International cooperation in field of observations of the near-Earth objects within ISON project

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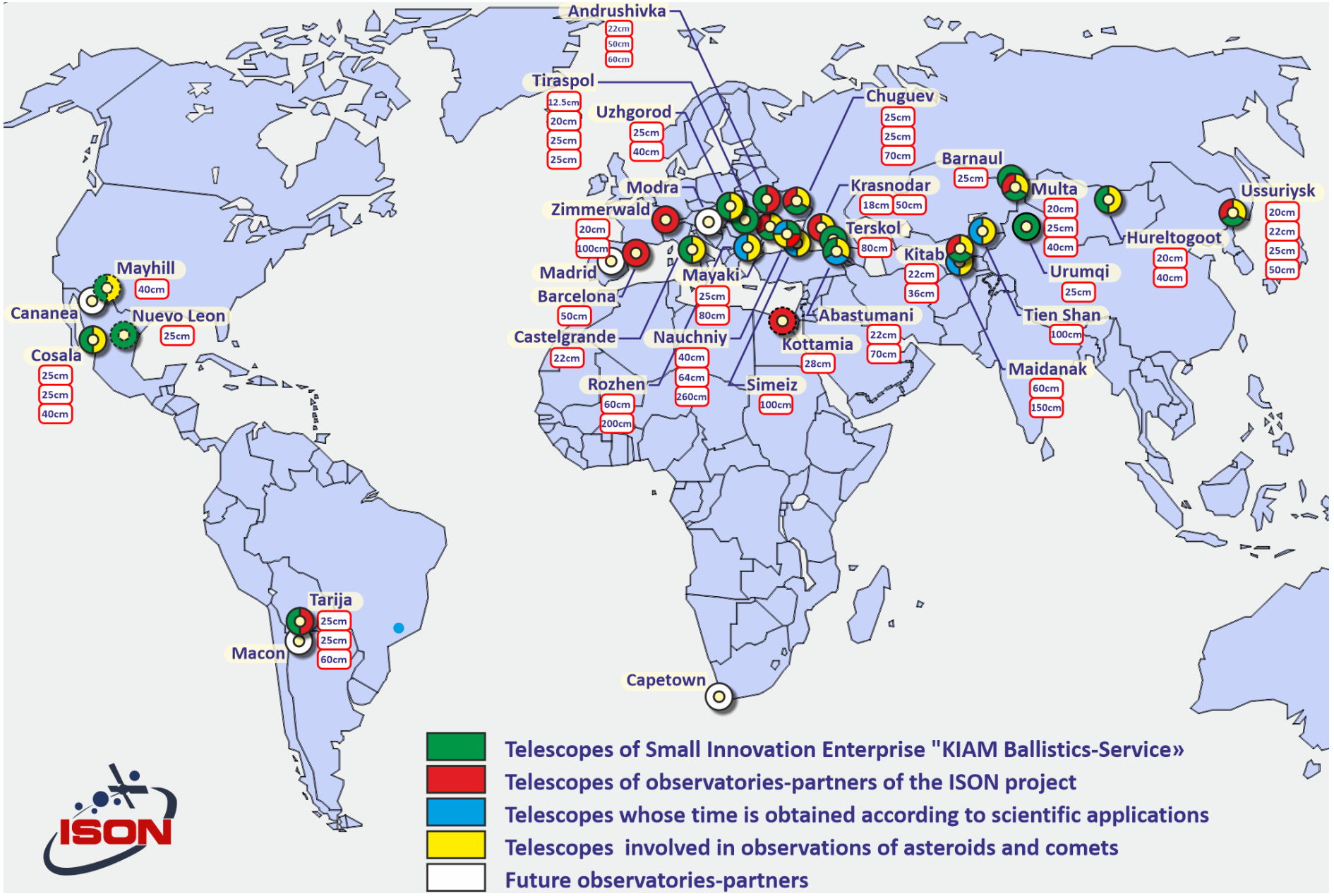
International Scientific Optical Network (ISON)

- ISON that have been started in 2004 is an open international project developed to be an independent source of data about natural and artificial space objects for scientific and applied purposes
- Main observation topics: space debris, asteroids, Gamma-Ray Bursts afterglows
- Core of ISON network is 30 own telescopes (mainly 20-cm – 40 cm apertures) installed in 18 observation points
- 12 telescopes (50 cm – 80 cm apertures) in 9 observatories-partners that have signed agreements on participation in ISON project
- 10 telescopes (60-cm to 2.6 m apertures) in 8 observatories allocate observation time based on consideration of annual scientific applications

Map of ISON telescopes&observatories



Asteroid activities of the ISON project

International cooperation:

- Institute of Astronomy, Karazin Kharkiv National University, Ukraine
- Astronomical Institute of the Czech Academy of Sciences, Czech Republic
- Informal collaboration: Arecibo Observatory, Jet Propulsion Laboratory, USA
- European Space Agency => UN IAWN project
- Purple Mountain Observatory, NAOC, China
- Cooperation of observatories (Abastumani, Georgia; Rozhen, Bulgaria; Tien-Shan, Kazakhstan, Maidanak and Kitab, Uzbekistan)

Observations:

- Asteroid surveys (temporarily suspended);
- Astrometry measurements of the near-Earth asteroids (NEA);
- Photometry observations of asteroids to measure the light curves;
- Polarimetry observations of asteroids and comets;
- Spectrometry observations of the NEAs.

Goals:

- developing asteroid survey technology using small wide-field telescopes;
- urgent follow up of new NEAs
- searching binary NEAs, asteroids with the YORP effect and BYORP effect;
- studying of physical properties of PHA, comets and radar targets

ISON photometry observation campaigns





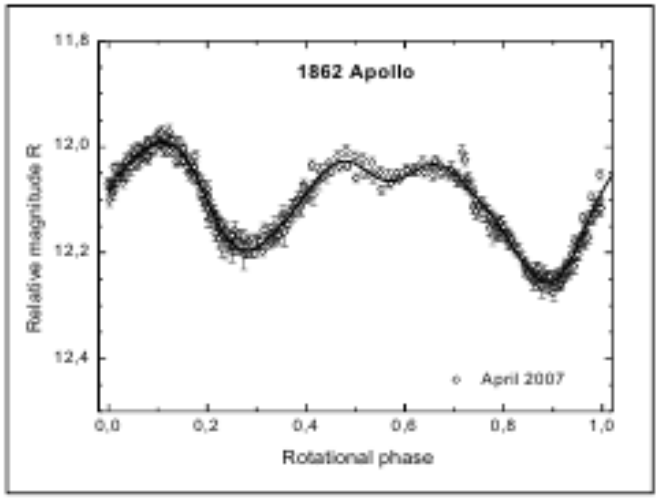



- 8 telescopes (2.6 m ZTSh in Nauchniy, 1 m Zeiss-1000 in Simeiz, 1 m Zeiss-1000 in Tien-Shan, 2 m Zeiss-2000 in Rozhen, 60 cm Zeiss-600 in Maidanak, etc.) participate in ISON photometry observations of asteroids each year since 2008
- Approx. 250 nights of observations and up to 80 asteroids per year (**800 light curves for 370 NEAs total to the date)**
- With ISON data YORP-effect was discovered for (1862) Apollo, (1620) Geographos, (3103) Eger, and (1685) Toro. **First time BYORP-effect is detected for binary (88710) 2001 SL9**

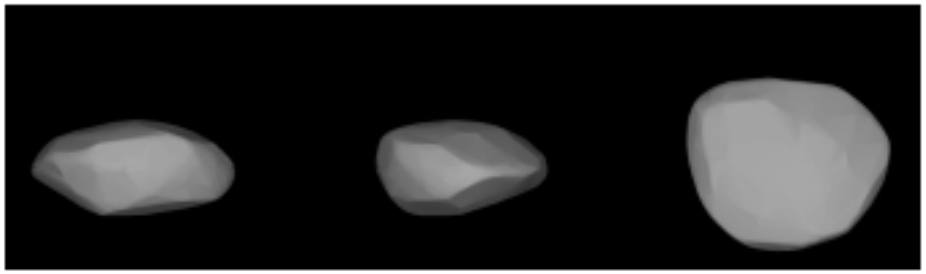
Detection of YORP effect: 1862 Apollo

Our observations on the NEA 1862 Apollo have been done at Simeiz Observatory (Crimea, Z-1000) in 2005. It was found a linear increase of the sidereal rotation period *P* in time *t as* $dP/dt = -4.5 \times 10^{-3}$ min/year. It was the first detection of YORP on an asteroid rotation (*Kaasalainen , Krugly et al. 2007, Nature 446, 420*).

Our new observations of Apollo in April 2007 have confirmed an influence of the YORP effect on Apollo's rotation period (*Durech , Krugly et al. 2008, A&A 488, 345–350*).



Composite lightcurve of Apollo.

