TOVS Sounding Data

The dataset of basic TOVS radiances starts 29 Oct 1978 and continues to the present time. The record is almost complete and there are very few missing days. NCAR has a copy of basic TOVS data for 29 Oct 1978 through 31 Mar 1992 (13.4 years). The volume is 631.2 Gbytes.

People want to use the derived 2.5° set of sounding data for reanalysis. This dataset gives vertical soundings from NOAA polar orbiting satellites. The data gives cloud-cleared radiances each 2.5°, and the associated derived sounding (the data are in satellite swath coordinates and lat/lons are given).

- NCAR and ECMWF shared costs (about June 1993) to purchase a copy of the NCDC archive of 2.5° TOVS. NCDC gave us a half-price deal of about $26,000 for the copy.
  - The range of dates on the combined tapes is 1 Jan 1979 to 3 Jan 1993, with a number of gaps.

- Later on, we found that NOAA/ERL in Boulder had obtained a copy of 75% of this same dataset, about 2 years earlier. These two copies of the NCDC dataset have common gaps, but they also each have different gaps.

- NMC was able to locate a dataset of 2.5° TOVS data that was prepared by a research group in NESS.
  - NCAR received three boxes with 167 cartridge tapes from NMC on 9 Feb 1994. These contain updates also. The total time period covered on these NMC tapes is 19 Feb 1979 to 9 Jan 1994.
  - The NMC tapes have all been read in and inventoried by Joey Comeau (now 16 Feb).
  - The data volume is 22.73 Gbytes, but a few days of data will be added.
  - NCAR is using the NMC set of data as the primary dataset. These tapes are more nearly complete than the NCDC tapes, and the order of the days is good. The date order on the NCDC tapes jumps around a lot.

- Listings available:
  - Daily inventory of NCDC TOVS tapes (Attachment 1)
  - Daily inventory of NMC TOVS tapes (Attachment 2)
  - Daily inventory of NMC reports minus NCDC (Attachment 3)
    - A positive count means NMC has more.
  - A daily inventory shows the days where NCDC has missing data, where NMC is missing, and where both are missing (Attachment 4).

- Gap fillers at Goddard. Goddard obtained the daily "dump tapes" from NMC from about 1985-on. These have observed data, NMC analyses, etc. It appears that Goddard has
been able to find many of the missing 2.5° TOVS data on these tapes. Siegfried Schubert from Goddard visited NCAR on Feb 15-16. He may be able to send the missing data.

- TOVS data on NMC history tapes (gap fillers). NMC produces a history tape that has the input (and output) data for the various production runs. A tape is prepared every day; the volume is high, and there is duplication of the observations. NMC kept only 1 or 2 years of these data on site, but Milt Halem (Goddard) stored them at Goddard from 1985-on. Goddard read the NMC history tapes for Apr-Jul 1986 and extracted gap fillers shown in Attachment 5. Unfortunately, the format was changed.

- TOVS starting dates:
  - Raw data starts 29 Oct 1978
  - NCDC 2.5° data starts 1 Jan 1979
  - NMC 2.5° TOVS data starts 19 Feb 1979 (it was a few months after the start of TOVS when NMC started to use it operationally, instead of the previous VTPR).
  - The combined 2.5° TOVS will start 1 Jan 1994, and we hope that ECMWF will extend this back to 29 Oct 1978 using raw data from NCAR.

- How many 2.5° TOVS data gaps still exist? On Attachment 4, "mm" shows data on the NCDC tapes, but not on NMC files. The letters "cc" show days when only the NMC tapes have data. And "**" shows days when neither dataset has data (some of these are nonexistent days at the end of a month).

NCAR is extracting data from the NCDC tapes for all days with an "mm" in Attachment 4. This will be a gap-filler tape to help complete the NMC tapes.

The Goddard gap fillers will fill nearly all of the gaps in the Apr-Jul 1986 period. Goddard or NMC may also obtain data from the NMC history tapes for (some of) the other "**" days.

Data for 29 Oct 1978 through 1 Jan 1979 only exist in raw form. The tentative plan is that NCAR would send these raw data to ECMWF, and they would prepare 2.5° cloud-cleared radiances and soundings.

- Bad dates on 2.5° TOVS. Only 6 of the 167 NMC cartridges had any TOVS soundings with bad dates. There were a total of 87 soundings with bad dates. For example, on one tape (Y19197 at NCAR), 21 soundings in a row had an impossible hour; the year/mo/day/hr on all of them was 88, 2, 3, 75. These bad times followed other data for 1980, month 2, day 3. The year 1988 vs. 1980 is odd too.

- Status of data preparation. By Apr 8, NCAR will have the gap fillers extracted from the NCDC tapes. NCAR does not have gap fillers from Goddard.
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**Atech 1**

**Feb 1994**

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**Daily Inventory of NCDC in hundreds of soundings**

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**2.5° TOVS made at NCAR. The counts are**
### NMC Daily Inventory

**INVENTORY OF VSNs:**

| YR | MO | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 79 | 01 | 19 | 41 | 62 | 83 | 104 | 125 | 146 | 167 | 188 | 209 | 230 | 251 | 272 | 293 | 314 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 |
| 79 | 02 | 41 | 62 | 83 | 104 | 125 | 146 | 167 | 188 | 209 | 230 | 251 | 272 | 293 | 314 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 | 629 |
| 79 | 03 | 83 | 104 | 125 | 146 | 167 | 188 | 209 | 230 | 251 | 272 | 293 | 314 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 | 629 | 650 | 671 |
| 79 | 04 | 125 | 146 | 167 | 188 | 209 | 230 | 251 | 272 | 293 | 314 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 | 629 | 650 | 671 | 692 | 713 |
| 79 | 05 | 167 | 188 | 209 | 230 | 251 | 272 | 293 | 314 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 | 629 | 650 | 671 | 692 | 713 | 734 | 755 |
| 79 | 06 | 209 | 230 | 251 | 272 | 293 | 314 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 | 629 | 650 | 671 | 692 | 713 | 734 | 755 | 776 | 797 |
| 79 | 07 | 230 | 251 | 272 | 293 | 314 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 | 629 | 650 | 671 | 692 | 713 | 734 | 755 | 776 | 797 | 818 |
| 79 | 08 | 251 | 272 | 293 | 314 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 | 629 | 650 | 671 | 692 | 713 | 734 | 755 | 776 | 797 | 818 | 839 |
| 79 | 09 | 272 | 293 | 314 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 | 629 | 650 | 671 | 692 | 713 | 734 | 755 | 776 | 797 | 818 | 839 | 860 |
| 79 | 10 | 293 | 314 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 | 629 | 650 | 671 | 692 | 713 | 734 | 755 | 776 | 797 | 818 | 839 | 860 | 881 |
| 79 | 11 | 314 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 | 629 | 650 | 671 | 692 | 713 | 734 | 755 | 776 | 797 | 818 | 839 | 860 | 881 | 902 |
| 79 | 12 | 335 | 356 | 377 | 398 | 419 | 440 | 461 | 482 | 503 | 524 | 545 | 566 | 587 | 608 | 629 | 650 | 671 | 692 | 713 | 734 | 755 | 776 | 797 | 818 | 839 | 860 | 881 | 902 | 923 |

### Daily Inventory of the NMC 2.5° TOVS CTPs

The counts are hundreds of soundings. The bigger numbers mean that two satellites were available.

**03/17/94**
| YR | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
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| 80 | 3 | 04 | 82 | 81 | 81 | 82 | 83 |
| 80 | 7 | 82 | 75 | 61 | 79 | 81 | 81 | 82 | 79 | 81 | 82 | 83 | 81 | 83 | 84 | 83 | 84 | 82 | 83 | 83 | 83 | 82 | 81 | 84 | 83 | 84 | 82 | 84 | 82 | 84 | 84 | 82 |
| 80 | 10 | 114 | 125 | 134 | 115 | 139 | 138 | 140 | 147 | 134 | 147 | 138 | 121 | 141 | 145 | 152 | 129 | 148 | 118 | 162 | 164 |
| 80 | 11 | 142 | 134 | 138 | 110 | 129 | 106 | 117 |
| 80 | 12 | 83 | 82 | 84 | 83 | 83 | 82 | 83 | 83 |
| 81 | 4 | 01 | 24 | 167 | 161 | 157 | 153 | 131 |
| 81 | 5 | 45 | 166 | 167 | 104 | 167 | 166 | 168 | 167 |
| 81 | 6 | 161 | 167 | 166 | 162 | 167 | 167 | 163 | 133 |
| 81 | 7 | 01 |
| 81 | 8 | 118 | 162 | 164 |
| 81 | 9 | 20 | -20 | -24 | -20 |
| 82 | 10 | 147 | 168 | 167 | 161 | 163 | 160 | 163 |
| 82 | 11 | -42 | 167 | 167 | 166 | 01 |
| 82 | 12 | 2.5° TOVS soundings - Difference in counts (# NMC - # NCDC)
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| 79    | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 79    | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 79    | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 79    | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 79    | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 79    | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 79    | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 79    | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 79    | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 79    | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 79    | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

** = both missing
cc = only NCDC data missing
mm = only NMC data missing

To vs 2.5° data. The ** shows when data is still missing on both tapes.
TOVS Satellite Sounder Data

TOVS atmospheric sounder data has visible channels, many IR channels, some microwave channels (MSU) and channels that measure stratospheric temperature (SSU). These data are needed for the reanalysis project.

