Sustainable River Basin Management

Dr. Franziska Steinbruch

Department of Civil Engineering

Indian Institute of Technology, Madras

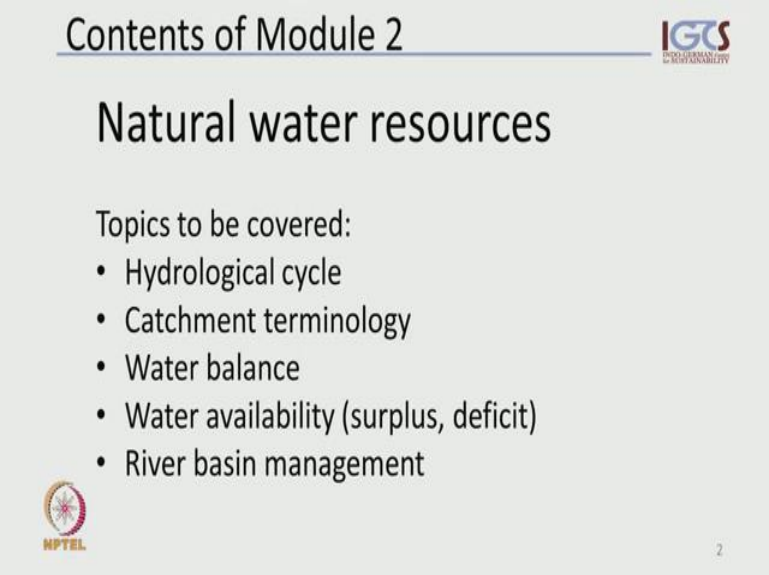
Module – 02

Lecture - 06

Part – 01

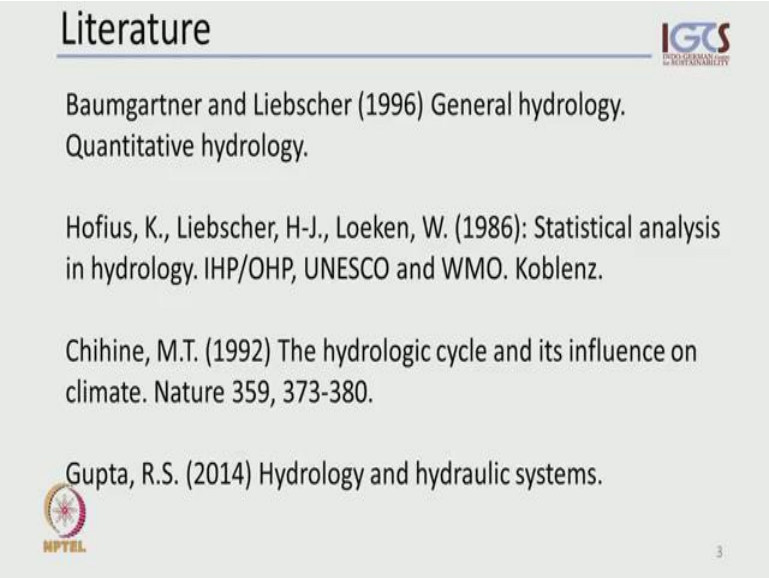
Welcome everybody to sustainable river basin management and we will start today our module two.

(Refer Slide Time: 00:28)



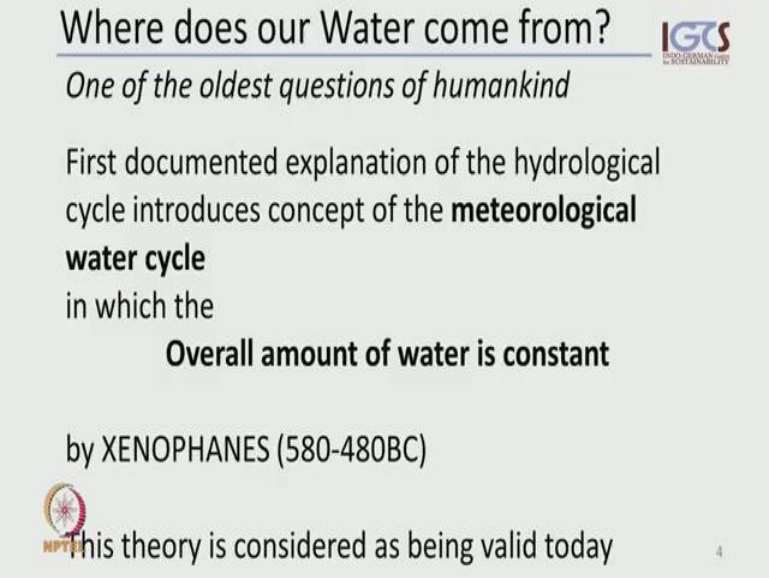
The contents of our module 2 will be about natural water resources and we will follow the topics: hydrological cycle, catchment terminology, we cover water balance, water availability and river basin management.

