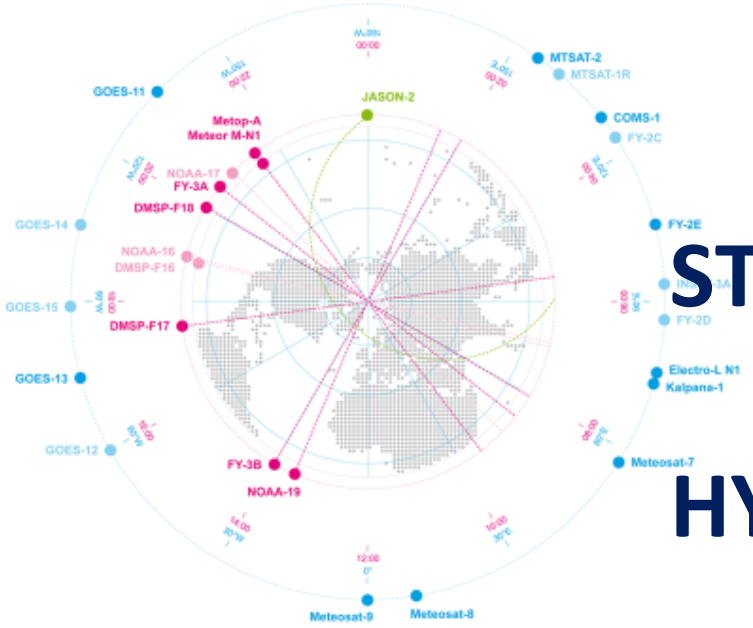


STATUS OF CURRENT AND FUTURE RUSSIAN HYDROMETEOROLOGICAL SATELLITE SYSTEMS

by Roscosmos / Roshydromet

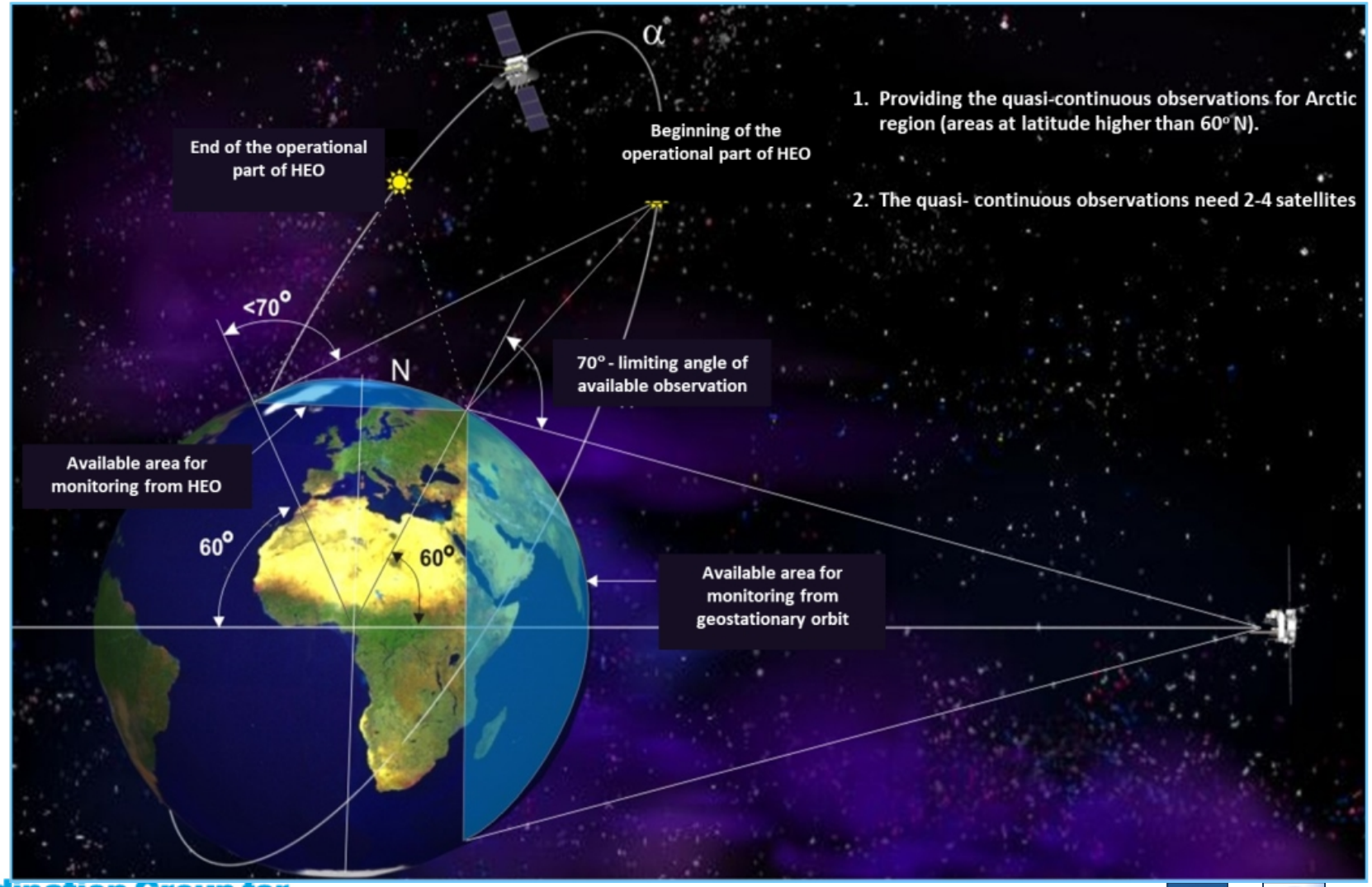
Presented to CGMS-50 plenary session

Overview

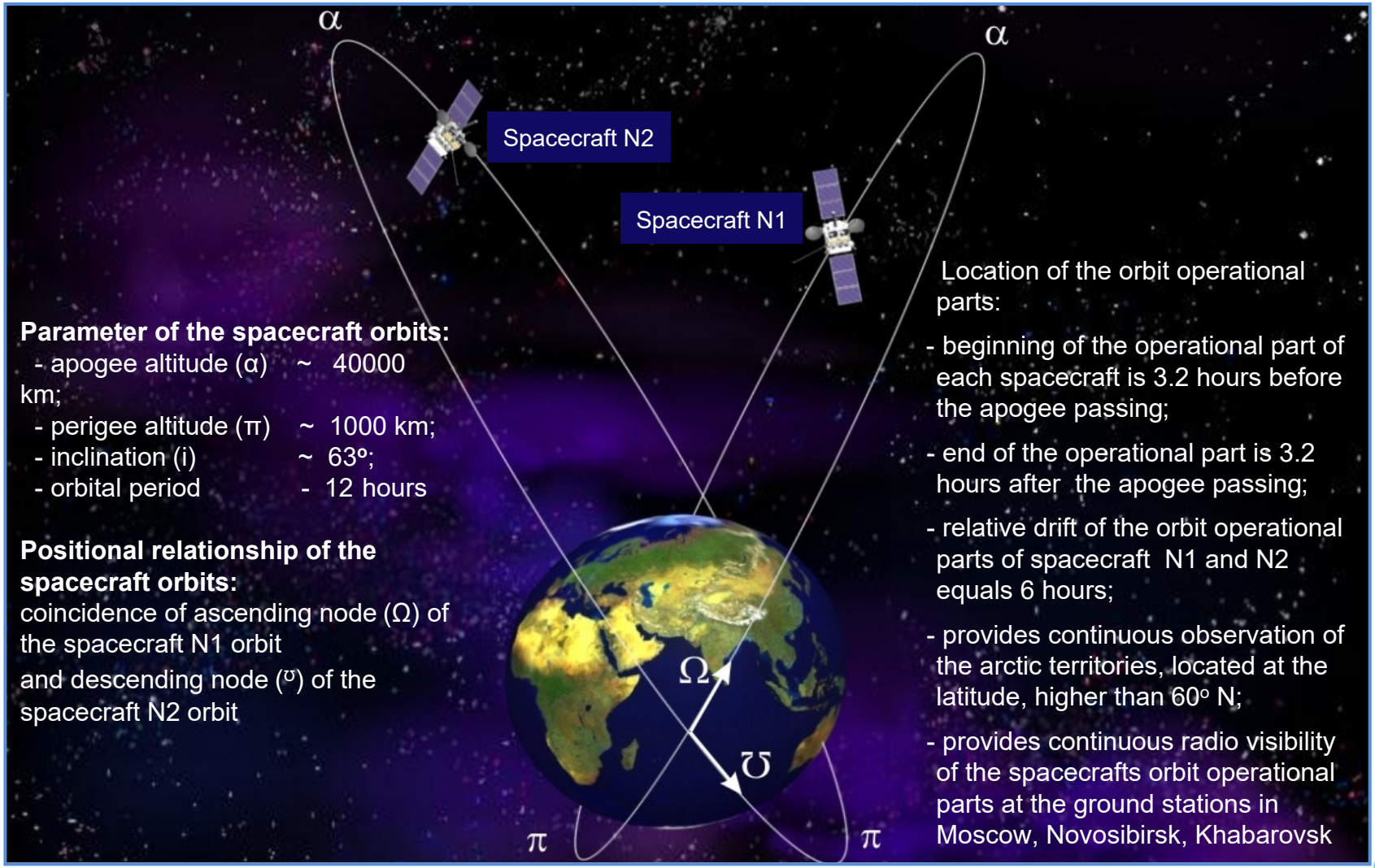
The Russian hydrometeorological satellite constellation has not changed since the last year, except for the commissioning of the first highly elliptical orbit meteorological satellite Arctica-M N1.

Arctica-M satellites provide frequent observations similar to geostationary satellites, but over the Arctic region. The payload of Arctica-M satellites is similar to those of Russian geostationary satellites.

Highly Elliptical Orbits (HEO) for Arctic Observations



Satellite System Ballistic Configuration



Parameter of the spacecraft orbits:

- apogee altitude (α) ~ 40000 km;
- perigee altitude (π) ~ 1000 km;
- inclination (i) ~ 63º;
- orbital period - 12 hours

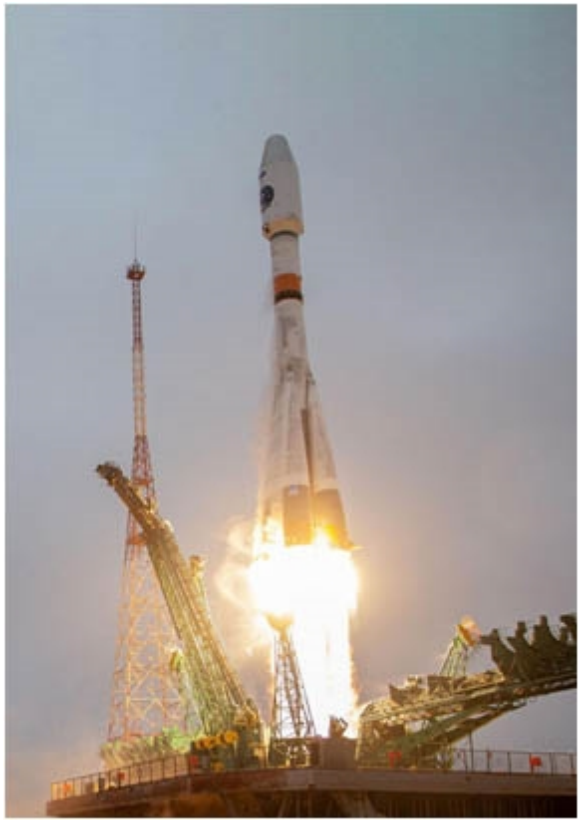
Positional relationship of the spacecraft orbits:

coincidence of ascending node (Ω) of the spacecraft N1 orbit and descending node (ʊ) of the spacecraft N2 orbit

Location of the orbit operational parts:

- beginning of the operational part of each spacecraft is 3.2 hours before the apogee passing;
- end of the operational part is 3.2 hours after the apogee passing;
- relative drift of the orbit operational parts of spacecraft N1 and N2 equals 6 hours;
- provides continuous observation of the arctic territories, located at the latitude, higher than 60º N;
- provides continuous radio visibility of the spacecrafts orbit operational parts at the ground stations in Moscow, Novosibirsk, Khabarovsk

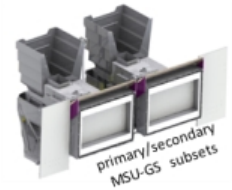
Arctica-M N1: Meteorological Satellite in HEO ("Molniya" orbit)



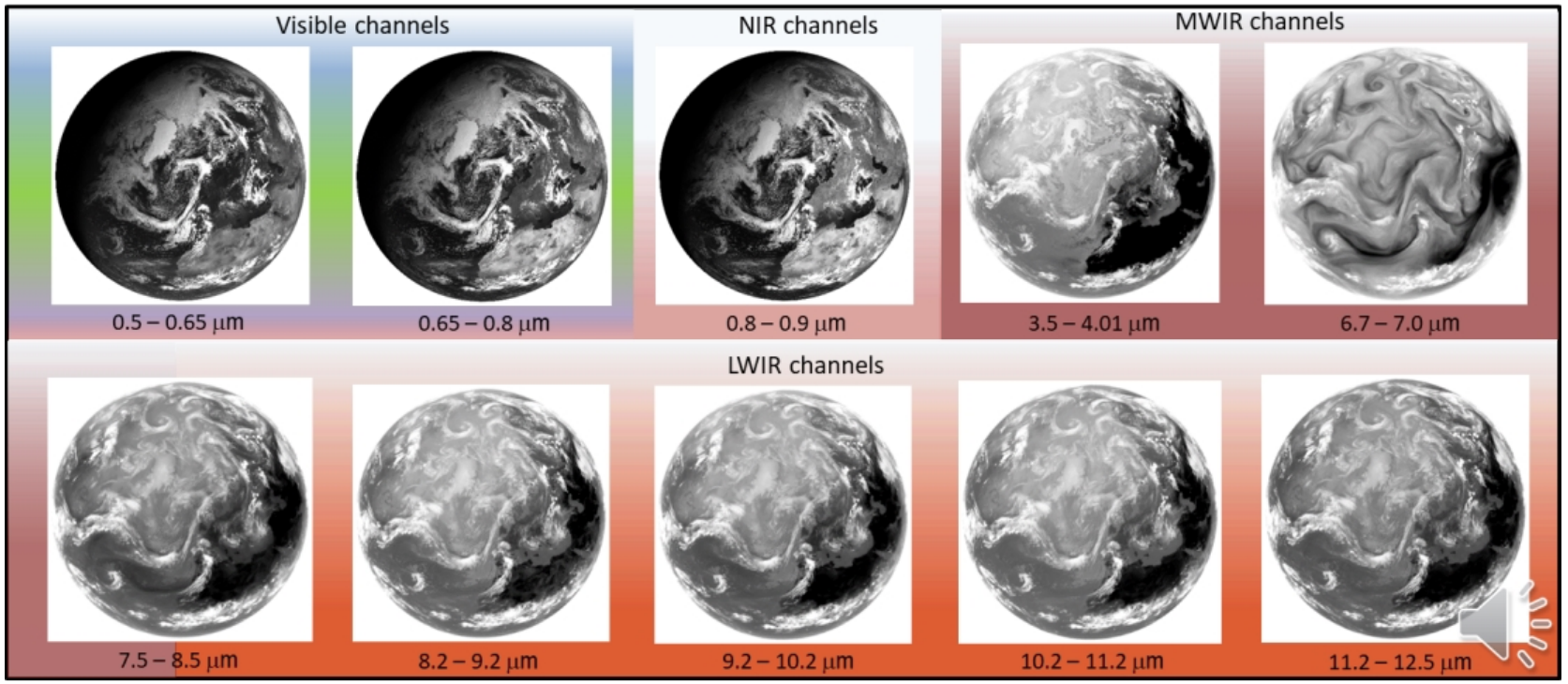
The launch of Arctica-M N1
28 February 2021

