Internship report

Compare the soil moisture data from Copernicus and Kisters

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Antea Group

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1. Introduction

Antea Group is an international and locally operating consultancy and engineering firm, specialized in the field of water conservancy engineering, environment, infrastructure, real estate. It has multiple offices in Belgium, but its main offices are located in the Netherlands. Outside of their European and North-American offices, they are also represented in many emerging market economies such as in Asia or in Africa [1]. The company's customers include government and private companies, the projects of the Belgian office are for a large part dependent on the request of the customer and are very broad and versatile.

I did my internship at the Ghent office, with occasional work-from-home, the internship period was thirty working days, from Aug. 2021 to Sep. 2021. My internship subject is part of a larger project to update the drainage categories of the soil map of Flanders. My internship included various learning areas, including:

- Making oneself familiar with data-driven modelling and scripting
- Perform and explore the dataset from two remote sensing products (Copernicus and KvdS)
- Visually compare Copernicus and KvdS with soil moisture dataset, find the relations, commonalities and discrepancies
- Compare the graphs generate by the soil moisture data from the Copernicus and the KvdS
- Create a graph to find the correlation between soil moisture datasets and soil moisture the groundwater level for year 2018
- Create a scatter plot to find the correlation between the Copernicus and KvdS soil moisture datasets
- Refine the python code
- Report the validation method and its results
- Give a conclusion of if it is worthful for government to buy the KvdS products

From a more concrete perspective, the expected outcome of the internship is to combine the knowledge of soils and groundwater with expertise in remote sensing and egotistical to get an insight into the accuracy of satellites when measuring soil moisture.

2. Internship contents

2.1 Scientific background

2.1.1 Soil moisture

Soil moisture is the water that exists in the unsaturated zone between the soil surface and the groundwater table. The water in this area is replenished by precipitation, irrigation, and deeper capillary ascent, and is depleted by drainage, soil evaporation, and plant transpiration. It is located at the intersection of the atmosphere and the surface of the earth and is the key to energy and water balance. Additionally, it forms the intermediate step between atmospheric processes (precipitation and evaporation) and groundwater. As such, understanding its dynamics, and its measurement, can aid in more accurate groundwater estimates.

The most basic measure of water content in the unsaturated zone is soil moisture, it is usually expressed as a percentage of saturation. It is worth noting that the amount of water that can be held in the soil is limited by the effective porosity. For common soil types, the porosity is usually between 0.3 and 0.7. Based on the nonlinear equation which simulate the volumetric soil moisture relationship to the water absorption head and the unsaturated conductivity[2], the soil water stress of plants can be inferred from the volumetric soil moisture measured by microwave satellites [3].

2.1.2 Copernicus - Soil Moisture Index (SWI) dataset

Copernicus is the European Union's Earth Observation Program, which extracts information services from satellite and in-situ observation data. It provides a large amount of real-time global data and is open source. The soil moisture index SWI1km which studied in this report uses the high-resolution SAR surface soil moisture (SSM) data and combines with the ASCAT scatterometer SSM data, the resulting product achieves high temporal and spatial resolution (daily, 1km X 1km) [4].

2.1.3 KvdS - Soil Moisture (SM) dataset

The KvdS Soil Moisture data service provides raster data collected from remote sensing satellites, the service is provided by KISTERS in cooperation with VanderSat, a company specialized in earth observations through satellites. This company has developed a unique algorithm to provide accurate high-resolution images and data of soil moisture, it provides soil moisture information globally, can achieve different root zone depths, the dynamic open water is also considered through the data flags method. It eliminates the interference of clouds, vegetation, and darkness, so high-precision measurement data with 100m X 100m resolution can be obtained, as such, it has the potential to improve modeling exercises that use similar data [3]. However, because it is a commercial product, so it is a pity that there is no documentation available on the algorithm itself, therefore, we try to analyze the product by observing the images and charts generated by its data.

Table 1 – Satellite products information of Copernicus and Kisters [3] [5]

Products	**Copernicus**	**Kisters**
Soil moisture content unit	m^3/m^3	m^3/m^3
Sensing depth	0-0.004m	0-0.005m
Resolution	1km x 1km	100m x 100m
Missing data	255	65535
Temporal resolution	Daily	Daily
Test period	2018-01-01 to 2018-12-31	2018-01-01 to 2018-12-31
Sensors	ASCAT, CSAR	AMSR-2, SMAP
Geodetic datum	WGS84	WGS84
Geographic projection	regular lat-lon	regular lat-lon

2.1.4 Comparison

The current project uses a Soil Water Index (SWI) product from Copernicus that has a (measured) resolution of 1000m x 1000m, which is lower than the KvdS dataset (100m X100m). However, the SWI dataset is not only open source but can be further improved using downscaling methods, allowing us to improve the resolution and to be comparable with the KvdS data. Thus, the study is mainly focused on investigating the relative value of the KvdS dataset over the Copernicus dataset. Table 1 compares the basic information provided by the two satellite data products

2.2 Theoretical basis

2.2.1 Copernicus Soil Water Index (SWI)

The Copernicus Global Land Service SWI1km product describes the soil moisture content of 1km spatial sampling. The moisture contained in the soil profile mainly comes from precipitation through the infiltration process, the SWI algorithm is based on a simple model that describes this penetration process and the SWI is calculated.

