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Interactive Comment

Interactive comment on "Extrapolating future Arctic ozone losses" *by* B. M. Knudsen et al.

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Is there really an alternative to the use of coupled chemistry-climate models? Part 2

Gravity wave forcing

Gravity wave forcing (GWF) and the cold pole problem is potentially the most serious issue affecting highly temperature dependent processes such as PSC formation. However, it is not as serious an issue for the Arctic as is implied by the authors. The temperature biases of a range of CCMs are shown in Austin et al. (2003) and the largest cold bias is in the upper stratosphere over the southern winter pole. This reaches 30K in models without a GWF scheme. In the lower stratosphere the zonal average temperature does not necessarily give the whole picture as the biases are somewhat smaller (5̃K). Here, tropospheric processes and the amplitudes of lower

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stratospheric planetary waves could have a larger impact than GWF in producing local temperature variations which determine PSC areas. In the lower stratospheric Arctic, there is certainly no clear indication that zonal average temperatures are improved with a GWF scheme. So based on results from the range of models of Austin et al. (2003) I would disagree with Shindell et al. (2003) and suggest that for the Arctic, model resolution is more important than GWF. In Austin et al. (2003) we had difficulty in following on from T < 195K areas to ozone amounts in the respective models. Unfortunately each model had to all intents and purposes a different PSC scheme so the areas were not necessarily representative of ozone depletion rates. So certainly, the UMETRAC results in Figure 6 are incorrect, as in that model (Austin and Butchart, 2003) ternary solutions were employed.

Ozone loss or ozone amounts?

For the past, the Figures are quite convincing for the years shown but need updating. The same information has largely appeared in previous work in slightly different form (Rex et al., 2004) so one has to question why the results are shown again without updates. For the future, depending on the assumptions adopted the ozone loss out to 2030 shows a small rise or a small fall. The authors have not included the case of zero water vapour trend with zero temperature trend, results that are perfectly plausible in view of the results from several CCMs and GCMs. Taking their solid green line in Figure 5, the impact of a halving of the PSC trend after 2003 is to reduce the ozone loss by about 7 Mt by 2030. So eliminating the trend entirely would presumably result in 14 Mt less ozone depletion. Without the H2O trend, we would get an additional 2-3 Mt, if I have interpreted Figure 5 correctly. Thus, alternative assumptions would give a year 2030 ozone depletion figure of order 24 Mt, approximately the same as the value in 1985.

While it is important to be able to understand the ozone loss rates from a scientific

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viewpoint, the relevant quantity is the ozone amount itself. In middle latitudes transport is equally important to a first order (Hadjinicolaou et al., 2002) and it might be anticipated that Arctic ozone columns are equally affected by transport. Thus as the chemical depletion reduces by 10 DU so the ozone might be expected to recover by 20 DU. These estimates would explain why many models may show a substantial ozone recovery by the year 2030, when viewed in the framework of the ozone amounts, and why the technique of the current authors is in my view inadequate.

Future simulations

In the future I would hope that our CCM simulations could include suitable additional tracers and diagnostics as discussed by the current authors and as indicated in Eyring et al. (2004). One tracer would be a passive ozone molecule so that the actual model depletion in a given winter could be determined. Another model internal diagnostic would be the actual PSC volume computed using the model PSC scheme rather than diagnosed off-line. This, I hope could reveal the true extent of CCM performance and give more confidence in their predictions.

References

- Austin, J. and Butchart, N., Coupled chemistry-climate model simulations for the period 1980 to 2020: ozone depletion and the start of ozone recovery, Q. J. R. Meteorol. Soc., 129, 3225-3249, 2003.
- Austin, J., Butchart, N. and Shine, K.P., Possibility of an Arctic ozone hole in a doubled-CO2 climate, Nature, 360, 221-225, 1992.
- Austin, J., D. Shindell, C. Brühl, M. Dameris, E. Manzini, T. Nagashima, P. New-

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man, S. Pawson, G. Pitari, E. Rozanov, C. Schnadt, and T.G. Shepherd, Uncertainties and assessments of chemistry-climate models of the stratosphere, Atmos. Chem. Phys., 3, 1-27, 2003.

