Effects of dust storms and wildfires on phytoplankton growth in the Southern Ocean and Tasman Sea, south eastern Australia

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Dust storms and wildfires occur frequently in south eastern Australia.

- Dust storm do not emit ground-sequestered carbon but wildfires does emit significant carbon into the atmosphere.

- Both of these natural events, however, promote phytoplankton growth in water bodies when emitted pollutants deposit on surface water.

- Phytoplankton growth reabsorbed carbon dioxide from the environment via photosynthesis process. The carbon balance of dust storm and wildfires are not well known.

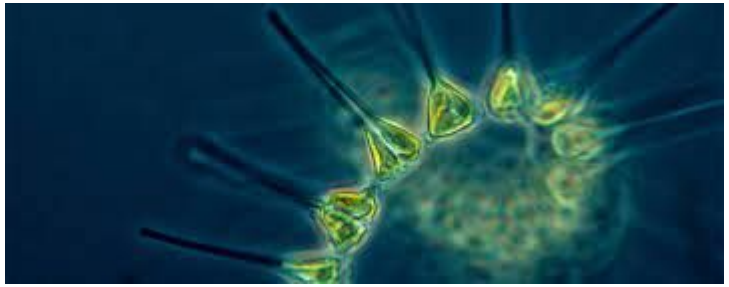
And with increasing frequency of wildfires in the future due to climate change, the carbon neutral process of reabsorbing emitted carbon by the forest can not be achieved with the result of net loss of carbon to the atmosphere and hence aggravates the warming climate change.

This study focusses on the association of dust storms and wildfires in south eastern Australia with phytoplankton growth in the Southern Ocean and Tasman Sea due to the February 2019 dust storm event and the 2019-2020 black summer wildfires

* Phytoplankton as microalgae plants contain the chlorophyll pigment.

* Of the two main types of phytoplankton, dinoflagellates and diatoms, diatoms can grow quickly in Fe rich environment. Dust storm has many metal elements of Fe

- Phytoplankton (especially diatoms) absorb CO_2 during photosynthesis leading an increase of CO_2 transferred from the atmosphere into the ocean.

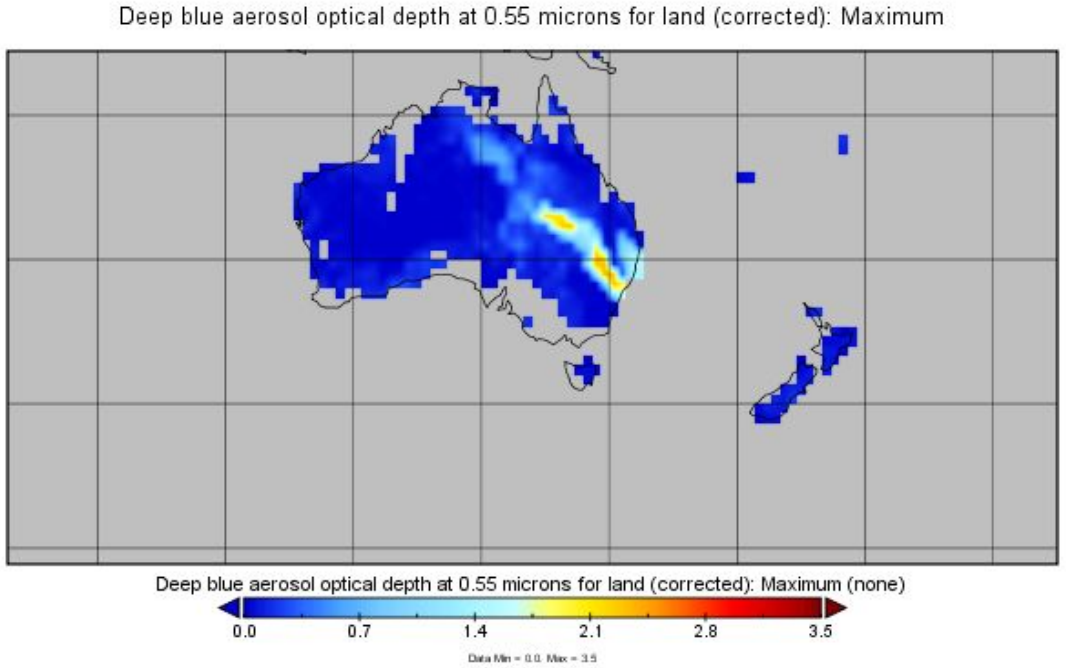


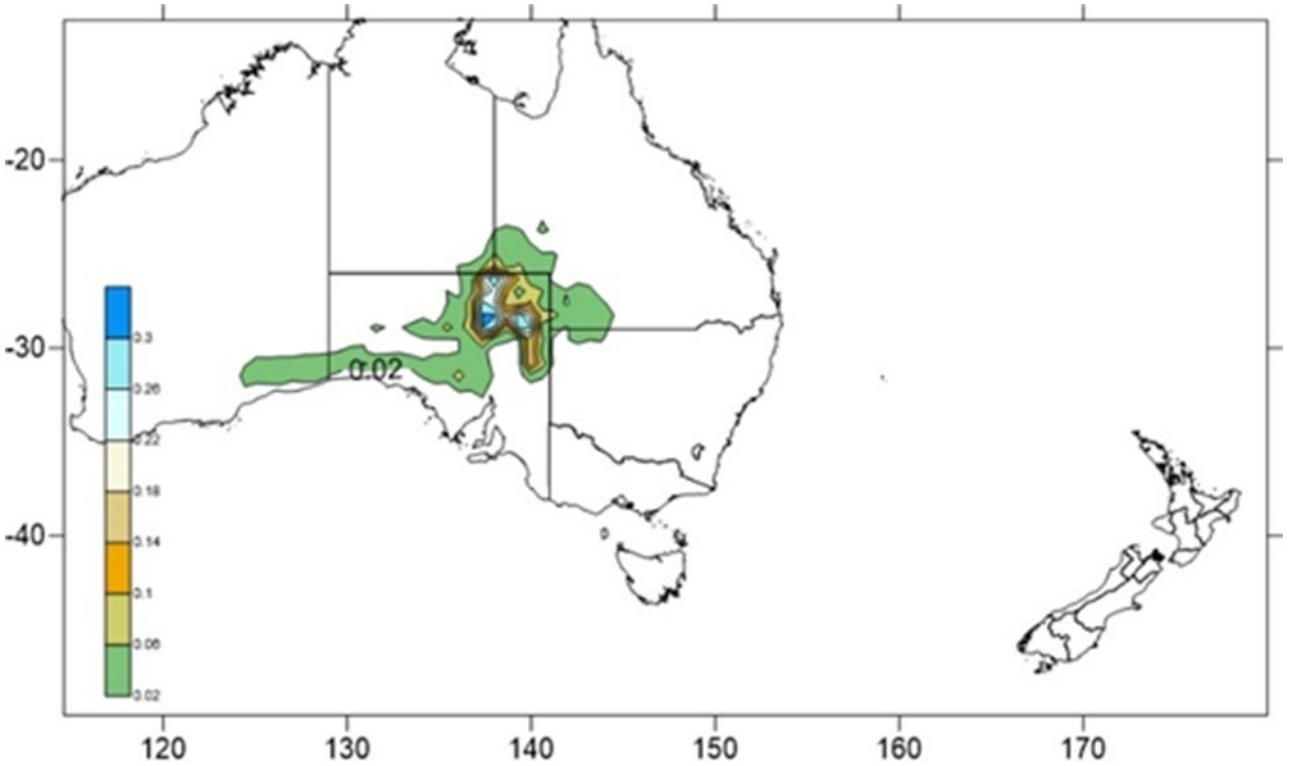
* Like other land-based plants, phytoplankton grows by absorbing CO_2 in sea water producing glucose and oxygen through photosynthesis.

