Comparison of land surface albedo between MODIS and ground-based measurements at the Thule High Arctic Atmospheric Observatory (THAAO) in Pituffik, Greenland

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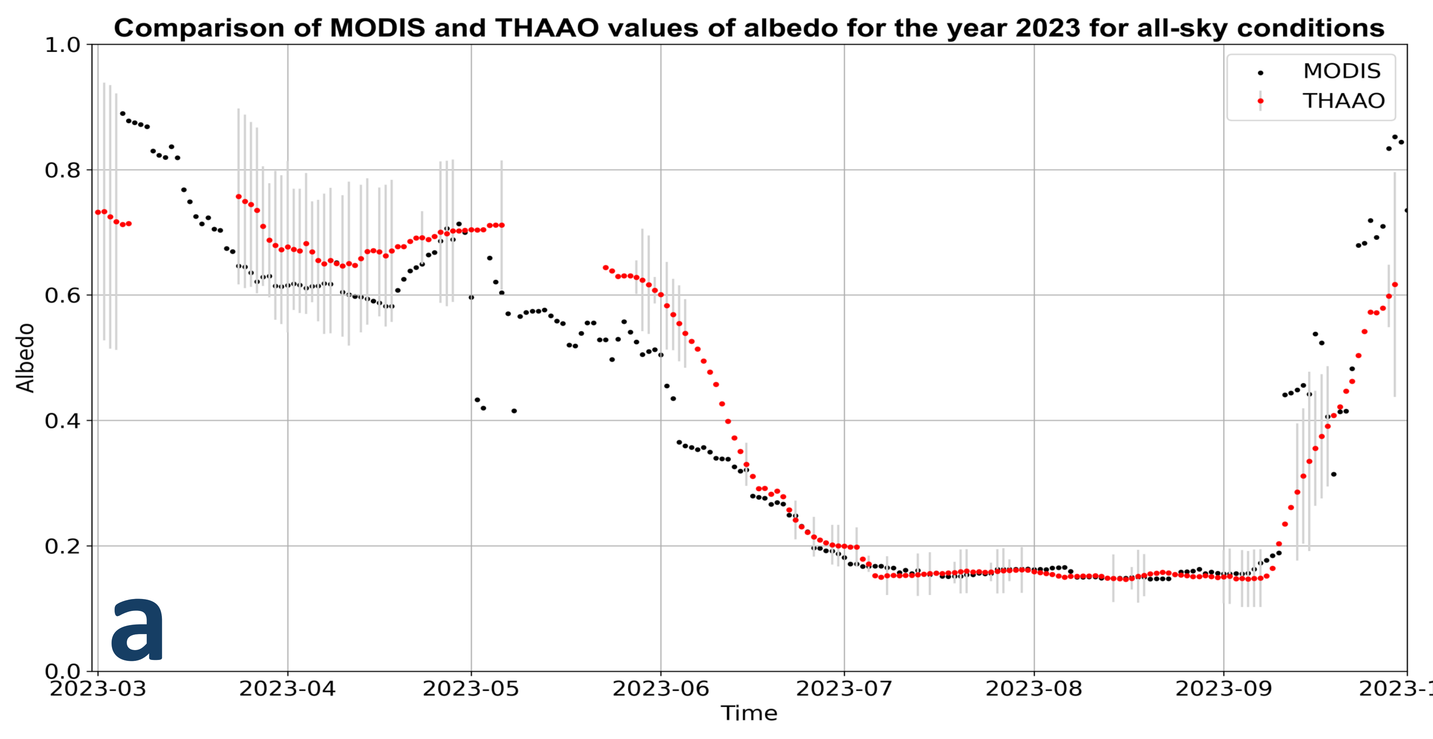
INTRODUCTION - OBJECTIVES

The albedo plays a crucial role in the radiative balance processes in the Arctic regions. The small number of operational ground-based instruments makes remote sensing observations, as those made from satellites, important, ion particular for cases of albedo rapid changes.
In this work, a comparison between ground based and satellite measurements, at the Thule High Arctic Atmospheric Observatory (THAAO) in Pituffik, Greenland, was conducted. The main objective was to assess how the satellite instruments are capable to evaluate the rapid albedo changes in polar areas.

INSTRUMENTS AND SITE

Ground based observations are made at the Thule High Arctic Atmospheric Observatory (THAAO, 76.52° N, 68.76° W, 220 m asl) in Pituffik, North Western Greenland. A Kipp and Zonen CMP21 radiometer is used to measure the solar downward irradiance, while an Eppley PSP monitors the upward solar irradiance (Figure 4). The radiation measurements are traceable to the World Radiation Reference scale. Observations from MODIS sensors, installed on Terra and Aqua satellites, were used. MODIS albedo is provided at a spatial resolution of 500 m, and as an average value over a period of 16 days. Data from July 2016 to October 2023 are used in the comparison.



