The use of meteorological satellites for the improvement of human health

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1.) **Introduction. A brief history of the remote sensing**

> "Close all shutters and doors until no light enters the camera except through the lens, and opposite hold a piece of paper, which you move forward and backward until the scene appears in the sharpest detail. There on the paper you will see the whole view as it really is, with its distances, its colors and shadows and motion, the clouds, the water twinkling, the birds flying. By holding the paper steady you can trace the whole perspective with a pen, shade it and delicately color it from nature."
> Daniel Barbaro, Venetian, 16th-century.

Since the older times men have observed and studied the optical phenomena in nature, like the formation of images, eclipses and sky observation. In 300 b.C. the Greek philosopher Aristotle observed the sun's image projected on the soil after the passage of the sunlight through a small orifice. He also perceived that the smaller was this orifice, the clearer was the image. It was the first (and rough) description of a *Camera obscura* (Latin name for the dark room). In the tenth-century the Arabian scholar Ibrahin Ibn Ibrahin reported the use of a small orifice in a dark room to project eclipses in a wall. European studious also used this technique some centuries later, like Leonardo da Vinci (1452-1519) that also wrote about the use of a similar device as a dark room. In the following years, studious, astronomers, painters and artists also used dark rooms for different proposals. The development of lenses and modern technologies has contributed to the man's desire of recording the scenes. In June/July 1827, Joseph Nicéphore Niepce, using a technique called heliography, obtained the first successful recorded image with the use of a sensor placed at some considerable distance of a target. However, the invention of photography cannot be credited to only one person. One of the most famous inventors is also the French Louis Jacques Mandé Daguerre, who had worked with Niepce and continued working after his death. Daguerre created a technique to fix an image in a copper shape covered with a thin silver pellicle, using mercury vapor. After few years, photographic cameras started to be mounted in free and captive balloons to produce aerial images. The aerial photography was extensively used in topography maps, war strategy and petroleum exploration. In the twentieth-century, new techniques were developed for the use of colors (~1900), infrared (~1930), ultraviolet and multi-spectral (~1960) images. In spite of the utilization of remote sensing devices since the nineteen-century, the term "remote sensing" became usual after the 1950's to describe a type of observation whose sensor is placed at some considerable distance from a target.

On the other hand, advances in "non-photographic" remote sensing were also occurring. In 1800 Sir William Herschel discovered the infrared spectral region, and almost 90 years later Hertz demonstrated the reflection of radio waves from solid objects. In the same time Langley made temperature measurements of electrical objects using a bolometer (an instrument to measure integrated fluxes in all electromagnetic spectrum). In the first years of the last century, scientists used thermopiles installed in airplanes to detect heat effects. This device was extensively used by British and Germans to locate airplanes from the thermal patterns at night. During the II World War, the first radars were developed to detect and track

