"Lenticularis" is the New Approach in L-band Ground Stations for LEO Satellites

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Content of the presentation

1. Who are we? Our 30 years experience in Remote Sensing.

2. “Lenticularis” L-band ground station - overview.

3. Spheres of applications of “Lenticularis”.

4. Briefly about “LoReTT” X-band Ground Station.

5. Accent on Education.

6. «Sealpups-2019» Project - overview

Our experience - 30 years in Remote Sensing!

The leading private company on the Remote Sensing market of Russia.

www.scanex.ru

Using space images it implements programs and projects for the scientific and applied environmental researches, education, design, tourism and study of local lore.

http://transparentworld.ru/en/

Private Russian Space Company.

https://sputnix.ru/ru/

Engineering Company «LoReTT» LLC is an innovative start-up, founded in April 2017 with participation of Internet Initiatives Development Foundation (IIDF). Since 23 March, 2018 «LoReTT» LLC is the resident of the «Skolkovo» Innovation Center.

http://lorett.org/

“Lenticularis” L-band Ground Station

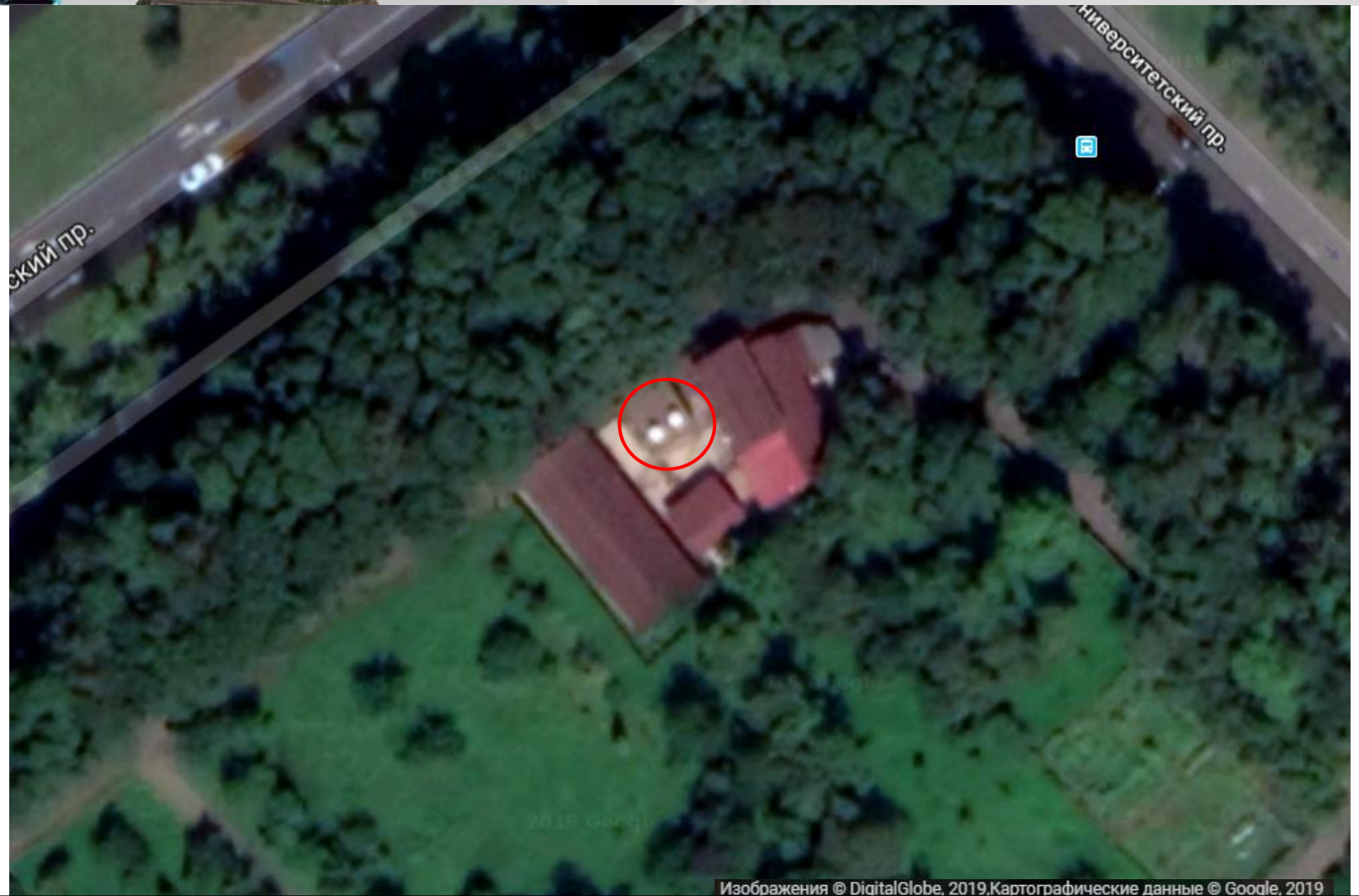
!!! New approach - no traditional expensive and complex antenna dish positioner (rotator).

“Lenticularis” is designed to receive, demodulate, decode, record and process digital information, transmitted from meteorological spacecrafts in low Earth orbits via L-band radio channels. It enbles to receive images from satellite series Meteor-M #2, NOAA, MetOp, FengYun-3.

The Complex provides receiving images from satellites in radius about 400 km from a point of Complex location and automatic data recording on computer disk.

Works on the basis of a standard laptop

Our Testing Ground



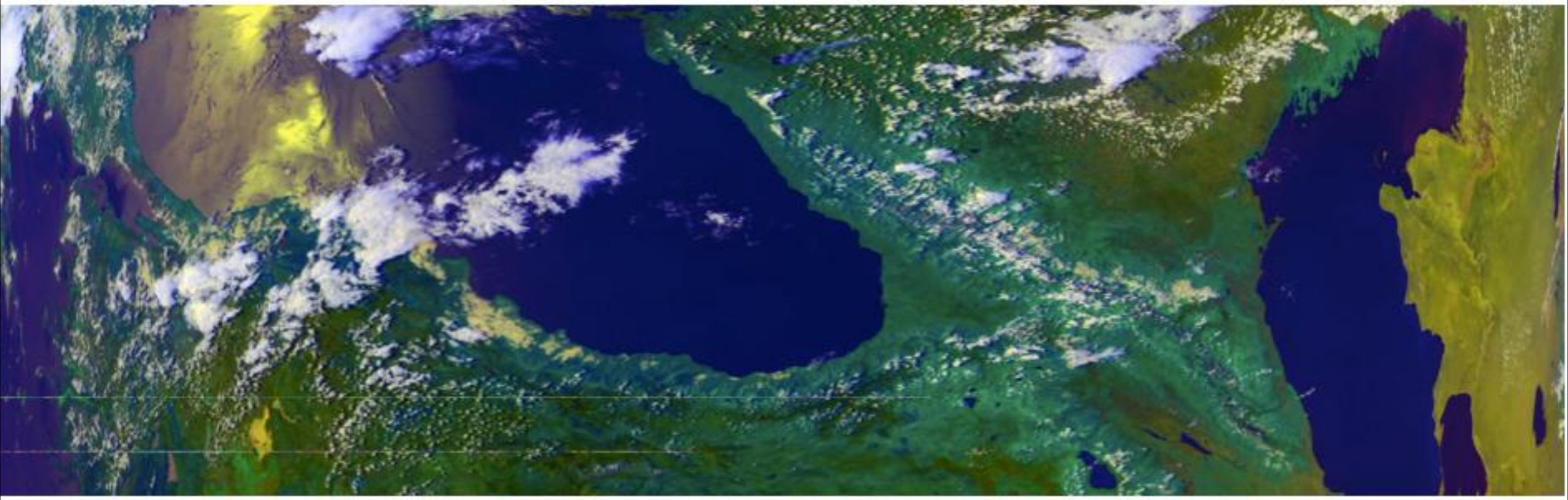
Our Testing Ground in the Lomonosov Moscow State University (Botanical Garden) on Google Maps.

Lenticularis (R=400 km)

VC

METEOR-M 2	2019-06-25 02:04:56	02:05:48	75.1
METOP-A	2019-06-25 02:31:51	02:33:05	83.2
METEOR-M 2	2019-06-25 13:21:32	13:22:38	79.6
METOP-A	2019-06-25 13:48:09	13:49:27	88.4
FENGYUN 3B	2019-06-26 21:02:39	21:03:53	84.1
NOAA-19	2019-06-26 22:27:22	22:28:38	82.3
NOAA-18	2019-06-27 02:16:48	02:17:18	71.5
FENGYUN 3B	2019-06-27 08:21:31	08:22:51	87.4
NOAA-19	2019-06-27 09:48:13	09:49:03	74.6
METOP-B	2019-06-27 14:21:25	14:22:07	73.3
NOAA-19	2019-06-27 22:15:51	22:16:53	77.0
NOAA-18	2019-06-28 02:04:42	02:06:00	87.7
METOP-B	2019-06-28 02:44:24	02:45:06	73.2
FENGYUN 3C	2019-06-28 02:55:07	02:56:19	81.8
NOAA-19	2019-06-28 09:36:21	09:37:37	84.4
NOAA-18	2019-06-28 13:25:20	13:26:38	85.3
FENGYUN 3C	2019-06-28 14:14:07	14:15:19	81.9
FENGYUN 3C	2019-06-29 02:40:21	02:40:47	71.2
NOAA-18	2019-06-29 13:13:52	13:14:40	74.0
FENGYUN 3C	2019-06-29 13:59:21	13:59:51	71.5
METEOR-M 2	2019-06-30 02:05:43	02:06:25	73.2
METOP-A	2019-06-30 02:28:26	02:29:42	89.0
METEOR-M 2	2019-06-30 13:22:17	13:23:17	77.7
METOP-A	2019-06-30 13:44:46	13:46:00	85.8
METEOR-M 2	2019-07-01 01:46:01	01:46:25	71.1
METOP-B	2019-07-02 03:01:33	03:02:25	75.5
METOP-B	2019-07-02 14:17:46	14:18:52	79.5
FENGYUN 3B	2019-07-02 21:11:57	21:13:05	80.1