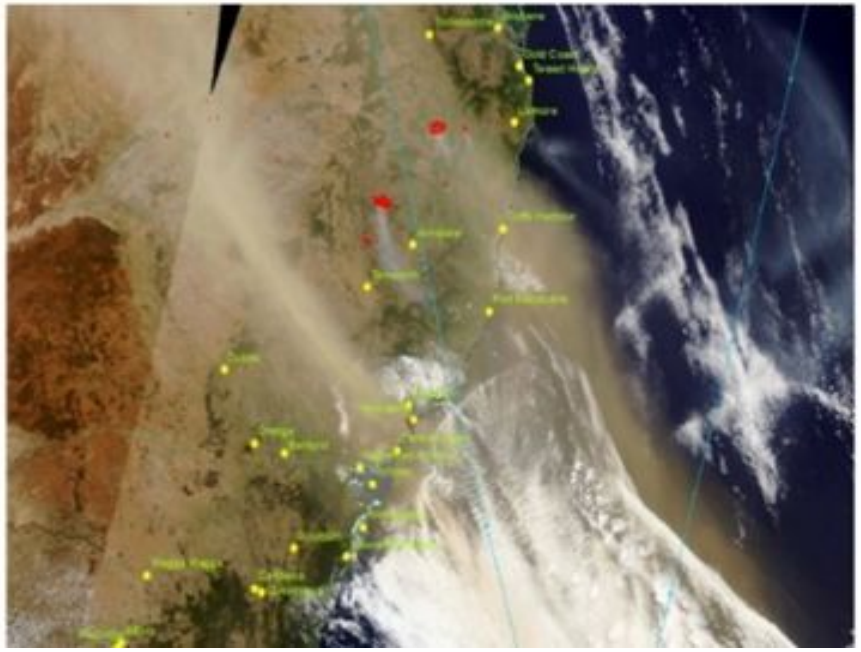
* Chlorophyll a concentration is used as an index of phytoplankton biomass. It is estimated that marine phytoplankton capture almost an equal amount of carbon as does photosynthesis by land vegetation (1).

* The global climate change models take into account the ocean important role of carbon sequestration in the Global Carbon Cycle.

In early February from 11 to 14 February 2019, dust storm originating from Central Australia has caused high particles concentration at many sites in New South Wales, both inland and along the coast



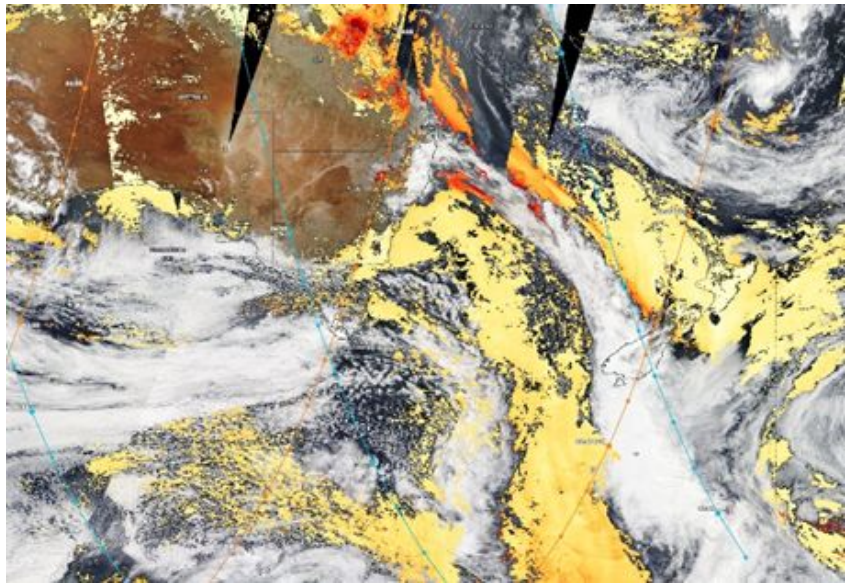


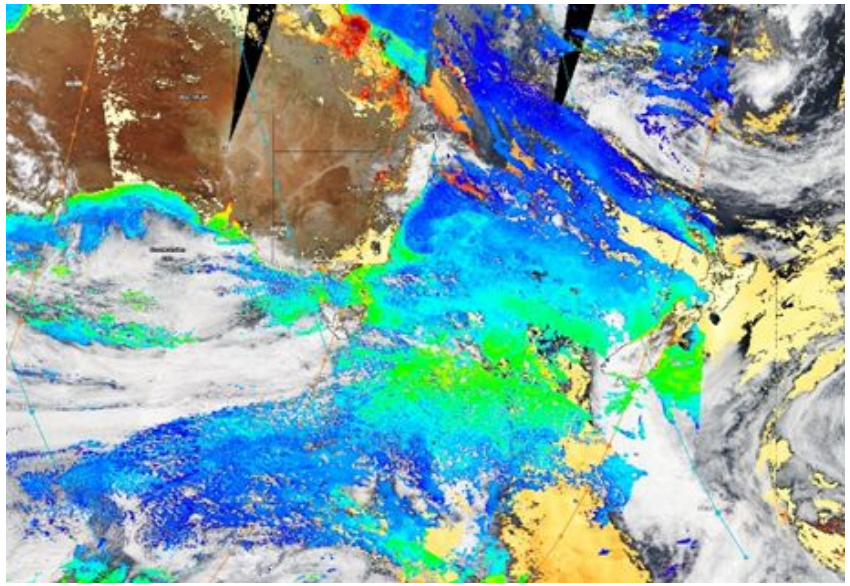


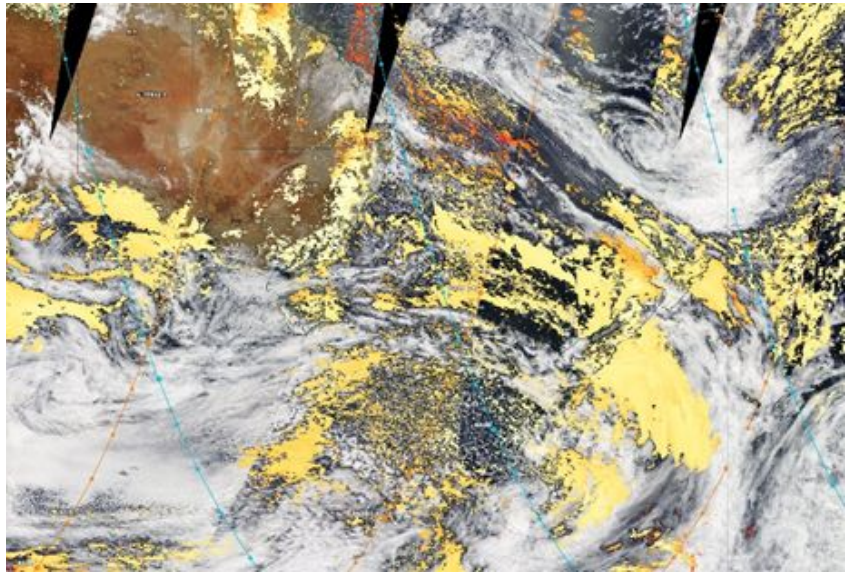
HYSPLIT forward trajectories from dust sources for 96 hours
from 11 February 2019 4:00 UTC