(Refer Slide Time: 00:42)



You should get hold of some basic literature on natural water resources. I have recommended some here, you can choose any other. If you already have literature at home, you can make use of those.

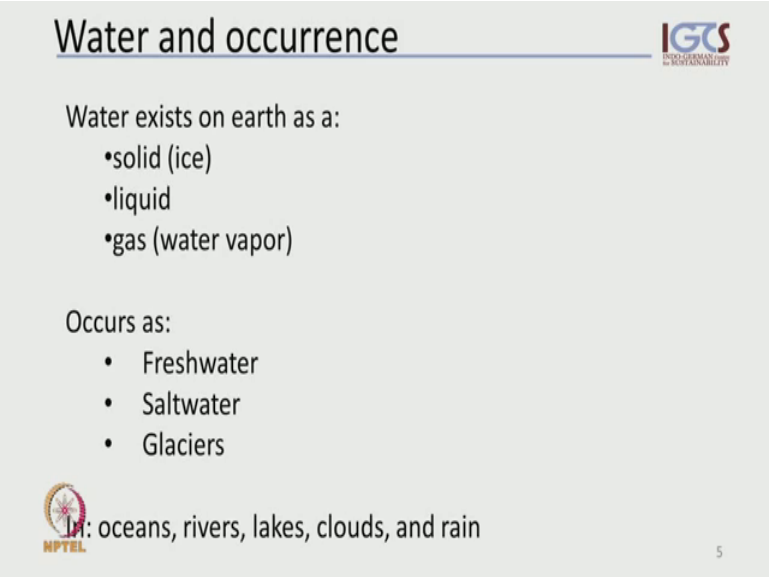
(Refer Slide Time: 01:01)



Let us start. What is the first question, the question that you may have asked as a child already, where does our water come from? And it is also one of the oldest questions of humankind, which is taken by our scientists and philosophers over centuries of years.

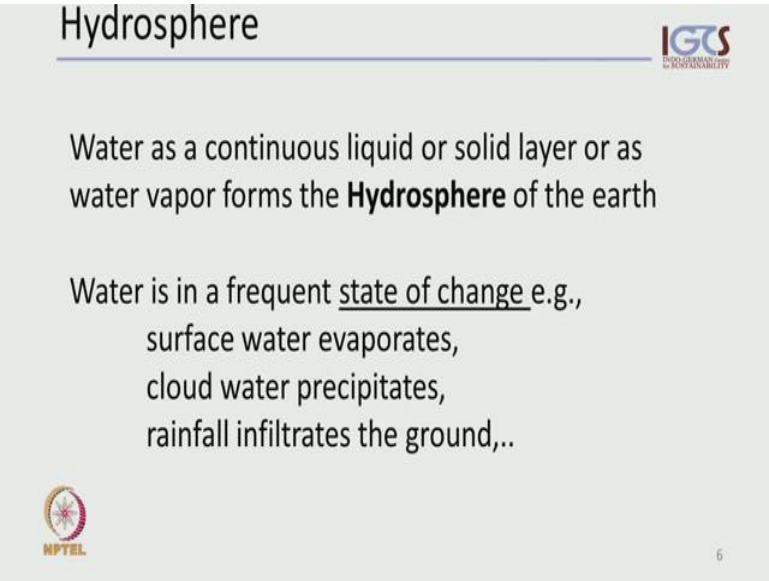
The first documental explanation of the hydrological cycle, which introduces the concept of the metrological water cycle was, is available by a Greek, the Greek Xenophanes about 580 years before our time. And he also introduced the idea of, that overall amount of water is constant. So, that we are working as a water cycle. And a constant amount of water, this theory is considered as being valid today and is a working theory up to now.

