ALL-SKY CAMERAS FOR OBSERVATION AND INVESTIGATION OF VARIABLE STARS AND METEOR SHOWERS

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ABSTRACT. This paper studies the capabilities of the all-sky weather (meteorological) cameras in investigation of bright variable stars and determination of apparent radiants of meteor showers.

1. Introduction

The elaboration of this experimental study within the framework of the "Astrobloknot" (Astronomical notebook) project using the meteorological all-sky camera images has been conducted in several steps and for several reasons:

– I. Sergey suggested carrying out observation of the Geminids meteor shower maximum activity using the all-sky cameras of the Tzec Maun project in Australia and in the USA.

– On having conducted the above-mentioned observation, I. Bryukhanov found that such images could be also used to determine extreme points of bright variable stars for the O–C research works as the limiting magnitude of those images was 6.5 m in good weather conditions; besides, the number of shots taken per day with certain cameras varied between 400 and 950.

– N. Samus and L. Berdnikov suggested continuing of such studies for eclipsing and the Cepheid variables, respectively, as there have been precious few extreme points of bright variable stars actually observed for the last 30 years.

So that is how the **All-Sky Beobachter** ('beobachter' means an observer in German) project for electronic surveillance of the meteor shower maxima and bursts of activity, as well as the bright variable extrema arose. That is a small supplement to the "Astrobloknot" project regarding bright stars.

Images from three all-sky cameras in the Southern Hemisphere and seven all-sky cameras in the Northern Hemisphere are currently available online to be downloaded free of charge.

New software to conduct such continuous sky monitoring, developed by D. Akulich, is available since July 2010.

2. Variable stars

I.Sergey carried out experiment focused on rapid processing of all-sky camera images with MaximDL programme. The results showed that the indicated programme enabled to more or less reliable measuring of brightness of only those stars, which are brighter than 3 m.

Due to a large number of all-sky camera shots per day (from 400 to 950 shots), the target star brightness and time of the average value were averaged over several images. The average value provides the measurement accuracy ~ 0.1 m; and the instant of time can be determined with accuracy to 7-10 minutes.

Eye-estimates of the investigated stars' brightness using the all-sky camera images displayed on the screen allow of measuring the brightness of stars of up to 6.5 m with normal accuracy.

The results of brightness measurements of faint stars have still been processed so far. The light curves of famous periodic classical variable stars, obtained by the methods described above, are presented here below (see Figs. 1-4).

