Remote Sensing: Principles and Applications
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Lecture-60
RS Data, Data Portals and Processing Tools-Part-2

Hello everyone, welcome to the next lecture in our course, we are discussing about remote sensing datasets, data portals and some of the processing tools. In the last lecture, we started discussing about remote sensing data and we saw example for an optical dataset and different levels of processing.

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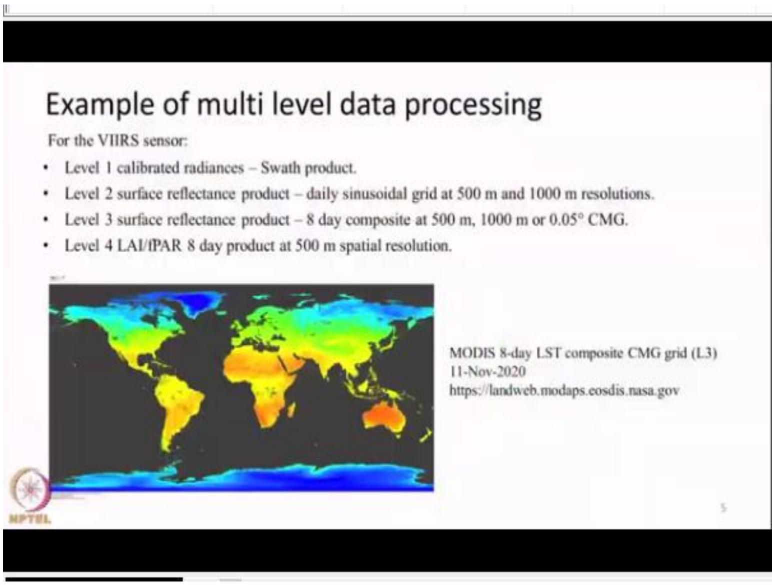

So, in the last lecture, I told you there can be 4 different levels of processing in remote sensing data and not all the sensors and all the satellites provide us all the 4 levels of data, it depends on what sort of goals the space agency has and what they envisage to give us. So, just I showed you one example of different levels of data processing acquired from VIIRS sensor which is essentially an optical sensor.

In the same way, we can also define the data for other sensors, like synthetic aperture radar, passive microwave radiometers, Lidar and everything. Just we will quickly see some examples for each of the dataset. The below slide shows an example for the different products available from the Sentinel-1 SAR satellite, it is a synthetic aperture radar satellite operating in C band. Here we have different levels of data in different modes.

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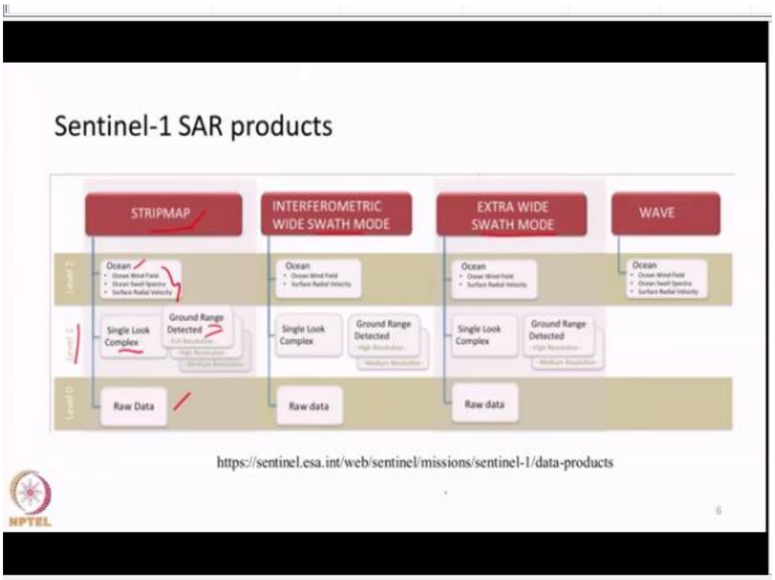

We can either improve the spatial resolution, by decreasing the swath width or obtain data over a large swath or obtain polarimetric data, like data in different, different polarizations, all these things are possible from SAR satellites. Similar thing is also applicable to the Sentinel-1 SAR. So, if you look at the data, the data can be obtained in different modes, strip map mode, interferometric wide swath, extra wide swath.

So, these things will differ on whether we want a large swath coverage instead of a very fine spatial resolution or whether we want a very fine spatial resolution, but we do not want a wide swath. Depending on our needs, we can choose the data, we can program the satellite to acquire such data. Here also we have level 0 raw data, which normally may not be given to us.

Level 1 data can be single look complex or ground range detected. So, ground range detected is the slant range geometry of the data that will be converted to ground range distance which we can use it for further processing. Whereas, a single look complex will contain both the phase information as well as the amplitude information of the wave that is received. So, these are level 1 products, what basically the SAR receives, then further it can be processed as level 2 data, to give variables like ocean wind field, ocean radial surface velocity and so on. So, these are some examples for data from Sentinel-1 SAR products. Similarly, if we move on to passive microwave radio meters, where there are different satellites available. I am just showing you one example for the SMOS data which is again an L band radiometer dedicated for observing soil moisture, ocean salinity and even freeze/thaw it will be able to provide.

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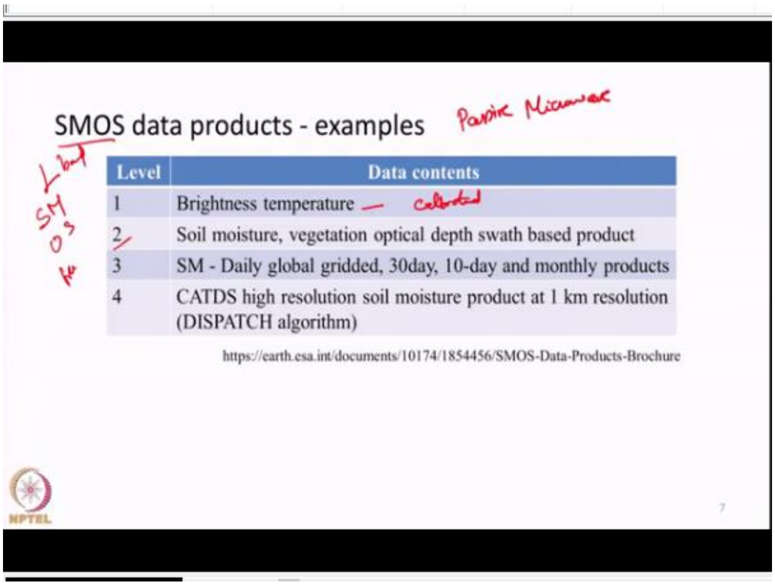

So, the first level of data is the calibrated brightness temperature values. Level 2 is always geophysical product. So, when you talk about earth's surface or its properties, then you can talk about soil moisture, soil moisture is one of the state variable of earth's system or you can talk about vegetation optical depth, which is the water content within the vegetation canopy, like a three dimensional structure which holds water or it is maybe ocean salinity product if it is over ocean, all these things. So, level 2 will be such datasets on a swath based product.

