

Model estimates of atmospheric Al, Ca, Fe, Si and Ti concentrations and deposition using EMIT surface mineralogy and comparison to observations

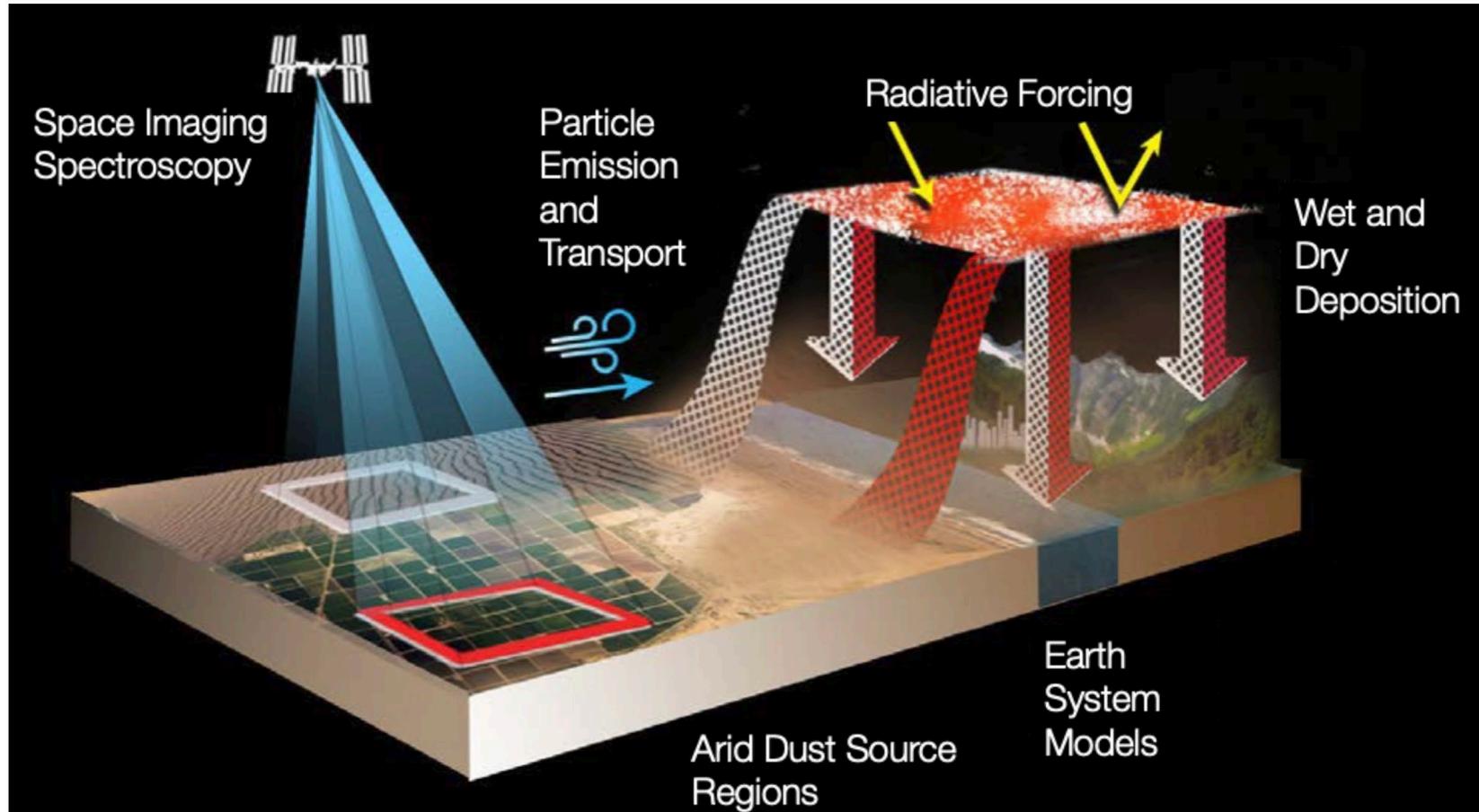
Natalie M. Mahowald^{1*}, Longlei Li¹, María Gonçalves Ageitos^{2,3}, Ronald L. Miller⁴, Carlos Pérez García-Pando^{2,5}, Paul Ginoux⁶, Vincenzo Obiso², Philip G. Brodrick⁷, Roger N. Clark⁸, Karine Desboeufs⁹, Robert O. Green⁷, Gregory Okin¹⁰, David R. Thompson⁷, Sagar Rathod¹¹, Esteban Gazel¹, Adrian Hornby¹, Emile Journet¹², Maria Grazia Alaimo¹³, Célia Alves¹⁴, Andres Alastuey¹⁵, Paulo Artaxo¹⁶, Alex R. Baker¹⁷, Francisco Barraza¹⁸, Silvia Becagli¹⁹, Clifton S. Buck²⁰, Giulia Calzolari²¹, Shankararaman Chellam²², Ying Chen²³, Patrick Y. Chuang²⁴, David D. Cohen²⁵, Cristina Colombi²⁶, Evangelia Diapouli²⁷, Gaetano Dongarra¹³, Konstantinos Eleftheriadis²⁷, Johann P. Engelbrecht²⁸, Corinne Galy-Lacaux²⁹, Cassandra Gaston³⁰, Dario Gomez³¹, Yenny González Ramos^{32,33}, Jenny Hand³⁴, Roy M. Harrison³⁵, Barak Herut^{36,37}, Philip K. Hopke^{38,39}, Zsafia Kertesz⁴⁰, Katriina Kyllönen⁴¹, Fabrice Lambert^{42,43}, Remi Losno⁴⁴, Franco Lucarelli^{21,45}, Willy Maenhaut⁴⁶, Christopher Marsay⁴⁷, Hitoshi Matsui⁴⁸, Randall V. Martin⁴⁹, Yasser Morera-Gómez⁵⁰, Adina Paytan⁵¹, Joseph Prospero³⁰, Sergio Rodríguez^{52,32}, Geraldine Sarthou⁵³, Rachel Shelley¹⁷, Ronald L. Siefert⁵⁴, Patricia Smichowski³¹, Daniela Varrica¹³

Submitted to GBC

Goal 1:

- Understand atmospheric cycling of biogeochemically important species: Al, Ca, Fe (done before), Si, Ti
- Al, Ca, Fe, Si, Ti are dominate elements in dust (with O)
- Oceans:
 - Fe: important as there are iron limited microorganisms. Studied previously.
 - Si: important for shell formation (e.g. diatoms)
 - Al: opal remineralization → linked to Si
 - Ca: lots of Ca in oceans already: important to links to CaCO_3
- Land and Atmosphere
 - Ca is important basic element to counteract acids
 - (Danny Leung's work here).