The dataset of basic TOVS radiances starts 29 Oct 1978 and continues to the present time. The record is almost complete, and there are very few missing days. A day-by-day inventory is included in the memo dated 1 Mar 1993 (enclosed).

The reanalysis project needs cloud-cleared radiances with a spacing of about 2.5°. An archive exists, starting Jan 1979, but it has many gaps. Different organizations need to cooperate to either fill the gaps, or to recalculate the data based on better algorithms than were used for operations. The NASA/NOAA TOVS Pathfinder project has a goal to recalculate data, but it will not be ready in time for reanalysis (needed by about Dec 1993).

A few facts are:

1. NMC obtained its present archive (2.5° data) in 1992 directly from the NESDIS research group. An inventory in these notes is dated Mar 5, 1993. This archive may have a different set of data gaps than data at SDSD.

2. The basic TOVS data at NCAR:

<table>
<thead>
<tr>
<th>Dates</th>
<th>Years</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 Oct 1978 - Sep 1989</td>
<td>10.92</td>
<td>496,766 Gbytes</td>
</tr>
<tr>
<td>TOTAL</td>
<td>13.42</td>
<td>631,200 Gbytes</td>
</tr>
</tbody>
</table>

   Notes: (1) About six bad input tapes are being fixed and will add a little to the volume
   (2) The basic TOVS data at SDSD should be up to date.

3. The TOVS 2.5° archive

   NCAR only has data for 1979, but SDSD is copying more years of data to send to NCAR. The data will be put onto the mass store and then NCAR will make an inventory.

4. I learned that Siri Khalsa at CIRES in Boulder (492-1445) has the 2.5° data for Jan 1981 through Dec 1991. His data came directly from SDSD. An inventory is enclosed here. John Bates is in this same group at CIRES; he has been communicating with ECMWF about TOVS, and is very committed to helping figure out a way to fill the gaps in the 2.5° data.

   - End -
Figure ___. Siri Khalsa (at CIRES, Boulder, Colorado, also obtained TOVS 2.5° data directly from SDSD (Jan 1981 - Dec 1991). This plot shows the gaps in the record on his tapes.
Satellite Sounders

Note: NCAR has the basic (Level 1) data for SIRS, VTPR, and TOVS. NASA should have the 1975-76 HIRS.
MEMO TO:     Dr. Masao Kanamitsu; Dr. Potaraze K. Rao
FROM:        Roy Jenne
SUBJECT:     Missing Data in the TOVS 2.5° Archive

For the reanalysis initiatives, the present plans at both NMC and ECMWF are to use the 2.5° archive of TOVS cloud-cleared radiances and derived soundings. There are problems with missing data that, in principle, could be fixed.

There are a number of missing time periods in the 2.5° archive of TOVS data. See Attachment 1 which shows the missing periods of data that are now known. When NCAR obtains the data, we will prepare an inventory.

The basic TOVS data has very little missing data. Please see Attachment 2 which shows the number of orbits per day of basic TOVS data that are archived. This inventory is for 29 Oct 1978 to 30 Sep 1989. NCAR will soon have a complete inventory through Mar 1992. Note that data are often available from two satellites.

Would it be possible to use the basic TOVS data to fill in missing data in the 2.5° archive? In other words, could NESDIS read in the basic TOVS archives and output a 2.5° archive to fill the gaps? If this is possible, I propose that it be done for all of the gaps and for Nov-Dec 1978. The latter two months have never been available for use in analyses.

- End -
TO: ROY TENNE

Telephone Number: 

FROM: GARRY AYRES - SOSO

Message: HERE IS A LIST OF THE DATES FROM OUR LOG THAT WE KNOW SHOULD BE MISSING.

Page 1 of: 3

Date sent: 2/24/93

If there are any problems with this transmission, please call at (301) 763-1372 immediately.
<table>
<thead>
<tr>
<th>Date</th>
<th>Data Missing</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/30/89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/31/89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/30/89</td>
<td>2/12/89</td>
<td>The tape is missing</td>
</tr>
<tr>
<td>2/13/89</td>
<td>2/14/89</td>
<td></td>
</tr>
<tr>
<td>1/15/90</td>
<td></td>
<td>Data missing</td>
</tr>
<tr>
<td>11/26/90</td>
<td>11/28/90</td>
<td></td>
</tr>
<tr>
<td>10/25/91</td>
<td>11/11/92</td>
<td>Only 11/12/92 is available</td>
</tr>
<tr>
<td>11/22/92</td>
<td>11/21/92</td>
<td>Processing problem</td>
</tr>
<tr>
<td>11/25/92</td>
<td>11/21/92</td>
<td>Only 11/22/92 is available</td>
</tr>
<tr>
<td>11/22/92</td>
<td>11/25/92</td>
<td>Only 11/22/92 is available</td>
</tr>
<tr>
<td>11/27/92</td>
<td>11/30/92</td>
<td>Only 11/23/92 is available</td>
</tr>
<tr>
<td>11/21/92</td>
<td>11/25/92</td>
<td>Only 11/22/92 is available</td>
</tr>
<tr>
<td>5/1/93</td>
<td>5/1/93</td>
<td>Only 5/1/92 is available</td>
</tr>
<tr>
<td>5/28/92</td>
<td>5/31/92</td>
<td></td>
</tr>
<tr>
<td>1/8/93</td>
<td>1/14/92</td>
<td>Only 1/30/92 is available</td>
</tr>
<tr>
<td>1/15/92</td>
<td>1/22/92</td>
<td>Only 1/6/92 is available</td>
</tr>
<tr>
<td>1/4/93</td>
<td>1/10/93</td>
<td></td>
</tr>
<tr>
<td>YEAR</td>
<td>MONTH</td>
<td>DAY</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>-----</td>
</tr>
<tr>
<td>78</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>79</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>80</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>81</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**Figure 1.** This is an inventory of NOAA TOVS sounder data. TOVS includes the HIRS, MSU, and SSU sounders. This gives the number of orbits (data files) each day for the HIRS instrument. Counts for MSU and SSU would be almost the same.
Dr. Roy Jenne  
Scientific Computing Division  
National Center for Atmospheric Research  
Boulder, Colorado  80307-3000  

Dear Dr. Jenne,

Thank you for your memorandum regarding missing data in the TOVS 2.5° archive.  

I have had my staff check into the possibility of reprocessing TOVS data for which sounding products are missing in the archives. In principle, this could be done; in practice, there are resource and science problems.

Reprocessing TOVS data from level 1b data sets is extremely complex, time consuming, and expensive, as we learned from the FGGF reprocessing effort in the early 1980s. The following are some of the factors and issues involved.

1. Although the data is missing for many short time periods, reprocessing would require more extensive time frames, as a minimum of two weeks spin-up time is needed for each time period for the generation of coefficients and mean radiance, temperature and moisture values.

2. The reprocessing would be done using current cloud clearing and physical retrieval algorithms, which would cause discontinuities in the sounding products prior to October 1992.

3. In addition to the level 1b data, many additional data bases are required, including: radiosonde files, NMC forecast files, land and sea surface temperature files, archived transmittance coefficient files, and the Navy's Joint Ice Center sea ice and snow cover files.

4. Significant additional computing power and personnel support would be required. Current staffing and limited NESDIS capability cannot accommodate this effort. Possibly this could be done at NCAR.
In summary, a reprocessing effort aimed at generating TOVS sounder products from 1979 to 1993 for missing time periods would be extremely expensive and time consuming. NCAR should seriously consider the importance of recovering the missing data in relationship to the significant cost and effort involved in retrieving it.

I hope this has been helpful.

