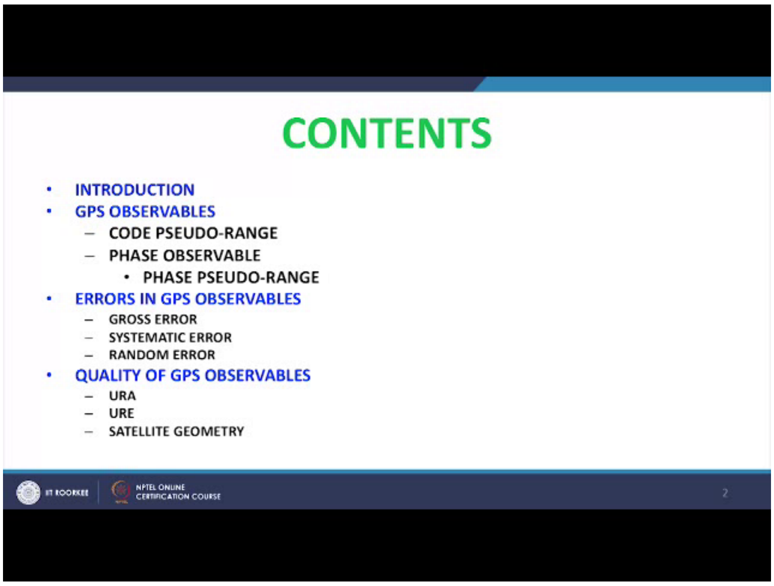
GPS Surveying
Dr. Jayanta Kumar Ghosh
Department of Civil Engineering
Indian Institute of Technology, Roorkee

Lecture – 09
GPS Observables (Types, Errors and Quality)

Welcome friends this is the 9th class on GPS surveying. Today I am going to discuss on GPS observables. As I told you in the last class that GPS observables are required to get the ranging information of the satellites from the receiver. So, this is the most important parameter required to determine the position of a receiver.

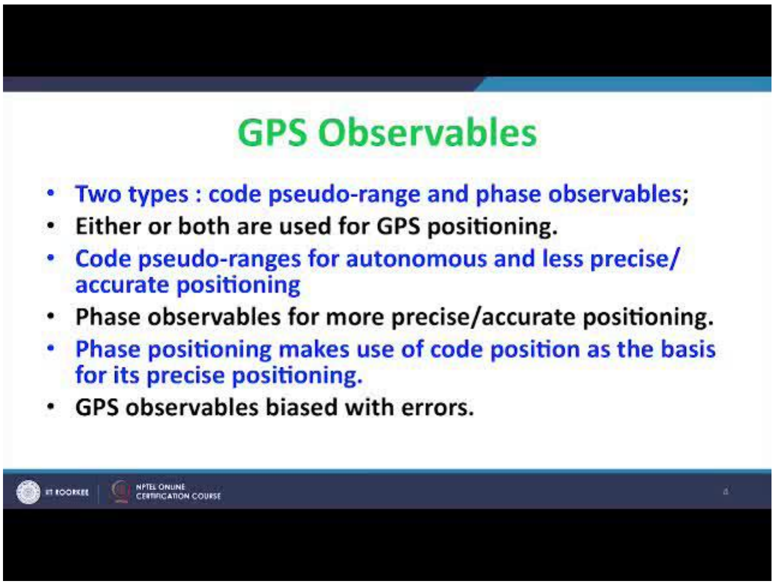
Now, these reservables are sometimes associated with also some errors. So, today's class I am going to discuss on, in the beginning I will like to discuss on GPS observables its types and then the errors that the GPS observables carry with.

(Refer Slide Time: 01:13)



And finally, because the quality of the GPS surveying will depend upon the quality of GPS observables, we need to test the quality of GPS observables. So, I will like to discuss on it using three parameters URA means user range accuracy, user range errors and satellite geometry.

(Refer Slide Time: 02:19)

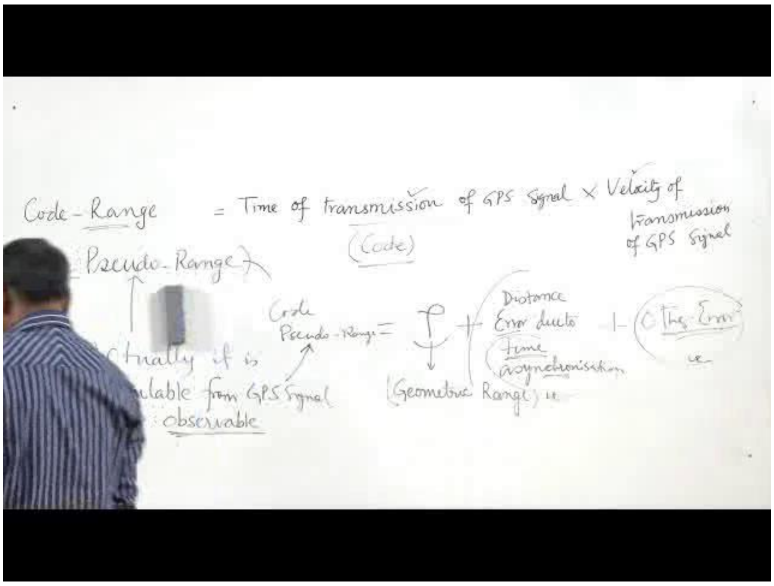


Now, what is GPS observable or GPS observables are the parameters which are available from GPS signal, and basically these are the parameters that is we get from GPS signal and there are two types of GPS observables that we are interested specifically for GPS positioning that is code pseudo range and phase observable. Now these two observables are based on from which part of the signal they are being derived from, like as the name itself says that the code pseudo range are the range of satellites from GPS satellite to GPS receiver that is find out from code information of the signal and phase observable is from the phase of the signal.