The quality of the surface soil moisture (SSM) is assessed against in-situ measurement provided by the International Soil Moisture Network (ISMN), in the previous time period it is integrated using the following formula:

$$SWI(t_n) = \frac{\sum_i^n SSM(t_i) e^{-\frac{t_n - t_i}{T}}}{\sum_i^n e^{-\frac{t_n - t_i}{T}}} \quad for\, t_i \le t_n$$

This formula describes how the SSM observations are converted to SWI. It represents a simple two-layer water balance model, with the first layer serving as the soil surface accessible by the C-band scatterometer, and the second layer as part of the profile, extending downward from the bottom of the soil surface. The factor T determines how fast the weights become smaller and how strongly SSM observations were taken in the past influence the current SWI. t_n is the observation time of the current measurement, t_i is the observation times of the previous measurements [5].

If we imagine a two-layer water budget model, suppose L is the reservoir depth and C is the pseudo-diffusion constant representing the area. Thus, the T value used for SWI could calculate as T=L/C, which means that if the soil diffusion rate is constant, a high T describes a deeper soil layer. This also means that different soils in the same depth could be represented by different T. The Copernicus product provides eight T values (2, 5, 10, 15, 20, 40, 60, 100). After previous comparison calculations by my supervisor Lore, we found that the SWI is generally the most reliable when T=60, so we use this set of data when comparing it with the SM in Kister's dataset.

In addition, as mentioned before, the quality flags (QFLAG) method is introduced into the SWI data, it can calculate for each T value and describe the input SSM data density for each SWI value. When no SSM input is available, or when indicates frozen ground, the QFLAG of a single pixel will decrease over time. If QFLAG is below the specified threshold, the pixel is set to a flag value of 254 (the flag indicates Low QFLAG) [5]. This method can further improve the accuracy of the data, because it can point out a variety of terrains, such as snow or severe rainfall, high vegetation, open water, etc. But due to time and data constraints, the simulation done in this report does not involve the application of the quality flag.

2.2.2 KvdS Soil Moisture (SM)

Vandersat's soil moisture data is obtained using microwave sensing technology. Unlike other satellite services, this technology is insensitive to clouds cover, and not hindered by vegetation, can capture high-precision measurement data, achieve global daily data coverage, and obtain near-surface depths of up to 5 cm data.

VanderSat has a patent for downscaling technology, which can be applied to passive microwave observations, it uses a large number of overlapping observation antennas to reduce the product resolution to 100×100 m, and then retrieves the model through the search algorithm for land parameters (LPRM) [6]. The basis of the search is based on the assumption that all natural surfaces emit thermal radiation in the microwave area as a function of temperature. The propagation of microwaves in the soil depends on the soil dielectric constant, which has an almost linear relationship with soil moisture.

Because VanderSat's soil moisture measurement refers to the top of the soil, the calculate of deeper moisture can be calculated through a simple model. The method of estimating the soil moisture in the root zone is the same as that of the Copernicus Global Land Service, in this method, it is assumed that the moisture content in the soil profile is only determined by the changes at the top of the profile. The soil moisture changes are first observed from the SSM and then extrapolated to deeper soil layers, the specific formula used to calculate soil moisture can refer to in the previous section in this report.

2.3 Results

2.3.1 Visual Comparison

Figure 1 shows the soil moisture (SM) maps generated by the two satellite products in different seasons. The depth of the color in the picture represents the level of soil moisture, ranging from 0-1. A value of 1 means that the relative water content of the soil is 100%.

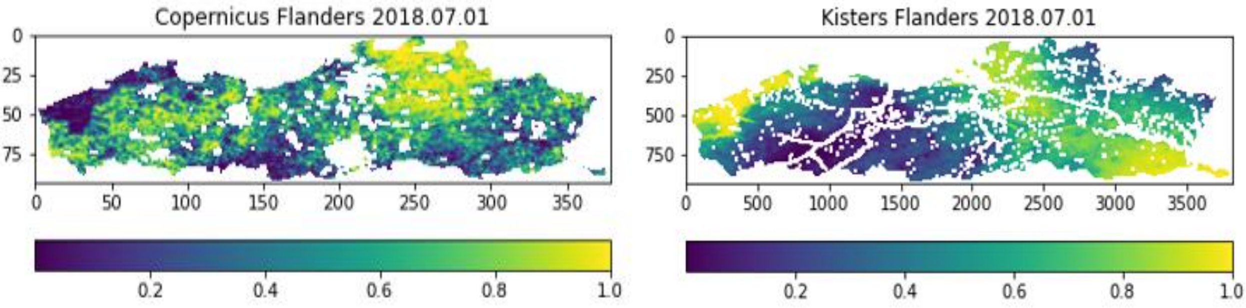

Figure 1: The Comparison of satellite map in Flanders (Copernicus VS Kisters)

First of all, by comparing the soil moisture maps of Copernicus and Kisters, we can find that they both have different degrees of missing data. By comparing with the topography map of Flanders in appendix (A1), it can be roughly judged that the missing data on the Copernicus map is the urban area, and the missing data on the Kisters map is the open water. For example, the cities Brussels and Antwerp in the central part of the Flanders region have a lot of blanks in the corresponding positions on the Copernicus map. The blank urban area in the map is due to the soil moisture there is much lower than the long-term average, thus the SSM algorithm used by the Copernicus ignores meaningless areas such as inland waters and urban areas [5]. It is worth noting that the urban area on the Kisters map is not blank, this is due to the data in urban areas is not real soil moisture but just the dielectric capacity of the concrete [4]. On another hand, on the Kisters map, the blank areas can roughly correspond to the rivers in the northern Flanders region, in addition to river flows, there are some clusters of "blank spots", which are supposed to correspond to some lakes, reservoirs, etc. In addition, by consulting the VanderSat operating manual [4], it can be known that the blank spots could also be the areas with high vegetation coverage, or areas affected by radio frequency interference (RFI), rain, and snow will also have data missing.

