Remote Sensing: Principles and Applications
Prof. R. Eswar
Department of Civil Engineering and Interdisciplinary Program in Climate Studies
Indian Institute of Technology Bombay

Lecture-50
Platforms for Remote Sensing Observations-Part-1

Hello everyone, welcome to the next lecture in the course. Today we are going to start a new topic where we are going to discuss about the various platforms that we use for remote sensing observations. Remote sensing basically needs some sensor to collect the energy from our target. so in order to carry those sensors we need certain platforms and the characteristics of those platforms will affect the way we do remote sensing.

So, that is what we are going to discuss starting from today and in the next few lectures. There are plenty of platforms available for performing remote sensing. And in the earliest lectures I told you there is no defined distance between the target and the sensor at which we call the observation as remote. We can even do some sort of measurements standing on the ground but we still do it without in contact with the land surface or whatever the target we need, we can call it as remote sensing, technically speaking.

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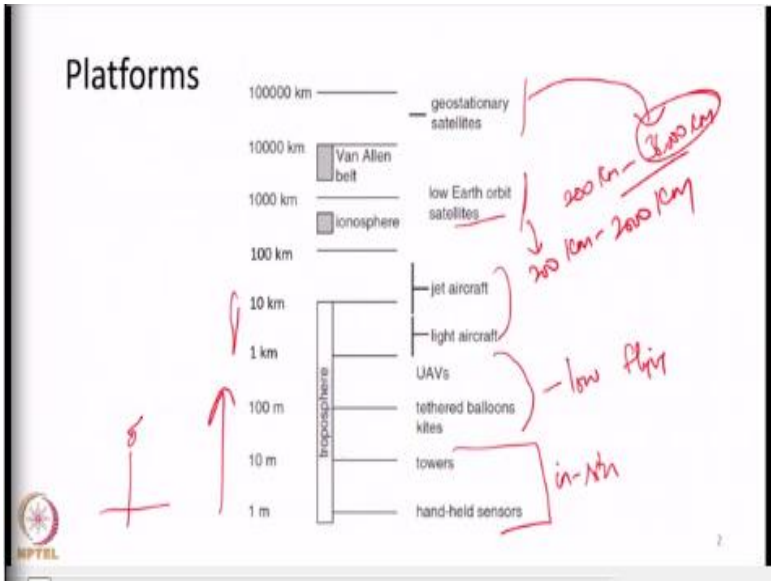

So, the platforms which we do to collect data or the platforms which we use to collect data can be classified into several kinds like ground based or in-situ platforms, aerial platforms or low attitude which is just fly short distance up in the sky or space-borne platforms. Like a few examples given in this particular slide. Here you can see if this is the target then the sensor can be placed anywhere in the distance ranging from 1 meter to whatever height at which we place the platform. So, the towers and handheld sensors are basically in-situ platforms or ground based platforms. Then we can have categories lilke UAV's, tethered balloons which are low flying platforms.

They are airborne but still they fly pretty close to the ground, then we have aircraft which can fly at a slightly higher altitude in the range of few kilometers. Then we have satellite whose altitude range is somewhere between 200 kilometers to 36,000 kilometer for earth observation. But we can place satellites at a very far distance also, like low earth orbit satellites and then geostationary satellites. Low orbit satellites are in the range of 200 kilometers to 2000 kilometers. Geostationary satellites are orbiting around 36000 kilometers away from the earth. So, this slide basically tells us the distance from the target at which we collect the data can vary very widely. And each platform has its own application in remote sensing. So, the first category of platform that we are going to discuss is the ground-based platform or in-situ observations. Ground based platforms in general means, whatever sensor we carry we keep it close to the ground.

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For example here, in this particular slide we have a person collecting data above the field with a handheld instrument. So, this handheld instrument is called spectroradiometer which is useful to collect spectral reflectance curve of the land surface objects. So, this is basically the sensor it has a computer here, it has a backpack here which contains the actual control unit and everything. So, it will observe earth or whatever the target source within a small solid angle similar to how a satellite based sensor observes. And we can use this as reference for our various applications, so this is an example for an handheld sensor.

