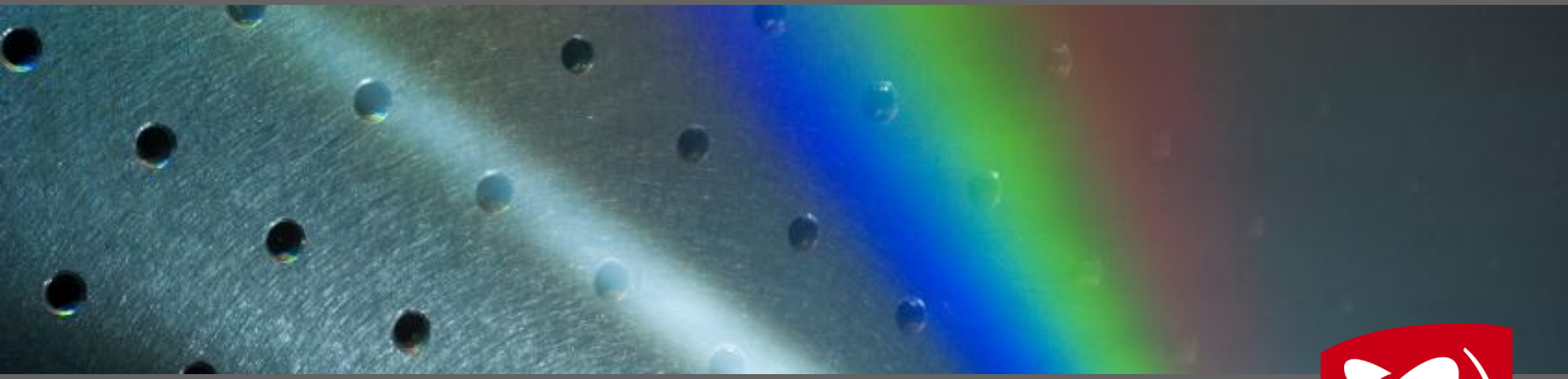
Evidence for the impact of particulate matter emissions from ships



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Context

GNS Science research on particulate matter composition and associated receptor modelling studies have shown:

- **that shipping emissions can have local and regional impacts on particulate matter concentrations**

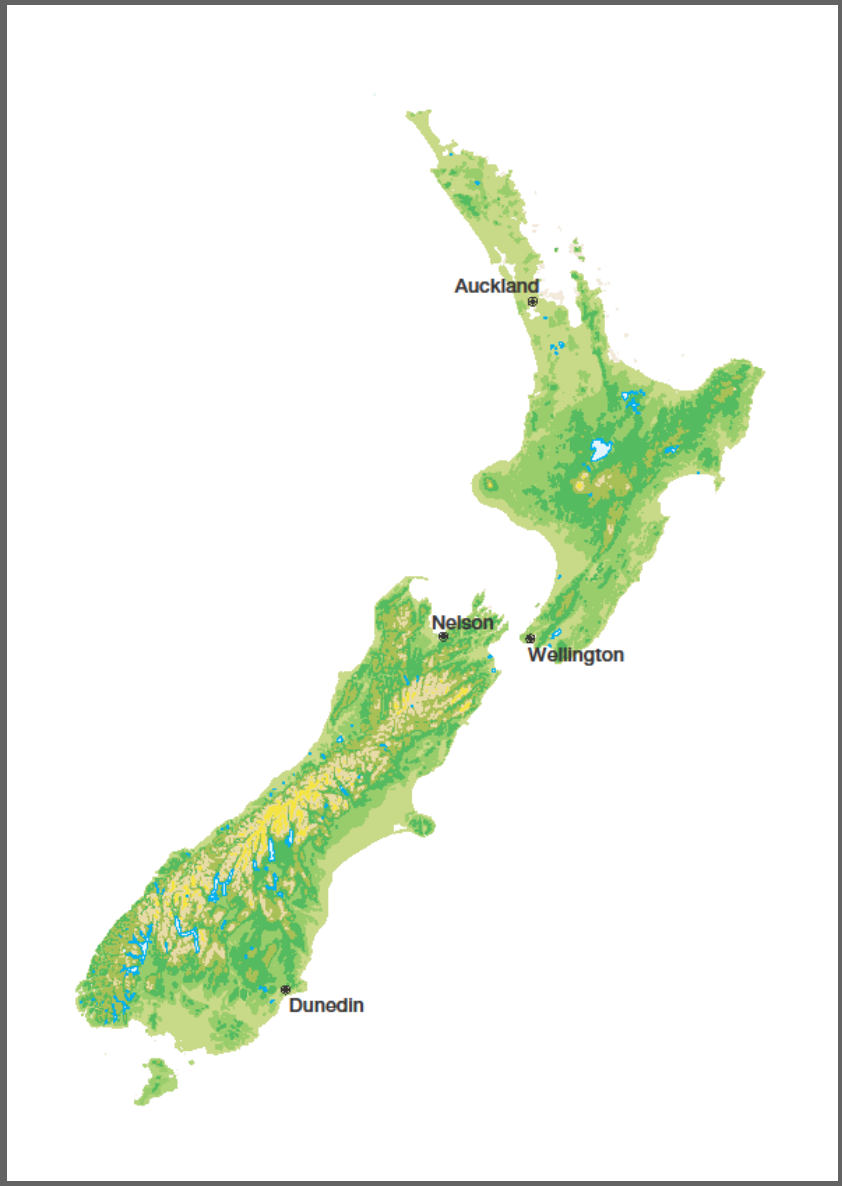
- **that the composition of particles emitted directly from shipping sources contain heavy metals**