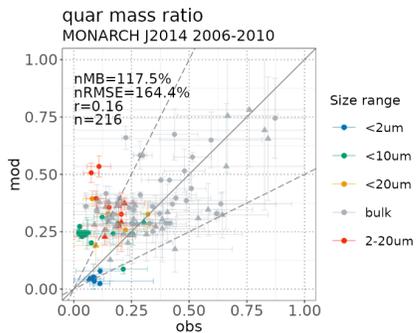
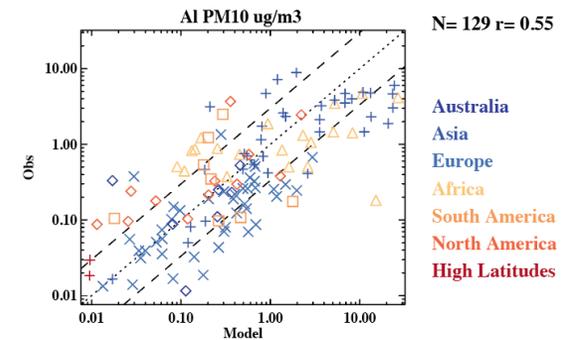
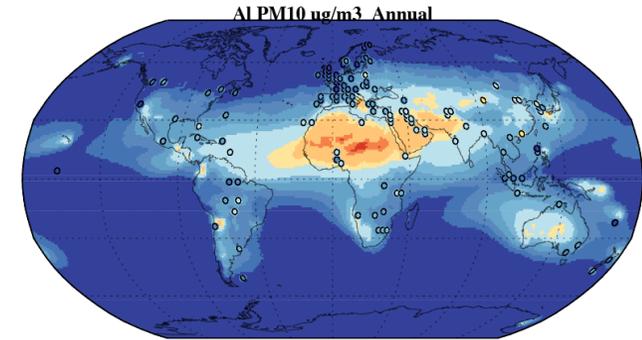
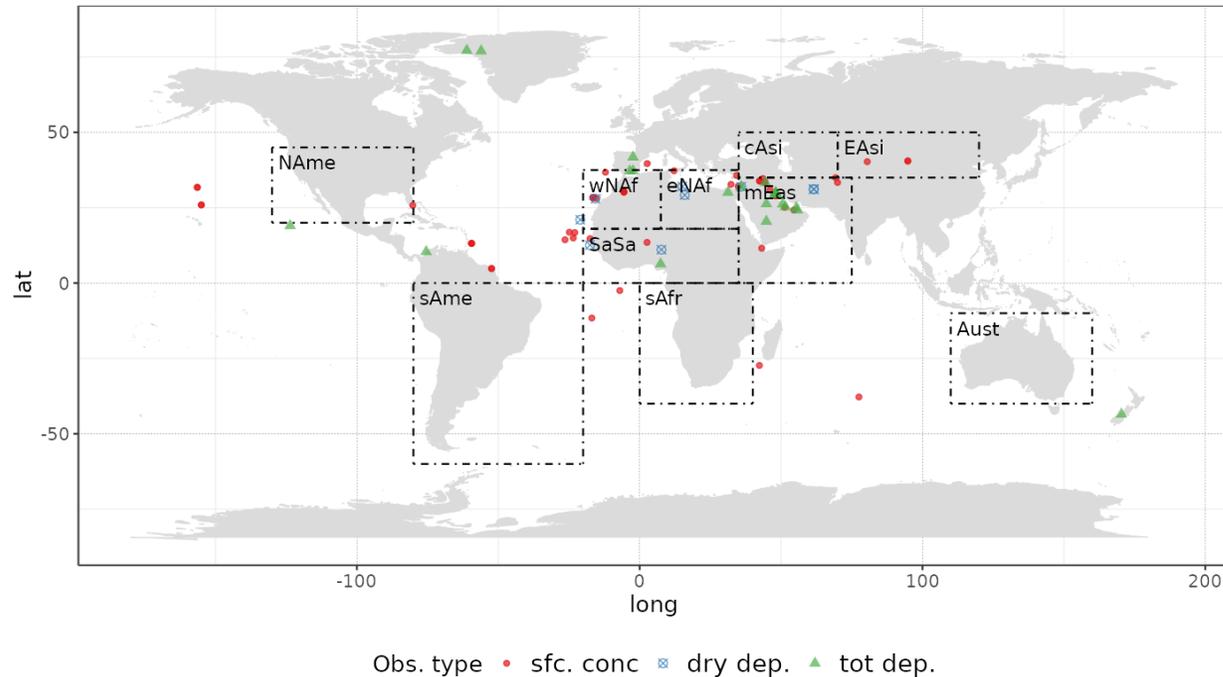
EMIT project: Earth surface mineral dust investigation: NASA Venture project



- Based on CESM simulations (Scanza et al., 2015): speciation of dust matters for radiative forcing
- Dust composition is important for RF
- Obtain info about dust composition from Imaging Spectrometer on Space station
- Input into models to calculate mineral compositions
- Models include 8 minerals from EMIT instead of one dust tracer.

Goal 2: Evaluate EMIT

More elemental data than mineralogy data



Individual measurements compiled in Perlwitz et al., 2015
(images courtesy of Maria Gonçalves Ageitos)

Annual mean concentrations
(compiled here, also in Mahowald et al., 2024)

How do we go from Minerals to elements?

Table S1. Mass percentage elemental composition of minerals in desert dust based on the measurement and compilations from (Menut et al., 2020).

Mineral	Al	Ca	Fe	Si	Ti
Calcite	0	40	0	0	0
Feldspar	10.96	3.84	0.34	25.24	0.04
Goethite	0.55	0.02	62.90	0.89	0.01
Gypsum	0	23.3	0	0	0
Hematite	2.67	0.12	57.48	2.11	0.22
<u>Illite</u>	10.47	1.45	4.01	24.11	0.52
Kaolinite	20.42	0.03	0.24	20.27	1.00
Quartz	0	0	0	46.7	0
Smectite	8.57	0.91	2.55	27.44	0.07
Vermiculite	6.84	0.98	6.7	16.09	0.65

Pro: more data than minerals

Con: not a 1:1 relationship

Only can use in dust dominated regions

Include not just dust sources, but other

- Add in literature search of other sources
- Based on Fe database:
 - Mining/Smelting
 - Industrial combustion
- Wildfires
- Volcanic (important for many)
- Etc.

