THE SCIENCE SPECIFICATIONS FOR PROCESSING SOUNDER DATA FROM THE NOAA-K,L,M SATELLITES

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ABSTRACT. The suite of sounder and imaging instruments on the NOAA-K,L,M satellites used for soundings includes the HIRS-3, the AMSU-A, the AMSU-B, and the AVHRR. As a group, data from these must be earth-located, calibrated, limb-adjusted, interpolated, cloud-cleared, and made into single sets of data before they are subjected to the retrieval process. Each of these involves either new algorithms for the AMSU-A, the AMSU-B, and the AVHRR or updated procedures for the HIRS-3. A document describing all the processes has been in preparation for several years, being constantly revised; it will be published after the launch of NOAA-K, but copies of the draft manuscript are available to qualified agencies.

1. Introduction.

With the launch of the NOAA-K satellite the first significant change in the TOVS suite of instruments will occur since the launch of TIROS-N in 1978. The MSU and the SUU will be supplanted by the AMSU-A and AMSU-B, and small changes in the HIRS-2 will result in a change of designation to HIRS-3. The measurements from the microwave instruments will constitute a major change in the observational material, from the standpoints of informational content (number of channels) and quantity of data (spatial resolution).

Beginning in 1983, the NOAA/NESDIS sounding effort has considered how the new data will be processed to produce a superior product. It was apparent that the processing system would have to be supplanted with an entirely new system which would eliminate some of the shortcomings of the current system, which has its roots in the NIMBUS-7 satellite launched in 1973. The software and the scientific logic of the TOVS operational system has undergone many changes and improvements over the years, and many of these changes are to be retained in concept. The structure of the software has long been a bane to changes, and this has been one of the principal objects of modifications.

2. The NOAA-K sounding instruments.

The HIRS-3 will contain the same channels, spatial resolution, and scan stepping. The only significant change is the deletion of the internal cold reference, leading to one additional scan line of earth observations in a "superswath" of 40 lines each 256 seconds. The time per scan line remains 6.4 seconds.

The AMSU-A and AMSU-B have 15 and 5 channels, and scan in 30 and 90 steps, respectively. The times per scan line are 8 seconds and 8/3 seconds, respectively. Thus, although all three instruments begin scanning at the same time each 32 seconds, they have independent but consistent observations during the 32-second period.

The HIRS-3 channels are unchanged from 1978 (see Reference [1]) except for Channels 10 and 17, and the characteristics will not be reproduced here. The AMSU-A and AMSU-B channels are given in Table 1.

Table 1. The AMSU-A (Channels 1-15) and AMSU-B (Channels 15-20) characteristics.

Channel	Frequency (GHz)	Bandwidth (MHz)	Beam width (degrees)	Polarization (nadir)
1	23.800	250	3 1/3	V
2	31.400	160	3 1/3	V
3	50.300	160	3 1/3	V
4	52.800	380	3 1/3	V
5	53.596±0.115	170	3 1/3	H
6	54.400	380	3 1/3	H
7	54.940	380	3 1/3	V
8	55.500	310	3 1/3	H
9	f0=57.290344	310	3 1/3	H
10	f0± 0.217	75	3 1/3	H
11	f0± 0.322±0.048	35	3 1/3	H
12	f0± 0.322±0.022	15	3 1/3	H
13	f0± 0.322±0.010	8	3 1/3	H
14	f0± 0.322±0.0045	3	3 1/3	H
15	89.00	2000	3 1/3	V
16	89.00±0.100	2000	1 1/9	V
17	150.00±0.100	2000	1 1/9	V
18	183.31±1.000	1000	1 1/9	V
19	183.31±3.000	2000	1 1/9	V
20	183.31±7.000	4000	1 1/9	V

3. Science specifications.

To give guidance to the producers of the operational software, a document has been in preparation for a number of years. As new algorithms and other changes are developed, this document has been altered accordingly.

The introduction section has been largely unaltered inasmuch as it reflects the philosophy with which the project was approached. Two basic tenets are emphasized: data are to be carried as fields to allow future flexibility; and separate stages of the processing are to be easily replacable to permit easy upgrading. Figure 1. shows the flow of data, taken from the introduction, indicating the various steps in the processing.

