*Progress Report*

# Trans-Atlantic Dust Deposition (TADD)


Hongbin Yu, NASA Goddard Space Flight Center

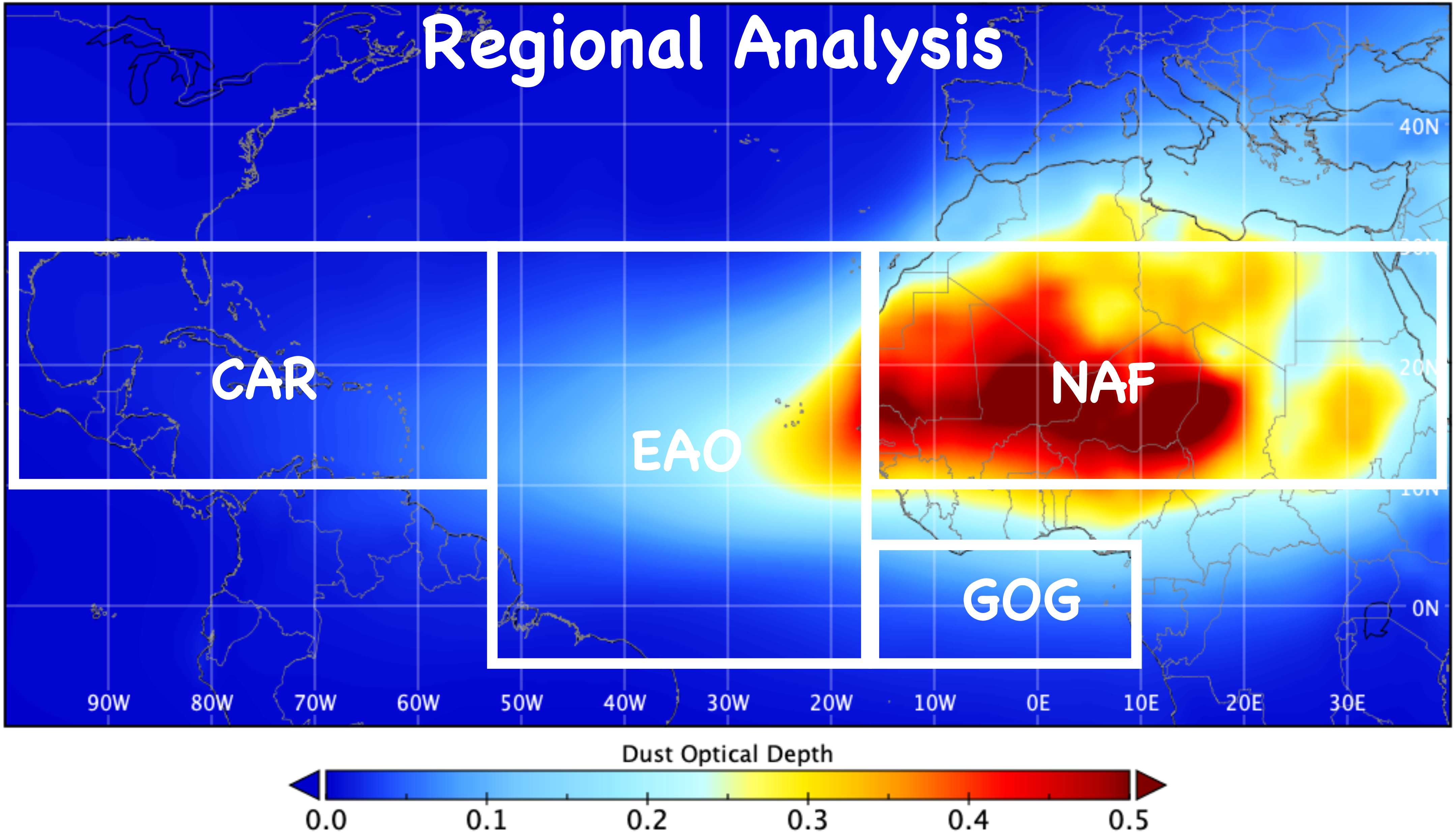
Hongbin.Yu@nasa.gov, 301-614-6209


**Objective:** To identify major model deficiencies in simulating the trans-Atlantic dust transport and deposition through comparisons against satellite and surface observations

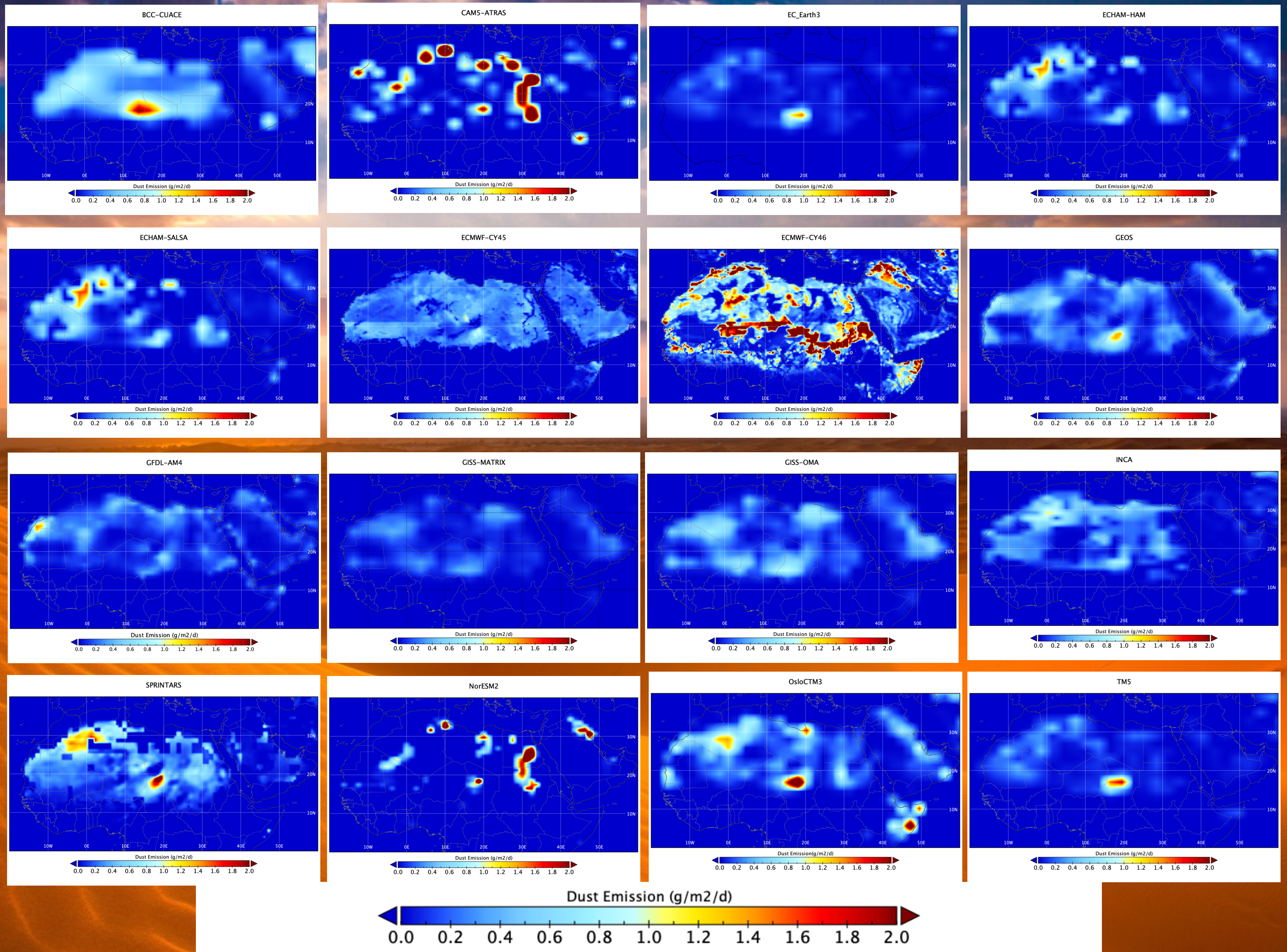
# AeroCom III CTRL Experiment (16 models)