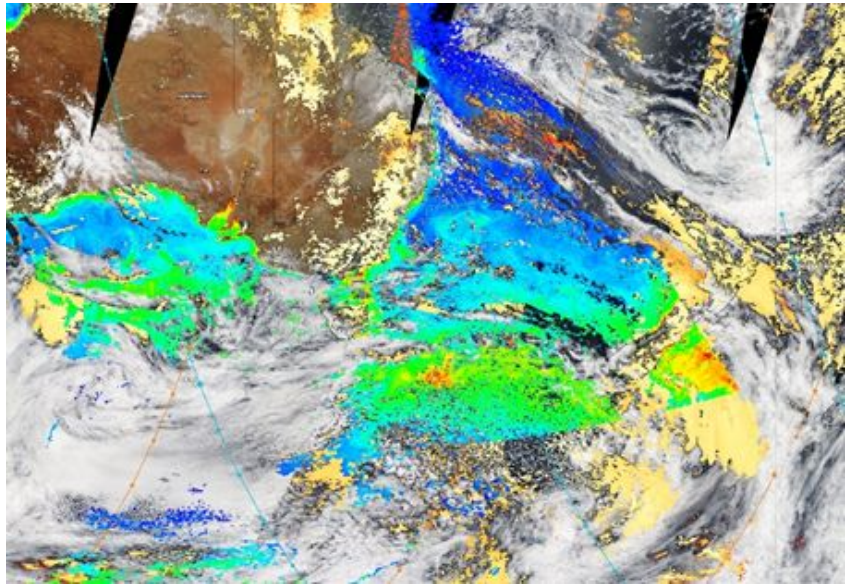
Dust storm of 14-16 February 2019

MODIS Terra/Aqua satellites









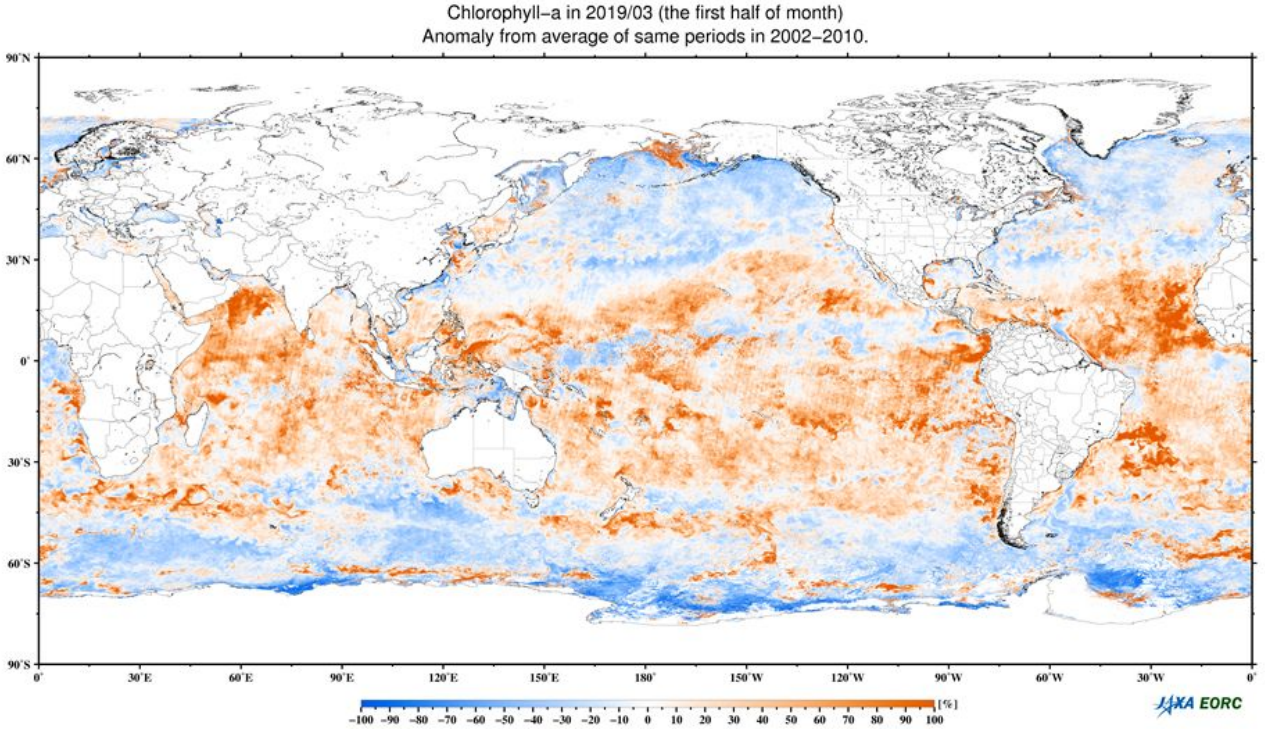
AOD and chlorophyll-a on

14 February 2019
(a) (b)

15 February 2019
(c) (d)

Himawarri geostationary satellite also provided real-time chlorophyll-a concentration over the Pacific Ocean from Japan to Australia.

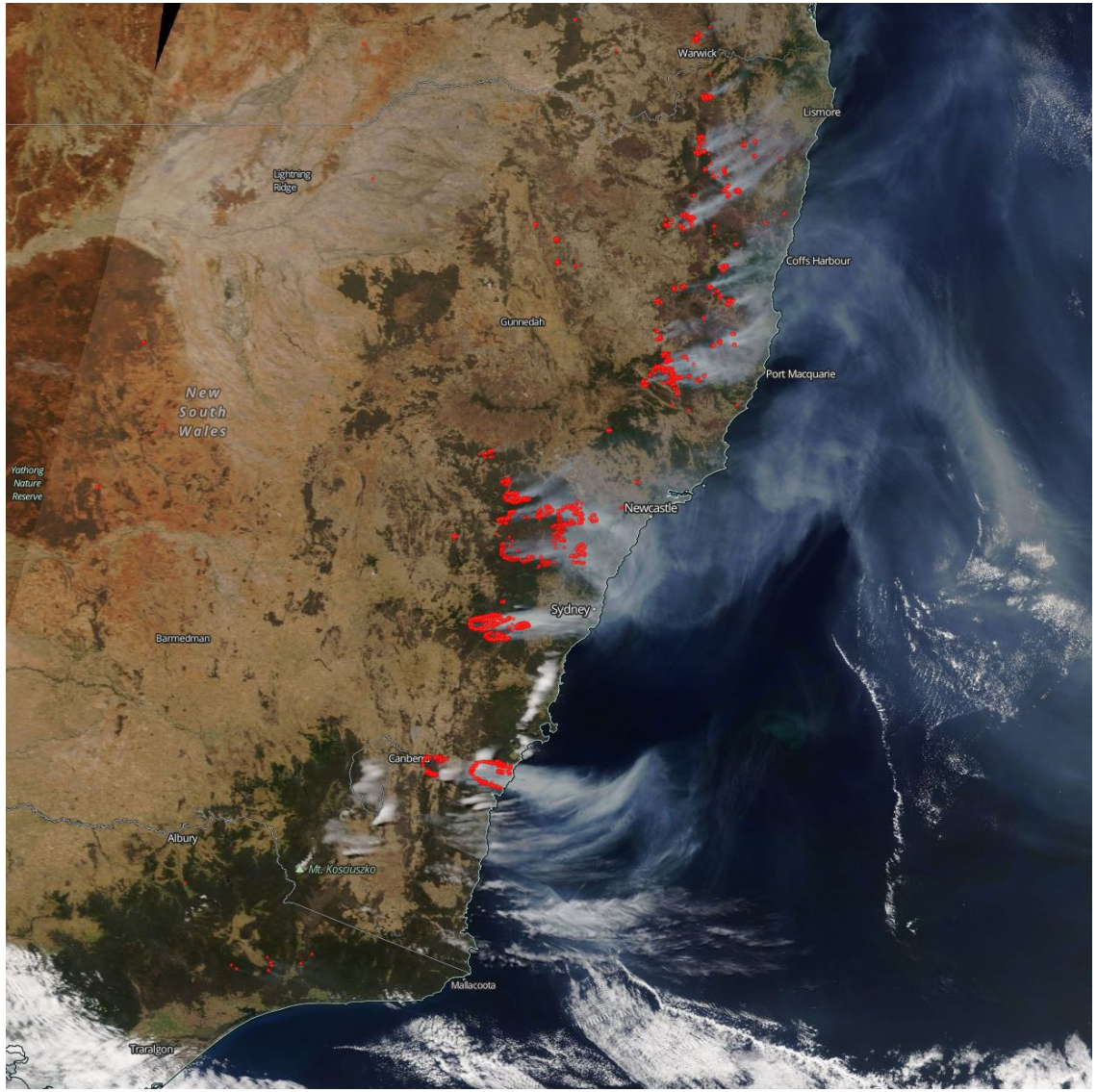
The Himawarri processed data from JAXA (Japan Aerospace Exploration Agency) are at temporal resolution (10-minutes, 1 hour, daily and monthly) and more detailed than those from polar orbital MODIS Aqua/Terra satellites

