Committee on Earth Observation Satellites

# Current State and Prospects of Russian Earth Observation Satellite Systems

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Roshydromet

CEOS Plenary 2019

Agenda Item # 3.6

Ha Noi, Viet Nam

14 – 16 October 2019

# Roshydromet Satellite Observation System Objectives

## HYDROMETEOROLOGY AND GEOPHYSICAL MONITORING

- atmosphere/ocean monitoring and forecasting;
- ice cover monitoring for navigation in Arctic and Antarctic regions, freezing seas of Russia;
- space weather information service;
- data collection (via satellites) from Roshydromet' observation sites.

## DISASTER MONITORING AND EMERGENCY SITUATION CONTROL

- disaster occurrence assessment;
- monitoring of emergency situations;
- evaluation of the damage caused by disaster event.

## GLOBAL CLIMATE CHANGE MONITORING

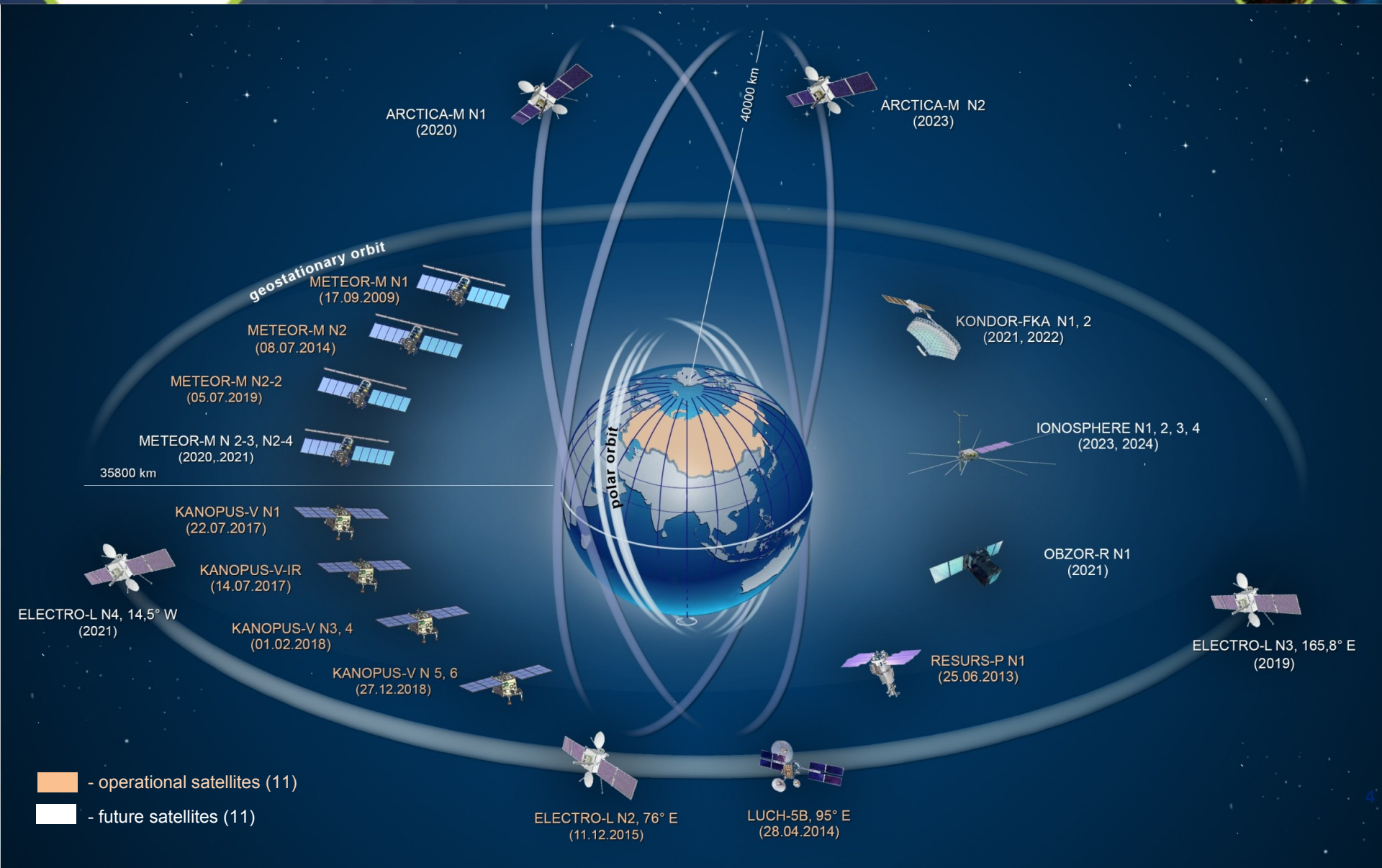
- studying of climate, ocean and landscape changes based on observations of earth-radiation budget, cloud cover, ozone, snow and ice cover, water temperature and color, vegetation cover, and etc.

## ENVIRONMENTAL POLLUTION MONITORING

- environmental pollution monitoring of land, atmosphere, and ocean;
- evaluation of probable pollution spread, including radioactive pollution.

# Global Earth Observation Satellite System

# Russian Earth Observation Satellite System

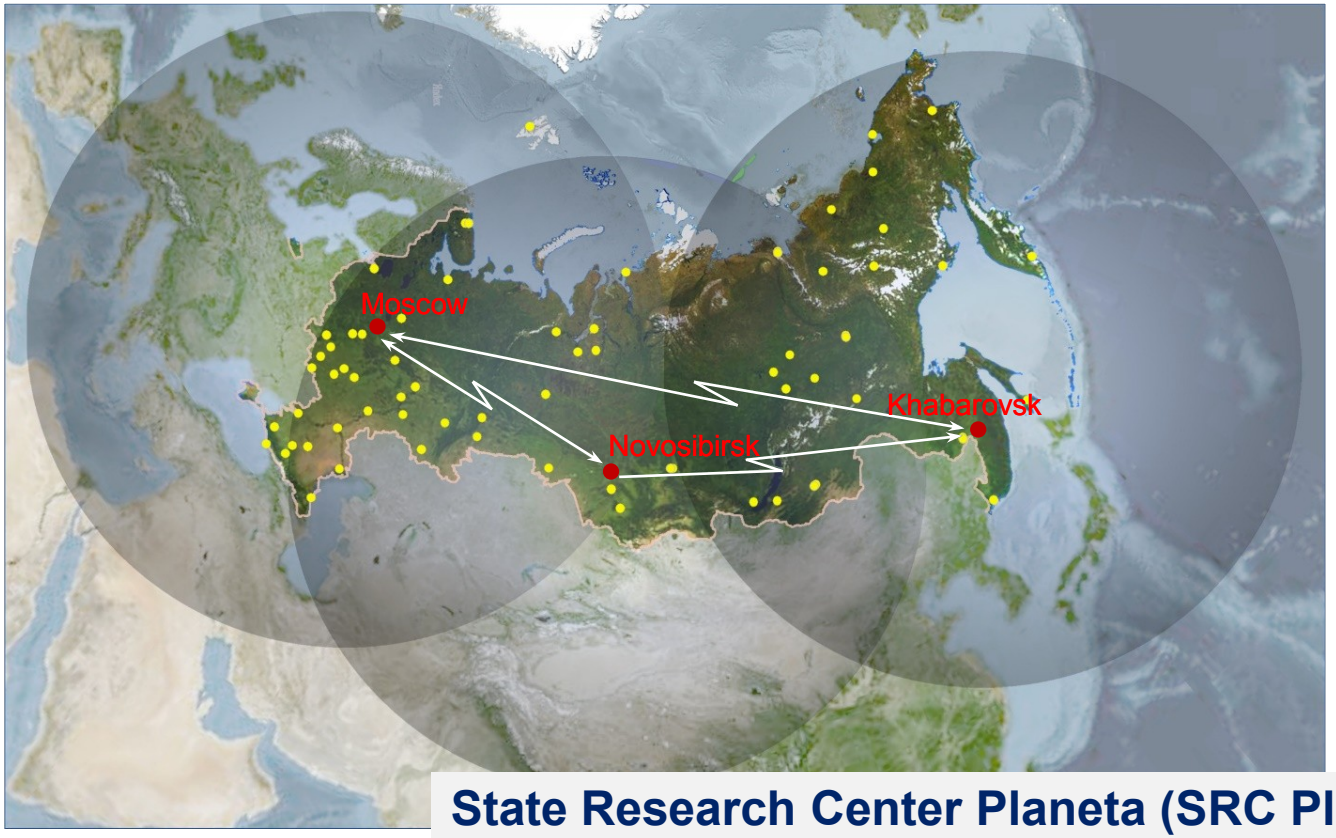


# Russian Earth Observation Satellites Program

## (Federal Space Program for 2005-2015 and 2016-2025)

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Geostationary meteorological system** | | | ELECTRO-L №1(14,5°W) - launched on January 20, 2011 | | | | | | | | | ELECTRO-L № 2 (76,°E) - launched on December 11, 2015 | | | | | |
| | | | | | | | | | | | | ELECTRO-L № 3 (165,8°E) | | | | | |
| | | | | | | | | | | | | ELECTRO-L № 4 (14,5°W) | | | | | |
| | | | | | | | | | | | | ELECTRO-L № 5 | | | | | |
| **HEO satellite system «Arctica»** | | | | | | | | | | | ARCTICA-M № 1 | | | | | | |
| | | | | | | | | | | | | | | ARCTICA-M № 2 | | | |
| | | | | | | | | | | | | | | ARCTICA-M № 3 | | | |
| | | | | | | | | | | | | | | ARCTICA-M № 4 | | | |
| | | | | | | | | | | | | | | ARCTICA-M № 5 | | | |
| **Polar-orbiting meteorological system** | | | METEOR-M № 1 - launched on September 17, 2009 | | | | | | | | | | | | | | |
| | | | | | | | METEOR-M № 2 - launched on July 8, 2014 | | | | | | | | | | |
| | | | | | | | | | METEOR-M № 2-1 - *lost at launch on November 28, 2017* | | | | | | | | |
| | | | | | | | | | | | METEOR-M № 2-2 - launched on July 5, 2019 | | | | | | |
| | | | | | | | | | | | METEOR-M № 2-3 | | | | | | |
| | | | | | | | | | | | METEOR-M № 2-4 | | | | | | |
| **R&D environmental satellites** | | | | | | | | KANOPUS-V № 1 - launched on July 22, 2012 | | | | | | | | | |
| | | | | | | | | | | KANOPUS-V-IR - launched on July 17, 2017 | | | | | | | |
| | | | | | | | | | | KANOPUS-V №3,4 - launched on February 1, 2018 | | | | | | | |
| | | | | | | | | | | KANOPUS-V №5,6 - launched on December 27, 2018 | | | | | | | |
| | | | | | | | | | | | | | | | | | KANOPUS-V №7,8 |
| | | | | | | | | | | | | | | | | | OBZOR-R № 1 |
| | | | | | | | | | | | | | | | | | KONDOR-FKA №1 |
| | | | | | RESURS-P № 1 - launched on June 25, 2013 | | | | | | | | | | | | | KONDOR-FKA №2 |
| | | | | | | | | | | | | | | | | | KONDOR-FKA-M №1 |
| | | | | | RESURS-P № 2 - launched on December 26, 2014 | | | | | | | | | | | | | RESURS-P № 4 |
| | | | | | RESURS-P № 3 - launched on March 13, 2016 | | | | | | | | | | | | | RESURS-P № 5 |
| | | | | | | | | | | | | | | | | | RESURS-PM № 1 |
| | | | | | | | | | | | | | | | | | RESURS-PM № 2 |
| | | | | | | | | | | | | | | | | | RESURS-PM № 3 |
| **Space weather satellites** | | | | | | | | | | | | | IONOSPHERE-M №1,2 | | | | |
| | | | | | | | | | | | | | IONOSPHERE-M №3,4 | | | | |

# Roshydromet Ground Segment of Earth Observation Satellite System




## Satellite Centers:

**European**
(SRC Planeta, Moscow-Obninsk-Dolgoprudny)

**Siberian**
(SRC Planeta, Novosibirsk)

**Far Eastern**
(SRC Planeta, Khabarovsk)

○ - more than **70** local reception sites

## State Research Center Planeta (SRC Planeta) daily activities:

- receives more than **1.4 TB** satellite data;
- produces more than **530 types** of satellite-based products;
- provides data for more than **560** federal and regional users.

# Users of Satellite Data and Products

## State Research Center Planeta

**European Center**
(Moscow, Obninsk, Dolgoprudny)

**Siberian Center**
(Novosibirsk)

**Far Eastern Center**
(Khabarovsk)

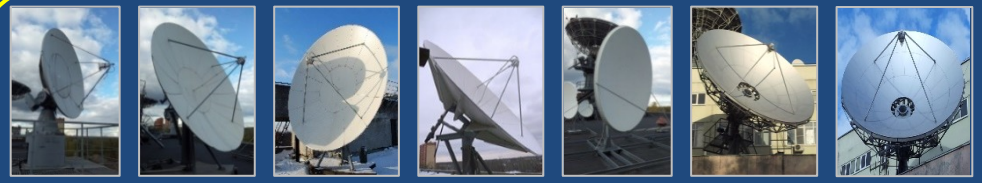
## USERS

- ROSHYDROMET
- NATIONAL METEOROLOGICAL SERVICES OF THE CIS COUNTRIES
- MINISTRY OF DEFENSE
- EMERCOM
- MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT
- FEDERAL AGENCY FOR FORESTRY
- FOREST FIRES AVIATION SERVICE
- FEDERAL AGENCY FOR WATER RESOURCES
- MINISTRY OF AGRICULTURE
- ROSCOSMOS
- MINISTRY OF TRANSPORT
- AIR TRAFFIC CONTROL CENTERS
- MINISTRY OF SCIENCE AND HIGHER EDUCATION
- RUSSIAN ACADEMY OF SCIENCES
- RUSSIAN FEDERAL AND LOCAL AUTHORITIES
- MASS MEDIA

# SRC Planeta Receiving Stations

## EUROPEAN CENTER

### DOLGOPRUDNY



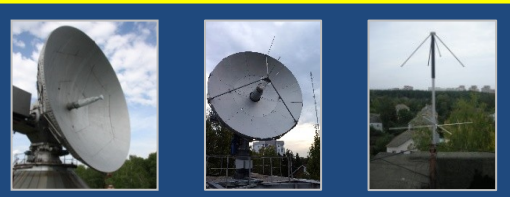
PK-3,5 | SKS-PRM 8/7 | SKS-PRD 8/7 | SKS-PRD 8/7 | SPOI-E2 | SPDP-E | SPDP-E

