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CLASSIFICATION OF THE REMOTE SENSING DEVICES AND TECHNOLOGIES FOR THE NATURAL HAZARDS STUDIES

Antoanetta Frantzova[1], Garo Mardirossian[1]

[1]Space Research Institute, Bulgarian Academy of Sciences; afrantzova@abv.bg; mardirossian@space.bas.bg
[2]Geophysical Institute, Bulgarian Academy of Sciences; boyko.ranguelov@geophys.bas.bg

ABSTRACT. Many remote technologies, units (satellites, aircrafts, etc.) and monitoring devices of different types are in everyday use for the observations, registrations and warning systems about the different natural hazards. Several classifications based on the philosophy "before", "during" and "after" the disaster occurrence have been created. The simple parameters such as effectiveness, reliability, different types of the technical equipment have been considered. Most popular remote techniques and units are included in these classifications giving the end users a possibility to use them for the comparative analysis between the different technologies and remote methods used. The generalization about the different types of the natural hazards is performed based on the principles of the generation mechanisms, physical properties and negative consequences they could create.
It's clear that for some natural hazards the remote techniques are high effective, for others not so, for the rest – not at all. The different effectiveness of the registrations, monitoring and warning systems depends strongly on the technologies and sensors used. The main parameters according the classifications are the frequency bands, sensitivity, resolution, physical principles and methods used, etc.
Our purpose was to create the comparative tables easy for use, especially about the not wade range of the professionals with different orientation. They could be useful for the civil defense authorities, risk managers, land use planners and other similar specialists in their everyday risk management practice, in case of emergency situations, etc.

КЛАСИФИКАЦИЯ НА ТЕХНИЧЕСКИТЕ СРЕДСТВА И ТЕХНОЛОГИИ ИЗПОЛЗВАНИ ЗА ИЗУЧАВАНЕ НА ПРИРОДНИТЕ ОПАСНОСТИ

Антоанета Францова[1], Гаро Мардиросян[1]
[1]Институт за космически изследвания, БАН; afrantzova@abv.bg; mardirossian@space.bas.bg
[2]Геофизичен иститут, БАН, boyko.ranguelov@geophys.bas.bg

РЕЗЮМЕ. В настоящата разработка за разгледани различните дистанционните методи и средства за изучаване и изследване на природни опасности.
Класификация е базирана на принципите на "преди", "по време на" и "след" бедственото явление. Взети са под внимание параметри като ефективност, приложимост, глобалност, експресност на информацията и т.н. Включени са най-популярните средства (сателити със съответните инструменти на борда) за дистанционно изследване на Земята.
Направеният анализ показва, че приложимостта и ефективността на дистанционнито средства и данните от тях зависи от множество параметри – спектрален диапазон, (работна честота), пространствена разделителна спосоност, експерсност при получаване, обработване и доставяне на данните, възможности за едновременно използването на данни от различни апаратури, полоса на обзор, орбитален период и т.н.
При избора и анализа на природните опасности (бедствия) са взети под внимание основните им физически характеристики, механизъм и начин на възникване и както и техния разрушителен потенциал.
Ясно е, че за изследването, изучаването и прогнозирнето на някой природни опасности дистанционните методи и средства са приложими и високо ефективни, докато за други са практически неприложими и/или неефективни.
Направените сравнителени таблици и графики са лесни за използване и предназначени предимно за широк кръг от потребители с различна специализация и ориентация. Предложените класификации дават на ползувателите (управленски кадри и планиращи органи) възможности за сравнителен анализ и оценка между различните методи и средства и тяхното приложение при различните видове природни опасности и бедствия.

Introduction

Despite enormous progress in the science and technology, most of the natural hazards and disasters are still unpredictable events and continuously brings people's life loses and cause huge damages all around the world.

During the last years, the space technologies (especially earth observing satellites) get wider application in research of natural hazards/disasters (Mardirossian, 2000). For example – the prediction of the most of the meteorological hazards is unthinkable without the use of the meteorological satellites.

The potential of the remote sensing for the monitoring of the Earth environment, risk application and their key role in risk management process are well known and largely used. Most of the remote sensing data are used in general by few people – mostly specialists of the observation and monitoring systems (Mishev, 1987).