Similarly we can mount some sensors in trucks and these are some example for it. There are plenty of sensors fixed within those boxes, they are mounted to trucks and they are used to collect data. They also subtend a small solid angle on the earth surface, collect the reflected energy or the immediate energy from the earth surface. Similarly we can place such sensors mounted on towers, it is also possible. It can be a semi permanent installation, for a few months or few years it can be there. So, the platforms for in-situ sensors actually vary or can come in different, different form. Human itself is a platform like the scientist given in this particular slide carries a sensor in her own hand. So, it is like a human being herself is acting like a platform. Similarly we can use trucks as platforms, we can use towers as platform and so on.

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Say again another example is given in this particular slide. So, here we have two persons who developed a movable truck which can move basically and it has array of sensors. It has a thermal infrared radiometers, a spectrometer, NDVI sensor, web camera, GPS receiver, weather monitoring sensors and all those things.

So, they use this for an integrated agricultural applications. So, these are the different ways in which we can collect data standing on the ground itself. This is also an example for remote sensing, technically speaking, we are not in contact with the earth surface from which you are collecting the data. Say we are having a thermal sensor at a certain distance and so the working principle of those sensors are remote. It absorbs the emission from the ground surface remotely whatever is coming within the solid angle and we can use it to estimate the land surface temperature. So, all these kind of platforms which we use for collecting data, standing on the ground, we call it as ground based platforms.

So, the ground based platform is essentially necessary for several things, one is calibration and validation of data from other sources. When I discussed about radiometric properties of optical sensors I told we need to do radiometric calibration. That is relationship between the DN recorded in the sensor with the actual radiance that is coming in from the ground. So, for those sorts of calibration exercises we need reference data which has to be collected from the ground. Because when we collect data standing close to the ground, we are effectively removing the effect of atmosphere**,** so that is one way.

Similarly for validation purposes, some variable we might have calculated from satellite based data, we may need to validate it. For such activities ground based observations are mandatory. For almost all satellite missions people will do a calibration and validation exercises, where they will collect ground data at the same time of satellite overpass or aerial flying and use it for validating the satellite based or aircraft based observation. Ground based observations can also be used for proof of concept testing of new sensors. Whenever a new kind of sensor for remote sensing is proposed it will not be directly put into a satellite and sent to orbit. First such sensors will be tested using ground based platforms.

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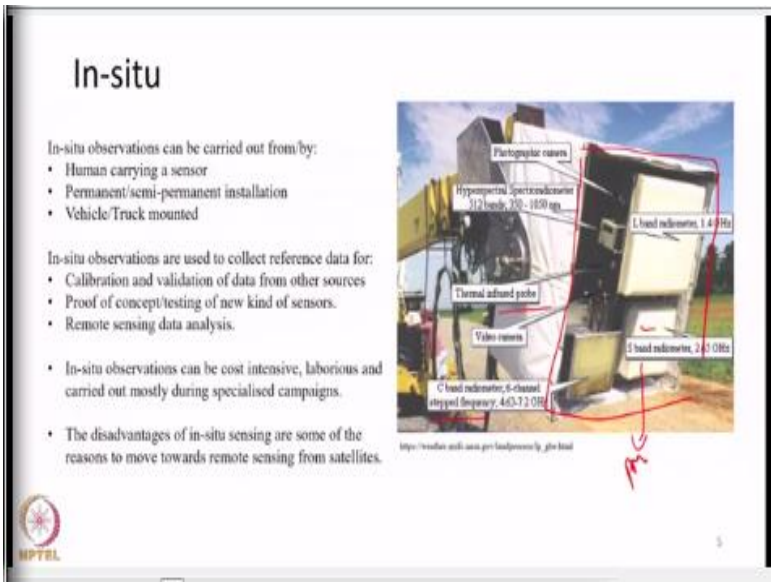

Say for example here you can see in this particular slide, behind this particular mount inside the truck has several sensors. It has an S band radiometer, a passive microwave radiometer, L band passive microwave radiometer, a hyperspectral spectroradiometer, a thermal infrared probe, a C band radiometer and so on. So, basically if some new kind of sensor has to be tested, first they will test it using ground measurements. Then it will move to aerial platform then only it will be sent to space in a satellite. So, for testing some sensors, ground based platforms will be useful.