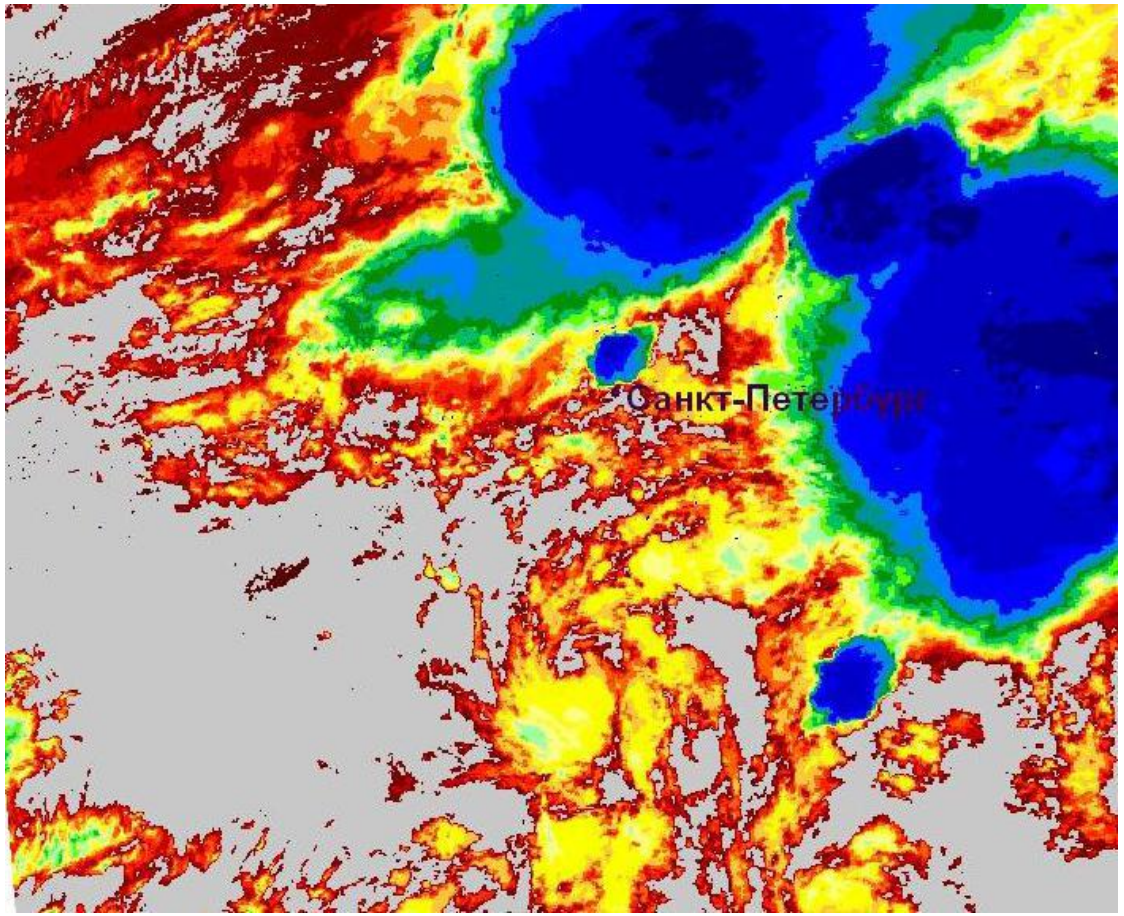
Lenticularis: image example



NOAA-19 image. Acquisition date: July 9, 2018

Received by «Lenticularis» complex in Educational Center «Sirius» (Sochi)

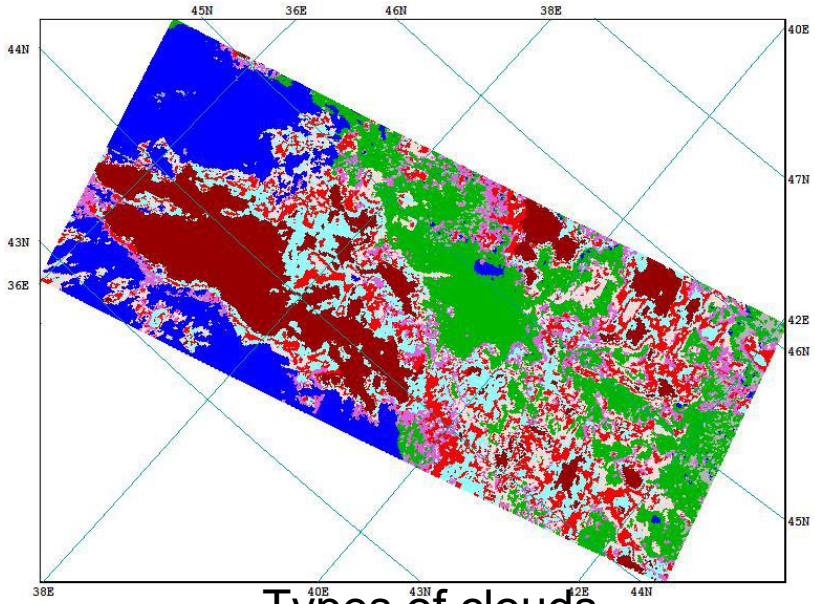
“MeteoLenta” Software



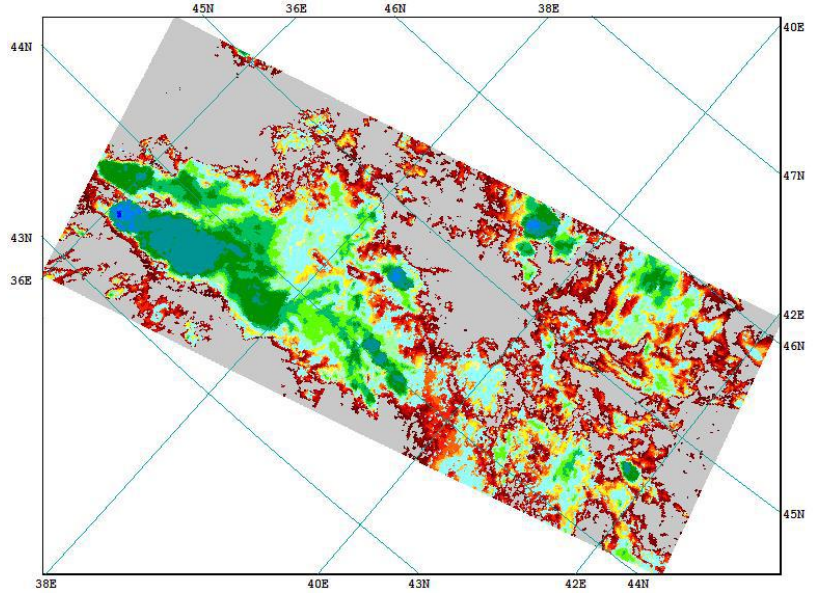
Windows based “MeteoLenta” Software package is designed to process satellite digital HRPT informtion of the AVHRR radiometer, received by “Lenticularis” Ground Station from NOAA and METOP satellites series for hydrometeorological and environmental monitoring purposes.

Currently, processing is possible for NOAA 15-19 satellites and METOP-A and B satellites.

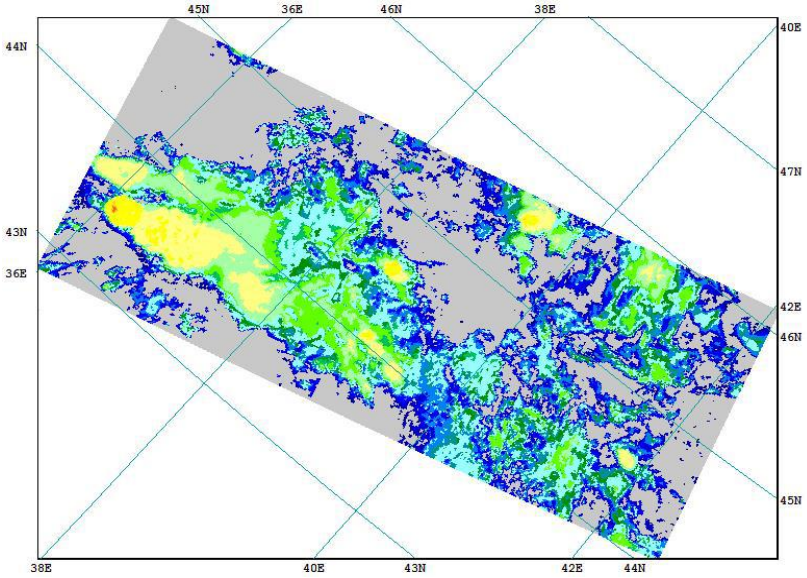
“MeteoLenta” Software - Processing results



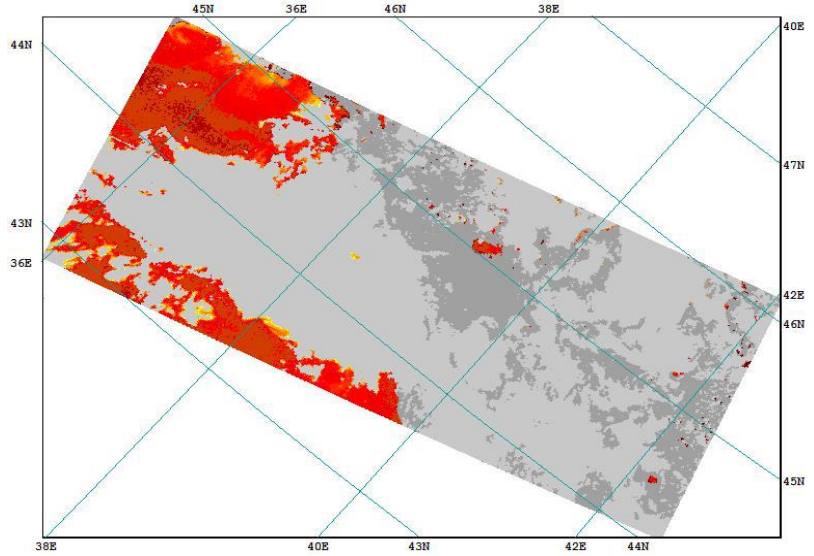
Types of clouds



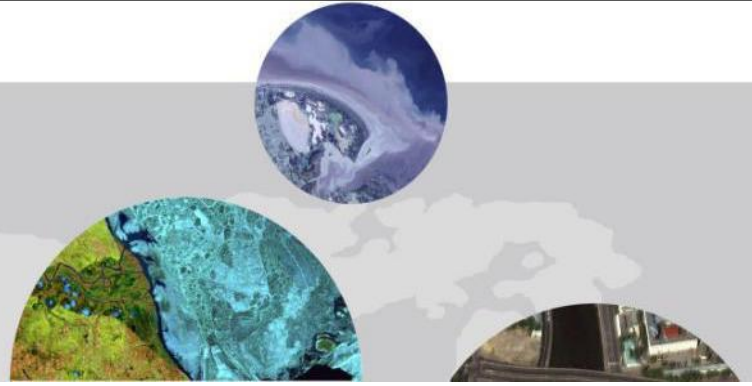
The temperature of the upper boundary of the clouds



Height of the upper boundary of the clouds



Water temperature



Spheres of application

- Multidisciplinary education
- Career guidance for students
- Situation centers
- Meteorology
- Emergency situations monitoring
- Technical engineering competitions

SATELLITE IMAGERY IN SCHOOL EDUCATION: INTERDISCIPLINARY COVERAGE

- GEOGRAPHY
- ECOLOGY
- NATURAL SCIENCES
- IT
- BIOLOGY
- PHYSICS
- LIFE SAFERY
- CHEMISTRY
- ASTRONOMY
- MATHS
- HISTORY
- TECHNOLOGY

IMAGES OF EARTH FROM SPACE AS A BASIS FOR IMPLEMENTATION OF ADDITIONAL EDUCATION PROGRAMS AND CAREER GUIDANCE ACTIVITIES

Purpose of additional education in the common space of the modern school is the early detection of the inclinations and talents of the child, the formation of his interests and help in professional self-determination.

