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Ocean Fertilization: Dust to Bloom

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We present evidence for Ocean Fertilization, using pattern recognition, with data from (1) the Sahara Desert, (2) the Taklamakan Desert, (3) the North Atlantic, (4) the Equatorial Atlantic, (5) the South Atlantic, (6) the Bay of Biscay, (7) the Strait of Hormuz, (8) the Bass Strait, (9) the Sea of Okhotsk, and (10) the Global Wind Circulation. Wind-driven dust fertilizes the oceans by delivering iron and other micronutrients that stimulate phytoplankton growth, strengthen the biological carbon pump, and influence global climate. The core idea is that dust acts as a nutrient delivery system from land to sea, especially in regions where iron limits productivity.

Introduction

Pattern recognition, which we used in this study, is the ability to identify recurring structures, regularities, or relationships in data, signals, or experiences. It's a fundamental principle in both human cognition and artificial intelligence, forming the basis of learning, problem-solving, and prediction. In this case, the sites where both wind-driven dust and phytoplankton blooms occur.

The Concept

Strong et al. (2009) note that the carbon dioxide that would otherwise be in the atmosphere is stored in the deep sea because the biological pump puts and keeps it there. Phytoplankton in the lighted surface layer take up nutrients (e.g., nitrate and phosphate) and grow, converting CO2 to organic matter that fuels marine food webs (Fig. 1).

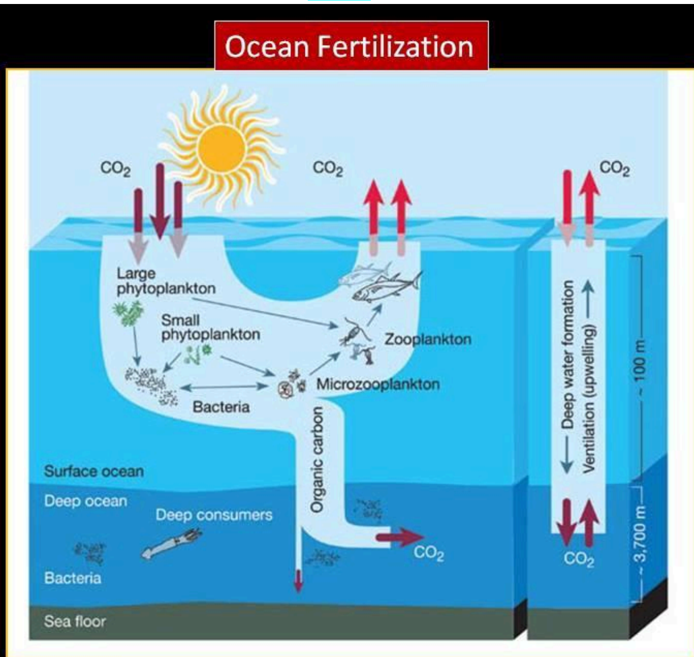
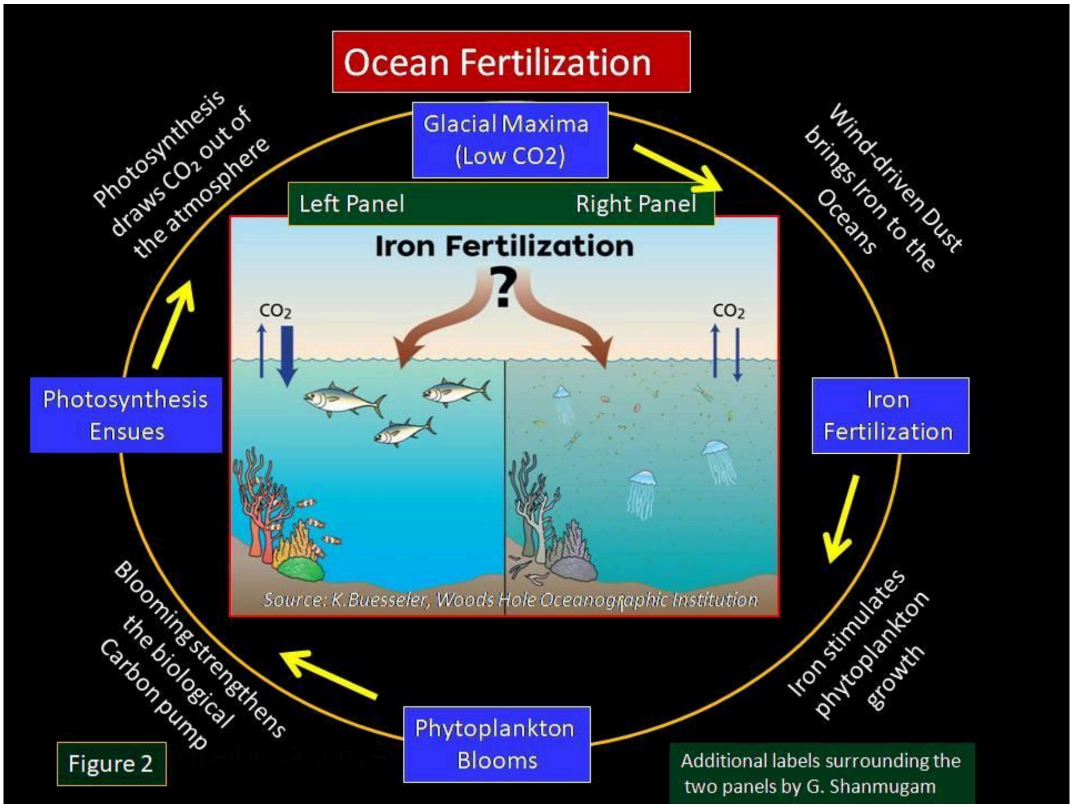


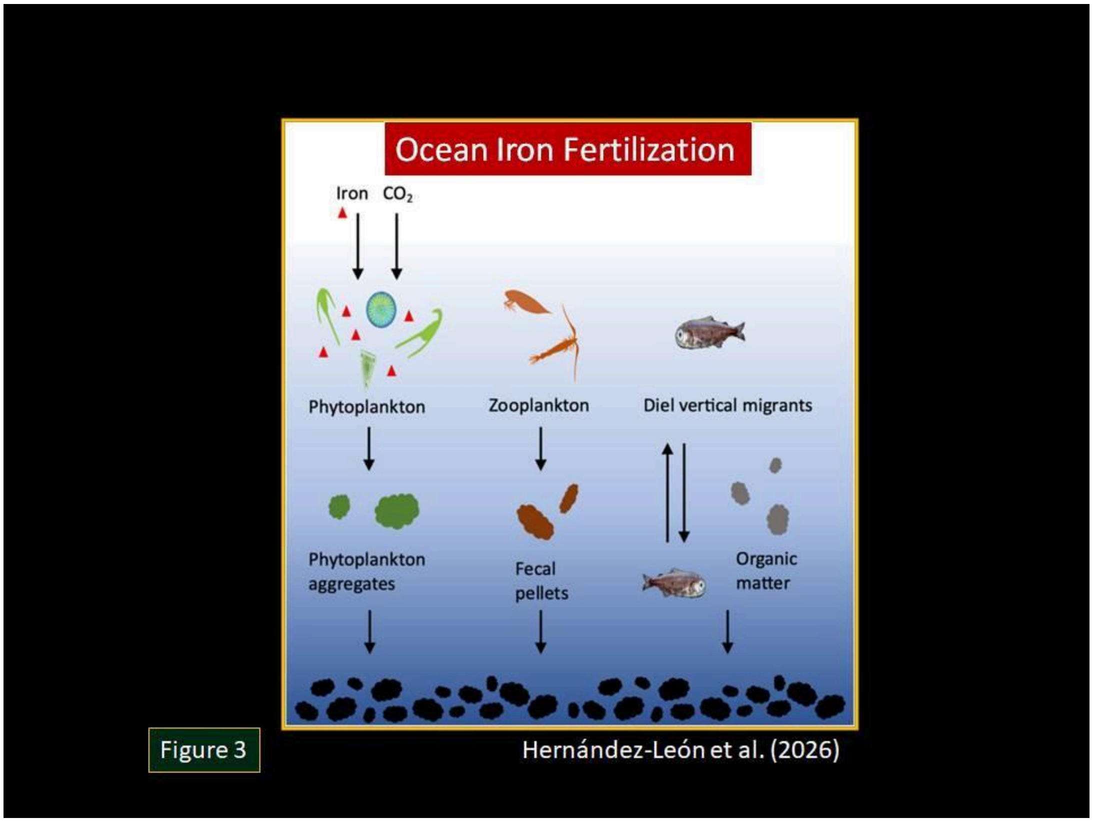
Figure 1 Original figure from Chisholm (2000) modified by Strong et al. (2009)