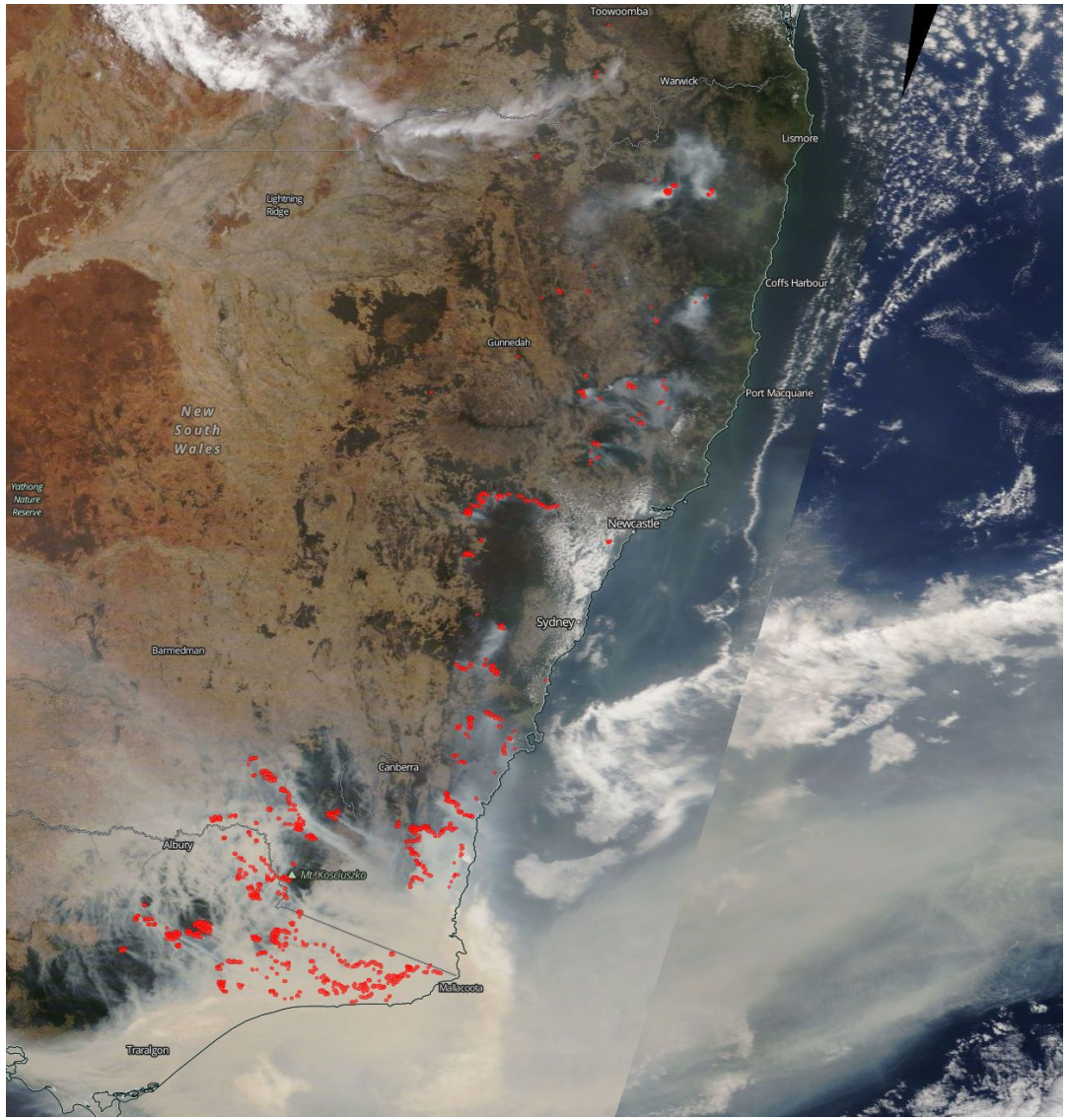


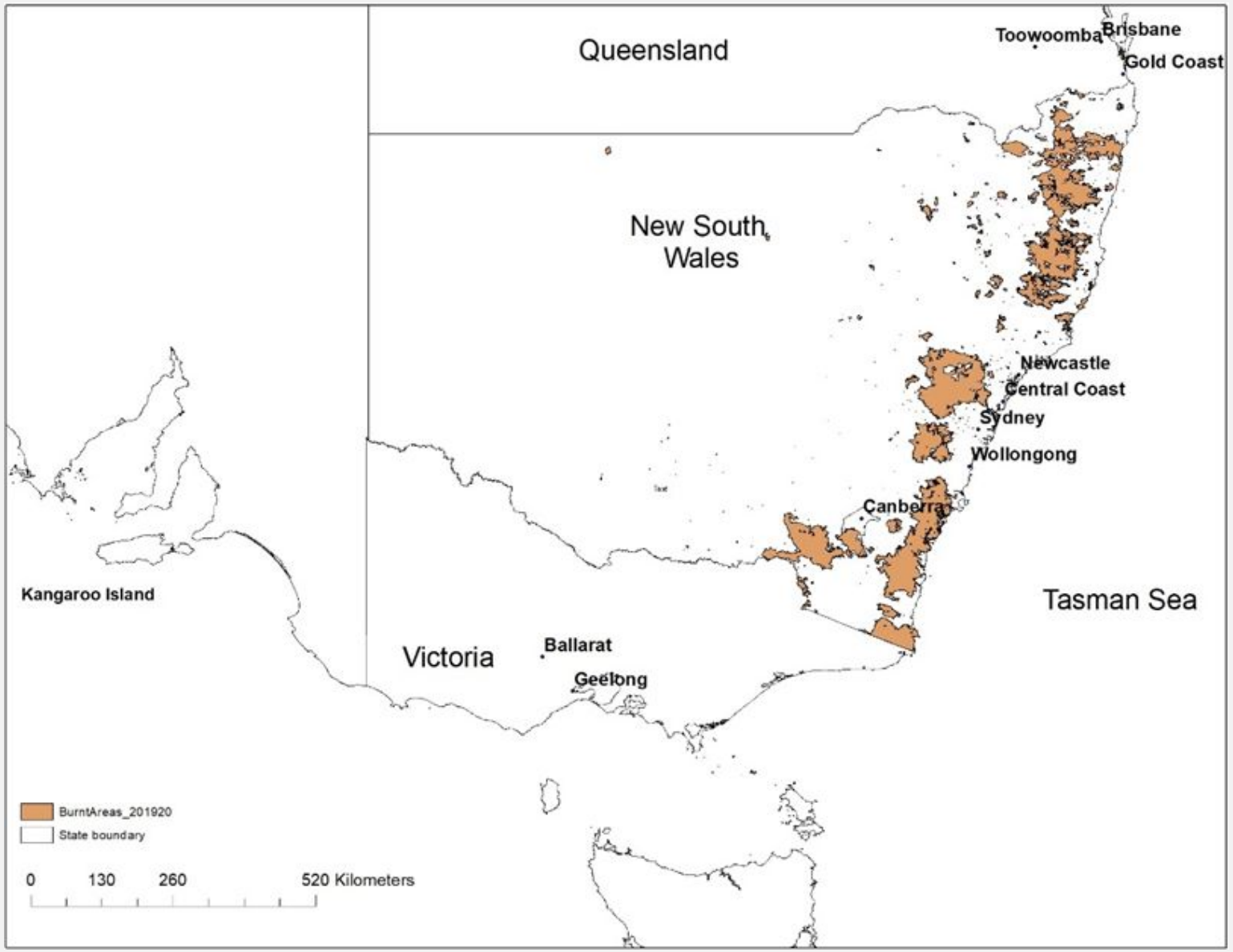
Anomaly of chlorophyll-a concentration in first half of March 2019 from average period 2002-2910 after the dust storm

Black Summer 2019-2020 wildfires

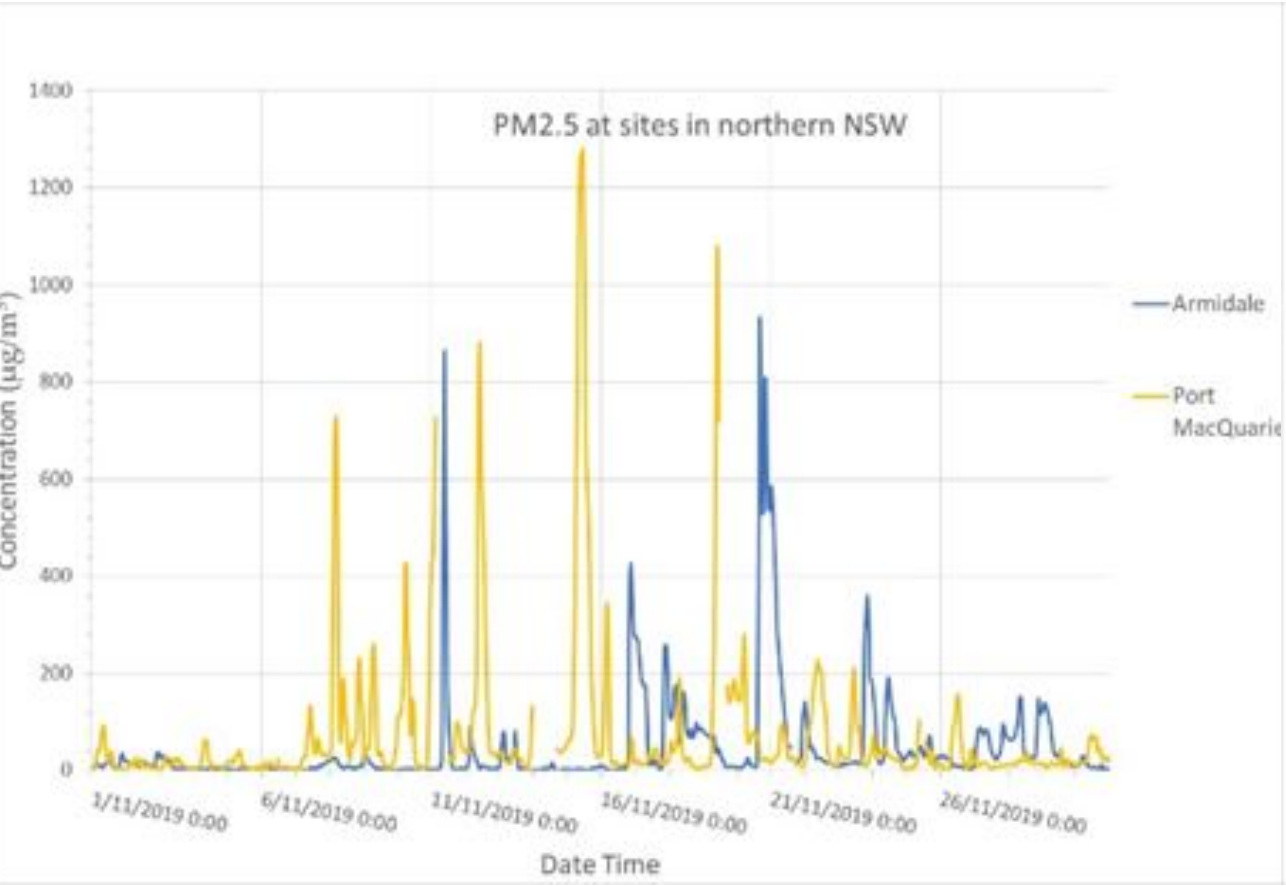
Fires occurred: MODIS images on 5 December 2019 and 3 January 2020

