

Bio Data

1. **Name** **Dr. Mrutyunjay Mohapatra**
2. **Date of Birth** **12th August, 1965**
3. **Present Affiliation** **Director General of Meteorology,
India Meteorological Department,
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m.mohapatra@imd.gov.in**
6. **Education** **M.Sc. (Physics) and Ph. D. (Physics)**
7. **Professional Training details**

Organization	Period		Details of Training
	From	To	
IMD, Pune	20 Oct. 1992	19 Oct. 1993	Meteorologist Gr II Training on General Meteorology (Weather forecasting)
IMD, New Delhi	12 Sep. 1994	23 Sep. 1994	Advance Refresher Course on Satellite and Radar input for cyclone warning
IMD, Pune	15Jan. 1996	19 Jan. 1996	Advance Refresher Course on Long Range Forecasting and Climate Change
Centre for Atmospheric Sciences, IIT, Delhi	08 Apr. 2002	04 May 2002	Third SERC School on Numerical Weather Prediction (NWP) on Parameterisation of physical processes
-Do-	14 Apr. 2003	10 May 2003	Fourth SERC School on NWP on Process modeling
Central Water Commission, Govt. of India, Bhubaneswar	9 Nov. 2003	13 Nov. 2003	Training workshop on „Design Flood Estimation for Water Resources Projects“
Administrative Staff College of India, Hyderabad	01 Aug. 2005	09 Sep. 2005	Advanced Techno-Management programme for Scientists and Technologists on Various theoretical aspects of management
Meteo-France and Meteo-France International, Toulouse, France	31 Aug. 2009	25 Sep. 2009	Weather forecasting for IMD and Synergie System Forecasters Factory Training on Application of satellite, radar and NWP in weather forecasting, nowcasting and heavy rainfall warning
National Hurricane Center (NHC), NOAA, Miami, Florida, USA	21 Mar. 2011	01 Apr. 2011	RA IV Training Workshop on Hurricane Forecasting and Warning and Public Weather Services

8. Employment records (in chronological order starting with the first job)

Name and address of employer/institution	Period		Details including designation and responsibility area		
	From	To	Designation of post held	Responsibility area	
Interim Test Range (ITR), Defence Research and Development Organisation (DRDO), Chandipur, Balasore, Orissa	29. 02. 1988	04. 03. 1990	Junior Scientific Assistant	Fiber Optic Communication and Data Management	
D. K. College, Jaleswar, Balasore, Orissa	05. 03. 1990	17. 10. 1992	Lecturer in Physics,	Teaching in undergraduate classes	
India Meteorological Department (IMD), Pune	20. 10. 1992	19. 10. 1993	Meteorologist Gr. II Trainee	Training	
Meteorological Centre, and Agromet Research Unit, IMD, Bangalore	20. 10. 1993	14 06.1998	Meteorologist Gr. II	Weather forecasting, Climatology, Aviation Meteorology, Agrometeorology	
Meteorological Centre, IMD, Bhubaneswar	15. 06.1998	09.12. 1998	Meteorologist Gr. II	Weather forecasting and Cyclone Warning, Climatology, Aviation Meteorology	
Meteorological Centre, IMD, Bhubaneswar	10. 12. 1998	22. 02.2004	Meteorologist Gr. I	Weather forecasting and Cyclone Warning, Climatology, Aviation Meteorology	
Regional Meteorological Centre, IMD, Guwahati	23. 02. 2004	16. 10. 2005	Director	Weather forecasting, Climatology, Aviation Meteorology	
National Weather Forecasting Centre (NWFC) formerly Northern Hemispheric Analysis Centre (NHAC), IMD, New Delhi	17. 10. 2005	30. 06. 2010	Director	Weather forecasting and Cyclone Warning,	
NWFC (Formerly NHAC), IMD, New Delhi	01.07. 2010	30.06. 2015	Scientist-E	Weather forecasting and Cyclone Warning, Disaster management.	
NWFC (Formerly NHAC), IMD, New Delhi	01.07. 2015	28. 01. 2016	Scientist-F	Weather forecasting, Numerical Weather prediction (NWP) and Cyclone Warning, Disaster management	
IMD New Delhi	29.01. 2016	31.07. 2019	Scientist-G	Weather forecasting, Numerical Weather prediction (NWP) and Severe weather warning, Disaster management	
IMD New Delhi	01.08. 2019		Director General of Meteorology	India Meteorological Department	

9. (a) Field of research.

Research work is mainly based on weather forecasting & cyclone warning including

- (i) Cyclonic disturbances,
- (ii) Monsoonal low pressure systems,
- (iii) Heavy rainfall,
- (iv) Thunderstorm and
- (v) Forecast verification

9. (b) Publications

- **Papers published in journals:85**
(National=50, International=35)
- **Proceedings in Symposia/Workshops/Conference:26**
(National = 11, International = 15)
- **Publication in Books:42** (National=17, International = 25)
- **Books edited: 18**(National = 4, International = 14)
- **Journals edited: 05** (National = 4, International = 1)
- **Journals/Books reviewed:18** National=4,
International=14)
- **Reports published by IMD** with my
contribution:18 Details of research work and
publications are given in **Enclosure – I (a-f)**
H-Index:18, I₁₀=38, RG score : 31.14

10. (a) Specialization

Weather forecasting Services

(b) Scientific Contribution

Given in **Enclosure II**

11. Membership of Societies

- (i) President, Indian Meteorological Society (2020-22)
- (ii) Vice-President, Indian Meteorological Society (2016-18)
- (iii) Life Member, Indian Meteorological Society
- (iv) Life Member, Indian Climate Congress
- (v) Life Member, Administrative Staff College of India Society

12. Awards and recognitions received

(a) Awards

- (i) Honorary Doctor of Science from FM University, Balasore, Odisha-2020
- (ii) Fellow, Indian Meteorological Society, 2019
- (iii) Fellow, Indian Climate Congress, 2019
- (iv) Bharat Gaurav Award-2019 by Jai Bharat Foundation, Cuttack Odisha
- (v) Felicitation by Sh. Naveen Pattanaik, Chief Minister, Odisha for outstanding contribution in disaster management
- (vi) Satyasai Samman-2019 by Satyasai Charitable and Education Trust, Odisha for distinguished contribution in cyclone forecasting and meteorological applications
- (vii) Bhumiputra Samman 2020 by the Biplbi Beera Chakradhar Smruti Sansad, Ghanteswar, Odisha for Cyclone Warning Services
- (viii) Achiever's Award-2013 for excellence in cyclone warning services to Cyclone Warning Division from India Meteorological Department
- (ix) Certificate of Merit for Young Scientist Award – 2008 by Ministry of Earth Sciences, for outstanding contribution in the field of atmospheric science and technology.
- (x) 25th Biennial Mausam Award (2008-2009) for the paper, published in MAUSAM
- (xi) Commendation certificate during 1989 from Defence Research and Development Organisation, for contribution to Integrated Guided Missile Development Programme
- (xii) Commendation Certificates-2019 and 2020 from various organizations for prediction of cyclone
 - Ganatantrik Nagarik Parishad, Bhadrak Odisha
 - Zila Biju Smriti Committee, Bhadrak Odisha
 - Odisha Forum, New Delhi
 - Retired Employees Association, Bhadrak, Odisha
- (xiii) Felicitation by Utkal University in recognition to cyclone warning services
- (xiv) Felicitation by Berhampur University, Odisha for excellence in cyclone warning services

