that mean planetary boundary layer height exhibits different daytime and nighttime seasonal patterns with greater daytime heights in the summer and nighttime heights in the winter over the Arabian Peninsula.



Conference Dinner

From Left to Right: Dr. S Sukumaran, Prof. Maithili Sharan, Prof. O.P. Sharma, Prof. S K Dube, Prof. Manju Mohan, Prof AD Rao, Dr. Vimlesh Pant, Dr. Dilip Ganguly, Dr. Sagnik Dey

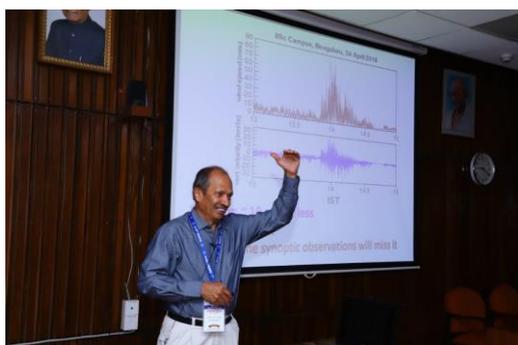


Participants in Conference Dinner



(From Left to Right) Dr. Prashant Kumar, Dr. Ravi K. Kunchala, Prof. A. Chandrasekar, Dr. Dilip Ganguly, Dr. Sandeep Sukumaran

The second day of the workshop (29 March 2019) had two sessions of scientific talks and a poster presentation session. The first session was entitled "Observations, diagnostic analysis and case studies for extremes". There were two keynote speakers of this session. The first keynote speaker, Prof. G.S. Bhat (Centre for Atmospheric & Oceanic Sciences, Indian Institute of Science, Bengaluru) presented a talk on Wind Extremes over India. Prof. Bhat pointed out that although the wind extremes events (other than cyclones) causes serious damage to the lives and properties of the common men, there is not much research done in this direction. He analysed observational data (wind speed and precipitation) collected during April-May 2018 from stations at Rajasthan, Uttar Pradesh Bihar and Bengaluru to study the wind extreme cases. The case studies revealed that no direct correlation exists between the wind speed and temperature gradient during these wind extreme cases. Since such events last for only a short duration (< 10 minutes), averaging of the in-situ data will result in loss of signal. Thus, these wind gusts around dust storm periods still remain as challenge for the modeling community. Prof. Bhat highlighted that lack of observational data of wind gusts/dust storms (especially within the height of near surface turbulent layer) is a serious issue for studying and modeling of these events. The second keynote speaker was Prof. SSVS Ramakrishna from Andhra University. Prof. Ramakrishna discussed North Indian Ocean Severe Cyclones and the associated physical processes. He observed that cyclonic storms over the Indian Ocean region shows a decreasing trend in the recent decade, whereas the severe cyclonic storms exhibit an increasing trend. He noted NOAA scheme gives better results for the cyclone simulations using WRF model. Sensitivity studies showed that incorporation of real time sea surface temperature (SST) improved the cyclone track prediction from WRF model. Also, initial thermodynamic sounding can play an important role for the accurate cyclone simulation and predictions.