Fe: iron oxides and illite

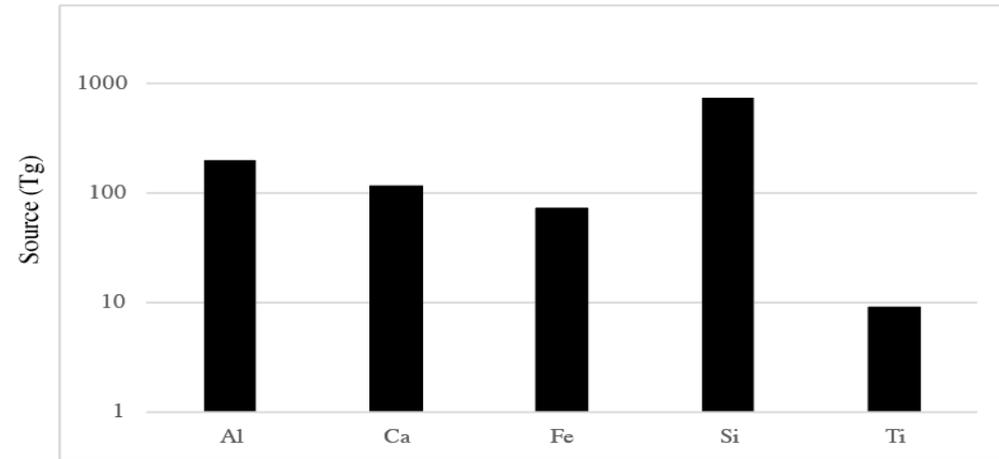
Al: Illite, Kaolinite, Feldspar

Ca: Calcite, Gypsum, Feldspar

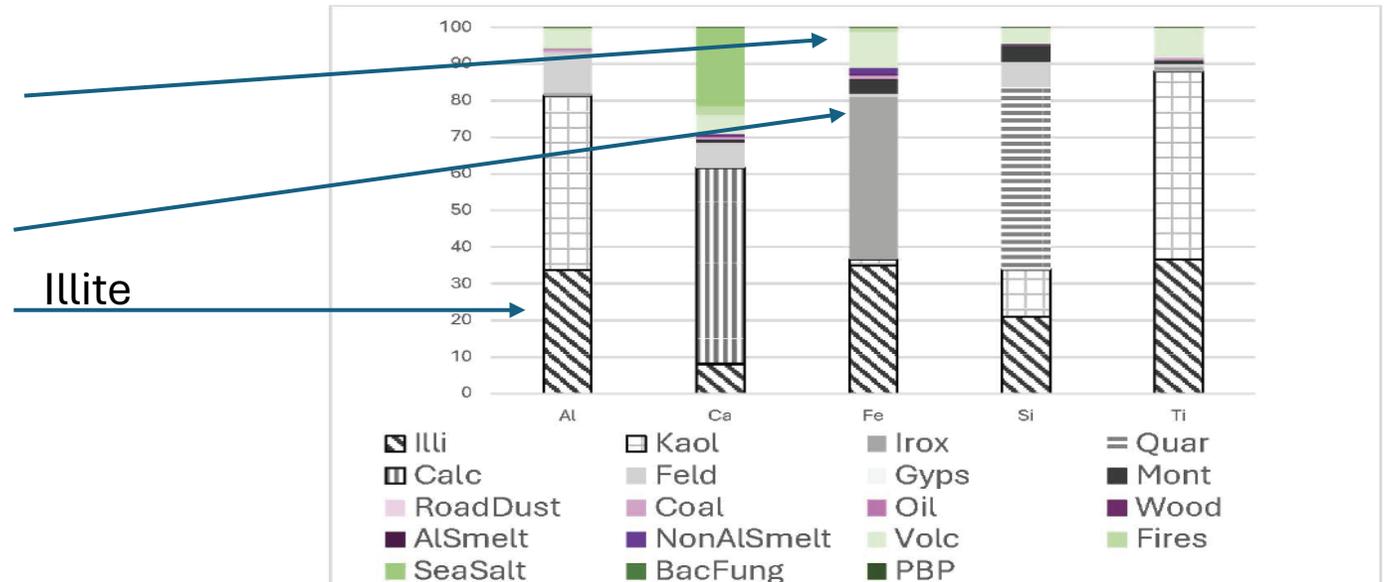
Si: quartz

Ti: Kaolinite, Illite..

