**Remote Sensing and GIS for Rural Development**
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**Centre for Technology Alternatives for Rural Areas (CTARA)**
**Indian Institute of Technology, Bombay**
**Week – 03**
**Lecture no. 02**
**Intro to Remote Sensing Data for Rural Development: Water**

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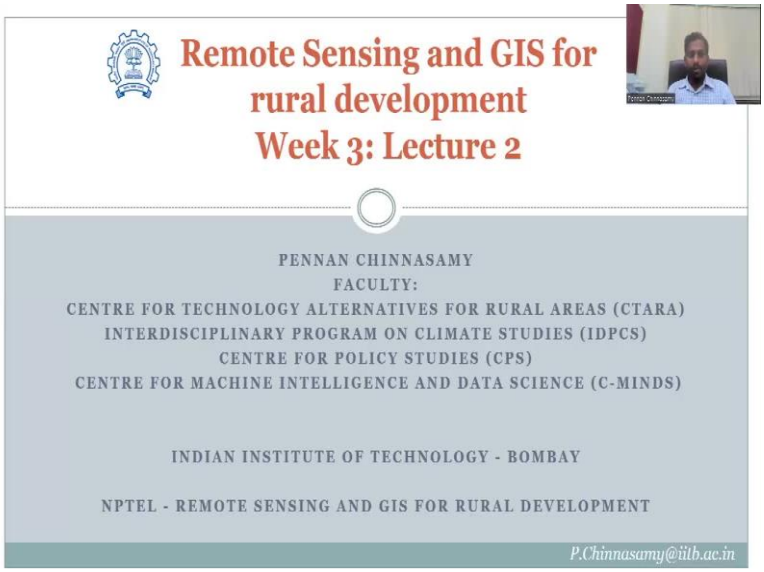


Hello everyone, welcome to remote sensing and GIS for Rural Development NPTEL course, this is week 3, lecture 2. In this week, we have been specifically looking at the Indian government datasets, open source data sets that can be used for getting data for rural development. The last class we had an overview of Bhuvan website portal and we looked at some random data and how to download and link the data for rural development. In today's lecture, let us look at the specific data that we use to take from Bhuvan for water resources.

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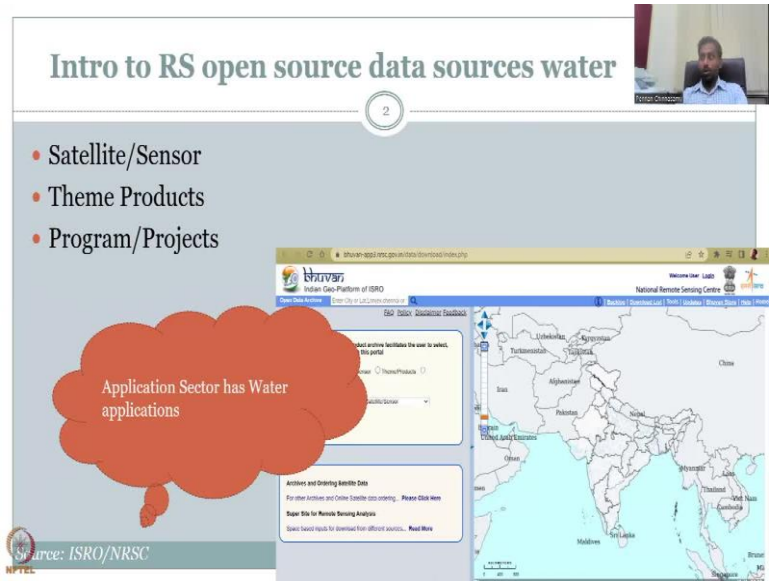


So, what is the theme here and we would like to look at the Bhuvan open a Data Archive. Yesterday or in the last class, I had mentioned how to pick different tabs in the dashboard and one of the tabs was the thematic products which are stored in the Open Data Archive. So, what do you see the Open Data Archive is, satellite and sensors that you will see here. Theme products, so basically some data is aggregated as thematic products and some other data is kept as program under program and projects.

So, we will now look at is ISRO's Bhuvan website to understand the different sectors and spaces that are looking upon water. But before that, I will also touch upon a link within the Bhuvan website that has applications on water and very-very limited focused applications.

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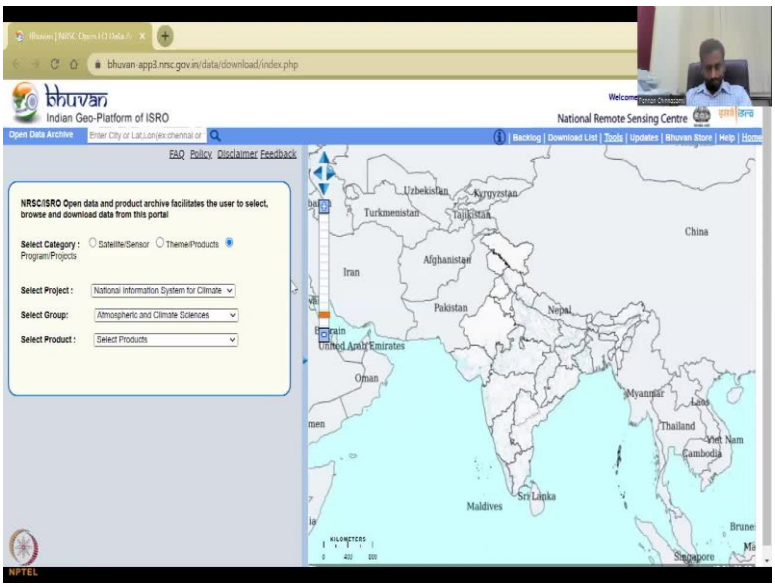

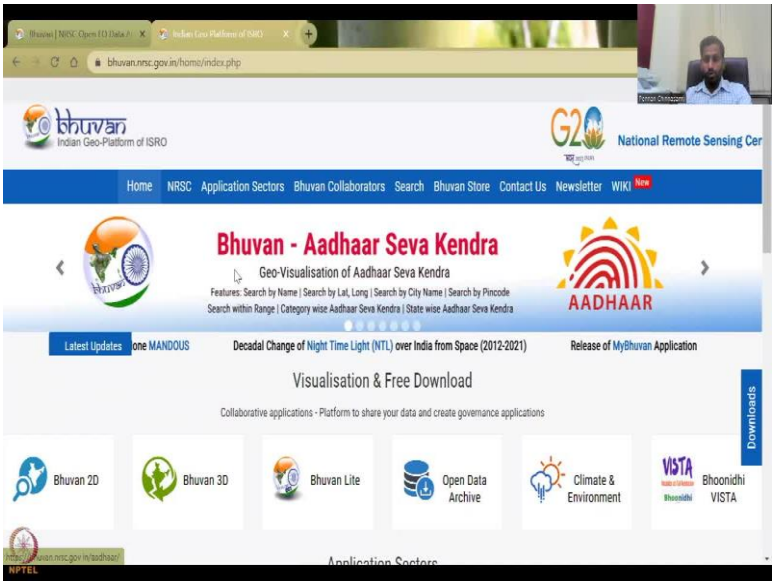


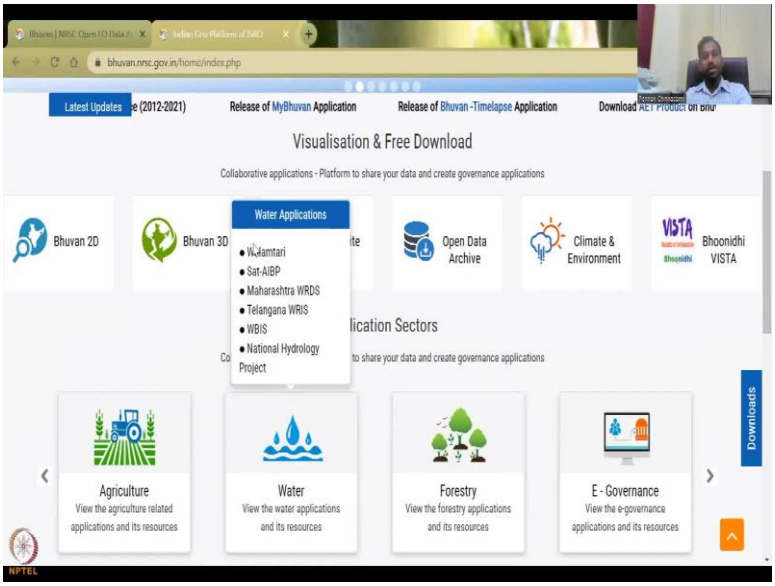


So, let us open the portal. So, we have Bhuvan website here and what we see is so we have the Bhuvan NRSC Open Data Archive, but before that, let me type the Bhuvan NRC website and show you that we do have if you scroll down the application sectors. In the application sectors we have water. So, in this there are very specific applications that have been developed using GIS data, one is Walamtari, Sat-AIBP, and Maharashtra WRDS, Telangana WIRS, does move so you can just click here to go back. And then you have the national hydrology project WBIS.

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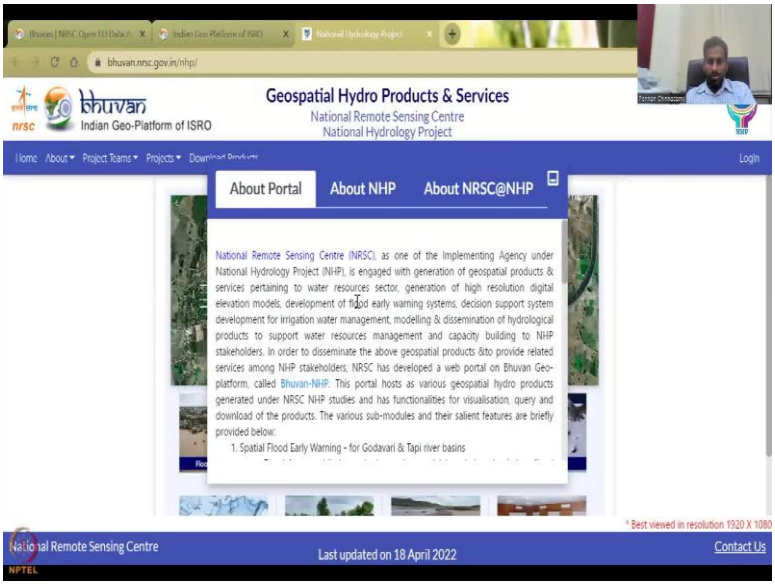


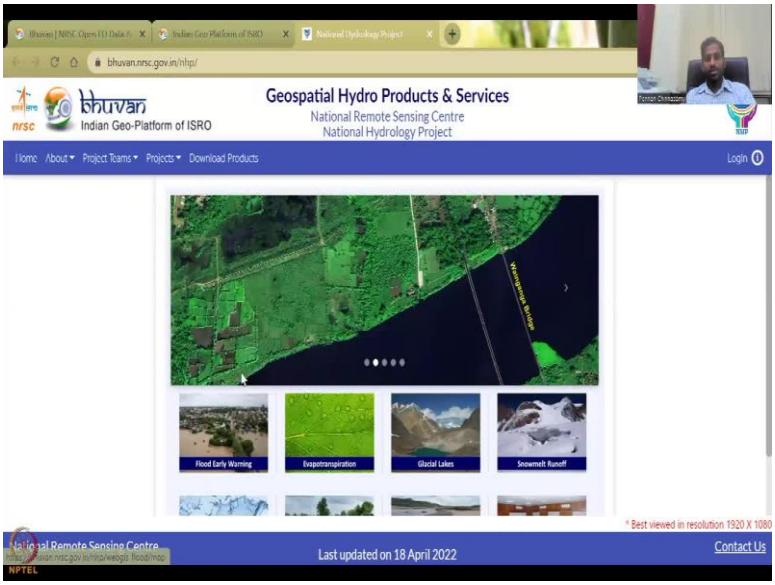


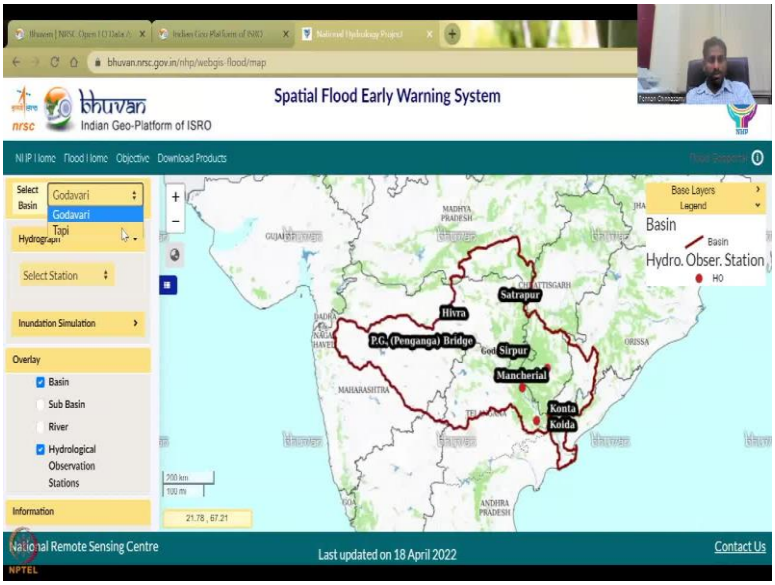

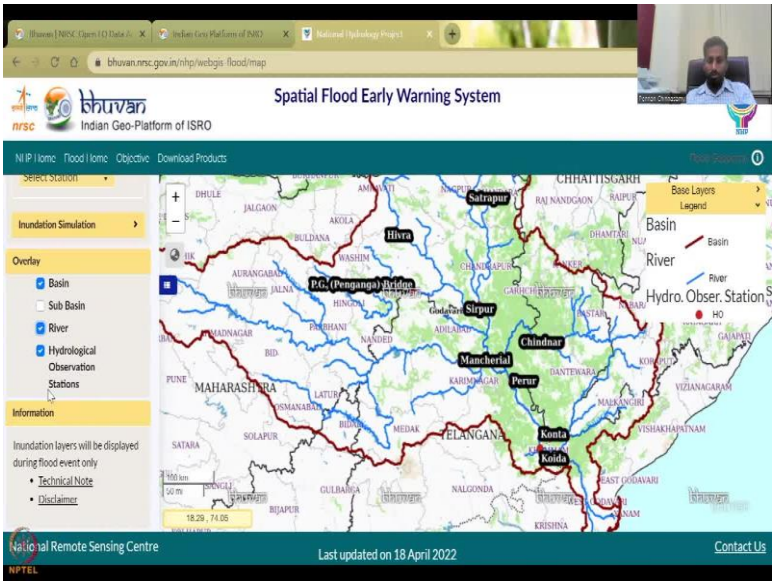


Let us click the national hydrology project to understand about the project and then where the data comes in. So, you could see read about the drought index they have created, decision support system, you can lower it and then see flood early warning systems that have been created for the basin. So, this here they have the Godavari basin or Tapi. So, across India, only two basins have been created that also clarifies the need for this course, that all areas cannot be mapped at once, it requires a lot of capacity and the students taking this course will be able to bring that capacity.

So, let us look at what are very basic for example, you have this Godavari basin and you have the observation data points. So, you can see here these are the observations data points, let us zoom in to see more. So, you have these observatory points and those are used to look at the rivers discharge and look at where the water is going to be about the flood level.

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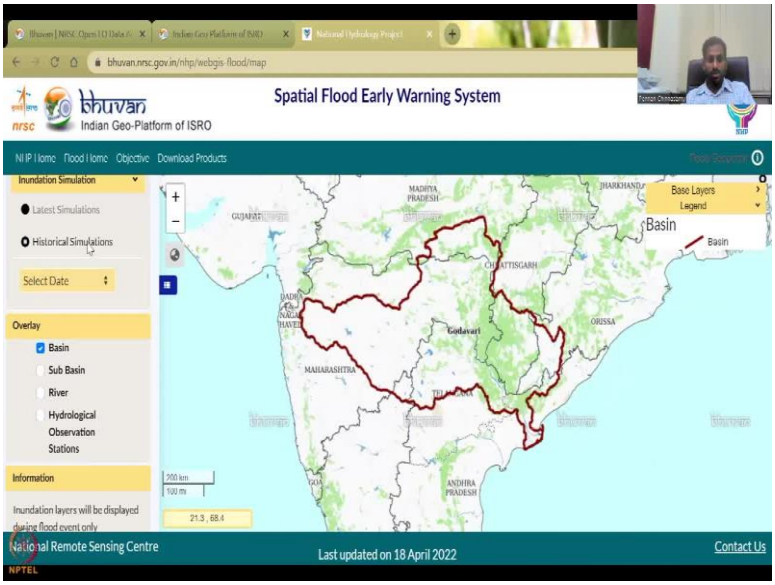