Our objective is to made classification of the remote sensing technologies and units used about natural hazards, according their usefulness and applicability in the different phases of the risk and disaster management (process) and to crate comparative tables easy for use, especially about the wide range of the non-professionals and non- specialists with different practical applications. Most of the space units have combined applications – to follow up not only the natural, but as well as the man-made accidents, pollution, other catastrophes. In this study we limited our task and focused only on the natural hazards

Classification and analysis of the remote sensing technologies about natural hazards and risk management

For our purposes two tables and two charts have been created. The first table is not presented, because of the large size. It includes most of the earth observing satellites in orbit, which are of great help for disaster mitigation studies. Attention is paid to the communications satellites and Search and Rescue System (COSPAS/SARSAT).

In the table for each type satellite are presented some orbital parameters, instruments carried on board, frequency band, spatial resolution and instrument swath. Most of those sensors have applications in disaster mitigation practice, though depending of the physical properties of the objects on Earth and the nature of the disaster itself.

With a review of the satellites in orbit and their sensors the present work provides an insight to the suitability of satellites and sensors to their applications due to the different natural disasters.

Table 2 is created on the basis of table 1. In table 2 the different instruments and their usefulness and applicability in risk management process of natural hazards/disasters are described.

The classifications is based on the philosophy "before", "during" and "after" the disaster occurrence. "Before" means – preparatory stages, early warnings, vulnerability and risk assessment; "During" means – disaster monitoring in real or near-real time when it is possible; "After" means – damage assessment, modelling the negative effects of the past of future events.

The table shows that different instruments, depending on their type, band and resolution are applicable for different hazards at the different stage of the hazards observations and the risk management process.

Thee levels of applicability (low, medium and high) and 14 hazards had been selected including global phenomenon as climate change, El Nino and La Nina.

However, there is not yet a specific or complex platform or sensor that is dedicated to retrieve information on a particular type of disaster(s). The result of this situation is the need of retrieving information simultaneously from several systems, which implies problems and hardens the process of production of the needed information.

Some space techniques, such as those of weather forecast, have become operational and are used in the everyday practice. These weather forecast techniques permit early warnings and monitoring for some of the weather hazards, such as tropical cyclones, hurricanes, typhoons. On the contrary, the management practice of the other disasters only by satellite technology is on a research phase. The general reasons are that in case on rapid onset disaster and in disaster situation (and emergency management) the data should be easily and timely acquired (Mardirossian, 2000).

That is why the aerial aerospace laboratories, rescue helicopters and other similar devices information and ground data are still of crucial important. For that reason in figure 1 the applicability of the aerospace data is presented. Figure 2 shows suitability of the ground data and information.

Table 2. Typology and applicability of the different satellites to the stages of the natural hazards

Satellite	Instrument	Before	During	After
Ikonos	camera system	(1),2,3,7,(8),9,10,11	(1),((8)), 9, (12)	1,2,3,7,8,9,10,11
QuickBird	BGIS 2000/	(1),2,3,7,(8),9,10,11	(1), ((8)), 9, (12)	1,2,3,7,8,9,10,11
Spot 5	HRG	1,2,3,7,8,9,10,11	1,(8),9,12,14	1,2,3,7,8,9,10,11
	HRS	1,2,7		
	VEGETATION 2	(7)	9	8,9
Landsat 7	ETM+	1,2,(4),3,7,8,9,10,11	1,8,9, (12),14	1,(2),3,7,8,9,10,11
DMC	ESIS, MSIS	1,2,3,7,8,9,10,11	1,8,9,(12),14	1,(2),3,7,8,9,10,11
ERS-2	AMI			
	(SAR	(1),(2),3,(4),7,(8),(9),10,11	(1),7,(9),10,11,(12),13,(14)	(1),2,3, 9,10,11
	Scatterometer)	4,6,(9),10, (11), 12	6,10,12	
	RA	((1)),((2)),((3)),4,6,(9),10, 12	6,(9),10,12,13	((3))
	ATSR2			
	(IRR	1,6,(8),(9),(10)	1,6,8,(9)	(1),(8)
	MWR)	((4)),(10),(11)	(10), (13)	
	GOME		1,5	1
ENVISAT	AATSR	1,6,((4)),(8),(9),(10)	1,6,8,(9),(14)	(1),(8)
	ASAR	(1),(2),3,(4),7,(8),(9),10,11	(1),7,(9),10,11,(12),13,(14)	(1),2,3, 9,10,11
	MERIS	((4)),((7)),8,9,((11)),((12))	((8)),9,(12), (13),(14)	8,9,((11))
	RA-2	((1)),((2)),((3)),4,6, (9),10,12	6,(9),10,12,13	((3))
	MWR	((4)),(10),(11)	(10), (13)	