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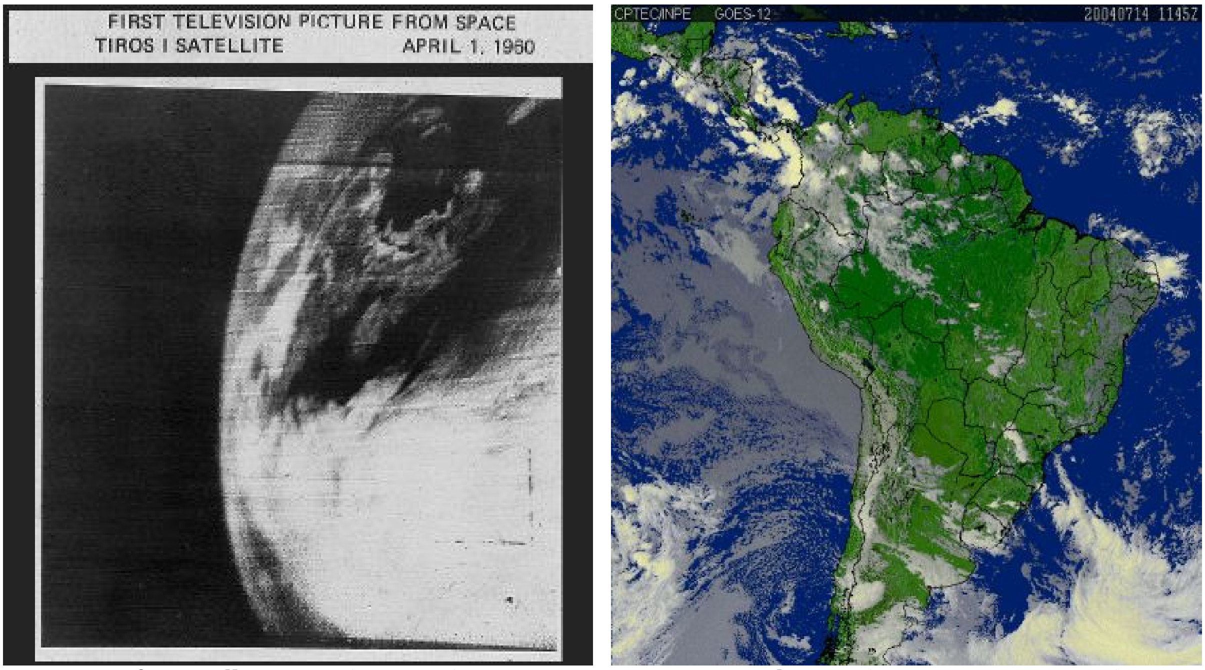
aircraft and ships, but only in 1950's the first concepts of a coherent moving and X-bands radars were developed. Finally, in the 1960's, we had the development of various detectors, which allowed the building of imaging and non-imaging radiometers, scanners, spectrometers and polarimeters. These sensors are commonly found in satellites devices. In the case of satellites, "remote sensing" describes a technique that sample electromagnetic radiation to extract information about characteristics of the Earth (atmosphere, land surface and oceans) and/or the solar system (planets, stars and galaxies). We can say that the first step to the development of the satellite technologies was done in 1891, when Rahmann proposed the use of a rocket as a photo platform. Almost 50 years later, the V-2 rockets made the taking of space pictures possible (1946).

The first satellite was launched in October 1957 by the former Soviet Union – the Sputnik – and after three months, US launched its satellite: Explorer 1. In April 1st, 1960, the first successful US meteorological satellite TIROS-1 (Television Infrared Observation Satellite) was sent to space and it obtained images of the Earth and its weather system as whole (figure 1 left). Until 1965, nine additional satellites were launched in the TIROS series, each one was carrying new devices for the improve of meteorological studies. At first, these sensors were basically TV cameras that gave black and white pictures in low resolution (little detail) of clouds and Earth's surface, but the fast technological development allowed the creation of new sensors to numerous weather satellites with the most different objectives. Amongst the most important satellites, the ones that we can distinguish are Nimbus series (US, 1964 – today), Meteor-1 and Meteor-2 (former Soviet Union/actually Russia, 1969 – today), Landsat (US, 1972 -), GOES (US, Geostationary Operational Environmental Satellite, 1975 –), GMS (Japan, Geostationary Meteorological Satellite, 1977), Meteosat (Europe, 1978 –), Baskhara (India, 1979 –). Nowadays satellite sensors measure radiation in different ways and spectral regions, commonly called by channels. Compositions between these channels provide high quality images which are necessary to comprehend and study the various atmospheric and land phenomena (figure 1 right).



first satellite image (TIROS-1) an actual image (GOES-12 composition)

Figure 1 – Satellite images: past and present

The understanding of these phenomena is an important tool in the study of the appearance, spread and behavior of several illnesses in living beings. For example, observations of the ultraviolet radiation variations reflected by the terrestrial atmosphere are used to estimate the total ozone content. The decrease in the amounts of this gas can increase the UV fluxes that reach the surface and increase the dangerous effects of this radiation, such as the occurrence of burns and the increase in the number of skin cancer cases in human beings. Satellites are also used to identify focuses of biomass burning and to follow the displacement of smoke and pollution plumes. The particles that compose these specific clouds are related to series of respiratory problems like the asthma and the lung emphysema. Endemic diseases, like schistosomiasis, yellow fever and malaria, are also subjects of studies from satellite observations. Identification of flooded areas, precipitation development and soil temperature are supplied by satellites and used to identify the development cycle and displacement of the vectors of these diseases. Observations of the sea surface temperature are also quite used to identify focuses of cholera. Table 1, adapted from Beck et al.'s work (2000), gives a summary between observed factors and possible diseases. Generally, remotely sensed factors are related to vector (mosquito, snail, worm, etc.) habitat, reservoirs, hosts, available food and environmental conditions.

