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Dust influence on glacial periods: a natural analogue tool to combat global warming

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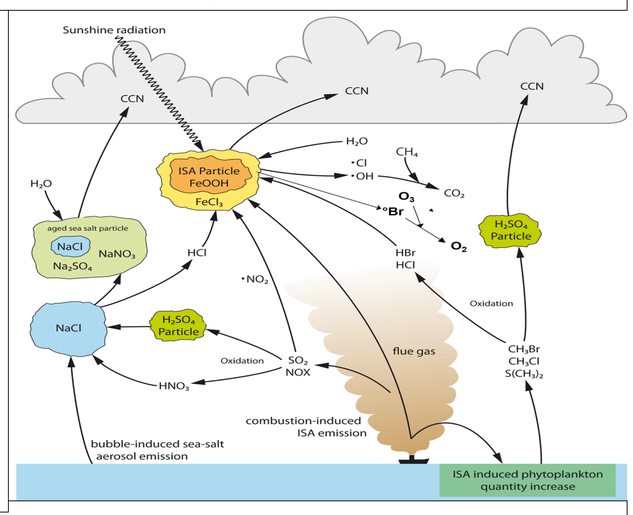
Abstract: A detailed analysis of the dust influence on Earth's climate reveals how mankind could benefit of this natural analogue to reduce the current GHGs levels, in order to stop rising temperatures, rising sea level, rising acidification, and preventing ocean anoxia.
The "Iron Salts Aerosol" (ISA) method proposed [1)] is very different from ocean iron fertilization which has several drawbacks [2)]: ISA acts both by SRM, CDR and GHG-removal on all biosphere compartments and not only on sea surface.
The multiple and very different climate cooling actions of the ISA method have many advantages over competing climate engineering proposals, also, it is currently already happening induced by volcanic eruptions or man-made flue gas emissions and few people are aware of it

Three facts not yet taken into account by climate models

- Anthropogenic IRON emissions from combustion sources are already cooling the planet and probably currently responsible of 50% of the oceans productivity [3-4)]
- The chlorine radical sink for tropospheric CH_4 depletion represents 2-4% globally [5)] but nearly 11% of CH_4 removal over the tropical Atlantic Ocean [6)] and is activated by Fe(III)/Fe(II) photocatalysis [7)]
- Ocean Iron Fertilization is well known [2)], but Continental Iron Fertilization might be as important [1, 8)] and over wetlands Iron reduces the amounts of CH_4 emissions [9)]

Principal Cooling Mechanisms of the Iron Salts Aerosol Method [1)]

- Planetary albedo increase by direct (ISA aerosols) and indirect (DMS generation) cloud whitening and cloud life-time elongation
- Atmospheric CH_4 depletion by photolytic chlorine activation
- Activation of the oceanic CO_2 absorption by surface cooling and pH increase
- At ocean surfaces: CO_2 absorption by generation of phytoplankton blooms
- On continents: CO_2 absorption activation by increase of forests, crops, orchards and plants primary assimilation and by chlorosis prevention and thus growth activation of plants and root-induced weathering activation
- Tropospheric ozone and soot aerosols depletion and prevention
- Reduction of CH_4 emissions by terrestrial landscapes, from wetlands, peat bogs and tidal flats, both by inhibition of CH_4 production & oxidation activation
- Preventing ocean stratification…



Findings:

- Previous numerous glacial ages are associated to high levels of dusts and their iron content [10-11)]
- Measures introduced to improve future air quality and reduce pollution could have large implications on the aerosol climate forcing, on the bio-available Iron emissions, decreasing marine productivity and increasing CH_4 emissions form wetlands [3),] decreasing their cooling effects [15)]...

Acceleration of C transport and solidification from atmosphere into rock formations by the ISA method [1)]

Acceleration of the C transport from atmosphere into ocean

A1 Activated weathering on continents, accelerated by fertilized plants, fungi, lichens, microbes and erosion: Solid silicate / M-CO_3 + CO_2 + N_2 + O_2 + H_2O → HCO_3^- + solubilized silicate + M-PO_4^- + NH_4^+ Mainly by physical and biochemical erosion/solution in the steady fluctuating red-ox milieu below the ice cap

A2 Activation of biotic and abiotic oxidation of CH_4 in the atmosphere, wetlands and sediments to CO_2 and HCO_3^-

A3 Assimilation of CO_2 by plants, lichens and microbes on continents and ocean surface: CO_2 and/or HCO_3^- + H_2O + sunshine radiation → organic C + M-CO_3 by fertilization

A4 Activation of the physico-chemical transformation of CO_2 into HCO_3^- by absorption of water on continents and at ocean surface by activating cooling the water surface, preventing stratification of the ocean and assimilation-induced alkalization

Activation of C transport and solidification from ocean into sediments and ocean crust

B1 Organic carbon oxidation activation within the food chain into HCO_3^- by accelerating the vertical ocean currents and activating the O_2 absorption by cooling the water surface and preventing ocean stratification

B2 Stabilizing the fixing of CH_4 hydrates in sediments by vertical water cycle activation by cooling the ocean surface and activating the ocean oxygenation

B3 Activating the HCO_3^- transformation into M-CO_3 rock in the alkaline sediment & crust environment according to the increased HCO_3^- transport capacity of the activated and cooled vertical cycling ocean currents.

