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Atmospheric Chemistry and Physics

Mixing of dust and NH_3 observed globally over anthropogenic dust sources

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GLOBAL-SCALE ATTRIBUTION OF ANTHROPOGENIC AND NATURAL DUST SOURCES AND THEIR EMISSION RATES BASED ON MODIS DEEP BLUE AEROSOL PRODUCTS

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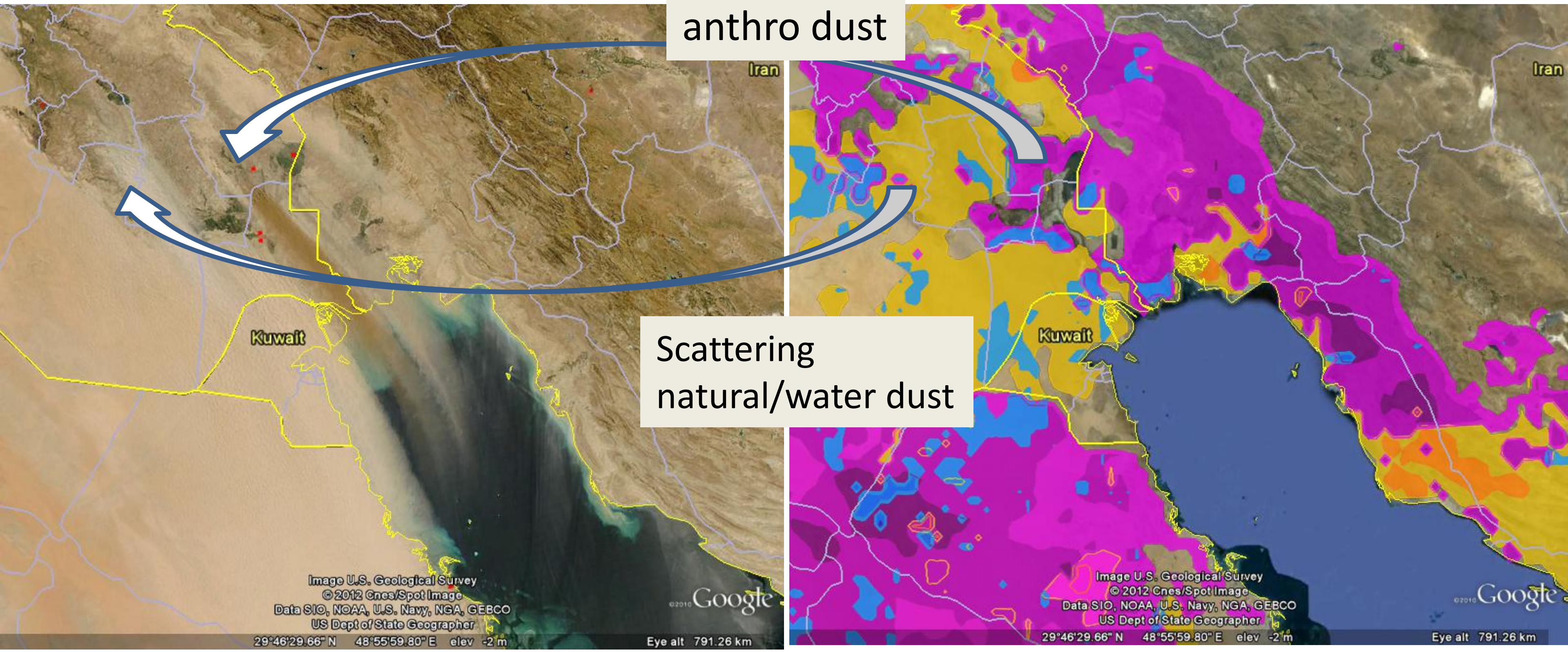
Different optical properties of dust depending on source location

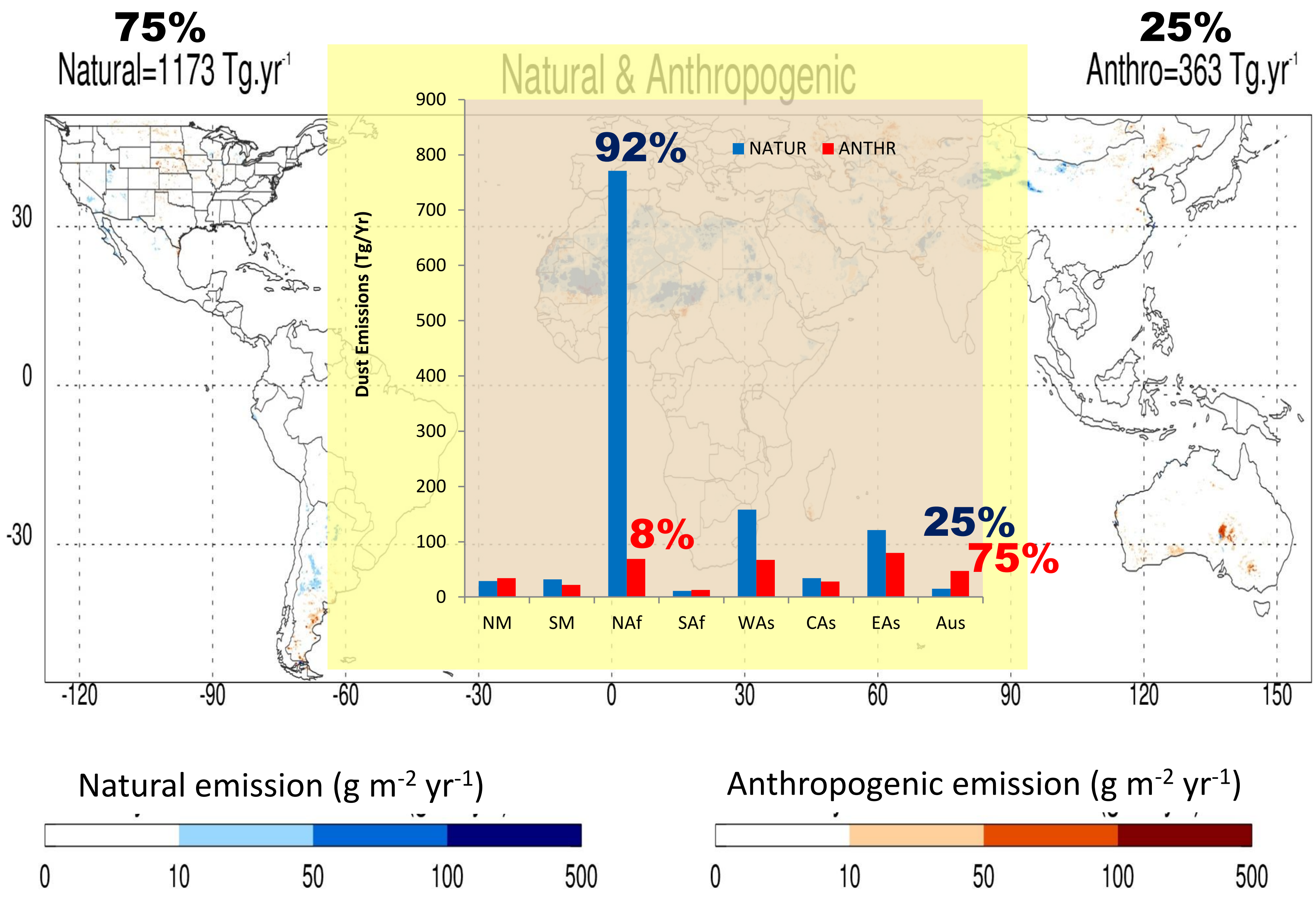
MODIS L1B on June 2, 2012:
White to brown dust plumes over Arabian Sea

M-DB2 FOO (*Ginoux et al., RoG, 2012*):
- Natural (yellow)
- Anthropogenic (magenta)
- Ephemeral waterbodies (blue)



Also, evidence of mixing of ammonium salts with anthropogenic dust (Ginoux et al., ACP, 2012) affecting optical properties, and formation of Fe(II), CCN and ICN.