Four study locations implicated (so far)

Sampling periods:

- **Auckland (2004 – 2009)**
- **Wellington (2005 – 2007)**
- **Nelson (2008 – 2009)**
- **Dunedin (2010)**

All locations are urban areas associated with ports



Emissions from Ships

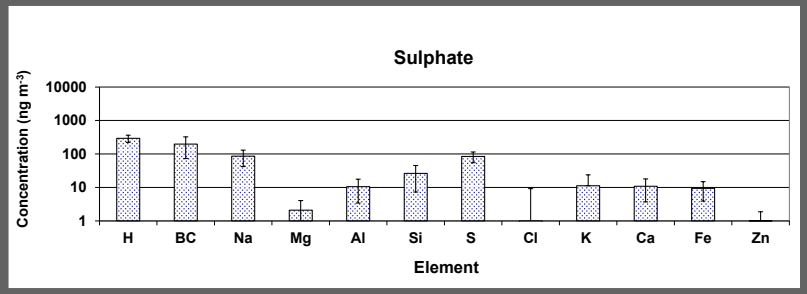
- Fuels are high in sulphur with traces of heavy metals (notably V and Ni)
- Emissions include gases (CO_2, CO, NO_x, SO_2) and particulate matter (carbon, organics, elements)
- The emitted SO_2 gas is converted in the atmosphere to form secondary sulphate particles (also H_2S and DMS)

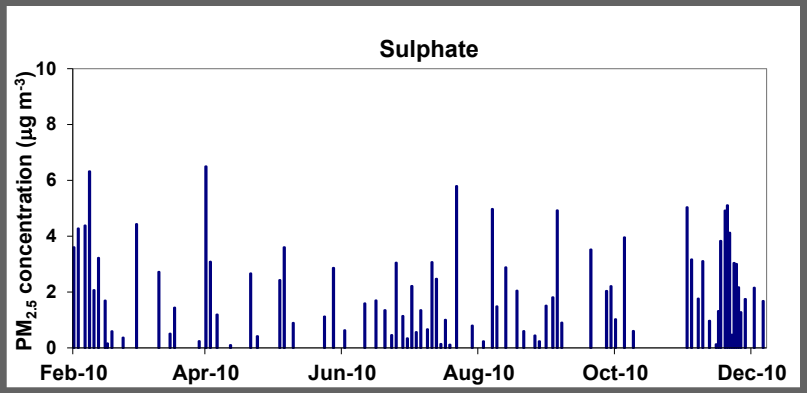
$$SO_2(g) \rightarrow SO_3 + H_2O \rightarrow H_2SO_4 + (NaCl, NH_4+) \rightarrow (Na)_2SO_4 + (NH_4)_2SO_4 + HCl + \ldots..$$

