Looking for Weak Meteor Showers Using ComZHR Software

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Abstract

This report describes new software of which the main goal is looking for the radiants of meteor showers and analyzing their structure. The software, for a given geocentric velocity, computes maps of mean Zenithal Hourly Rates (ZHRs) averaged over a given time interval. The pixels of this map where true radiants exist should have high mean ZHRs comparing to others, making the detection of new showers possible.

1 Introduction

The activity of a meteor shower can be described using the well known formula for Zenithal Hourly Rate (ZHR):

$$ZHR = \frac{n \cdot F \cdot r^{(6.5-LM)}}{T_{eff} \cdot \sin^{\gamma} H_{rad}} \tag{1}$$

where n is the number of meteors observed during effective time T_{eff}, F is the cloud correction factor, LM is the stellar limiting magnitude in the field of view, r is the population index, γ is the zenith correction factor often assumed as equal to 1.0, and H_{rad} is the altitude of the radiant.

We can choose any point in the sky and, assuming that there is a real radiant, check its activity using standard methods of visual meteor observations given for example in the *IMO Handbook for visual meteor observers*. Instead of computing the activity profile, we can compute the mean ZHR averaged over the entire time interval selected. Changing time intervals and geocentric velocities, we can construct the mean ZHR maps for any region of the sky. If there is a real radiant and if its geocentric velocity and activity period are well matched, the mean ZHRs from the radiant region should be higher than those from other points in the sky.

Such a method for looking for meteor radiants is completely different from the method implemented in the RADIANT software (Arlt 1992). This software produces maps of probability of the presence of a radiant (PPR maps for short), based on the probability distributions generated by each meteor event on the sky. The probabilities generated by all meteors are then summed and the map of the given region of the sky is computed. The map is normalized to the point with the highest PPR. This operation causes serious problems with comparison of different maps computed for different or even overlapping regions in the sky.

Software producing ZHR maps is free from this disadvantage because it produces a mean ZHR for each point in the selected region. This mean ZHR can be directly compared with the mean ZHR of any different point in the sky.

2 New software

We decided to write such software and compare the ZHR maps produced using it with PPR maps computed using the RADIANT software.

Our software which we called (maybe temporarily) ComZHR consists of two programs: the the main body written in Fortran and the tool producing sky maps written in MATHLAB. It requires four files as an input:

- `coor.txt` A file containing the coordinates and angular velocities of the meteors. The format of this file is the same as the *Polish Visual Meteor Database (PVMDB)* - see Olech et al. (2001) for details.
- `head.txt` A file containing basic parameters describing the observations. The format is the same as the *PVMDB*.
- A list of equatorial coordinates for which the ZHR should be computed.
- A parameter file containing values of geocentric velocity, date of the maximum, daily drift, population index, zenith exponent and activity period.

Different sizes and resolutions of the sky regions to be input were tried. The best results were obtained using fields with a size of about 50 degrees and a resolution of 100×100 pixels, and all pictures shown in this report were computed in this regime. We must mention that this option is quite computationally expensive because a resolution of 100×100 requires checking ten thousand radiants, sometimes for over ten thousand meteors.

3 Comparison with the RADIANT software

3.1 Lyrids

We selected a few well known showers to compute for them the ZHR and PPR maps. The first was the Lyrid shower. Our sample contained 669 meteors. This is not an impressive number but as we can see the RADIANT software produces a well defined radiant in the right place (see left panel of Fig. 1).

The ComZHR produces a much worse picture (right panel of Fig. 1). What is the reason for this? First, we should mention that for ZHR calculations we use only those points in the sky which had an altitude of at least 25 degrees. In case of the Lyrids, which we can observe mainly in the second part of the night, the events observed in the evening hours are not included in the analysis made using the ComZHR. Unlike our software, RADIANT uses all recorded events.

When analyzing only a few meteors, RADIANT produces much smoother pictures. This is because the probability of the radiant presence computed for each event is described by a Gaussian function which is smooth and continuous.

