PRACE GEOGRAFICZNE, zeszyt 107

Instytut Geografii UJ
Kraków 2000

Izabela Dyras, Bożena Łapeta

NEW GENERATION METEOROLOGICAL SATELLITES – POTENTIAL APPLICATION FOR CLIMATOLOGICAL RESEARCH

Abstract: Satellite data have been widely used in climatological research as a significant addition to ground measurements network. The launch of the polar orbiting satellite NOAA-15 (in 1998) from the new series NOAA K,L,M has enhanced the quality of measurements especially in the microwave spectral region. The long term programs were established for two satellite systems: MSG and METOP. The aim of this paper is to convey the general information concerning new satellite systems and their possibility to provide the global products such as clouds type and cover maps; Global Vegetation Index; Sea Surface Temperature; Earth Radiation Budget; ozone vertical profiles as well as total ozone maps; snow and ice maps; temperature and moisture profiles used for climate monitoring, modelling and forecasting.

Key words: remote sensing, satellite climatology, NOAA, MSG, METOP.

1. Introduction

Climate modelling has undergone rapid development in the recent years (Rong-Shyang Sheu et al. 1996). The new Meteosat Second Generation (MSG) can provide the measurements for climate modelling over Europe and Africa every 15 minutes in a broad range of electromagnetic spectrum. In contrast, the polar orbiting satellites such as NOAA KLM (Goodrum et al. 1998; NESDIS 1998), and later – METOP (Chedin 1998; Smith 1998), only sample the atmosphere and surface four times a day but with higher spatial resolution.

The unique ability of satellites to follow cloud systems through their whole life cycle is highlighted as an exciting new capability. There is also general agreement that surveys are needed because the detailed phenomenology of different cloud types is still poorly known (Kuan-Man Xu, Randall 1996). Special emphasis should be given to obtaining improved particle size information and liquid and ice water amounts (Bin Lin 1998; Bin Lin et al. 1998; Ferraro et al. 1998a, 1998b, 1998c; Grody et al. 1998a, 1998b; Weng et al. 1997a, 1997b).

The aim of this paper is to present the description on the planned satellite systems and their contribution to climate studies development in terms of data quality in their spatial, spectral and temporal resolution, respectively.

2. Satellite Systems

Polar orbiting satellites circle the Earth in a nearly polar orbit, 700-900 km above the surface, with the period of about 100 minutes. The exact speed and orbit parameters are chosen such that viewing angle enables complete global coverage within a given number of orbits). The sensors onboard of orbiting satellites are characterised by much better spatial resolution. This allows to observe phenomena that require more detailed routine observations. More detailed information is presented in Table 1.

Geostationary satellites stay over the same place on Earth because their period of ration is the same as the Earth (24 hours). To maintain this orbit satellite is placed over the equator at a height of about 36,000 km. Geostationary satellites are used for continuous observation of a large area of the Earth's surface and monitoring of temporal resolution processes (Cihlar et al. 1999; Gutman et al. 1995).

2.1. National Oceanic and Atmospheric Administration (NOAA) Satellites

NOAA–15 has been launched in late 1998 as a first of the new generation satellite series NOAA-KLMN. The major improvement was made in AVHRR/3 by adding 1.6 mm channel as well as significant enhancement of the spatial and spectral resolution of microwave sounding units (AMSU-A and AMSU-B) as presented in Table 1. The use of microwave sounders allows discrimination between clouds and sea ice and snow (Hillger 1999; Ferraro 1997; Ferraro et al. 1998a, 1998b; Goldberg, Fleming 1995).

2.2. METEOSAT Second Generation Satellites

The MSG satellites (MSG - 1,2,3), that are planned to start operate in 2001, have been designed to continue providing data for weather forecasting, although their capabilities have been considerably expanded. These new capabilities also offer significant potential for land observations. Most of the new MSG capabilities are embedded in the principal sensor, the Spinning Enhanced Visible and InfraRed Imager (SEVIRI). The spectral, radiometric and spatial characteristics of this instrument's 12 spectral channels are given in Table 2. It will enable observations of land surface parameters and processes, in addition to those of the atmosphere. MSG will also carry Geostationary Earth Radiation Budget (GERB) that will monitor the Earth's radiation budget at the top of the atmosphere and therefore can make the unique contribution towards the understanding of Earth's climate balance.

Climatological products to be provided by EUMETSAT MSG program include the atmospheric wind vectors at various altitudes, derived from the motion of clouds

Tab. 1. List of NOAA and METOP Instruments (resolution given at sub-satellite track).