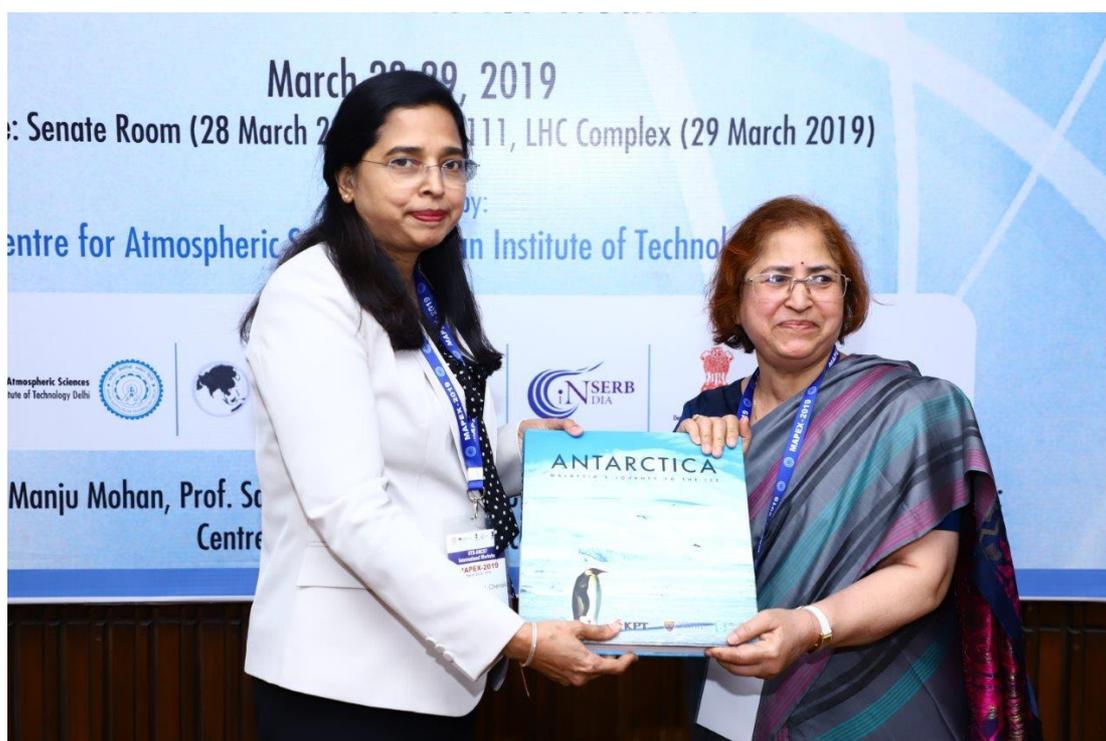


Prof. G.S. Bhat



Prof. SSVS Ramakrishna

One of the corporate sponsoring partners, TSI Solutions, introduced various instruments for monitoring the aerosol and dust particles in the atmosphere. They highlighted that TSI is able to develop instruments of high quality that are less expensive. Real time aerosol mass and size measuring instruments were also introduced. They also informed that lightweight and portable instruments for measuring PM₁, PM_{2.5}, PM₁₀ etc., particles are also available with them for the research and commercial purposes.



Dr. Sheeba Nettukandy Chenoli presenting Coffee table book on 'Antarctica' to Prof. Manju Mohan, Convener; MAPEX-2019

The next talk in this session was from Dr. Sheeba Nettukandy Chenoli from University of Malaya, Kuala Lumpur. Dr. Chenoli presented case studies of extreme rainstorms that caused Devastating Flooding across the East Coast of Peninsular Malaysia during Northeast Monsoon of year 2014 over the east coast of Malaysia.

She discussed that ENSO events are found to be a regulating factor for the rainfall events over this region. Combined action of cold surges (Northeastern surge) and easterly surge together intensifies the extreme rainfall events. Further, during El-Nino, the Siberian High was found to be weaker and neutral events experience strongest cold surges.

The second technical session of the day was on "Assessment of projected changes of extremes in warming climate". The first keynote speaker of this session, Prof. D. Sengupta from Indian Institute of Science Bengaluru (IISc), gave a talk entitled "River water and Bay of Bengal cyclones". Prof Sengupta discussed the response of the Bay of Bengal to the passage of cyclone Phailin in October 2013, with help of open ocean mooring observations and a one-dimensional model. Prior to Phailin, salinity stratification was very high at the base of a shallow, fresh layer coming from the Ganga-Brahmaputra-Meghna river; a deep, nearly isothermal layer lay underneath. We find that vertical mixing due to enhanced vertical shear of near-inertial currents deepens the mixed layer from 10 m to at least 50 m; sea surface salinity increases by 1.6 psu, but SST does not cool. The combined effects of shallow stratification and deep warm layer inhibits mixed layer deepening and inhibits SST cooling. Prof Sengupta inferred that cyclones may intensify rapidly over low-salinity river water in the Bay of Bengal.



Prof. D. Sengupta



Prof. Someshwar Das

The second keynote speaker, Prof. Someshwar Das (Central University of Rajasthan) talked about modelling and forecasting of severe storms over the Himalayas and adjoining regions. He presented case studies of observations and simulation of cloudbursts, Nor'westers and desert storms. Taking a case study of Nepal, he explained the series of synoptic condition that lead to cloudburst which includes (i) equatorward intrusion of upper-level westerly trough, (ii) upper level

jet entrance regions closer to the Himalayas, (iii) positive potential vorticity anomaly associated with steep tropopause fold and interaction with elevated topography, and (iv) Monsoon trough shift over the Himalayas. He also demonstrated performance of WRF model and ECMWF forecast for precipitation associated with cloudburst. Prof Das summarized that though, models are able to predict the signature of the rainstorms fairly well, skill of predicting precise location, time and intensity needs improvement. Further, assimilation of doppler radar and satellite data improves the prediction.

Dr. R. K. Jenamani (IMD IGIA Delhi) explained in detail about large-scale and meso-scale process that have been found to lead to extreme dense Fog/smog Spells across Indo Gangetic Plain and at Indira Gandhi International Airport in Delhi. Dr. Jenamani presented a case study of application of fog model for predicting the onset of fog and discussed the forecasting challenges



Dr. R. K. Jenamani

Next, Dr. Amita Prabhu, Indian Institute of Tropical Meteorology Pune, presented a case study of analyzing influence of low-frequency wintertime Eurasian snow forcing on Summer Monsoon Rainfall over North East India (NEISMR) through the north Atlantic SST Bridge. Dr. Prabhu discussed that while the summer monsoon rainfall over major parts of India (excluding the NE region) appears to be related with events in the Southern Hemisphere, namely the Southern Annular Mode through the Pacific SSTs, the variation of NEISMR appears to be related with events in the Northern Hemisphere through the Arctic Oscillation, Eurasian snow and Atlantic SSTs.



