D

Appendix D: Quantitative Products from Satellite Observational

Interpreting clouds from satellite pictures was the first application of remotely sensed data from environmental satellites in the early 1960s. Satellite image interpretation is still critical today for monitoring weather patterns, severe storms, snow and ice fields, flood coverage, biomass burning, volcanic ash dispersion, and numerous other applications. High and low resolution satellite imagery are received by users worldwide in real time through local ground receivers and by central processing facilities where the image data are further processed into quantitative products.

Three operational satellite systems provide continuous views of the Earth-the Geostationary Operational Environmental Satellite (GOES) and the polar-orbiting National Oceanic and Atmospheric Administration (NOAA) satellites, both operated by NOAA; and the Defense Meteorological Satellite Program (DMSP), operated by the Department of Defense (DOD). NOAA and DOD work closel y together in exchanging data from their respective programs. The two most common modes of receiving real time NOAA polar imagery are through the Automatic Picture Transmission (AFT) and High-Resolution Picture Transmission (HRPT) direct broadcast systems.

APT and HRPT require receiving antennae that acquire imagery at ground resolutions of 4 kilometers and 1.1 kilometers, respectively. Geostationary satellites provide similar direct broad

[1] Arthur L. Booth, National Oceanic and Atmospheric Administration/National Environmental Satellite, Data, and Information Systems.

