

SPECIAL PROJECT INTERIM REPORT

Interim Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year July 2004 – June 2005

Project Title: Climate Monitoring by Advanced Spaceborne Sounding and Atmospheric Modelling

Computer Project Account: SP ATAC

Principal Investigator(s): Prof. Gottfried Kirchengast

Affiliation: Institute for Geophysics, Astrophysics, and Meteorology, University of Graz (IGAM/UniGraz)
and
Wegener Center for Climate and Global Change, University of Graz (WegCenter/UniGraz)

Name of ECMWF scientist(s) collaborating to the project
(if applicable)

Start date of the project: November 2001

Expected end date: December 2008

Computer resources allocated/used for the current year and the previous one
(if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	30000.0	~30500	30000.0 ¹ [270,000.0 ²]	8778.4 ¹ [101,643.1 ²]
Data storage capacity	(Gbytes)	250	117	300 ¹	730 ³

¹ account SPATAC

² additional resources allocated via account ATAC01 (within the ZAMG/Austrian Met Service resources)

³ accounts SPATAC + ATAC01

Summary of project objectives

(10 lines max)

This ECMWF Special Project is undertaken to support a research programme on climate change monitoring and climate modelling, which aims at providing a better understanding of climatic changes in the atmosphere's thermal, moisture, and ozone structure, both due to natural and anthropogenic influences. The programme, carried out in the new Wegener Center and the IGAM at University of Graz under the lead of Prof. Kirchengast, is currently scheduled to last until end 2008 and its focus is to employ for the purpose advanced spaceborne remote atmospheric sounding techniques and atmospheric modelling, including regional climate modelling, with high resolution and accuracy.

Summary of problems encountered (if any)

(20 lines max)

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Summary of results of the current year (from July of previous year to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

Introduction.

At the advanced spaceborne sounding side the primary data sets involved are refractive and absorptive occultation data from novel sensors such as the GPS radio occultation sensor on the German CHAMP satellite and the GOMOS (Global Ozone Monitoring by Occultation of Stars) sensor on ENVISAT. Further main data sets foreseen to be involved are high-spectral-resolution thermal infrared data from advanced sensors including the MIPAS (Michelson Interferometric Passive Atmospheric Sounder) on ENVISAT and the AIRS (Advanced Infrared Sounder) on the U.S. AQUA satellite (in "preparation mode" also the Infrared Atmospheric Sounding Interferometer, IASI, currently built for the European METOP satellite series).

The Special Project aids at the atmospheric modelling side of the programme, mostly by enabling seamless access to ECMWF data products, in particular atmospheric analysis fields from ECMWF's MARS archive. Furthermore, the Project enables that some pre-processing operations on atmospheric fields and some related data analysis and modelling activities can be performed within the ECMWF computer and storage infrastructure so as to avoid the transfer of large data volumes from ECMWF/Reading to IGAM/Graz in cases where this would seem an inefficient work approach. The primary areas of exploitation of ECMWF products include (i) the use of ECMWF data as reference for the quality control and the validation of new satellite data and (ii) the use of (averaged) ECMWF analysis fields as basis for optimal assimilation of advanced spaceborne sounding data to obtain three-dimensional nearly unbiased monthly or seasonal analyses of temperature, humidity, and ozone. Analysed temperature, moisture, and ozone fields will then be validated against model-independent, highly stable occultation data climatologies.

Regarding the further use of the data thus obtained, it is foreseen later to compare these climatologies and analyses — expected to be climate evolution monitors of unprecedented climatological quality — to climate GCM predictions and to assess improvement potentials in GCM physics (e.g., in radiation, humidity, and cloud modelling) and in GCM forcing input (e.g., in volcanic and solar forcing). Furthermore, preparation of climate change detection and attribution schemes based on these novel data sets is foreseen.

Work from July 2004 until June 2005.

Global ECMWF analysis fields up to T511L60 resolution have been used to generate realistically simulated radio occultation measurements employing high-precision ray tracing. These simulated data have been used to analyse the sensitivity of radio occultation data to various potential error sources in the atmosphere or the observing system. The ECMWF data were in particular valuable also for these types of use within performance analyses of the LEO-to-LEO cross-link occultation concept in the framework of the ESA ACE+ (Atmosphere and Climate Explorer) Phase A study.