Basic and additional education at school should be a holistic educational space.

THE WORLD EXTREMELY CHANGES.

65% NAMES OF FUTURE PROFESSIONS (2030-2035)

ARE NOW UNKNOWN ...

Lenticularis:
engineering competition between school students' teams

1st step: teams set up the stations…

Stations are ready for data reception!

2nd step: satellite data reception and processing

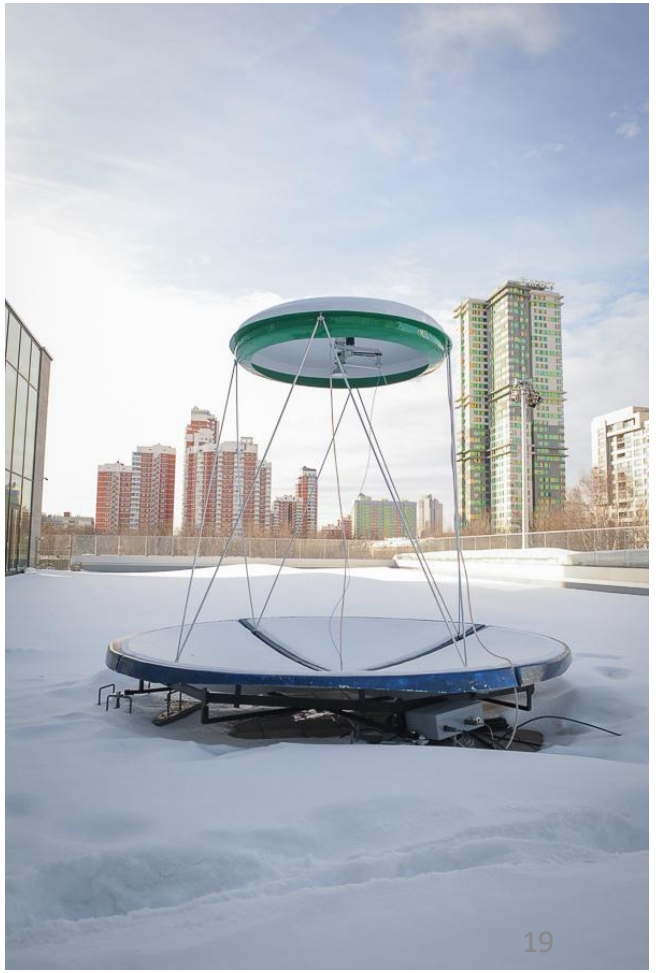
“LoReTT” X-band Ground Station

"LoReTT" (Local Real Time Tool) X-band Ground Station is designed to receive, demodulate, decode, record and process digital information, transmitted from spacecrafts in low Earth orbits via X-band radio channels with the range of demodulation speeds 0.2–100 Msps (with option up to 350 Msps).

!!! New approach - no traditional expensive and complex antenna dish positioner (rotator).

Complex provides automatic data recoring on computer disk and receiving images from satellites in radius about 200 km from a point of Complex location.

Works on the basis of a standard laptop



Demodulator-500 M (DEM-500M)

DEM-500M is designated for receiving and demodulating the high-speed signals of the Remote Sensing systems (RS). With the option of transmitting output signals both on external outputs and directly into the PC memory through DMA.

The Windows-7, Windows-8 and Windows-10 software has a friendly interface and provides access to the main settings which makes it possible to adapt the device both to the existing and advanced signals of RS.

Software can be present both as a setup program and as a collection libraries to enable the Client to design their own applications.

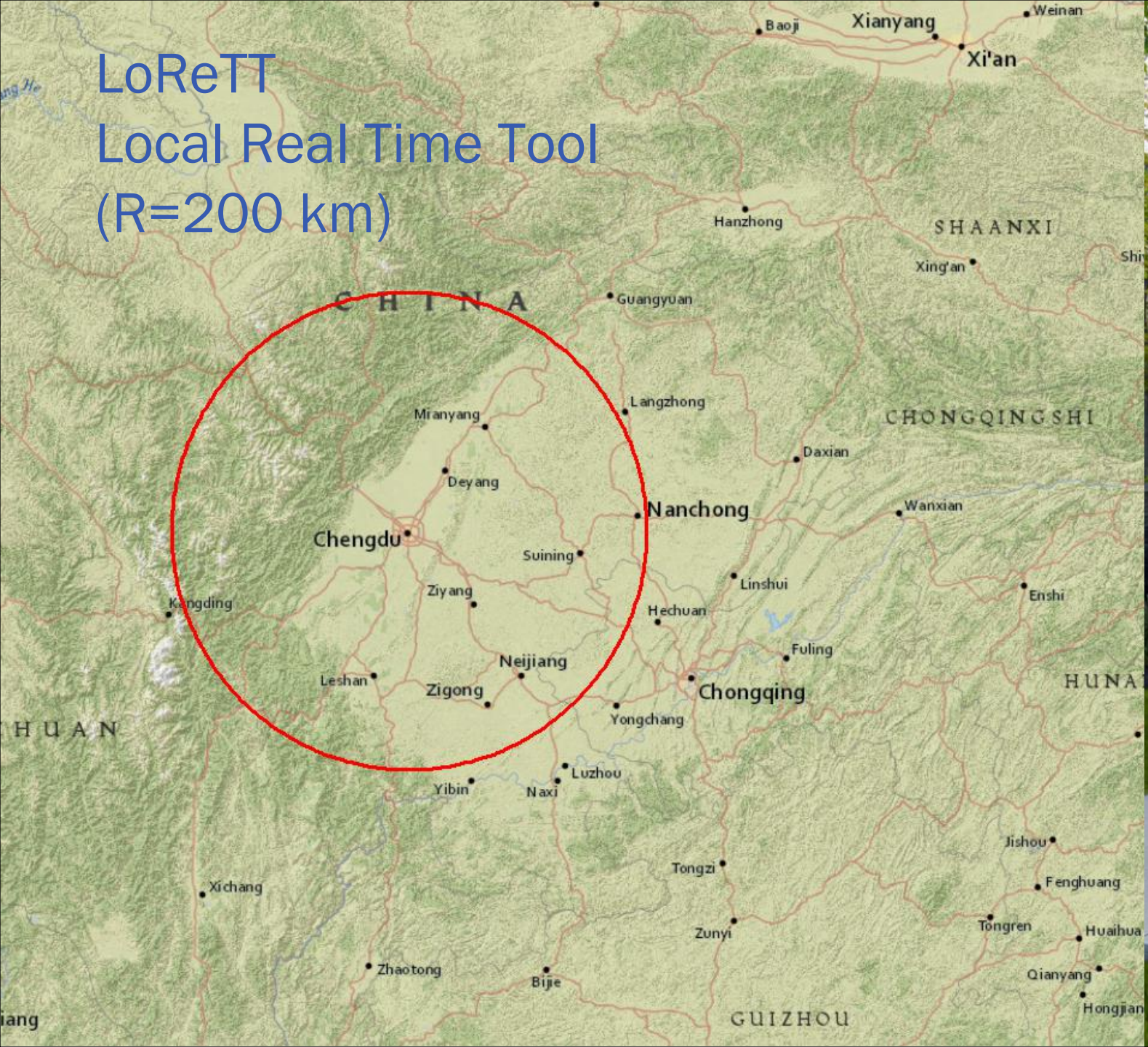
Demodulator is designed as an extension module in accordance with the PCI-Express bus specification. Demodulator is mounted within the housing of an industrial PC.

Demodulator-500 M (DEM-500M)