(b)Appreciations

- (i) Appreciations received for improvement in cyclone warning services
 - Appreciations received globally and nationally from government and non- government agencies including WMO, NDRF, IAF, State Govts for successful predicting of cyclones during 2013-2020
 - Publications in leading TV/News Papers of India highlighting the role of Dr M Mohapatra in improvement of cyclone warning services
 - Documentary/interview in TV and Newspapers on life and achievements of Dr M Mohapatra
- (ii) Appreciations from WMO, NIDM, IMD for official publications
- (iii) Appreciations from WMO, IMD for delivering and organizing lectures, conference/workshop

(c) Chairperson/ expert member of the International and National Committees

1. Chairman of International Committee

- (i) Chairman, WMO/ESCAP Panel on Tropical Cyclones for 2017- 18.
- (ii) Chairman, Regional Sub-project Management Team of Severe Weather Forecast Programme for South Asia
- (iii) Chairman, Task Team for finalization of Meteorological Payloads of INSAT-4 satellites to be launched 2025
- (iv) Chairman, Committee for revision of NDMA Guidelines for cyclone management,
- (v) Chairman, Technical Evaluation Committee for Consultancy on National Cyclone Risk Mitigation Project NDMA, Govt. of India.

2. Expert Member of the International Committees

- (i) Permanent Representative of India with WMO with effect from June, 2019
- (ii) Member Executive Council, WMO with effect from June, 2019-23
- (iii) Storm Surge India (SSI) group under the auspices of Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) since 2009
- (iv) International Organising Committee (IOC) of WMO's 8th and 9th International Workshop on Tropical Cyclones (IWTC-9), 2014 and 2018 and WMO's 4th International Workshop on Tropical Cyclone Landfall Processes (IWTCLP-4), 2014 and 2017
- (v) WMO's Tropical Cyclone Panel : climate impact on tropical cyclones.
- (vi) WMO Commission for Climatology (CCI): Weather and Climate Extremes evaluation committee for Weather Mortality extremes.
- (vii) WMO Executive Council of Panel of Experts on Polar and High Mountain Observations, Research Services (EC-PHORS)
- (viii) WMO Committee for deciding mortality extremes due to severe weather events.

3. Chairman of National Committees

- (i) President, Indian Meteorological Society since 2020,
- (ii) Vice President of Indian Meteorological Society during 2017-18
- (iii) Project Review Board of National Institute of Ocean Technology

4. Expert Member of the National Committee

- i. Committee by National Disaster Management Authority (NDMA), Government of India for preparation of Cyclone Hazard Prone Districts of India.
- ii. Committee constituted by Ministry of Home Affairs (MHA), Govt. of India for preparation of Blue Book on lessons learnt on management of cyclones.
- iii. Management Committee to review the progress/functioning of existing Research Chairs established in IITs/NITs on Climate Change
- iv. Committee for development of Chennai Flood warning System
- v. Expert Member from MoES for the Bureau of Standards Smart City
- vi. Sub-committe for Atmospheric Applications and Research for better coordination between ISRO/DOS and ESSO-MoES in enhancing satellite data utilization for weather and climate.
- vii. Committee constituted by Central Electricity Authority to study the causes of frequent

- failures of transmission towers and sub-station equipment in and around Agra region
 - viii. Cauvery Water Regulation Committee constituted by Ministry of Water Resources
 - ix. Committee constituted by NDMA for preparation of Guidelines on Thunderstorms, Squall and Lightning.
 - x. Management Committee and Chairman of the sub-committee on “Short and Medium range Forecast” for development of Monsoon Mission Products website and Mobile App.
 - xi. Cyclone Resistant Structure Sectional Committee (CED-57), Bureau of Indian Standards for development of guidelines for design and construction of Cyclone Shelters/Tsunami Shelters.
 - xii. Steering Committee for Common Alert Protocol (CAP) project of NDMA
 - xiii. Research Advisory Committee of INCOIS to provide the guidance for the scientific research and technical activities undertaken at INCOIS during 2015-19
 - xiv. National Coordination Committee for Polar Science Programme (NCCPSP)
 - xv. Monsoon Mission Programme, Ministry of Earth Sciences
 - xvi. Governing Council, Indian Institute of Tropical Meteorology, Pune
 - xvii. National Water Development Authority, Ministry of Jal Shakti
 - xviii. National Maritime Search and Rescue Board
 - xix. Peer Committee constituted by Indian National Academy of Engineering for technological preparedness for dealing with national disruptions.
- (d) Recognition as Guide for research**
- (i) Recognised as Guide for Ph.D work in
 - (a) Banaras Hindu University
 - (b) Amity University, Gurgaon, Haryana,
 - (c) Amity University, Noida,
 - (d) IIT, Delhi.
 - (ii) Ph.D. Awarded/submitted: 2 and Continuing: 4
 - (iii) Acted as Guide for B. Tech project thesis for seven students including one from UK and other from USA.