	GOMOS MIPAS SCIAMACHY	 (4) (4)	1,5 (1), (5) (1), (5)	1 (1) (1)
RADARSAT	SAR	(1),(2),3,(4),7,(8),(9),10,11	(1),7,(9),10,11,(12),13,(14)	(1),2,3, 9,10,11
AURA	(As whole) HIRDL MLS OMI TES	4	1,5 1 1,5	1 1 1
AQUA	(As whole) AIRS AMSU-A HSB AMSR-E MODIS CERES	4,(9),10,11 4 6,(4),((7)),((8)),(9),10,11,12 (1), ((2)), ((6)),(7),(8),(10),(11) (4)	(9),10,11 6,((7)),(9),10,11,12,13 1, ((6)),8,9,(12),14	1 1, 8,9,(10),(11)
CALIPSO	CALIOP	4	1,8	1,8
PARASOL	POLDER-P/Lidar	4	1,8	1,8
CloudSat	CPR	4,10,11	1,8,10,11,12	1,8
IceSat	GLAS	4	(1),(8),13	(1),(8)
Jason-1	RA	((1)),((2)),((3)),4,6, (9),10,12	6,(9),10,12	((3))
TOPEX/ Poseidon	ALT	((1)),((2)),((3)),4,6,(9),10,12	6,(9),10,12	((3))
GRACE	K-band Ranging	Geodesy, Oceanography, ((2))		
GPS		1,2	7	1,2
LAGEOS	laser reflector	((1)), (2)		((1)), (2)
TERRA	ASTER CERES MISR MODIS MOPIT	1, 2, (3), (4),((6)),7,8,9,10,11 (4) (4) (1),((2)),(4),((6)),(7),(8),(10),(11) ((4))	1, ((6)),8,9,((11)),12,14 ((8)),9,14,(12),14 1, ((6)),8,9,(12),14	1,(2),(3),8,9,10,11 1,8, 1, 8,9,(10),(11)
ADEOS/ MIDORI II	AMSR GLI Scatterometer ILAS-II POLDER	6,(4),((7)),((8)),(9),10,11,12 (1),((2)),(4),((6)),(7),(8),(10),(11) 4,6,(9),10, (11), 12 ((4))	6,((7)),(9),10,11,12,13 1, ((6)),8,9,(12),14 6,10,12 (1), (5)	 1, 8,9,(10),(11) (1)
NOAA/POES series	(As whole) AVHRR/3 HIRS/3 AMSU-A AMSU-B MHS SBUV/2 SARSAT SEM/2	4,6,(7),8,9,10,11,12 1,((7)),(8),(9), 10 Search and rescue system Space weather	6,(7),8,9,10,11,12 1,8,(9),10,(14) 1,(5)	 (1),(8) 1
MetOp	(As whole) AVHRR/3 HIRS/4 AMSU-A MHS IASI Scaterommeter GOME-2 GRAS SARSAT SEM-2	4,6,(7),8,9,10,11,12 1,((7)),(8),(9), 10 4,6,(9),10, (11), 12 Search and rescue system Space weather	6,(7),8,9,10,11,12 1,8,(9),10,(14) (1), (5) 6, 10, 12 1,5	 (1),(8) (1) 1
NOAA/GOES	(As whole) Imager Sounder SEM SARSAT	4,6,(7),8,9,10,11,12 Space weather Search and rescue system	6,(7),8,9,10,11,12 ((1)),((8))	

MeteoSat (second generation)	(As whole) SEVIRI GERB SARSAT	4,6,(7),8,9,10,11,12 Search and rescue system	6,(7),8,9,10,11,12 ((1)),((8))	

Legend: 1 – Volcano activity; 2 – Earthquakes; 3 – Tsunamis; 4 – Climate change, research and modeling; 5 – Ozone hole; 6 – El Nino, La Nina (ENSO) – SST; 7 – Landslides; 8 – Forest fires; 9 – Droughts; 10 – Storms, hurricanes (incl. high rain rates, strong winds); 11 – Floods (river), flash floods (incl. snow melt); 12 – Winter storms; 13 – Polar ice sheet; 14 – Global land coverage (incl. deforestation and desertification); (( )) – low applicability; ( ) – medium applicability; without bracket – high applicability

Acronyms and abbreviations:

AATSR - Advanced Along-Track Scanning Radiometer
AIRS - Atmospheric Infrared Sounder
ALT - Radar Altimetry
AMI - Active Microwave Instrument
AMSR - Advanced Microwave Scanning Radiometer
AMSR-E - Advanced Microwave Scanning Radiometer
AMSU - Advanced Microwave Sounding Unit
ASAR - Advanced Synthetic Aperture Radar
ASCAT - Advanced Scatterometer)
ASTER - Advanced Spaceborne Thermal Emission and Reflection Radiometer
ATSR - Along-track scanning radiometer
AVHRR/3 -Advanced Very High Resolution Radiometer

BGIS 2000 - Ball Global Imaging System 2000
BHRC 60 - Ball High Resolution Camera 60

CALIPSO - Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
CALIOP - Cloud-Aerosol Lidar with Orthogonal Polarization
CERES - Clouds and the Earth's Radiant Energy System
CMT - China Mapping Telescope
COBAN - Multiband Camera
CPR - The Cloud Profiling Radar

DMC Disaster Monitoring Constellation

EPS - Energetic Particle Sensor)
ESIS - Extended Swath Imaging System)
ETM+ - Enhanced Thematic Mapper Plus

GERB - (Geostationary Earth Radiation Budget)
GLAS - Geoscience Laser Altimeter System
GLI - Global Imager
GOME - global ozone monitoring experiment
GOMOS - Global Ozone Monitoring by Occulation of Stars
GPS - Global Positioning System
GPS Reflectometry ExperimentCLEO
GRACE - Gravity Recovery And Climate Experiment)
GRAS - GNSS Receiver for Atmospheric Sounding

HIRDLS - High Resolution Dynamics Limb Sounder
HIRS/4 - High Resolution Infrared Sounder
HIRS/3 - High Resolution Infrared Sounder
HRG - High Resolution Geometric
HRS - High Resolution Stereoscopic
HSB - Humidity Sounder for Brazil

IASI - Improved Atmospheric Sounder Interferometer
IIR - Imaging Infrared Radiometer
ILAS-2 - Improved Limb Atmospheric Spectrometer 2
IRR - Imaging Infra-Red Radiometer

JMR - Jason Microwave Radiometer

MERIS - Medium Resolution Imaging Spectrometer
MHS - Microwave Humidity Sounder)
MIPAS Michelson Interferometer for Passive Atmospheric Sounding
MISR - Multi-angle Imaging Spectroradiometer
MLS - Microwave Limb Sounder
MODIS - Moderate Resolution Imaging Spectroradiometer
MOPITT - Measurements of Pollution in the Troposphere
MSIS - Multispectral Imaging System
MWR - Microwave Radiometer
MWS (MS) - microwave sounder:

OMI - Ozone Monitoring Instrument

PanCam - Panchromatic Camera)
PARASOL (Polarization and Anisotropy of Reflectances for Atmospheric Science coupled with Observations from a Lidar)
POLDER - Polarization and Directionality of the Earth's Reflectance
RA - Radar Altimeter

SAR - Synthetic aperture radar
SARSAT - Search and Rescue System
SBUV/2 - Solar Backscatter Ultraviolet Radiometer),
SEM-2 - Space Environment Monitor-2)
SEVIRI - Spinning Enhanced Visible and Infrared Imager),
SCIAMACHY - Scanning Imaging Absorption Spectrometer for Atmospheric Cartography
SSALT - Single-Frequency Solid-State Altimeter- Experimental

TES - Tropospheric Emission Spectrometer
TMR - Topex Microwave Radiometer
WFC - Wide-Field Camera
XRS - Solar X-Ray Sensor

Visualization of the typologies

For the easier interpretation and better orientation of the end users, the graph plots of the data and information synthesized in the tables are presented as graphics. The first graph (Fig. 1) presents the suitability of the remote sensing data about the practical use before, during and after the natural hazards action stages. The natural hazards are grouped as in the previous tables and 3 levels of use are defined – low – 1; medium – 2; and high – 3. These levels show the possibility to obtain reliable data for the practical use, according the reliability and usefulness of the information retrieved by the respective remote sensing devices in general. Low – means limited use and effectiveness less then 20%; 2 – means effectiveness up to 50% and high means – more than 50%. These statistics are extracted from the theoretical assumptions and practical observations, by the different case studies, expert considerations, etc.