Sincerely,

P. Krishna Rao
Director, Office of Research and Applications
NOAA—Nesdis

2 Apr 1993

Tony,

I will be in Washington DC April 5-7, and will visit NMC Apr 7. I will be able to talk about this subject then, and will contact you later.

The satellite data people said that they are in the process of copying the 2.5° TOVS tapes. They didn’t know whether you had sent half the money yet, or not.

Take care

Roy James

PS: It seems to me that if ECMWF & NMC can obtain cloud cleared radiances, any needed retrievals can be handled within the assimilation.
MEMORANDUM

Subject: Missing and Bad TOVS Tapes

To: Bob Kistler, M. Kanamitsu, E. Kalney

From: Jie Meng

Date: March 5, 1993

The TOVS tapes from 2/19/79 to 5/17/92 have been checked carefully for missing data and bad tapes. Attached are two tables, one for missing data, and another for bad tapes need to be replaced. Also, check has been done against the missing data list from NCAR. We have some of data they miss, but we have much more data missing than what in their list. The marks on the NCAR’s list is attached.

Table 1. Missing TOVS Data

<table>
<thead>
<tr>
<th>Tape Vol</th>
<th>Missing date</th>
<th>NCAR has these</th>
<th># days</th>
</tr>
</thead>
<tbody>
<tr>
<td>900446</td>
<td>800124 - 800126</td>
<td>NCAR has these</td>
<td>3</td>
</tr>
<tr>
<td>900479</td>
<td>830806</td>
<td>Mix all phases</td>
<td>1</td>
</tr>
<tr>
<td>900481</td>
<td>831002 - 831004</td>
<td>Mix all phases</td>
<td>3</td>
</tr>
<tr>
<td>900495</td>
<td>841229</td>
<td>NCAR missing 16-29; IRL has all</td>
<td>1</td>
</tr>
<tr>
<td>900509</td>
<td>860314 - 860315</td>
<td>Mix all phases</td>
<td>2</td>
</tr>
<tr>
<td>900510</td>
<td>860413 - 860529</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>900510</td>
<td>860602 - 860616; 860621</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>900511</td>
<td>860728 - 860804</td>
<td>Mix all phases</td>
<td>8</td>
</tr>
<tr>
<td>900512</td>
<td>860822 - 860823; 860825 - 860903</td>
<td>Same but NCAR has Aug 31 data</td>
<td>14</td>
</tr>
<tr>
<td>900513</td>
<td>860921</td>
<td>Mix all phases</td>
<td>1</td>
</tr>
<tr>
<td>900514</td>
<td>861013</td>
<td>Mix all phases</td>
<td>1</td>
</tr>
</tbody>
</table>
Total: 30 tapes, 33 months, 177 days.

Table 2. Data Need Replace

Some data with bad date or non-chronological order can be got around.
Some tapes are big mess and needed to be replaced or rewritten.
<table>
<thead>
<tr>
<th>Vol</th>
<th>Coverage</th>
<th>missing days</th>
</tr>
</thead>
<tbody>
<tr>
<td>900441</td>
<td>790301 - 790331</td>
<td>NCAR has this</td>
</tr>
<tr>
<td>900510</td>
<td>860406 - 860706</td>
<td>This is the big gap, NCAR has part</td>
</tr>
<tr>
<td>900512</td>
<td>860822 - 860903</td>
<td>32 comments on first page</td>
</tr>
<tr>
<td>900513</td>
<td>860911 - 860922</td>
<td>NCAR has all but 1 day</td>
</tr>
<tr>
<td>900560 - 900570</td>
<td>900226 - 901028</td>
<td>11 - 8 months, NCAR has most but with gaps</td>
</tr>
</tbody>
</table>

Total: 15 tapes, 16 months.
13 October 1993

MEMO TO: Rex Gibson
FROM: Roy Jenne
SUBJECT: Gaps in 2.5° TOVS Data (this covers the period 30 Oct 1978 - 3 Jan 1993)

If the NMC inventory of their gaps was fairly complete, my guess is that the final set of gaps in the 2.5° TOVS data (after using our sources and NMC) will be about as follows:

781030 - 781231 2 months in 1978
830806
831002-04
841229
860314-15
860413 - 860706 huge gap (3 months), NCAR has some
860728 - 860804
860822 - 860903
860921
861013
870119 and 26
870303-04 and 08
870420-21
870712-18 and 26, 28
870802 and 23-29
870906-07
880329
880405 and 26
880517
880802-03
890101 and 8-17 and 30-31
891214
900610
900903-11
901014
901126-29
910202-04
911030

Note: The basic TOVS is more complete
920309-13 NCAR has some
920406
920323 - 920425 A whole month
920431 - 920509 NCAR has some days

NMC inventory now ends 17 May 1992. NCAR has several gaps after that time. NMC will send us their archive in about 3 weeks to help fill gaps. It would be desirable if this included all of 1992, but we need the first batch quickly.

Rex, how much data will you need before a gap starts? Our raw TOVS data is now through March 1992. There are very few gaps in the raw TOVS data. You have an inventory or could get another one from Dennis.

- End of Memo -

cc: Bob Kistler, NMC
Comments about the 2.5° TOVS Dataset

1. The TOVS Sounder Data

For reanalysis, both NCEP and ECMWF are using the same set of 2.5° TOVS data produced by NOAA/NESDIS. This dataset has cloud-cleared radiances and derived soundings. The version being used is the set from the research archives at NESDIS/NCEP, because it has the fewest gaps and the best date order. NCAR got this research archive from NCEP, and also got a copy of the archives at Asheville. We made extensive inventories and used the NCDC set to fill a few gaps in the research set. Goddard obtained some more gap fillers from NCEP daily dump tapes that they have. These were sent to NCEP. There are still a few gaps in the set of 2.5° TOVS. ECMWF has prepared a program to start from Level 1B TOVS from NCAR and calculate cloud-cleared radiance data, etc., to fill most of the remaining gaps. This work is now going on. ECMWF helped to pay for the copy of the NCDC archive. They got a copy of the research archive and the gap fillers via NCAR. I think they also got the gap fillers from NASA via NCEP.

- Later on, we should insure that a combined set of 2.5° TOVS, with gap fillers, exists in 2 or 3 archives.

2. Messages from NCEP about bad data in 2.5° TOVS

2.1 Message from Kistler (NCEP) to Gibson (ECMWF), 27 Apr 1995

Rex, for your information, we have found 3 periods where our 5-test screening of TOVS data indicated problems:

- 16-17 Dec 1982
- 1-2 Jan 1986
- 1-2 Jan 1987

2.2 Message from Kistler, 2 Jan 1996 (two more bad dates)

Our QC of TOVS for 1979 has revealed two suspicious days so far, Jan 16 and Feb 18 1979.

3. Information from ECMWF, Apr 1995

They have just produced the first locally regenerated CCR data from full NESDIS 1b TOVS data, using the system they hope to use for gaps in the 250 km CCR data. They have also, with help from NESDIS, been successful in recovering some of the mislocated satellite data by recomputing positions from orbital information.

- Question: Did this fix some of the data that NCEP identified as being wrong?

More information (Aug 3, 1995): The TOVS sounder 1b data (basic radiances) has been useful—they used it successfully for the October 1983 gap in 2.5° TOVS data, and plan to
use it for the remaining gaps. But they are still learning, and will re-do the October case several times in order to refine the methods.

4. Other comments about TOVS

At the end of reanalysis that uses TOVS data for 1978-96, we should make sure that information about bad data, etc., is available for future users. Also, we should make all of the best data available. Some comments are:

- The NESDIS research archives of TOVS 2.5° data are the primary data being used. It was most complete and is in the best date order.

- NCAR and ECMWF shared the cost ($31,096, a half-price deal) to obtain the TOVS 2.5° data fix from NCDC for 1 Jan 1980 -3 Jan 1993 with a number of gaps. NCAR had previously purchased data for 1979.

This NCDC data is being used for the Jan 1 - Feb 18, 1979 period and to fill some of the other gaps in the research set.

- Level 1 TOVS data is available starting 29 Oct 1978. It could be used to calculate 2.5° TOVS for 29 Oct - 31 Dec 1978. I hope that ECMWF will do this.

- NASA Goddard extracted about 4-6 weeks of gap fillers from the NCEP daily dump tapes that they have. These were sent to NCEP. NCAR does not have a copy of these gap fillers.

