

Marine Aerosol

Mike Harvey



NEW ZEALAND BRANCH SEMINAR
Friday 12 June, 2015 - Auckland, NZ

Particle life cycles

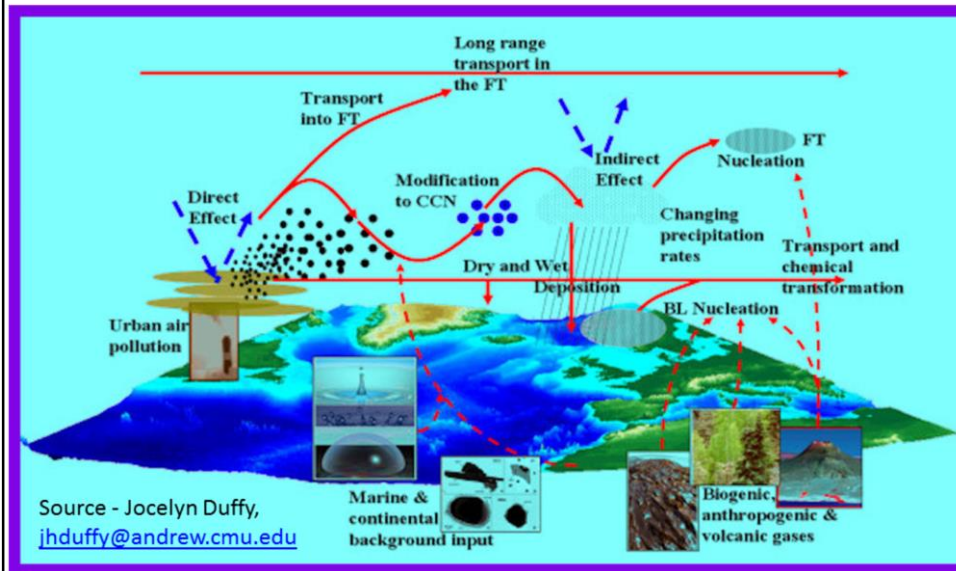
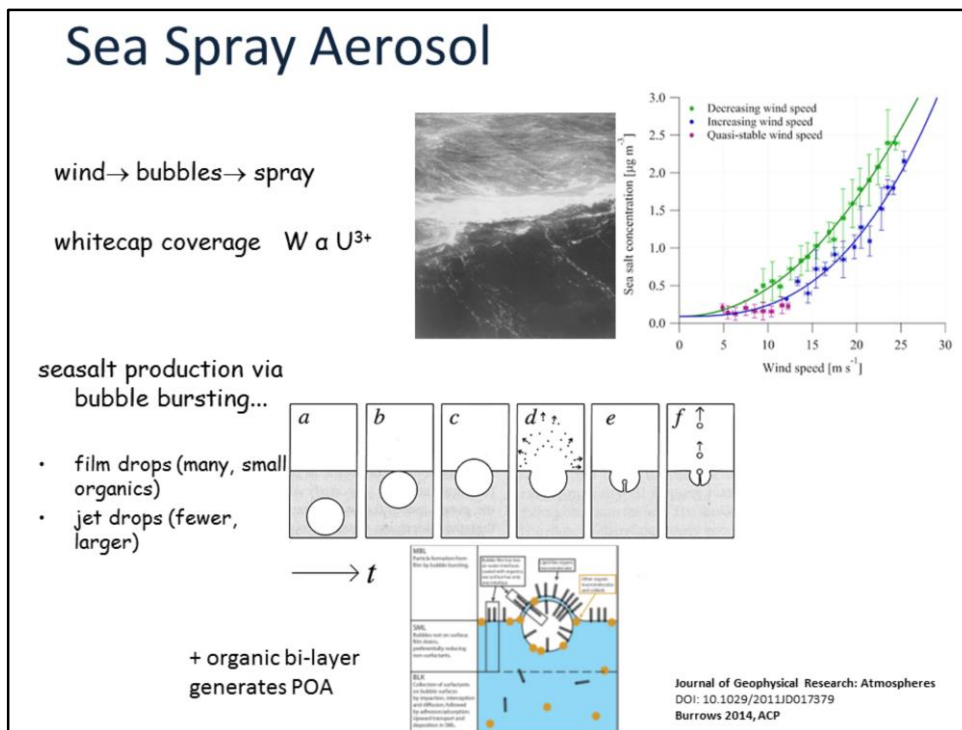