Now, this either the code pseudo range or code pseudo range followed by phase range these two are made used to find out the GPS position. Now, the code pseudo range is always the fast parameter which is used to find out the position of a GPS receiver and that is quite approximate then that is the first thing we need to determine and subsequently for precise estimation of position we need to go for making use of phase observables. However, since these observables are we received or we get from GPS signal and GPS signal measurement and the measurements are always associated or with errors. So, these observables are also having some errors which we need to know in details so that those errors can be removed are from the observables and we may end up with more accurate or precise position.

Now, let me discuss on code pseudo range. As the name itself tells code pseudo range is determined by measuring the time of transmission from satellite to receiver from the code information available in the signal and the velocity of transmission of the signal from satellite to receiver.

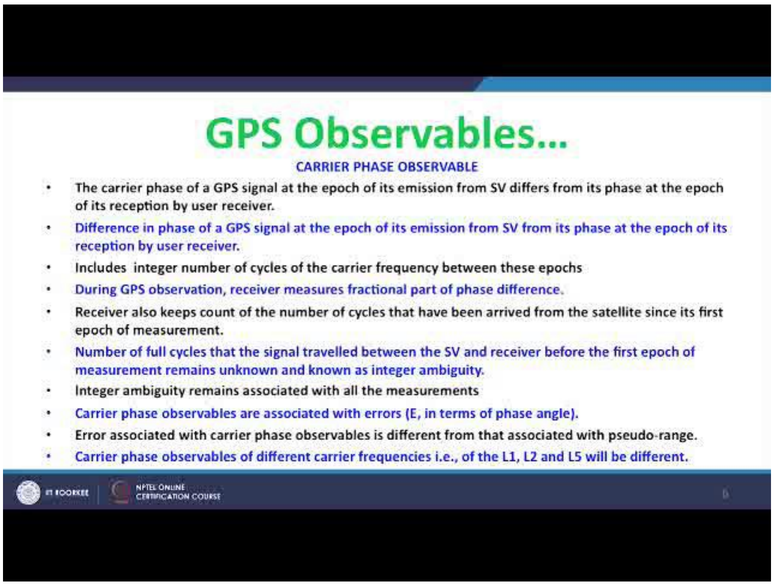
(Refer Slide Time: 04:24)



So, it is the time of transmission of GPS signal multiplied by the velocity of transmission of GPS signal. Now this provides us the range, now when the time of transmission of the GPS signal is measured from code part of the GPS signal then it is the code range and also this, you can see this; that means, there are two parameters we need which is involved in range competition. So, this measurement of these parameters involved some errors and also the there is a lack in synchronization between the satellite clock and receiver clock. So, primarily due to this and due to other factors there will be large errors. So, the range which we will get really from the GPS observable that is called not the actual range, but the pseudo range.

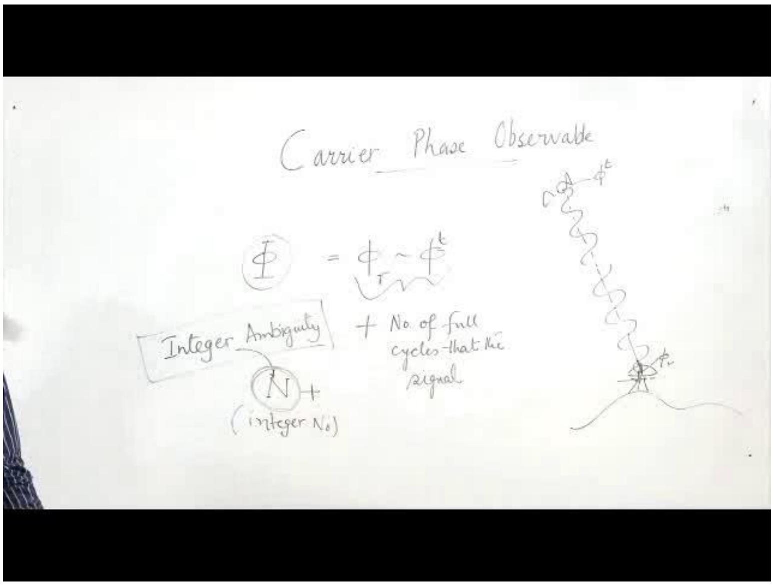
So, it is measured from using code. So, code pseudo range this is actually this is available with us, available from GPS signal as observable. So, in subsequently we need to process these observables to find out the actual range. So, actually code pseudo range is equal to geometric range plus. So, code pseudo range that we get from GPS signal this is the geometric range; that means actual range plus the error due to time synchronization plus other error. So, this is what is our GPS code observable, this will consist of these three parts so we need to know these errors and we have to remove this thing and after removing this thing we have to determine this time synchronization error and once we know this thing then from this and this we will be able to find out the position correctly, this is the idea.

