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SATELLITE INSTRUMENTS PROVIDING CLIMATOLOGICAL DATA

Abstract: Since the launch of the first meteorological satellites in the sixties, climatology has gained a new source of the information about the atmosphere and ground surface especially from the scarcely populated areas as well as wide areas of the seas and oceans. The time span between the first and present satellite systems allows to follow the different atmospheric parameters change. The paper presents brief information concerning different satellite systems and their sensors. The spectral range characteristics and their usefulness for climatological purposes are discussed. Among the products derived from the collected data, the following are addressed: radiative budget, clouds climatology, atmospheric temperature and humidity, total ozone amount and trace gases concentration.

Key words: remote sensing, satellite climatology, spectral channels.

1. Introduction

Earth-orbiting satellites have provided a wealth of data which has spawned a revolution in the sciences of meteorology and climatology (Rao et al. 1990). They are a crucial source of the information about the atmosphere and ground surface especially from the scarcely populated areas as well as wide areas of the seas and oceans. Aside from obvious implications for meteorology, satellites have broader implications for the study of the large-scale climate dynamics (Ohring et al. 1989).

Important fields, in which remote sensing made direct contribution are: studies of Earth's energy budget and energy transport, measurements of atmospheric moisture content and precipitation, monitoring of ice and snow as well as trace gasses. In the presented paper, main satellite sensors and their use for climatological data derivation is discussed.

2. Satellite Systems

There are many operating satellite platforms. They differ in orbit characteristics, sounding systems, spectral range and spatial resolution. The brief overview of the most known satellite systems is presented in the Table 1.

Tab. 1. Basic information concerning major satellite systems.

Platform	Image Size	Resolution (in the satellite sub-point)	Repeat Mapping	Scale
METEOSAT (geostationary)	Hemisphere	2.5 or 5.0 km depending on channel	1/2 h	global
GOES (geostationary)	Hemisphere	1, 4, 8 or 10 km depending on channel	1/2 h for GOES-E 15 min for GOES-W	global
NOAA (AVHRR) (orbiting)	5000 km	1 km	12 hours	regional
Landsat (TM) (orbiting)	185 km	30 m	16 days	1:1 000 000 to 1: 100 000
SPOT (HRV) (orbiting)	60 km	20 m (10 m)	27 days	1: 100 000 to 1: 25 000

2.1. Orbit Parameters

Most frequently, satellite systems are classified according to their orbits parameters as geostationary and polar orbiting. Geostationary satellites, such as METEOSAT, GOES or GMS, hover over the same place on Earth because their period of rotation is the same as the Earth's (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 (Vaughan 1994). A disadvantage of this orbit is poor coverage for high latitudes - the spatial resolution is about 8-14 km depending on spectral channel. Moreover, current geostationary satellites, except GOES, provide data only in three spectral ranges, visible, infrared and water vapour channel, what reduces the amount of potential parameters.

Second group of satellites there are polar orbiting satellites, such as NOAA, Nimbus, ERS, METEOR, Landsat or SPOT that 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 (Tab. 1). The sensors onboard of orbiting satellites are characterised by much better spatial resolution, which varies from 1 km for NOAA/AVHRR to 10-20 m for SPOT. This allows to monitor the phenomena that require more detailed routine observations.

2.2. Spectral Channels and their Usefulness for Climatological Applications

Information concerning sensed object is obtained from electromagnetic radiation. The useful range of wavelengths extends from the ultraviolet, through the visible and infrared, thermal and microwave into long radiowave region. Choice of appropriate wavelength depends on studied parameter. In the Table 2, spectral ranges useful for different atmospheric parameters derivation are presented together with the list of satellite systems.

Tab. 2. Sensors and satellite platforms for monitoring some climate parameters.

