



THE AUSTRALIAN NATIONAL UNIVERSITY

# Future Tropospheric Ozone and Health Impacts Under a Changing Climate

**Greenhouse 2011**

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## CSIRO and EPA Future Air Science Teams

### ‘Future Air Project’



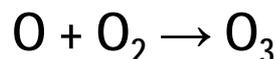
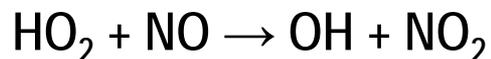
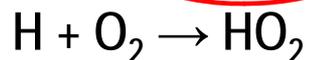
**Australian Government**  
**Bureau of Meteorology**

- The Centre for Australian Weather and Climate Research
- A partnership between CSIRO and the Bureau of Meteorology



- **Introduction**
- **Research scope**
- **Research methods**
  - **Estimating future health impacts associated with air pollution**
  - **Projecting ozone concentrations corresponding to climate change**
- **Results**
  - **Estimates of climate-driven ozone concentrations**
  - **Estimates of health impacts associated with the climate-driven ozone**
- **Conclusions**

- Not directly emitted but it can be formed through photochemical reactions from both
  - Biogenic sources: Volatile Organic Compounds (VOCs)
  - Anthropogenic sources: NO, NO<sub>2</sub>, CO and VOCs
- Temperature is a major climate variable affecting ozone
  - Temperature rise: emissions and formations of ozone precursors such as isoprene



- **Air pollutant: Ozone**
- **The Port Phillip Region**
- **Health outcomes: mortality and hospital admissions for cardiovascular and respiratory disease**
- **Climate change scenario: SRES A2**
- **Reference period: 1996-2005 (D1)**
- **Projected periods : 2025-2034 (D2) and 2065-2074 (D3)**

# Estimating Health Impacts Associated with Air Pollution

## Climate Penalty

*Varied* : GHG emissions

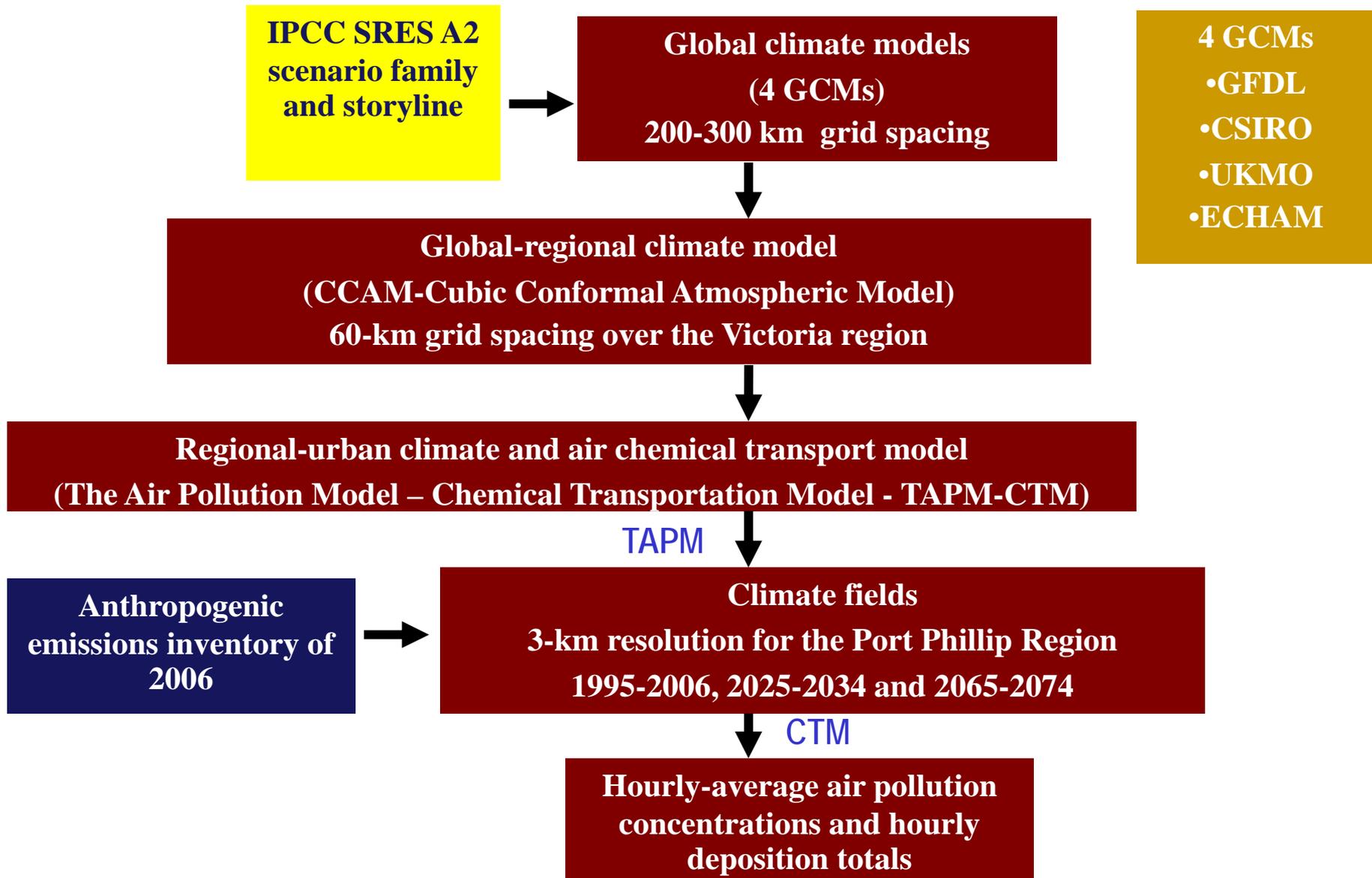
*Fixed* : anthropogenic emissions inventory and other population factors