Parameter	*Value*
Orbit:	
Apogee, km	**40 000**
Perigee, km	**1 000**
Inclination, deg	**63,4**
Period, h	**12**
1st apogee longitude, deg	**25 W**
2nd apogee longitude, deg	**155 E**
Full number of MSU-GS/A spectral channel	**10**
Spectral range, μm	from **0,5** to **12,5**
Resolution (at nadir):	
- VIS-channel, km	**1**
- IR-channel, km	**4**
Frequency of Arctic region' observation, min:	
- regular mode	**30**
- frequent mode	**15**

MSU-GS/A Arctica-M N1
Basic Instruments Specifications

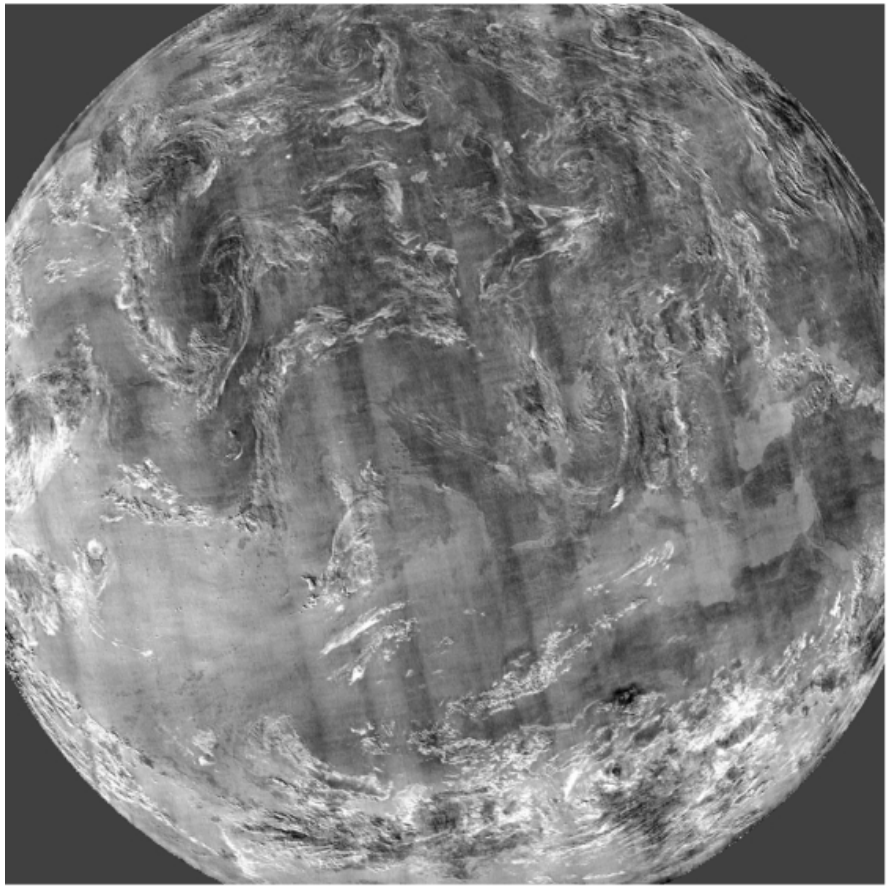


Spectral range: 0,5 – 12,5 μm (10 spectral channels).
Spatial resolution: visible and near-infrared (NIR) channels – 1 km,
mid-wave Infrared (MWIR) and long-wave Infrared (LWIR) channels – 4 km.
Coverage: visible Earth disk , part of the near-Earth space.
Cycle: 15 min.

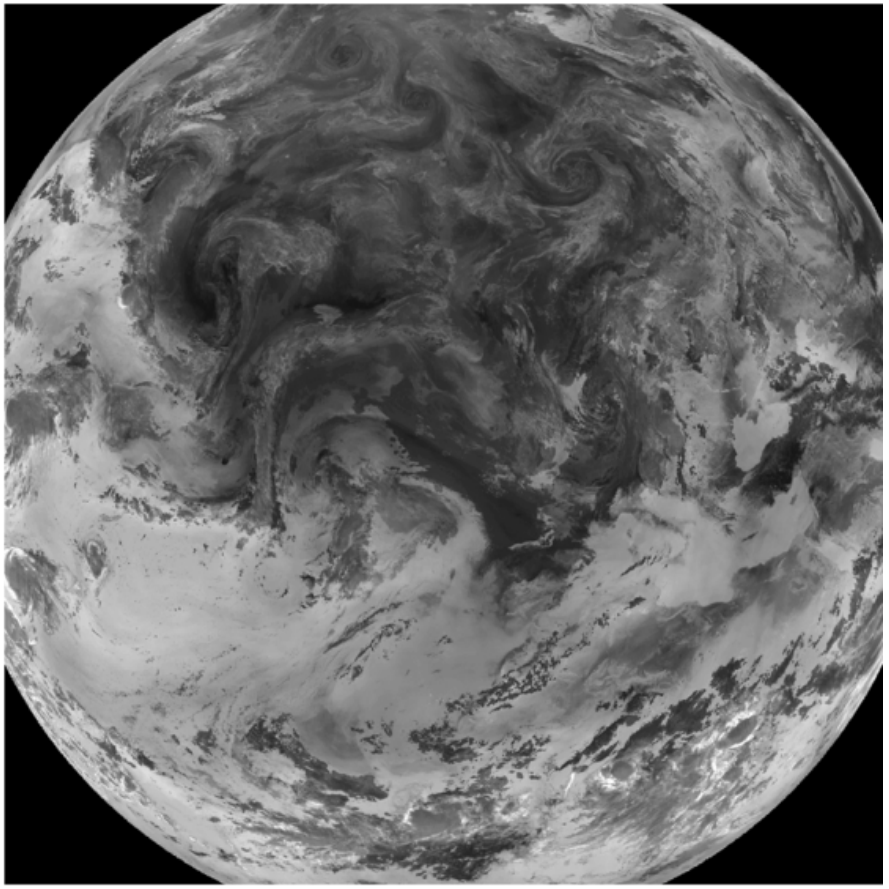


10.7 & 11.7 μm Channel Difference
MSU-GS/A Arctica-M N1

After L1 processing software



After applying the artificial intelligence algorithm

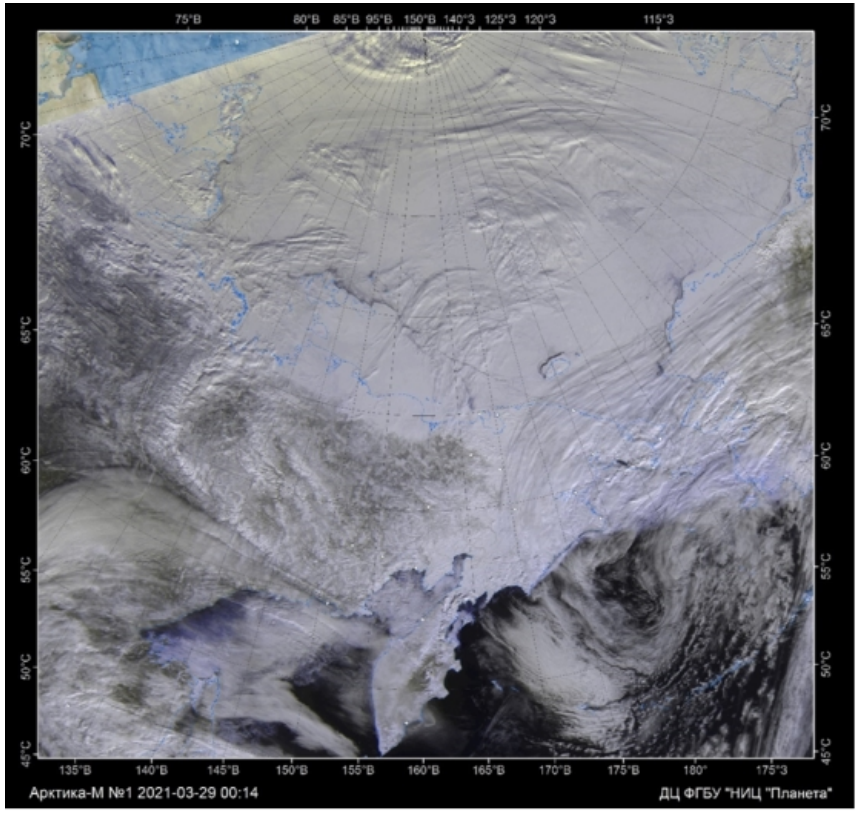


2021.08.17 00:30-05:30 UTC

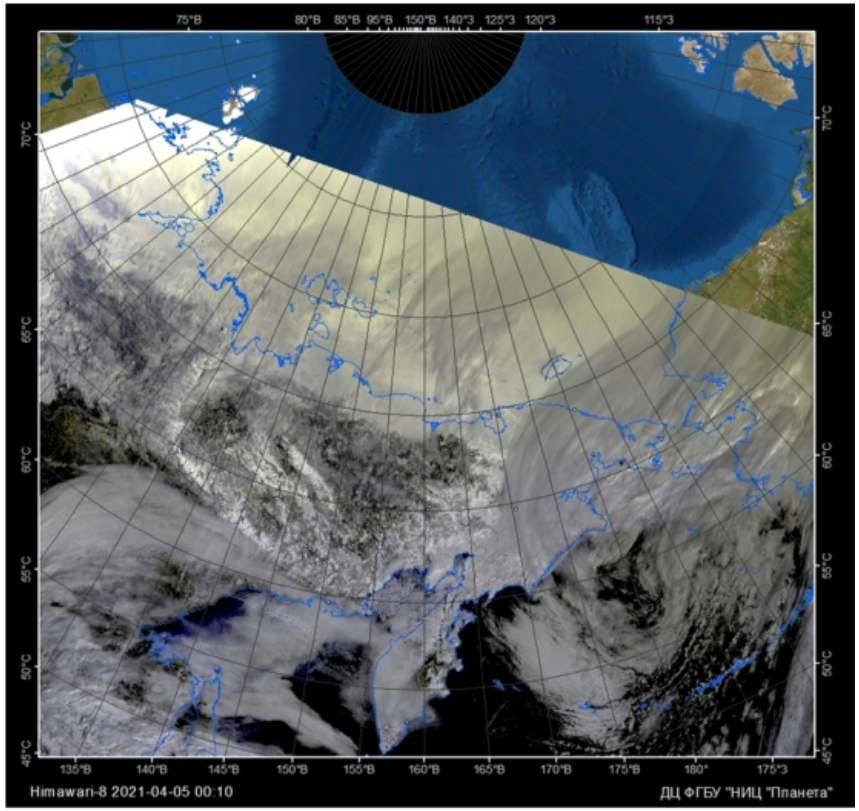
Status of Arctica-M

- **MSU-GS/HE** instrument is fully functional;
- **GGAK-HE** instrument is functional;
- **DCS** is functional;

Comparison of MSU-GS/A Arctica-M N1 imagery with reference data (AHI Himawari-8)