If someone designs a sensor, first people will mount it on in-situ platforms either on a tower or on a truck, they will collect data from the ground, they will try to analyze it in conjunction with other variables say crop variables or land surface variables. Then they will understand the new sensor is pretty much useful in a particular manner. So, for that sort of proof of concept testing, in-situ observations will be useful. And then in remote sensing data analysis, the spectral reflectance curve can be used as a reference and we can match our satellite observed spectral reflectance curve and assure that the particular pixel in a satellite gives a spectral reflectance curve similar to vegetation. So, the pixel there may contain vegetation, for this sort of image analysis to understand what is contained in an image, the reference data can be useful. And for collecting such reference data a ground based platforms can be used.

So, as I said before the ground based data can be collected in many different ways. But ground based platforms comes with its own limitations, they are, it needs extreme or careful planning like what data to collect, in which mode we have to collect? All this kind of planning should go on, it is laborious, we need people physically visiting the field to collect the data. It is cost intensive, it needs lot of money to conduct ground campaigns. So, it is expensive, it is laborious, lot of people should spend enormous amount of time in the field, preparing the field, preparing the ground based sensors, going to field, travel involved and after data collection, processing, all those things takes enormous amount of time.

Actually in order to overcome the disadvantages of the in-situ observations remote sensing has gained so much attention. We cannot do in-situ observations all across the globe, it is next to impossible I will say, if not perfectly impossible. Because we observe hundreds, if not thousands of variables related to this earth system and if you want to monitor everything sitting from the ground it is going to be extremely difficult if not impossible.

We cannot conduct ground based campaigns for everything, but without ground based observations remote sensing from space does not exist which means it will not be of much use, we need always some sort of ground based data collection to advance or to support remote sensing activities from space. So, in-situ observations are in indeed needed, without that remote sensing is not going to be as effective.

Here remote sensing I mean, remote sensing from space, it is not going to be as effective. But at the same time in-situ observations alone cannot help us to collect various data we need over different places across the globe**.** Now we move on to discussing about the low attitude aerial platforms. So, what are low attitude aerial platforms? They are those platforms which will carry the sensor to a small amount of height, say hundreds of meters or less than a kilometer basically from the earth surface.

Or utmost can be tens of kilometers utmost, I will say. In the olden days people were using hot air balloons or motorized balloons called blimps or in very olden days people were using very large

kites to carry photo cameras. They will fly it in space and observe various parts on earth or even pigeons attached with some sort of camera fitted to it is body.

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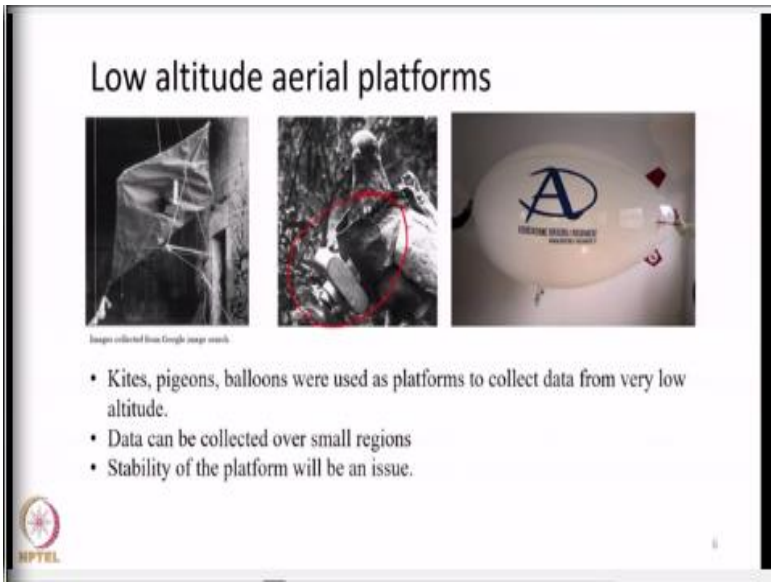

