Remote Sensing and GIS
Prof. Rishikesh Bharti
Department of Civil Engineering
Indian Institute of Technology – Guwahati

Lecture – 24
Applications of Remote Sensing and GIS - II

This one is the last lecture of this course. In this lecture, we will see some more examples as well as the applications of the remote sensing and GIS technology. So, let us start with this application of remote sensing and GIS in cryospheric studies. So, here as we know, that cryosphere is basically the Earth's cover of snow and ice. So, let us see how we can apply this understanding

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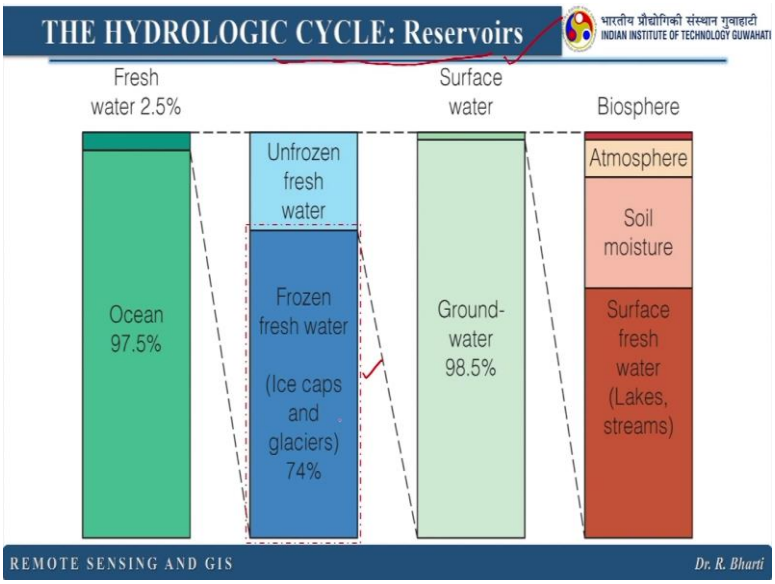

To identify or to extract some meaningful information. So, just to give you a background of this problem, so, let us go through this slide where I have explained how water is stored in different reservoirs. So, that is why the heading of this slide is the hydrological cycle and reserviors. So, these are different reservoirs present in our earth system. So here you can see that frozen freshwater, ice cap and glaciers.

So all are basically included in this right. Let us understand this cryosphere in little bit more detail.

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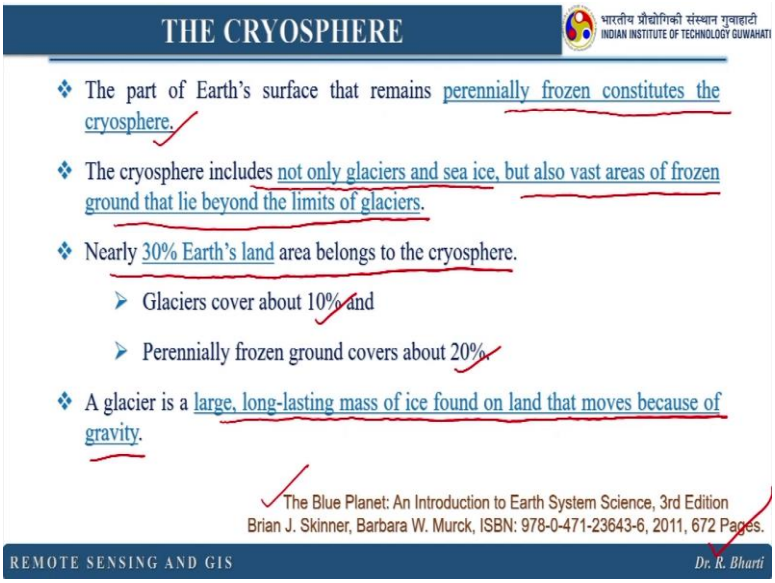

The part of Earth is surface that remains perennially frozen constitutes the cryosphere right? The cryosphere includes not only glaciers and sea ice, but also vast areas of frozen ground that lie beyond the limits of glaciers. So this is taken from this particular book. This is a very standard book in this area, The Blue Planet, and introduction to Earth System Science. So here you can get all the different types of systems which are involved in our Earth, right.

So that is why we are talking about Earth System. Now the third point here, it says nearly 30% of the Earth's land are belongs to the cryosphere. Where the glacier covers about 10% and perennially frozen ground covers about 20%. All together cryosphere covers 30% of the land area. Now a glacier is large long lasting mass of ice found on land. That moves because of the gravity, because you must have heard that glacier is moving.

Glacier is coming down it is at very high speed it is at low speed. So, why it is moving because of the gravity. So, those components you can study which are involved in this movement as well as this glacier formation using this remote sensing and GIS.

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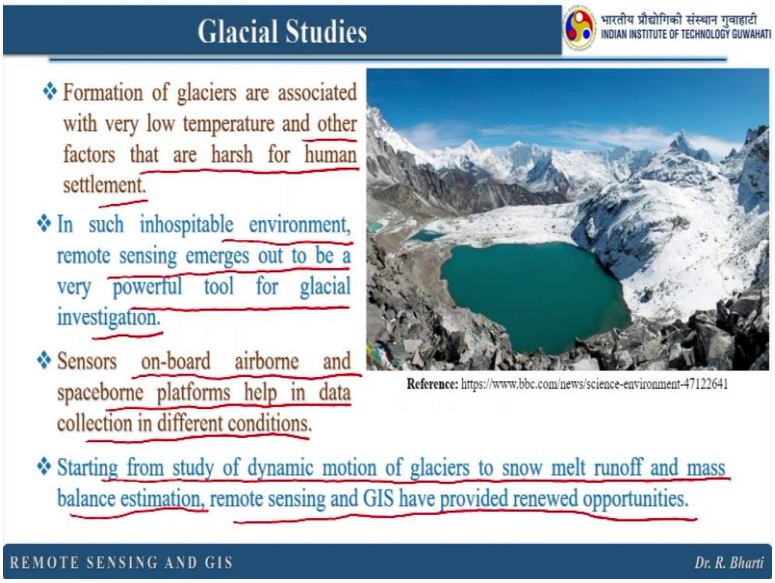

So, formation of glaciers are associated with very low temperature and other factors that are harsh for human settlement. We cannot survive in those conditions where these glaciers have been formed in such inhospitable environment, remote sensing emerges out to be a very powerful tool for glacier investigation. Why? Because you need not have to go there. You just have to access the data captured from these satellites and you can do n number of different investigations right. So, for conventional technique, you have to visit the ground you have to take the sample you have to do some in-situ experiments then only you can derive meaningful information. But here when remote sensing is involved, you can do it from your office or from your lab provided you should have access of the appropriate remote sensing data.

Sensor on board air borne and space borne platforms helps in data collection in different condition. That is true. Starting from the study of dynamic motion of glacier to snow melt runoff and mass balance estimation. Remote sensing and GIS have provided renewed opportunities. So, there are lots of data available nowadays. So, you just have to identify appropriate data suitable in your studies.

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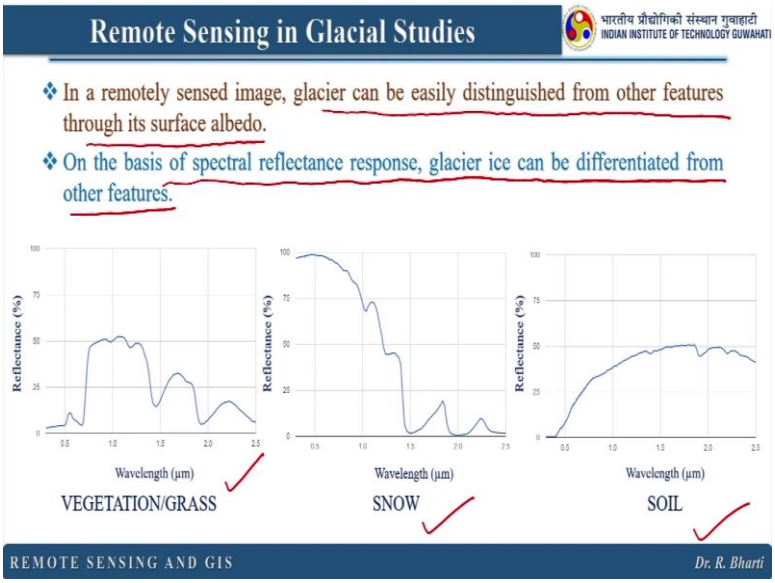

In a remotely sensed image, glacier can be easily distinguished from other features through its surface albedo. That we have already understood in hyperspectral remote sensing as well as the field spectroscopy part right, where I have explained you, if there is a change in or slight change in the composition, your absorption feature is going to identify that right. On the basis of spectral reflectance response glacier ice can be differentiated from other features, right. So here you have typical vegetation or grass spectra. This is for the snow and this is for this soil. So you can see all these three are different without any spectral analysis. By looking at this spectra, you can easily find out the differences right. So, this is what qualitative analysis mean. But when you are involved in quantitative then definitely you have to quantify for that you have to conduct spectral analysis right.