| Model | Model version | xdim | ydim | zdim | dlon | dlat | Institution/Country | POCs (name, email) |
|---|---|---|---|---|---|---|---|---|
| BCC | BCC-CUACE | 128 | 64 | 26 | 2.813 | 2.813 | CMA, China | Hua Zhang (huazhang@cma.gov.cn), Bing Xie (xieb@cma.gov.cn) |
| CAM5 | CAM5-ATRAS | 144 | 96 | 30 | 2.500 | 1.875 | Nagoya Univ, Japan | Hitoshi Matsui (matsui_at_nagoya-u.jp) |
| EC-Earth3 | EC-Earth3-AerChem-met2010 | 120 | 90 | 34 | 3.000 | 2.000 | KNMI, Netherlands | Twan van Noije (noije@knmi.nl) |
| ECHAM-HAM | ECHAM6.3-HAM2.3 | 192 | 96 | 47 | 1.875 | 1.875 | MPI, Germany | David Neubauser |
| ECHAM-SALSA | ECHAM6.3-SALSA2.0 | 192 | 96 | 47 | 1.875 | 1.875 | | Harri Kokkola |
| ECMWF-CY45 | ECMWF-IFS-CY45R1-CAMS | 1024 | 512 | | 0.352 | 0.352 | ECMWF | |
| ECMWF-CY46 | ECMWF-IFS-CY46R1-CAMS | 1024 | 512 | | 0.352 | 0.352 | ECMWF | |
| GEOS | GEOS-i33p2 | 360 | 181 | 72 | 1.000 | 0.994 | NASA GSFC, USA | Huisheng Bian (huisheng.bian@nasa.gov), Tom Kucsera (tom.l.kucsera@nasa.gov), Mian.Chin@nasa.gov |
| GFDL | GFDL-AM4 | 288 | 180 | 33 | 1.250 | 1.000 | NOAA GFDL, USA | Paul.Ginoux@noaa.gov |
| GISS-MATRIX | GISS-modelE2p1p1-MATRIX | 144 | 90 | 40 | 2.500 | 2.000 | NASA GISS, USA | Kostas Tsigaridis (kostas.tsigaridis@columbia.edu); Susanne Bauer (susanne.bauer@columbia.edu) |
| GISS-OMA | GISS-modelE2p1p1-OMA | 144 | 90 | 40 | 2.500 | 2.000 | NASA GISS, USA | Kostas Tsigaridis (kostas.tsigaridis@columbia.edu); Susanne Bauer (susanne.bauer@columbia.edu) |
| INCA | INCA | 144 | 143 | | 2.500 | 1.259 | IPSL-LSCE, France | Ramiro Checa-Garcia <rcheca@lsce.ipsl.fr> |
| SPRINTARS | MIROC-SPRINTARS | 640 | 320 | 40 | 0.563 | 0.563 | Kyusu Univ., Japan | Toshihiko Takemura (toshi@riam.kyushu-u.ac.jp) |
| NorESM2 | NorESM2-met2010 | 288 | 192 | 32 | 1.250 | 0.938 | Norway | |
| OsloCTM3 | OsloCTM3v1.01-met2010 | 160 | 80 | 60 | 2.250 | 2.250 | CICERO, Norway | Gunnar Myhre (gunnar.myhre@cicero.oslo.no) |
| TM5 | TM5-met2010 | 120 | 90 | 34 | 3.000 | 2.000 | KNMI, Netherlands | Twan van Noije (noije@knmi.nl) |