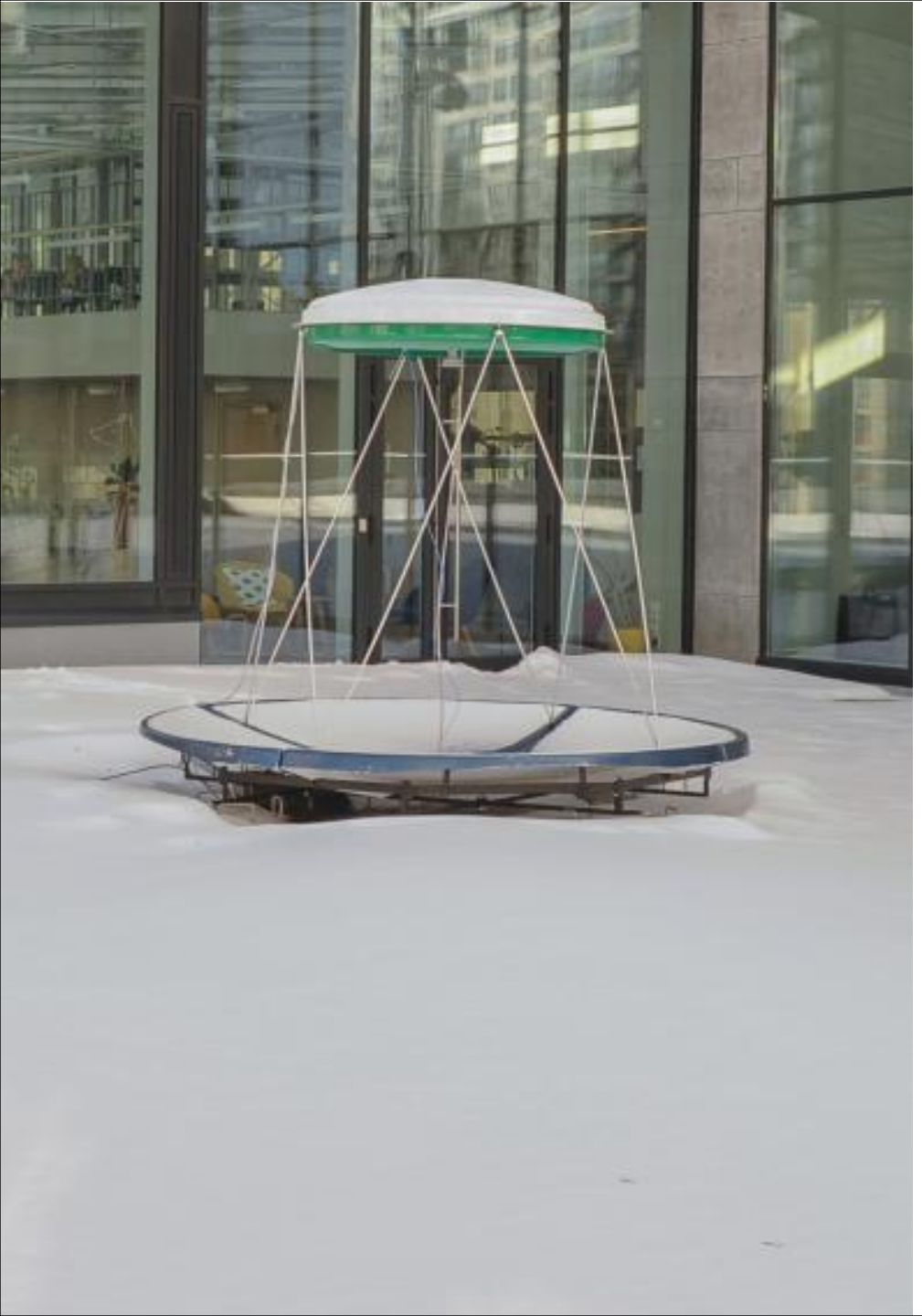
Main technical characteristics

Input frequency range, MHz	750 – 2000 or 720±200
Modulation types	BPSK, QPSK, OQPSK, 8PSK, 16APSK, 16QAM
Signal speed range, Mbps	1 – 350 (BPSK) 2 – 700 (QPSK, OQPSK) 3 – 1050 (8PSK) 4 – 1400 (16APSK, 16QAM)
Frequency step, Hz, not more than	1
Change of speed step, bps, not more than	1
Input impedance, Ohm	50
Input signal level, dBm	minus 60 – minus 25
Energy loss at BER=10^{-4}, dB,	0.3 (< 200 Mbaud)
not more than	0.5 (> 200 Mbaud)
Viterbi decoder	1/2 (BPSK) 1/2, 3/4, 7/8 (QPSK, OQPSK)
LDPC decoder	in accordance with CCSDS 131.1-O-2
Reed-Solomon decoder	in accordance with CCSDS 101.0-B-3
4D-8PSK-TCM decoder	in accordance with CCSDS 401.0-B (2/3, 3/4, 5/6, 11/12)
DVB-DSNG decoder	in accordance with ETSI EN 301 210 5/6 8PSK
VCM SCCC decoder	in accordance with CCSDS 131.2-B-1
VCM CCSDS Space Link Over DVB-S2 decoder	in accordance with CCSDS 131.3-B-1
Pluggable discrambler	included
Pluggable differential decoder	included
Output signal format	LVDS
Maximum speed of data recording into the PC memory, MBps, not less than	400
Relative error of the frequency setting, not more than	5×10^{-8}

LoReTT
Local Real Time Tool
(R=200 km)



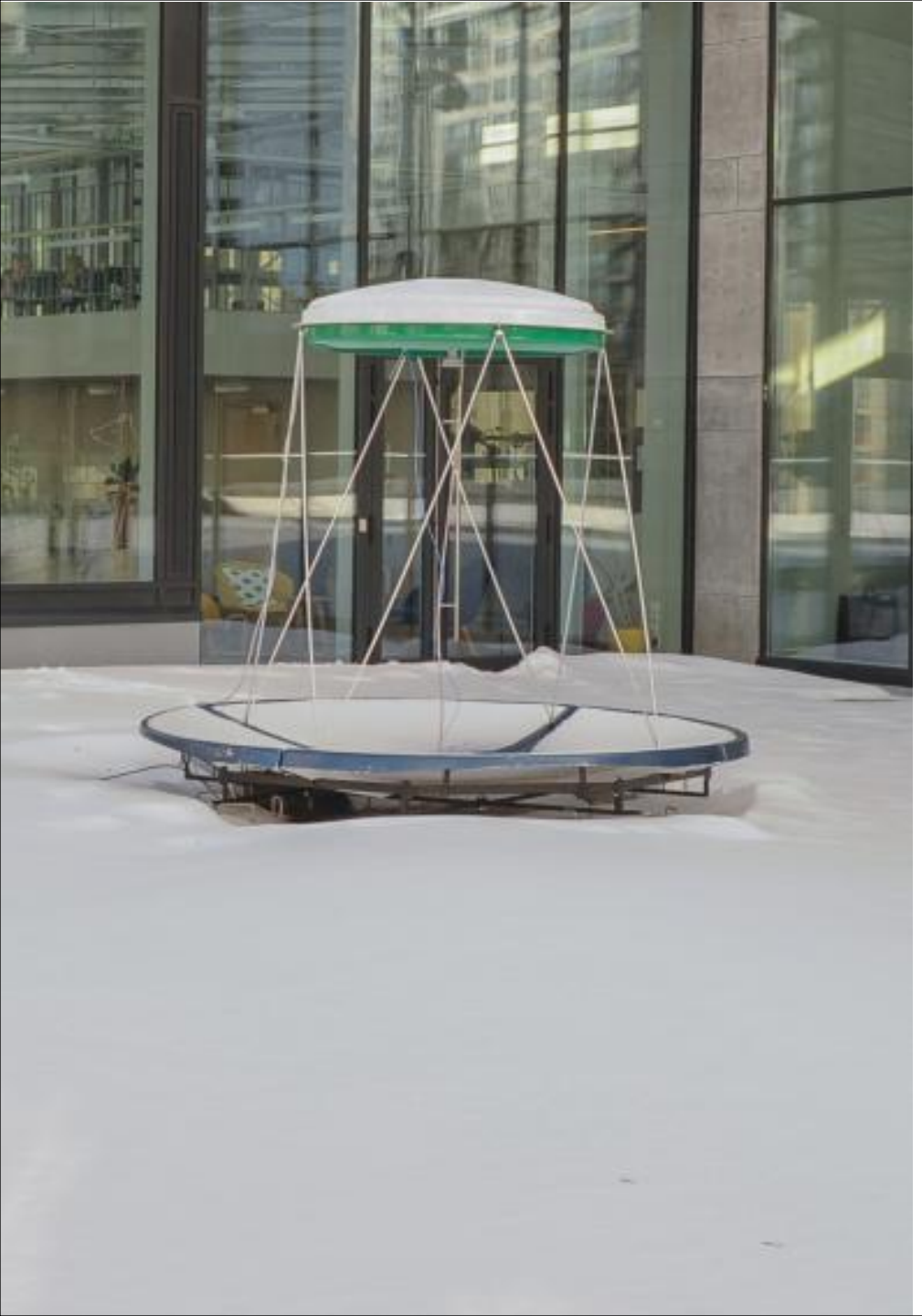
ENGINEERING COMPANY
LORETT



High resolution

DMC3-FM3	2019-06-25 03:19:13	03:20:05	79.8
KAZEOSAT 1	2019-06-25 04:08:48	04:09:36	75.1
KAZEOSAT 1	2019-06-25 15:15:34	15:16:32	78.4
NUSAT-4 (ADA)	2019-06-25 18:49:00	18:49:44	87.7
DMC3-FM2	2019-06-26 03:13:52	03:14:26	73.8
AIST-2D (RS-48)	2019-06-26 03:18:45	03:19:27	87.2
ARIRANG-3 (KOMPSAT-3)	2019-06-26 06:10:03	06:11:05	84.6
NUSAT-2 (BATATA)	2019-06-26 16:11:17	16:12:01	86.2
KAZEOSAT 2	2019-06-27 03:37:45	03:38:33	79.7
DEIMOS-2	2019-06-27 03:53:46	03:54:44	88.5
NUSAT-1 (FRESCO)	2019-06-27 04:41:45	04:42:27	84.7
AIST-2D (RS-48)	2019-06-27 15:50:23	15:50:59	79.6
DMC3-FM3	2019-06-27 16:08:57	16:09:35	74.1
ARIRANG-3 (KOMPSAT-3)	2019-06-27 18:50:56	18:51:52	80.2
NUSAT-2 (BATATA)	2019-06-28 04:49:36	04:50:18	84.8
DMC3-FM2	2019-06-28 16:03:19	16:04:11	79.9
AIST-2D (RS-48)	2019-06-29 03:20:16	03:20:56	87.6
DMC3-FM3	2019-06-29 03:27:40	03:28:34	80.9
NUSAT-3 (MILANESAT)	2019-06-29 12:31:38	12:32:28	83.3
DMC3-FM1	2019-06-29 15:56:37	15:57:37	87.4
KAZEOSAT 2	2019-06-29 16:06:51	16:07:45	81.2
NUSAT-3 (MILANESAT)	2019-06-29 19:15:00	19:15:52	89.6

VC



Low resolution

TERRA	2019-06-25 03:44:33	03:44:57	71.6
SUOMI NPP	2019-06-25 18:44:16	18:45:26	81.4
AQUA	2019-06-25 19:01:57	19:02:57	82.4
SUOMI NPP	2019-06-26 06:01:34	06:02:40	79.3
FENGYUN 3D	2019-06-26 18:58:29	18:59:39	80.5
FENGYUN 3B	2019-06-26 21:02:39	21:03:53	84.1
FENGYUN 3D	2019-06-27 06:15:37	06:16:51	82.9
FENGYUN 3B	2019-06-27 08:21:31	08:22:51	87.4
AQUA	2019-06-27 18:50:00	18:50:28	72.1
NOAA 20	2019-06-27 18:56:38	18:57:34	76.0
NOAA 20	2019-06-28 06:13:48	06:14:52	78.1
TERRA	2019-06-28 15:14:44	15:15:48	88.6
NOAA 20	2019-06-28 18:38:12	18:38:24	70.3
TERRA	2019-06-30 04:02:53	04:03:07	70.7
SUOMI NPP	2019-06-30 18:50:30	18:51:46	87.1
SUOMI NPP	2019-07-01 06:07:45	06:09:03	89.3
AQUA	2019-07-01 06:20:15	06:21:19	88.0
FENGYUN 3D	2019-07-01 19:04:15	19:04:39	71.1
TERRA	2019-07-02 03:50:15	03:51:19	84.0
FENGYUN 3D	2019-07-02 06:21:16	06:21:58	73.2
FENGYUN 3D	2019-07-02 18:45:06	18:45:58	75.0
AQUA	2019-07-02 19:08:28	19:08:34	70.1
FENGYUN 3B	2019-07-02 21:11:57	21:13:05	80.1