Analyses fields in lower resolution (T42L60) have been systematically used as quality control and inter-comparison background within a radio occultation climatology processing system based on CHAMP radio occultation data. For this purpose, global fields of temperature, pressure, and humidity are extracted for every single day from the MARS archive.

ECMWF analysis fields and associated short-term forecast fields were also utilised to develop IASI/AIRS retrieval algorithms, in particular to allow the simulation of realistic IASI/AIRS measurements (using the analysis) and to deliver a priori temperature and humidity profiles (using the short-term forecasts). In addition, they were used in ENVISAT/GOMOS validation work.

Furthermore, specifically prepared T42L60 and T21L60 fields, derived from high-resolution operational analyses, are currently used (as background fields) for a 3D-VAR assimilation scheme under development for global climate analyses initially based on CHAMP/GPS radio occultation data.

A new project within ARSCLiSys is: High Resolution Climate Modelling in the Alpine Region. The Wegener Center (WegCenter) currently participates in the 3-year project "Research for Climate Protection: Model Run Evaluation" (reclip:more), conducted by five Austrian research institutions. It is designed to evaluate the capability of mesoscale models for dynamically downscaling global climate scenarios in the Alpine Region at high horizontal resolution (grid spacing 10 – 15 km) and to develop and evaluate diagnostic and statistical techniques to reach even finer resolutions (grid spacing ≤ 1 km) or the station scale, respectively. One further major goal is to provide regional climate scenarios and analyses. WegCenter delivers three climate scenarios/analyses for the Alpine region for two periods; For the period 1981 – 1990 RCM runs forced by re-analysis data (ERA-40) will serve as high-resolution climate analysis for "present day" conditions and runs forced by data from a general circulation model (ECHAM5 with T106 resolution) will serve as control for the planned future scenarios describing the period 2041 – 2050.

In this framework, WegCenter applies the non-hydrostatic mesoscale model MM5 as RCM to create high-resolution climate-analyses of the greater Alpine region with 10 - 15 km grid spacing (hindcasts) based on ERA-40 lateral boundary conditions and two 10-year simulations driven by GCM (ECHAM5) data. Furthermore, several shorter-term (maximum 1 year) runs are conducted to test the model's sensitivity to various domain setups, nesting strategies, and model parametrizations.

Apart from the work in the framework of reclip:more, WegCenter focuses on non-hydrostatic climate simulation in the sub-10km scale and on very-high resolution downscaling of the near-surface wind-field (100 m horizontal grid spacing).

Regarding regional climate modelling, the ECMWF high performance computing system has been used extensively. Several sensitivity studies with MM5 have been conducted including the simulation of several few-days episodes and two one-year simulations. Further more, the first medium-term climate run has been finished spanning the period 1979-1990. MM5 was driven by ERA-40 lateral boundary conditions and applied a double nesting strategy reaching 15 km grid spacing in the inner domain.

List of publications/reports from the project with complete references

Selected list of publications where the underlying work benefited from SP ATAC:

Foelsche, U., A. Gobiet, A. Löscher, G. Kirchengast, A.K. Steiner, J. Wickert, and T. Schmidt, The CHAMPCLIM project: An overview, in *Earth observation with CHAMP - Results from three years in orbit*, C. Reigber, H. Lühr, P. Schwintzer, and J. Wickert (Eds.), Springer, Berlin-Heidelberg-New York, 615-620, 2005.

Foelsche, U., and G. Kirchengast, Sensitivity of GNSS radio occultation data to horizontal variability in the troposphere, *Phys. Chem. Earth*, 29(2-3), 225-240, doi:10.1016/j.pce.2004.01.007, 2004.

Gobiet, A., U. Foelsche, A.K. Steiner, M. Borsche, G. Kirchengast, and J. Wickert, Climatological validation of stratospheric temperatures in ECMWF operational analyses with CHAMP radio occultation data, *Geophys. Res. Lett.*, 32, L12806, doi:10.1029/2005GL022617, 2005.