Diagram of the life cycle of aerosol in the atmosphere, showing emission, deposition and transport processes and the action of aerosol while in the atmosphere

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- The production of seasalt aerosols is highly wind speed dependent.
- Traditionally aerosols from seaspray were believed to be composed largely of seawater.
- Now evidence that organic compounds from seasurface are a major component of these aerosols, but little is known about them.

Jet drops are relatively few in number and produce larger aerosols. They are produced by small bubbles.

Film droplets generate more numerous but smaller aerosols.

For concentration:

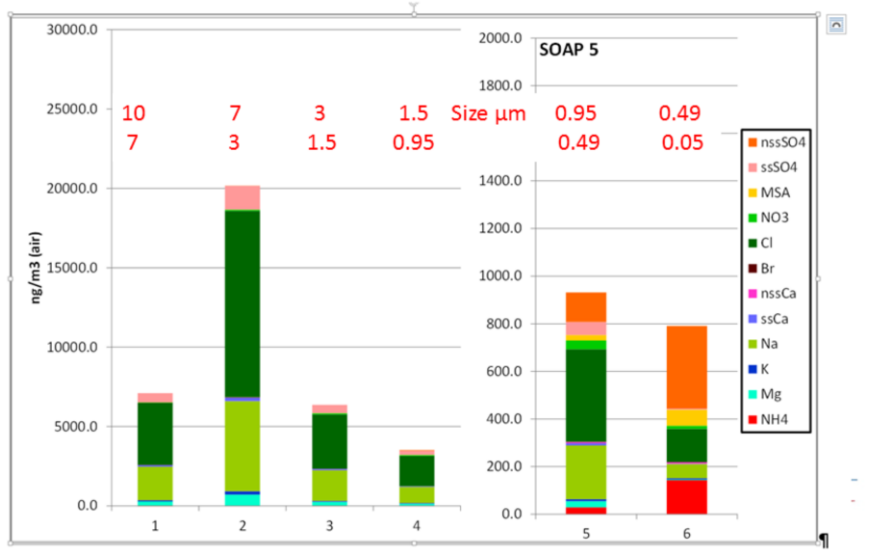
Sea salt wind speed–concentration relationships for increasing and decreasing wind speed history regimes: increasing is in dark blue; decreasing is in green. Purple represents quasi-stable wind speed conditions just after the decreasing wind speed regime (12:00 UTC 12th November–12:00 UTC 13th November 2010). Five-minute data points are binned to the wind speed intervals equal to 1 m s^{-1} .

For years it was thought that seasalt contributed only to coarse mode aerosols, but appears that there is significant production of coarse mode aerosols via sea spray

What size is sea salt aerosol?