MSU-GS/A Arctica-M N1
2021.03.29 00:14 UTC

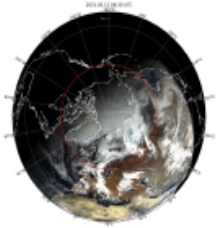


AHI Himawari-8
2021.03.29 00:10 UTC

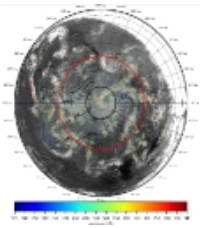
Arctica-M applications

Weather forecasting

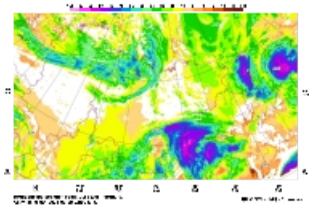
Animated maps



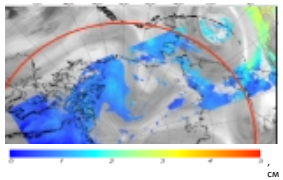
AMVs



Cloud top temperature, cloud top height

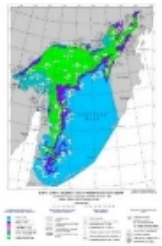


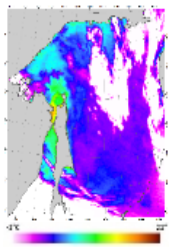
Total water content



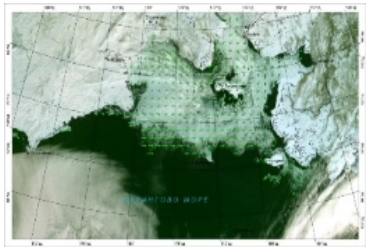
Sea and ice analysis

Ice cover and temperature maps

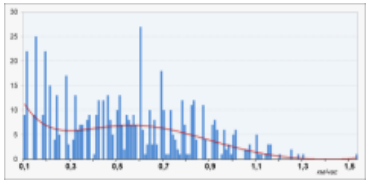




Ice drift

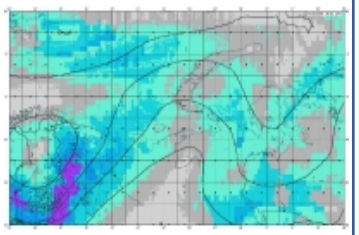


Ice drift velocity

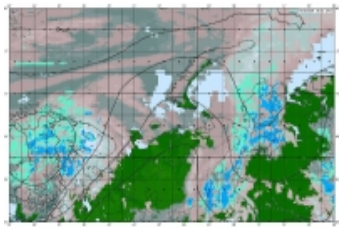


Aviation-related products

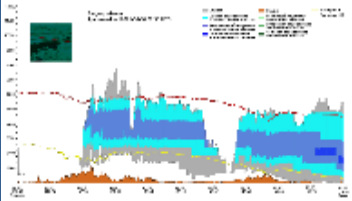
Near-surface wind gusts speed



Precipitation area and intensity

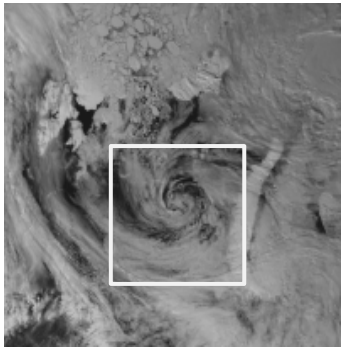


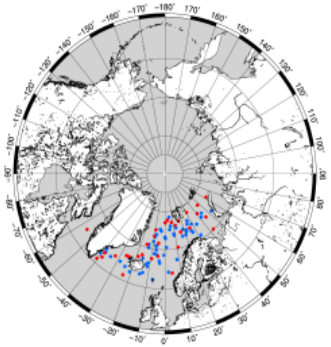
Vertical sections of clouds and ice



Natural hazards

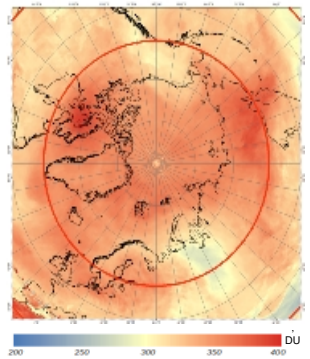
Polar mesoscale cyclones



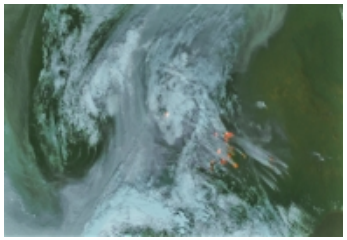


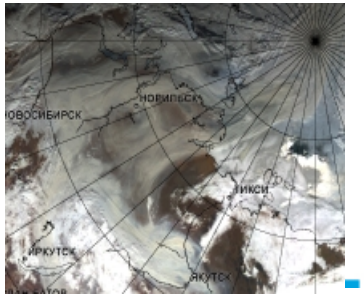
Ecological applications

Total ozone content

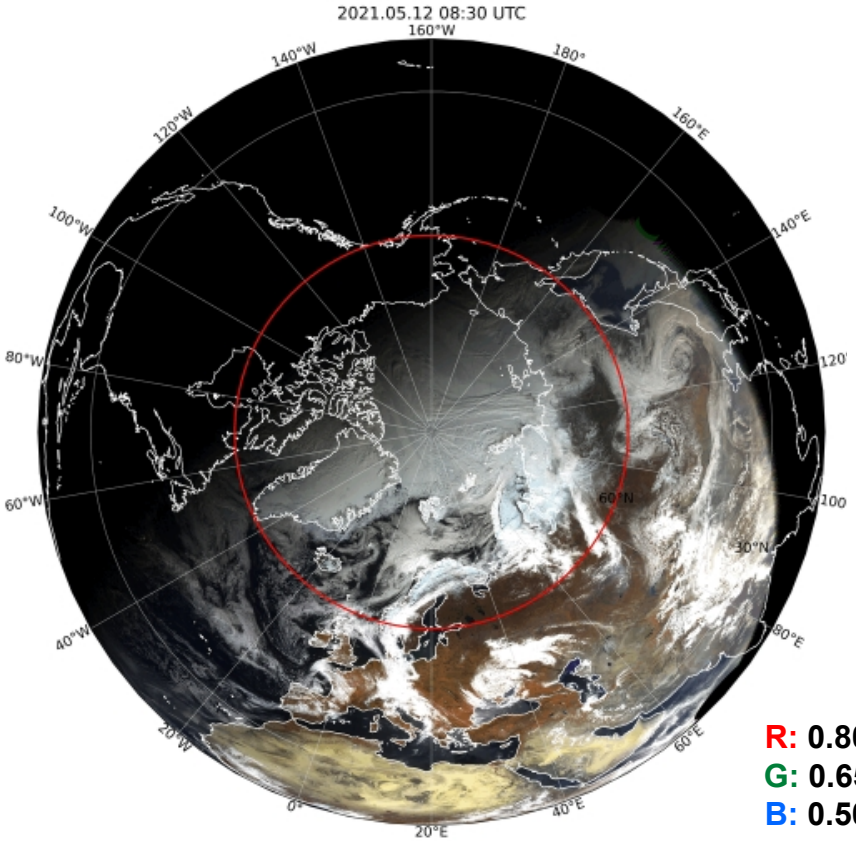


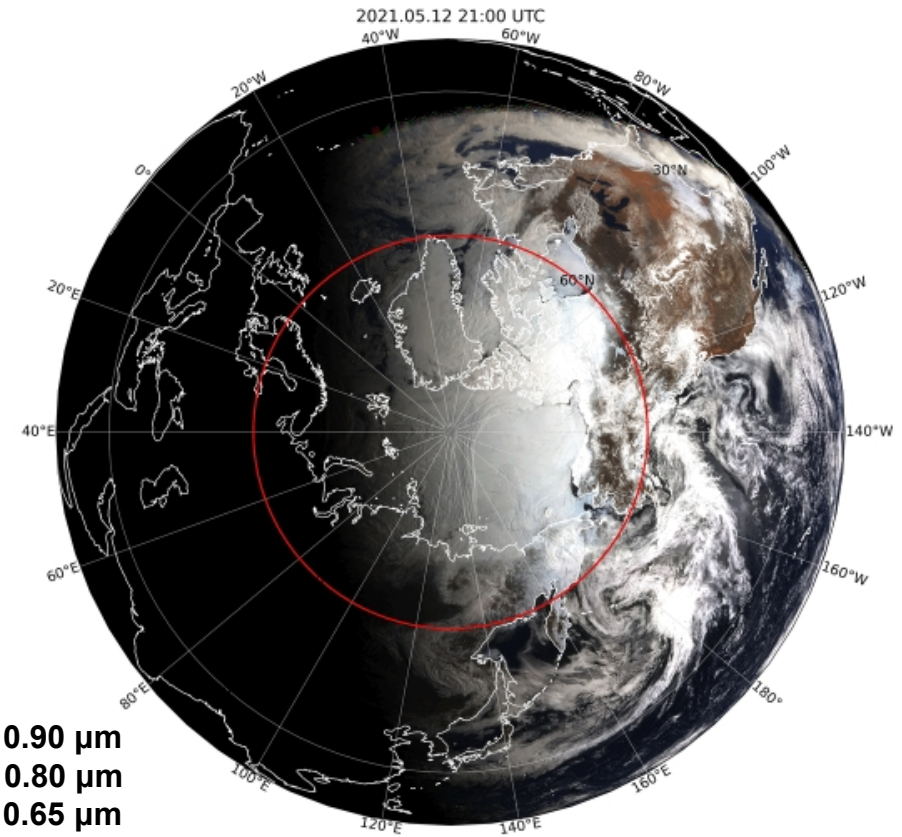
Forest fires





Cloud animation in VIS based on Arctica-M N1 data





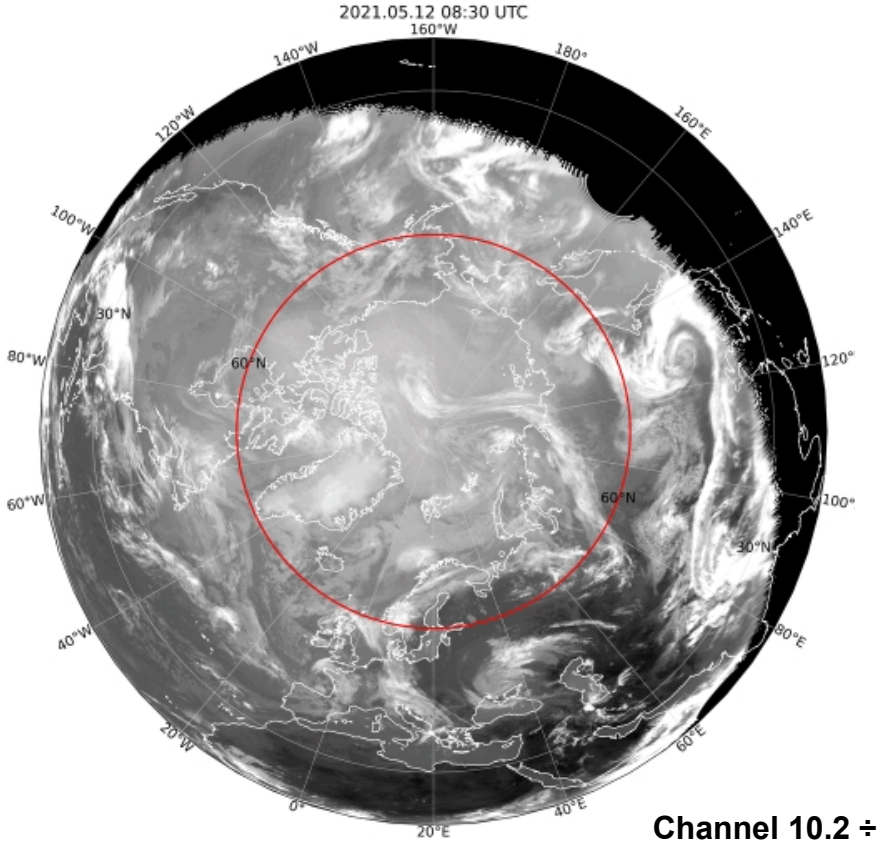
R: 0.80 ÷ 0.90 µm
G: 0.65 ÷ 0.80 µm
B: 0.50 ÷ 0.65 µm

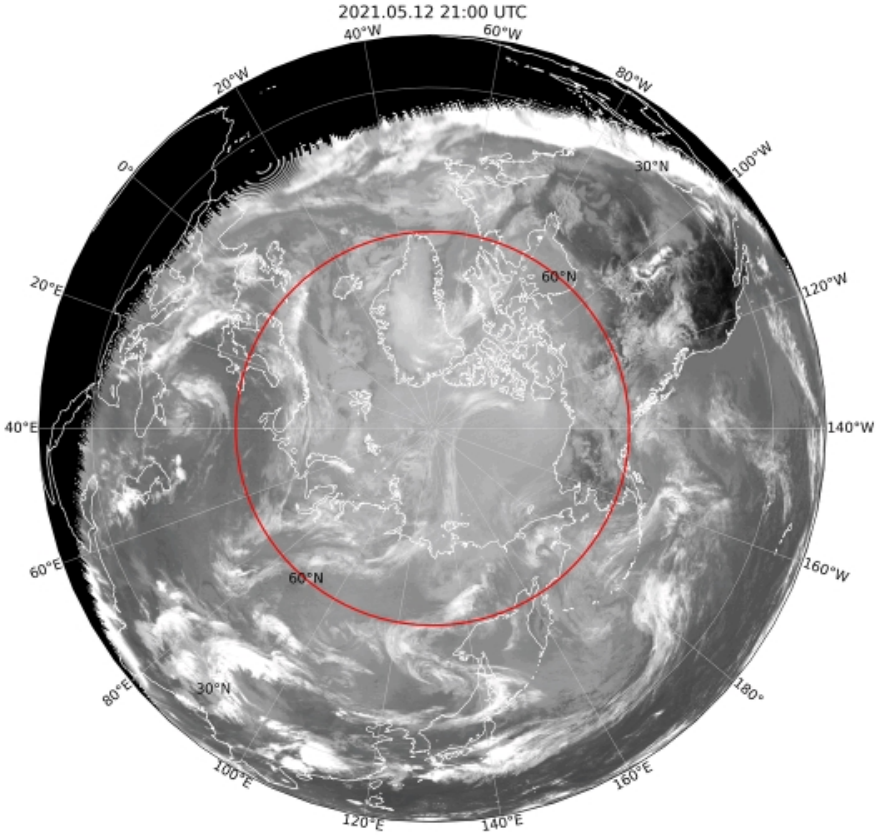
“Eastern” pass

“Western” pass

Animated maps from 15/30 min scans allows to track the evolution of clouds in the daytime

