Ministry of Earth Sciences (MoES)
Summary of Important Developments –April, 2019

1. Important policy decisions taken and major achievements during the month: Provided in Annex I.

2. **Important policy aspects / matters held up on account of prolonged Inter- Ministerial consultations/ delays, etc.:** Nil

3. Compliance of COS decisions:

S.No.	**Number of COS decisions pending for compliance**	**Proposed action plan/timelines**	**Remarks**
1.	Dt 14/08/2014 PROPOSAL FOR KRILL FISHING MoES, in collaboration with MEA, will study the experience of different countries showing varied interest in krill fishing so that India could learn from their experiences.MEA, in collaboration with MoES, will examine and identify the countries with which India can collaborate for krill fishing. MoES will ascertain the interest of Indian industry in krill fishing and also explore the feasibility of Indian companies collaborating directly with foreign companies MoESwill study legislations enacted by other member countries before finalising the draft legislation as part of international convention obligations. MoES will bring out a paper on krill fishing giving a detailed account of demand analysis, financial viability, interest of industry, experiences of other countries, criteria for fishing license, existing knowledge gap, etc. Thereafter, the CoS will meet again to decide whether India should engage in commercial krill fishing.	The Ministry has examined the aspect of Krill fishing. Japan &Norway have developed expertise and these countries have been tentatively identified for collaboration on Krill fishing. Their experiences have been obtained. Indian Industries have been approached for Krill fishing to ascertain their interests. However, so far we have not received any response. The draft paper is prepared and suggestions of Cabinet Secretariat have been obtained.	A proposal has been received for krill fishing which is under examination.

- **Cases of sanction for prosecution pending in the Ministry for more than three months:** Nil

- **Particulars of cases in which there has been a departure from the Transaction of Business rules of established policy of the Government:** Nil

- **Status of implementation of e-Governance :** Being implemented

- **Status of Public grievances:**

No. of Public Grievances redressed during the month	No. of Public Grievances pending at the end of the month
21	40

8. Information on the specific steps taken by the Ministry/Department for utilization of the Space Technology based tools and applications in Governance and Development:

Potential Fishing Zone advisories are generated using the satellite derived parameters viz. Sea Surface Temperature, and Chlorophyll. Further, data from Global satellite data are used on continuous basis for generating short range and medium range weather forecasts.

9. (i) **Confirmation that the incumbency details of all posts in the Ministry/Department and its organizations falling under the purview of the ACC have been updated on AVMS**: It is confirmed that the incumbency details of all the posts in the Ministry/Department and its organizations falling under the purview of the ACC have been updated on AVMS and are placed at Annex-II.

(ii)**Status regarding compliance of the directions of ACC**: It is also confirmed that the directions of ACC are complied with.

(iii)**Status of cases where recommendations from PESB have been received but the proposals are yet to be submitted to the ACC Secretariat**: NIL

****

Annex-I

Important policy decision taken and major achievements:

1. **The Extremely Severe Cyclonic Storm(ESCS), FANI** (26 April-04 May) developed over the Bay of Bengal which crossed Odisha coast close to Puri with maximum sustained wind speed of 175-185 kmph during 0800 to 1000 hrs IST of 03rd May, 2019 was closely monitored and predicted continuously by IMD with the help of available satellite observations, and available ships & buoy observations in the region. Accurate landfall point forecast near Puri and its intensity at the time of landfall on 3rd May, 2019 with sufficient lead time (at least 72 hrs before landfall) helped in minimising loss of human lives due to this cyclone. The forecasts issued on 30th April, 1st & 2nd May were almost same as actual track of the cyclone. Various numerical weather prediction models developed by MoES institutions and dynamical-statistical models were utilized to predict the genesis, track, landfall and intensity of the cyclone. A digitized forecasting system of IMD was utilized for analysis and comparison of various model guidance, decision making process and warning product generation. All the efforts by IMD in collaboration with other MoES institutions viz. NCMRWF, IITM, INCOIS and NIOT in combating disaster due to the cyclone, FANI through accurate weather forecasts and effective early warning system have been widely appreciated by the United Nations and other agencies including disaster managers, press, electronic & social media and general public.
2. **Long Range Forecast of the 2019 Southwest Monsoon Seasonal Rainfall** indicates that the monsoon seasonal (June to September) rainfall is likely to be 96% of the Long Period Average (LPA) of 89 cm with a model error of ± 5% .
3. **Seasonal Outlook for the Temperatures during April-June, 2019:**The April to June (AMJ) season average maximum temperatures are likely to be warmer than normal by 0.5°C over most of the meteorological subdivisions from central India and some subdivisions from northwest India. Near normal maximum temperatures are likely in the remaining subdivisions. The seasonal average minimum & mean temperatures over West Rajasthan are likely to be above normal by more than 1.0°C. Above normal heat wave conditions are likely in the core heat wave (HW) zone during the season (April to June).

