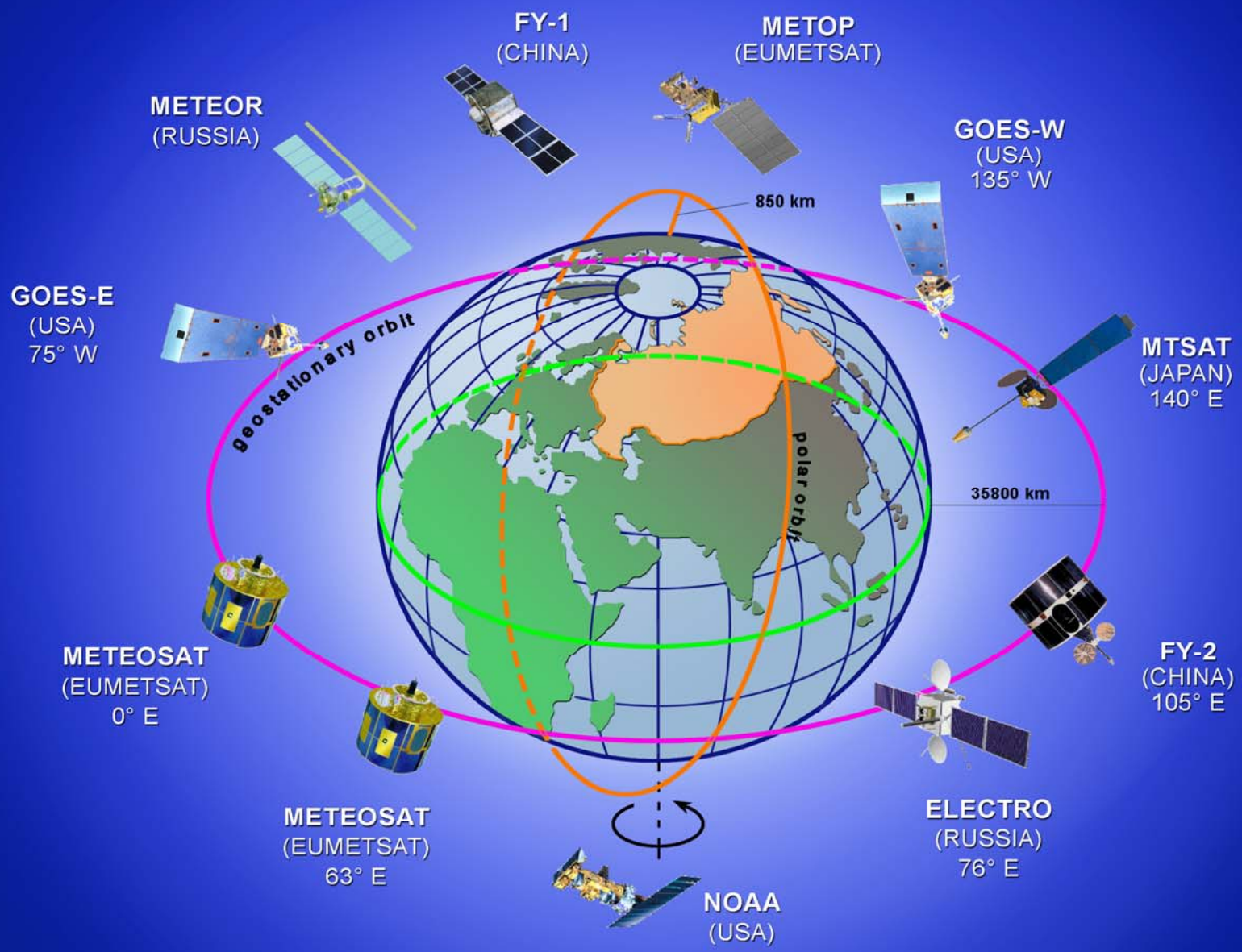
ITSC-16
Angra dos Reis, Brazil, May 07 –13, 2008

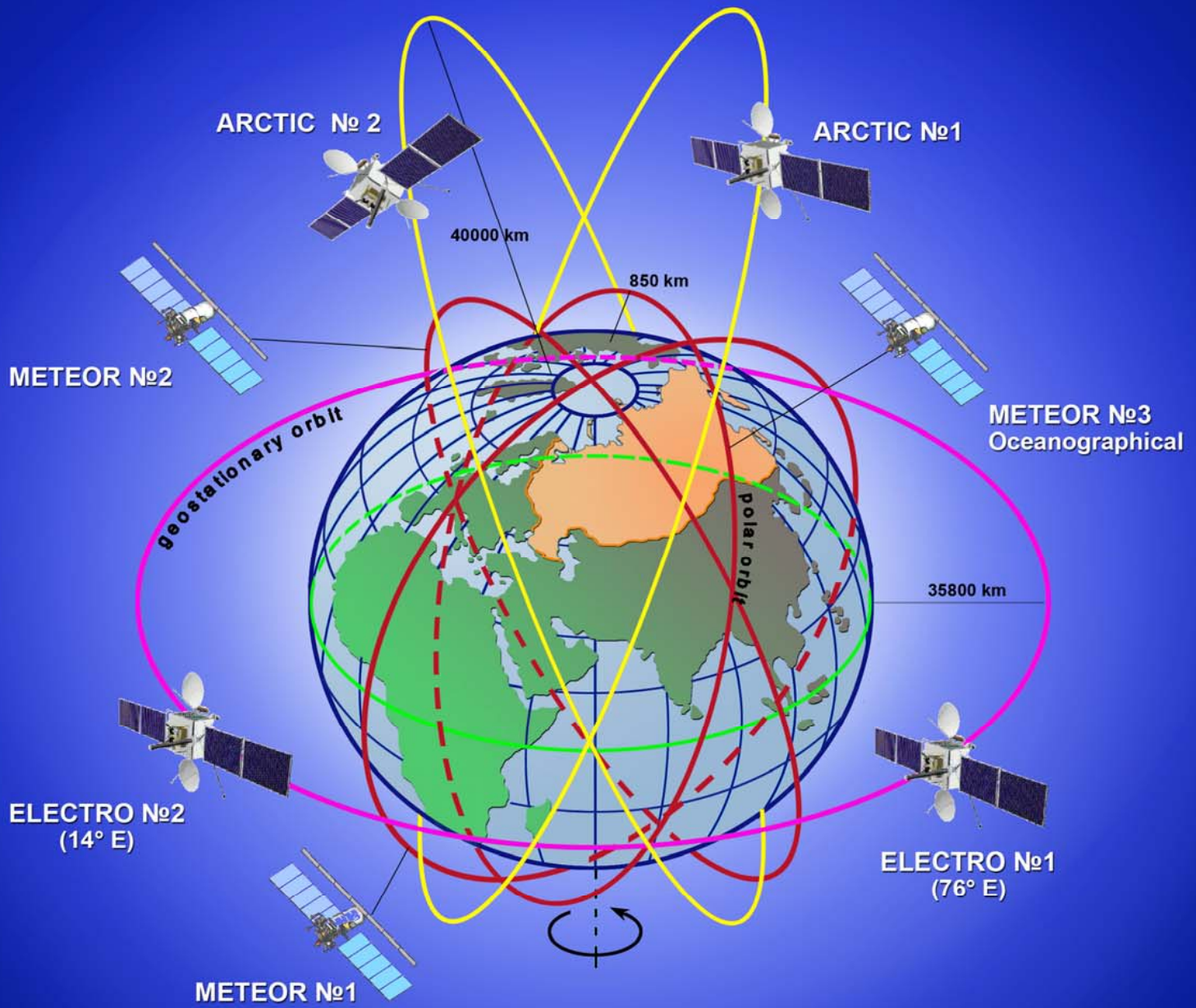
Status of current and future Roshydromet satellite programmes

Uspensky A.B.
State Research Center on Space Hydrometeorology PLANETA, Moscow, Russia

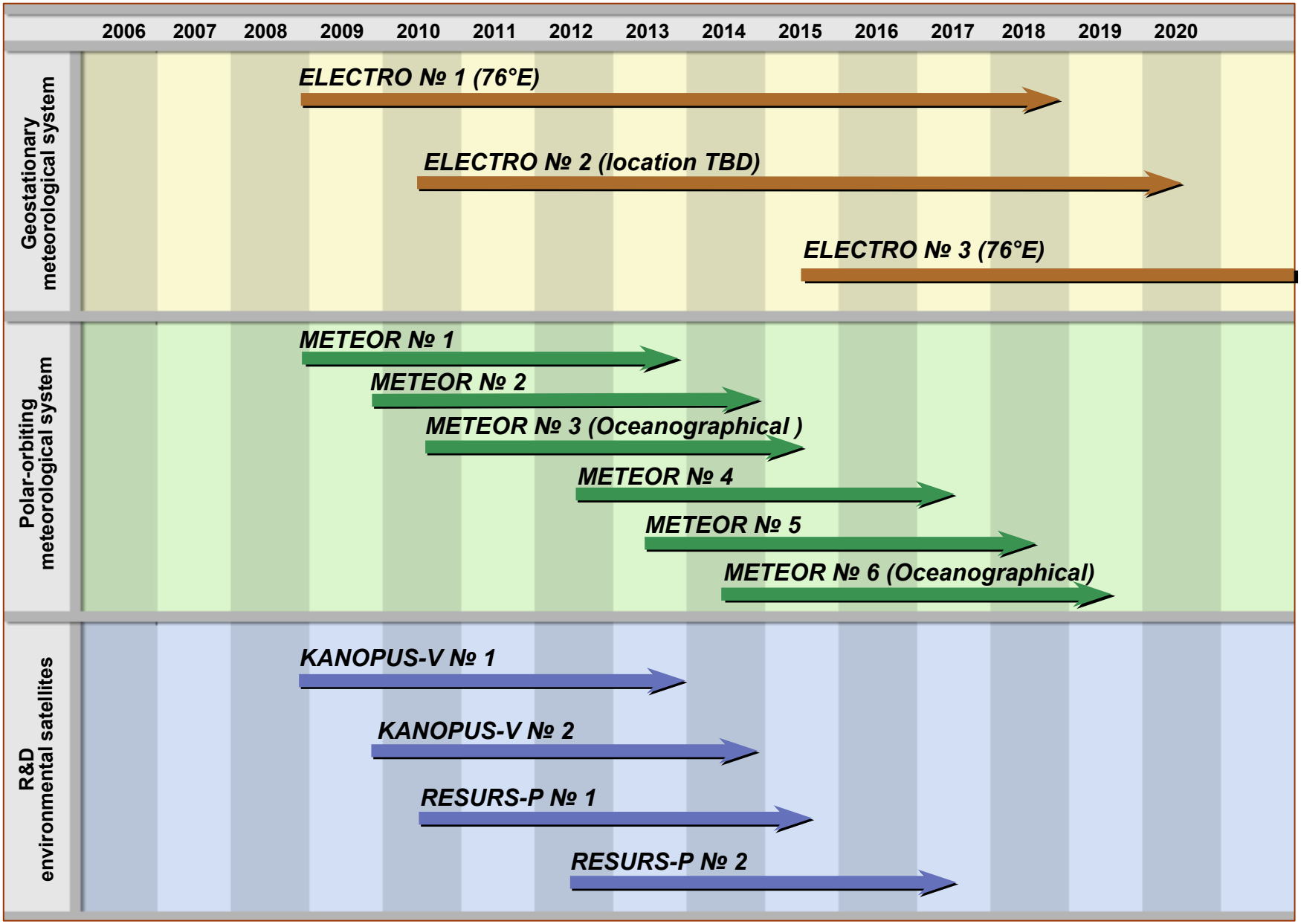
EARTH OBSERVATION SATELLITE SYSTEM



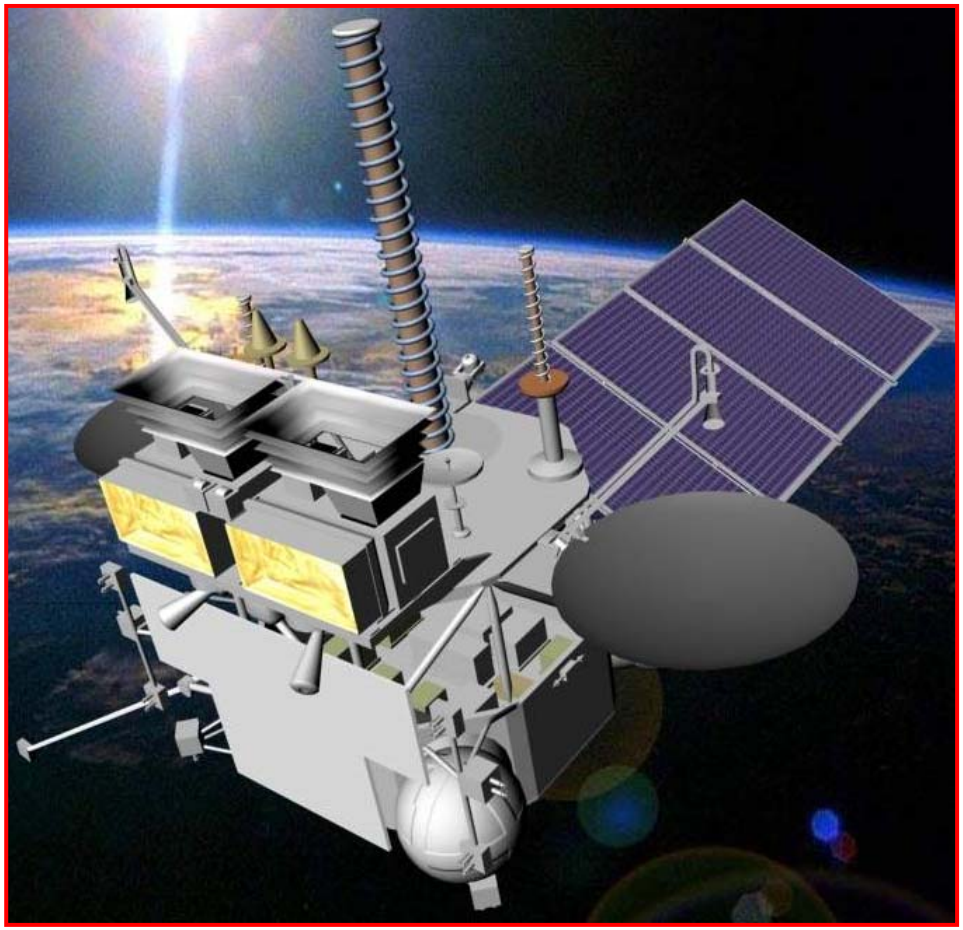
RUSSIAN HYDROMETEOROLOGICAL SATELLITE SYSTEM