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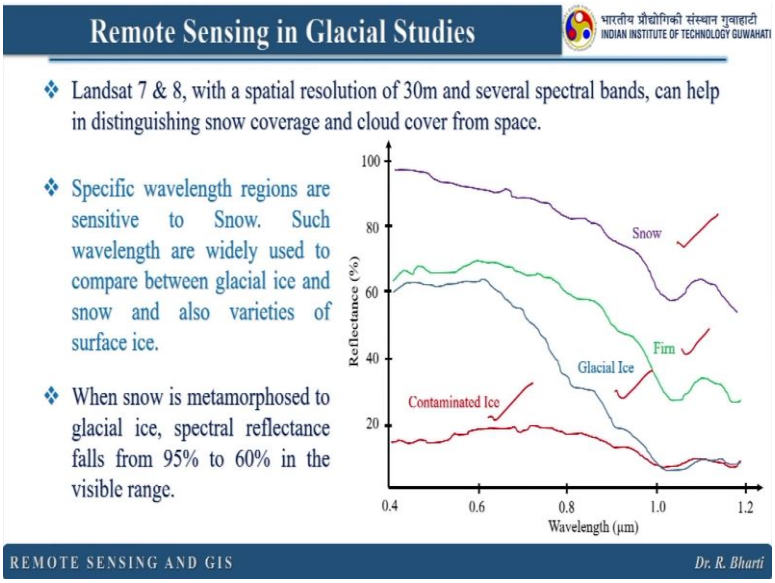

Landsat 7 & 8, with a resolution of 30 meter and several spectral bands, can help in distinguishing snow coverage and cloud cover from space. Specific wavelengths are sensitive to snow. Such wavelength are widely used to compare between glacial ice and snow and also varieties of surface ice. When snow is metamorphosed to glacial ice, spectral reflectance falls from 95% to 60% in the visible range.

This is from one study where you can easily find out the difference between snow, fern glacial ice and contaminated ice from each other by looking at the spectral profile. So this is the beauty of remote sensing and GIS where you do not have to visit the place, but definitely you need some ground data to validate it, but most of the time you can use this remote sensing and GIS directly to interpret or derive the result.

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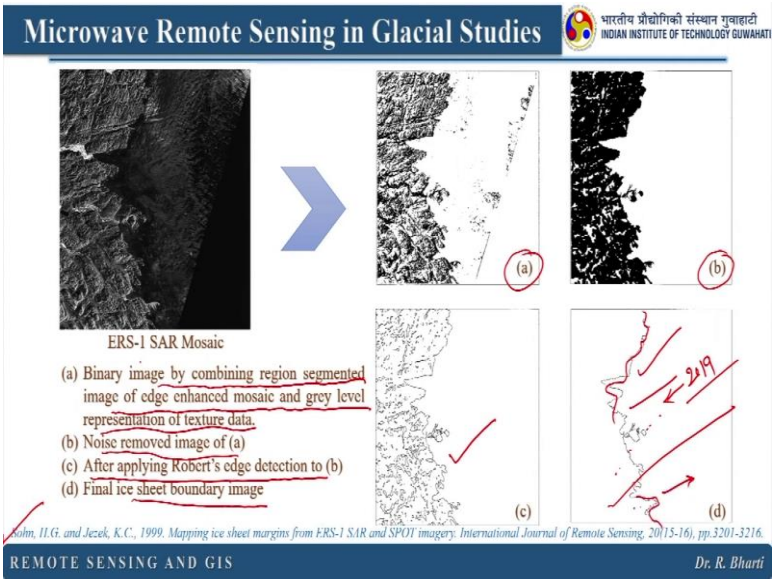

Now, let us see how this microwave remote sensing has been used in glacial studies. So this is one word which has been published by this gentleman. So here you can see this ERS-1 SAR mosaic has been used to identify the boundaries of this snow. So binary this is the rights. So binary image by combining region segmented image of edge enhanced mosaic and grey level representation of texture data.

Now, the next one is (b) were noise has been removed and in the (c) you can see after applying Robert's edge detection it has come to this level now, our interest to just find out the boundary then the final ice sheet boundaries have been derived again further using the filters right. So, here you can easily find out how this is changing with respect to time. So, let us say this is for the 2019 right.

So, similarly you can find out previous years and then you can easily find out how these boundaries are shifting either lower side are up.

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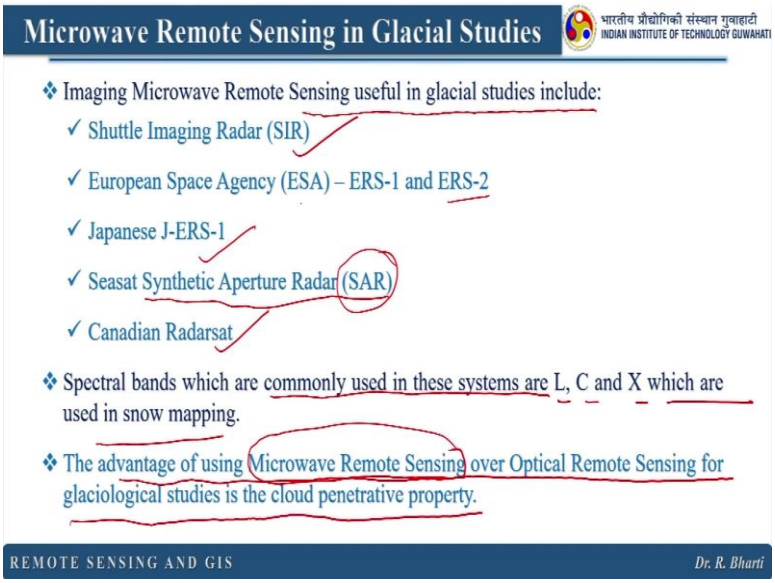

Imaging microwave remote sensing useful in glacial studies include this SIR data SIR then European space Agency ESA So, that satellite name is ERS 1 and ERS 2 then Japanese JERS 1 then Seasat Synthetic Aperture Radar that is SAR then Canadian Radarsat so Radarsat 1 2. Spectral bands which are commonly used in these systems are L band C band and X band which are used in snow mapping right. So, what is the advantage of this microwave remote sensing in glaciological studies because glaciers are found to be at the higher altitude? So, what happens most of the time you will have the cloud covers and the light rain right. So, because of that the optical remote sensing data sets are not very useful. That is why this is microwave remote sensing images are more useful or more used in Glacier studies. So, the advantage of using microwave remote sensing over optical remote sensing for glacial logical studies is the cloud penetrative property.

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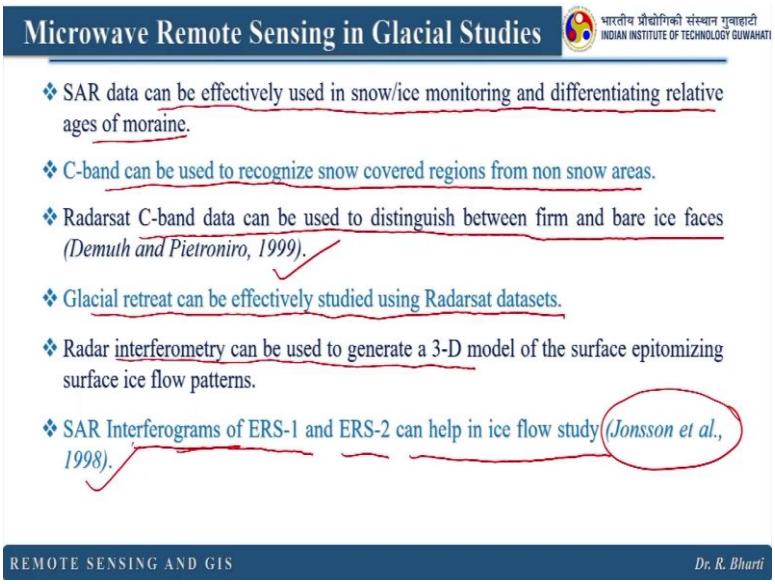

SAR data can be effectively used in snow ice monitoring and differentiating, relative ages of moraine. That is also one application, C band can be used to recognize snow covered regions from non-snow areas. So, with C band it will be very easy, Radarsat C band data can be used to distinguish between firn and bare ice faces this particular paper, they have already explored this possibility. Glacial retreat can be effectively studied using Radarsat datasets. Radar interferometry can be used to generate 3D model. So this is another area where lots of opportunities are available. So, you can think of generating a 3D model for glacier region. Where you can utilize optical remote sensing as well as the microwave remote sensing data, SAR Interferograms of ERS 1 and ERS 2 can help in ice flow that already these people have explored, right? Why I am explaining you all these applications.

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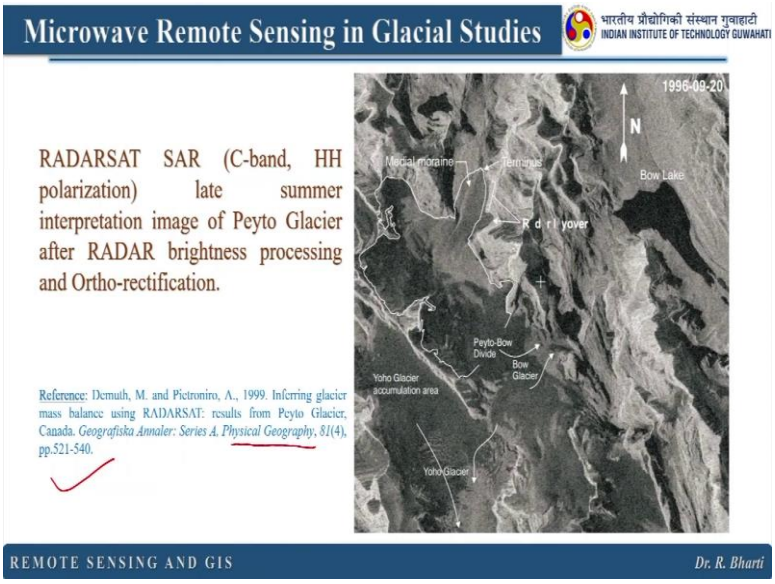

Because you need to understand the capabilities of remote sensing and GIS and their potential applications. So, where you can directly use this technology as a tool. And you can solve a problem which can be related to a society or maybe a nation, right. This is another work which has been published in physical geography.