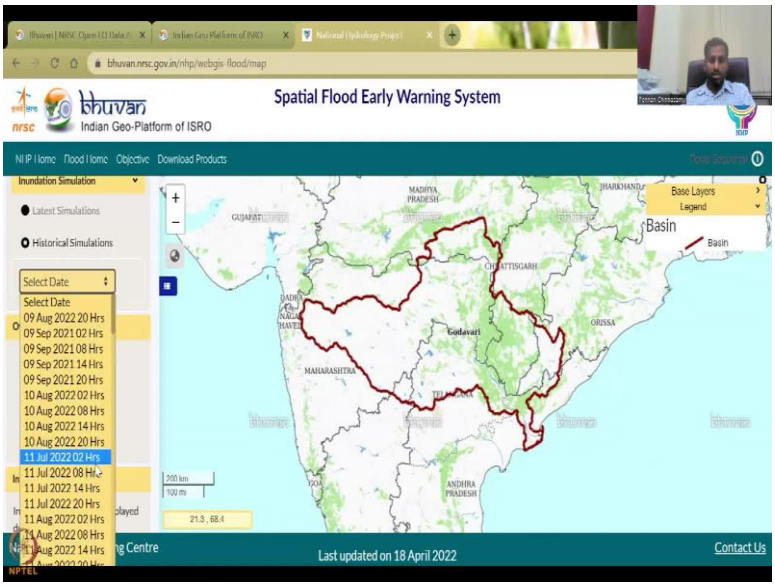


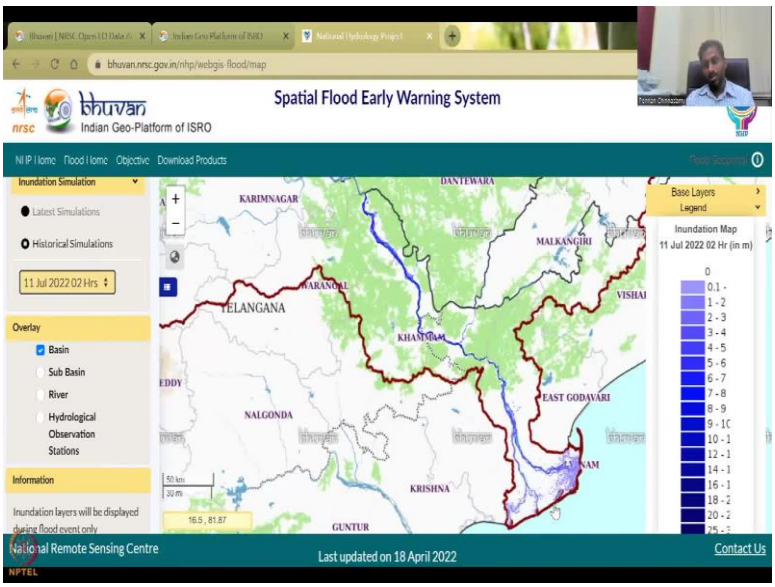

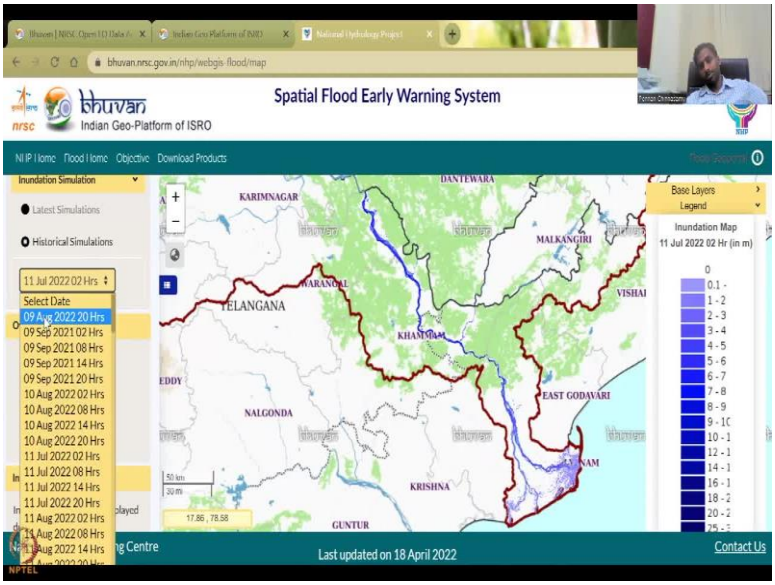


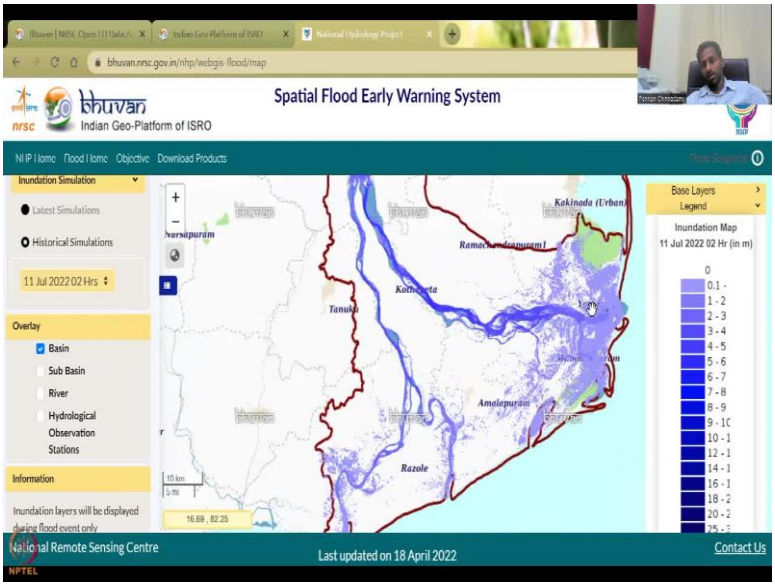


So, you can do an inundation simulation and remove these for now. And then you could see historic simulations, select a date, let us say some hours and you could see that these are where inundation happens, inundation is the level increases and comes out as floods. So, this is a very focused application and the latest data you have is August 9, 2022. So, there is a bit of delay, but still it is a good effort and a lot of understanding can be taken from this image like mostly here to see that the downstream locations are mostly getting flooded. So, you can see here the flood is here, so all these areas could be given a warning to go to different areas during floods, evacuate.

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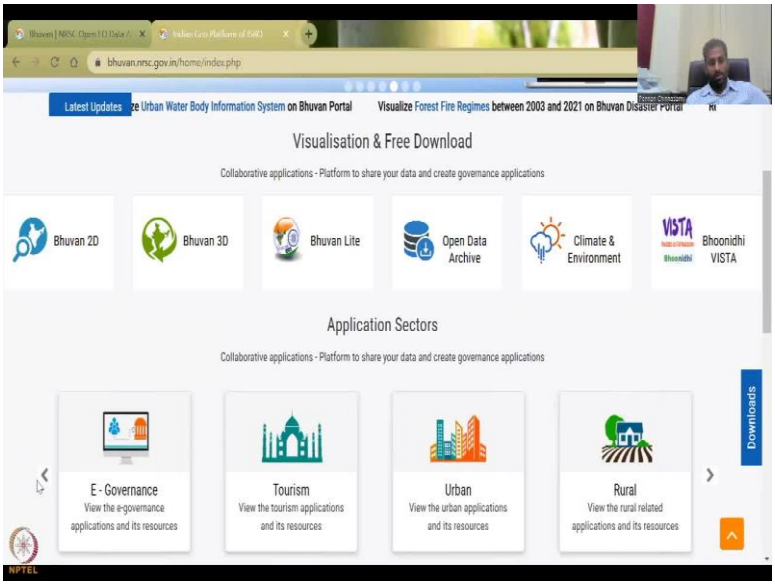


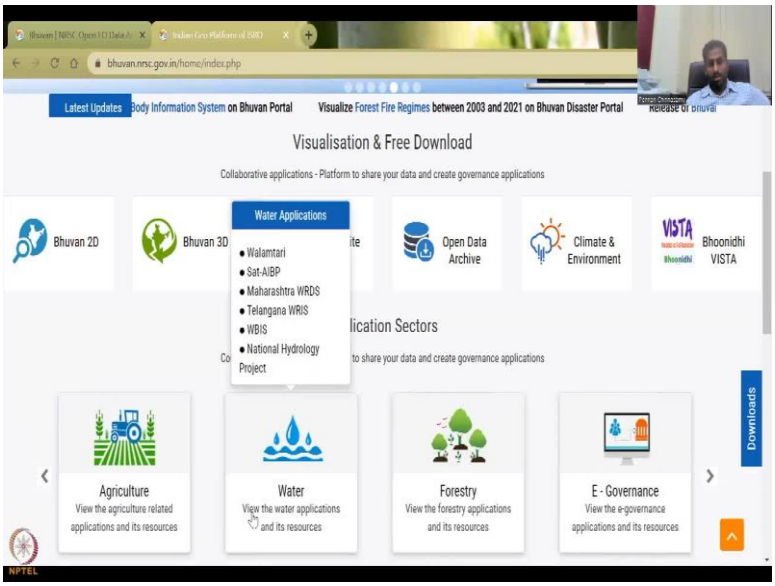


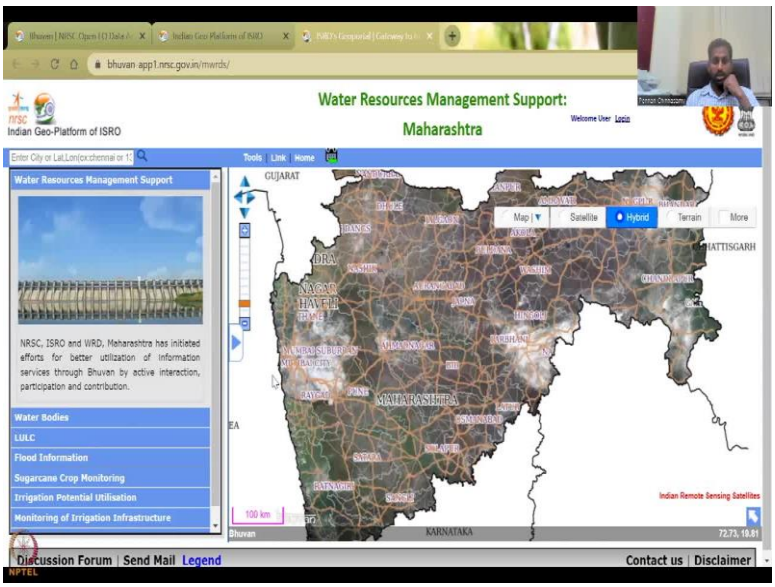

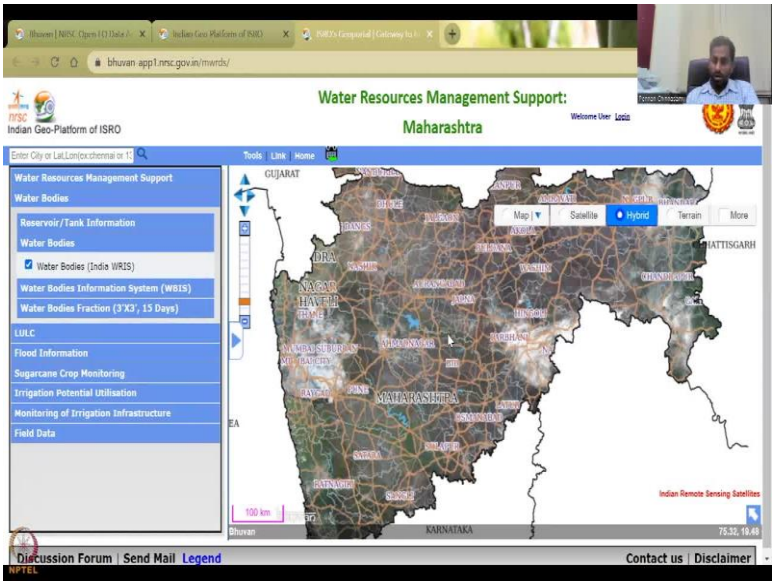
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Indian Geo-Platform of ISRO
Water Resources Management Support:
Maharashtra
Water Resources Management Support
Water Bodies
Reservoir/Tank Information
Water Bodies
Water Bodies (India WRIS)
Water Bodies Information System (WBIS)
Water Bodies Fraction (3*X3', 15 Days)
LULC
Flood Information
Sugarcane Crop Monitoring
Irrigation Potential Utilisation
Monitoring of Irrigation Infrastructure
Field Data
Map
Satellite
Hybrid
Terrain
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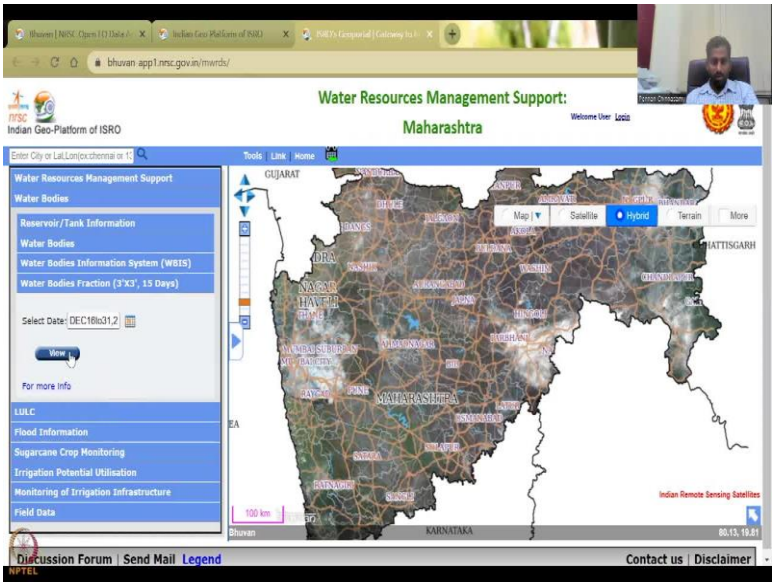
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Sugarcane Crop Monitoring
Irrigation Potential Utilisation
Monitoring of Irrigation Infrastructure
Field Data
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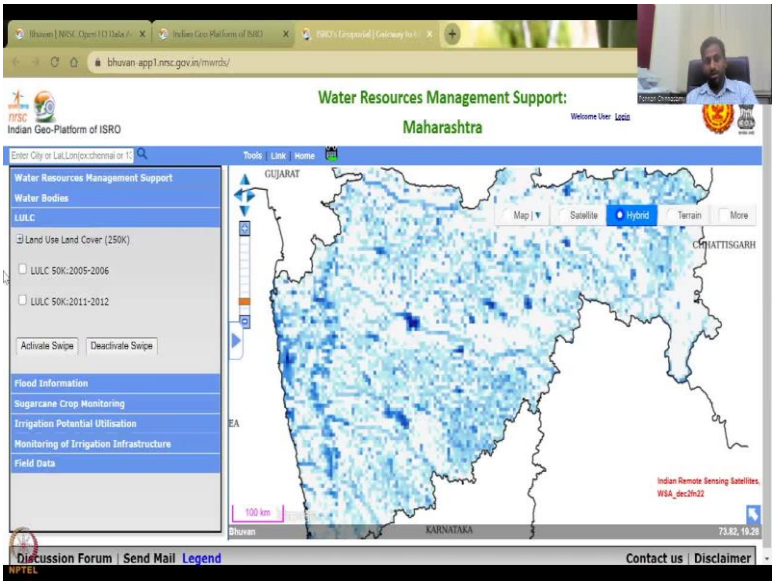
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Indian Geo-Platform of ISRO
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LULC
Land Use Land Cover (250K)
LULC 50K:2005-2006
LULC 50K:2011-2012
Activate Swipe
Deactivate Swipe
Flood Information
Sugarcane Crop Monitoring
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So, this is one example there are multiple other examples for the application sector. I will do the Maharashtra WRDS, where it gives you resource support for managing the water. So, these are the dams that are in the Maharashtra state and for example, if I click water bodies, I can click that and all the water bodies are now coming up. So, initially, there was no water bodies, but now water bodies are coming up. And then you have a date to see what is the fraction and you have up to 2022 but let us do a few and then you can have number of water bodies fraction where the water bodies are present and the fraction etcetera.

So, you can see that the land use land cover is also done for two years. So, now if you see the land use land cover is done for two years for Maharashtra, one is in 2006 and another is 2012. So, definitely it is at least 10 years lag, so how would you use a 10 year old data is a question and for that we need to make our own land use land cover maps, either unsupervised or supervised classification based on our research needs.

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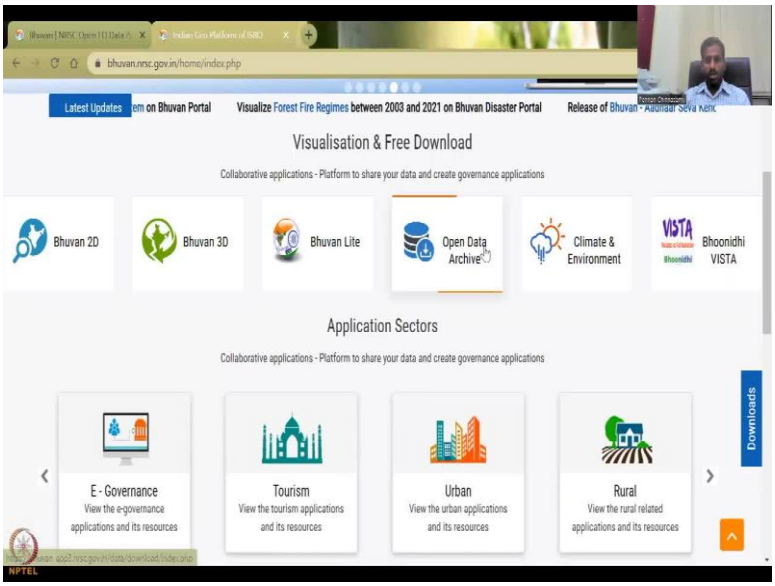

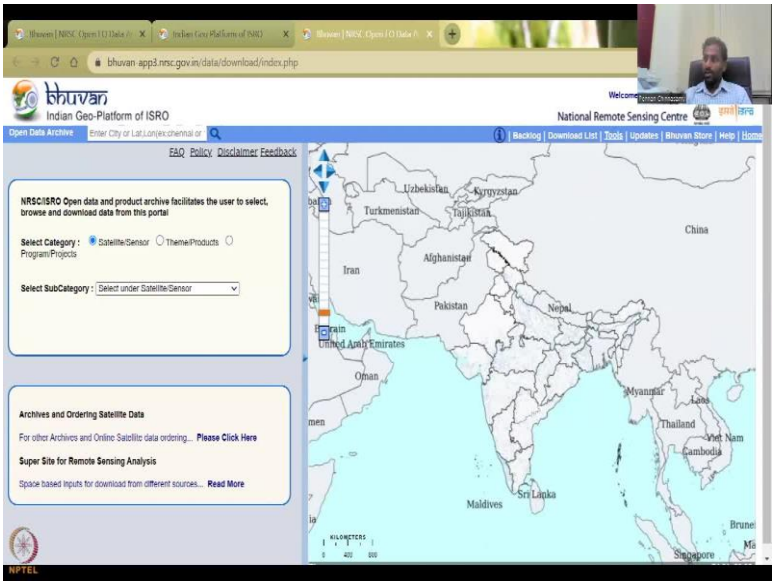


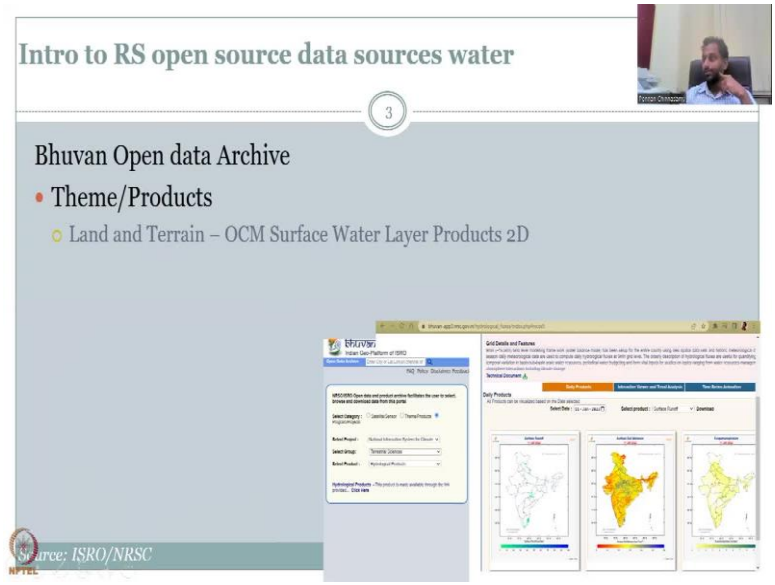


So, let us jump into the Open Data Archive. I hope it has come up. So, I will say again, we will be doing two important phases, let us go back to the slides and then I will show you what we will be showcasing. We will be doing so now we have looked at applications now we will get into the open source data in Bhuvan for water, I have opened the Bhuvan Open Data Archive and thematic products we will be looking at the land and terrain OCM surface water layer products. So, I am going back to my portal.

