THE NDSC OZONE AND TEMPERATURE LIDAR ALGORITHM INTERCOMPARISON INITIATIVE (A2I): PROJECT OVERVIEW


(1) Jet Propulsion Laboratory, California Institute of Technology, Table Mountain Facility, P.O. Box 367, Wrightwood, CA 92397, USA, leblanc@tmf.jpl.nasa.gov
(2) Alfred Wegener Institute for Polar and Marine Research, Telegrafenberg A43, D-14473 Postdam, Germany
(3) Alfred Wegener Institute for Polar and Marine Research, Postfach 120161, D-27515 Bremerhaven, Germany
(4) Norsk Institutt for Luftforsknings (NILU), NO-9296 Tromsø, Norway
(5) Deutscher Wetterdienst, Albin-Schwaiger-Weg 10, D-82383 Hohenpeissenberg, Germany
(7) Inst. Pierre Simon Laplace, Lab. de Phys. de l’Atm., Univ. de La Reunion, 15 av. R. Cassin, 97715 St-Denis, France
(8) Laboratoire de Physique de l’Atmosphère, Univ. de La Reunion, 15 av. René Cassin, 97715 St-Denis C9, France
(9) RIVM, P. O. Box 1, NL-3720 BA Bilthoven, The Netherlands
(10) NASA Goddard Space Flight Center, Laboratory for Atmospheres, Code 916, Greenbelt, MD 20771, USA.
(11) SRI International, 333 Ravenswood Avenue, Menlo Park, CA 94025
(12) Institut Pierre Simon Laplace, Service d’Aéronomie du CNRS, BP3, 91371 Verrières-le-Buisson Cedex, France
(13) Service d’Aéronomie du CNRS, BP3, 91371 Verrières-le-Buisson Cedex, France
(14) Mauna Loa Observatory, NOAA-CMDL, P. O. Box 275, Hilo, HI 96721, USA.

ABSTRACT

In September 2003, the Lidar Working Group (LWG) of the Network for Detection of Stratospheric Change (NDSC) initiated an extensive project to compare the ozone and temperature algorithms used within NDSC. This initiative, referred to later as Algorithm Intercomparision Initiative (A2I), uses simulated lidar signals to test and compare various parts of the ozone and temperature lidar algorithms. In addition to the fact that it meets the requirement of the NDSC protocols, the A2I is to try to find common grounds in the way ozone and temperature can be retrieved in order to reduce and possibly eradicate discrepancies due to algorithm issues alone. Specific issues such as homogenizing the choice of Rayleigh extinction cross-sections, ozone absorption cross-sections, a priori information, and the definition of the vertical resolutions are among the primary targets of the A2I outcome.

1. INTRODUCTION

The Network for the Detection of Stratospheric Change (NDSC, see web site http://www.ndsc.ws) is a set of high-quality remote-sounding research stations for observing and understanding the physical and chemical state of the middle atmosphere (typically 10-90 km altitude). It is a major component of the international upper atmosphere research effort and has been endorsed by national and international scientific agencies, including the International Ozone Commission, the United Nations Environment Programme (UNEP), and the World Meteorological Organization (WMO). It was formed to provide a consistent, standardized set of long-term measurements of atmospheric trace gases, particles, and physical parameters via a suite of globally distributed sites. The principal goals of the network are: (1) to study the temporal and spatial variability of atmospheric composition and structure in order to provide early detection and subsequent long-term monitoring of changes in the physical and chemical state of the stratosphere and upper troposphere, (2) to establish the links between changes in stratospheric ozone, UV radiation at the ground, tropospheric chemistry, and climate, (3) to provide independent calibrations and validations of space-based sensors of the atmosphere and to make complementary measurements, (4) to support field campaigns focusing on specific processes occurring at various latitudes and seasons, (5) to produce verified data sets for testing and improving multidimensional models of both the stratosphere and the troposphere. To meet the prerequisite of a network of high-quality remote sensing instruments, the NDSC protocols require that all NDSC participating instruments and algorithms be intercompared.

Lidar measurement inter-comparison campaigns are continuously carried out using mobile systems serving as “reference” instruments (e.g., [1], [2]). Various steps
of the temperature and ozone analysis algorithms were
tested previously, this time using simulation of lidar
signals [3]. The effect of vertical filtering in the ozone
retrieval was also performed a few years ago [4]. In
September 2003, the NDSC Lidar Working Group
(LWG) initiated a project to compare the ozone and
temperature lidar analysis algorithms currently
processing the raw data of 23 instruments around the
globe. As was done in the past for a small number of
lidars within and outside NDSC, the project is based on
the use of simulated lidar signals. It will be referred to
as A2I (Algorithm Intercomparison Initiative) in the
rest of this short paper. An overview of the A2I is
presented here.

