

PALUPERA BASIC SCHOOL

**COMPARISON OF CLOUDS OBSERVED BY PALUPERA
GLOBE MEMBERS AND NASA SATELLITES**

Research

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INTRODUCTION

In our research project "Comparison of clouds observed by Palupera GLOBE members and NASA satellites" we compare our measured and the NASA satellites observed data on clouds at the Palupera GLOBE's measurement point.

Our place of measurement is next to the schoolhouse in the park. The school is located in Elva Parish, South Estonia. The studies take place in an old manor house with a centuries-old atmosphere and a modern learning environment. The school participates in the GLOBE program for 10 years now.

We are members of the GLOBE program since autumn of 2016 and are engaged in atmospheric measurements and data transfer to the GLOBE database. In addition, we have introduced the GLOBE program and atmospheric surveys to both younger schoolmates and visitors.

Considering the feedback from NASA's Langley Research Centre, the idea was to compare clouds at our measurement site with the data on clouds collected by NASA satellites in the period from August 2017 to August 2018.

Hypothesis: Data fixed by the human eye and satellite sensors coincides by at least half, or 50%.

1. RESEARCH METHODOLOGY

1.1 Planning the research

The research began with the planning of work and the drafting of the plan. We started in autumn 2018. We used the GLOBE's cloud classification to determine the types of clouds. We searched for information about English-language web materials on satellites.

1.2 Data processing

To obtain the data, we worked through 180 days of data received by e-mail as feedback from NASA. NASA sent data for each day in a table that you see. The following sample (figure 1).

NASA Cloud Observation and Satellite Match			
Satellite	GEO	Terra	Your Observation
Universal Date/Time 2018-04-21	10:10	10:01	10:00
Latitude Range	57.8 to 58.44	57.72 to 58.52	Latitude 58.12
Longitude Range	26.02 to 26.66	25.93 to 26.73	Longitude 26.33
Total Cloud Cover	Overcast 100.00%	Overcast 97.99%	Overcast (>90%)
H I G H Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity		No Clouds	
M I D Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Broken 65.85% 2.26 (km) Water 270.26 (K) Opaque	No Clouds	
L O W Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Scattered 34.15% 1.79 (km) Water 273.22 (K) Translucent	Overcast 97.99% 1.56 (km) Mixed 270.76 (K) Opaque	 Stratus Overcast (>90%)
Corresponding NASA Satellite Images. Click to view image --->	METEOSAT-11 Infrared 	MODIS Rapid Response Webview 	Sky Visibility - no report Sky Color - no report Windowsi aktiveerin Windowsi aktiveerin
	GEO Tutorial	MODIS Guide	

Figure 1 An excerpt from the data received from NASA.

This table contains the data sent by the Palupera School's GLOBE students and data from the satellites which crossed over the GLOBE observation site +/-15 minutes compared to the GLOBE observation time.

The data from the e-mails was transferred to our own tables. The data was manually transferred to the table because it was more convenient and faster: one of us searched and opened e-mails, read the data and another carried the data into the table (figure 2).

LEHT 12

Palupera GLOBE pilvevaatluste ja NASA satelliitide andmete võrdlustabel

Vaatluse nr	Kuupäev	Taeva kaetavus (%)	GLOBE	GEO	Aqua	Terra	Aura		
122	04.07 2018	üldine	30	37				+	
		kõrged pilved	0	0				-	
		keskmised pilved	0	45					
		madalad pilved	30-30	52				+	
123	05.07 2018	üldine	30	100	38			+	+
		kõrged pilved	0	0	0			-	-
		keskmised pilved	0	100	60				
		madalad pilved	30	0	38			-	-
124	06.07 2018	üldine	30	100				+	
		kõrged pilved	0	0				+	
		keskmised pilved	0	60				-	
		madalad pilved	30	39				-	
125	07.07 2018	üldine	50-30	88				+	
		kõrged pilved	0	0				+	
		keskmised pilved	0	65				-	
		madalad pilved	50-30	23				-	
126	08.07 2018	üldine	30	100				+	
		kõrged pilved	0	5				+	
		keskmised pilved	0	34				-	
		madalad pilved	30	0				-	
127	09.07	üldine	50-30	30				-	
		kõrged pilved	0	0				+	
		keskmised pilved	0	62				-	

Figure 2 Excerpt from the table of data. Photo by A.Silk

As satellites do not specify cloud-type, a table of clouds is divided into three groups based on the altitude of the clouds, and the coverage of high (upper), middle and low clouds is defined as percentages, as well as the overall cloud coverage of the sky in percentages.

