# Annual Report

# 2006

EQUAL

Envisat Quality Assessment with Lidar

Prepared by: Yasjka Meijer (RIVM)
Issued on: 12-04-2007
Contract no: 18193/04/NL/AR
ESA name: Technical Assistance to Envisat Validation by LIDAR

# Table of Contents

## Summary

This is the 2006 annual report of the EQUAL project. This project supports and performs the quality assessment of ozone and temperature profiles retrieved from ENVISAT data using lidar data. Initially eleven and since 2006 in total thirteen lidar stations are part of the EQUAL network and they have submitted in HDF-format over 5600 profiles to the correlative database, which is maintained by NILU in Norway.

The availability of ENVISAT data suitable for validation has significantly improved in 2006. For MIPAS, we had level-2 data available in version 4.61/4.62 of the mission until March 2004. For SCIAMACHY, we had the ESA offline data product starting from November 2004, but no reprocessing of earlier level-2 data is available as this product will be revised. Newer data of SCIAMACHY (OL-v3.00) were generated by ESA concerning the validation reference data set and additionally for all new data since July 2006. We also received 'scientific' data of SCIAMACHY from IFE in Bremen. For GOMOS, we received the level-2 data from the complete mission reprocessing effort by ACRI-ST (GOPR v6.0cf). Preliminary data processed with ESA's prototype processor at ACRI were available using several different processor settings. The ESA offline data product is available since July 2006.

In 2006 we have furthermore focused on setting up a robust validation approach. For all three instruments we have generated lists of collocated measurements within 800-km radius and 20 hours time difference with a lidar observation. These lists are the basis of all validation activities. A tool has been developed to generate a HDF file from ENVISAT data, which contains one collocated profile. This tool is now operational for all involved ENVISAT products.

Validation of MIPAS data will lead to contributions in two joint validation papers which will be part of an ACP-journal special issue. The SCIAMACHY validation reference set has been extensively validated. Dedicated tools were developed enabling to estimate the remaining altitude shift in the SCIAMACHY data. A shift is still present and the data show a negative bias. Results were presented in Bremen during a dedicated workshop. In addition, we examined scientific retrievals of SCIAMACHY ozone profiles from IFE. These results revealed two different attitude problems; observed as an altitude shift compared to lidar profiles. GOMOS ozone profiles have extensively validated and an initial assessment has been made of the high-resolution temperature product. Results of all three instruments have been presented during the third dedicated atmospheric chemistry validation of ENVISAT (ACVE-3) workshop held from 4–7 December 2006 in Frascati, Italy. The proceedings papers of these contributions can be directly accessed via:

MIPAS ozone profile validation: 20061204-MIP09_ACVE-3-meijer1.pdf
MIPAS temperature profile validation: 20061204-MIP14_ACVE-3-ridolfi.pdf
GOMOS ozone profile validation: 20061205-GOM06_ACVE-3-meijer2.pdf
SCIAMACHY ozone profile validation: 20061207-SCIA32_ACVE-3-meijer3.pdf

MIPAS ozone profiles (IPF 4.61/4.62) show a good agreement with lidar data. In the altitude range 15–40 km the bias is within ±5%, and above and below this range the bias increases to 15–20%. In the tropical and mid-latitudinal regions MIPAS is slightly too high in the ozone peak. MIPAS temperature profiles show good agreement with lidar data indicating an altitude-dependent bias which is generally smaller than 1–2 K. GOMOS ozone profiles (GOPR 6.0cf and IPF 5.00) show an excellent agreement of with correlative observations. In the altitude range 15–50 km the bias is within ±5%, and with a precision smaller than about 15%. SCIAMACHY ozone profiles (IPF 3.00 and IFE 1.63) show a significant improvement over previous versions and are in reasonable agreement with lidar data. In the altitude range 18–38 km the negative bias varies between 10–20%.

# 1 Introduction

This is the annual report of the EQUAL project led by RIVM. The objective of this project is to ensure that adequate support is available to the Agency to assess and report on the product quality of ozone and temperature profiles retrieved from ENVISAT data. The project activities will ensure that sufficient expertise and resources are available to acquire and analyze collocated datasets and investigate discrepancies. This includes ensuring availability of adequate tools for data handling and analysis.

The two Work Packages (WPs) in this project involve lidar data submission to the NILU database and validation activities of ENVISAT data with these data. In section 2 the availability of lidar data is presented. The satellite instruments involved are GOMOS, MIPAS and SCIAMACHY, and in this project their results regarding ozone and temperature profiles are investigated. In section 3 the availability of the ENVISAT data is presented. In section 4 the analysis approach is outlined. In section 5 the validation activities performed in the year 2006 are described. An overview of the EQUAL activities and the project plan has also been presented on the internet and can be accessed at the following URL:

http://www.esa.int/esaLP/SEMPP23AR2E_LPcampaigns_0.html.

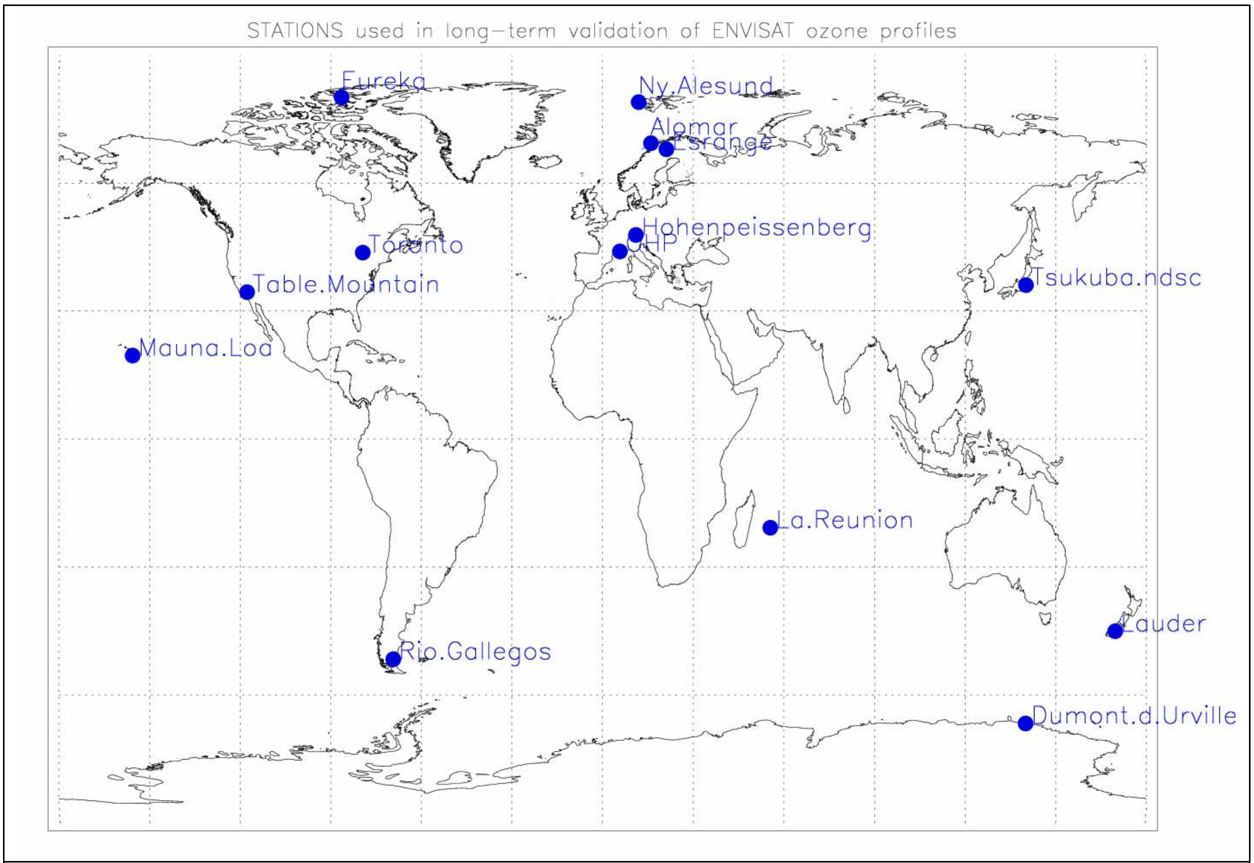


**Figure 1**. Station locations of all lidar instruments used in the EQUAL project.

# 2 LIDAR Data

## 2.1 Overview of Data Submission - Figures

The EQUAL network initially consisted of eleven lidar stations, but at the beginning of 2006 it has been extended with two more stations; one in Southern Argentina and one on the Antarctic (see **Figure 1** and **Table 1)**. The statistics of the lidar data that have been measured, processed, converted (to HDF) and submitted to the ENVISAT Cal/Val database (maintained by NILU) are shown in **Figure 2** for the ozone profiles and in **Figure 3** for the temperature profiles. Each figure presents per month the number of days with lidar measurements. Note that multiple profiles per day are counted as one in this representation. The first set of panels regard the ozone measurements, while the second part concerns the temperature measurements. In each panel title we have indicated with an acronym the station location (see **Table 1**) and the system name which corresponds to the filename in the NILU database (e.g., files with MSC003 in their name contain ozone profile information and MSC004 temperature profile information, and both for Eureka, Canada).