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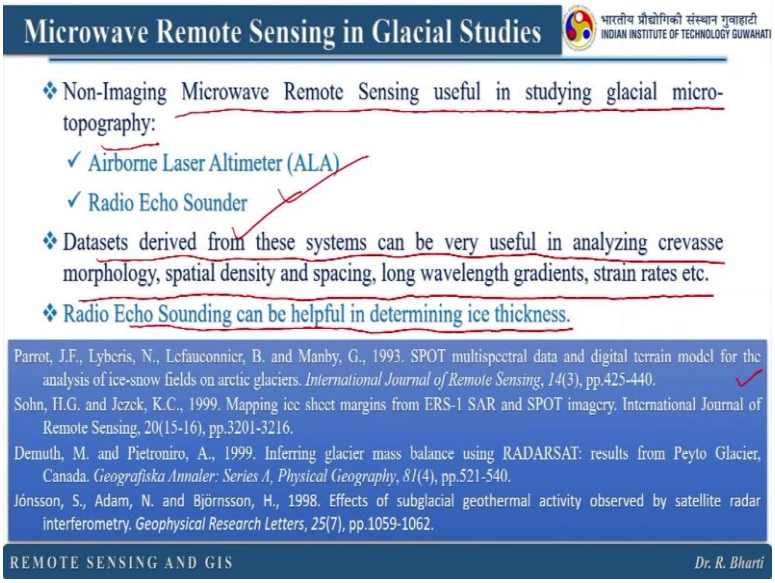

Non-imaging microwave remote sensing, useful in studying glacial micro topography, this is another possibility where you can think of applying this remote sensing and GIS. So, here Airborne Laser Altimeter is used Radio Echo Sounder is used. Datasets derived from these systems can be very useful in analysing crevasse, morphology, spatial density and spacing, long wavelength gradients, strain rates, etc. Radio Echo Sounding can be helpful in determining ice thickness. So, now you can see not only this surface but we are thinking about the volume also right. These are some selected references which you can go through if you are interested in glacial related studies. So, these are very good publication, you can have a look.

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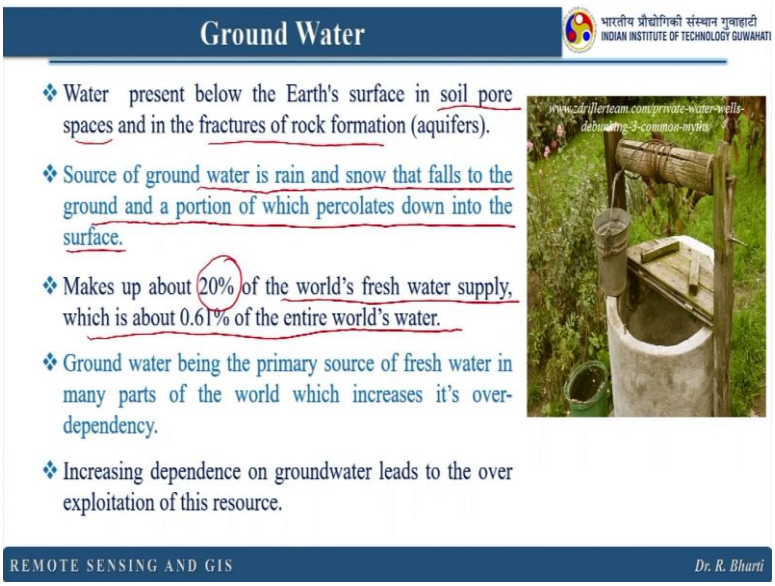

Now let us see what is the potential application of remote sensing and GIS in groundwater exploration, right. So here, I will give you a little background of this problem why it is so

important. I think you know why water is important and especially groundwater. So, Water present below the Earth surface in pore spaces in the fractured rock formation. So basically we are talking about the soil pores spaces where water is present, or the fracture of rock formation, where water is present. Source of groundwater is rain and snow that falls to the ground and a portion of which percolates down into the surface, right. Which makes up about 20% of the world's freshwater supply, which is about 0.61 of the entire world's water, Ground water being the primary source of freshwater in many parts of the world which increases it's over dependency.

As we know, in many parts of the world, the groundwater is the only source of freshwater art. In other words, you can say, for drinking water, right. So it is very demanding to study and preserve this groundwater or to explore this groundwater in certain areas where you have scarcity, right. Increasing dependence on groundwater leads to the over exploitation of this resource. That is the main reason we have to worry about our groundwater, or in other words, drinking water.

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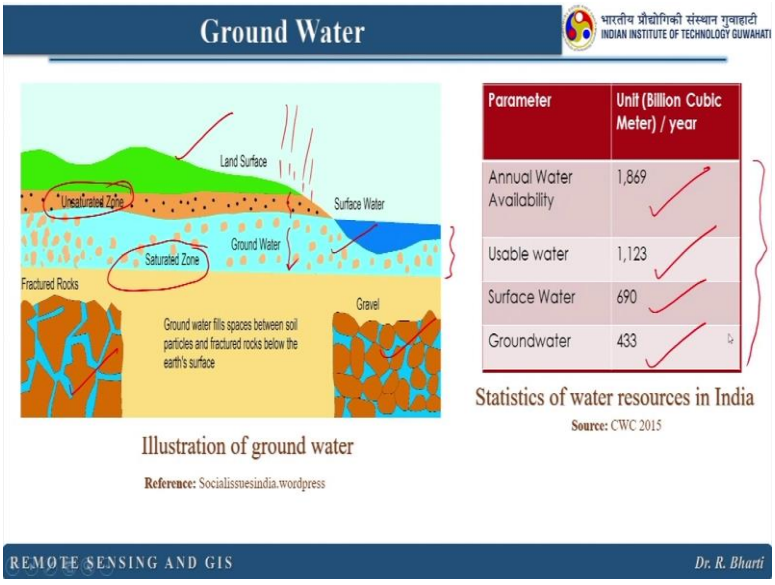

In this figure, basically, I want to explain where exactly your groundwater is, right. So you can see this is a Saturated Zone, this is Unsaturated Zone. So basically, this is our topography. So, when rainfall is coming here or falling here, so, it is getting percolated and it is coming to this aquifers zone right. And why this water is present in this particular strata. Why because you have fractured rock or gravels where you have pore spaces which are getting filled with water right. So, basically this is the process by which your groundwater is stored or it is getting explored. Here you can see the annual water availability is this much

usable water is this much surface water is this groundwater is this so you can think about some problem where you can utilize this remote sensing and GIS technology.

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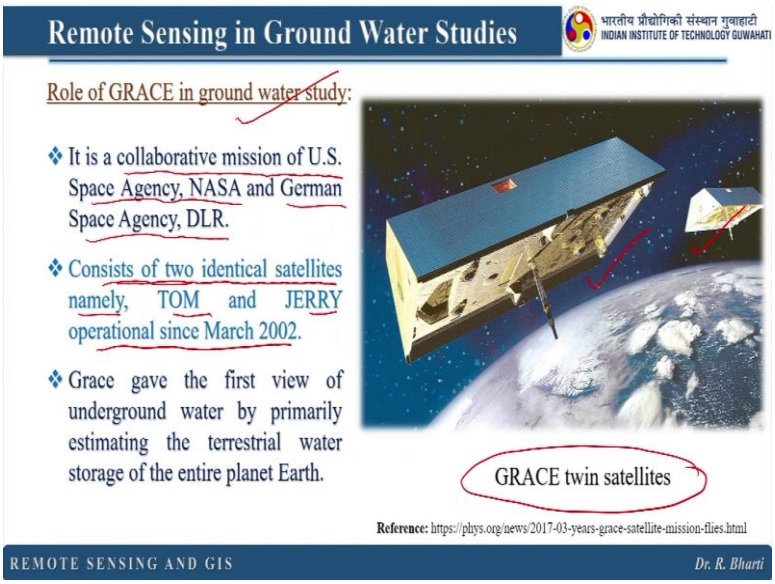

So, to address this problem, we have our satellite called GRACE twin satellites Right. So role of GRACE in groundwater study. It is a collaborative mission of US Space Agency, NASA and German space agency that is DLR. It consists of two identical satellites namely, TOM and JERRY. So one is known as Tom, another one is known as Jerry. Operational since March 2002. Grace gave the first view of groundwater by primarily estimating the terrestrial water storage of the entire planet, right. I am talking about the earth right. Now, how do we determine this TWS? TWS is basically terrestrial water storage TWS is all forms of water stored above and below the earth surface.

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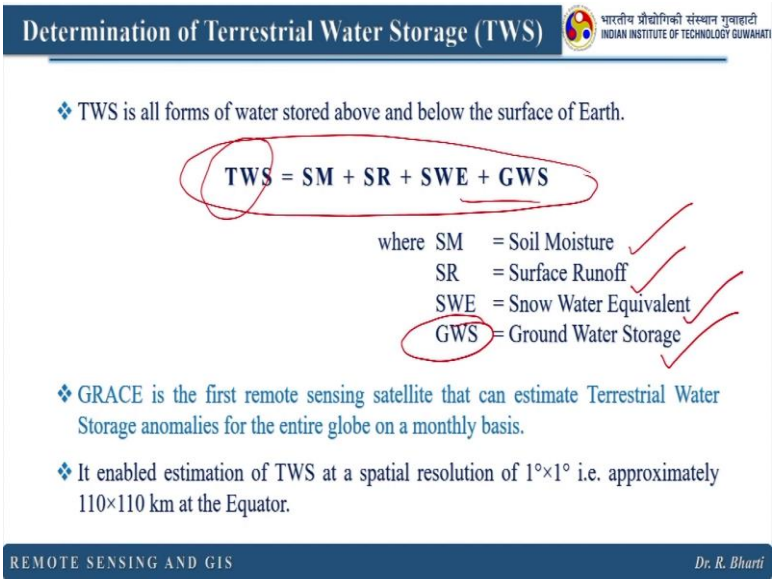

So here this is the equation. I hope you are familiar with this TWS is equal to SM plus SR plus SWE plus GWS where SM is soil moisture SR is basically surface runoff, SWE is basically your snow water equivalent GWS is basically your ground water storage. So basically we want to derive this one if we know all other parameters right. Grace is the first remote sensing satellite that can estimate terrestrial water storage anomalies for the entire globe on a monthly basis.