This was followed by data processing to investigate how much of the data from the GLOBE site matched that of the satellites. The match was marked with a "+" including a small difference of up to 10%. The non-match was marked by "-" in the tables (figure 3).



Figure 3 Authors of the research project working on processing the data. Photo by A.Silk

1.3 Data analysis

To analyze the data, get results and draw conclusions we read together "plusses" and "minuses" and compared them. Based on this, we compiled tables and graphs in Excel.

Based on charts and tables, we formulated the results and tried to explain the mismatch between our data and the satellite data.

2. RESULTS AND CONCLUSIONS

2.1 Cloud coverage in the GLOBE and satellite data

Cloud coverage at Palupera GLOBE site was compared to cloud coverage observed by satellites Aqua, Terra and GEO. We compared the general cloud coverage, and cloud coverage of high (or upper), middle and low clouds. The "plusses" are the recorded hits and the "minuses" are the misses between the collected and observed data (table 1, figure 4).

Table 1 Cloud coverage- coparison of collected and satellite data

		plusses	minuses
general	GLOBE - AQUA	36	9
	GLOBE - TERRA	24	21
	GLOBE - GEO	84	56
High (upper) clouds	GLOBE - AQUA	36	13
	GLOBE - TERRA	28	17
	GLOBE - GEO	90	50
middle clouds	GLOBE - AQUA	30	19
	GLOBE - TERRA	28	17
	GLOBE - GEO	55	85
lower clouds	GLOBE - AQUA	25	24
	GLOBE - TERRA	13	26
	GLOBE - GEO	31	109

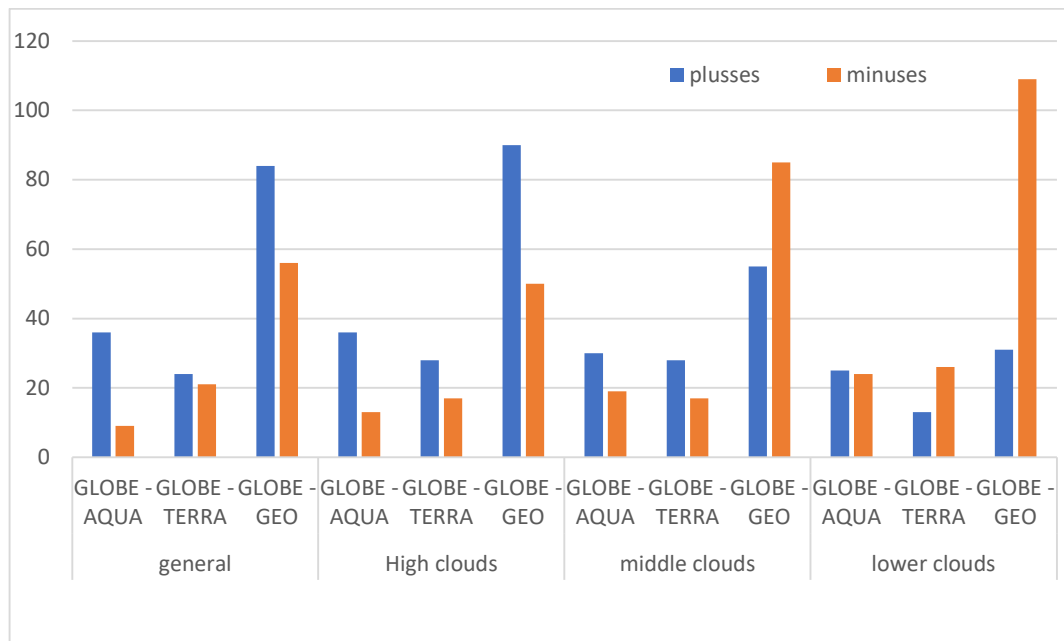


Figure 4 Cloud coverage- coparison of collected and satellite data.