(Refer Slide Time: 02:09)



Where does water occur and what is water in general? Water exits on earth in the form of solids, it is ice, in liquid format as you know, and gas of water vapor and it occurs as fresh water, as salt water, as glaciers, in oceans, rivers, lakes, clouds and rain. What is relevant first as water usage is the fresh water component of it.

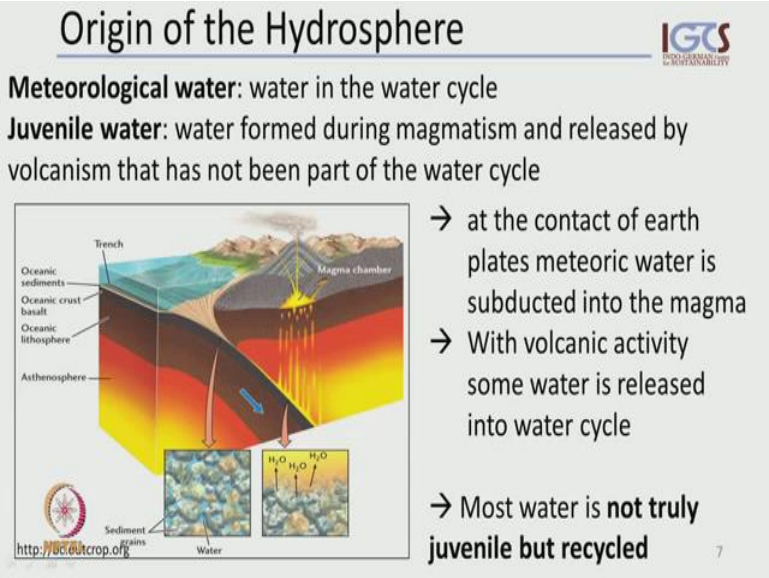
(Refer Slide Time: 02:45)



Let us introduce the term hydrosphere here. What do you mean by hydrosphere is, a continuous layer of water in liquid, solid or gaseous state. This continuous layer we call hydrosphere of the earth. Also important to introduce quite in the beginning is, that water is in a frequent state of change. That means, it what we measure into as of today is will be different the next moment we measure or observe it again. And this is also one of the challenges of water management.

So, what it means is, the way of, just giving an example, this surface water will evaporate, that clouds will condensate when travel, precipitate as rainfall or snowfall and that rainfall they reach the count and possibly infiltrate and become count bottom and so on.

(Refer Slide Time: 03:52)

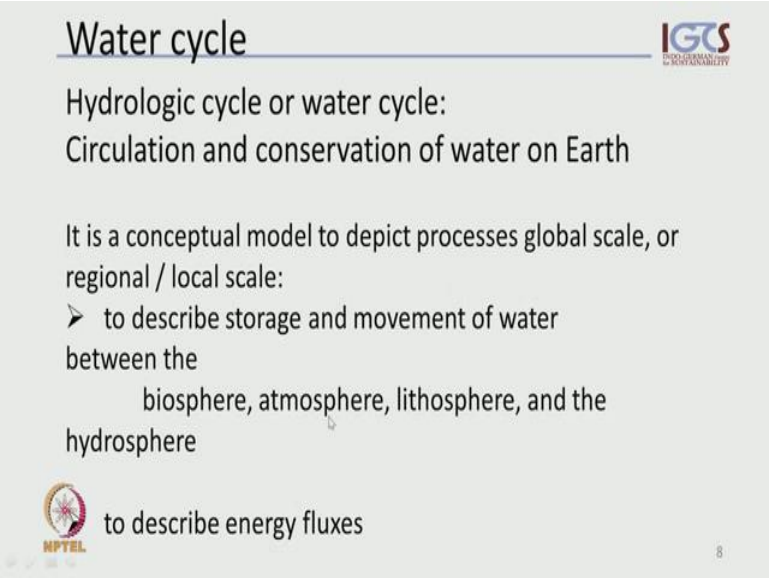


Now, let us just reflect upon the origin of our hydrosphere and our two concepts of where water, our water is formed. The first one is the meteorological water and the second, the so called Juvenile water. The meteorological water is water that is part, currently part of our water cycle, whereas the juvenile water is water that is formed during magmatism and released in volcanoes, volcanism is the process. And the ((Refer Time: 04:32)) that has not been part of the water cycle yet, that is why juvenile. How is this possible?