disease	RSF	disease	RSF
Chagas disease	Vegetation / crop type; Deforestation; Urban features	Lyme disease	Vegetation / crop type; Vegetation/green-up; Ecotones; Forest patches; Soil moisture
Cholera	Wetlands; C (Ocean color); T (Sea surface temperature); H (Sea surface height)	Malaria	Vegetation / crop type; Vegetation/green-up; Deforestation; Flooding; Permanent water; Wetlands; Soil moisture; Canals
Dengue fever	Urban features	Onchocerciasis	Permanent water; Canals
Encephalitis	Wetlands	Plague	Vegetation / crop type; Vegetation/green-up
Filariasis	Permanent water; Urban features	Rift Valley fever	Vegetation/green-up; Flooding
Hantavirus	Vegetation / crop type; Vegetation/green-up	Schistosomiasis	Vegetation / crop type; Flooding; Permanent water; Wetlands; Soil moisture; Canals
Helminthiasis	Soil moisture	Trypanosomiasis	Vegetation / crop type; Vegetation/green-up
Leishmaniasis	Vegetation / crop type; Ecotones; Urban features	Yellow fever	Vegetation / crop type; Deforestation; Forest patches

Captions – remotely sensed factors (RSF)

Vegetation / crop type		Vegetation/green-up	
Deforestation		Urban features	
Ecotones		Forest patches	
Soil moisture		Canals	
Flooding		Permanent water	
Wetlands		Ocean color	C
Sea surface temperature	T	Sea surface height	H

Table 1. Potential links between remotely sensed factors and main diseases

Beyond this range of usefulness, the meteorological satellites had an important role in the prevention and control of diseases that reach, mainly, poor countries and the ones in development. The following sections will summarize the most important topics about satellite meteorology, including brief summaries about basic theory, properties, orbits and sensors of the satellites and applications for satellite imagery.

2.) **Solar and terrestrial radiation**

Most of remote sensing methods are based on electromagnetic radiation (EMR) variations that excite a target sensor. A fundamental property of the EMR is its transport of energy that consequently will reach this sensor. EMR waves are consisted of electric and magnetic fields that propagate alternatively in perpendicular directions. It is characterized by a broad range of wavelengths (distance between crests of one of the fields) and frequencies (rate which the fields oscillate at a point) associated with a specific intensity (or amplitude) and quantity of energy (figure 2). The variation plot of the quantity of energy related to the wavelengths gives rise to a specific pattern or curve that is the spectral signature for the substance or feature that is being observed.