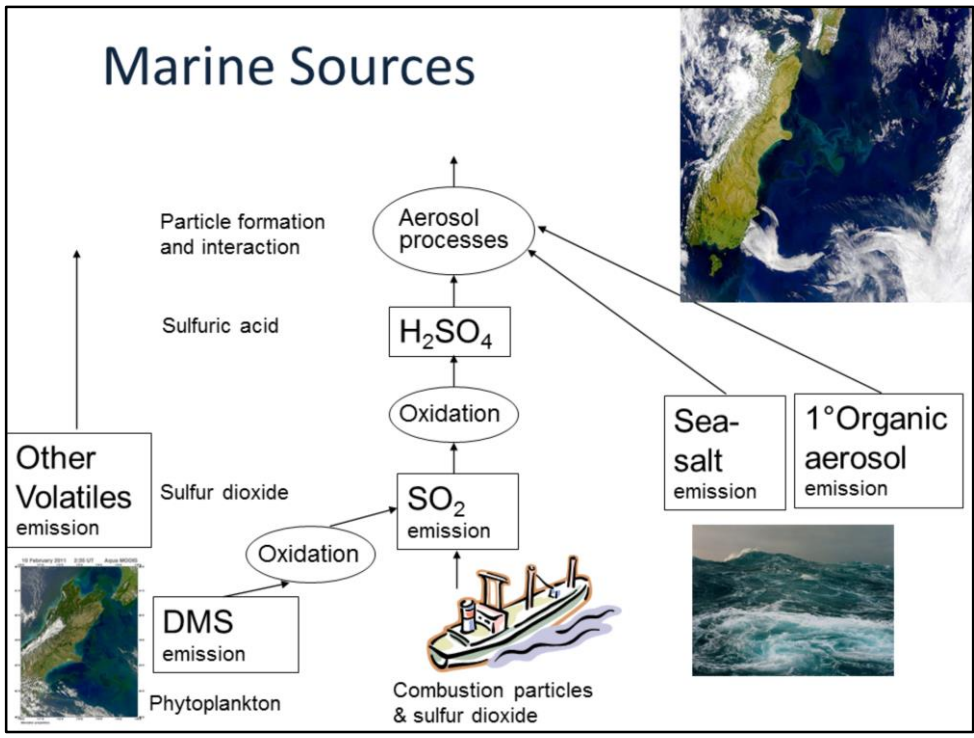
Harvey
"SOAP" data

Windy ocean surface example – Av windspeed 10 m/s Max 20 m/s
Proportion in 0.5 to 3 μm grows as wind increases $\sim 40\mu\text{g}/\text{m}^3$ over days

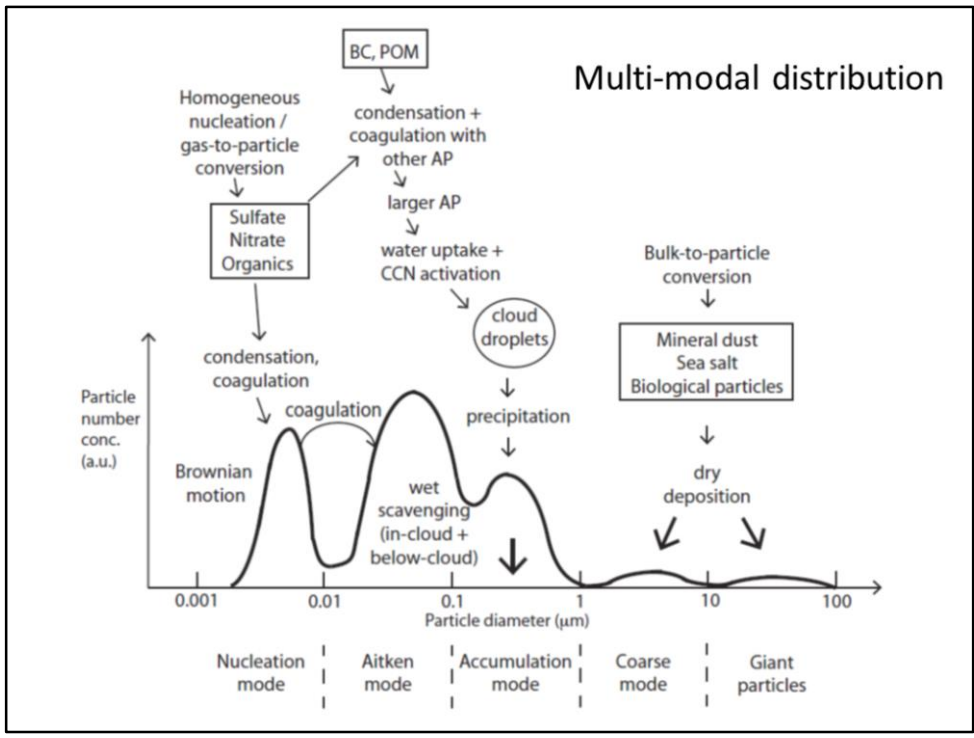


Example from Hi-Volume cascade impactor mass distribution. SOAP experiment Feb 2012 (summer over phytoplankton bloom, biologically active waters and strong winds)
Much of the non-sea-salt components are in the sub-micron size ranges, especially nss & MSA, NH4 in the marine environment

This sample is high mass under windy conditions. In strong winds, there is a reduction in the relative mass of $>3\ \mu\text{m}$ aerosol – sometime a reduction in amount has been observed. There is an increase in the amount of sub-micron sea-salt as well.



