Supplementary material The effects of intercontinental emission sources on European air pollution levels: Supplementary tables and figures

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In this supplementary material we include additional tables and figures not included in the paper. Table 1 provides basic information and references to the HTAP2 models included in this study. In addition we include comparisons of surface and sonde measurements and model results from models. In the paper the main focus is on Europe, and this is also reflected in the selection of measurement sites.

Below we also compare model results to measurements at mountain sites. These results should be interpreted with great caution as the height of the measurement sites will be well above the model surface for all models. Elevation will also differ between the models depending on vertical and horizontal resolution and model topography.

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Table 1: Models providing vertical profiles of ozone for the TF HTAP intercomparison. Documentation of the models can be found at http://www.htap.org/ under the heading: Model Descriptions. Only the 7 first models (in bold) provided vertical profiles for the SR20% scenarios. The models were required to use a 6 months spin-up for all model runs.

Model	Resolution (lat long)	layers	Meteorology	Institution	Main reference
EMEP rv48	0.5° x 0.5°	20[1]	ECMWF (IFS)	Met Norway, Oslo, Norway	Simpson et al. (2012)
IFS_v2	0.7° x 0.7°	54	Relaxed to ERA interim	ECMWF, UK	Huijnen et al. (2016)
OsloCTM3_v2	2.8° x 2.8°	60	ECMWF (IFS)	Univ. of Oslo, Norway	Søvde et al. (2012)
CAMchem	1.9° x 2.5°	56	GEOS5 v5.2	NCAR, CO, USA	Tilmes et al. (2016)
CHASER-t42	2.8° x 2.8°	32	Mainly ERA iterim	Univ. Nagoya, Japan	Sudo et al. (2002)
CHASER-t106	1.1° x 1.1°	32	Mainly ERA iterim	Univ. Nagoya, Japan	Sudo et al. (2002)
GEOSCHEMADJ.	2.0° x 2.5°	47	GEOS5 (MERRA)	Univ. Colorado, Boulder, CO, USA	Henze et al. (2007)
GFDL AM3	1.25° x 1.0°	48	NCEP[3]	Univ. Colorado, Boulder, CO, USA	Lin et al. (2012,2015,2017)

[1] O_3 read in from ECMWF IFS model every 3 hours at upper boundary

[2] Interpolated from 100 x 100km^2 polar stereographic grid, N. hemisphere only. No chemistry above approximately 14000m. Prescribed O_2 and NO_y above 30hPa.

[3] The GFDL-AM3 simulations for HTAP2 include interactive stratospheric and tropospheric aerosols and chemistry nudged to NCEP winds using a pressure-dependent nudging technique (Lin et al., 2012). Analysis of long-term observations indicate that GFDL-AM3 captures the impacts of rising Asian emissions on free tropospheric and surface ozone trends over North America over the past few decades (Lin et al., 2015, Lin et al., 2017).