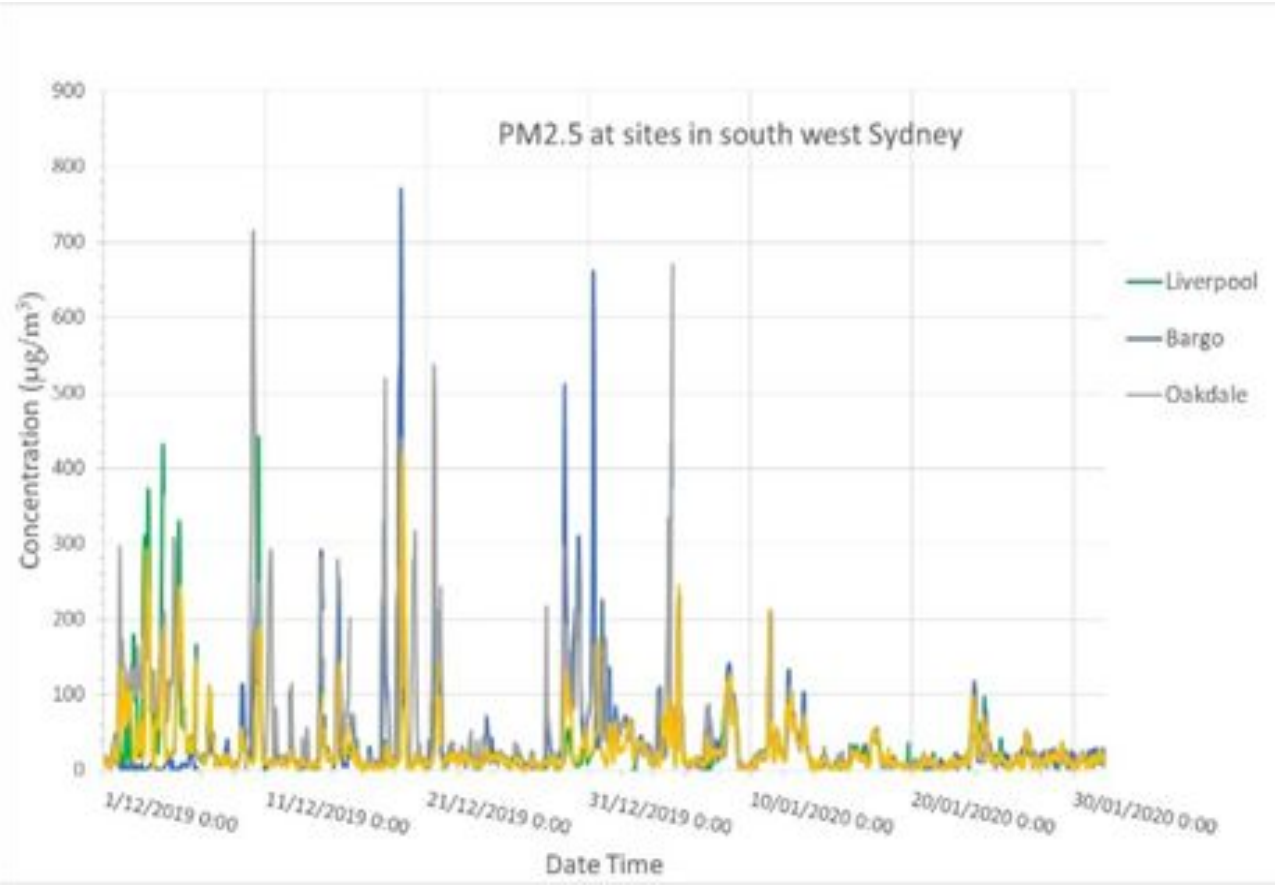






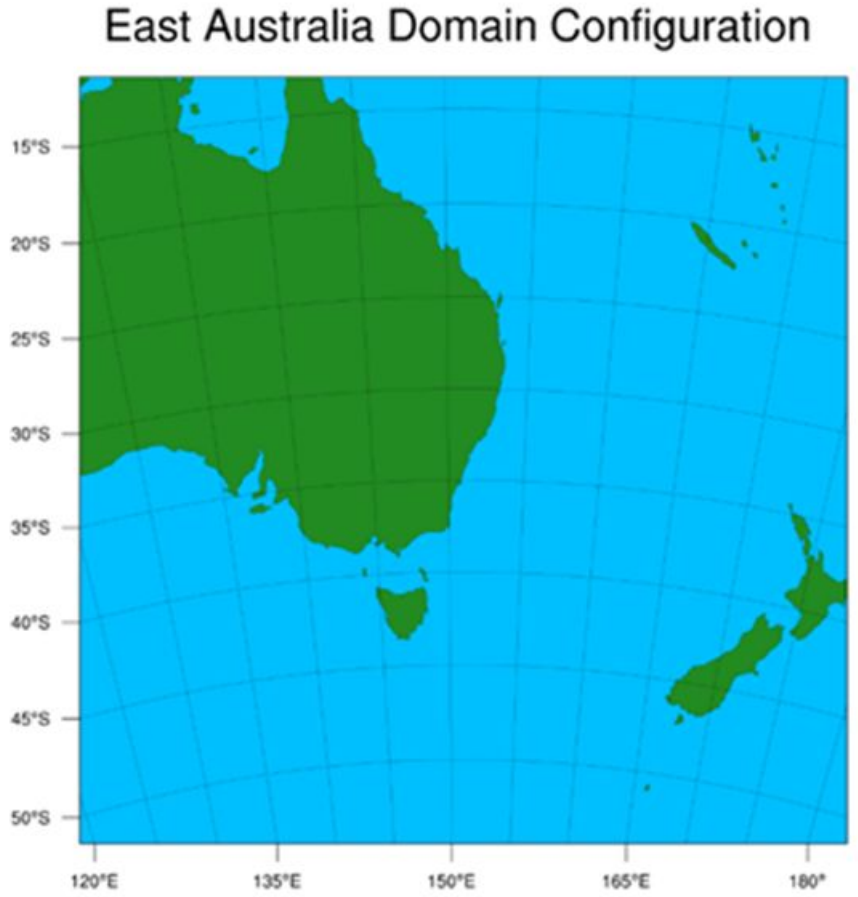
Total burnt areas in NSW in summer 2019-2020 bushfire event

