Sky Clarity Comparison between Riga and Metsähovi SLR Stations

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Abstract: The information from the sky clarity sensors operating at both SLR stations has been combined to find the statistical distribution of the hourly simultaneous cloud cover conditions for a 6-month period in 2017, using a 5 level cloud cover level and a joint 4 level classifications. Given the relatively short distance (<400 km) between Riga and Metsähovi, this information is useful for the evaluation of joint observation optimization strategies, in particular for possible bistatic space debris tracking operations.

Sky Clarity as defined as the difference between the sky and ground level temperatures, and it is directly related to the cloudiness level. Both SLR stations are using commercial sky clarity cameras and all-sky cameras for the primary goal of real time sky monitoring and security alert for rain/snow conditions. Additional information is reported for each sensor, apart of the basic epoch, ground/sky temperatures and associated clarity values, depending on the sensor model used. (see Table 1). This information is sampled at different rate on each station. We used a 6-month data set period during 2017 (see Table 2) for this presentation.

We carried out the following processing steps:

Five level cloud cover classification:
In practice the sky clarity information can be reported as binary cloudy/clear values using a clarity value of ~30 °C as the cutoff limit.

Using the March-April Riga data, we found that a 5 level cloud classification with a clarity value step of 15°C gives a reasonable fine-grained description of the cloud cover for our area (see Figure 1) when compared with the all-sky images taken at the same time. (see the workshop PowerPoint presentation for examples)

Splitting and processing the clarity data:
For both SLR stations the sensors data is stored on long files with minimum length of a month. For the first step this data is separated in daily files keeping only the information of interest for our purpose: epoch (UTC), ground/sky temperatures, clarity values and day/night/twilight sensor data.

Then, each daily file was processed to calculate the hourly mean values of the stored data. On each hourly data line, apart of the mean values calculated, was also included the number of data points used, and the RMS values of interest and saved in a different name daily file.

Calculating the simultaneous clarity and cloud cover values:
The hourly daily data files for both stations were combined on the following way:

For each common hour data, the mean clarity for each station was converted into one of the 5 cloud level values. The 2-hour cloud levels combination was used to fill a cell of the 5*5 array. These combination pairs cells were blocked into groups and counted into 4 joint cloud cover categories: fully covered in both stations, fully clear in both, very cloudy/clear and cloudy/clear.

This processing was done for the full 24h period and for the night/twilight only using the Riga values from the day/night sensor.

This final daily 4 joint cloud cover categories count is saved for further statistical processing in a single line per day file with the number of hours on each category. The full data flow is shown (see Figure 2). The hourly 4 category distributions were calculated in % and shown as Pie plots (see Figure 3).

Conclusions:
For the period analyzed we found that the % of time in which conditions for simultaneous tracking could be attempted with some probability of success (in the "both clear" and "cloudy/clear" conditions), is of the order of ~50%. This is valid for the 24 hours (55.2%) or the Night/Twilight (46.9%) cases (see Figure 3).

We will continue this analysis on a regular basis, with the goal to cover all seasons on a multiyear frame.

As further development we will:

- Test the use of a 20-minute time resolution, closer to a typical LEO satellite pass duration.
- To compare a 6-level cloud cover classification against the 5-level in use.

We recommend all pairs of close SLR stations using this kind of sensors, to carry out this kind of analysis in a regular way.

Table 1: Sensors basic information

Sensor type	SLR	Model	FOV (HW)	FOV (10%)	Sampled at
Sky Clarity sensor	Riga	Aurora Cloud Sensor III	89.6°	110°	1 min
	Metsähovi	Boltwood Cloud Sensor II	~80°	~120°	5 min
All-Sky camera	Riga	Moonglow Technologies	Full Sky		
	Metsähovi	Alcor OMEA-2.0M-HCA	Full Sky		

Table 2: Data information

Data span used	2017-03-15 to 2017-09-08	178 days, 4272 hours
Common data used		148 days, 3048 hours
Instantaneous values		
Max/Min Clarity: Riga	**67.7** (2017-05-09, 09:33:16)	**-8.6** (2017-07-26, 05:34:03)
Max/Min Clarity: Metsähovi	**68.2** (2017-05-03, 10:51:00)	**-1.4** (2017-03-20, 01:49:00)
Hourly values		
Max/Min Clarity: Riga	**54.2** (2017-02-07, 08h)	**2.5** (2017-07-27, 01h)
Max/Min Clarity: Metsähovi	**56.0** (2017-06-29, 05h)	**-0.1** (2017-03-20, 02h)

Notes:
The Common data used was 71.3% of the total possible amount.
We had several instances in which one of the sensors stopped recording or the data was corrupted
Due to construction work at Metsähovi, the sensor location changed on 2017-08-30 at 7UTC and few days of data were lost.

