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Application of Remote Sensing in Aviation Weather Forecasting to Predict Adverse Weather Phenomena for Civil & Defence Operations

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ABSTRACT

This is an abridged introduction as of 30 Dec'25; to the panorama of Remote Sensing comprising remote sensing devices viz. satellites, weather satellites, and defence (spy), and NISAR- satellites i.e. Polar-orbiting and Geostationary satellites with their applications in studying the land, Ocean and cryosphere interactions affecting the aviation, meteorological data resulting in Convective Mesoscale Systems, and Weather analysis to predict Adverse Weather Phenomena(Thunderstorm, Dust storm, Sandstorm, hailstorm, Tropical Cyclones, hurricane, tornadoes, squalls, and poor visibility etc.) for civil and defence operations during Peace and Wars.

It gives glimpses of the advanced Remote Sensing techniques e.g. WINDCO (high level wind measurements through satellite imageries by using Mc IDAS (Man-Computer-Interaction-Data-Access-System). It also deals with the impact of Adverse Weather and Environmental pollution (Air, Water), on Global Warming, Climate Change and the Disasters affecting, health, ecology and the Global economy.

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Introduction

SATELLITES are the Eyes in the Sky. Man-Made Machines orbiting in the Space in Polar or Sun-Synchronous Orbits. There are two categories of satellites viz. **Polar Orbiting Satellites**. (TIROS, DMSP, IRS-1A-Series), and **Sun –Synchronous or Geostationary Satellites** (INSAT-Series). Based on application the other three types are:

Weather Satellites: Kalpana-1 was the first dedicated meteorological satellite

Defence (Spy) Satellites.

Latest High Resolution multirole NISAR-Satellite- 2025.

METSAT(Kalpana-1) was the first dedicated meteorological satellite launched by Indian Space Research Organisation using Polar Satellite Launch Vehicle on 12 SEP'2002, METSAT (renamed as Kalpana - 1 on February 5, 2003, after the Indian-born American Astronaut Dr. Kalpana Chawla, died on February 1, 202003 and the US Space Shuttle Columbia disaster)

Mission duration: Planned: 7 years; Achieved: SATCAT no.: 27525Reference system: Geocentric Dry mass: 498 kilograms (1,098 lb),Launch vehicle: PSLV – C4 Launch site: SHAR, Srihari Kota Payload: Very High-Resolution Radiometer (VHRR) & Data Relay Transponder (DRT). Geostationary. INSAT-3D-IMG (WX. SATELLITE) & Satellite-Imagery (Figure)1.

IKONOS was a commercial Earth observation satellite and was the first to collect publicly available high-resolution imagery at 1- and 4-meter resolution. It collected multispectral and panchromatic imagery.

Launch date: 24 September 1999Orbit height: 681 km Speed on orbit: 7.5 km/s: Lockheed Martin Space

The IKONOS satellite sensor is a high-resolution satellite operated by Digital Globe. Its capabilities include capturing a 3.2m multispectral, Near-Infrared (NIR).

the first of the series of indigenous state-of-the-art remote sensing satellites, was successfully launched into a Sun-synchronous orbit on 17 March 1988 from the Soviet Cosmodrome at Baikonur [1].

Launch mass: 975 kg (2,150 lb)Rocket: Vostok-2M s/n L15000-79 Mission duration: 3 years (planned); 4 years ...Apogee altitude: 917 km (570 mi). The IRS-1A satellite, with its LISS-I and LISS-II sensors quickly enabled India to map, monitor and manage its natural resources at coarse and medium spatial resolutions.

Figure 1: IRS-I A.

Summary-INSAT-3D-IMG
*Seas scattered and reflected energy. *Available during Daytime only. * Sees clouds and earth surface. *Sensitive to soil, water, and cloud type * Sees fog in daytime. *Used for tracking cloud features in time to estimate atmospheric motion.

* The satellite is a follow on of INSAT-3DR mission, built by the ISRO (Indian Space Research Organization) and launched from Satish Dhawan space Centre (SDSC). It has initiated the Earth Imaging Operations from 07 March 2024.