2. A2I PRINCIPLE
The handling of the A2I is very similar to the handling
of past collaborative efforts using simulated lidar
signals whose goal was to optimize the analysis
algorithms of the temperature lidar groups of the Jet
Propulsion Laboratory and the Service d’Aéronomie du
CNRS [3]. An extension of this work later led to the
test and optimization of several temperature algorithms
outside NDSC (e.g., the Australian Rayleigh lidar based
at Davis, Antarctica), and to preliminary tests of the
algorithm of the stratospheric ozone lidar group of the
Service d’Aéronomie du CNRS. The principle of the
A2I is outlined below:

Given the known characteristics (temperature, and
composition) of a typical middle atmosphere (called the
“original profiles”), lidar signals with magnitude
representative of the participating instruments are
simulated (called the “simulated signals”) using the
basic theoretical lidar equations for Rayleigh and
Raman scattering (e.g., equation 7.14 in [5]). For
example, typical real and simulated signals for the
stratospheric DIAL-ozone lidar instrument in La
Reunion Island (NDSC candidate) are shown in Fig. 1.
The simulated signals are then sent to each participant
in order to be processed by their ozone and/or
temperature analysis algorithm. The results of the
analysis (called “retrieved profiles”) are then compared
to the “original profiles”. If discrepancies between the
retrieved and original profiles are detected, an attempt
is made to identify the sources of the discrepancies. If
the source is identified, then the algorithm in question is
corrected accordingly, and another set of simulated data
is sent for reanalysis until no discrepancy remains.
Because potential sources of discrepancy are numerous,
the simulated data are generated in such a way that only
one part of the analysis at a time is tested. In the
particular case of Fig. 1 the simulated signals were
created to be as close as possible to real signals, and
therefore contain noise as well. In most cases the
simulated signals will not contain noise, so that the
target issue during a given test can be easily identified.
Those sources of discrepancy that are either easy to
identify, or which assessment has been considered a
priority are now detailed.

Fig. 1. Example of typical real (a) and simulated (b)
signals for the stratospheric ozone lidar at La Reunion
Island.

3. AIMS OF THE A2I
Following the general lidar equation theory, there are
well known specific corrections to apply to the lidar
signals in the retrieval of ozone and temperature. For
temperature, these corrections are (1) the geometrical
factor (known as the range\(^2\) correction), (2) the
Rayleigh extinction by the air molecules along the laser
pulse round-trip path between the ground and the
altitude considered, and (3) the ozone absorption along
that same path. For ozone retrieval (differential
absorption technique), corrections (1) and (2) are
similar to that for temperature retrieval, and correction
(3) is reduced to a problem of absorption cross-section
differential. Because of the need for laboratory values
of cross-sections, and the need to consider a priori
atmospheric conditions (molecular density for (2), and
ozone for (3)), these corrections can ultimately lead to
significant differences in the retrieved products from
one algorithm to the other. Also, though one may start
with similar assumptions, and identical corrections (1)-(3),
the use of differing vertical resolutions, and
 differing error assessments, can lead to significantly
different results in the final products. This is what the A2I is aimed to assess: Can the NDSC lidar participants find common grounds in their choice of cross-sections, and a priori assumptions? Can they find common grounds in using a “unique” definition of vertical resolution, and in defining a “unique” way of assessing errors and uncertainties?

Note that other lidar signal corrections, those exclusively connected to the instrument configuration and components such as pile-up effects, background and signal-induced noise, etc., are not within the priority aims of the A2I, because they are not easily controllable when using simulated signals. However, though errors due to these corrections cannot be assessed for each individual instrument, they can still be generally assessed using the simulated signals. Then, it is the participating science team’s role to use the general conclusions obtained using the simulations, to adequately assess issues associated with their own instrument.

To illustrate some of the numerous possible effects of a priori information, we show in Fig. 2 the effect on retrieved temperature of a 10% overestimation of the Rayleigh cross-section in the Rayleigh extinction cross-section.

Then, we show on Fig. 3 the effect on the ozone retrieval of the same 10% overestimation, depending on what wavelength(s) the overestimation was made. These two examples were taken from a past investigation using the same lidar signal simulation technique, and display the difference between the retrieved and the original profiles. Similar results, this time applied to the specific A2I participating instruments, are anticipated. Note in the case shown that the effect of the 10% Rayleigh extinction overestimation is identical to the effect of a 10% systematic overestimation of the a priori molecular density used in the algorithm. This again illustrates the crucial importance of a priori assumptions, and the need for homogenizing them within the NDSC participants.

