Climatology of urban environments

Heat islands, climate change, air pollution: physical, chemical and biological indicators

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Urban microclimates are extremely variable from shaded and sunny sites, north and south sides of buildings and from exposures to prevailing wind directions. The *built centres of cities, with solid high buildings and black road surfaces* strongly absorb sunlight and reduce wind speeds, thus creating a heat island effect. Urban air pollution creates smog and haze reducing sunlight. With the mixed heights of buildings the smoke from a chimney from a house can directly enter a nearby multiple level apartment building. Passive solar homes in New Zealand have been shown to reduce imported heating requirements by between 40 and 90 %. This simple building design and building approach would drastically reduce the need for fossil fuels, air pollution and heating costs for an increase in capital cost of less than 5 % of the building costs.

In Christchurch there are three primary forms of air pollution. We have strong winter smoke from domestic fires that builds up to health threatening levels on anticyclonic winter nights. Motor vehicles produce a wide range of pollutants all year around, primarily during the day. Both of these sources of pollution produce acute respiratory and cardiovascular illness and death and add chronically to the cancer incidence. The third form of air pollution is electromagnetic radiation (EMR). EMR is strongly shown to be genotoxic and produces cancer, cardiac, neurological and reproductive problems. Mutations have been seen in plants, animals and people.

The mixture of fog and smoke that forms winter smog has drastic effects on the very young, very old and asthmatics and those with cardiovascular disease. With each increase in PM10 of 10 mg/m^3, there is a 1 % increase in all mortality and a 4 % increase in respiratory mortality (Figs. 1, 2.) All combustion processes produce toxins, including carcinogens. The very fine (PM2.5) particles that are deposited deeply into our lungs are coated with complex molecules including many carcinogens. Energy efficiency in new and existing homes is the fundamental way to reduce air pollution while heating cold homes with lower mean heating bills.

Fig. 1. Total mortality as a function of daily mean PM10 air pollution concentrations.

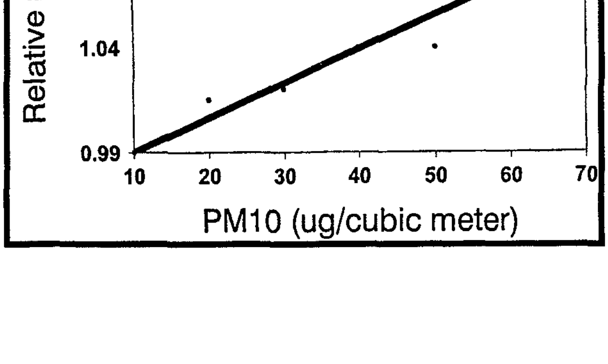
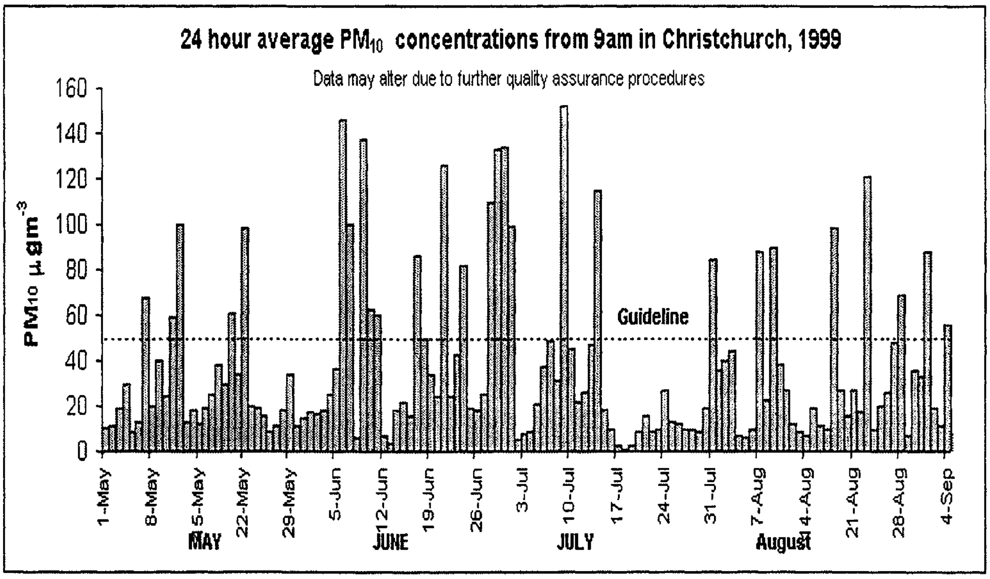