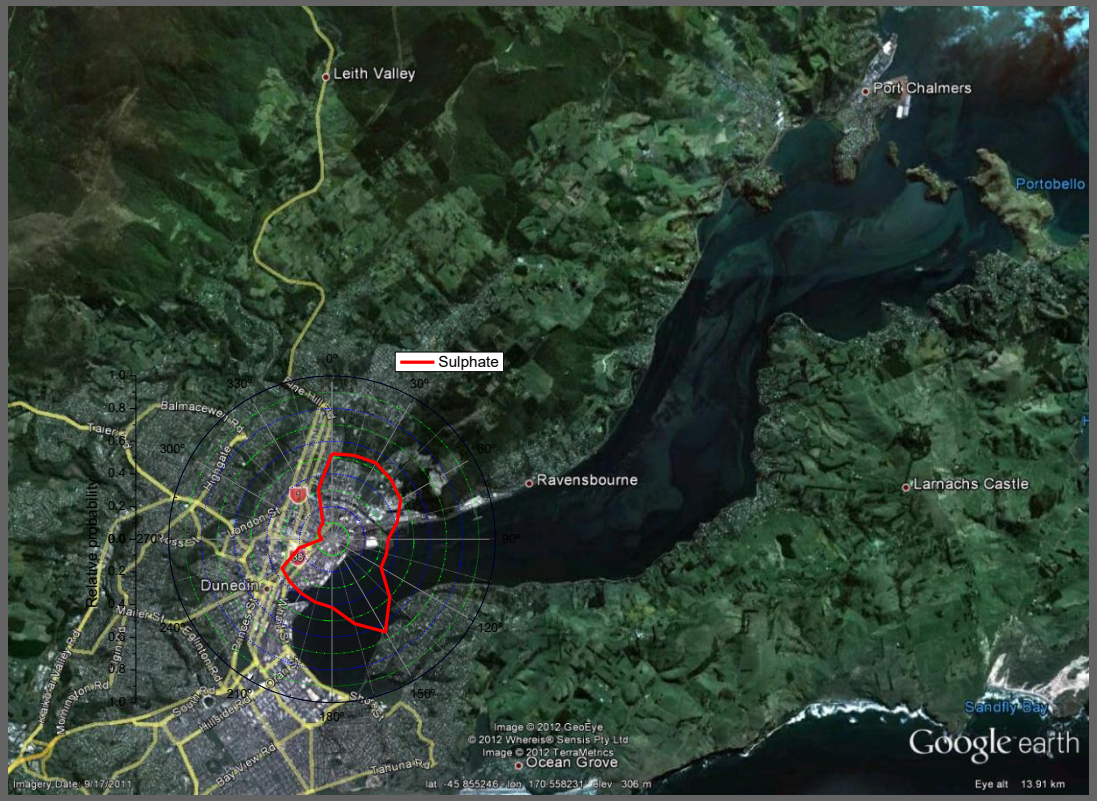
- Ship engines are large (up to 80 MW)
- Euro 5 truck particle emissions around 0.02g/KWh whereas ships are in the order of 1-2g/KWh

Dunedin Secondary sulphate (Samples: 105 $PM_{2.5}$)

- Secondary sulphate particle source chemical profile indicates combustion origin (BC)
- CPF source directionality shows alignment with harbour (Port Chalmers)