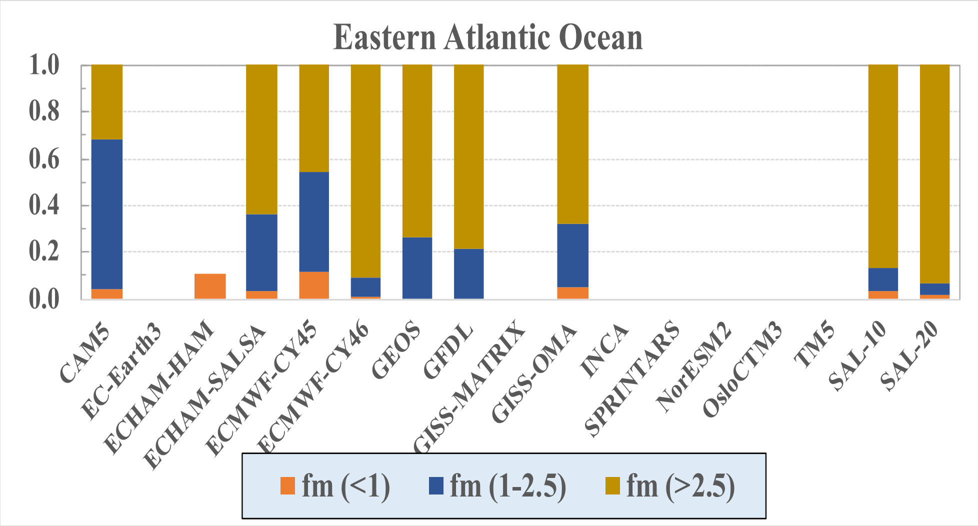
# Regional Analysis



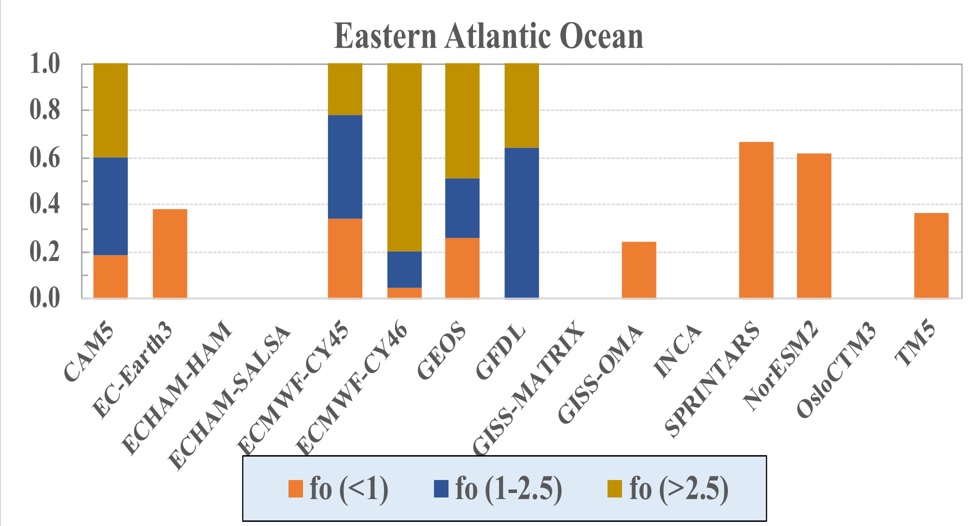
# Dust emissions



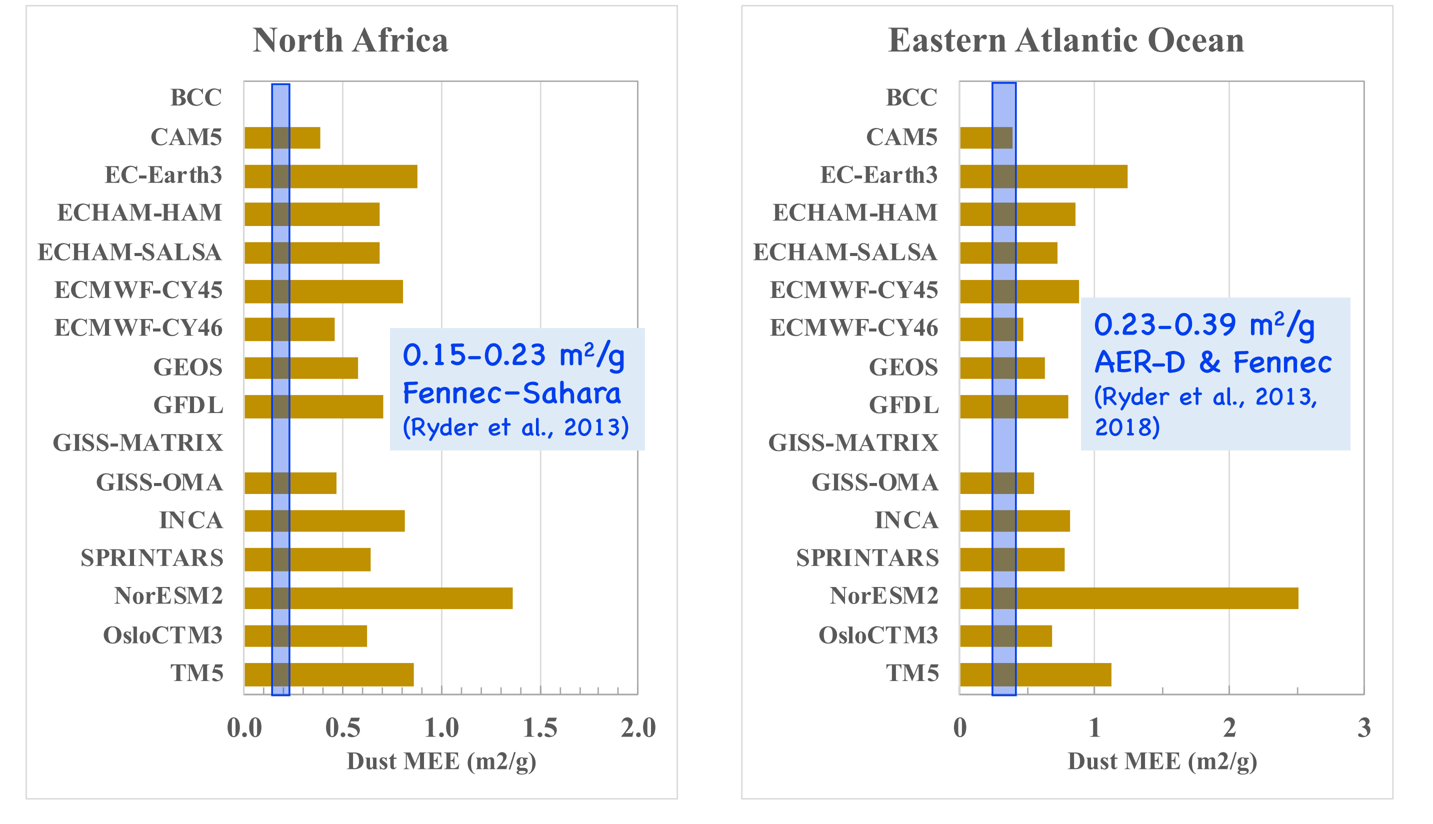
## PSD wrt dust mass



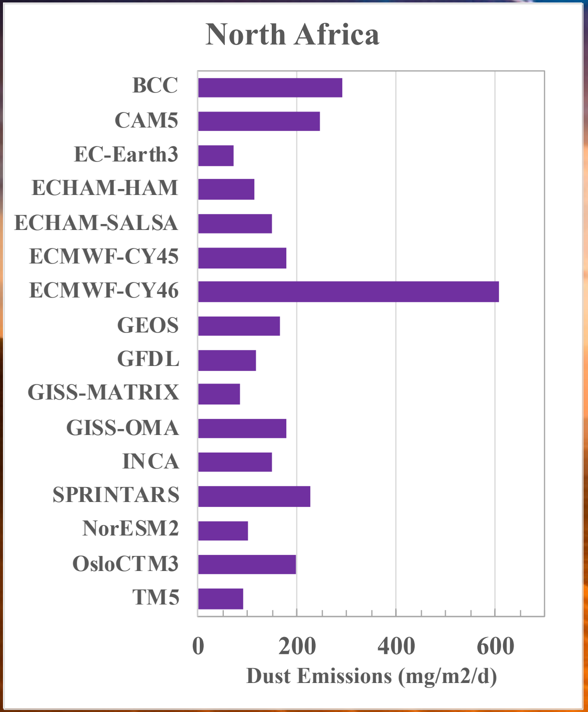

## PSD wrt dust optical depth

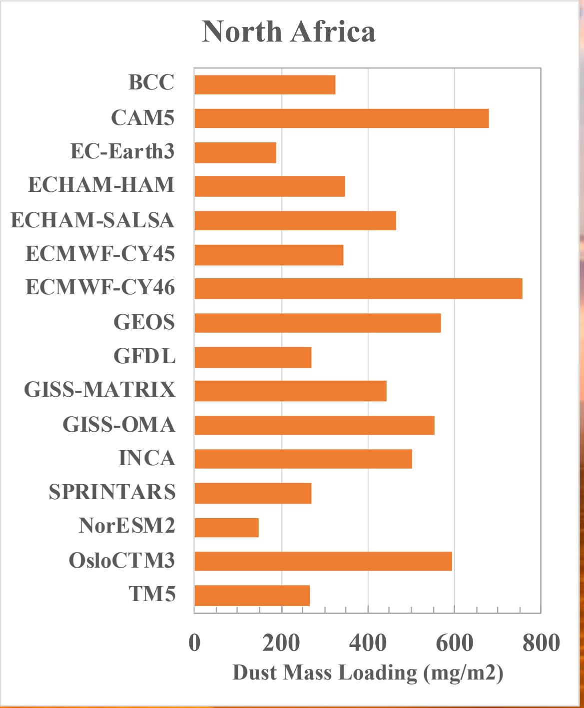


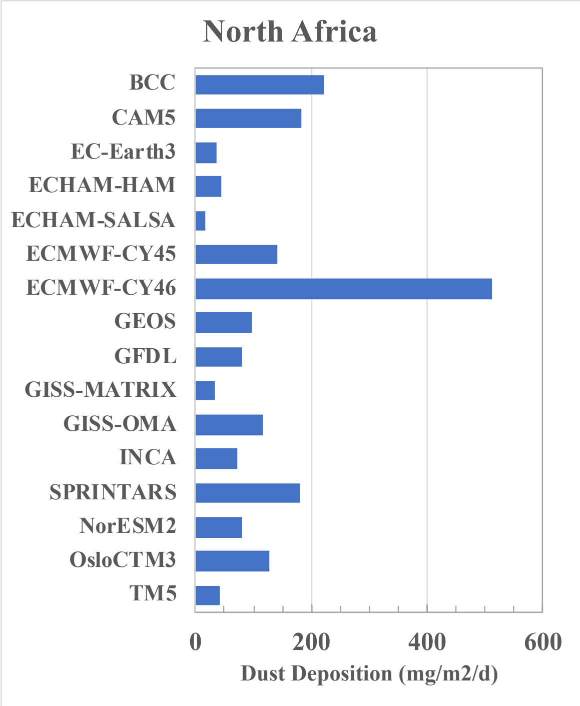

## Dust MEE @ 550 nm

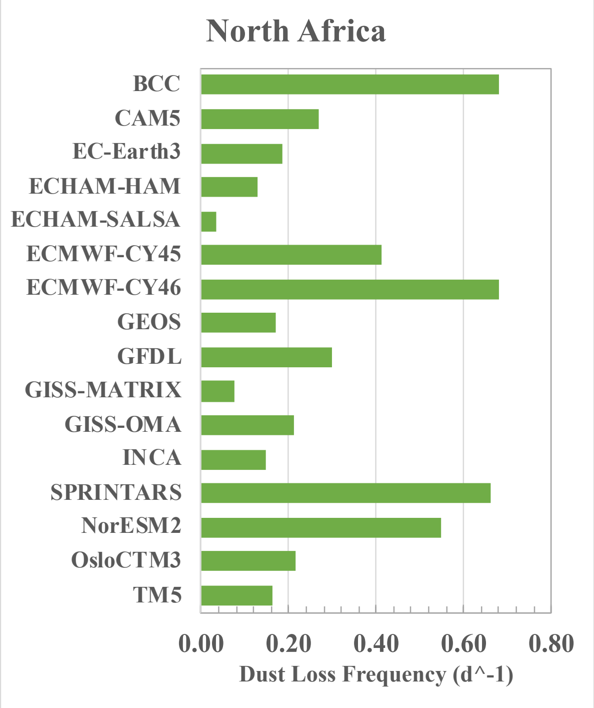


# Dust Source regions



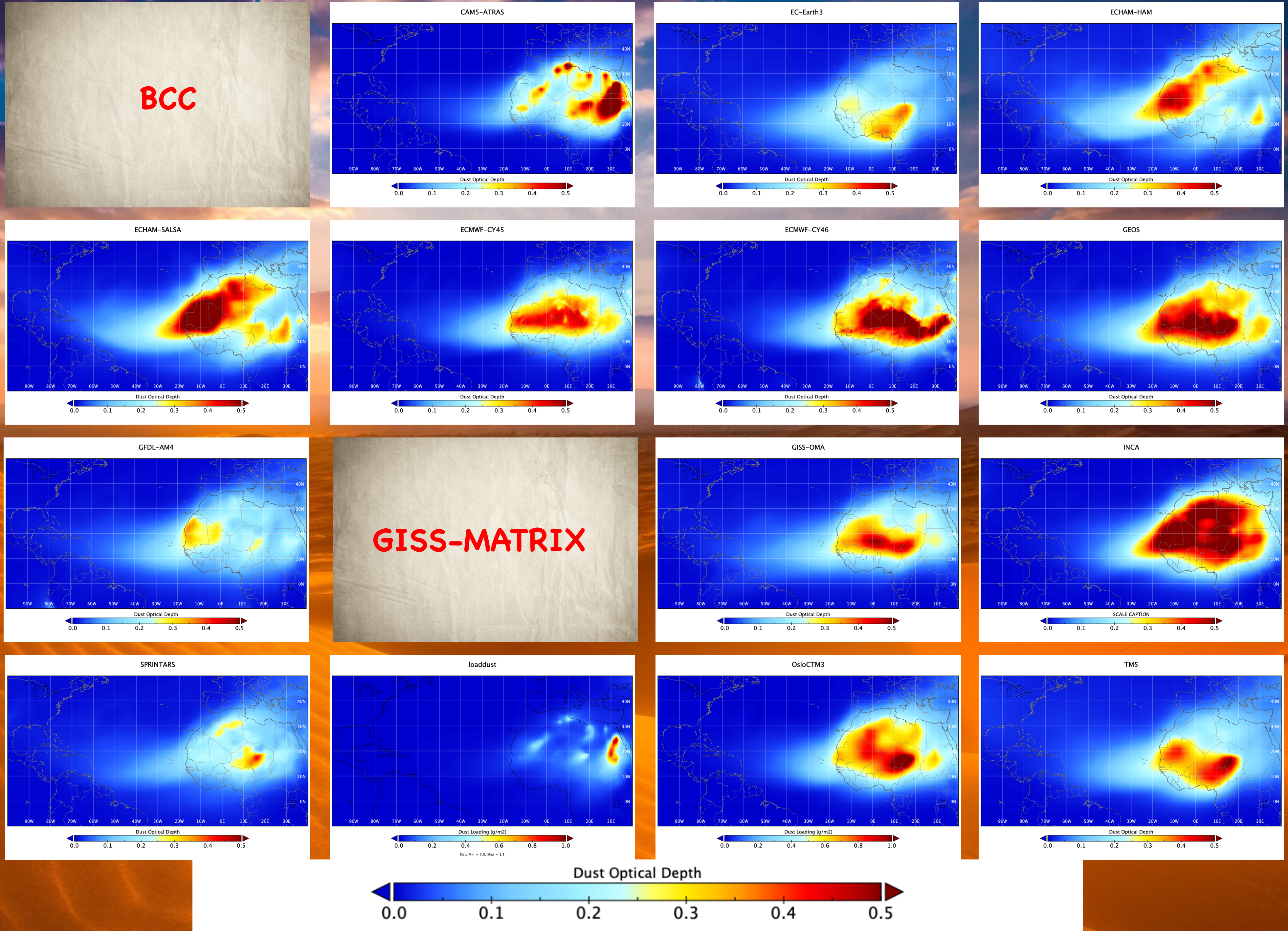