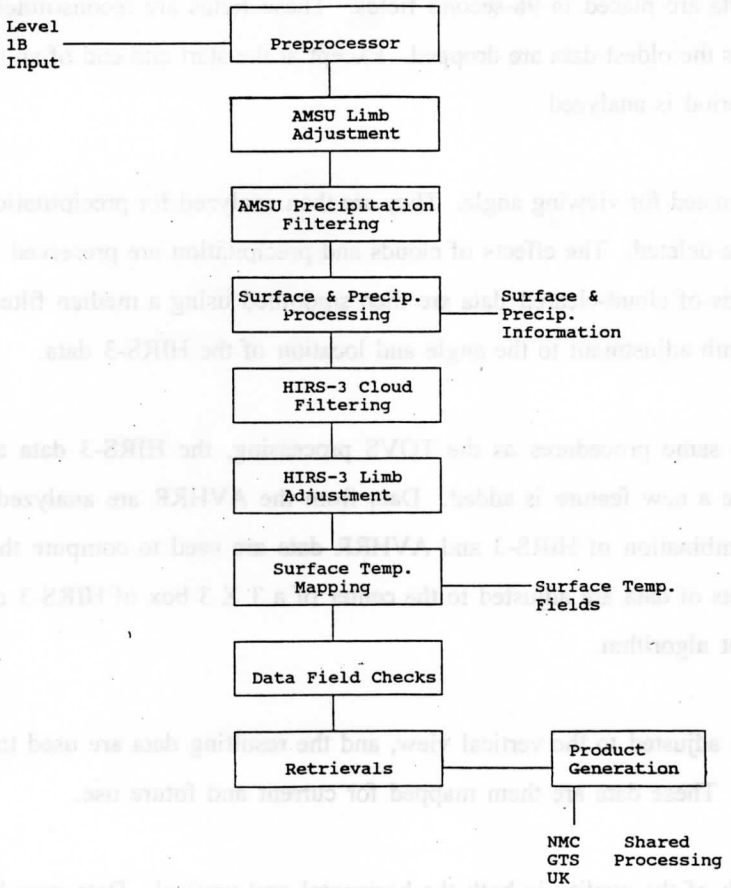

Figure 1. Flow diagram of the on-line NOAA-K,L,M sounder processing system.

1. The Level 1-B file contains earth locations, times, calibration coefficients, spacecraft height and local zenith angles, quality indicators, and all the instrument telemetry. The spacecraft telemetry are no part of the 1-B data. This processing is performed separately and prior to the sounding processing. In Chapter 0 the procedures to be followed in producing the calibration coefficients. Earth location is computed by the same procedures as heretofore with TOVS data. The essential changes involve more accurate HIRS-3 calibrations and very carefully crafted calibrations of the AMSU-A and AMSU-B data developed in a joint NOAA/NESDIS-British Meteorological Office collaboration.

2. The preprocessor is an initial stage in which data are prepared for later stages of the processing. It is at this point that data are placed in 96-second fields. These fields are reconstituted each 32 seconds with new data as the oldest data are dropped. Except at the start and end of an orbit, only the middle 32-second period is analyzed.

3. The AMSU-A are adjusted for viewing angle. They are then analyzed for preciptitation effects, adjustments made or data deleted. The effects of clouds and precipitation are preserved for a later state. The resulting fields of cloud-cleared data are then smoothed using a median filter. This is followed by a reverse limb adjustment to the angle and location of the HIRS-3 data.

4. Following much the same procedures as the TOVS processing, the HIRS-3 data are cloud-cleared. At this juncture a new feature is added. Data from the AVHRR are analyzed for each HIRS-3 spot and the combination of HIRS-3 and AVHRR data are used to compute the HIRS-3 clear radiances. Both sets of data are adjusted to the center of a 3 X 3 box of HIRS-3 data using a "local" limb-adjustment algorithm.

5. The HIRS-3 are then adjusted to the vertical view, and the resulting data are used to compute the surface temperature. These data are them mapped for current and future use.

6. There is a final check of the quality in both the horizontal and vertical. Data may be deleted at this point, but no other operation is conducted on the data. The data are now prepared for the retrieval process.

7. The retrievals are a three-stage process. Using a first-guess based on the AMSU-A data, a physical retrieval is conducted on the AMSU-A/HIRS-3 data, producing both temperature and humidity profiles. Next, the temperature profile is used as a first guess for AMSU-B humidity profiles at the full spatial resolution. The average humidity profiles then are used to perform a second temperature retrieval.

8. The products are formatted in ways required by users, and are saved in an archive.

4. The specifications document.

All the procedures have been spelled out in the specifications document [Wark, et al., 1995). This has been prepared over several years, and has gone through several transformations as new information on the instruments has become available, as algorithms are improved or replaced, and as tests show where weaknesses occur. The latest draft version is up to date as of March 1995, but it will not be published until after the launch of NOAA-K. Copies may be obtained by communicating with the author.

5. References.

Werbowetzki, A., (editor) 1981: Atmospheric Sounder Users Guide. NOAA Technical Report NESS 83, NTIS Springfield, VA, 82 pp.

Wark, D. Q., et al., 1995: Science Specifications for the NOAA-K,L,M Satellite Sounders. NOAA Technical Report in preparation. Draft copies available from the principal author, NOAA/NESDIS, Washington, D.C. 20233, USA, xx pp.

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