Future OF Weather Forecasting: **Taking Action on Weather**

Goal for 2047

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- **Foundation Day Greetings to all IMD colleagues (present/past) for their Service to the Nation**

- **Honouring 150 Years of IMD Excellence:** Pay homage to the IMD's 149-year rich legacy of meteorological excellence, a testament to its invaluable contributions that have significantly shaped our current understanding of atmospheric sciences.

- As we step into the 150th year, let each of us leave our mark—a contribution to a narrative of progress, discovery, and responsible management of our atmosphere.

Vision 2047: Transitioning beyond Conventional Weather Forecasting

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- Best possible services (over the Land, at Sea and in the Air)
- Earth System approach (Atmosphere, Ocean and Polar)
  1. Strengthening observations (in-situ & Remote sensing)
  2. Need better understanding (Science, Innovation and Methodology)
  3. Improve our Model / Assimilation/ Augment of HPC
  4. Forecast dissemination: Effective communication with Society
- Weather forecast to Weather Management

UN Early warning for All (EW4All)

Envision a new era in Earth System Science approach, moving beyond traditional weather forecasting to embrace weather modification and active management as integral components of our approach.

1. Observations

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- Over the oceans/ tropics / Southern ocean – Less observations!

- **Spatial, Temporal and Vertical** (to resolve convective processes and mesoscale dynamics)
  - Strengthening AWS/ARG, Radiosonde (one order more?) – Need OSSE!
  - Augmenting Drones, vertical wind profiler, Radiometers,….. (for higher temporal & vertical)
  - Remote sensing: Radar coverage throughout India / Satellites (not only spatial but also vertical resolution)
  - Need for testbed, aircraft observations, cyclone reconnaissance
  - Crowdsourcing, social media, Citizen science initiatives, IoT enabled sensors at granular level
  - Need for high quality winds (Vertical) ~ AEOLUS (Doppler wind Lidar profilers)….Nano/ Micro satellites?
  - LiDAR / Hyperspectral imaging!

Observation

- Over the oceans/ tropics / Southern ocean – Poor observations!
- In-situ (AWS, Radiosonde, ..) & Remote sensing (Radars and satellites)
- Observing System simulation experiments (OSSEs) to identify the requirements
- Need for testbed (aircraft observations, cyclone process studies)
- Crowdsourcing, social media, real time assimilation by local weather
- Spatial, Temporal and Vertical (to resolve convective processes and mesoscale dynamics)
  - Strengthening AWS, Radiosonde
  - Augmenting Drones, vertical wind profiler, Radiometers,….. (for higher temporal)
  - Remote sensing: Radar coverage throughout India / Satellites (not only spatial but also vertical resolution)
  - Need for high quality winds (Vertical) ~ AEOLUS (Doppler wind Lidar profilers)….nano/ micro satellites

Similarly for Oceans and Polar regions for Earth System approach

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2. Science

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- Cloud processes and its dynamics
- Teleconnections (Meridional Vs Zonal)
- Forcing (External Vs internal)
- Linear Vs Non-linear processes
- Interactions (Atmosphere, ocean, ice dynamics/sea-ice….)
- Model physics:
  - Sub-grid scale processes / parameterization (cloud/MLD)?
- Atmosphere: T,Wv,U (atmospheric chemistry
- Ocean: T, S, U (biogeochemistry)
- Observing System simulation experiments (OSSEs) to identify the requirements

3. Modelling

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- Vertical & Horizonal structure of Met/Ocean parameters in the tropics / Equ. Regions is poorly modelled

- *Very High-Resolution Modelling:* Striving for simulations that offer unparalleled accuracy and detail in representing atmospheric/oceanic processes

- Synoptic, Statistical, Numerical, AI/ML based, **combination of all**
- **Big data analytics & AI –** New avatar for weather prediction and climate services
- Assimilation technique/scheme!
- Real time assimilation of local weather from IoT, social media, crowd source….
- Ensemble forecasting/range of probable scenarios

- **Super computing advancements:** *Prioritising HPC Capabilities:* Enhancing computational power to tackle complex simulations (CPU, GPU, Quantum)
- Doubling resolution need 8 times higher CPUs!

4. Forecast and Dissemination

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- GIS- based and Automated Decision Support System
- Communicate the level of uncertainty- different weather conditions
- Mobile App, Website, Social media,..
- Develop trust and strengthen communication with society
- Awareness about complexity of Weather to society
- Data dissemination without scientific jargon- simple, understandable terms
- Through Augmented reality (AR) and Virtual reality (VR)

Weather Modification

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- Artificial suppression / enhancement of Rain, Hail, Thunderstorm, lightning
- Interventions: Seeding or dispersing into clouds/fog
- Altering drop size distribution, Producing / suppressing ice crystals, Coagulating droplets, etc
- Influencing the natural development cycle of clouds
- Fires / heat sources to influence convective circulation,
- Modifying Solar radiation (Geo-engineering, shock wave or acoustic sources to the atmosphere)
- Though controversial, but potential key to weather resilience

Need Better understanding!

Weather Management System

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- Establishing a Robust Weather Management system through Integrated Approach: Combining Observations, Modeling, and strategic interventions (Pros/Cons, Ethical,…)

- Synergy to ensure a resilient and dynamic weather management system, capable of responding effectively to the intricacies of atmospheric conditions

Transformative Outcomes

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- **Improved Weather Forecasts:** Timely and accurate predictions (Block level) benefiting various sectors.
- **Capability to Modify Weather Patterns:** Mitigating impacts of extreme weather events.
- **Strategic Measures:** Proactive natural disaster mitigation and adaptive responses.
- **Safeguarding Against Threats:** Monitoring and countering potential adversarial attempts.
- **Weather Warfare Considerations:** Addressing ethical and geopolitical aspects, emphasising responsible use of atmospheric science advancements.

Call to Action

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- We are on a path to revolutionise atmospheric sciences & master atmospheric dynamics for a positive global impact, contributing to a safer, more resilient, and adaptive global environment
- Need for more collaborations, research, and responsible application of Earth science advancements.
- Implementation Plan for realising Vision 2047
- Envision a future, where humanity coexists harmoniously with the atmosphere, leveraging science for the betterment of our world.

Thank you for your Attention

Comments/suggestions!