PK-9 | PS-LRPT | SPOI-2L | SPOI-E | APPI-MD | APPI-M | DUAL MEOS Polar

### MOSCOW

DVB-S2 | DVB-S2 | DUAL MEOS Polar | SKS-PRM 8/7

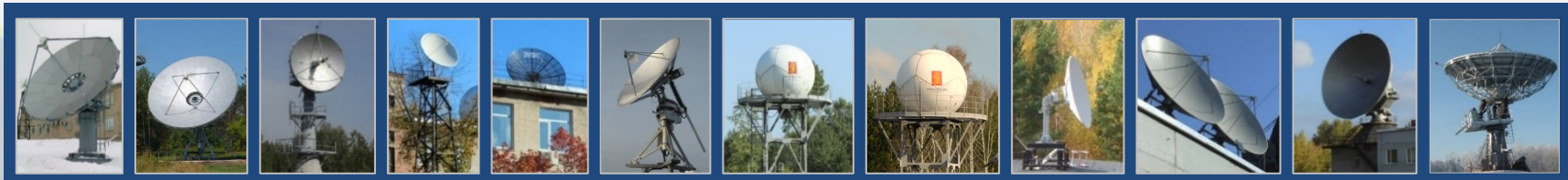
### OBNINSK



PRI-PM | KPI 4.8 | PS-LRPT

## SIBERIAN CENTER

### NOVOSIBIRSK



SPDP-L | SPDP-E | KPI-4,8 | APPI-M | SPOI-E | SPOI-2L | DUAL MEOS Polar | UniScan | SKS-8/7 | PRI-PM | PK-9M

## FAR EASTERN CENTER

### KHABAROVSK

SPDP-L | KPI-4,8 | APPI-MD | SPOI-E | APPI-GD | SPOI-2L | DUAL MEOS Polar | SPOI-2S | UniScan | SKS-PRD 8/7 | SKS-PRM 8/7 | PK-9 | PK-9M

# ELECTRO-L
## Geostationary Meteorological Satellite

| Parameter | Value |
|---|---|
| Three-axis high-precision stabilization | |
| In-orbit mass | ~ 1500 kg |
| Payload mass | ~ 370 kg |
| Lifetime | 10 years |
| Longitude | 76°E,14.5°W, 165.8°E |
| Altitude | 830 km |
| Data dissemination format | HRIT/LRIT |
| Coverage/Cycle | Full disk every 30/15 min |

ELECTRO-L N2 (76°E) launched on 11 December 2015

**ELECTRO-L N3 (165.8°E) — planned for 2019**

**Mission objectives**

- Operational observation of the atmosphere and the Earth surface
- Heliogeophysical measurements
- Maintaining Data Collection System and COSPAS/SARSAT Service

# Data collection system (DCS) at Roshydromet' Observation Network

LUCH-5B (95°E)

ELECTRO-L N2 (76°E)

DCS comprises of the network of data collection platforms at Roshydromet' observation sites, relay transponders at Russian geostationary satellites of ELECTRO and LUCH series, and ground receiving stations at SRC Planeta centers. The system will be further complemented with the launch of highly elliptical orbit satellites of ARCTICA series.

European center | Siberian center | Far Eastern center

SRC Planeta

Data is currently being collected from 662 Roshydromet' observation network (•••), including difficult to access (•) stations (136), and hydrological (•) sites (44).

# METEOR-M
# Polar-orbiting Meteorological Satellite

| Parameter | Value |
|---|---|
| In-orbit mass | ~ 2700 kg |
| Payload mass | ~1200 kg |
| Lifetime | 5 years |
| Orbit | Sun-synchronous |
| Altitude | 830 km |
| Data dissemination format | HRPT/LRPT |

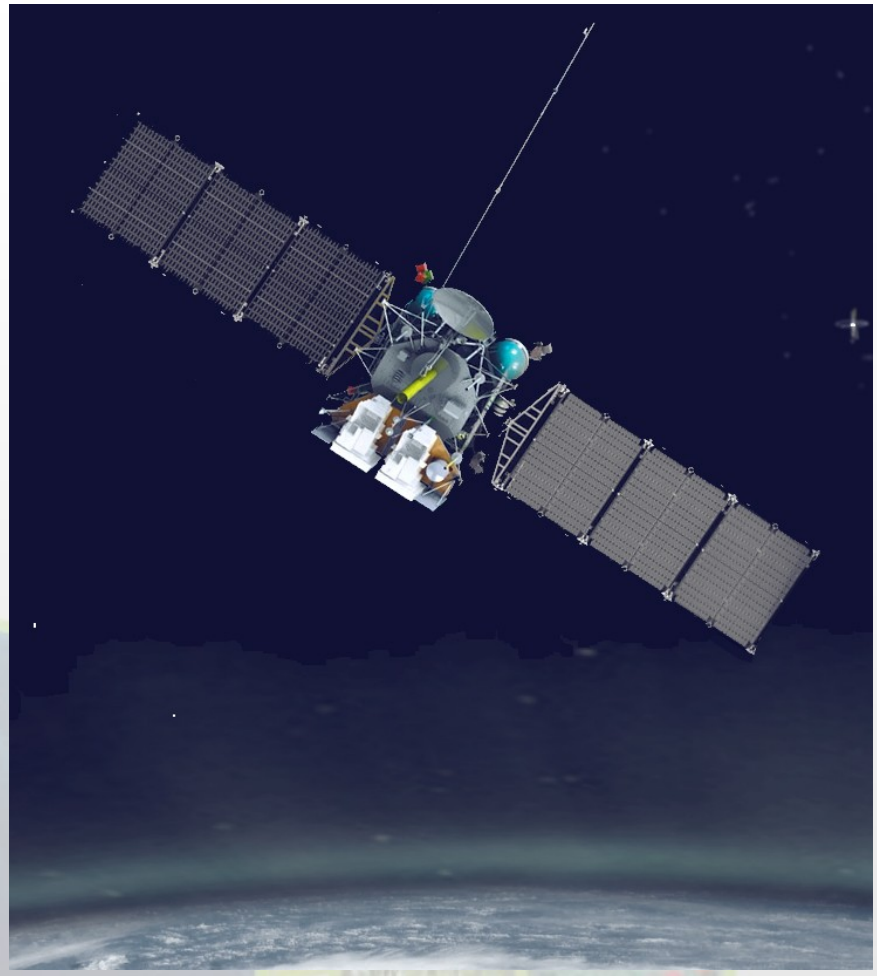
METEOR-M N2 (ECT 09:30) launched on 8 July 2014

**METEOR-M N2-2 (ECT 15:00 ) launched on 5 July 2019**

**Mission objectives**

- Weather analysis and forecasting on global and regional scales
- Global climate change monitoring
- Sea surface observations
- Space weather analysis and prediction

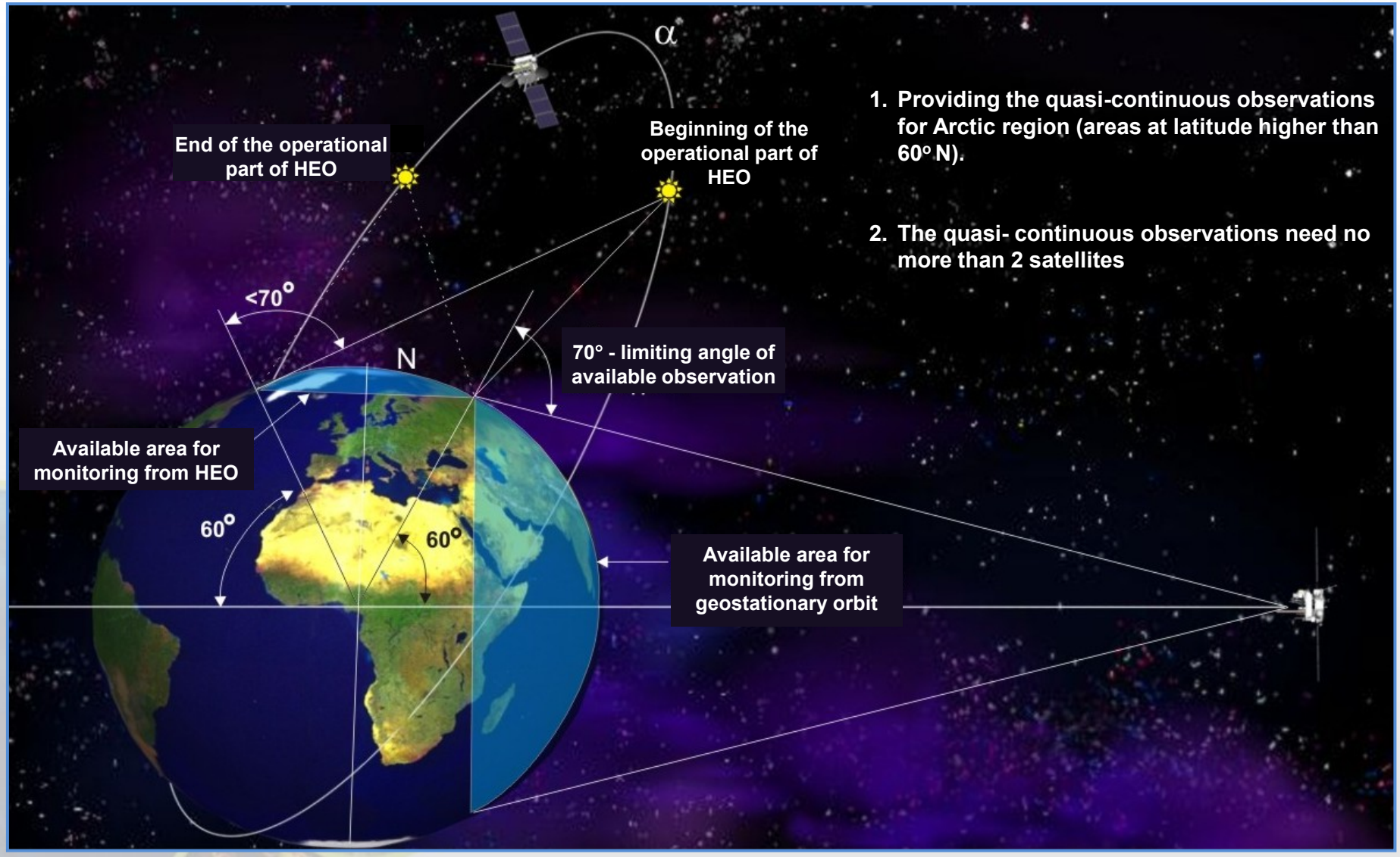
# ARCTICA-M Highly Elliptical Orbit (HEO) Meteorological Satellite



**ARCTICA-M N1 — planned for 2020**
**ARCTICA-M N2 — planned for 2023**

| Parameter | Value |
|---|---|
| *Orbit:* | |
| Apogee, km | 40000 |
| Perigee, km | 1000 |
| Inclination, deg | 63.4 |
| Period, h | 12 |
| Number of MSU-GS/HE spectral channel | 10 |
| Spectral range, μm | from 0.5 to 12.5 |
| *Resolution (at nadir):* | |
| - VIS-channel, km | 1 |
| - IR-channel, km | 4 |
| *Field-of-view from the Molniya orbit, min:* | |
| - regular mode | 30 |
| - frequent mode | 15 |
| Spacecraft mass, kg | 2000 |

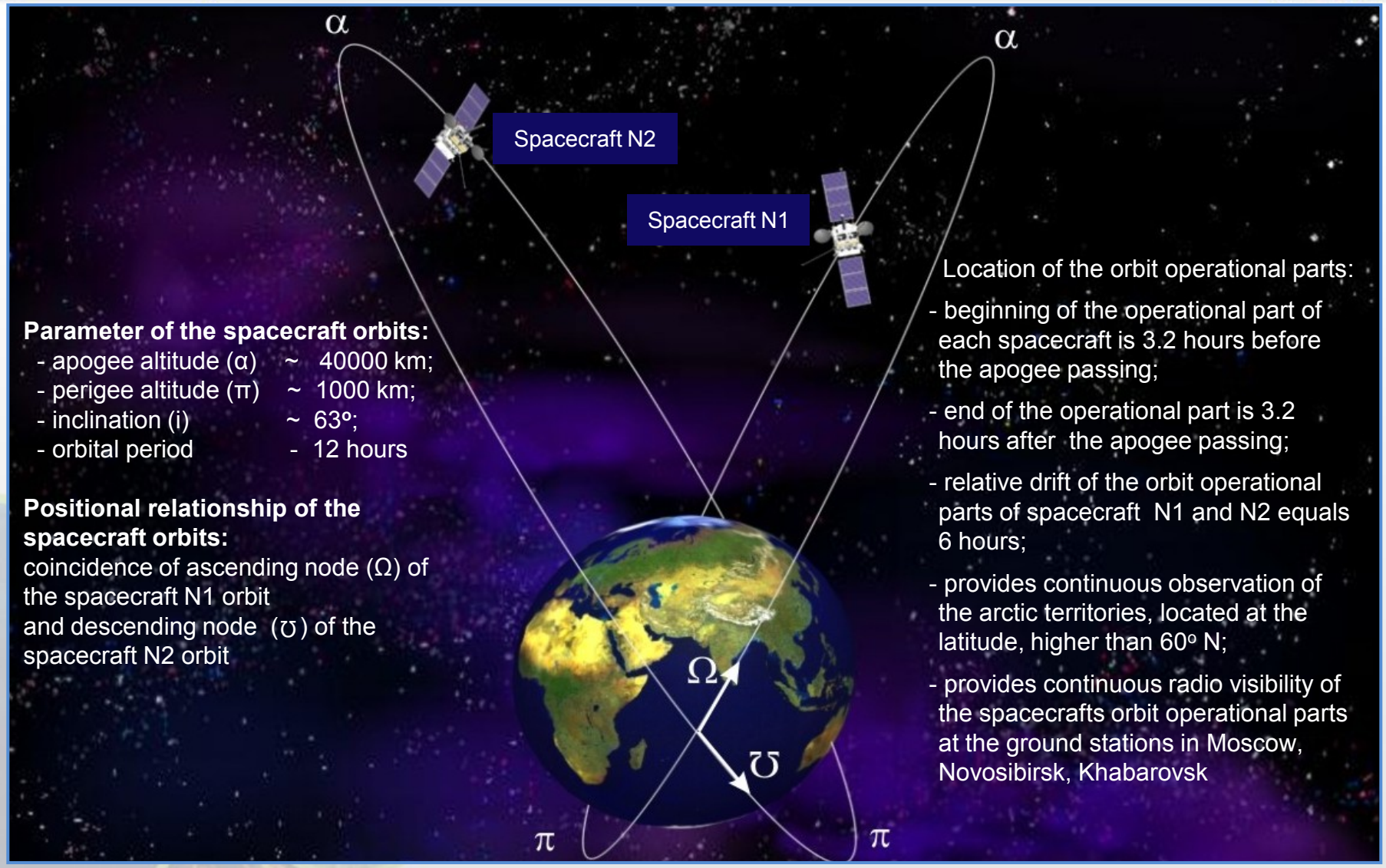
# HEO for Arctic Observations




1. Providing the quasi-continuous observations for Arctic region (areas at latitude higher than 60° N).

2. The quasi- continuous observations need no more than 2 satellites

# 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

# KANOPUS-V
# Disaster Monitoring Satellite

KANOPUS-V N1
launched on 22.07.2012
KANOPUS-V-IK
launched on 14.07.2017
KANOPUS-V N3, 4
launched on 01.02.2018
KANOPUS-V N5, 6
launched on 27.12.2018

| Parameter | Value |
|---|---|
| In-orbit mass | 465 kg (N1,3-6) & 600 kg (IR) |
| Payload mass | 106 kg (N1,3-6) & 191 kg (IR) |
| Lifetime | 5 years |
| Orbit | Sun-synchronous |
| Altitude | 510 - 540 km |
| Orbit inclination | 97,4 ° |