% change in health impacts

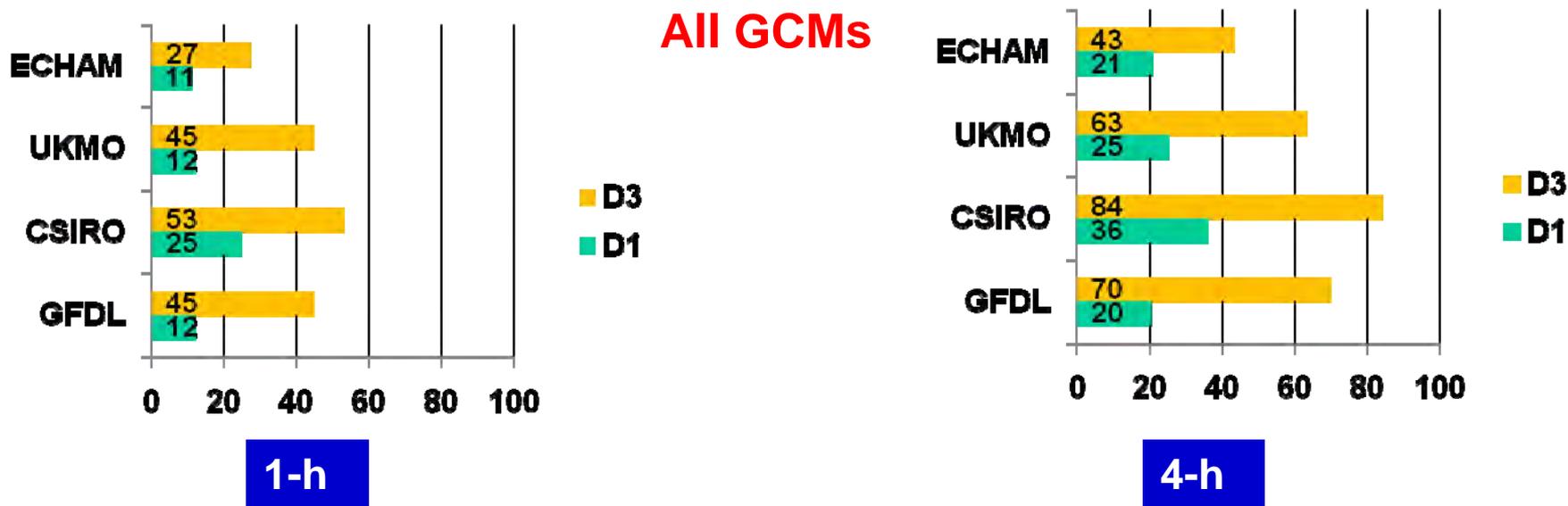
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( % increase in health outcomes for ozone pollution) \*  $\Delta C$