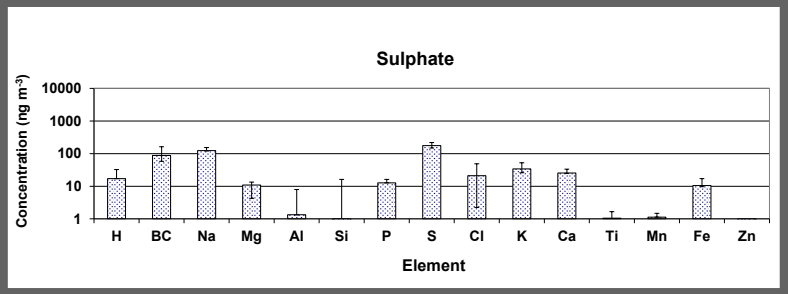


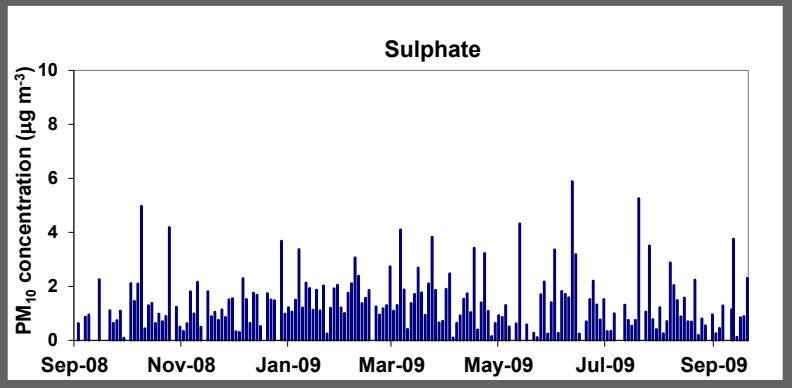


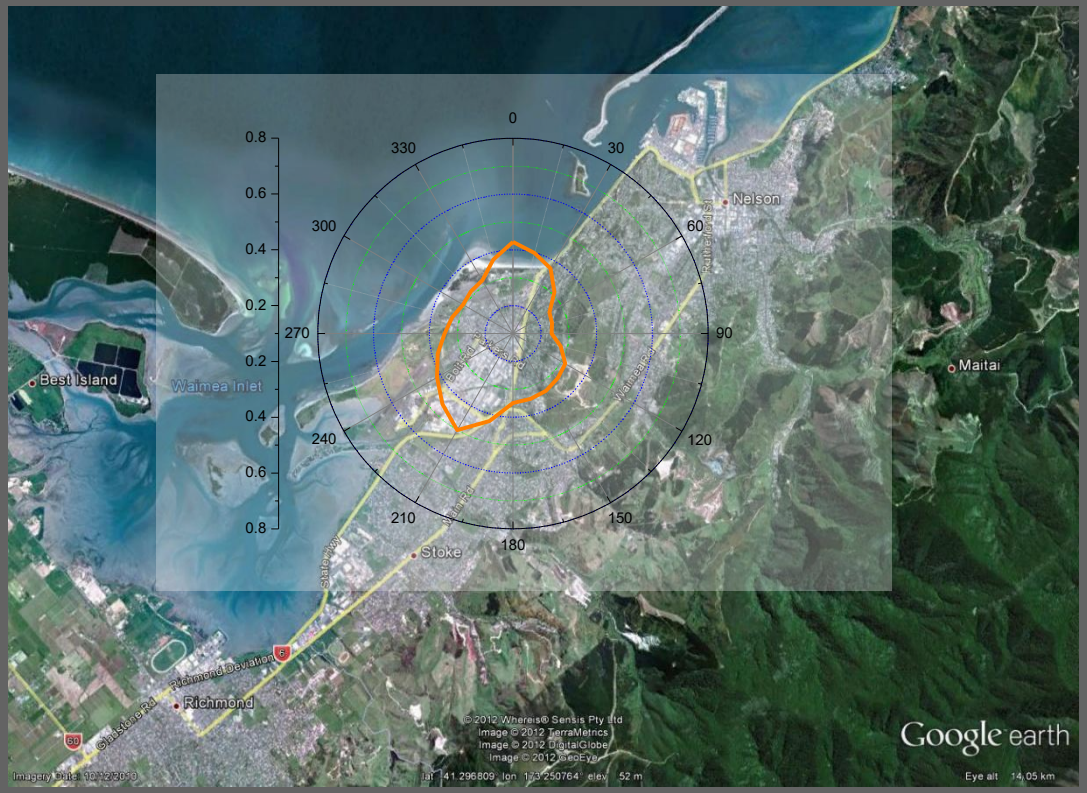


Nelson Secondary sulphate (Samples: 185 PM_{10})

