Proposal in Response to the 2010 Call for the Formation of an ISSI International Team in Space Science on:

Critical Assessment and Standardized Reporting of Vertical Filtering and Error Propagation in the Data Processing Algorithms of the NDACC Lidars

Submitted by

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Synopsis:

The international Network for the Detection of Atmospheric Composition Change (NDACC[1]) is a global network of high-quality, remote-sensing research stations for observing and understanding the physical and chemical state of the Earth atmosphere. As part of NDACC, over 20 ground-based lidar instruments are dedicated to the long-term monitoring of atmospheric composition and to the validation of space-borne measurements of the Earth atmosphere from environmental satellites such as Aura (NASA) and ENVISAT (ESA). One caveat of large networks such as NDACC is the difficulty to archive measurement and analysis information consistently from one research group (or instrument) to another. Yet the need for consistent definitions has strengthened as datasets of various origin (e.g., satellite and ground-based) are increasingly used and ingested together in global assimilation systems.

It is therefore proposed to gather lidar experts to address existing issues in at least three critical aspects of the NDACC lidar data retrievals: 1) signal filtering and the vertical filtering of the retrieved profiles, 2) the quantification and propagation of the uncertainties, and 3) the consistent definition and reporting of filtering and uncertainties in the archived products. Additional experts from the satellite and global data standards communities will complement the group to address the issues specific to the latter aspect. Additional aspects of lidar data processing will be discussed if they are considered of critical relevance.

The first meeting will consist of a review and critical assessment of the methodologies used in the NDACC lidar analysis algorithms. Among them, the filtering schemes and the definition, quantification, and propagation of uncertainties will be reviewed and discussed. Based on the results of the first meeting, recommendations on the use of specific methodologies and/or approaches will be conveyed to the entire NDACC lidar community between the first and second meeting. Based on the conclusions of the first meeting and on the feedback received from the NDACC lidar community, the second meeting will consist of elaborating standardized definitions of the recommended methodologies/approaches, and implementing these methodologies so that critical information in connection with the use of these methods can be durably and consistently reported in the NDACC lidar data files. The last meeting will consist of the elaboration of one or several Technical Report(s) to be used as Reference Guide(s) by NDACC data users within both the NDACC and satellite communities.

Scientific rationale, goals, and timeliness of the project:

The NDACC (formerly known as NDSC, Network for the Detection of Stratospheric Change) is composed of more than 70 high-quality, remote-sensing research stations for observing and understanding the physical and chemical state of the stratosphere and upper troposphere, and assessing their impact on the underlying troposphere and on global climate. The objectives of the network include the detection of trends in overall atmospheric composition, establishing links between climate change and atmospheric composition, as well as the long-term validation of space-borne measurements of the Earth atmosphere from environmental satellites such as Aura and ENVISAT.

As part of NDACC, a remarkable set of high quality ground-based lidar instruments is dedicated to the long-term monitoring and satellite validation of stratospheric and upper tropospheric ozone

(3-50 km), middle atmospheric temperature (10-90 km), upper tropospheric water vapor (5-20 km), aerosols (5-30 km) and clouds. In order to ensure highest quality, the participating NDACC lidar Research groups are committed to undergo numerous measurements and algorithm intercomparisons[2,3,4].

When it comes to archiving the results on a centralized database, one caveat of large networks such as NDACC is the difficulty to report information of similar nature consistently from one research group (or instrument) to another. This inconsistency can lead to the misinterpretation of the results by users unfamiliar with the data. ***Figure 1*** shows schematics of the information flow during the lidar data processing. As suggested by this figure, data filtering and propagation of uncertainties can be applied in very different ways, and at various stages of the analysis, depending on the algorithm used. ***Figure 2*** shows the effect of vertical smoothing using different filtering schemes. The number of points used to convolve the original profile with the filter coefficients is often reported in the data files as the "vertical resolution". As suggested by Figure 2, using this metrics without a detailed knowledge of the filter properties can lead to erroneous interpretation of the results[5]. Furthermore, information on other aspects of the lidar data processing is sometimes omitted, such as the choice of absorption and extinction cross-sections or the choice of *a priori* atmospheric density or temperature used in the temperature retrieval.