Let us just look in to a brief example. You may have heard about plate tectonics or continental plates and, or oceanic plates and those plates move shift around permanently or constantly. And at the borders of such plates, at the ends of plates like the oceanic plate may be pushed underneath the lighter or less stems plates, the continental plate and in that way any water that was incorporated into a sediment pack here. Just like sediment layer at the bottom of our oceans gets subtracted and incorporated into our magma and incorporated into a new phase of magmatism, it is in the same way water can reach compact to and join our water cycle.

So, volcanic activity and those are small amounts on both sides and that is why we can still say, that our water over water amount remains constant. What we also have to state, if you think about this model here, that most of our water is not truly juvenile, but it has to be called recycled water.

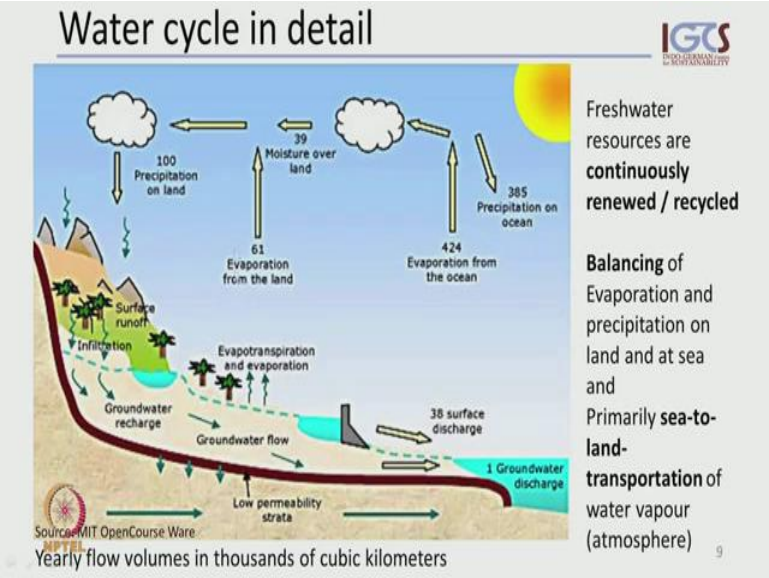
(Refer Slide Time: 06:15)



Now, if we are talking about cycling in water, water cycle is already, let us just define the term we can say water cycle, but we can also use the term hydrological cycle is one and the same and it expresses the circulation and conservation of water on earth. It is basically a conception model, which depicts process at base scales. It can be used a global scale, regional or even local scale. And it describes two things, the storage and movement of water, between our spheres and we differentiate between the biosphere and the atmosphere, lithosphere and the hydrosphere.

There we have talked about the hydrosphere already and we will be coming back to the other spheres throughout the course and the same conception model can be used to describe energy fluxes.

(Refer Slide Time: 07:19)



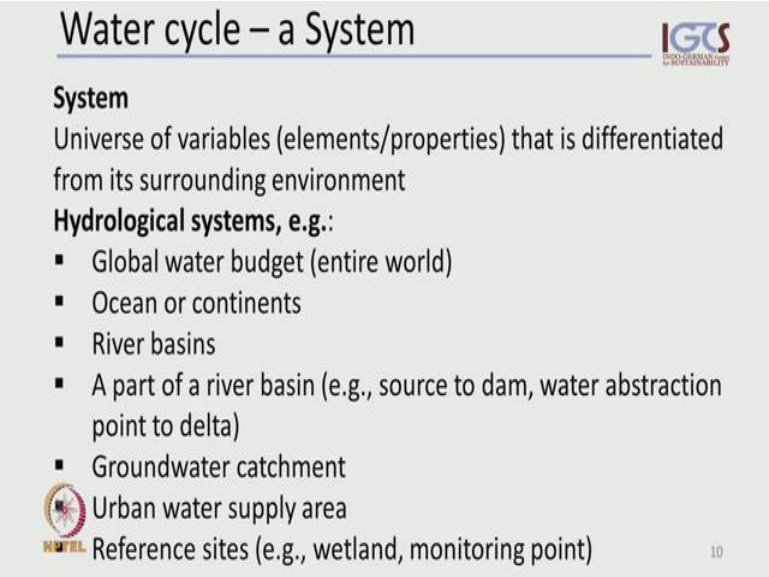
Now, let just take a look into the water cycle in more detail. This picture here shows us the water cycle. It shows us the sun, the very, very important part of the water cycle and it shows us the oceans, part of the ocean and it shows us the land's surface here. And then, we have clouds and there was showing us our, our moment over, of water particles. But, you can see, that we can look at this from a large cycle, but we can also look into a smaller cycles, just the cycle between the ocean and the land's surface or cycles between different parts of land's surfaces.