Cloud animation in IR based on Arctica-M N1 data



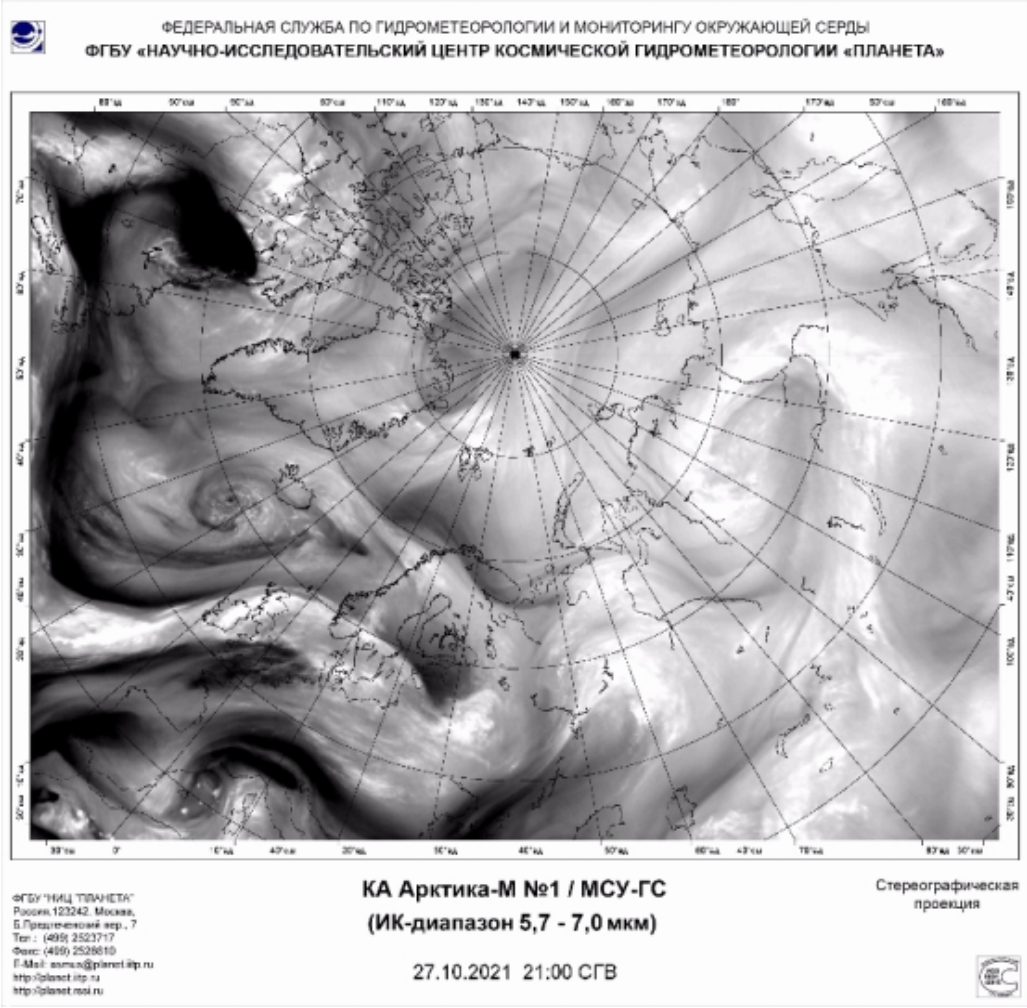


Channel 10.2 ÷ 11.2 μm

“Eastern” pass **“Western” pass**

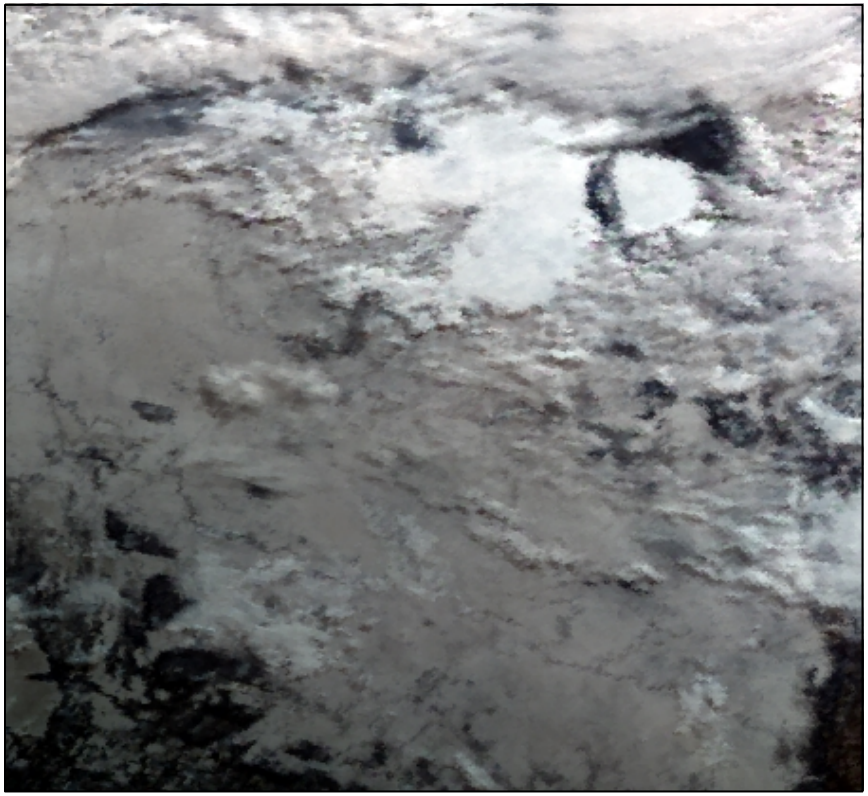
Cloud animations based on MSU-GS/A data in IR spectral band allows observing the evolution of cloud formations in the Arctic region.

Arctica-M N1 water vapour channel animation

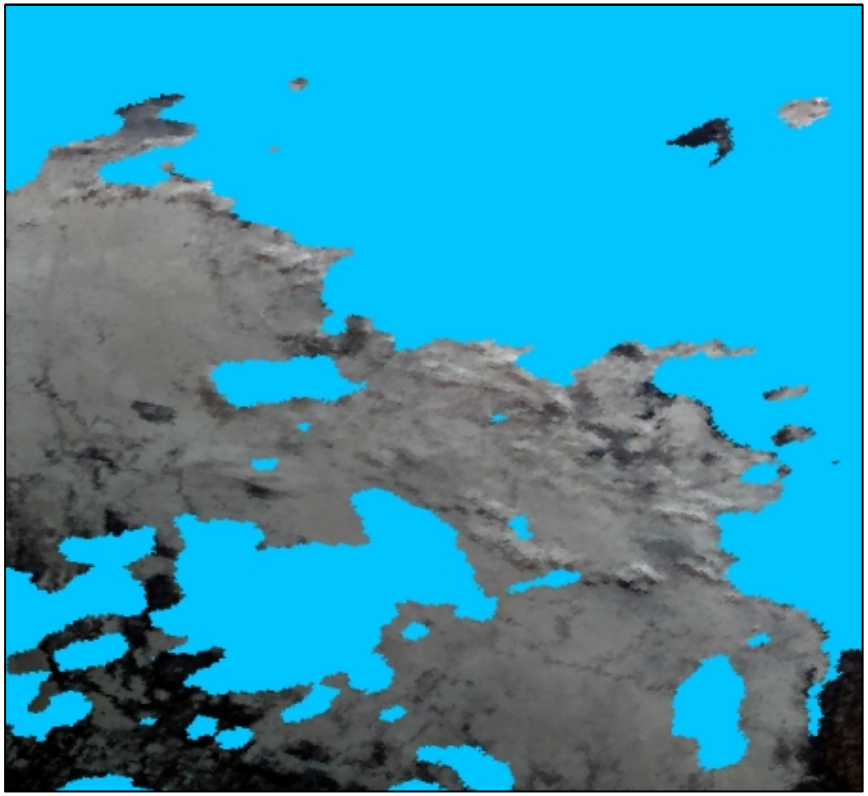


Cloud mask based on Arctica-M N1 data

Channels
R: 0.5 ÷ 0.65 μm G: 0.65 ÷ 0.8 μm B: 0.8 ÷ 0.9 μm

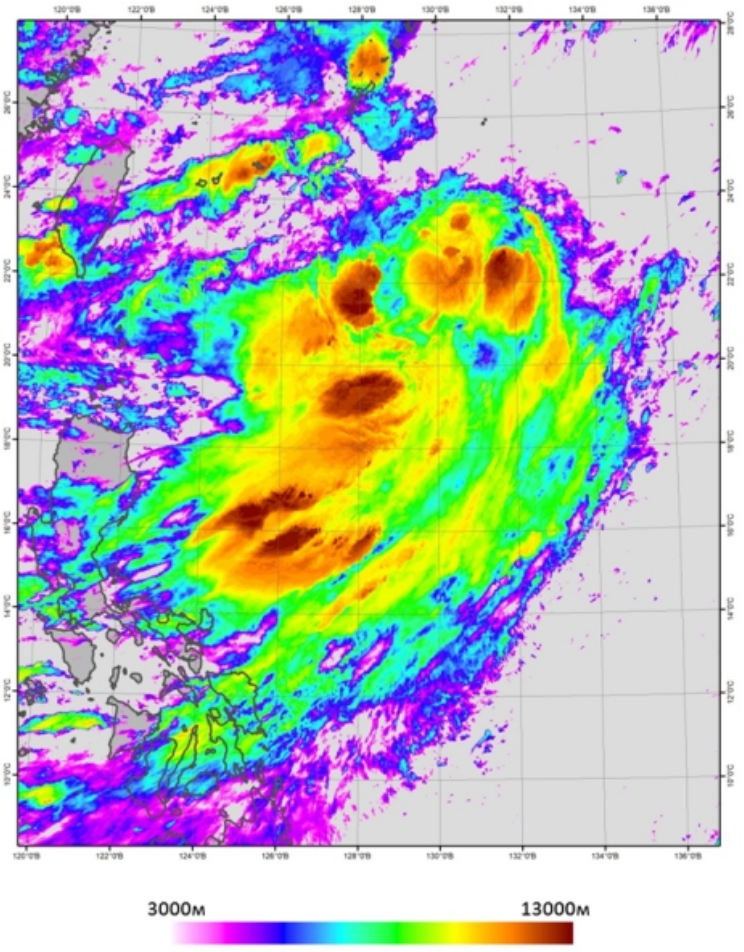


Clous mask
( )

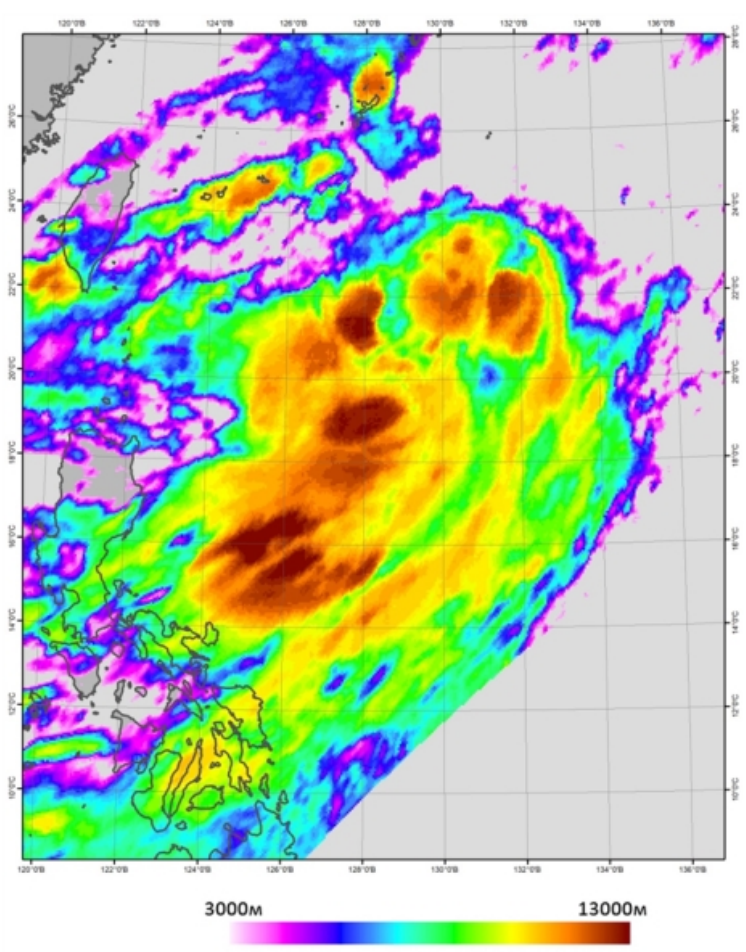


2021.12.31 20:00 UTC

Cloud Top Height from MSU-GS/A Arctica-M N1

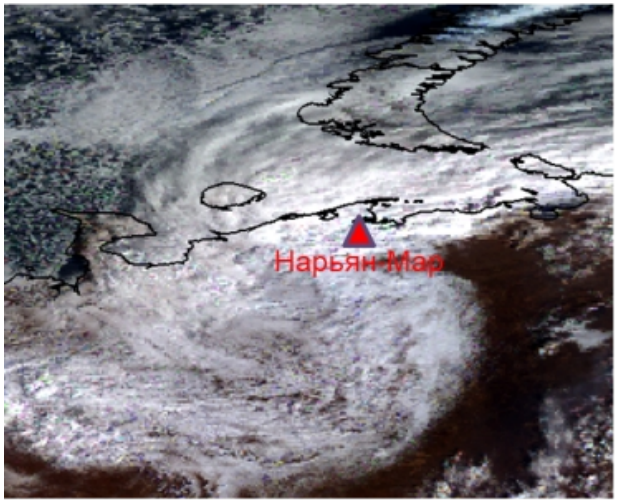


MSU-GS/A Arctica-M N1
2021.06.19 22:00 UTC

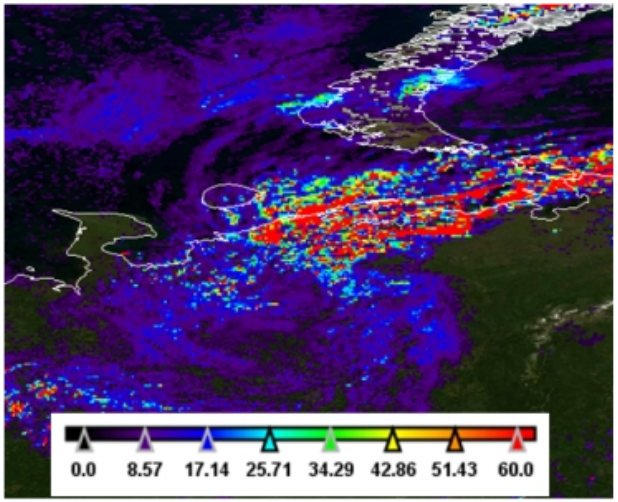


VIIRS Suomi NPP
2021.06.19 22:00 UTC

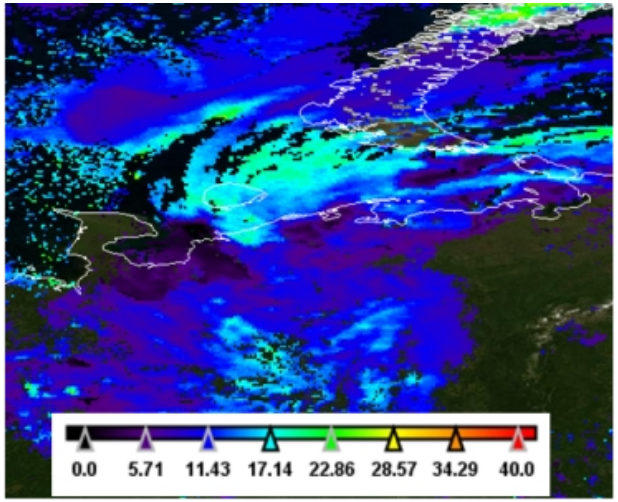
Cloud Microphysical Properties from MSU-GS/A Arctica-M N1



