

## 2.4 NOAA POLAR INSTRUMENT DATA GENERATION FOR LEVEL 1B USERS

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### 1.0 INTRODUCTION

The National Oceanic and Atmospheric Administration (NOAA)/National Environment Satellite Data and Information Service (NESDIS)/Office of Satellite Data Processing and Distribution (OSDPD)/Information Processing Division (IPD) receives and formats raw spacecraft instrument data from the TIROS series of polar-orbiting operational environmental satellites (POES) into user-friendly Level One-B-Star (1B\*) (unpacked) and One-B (1B) (packed) formats for distribution to the NOAA polar data user community. Level 1B\* data is used internally and Level 1B is distributed to users nationally and internationally. Throughout this paper, these data sets will be collectively referred to as Level 1B. The Pre-Product Processing (PPP) system is used to create and monitor the quality of the 1B data sets produced from ingested raw polar satellite data. The PPP subsystems that process the ingested polar spacecraft data perform the following functions:

- (i) Calibration—maintains a spacecraft-specific database for each POES
- (ii) Earth Location—provides POES spacecraft geolocation information included in the 1B data
- (iii) Polar Data Preprocessing (PDP)—executes the algorithms for calibrating, Earth locating, quality checking, and formatting the ingested polar satellite data
- (iv) Quality Control (QC) Monitoring System—performs quality checks, produces trending plots, and is used to analyze and evaluate the Level 1B data

In this paper, we describe the NOAA PDP of Level 1B data with particular emphasis on the user utilization of this data to generate various products.

### 2.0 NOAA POLAR INSTRUMENT DATA 1B PROCESSING

#### 2.1 Polar Instruments Data Types

The PDP processors create Level 1B formats from the ingested POES raw satellite Level 1A data sets. These processors generate and distribute the following thirteen 1B data types:

AMSU-A — Advanced Microwave Sounding Unit – A<sup>1</sup>  
AMSU-B — Advanced Microwave Sounding Unit – B<sup>1</sup>

DCS — Data Collection System  
GAC — Global Area Coverage Advanced Very High Resolution Radiometer (AVHRR)  
HIRS — High-Resolution Infrared Radiation Sounder  
HRPT — High-Resolution Picture Transmission AVHRR  
LAC — Local Area Coverage AVHRR (recorded)  
MSU — Microwave Sounding Unit<sup>1</sup>  
SAR — Search and Rescue  
SBUV — Solar Backscatter Ultraviolet Radiometer  
SEM — Space Environment Monitor  
SSU — Stratospheric Sounding Unit  
TIP — TIROS Information Processor

#### 2.2 Ingest and Preprocessing

Operation of the various NOAA polar satellite Level 1B data processing systems is principally the responsibility of IPD. IPD receives data from the Satellite Operations and Control Center (SOCC) and processes it into Level 1A and 1B data in the Central Environmental Satellite Computer System (CEMSCS). The CEMSCS has ingest and preprocessing systems for NOAA polar, NOAA geostationary, and some non-NOAA satellites. The system described in this document is most relevant to the NOAA PDP system. The PDP operation consists of components such as prelaunch activities, ingest 1A processing, 1B processing, calibration, navigation, product generation, and archive. The software systems that are implemented, operated, and maintained are in the following functional categories: Ingest (Level 1A), satellite dataset processing (Preprocessing Level 1B), product processing, archiving, QC monitoring, navigation and Earth-location, data communications, calibration (pre- and post-launch), and shared processing.

#### Ingest

The ingestor transforms the satellite Level 0 (raw data) into a more processing friendly Level 1A data set as follows:

1. Accepts and synchronizes frames of Level 0 satellite data.
2. Performs first-level quality control of data stream, filling data gaps as necessary.
3. Extracts instrument and spacecraft data from Level 0 data and reformats it into the Level 1A file format.
4. These Level 1A data sets are made available for Level 1B generation under a unique data set name

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<sup>1</sup> MSU and SSU sounding instruments were replaced with AMSU-A and B instruments on the NOAA KLM series (NOAA-15, NOAA-16, ...).

that includes orbit number identifiers and time duration for the pass.