(Refer Slide Time: 09:01)



Next observable the other type of observable is Carrier Phase Observable.

(Refer Slide Time: 09:08)

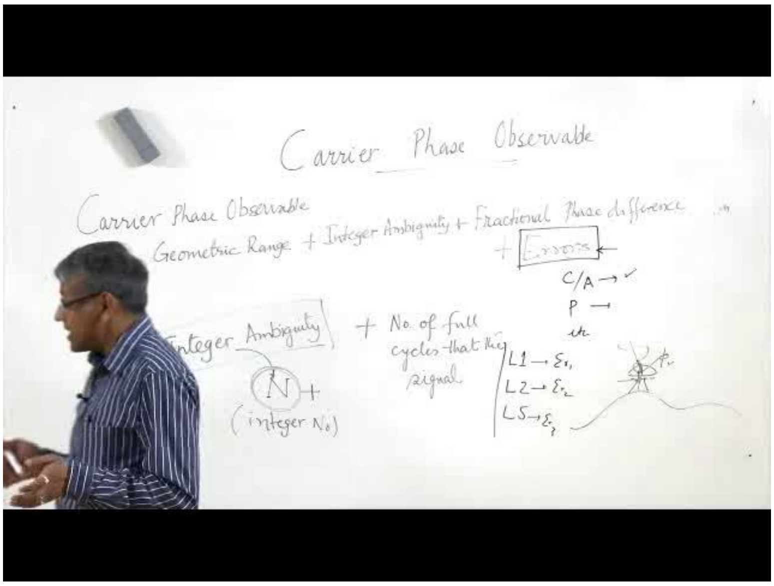


Basically career phase observable is the difference in phase between the signal that is transmitted by the satellite and at the instant of its transmission and the instant of its reception at the receiver. So, we will find that there is a phase at the time of transmission say phi t and and there is a phase suppose at the time of reception. So, the difference between these two is what is carrier phase, but this also includes plus number of full cycles that the signal travels during transmission to reception.

So, if we see like this is suppose satellite and this is the receiver. So, what is there, we can see that is a phase transmission and the phase reception, but in between these two phase there will be suppose this is the; now I can see here that is a difference between the transmission and reception, but apart from that there will be full numbers of cycles. So, like that there will be full numbers of cycles. So, the carrier phase of them will fundamentally consists of the difference in phase between the transmitted between of the signal at that instant of transmission and that at the time of reception plus full numbers of cycles.

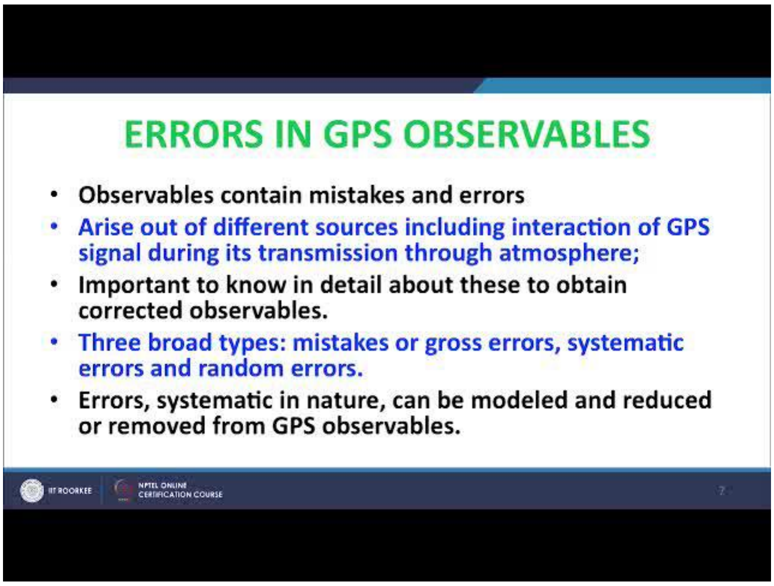
Now, for these actually GPS receiver counts the actually measures the phase at the time of transmission as well as at the time of reception, as well as it keeps the counts the full number cycle that it transmit that it receives between two consecutive epoch. But, the receiver will not be able to register the full number of cycle that the signal has struggled before the first epoch of observation. So, always there will be a number, an integer number n which will be associated with the carrier phase measurement observable which is not known for the user and that is known as integer ambiguity. So, in case of phase measurement there is another parameter which is coming which is not known and apart. So, we may end up with a relation like this carrier phase observable will be equal to a geometric range plus integer ambiguity plus fractional phase difference plus errors.