RGB: R: 0,9 μm G: 0,7 μm B: 0,6 μm



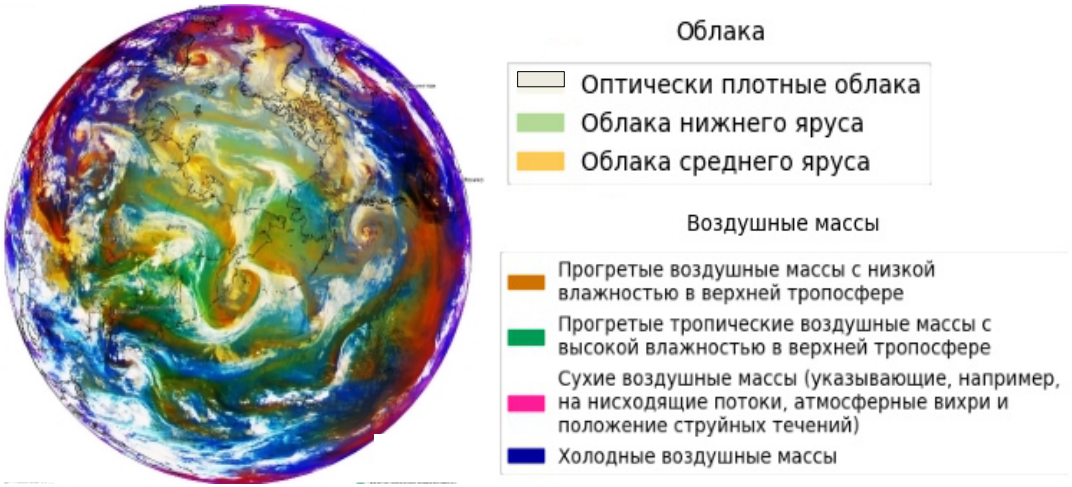
Cloud optical thickness

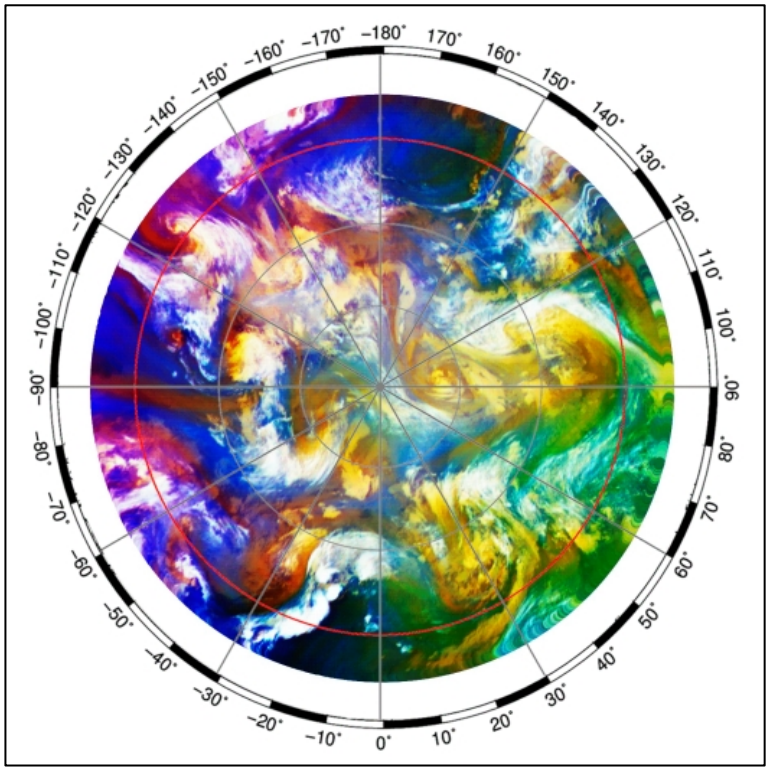


Cloud particle effective radius, μm

2021.08.23 05:45 UTC

Airmass RGB analysis based on Arctica-M N1 data



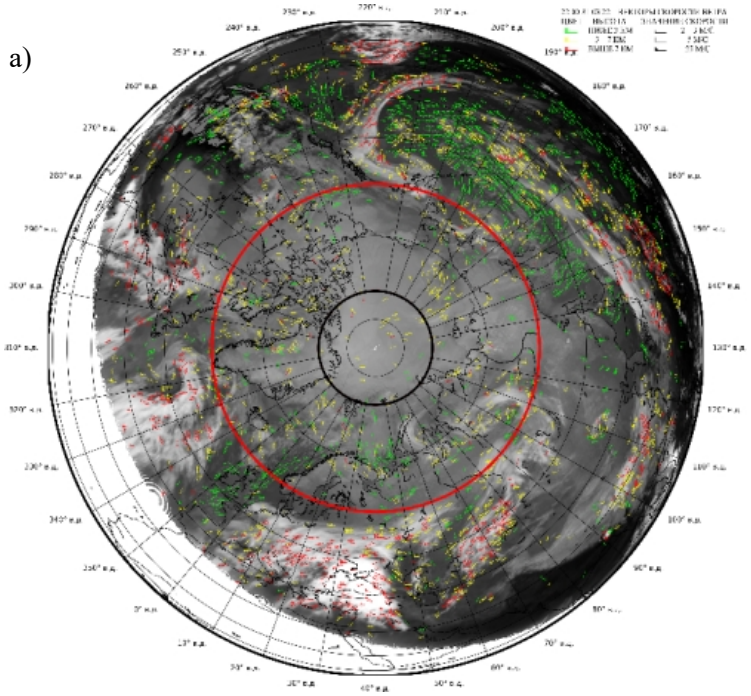


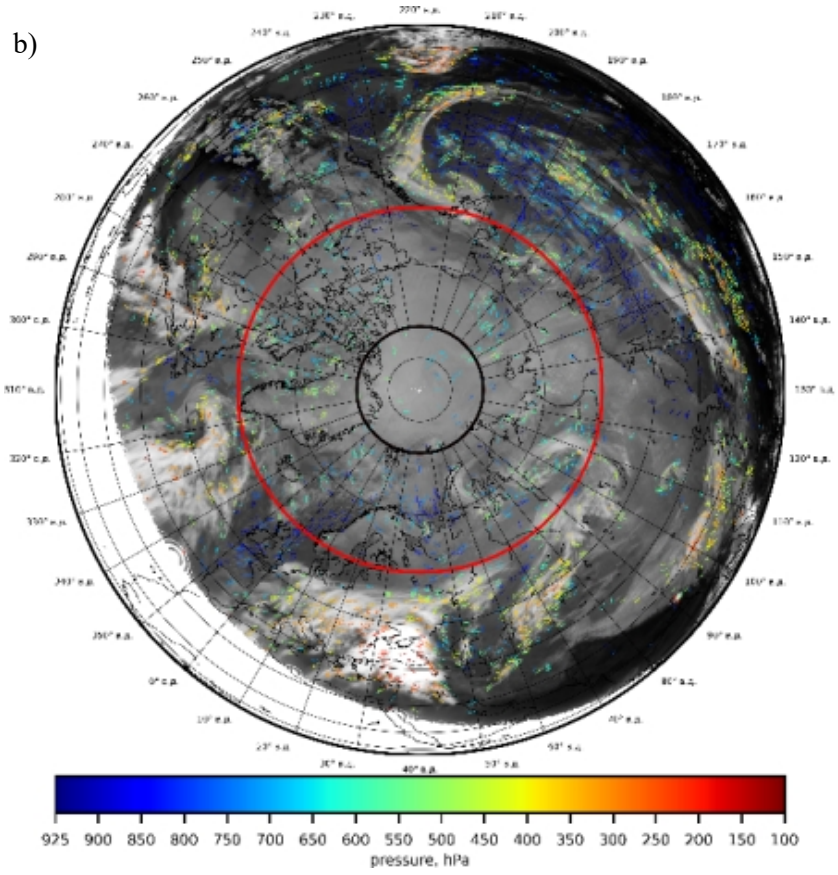
2021.08.26 13:15 – 16:45 UTC

R: (5.7 ÷ 7.0) – (7.5 ÷ 8.5) μm
G: (9.2 ÷ 10.2) – (10.2 ÷ 11.2) μm
B: 5.7 ÷ 7.0 μ

Air mass images make it possible to determine the position of jet streams, deformation zones, and estimate the moisture content of the upper tropospheric layers. It provides recognition of cold and warm air masses at upper levels, and also contributes to the detection of areas of cyclogenesis.

Atmospheric motion vectors from MSU-GS / Arctica-M No.1 data

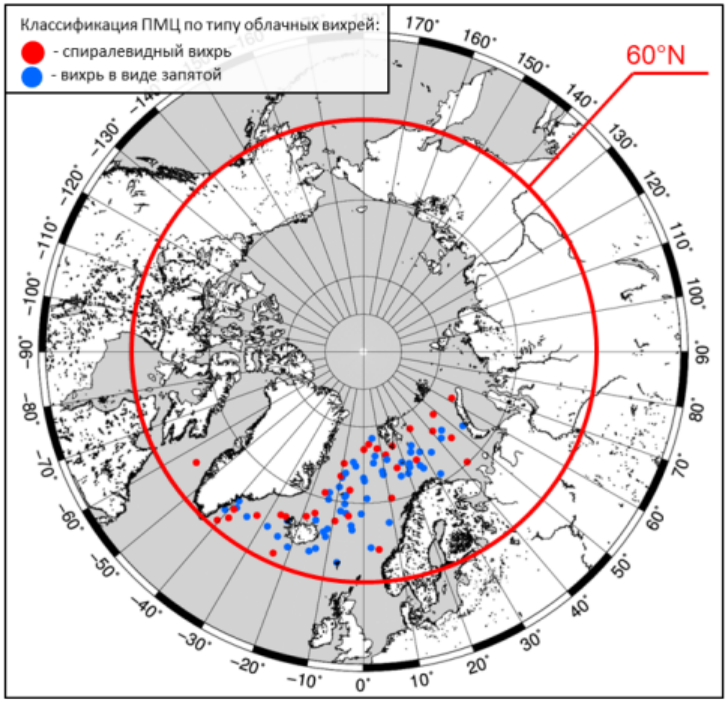




(a) Map of wind vectors, 31.03.2022 22:00 UTC
(b) Map of wind vectors for various isobaric levels, 31.03.2022 22:00 UTC

MSU-GS/A Arctica-M N1 data received with high frequency (during the western and eastern passes) can be considered as unique for identification of atmospheric motion vectors (speed and direction at different levels) in the area. For the first time maps of wind vectors for the Arctic region and neighbouring territories are prepared with a high temporal resolution – every 15 minutes.

Polar mesoscale cyclones evolution detected with Arctica-M N1 MSU-GS/A data



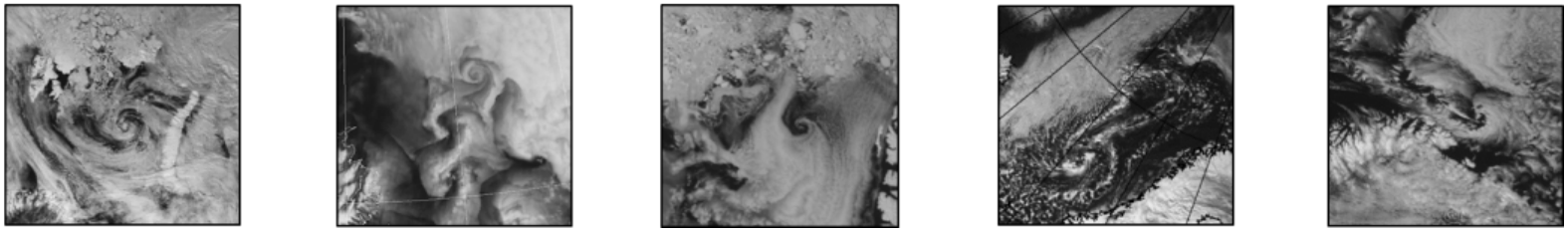
Recurrence map of the polar mesoscale cyclones for 2021.03.22 – 2021.06.16

Getting the data in 15 minute cycle for the first time in polar region resulted in detection and evolution tracking of 92 mesoscale cyclones for the period from 22.03.2021 to 16.06.2021 .

At the first stage the analysis was performed of about 3000 frames taken during western passes over the area of the most active mesoscale cyclones formations.
At the next step it is planned to analyze the data from the eastern passes and to perform in-depth study of all the stages of the polar mesoscale cyclones.

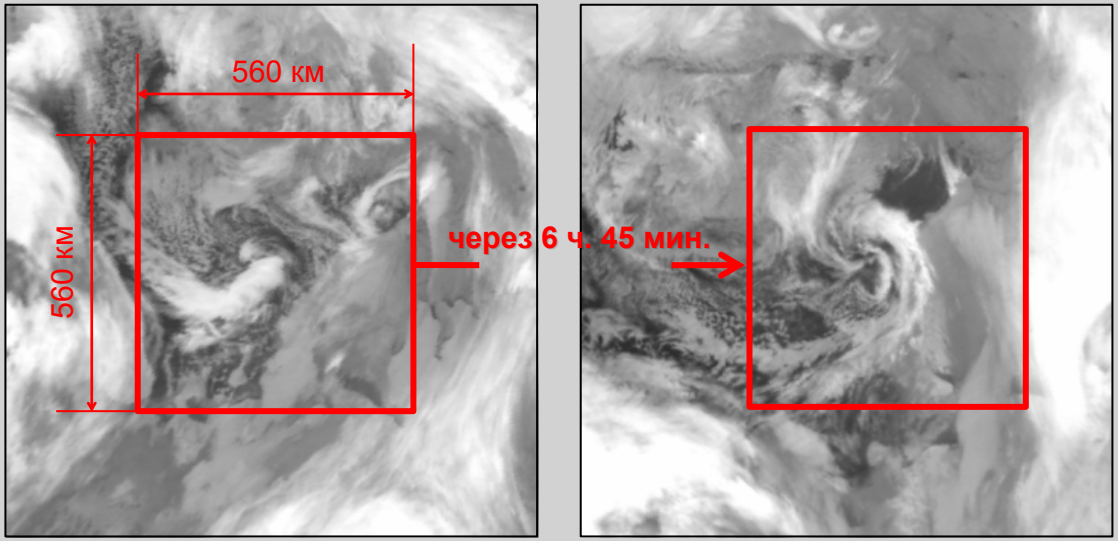
Polar mesoscale cyclones are hard to predict and known to cause quickly developing high impact weather events in the area, like strong waves, wind gusts, ships icings and strong snowfalls.

Developing of forecasting techniques for polar mesoscale cyclones is considered as one of most important tasks for operational meteorology in the region.