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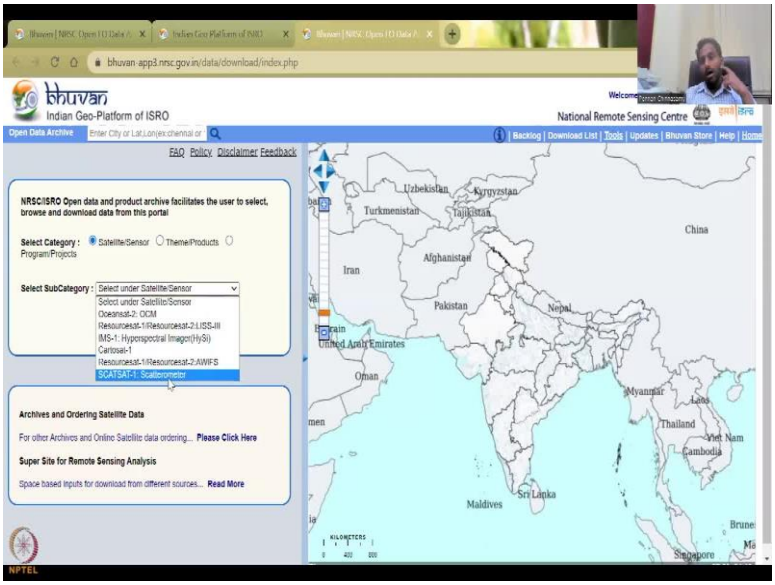


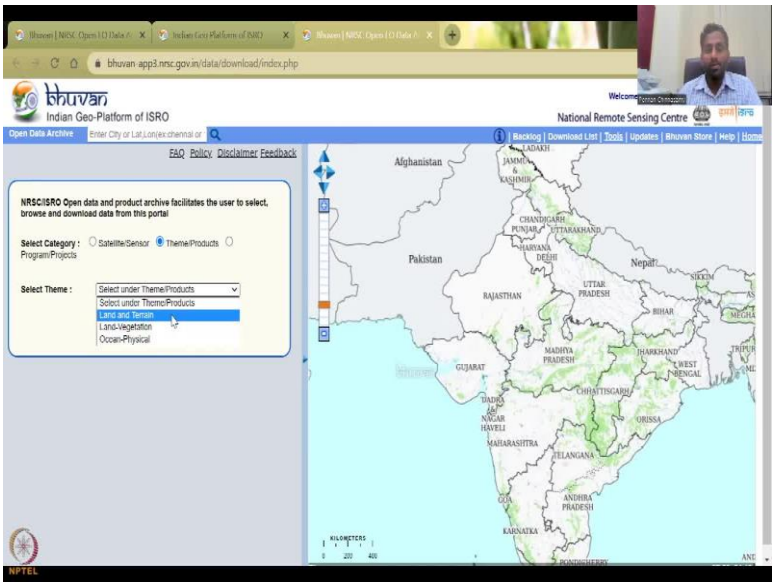


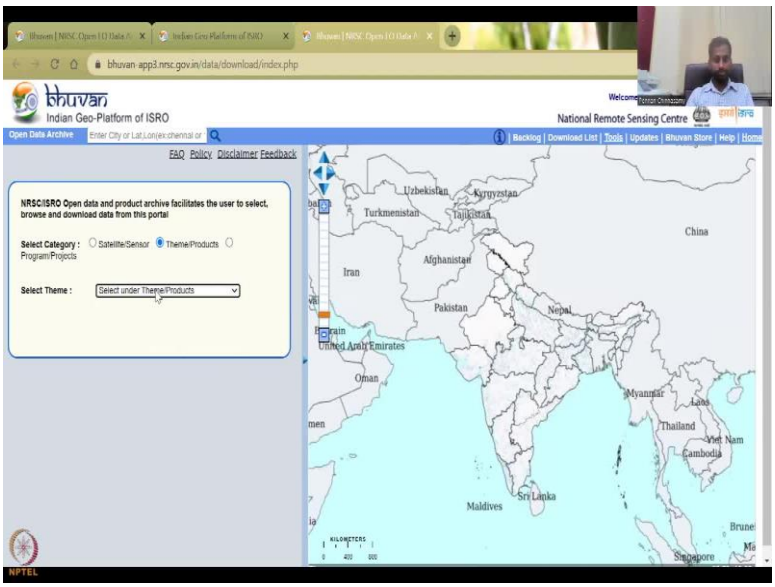

So, under theme and products. So, satellites, you have multiple satellites, but not readily they are marked as water, water needs some processing of the data. So, you have a multi spectral reflectance curves or you have hyper spectral images and from these images you construct the water bodies, you understand where the water bodies are present in across India at rural scales.

So, for that we will go to theme and products and we will say either of these so we have ocean and physical, we have land and vegetation and then we have land and terrain. So, land and terrain includes the water bodies inside the land, land and vegetation is mostly on the crops and the land, so it is mostly led by crops, whereas ocean and physical includes the ocean and physical products, so mostly in the sea and oceans.

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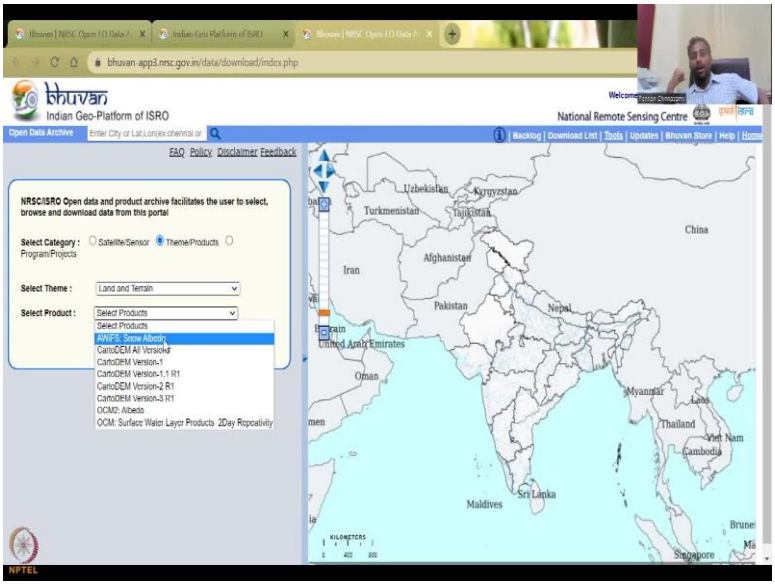


Since we are more focused on the rural entities, the rural entities are present mostly inside the land. So, let us take land and terrain and if I click this products, you will see multiple products that are kept. So, what we would need to do is, we would need to select the one which has relationships to water.

So, you have snow albedo, snow cover is converted to water availability in the Himalayan region, because there is a lot of snow and the snow is volume is then converted into a depth of water and which goes into the Ganges and other rivers so that is for that and mostly for your river discharge, but we will go to the OCM, OCM surface water layer two products.

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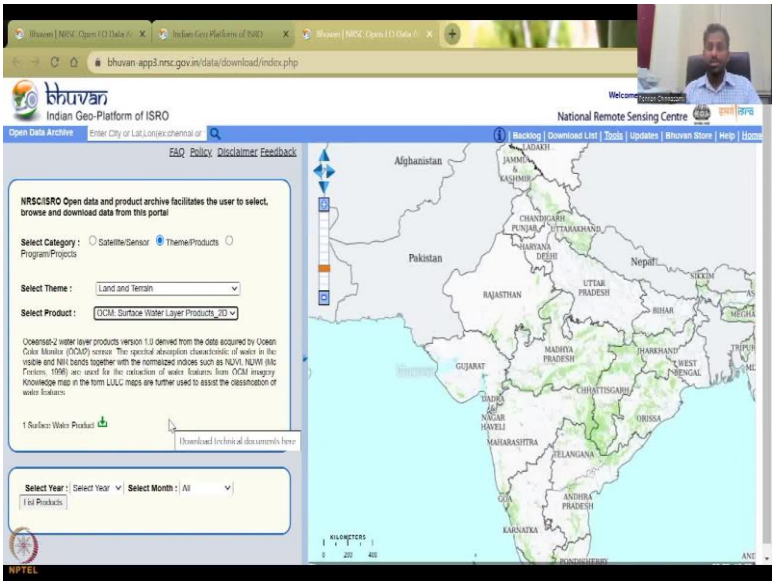


It is a 2d product, which means it will give you the x-y dimensions across space, it will not give you the z which is the depth, that is tricky, it is harder to estimate but for now, we will only look at the 2d surface. So, it says ocean to water bodies version number 1, so version is how many iterations they have, how many updates they have, so we are still it is in version 1. It is dried from the ocean color monitor OCM to sensor and then it is in the visible and NIR bands.

So, the spectrum that is being analysed is the visible spectrum and some NIR bands with normalize in the sense such as NDVI, NDWI etc. which are used to extract the water bodies. So, based on the reflectance of the water and land into the satellite, they can estimate if it is coming from land, if it is coming from water. Again, this requires you to take the basics of remote sensing there are a lot of NPTEL courses, I have already mentioned that, it is slightly advanced we are looking at for rural development. So, then they have used some other knowledge maps to do classifications and some categorization of the data.

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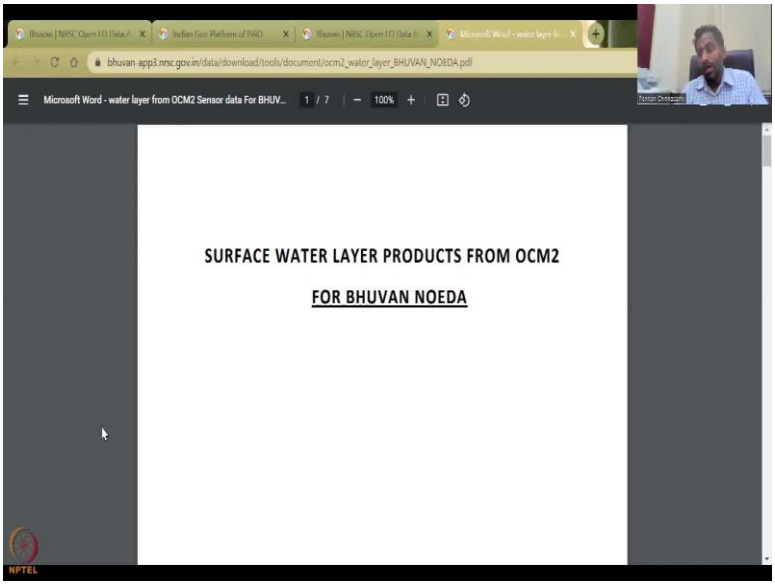


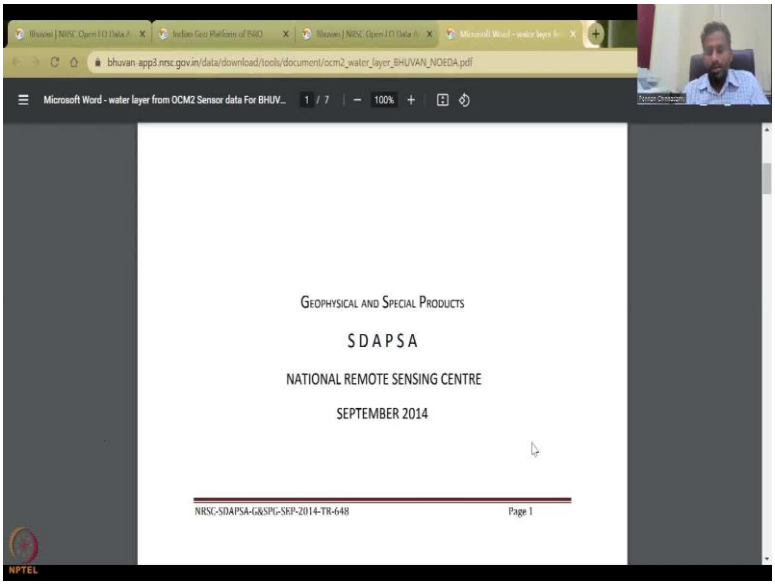


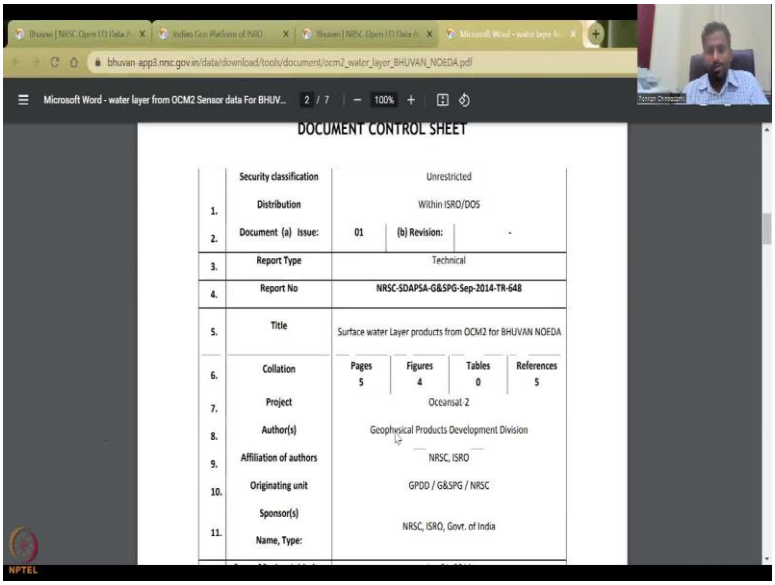

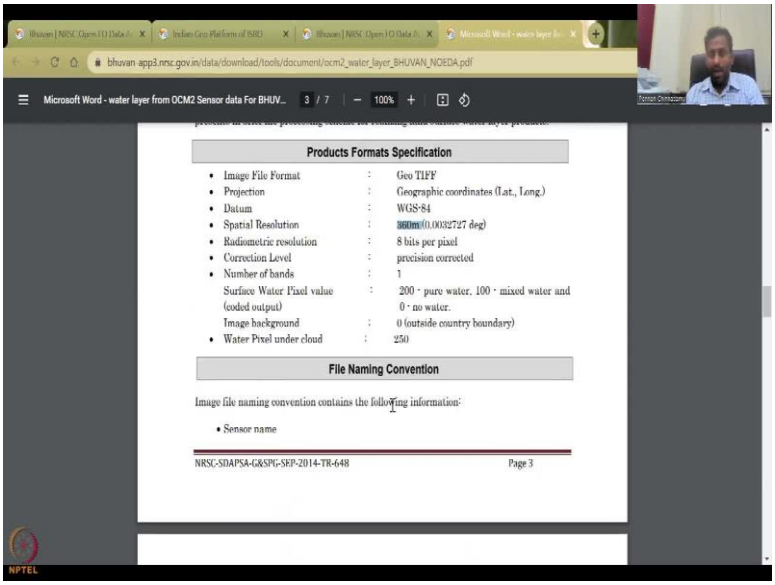


So, let us look at the surface water product. Please give it some time to load and if you could come down it is still 2014, 8 years old document but has been used well for the product. So, you have water and no water is 0, pure water is 200, mixed water is 100 and then you have a spatial resolution of 360 meters, each pixel is 360 meters, there is no definite amount of temporal resolution, but I think since it is a driven model, you do get it every lakh days of one or two days.

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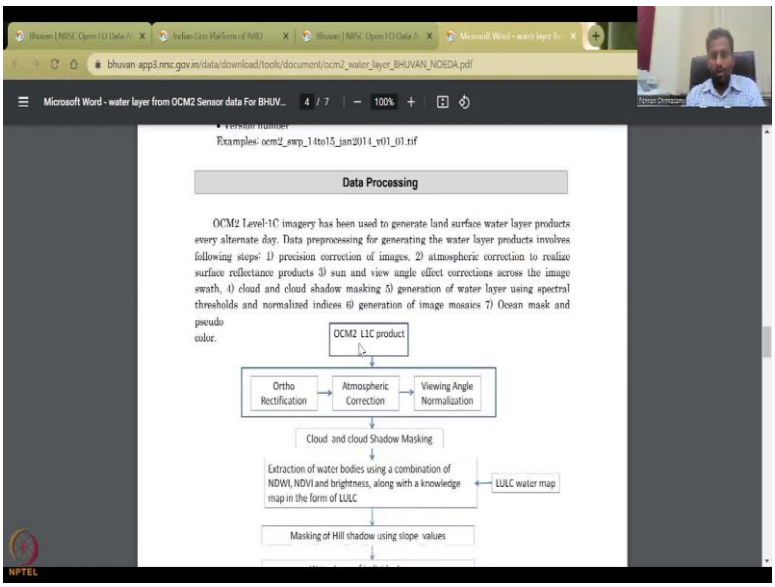

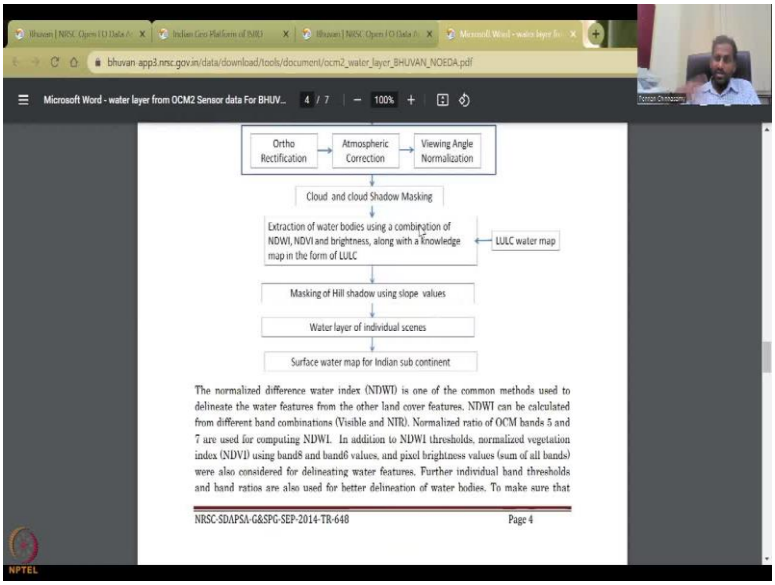


And then it shows you how the data has been processed. So, first the product comes from the sensor, there is some rectification, atmospheric correction, and then angle normalization, because, if the satellite is tilted, then you have an elongated image. So, all these angles are normalized, atmospheric errors are corrected, the cloud cover everything is corrected, ortho-rectification is done and then cloud shadow masking is taken out the cloud, shadow is also casting some images distortion in the images that is also removed. And then water bodies are extracted using a combination of NDWI, NDVI, brightness, so all these are indices, indices which are created by a combination of the bands.