Both of the two satellite maps above show the soil moisture data on July 1, 2018. It is not difficult to see that in general, the soil moisture in the west is lower than that in the east, but if you look further and discuss each area, you will find there are large discrepancies. For example, in the west, the soil moisture displayed by Kisters is obviously smaller, reaching about 0.2, but the soil moisture of Copernicus is about 0.6. Besides, in the west area, the Copernicus map has higher soil moisture in the hinterland compared to the polder, and the Kisters map does the opposite. Due to the resolution of Kisters data is relatively high, it can be well seen that the soil moisture becomes smaller as the distance from the river becomes further, it shows a decreasing trend, in contrast, it is difficult to find the decreasing trend on the Copernicus map.

In addition, in the lower east part of Flanders, the soil moisture in the east is significantly higher than that on the west, it is guessed that this may be due to the influence of the local altitude. Compared with the topography map in appendix A1, we can find that an interesting phenomenon in the Copernicus map, that is the soil moisture is relevant to the topography to some extent. For example, the high altitude in the south will show lower soil moisture than in other areas, such phenomenon is not found in the Kisters map.

Another point worth noting is that if we observe the polder area of the Flanders map, we will find that its soil moisture is opposite in the two satellite maps. On the left map, the soil moisture is less than 0.2, however, on the right map, the soil water is abnormally high, even exceeding 0.8. To analyse this phenomenon, compare it with Flanders' soil distribution map in Appendix A2, it is found that the soil texture in the polder area is dominated by clays whilst the surrounding area mainly consists of sand and loam. Therefore, I speculate that the calculated proportions of these two products for soil texture are different when simulating soil moisture data.

In addition, we also expect significant changes in soil moisture around rivers. For example, the closer the river is, the wetter the soil will be, as the distance from the river becomes longer, the soil moisture content will show a downward trend. This phenomenon has not been observed on the Copernicus map but could observe on the Kisters map. However, in some maps (Appendix A3), this phenomenon appears not very obvious, I assume that perhaps the lush vegetation around the river will obstruct the observation and affect the soil moisture measurement. In addition, it could also be due to the seasonal component, especially according to the record, the year 2018 is a very dry year, this can be a crucial reason for the abnormal measurements. Appendix A3 shows the comparison of the four seasons of two satellite maps. I extracted four days (1st Jan., 1st Apr., 1st Jul. and 1st Oct.) from the daily data in 2018 to represent the four seasons of spring, summer, autumn, and winter. From this, we can analyze how SM changes with the seasons.

Roughly speaking, it is hard to sum up the pattern from the first impression, but both products maps show that the soil moisture in the east of Flanders is lower in spring and winter, and it becomes much higher in summer. In addition, if you simply visual inspection the Copernicus map, you will find that the soil texture has a significant impact on the seasonal changes of soil moisture, and this phenomenon has not been found in the Kisters map. When we simply analyse the Kisters map, we will find that the river basin and topography will have a more obvious impact on the seasonal changes of soil moisture, and this phenomenon is not reflected in the Copernicus map.

In addition, when we observe the silt loam area in the south of the Copernicus maps, we will find that the soil moisture in this part is obviously different from the surrounding soil and will show obvious changes with the four seasons. Besides, when we observe the soil moisture around the river in the right picture changes, you will find that it fluctuates significantly with the four seasons. And perhaps because of the higher resolution of Kister, when comparing the overall with Copernicus, you will find that the soil moisture measured by Kisters changes in the entire region is larger, and the changes in the geographic range appear smoother.

2.3.1 Visual Comparison

These histograms in figure 2 shows the frequency of observations of Soil moisture in one day. Pink and blue represent the data of Kisters and Copernicus respectively. The four histograms represent winter and summer to show the comparison of the data of the two satellite products. As mentioned above, the four dates represent the four seasons.