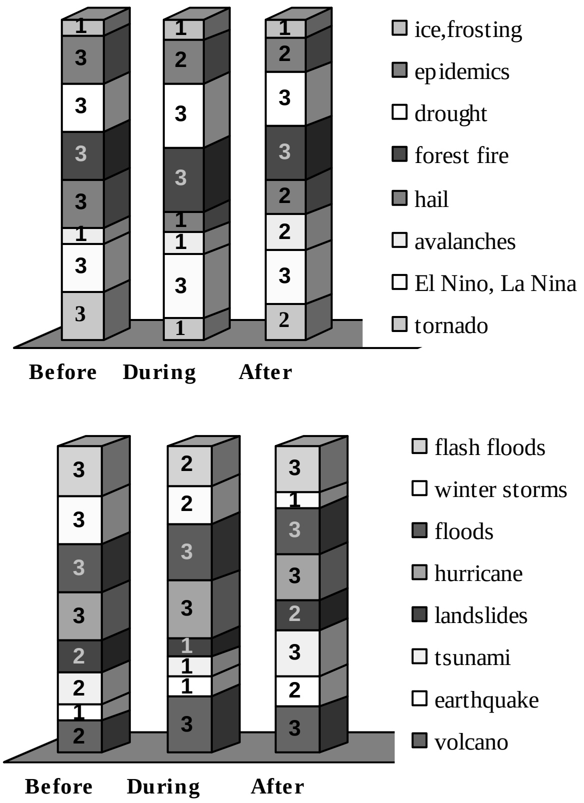
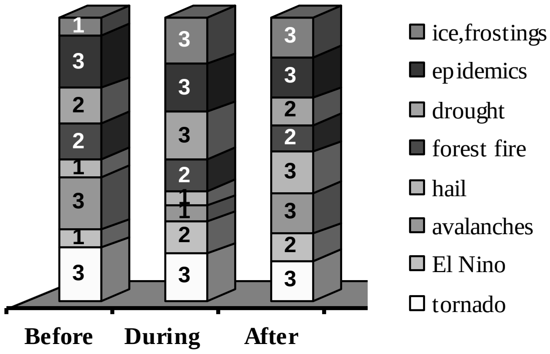


Fig. 1. Applicability (usefulness) of remote sensing (aerospace) data in the risk management process: "before" means – early warning, preparedness, and risk and vulnerability assessment, (including modeling); "during" – monitoring and fast response; "after" – damage assessment, (including modeling); 1 – low; 2 – medium; 3 - high

The use of the ground data and information is still the leading tendency in the recent practice. To compare the usefulness of the remote sensing data and the land installed devices the summary of the ground data effectiveness is made. The levels of use are defines by the same way as before; low – 1; medium – 2; high – 3.



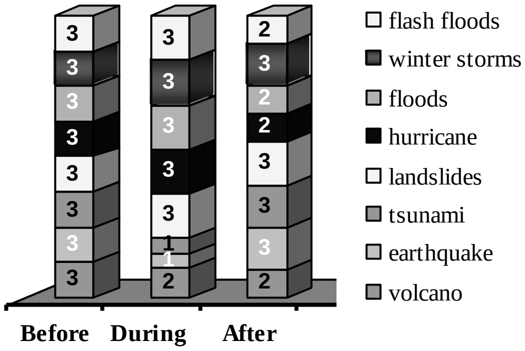


Fig. 2. Applicability (usefulness) of the ground data and on land observations in the risk management process: "before" means – early warning, preparedness, risk and vulnerability analysis, (includes modelling); "during" – monitoring and possible fast response; "after" – damage assessment, (includes modelling as well as); 1 – low; 2 – medium; 3 – high

Conclusions

Several classification and typologies are created about the recent satellites in use for the observations, monitoring, (hazards, vulnerability and risk assessment), which could be of practical use of the decision makers and rescue teams. The tables of the different satellites, their equipment and suitability for the risk management process contain data and information about the practical abilities of all these devices.

Graphical expressions about the possible use of the different space and land technologies for the "before", "during" and post disaster stages are presented, thus making easier interpretation and visualization of the devices in use.

Such kind of classifications and typologies are targeted to the everyday practice of the risk managers, decision makers and the rescue teams and could be implemented in their everyday practice. The analysis shows that the most critical points are connected to the fast communication of the data retrieved, the visualization and the automatic analysis, which could support the decision making process.

After the deeper analysis it is shown that the effectiveness of the remote sensing and technologies depends of several parameters – complexity, simultaneous use of the earth data and remote sensing data, frequency band, sensitivity, high/low resolution, sampling frequency of the measurements, reliability of the communication and data transfer, software tools and velocity of the data processing, etc.

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