Comments on "Estimates of sources of air pollution in Christchurch compared with recorded concentrations" by Pat Palmer (Weather and Climate, Volume 27, pp65-76).

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Background

An article appeared in the previous issue of this journal (Palmer, 2007) which is critical of work carried out around a decade ago (Gimson & Fisher, 1997). I am grateful to the editor of *Weather & Climate* for an opportunity to reply to this, and to make some comments on the paper by Mr Palmer.

Our work in 1997 was concerned with the wintertime levels of particulate pollution in Christchurch, New Zealand, specifically the relationship between ambient pollution levels in the central urban area, and emissions of air pollutants. A simple 'box' model was used – this treats the air as a layer over the city through which pollution is uniformly mixed. Inputs to the model are the total emissions into the layer, the wind speed, and the mixing height (that is, the depth of the layer). All parameters varied in time, and the output was the hourly volume-averaged ambient concentration. Emissions were obtained from the inventory available at the time, and the mixing height estimated. The modelled PM_{10} (particles less than 10 microns in diameter) concentration was compared with observations in central Christchurch for a selection of worst-case wintertime pollution events over previous years.

The results were reported to Environment Canterbury (ECan) (Gimson & Fisher, 1997). A subsequent study considered a whole winter and derived mixing heights from meteorological observations (Gimson, 1999). This produced consistent results with the previous work.

The model was used by ECan to determine the impact of changes in emissions on the worst-case daily PM_{10} concentration, and to derive weighting factors for each source type (domestic heating, industry and motor vehicles). The weighting factors were applied to projected

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emissions determined by the ECan emissions model, for different future scenarios.

The Article in Weather and Climate by Pat Palmer

Pat Palmer and the Association for Independent Research (AIR) are vigorous contributors to the debate on air quality in Christchurch. They regularly write to the local press, and have made several submissions to the Environment Court on ECan's Air Plan. They are concerned that air quality management measures are too focused on home heating, and that regulations may restrict the use of solid-fuel heaters which are used in a high proportion of homes in Christchurch.

Christchurch's winter smog is mainly due to smoke from domestic fires. The circumstantial evidence for this is overwhelming, as is the scientific evidence (see below). It is logical, therefore, that regulations designed to reduce the impacts of air pollution on human health should be targeted towards this specific source of pollutants. The AIR group does not accept this evidence, nor the consequent planned measures, yet they have never presented any evidence to the contrary.

I have to express my disappointment that, given its content, this article by Pat Palmer has appeared in a scientific journal. The article is based on an erroneous premise; that the box model was used to validate the emissions inventory. The logical path taken by Palmer (2007) is as follows: the box model does *not* validate the emissions inventory, therefore the basis of ECan's air quality management strategy is invalid, and the strategy itself is fundamentally flawed. If so, restrictions on the use of solid-fuel heaters are not justified.

It is Mr Palmer's logic which is fundamentally flawed.

My assertion in response is that the box model was *not* used to validate the emissions inventory. No reasonable person would do this, as emissions data are *inputs* to *any* air-dispersion model. I also point out that emissions inventories are not the only air quality management tools. Other information is provided by observations of particulate pollution and, more recently, the chemical analysis of particulate samples for the purpose of source-apportionment

Limitations of the box model, and even any alleged shortcomings in the emissions inventory, do not invalidate plans to reduce winter smog by reducing emissions from domestic fires.

Much of the article by Palmer (2007) is critical of the box model. The next section responds to the technical points raised.

Box-Model Criticisms

The spreadsheet-based model simulated PM_{10} events reasonably well. It turned out to be a useful tool, within its limitations. Palmer (2007) examines supposed flaws in the model. These relate to the applicability of the model to the simulation of other pollutant species, such as carbon monoxide (CO) and oxides of nitrogen (NO_X). He is critical of the choice of mixing height in the models of Gimson and Fisher (1997) and Gimson (1999). In the former paper, the mixing height was based on an estimate of depth of visible smog layers; in the latter, it was based on observations of the wind speed and temperature profiles.