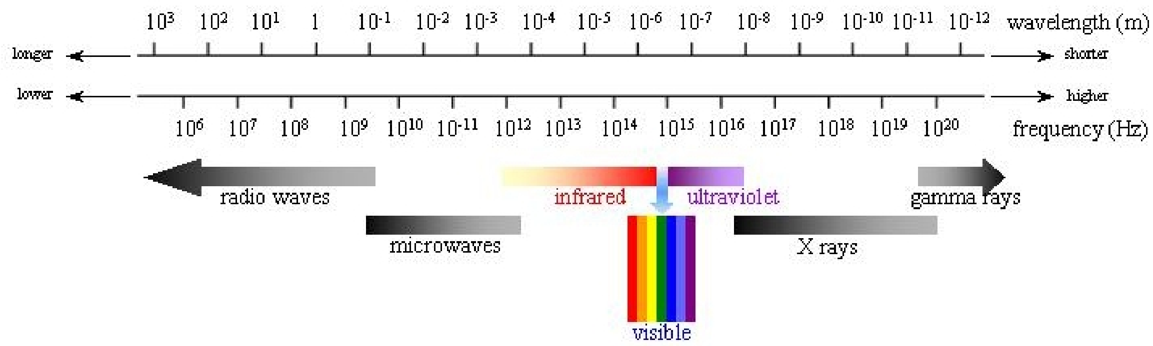


figure 2 – electromagnetic spectrum

Sun emits EMR in practically all-spectral range. However, 99% of this radiation is emitted between the following regions: ~7% in ultraviolet (0.2 – 0.4μm), ~ 45% in visible (0.4 – 0.7μm) and ~ 45% in near-infrared (0.7 – 3.0μm) – [1μm = 10^{-6} m]. Sun radiation interacts with atmospheric elements (air and aerosol particles, gaseous molecules, moisture, etc.) and Earth surface (land or ocean) before reaching a certain target. These interactions will absorb or scatter solar fluxes that arrived at the top of the atmosphere in different directions. The remaining radiation will arrive in the surface transmitted or scattered forward. At the surface, a fraction of the radiation is absorbed and another part is reflected back to the atmosphere. After hence, new interactions occur until the residual radiation leaves the atmosphere and reaches the satellite sensor. Thus, basically three types of interactions occur between solar radiation and Earth-atmosphere system: transmission, reflection and absorption. Earth and atmosphere also emit radiation, but it is practically only in the infrared region above 4μm. This type of radiation also reaches the satellite sensor and it can be used to study atmospheric and land phenomena.

The spectral region in which a satellite sensor operates is related to the specific interactions between solar and terrestrial radiation and the atmospheric components. For example, in the infrared region, the range between 10.5 μm and 12.5 μm is known as spectral window by presenting low radiation absorption. However, other spectral bands suffer strong atmospheric gaseous absorption. For example, water vapor in 6.4 μm, ozone in 9.6 μm and carbon dioxide in 15.0 μm. The gaseous absorption is not just a limit to these wavelengths, but to infinity of spectral bands. Therefore, the study of gaseous absorption is very complex. In the visible region of the spectrum, these gases weakly absorb solar radiation. However, it suffers strong scattering, mainly, due to the clouds and aerosols present in the terrestrial troposphere. In the ultraviolet region, scattering is stronger and the radiation is also strongly absorbed by oxygen (< 0.25 μm) and ozone (between 0.2 and 0.3 μm). Information about one or several channels centered in certain regions of the spectrum allow to studying certain phenomenon. For example, measurements of the emitted radiation in certain infrared bands allow the evaluation of profiles and contents of atmospheric components as the water vapor, carbon dioxide and ozone. Visible radiation reflected by the aerosols combined with information of the spectral window located in 2.1 μm can supply information concerning contents of these particles in continental areas. Moreover, observations of the ultraviolet radiation reflected by air molecules in different UV bands are used to estimate vertical distribution of this gas in the atmosphere. The reader can find more detailed information in Liou (2002).

3.) **Satellites**

Nowadays a large number of satellites travel around and beyond the frontiers of the Earth. Those that are flying around our planet show different orbits, purposes and characteristics. They are launched to perform earth observations, like the meteorological and environmental satellites, as well as for broadcast and communication use, like the telecommunications satellites. In this section, we will show only essential information, mainly about meteorological satellites. However, among several good references, readers can find more detailed information not only for meteorological satellites in Chen (1985, 1997), but also in Kidder and Haar (1995) and Roddy (2001).

The basic components of the most part of the satellites are the command control, communication device, payload, pointing control, power supply and the thermal control. The command center controls all the functions of the spacecraft through the flight computer. The brain of the satellite uses communication devices like transmitters, receivers and antennas to relay messages between the satellite and Earth. Payload is everything that a satellite needs to perform its specific mission: instruments, sensors, telescopes, antennas, etc. Pointing control keeps the satellite steady and pointing to the right direction using direction detectors and propulsion mechanisms or momentum wheels. The satellite use solar arrays to make electricity from sunlight, batteries to store the electricity, and distribution units that send the power to all satellite instruments. These parts mentioned before are the power supply of a satellite. In orbit, a satellite is exposed to extreme temperature changes, from –120°C to +180 °C. For this reason, a satellite must have a good thermal control that protects all the satellite equipment from damage in the space, using heat distribution units and thermal blankets.

