The University of Malta Giordan Lighthouse – Background Trace Gas Monitoring Station on Gozo

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Introduction

The Physics Department of the University of Malta conceived the idea of setting up a background trace gas monitoring facility in the early 1990's; more specifically 1993 when Dr R Ellul and Prof. Paul Crutzen of the Max Planck Institute for Atmospheric Chemistry in Mainz, Germany collaborated on questions of climate change and the pollutant trace gases responsible for this in the Mediterranean region.

In 1995 Prof. Crutzen was awarded the Nobel Prize for Atmospheric Chemistry; he has visited Malta twice in connection with this work.

In 1996 the University allocated a sum of money to this work and, with the kind consent of the Maritime Authority who hold the title to Giordan Lighthouse, Gozo, and the help of the Ministry for Gozo, instruments donated first by the Max Planck Institute and later by the International Bureau in Bonn were installed (Figure 1).

Figure 1: The Giordan Lighthouse station

These instruments comprised ozone monitors, a full set of meteorological instruments measuring wind speed and direction, relative humidity, temperature, atmospheric pressure and radiation intensity. Later another ozone monitor, designed to serve as a standard, and meteorological instruments were installed at the University Gozo centre. This centre, which had just been opened in cooperation with the Ministry for Gozo, serves as a base for the operation which cannot realistically be run from the main University campus in view of the maintenance required for all the instruments.

Gas monitors

The International Bureau in Bonn as well as the Institute for Climate research in Karlsruhe continued to support the initial work with the further provision of carbon monoxide and sulphur dioxide monitors as well as annual calibration facilities for the ozone monitors. Ozone, being an unstable trace gas, cannot be calibrated in the normal way using 'standard' gas mixtures but requires a special transfer standard technique related to a primary standard only available in a few of the larger European laboratories.

Over the years the collection of data has grown more sophisticated so that the standard procedure is now the daily downloading of all the data to, as well as the remote calibration of the instruments from the Xewkija station. Weekly visits to the lighthouse are still, however, an essential part of the programme as these very delicate instruments need careful maintenance to be able to reliably and reproducibly detect the very low concentrations of ozone, carbon monoxide, and sulphur dioxide. We are talking here of parts per billion concentrations i.e. only a few molecules per one thousand million molecules of air.

Global atmospheric watch status

In the year 2000 the Giordan lighthouse station achieved Global Atmospheric Watch Status with the United Nations Environment programme of the World Meteorological Organisation.

The Global Atmospheric Watch programme (GAW) was set up in the 1980's and contains 22 'global' stations around the world in extremely remote spots away from direct man-made (anthropogenic) influences as well as another set of regional stations in geographically critical positions.

These stations record trace gas concentrations and meteorological parameters and annually pass their results to the World Data Centre for Greenhouse Gases based in Tokyo at the Japanese Meteorological Agency's headquarters. These results are worked into an annual publication showing all the greenhouse gas changes in the northern and southern hemisphere.

The Giordan Lighthouse station (registration number 16587) is located in a strategically important position between Europe and North Africa and can be found on the GAWSIS website with all details necessary. The GAW network also works with and is slowly becoming interchangeable with the EMEP network run from the Norwegian Institute for Atmospheric Research – Cooperative programme for the monitoring and evaluation of the long-range transmission of air pollutants in Europe (NILU).

Dr Julian Wilson of the EU's Joint Research Centre in Ispra as well as other researchers at WMO Geneva and NILU are presently engaged in unifying the two systems into one common database which can be used by climate researchers worldwide.

It is interesting to note that on 1 April 2005 Dr Slobodan Nickovic, formerly employed at the Euro Mediterranean Institute for Coastal Dynamics (ICOD) at the Foundation for International Studies, Valletta, has moved to join the team at WMO Geneva.

Expansion of the lighthouse instruments

The Giordan lighthouse monitoring station has now been running for eight years and the sum of Lm250,000 from German and Maltese taxpayers' money has been expended in the setting up and running of this facility. In the pipeline is an expansion of the station's instruments and facilities to work directly with MEPA as the environment agency responsible for reporting to the European Union the air quality in the Maltese islands. Also being worked on is a link to the meteorological office at MIA which requires the data for civil aviation purposes and is the official link to WMO in Geneva.