***Table 1. Overview of LIDAR systems: acronyms, locations and parameters***

| **Ground station** | **Acro** | **Lat.** | **Long.** | **Parameter** | **System name** |
|---|---|---|---|---|---|
| Eureka | EUR | 80.05 | –86.42 | Ozone, temperature | MSC003, MSC004 |
| Ny Ålesund | NYA | 78.92 | 11.93 | Ozone, temperature | AWI001, AWI002 |
| Alomar | ALO | 69.30 | 16.00 | Ozone, temperature | NILU001, NILU002 |
| Esrange | ESR | 67.88 | 21.10 | Temperature | UBONN003 |
| Hohenpeissenberg | HOH | 47.80 | 11.02 | Ozone, temperature | DWD001, DWD002 |
| Obs. Haute Provence | OHP | 43.94 | 5.71 | Ozone, temperature | CNRS.SA001, RMR_CNRS.SA001 |
| Toronto | TOR | 43.66 | –79.40 | Ozone | MSC001 |
| Tsukuba | TSU | 36.05 | 140.13 | Ozone, temperature | NIES001, NIES002 |
| Table Mountain | TMF | 34.40 | –117.70 | Ozone, temperature | NASA.JPL003 (was CNRS.SA003), NASA.JPL004 (was CNRS.SA002) |
| Mauna Loa | MLO | 19.54 | –155.58 | Ozone, temperature | NASA.JPL001 (was CNRS.SA004), NASA.JPL002 (was CNRS.SA005) |
| La Reunion | LAR | –20.80 | 55.50 | Ozone, temperature | LPA001, LPA002 |
| Lauder | LAU | –45.04 | 169.68 | Ozone, temperature | RIVM002, RIVM003[#] |
| Rio Gallegos | RGA | –51.6 | –69.3 | Ozone | CEILAP001 |
| Dumont d'Urville | DDU | –66.67 | 140.01 | Ozone, temperature | CNRS.SA007[#], RMR_CNRS.SA002[#] |

[#] Data of these systems should become available in the future, but currently they are unavailable.

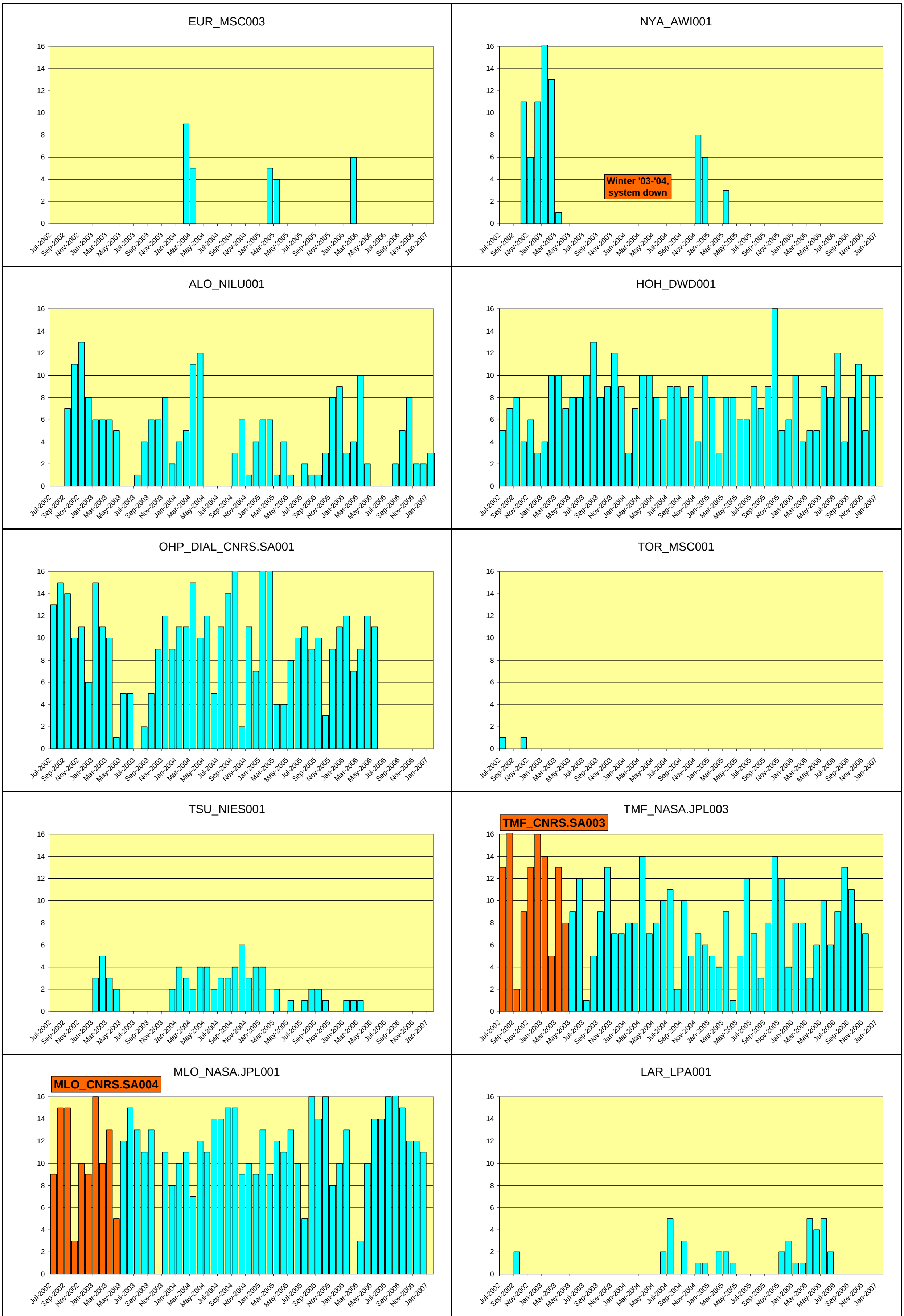


**Figure 2**. Statistics of available OZONE lidar data in the NILU database. Numbers indicate the number of days per month with lidar measurements. Note that the maximum range for the numbers is fixed to 16 and larger numbers are not displayed (see appropriate Tables in section 2.2 for these values).