Russian Earth Observation Satellites Program 2006-2015



ELECTRO-L General Design



- Three-axis high-precision stabilization
- In-orbit mass - 1500 kg
- Payload mass - 370 kg
- Lifetime - 10 years
- Longitude - 76E
- Data dissemination format - HRIT/LRIT
- Image repeat cycle – 30/15 min

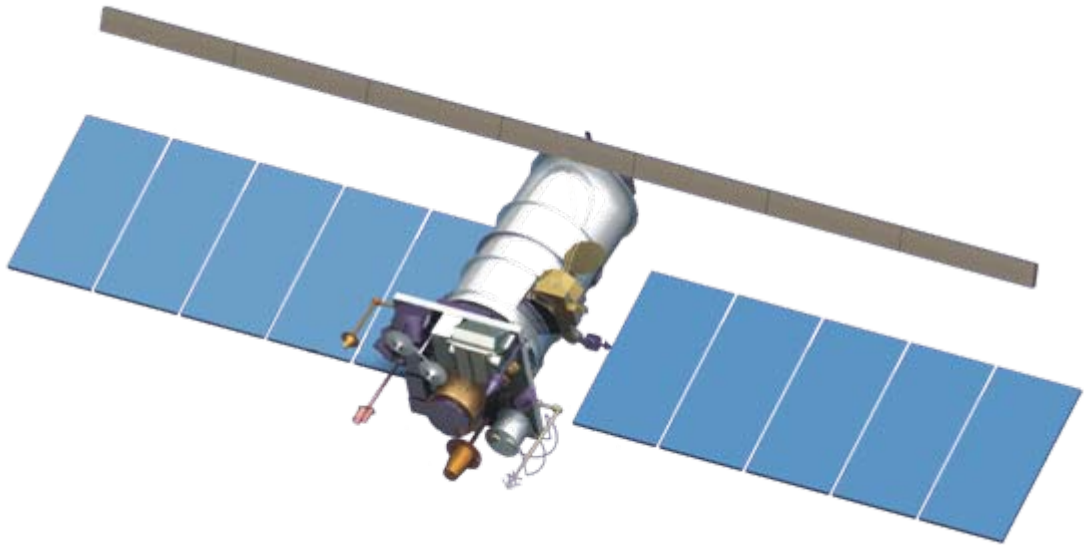
Mission objectives

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

MSU-GS Basic Performance Characteristics

1.	Number of channels • VIS • IR	10 3 7
2.	Spectral range at half maximum of spectral response function (μm)	0.5-0.65; 0.65-0.80;0.8-0.9; 3.5-4.0; 5.7-7.0; 7.5-8.5;8.2-9.2; 9.2-10.2; 10.2-11.2; 11.2-12.5
3.	Image frame (deg x deg)	20 ± 0.5 x 20 ± 0.5
4.	HRIT ground resolution in subsatellite point (km)	1.0 (VIS); 4.0 (IR)
5.	S/N ratio for VIS channels	≥ 200
6.	NEΔT at 300K (K) • in the band 3.5-4.0 μm • in the band 5.7-7.0 μm • in the band 7.5-12.5 μm	 0.8 0.4 0.1-0.2
7.	Power (W)	≤ 150
8.	Weight (kg)	≤ 88
9.	Lifetime of basic and reserve units (years)	10

METEOR-M General Design



- In-orbit mass – 2700 kg
- Payload mass – 1200 kg
- Lifetime – 5 years
- Orbit – Sunsynchronous
- Altitude – 830 km
- Data dissemination format – HRPT/LRPT

METEOR-M Mission Objectives and Basic Instruments

Instrument	Application	Spectral Band	Swath-width (km)	Resolution (km)	Instruments for interca-libration
MSU-MR	Global and regional cloud cover mapping, SST, LST, …	0.5 – 12.5 μm (6 channels)	3000	1 x 1	AVHRR/NOAA
KMSS multichannel scanning unit	Earth surface monitoring	0.4-0.9 μm (3 channels)	100	0.06/0.1	
MTVZA imager/ sounder	Atmospheric temperature and humidity profiles, sea surface wind	10.6-183.3 GHz (26 channels)	2600	12 – 75	SSMIS/DMSP AMSR/EOS-AQUA AMSU/NOAA
IRFS-2 advanced IR sounder *	Atmospheric temperature and humidity profiles	5-15 μm	2000	35	
Severjanin (SAR)	Ice monitoring	9500-9700 MHz	600	0.4 x 0.5	
Radiomet* (radio occulation unit)	Atmospheric temperature and pressure profiles.				

*** - to be launched on board METEOR-M №2**

MTVZA-GJa instrument (Meteor-M N 1)

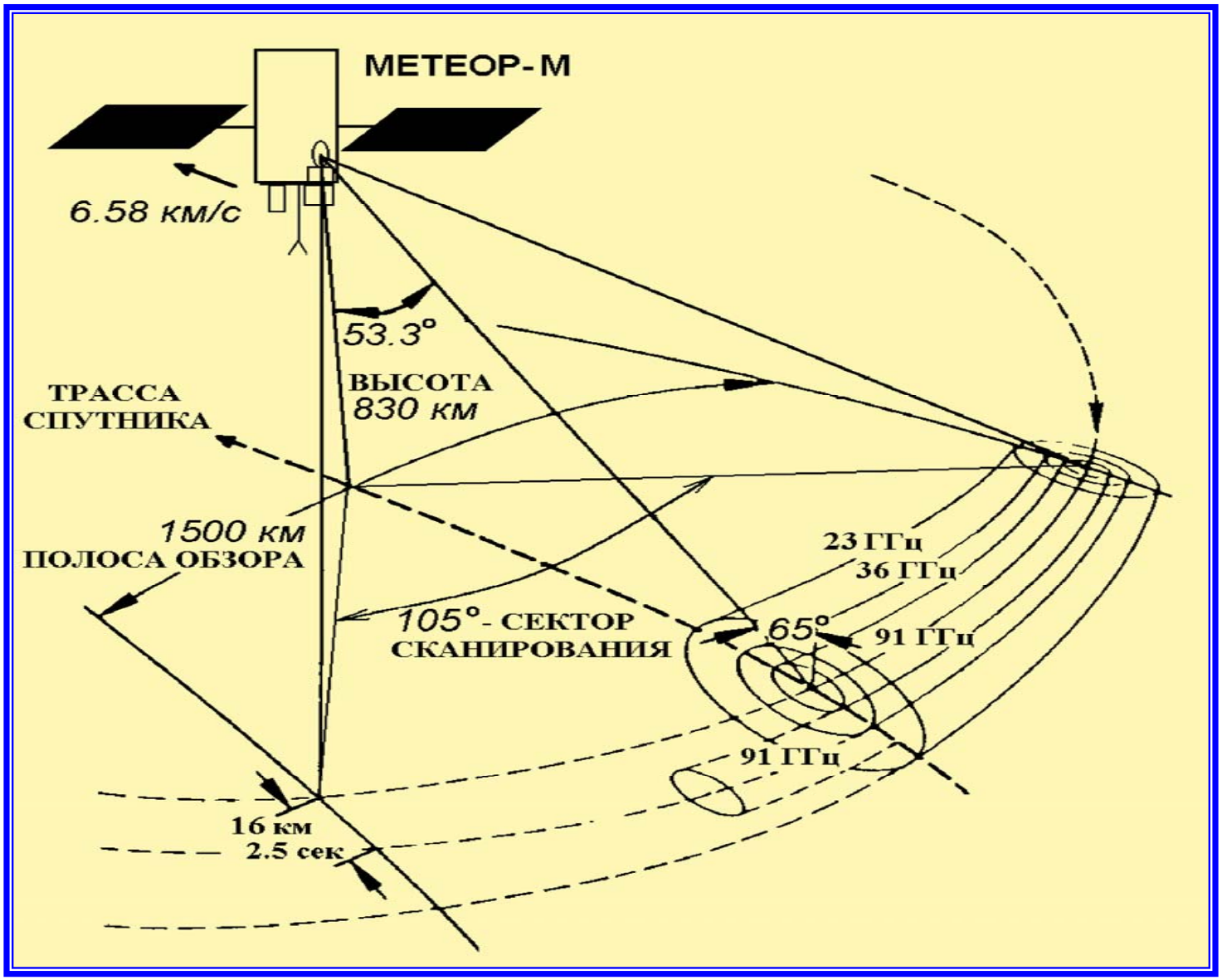
Basic performance characteristics of MTVZA-GJa

Instrument	MTVZA-GJa
Spectral range	10.6, 18.7, 23.8 31.5, 36.7, 42, 48, 52-57, 91, 183.31, GHz
Spatial resolution: - horisontal - vertical	16-198 km 1.5-7 km
Swath width	1500 km
Scanning regime	conical
Regime	continious
Scanning duration	2.55 sec
Data flow	35 kbit/sec
Weight	90 kg
Power	80 W

MTVZA-GJa channel characteristics

Frequency (GHz)	Spatial resolution (km x km)	Pixel within imagery (km x km)	Sensitivity (K/pixel)	Altitude of Weighting function maximum (km)
10.6	89x198	32x32	0.5	-
18.7	52x116	32x32	0.4	-
23.8	42x94	32x32	0.3	-
31.5	35x76	32x32	0.3	-
36.7	30x67	32x32	0.3	-
42	26x60	32x32	0.4	-
48	24x43	32x32	0.4	-
52.80	21x48	48x48	0.4	2
53.30	21x48	48x48	0.4	4
53.80	21x48	48x48	0.4	6
54.64	21x48	48x48	0.4	10
55.63	21x48	48x48	0.4	14
57.290344±0.3222±0.1	21x48	48x48	0.4	20
57.290344±0.3222±0.05	21x48	48x48	0.7	25
57.290344±0.3222±0.025	21x48	48x48	0.9	29
57.290344±0.3222±0.01	21x48	48x48	1.3	35
57.290344±0.3222±0.005	21x48	48x48	1.7	42
91	14x30	16x16	0.6	Surface
183.31 ± 1.0	9x21	32x32	0.8	5.3
183.31 ± 3.0	9x21	32x32	0.6	2.9
183.31 ± 7.0	9x21	32x32	0.5	1.5

Scanning geometry of MTVZA-GJa (Meteor-M №1)



Basic performance characteristics of IRFS-2

№	Parameter	Units	Value
1	Spectral range: wavelength wave number	μm cm^{-1}	5-15 2000-665
2	Reference channel wavelength	μm	1.06
3	Maximum optical path difference (OPD)	mm	17
4	Angular size of FOV	mrad	40 x 40
5	Spatial resolution (at subsatellite point)	km	35
6	Swath Width and spatial sampling	km	2500, 110 2000, 100
7	Aperture angle of beams reaching the detector	degree	63
8	Duration of the interferogram measurement	s	0.5
9	Dynamic range		2^{16}
10	Number of reference points in two-sided interferogram		2^{15}
11	Frequency band of measuring channel	kHz	4.5-13.5
12	Reference signal frequency	kHz	65.5
13	Frequency band of reference channel	kHz	61-70
14	Weight	kg	45-50
15	Power	W	50

Spectral regions used by the IRFS-2 instrument

№	Spectral region	Absorption band	Application
1	665 to 780 cm^{-1}	CO_2	Temperature profile
2	790 to 980 cm^{-1}	Atmospheric window	Surface parameters (T_s, ε_ν) Cloud properties
3	1000 to 1070 cm^{-1}	O_3	Ozone sounding
4	1080 to 1150 cm^{-1}	Atmospheric window	T_s, ε_ν, Cloud properties
5	1210 to 1650 cm^{-1}	H_2O, N_2O, CH_4	Moisture profile, CH_4, N_2O column amounts