5. TOVS Level 1b sent from NCAR to ECMWF

Between Apr 1995 and Oct 1995 Dennis Joseph sent the following primary data:

| High-density 3490 cartridges | -112 |
| MSS files | -965 (NCAR mass store) |
| TOVS files (HIRS, MSU, SSU) | -24,856 files |
| Data volume | -39,617 MB |
| Approximate days of data | -290 days |

Data was for 24 different time periods from the period Sep 1983 through Feb 1991. Most periods requested were 5 to 12 days in length. They included extra days around the gap in 2.5° TOVS. Approximately 290 days were extracted to send to ECMWF. The few longest periods were:

<table>
<thead>
<tr>
<th>Period</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Apr 1986 - 3 Jul 1986</td>
<td>82</td>
</tr>
<tr>
<td>20 Aug 1986 - 5 Sep 1986</td>
<td>17</td>
</tr>
<tr>
<td>6 Jan 1989 - 19 Jan 1989</td>
<td>14</td>
</tr>
<tr>
<td>2 Sep 1990 - 13 Sep 1990</td>
<td>11</td>
</tr>
</tbody>
</table>

- 2 -
Some more information about VTPR data

- ECMWF scientists had trouble finding which instruments were used on each NOAA satellite. In spite of this, I think they were able to figure out how to use the data — need some info from them.

- NCEP VTPR and TOVS had an overlap period (data from both) during Nov 1978 - Feb 1979. NCEP did a reanalysis experiment during the overlap period using (a) only TOVS, (b) only VTPR, and (c) no satellite sounded data. We include some figures from those tests in a paper here.

- It would be useful to have similar information from ECMWF.

Ray Fenne
5 Feb 2001
<< NOAA Technical Report NESS 65 >>

The Retrieval Program uses the first guess temperature profile, a first guess humidity value, and atmospheric transmittance values to compute the vertical atmospheric profiles from the input of clear radiances. (VTNR Satellite soundings)

The final output data are quality checked and reformatted onto three magnetic tapes. One tape is forwarded to the National Meteorological Center (NMC) for input to their numerical analysis and primitive equation (PE) forecast model. The second tape is given to the National Weather Service communications center for transmission to users. Data that pass the quality check are added to the archive tape, which is then transmitted to other users (Goddard Institute for Space Studies, for example) and to the permanent archive of the NOAA Environmental Data Service.

B. Geographical Location of Data

Earth location of the data is performed in two steps. The first step is performed in an Earth Location Program, which calculates latitudes and longitudes for centers of the areas for which VTPR temperature and humidity profiles are to be calculated. The second step is performed as a subroutine of the calibration program. This subroutine calculates the locations of the VTPR scan spots in the grid on which the sea-surface temperatures are provided.

The location of a scan spot is determined by a point called the sensor principal point. This point is the center of a scan spot on a plane surface perpendicular to the viewing angle of the instrument. Because of the curvature of the earth, this point is the exact center of a scan spot only when the instrument is viewing along the local nadir. In the earth location procedure, principal points are calculated for spots 5, 12, and 19 of the fourth of eight scan lines (fig. 9). To locate these principal points, the satellite position, the satellite attitude, the sensor mounting position, and the mirror position must be known. Attitude information in the form of $\theta_{\text{max}}$ and $\lambda$ (RCA 1972) is supplied by the Satellite Operations Control Center (SOCC); $\theta_{\text{max}}$ is the maximum roll angle during an orbit; and $\lambda$ is the angle from the ascending node to the point of maximum yaw. Values of $\theta_{\text{max}}$ and $\lambda$ are easily converted to roll and yaw angles. The SOCC attempts to control $\theta_{\text{max}}$ to within 0.5° tolerance, with a maximum error of about 1°. The pitch tolerance is generally kept to within 0.5°.

Weekly orbital element data are supplied by the NASA. These data and the General Electric orbital predictor package (Brower 1959) and Lyddane (1963) are used to determine satellite position. Once the satellite position is determined, a series of matrix
### Table 1: The Satellites with VTPR DATA

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Launched</th>
<th>Deactivated</th>
<th>VTPR Instrument</th>
<th>Period (MIN)</th>
<th>Inclination (DEG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOAA 2</td>
<td>15 OCT 1972</td>
<td>30 JAN 1975</td>
<td>1 and 3 ?</td>
<td>114.9</td>
<td>98.6</td>
</tr>
<tr>
<td>NOAA 4</td>
<td>15 NOV 1974</td>
<td>18 NOV 1978</td>
<td>? and ?</td>
<td>101.6</td>
<td>114.9</td>
</tr>
<tr>
<td>NOAA 5</td>
<td>29 JUL 1976</td>
<td>16 JUL 1979</td>
<td>? and ?</td>
<td>116.2</td>
<td>102.1</td>
</tr>
</tbody>
</table>

**Note:**
1. VTPR data available for ERA40: **16 JAN 1973 - 28 FEB 1979**
2. From “NOAA Technical Report NESS 65”, there were at least four VTPR instruments (Set 1 to Set 4) used on these four satellites, therefore at least four filters. Two VTPR instruments were used on each of them. And we’ve got the filters for the first four VTPR instruments.

**QUESTIONS** (mainly on the VTPR instruments or filters):
1. The difference among these filters is significant or not? If yes, we need use the corresponding filter to calculate CO2 transmittances and the resulting weighting functions!
2. Totally, how many VTPR instruments were used on these four satellites? Four or more?
3. And what kinds of VTPR instruments were on specific satellite?

For example, based on “NOAA Technical Report NESS 65”, instruments 1 and 3 were used on NOAA 2; However, from the VTPR data we’ve got from NCAR, the instrument number was 1 or 2 for NOAA 2 (So, here 2 means instrument 3 and 1 means instrument 1?).

And sometimes, the instrument numbers were 0, especially sometimes only to some channels, what did it mean?

In data we have **1+2** for NOAA-2

Roy Jeane.
I wrote a script to make an automated search for gaps which fit Roy’s latest specifications, (2 or more consecutive days with less than 4 orbits) and found the following:

The first and last gaps pre-date and post-date the period of record, so there are really only 24 gaps. These include a total of 106 days. I checked the NMC ADP SIRSOb inventories and found the following potential gap fillers:

**ARC3 GAP:**

<table>
<thead>
<tr>
<th>Date</th>
<th>NMC ADP SIRSOb GAP FILLER:</th>
</tr>
</thead>
<tbody>
<tr>
<td>72jan01-72nov19</td>
<td>none - no SIRSOb data (first day is 73jan01)</td>
</tr>
<tr>
<td>72nov22-72nov23</td>
<td>none - no SIRSOb data (first day is 73jan01)</td>
</tr>
<tr>
<td>72dec11-72dec12</td>
<td>none - no SIRSOb data (first day is 73jan01)</td>
</tr>
<tr>
<td>73sep15-73oct03</td>
<td>normal twice daily available all but one time</td>
</tr>
<tr>
<td>N/A</td>
<td>no SIRSOb data for 73nov21-74feb21 **</td>
</tr>
<tr>
<td>74mar11-74mar14</td>
<td>SIRSOb available 74mar11.00 &amp; 74mar14.12, but not between</td>
</tr>
<tr>
<td>74mar18-74mar21</td>
<td>SIRSOb available 74mar18.00, 19.12, 20.00, 20.12, 21.00,</td>
</tr>
<tr>
<td></td>
<td>but very low or missing other times</td>
</tr>
<tr>
<td>74jun02-74jun03</td>
<td>SIRSOb available 74jun02.00, but very low or missing other</td>
</tr>
<tr>
<td></td>
<td>times</td>
</tr>
<tr>
<td>74jun07-74jun10</td>
<td>some SIRSOb available 74jun07.00, but very low or missing</td>
</tr>
<tr>
<td></td>
<td>other times</td>
</tr>
<tr>
<td>74jul22-74jul24</td>
<td>normal twice daily available</td>
</tr>
<tr>
<td>74sep04-74sep10</td>
<td>normal twice daily available all but one time</td>
</tr>
</tbody>
</table>
74oct17-74oct18 SIRSOB available 74oct17.12 - 74oct18.12 only
74nov19-74nov23 normal twice daily available all but one time
75jun19-75jun22 normal twice daily available
76apr04-76apr06 normal twice daily available
   N/A no SIRSOB data for 76jun17-76aug21 **
76sep28-76sep30 normal twice daily available
77jan08-77jan28 normal twice daily available
77apr29-77apr30 some SIRSOB available 74apr29.12, normal 74apr30
77may18-77may19 normal twice daily available

COMMENT - SIRSOB four times daily starts 78jan01, counts at 06Z & 18Z
   about 30-50% of those at 00Z & 12Z
78jan22-78jan23 normal 4x daily available
78aug10-78aug13 generally normal 4x daily available, 06Z & 18Z a little low
   on aug11-13
78aug20-78aug21 normal 4x daily available
78sep03-78sep05 normal 4x daily available
78sep24-78sep25 generally normal 4x daily available, but 18Z low
78oct20-78oct21 generally normal 4x daily available, but 78oct21.18 low
79feb03-79feb04 none - no SIRSOB data (last day was 79jan06)
79feb28-79dec31 none - no SIRSOB data (last day was 79jan06)

** archive spoiled years ago when Paul migrated the tapes to the
   TBM (the first mass store)

Gregg
UARS Data

UARS is a NASA mission to measure data in the upper atmosphere (above 10 km). The UARS satellite was launched Sep 15, 1991. The following information is from several sources, including a talk with James Johnson, Goddard DAAC (301-286-0793).