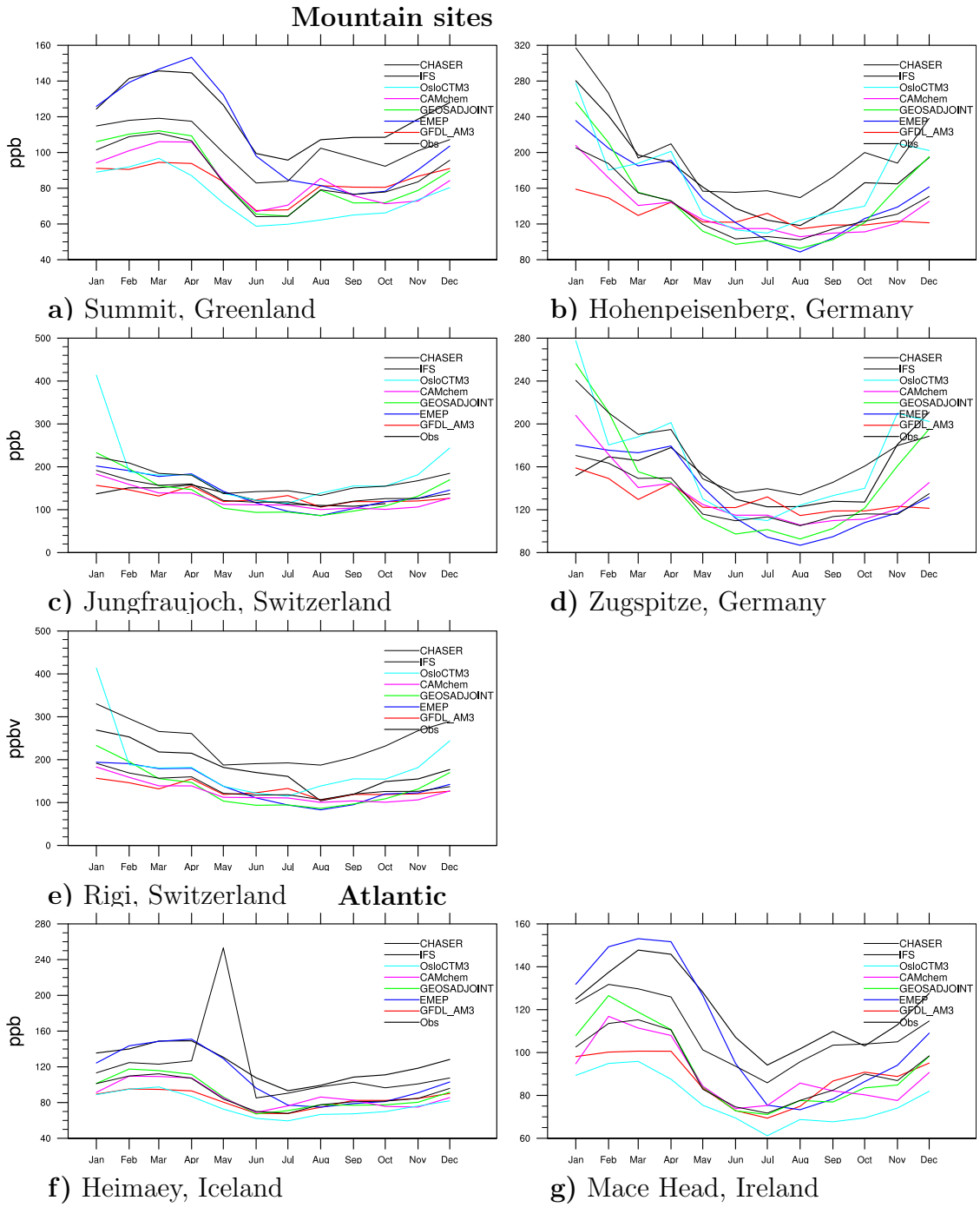
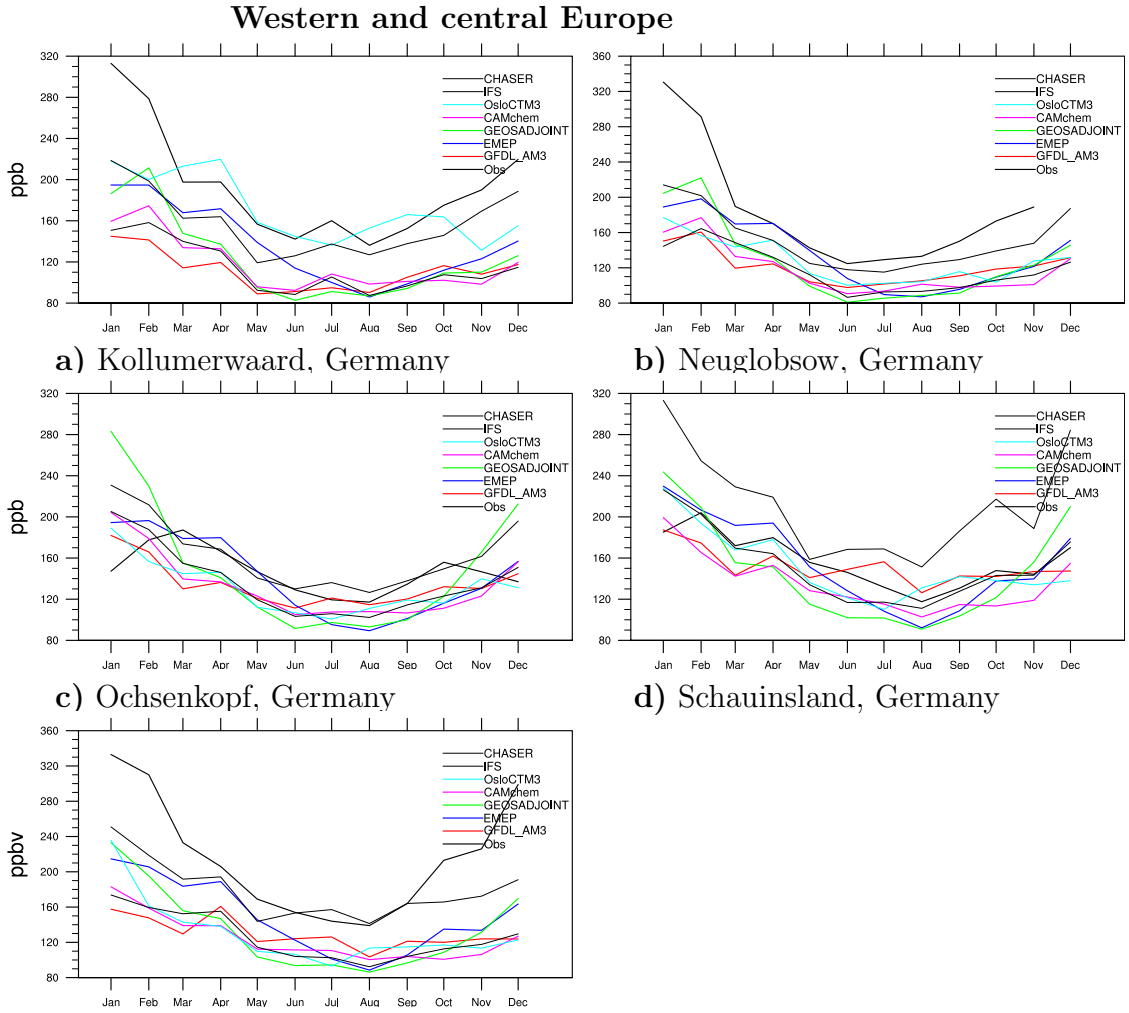