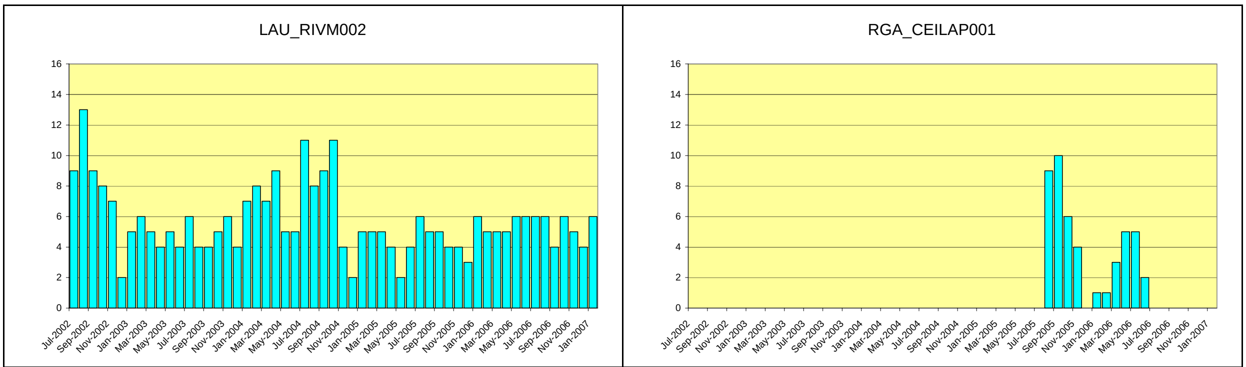


**Figure 2**. Cont.

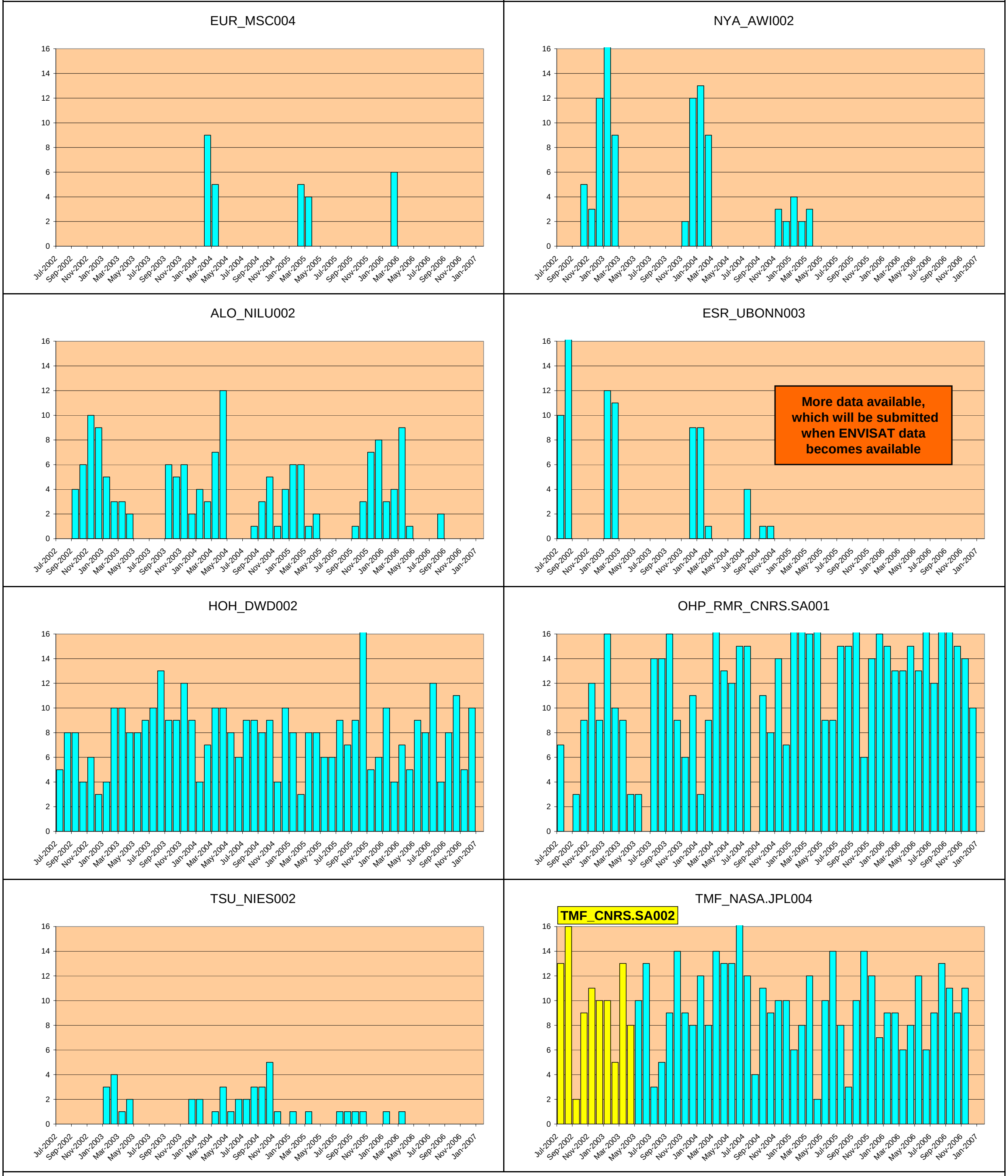


**Figure 3**. Statistics of available TEMPERATURE lidar data in the NILU database. Numbers indicate the number of days per month with lidar measurements. Note that the maximum range for the numbers is fixed to 16 and larger numbers are not displayed (see appropriate Tables in section 2.2 for these values).

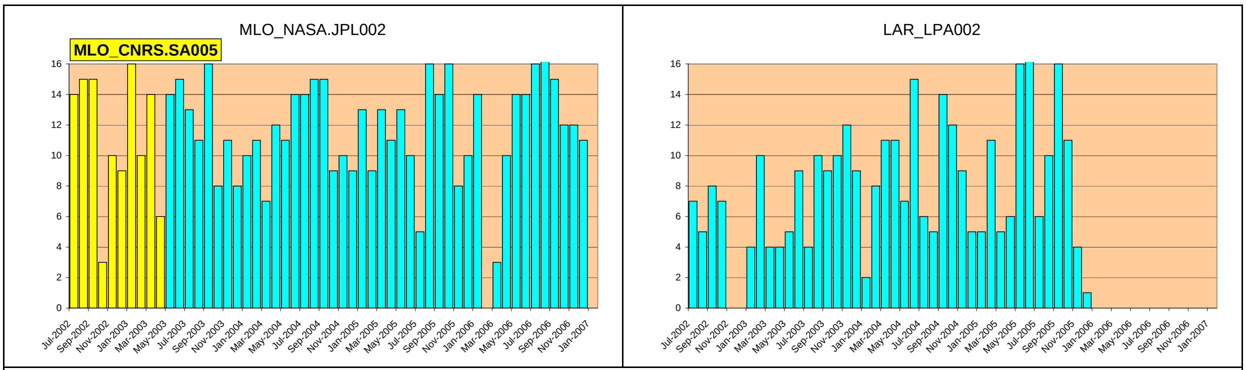


**Figure 3.** Cont.

## 2.2 Overview of Data Submission – Tables

In this section we give an overview of the lidar data submitted to the ENVISAT Cal/Val database at NILU in Table form. In **Table 2** we present the number of days (661) with measurements during the Commissioning Phase of ENVISAT, and most of these data have been submitted prior to the EQUAL project. In **Table 3** we present the statistics for the data measured in 2003. Although the EQUAL project formally started in January 2004, the project partners additionally contributed data of 2003 and hence filled the gap between the end of the Commissioning Phase and the start of the project, which is a bonus for the project and amounts in total an extra 1258 days with measurements. In **Table 4** we present the data measured in 2004, which come to a total of 1379 days. In **Table 5** we present the data measured in 2005, which come to a total of 1258 days with measurements. In **Table 6** we present the data measured in 2006, which now come to a total of 1049 days with measurements submitted to the database.

***Table 2. Data submission statistics, Commissioning Phase (2002)***
***(in gray temperature lidar systems)***

| Station | System | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|
| ALO | NILU001 | 0 | 0 | 7 | 11 | 13 | 8 | 39 |
| ALO | NILU002 | 0 | 0 | 4 | 6 | 10 | 9 | 29 |
| ESR | UBONN003 | 10 | 19 | 0 | 0 | 0 | 0 | 29 |
| HOH | DWD001 | 5 | 7 | 8 | 4 | 6 | 3 | 33 |
| HOH | DWD002 | 5 | 8 | 8 | 4 | 6 | 3 | 34 |
| LAR | LPA001 | 0 | 0 | 2 | 0 | 0 | 0 | 2 |
| LAR | LPA002 | 7 | 5 | 8 | 7 | 0 | 0 | 27 |
| LAU | RIVM002 | 9 | 13 | 9 | 8 | 7 | 2 | 48 |
| LAU | RIVM003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MLO | CNRS.SA004 | 9 | 15 | 15 | 3 | 10 | 9 | 61 |
| MLO | CNRS.SA005 | 14 | 15 | 15 | 3 | 10 | 9 | 66 |
| NYA | AWI001 | 0 | 0 | 0 | 11 | 6 | 11 | 28 |
| NYA | AWI002 | 0 | 0 | 0 | 5 | 3 | 12 | 20 |
| OHP | l_CNRS.SA001 | 13 | 15 | 14 | 10 | 11 | 6 | 69 |
| OHP | r_CNRS.SA001 | 7 | 0 | 3 | 9 | 12 | 9 | 40 |
| TMF | CNRS.SA003 | 13 | 16 | 2 | 9 | 11 | 10 | 61 |
| TMF | CNRS.SA002 | 13 | 17 | 2 | 9 | 13 | 16 | 70 |
| TOR | MSC001 | 2 | 0 | 1 | 2 | 0 | 0 | 5 |
| TOTAL all systems | | 107 | 130 | 98 | 101 | 118 | 107 | 661 |

| *Table 3. Data submission statistics, 2003 (in gray temperature lidar systems)* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station** | **System** | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **Jun.** | **Jul.** | **Aug.** | **Sept.** | **Oct.** | **Nov.** | **Dec.** | **Total** |
| ALO | NILU001 | 4 | 5 | 11 | 12 | 0 | 0 | 0 | 0 | 3 | 6 | 1 | 4 | 50 |
| ALO | NILU002 | 4 | 3 | 7 | 12 | 0 | 0 | 0 | 1 | 3 | 5 | 1 | 4 | 32 |
| ESR | UBONN003 | 9 | 1 | 0 | 0 | 0 | 0 | 4 | 0 | 1 | 1 | 0 | 0 | 32 |
| HOH | DWD001 | 3 | 7 | 10 | 10 | 8 | 6 | 9 | 9 | 8 | 9 | 4 | 10 | 108 |
| HOH | DWD002 | 4 | 7 | 10 | 10 | 8 | 6 | 9 | 9 | 8 | 9 | 4 | 10 | 111 |
| LAR | LPA001 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 0 | 3 | 0 | 1 | 1 | 0 |
| LAR | LPA002 | 2 | 8 | 11 | 11 | 7 | 15 | 6 | 5 | 14 | 12 | 9 | 5 | 90 |
| LAU | RIVM002 | 7 | 8 | 7 | 9 | 5 | 5 | 11 | 8 | 9 | 11 | 4 | 2 | 58 |
| LAU | RIVM003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MLO | CNRS.SA004 | 16 | 10 | 13 | 5 | End | - | - | - | - | - | - | - | 44 |
| MLO | NASA.JPL001 | - | - | - | Start | 12 | 15 | 13 | 11 | 13 | 0 | 11 | 8 | 83 |
| MLO | CNRS.SA005 | 16 | 10 | 14 | 5 | End | - | - | - | - | - | - | - | 45 |
| MLO | NASA.JPL002 | - | - | Start | 1 | 14 | 15 | 13 | 11 | 16 | 8 | 11 | 8 | 97 |
| NYA | AWI001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 6 | 35 |
| NYA | AWI002 | 13 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 41 |
| OHP | l_CNRS.SA001 | 11 | 11 | 15 | 10 | 12 | 5 | 11 | 14 | 17 | 2 | 11 | 7 | 84 |
| OHP | r_CNRS.SA001 | 3 | 9 | 17 | 13 | 12 | 15 | 15 | 0 | 11 | 8 | 14 | 7 | 111 |
| TMF | CNRS.SA003 | 10 | 5 | 13 | 7 | End | - | - | - | - | - | - | - | 35 |
| TMF | NASA.JPL003 | - | - | - | Start | 9 | 12 | 1 | 5 | 9 | 13 | 7 | 7 | 63 |
| TMF | CNRS.SA002 | 14 | 5 | 13 | 8 | End | - | - | - | - | - | - | - | 40 |
| TMF | NASA.JPL004 | - | - | Start | 1 | 10 | 13 | 3 | 5 | 9 | 14 | 9 | 8 | 72 |
| TSU | NIES001 | 3 | 5 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 15 |
| TSU | NIES002 | 3 | 4 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 12 |
| TOTAL all systems | | 172 | 138 | 115 | 65 | 79 | 90 | 75 | 92 | 110 | 97 | 114 | 111 | 1258 |