Fig. 2. In Christchurch the daily mean PM10 levels frequently exceeds the management target of 50 mg/m^3 (source: Environment Canterbury).



All year round motor vehicles produce CO and NOx and a host of carcinogens, including the indicator chemical, benzo(a)pyrene and dioxin. Lichens, through their density or diversity, are good biological indicators of air quality (Fig. 3). In Christchurch they decrease in incidence and diversity as we travel from Lincoln to the centre of the city. A science fair project showed an increase in lichen from the heavy traffic Kilmarnock Street, Harakeke Street, Matai Street and Mona Vale. Public transport, involving buses integrated with shuttles and taxis can cope with over 80 % of urban travel, leaving the present road clear for the occasional car trip. This is enhanced significantly with appropriate urban form that can be designed and developed to minimize the need for individual travel, thus cleaning up the air and significantly enhancing social cohesion and personal safety (cf. Fig. 4).

Fig. 3. The percentage of lichen cover is strongly reduced by particulate air pollution concentrations in Christchurch (from Larry Burrows, Landcare Research, Lincoln).

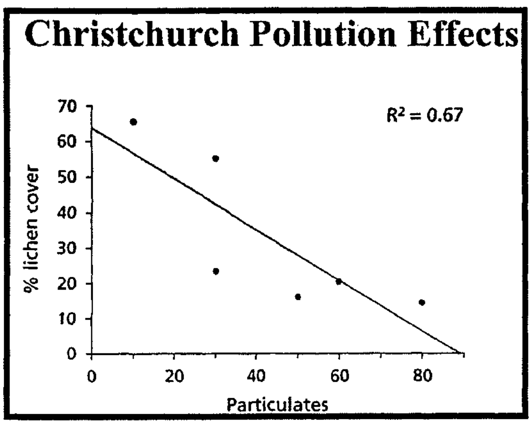
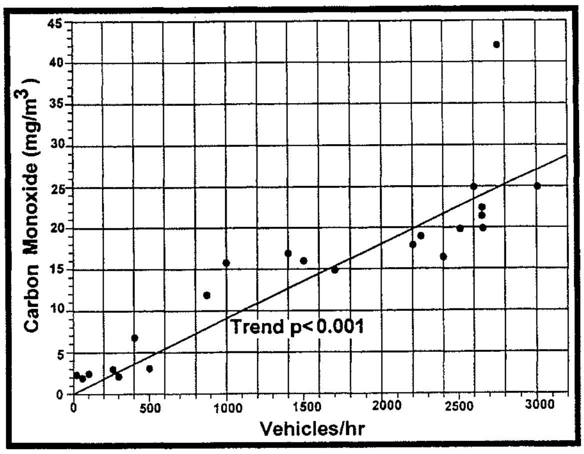


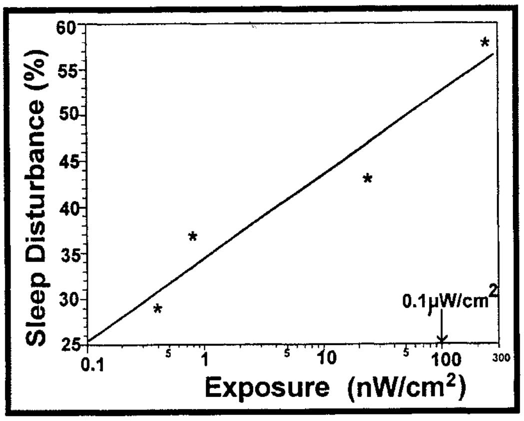
Fig. 4. Motor vehicles produce carbon monoxide in proportion to the vehicle density per hour in Riccarton Road when the wind speed is less than 2 m/s (source: Environment Canterbury).