There was no matter pending before the Cabinet requiring decision/approval.

Minimum Government, Maximum Governance:

- Dissemination of Agromet Advisories to user communities through SMS and IVR technology is continued in the country through Kisan Portal and under PPP mode. Presently, 40 million farmers in the country are getting advisories through SMS directly.
- Adverse-weather SMS warnings are being sent through mobile to the State Government officials / Disaster-related officials / Central Government organizations/common man.
- Daily forecast along with warning and city forecast for many cities are disseminated through email to all users including state authorities, electronic and print media.

Atmospheric Observation Systems Network

Observation Type	Commissioned so far	Installations during the month	Data Reporting
Automatic Weather Station (AWS)	682	--	232
Automatic Rain Gauge (ARG)	1350	--	498
GPS Sonde based RS/RW Stations	43	--	38
Doppler Weather Radar (DWR)	25	--	24
Ozone (Ozone Sonde + Total Ozone)	05	--	04
Surface Ozone (Electrochemical Concentration Cell method)	07	--	07
Nephelometer	12	--	12
Sky Radiometer	20	--	19
Black Carbon Monitoring Systems (Aethalometer)	25	---	23
Air Quality Monitoring System (SAFAR)	10(Delhi) 10(Mumbai) 10(Ahmedabad)	--	10(Delhi) 10(Mumbai) 10(Ahmedabad)
Hydromet. (IMD & Extra-departmental excluding AWS & ARG)	---	--	2570
Aviation	79		79

Atmospheric Processes, Modelling and Services

Rainfall in April,2019: Rainfall during the month of April, 2019 was large excess in 10, excess in 3, normal in 11, deficient in 10, large deficient in 3 and no rain in 0 of 36 meteorological sub- divisions. The rainfall for the country as a whole for the month of April, 2019 has been recorded as 29.9 mm which is 22% below its Long Period Average (LPA) of 38.3 mm.

Temperature Scenario: The Mean Temperature for the month for the country as a whole was 28.82°C; this was slightly above normal (+0.77°C).

Monthly weather summary:

(a) Extremely Severe Cyclonic Storm, FANI: The Extremely Severe Cyclonic Storm (ESCS) "FANI" (26 April-04 May) developed over the Bay of Bengal as a low pressure system near the equator on 25th April morning. It initially moved north-northwest wards till 30th April towards west-central Bay of Bengal off south Andhra Pradesh coast. It then moved north-northeastwards and crossed Odisha coast close to Puri as an extremely severe cyclonic storm (ESCS) with maximum sustained wind speed of 175-185 kmph during 0800 to 1000 hrs IST of 03rd May, 2019. Thereafter it moved across coastal Odisha, Gangetic West Bengal and Bangladesh and weakened gradually becoming a low pressure area over Central Assam. This cyclone had following unique features:

(i) It had one of the longest track with track length of about 13,500 km

(ii) It had a recurving track as it moved north-northwestwards initially and later moved north-northeastwards upto northeastern states across coastal Odisha and West Bengal.