Figure 1: Models versus measurements of CO in ppb at mountain and Atlantic sites. Annual average concentrations and correlations are tabulated in the paper.



a) Kollumerwaard, Germany

b) Neuglobsow, Germany

c) Ochsenkopf, Germany

d) Schauinsland, Germany

c)Payerne, Switzerland

Figure 2: Western and central Europe models versus measurements of CO in ppb. Annual average concentrations and correlations are tabulated in the paper.

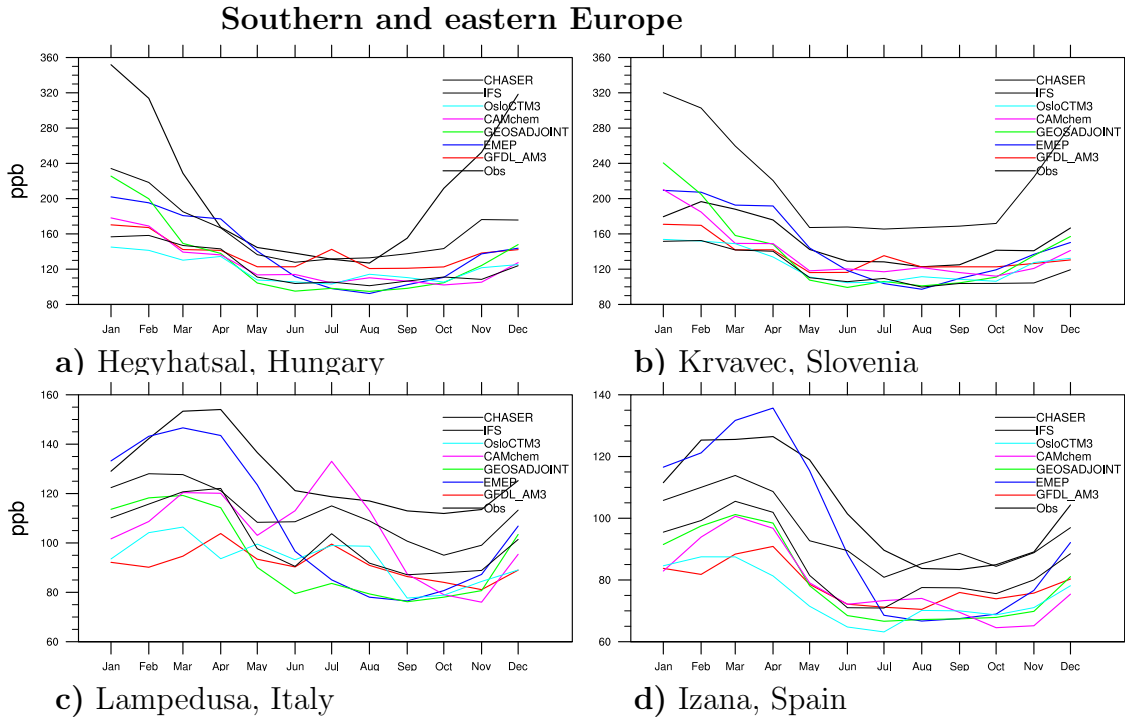


Figure 3: Eastern and southern Europe and Models versus measurements of CO in ppb. Annual average concentrations and correlations are tabulated in the paper.

