RUSSIAN ENVIRONMENTAL SATELLITES: CURRENT STATUS AND DEVELOPMENT PERSPECTIVES

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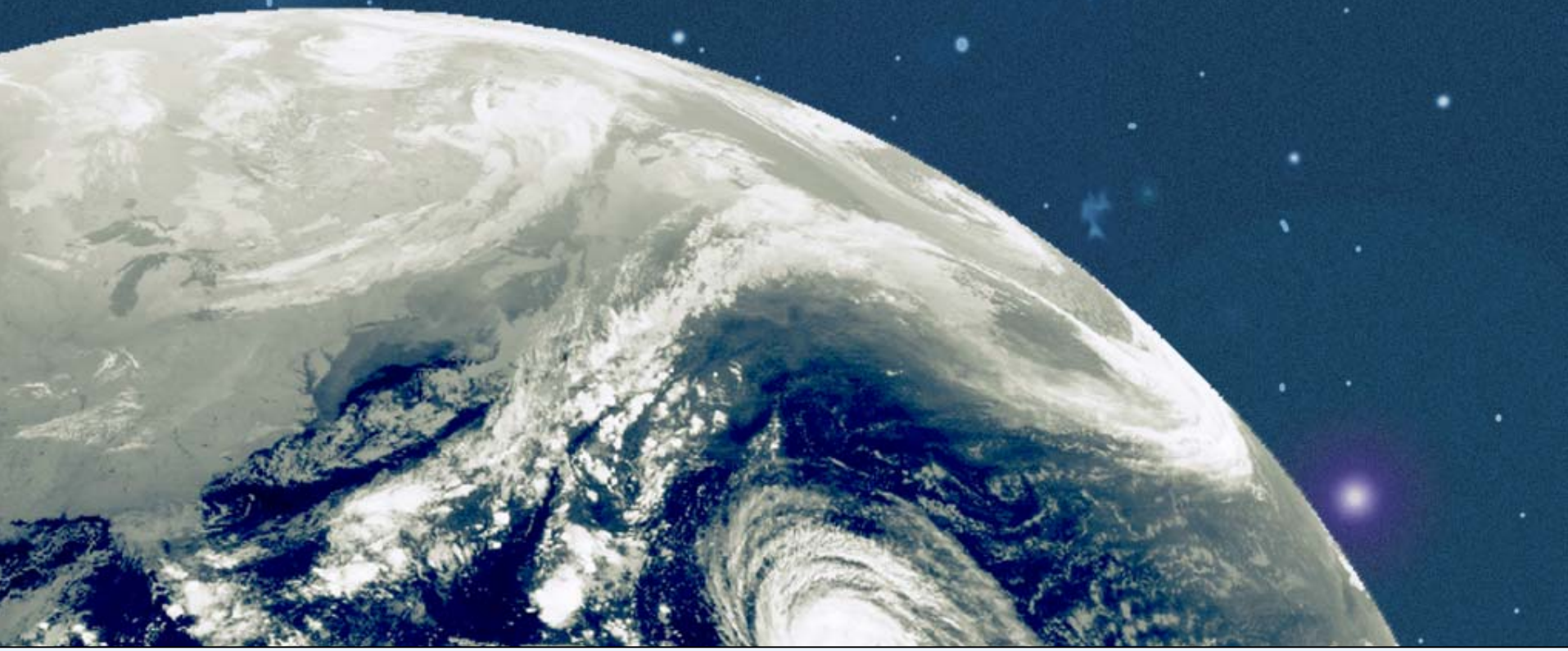


THE 13th INTERNATIONAL TOVS STUDY CONFERENCE
Sainte Adele, Canada, 29 October – 4 November 2003

OUTLINE

1. Current status and development perspectives for polar orbiting satellites of METEOR series

2. Future geostationary meteorological satellite GOMS/Electro N2

3. Oceanographical satellite SICH-1M

4. Environmental satellites RESURS-DK1, MONITOR-E

5. Satellite products and applications:
   - cloud imagery and cloud analysis
   - sea ice mapping
   - snow cover and ice concentration maps
   - forest fires detection
   - climate applications

BASIC INSTRUMENTS PAYLOAD OF THE METEOR-M

	Application	Spectral Band	Swath-width (km)	Instrument
MSU-MR	Global and regional cloud cover mapping, SST, LST, …	0.5 – 12.5 μm (6 channels)	3000	1 x 1
KMSS multichannel scanning unit	Earth surface monitoring	0.4-0.9 μm	100	0,1
MTVZA imager/ sounder	Atmospheric temperature and humidity profiles, sea surface wind	10.6-183.3 GHz (26 channels)	2600	12 – 75
IRFS-2 advanced IR sounder	Atmospheric temperature and humidity profiles	5-15 μm	2000	35
Severjanin (active radar)	Ice monitoring	9500-9700 MHz	450	0.7 x 1.0
Radiomet* (radio occulation unit)	Atmospheric temperature and pressure profiles.			

MICROWAVE IMAGER/SOUNDER OF RUSSIAN METEOROLOGICAL SPACECRAFTS

MTVZA – "Meteor-3M" N1, launched – 2001,

MTVZA-OK – "Sich-1M", launch – 2004,

MTVZA-GY – "Meteor-M" N1, launch – 2006,

MTVZA-GY is the same as MTVZA-OK, but in addition will include a polarimeter

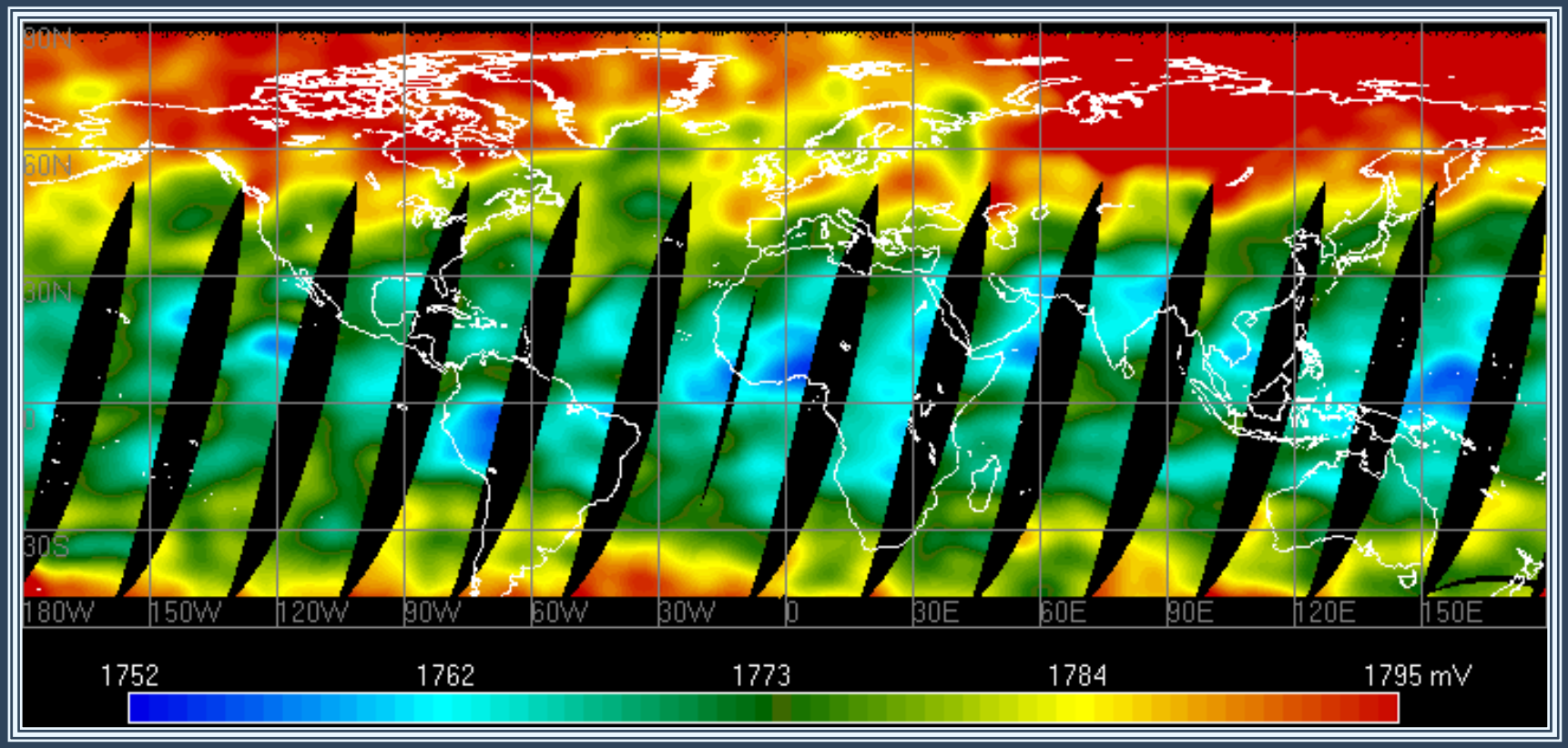
PERFORMANCE CHARACTERISTICS MTVZA

Frequency (GHz)	18.7	22.2	33.0	36.5	42.0	48.0	52-57	91.6	183
Polarization V/H	V, H	V	V, H	V, H	V, H	V, H	V	V,H	V
Number of Channels	2	1	2	2	2	2	5	2	3
IFOV (kmxkm)	75x136	68x124	45x82	41x75	36x65	32x58	30x55	18x33	12x22
Imagery pixel (kmxkm)	35.6x31.6						71.2x63.2	17.8x15.8	71.2x63.2
Sensitivity (K/pixel)	0.25	0.25	0.35	0.38	0.45	0.45	0.3	0.5	0.4
Antenna Beam Efficiency, %	93.7	93.4	93.5	93.5	92.8	93.9	94.2	95	95
Cross-Polarization Isolation, dB	-24	-24	-25	-24	-20	-23	-25	-24	-25
Conical Scanning Period (ms)	2500.0±0.8								
Viewing Angle (deg.)	53.5								
Incident Angle (deg.)	69								
Swath Width (km)	2200								
Mass (kg)	107								
Power Consumed (W)	110								