Then level 3, everything will be properly gridded. Earth can be divided into various grids and the data can be perfectly populated into those grids and it can be given to us with different temporal scale, maybe daily, 3 daily, 10 day ones or monthly product. Say we know that each satellite will have more than 1 orbit in a given day across the globe. So, all the things will be properly combined to get us a global product, that is one on level 4 say whatever the SMOS observes they are fed into another model and they will provide some other advanced variables as output.

Say in SMOS level 4 we also have like a very high spatial resolution product like at 1 kilometer, they are using like a disaggregation algorithm to do it. Similarly, if you talk in terms of SMAP satellite, which is another L band radiometer available in space, again level 1 data is brightness temperature, level 2 data is soil moisture at swath level, level 3 is like global gridded daily soil moisture product.

And level 4 can be a root zone soil moisture product or a modelled 3 hourly soil moisture and so on. So, essentially these satellites, passive microwave radiometers provide data related to brightness temperature, soil moisture or some of the passive microwave radiometers may provide even wind velocity over oceans, sea ice thickness, all these things can come as output from passive microwave radiometers.

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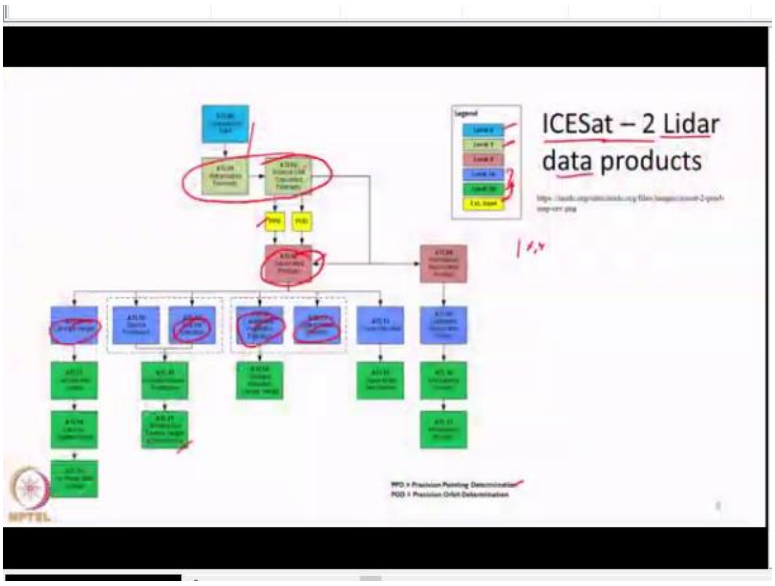

Then this slide shows example for Lidar data products from ICESat-2 satellite basically, from the Atlas sensor, here also we have from level 0 to level 3 data. So, level 0 is whatever the satellite is sending and level 1 data is basically the reformatted telemetric data, whatever sent by the satellite is converted into science units under the distance and other parameters.

So, when the distance is combined with the precise orbit determination parameters and the precise position determining parameters like where the satellite is pointing and what the satellite operates? If these 2 are combined, then we will be able to estimate the ground coordinates of each and every point. That is the basic principle of Lidar system and that is level 2 datasets.

So, this level 2 dataset will tell you the geo located photons where each photon hits x, y, z coordinates, it will also give a normalized backscatter profiles. So, then comes level 3, level 3 is geo located photons after when you do processing over it, we will be able to retrieve the thickness of ice, thickness of vegetation and so on. So, all these things are combined in and given in level 3, land, ice height, sea ice elevation, land or water vegetation elevation, inland water elevation, level of inland water bodies and so on. So, all these things are level 3. So, level 3 can further be classified to level 3a and 3b. So, 3b has weekly product, gridded product and so on. So, these are some examples of datasets available from ICESat-2 Lidar sensor.

So, the major aim of giving examples of all these data products is to introduce the students who are new to this field to the wide variety of data available, conventionally we think everything has in form of an image consisting of spectral DN values, spectral reflectance and so on. But remote sensing provides a variety of data sources which we can directly use for many different applications. Now, we will see what are the common formats in which these data are supplied? So, satellite has acquired some data, maybe an image or non-image, but everything will be converted to some form of a computer readable file format and then it will be delivered to us.

What are the common remote sensing data formats? Again, I am telling this list is not exhaustive. I am just mentioning 3 of the most commonly used datasets, there can be many different data formats available, but we cannot list and explain all of them, I will just pick 3 of the commonly used data.

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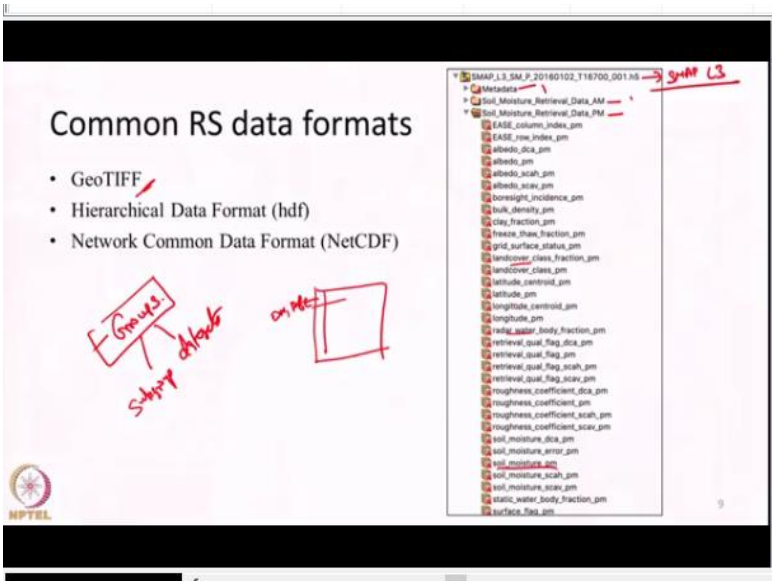

The first one is the GeoTIFF format, the most conventionally used format for images, say when you acquire Landsat image or when you acquire any IRS image normally, you will be getting the image in GeoTIFF format, it is like a photograph of earth. So, which you can visualize and there are special commercial based as well as open source freely available software's to open it are there to open it and visualize it. So, everything is imaged, it will be composed of pixels, each pixel may contain a DN or a reflectance and so on. So, each band will be represented by one one image.