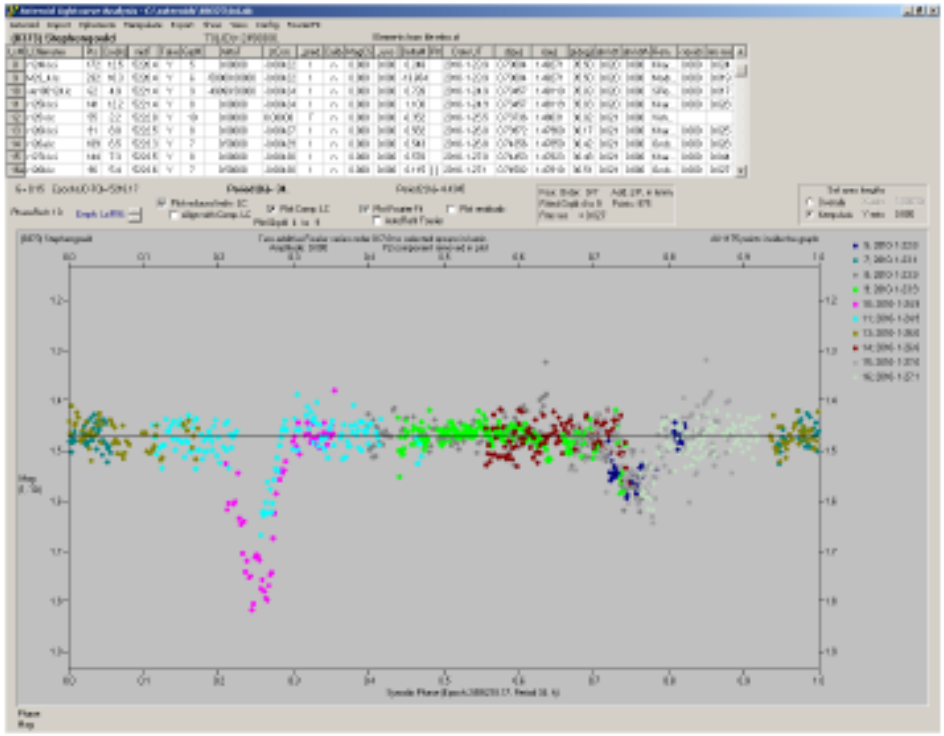


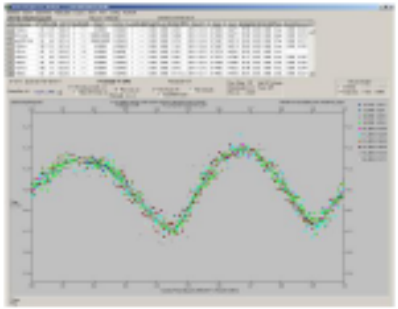
The shape model of Apollo shown at equatorial aspect (*left and centre, 90° apart), and at pole-on (right).*