## KANOPUS-V Basic Characteristics

| | **Spectral channels *(μm)*** | **Resolution *(m)*** | **Swath width *(km)*** |
|---|---|---|---|
| Panchromatic film-making system (PSS) | 0.54-0.86 | 2.1 | 23 |
| Multispectral film-making system (MSS) | 0.46-0.52<br>0.51-0.60<br>0.63-0.69<br>0.75-0.84 | 10,5 | 23 |
| Multi-channel medium and IR range radiometer (MSU-IK-SR)* | 3.5-4.1<br>8.4-9.4 | 200 | 2000 |

* - onboard KANOPUS-V-IK

# RESURS-P
# Environmental Monitoring Satellite

**RESURS-P N1**
**launched on 25.06.2013**
RESURS-P N2
launched on 26.12.2014
(inactive since 19.12.2017)
RESURS-P N3
launched on 13.03.2016
(inactive since 28.02.2017)
**RESURS-P N4**
**planned for launch in 2020**

| Parameter | Value |
|---|---|
| In-orbit mass | - 6275kg |
| Payload mass | - 2258 kg |
| Lifetime | 5 years |
| Orbit | elliptical, sun-synchronous |
| Altitude | 475 km |
| Orbit inclination | 97,27 ° |

## Resurs-P Basic Characteristics

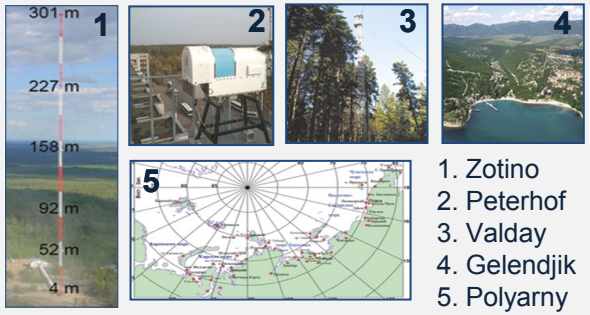
| | High-resolution instrument GEOTON-L1 | Multispectral wide swath suit (high|/medium resolution) | Hyperspectral imaging equipment GSA |
|---|---|---|---|
| Spectral Bands *(μm)* | | | 96 spectral channels in the range 0.4-1.1 μm |
| *panchromatic mode* | 0.58-0.8 | 0.43-0.9/0.43-0.7 | |
| *multispectral mode* | 0.45-0.52; 0.52-0.6; 0.61-0.68; 0.67÷0.7; 0.7-0.73; 0.72-0.80; 0.80-0.90 | 0.43-0.51; 0.51-0.58; 0.60-0.70; 0.70-0.90; 0.80-0.90 | |
| Resolution *(m)* | | | 25-30 |
| *panchromatic mode* | 1 | 12/60 | |
| *multispectral mode* | 3-4 | 24/120 | |
| Swath width (km) | 38 | 96/480 | 25 |

# CAL/VAL
# System for Satellite Data and Products

## Standard measurements

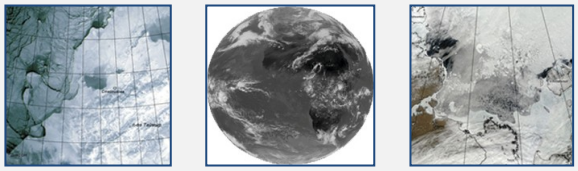
### Roshydromet' observation sites

### Test sites




1. Zotino
2. Peterhof
3. Valday
4. Gelendjik
5. Polyarny

### Foreign satellite data



NOAA/AVHRR | METEOSAT/SEVIRI | TERRA/MODIS

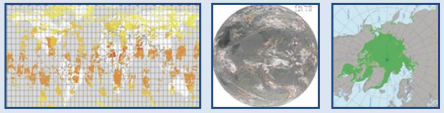
## Russian meteorological satellites of ELECTRO-L and METEOR-M series data

→ Data calibration
Data inter-calibration

→ Thematic processing

→ Validation

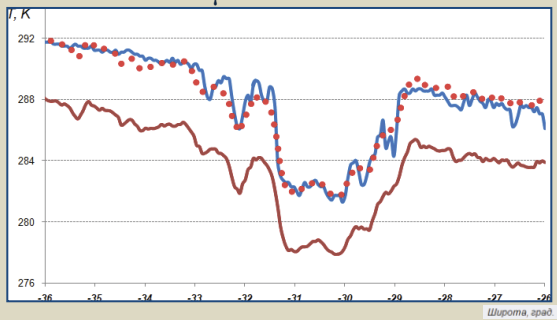
→ Satellite products



→ Numerical weather prediction

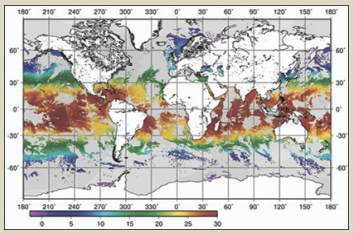
## Cal/Val examples

### Data inter-calibration for channel 10.2-11.2 μm over sea surface

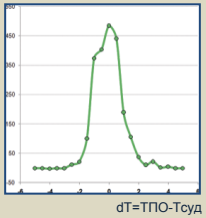



- METEOSAT-10/SEVIRI data
- ELECTRO-L/MSU-GS data
- ELECTRO-L/MSU-GS data (after intercalibration)

### Sea surface temperature validation *vs* ship measurements



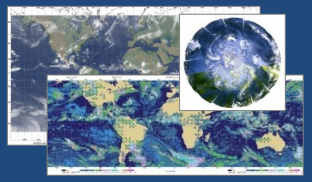
SST derived from METEOR-M/MSU-MR

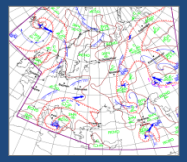


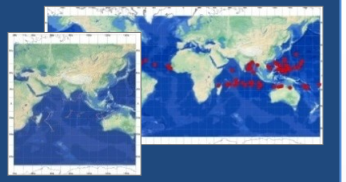

Bias = -0,01° K
RMSE = 0,9° K

# Satellite-based Products

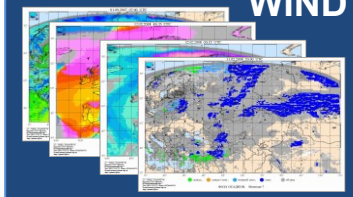
## CLOUD COVER

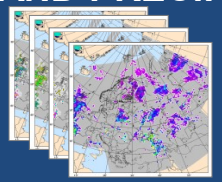

Cloud cover monitoring

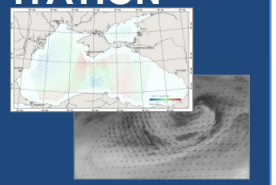

Nephanalysis map


Tropical cyclone monitoring

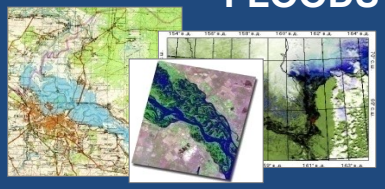
## WIND AND PRECIPITATION

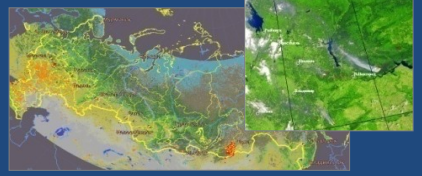

Meteorological phenomena monitoring


Precipitation and cloud cover parameters

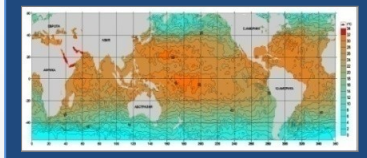

Atmospheric motion winds

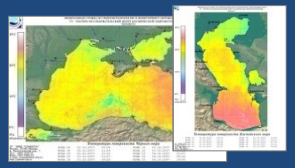
## FLOODS AND FIRES

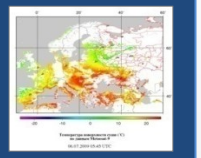

Flooding map


Fires map

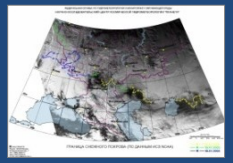
## SEA AND LAND SURFACE TEMPERATURE

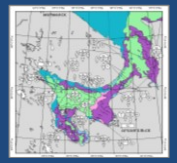

Ocean surface temperature


Sea surface temperature


Land surface temperature

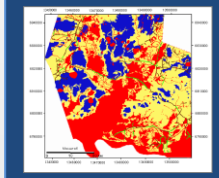
## SNOW AND ICE COVER


Snow cover map


Sea ice cover map

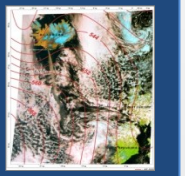

Sea ice drift map

## ENVIRONMENTAL MONITORING

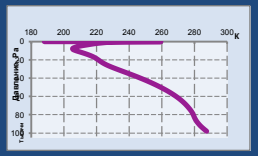

Risk areas for pollution spread


Vegetation index

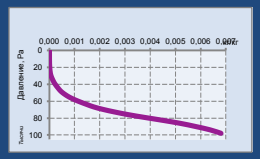

Water pollution


Volcanic ash spread

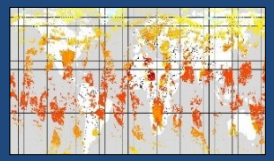
## ATMOSPHERIC SOUNDING



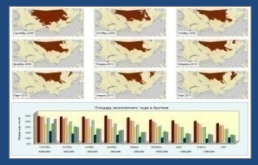
Temperature profile



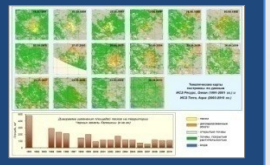
Humidity profile


Atmospheric sounding data coverage

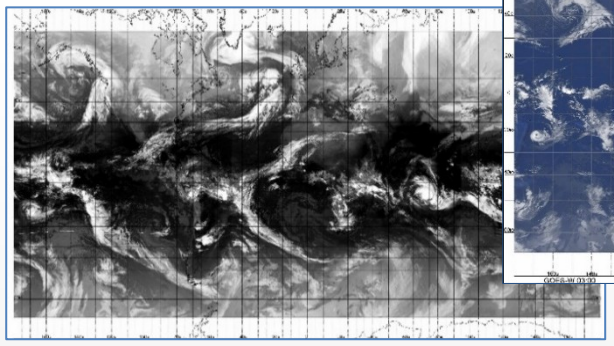
## CLIMATE CHANGE


Old ice cover monitoring in Russian Arctic

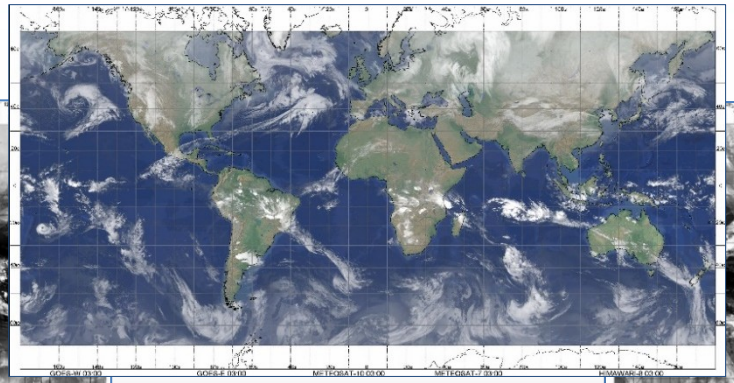

Seasonal changes in Caspian Sea Ice cover


Desertification monitoring (Kalmyk Republic)

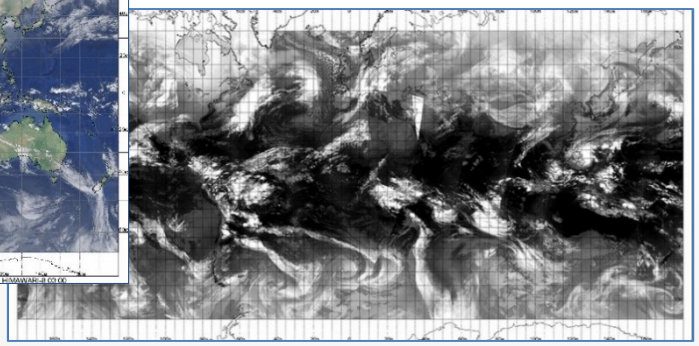
# Cloud Cover: Global Monitoring



*GOES-W, GOES-E, METEOSAT-11, ELECTRO-L N2, HIMAWARI-8*

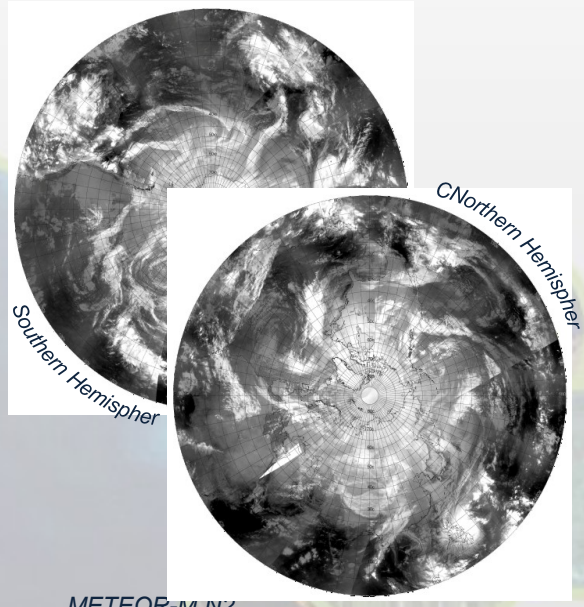


*GOES-W, GOES-E, METEOSAT-11, METEOSAT-8, HIMAWARI-8*

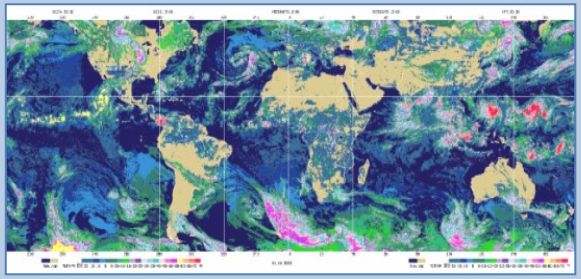


METEOR-M-M N2

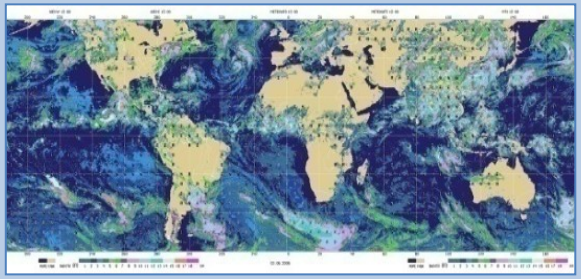
**Global Cloud Maps**




*METEOR-M N2*

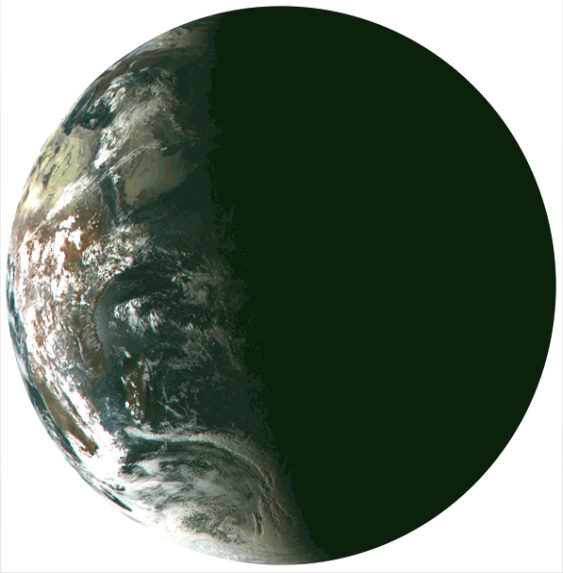


*Cloud Top Height Temperature*



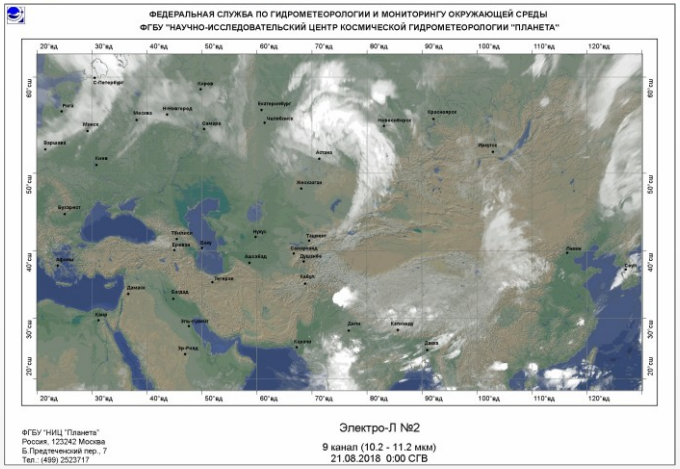
*Cloud Cover Fraction and Cloud Top Height*

