SPECIAL PROJECT FINAL REPORT

Project Title:	Meteorological Data for EMEP
Computer Project Account:	spnoemep
Start Year - End Year :	2011 - 2012
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Summary of project objectives

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The objective of this project was to generate a multi-year set of global IFS meteorological data on T799 spectral resolution for use in the EMEP/MSC-W chemical transport model. The aim was to obtain a complete data set covering the years 2000 to 2010.
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Summary of problems encountered

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No major problems have been encountered. Occasionally we had problems transferring the (large) files to our Norwegian disk storage, but this was not due to ECMWF.
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Experience with the Special Project framework

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The administration of the project was easy. The application was procedure was transparent and the reporting requirements are reasonable.
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Summary of results

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Foreword

This Special Project was already completed in summer 2012, when the progress report was due. This final report is thus very similar to the progress report submitted in 2012. However, updated information (further analyses including figures, and additional references) have been added.

Background

Air pollution continues to be a serious environmental and societal problem both in Europe and in other parts of the world. Under the UN Convention on Long-range Transboundary Air Pollution (LRTAP), which has been in force since 1979, the EMEP Programme (European Monitoring and Evaluation Programme, http://www.emep.int) has for many years provided the scientific background for policy decisions. The Meteorological Synthesizing Centre - West (MSC-W), hosted by the Norwegian Meteorological Institute is one of the five EMEP centres under the UN LRTAP convention and has been performing extensive modelling studies with focus on acidification (e.g. acid rain), eutrophication (increasing nutrient content in soil and water bodies), ground level ozone and particulate matter in air, which are relevant for both air pollution and climate. In addition MSC-W is involved in numerous national and international projects that are in the forefront of research on air quality modeling and interactions between air pollution and climate change.

The EMEP MSC-W model, which is our main research tool, uses meteorological data from external sources in order to calculate dispersion and deposition of air pollutants. At present, our main source of meteorological data is the IFS model at ECMWF. We generate these data ourselves at ECMWF. Nearly all our activities rely on the development and application of the EMEP MSC-W model. The code has been developed for more than 10 years and the EMEP MSC-W model is recognized as one of the most accurate and efficient models for its purposes. An updated description of the model has recently been published by Simpson et al., 2012 (http://www.atmos-chem-phys.net/12/7825/2012/acp-12-7825-2012.pdf). It is also available as Open Source code and available at EMEP's international website http://www.emep.int. Model results are published in many peer-reviewed publications, but also in the widely known EMEP reports that can be downloaded free of charge at http://emep.int/mscw/mscw_publications.html and serve as scientific input to policy decisions within UN ECE.

Achievements/Results

The calculation of meteorological data was the purpose of this special project. We have generated meteorological data for the years 2000 to 2004 and (partly) later years, e.g. 2011. The CPU quota was used complementary to the quota that is allocated to our research group through the Norwegian Meteorological Institute (met.no) on an annual basis. Using these meteorological data, detailed trend analysis for the entire decade, but also status calculations for 2010 have been calculated with the EMEP MSC-W model.

Generating one year of meteorological data takes approximately 400000 SBUs so that the 5 years have required about 2 million SBUs. These were provided through this special project. The data have been generated on T799 spectral resolution and in 60 vertical layers, including all necessary parameters. This required about 3.6 Tbyte of disk storage. One year was generated at a time and then downloaded to a local disk in Norway before the next year of data was generated.

The next step of the project was to make a first trend analysis using a 10-year data set (to be discussed in 2013 status report). This has been achieved. The results were shown at the EMEP Steering Body meeting (September 2012) and at the EMEP Bureau meeting (March 2013).

In particular, two 11-year simulations have been made, one where emissions were kept constant at year 2000 level and another one where emissions varied according to best estimates based on officially reported emissions from EMEP. Figure 1 shows the variability of these emissions at the example of NOx emissions in the 'Greater BeNeLux' area, as it was defined in the EU FP7 collaborative project CityZen (https://wiki.met.no/cityzen/region_definitions).

