

## Supplement

The first part of the supplement presents a modified version of Fig. 4. In contrast to the original figure, in Fig. S1 the error bars are shown for the retrievals assuming a box-profile (shape parameter = 1).

The second part of the supplement (Figs. S2 – S11) presents the individual graphs of the correlation analyses between the MAX-DOAS results versus independent measurements as well as between MAX-DOAS results of the different telescopes.

In the third part of the supplement, the results of the normalised radiance and the normalised  $O_4$  dAMF $_{\alpha}$  (Fig. S12) are shown for the whole campaign.

The fourth part of the supplement (Fig. S13) presents results for individual days (individual elevation sequences) are shown. For comparison, AOD from the AERONET station at Ispra,  $NO_2$  and HCHO mixing ratios from the long path DOAS instrument, and HCHO mixing ratios from the Hantzsch instrument are also included.

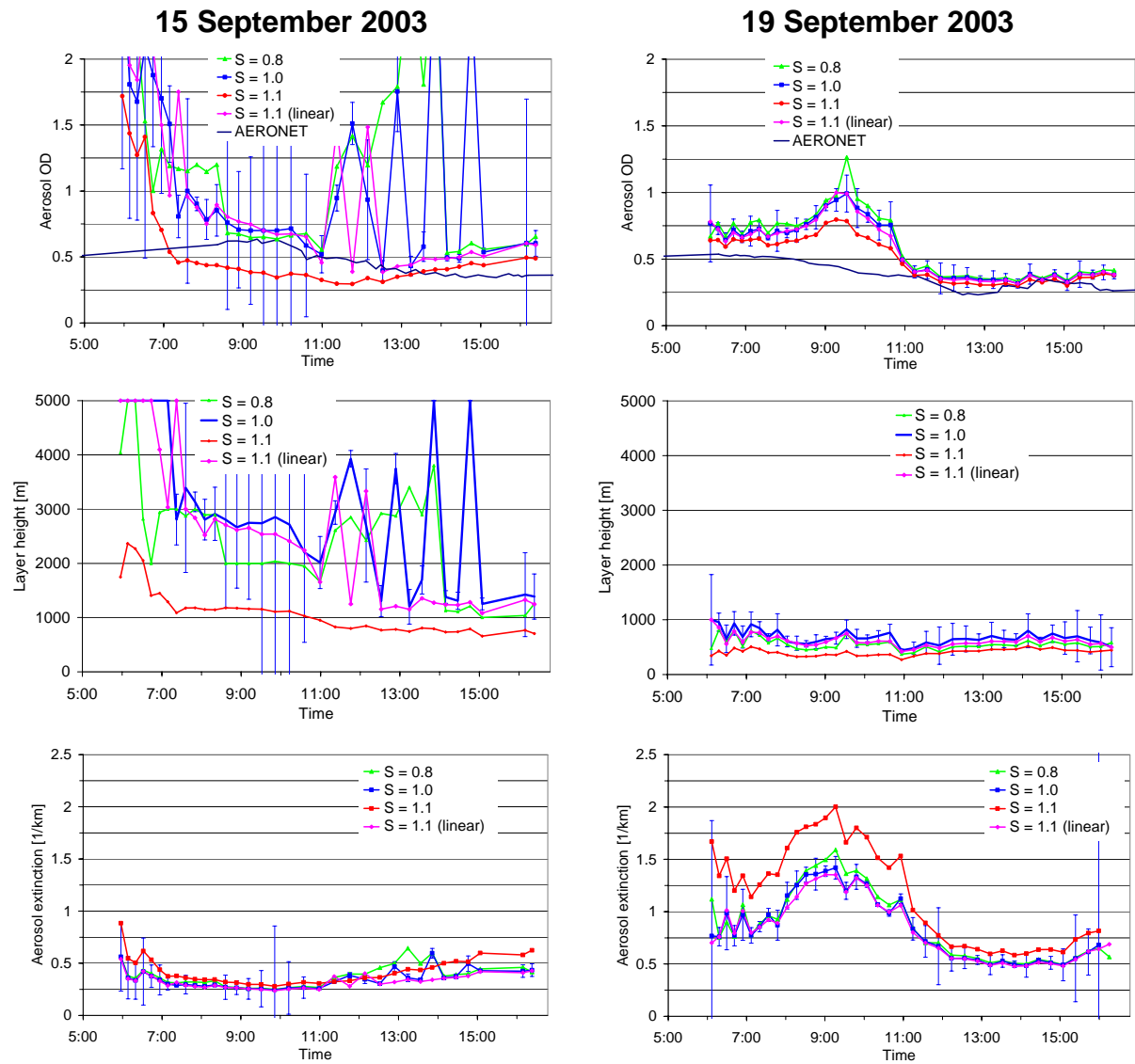


Fig. S1 Diurnal variation of the AOD (top), layer height  $L$  (middle) and aerosol extinction  $\epsilon$  (bottom) for two selected days (southern telescope) for different shape parameters. For comparison, the AOD from sun photometer measurements (AERONET) at Ispra are also shown (black line). Except the early morning of 15 September 2003 (before about 7:00), both days were cloud free (same as Fig. 4, but error bars shown for retrievals with shape parameter = 1).

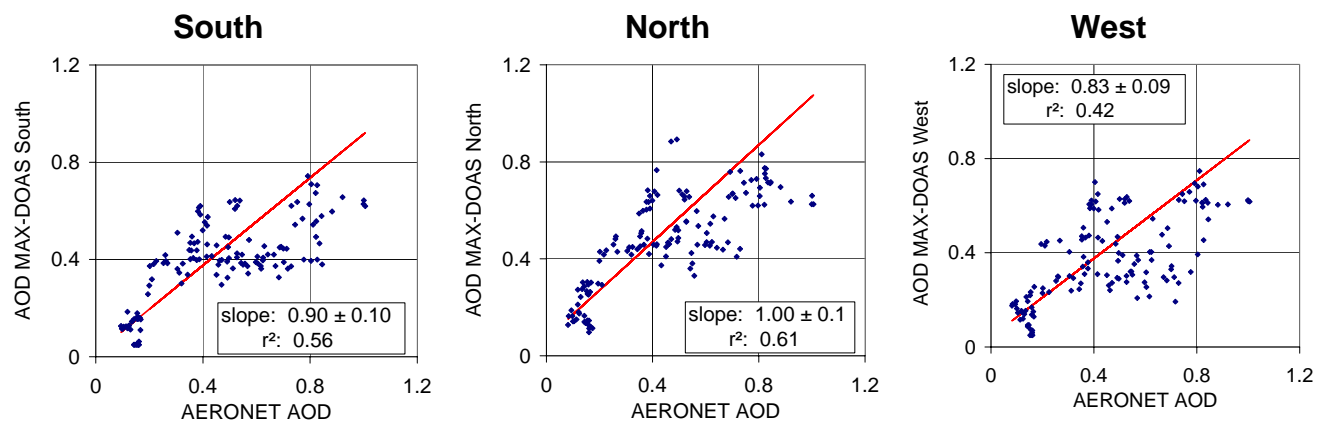


Fig. S2 Correlation analyses for the AOD from MAX-DOAS (at Bresso) versus AERONET (at Ispra). Only clear sky measurements (half hour averages) for the period 12 – 26 September 2003 were used.

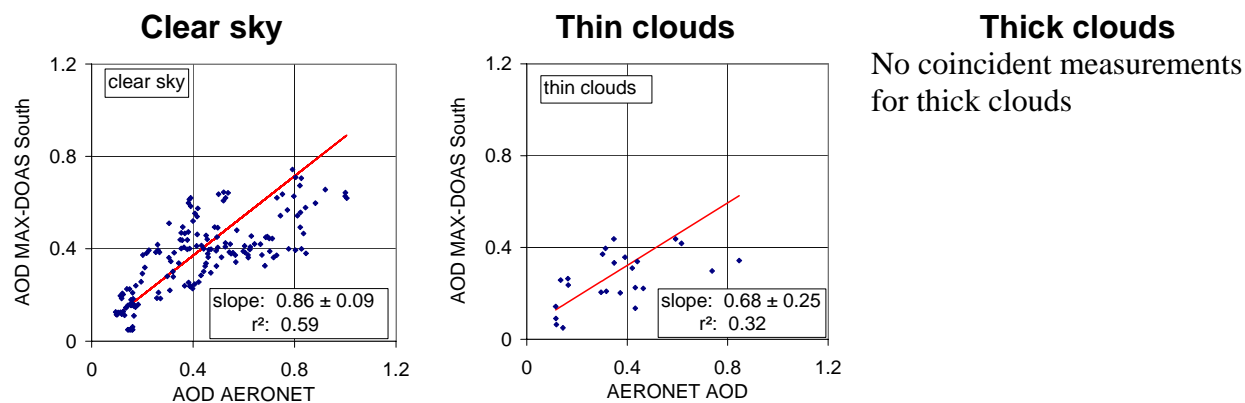


Fig. S3 Correlation analyses for the AOD from MAX-DOAS (at Bresso) versus AERONET (at Ispra) for clear sky (left) and thin clouds (center) (no coincident data points were found for thick clouds). Measurements of the southern telescope for the whole campaign were used (half hour averages) excluding observations from 05 and 07 September 2003, when a fog layer was present at Ispra, but not at Bresso.

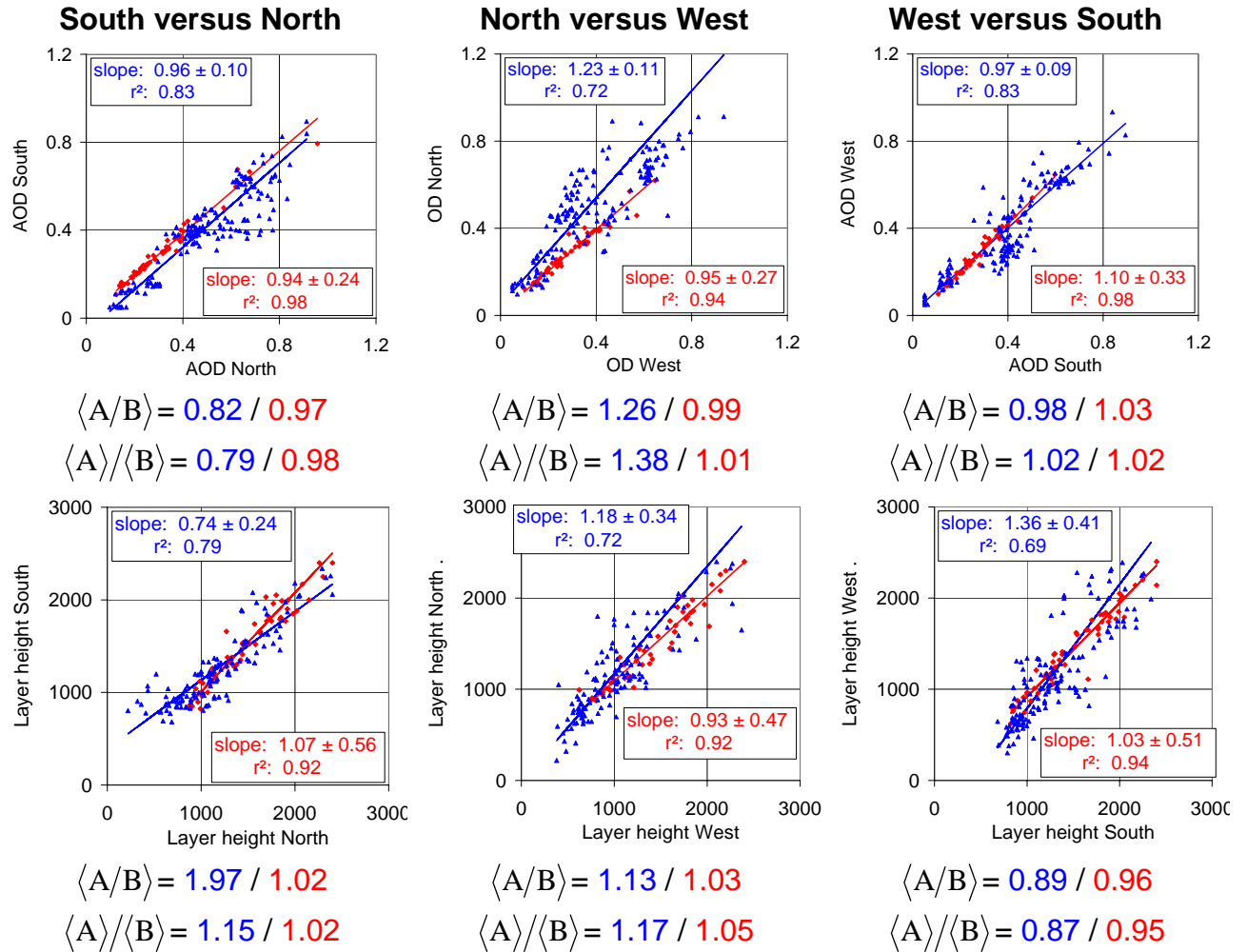


Fig. S4 Correlation analyses for the AOD (top) and aerosol layer heights (bottom) retrieved from the different telescopes (only clear sky observations). Red points indicate measurements during the first part of the campaign (4 – 11 September 2003) when all telescopes were pointing at the same azimuth angle (south). Blue points indicate measurements during the second part of the campaign (12 – 26 September 2003) when the telescopes were pointing at different azimuth angles. For correlation of the layer heights, values  $>2.5\text{km}$  are skipped. Also the mean value of the individual ratios and the ratio of the mean values of both data sets are shown.