$\Delta C$  = change in future ozone relative to baseline pollution levels



## Total number of exceedence days\* in ‘summer months’<sup>†</sup> for Decade 1 and 3<sup>†</sup>



\* The National Environment Protection Measure Ambient Air Quality Standard for Ozone - 100 ppb (1-h) and 80 ppb (4-h)

<sup>†</sup> Summer months include January and February

GFDL = USA Geophysical Fluid Dynamics laboratory Climate Model version 2.1

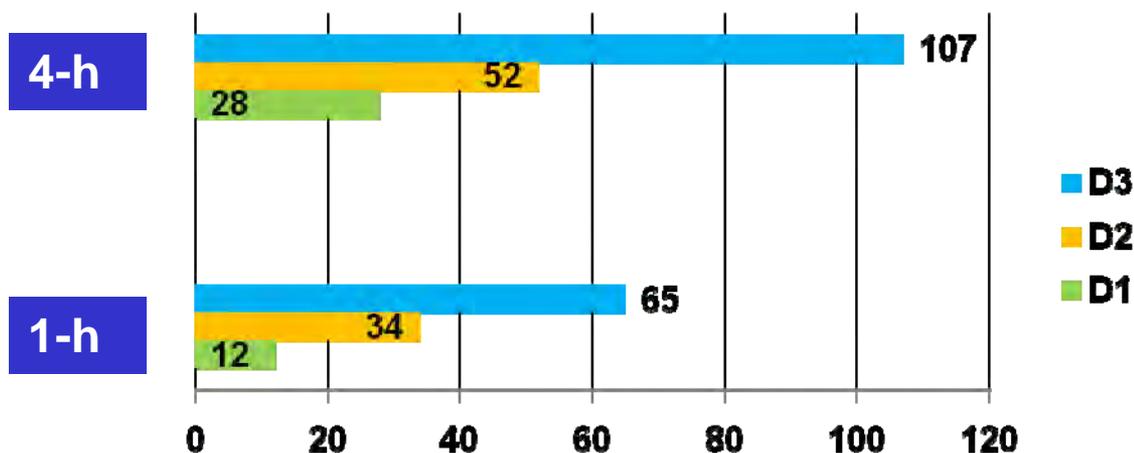
CSIRO = CSIRO Mk 3.5 GCM

UKMO Had = the United Kingdom UKMO-HadCM3 GCM

ECHAM = German ECHAM5/MPI-OM GCM

Total number of exceedence days\* in ‘all months for all the decades’

**GFDL**



\* The National Environment Protection Measure Ambient Air Quality Standard for Ozone - 100 ppb (1-h) and 80 ppb (4-h)