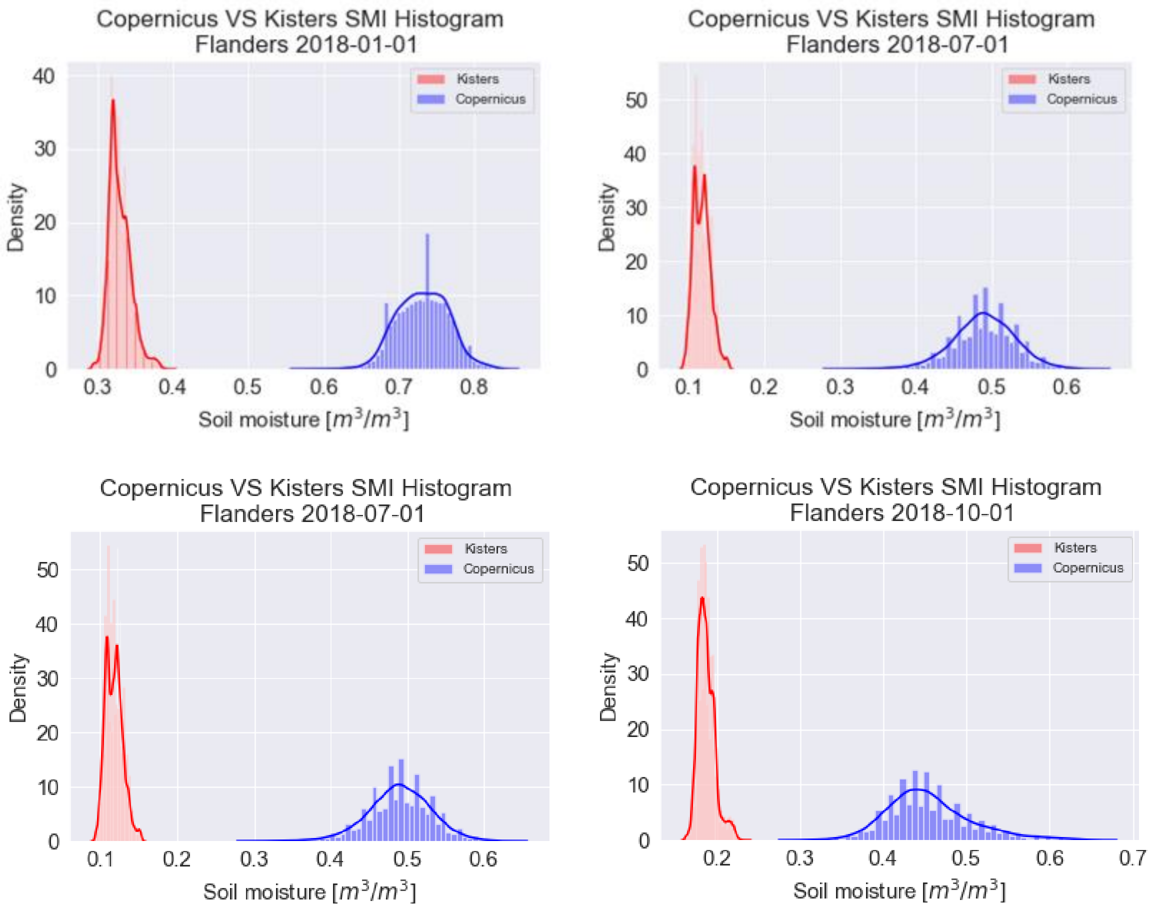

Figure 2 – Seasonal comparison of the daily soil moisture in histogram (Copernicus VS Kisters)

First of all, you can see that these two sets of values are not in an overlapping state, but are distributed in different numerical ranges. Kisters' soil moisture is distributed between approximately 0-0.4, and Copernicus's soil moisture is distributed between 0.2-1, which leads to this gap. One of the biggest reasons may be that the soil depths measured by the two products are different. Another obvious difference is that the Copernicus data has a wider distribution range, the distribution shape is closer to the normal distribution, and the characteristic is smoother, but the peaks and valleys are not very obvious. At the same time, the distribution of Kisters data is more compact, the distribution curve is steeper, and sometimes there is more than one peak. In addition, Kisters' data density is higher, because its products have higher resolution, so there are more data. This effect can be ignored when analysing the distribution of soil moisture values.

However, when we compare from the seasonal scale, we will find that the two products have a lot in common. For example, for the two datasets, the peaks in spring and winter are relatively close, and both are higher than the peaks in summer and autumn. This may be because there is less sunshine in winter and spring, and the evaporation rate of rainfall or snowfall is slower, so the soil moisture can be kept at a higher level more stably. In addition, it can be observed that the soil moisture peaks in autumn and summer are relatively larger, but the density fluctuations are also greater. The value of soil moisture is more extreme and the distribution range is larger than that in winter and spring. This may be due to the fall and summer's rainfall is greater and more frequent, resulting in higher peaks and greater density. However, due to sunlight evaporation, vegetation, runoff, and other reasons, the soil moisture declines faster, which also resulted in many extremely low soil moisture values during this period.

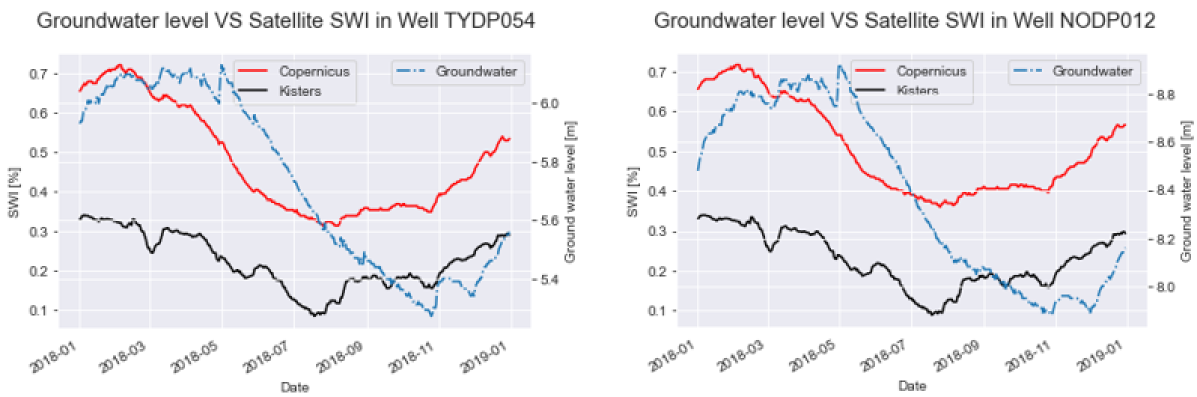

Figure 3 – Compare the groundwater level with soil moisture satellite data from Copernicus and Kisters in 2 wells in Flanders

First, observe the soil moisture of the two products in figure 3, they show a basically consistent trend in the time series, but it can also be found that the peaks and troughs of the Copernicus data are not as accurate as Kisters. In addition, it can be seen that their soil moisture dataset do not overlap but two curves that are almost parallel to each other. The main reason for this phenomenon has been mentioned before, which is caused by the difference in the depth of soil moisture measured.

