IOCCG

International Ocean-Colour Coordinating Group

16th IOCCG Committee annual meeting

Plymouth, UK 15-17 February 2011

The Meteor-3M satellite mission:

Present status and near future plans

MISSION AIMS

Satellites of the series "METEOR-M" are purposed for operational provision of

- global hydrometeorological data for weather forecast,
- keeping track of the ozone layer dynamics
- assessment of the radiation field in near-Earth space
- monitoring of marine environments and ice cover in polar regions

METEOR-3M

Satellite “METEOR-3M” continues the series of multi-purpose space stations “METEOR-1” and “METEOR-2” whose total number exceeded 50 over the previous 25 years.

A gap of 5 years preceded the launch of the 1st satellite of this new series - “METEOR-3M” № 1

“METEOR-3M” №1: some general characteristics

Orbit type	Near-circular, close to a sun-synchronous orbit
Mean height over the Earth surface, km	832
Orbital period, min	101.307
Orbit inclination,deg	98,786
Repetitiveness of the orbit projection on the surface at the expiry of 24 hours (circuits)	14 (199)
Orbit correction facility	none
The system orientation: type orientation accuracy stabilization accuracy, (3σ) angular speed in stabilization mode	 triaxial, electromechanical 0.1 deg 1.8 s of arc/s 0.005 deg/s
Autonomous operation time	4 days

“METEOR-3M” №1: some general characteristics (continuation)

Autonomous system of navigation	available
Expected life-time	5 - 7 years
Planet coverage periodicity	2 times per 24 hours

“METEOR-3M” №1: Payload

MSU-M3 (МСУ-М3) = multi-spectral scanning low resolution sensor	**Spatial resolution: 1000 m** **Swath: 2800 km** **Covered spectral region: 500 – 12500 nm** **Number of spectral channels: 6**
KMSS (КМСС) = a set of multi- spectral sensors	
Microwave radiometer for sounding atmospheric temperature and humidity	Spatial resolution: 1 -100 k m Swath: 2000 km Covered spectral region: 18.7 -183 ГHz Number of spectral channels: 26
IR Fourier spectrometer	Spatial resolution: 35 k m Swath: 2500 km
Multi-spectral scanning device for both studying the bioproductivity of marine environments and detection of forest fires (an experimental device)	Spatial resolution: 300 – 500/100 m Covered spectral region: 3.5 -12.5 μm/0.45- 1.4 μm
On board radar	Spatial resolution: 0.4x0.5 -0.7x1 km Swath: 450 km
Set of devices for heliogeophysical measurements and radio-sounding “Radiomet”	

KMSS

Composition	Two MSU-100 and one MSU-50 sensors
Combined swath by two sensors operating simultaneously at H=830 km	ca 940 km
Angle of tilt with respect to local vertical	0° for MSU-50 ± 14° for MSU-100
Pixel size	120 m for MSU-50 60 m for MSU-100
Array of photodetectors: CCDs (charge-coupled detectors) with a dynamic range 5000	**three CCD strips [SONY ILX508A] in the focal plane of each sensor.** **the strips are oriented perpendicularly to flight direction;** **the image is thus formed by means of an electronic scanning of the CCD elements and by fore-and-aft scanning due to the satellite flight along the orbit;** **CCD strips are placed in each sensor behind the common objective;** **in front of each CCD strip there is an optical filter to assure getting data in three spectral channels**