(Refer Slide Time: 13:34)



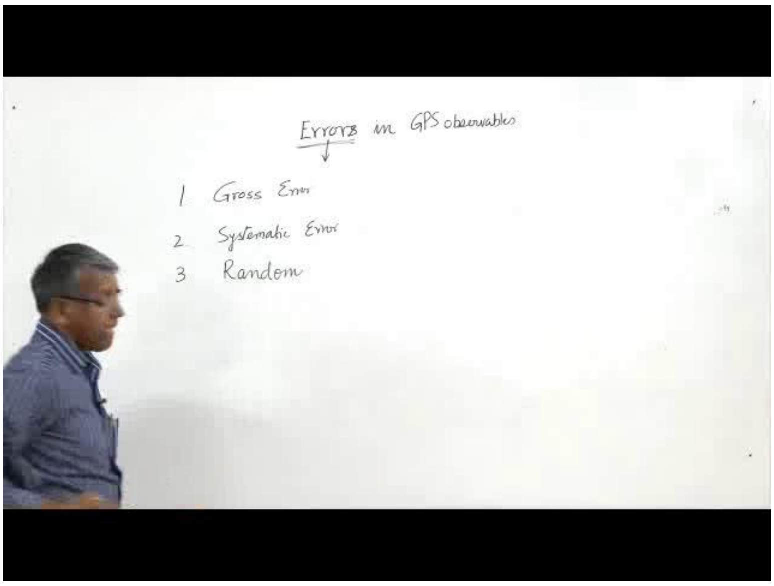
Now, though we have find that the errors are present both in case of pseudo range measurements as well as carrier phase observable, but the amount of errors in carrier phase observable will be different from that available in pseudo range that is one thing has to be mentioned or to be marked. That the amounts of error that will be available along with the observables are different for different types of code as well as different for different types of carrier, as we know we have different types of code like c a code p code etcetera, so the errors will be different in this case. Similarly we have L1 L2 L5 carrier frequency for them also errors will be error 1, error 2, error 3, something like that. So, we can we see that the both the observables are fought with errors and since the GPS position will depend on the GPS observables. So, these observables should be free from those errors otherwise our position determination from those observables will also be associated with some errors.

(Refer Slide Time: 16:11)



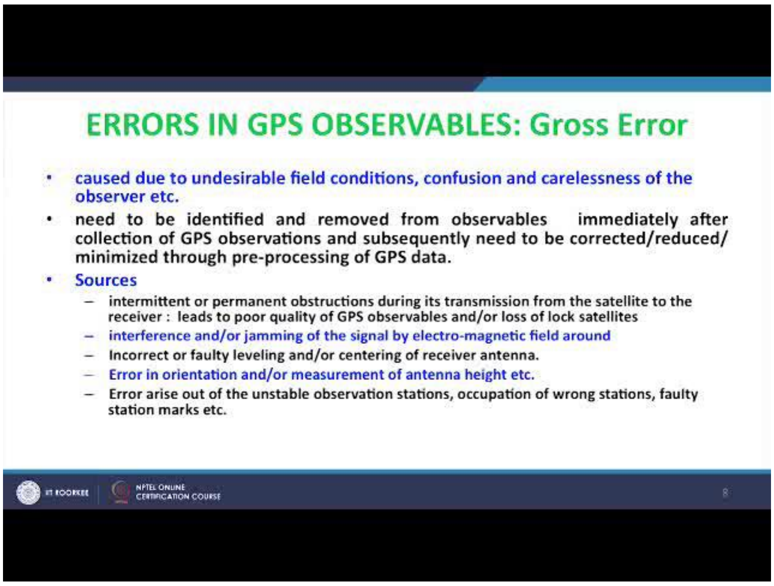
So, I will now discuss about errors, Errors in GPS observable.

(Refer Slide Time: 16:19)



The errors in GPS observables arises out of different sources, different reasons. However, from the nature of the errors we do classify the errors under three categories - number one, cross error; number two, systematic error and number three, random error. Now, gross errors are the errors or sometimes we say as mistakes that are caused due to undesirable condition as well as it depends also on persons who is taking the GPS data, or also maybe due to some other reasons which is not seen to the observer.

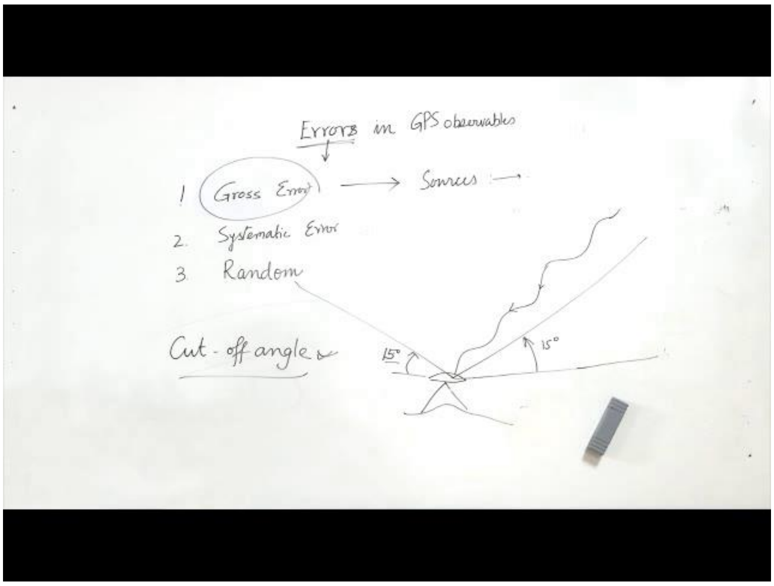
(Refer Slide Time: 17:03)



However, these errors need to be removed immediately after collection of GPS data. So, of course, before we move in we need to identify whether our data is associated with gross error or not and if the data is associated with gross error then we have to relate those errors.