Since pigeon has a very good directional capacity, we can ask it to go to one particular place and come back, if the photograph can be taken automatically by the camera then the pigeon has to just fly and come back. So, we can take the photographs and use it for reconnaissance purposes.

So, mostly this kind of aerial platforms developed in olden days for mainly military applications. Especially they grew or they got so much attention during world war, even before the invent of aircraft, like world war I, where the aircraft technology was still at its nascent stage, they were useful. Even before world war, people were using this sort of reconnaissance mechanisms, so they were used in much olden days.

Now in recent decades like last one decade or so, unmanned aerial vehicles has gained tremendous attention and that particular field has grown leaps and bounds. So, UAVs or in short can come in many different forms. A few examples are given in this particular slide; you can see UAVs comes in different, different forms, they come with different capabilities and so on. So, these sorts of UAVs can fly even very close to the earth surface or in altitude of few tens of kilometers, some military grade autonomous UAVs can fly at a very high altitude for reconnaissance purposes. So, these UAVs can carry multiple sensors, they can fly whenever we want etcetera.

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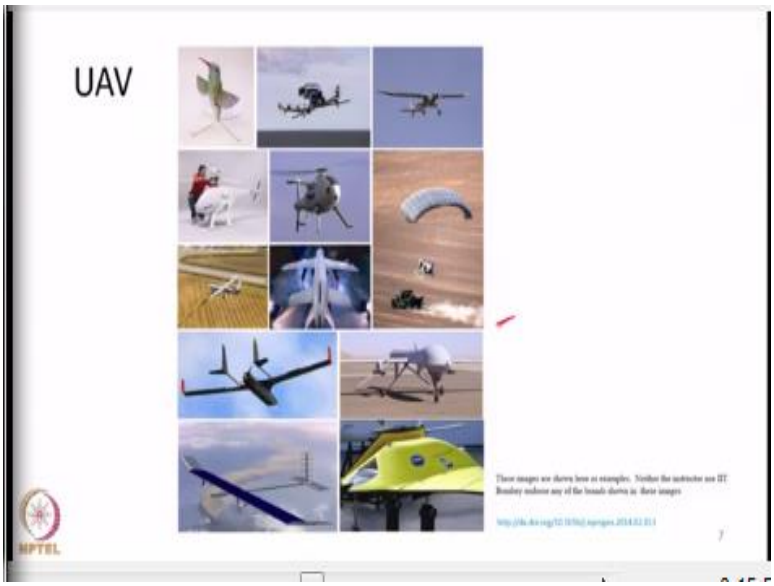

So, this kind of UAVs have also gained lot of attention, and in recent decades people are using it for anything, we might have even seen it in our friends or relatives wedding. Starting from simple photography to various remote sensing applications, we can use UAV. And UAVs are kind of one of the most widely used low altitude aerial platforms.