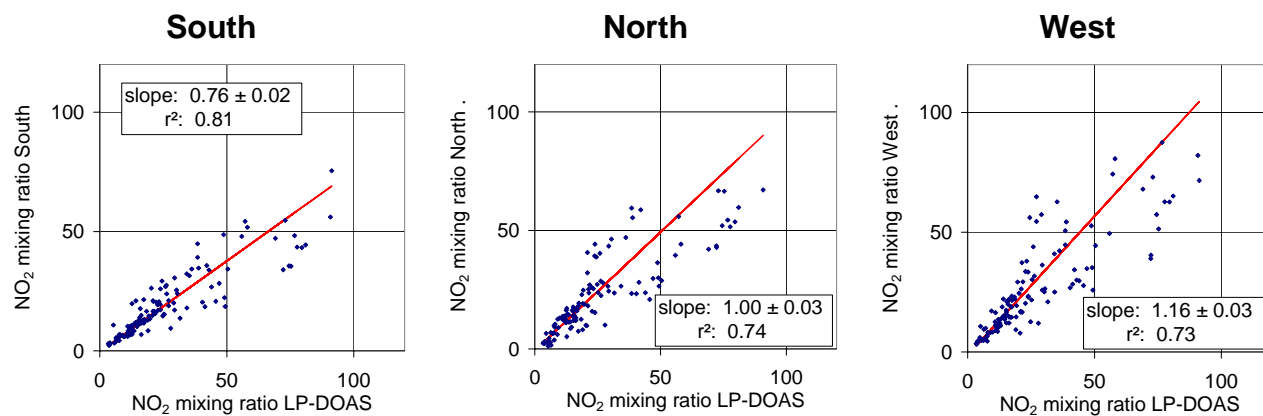


Fig. S5 Correlation analyses for the NO<sub>2</sub> mixing ratio from MAX-DOAS versus LP-DOAS. Only clear sky measurements (half hour averages) for the period 12 – 26 September 2003 were used.

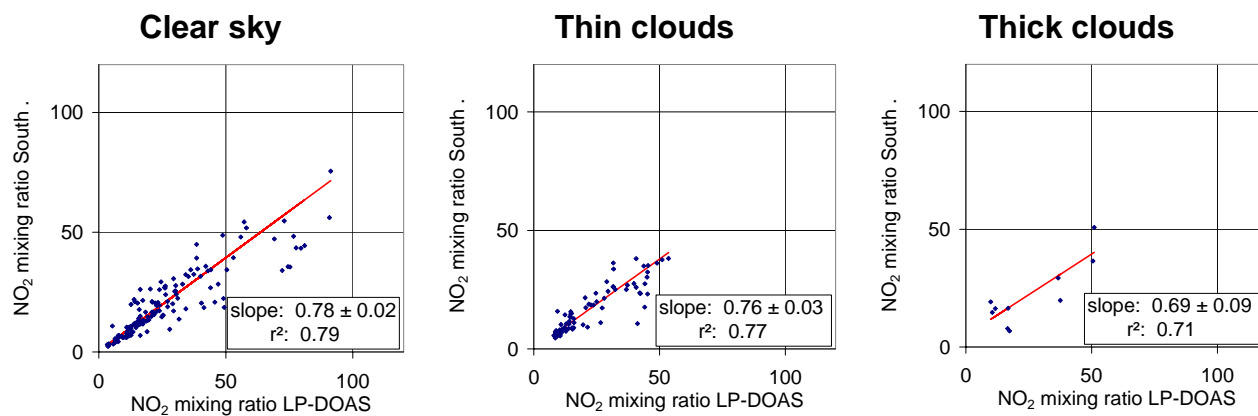


Fig. S6 Correlation analyses for the NO<sub>2</sub> mixing ratio from MAX-DOAS versus LP-DOAS for clear sky (left), thin clouds (center) and thick clouds (right). Measurements (half hour averages) of the southern telescope for the whole campaign were used.

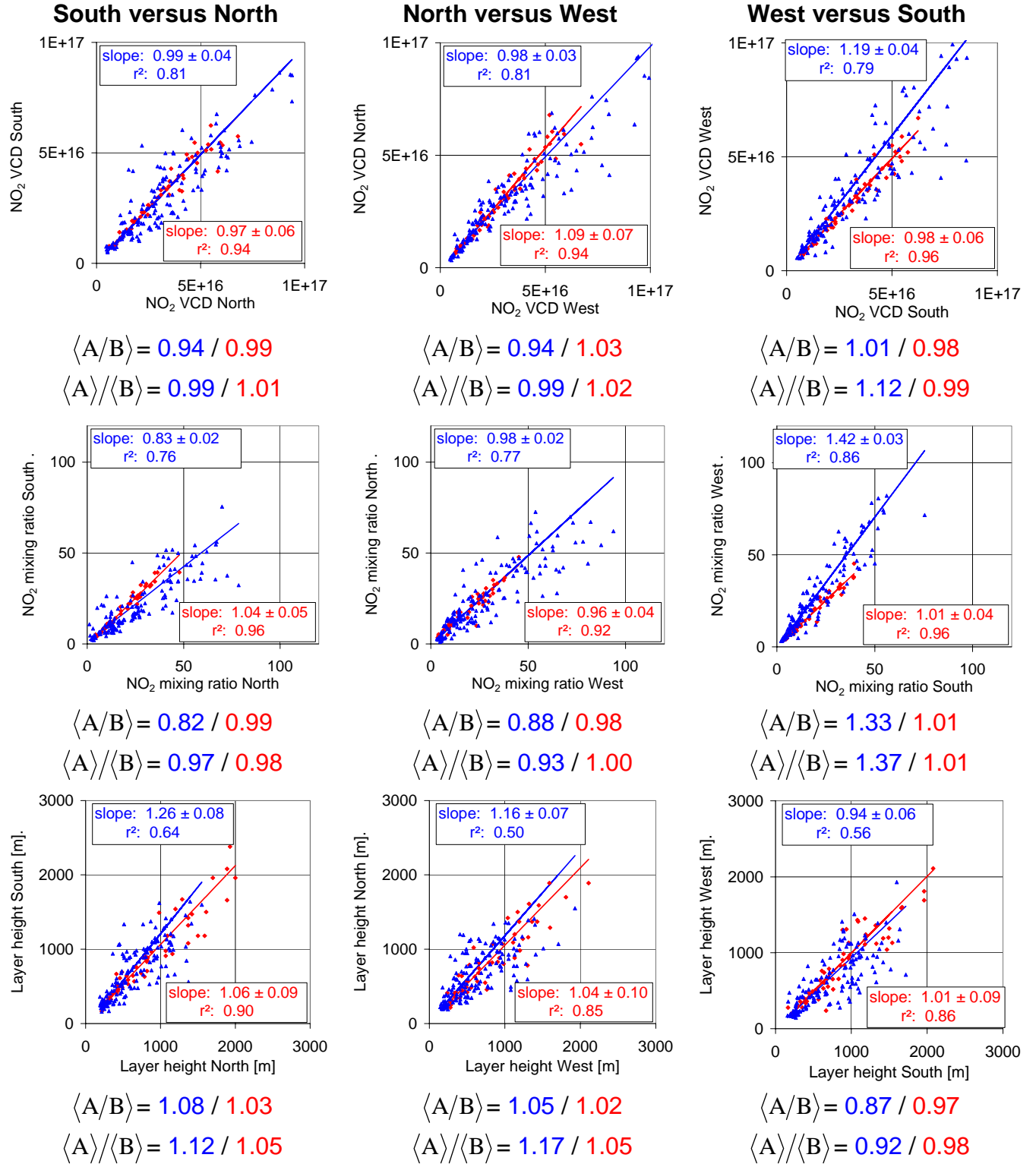


Fig. S7 Correlation analyses for the NO<sub>2</sub> VCDs (top), mixing ratios (center) and NO<sub>2</sub> layer heights (bottom) retrieved from different telescopes (only clear sky observations). Red points indicate measurements during the first part of the campaign (4 – 11 September 2003) when all telescopes were pointing at the same azimuth angle (south). Blue points indicate measurements during the second part of the campaign (12 – 26 September 2003) when the telescopes were pointing at different azimuth angles. For correlation of the layer heights, values >2.5km are skipped.  $\langle A/B \rangle$  indicates the mean value of the individual ratios and  $\langle A \rangle / \langle B \rangle$  the ratio of the mean values.



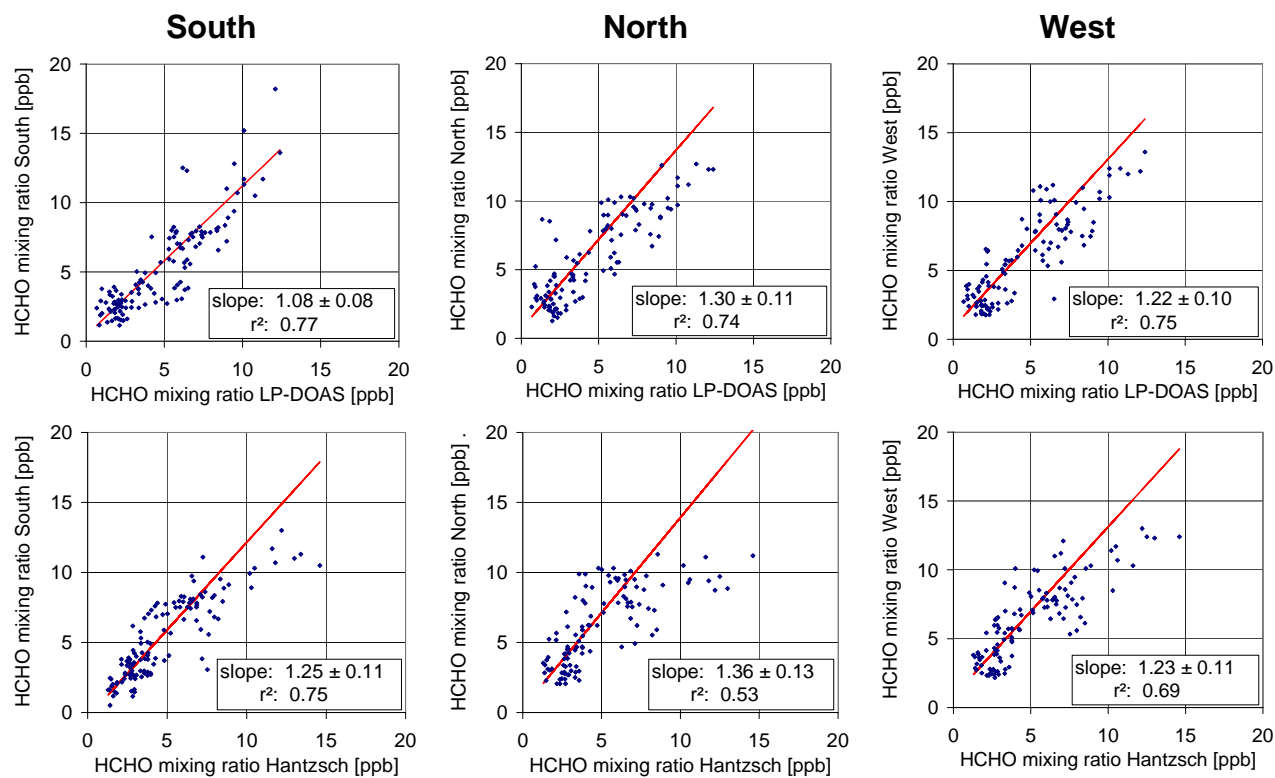


Fig. S8 Correlation analyses for the HCHO mixing ratio from MAX-DOAS versus those from LP-DOAS (top) and Hantzsch instrument (bottom). Only clear sky measurements (half hour averages) for the period 12 – 26 September 2003 were used.

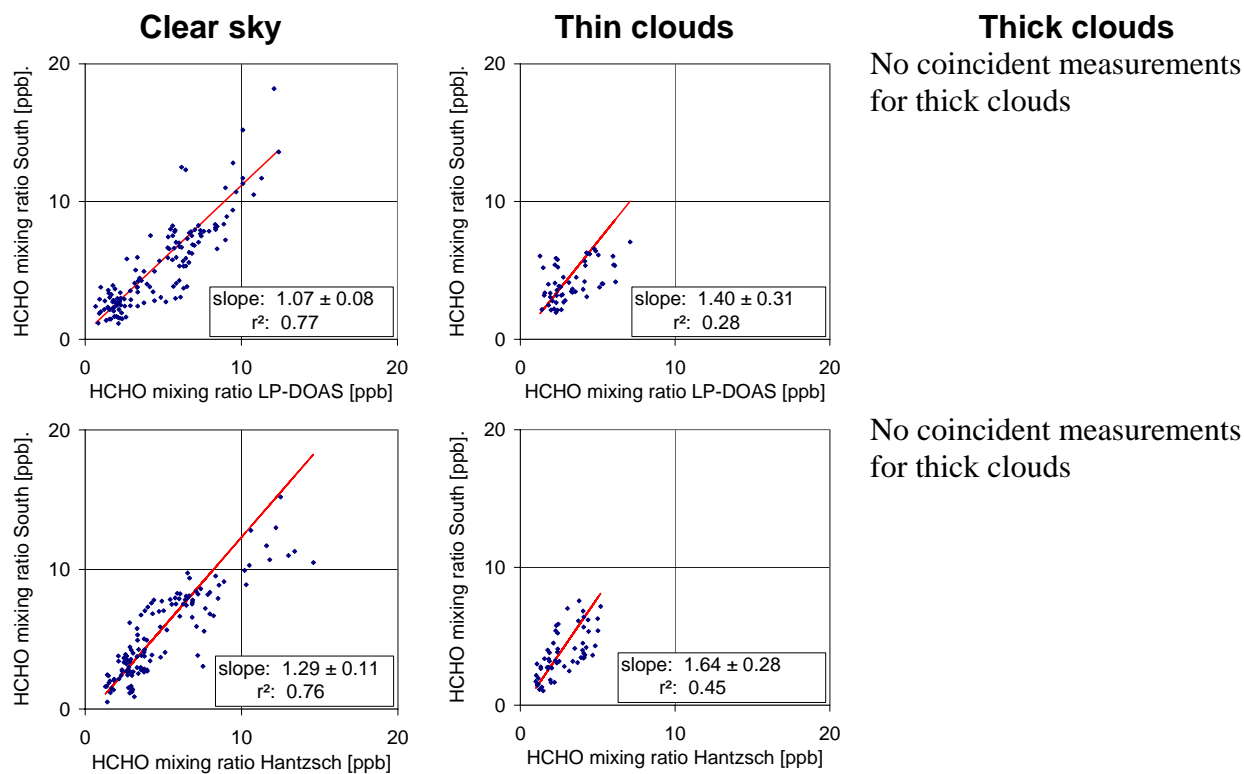


Fig. S9 Correlation analyses for the HCHO mixing ratio from MAX-DOAS observations versus LP-DOAS (top) and the Hantzsch instrument (bottom) for clear sky (left), and thin clouds (center) (no common data points were found for thick clouds). Measurements for the whole campaign were used (half hour averages).