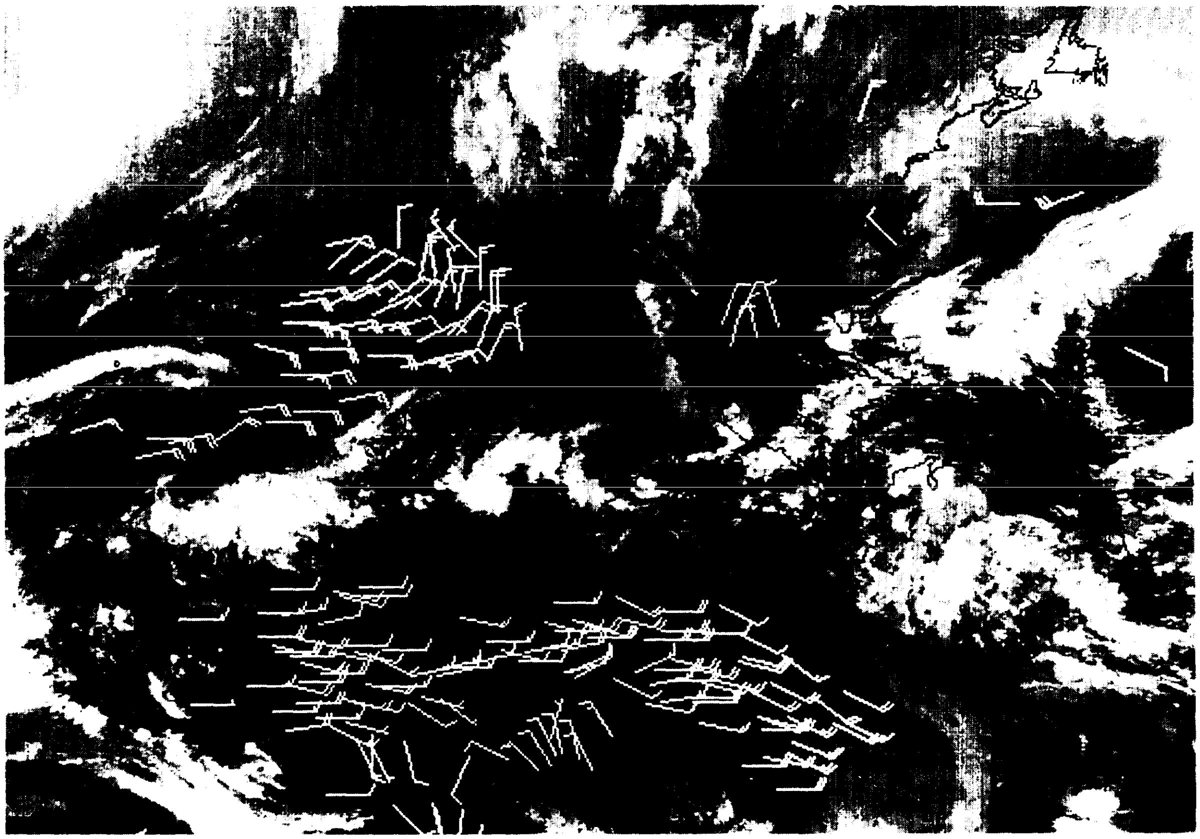


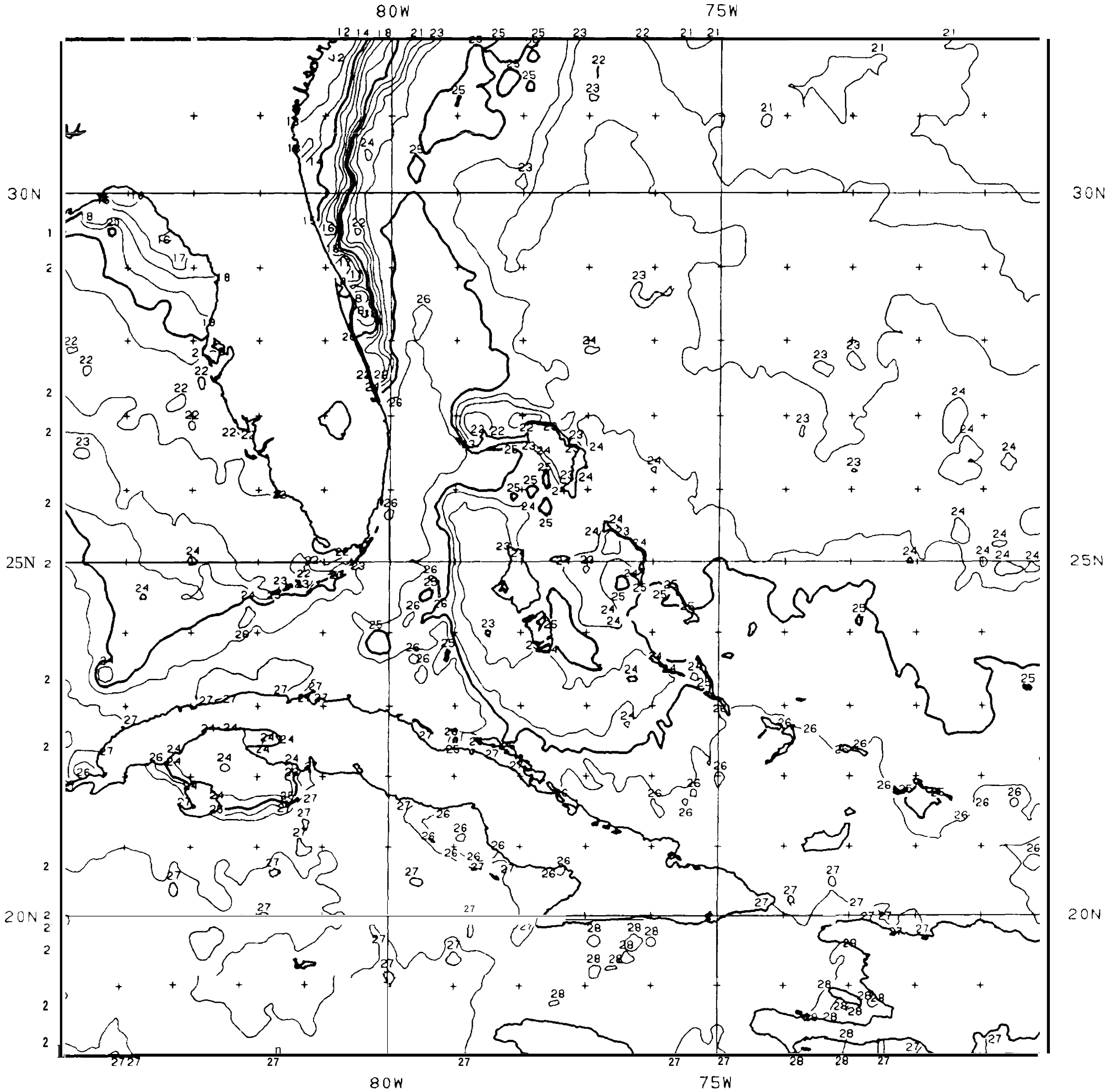
Image of cloud cover and derived wind speeds from GOES-7, 19 May 1994

cast services through Weather Facsimile (WEFAX) and regularly scheduled (normally every half-hour) direct transmissions.