MICROWAVE IMAGER/SOUNDER MTVZA

(Spacecraft «Meteor-3M», Launched – December 10, 2001)

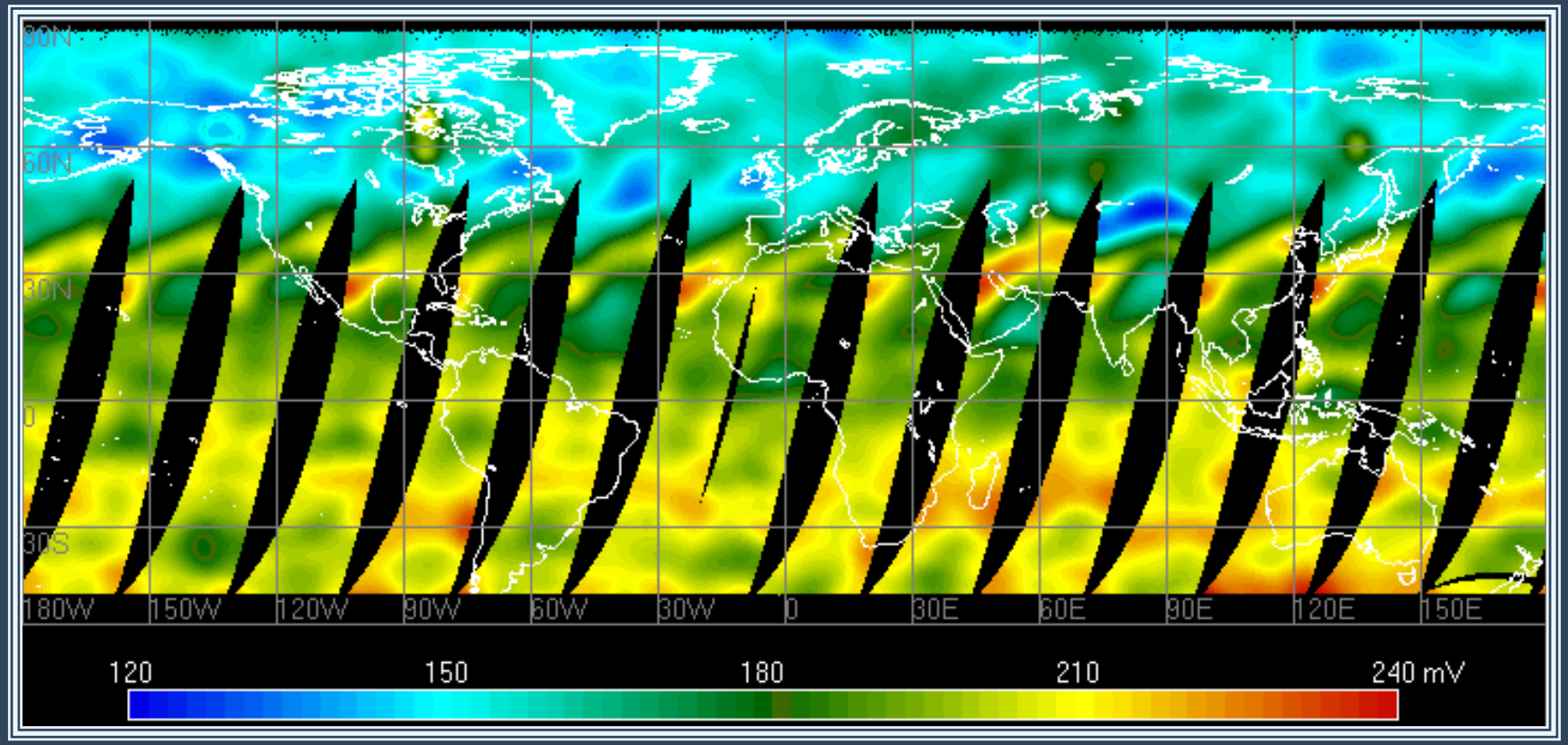
GLOBAL MOZAIC OF MTVZA DATA
MAY 3, 2002



ch. 55.65 GHz (weighting function max ~ 14 km)

GLOBAL MOZAIC OF MTVZA DATA

MAY 3, 2002



ch. 52.80 GHz (weighting function max ~ 2 km)

MTVZA-OK MICROWAVE FREQUENCY CHANNEL CHARACTERISTICS

Channel No.	Center Frequency (GHz)	No. of pass bands	Band-width (MHz)	Effective FOV (kmxkm)	Imagery pixel (kmxkm)	Sensitivity (K/pixel)	Approximate peak sensitivity altitude (km)
1	6.9	1	350	112x260	38x38	0.3	-
2	10.6	1	100	76x177	38x38	0.5	-
3	18.7	1	200	45x104	38x38	0.4	-
4	23.8	1	400	36x86	38x38	0.3	-
5	31	1	1000	30x69	38x38	0.3	-
6	36.5	1	1000	26x60	38x38	0.3	-
7	42	1	1000	22x53	38x38	0.4	-
8	48	1	1000	21x47	38x38	0.4	-
9	52.80	1	400	18x43	38x38	0.4	2
10	53.30	1	400	18x43	38x38	0.4	4
11	53.80	1	400	18x43	38x38	0.4	6
12	54.64	1	400	18x43	38x38	0.4	10
13	55.63	1	400	18x43	38x38	0.4	14
14	57.290344□0.3222□0.1	4	50	18x43	57x57	0.4	20
15	57.290344□0.3222□0.05	4	20	18x43	57x57	0.7	25
16	57.290344□0.3222□0.025	4	10	18x43	57x57	0.9	29
17	57.290344□0.3222□0.01	4	5	18x43	57x57	1.3	35
18	57.290344□0.3222□0.005	4	3	18x43	57x57	1.7	42
19	89	1	4000	12x28	19x19	0.6	surface
20	183.31 □ 7.0	2	1500	8x19	38x38	0.5	1.5
21	183.31 □ 3.0	2	1000	8x19	38x38	0.6	2.9
22	183.31 □ 1.0	2	500	8x19	38x38	0.8	5.3

Channels 1-8, and 19 (imager) operate on both vertical and horizontal polarization.
Channels 9-13, and 20-21 (sounder) operate on vertical polarization.
Channels 14-18 (sounder) operate on horizontal polarization.
Channels 2, 3, and 6 (polarimeter) operate to determine four Stocks parameters (next version MTVZA-GY for spacecraft "Meteor-M", launch - 2006).

BASIC PERFORMANCE CHARACTERISTICS OF IRFS-2

№	Parameter	Units	Value
1	Spectral range: wavelength wave number	μm cm^{-1}	5-15 200 0-665
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

GOMS/Electro N2

GENERAL DESIGN

MSU-G SPECTRAL CHANNEL CHARACTERISTICS

NN	Channel	Spectral range	S/N for VIS NEDT for IR
1	Vis 0.6	0.5 - 0.65	> 10
2	Vis 0.7	0.65 - 0.8	> 10
3	Vis 0.8	0.8 - 0.9	> 7
4	IR 3.7	3.5 - 4.01	< 0.35 K
5	IR 6.7	5.7 - 7.0	< 0.75 K
6	IR 8.0	7.5 - 8.5	< 0.28 K
7	IR 8.7	8.2 - 9.2	< 0.28 K
8	IR 9.7	9.2 - 10.2	< 1.5 K
9	IR 10.7	10.2 - 11.2	< 0.3 K
10	IR 11.7	11.2 – 12.5	< 0.3 K
11*	Vis 1.6		>3
12*	IR 13.4		< 1.8 K

BASIC INSTRUMENTS PAYLOAD OF THE SICH-1M SATELLITE

Instrument	Application	Spectral Band	Swath-width (km)	Resolution (km)
RLSBO – Side Looking Radar	**Sea ice mapping,** **snow coverage,** **Earth surface monitoring**	3.2 cm	450	1,3 x 2,5
RM-08 MW imager	**Sea ice mapping**	0.8 cm	550	25
MSU-M Optical imager (low resolution)	**Earth surface monitoring**	4 channels: 0.5 – 0.6, 0.6–0.7, 0.7–0.8, 0.8–1.1 μm	2000	1.7
MSU-EU Optical imager (high resolution)	**Earth surface monitoring**	3 channels: 0.5 – 0.6, 0.6–0.7, 0.8–1.1 μm	45	0,045
MTVZA OK Combined MW and optical imager/sounder	**Atmospheric temperature and humidity profiling, monitoring of ice and snow, sea surface wind speed TPW, CLW, precipitation, ocean colour**	22 MW channels: 6.9; 10.6; 18.7; 23.8; 31.5; 36.7; 42.0; 48.0; 52-57; 89.0; 183 GHz. 5 channels in VIS/IR: 0.37-0.45; 0.45-0.51; 0.58-0.68; 0.68-0.78; 3.55-4.0 μm	2000	20 – 200 for MW, 1.1 for VIS/IR
“Variant” unit	**Heliogeophysics Space environment monitoring**		-	-