The third form of air pollution is electromagnetic radiation from powerlines, radio and TV stations and cell sites. EMR is shown in 15 studies to reduce the vital neurohormone, melatonin, in people. This means that bio-indicators of electro-smog include sleep disturbance, headaches and miscarriage. These are short-term effects that, unlike cancer, occur over days to months. All three have been shown to increase in a dose-response manner with EMR exposure, with a threshold of effect close to zero exposure. This makes them good bio-markers and indicators of very serious health effects.

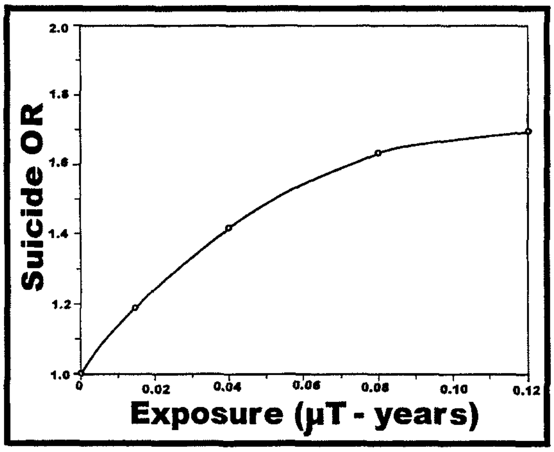
Short-wave radio exposure in Switzerland produced a causal disturbance of sleep in a dose-response manner, with changing the beams and with a significant improvement when the transmitter was secretly turned off for three days, including for those in the lowest exposure group (Fig. 5).

Fig. 5. Dose-response relationship for sleep disturbance at Schwarzenburg with exposure in nW/cm. Note: 1nW/cm^2 = 0.001μW/cm^2, Altpeter et al. (1995).



This shows the extremely sensitive nature of the human brain to radio frequency (RF) exposure. Melatonin was shown to be reduced both in people and cows. Reduced melatonin is associated with sleep disturbance, neurological effects, cancer, cardiac problems and miscarriage. A similar non-linear dose-response was found for another melatonin related health problem, suicide, in electric utility workers in the United States (Fig. 6.)

Fig. 6. Dose response relationship of suicide after recent monitored exposure to cumulative 50 Hz magnetic fields for men <50 years, adjusted for work, class, location and exposure to sunlight and solvents, Van Wijngaarden et al. (1999).



In Greece mice became totally infertile after 3 to 5 generations at extremely low exposure levels to radio and TV signals (Fig. 7), Magras and Xenos (1997).

Fig. 7. Reproductive rates in two groups of mice exposed to extremely low intensity radio signals, showing a dose response in the time taken to achieve full infertility of 3 matings for 1.503μW/cm^2 and 5 matings for 0.168μW/cm^2.