The Problem

According to ACE (Antarctic Climate & Ecosystems) (2008), "While controlled iron fertilization experiments have shown an increase in phytoplankton growth, and a temporary increase in drawdown of atmospheric CO2, it is uncertain whether this would increase carbon transfer into the deep ocean over the longer-term." As illustrated by K. Buesseler of the Woods Hole Oceanographic Institution (Fig. 2), it is not yet known whether fertilization might generally enhance ecosystem production and drawdown of CO2 (in left panel), or whether this might lead to substantial and unwanted ecosystem changes that ultimately might diminish production and do little or nothing to enhance CO2 drawdown (right panel).

Furthermore, Hernández-León and Lichtfouse (2026) cautioned that many issues are yet to be investigated. For instance, the zooplankton burst that follows the phytoplankton bloom, and the carbon export by large fecal pellets remain poorly known (Fig. 3).





Also, it would be nice to be able to say which nutrient is responsible for the bloom, if it has been driven by iron (dust) alone or by other nutrients, such as phosphates, or nitrates for diatoms. Although we do not have answers to many questions, we must proceed with our efforts to gather data. We hope that this study will provide the incentives for young researchers who wish to explore this crucial climate issue.

The Evidence

We present a plethora of published data and images related to understanding Ocean Fertilization.

- Knippertz (2014) provided a schematic depiction of a convective dust storm in the foothills of the Atlas Mountains in northwestern Africa (Fig. 4). The mountains serve as a trigger for deep moist convection. Evaporation on the dry Saharan side leads to evaporative cooling and the generation of a dust density current (Knippertz et al. 2007). Although developed for the Sahara Dust Storms, this model is applicable in general from a fluid mechanics viewpoint.

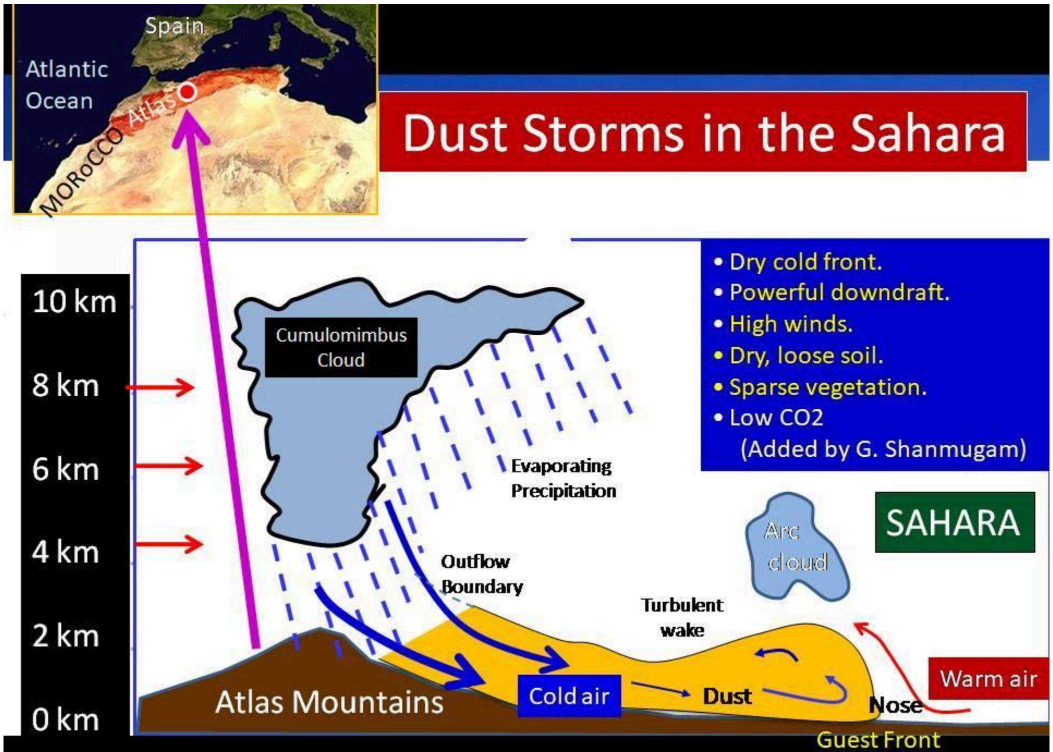
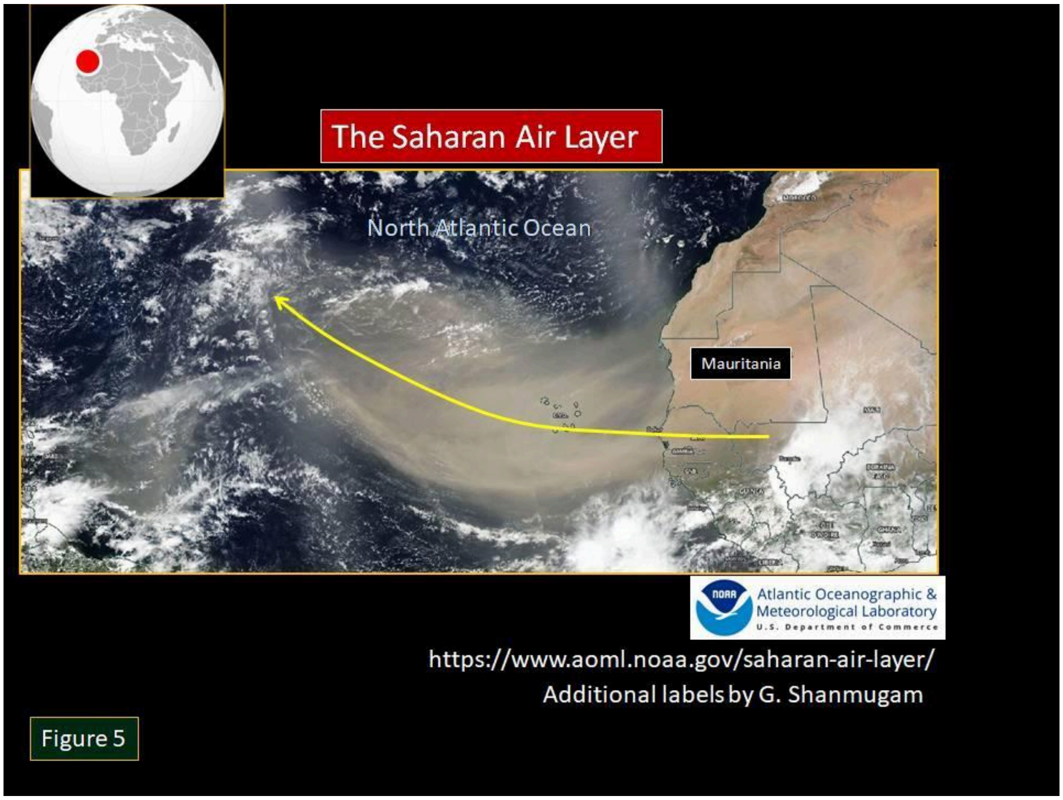