We have basically two types of sensors in meteorological satellites: Imagers and sounders. The apertures and optics of these sensors determine the size of the scene that is framed in the system that defines the field of view (FOV). Commonly these sensors scan scenes point-by-point along successive lines through the time (scanning system). Optical imagers provide imagery of the Earth's surface and cloud cover using basically a rotating mirror and a telescope. On the other hand, the sounders are designed to collect data samples from different levels of the atmosphere to provide a three-dimensional array of its conditions such as pressure, temperature and humidity. A satellite imager scans across the scene below, collecting up-welling radiation from small areas or scan spots, directing the radiation to a radiometer that measures its intensity. The collected data can be the reflected sunlight by the surface and/or the atmosphere when the sensor is sensible to visible radiation. The disadvantage of the visible sensor is that it only allows the collect of images during the day. If the sensor can see infrared radiation, the data refers to the radiated heat emitted by all objects on Earth and, consequently, the measurements can also be done during the night. Normally, fluxes measured in infra region are converted to a temperature measurement. Besides visible and infrared regions, microwave data is also used to study atmospheric phenomena. In this spectral region, imagers work as a radar. They transmit microwave signals to the Earth's surface and measure the reflected signal. Once the radar has emitted a microwave signal, the power reflected by the objects hit by the signal is measured. This is called backscatter. In this data, the rougher the object is, the higher the backscatter and, consequently, the brighter the image is. For example, cities and mountains are very rough surfaces and generally very bright. On the other hand, a calm sea is a very smooth surface and it is darker. The microwave can be acquired day and night and its signal penetrates clouds, so images can be acquired regardless of current weather conditions.

Observations of a determined phenomenon depend on the movement that the satellite does around the earth. The most known orbits are the polar, sunsynchronous and geosynchronous ones. Each one of them is chosen in agreement with different purposes, advantages and disadvantages. Polar orbits (or near-polar orbits) have an inclination near 90 degrees. This allows the satellite to see virtually every part of the Earth as the Earth rotates underneath it. A polar satellite must travel very fast (~ 27,500 km/h) to compensate the Earth's gravitational attraction. With this speed, it can circle Earth in about 100 minutes flying in an altitude around 1000km. Due to its nearness they are very useful to obtain very accurate images of the Earth. Besides the north-south direction (polar orbits), the low Earth orbits can have other directions. These satellites have many uses such as measuring ozone concentrations in the stratosphere and temperatures in the atmosphere, observations of the polar aurora and for magnetosphere studies. In a special polar orbit named sunsynchronous, the satellite moves over a given section (latitude) almost around the same local time every day. The term sunsynchronous means, "moving at the same rate of the Sun". These satellite image scenes have around the same sun time during each passage, so that lighting remains roughly uniform. As the year has 365 and a circle has 360 degrees, it means that the satellite has to shift its orbit by approximately one degree per day. The low altitude of a sun-synchronous orbit (700–800 km) provides a good ground resolution. It also enables easier active measurements with radar or lidar. A limitation of these satellites, the continuous temporal observation, is not possible with only one sun-synchronous satellite. A constellation of satellites is necessary to solve this problem. The idea of geosynchronous satellites (GEO) is to find an orbit over the equator in which the satellite travels around the earth at the same rate that the earth spins on its axis. In other words, it needs to find an orbit with a period of approximately 24 hours (*geo* = Earth; *synchronous* = moving at the same rate). Commonly, GEO's are also called by geostationary. Both terms have practically the same meaning, but to be GEO the satellite must have zero inclination and eccentricity (the orbit must be circular). These satellites are located above the equator, approximately 36,000 km high, and point directly over the same spot on Earth. GEO's orbits allow the satellite to observe almost a full hemisphere of the Earth, and they are generally used to study large-scale phenomena such as fronts, hurricanes and cyclones. These orbits are also used for communication satellites. The disadvantage of this type of orbit is that since these satellites are very far away, they have poor resolution. The other disadvantage is that a GEO satellite has troubles to monitor activities near the poles. In these cases, it is possible to use an elliptical north-south orbit satellite to scan these extreme regions.

4.) **Remote sensing and human health**

Remote sensing data is an important tool to study, even indirectly, environmental factors related to the location and propagation of certain endemic diseases, like malaria, schistosomiasis, trypanosomiasis, chagas disease, yellow fever, among others. Vegetation cover, landscape structure and water bodies are the most used variables usually obtained from observations of Landsat, SPOT and NOAA satellites. Landsat orbits the Earth in approximately 100 minutes at an altitude of 705 km. The whole surface is covered in 16 days. Landsat version 5, launched in 1984 and operating, is equipped with two optical sensors used in human health studies, the Multispectral Scanner (MSS), that delivers data in four spectral channels, and the Thematic Mapper (TM), that delivers data in seven spectral channels. In 1999, the 7^{th} version of Landsat was launched with the previous sensors substituted by the Enhanced Thematic Mapper Plus (ETM+), with seven channels plus a panchromatic channel between 0.52 to 0.90 μm. However in 2003 a serious problem was detected in this sensor.