Gobiet, A., G. Kirchengast, J. Wickert, C. Retscher, D.-Y. Wang, A. Hauchecorne, Evaluation of Stratospheric Radio Occultation Retrieval Using Data from CHAMP, MIPAS, GOMOS, and ECMWF Analysis Fields, in *Earth observation with CHAMP - Results from three years in orbit*, C. Reigber, H. Lühr, P. Schwintzer, and J. Wickert (Eds.), Springer, Berlin-Heidelberg-New York, 531-536, 2005

Gobiet, A., H. Truhetz, and G. Kirchengast, reclip:more - IGAM Report #1, Project Year 1 (Nov 2003 -Jun 2004), *Tech. Report for ARC No. 1/2004*, 38 p., IGAM, Univ. of Graz, Austria, 2004.

Kirchengast, G., S. Schweitzer, J. Ramsauer, J. Fritzer, and M. Schwaerz, Atmospheric Profiles Retrieved from ACE+ LEO-LEO Occultation Data: Statistical Performance Analysis using Geometric Optics Processing, *Tech. Report for ESA/ESTEC No. 1/2004*, 135 p., IGAM, Univ. of Graz, Austria, 2004.

Kirchengast, G., J. Fritzer, M. Schwaerz, S. Schweitzer, and L. Kornblueh, The Atmosphere and Climate Explorer Mission ACE+: Scientific Algorithms and Performance Overview, *Tech. Report for ESA/ESTEC No. 2/2004*, 32 p., Inst. for Geophys., Astrophys., and Meteorol., Univ. of Graz, Austria, 2004.

Kirchengast, G., and the ACEPASS Study Consortium, The ACE+ Phase A Scientific Support Study ACEPASS: Summary Report, *Tech. Report for ESA/ESTEC No. 2/2005*, 16 p., Inst. for Geophys., Astrophys., and Meteorol., Univ. of Graz, Austria, 2005.

Löscher, A., Assimilation of GNSS Radio Occultation Data into GCM Fields for Global Climate Analysis, Ph.D. thesis, *Wissenschaftl. Ber. No. 22*, 211p., IGAM, Univ. of Graz, Austria, 2004.

Retscher, C., C. Rehl, A. Gobiet, and G. Kirchengast, Stellar Occultation Algorithm and Validation for GOMOS on Envisat and a Performance Analysis for the Complementary Solar Occultation Concept SMAS, *Tech. Report for ASA No. 2/2004*, 110p., IGAM, Univ. of Graz, Austria, 2004.

Schwärz, M., Joint Temperatur, Humidity, Ozone, and Sea Surface Temperature Retrieval from Infrared Atmospheric Sounding Interferometer Data, Ph.D. thesis, *Wissenschaftl. Ber. No. 21*, 188p., Inst. for Geophys., Astrophys., and Meteorol., Univ. of Graz, Austria, 2004.

Steiner, A.K., and G. Kirchengast, Error analysis for GNSS radio occultation data based on ensembles of profiles from end-to-end simulations, *J. Geophys. Res.*, 110, in press, 2005.

Summary of plans for the continuation of the project

(10 lines max)

The primary areas of exploitation of ECMWF products will continue to include (i) the use of analysis fields to provide a reference for quality control and validation of new satellite data (ii) the use of monthly mean fields as inter-validation datasets for measured climatologies, and (iii) the use of (averaged) analysis fields as basis for optimal assimilation of advanced sounding data in order to obtain three-dimensional nearly unbiased monthly and seasonal analyses. ECMWF CPU resources will be used for simulations of a large ensemble of radio occultation data based on outputs from 25 years ECHAM5 GCM runs within a climate observing system simulation experiment.

From August 2005 till December 2005 two 10-year regional climate simulations (MM5 driven by ECHAM5 lateral boundary conditions) are planned. Starting with Jan. 2006 extensive experiments will be necessary to evaluate the performance of the wind downscaling system on climate scales.