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Algorithm Review

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1 BACKGROUND

Based on user recommendations (GOME User Consultation Meeting during Jan. 2002 at ESRIN) ESA issued during June 2002 an Invitation to Tender with the objective to develop a GOME total ozone column retrieval algorithm producing ozone data useful for ozone trend monitoring (ability to measure 1% change in total ozone concentrations globally over a period of 10 years) that can be included into the next planned ozone assessment report (to be issued by WMO during 2006).

3 institutes were awarded with a contract to perform this work in competition namely BIRA/IASB (Belgium Institute for Space Aeronomy), KNMI (Dutch Met. Office), and University of Bremen. The contracts started during autumn 2002 with a duration of about 1 year.

Mid November 2003 documents describing the theoretical background of the algorithms as well as geophysical validation results were provided to ESA external reviewers, who are giving advise to ESA on the selection of the most suitable algorithm for ozone trend monitoring. The external reviewers are W. Thomas (DLR), N. Harris (European Ozone Research Coordination Unit), R. Munro (EUMETSAT), PK. Bhartia, J. Gleason (NASA), and C. Zerefos (University Athens, WMO representative).

During December 02/03 2003 a dedicated GOME algorithm review meeting (all 3 consortia presenting their results to the external reviewers) took place at ESRIN and the reviewers asked for more validation work.

The 3 consortia finished this delta validation work at the end of Jan. 2004 by the provision of delta-validation reports and this document summarises the recommendations of the external reviewers to ESA based on this additional documentation.

All reviewers noted that the consortia have done an excellent job in this short time period and have produced high quality input for this (delta) review.

2 RECOMMENDATIONS TO ESA

3 different new GOME total ozone retrieval algorithms are being reviewed for possible operational implementation into the ESA ERS ground-segment: **GDOAS** (improved classical DOAS scheme), **TOGOMI** (improved classical DOAS scheme), and **WF-DOAS** (Weighting-Function DOAS)

Review Results:

All three algorithms agree significantly better with TOMS V8 and with ground-based stations than does GDP V3, with the exception of some stations in Antarctica, particularly Halley Bay. Though there are well known problems with Dobson instruments and algorithms in winter/spring high latitudes, one cannot rule out the possibility that some error common to all 3 DOAS algorithms, e.g. how they handle clouds, may be causing the problem.

The three algorithms show very similar and consistent results between themselves for SZA less than 60deg. In addition cyclic features relative to the ground-based data have been almost removed.

Since all three algorithms perform well and similar in the low and middle latitudes, the reviewers identify as the main selection criteria the algorithm performance at high latitudes, the algorithm sensitivity to temperature, and the algorithm operational implementation complexity.

Algorithm Performance at High Latitude:

GDOAS shows smaller differences at high latitudes, relative to TOGOMI and WFDOAS when compared with TOMS V8 and ground-based measurements.

However all three algorithms have still problems in this region and peak-to-peak differences of up to 6% occur among the three algorithms.

Algorithm Sensitivity to Temperature:

TOGOMI is using ECMWF temperature analyses and is sensitive to temperature trends in this data, which may arise from trends in ground-based or satellite data, not attributable to real atmospheric changes. The other two consortia claim that reliable temperature can be obtained from the fit, but provided no proof that they can correctly measure the seasonal variation of the temperature in high latitudes.

WFDOAS includes a temperature correction, so feedback from temperature is difficult to analyse. For GDOAS the main link is through the temperature dependence of the ozone absorption crosssection, where spectra at two distinct temperatures are used. It is expected that this method would minimise the sensitivity to potentially spurious temperature trends.

In general this remains an unsolved issue, and perhaps it is one reason why the 3 algorithms still differ in high latitudes.

Algorithm Operational Implementation Complexity:

The WFDOAS is using huge look up tables and has therefore been identified as the most complex algorithm for operational implementation. GDOAS and TOGOMI seem to provide the same level of simplicity.

Algorithm Selection:

Based on the issues mentioned above the review committee has a slight preference to choose GDOAS for operational implementation into the ERS-2 ground-segment.

Further Recommendations on future GOME total ozone algorithm development:

An algorithm should be developed that is less dependent on a priori ozone profiles than these 3 algorithms are at large solar zenith angles. Such an algorithm must use shorter wavelengths to account for profile variations.

The FRESCO derived cloud heights over bright surfaces need to be examined carefully to see if they are producing reasonable values. If not, clouds should be ignored over very bright surfaces (in UV).

All three consortia should take a careful look at their algorithms in high latitudes to see if either table interpolation, temperature, assumed profile, or some other error might be causing the differences among them.

Unless it can be convincingly demonstrated that the DOAS technique can provide effective temperatures more accurately that can be provided by ECMWF, the operational total ozone algorithm should use ECMWF temperature data. The temperature trend problem can be handled by providing users an estimate of the sensitivity of derived total O3 to temperature errors.