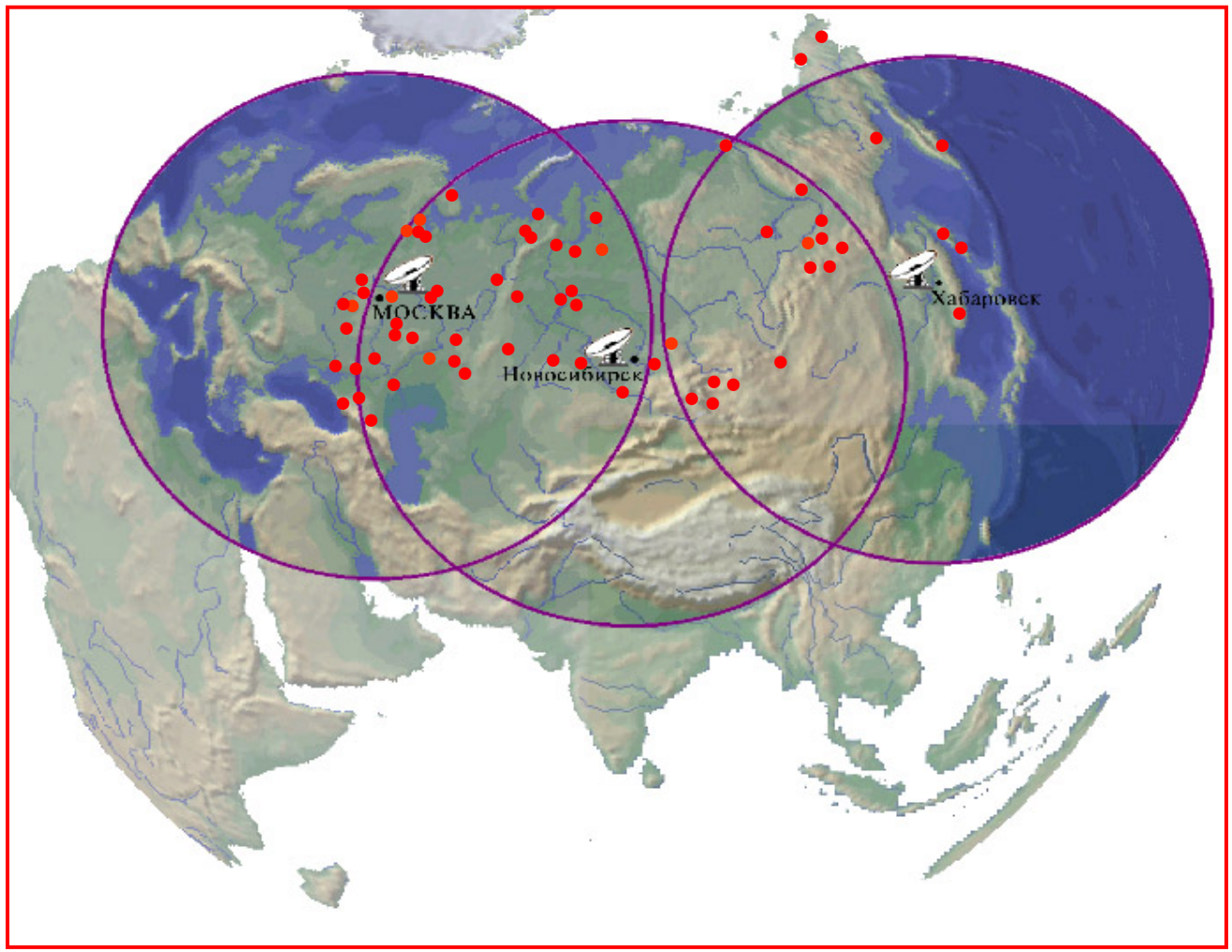
Roshydromet Satellite Ground Segment

3 Main centers:
Europe
(Moscow-Obninsk-Dolgoprudny)

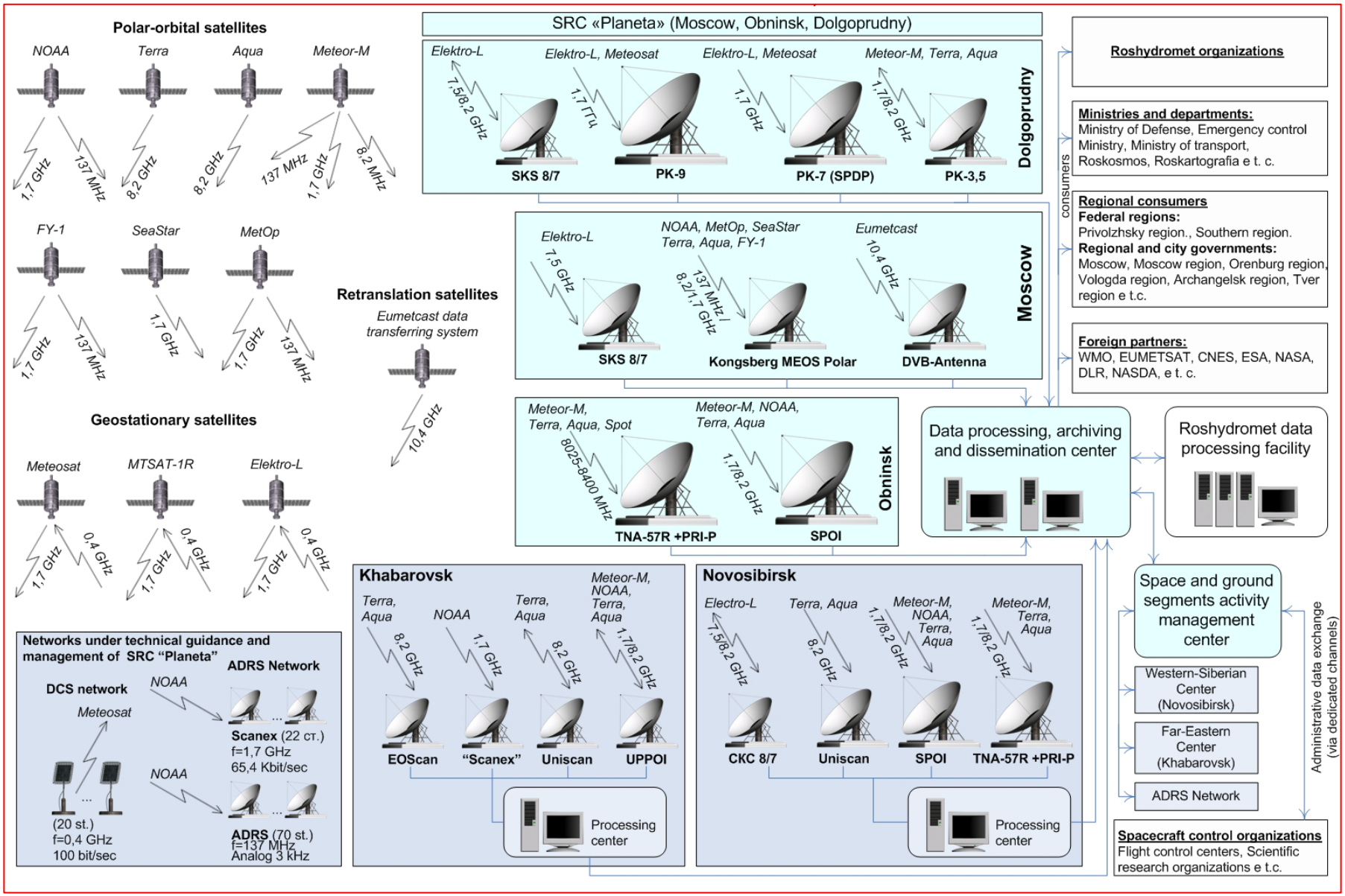
Siberia
(Novosibirsk)

Far-East
(Khabarovsk)

- **- 68 Local centers**



Status of Roshydromet Ground Segment



Federal Service for Hydrometeorology and Environmental Monitoring

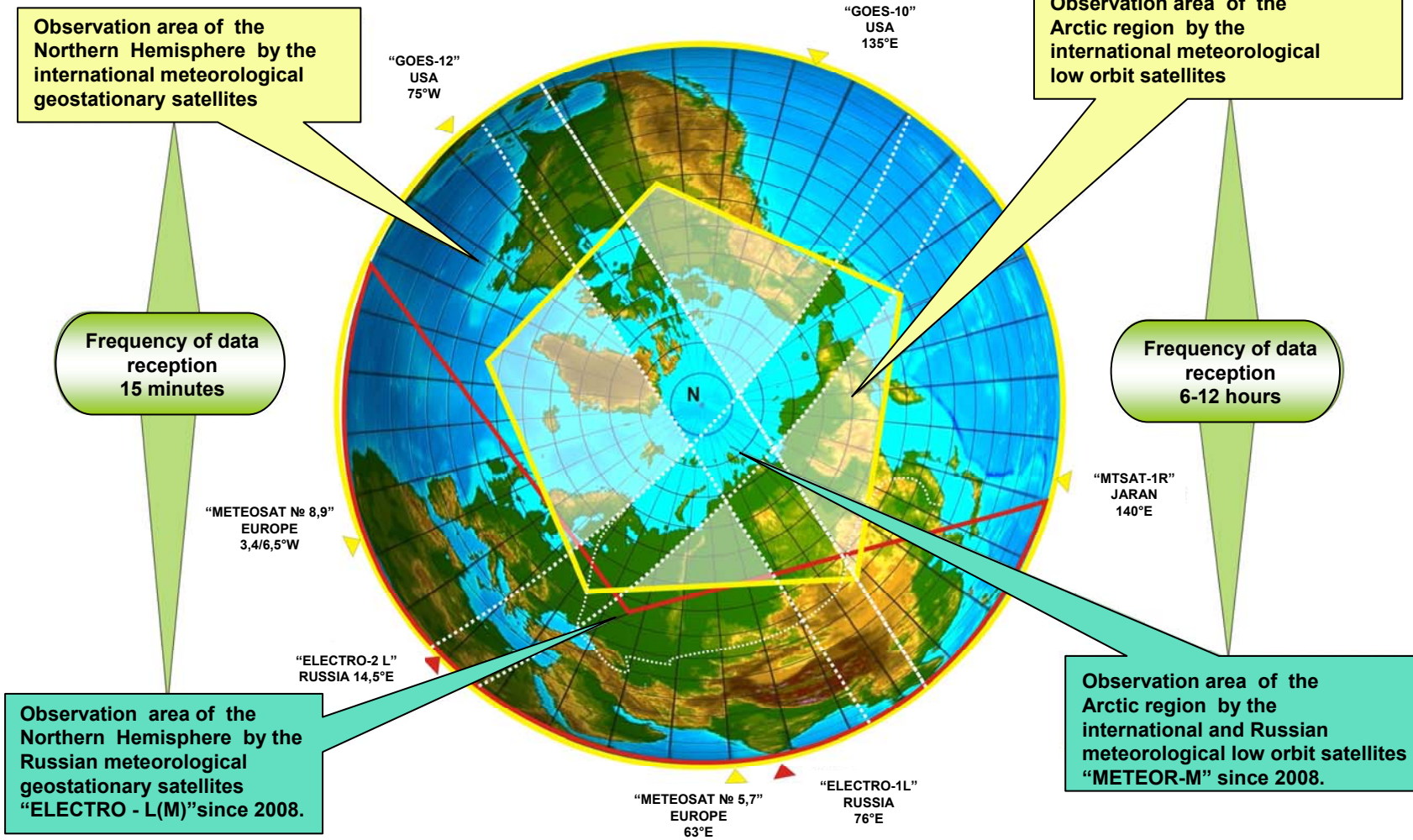
Russian Federal Space Agency

High-elliptical Orbits Satellite System "Arctica"

State Centre on Space Hydrometeorology "Planeta"

Lavochkin Association

Earth observation by the international meteorological satellite system



Mission objectives

Monitoring of the Earth atmosphere and surface in Arctic region (inaccessible for observation from geostationary orbit) on the base of multispectral imaging with high temporal resolution (15 – 30 min).

Providing heliogeophysical information in polar areas.

Maintaining data collection system, telecommunication service for data exchange and retransmission.

Search & Rescue service (COSPAS-SARSAT).