- CPF source directionality shows alignment with Nelson's port area

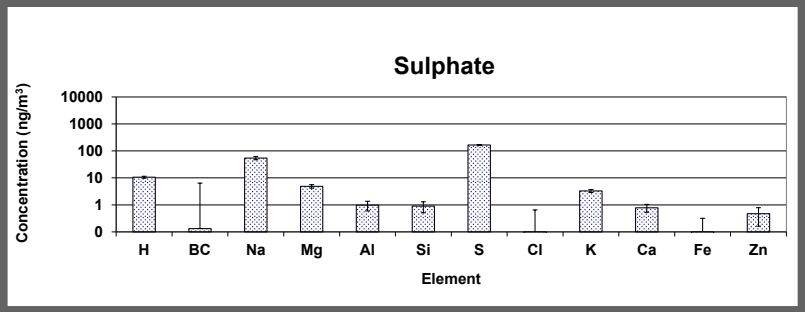


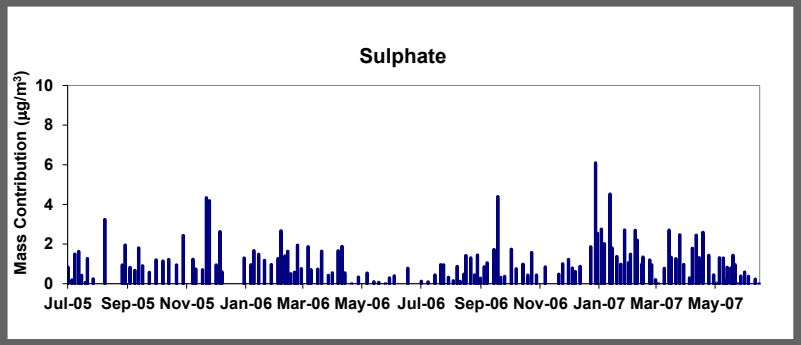




Wellington (Seaview) Secondary sulphate (Samples: 140 $PM_{2.5}$)

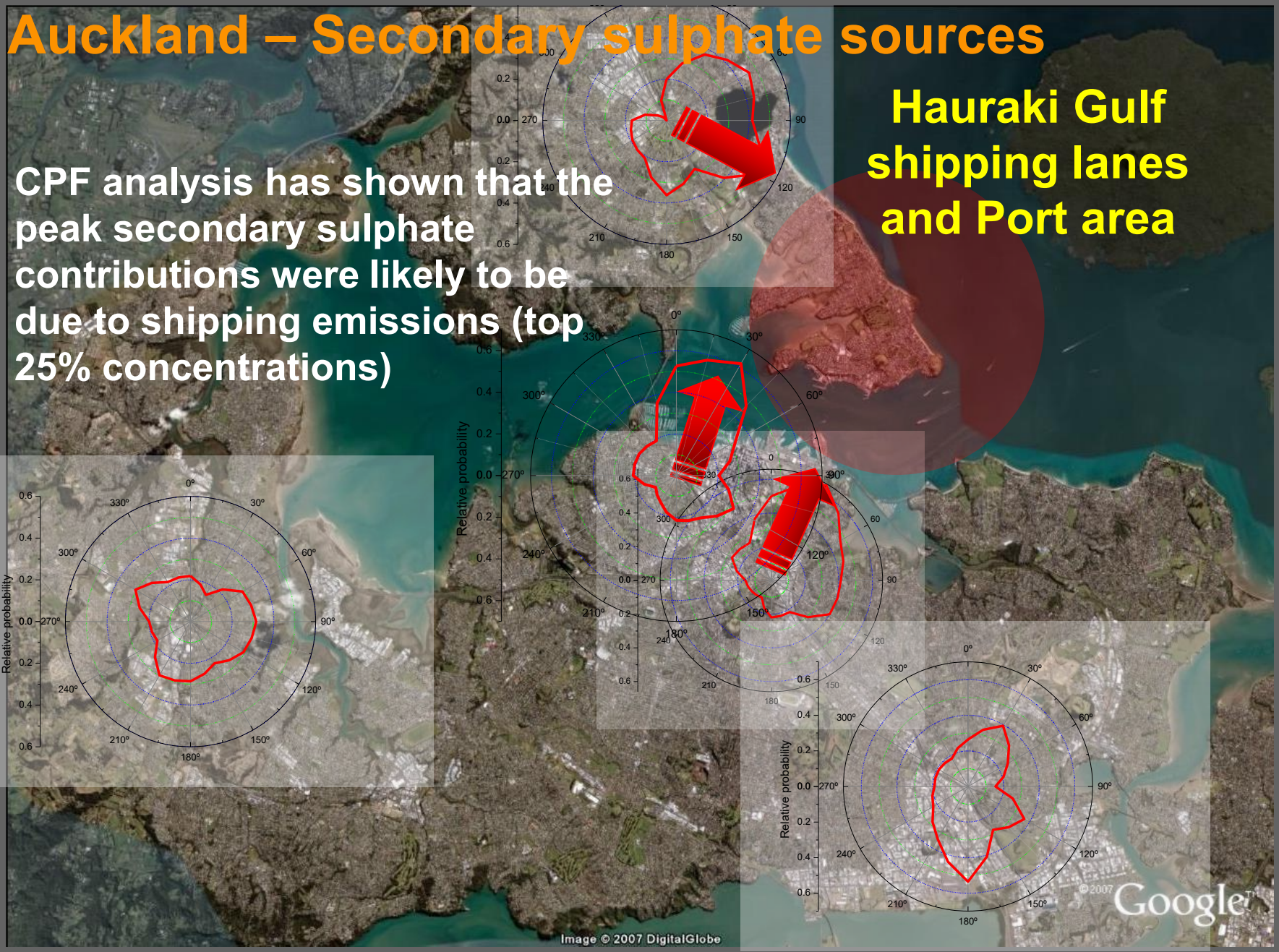
CPF source directionality shows alignment with Wellington's port area