GFDL = USA Geophysical Fluid Dynamics laboratory Climate Model version 2.1

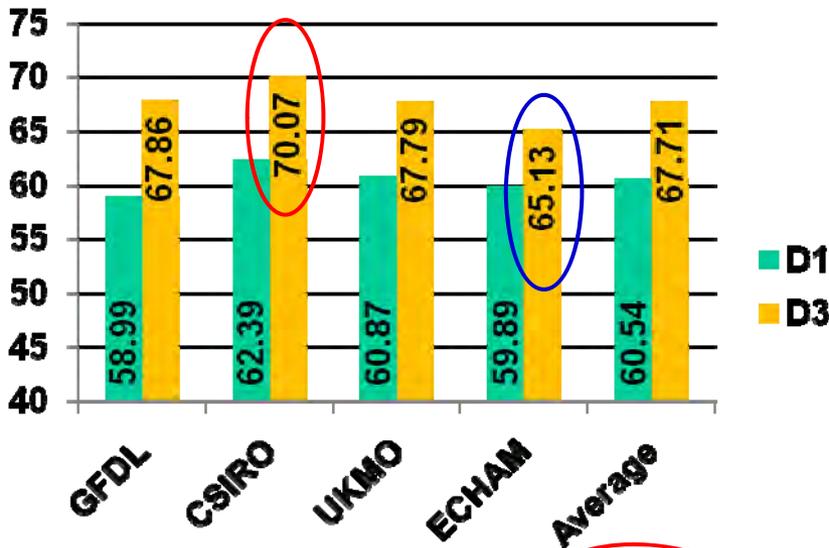
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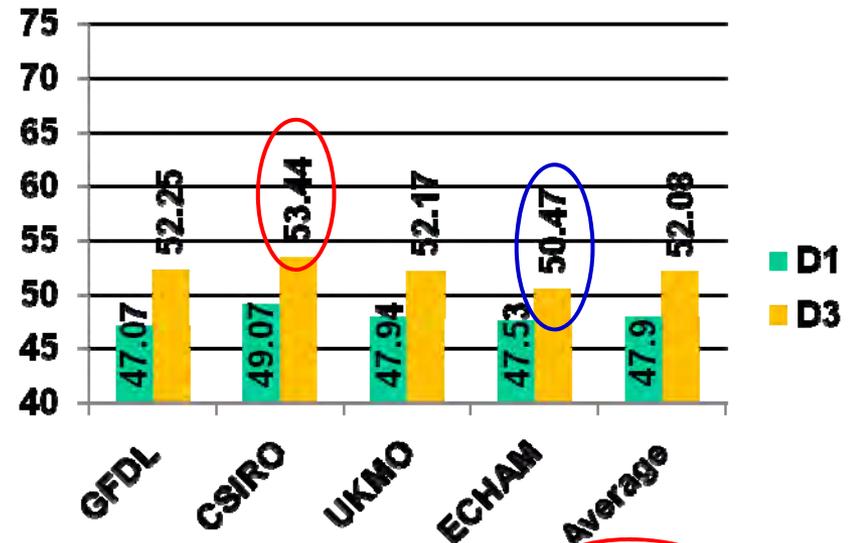
# Results – Effect of Climate Change on Ozone

Summer average\* of daily maximum '1-h' ozone concentrations' (ppb) from all GCMs



%D3-D1	15.04	12.32	11.36	8.75	11.86
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Summer average\* of daily maximum '8-h' ozone concentrations' (ppb) from all GCMs