Main Tasks and Applications

Utilization for analysis and forecasting :

- weather in the regional (Arctic) and global scales
- ice cover in Arctic
- flight conditions for aviation (cloudiness, wind, jet-streams etc.)
- snow cover
- heliogeophysical conditions in the near Earth Space

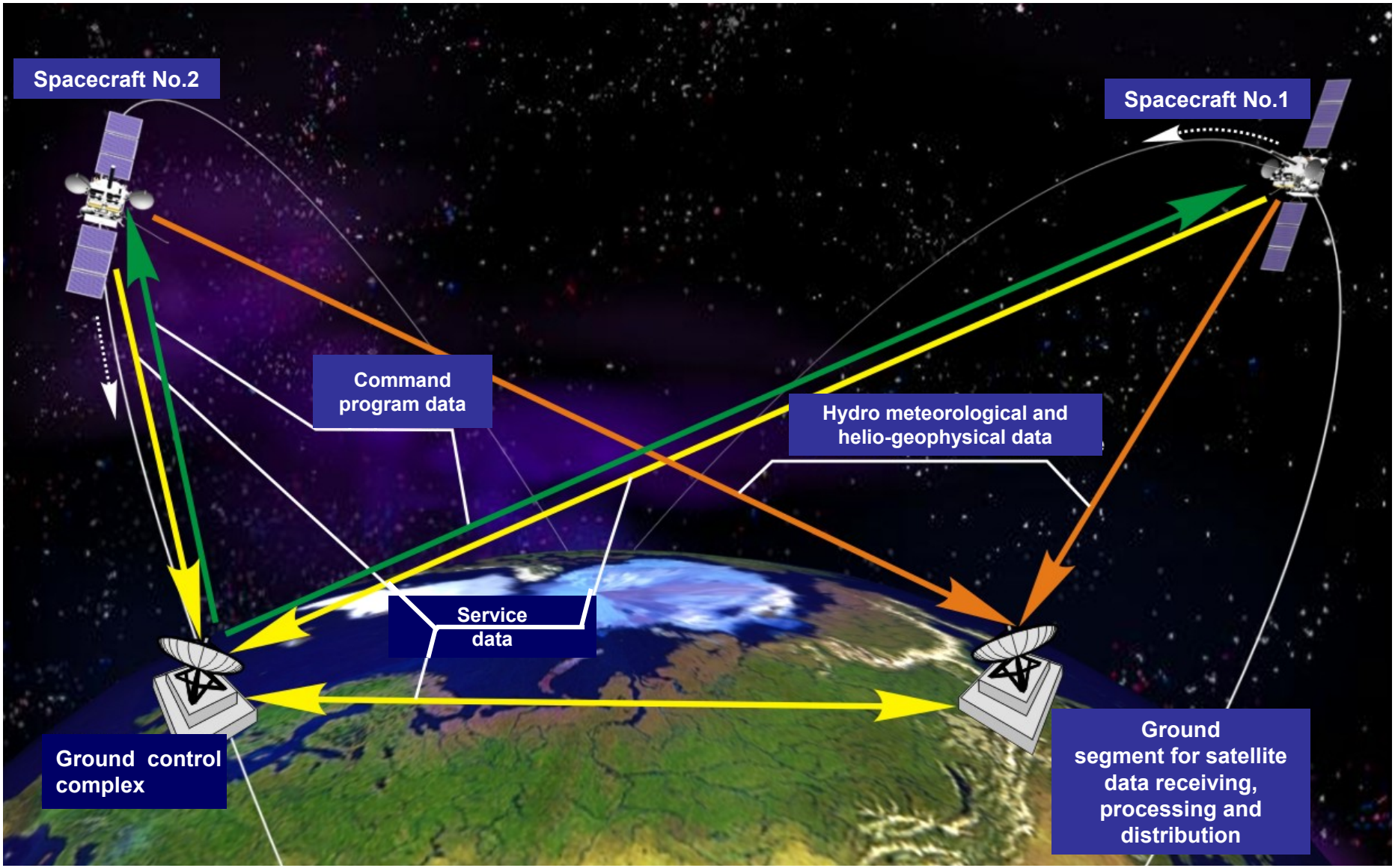
Monitoring of disasters (fires, floods, volcanic eruptions etc.)

Monitoring of climate changes

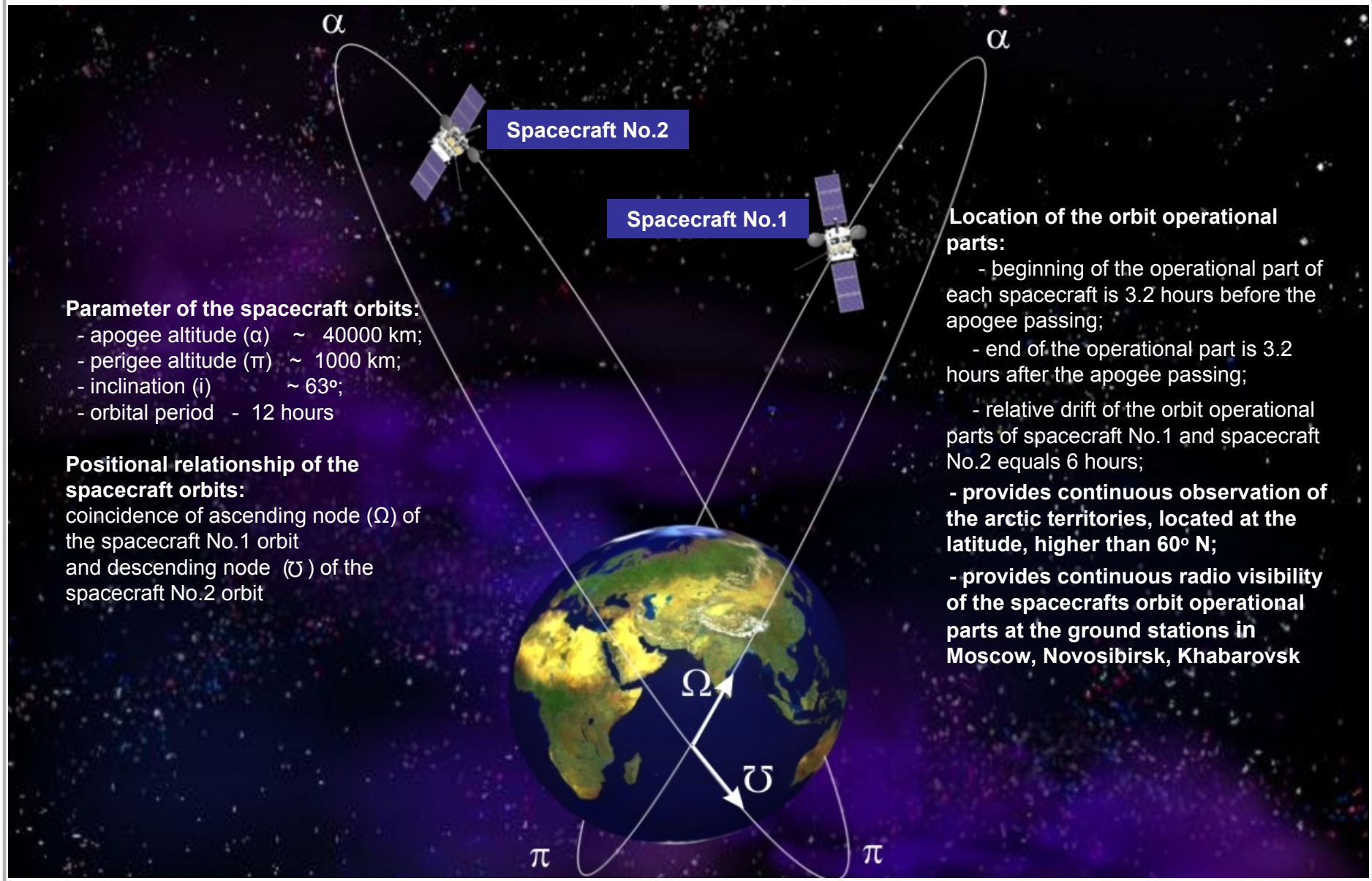
Data collection and relay from land-, sea- and air-based observing platforms

Exchange and dissemination of processed satellite, meteorological and heliogeophysical data

"Arctica" System General Design



Ballistic configuration of the space system



Parameter of the spacecraft orbits:
- apogee altitude (α) ~ 40000 km;
- perigee altitude (π) ~ 1000 km;
- inclination (i) ~ 63°;
- orbital period - 12 hours

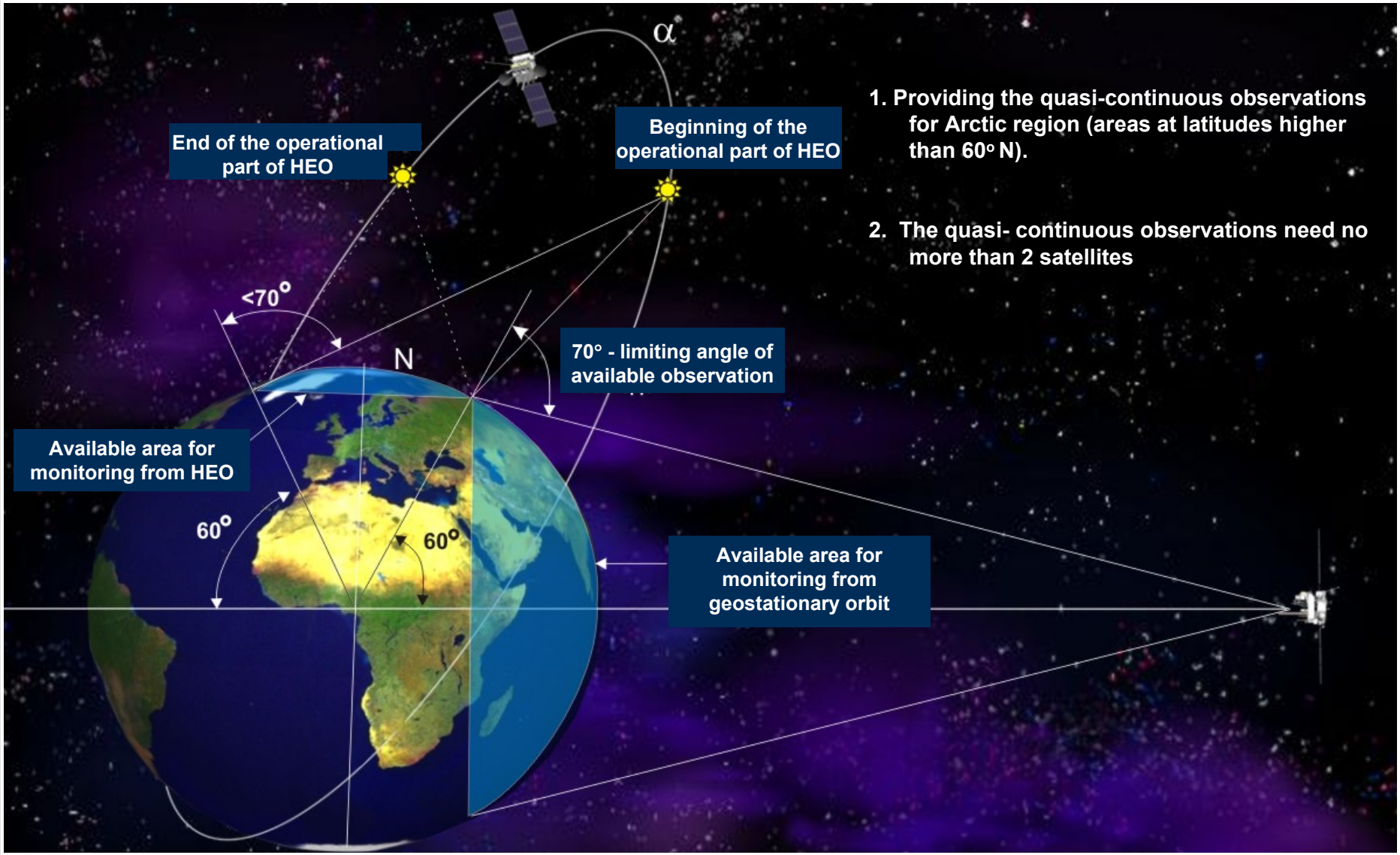
Positional relationship of the spacecraft orbits:
coincidence of ascending node (Ω) of the spacecraft No.1 orbit and descending node (℧) of the spacecraft No.2 orbit

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 No.1 and spacecraft No.2 equals 6 hours;

- provides continuous observation of the arctic territories, located at the latitude, higher than 60° N;

- provides continuous radio visibility of the spacecrafts orbit operational parts at the ground stations in Moscow, Novosibirsk, Khabarovsk

Advantages of the high- elliptic orbits (HEO) over geostationary orbits for Arctic observations



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

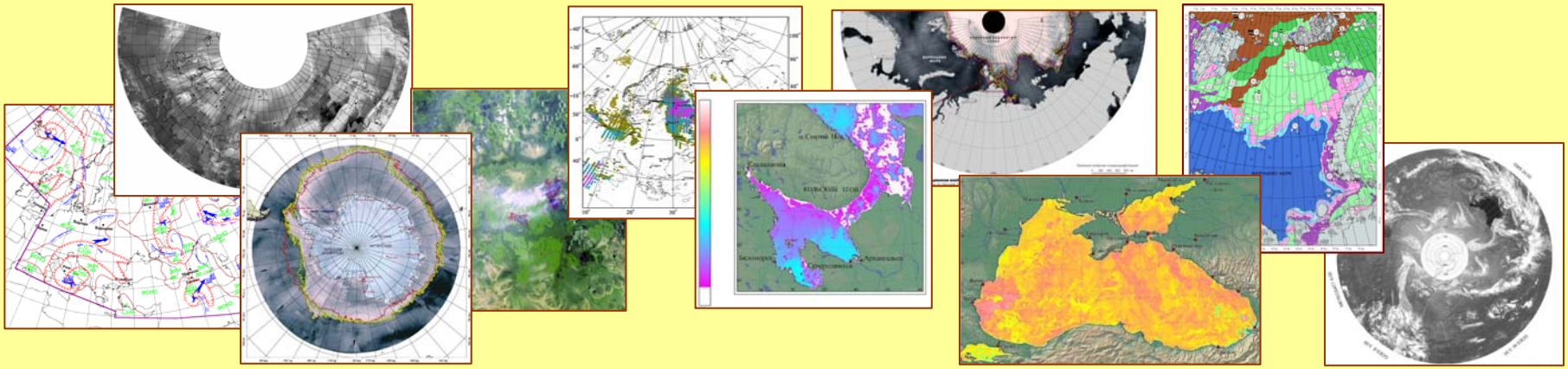
2. The quasi- continuous observations need no more than 2 satellites