*GOES-W, GOES-E, METEOSAT-8, 11, HIMAWARI-8*

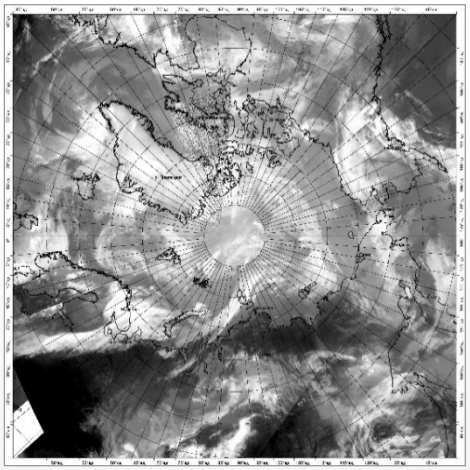


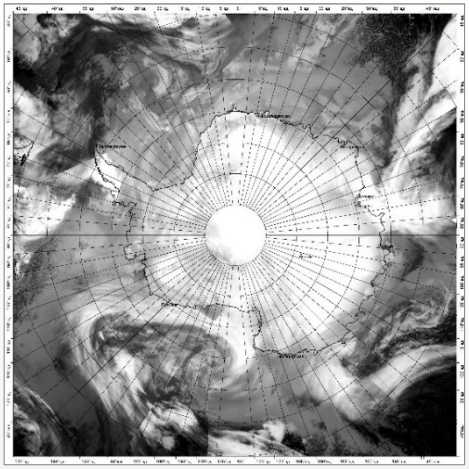
*ELECTRO-L N2*

# Cloud Cover: Regional Monitoring

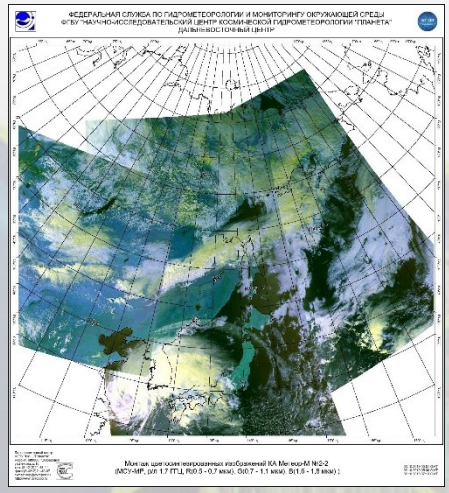



Cloud Cover Animation, Eurasia
*(ELECTRO-L N2/MSU-GS)*

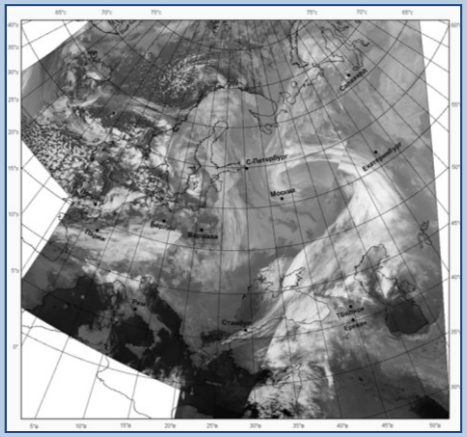


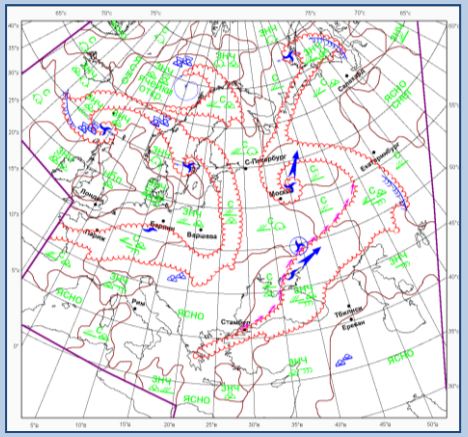


Arctic and Antarctic Mosaics of IR Images
*(METEOR-M N2/MSU-MR)*



Cloud Cover, Far-Eastern region
*(METEOR-M N2-2/MSU-MR)*

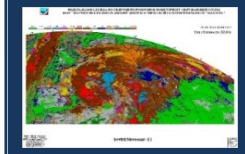


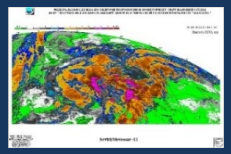


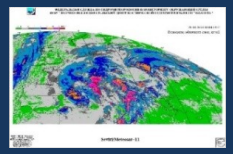
Nephanalysis Map
*NOAA/AVHRR (IR-channel: 10.3 -11.3 μm)*

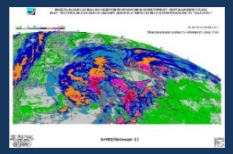
# Cloud Cover Parameters

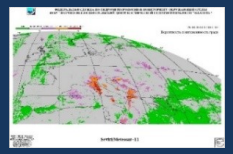
## EUROPEAN REGION

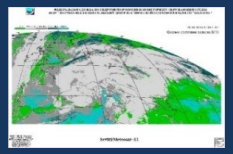

Cloud types

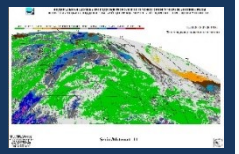

Cloud top height


Maximum water content of cloud layer


Total liquid water content

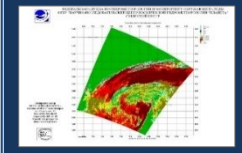

Hail probability and intensity

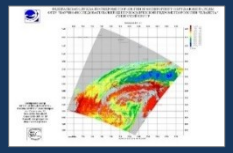

Cloud top water phase

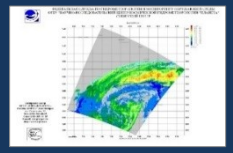

Precipitation type (at surface)