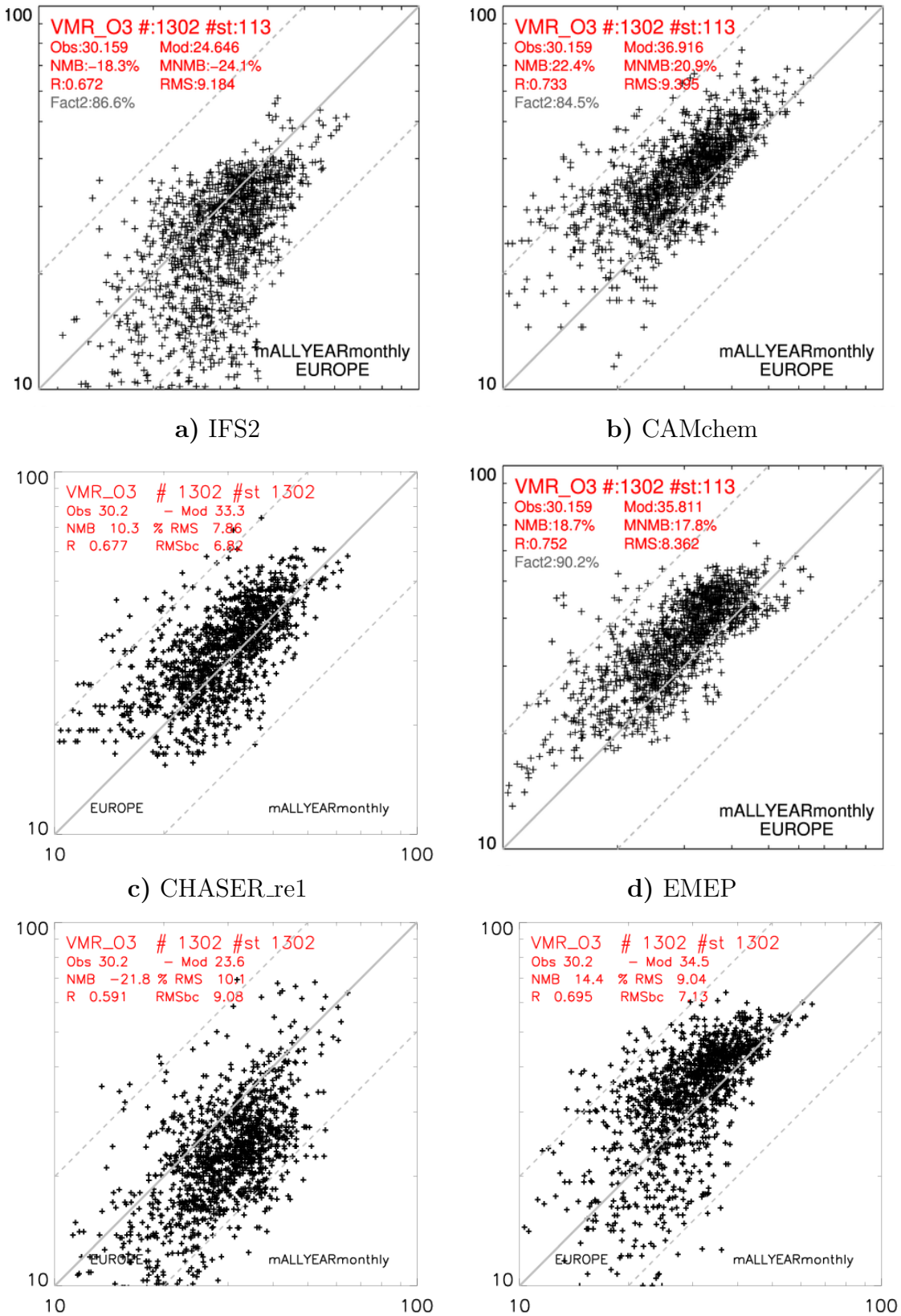


Figure 4: O_3 annual scatter plots in ppb. Model: x-axis, measured:y-axis.