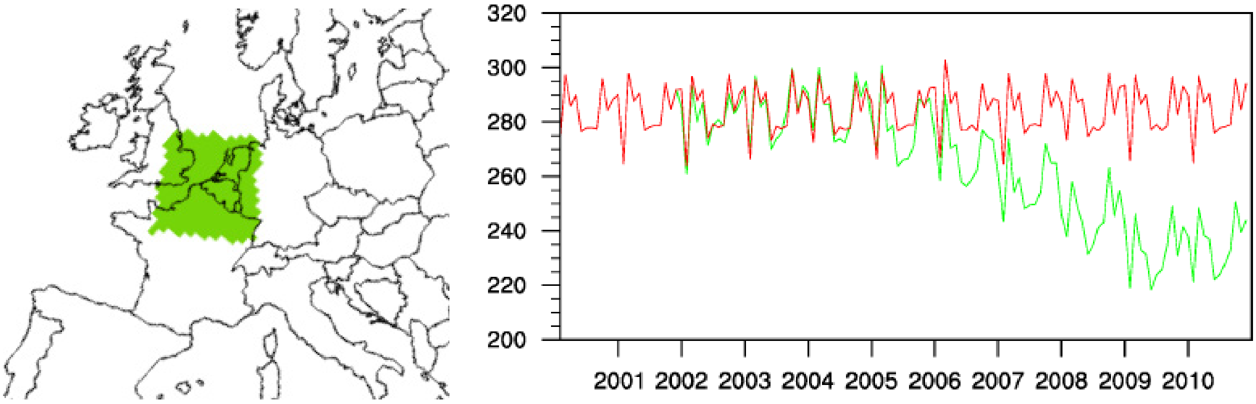

Figure 1: *Left: 'Greater BeNeLux' area shaded in green, as defined in the EU project CityZen. Right: NOx emissions from Greater BeNeLux, used in the trend calculations. Red: constant (year 2000) anthropogenic emissions, Green: varying anthropogenic emissions (2000-2010). Unit: ktonne(N)/yr.*

The difference between these two simulations would then represent the effect of emission changes during this 11-year period.

As an example, Figure 2 shows surface concentrations of NOx and ozone averaged over the Greater BeNeLux area. A downward trend is seen in NOx as a response to emission regulation (i.e. green curve lower than red curve). The response of ozone (produced by photochemistry in the presence of NOx) is less pronounced. In winter there is even an increase in ozone due to emission reductions. This is due to less titration of ozone when NOx concentrations are lower. However, summer is the time when critical ozone levels (with adverse health effects) are exceeded, so that the reduction in summer ozone is assumed to be more relevant than the (small) increase in winter ozone. Also, the inter-annual variability of ozone due to meteorological variations is striking. This makes the available of accurate meteorological data all the more important.

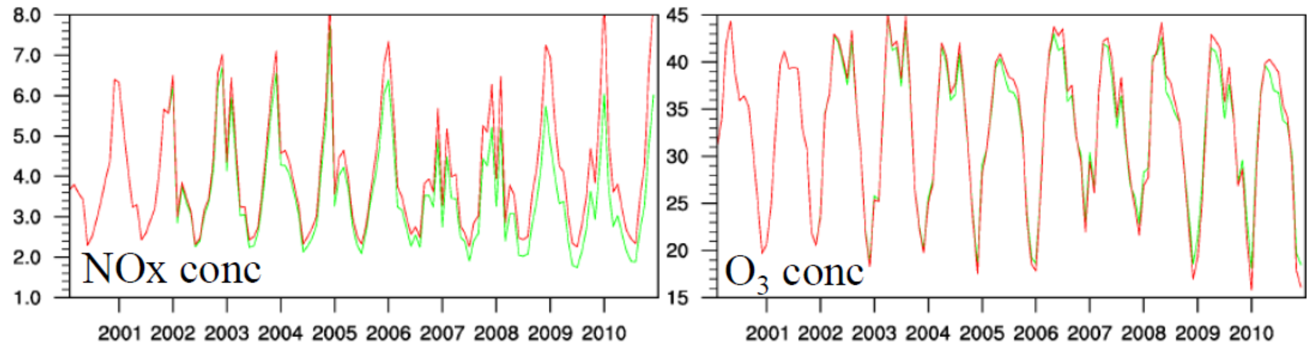

Figure 2: *Surface concentrations of NOx and ozone in the 'Greater BeNeLux' area from 2000 to 2010 as modeled by EMEP MSC-W using IFS meteorological data generated at ECMWF. Green: Emissions as reported by the countries to the EMEP emission Center CEIP, red: emissions fixed at year 2000 level.*