Landsat satellite contains 7 different bands plus a panchromatic band total 8 images. So, each image corresponds to each band. But the only difference between a normal photograph and a GeoTIFF is in a common man language it is the addition of geographical information.

In our normal photograph, it will contain the DN values but here since it is a photograph obtained over earth, each pixel will have its own coordinate information. So, in general for an image you need to provide over which area it is taken, its projection, the datum, students from survey background may know all these things. Essentially, they are all useful for defining the exact location over which the image was acquired. So, those information will be there attached with this. It is a normal TIFF format tagged image file format, but with geographic information, GeoTIFF. It is one of the most widely used format for imaging sensors especially in the optical domain.

Then comes hierarchical data format HDF. So, this HDF is one of the very widely used format for dissemination of data acquired from different satellites, especially sensors like MODIS, VIIRS, SMAP, even some of the Indian sensors nowadays mostly give data in a hierarchical data form, it is a highly structured data format and also helps us to save memory. Normally a GeoTIFF image maybe of enormous size, if you try to download a Landsat image it may be close to 1 GB.

Whereas, level 2 or level 3 product contain several variables, if you store everything in GeoTIFF it will become enormous amount of data. So, HDF provides a simple structured format, where we can store the data. So, one example of HDF data is given in the slide. So, this is taken from SMAP L3 data product.

So, hierarchical data format basically contains groups and within the groups there can be further sub groups or the actual datasets. So, it has 3 groups, metadata is one group, soil moisture retrieval data AM is one group, PMS is one group. So, within this you can have several other datasets or another sub groups and so on. Say for example, land cover class, latitude, longitude, water body fraction, all these things are basically data, soil moisture itself is a data, all these things.

One of the advantage of hierarchical data format is, there are a lot of software's available to open them, but at the same time, it is also easy to process everything using automated computer codes also. We can just open them and there are again different libraries available in various languages, MATLAB, Python, R etc., where we can open them and process them. It is highly amenable to computer processing, we can just extract whatever data we want and without need to open the entire dataset. The next commonly used format is net CDF network common data format.

Similar to HDF 5, fifth version of HDF format, most of the climate related variables are given in net CDF format. So, these are some of the commonly used file formats. And also if you want to program everything with respect to some sort of programming language, again there are specialized packages to open these datasets and use it.

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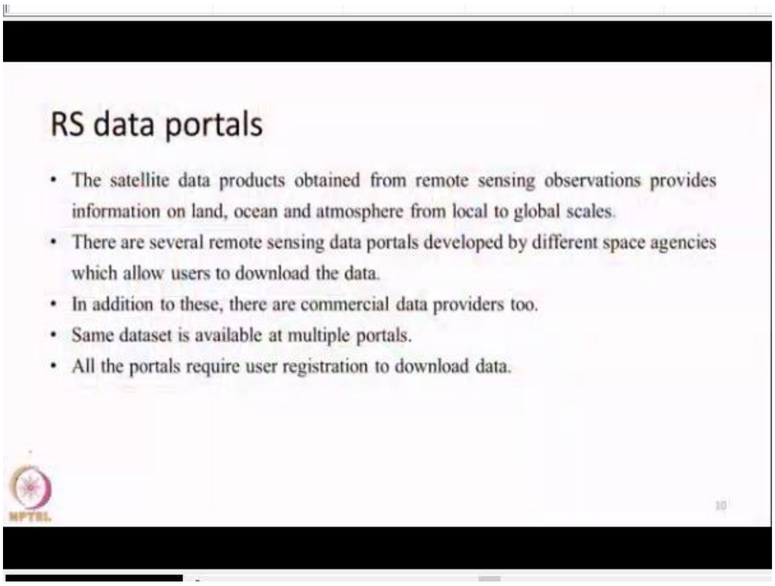

So, this concludes our discussions related to different datasets that are available. Just a very brief discussion with few examples, then we move on to remote sensing data portals, different datasets are available that we now came across, but from where to download all these datasets. So, the places from which these datasets can be searched and downloaded are called data portals.

Again, there are a large number of different portals available. Almost all the portals require the users to register beforehand and they will send us some user ID, password and everything. Once we have access to it, we can search whatever data contained within it and download the data. And the same dataset can be downloaded from different, different portals.

So, each portal is kind of a small gateway, the data will be stored in some server, located somewhere physically. So, it acts as an interface between the data server and you. But through each data portal we can gain access, search the data, for example we may be interested collecting data acquired during the month of October 2020 over Mumbai, I can search such images maybe from Landsat satellite or Indian remotes sensing satellite. So, the data portals will give me capability to search the data. Then I should be able to download it, again that capability should be provided. So, there are different data portals available, we will discuss some of the commonly used.