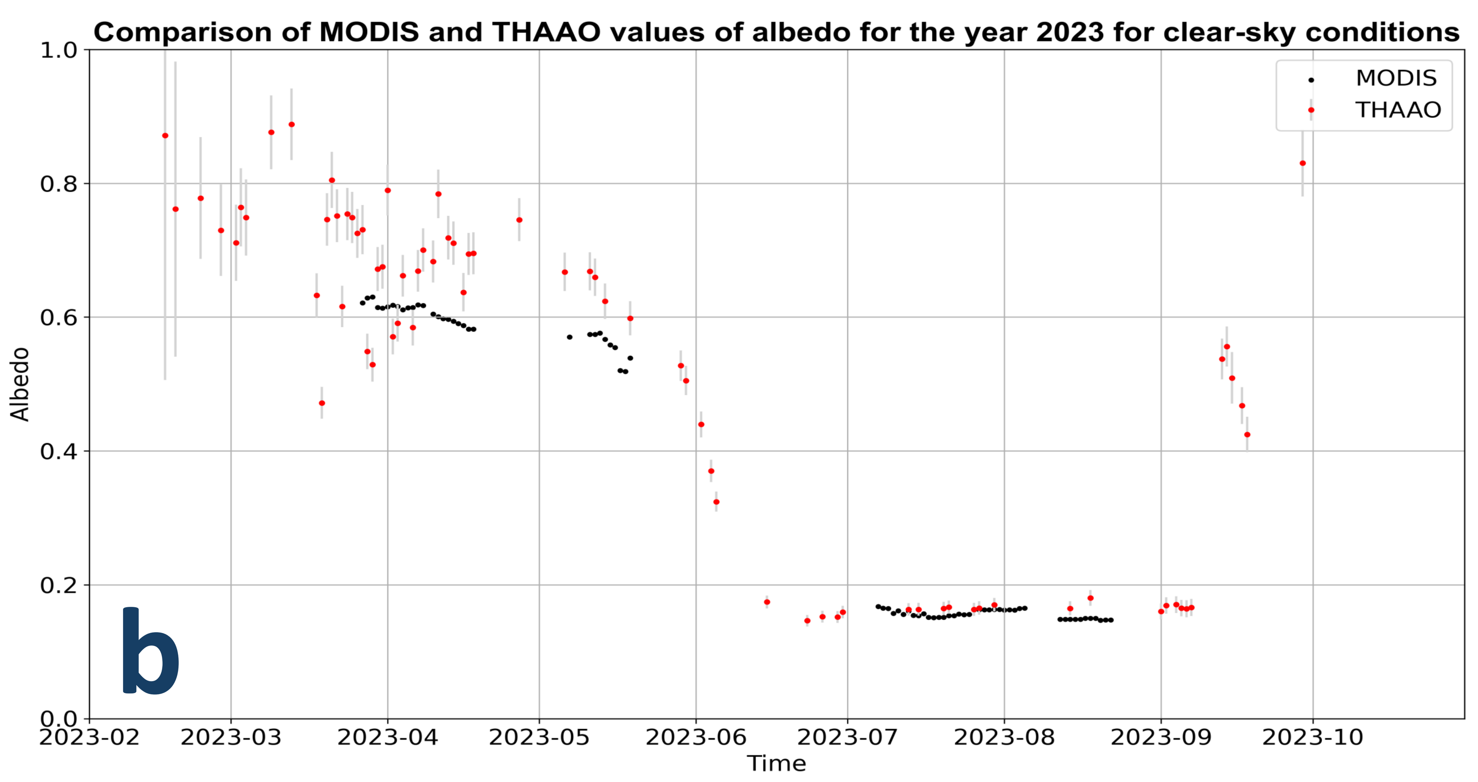


Figure 1: comparison between MODIS and THAAO daily values of albedo for clear-sky (a) and all-sky (b) conditions.

	All Sky Conditions				Clear Sky Conditions		
	Spring	Summer	Autumn		Spring	Summer	Autumn
MODIS	0.6079	0.1913	0.3301	MODIS	0.5485	0.1634	//
THAAO	0.7050	0.2025	0.4663	THAAO	0.7085	0.1872	0.5132
MODIS - THAAO	0.0971	0.0112	0.1362	MODIS – THAAO	0.1601	0.0229	//

Table 1: Seasonal averaged values of albedo for ground-based observations (THAAO) and satellite observations (MODIS) averaged over the eight years period considered (2016-2023).
The low amount of data available for the comparison of clear-sky analysis (157 days over 2922 of total days), specially during spring season (shown in yellow), leads to high differences on the comparison.