Now, how, what keeps all these moving is our solar radiation. Our sun is the engine of this entire movement. What you can see is, we have our major portions of water cycling is taking place. We can see is, that ground water is a minor source here and the major part of that participates quickly in our water cycle are surface components. Now, important here is, that the balance between evaporation process is, evaporation has to take place, water supply has to take place to be able to have rainfall taking place over other parts of the water cycle.

So, there must be a balance between those two and essentially this process starts from the large stock that we have, which is our ocean. We have minor stocks in, in countries, which are land-locked and very distant from oceans. Very often, this land, the evaporation from land may play a major role or even the most, the only important role of

water, water supply and in this, in this part of a water cycle. We come back to this at a later stage.

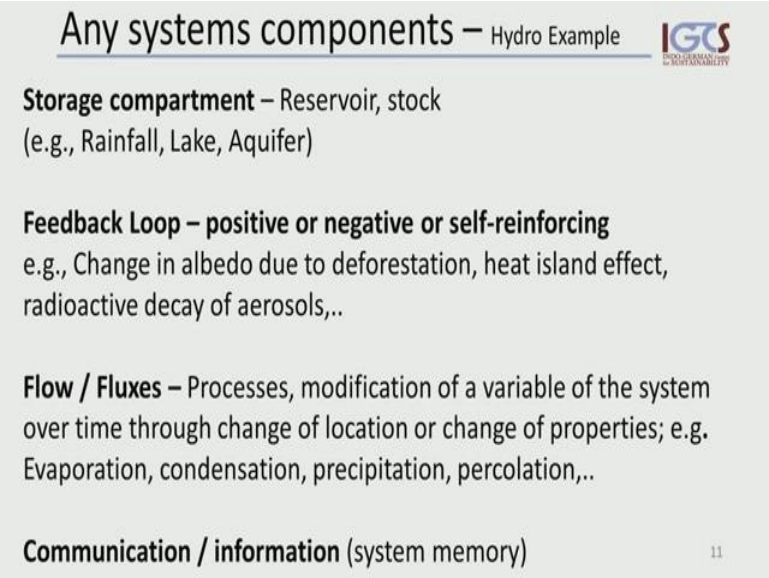
(Refer Slide Time: 09:45)



Now, let us take this, move away from this conceptual model of the water cycle and try to look at it as a system from a system's perspective. And let us define system first. A system is a universe of variables in this variable could be elements of properties which can be differentiated from it is surrounding environment and hydrological systems could be for example, the global water budget it could be a ocean or continents, it could be a river basins, it could be part of river basin.

For instance, if we just one to understand what happens between the source of the water and attempt between a water abstraction point in the delta, it could be a groundwater catchment it could be a urban water supply area it could be any other reference of research site of interest, all of those we can define as system or subsystems.

(Refer Slide Time: 10:51)



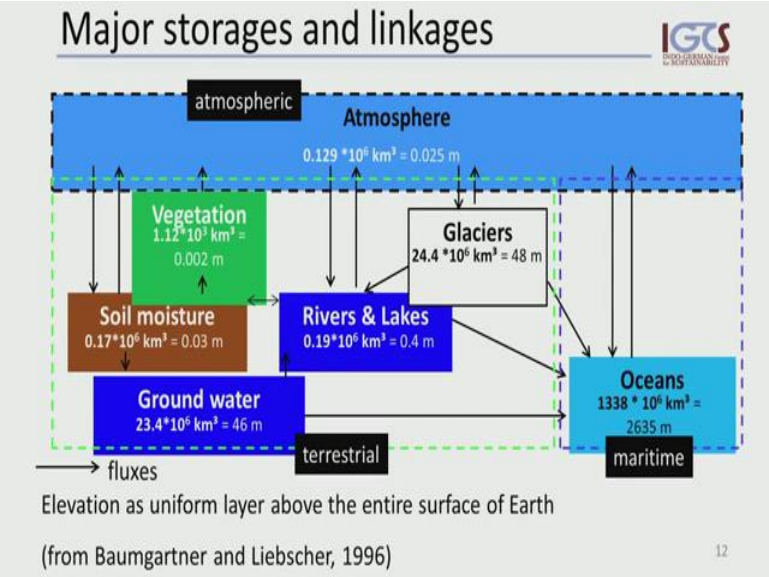
Now, let us looking two the components of such systems in general and let us apply it to our hydrological systems. Very important component, our storage compartments, we can use alternative terms and you can see this and the literature also, rest of our stock, if you look into financial applications and such a rest of it could be for instance, our clouds, our rain fall it could be a lake, it could be an aquifer as a example.