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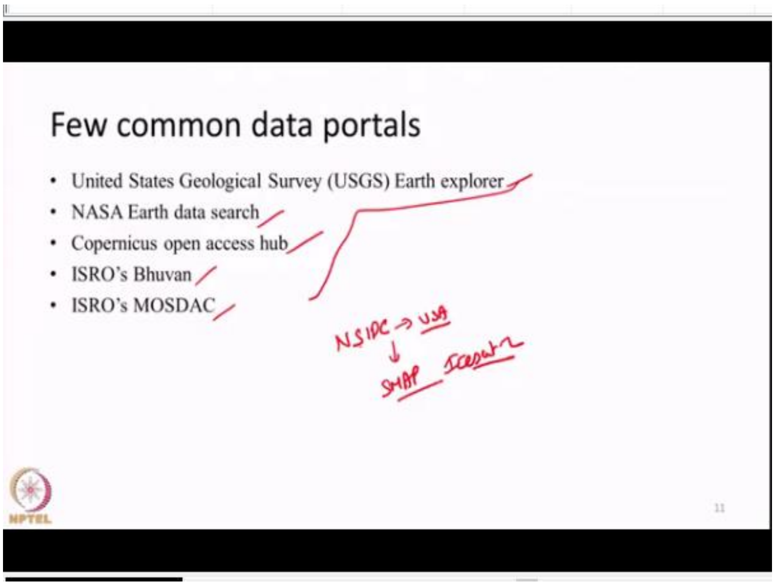

So, these are some of the commonly used data portals, United States Geological Survey, Earth Explorer, NASA Earth data search, Copernicus open access hub, ISRO's Bhuvan and ISRO's MOSDAC. So, these are some of the things we are going to discuss but again there are plenty of other data portals like NSIDC national snow and ice data center located in United States of America, which gives us access to SMAP datasets. ICESat-2 datasets and so on. So, there are plenty of data portals available, but we will restrict our discussions only to these.

So, first thing we are going to see is the USGS Earth Explorer maintained by United States Geological Survey, the web link is earthexplorer.usgs.gov, one of the most popular web portal for searching and downloading publicly available space-borne and other derivative products. Basically, it helps us to query the server, query means specifying the need to get all the data for it.

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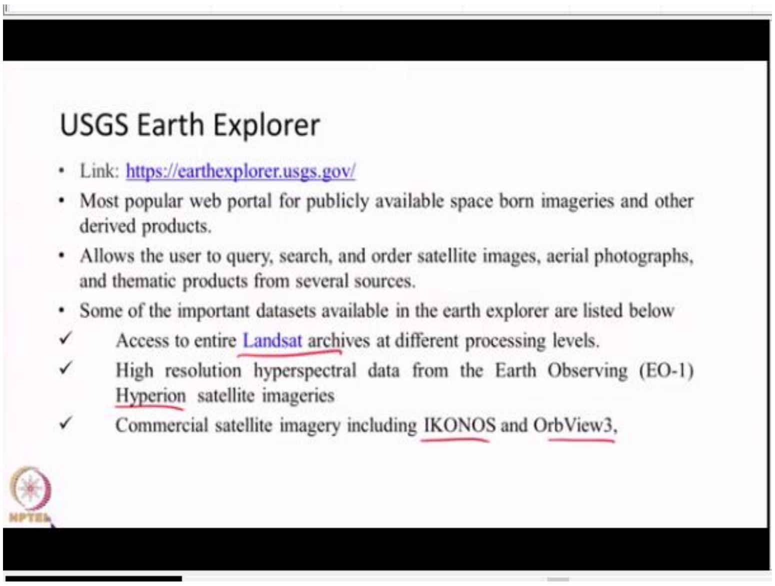

So, we can search for the data; have a look at the data what is called as look images. So, we need not download the data immediately we can just take a look how the data is, especially for imaging sensors, we can take a small look how the data is, then we can download. So, such facilities are available, and not only satellite images, but also thematic products such as land use, land cover maps, elevation information are all available. One of the most commonly downloaded data from this portal is the Landsat series of satellites. Landsat series of satellites are maintained by United States geological survey. So, the data from Landsat satellite are primarily housed here. Apart from Landsat we can also download data from hyperion which is a hyperspectral sensor, even commercial satellite images like IKONOS and OrbView3 are available.

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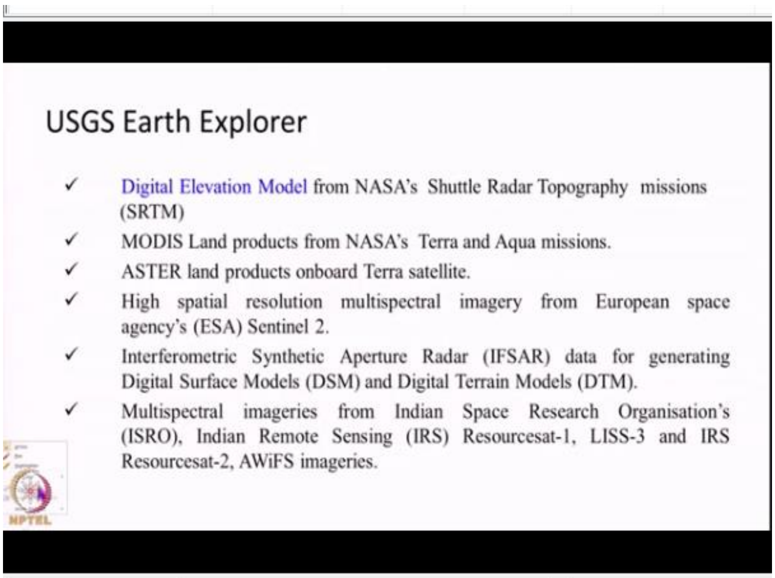

Then apart from satellite images, you can download digital elevation models. We can also even search and download data about MODIS, ASTER, even Indian remote sensing series of satellites resourcesat-1, LISS3 sensor, resourcesat-2, many things are available from this data portal which acts as a gateway to multiple different data.

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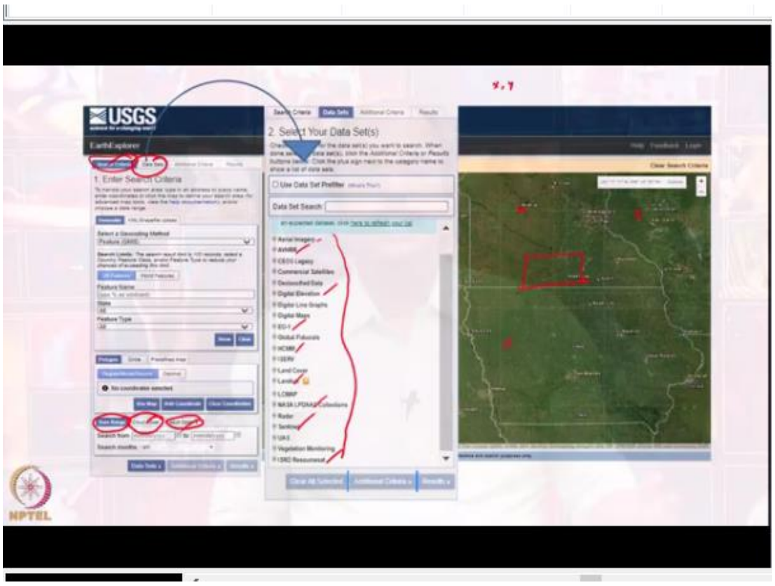

