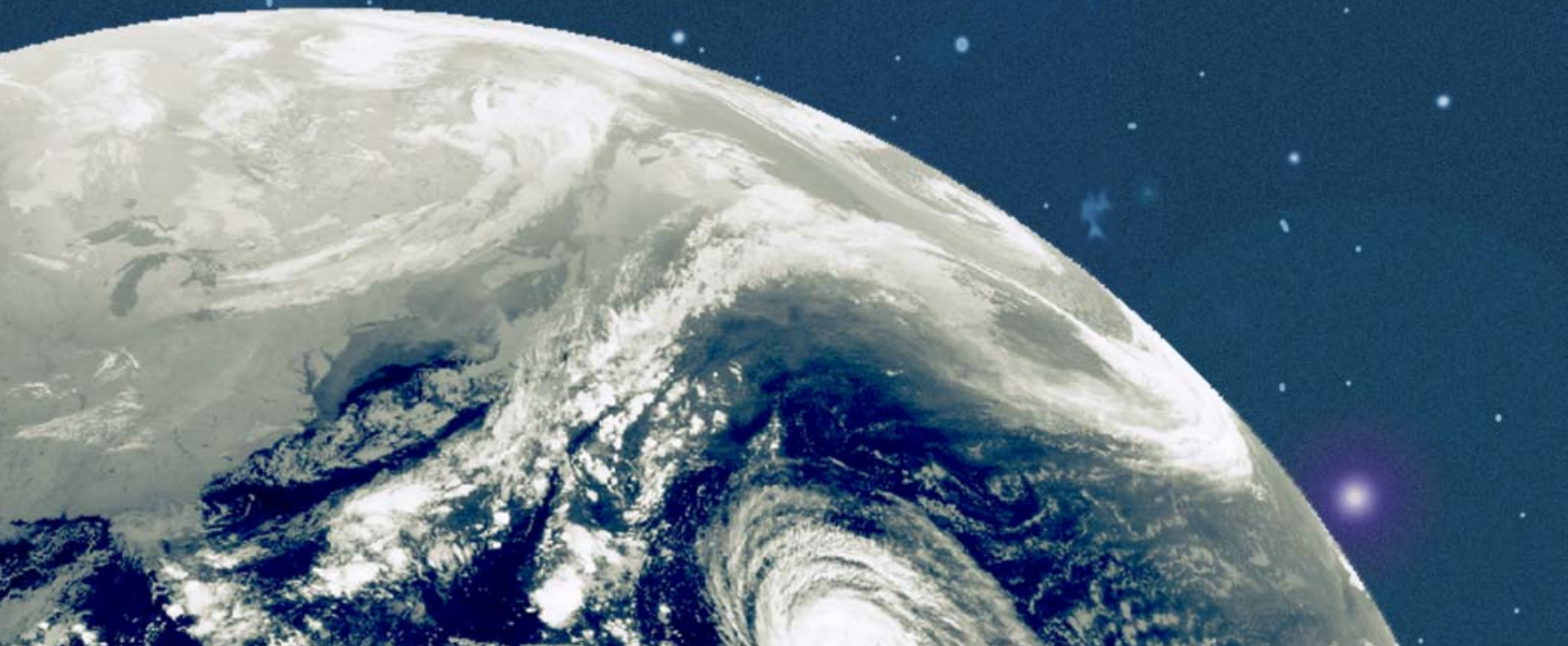


# **RUSSIAN ENVIRONMENTAL SATELLITES: CURRENT STATUS AND DEVELOPMENT PERSPECTIVES**

**Uspensky A.B.,\* Asmus V.V\*., Dyaduchenko V.N\*\*., Milekhin O.E\*.**

**\*State Scientific and Research Center «Planeta», Russia**

**\*\*Russian Federal Service on Hydrometeorology and Environmental Monitoring**



**THE 13<sup>th</sup> 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
<b>MSU-MR</b>	Global and regional cloud cover mapping, SST, LST, ...	0.5 – 12.5 $\mu\text{m}$ (6 channels)	3000	1 x 1
<b>KMSS multichannel scanning unit</b>	Earth surface monitoring	0.4-0.9 $\mu\text{m}$	100	0,1
<b>MTVZA imager/sounder</b>	Atmospheric temperature and humidity profiles, sea surface wind	10.6-183.3 GHz (26 channels)	2600	12 – 75
<b>IRFS-2 advanced IR sounder</b>	Atmospheric temperature and humidity profiles	5-15 $\mu\text{m}$	2000	35
<b>Severjanin (active radar)</b>	Ice monitoring	9500-9700 MHz	450	0.7 x 1.0
<b>Radiomet* (radio occultation unit)</b>	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	<u>52-57</u>	91.6	<u>183</u>
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)	75x13 6	68x12 4	45x82	41x 75	36x65	32x 58	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								