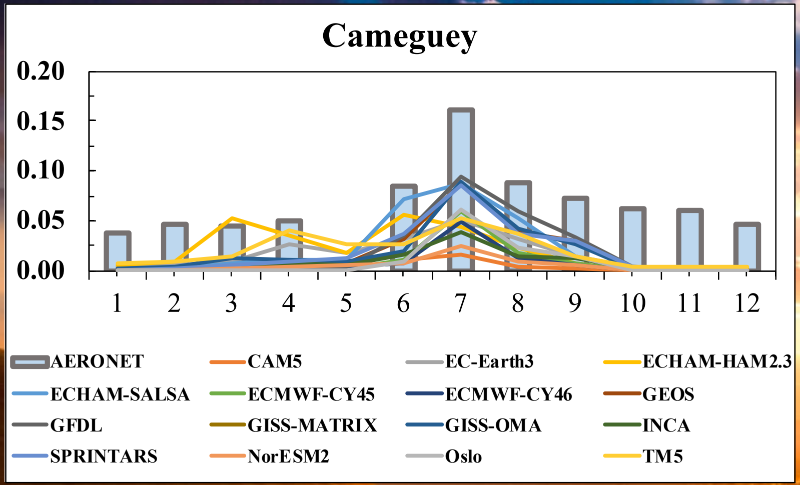



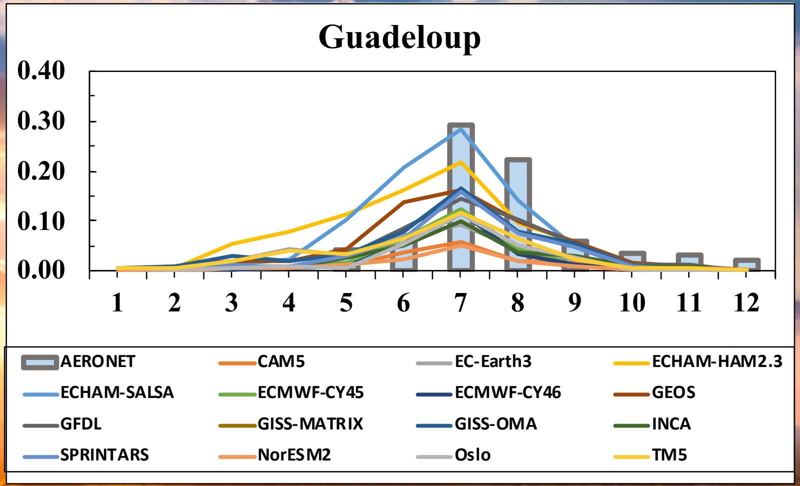

| | Dust Emission (mg/m2/d) | Dust mass loading (mg/m2) | Dust deposition (mg/m2/d) | Loss Frequency (1/d) |
|---|---|---|---|---|
| Model median [diversity] | 158 [70%] | 393 [42%] | 89 [95%] | **0.213 [73%]** |

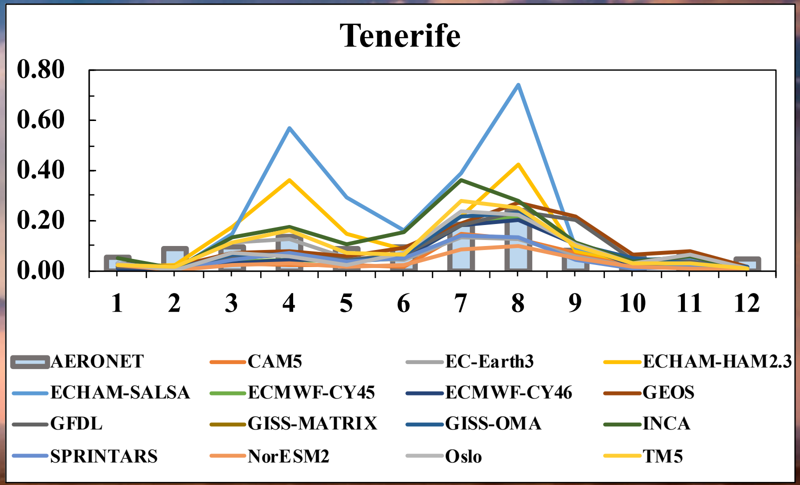
# Dust Optical Depth

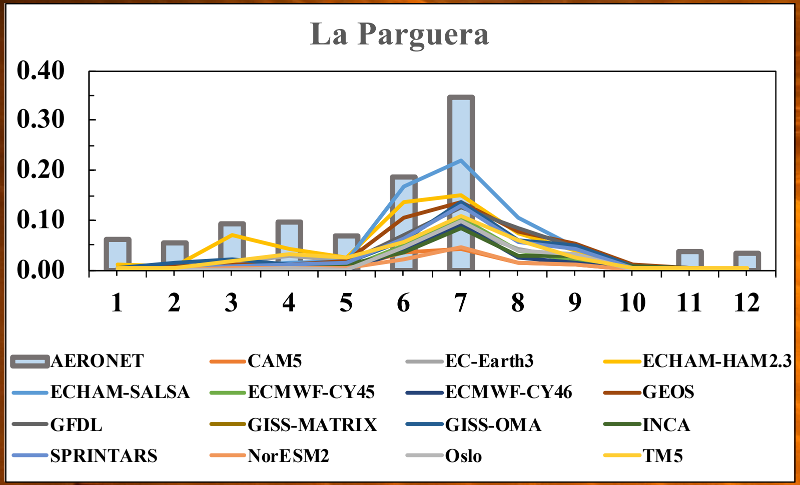


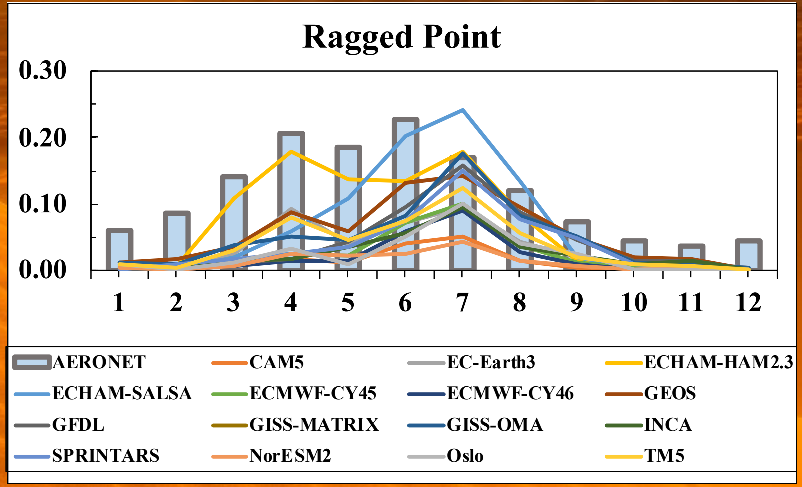
# Dust optical depth – compared with AERONET

