ON THE NEAR-REAL TIME OPERATIONAL USE OF TOVS DATA

K. Dieter Klaes
EUMETSAT¹
Darmstadt, Germany

1. INTRODUCTION
Satellite data have gained an immense importance in the last decade for use in research as well as in operational analyses and forecasts. Specially for providing early information on hazardous events as well as providing information at all over data sparse areas like the oceans or/and in case of failure of the 'conventional' data sources. The TOVS (TIROS Operational Vertical Sounder) instrument (see e.g. Smith et al., 1979) aboard the polar orbiting satellites of the NOAA/TIROS-N series has proven its feasibility to provide information on the three dimensional structure of the atmosphere in a time- and spatial scale allowing to cover meso scale phenomena.

As model analyses and forecasts are available in a routine manner always at the same times but after considerable cutoff and transmittance times, satellite derived fields from locally received direct readout data may fill the gaps in time and areal cover to give an early assessment of the atmospheric state.

The "3I" (Improved Initialization Inversion) retrieval algorithm designed for the sounding of atmospheric parameters from the TOVS-data (Chédin and Scott, 1983; Chédin et al., 1985), has already been used in a wide spectrum of applications. They range from meso scale applications in polar regions (Claud et al., 1988; Claud et al., 1990, Heinemann, 1989) and in midlatitudes (Prangsma et al., 1987, Klaes, 1991, Klaes, 1992) to global applications (Chédin, 1989, Flobert et al., 1991; Chédin et al., 1992).

In the past years "3I" underwent many improvements (Tahani et al., 1990; Chédin et al., 1990). For the operational application "3I-2" is applied, using the TIGR-2 (TOVS Initial Guess

¹This study was carried out, when the author was responsible for the Satellite Data Processing at the German Military Geophysical Office (GMGO), Mont Royal, D-5580 Traben-Trarbach, Germany.
KLAES, K.D. ON THE NEAR REAL TIME OPERATIONAL USE OF TOVS DATA

Retrieval) dataset.

This paper shows the first application in the near real time use of the "3I-2" retrieval package at the German Military Geophysical Office (GMGO), where it has been installed in June 1992 and is used in routine service 24 hours a day 7 days a week. It is demonstrated that the satellite derived data fields by themselves may be a considerable contribution to operational service.

2. DATA PROCESSING AND DATA

The "3I-2" version used for operational purposes at the German Military Geophysical Office (GMGO) is the VAX-Version created in July 1991 (Klaes et al., 1991). It is running on the Satellite Data Processing System (SDPS, see Klaes, 1990; Klaes and Georg, 1992; Klaes et al., 1992), where it has been put into the real time operational cycle. At the moment "3I" is running as the last part of the processing chain, which means that the results will be available about one hour after the reception started. The wall clock time used for the processing of one local data set (about 15 - 18 min worth of data) is about 30 min. The results are routed to the Interactive Graphics System IGS, where they can be displayed together with all the other available meteorological information.

The first operational result was obtained the 01 June 1992 with NOAA-11 data received at 0406 UTC (beginning time of the reception).

The results shown are one week of NOAA-11 derived results, displayed on the Interactive Graphics System together with the model results of the BKFG, the GMGO version of the "Baroklin Feucht Model" BKF of the Deutscher Wetterdienst (Edelmann and Reiser, 1976), which were nearest in time. In addition the Channel 4 data of the Advanced Very High Resolution Radiometer AVHRR were available. Retrieval data were available since 1 June, nevertheless the time period from 06 July 1992 to 10 July 1992 is shown, since during this period the model data were available for all the satellite overpasses. Table 1 gives an overview over the data configuration.
Table 1: Satellite and 'conventional' data for the period from 06 July 1992 to 10 July 1992.