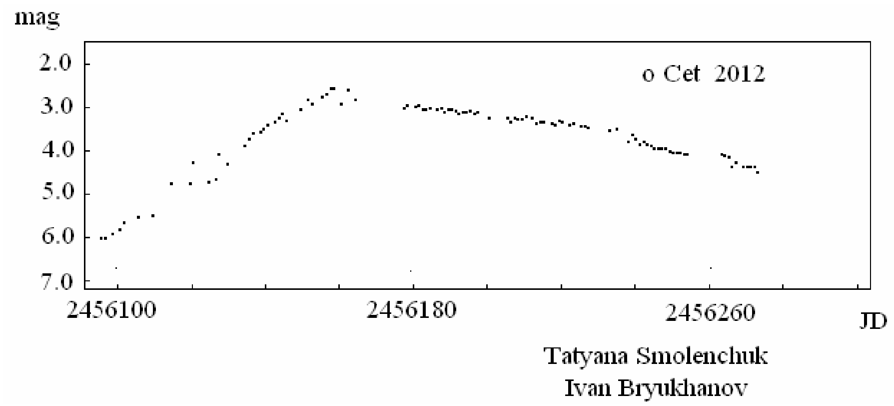


Figure 1

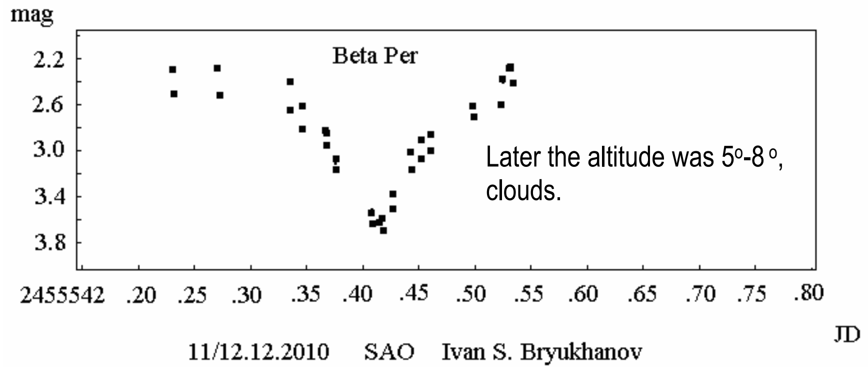


Figure 2

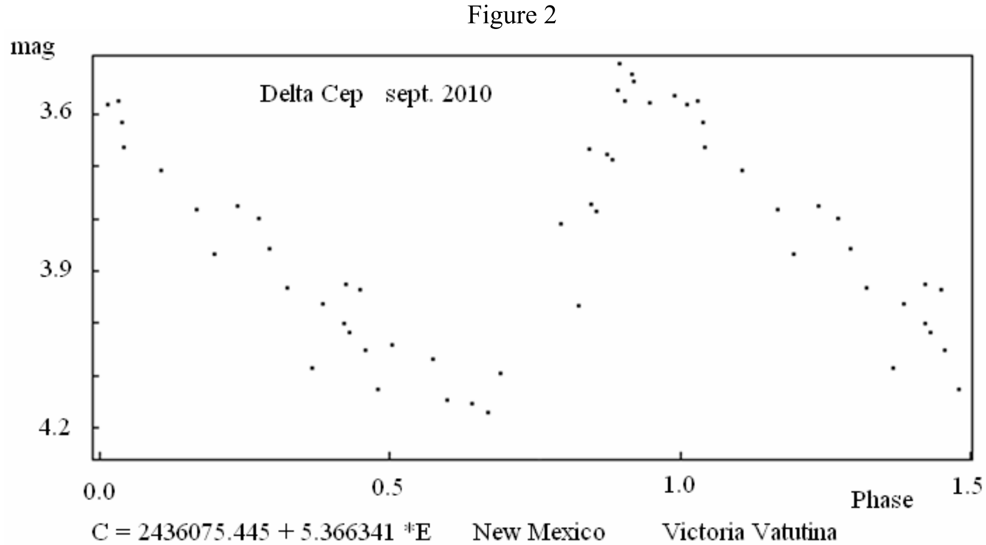


Figure 3

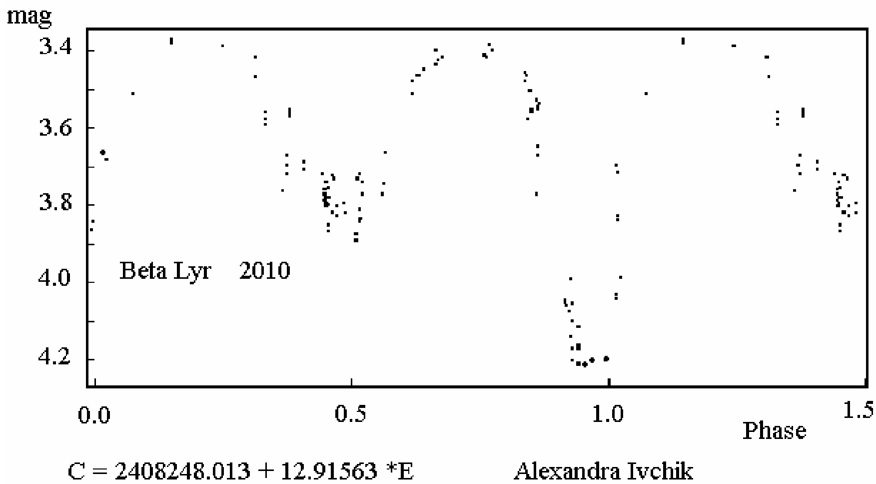


Figure 4

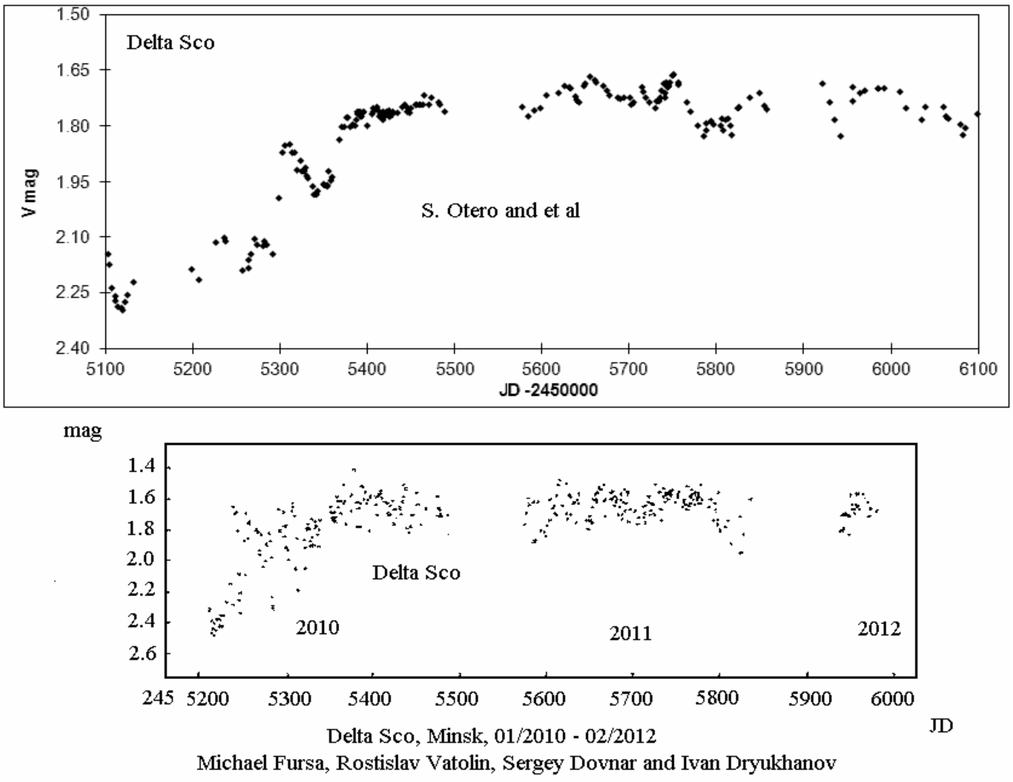


Figure 5

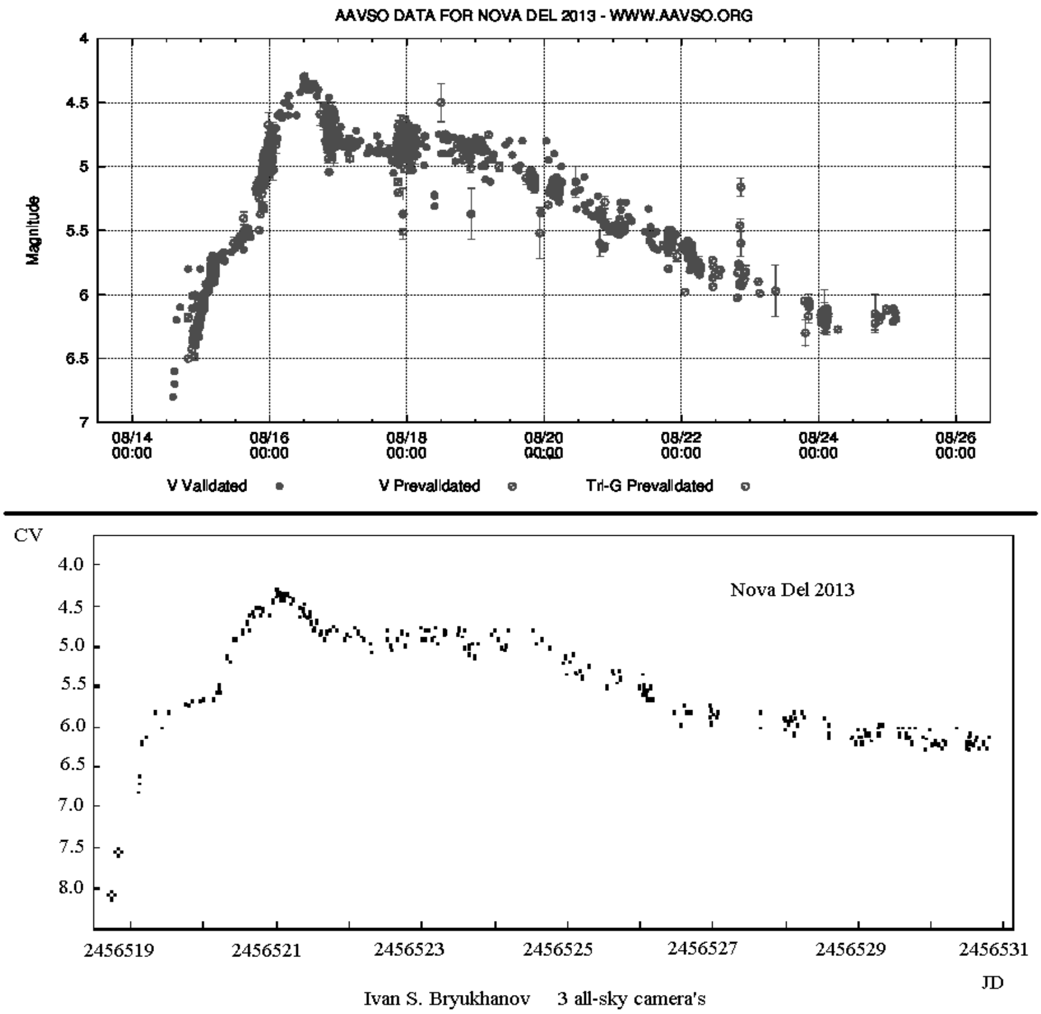
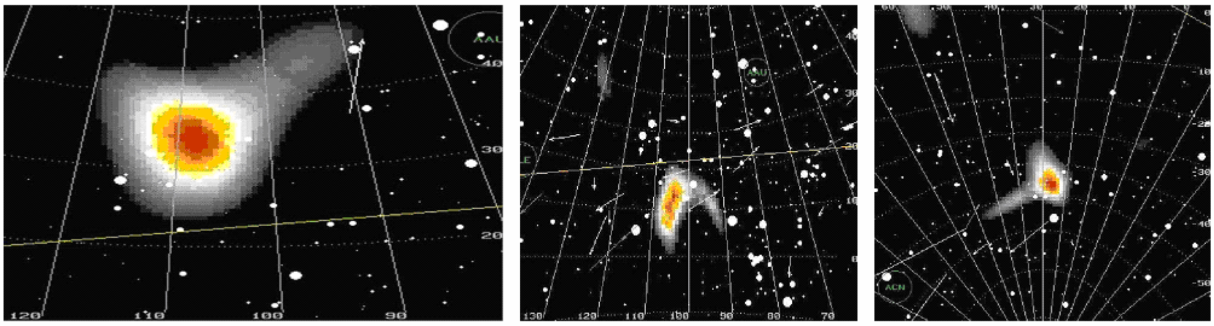


Figure 6



Left: The Geminids' radiant on 2009 December 13–14 at $\alpha = 108°$ and $\delta = +34°$ ((all-sky camera in New-Mexico, United States). *Center*: The Monocerotids' radiant on 2009 December 6–8 at $\alpha = 105°$ and $\delta = +13°$ (all-sky camera in Pingelly, Australia). *Right*: The Phoenicids' radiant in 2009 at $\alpha = +28°$ and $\delta = -47°$ (all-sky camera in Pingelly, Australia).

Figure 7

The measurements of brightness were conducted in the CV rays (and in more practical classical degrees of brightness) as the main goal of such surveillances is to determine the extreme points.

The measurements of unique blue flaring variable Delta Scorpii were performed as an experiment, and the periastron passage fell on July 2011 and could be controlled. By assent of Sebastian Otero, the multi-observer diagram by foreign observers and those in Minsk is presented in Figure 5; as is shown, it is possible to obtain normal qualitative photometric data for bright variables with amplitude of more than 0.5 m using even the simplest meteorological all-sky cameras.

By the time of this article preparation, on the night of 14/15 of August 2013 a possible Nova burst in Delphinus was discovered by Japanese amateur astronomer Koichi Itagaki with 60-cm reflector and the CCD-camera without filters.

Ivan Bryukhanov carried out almost 24-hour measurements of brightness using the images from all-sky cameras in Chile, Australia and SAO RAS purposely to settle the issue how it is possible for a single observer to accurately and reliably determine the variable brightness using several cameras and plot a diagram of the nova outburst. The results were just as well as those of 381 AAVSO observers (Fig. 6).