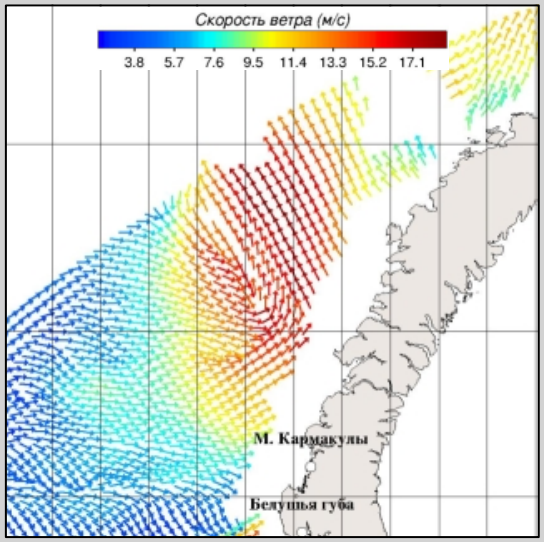
Monitoring of the polar mesoscale cyclone (PMC) development in the Barents Sea from Arctica-M No. 1 data, 16.01.2022

Channel 10.2 ÷ 11.2 μm MSU-GS Arctica-M №1



The eastern section of the orbit
01:30-06:45 UTC

The western section of the orbit
13:30-18:45 UTC



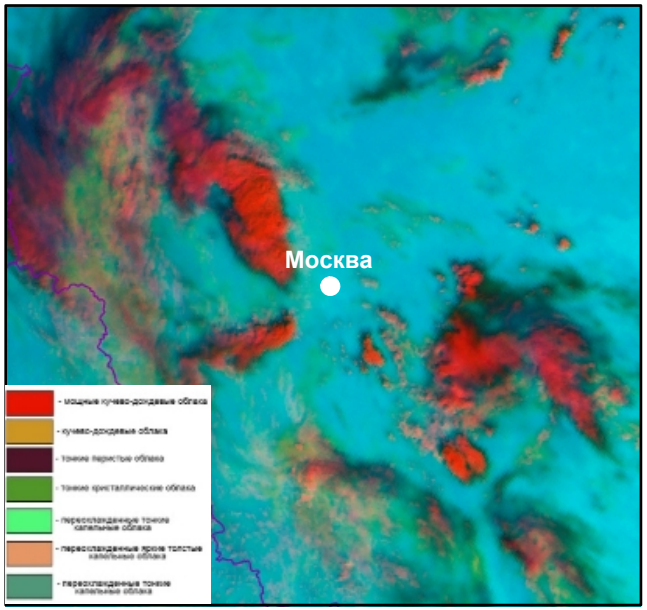
ASCAT MetOp-C
2022.01.16 10:03 UTC

Coordinates of the center of the PMC (at the time of detection)	73° с. ш., 47° в. д.
The shape of the PMC cloud vortex	comma
Diameter of the PMC	~ 300 км

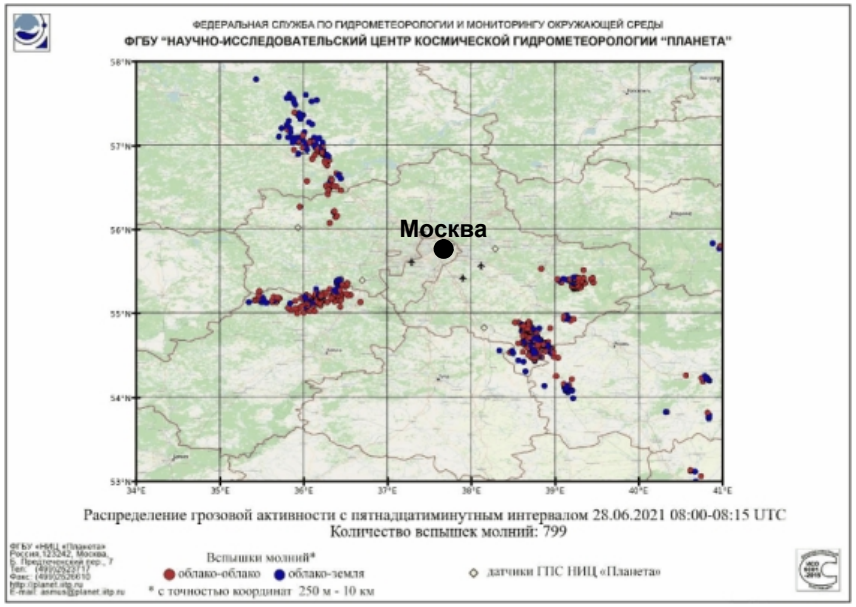
The value of the maximum wind speed in the area of the formation of the PMC	19 m/s

The use of data from the Arctic-M No. 1 will improve the PMC prediction, which is a priority task of operational meteorology.

Convection bursts detected with Arctica-M N1 data



Arctica-M N1
R: 0.8 ÷ 0.9 μm G: 3.5 ÷ 4.01 μm B: 10.2 ÷ 11.2 μm
2021.06.28 08:00 – 10:00 UTC



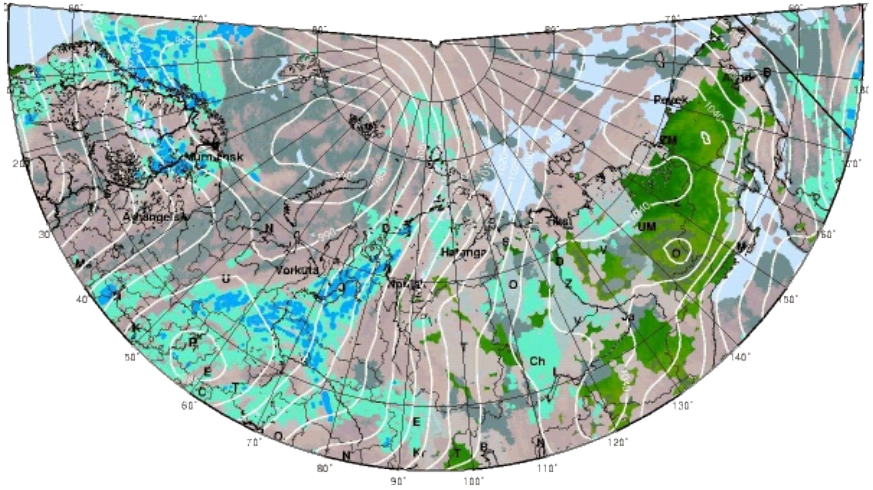
Ground-based lightning detection system

Convection bursts accompanied by intense wind, thunderstorms and hail poses serious danger to aviation and ground infrastructure.

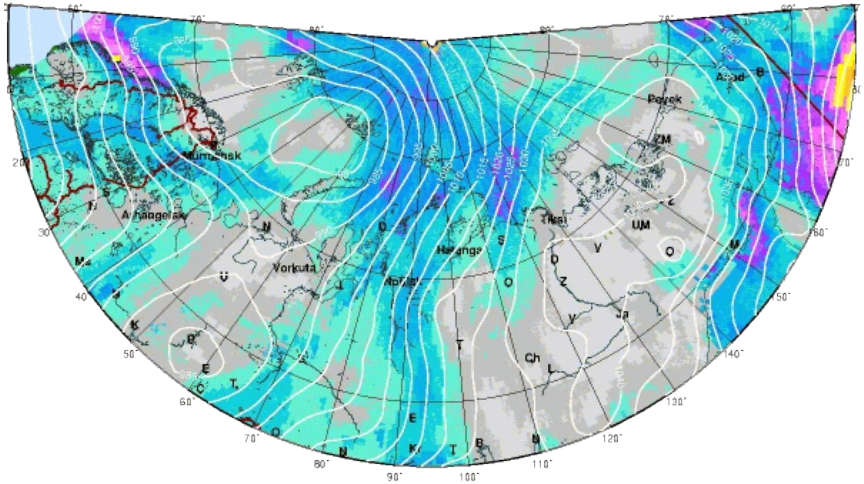
Strong ("explosive") convection is an intensive process of the formation of powerful cumulonimbus clouds, which is usually accompanied by destructive wind gusts, anomalous showers, intense thunderstorms, and hail.
Possible consequences: falling trees, collapsing buildings, breaking power lines, flooding roads and buildings, raising the water level on rivers, lakes and reservoirs to dangerous levels, damage to cars, human casualties.

Near-surface wind gusts and precipitation intensity in the Arctic region

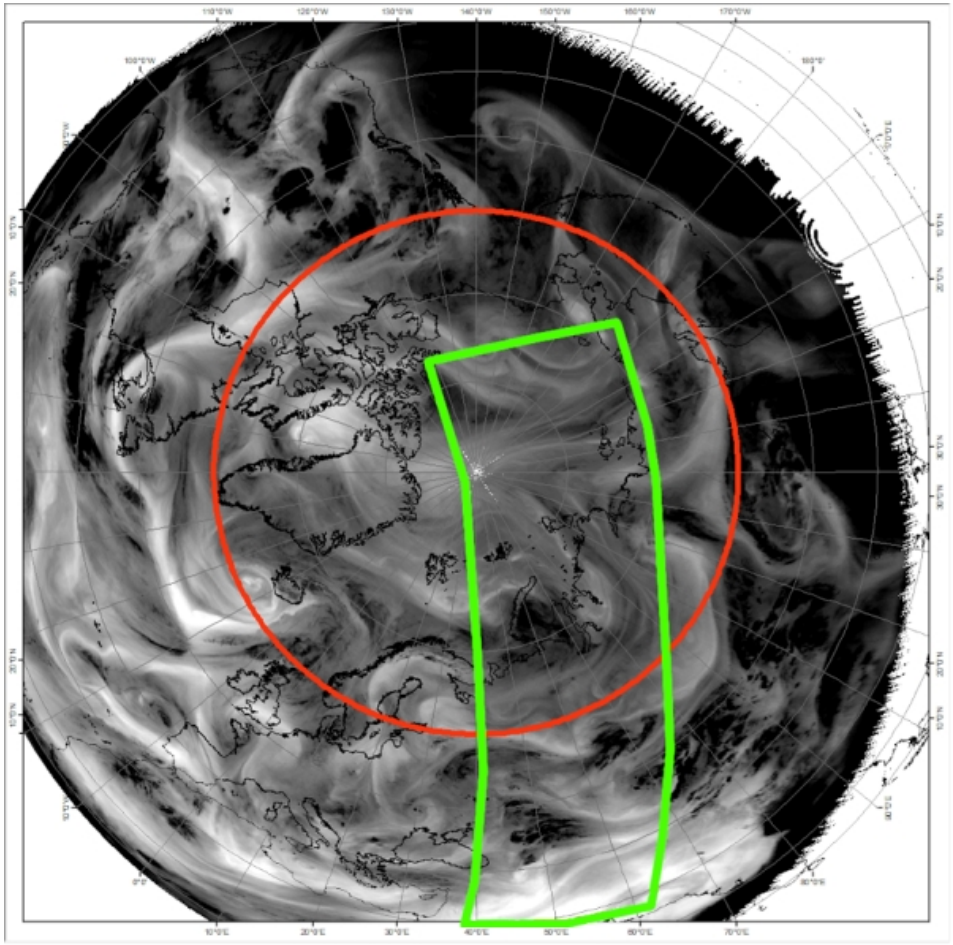
Precipitation intensity



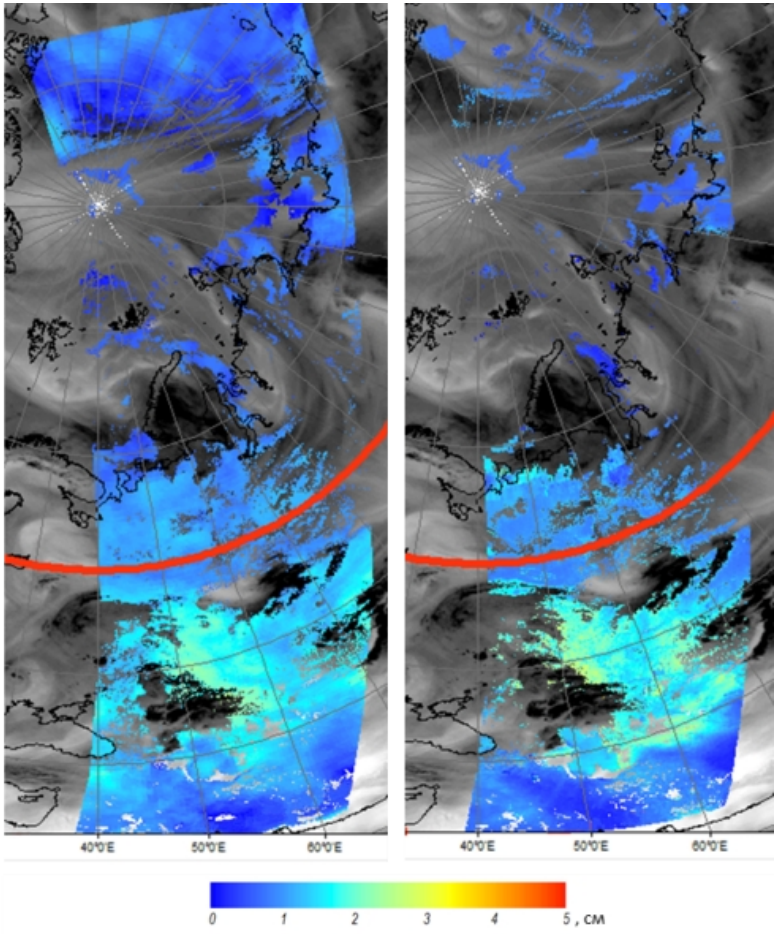
Near-surface wind gusts (m/sec)