Fig. 4. Origin of Dust Storms in the Sahara. From Knippertz (2014). Map Wikipedia

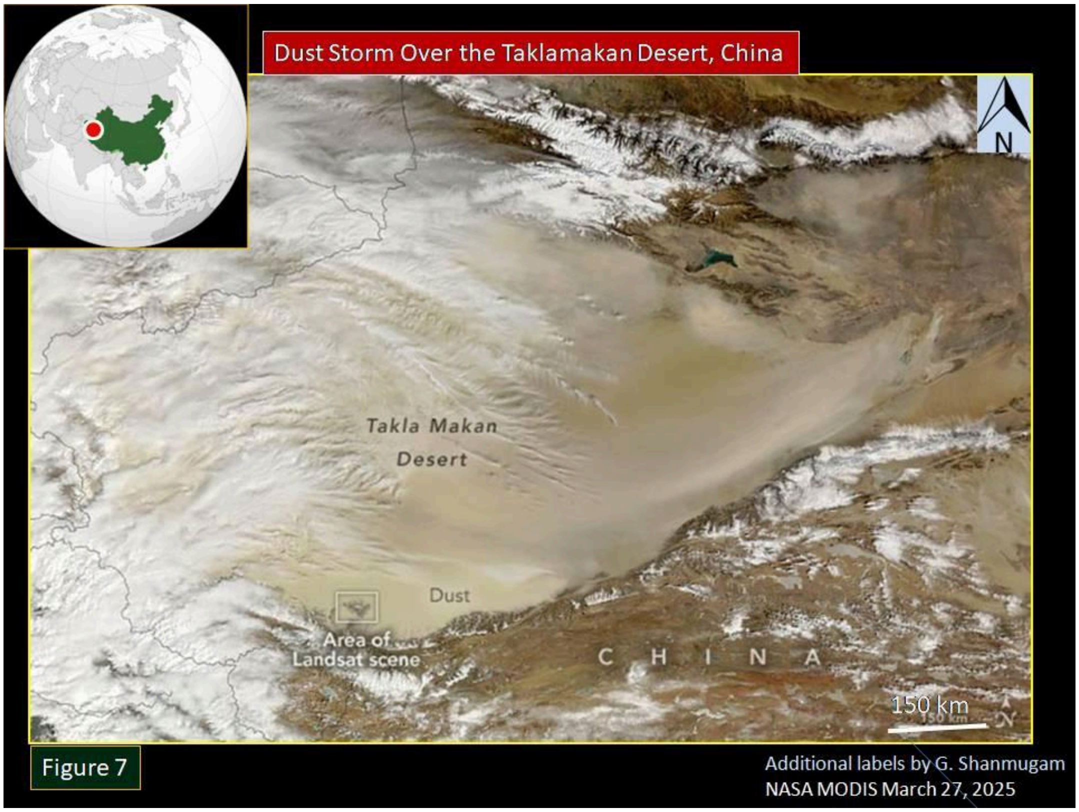
- The Saharan Air Layer (SAL) has unique properties of warmth, dry air, and strong winds that can have significant moderating impacts on tropical cyclone formation and intensification. There are three characteristics of these Saharan dust outbreaks that can affect tropical cyclones, tropical disturbances, and the general climatology of the Atlantic tropical atmosphere: In the context of Ocean Fertilization, SAL carries large amount of dust across the Atlantic (Fig. 5).

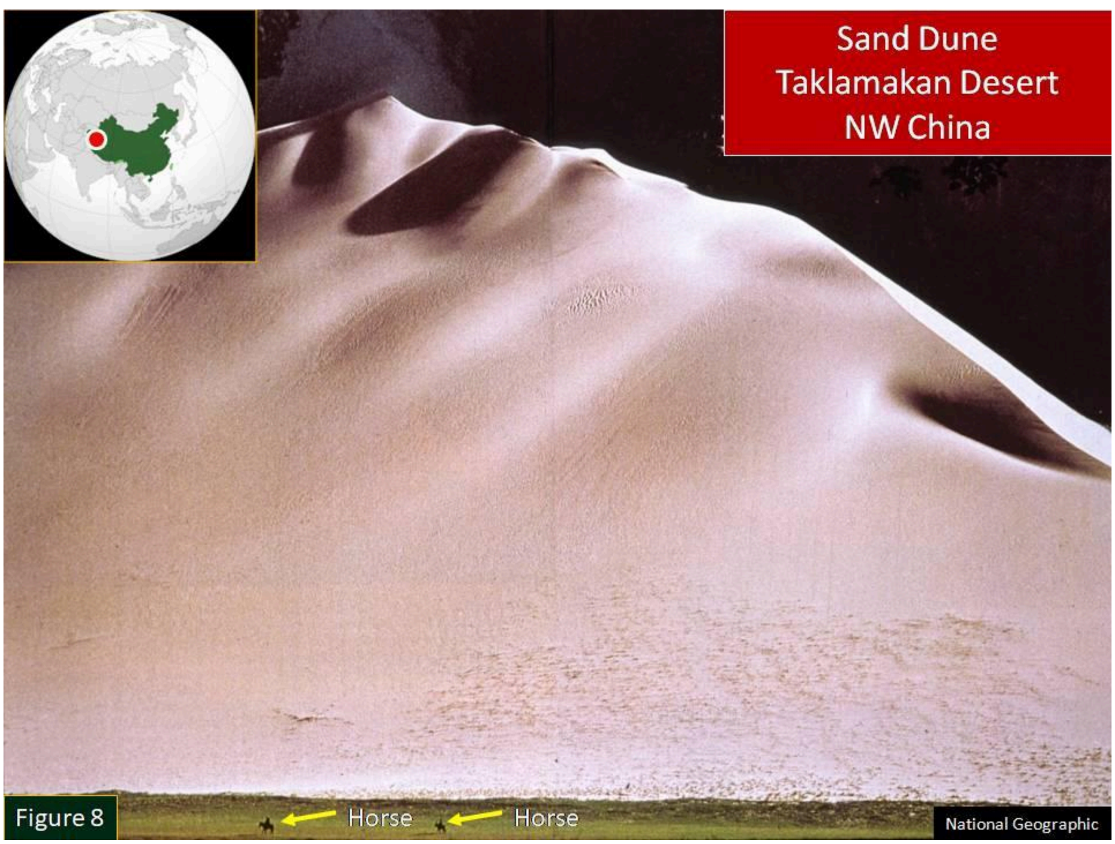


- The World's deserts serve as the source of particles for dust storms. The Sahara Desert has an estmated area of 9.2 million km² (Fig. 6). Most dust storms originate from dry, disturbed soils, playas, agricultural lands, and alluvial deposits.