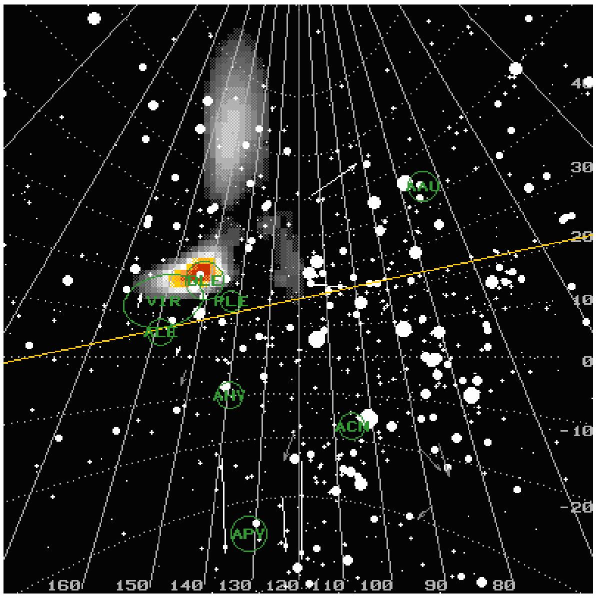
3. Meteor showers

The astrometry data for meteors were processed with the programme "RADIANT-1.42" developed by the IMO Visual Commission Director Rainer Arlt.

The first data as such the results of comparison between the photographic visual estimation of the radiant for the Geminids meteor shower and the 2009-2010 all-sky camera images were applied into print during the IMC-2011 conference in Sibiu in Romania.

At that time the Geminids activity was rather high and allowed of detecting many meteors in the all-sky camera images and consequently finding real radiant for each year. The Monocerotids and Phoenicids radiants in 2009 were also accidentally detected and estimated using those images (Fig. 7).

As an experiment the surveillance of the 2010-2012 all-sky camera images of the Leonids, the peak activity of which was rather low – not more than 15-17 meteors per hour (and the Moon was shining near the radiant in 2011), was conducted. The Leonids radiant was estimated (Figures 8-10).



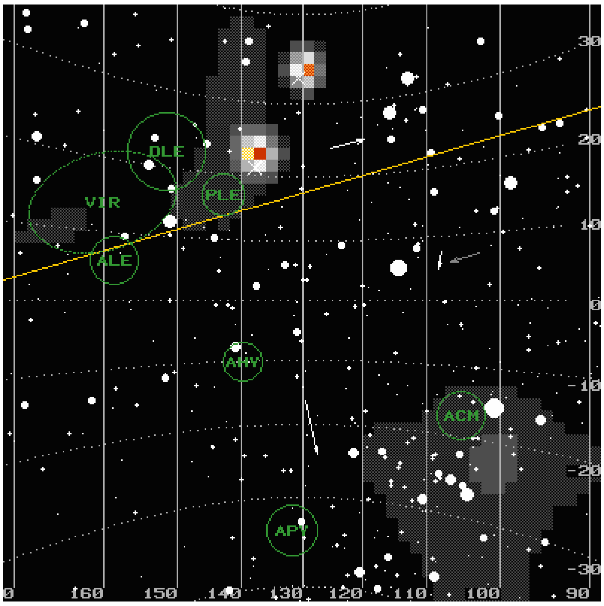
The Leonids radiant on 2010 November 15-18 (RA = 154° and Dec = +21° (all-sky camera in New-Mexico, United States)

Figure 8

In 2011 there was a burst of the October Draconids with one peculiarity that the event occurred at nearly full Moon. In fact, all images by the all-sky cameras were light-struck. However, the third auxiliary camera in SAO enabled to determine the meteor shower radiant. Meanwhile, a weak all-sky camera in Kiruna properly recorded bright red meteors of the Draconids, and the result of the radiant estimation using that camera images turned out to be the most reliable one (Fig. 11, 12).