Enclosure I: Publications and Research & Development

(a) Papers published in reviewed national and international journals

1. U C Mohanty, **M Mohapatra** , Karumuri Ashok , R Krishnan , Jasti S Chowdary and Parthasarathi Mukhopadhyay, 2020 Indian Monsoons Variability and Extreme Weather Events: Recent Improvements in Observations and Modelling, Proc Indian Natn Sci Acad 86, 503-524
2. K. Singh, , Panda, J. & **M. Mohapatra**, 2020 Robustness of best track data and associated cyclone activity over the North Indian Ocean region during and prior to satellite era. *J Earth Syst Sci* **129**, <https://doi.org/10.1007/s12040-020-1344-x>
3. SD Sanap, **M Mohapatra**, MM Ali, P Priya And D Varaprasad, 2020, On the dynamics of cyclogenesis, rapid intensification and recurvature of the very severe cyclonic storm, Ockhi, J. Earth Syst. Sci., 129, <https://doi.org/10.1007/s12040-020-01457-2>
4. P Mukhopadhyay, R Krishnan, RS Nanjundiah, **M Mohapatra**, 2020, Prediction of Extreme Events: Current Status and Future Pathways against the backdrop of climate change, Bulletin of the American Meteorological Society, <https://doi.org/10.1175/BAMS-D-20-0037.1>
5. Shyama Mohanty, Raghu Nadimpalli, UC Mohanty, **M Mohapatra**, A Sharma, Ananda K Das, S Sil, 2020, Quasi-operational forecast guidance of extremely severe cyclonic storm Fani over the Bay of Bengal using high-resolution mesoscale models, Meteorology and Atmospheric Physics, 1-18
6. **M. Mohapatra** and M. Sharma, 2019, Cyclone Warning Services in India during recent years: A review, Mausam, 70,4 (October, 2019), 635-666
7. S Parihar, AK Mitra, **M Mohapatra**, LS Rathore, R Bhatla, RS Singh, 2019, Use of the Moon to promote on-board calibration of INSAT-3D imager visible channel, Indian Journal of Physics 93 (10), 1241-1246
8. T. Knutson, S. Camarago, JCL Chan, K Emanuel, C H Ho, J. Kossin, **M. Mohapatra**, M. Satoh, M. Sugi, K. Walsh, L.Wu, 2019, Tropical Cyclones and Climate Change Assessment: Part II, Projected Response To Anthropogenic Warming, Bulletin of the American Meteorological Society
9. Soma Sen Roy, **M. Mohapatra**, Ajit Tyagi And S. K. Roy Bhowmik, 2019, A review of Nowcasting of convective weather over the Indian region, Mausam, 70, 3 (July 2019), 465-484
10. Thomas Knutson, Suzana J. Camargo, Johnny C. L. Chan, Kerry Emanuel, Chang-Hoi Ho, James Kossin, **Mrutyunjay Mohapatra**, Masaki Satoh, Masato Sugi , Kevin Walsh, Liguang Wu, 2019, Tropical Cyclones and Climate Change Assessment: Part I. Detection 2 and Attribution, Bulletin of the American Meteorological Society, 10.1175/BAMS-D-18-0189.1.
11. Subimal Ghosh, Subhankar Karmakar, Anamitra Saha, Mohit Prakash Mohanty, Shees Ali, Satya Kiran Raju, Vrinda Krishnakumar, Maneesha Sebastian, Manasa Ranjan, Behera, R Ashrit, P L N Murty, K Srinivas, B. Narasimhan, Tune Usha, M V Ramana, Murthy, P Thiruvengadam, J Indu, D Thirumalaivasan, John P. George, S Gedam, A B Inamdar , B S Murty, P P Mujumdar, **M Mohapatra**, Arun Bhardwaj, Swati Basu, 2019, Development of India's First Integrated Expert Urban Flood Forecasting System for the City of Chennai, Current Science, 117(5), 741-745
12. Julian Heming, Fernando Prates, Morris Bender, John Cangialosi, Phillippe Caroff, James Doyle, Anumeha Dube, Ghislain Faure, Brian Howell, Yohko Igarashi, Ron McTaggart- Cowan, **Mrutyunjay Mohapatra**, Jon Moskaitis, Jim Murtha, Rabi Rivett, Monica Sharma, Chris Short, Amit Singh, Vijay Tallapragada, Helen Titley, Yi Xiao, 2019, Review of Recent Progress in Tropical Cyclone Track Forecasting and Expression of Uncertainties, Tropical Cyclone Research and Review, 8 (4), 181-218

13. K Singh, J Panda, M Sahoo, **M Mohapatra**, 2018, Variability in Tropical Cyclone Climatology over North Indian Ocean during 1891 to 2015, *Asia-Pacific Journal of Atmospheric Sciences*, 1-19
14. S, Parihar, AK Mitra, **M Mohapatra**, R Bhatla, 2018, Potential of INSAT-3D sounder-derived total precipitable water product for weather forecast, *Atmospheric Measurement Techniques*, 11, 6003-12
15. S Goyal, A Kumar, **M Mohapatra**, LS Rathore, SK Dube, R Saxena, 2017, Satellite-based technique for nowcasting of thunderstorms over Indian region, *Journal of Earth System Science* 126 (6), 79
16. S, Goyal, **M Mohapatra**, P Kumari, SK Dube, K Rajendra, 2017, Validation of Advanced Dvorak Technique (ADT) over north Indian Ocean, *MAUSAM* 68 (4), 689-698
17. N,Kumar, AK Jaswal, **M Mohapatra**, PA Kore, 2017, Spatial and temporal variation in daily temperature indices in summer and winter seasons over India (1969–2012), *Theoretical and Applied Climatology* 129 (3-4), 1227-1239
18. Pattanaik, D.R., **M Mohapatra**, AK Srivastava, A Kumar, 2017, Heat wave over India during summer 2015: an assessment of real time extended range forecast, *Meteorology and Atmospheric Physics* 129 (4), 375-393
19. Randall S Cervený, Pierre Bessemoulin, Christopher C Burt, Mary Ann Cooper, Zhang Cunjie, Ashraf Dewan, Jonathan Finch, Ronald L Holle, Laurence Kalkstein, Andries Kruger, Tsz-cheung Lee, Rodney Martínez, **M Mohapatra**, DR Pattanaik, Thomas C Peterson, Scott Sheridan, Blair Trewin, Andrew Tait, MM Abdel Wahab, 2017, WMO Assessment of Weather and Climate Mortality Extremes: Lightning, Tropical Cyclones, Tornadoes, and Hail; *Weather, Climate and Society* 9 (3), 487-497
20. N Kumar, **M Mohapatra**, AK Jaswal, 2017, Meteorological features associated with unprecedented precipitation over India during 1st week of March 2015, *Journal of Earth System Science* 126 (5), 62
21. DR Pattanaik, **M Mohapatra**, 2017, Active North-East Monsoon Over India During 2015–An Assessment of Real Time Extended Range Forecast, *Current Science*, 112 (11), 2253-2262
22. **M Mohapatra**, B Geetha, M Sharma, 2017, Reduction in uncertainty in tropical cyclone track forecasts over the North Indian Ocean, *Current Science* 112 (9), 1826
23. **M Mohapatra**, VV Kumar, 2017, Interannual variation of tropical cyclone energy metrics over North Indian Ocean, *Climate Dynamics*, 48, 1431-1445
24. PLN Murty, J Padmanabham, T Srinivasa Kumar, N Kiran Kumar, V Ravi Chandra, SSC Shenoi, **M Mohapatra**, 2017, Real-time storm surge and inundation forecast for very severe cyclonic storm ‘Hudhud’, *Ocean Engineering*, 131, 25-35
25. S Goyal, **M Mohapatra**, A Kumar, SK Dube, K Rajendra, P Goswami, 2016, Validation of a satellite-based cyclogenesis technique over the North Indian Ocean, *Journal of Earth System Science* 125 (7), 1353-1363
26. S Goyal, **M Mohapatra**, SK Dube, P Kumari, I De, 2016, Mesoscale convective systems in association with tropical cyclones over Bay of Bengal, *Natural Hazards* 82 (2), 963-979
27. D.R. Pattanaik, **M. Mohapatra**; 2016; Seasonal Forecasting of Tropical Cyclogenesis over the North Indian Ocean; *Journal of Earth System Science*; 125, 231-250; DOI:10.1007/s12040-016-0663-4
28. M. Mandal, K. S. Singh, M. Balaji, **M. Mohapatra**; 2016; Performance of WRF-ARW model in real-time prediction of Bay of Bengal cyclone ‘Phailin’; *Pure and Applied Geophysics*; 173, 1783-1801, DOI:10.1007/s00024-015-1206-7
29. U.C. Mohanty, Krishna K. Osuri, Vijay Tallapragada, Frank D. Marks, Sujata Pattanayak, **M. Mohapatra**, L. S. Rathore, S. G. Gopalakrishnan, Dev Niyogi; 2015; A Great Escape from the Bay of Bengal “Super Sapphire-Phailin” Tropical Cyclone: A Case of Improved Weather Forecast and