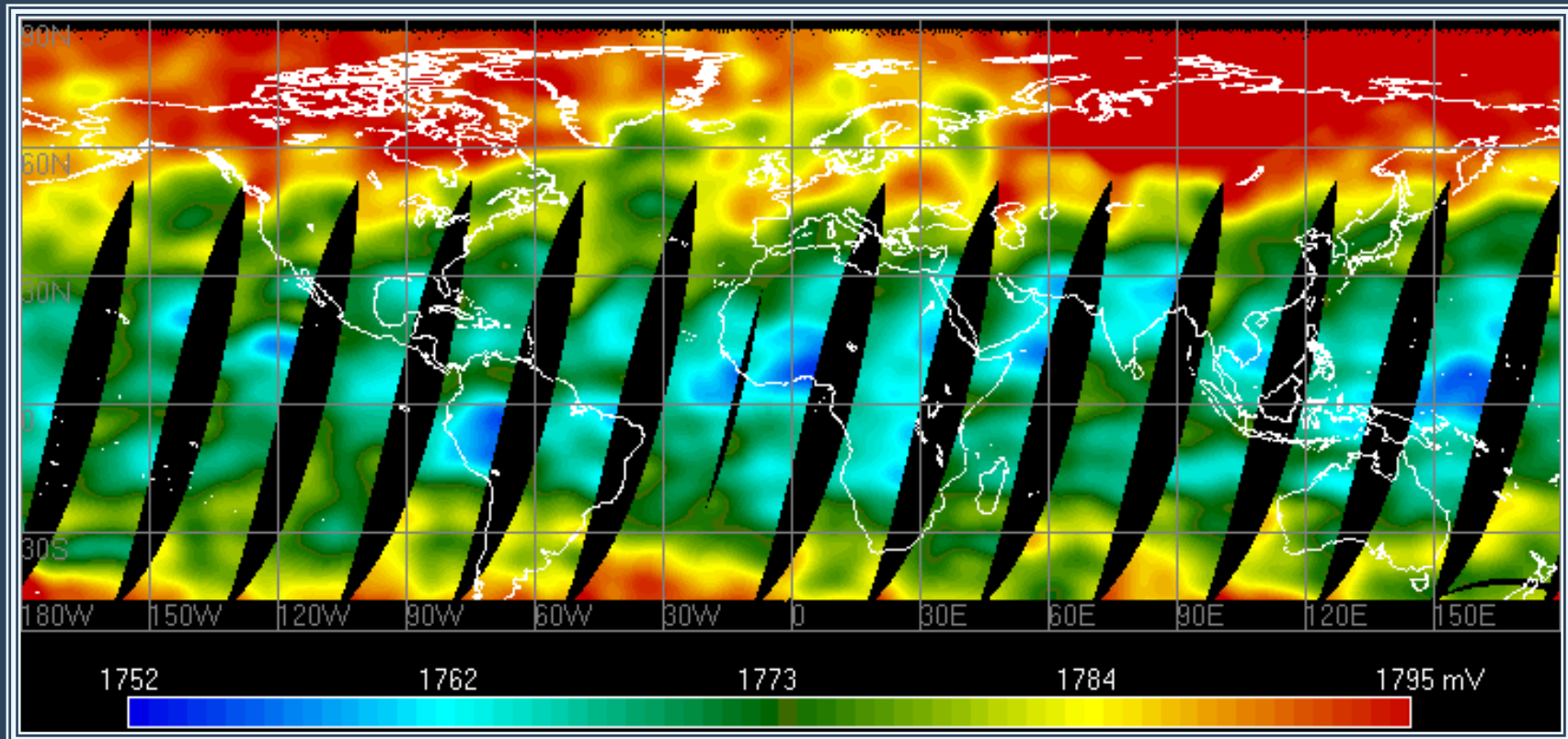
# MICROWAVE IMAGER/SOUNDER MTVZA

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



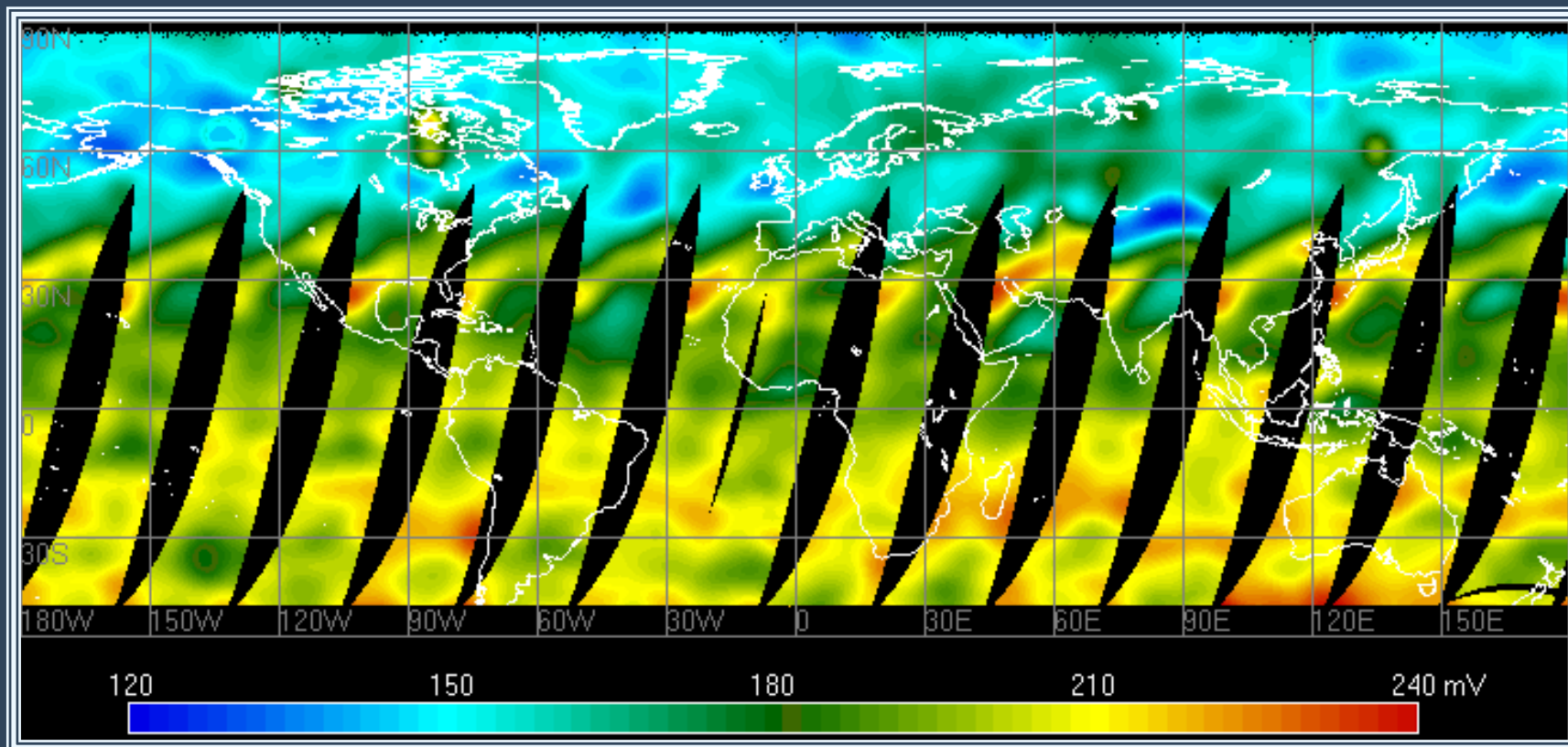
# GLOBAL MOZAIC OF MTVZA DATA

## 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	Bandwidth (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

No	Parameter	Units	Value
1	Spectral range: wavelength wave number	$\mu\text{m}$ $\text{cm}^{-1}$	5-15 200 0-665
2	Reference channel wavelength	$\mu\text{m}$	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)
<b>RLSBO – Side Looking Radar</b>	<b>Sea ice mapping,  snow coverage,  Earth surface monitoring</b>	3.2 cm	450	1,3 x 2,5
<b>RM-08 MW imager</b>	<b>Sea ice mapping</b>	0.8 cm	550	25
<b>MSU-M Optical imager (low resolution)</b>	<b>Earth surface monitoring</b>	4 channels: 0.5 – 0.6, 0.6–0.7, 0.7–0.8, 0.8–1.1 $\mu\text{m}$	2000	1.7
<b>MSU-EU Optical imager (high resolution)</b>	<b>Earth surface monitoring</b>	3 channels: 0.5 – 0.6, 0.6–0.7, 0.8–1.1 $\mu\text{m}$	45	0,045
<b>MTVZA OK Combined MW and optical imager/sounder</b>	<b>Atmospheric temperature and humidity profiling, monitoring of ice and snow, sea surface wind speed TPW, CLW, precipitation, ocean colour</b>	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;	2000	20 – 200 for MW, 1.1 for VIS/IR
<b>“Variant” unit</b>	<b>Heliogeophysics Space environment monitoring</b>	0.58-0.68; 0.68-0.78; 3.55-4.0 $\mu\text{m}$	-	-

# OPTICAL - MICROWAVE IMAGER/SOUNDER MTVZA -OK

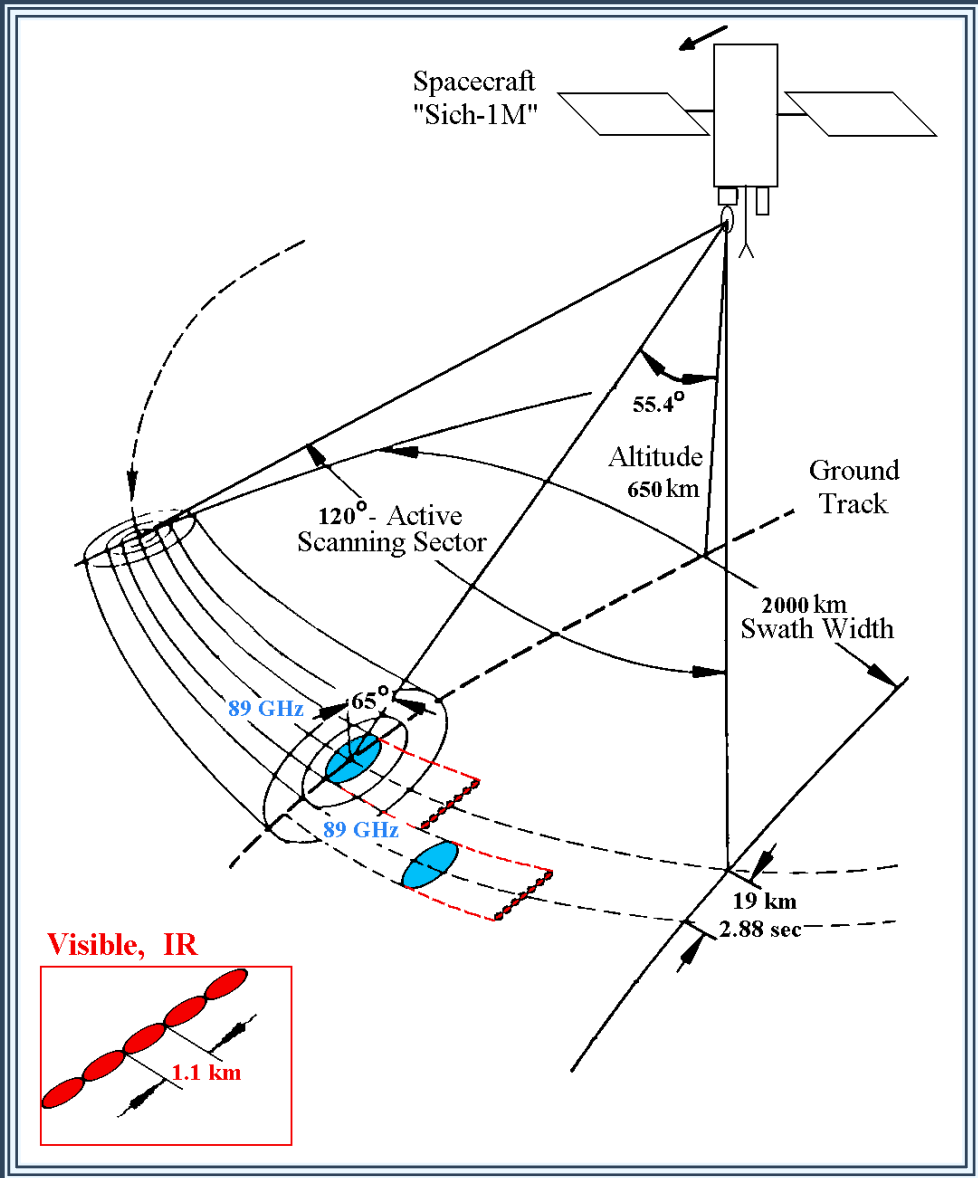
(Spacecraft «Sich-1M», Launched 2004)



# MTVZA-OK PERFORMANCE CHARACTERISTICS

System	Optical	Microwave
	<b>Spectral Range (micrometers):</b>  0.37-0.45 0.45-0.51 0.58-0.68 0.68-0.78	<b>Frequency (GHz):</b>  6.9, 10.6 18.7, 23.8 31, 36.5 42, 48 <u>52.3-57.0</u>
Spatial Resolution (km)	3.55-3.93    1.1	89            12-260 <u>183.31</u>
Swath Width (km)	2000	
Data Rate (kbps)	665.4	
<b>Conical Scanning</b> Period (sec)	2.88	
<b>Instability Scanning</b> Period	10 <sup>-4</sup>	
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 $\mu\text{m}$
Spatial resolution	1 m

•Multichannel mode

Spectral bands	0.5 – 0.6; 0.6 – 0.7; 0.7 – 0.8 $\mu\text{m}$
Spatial resolution	2 - 3 m

•Swath width 28.3 km

## MONITOR-E SATELLITE (2004)

(Sun-synchronous circular orbit with the orbit inclination  $97.5^\circ$  at an altitude about 540 km).