So this is how the portal will look. So, the search criteria, the first tab here, we can just mention whatever feature we need to search, we can either search based on a location or we can draw a small polygon on the map on the right side and we can decide or we can give some coordinates, x, y values. If I give it then it redirects those ground points, display in the map and search data for it. That is possible. We can search the data which range to which range? What fraction of cloud cover I need? Normally for some application, we may require data containing less than 10% of cloud, we can specify that.

Once you go to datasets you can just see how much different varieties of data available, aerial images, AVHRR sensor, digital elevation model, EO-1 satellite, HCMM, one of the oldest thermal mission, Landsat, NASA LPDAAC, which is the MODIS, VIIRS collection, Sentinel, all these things, even ISRO Resourcesat, many different data products are available, we can search them and download them through this data portal. The next important portal is NASA earth data search, the web address is search.earthdata.nasa.gov. If you remember the name of the portals, you can just search them in any of the commonly found search engine and get access to it, you need not even remember the web address, you can just remember, this is USGS earth explorer portal, NASA earth data search.

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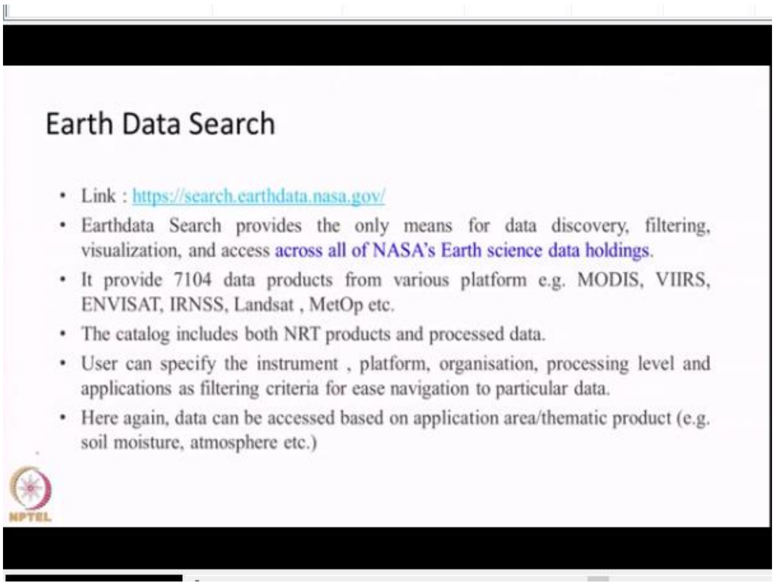

If you remember the name, you can just search using any of the common search engines; you will be able to land up in those portals. So, that is like the beauty, it is so highly used, you need not even remember the web address basically. So, the NASA earth data search portal provides us access to almost all of NASA's earth science data holdings. So, whatever data NASA collects with respect to earth, most of them are available in public domain and almost all of them are available from this particular portal.

Not only satellite images, data from model, ground based experiments, in-situ observations, airborne observations, everything is available in this portal, whatever NASA things it can be publicly given, they give it through this particular portal. Also from this portal you can download near real time data. As soon as a satellite acquires data, we will be getting it. This is highly important for metrological applications or say volcanic observations, fire monitoring, natural hazard monitoring. For all these applications, we need near real time data, that can be downloaded within few hours of data acquisition. Some data may have a small lag time, say 2 to 3 days, 1 month etcetera. So, all different kinds of data are there in this particular portal.

And there are plenty of options, we can specify from which instrument we want, say MODIS sensor itself is available in 2 different satellites Terra and Aqua, whether I want data from Terra MODIS or aqua MODIS, I can specify. VIIRS sensor is available in 2 sensor JPSS and Suomi NPP, we can search it; like this many different satellites are there. Here again not only images, but also thematic products are available. Based on satellite images, based on the theme in which you need the data, we can choose.

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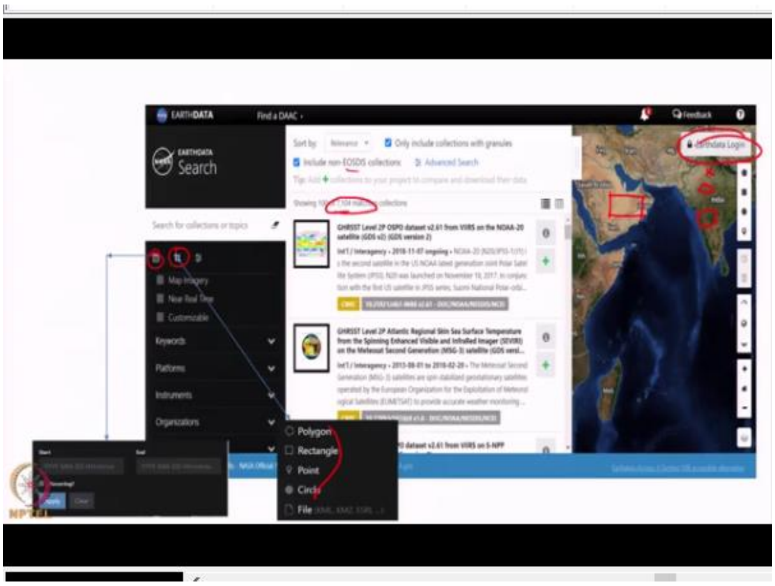

This is the general look of earth data portal website. Here we can choose the date range, location over which you are interested, bounding rectangle or polygon we can draw. So, all these options are available. We need to register before even we search or download a data, we can see earth data login, definitely we should register, get a login and then only we will be able to get access to the datasets.