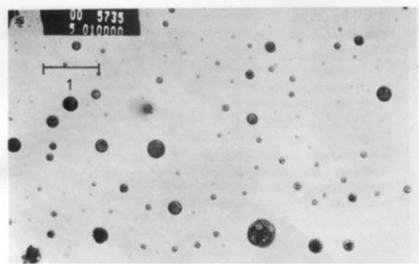
Maijor marine aerosol sources



How the marine aerosol evolves

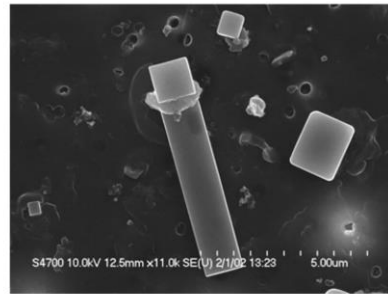
Marine aerosol micrographs

Accumulation mode



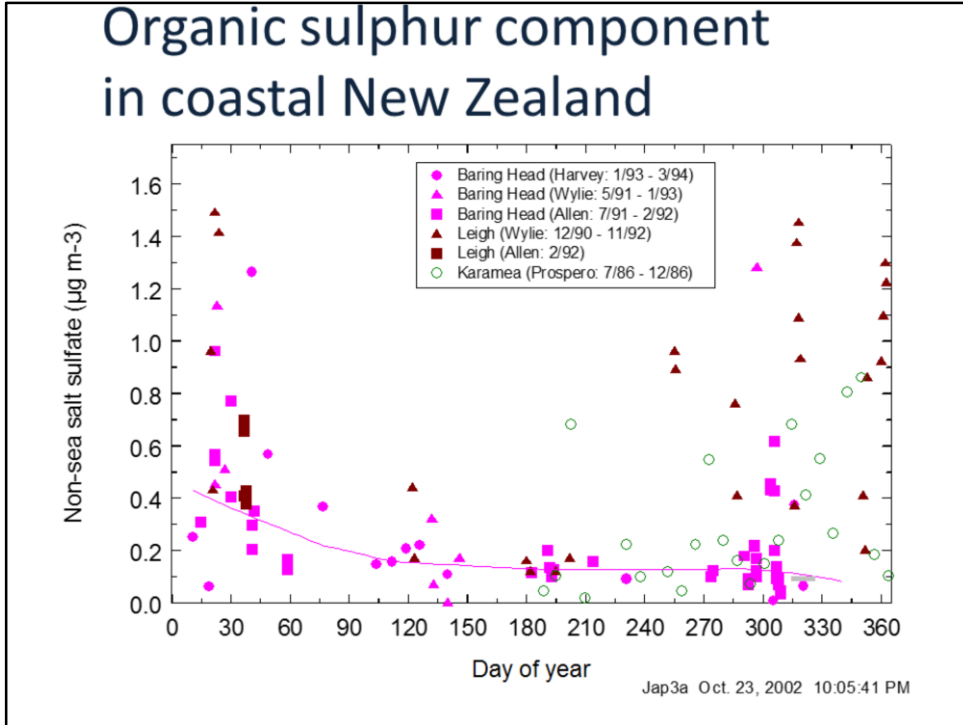
Antarctic "clean"
atmosphere sulphate in
accumulation mode by
low pressure
impaction & low
intensity TEM
(Harvey)

Coarse mode



Sea Salt Aerosol at Baring Head, NZ (Jim Anderson)