Natural & Anthropogenic annual emissions



A new global mineralogical database for studying dust properties

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Direct radiative effect

The mineralogy affects both the sign and amplitude of the radiative effect

(Sokolik and Toon, 1997; *Sokolik et al, 1998; Claquin et al., 1999; Myrhe et al., 2005; Balkanski et al., 2007)*

Atmospheric chemistry

Reactivity/hygroscopicity of dust will depend on: calcite and aluminosilicates

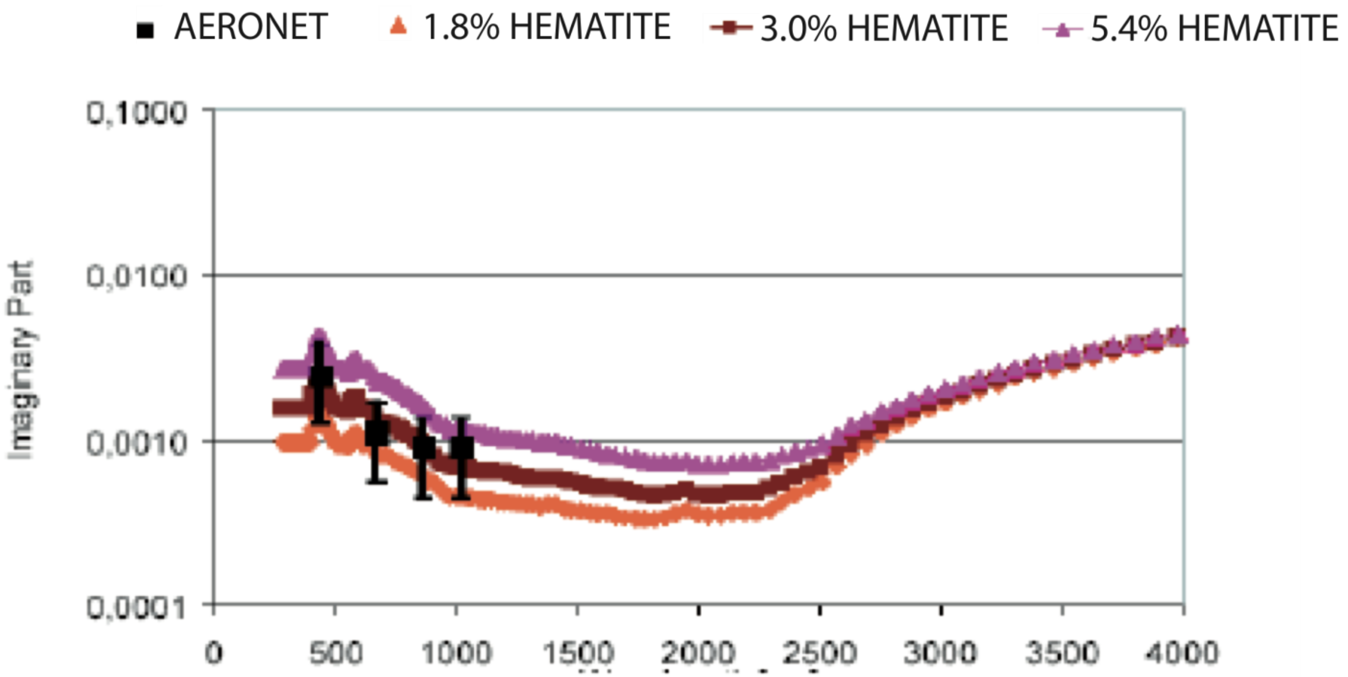
(e.g. *Sulivan et al, 2007; Fairlie et al., 2009)*

Marine Biogeochemistry

Marine productivity can be enhanced by soluble iron in oligotrophic waters

(e.g. *J. Martin*; *Fung et al., 2000; Mahowald et al., 2009)*

Dust refractive index for 1.8; 3.0 and 5.4% hematite by mass



Wavelength (nm)

Which minerals need to be quantified?

The main ones (in mass) and the ones which affects certain processes**.**

Important minerals contained in dust:

- **SILICATES** (quartz, feldspars and clays)
  → (illite, montmorillonite, kaolinite,…)
- **NON-SILICATES** (Calcite, gypsum, iron oxides)
  → Hematite, goethite

Minerals that we want to isolate:

Optical properties	Atmospheric chemistry	Iron flux:
Quartz / Feldspars / Clays / hematite / goethite	Silicates / calcite / gypsum iron oxides	Illite / montmorillonite / chlorite / vermiculite

In all: **an ensemble of 12 minerals**

How was the mineralogical database established?

Clay fraction	Silt fraction
Illite	
Smectite	
Kaolinite	
Chlorite	Chlorite
Vermiculite	
Feldspars	Feldspars
Quartz	Quartz
Calcite	
Hematite	
Goethite	Goethite
	Mica
	Gypsum

Total iron is also determined

Journet, Balkanski, Harrison, in prep.

Objective :

Map the size-resolved mineralogical composition of the erodible soil fraction (fraction < 63 µm)

Method used (based upon Claquin et al., 1999)

Describe the mineralogical composition of the erodible fraction of the different soil classes described by the FAO

The FAO classification relies on pedogenic, physical and chemical criteria but not on MINERALOGICAL ones!

Hypothesis

The soil mineralogical composition is linked to pedogenesis and physico-chemical properties, hence a mean mineralogical composition is characteristic of a soil class

The hamonized soil classification from the FAO

- Acrisol - AC
- Alisol - AL
- Andosol - AN
- Arenosol - AR
- Anthrosol - AT
- Chernozem - CH
- Calcisol - CL
- Cambisol - CM
- Fluvisol - FL
- Ferralsol - FR
- Gleysol - GL
- Greyzem - GR
- Gypsisol - GY
- Histosol - HS
- Kastanozem - KS
- Leptosol - LP
- Luvisol - LV
- Lixisol - LX
- Nitisol - NT
- Podzoluvisol - PD
- Phaeozem - PH
- Planosol - PL
- Plinthosol - PT
- Podzol - PZ
- Regosol- RG
- Solonchak - SC
- Solonetz - SN
- Vertisol - VR
- Rock Outcrops - RK
- Sand Dunes - DS