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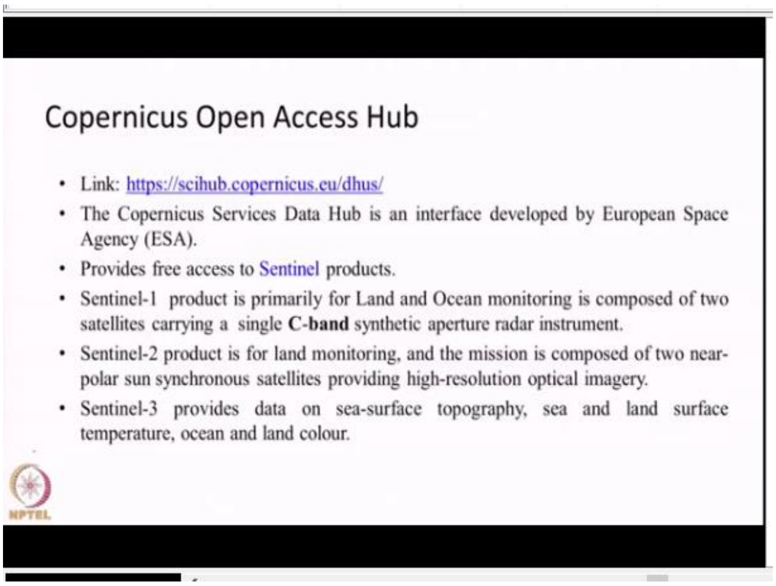

Apart from NASA, the other main space agency that gives publicly available space or remote sensing datasets is the European Space Agency which is the data portal of the Copernicus open access hub. So, the Copernicus data hub is an interface developed by the European Space Agency and it provides free access to Sentinel products.

So, Sentinel-1 SAR data, Sentinel-2 optical data, Sentinel-3 provides sea surface topography, land surface temperature and also its combination of thermal and altimeter data all these things. So, all these data are available from this Copernicus open access hub.

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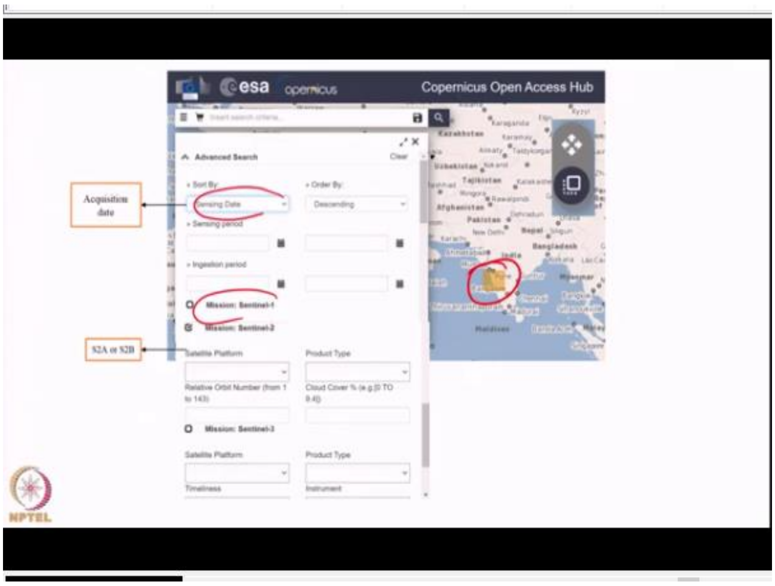

This is how the portal will look we can search by date range, mission, platform, like Sentinel-1 is available Sentinel-1A, 1B, Sentinel-2, two satellites, Sentinel-2A, 2B like this we can search and here we can draw a small bounding box with which we can search the data. So, this is again one of the popularly used data portals for searching and downloading Sentinel datasets.

And among these portals NASA earth data search also provides us a bulk download option. If I need to do a time series analysis. I cannot just keep on click and download button, so many 1000 times to download all the data. It will give us a single text file which will store all the URLs of the datasets; we can do some sort of automated scripts or use downloading software's. If we feed this text file as input to them, the download will happen automatically. So, such kind of facility is also available.

One more commonly used portals ESA’s EO catalog, which is European Space Agency's Earth observation catalog. The website address is given at eocat.esa.int provides search and data download facility to many common satellite datasets like ALOS PALSAR, which is L band SAR data, SMOS, Envisat, SPOT, Landsat, SPOT is again an optical sensor, Landsat data. So, many different types of data are available. This is not very widely used, but still it has enormous potential where we can search and download the data.

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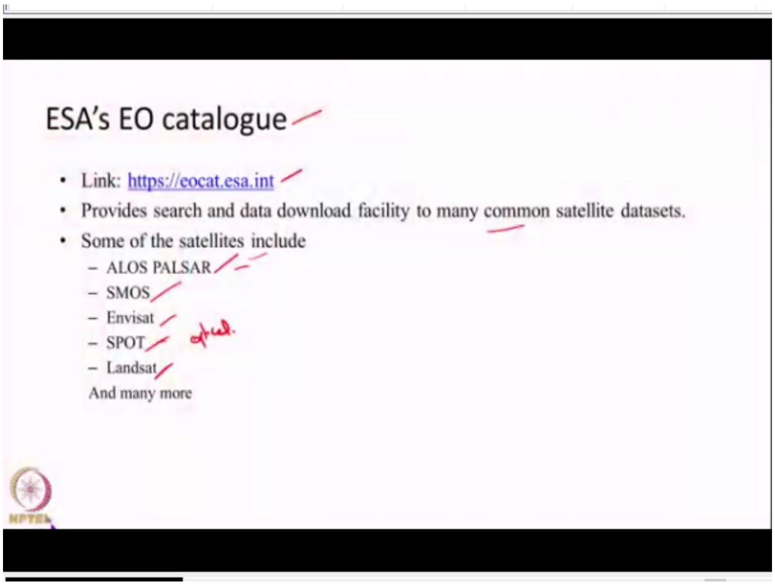

