

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 2008 – June 2009

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

Computer Project Account: SPATAC.....

Principal Investigator(s): Prof. Gottfried Kirchengast

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

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

Start date of the project: November 2001

Expected end date: December 2011

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

Please answer for all project resources

		Previous year (2008)		Current year (2009)	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	25,500.0 ¹ [400,000.0 ²]	31,841.06 ¹ [395,668.69 ²]	30,000.0 ¹ [400,000.0 ²]	35,995.95 ¹ [161,685.56 ²]
Data storage capacity	(Gbytes)	300 ¹ [700 ²]	1,478 ³	300 ¹ [700 ²]	938 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 trace species composition structure, both due to natural and anthropogenic influences. The programme, carried out at the WegCenter and IGAM of the University of Graz under the lead of Prof. Kirchengast, is currently scheduled to last until 2011. Its focus is to employ for the purpose advanced spaceborne atmospheric sounding and atmospheric modelling, including regional climate modelling, with high resolution and accuracy.

Summary of problems encountered (if any)

(20 lines max)

.....

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 satellite-borne data sets, which are continuously exploited, are occultation data from the GPS radio occultation (RO) sensors on the German CHAMP satellite and the GPS RO sensors of the Taiwan/U.S. FORMOSAT-3/COSMIC constellation. Recently the use of RO data from the MetOp satellite (GRAS instrument) has started, and RO data from GRACE-A and SAC-C are currently processed for selected timer periods. Furthermore, next-generation occultation techniques combining microwave occultation and infrared laser occultation for accurate joint profiling of thermodynamic variables, greenhouse gases and wind are explored. Until end 2007 also performance investigations have been pursued for high-spectral-resolution thermal infrared data from the Atmospheric Sounding Interferometer (IASI) on MetOp.

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 and short-range forecast fields from ECMWF's MARS archive. The Project also 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 WegCenter/Graz in cases where this would seem an inefficient work approach. Furthermore, the project provides important computational resources and data from re-analysis and operational analysis for regional climate modelling.

Primary areas of exploitation of ECMWF data include (i) the use of ECMWF analysis fields (frequently spatially-horizontally averaged to ~T42 resolution) as reference for the quality control and the validation of new satellite data and derived, essentially model-independent climatologies, (ii) the use of ECMWF short-term forecast fields as background for optimal estimation retrieval to again obtain high-quality monthly or seasonal climatologies of atmospheric variables such as temperature, humidity, and geopotential height of pressure levels from the satellite data, and (iii) the use of ECMWF re-analysis (ERA-40) and operational analysis (IFS) for regional climate modelling. Computational (CPU) resources are primarily assigned to regional climate modelling applications.

Regarding additional use of the processed data obtained, these climatologies and analyses are also compared to climate GCM simulations and predictions 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, climate change detection and attribution studies based on these new data sets have been started in 2007/08.

July 2009

This template is available at:
http://www.ecmwf.int/about/computer_access_registration/forms/

Work from July 2008 until June 2009.

As quality control and inter-comparison background within our radio occultation processing and analysis system for GPS radio occultation data, ECMWF analysis and short-term forecast fields are continuously used in lower resolution (T42L60 until end January 2006, T42L91 since February 2006). For this purpose, global fields of temperature and humidity (and related basic parameters such as surface pressure and orography) are extracted for every single day, four time layers a day from the MARS archive. Since mid 2001 this been done for the processing and validation of CHAMP RO profiles. Meanwhile ECMWF fields are also used in the processing of RO data from Formosat-3/COSMIC, Metop-A, GRACE, SAC-C, and GPS/MET. This work also provides valuable feedback on the (steadily increasing) ECMWF analysis data quality regarding absolute accuracy, since the GPS RO data serve as essentially independent reference state. With the aid of RO data we have carried out a climate signal detection study and a study on the diurnal cycle in the free atmosphere.