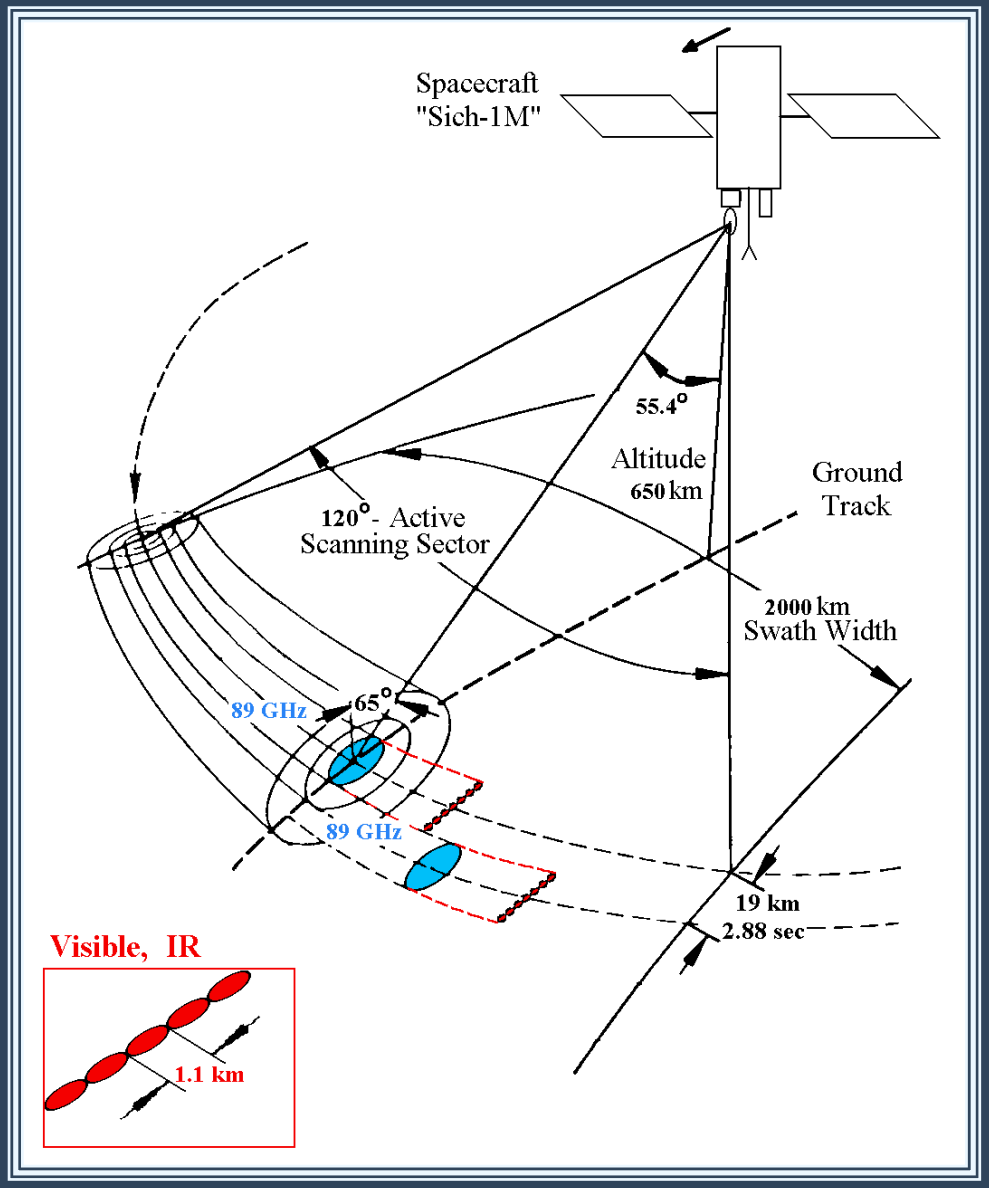
OPTICAL - MICROWAVE IMAGER/SOUNDER MTVZA -OK

(Spacecraft «Sich-1M», Launched 2004)

MTVZA-OK PERFORMANCE CHARACTERISTICS

System	Optical	Microwave
	Spectral Range (micrometers): 0.37-0.45 0.45-0.51 0.58-0.68 0.68-0.78 3.55-3.93	Frequency (GHz): 6.9, 10.6 18.7, 23.8 31, 36.5 42, 48 52.3-57.0 89 183.31
Spatial Resolution (km)	1.1	12-260
Swath Width (km)	2000	
Data Rate (kbps)	665.4	
Conical Scanning Period (sec)	2.88	
Instability Scanning Period	10^{-4}	
Mass (kg)	115	
Power Consumed (W)	240	

MTVZA –OK SCANNING GEOMETRY



RESURS-DK1 SATELLITE (2004)

The satellite RESURS-DK1 will operate on near-circular orbit at an altitude about *350* km with the orbit inclination about 65°.

The new optoelectronic imager will operate in panchromatic and multichannel modes

•Panchromatic mode

Spectral band	0.58 – 0.8 μm
Spatial resolution	1 m

•Multichannel mode

Spectral bands	0.5 – 0.6; 0.6 – 0.7; 0.7 – 0.8 μm
Spatial resolution	2 - 3 m

•Swath width 28.3 km

MONITOR-E SATELLITE (2004)

(Sun-synchronous circular orbit with the orbit inclination 97.5° at an altitude about 540 km).