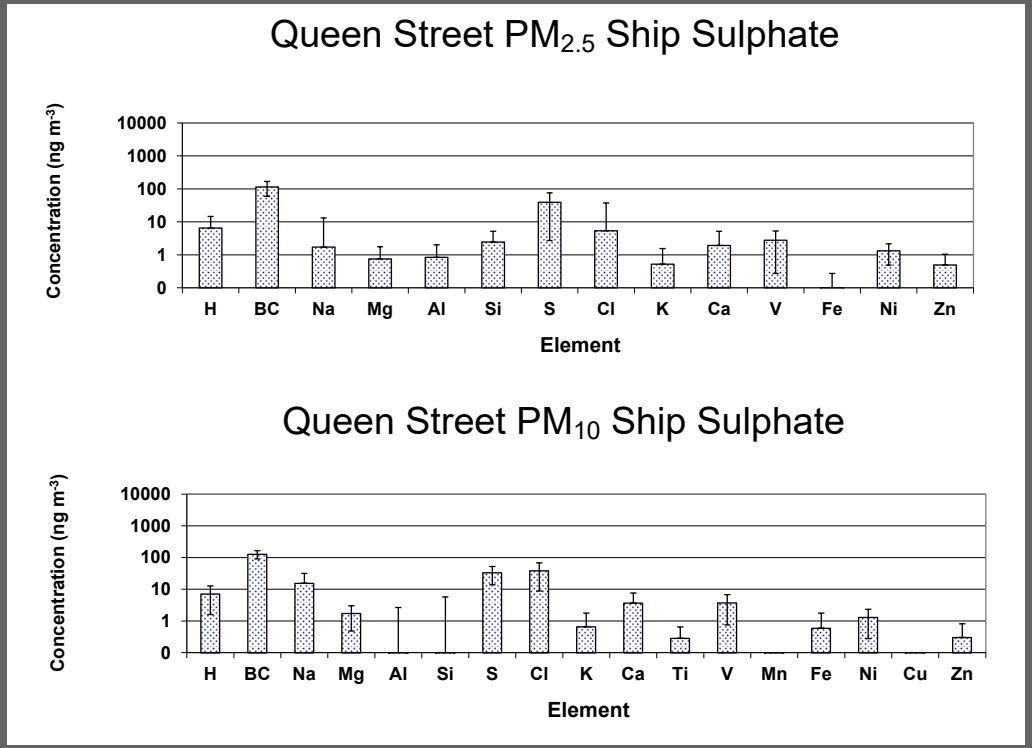
Auckland – Secondary sulphate sources

- CPF analysis has shown that the peak secondary sulphate contributions were likely to be due to shipping emissions (top 25% concentrations)