a. Budgets



b. Percentage Contribution

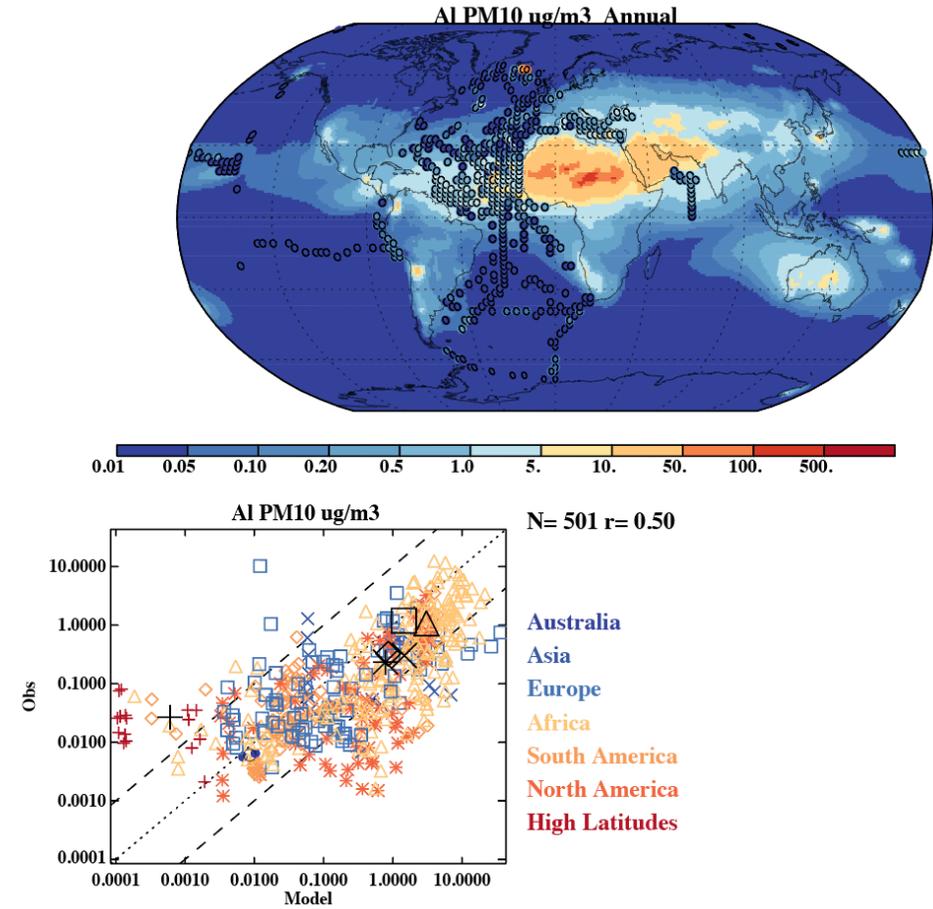
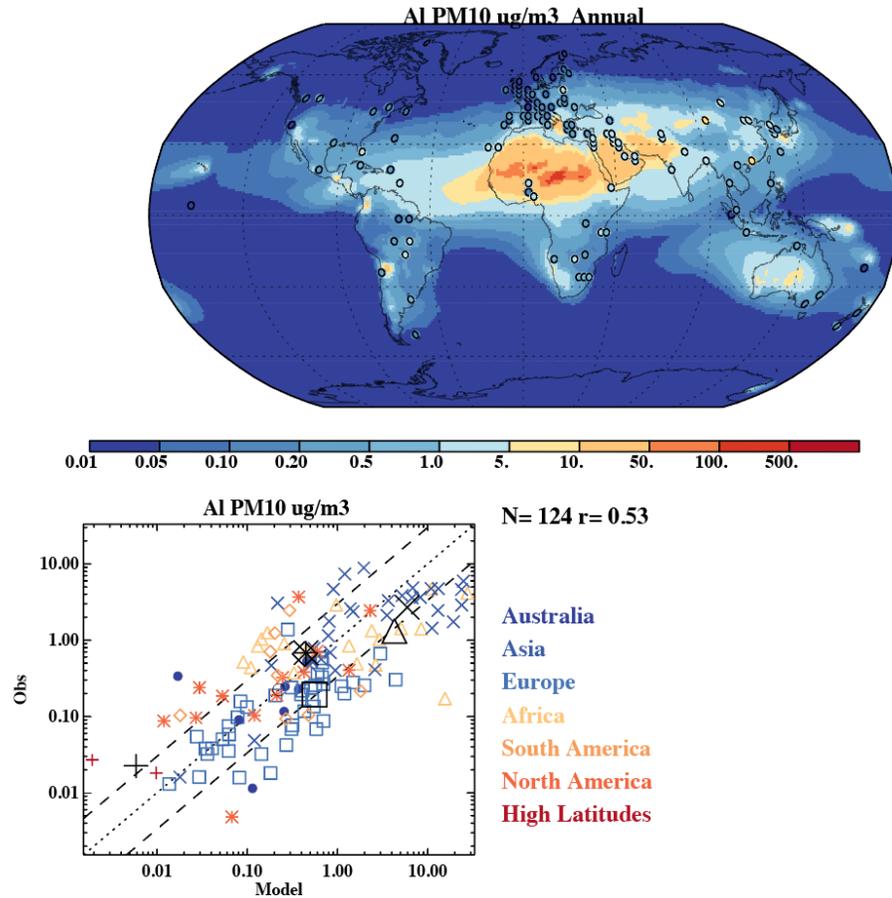


Iron oxides

Illite

AI PM10

- Do ok job simulating
- But not great...

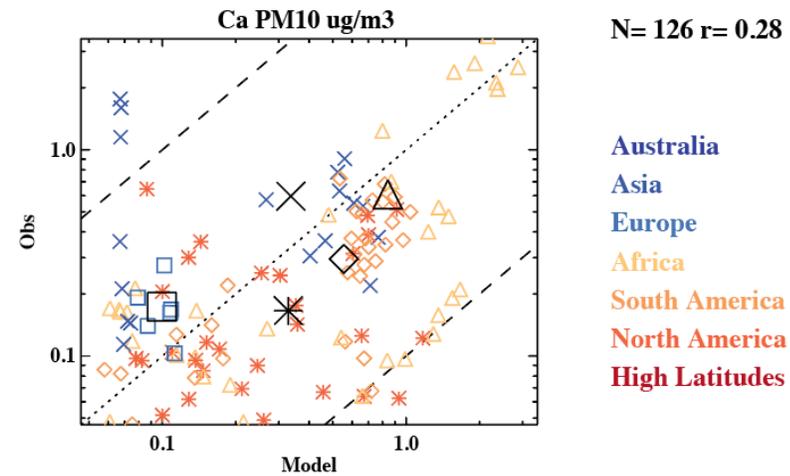
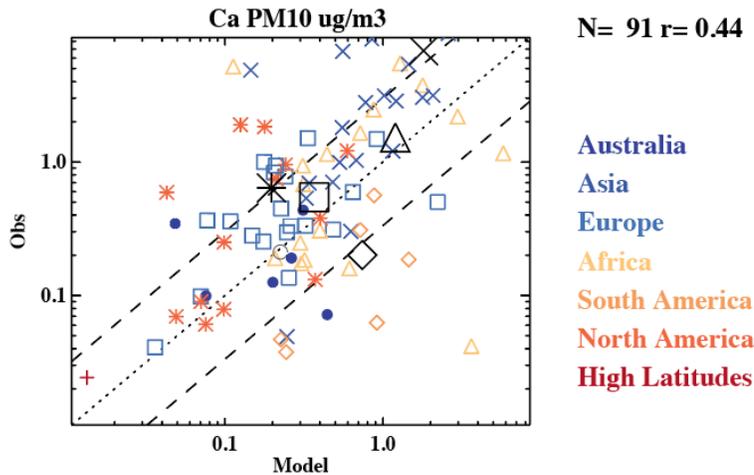
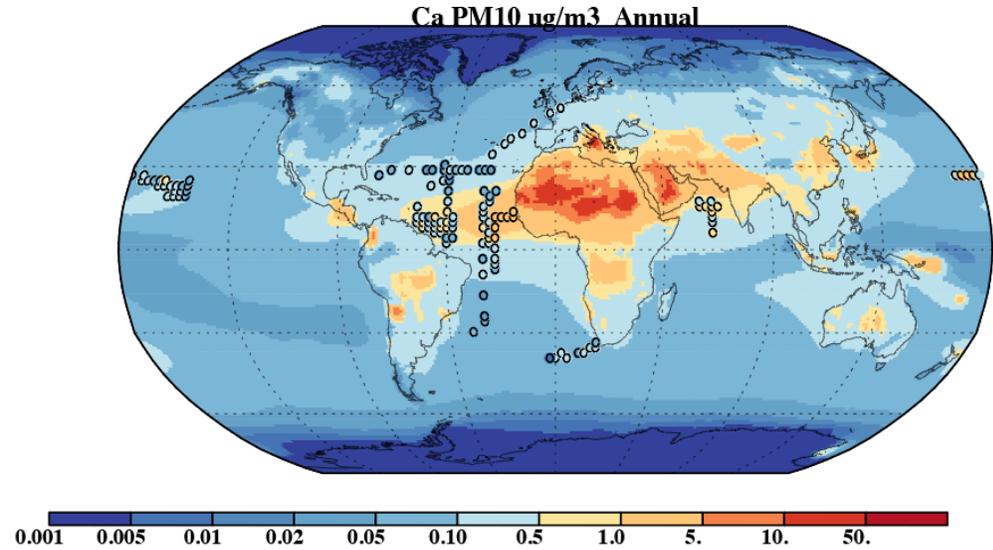
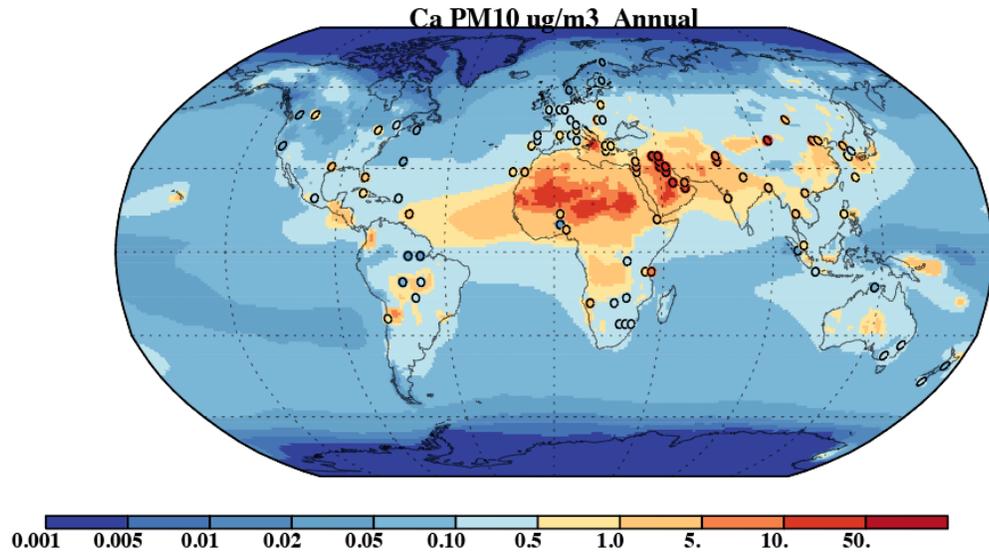