The instruments payload includes two imagers

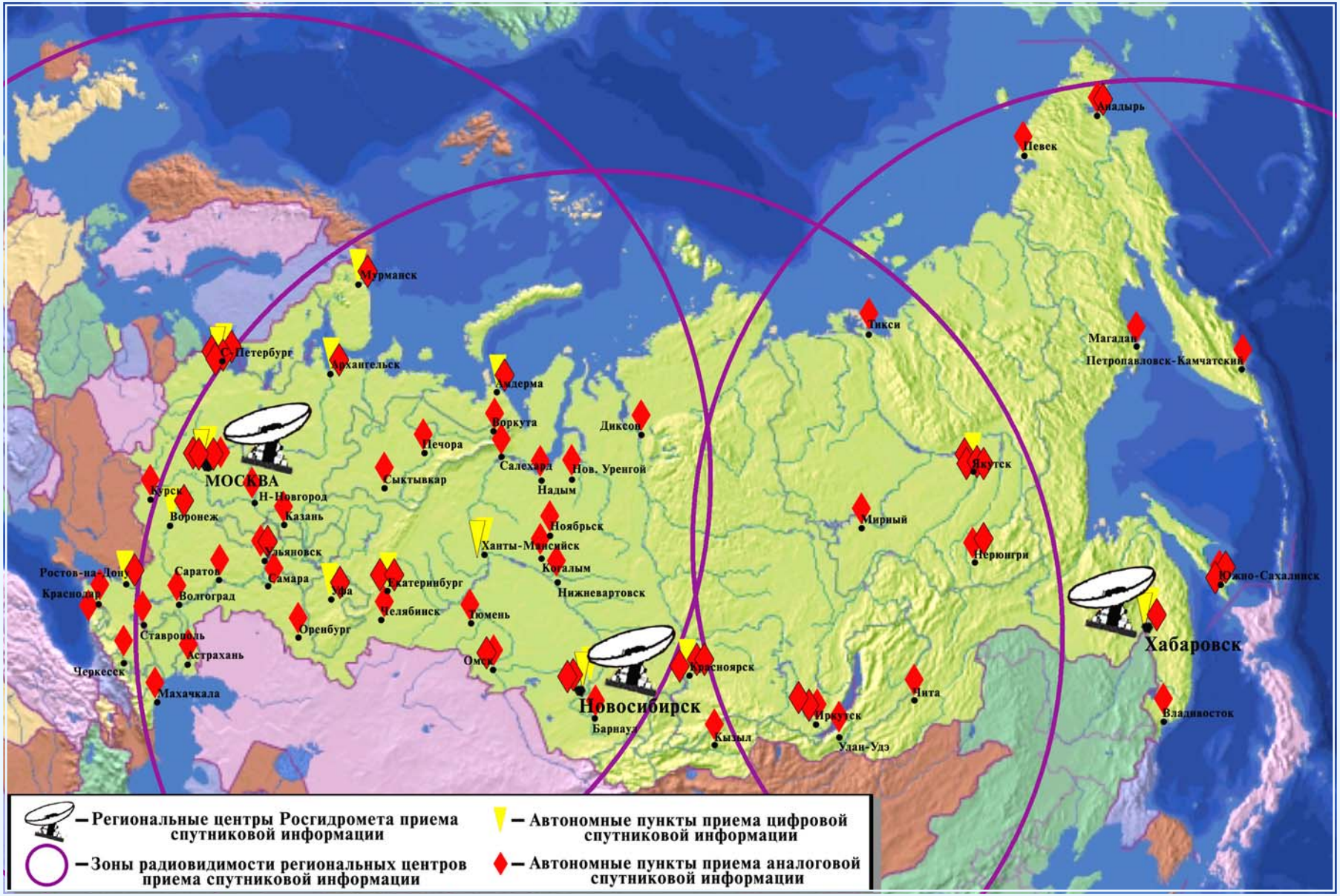
•Panchromatic imager

Spectral band	0.58 – 0.8 μm
Spatial resolution in nadir	8 m
Swath width	93.8 km

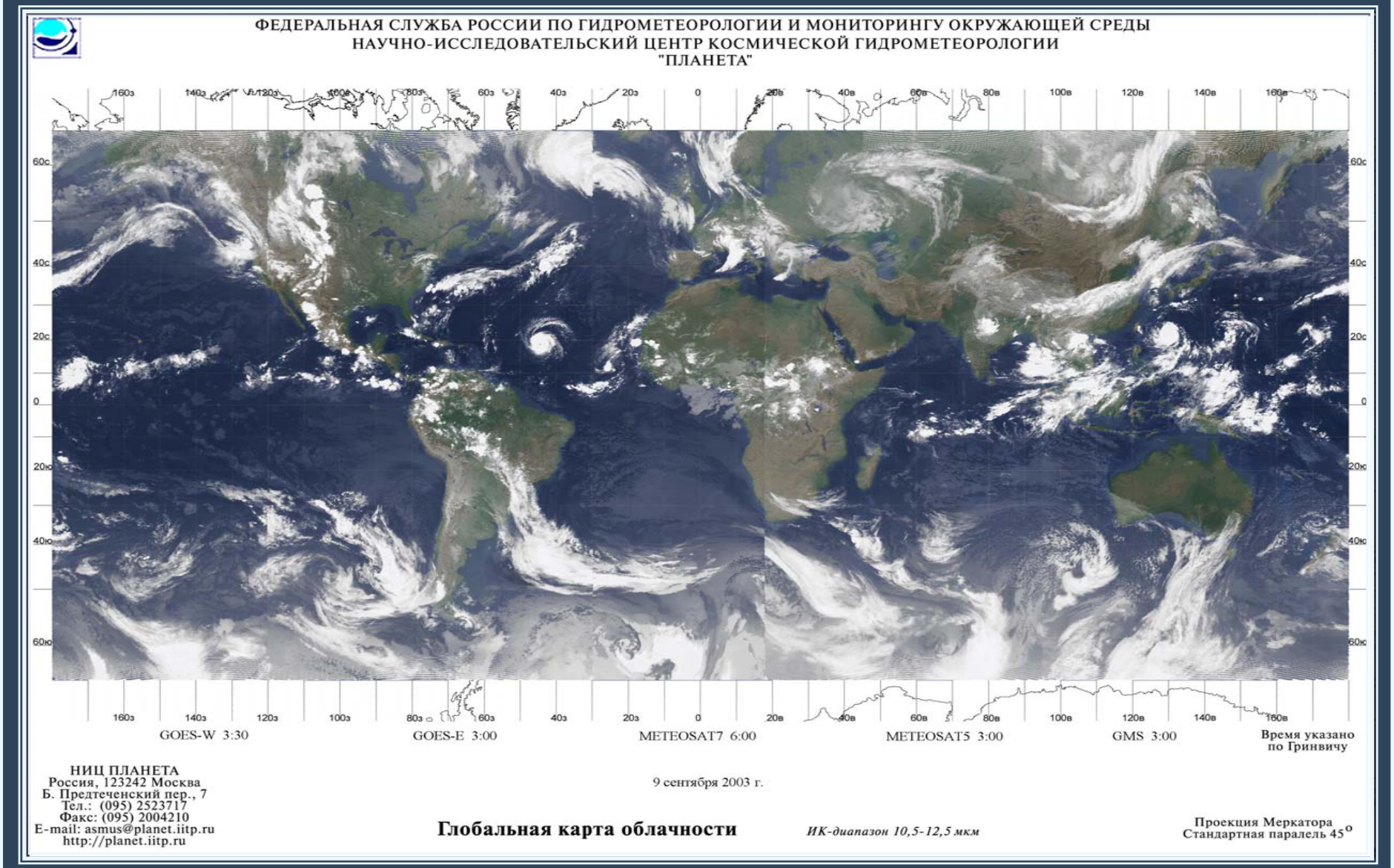
•Multichannel imager

Spectral bands	0.54 – 0.59; 0.63 – 0.68; 0.79 – 0.9 μm
Spatial resolution in nadir	20 m
Swath width	160 km