Total Water Vapour Content from MSU-GS/A Arctica-M N1

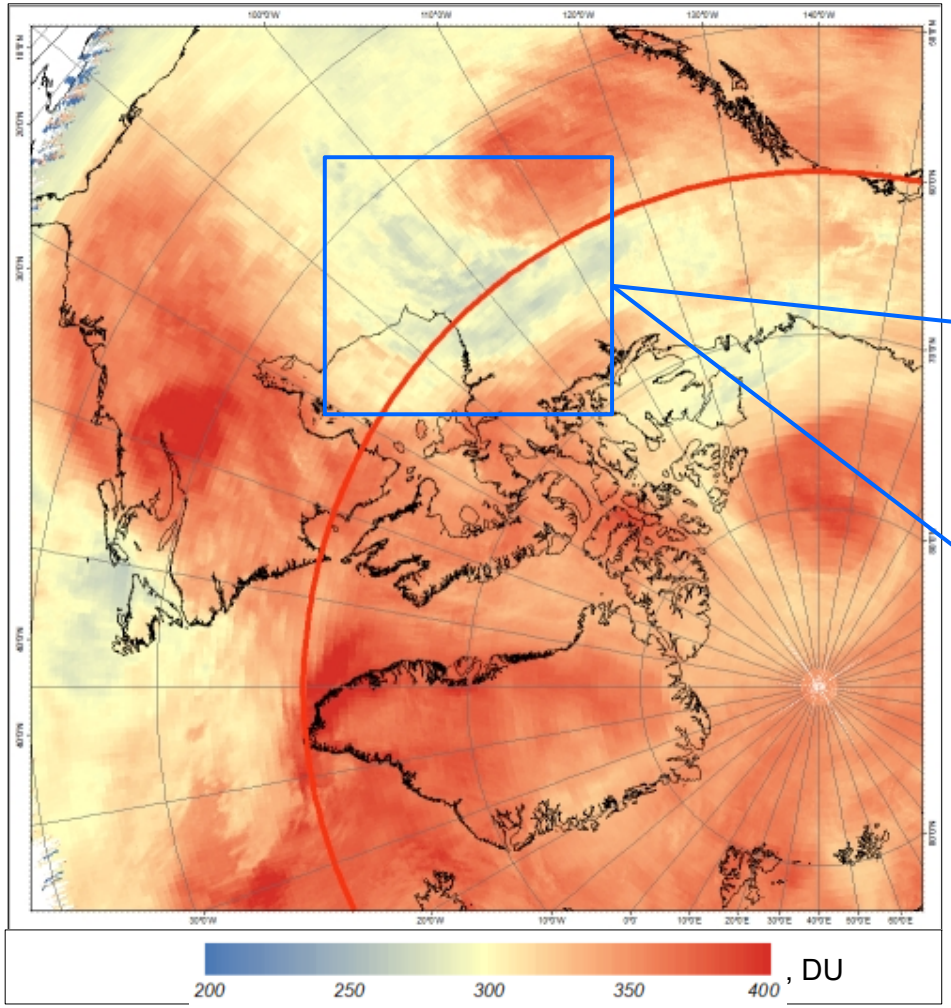


MSU-GS/A Arctica-M N1
Channel 6.4 μm
2021.08.16 06:00 UTC



MSU-GS/A Arctica-M N1
Channel 6.4 μm
2021.08.16 06:00 UTC

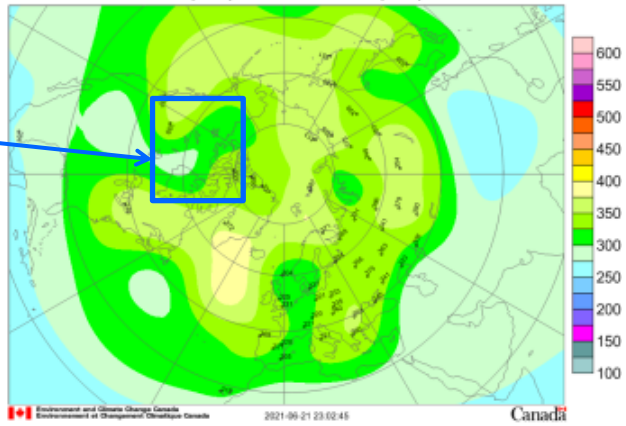
Total Ozone Content based on Arctica-M N1 data



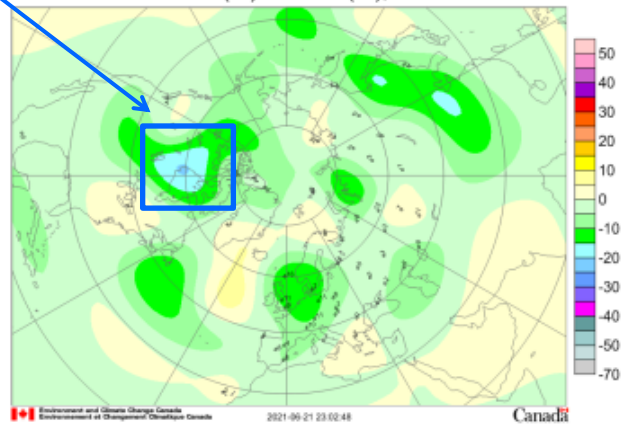
Arctica-M N1 2021.06.16 18:00 UTC

In-situ data from The World Ozone and Ultraviolet Radiation Data Centre (WOUDC)

Average daily values of TOC



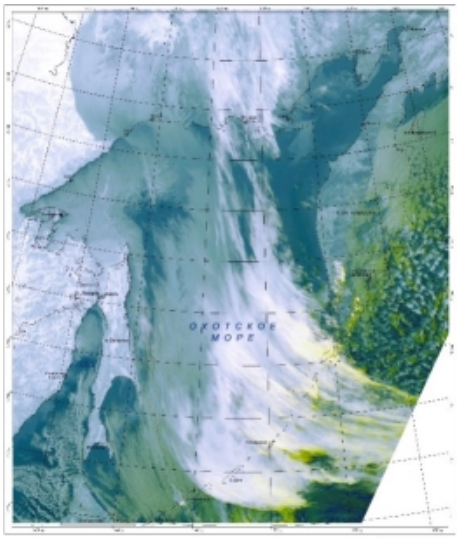
Deviation of TOC from the mean values



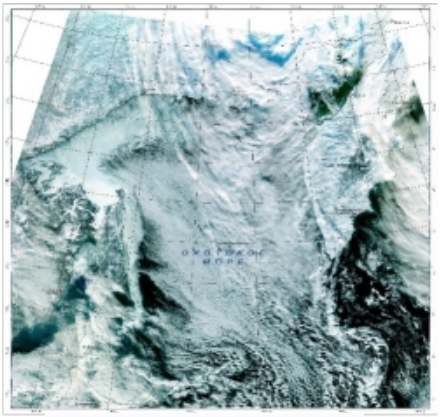
Coordination Group for Meteorological Satellites

CGMS

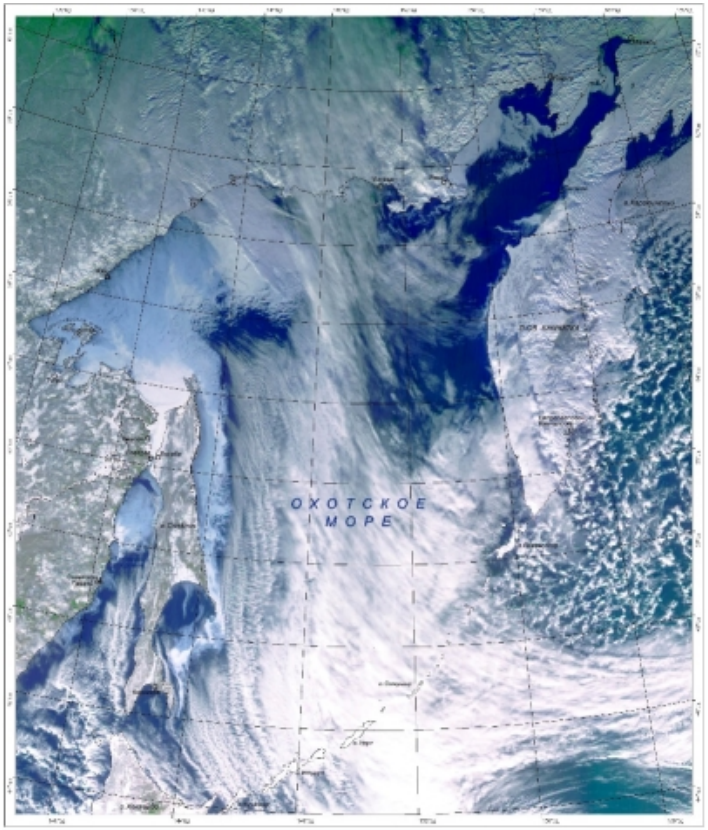
Sea ice charts based on Arctica-M N1 data



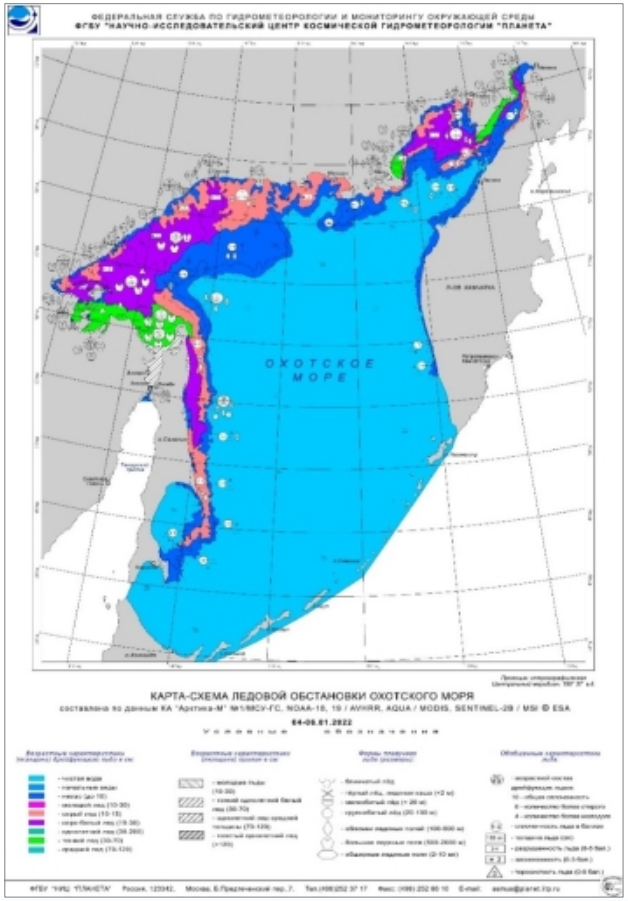
NOAA/AVHRR 2022.01.04



TERRA/MODIS 2022.01.05



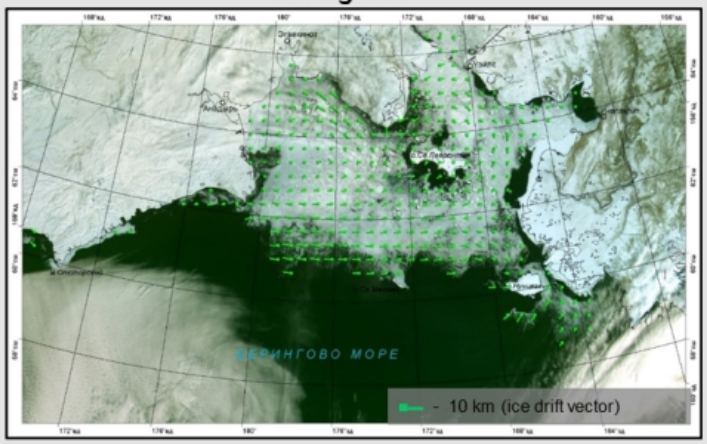
Arctuca-M N1 2022.01.06 05:15 UTC
0.50÷0.65; 0.65÷0.80; 0.80÷0.90 μm



Okhotsk sea
2022.01.04-06

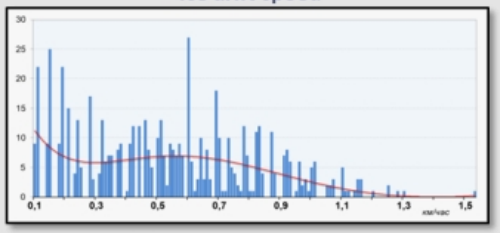
Sea Ice Drift based on MSU-GS/A Arctica-M N1

Bering Sea



Large-scale ice drift map
(00:00 - 22:00 UTC 2021.04.24) combined with
MSU-GS/A RGB imagery

Ice drift speed



Ice drift direction distribution

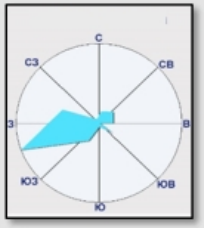
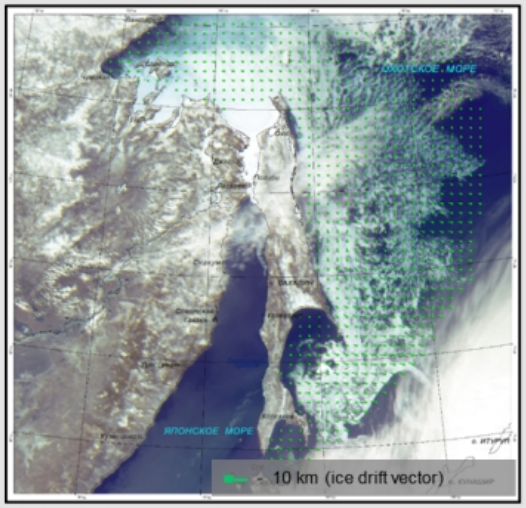


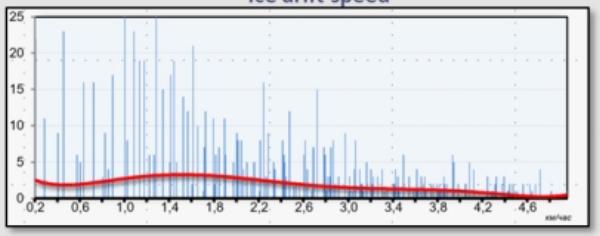
Diagram of ice drift speed and direction

the Sea of Okhotsk

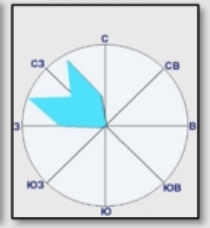


Large-scale ice drift map
(02:30 - 07:30 UTC 2021.03.26) combined with
MSU-GS/A RGB imagery

Ice drift speed

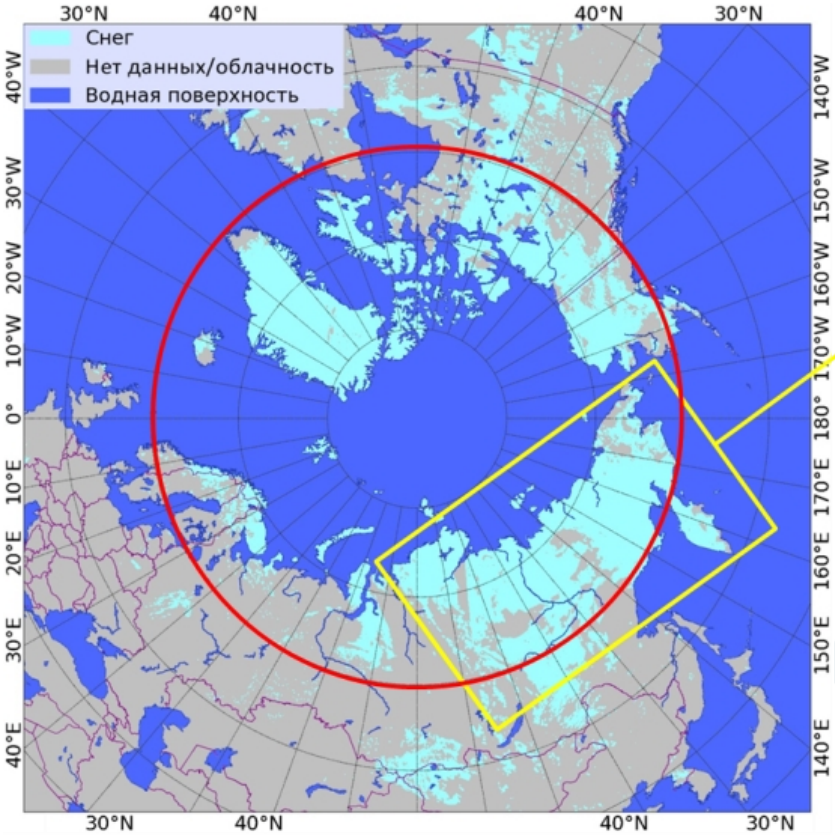


Ice drift direction distribution

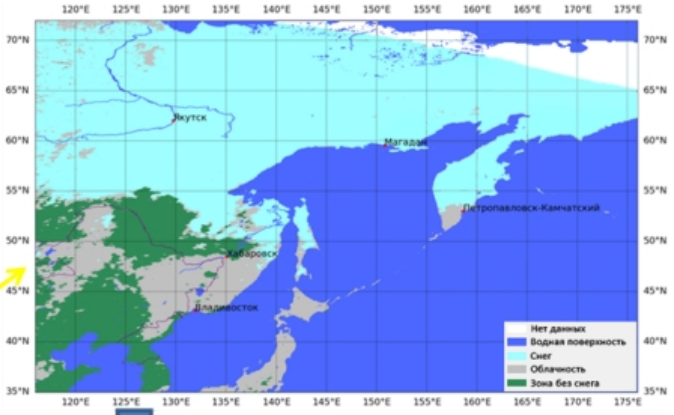


MSU-GS/A Arctica-M data enables to track large-scale ice drift in a short time interval and determine areas of intense ice drift at a speed of at least 1 km/h, which pose a particular danger to shipping and maritime industries.