The instruments payload includes two imagers

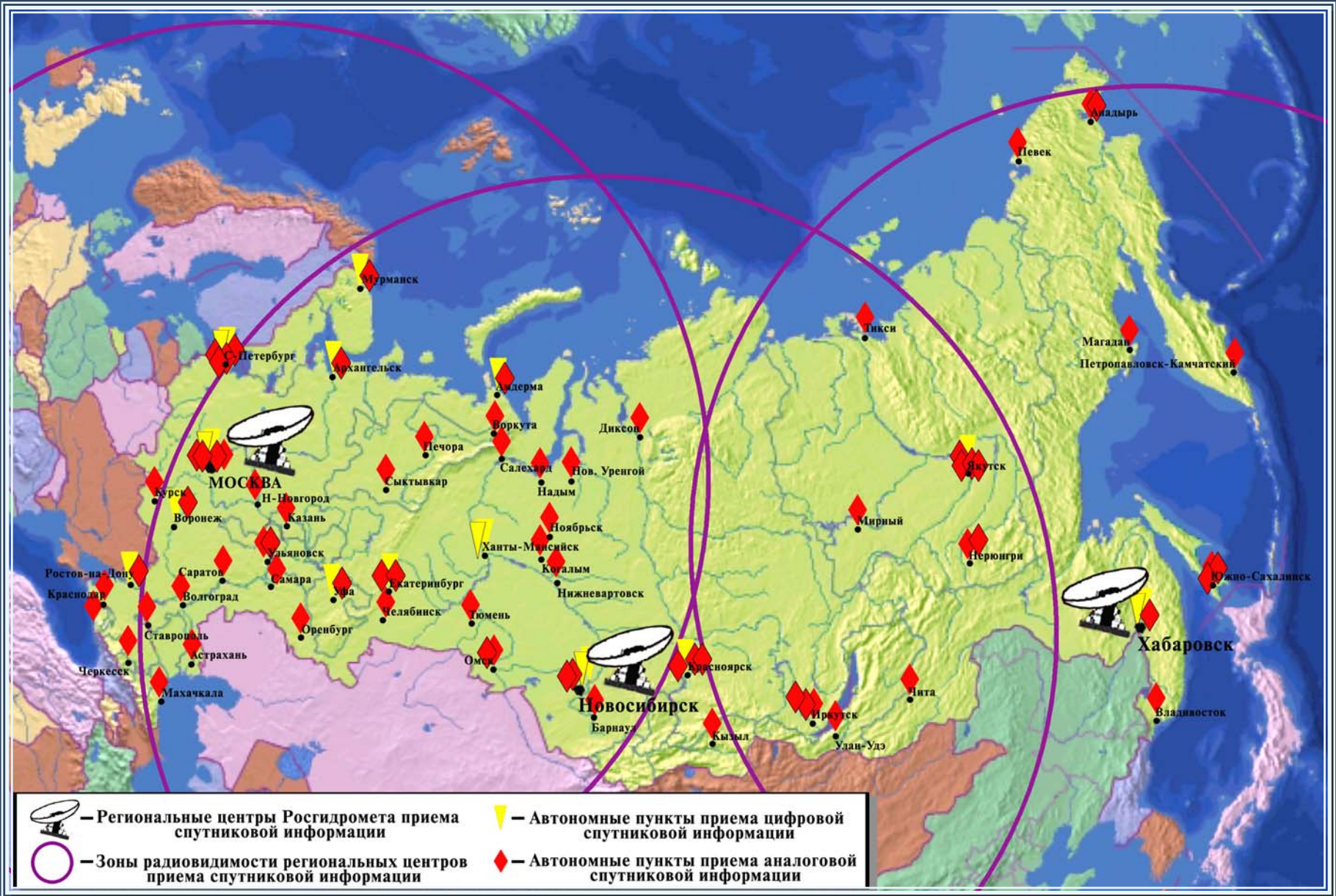
- Panchromatic imager





Spectral band	0.58 – 0.8 $\mu\text{m}$
Spatial resolution in nadir	8 m
Swath width	93.8 km

- Multichannel imager

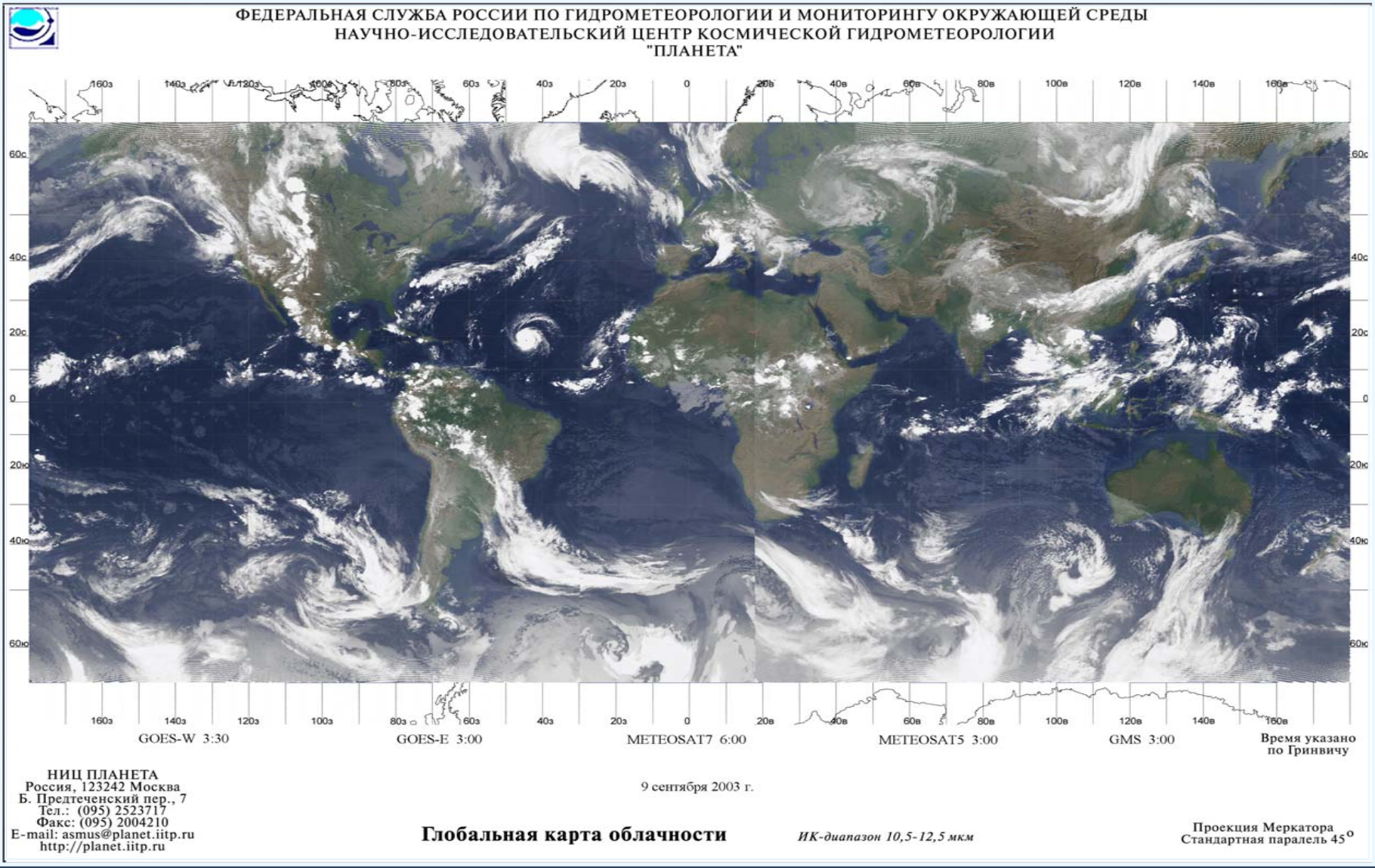
Spectral bands	0.54 – 0.59; 0.63 – 0.68; 0.79 – 0.9 $\mu\text{m}$
Spatial resolution in nadir	20 m
Swath width	160 km

