Modeling Atmospheric Dust and Iron/Phosphorous Fluxes

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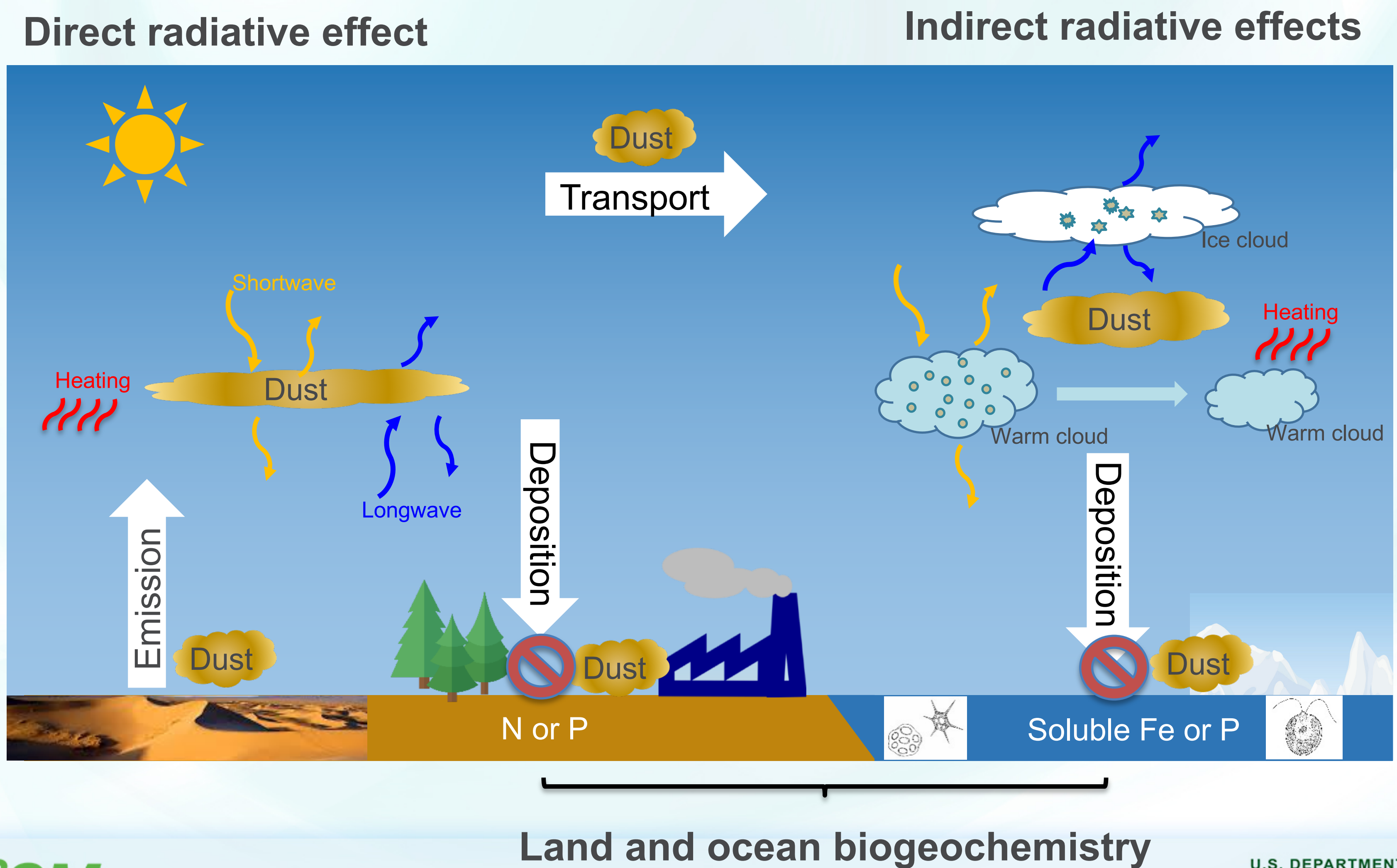
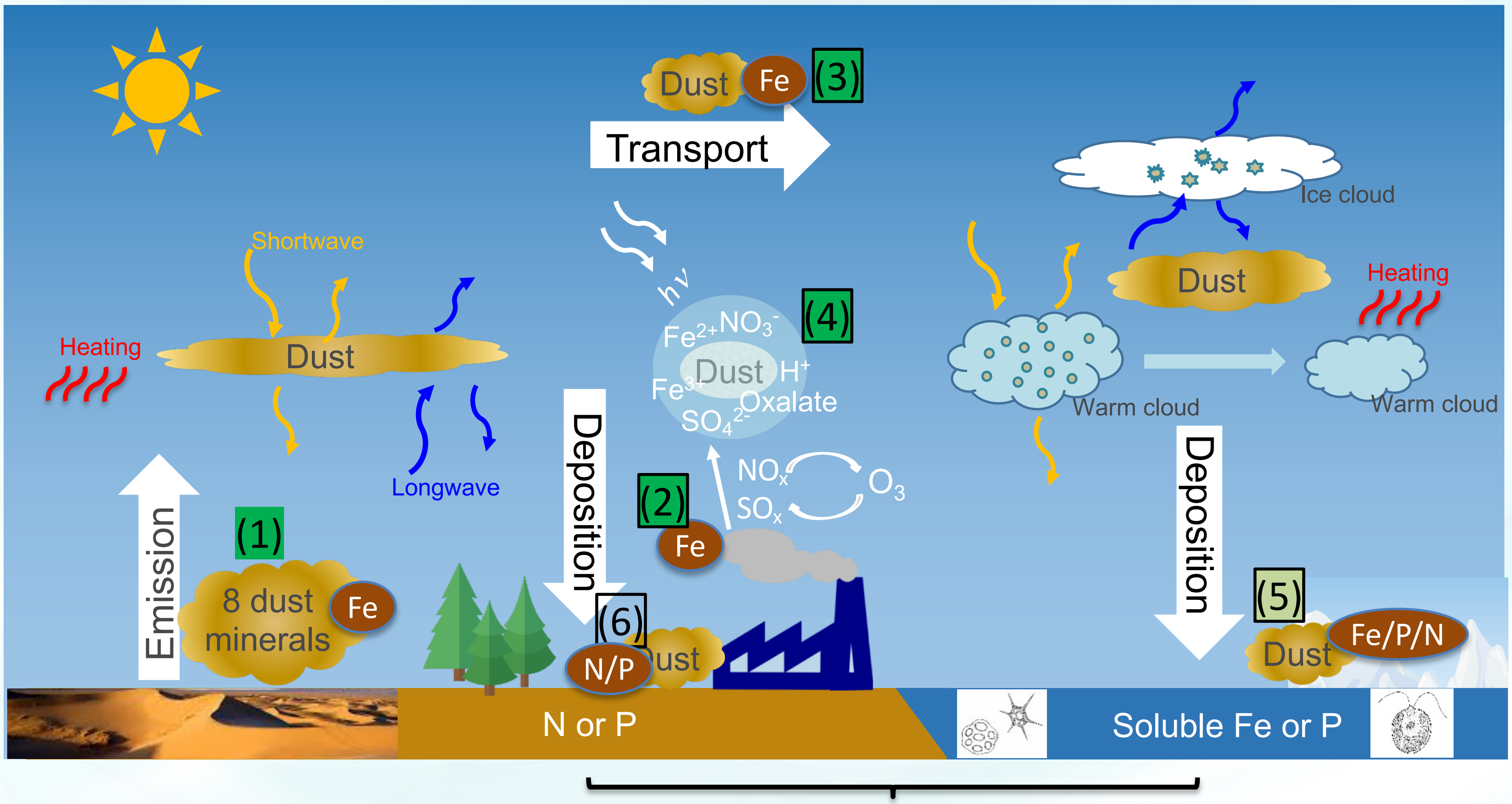
- Objectives
  - Improve dust emission and radiative properties (Water Cycle)
  - Incorporate treatments for dust and combustion iron/phosphorous dissolution (BGC nutrient cycle)
  - Coordinated with the university-funded project (PI – Mahowald/Cornell Univ) for the development of dust and combustion iron/phosphorous dissolution models