This grace satellite enables estimation of TWS total water storage at a spatial resolution of one degree by one degree that is approximately 110 or 111 kilometre square at the equator right.

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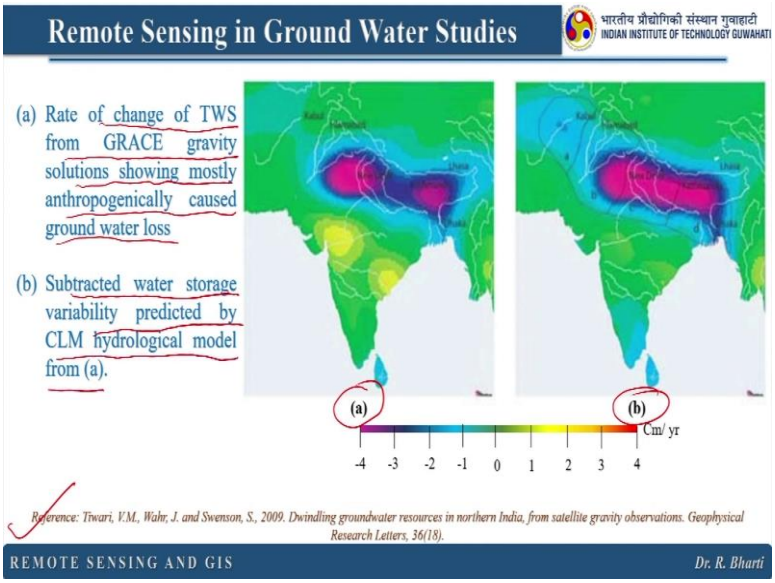

You can see this image this is from this particular paper. So (a) basically I am talking about this. So rate of change of TWS from grace gravity solutions showing mostly anthropogenic ally caused groundwater loss. And (b) in this figure subtracted water storage variability predicted by CLM hydrological Model from (a) right.

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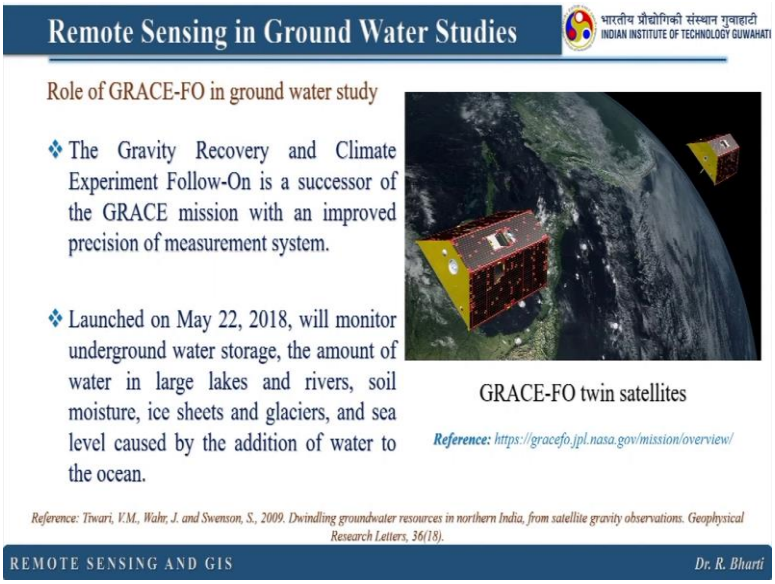

Now we have GRACE-FO the gravity recovery and climate experiment follows on is a successor of the grace mission which is basically an improved version right for the precise measurement launched on May 22, 2018. And this is to monitor underground water storage, the amount of water in large lake and river, soil moisture, ice sheets and glaciers, and sea level caused by the addition of water to the ocean. Basically here I want to tell you that there are certain problems, which are so critical for which we have launched a dedicated satellites.

So, there are many such satellites, which have been launched for a dedicated problem right. or dedicated research, but apart from that, you can always explore those data sets for other type of studies, right.

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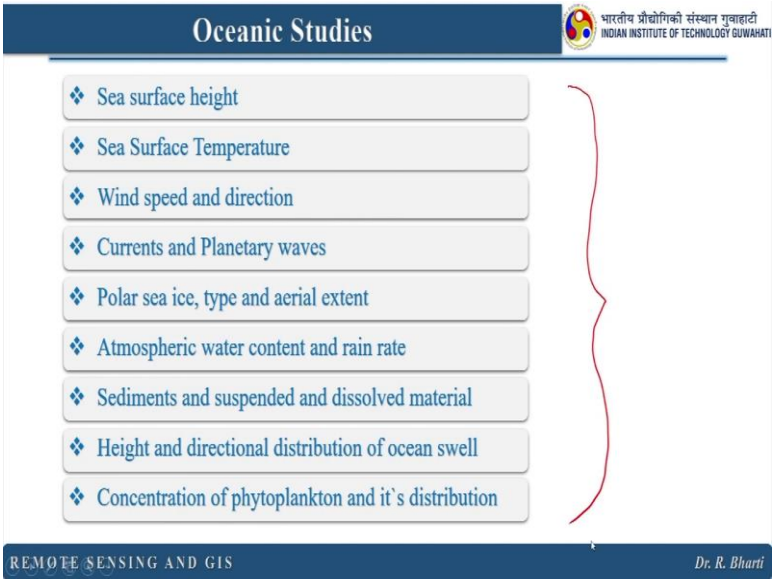

Let us see Oceanography, how we can utilize this remote sensing and GIS. So here you can see a list of areas where you can use this remote sensing and GIS. So first one is sea surface height. You might have heard that sea surface is rising and then it is approaching the land or maybe the settlement areas. So, why it is happening because water is coming up from the sea surface right.

So, the sea surface height is an important parameter to study the climate right because everything is related to each other because we are talking about the earth system. Now the second application is sea surface temperatures. Why it is important? because that regulate your land surface temperature, wind speed and direction, currents and planetary waves, Polar sea ice type and aerial extent, atmospheric water content and rain rate, sediments and suspended solids right, height and direction distribution of Oceans wells, concentration of phytoplankton and its distribution because this is one very important area, which we have to study to understand more about our environment to more about our weather system or more about our climate right.

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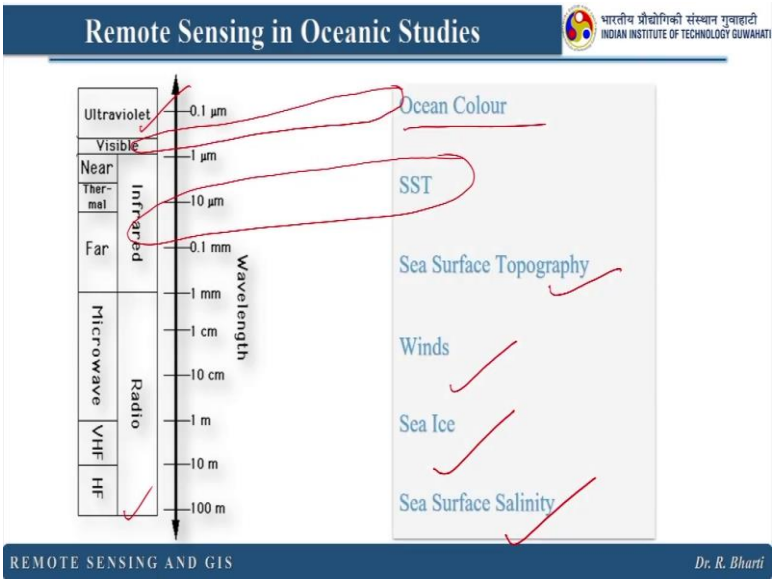

Now, let us see how this remote sensing and GIS are used in these applications. So, here starting from ultraviolet to radio, this is our wavelength region and these are very selected important areas where we want to study using this remote sensing and GIS. So, let us see how we can derive this ocean colour. So, for that we need to use visible data.

So, which says the satellite which are active and can measure the images in visible wavelengths can be used to extract this ocean colour. For sea surface temperatures we have to use this infrared images. For sea surface topography wind, sea ice, sea surface salinity, we have to depend on the microwave images, right? You can see these are the list of areas where you can perform a new research right but for that you need to have basic understanding of remote sensing and GIS and how they are used in this particular application.