# ROSHYDROMET CORE GROUND SEGMENT

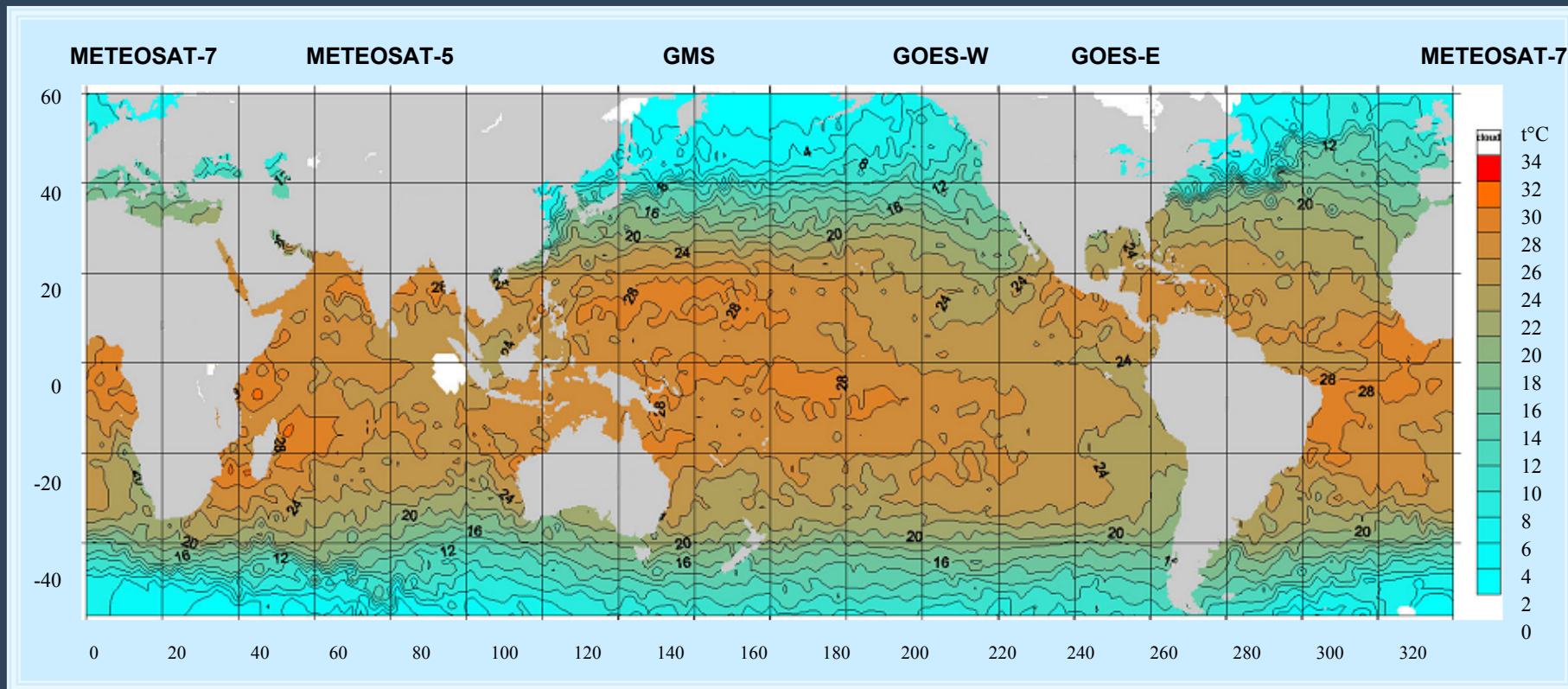


	— Региональные центры Росгидромета приема спутниковой информации		— Автономные пункты приема цифровой спутниковой информации
	— Зоны радиовидимости региональных центров приема спутниковой информации		— Автономные пункты приема аналоговой спутниковой информации

