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Geodätisches Institut

Titel der Studien- oder Diplomarbeit evtl. eine zweite Zeile

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Geodäsie und Geoinformatik

an der Universität Stuttgart

Vorname V. Name

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Erkl%■rung der Urheberschaft

Ich erkl%■re hiermit an Eides statt, dass ich die vorliegende Arbeit ohne Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe; die aus fremden Quellen direkt oder indirekt ¸bernommenen Gedanken sind als solche kenntlich gemacht. Die Arbeit wurde bisher in gleicher oder %■hnlicher Form in keiner anderen Pr¸fungsbehˆrde vorgelegt und auch noch nicht verˆffentlicht.

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In diesem kurzen Text erfolgt die Zusammenfassung der Arbeit oder – auf Englisch – das Abstract.

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Chapter 1

Introduction

1.1 Water Cycle

Water is one of the most necessary resources for human beings. It is the most important ingredient of life; it has a regulating effect on climate and all industries can not function well without it. However, 98 % of the water on the earth is in the oceans, 1.6% is in ice caps, which means only 0.4 % is the fresh water on land. So, a very little variability of the hydrology cycle can have big effects on water resources.

The hydrology cycle (see figure 1.1) includes 3 major parts: evaporation, precipitation and runoff. The water evaporates from the oceans and the land surface as vapor to become part of the atmosphere along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil and the cooler temperature causes the vapor into clouds. The clouds fall out of the sky as precipitation, which includes rain, snow and ice. Most precipitation falls back into the oceans or onto land. Precipitated water may be intercepted by vegetation, become overland flow over the ground surface, flow through the soil as subsurface flow and discharge into streams as surface runoff. The process can be simplified as:

$$\frac{dS}{dt} = Pre - ET - R \tag{1.1}$$

where

Pre	Precipitation
ET	Evatranspiration
R	Surface Runoff
dS/dt	total water storage change

1.2 Observation from Satellite

It was extremely difficult to measure the global water storage change consistently. In some way, remote sensing with satellite is the perfect tool for hydrology research, which has the ability to provide the data globally in a long term.

The GRACE twin satellites, launched 17 March 2002, are making detailed measurements

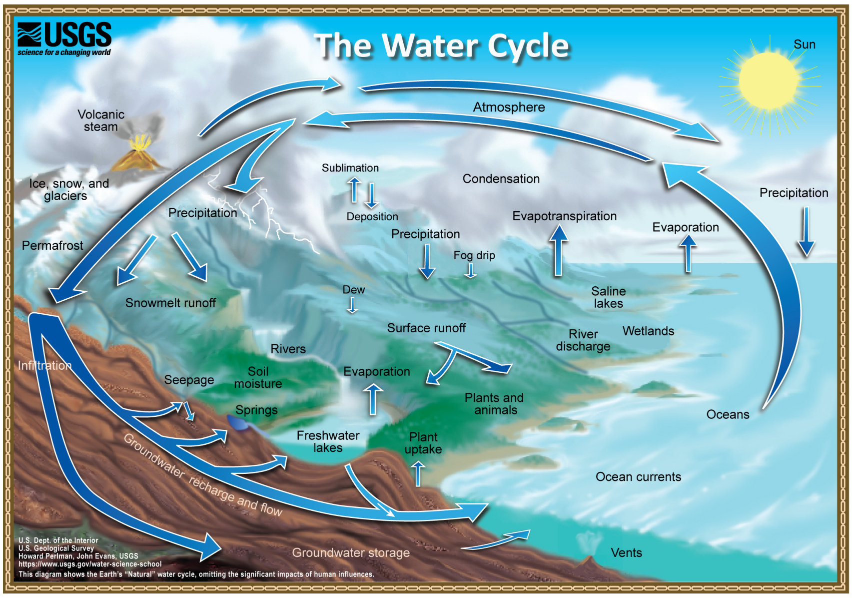

Figure 1.1: *Horologic Cycle*

of Earth's gravity field, which are caused by monthly changes in mass. The mass changes can be thought of as concentrated in a very thin layer of water thickness changes near the Earth's surface by moving ocean, atmospheric and land ice masses and by mass exchanges between these Earth system compartments.

There are 2 satellites with tandem polar orbit. Since the orbit is around the pole and the earth rotates itself, the satellites were able to get the whole view of the earth. Unlike the normal remote sensors, the GRACE satellites measured the gravity field of the earth. When the 2 satellites went over a mass anomaly like a big mountain, the distance of them will be a little bit smaller. By calculating this distance difference with the help of GPS system, the gravity field anomaly of the earth along with the total water storage anomaly are able to be plotted monthly.

It is shown, that GRACE delivers the highest temporal resolution and is thus able to observe monthly mass variation with a spatial resolution of less than 1000 km. In (Wahr et al., 1998) it was predicted that GRACE would be able to measure these effects with an accuracy of about 2 mm of water equivalent heights. Though this accuracy has not yet been achieved because of the errors in spherical harmonic coefficients of short-wavelength, it was shown in many publications that the Stokes coefficients from GRACE indeed contain hydrological signals as the monthly solutions from GRACE showed a good agreement with mass variations from hydrological models.