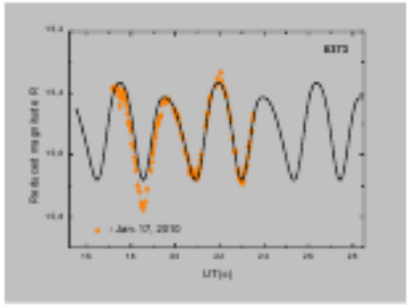
Search for binary asteroids

- ~15% small asteroids are found to be binary systems

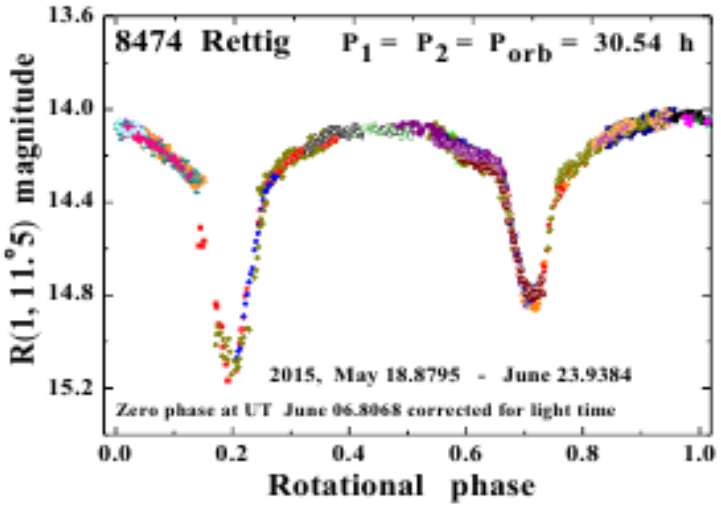
Asynchronous binary's lightcurves

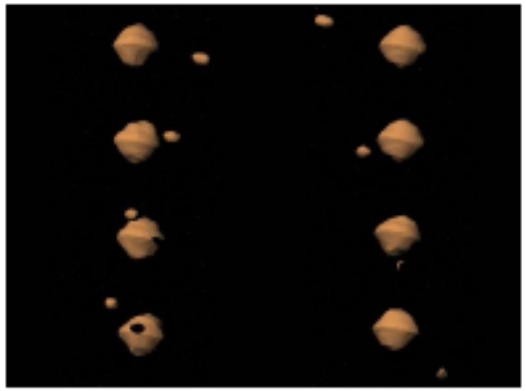






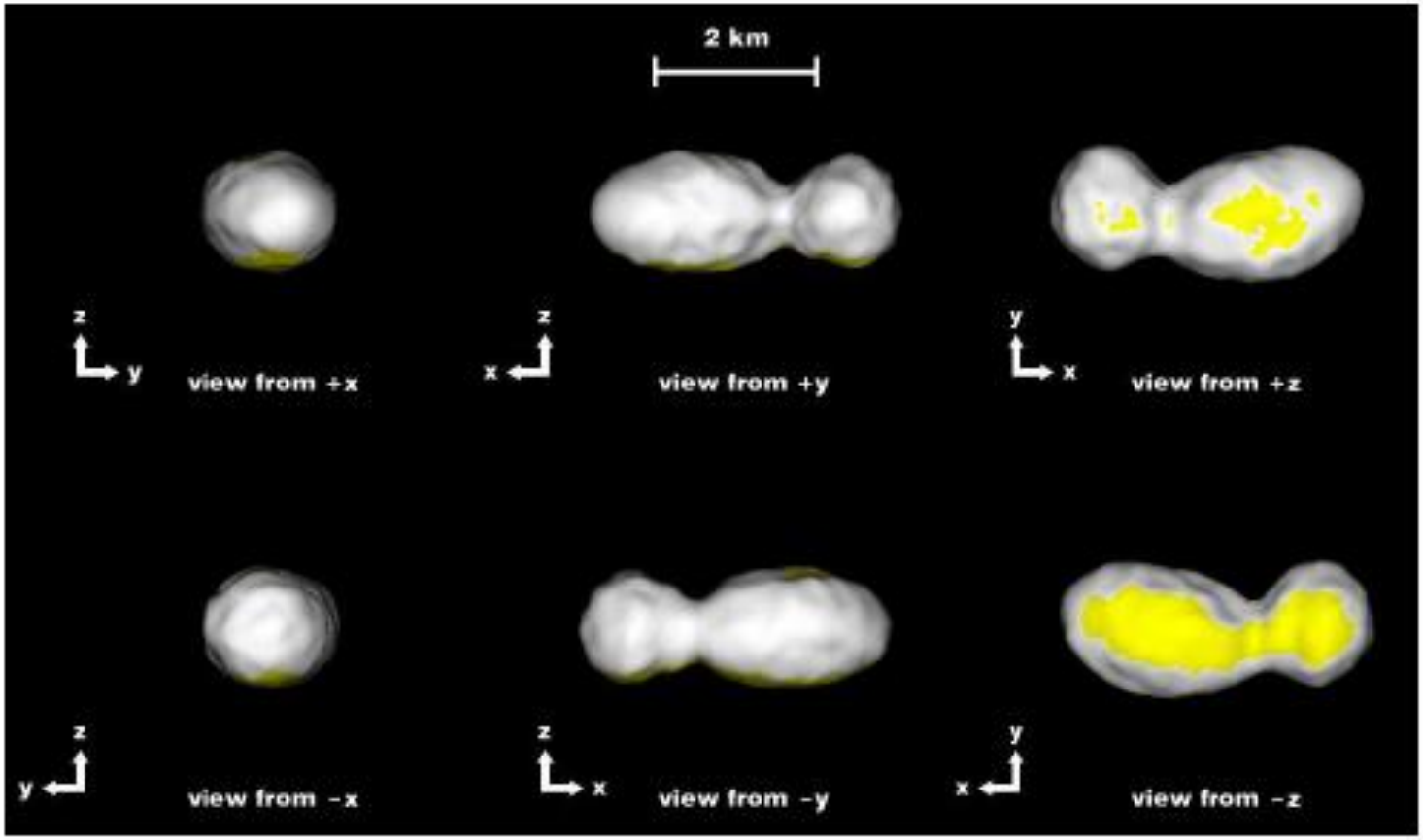
Synchronous binary's lightcurve





Shape Model of *8567 1999 HW1*

Radar and Photometry

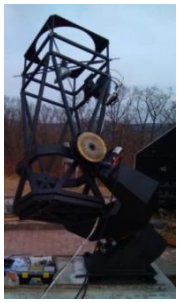


Magri, Krugly et al. 2011. Icarus 2014, 210-227.