# GLOBAL OBSERVING IMAGE

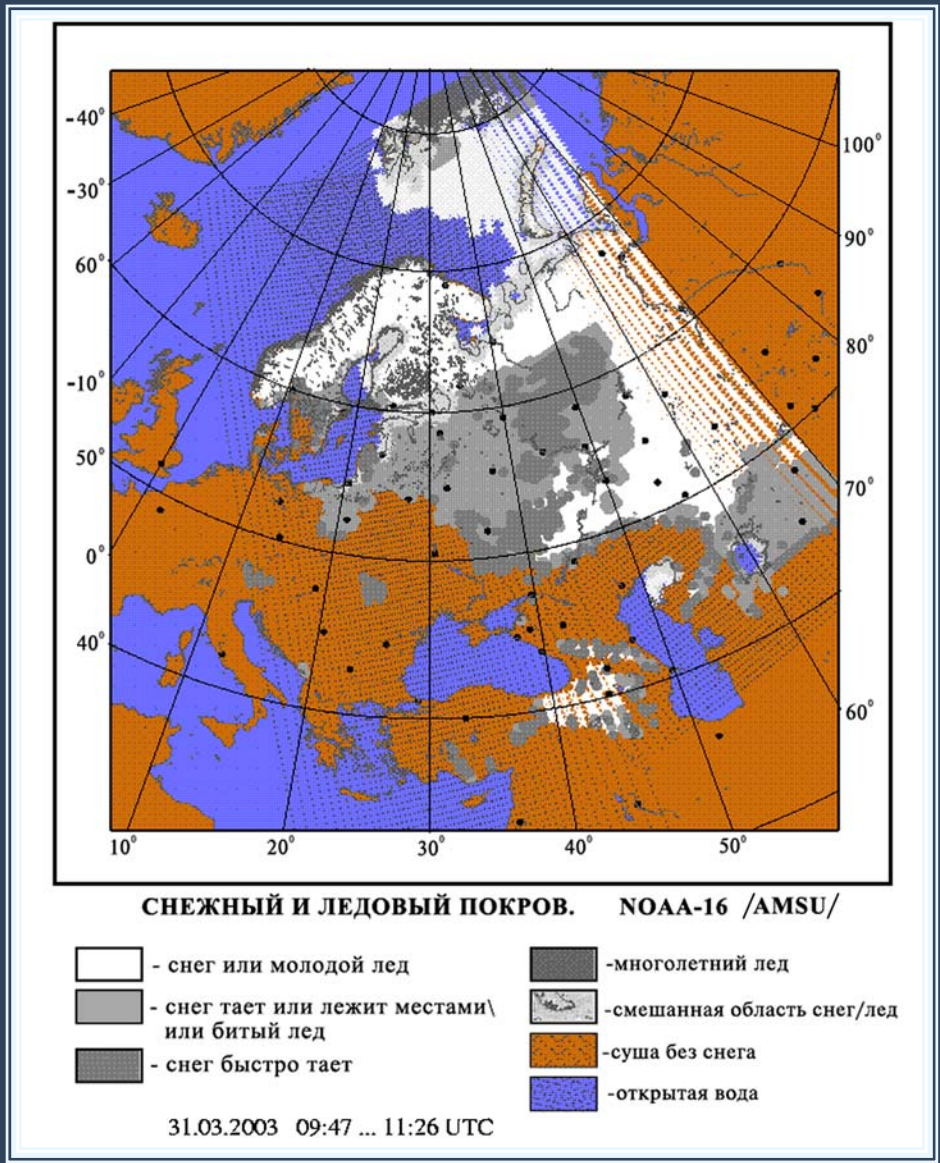


# GLOBAL SEA SURFACE TEMPERATURE IMAGE MAP

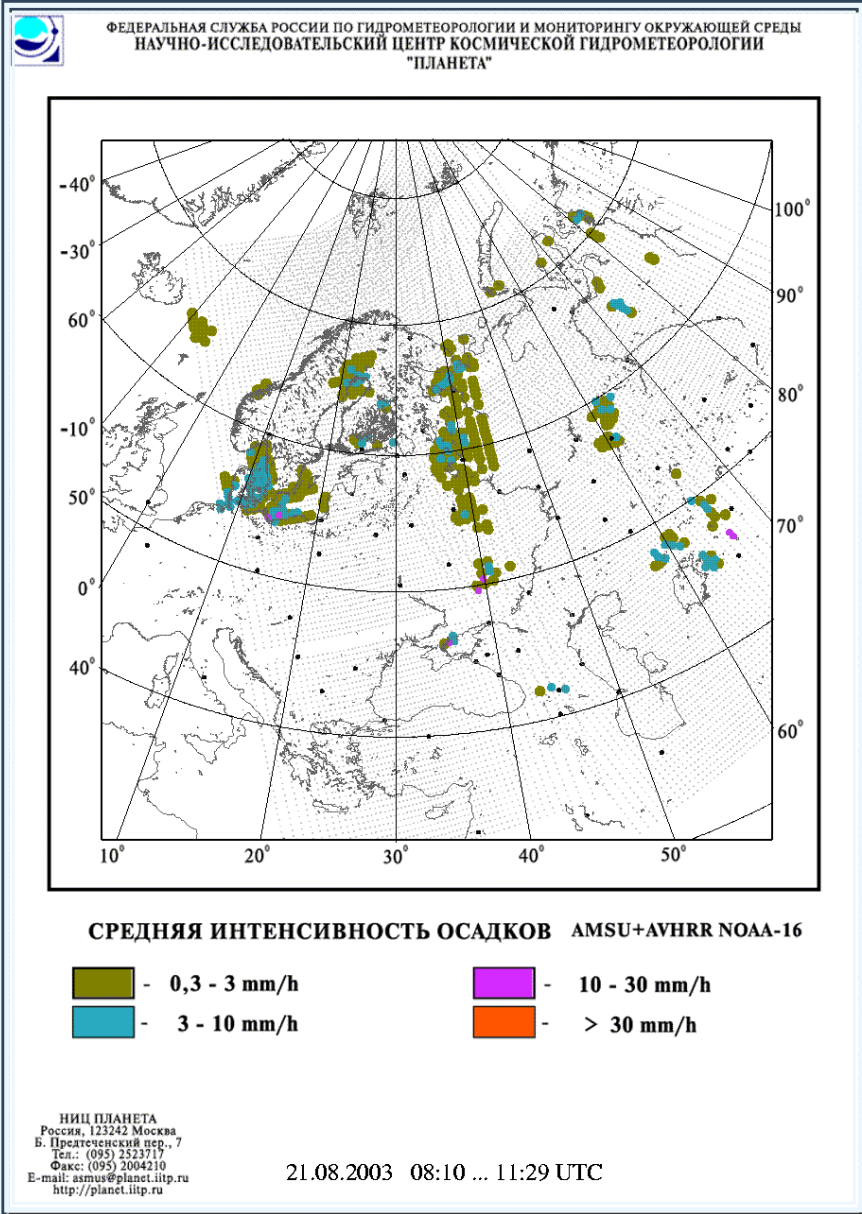


SST MAP COMPOSED FROM METEOSAT, GOES, GMS DATA

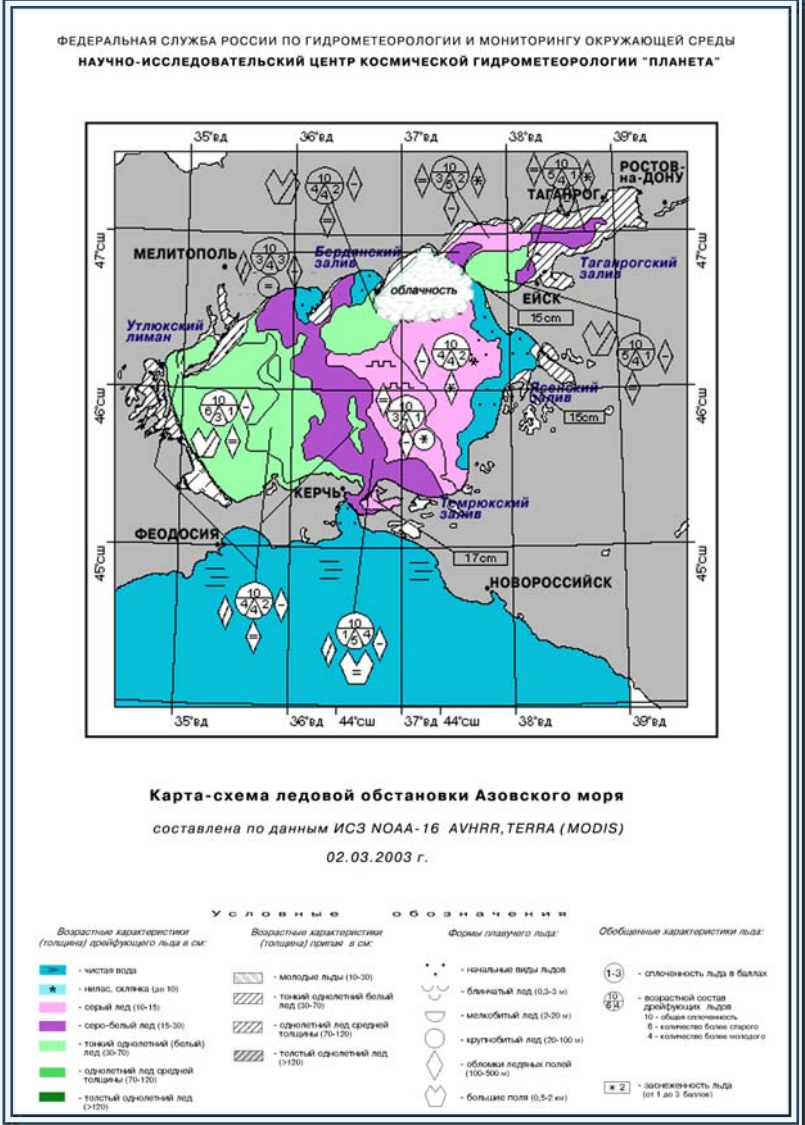
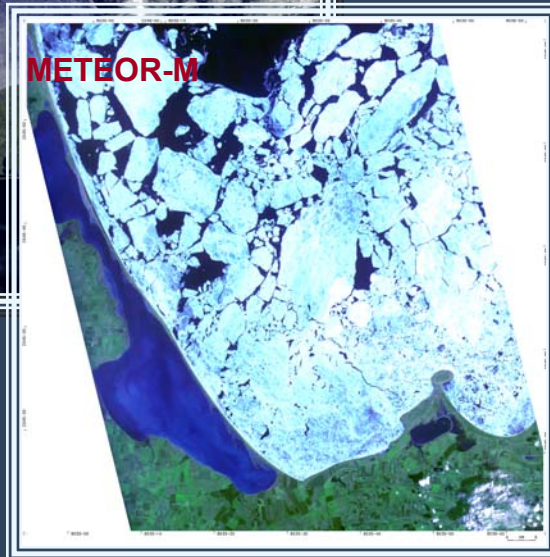
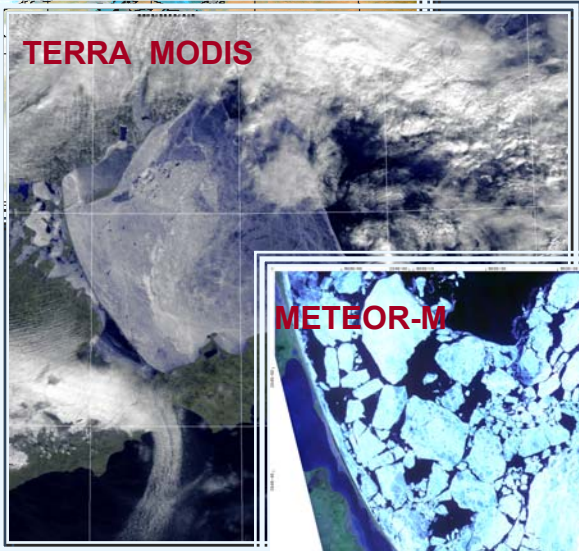
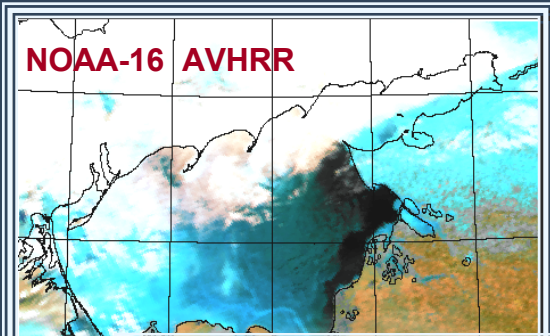
# AMSU+AVHRR-BASED SNOW-ICE COVER MAP