### Preprocessing

The primary function of the data preprocessing is to create the Level 1B datasets. The software formats, error checks, calibrates, Earth locates, and otherwise manages the ingested data. Raw spacecraft data is received via the Polar Acquisition and Control Subsystems (PACS) operated in SOCC and is made available to the Preprocessing operation from the Ingest System as Level 1A data sets. The transformation from the Level 1A format to Level 1B format primarily consists of the addition of instrument calibration coefficients, Earth location information, quality control information to the raw data stream, and supplemental data about the spacecraft and the instruments onboard the satellite. Data in the Level 1B format is made accessible for internal product processing, archival, and file transfer for use by the meteorological, oceanographic, and climatological communities.

### Calibration

As part of normal operations, the data preprocessing software performs online instrument data calibration and monitors instrument telemetry to detect anomalies. Instrument channel calibration coefficients are derived from the Instrument's observations of a warm internal target and a cold external target (space). The software appends these coefficients to the scan line for later product processing. When anomalies are detected, the data is flagged as suspect for the product systems.

### Earth Location

The Advanced Earth Location Data System (AELDS) produces the Earth location data contained in the Level 1B. An online Earth location system, AELDS, uses scan line time codes to produce latitude and longitude Earth location parameters. The AELDS process provides more than just latitude and longitude information. Given the satellite position and velocity vector, the Greenwich hour angle (GHA), scan time, stepping time, stepping angle, and number of positions desired, AELDS will provide the following for the requested scan point of a specific instrument:

Satellite height	Solar zenith angles
Satellite zenith angle	Solar azimuth angles
Satellite azimuth angles	Relative azimuth angles
Latitude angles	Longitude angles
Northbound/southbound indicators	

### Monitoring and Quality Assurance

Monitoring software examines the real-time operation of the software system or performance of an instrument and generates operator error messages, statistics, and reports. Comparison with appropriate "truth" data is required in the monitoring system. Printouts and/or interactive data displays are examined for credibility. To ensure that the Earth location and navigation information provided by IPD lies within acceptable accuracy limits, QC operations are performed before, during, and after generation of the data. At present, four types of checks are used:

**Navigation:** When the user ephemeris file (UEF) containing predicted satellite position and velocity data is generated, the radius vector is compared to that generated using the elements for the previous 7 days (delta-R). Generally, these differences remain less than 1 kilometer for at least 7 to 10 days.

**Online Earth location:** An Earth location tolerance check of the satellite subpoint (nadir) location has been integrated into the AELDS process. An independent method calculates the subpoint position and compares it to the AELDS generated position. The acceptable value of the difference can be reset and checking can be turned on or off. This tolerance check gives the reassurance that the Earth location algorithm is behaving correctly.

**Post-processing Earth location:** An image QC system is used to verify the accuracy of the Earth location data embedded in the AVHRR instrument Level 1B files. Generally, the Earth location error seen in the image data around the satellite subpoint remains within 0 to 2 kilometers (specifications for AVHRR are 4 to 5 kilometers). The error near the limb is expected to be larger and is often near 5 kilometers. The current exception is an anomaly seen in the Northern Hemisphere ascending passes and the Southern Hemisphere descending passes, which displays an additional 4- to 5-kilometer error along track. Using the above-image QC techniques provides greater insight into the magnitude and source of Earth location errors.

**Trending:** Daily monitoring is also performed using the quality control and instrument trending system providing graphical statistics on the Level 1B data for each instrument. More than 3,400 instrument parameters are analyzed using this system. The PPP website address cited in the summary section of this paper provides access to a subset of this system. (Click on **Instrument and Calibration Trending**).

### 3.0 CUSTOMER UTILIZATION OF LEVEL 1B DATA

The following products are generated from the NOAA/NESDIS Level 1B data. For details on these products, go to the Products Systems Branch (PSB) website provided in the summary.