So, remote sensing tells that color white color is not white it is in different bands with GI. So, same thing when pulse light pulse gets reflected it can come in multiple bands and depending on your sensors acceptance or absorption, you will collect data. So, here we are using a visible spectrum an NIR spectrum, so you will get some VGR plus near infrared and that is enough to make this NDVI and NDWI. Just search for NDWI or NDVI you will get a lot of materials on how it is calculated. Sometimes added here, sometimes they do not but that is fine.

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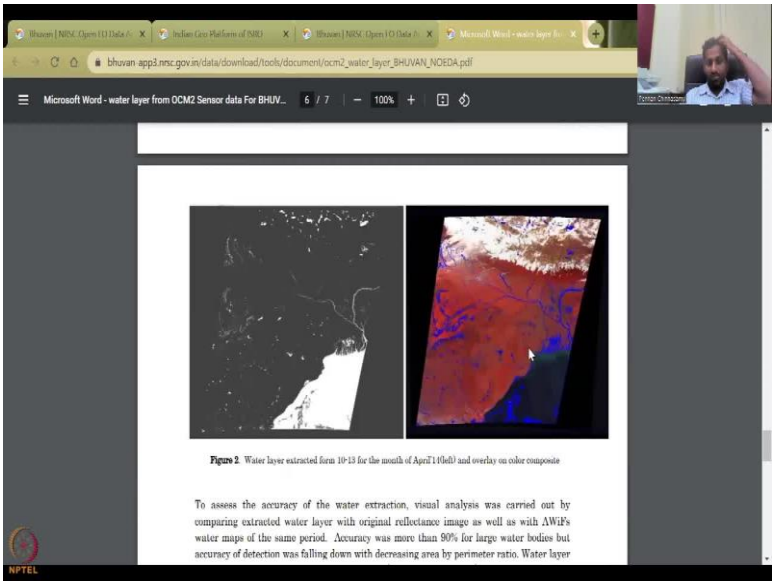


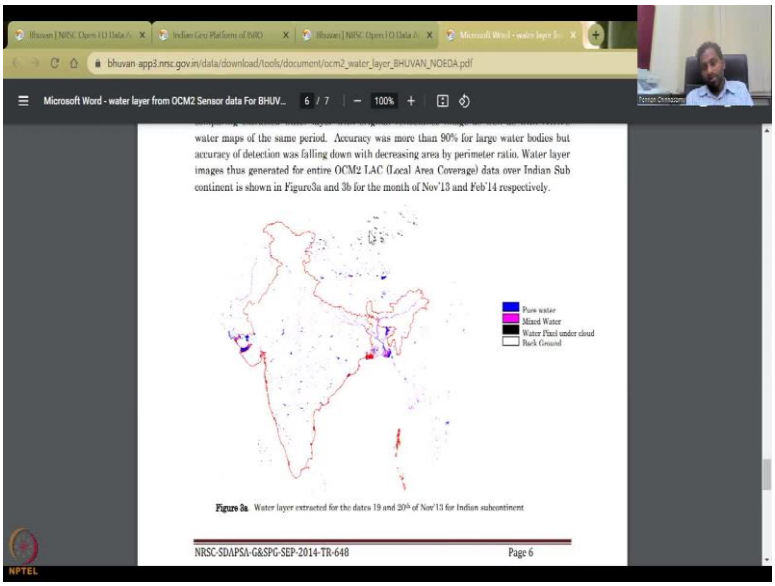


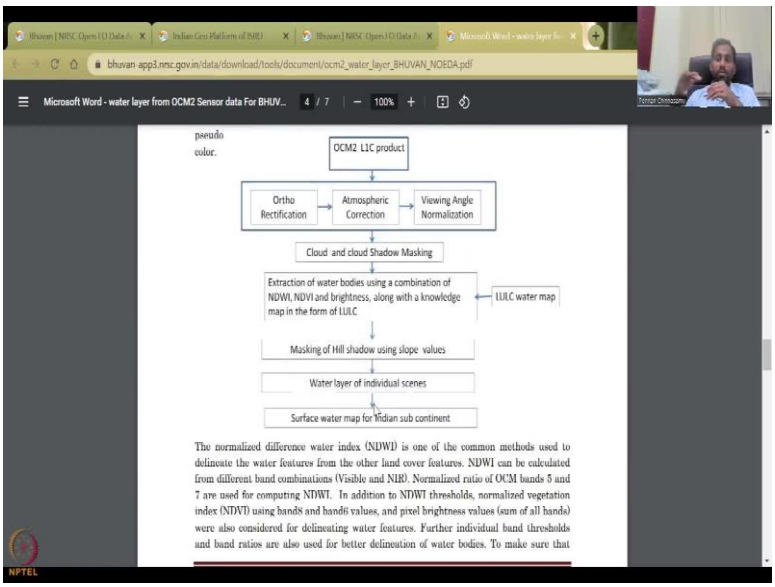

And then you could see here that how a raw image is then converted into color composite where coloring is given blue for water. And then you have this entire India map extracted with pure water as blue, mix water as pink color, water pixel under cloud is black, mostly the hilly regions and then background is white. So, these are the water bodies based on the reflectance for different dates, so that is done.

But most importantly, you should know that it is multiple banks. So, it is like for example, green minus NIR by green plus NIR, so this is a fraction and then the fraction converts into in index. So, that index is used here for calculating the water bodies, that is all this document says, you will learn all this in the basics of remote sensing again.

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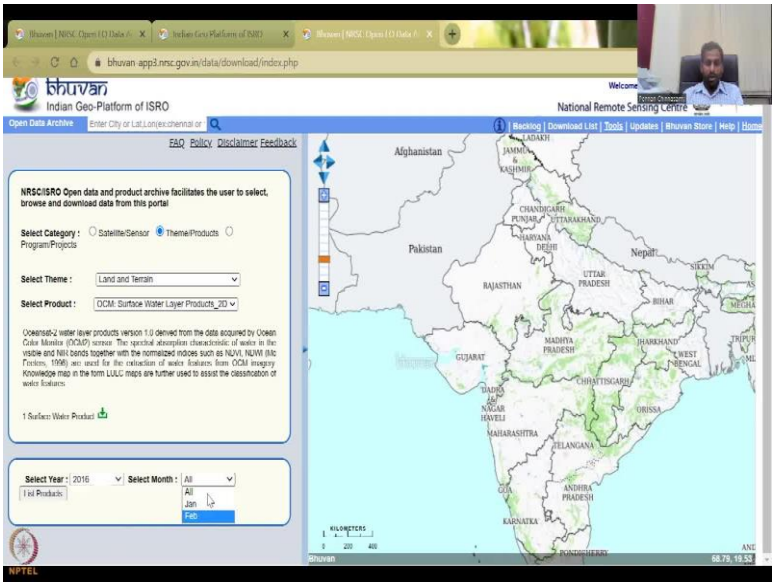
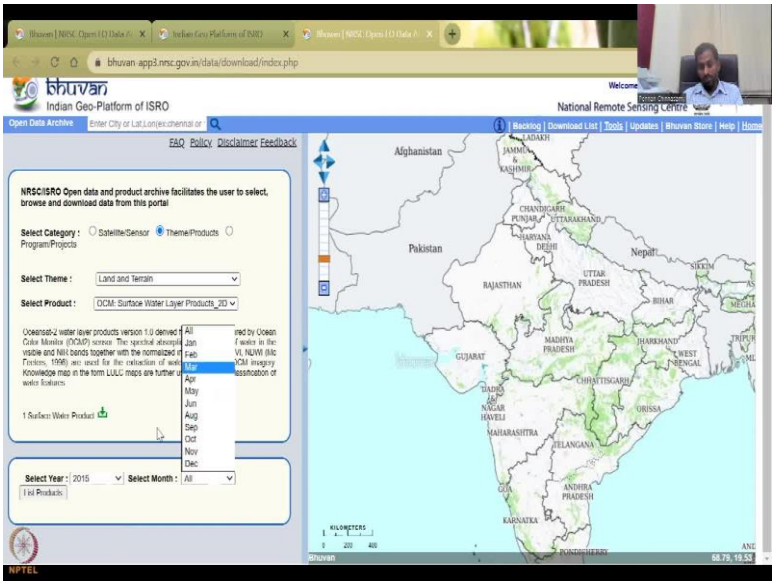
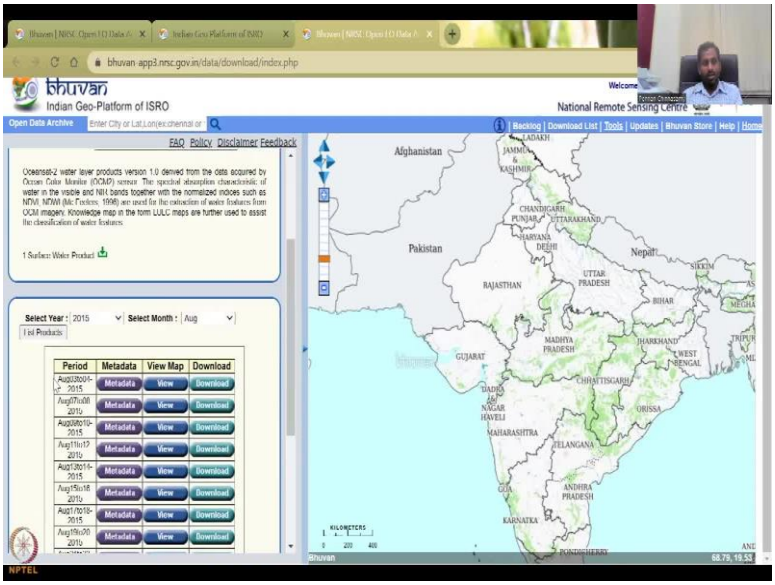
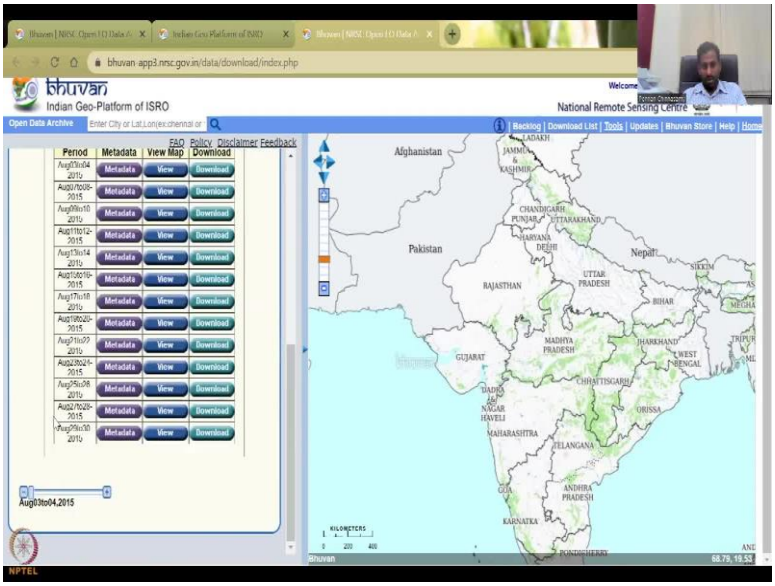


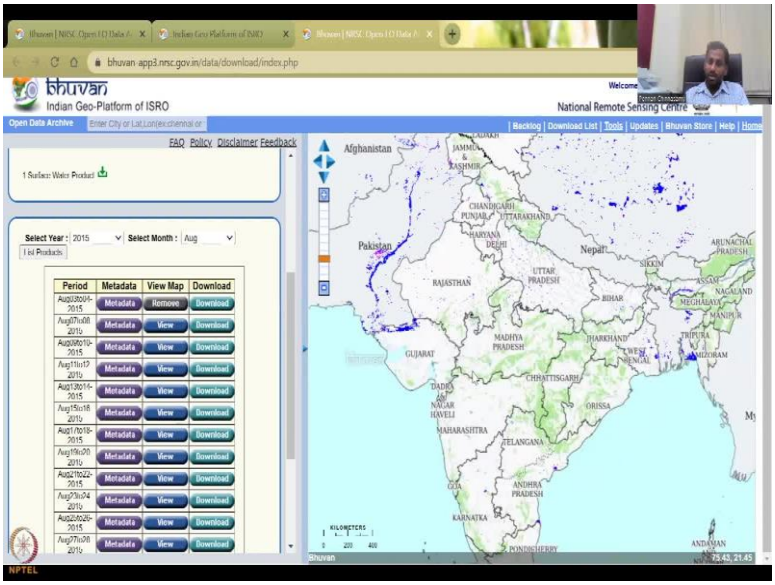



So, here you could select a year. So, you could see that 2016 is the latest. So, why I am asking you to learn these from Bhuvan and other things is so that you could construct the latest data for your research. Here, they have already done it for time period and you know, that they have used ocean stat to which has near infrared and visible spectrum, so there are multiple data that we will come across in the next lectures, you can construct the same image that I am going to show for a much-much newer date here, it is only 2016 and only two months, if it is 2015, you have all the months. So, even 2016, only two months are available, let us say 2015 and then let us say we peak August.

(Refer Slide Time: 16:12)

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1 Surface Water Product
Select Year : 2015
Select Month : Aug
Period
Metadata
View Map
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ORISSA
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TELANGANA
ANDHRA PRADESH
KARNATAKA
PONDICHERRY
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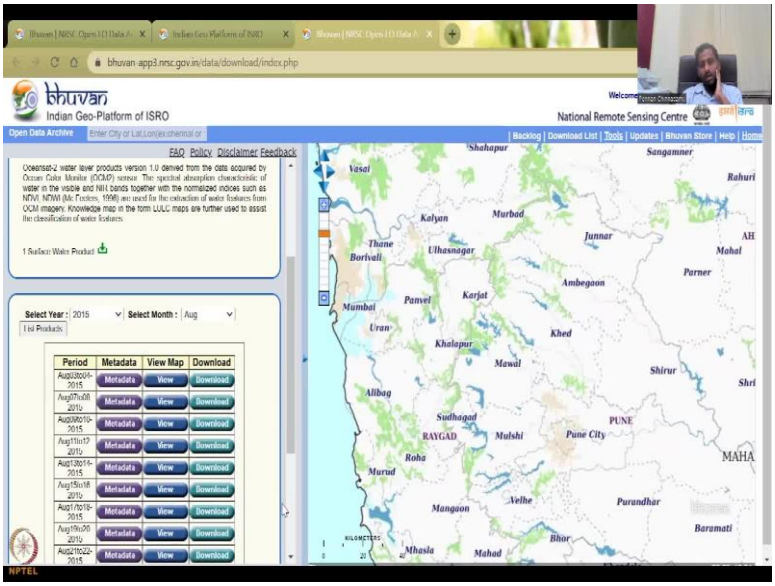
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Oceansat-2 water layer products version 1.0 derived from the data acquired by Ocean Color Monitor (OCM) sensor. The spectral absorption characteristic of water in the visible and NIR bands together with the normalized indices such as NDVI, NDWI (Mc Feeters, 1996) are used for the extraction of water features from OCM imagery. Knowledge map in the form LULC maps are further used to assist the classification of water features.
1 Surface Water Product
Select Year : 2015
Select Month : Aug
Period
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Vasai
Rahuri
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Karjat
Mumbai
Uran
Khed
Khalapur
Mawal
Shirur
Alibag
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RAYGAD
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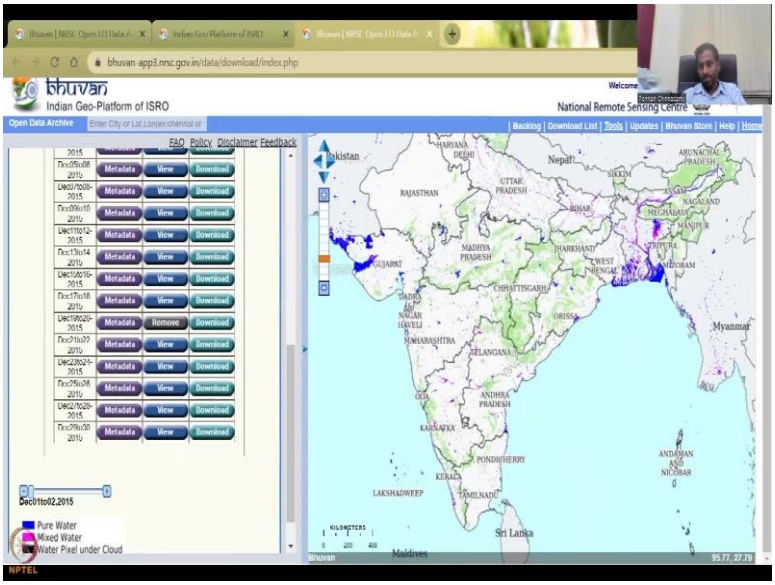
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Dec01to02.2015
Pure Water
Mixed Water
Water Pixel under Cloud
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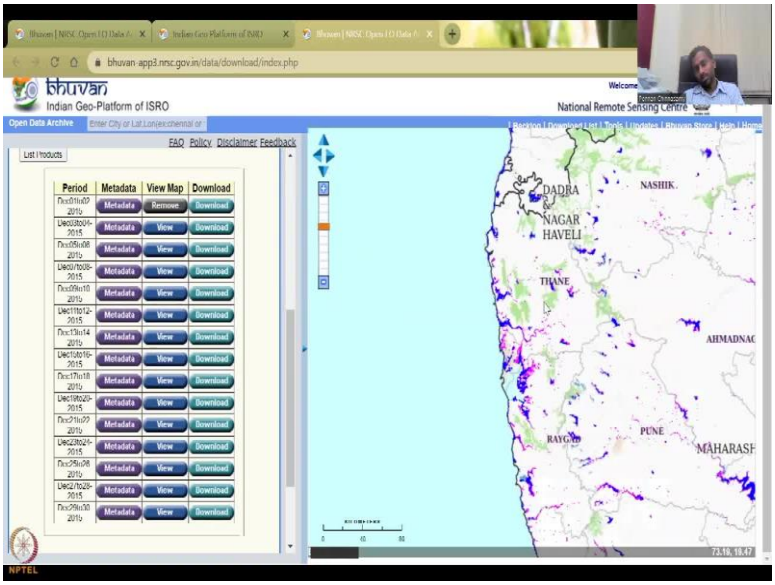
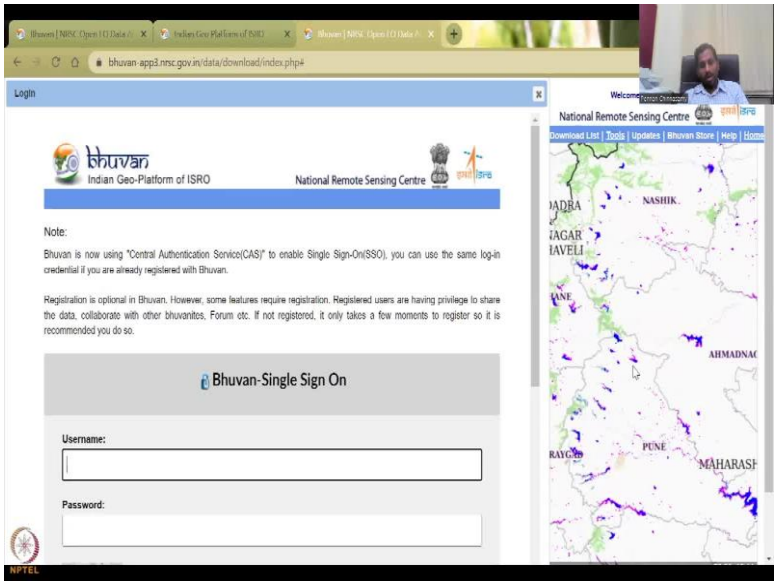
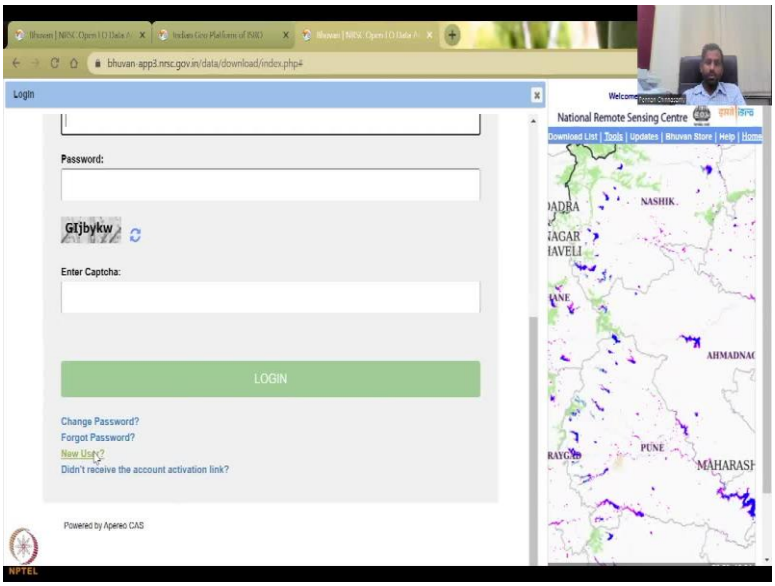