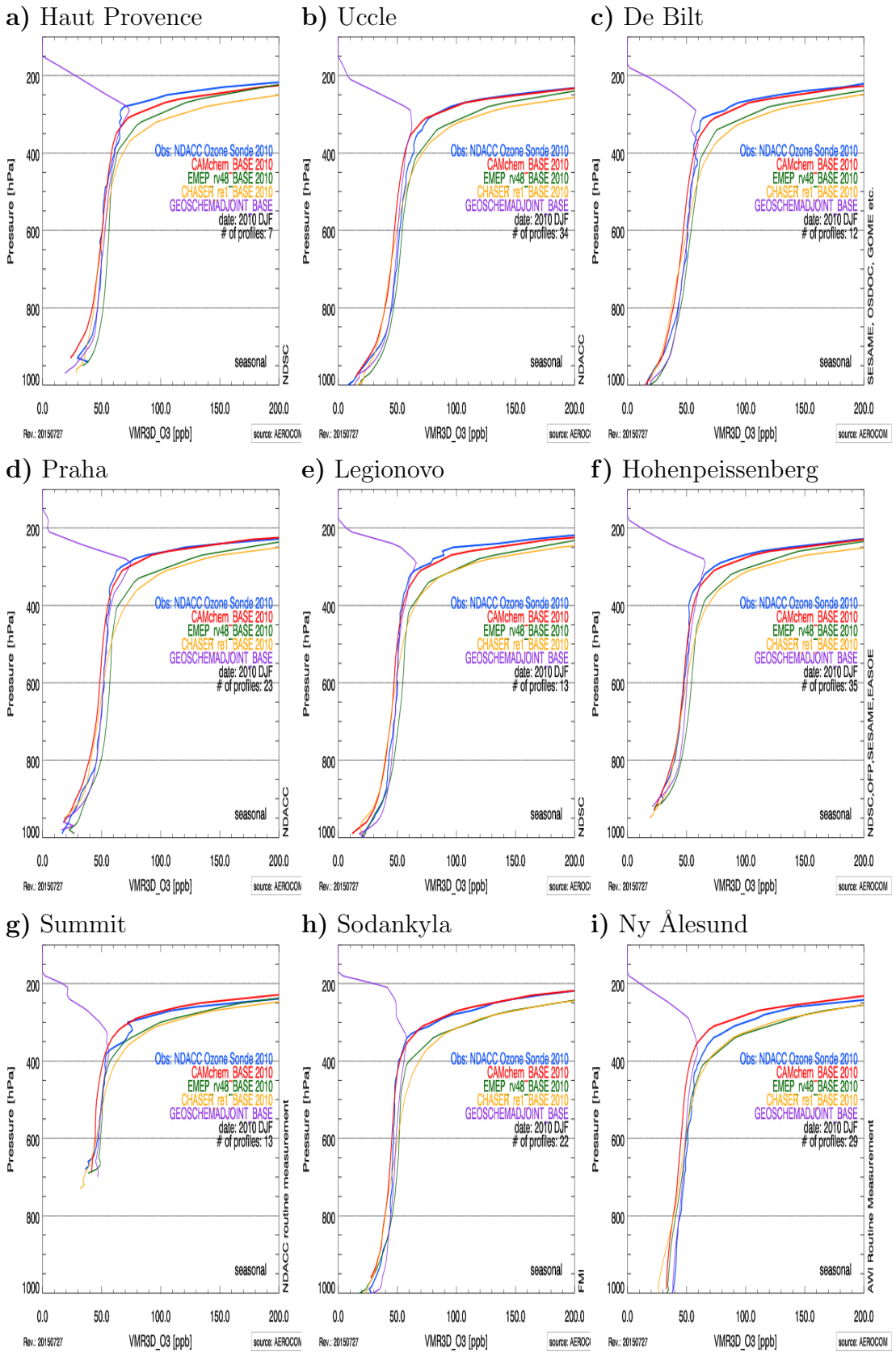


Figure 5: Model calculated O_3 vertical profiles versus ozone sondes averaged for the winter months December, January and February. The Model calculated vertical ozone are calculated based on the approximate same dates and times as the sonde measurements. The number of sonde measurements included for each site is listed in the panels.