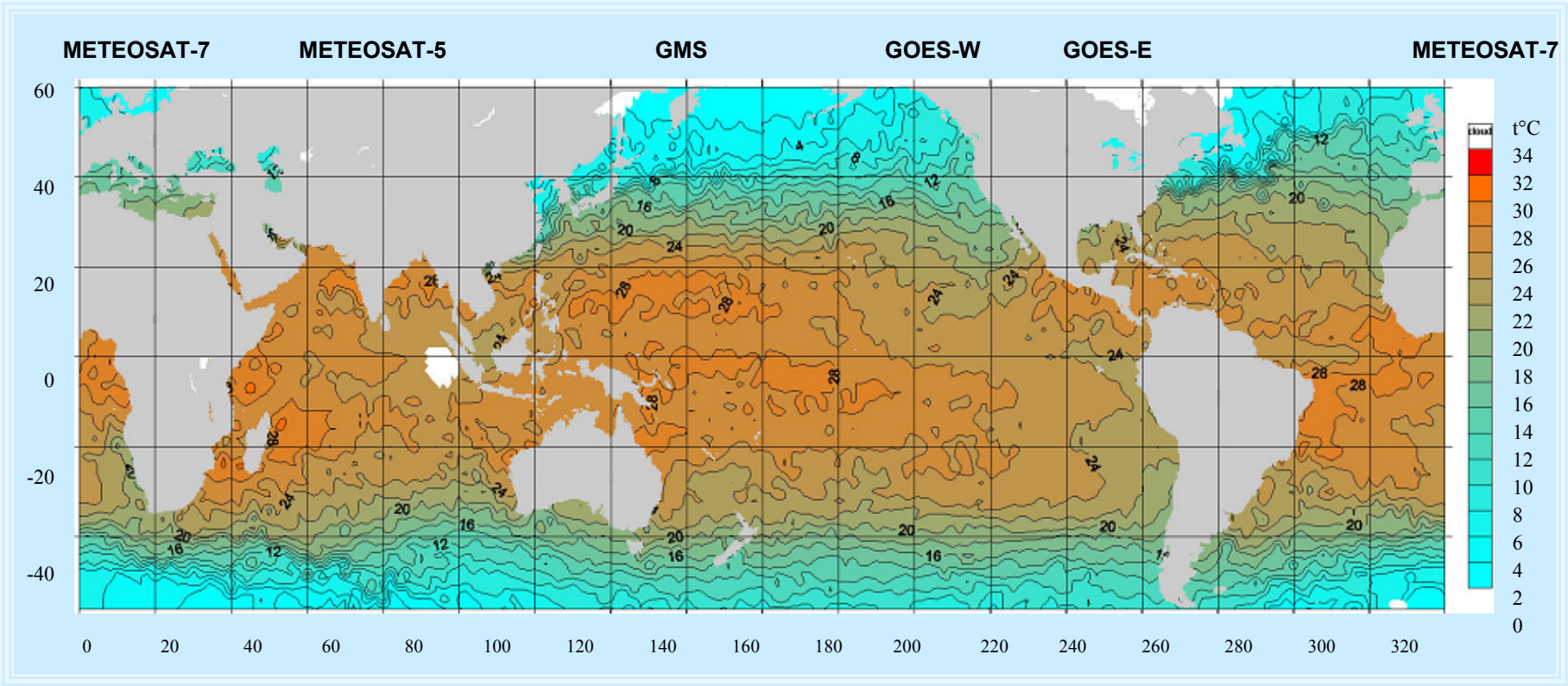
ROSHYDROMET CORE GROUND SEGMENT



GLOBAL OBSERVING IMAGE

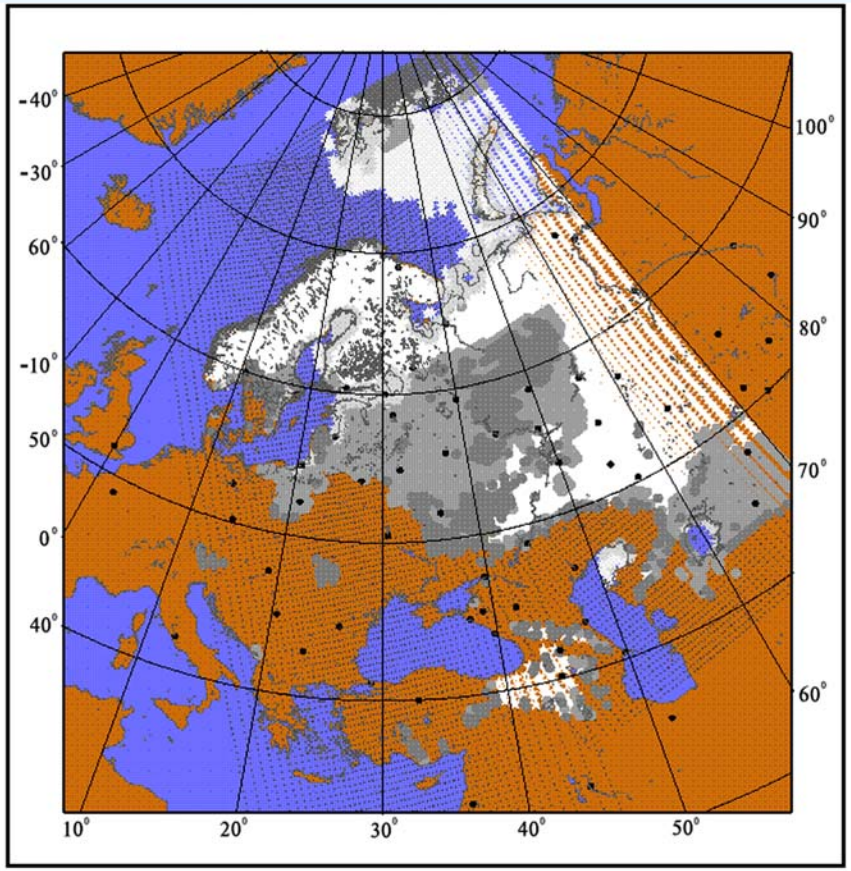


GLOBAL SEA SURFACE TEMPERATURE IMAGE MAP



SST MAP COMPOSED FROM METEOSAT, GOES, GMS DATA

AMSU+AVHRR-BASED SNOW- ICE COVER MAP

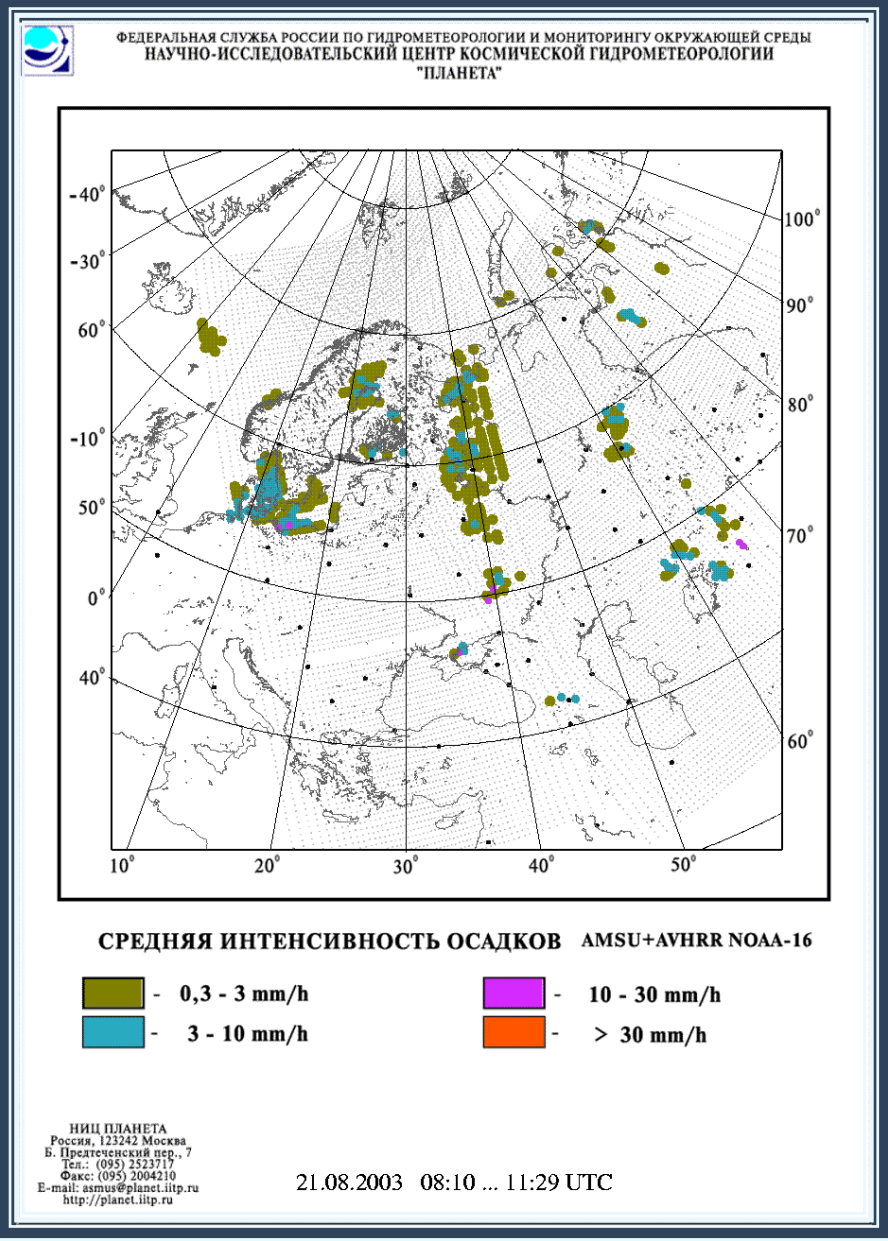


СНЕЖНЫЙ И ЛЕДОВЫЙ ПОКРОВ. NOAA-16 /AMSU/

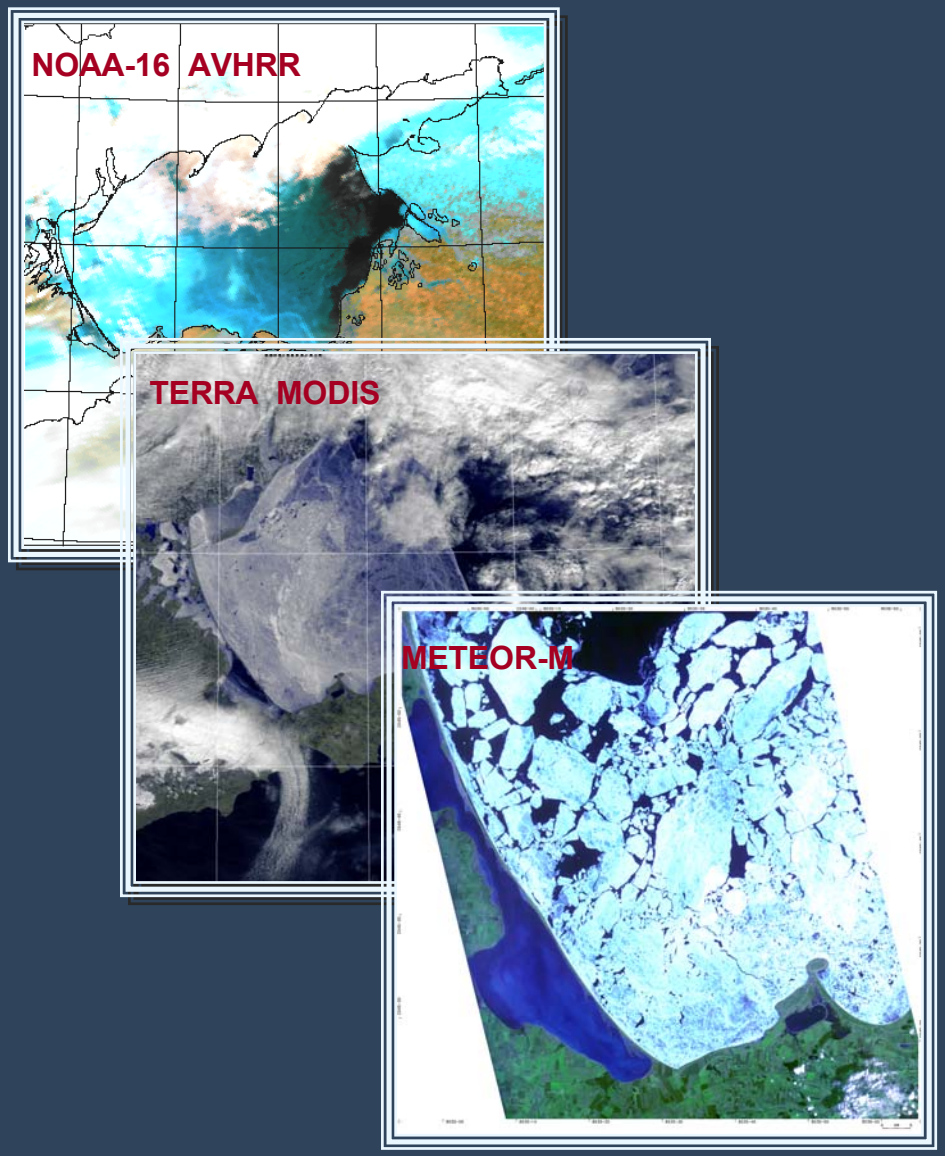
- снег или молодой лед
- снег тает или лежит местами\ или битый лед
- снег быстро тает
-многолетний лед
-смешанная область снег/лед
-суша без снега
-открытая вода