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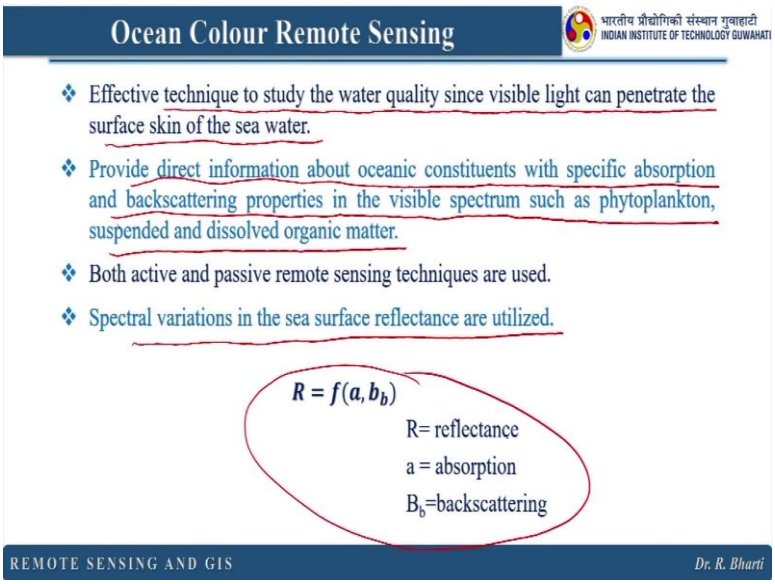

Now, let us see ocean colour remote sensing. This is a very effective technique to study the water quality since visible light can penetrate the surface skin of seawater, which provide direct information about oceanic constituents with specific absorption and back scattering properties in the visible spectrum such as phytoplankton, suspended and dissolve organic matter. Both active and passive remote sensing techniques can be used here, because for different types of application you need either active or passive and what resolution you want that decide the active or passive remote sensing data. So, spectral variations in the Sea surface reflectance are utilized using this particular concept. Where reflectance is equal to function of absorption and back scattering right.

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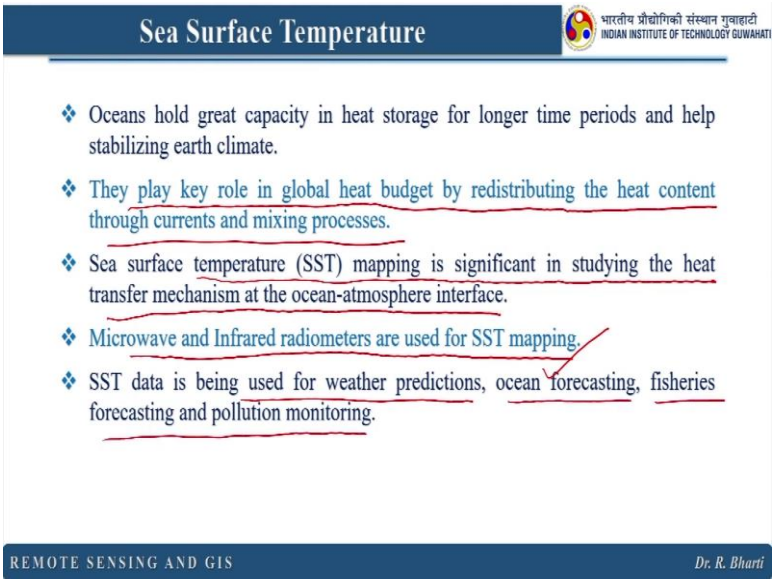

Oceans hold great capacity in heat storage for long time period and help stabilizing Earth climate. They play a key role in global heat budget by redistributing the heat content through currents and mixing processes, because we need to have a mechanism to redistribute our atmospheric temperature otherwise what will happen our surface will be too hot. So, Sea surface is acting as a normalization.

See surface temperatures mapping is significant in studying the heat transfer mechanism at the ocean atmosphere interface, microwave and infrared radiometers are used for Sea Surface Temperature Mapping you can visit some of the space agency's website and you may find some of the these parameters are actually readily available to you. SST data is being used for weather predictions, ocean forecasting, fisheries forecasting and pollution monitoring.

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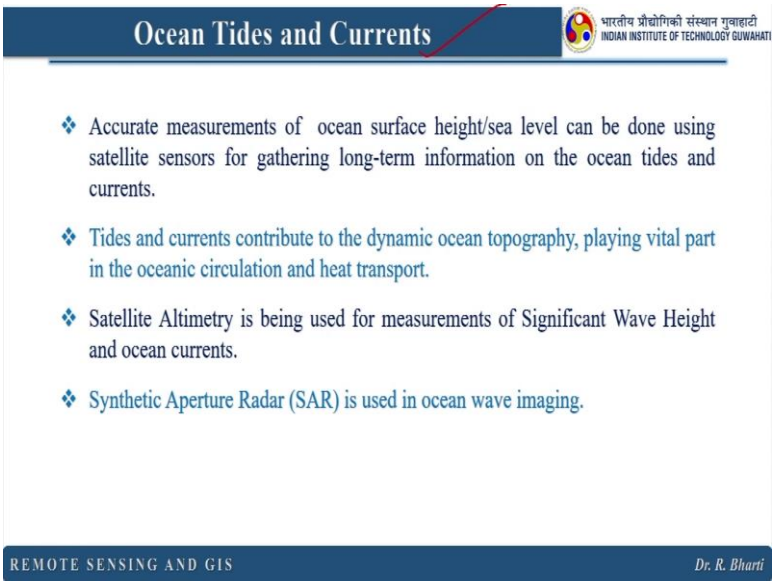

Now we are talking about ocean tides and current accurate measurement of ocean surface height or sea level can be done using satellite sensor for gathering long term information on the ocean tides and currents right. Tides and currents contribute to the dynamics of ocean topography playing vital role in the oceanic circulation and heat transport where satellite remote sensing can give you a clear cut picture. Satellite altimately is being used for measurement of significant wave height and ocean currents, particularly synthetic aperture radar images is used in ocean wave imaging.

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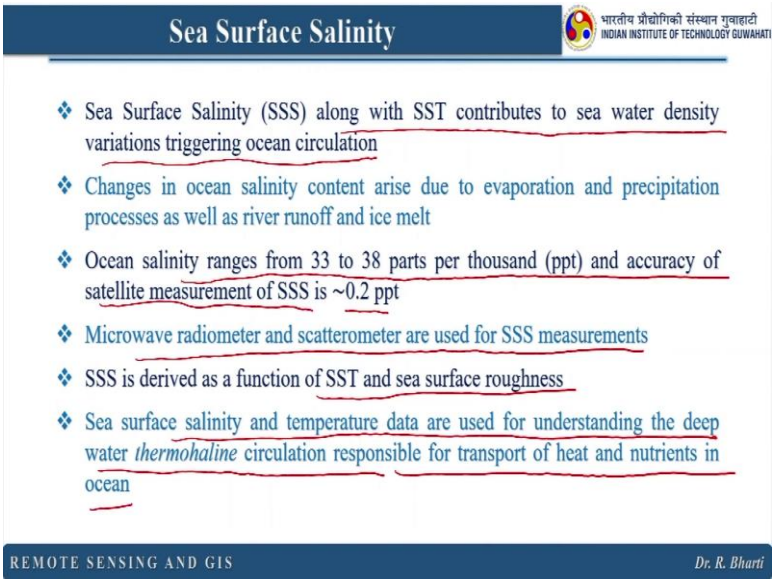

When we talk about sea surface salinity. So basically, the sea surface salinity along with SST contributes to seawater density variation triggering ocean circulation. Changes in ocean salinity content arise due to evaporation and precipitation processes as well as river runoff and ice melt. So now you can see or you can visualize all these different system or earth

systems are linked with each other. So, if you have a problem in one system, that effect can be seen in another system. Ocean salinity ranges from 33 to 38 parts per thousand. And accuracy of satellite measurement of SSS Sea Surface Salinity is about 0.2 PPT right. So, you have very accurate measurement from the satellite, microwave radiometer and scatterometer are used for sea surface salinity measurement. Sea surface salinity is derived as a function of sea surface temperature and sea surface roughness, because all of them are linked with each other. Sea surface salinity and temperature data are used for understanding the deep-water thermohaline circulation, responsible for transport of heat and nutrients in the ocean.

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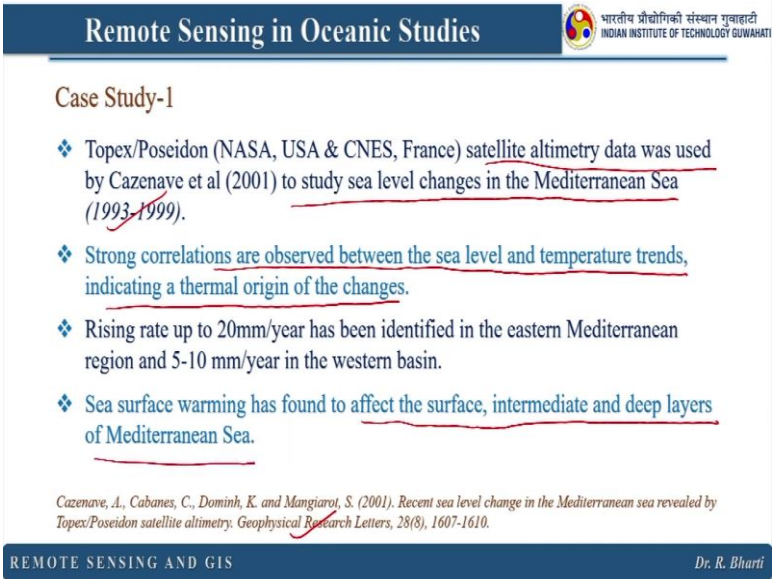

I will show you some of the case studies where people have successfully used this remote sensing technique. In this particular world satellite ultimately data was used to study the sea level changes in the Mediterranean Sea. And which is for the 1993 to 1999 strong correlation are observed between the sea level and temperature trends indicating a thermal origin of the changes rising up to 20 mm per year has been identified in the eastern Mediterranean region. And 5 to 10 mm per year in the western basin. Sea surface warming has found to affect the surface immediate and deep layer of Mediterranean Sea.