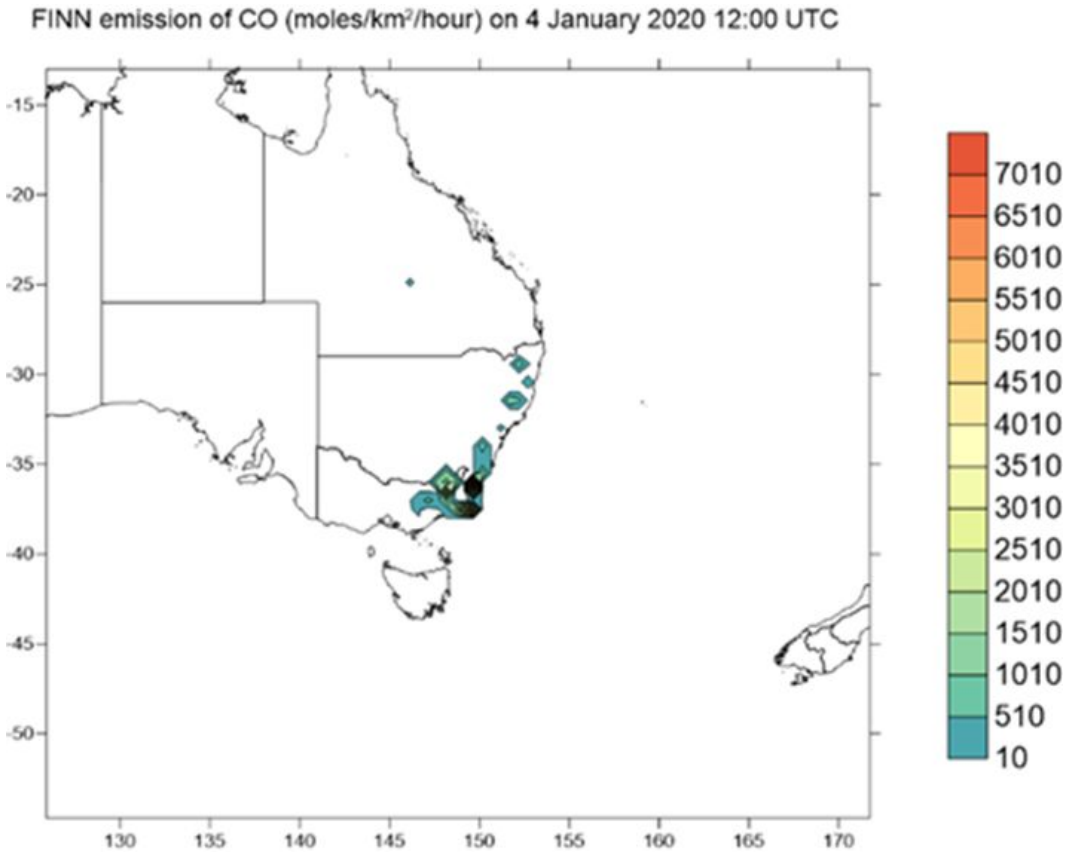




PM2.5 concentration in Northern NSW during November 2019 and in South West Sydney for December to January

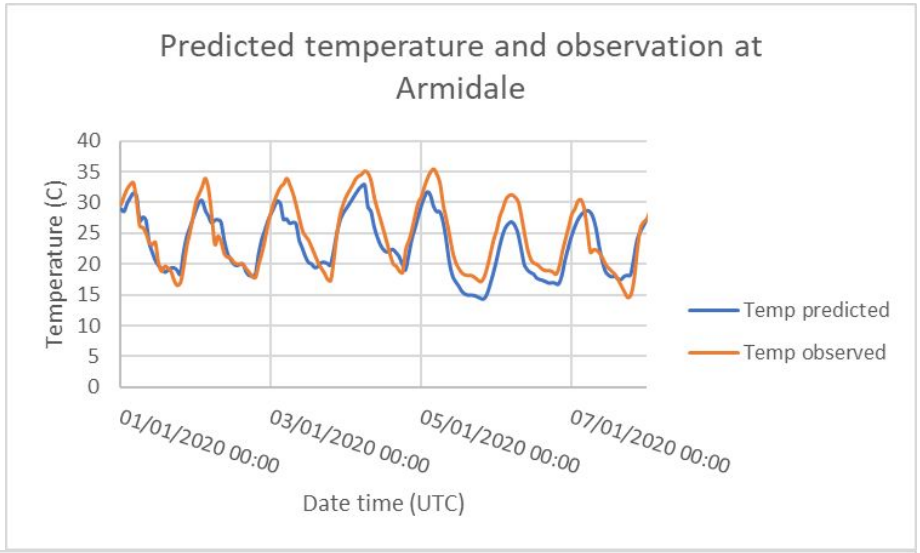
Simulation of summer 2019-2020 bushfire using WRF-Chem and Fire Emission Inventory from NCAR at 12km resolution