Parameter	Spectral Region		Satellite Platform(s)
Clouds: coverage, type, etc.	VIS, NIR TIR	0.4-0.7 μm 1.0-2.7 μm 8.0-14.0 μm	NOAA, GOES, DMSP, Nimbus
Water Vapour	H_2O microwave	6.3-9.0 μm 8, 21, 22, 31, 37, 90, 183 GHz	GOES, METEOSAT, Nimbus, DMSP, NOAA
Sea Surface Temperature	TIR microwave	8.0-15.0 μm 6.6GHz	NOAA, Nimbus, Seasat
Snow-Cover & Sea Ice	VIS NIR TIR microwave	0.4-0.7 μm 1.51-3.9 μm 8.0-14.0 μm 23 cm	NOAA, GOES, DMSP, Seasat, Nimbus
Vegetation	VIS NIR microwave	0.6 μm 0.9 μm 37 GHz	NOAA, Landsat, Nimbus, SPOT
Earth Radiation Budget	VIS NIR TIR	All available All available All available	NOAA, GOES, ERBS, METEOSAT, Nimbus
Trace Gases: CO_2 Ozone	UV-C, -B TIR IR	0.2-0.3 μm 9.6 μm 15 μm	Nimbus, ERS, NOAA

Ultraviolet radiation (UV) (0.2-0.4 mm) is strongly absorbed by ozone so, this spectral range is used for ozone monitoring. Ozone measurements in the UV are performed by Nimbus/TOMS, ERS/GOME satellite sensors.

Visible (VIS) (0.4-0.8 mm) and near-infrared (NIR) (0.8-2 mm) radiation is mainly reflected by the Earth's surface or atmospheric layers with high water vapour contents (clouds, fog, haze). Measurements in these spectral channels provide information about ground cover, vegetation in cloudless conditions. It is also used for clouds classification and Earth radiation budget calculations. The most known VIS and NIR sensors are NOAA/AVHRR, METEOSAT/VIS, GOES/IMAGER, Landsat/TM and Landsat/MSS, and SPOT/XS.

In the mid-infrared spectral range (2-8 mm) sensors measure mainly terrestrial radiation. The channels of AVHRR, GOES/IMAGER as well as METEOSAT/ are especially useful for mapping global extend of water vapour (Vaughan 1994).

As the thermal infrared range (8-15 mm) lies in the „window region" in which atmospheric absorption is weak (with the exception of 9.6 mm ozone absorption band), it provides information about sea surface temperature, temperature and humidity profiles, clouds' top temperature and, to some extend, about snow and ice cover. The thermal infrared radiation is measured by NOAA/AVHRR, NOAA/HIRS, METEOSAT/IR, GOES/IMAGER and /SOUNDER, ERS/ATSR and radiometers onboard of Nimbus.

In the microwave range (1 mm-1 m) atmosphere is almost transparent, what makes this spectral region suitable for monitoring such parameters as ice and snow extends. Additionally, microwave radiation that is measured by satellite, does not depend on solar illumination and cloud conditions. Microwave radiometers are carried on NOAA and ERS satellites.

3. Conclusions

Both spectral and spatial sampling resolutions of satellite systems allow to derive wide range of atmospheric parameters. Moreover, the satellite-derived data series meeting the climatological needs are now available. For instance, global cloud climatology has been obtained within International Satellite Cloud Climatology Project (ISCCP) aimed at integrating data from the geostationary satellites with the polar orbiting system (Rossow, Schiffer 1991). ISCCP started in 1983 and it has been very successful in producing a cloud climatology, which enables a wide range of research on clouds and climate (Slingo 1994).

Second factor of crucial importance for climate studies is the Earth's radiation budget (McGuffie 1994). Radiation budget has been the subject of intensive satellite monitoring, especially within the frame of the Earth Radiation Budget Experiment (ERBE). Satellite data are used to estimate, on the global scale, solar constant as well as incoming solar and outgoing terrestrial radiation.

Satellites data are also applied to monitor the impact of the man-made environment changes. This is satellite data that confirmed, in 1986, the Antarctic ozone hole appearance and has now become a main source of information about distribution of total ozone amount as well as other trace and greenhouse gases.

The last three decades are characterised by the enormous development in satellite sounding techniques contributing to climate monitoring and modelling. It seems that next years will mark another milestone in satellite climatology when the planned satellites are launched and operated.

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