# IPID4all Doctorate Research Exchange with Carl von Ossietzky University of Oldenburg

## Feedback report

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*Exchange period: 15-10-16 to 15-01-17*
*Exchange topic: Using Heliosat method for high latitude solar radiation estimation*

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### Introduction

Solar radiation estimations for Northern Norway will play a positive role in the future solar PV and thermal installations in the region. Such measurements could be recorded by using pyranometers, the installation and maintenance of such equipment requires man power. Due to the low population density of Norway, which further decreases in the northern parts, there are a few meteorological stations in the region and even fewer record solar radiations by dedicated equipment. The second most reliable method for estimating solar radiation is by using satellite images. Either geostationary or polar orbiting satellites could be used for estimations, both such techniques have their advantages and draw backs. Geostationary satellites provide data at high spatiotemporal resolutions but do not cover the whole earth, especially the resolution and accuracy decreases above 65 degrees. On the other hand, polar orbiting satellites provide images for the whole globe but with lower temporal resolution. In this collaborative work, we worked on using the Heliosat method and images taken from geostationary MSG (meteosat second generation) satellites for estimations on sites beyond 65 degrees north in Norway and Sweden.

**Research Undertaken**

The focus of the research was using geostationary satellites for estimating solar radiation in high latitude locations. In the first phase, satellite images processed to estimate solar radiation by Heliosat algorithm were analysed for Tromsø, Sortland, Kiruna and Visby. These estimations were not taking into account the snow covers present in these areas. Month between April and August were analysed in this research to avoid the polar night phenomenon in the winters that would have improved the overall error profiles. The clear sky model used in Heliosat was also investigated on Kiruna and Visby, because DNI (Direct Normal Irradiation) values were not available for other locations. It was also observed that the clear sky model, in this case SOLIS was having an underestimating profile for these locations.

In the second phase Heliosat estimations with snow cover adjustments were analysed. Without using snow covers, the algorithm would treat them as clouds because it cannot differentiate between clouds and snow covers. NDI (normalized differential snow indices) are used to differentiate between snow and clouds by using 0.66µm VIS channel and 1.6µm IR channel. When the results were compared to the previous estimations, there was a remarkable improvement in the results. Further analysis showed that even after considering snow covers there was an underestimation, especially on clear sky condition.

To improve the results obtained from the Heliosat method, further analysis were performed to find the cause of error. It was observed that the underestimation could be possibly due to two main reasons. First, the reflection from the snow covers which increases the diffuse portion of the light that is observed by the ground measuring equipment but are not taken into account by the Heliosat algorithm. Second, the composition of atmosphere in the arctic areas where there is less absorption of solar radiation as compared to equatorial regions and the longer distances light has to travel

through the atmosphere before reaching the satellite sensor. Calibrating the Heliosat algorithm for high latitude locations and snow cover regions could improve such estimations.

**Personal Experience**

I had an excellent experience in Oldenburg where I improved upon my technical skills by working on satellite images and Heliosat method. Besides, I also had a social experience of working in Germany that was very pleasant. The working group had been extremely helpful and supportive, and I look forward for future collaborations.

**Conclusions**

Over all it had been an excellent opportunity to work and explore the possibilities of using geostationary satellites for high latitude locations. Areas that need further improvement were identified and I hope we would be able to further improve the results.

**Outlook**

- A conference submission and journal paper is under consideration on the work done at University of Oldenburg.
- Depending on available funds, possibly a second exchange will take place in summer 2017.
- Besides working on solar radiation there is a good potential in collaborating on wind energy.

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