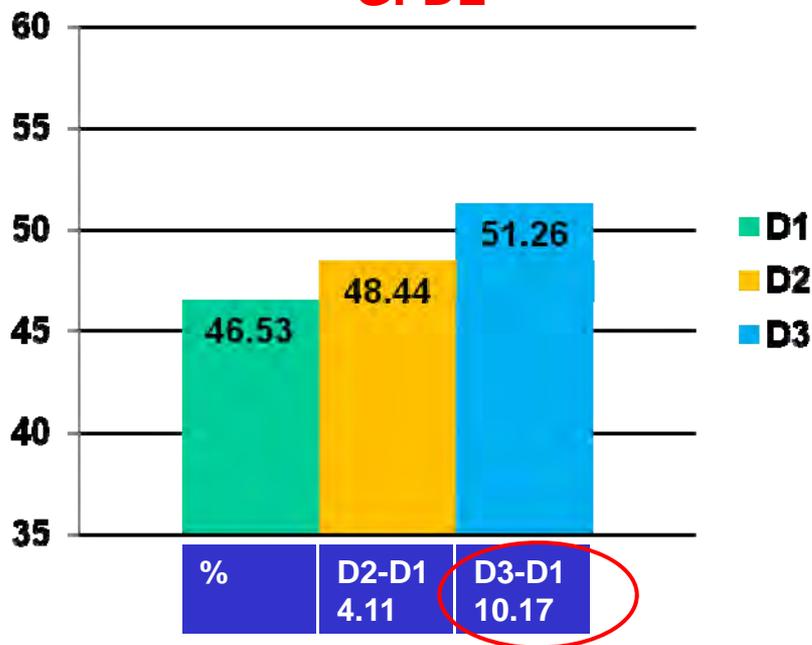


%D3-D1	10.99	8.90	8.82	6.18	8.72
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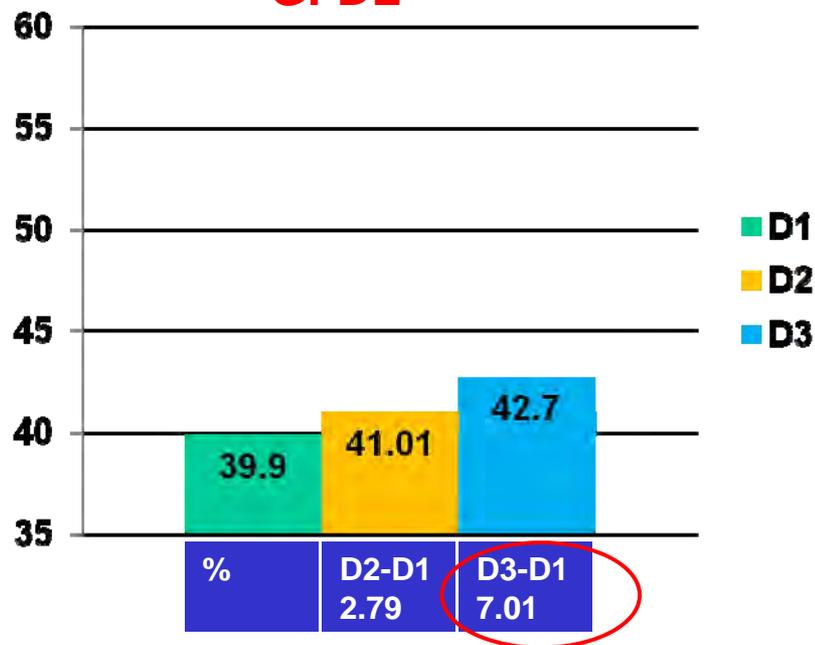
\*This value is calculated by averaging over the 10 years of the sum of projected daily maximum average ozone concentration of all the grid points for everyday of each decade.