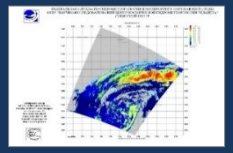
METEOSAT-11 / SEVIRI

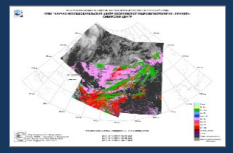
## SIBERIAN REGION

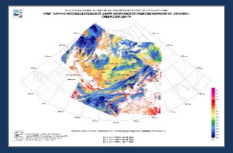

Cloud types

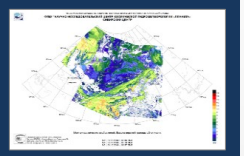

CTH temperature


Cloud top height


Cloud water content


Cloud types

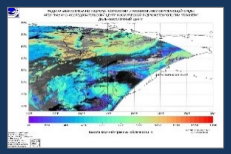

CTH temperature

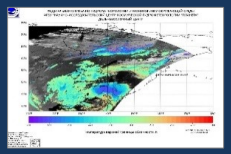

Cloud top height

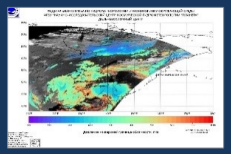
METEOSAT-11 / SEVIRI

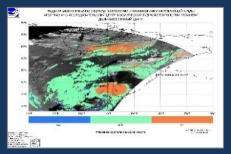
METOP / AVHRR

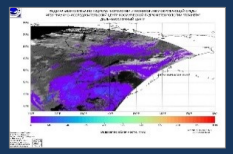
## FAR EASTERN REGION

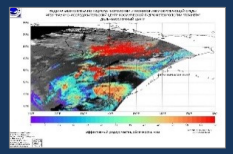

Cloud top height

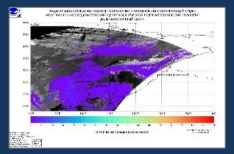

CTH temperature


CTH pressure

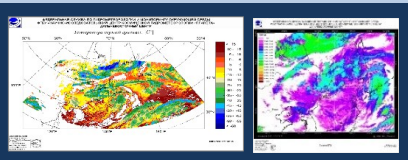

Cloud phase

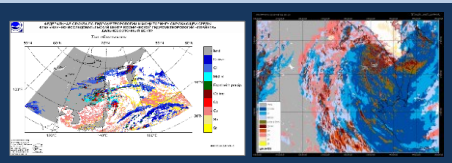

Cloud water content

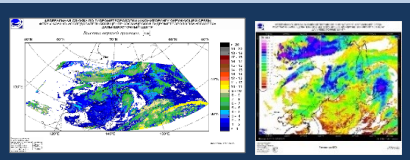

Effective radius of cloud particles

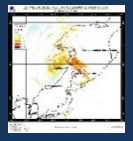

Cloud optical depth

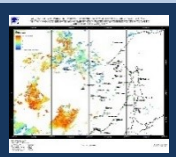
METEOR-M N2 / MSU-MR


CTH Temperature


Cloud types


Cloud top height

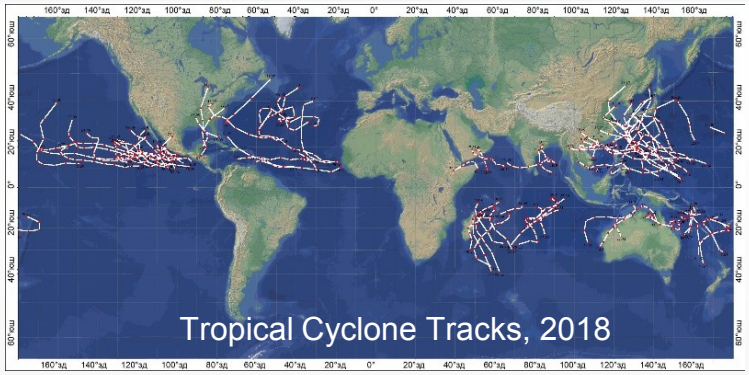

Precipitation rate

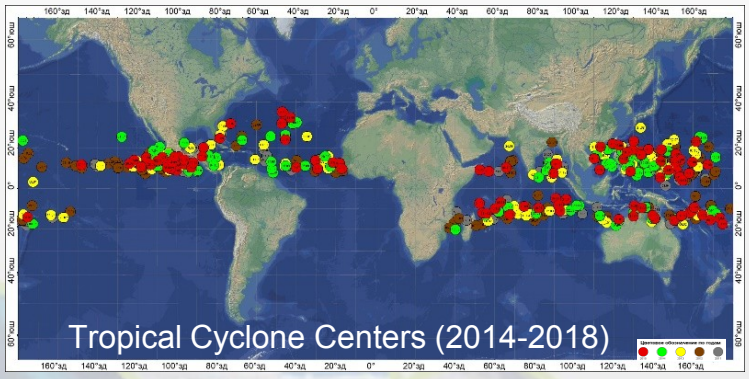

Fog probability

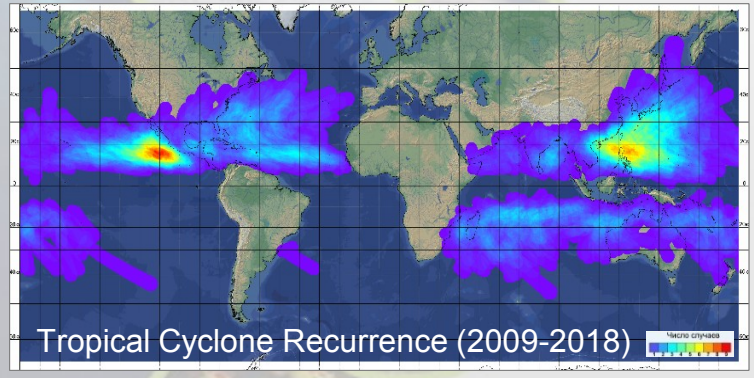
HIMAWARI-8 / AHI

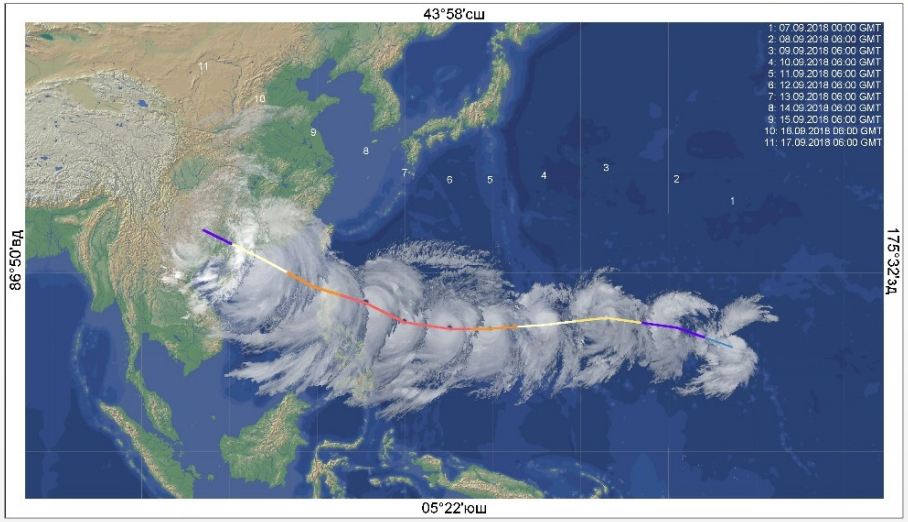
# Tropical Cyclone Monitoring

## (geostationary satellites)

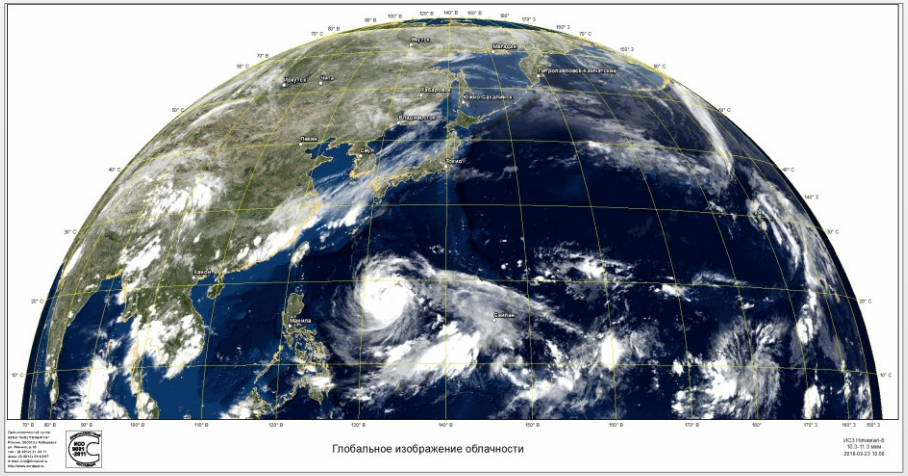


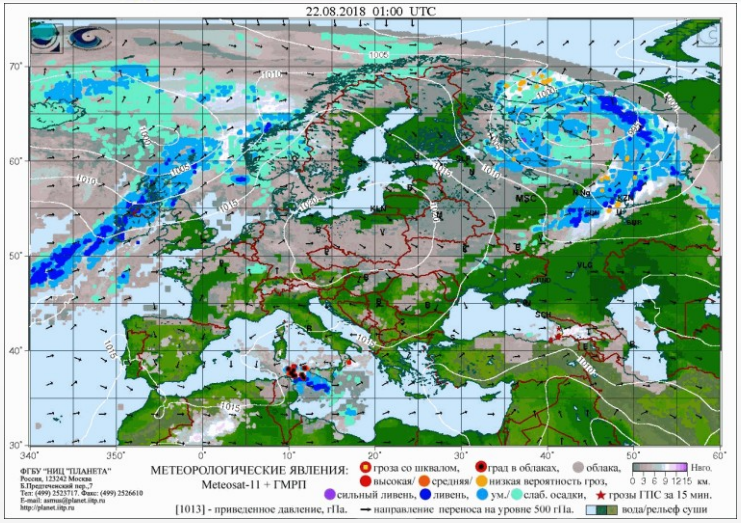




Tropical Cyclone MANGKHUT 7.09.2018 - 17.09.2018

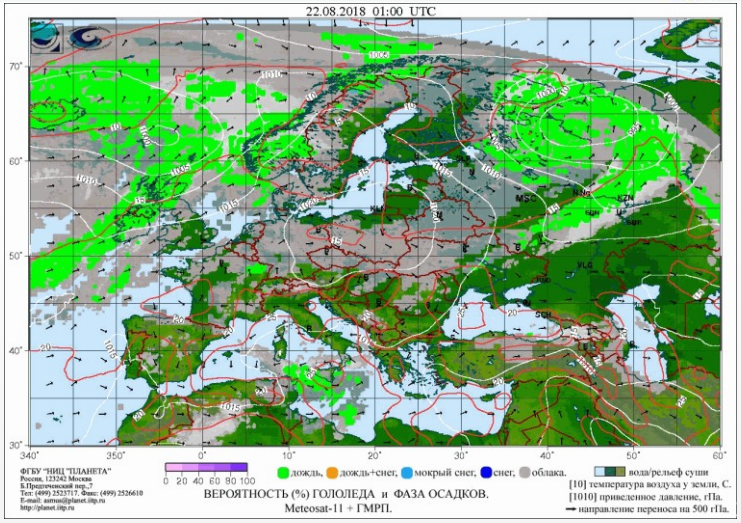



Tropical Cyclone TRAMI 23-26.09.2018

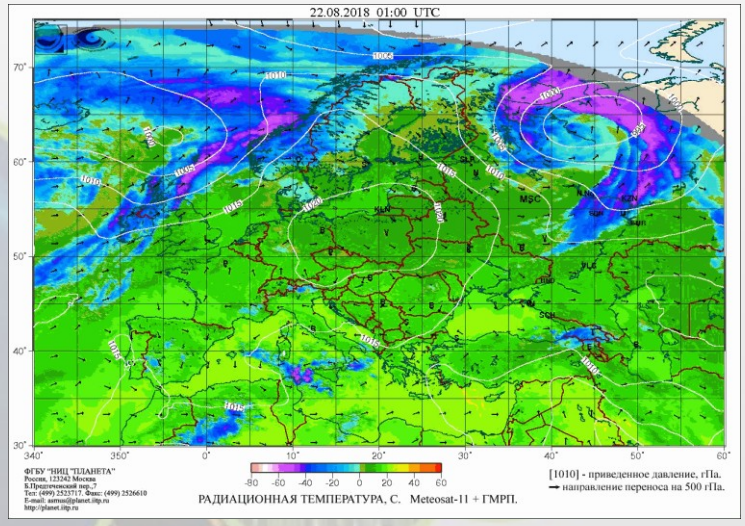
# Meteorological Phenomena Monitoring



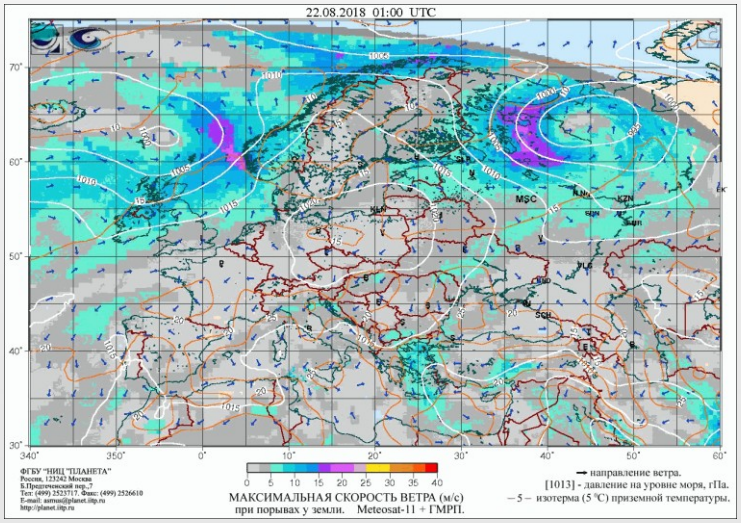

Atmospheric phenomena




Precipitation phase




Radiative temperature

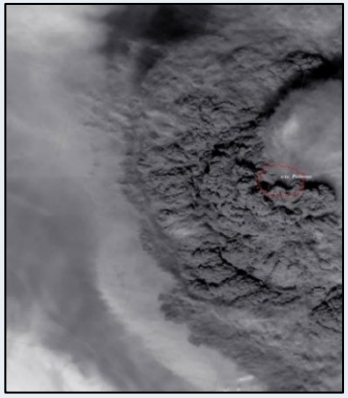



Maximum wind speed (wind gusts)

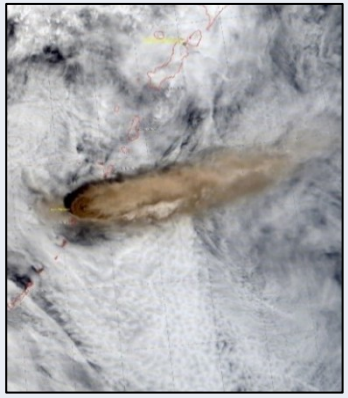
# Volcanic Activity Observations

Roshydromet provides operational monitoring of volcanic activity in Kamchatka and Kuril Islands. During the period of eruptions, satellite images of volcanic plumes are produces. The following eruption parameters are detected based on the satellite data: effective particle radius, optical depth and ash content, total sulfur dioxide content.

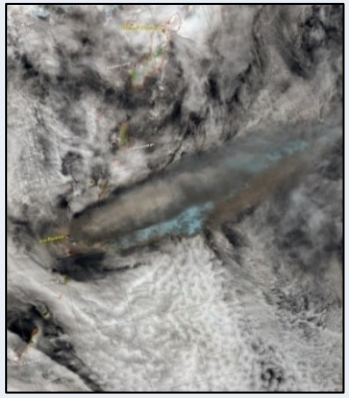
**Satellite Imagery**



*Kanopus-V N1, 21.06.2019 01:17 UTC*

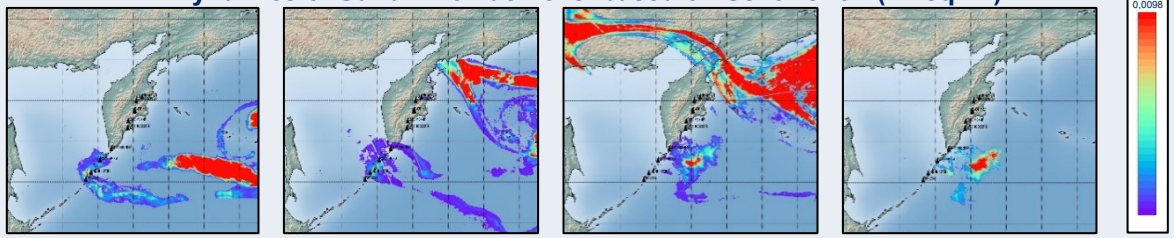


*TERRA, 21.06.2019 01:25 UTC*



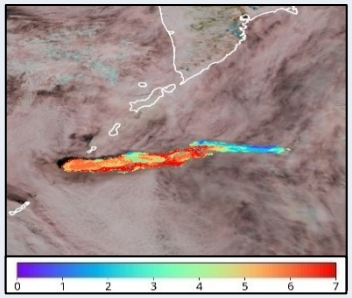
*Suomi NPP, 21.06.2019 02:13 UTC*

**Dynamics of Sulfur Dioxide Level based on Sentinel-5P (ml/sq.m.)**

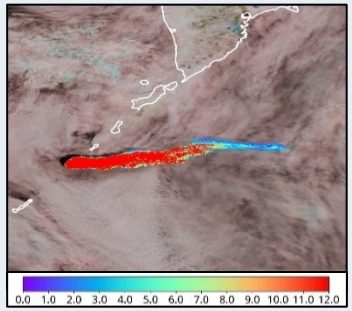



*23.06.2019, 02:01 UTC* *24.06.2019, 01:41 UTC* *25.06.2019, 01:21 UTC* *25.06.2019, 03:01 UTC*

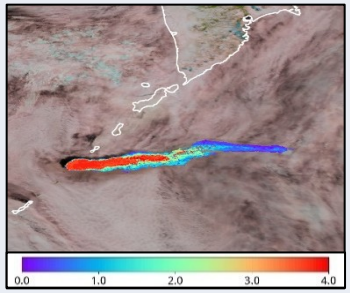
**Eruption parameters based on AVHRR, 23:55 UTC**




*Effective radius of ash particles, μm*

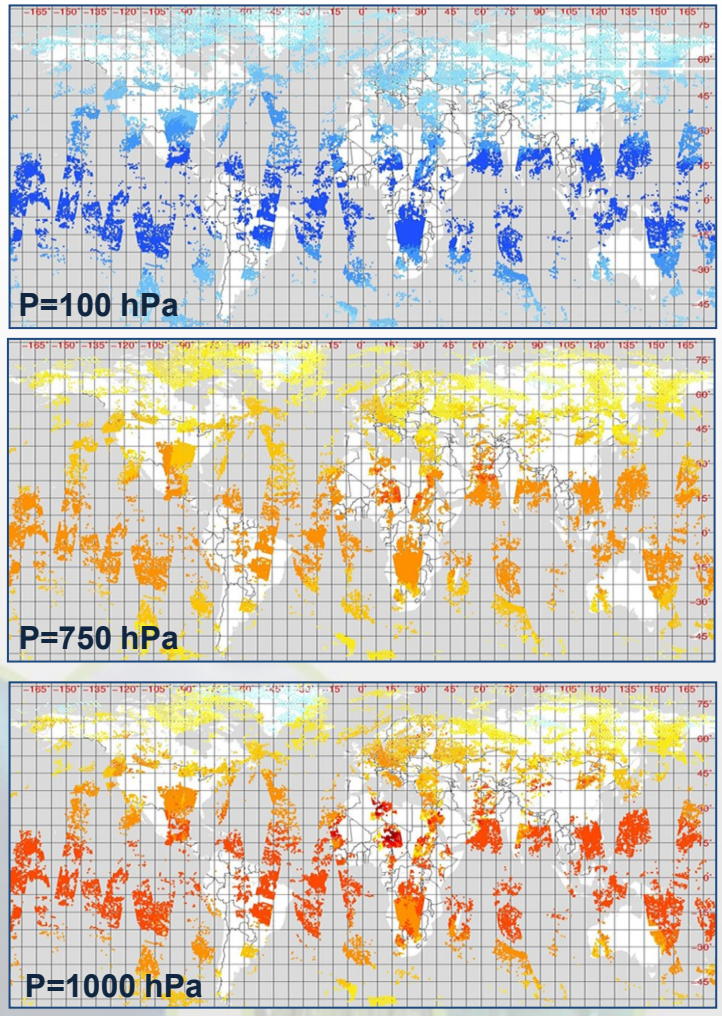



*Ash content, g./sq.m.*




*Optical depth at 11 μm*

# IR Sounder IKFS-2 / METEOR-M N2, 2-2
## Atmospheric Sounding

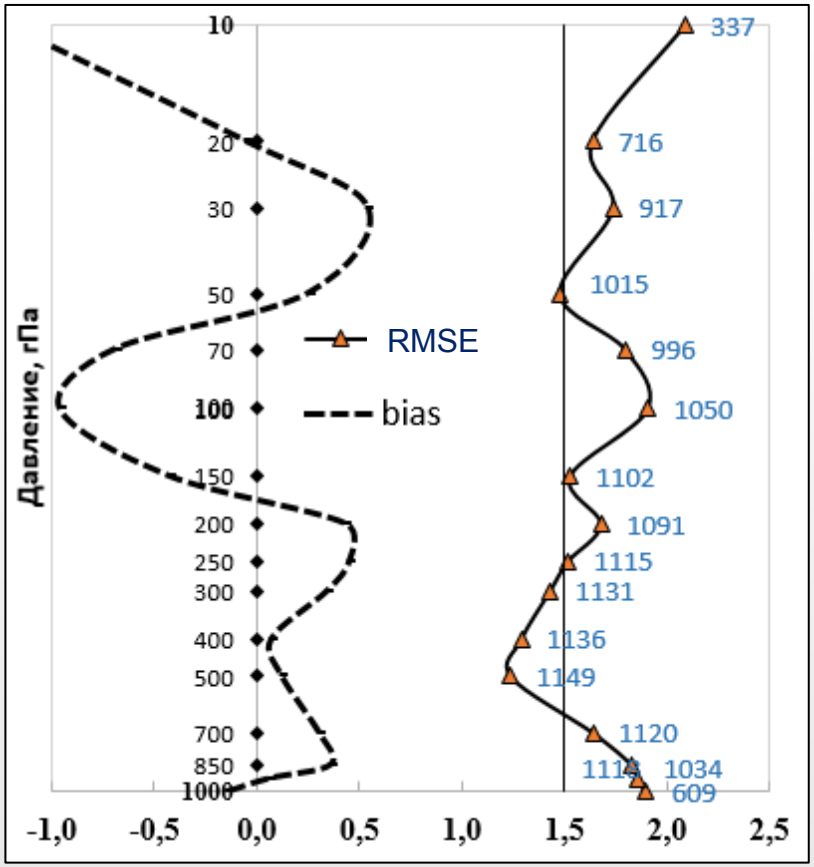



Temperature fields: IKFS-2 infrared sounder data

200 220 240 260 280 300 320 K

21.05.2019

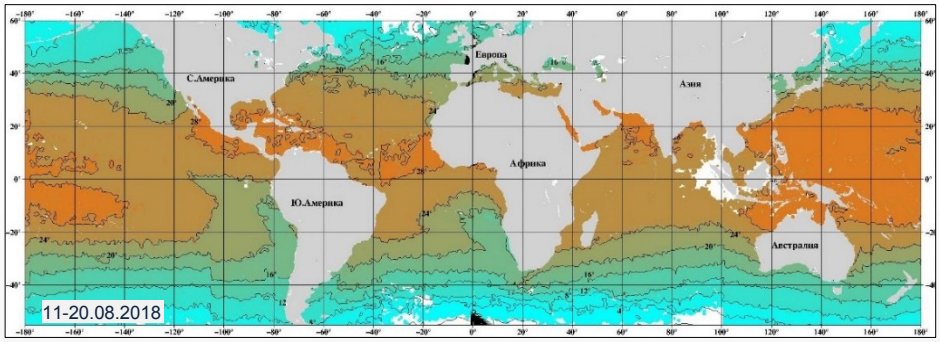
Meteor-M N2: April-June 2019




$T_{zond} - T_{ret}$, K

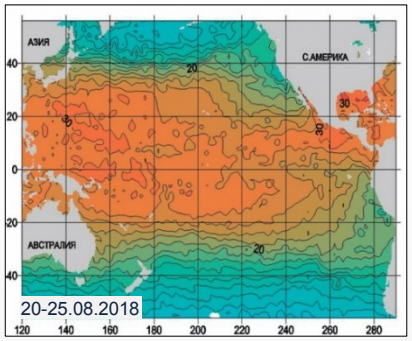
Error statistics for temperature profile retrievals