RESULTS

Two main analyses were conducted:

- Albedo retrieved in all-sky conditions (without any filtering on cloud conditions) were compared. The results for year 2023 are shown in the Figure 1a. For better comparison, the ground-based values of albedo were averaged over a period of 16 days, similarly to MODIS values.
- Data for clear-sky conditions were selected: the MODIS Quality Flags (all quality flags equal to zero) were used to select satellite data, while a cloud screening algorithm based on zenith sky pyrometer data (Pace et al., 2024) was applied to the ground-based observations. The results for the year 2023 are presented in Figure 1b.

In both figures uncertainties on albedo determination from ground-based measurements are shown in grey.
The albedo obtained in the other years presented the same seasonal trend, with higher values during spring and lower values during summer. Better agreement between satellite and ground-based values is found during the summer season when the melted snow leads to the homogeneous colour of the ground.

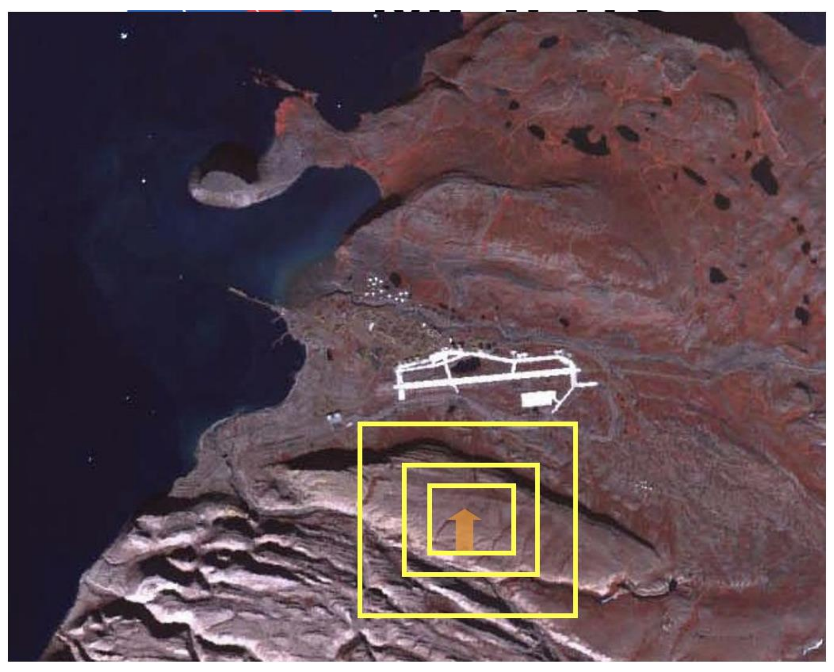
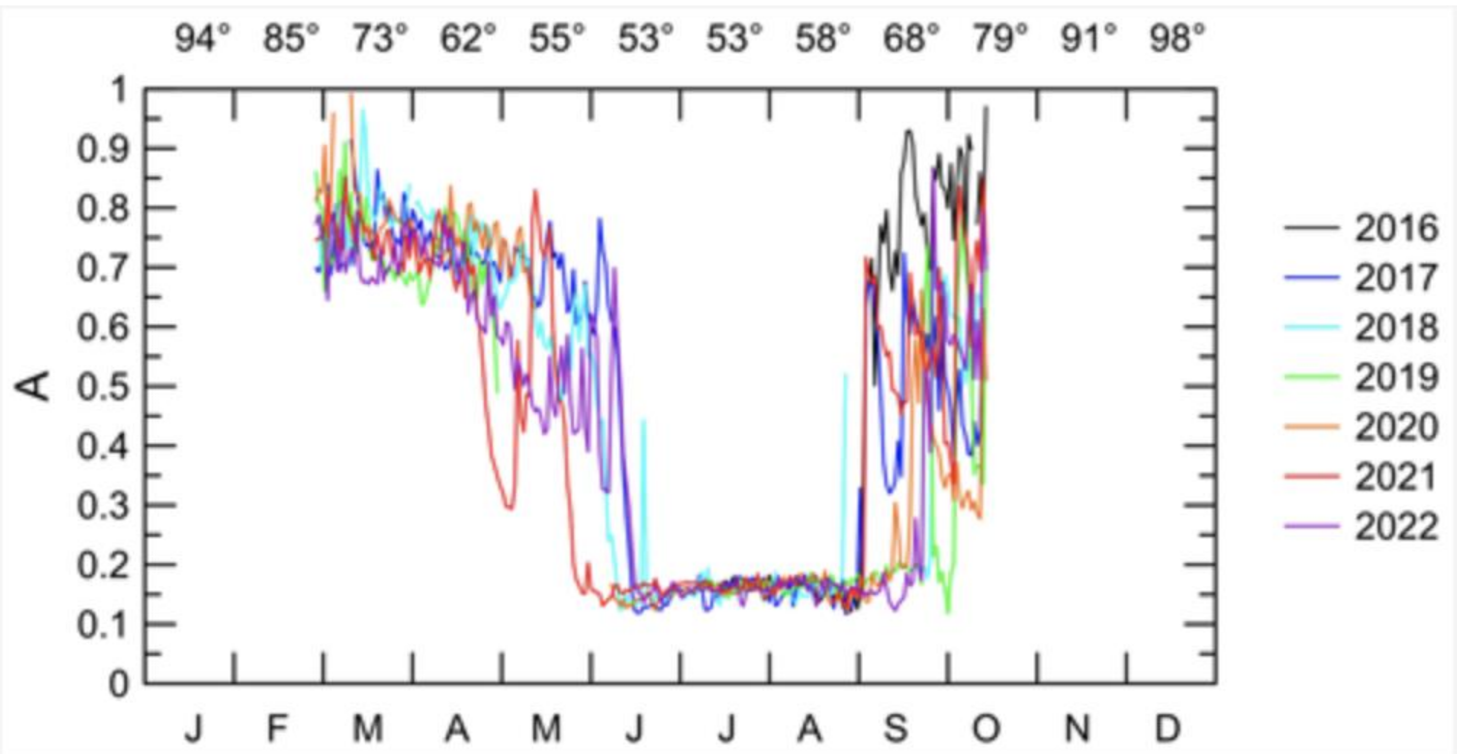