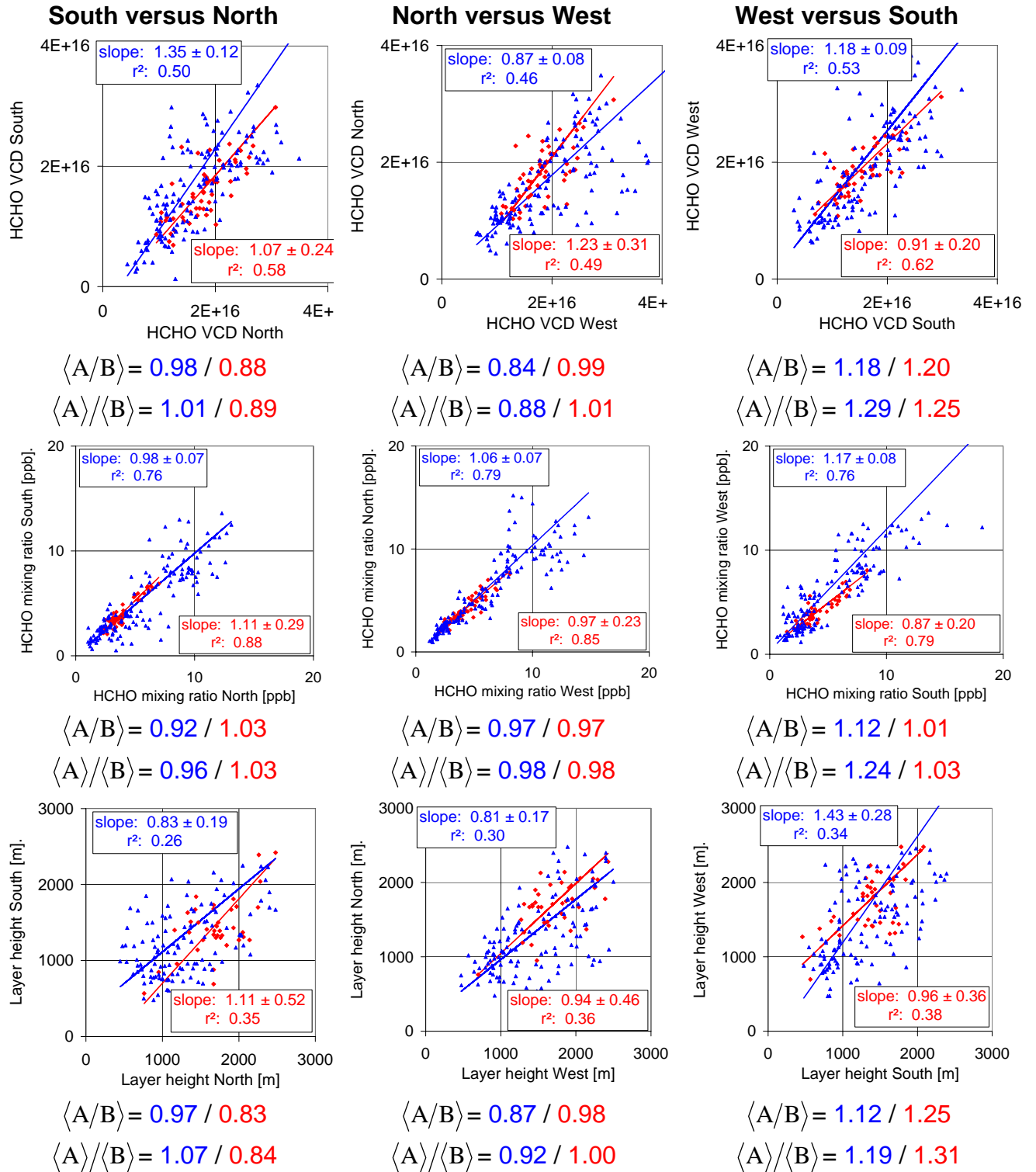


Fig. S10 Correlation analyses for the HCHO VCDs (top), mixing ratios (center) and HCHO layer heights (bottom) retrieved from different telescopes (only clear sky observations). Red points indicate measurements during the first part of the campaign (4 – 11 September 2003) when all telescopes were pointing at the same azimuth angle (south). Blue points indicate measurements during the second part of the campaign (12 – 26 September 2003) when the telescopes were pointing at different azimuth angles. For the correlation of the layer heights, values  $>2.5\text{km}$  are skipped.  $\langle A/B \rangle$  indicates the mean value of the individual ratios and  $\langle A \rangle / \langle B \rangle$  the ratio of the mean values.

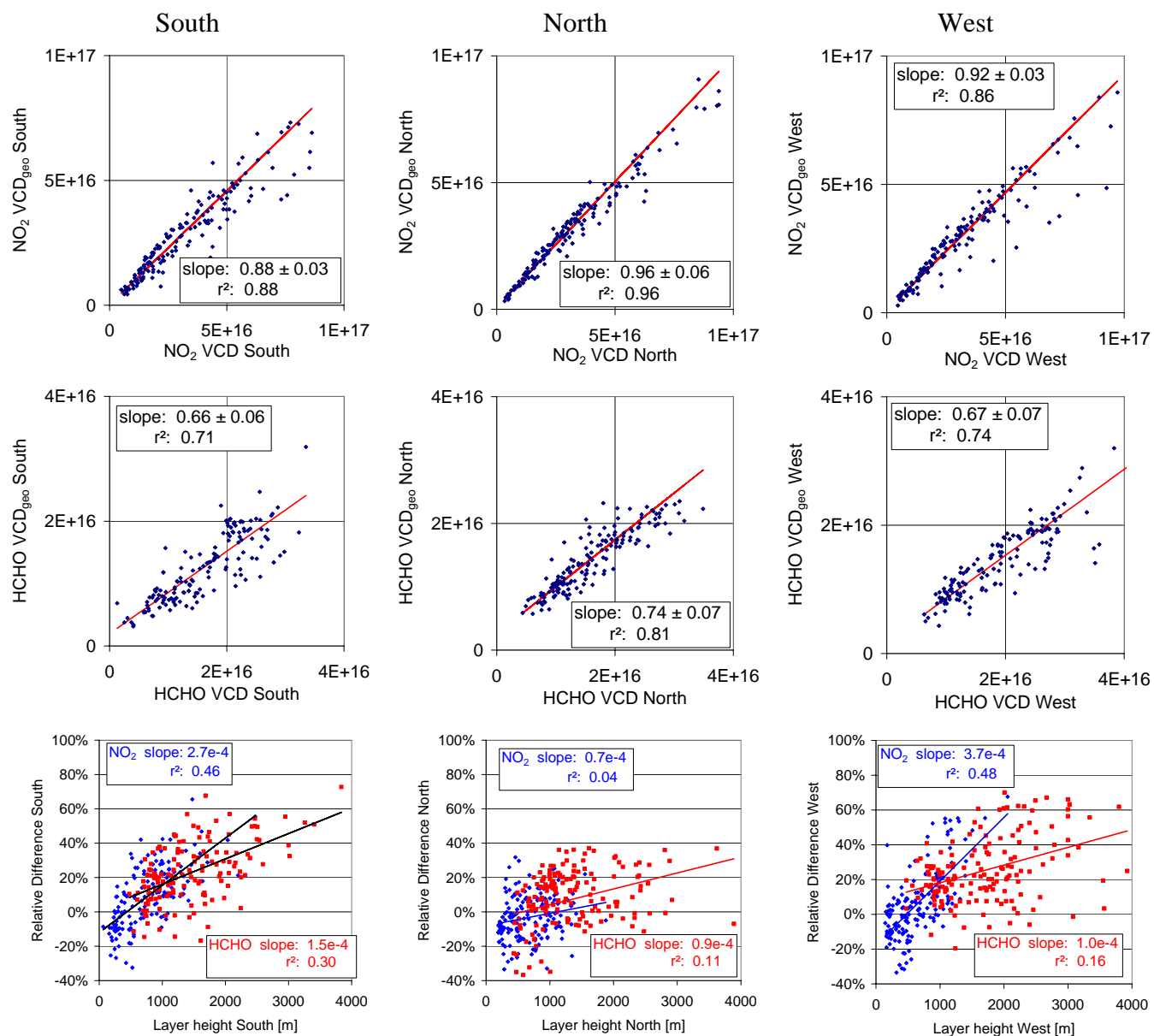


Fig. S11 Correlation analyses for the geometric VCDs of NO<sub>2</sub> (top) and HCHO (center) versus the respective VCDs derived from the profile inversion. The relative difference between both types of VCDs is plotted as a function of the layer height (bottom).

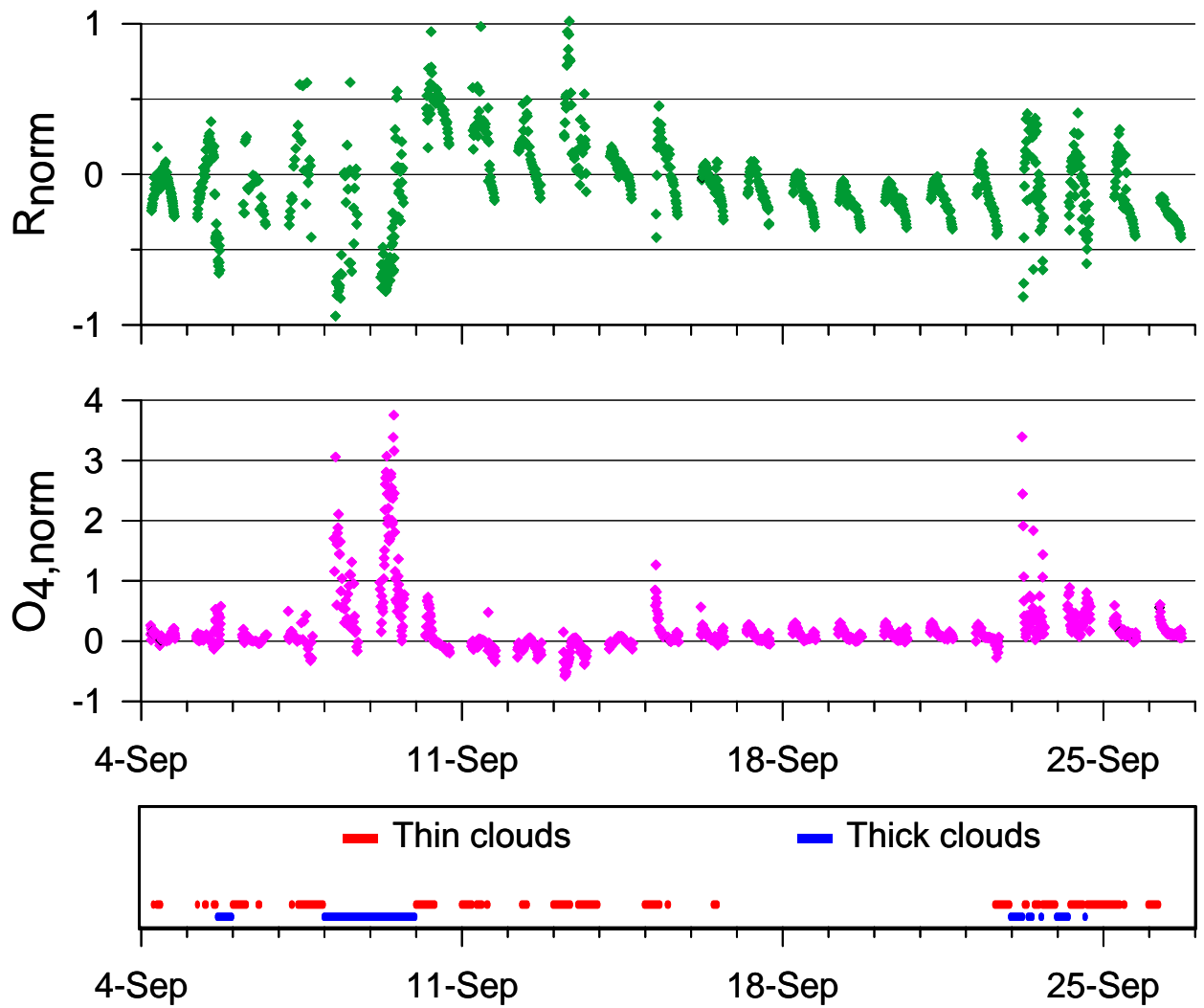
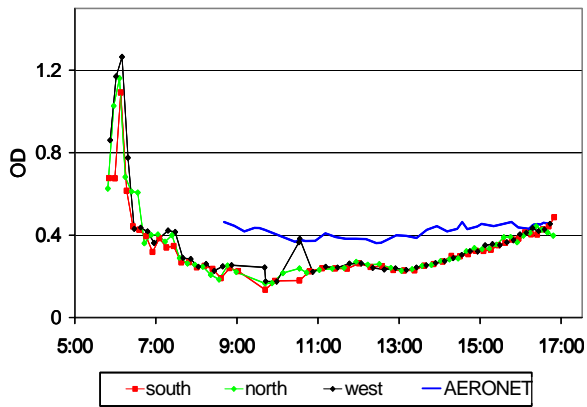
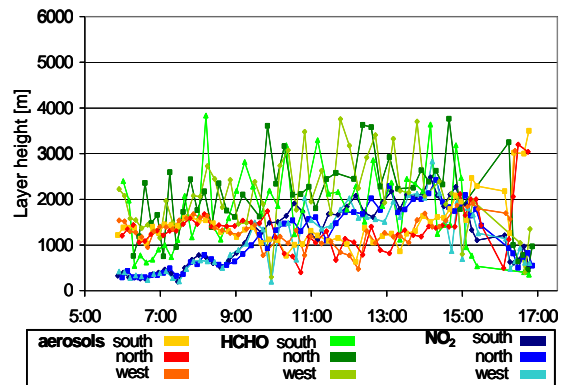
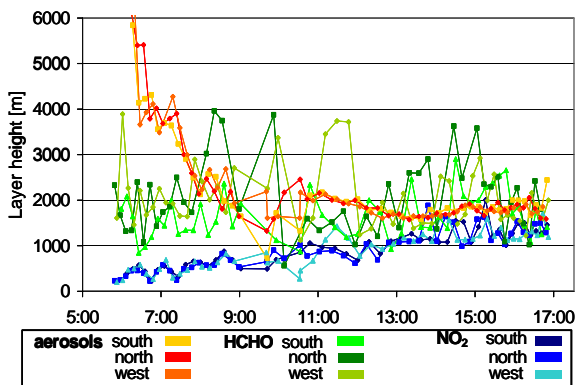
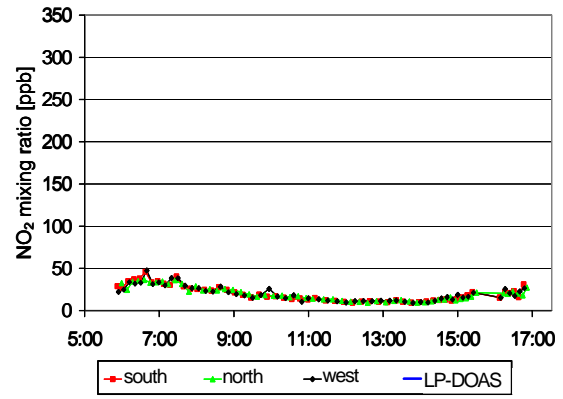
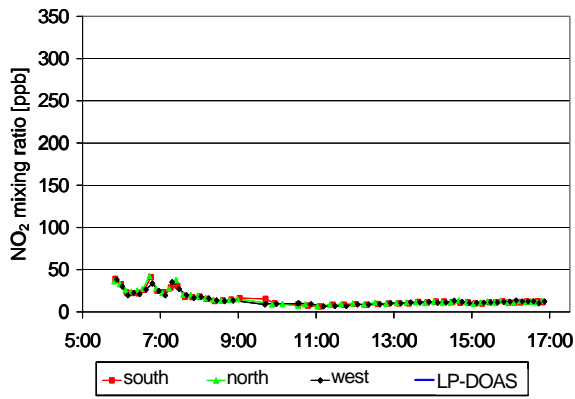
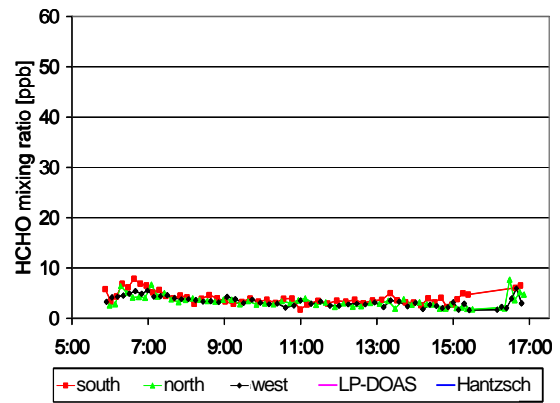
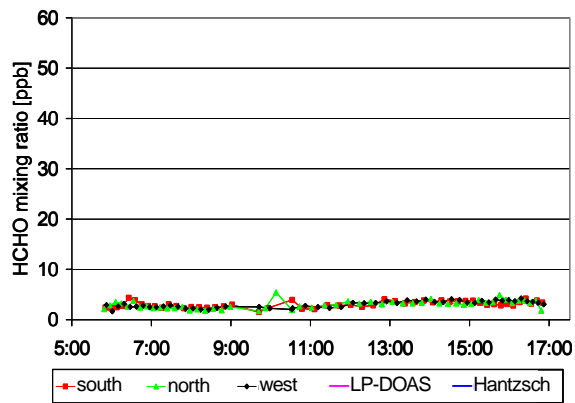
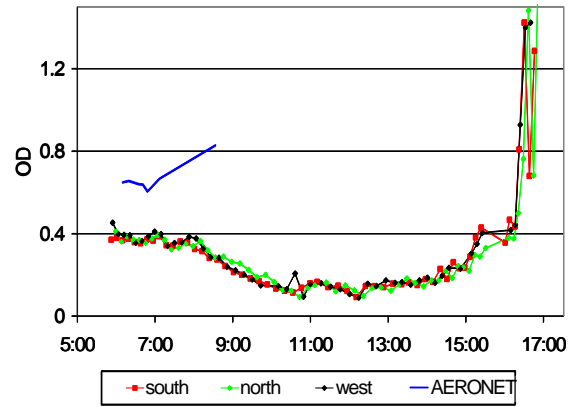