- Societal Response for Disaster Mitigation; Earth Interactions; **pp**; 19(17):151104123042003. DOI:10.1175/EI-D-14-0032.1
30. T. Srinivasa Kumar, P.L.N. Murty, M. Pradeep Kumar, M. Krishna Kumar, J. Padmanabham, N. Kiran Kumar, S.C. Shenoj, **M. Mohapatra**, Shailesh Nayak, Prakash Mohanty; 2015; Modeling Storm Surge and its Associated Inland Inundation Extent Due to Very Severe Cyclonic Storm Phailin; Marine Geodesy; 38(4); 345-360; DOI:10.1080/01490419.2015.1053640
 31. **M. Mohapatra**, Monica Sharma; 2015; Characteristics of surface wind structure of tropical cyclones over the north Indian Ocean. Journal of Earth System Science; 124(7):1573-1598. DOI:10.1007/s12040-015-0613-6
 32. **M. Mohapatra**, B. Geetha, S. Balachandran, L.S. Rathore; 2015; On the Tropical Cyclone Activity and Associated Environmental Features over North Indian Ocean in the Context of Climate Change; Journal of Climate Change, 1, 1-26.
 33. **M. Mohapatra**; 2015; Tropical cyclone forecast verification by India Meteorological Department For north Indian Ocean: a review; Tropical Cyclone Research and Review, 03, 1-14
 34. **M. Mohapatra**, D P Nayak, Monica Sharma, R P Sharma, B K Bandyopadhyay; 2015; Evaluation of official tropical cyclone landfall forecast issued by India Meteorological Department; Journal of Earth System Science; 124(4), 861-874; DOI:10.1007/s12040-015-0581-x
 35. **M Mohapatra**; 2015; Cyclone hazard proneness of districts of India; Journal of Earth System Science; 124(3), 515-526; DOI:10.1007/s12040-015-0556-y
 36. Manorama Mohanty, **M. Mohapatra**, SNA Jaaffrey; 2014; Some characteristics of rainfall over major urban centres of Gujarat; Mausam; 65; 608-618
 37. Krishna K. Osuri, U. C. Mohanty, Ashish Routray and **M. Mohapatra**; 2013; Real-Time Track Prediction of Tropical Cyclones over the North Indian Ocean Using the ARW Model; Journal of Applied Meteorology and Climatology; 52(11), 2476-2492
 38. **M. Mohapatra**, B K Bandyopadhyay, D P Nayak; 2013; Evaluation of operational tropical cyclone intensity forecasts over north Indian Ocean issued by India Meteorological Department; Natural Hazards; 68(2); 433-451; DOI:10.1007/s11069-013-0624-z
 39. **M. Mohapatra**, D P Nayak, R P Sharma, B K Bandyopadhyay; 2013; Evaluation of official tropical cyclone track forecast over north Indian Ocean issued by India Meteorological Department; Journal of Earth System Science; 122(3); 589-601; DOI:10.1007/s12040-013-0291-1
 40. D.R. Pattanaik, **M. Mohapatra**, B. Mukhopadhyay, Ajit Tyagi; 2013; A preliminary study about the prospects of extended range forecast of tropical cyclogenesis over the north Indian Ocean during 2010 post-monsoon season; Mausam; 64(1);171-188.
 41. T.N. Jha, **M. Mohapatra**, B.K. Bandyopadhyay; 2013; Estimation of intensity of tropical cyclone over Bay of Bengal using microwave imagery; Mausam; 64(1);105-116.
 42. Suman Goyal and **M. Mohapatra**; 2013; Comparison of best track parameters of RSMC, New Delhi with satellite estimates over north Indian Ocean; Mausam; 64; 25-34.
 43. **M. Mohapatra**, D.R. Sikka, B.K. Bandyopadhyay, Ajit Tyagi; 2013; Outcomes and challenges of Forecast Demonstration Project (FDP) on landfalling cyclones over Bay of Bengal; Mausam; 61(1):01-12.
 44. **M. Mohapatra**, G. S. Mandal, B. K. Bandyopadhyay, Ajit Tyagi, U. C. Mohanty; 2012; Classification of cyclone hazard prone districts of India. Natural Hazards; 63(3); 1601-1620; DOI:10.1007/s11069-011-9891-8
 45. Krishna K. Osuri, U. C. Mohanty, A. Routray, Makarand A. Kulkarni, **M. Mohapatra**; 2012; Customization of WRF-ARW model with physical parameterization schemes for the simulation of

