doctoral students in the next five years, in collaboration with mentors in premier scientific institutions and laboratories. Also, central coordination of skill development internships will provide opportunity to ~5000 potential postgraduate students during next five year duration. The current call for applications invites event organizers for the winter season (December 2020–January 2021).

Another component, 'Samoohan', aims to aggregate and consolidate all scientific interactions in the country on a common platform. 'Samoohan' has been sub-divided into two programmes: 'Sayonjika' and 'Sangoshti'. Sayonjika is an integrated, open-ended programme to catalogue all capacity building activities in S&T in India supported by various government funding agencies. This programme is being implemented through an Inter-Ministerial Overseeing Committee (IMOC) involving all scientific departments/ministries and few other significant entities such as UGC. Whereas Sayonjika aims to encourage skill conference/workshop organizers to register with the Accelerate Vigyan online portal, utilize its logo and submit completion report as well as outcomes, Sangoshti is a minor rebranding of SERB's pre-existing programme 'Seminar and Symposia', as brought out earlier.

The repository of skilled manpower developed across different disciplines and the final outcomes captured in the process, through all the sub-components of the Accelerate Vigyan, will be available to all stakeholders (students, teachers, researchers, science administrators and policy makers) and help in planning, conducting and participating in capacity building activities in the country.

A bigger challenge is to ensure that interested students are offered the possibility of acquiring real skill development with seamless involvement as well as personal commitment of expert faculty/scientists and support from their institutions. Thus it is important that the skill/technical workshop organizers (mentors) have a high level of commitment not only as scientists, but also present themselves as defining role models. At the same time, it is also important not to set over-didactic standards. It is expected that faculties/scientists who serve as their mentors would get involved and invest their valuable time as a part of scientific social responsibility. The latter is an important and much needed paradigm to diffuse science and technology in the country.

The capacity development of such nature, specifically on the skills acquired at high-end equipment will create a pool of the enthusiastic researchers who will not only contribute in research ecosystem, but can also aspire to join Start-up India, Make-in-India initiatives to exponentially expand expert base and creation of knowledge-driven economy. This is important as we commit our time and resources for a better future.

Toward this end, Accelerate Vigyan through its planned current and future outreach and awareness activities also endeavour to reach out to the entire length and breadth of this country, and bring the benefits of this scheme to relevant stakeholders in real-time. Future will also see the launch of SERB-Accelerate Vigyan mobile app, management information system, gamification modules, and much more to make this scheme vibrant, user-friendly and easily accessible.

Accelerate Vigyan is expected to be a game changer for developing R&D career paths and developing skilled S&T manpower for the nation.

Rajeev Kumar Mehajan* and **Sandeep Verma,** Science and Engineering Research Board, Department of Science and Technology, New Delhi 110 070, India.
*e-mail: mehajan.rk@nic.in

MEETING REPORT

Prospective applications of artificial intelligence/machine learning techniques in earth sciences*

Over the last decade, rapid developments in artificial intelligence (AI) and machine learning (ML) framework have reached a point where these techniques can be used for solving complex problems and to bring new insights to predictive capabilities. Now it is an opportune time to utilize these concepts in earth sciences problems such as weather/climate forecast, climate change, geophysics and other domains. The Ministry of Earth Sciences (MoES), Government of India (GoI) is keen to apply these technologies in improving the weather forecast generated from numerical models.

For kicking-off such activities at MoES, a three-day meeting on the application of AI/ML to earth sciences problems was conducted. The main aim of the meeting was to gather researchers working on AI/ML and scientists from different areas of earth sciences to exchange knowledge, and develop innovative ideas and strategies to demonstrate a wide range of open problems utilizing the potential of AI/ML. Thirty-four delegates from research organizations, industry and academic institutions participated in this meeting. The meeting was inaugurated by the Secretary, MoES, who highlighted the explosive growth of data availability in the field of earth sciences. He emphasized the need of extracting scientific information from these data, and mentioned that computational resources required for such data analysis are now available and AI/ML can offer efficient techniques to retrieve useful information. However, one needs to identify specific areas where these techniques could be used and also the persons/groups who can develop AI/ML tool to address such problems.

The delegates shared their opinions about prospective work that could be pursued on topics related to earth sciences. Few of these are mentioned below.

*A report Meeting on the Application of AI/ML to Earth Sciences held at Indian Institute of Tropical Meteorology, Pune during 25–27 March 2019.