Organic sulphur component in coastal New Zealand

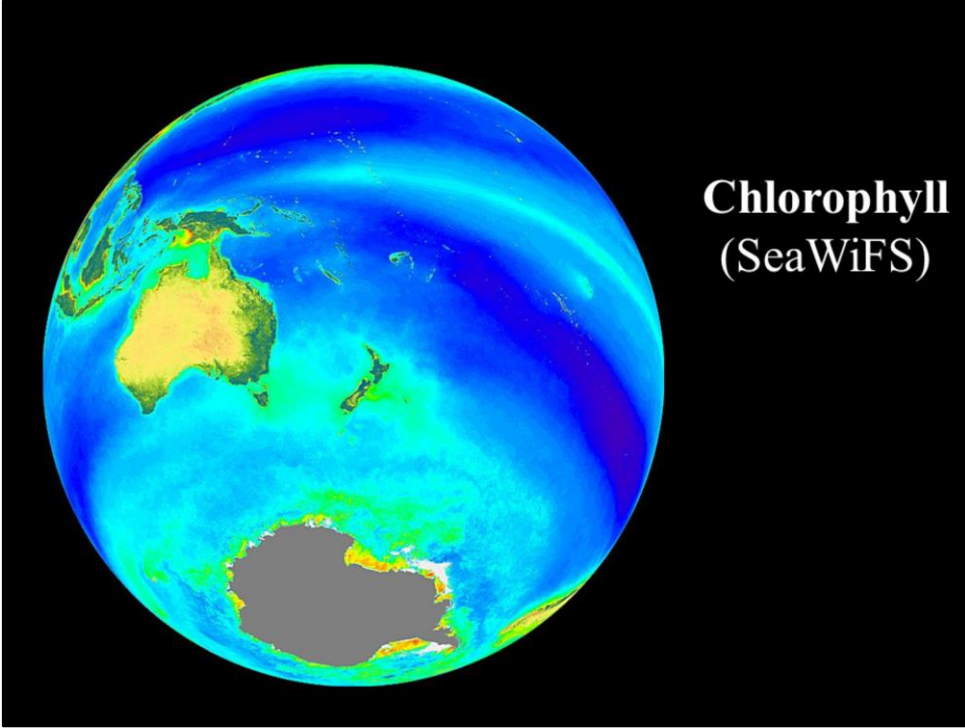


Seasonality was investigated in non-sea-salt sulphur aerosols.

The total atmospheric sulphate loading is about $1.2 \mu\text{g m}^{-3}$ in onshore winds and $1.0 \mu\text{g m}^{-3}$ in offshore winds. The order is reversed for non-sea-salt sulphate with an average concentration of $0.4 \mu\text{g m}^{-3}$ and $0.6 \mu\text{g m}^{-3}$ in offshore and onshore winds, respectively.

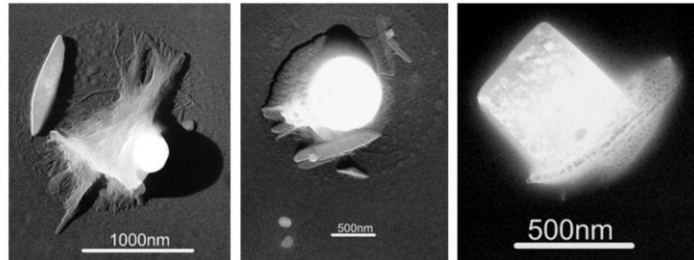
In onshore winds, there is evidence for a seasonal cycle in non-sea-salt sulphate and methanesulphonic acid with concentrations rising around November and falling off again in March. This cycle is likely to be associated with the seasonal cycle in dimethylsulphide precursor which has been measured at the site.

Similar trends in sulphur components have been observed at Leigh and Karamea where aerosol measurements have also been made.



