# Formaldehyde Over the Eastern Mediterranean During MINOS: Comparison of Airborne In-situ Measurements with 3D-Model Results


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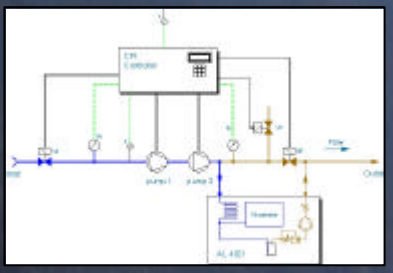
## Experimental:

Airborne HCHO measurements were made during the MINOS campaign in August 2001 on board of the German research aircraft Falcon. The measurements were obtained with a commercial instrument (AERO Laser AL4021) based on the Hantzsch pyridine synthesis followed by fluorimetric detection, modified for airborne operation by use of a constant pressure inlet.



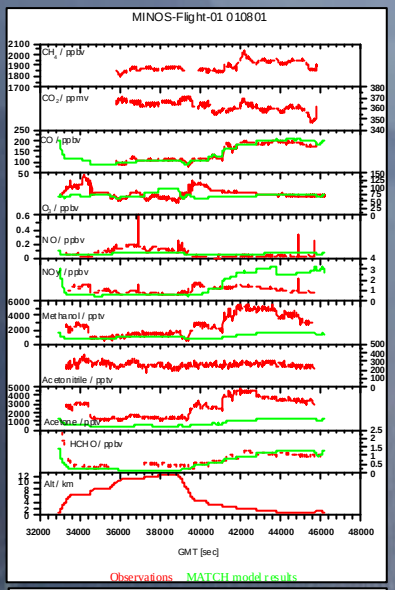
Experimental set-up consisting of the AL4021 "Hantzsch" HCHO analyser and the constant pressure inlet.

## Instrument performance:

| | | |
|---|---|---|
| Calibration method: | liquid phase calibration | |
| Calibration interval: | typ. before and after flight, zeros during flight | |
| Calibration concentration: | 9.93 ppbv | |
| Accuracy: | Detection limit: | 42 pptv |
| | Evaporization effect: | < 50 pptv |
| | Cross sensitivity to $H_2O_2$: | < 1:100 |
| | Cross sensitivity to ozone: | 1:399 (corrected in the data) |
| | Temperature dependency: | 1.6 % / °C (corrected in the data) |
| | Uncertainty of cal. sol.: | 5 % |
| Precision: | Reproducibility of cal.: | 1.4 % |
| Total uncertainty @ 300 pptv: | | < 26 % |
| Time resolution (3 dB): | | approx. 7.3 min |

## Observations:

14 measurement flights were made in the eastern Mediterranean between August 1 and 22, 2001, up to a maximum altitude of 12.5 km. Backward trajectories indicated that air masses in the marine boundary layer and the lower free troposphere up to about 4 km were advected from central and eastern Europe. In the middle troposphere (4-8 km) Asian and to a lesser extend North American pollution is transported from the west. Air masses in the upper tropopshere were additionally influenced by easterly flow from the Asian monsoon over India.



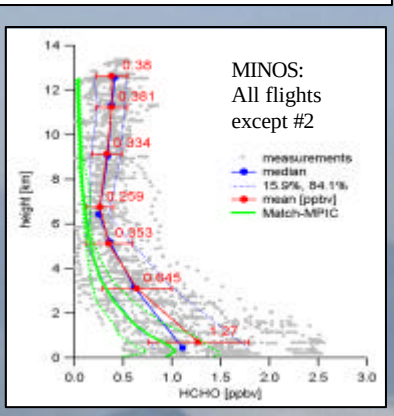

Trace gas measurements (red) and MATCH model simulations (green) obtained during the first MINOS measurement on August 1, 2001.

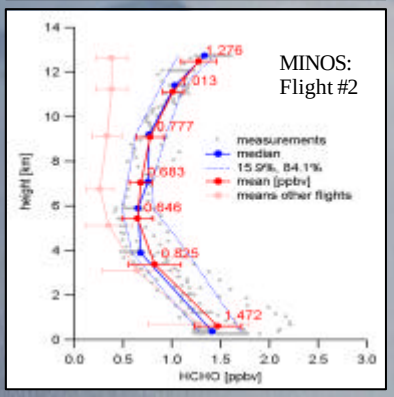
## Comparison with MATCH:

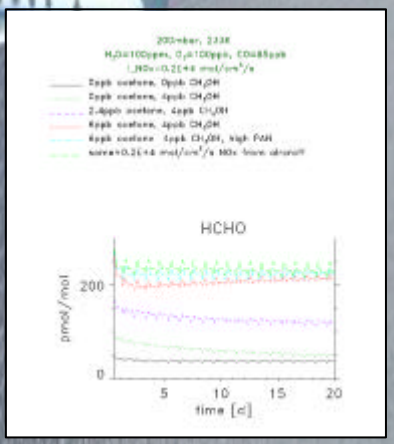
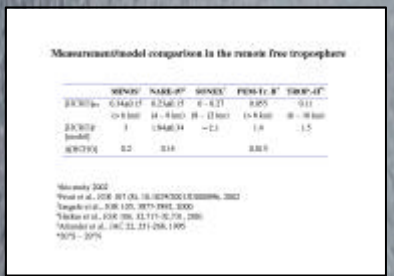
In the marine boundary layer average HCHO concentrations were of the order of 1.3 ppbv in reasonable agreement with results from a 3-dimensional global model of the lower atmosphere including NMVOC chemistry (MATCH). At higher altitudes (above 6 km) HCHO levels decreased to 0.34 ppbv on average, much higher values than predicted by the model (~ 0.05 ppbv). Significant positive correlations of HCHO with CO, acetone and methanol indicate that the formaldehyde precursors were predominately associated with anthropogenic sources. At least part of the large discrepancy between the model results and the measurements of HCHO in the free troposphere are due to a strong underestimation of the upper tropospheric acetone concentration by up to a factor of ~ 10 by MATCH.

## Comparison to a box model:

Sensitivity studies including box modelling with more detailed NMVOC chemistry are used to study the free tropospheric HCHO budget during MINOS. Although increased acetone (2.4 ppbv) and methanol (4 ppbv) yield higher HCHO (100 – 150 pptv), the model still underestimates HCHO by a factor of 3, indicating either an experimental offset or a missing HCHO source. This finding is supported by observations during previous campaigns (NARE-97, SONEX, PEM-Tropics B, TROPOZ II) that all indicated a significant underestimation of HCHO levels in the remote free troposphere by state of the art models.




Average profiles of HCHO obtained for all MINOS flights (top) and for MINOS flight #2 (bottom). This particular flight showed the strongest influence of Asian monsoon outflow.