SPOT is the acronym of Système pour l'observation de la Terre, a satellite developed by the French Centre National d'Etudes Spatiales (CNES). The first SPOT was launched in 1986 and the last (5^{th}) in 2002. Actually, three SPOTs are in operation. These satellites observe the same area on the globe every 26 days. It is commonly referred as a pushbroom scanner meaning that all scanning parts are fixed and scanning is accomplished by the forward motion of the scanner. This is different from Landsat that scans with 16 detectors perpendicular to its orbit. SPOT 5 can operate in a multispectral mode, with four sensors between visible and infrared region, and in a panchromatic mode, with two broadband channels between 0.48 and 0.71 μm. Composition between both panchromatic channels provides images with 2.5 m of spectral resolution.

The Polar Orbit Environmental Satellites (POES), like National Oceanic and Atmospheric Administration (NOAA) systems, offer the advantage of daily global coverage, by making nearly polar orbits roughly 14.1 times daily. The first POES, named TIROS, were launched in 1960's (see section 1). The current configuration is the same the NOAA-15 (also named NOAA-K), launched in 1998 that was the first in a series of five satellites with improved imaging and sounding capabilities. The last NOAA family satellite was launched in 2002: NOAA-17 (or NOAA-M). Since 1979, NOAA satellites have carried an Advanced Very High Resolution Radiometer (AVHRR) providing up to six-band multispectral data. The AVHRR, actually in the version 3, is a radiation-detection imager that can be used for remotely determining cloud cover and the surface or cloud top temperatures. There is fairly continuous global coverage, with morning and afternoon acquisitions available. Table 2 shows AVHRR/3 channels.

#	wavelength (μm)	typical use
1	0.58 - 0.68	daytime cloud and surface mapping
2	0.725 - 1.00	land-water boundaries
3a	1.58 - 1.64	snow and ice detection
3b	3.55 - 3.93	night cloud mapping, sea surface temperature
4	10.30 - 11.30	night cloud mapping, sea surface temperature
5	11.50 - 12.50	sea surface temperature

Table 2. AVHRR/3 channels – resolution 1.09km – (adapted from http://noaasis.noaa.gov)

Another modern sensors were launched in the last years. For example, a very useful device for human health-related studies, the Moderate Resolution Imaging Spectroradiometer (MODIS), aboard Terra (EOS-AM) and Aqua (EOS-PM) satellites, provides a large amount of information about Earth surface and atmosphere. Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon. This way, these sensors observe the entire Earth's surface every 1 to 2 days. The data are collected in 36 different spectral channels according to 11 different subjects of study as table 3 shows. Combinations between these channels can provide infinity of different analysis.

However human diseases studies are not only related to surface observation, but also with atmospheric parameters like gaseous, particles and other components distributions. For example, high levels of ultraviolet radiation (UVR) can cause different problems to the terrestrial and aquatic ecosystems of the Earth, mainly for the mammals, fishes, plants, phyto- and zooplankton. Particularly for human beings, the excess of UVR can cause sunburn (erythema), premature aging of the skin, cataracts, suppression of the immune system and different types of skin cancer. However, small quantities of this radiation act as a catalyst in the generation of cholecalciferol (vitamin D) and are essential to human health. Ozone is the main absorber of the UVR that can reach Earth surface. Almost 90% of the ozone content extends upward from about 20 to 40 km (the "ozone layer") and protects life on earth from the sun's harmful UVR. The other 10 or 15% is located at the ground level and it is known by "bad ozone", an air pollutant emitted by motor vehicle exhaust and industrial emissions that damages human health, vegetation, and many common materials.

In the last decades, scientists have alerted people about the ozone layer depletion (in spite of a "bad ozone" increment) caused by intense anthropogenic activities. Due to the relevant importance of this subject, satellite observations are essential to monitor and study the behavior of ozone variations and UVR levels. The monitoring of ozone content and its vertical profile is generally accomplished using UV detectors. However, and in spite of larger uncertainties, some sensors like the High Resolution Infrared Sounder (HIRS) at the NOAA satellite or MODIS at the EOS/Earth and Aqua satellites (see table 3) also measure ozone using infrared channels. Total Ozone Mapping Spectrometer (TOMS) and Solar Backscattering Ultraviolet Instrument (SBUV/2) are the most popular sensors installed in Earth Probe and NOAA satellites respectively. They measure reflected radiation in several UV wavelengths providing an accurate description of the ozone content in the atmosphere. The difference between both instruments is that SBUV/2 looks directly downward direction with 12 different channels, while TOMS scans a global coverage of the sunlite portion of the Earth with only 6 channels. These differences allow SBUV/2 to provide ozone profile, beyond the total ozone content. These measurements also allow the total erythemal UVR estimate that reaches Earth surface.