VC

AIST-2D image. Acquisition date: May, 2019

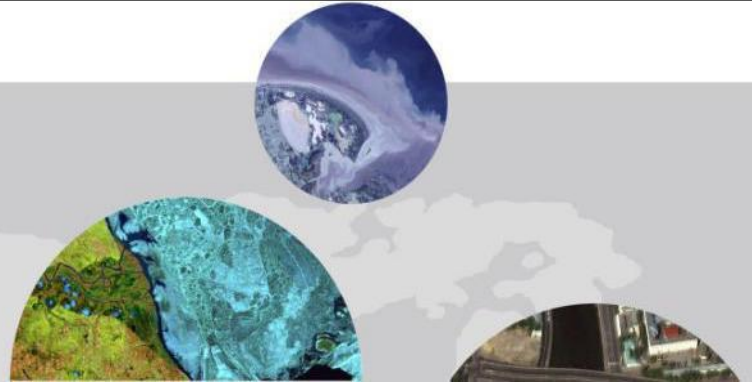
Received by «LoReTT» Ground Station (Moscow region)

B2B – Private schools and universities

B2G – Governmental schools and universities

B2C – Family Edutainment

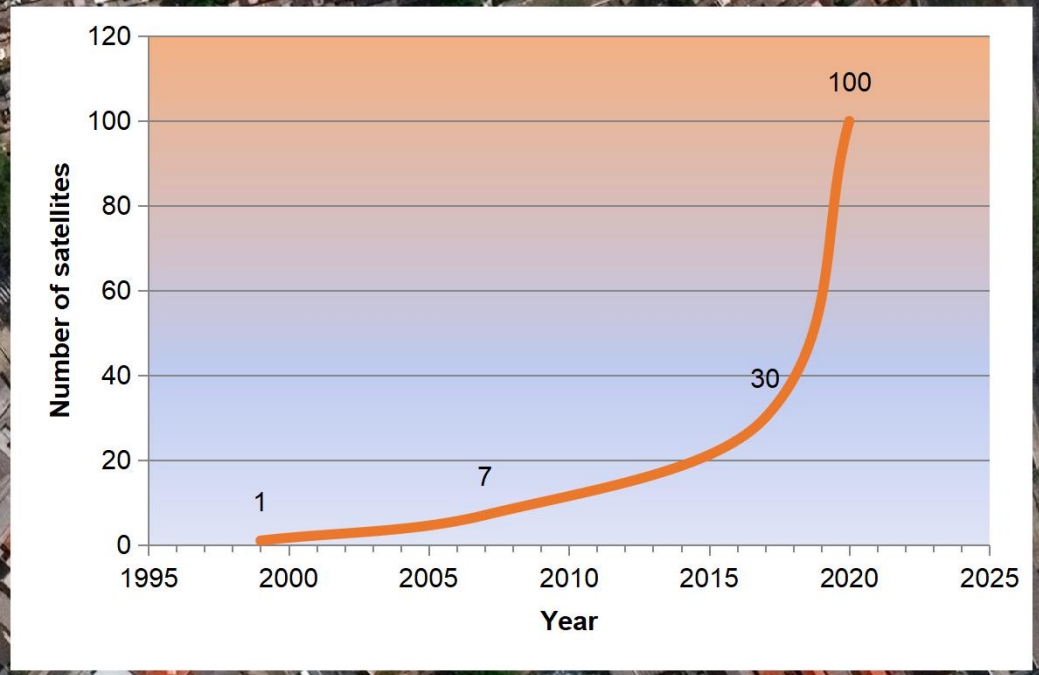
Our advantage



Problems and tasks

1. Increasing number of satellites with VHR.
2. Increasing number of companies in area of Business Intelligence.
3. Lack of data with Zero Latency delivery.
4. Open (copyright free) images from Space are usually “old” and therefore cannot help to act in Real Time.
5. Education — lack of modern laboratory tools for schoolchildren teaching and future profession choice.

SATELLITES WITH VHR: THE DEVELOPMENT TREND



São Paulo, Brazil.
Worldview-3 satellite image (0.3 m resolution)

Evaluation of the consequences of the fire season in Russia and Canada

Search and mapping of coniferous forests damaged by bark beetle

Detection of disturbances in salmon extraction using fixed nets

Search for harp seals whelping grounds during the breeding season

Search for illegal construction in water protection zones

Monitoring Elephant Safaris in African national parks

Identify the causes of the disappearance of tropical forests

ENGINEERING COMPANY LORETT

SATELLITE IMAGERY IN SCHOOL EDUCATION

EXAMPLES OF PROJECTS

«Sealpups-2019»

All-Russian contest for schoolchildren
in the frames of «On Duty for Planet» program

ДЕЖУРНЫЙ ПО ПЛАНЕТЕ

Goal of the project: organization of the operational headquarters
in order to prevent the death of sealpups during icebreaking in the White Sea

ФОНД СОДЕЙСТВИЯ ИННОВАЦИЯМ

РОСКОСМОС

Skoltech
Сколковский институт науки и технологий

Сириус
Образовательный центр

Кружковое движение

Project team location:
Educational Center «Sirius»
Russia, Sochi

Final Stage of the project: March 1-10, 2019

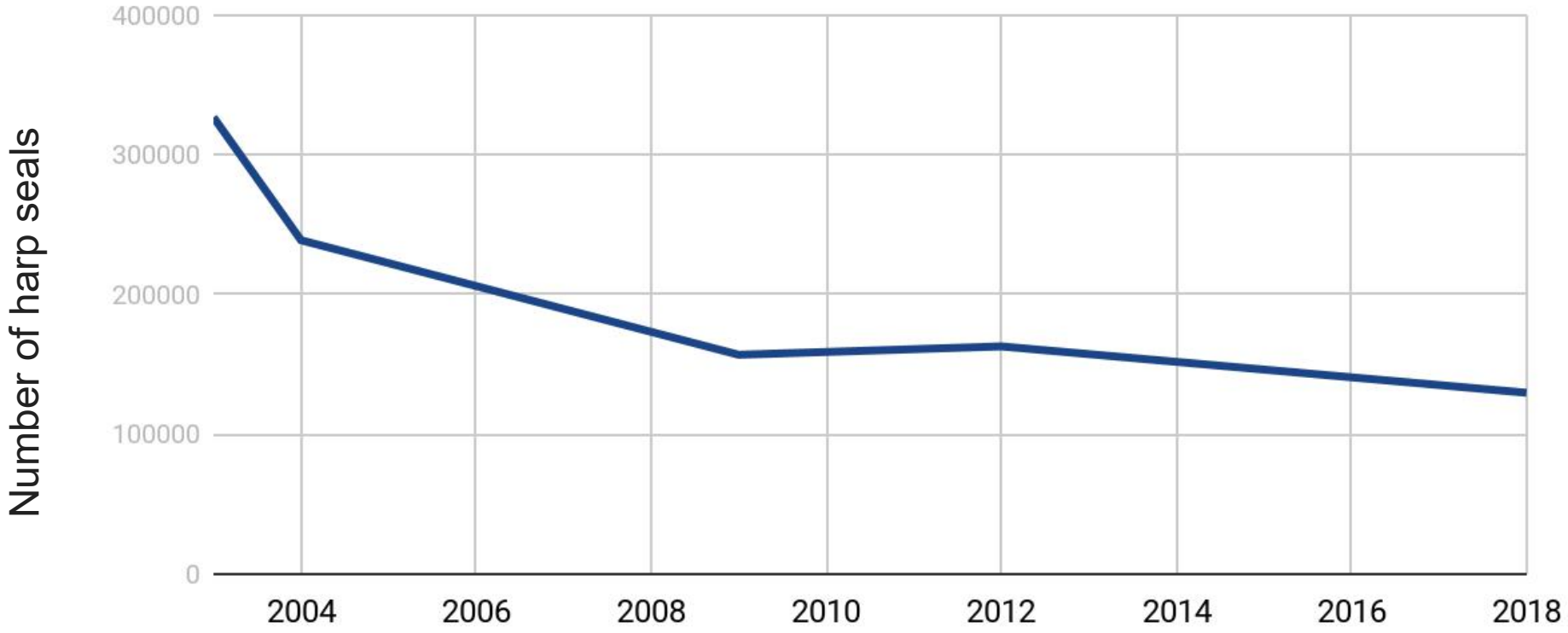
Sealpup – baby harp seal

Project participants

15 children (13-17 years old) from all over Russia saved sealpups in the White Sea

Problem

Reduction of the White Sea harp seal population



Goal of the Project

Organization of the operational headquarters in order to prevent the death of sealpups during icebreaking in the White Sea

Staff Algorithm

1. Satellite images reception
2. Satellite images processing and analysis
3. Find harp seals whelping grounds
4. Predict the movement of ice
5. Notify the ports' administration
6. Reporting

We thank our Partners!