1. The UARS Orbit

UARS operates 585 km above the earth in an orbit which is nearly circular, and inclined 57° to the equator. This allows the UARS sensors to view up to 80° latitude. There are 10 science instruments on UARS.

2. A CD-ROM with UARS data

The first 3 years of UARS data are now on a CD-ROM. It has data from Sep 1991 to Sep 1994. Many data types and levels of processing are on it.

To find information on the web:

http://daac.gsfc.nasa.gov/

then link to UARS home page
then find the CD-ROM

3. The Sounding Instruments

Most of the instruments take measurements by looking along the limb of the earth. The result is a string of vertical profiles along the earth's limb which is parallel to the orbit of the satellite.

The HALOE instrument depends on looking at sunlight as it comes through the limb (at sunset or sunrise). This is able to take only 28 or 30 vertical profiles each day.

The other sounding instruments are all based on emissions (IR or microwave), so measurements can be taken along the limb, all of the time.

4. The Sensors on UARS

UARS carries nine Principal Investigator (PI) experiments that will provide data in three general areas.

- Energy Input
  SOLSTICE—Solar Stellar Intercomparison Experiment
  SUSIM—Solar Ultraviolet Spectral Irradiance Monitor
  PEM—Particle Environment Monitor

- Species and Temperature
  CLAES—Cryogenic Limb Array Etalon Spectrometer
  ISAMS—Improved Stratospheric And Mesospheric Sounder
MLS—Microwave Limb Sounder
HALOE—Halogen Occultation Experiment

- Winds
  - HRDI—High Resolution Doppler Interferometer
  - WINDII—Wind Imaging Interferometer

*Notes about the instruments and their health*

a. The ISAMS instrument acquired data only intermittently because of a hardware problem and is no longer being operated (died about Aug 1992).

b. The CLEAS instrument exhausted the supply of cryogen and is no longer operating (data to about May 1993).

c. MLS: lost one of three radiometers in 1993 or 1994. The 183 GHz channel quit. This channel was for water vapor and mesospheric ozone. This instrument also gives vertical profiles along the limb, up to 60 or 80 Km.

5. Instruments to Study Winds

Two instruments on UARS study winds in the upper atmosphere by sensing the Doppler shift in the light emitted from atmospheric molecules. The wind instruments are:

- High Resolution Doppler Imager (HRDI)
- Wind Imaging Interferometer (WINDII)

6. HRDI wind data

The DAAC has data to within 3 months of now.

The HRDI instrument has 2 modes, stratosphere and mesosphere (roughly 15-50 km and 55-105 km). The DAAC gets the 3A data which is a stack of winds each 4 degrees of latitude, up to 70 or 80 degrees latitude. Another dataset, 3AT, gives data about each 65 seconds along the orbit. For winds, Johnson thinks the data is about each 3 km in stratosphere and each 5 km in mesosphere.

7. Wind and temperature data

These are all limb sounders, so we get a vertical stack of measurements along the limb on each orbit. The wind sounder looks forward and back along the limb to get wind components. Since the soundings are based on emitted radiation, solar radiation (sunlight) is not necessary to obtain data.

8. WINDII data

This is for the higher regions, about 90 to 120 km. The DAAC has data to about Apr 1994. Johnson thinks the instruments use visible light, so is the sun needed??

*Note:* The UARS project prepares the data and gradually gives part of it to the Goddard DAAC.

9. UARS Quality Comments by Paul Bailey, NCAR (Oct 95)
Bailey notes that a coming issue of JGR will have lots of UARS papers.

a. Winds: The winds that they have put out are good. They are useful for research 50 Km and above.
Winds from HRDI: There have been problems. They hope to sort it out and give useful winds for the stratosphere too.

b. Temp, Ozone, etc.
Temperature is OK. MLS-not good above 50 Km, but good below this.
Water and ozone are good. Claes data: "pretty good."

10. Level 3A Atmospheric Data

This data represents geophysical parameters (temperature profile, winds, gas concentrations, etc.), that are in a common format and equally spaced in time (level 3AT, data each 65.5 seconds) or in latitude (Level 3AL, every 4 degrees). These measurements are a string of vertical profiles along the earth's limb. At the equator there will be about 26° Longitude between measurements from one orbit and the measurements from the next orbit.
Questions about UARS Data

1. Periods with available data

   For each of the nine UARS instruments, I want to know whether they are still working or when they quit.

2. Wind and temperature data

   Now I especially need information about winds and temperature from the four instruments: ISAMS, MLS, HRDI, and Wind II. For each instrument, about how high do the measurements go (in km)?

3. Daily global analyses of wind and temperature

   I would like global grids (not zonal means). Are they available? How high do they go?

   A user now needs data at 50 km. Are the analyses now done separately for instruments, or do analyses use all temperature data or all wind data?

4. Monthly mean analyses

   Are these available?

5. Publication

   Do you have one or two references in common publications that give an overview of all of the instruments and measurements?

6. The present user

   A person just called from Sandia National Labs who needs wind data at 50 km. Time is pressing for them, they hope to have actual data within 2 weeks.

   I have one other data source, but I think that UARS is probably best for his needs.

---

Roy Jenne
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Phone: 303-497-1215
Fax: 1298
email: jenne@ncar.ucar.edu
TOVS Sounding Data

The basic TOVS sounder data is measured about every 42 km, along cross-track data swaths under the satellite orbits. Each HIRS sounding has radiances from 20 channels (2 visible and 18 IR). Several additional channels are in the separate stratospheric sounding sensor unit (SSU). Several microwave samples come from another sensor (MSU). The resolution of the HIRS data is 17.4 km. This gives radiation data from many levels in the atmosphere, which can be used to derive thermal and moisture data. Usually, there are two satellites in orbit that produce TOVS data. There are three main forms of the TOVS sounder data:

1. The basic TOVS data starts 29 Oct 1978. The primary archive is at NOAA/SDSD. NCAR has a copy. NASA has a partial copy.

2. Extracted radiances based on sets of 3x3 HIRS pixels. These data have not been archived.

3. Extracted radiances and soundings for 250 km boxes. These data are archived.

NESDIS uses 3x3 samples to derive cloud-free radiances in an 80 km box (in satellite coordinates along scan lines). (Question: 3x3 would be a 120 km box??) They then prepare cloud-free radiances (also "corrected" for slant range) for 250 km boxes. Then a sounding is derived for the 250 km box. The archive has both the clear radiances and derived thermal data (15 layers) each 250 km.

NESDIS has an archive of the 250 km data from Jan 1979-on. Most of the time two satellites have been available; for these periods, the archive has data for two satellites. One tape per week has been archived, with data from one or two satellites. As of Jan 1993, there are about 680 tapes in the archive. These tapes are like 1600 BPI equivalents, and are not always full. We need information about data volume. At normal prices, the cost for the data would be about $70,000. I think that we can obtain a package price that is less, perhaps $35,000. Then NCAR and ECMWF could roughly share this cost.

I told Kay Metcalf (NOAA/SDSD, located near NMC) that NCAR could make a detailed inventory and prepare volume information. NCAR could ship the data to ECMWF on cartridges. NOAA will think about this and give me their views.

Details about 3x3 TOVS Sample Areas

We will now describe the details of how NESDIS selects groups of 3x3 HIRS spots which they call "80 km" boxes. There are 56 spots in a scan line. They don't use the end spots, so 54 spots remain (there are 18 groups with 3 spots each).

They use 40 scan lines at a time;

- The first 3 lines are used for calibration
- They don't use the 4th or the 40th scan lines
- Lines 5, 6, and 7 are used to make 18 groups of 3x3 spots each, along the scan lines
• Don't use line 8
• Then use scan lines 9, 10, and 11 for another set of 18 groups of 3x3 spots each
• Etc.