Now, what are the sources of gross errors? The most important and widely prevalent gross error is due to the physical obstruction of the signal as it is received from supply.

(Refer Slide Time: 18:06)



Because many times we will see that our signal may not get clear sky, they may be interrupted by some trees or there may be some birds which are flying, so the signal may be disturbed by them or there may be some aeroplanes, or may be other way how it can be there. That means, physical obstruction of signal during its transmission from satellite to receiver due to that there may be some gross error.

Another important source is that interference of the signal because GPS signal is electromagnetic in nature and there may be some electromagnetic field in the field like transformer there may be high tension line or there may be (Refer Time: 19:10) activity in the atmosphere. So, all those may get some interference in the GPS signal which may lead to some gross error. Apart from that the observer may not take care to set up the instrument exactly on the station or it may not be levelled properly or the measurement like height of the instrument measurements all those things may not be taken properly. Sometimes there may be instability in the station occupation. So, all these causes gross errors in the data. So, the how we can minimize or remove?

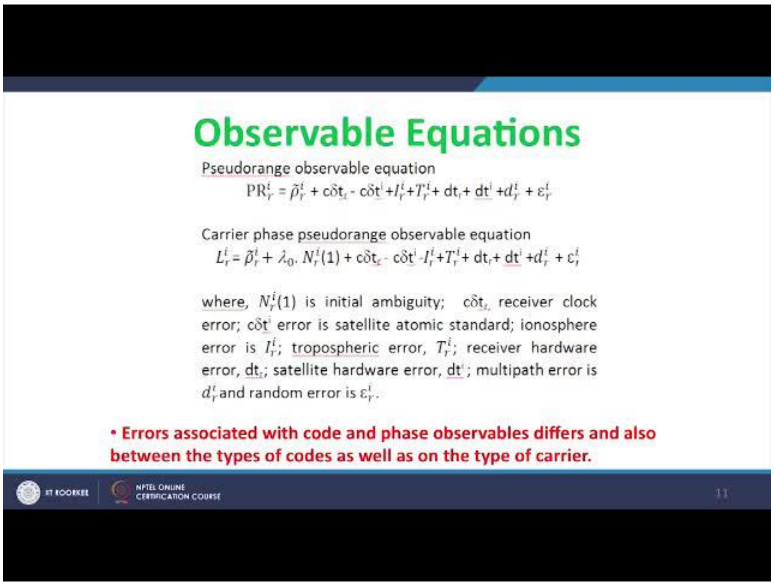
First thing is that we should plan our GPS observation in such a way that there is enough number of satellites visible during the time of observation. We should keep enough cut off angle, cut off angle, now what is cut off angle? So, it is the angle which we have to provide to the receiver at the time of receiving this signal beyond which there will not be any obstruction. So, suppose cut off angle is 15 degree we have given. So, we should see in the field that if we take a line having 15 degree from horizontal there should not be any obstruction like this, so this is cut off angle. So, in that case there will be less possibility to get obstruction.

Then another thing we have to see that they are near the station of observation there should not be any transformer or high tension line. So, that there is no interference of the signal. Then before setting up an instrument we should take care that this station is on a stable ground, and it has been properly levelled as well as centred properly and the parameters to be noted down has to be taken properly like height of the instrument and many other parameters we will be in need that those has to be noted down properly for subsequent use. So, the best way to avoid gross error is to take care before starting our observation. Once the observation is available then we have to check whether there is any gross errors then, that has to be removed those data has to be removed from further computation.

Next source of errors are systematic errors, systematic errors are errors which definitely follow some physical rule. So, this is specific to the instrument or procedure related. So, GPS there may be different types of systematic errors that is present in that may be present in GPS observation; that may arise out of our satellite space segment; that may be arises out of that during transmission through atmosphere, it may be arises from the receiver or may be other way. This in detail I will take up in the next class. But systematic error can be minimized or removed because it follows some physical rules.

And the last, but not least in also important is the random error which does not follow any definite rule. So, it cannot be modelled and we do not have any control on random error. So, that can only be limited by taking proper care during planning and execution of the serving and later after removing the gross error and systematic error when the data will be processed then we we should check about the random error. If it is available then statistically we have to adjust the error among different parameters so that the effect on position gets minimized. So, whatever it is.

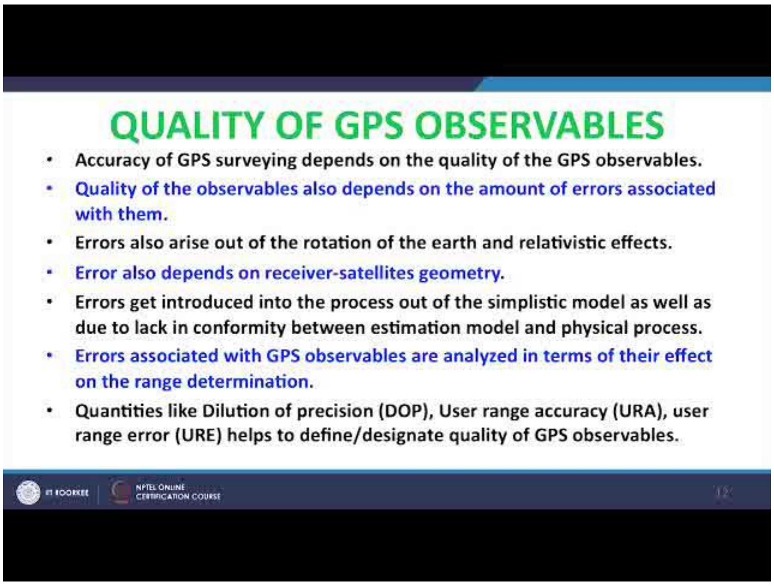
(Refer Slide Time: 24:17)