Next, when we compare the soil moisture curves with the groundwater level curve, we will find that the groundwater level fluctuates in a similar trajectory in time sequence. In detail, they both maintain a high level in winter and spring, then in summer shows a downward trend, reaching the lowest value in late summer or autumn and then slowly rising again.

In addition, the value of groundwater level varies more widely, and its fluctuation is delayed compared to soil moisture curves. It can be concluded that soil moisture and groundwater level have a significant correlation. The declining trend in summer can be regarded as the influence of solar evaporation and vegetation absorption, while the increasing trend can be regarded as the decrease of sunlight, the decrease of temperature, the decrease of evaporation, and the extraction of vegetation, water capacity declines, etc. Furthermore, the delayed phenomenon of groundwater level can be explained as the soil moisture measurement is in the surface soil, which makes it the first to feel the changes in the external environment, such as rainfall and evaporation, while groundwater is usually deeper underground. Therefore, it is less affected by climate and external influences. In addition, it takes a certain time for rainfall to penetrate the soil and enter the groundwater, which may cause the delay of its response as well.

When I calculate the correlation (R) between the two soil moisture products and groundwater level, we found out the correlation between Copernicus SM and groundwater level is 0.685, the correlation between Kisters SM and groundwater level is 0.539. In order to confirm the reliability of this result, I also used the Kendall rank corelation calculation method, and the results are 0.332, 0.288 respectively. The correlation results look very reasonable, and for both correlation results the R between groundwater with Kisters is surprisingly lower than with Copernicus, this is completely different from our expectation that Kisters with higher accuracy will have better correlation results.

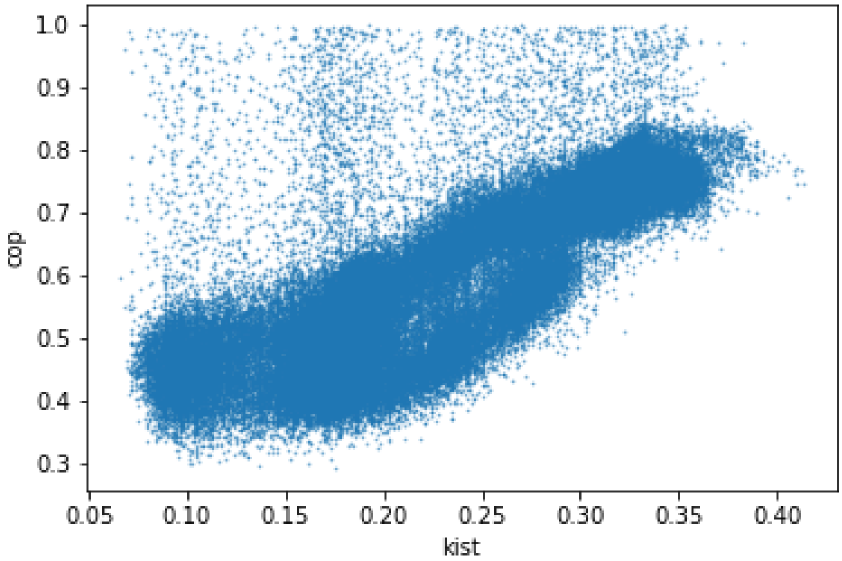

Figure 4 - the correlation between two soil moisture products——Copernicus(cop) & Kisters (kist)

To interpret the correlation between Kisters SM and Copernicus SM from the scatter plot in figure 4, we compare the SM data covered the whole of Flanders within 1 year. In the previous histograms, the SM data were compared from the whole Flander area in 1 day, and in the line plots, the SM data were compared from one point for while year, this indicates that the study was trying to analyze from different perspectives.

In the scatter plot, as the data show an uphill pattern from left to right along the x-axis, this indicates a positive relationship between Kisters and Copernicus, as the Kisters soil moisture increase, the Copernicus soil moisture tends to increase. In addition, the calculated Copernicus and Kister's correlation is 0.938, in the Kendall rank correlation is 0.85166, which shows an obviously high correlation relationship.

2.4 Discuss and Conclusion

The main purpose of this study is to compare Kisters and Copernicus satellite products in various ways and get an insight into the accuracy of satellites when measuring soil moisture. There are two main ways to compare, a visual comparison and figures comparison. In visual comparison, I created the daily Flanders maps and compare the similarity and differences between the two products, the result shows that both products have different degrees of missing data, for Copernicus, it is urban areas, for Kisters it is mainly open water. Generally, the SM of the two products is roughly the same in terms of seasonal changes, but in detail, different areas show divergent results. In addition to geographical and seasonal factors, I also observed other parameters that influence the SM measurements. For instance, the soil texture has a significant influence on Copernicus SM, but less influence on Kisters, and topography has an intensive influence on Copernicus, but the not an obvious influence on Kisters. In addition, it is obvious from the map that Kisters has higher resolution and smoother changes in SM, but it is difficult to determine which product has more accurate data from visual comparison alone, so I proceed to the next step which is figure compare.

The figure comparison includes comparing the daily SM density of Flanders area in histograms, showing the changes of SM at certain coordinates along a year in line graphs, and showing the correlation between two products through the scatter plot. In histograms, it can be observed that the SM density of the two is similar in seasonal changes, but it also shows that the distribution of Kisters data is more compact, the distribution curve is steeper and more peaks occur, which means that Kisters products are more sensitive to measurements. While comparing SM to groundwater level In the line graphs, the SM of two products show a basically consistent trend in the time series and fluctuates in a similar trajectory with groundwater level, thus both SM datasets have a significant correlation with groundwater level. Another worth noting is that the correlation of groundwater level with Copernicus SM and Kisters SM is 0.685 and 0.539 respectively, which means that the correlation between Copernicus SM and groundwater is higher. Last but not the least, it is obvious that there is a positive correlation between the two products In the scatter chart, and the calculated value R is as high as 0.938, this also indicates they have a significant correlation.