MSU-50 : exterior view

МСУ-50

MSU-100:
exterior view

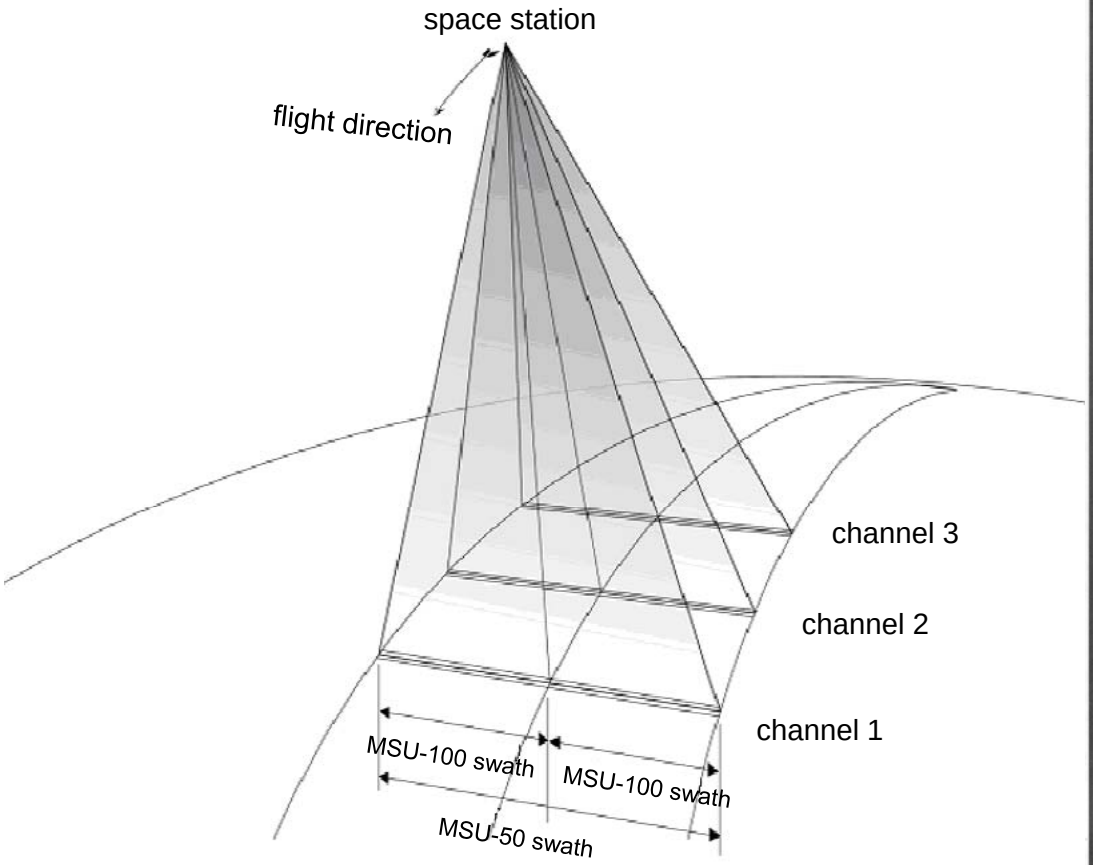
МСУ-100

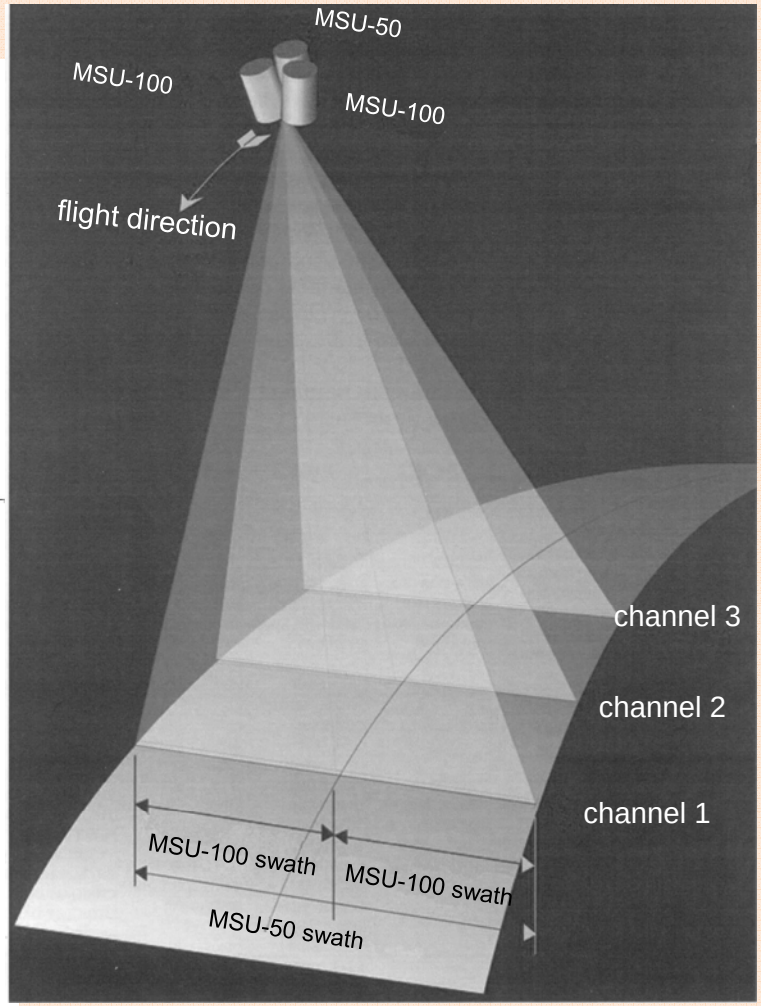
MSU sensors mutual orientation

- MSU-100 and MSU-50 are oriented such that the angle between their optical axes be 28° in order to achieve a partial overlapping of the FOV corresponding to the swath of ca 900 km.

- The same swath is attained by MSU-50 with the optical axe nadir-oriented.

- However, the spatial resolution provided by MSU-100 is twice better