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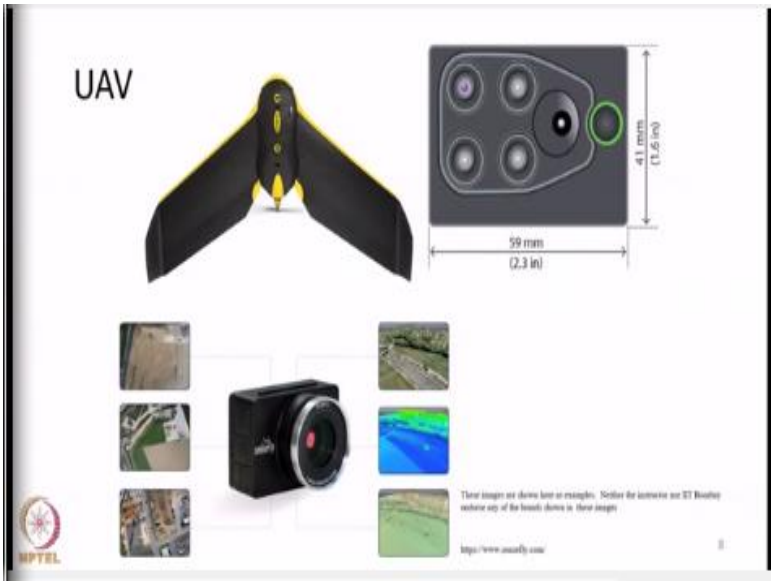

Then comes aircraft, which can be classified as aerial platform, which is capable of flying at certain amount of height. It can fly above UAVs or whatever like pigeons, kites, balloons etcetera. After the development of this aircraft technology, immediately it came to use for remote sensing observations, especially for military needs.

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During World War II aircrafts are used extremely for military reconnaissance applications. So, even from that day and even now aircraft plays the major role. Whenever a new sensor is going to be developed, people will always conduct ground based campaigns and aerial campaigns. Aerial campaigns means a prototype of a sensor which has to be sent to space will be mounted in an aircraft, it will be flown at different places across the globe and then people at the same time will collect ground based data. So, the sensor characteristics will be studied in detail from the aircraft first, before moving to a satellite, that is one thing. So, aircraft is again widely used even before a sensor is launched.

We now just got briefly introduced to different kind of low attitude platforms, starting from kites, pigeons, balloons, UAVs and aircrafts. So, now it is time for the students to think, please pause the video for a second and then compare these different lower aerial platforms and analyze it in terms of cost, spatial coverage, what are it is advantages, platform stability, accuracy of output products, anything, so please pause this, think in detail about such aerial platforms. And then you can re-watch the video for further discussions**.** Now hope you all like had a chance to think about these platforms, we will discuss these platforms and compare them with each other.

The major advantage of aerial platforms is, we will be able to collect data whenever we need, that is a major thing. Say for example, in satellite we will not be sure whether the space-borne satellite

will be collecting data at a place at a given time, satellites are defined by its own orbit which we will see later. We have to wait till a satellite comes to our place, similarly ground based platforms also may take sometime, we have to plan and go to field. Say if you want to collect data over a big district then ground data collection may take weeks together. But aerial platforms are relatively faster than ground based platforms, so data collection can happen quickly compared to in-situ observations.

We can collect data whenever we need. If there is flood in a given state, we can use airborne sensors to collect data over the field even if satellite is not there. If something happens during night time, when satellites are not overhead, immediately one can fly an aircraft if it is available with government agencies. So, in all these, anytime operation is the major advantage of aerial platforms. But if we compare the different kinds of aerial platforms what we can understand? The first thing is we will discuss in terms of cost, like the kites, balloons, pigeons they are very rudimentary which are used by olden days people. In fact balloons are still being used, but still they are somewhat relatively older technology, cost wise they are less expensive.

So, kites, pigeons, balloons, UAVs and aircraft, three different aerial platforms I am discussing. So, the kites, balloons they are relatively low cost. The major cost will be towards the sensor other things will be cheap. Then if you come to UAV, it is slightly expensive, say if you talk in Indian context the UAV will be costing in terms of few lakhs even a basic model. Even when you use UAVs that are being used for photography in weddings, they even cost few lakh of rupees. And if you want a real good survey grade UAVs, they cost few tens of lakhs and really advanced UAVs they may even cost in cores of rupees, so UAVs are expensive. Similarly, the sensors that comes with UAV are again expensive and also nowadays most UAVs comes bundled with its sensor. There are different, different manufacturers for UAVs and they develop their own sensors.