Indirect activation of C transport and solidification by additional induced cooling effects

C1 Activating the increase of cloud albedo according to the generation of cloud condensation nuclei (CCN)

C2 The phytoplankton fertilization increases organic S and halogen emissions & induces cloud albedo increase by H_2SO_4 aerosol CCN generation and CH_4 depletion activation by additional tropospheric HCl content

C3 Catalytic tropospheric O_3 depletion by ISA generated halogen atoms

C4 Accelerated black C aerosol rain out by soot particle hydrophilization

C5 Activating lightning-induced NO_3^- generation by CCN increase [16)]

C6 Stabilizing the ice caps by ISA cooling preserves the physical, chemical, and anaerobical [17, 18,19)] generated provision of macro and micro nutrients to the polar oceans and their cooling effects.

The "Faustian" dilemma of cutting emissions

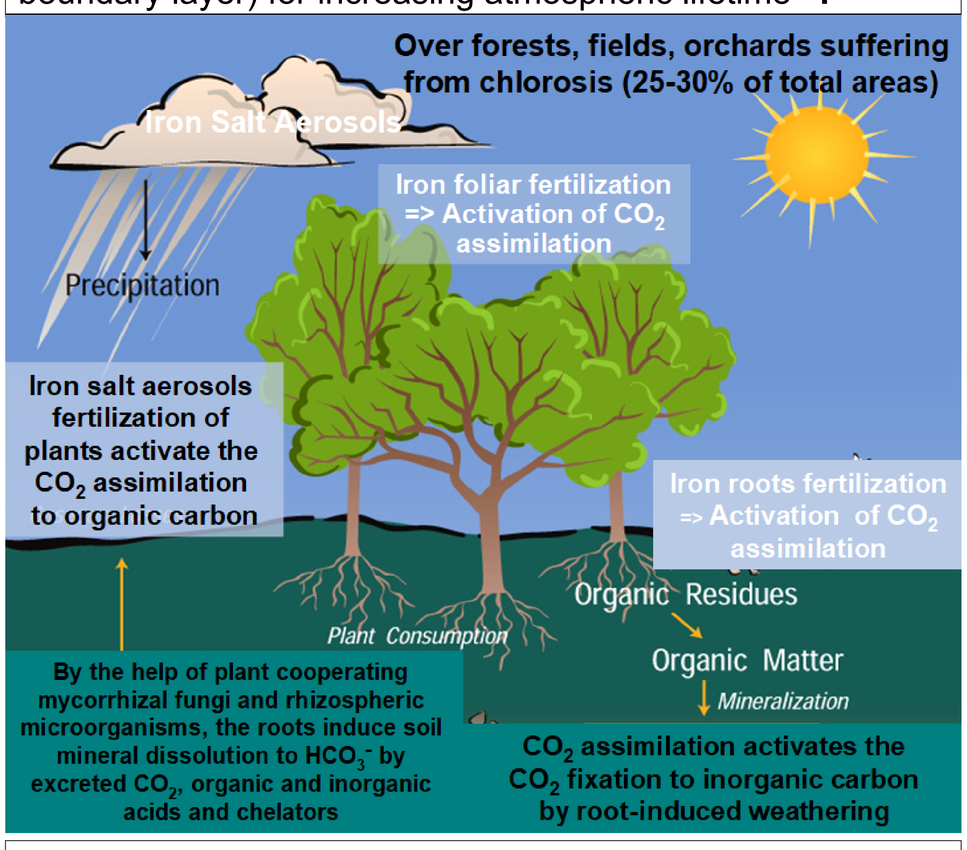
Emissions from fossil-fuel power stations create aerosols with both beneficial and harmful consequences.

- **Benefit**: Shield from solar radiation (SRM). Removal of sulphates and other aerosols would cause a sudden rise in surface temperatures.
- **Harm**: Asthma, pulmonary diseases, death of humans and livestock, reduced harvests and crop yields.

First ISA method proposal [1)]

To keep the benefit and reduce the harm, existing coal-fired power production should be modified:

- 100% of power plants should be equipped with filters and electrostatic precipitators to remove solid particles ($PM_{2.5}$; soot, BC, mineral dust…) and their efficiency improved.
- 98% of power plants should be equipped with alkali scrubbers or filters to remove acidic gases (NOx & SOx);
- **acidic iron aerosols (FeOOH + HCl or $FeCl_3$) should be added** to the remaining 2%, that should also be equipped with higher chimneys or with enhanced exhaust engines able to elevate emission to free troposphere (above boundary layer) for increasing atmospheric lifetime [6)].



Conclusions: many health benefits!

- Reduces local pollution, saves human lives, reduces health costs, increases crops harvest, allows economic savings…
- Keeps the cooling produced using only a fraction of the existing aerosols, by release at a lower altitude than SRM helping to resolve the 'Faustian bargain' [13)]
- Uses existing technology with limited investment costs
- Probably will have better public acceptance than other SRM proposals and the cheapest of the CDR methods.

ISA is feasible because it currently occurs!

But we don't need to burn coal or other fossil fuel power plants to do so. ISA can be released by different measures, for instance by a balloon like in the "spice experiment" [14)] by spaying or burning or condensation >500m <1000m above the boundary layer (not in the stratosphere) an iron complex dissolved.

Further work

- Apply global circulation models to predict fate of iron aerosols cooling effects
- Quantify benefits more precisely e.g. lives saved on Disability Adjusted Life Years basis
- Compare against benchmarks e.g. SRM and CDR or GHGR methods proposed
- Assess risks: e.g. social acceptability, …

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