So, these errors will be available so with this errors we can say that the observable equations we find like this or pseudo range is the genetic range then it is the error due to your receiver clock error, error due to satellite clock error, ionospheric error, topospheric error, receiver satellite hardware error, then this is multipath error, then it is the random error.

So, we can say that the pseudo range consists of so many parts like geometric this is the thing which we are really looking for, but there are so many errors which we have to reduce or minimize or reduce or take out. Similarly carrier phase this is also having these parameters like additional parameter this one that is called integer ambiguity parameter. But, though I am using the same symbols the amount of error those will be associated with code pseudo range observables, and those in the phase observables will not be the same.

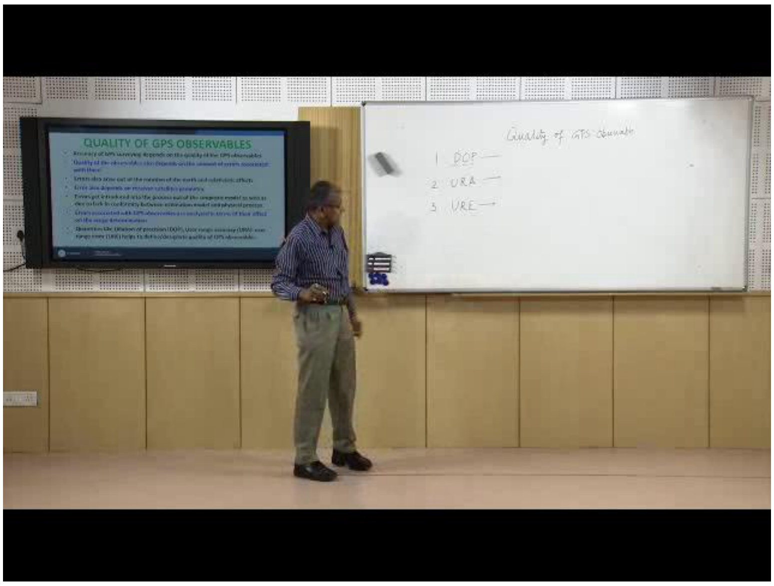
(Refer Slide Time: 25:25)



Anyways, ultimately the quality of the GPS observable will depend on what is the amount of error that is available in the observable.

So, now I will talk on Quality of GPS observable.

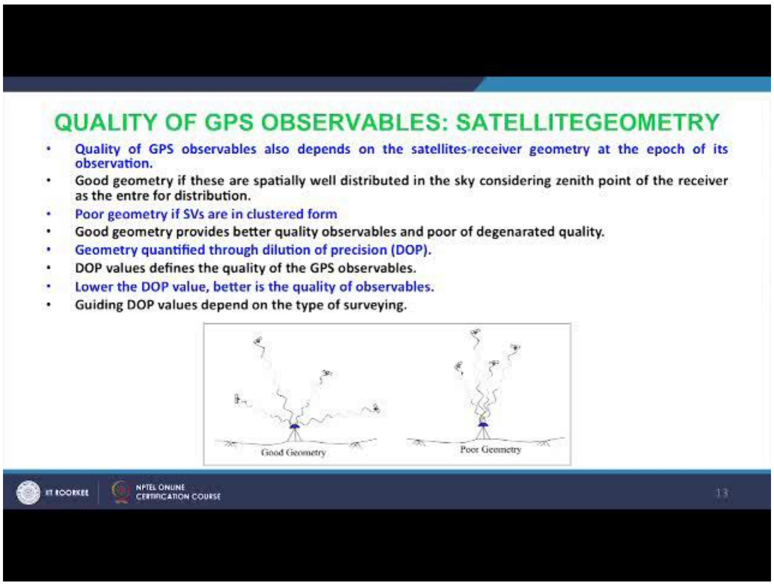
(Refer Slide Time: 25:45)



So, the quality of the GPS observable will depend upon what is the amount of error that is it has; the errors that will be available in the GPS observable already I had told you different sources, apart from that there may be error due to earth and relativistic effect, due to the geometry of the satellites with respect to the receiver then, the models that will be used for to remove the errors, maybe very simply enough it does not represent the physical process, an error may come. So, like that there may be different sources; however, we have some parameters by which we can identify what is the quality.