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME OF SATELLITE RISE (UTC)</th>
<th>BKFG MODEL TIME (UTC)</th>
<th>STATUS OF AVHRR DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>06 07 1992</td>
<td>0348</td>
<td>0000 + 06</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td></td>
<td>0530</td>
<td>0000 + 06</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td></td>
<td>1201</td>
<td>0000 + 12</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td>07 07 1992</td>
<td>0338</td>
<td>0000 + 00</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td></td>
<td>0518</td>
<td>0000 + 06</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td></td>
<td>1149</td>
<td>0000 + 00</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td>08 07 1992</td>
<td>0328</td>
<td>0000 + 00</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td></td>
<td>0506</td>
<td>0000 + 06</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td></td>
<td>1138</td>
<td>0000 + 12</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td>09 07 1992</td>
<td>0312</td>
<td>0000 + 00</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td></td>
<td>0453</td>
<td>0000 + 06</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td></td>
<td>1304</td>
<td>1200 + 00</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td>10 07 1992</td>
<td>0300</td>
<td>0000 + 00</td>
<td>AVAILABLE</td>
</tr>
<tr>
<td></td>
<td>0441</td>
<td>0000 + 06</td>
<td>AVAILABLE</td>
</tr>
</tbody>
</table>

3. RESULTS

The results shown are thickness fields 500/1000 to give examples of the retrieval of the temperature field in an operational environment. Since it was a test installation, there has been only the possibility to derive NOAA-11 fields. Future application will make full use of the polar orbiting satellite system, which will allow to retrieve data from about 12 overpasses per day (see table 1 as a reference for a local reception list for GMGO's HRPT station).

The "31" results are shown on the "box" resolution to account for the original resolution of the retrieval data. Statistics shown in the second section were made for the overpass areas and are summarized for this one week.

3.1 Weather situation

The weather situation over Central Europe on the 06 July 1992 was dominated by a nearly cut off low over the Alps as can be seen in the 500hPa map by the Berlin Weather Map (FU Berlin,
KLAES, K.D. ON THE NEAR REAL TIME OPERATIONAL USE OF TOVS DATA

1992, Figure 1a). The axis of the trough is directed towards Spain. In the western part there is a narrow ridge with its axis west of Ireland from the Canarian Islands. Weaker secondary ridges are pointing towards Jutland and the Eastern Baltic Sea. Over Scandinavia there is a weaker gradient of the flow. The according surface map (Figure 1b) shows an occluded low pressure system north of the Alps. The front of the low pressure system has already reached the Balkans and ranges towards Central Italy and North Africa/Southern Spain. A warm front was analyzed North of the Black Sea. High pressure was analyzed over Scandinavia connected to the ridge over the British Isles.

Figure 1a: 500 hPa map of 060792, 0000 UTC (FU Berlin, 1992).

Figure 1b: Surface map of 060792, 0600 UTC (FU Berlin. 1992)
At the following 07 July 1992 the trough has moved more to the south east. The ridge in the west has widened and its axis is now pointing over the British Isles. Over the Finland area there is a delta region. The surface low is now positioned over the Alps, there is no more development at this time, though the occlusion still causes rainfall. In general the surface pressure gradients over Central Europe are weak. An other low is developing south of Greenland. The central Atlantic is covered by a large High pressure system.

The next day shows the through weakening further, its axis still from Finland through Spain. The ridge is now pointing towards Jutland and sharpening. The flow gradient gets stronger over the North Atlantic and the Baltic Sea. There is a new trough with its axis from Iceland to the south approaching Central Europe. On the surface there is now high pressure influence over central Europe, according to the upper ridge. There are still remnants of the occlusion over the Alps. There was not much precipitation reported in Central Europe. The Atlantic area is dominated by high pressure in the Azores area. A surface low is analyzed over the Denmark Strait.

On the 09 July 1992 the upper air analysis shows the ridge over the East of Scandinavia. A stationary upper low is situated over Genoa. A strong trough with axis towards the Black Sea is in the East over Russia, a weaker one over Iceland. The strongest flow gradient is analyzed over the British Isles. At the surface the high pressure system has moved over Poland. There is a frontal band reaching from the Baltic over England top the south of the Azores. The occluded system over Northern Italy is connected with the cut off system over Genoa, it has produced strong rainfall in this region. Over Central Europe there was not much rain reported a on this day.

At 500 hPa the 10 July 1992, the last day of the sequence considered here, shows the trough from the west now arrived over the British Isles with a secondary trough pointing towards the Alps. A ridge is now reaching from Greece towards Poland and the Baltic Sea. Over the Central Atlantic there is nearly zonal flow. At the surface there still is a weak pressure gradient over Central Europe. There was again not much precipitation reported over Central Europe.

Generally the whole week can be considered to be very warm in temperature over Central Europe.