Biologically active waters of the sub-tropical convergence to west and east of NZ shown in the long term composit

Sea salt plus

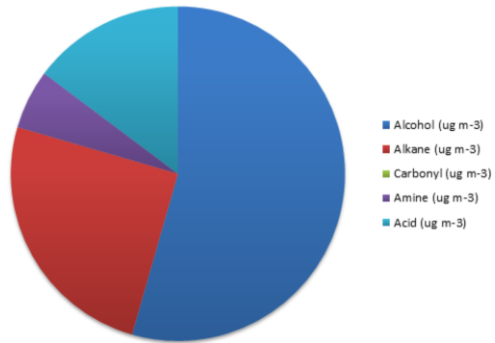


When recently injected into the atmosphere, they are surrounded by extensive organic material

enhancing the benefits of New Zealand's natural resources

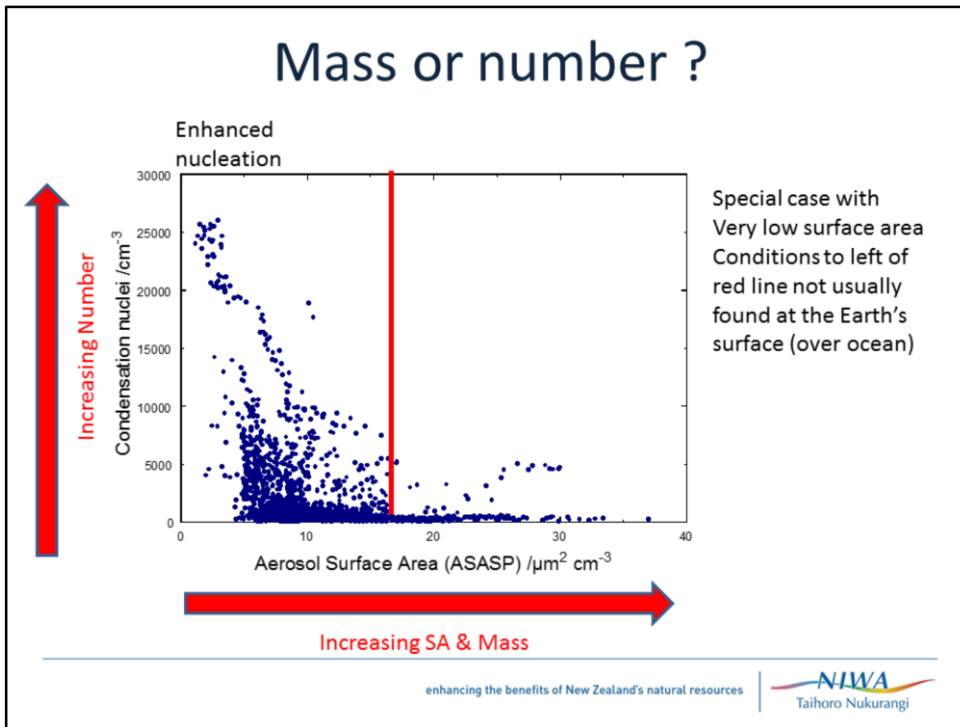


Organic carbon component of marine boundary-layer aerosol



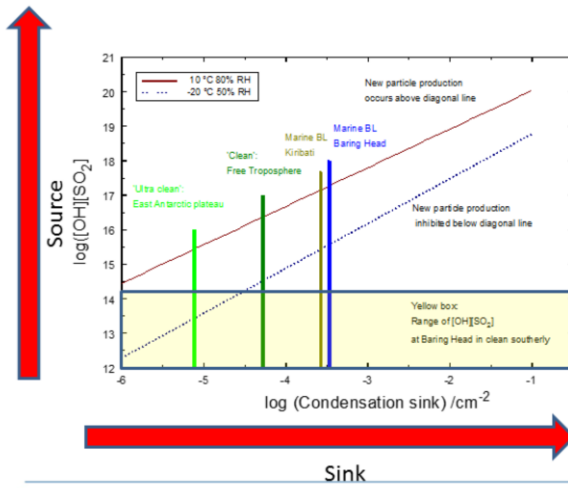
P. Vaartovaara (U. East Finland), M. Mallet, L. Cravigan, M. Ristovski (QUT, Australia), R. Modini (Scripps)

Less is known about the full speciation of POA



In very clean air, nucleation is more prevalent

(Mass) Surface area / number interaction



This is a clean air idealised case.