From the above observations, it can be found that each product has its own advantages, and it is difficult to conclude which one is a generally better choice, especially because Kisters is a commercial product but it did not show the expected performance that greatly exceeds the performance of Copernicus products, so currently I do not recommend using Kisters products to replace Copernicus. However, because this study did not take into account the Data flags of the two products, it ignored conditions such as vegetation coverage, open water, frozen soil, and areas affected by radio frequency interference (RFI), rain, and snow, such data make the Kisters products have a very detailed data classification, thus it is expected that after considering Data flags, the details and the accuracy of the Kisters dataset will be improved to a certain extent.

3. Critical reflection

3.1 Reflection on Company

In the company, there are a lot of different divisions, each with its own projects. The Ghent office has about sixty employees, and two or three employees worked with me on the project. In theory, there was no need for cross-divisional interaction, but in practice, I got to know other employees very well, over lunch or just in casual conversation during or outside working hours. Each Friday afternoon, there was a food truck event organized by the company, which allowed a lot of friendly conversations and friendships to start over food.

From my perspective, the relationship between the employees was very good, I liked very much the casual atmosphere between employees. In comparison to my previous internship in Poland and in Huawei, Antea created a very inclusive and international environment. In the laboratory in Poland, I was the first non-Polish employee, which made it more difficult to have tight connections between the employees. In Huawei, though I learned a lot of skills in that job, but at the same time, I also faced frequent overtime and high work pressure.

In contrast, I prefer the working environment of Antea Group. one of my impressions was that there weren't any fixed working hours. Employees were free to come and go as long as they finished their projects in a timely manner. Overall, one employee should work eight hours a day, but an employee can choose themselves where these eight hours fall. In addition, I thought that the hierarchy structure within the company was different from what I know. As a Chinese, there is a very strict hierarchy within most Chinese companies. However, after one month of internship, to me, it was not clear who was the CEO of the company, or who was the leader. The hierarchical structure was very flat, and the power distance between the different employees was very small. If I needed help from a certain expert within the company, I could in theory directly contact the expert, without having to first ask permission from my boss. This company structure was very different from what I have experienced in the past and showed me the possibilities of the corporate hierarchy.

Finally, I want to be thankful to my supervisor because he is the most enthusiastic supervisor I have ever met. Whenever I encountered a problem and asked for help, he would always reply in great detail to my questions. I thought he was very gifted at solving problems creatively as he inspired me to think like an engineer and not as a student. I am also very grateful to my other supervisor, she was a very logical, clever, and patient supervisor. She taught me how to code logically so that the codes can be more understandable reviewed by other engineers. She also guided me patiently to code concise and effective like an engineer It is very impressive that she is willing to listen and is good at inspiring people's creativity. In general, my supervisors made me realize that you should consider certain obstacles from a larger point of view in order to think further ahead and evade problems further along the road.

3.2 Reflection on IUPWARE program

I have now completed the one-year course of the project. The diverse courses and solid basic knowledge teaching impressed me. Among them, the courses in groundwater hydrology and surface water hydrology have greatly helped my internship, they provided me with a basic knowledge reserve for analysing hydrological problems. The QGIS course gave me a preliminary understanding of hydrological maps and the ability to analyse and create basic maps. However, I feel that there is a big difference between my studies and what I was asked to do in my internship. There is little focus on coding in my studies, we only learn the basics of the Python programming language, but ninety percent of my work at the company was engineer-level coding in Python. This caused a lot of difficulties in my early internship, I had to spend a lot of time familiarizing myself with how to solve hydrological problems from programming thinking and implement it with code.

In addition, I feel that my understanding of the model is still very limited, and I am still very new to the knowledge of satellite monitoring. I find it a pity that, in my current semester, the third semester, several advanced modelling courses are introduced, which aim to improve our modelling skills in programming, furthermore, the Earth Observation course is introduced this semester as well, which covers the knowledge of satellites and analysis of earth observation results, In my opinion, this knowledge would be very helpful to perform well in the internship, therefore, the internship might be more suitable and worthful for someone who has already passed all the courses in the third semester.

We did learn about some water engineering software, like Faoclim, Modflow, QGIS, python in class, which are very useful, they allow me to have a general understanding of the field where I need to work, and provides me with ideas for solving problems. But I experienced that there is still a large difference between learning about it and applying it to concrete situations. The internship was therefore a good experience to see how certain programs and models are applied in real life. Thinking like an engineer to solve the problem was really hard, At work, I have to start from the perspective of problem-solving, selectively learn the knowledge I need, and apply it in time. I learn new things with a concrete goal in mind, this makes me feel very Interesting and challenging, ties me to learn the knowledge in a deeper understanding and more applicable way. In class, however, I just study what the professors provide, trying to get good grades, but don't realize the utility of the things I learn. In one word, the internship made me realize where my interest lies in the water engineering field, now I have a more clear idea of which job might suit my strengths more.

3.3 Reflection on personal performance and development

Overall, I think this internship is very worthwhile but I performed a bit below expectations. Even though I learned a lot, I was not able to follow the planned schedule tightly.