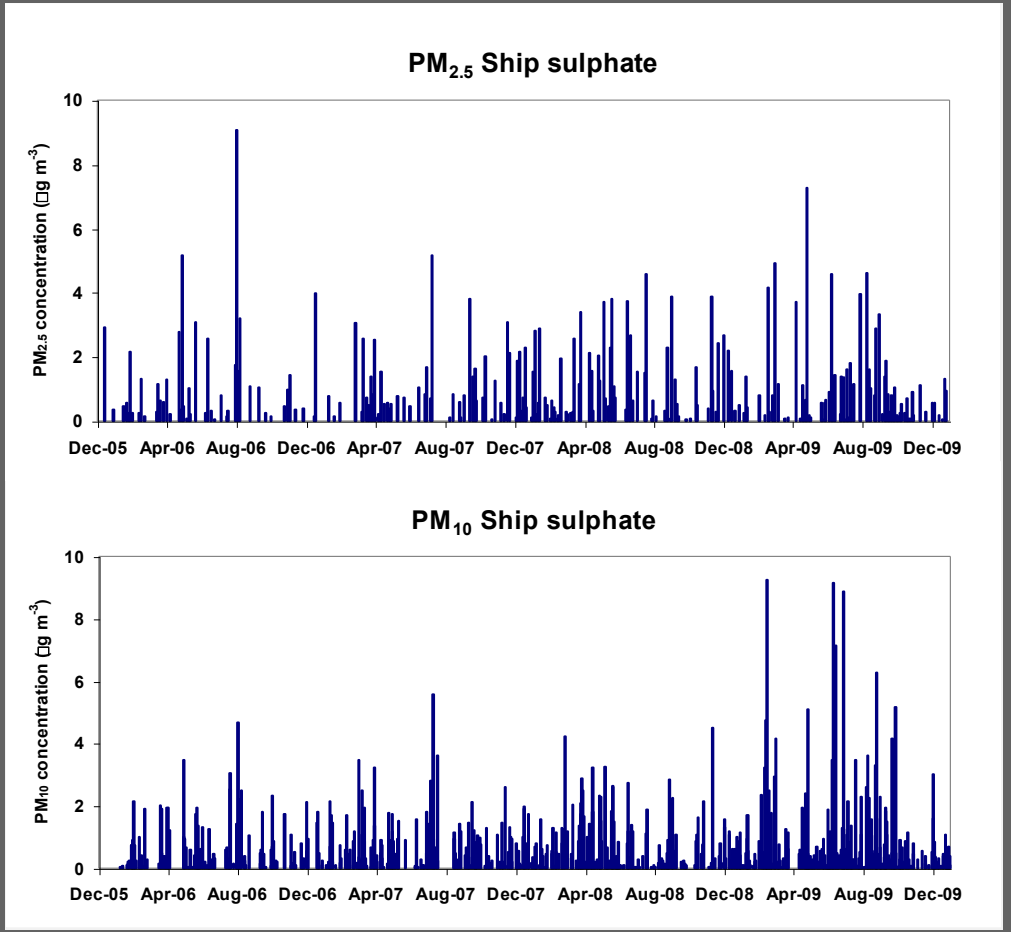
Queen Street - Primary sulphate ship emissions (Samples: 450 $PM_{2.5}$, 1240 PM_{10})

- Source elemental profiles for $PM_{2.5}$ and PM_{10} are shown
- This is a primary sulphate source i.e. sulphur acid gases or sulphate particles emitted directly from ships engines
- Includes vanadium and nickel – contaminants in fuel oil



