The role of carbon dust emission as a global source of atmospheric CO_2

Nicholas Webb[1], Adrian Chappell[2], Harry Butler[3], Craig Strong[4], Grant McTainsh[4], John Leys[5], Raphael Viscarra Rossel[2]

Introduction

Soil erosion plays an important role in the global carbon cycle. Wind erosion contributes to the carbon cycle by selectively removing soil organic carbon (SOC) from vast land areas and transporting it quickly offshore (Fig 1). This augments the net loss of carbon from terrestrial systems. However, the contribution of wind erosion to rates of carbon release and sequestration is poorly understood. Here we quantify SOC losses in dust emissions from Australia and demonstrate the need for wind erosion to be included in carbon accounting systems.

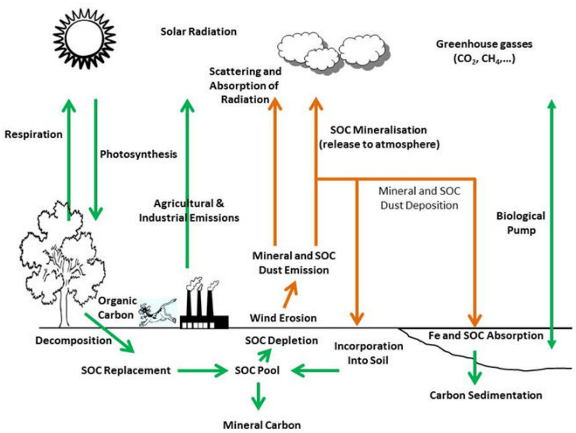

Figure 1: Illustration of the impacts of wind erosion on the carbon cycle, including soil organic carbon (SOC) depletion at eroding sites, the release of SOC to the atmosphere through mineralisation processes, and SOC deposition over terrestrial systems, water bodies and the oceans.

Methods

We developed a physically-based approximation of SOC enrichment to estimate SOC emissions with the Computational Environmental Management System (CEMSYS) national dust emission model[1]. The methodology represents spatio-temporal variations in SOC enrichment within dust emissions due to the amount of surface SOC and the location and intensity of wind erosion (Fig 2).

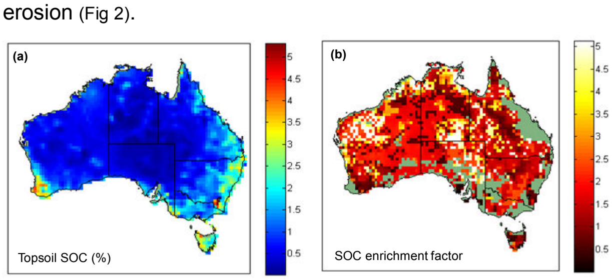

Figure 2: Maps showing the spatial distribution of (a) per cent soil organic carbon (SOC) in the Australian topsoil (0-10 cm); and (b) modelled mean SOC enrichment factor for SOC dust <22 µm, capable of long-range transport off the Australian continent. SOC enrichment in dust results from the selective removal of SOC from the topsoil as a consequence of wind erosion.

We ran CEMSYS at a 50 km spatial resolution to calculate total monthly dust and SOC emissions for 2000–2011. We then evaluated the SOC emissions by land use to quantify sectoral contributions to existing components of the national carbon accounting system.

Australian mineral and SOC dust emission

The total mineral dust emission for Australia is estimated to be 118 Tg yr^{-1}. The total SOC dust emission is estimated to be 1.59 Tg SOC yr^{-1} (Fig 3).

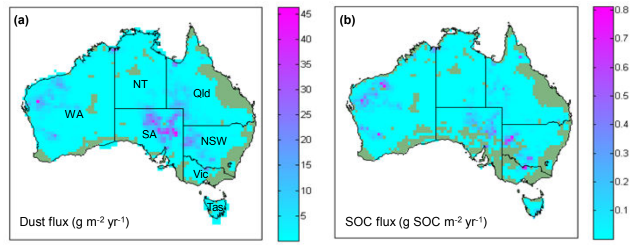

Figure 3: Australian mineral (a) and soil organic carbon (b) dust emissions simulated using CEMSYS. Maps show the mean annual emissions for the period 2000-2011.

► Mineral dust emissions originate from the Lake Eyre Basin (South Australia), the Murray-Darling Basin (New South Wales), and the Pilbara and Gascoyne regions of Western Australia (Fig 3a).

► SOC dust emissions (Fig 3b) reflect patterns of mineral dust emission, topsoil SOC content, and the efficiency of SOC emission and enrichment during wind erosion (Fig 2).

SOC dust emissions by land use

► Rangelands produce on average larger total mineral and SOC dust emissions than agricultural lands due to their large eroding area (Table 1).

► Mean SOC dust emissions per hectare are greater for agricultural land uses because of their larger topsoil SOC content.

Table 1: Mineral and soil organic carbon dust emissions (<22 µm) by land use class for Australia (2000-2011).

Land Use	Mean mineral dust flux (g m^{-2} y^{-1})	Mean SOC enrichment ratio	Mean SOC dust flux (g SOC m^{-2} yr^{-1})	Total SOC dust emission (Tg SOC y^{-1})
Rangeland	35.96	2.48	0.46	1.34
Agriculture	19.10	1.92	0.50	0.11
Australia	35.20	2.44	0.48	1.59

► Assuming SOC dust emissions (<22 µm) are transported offshore, wind erosion of Australian SOC may result in a loss of ~5.83 Tg CO_2-equivalents yr^{-1}. This constitutes ~5% of the annual CO_2 emissions from the Australian rangelands (including land use and land cover change, agricultural emissions and savanna burning[3]).

Conclusions

SOC dust emission is greatest in agricultural areas with disturbed soils. The removal of SOC from vast rangeland soils produces the single largest source of SOC dust, from an area which is highly sensitive to SOC change. Global land use and climate change have potential to enhance and activate new dust emission sources, and increase SOC emissions. Tracing the fate of wind-eroded SOC in the dust cycle and quantifying CO_2 releases is now required to better understand the contribution of SOC dust emission to carbon sources and sinks.

Author Institutions

[1] USDA-ARS Jornada Experimental Range, Las Cruces, USA
[2] CSIRO Land and Water, Canberra, Australia
[3] University of Southern Queensland, Toowoomba, Australia
[4] Griffith University, Brisbane, Australia
[5] NSW Office of Environment and Heritage, Gunnedah, Australia

References

1. Shao et al. (2007) *Geophysical Research Letters* **112**, D08207, doi:08210.01029/02006JD007767.
2. Webb et al. (2012) *Global Change Biology* 18, 3275-3278
3. Australian Greenhouse Office (2005)

Acknowledgements

This research was partially funded by the CSIRO Sustainable Agriculture Flagship and the DAFF Caring for Our Country program.

contact: Nicholas Webb
phone: 575-646-3584
email: nwebb@nmsu.edu
web: http://jornada.nmsu.edu

The Jornada
http://jornada.nmsu.edu
Arid Land Research Programs