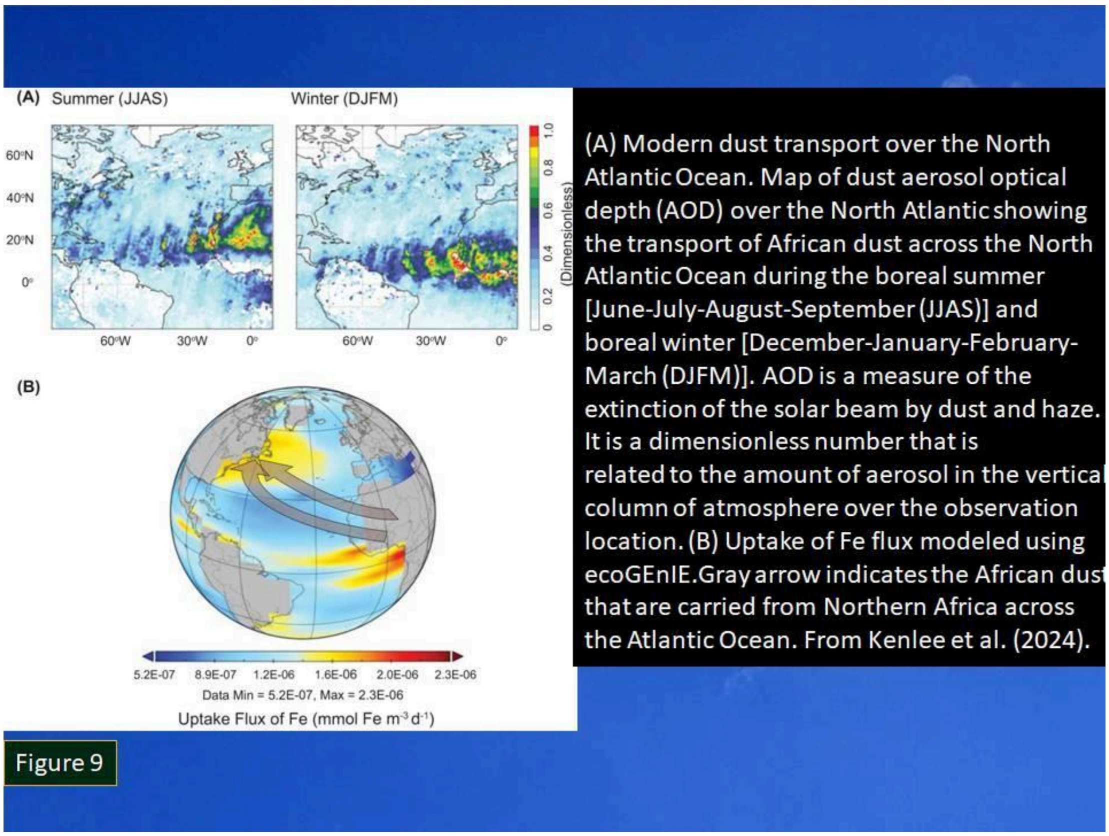
Figure 6

- Although sand dunes are an important component of a desert environment, such as the Taklamakan in NW China (Figs. 7 and 8), they are not major sources of particles for dust storms. The reason is that sand dunes are dominated by coarse sand, whereas fine silt and clay — the particles that create dust storms — are scarce.


Dust Storm Over the Taklamakan Desert, China
N
Takla Makan
Desert
Dust
Area of
Landsat scene
C H I N A
150 km
Figure 7
Additional labels by G. Shanmugam
NASA MODIS March 27, 2025


Sand Dune
Taklamakan Desert
NW China
Figure 8
Horse
Horse
National Geographic

- In documenting the “Long-range transport of dust enhances oceanic iron bioavailability”, Kenlee et al. (202) (Fig. 9) evaluated the supply of wind-borne bioavailable Fe and its potential impact on Fe-based climate feedbacks over the last 120,000 years. They examined sediment profiles from four localities that define a proximal to distal transect relative to Saharan dust inputs. Bulk d56Fe isotope compositions (average = -0.05‰) and FeT/Al ratios suggest crustal values, which pointing to a dominant dust origin for the sediments at all four sites.



- Satellite imagery shows that a 800-km long tongue of the Saharan dust storm penetrates into the Bay of Biscay with a phytoplankton bloom along the coast of France (Fig. 10). This occurrence of bloom near the tip of the dust storm is fortuitous.