* It's a next generation INSAT-3Ds Meteorological Satellite with meteorological payloads (6-channel Imager and 19 channel Sounder) It's meant to provide images for climate observations and predict extreme Weather forecasts of Local (50Km around), Route forecasts in the micro and meso- scales. The dynamic image of the Earth is shown below:

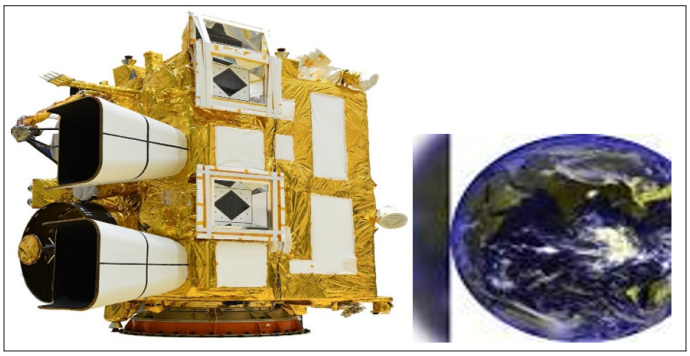

Figure 2: INSAT-3Ds (Built Launched 17Feb'24) by ISRO from the SDSC

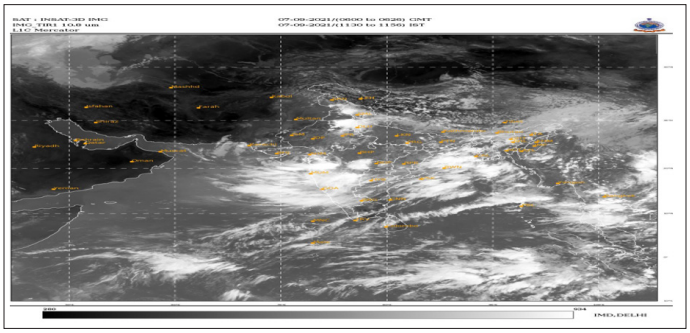

Figure 3: Imagery-INSAT-3D-IMG

Remote Sensing Devices: <Defence (Spy) Satellites. (IAF-ASC & ISC)>
Currently, 10 Indian Satellites are in the orbit but, the few are used for military purposes (SPY SATELLITES) having spatial resolution of 1 meter or below e.g.
Technology Experiment Satellite (TES): having panchromatic camera (PAN) with a resolution of 1-metre.

RISAT 2: capable of imaging in all-weather conditions and has a resolution of one meter.

CARTOSAT-2, CARTOSAT-2A & CARTOSAT-2B which carries a panchromatic camera which has a resolution of 80 centimetres (black and white only).

INSAT-Series by ISRO
Expected future acquisitions of Remote Sensing Devices: Stealth Unmanned Combat Air Vehicle (UCAV). DRDO's Airborne Early Warning & Control System AEW&CS) [2].

Remote Sensing Devices: < Satellites> (Indian Navy)
Naval satellite(GSAT-7): fabricated by ISRO for 7 years life was India's first exclusive defence Satellite, successfully launched by European space consortium Arianespace's rocket from Kourou spaceport in French Guiana in August 2013 at 74°E, providing UHF, S-band, C-band and Ku-band relay capacity.

Its Ku-band allows high-density data transmission, including both audio and video. This satellite also has a provision to reach smaller and mobile terminals with a footprint of 3,500-4,000 kilometres (2,200-2,500 miles; 1,900-2,200 nautical miles) over the Indian Ocean region, including both the Arabian Sea and the Bay of Bengal region [3].

