Spatial variation of climate change issues using remote sensing technique

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Abstract. The assessment of climate change can be carried out by analysing rainfall variability, temporal climatic changes, spatial interpolation of climatic factors and climatic risking. The climatic changes have consequences on precipitation pattern changes, temperature variation, and crop growing season alteration, increase of sea ice and grounded ice sheets. This has implications on ecosystem, human health, settlement and agriculture. Some of the repercussions attributed to temperature and precipitation increase is an increase of Cyclonic activities with increase of cyclonic wind speeds, Increase in Extreme Precipitation events like floods and droughts, agricultural yield is projected to decrease and negative impact on subsistence agriculture. The Tropical Cyclones intensifying in eastern Indian Ocean and crossing the coasts of Indian subcontinent year after year is a major cause of concern. The Latent Heat Release (LHR) of cyclones of Bay of Bengal carried out using advanced sensors like SSM/I (Special Sensor Microwave/Imager) on-board DMSP satellites (Defence Meteorological Satellite Program of US) for assessing spatial distribution of precipitation since LHR is responsible for maintenance and intensification of tropical cyclones and LHR can also enable measurement of brightness temperatures of atmospheric/ocean surfaces. The images of the clouds in visible and infrared region provide information about cloud aerial extent, type, and growth/decay. The raining clouds have high visible band reflectance and are tall due to upward motion indicating deep convection. These issues pertaining to climate changes through Remote sensing techniques is discussed in the paper.

1. Introduction
The consequence of climatic changes are manifold such as precipitation pattern changes, temperature variation, crop growing season alteration, increase of sea ice, grounded ice sheets etc. The climatic changes can also result in regional disturbances such as agriculture impact, water balance changes, forestry biomass degradation, disturbance to fish apart from effect on human health and settlements [2]. Environmental impacts accrued due to human induced climatic changes are now larger, faster, more widespread predominantly affecting tropics, high latitudes and elevated landscapes, major deltas, coastlines etc. Climatic change study should identify consequences that are vulnerable to populations and societies apart from evaluation of issues which are ecologically and climatologically sensitive [4].
This can ensure planning for mitigation measures rather than follow the adaptation for climatic changes based upon geographic location.

Hyper spectral remote sensing has become a potent source due to its potential in identification of ocean related parameters. The features can be identified more accurately in comparison to broad band multispectral data. Large volume of data in hyper spectral sensing possesses a challenge for traditional processing techniques such as removal of redundancy and provision of continuous relevant information pertaining to climatic studies. High spectral resolution in region of 0.4 to 2.5 micrometre can be used for identifying large range of ocean cover features that cannot be identified with broad band, low spectral resolution imaging system.

Latent Heat Release (LHR) of cyclones of Bay of Bengal has been done using advanced sensors like SSM/I (Special Sensor Microwave/Imager) on board DMSP satellites (Defence Meteorological Satellite Program of US) for assessing spatial distribution of precipitation as LHR is responsible for maintenance and intensification of tropical cyclones. It also measures brightness temperatures of atmospheric/ocean surfaces. Cloud images (Visible/IR) provide cloud aerial extent, type, and growth/decay [8]. The raining clouds have high visible band reflectance and are tall due to upward motion indicating deep convection.

Satellite measurement of wind speed using SSM/I is useful for meteorological and oceanographic studies like moisture transport, upwelling phenomena, sea state and air-sea interactions [3]. SEASAT active and passive sensors contains radar altimeter, scatter meter and scanning multichannel microwave radar (SMMR) can give wind speed over ocean surface.

2. Remote Sensing methodology for climate studies

Figure-1 gives the methodology for generating outputs using remote sensing data for climatic studies. The methodology include synergistic studies using imaging and non-imaging sensors in visible, infrared and microwave bands for integration as per process models to obtain derived outputs required in climate change analysis.

![Figure 1. Methodology for climate change studies](image-url)

The outputs create awareness amongst the people about climate change issues and capacity to cope with climate variability apart from helping local authorities and communities to develop and access a range of adaptive measures along with enabling related policies. The action plans for mitigating the effect of climatic changes involve reforestation, planting agricultural crops and trees more suited to
warmer temperatures and drier soil conditions, investing in infrastructure (e.g. drainage systems and conservation schemes), and establishing disaster early warning systems to tackle chronic conditions such as higher temperatures, more or less rainfall, less predictable seasons, sea level rise and saline intrusions. The remote sensing data can be utilized for mapping the decrease in snow covered area attributed to climatic changes [1]. The snow melt runoff due to melting of glaciers and consequent reduction in its area is considered as a negative impact of climatic change. The snow covered area once mapped can be integrated with altitude and other meteorological data into various models for quantifying the snow melt runoff arriving into the river or oceans [5]. The methodology for estimating the snow melt runoff using remote sensing data is given in figure 2.