Figure 2: the first analysis conducted in this work was the selection of the area for the satellite observations. In first place three different sizes were considered: 1 km^2 , 4 km^2 and 16 km^2. The area selected for the comparison is the smallest one.

Figure 3: Annual evolution of the daily average surface albedo values from 2016 to 2022. The upper *x* axis indicates the minimum SZA for each month. (Meloni et al., 2024)



THAAO observatory in Greenland
https://www.thuleatmos-it.it

CONCLUSIONS

Selecting an area of 1 km^2 for the satellite observations (selection shown in Figure 2):
- MODIS is capable to evaluate a good value of albedo compared to the ground-based observation, even on cloud conditions when the MODIS algorithm is used;
- The annual trend of albedo is well shown in both analyses;
- A further analysis on clouds and other meteorological parameters will be conducted in future works

REFERENCES

- G. Pace et al., (2024), doi.org/10.5194/amt-17-1617-2024
- D. Meloni et al., (2024), doi.org/10.5194/essd-16-543-2024
- https://search.earthdata.nasa.gov/search

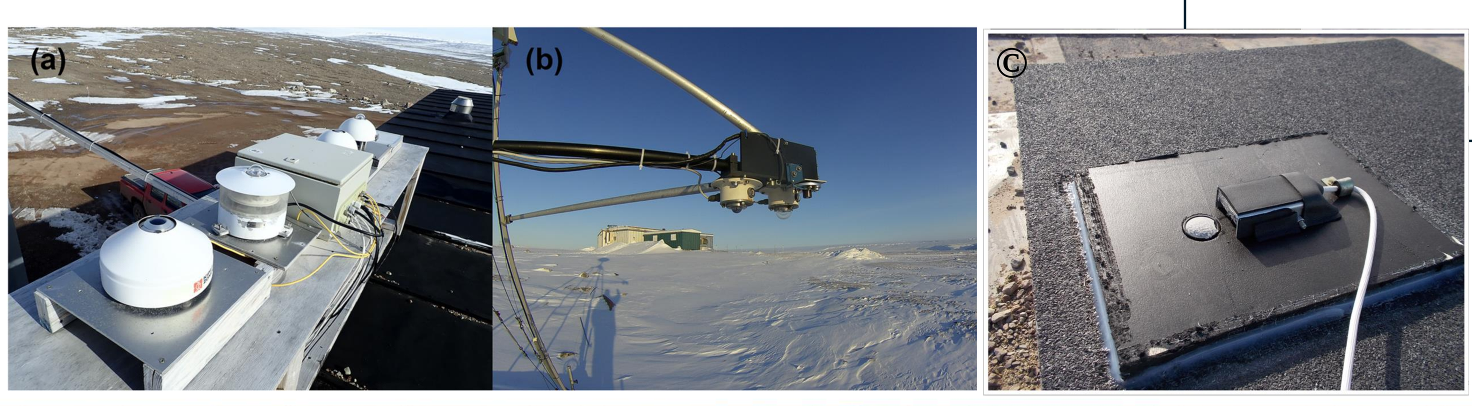


Figure 4: Kipp and Zonen CMP21 are showed in figure a, Eppley PSP are showed in figure b and the pyrgeometer is shown in figure c