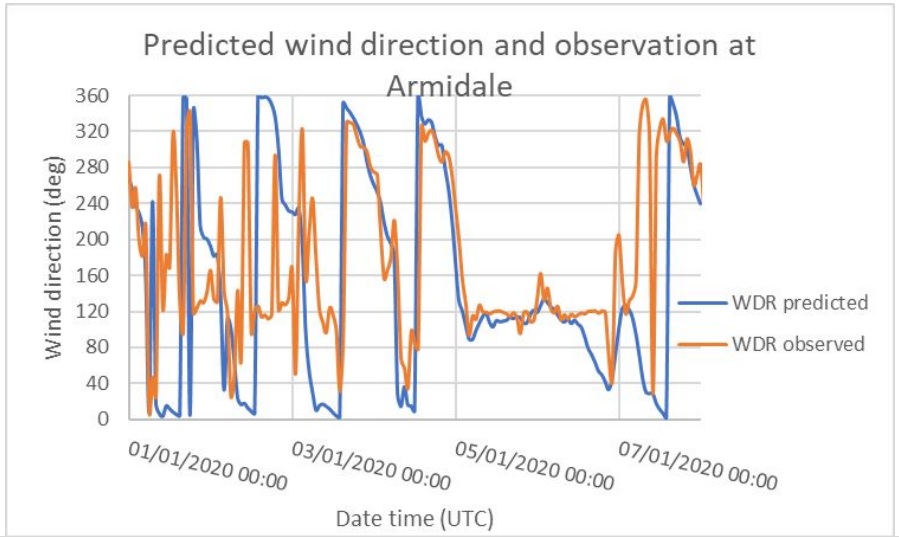


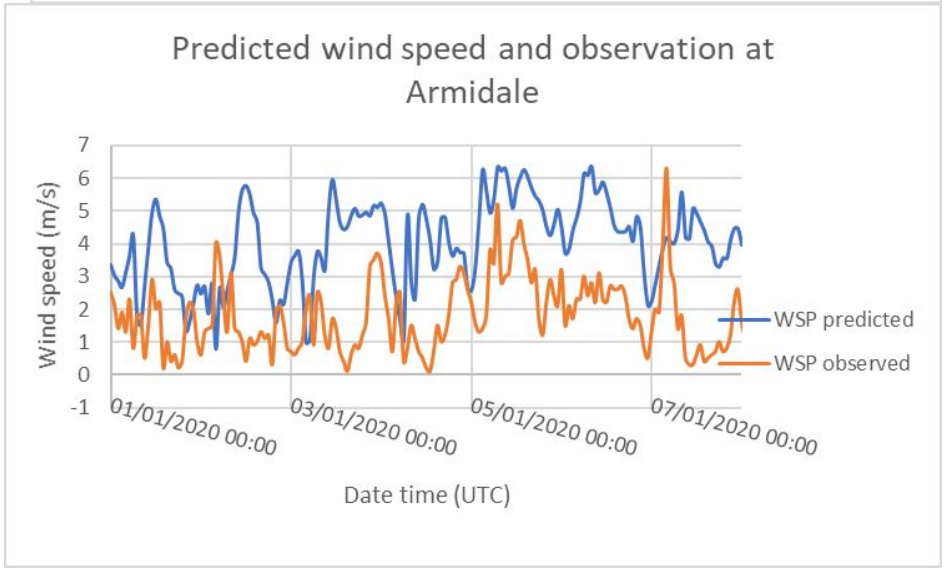


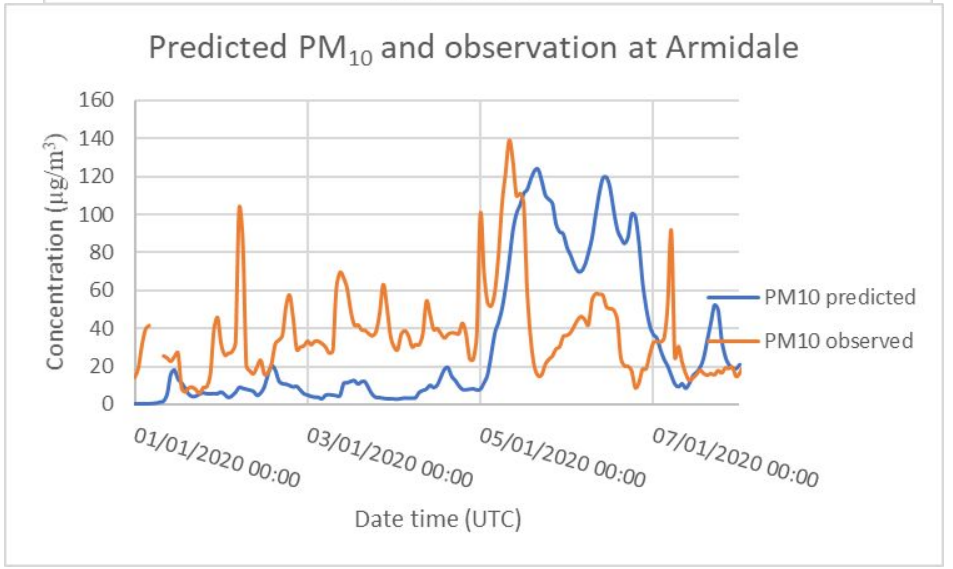
(a) WRF-Chem domain configuration (b) Emission fluxes of CO from wildfires on 4/1/2020 at 12UTC as provided from FINN

