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Hello everyone, I’m Ziqing Yu, today I’ll present my Bachelor thesis to you, The title is Under standing the positive trend in total water storage of OB basin using space born observation. And it was supervised by Dr tourian and Mr Saemina

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It includes an Introduction, the Research Area t, the Data and method ,the results and a conclusion.

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Now we are talking about water, as we understand it, water is a necessary ingredient of life. So it’s earth, we call it a blue planet, evertything blue in this picture is water, and of course al thing white here is water. About 98% of water is in the oceans, 1.6% is in ice caps, only 0.4% is stored on land, most of them is ground water. So, a very small change on the water cycle can cause a big effect on how water deliveres into the continent and water resources

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The Total Water Storage (TWS) is the sum of all above and below surface water storages, including canopy water, rivers and lakes, soil moisture and groundwater, and it represents a synthetic proxy of the dynamic of slow-responding hydrological quantities.

Water is not static at all, it is very dynamic, it evaporates and transpirate from the surface, it moves over land, it rain down as precipitation, this can be simplified as this equation: the deviation of total water storage is equal to precipitation minus evapotranspiration minus run off in an area. We are always tring to close this budget.

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However, even though this equation looks very easy, hydrology is very hard. There is not many observations globally, the water changes so fast in space and time, in some ways, the remote sensing is a perfect way to do it. Using satellite we can observe it globally in a long term. One mission of them is GRACE

The GRACE mission is a joint partnership between the National Aeronautics and Space

Administration (NASA) in the United States, the Deutsche Forshungsanstalt fuer Luft und

Raumfahrt (DLR) in Germany. It makes an mearsument of earths gravity field, which are caused by monthly changes in mass. Unlike normal remote sensing satellite, there are two identical satellites in in the same orbital plane at an approximate distance. The distance between these 2 satellites are not identical because of the earth mass change and by measuring that, the mass changes can be detected. 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.

The GRACE mission ended in october 2017. GRACE FO launched as followers launched in May 2018. Which means there is a gap about 7 months in the data we have

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This is a figure from a paper in nature,

As we can see in this figure, since the launch of GRACE, the water storage in many area has changed, the blue area in this figure has gain water from other places, including Ob basin area

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This is the water storage change from Jan 2003 to Dec 2019 from the mascon solution (解释 mascon) of CSR Rl06, if we make an linear regression here we are able see an positive trend in general and we notice that from 2016 to 2015 this tendency is strong. We are interested to see the what was actually happening, we are interested to see the behavior in this area during this time.

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So we are talking about Ob river basin. What is it, what’s the speciaty?

Ob River is a river of central Russia in West Syberia, and it is one of the gratest river of Asia, it’s about 3650 kilometre long, the basin area covers 2975000 quadkilometer, and 85% of lay in west siberian plain.

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According to Köppen Gerger climta classification, major part of this basin, major part of this basin belons to subarctic climate, it has a short warm summer and long cold winter. The rainfall occurs mainly in summer. The snow last for 240 to 270 dazs in the north and 160 to 170 dazs in the south and it is deepest in the forest yone and in the mountains.

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So as mentioned, we use GRACE to determine the total water storage, there are several centers who provides level 2 GRACE grace and grace fo data. We’ve used solutions from JPL,CSR,GFZ and ITSG. Using the EWH bundle developted by institude, we can calculate the equivalent water height, which represent the total water storage from these level-2 data.

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For precipitation and evapotranspiration, there are a lot datasets, they use models to represent these 2 phenomenon basing on the insitu gauge measurement. The properties of them are of course not identical. These 2 tables shows the datasets we used in this work. This shows the timespan, the temporal and apatial resolutions and spatial coverage(有一个60N？)

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For Runoff we have the models as well. A tricky thing we also have the runoff insitu data collected in salekhard from GRDC. But this insitu data only exist till 2010. If we compared these models and insitu data before 2010, for example, by calculation the RMSE, we can see the error are quite big, and even if the best model ERA5, there is a lag between this model and insitu.

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We may think, we have this equation, right? This terrestrial water balance , R is equal to P-et

-dS/dt. But there is paper, which shows, this is not a good way to do that. These are some cut from the paper, it uses 3 metrics to do the estimate: percentage bias, the nash-sutcliffe efficiency which summers this 2 issues and correlation. For percentage bias we need it less than 25% to say, ok this is a good estimate but we can see we hardly reaches this standard. For some areas like amazon, the result looks good ,bur for most area and especially for Ob, this estimation is not ideal.

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Fortunatly, there is another way we can do to calculate the discharge, the runoff. We can use the satellite altimetry to do that from the water level. We’ll talk about the methods later. Now i’m showing the satellite missions we’ve considered. They are Envisat(Environmental Satellite), from 6.2006 to 10 2010, SARAL(**S**atellite with **AR**gos and **AL**tiKa) from 2013 to 2016 and Sentinel3 since 2016

We can using the altbundle developed by the institute to get the water level data.

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So we have 4 timeseries for total water storage with uncertainties, we can use the gauss markov adjustment to merge these four time series into one, this equations shows how to do it for one month, of course we don’t need to do that month by month, instead we can build a large matrix to do it by once, this shows the basic ideas.

And we can also do this for our precipitation and evapotranspiration, the problem is, we don’t have the uncertainties for these two components. We do it that way, we assume the precipitation or evapotranspiration in the same month, January, follows the normal contribution, , then we calculate the standard deviation and use it as the the uncertatinty for this month for each datasets.

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And for total water storage we need the trend for it, so we use the centre deviation since we have the monthly tws. To find the changing point, we used the moving average. Its 12 here because we have 12 months in a year and then we searth the abrupt change in the mean value in movingg average series. These 2 steps can be down using matlab function movmean and ischange

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Now it’s the method provide by this paper to calculate the runoff from water level.

Now we have 2 time series one, another one

Note the time span

Cumulative distribution function for each of them, at last, we can find the relationship between them.

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We’ve chosen several vitual station to observe the waterlevel, for each satellite mission, in order to get the better approach, we choose the time series, whose vitual station near the salekhard, where the insitu runoff are measured, blue for envisat ,the blue one for saral and red one here for sentinels

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So we generate an time series for river discharege from water level, there were some gaps, we us interpolation to fill them.

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Now we can have our results,

Twsa from 4 datacentres

After merging

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Trend of twsa

Moving average and the changing point

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The spatial behavior of this basin using mascon CSR RL06, it has decrease in the first period, this reduction in west part

Second period, the basin gaind a lot water from the outside, especially in north and west

Third period lost water, it occurs same as the second ,but also in south east.

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Before we see time series of precipitation and see if they are identical in this area.

We take June of 2003

We can see the different spatial resolution for different models, but still east and west are highter, in the mitte and south

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For all datases

After merging them into 1

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We do the same for evapotranspiration, SSEBO shows a bit different from other in west south.

But

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And here

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Then we can calculate the mean value with uncertainties for each of these component in the 3 period we detected.

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If we summer all these numbers into a table, we can judge the quality of them. the statement of terristrial water balance p-et-r-ds/dt should equal to 0.

The first 4 rows are same as we see in the diagramms before

If we take the first period as a baseline,

The results are acceptable.

Now let’s analyze the trends of these water components

From the first period to the second, the trend value grows, the water in this area has gained