Station data: climatological averages

Cruise data: individual measurements

Ca PM10

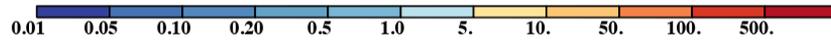
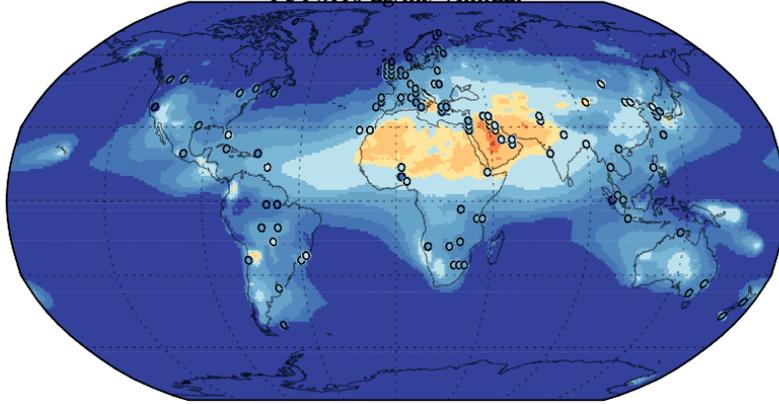
Again, ok, in the right range, but not great.



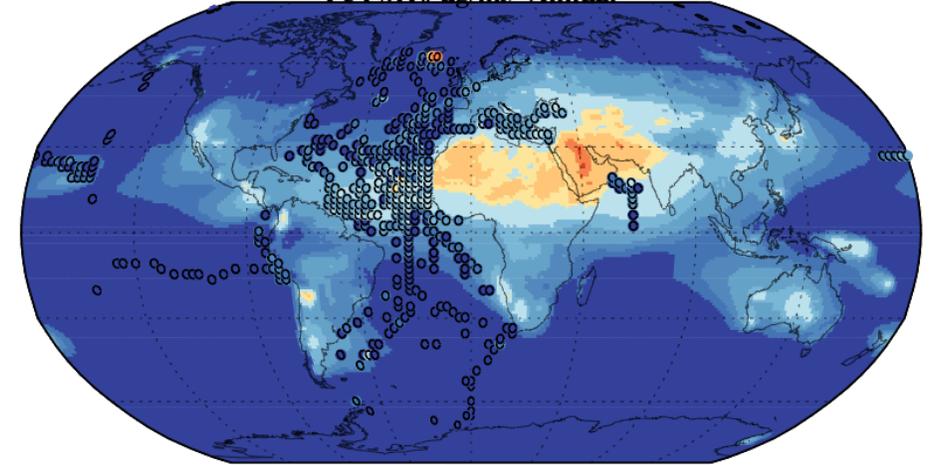
Fe PM10

We do better for Fe: we've been doing it longer
Better emission datasets

Fe PM10 ug/m3 Annual

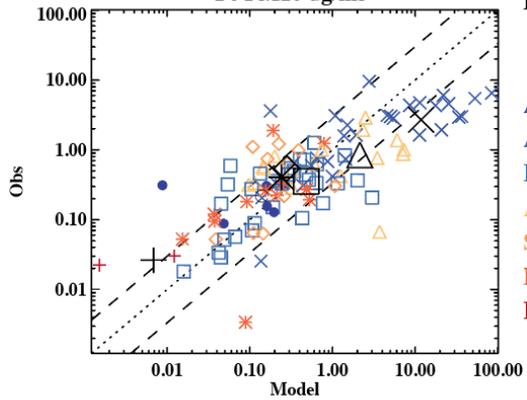


Fe PM10 ug/m3 Annual



Fe PM10 ug/m3

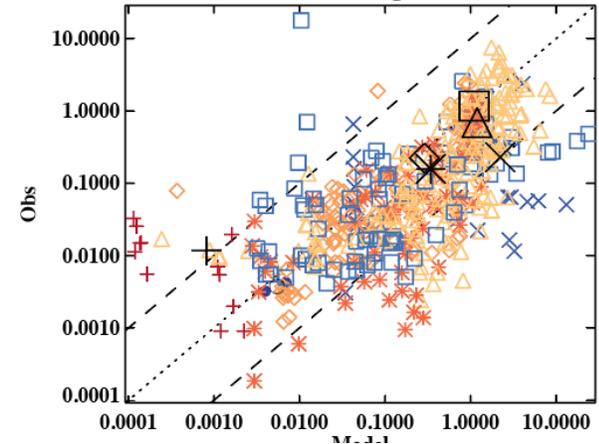
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Australia
Asia
Europe
Africa
South America
North America
High Latitudes