Fig. S12 Top: Normalised radiance (Eq. 17) observed from the zenith direction during the whole campaign. Center: Normalised  $O_4$  AMF (Eq. 18) for the zenith direction during the whole campaign. Bottom: Periods classified as covered by ‘thin clouds’ (red) and ‘thick clouds’ (blue), see section 4.2.

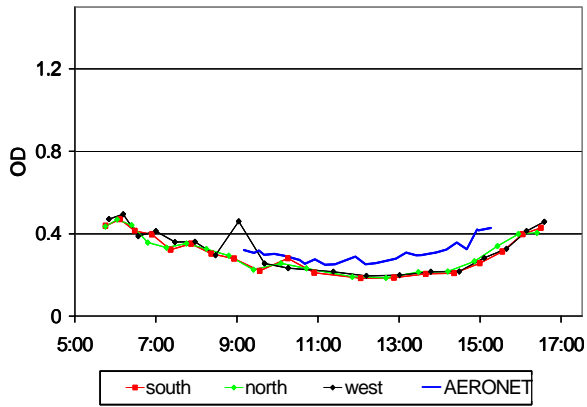
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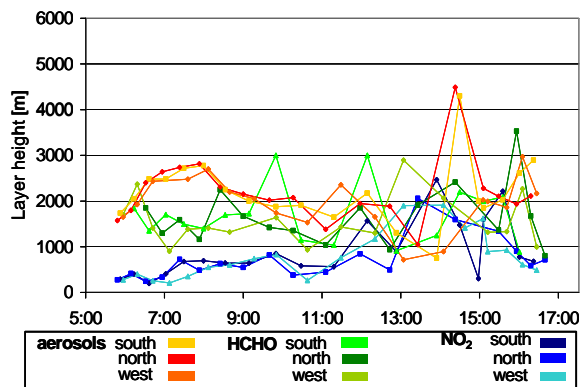
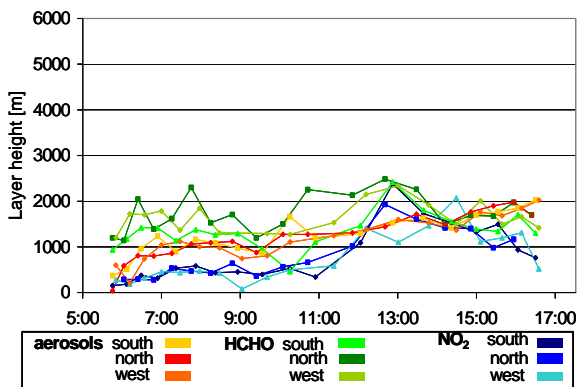
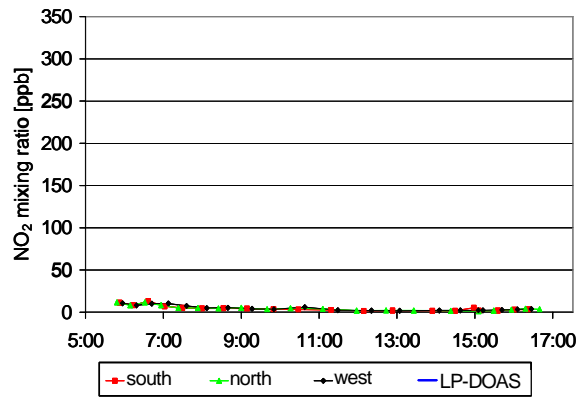
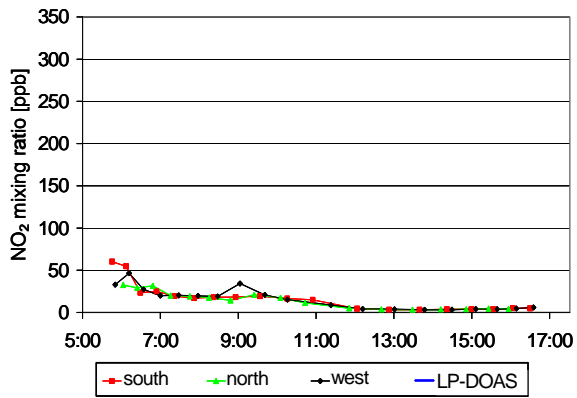
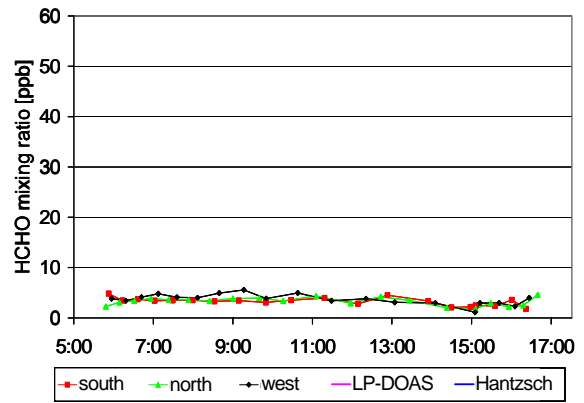
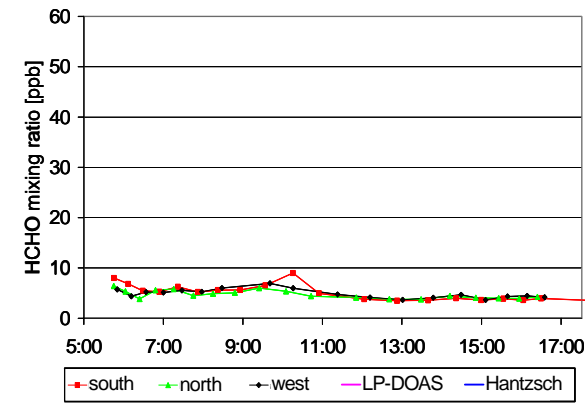
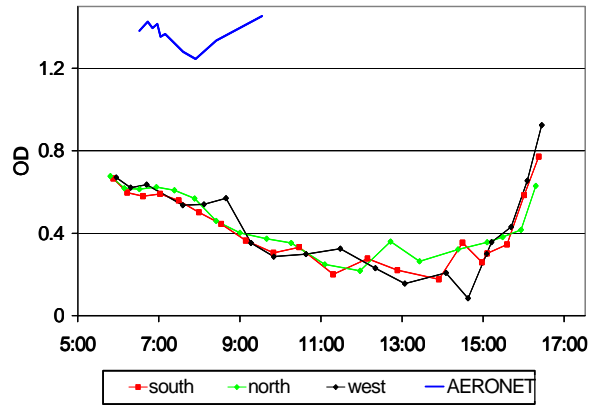
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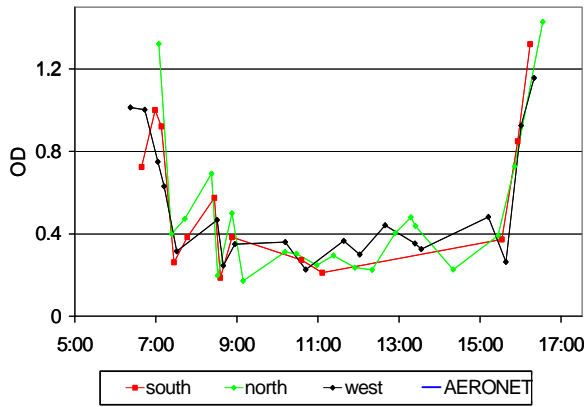
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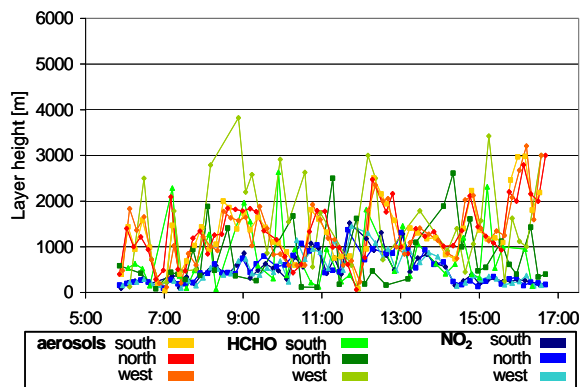
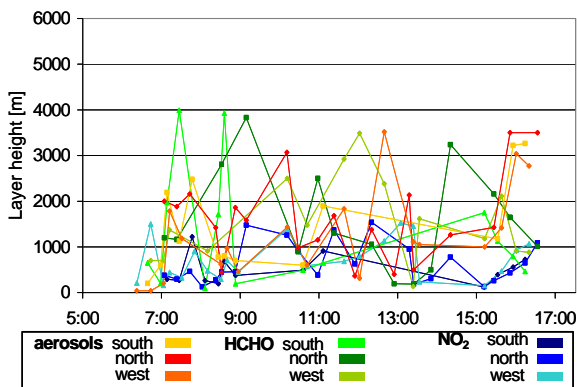
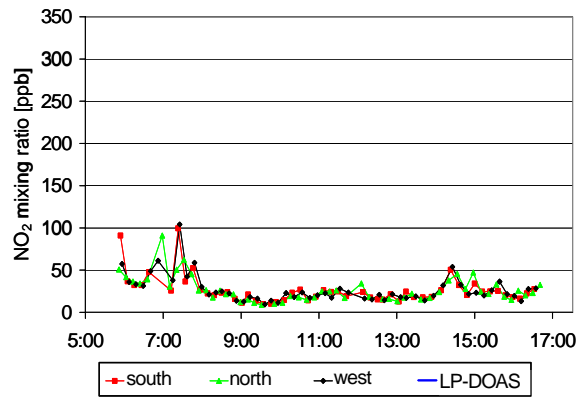
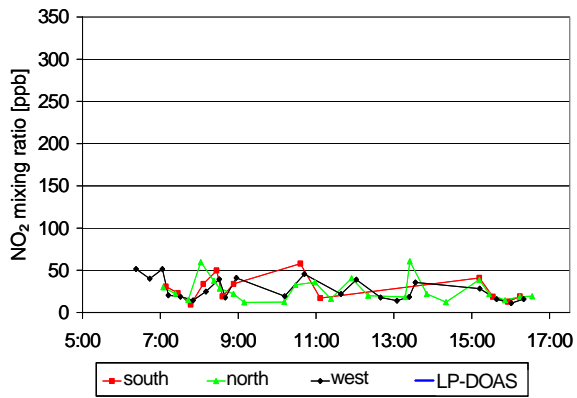
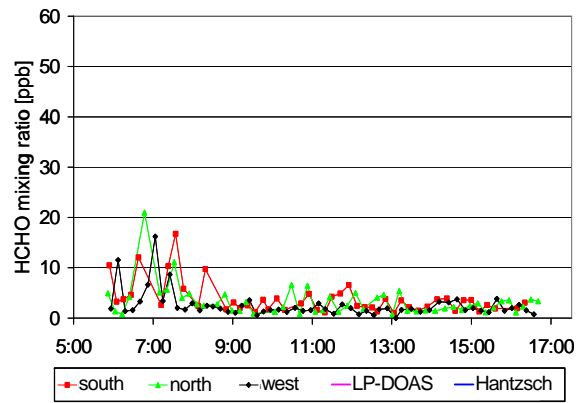
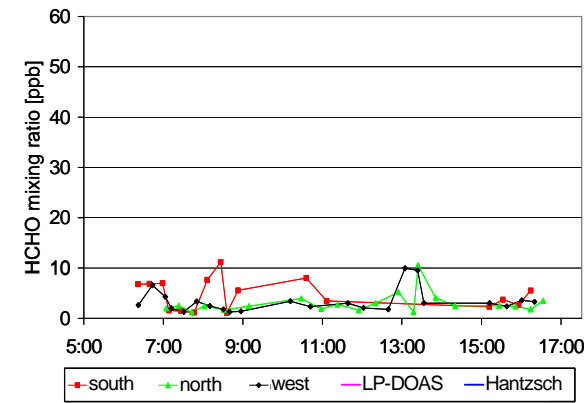
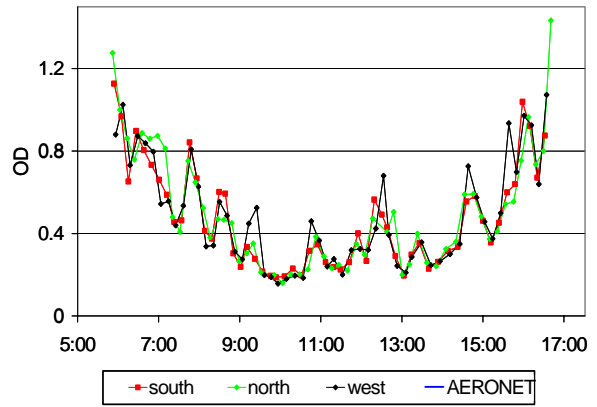
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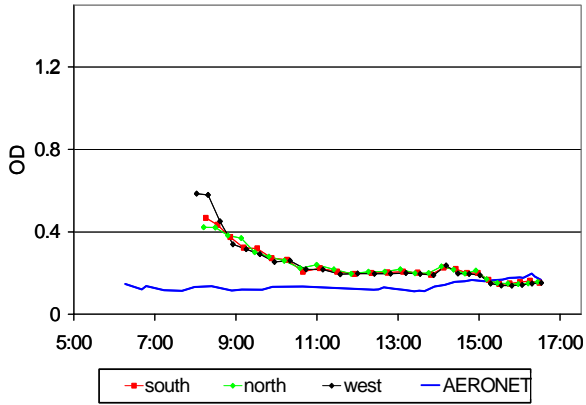