# Global Sea Surface Temperature



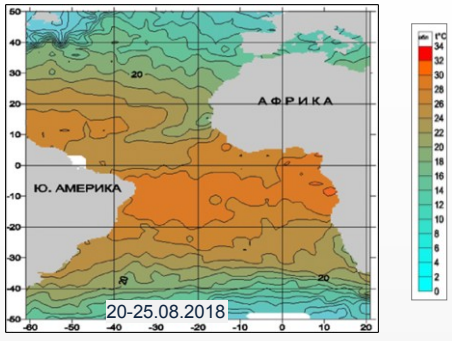

*GOES-W, GOES-E, METEOSAT-11, METEOSAT-8, HIMAWARI-8*

Global sea surface temperature



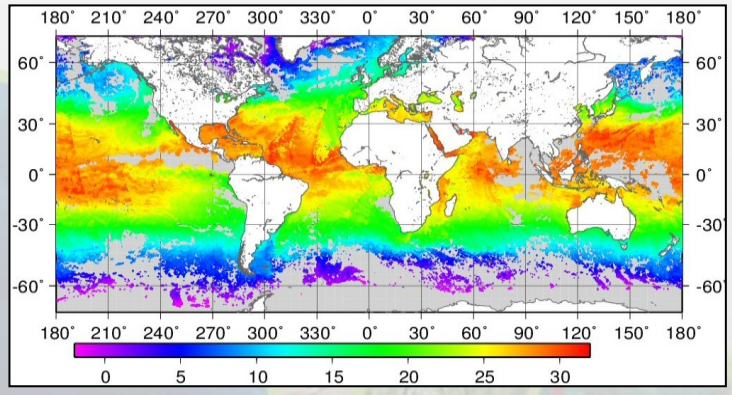

*HIMAWARI-8, GOES-W*

Pacific Ocean
surface temperature



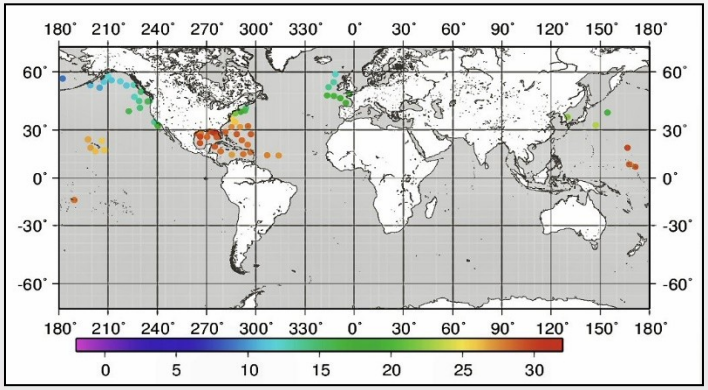

*METEOSAT-11*

Atlantic Ocean
surface temperature

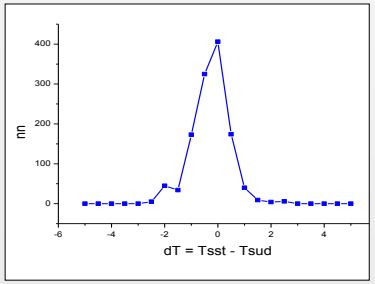



*METEOR-M N2/MSU-MR*

Global Sea surface temperature
(5-7.07.2017)




Buoy measurements (6.07.2017, 12:00 UTC)

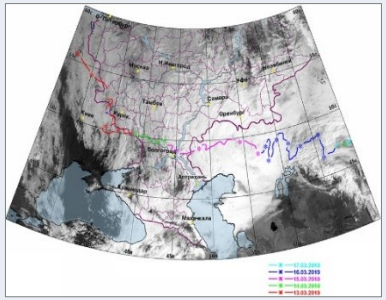



Bias=-0.26K, RMSE=0.75K, N=1221
(6.07.2017, 12:00 UTC)

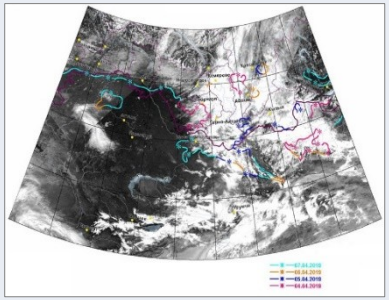
MSU-MR SST estimates vs buoy measurements

# Snow Cover Monitoring

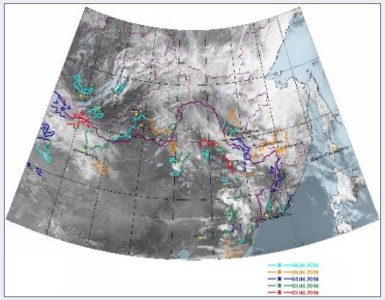
## Snow cover boundary maps



European region
(daily product)



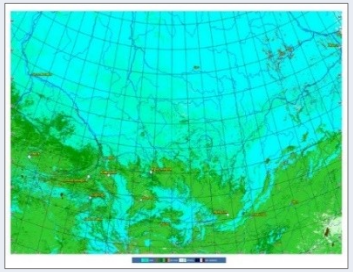
Siberian region
(daily product)



Far Eastern region
(daily product)

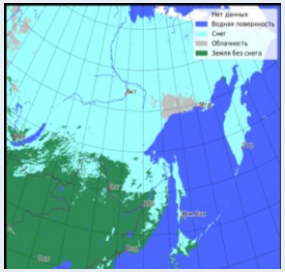
*METEOR-M N2/MSU-MR*

## Snow cover distribution maps



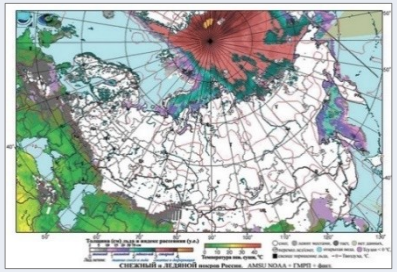
*TERRA/MODIS, Suomi NPP/VIIRS*

Siberian region
(16-day composite product)



*METEOR-M N2/MSU-MR*

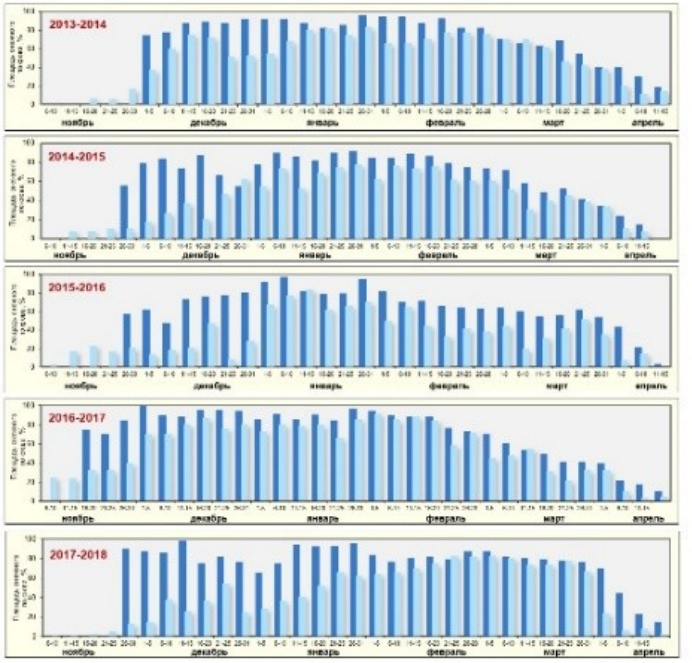
Far Eastern region
(8-day composite product)



*NOAA/AMSU*

Russian territory
(daily product)

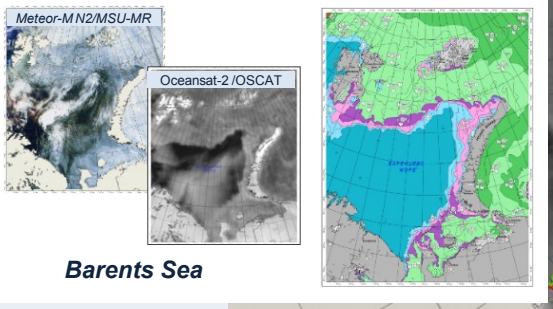
## Snow cover monitoring
## European territory of Russia (2013-2018)




- *solid snow cover (Meteor-M / MSU-MR)*
- *dry snow cover (NOAA/AMSU)*

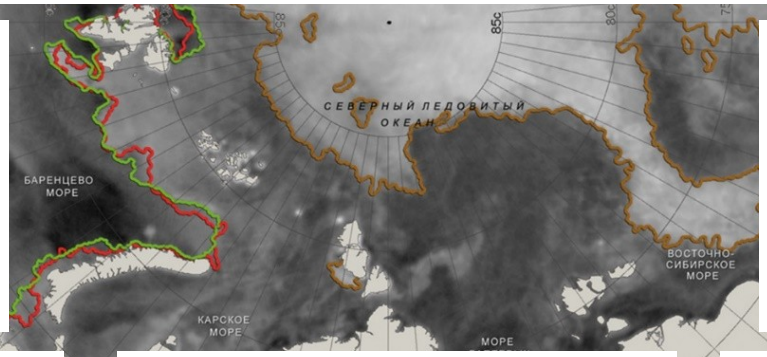
# Ice Cover Monitoring
# Northern Sea Route

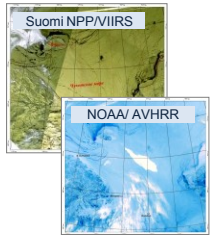
*Russian Sector of Arctica. Sea Ice Distribution*



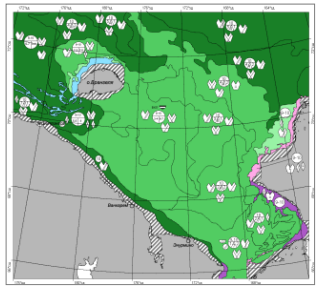

***Barents Sea***

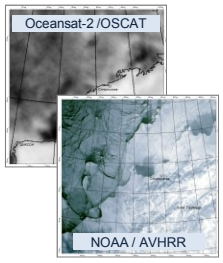




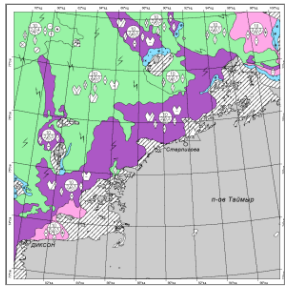



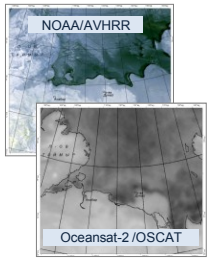

***Chukchi Sea***



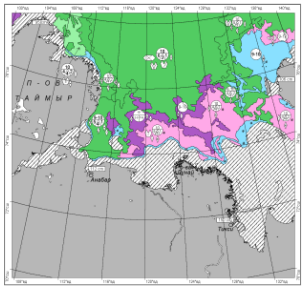


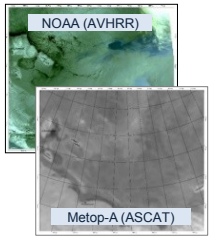

***Kara Sea***



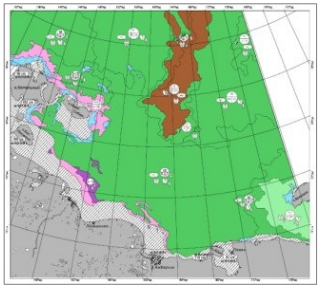



***Laptev sea***






***East-Siberian Sea***



PACK ICE DEVELOPMENT (cm):

- ice-free
- nilas (10)
- grey ice (10-15)
- grey-white ice (15-30)
- thin first-year ice (30-70)
- first-year ice of medium thickness (70-120)
- old ice (3 m and more)

FAST ICE DEVELOPMENT (cm):

- young ice (10-30)
- thin first-year ice (30-70)
- medium first-year ice (70-120)
- thick first-year ice (>120)
- -- old ice (>200)

FORMS OF FLOATING ICE (m):

- new ice
- pancake ice (0.3-3.0)
- ice cake (2-20)
- small floes (20-100)
- medium floes (100-500)
- big floes (500-2000)

GENERAL CHARACTERISTICS:

1-3 – total ice concentration in tenths

10 / 6 | 4 – 10 - total ice concentration in tenths
6 - partial concentration of the thickest ice
4 - partial concentration of the less thickest