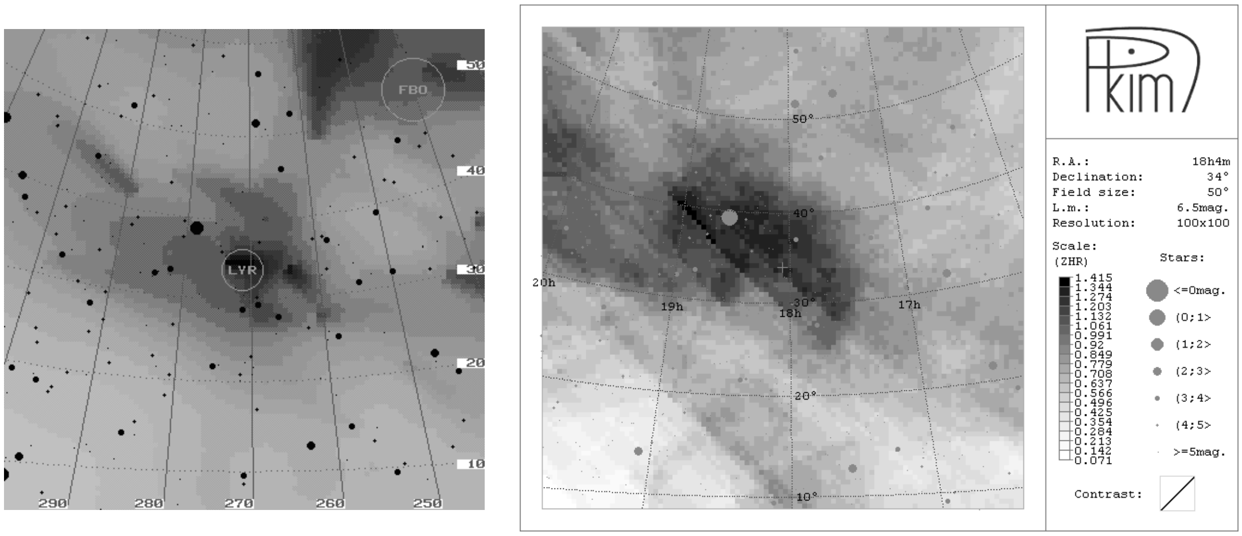

Figure 1: *Radiant pictures of the Lyrid shower obtained using* RADIANT *(left panel) and* ComZHR *(right panel) software. Maps are computed using 669 meteors recorded in the period April 15-26. The geocentric velocity is $V_\infty = 49$ km/s.*

When handling few meteors, ComZHR produces sharp edges which are the boundaries between including and not including the meteor in the pixel under consideration as a radiant.

3.2 Perseids

A much larger sample was available for the Perseids. In this case we analyzed only meteors observed before the shower maximum. In our sample we have almost ten thousand meteors plotted in the interval of July 13 - August 08.

The map produced by the RADIANT software shows a clear radiant for the Perseid shower (Fig. 2). But this radiant is shifted and elongated toward the α-Cygnid radiant. Although the Perseids are much more active than α-Cygnids, the meteors from the Perseid shower are very often not plotted especially at the end of July and the first part of August. Thus our sample contains almost all observed α-Cygnids but few Perseids.

On the other hand, in this case we can see the power of the ComZHR software which is based on ZHR calculations. Because the ZHRs of the Perseid shower are much higher than those of the α-Cygnids, in this case we can see a good picture of the Perseid radiant without any trace of elongation toward the α-Cygnid radiant (right panel of Fig. 2).

3.3 κ-Cygnids

Surprisingly, despite quite a large sample (almost 3500 meteors), both PPR and ZHR maps obtained for the κ-Cygnid radiant were of bad quality (see Fig. 3).