Primary Use	Band	Bandwidth (μm)	Primary Use	Band	Bandwidth (μm)
Land/Cloud/ Aerosols boundaries	1	0.620 – 0.670	**Surface and cloud temperatures**	20	3.660 – 3.840
	2	0.841 – 0.876		21	3.929 – 3.989
Land/Cloud/ Aerosols properties	3	0.459 – 0.479		22	3.929 – 3.989
	4	0.545 – 0.565		23	4.020 – 4.080
	5	1.230 – 1.250	**Atmospheric temperature**	24	4.433 – 4.498
	6	1.628 – 1.652		25	4.482 – 4.549
	7	2.105 – 2.155	**Cirrus clouds/ Water vapor**	26	1.360 – 1.390
Ocean color/ Phytoplankton/ Biogeochemistry	8	0.405 – 0.420		27	6.535 – 6.895
	9	0.438 – 0.448		28	7.175 – 7.475
	10	0.483 – 0.493	**Cloud properties**	29	8.400 – 8.700
	11	0.526 – 0.536	**Ozone**	30	9.580 – 9.880
	12	0.546 – 0.556	**Surface and cloud temperatures**	31	10.780 – 11.280
	13	0.662 – 0.672		32	11.770 – 12.270
	14	0.673 – 0.683	**Cloud top altitude**	33	13.185 – 13.485
	15	0.743 – 0.753		34	13.485 – 13.785
	16	0.862 – 0.877		35	13.785 – 14.085
Water vapor	17	0.890 – 0.920		36	14.085 – 14.385
	18	0.931 – 0.941			
	19	0.915 – 0.965			

Orbit: 705 km, 10:30 a.m. descending node (Terra) or 1:30 p.m. ascending node (Aqua), near-polar, sun-synchronous, circular.
Spatial resolution: Bands 1-2 (250m), bands 3-7 (500m) and bands 9-36 (1000m)

Table 3. MODIS specifications (adapted from http://modis.gsfc.nasa.gov/, available in July 21, 2004)

Another important task of the meteorological satellites is the observation of the pollution sources and their displacements, like biomass burning focuses and smoke clouds. Air pollution is made up of many kinds of gases, droplets and particles which reduce the air quality, and it can cause serious adverse environmental effects and health problems, such as cancer, respiratory and heart diseases, reproductive effects or birth defects. Beyond the “bad ozone”, toxic air pollutants can have more than 100 different gases, including benzene, which is found in gasoline; perchlorethlyene, which is emitted from some dry cleaning facilities; and methylene chloride, which is used as a solvent and paint stripper by a number of industries.

Examples of other listed air toxics include dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium, and lead compounds (EPA, 2004). Particularly, the smoke is made up of a complex mixture of gases and fine particles produced when organic matter burns. The biggest health threat from smoke comes from microscopic particles. These particles may get into the eyes and respiratory system, where they may cause health problems such as burning eyes, runny nose, and illnesses such as bronchitis. Fine particles also can aggravate chronic heart and lung diseases, and even are linked to premature deaths in people with these conditions. Air can be polluted not only in the cities, but also in the country or wild areas. In the cities, basically the automobiles as well as the industry cause air pollution. In the non-urban areas, pollution can be caused mainly by biomass burning and forest fires. However, it is very common that the smoke from forest fires reaches urban cities located far from the fire focuses. It represents an additional source of pollution to those urban areas. Several studies about the air pollution are focused in this subject and the satellites are an important tool for these works. Figure 3 shows two of these satellites products. The left figure shows fire focuses in South American continent based on NOAA-12 observations. Sometimes, more than 6,000 points are detected daily, and the most part are found over Amazonian Region. Daily bulletins inform critical situations over Brazilian rainforest (more information about this work can be found in http://www.cptec.inpe.br/queimadas). The right figure shows a high-resolution MODIS image over South America. In this image we can see Andes Mountain as a barrier to the smoke produced in the continent. These fires are located mainly in rural areas of Brazil, Bolivia and Paraguay, but the smoke reaches many cities of these countries. For example, Asunción – capital of Paraguay – is severely affected during the burning seasons and biomass smoke can also be detected by surface sensors installed in São Paulo city, located in Southeast Brazilian coast. Besides, forest fire smoke does not affect only human health. Several studies show influences on UV radiation (Corrêa e Coronel, 2002), photosynthetically active radiation (Yamasoe et al., 2000), radiative forcing (Procopio et al., 2004), and clouds (Twomey, 1977; Kaufman et al., 1993).