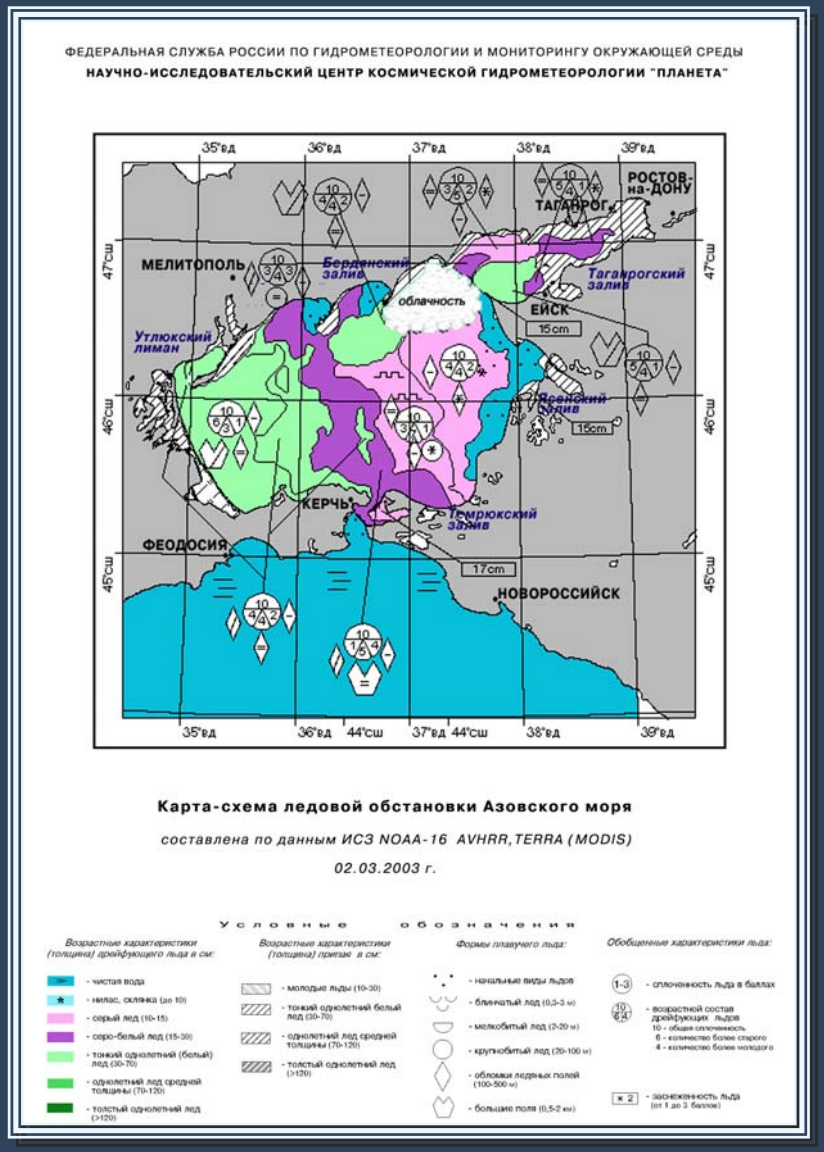
31.03.2003 09:47 ... 11:26 UTC

AMSU+AVHRR-BASED RAIN MAP



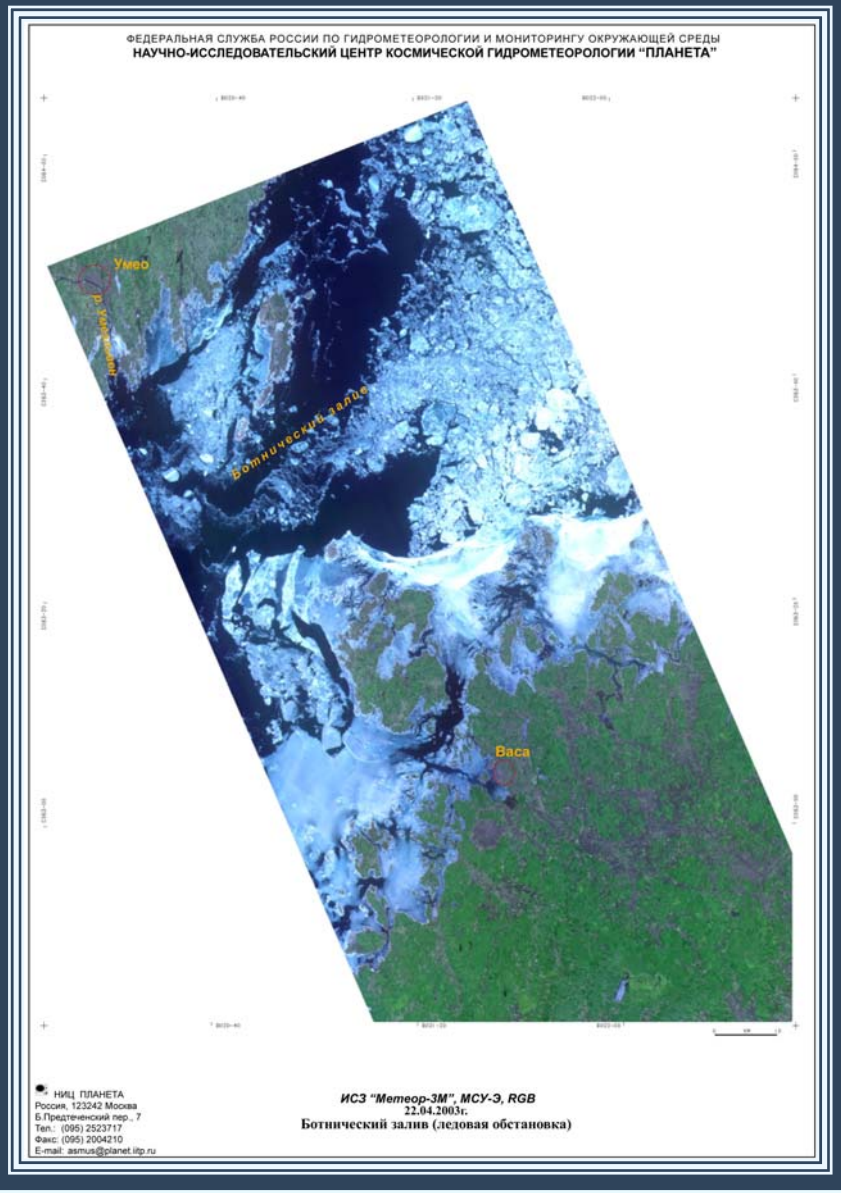
SEA ICE CONDITION CHART OF THE AZOV SEA DERIVED FROM NOAA-16 AVHRR, TERRA MODIS, METEOR-3M MSU-E .





ICE COVER MONITORING, BALTIC SEA.

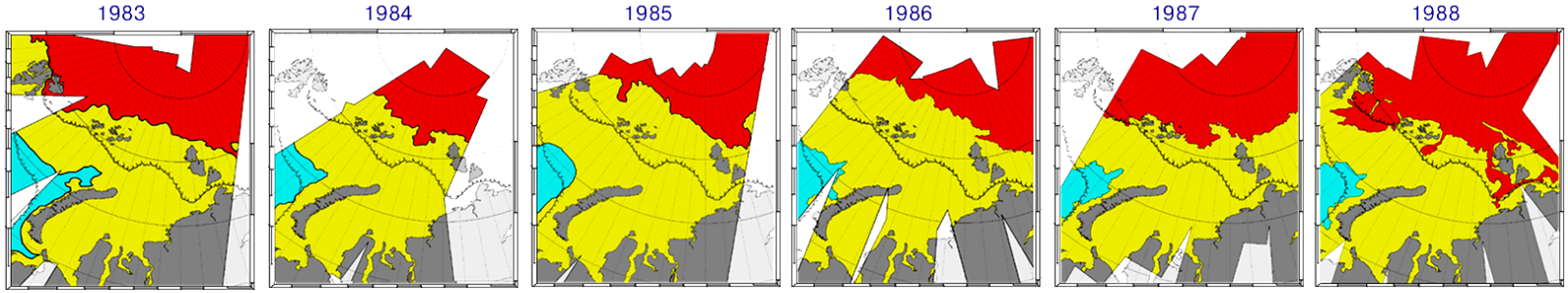
METEOR-3M N1, MSU-E, 22.04.2003



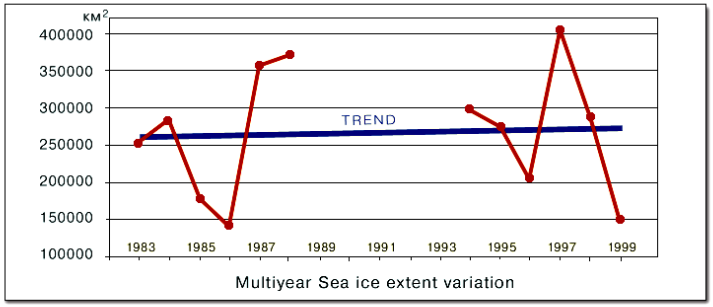
ICE COVER MONITORING, VOLGA RIVER.
METEOR-3M N1, MSU-E, 14.04.2003