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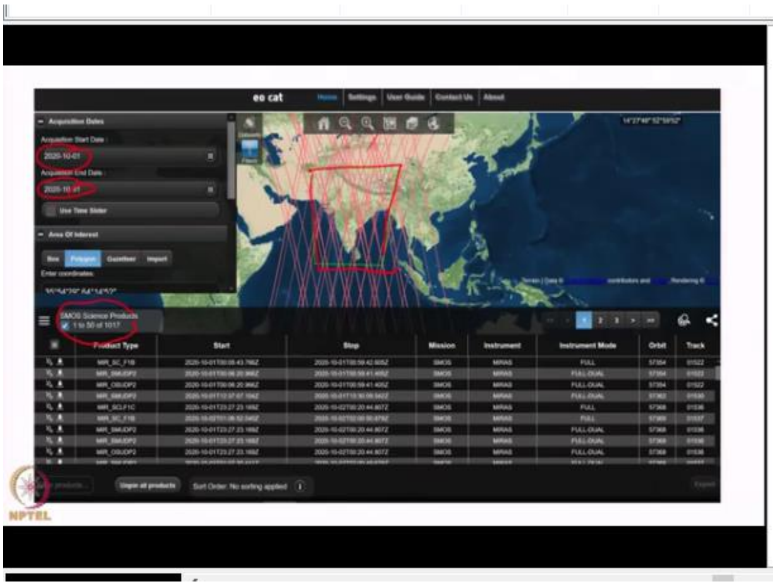

And glimpse of the data portal is given here in this slide. So, this shows the search has been carried out for the SMOS science product for all the data acquired between October 1 to October 31 of 2020, a large bounding box is given covering like the entire Indian subcontinent and these are all the orbits that SMOS had over this particular zone within this particular date range.

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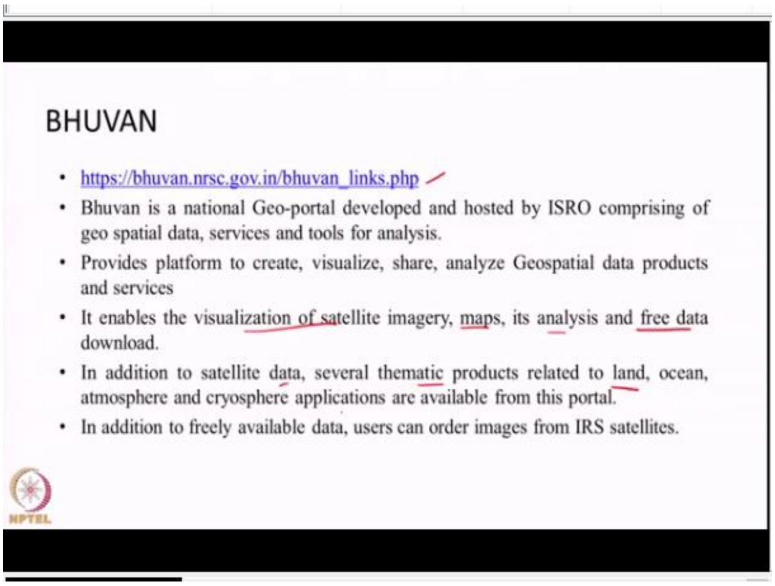

Then we are moving on to data portals developed by ISRO. So, ISRO has Bhuvan and MOSDAC as their primary data portals. Bhuvan is developed by NRSC national remote sensing center of ISRO. The web address is Bhuvan.nrsc.gov.in. So, it provides a platform to visualize, share even analyze geospatial data products, not only we can search the data and download but we can also do some sort of simple geospatial analysis.

So, it also provides us some simple analysis tools. It has a lot of capabilities. Actually ISRO conducts lot of training programs, online webinars, etcetera to educate people about the usage and the huge variety of application for which these portals can be used. So, the Bhuvan enables us to do visualization of satellite imagery, maps, also its analysis and whatever data is publicly available from ISRO we can search and download it. In addition to satellite data, several thematic products led to land, ocean, atmosphere and cryosphere also available from this portal,

In addition to it from NRSC side we can also search for IRS images some of Indian remote sensing satellite images, we have to search for it, order and pay some money to get it. That facility is also available; the links are available within the portal. In Bhuvan portal, users can also use the thematic datasets in the portal and integrate into their systems as OGC Web Services, that is open geospatial consortium web services, whatever data is there, we can use it into our own applications, application in the sense, I may have some software running in my computer, I may not be able to download all the data. But I can just take a link out of it, where my software will work with the data along with my own datasets, combine everything, do an integrated analysis, that is possible with the data available from Bhuvan portal

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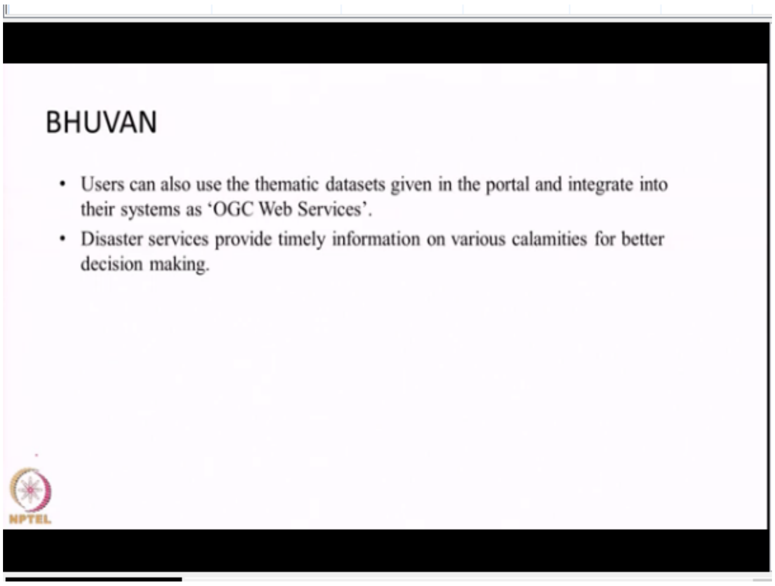

It provides timely information on various calamities, especially natural hazards, heavy rainfall, droughts, all the information will be provided in the Bhuvan portal.