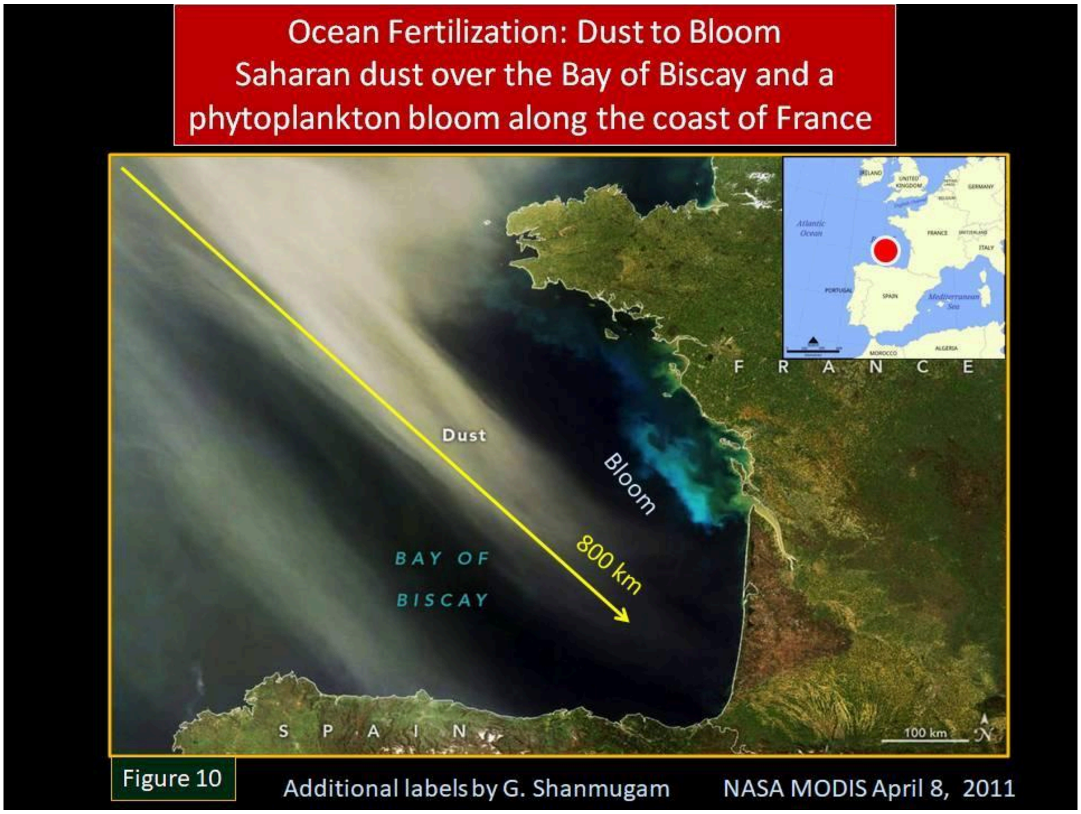
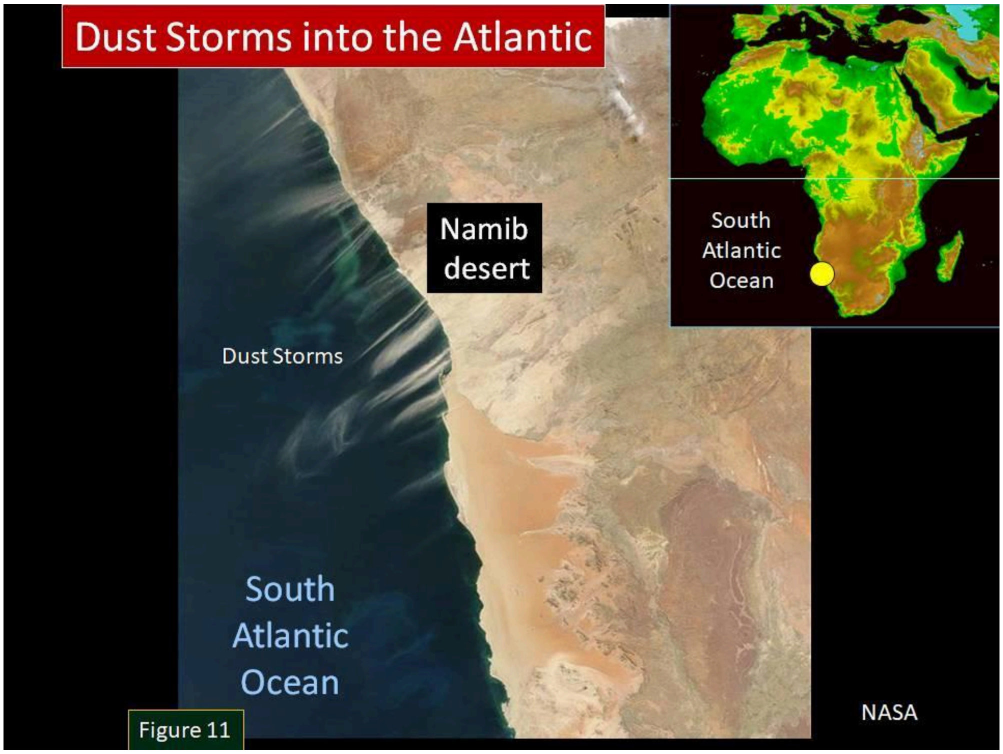
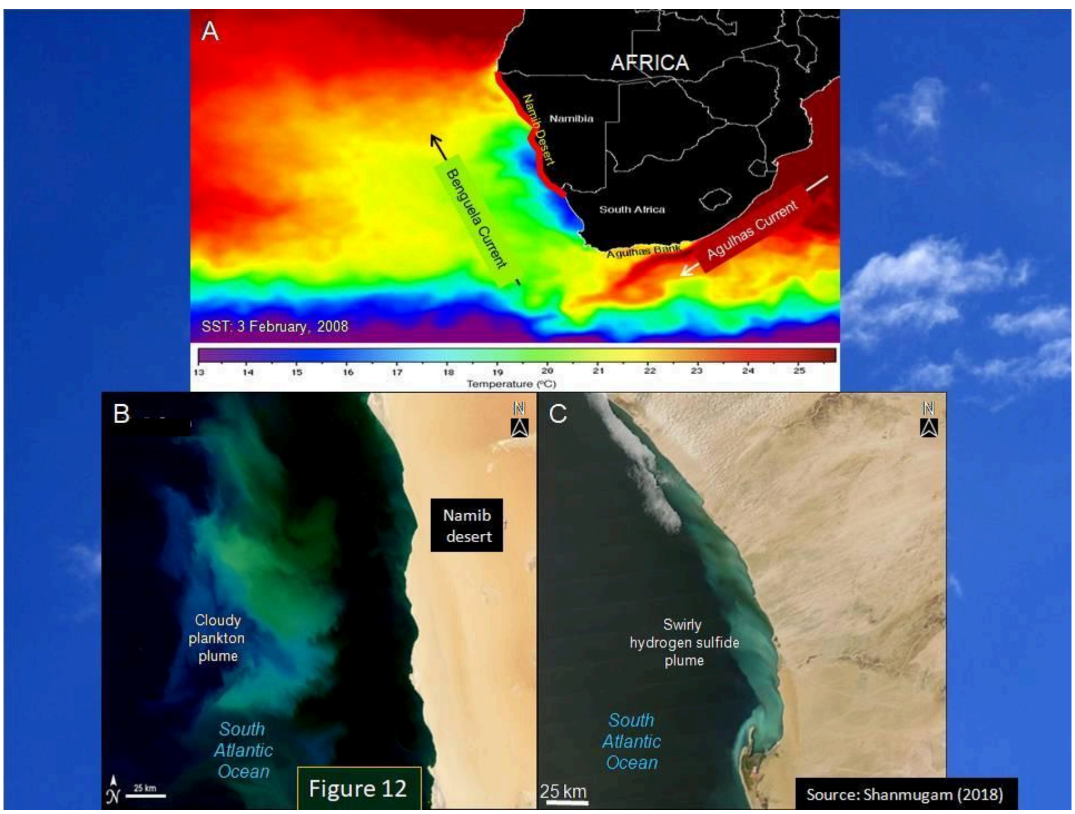


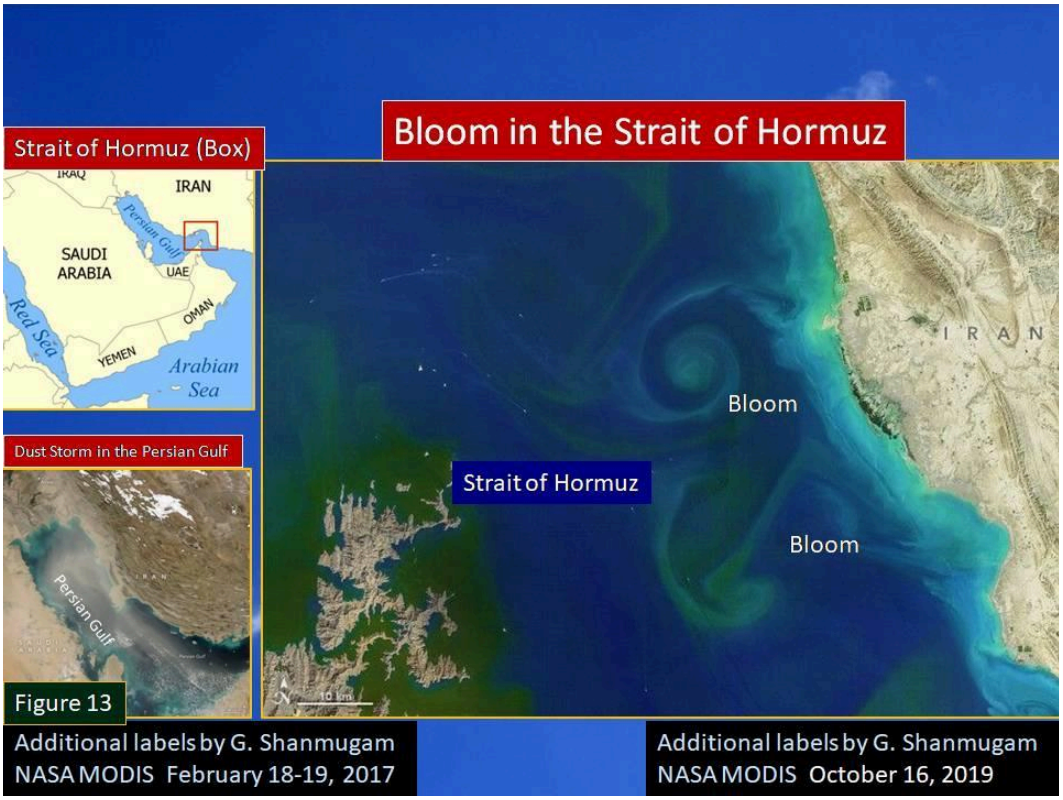
Figure 10

- In the South Atlantic Ocean, the occurrence of dust storms and blooms Off Namib Desert is striking (Shanmugam, 2018) (Figs. 11 and 12).