SATELLITE RADAR DATA APPLICATION TO WESTERN ARCTIC SEA ICE COVER CLIMATOLOGICAL STUDIES

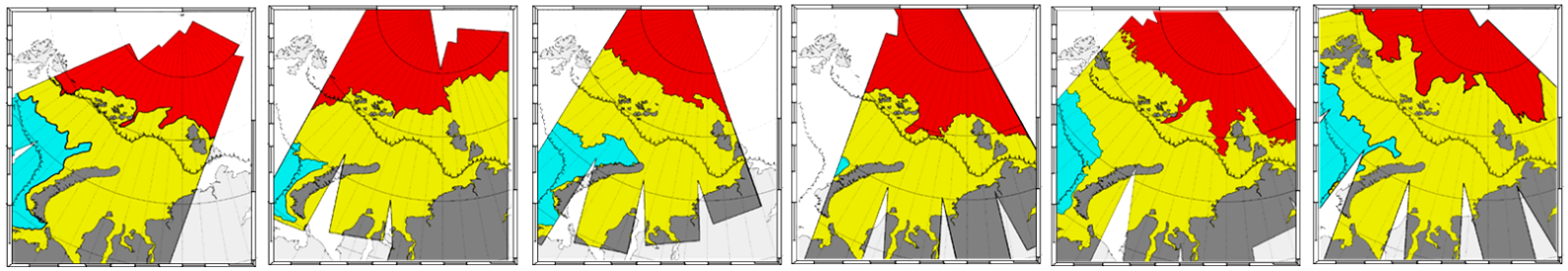
Satellite radar data application to Western Arctic sea ice cover climatological studies



Multiyear sea ice cover extent is estimated within the area between southern multiyear ice boundary and 85°N and between 40°E-105°E



Multiyear sea ice in Western Arctics covered in 1990th 10% more then in 1980th



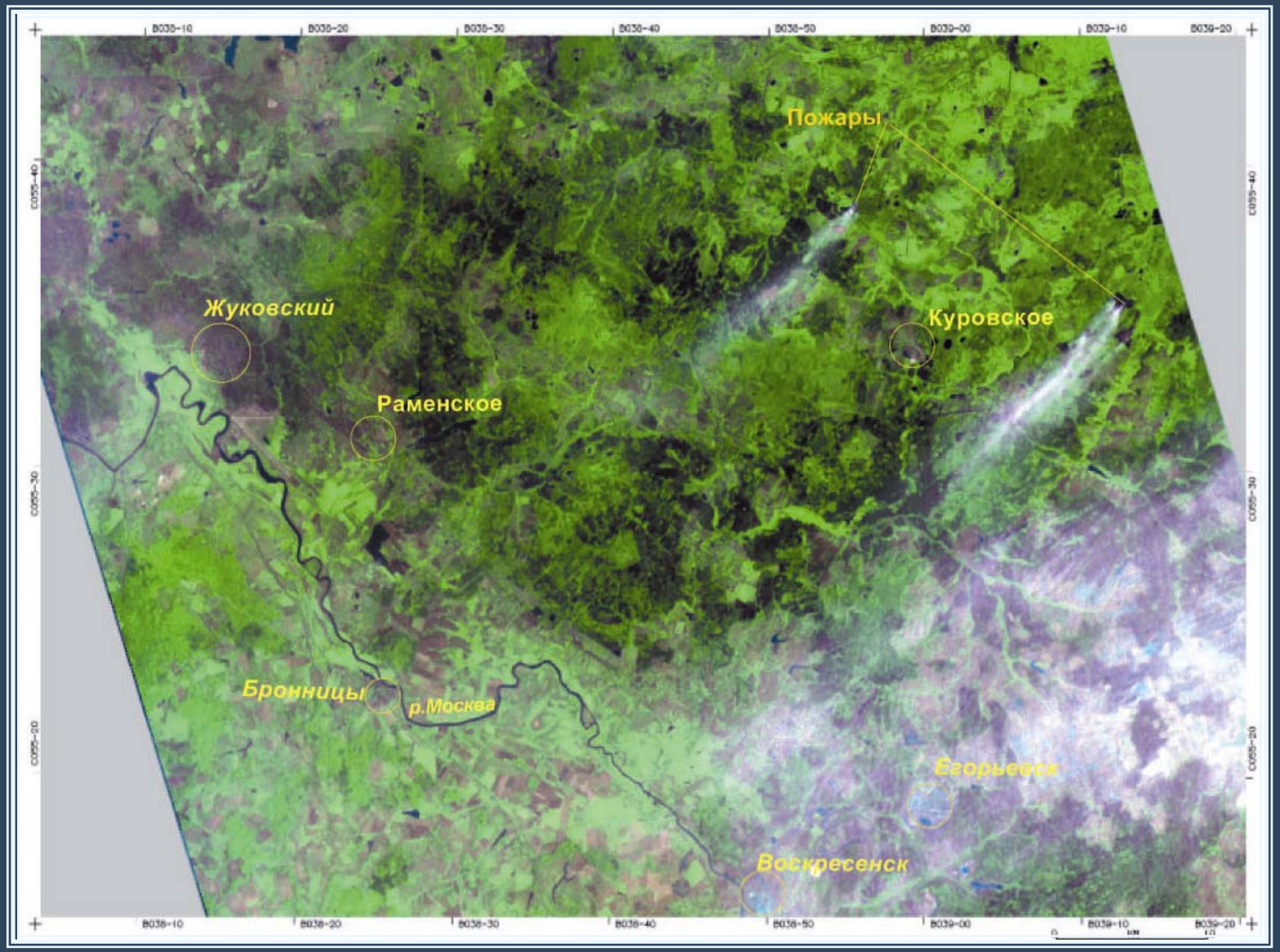
Dynamics of Western Arctic floating ice distribution in 1983 - 1999 using OKEAN-O1 SLR data

- Earth surface
- Multiyear ice
- First year ice
- Open water

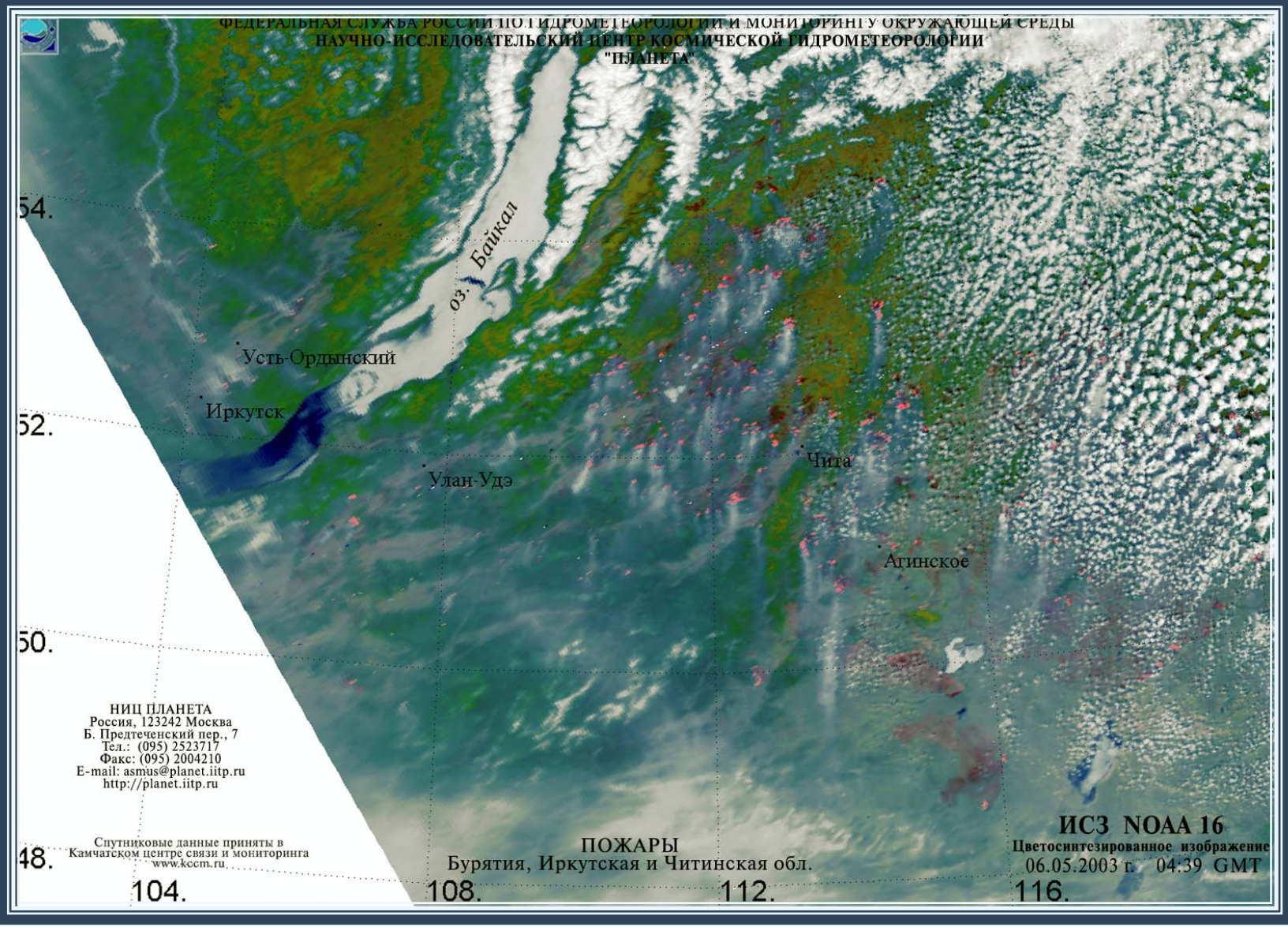
a b - Borders of minimal (a) and maximal (b) zone of floating ice distribution (on the base of cartographic data)