28 soil classes

230 sub-classes

<u>Example</u>

Class : **ARENOSOLS**

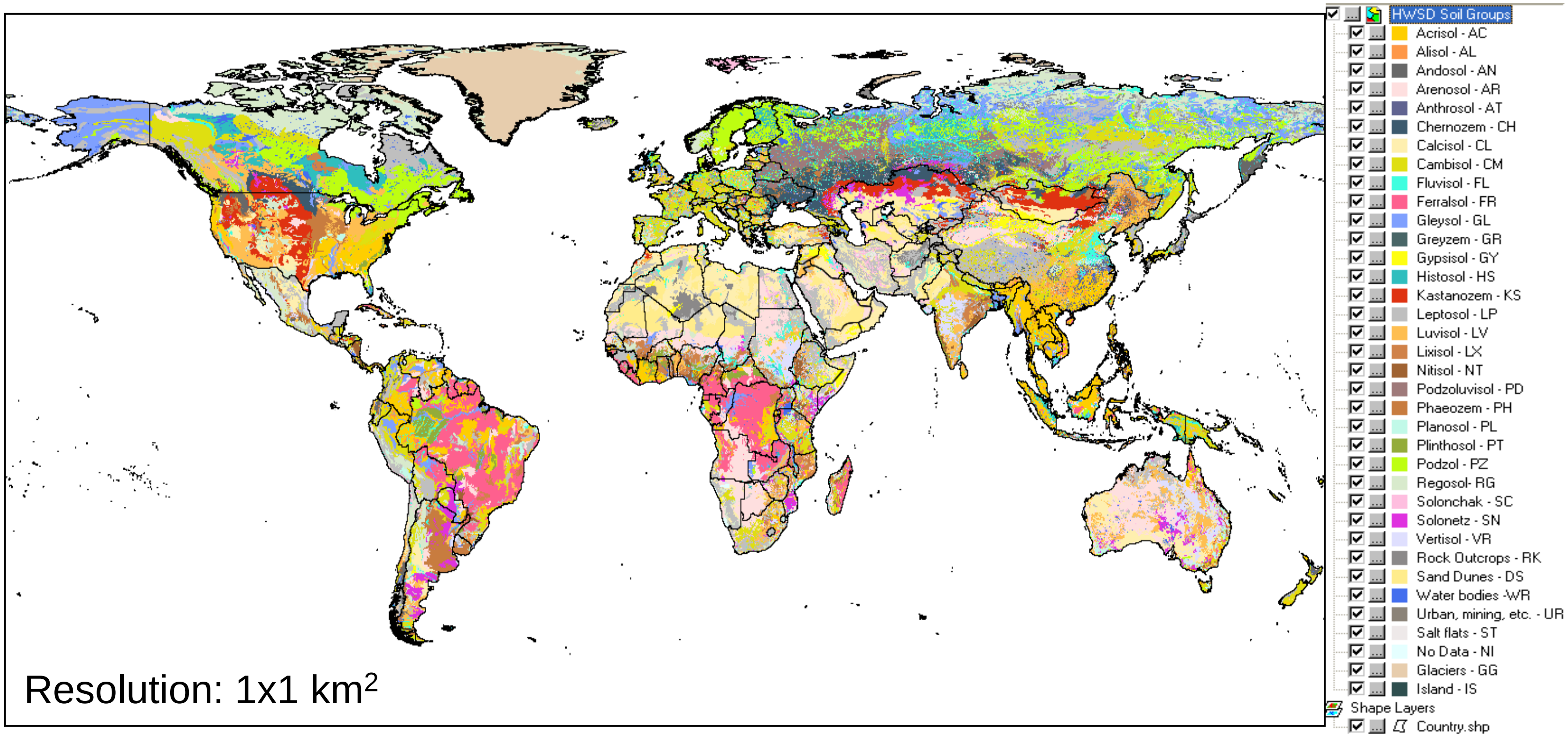
Sub-classes :

Albic	ARENOSOLS
Calcaric	ARENOSOLS
Cambic	ARENOSOLS
Ferralic	ARENOSOLS
Gleyic	ARENOSOLS
Haplic	ARENOSOLS
Luvic	ARENOSOLS

230 soils to document!

Harmonized World Soil Database (HWSD)

Global 1x1 km^2 soil database



The Land Use Change and Agriculture Program of IIASA and the Food and Agriculture Organization (FAO)

HWSD has information on soil type and physico-chemical caracteristics (granulometry, calcite content …)

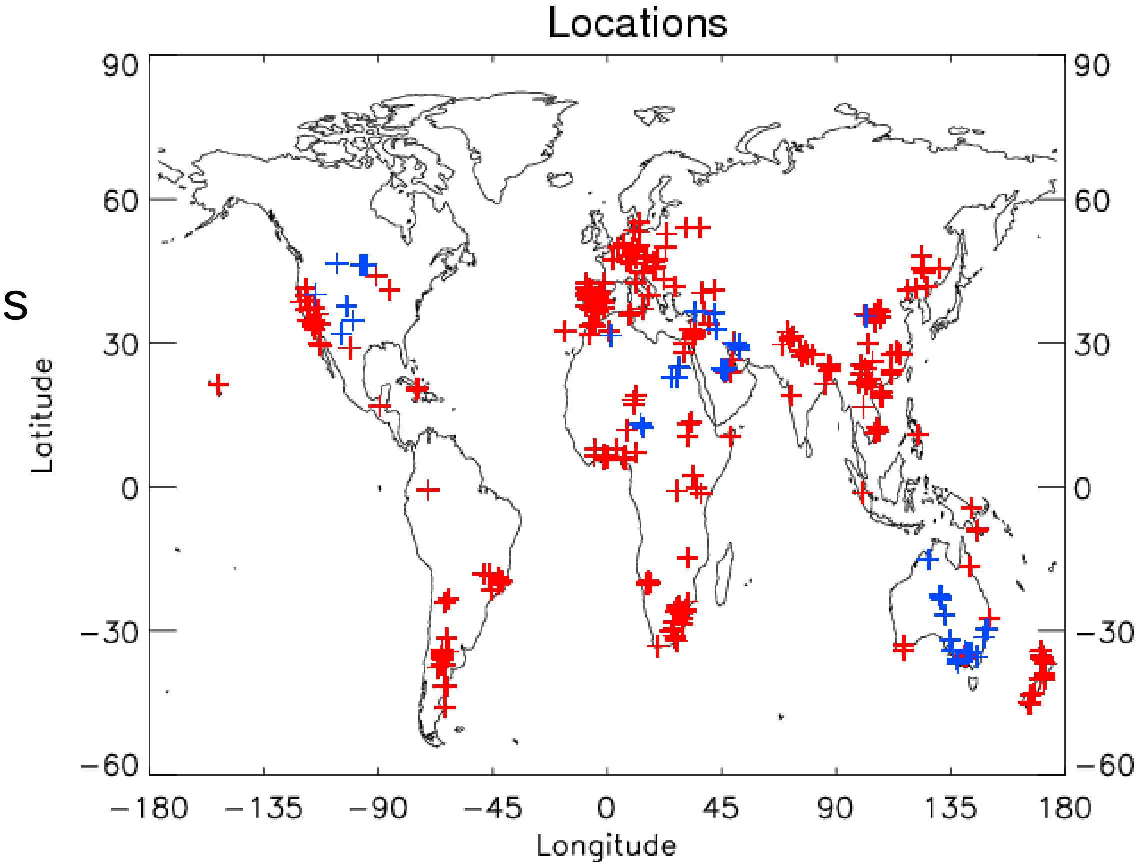
Building up the database

Selection criteria :