- tropical cyclones over North Indian Ocean; Natural Hazards; 63(3); 1-23; 1337-1359; DOI:10.1007/s11069-011-9862-0
46. Geeta Agnihotri, **M. Mohapatra**; 2012; Prediction of occurrence of daily summer monsoon precipitation over Karnataka; Meteorological Applications; 19(2); 130 – 139; DOI:10.1002/met.246
47. AJ Litta, UC Mohanty, S. Kiran Prasad, **M. Mohapatra**, AjitTyagi, SC Sahu; 2012; Simulation of tornado over Orissa (India) on March 31, 2009, using WRF–NMM model; Natural Hazards; 61(3).; 1219-1242; DOI:10.1007/s11069-011-9979-1
48. Krishna K. Osuri, U. C. Mohanty, A. Routray, **M. Mohapatra**; 2012; The impact of satellite-derived wind data assimilation on track, intensity and structure of tropical cyclones over the North Indian Ocean; International Journal of Remote Sensing; 33(5-5); 1627-1652; DOI:10.1080/01431161.2011.596849
49. **M. Mohapatra**; 2012; Evaluation of Cone of Uncertainty in Tropical Cyclone Track Forecast over North Indian Ocean Issued by India Meteorological Department; Tropical Cyclone Research and Review, 01, 331-339
50. **M. Mohapatra**, B. K. Bandyopadhyay, AjitTyagi; 2012; Best track parameters of tropical cyclones over the North Indian Ocean: A review; Natural Hazards; 63(3); 1285-1317
51. Suresh Ram and **M. Mohapatra**, 2012, Some aspects of squall over Indira Gandhi International Airport, Mausam, 63, 4, 623-638
52. N. Kumar, **M Mohapatra** and B.P. Yadav, 2011, Boundary layer impact on mountain waves across Western Ghats of India, Mapana, J. Science, 10, 1, 25-31
53. Charan Singh, **M. Mohapatra**, B.K. Bandyopadhyay, AjitTyagi; 2011; Thunderstorm climatology over northeast and adjoining east India; Mausam; 62(2); 163-170.
54. **M. Mohapatra**, R.H. Biswas, G.K. Sawaisarje; 2011; Spatial variability of daily rainfall over northeast India during summer monsoon season; Mausam; 62(2); 215-228.
55. **M. Mohapatra**; 2011; Weather and weather system at Schirmachar Oasis (Maitri): - A review during past two decades; Mausam; 62; 513-534.
56. **M. Mohapatra**; 2011; Modulation of cyclonic disturbances over the north Indian Ocean by Madden - Julian oscillation; Mausam; 62; 375-390.
57. U. C. Mohanty, Krishna K. Osuri, A. Routray, **M. Mohapatra**, Sujata Pattanayak; 2010; Simulation of Bay of Bengal Tropical Cyclones with WRF Model: Impact of Initial and Boundary Conditions; Marine Geodesy; 33(4); 294-314; DOI:10.1080/01490419.2010.518061
58. **M. Mohapatra**, Naresh Kumar, B K Bandyopadhyay; 2010; Role of mesoscale low and urbanization on exceptionally heavy rainfall event of 26th July 2005 over Mumbai: Some observational evidences. Mausam; 60(3); 317-324
59. Ramesh Chand, **M. Mohapatra**; 2010; Diagnostic study of a recurving cyclone - 'MALA' over the Bay of Bengal. Mausam; 61(1); 11-18.
60. **M. Mohapatra** and S. Adhikary; 2010; Seasonal prediction of cyclonic disturbances over the Bay of Bengal during summer monsoon season: identification of potential predictors; Mausam; 61; 461-486.
61. **M. Mohapatra**, Naresh Kumar, B K Bandyopadhyay; 2010; Unprecedented Rainfall over Bangalore City during October, 2005; Mausam; 61(1); 105-112.
62. **M. Mohapatra**, H.R. Hatwar, B.K. Bandyopadhyay, V. Subrahmanyam; 2009; Evaluation of heavy rainfall warning over India during summer monsoon season; Mausam; 60(4); 475-490.
63. **M. Mohapatra**, H.R. Hatwar, S.R. Kalsi; 2009; Verification of heavy rainfall warning over Bihar and Uttar Pradesh; Mausam; 60(2); 175-184.

64. **M. Mohapatra**, U.C. Mohanty; 2009; Excess and deficient summer monsoon rainfall over Orissa in relation to low pressure systems; *Mausam*; 60(1); 25-38.
65. Sunit Das, **M. Mohapatra** and Suresh Ram; 2009; Some characteristics of heavy rainfall over northeast India during monsoon season; *Mausam*; 60; 525-533
66. **M. Mohapatra**; 2008; Sub-divisional monsoon rainfall over Orissa in relation to low pressure systems over Bay of Bengal and adjoining land regions during 1982-1999; *Mausam*; 59(3); 327-338.
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Enclosure I: Publications and Research & Development

(b) : Research papers published in Proceedings of Symposia/Seminars/Conference/Workshop

1. Julian Heming, Fernando Prates, Morris Bender, John Cangialosi, Phillippe Caroff, James Doyle, AnumehaDube, Ghislain Faure, Brian Howell, Yohko Igarashi, Ron McTaggart- Cowan, **Mrutyunjay Mohapatra**, Jon Moskaitis, Jim Murtha, Rabi Rivett, Monica Sharma, Chris Short, Amit Singh, Vijay Tallapragada, Helen Titley, Yi Xiao, 2018, Review of Recent Progress in Tropical Cyclone Track Forecasting and Expression of Uncertainties, Reports of WMO/TCP/WWW Ninth International Workshop On Tropical Cyclones (IWTC-9) held at Honolulu, USA
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8. Grant Elliott, Munehiko Yamaguchi, Thomas Birchard, Johnny C. L. Chan, Thierry Dupont, Russell L. Elsberry, T C Lee, Xiaotu Lei, Sharanya J. Majumdar, **M Mohapatra** and Li Ying; 2014; Tropical Cyclone Motion - Recent Advances; Eighth International Workshop on Tropical Cyclone(IWTC), Topic 2, 1-44pp.
9. Monica Sharma and **M. Mohapatra**; 2013; Possible causes of explosive intensification of VSCS GIRI over the Bay of Bengal; Proceedings of International Conference on Indian Ocean Tropical Cyclone and Climate Change (14 - 17 February 2012) New Delhi, India, published by WMO, WWRP 2013-4, 131-138

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16. U. C. Mohanty and **M. Mohapatra**; 2007; Heat waves over Orissa : Problems and perspectives; Understanding heat waves in Orissa, Proceedings of national workshop on heat wave held on 13. 03. 2006 organised by Orissa State Disaster management Authority, Bhubaneswar
17. **M. Mohapatra**, 2003; Southwest monsoon circulation and rainfall over Orissa- A review of characteristics; 7th Orissa Vigyan Congress, Bhubaneswar
18. **M. Mohapatra**; 2003; Climate change and environmental hazards; Seminar on Mitigation of Environmental Hazard- Utkal University
19. S. Mishra, **M. Mohapatra** and U.C. Mohanty; 2002; Some characteristics of monsoon activity over Orissa; National symposium, TROPMET, 2002, organised by Indian Meteorological Society
20. **M.Mohapatra**, U.C. Mohanty, S. Mishra and L. Maharana; 2002; Characteristics of monsoon circulation leading to flood and drought over Orissa; National symposium, TROPMET, 2002, organised by Indian Meteorological Society
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24. **M. Mohapatra**, 2000; Weather related disasters and their management; National Seminar on Environment and Disaster Management organised by Utkal University
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26. **M. Mohapatra** and G.S. Vijayraghavan; 1997; Climatic variation of temperature over Bangalore; IGBP National Symposium at Bhubaneswar