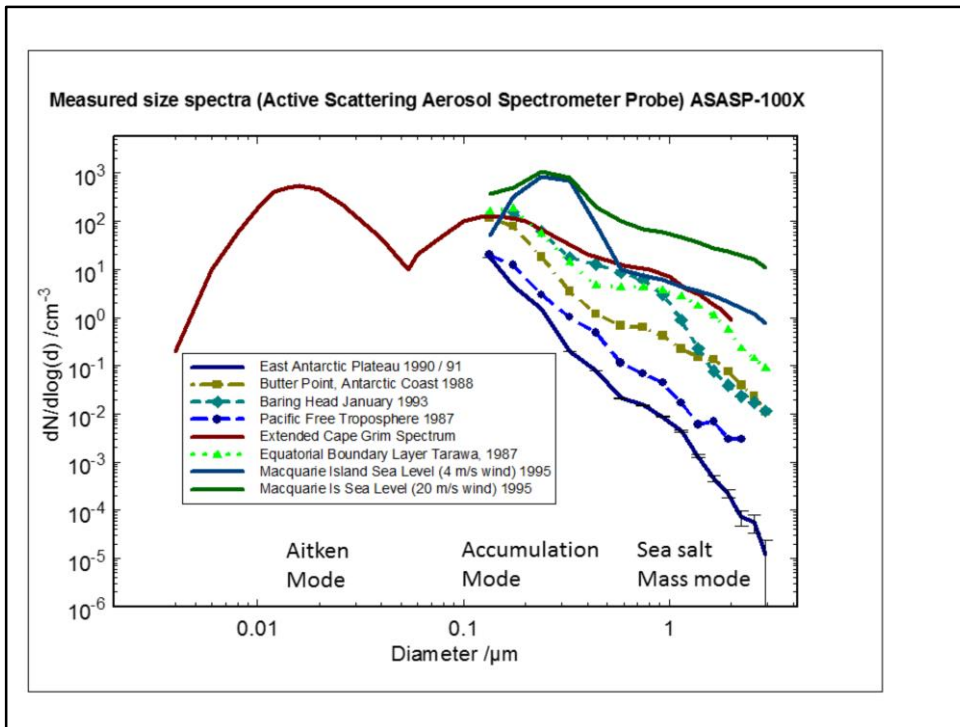
Recent discoveries have found mechanisms for new particle production with large condensation sinks

Cainey and Harvey 1992

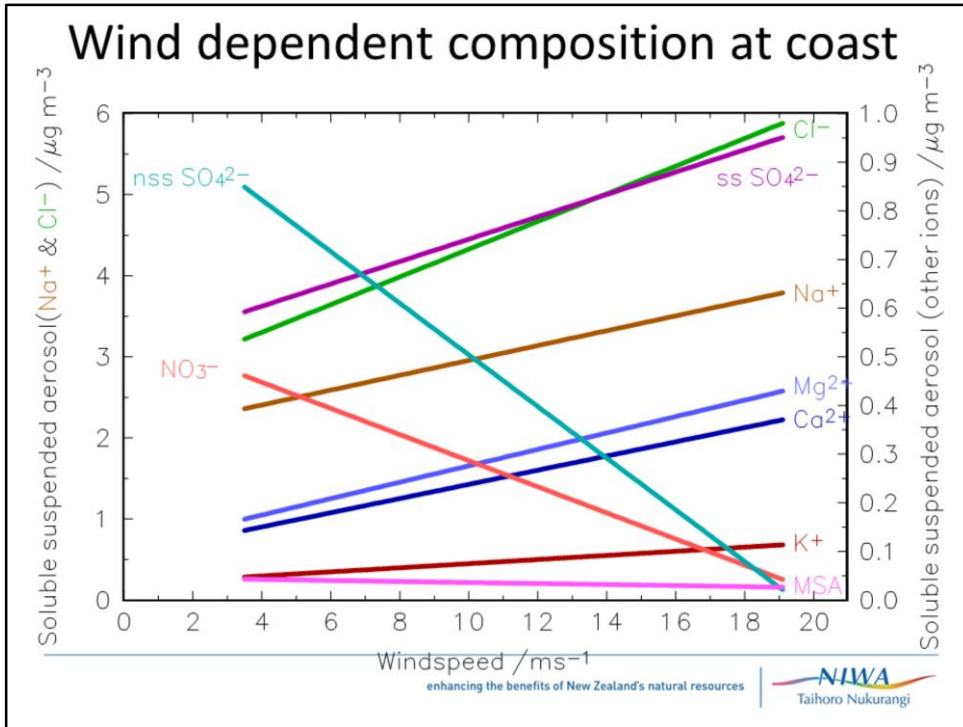
enhancing the benefits of New Zealand's natural resources