- 1. Sea Surface Temperature (SST) Products:** NOAA/NESDIS produces and archives two types of SST products, gridded products and geographically organized retrievals. The sea surface temperature products include SST anomalies, contour charts, and analyzed fields. Also provided are maps of current SSTs, ocean surface winds, hot spots, and degree heating weeks, which are useful for monitoring coral bleaching at various sites around the globe.
- 2. Mapped GAC Products:** The mapped GAC products comprise mapped mosaics displayed on polar stereo graphic and Mercator map projections with both forms available on digital media. The mapped mosaics consist of daytime visible (VIS) and infrared (IR), and nighttime IR imagery. NESDIS/IPD also produces an operational mapped GAC product, which is known as the *Global Vegetation Index Product*. This product

provides a means of monitoring the density and vigor of green vegetation over the growing areas of the Earth.

3. **Radiation Budget Products:** The Radiation Budget products include daily and monthly mean global maps of outgoing longwave (infrared) radiation and absorbed and available incoming shortwave (solar) radiation. This data is frequently used to study global climate change.
4. **Sounding Products:** A sounding is a vertical atmospheric temperature or moisture profile derived from radiance measurements. NESDIS currently has the capability of producing a maximum of 3,175,000 soundings every 24 hours from three operational spacecraft. ATOVS from NOAA-15 or 16 generates retrievals with a 60 km resolution (40 km at nadir). AMSU-B from NOAA-15 or 16 generates retrievals with a 15 km resolution and 15 km spacing between retrievals; the data are sampled to reduce the data volume by half.
5. **Coast Watch Product:** The Coast Watch program provides high-resolution (1km/4km) satellite data and derived products (including sea surface temperature) for coastal regions. The data is frequently used by fisherman.
6. **Snow and Ice Products:** Meteorologists and climatologists are interested in short-term and long-term observations of snow and ice cover because of its affect on weather forecasting and climatic processes. Snow and ice analysts in the NOAA NESDIS have been creating weekly maps showing the extent of snow cover for the Northern Hemisphere since 1966.
7. **Ozone (SBUV/2) Products:** The Ozone products are generated from the SBUV/2 (Solar Backscattered Ultraviolet Radiometer/Version 2). The SBUV/2 is a non-scanning, nadir-viewing instrument designed to measure scene radiance in the spectral region from 160 to 400 nm. SBUV data is used to determine the vertical distribution of and total ozone in the atmosphere and solar spectral irradiance.

The SBUV/2 sensor data consists of radiance and irradiance measurements taken in both the discrete mode (12 wavelengths) and the sweep mode (1680 wavelengths) at approximately 2 Angstrom intervals.

8. **Aerosol/Optical Thickness Products:** The aerosol products are produced from NOAA-16 AVHRR data on a weekly basis. The primary products are a global 1-degree map of aerosol optical thickness (AOT) based on a composite of 1 week's worth of data and the monthly mean product. Also, there are contour plots of weekly composites and monthly means.

#### 4.0 SUMMARY

The IPD is making every effort to provide quality Level 1B data to the user community in fulfillment of the NOAA/NESDIS mission "to provide and ensure timely access to global environmental data from satellites...."

Enhancements to improve the efficiency and accuracy of the Level 1B generation process and the product itself are planned to support future missions (such as NOAA-M, NOAA-N, and MetOp). Users interested in getting more information on the Level 1B process, products, and updates should check the following websites:

<http://www.osdpd.noaa.gov/> — general information on the IPD

<http://www.osdpd.noaa.gov/PSB/PSB.html> — information on the products from PSB

<http://www.osdpd.noaa.gov/PSB/PPP/PPP.html> — information on the Level 1B calibration, Earth location, QC, and instrument trending.

Those users interested in archived Level 1B data may consult the NOAA Satellite Active Archive (SAA) website, <http://www.saa.noaa.gov/>. The mission of the SAA is to provide electronic distribution of data and derived data products from U.S. POES.

#### 5.0 REFERENCES

NOAA/NESDIS/OSDPD website, <http://www.osdpd.noaa.gov/>. NOAA *KLM User's Guide*, May 1999 version, <http://www2.ncdc.noaa.gov/docs/klm/index.htm>