(iii) It was the most intense cyclone to cross Odisha coast after Phailin in 2013 which crossed coast with a maximum sustained wind speed of 215 kmph.

(iv) It had rapid intensification during 29th to 30th April evening over westcentral Bay of Bengal, mainly due to higher Ocean heat content .

IMD maintained round the clock watch over the north Indian Ocean and the cyclone was monitored one week prior to the formation of low pressure area over the Bay of Bengal and adjoining equatorial Indian Ocean on 25th April. First information about formation of low pressure during week ending 25th and beginning of week ending at 2nd May with probability of intensification into depression was indicated in the extended range outlook issued by IMD on 18th April. Thus the cyclone was monitored & predicted continuously from 18th April onwards by India Meteorological Department (IMD) even prior to development of low pressure area over east equatorial Indian Ocean and adjoining southeast BoB on 25th April.

The cyclone was monitored with the help of available satellite observations from INSAT 3D and 3DR, polar orbiting satellites, and available ships & buoy observations along with associated ocean state parameters waves, current speeds and other oceanic parameters offshore and near shore in the region. From 1st May onwards till 4th May, the system was tracked gradually by IMD Doppler Weather Radars at Chennai, Machillipatnam, Visakhapatnam, Gopalpur, Paradeep and Kolkata as it moved from south to north.

Various numerical weather prediction models developed by MoES institutions and dynamical-statistical models were utilized to predict the genesis, track, landfall and intensity of the cyclone. A digitized forecasting system of IMD was utilized for analysis and comparison of various model guidance, decision making process and warning product generation.

Comparative analysis of the forecast performance for these cyclones with the long period average indicates that the errors in landfall, track and intensity forecast were remarkably less. Accurate landfall point forecast near Puri and its intensity at the time of landfall with sufficient lead time (at least 72 hrs before landfall) helped in minimising loss of human lives due to this cyclone. The track forecast issued 72 hrs prior to landfall alongwith the actual track indicating accurate prediction of landfall point near Puri. The forecasts issued on 30th April, 1st & 2nd May were almost same as actual track of the cyclone.

IMD issued warning and advisory bulletins to National & State Disaster Management Agencies, general public and media since inception of the system over BOB on 25th April 2019. A few salient features of warnings and advisories issued by IMD are as follows:

- Cyclone Watch (about 90 hrs prior to landfall) for Odisha coast was issued at 1430 IST of 29th April when it was indicated that the system would move northwestwards till 1st May and recurve north-northeastwards towards Odisha coast. The cyclone watch was extended to West Bengal coast at 1200 hrs IST of 30th April.
- It was further indicated at 2100 hrs IST of 29th that the system would cross Odisha coast around Puri in the early morning of 4th May (about 84 hrs prior to landfall) as an extremely severe cyclonic storm with maximum sustained wind speed of 160-170 gusting to 190 kmph.
- Cyclone Alert: for Odisha, West Bengal & Srikakulam and Vijayanagaram Districts of Andhra Pradesh coasts was issued at 1520 hrs IST of 30th April indicating that the cyclone would cross Odisha coast to the south of Puri around 3rd May afternoon with wind speed of 175-185 kmph gusting to 205 kmph (about 66 hrs prior to landfall). The time of landfall was revised to 3rd May forenoon at 1600 IST of 2nd May.
- Cyclone Alert was upgraded to Cyclone Warning at 2030 IST of 1st May.

The tropical cyclone forecasts along with expected adverse weather like heavy rain, gale wind and storm surge was issued with every three hourly update during cyclone period and hourly update from one day prior to landfall to the central, state and district level disaster management agencies including MHA NDRF, NDMA, all concerned states (Kerala, Tamil Nadu, Puducherry, Andhra Pradesh, Odisha, West Bengal, Assam and Meghalaya). The warning bulletin also contained the expected damages and suggested action for disaster managers and general public in particular for fishermen. These bulletins were also issued to defence including Indian Navy, Indian Coast Guard & Indian Air Force. The warning SMS were also sent to 3 lakh registered users in the east coast of India and at Andaman & Nicobar Islands.