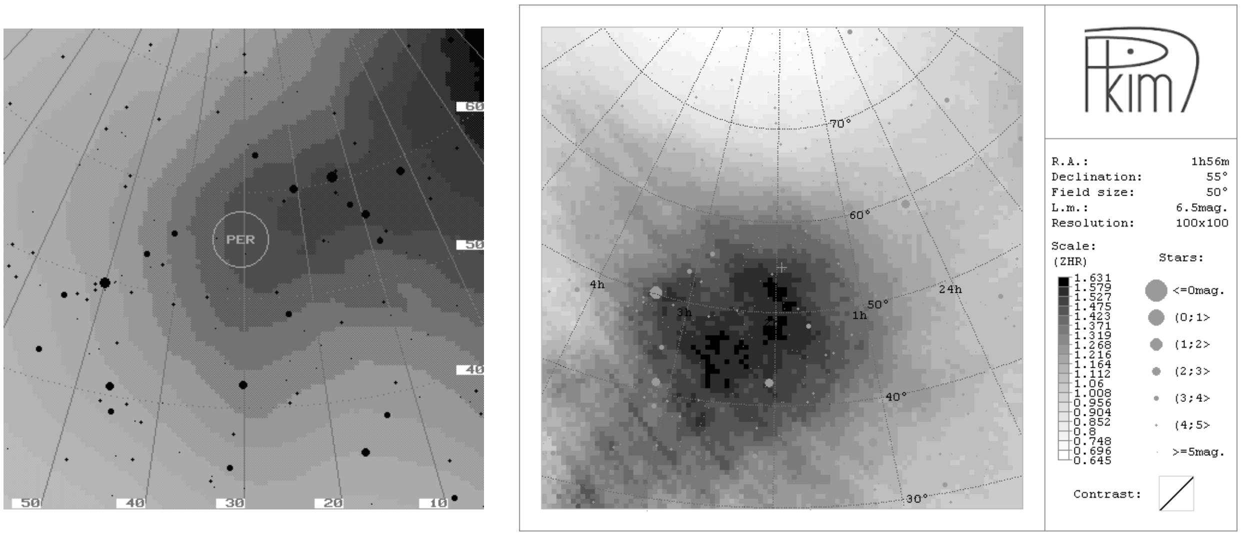

Figure 2: *Radiant pictures of the Perseid shower obtained using* RADIANT *(left panel) and* ComZHR *(right panel) software. Maps are computed using 9641 meteors recorded in the period July 13 - August 8. The geocentric velocity is* $V_\infty = 59$ *km/s.*