# AMSU+AVHRR-BASED RAIN MAP

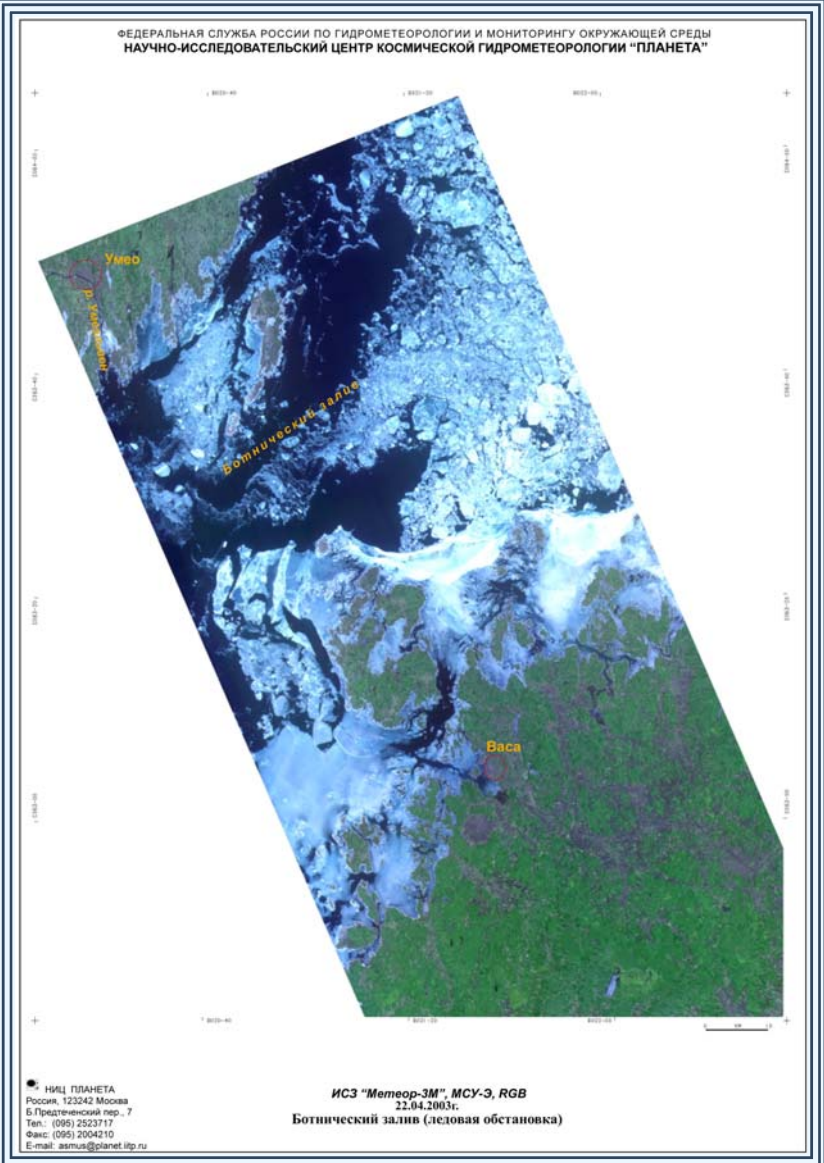


# SEA ICE CONDITION CHART OF THE AZOV SEA DERIVED FROM NOAA-16 AVHRR, TERRA MODIS, METEOR-3M MSU-E.

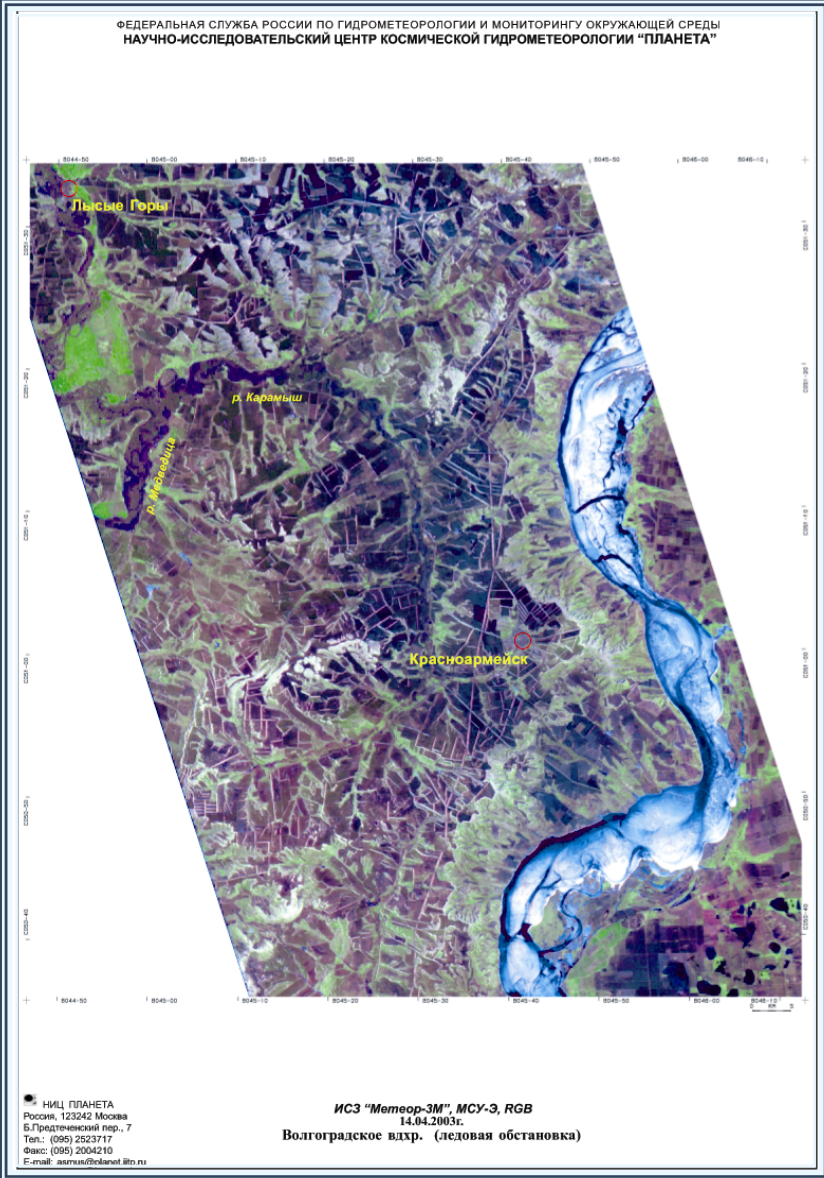




# ICE COVER MONITORING, BALTIC SEA. METEOR-3M N1, MSU-E, 22.04.2003

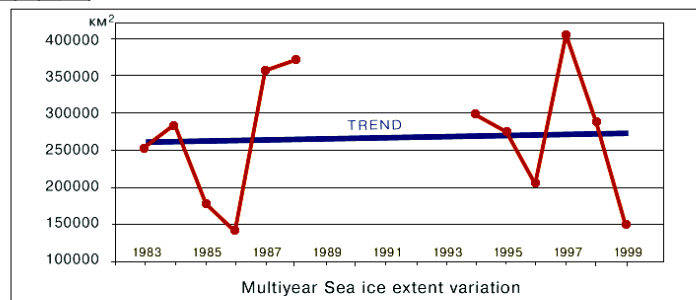
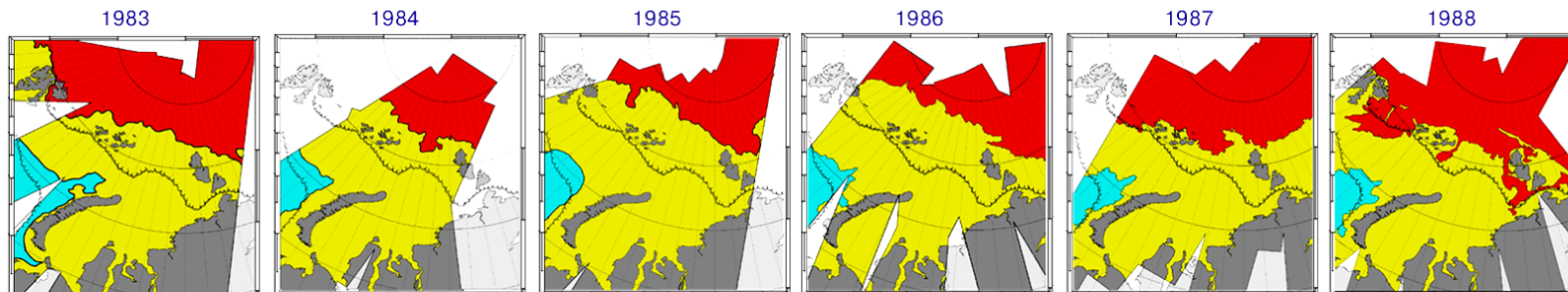