Instruments on board of		Function	Main data applications	Resolution	Provided by
NOAA - K,L,M	METOP				
AVHRR/3	AVHRR/3	VIS-IR Images	Global imagery, global sounding, ocean measurements (SST), clouds, earth radiation budget, land measurements	1.1 km	NOAA
AMSU–A	AMSU–A	Microwave Temperature	Global sounding, sea ice	45 km	NOAA
AMSU- B	MHS	Microwave Humidity	Global sounding, cloud and earth radiation budget, sea ice	17.6 km	NOAA
HIRS/3	HIRS/4	IR Sounding	Global sounding, (temperature and humidity vertical profiles)	10 km	NOAA
SBUV/2	GOME	Ozone	Atmospheric minor constituents (ozone content and profile)	40x2 km	NOAA | ESA/ EUMETSAT
	IASI	Advanced IR sounding	Improved global sounding, ocean measurements (SST), clouds and earth radiation budget, atmospheric minor constituents, land measurements	12/25 km	CNES/ EUMETSAT
	GRAS	Atmospheric sounding	Atmospheric refractive index measurements in limb-sounding mode		ESA/ EUMETSAT
	ASCAT	Ocean winds	Ocean measurements (surface stress and surface wind), sea ice coverage		ESA
ARGOS/2	ARGOS/3	Data collection	Data collection and location, collection of climate data		CNES
SEM		Space environment	Monitoring of the local space plasma and radiation environment		NOAA
SarSat	SarSat	R&S	Humanitarian		NOAA

Tab. 2. MSG Instruments description (resolution given at satellite sub-point).

Description	Resolution	Spectral range
Radiometer SEVIRI	**12 channels**	
Sampling distance		
3. VIS	3 km	0.6, 0.8 m
4. HRV	1 km	0.75 m
5. IR	3 km	1.6, 3.9, 8.7, 9.7, 10.8, 12.0, 13.4 m m
6. WV	3 km	6.2, 7.3 mm
Radiometric resolution	0.25 K	
Image repeat cycle	15 min	
Radiometer GERB	**2 channels**	
Sampling distance		
7. SW	44.6 km x 39.3 km	0.32-4.0 m
8. LW		0.32-30 m
Image repeat cycle	15 min	

and other tracers (water vapour and ozone); cloud analysis providing identification of cloud layers with coverage, height and type including data for International Satellite Cloud Climatology Project dataset (WMO 1996), Tropospheric Humidity at medium and upper levels, High Resolution Precipitation Index; Clear Sky Radiances and Total Ozone Product. In addition to these centrally produced products there will be a wide range of specialised products from Satellite Application Facilities (SAF) located in various countries in Europe.

2.3. EUMETSAT Polar System (EPS) Satellites

The new satellites, METOP - 1,2,3 (planned launch in 2003) are a result of an international partnership of EUMETSAT, European Space Agency (ESA), French National Space Agency (CNES). As a polar orbiting units, they will orbit at an altitude of about 840 km, circling the planet 14 times a day. The EPS System is designed to be complementary to the satellites in geostationary orbit.

METOP will carry some of already operating instruments (AVHRR, AMSU-A, S&R) as well as improved NOAA and ERS instruments (HIRS, GOME, ARGOS). Additionally, new sounders (MHS, IASI, GRAS, ASCAT) will be installed. The instruments and short description of the collected data can be found in Table 1.

The data collected by METOP will be used to provide similar information as the ones described for MSG, however, with the better spatial resolution. Moreover,

the measurements in the micro wavelengths can be applied to snow and ice cover mapping, land cover study regardless of the cloud cover and solar illumination conditions.

3. Conclusions

Climate research will be widely addressed by planned satellite systems. They will provide data with the better spectral, spatial and time resolution and quality. Such amount of high quality data should contribute to the rapid development of the climate monitoring, modelling and forecasting.

To be able to receive data from the new satellite systems it is necessary to modernise the ground facilities. The presently operating satellite station in the Institute of Meteorology and Water Management (IMWM) in Cracow receives data from NOAA- 11, 12, 14, 15 as well as the METEOSAT data in visible, infrared and water vapour channels. The data, after processing, are distributed to other IMWM Departments through the network. Intensive works aiming at preparation for the new ground facilities installation are currently carried out to allow complete MSG and METOP data receiving. In the same time, the satellite products for climate studies are intensively developed.

References

Bing Lin, 1998, *Estimation of Water Cloud Properties From Satellite Microwave, Infrared and Visible Measurements in Oceanic Environments: 1. Microwave Brightness Temperature Simulations*, Journal of Geophysical Research, 103, D4, 3873-3886.