Note that the group of 3x3 spots are called 80 km boxes. The separation of spots is about 42 km at Nadir. Therefore, spots 1 and 3 are separated by about 84 km; I would have expected these boxes to be called 120 km boxes, but they aren't. We have described how the HIRS radiances are obtained. The MSU and SSU spots are sampled differently from HIRS, and those radiances are also obtained for each "80 km" box.

How does NESDIS make a 250 km sounding? They don't average the 80 km spots; they select one of them. This detailed information was from Bert Katz, NMC (22 Jan 1993).
### Table 4.0-1 Instrument Parameters for TOVS Sensors

<table>
<thead>
<tr>
<th>TOVS Instrument Parameters</th>
<th>HIRS/2</th>
<th>SSU</th>
<th>MSU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration</td>
<td>Stable black-bodies (2) and</td>
<td>Stable black-body and space</td>
<td>Hot reference body and space</td>
</tr>
<tr>
<td></td>
<td>space background</td>
<td>and space background</td>
<td>background and scan cycle</td>
</tr>
<tr>
<td>Cross-track scan angle</td>
<td>+49.5</td>
<td>+40.0</td>
<td>+47.35</td>
</tr>
<tr>
<td>from nadir</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scan time (seconds)</td>
<td>6.4</td>
<td>32.0</td>
<td>25.6</td>
</tr>
<tr>
<td>Number of steps</td>
<td>56</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Angular FOV (degrees)</td>
<td>1.25</td>
<td>10.0</td>
<td>7.5</td>
</tr>
<tr>
<td>Step angle (degrees)</td>
<td>1.8</td>
<td>10</td>
<td>9.47</td>
</tr>
<tr>
<td>Step time (seconds)</td>
<td>0.1</td>
<td>4.0</td>
<td>1.84</td>
</tr>
<tr>
<td>Ground IFOV at nadir</td>
<td>17.4</td>
<td>147.3</td>
<td>109.3</td>
</tr>
<tr>
<td>Ground IFOV at end of scan</td>
<td>58.5 km cross-track x 29.9 km</td>
<td>244 km cross-track x 186.1 km</td>
<td>323.1 km cross-track x 178.8 km</td>
</tr>
<tr>
<td>along-track</td>
<td></td>
<td>along-track</td>
<td>along-track</td>
</tr>
<tr>
<td>Distance between</td>
<td>42.0</td>
<td>62.3</td>
<td>168.1</td>
</tr>
<tr>
<td>IFOV centers (km</td>
<td>+ 1120 km</td>
<td>+ 737 km</td>
<td>+ 1174 km</td>
</tr>
<tr>
<td>along-track</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swath width</td>
<td>2880</td>
<td>480</td>
<td>320</td>
</tr>
<tr>
<td>Data rate (bits per</td>
<td>13</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>second)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data precision (bits)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time between start of each</td>
<td>6.4 sec</td>
<td>32 sec</td>
<td>25.6 sec</td>
</tr>
<tr>
<td>scan line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step and dwell time</td>
<td>0.1 sec</td>
<td>4.0 sec</td>
<td>1.81 sec</td>
</tr>
<tr>
<td>ΔTime *</td>
<td>0.5 sec</td>
<td>2.0 sec</td>
<td>0.9 sec</td>
</tr>
</tbody>
</table>

*ΔTime - The difference between the start of each scan and the center of the first dwell period.*

Table 4.0-1 is from the "NOAA Polar Orbiter Data (Tiros N, NOAA-6, 7, 8, 9, 10, --) Users Guide"; NOAA, Dec 1986.

### Some Facts:

The radius of earth is 6371 km (40,030 km circumference).

The orbit period of a NOAA satellite (with TOVS) is 102 min (about 14.1 orbits per day).

- Therefore the ground speed along the orbit is about 6.54 km/sec.
- Since the time between the start of successive HIRS scan lines is 6.4 sec, the distance (at the ground) between scans is about 42 km.
Selected Datasets for the Upper Atmosphere

Following is information about selected datasets for the upper atmosphere.

1. Datasets of analyses at NCAR

   We have many datasets of analyses at NCAR. A number of these go up to at least 10 mb (about 31km). One dataset of daily analyses of temperature and height goes up to 0.1 mb (65km).

   BAILEY x 1410

2. Limb Sounders (see John Gille at NCAR)

   These scanners of the earth's limb produced soundings above about 10 km of temperature and chemical constituents.

   1. LRIR--Limb sounder on Nimbus 6
      The data are for 19 Jun 1975 to 7 Jan 1976 (6.6 months)
   2. LIMS--Limb sounder on Nimbus - 7
      The data are for 25 Oct 1978 to 29 May 1979 (7.1 months)
      The LIMS temperature soundings for FGGE went up to 1 mb.

3. Average data for the region above 65km

   The following summary of products was prepared by Roy Barnes in the Data Support Section at NCAR.

   CHARACTERIZING THE MESOSPHERE AND IONOSPHERE

   Three climatological models (IRI, MSIS, and HWM) are often used to characterize the Mesosphere (65-85km) and Ionosphere (85-1000km). Based on observational data, each model (Fortran subroutines with example driver programs) uses location, time of year and solar activity to list species concentrations, IRI for ions and MSIS for neutrals. The NCAR Data Support Section has a copy of these models in the CEDAR database. They may also be run interactively on the WWW at URL:

   http://nssdc.gsfc.nasa.gov/space/model/models_home.html

   MSIS-90 (Mass Spectrometer Incoherent Scatter 1990 version) extends the previous altitude range through the Mesosphere down to the surface; see JGR, 96, 1159-1172, 1991 for details.

   HWM-93 (Horizontal Winds Model) also extends downward to the surface and is an update to the 1990 version, described in JGR, 96, 7657-7688, 1991.

   IRI-90 (International Reference Ionosphere) excludes the Mesosphere stopping at about 90km; see NSSDC-WDC-A-R&S 90-22, Nov 90.

(Prepared by Roy Barnes, May 1996)

4. The NCAR CEDAR Data Base Catalogue

A catalog of upper atmosphere datasets has been prepared at NCAR. It is usually updated each year. The last version is dated June 1995.

5. Data from the UARS Satellite

UARS was launched Sep 15, 1991. It gives temperature and wind data from about 10 to 105km. It gives chemistry data for about 10 to 60km. We have a short text and notes about the UARS data. Several CD-ROMs (by NASA) have 3 years of UARS data (Sep 91-Sep 94).

Roy Jenne
NCAR (x 1215)
Section L

STRATOSPHERIC DATA (Primary Sets), AND OZONE
(At NCAR)


2. DS 188: German stratospheric grids, daily, N. Hem., 50, 30, 10 mb, Ht, temp. Only few 10 mb in recent years. November 1964 - June 1981. 10 degree grid. 2 tapes. (From K. Labitzke, Free Univ. Berlin) Now updated through Dec 85.


4. DS 67.1: Daily tropo and strato data from basic Gelman archive Global, 1000 mb to .4 mb., (Oct 1978 - Dec 1987), 16 tapes (6250 bpi). Sfc through 100 mb is from Flattery method through 26 July 1984. Then it should be same as other NMC global archives. 70 to .4 mb is the same as in DS 67. The stratosphere analyses are stacked up using this 100 mb height and temperature.

5. Monthly adjusted stratospheric grids, global, from NMC. Time: Oct 78 - Dec 88, not corrected. Oct 78 - Dec 86, corrected. Based on daily analyses, 70-.4 mb, with adjustments for temperature calibration at 5 mb and higher. From Mel Gelman, CAC. Separate text is available.


7. DS 190.3: Weekly stratospheric grids, N. Hem., 5, 2, 1, .4 mb, July 1976 - April 1980, 65x65 grids. 1 tape.


9. DS 855: Rocket soundings, global, from NCC. 1969 - 1987, usually weekly. (1 tape per year, could be fewer).
10. DS 679: Data along the orbits for five brightness channels, Nimbus-5 SCR. Dec 1972 – Dec 1974. 5 tapes. From C. Rodgers, UK. Also: daily global analyses of the channels, 1 tape.


13. DS 805.0: Daily total ozone from London station ozone data.
   — 1957 – 1975 in dataset
   — 1957 – 1979 with an unresolved error shown in work folder


Also: satellite soundings, grid sets surface to 100 mb. Tropopause analyses.
Impact of Satellite Data on the CDAS–Reanalysis System

K. C. MO AND X. L. WANG

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Development Division, National Meteorological Center, NWS/NOAA, Washington, D.C.