Enclosure I: Publications and Research & Development

(c) Publications in books/reports

1. **M. Mohapatra** and M. Sharma, 2019, Recent Advances in Cyclone Warning Services in India, Article for Souvenir published by ClimFishCon (2019)
2. **M. Mohapatra** and M. Sharma, 2019, India's contribution in trans boundary early warning system in south Asia: A review, South Asia Disaster Report (2019)
3. **M Mohapatra**, AK Srivastava, S Balachandran, B Geetha, 2017, Inter-annual Variation and Trends in Tropical Cyclones and Monsoon Depressions Over the North Indian Ocean, In Observed Climate Variability and Change over the Indian Region, Ed. M. Rajeevan and ShaileshNayak, published by Springer, Germany, 89-106.
4. K Ray, **M Mohapatra**, K Chakravarthy, SS Ray, SK Singh, AK Das, 2017, Hydro- Meteorological Aspects of Tropical Cyclone Phailin in Bay of Bengal in 2013 and the Assessment of Rice Inundation due to Flooding, In Tropical Cyclone Activity over the North Indian Ocean, Ed.M.Mohapatra, B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 29-43
5. M Sharma, **M Mohapatra**, 2017, Standard Operation Procedure for Tropical Cyclone Vital Parameters over North Indian Ocean, In Tropical Cyclone Activity over the North Indian Ocean, Ed.M.Mohapatra, B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 367-381
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7. B Sabade, **M Mohapatra**, 2017, Very Severe Cyclonic Storm MADI over Bay of Bengal, 6– 13 December 2013: A Diagnostic Study, In Tropical Cyclone Activity over the North Indian Ocean, Ed.M.Mohapatra, B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 117-130
8. PS Chinchole, **M Mohapatra**, 2017, Some Characteristics of Translational Speed of Cyclonic Disturbances Over North Indian Ocean in Recent Years, In Tropical Cyclone Activity over the North Indian Ocean, Ed.M.Mohapatra, B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 165-179
9. DP Nayak, **M Mohapatra**, 2017, Rapid Movement of Cyclone Viyaru Just Before Landfall- A Case Study, In Tropical Cyclone Activity over the North Indian Ocean, Ed.M.Mohapatra, B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 149-163
10. SVJ Kumar, SS Ashthikar, **M Mohapatra**, 2017, Life Period of Cyclonic Disturbances Over the North Indian Ocean During Recent Years, In Tropical Cyclone Activity over the North Indian Ocean, Ed.M.Mohapatra, B.K. Bandyopadhyay and L.S. Rathore, Co-published by Capital Publishers, New Delhi and Springer, Germany, 181-198
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12. RP Sharma, **M Mohapatra**, 2017 Rapid Weakening of Very Severe Cyclonic Storm „Lehar“– A Case Study, In Tropical Cyclone Activity over the North Indian Ocean, Ed.M.Mohapatra, B.K. Bandyopadhyay and L.S. Rathore, 2017, Co-published by Capital Publishers, New Delhi and Springer, Germany, 131-147
13. **M Mohapatra**, 2017, Monitoring and Forecasting of Tropical Cyclones over North Indian Ocean, In Advanced Numerical Modeling and Data Assimilation Techniques for Tropical Cyclone Prediction, Ed. UC Mohanty and SG Gopalakrishnan, Co-published by Capital Publishers, New Delhi and Springer, Germany, 409-447 pp.
14. **M. Mohapatra**, M.R. Ranalkar& S. Sunitha Devi, 2015, Validation of automatic weather station

- (AWS) data for monitoring and prediction of the low pressure systems during the monsoon season, IMD Met. Monograph: ESSO Document No.: ESSO/IMD/SYNOPTIC MET/01(2015)/17, pp171-188., IMD, Pune
15. **M. Mohapatra**, B.K. Bandyopadhyay, B. Geetha, Bharati S. Sabade, D.P. Nayak, Monica Sharma, R.P. Sharma, P.S. Chinchole, R.G. Bali, S.V.J. Kumar & V. Vijayakumar, 2015, "Cyclonic activities over north Indian ocean during 2014" and "Performance of track and intensity predication of cyclones by IMD during 2014", IMD New Delhi, Report No. ESSO/IMD/CWD-1(2015)/13, IMD, New Delhi
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28. **M. Mohapatra**, TN Jha, Suman Goyal, Charan Singh, Naresh Kumar, SD Kotal, K Nagaratna, S Balachandran, Osuri Krishna, AjitTyagi, BK Bandyopadhyay, OP Singh, UC Mohanty, DR Sikka, Kusuma G Rao and EN Rajagopal., 2011, Forecast Demonstration Project (FDP) for improving track, intensity and landfall of Bay of Bengal tropical cyclones, Implementation of Pilot Phase, 2010: A report, Research Report, Cyclone Warning Division, IMD, New Delhi
29. A.J. Litta, U.C. Mohanty, S.C. Bhan, and **M. Mohapatra**, 2011, Simulation of Tornadoes over India Using WRF-NMM Model, Challenges and Opportunities in Agrometeorology, Eds. S. D. Attri, L. S. Rathore, M. V. K. Sivakumar, S. K. Dash, Springer Publications Ltd, pp. 173-186,
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36. **M. Mohapatra**, Tyagi, Ajit and B.K. Bandyopadhyay, 2009, Monitoring and Prediction of Cyclonic Disturbances over North Indian Ocean by Regional Specialized Meteorological Centre, New Delhi (India): Problems and Prospective, InIndian Ocean tropical cyclones and climate change, Ed. YassineCharabi, 93-103, Springer Publications Ltd
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42. U.C. Mohanty etal including **M. Mohapatra**, 2007, Weather summary, analysis and preliminary evaluation of meso scale model during pilot experiment of STORM programme–2007, Research report, DST, Govt. of India, New Delhi