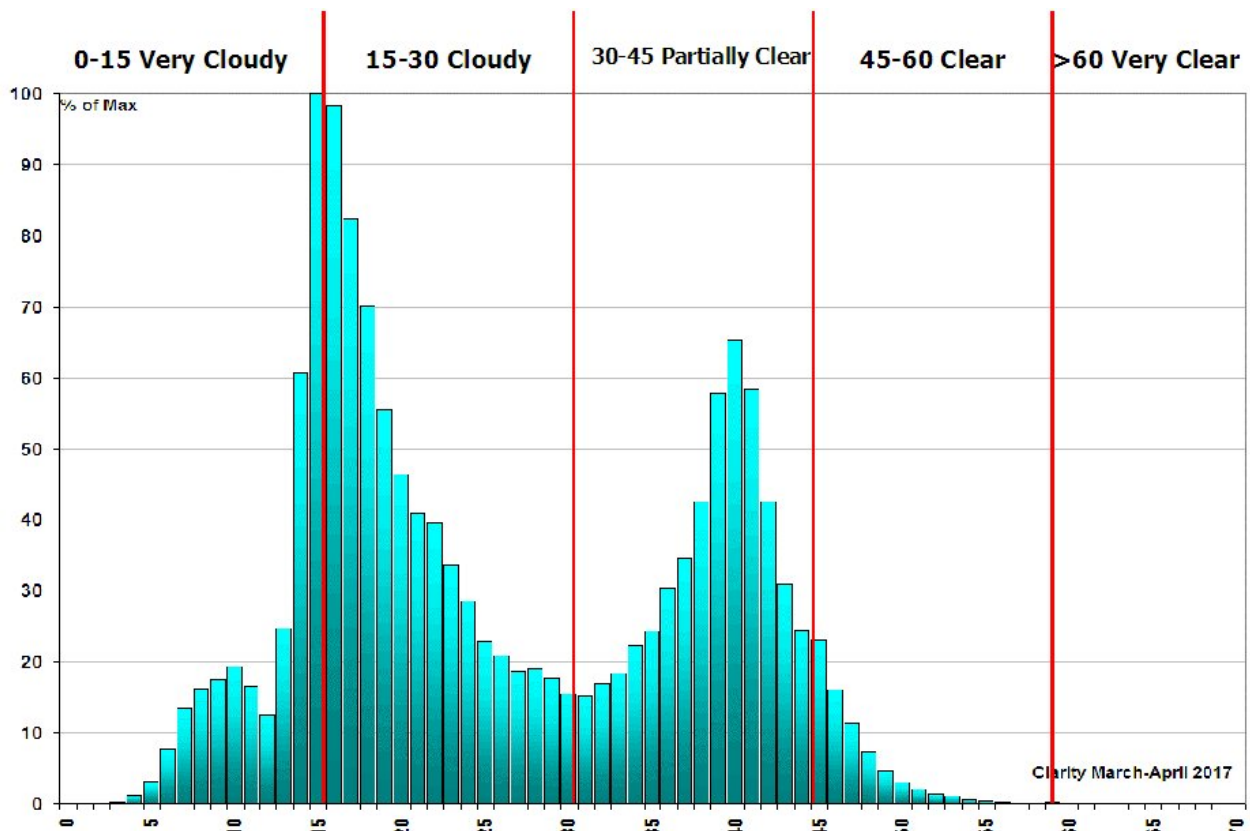

Fig. 1 Five level cloud cover classification example (using the March-April 2017 Riga data)