- Butchart, N., Austin, J., Knight, J.R. Scaife, A.A. and Gallani, M.L., The response of the stratospheric climate to projected changes in the concentrations of the well-mixed greenhouse gases from 1992 to 2051, J. Climate, 13, 2142-2159, 2000.
- Eyring, V., et al., A strategy for process-oriented validation of coupled chemistry-climate models, SPARC Newsletter No. 23, In Press, 2004.
- Fahey, D.W., Gao, R.S., Carslaw, K.S. et al., The detection of large HNO_3-containing particles in the winter arctic stratosphere, Science, 291, 1026-1031, 2001.
- Hadjinicolaou, P., A. Jrrar, J.A. Pyle and Bishop, L., The dynamically driven long-term trend in stratospheric ozone over northern middle latitudes, 128, 1393-1412, 2002.
- Hein R., Dameris, M., Schnadt, C., Land, C., Grewe, V., Kohler, I., Ponater, M., Sausen, R., Steil, B., Landgraf, J., and Brühl, C., Results of an interactively coupled atmospheric chemistry - general circulation model: comparison with observations, Annales. Geophysicae, 19, 435-457, 2001.
- IPCC, Climate Change 2001, The scientific basis, Cambridge University Press, Cambridge, U.K., Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J., Dai, X., Maskell, K. and Johnson, C.A. (Eds.), 2001.
- Joshi, M.M. and Shine, K.P., A GCM study of colcanic eruptions as a cause of increased stratospheric water vapor, J. Climate, 16, 3525-3534, 2003.

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- Oltmans, S.J., Vomel, H., Hofmann, D.J., Rosenlof, K.H. and Kley, D., The increase in stratospheric water vapor from balloonborne, frostpoint hygrometer measurements at Washington, D.C. and Boulder, Colorado, Geophys. Res. Lett., 27, 3453-3456, 2000.
- Ramaswamy et al., Stratospheric temperature trends: observations and model simulations, Rev. Geophys., 39, 71-122, 2001.
- Randel, W.J. and Wu, F., Cooling of the Arctic and Antarctic polar stratospheres due to ozone depletion, J. Clim., 12, 1467-1479, 1999.
- Randel, W.J., Wu, F. and Oltmans, S.J., Interannual variability of stratospheric water vapor and correlations with tropical tropopause temperatures, J. Atmos. Sci., In Press, 2004.
- Rex, M., Salawitch, R.J., von der Gathen, P., Harris, N.R.P., Chipperfield, M.P. and Naujokat, B., Arctic ozone loss and climate change, Geophys. Res. Lett., 31, 10.1029/2003GL018844, 2004.
- Schnadt, C., Dameris, M., Ponater, M., Hein, R., Grewe, V., and Steil, B., Interaction of atmospheric chemistry and climate and its impact on stratospheric ozone, Clim. Dyn., 18, 501-517, 2002.
- Shindell, D.T., Rind, D. and Lonergan, P., Increased polar stratospheric ozone losses and delayed eventual recovery owing to increased greenhouse gas concentrations, Nature, 392, 589-592, 1998.
- Shine, K.P., et al., A comparison of model-simulated trends in stratospheric temperatures, Q.J.R. Meteorol. Soc., 129, 1565-1588, 2003.
- SPARC, SPARC assessment of upper tropospheric and stratospheric water vapour, Edited by D. Kley, J. M. Russell III, WCRP-113, WMO/TD No. 1043, SPARC Report No. 2, Dec. 2000.

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- Waibel, A.E., Peter, T., Carslaw, K.S., Oelhaf, H., Wetzel, G., Crutzen, P.J., Poschl, U., Tsias, A., Reimer, E., and Fischer, H., Arctic ozone loss due to denitrification, Science, 283, 2064-2069, 1999.
- WMO, Scientific Assessment of Ozone depletion: 2002, WMO Gobal Ozone Research and Monitoring Project, Report No. 47, Geneva, Switzerland, 2003.

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 3227, 2004.

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4, S1073–S1078, 2004

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