# ICE COVER MONITORING, VOLGA RIVER. METEOR-3M N1, MSU-E, 14.04.2003



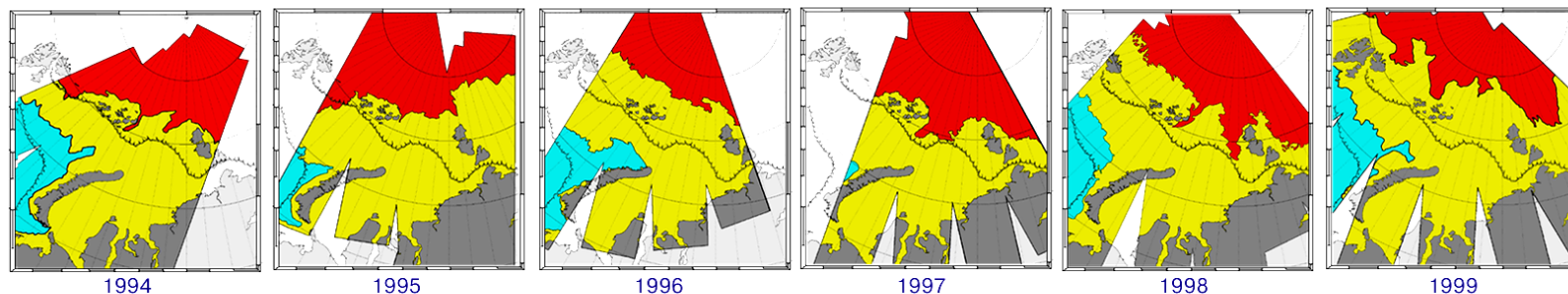
# SATELLITE RADAR DATA APPLICATION TO WESTERN ARCTIC SEA ICE COVER CLIMATOLOGICAL STUDIES

## 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

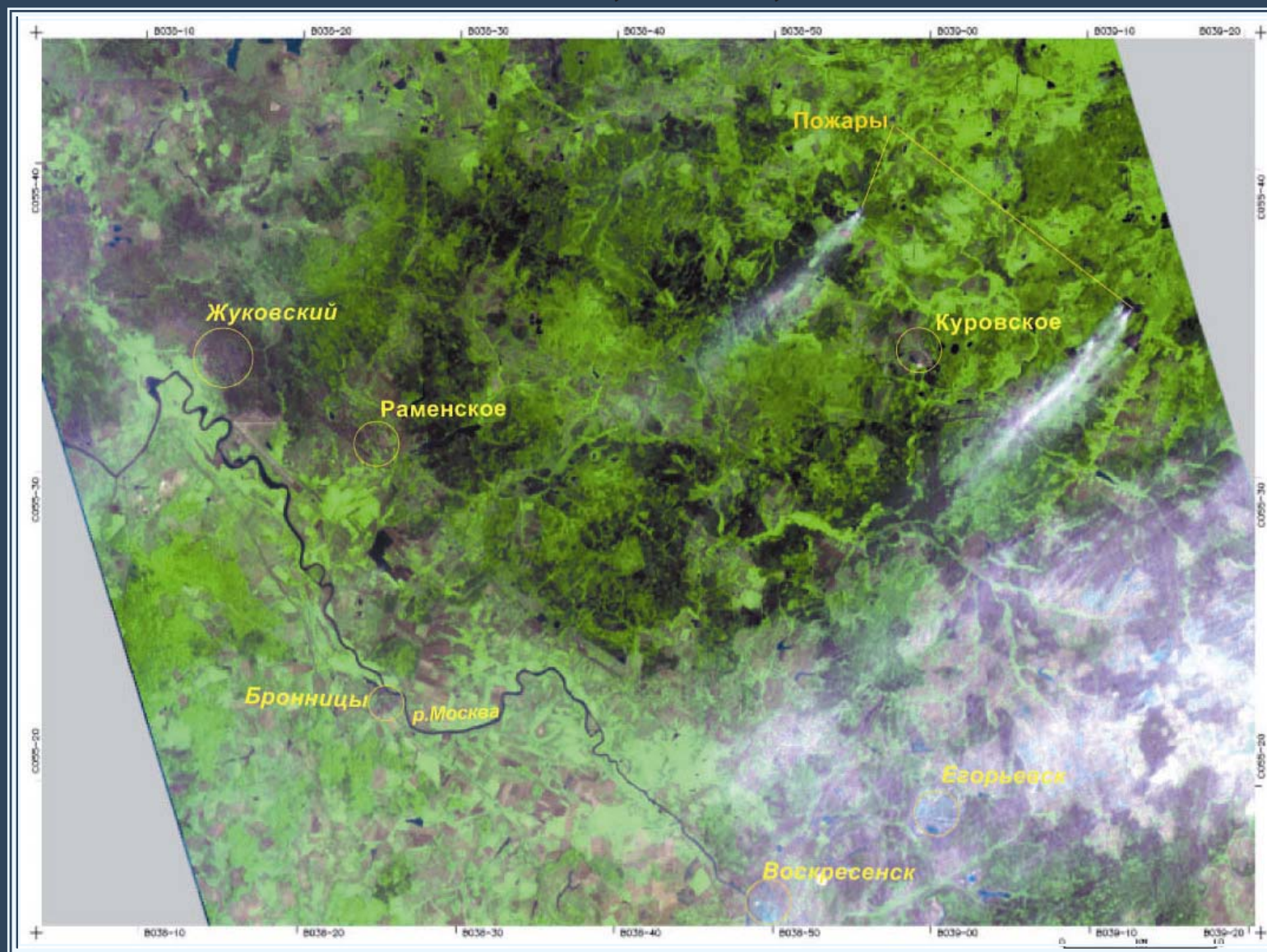
Multiyear sea ice in Western Arctics covered in 1990th 10% more then in 1980th



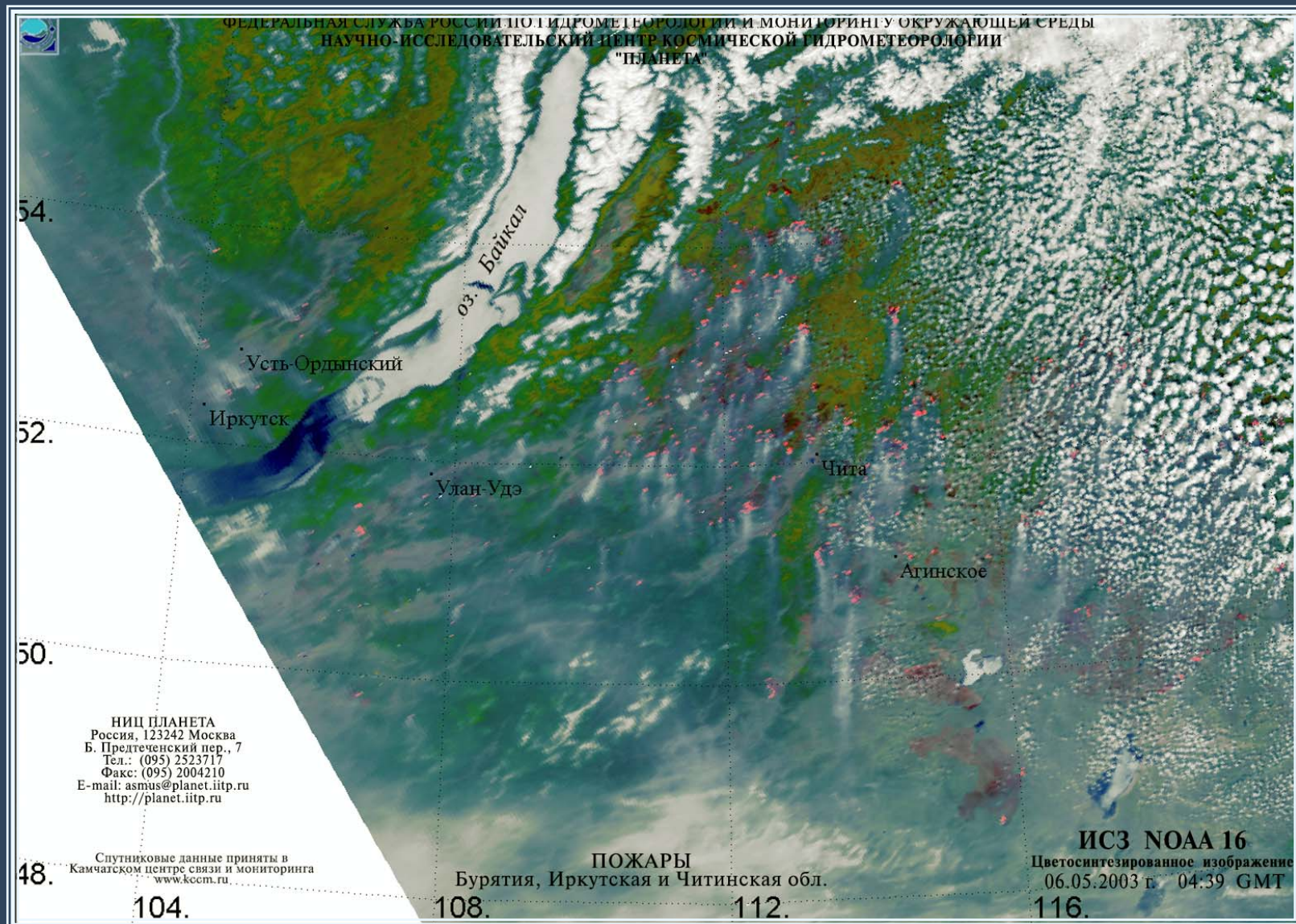
Dynamics of Western Arctic floating ice distribution in 1983 - 1999 using OKEAN-01 SLR data