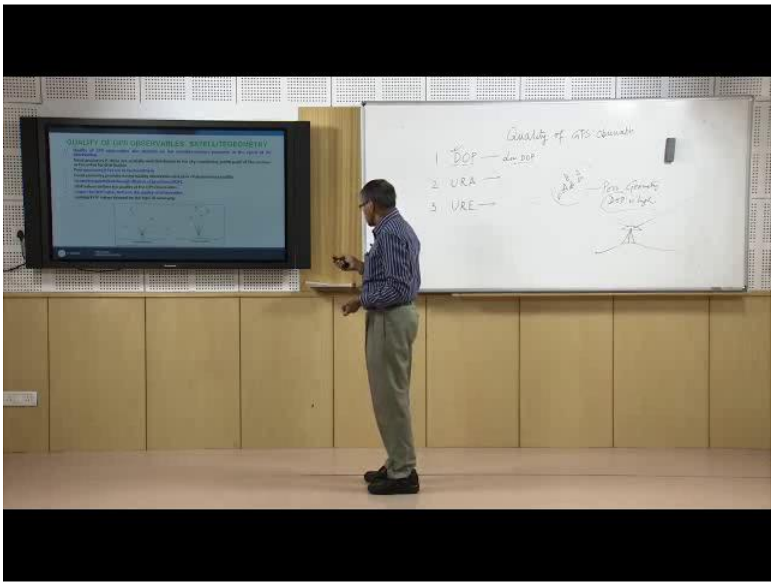
Number one, by dilution of precision; number two, user range accuracy and thirdly, user range error. So, these are the three parameters we make use to identify the quality of the GPS observable. Now from the name itself dilution of precision, now what is that? It is the parameter which defines the geometry of the satellite with respect to the receiver.

(Refer Slide Time: 27:16)



Like you can see here that when the satellites are here - if we take a receiver then the vertical line above it is called zenith point.

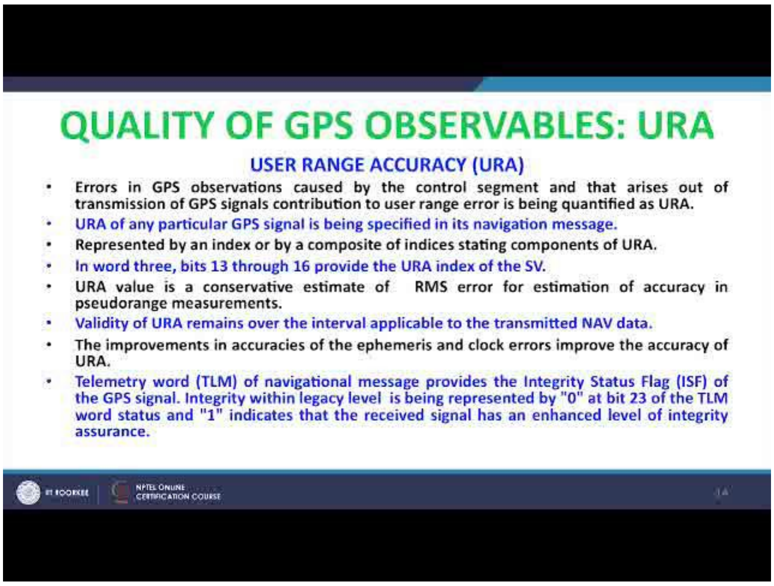
(Refer Slide Time: 27:24)



And if we have our satellites well spread over this, with respect to this line and above the cut off angle then this geometry is called good and in that case we will have a low dop, so good geometry low dop. And if the satellites are clustered at some point some location then the geometry is called this is a poor geometry, poor geometry and our dop value will be, dop value will be high. So, when we will take our observation the controller will provide us the dop value. So, if the dop value is low then we will expect that our observables are of good quality, if the dop value is very high or very high like 8 or 10 something like that then we will think that our observables are not of good quality then we should stop taking our observation.

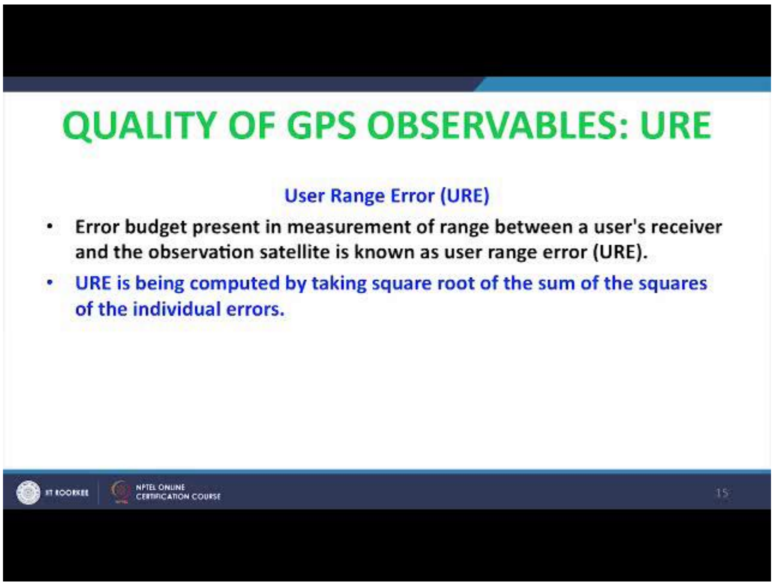
Another, so in that way during the collection of the data we can control the quality of our observation. Now once the data has been received. So, then also we can check about the quality of this by using the parameter called URA.