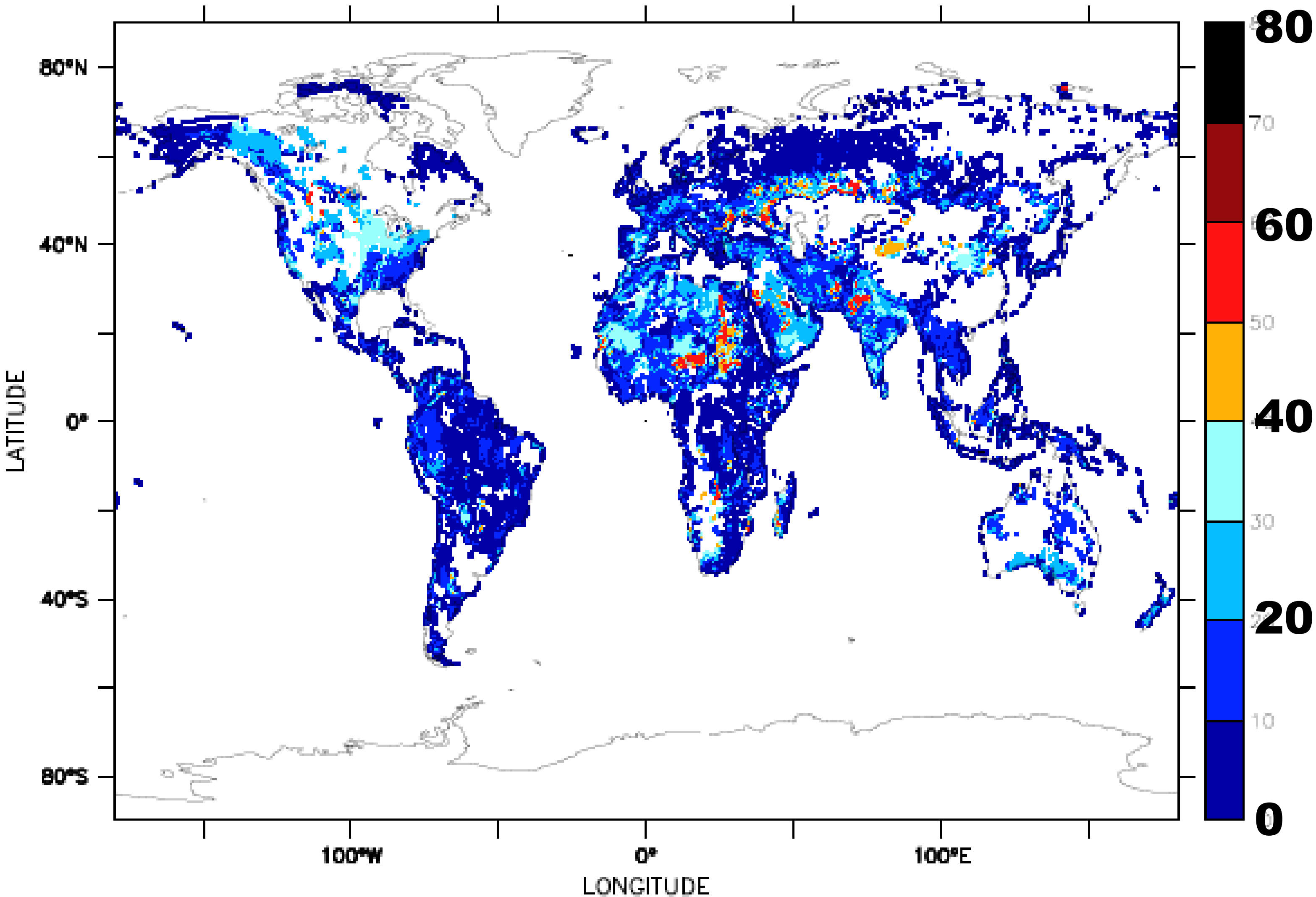
1)Mineralogical information has to be size-resolved < 63 µm
2)Surface horizon
3)The soil under study has to be linked to one of the FAO sub-classes

Data inventory:

- **594 descriptions** of soils in the database
- from more than **120 references**



Illite fraction (%) in soils



Additional hypothesis

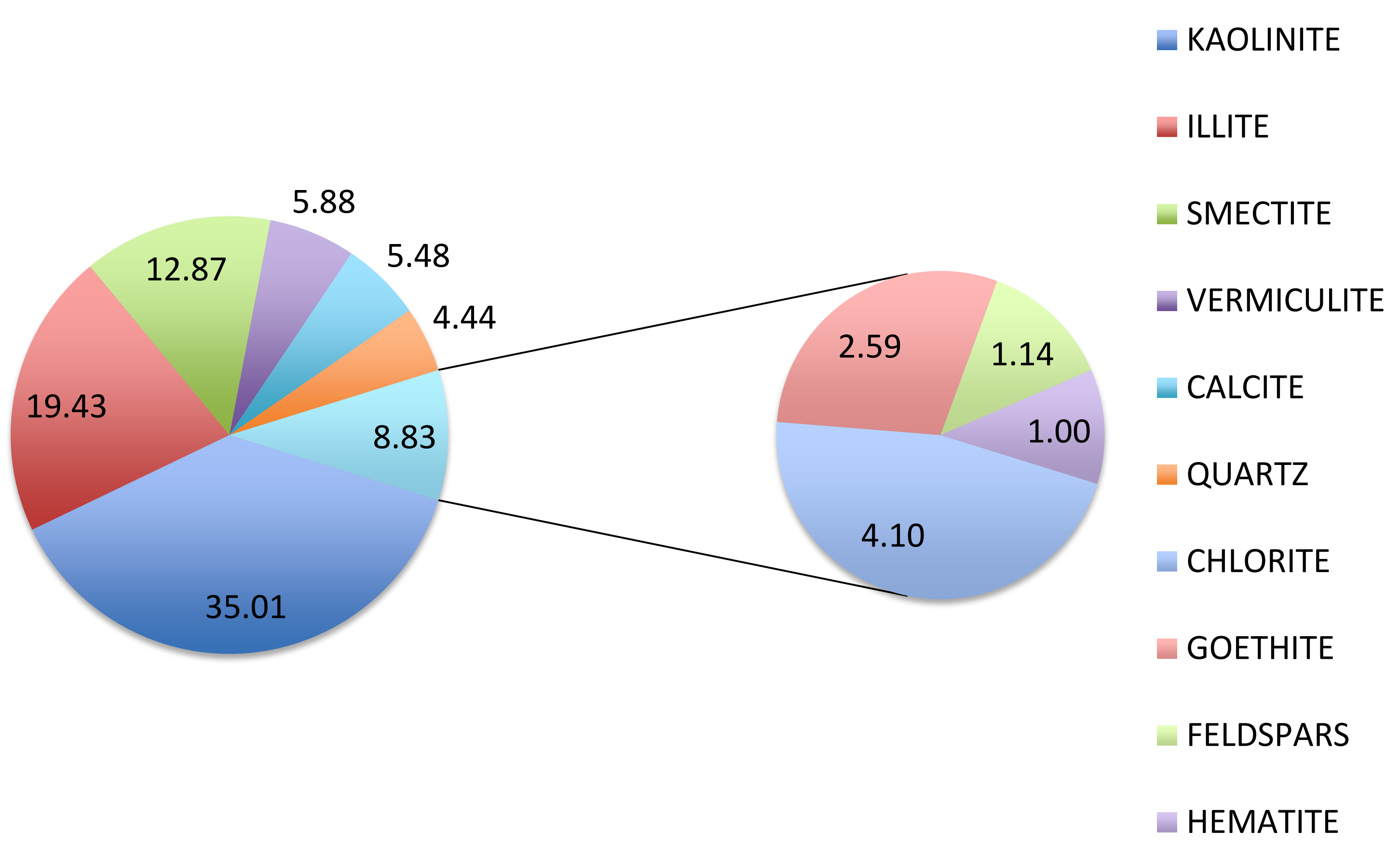
Allocate to soils for which the mineralogy is not described,

CASE 1: the mineralogical composition of the soil with the closest characteristics,