Fe PM10 ug/m3

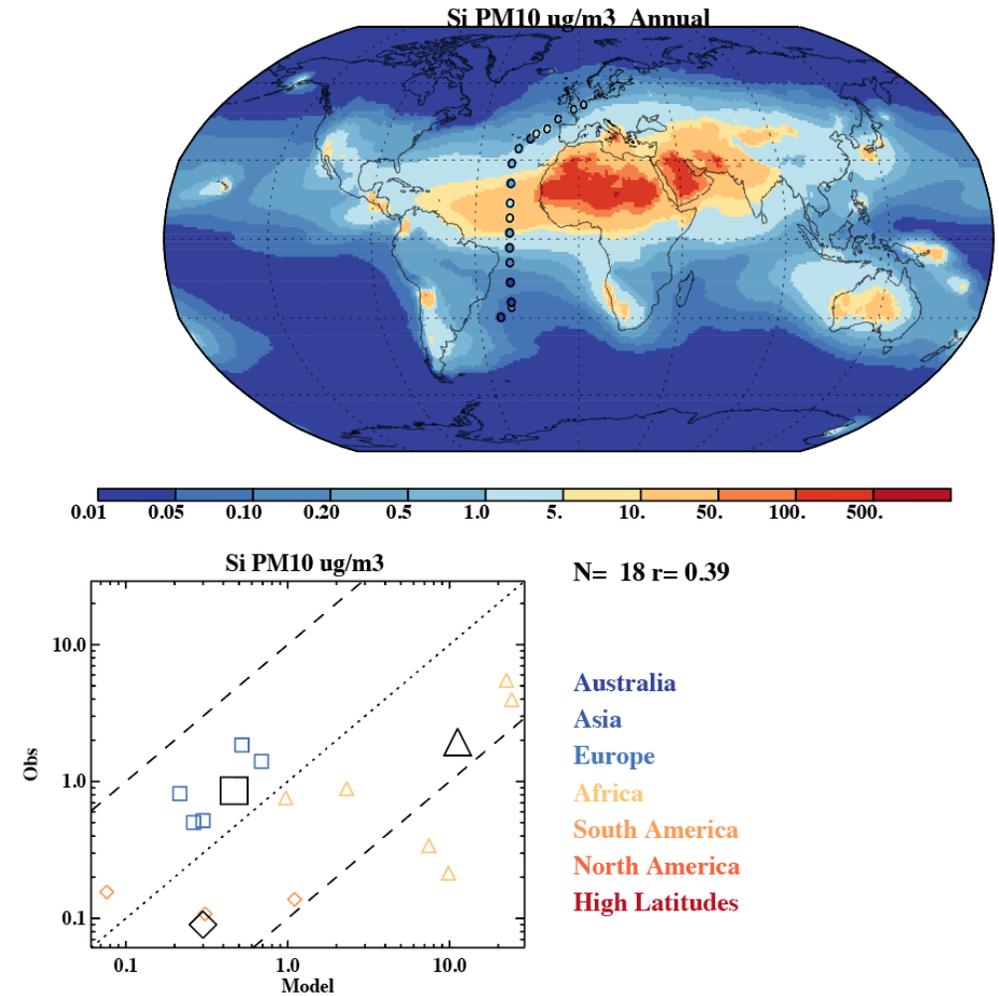
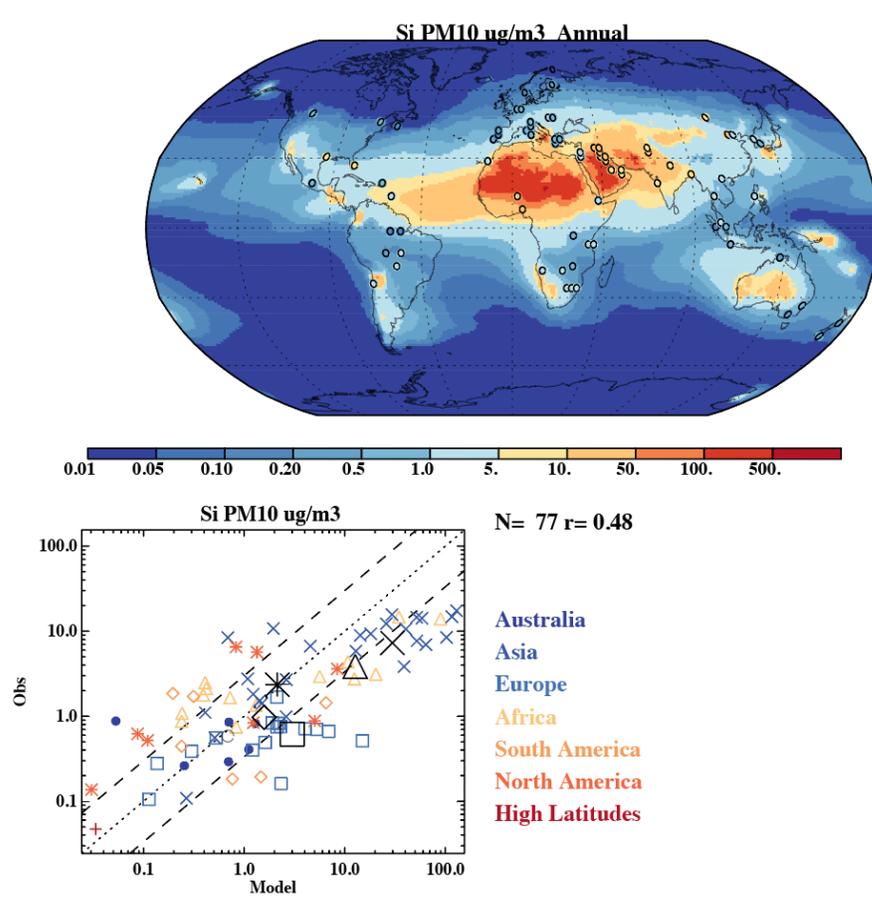
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Australia
Asia
Europe
Africa
South America
North America
High Latitudes