Works in 2019

- **Creation of the subsystem for follow up NEAs**

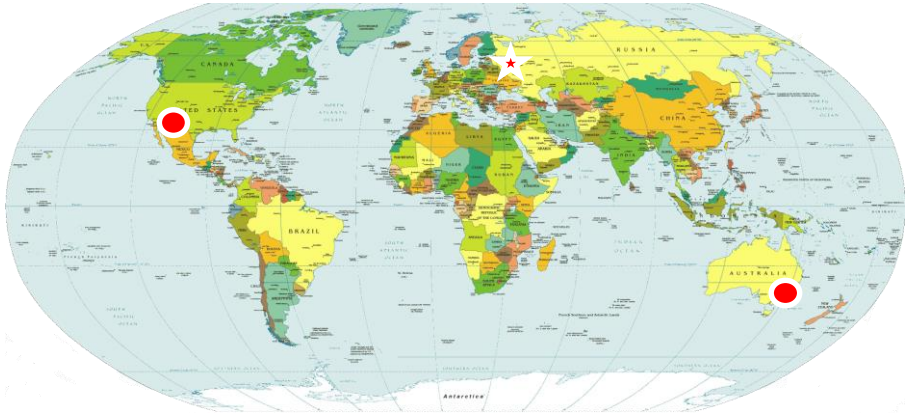



- 50-cm RC-500 Krasnodar, 36-cm RC-360 Kitab, 40-cm ORI-40 Khuraltogote , 50-cm ChV-500 Ussuriysk, 60-cm Zeiss-600 Tarija
- **Photometry of 70 NEAs was carried out during over 300 nights**
- Rotation periods were found for 18 NEA ((18172) 2000 QL7; (89959) 2002 NT7; (152754) 1999 GS6; and (162082) 1998 HL1)
- Selected (68216) 2001 CV26 as new candidate in binary system
- **Collaboration with UN IAWN project under ESA order**
- Astrometry follow up of the 10 objects
- Photometry observations (2 objects, 26 light curves, including the binary NEA (66391) 1999 KW4 was observed during 55 nights using 10 telescopes)
- Polarimetry (2 NEAs) and spectroscopy observations (1 objects)

ISON asteroid surveys

- Two surveys with 40 cm telescopes in New Mexico, USA (**1.76x1.76 degree**) and Siding Spring, Australia (**2x2 degree**) (joint project with AIUB team) with centralized scheduling and processing in KIAM allowed adjust technique and software, and stopped in end of 2018
- Such spreading in latitude and longitude, allowed, in the presence of weather, to conduct almost continuous monitoring and quick follow up of the discovered objects
- Both telescopes in the USA and Australia cover 900 square degrees per night with a **limiting magnitude up to 20.5 m**
- 1 230 500 astrometry measurements, it is discovered **17 NEAs, 8 comets**, 20 Trojans of Jupiter, 4 objects from the family of Hilda, 4 objects of family Centaur, and **1605 main belt** asteroids.



Space debris activities with KIAM/ISON

International cooperation:

- Zimmerwald observatory, Astronomical Institute, Bern University, Switzerland;
- Castelgrande observatory, GAUSS team, Italy;
- Barcelona observatory, TFRM team, Spain;
- Urumqi observatory, National Astronomical observatories CAS, China;
- Cosala observatory, Autonomous University of Sinaloa, Mexico;
- Kottamia observatory, NRIAG, Egypt