IMD also issued regular bulletins to WMO/ESCAP Panel member countries including Bangladesh, Myanmar, Sri Lanka, and Thailand. It may be mentioned here that IMD acts as World Meteorological Organisation (WMO) recognised Regional Specialised Meteorological Centre (RSMC New Delhi) for issue of advisories to WMO/ESCAP Panel member countries including Bangladesh, India, Myanmar, Maldives, Oman, Pakistan, Sri Lanka, Thailand, Yemen, Iran, Qatar, Saudi Arabia and UAE.

All the efforts by IMD in collaboration with other MoES institutions in combating disaster due to the cyclone, FANI through accurate weather forecasts and effective early warning system have been widely appreciated by the United Nations and other agencies including disaster managers, press , electronic & social media and general public.

(b) Heavy Rainfall Activity: Heavy Rainfall Activity: Very heavy rainfall observed at isolated places over Assam & Meghalaya & Bihar and heavy rainfall at isolated places over Punjab, Haryana, Arunachal Pradesh, Nagaland, Manipur, Mizoram & Tripura, West Bengal & Sikkim, Karnataka, Coastal Andhra Pradesh, Telangana, Lakshadweep and Andaman & Nicobar Islands on one or two days of the month April, 2019.
No. of Heavy rainfall events and (% correct) of spatial distribution of warnings during April 2019 are given below:

Lead Time	No. of Heavy Rainfall (Events): 31 (>64.4mm)
24 Hour	95%
48 Hour	96%
72 Hour	96%

(c) Thundersquall & Hailstorm activity: Thundersquall & Hailstorm activity during the month is given in the table below**:**

S. No.	Region	TS Days	Date of Maximum TS Activity	Hail Events	Squall Events
1.	South Peninsular India	21	22-04-19	Nil	Nil
2.	Northwest India	20	16-04-19	04(Sundernagar, Baharaic, Basti, Tehri on 06-04-19) 02(Pantnagar, Tehri on 08-04-19) 01(Shimla on 18-04-19)	01(Amritsar on 15-04-19)
3.	Northeast India	11	02-04-19	01(Shillon on 06-04-19) 01(Shillon on 20-04-19)	02(Agartala on 02-04-19) 01(Agartala on 06-04-19) 01(Gauwahati on 20-04-19) 01(Lengpui on 20-04-19)
4.	East India	18	06-04-19	01(Gopalpur on 01-04-19) 02(Gangtok, Tadong on 02-04-19) 01(Bankura on 02-04-19) 01(Bhagalpur on 09-04-19) 01(Balasore on 21-04-19)	02(Alipur 05-04-19) 04(Alipore, Haldia, Digha Bankura 06-04-19) 02(Alipore, DumDum 06-04-19) 01(Jharsuguda 06-04-19)
5.	Central India	18	11-04-19	02(Guna, Sagar 17-04-19)	01(Nagpur 15-04-19) 02(Nagpur 16-04-19) 01(Nagpur 21-04-19)
6.	West India (Goa only)	06	15-04-19	01(Aurangabad on 13-04-19) 01(Aurangabad on 13-04-19)	Nil

Note: The convective activities mentioned above had been predicted and corresponding warnings were issued about 4-5 days in advance of the occurrence of the event. Daily regular bulletins and 3-hrs nowcast against severe weather was

issued by IMD at 433 stations and all district levels. Two press release were issued prior to enhanced rainfall/thunderstorm activity over north India during 16-18 April 2019.

(d) Heat wave and maximum temperature: Heat wave to severe heat wave observed at a few places over Vidarbha on a few days and over Rajasthan, south Uttar Pradesh & West Madhya Pradesh on one or two days. Heat wave observed at a few places over Gujarat, Madhya Maharashtra, Marathwada and Telangana on a few days and over south Chhattisgarh, Himachal Pradesh & Haryana on one or two days of the month. The highest maximum temperature of 47.50C was recorded at Khargone (West Madhya Pradesh) on 24th April 2019 over the plains of the country during the month of April, 2019.