(Manuscript received 11 February 1994, in final form 9 May 1994)

ABSTRACT

In preparation for the execution of the National Meteorological Center and National Center for Atmospheric Research (NMC/NCAR) Reanalysis Project, which will cover the period 1958–93, the impact of satellite data on both analyses and forecasts has been assessed. This was done by diagnosing two sets of analyses and forecasts made with and without the use of satellite data (SAT and NOSAT) within the data assimilation. The analyses and forecasts were performed using a state-of-the-art global data assimilation system and were evaluated for August 1985.

The impact of satellite data is smaller than that obtained in previous impact studies during the First GARP (Global Atmospheric Research Program) Global Experiment (FGGE) that took place in 1979, reflecting the effect of improvements that have been implemented in the global analysis scheme and the model. In the Northern Hemisphere (NH), there are no significant differences between SAT and NOSAT analyses for both primary variables and eddy transports. The satellite impact on the forecasts in the NH is positive but very small, reaching about 1% in the 5-day forecasts, as measured by the average rms errors and anomaly correlations. In the Southern Hemisphere (SH), the difference between the SAT and NOSAT analyses is estimated to be equivalent to the difference between 1.5-day SAT forecasts and the verifying analyses. After 5 days, the SAT forecasts are shown to be superior to the NOSAT forecasts by about 1 day, an advantage apparent whether they are verified against SAT or NOSAT analyses. A comparison of SAT and NOSAT analyses suggests that the NOSAT captures well over 90% of the variance of monthly mean stationary waves of the SAT analyses in most of the Tropics and Southern Hemisphere from 20° to 60°S. The daily variability is captured at 70%–90% in the Tropics and Southern Hemisphere, except above 200 hPa and south of 60°S.

In several earlier satellite data impact studies performed using FGGE (1979) data, it was observed that satellite data, which cannot resolve smaller-scale features, have a damping effect on the apparent atmospheric circulation. With the improvements in data assimilation methods, it is seen that the smoothing effect is much less apparent. A comparison of the SAT and NOSAT monthly tropical precipitation derived from the 0–6-h forecast cycle shows a general agreement with the rain estimates from satellite data.

Overall, these results are very encouraging, indicating that a reanalysis spanning the years before and after satellite data was available should be useful. In the NH, the analyses are basically unaffected by the satellite data. Even in the SH a large component of both the monthly and the daily anomalies can be captured in the absence of the satellite data, except in the stratosphere and Antarctic region.

1. Introduction

The National Meteorological Center (NMC)–National Center for Atmospheric Research (NCAR) Climate Data Assimilation System (CDAS) and Reanalysis Project started its operational phase in early 1994. The basic idea of the CDAS–Reanalysis Project is to use a frozen 1994 state-of-the-art analysis–forecast system and perform data assimilation using past data, from 1958 to the present (reanalysis). Moreover, the same frozen analysis–forecast system will be used to continue to perform data assimilation into the future (CDAS), so that climate researchers will have access to more than 35 years of relatively homogeneous reanalysis to compare with present analyses (Kalnay and Jenne 1991; Kalnay et al. 1993).

Since the reanalysis project will cover the presatellite period, it is important to assess the impact of satellite data on the analysis–forecast system. Since most satellite data became available for data assimilation in the late 1970s, the reanalyses for earlier years will be useful only to the extent that the analyses are relatively unaffected by satellite data. During and after the First GARP (Global Atmospheric Research Program) Global Experiment (FGGE) of 1979, the impact of satellite observations on numerical forecasts and analyses was studied extensively (e.g., Tracton et al. 1980;
Data Sets for Meteorological Research

Roy L. Jenne
CHAPTER 9. SURFACE SYNOPTIC OBSERVED DATA
1. INTRODUCTION
2. FILED IN SYNOPTIC SEQUENCE
3. FILED IN TIME SERIES ORDER

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2. MONTHLY MEAN REPORTS FROM SURFACE STATIONS
3. ATLAS OF MEAN SURFACE TEMPERATURE AND PRESSURE BY MONTHS 1881-1960
4. TREE RING DATA FOR WESTERN AMERICA
5. N. AMERICAN CLIMATE DATA TO 10,000 YEARS
6. DATA BANK OF EARLY CLIMATOLOGICAL SOURCES

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2. CLIMATOLOGICAL GRID DATA PREPARED BY RAND
3. STRATOSPHERIC CLIMATOLOGY

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3. HEIGHT AND TEMPERATURE ANALYSES FROM AFGWC (AIR FORCE)
4. DAILY HEIGHT AND TEMPERATURE ANALYSES FROM NMC
5. DAILY HEIGHT AND TEMPERATURE ANALYSES PREPARED IN GERMANY
6. WEEKLY CONSTANT PRESSURE GRIDS AT 5, 2, AND 4 MB
7. STRATOSPHERIC ANALYSES FROM GERMANY
8. STRATOSPHERIC CLIMATOLOGY
9. RAWINSONDE DATA
10. MONTHLY THICKNESS DATA FROM SATELLITES AT NCAR
11. ROCKETSONDE DATA AT NCC

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3. ARCHIVE OF NESS SCANNER IR AND VISIBLE DATA
4. LIRI DATA
5. OTHER SATELLITE IR DATA
6. MOISTURE DATA FROM NESS
7. CLOUD DRIFT WINDS AND MOVIE LOOPS
8. SOLAR PROTON MONITOR DATA
9. GENERAL INFORMATION ABOUT SATELLITE SIRS AND VTPR DATA
10. VTPR SATELLITE IR SOUNDING DATA FROM NESS
11. DEFENSE METEOROLOGICAL SATELLITE PROGRAM (DMSP) (WAS DAPP)
12. SEA SURFACE TEMPERATURE DATA FROM NESS
13. SCR SOUNDING DATA FROM NIMBUS-4 SATELLITE
14. NIMBUS-5 DATA
15. OZONE SOUNDING DATA FROM SATELLITE
16. ICE AND SNOW AND ESMR MICROWAVE DATA
17. SATELLITE DATA FOR THE GATE EXPERIMENT
18. SEASAT SATELLITE
19. ERTS DATA
Chapter 13

visible, the day IR, and the night IR. From these NESS is also calculating the albedo, the absorbed solar radiation, and the total outgoing long-wave radiation (about $10^6$ bits per day). Thus, there will be a gap in the larger scale averaged data from September 1972 through May 1973. T. Gray says that there was some trouble with the digital data for January - May 1973, even though the analog data were all right.

4. **LRIR Data** (low resolution infrared)

Recently these have been FPR data (flat-plate radiometer).

a. These are from a flat-plate radiometer.

The approximate dates of LRIR data availability are as follows:

ESSA-5  9 May 1967 - 30 Sep 1967
ESSA-7  3 Sep 1968 - 22 Jun 1969
ESSA-9  1 May 1969 - 15 Apr 1970

The tapes (about 30) are at NCC and at NESS (see S. Brown).

b. Tapes of the FPR data are at NESS (see Phillips and Rubin, 1972):

NOAA-1  4 Feb 1971 - 27 May 1971

Volume: $1320 \times 24 \times 24$ bits/day = $7.6 \times 10^5$ bits/day

5. **Other Satellite IR Data**

a. Tapes with $5^\circ$ latitude-longitude average IR data are available for the TIROS 7 period of about June 1963 - June 1964; the sampling was poorer for the following year. Window channel.

b. ITOS - about June 1970 to April 1971

The daily global IR is available on $2048 \times 2048$ grids for each hemisphere. About two days per tape per hemisphere; thus, about one tape per day. Daily values for day and night.

The data are very noisy and badly calibrated. Gray thinks it would take more time to summarize than it is worth. The tapes show erroneous warm and cold strips of water in the Gulf Stream, etc.
c. NOAA-1 19 April 1971 to 10 July 1971.

The 5° IR data are at NESS and NCAR.

d. Note from Table 2 that MRIR (medium resolution infrared) instruments were on Tiros 2, 3, 4, 5, etc.

e. Some of the IR data have been gridded and processed into average heat budget data for the periods shown below. Total IR, albedo from top of atmosphere, and net radiation assuming a solar constant are included. T. Vonder Haar at Colorado State University (CSU) has these data on tape and he and J. Ellis have just published an atlas (Vonder Haar and Ellis, 1974).

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Instrument</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jul 1964 - Nov 1965</td>
<td>Experimental</td>
<td>Vonder Haar (C.S.U.) monthly average</td>
</tr>
<tr>
<td>15 May - 15 Jul 1966</td>
<td>Nimbus 2</td>
<td>Raschke and Bandeen (GSFC) 15-day average</td>
</tr>
<tr>
<td>Dec 1966 - Jan 1967</td>
<td>ESSA-3</td>
<td>McDonald (NESS)</td>
</tr>
<tr>
<td>1968 - Apr 1969</td>
<td>ESSA-5</td>
<td>NOAA/NESS Not final</td>
</tr>
<tr>
<td>May 1969 - Jan 1970</td>
<td>Nimbus-3</td>
<td>Vonder Haar and Ellis Ten 15-day periods</td>
</tr>
</tbody>
</table>

6. **Moisture Data from NESS**

Since about July 1973, NESS has been preparing data on total precipitable water (from VTPR), but has not archived it. (We would like to see it saved.)