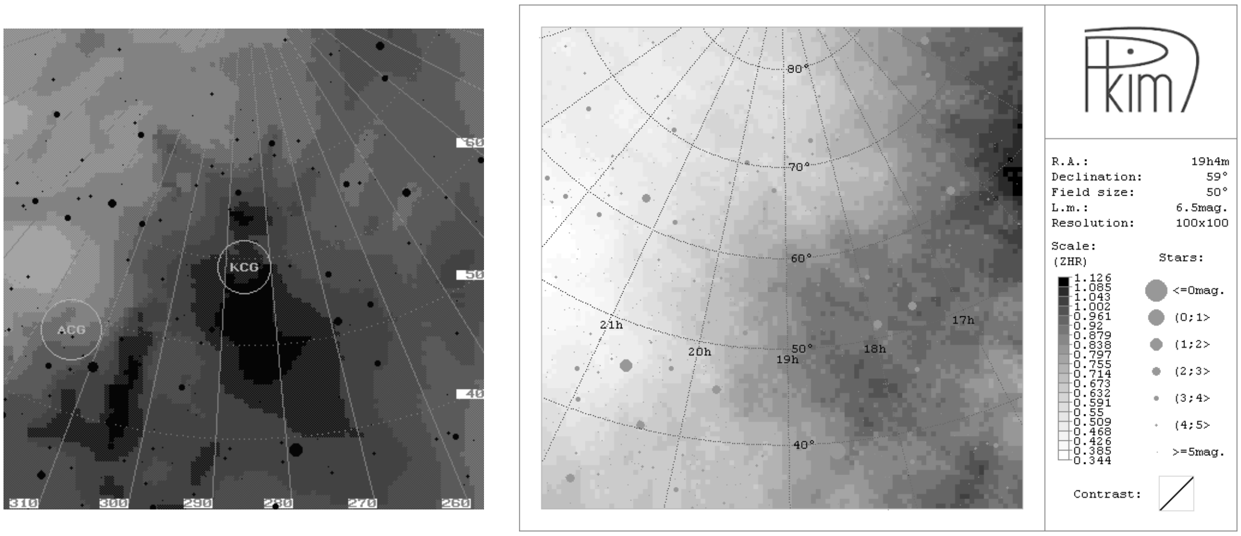

Figure 3: *Radiant pictures of the* κ*-Cygnid shower obtained using* RADIANT *(left panel) and* ComZHR *(right panel) software. Maps are computed using 3472 meteors recorded in the period August 2-26. The geocentric velocity is* $V_\infty = 25$ *km/s.*

3.4 α-Aurigids

The same situation as the Perseids appeared during the analysis of the α-Aurigid radiant. In the PPR map we can see a clear shift and elongation of the α-Aurigid radiant toward the radiant of the late Perseids.

This is not the case with the ZHR map. The elongation is detected in a completely different direction. This is because the region of the sky shown in the lower-left corner always has a low altitude and its mean ZHRs may be artificially overestimated (Fig. 4).

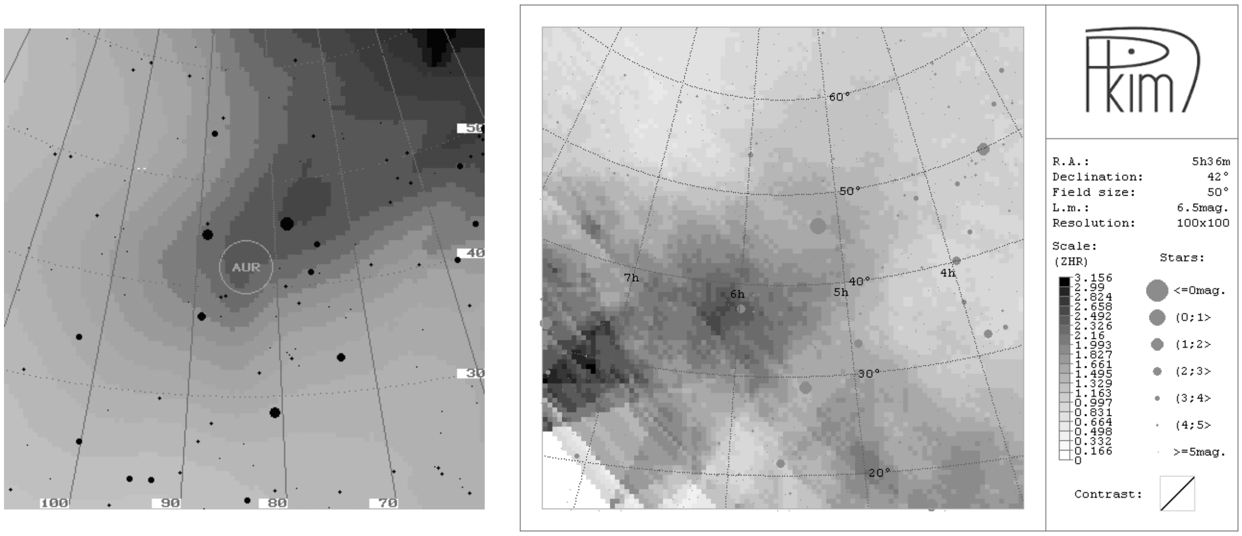

Figure 4: *Radiant pictures of the α-Aurigid shower obtained using* RADIANT *(left panel) and* ComZHR *(right panel) software. Maps are computed using 2625 meteors recorded in the period August 25 - September 6. The geocentric velocity is $V_\infty = 66$ km/s.*

