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# A climatology of surface ozone in the extra tropics: cluster analysis of observations and model results

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Abstract. Important aspects of the seasonal variations of surface ozone are discussed. The underlying analysis is based on the long-term (1990–2004) ozone records of the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) and the World Data Centre of Greenhouse Gases, which provide data mostly for the Northern Hemisphere. Seasonal variations are pronounced at most of the 114 locations at all times of the day. A seasonal-diurnal variations classification using hierarchical agglomeration clustering reveals 6 distinct clusters: clean background, rural, semi-polluted non-elevated, semi-polluted semi-elevated, elevated and polar/remote marine. For the "clean background" cluster the seasonal maximum is observed in March-April, both for night and day. For those sites with a double maximum or a wide spring-summer maximum, the spring maximum appears both for day and night, while the summer maximum is more pronounced for daytime and hence can be attributed to photochemical processes. The spring maximum is more likely caused by dynamical/transport processes than by photochemistry as it is observed in spring for all times of the day. We compare the identified clusters with corresponding data from the 3-D atmospheric chemistry general circulation model ECHAM5/MESSy1 covering the period of 1998–2005. For the model output as for the measurements 6 clusters are considered. The simulation shows at most of the sites a spring seasonal maximum or a broad spring-summer maximum (with higher summer mixing ratios). For southern hemispheric and polar remote locations the seasonal maximum in the simulation is shifted to spring, while the absolute mixing ratios are in good agreement with the measurements. The seasonality in the model cluster covering background locations is characterized by a pronounced spring (April–May) maximum. For the model clusters which cover rural and semi-polluted sites the role of the photochemical production/destruction seems to be overestimated. Taking into consideration the differences in the data sampling procedure, the comparison demonstrates the ability of the model to reproduce the main regimes of surface ozone variations quite well.

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