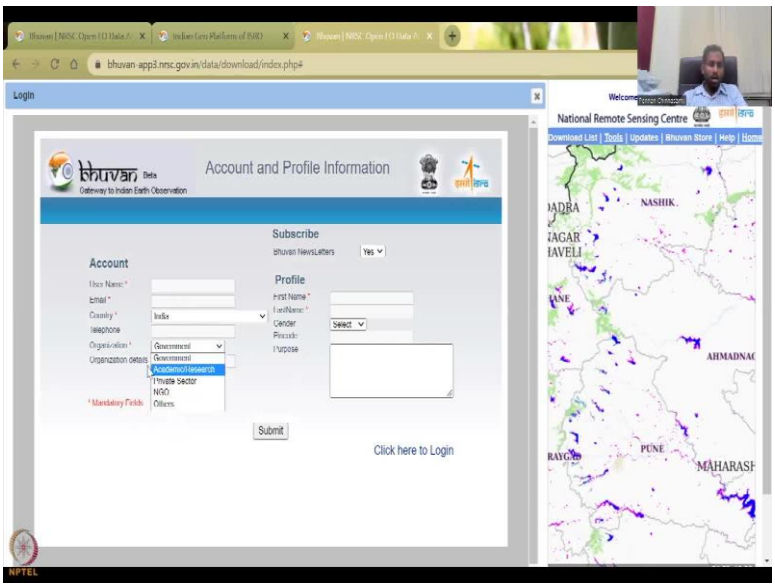

So, every third day as I said, has been given in August. So, it was 3, 4, 7, 8, 9, 10, so there are some lags and delays. If I see click view, you can see the data now being map. So, the blue is again the water bodies, the pink is the mix color and black is no water and incomplete data or water pixel under cloud. So, basically, which is masked there are some but there. And we know that during August, we get some good floods in Maharashtra. So, you can see that it is so let us remove the layer and you will see an updated layer now, where we need to do a view again. So, you will see all these blue-blue colors coming up.

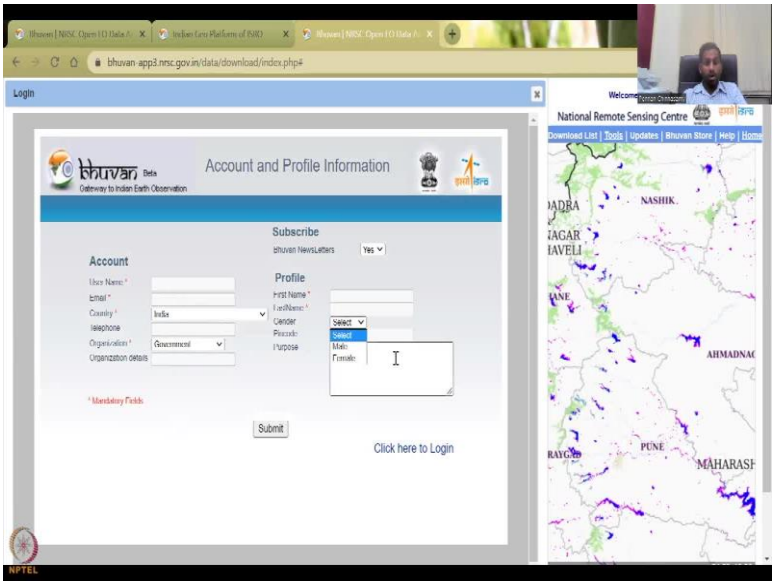
Let us select another month, we do know that in December month, it was really flooding in some areas. You see all the floods have come up excess water, so all the surface water getting big. These actually show that there has been a lot of inundation and water impure water because of mixing with soil, eroded soil and other resources. So, this is very-very important, you could download this data, I will show you how to log in.

(Refer Slide Time: 17:55)

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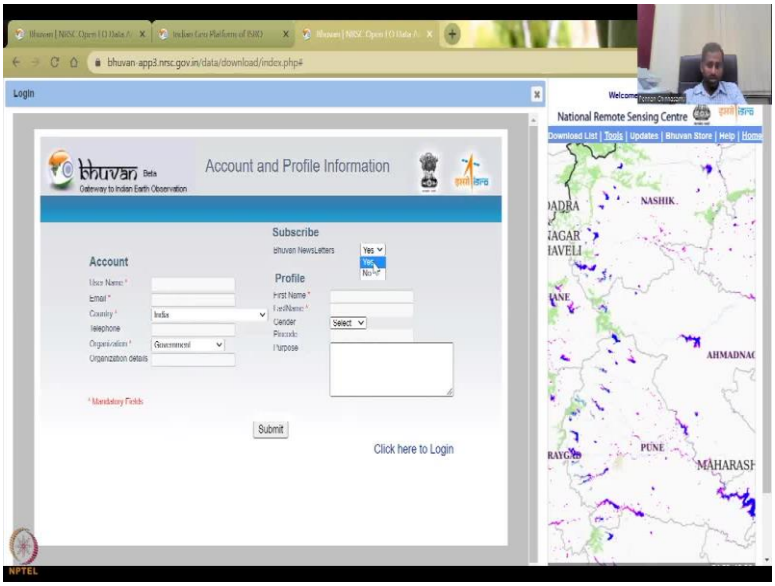
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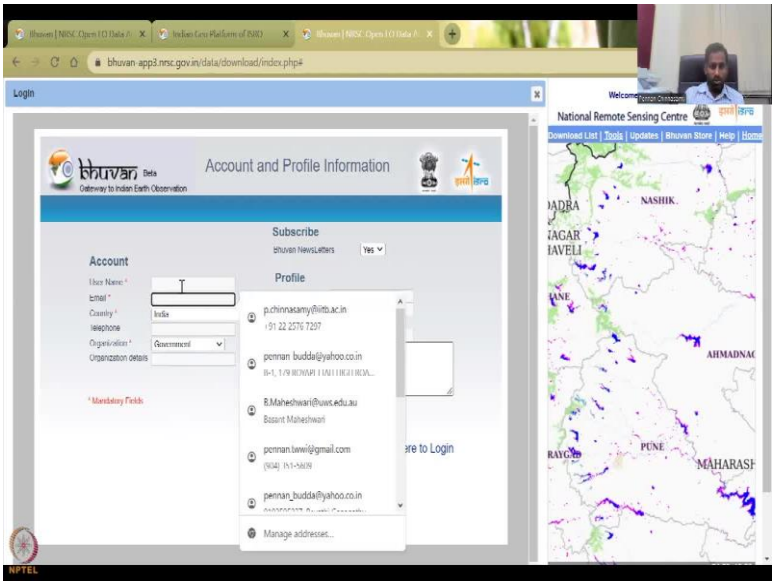
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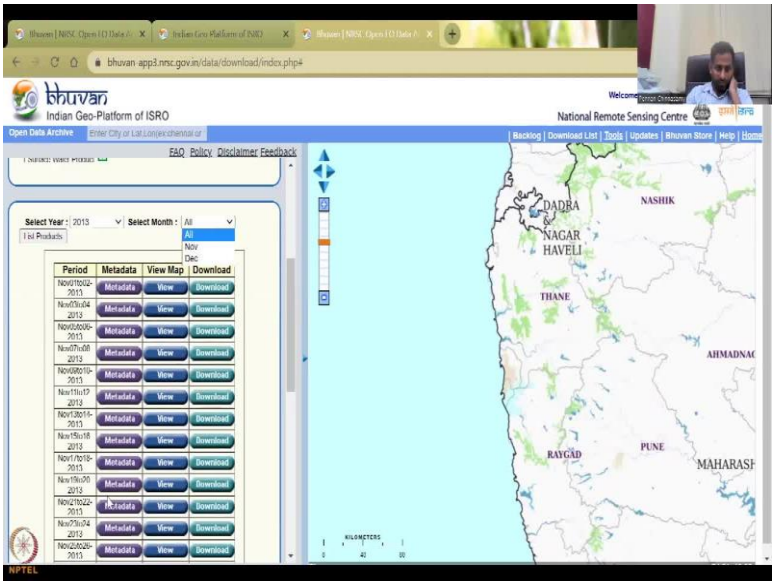
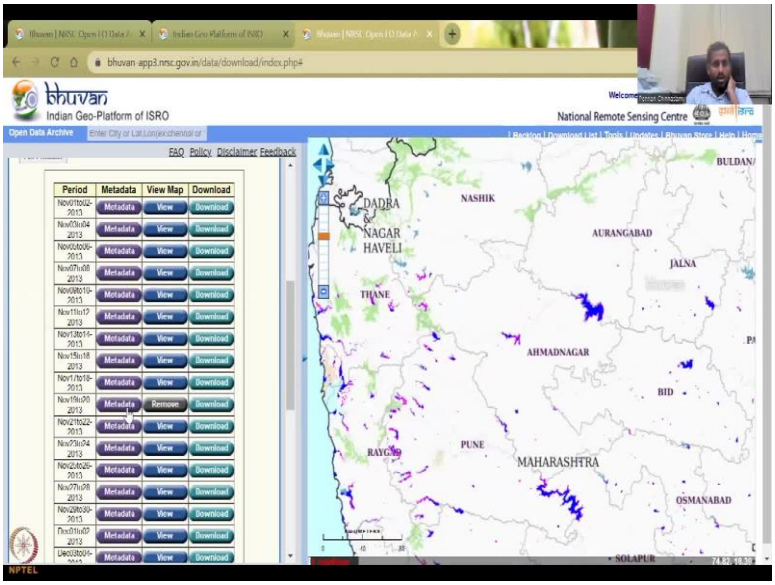
So, if you click login, it will ask for your username and password. I already have a username setup, but you can also do a new user or forgot password. What you should what you should be knowing is that these passwords are important and you can go through the new user setup. As I said, you will have to give the user name, your organisation, if your government, private sector or what organisation details, first name, last name, gender address, PIN code and what you are going to use it for purpose. You do want to subscribe for the letters, Yes or No. You will get an email link for your acceptance, so you can definitely go and see but username is there your email you could see and then.

So, let me type in my login so that we can quickly see if it is eligible to log in. So, sometimes you have to update your login. So, make sure that you have an updated email. If you forget your login, you can always get the password back by sending a request link. So, I am going to get the links that are needed for this password. And yes, in the next class, I will log in and come I do not want to share my credentials online. So, let me log in for the next class and then show you how to extract these data.

(Refer Slide Time: 19:58)