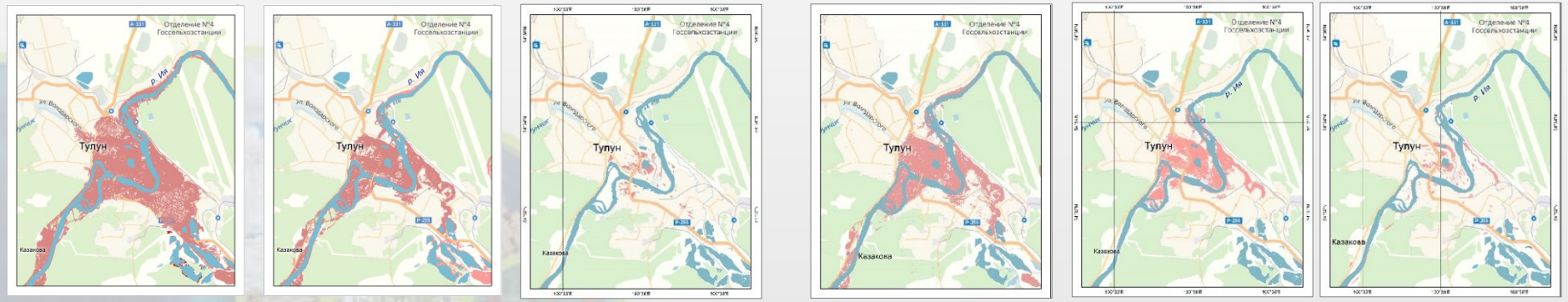
100 sm – ice thickness indicator

– cracks

# Extreme Flooding
# In Irkutsk Region, Tulun city (2019)

*The first flood wave* *The second flood wave*


Satellite Imageries



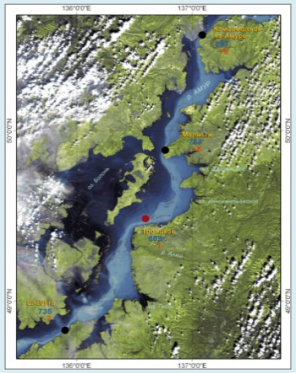

*29 June* *01 July* *10 July* *31 July* *02 August* *05 August*

Flood maps

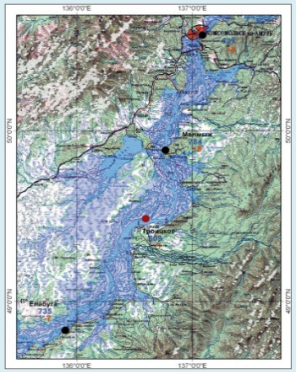
*(Kanopus-V/PSS, MSS, Sentinel-2/MSI)*

- *flooded area*

# Extreme Flooding
# In Amur River Basin (2013)

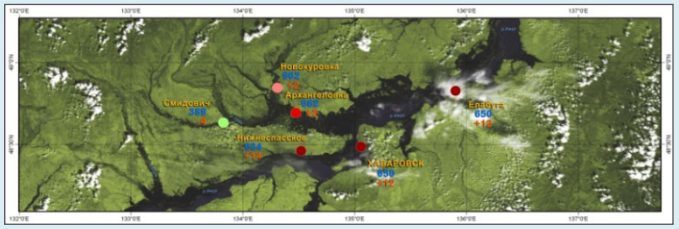


TERRA/MODIS

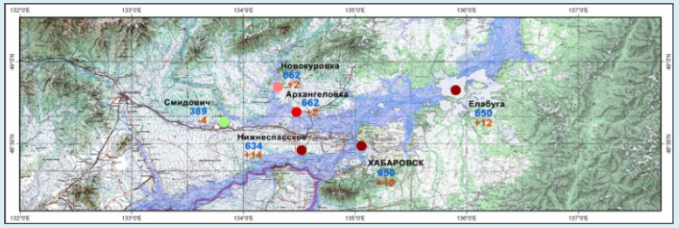


Flood map

*Amur Region*



TERRA/MODIS




Flood map

*Jewish Autonomous Region*

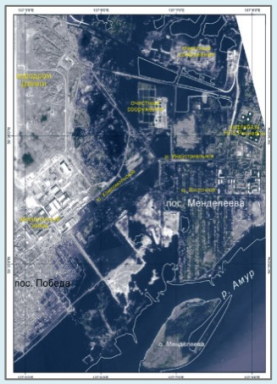
○ - floodplain depth based on the scale:

50 100 150 200 250 300 350 400 >400 sm

369 – water level (sm)

+5 - daily water level change (sm)

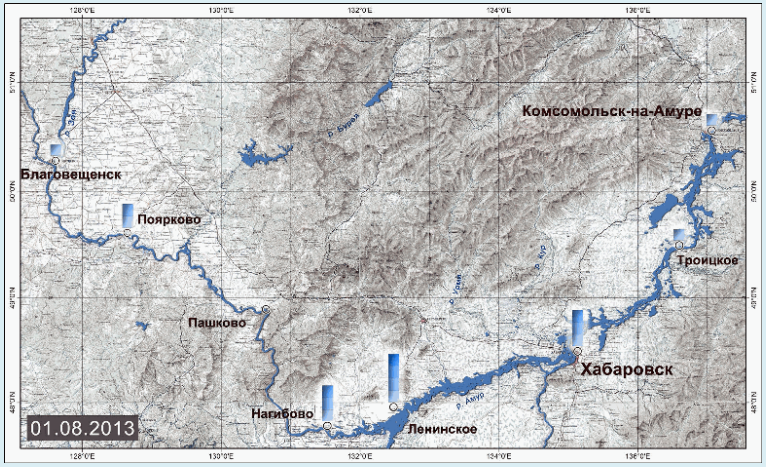
- flooded areas



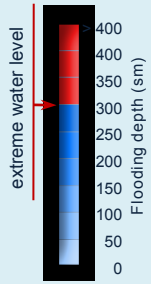
2.09.2013 (**beginning**) 12.09.2013 (**maximum**) 22.09.2013 (**decline**)

*Kanopus-V, resolution 3 m*

**Flooding development** (Komsomolsk-on-Amur city)




**Roshydromet ground-based hydrological data**

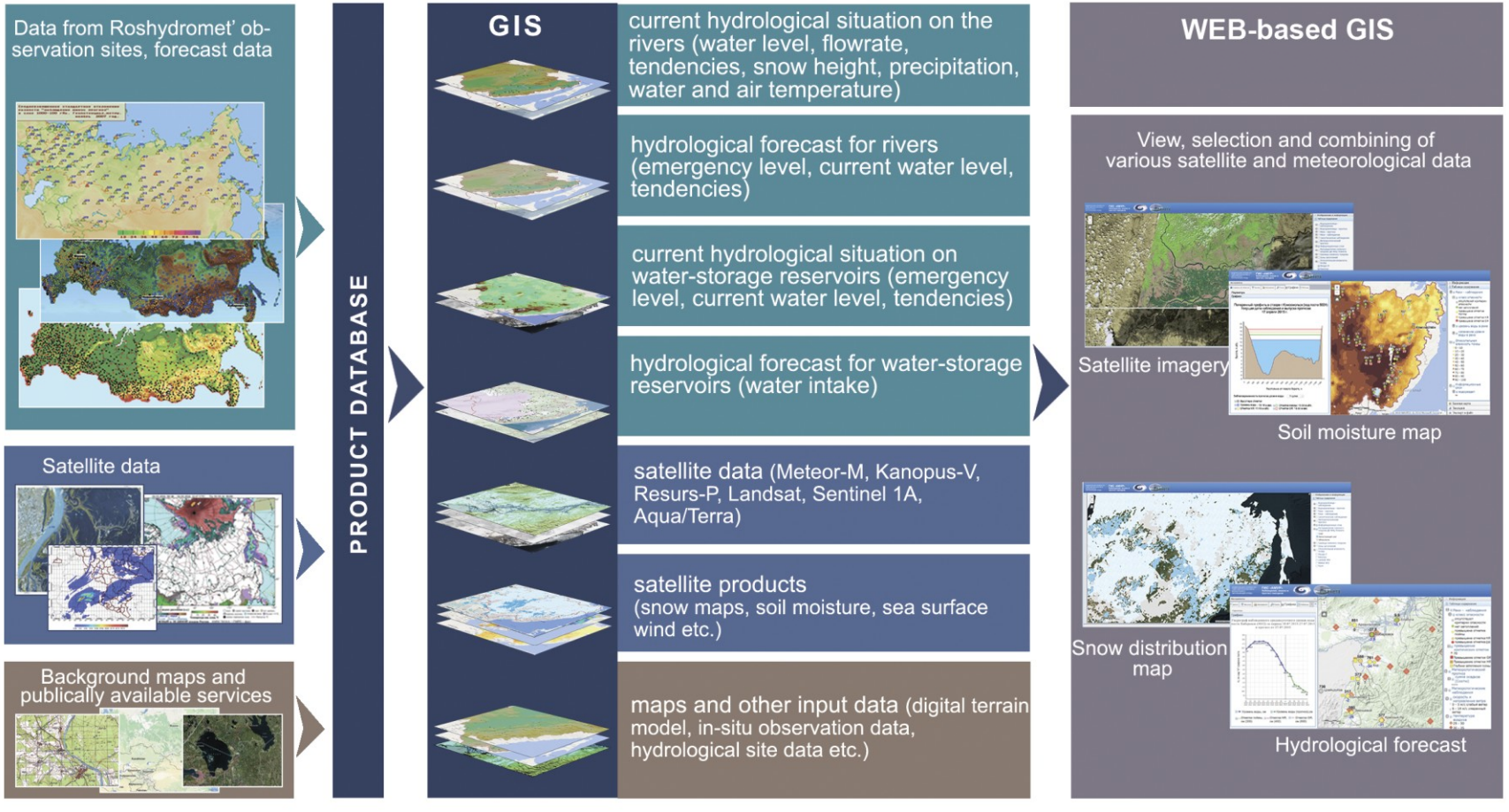



**Map of the hydrological situation in the Amur river basin**

(based on the satellite and in-situ data)

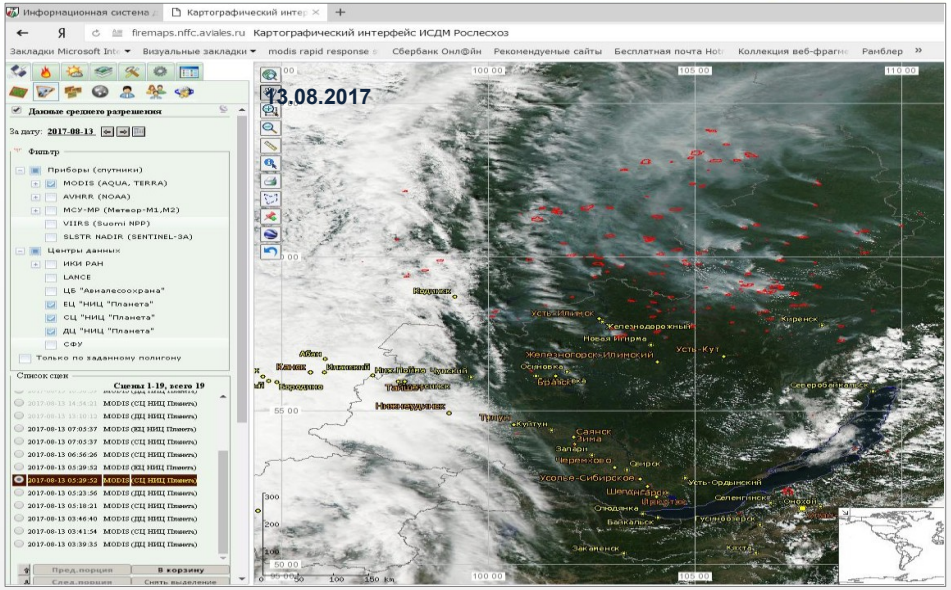
# Problem-oriented Information System: Flood Monitoring, Forecasting and Early Warning

«GIS Amur» relies on combination of in-situ data from Roshydromet' observation network, satellite data and hydrological modelling and forecasting data for Amur river basin. The system utilizes the WEB and GIS technologies and is targeted on data provision to the local authorities in order to minimize the damage caused by high water.

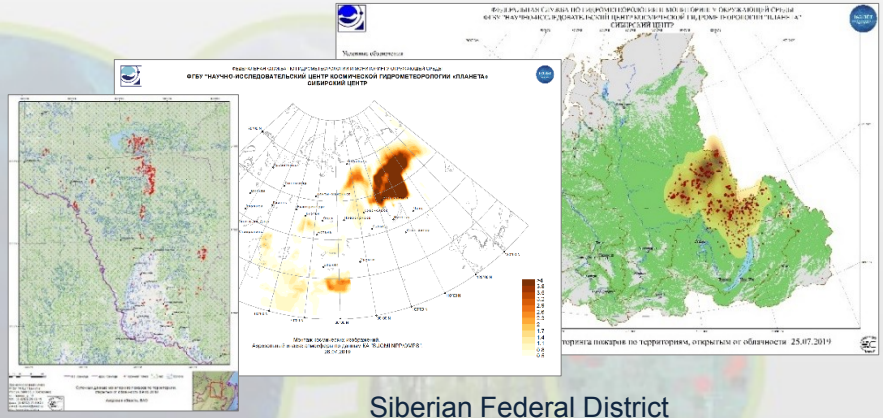


# Problem-oriented Information System: Forest Fire Monitoring


Daily forest fires monitoring: Russian Federation



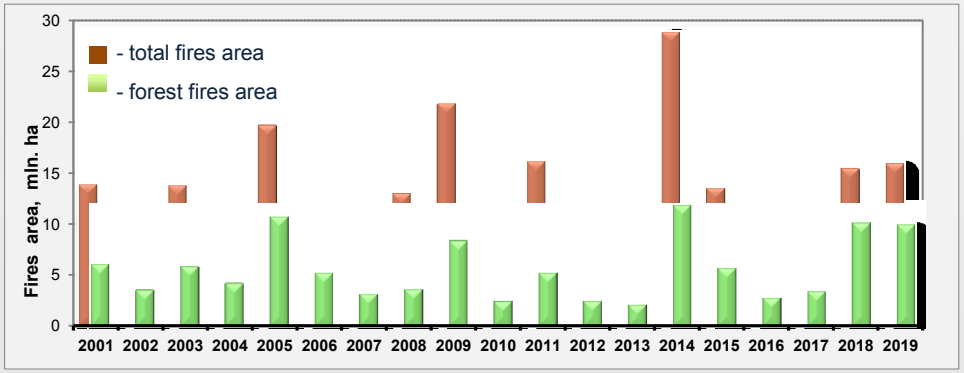

Combination of various satellite data for fires monitoring



Amur Region

Siberian Federal District

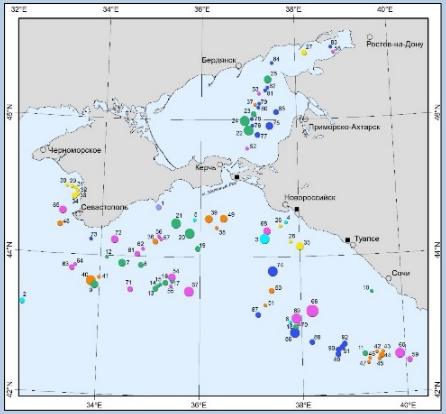
Regional forest fires monitoring



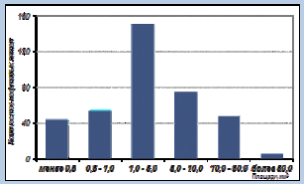

Fires area

# Problem-oriented Information System: Water Pollution Monitoring

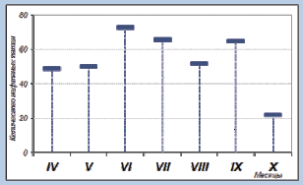
## Composite products




Complex map of oil slick distribution

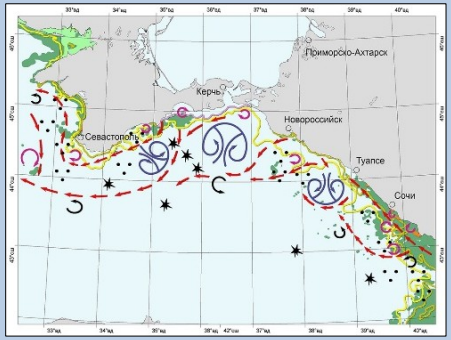


(a)