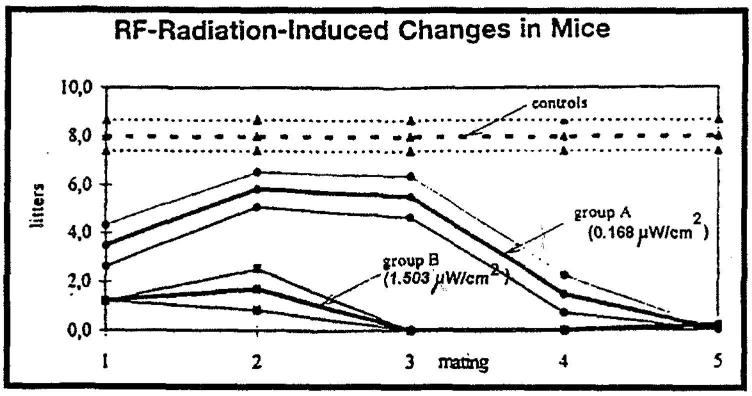
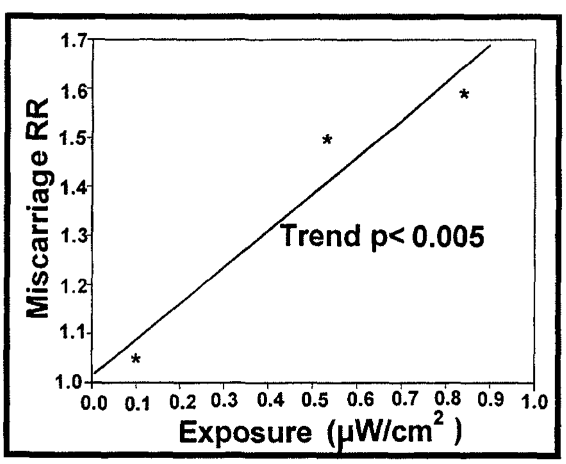


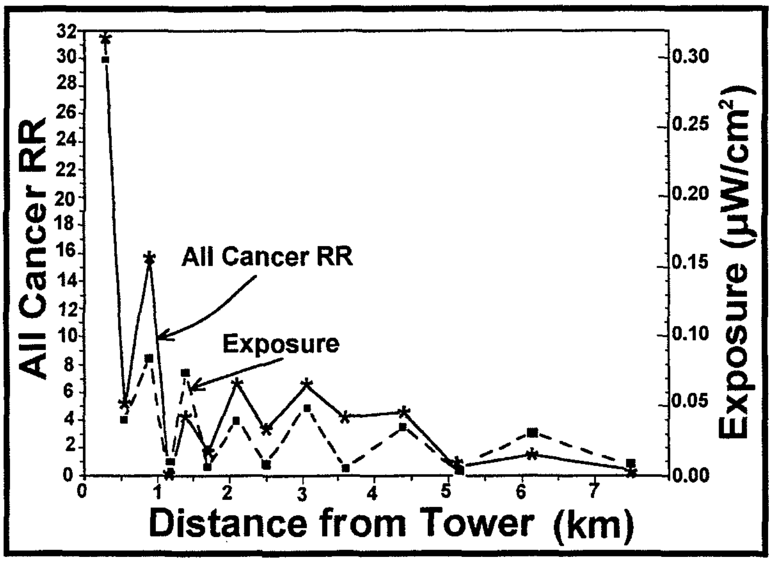
Fig. 8. Microwave exposure associated miscarriage for pregnant physiotherapists, Ouellet-Hellstrom and Stewart (1993).



A large study of U.S. physiotherapists showed a significant dose-response increase in miscarriage with monthly mean microwave exposure (Fig. 8).

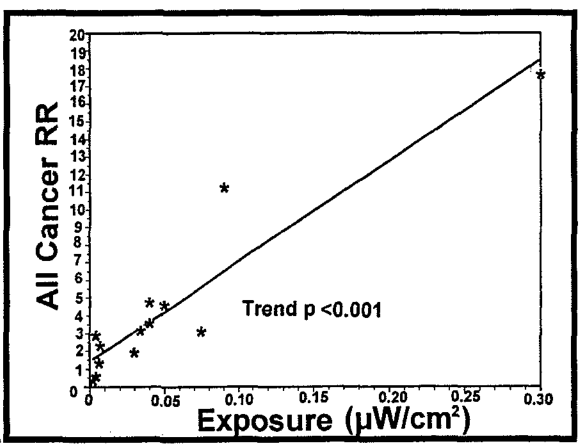
Childhood cancer in the white population around the Sutro Tower in San Francisco shows a remarkable match with the declining and undulating RF radiation pattern from the high powered antennas on the tower (Fig. 9).