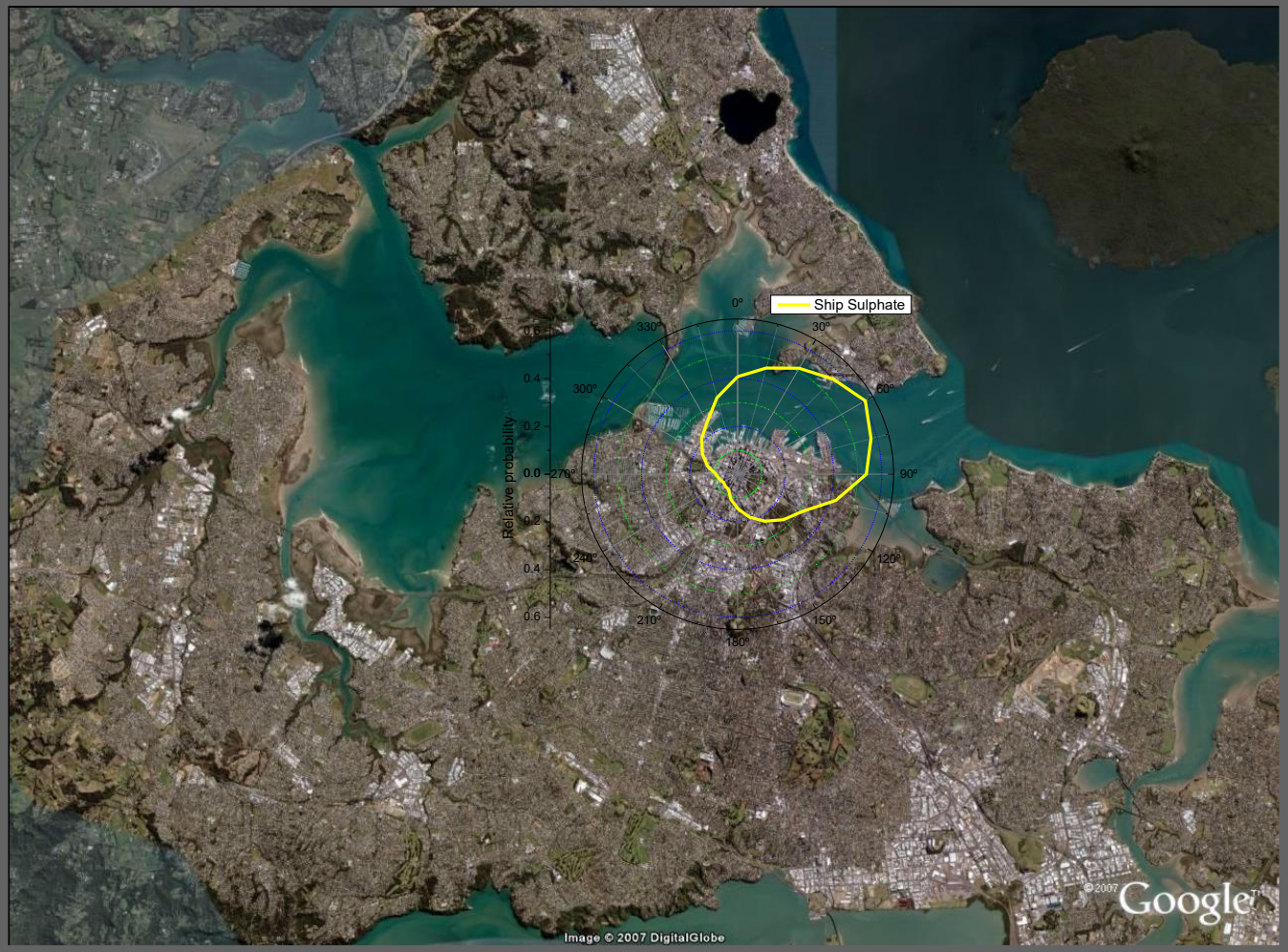
Queen Street - Primary sulphate ship emissions Time series:

- Source contributions for $PM_{2.5}$ and PM_{10} are shown (note that $PM_{2.5}$ is one-day-in-3 and PM_{10} is daily sampling)
- Average contribution is 0.4 - 0.6 μg m^{-3} and peaks are 8 - 9 μg m^{-3}
- Contributions are a function of shipping activity and wind direction (each ship is a point source)



Queen Street - Primary sulphate ship emissions

- CPF plot for Queen Street Ship sulphate source



Summary

- Particle composition analysis and receptor modelling studies indicate an impact from ship emissions on urban areas located around ports
- The effect is dependent on frequency of ship visits, ship size, the number of ships within a port and meteorology
- The monitoring location is also critical for point source emissions

Acknowledgements for the use of their data:

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