4. A2I PARTICIPANTS AND TIMELINE

As a result of the September 2003 LWG meeting decision, the science/engineering groups of the 27 participating NDSC (or NDSC candidate) lidars have been contacted. Teams in charge of 23 instruments have responded, and expressed their interest in participating to the A2I. The initial stage of the A2I, which took place in late 2003-early 2004, consisted in gathering the instrumental characteristics of all the participating lidars.

The list of participants who took part to this initial stage is shown in table 1. Typical raw-signals have been generated following conditions that are as close as possible to the acquisition conditions of real signals (an example was shown in Fig. 1). Even the raw data format of the simulated signals has been kept identical to that of actual raw data whenever possible, in order to reenact the actual conditions of the NDSC routine data acquisition and analysis.
Now that all the instrumental information has been gathered, the testing phase is to begin in March 2004. It will consist of sending noise-free simulated signals that contain only one correction at a time in order to detect possible discrepancies between the retrieved and original profiles that are related to that single correction. The corrections (1)-(3) listed above, as well as other data processing parts of the temperature and ozone algorithms will be successively targeted. A first outcome of the A2I will be presented at the ILRC meeting in July. More comparisons will be following, so that the bulk of the A2I assessment should take place in the second half of 2004.

ACKNOWLEDGMENTS

The work described in this paper was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under an agreement with the National Aeronautics and Space Administration.

REFERENCES


<table>
<thead>
<tr>
<th>Algorithm name</th>
<th>NDSC Site</th>
<th>T O3</th>
<th>PI and/or Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>O3NA200 LidarTempv1</td>
<td>Ny-Alesund, Arctic station</td>
<td>X</td>
<td>Von der Gathen., Schrems, Neuber Müller, Schrems, Neuber</td>
</tr>
<tr>
<td>ArcLiteMain</td>
<td>Sondrestrom, Arctic station</td>
<td>X</td>
<td>Thayer, Livingston, Pan</td>
</tr>
<tr>
<td>O3eval</td>
<td>Alomar, Arctic station</td>
<td>X X</td>
<td>Stebel, Hansen</td>
</tr>
<tr>
<td>DIALPRO</td>
<td>Hohenpeissenberg, NH midlatitude station</td>
<td>X X</td>
<td>Steinbrecht, Claude</td>
</tr>
<tr>
<td>DIAL v3.xx</td>
<td>Obs. de Haute Provence, NH midlatitude station</td>
<td>X</td>
<td>Pazmino, Godin-Beekmann</td>
</tr>
<tr>
<td>Ohp_main</td>
<td>Obs. de Haute Provence, NH midlatitude station</td>
<td>X</td>
<td>Ancellet, Pinsard</td>
</tr>
<tr>
<td>Temper v4</td>
<td>Obs. de Haute Provence, NH midlatitude station</td>
<td>X</td>
<td>Keckhut, Hauchecorne, Pinsard</td>
</tr>
<tr>
<td>LidAna v5.xx</td>
<td>Table Mountain Obs. , NH midlatitude station Mauna Loa Obs. , tropical station</td>
<td>X X</td>
<td>Leblanc, McDermid</td>
</tr>
<tr>
<td>DIAL_reunion</td>
<td>La Reunion Island, tropical station</td>
<td>X</td>
<td>Baray, Godin-Beekmann, Portafaix</td>
</tr>
<tr>
<td>Temper v5</td>
<td>La Reunion Island, tropical station</td>
<td>X</td>
<td>Bencherif, Keckhut, Faduilhe</td>
</tr>
<tr>
<td>OHP_Main</td>
<td>La Reunion Island (not NDSC)</td>
<td>X</td>
<td>Baray, Ancellet</td>
</tr>
<tr>
<td>ozoneprofile_sin v8.1</td>
<td>Lauder, SH midlatitude station</td>
<td>X X</td>
<td>Meijer, Swart</td>
</tr>
<tr>
<td>Eval6</td>
<td>MARL (mobile)</td>
<td>X</td>
<td>Immler, Schrems</td>
</tr>
<tr>
<td>LiDAP v2.4.5, TFP v5.8</td>
<td>STROZ (mobile) AROTAL (mobile, not NDSC)</td>
<td>X X</td>
<td>Twigg, McGee, Sumnicht</td>
</tr>
</tbody>
</table>

Table 1. Current list of A2I active participants.