WRF-Chem results as compared with observation 1 to 7 January 2020

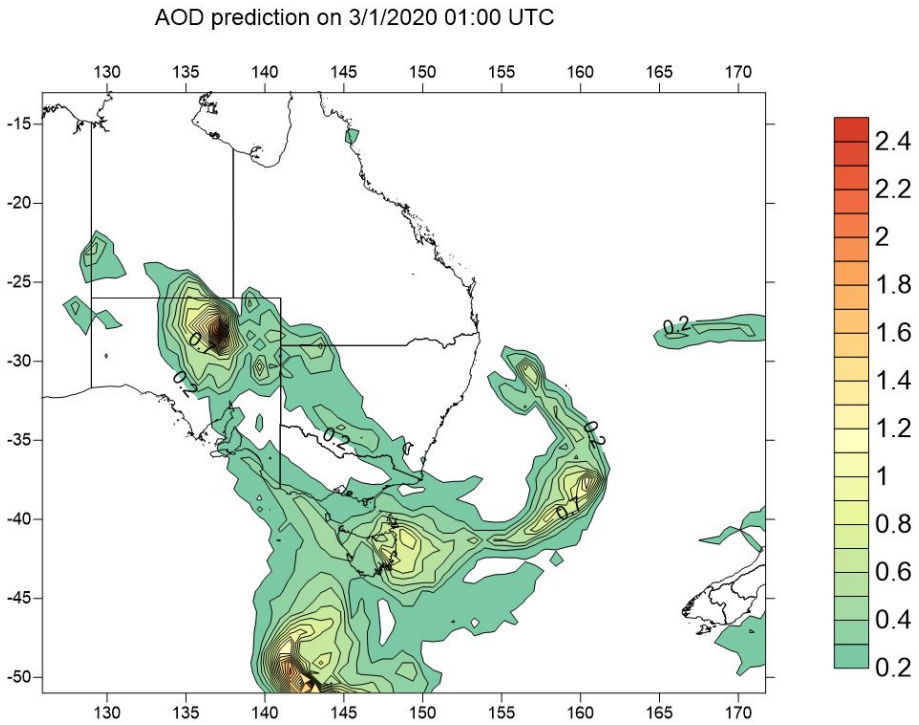


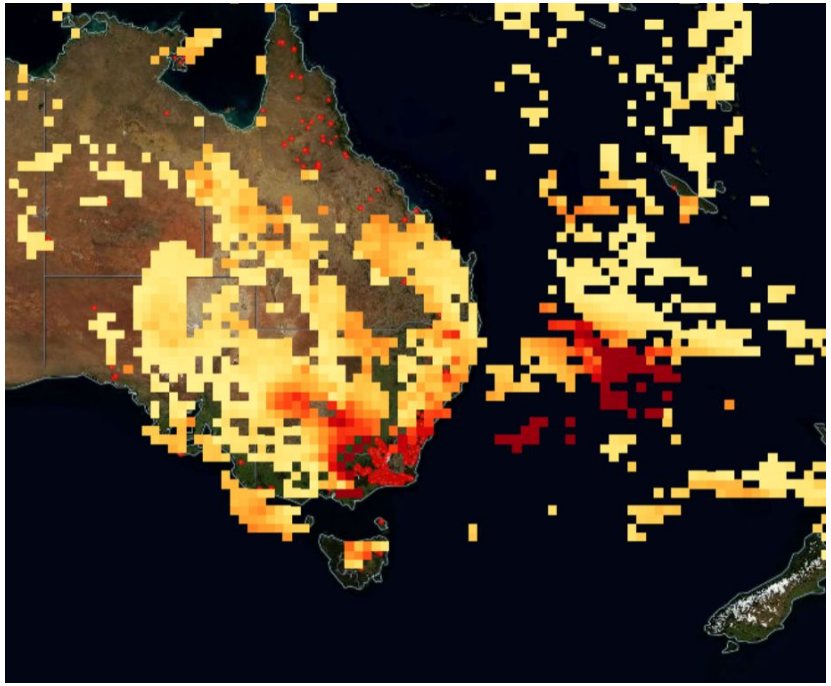


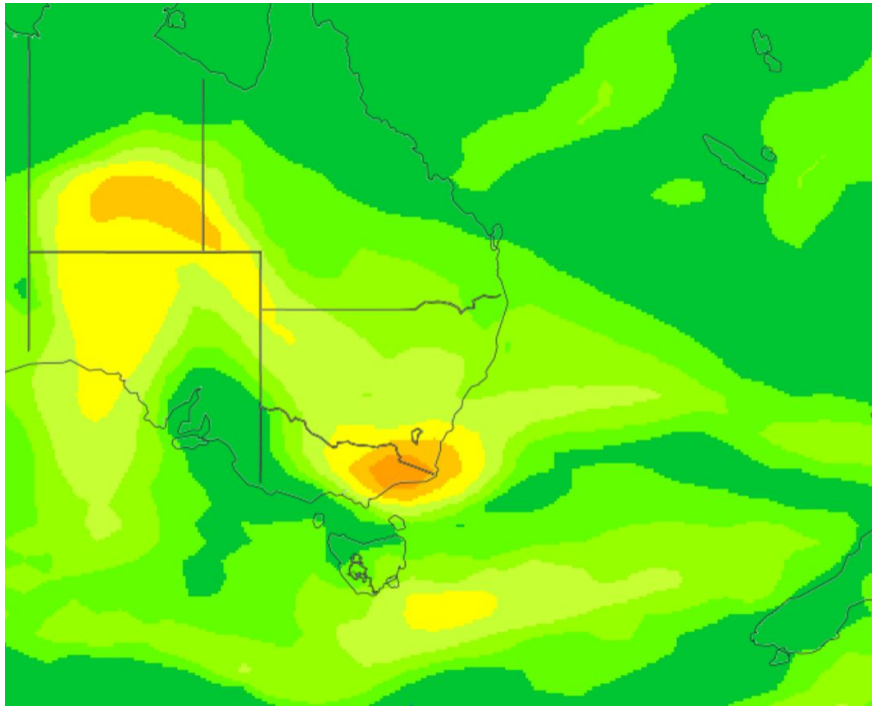




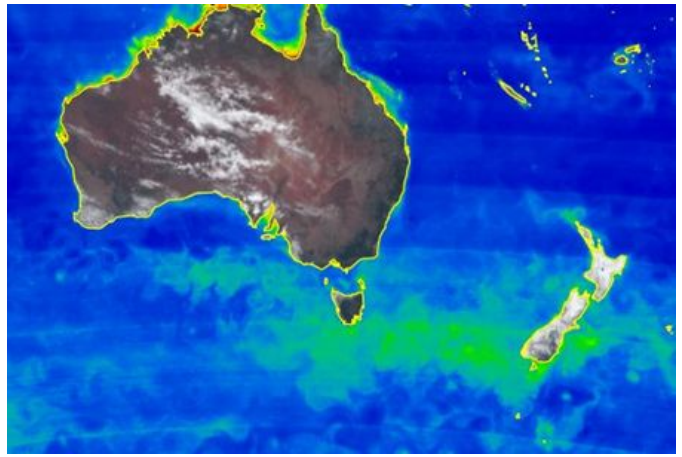
WRF-Chem simulation of bushfires



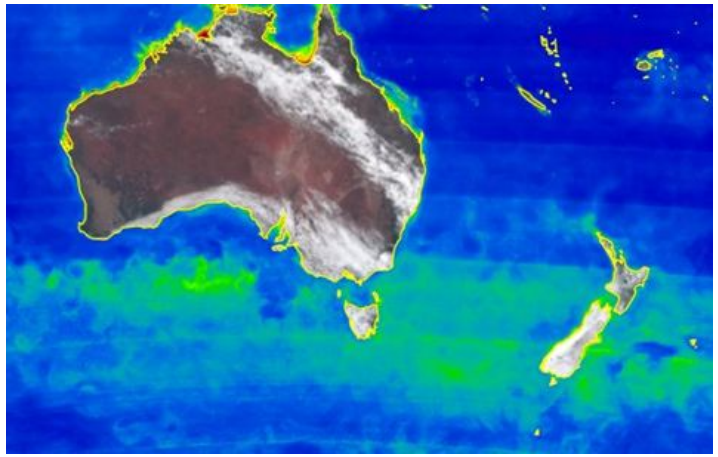




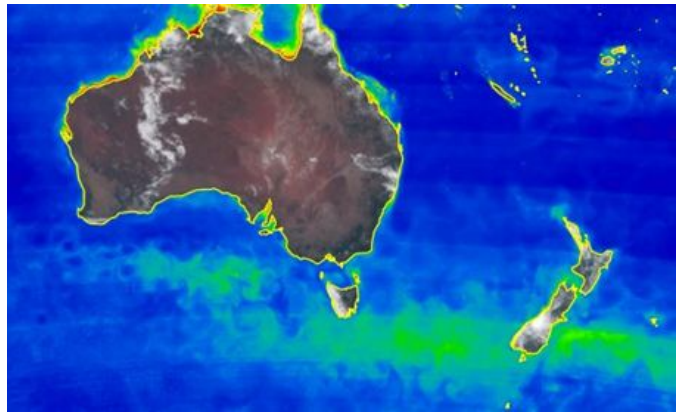
Monthly concentration of chlorophyll-a



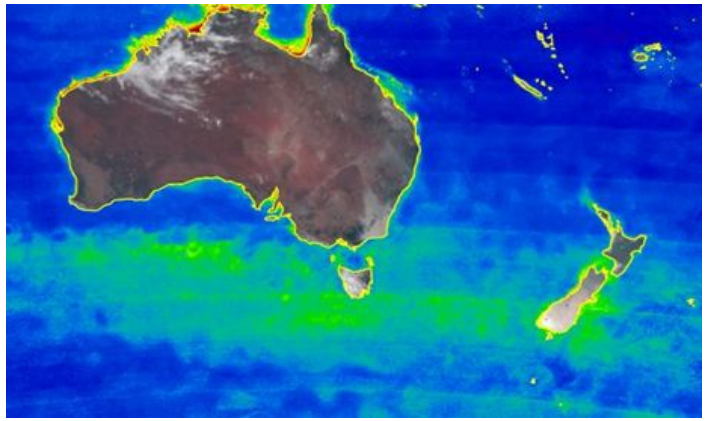
December 2018



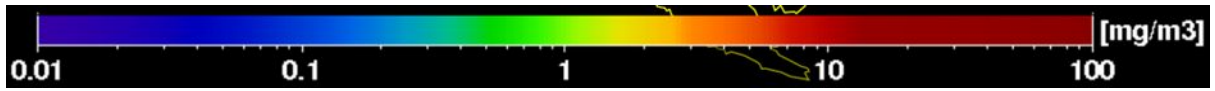
December 2019



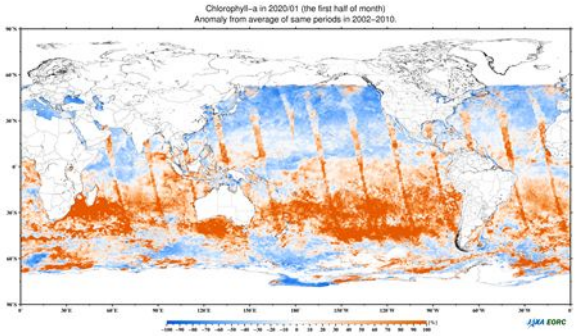
January 2019



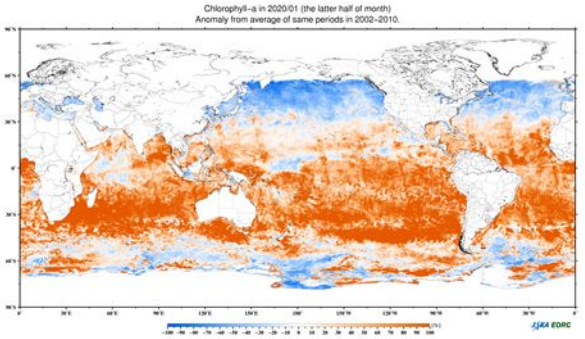
January 2020



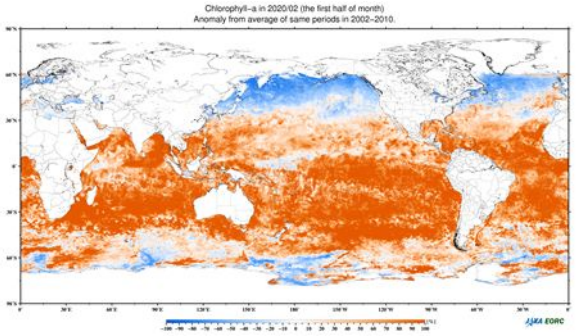
Chlorophyll-a anomaly in January, February and March 2020 from the same period in 2002-2010



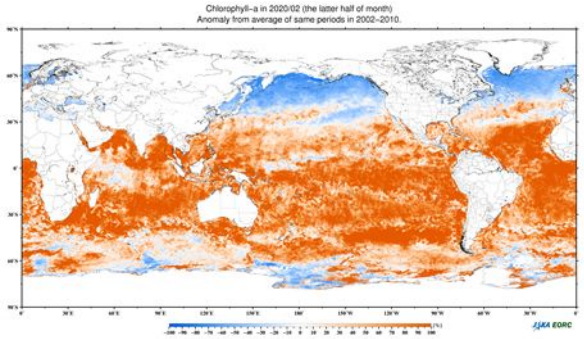
First half of January 2020



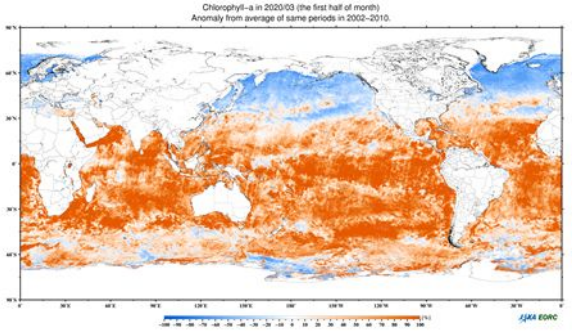
Second half of January 2020



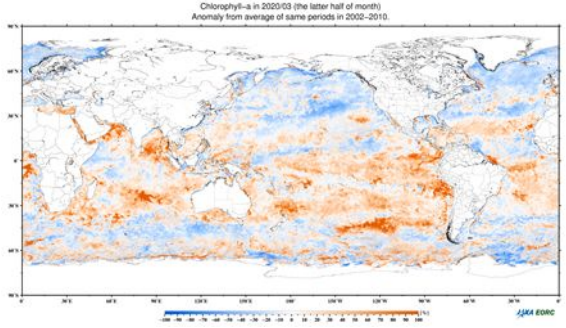
First half of February 2020



Second half of February 2020



First half of March 2020



Second half of March 2020

Conclusion

(1) The February 14-16 dust storm and the megafires in November to January 2019-2020 were studied on phytoplankton growth in the Tasman Sea and Southern Ocean

(2) Both events promoted phytoplankton growth but the megafires triggered a massive growth all around the southern hemisphere

(3) The megafires were much bigger and longer and the emitted carbonaceous nutrients from the fires deposited on water surface can promote stronger growth of phytoplankton.

(4) The phytoplankton blooms occurred from January to early March 2020. After that the growth disappeared. Probably nearly all carbon emitted by the megafires were reabsorbed by the ocean.