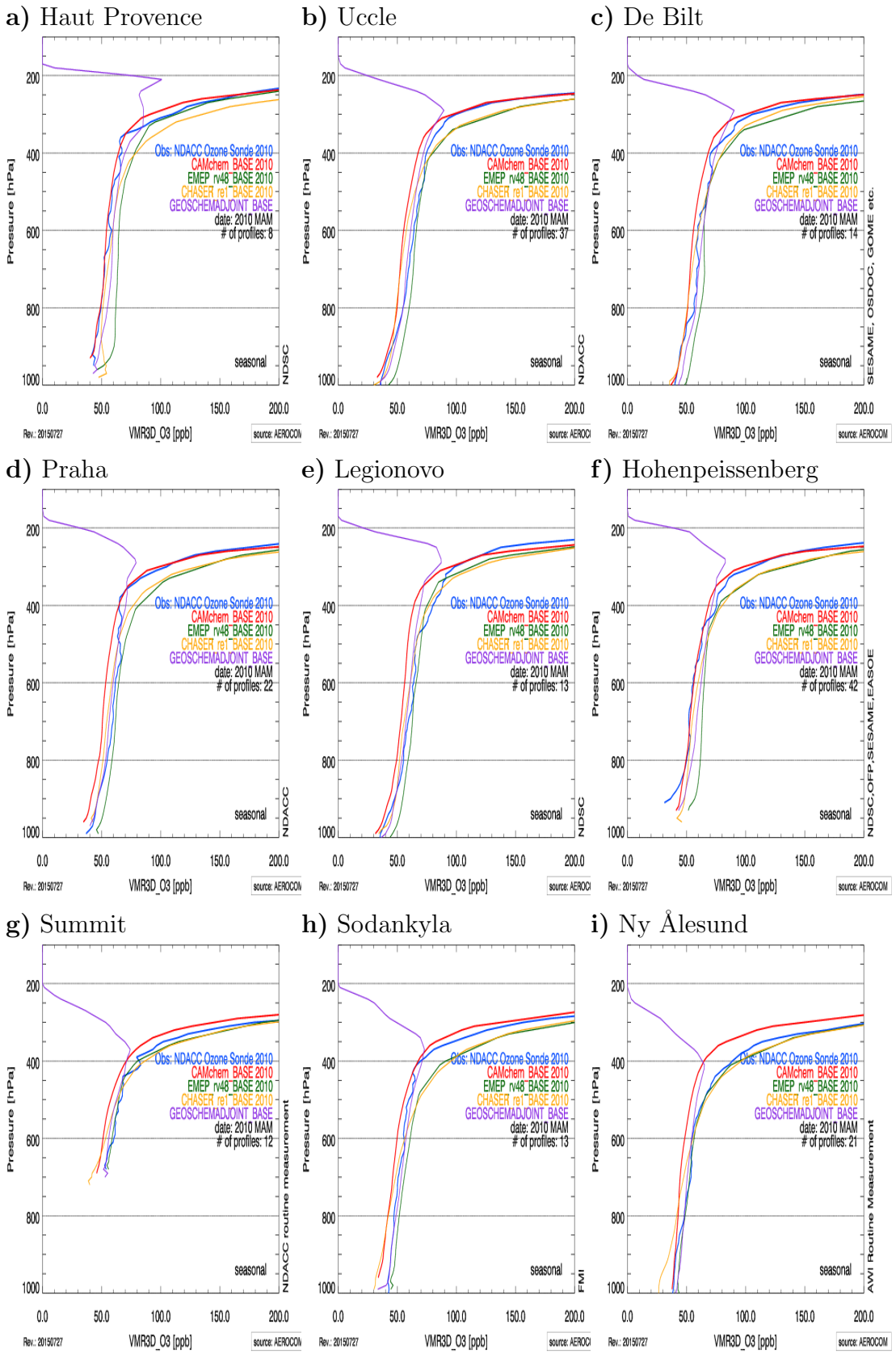


Figure 6: Model calculated O_3 vertical profiles versus ozone sondes averaged for the spring months March, April and May. The Model calculated vertical ozone are calculated based on the approximate same dates and times as the sonde measurements. The number of sonde measurements included for each site is listed in the panels.