Enclosure I: Publications and Research & Development

(d) : Details of Books Edited

1. Annual Cyclone Review- 2007 for WMO/ESCAP Panel countries, Ed. **M. Mohapatra** and other representatives from WMO/ESCAP Panel countries, 2008, WMO, Geneva
2. Annual Cyclone Review-2008 for WMO/ESCAP Panel countries, Ed. **M. Mohapatra** and other representatives from WMO/ESCAP Panel countries, 2009, WMO, Geneva
3. Annual Cyclone Review-2009 for WMO/ESCAP Panel countries, Ed. **M. Mohapatra** and other representatives from WMO/ESCAP Panel countries, 2010, WMO, Geneva
4. Annual Cyclone Review-2010 for WMO/ESCAP Panel countries, Ed. **M. Mohapatra** and other representatives from WMO/ESCAP Panel countries, 2011, WMO, Geneva
5. Annual Cyclone Review-2011 for WMO/ESCAP Panel countries, Ed. **M. Mohapatra** and other representatives from WMO/ESCAP Panel countries, 2012, WMO, Geneva
6. Annual Cyclone Review-2012 for WMO/ESCAP Panel countries, Ed. **M. Mohapatra** and other representatives from WMO/ESCAP Panel countries, 2013, WMO, Geneva
7. Monitoring and prediction of Indian Ocean tropical cyclones and climate change Ed. U.C. Mohanty, **M. Mohapatra**, O.P. Singh, B.K. Bandyopadhyay and L.S. Rathore, 2013, Co-published by Capital Publishers, New Delhi and Springer, Germany
8. High impact weather events over SAARC region, Ed. K. Ray, **M. Mohapatra**, B.K. Bandyopadhyay & L.S. Rathore, 2014, Co-published by Capital Publishers, New Delhi & Springer
9. Annual Cyclone Review-2013 for WMO/ESCAP Panel countries, Ed. **M. Mohapatra** and other representatives from WMO/ESCAP Panel countries, 2014, WMO, Geneva
10. Cyclonic disturbances over north Indian Ocean during 2013, IMD New Delhi
11. Annual Cyclone Review-2013 for WMO/ESCAP Panel countries, Ed. **M. Mohapatra** and other representatives from WMO/ESCAP Panel countries, 2014, WMO, Geneva
12. Cyclonic disturbances over north Indian Ocean during 2014, IMD New Delhi
13. Annual Cyclone Review-2014 for WMO/ESCAP Panel countries, Ed. **M. Mohapatra** and other representatives from WMO/ESCAP Panel countries, 2015, WMO, Geneva
14. Annual Cyclone Review-2015 for WMO/ESCAP Panel countries, Ed. **M. Mohapatra** and other representatives from WMO/ESCAP Panel countries, 2016, WMO, Geneva
15. Tropical Cyclone Activity over North Indian Ocean, Ed. **M. Mohapatra**, B.K. Bandyopadhyay and L.S. Rathore, 2017, Co-published by Capital Publishers, New Delhi & Springer, Germany, 365 pp.
16. Monsoon 2016- A report, Ed PCS Rao, DS Pai and **M Mohapatra**, 2017, Published by India Meteorological Department, Pune, 374pp.
17. Annual Cyclone Review-2016 for WMO/ESCAP Panel countries, Ed. **M. Mohapatra** and other representatives from WMO/ESCAP Panel countries, 2017, WMO, Geneva
18. Monsoon-2017- A report, Ed O.P. Sreejith, DS Pai and **M Mohapatra**, 2018, Published by India Meteorological Department, Pune

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(e) Details of Journals edited

1. Editor, **Mausam** published by IMD since August 2019
2. Associate Editor, **Journal of Climate Change**, 2015 onwards, Capital Publishing Co, New Delhi
3. Editor, Special Issue of Journal, **Mausam (Volume, 64, No. 1)** on Proceedings of National Conference on Bay of Bengal Tropical Cyclone Experiment (BOBTEx)-2011, Ed. D.R. Sikka, M. Mohapatra and BK Bandyopadhyay, 2013, IMD, New Delhi
4. Editor, Special Issue of Magazine, „**Geography and You**“ on cyclone, **2014**, Published by Iris Publication, New Delhi, India
5. Member of Editorial Board, **Tropical Cyclone Research and Review**
6. Member of Editorial Board, **Vayu Mandal**
7. Member of Editorial Board, **Arabian Journal of Geo Sciences**
8. Guest Editor, Special Issue of **Journal of Natural Hazards, 2020**

**Enclosure-II:
Scientific Contribution**

(i) Major projects/programmes dealt

- Project/ programme: Modernisation of Indian Meteorological observational systems and applications (MIMOSA)/ VARSAMAN Project as Associate Project Director.
- Project/programme: Modernisation of Cyclone Warning System as Project Director
- Project/Programme: Forecast Demonstration Project (FDP) on landfalling cyclones over the Bay of Bengal as Project Director
- Project/ programme: FDP on Severe Thunder Storm Observation and Regional Modeling (STORM) project (2006-18)
- Project/ programme: FDP on Winter Weather (2016-19)
- Project/ programme: FDP on southwest monsoon (2017-18)

(ii) Policy and Planning

National

- Vision document on cyclone and weather forecasting
- Benchmarking of severe weather forecasting
- Standard Operation Procedure (SOP) for weather forecasting and cyclone warning services
- Introduction of district level impact based forecast and its verification for all severe weather events.
- Chairman/member of expert committee for NDMA Guidelines for (i) cyclone management, (ii) Thunderstorm management, (iii) heat wave management
- Chairman of Technical Evaluation Committee for Consultancy on World Bank aided National Cyclone Risk Mitigation Project (NCRMP), Govt. of India
- Disaster Risk Reduction as member of various committees for policy, planning and guidelines

International

- Contributed as Permanent Representative of India with WMO with effect from 10th June, 2019
- Contributed as Member Executive Council, WMO with effect from 13th June, 2019 for the period 2019-23
- Contributed as Chairman of WMO/ESCAP Panel on Tropical Cyclones over Bay of Bengal and Arabian Sea for 2017-2018 for development of Coordinated Technical Plan
- Contributed as Chairman for Regional Sub-Project management Team for WMO's SWFDP-Bay of Bengal and prepared implementation plan
- Contributed as Rapporteur of WMO/ESCAP Panel on Tropical Cyclones for development and updating of Annual Tropical Cyclone Operational Plan for the region

(iii) Modernisation of Weather Forecasting & Warning System and Services:

(a) Introduction of Scientific and technological methodology:

- Extension of Probabilistic cyclogenesis forecast to three days (from 2014) & to five days (from 2018)
- Extended range forecast of cyclogenesis for next two weeks issued every Thursday from 2018,
- Track, cone of uncertainty and intensity forecast upto 72 hrs since 2009 and 120 hrs since 2013
- Track and intensity forecast from deep depression stage since 2009 and from depression stage since 2018
- Hourly update on day of landfall since 2013
- Nowcasting of severe weather for all districts round the clock and for 433 cities and towns by 2018
- Bi-weekly outlook for all severe weather events
- Forecast demonstration project for all severe weather events round the year from 2016
- Prognostic & diagnostic features and cyclone since 2009 and other severe weather events since 2016
- Warning graphics since 2009,
- Fishermen warning for entire north Indian Ocean valid upto five days from 2018.
- Colour coded impact based forecast & warning for all districts & all severe weather events from 2018 and warning with impact information & suggested actions since 2020.
- Introduction of Movie loop on 5 days forecasts and warning in IMD website and in Door Darshan