Operators’ headquarters

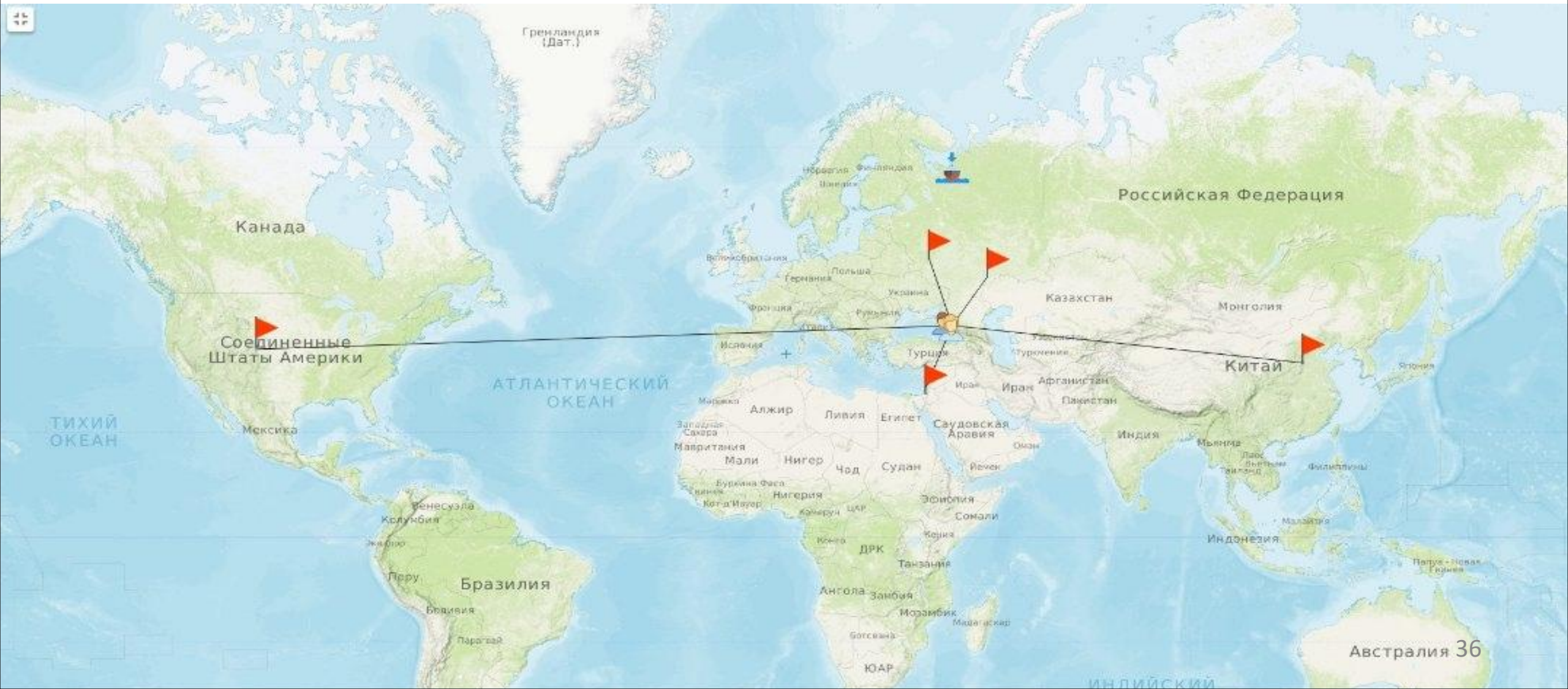
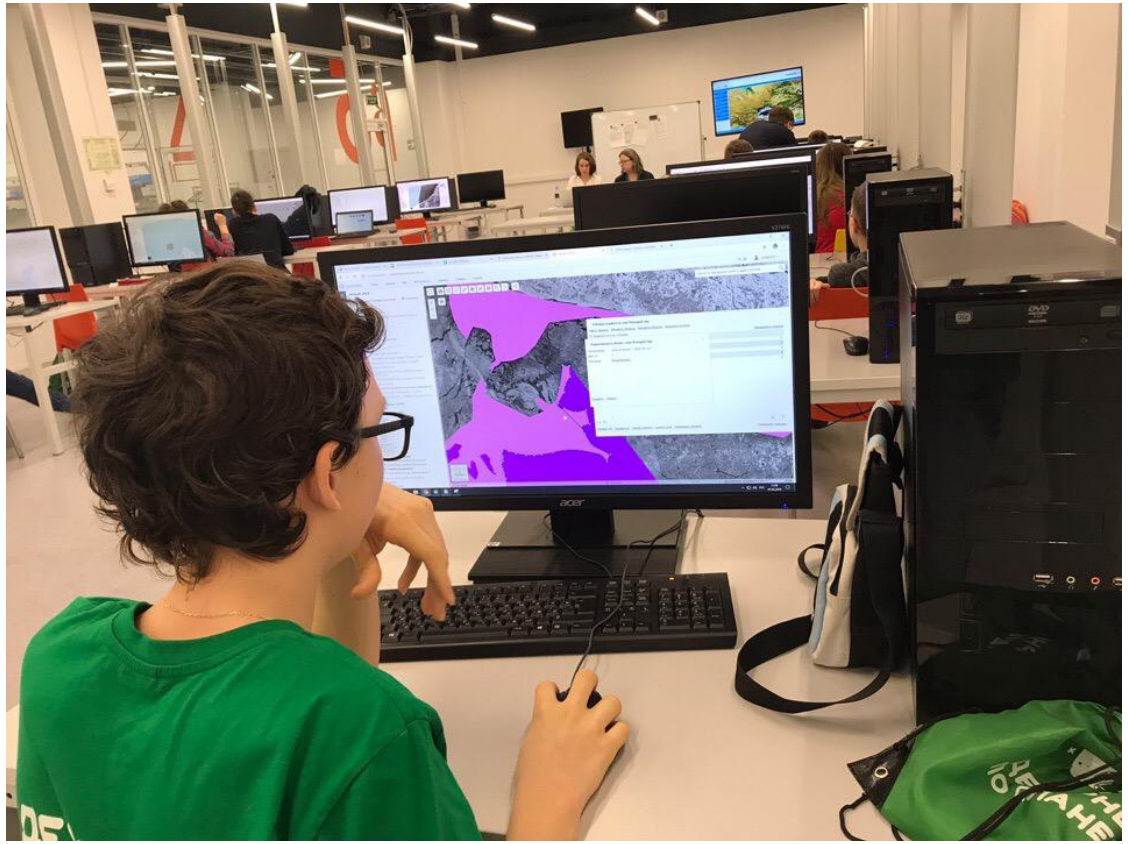