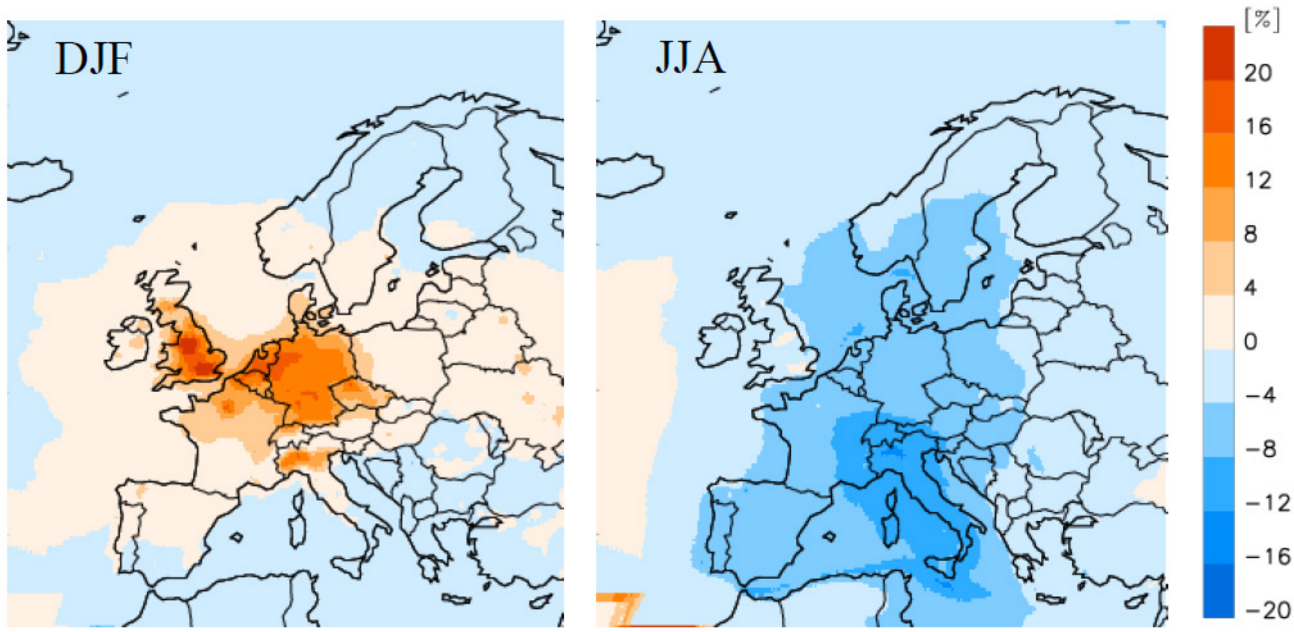

Figure 3: *Percentage change in surface ozone due to emission change since 2000 (until 2010), as calculated by the EMEP MSC-W model. Left: winter (Dec, Jan, Feb), right: summer (Jun, Jul, Aug).*

Figure 3 shows changes in ozone surface concentrations from 2000 to 2010, averaged over the entire EMEP domain for the summer and winter seasons, further illustrating the different ozone trends in summer and winter.

The trends in ozone (and particulate matter), as a response to emission control measures are currently a hot topic, both scientifically and politically. The results from EMEP MSC-W have supported the revision of the Gothenburg protocol and the revision of European (EU) Air quality policy.

Meteorological data for the year 2011, also generated through this special project, have been used in model runs to assess the effect of ship emissions responding to new emission regulations (reductions of sulfur emissions after 2010). This analysis has been done, presented and reported to the BSR Innoship project (http://www.baltic.org/projects/bsr_innoship), and will be published in the peer-reviewed literature in 2013 by J.E. Jonson et al. (manuscript in preparation).