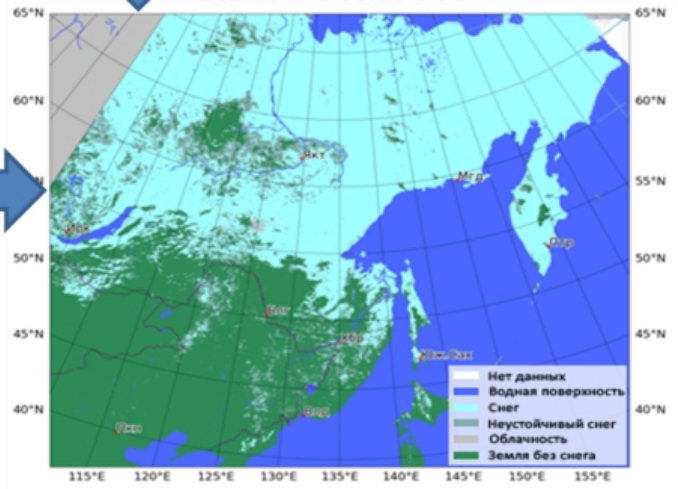
Snow Cover Monitoring based on MSU-GS/A Arctica-M N1



Arctica-M N1
2021.04.18 03:00 UTC



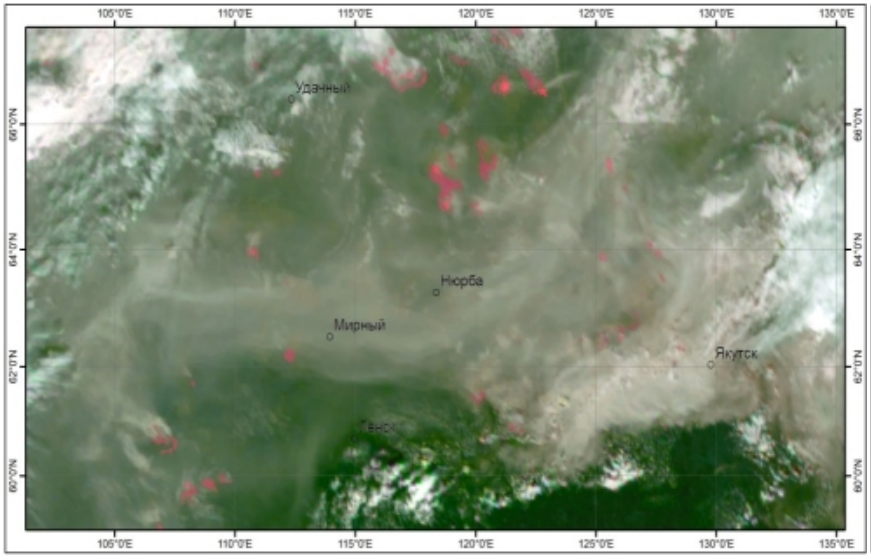
Terra
2021.04.18 00:05 UTC



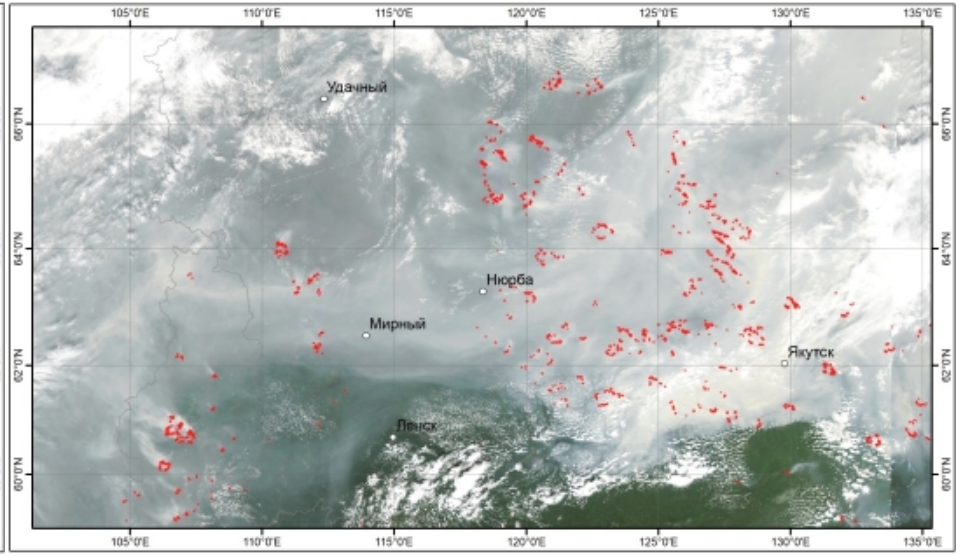
8-day composite
2021.04.18-25

Forest fires detection with Arctica-M N1 data

Sakha (Yakutia) region



Arctica-M N1
R: 3.5 ÷ 4.01 μm G: 0.65 ÷ 0.8 μm B: 0.8 ÷ 0.9 μm
Resolution 4000 m
Refresh rate 15/30 min
2021.08.12 05:00 UTC



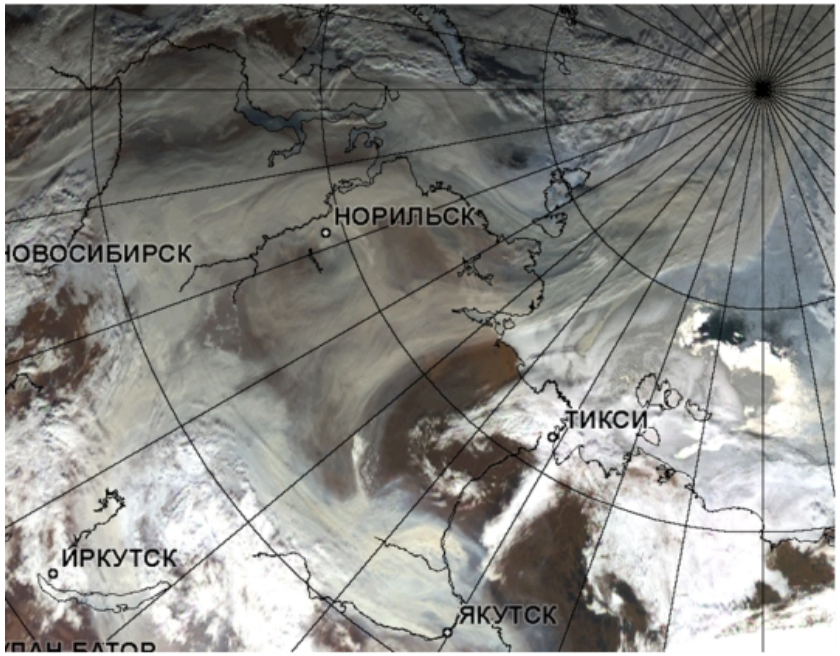
MODIS Aqua
R: 0.62 ÷ 0.67 μm G: 0.55 ÷ 0.57 μm B: 0.46 ÷ 0.48 μm,
Forest fires: 3.66 ÷ 3.84 мкм
Resolution 1000 m
Refresh rate 2 times per day
2021.08.12 05:06 UTC

Recently, there has been a tendency to an increase in the number of forest fires in northern latitudes, including in the Republic of Sakha (Yakutia), where long-term catastrophic fires are observed annually.

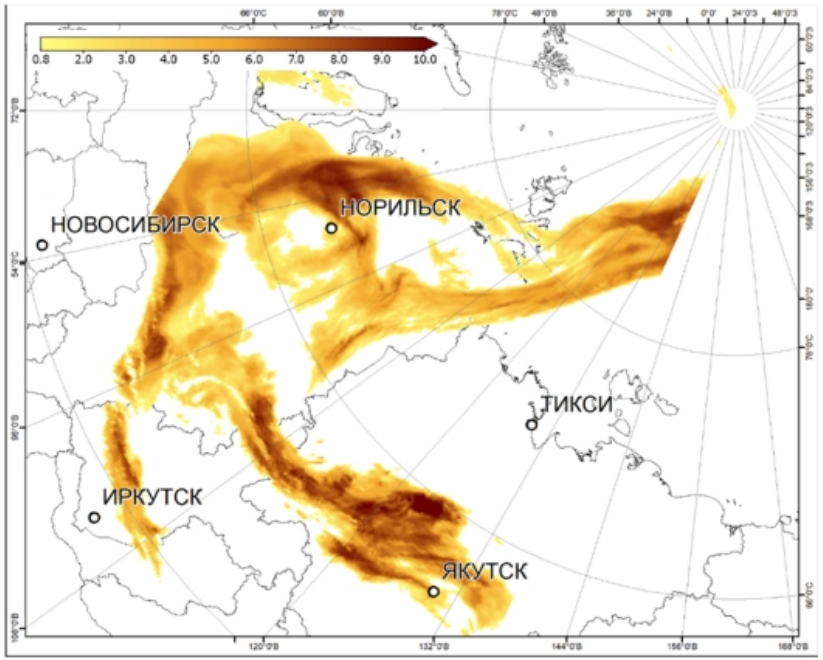
Wildfire smoke spread across the Far-Eastern part of Russia

Forest fires in the Republic of Sakha (Yakutia)

Wildfire smoke spread



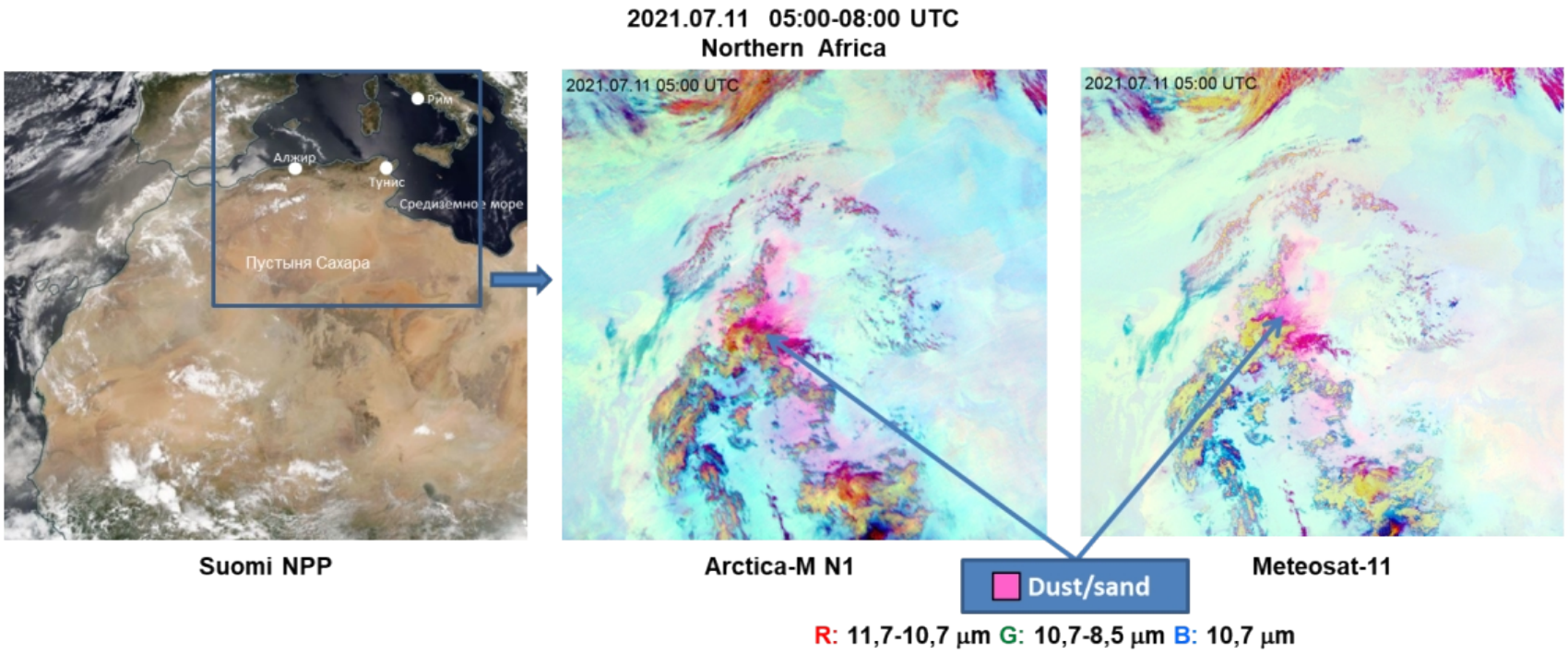
MSU-GS/A Arctica-M N1
R: 0,9 μm G: 0,7 μm B: 0,6 μm
2021.08.06 01:30 - 07:00 UTC



TROPOMI Sentinel-5P ©*ESA*
2021.08.06 03:55 UTC

MSU-GS/A data is used for global monitoring of the wildfire smoke spread in the Arctic region.

Dust storms Monitoring based on MSU-GS/A Arctica-M N1



The transport of dust (sand) particles is clearly traced based on satellite data presented on this slide. To detect clouds of dust (sand), combinations of specific satellite channels are used in wavelength ranges that are sensitive to certain fractions, in this case to dust (sand) particles. In the images, dust is depicted in pinkish colors.

Thanks for attention!