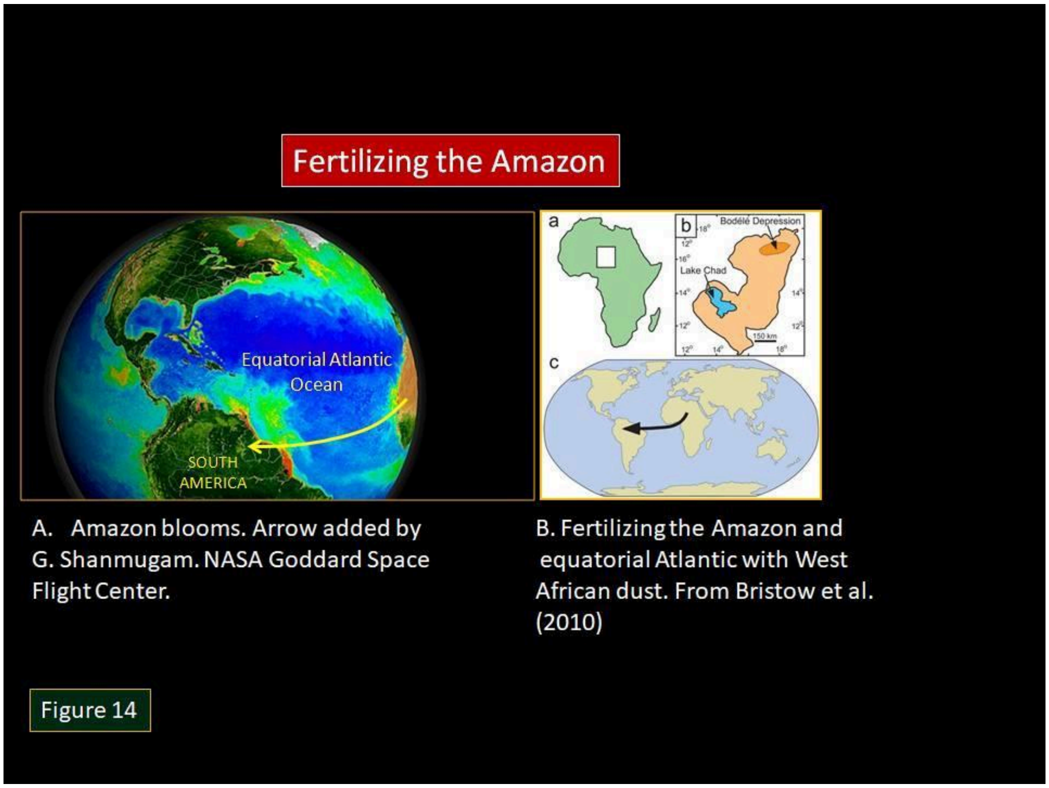




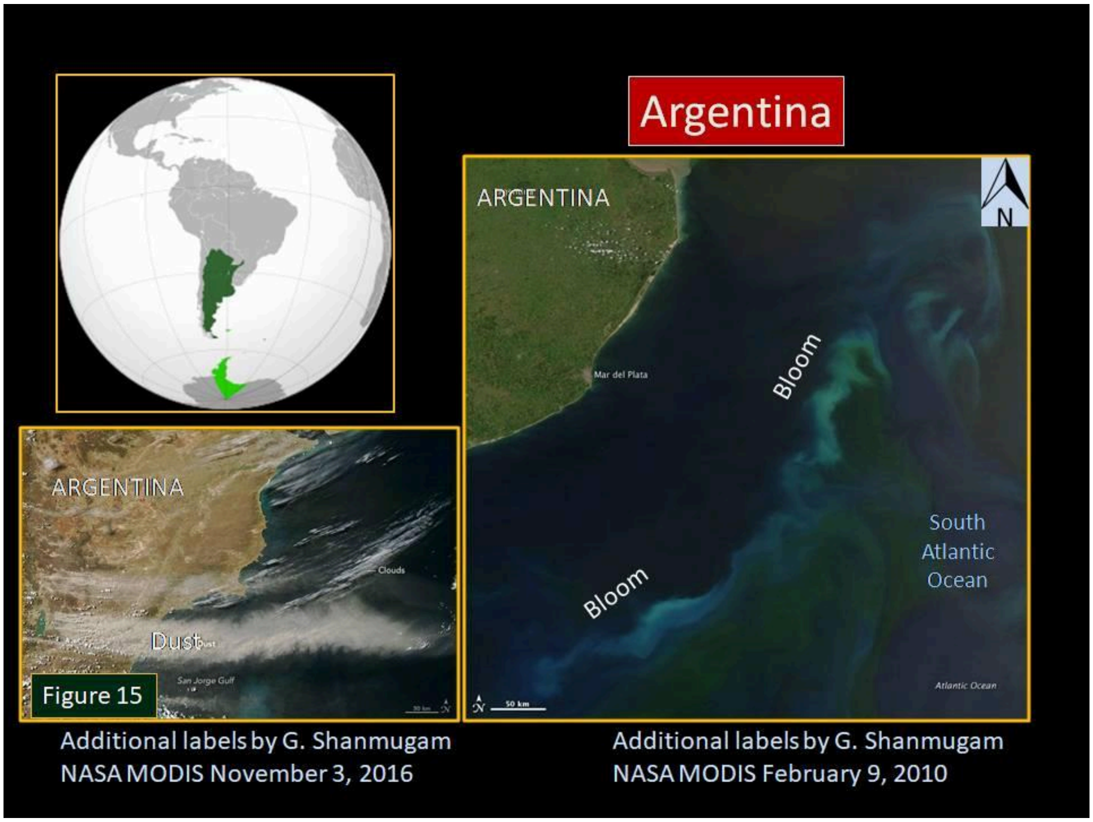
- Blooms in the Strait of Hormuz resemble modern painting (Fig. 13). This area is constantly swept by dust storms.