Each MSU sensor provides a 3-channel image in three spectral bands. Thus, one and the same area of the land/ocean surface is registered with a time interval $\Delta t = 38.7$ or 19.35 s. This results in a mutual shift of the image registered in three spectral channels as large as 6048 or 3024 pixels.

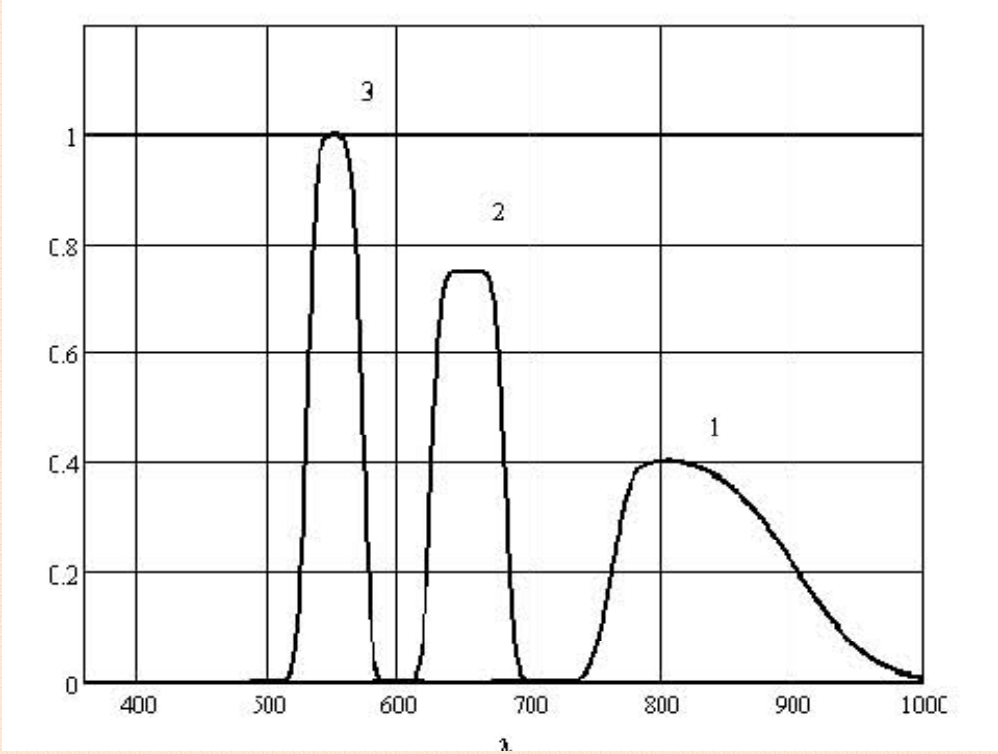
MSU-100:
technical characteristics

focal length, mm	**100**
Lens aperture	1:6
Viewing angle, deg	31
Size of the CCD element, µm	7x7
Number of spectral channels	3
Spectral zones, nm (at a 0.5 level)	535-575;0.630-680; 760-900
Length of the image line	7926 elements
Max energy consumption, Watt	6.8
Weight, kg	2.9