Conclusions

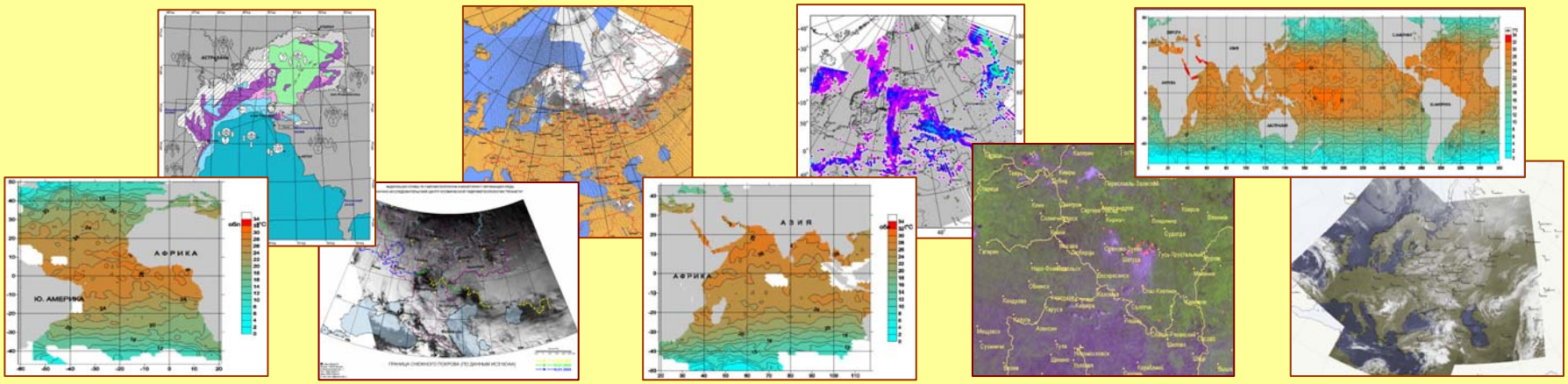
1. To a great extent the progress of global and regional numerical weather forecasting, as well as providing safety navigation along Northern Sea Route together with many other Earth monitoring problems depends on the capabilities to provide hydrometeorological information for the Arctic region (at the latitudes higher than 60 deg. N) in quasi-continuous mode with high temporal resolution.

2. Geostationary meteorological satellites cannot provide such information and therefore the proposed "Arctica" system should supplement existing global satellite observation system.

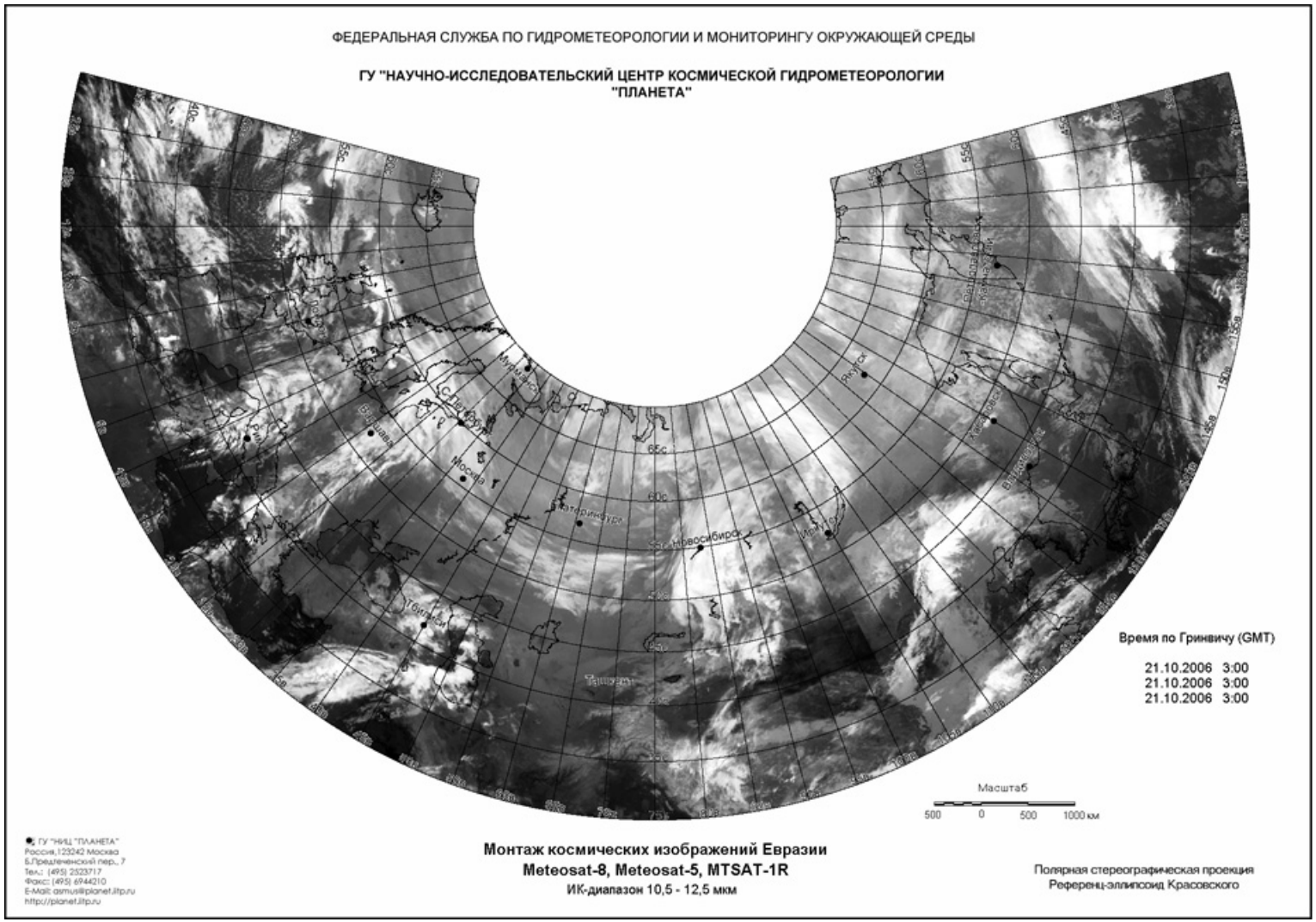
3. Russia has great experience on design and exploitation HEO satellite systems, as well as the technical stock on the development of "Electro-L" and "Spectr-R" type spacecrafts. Based on this Roscosmos and Roshydromet (as responsible Russian governmental bodies) propose to realize "Arctica" project in the frame of wide international cooperation.



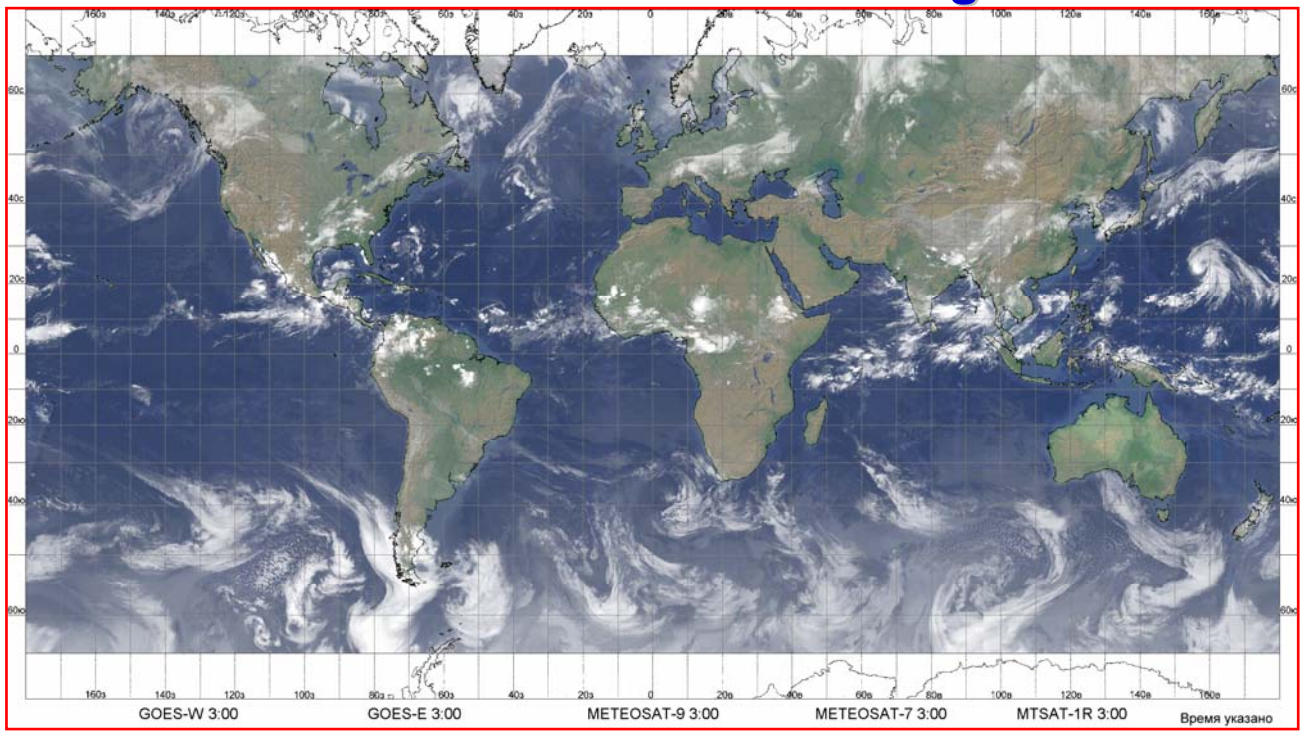
OPERATIONAL PRODUCTS



Cloud cover monitoring: Russia



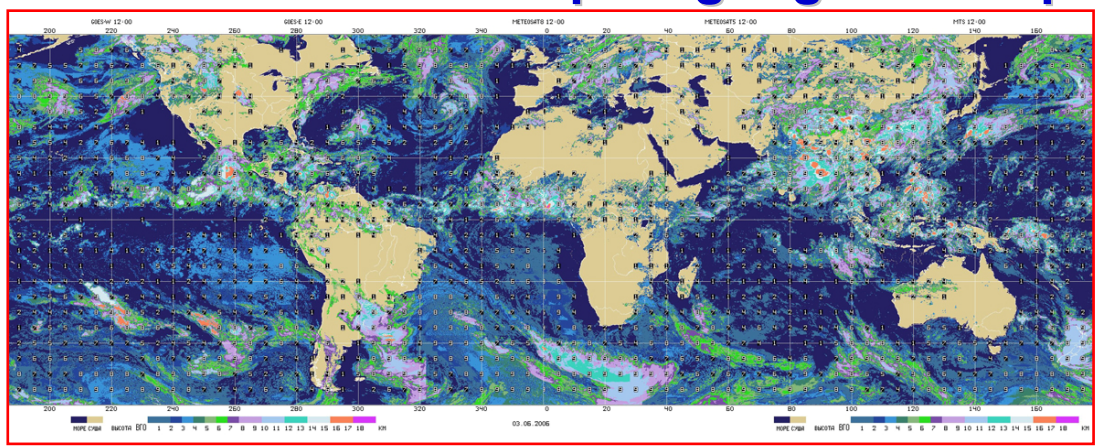
Global mosaics of IR images



Глобальная карта облачности

ИК-диапазон 10.5-12,5 мкм
28.02.2008 г.