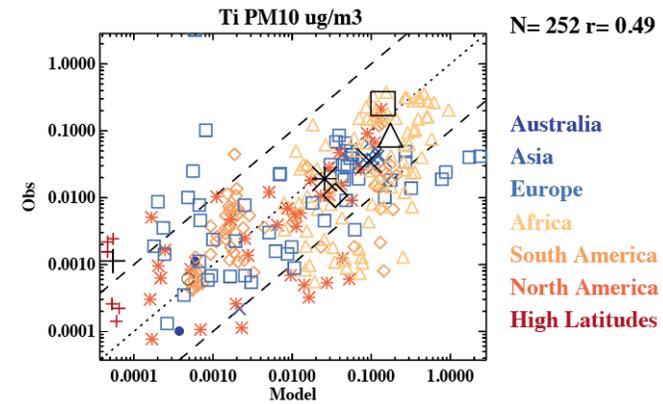
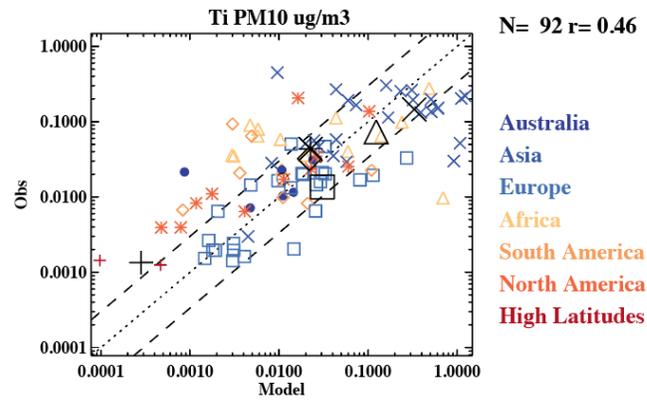
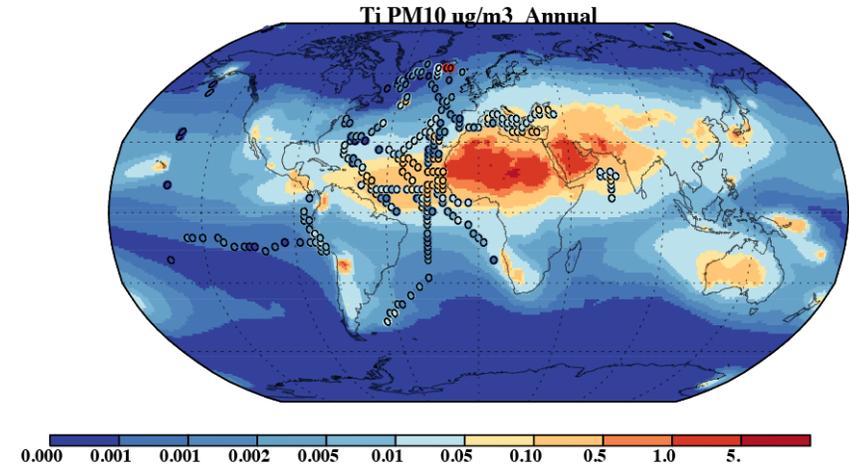
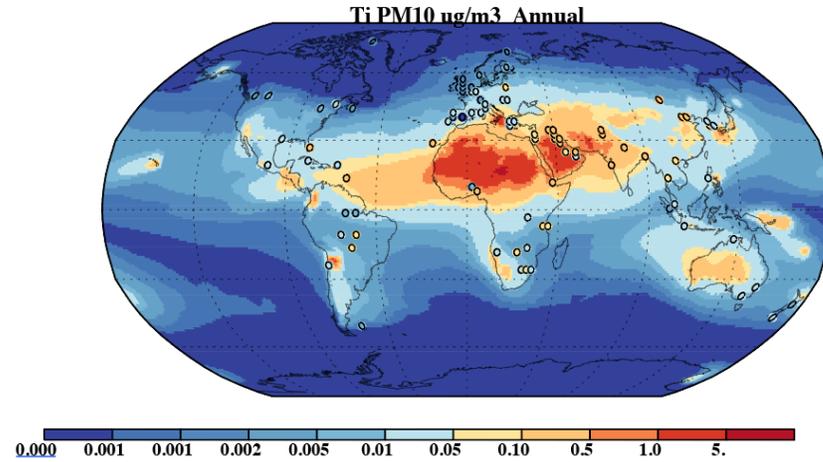
Si PM10