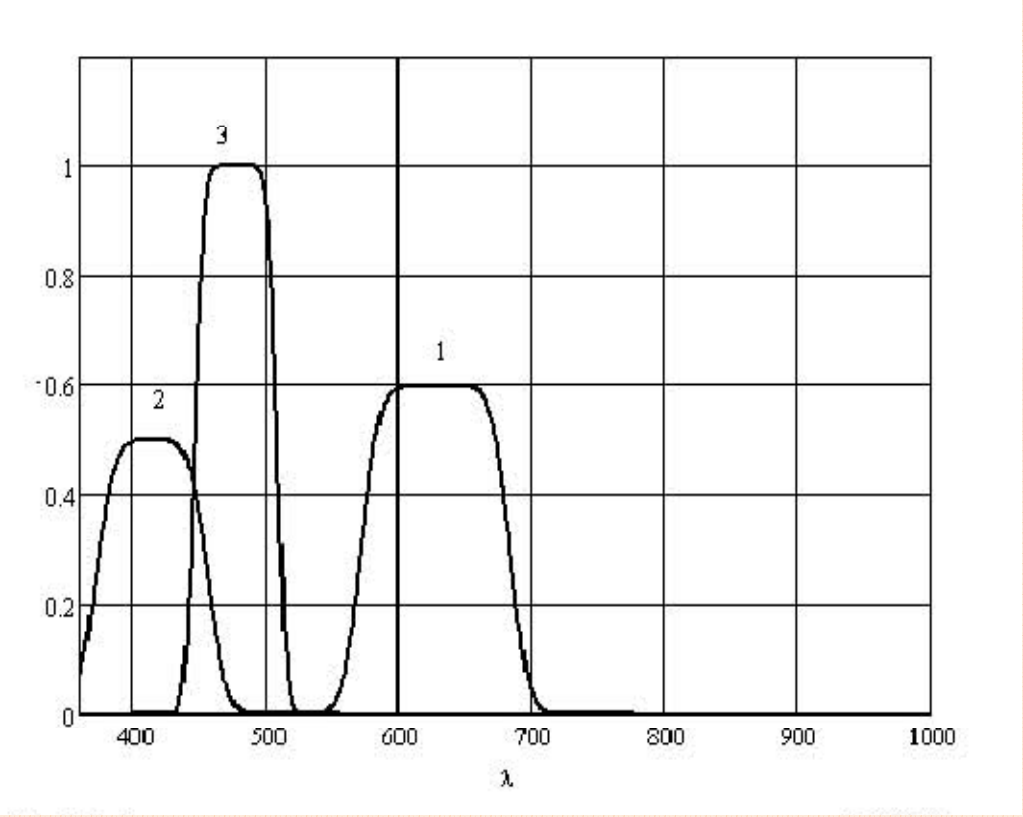
MSU-50:
technical characteristics

Focal length, mm	**50**
Lens aperture	1:6
Viewing angle, deg	58
Size of the CCD element, µm	7x7
Number of spectral channels	3
Spectral zones, nm (at a 0.5 level)	370-450; 450-510; 580-690
Length of the image line	7926 elements
Max energy consumption, Watt	6.8

MSU-100:
relative spectral sensitivity of channels 1-3



MSU-50:
relative spectral sensitivity of channels 1-3



Data transmittance

At the output, MSU sensors produce data fluxes of 8-bit values of radiance. Video data are accompanied by control and troubleshooting information (gain factor, shifting of the video-signal for each CCD, dark pixel signals from each CCD element).

The duration of teleconnection sessions is not in access of 20 min for each circuit. The data can be stored in a data storage device with the memory capacity of 100Гbit. The stored data can be eventually transmitted to receiving stations through a radio-line during teleconnection sessions.

There is a sensor of stellar orientation [assured accuracy is 2/20 arc s (1σ) depending on the axe]

The accuracy of imagery matching is about 1 MSU-100 pixel.