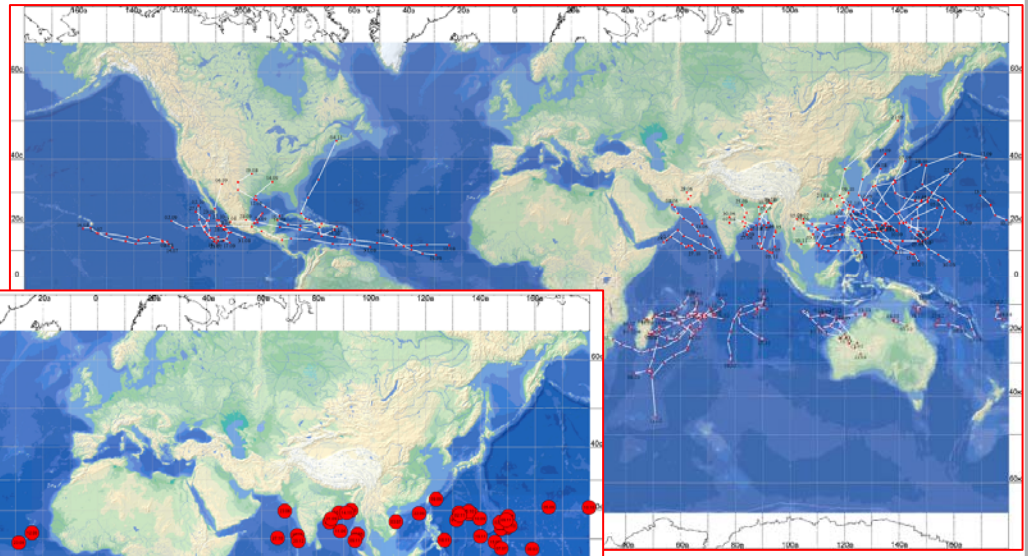
Cloud fraction and top height global map



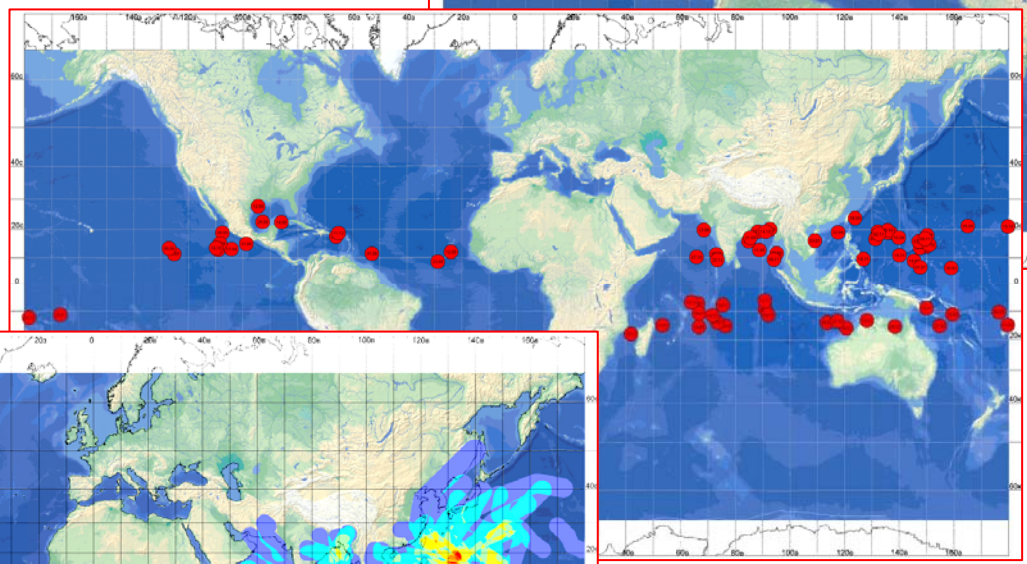
Глобальная карта облачности (балльность, высота) по данным геостационарных ИСЗ