Remote Sensing Devices:<Défense Meteorological Satellite Pictures (DMSP), USAF>: These are Polar orbiting Satellites, with VR, IR and Resolution <1 deg.> Dr Virendra Goswami Worked on USAF- **Défense Meteorological Satellite Pictures (DMSP)**,), at Space Science Engineering Centre (SSEC)-NASA, Univ. of Wisconsin, USA With Prof. Sikdar, Prof. Suomi, and Dr Martin, On Cloud Clusters over the SE-Asian region (70DegE-120degE & 20N-20S)

Latest High Resolution multirole NISAR-Satellite- 2025
NISAR(NASA-ISRO) -Satellite Data: <Space.com30July25> reported the launch of NISAR-Satellite and released the launch-video as well. NISAR (NASA-ISRO) Satellite launched by ISRO-Geosynchronous Satellite Launch Vehicle (GSLV) on 30th Jul'25, is a joint effort between NASA and ISRO. It aims to study Earth planet in detail from orbit for at least five years using Synthetic Aperture Radar (SAR), capable to gather data in all weather and lighting conditions. In the word of ISRO Officials, "NISAR will image the global land and ice-covered surfaces, including islands, sea ice and selected oceans every 12 days," .NISAR's "primary object land and ice deformation, land ecosystems and oceanic regions in areas of common interest to the U.S. and Indian science communities," they added.

The NISAR Launch is the 18th Liftoff to Date for the GSLV an expendable three-stage rocket that stands 169.6 feet (51.7 meters) tall , 5,300-pound (2,400-kilogram) in weight deployed into orbit about 18.5 minutes after liftoff on 30thJuly 2025. It would work from a circular orbit 464 miles (747 kilometres) above Earth that takes it over the planet's poles. Also, NISAR is a dual-frequency band radar. The L-band radar, which transmits microwaves between 1 and 2 gigahertz (GHz), was built by NASA's Jet Propulsion Laboratory (JPL) in Southern California, while ISRO provided the S-band radar operating between 2 to 4 GHz. The S-band is sensitive to vegetation and foliage, whereas the L-band can see through the trees to monitor the bare surface, be that rock or ice [4].

The Synthetic Aperture Radar SAR technique gives NISAR powers of high resolution, and it takes advantage of the moving capacity of the NISAR wherein; spacecraft beams down radar pulses while flying along, the area on the ground covered by each radar beam while switched on is about 10 kilometres (6 miles) long.

Figure 4: Sharp eyed US-Indian Satellite Set to Launch July 30 to Monitor Earth's Surface, for the Prediction of Natural Disasters.

Keith Cooper published in the Space.com that On July 24, reported that Indian Space Research Organization (ISRO) rolled the NISAR (NASA-ISRO Synthetic Aperture Radar) spacecraft and its GSLV rocket out to the pad at Satish Dhawan Space Centre in Srihari Kota, India.

The NASA-ISRO Synthetic Aperture Radar is capable to scan Earth planet and provide detailed map of the ground or ice creeping by degrees of less than a centimetre helping to avert, or minimize, the effects of natural disasters e.g. Earthquakes, Volcanoes, land subsidence, swelling, and the movement, deformation of melting of ice sheets , glaciers, and tracking of wildfires and floods. This would help to predict Earthquakes in particular, by tracking the smallest shifts in the landscape as the precursor to a major disaster. For example, the “slow" landslides in mountainside or cliff move by just a few centimetres per day, before reaching a tipping point and crashing down would be observed by NISAR enabling to see that slow creep/subtle movement of tectonic plates, and forecast the when and where the disaster would take place [5].

Nicky Fox, associate administrator of NASA's Science Mission Directorate, on 21 July 25 said, “Where moments are most critical, NISAR's data will help ensure the health and safety of those impacted on Earth as well as the infrastructure that supports them,".

Also, NASA’s," Edelstein said, "I've spent my entire career working on radar missions for JPL, and NISAR is the highlight for me "I can't wait to see the science that it produces and the impact that it has. I think it will help people around the world."