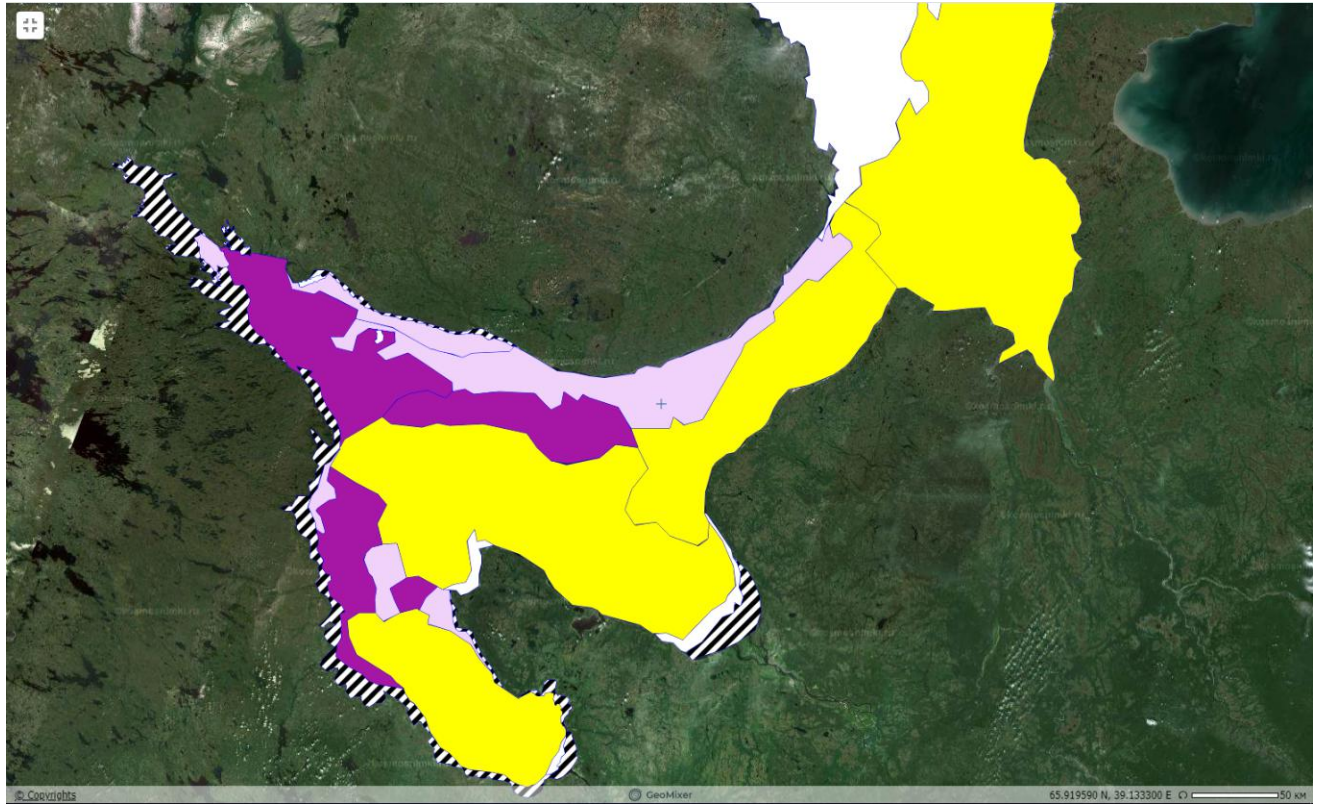
Image Processing & Analysis

Scanex Image Processor software

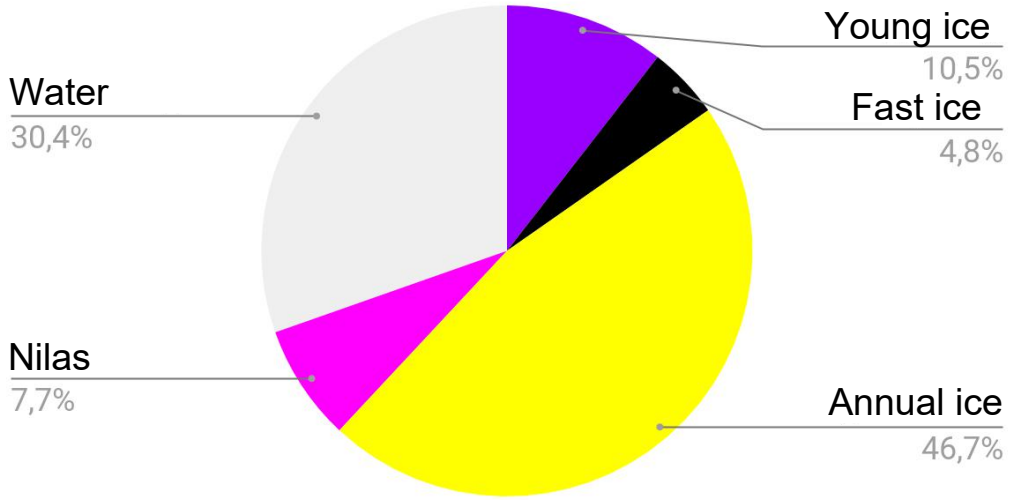


Scanex Web Geomixer geoportal

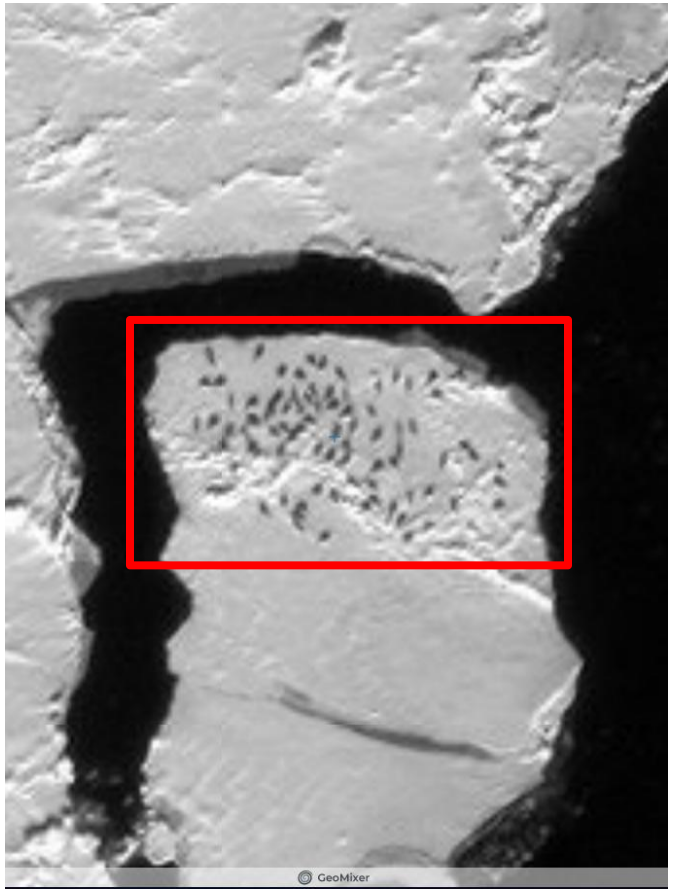
Ice mapping



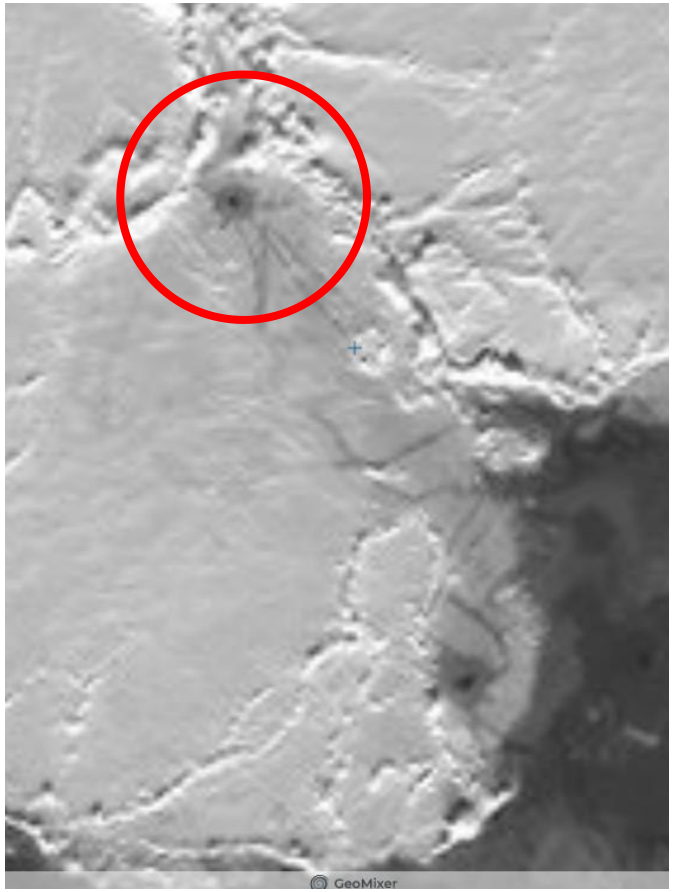
March 3, 2019



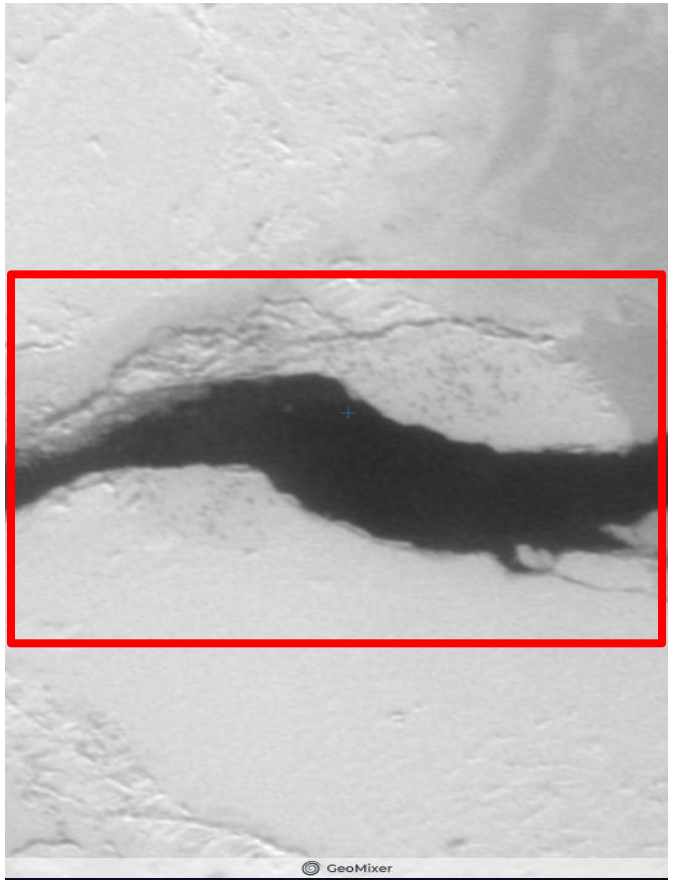
Search for whelping grounds



GeoEye-1 2019-03-03 9:25



GeoEye-1 2019-03-03 9:25



Resurs-P 2019-03-05 11:54

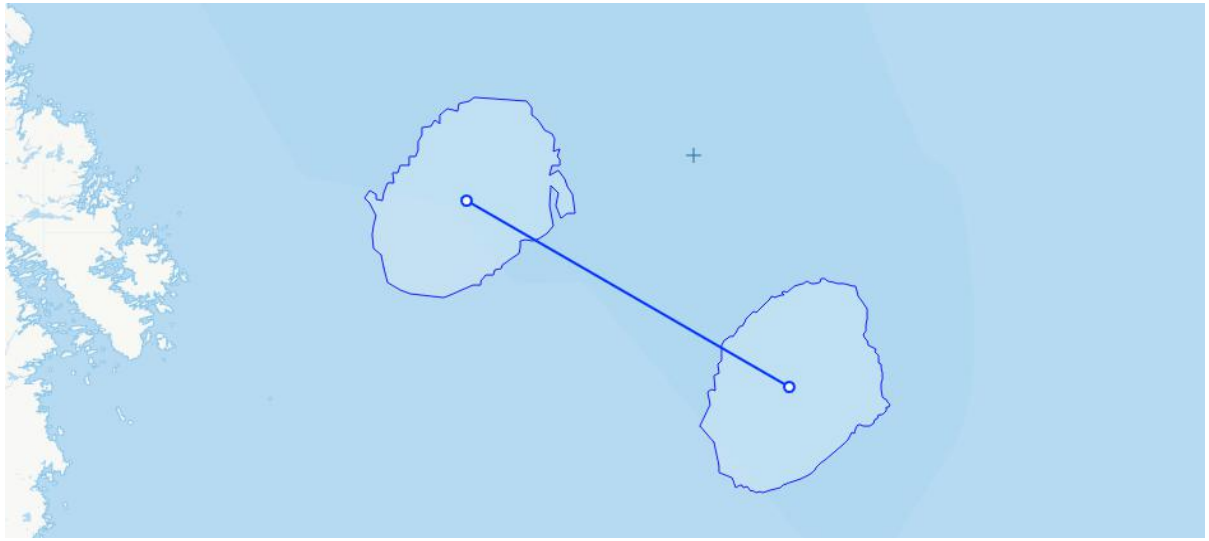
Headquarters activity results

1. The first whelping ground was discovered on March 5, 2019.
   Totally 20 whelping grounds were found during the project.

2. Cloudless images from AIST-2D, Resurs-P, GeoEye-1, WorldView-1/2, EROS B and Gaofen-3 satellites were received daily.

3. Images received during the project cover a large part of the White Sea, approximately 19,794 sq. km

Ice drift calculation



```
  for i in range(0, len(mean), 2):
    vector_sum += to_vector(wind_speed(float(mean[i])), wind_angle(float(mean[i+1]) + 28))
    num+=1
  return vector_sum / num


def calculate_speed(x):
  distance = math.sqrt(x[1][0]**2 + x[1][1]**2)
  return distance
def calculate_angle(x):
  cs = x[1][0] / calculate_speed(x)
  sn = x[1][1] / calculate_speed(x)
  if cs >= 0 and sn >= 0:
    return(from_radian(math.acos(cs)))
  elif cs <= 0 and sn >= 0:
    return((360 + from_radian(math.acos(cs))) % 360)
  elif cs >= 0 and sn <= 0:
    return((360 + from_radian(math.asin(sn))) % 360)
  else:
    return(-(from_radian(math.asin(sn))) + 180)



print('Введите данные>>')
data = input()
data = mean(data)
print('Скорость дрефа состовляет ' + str(calculate_speed(data)) + ' км в сутки')
print('Угол дрейфа в математических координатах равен ' + str(calculate_angle(data)) + ' градусов')
```

```
Введите данные>>
6.5, 230, 7, 265, 5, 239, 7, 265, 5, 241, 8, 262, 3, 225, 3, 135, 6, 88, 7, 103
Скорость дрефа состовляет 2.3323313732665882 км в сутки
Угол дрейфа в математических координатах равен 160.69283778039107 градусов
```

Ice drift from 28.02.2019 to 01.03.2019

- Distance: 35.5 км
- Direction: SE
- Average Speed: 11.8 km/day

Data transfer to sea ports

The coordinates of the detected whelping grounds were promptly transferred to the White sea ports in order to organize alternative icebreaker routes

ДЕЖУРНЫЙ ПО ПЛАНЕТЕ

Добрый день!

Согласно информационному сообщению от 1 марта 2019 года №18/02-04/09 «О предотвращении гибели гренландских тюленей в Белом море» направляем вам следующую информацию.

В результате дешифрирования космических снимков было обнаружено скопление гренландских тюленей (по косвенным признакам) в районе со следующими координатами:
65.417521 N, 36.896488 E
65.410673 N, 36.896488 E
65.410673 N, 36.928610 E
65.417521 N, 36.928610 E

Непосредственно тюлени (по данным прямых наблюдений, предположительная численность составляет порядка 75 особей) обнаружены в районе с координатами:
65.399798 N, 36.983681 E
65.381129 N, 36.983735 E
65.381165 N, 37.005794 E
65.399796 N, 37.005772 E

По предварительному прогнозу, в результате дрейфа льдов с учетом метеоусловий на ближайшие 2 дня области нахождения тюленей (льдины) будут перемещаться в ЮВ направлении со скоростью 3-6 км/сутки.

К данному письму прикреплены shp-файлы – контуры районов на карте с привязкой к координатам.

Первый shp-файл соответствует первым координатам, указанным нами в письме, второй – вторым соответственно.

Благодарим вас за сотрудничество!

--

С уважением,
оперативный штаб проекта «Бельки-2019» — команда участников космической смены в ОЦ «Сириус» в рамках программы «Дежурный по планете»

05.03.2019

Добрый день, ДЕЖУРНЫЙ ПО ПЛАНЕТЕ!
Благодарим Вас за сотрудничество!