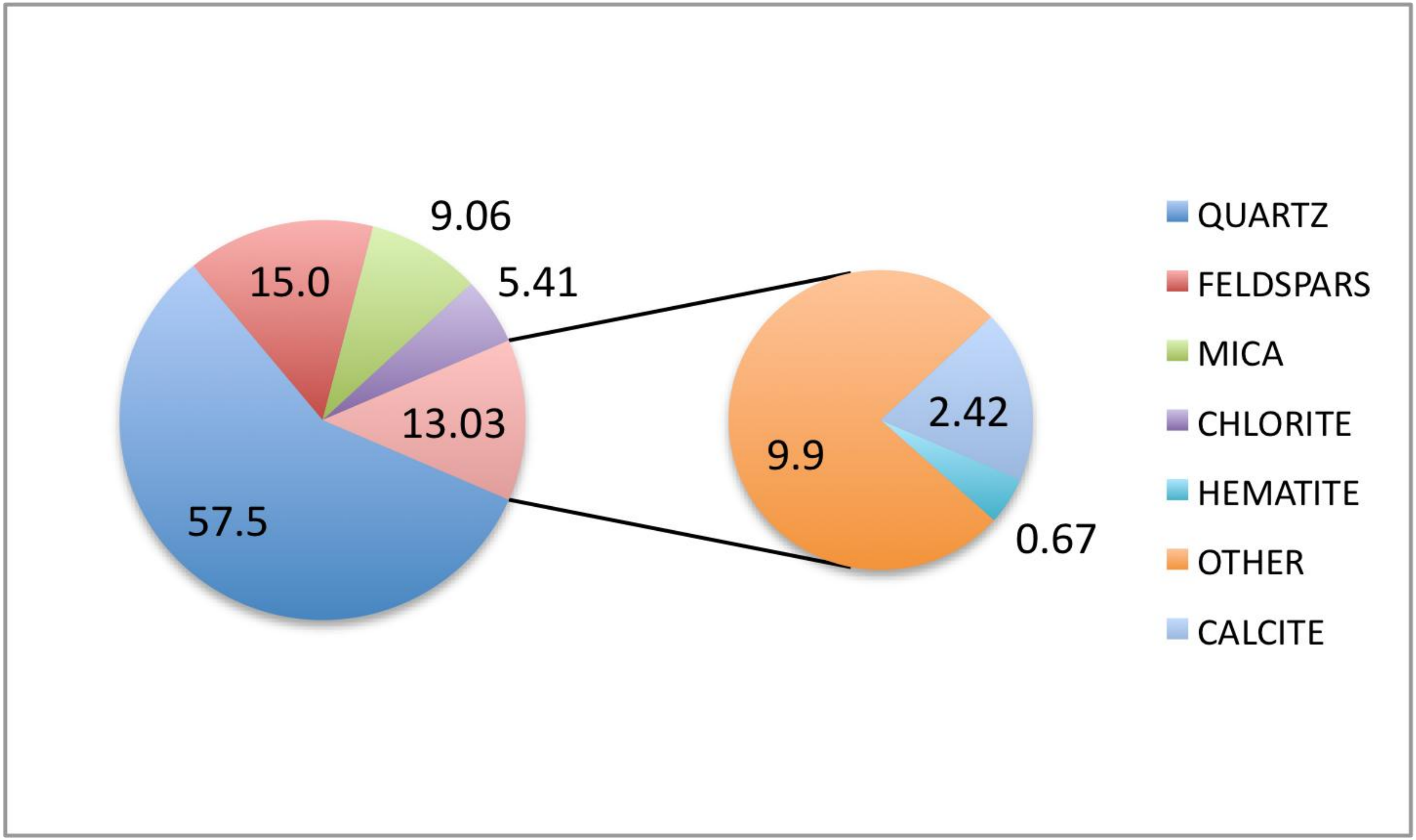
CASE 2: the average mineralogical composition of the major soil class to which they belong.

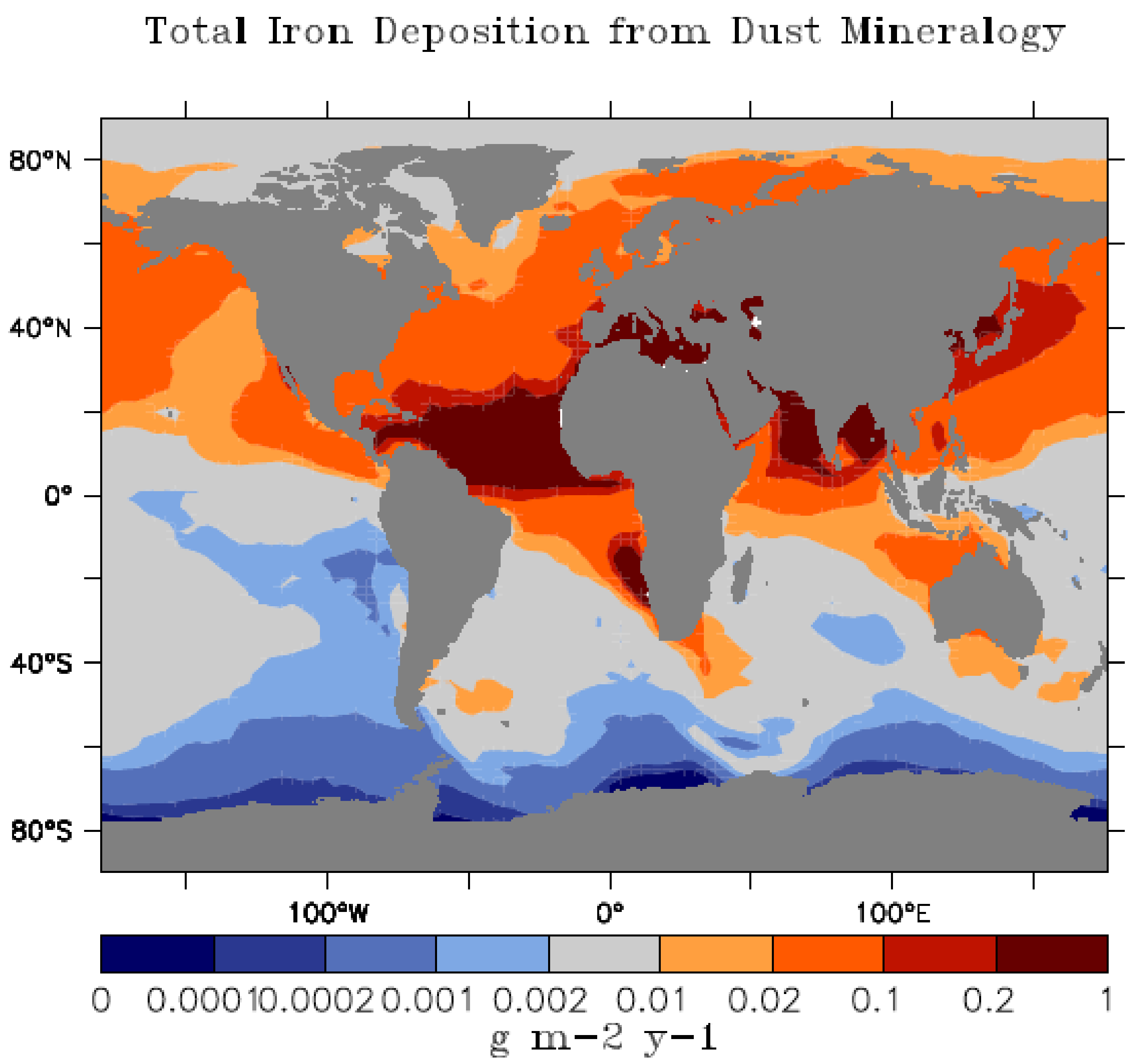
CASE 3: the mineralogical composition of the surrounding soils.