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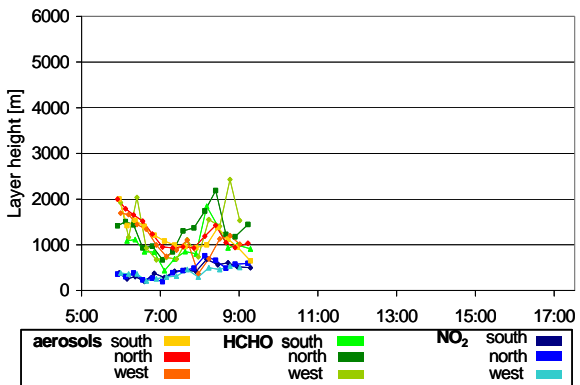
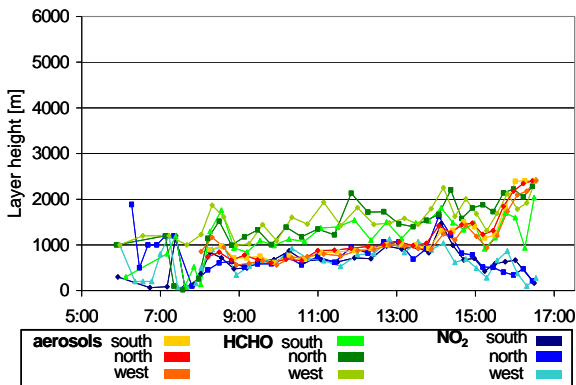
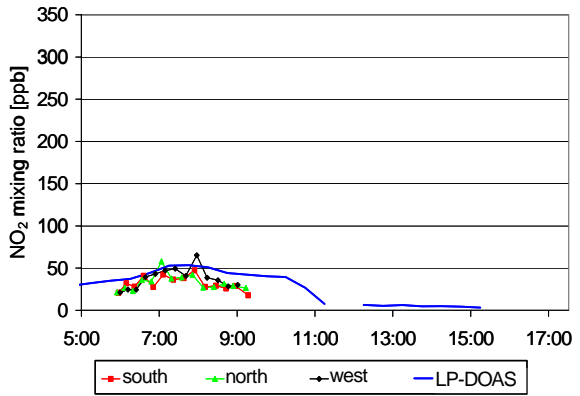
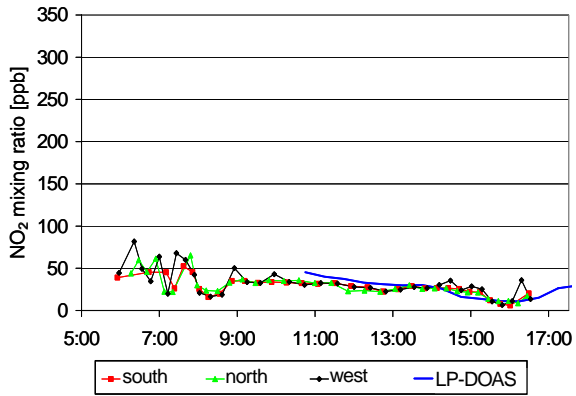
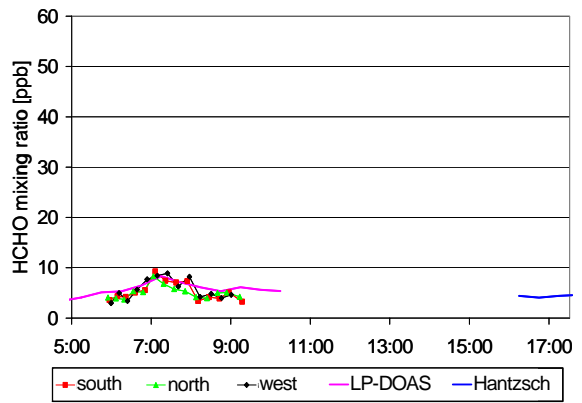
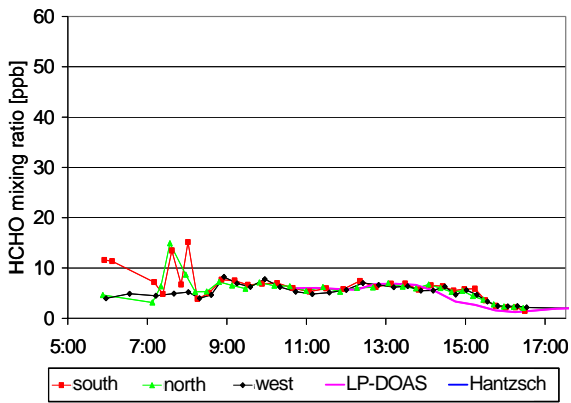
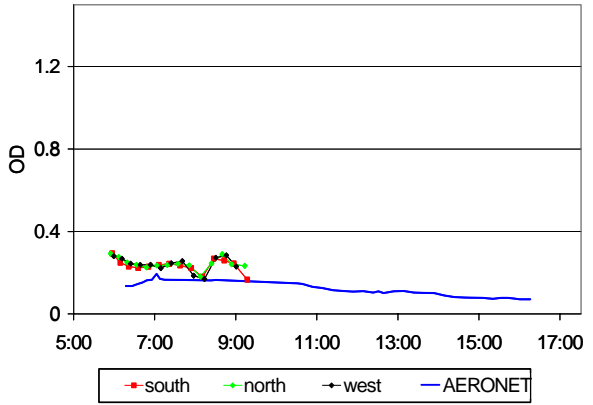