Figure 5: The GSLV Rocket Carrying the U.S.-Indian NISAR Earth-Observing Satellite Rolls out to the Launch Pad on July 24, 2025. (Image credit: ISRO)

Adverse Atmospheric Weather Phenomena

Adverse atmospheric Weather Phenomena is directly related to Atmospheric Conditions resulting the Severe Weather hazards which may be summarized as:

Poor Visibility due to Fog, Smog, Mist, Haze, Dust Haze. Heavy Rains, etc. Low Pressure, Depressions, Cyclonic Storms, Severe Cyclonic Storms (Hurricanes/Typhoons) Thunderstorm, Thunder Showers, Hailstorm, Dust Storm, Dust devils, Hot Winds (Loo), Squalls, Tornados, High Altitude Phenomena e. g. CAT (Clear Air Turbulence), Jet Stream, Icing. Turbulence, Low Level Turbulence (LLT), LLT due to Land-Ocean Interaction over Islands, Mountain Waves & Valley Turbulence. Earthquakes, Tsunami Seasonal Hazards (SW-Monsoon/ NE-Monsoon), Droughts, Floods Remote Weather Phenomena e. g. El’ Nino, SSTs, High Waves (Tides), NH-SH Weather Systems. Extreme Weather Conditions, diurnal Variation of Temperatures, Very High & Very Low Temperatures. Hot Waves & Cold Wave Conditions. White-out, Frostbite, Snowstorms. Environmental Pollution. Global Warming &Climate Change [6].

The few Practical Experiences of Adverse Weather

Although, weather Hazards do affect everybody (Humans, Animals, Species) all type of Operations (Civil & Military) during Peace & War but, most affected are Air & Sea Operations of Civil Aviation, Merchant Ships, Air Force, Army Airwing, and Naval Forces respectively.

The few practical Experiences of Adverse Weather by the IAF-Wing Commander (Dr.) Virendra Goswami over the Indian Subcontinent & the other Five Continents (Asia, Africa, Europe, North & Latin America)

Adverse Weather Phenomenon& Weather Reconnaissance Sorties over typical terrain (High Mountainous, Oceanic, Land) Over Western, Eastern, Northern & Southern & Central India as well as overseas (USA, Sri Lanka) are as below:

(a) 1971-Indo-Pak War (b) Tri-Services Exercise at Andaman Nicobar Islands (c) IPKF-Sri Lanka Operations(d) Siachen Valley, (e)Eastern & Western Borders, (f) Car-Rally& Bareilly

Indian Sub-Continent and its vicinity (National)

Although the above-mentioned weather Hazards do affect all types of Military Operations all the time, but, most affected are Air & Sea Operations of Air Force & Naval Forces. Well, the author being an Indian Air Force Officer for more than27 years, had an opportunity to fly as a Supernumerary Crew in the different aircrafts (Microlight, Transport Aircrafts, Bomber and Fighter Trainer Aircrafts, Helicopters (Reconnaissance and attack), logging about 550 hours of flying in all type of flying-worthy weather, over all type of terrains comprising high ranges of mountains (Himalayas, Siachen), land and Oceanic Surfaces of Bay of Bengal, Arabian Sea & Indian Oceanic regions of Cape Comorin (Kanyakumari), Extreme NW & NE, and Central terrains during War and Peace operations carried out my all three Indian Armed Forces amalgamated with INS-Vikrant, (IAF in particular),Naval Ships and Submarines during Inter Services operational exercises e.g. Indian Peace Keeping Force (IPKF),Sri Lanka (1987-88), Andaman-Car Nicobar Islands,1971-Indo-Pak War followed by delineation of the LOC (Line of Control) during 1972-23 and Search cum Rescue (S&R) during floods, droughts and anti-terrorist Operations during 1989-1998 or so [7].

Iner-Continental Flying mainly as a ‘Visiting Scientist’: NASA, WMO, ICAO&UNIDO International Flying): Well, God was kind to bless me with an opportunity to study Weather phenomena in all the said five Continents (32 Countries with 40 Internation sorties), in the capacity of the ‘Visiting Scientist’: (NASA, WMO, ICAO&UNIDO), Graduate student (Univ. of Wisconsin), & Post-Doctoral (Univ. of Illinois) after having got awarded Doctorate from the Indian Institute of Technology (IIT), Kharagpur.

Adverse Climate Change / Global Warming affecting all types of Operations (Civil & Military): <Centre for Land Warfare Studies (CLAWS), New Delhi,2017 Report)

Increased risk to infrastructure and life by erratic climate and weather extremes. Altered ecosystems and habitats, human health, and society. Change in role: civilian support/aid to civil authorities. Strategic, operational and tactical changes: Nature of operations, force structure, multi functionality. Need to review strategy, policies, operational plans, and training. Strategic communications and outreach. Environmental assessment and prediction [8].