| Table 4. Data submission statistics, 2004 (in gray temperature lidar systems) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station** | **System** | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **Jun.** | **Jul.** | **Aug.** | **Sept.** | **Oct.** | **Nov.** | **Dec.** | **Total** |
| ALO | NILU001 | 4 | 5 | 11 | 12 | 0 | 0 | 0 | 0 | 3 | 6 | 1 | 4 | 46 |
| ALO | NILU002 | 4 | 3 | 7 | 12 | 0 | 0 | 0 | 1 | 3 | 5 | 1 | 4 | 40 |
| ESR | UBONN003 | 9 | 1 | 0 | 0 | 0 | 0 | 4 | 0 | 1 | 1 | 0 | 0 | 16 |
| EUR | MSC003 | 0 | 9 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 |
| EUR | MSC004 | 0 | 9 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 |
| HOH | DWD001 | 3 | 7 | 10 | 10 | 8 | 6 | 9 | 9 | 8 | 9 | 4 | 10 | 93 |
| HOH | DWD002 | 4 | 7 | 10 | 10 | 8 | 6 | 9 | 9 | 8 | 9 | 4 | 10 | 94 |
| LAR | LPA001 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 0 | 3 | 0 | 1 | 1 | 12 |
| LAR | LPA002 | 2 | 8 | 11 | 11 | 7 | 15 | 6 | 5 | 14 | 12 | 9 | 5 | 105 |
| LAU | RIVM002 | 7 | 8 | 7 | 9 | 5 | 5 | 11 | 8 | 9 | 11 | 4 | 2 | 86 |
| LAU | RIVM003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MLO | NASA.JPL001 | 10 | 11 | 7 | 12 | 11 | 14 | 14 | 15 | 15 | 9 | 10 | 9 | 137 |
| MLO | NASA.JPL002 | 10 | 11 | 7 | 12 | 11 | 14 | 14 | 15 | 15 | 9 | 10 | 9 | 137 |
| NYA | AWI001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 6 | 14 |
| NYA | AWI002 | 13 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 27 |
| OHP | l_CNRS.SA001 | 11 | 11 | 15 | 10 | 12 | 5 | 11 | 14 | 17 | 2 | 11 | 7 | 126 |
| OHP | r_CNRS.SA001 | 3 | 9 | 17 | 13 | 12 | 15 | 15 | 0 | 11 | 8 | 14 | 7 | 124 |
| TMF | NASA.JPL003 | 8 | 8 | 14 | 7 | 8 | 10 | 11 | 2 | 10 | 5 | 7 | 6 | 96 |
| TMF | NASA.JPL004 | 12 | 8 | 14 | 13 | 13 | 17 | 12 | 4 | 11 | 9 | 10 | 10 | 133 |
| TSU | NIES001 | 4 | 3 | 2 | 4 | 4 | 2 | 3 | 3 | 4 | 6 | 3 | 4 | 42 |
| TSU | NIES002 | 2 | 0 | 1 | 3 | 1 | 2 | 2 | 3 | 3 | 5 | 1 | 0 | 23 |
| TOTAL all systems | | 106 | 127 | 143 | 138 | 100 | 113 | 126 | 88 | 135 | 106 | 101 | 96 | 1379 |

| *Table 5. Data submission statistics, 2005 (in gray temperature lidar systems)* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station** | **System** | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **Jun.** | **Jul.** | **Aug.** | **Sept.** | **Oct.** | **Nov.** | **Dec.** | **Total** |
| ALO | NILU001 | 6 | 6 | 1 | 4 | 1 | 0 | 2 | 1 | 1 | 3 | 8 | 9 | 42 |
| ALO | NILU002 | 6 | 6 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 8 | 34 |
| DDU | l_CNRS_SAx?x | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DDU | r_CNRS_SAx?x | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ESR | UBONN003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| EUR | MSC003 | 0 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| EUR | MSC004 | 0 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| HOH | DWD001 | 8 | 3 | 8 | 8 | 6 | 6 | 9 | 7 | 9 | 16 | 5 | 6 | 91 |
| HOH | DWD002 | 8 | 3 | 8 | 8 | 6 | 6 | 9 | 7 | 9 | 17 | 5 | 6 | 92 |
| LAR | LPA001 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 10 |
| LAR | LPA002 | 5 | 11 | 5 | 6 | 16 | 17 | 6 | 10 | 16 | 11 | 4 | 1 | 108 |
| LAU | RIVM002 | 5 | 5 | 5 | 4 | 2 | 4 | 6 | 5 | 5 | 4 | 4 | 3 | 52 |
| LAU | RIVM003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MLO | NASA.JPL001 | 13 | 9 | 12 | 11 | 13 | 10 | 5 | 16 | 14 | 16 | 8 | 10 | 137 |
| MLO | NASA.JPL002 | 13 | 9 | 13 | 11 | 13 | 10 | 5 | 16 | 14 | 16 | 8 | 10 | 138 |
| NYA | AWI001 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| NYA | AWI002 | 4 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| OHP | l_CNRS.SA001 | 17 | 17 | 4 | 4 | 8 | 10 | 11 | 9 | 10 | 3 | 9 | 11 | 113 |
| OHP | r_CNRS.SA001 | 18 | 18 | 16 | 17 | 9 | 9 | 15 | 15 | 20 | 6 | 14 | 16 | 173 |
| RGA | CEILAP001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 10 | 6 | 4 | 0 | 29 |
| TMF | NASA.JPL003 | 5 | 4 | 9 | 1 | 5 | 12 | 7 | 3 | 8 | 14 | 12 | 4 | 84 |
| TMF | NASA.JPL004 | 6 | 8 | 12 | 2 | 10 | 14 | 8 | 3 | 10 | 14 | 12 | 7 | 106 |
| TSU | NIES001 | 4 | 0 | 2 | 0 | 1 | 0 | 1 | 2 | 2 | 1 | 0 | 0 | 13 |
| TSU | NIES002 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 6 |
| TOTAL all systems | | 119 | 113 | 113 | 79 | 90 | 98 | 85 | 104 | 130 | 131 | 102 | 94 | 1258 |

| *Table 6. Data submission statistics, 2006 (in gray temperature lidar systems)* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station** | **System** | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **Jun.** | **Jul.** | **Aug.** | **Sept.** | **Oct.** | **Nov.** | **Dec.** | **Total** |
| ALO | NILU001 | 3 | 4 | 10 | 2 | 0 | 0 | 0 | 2 | 5 | 8 | 2 | 2 | 38 |
| ALO | NILU002 | 3 | 4 | 9 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 19 |
| DDU | l_CNRS_SAx?x | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DDU | r_CNRS_SAx?x | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ESR | UBONN003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| EUR | MSC003 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| EUR | MSC004 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| HOH | DWD001 | 10 | 4 | 5 | 5 | 9 | 8 | 12 | 4 | 8 | 11 | 5 | 10 | 91 |
| HOH | DWD002 | 10 | 4 | 7 | 5 | 9 | 8 | 12 | 4 | 8 | 11 | 5 | 10 | 93 |
| LAR | LPA001 | 1 | 1 | 5 | 4 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 18 |
| LAR | LPA002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LAU | RIVM002 | 6 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 4 | 6 | 5 | 4 | 64 |
| LAU | RIVM003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MLO | NASA.JPL001 | 13 | 0 | 3 | 10 | 14 | 14 | 16 | 18 | 15 | 12 | 12 | 11 | 138 |
| MLO | NASA.JPL002 | 14 | 0 | 3 | 10 | 14 | 14 | 16 | 18 | 15 | 12 | 12 | 11 | 139 |
| NYA | AWI001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NYA | AWI002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OHP | l_CNRS.SA001 | 12 | 7 | 9 | 12 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 |
| OHP | r_CNRS.SA001 | 15 | 13 | 13 | 15 | 13 | 17 | 12 | 18 | 17 | 15 | 14 | 10 | 172 |
| RGA | CEILAP001 | 1 | 1 | 3 | 5 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 17 |
| TMF | NASA.JPL003 | 8 | 8 | 3 | 6 | 10 | 6 | 9 | 13 | 11 | 8 | 7 | 0 | 89 |
| TMF | NASA.JPL004 | 9 | 9 | 6 | 8 | 12 | 6 | 9 | 13 | 11 | 9 | 11 | 0 | 103 |
| TSU | NIES001 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| TSU | NIES002 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| TOTAL all systems | | 107 | 73 | 83 | 88 | 108 | 83 | 92 | 98 | 94 | 92 | 73 | 58 | 1049 |

# 3 ENVISAT data

In this section we give an overview of the available ENVISAT data (level 2) for the EQUAL project during 2006 (see **Table 7a, 7b, and 7c**). Note that data might have been (temporarily) available but not acquired within the EQUAL project. These tables serve as a rough indication and they are not a precise representation of actual data availability.