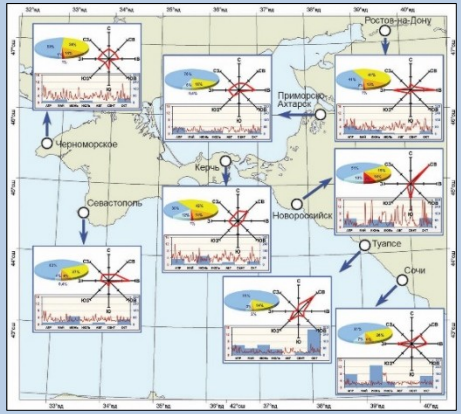



(b)

Oil slick distribution in terms of spill area (a) and month of detection (b)



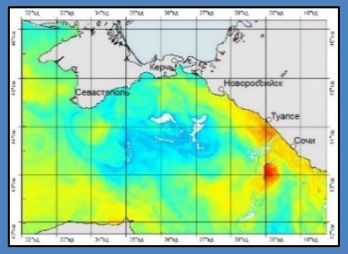

Complex map of water environmental conditions



- wind rose
- wind speed distribution (%)
- precipitation (mm)
- wind speed (m/s)

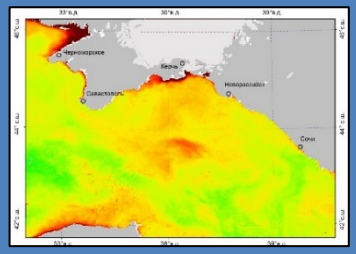
In-situ data

## Operational products



*TERRA/MODIS*

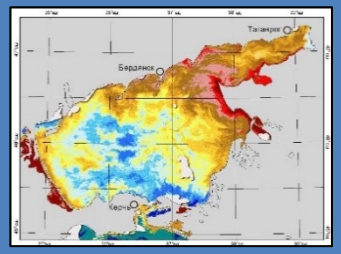
Sea surface temperature map



*TERRA/MODIS*

Chlorophyll-a concentration, mg/m3
0.02 0.08 0.28 1.06 4.00

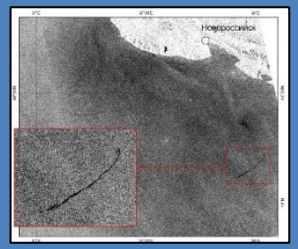
Chlorophyll-a concentration map



*AQUA/MODIS*

Water turbidity category
low high

Water turbidity map



*SENTINEL-1B/SAR-C*

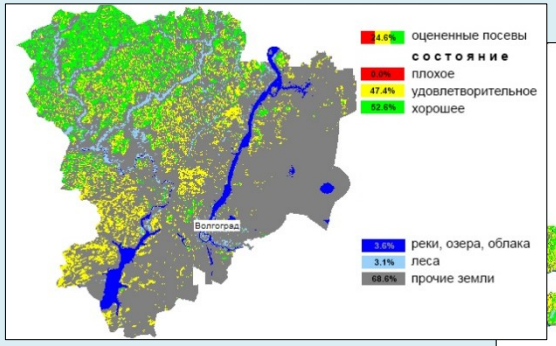
Oil slicks from ships

*TERRA/MODIS*

Water motion map

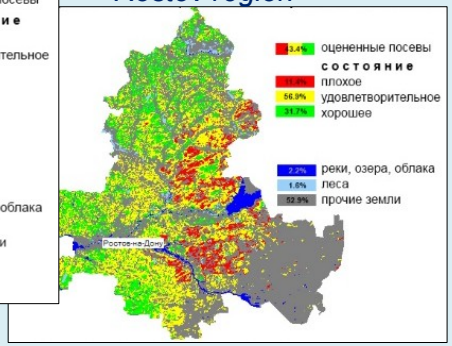
# Crop Condition Monitoring

## Cereal crops conditions: Russian federal subjects

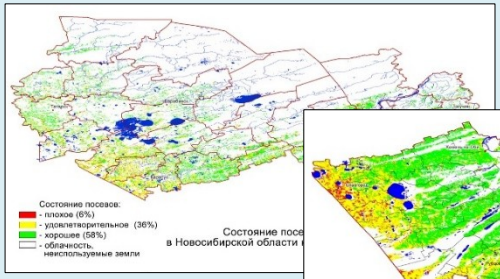



Volgograd region

Rostov region

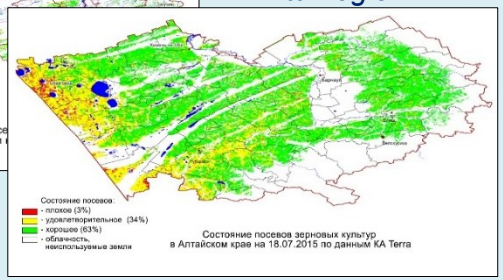



NOAA/AVHRR



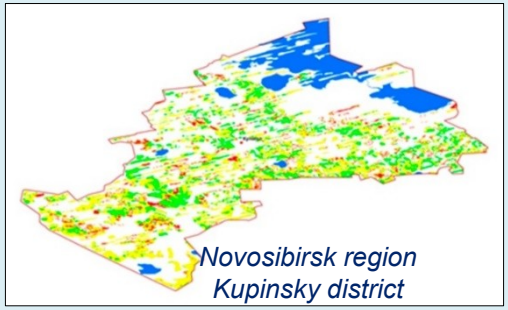

Novosibirsk region

Altai region



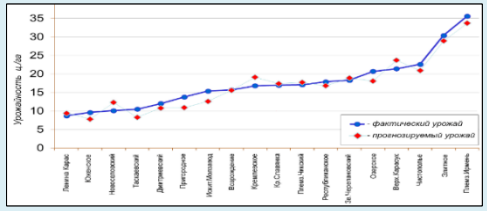

TERRA/MODIS

## Cereal crops conditions: Russian administrative districts and farms




- poor crop conditions (10%)
- satisfactory crop conditions (28%)
- good crop conditions (62%)
- clouds, unused lands

TERRA/MODIS

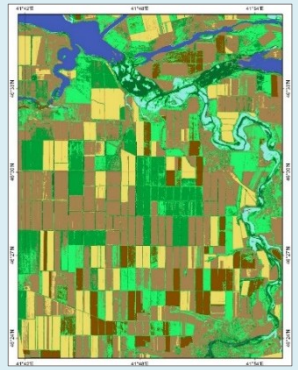




Spring wheat yield forecasting and its actual productivity: Novosibirsk region' farms

## Agricultural Land Monitoring

KANOPUS-V N4/PSS,MSS 29.06.2018

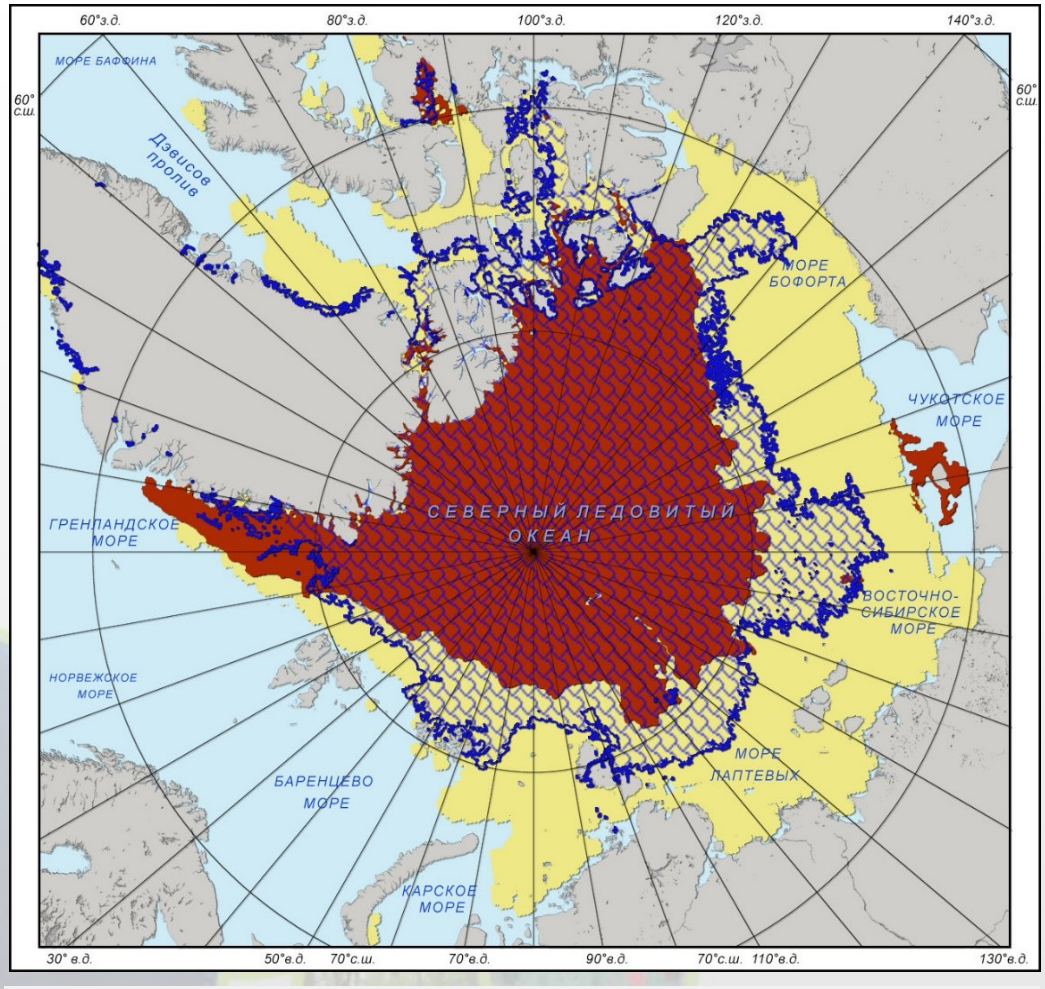
Rostov region, Russia



Agricultural land map based on automated unsupervised classification

- water bodies
- wetlands
- bare soils (fallow lands)
- soil after harvesting, plowed land
- stubble after harvesting
- satisfactory crop conditions
- good crop conditions
- dense vegetation in the floodplain

# Sea Ice Cover Dynamics in Arctic Region




## Minimum sea ice extent

*In 2018*

- *16.09.2018* - ***4,88*** *million km²*

*Minimum*

- *16.09.2012* - ***3,51*** *million km²*

*Maximum*

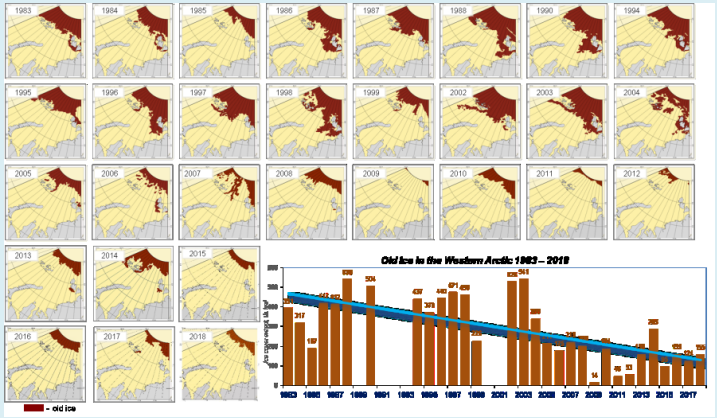
- *10.09.1996.* - ***8,27*** *million km²*

- *sea ice concentration of 0-10%*
- *land*

*The product is based on microwave (active, passive), visible and infrared data from Russian (OKEAN, METEOR series) and foreign (Metop, NOAA, EOS series) satellites.*

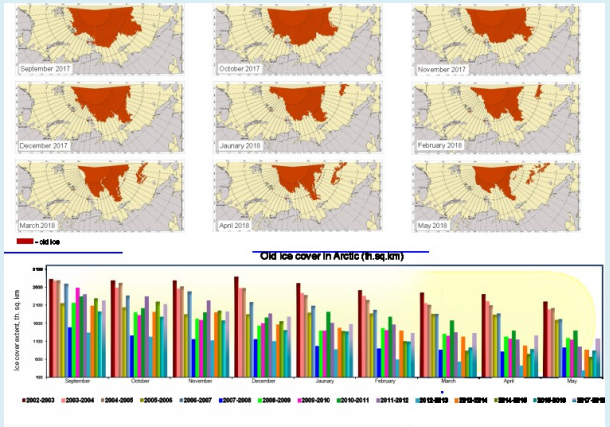
# Global Climate Change Monitoring

## Dynamics of Old Ice in the Western Arctic, 1983-2018



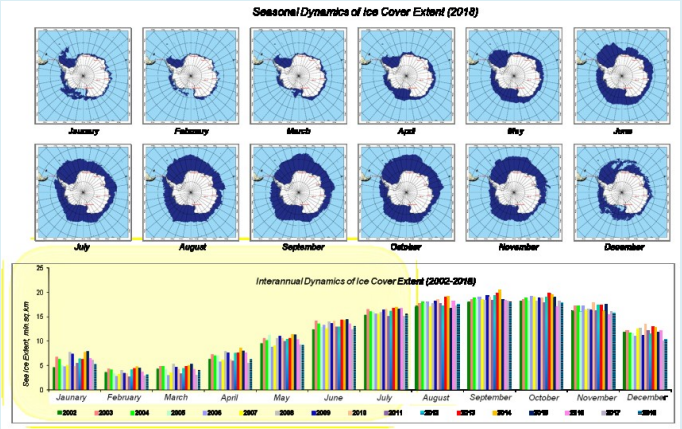

*OKEAN satellite,1983 -1999, QuikSCAT/SeaWinds, ENVISAT/ASAR, AQUA/AMSR-E, MetOp/ASCAT, Oceansat-2/OSCAT, Meteor-M №2/ BRLK "Severyanin-M", Sentinel/SAR-C, 2002-2018*

## Dynamics of Old Ice in the Russian Arctic, 2002-2018



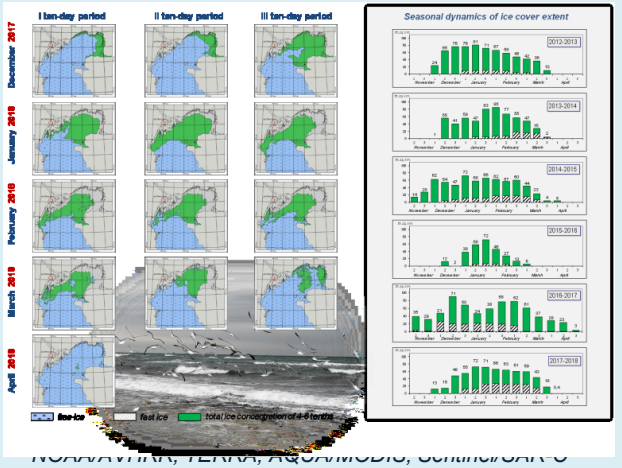

*Metop-A/ASCAT, EOS/AMSR-E,MODIS, Meteor-M/MSU-MR, NOAA/AVHRR, Sentinel/SAR-C*

## Dynamics of Antarctic Ice Cover, 2002-2018




*Metop/ASCAT, Oceansat-2/OSCAT, Meteor-M/MSU-MR*

## Dynamics of Caspian Sea Fast and Drift Ice, 2012-2018




*NOAA/AVHRR, TERRA, AQUA/MODIS, Sentinel/SAR-C*

Committee on Earth Observation Satellites

# Thank you!

Roshydromet

CEOS Plenary 2019

Agenda Item # 3.6

Ha Noi, Viet Nam

14 – 16 October 2019