Chapter 3

A near-real-time processing system for satellite data

The main goal of this work is the use of satellite-based measurements of atmospheric water vapour within the assimilation framework of a numerical weather prediction system. For this purpose, it is necessary that the satellite data fulfils several requirements. On the one hand, the data has to be of a certain accuracy, especially the error characteristics have to be known. This topic will be dealt with in section 5.2.2. On the other hand, the satellite data is subject to a very fundamental condition: it has to be available within a short time after the satellite overpass in order to be useful for the operational assimilation process. Assimilation cycles typically take place in 3 or 6 hours intervals. Especially in rapidly changing meteorological situations information older than one assimilation cycle is generally already useless for the model. Typically, the data should be available within a time interval of 90 minutes after the satellite overpass. In this work only the results from a non-operational assimilation experiment are shown where this condition is not as important as the satellite data can be prepared a posteriori. However, in order to make future assimilation experiments possible, a near-real time processing system for satellite data was developed which allows the automated creation of different atmospheric products from satellite radiances, including precipitable water. The timely preparation of satellite data for data assimilation was one purpose of this

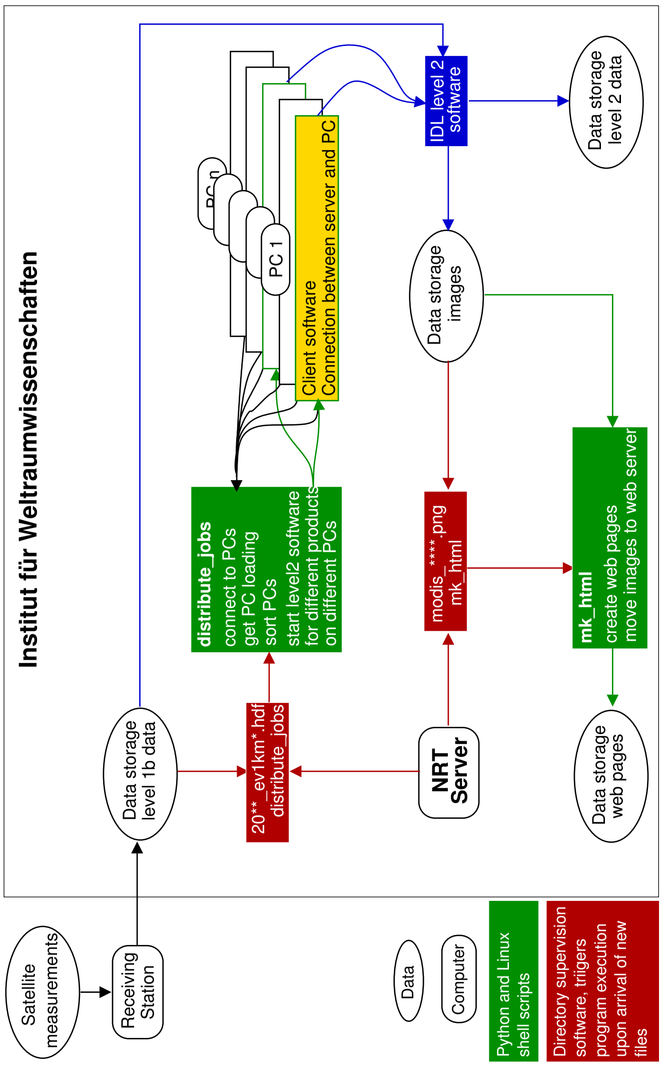

Figure 3.1: Flowchart of the near-real-time processing system used at the *Institut für Weltraumwissenschaften* for the automated retrieval of atmospheric water vapour and cloud properties from MODIS data and the display of results on the Internet.