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

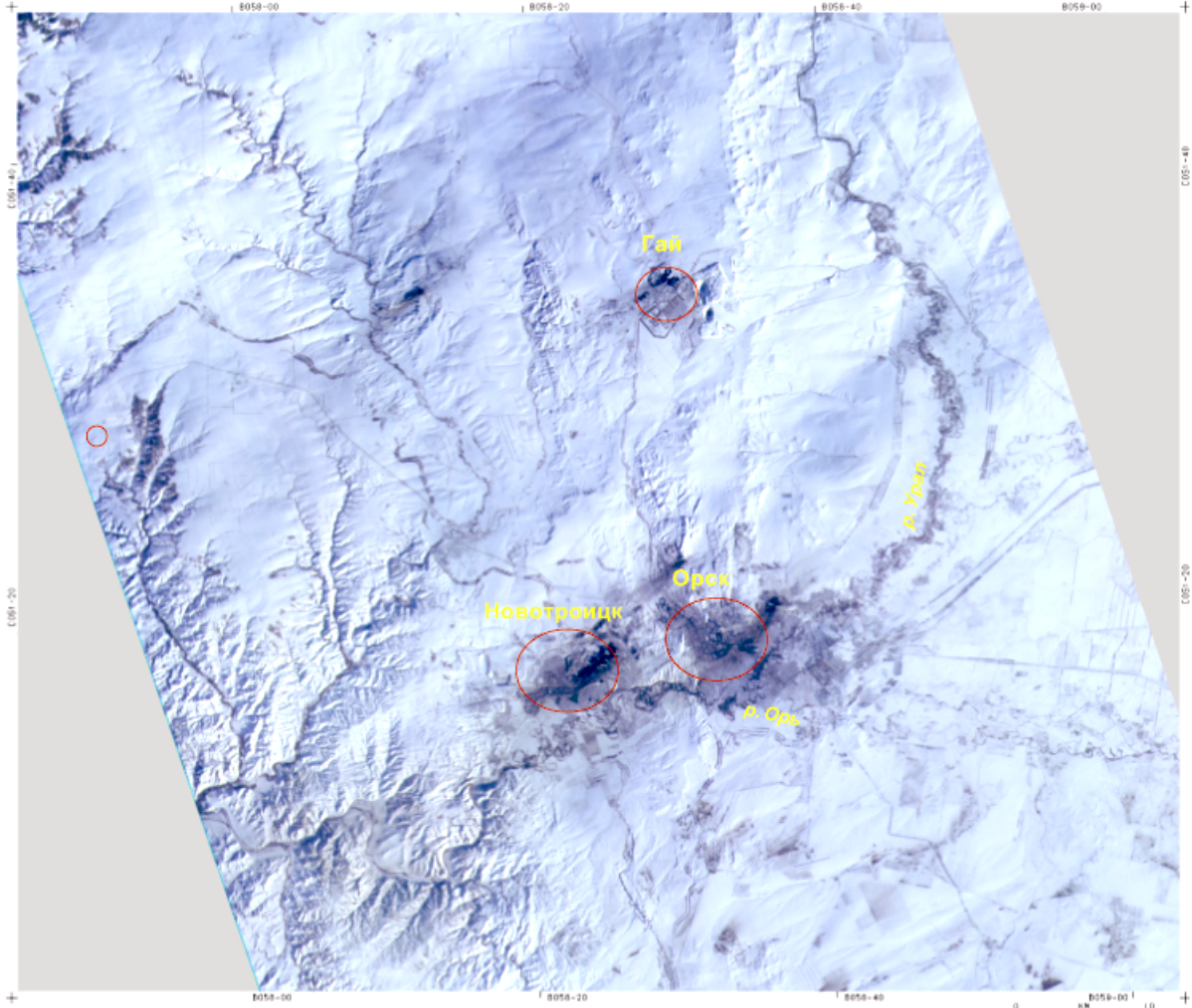


# DETECTION OF FOREST FIRES, SMOKES AND BURNINGS, EAST SIBERIA, NOAA, AVHRR 06.05.2003



# DETECTION OF SNOW POLLUTION

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

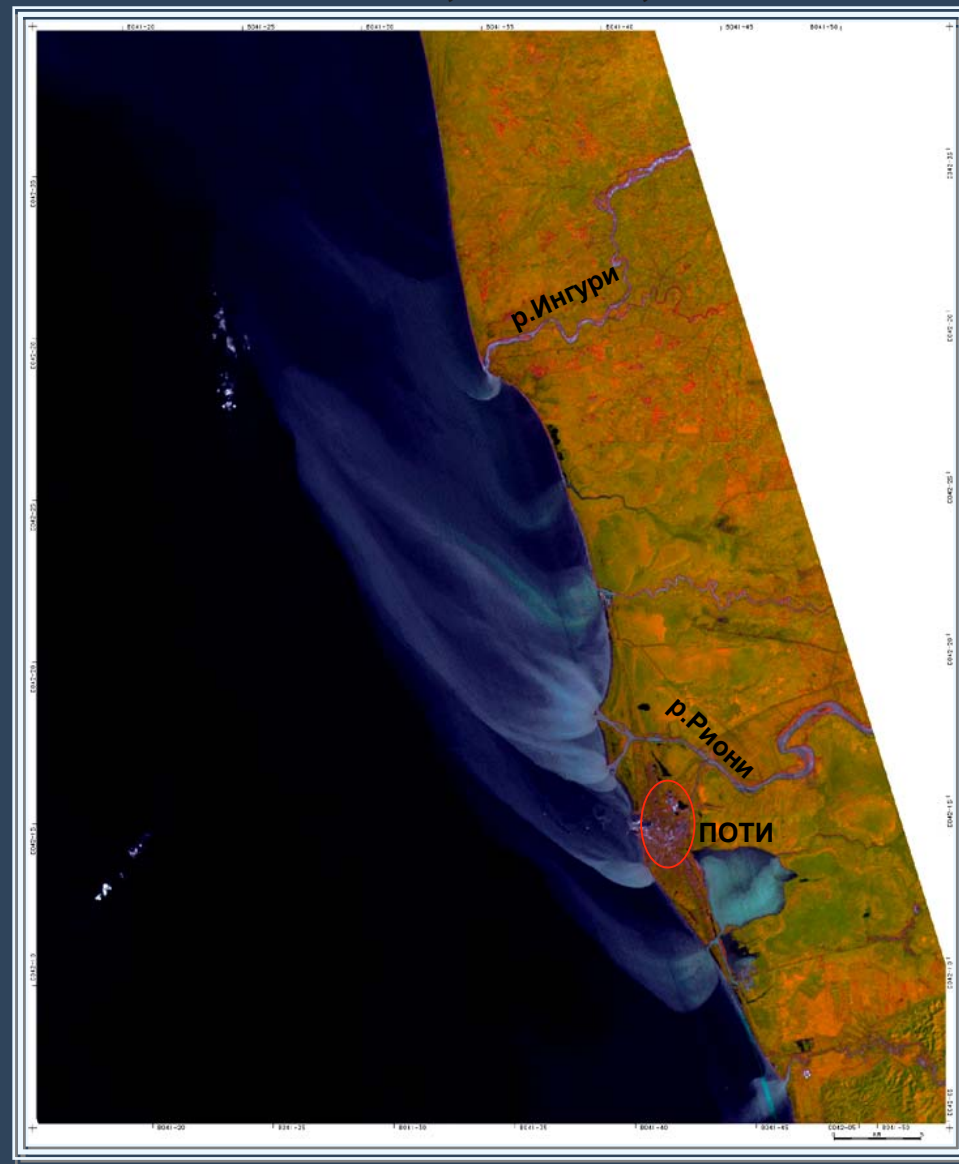


● НИЦ ПЛАНЕТА  
 Россия, 123242 Москва  
 Б.Предтеченский пер., 7  
 Тел.: (095) 2523717  
 Факс: (095) 2004210  
 E-mail: [asmus@planet.litp.ru](mailto:asmus@planet.litp.ru)

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

# POLLUTION MAP BLACK SEA

## METEOR-3M N1, MSU-E, 22.09.2003



International TOVS Study Conference, 13<sup>th</sup>, TOVS-13, Sainte Adele, Quebec, Canada, 29  
October-4 November 2003. Madison, WI, University of Wisconsin-Madison, Space Science and  
Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2003.