1.3 Motivation

A time series is a series of data points indexed (or listed or graphed) in time order. Most commonly, a time series is a sequence taken at successive equally spaced points in time. Thus

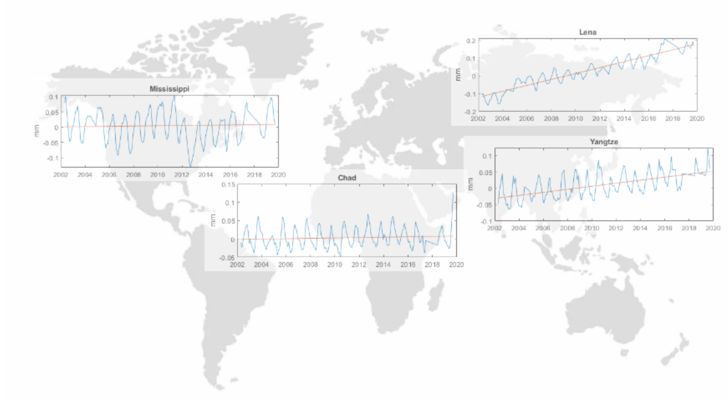

Figure 1.2: Water Storage Change

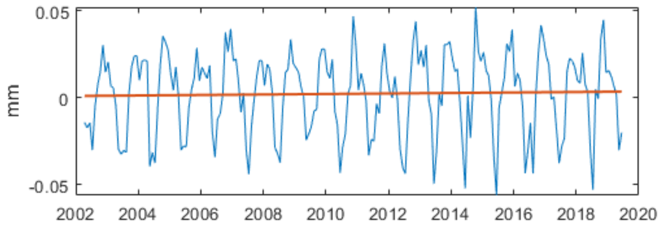

Figure 1.3: Ob basin

it is a sequence of discrete-time data. In hydrology, most variables are observed in time series, including Total Water Storage Anomaly(TWSA). In the hydrological cycle, this should reflect seasonal behavior and is in long term relatively stable. However, it was shown that since 2002 the TWSA of many big basins has increased (see figure 1.2). One important basin of them is Ob basin in west Siberia (see figure 1.3). How did this trend happen is a very interesting topic. Through the analysis of the trend of the time series, it is possible to further understand the changes that have taken place before and future changes can also be predicted based on the stationary analysis.

1.4 Objective

In this thesis, the beginning point of the changing trend is to be found by analyzing the TWSA time series from GRACE data. In order to find the reason of the change, the precipitation, the evatranspiration along with the runoff in the same period from different data center would also be processed and compared with the TWSA. At the end, how was the changes of the TWSA and the reasons for this change would be discussed.

Chapter 2

Study Area

Ob River (see figure 2.1), river of central Russia. One of the greatest rivers of Asia, the Ob flows north and west across western Siberia in a twisting diagonal from its sources in the Altai Mountains to its outlet through the Gulf of Ob into the Kara Sea of the Arctic Ocean. It is a major transportation artery, crossing territory at the heart of Russia that is extraordinarily varied in its physical environment and population. Even allowing for the barrenness of much of the region surrounding the lower course of the river and the ice-clogged waters into which it discharges, the Ob drains a region of great economic potential.

The Ob proper is formed by the junction of the Biya and Katun rivers, in the foothills of the Siberian sector of the Altai, from which it has a course of 2,268 miles (3,650 km). If, however, the Irtysh River is regarded as part of the main course rather than as the Ob's major tributary, the maximum length, from the source of the Black (Chorny) Irtysh in China's sector of the Altai, is 3,362 miles (5,410 km), making the Ob the seventh longest river in the world. The catchment area is approximately 1,150,000 square miles (2,975,000 square km). Constituting about half of the drainage basin of the Kara Sea, the Ob's catchment area is the sixth largest in the world.

Figure 2.1: River Basins Ob

The Ob basin has short, warm summers and long, cold winters. Average January temperatures range from −28°C on the shores of the Kara Sea to −16°C in the upper reaches of the Irtysh. July temperatures for the same locations, respectively, range from 4 °C to above 20°C. The absolute maximum temperature, in the arid south, is 40°C, and the minimum, in the Altai Mountains, is −60°. Rainfall, which occurs mainly in the summer, averages less than 400 mm per year in the north, 500 to 600 mm in the taiga zone, and 300 to 400 mm on the steppes. The western slopes of the Altai receive as much as 1,575 mm per year. Snow cover lasts for 240 to 270 days in the north and for 160 to 170 days in the south. It is deepest in the forest zone, where it ranges from 60 to 90 cm, and in the mountains, where it averages 200 cm per year. It is much shallower on the tundra, ranging from 30 to 50 cm, and very thin on the steppe, where 20 to 40 cm fall.

The Ob River contributes on average 402 km^3 freshwater per year, or about 15% of total fresh water flow into the Arctic Ocean. The drainage basin is classified as cropland (36%), forest (30%), wetland (11%), grassland (10%), shrub (5%) , developed (5%) and irrigated cropland (3%). Basin total population is about 27 million, with 39 cities having a population of more than 100 000. The steppe zones in the southern portion of the basin are the major wheat production regions in Russia. The west Siberian oil and gas field, located in the taiga and tundra zones of the middle and lower Ob, contribute about two-third of the country's crude oil and natural gas outputs.

Chapter 3

Drittes Kapitel

3.1 Absatz

Hier mal eine Aufz%■hlung

1. erster Punkt
2. noch ein Punkt
3. letzter Punkt

Super, oder?

Chapter 4

Viertes Kapitel

4.1 Eine Sektion

Hier mal eine Auflistung von Elementen

- erstes Element
- zweites Element
- noch ein Element

Und Schluss mit der Vorlage ...

Bibliography

Appendix A

Und das hier ist noch der Anhang...