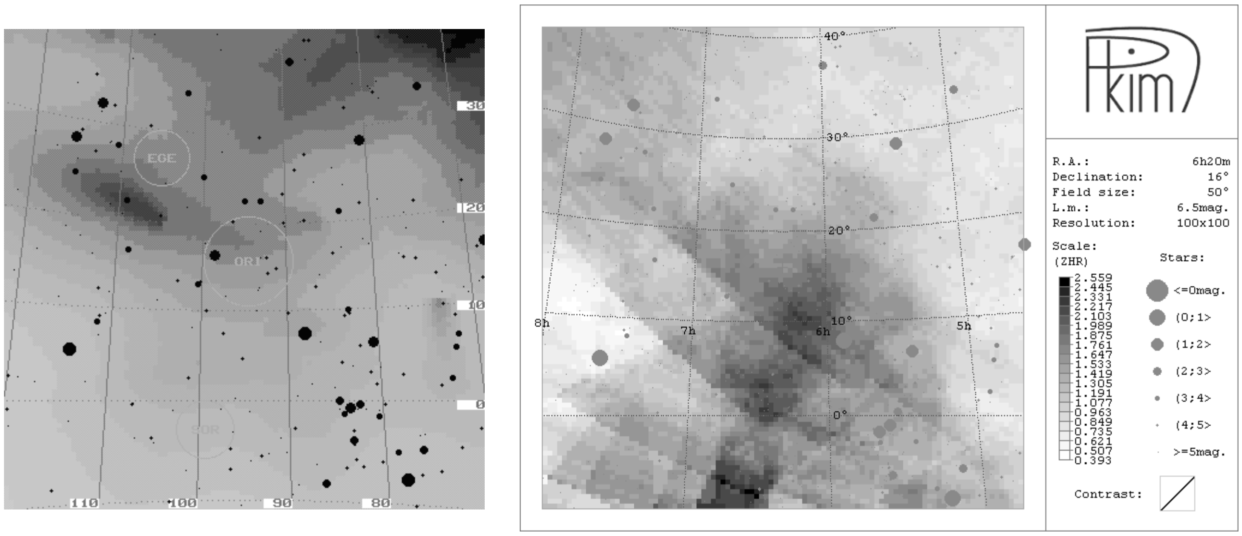

Figure 5: *Radiant pictures of the Orionid shower obtained using* RADIANT *(left panel) and* ComZHR *(right panel) software. Maps are computed using 1684 meteors recorded in the period October 1 - November 7. The geocentric velocity is $V_\infty = 66$ km/s.*

3.5 Orionids

Another surprise was caused by the Orionid shower. In spite of the large number of analyzed meteors, the radiant of this shower is almost invisible in the PPR map computed by the RADIANT software (left panel of Fig. 5).

The ZHR map (right panel of Fig. 5) shows a slightly better situation. But again we can detect strong pollution from the regions always having low altitudes at Polish latitudes.

3.6 Geminids and Ursids

Again, in case of the Geminids where we have a small sample (only 362 meteors), the PPR map is significantly better than the ZHR map (Fig. 6).

The situation is similar for the Ursid shower (a sample with only 297 meteors). The PPR and ZHR maps for this shower are shown in Fig. 7.