As pointed out above, the model 'works' for PM_{10}. Good estimates of the necessary inputs lead to a good match of the output concentrations with observations of PM_{10} at a central location in Christchurch. As the 'box' volume comprises the whole area of the city, up to the mixing height, the output concentration is a volume-average of a well-mixed pollutant. Other pollutants, such as CO and NO_X, are emitted in different proportions from different sources. According to the emissions inventory, NO_X emissions are predominantly from motor vehicles, and CO is emitted from domestic fires and motor vehicles roughly equally. This means that the dispersion characteristics of PM_{10}, CO and NO_X are different.

A box model may not be suitable for all pollutants. Our focus at the time was PM_{10}, as guideline concentrations of this contaminant were, and still are, being regularly breached. Had the brief at the time included CO and NO_X we would have used alternative models. Indeed, at around the same time, we *were* using specific dispersion models to examine CO from transport in other NZ cities.

Sources of Air Pollution in Christchurch

As mentioned above, the predominant source of wintertime smog in Christchurch is smoke from home heating. No resident of Christchurch is in doubt about that. The evidence is as follows, which may be seen from air quality monitoring reports produced annually by ECan and from the scientific literature:

(a) winter PM_{10} concentrations peak in the late evening, often between 10 pm and midnight, while residential fires are burning. Concentrations at that time are much higher than during the peak morning period when more traffic activity occurs;

(b) breaches of the National Environmental Standard (NES) for PM_{10} occur more often at residential monitoring sites than at roadside sites, and mobile monitoring during winter nights shows higher PM_{10} in the residential areas than in the central city;

(c) there have been no breaches of the NES for NO_2 in Christchurch since monitoring began in 1988;

(d) breaches of the NES for CO do occur, but the number of these has decreased over the last 20 years. There were no breaches between 2003 and 2005. When they occur in Christchurch, CO breaches coincide with very high PM_{10} concentrations.

(e) analysis of PM composition and source apportionment techniques show that the average wintertime $PM_{2.5}$ is 79% due to residential heating (Scott and Sturman, 2006), and this percentage is higher on the worst-case days.

Thus a consistent picture of the sources of air pollution in Christchurch has been provided by independent data sources and analysis techniques, giving a reliable basis for the formulation of air quality policy. None of the items listed relies on results of air-dispersion modelling, and they are also independent of the emissions inventory.

Christchurch's air quality is degraded (insofar as the NES regulations are breached) by fine particulate matter from domestic fires. Therefore, regional policy targeting such emissions is appropriate. Accordingly, several of the policies the ECan Air Plan relate to home heating, proposing the prohibition of open fires, and limiting the number of dwellings burning solid fuel in any kind of appliance. The Air Plan is the air quality policy chapter of the Natural Resources Regional Plan (NRRP). This chapter was notified in June 2002 and has been through the submission and hearing process, with the regional council releasing its decisions on submissions in September 2007. The proposed policy may be found on the ECan website http://www.ecan.govt.nz/Our+Environment/Air/Air+Plan/ASummary.htm, and appeals against the decisions are being addressed through the Environment Court.

Concluding Remarks

The focus on a particular piece of work carried out eleven years ago is detrimental to progress in air quality science and policy development, as it ignores work carried out by the air quality community in the meantime.

For instance, programmes of research into urban air quality have been in progress under the auspices of NZ's Foundation for Research, Science and Technology (FRST) since 1998. These include research on emissions inventory development, ambient monitoring methods, public-health effects of air pollution, and the development of sophisticated modelling tools to simulate dispersion and atmospheric chemistry. Recent reports and papers resulting from this research are posted here: http://www.niwa.co.nz/ncces/projects/air-quality/reports.

Among other things, the research is intended to provide the scientific basis for guidance issued by the NZ Ministry for the Environment (MfE) and policy development by regional councils. It is beyond the scope of this article to comment on the social and economic consequences of measures to reduce emissions from domestic fires – these are the realm of the MfE Regional Councils and are certainly being taken into account.

Disclaimer

The author is a staff member of Golder Associates (NZ) Ltd. However, this article contains the author's personal views, which are not necessarily those of Golder. This work has not been through Golder's usual internal review procedures, though I thank my colleagues in the wider air quality community for their comments on draft versions.

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