DETECTION OF FOREST FIRES AND SMOKES, MOSCOW REGION

METEOR-3M N1, MSU-E, 30.07.2002

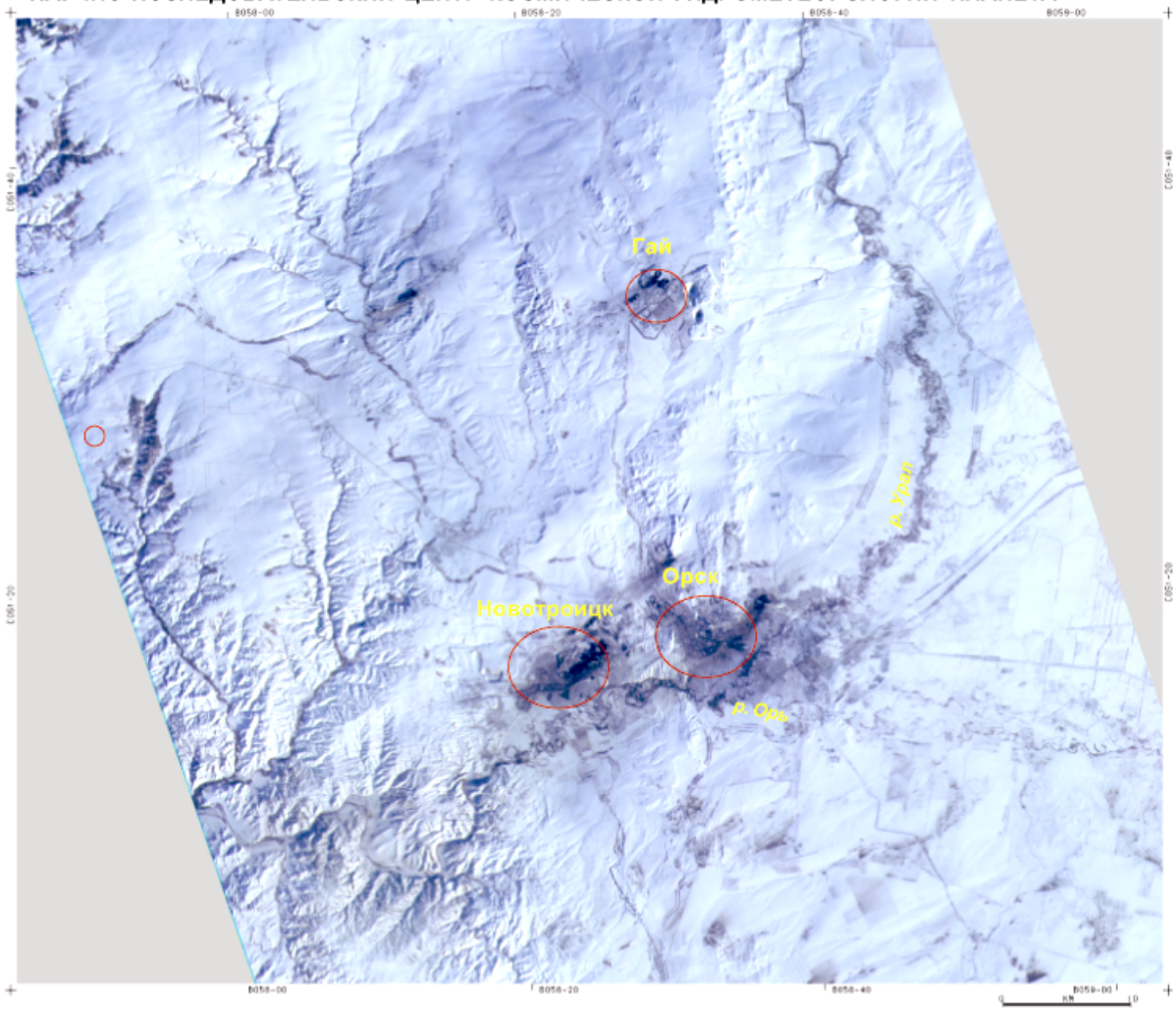


DETECTION OF FOREST FIRES, SMOKES AND BURNINGS, EAST SIBERIA, NOAA, AVHRR 06.05.2003



DETECTION OF SNOW POLLUTION

ФЕДЕРАЛЬНАЯ СЛУЖБА РОССИИ ПО ГИДРОМЕТЕОРОЛОГИИ И МОНИТОРИНГУ ОКРУЖАЮЩЕЙ СРЕДЫ
НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ЦЕНТР КОСМИЧЕСКОЙ ГИДРОМЕТЕОРОЛОГИИ"ПЛАНЕТА"



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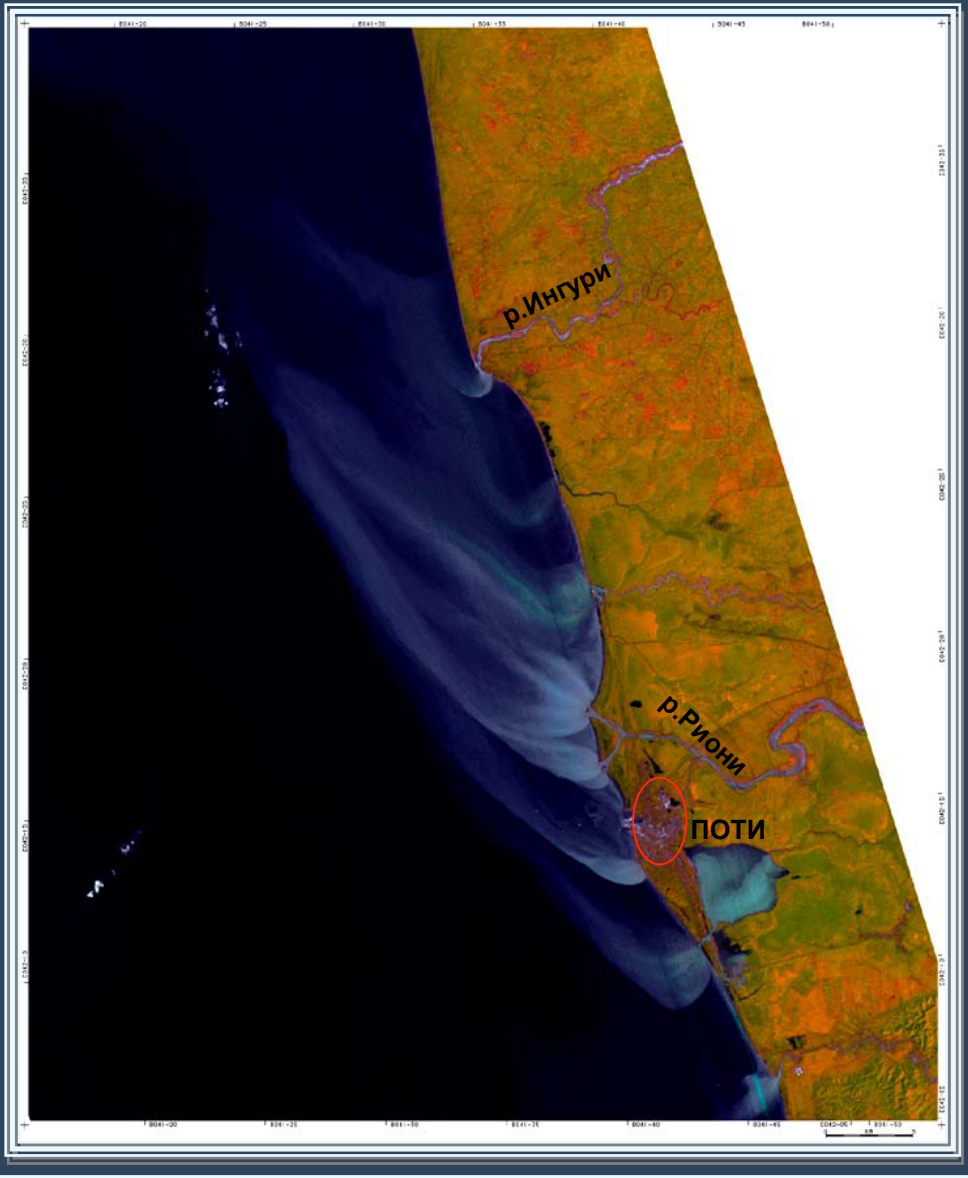
ИСЗ "Метеор-3М", МСУ-Э, RGB
13.02.2003г.
Башкирия (г. Орск)

POLLUTION MAP BLACK SEA

METEOR-3M N1, MSU-E, 22.09.2003