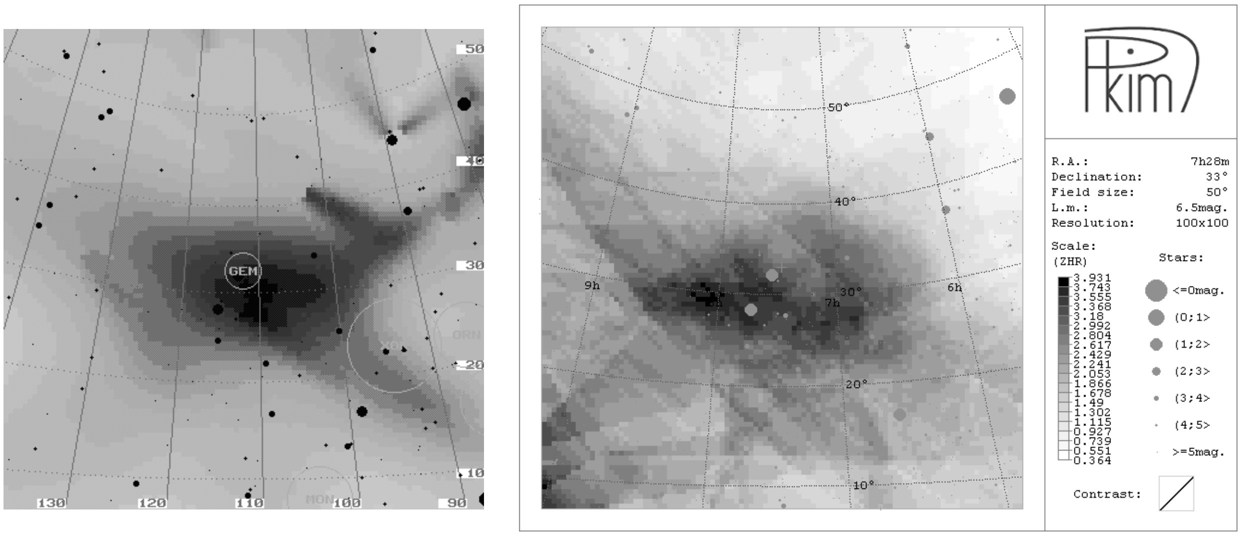

Figure 6: *Radiant pictures of the Geminid shower obtained using* RADIANT *(left panel) and* ComZHR *(right panel) software. Maps are computed using 362 meteors recorded in the period December 6-18. The geocentric velocity is* $V_\infty = 35$ *km/s.*

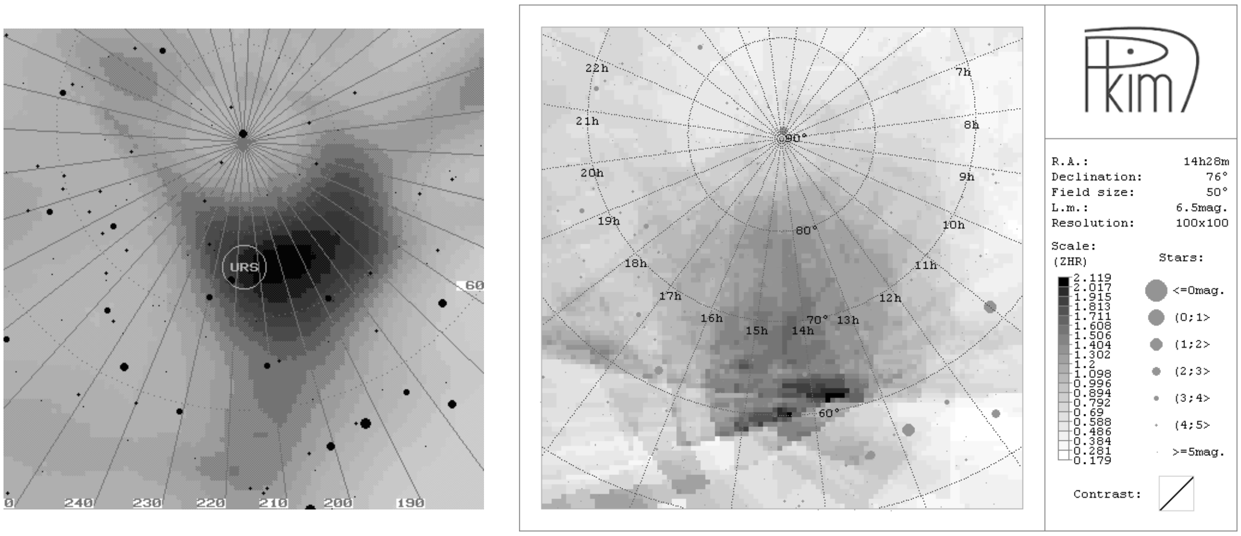

Figure 7: *Radiant pictures of the Ursid shower obtained using* RADIANT *(left panel) and* ComZHR *(right panel) software. Maps are computed using 297 meteors recorded in the period December 16-27. The geocentric velocity is* $V_\infty = 33$ *km/s.*

3.7 α-Cygnids

We decided not only to test our software on well known showers but also to check its ability to detect weak showers. A good example is the α-Cygnids. Recently, Polish observers belonging to the *Comets and Meteors Workshop* reported that this minor shower, not included in the *IMO Working List of Meteor Showers*, is still detectable using visual and telescopic observations (Olech et al. 1999, Stelmach & Olech 2000, Olech & Wiśniewski 2002). These results were also confirmed by video observations (Molau 2000).