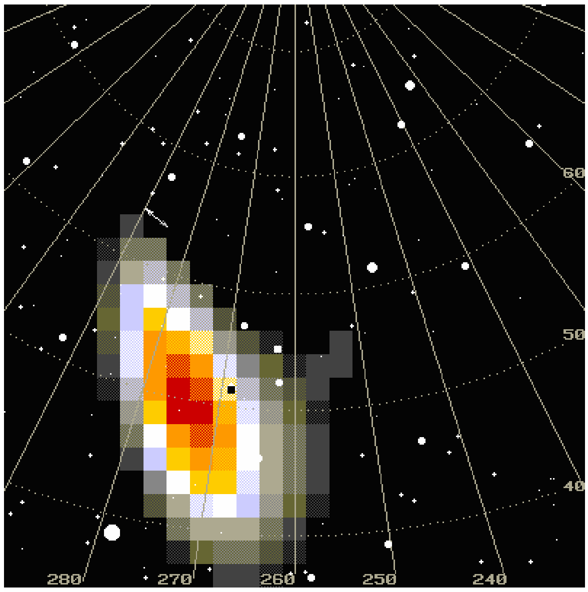
Our colleagues from the IMO suggest fixing just upon the radiant estimation and using of the all-sky camera images to confirm high activity and outbursts of meteor showers, including unlabelled ones.

The brightness estimations for bright variables using the all-sky camera images can be combined with measurements using photographic plates from Odessa photographic glass plate archive in the V band for stars of magnitude 5 and fainter ones.



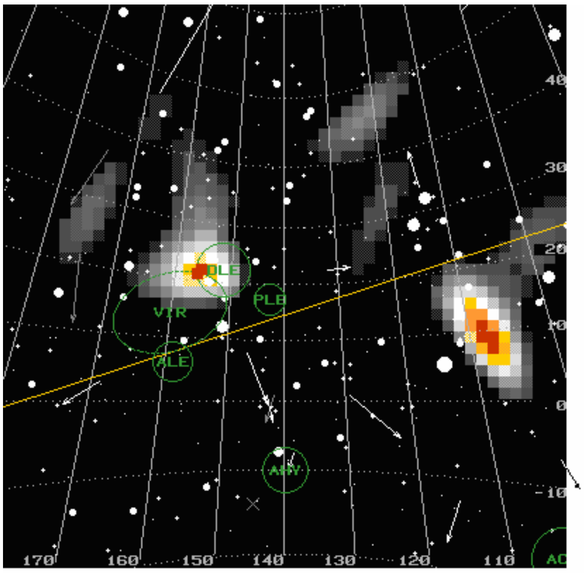
The Leonids radiant on 2011 November 17-18 (RA ~ 138° and Dec = +22° (all-sky camera Special Astrophysical Observatory, Russia)

Figure 9



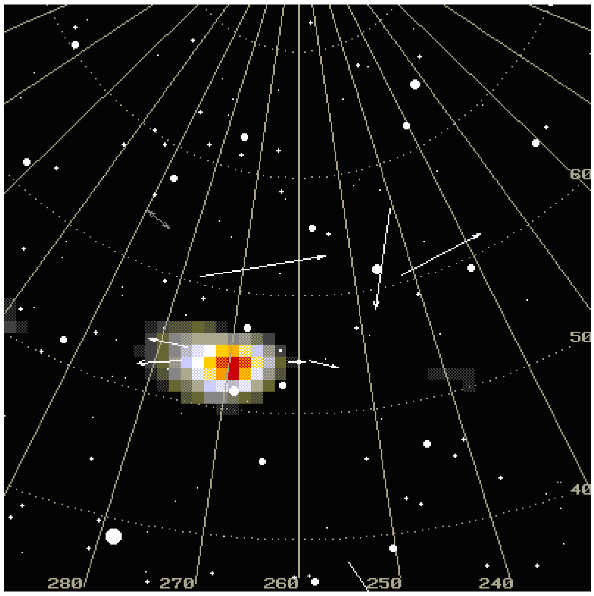
The Draconids radiant on 2011 Oktober 08-09 (RA = 275° and Dec = +49° (all-sky camera Special Astrophysical Observatory, Russia)

Figure 11



The Leonids radiant (RA = 156° and Dec = +21°) and Alpha-Monocerotids radiant (RA = 108° and Dec = +10°) on 2012 November 16-19 (all-sky camera in New-Mexico, United States)

Figure 10



The Draconids radiant on 2011 Oktober 08-09 (RA = 269° and Dec = +54° (all-sky camera The Swedish Institute of Space Physics, Kiruna)

Figure 12

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