Climate Change & Navy: *Rising sea temperature will impact underwater warfare& aircraft operations on board aircraft carriers. Temperature variation affects hydrological conditions thus affecting sonar operating conditions on ships, radar operations, helicopter operations, communications, etc.

Rise in sea level will affect naval establishments located on the sea-coast, and re-location would incur enormous infrastructural costs.

Ships would require greater sea-keeping ability for higher sea states and prolonged extreme weather operations.

The Indian Ocean region& South Asia has experienced numerous natural disasters during the last few decades. With climate change, such calamities are likely to increase in frequency and intensity.

This would demand the frequent deployment of militaries from the region for humanitarian assistance as was evidenced by the role of the Indian Navy for HADR (Humanitarian Assistance & Disaster Relief) activities during the Tsunami of 2004.

How to Fight with Adverse Weather Phenomena& Climate Change Impact: Intelligence: MoD, IDS and Services HQ must incorporate climate intelligence into strategic plans. MI, Naval Intelligence, and Air Intelligence must have operational and tactical climate assessment e.g. If a glacier melts, what will be the watershed path, potential impact on bases around it? Heavy lift (especially airlift) & Amphibious capacity for beach landing and inland riverine movement. Climate change exacerbates threats to national security. It poses direct and indirect threats to the military. A modification of the doctrinal and tactical approaches to accommodate such changes/challenges is necessary. Modification of training patterns is needed. Accurate Weather Forecasting & Avoiding Adverse Weather Phenomena. Research & Development of Innovative Technologies to deal with weather Hazards. Control of GW (Global Warming) & Climate Change by Chemical Processes & Green Energy. Armed forces must have institutional expertise in climate science and mechanisms. Invest in sophisticated modelling techniques to understand micro-level impact in geographies of interest, and Science: Set up a Climate Science Department, that ensures sufficient expertise in climate science, and Collaborate with DRDO (Defence Research Development Organizations), IMD (India Meteorological Department), Department of Space, Universities, and Private sectors [9].

Prediction/ Forecasting Adverse Weather Phenomena

Forecasting Technologies for Severe Weather Phenomena e.g. (Thunderstorm, Cyclonic Storms, Tornados, Precipitation, Poor Visibility) etc.

Conventional (Local Forecast, Route Forecast, Terminal Aerodrome Forecast (TAFOR), Operational Forecast Numerical weather Prediction & Weather Modelling Remote Sensing- High Resolution Satellites) Control of Global Warming & Climate Variability

Proposed Research in the Field of Atmospheric Sc. and Remote Sensing

Aviation, Tropical, Monsoon &Satellite Meteorology. Cloud clusters. Tropical Storms Depressions. Tele-connection of NH&SH convective features Global Warming, Climate Change & Land-Ocean interaction. Atmospheric Sciences, Atmospheric Chemistry. Space Sciences, Lunar Sciences. Geological, Earth Sciences, GW & Climate Variability. Interaction of LAOC (Land-Atmosphere-Ocean-Cryosphere)

Application of Remote Sensing to Study the Impact of Atmospheric Phenomena on Defence Operations During War & Peace"

Indian Armed Forces is the world's ninth-largest employer by number of employees (1.3 million)

Indian Air Force (IAF), Indian Army (IA) & Indian Navy (IN) with 4th ranking in the World's Armed Forces after USA, Russia & China & in the 5th rank of the Military Strength Indicator (MSI) after USA, Russia China & Japan.

India spends more amount of money on her Armed Forces in terms of billions of US $ Bn. (66.5) in comparison to even Russia (61.4), U.K. (50.0), European, Asian & other Countries but, less than Saudi Arabia (67.6), China (250.0) & USA (648.8) as per the 2019 Fact Sheet for 2018 of Stockholm International Peace Research Institute (SIPRI).