# Results – Effect of Climate Change on Ozone

Annual average\* of daily maximum '1-h' ozone concentrations' (ppb) from GFDL

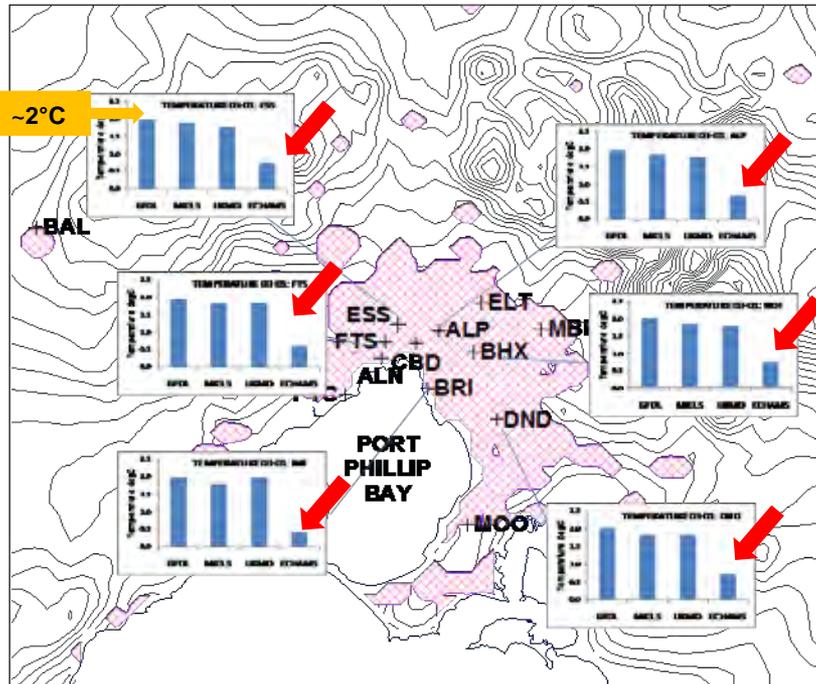


Annual average\* of daily maximum '8-h' ozone concentrations (ppb) from GFDL

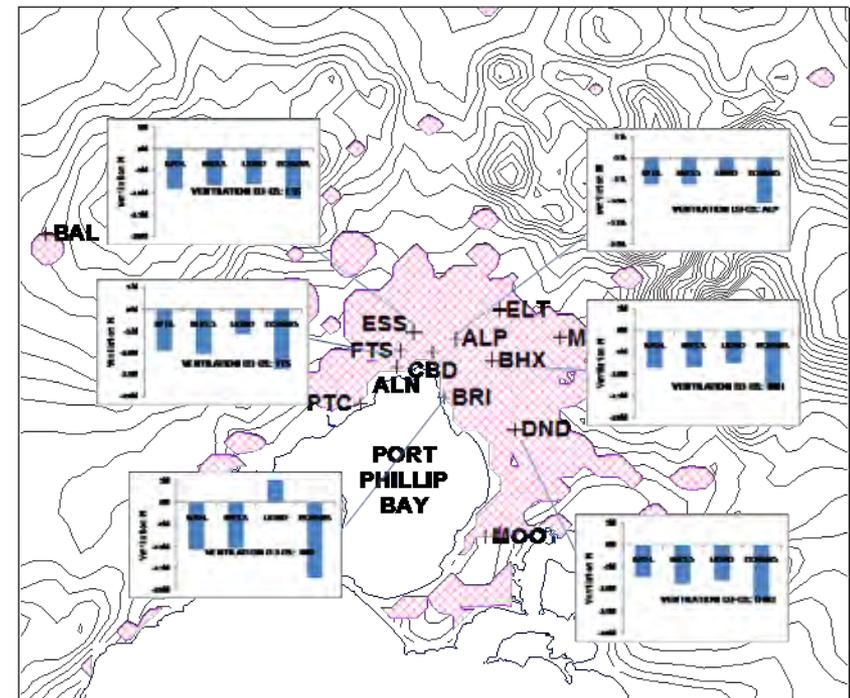


\*This value is calculated by averaging over the 10 years of the sum of projected daily maximum average ozone concentration of all the grid points for everyday of each decade.

**Difference (D3-D1) between the average 24-h temperatures (°C) in summer for the 4 GCMs**



**Difference (D3-D1) between the average 24-h ventilation rates (%) in summer for the 4 GCMs**



The graph columns from left to right: GFDL, CSIRO, UKMO, ECHAM

# Percentage increases in health effects for estimating future health impacts associated with ozone

## Mortality associated with '1-h' Ozone

	Total all cause		Cardiovascular		Respiratory	
	all ages	+75 years	all ages	+75 years	all ages	+75 years
summer	0.1 (0.0-0.2)	0.1 (0.0-0.2)	0.1 (0.0-0.2)	0.2 (0.0-0.3)	-	
all year	0.1 (0.0-0.2)	0.1 (0.0-0.3)	0.2 (0.1-0.3)	0.2 (0.0-0.3)	0.2 (0.0-0.4)	0.3 (0.0-0.5)

## Hospital Admissions\* associated with '1-h' Ozone

	Respiratory (1-4 years)	Asthma (1-4 years)
summer	0.4 (0.2-0.5)	0.5 (0.3-0.7)
all year	0.2 (0.0-0.3)	-

\* % increase in health effect and 95% confidence interval per a one ppb increase in ozone

Source: Environmental Protection and Heritage Council (2010). Expansion of the Multi-city Mortality and Morbidity Study: Final Report.

a) Based on the data in the period 1998-2001

b) Pooled estimates from 4 Australian cities including Sydney, Melbourne, Brisbane and Perth