Besides the necessary requirements needed to perform better as an intern at Antea Group, there were two other personal factors and one general factor which inhibited my progress at the firm. The first personal factor was my medical condition made it difficult for me to focus on the tasks at hand. On multiple occasions, I had to go see the doctor and take heavy medication. The second personal factor is that I had make-up exams during my internship period, which added to the already existing workload of the internship. Both of these factors are conditional and are therefore most likely not applicable to other students. One other general factor is that the company is located in Gent, which makes it difficult for students who are based in Leuven to do an internship there. You could decide to commute from Leuven to Ghent, but this will takes three to four hours a day on commuting without a car. You could finally also decide to work from home, this was encouraged because of the pandemic, which means that receiving feedback from supervisors is not as direct and not as easy.

Due to the reasons mentioned above, also due to the deviation of my understanding of the skills required for the internship content, the results of my internship were somewhat lower than my initial expectations. Last but not least, I think I can still improve my programming skills a lot as well. In the beginning, I didn't expect that there would be this much programming and that I had to help resolve certain problems through intensive discussions with my team. Most of my time was spent getting familiar with the coding techniques and basic abilities. I felt the project ended up being more independent than I anticipated, and it would be much helpful to do more extensive preparation before the start of the internship.

Even though I did not perform as well as I thought I would, but I still learned more working skills and knowledge from my supervisors than I expected, and I actively advise new students from water engineering to also take this internship, but maybe after the third semester instead. The company and the supervisors are really nice and helpful and the internship overall was a positive and enjoyable experience.