One of the main advantages of the Giordan lighthouse station is its location on the seashore and its proximity to the main shipping lane between Gibraltar and the Suez Canal. It is estimated that 25 per cent of the world's shipping uses this route and hence measurement of the pollution from this 'source' is a critical part of the programme.

Indeed it is possible that the high concentration of ozone measured here could partly be due to this shipping intensity. (Figure 2)

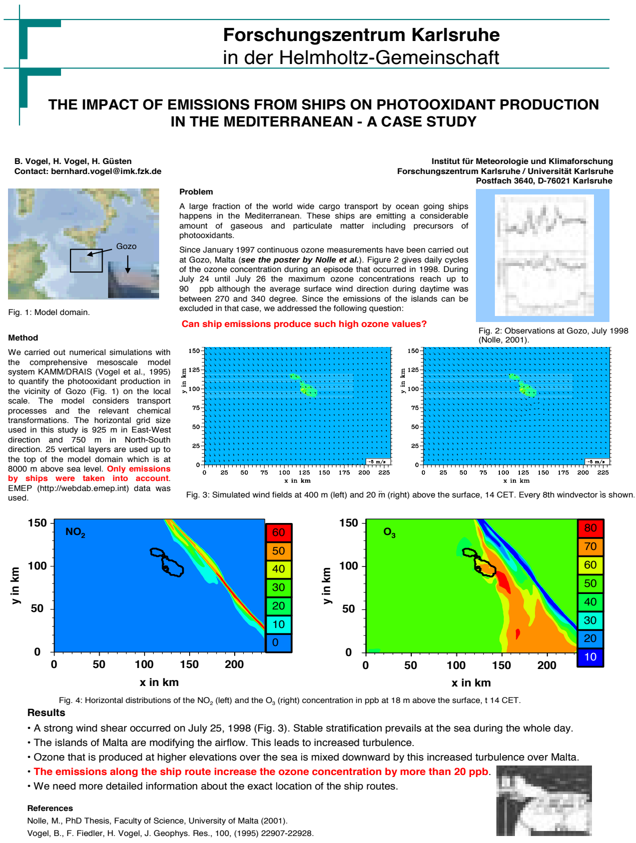

Figure 2: Poster showing a summary of the role of shipping in creating ozone in the **Mediterranean (presented at a conference in Crete in 2002)**

Measuring aerosols

The location of the station is also excellent when it comes to measuring aerosols which are thought to be a primary factor in climate change. Put very simplistically the effect of aerosols is to change the reflectivity of the Earth's surface to the sun's radiation (albedo). This results in trapping of the heat rays in the atmosphere leading to an enhanced greenhouse effect and lower precipitation (rain) in the Mediterranean. The overall effect is an increase in the surface temperature of the Earth and hence global warming. Figure 3 shows the effect of a dust cloud (fine-coarse aerosol) and Figure 4 the eruption of Etna which sent a dense sulphur dioxide cloud as well as aerosol over the Mediterranean. At one point this cloud was directly over the Maltese islands.

Figure 3: The effect of a dust cloud in the Mediterranean

Figure 4: The eruption of Etna

The results from Giordan lighthouse show that the concentration of surface ozone in the Mediterranean is one of the highest in the world and very slowly but steadily increasing. In 2004 the mean concentration was 53 parts per billion by volume. A comparison of the data for Malta, Crete, Cyprus, and Athens shows that differently originating air masses are measured by these stations. While the Gozo station measures air masses from the Atlantic modified by passage over Spain and France, the Greek stations measure air masses originating over northern Europe and moving south via the Balkans.

In 2002 an atmospheric measurement campaign based on the island of Crete and led by the Max Planck Institute for Airchemistry in Mainz, Germany (the MINOS campaign) resulted in clarification of some of the mechanisms that lead to pollution of the Mediterranean region. It is clear that pollution finds its way directly into the upper levels of the Mediterranean from both the American continent and as a result of the south east Asian regime (Figure 5).