- Synergised SOP with INCOIS for Ocean state, marine weather and cyclone forecast and warning.
- Verification of forecast from 2008 and for past forecasts upto 2003 for heavy rain and cyclone.
- Verification of forecast from 2008 and for past forecasts upto 2003 for heavy rain and cyclone.
- Introduction of Sub-city forecast and city scale IBF for heavy rainfall in 2020
- Modification of NDMA guidelines for thunderstorm and lightning, heat wave, cold wave and fog in 2019
- Extension of city forecast to 470 stations in 2020
- Extension of nowcast for all severe weather and all districts and 894 stations by 2020
- Cyclone forecast in GIS in 2020
- Extensive use of social media including press release, press conference, Facebook, Twitter, Instagram, Blog, You Tube, Videos, whats-app group etc since 2019-20
- Augmentation of Sectoral applications
 - Implementation of IFLOWS for Chennai and Mumbai for urban flood warning
 - Introduction of probabilistic quantitative precipitation forecast(QPF) for all river basins)
 - Introduction of extended range forecast for 10 river basins
 - Agriculture sector (Connectivity among SMS, MCs/RMCs through VC and Whats app group, dissemination improvement)
 - Graphics product for fishermen warning covering entire north Indian Ocean, IBF over the Ocean
 - Augmentation of model guidance, observational network and number of airports under Udaan Scheme
 - Observational and forecast service for Railways along the Railway line
 - Observational and Forecast services for Golden Quadrilateral
- (b) Introduction of new technology:**
 - Adaption of new versions of global & regional deterministic & ensemble models
 - Implementation of atmosphere Ocean coupled Hurricane weather research forecast model
 - Tropical Cyclone Module and Ensemble prediction system (EPS)
 - Synthetic vortex of cyclone for NWP model improvement.
 - IIT Delhi storm surge model and INCOIS Coastal inundation model
 - Digital Forecasting workstation and PWS
 - Visualisation tool and decision support system, METCAP PLUS
 - Development of forecasting infrastructure for all MCs and RMCs
- (c) Networked programmes initiated/conducted:**
 - **Between lab to lab** Network programmes initiated and continued with
 - (i) INCOIS for storm surge modeling, HWRF modeling and warning dissemination
 - (ii) NIOT for meteorological buoy network planning and data exchange and evaluation
 - (iii) NCMRWF for implementation of global deterministic and ensemble models,
 - (iv) ISRO for customized satellite product development, planning and validation of products
 - (v) IAF, Indian Navy for meteorological observations including lightning data
 - (vi) IIT Delhi for storm surge modeling, coastal inundation
 - (vii) IIT, Bhubaneswar for HWRF Modeling
 - **Bilateral/Multilateral** network programmes conducted with
 - (i). NOAA USA for adaptation of HWRF model in IMD,
 - (ii). JMA for Ensemble prediction system,
 - (iii). WMO/ESCAP Panel for regional cyclone operational plan,
 - (iv). WMO Typhoon Committee for synergized SOP for coastal multi-hazard warning,
 - (v). WMO's Severe weather forecast demonstration project(SWFDP)-southeast Asia
 - (vi) WMO's SWFP-South Asia for forecast on heavy rain, wind, wave & storm surge
 - (vii) International best track archives for climate stewardship (IBTrACS),USA
 - (viii) Typhoon committee and WMO/ESCAP Panel on Tropical Cyclones for synergized standardized Operation procedure (SSOP) for coastal hazards in the region
 - (ix) NDMA and state Govts for Guidelines and common alert protocol,
 - (x) Bureau of Indian Standards for Standardisation of smart cities, cyclone shelters etc,
 - (xi) Ministry of Urban Affairs for preparation of Vulnerability Atlas

(d) R&D activity

- **Forecast demonstration projects (FDP)** on landfalling cyclones during 2008-2019
- **FDP** on winter season severe weather events since 2016-17
- **FDP** on pre-monsoon convective weather systems since 2017
- **FDP** on southwest-monsoon season since 2017
- **Data bases prepared** for R&D activity: **(i)** Six hourly best track parameters of cyclones during 1990-2018, **(ii)** Digitisation of Annual RSMC Reports during 1990-2017, **(iii)** Hazard proneness of coastal districts, **(iv)** Tropical Cyclone Energy Metrix, **(v)** Life Cycle, **(vi)** Structure, **(vii)** Translational Speed and direction of Movement since 1990 onwards
- **Organisation Conference and Workshops and Publication of research papers**

(e) Warning dissemination mechanism:

Introduced **(i)** Press Conference, **(ii)** Press release, **(iii)** Dedicated website for cyclone, **(iv)** SMS alert to fishermen, farmers, disaster managers, **(v)** Email for warning service **(vi)** Experimentation of common Alert protocol in different MCs/RMCs for warning dissemination, **(vii)** Development of dedicated website for cyclone and dedicated web pages for monsoon, heat wave, nowcast etc. **(viii)** Development of new website for general public (www.mausam.imd.gov.in), development of mobile apps (Umang, Damini and Mausam)

(f) Confidence building measures for disaster managers:

- ❖ Organisation of users workshop for severe weather and documentation on each cyclone and its forecast since 2008
- ❖ Pre-cyclone and pre-monsoon exercise with disaster managers
- ❖ Verification of all forecasts

(g) Outreach programmes

- FAQs, Terms and Terminology of weather monitoring and forecasting,
- Popular talks/lectures, Popular articles
- **Production of video films on**
 - i. A Glorious Decade of IMD (2006-2016) released on First Decadal Celebration of Ministry of Earth Sciences, Govt. of India
 - ii. Cyclone Warning in India: A Success Story, released on Foundation Day of India Meteorological Department on 15 January 2017.
 - iii. Early Warning System of IMD released on Foundation Day of India Meteorological Department on 15 January 2019.

(h) Outcome:

- The forecast accuracy is at par with leading centres of the world. The cyclone track forecast errors of IMD has reduced from 124 km in 2009-13 to 61 km in 2015-19 (35% improvement) for 24 hr forecast, from 202 to 126 km (38% improvement) for 48 hrs forecast and from 268 to 171 km (36% improvement) for 72 hrs forecast.
- The uncertainty in track forecast for all the lead period upto 5 days has been reduced by about 30% during the same period.
- The 24 hr cyclone landfall forecast error has reduced from 91 km to 45 km during the same period (improvement by 51%).
- The error in intensity forecast is also less (about 10-15 knots for 24-72 hr forecasts).
- Accuracy of adverse weather warning including rainfall, thunderstorm, fog, storm surge and wind also improved significantly by about 10-20% in recent five years compared to previous five years.
- There has been increase in confidence of disaster managers and public leading to
 - Minimum loss of human lives (limited to double digits) in recent years
 - Decrease in area of evacuation by 100 km in 5 years and hence evacuation cost.
 - Decrease in ex-gratia paid by Govt. to survivors
 - Awards and Appreciations to India and IMD from various national and international agencies.