“METEOP-3M” № 1: example of application

Assessment of the Northern Caspian Sea ecological State:

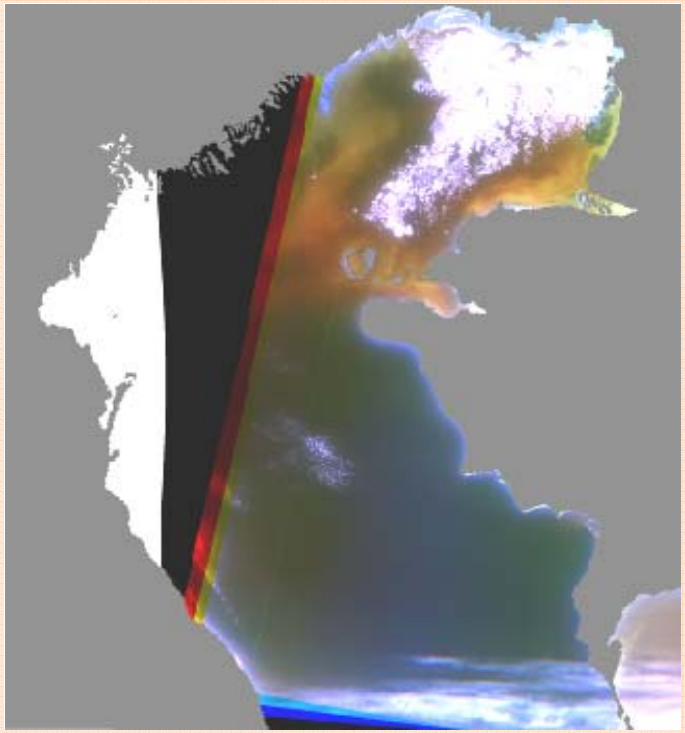
(normalized water leaving spectral radiance, nL_u at 555 and 667 nm, concentration of phytoplankton chlorophyll, suspended minerals, bulk attenuation coefficient at 555 nm, Secchi disc depth, detection of thick oil spills/films)

Approach: Neural network (NN) algorithm; MODIS-based training data array;

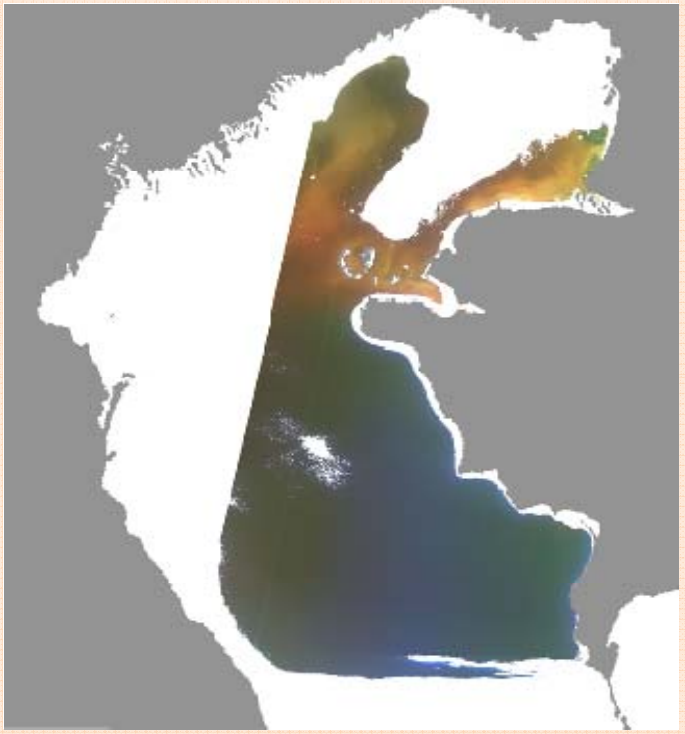
Four NN algorithms were developed for cloud flagging, retrieval of nL_u at 555 and 667 nm, b_b for *tsm.*

“METEOP-3M” № 1: example of application

- Cloud flagging:



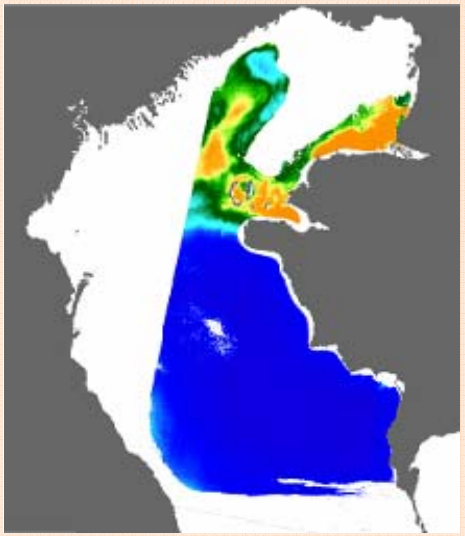
RGB MSU-100 image before cloud flagging

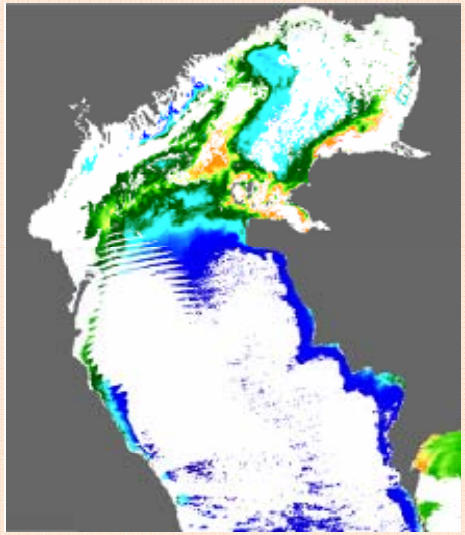


RGB MSU-100 image after cloud flagging

“METEOP-3M” № 1: example of application

KMSS

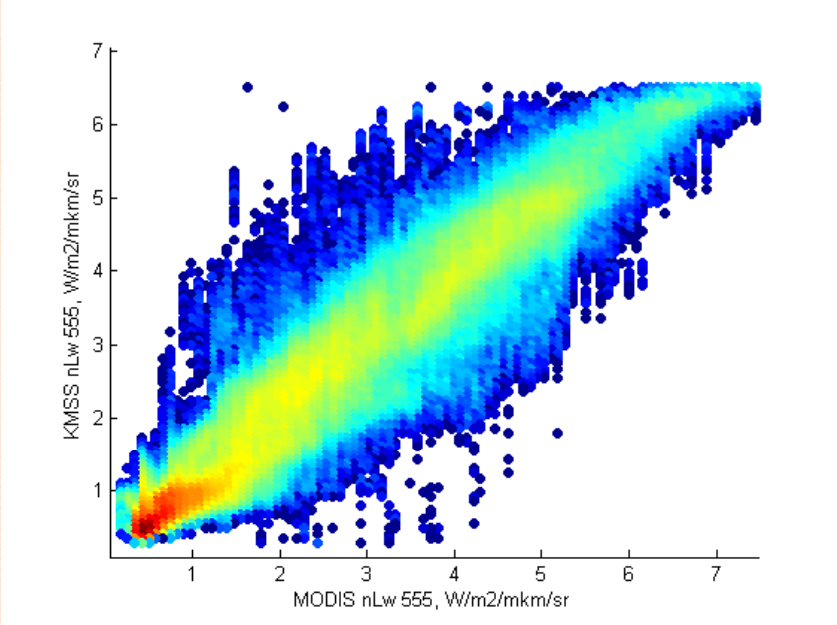




MODIS

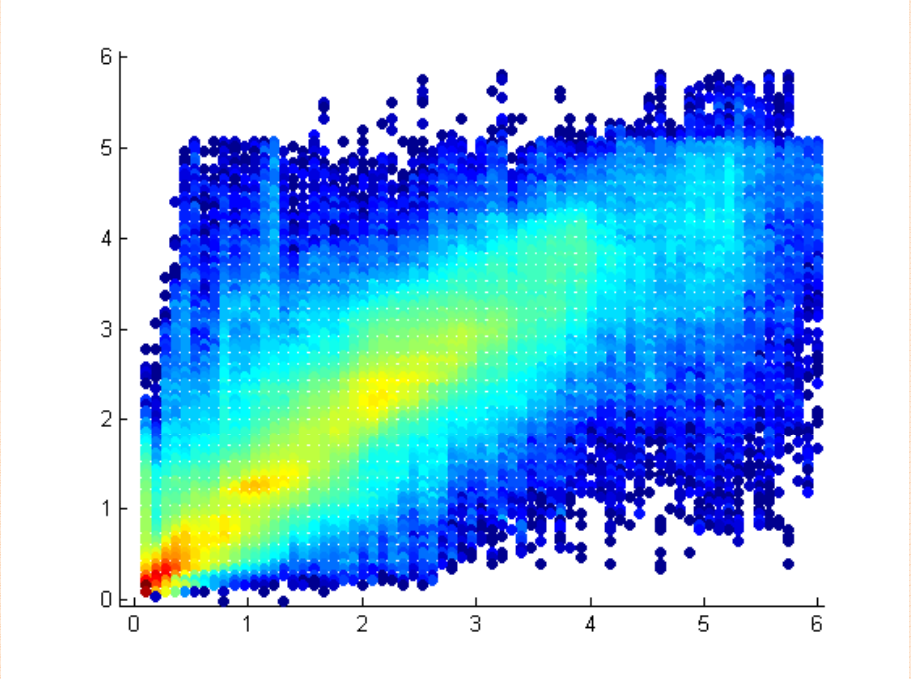
Comparison of retrievals of nLw-555 from KMSS and MODIS
[images were taken on 27 March, 2010)

“METEOP-3M” № 1: example of application



Comparison of nLu-555, obtained from MODIS (after atmospheric correction) and processing KMSS data with our NN

“METEOP-3M” № 1: example of application



Comparison of SM concentration retrievals yielded by MODIS (axe X) and KMSS (axe Y)

“METEOP-3M” № 1: example of application

- Table Quantitative assessment of compatibility of MODIS and KMSS data

Parameter	nLu-555	nLu-667	SM
Correlation coefficient	0.97	0.93	0.91
Absolute mean square error (MSE)	0.14 W/m2/sr	0.3W/m2/sr	0.002 mg/l
Relative MSE	8	9	0.5

“METEOR-3M” mission continuation

1. To be launched in 2013, “METEOR-3M” №2 will be a replica of “METEOR-3M” №1

2. “METEOR-3M” №3 is scheduled for 2015

“METEOR-3M”№ 3

“METEOR-3M”№ 3 is intended to complement data provided by “Meteor-M” Nos. 1 and 2 in order to significantly extend the spectrum of environmental remote sensing tasks.

“METEOR-3M”№ 3: payload

- On-board radar
- Scatterometer
- Scanner of open marine waters coloration
- Coastal Zone Colour Scanner
- Radio-sounding of the atmosphere
- On-board information system

“METEOR-3M”№ 3: onboard radar