Figure 4 shows that there is a match between the GLOBE and satellite data in the case of overall cloud coverage and high (upper) clouds. The biggest difference occurred in the case of low clouds. The potential reason could be that the observers mixed up the low and middle clouds. Further reasons were found to explain the differences and were transferred to the table (table 2).

Table 2. Reasons for differences between gathered and observed satellite data

GLOBE	SATELLITE
Data collection relies on the human eye	Data collected by sensors
Clouds observed bottom-up	Satellite pictures taken top-down
In the case of 100% of low clouds the upper clouds cannot be seen	Satellite sensors determine cloud layers at different altitudes
In winter, snow and clouds are observed separately	Satellite pictures do not differentiate between snow, ice and the light colour of clouds.
Airplane trails are distinguishable from clouds.	Airplane trails are not very distinguishable from clouds
The human eye is more reliable	Technology can break down

2.2 Results of measurements of different satellites

Sometimes there are two or three satellites crossing over at the same time. There was an interest in whether the data measured by satellites coincided with one another. The following are comparisons between the Aqua, Terra and/or GEO satellite data (table 3, figure 2).

Table 3 Comparison of observation data for different satellites

	Cloud coverage	plusses	minuses
AQUA - TERRA	general	10	0
	High (upper)	9	1
	middle	8	2
	lower	9	1
GEO - TERRA	general	11	11
	high	17	5
	middle	12	10
	lower	15	7
AQUA - GEO	general	18	8
	high	22	4
	middle	11	15
	lower	14	12

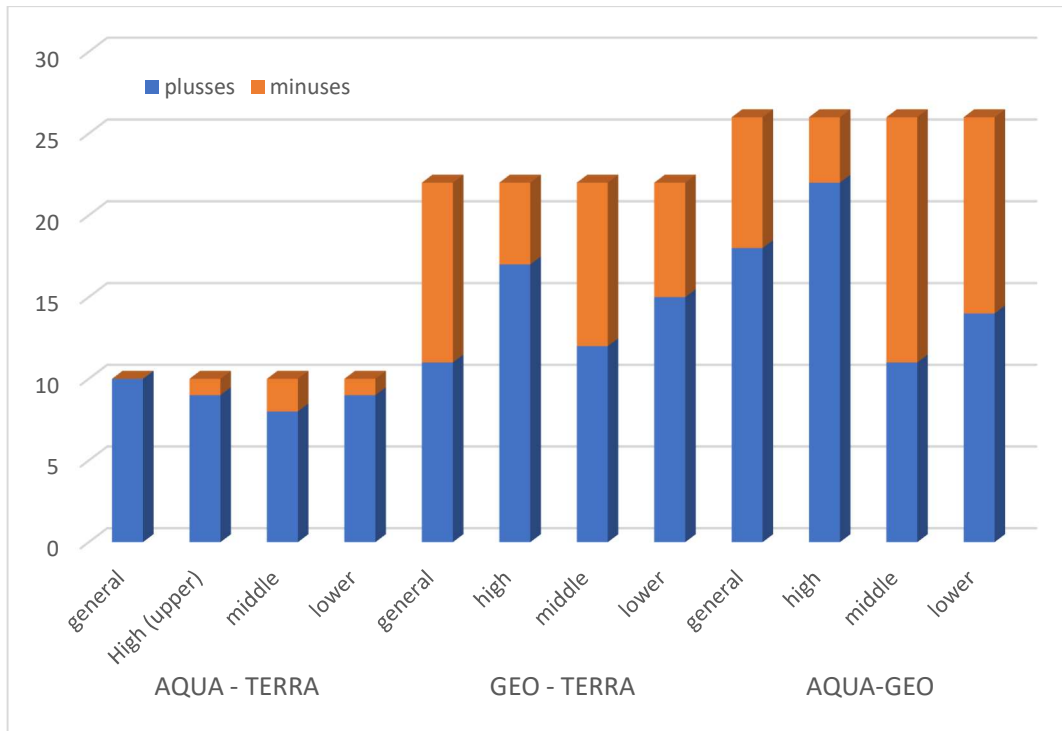


Figure 5 Comparison of observation data for different satellites.