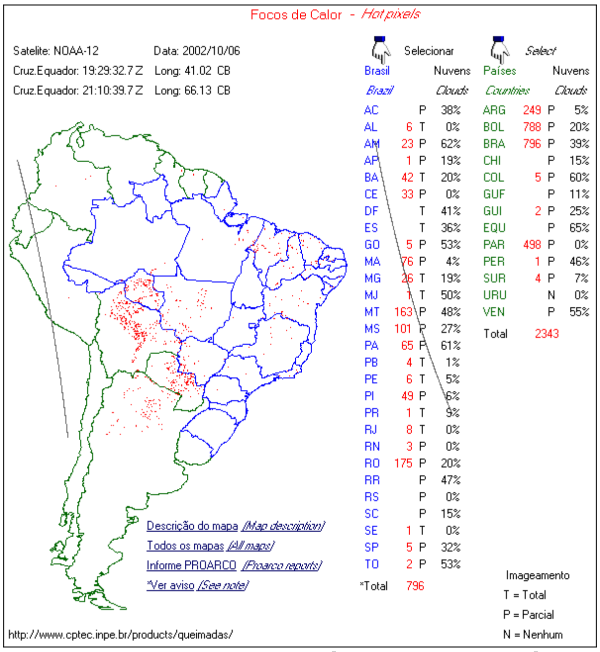


Figure 3a – Fire spots in South America at October 6, 2002. DSA/CPTEC available product.

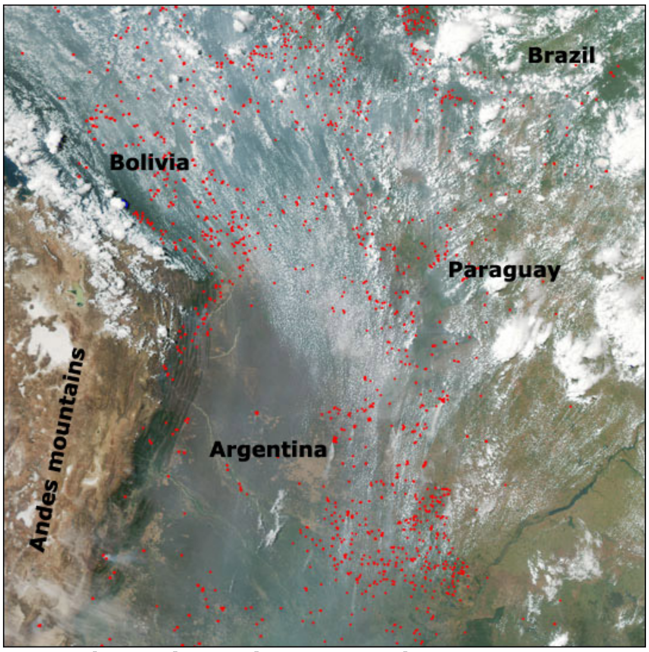


Figure 3b – Widespread Fires in South America. MODIS – EOS/Aqua image in October 6, 2002.

5.) **Final considerations**

This article showed a brief discussion on subjects related to the use of meteorological satellites in the detection and attendance of several illnesses that reach human beings around the world, mainly in the poorer countries. For this reason, the satellite is a fundamental tool in the monitoring and prevention of many diseases, resulting in an improvement of life quality. In this text, the author tried to summarize the most interesting aspects related to this subject, indicating more complete texts to the readers. The sections are divided in a chronology of the remote sensing, basic theory involved in satellite measurements, anatomy and operation characteristics of these devices and a summary about the use of satellites in health studies.

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