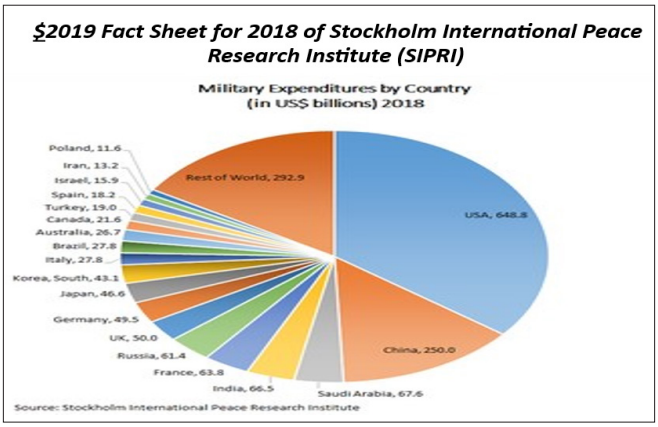

Figure 6: Military Expenditure Report by Country (SIPRI-2018)

Application of Remote Sensing in Defense Operations (War & Peace).

Air Operations & Adverse Weather: Air Operations comprising Offensive & Defensive Operations during War & Peace are most vulnerable to adverse Atmospheric phenomena resulting adverse unprecedented weather conditions due to severe weather phenomena. Innovative solutions to the problems are to be devised by making use of more secure remote sensing technologies e.g. High-Resolution Satellite imagery, data access, assimilation, HPC & cloud computing for real-time analysis. Also, it's important to get well versed in the types of Air operations and the related Air Power vis-à-vis Atmospheric Weather Phenomena and the Weather Forecasting Technologies comprising Numerical Weather Prediction Modeling.

Adverse atmospheric Weather Phenomena does not have barrier of War & Peace as it is directly related to Atmospheric Conditions resulting in the severe Weather hazards, as enlisted above.

Application of Remote Sensing in Armed Forces (IAF, IA, IN) Peace Operations Consisting of

* Disaster relief operations (Land, Air, Sea), Using (Weather

Satellites). *Deterrence against war or intervention, using (Spy Satellites.) *Rescue & Relief Operations (Geo. Sat) &Help Civil Admin. (Drones). * Anti-Insurgency (Terrorist) Operations & UN-Peace Mission. Integrated Space Cell Operated by(Indian Armed Forces. IN: ensures Security of India's Sea-territorial integrity, citizens, offshore assets from sea-borne threat. Safeguard India's mercantile marine, marine and maritime trade, national interests and maritime security. **4.1(c). IAF: Safeguarding Indian Airspace.** # close air support to the Indian Army, # Airlift of Personnel & Floods Relief supplies to affected areas due to Adverse Weather. # Aerial Refuelling.

The Techniques to be Used are: * High Resolution Satellite imageries. * Data access, assimilation, HPC & cloud computing for real-time analysis Depending upon type of Air Ops. & Air Power. *Atmospheric Weather Phenomena and the * Weather Forecasting Technologies (Conventional * Numerical Weather Prediction Modelling.

Climate Change and Global Warming: The Climate is getting adversely affected by toxic gases polluting the air. Air pollution is killing around 25,000 people every year in Delhi NCR and the climate change seriously affects 325 million people every year, a number that will become more than double in 20 years. Economics losses due to global warming vis-à-vis Climate Change amount to over $125 billion annually and are expected to rise to $340 billion each year by 2030.

Climate change is altering our environment affecting agriculture, water availability, and sea-levels. It's increasing the intensity of natural disasters, rate of species extinction, diseases & ENTROPY. This increase in earth's average temperature is called Global warming.

Global Warming is one type of Climate Change Specific
Global warming means an increase in Earth's average temperature over time. The increase either may be due to natural or unnatural processes or an increase in Green House Gases (GHG), mainly from the burning of fossil fuels.

This warming is measurable in Earth's atmosphere and oceans. It can be seen in retreating ice caps, dry lakes, global temperature rises, shifts in weather, coral bleaching, sea-level rise and more droughts, floods, heat waves, change in rainy patterns, acute water shortage, food production down etc.)