In addition to collecting cloud and surface imagery, environmental satellites also provide global data used in generating quantitative products for numerical weathcr prediction models, assessments, and analyses of the oceans, atmosphere, coastal zone and land areas. NOAA currently produces about 80 quantitative satellite products on an operational basis. Many products are generated in special formats, grids, and projections to meet operational and research requirements for global, regional, and local applications. Moreover, many quantitative products have been produced on a routine operational basis from NOAA satellites since the late 1970s. resulting in one of the largest and longest continuing time series of satellite-derived global measurements in the world. These products provide important sources of global data in climate and global change studies.

Although the majority of products currently produced are derived from NOAA polar-orbiting operational data, important quantitative products are also developed from research satellites (e.g., NIMBUS and Upper Atmosphere Research Satellite (UARS) managed by the National Aeronautics and Space Administration (NASA).

Quantitative products have been made possible over time by improvements in sensor resolution, spectral coverage (e.g., infrared and microwave), and ground coverage in successive generations of satellite programs. Routine production of quantitative products from operational satellite observations started in the early 1970s with the Improved TIROS Operational System (ITOS) and improved considerable y with the launch of the current NOAA series in 1978.



NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, 1994

Sea surface temperature (SST) contours around Florida, the Bahamas, and Cuba, derived from the AVHRR sensor aboard a NOAA *POES* satellite on *Feb. 2, 1993. Increasing numbers indicate increasing temperatures (degrees centigrade).*

Satellite products are typically generated at central automated processing facilities where the full-resolution data are received from satellite readout stations and processed through a series of steps commonly designated as Levels 1, 2, and 3. Each level results in the creation of a digital data set, or product, with data volumes decreasing with each higher level of processing. Level 1 is a preprocessing step in which the raw satellite data are ingested and formatted into sensor-specific data sets with calibration, Earth-location, and quality control information appended to the data set. A global, 24-hour, Level 1 data set contains on the order of hundreds of millions of bytes of data. The next step, Level 2, uses statistical or physically based retrieval algorithms to transform the raw satellite data into geophysical products at satellite observation locations. For example, NOAA produces global sea surface temperatures on an 8-kilometer grid and global ozone measurements on a 200-kilometer grid. A typical global Level 2 product contains on the order of tens of millions of bytes of data. Level 3 products usually involve interpolation and analysis and are generally mapped to standard global or regional map projections and grids. For example, NOAA maps some products depicting aerosol concentrations into 10-degree latitude and longitude grids. A typical Level 3 product contains approximately several hundred thousand bytes of data and is in a format most accessible to the user community. NOAA performs its validation of satellite measurements in most Level 2 and 3 processing steps. Validation involves merging and intercomparing satellite measurements with conventional meteorological and geophysical data (e.g., surface-based radar, radiosonde ascents, ocean buoys, and rain gauges).

All quantitative products require special processing to correct for clouds, the atmosphere, seasonal changes, the sun-Earth-satellite geometry, and sensor calibrat ion degradation and anomalies. Two important automated processing functions (usually done in Level 2 processing) are "cloud clearing" and atmospheric attenuation. A "cloud clearing" step is necessary to identify an observation as either clear, partly cloudy, or cloudy. The information is critical for surface variables that require cloud-free, or clear-view, satellite observations, such as sea surface temperature and vegetation measurements, However, atmospheric variables such as temperature profiles and outgoing longwave radiation also require accurate cloud detection and estimates. NOAA averages some surface products, such as vegetation and sea ice measurements, over a 7- to 10-day period to insure removal of all cloud effects. Also, satellite-derived measurements must be corrected for the effects of the intervening atmosphere (attenuation) resulting from atmospheric gases (e.g., water vapor) and aerosols (e.g., dust and volcanic ash).

NOAA transmits satellite data and derived products in real time to operational users through dedicated networks. Many of the products are transmitted to customers over worldwide networks, such as the Global Telecommunications System (GTS). For researchers and the general user community, all satellite data and products are available through NOAA's three National Data Centers—the National Climatic Data Center, the National Geophysical Data Center, and the National Oceanographic Data Center. NOAA is currently improving access to its satellite data holdings by providing users with online access and services to data browse and inventory information, and data set downloading on the Internet.