The need for archiving data with consistent definitions has become critical as datasets of various origin (e.g., satellite vs. ground-based) are increasingly used and ingested together in global assimilation systems. It is therefore proposed to gather NDACC lidar experts to address at least three critical aspects of the lidar data retrievals: 1) signal filtering and the vertical filtering of the retrieved profiles, 2) the quantification and propagation of the uncertainties, and 3) the consistent definition and reporting of filtering and uncertainties in the archived products. Additional aspects of the data processing will be reviewed and assessed should the need be identified early-on by the ISSI Team.

The proposed timeline (mid-2010 to late-2011) fits very well within that of the major space agencies' currently highest priorities. ESA for example, is undergoing in close collaboration with NASA, the definition of a Generic Environment for Calibration/validation Analysis (GECA), and a set of Generic Earth Observation Metadata Standards (GEOMS). These standards are being defined with the objective of allowing a systematic and consistent data exploitation, not only for validation of spaceborne measurements, but also for both the operational and research-grade assimilation of environmental data. Furthermore, the ISSI Team, as proposed herein, will have nearly completed its task by Fall 2011, which coincides with the International Symposium celebrating the 20th Anniversary of NDACC's creation. The presentation at the Symposium of the outcome of the proposed ISSI Team will be a great opportunity to point up the degree of maturity of the Network operations.

Expected Output:

In addition to several peer-reviewed papers that should be written by the individual members of the ISSI Team, a major output will be the publication of one or several Technical Reports that will serve as Reference Guidelines for future NDACC data originators and users. These reports will not only contain detailed information on the work done during the ISSI meetings, but also detailed information on the recommendations made for the production and use of future NDACC lidar measurements. Through well detailed templates, these reports are expected to be included in the set of supporting tools made available by the national and international space agencies such as NASA, and ESA (for example in the framework of GECA). Additionally, one or several "pilot" version(s) of lidar algorithm software that use the recommended methodologies and appropriate definitions will be produced and offered to all members of the NDACC lidar community, should they be interested.

Added Value provided by ISSI:

As mentioned earlier, the NDACC Lidar Working Group has struggled for two decades now to progress efficiently on the standardization of their data analysis algorithms. Unfortunately, the priorities of the various research groups did not allow enough time and commitment for these

activities. The proposed ISSI Team is a unique opportunity to overcome that difficulty. By gathering a reduced number of committed experts, and by concentrating the 3 proposed meetings within an 18-month period, sustainable efforts can be made and should lead quickly and efficiently to significant results. The studious, yet friendly, atmosphere offered by ISSI is a perfect environment for the successful completion of this ambitious project.

Project Schedule:

It is proposed to focus primarily on three critical aspects of the NDACC lidar data retrievals: 1) signal filtering and the vertical filtering of the retrieved profiles, 2) the quantification and propagation of the uncertainties, and 3) the consistent definition and reporting of filtering and error propagation in the archived product. However, if time allows it, or if the early discussions of the first meeting call for it, alternate and/or additional topics will also be addressed.

The first meeting (5 days), to be held in Fall 2010, will consist of a review and critical assessment of the methodologies used by the NDACC lidar Researchers. During the first half (1-2 days), the filtering schemes (filter type, vertical resolution, equivalency to digital filter, etc.) will be reviewed and discussed. In the second half (1-2 days), a similar assessment and discussion will apply to the definition, quantification, and propagation of uncertainties. A review and summary will conclude the first meeting, followed by a discussion during which recommendations on the use of specific methodologies and/or approaches will be made. Shortly after the meeting, these recommendations will be conveyed to the entire NDACC lidar community.

Based on the results of the first meeting and on the feedback received from the NDACC lidar community, the second meeting (5 days), to be held in Spring 2011, will consist of elaborating standardized definitions for a consistent reporting of the recommended methodologies and approaches onto the NDACC data archiving center. Analytical tools will be developed with the objective of testing and verifying the proper implementation of these methodologies and their definition into one or several “Pilot” lidar data processing softwares. The presence of one or two experts on global data standards (NASA and ESA) will guarantee a smooth interface and a successful implementation of the ISSI Team recommendations into the global environmental data systems. This interface is critical as it allows a rapid assimilation of the newly (re)defined NDACC-lidar standards by the non-NDACC (e.g., satellite) community.