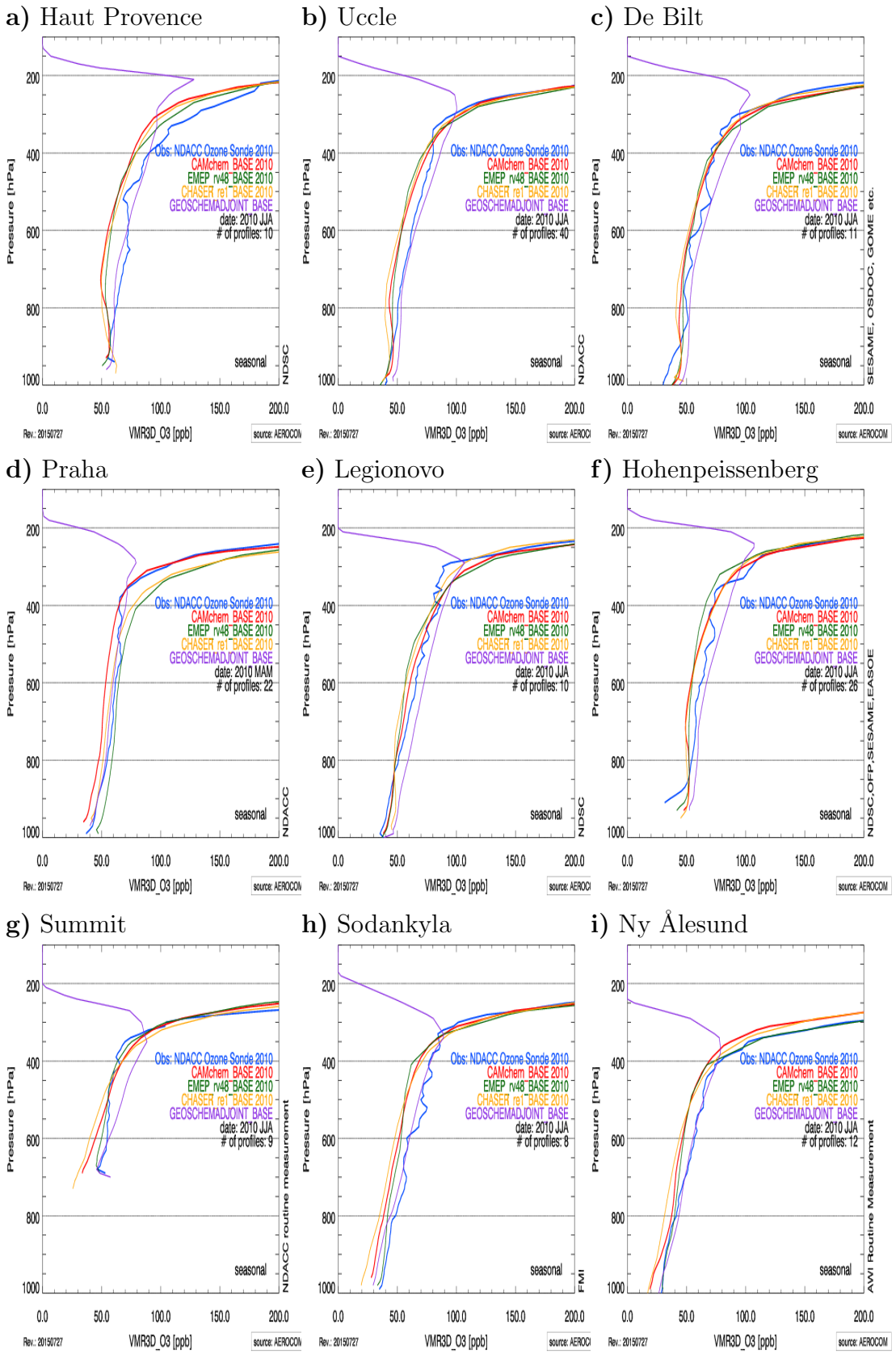


Figure 7: Model calculated O_3 vertical profiles versus ozone sondes averaged for the summer months June, July and August. The Model calculated vertical ozone are calculated based on the approximate same dates and times as the sonde measurements. The number of sonde measurements included for each site is listed in the panels.