*Table 7a. Available ENVISAT Data from IPF Processor*

**Legend:** …… = potential data, …… = available data, …… = available data at end of 2006.

| **Instrument** | **2002** | **2003** | **2004** | **2005** | **2006** |
|---|---|---|---|---|---|
| GOMOS | ………. | …………… | …………… | …………… | …………… |
| MIPAS | ………. | …………… | …………… | RR-mode.. .. .. | …………… |
| SCIAMACHY | ………. | …………… | …………… | …………… | …………… |

*Table 7b. Available ENVISAT Data from Prototype Processor*

| **Instrument** | **2002** | **2003** | **2004** | **2005** | **2006** |
|---|---|---|---|---|---|
| GOMOS | ………. | …………… | …………… | …………… | …………… |
| MIPAS | ………. | …………… | …………… | RR-mode.. .... | …………… |
| SCIAMACHY | ………. | …………… | …………… | …………… | …………… |

*Table 7c. Available ENVISAT Data from Scientific Institutes*

| **Instrument** | **2002** | **2003** | **2004** | **2005** | **2006** |
|---|---|---|---|---|---|
| GOMOS* | ………. | …………… | …………… | …………… | …………… |
| MIPAS | ………. | …………… | …………… | RR-mode.. .... | …………… |
| SCIAMACHY | ………. | …………… | …………… | …………… | …………… |

* As enough GOMOS data are available through the nominal ESA processing chain, we only obtained access to a 'scientific' data set of the high-resolution temperature product (HRTP).

## 3.1 GOMOS Data

The prototype processor of ESA at ACRI has been used to reprocess GOMOS data from the start of the mission until July 2006 (GOPR_lv2_6.0cf). In addition, GOMOS data are available by FTP at D-PAC, Germany since July 2006 with 1–2 months backlog. These data have been processed with the operational ESA processor version 5.00 (OL-v5.00).

The prototype processor has also been used to generate several small data sets in order to verify certain settings on the retrieval outcome. In 2006 there was one new processing (GOPR_lv2_6.0dh) using this processor on the GOMOS validation reference set. The high-resolution temperature product (HRTP) of GOMOS is available in the operational product, but the quality of this product is still insufficient. Therefore we have also obtained preliminary data from a project led by FMI for improving the HRTP. The processing has been done on a reduced set of the validation reference set. The reduction is a result of stricter collocation criteria, which are required for temperature profile validation.

## 3.2 MIPAS Data

The data from the operational ESA processor have been made available though the D-PAC ftp-site. These data are from MIPAS measurements using the full resolution mode and were processed either with version IPF 4.61 or IPF 4.62. Data are available up to March 2004 when the instrument encountered an anomaly and has no longer measured in full resolution mode.

MIPAS resumed its operations in January 2005. The measurement strategy has been altered to a reduced resolution mode (RR-mode) and as a consequence also the data processing requires an upgrade dealing with this new data. This upgrade has been implemented at the end 2006 and will be used on the MIPAS validation reference set. Level-2 data will become available early 2007 for initial validation studies.

## 3.3 SCIAMACHY Data

The data from the operational ESA processor are available through the D-PAC ftp-site. These data cover observations since November 2004 in offline version OL-v2.5. The processor has been upgraded in July 2006, and since then data are available in version OL-3.0. This latter version has also been used to process the SCIAMACHY validation reference set. A major reprocessing effort is pending as initial validation studies should reveal the expected quality of the upgraded processor.

Temperature profiles in the files are climatological values and they are not retrieved. Originally it was foreseen to retrieve temperature information from the infrared channels, but these measurements suffer from ice on the detectors, which makes it impossible to retrieve temperature. The current status for alternative algorithms using measurements from the other channels is unclear for the operational processor.

In addition, we have contacted the IFE group in Bremen (Germany) for non-operational products (C. von Savigny). These products concern ozone profiles retrieved from limb data using the level-1 data of the validation reference set.

# 4 Validation Approach

## 4.1 Introduction

The validation approach used in this project has been outlined in 'EQUAL Annual Report 2004' [Meijer and Swart, 2005], which as a final preparation result provides lists containing direct pointers to two collocated profiles (i.e., filenames and other directional information). The validation approach and target level-2 data quality have also been mentioned in 'EQUAL Annual Report 2004' [Meijer and Swart, 2006]. In this section we only provide an update on the status per instrument and the developed software.

## 4.2 Status per Instrument

For GOMOS data coincident with the measurements of the lidar stations in the EQUAL network, the overpass tables and collocation lists have been generated for the complete period between July 2002 and December 2006. The lists are based on available reprocessed and operational GOMOS data. In order to support the algorithm development of the high-resolution temperature product, we have generated special lists focusing on some near-perfect collocated observations. We have generated HDF files of GOMOS data in collocation with ground-based stations. Each of these files contains one profile with all relevant additional information required for validation studies.

For MIPAS data coincident with the measurements of the lidar stations in the EQUAL network, the overpass tables and collocation lists have been generated for the period between July 2002 and April 2004. These lists have been generated using available (and downloaded) MIPAS data that were successfully converted to HDF files. In these files we have added ECMWF collocated pressure, temperature and geometric altitude information with the support of KNMI using their TOSTI software (Tool for Orbital Spatial and Temporal Interpolation by Arjo Segers, http://www.knmi.nl/~segers/tosti/html/tosti.html).

For SCIAMACHY data coincident with the measurements of the lidar stations in the EQUAL network, the overpass tables and collocation lists have been generated for the complete period between July 2002 and December 2005. We have anticipated receiving data from both the nadir and limb observations of SCIAMACHY. The lists are based on planned measurements available on the SOST website and they do not take into account instrument unavailability. Lists have also been generated based on the available (OL_2P) SCIAMACHY data covering the period after November 2004. Available profiles data have also been converted to HDF files containing one profile with all relevant additional information required for validation studies. Special attention has been put to secure unique file naming for each of the potential 4 profiles per limb measurement state and for different data sources (operational (ESA) and scientific (e.g., IFE)).

## 4.3 Software Development

The validation software has been extended and can generate overpass tables and collocation lists for any list of ground-based stations and is suitable for balloon ozone sonde, lidar and microwave radiometer data from the NILU database. Software has been used to supply other validation scientists with overpass tables and collocation lists (e.g., for sites like L'Aquila, Potenza, OHP) relating to ENVISAT validation studies. The software can also deal with both mission planning information and performed/available ENVISAT data.

In 2006 we have also focused on a better, more robust methodology for estimating the remaining altitude shift. Both MIPAS and SCIAMACHY suffer from inaccurate attitude information of the satellite platform resulting in an altitude shift of the limb profile data. A software tool based on correlation has been developed for an objective estimation of this shift. Both this tool and other validation software can analyze any sub set of the data including per station/instrument analysis.

# 5 Validation Activities and Publications

This section describes per instrument the validation activities performed during the year 2006 using lidar data of one of the EQUAL partners. A large number of proceeding contributions result from two major conferences, initially from 8–12 May the First conference on Atmospheric Science (ATMOS, link to website) [Meijer et al., 2006a; Ridolfi et al., 2006; Stebel et al., 2006b] and later from 4–7 December the Third Workshop on Atmospheric Chemistry and Validation of ENVISAT (ACVE-3, link to website) [Meijer et al., 2006b; Meijer et al., 2006c; Meijer et al., 2006d; Snoeij et al., 2006; Stebel et al., 2006a] were held in Frascati, Italy. The EQUAL project leader has also been asked to present his work in the SPIE online newsroom [Meijer, 2006].