The last meeting (5 days), to be held in late summer 2011, will consist of the elaboration/finalization of one or several Technical Report(s) to be used as Reference Guide(s) by lidar data users within both the NDACC and GECA communities. These documents will be advertised at the International Symposium for the 20th Anniversary of NDACC to be held in early fall 2011.

Note: the above timeline follows a “fast-track” schedule (project completed within one year of the kick-off meeting) in order to meet the deadline of the NDACC 20th Anniversary Symposium. If discussions at the first meeting call for a slower track, the second meeting can be planned for summer 2011 and the last meeting for early 2012. A report of the ISSI Team progress can still be presented at the NDACC 20th Anniversary Symposium in Fall 2011.

Logistical and Financial Support

Typical logistical support for three 1-week-long meetings of 10-12 participants is required. This includes one or two PC projector(s), internet access, and occasional printing capability. Additional technical support such as one or two large size computer monitors is desired.

According to ISSI guideline, travel reimbursement is requested for the Team Leader’s travel expenses (airplane tickets, lodging and meals). Following ISSI guideline, per-diem and hotel support is requested for all Team Members during their stay in Bern. Several members might be able to provide their own travel support if necessary.

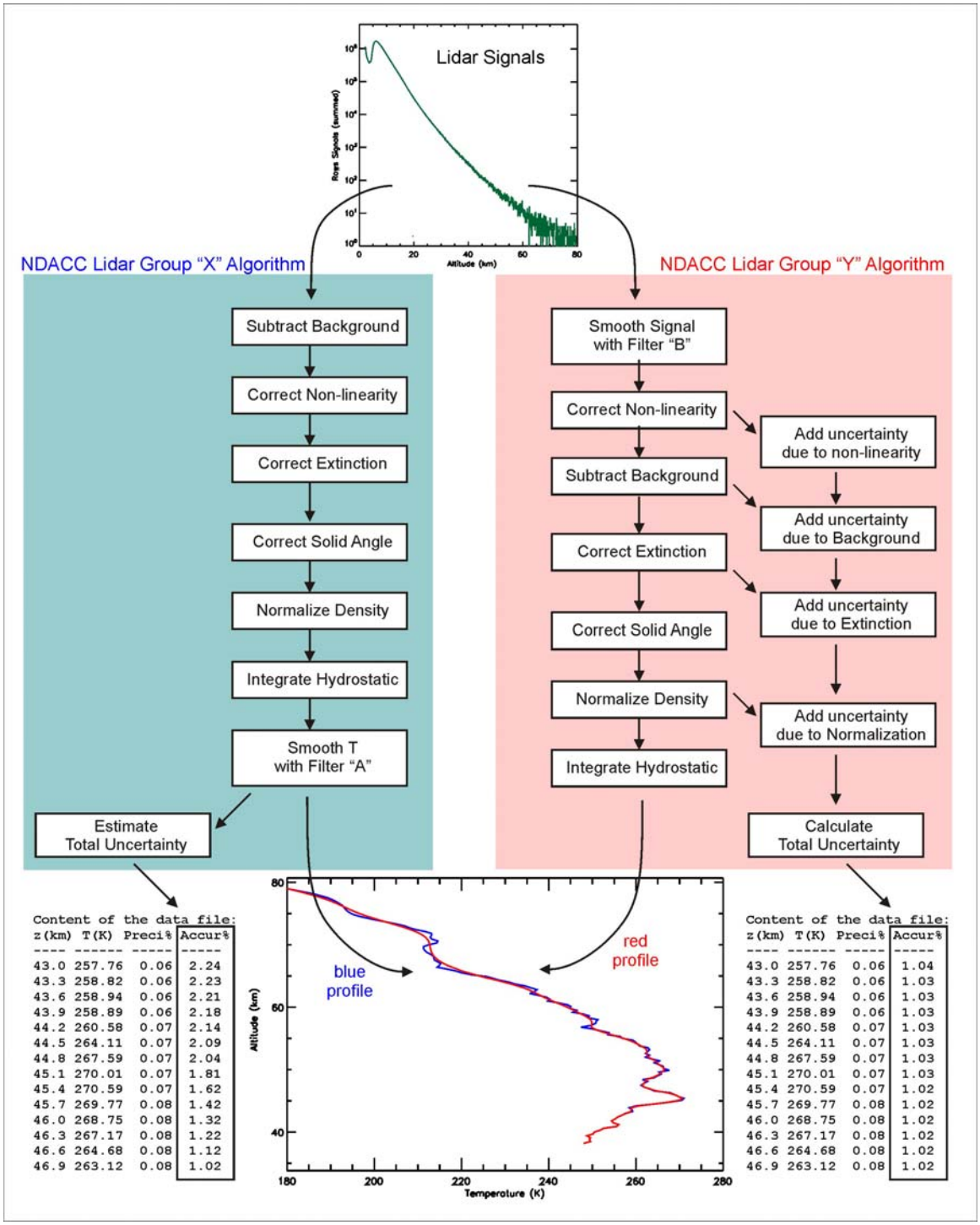

Figure 1: Example of information flow and inconsistent output of two typical Lidar Analysis Algorithms processing the same raw lidar signals

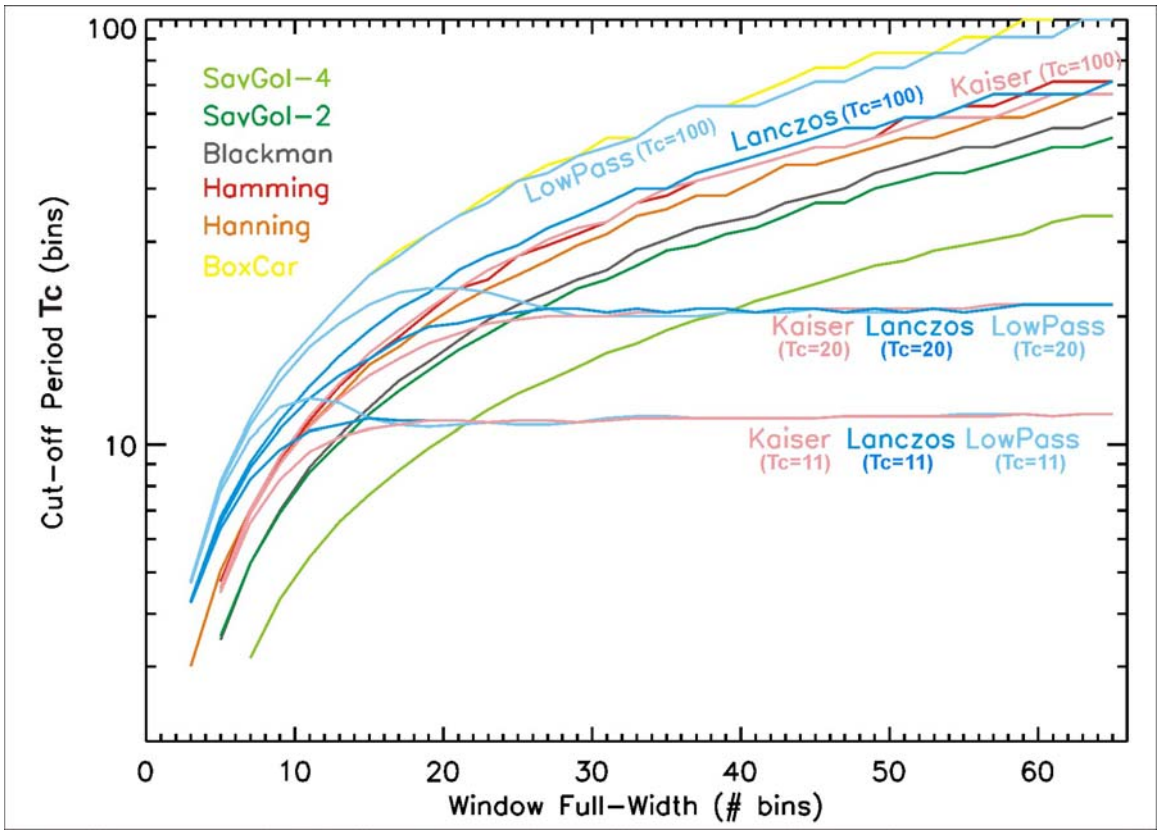

Figure 2: Actual filtering effect of 9 different filtering schemes. The X-axis is sometimes referred as the "vertical resolution" most often reported in the NDACC data files, while the Y-axis is the actual cut-off period of the filter used, reported occasionally in the NDACC data files.