![Methodology for snow melts runoff estimation](image)

**Figure 2.** Methodology for snow melts runoff estimation.

The snow melt runoff can be estimated well before the arrival of actual quantity of water into the river site or ocean site. This will enable planning in advance for any eventuality.

![ATSR (Along track scanning micrometre) a sensor of ERS-1 and ERS-2](image)

**Figure 3.** Methodology for determining sea surface temperature

The atmospheric behaviour and the climatic studies for weather prediction using surface fluxes over the oceans are linked to estimation of sea surface temperature (SST) [6]. The along track scanning micrometre (ATSR) sensor on board ERS-1 and ERS-2 is used to prepare SST contour maps on a weekly basis. Figure-3 shows the methodology for arriving at SST contour map using ATSR sensor. The SST determination from satellites helps in monitoring of global climate and related studies and for
useful climate application [7]. The accuracy standards of 0.3 degree kelvin have been specified by International Tropical Ocean Global Atmosphere (TOGA). The nutrient concentration such as nitrates, ammonia, phosphorous, dissolved inorganic carbon etc, is linked with phytoplankton concentration and is inversely related to temperature. The relation is dependent upon seasons and geographical locations.

3. Results and Discussions

Himalayas are one of the largest glacier concentrations outside polar region and Temporal Remote sensing observation over extended periods using IRS, TM, and MSS image data can give an assessment regarding Accumulation Area Ratio (AAR), Wherein the AAR is given by

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\text{AAR} = \frac{\text{Snow accumulation area}}{\text{Total glacier area}}.
\]

It has been observed that one degree centigrade global warming in the glacial region can melt the glaciers by almost 50% with appreciable drop in specific mass balance values as mass of ice is highly sensitive to minor variation of atmospheric temperature.

![Figure 4. AAR versus Specific Mass Balance Plot](image)

Figure 4 illustrates the graphical representation between AAR and specific mass balance. It is observed that the glacial area with less than 0.42 AAR are losing more ice mass than accumulation of snow and with AAR more than 0.42 glacial accumulation occurs with change in thickness. The data from Coastal Zone Colour Scanner (CZCS) satellite ocean colour information (visible and thermal) can give information pertaining to concentration of phytoplankton pigment at less than one meter depth in high turbid area and up to 25 to 30 meter depth in low turbid area. (This means the pigment concentration < 0.3 mg/cubic meter). In this context figure-5 gives a graphical plot of phytoplankton concentration versus the temperature of water at 50 m depth. The temperature at 50 meters depth is obtained from climatologic atlas since CZCS measures only the surface temperature.
In Arabian Sea the nutrient concentration such as nitrates, ammonia, phosphorous, dissolved inorganic carbon etc is linked with phytoplankton concentration due to sufficient light throughout the year and nutrient concentration is related to temperature. The relation depends upon seasonal variation and geographical location. Figure 5 gives a plot of Geo-satellite of US Navy Ku band radar altimeter obtained wind speed (using models) versus the wind speed obtained from SSM/I microwave satellite.

It is observed that the standard deviation is 4.08 m/sec for difference of two wind speeds for the data obtained in Indian Ocean tropics period varying from Oct to Dec (10-25 deg. N and 40-90 degree E).

4. Conclusion
SSM/I measurement of wind speed obtained at less than 2hrs interval and 0.15 degree spatial resolution based on surface emissions is governed by wave structures and has a RMS error of +/- 0.5m/sec. This can help evaluation of moisture transport, upwelling phenomena, and sea state and air-sea interactions. Upwelling radiation expressed as brightness temperature can be different for raining and non-raining clouds and can be inferred by microwave radiometer against the backdrop of oceans. This brightness temperature is reliable as the oceans have cool and uniform emissions. Large raindrops (>λ) and ice particles reduces brightness temperature because of scattering of upwelling radiation away from the direction of sensor.
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