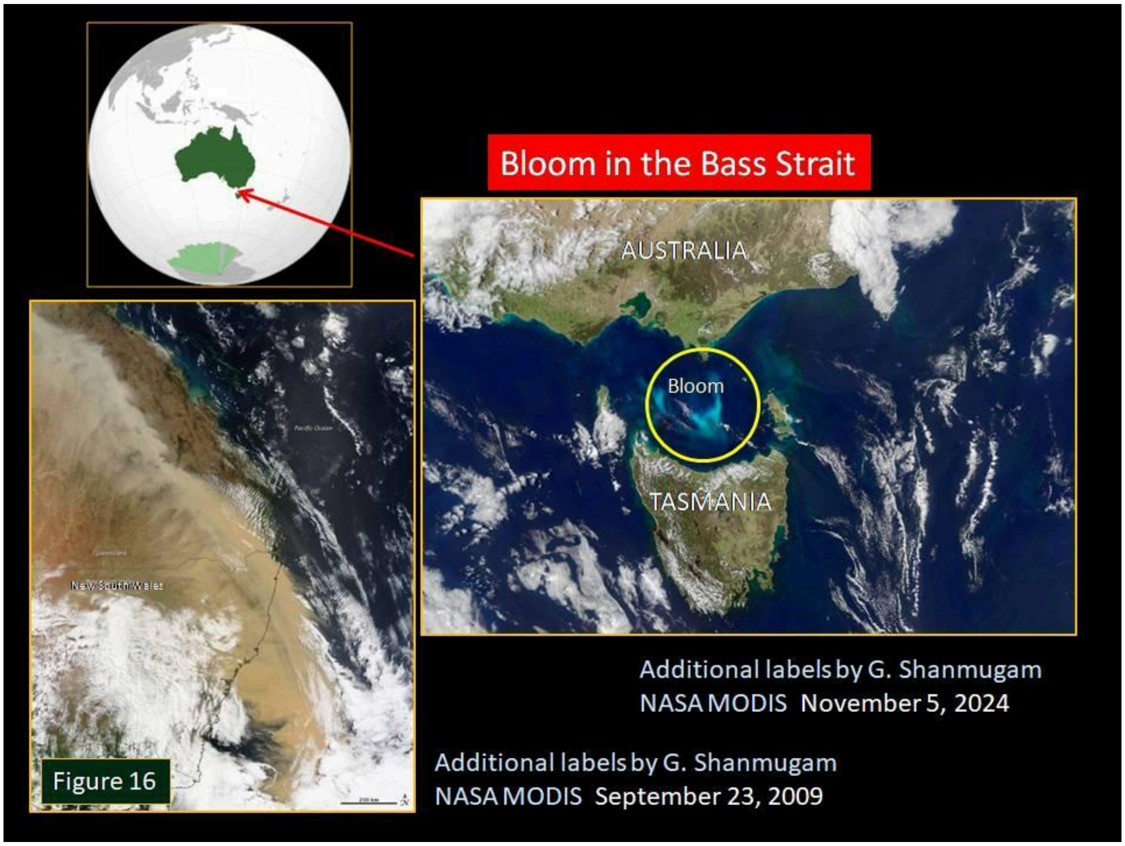
- In the Equatorial Atlantic, fertilizing the Amazon region (Fig. 14) with West African dust was discussed by Bristow et al. (2010). They presented the results of chemical analysis of 28 dust samples collected from the source area, which indicate that up to 6.5 Tg of Fe and 0.12 Tg of P are exported from the Bodélé Depression every year. This suggests that the Bodélé may be a more significant micronutrient supplier than previously proposed.



- In the South Atlantic Ocean, the occurrence of dust storms and blooms Off Argentina is also striking (Shanmugam, 2018) (Fig. 15).



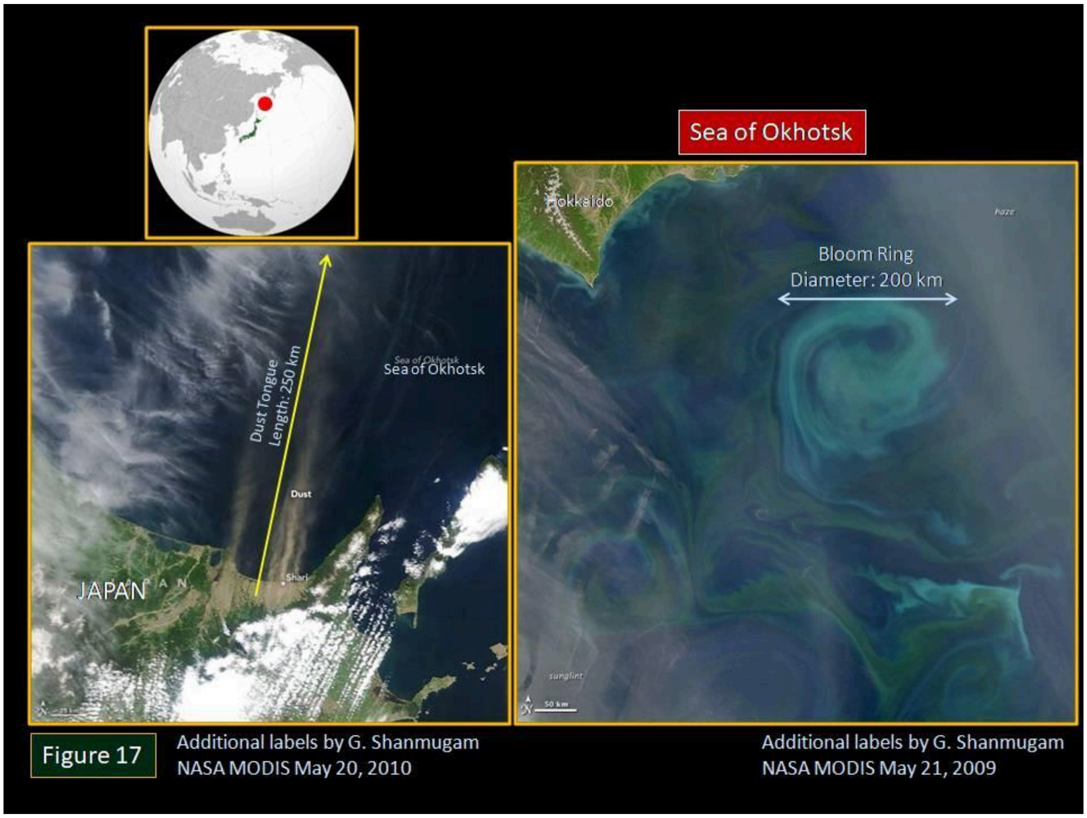
- Dust and Bloom in the Bass Strait, between Australia and Tasmania (Fig. 16), have been documented.



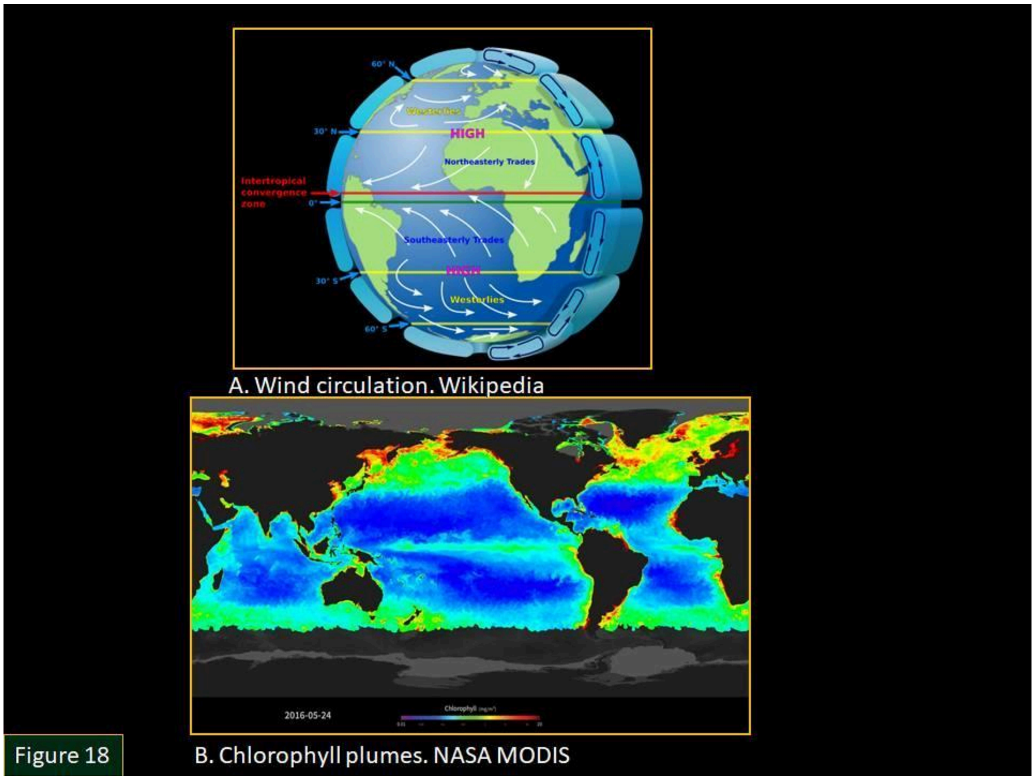
- Sea of Okhotsk

  Left Panel: Dust Tongue Length: 250 km (Fig. 17A)

  Right Panel: Bloom Ring Diameter: 200 km (Fig. 17B)



- Finally, there is a general correlation between the Global Wind Circulation (Fig. 18A) and the Global Chlorophyll plumes (Fig. 18B).