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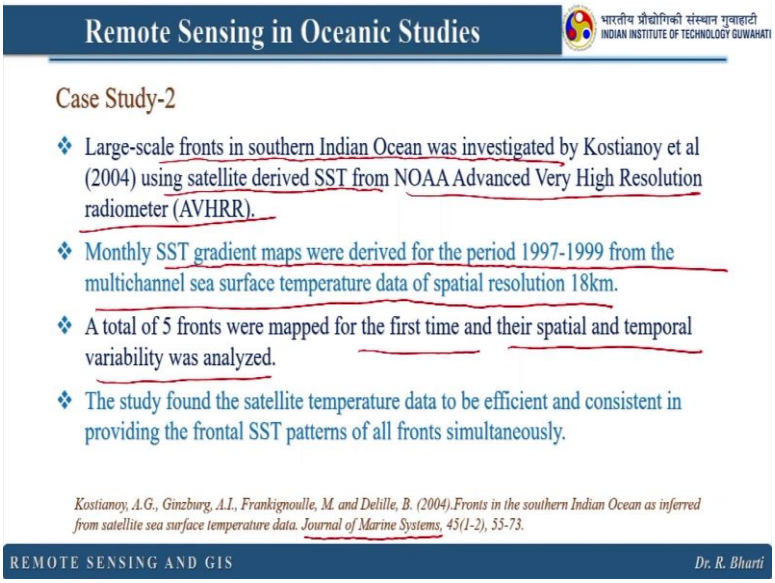

In another study this is published in Journal of Marine system, the large scale fronts in southern Indian Ocean was investigated using satellite derived, sea surface temperature from NOAA advanced very high resolution radiometer that is known and known as AVHRR. Monthly sea surface temperature gradient map were derived for the period of 97 to 1999. From the multi channel sea surface temperature data of a spatial resolution of 18 kilometres.

A total of 5 fronts were mapped for the first time and their spatial and temporal variability was analyzed. This study found the satellite temperature data to be efficient and consistent in providing the frontal sea surface temperature pattern of all fronts simultaneously. So that is the beauty of Remote Sensing from space. So, you have full coverage and you can easily find out what are the changes is being occurred. Urban Planning is another potential application of remote sensing and GIS.

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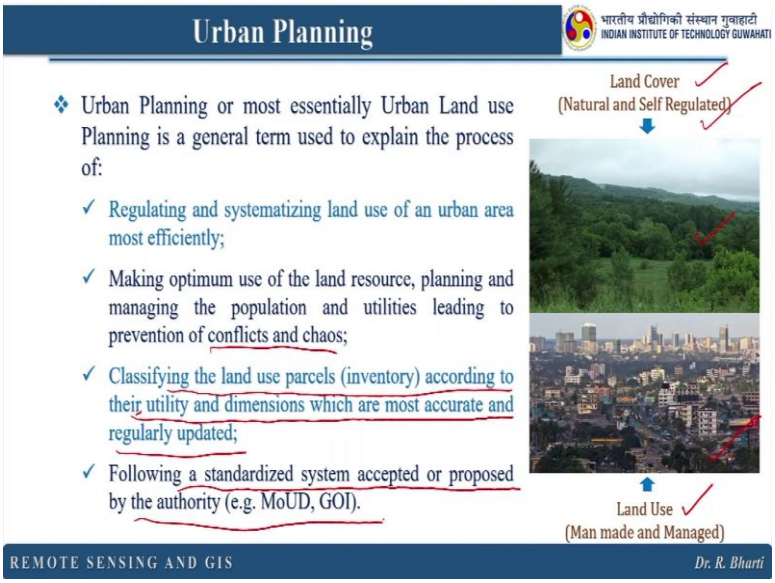

So, here you can see this is land cover. So, basically here we are talking about natural and self regulated classes right. And here we are talking about the man made and managed land use land cover right. So, this is known as land use this is known as land cover. So, land use how we are utilizing the land cover or the natural land cover right.

Urban Planning or most essentially urban land use planning is a general term used to explain the process of regulating and systematizing land use of an urban area. Most efficiently making optimum use of the land resources planning and managing the population and utilizing leading to prevention, the conflicts and chaos. Further classifying the land use parcels according to their utility and dimensions which are most accurate and regularly updated right. So, this you can think in remote sensing and GIS data sets following a standardized system accepted or proposed by the authority like MOUD or Government of India, right. Land Use maps are the most important tools for urban planning and modelling different urban processes and phenomena.

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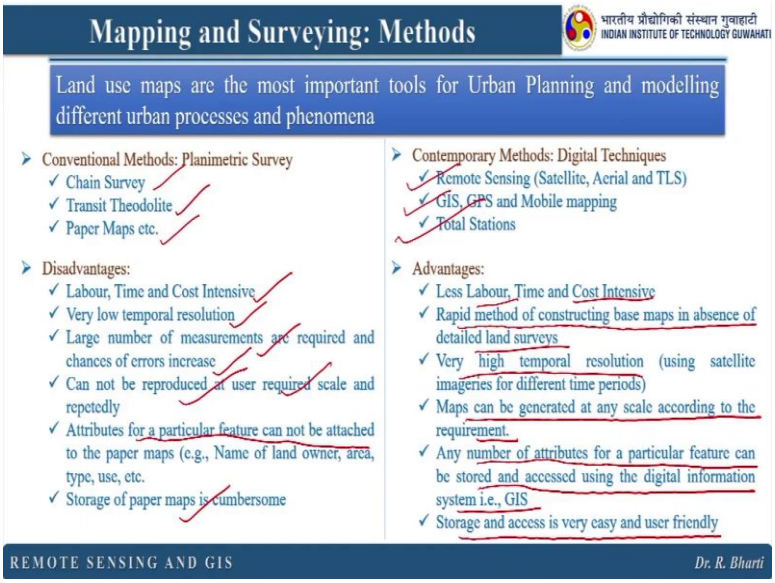

Conventional methods for planimetric survey includes chain survey, transit theodolite, paper maps, etc. And what are the disadvantages are associated with such methods, Labour, Time, Cost Intensive, Very low temporal resolution, Large number of measurements are required and chances of error increases, Cannot be reproduced and updated, Attributes for particular feature cannot be attached, because this is a hardcopy output right. Storage of paper map is tedious job. Now, on the other hand, when we are talking about the contemporary methods, that means latest method or the advanced methods, recent methods, digital techniques so, first one is remote sensing, then GIS GPS mobile mapping then total station right. And here, what are the advantages we have? We have less labour time and cost intensive right, rapid method of constructing base map in absence of detailed land survey, very high temporal resolution.

So, that means, you will have more detail, Map can be generated at any scale according to the requirement because, let us assume that you have a data of 0.25 centimetres, you can generate very high resolution maps, but, if you need very Course resolution then also you can reproduce this you can resample this high resolution data to low resolution. Any number of attributes for a particular feature can be stored and access to using digital information. Storage and access is very easy and user friendly.

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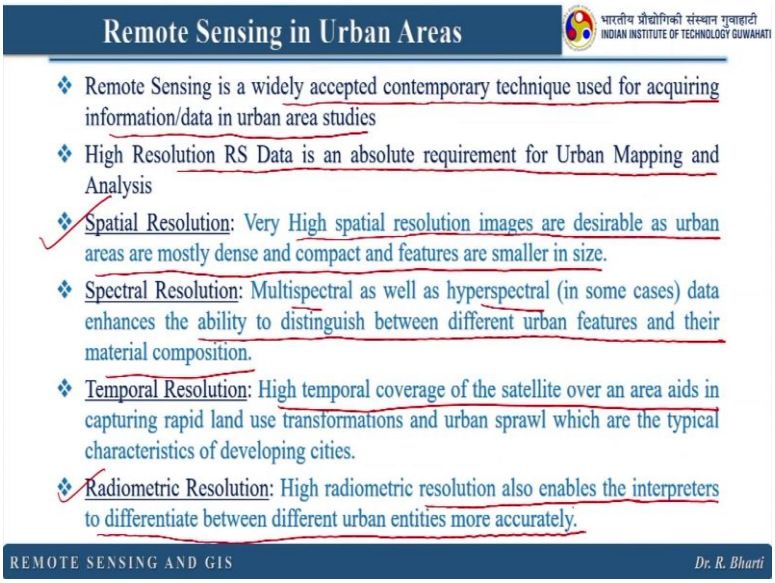

Now let see remote sensing in urban areas how it is going to help. Remote Sensing is a widely accepted contemporary technique used for acquiring information or data in urban area studies. High resolution remote sensing data is an absolute requirement for urban mapping and analysis. When we talk about spatial resolution. Very high spatial resolution images are desired as urban areas are mostly dense and compact and features are very small.

When we talk about spectral resolution, multi spectral and hyper spectral data, which gives ability to distinguish between different urban feature and their material composition that I hope you have understood in the previous lectures. Temporal resolution, high temporal resolution can give you the changes right. Change detection can be done using this temporal resolution, when we talk about radiometric, so, when radiometric resolution is involved, and you have high radiometric resolution which enables the interpreters to differentiate between different urban entities more accurately, because you will have more labels of grey label. When we talk about 30 meter satellite images, it looks like this, when we talk about 5.8 meters, it looks like this. When we talk about 1 meters, then you have more information. So, you can just think of how this spectral, spatial and radiometric resolution are going to help you.

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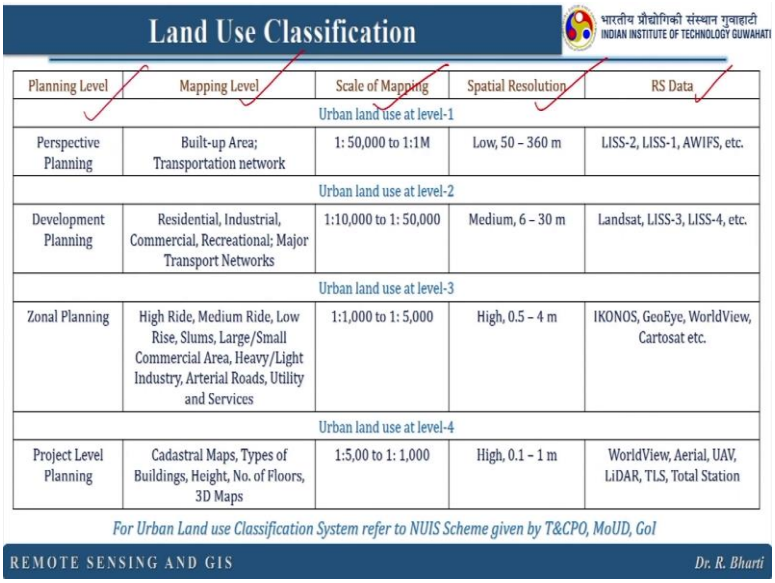

In this particular table, I just want to highlight what kind of satellite images are available, what are the different spatial resolution they have, and what scale of mapping they can produce or what scale of map they can produce. And which can be used for different mapping labour and planning level. Right, so you can just go through it, where most of the common satellites are listed.