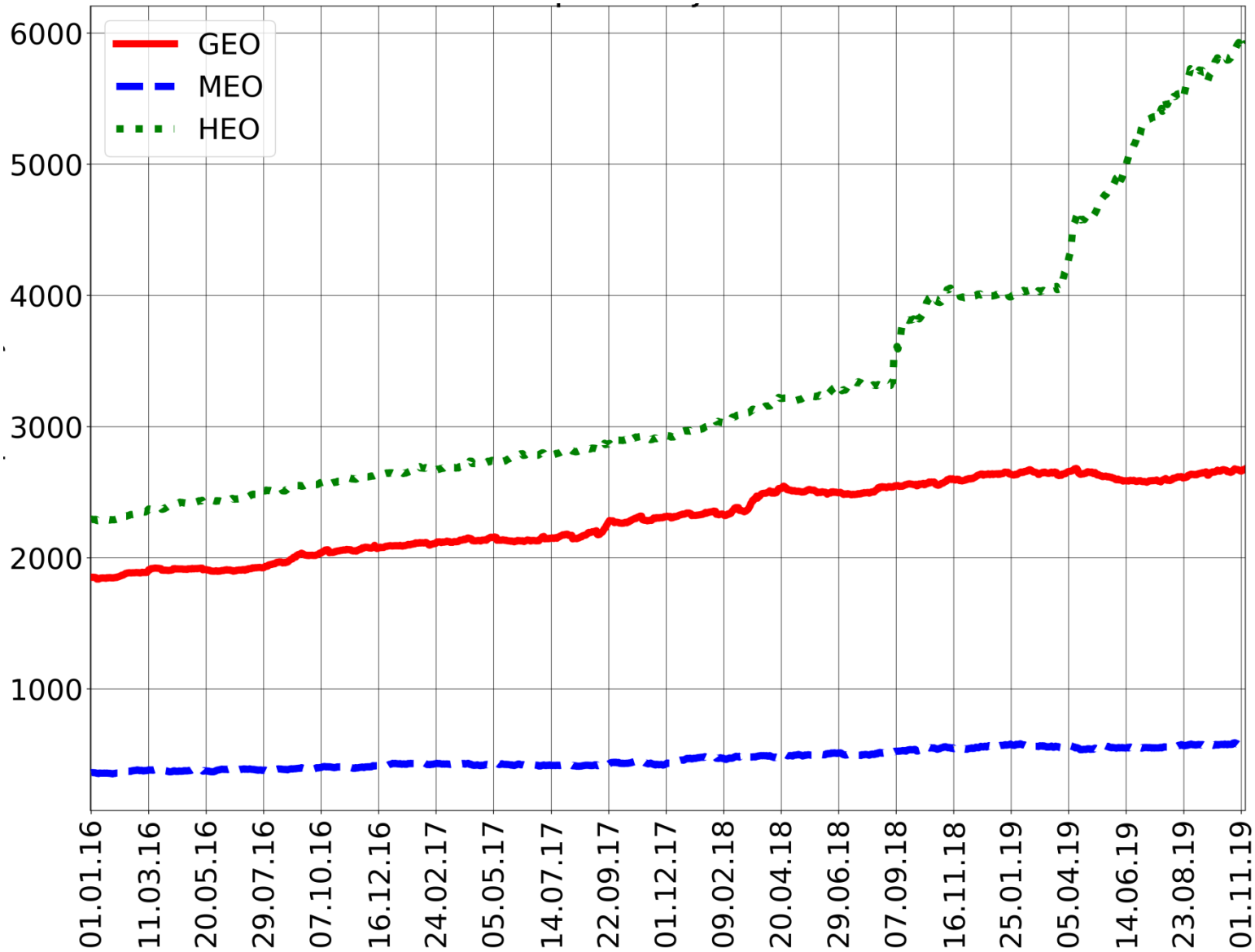
Observations:

- global surveying of all GEO orbits ;
- tracking of bright GEO, HEO and MEO objects;
- searching and follow up of faint debris objects at high orbits;
- developing the new methods and techniques of observations.

Goals:

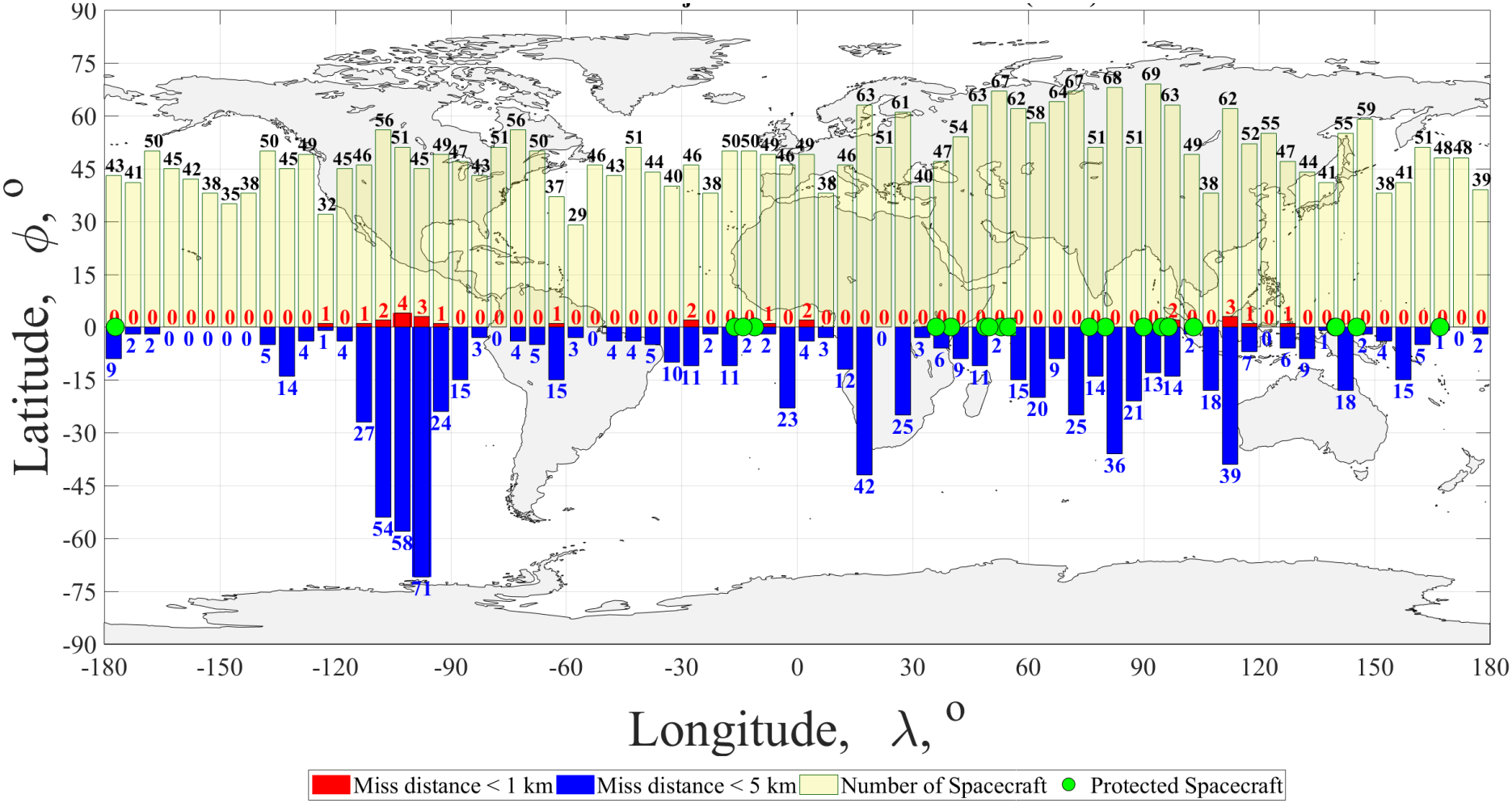
- Maintenance of the **high-orbit space debris database**, as a central information node to perform space debris research in RAS;
- Develop the space debris **population model** at high orbits;
- Support the **conjunction assessment analysis** for high-orbit satellite constellation;
- Various tasks for Russian and foreign customers.

High orbit population growth



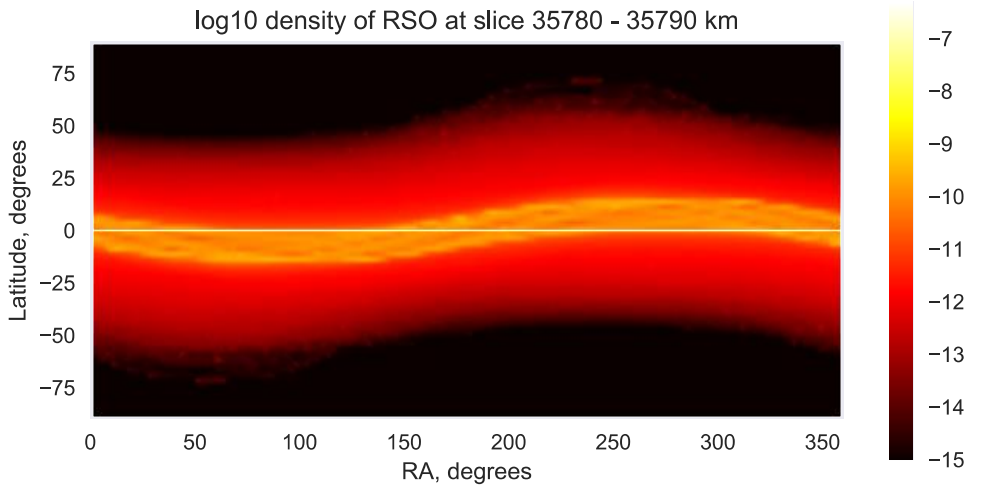
More 9000 space objects at high orbits. Quantity of cataloged objects in HEO orbits increased dramatically, that significantly reduced the quality of the catalog in the whole