And then we have a way important the additional component, which is so called a feedback loop .Those can be positive, they could be negative and they could be a self reinforcing or they could be a positive self-reinforcing, on negative self-reinforcing. And those are components, as you can see, which are not actually as such part of what we have seen from our water cycle, those are inputs to our system, such as, for example, the change in a albedo due to deforestation the heat island effect in open area or for example, radioactive decay of aerosols.

In the third important component of systems is the flow, the fluxes take place and those are processes and the process always means a modification of variable of the system over time and this can be through change of location, might it could be a through change of properties. For example, in the case of the hydrology, evaporation, condensation, precipitation, percolation, percolation it could also be a contaminant transport or contamination pollution processes and then we have a forth component of systems which is usually call communication or information and this is in hydrological systems often

referred to as system memory. We come back to these all those components throughout our lecture again.

(Refer Slide Time: 13:20)



Now, let us look into the storages or the stock, that I just mentioned before and the fluxes, the flows that takes place in between them. The arrows already shown here show us the fluxes. Now, we have seen from our hydrological cycle, that we essentially move water are particles through three different spaces, through our atmosphere, through our land surface, the terrestrial part and through our maritime or ocean parts, so the major part. And then, we look into the terrestrial. It becomes very complex and it can be even more complex.

And what I am showing here, that water actually moves to vegetation, soil moisture. It is in our rivers and lakes, wetlands and also in ground water, ((Refer Time: 14:28)), in addition in a solid long-term changing state in glaciers. And then, we have all of this interacting with each other at different at various stages and after all joining at any time again our oceans faster or slower in the process. And any feedback takes place between our atmosphere and our terrestrial part and the oceans and the atmosphere. But, it does not take place from the oceans to our terrestrial or land part.

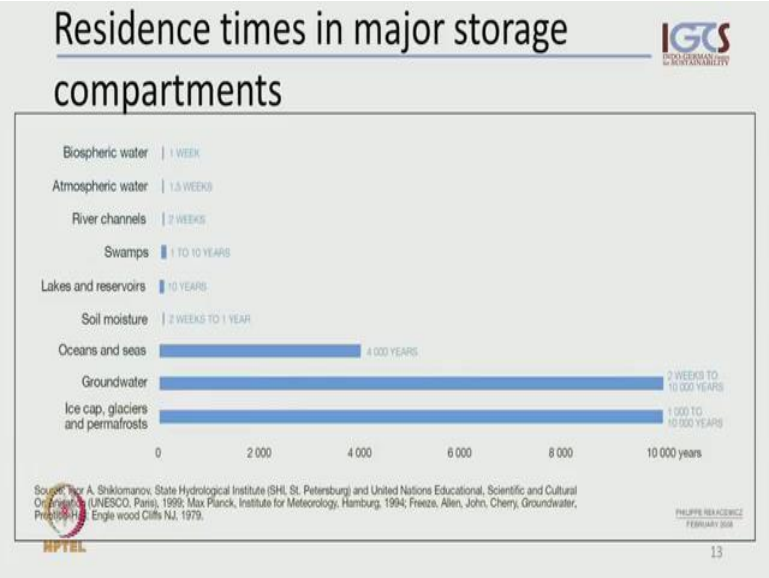
Now, if you want to get an idea of the size of our storages, we can see the numbers that I have just clicked into this presentation and we can see, that the oceans are by far our largest stock. This is over all the source of all our water. And the smallest, a very fairly, a

comparably very small stock is our atmosphere and this suggests, that any water that becomes, is moved through our water cycle, has a very short residence time in the atmosphere. But, we can also see here is, that major storages, major stocks on our ground water reserves and our glaciers.