There has also been a number of publications, resulting from lidar data partially measured and funded through the EQUAL project, which are of a more scientific nature. During the EGU general assembly in Vienna, 2–7 April 2006, we contributed to two proceeding papers presented at an oral session [Kyrölä et al., 2006; Steinbrecht et al., 2006a]. The long-term ozone trend analyses by Steinbrecht et al. has also been published in the Journal of Geophysical Research [Steinbrecht et al., 2006b] and led to a press release by *Rijksimstituut voor Volksgezondheid en Milieu* [RIVM, 2006] which was picked up by several Dutch national and regional news papers and web sites.

## 5.1 GOMOS Ozone and Temperature Profile Validation

The availability of the complete mission data set of GOMOS led to an intensive validation activity analyzing these data. Initial results were presented during the Quality Working Group (QWG) meeting #10 from 8–9 February 2006. More in-depth analysis results were presented during the ATMOS and ACVE-3 conferences at ESRIN, Frascati [Meijer et al., 2006a; Meijer et al., 2006b]. During both conferences we have contributed to the general discussion and provided recommendations for product improvements and usability. Currently the validation results show an excellent agreement of GOMOS (GOPR 6.0cf and IPF 5.00) with correlative observations. In the altitude range 15–50 km the bias is within ±5%, and with a precision smaller than about 15%.

The validation of the high-resolution temperature profile of GOMOS was performed in a joint contribution of the EQUAL and Norwegian Prodex project led by NILU. The results were presented during the ATMOS and ACVE-3 conferences [Stebel et al., 2006a; Stebel et al., 2006b]. Although the HRTP has significantly improved, the quality and reliability of this product is still insufficient for scientific use, and we recommend further improvements.

## 5.2 MIPAS Ozone and Temperature Profile Validation

Significant amount of work has gone in the comparison of MIPAS ozone and temperature profiles for the joint validation papers that will be part of a special issue of the Atmospheric Chemistry and Physics (ACP) online journal. Preliminary results were also presented during the ATMOS and ACVE-3 conferences [Meijer et al., 2006a; Meijer et al., 2006c; Ridolfi et al., 2007a; Ridolfi et al., 2006]. The results of MIPAS ozone validation were also presented by *Cortesi et al.* during the ATMOS conference but did not lead to a proceeding paper. The lidar data measured at the Esrange station have been used in more dedicated temperature profile validation and altitude registration study of MIPAS data. Results are now being finalized and combined in two separate joint papers which will be submitted to ACP in 2007 [Cortesi et al., 2007; Ridolfi et al., 2007b].

The ozone profile validation results show a good agreement of MIPAS (IPF 4.61/4.62) with lidar. In the altitude range 15–40 km the bias is within ±5%, and above and below this range the bias increases to 15–20%. In the tropical and mid-latitudinal regions MIPAS is slightly too high in the ozone peak. The results of the comparison with MIPAS temperature profiles indicate an altitude-dependent bias which is generally smaller than 1–2 K, consistent with the specified MIPAS systematic error component.

## 5.3 SCIAMACHY Ozone and Temperature Profile Validation

Validation of SCIAMACHY ozone profiles has been quite extensive. In January the ACPD paper of [Brinksma et al., 2005] was published in ACP [Brinksma et al., 2006]. In the comparison we show summary analysis results for lidar compared with SCIAMACHY IPF 2.5 and IFE (Bremen) 1.62 data. A complete overview of these results and other findings are published in a RIVM report by [Lolkema et al., 2007]. We have also contributed to the final report of the NIVR project for SCIAMACHY validation led by KNMI [Piters et al., 2006].

The prototype and operational processor have been upgraded to IPF version 3.00. This algorithm has been used for the validation reference set. The quality of the level-2 data has significantly improved compared to previous versions. Currently SCIAMACHY ozone profiles from the validation reference data set (IPF version 3.00) show a reasonable agreement with lidar, sonde and microwave data. There is a negative bias of 5–20% in the altitude range 18–38 km with the smaller values in the range 25–35 km. At 40-km altitude there is a 25% negative bias in the SCIAMACHY profiles. Comparisons in the altitude range 18–38 km show that the precision of SCIAMACHY is better than 10–15%. In the Polar Regions the SCIAMACHY ozone profiles show a larger negative bias above the ozone peak. In general for all regions, the high ozone concentrations in the ozone peak and the profile just below the peak are underestimated by about 10–20%. The validation results do not indicate a clear dependence of the derived bias on solar zenith angle and validation instrument. The data retrieved using the IFE 1.63 algorithm show similar validation results and are consistent with IPF 3.00.

Despite the decrease in the magnitude of the altitude shift, there is still a remaining altitude shift of the order of 800 m [Meijer et al., 2006d; van Gijsel and Meijer, 2006]. There has been a prompt response by ESA to this issue which has received much attention in the second half of 2006. The investigations yielded some promising results toward resolving the problem to within the pre-launch attitude specifications.

# 6 Conclusions

The aim of this project is to assess the quality of ENVISAT’s ozone and temperature profiles with lidar data, and check for possible dependencies on certain parameters. One of the main objectives is to make lidar ozone and temperature profiles available for validation activities. Currently over 5600 profiles are stored in HDF-format in the correlative database at NILU. These profiles are quite evenly spread over the period July 2002 until the end of 2006, and cover several different global regions.

From data of the planned measurements for GOMOS, MIPAS and SCIAMACHY coincidences have been derived with the lidar stations and from the currently available lidar data we have derived listings of collocated measurements. Compared to 2005 there is a significant improvement in the ENVISAT data availability, which resulted in several assessment studies and algorithm development support.

The current status of the validation activities is that an extensive analysis of ENVISAT data has been performed for GOMOS ozone, MIPAS ozone and MIPAS temperature profiles. The GOMOS HRTP and SCIAMACHY ozone profiles have been validated on a limited data set and their data still require further improvement before an extended processing and analysis are feasible. A complete overview of the validation status of each instrument is provided in **Table 8**. Furthermore, we have included in **Appendix 1** the main analysis results per satellite instrument compared to EQUAL lidar data.

In 2007 we will focus on the new products coming from the MIPAS measurements in RR mode and for SCIAMACHY from processor upgrades. For both data sets this should support decisions on the final processing settings for a potential mission reprocessing effort.

***Table 8a. Validation status of ENVISAT Data from IPF Processor***

**Legend:** …... = complete assessment, …... = initial assessment, …... = no assessment.

| **Instrument** | **Ozone version** | **Temperature version** |
|---|---|---|
| GOMOS | GOPR 6.0cf, several intermediate, IPF 5.0 | HRTP from GOPR 6.0cf |
| MIPAS | IPF 4.61/4.62 | IPF 4.61/4.62 |
| SCIAMACHY | IPF 2.5, IPF 2.8, IPF 3.0 | not applicable |

***Table 8b. Validation status of ENVISAT Data from ‘Scientific’ Processing***

**Legend:** …... = complete assessment, …... = initial assessment, …... = no assessment.

| **Instrument** | **Ozone version** | **Temperature version** |
|---|---|---|
| GOMOS | Only from prototype | HRTP from FMI |
| MIPAS | None | None |
| SCIAMACHY | IFE 1.62, IFE 1.63 | Not applicable |

# 7 References


Brinksma, E.J. et al., 2005. Geophysical Validation of SCIAMACHY Limb Ozone Profiles, Atmospheric Chemistry and Physics Discussions. Copernicus, pp. 4893-4928.

Brinksma, E.J. et al., 2006. Geophysical Validation of SCIAMACHY Limb Ozone Profiles, Atmospheric Chemistry and Physics. Copernicus, pp. 197-209.

Cortesi, U. et al., 2007. Geophysical validation of MIPAS-ENVISAT operational ozone data, Atmospheric Chemistry and Physics Discussions.

Kyrölä, E. et al., 2006. GOMOS/ENVISAT overview, European Geosciences Union 2006. Geophysical Research Abstracts, Vienna, Austria, pp. 6507.

Lolkema, D.E., Meijer, Y.J. and Swart, D.P.J., 2007. Validation of SCIAMACHY limb ozone profiles with lidar. 722611 004, RIVM, Bilthoven, The Netherlands.

Meijer, Y.J., 2006. Satellite ozone profiles checked using ground-based laser radars. SPIE Newsroom: pp. 3.

Meijer, Y.J. et al., 2006a. Long-term validation of GOMOS, MIPAS and SCIAMACHY ozone and temperature profiles by the ENVISAT quality assessment with lidar (EQUAL) project, First Atmospheric Science Conference. ESA SP-628. European Space Agency, ESRIN, Frascati, Italy, pp. 6.

Meijer, Y.J. et al., 2006b. Pole-to-pole validation of GOMOS ozone profiles by the Envisat Quality Assessment with Lidar (EQUAL) project, Third workshop on Atmospheric Chemistry Validation of ENVISAT (ACVE-3). ESA SP-642. European Space Agency, ESRIN, Frascati, Italy, pp. 11.

Meijer, Y.J. et al., 2006c. Pole-to-pole validation of MIPAS ozone profiles by the Envisat Quality Assessment with Lidar (EQUAL) project, Third workshop on Atmospheric Chemistry Validation of ENVISAT (ACVE-3). ESA SP-642. European Space Agency, ESRIN, Frascati, Italy, pp. 7.