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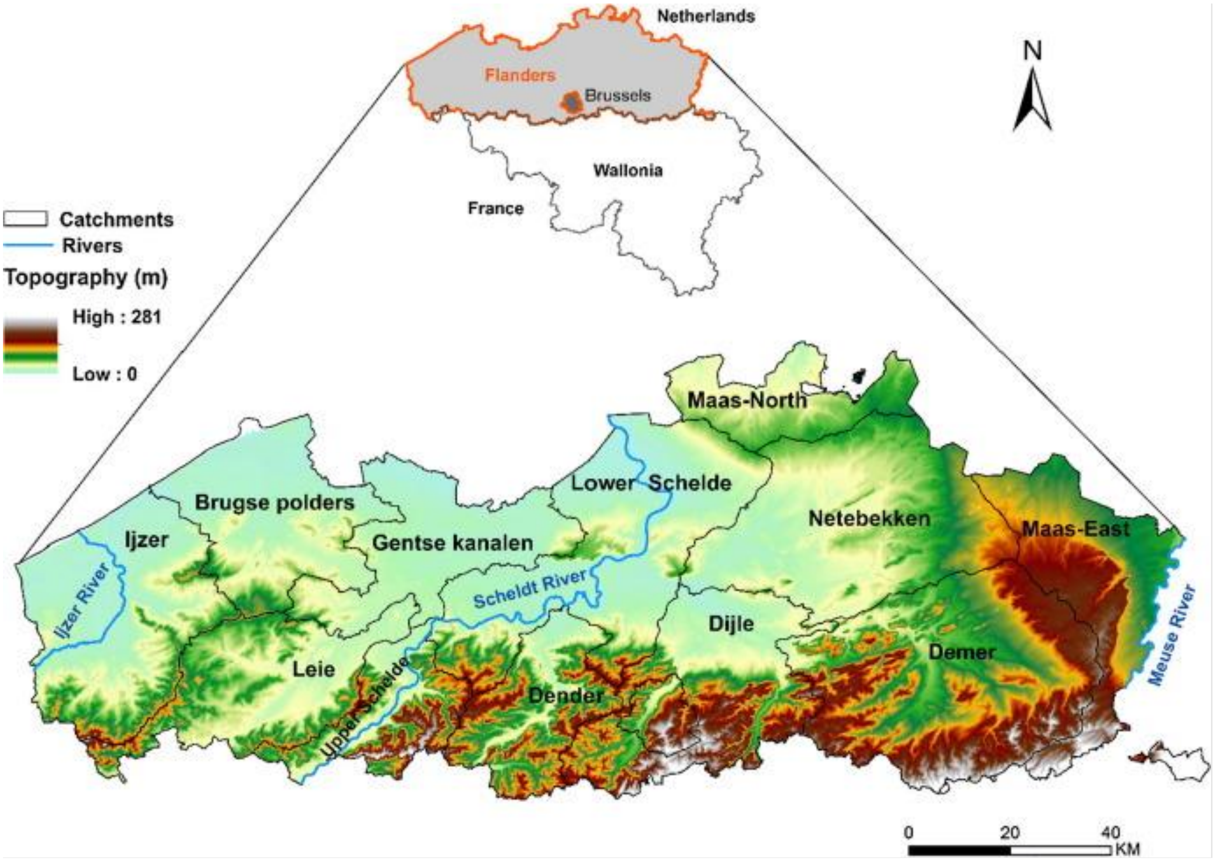
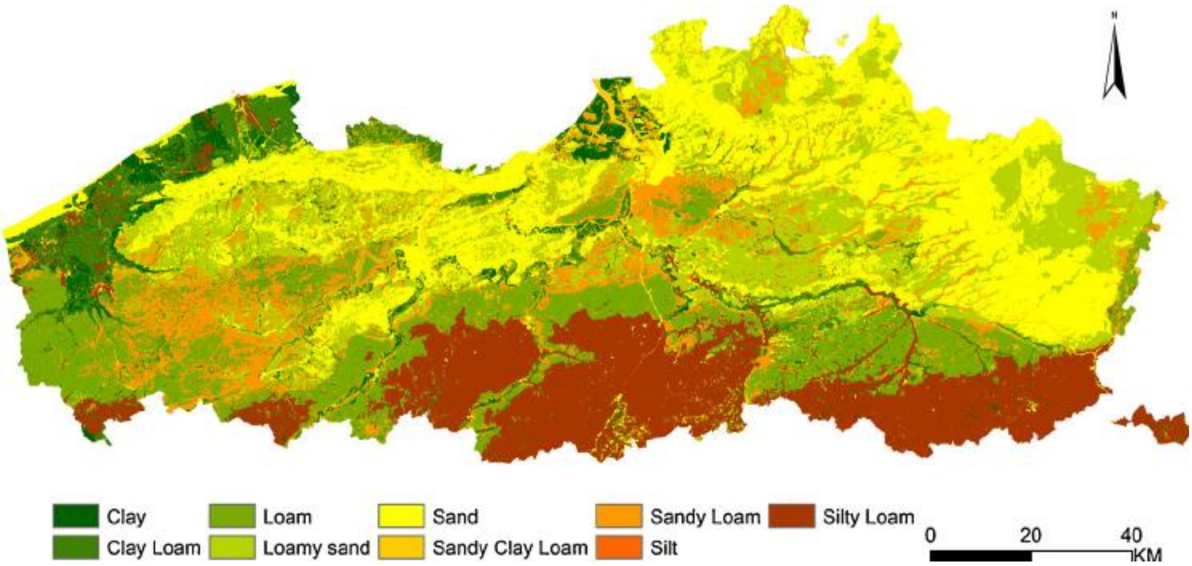
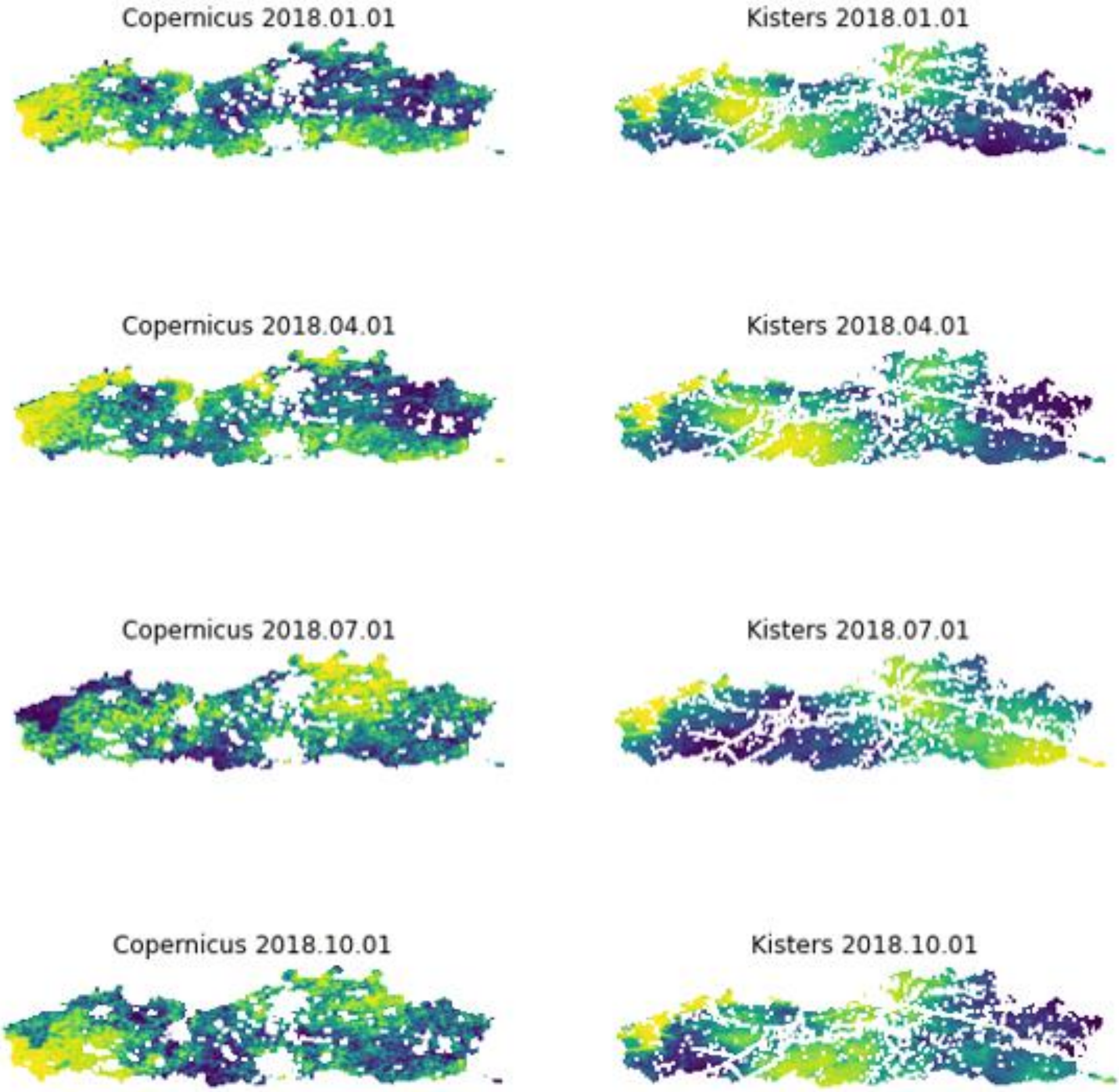


A1 – The topography map of Flanders, Belgium [7]



A2 – The soil texture map of Flanders, Belgium [8]



A3 - The seasonal comparison of satellite maps in Flanders (Copernicus VS Kisters)