# Percentage increases in health effects for estimating future health impacts associated with ozone

## Mortality associated with '8-h' Ozone

	Total all cause		Cardiovascular		Respiratory	
	all ages	+75 years	all ages	+75 years	all ages	+75 years
summer	0.1 (0.0-0.2)	0.2 (0.0-0.3)	0.2 (0.0-0.4)	0.2 (0.0-0.4)	-	-
all year	0.1 (0.0-0.3)	0.1 (0.0-0.3)	0.3 (0.1-0.4)	0.3 (0.0-0.5)	0.3 (-0.0-0.6)	0.3 (0.0-0.7)

## Hospital Admissions\* associated with '8-h' Ozone

	Respiratory (1-4 years)	Asthma (1-4 years)
summer	0.6 (0.4-0.8)	0.6 (0.3-0.9)
all year	0.2 (0.0-0.5)	-

\* % increase in health effects and 95% confidence interval per a one ppb increase in ozone

Source: Environmental Protection and Heritage Council (2010). Expansion of the Multi-city Mortality and Morbidity Study: Final Report.

a) Based on the data in the period 1998-2001

b) Pooled estimates from 4 Australian cities including Sydney, Melbourne, Brisbane and Perth

## Percent change in health impacts associated with future ‘1-h’ ozone

% Change in health impact	D2-D1	D3-D1	D3-D1
	GFDL (all year)	GFDL (all year)	all GCMs (summer)
<b>Mortality for all causes</b>			
+75 years	0.19 (0.0-0.57)	0.47 (0.0-1.42)	0.72 (0.0-1.44)
all ages	0.19 (0.0-0.38)	0.47 (0.0-0.95)	0.72 (0.0-1.44)
<b>Mortality for total cardiovascular</b>			
+75 years	0.38 (0.0-0.57)	0.95 (0.0-1.42)	1.44 (0.0-2.15)
all ages	0.38 (0.19-0.57)	0.95 (0.47-1.42)	0.72 (0.0-1.44)
<b>Mortality for total respiratory</b>			
+75 years	0.57 (0.0-0.96)	1.42 (0.0-2.37)	-
all ages	0.38 (0.0-0.76)	0.95 (0.0-1.89)	-
<b>Admissions for total respiratory</b>			
1-4 years	0.38 (0.0-0.57)	0.95 (0.0-1.42)	2.87 (1.44-3.59)
<b>Admissions for asthma</b>			
1-4 years	-	-	3.59 (2.15 -5.02)

# Results – Health Impacts Associated with Effect of Climate Change on Ozone

## Percent change in health impacts associated with future ‘8-h’ ozone

% Change in health impact	D2-D1	D3 –D1	D3-D1
	GFDL(all year)	GFDL(all year)	all GCMs (summer)
<b>Mortality for all causes</b>			
+75 years	0.11 (-0.0-0.33)	0.28 (-0.0-0.84)	0.84 (-0.0-1.25)
all ages	0.11 (0.0-0.33)	0.28 (0.0-0.84)	0.42 (0.0-0.84)
<b>Mortality for total cardiovascular</b>			
+75 years	0.33 (0.0-0.56)	0.84 (0.0-1.40)	0.84 (0.0-1.67)
all ages	0.33 (0.11-0.44)	0.84 (0.28-1.12)	0.84 (0.0-1.67)
<b>Mortality for total respiratory</b>			
+75 years	0.33 (0.0-0.78)	0.84 (0.0-1.96)	-
all ages	0.33 (-0.0-0.67)	0.84 (-0.0-1.68)	-
<b>Admissions for total respiratory</b>			
1-4 years	0.22 (-0.0-0.56)	0.56 (-0.0-1.40)	2.51 (1.67-3.34)
<b>Admissions for asthma</b>			
1-4 years	-	-	2.51 (1.25-3.76)

- **The effect of climate change on ozone is to increase concentrations in the Port Phillip Region, for all Global Climate Models.**
- **Increases in temperature and decreases in ventilation rate are the principal drivers of the changes in future ozone concentrations.**
- **The changes in future ozone are likely to cause increases in health burdens particularly in children and the elderly.**
- **Future work**
  - **Predicting other air pollutants and their health impacts particularly particulate matter and their components**
  - **Modeling of the combined effect of climate change and realistic future trends in emissions**

**Thank you for your attention**