Meijer, Y.J. et al., 2006d. Pole-to-pole validation of SCIAMACHY ozone profiles by the Envisat Quality Assessment with Lidar (EQUAL) project, Third workshop on Atmospheric Chemistry Validation of ENVISAT (ACVE-3). ESA SP-642. European Space Agency, ESRIN, Frascati, Italy, pp. 9.

Meijer, Y.J. and Swart, D.P.J., 2005. Envisat Quality Assessment with Lidar: Annual report 2004, RIVM, Bilthoven.

Meijer, Y.J. and Swart, D.P.J., 2006. Envisat Quality Assessment with Lidar: Annual report 2005, RIVM, Bilthoven.

Piters, A.J.M. et al., 2006. SCIAMACHY validation 2003-2005 -- Dutch contribution -- Annual Report 2005, KNMI, De Bilt.

Ridolfi, M. et al., 2007a. Geophysical validation of MIPAS/ENVISAT temperature, International Union of Geodesy and Geophysics (IUGG), Perugia, Italy.

Ridolfi, M. et al., 2006. Geophysical validation of temperature retrieved by the ESA level 2 processor from MIPAS/Envisat measurements, First Atmospheric Science Conference. ESA SP-628. European Space Agency, ESRIN, Frascati, Italy, pp. 6.

Ridolfi, M. et al., 2007b. Geophysical validation of temperature retrieved by the ESA processor from MIPAS/ENVISAT atmospheric limb-emission measurements, Atmospheric Chemistry and Physics Discussions. Copernicus.

RIVM, 2006. Ozonlaag herstelt, Press release, Bilthoven, pp. 1.

Snoeij, P. et al., 2006. Summary of the atmospheric chemistry instrument validation results as presented at the ACVE-3 workshop, Third workshop on Atmospheric Chemistry Validation of ENVISAT (ACVE-3). ESA SP-642. European Space Agency, ESRIN, Frascati, Italy, pp. 10.

Stebel, K. et al., 2006a. Comparison of GOMOS high-resolution temperature profiles (HRTP) with data from selected EQUAL lidar and radiosonde sites, Third workshop on Atmospheric Chemistry Validation of ENVISAT (ACVE-3). ESA SP-642. European Space Agency, ESRIN, Frascati, Italy, pp. 9.

Stebel, K. et al., 2006b. Validation of the GOMOS high-resolution temperature product (HRTP) using lidar, First Atmospheric Science Conference. ESA SP-628. European Space Agency, ESRIN, Frascati, Italy, pp. 6.

Steinbrecht, W. et al., 2006a. Is upper stratospheric ozone beginning to turn around? European Geosciences Union 2006. Geophysical Research Abstracts, Vienna, Austria, pp. 6366.

Steinbrecht, W. et al., 2006b. Long-term evolution of upper stratospheric ozone at selected stations of the Network for the Detection of Stratospheric Change (NDSC). Journal of Geophysical Research, 111(D10308).

van Gijsel, J.A.E. and Meijer, Y.J., 2006. Remaining Altitude Shift in SCIAMACHY Data (technical note to SCIAVALIG and SCIA-qwg), RIVM, Bilthoven.

# Appendix 1 Overview of Main Validation Results

In this section we present the main analysis results for each instrument and species. In **Figure 4** we show the comparison results of GOMOS ozone profiles (GOPR 6.0cf) compared to lidar observations for the period July 2002 until July 2006. In the top panels we have applied the selection criteria provided in the disclaimer. For the analyses presented in the bottom panels we have used slightly different, more relaxed, selection criteria which include much more data observed under so-called straylight conditions. The overall conclusion is that GOMOS ozone profile show an excellent agreement with lidar data. The bias is within 5% between 15–45 km altitude.

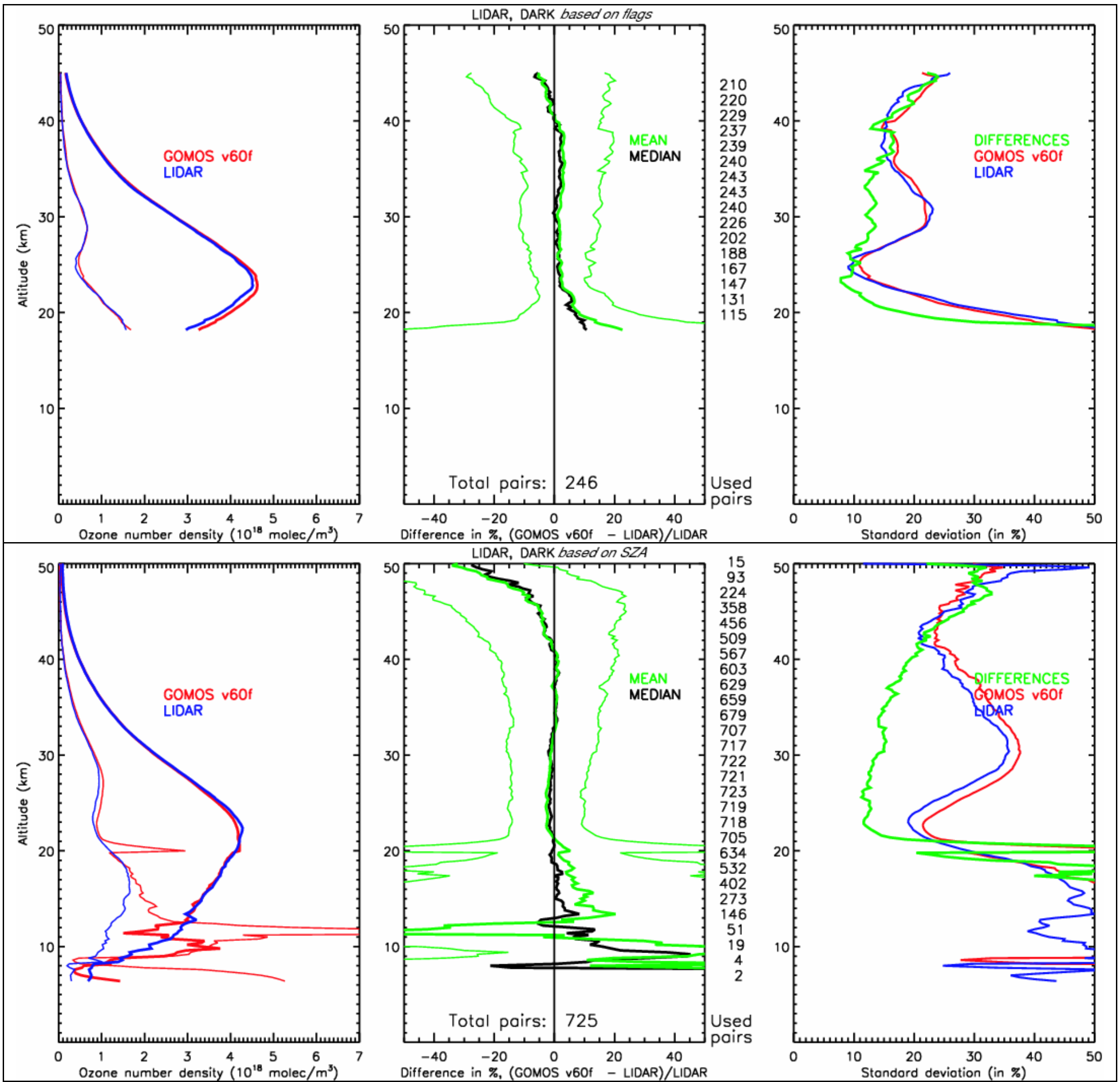


**Figure 4.** Intercomparison results of all accepted GOMOS and paired LIDAR correlative data. (left) Mean GOMOS (bold red line) and LIDAR (bold blue line) ozone profiles and their standard deviations (thin lines in corresponding colors). (middle) Mean (bold green line) and median (black line) differences between all the paired GOMOS and LIDAR data as a percentage of the latter. For the mean profile, we also plotted the (1σ) standard deviation of the differences (thin green line). Numbers at the right of the middle panel indicate, for some altitude levels, the number of pairs used at that level. (right) A comparison between the standard deviation of the differences (green line) and the standard deviation of all GOMOS (red line) and LIDAR (blue line) ozone profiles.

Upper panels show results for GOMOS using the selection criteria as currently provided in the disclaimer. Bottom panels show results which use a selection procedure only based on solar zenith angle (SZA) and hence also including measurements in which GOMOS observes with straylight conditions.

In **Figure 5** we show MIPAS (v4.61 and v4.62) validation results when compared to lidar measurements. The top panels show the results of the ozone profile comparison and the bottom panels the results of the temperature profile comparison. Collocation criteria were 400 km and 10 hours for the allowed maximum spatial and temporal differences, respectively. The ozone profiles show a good agreement with lidar data, and the bias (slightly positive) is generally within 10% between 12–45 km altitude. The temperature profiles also show a good agreement with lidar data, and the bias is slightly positive (+1 K) at lower altitudes (15–42 km) and slightly negative (–2 K) at higher altitudes (42–68 km).