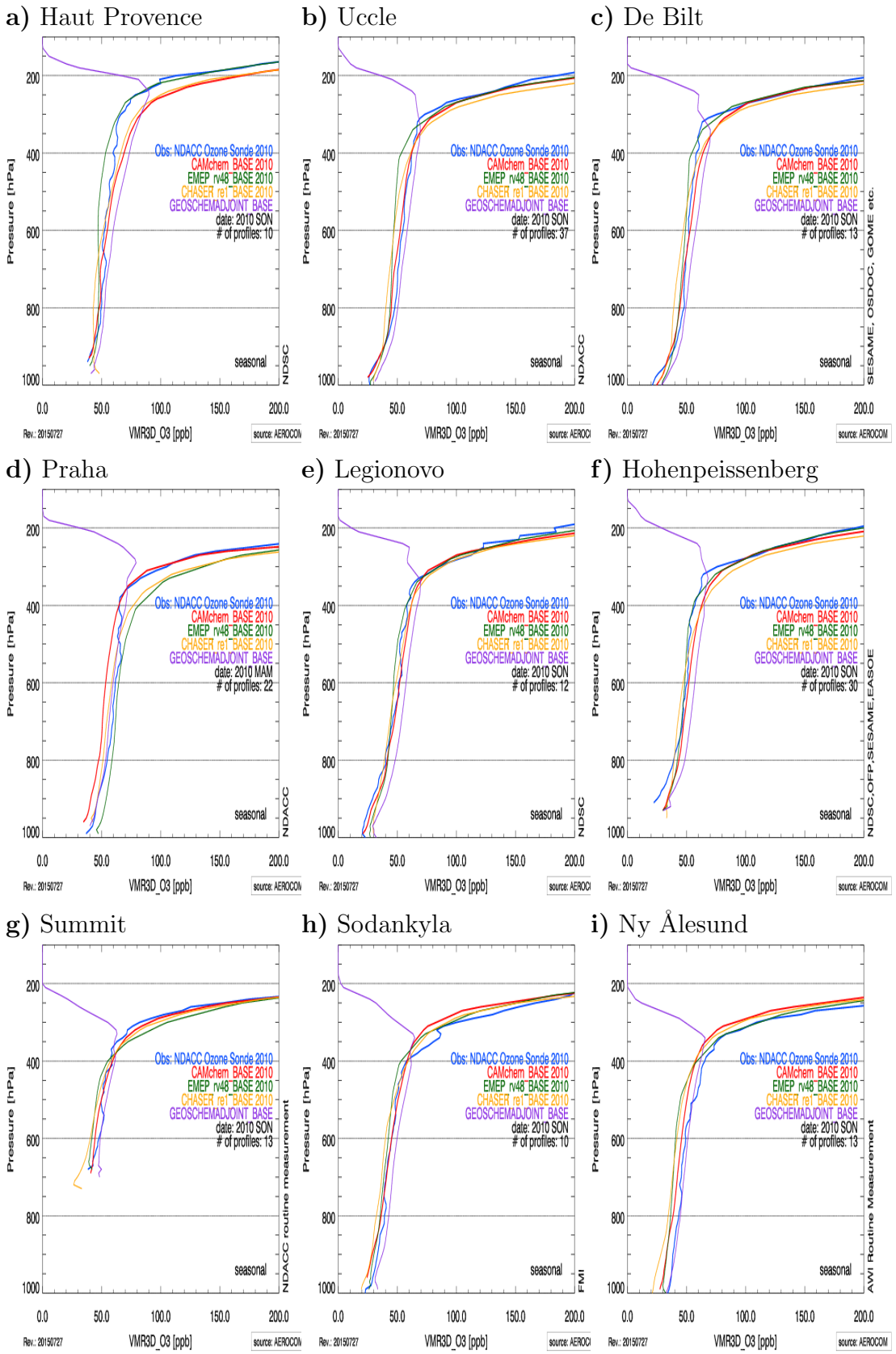


Figure 8: Model calculated O_3 vertical profiles versus ozone sondes averaged for the autumn months September, October and November. The Model calculated vertical ozone are calculated based on the approximate same dates and times as the sonde measurements. The number of sonde measurements included for each site is listed in the panels.

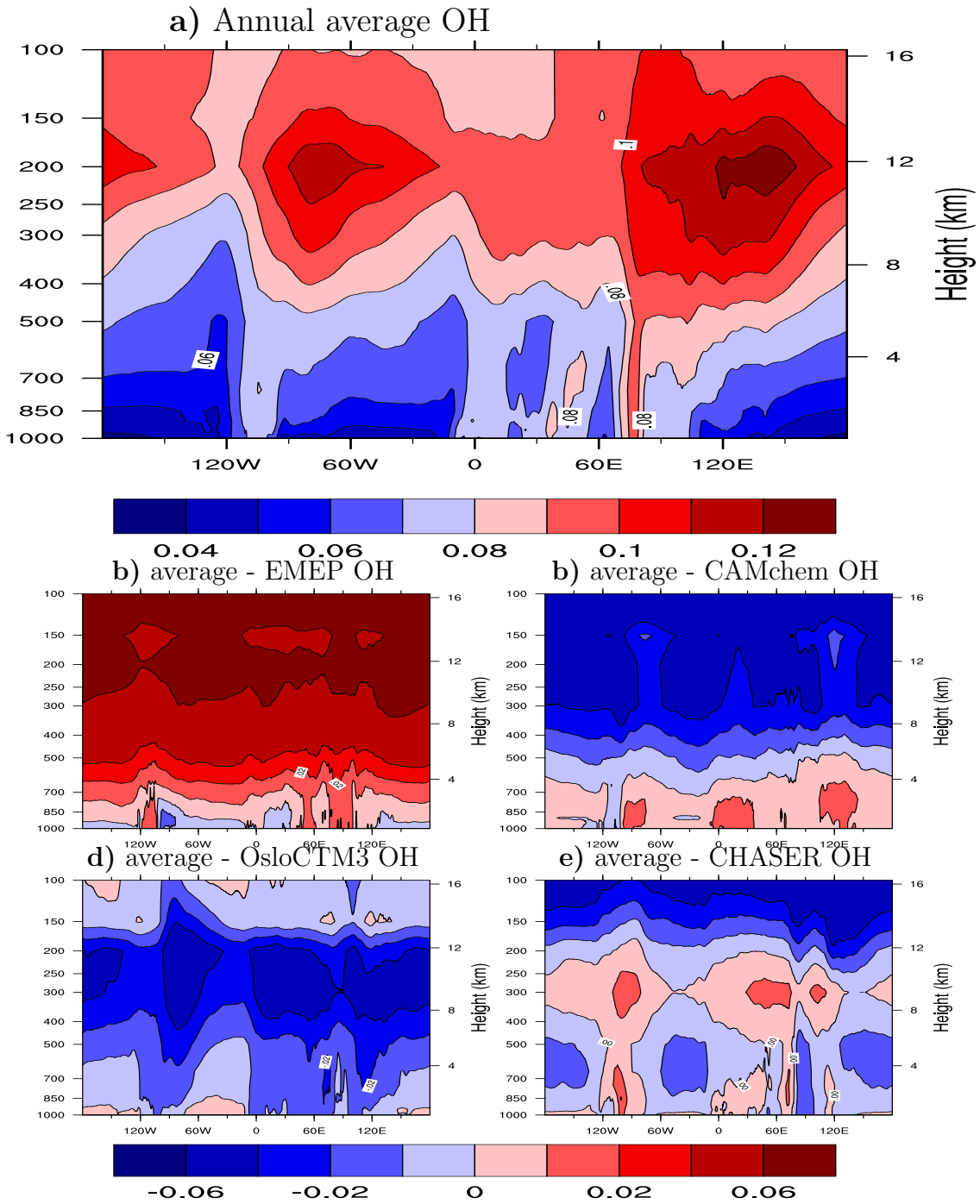


Figure 9: Top, annually averaged OH in ppt between 30 and 40 degrees north for the four models: EMEP_rv4,8, CAMCHEM, OsloCTM3, CHASER_re1. b,c,d,e are difference between average OH and the same four models.