Global ECMWF analysis fields at T511L91 resolution have been used to generate realistically simulated occultation observables employing high-precision ray tracing. These simulated data have been used to analyse the sensitivity of occultation data to horizontal variability within the atmosphere. ECMWF data were and are particularly valuable for end-to-end performance analyses of the LEO-to-LEO cross-link occultation concept ACCURATE proposed in the framework of the European Space Agency (ESA). ACCURATE is currently undergoing various scientific studies and pre-developments in this context (ESA studies and studies in the Austrian Space Applications Programme ASAP). In these cases, where the novel combined microwave and infrared laser occultation concept (conceived at the Wegener Center) is investigated, also additional state variables like ozone and wind fields, as well as cloud liquid and ice water content fields, are utilized.

Regarding regional climate modelling, the ECMWF high performance computing facility has been used to conduct 11 highly resolved (10 km, 3.3 km, and 1.1 km grid spacing) simulations with the non-hydrostatic mesoscale model MM5. The driving lateral boundary conditions (LBCs) have been derived from the re-analysis dataset ERA-40, from ECMWF's operational deterministic analysis and forecast system (IFS) and from model-output of the Regional Model (REMO) provided by the Max-Planck Institute for Meteorology, Hamburg:

Eight highly resolved simulations with 10 km, 3.3 km, and 1.1 km grid spacing were conducted in relation to the three-year project "Non-hydrostatic climate modelling – NHCM-1" (see annual report of the last year). These simulations (periods June / July 2007 and December / January 2007 / 2008) were driven by 3-hourly lateral boundary conditions from the IFS (T799L91) to investigate the potential and shortcoming of MM5 on very highly resolved grids and to find the optimum model configuration for high resolved simulations in the Alpine region. Furthermore, a one-year simulation (January 2007 to January 2008) covering the Eastern Alps (3.3 km grid spacing) was conducted to prepare well suited initialisation fields (soil moisture and soil temperature) for the next mini-ensemble of short-term simulations on 1.1 km grids.

In addition, two highly resolved (1.1 km grid spacing) two-months simulations were conducted in the framework of the international FP-6 EU-project "Climate Change and Variability: Impact on Central and Eastern Europe" (CLAVIER, <http://www.clavier-eu.org/>) in order to investigate the model's ability in simulating heavy precipitation events in the West Carpathian region, Hungary, and in the Romanian Carpathians, as a post-processing downscaling-step of REMO.

List of publications/reports from the project with complete references

Selected list of publications where the underlying work benefited from SPATAC (i.e., where ECMWF data products and/or computational resources aided the work):