Global mean fraction (in mass) for the minerals, clay size (<2 microns)

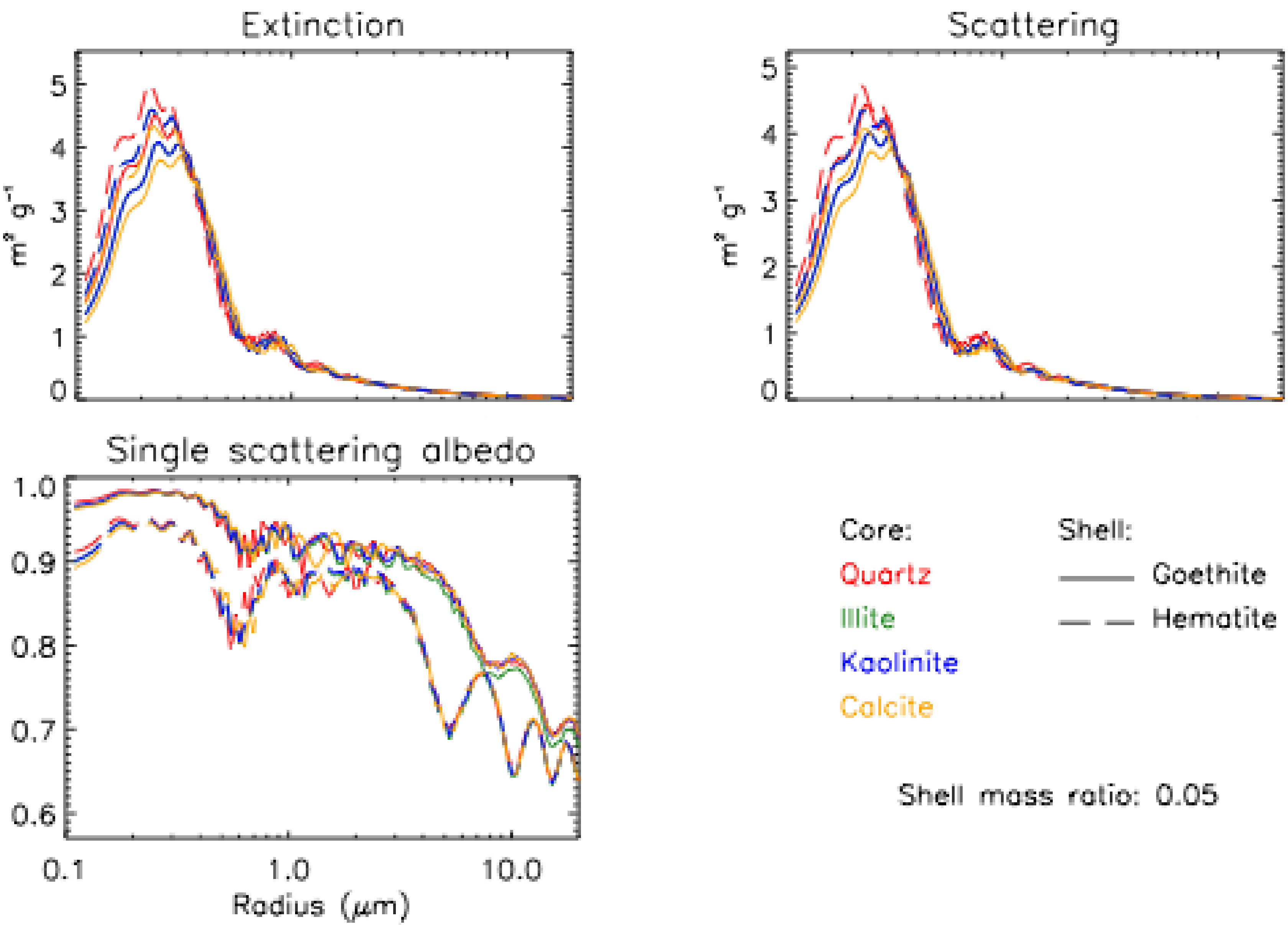


Global mean fraction (in mass) for the minerals, silt size (>2 microns)

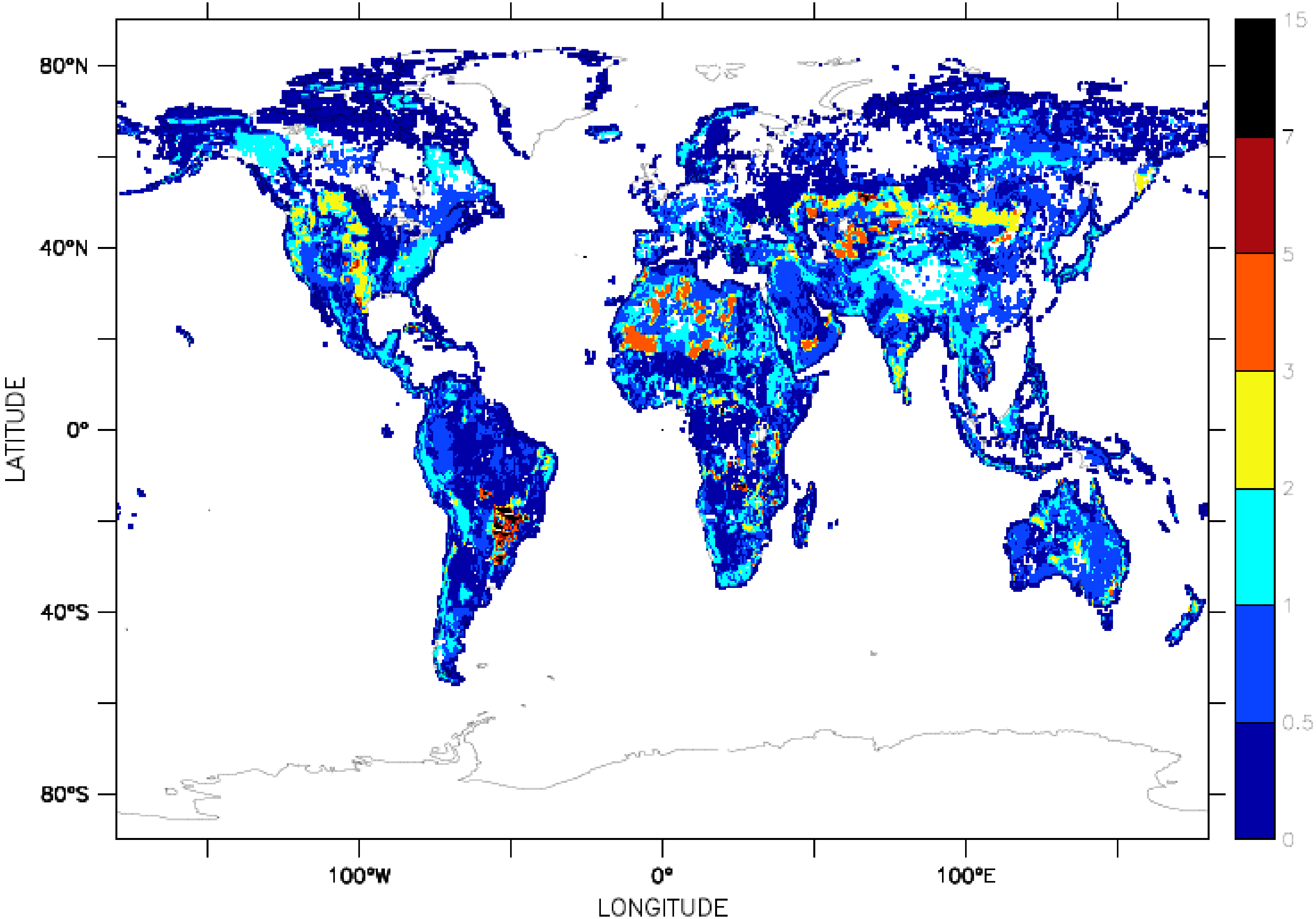



Total Iron Deposition from Dust Mineralogy
80°N
40°N
0°
40°S
80°S
100°W
0°
100°E
0
0.0001
0.0002
0.001
0.002
0.01
0.02
0.1
0.2
1
g m-2 y-1