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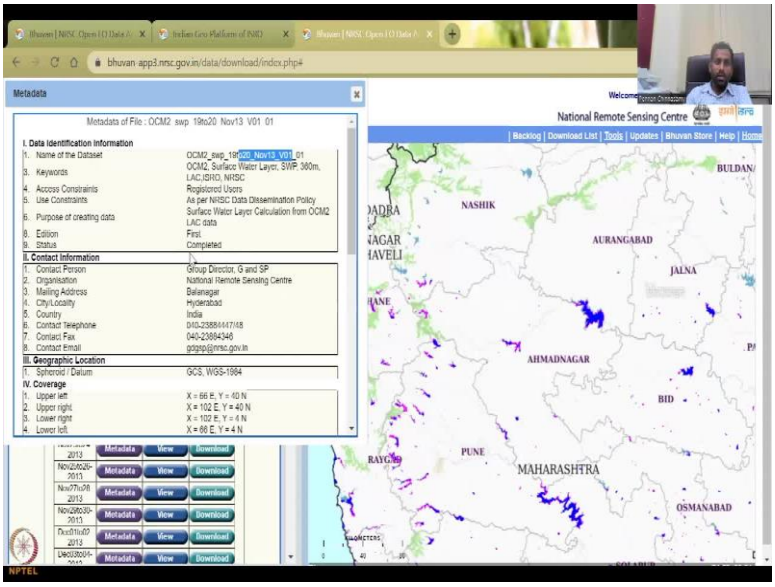
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4. Access Constraints
Registered Users
5. Use Constraints
As per NRSC Data Dissemination Policy
6. Purpose of creating data
Surface Water Layer Calculation from OCM2 LAC data
8. Edition
First
9. Status
Completed
II. Contact Information
1. Contact Person
Group Director, G and SP
2. Organisation
National Remote Sensing Centre
3. Mailing Address
Balanagar
4. City/Locality
Hyderabad
5. Country
India
6. Contact Telephone
040-23884447/48
7. Contact Fax
040-23864946
8. Contact Email
gdgsp@nrsc.gov.in
III. Geographic Location
1. Spheroid / Datum
GCS, WGS-1984
IV. Coverage
1. Upper left
X = 66 E, Y = 40 N
2. Upper right
X = 102 E, Y = 40 N
3. Lower right
X = 102 E, Y = 4 N
4. Lower left
X = 66 E, Y = 4 N
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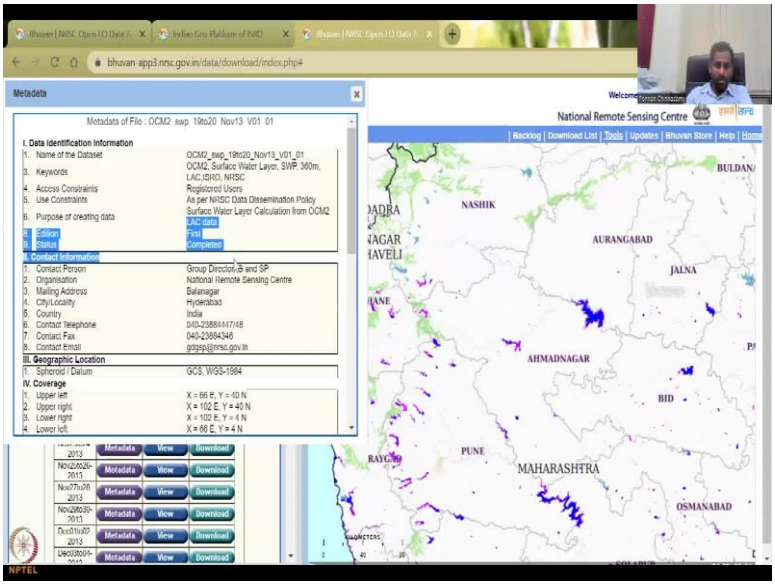
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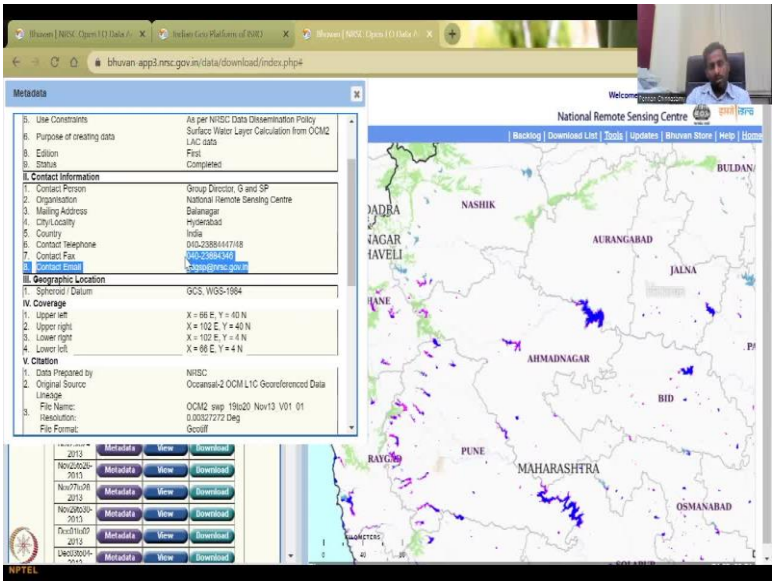
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2. Original Source Linkage
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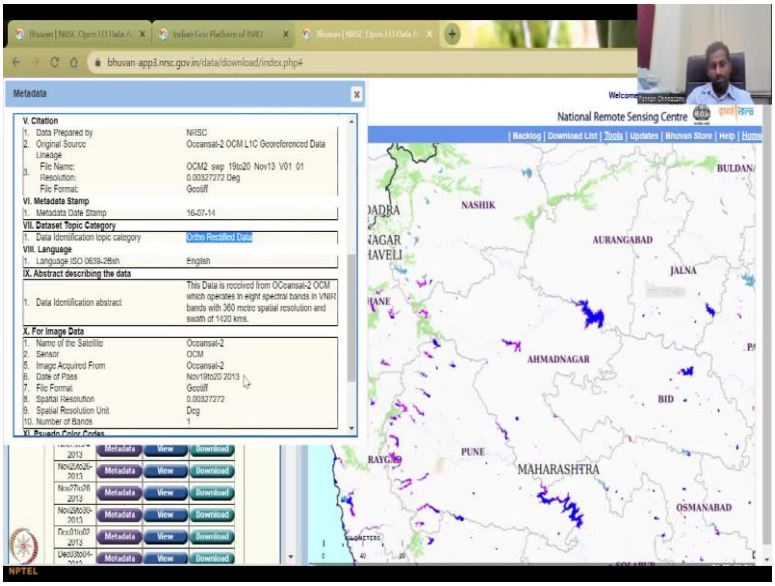
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File Format:
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2. Sensor
OCM
5. Image Acquired From
Oceansat-2
6. Date of Pass
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7. File Format
GeoTiff
8. Spatial Resolution
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Deg
10. Number of Bands
1
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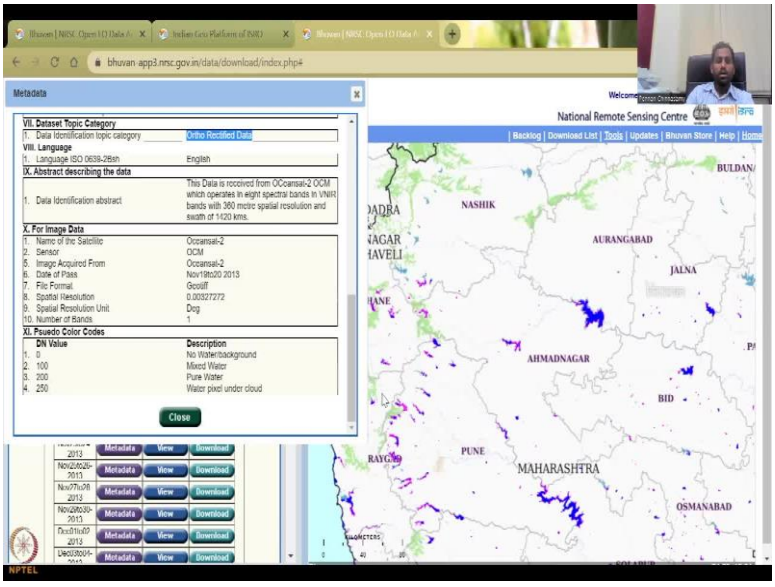
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2. Sensor
OCM
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XI. Psuedo Color Codes
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3. 200
Pure Water
4. 250
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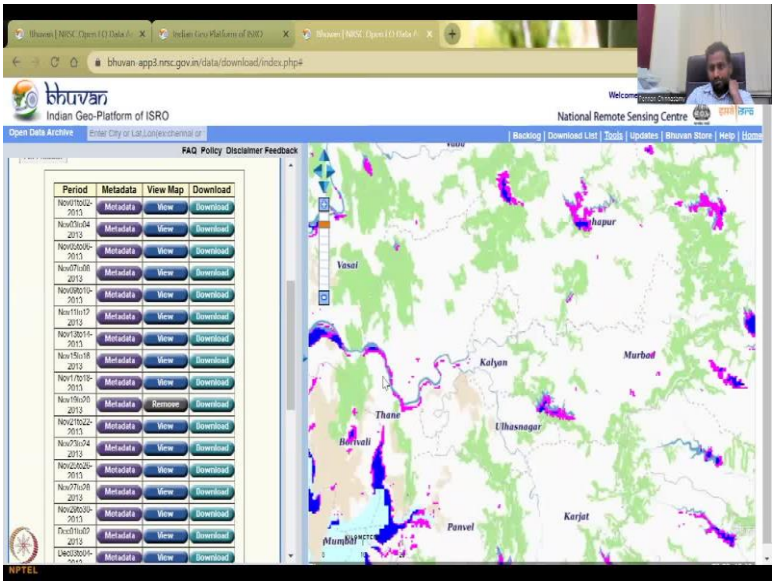
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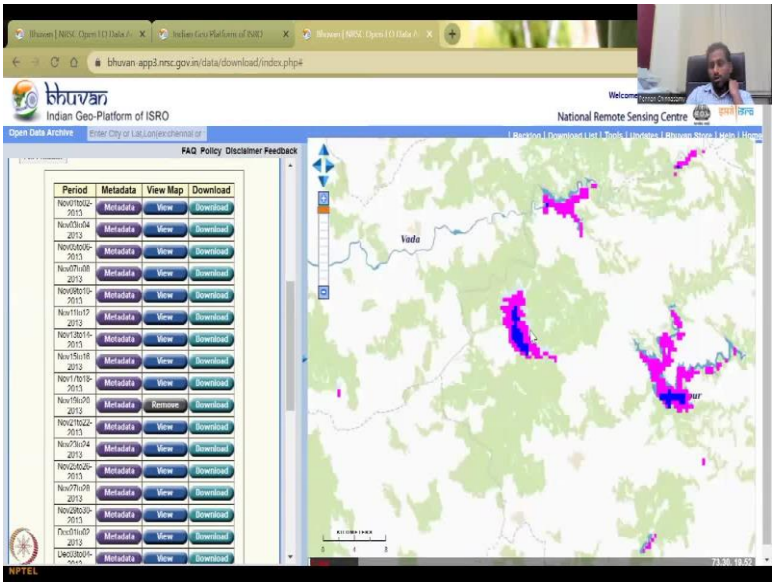
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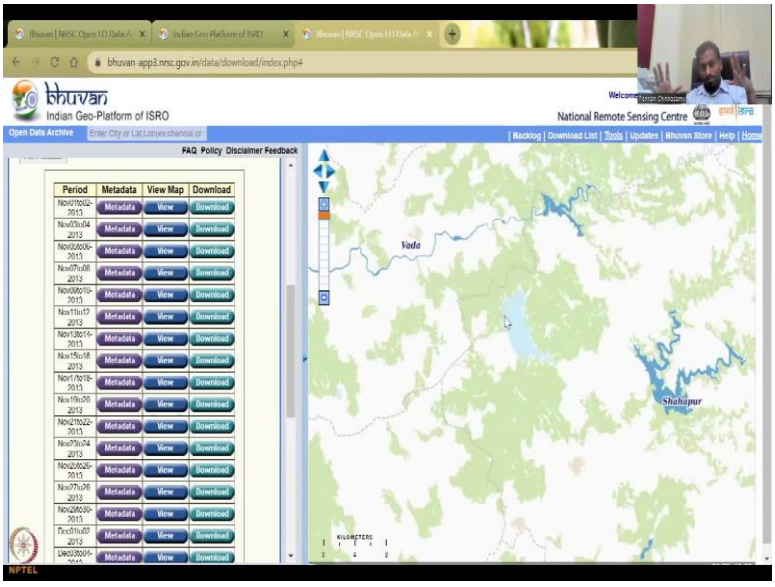
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So, this is how you would log in and collect data for your exercise. And again, you can refresh it to another year, let us say 2013, all months this products, then all the months will come that the data is available. Only November, December is available, that is fine. And then we can do the view, you could have the sea and nation, the water bodies coming up, and then you could do the download button, you need to log in as I said, it will ask you for the login, but more importantly, you could look at the metadata.

So, where was this data collected, when was it collected, and then where was it sample, what was the number of addition? If you have any questions, you could send an email or call them and then the coverage area coverage, those kinds of things. So, any rectification done, what rectification was done? And then it says 8 spectral bands be NIR band which is 360 meter resolution and sort of 1420 kilometers. Number of bands is only one use for this study. And what are the values is 0, 100, 200, 250. 0 is the background which is white color, whereas mix water is pink, pure water is blue, and water pixel under cloud is kept as black. You do not see that here, but you could see definitely, let us say near the Powai region and stuff.

So, what you see here is pink color on the sides. I hope you could see that in this water bodies, which is blue. And then let me remove it just for the sake of it, you can see this is a water body in a normal map. So, the base map is a Bing map or a Google map which is just a normal map which is colored taking on the land use land cover for a particular year, but what has happened is when you add the satellite data which predicts the water boundary, so sometimes there is overlap and goes beyond.

So, this is where you can calculate the area of the water body when you download, there is an exercise that we will do to show you how to estimate this water body area and then take the value out. And then you have the pink color, the pink color resembles the mixed water so which means it is not blue exactly in color, but it could be muddy, sandy or brown water it is because of water mixing and an runoff that comes on the streets. So, you could see that on the boundaries it is always impure but in the centre of the lake it is still okay.

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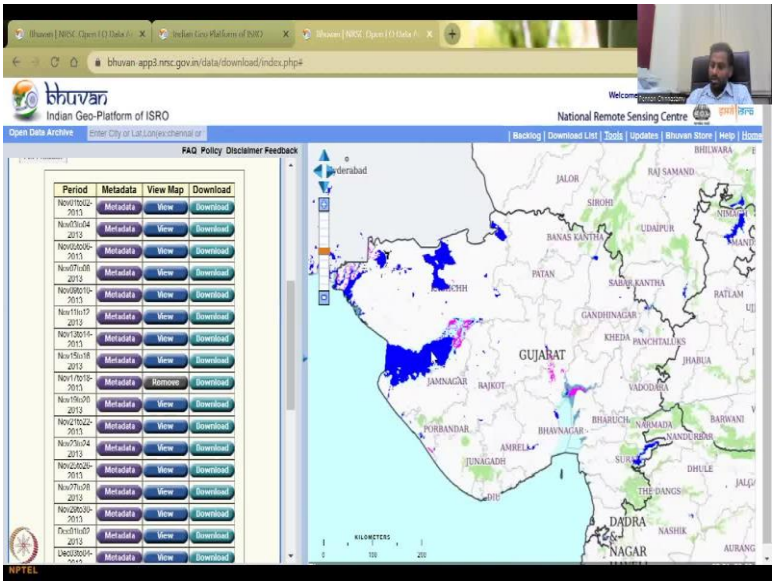


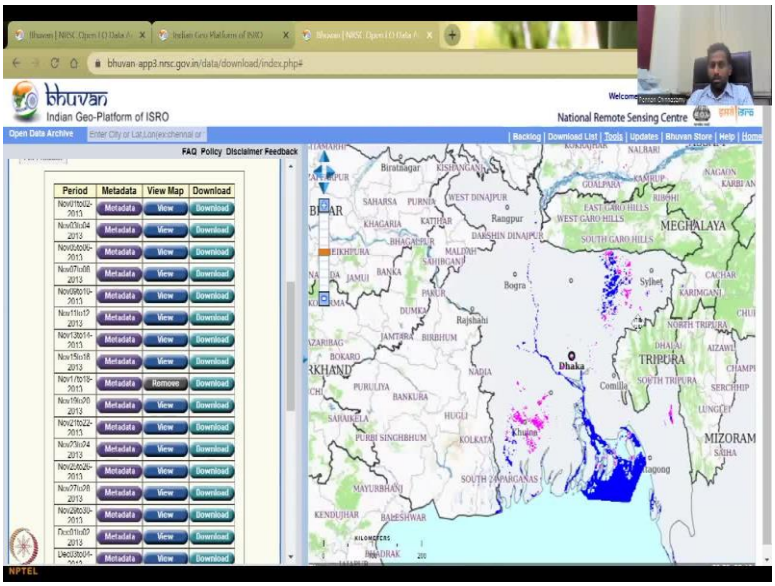


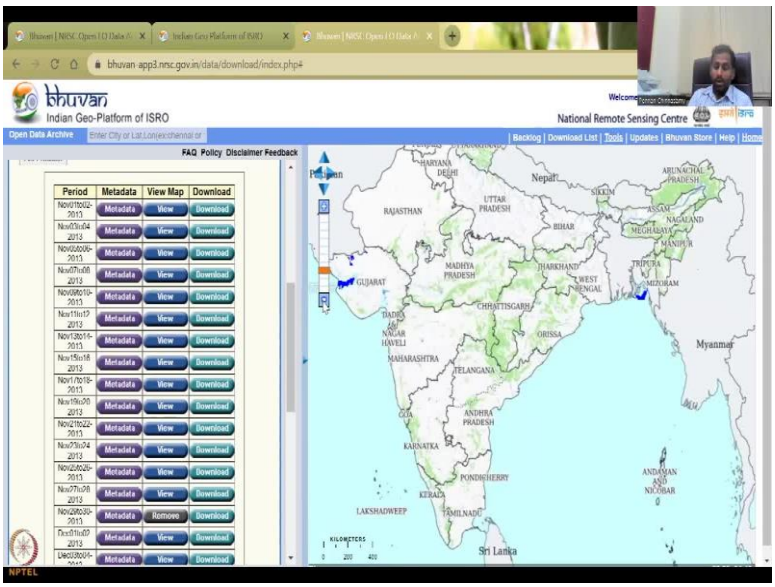

This is the same anomaly for your water bodies also in terms of the rivers. Sometimes this is also considered blue because the boundary is kept like this, boundary is kept like this so you will see some blue color there and Bangladesh is also monitored. So, we have come across a layer where readily you could take the data, I would request you to look at what is NDVI and in NDWI, and then you will understand how these maps are made for data. So, moving on, we will go to the next product.

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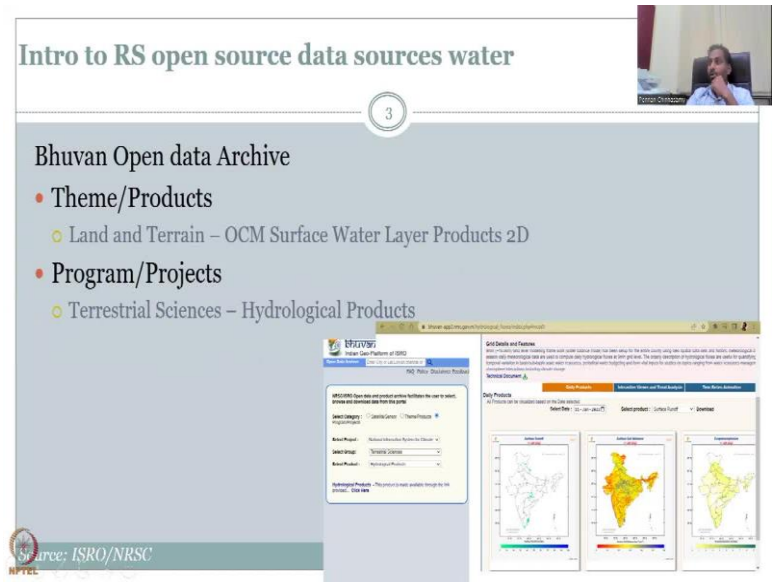