Fig. 9. The radial all cancer risk ratio and the mean residential RF exposure. Note the different scales.



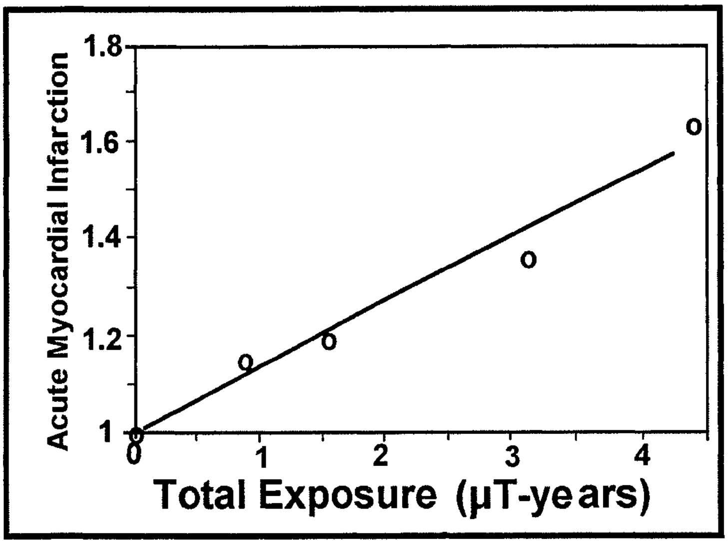
Because of the complex nature of residential radial broadcast tower exposure patterns (Fig. 9), the chance of confounding effects are extremely small. The match shows that no other factor can explain this result than the RF exposure from the Sutro Tower. Thus this indicates a causal relationship. This data is plotted as a dose-response curve in Fig. 10.

Fig. 10. All cancer risk ratio for childhood cancer as a function of estimated radial group mean personal exposure to RF/MW radiation from the Sutro Tower, San Francisco, using the spatial childhood cancer data presented in Selvin et al. (1992). The dose-response relationship is extremely significant (t= 8.33, df = 11, p<0.0001).



U.S. Utility workers also have a significant dose-response increase in heart attack as a function of extremely low annual mean level of low frequency EMR exposure (Fig. 11).

Fig. 11. Acute myocardial Infarction as a function of cumulative exposure to 60 Hz fields in U.S. electricity utility workers, Savitz et al. (1999).



A clean, sustainable city would have all its stationary sources of EMR, including radio, TV, telephone, fax, internet, etc, in fiber-optic cables.

Global climate change is accelerating because of the massive inefficient and unsustainable use of fossil fuels. This is changing the dynamics of anticyclones and depressions in the New Zealand region, causing a significant drying trend in Canterbury (Fig. 12). This has been shown by Dr Stuart Larsen, Lecturer in Meteorology, Lincoln University, to be caused by a Global Warming related change in the Australasian anticyclone (Fig. 13).

Fig. 12. Deficit day data for Lincoln University using a 100 mm soil moisture capacity model.