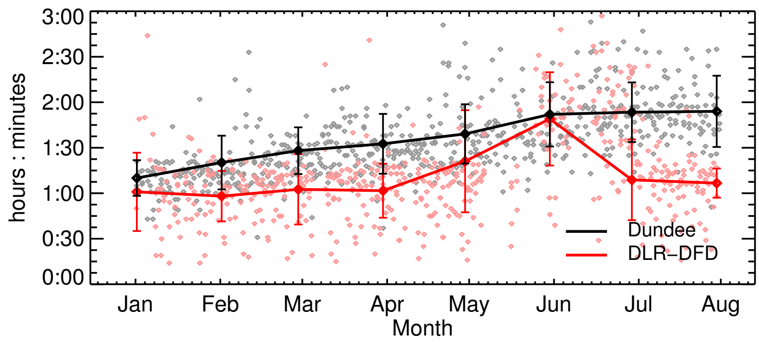

Figure 3.2: Time delay between begin of MODIS daytime overpasses and start of ftp-transfer of level 1b data for two satellite receiving stations. The dots show values for individual overpasses, the lines indicate monthly mean values. Overpasses with a time delay larger than 3 hours were omitted.

system, the other goal was to make images of the derived products available on the internet for the aid of forecasters at different national weather services.

The near-real-time processing system is built modularly, making future additions, e.g. the integration of new algorithms, very easy. It is based on two core functionalities. The first is a routine designed for the continuous monitoring of directories for the creation of new files. In case a new file is available, it can start a certain application to which the filename is passed as parameter, e.g. the product algorithm for MODIS level 1b data or a routine creating *html* pages in case of image files. The second basis is a set of programs for the communication with one server and different client computers. With this software package, the server can obtain information about the processing load and the memory usage of the different clients, and it can start programs on each individual client.

Figure 3.1 illustrates how these routines are combined for the near-real-time processing at the *Institut für Weltraumwissenschaften* for the retrieval of atmospheric water vapour as well as of different cloud properties from MODIS measurements: The directory, to which the MODIS level 1b data is transferred is continuously monitored. In case of a new file arriving, the server connects to the available clients, reads the processor loading and determines the least busy clients. On those, the different product algorithms are started. They read the level 1b files and produce the

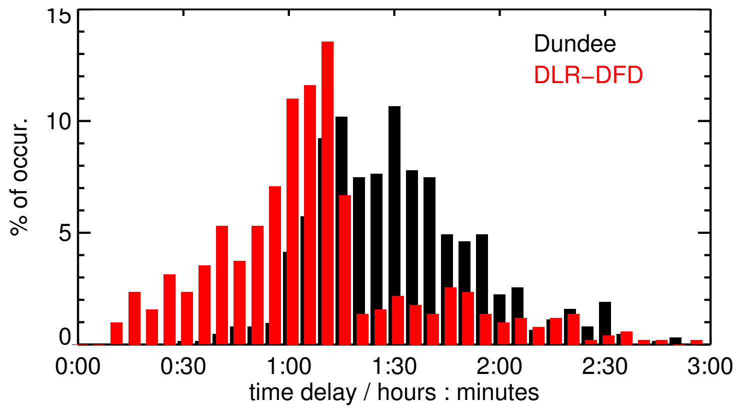

Figure 3.3: Histogram of the time-delays shown in figure 3.2.

appropriate level 2 products and image files.

The directory to which the image files are written is also monitored by a second program. If a new file appears, the appropriate *html* pages are created and the images and the web pages are put to the web server directory.

MODIS level1b data is continuously transferred to the institute via ftp from two different satellite receiving stations: the Dundee Satellite Receiving Station[1] and the German Remote Sensing Data Center DLR-DFD[2] in Oberpfaffenhofen. There, the raw MODIS satellite data is received and transformed into level 1b data which form the input of the retrieval algorithms. After completion, the level 1b data is automatically transferred via ftp to the *Institut für Weltraumwissenschaften.*

In Figure 3.2, the time delay between the begin of the MODIS overpass and the start of the ftp-transfer is shown from January to August 2003 for both receiving stations. As atmospheric water vapour can only be retrieved during daytime, only daytime MODIS overpasses were accounted for. The aim of this Figure is to illustrate the typical time-delay under "normal" circumstances, therefore overpasses with a time delay exceeding 3 hours due to exceptional technical difficulties were completely omitted. The majority of received overpasses was transferred within 3 hours, though. Details are given in Table 3.1. The time-delay for the MODIS data

[1] http://www.sat.dundee.ac.uk/auth.html
[2] http://www.caf.dlr.de/caf/institut/dfd/