3.2 Analyses and "3I" Retrievals

In the following Table 2 meteorological phenomena are described of the model outputs and the retrievals of the thicknesses 500/1000. The items listed in the table are not meant to give a complete analysis of the weather situation but to address the phenomena, which are in common by both datasets. In the right column cloud information is added according to the AVHRR channel 4 (12.5 micron) data. The comparison is made with the philosophy that neither of both
information is considered as the "truth".

Table 2: Comparison between analyses and forecasts. "31-23 retrieved fields and their relation to the AVHRR-Channel 4 image. The times denote satellite rise time and model time respectively.

<table>
<thead>
<tr>
<th>DATE/TIME SAT TIME MOD</th>
<th>&quot;31-2&quot; THICKNESSES 500/1000</th>
<th>ASSOCIATED AVHRR CHANNEL 4 IMAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>060792 0348 UTC 0000 UTC+06</td>
<td>-well simulated, specially warm air ridge in the west of Europe -two cold centres over Northern Spain and Northern Italy -cut off simulated in the south -cold air in the North East -the gradients are well simulated</td>
<td>-cloudy regions over Balkans not retrieved by TOVS, over mountainous regions no 1000 hPa surface -clouds show a Genoa Cyclone of which the circulation centre has passed to the Balkans -a frontal zone can be recognized from Greenland over UK -Cold front over southern Italy</td>
</tr>
<tr>
<td>060792 0530 UTC 0000 UTC+06</td>
<td>-Cold air pool SE of Greenland -gradients are simulated -warm air tongue retrograded a bit</td>
<td>-frontal system cloud band ahead of the cold side of the gradient zone -warm ridge surrounded by cloud band (frontal zone)</td>
</tr>
<tr>
<td>060792 1201 UTC 0000 UTC+12</td>
<td>-gradients well met -cloudy regions not retrieved -relatively warmer zone north of Finland</td>
<td>-Centre of cyclonal circulation still over the NE Balkans -only few real cloud free regions</td>
</tr>
<tr>
<td>NO model analysis available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>070792 0338 UTC 0000 UTC+00</td>
<td>-warm centre south of Ireland -cold spots over the Rhône valley -cut off simulated -warm ridge Northern Finland</td>
<td>-frontal clouds NE Finland-Southern Sweden</td>
</tr>
<tr>
<td>4 hours difference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>070792 0518 UTC 0000 UTC+06</td>
<td>-cold air SE of Greenland -warm ridge decreasing, tilting further east -gradients well simulated -warm core of ridge west of Scotland</td>
<td>-frontal cloud band ahead of the cold pool SE of Greenland -clouds in the western part of the warm core over the British Isles</td>
</tr>
<tr>
<td>Time</td>
<td>Analysis</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 070792 1149 UTC 0000 UTC+12 | -weak warm ridge in the SE  
  -gradients well simulated  
  -cold air pool in the North, weakening | -convective clouds in the SE  
  -frontal clouds in the north, diminishing |
| 080792 0328 UTC 0000 UTC+00 | -orbit not completely received due to antenna problems  
  -warm core south of Norway  
  -gradient well simulated | -frontal cloud system west of the warm ridge |
| 080792 0506 UTC 0000 UTC+06 | -information over the Atlantic Ocean  
  -gradients well simulated  
  -splitting of the warm tongue is simulated | -frontal clouds west of the warm tongue  
  -nearly no cloud free area |
| 080792 1138 UTC 0000 UTC+12 | -cold air centres in the east  
  -warm ridge over Sweden/Norway | -overcast over Norway  
  -broken clouds over Southern Russia |
| 090792 0312 UTC 0000 UTC+06 | -cold air cut off Northern Italy  
  -warm air ridge shows structures inside  
  -cold air regions in the NW and NE  
  -gradients well simulated | -cloud bands along the west of the warm air ridge  
  -convective systems over Italy, no retrievals there |
| 090792 0453 UTC 0000 UTC+06 | -large cold air pool over the Northern Atlantic  
  -cold trough west of British Islands | -frontal clouds ahead of cold trough  
  -nearly no cloud free region in orbit area |
| 090792 1304 UTC 1200 UTC+00 | -omega like situation  
  -wide trough of cold air over the Norwegian Sea  
  -gradients ok | -frontal clouds ahead of cold trough west of Norway  
  -Eastern Europe cloud free |
| 100792 0300 UTC 0000 UTC+06 | -cold trough in the west  
  -cold air extending towards Northern Italy, Balkans  
  -large warm area over Eastern Europe  
  -gradients well simulated | -frontal cloud system west of the large trough in the west as well as north and north east of the cold air trough versus Italy |
3.3 Discussion