And normally a sensor from one manufacturer may not fit in the UAV for sensor from another manufacturer. So, that sort of interoperability is still not there, we have to purchase a particular UAV brand then we may have to go to the sensors from that particular brand actually. The interoperability of sensors is still not there, so it is expensive. Further maintaining an aircraft, we may not do, we may have to hire an aircraft, the rent itself may be extremely costly. And also we

need extreme amount of training. Even for UAV you need a minimal training. But for piloting an aircraft, operating a sensor sitting within aircraft they have lot of technical complexities. Starting from these balloons to UAVs to aircraft, cost will increase in that order, similarly complexity also will increase in that particular order.

Then we will talk about the spatial coverage of this. So, normally balloons, kites etcetera, they are used to collect data over a small region, maybe a single village or so. Those platforms we cannot rely to collect data overall like a large region even like 2, 3 streets they may cover, thats it, very small amount of area. UAVs can be used in terms of like square kilometers**.** Some UAVs are capable of flying even for tens of kilometers, but whatever we have access to, normally what we use for our typical day to day applications for remote sensing activities. They can fly for certain distances and maybe a few square kilometers of area we can cover in one shot. Aircraft have a really good spatial coverage, they can fly hundreds, even thousands of kilometers. If properly planned, they can cover a very large region in a short amount of time, so that is the spatial coverage.

And also time wise aircraft can give you really quick coverage over a large area. Only thing is aircraft needs a perfect landing and takeoff facility, whereas UAVs may not need it. Some UAVs can take off and land from anywhere**.** So, spatial coverage is extremely good in aircraft, good in UAVs and pretty much low in balloons or kites. Any of the aerial platforms can be carried out for anytime operation. Then comes the important thing the platform stability. So, normally balloons or UAVs they are highly affected by wind or other disturbing factors that may change the platform stability and change its attitude. Say you are flying a balloon attached with some sensors. If a sudden gust of wind blows the balloon may deviate from its path, same thing may happen with the UAV also.

If a UAV is flying suddenly its attitude may change, it may give a small roll, it may pitch, it may yaw, whatever can happen affecting the platform stability. Once the platform stability is affected then the image we collected may not be as good enough, it may not satisfy the specifications that we need. But aircraft provides a really stable platform, among these thing aircraft is the best platform to achieve stability. Because it can fly well over any sort of disturbances, like wind gust and everything. So typically it will be more stable when you compare with other things. Ultimately

the platform stability will affect the accuracy of the output products. Say normally nowadays when we do air based or airborne data collection, definitely we need the coordinates of the aircraft or the platform to be collected every day.

Like normally people who are used to UAV technologies will know this almost. All the survey grade UAVs comes with a GPS receiver, it will be collecting data from GPS satellites continuously. That is to improve the accuracy, unless we know the position of the aircraft, it will be impossible for us to geo reference the image. Same thing applies with aircraft and also to satellites; we need to know that it is positioned perfectly. So, the position of the aircraft plus the attitude of the aircraft whether it is perfectly straight or if it is tilted in some direction, we call it as attitude. So, that attitude of the platform plus its position will ultimately determine the final accuracy of our remote sensing product, the geometric accuracy. Say if you are collecting data over a particular region, your image should perfectly tell the coordinate of that region**.** So, that is what we call as geometric accuracy.

The image should not be distorted, if there is a circular feature on the ground it should appear like a circle in the image, all these things relate to geometric accuracy concepts. So, aircraft gives you the highest you can achieve and very high geometric accuracy. Even from UAVs if the operations are performed in a extremely careful and planned manner with lot of ground based GPS stations, we can achieve very good accuracy. But with balloon we will always have to sacrifice accuracy to certain extent.

So, as a summary in this class we just got introduced to what a platform is, platform is like a tool or a medium to carry a remote sensing sensor. And platforms can be of many types ground based, air based and space based. So, in this class we got introduced to ground based platforms and aerial platforms. And we discussed different class of aerial platforms; with this we end this particular lecture.

Thank you very much.