Modelling and Research

1) Hurricane Weather Research and Forecasting (**HWRF**) analysis system was modified to assimilate INSAT radiances and Atmospheric Motion Vectors(AMVs). Using this analysis scheme, HWRF forecasts for the Tropical Cyclone Fani have been generated

2) During April, on daily basis, National Centre for Medium Range Weather Forecasting(NCMRWF), an attached office of MoES provided customized Sea-Ice forecast up to 10 days in advance for the region off Maitri, the Indian station of Antarctica to facilitate day-to-day operations related to ship movements for the Antarctica Expedition. NCMRWF coupled ocean-atmosphere-Sea-Ice model was used for the Sea-Ice forecasts which were found to be very useful and reliable.

3) Development of the "Modeling framework for thunderstorm/ lightning prediction" has been set up by Indian Institute of Tropical Meteorology for operation based on a new approaches using 'dynamical lightning parameterization' in WRF. The system is presently generating Real Time Forecast every day at High Performance Computer "Aaditya" and the forecast is made available at the link: http://srf.tropmet.res.in/srf/lightening_flash/index.php .

4) An MOU was signed with Nuclear Power Corporation Limited (NPCIL) for exchange of data for mutual use in research and operations on 10th April 2019 at Mumbai. The data from NCMRWF will be used in Real time On-line Decision Support System (RO_DSS) for estimation and prediction of radiation doses in the public domain during nuclear emergencies.

Bulletins / Operational Reports/ Services during the month

1) All India Weather Bulletins, All India Inference and Severe Weather Warnings 120 each and 60 (daily twice) Heat Wave Bulletins were issued during the month; Current Weather Outlook and Forecast for next two weeks (4) , All India Weekly Weather Reports (4) and 30 (daily once) Forecast Demonstration (FD) Storm Bulletins were also issued during the month. Sixty (60) mountain weather bulletins including severe weather warnings for western and central Himalayan region were issued during the month.

2) A total of 60 Nowcast Guidance Bulletins for severe weather were issued (daily twice) during the month.
All India Weather Bulletins and All India Inference and Severe Weather Warnings (120 each) were issued.

3) Daily All India Weather Summary and Weekly Weather Reports and are being brought out on routine basis.
Monsoon Report 2018 released on 27 April 2019.

4) ENSO bulletin & Indian Ocean Dipole (IOD) Bulletin for the month of April 2019 and Seasonal Climate Outlook for South Asia for the month of April to July 2019 were issued. (Quick Link : www.imdpune.gov.in/Clim_Pred_LRF_New/Products. html).

5) Climate Diagnostics Bulletin of India for March 2019 was brought out and has been uploaded in IMD Pune website.

Geoscience Research

Seismological Observational Network

Observation Type	Target	Commissioned so far	Data reporting during the month
Seismic stations	115	115	106
GPS stations	40	20#	19

#10 VSATS (6) have been dismantled to shift them to new locations.

Earthquake and Tsunami monitoring

Earthquake: 52 earthquakes were monitored in the Indian region out of which 16 events were greater than magnitude (M) of 5.0.
Tsunami**:** 2 seabed earthquakes (M> 6) with a potential to generate tsunami occurred. This information was provided within 12 minutes of occurrence for both the events.

Ocean Observation System

Type of Platform	Target	Commissioned till April, 2019	Data received during April, 2019
Argo Floats *	200	328	131
Drifters*	150	108	2
Moored Buoys	16	22	19
Tide Gauges	36	36	26
High Frequency(HF) Radars	10	10	10
Current Meter Array	10	11	2
Acoustic Doppler Current Profiler(ADCP)	20	20	17
Tsunami Buoys	7	9	6
Wave Rider Buoy	16	22	15

*The remaining floats/drifters have completed their life time and as such no data can be received from them.