A. Wind circulation. Wikipedia

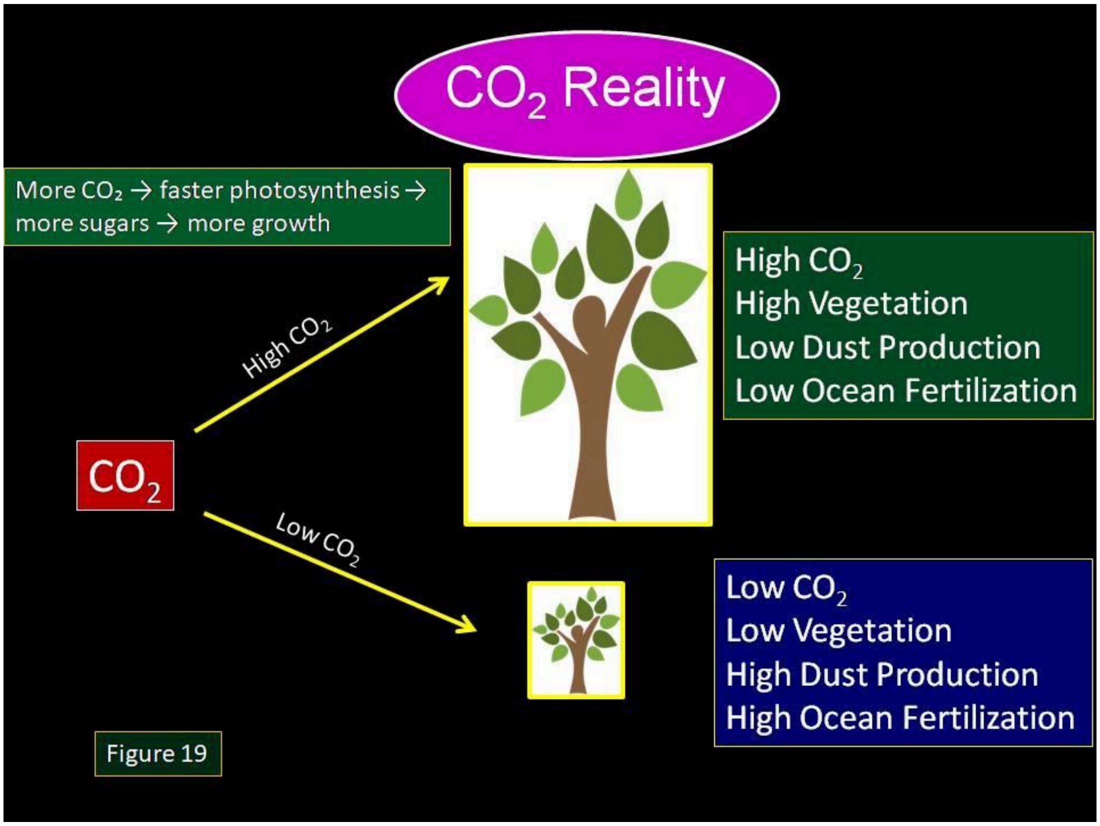
Figure 18 B. Chlorophyll plumes. NASA MODIS

CO2 Reality

By combining results of this study with earlier works on dust storms by Shanmugam (2026 and by Elias and Palmer (2016), we make some general inferences (Fig. 19).

They are:

1) Glacial Maxima
2) Low CO_2
3) Low Vegetation
4) High Dust Production
5) High Ocean Fertilization

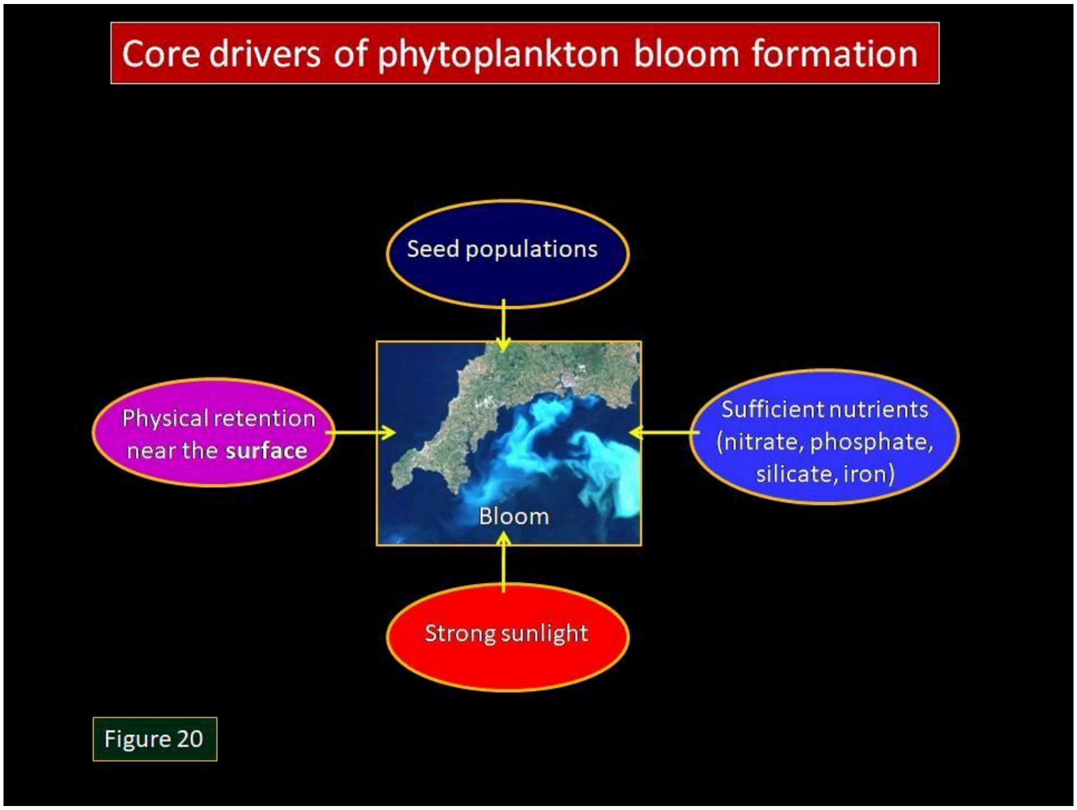


Furure Research

Core drivers of phytoplankton bloom formation **are (Fig. 20):**

- Seed populations of phytoplankton already present in the water
- Sufficient nutrients (nitrate, phosphate, silicate, iron)
- Strong sunlight
- Physical retention near the **surface** so cells stay in the euphotic zone.

In this article, We have addressed the role of just one nutrient (iron). There is much more research to be done.



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