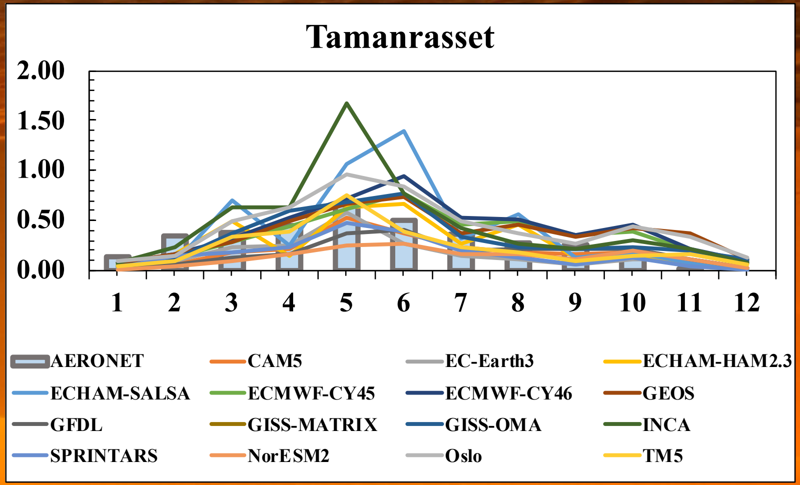


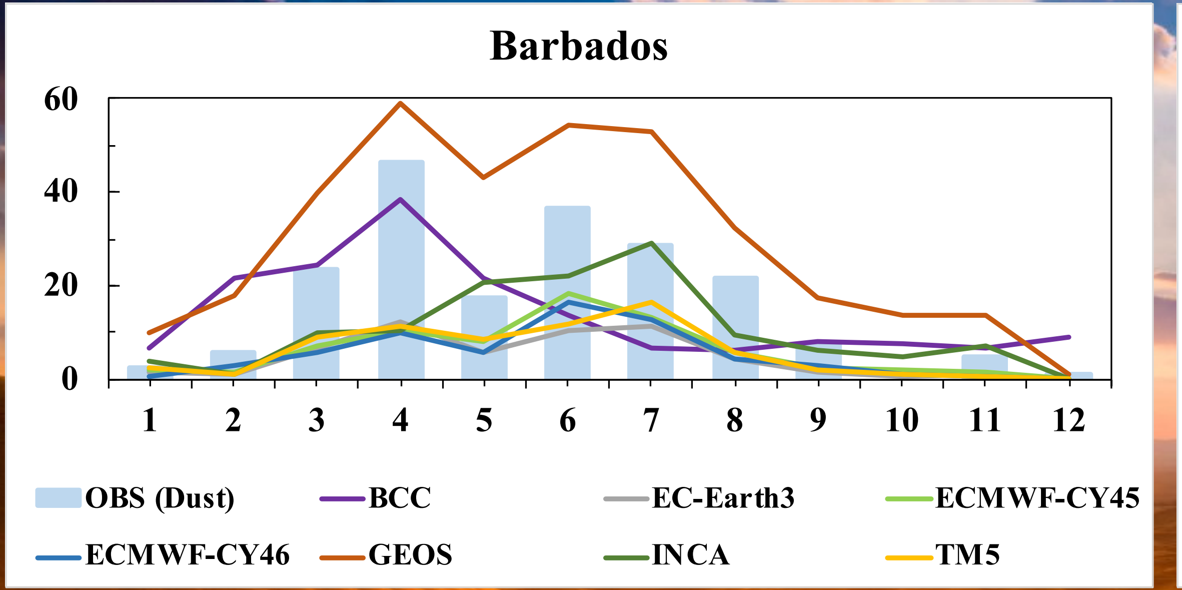



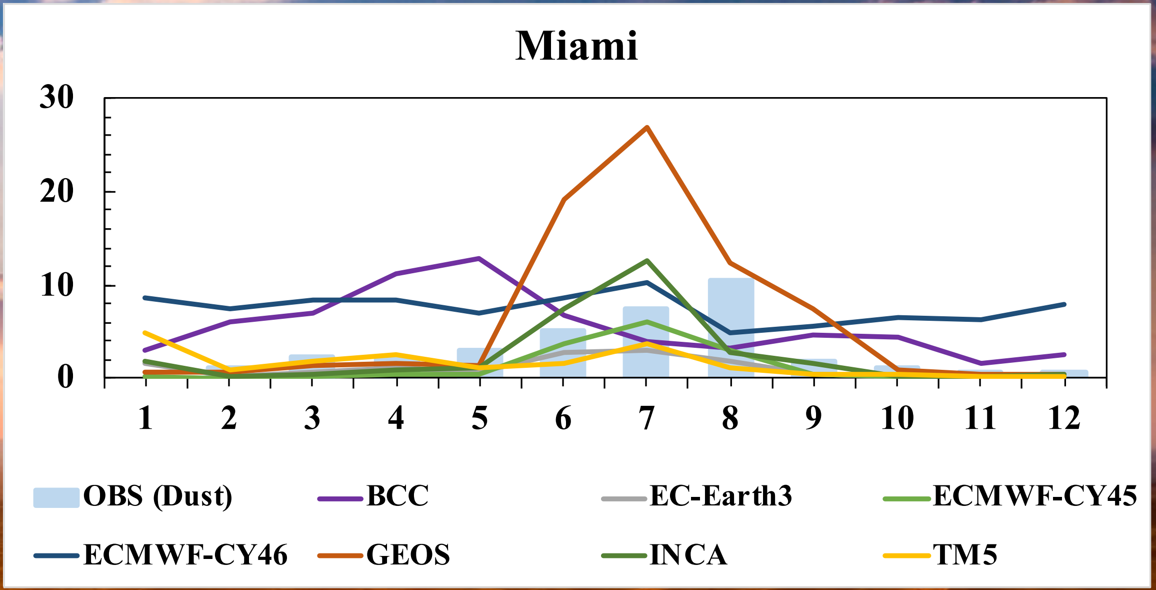




AERONET coarse-mode AOD from SDA retrieval

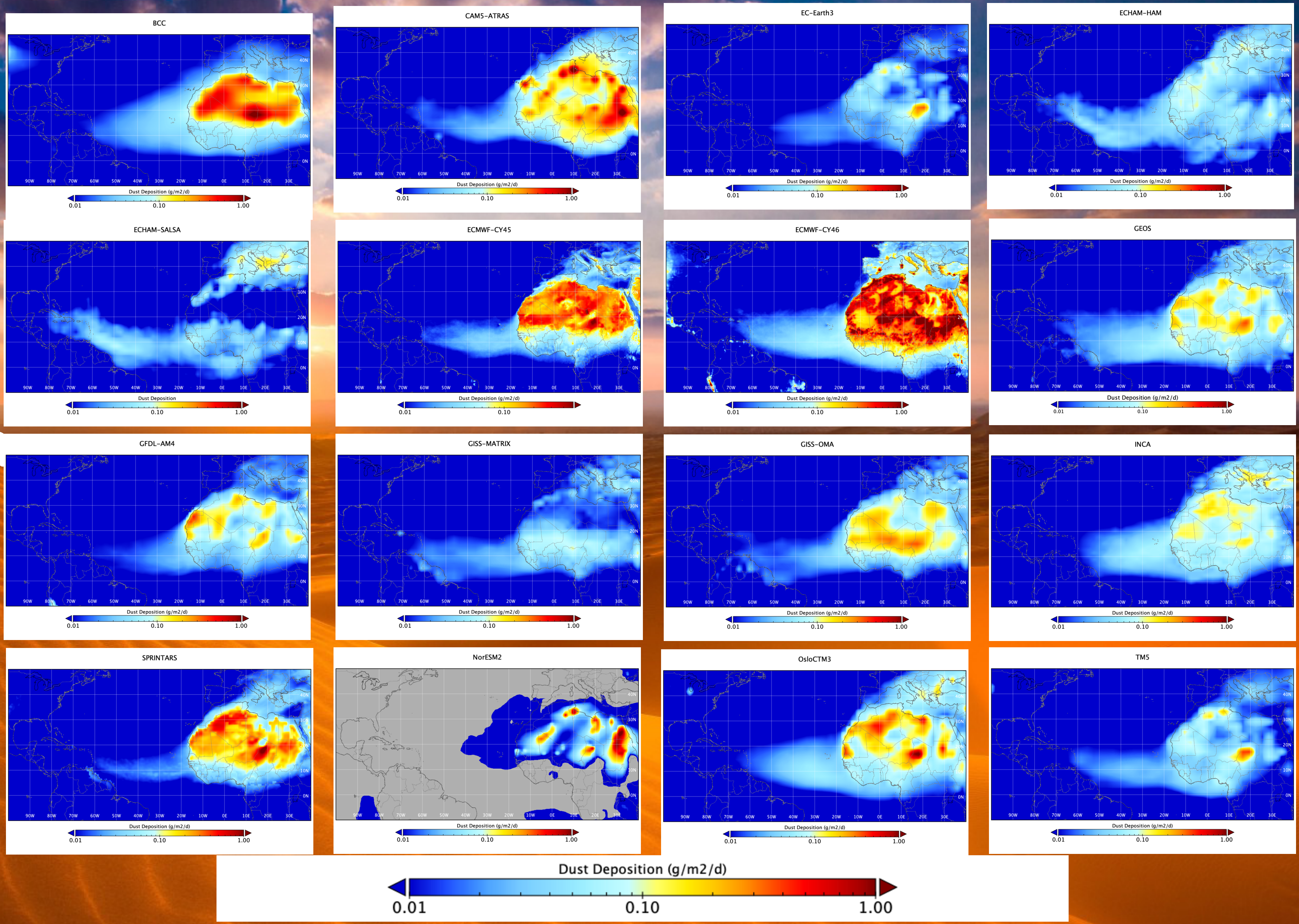
# Surface dust concentration



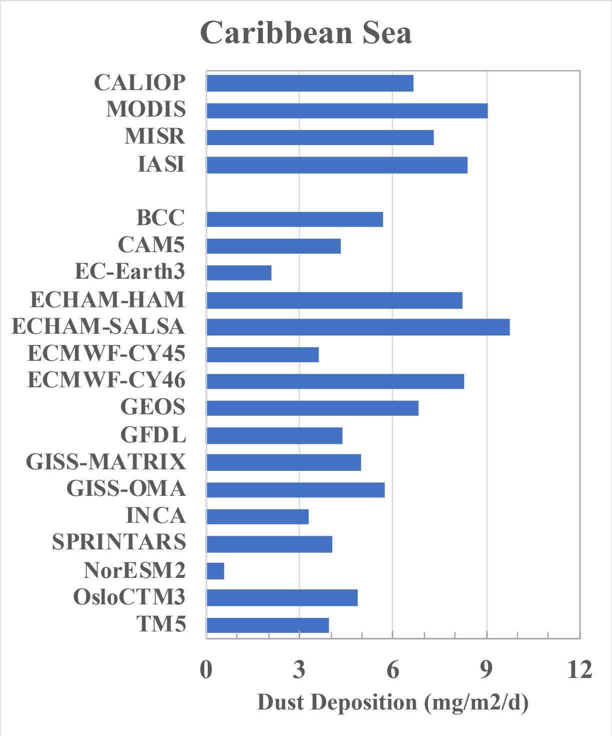



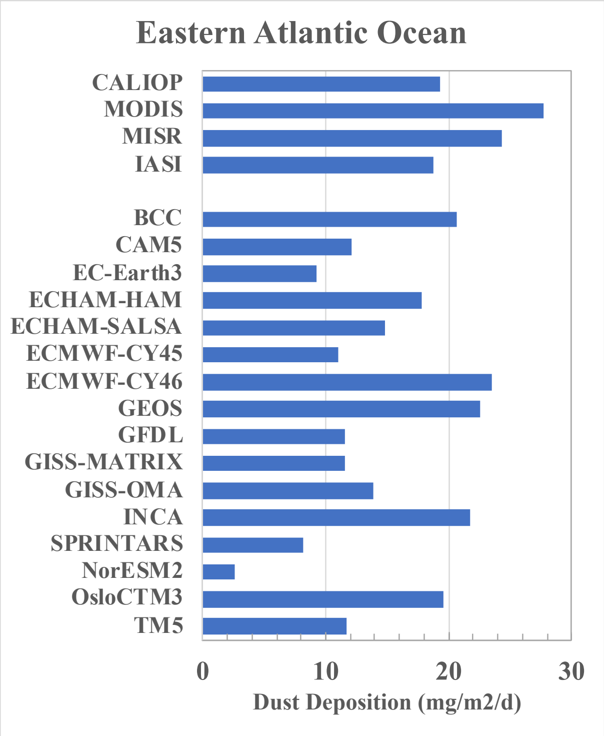

- We will also look into surface $PM_{10}$ concentrations measured in Cayenne, and 3 AMMA sites along the Sahelian dust transect (i.e., Banizoumbou, Cinzana, Mbour)
- But it is a bit tricky because not all models cut off at 10 $\mu$m.

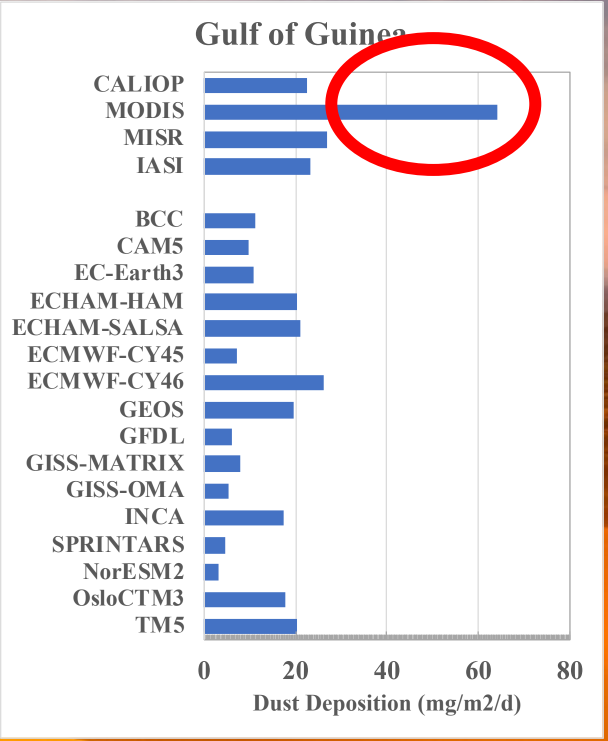