The α-Cygnids can be observed during the whole of July, and thus in this case our sample was very large with as many as 11629 plotted meteors.

In case of the PPR map, shown in the left panel of Fig. 8, we can see a clear and circular radiant of the α-Cygnid shower. What is interesting is that in the upper-right corner we can also detect a clear radiant of the o-Draconid shower. Its presence is indeed real because this shower was never included in any meteor shower list sent to our observers. Thus its detection does not suffer from any biases caused by suggestions of the visual observers.

The ZHR map shown in the right panel of Fig. 8 is almost identical to the PPR map, indicating that for very large sample sizes both programs produce comparable results.

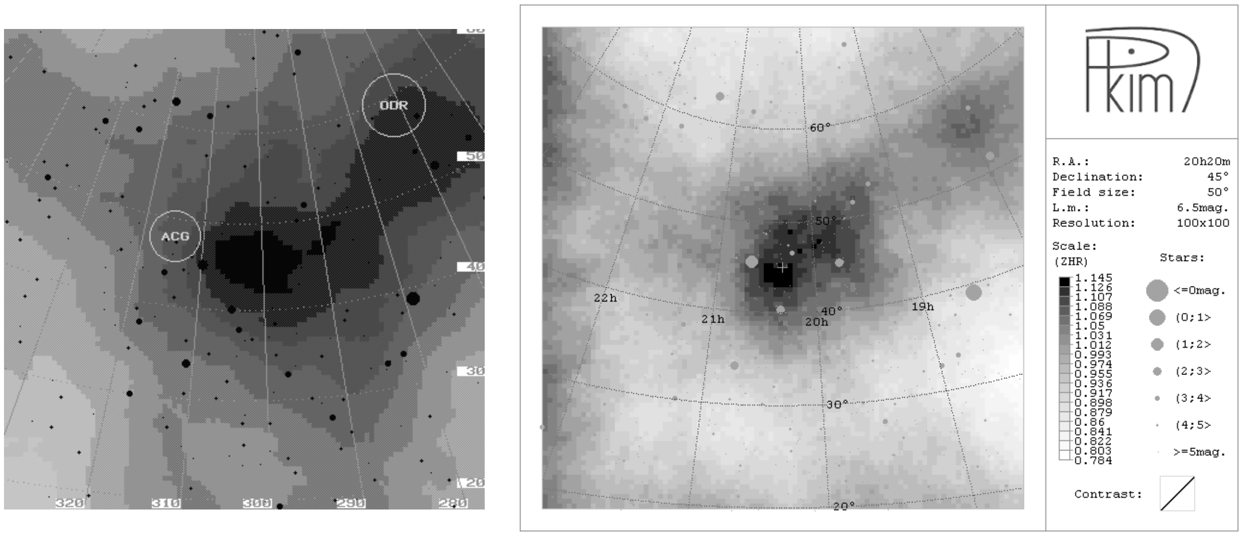

Figure 8: *Radiant pictures of the α-Cygnid shower obtained using* RADIANT *(left panel) and* ComZHR *(right panel) software. Maps are computed using 11629 meteors recorded in the period June 29 - July 31. The geocentric velocity is $V_\infty = 41$ km/s.*

4 What should be done?

The ComZHR software is still under construction and there are many things to be done. The most important of them are listed below:

- a good user-friendly interface,
- fitting a two-dimensional Gaussian function to the selected region of the picture,
- smoothing and changing the contrast of the pictures,
- reading files with `unplotted` meteors and computing activity profiles for each point of the picture.

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Arnold Tukkers, Min Guan, Casper ter Kulie, Jin Zhu and Jos Nijland in front of the Kopernik hotel