- Dust and Fe/P/N nutrients in the V1 atmospheric model



- Dust and Fe/P/N nutrients in the V2/V3 atmospheric model

Direct radiative effect | **Iron dissolution chemistry** | **Indirect radiative effects**



Land and ocean biogeochemistry

Highlight of the Progress

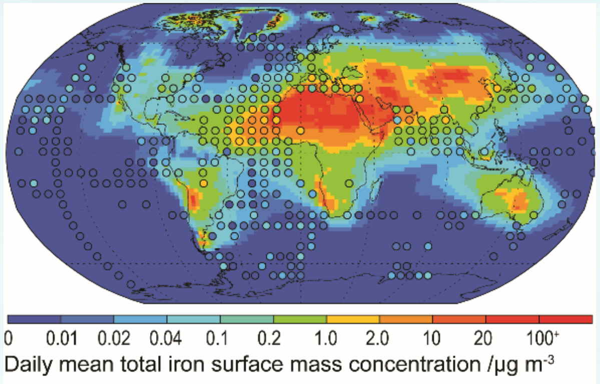
- *Fe dissolution model - Mechanism of Intermediate complexity for Modelling Iron (MIMI) – has been evaluated with CAM5 by Cornell Univ. (Hamilton et al. 2019)*

MIMI
8 dust mineral tracers 6 Fe tracers
Time-varying Fe sources: (1) dust emission scheme on time-varying soil states (2) Combustion Fe sources (3) Wildfire Fe sources
Detail dissolution chemistry (1) Proton-promoted dis. (2) In-cloud oxalate-induced Fe dis.