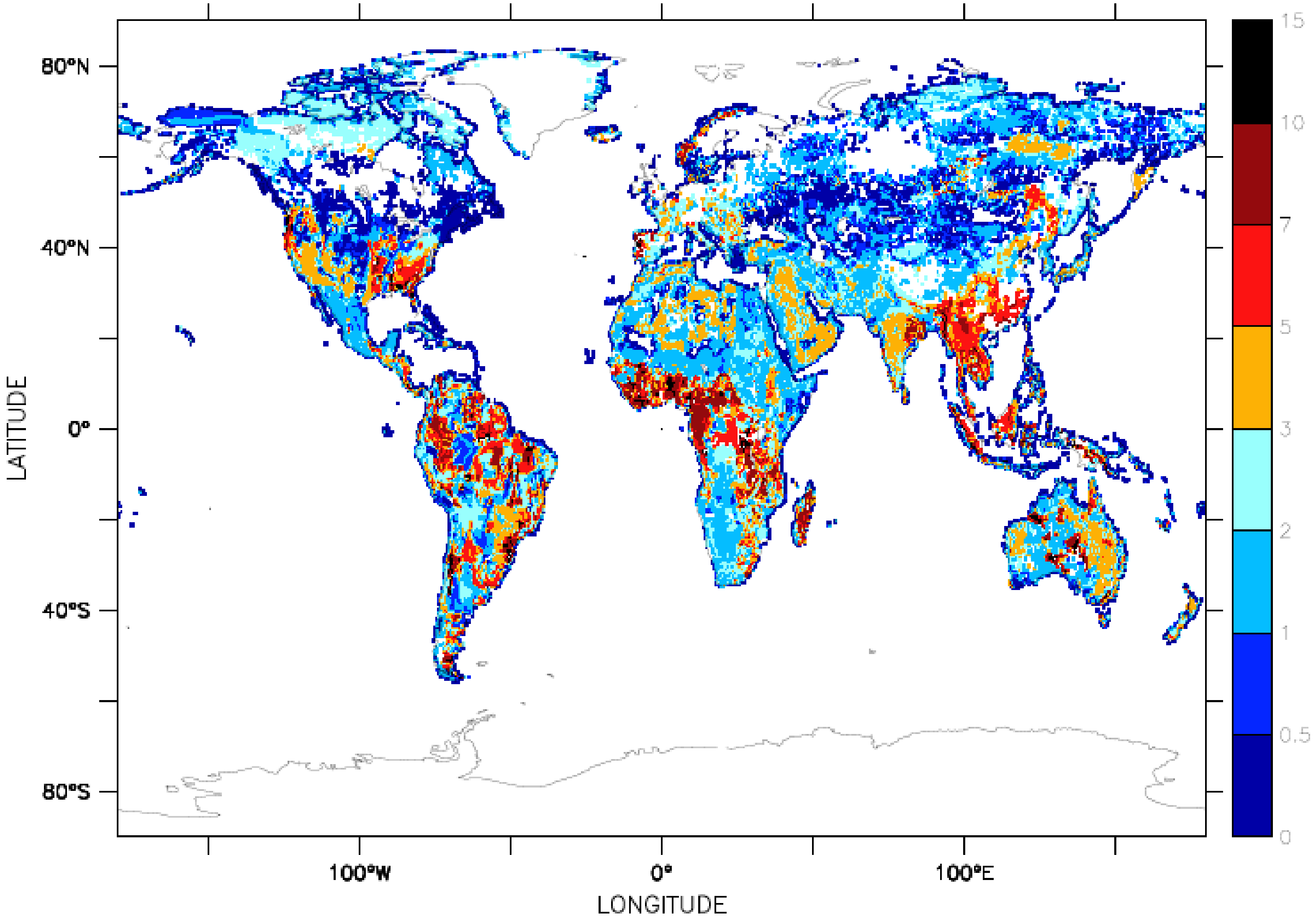
Optical properties of core-shell mixtures



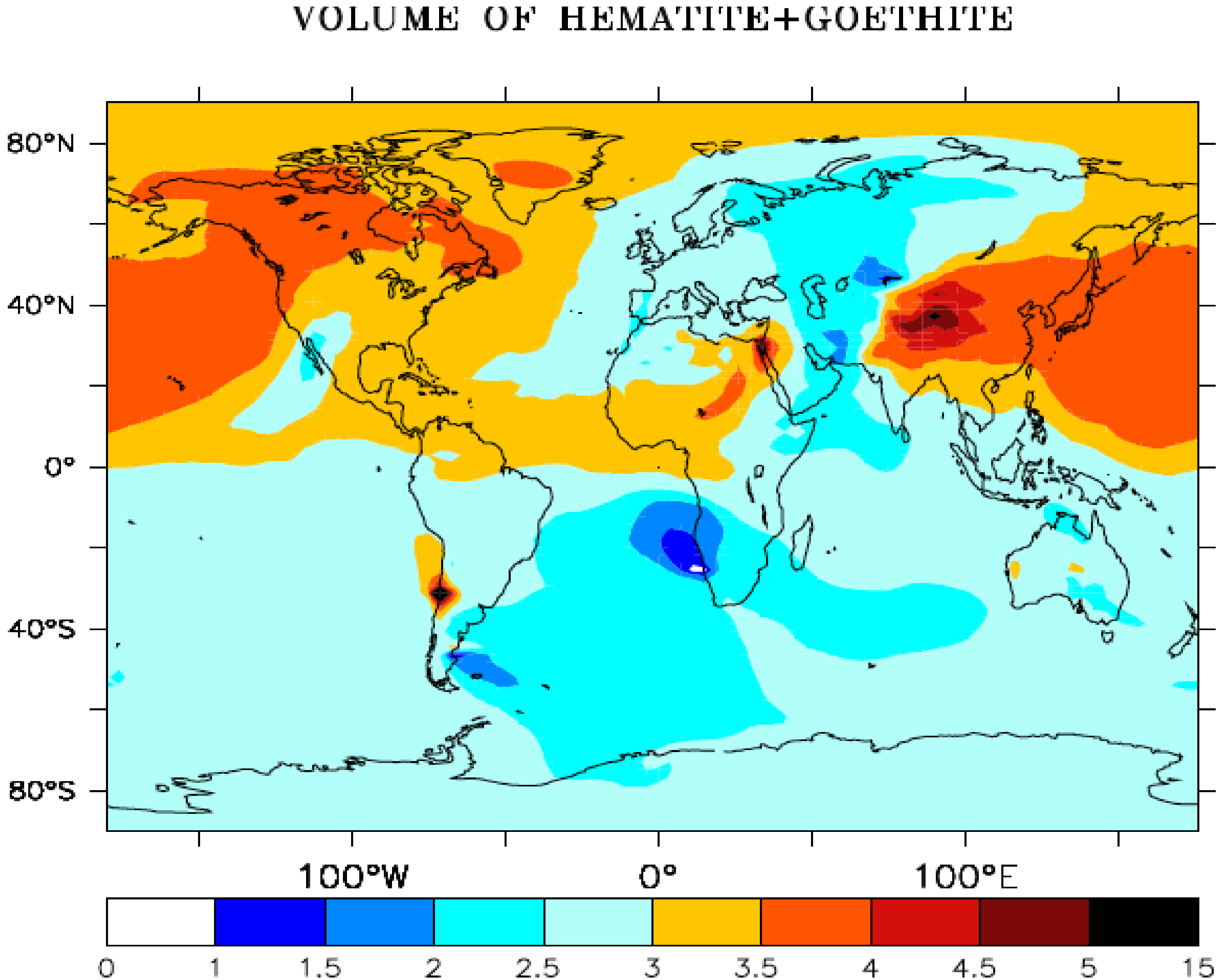
Hematite fraction (%)