- Awan, N.K. and A. Gobiet**, A comprehensive sensitivity analysis of high resolution regional climate simulations with WRF in the European Alpine region (oral), *Geophysical Research Abstracts*, 11, EGU2009-8118, EGU General Assembly 2009, Vienna, Austria, 2009
- Borsche, M.**, Global atmospheric climatologies from radio occultation data and derivation of diagnostic parameters for climate monitoring (Ph.D. thesis), *Scient. Rep. No. 22-2008*, ISBN 978-3-9502308-6-5, Wegener Center Verlag Graz, Austria, 2008
- Borsche, M., U. Foelsche, B. Pirscher, A. K. Steiner, C. Lackner, J. Fritzer, M. Pock, and G. Kirchengast**, Radiookkultation für globale und regionale Klimabeobachtung der Atmosphäre: Ergebnisse des Wegener Zentrums Graz, *Proc. 10. Österr. Klimatag*, March 2008, Vienna, Austria, V08, 2008
- Foelsche, U., G. Kirchengast, A. K. Steiner, L. Kornblueh, E. Manzini, and L. Bengtsson**, An observing system simulation experiment for climate monitoring with GNSS radio occultation data: setup and testbed study, *J. Geophys. Res.*, 113, D11108, doi:10.1029/2007JD009231, 2008
- Foelsche, U., G. Kirchengast, M. Borsche, B. Pirscher, and A.K. Steiner**, Creating a Consistent Radio Occultation Data Base for Climate Studies in the Upper Troposphere and Lower, Stratosphere, *Proc. of the ECMWF GRAS-SAF Workshop on Applications of Radio Occultation Measurements*, June 2008, ECMWF, Reading, UK, 151-165, 2008
- Foelsche, U., B. Pirscher, M. Borsche, G. Kirchengast, and J. Wickert**, Assessing the climate monitoring utility of radio occultation data: From CHAMP to FORMOSAT-3/COSMIC, *Terr. Atmos. Oceanic Sci.*, 20(1), 155-170, doi: 10.3319/TAO.2008.01.14.01(F3C), 2009
- Foelsche, U., B. Pirscher, M. Borsche, A. K. Steiner, G. Kirchengast, and C. Rocken**, Climatologies Based on Radio Occultation Data from CHAMP and Formosat-3/COSMIC, in *New Horizons in Occultation Research: Studies in Atmosphere and Climate*, A. K. Steiner, B. Pirscher, U. Foelsche, and G. Kirchengast (Eds.), Springer Berlin Heidelberg, 179-192, in press, 2009
- Gobiet, A., A. Dalla-Via, F. Pretenthaler, H. Truhetz**, A Climate Change Scenario for Southern and Eastern Styria and Potential Impacts on Water Availability, *Beiträge zur Hydrogeologie*, 56, 63-68, 2008
- Gobiet, A., M. Themeßl, S. Pfeifer, P. Lorenz, D. Jacob**, On the value of empirical-statistical model error correction methods for climate scenario production (oral), EMS8/ECAC7 Abstracts, Vol. 5, EMS2008-A-00522, 8th Annual Meeting of the EMS / 7th ECAC, Amsterdam, Netherlands, 2008
- Gobiet, A., M. Suklitsch, A. Prein, H. Truhetz, N.K. Awan, H. Göttel, D. Jacob**, High resolution dynamical downscaling error components over complex terrain (oral), 2nd International Lund RCM Workshop, Lund, Sweden, May, 2009
- Ho, S.-P., G. Kirchengast, S. Leroy, J. Wickert, T. Mannucci, A.K. Steiner, D. Hunt, W. Schreiner, S.V. Sokolovskiy, C.O. Ao, M. Borsche, A. von Engeln, U. Foelsche, S. Heise, B. Iijima, Y.-H. Kuo, E.R. Kursinski, B.C. Lackner, B. Pirscher, M. Ringer, C. Rocken, and T. Schmidt**, Estimating the uncertainty of using GPS radio occultation data for climate monitoring: Inter-comparison of CHAMP refractivity climate records 2002-2006 from different data centers, *J. Geophys. Res.*, submitted, 2009
- Kirchengast, G., S. Schweitzer, B. Pirscher, M. Pock, F. Ladstädter, B.C. Lackner, I. Thaler, M. Borsche, U. Foelsche, A.K. Steiner, and J. Fritzer**, EOPSCLIM – End-to-end Occultation Processing System and Climate Monitoring Service: MetOp GRAS and ACCURATE Integration (Final Report), *Tech. Rep. for FFG-ALR No. 2/2008*, 4 pp (Exec.Summary) + FFG-ALR Rep. No.5/2007 and No.1/2008, Wegener Center, Univ. of Graz, Austria, 2008
- Luntama, J.-P., G. Kirchengast, M. Borsche, U. Foelsche, A.K. Steiner, S. Healy, A. von Engeln, E. O’Clerigh, and C. Marquardt**, Prospects of the EPS Gras mission for operational atmospheric applications, *Bull. Amer. Met. Soc.*, doi: 10.1175/2008BAMS2399.1, 2008
- Pirscher, B., U. Foelsche, M. Borsche, and G. Kirchengast**, Globale Analyse des Temperatur-Tagesgangs in der oberen Troposphäre und unteren Stratosphäre mittels Radio-Okkultations-Daten, *Proc. 10. Österr. Klimatag*, March 2008, Vienna, Austria, V09, 2008
- Pirscher B., U. Foelsche, M. Borsche, and G. Kirchengast**, Sampling of the Diurnal Cycle of Temperature Using Formosat-3/COSMIC Data, in *New Horizons in Occultation Research: Studies in Atmosphere and Climate*, A. K. Steiner, B. Pirscher, U. Foelsche, and G. Kirchengast (Eds.), Springer Berlin Heidelberg, 129-138, in press, 2009