# Dust Deposition

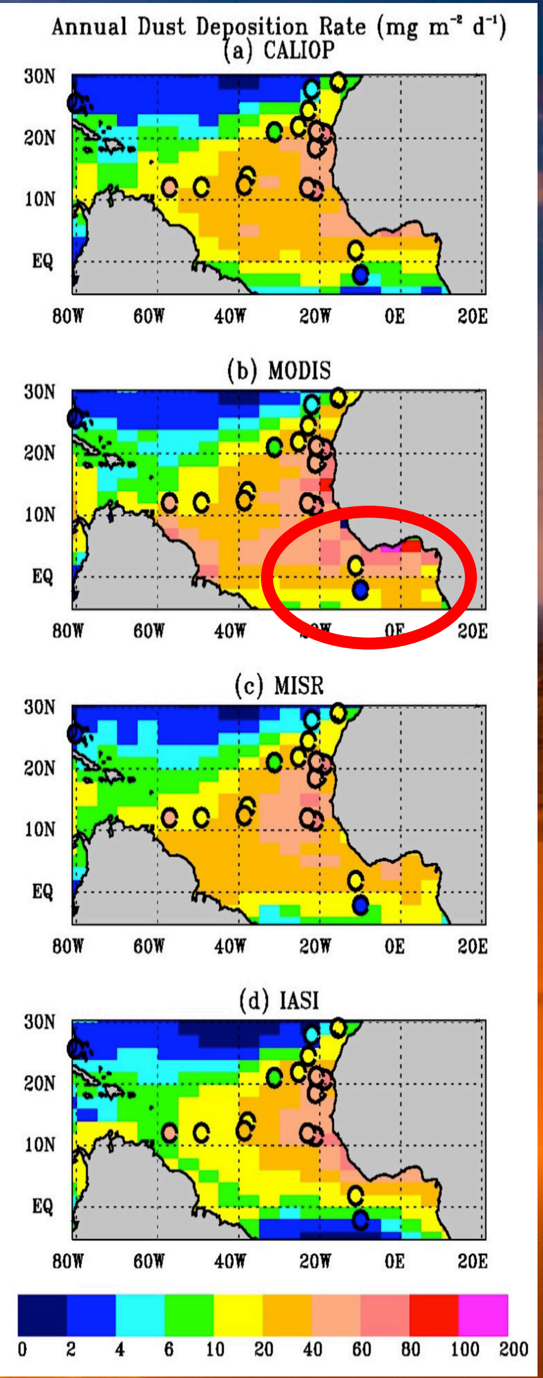


# Regional Dust Deposition



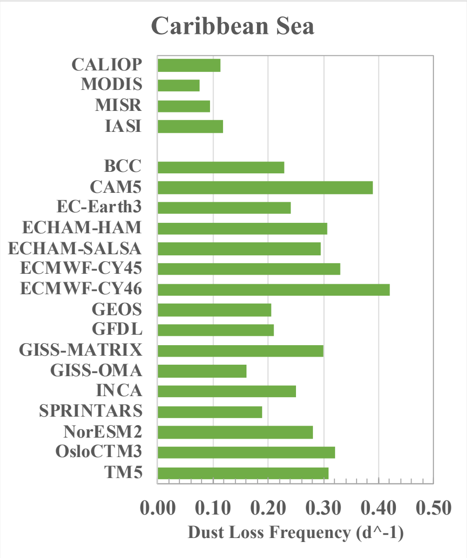



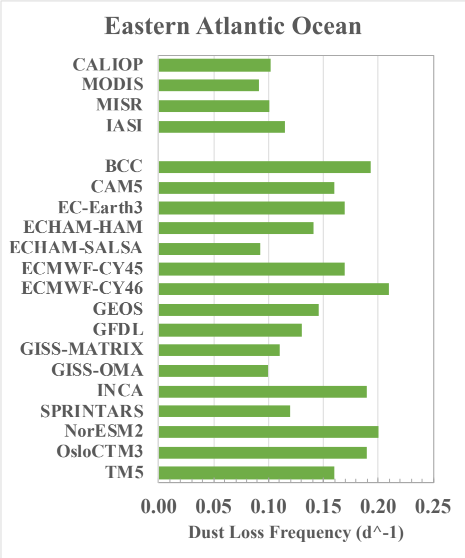
# Dust Loss Frequency

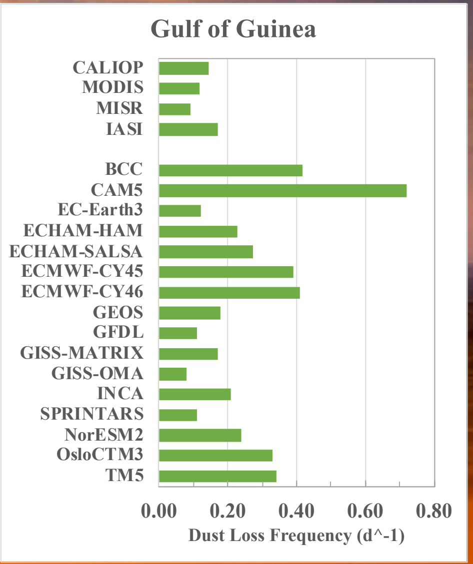
Loss Frequency (LF) = 

$$\frac{\text{Dust Deposition Rate}}{\text{Dust Mass Loading}}$$

- how fast dust is removed from the atmosphere
- a reciprocal of dust residence time
- more accurate than dust deposition and mass loading
- only possible from satellites
- useful for isolating uncertainty of transport/removal from that of emissions