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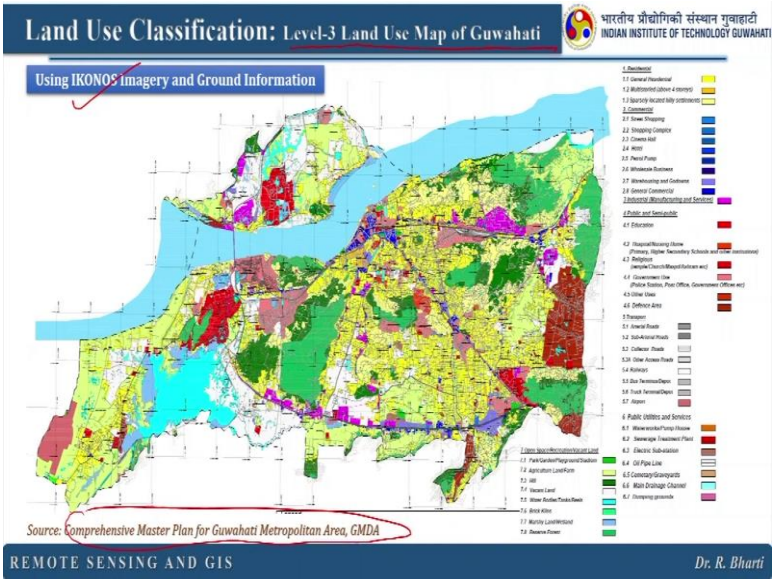

Here, this is one land use classification output. This is the level three land use map of Guwahati city. This is produced using this IKONOS imagery and ground information and this is from the comprehensive master plan of Guwahati metropolitan area from GMDA right. So, you can see how much detailed mapping you can perform when you are having high spatial resolution data right. In this particular slide, I will highlight the advantages when you have high spectral resolution.

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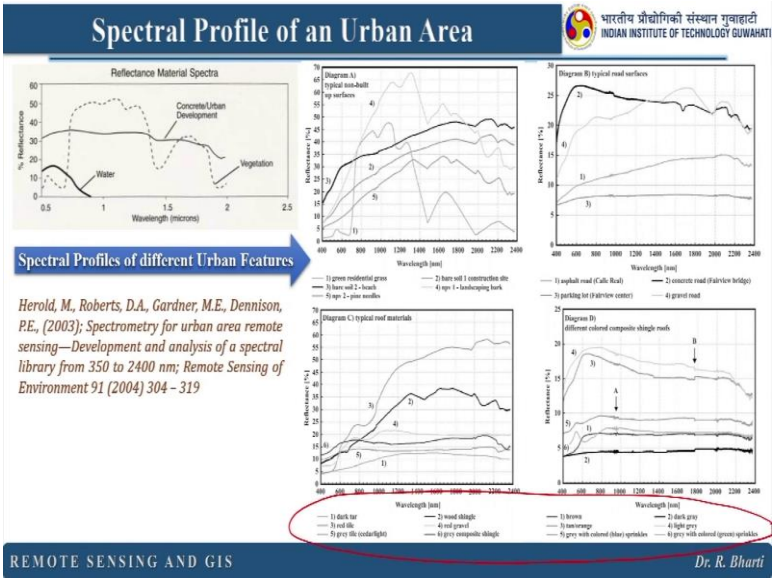

So, you can see here the vegetation, concrete and water body they are having different spectral profile right, and it can be used to identify different classes of urban right, here you can see different profiles associated with different objects. Right, and how they are different from each other, this is one of the potential areas where you can utilize the high spectral resolution information. So, this is in case of Urban Studies.

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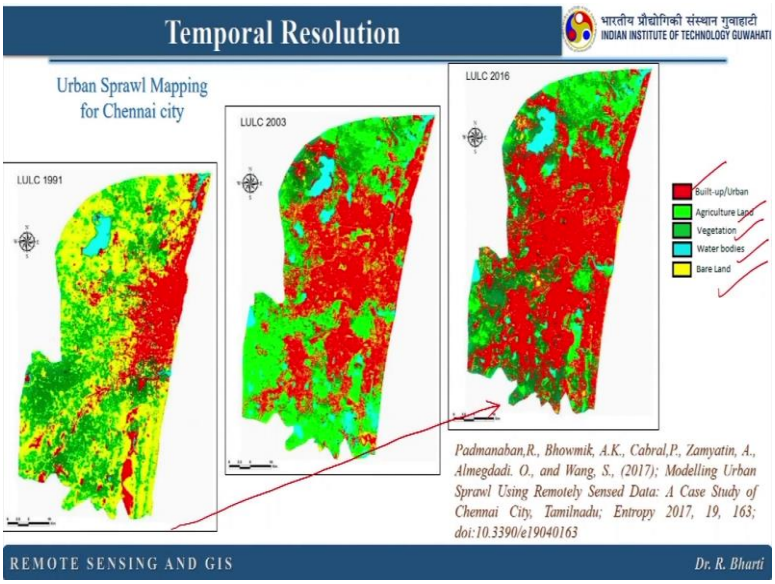

Now, here when you are having temporal resolution, so, more images are available for the same area from the same satellite, you can produce such maps and you can analyze how these build up area, agriculture, land, vegetation, water body, bare lands are changing with respect to time. So, basically what is happening here, one class is getting converted into another class depending upon the demands of the people.

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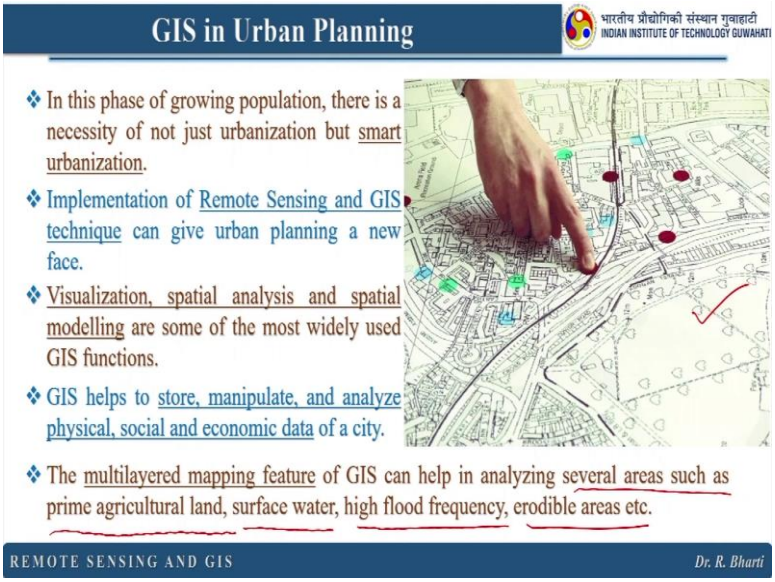

When we talk about GIS, in this phase of growing population, there is a necessity of not just urbanization but smart urbanization right. Implementation of remote sensing and GIS technique can give urban planning a new face that I hope you can understand by this example. Visualization, spatial analysis and spatial modelling are some of the most widely used GIS function. GIS helps to store, manipulate, and analyse physical, social and economic data of a city. The multi layered mapping feature of GIS can help in analyzing several areas such as Prime agricultural land, surface water, high flood frequency, erodible areas, etc. Right.

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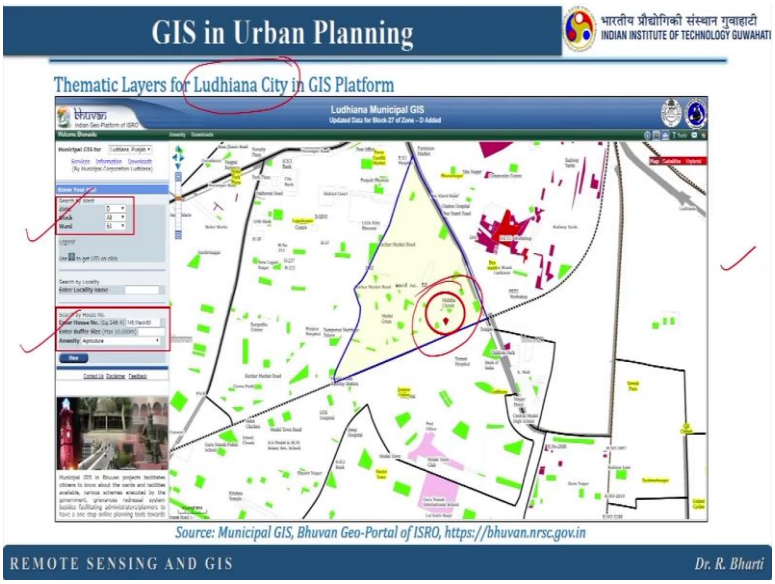

So this is one example where GIS has been exploited to derive or to generate a thematic map of Ludhiana city. So here, you can just put the search keywords or maybe the zone, ward Number and then house number, buffer size, amenity and then you can easily find out where they are right. So, that will get highlighted. So, it is very easy to identify any kind of information for urban city using this GIS technique.