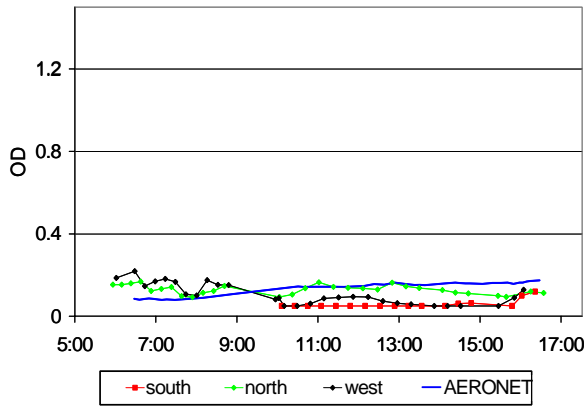
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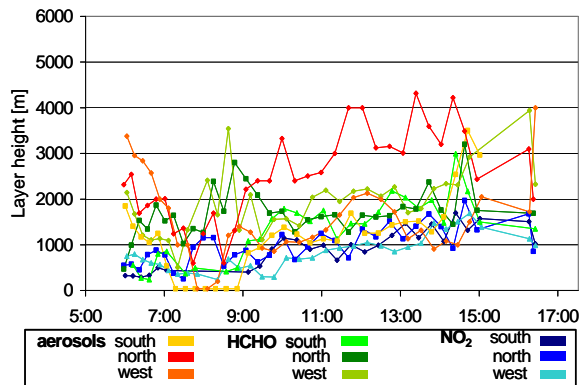
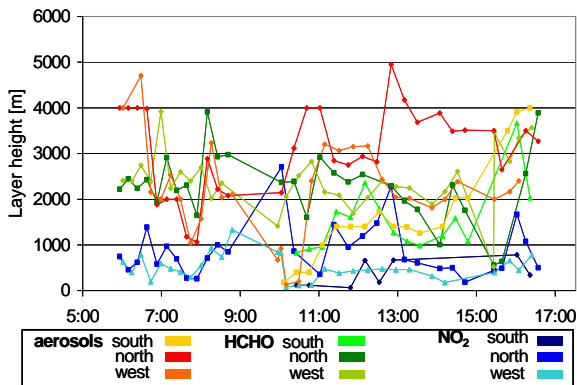
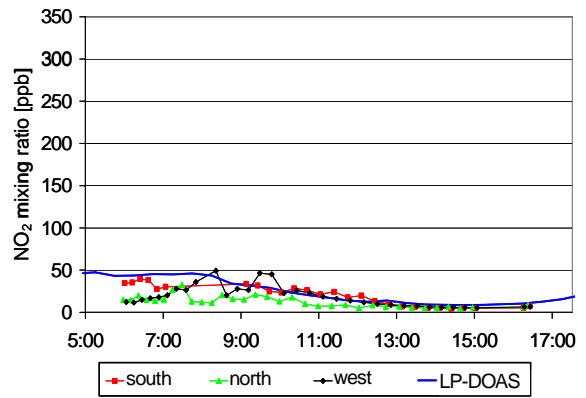
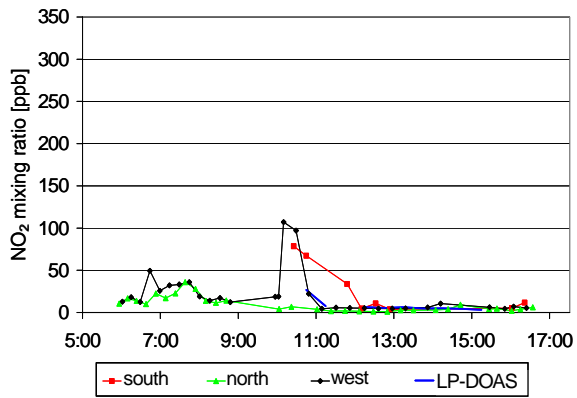
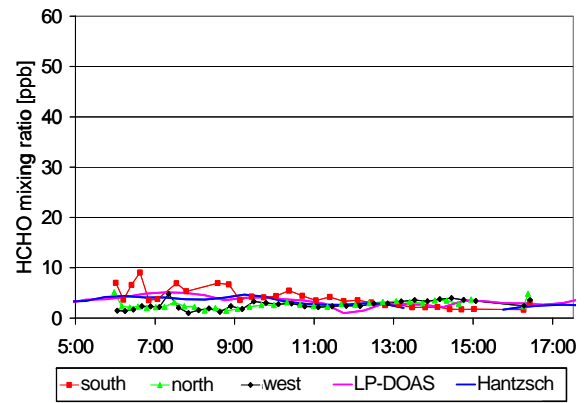
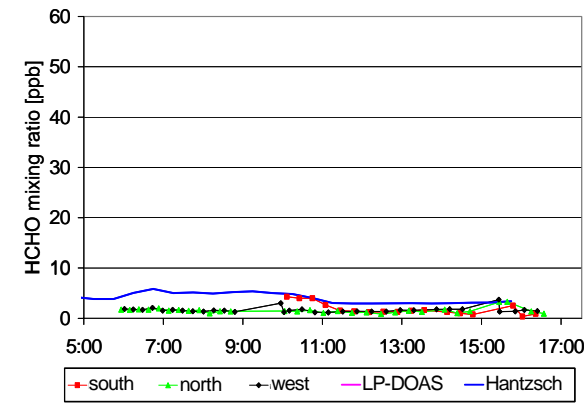
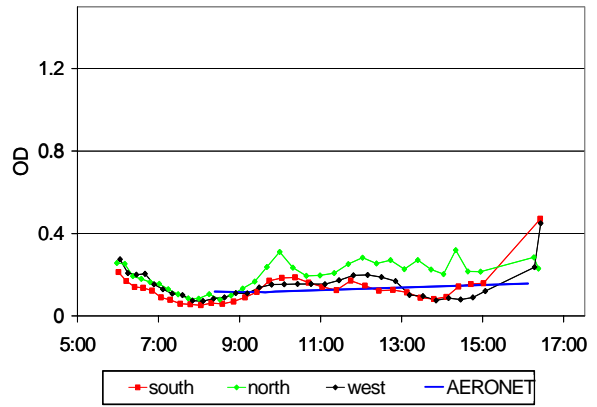
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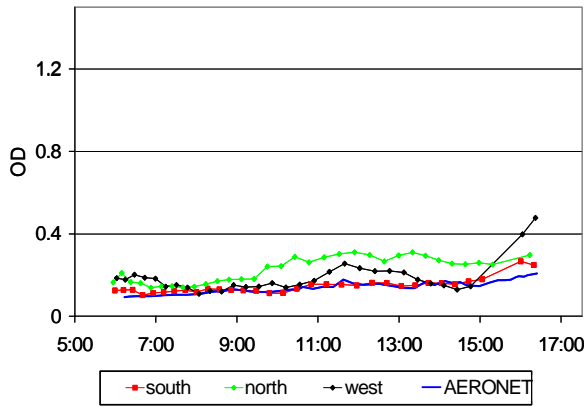
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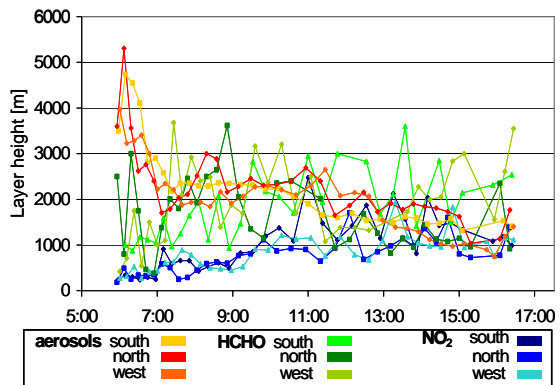
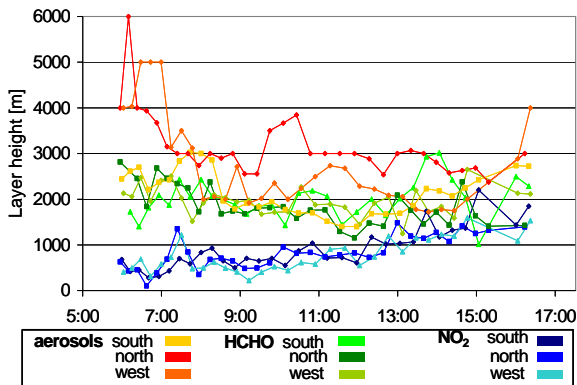
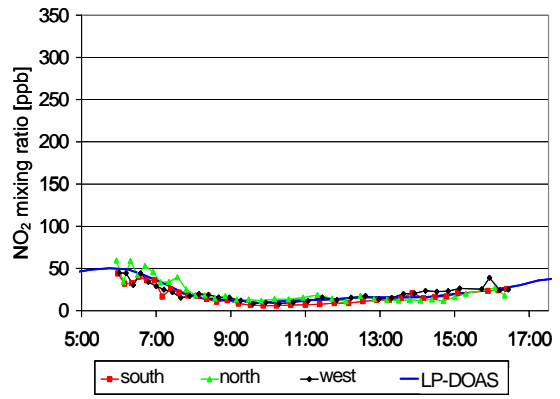
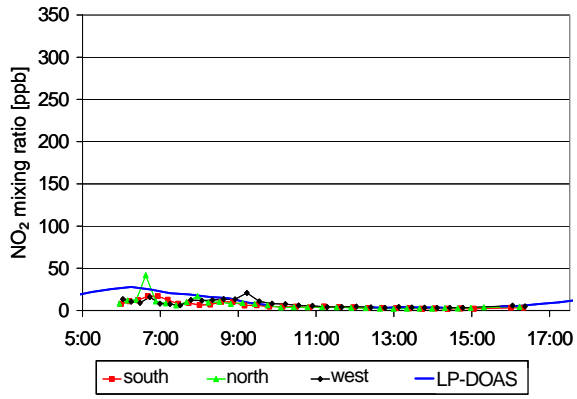
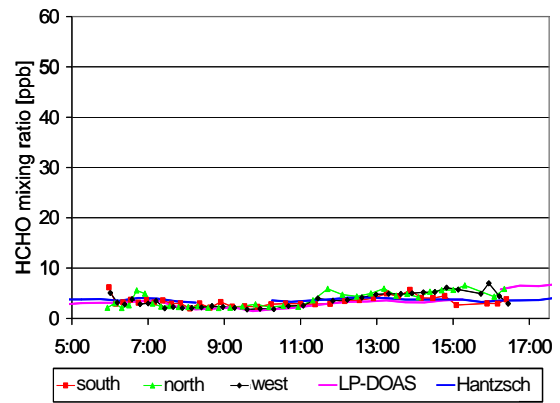
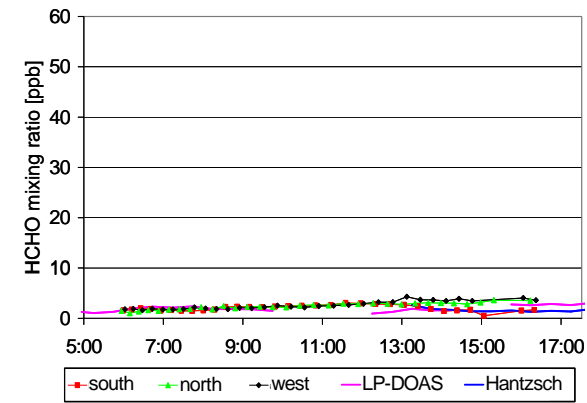
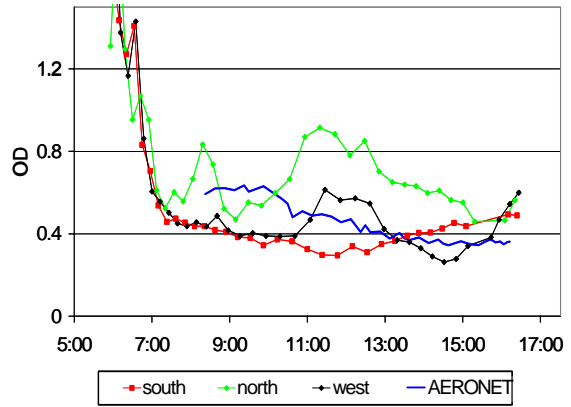
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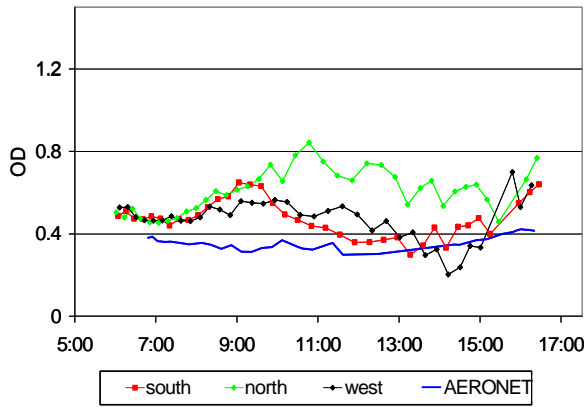
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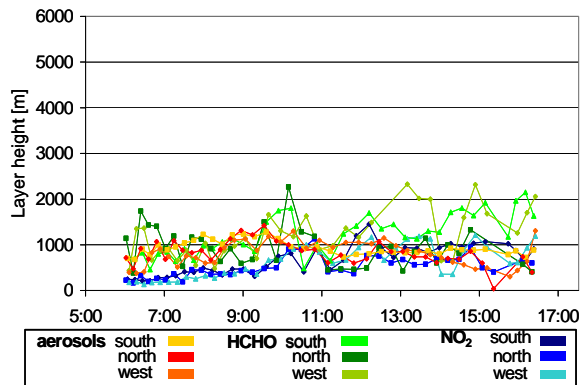
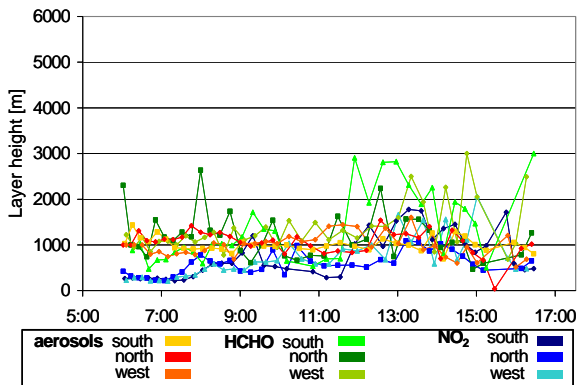
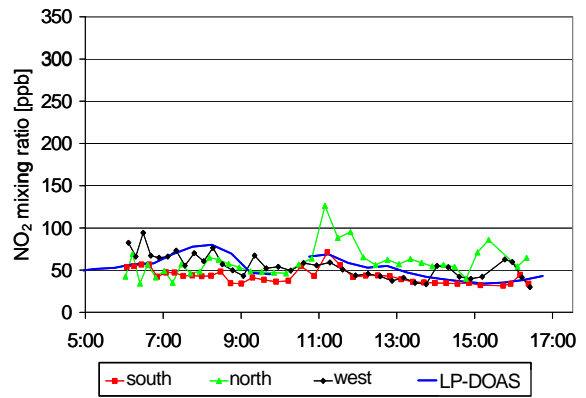