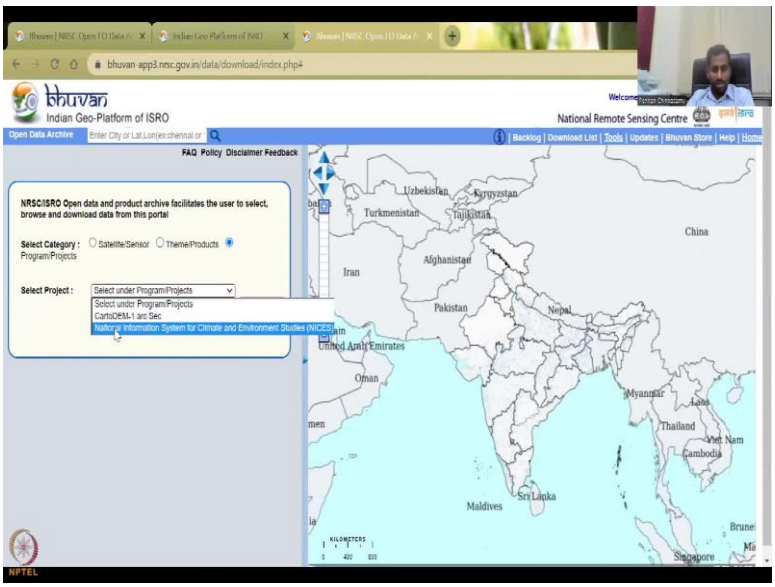

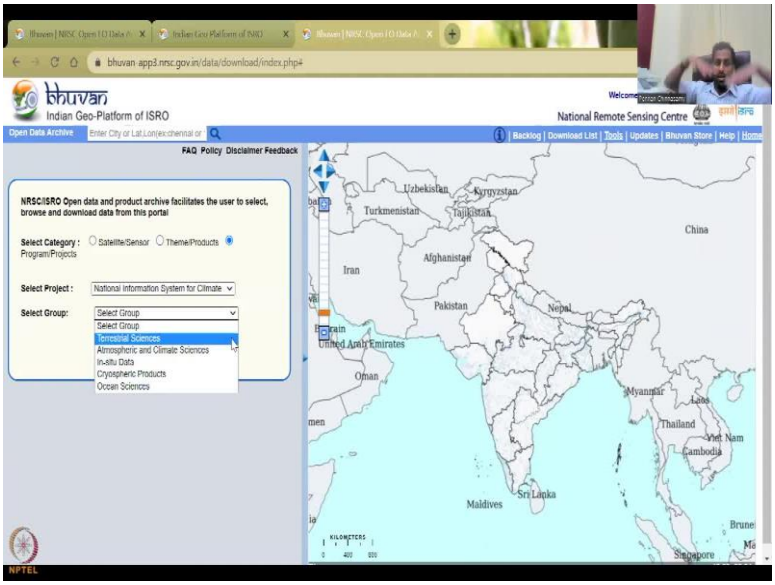
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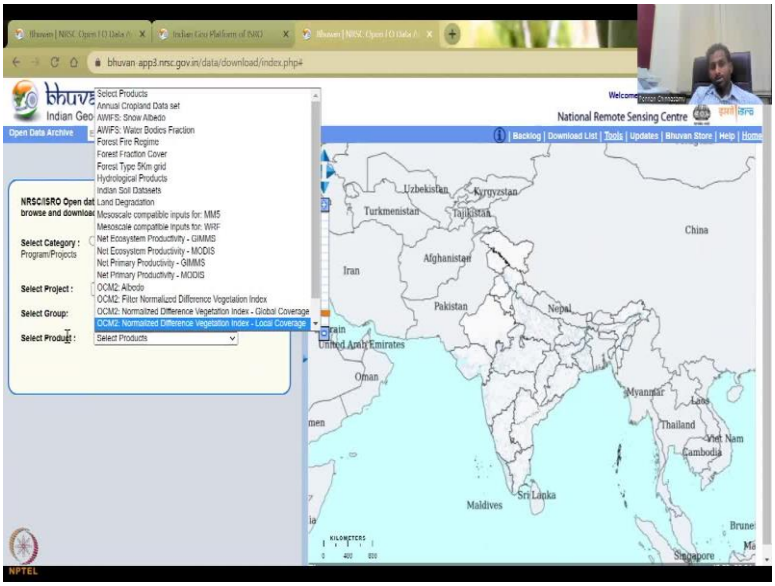
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Land Degradation
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Mesoscale compatible inputs for: WRF
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Net Ecosystem Productivity - MODIS
Net Primary Productivity - GIMMS
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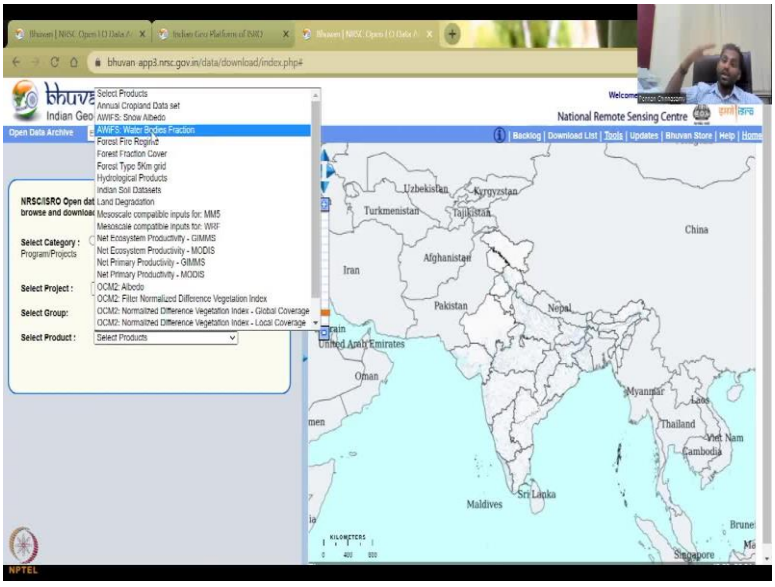
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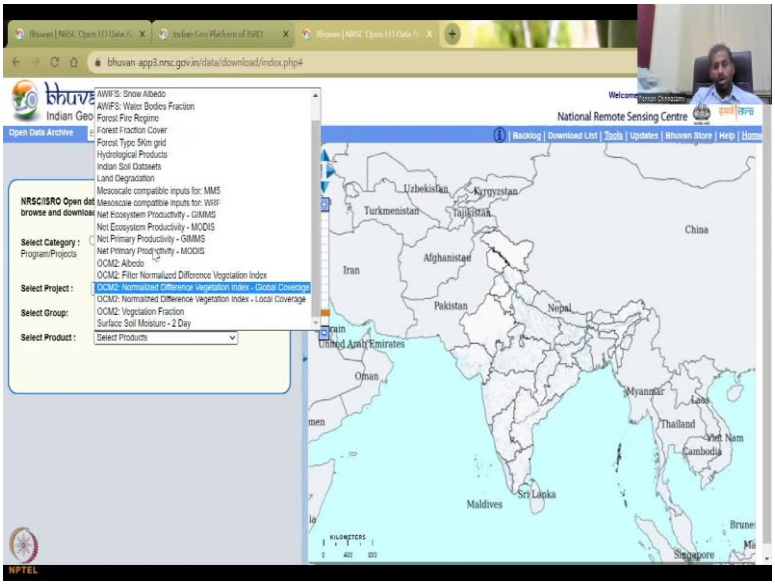


So, we have looked at the applications we have had Open Data Archive, Theme products, land and terrain product has been looked at, now we will go to program projects terrestrial, science, and hydrological products here we will have many-many different products. So, we will have to go back to program and project so resets itself and in the program and products National Information System for climate and environmental studies NICES and under that there is a hydrological terrestrial sciences, so terrestrial is land, atmospherics above the land in situ data is the observation data, Cryospheric is the cold regions, whereas Ocean Sciences is there in the ocean. So, Cryosphere is mostly on the Himalayan regions, let us say terrestrial.

And then here you will see a lot of products, select a product, select a project, select the group in the group base as a terrestrial and in the terrestrial what do you want to see. So, there is a lot of land products and water products. So, for example, you have cropland data, snow albedo, water bodies fraction, forest fire, forest fires are more land. There is a hydrological products that is what we want to see. And then in Indian soil database, land degradation, soil surface soil moisture, the soil keep for the next class, but we will look at the hydrological products.

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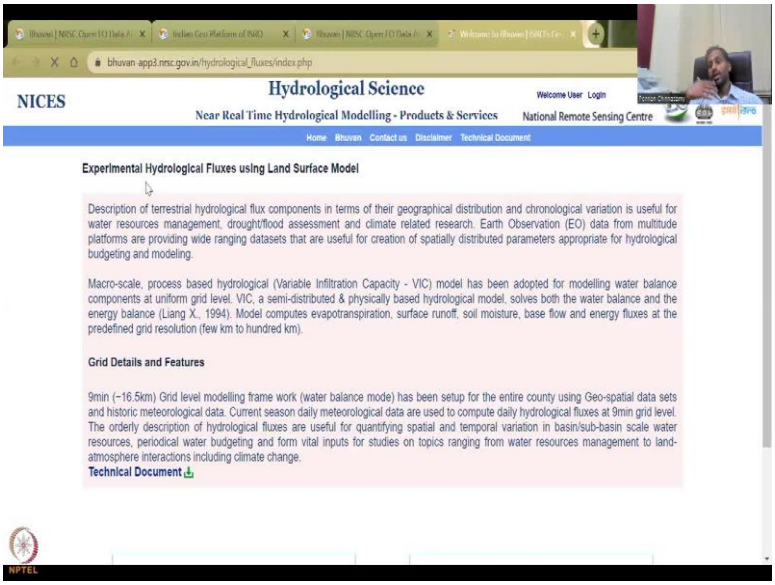


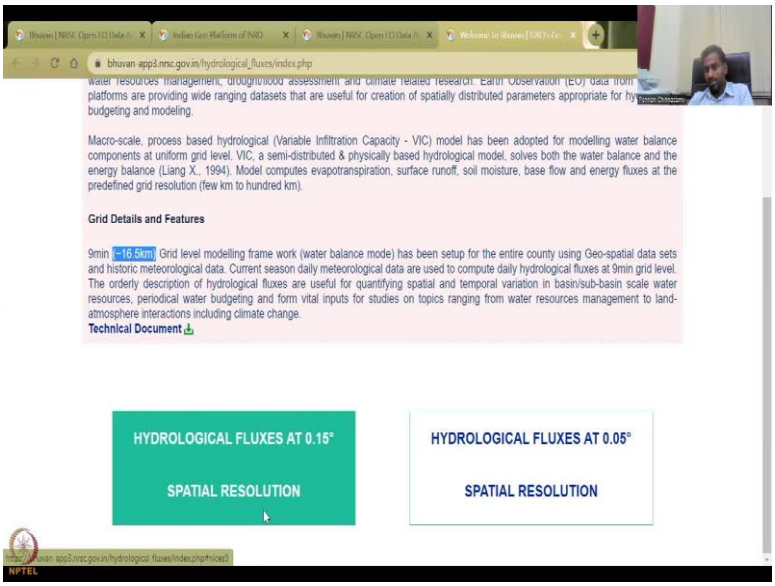


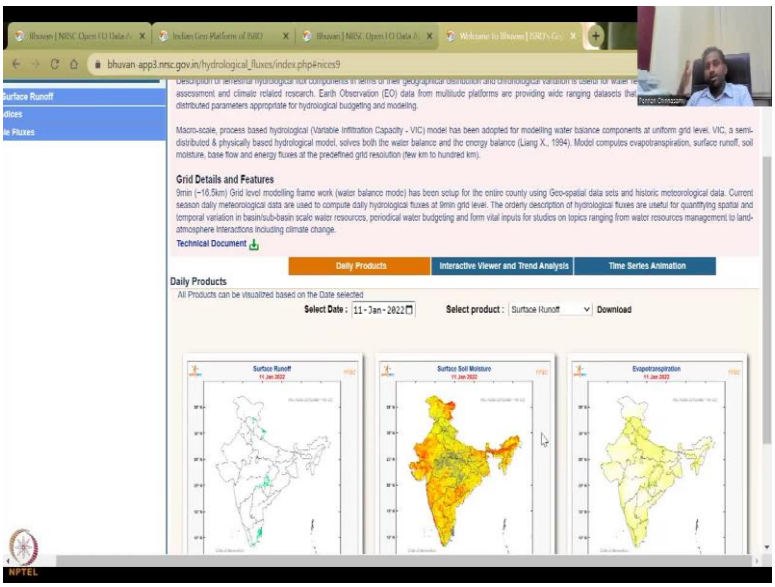

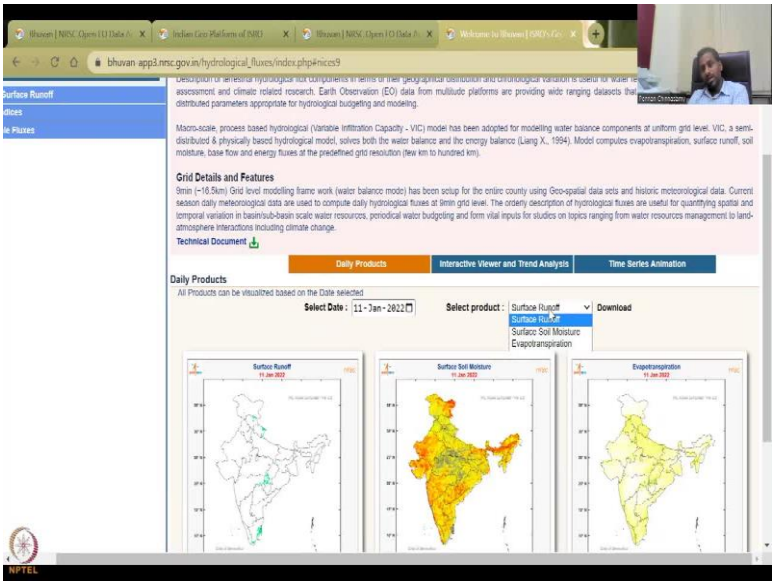
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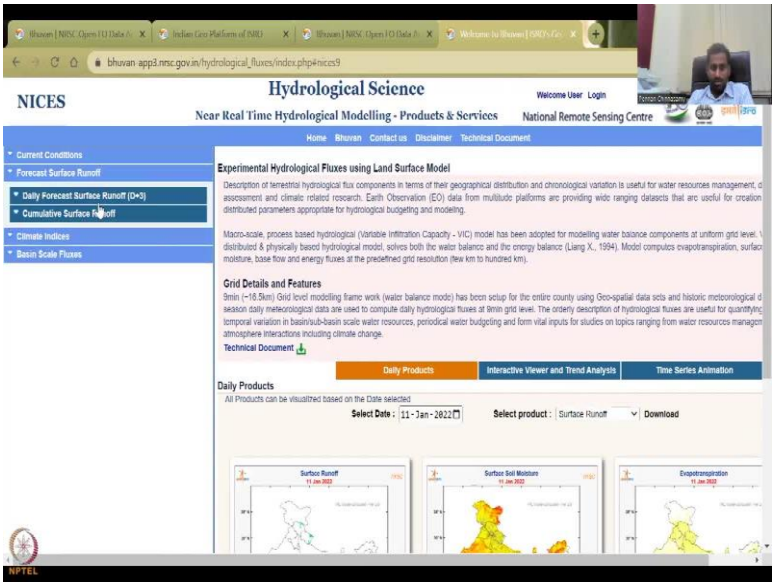
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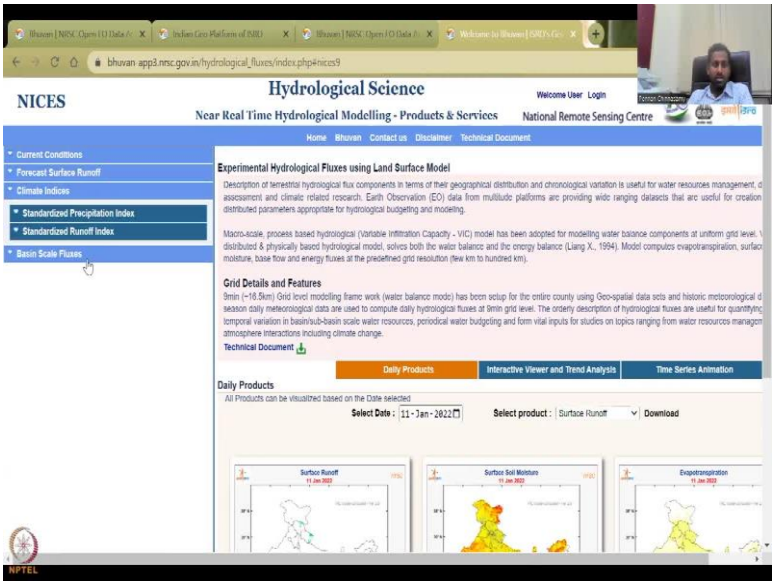
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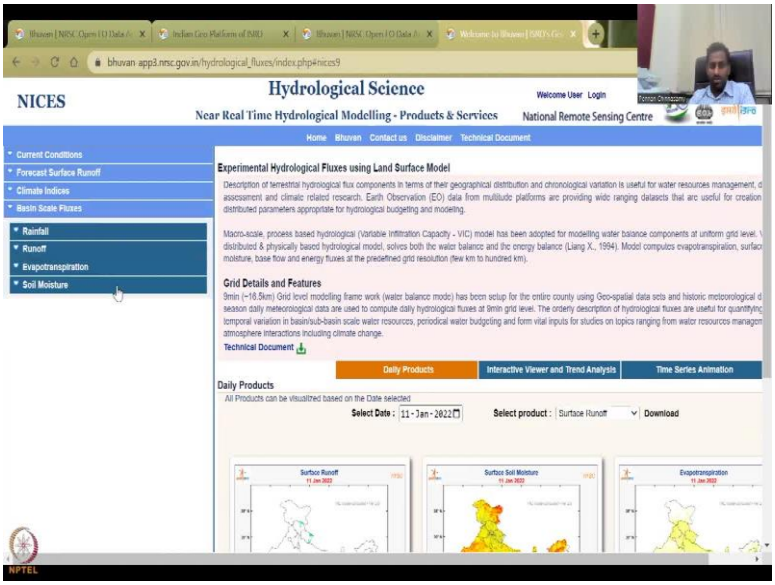


If you click hydrological products, you will be opening up a new website. So, it goes here with some technical documentation which gives you what is the pixel level and you could see it as 16.5 kilometers, it is pretty big, but it is good for some applications. Let us look at a hydrological fluxes spatial resolution 0.15. So, you could see here on eleventh January, what are the different hydrological parameters that has been measured. So, if you remember in the lecture 2, we looked at the water balance for a rural village, which includes the precipitation, surface runoff, storage, and then evapotranspiration, which is the water taken out of the system due to plant and evaporation, and all the other things.

So, what has happened is for a particular date, you can look at the data products. So, here you do not have data for 2023, Jan, the latest you have is eleventh and then you have three products you can take. Surface runoff, evapotranspiration, and surface soil moisture, there is no rainfall, so rainfall you have to estimate separately this is only the products that are taken. On the left hand side, we can also look at forecasts surface runoff, cumulative surface runoff, climate indices is precipitation index, centralized runoff index and then fluxes.

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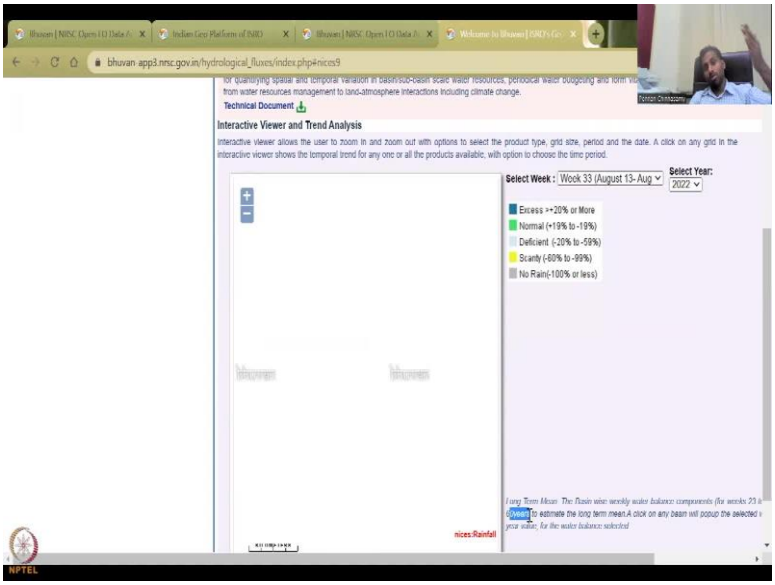


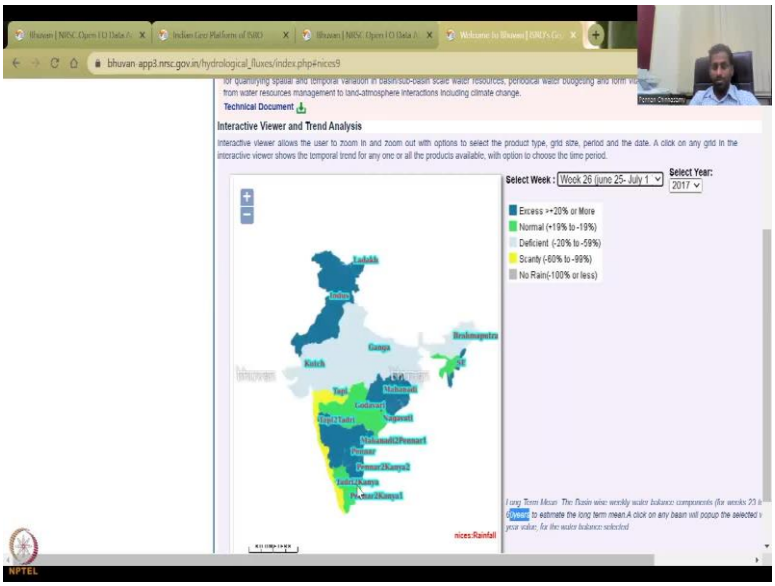


So, rainfall you can get it from here for a particular date. So, you can see a particular date for a particular year you can take, so let us say 2022, you can take for week 33 I have selected, does take some time and it tells you if there is access to them. So, basically from an average it has a 20-30 year average, and above average or below average is the 60 years they have taken.

So, 60 years average and above or below the water level is it there or not this is what are the product this purchase, there are some other products which looks at only 20 to 30 years, but this product looks at 60 years and for some reason it does not pick up. So, let us do a different, now when it comes up.

Now you could see as basins and in the basins is the water level for 2017, 25 July, June to July first in that week is in excess or normal. So, deficient these Ganga region has been deficient whereas others have been in excess, scanty is very-very less rainfall below deficient and then no rain is black. So, this is for the rainfall again we will come back to just the hydrological products.