The thicknesses 500/1000 of both datasets were treated statistically to obtain values of bias, RMS and standard deviation. Each day was considered separately as well as the whole ensemble. The statistics for the single days and the whole week are summarized in Table 3. In general the values are positioned along the diagonal with a tendency towards lower thicknesses of "31", compared with the model results. The average RMS error is around 2 gpdam, the bias reaches from -0.6 gpdam and -2.29 gpdam, the latter value occurs at the last day of the five considered. For the whole ensemble the RMS error is 2.4 gpdam with a bias of -0.972 gpdam.

Table 3: RMS error, standard deviation and bias of thicknesses 500/1000 derived from TOVS by "31-2" and based on BKFG forecast model.

<table>
<thead>
<tr>
<th>DATE</th>
<th>#ITEMS</th>
<th>RMS/gpdam</th>
<th>STDV/gpdam</th>
<th>BIAS/gpdam</th>
</tr>
</thead>
<tbody>
<tr>
<td>06/07/92</td>
<td>258</td>
<td>2.198</td>
<td>2.112</td>
<td>-0.6085</td>
</tr>
<tr>
<td>07/07/92</td>
<td>297</td>
<td>2.144</td>
<td>2.059</td>
<td>-0.5993</td>
</tr>
<tr>
<td>08/07/92</td>
<td>216</td>
<td>2.454</td>
<td>2.263</td>
<td>-0.9491</td>
</tr>
<tr>
<td>09/07/92</td>
<td>265</td>
<td>2.662</td>
<td>2.281</td>
<td>-1.373</td>
</tr>
<tr>
<td>10/07/92</td>
<td>78</td>
<td>2.919</td>
<td>1.805</td>
<td>-2.295</td>
</tr>
<tr>
<td>ALL DAYS</td>
<td>1114</td>
<td>2.407</td>
<td>2.202</td>
<td>-0.9721</td>
</tr>
</tbody>
</table>

If the single thickness values are regarded it appears that values below 540 gpdam and above 572 gpdam are having a larger bias than the remaining. Nevertheless there are not enough items to come to a final conclusion.
4. CONCLUSION

As far as the data amount allows the representation of the average temperature field as retrieved by "3I-2" from data of the TOVS instrument coincides well with the results of model runs of the same parameter. The statistical numbers obtained are valid for the type of weather situation only, which occurred during the week regarded.

As both the retrieved results as well as the model results were obtained operationally, the former were in some cases available up to 1 h hours earlier than the associated model analysis, based on "conventional" observation data ("cut off time"), this demonstrates the usefulness of satellite derived data alone for use out of numerical models.

In addition to give an early information for nowcasting purposes the satellite data may also be a backup in case of model failure as well as additional information over data sparse regions, namely the Oceans.

5. REFERENCES


KLAES, K.D. ON THE NEAR REAL TIME OPERATIONAL USE OF TOVS DATA


KLAES, K.D. ON THE NEAR REAL TIME OPERATIONAL USE OF TOVS DATA


6. ACKNOWLEDGMENTS
The author thanks the ARA/LMD group, specially Dr. Alain Chédin and Dr. Noelle Scott, Ecole Polytechnique, Palaiseau, France, for making "31-2" available for this pre-operational study and for many fruitful discussions.
Figure 2a,b: Thicknesses 500/1000, derived by "3I-2", together with output of BKFG forecast model (a) and AVHRR Channel 4 data together with BKFG derived thicknesses 500/1000 (b), respectively for 06/07/92 over Europe.
TECHNICAL PROCEEDINGS OF

THE SEVENTH INTERNATIONAL TOVS STUDY CONFERENCE

Igls, Austria

10-16 February 1993

Edited by

J R Eyre

European Centre for Medium-range Weather Forecasts
Shinfield Park, Reading, RG2 9AX, U.K.

July 1993