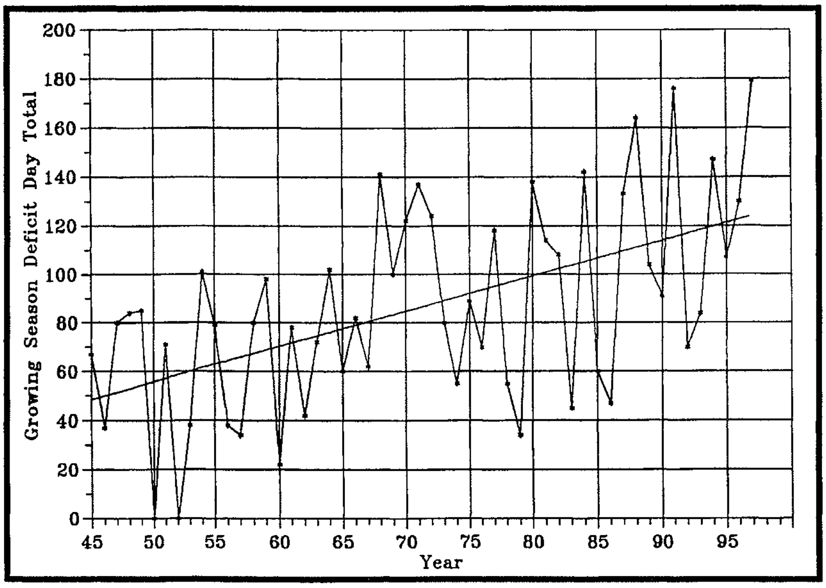
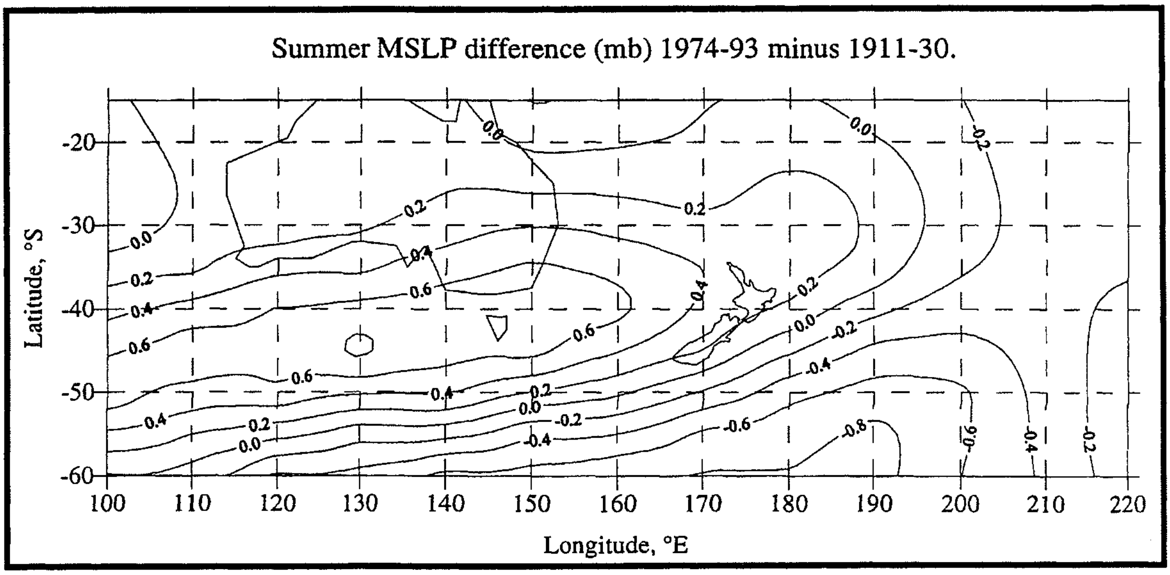


Fig. 13. Sea level pressure anomaly from the 20 year average pressure patterns in 1911-30 and 1974-93 (from Stuart Larsen, Lincoln University).



The mean high pressure anomaly shows an extension into the Tasman Sea and a strengthening of the WSW winds. This enhances the westerly winds approaching the Southern Alps and reduces the Canterbury rainfall.

The soil moisture model used to record drought conditions uses a 100 mm soil moisture capacity with rainfall input and Penman Evapotranspiration output. A day with zero soil moisture is a deficit day. The deficit days for a growing season are summed to form the annual index (Fig. 12). This makes competition for water resources more pressing and the need for careful and efficient use of water in Christchurch much more urgent. A healthy city will have reduced all forms of pollution and have plentiful green spaces, including grass, flowers, bushes and trees that are maintained with clean and adequate water.

Air pollution from fires and cars contributes carbon dioxide to enhance Global Warming. Global Warming is associated with significant climate change in Canterbury, in particular a strong drying trend. In a warmer, drying climate, with a more dense, more pleasant, green-belt limited city, this will require particular care with extensive inter-disciplinary design and management.

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