The AT2 e-learning module on the remote sensing of nitrogen dioxide from space

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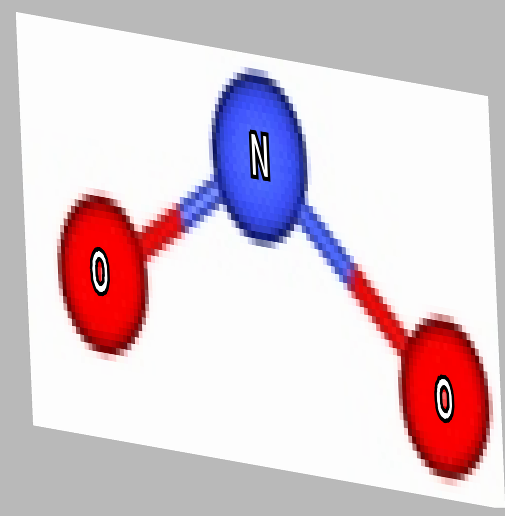

Introduction

In the face of a rapidly growing population demanding ever-increasing amounts of energy and food and producing increasing amounts of pollution. Understanding of global tropospheric chemistry is therefore of high interest with respect to climate change. As follows in the last 20 years the development in the use of remote-sensing satellite gets more and more interesting. It is very important to measure the distribution of NO_2 with high spatial and temporal resolution and with a good global coverage because it is known that NO_2 is an indicator of pollution events and it is one of the precursors of tropospheric O_3 and has therefore an important role in atmospheric chemistry.
A new generation of satellite based instruments like the Global Ozone Monitoring Instrument (GOME) [Burrows et al., 1999] onboard the ERS-2 satellite and SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY) [Bovensmann et al., 1999, Gottwald et al, 2006] onboard Envisat, - operating successfully for 10 years - provides an excellent spectroscopic data set to launch a study of tropospheric NO_2. Within an EU pilot project the AT-2 e-learning module was developed to explain why satellite based instruments should be used to determine tropospheric NO_2 [Richter and Burrows, 2002]. In addition using this module the questions why and how to retrieve tropospheric columns of NO_2 from this spectroscopy dataset should be answered by using this module.

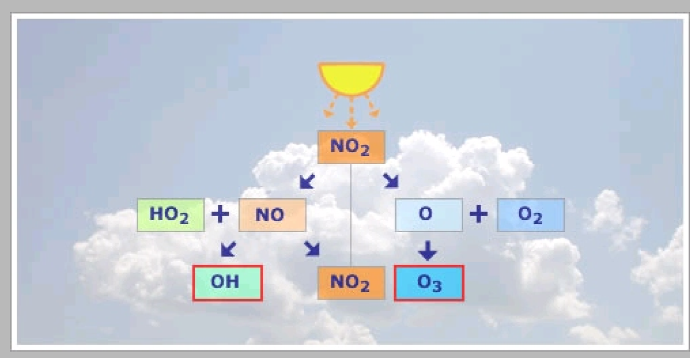

Fig. 2. NO_2 and ist photochemical reaction within the troposphere.