Not much Si data, especially cruises



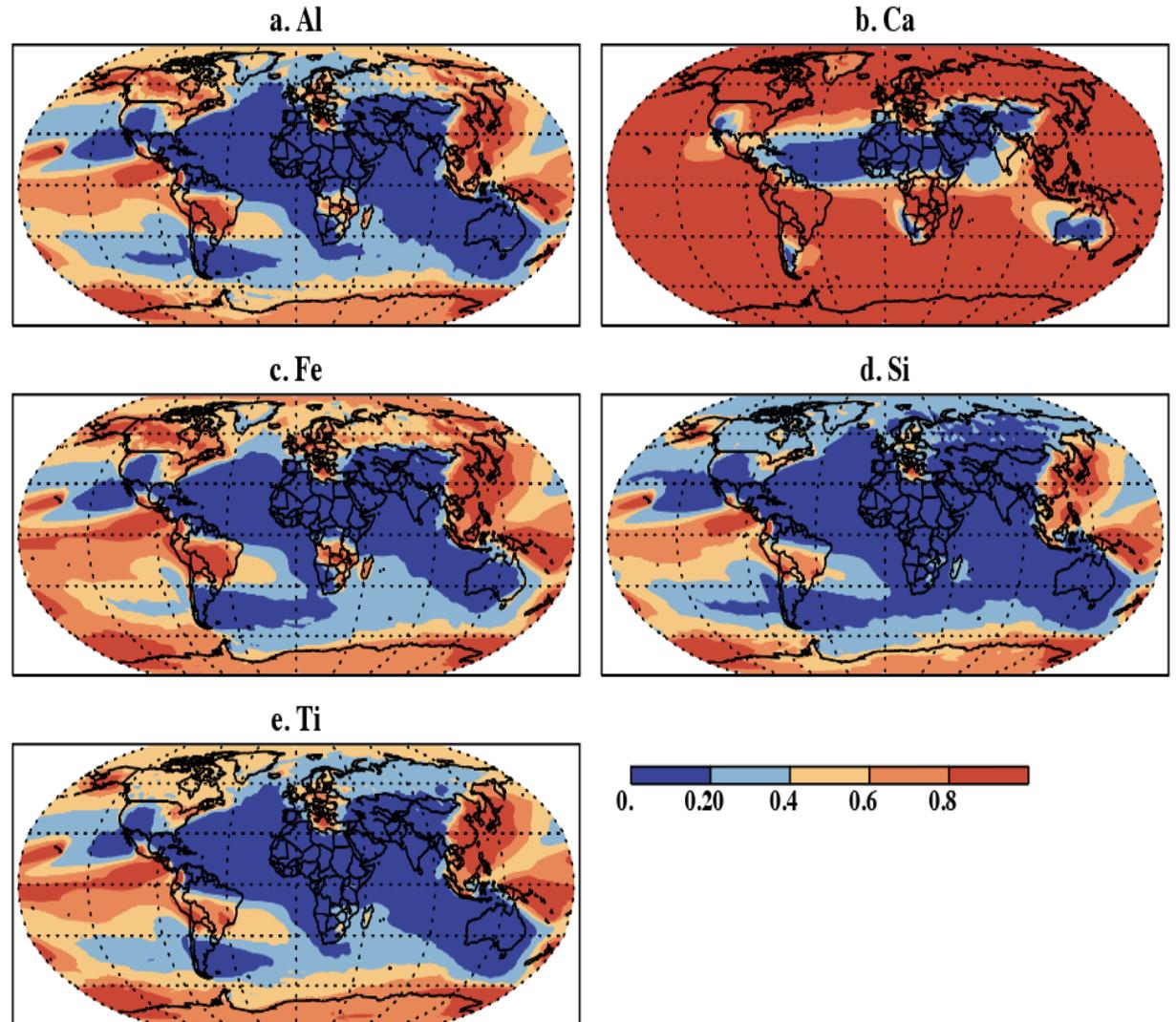
Ti PM10

Some ability, but little data.



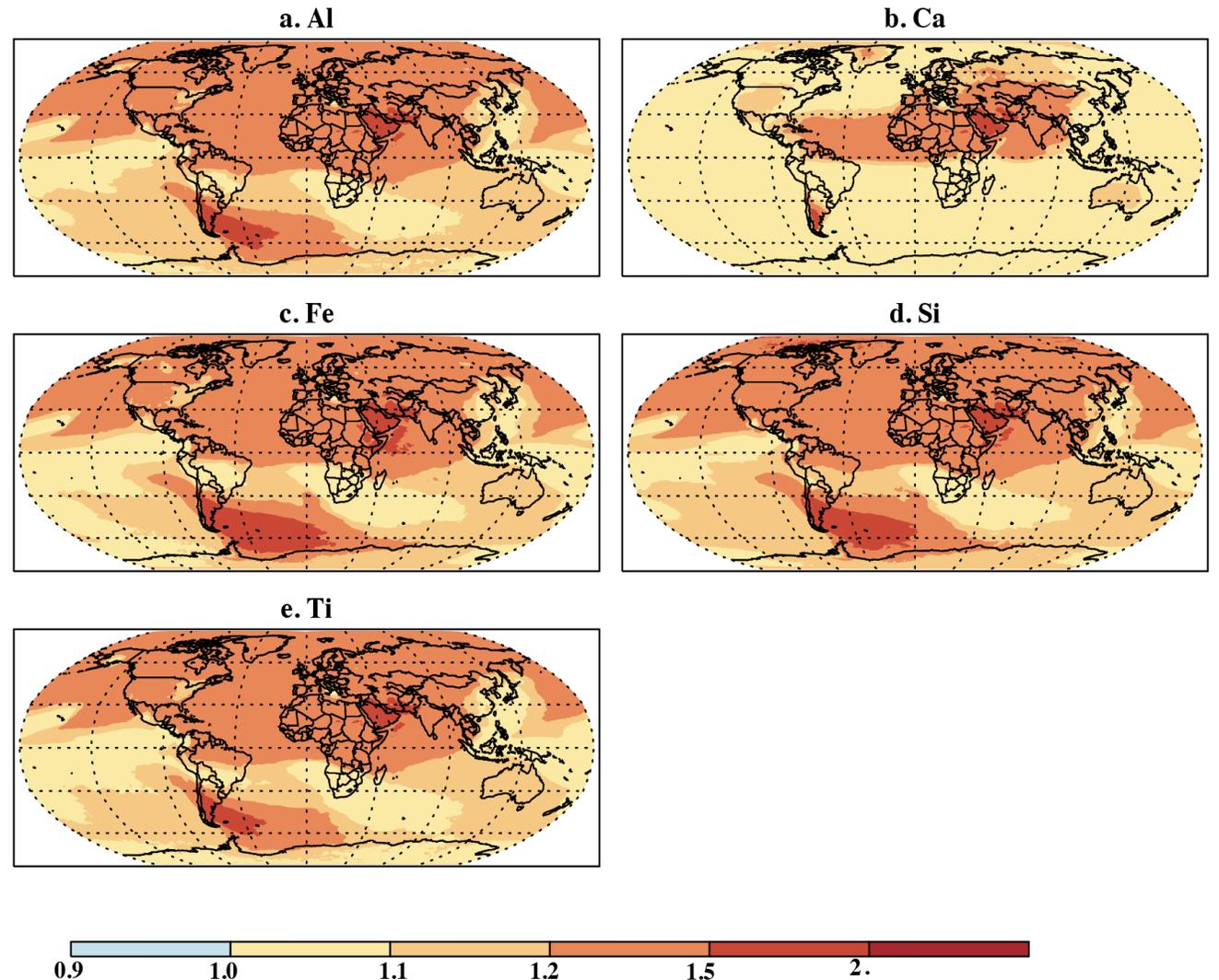
Non dust fraction

- Differs by element: Ca has largest area, Fe smallest area
- Cannot use these elements as proxies for dust in non-dust dominated regions
- We needed to do all the sources to estimate where we can use these elements for dust.



Dep ratios PD/PI

- Using Kok et al., 2023, for 55% dust increase since PI
- Dust dominated minerals show 50% increase....
- Ca has lowest increase (natural sources with no data to indicate change are important)
- Most of Northern Hemisphere shows large increase



Elemental distributions

- First estimates of Al, Ca, Si and Ti from non-dust sources
 - Tells us where these elements can be used as proxy for dust, and where not.
 - Can be improved. (we are working on volcanoes: see Lily Wu's talk)
- New distributions and deposition
 - Deposition could be important for ocean and land biogeochemistry
 - Increased deposition of these minerals since preindustrial due to dust and anthropogenic increases.
- Can provide limited information about EMIT:
 - Can we hard to interpret as one mineral, but we will test more rigorous in upcoming paper