Dr. Amita Prabhu



Dr. Anurag Kandya

The final talk of the session was given by Dr. Anurag Kandya from Pandit Deendayal Petroleum University, Gujarat. Dr. Kandya presented a comprehensive investigation of the dynamics of urban heat island (UHI) effect in megacity Delhi during 2001-18. Dr. Kandya revealed that Delhi as whole has experienced a warming trend for the annually averaged nighttime LST during 2003-2018. 26% of Delhi witnessed an increasing trend in the nighttime UHI intensities. Dr. Kandya stressed the importance of UHI mitigation measures to take forward the concept of sustainable cities.

The poster session on the second day included posters from students and early career researchers. The posters included interesting studies on multi-faceted aspects of extreme weather such as use of numerical weather prediction models to study extremes, role of air quality parameters such as aerosols, observational analysis of extremes and various indices, heat stress, evaluation of weather and climate models along with atmospheric chemistry models and many others. The works of these young minds in poster session was well received and appreciated by many senior scientists and researchers.



Poster Session

The final session of the day was a panel discussion headed by Dr. KJ Ramesh (DG, IMD), Dr. Akhilesh Gupta (Adviser/Scientist-G & Head, SPLICE, Department of

Science and Technology, Govt of India), Dr. Swati Basu (Former Scientific Secretary in the office of Principal Scientific Adviser to Government of India and formerly, Adviser, Ministry of Earth Sciences), Dr. R.K. Mehajan (Head-Earth Atmospheric Sciences Division/Scientist G, Science and Engineering Research Board, Department of Science and Technology, Govt of India) and Prof Manju Mohan (IIT Delhi).



Panelists: (From left to right) Dr. Akhilesh Gupta, Dr. K.J. Ramesh, Dr. Swati Basu, Dr. R.K. Mehajan, Prof. Manju Mohan

The major points of the talks over the two days were discussed. Some key recommendations arose from the panel discussion:

- (i) Encouragement of efforts amongst premiere and older institutions with newer universities and institutions for collaborative research projects.

- (ii) The operational models to be available to the research community with test data for IC/BC and validation for incessant model development activities. Model inter-comparison exercises shall be conducted periodically amongst the user communities and operational agencies.
- (iii) Automatic weather station measurements utilized for routine forecasts shall be upgraded for research purposes to include radiation, flux tower measurements and other state-of-the-art equipments.
- (iv) Observational network shall be enhanced keeping in view the area most impacted by extreme weathers such as extreme rainfall, drought, cyclones, thunderstorms, fog etc.
- (v) Focus on research aspects such as data assimilation with satellite products.
- (vi) A lot of observational data (DWR, satellite, networks, field campaign etc.) amongst academic institutions, operational agencies, space and other research organizations is available and could be integrated through coordinated efforts and shall be brought on common platform through a designated agency for this purpose.
- (vii) A gap between enormous availability of data (both from newer technological platforms such as DWR, satellite etc and routine networks), with its utilization for improving scientific understanding and incorporation in operational models exist and growing day by day that shall be reduced by enhancing capacity building programmes in meteorology and related fields.
- (viii) Suitable career avenues with schemes for attracting bright students and early career researchers in a sustainable manner shall be created.
- (ix) Greater cooperation amongst Asian nations facing extreme weather situations for sharing of model data, observations, experiences etc., as also collaborative projects shall be enhanced.
- (x) Parameterisation of microphysics, land-surface processes, boundary layer, aerosol-cloud interactions, convective processes etc shall be based on locally developed parameterisations.

- (xi) Implementing seamless high resolution models effective at local scale for research and operational purposes to be adopted to take care of local, regional, and large scale circulations
- (xii) Cityscale forecast model development for extreme weather events shall be given high priority.

MAPEX 2019 concluded with a valedictory session. Certificates were distributed to all student participants. Best posters of the sessions were also awarded. The winners were Shreyas Dhavale (Savitribai Phule Pune University, Pune) at 1st place, Ankur Prabhat Sati (IIT Delhi) and Vivek Singh (IIT Delhi) jointly at 2nd place and Reshmi Mohan (Indira Gandhi Centre for Atomic Research, Kalpakkam) and Dipjyoti Mudiar (Indian Institute of Tropical Meteorology, Pune) jointly at 3rd place. The convener, Prof Mohan, thanked all participants for their contributions.



Closing session with conveners and volunteers

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