Bing Lin, Minnis P., Wielicki B., Doelling D. R., Palikonda R., Young D. F., Uttal T., 1998, *Estimation of Water Cloud Properties From Satellite Microwave, Infrared and Visible Measurements in Oceanic Environments: 2. Results*, Journal of Geophysical Research, 103, D4, 3887-3905.

Cihlar J., Belward A., Govaerts Y., 1999, *Meteosat Second Generation Opportunities for Land Surface Research and Applications*, EUMETSAT Scientific Publications.

Chedin A., 1998, *Reanalysis of TOVS Data: Lessons Learned for Climate Studies of the EOS and METOP Era*, 9th Conference on Satellite Meteorology and Oceanography, Paris, 25-29 May 1995, 13-14.

Ferraro R. R., 1997, *Special Sensor Microwave Imager Derived Global Rainfall Estimates for Climatological Applications*, Journal of Geophysical Research, 102, D14, 16, 715-16, 735.

Ferraro R. R., Kusselson S. J., Colton M., 1998a, *An Introduction to Passive Microwave Remote Sensing and its Application to Meteorological Analysis and Forecasting*, National Weather Digest, 23, 3, 11-23.

Ferraro R. R., Smith E. A., Berg W., Huffman G. J., 1998b, *A Screening Methodology for Passive Microwave Retrieval Algorithms*, Journal of the Atmospheric Sciences, 55, 1583-1600.

Ferraro R. R., Grody N., Weng F., Moore D., 1998c, *Microwave Surface and Precipitation Products from the AMSU*, Conference on Interactive Information and Processing Systems (IIPS), Phoenix, AZ.

Goodrum G., Kidwell K. B., Winston W., 1998, *NOAA KLM User's Guide*., NOAA.

Goldberg M.D., Fleming H.E., 1995, *An Algorithm to Generate Deep-Layer Temperatures from Microwave Satellite Observations for the Purpose of Monitoring Climate Change*, Journal of Climate, 8, 5, 993-1004.

Grody N.C., Weng F., Ferraro R. R., 1998a, *Comparison Between AMSU and DSMP Measurements*, 9th Conference on Satellite Meteorology and Oceanography, Paris, 25-29 May, 1995, 476-479.

Grody N., Rosenfeld S., Basist A., 1998b, *Relationship Between SSM/I Measurements and Snow Parameters*, 10th Symposium on Meteorological Observations and Instrumentation, 11-16 January, 1998, Phoenix, Ed. by American Meteorological Society, Boston, MA.

Gutman G., Tarpley D., Ignatov A., Olson S., 1995, *Global Land Data Base for Climate Studies*, 9th Conference on Applied Climatology, Dallas, Texas, 15-20 January, 1995, 170-175.

Hillger D.W., 1999, *Using the New 1.6 mm Channel on NOAA–15 in Satellite Product Development*, 10th Conference on Atmospheric Radiation, 28 June-2 July, 1999, Madison, ed. by the AMS, Boston, MA.

Kuan-Man Xu, Randall D. A., 1996, *A Semiempirical Cloudiness Parametrization for Use in Climate Models,* Journal of the Atmospheric Sciences, 53, 21, 3084,-3102.

NESDIS, 1998, *Polar-Orbiting Environmental Satellite (POES) Program*, 78, The Annual Meeting of the American Meteorological Society, January 11-16, 1998, Phoenix, AZ.

Rong-Shyang Sheu, Curry J. A., Guosheng Liu, 1996, *Satellite Retrieval of Tropical Precipitation Using Combined International Satellite Cloud Climatology Project DX and SSM/I Data*, Journal of Geophysical Research, 101, D16, 21,291-21,301.

Smith W.L., 1998, *Satellite Remote Sounding- the Evolution of a Global Observing System*, 9th Conference on Satellite Meteorology and Oceanography, Paris, 25-29 May 1995, 1-4.

Weng F., Grody N. C., Ferraro R. R., Zhao Q., Chen C. T., 1997a, *Global Cloud Water Distribution Derived from Special Sensor Microwave Imager/Sounder Comparison with GCM Simulation*, Adv. Space Res, 19, 3, 407-411.

Weng F., Grody N. C., Ferraro R. R., Basist A., Forsyth D., 1997b, *Cloud Liquid Water Climatology from the Special Sensor Microwave/Imager,* Journal of Climate, 10, 5, 1086-1098.

WMO, 1996, *Int. Workshop on Research Uses of ISCCP Datasets,* World Climate Research programme, WMO/TD No. 790.

Izabela Dyras, Bożena Łapeta
Institute of Meteorology and Water Management, Branch Cracow
Cracow
Poland