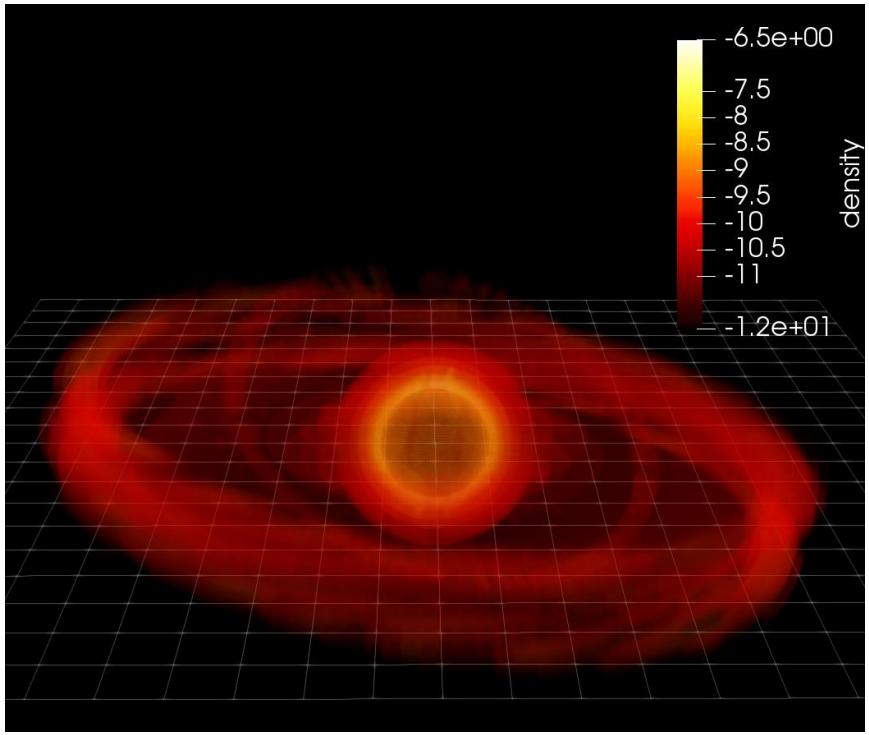
Statistics of rapprochements between all active GEO satellites and all catalogued GEO and HEO space objects during 2019

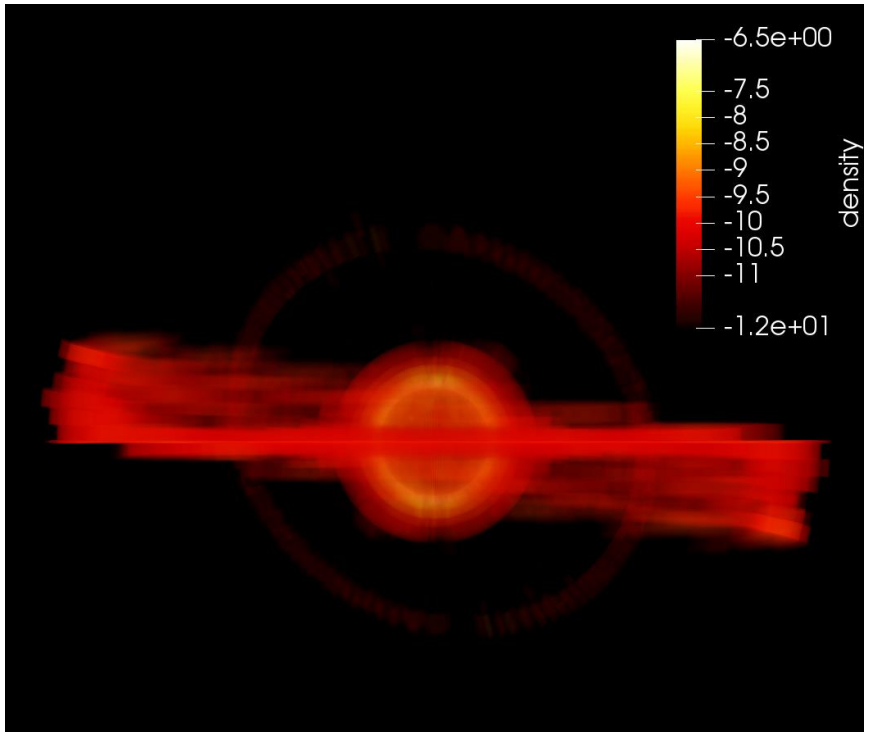


Statistical model derived from cat. objects

- 306 normal local centers were generated out of 18177 RSO (2017-05).
- Naturally describes high density areas (e.g. intact GSO) by means of covariance matrix







Cooperation with the UN

- Since 2008, the ISON results have been presented annually to the Scientific and technical Subcommittee of the UN Committee on the peaceful uses of outer space in Vienna
- On 1 June 2012, during the 55th session of the UN Committee on the peaceful uses of outer space (COPUOS), an open seminar was held on the accession of the ISON project to the UN Basic space science initiative.
- In June 2019 it was signed MoU with UN for cooperation of ISON with the new UN Open universe initiative (**installation of telescopes in developing countries**, training of observers, coordination of joint observations, exploration the use of Open Universe platform, etc).