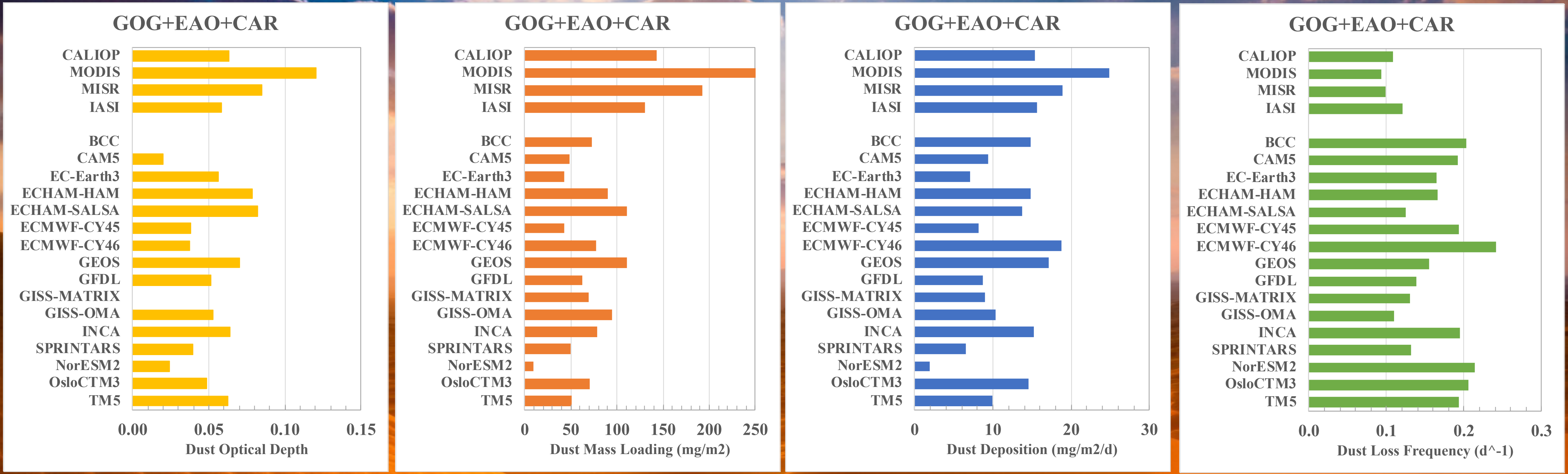


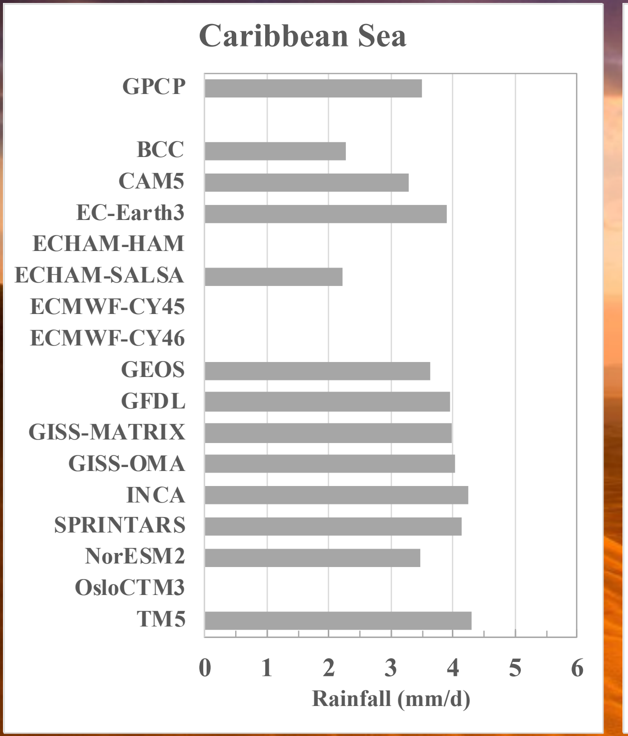

| | Caribbean Sea | E. Atlantic Ocean | Gulf of Guinea |
|---|---|---|---|
| Satellite median | 0.131 | 0.102 | 0.104 |
| Model median *[diversity]* | 0.288 *[26%]* | 0.160 *[24%]* | 0.234 *[60%]* |

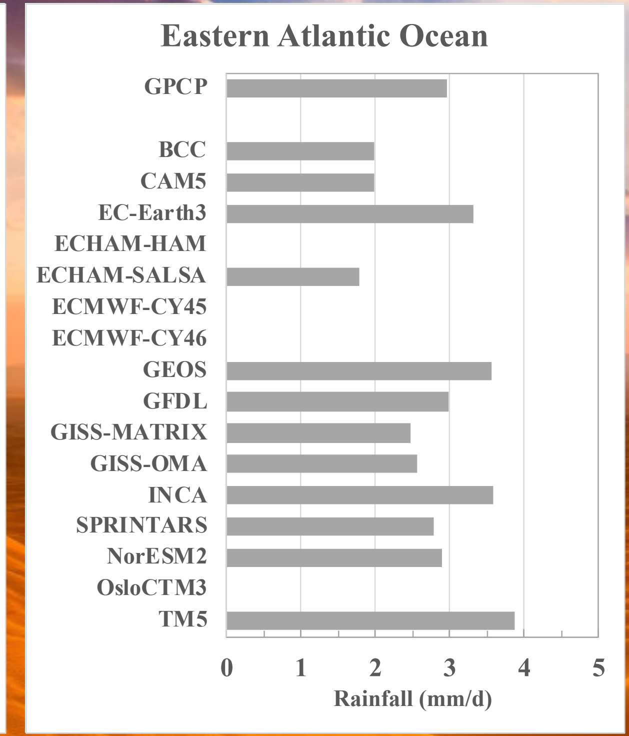
# Gulf of Guinea + E. Atlantic + Caribbean Basin

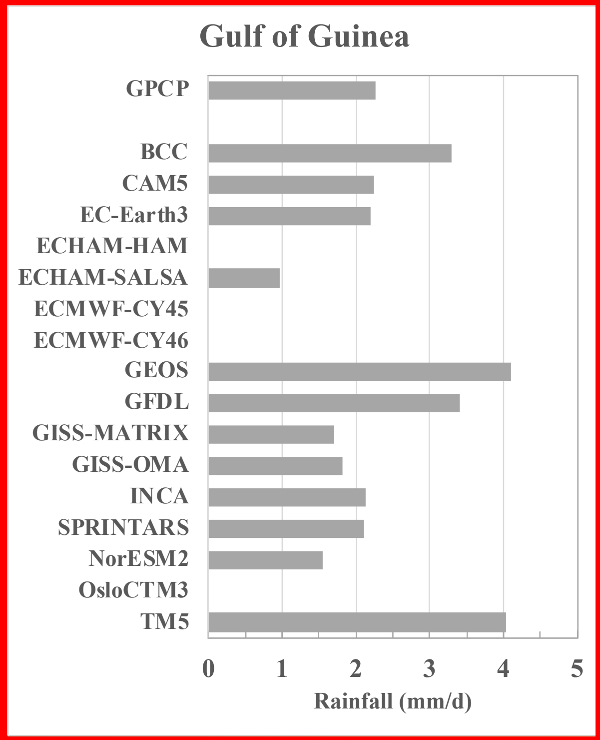


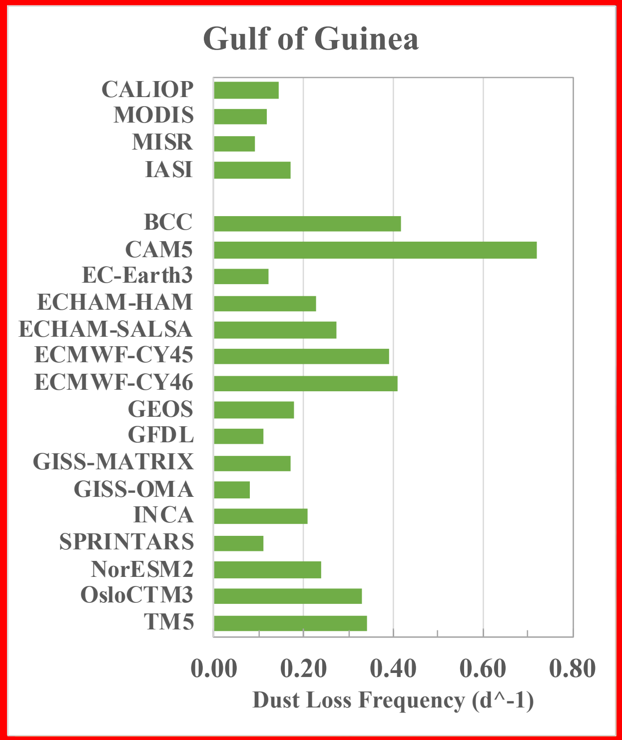

| | Dust optical depth | Dust mass loading (mg/m2) | Dust deposition rate (mg/m2/d) | Dust loss freq. (1/d) |
|---|---|---|---|---|
| Satellite median [range] | 0.074 [0.059~0.120] | 168 [130~266] | 17 [15~25] | 0.103 [0.093~0.121] |
| Model median [diversity] | 0.052 [36%] | 70 [40%] | 10 [40%] | 0.178 [22%] |