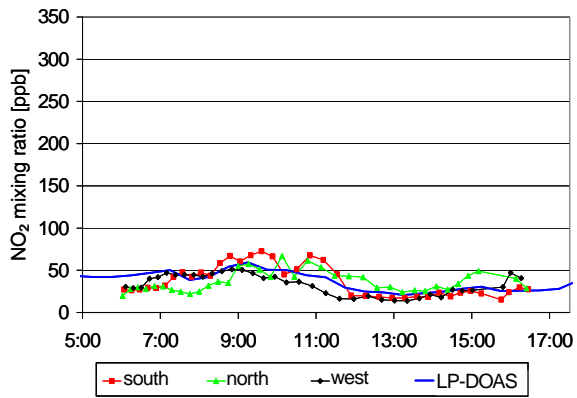
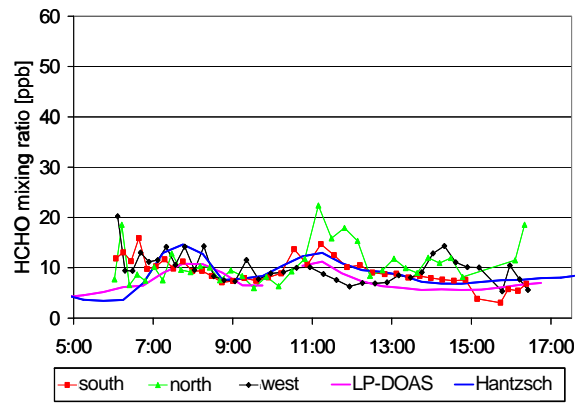
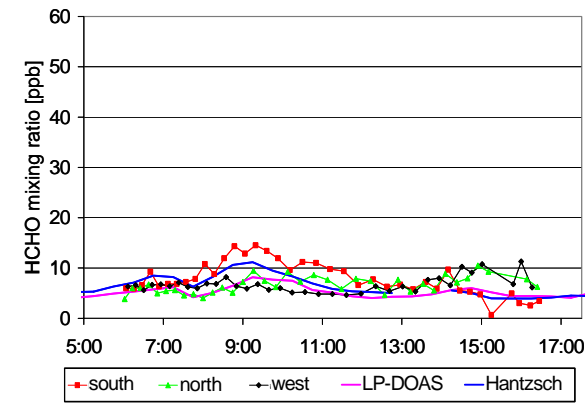
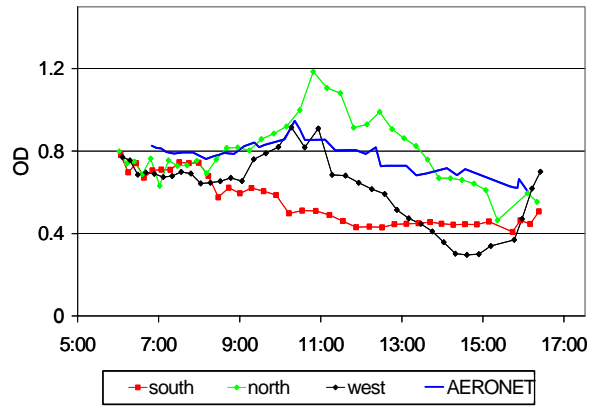
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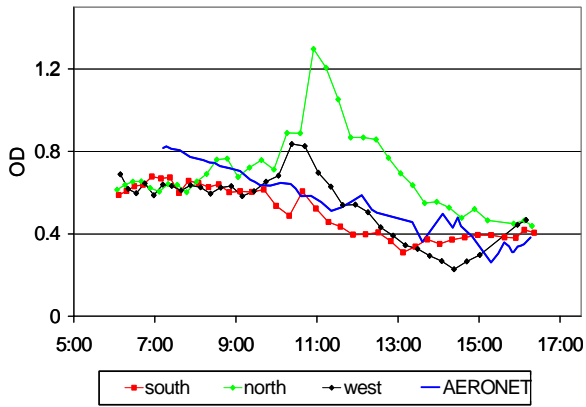
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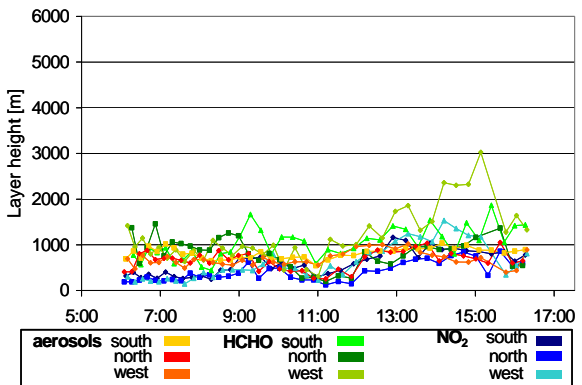
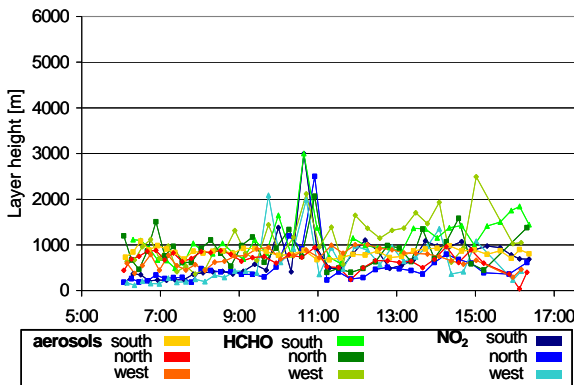
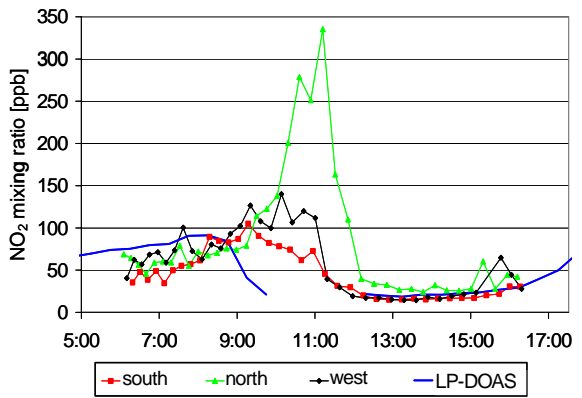
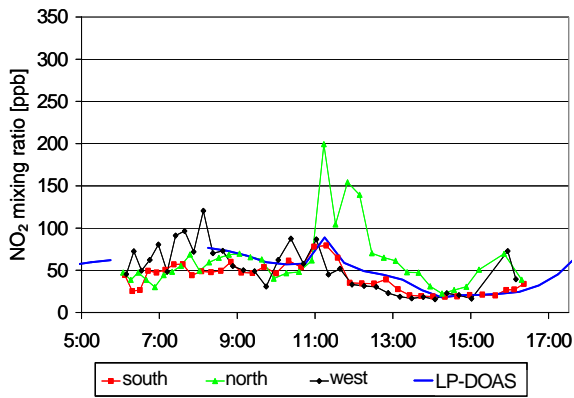
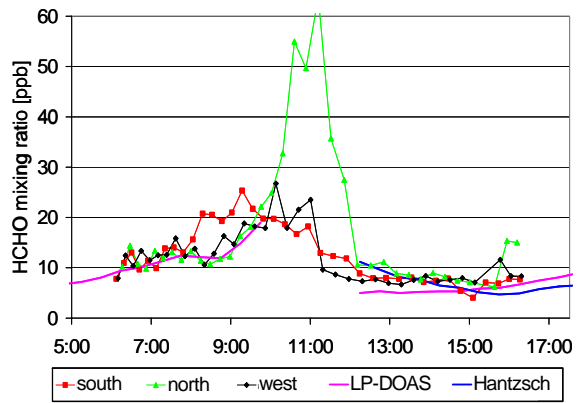
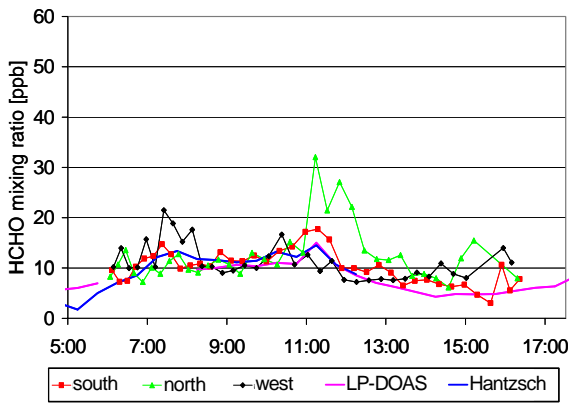
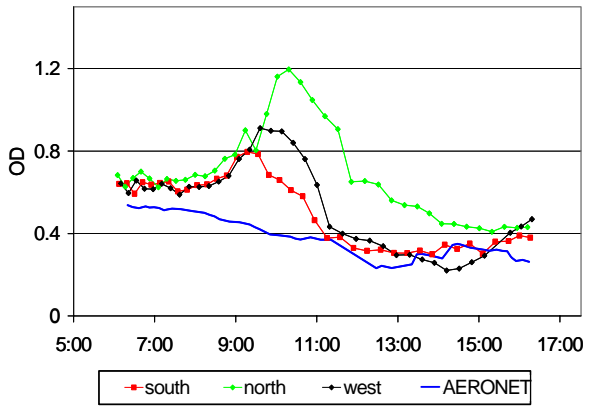
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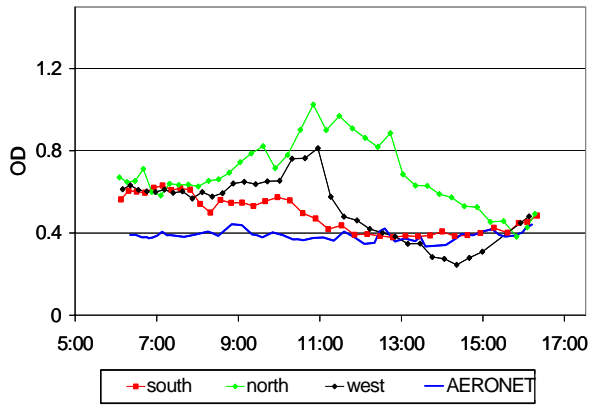
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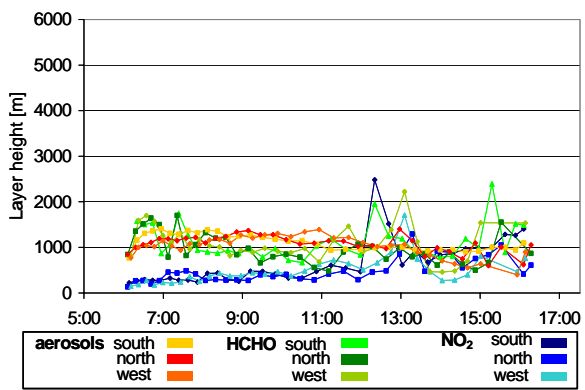
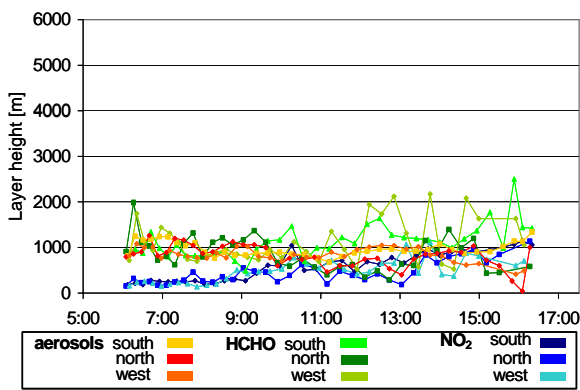
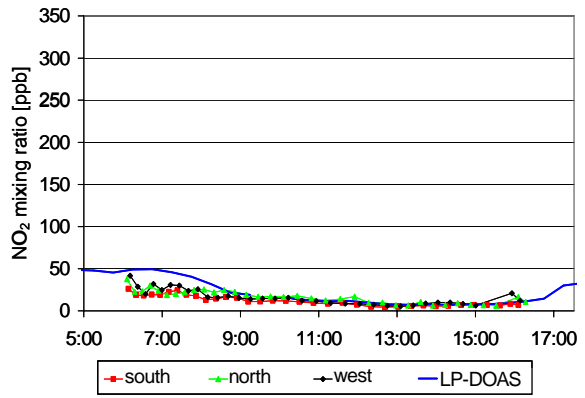
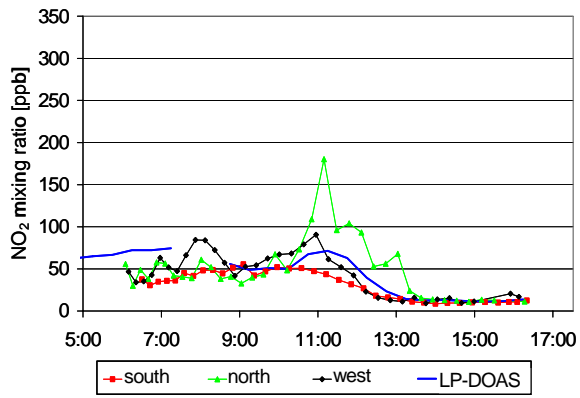
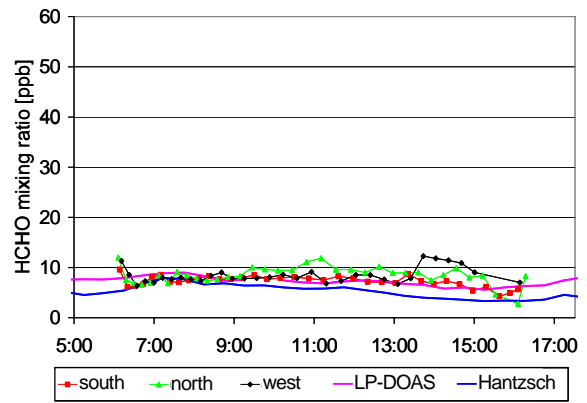
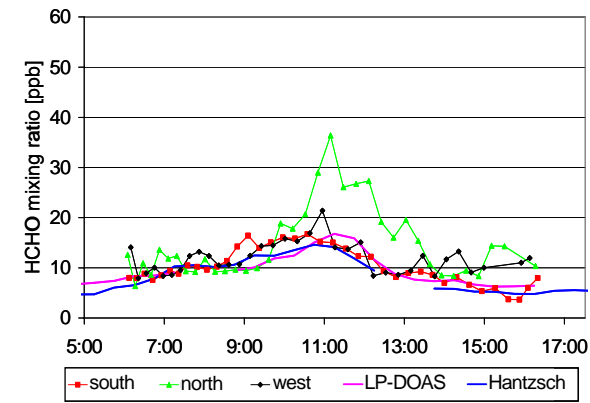
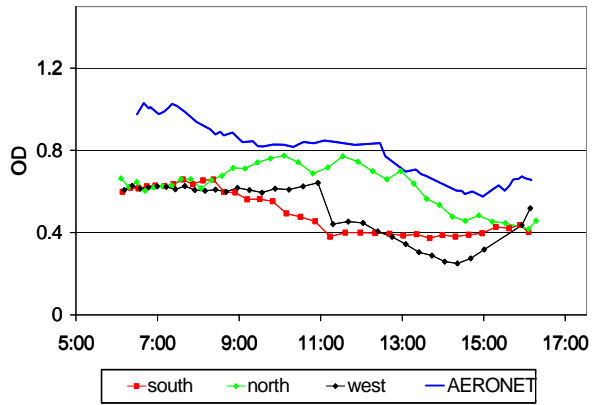
### 19 September 2003