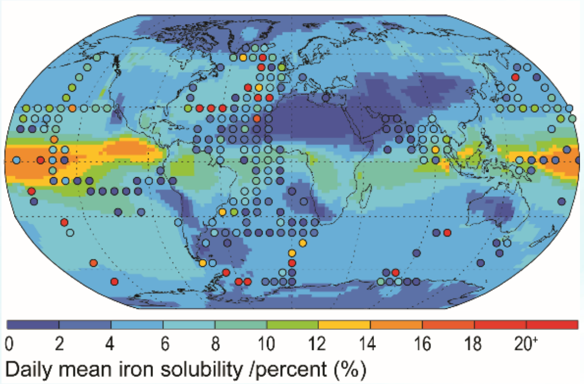
Annual mean emissions /Tg a^{-1}

	BAM-Fe	MIMI	Luo et al. (2008)	Multi model
Dust	1800	3100	1600	1200-5100
Dust iron	57	126	55	38-134
Fire&Comb. iron	1.9	5.5	1.7	1.8-2.7

Total Fe concentration



Fe solubility (%)



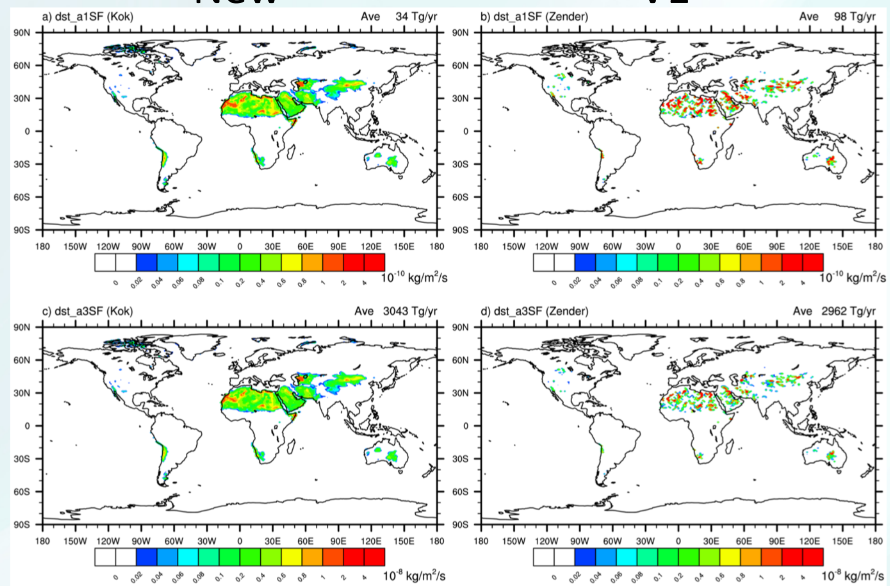
- Publications
- Hamilton, D.S., Scanza, R.S., Guinness, J., Kok, J., Longlei, L., Mingxuan, W., Rathod, S., Wan, J.S.1, Xiaohong, L., Feng, Y. and Mahowald, N.M., Improved methodologies for Earth system modelling of atmospheric soluble iron and observation comparisons, *to be submitted*, 2019.

Improved Dust Emission for V2

Dust emission flux $\phi_d = C_{tune} \cancel{S} F_d$

	V1		New
Soil erodibility	S	Empirical map (lat, lon)	Calculated in F_d
Flux per eroding area per time	F_d	Depends on soil threshold velocity	F_d Strongly depends on soil threshold velocity (soil moisture; aggregation)
Climate regime	Current		Sensitive to predicted soil state
High-lat dust	little		Comparable to recent obs

New V1



Feature	What improvement for V2 (status)	Readiness
New emission scheme (Kok et al., 2014)	• Time-varying soil erodibility (testing)-> dust aerosol climate sensitivity • High-latitude dust -> Arctic IN source • Enhanced climate-dust feedback in coupled runs (unknown)	3-6 months

E3SM Energy Exascale Earth System Model

U.S. DEPARTMENT OF ENERGY

Milestones (past achievements and future plan for V2)

- Oct. – Dec. 2018:

Evaluate dust seasonal cycle and vertical profiles

- Jan.- Mar. 2019:

Implement the dust new emission and speciation codes

- Apr. – Jun. 2019:

Evaluate the new dust emission scheme and speciation

- Jul. - Sept. 2019:

Implement the dust and combustion iron dissolution model

- Oct. – Dec. 2019:

Test the dust and combustion iron dissolution model