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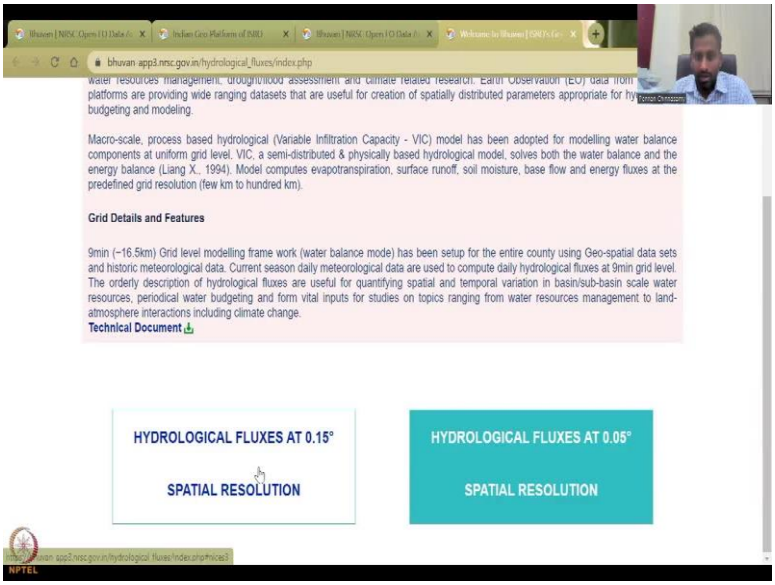


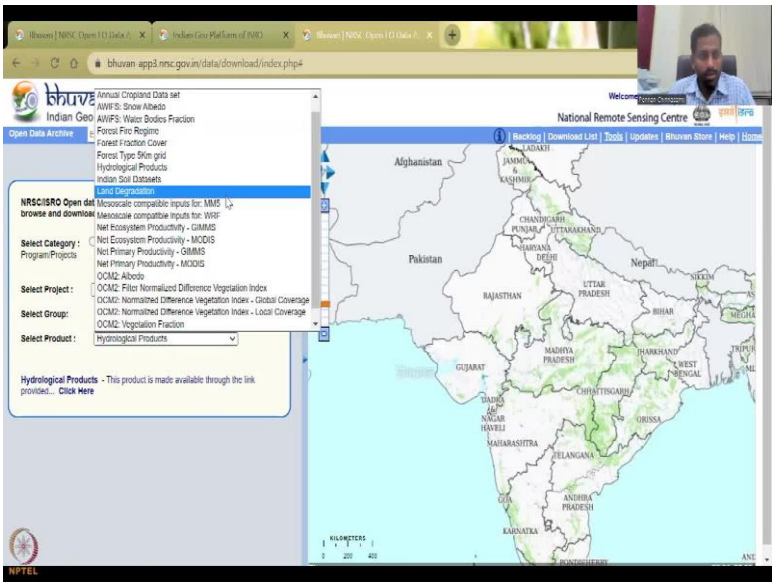

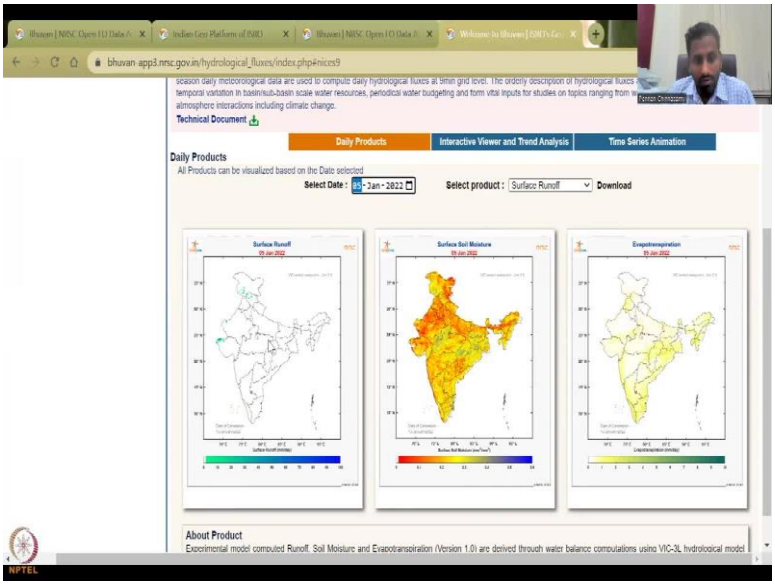


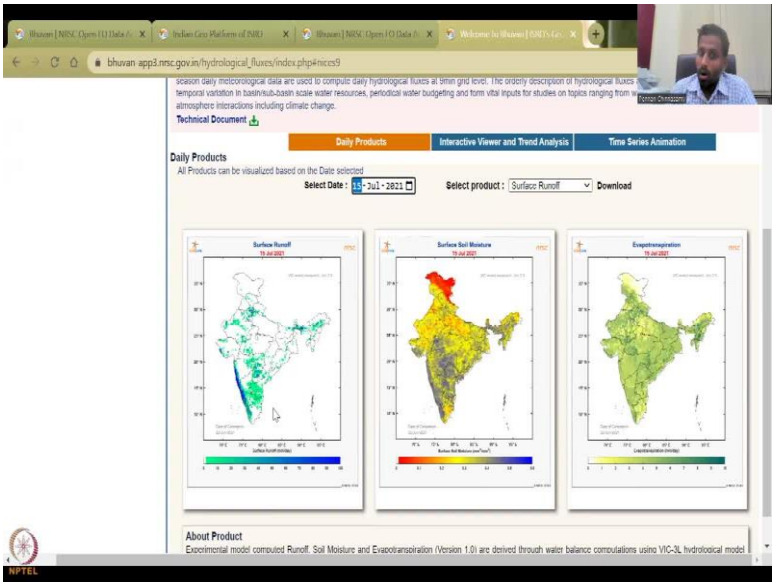


Then we will take the spatial resolution, let us take 0.05 degree which is much-much smaller, does not load because of internet speed. Let us do again hydrological products and then we will do 0.15, it readily opens, sometimes there is a lag on the so I am showing it live for the class so that is why we cannot record it, so I am just doing it while I am conducting the lecture, there is sometimes it does not work. So, just be patient with the Bhuvan website, you have this products.

So, you can select a different date let us select first of Jan or fifth of Jan. And then you could see that the surface runoff millimeters per day is there, soil moisture available and then where is the evapotranspiration happening. So, there is less runoff here and almost no runoff in the other areas in that day. So, in that day there has been only when there is a rain is there is runoff, do not think that all rivers flowing, why is there enough not accounted for, that is discharge, but there is rainfall and rainfall pushes the water.

So, when is the big monsoon season at least in Maharashtra it is in the June. So, let us take June, July, kind of mid July and you can see here now all the areas green in most part and Western ghats where the monsoon is picking up that is in blue color, there is more surface runoff, because there is rainfall and water brings out the discharge.

And then you have because there is water there is positive soil moisture and if you see the soil moisture also increasing in most parts blue color, this is like light blue, this color is not black, it is blue, which means that it is above an increasing and then evapotranspiration. This is driven by the plants, crops and then trees, so you can see that most of these Western Ghats and other regions is very-very high, which means there is a lot of water that is taken up by the plants and transpired.

So, you could also download these products as I said, it is not at real time or near real time scenarios. However, you can learn on how to use this data and then use to do the data, like use the tools that we are going to teach this class to do the data.

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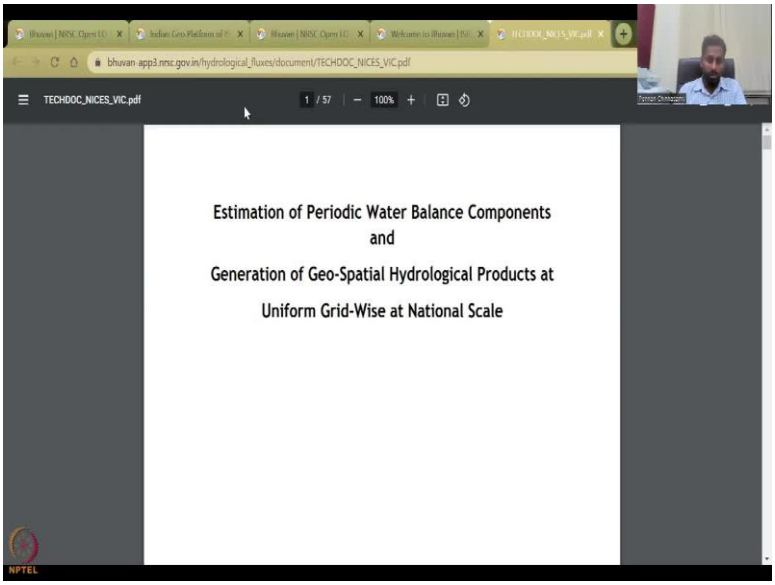

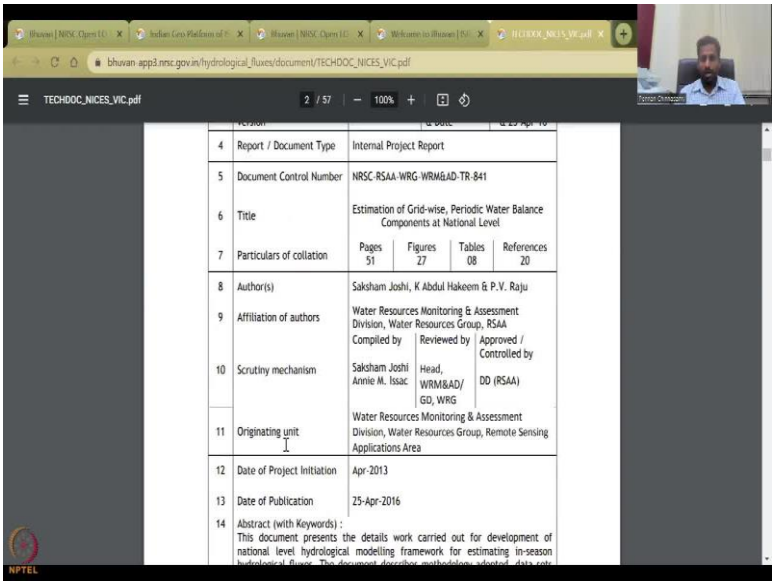


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|---|---|---|
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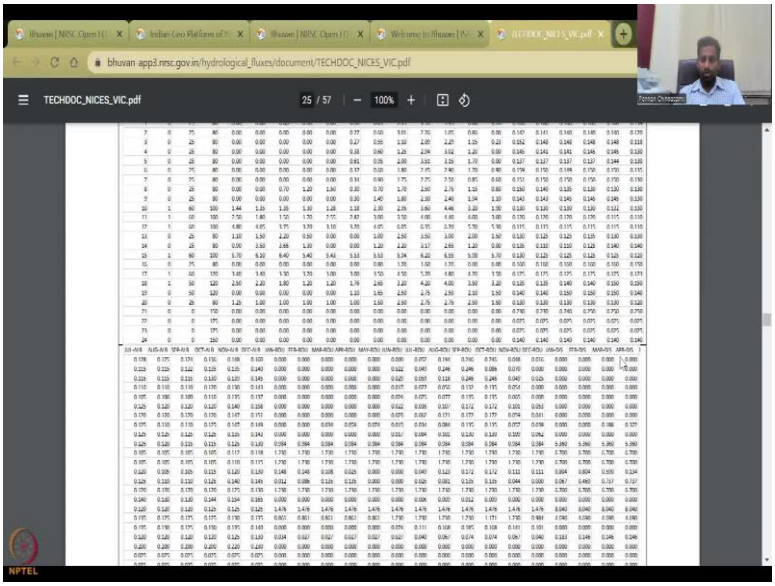
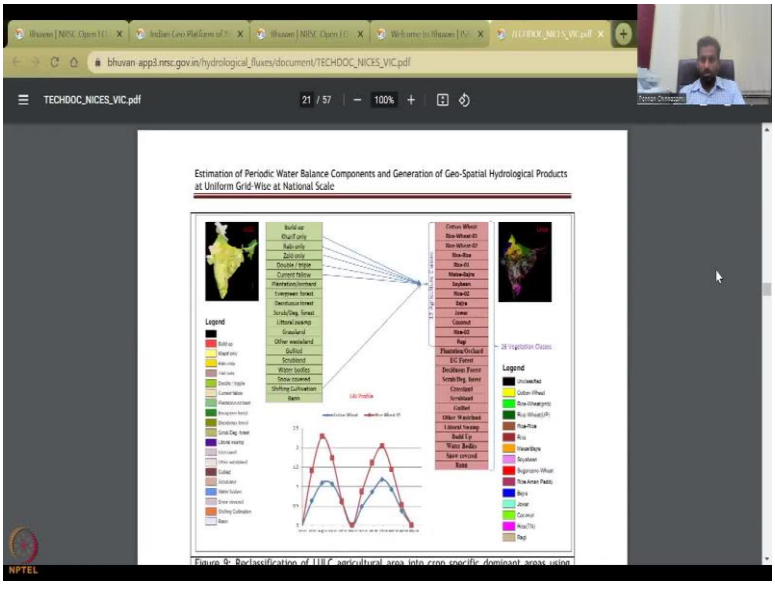
| 5 | Document Control Number | NRSC-RSAA-WRG-WRM&AD-TR-841 |
| 6 | Title | Estimation of Grid-wise, Periodic Water Balance Components at National Level |
| 7 | Particulars of collation | Pages: 51 \| Figures: 27 \| Tables: 08 \| References: 20 |
| 8 | Author(s) | Saksham Joshi, K Abdul Hakeem & P.V. Raju |
| 9 | Affiliation of authors | Water Resources Monitoring & Assessment Division, Water Resources Group, RSAA |
| 10 | Scrutiny mechanism | Compiled by: Saksham Joshi, Annie M. Issac \| Reviewed by: Head, WRM&AD/ GD, WRG \| Approved / Controlled by: DD (RSAA) |
| 11 | Originating unit | Water Resources Monitoring & Assessment Division, Water Resources Group, Remote Sensing Applications Area |
| 12 | Date of Project Initiation | Apr-2013 |
| 13 | Date of Publication | 25-Apr-2016 |
| 14 | Abstract (with Keywords) : This document presents the details work carried out for development of national level hydrological modelling framework for estimating in-season | |



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Estimation of Periodic Water Balance Components and Generation of Geo-Spatial Hydrological Products at Uniform Grid-Wise at National Scale

The area under each soil textural class is converted into corresponding soil property and grid-wise representative value for each soil property is estimated through area weighted average.

The hydraulic properties of different soil texture classes used in preparation of soil parameter are given in the Table 3 and sample extract presented in Figure 7.

Table 3: Hydraulic properties of the various soil types used in the study

| Property | Soil Texture | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | clay-heavy | silty-clay | clay-light | silty-clay-loam | silt | silt-loam | sandy-clay | loam | sandy-clay-loam | sandy-loam | loamy-sand | sand |
| k_sat | 0.11 | 0.37 | 0.11 | 0.57 | 2.20 | 1.61 | 0.14 | 1.55 | 1.13 | 5.03 | 9.67 | 10.81 |
| bulk density | 1.42 | 1.37 | 1.42 | 1.40 | 1.29 | 1.45 | 1.58 | 1.53 | 1.64 | 1.61 | 1.56 | 1.53 |
| bubbling | 37.30 | 34.19 | 37.30 | 32.56 | 37.30 | 20.76 | 29.17 | 11.15 | 28.08 | 14.66 | 8.69 | 7.26 |
| field capacity | 0.88 | 0.79 | 0.88 | 0.75 | 0.63 | 0.65 | 0.82 | 0.61 | 0.63 | 0.40 | 0.26 | 0.22 |
| wilting point | 0.60 | 0.519 | 0.60 | 0.431 | 0.125 | 0.229 | 0.568 | 0.304 | 0.395 | 0.178 | 0.109 | 0.109 |
| quartz content | 0.25 | 0.08 | 0.25 | 0.09 | 0.05 | 0.19 | 0.50 | 0.41 | 0.61 | 0.69 | 0.85 | 0.95 |
| Slope of retention curve 'b' | 12.28 | 9.76 | 12.28 | 7.48 | 3.05 | 3.79 | 1.19 | 5.30 | 8.66 | 4.84 | 3.99 | 4.10 |
| Max. Soil Moisture (fiv) | 0.50 | 0.52 | 0.50 | 0.51 | 0.48 | 0.48 | 0.44 | 0.46 | 0.43 | 0.45 | 0.46 | 0.46 |

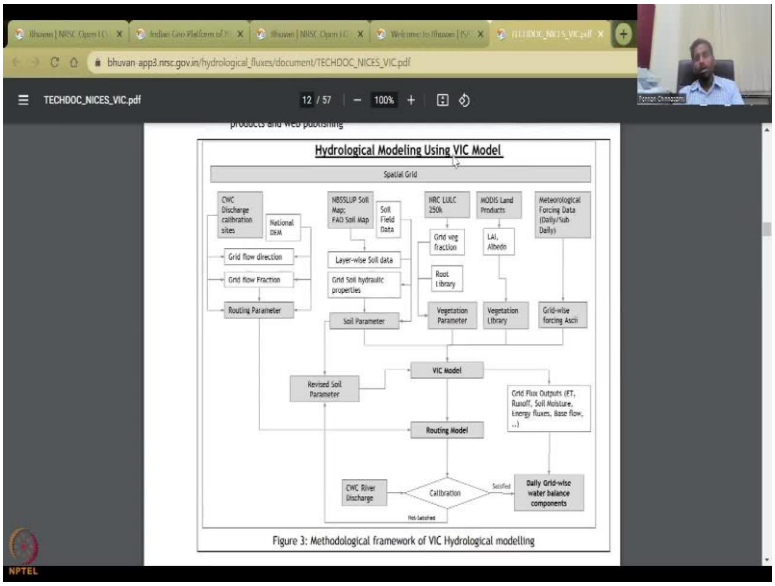

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Figure 3: Methodological framework of VIC Hydrological modelling

# Conclude

4

- Indian RS data exist.
- More info on the dataset and tutorials from ISRO are available at:
  - BHUVAN: https://youtu.be/GjaueiRlEU4
  - VEDAS: https://youtu.be/Qy1hIu8FNQ8
  - MOSDAC: https://youtu.be/q33C4PriTLo

And here is the water balance components and how they have created so I just clicked on a technical document and you can read it. So, as an exercise, when you can discuss these in your classwork, in your research work, I recommend you to go through this these kinds of materials, because it gives you a good reading document. And here they are given how they calibrate the model. So, the model we are using is VIC variable infiltration capacity model.

So, I think this is good for introducing the remote sensing data for water from Bhuvan resources. That is, it for the Bhuvan data products. With this, I conclude today's lecture. Again, I am putting the video tutorials for these products, feel free to go and look at these products for your research. Thank you.