Ocean Science Services

No	Types of forecasts	No. of advisories issued during the month
1	Integrated Potential Fishing Zone (PFZ) advisories (Sea Surface Temperature(SST), Chlorophyll., wind)	30
2	Tuna Fishing Advisories	28
2	Ocean State Forecast(OSF)-Wave, Wind, Currents, SST, MLD and D20 forecasts	30
3.	Near Real time global ocean analysis (5-day averaged)	6
4.	Real time global ocean analysis (daily)	29
5.	Coral Bleaching Alert System	10

Perigean Spring Tide Alert issued for the coastline of India for the period during February 19-24, 2019.

Marine Living Resources

1) Recent diving surveys conducted in Lakshadweep waters brought 2 species of polyclads new to science along with new records of 5 species of polyclads and 2 species of echinoderms viz *Lamprometra palmata*, *Ophiarachnella septimspinosa.* Compilation of published records of marine faunal species from the Indian waters based on check-lists and observational literature sources yielded 13,259 species across 24 animal phyla. These data entitled as "Check-list (Version 1)" has been uploaded to the Ocean Biogeographic Information System (OBIS) website hosted by Centre for Marine Living Resources and Ecology, an attached Office of MoES.

2) Report of the project "*Marine Ecosystem Dynamics of eastern Arabian Sea (MEDAS)"* has been released during the review meeting held at NCPOAR, Goa on 8-9th April, 2019. The report indicates that the ecosystem of central western shelf of India between 12-18°N (equivalent to 50% of entire west coast of India) is under severe stress during late summer monsoon (September) due to intense anoxic conditions which is naturally formed, with no traces of fertilizer runoff as reported earlier, but due to upwelling of highly deoxygenated waters from the core of the strong oxygen minimum zone of the Arabian Sea. This infers that the western shelf ecosystem is least perturbed by the anthropogenic effects (excluding solid wastes like plastic, debris, etc.). Intense anoxic regions have been found as 'hot spots' for the greenhouse gases (CO_2, N_2O and CH_4) production.

3) For the first time mesozooplankton elemental composition with respect to carbon(C) and nitrogen (N) concentrations has been studied and found that they vary significantly among its groups; copepods, a predominant group, are highly enriched (40-60% C and 8-12% N) and almost double to that of ostracods, and no seasonality in their elemental concentrations. These findings are very important to understand the energy transfer between the trophic food chain and accurate estimation of tertiary (fishery) production.

Polar Science and Expedition

The Ice class chartered vessel MV Vasiliy Golovnin carrying 38 expedition members of 30th Indian Scientific Expedition to Antarctica including helicopter pilots and 44 ship's crew were stranded in Antarctic sea due to hardening of sea ice owing to early arrival of winter season. On 2nd April, the vessel came out of the icy waters with the help of the Polar Research Vessels RV Akademic Fedorov of Russian Arctic and Antarctic Institute.

Coastal Research

Shoreline change maps for Tamil Nadu, Andhra Pradesh , Odisha and West Bengals (1990-2016) are updated with latest shoreline data of year 2017.

Capacity Building and Outreach

The half yearly review meeting of programmes of MoES was organised in Goa from 8-9 April, 2019 and detailed presentations were made in respect of various components of the schemes of MoES.

Utilization of Ocean Research Vessels during the month

Vessel	Days at Sea / Utilization	Maintenance/ Inspection /Scientific Logistics / Cruise Preparation	No. of Cruise
Sagar Nidhi	20	510	2
Sagar Manjusha	22	8	2
Sagar Purvi	15	15(maintenance)	2
Sagar Kanya	19	11	1
Sagar Sampada	0	30(assessment of fire incident)	-

Publications in Science Citation Index(SCI) journals and PhDs awarded

Subject	Publications		Ph.Ds	
	April, 2018 - March, 2019	April, 2019	April, 2018 - March, 2019	April, 2019
Atmospheric Sciences	216	15	6	--
Ocean Science and Technology	74	8	2	-
Polar Sciences	25	2	-	-
Geosciences and resources	7	-	1	--
Total	322	25	9	--