The heterogeneous sink of sea-spray aerosol could be limiting nucleation in the MBL



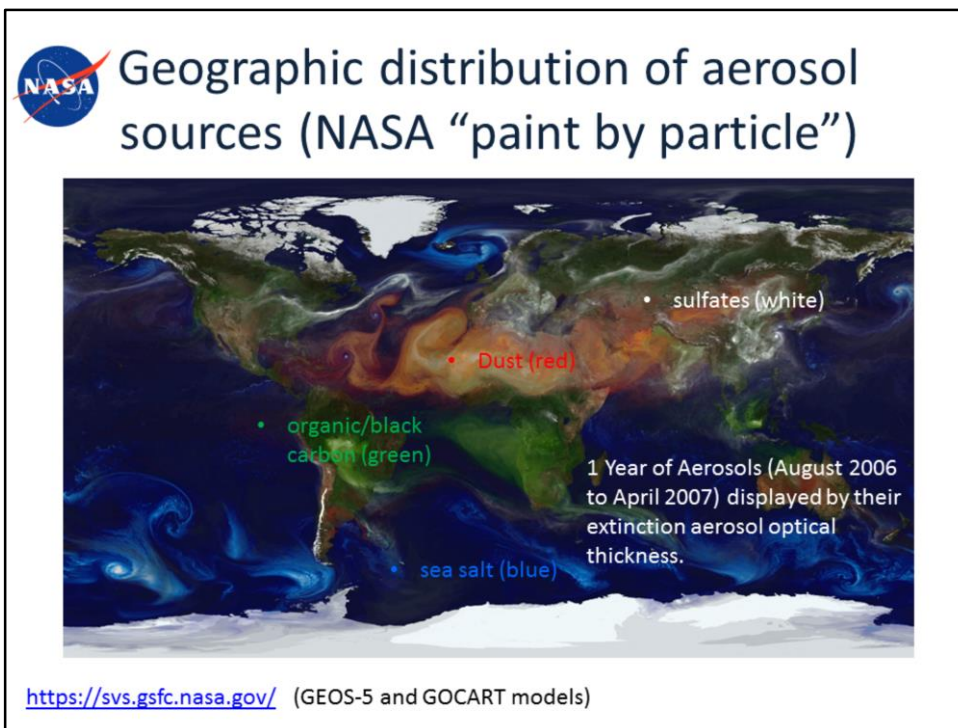
~6 orders of magnitude difference in concentration between very clean atmosphere and strong-wind MBL



The dependence of aerosol concentration on windspeed is illustrated using a simple linear regression relationship for all data.

The concentration of primary marine aerosol (eg Na^+ , Cl^- , Mg^{2+} , ssSO_4^{2-}) and rate of formation at the sea-surface increases with windspeed.

The concentration of secondary aerosol derived from anthropogenic sources (eg NO_3^- , nssSO_4^{2-}) decreases with windspeed because of the diluting effect.



An excellent movie is downloadable from the NASA svcs. Search for Paint by Particle

Note – China hot spot of sulfates, Saharan dust

0:50 – Trans-Tasman dust

1:20 – 1:40 SH biomass burning season

4:40 Aussie Bush fires

4:55 Karthala Eruption, Madagascar 12 Jan 2007

5:20 Cyclones