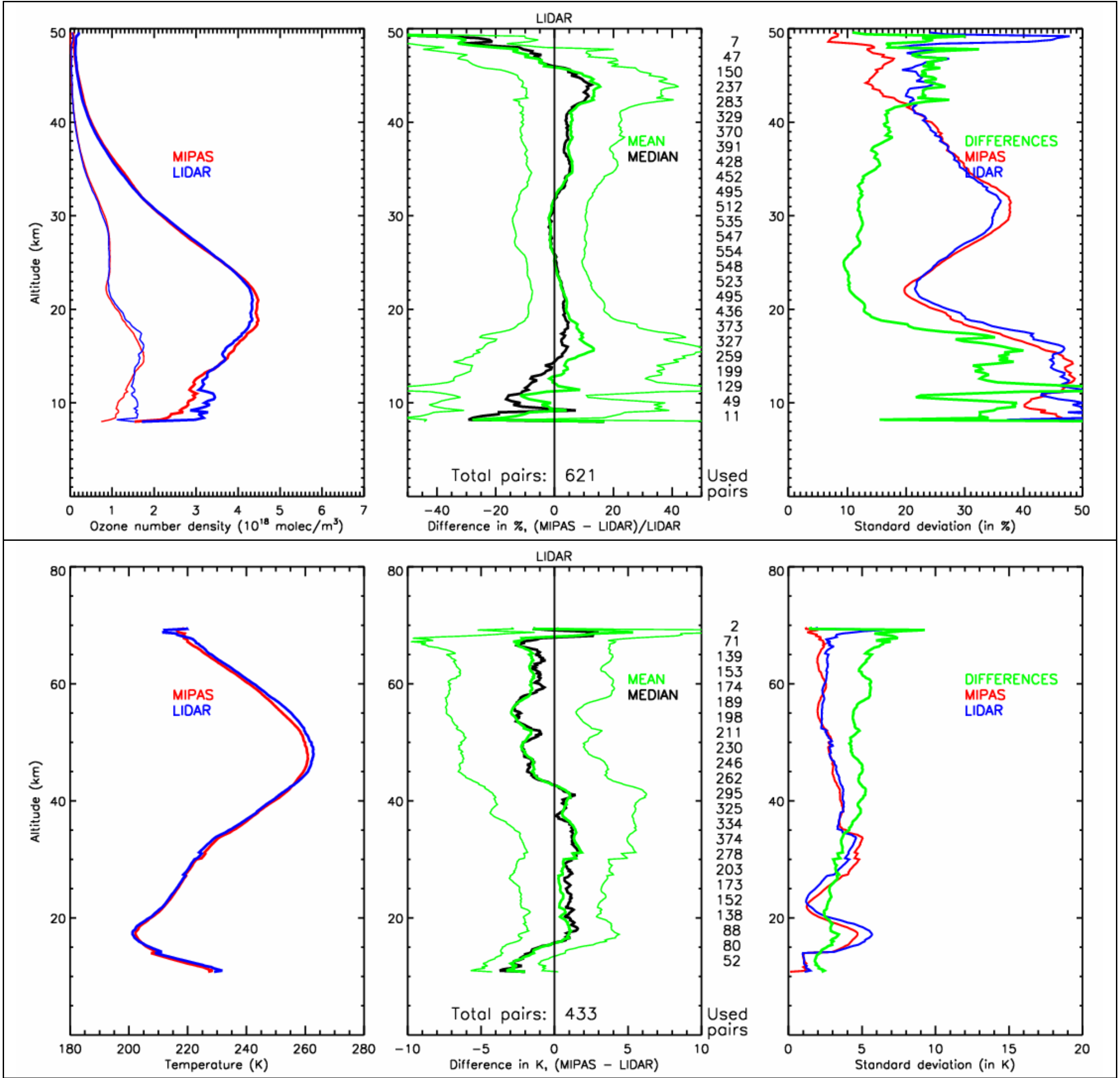


**Figure 5.** Same as Figure 4, but now showing results of (top) MIPAS ozone profiles and (bottom) MIPAS temperature profiles compared to lidar data. Note that the scale used for the temperature comparison is absolute rather then relative (middle and right bottom panels), and that the altitude range is more extended. The altitude information for the MIPAS profiles has been obtained by transferring MIPAS pressure data to geometric altitude using ECMWF data interpolated to the position of the MIPAS profile.

In **Figure 6** we show validation results of SCIAMACHY ozone profiles from the validation reference set compared to lidar data. In the top panels profiles are used which were retrieved using IPF 3.00. In the bottom panels we have used data provided by IFE (Bremen) from their scientific retrieval scheme IFE 1.63. One of the differences between these two algorithms is that IFE retrieves all four profiles available in one limb scan, hence one of the reasons for the larger number of collocated observations. In the altitude range 18–38 km the bias is negative and varies in magnitude from 5–20%. The precision is estimated to be smaller than about 10–15%. At 40-km altitude the bias peaks and is 25% negative. The bias in the Polar Regions is larger, and in all regions the ozone values at and below the ozone peak are underestimated by about 10–20%.

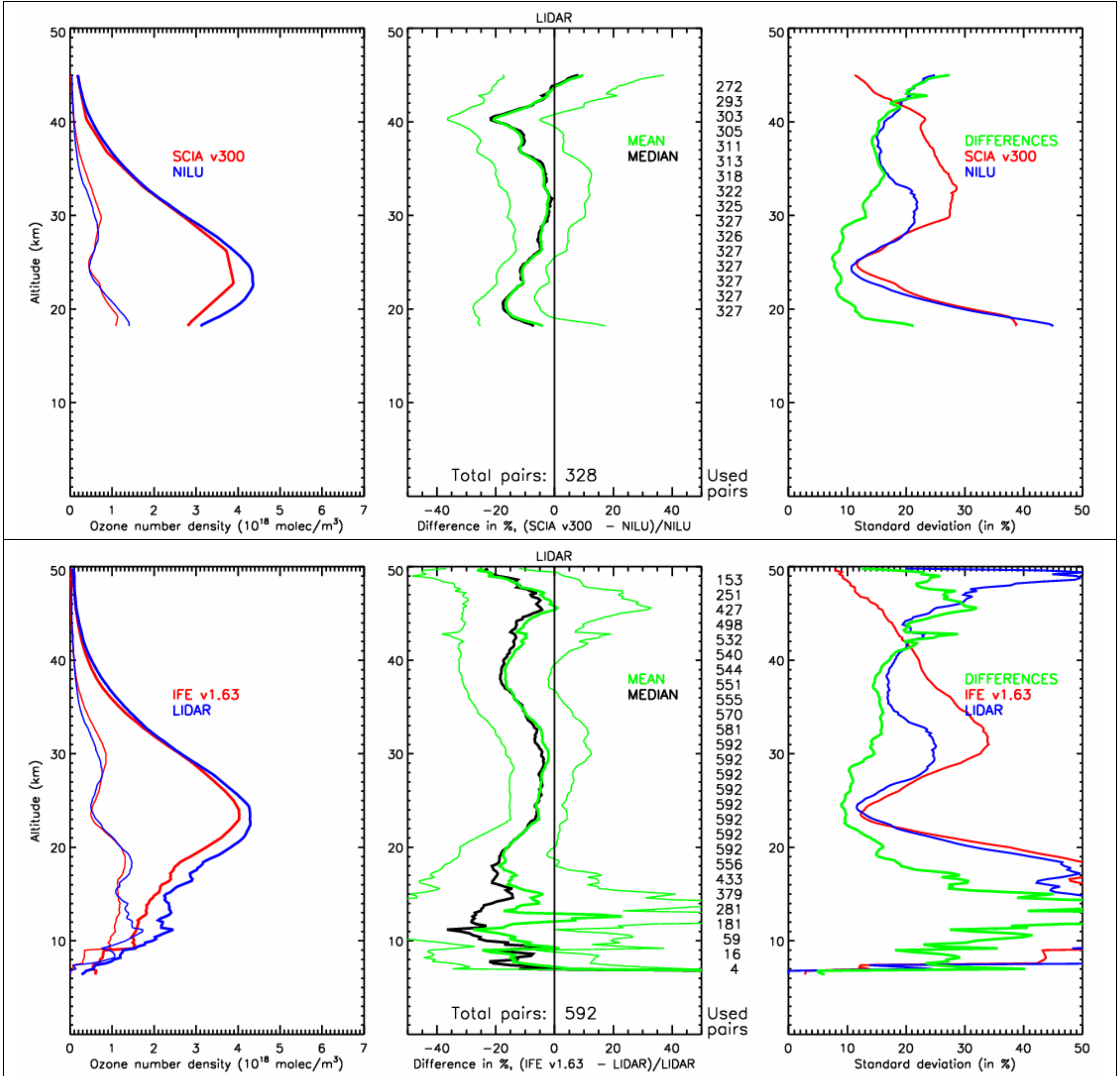

**Figure 6.** Same as Figure 4, but now showing results of SCIAMACHY ozone profiles retrieved with (top) the operational processor IPF 3.00 and (bottom) the scientific processor IFE 1.63.