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So, there are several applications of urban land use map like urban growth modelling, urban hydrological modelling. Urban disaster protection and analysis, population studies, property taxes and monitoring, utility service mapping, urban climate studies, urban transportation modelling, urban waste management studies etc. So, these are few potential areas where you can think of utilizing this remote sensing and GIS technique.

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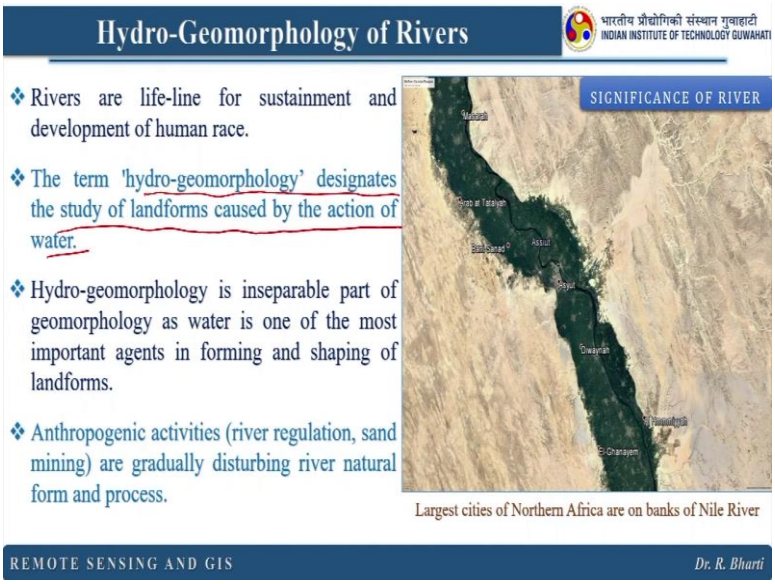

Now, let us see one of the very important area that is Hydro Geomorphology. How this rivers are playing critical role in our life that is already well known. So, let us see how we can utilize this remote sensing and GIS in this particular problem. Rivers are lifeline for sustainment and development of human face. The term hydro geomorphology designates the study of land form caused by the action of water. Hydro geomorphology is inseparable part of geomorphology as water is one of the most important agents in forming and shaping of land form. Anthropogenic activities such as river regulations and mining are gradually disturbing river natural processes and forms right. So it is very important to monitor and see the changes of any given reverse system.

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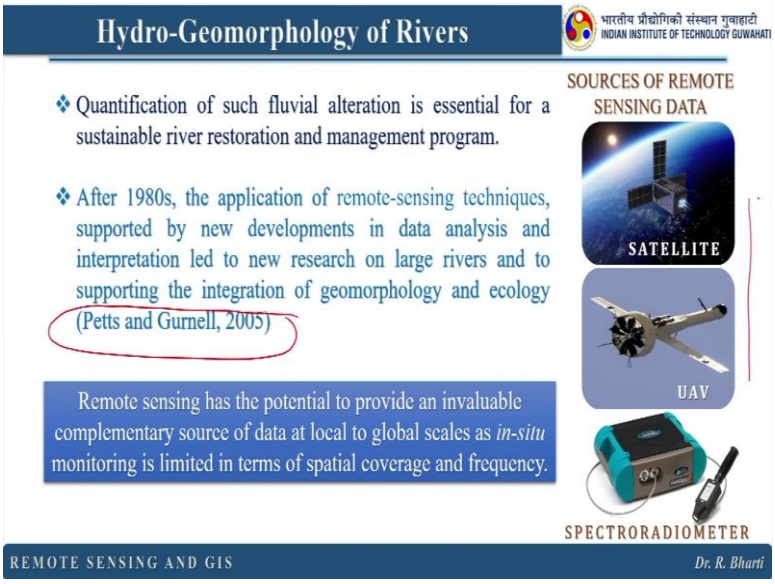

Remote Sensing has the potential to provide an invaluable complimentary source of data at local to global scale as in situ monitoring is limited in terms of spatial coverage and frequency right. So, quantification of such fluvial alteration is essential for a sustainable river restoration and management program after 1980s, the application of remote sensing techniques supported by new development in data analysis and interpretation led to new research on large river and to supporting the integration of geomorphology and ecology. That his already been addressed in this particular paper. So, these are the different source of remotely sensed images are remote data sets.

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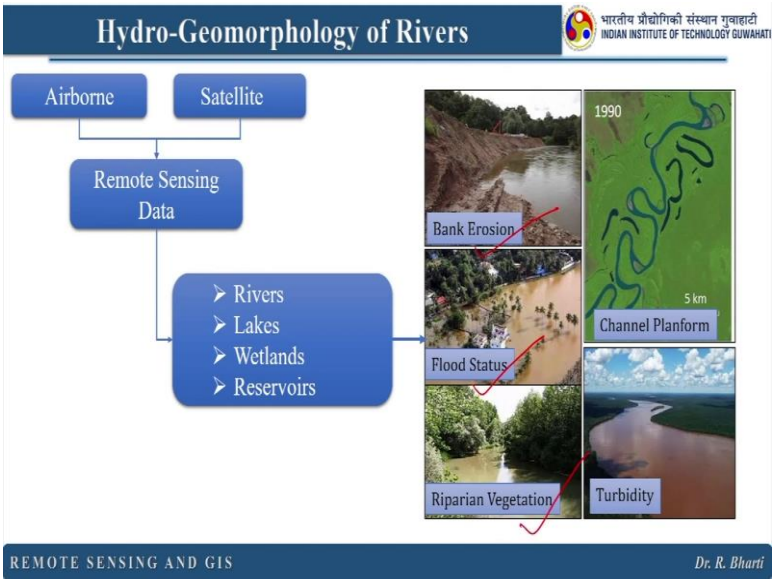

This is a very generic methodology, when we talk about hydro geomorphology studies from remotely sensed images. So, where we can think of utilizing this information for bank erosion, Flood status, and then what is the vegetation status in those areas channel planform, turbidity. So, these are some of the potential areas right.

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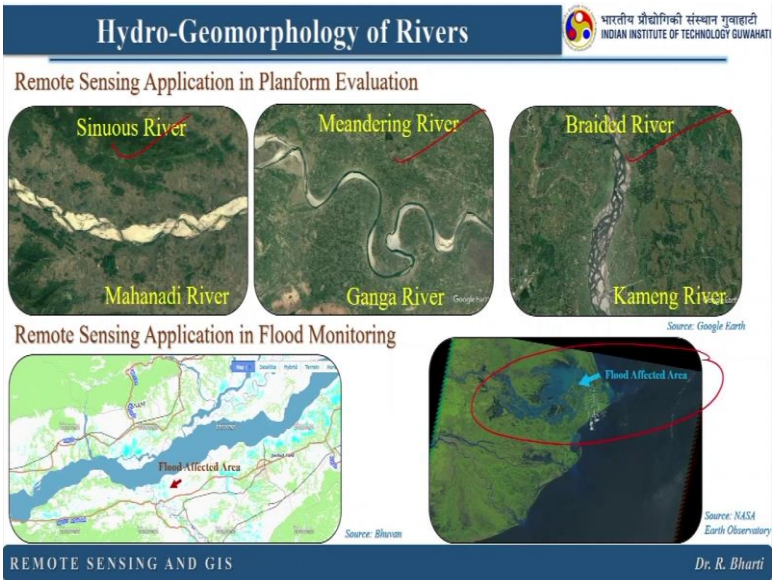

Remotely sensing images can be used for planform analysis or evaluation. So, when we have sinuous river, meandering river, braided river, you can always think of utilizing this remotely sensed images from space because that will give you a very big area coverage right. When we talk about flood monitoring. Then also you can see it can give you a clear cut picture about the flood prone areas or floodplains right.

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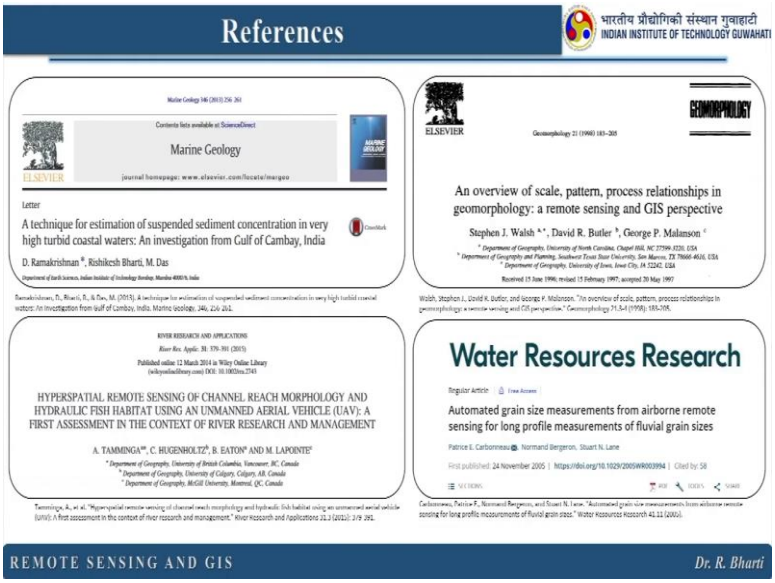

These are few, references you can go through it, if you are interested in such studies. Now, with this I will end my lecture as well as this course here. I hope you have enjoyed this course, and you have learned this subject, it is expected that end of this course, you will be able to utilize this particular technique in your research right. At the end of this course, I would like to acknowledge some of the eminent scientists and professors who have contributed a lot in this remote sensing and GIS domain. This is my contact details. So, in case if you are interested, you can visit my web page. With this I will end my course here. Thank you.