Tropical Cyclon monitoring

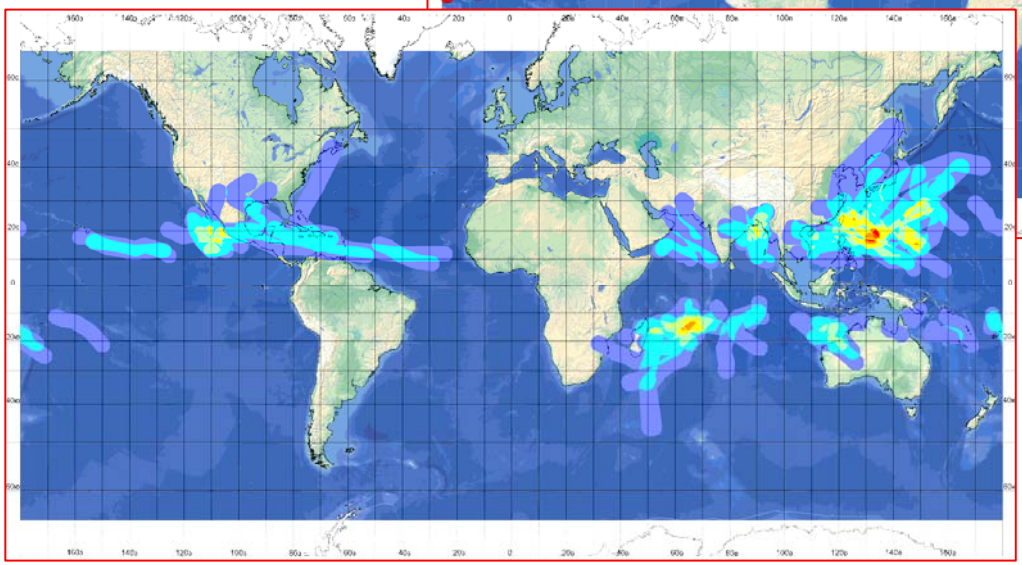
01.01.2007 – 31.12.2007



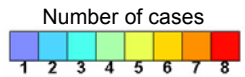
Tropical Cyclon Trajectories Map



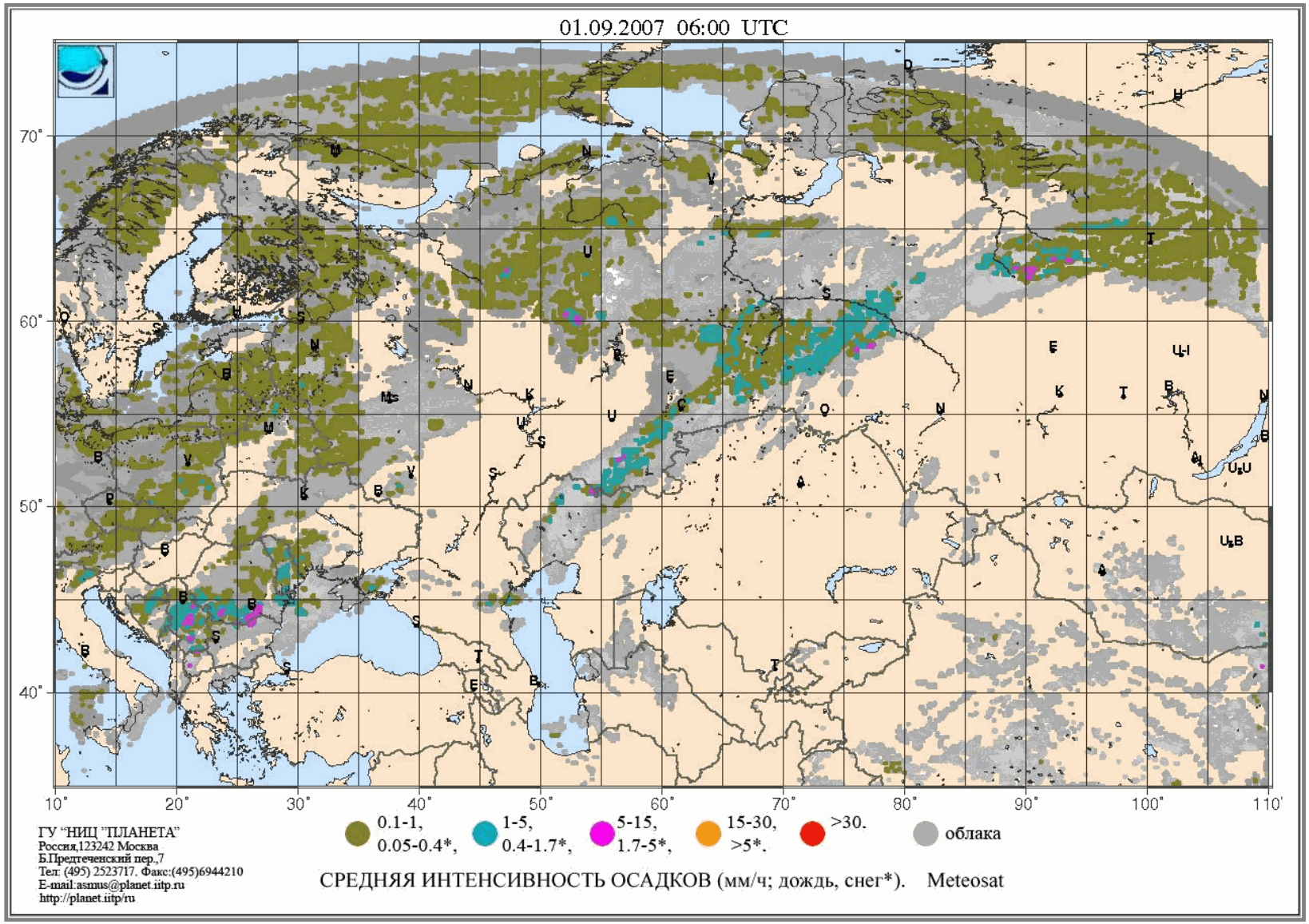
Tropical Cyclon Centers Map



Tropical Cyclon Recurrence Map

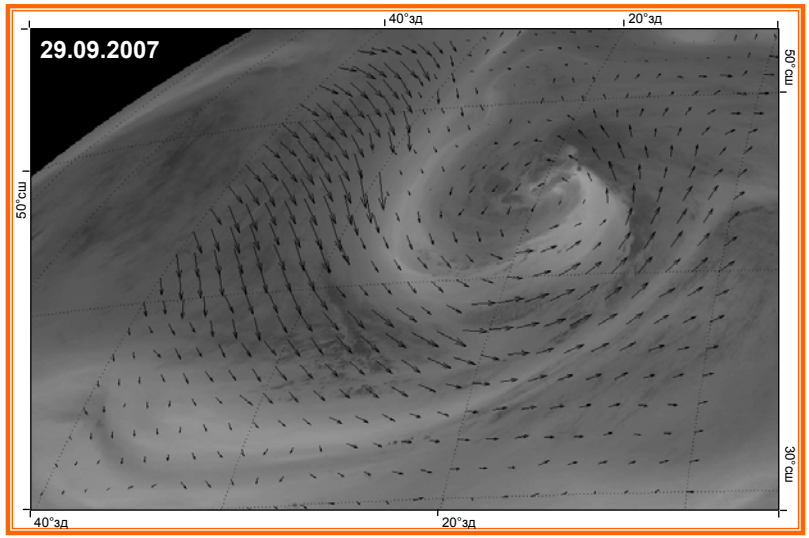


Precipitation intensity

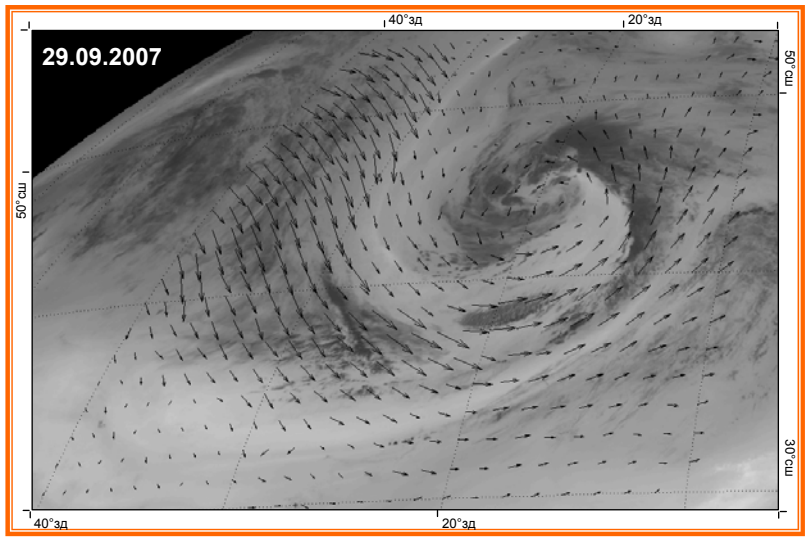


Atmospheric Motion Winds

Wind vectors

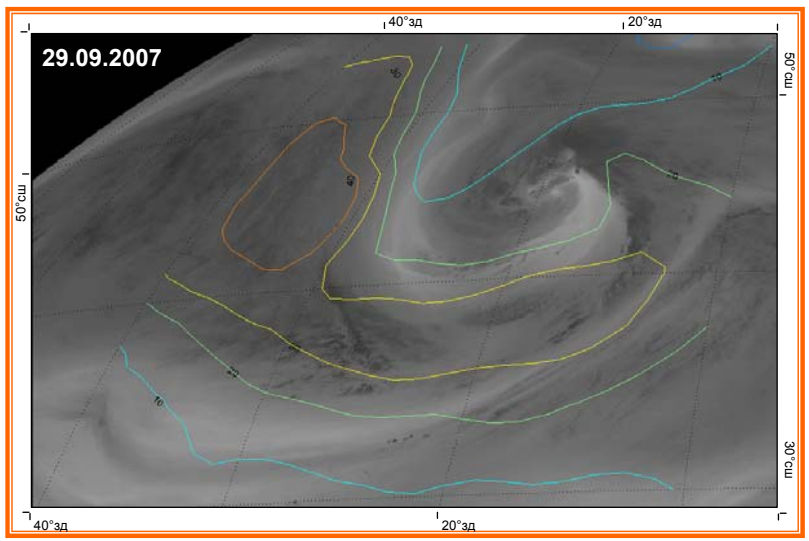


ch 6.2 μm

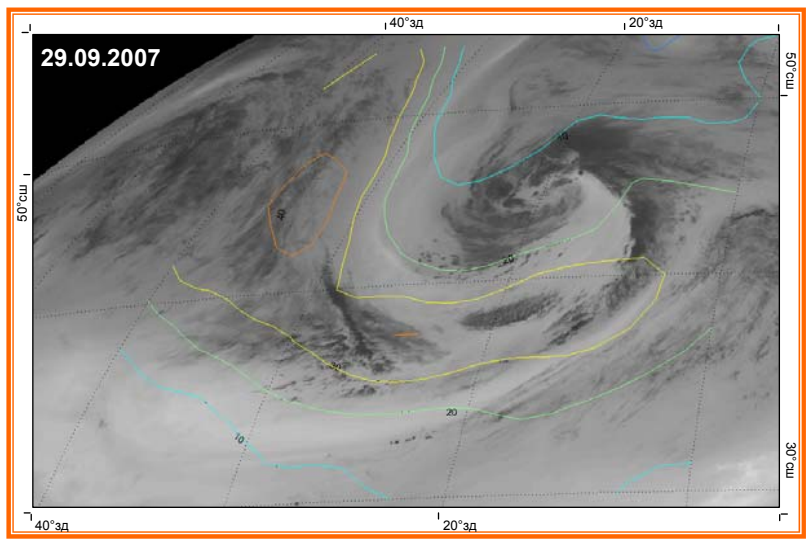


ch 7.3 μm

Wind vector module, m/sec

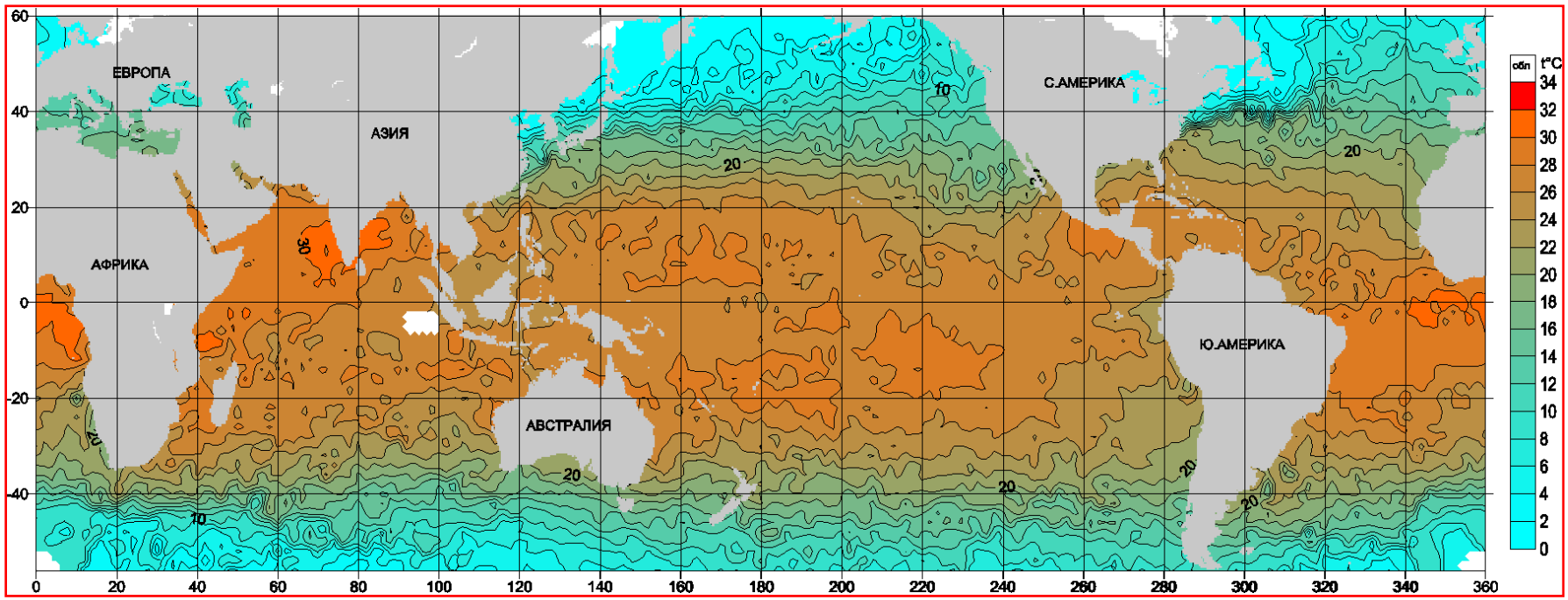


ch 6.2 μm

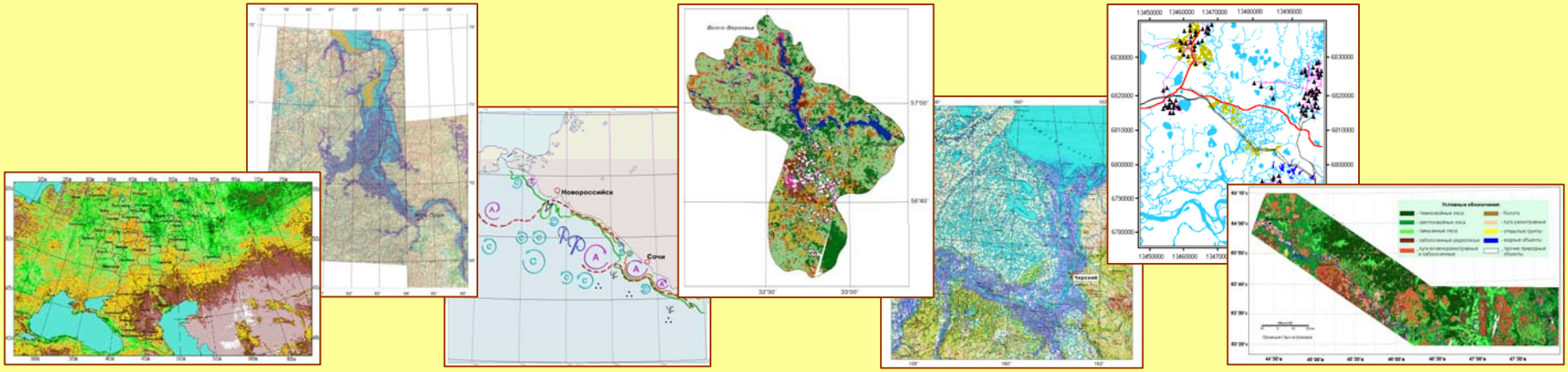


ch 7.3 μm

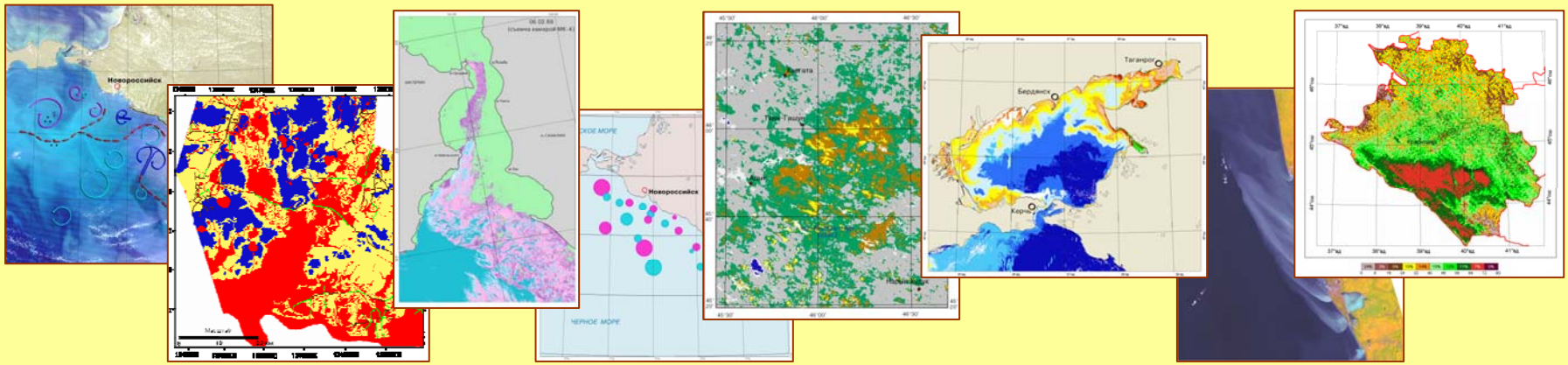
Global SST map (5 Geostationary Satellites)



01.09 – 10.09 2007 г.



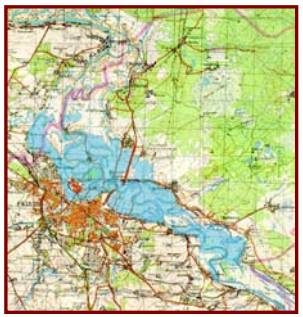
REGIONAL MONITORING



Floods mapping: Russian rivers

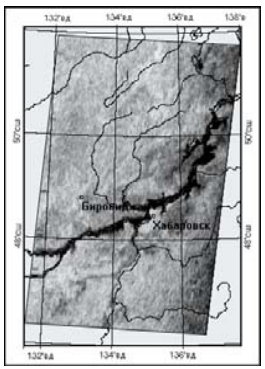
Пойма реки Оки

Выделение воды на космическом изображении (МСУ-Э)

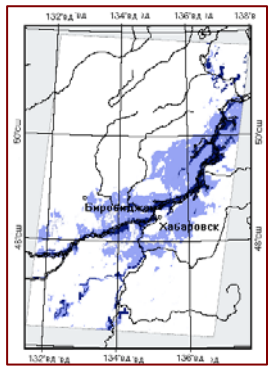


Карта затопления поймы р. Оки

Среднее течение реки Амур

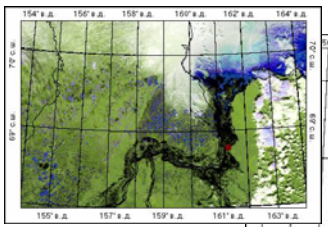


Космическое изображение (РЛСБО)

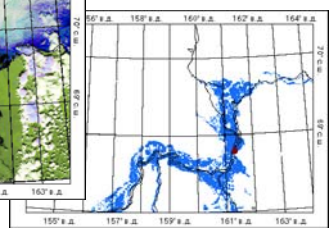


Карта-схема затопления

Нижнее течение реки Колымы

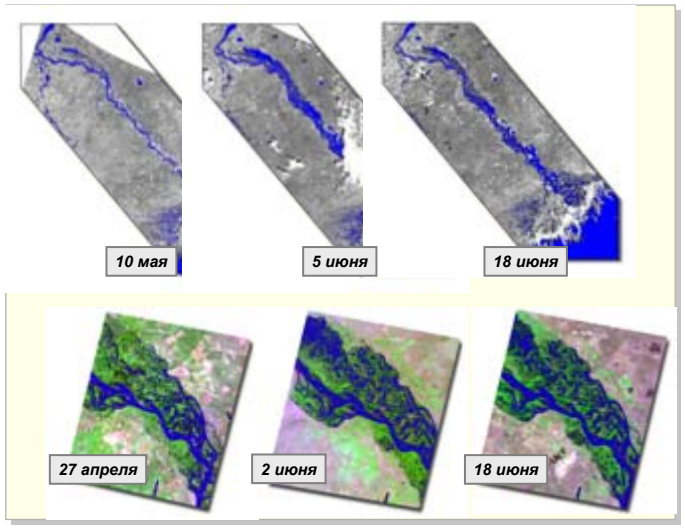


Космическое изображение (NOAA/AVHRR)



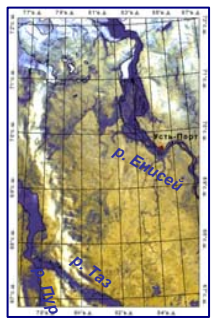
Карта-схема затопления

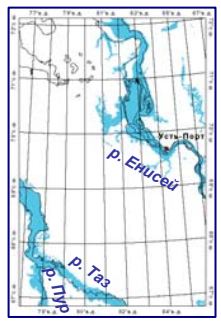
Реки Волга и Ахтуба

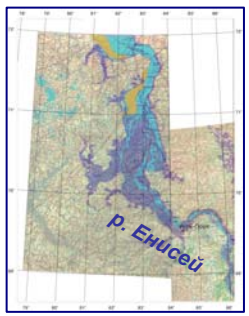


Мониторинг наводнений на основе данных высокого (МСУ-Э) и среднего разрешений (МСУ-СК)

Нижнее течение рек Енисея, Таза и Пура







Выделение воды на космическом изображении (NOAA/AVHRR)

Карта-схема затопления

- гидрографическая сеть
- пойменный разлив
- речной лед

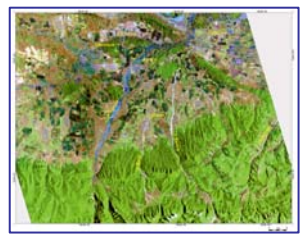
Чрезвычайная паводковая ситуация на реках Северного Кавказа

(ИСЗ «Метеор-3М»)