Global Warming is one type of Climate Change Non-Specific
Climate is a statistical record of average pressure, temperature, humidity, precipitation and weather trends. Correlation of Deaths/ Health Disease with Environmental Pollution (Air & Water). Air Pollution has significant health impact apart from the other pollutants e. g. tobacco, smoke, pesticides, chemical and heavy metal contamination. Air Pollutants: Particulate Matter (PM), SO2, NO2, GHG, O3. The various respiratory ailments are due to air Pollution. CPCB (Central Pollution Board, India) plans to install Air Filters on roofs of buses, Purifiers on streets. **5.3. Air Pollutants, Antibiotics & Superbugs**.

The All-India Institute of Medical Sciences (AIIMS), New Delhi reports that the Antibiotics, painkillers and other leftover medicines thrown in the Water bodies directly or through the garbage; come back to us in milk, vegetables and other agricultural produce and give rise to SUPERBUGS that most antibiotics cannot kill.

Monitoring Air Pollution by Satellites (Hindustan Times: 13Jun'18)
Satellites generate data used to calculate Aerosol Optical Depth (AOD, capturing how much sunlight is blocked by aerosol particles from reaching the Earth's surface by measuring of total amount of pollutants from the ground up to the satellite-the column of air. In my View AOD in Night would be perhaps capturing of moonlight blocked by aerosol.

NASA's MODIS data set is the most reliable source of AOD. Satellite measurements are combined with a chemical transport model that incorporates meteorological measurements and how pollutants move & chemically change in the atmosphere to produce surface level estimates. India has 703 manual monitoring stations in 307 cities,100 continuous monitoring stations in 57 cities.

Water Pollution due to Toxin. Water gets polluted due to four types of toxic entities: # Chemical, # Biological, # Physical # Radiation. Water gets polluted due to: # Particulate matter, # Disinfectants or Herbicides. # Pesticides and Contaminants from water e. # Microbial pathogens, # Viruses and # Bacteria.

Ground water contamination takes place from the motor pumps and borewells resulted due to seeping of Chromium into the water by the industrial units over the decade. Marine Pollution CO2 absorption by the Sea. Over 25 million tons of CO2 dissolve in Seawater everyday resulting Carbonic acid leading to fall in pH, slowing down Ocean Dynamics &leading to ocean acidification.

Scope: Latest Innovations: {C.f. SOLAS (Safety of Life at Sea) Newsletter Dated 13 Aug'21}: The ocean is mitigating global warming by absorbing large amounts of excess carbon dioxide from human activities. To quantify and monitor the ocean carbon sink, we need a state-of-the-art data resource that makes data submission and retrieval machine-compatible and efficient.

The comment from Tanhua et al. (2021) describes the challenges of quantifying the interior ocean storage of anthropogenic carbon and the utility of the reference data product GLODAP (The Global Ocean Data Analysis Project.

(NASA), is designing Satellites which would measure regional and global fields of turbulent air-sea interactions, and from which all the components of the turbulent heat and moisture are derived.

Innovative Solutions to Control Global Warming: Environmental Energy Cycle: To clean & sustain clean Environment; the Environmental Energy Cycle has got three Energy points viz. Solar (S), Air (A) and Water (W) with its Centre as Energy (SAW). **Use Green Chem. & Nano-Tech. To Control GW**, reduce the number of heat-trapping emissions we are putting into the atmosphere. **Reduce personal carbon emissions. Use Renewable energy** and transform energy system to Green Energy i.e. cleaner and less dependent on coal and other fossil fuels. Increase vehicle fuel efficiency and support other solutions that reduce oil use.

Latest Innovations: Water Car & Water Harnessing from Fog Humid Atmosphere
Car has been run on Water energy in Gujarat. By using special **Mesh-Curtains**, the fog particles i.e. Low clouds are entrapped, and water is produced. **Water ATM's** machines may be designed in future. **Tree plantation Drone** developed by Bio Carbon Engineering, Australia. **Zero Mass Water**: US firm uses technology to harvest drinking water out of thin air, using a

combination of materials science, solar power, and predictive data.

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