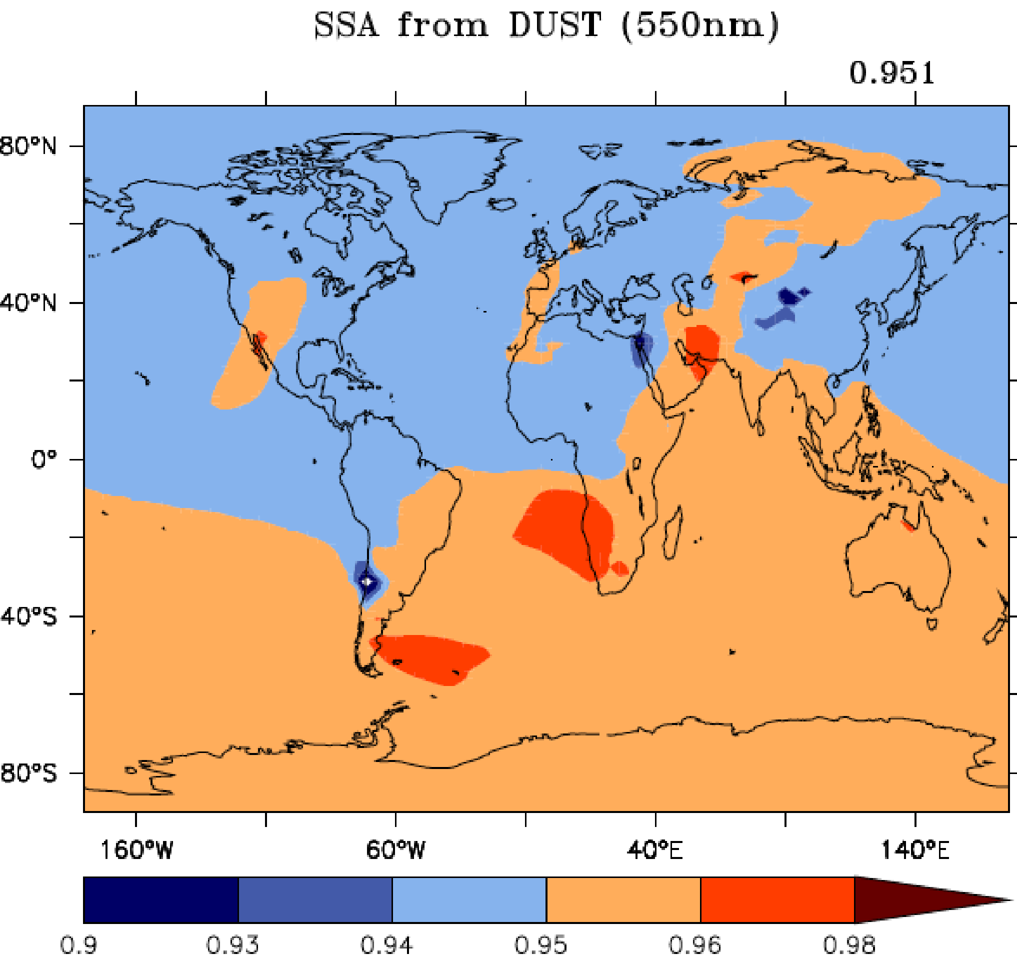
Goethite fraction (%) in soils

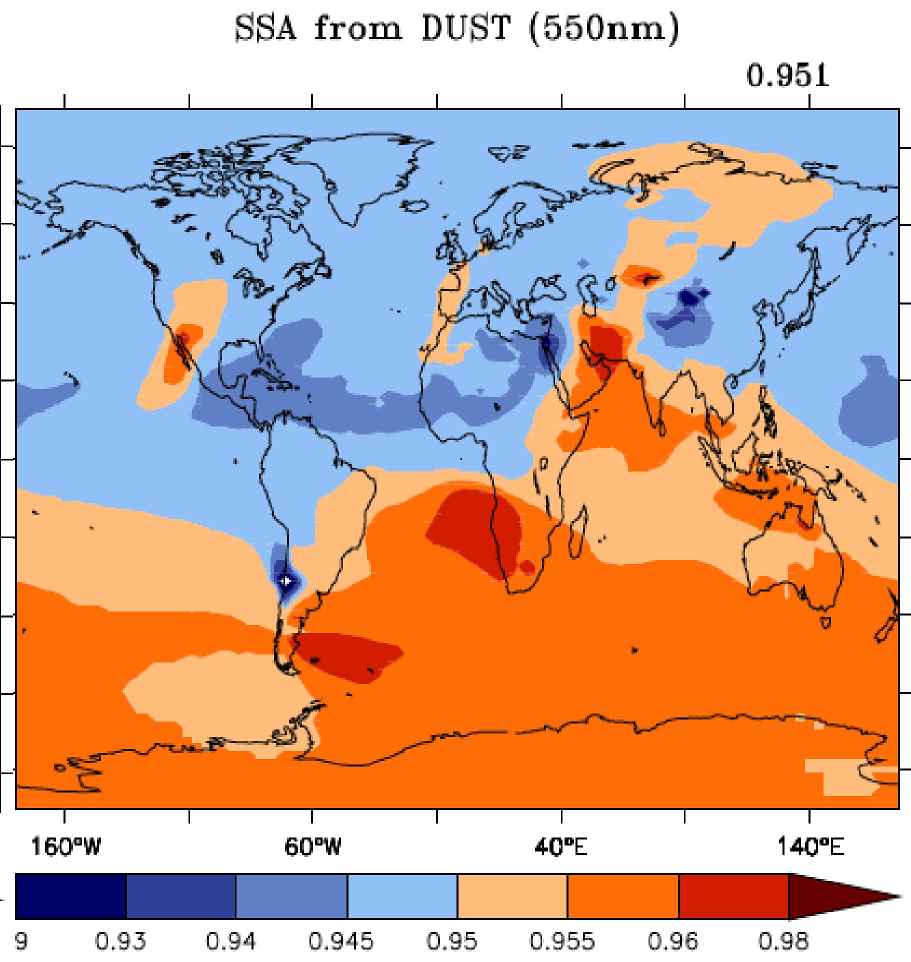


Airborne fraction (%) of hematite + goethite



Single scattering albedo computed from the relative ratios of hematite to goethite





Summary and remarks

We extented a mineralogical database accounting for more than 500 published mineralogical analysis from more than 120 sites around the world.

This new database permits to access new information since it has a global coverage:

-Separation between goethite and hematite

-Possibility to estimate sources of Paleo Dust

-Estimate both total iron and soluble iron

(*Journet, Balkanski, Harrison, in prep.*)

It will allow to address the role of mineralogy on the following questions:

- The radiative effect of dust
- The role of soluble iron inputs into the ocean
- How calcite can limit HNO3 uptake by dust