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List of publications/reports from the project with complete references

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Since 2010 the meteorological data created at ECMWF have been the main driver of the EMEP/MSC-W model. Thus this special project has been feeding directly or indirectly into almost all studies and publications with EMEP/MSC-W model participation. From an EMEP perspective the most relevant are the annual status reports submitted to the UN Convention on Long-range transboundary air pollution. ECMWF is clearly acknowledged by the sentence “The CPU time made available by the ECMWF to generate meteorology has been of crucial importance for this year’s status and trend calculations.” in the EMEP status reports.

<u>Peer-reviewed EMEP publications</u>

Angelbratt J., J. Mellqvist, D. Simpson, J. E. Jonson, (2011) Carbon monoxide (CO) and ethane (C2H6) trends from ground-based solar FTIR measurements at six European stations, comparison and sensitivity analysis with the EMEP model Atmos. Chem. Phys. , 2011, 11 (17), 9253-9269.

Colette, A., C. Granier, Ø. Hodnebrog, H. Jakobs, A. Maurizi, A. Nyiri, S. Rao, M. Amann, B. Bessagnet, A. D’Angiola, M. Gauss, C. Heyes, Z. Klimont, F. Meleux, M. Memmesheimer, A. Mieville, L. Rouil, F. Russo, S. Schucht, D. Simpson, F. Stordal, F. Tampieri, and M. Vrac, (2012) Future air quality in Europe: a multi-model assessment of projected exposure to ozone, Atmos. Chem. Phys., 12, 10613–10630, doi:10.5194/acp-12-10613-2012.

Simpson, D., A. Benedictow, H. Berge, R. Bergström, L. D. Emberson, H. Fagerli, C. R. Flechard, G. D. Hayman, M. Gauss, J. E. Jonson, M. E. Jenkin, A. Nyíri, C. Richter, V. S. Semeena, S. Tsyro, J.-P. Tuovinen, Á. Valdebenito, and P. Wind, (2012) The EMEP MSC-W chemical transport model – technical description, Atmos. Chem. Phys., 12, 7825-7865.

Tsyro S., W. Aas, J. Soares, M. Sofiev, H. Berge, & G. Spindler, (2011) Modelling of sea salt concentrations over Europe: key uncertainties and comparison with observations Atmos. Chem. Phys., 2011, 11 (20), 10367-10388.

<u>EMEP reports</u>

- EMEP Status Report 1/11: "Transboundary acidification, eutrophication and ground level ozone in Europe in 2009", Joint MSC-W & CCC & CEIP Report, http://emep.int/publ/reports/2011/status_report_1_2011.pdf

- EMEP Status Report 1/12: "Transboundary acidification, eutrophication and ground level ozone in Europe in 2010", Joint MSC-W & CCC & CEIP Report, http://emep.int/publ/reports/2012/status_report_1_2012.pdf

- Supplementary material to EMEP Status Report 1/12, "EMEP Unified model performance for acidifying and eutrophying components and photo-oxidants in 2010", Joint MSC-W & CCC Report, http://emep.int/publ/reports/2012/Validation_2010.pdf

- EMEP Status Report 4/11, "Transboundary Particulate Matter in Europe: Status Report 2011", Joint CCC & MSC-W & CEIP & CIAM Report

- Klein, H., M. Gauss, A. Nyıri, & B.M. Steensen. Transboundary Data by Main Pollutants (S, N, O3) and PM Country Reports. EMEP/MSC-W Data Note 1/2011.

- Gauss, M., A. Nyıri, B.M. Steensen & H. Klein. Transboundary Data by Main Pollutants (S, N, O3) and PM Country Reports. EMEP/MSC-W Data Note 1/2012.

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Future plans

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Currently, the CPU quota allocated to the Norwegian Meteorological Institute (met.no) suffices to satisfy our data needs. However, a new special project will be considered when the met.no quota is not sufficient for EMEP's needs.

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