- Schweitzer, S., B. Pirscher, M. Pock, F. Ladstädter, M. Borsche, U. Foelsche, J. Fritzer, and G. Kirchengast**, End-to-end Generic Occultation Performance Simulation and Processing System EGOPS: Enhancement of GPS RO Data Processing and IR Laser Occultation Capabilities, *Tech. Rep. for FFG-ALR No. 1/2008*, 47 pp, Wegener Center, Univ. of Graz, Austria, 2008
- Steiner, A. K., B. Pirscher, U. Foelsche, and G. Kirchengast (Eds.)**, New Horizons in Occultation Research Springer Berlin Heidelberg, in press, 2009
- Steiner, A. K., G. Kirchengast, M. Borsche, and U. Foelsche**, Lower stratospheric temperatures from CHAMP RO compared to MSU/AMSU records: An analysis of error sources, in *New Horizons in Occultation Research: Studies in Atmosphere and Climate*, A.K. Steiner, B. Pirscher, U. Foelsche, and G. Kirchengast (Eds.), Springer Berlin-Heidelberg, 217-233, in press, 2009
- Steiner, A.K., G. Kirchengast, B.C. Lackner, B. Pirscher, M. Borsche, and U. Foelsche**, Atmospheric temperature change detection with GPS radio occultation 1995 to 2008, *Geophys. Res. Lett.*, submitted, 2009
- Suklitsch, M., A. Gobiet, A. Leuprecht, and C. Frei**, High Resolution Sensitivity Studies with the Regional Climate Model CCLM in the Alpine Region, *Meteorol. Z.*, 17 (4), 467-476, doi: 10.1127/0941-2948/2008/0308, 2008
- Suklitsch, M. and A. Gobiet**, Investigation of Added Value at very high resolution with the Regional Climate Model COSMO-CLM (oral), 2nd International Lund RCM Workshop, Lund, Sweden, May 2009
- Suklitsch, M., A. Gobiet, H. Truhetz, N. K. Awan, H. Göttel and D. Jacob**, Error characteristics of high resolution regional climate simulations in the Alpine Region (oral), *Geophysical Research Abstracts*, 11, EGU2009-7265, EGU General Assembly 2009, Vienna, Austria, April 2009
- Themeßl, M., A. Gobiet, G. Heinrich, A. Leuprecht**, Empirical-statistical error correction of daily precipitation from a regional climate model and its impacts on the climate change signal (oral), FREE workshop on precipitation downscaling and modelling, Climate Research Unit, Norwich, Great Britain, April 2009

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 a constantly increasing number of new satellite data (with focus on occultation data), (ii) the use of monthly mean fields as inter-validation datasets for measured climatologies, (iii) the use of short-term forecast fields as basis for optimal estimation retrieval using advanced sounding data, (iv) the use of analysis and forecast fields for supporting end-to-end performance analysis studies of next-generation combined microwave and infrared laser occultation systems, and (v) the use of re-analysis and operational analysis and forecast fields to prepare lateral boundary conditions for regional climate models operated at very high resolution (10 km to 1 km scale).

Regarding specifically the computational resources, ECMWF CPU resources will be used (i) for simulations of a large ensemble of radio occultation data based on outputs from 25 years of ECHAM5 GCM runs within a climate observing system simulation experiment, (ii) for long-term region climate simulations (period 1961 to 2050) within the Austrian research project “Entwicklung eines Datensatzes regionalisierter Klimaszenarien – reclip:century” preparing the next generation of highly resolved (10 km grid spacing) climate scenarios for the Alpine region, and (iii) for further high-resolution simulations within the “Non-hydrostatic climate modelling – NHCM-1” project (mentioned already in the description of the work of last year above) building the basis of the international model-inter-comparison study on cloud-resolving scale “Local Climate Model Intercomparison Project” (LocMIP) contributed by the Max-Planck Institute for Meteorology (MPI-Met), Hamburg, Germany, the Lehrstuhl für Umweltmeteorologie, BTU Cottbus, Germany, and the Illinois State Water Survey, U.S..