On-board radar is being designed with an active phase-locked antenna array in order to perform radar multi-mode surveillance of stationary and moving on-land and marine targets and also for receiving data on the state of the land and world’s oceans surface.

Operating frequencies are within the X band

Mode of operation	Special resolution, m	Size of the frame, km across & along the flight trajectory	
Plain overview	500; 299; 500	130; 600; 750	Up to 4000
Along the flight trajectory	5.0	30	Up to 4000
Area-specific (in case of emergency situations)	1.0; 5.0	10; 50	10; 50

“METEOR-3M”№ 3:

Scanner of open marine waters coloration

Satellite scanner of water surface chromaticity characteristics will retrieve from TOA upwelling radiance measurements

The software for the scanner will include the atmospheric correction function.

Parameter	Value
Swath, KM	3000
Spatial resolution at nadir, km	not worse than 1
Number of spectral channels	8
Spectral bands (at a level of 0.5 µm), nm	402-422 433-453 480-500 500-520 545-565 660-680 745-785 845-885
Signal to noise ratio at the nominal simulated radiance	Not less than 500

“METEOR-3M”№ 3:
Coastal Zone Scanner

Intended to monitor shelf and near coast zones in the visible

Parameter	Characterization
Number of spectral channels	6
Spectral bands (at a level of 0.5 µm), nm	410-420 485-495 550-565 580-610 655-675 772-786
Swath, km	not less than 800
Spatial resolution at nadir, m	not less than 80
Signal to noise ratio at the nominal simulated radiance	200
Radiometric resolution, bits	10