(Refer Slide Time: 29:08)



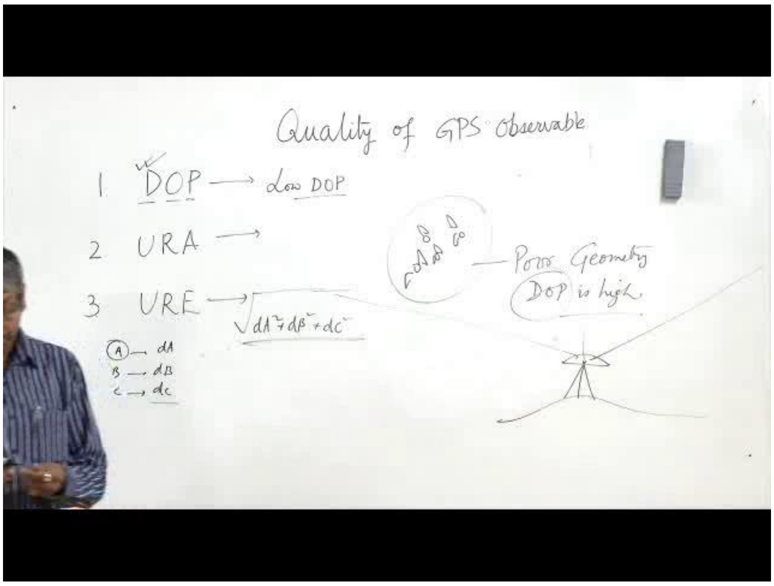
This URA means User Range Accuracy, this parameter is available in the GPS navigational data and it is represented by some index which is available in the third word of the navigational data bits 13 to 16 and this gives us the indication whether our data is good or not. And also there is a parameter which is available in the telemetry world in the at the bit 23, if that bit represents 1 that indicates that the received signal has an enhanced level of integrity; that means, it is a good quality and if it is zero then the integrity is poor; that means, the quality is not good. So, using this also we can have information about the quality of the GPS observable.

(Refer Slide Time: 30:17)



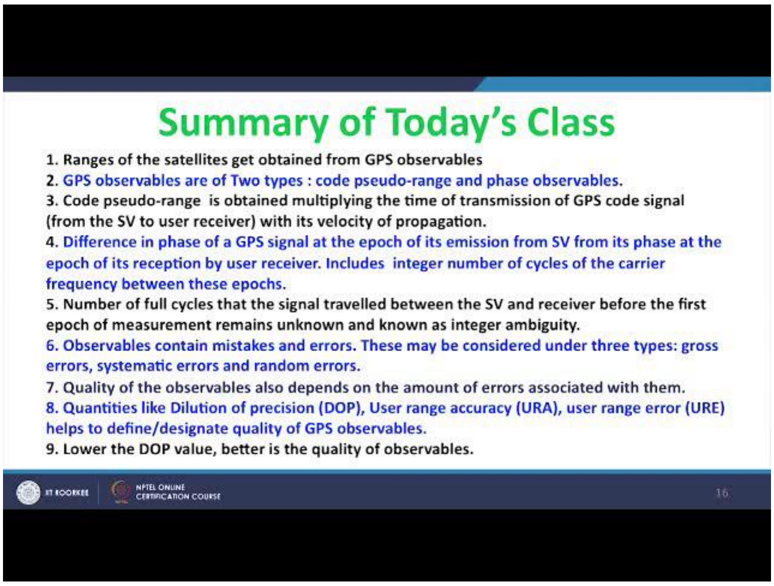
Next, another parameter which is most popularly used that is called URE - User Range Error. It is a quantitative parameter which we get from; we compute by taking square root of sum of the squares of individual errors. Actually errors are taken as it effects on the range measurement. So, what is the error of some particular error, how much it is causing error in the measurement of a range measurement? So, that is taken.

(Refer Slide Time: 30:53)



So for some parameters of A B C for this parameter what is the error? d A is the error in range measurement, d B is the error in range measurement, d C is the error in range measurement. So, your range error will be square root of d A square plus d B square plus d C square. So, lower the value better the quality of the observable. In that way also we may test the quality of GPS observable.

(Refer Slide Time: 31:29)



With this I want to conclude today's class, but before that I will have to summarize GPS observables of the most fundamental parameters which we like to measure of we like to take out from GPS signal. There are two types of GPS observables that is available in GPS signal - one is code pseudo range, which we obtain from the code part of the signal another is the phase observables, carrier phase observables that is obtained from the carrier phase of the GPS signal. From these two, using pseudo range we do get the code positioning and from subsequently we use code pseudo range positioning to find out the position using phase pseudo range.

These observables are fought with errors and these errors has to be removed or minimized before we go for processing and the quality of a GPS observable will depend on how much errors it is associated with less of the error, but for the quality and that we can judge or we can find out quantitatively using three parameters like that, URA and URE and the most simple and widely available parameter is dop which we can check even during our GPS observation, GPS surveying. So, during GPS surveying we should look for we should take those data when the dop value is less, less means may be 1 or 2 something like that of course, this value will depend upon the nature of the (Refer Time: 33:19).

With this I will have to conclude today's class. Thank you; see you again in the next class. Next class I will be taking on systematic errors in GPS observables.

Thank you very much.