Река Терек

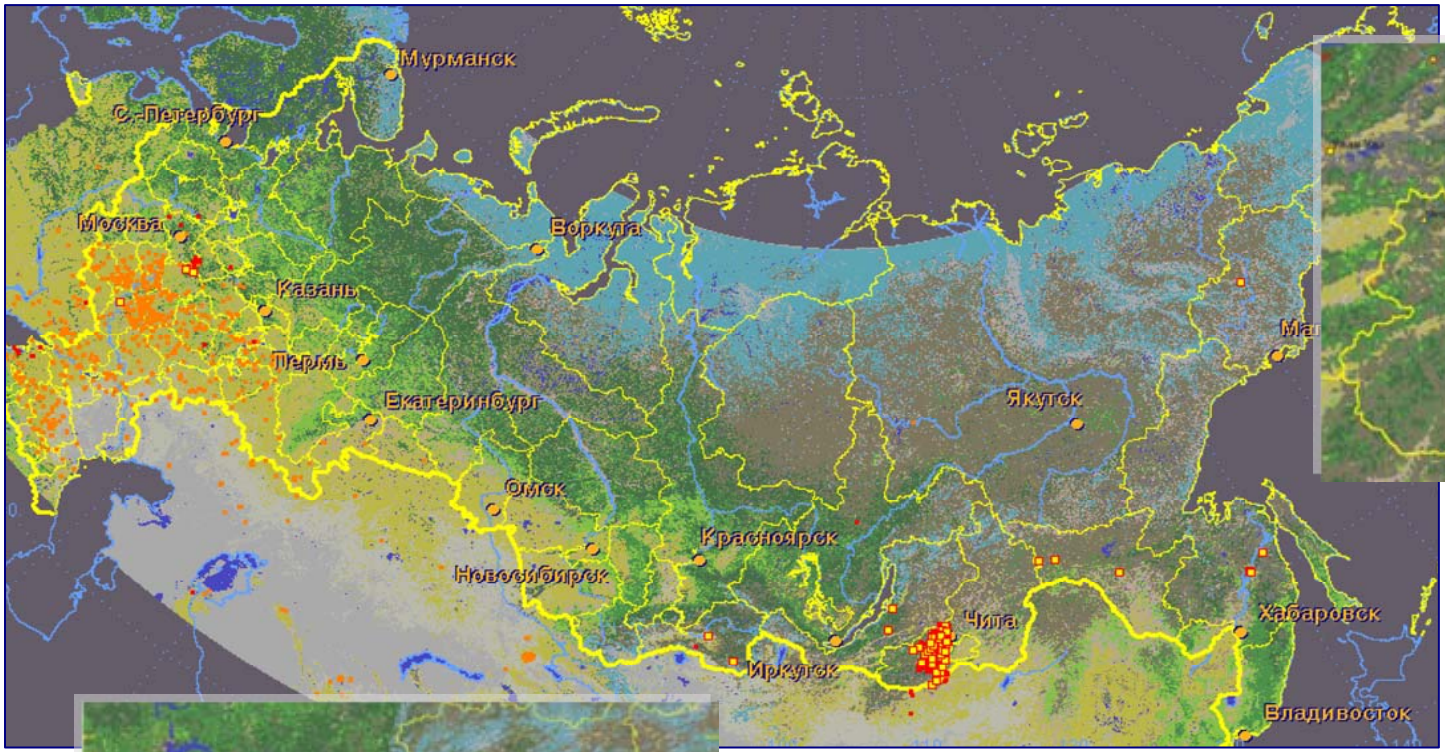
Реки Терек и Аргун

Реки Асса и Фортанга

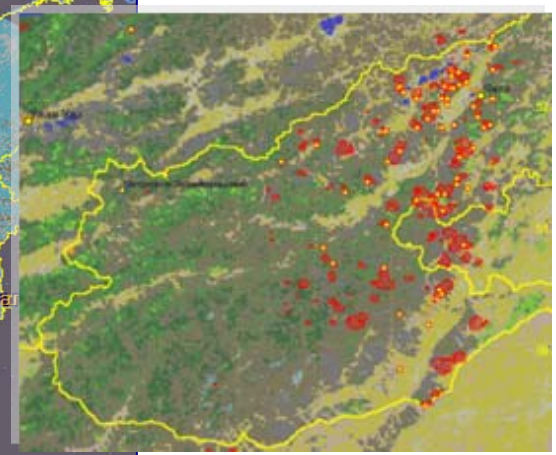


Река Аргун

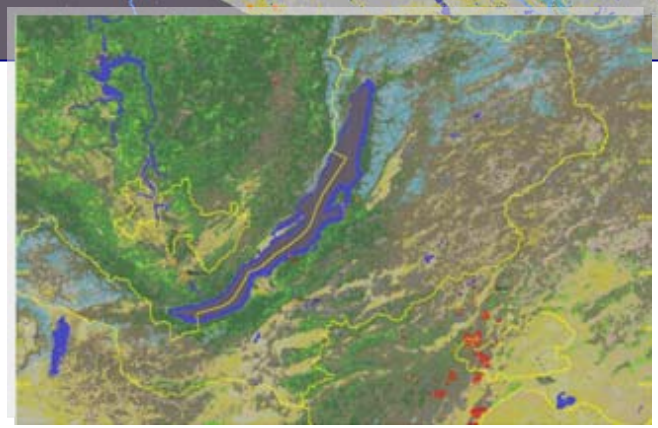
Fire Maps: Russia



Eurasia (*NOAA, TERRA, AQUA, 14.08.2007*)

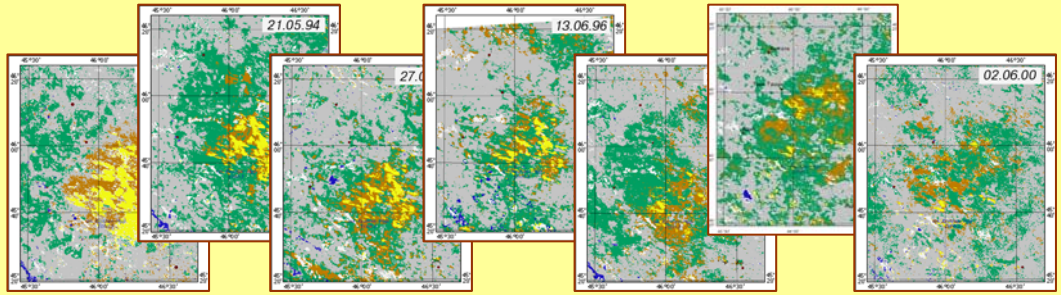


Buryatia republic
(*NOAA, 20.08.2007*)

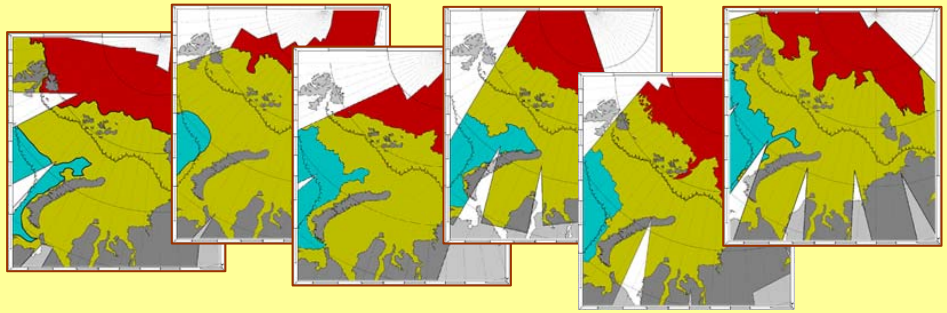


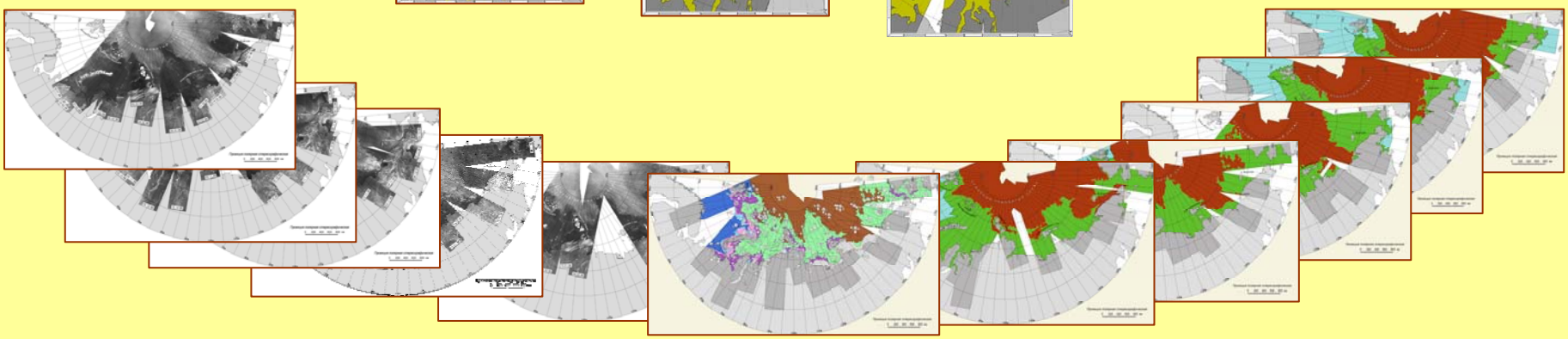
Chita region *(NOAA, 14.08.2007)*

- **горячие пятна (лесные территории) по спутниковым данным**
- **горячие пятна (нелесные территории) по спутниковым данным**
- **области горения по спутниковым данным**
- **крупные пожары по данным Службы Авиалесохраны**
- **границы регионов**



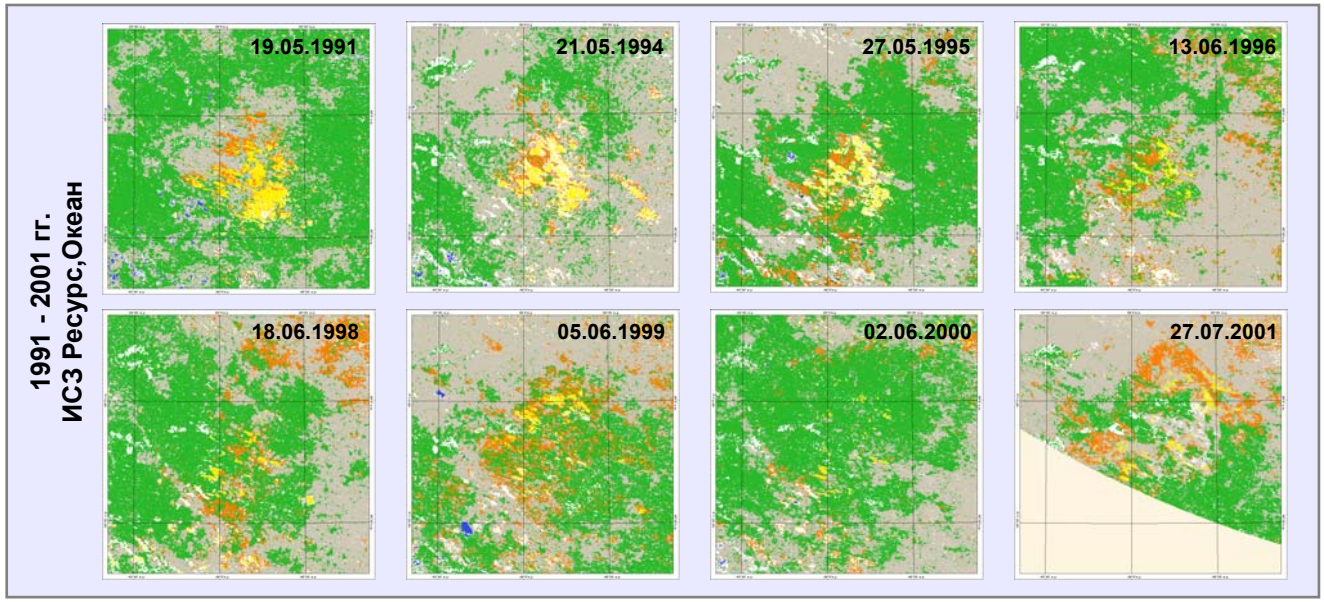
CLIMATOLOGICAL STUDIES

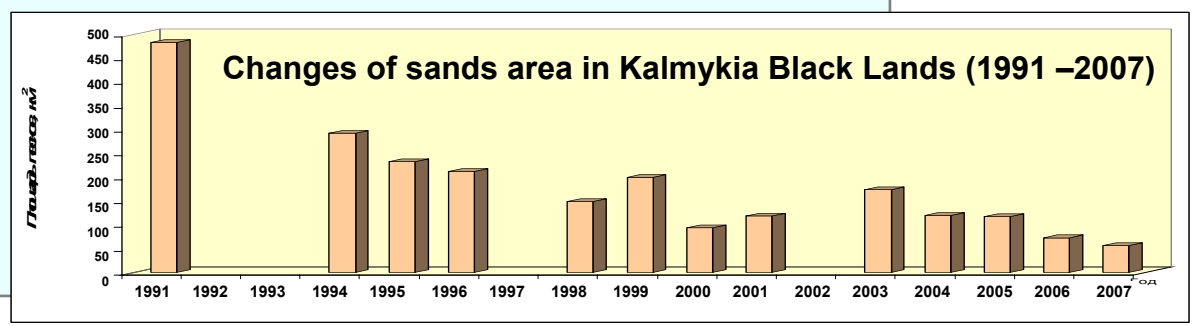




Drought monitoring: Kalmykia

Changes of soil and vegetation cover in Kalmykia Black Lands





THANK YOU !