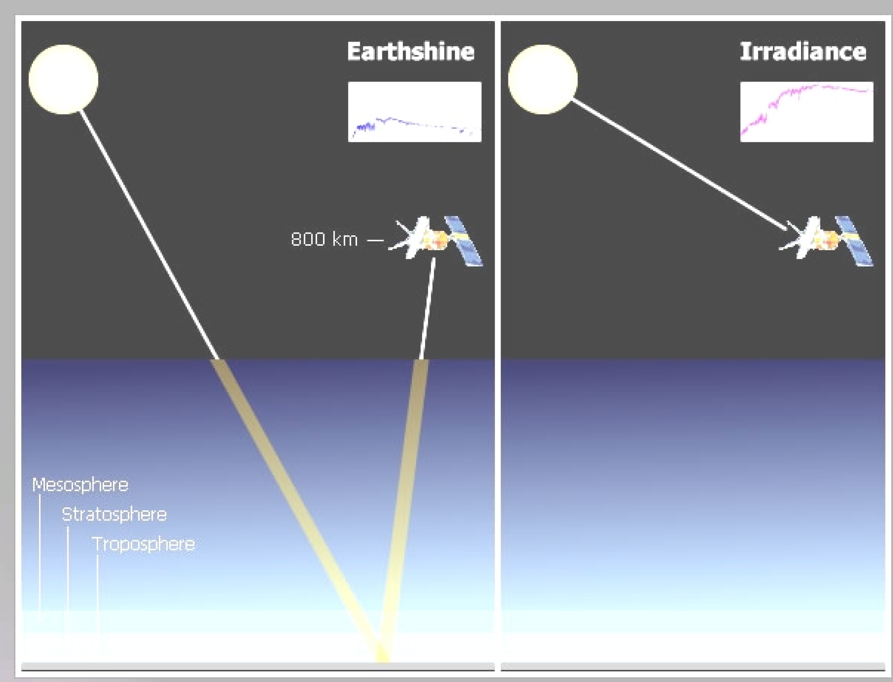

Fig. 3. Measurement from a satellite: earthshine and solar irradiance. Their spectral differences contain valuable information about the atmospheric composition (tropospheric and stratospheric amount).

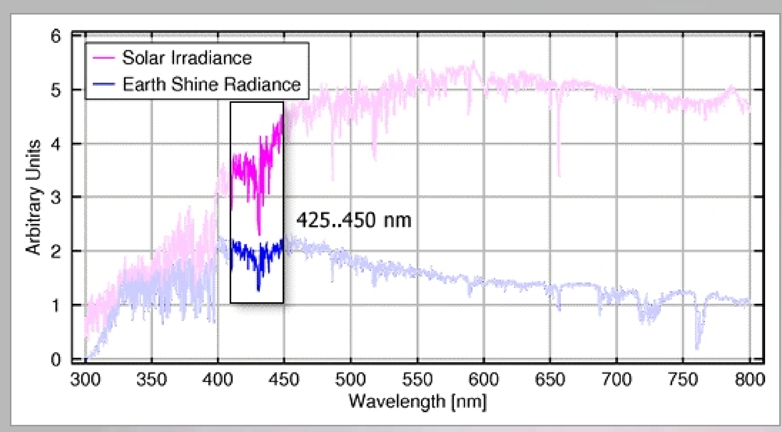

Fig. 4. In the wavelength region 425-450 nm the trace gas NO_2 is retrieved.

Content

The main structure of the AT2-e-learning module (see Fig.1) is as follows: a short summary of the module is given in "About this module". The main part of the tool consists of three chapters: Remote Sensing, Radiation Basics and Retrieval Procedures. The chapter "Remote Sensing" describes the chemical importance of NO_2 in both atmospheric layers: the stratosphere and the troposphere and the reason why it is important to retrieve one of the nitrogen oxides ($NO_x=NO+NO_2$), the tropospheric amount of NO_2 (see Fig. 2) [Wayne, 1991]. In addition the question why satellite based instruments are used for determining tropospheric NO_2. Are there some relevant chemical processes? The instruments GOME and SCIAMACHY and measurements are described in more detail in the following. General basics in spectroscopy as well as radiation transfer and finally the radiation transfer equation are explained in chapter "Radiation Basics" (see Fig. 3). The chapter "retrieval procedures" describes step by step the DOAS (Differential Optical Absorption Spectroscopy) algorithm [Platt, 1994] and how to retrieve the tropospheric vertical column amounts of NO_2 from the satellite based measurements of GOME and SCIAMACHY (see Fig. 4) [Richter and Burrows, 2002]. The use of the different types of Exercises (Gap, option exercise, Gap-fill exercise, Type-in exercise, multiple choice exercise, annotated text) deeps the knowledge in retrieving tropospheric NO_2. That means 18 different exercises can be found for each chapter "Remote Sensing and Radiation Basics" and 4 exercises help to understand how to retrieve the tropospheric amount of NO_2. In "All my Scores" a list of all pointed answers can be found and an overview where lacks in knowledge are can be found very easily. The alphabetic Index, the index of pages and the index of exercises help to guide through this e-learning tool.
This e-learning tool includes around 100 pages of information (written overviews, diagrams, animations, related exercises). So you need several hours to go through this tool. We recommend concentrating on one of the three main chapters, making all exercises and then going ahead.