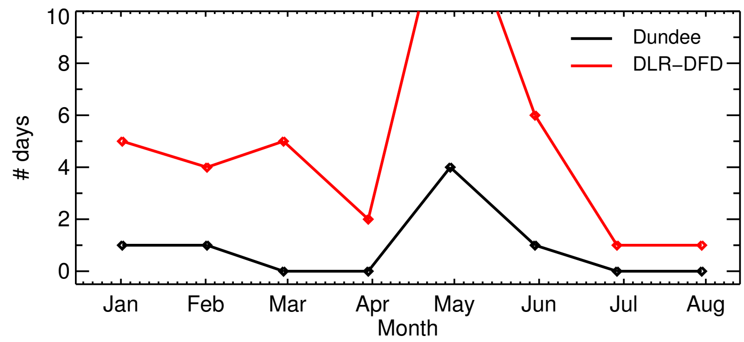

Figure 3.4: Number of days per month for which no MODIS daytime overpasses were transmitted within 3 hours from the two receiving stations of Figure 3.2.

coming from Dundee has continuously increased over the year, while the time-delay of the DLR-data has been relatively constant, except for May and June, where it has been significantly larger. This behaviour is also reflected in the frequency distribution of time-delays shown in Figure 3.3.

Finally, Figure 3.4 illustrates for how many days no MODIS information was available at all. Generally, in the DLR data more days are missing compared to Dundee, while both stations encountered problems in May in June.

It should be noted here that Europe is typically covered by 4 daytime overpasses, which are illustrated in Figure 3.5. From these overpasses, the westernmost is only received by Dundee, while the Easternmost is only received by DLR. The two central overpasses are generally much larger in size, resulting in slightly longer level 0 to level 1b processing time at the receiving stations. Table 3.1 summarises the above statistics, the mean time-delay is given for all daytime overpasses and for the central overpasses, respectively.

The time-delay is calculated from the begin of the MODIS overpass, therefore the actual time-delay for any point within the overpass can be up to approximately 15 minutes less, depending on its geographical latitude.

The computing time of the different algorithms is in the order of 10 minutes per overpass, therefore, at least with the data from DLR, the initial time limit of 90 minutes is still a difficult goal but possible to achieve.

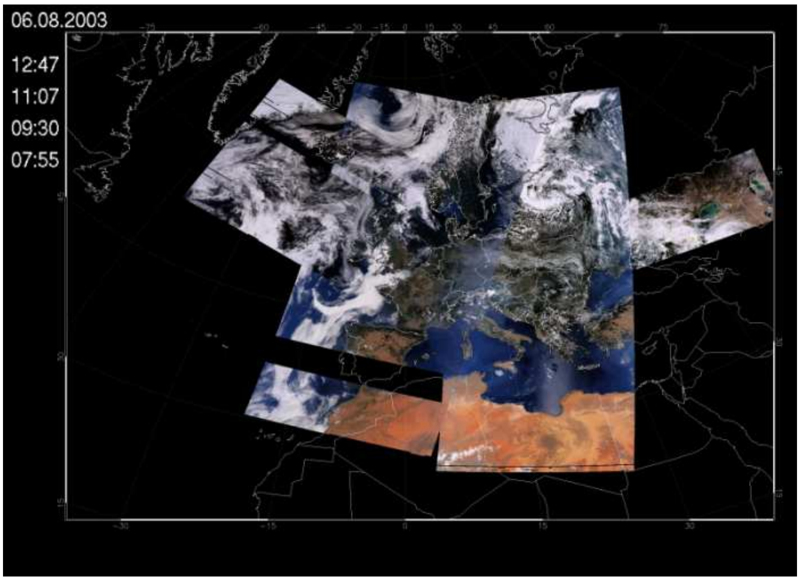

Figure 3.5: Mosaic of true colour images from four daytime MODIS overpasses on 6^{th} August, 2003

Table 3.1: FTP transfer statistics for the Dundee Satellite receiving station and the DLR-DFD in Oberpfaffenhofen for the period January to August 2003. (The number in brackets are for the two central overpasses only)

	# of over-passes within 3 hours	# of over-passes with a delay > 3 h	average number of overpasses / day	average number of missing days / month	average time-delay [min]
Dundee	628	22	2.9	0.9	93 (101)
DLR	509	34	2.4	4.9	70 (84)