Figure 5 shows that the highest data match was between the Aqua and Terra satellites. Aqua and GEO satellites data had differences between low- and medium-altitude clouds. Similar results occurred between measured data and the GEO satellite. In half of the cases there were matches between GEO and Terra satellites. Figure 6 shows the frequency of occasions where one, two or three satellites were measuring at the same time within the 180 days. For example, two satellites measured at the same time on 40 days, three satellites on seven days and one satellite on 133 days.

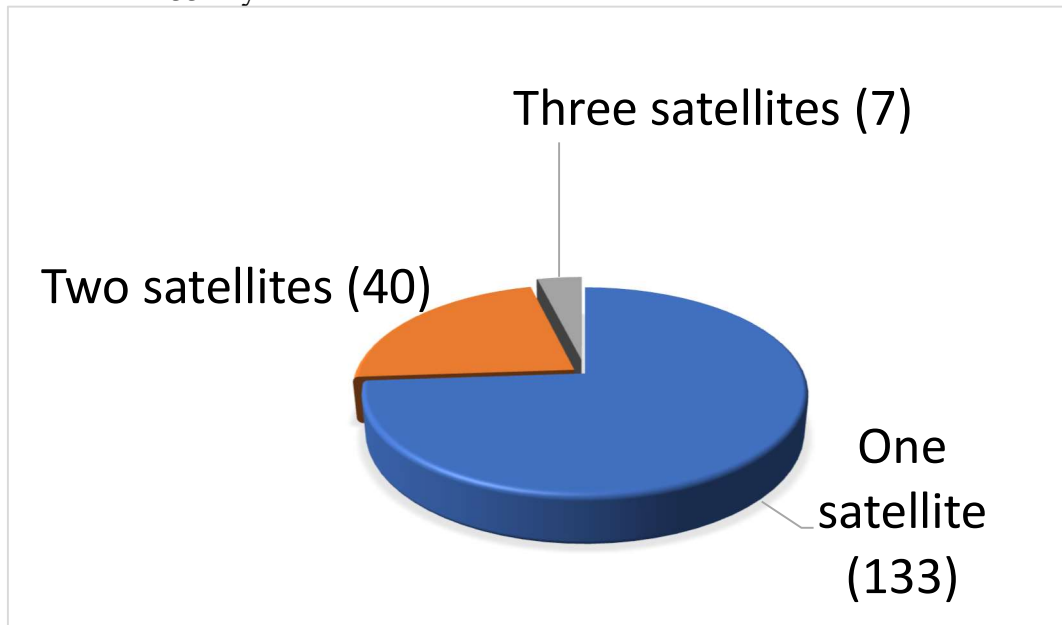


Figure 6 Number of days when measurements were made by one or more satellites at a time.

SUMMARY

The analysis of data covered the period from 15 August 2017 to 28 August 2018, or almost one calendar year. The comparison could be carried out for 180 days with no satellite data available for the other days since only the data was taken into account when the satellite was passed from the GLOBE observation site for +/-15 minutes compared to the GLOBE observation time. The first data of the observation period are from satellites Aqua and Terra. The GEO satellite began to fly over the observation site from January 2018. By August 2018 there was consistent GEO satellite data, other satellites rarely crossed the site.

The greatest match in the results of gathered and satellite data were in the cases of general cloud coverage and upper (high) clouds. Medium and low clouds were in many cases exchanged. The biggest difference was between the Palupera GLOBE site data and the GEO satellite data. In cases where the measurements were carried out by two or three satellites at the same time, the biggest match was between Aqua and Terra GEO satellite data differed from other satellites data, not just the data from the Palupera GLOBE site

The hypothesis was confirmed — in the case of overall sky clouds, the result match was more than 50%, with GEO satellite results being greater.

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