Оперативная группа (ШЛО) Бассейновой комиссии по организации ледокольной проводки судов в замерзающих портах ФГБУ «АМП Западной Арктики» и на подходах к ним осуществляет повседневную оперативную работу по планированию и руководству ледокольными проводками в Белом море.

В связи с началом образования на ледовых полях Белого моря щенных залежек гренландских тюленей и в целях предотвращения гибели животных Информационным сообщением № 18/02-04/09 от 01.03.2019 г был организован сбор информации о местах массовых залежек зверя. На заседаниях оперативной группы (ШЛО) в Архангельске составляются рекомендованные курсы плавания судов, с учетом мест расположения морзверя, а специалистами ФГБУ «Северное УГМС» ледовые карты с указанием месторасположения лежек тюленей и рекомендации ледового плавания.

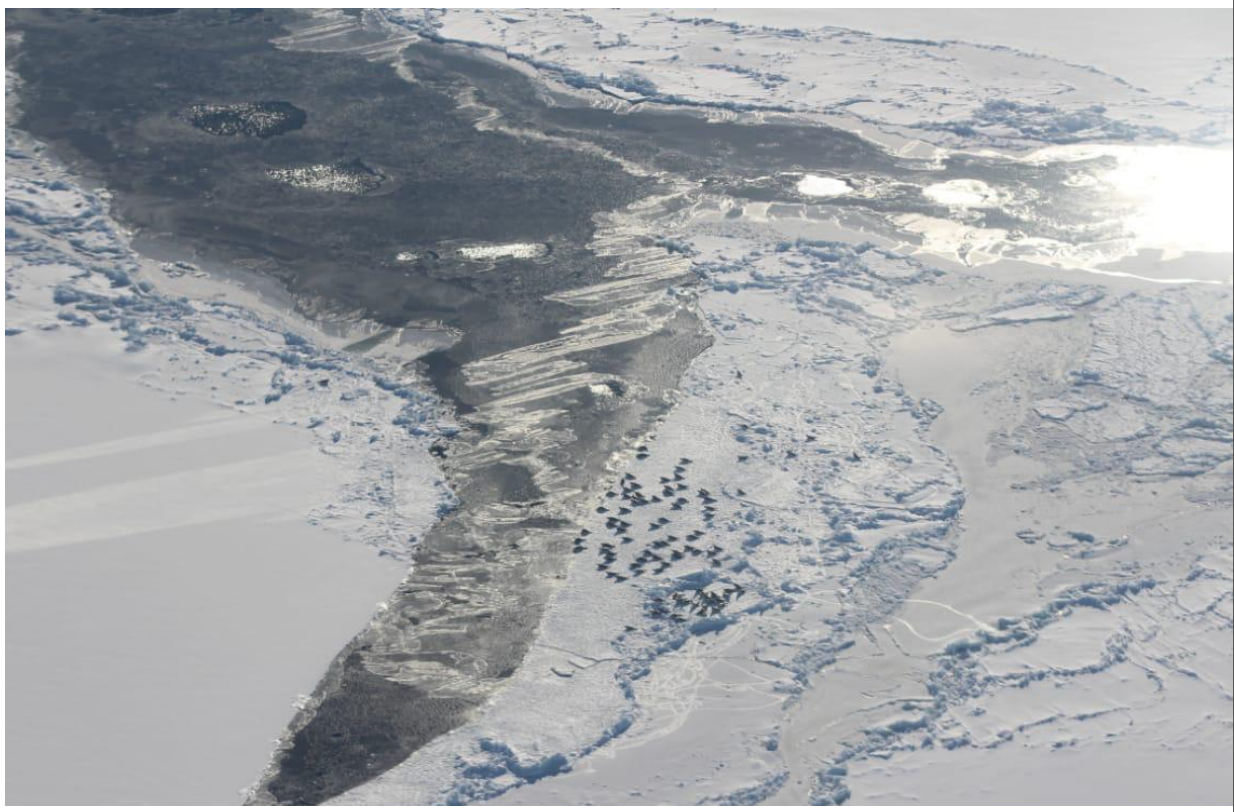
Нашу информацию по рекомендованным курсам и местоположении тюленей Вы можете найти на сайте ФГБУ «Администрация морских портов Западной Арктики» www.mapm.ru – Деятельность – Организация ледокольной проводки – Информация Комиссии и ШЛО – оперативная информация – ледовая обстановка в морском порту Архангельск и Белом море на …. число (в рабочие дни к информации будет приложена карта-схема).

Надеемся на дальнейшее сотрудничество и желаем Вам успехов и удачи!
Наш контактный E-mail – psc@mapa.ru

С уважением,
ШЛО

Positive response from ice operations headquarters of the Western Arctic Seaport Authority (received the next day after the report was sent)

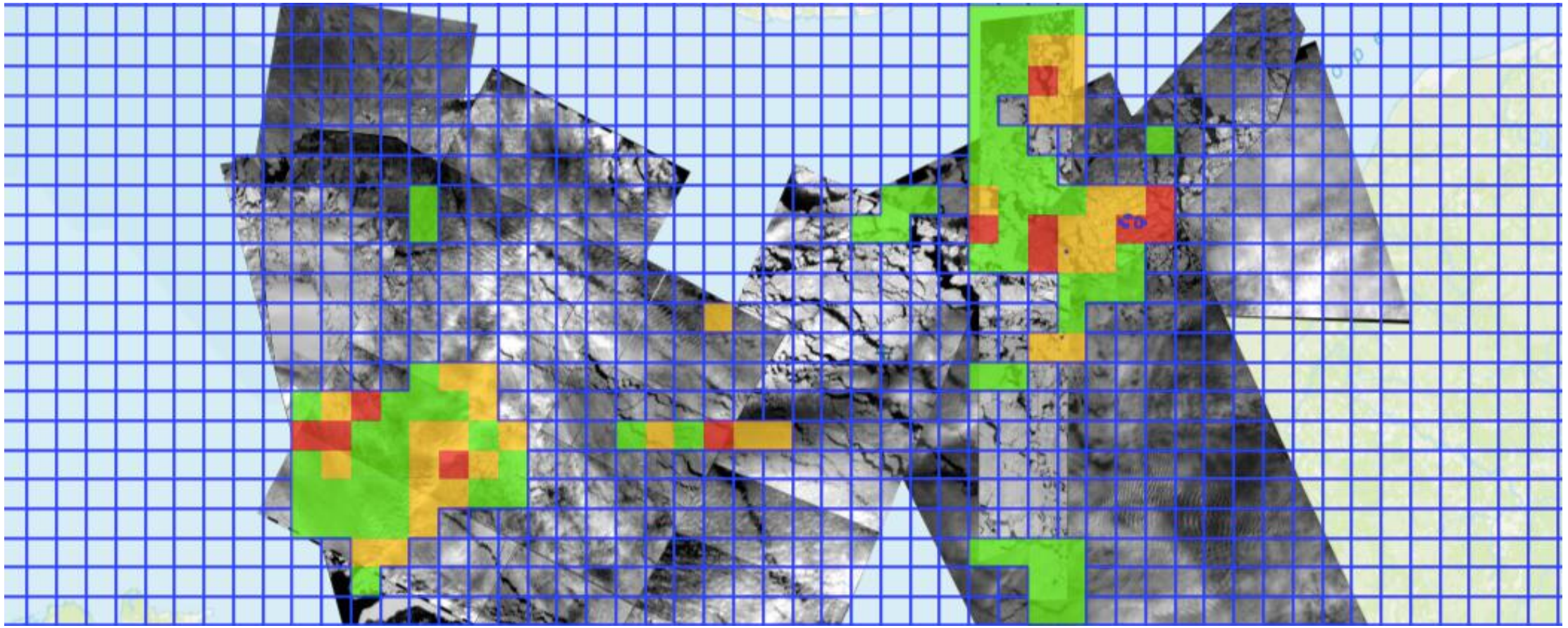
Air reconnaissance results



On March 6, 2019 Andrey Solovyov, the participant of the project «Sealpups-2019» took part in the airplane flight over the White Sea in order to verify the coordinates of harp seals whelping grounds and make aerial photos of the animals.

Crowdsourcing imagery analysis

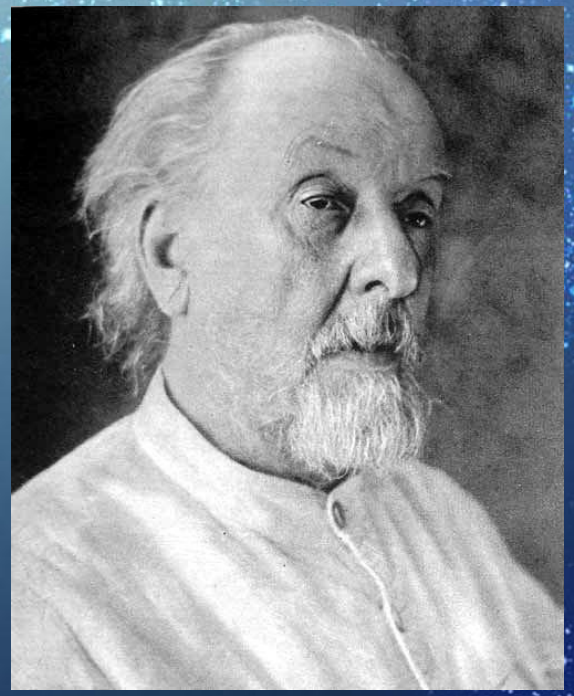
We invited everyone to participate in satellite data analysis for further training of the neural network:



No seals/signs

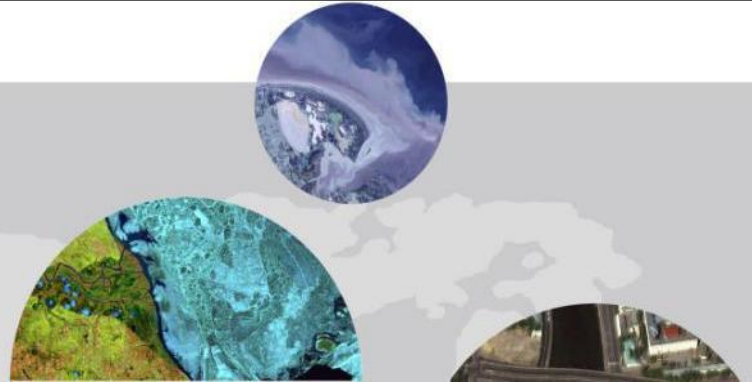
Seals/signs detected

Probably there are seals/signs



The impossible will be possible tomorrow ...

Konstantin E. Tsiolkovsky,
teacher of arithmetic and
geometry



Thank you for your attention!
We invite you to cooperate!

«LoReTT» Engineering Company
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