Reactive nitrogen, ozone and CO concentrations and correlations in the East Mediterrannean region during the MINOS campaign: A modeling study

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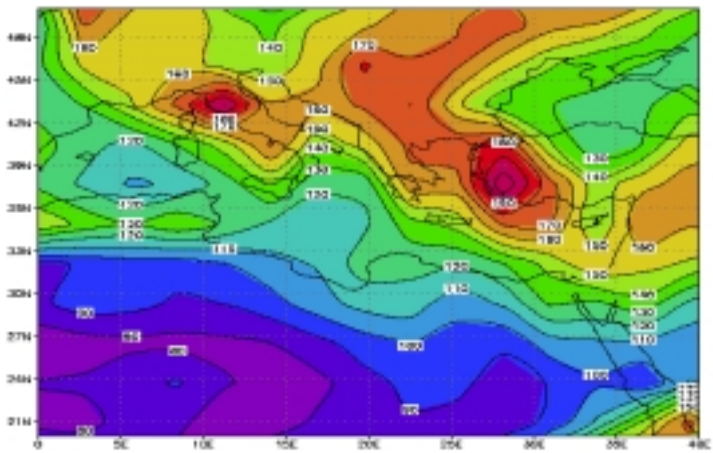
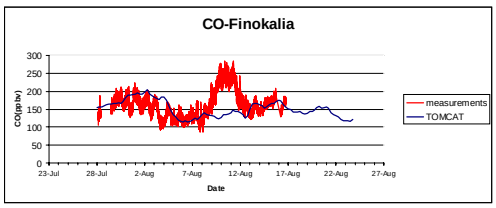
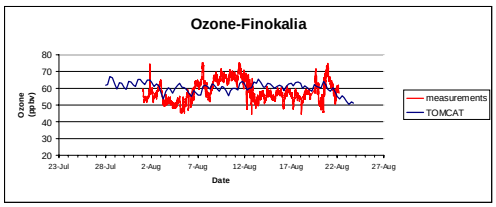
The TOMCAT model

TOMCAT is a three-dimensional chemical transport model with a tropospheric chemistry scheme including several non-methane hydrocarbons. Large-scale advection is driven by analyses from the European Centre for Medium-Range Weather Forecasts (ECMWF) and detailed treatments of convection, wet and dry deposition and the boundary layer are all included. The model was initialized on 1 March 2001 and integrated until end August, allowing five months of spin-up before the time period of interest. It was run at a horizontal resolution of 2.8ºx2.8º with 31 levels in the vertical extending from ground to 10hPa in the stratosphere.

The figure opposite shows the distribution of CO in ppbv at ground on 11 August 2001 (noon) as depicted by the TOMCAT model. The model exhibits high CO values north of Italy and in West-Central Turkey with a strong gradient east of Greece.

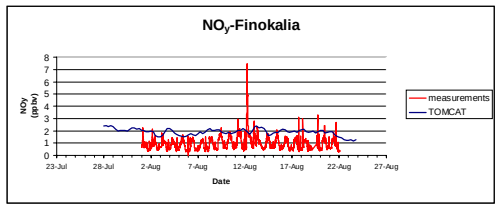






TOMCAT at ground level

We show the comparison of TOMCAT model with the observational data from Finokalia measuring station for the whole duration of MINOS campaign (August 2001). TOMCAT shows in general. a good comparison of CO and ozone with observations (figures to the left). However, CO tends to be underestimated in the model most noticeably around 10-11 August, when the discrepancy between model and observations reaches as high as 80 ppbv. Most of the CO on these days originates from the biomass active regions of Turkey/East Europe, transported to Crete with the N-NE etesian winds typical of the Greek summer. TOMCAT actually shows a steep gradient from Greece to Turkey as the above figure shows. Therefore, the misplacement of the modeled gradient in relation to the true one, can partly explain the model discrepancy.
Ozone comparison is better but noticeably, there is a discrepancy at the same time period when there was a mismatch between the modeled and measured CO. With such high measured CO, the airmasses are probably photochemically active and given that the model underestimates CO, ozone is also underestimated.



The figure above shows the comparison of NO_y TOMCAT data with measurements. As well as TOMCAT overestimating the measured NO_y by a factor of 2, the measurements exhibit a strong diurnal variation, which is not captured by the model. This is mainly due to the modeled HNO_3 being too high (although this is partly compensated for by modeled PAN being too low). The modeled HNO_3 could be too high because the model is underpredicting the amount of convective and/or large-scale rainfall. Because the modeled NO_y is dominated by HNO_3, this may explain why the modeled NO_y doesn't show any diurnal variation.

TOMCAT aloft

The figures to the right show how TOMCAT compares with observational data from the Falcon flight of 3 August 2001. In addition, the flight altitude plot is also presented.

Before 9:00UTC the measurements show a peak in ozone levels and at the same time CO reaches very low values.
This implies that the origin for these high ozone values is the stratosphere with an intrusion to the upper troposphere. Another peak arises near 09:30UTC when the plane was flying at around 500hPa and also around 10:30UTC. CO values all these times are low suggesting that continental boundary layer pollution is not the source of high ozone values. TOMCAT model manages to capture these peaks in ozone although the values are underestimated.
CO modeled values are also underestimated during these times. During other times, when the plane flies closer to the ground modeled CO is an overestimate of the measured CO. On this day, the air masses were arriving to Crete from East Europe/Turkey. As the Finokalia figure for CO shows above TOMCAT values further to the East of Heraklion (where Finokalia actually is) are much closer to the measured values on 3 August, i.e. the model has a steep gradient in its concentrations as we approach the continental region. Ozone values close to ground approach 50-60ppbv and are well simulated by the model, implying that active photochemical ozone production was dominant over the continent.