(1) Dynamics-based data-driven models and observation for earth sciences applications

Advances in dynamic understanding and HPC systems have driven the current phase of growth in modelling, predicting and observing earth systems, both in research and operation. With increased availability of remotely sensed and *in situ* observations, the time has now come for earth system scientists to leverage new advances in data-driven ML to improve their dynamic models. There are several ways in which dynamics-based data-driven modelling systems can be developed and utilized. Some of these are:

(a) Big data techniques may be utilized to analyse the vast database of dynamic model outputs to drive insights, thereby (machine) learning the parameters and for tuning of the dynamic models.
(b) Big data platforms and data engineering could enable running massive ensembles that rigorously quantify the uncertainty in forecasts.
(c) Novel ML techniques could be developed to minimize the error between prediction and observation, for example, through data-driven turbulence closure schemes.
(d) ML and AI hold great promise in improving real-time data assimilation without throwing away or thinning of data.
(e) Statistical learning theory could be efficiently applied for problems in downscaling, data gridding, initial and boundary condition estimation from a suite of multi-sensor and multi-model data, rigorously accounting for known uncertainties and climatology.
(f) Repetitive tasks in running dynamic models may be automated by the application of ML paradigms.

Most importantly, the successful application of AI/ML techniques to develop dynamics-based data-driven modelling, predicting and observing systems for earth sciences problems requires computational equipment and trained interdisciplinary researchers. Individual researchers or collective teams must have expertise not in one subject area but in three areas, namely data science, geosciences and computational science.

(2) Hybrid modelling approach and data availability

Many delegates shared their views about data access and its management. They mentioned that there should be data access in a standard format but with some protocols for data sharing, controlled by MoES. Other suggestions are listed below.

(a) There should be an initiative to promote hybrid approach for combining physics-based models (such as LES/DNS) with AI/ML techniques.
(b) Some challenging problems may be formulated and these hybrid models should be employed to solve them. This can provide an opportunity to assess the merits and demerits of various approaches used in the model developed.
(c) MoES may support (financially) a small number of blue-sky proposals to work on fundamental theoretical breakthroughs required to apply ML to earth sciences problems. These problems may be high-risk and high-reward, such as prediction of extreme events.

Most of the delegates opined that extensive data are required to work on the AI/ML models and therefore such data should be available in a common platform user-friendly manner.

(3) Hydrological modelling

Delegates from the field of hydrology provided suggestions for adequate use of AI/ML in modelling of hydrological flows. According to them, there is considerable scope for the use of AI/ML to tackle many unsolved problems in the field of earth sciences. Few important research problems in this area, where AI/ML approaches can be applied, are as follows:

(a) Hydrological modelling and hyperspectral image processing for natural resource mapping.
(b) Downscaling of climate products (rainfall and temperature) focusing on extreme events, prediction of rainfall and stream flow over a river basin considering inherent time-varying characteristics.

(4) Geoscience and seismology

The prospective scope of ML in geoscience and seismology was discussed. The main topics in seismology where the AL/ML techniques can be applied include: (a) earthquake detecting and phase picking, (b) earthquake early warning, (c) prediction of ground motion, (d) seismic tomography and (e) to understand earthquake geodesy and deformation.

Meeting conclusions. During this meeting it was acknowledged that there is a lack of trained people available in the country. Moreover, experts from this area should be connected to each other by working under one umbrella. Therefore, it is important to create a community of researchers working on applications of AI/ML, specifically targeted towards weather, climate and related areas.

It also stressed that researchers in the community should share their ideas on AI/ML as well as on the data. MoES can list its strategic goals for AI/ML and invite proposals for the same. These goals may also include management/decision-making problems, which an AI/ML expert can easily solve, and these well-defined problems can be floated as open challenges. A joint framework allowing such free exchange would be ideal. Another point raised was to publish such meeting/workshop reports in journals to apprise the scientific community.

At the end of meeting an open panel discussion was held that aimed to understand the state-of-the-art applications of AI/ML techniques for weather/climate forecasting and other earth sciences problems. This discussion provided a valuable opportunity to develop better understanding of the challenges involved in applying AI/ML techniques in the following areas: (i) Improving weather forecast modelling; (ii) Hydro-climate database management; (iii) Oceanography modelling; (iv) Management of big data obtained from numerical models; (v) Data-driven problems from geoscience and seismology; (vi) Remotely sensed data; (vii) Flow computations.

Bipin Kumar*, Ravi S. Najundiah and **Moumita Bhowmik,** Indian Institute of Tropical Meteorology, Pune 411 008, India; **Ravi S. Najundiah,** Centre for Atmospheric and Ocean Sciences, Indian Institute of Science, Bengaluru 560 012, India.
*e-mail: bipink@tropmet.res.in