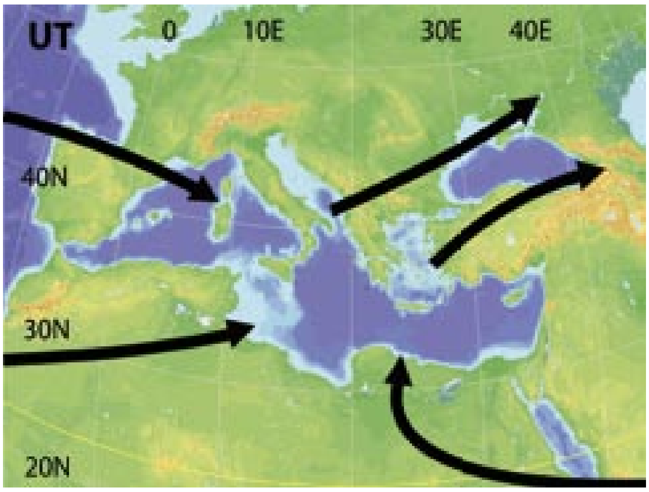

Figure 5: Direction of pollution from North America and South East Asia.

A campaign planned for 2005-07 and based on aircraft measurements from Malta, has failed to materialize at present owing to a shortage of EU funds in the VIth framework programme. However, it is hoped that this will be remedied in the next round due next year.

The results from the carbon monoxide and sulphur dioxide instruments enable us to pick out pollution episodes that affect the Maltese islands. During the summer months we find many examples of locally-recirculated pollution that comes back to effect us directly. However, the opposite is also true. Indeed

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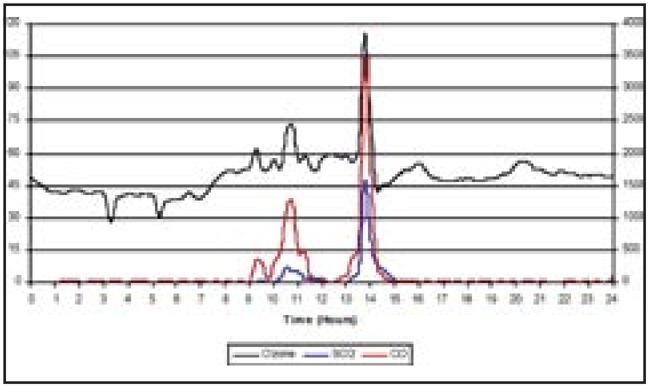

Figure 6: Coincident Ozon, CO and SO2 peaks on 14 February 2004.

one such episode occurred last year on 14 August 2004 when three very high peaks of ozone, carbon monoxide, and sulphur dioxide were recorded. Analysis of the origin of these air masses using the so-called HYSPLIT - 4 model available from NCAR, Boulder Colorado, USA showed a track directly from the north west. It is probable that a strong pollution event, possibly the illegal discharge of hydrocarbons, took place and hit the Maltese islands in the afternoon of that day (Figures 6 & 7).

Conclusion

In conclusion the facility has obviously proved its worth both in scientific terms as well as practical usage and the University hopes it can continue to grow in collaboration with the environmental and civil protection agencies as well as serving as a major and southernmost European and UN station for climate change monitoring.

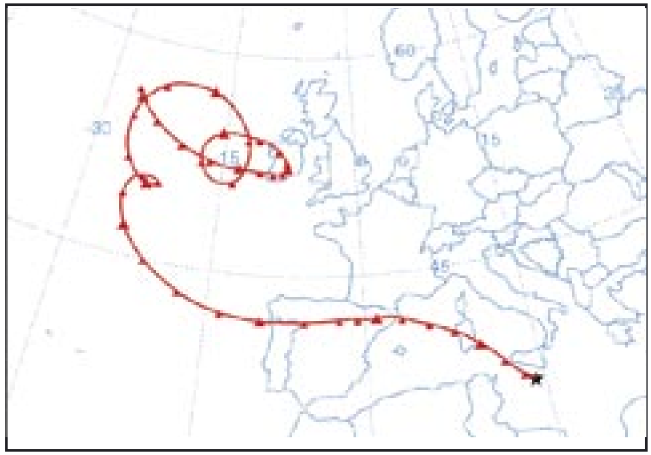

Figure 7: Ten-day backward trajectory showing a possible path of pollution event.

Dr Raymond Ellul obtained his B.Sc. in Chemistry and Physics in 1976 and M. Sc. in 1978 from the University of Malta. He subsequently obtained his Dr. Rer. Nat. working at the Max Planck Institute fur Strahlenchemie in Mulheim/Ruhr, Germany. He currently lectures on Mechanics, Atomic Physics and Atmospheric Physics.

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