Publications:

1. Kurylo, M. J. and S. Solomon, Network for the detection of stratospheric change, NASA Rep., Code EEU, 1990.

2. Godin, S., et al., Ozone differential absorption lidar algorithm intercomparison, *Appl. Opt.,* **38**, 6225-6236, 1999

3. Leblanc, T., et al., Evaluation of optimization of lidar temperature analysis algorithms using simulated data, *J. Geophys. Res.,* **103**, 6177-6187, 1998.

4. Steinbrecht, W., et al., NDSC Intercomparison of Stratospheric Aerosol Processing Algorithms, *Advances in Atmospheric Remote Sensing with Lidar*, Springer New York-Berlin-Heidelberg, 501-504, 1996.

5. Georg Beyerle and I. Stuart McDermid, Altitude Range Resolution of Differential Absorption Lidar Ozone Profiles, *Appl. Opt.*, **38**, 924-927, 1999.

Appendix A: Proposed Team Members:

Because of the particular focus of each proposed meeting, and the diverse role of the proposed team members, the presence of all team members listed below at all meetings will not be necessary. The first meeting will gather the highest number of participants (12-15). It will gather experts from the lidar community, and experts from the satellite (Aura, ENVISAT), and network (NDACC, EARLINET, GRUAN) communities. The second meeting will gather only specialists of lidar analysis algorithms (~10 participants, referred below as the "core" team), while the third meeting will gather a reduced core team on lidar algorithms and specialists of networks and data archive management (~10-12 participants).

The following investigators have confirmed their sustained commitment and will be part of the "core" task team on lidar algorithms (CV appended):

Dr. Thierry Leblanc, Team Leader and Coordinator, representing the NDACC lidars of JPL (USA)

Dr. J.-L. Baray, Team Member representing the NDACC Lidars of La Reunion Island (France)

Dr. S. Godin-Beekmann, Team Member, representing the NDACC lidars of CNRS (France)

Dr. P. Keckhut, Team Member, representing the NDACC Lidars of CNRS (France)

Dr. G. Liberti, Team Member, representing the NDACC Lidar of Rome-Tor Vergata (Italy)

Dr. F. Madonna, representing the Potenza lidar (Italy), and European network EARLINET (EU)

Dr. T. McGee, Team Member, representing two NDACC mobile lidars of NASA-GSFC (USA)

Dr. K. Stebel, Team Member, representing the NDACC arctic lidars of NILU (Norway)

Dr. B. Tatarov, Team Member, representing the NDACC Lidar of NIES (Japan)

Dr. T. Trickl, Team Member, representing the NDACC Lidar of IMK (Germany)

Mrs. A. vanGijsel, Team Member, representing the NDACC lidar of RIVM (The Netherlands)

The following investigators have confirmed their sustained commitment and will actively complement the efforts of the core team (CV appended):

Mr. F. Gabarrot, lidar specialist, complementing Dr. Baray's efforts (France)

Dr. F. Immler, representing GRUAN (WMO)

Dr. G. Pappalardo, representing EARLINET, and complementing Dr. Madonna's efforts (EU)

Dr. C. Retscher, Team Member, representing NASA's Aura Validation Data Center AVDC (USA)

The following investigators have expressed strong support to the project. They are potential substitutes to the above participants should the latter be unable to participate.

Prof. B. Sica, representing the NDACC Lidar of University of Western Ontario (Canada)

Dr. E. Wolfram, representing the NDACC Lidar of Rio Gallegos (Argentina)

Dr. B. Bojkov, representing ESA/ESRIN CEOS CAL/VAL efforts (EU)

Dr. J-C. Lambert, representing NDACC-satellite (EU)

Dr. Y. Meijer, representing ESA/ESRIN CAL/VAL efforts (EU)

Dr. M. Snels, representing the NDACC Lidar of McMurdo Antarctic Base (Italy)

Dr. D. Whiteman, representing the NDACC Mobile Lidar ALVICE of NASA-GSFC (USA)