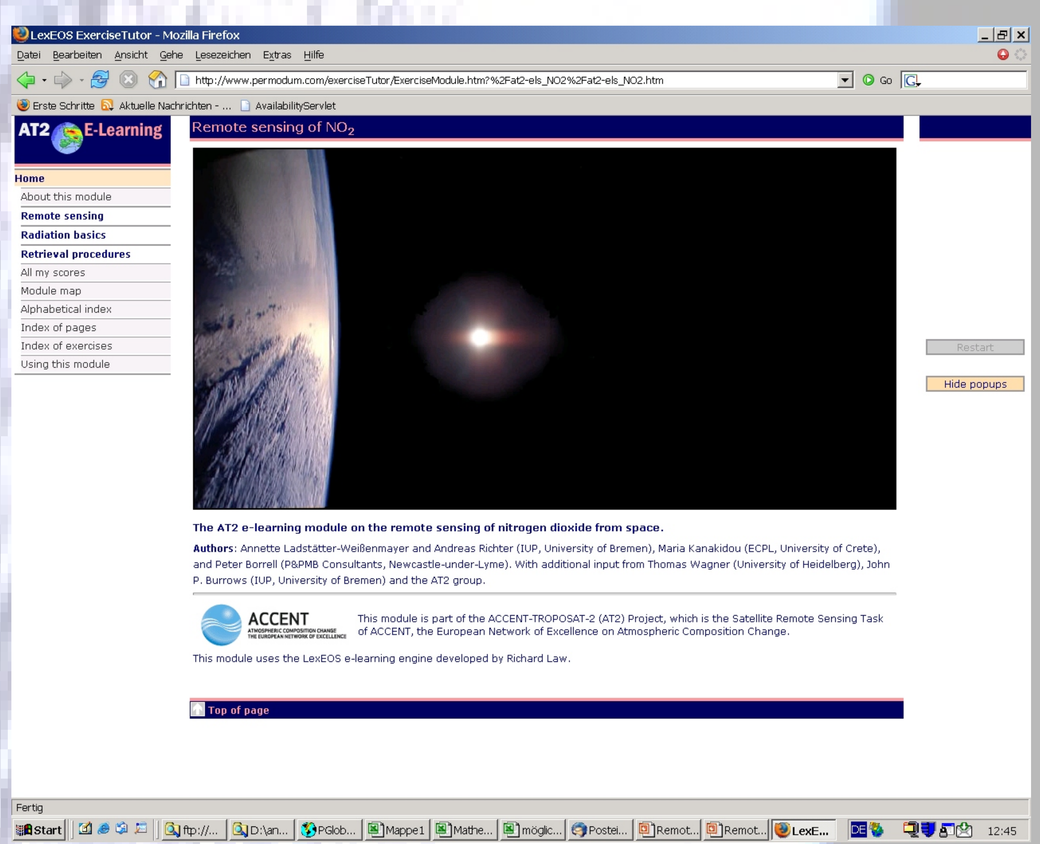

Fig. 1. First page including all the different main chapters. The three segments in the browser window give you an index and your current position in the module (left column), help you to navigate within the same level (right column) and give you information within the main text and questions (middle part).

Conclusions

The AT2 Remote Sensing e-Learning Module is not a collection of material of Basics and on an advanced level of Remote Sensing, Radiation Transfer and Retrieval Procedures. It is not an electronic book including animations and exercises. This e-learning tool can be implemented in lecture as an extension. The aim of this work was not to replace the traditional learning methods but to complement traditional textbooks and coursework. Students should have an understanding of Physical Chemistry and particularly in spectroscopy. In addition students of Environmental Physics and Chemistry should use it to learn about the remote sensing of tropospheric NO_2 from space, to deep knowledge of lectures, to understand complex relationships between Remote Sensing, Radiation Transfer and Retrieval Procedures of tropospheric NO_2.
The AT2 Remote Sensing e-Learning Module can be found on the following websites:
www.accent-network.org
www.iup.physik.uni-bremen.de/lehre/elearning/index.html

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