Since about July 1972 NESS has been preparing estimates of relative humidity for two layers over the Pacific Ocean, Western Atlantic, and Gulf of Mexico. The layers are surface to 700 mb and 700 to 500 mb. The estimates are made from cloud pictures. The data are not archived. Surface bogus reports are saved, and contain estimates of present weather and cloud amount.

7. **Cloud Drift Winds and Movie Loops**

The winds derived by NESS from satellite cloud pictures are included on the upper air data tapes from NMC. Some of the winds have been estimated by looking at single pictures showing the cirrus plumes blowing off of the tops of cumulonimbus clouds.
Fig. 13-4. Launch and termination dates of satellites (from Stoldt and Havanac, 1973).
The NASA series of Nimbus satellites

NIMBUS I
HIGH RESOLUTION RADIATION DATA
CATALOG AND USERS' MANUAL

Volume 1
Photofacsimile Film Strips

The film strips start Aug 28, 1964

By
Staff Members
of the
Aeronomy and Meteorology Division
Goddard Space Flight Center
National Aeronautics and Space Administration

January 15, 1965
Figure 18—Typical HRIR data coverage for Nimbus 1 shortly after launch. Subpoint tracks are shown corresponding to those portions of the orbits discussed in the example of Figure 17 from which data were successfully recovered.
NIMBUS II USERS' GUIDE

JULY 1966

Prepared by
ARACON Geophysics Company
Concord, Massachusetts
A Division of Allied Research Associates, Inc.

For the
Nimbus Project
Goddard Space Flight Center
Greenbelt, Maryland
THE NIMBUS II DATA CATALOG
Volume 1
15 May through 30 June 1966

439 Pages

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Greenbelt, Maryland
THE NIMBUS II DATA CATALOG

Volume 5

1 October through 15 November 1966
(ORBITS 1847 - 2458)

December 1966

Prepared By

ALLIED RESEARCH ASSOCIATES, INC.
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Nimbus Project
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THE NIMBUS 5 USER'S GUIDE

0 162 pages in this

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February 1975
Planning for Earth Measurements by Satellite  
(Reflections on CES, 1993-1996)

The CES committee of the Academy oversees the planning for satellites that take measurements for the earth sciences (the atmosphere and the surface of the land and ocean).

I became a member of the CES in June 1993. The briefings by experts to the committee have been very interesting and useful. There are usually three meetings each year, and each meeting has a briefing by the head of satellite earth observing programs in NASA and NOAA. Some info about the military DMSP program is included.

After a while I will be rotating off of the CES committee, and I thought it would be useful to write down a few reflections about the 1993-1996 period.

1. The process to define requirements needs examination

For a given type of mission, various groups (to set requirements) suggest all the variables that need to be measured (this is OK). Panels then help define data resolution, number of channels and data rates (fine).

The problem is that the process has been too much like throwing requirements over a wall without knowing the cost consequences of given decisions. Also, the process often has lacked cost goals, and this allows costs to spin out of control.

We will give some examples. Around 1986, people defining the HIRIS sensor were talking about average data rates of 600 to 900 mbit a sec and we would just archive all of the data. No one told us about the costs of archiving high data rates, or the engineering limitations. A few months later, some reality had entered the process. Soil moisture is an important variable, so it quickly gets on the list of necessary data. For crops, we need the moisture in the top meter or so. The satellite can measure the moisture in the top 2 or 3 cm. Also the signal is confused by vegetation more than about 1 meter tall. In cases like this, we should know whether we can really get useful information and what it costs. It may be that it is better to gather more precipitation data and model the soil moisture. The point is that the CES committee often does not hear about this sort of analysis of the problem.

2. The Seasat satellite (and the planning process)

In mid-1978, NASA launched a wonderful satellite for oceanography - called Seasat. It had several good sensors. The data was good. The problem was that it failed after 100 days.
I was told that the 1978 satellite cost about $85m. The community wanted to replace Seasat. A big planning process was carried out in 1980. The price tag was $1.0 billion, a remarkable increase. The proposal bounced around the government for a couple of years and then was turned down, because it cost too much money. This should be called bad planning and no cost control.

About 1985, the initiative started again. This time the plans led to costs of $1.35 billion, and again the plans were turned down because it was too much money.

*Lessons learned from Seasat history:* A history of costs of related missions should always be available. When costs show a dramatic increase, people should ask questions. Two or three options should be given when appropriate. At the start of the plans, approximate cost constraints should be given for a mission.

3. The costs of planning too much

It has been found that working with the government usually adds about 30% to the cost of a contract (compared with a private contract). NASA realizes this is a problem and is trying hard to define a new way of doing business. A Hughes contractor told me that working for NASA was harder than working for the USAF.

4. Model assimilations are important

We need reliable descriptions of the winds, temperature, etc. of the whole atmosphere. This can be achieved by combining good observations with modern methods for data assimilation. There is very little sensor data on EOS am-1 that will help assimilations. New sounders will come later and they will help. Will we ever get a wind satellite?

5. Need for global wind data

The main new measurement that is needed to help global forecasting, and to provide more accuracy in assimilations is global wind data. These winds would also contribute to the accuracy of analyses of the boundary layer (the lowest 1 to 3 Km).

- The world has duplicate data of some types while we do not have this wind data.
- The planning process (in the 1980's) for windsat got too lengthy and it aimed for the $800m satellite.
- An excellent 1-3 year wind mission can be built and flown for about $120m (from talk to CES in Jul 1995). After the start of the project, the launch can be within three years.
• This wind mission may keep slipping through out hands as it has for the past decade.

6. The options for doing one mission often are not clear.

Consider the possible Windsat mission. In Spring 1995 we (on CES) asked to be briefed on the mission. I visited Marshall in June 1995 to hear initial briefings, as a representative of CES. I suggested that CES should be told about two or three mission options, not just one. As I recall, they came in with an $80m option, a $100-120m option, and $850m option. An estimate was that the winds from the $100-120m option would provide 75-80% of the utility of the $850m option. If this type of information is presented to CES and to NASA management, the US will be able to obtain a better return on the dollar. By 1995, everyone knew that no one would obtain $850m for a wind satellite. This fact also helped to inspire a quest for other options.

7. There are many satellites like Landsat on the books

CES was shown a table that listed about 20 different missions in the world for data like Landsat. The panel asked itself: how many does the world really need? This discussion was about early 1996.

8. The cost of Landsat satellites

CES has had various briefings about Landsat-type satellites. Based on these, I have the feeling there has been a lack of cost control in the planning process in some of the early years. It seems that this situation has improved a lot in the past few years. It would help to review the history of costs, to obtain a better feeling for what functions can be achieved for given amounts of money. We have to recognize that new technology is also a key factor in helping to reduce costs.

9. Data systems for Landsat data

It appears that some of the commercial Landsats will have low cost data systems. It would help to have a comparison of the data system costs for various Landsats in the US, Europe, and Japan.

• There are basic costs that can not be avoided.
• It is easy to establish data systems that cost any amount of additional money.
• A part of the costs is directly associated with the amount of new data that is captured each year.
• There has been a lot of trouble in achieving sensible planning for data systems that should solve the data problem and control costs.
10. Data systems costs should be estimated early in planning

About Fall 1995, NASA included an important concept on a briefing slide for CES. The slide said that approximate data system costs should be known before a mission is approved. This concept deserved at least three cheers, and should be built into the planning process. If one data archive can't achieve a reasonable cost, then another should be used.

- If the data are just thrown over a wall into a data system, costs are likely to spin out of control.
- If data costs are "planned" by the normal process, costs will also probably spin out of control. Hard nosed cost control is needed plus a dedication to good service for relatively low cost. To achieve this, cost analyses and cost comparisons are needed.

11. Briefing materials for CES.

A lot of very interesting material is presented to CES. I would have seen only a fraction of it from other sources if I had not been on CES. There are some summary catalogs of satellite specs that I would not have been aware of without CES.

Perhaps a large subset of the briefing slides and other documents should be placed on a CD-ROM for a wider community to use--and for the historical record. However, this would have to be handled so that it does not impede the free flow of information.