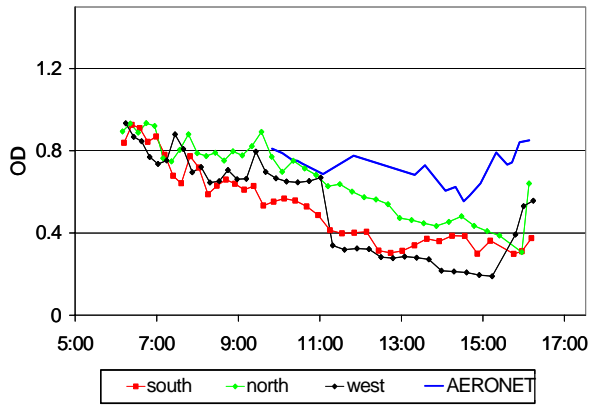
## 20 September 2003



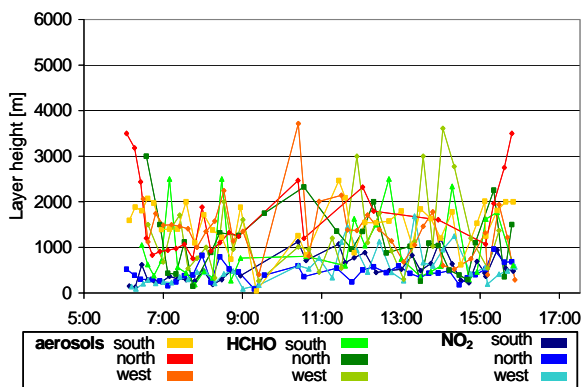
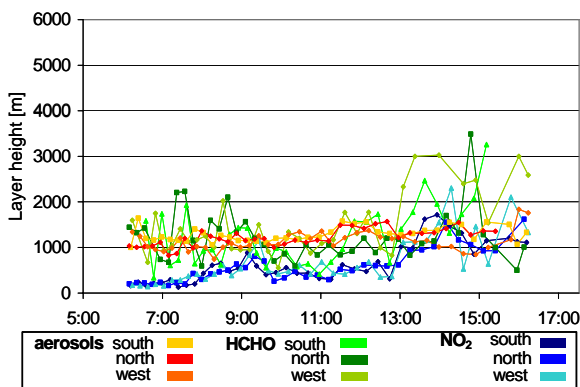
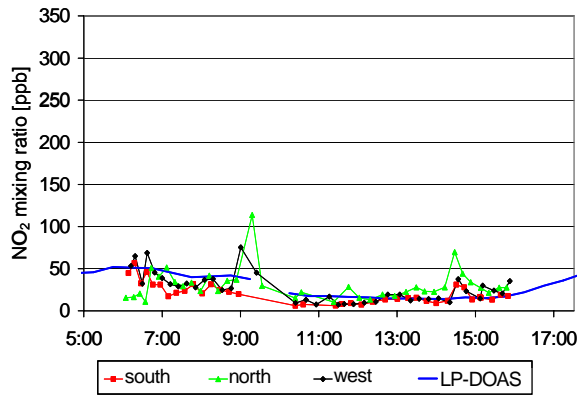
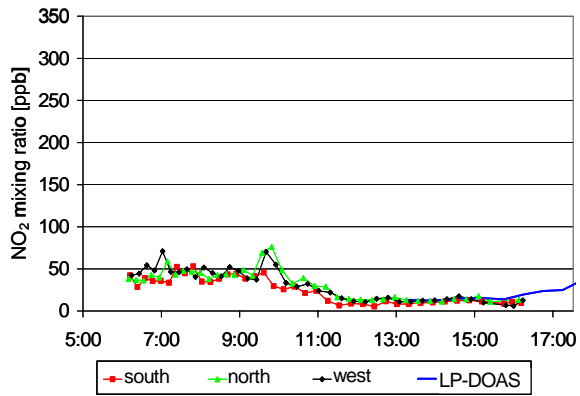
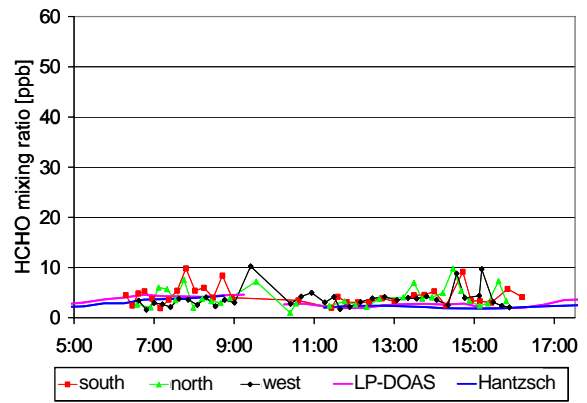
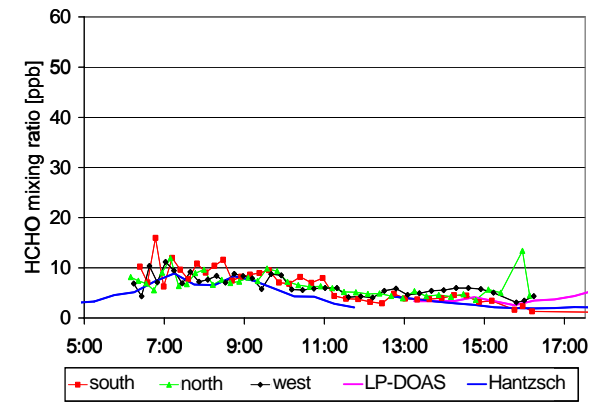
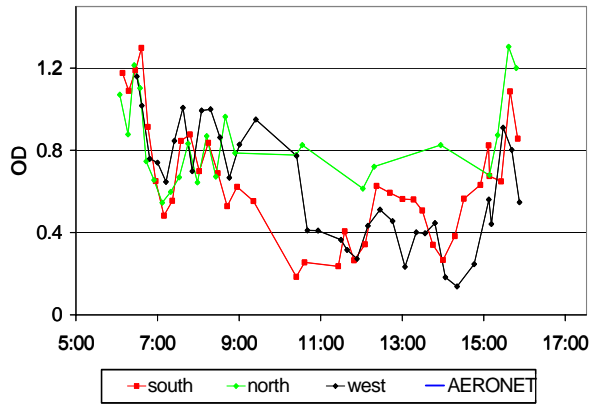
## 21 September 2003



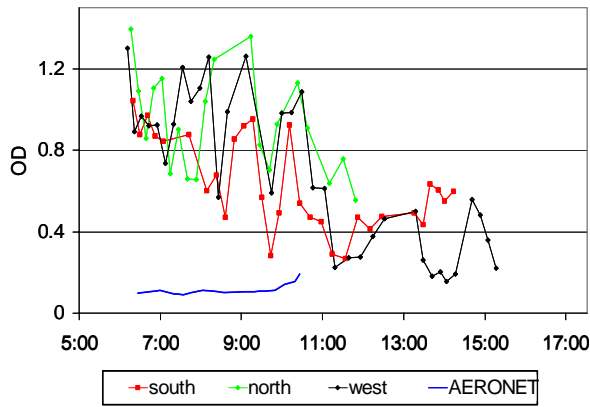
## 22 September 2003



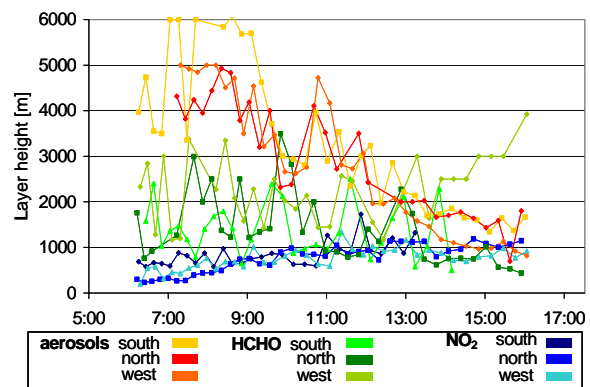
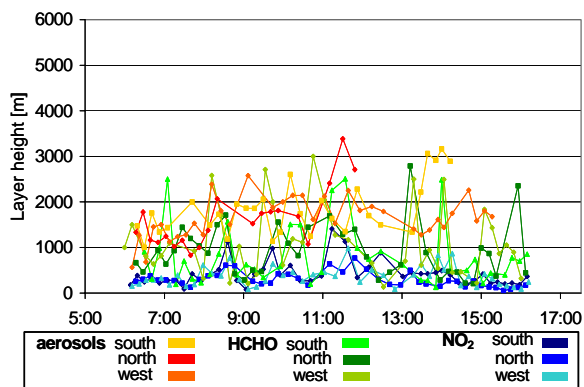
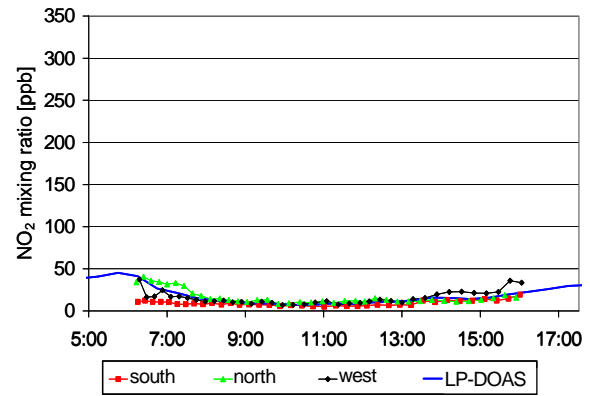
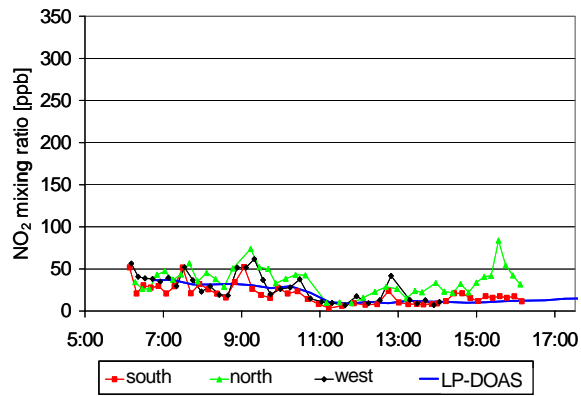
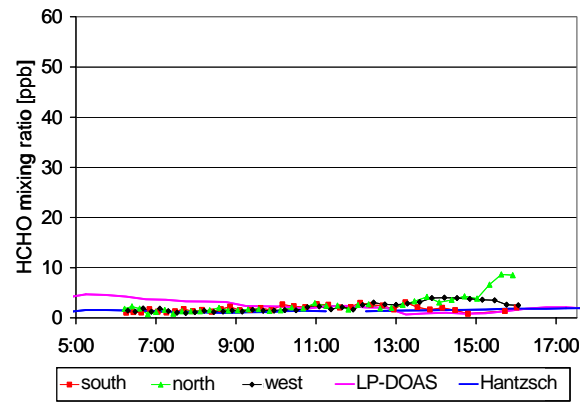
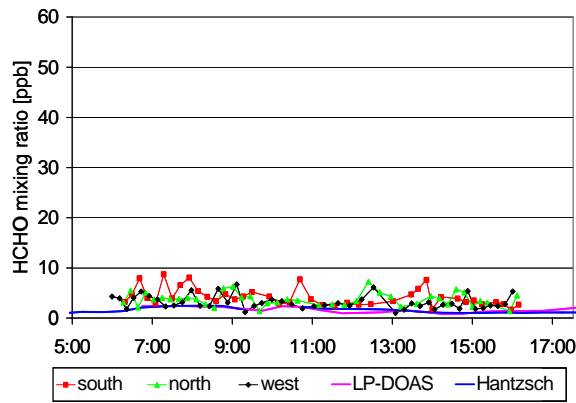
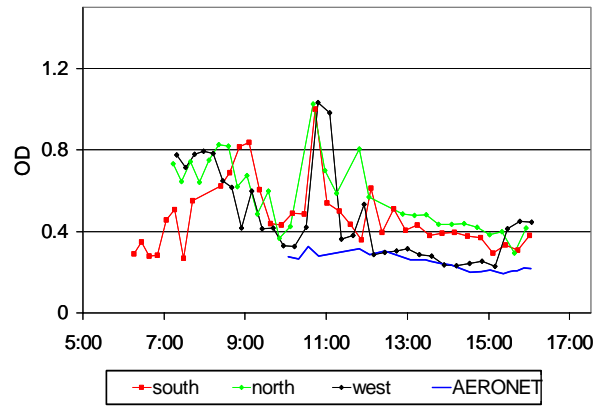
## 23 September 2003



## 24 September 2003



## 25 September 2003





## 26 September 2003

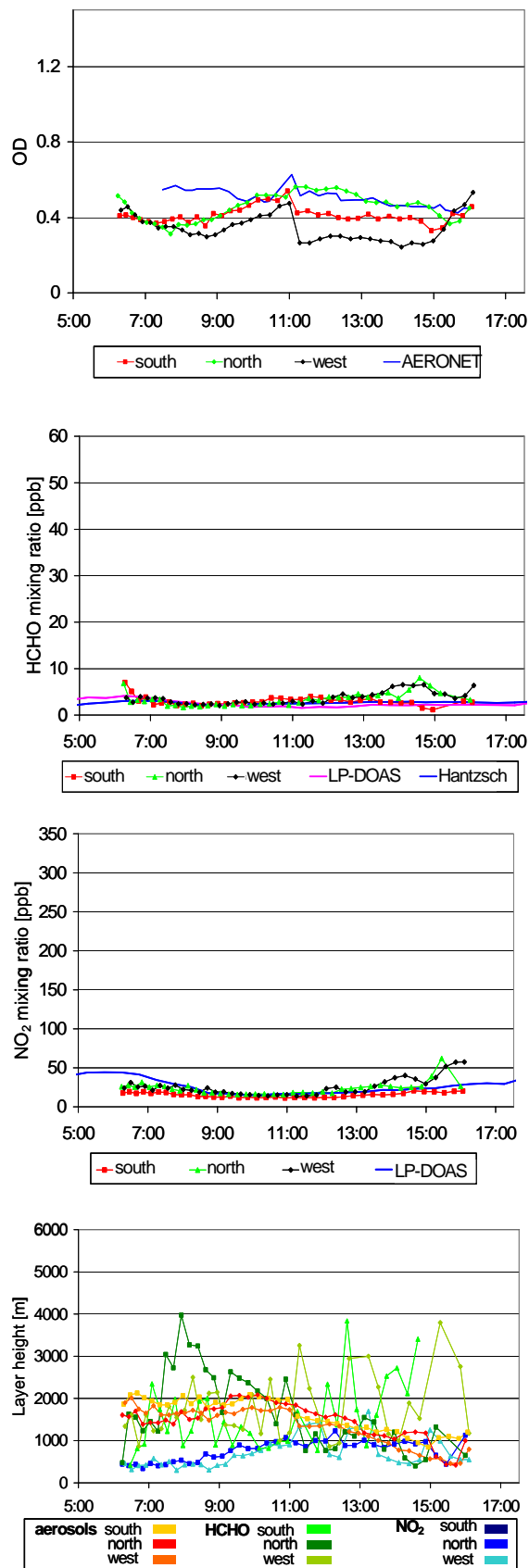


Fig. S13 Results of the AOD, mixing ratios of HCHO and NO<sub>2</sub>, and layer heights from individual elevation sequences for selected days. The results for the LP-DOAS and Hantzsch instrument and the AERONET AOD (at Ispra) are also shown for comparison. Only results with  $\chi^2 < 0.05$  are shown. In addition results were skipped, for which the layer height showed strong and rapid variations (of more than 3000m between subsequent measurements).