Now, keep in mind, that with climate change, some of this is changing and our glaciers are becoming smaller. So, this means, that this number will also be changing. It will become smaller and this water will join our rivers, ground water, end up in our oceans and as such be part of our water cycle.

Again, the number in meters that you can see next to the storage size indicates, is a different expression of the same. It simply tells us the distribution. If you would distribute those amounts as a uniform layer above the entire surface of the earth, what, how it would look like. If you can imagine, imagine a sandwich with different layers and then, we would have the oceans as the thickest sandwich layer and followed by ground water and glaciers and so on. This way, smaller layers of that.

(Refer Slide Time: 17:30)

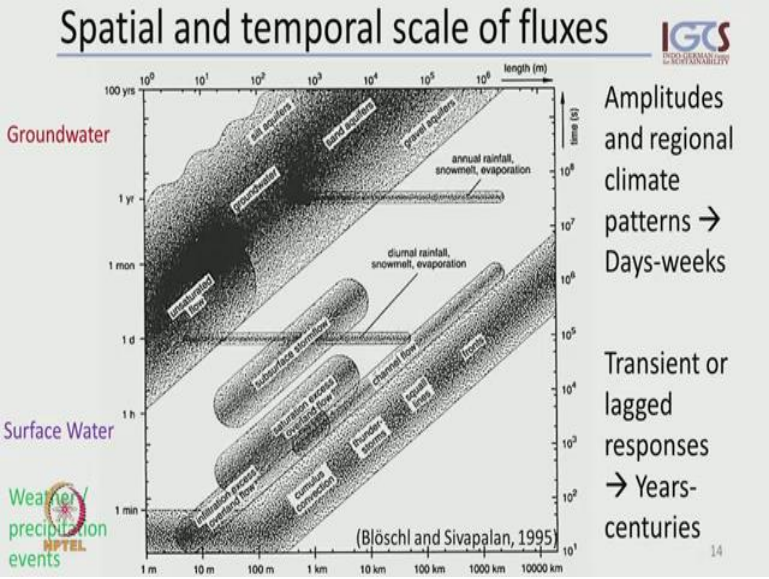


Now, I mentioned residence times already when we, because it we can see it already from storage size and the relevance and importance of some of our storages. There is an interesting figure that I want to show you, which summarizes all this. We have here our different water stocks, different water storages here and then we have here our years and this start from 0 to about 10,000 years. And what you can see is, that the biospheric

water means water stored in living matter is fairly short, very sort lived. So, this water participates very quickly in the water cycle and the same applies to our atmosphere water, comes to about 10 days of water, that from evaporating to becoming rainfall again, it only remains about 10 days in the atmosphere.

And you can also see that the longest looking into fresh water components is a ground water. Ground water is a very long residence time in our resident storage, in our active phase, which can reach about 10,000 years. So, this is important from management perspective, from a water quality and water quantity, water availability perspective. We come back to this at a later stage.

(Refer Slide Time: 19:30)



The other important factor besides the residence time is the spatial and temporal scale of these fluxes, which I want to demonstrate you as well here. This is a graph that shows two dimensions, one is the distance in terms of the geographical range and this is year in terms of the spatial range, in terms of temporal range, I am sorry.

And I have individual events, those dots, all different events clustered as type of an event and the distance it impacted on the temporal scale, it took on. And what we can see is, that the weather events, the daily weather records that we observed have a, all occurred in, within the very short term spatial and temporal scale window, whereas the surface water events, like flood events, like stone flows, overland flows, occur in a time window of hours and days.

And within range of around a few kilometers up to about 10 kilometers and those are the events that form or shape our climate viability, or climate pattern in our respective region. And then we have a large cloud of events, which are all related to ground water interactions, ground water events in different types of aquifers and different conditions fertile and unfertile, which take place over a short to very, very long period of time, over short or small geographical ranges to very large geographical ranges.

And those we usually shape our long term or our lagged responses on water, on the water cycle and on climate, such that this what we also call climate, as you remember from our previous class.

At this point I want to stop and I see you again for the next class.