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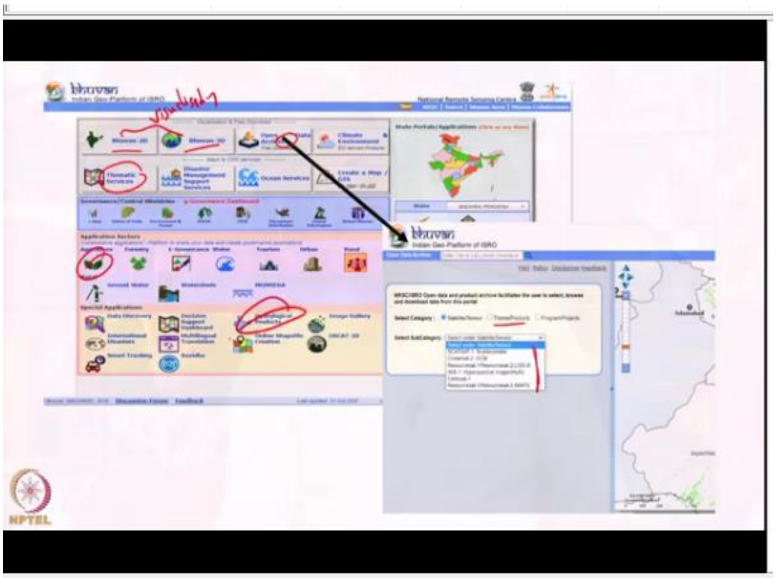

Say this is example of how Bhuvan portal will look. So, this open data archive will take us to some of the freely available datasets, we can choose which satellites sensor we want, which theme or product we want. We can see 2D and 3D portals provides us visualization, we can visualize various datasets, it provides thematic services, it provides data in different application sectors, what is needed for agriculture, what is needed for hydrology, all these things are available within this portal. If the data is not directly available within this, it will also provide us the links from where to get it within the ISRO's domain. So, that is the advantage of Bhuvan portal.

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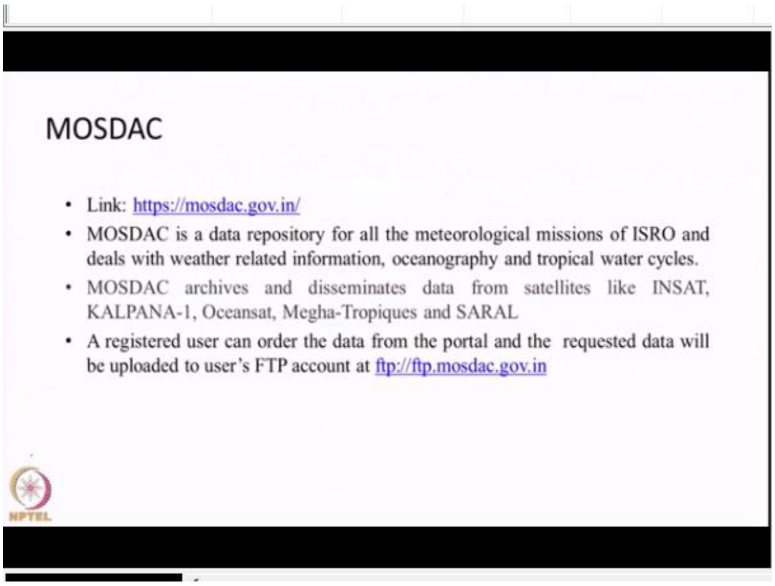

So, the next data portal which you are going to see is the MOSDAC which is the data repository again created by ISRO, but from meteorological missions. It mostly contains data acquired from satellites dealing with meteorological applications, oceanography and tropical water cycles. Say MOSDAC portal archives and disseminates data from satellites such as INSAT, Kalpana-1 which are all geostationary satellites, Oceansat, Megha Tropiques, SARAL, etc,. So, it is for meteorological and oceanographic applications developed by the space application center. The Bhuvan portal was from NRSC national remote sensing center, this one is from space application center, but everything is different arms of ISRO, with definite specialization. Again, we have to register before we can search for the data and download it.

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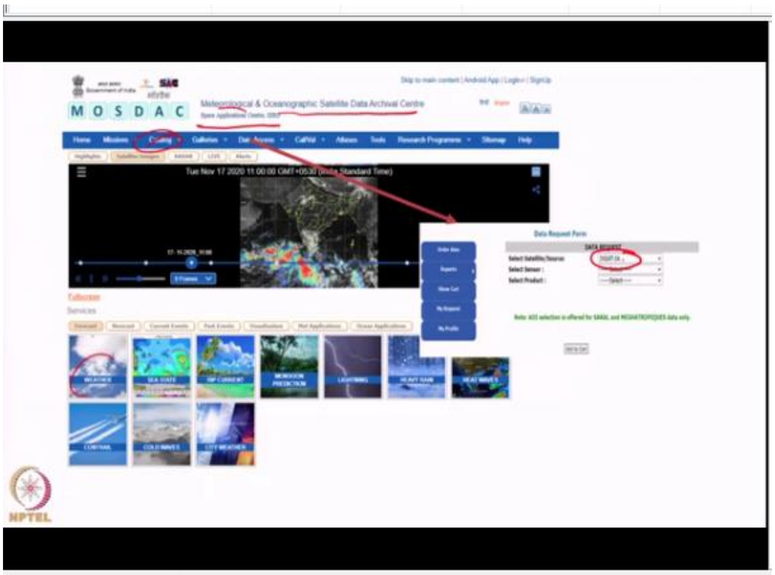

See this is example for the MOSDAC portal. So, here INSAT-3A is one of the geostationary satellites. Similarly, we have Kalpana-1 INSAT 3D, where the data catalog is provided, for different applications you have datasets available. So, MOSDAC stands for metrological and oceanographic satellite data archival centre developed by space application center of ISRO. So, again, even for this particular portal, ISRO has provided online webinars which are available in various platforms, which users can see and get expertise within this data portal. Apart from this, ISRO is also developing a portal called Vedas which provides us some sort of analytical capability. We can do some sort of analysis over the data acquired from different sensors.

So, as a summary in this lecture, we have seen about some of the commonly used data formats and also some of the commonly used data portals. So, the interested students can explore more. And also one dataset can be available from many portals and some datasets can be accessed only from a particular portal. Say INSAT 3D data can be obtained only from the MOSDAC portal, you cannot search it anywhere else, it would not be available. So, it is always better for us now, this is a satellite which I am going to use, from where I can get the data.

If we know this particular knowledge, it will help us whenever we are doing some sort of research activity or a project activity. So, the intellectual students are always welcome and encouraged to explore all these portals and understand what are the capabilities of portal, they are not just data providing portals, they provide data analysis capabilities too. So we are always free to explore that. So, with this we end this particular lecture.

Thank you very much.