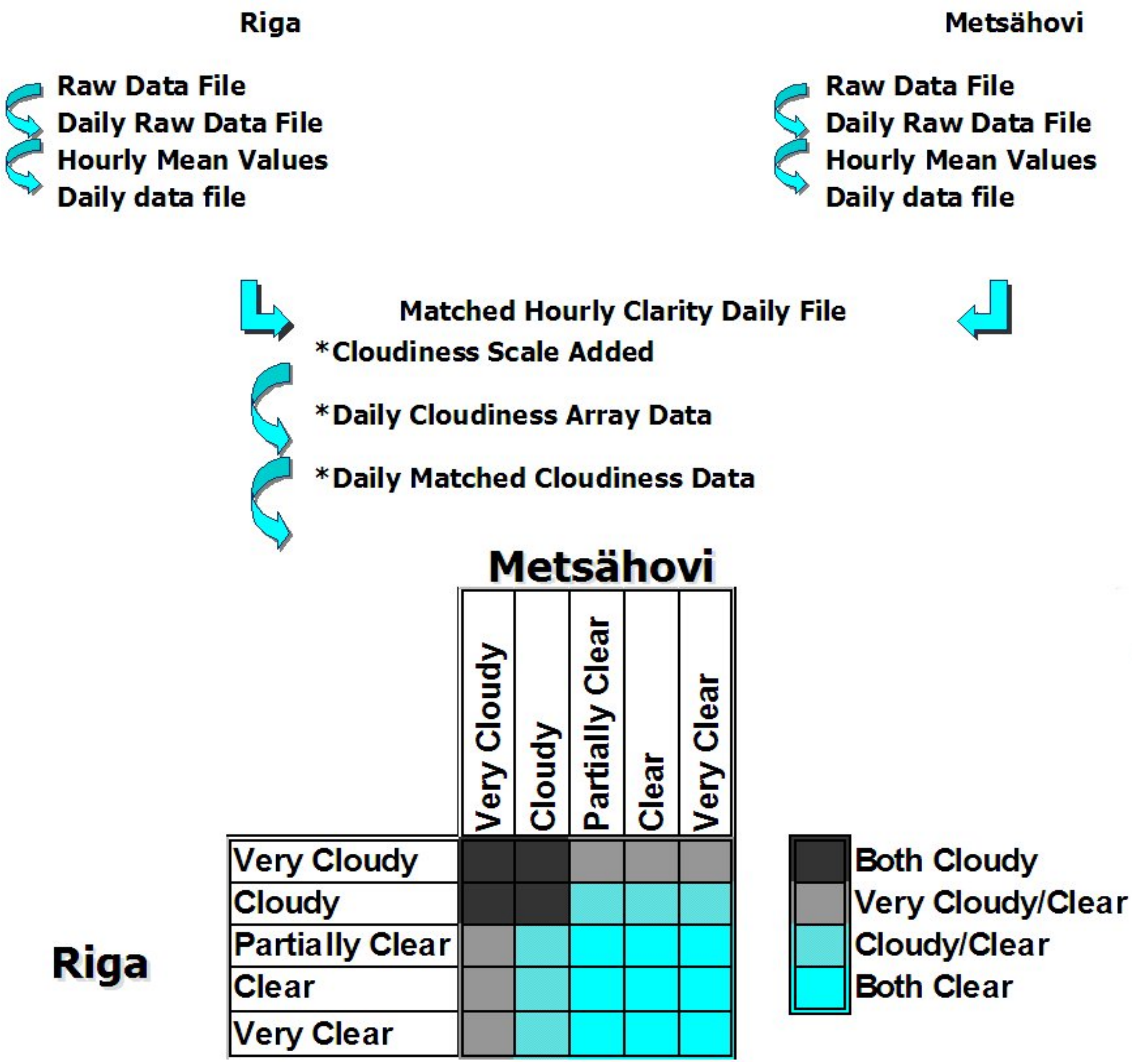

Fig. 2. Processing steps and data flow including the cloud pair and final category arrays.

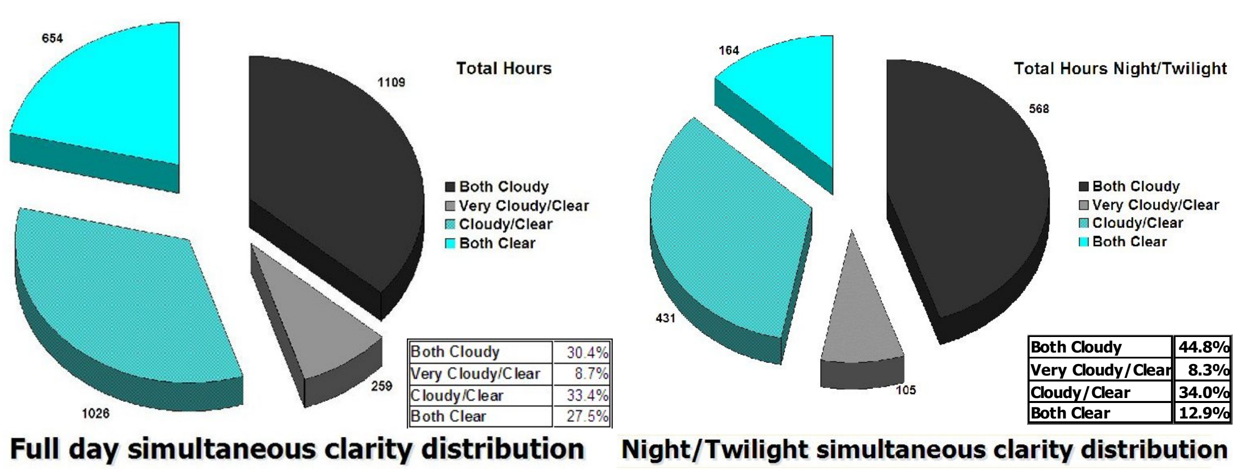

Fig. 3 Simultaneous clarity distributions for the full day and night/twilight cases.