# Rainfall bias compared to GPCP



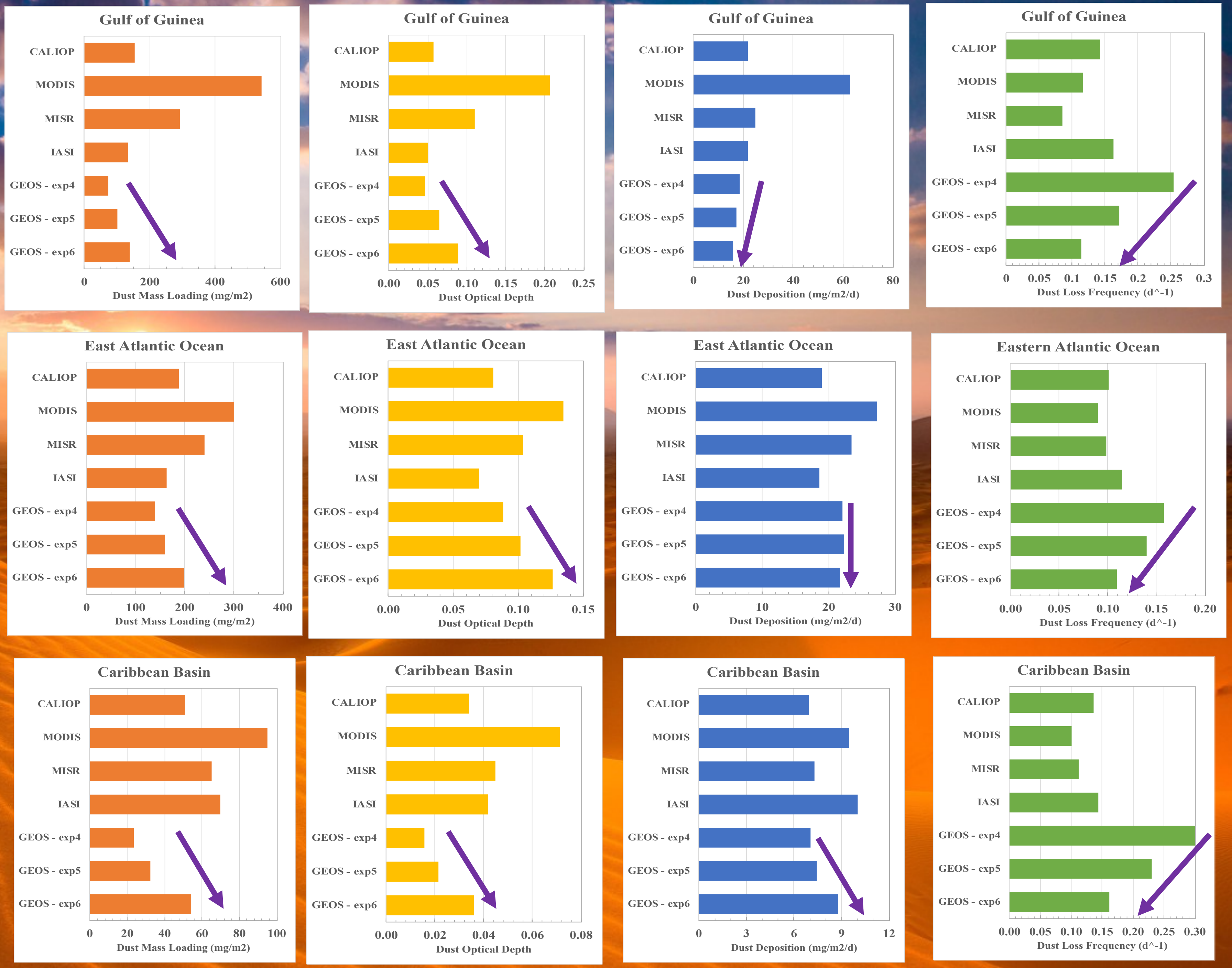



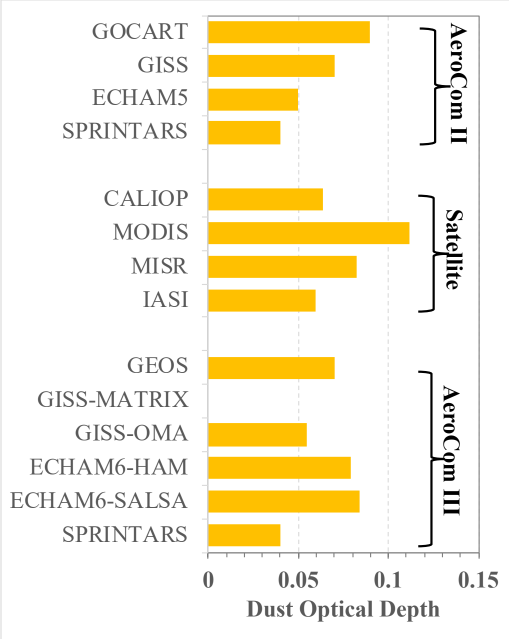

- High bias in precipitation is consistent with larger loss frequency for some models in Gulf of Guinea (e.g., BCC, TM5)
- Other possible factors include wet/dry removal parameterizations (e.g., scavenging coefficients), vertical distributions, etc.

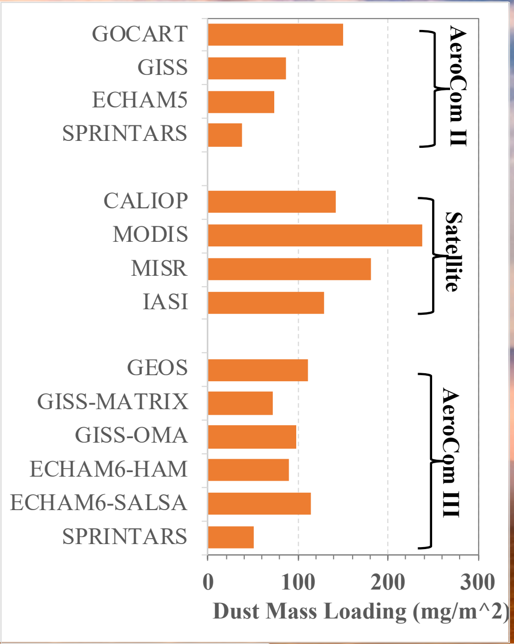
# GEOS model sensitivity tests

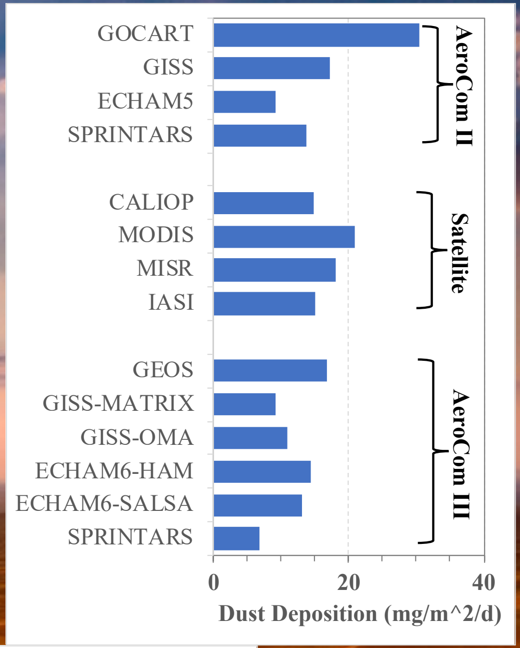
| Exp name | $f_{con}$ | $f_{wet}$ |
|---|---|---|
| Exp4 | 1.0 | 0.3 |
| Exp5 | 0.2 | 0.8 |
| Exp6 | 0.1 | 0.5 |



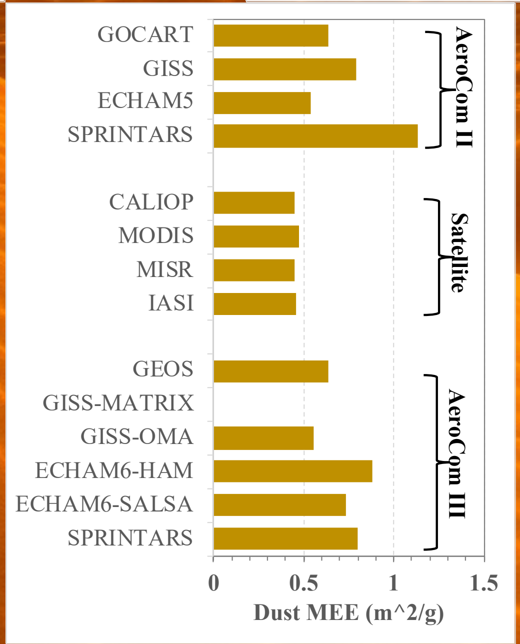
# Evolution from AeroCom II to AeroCom III

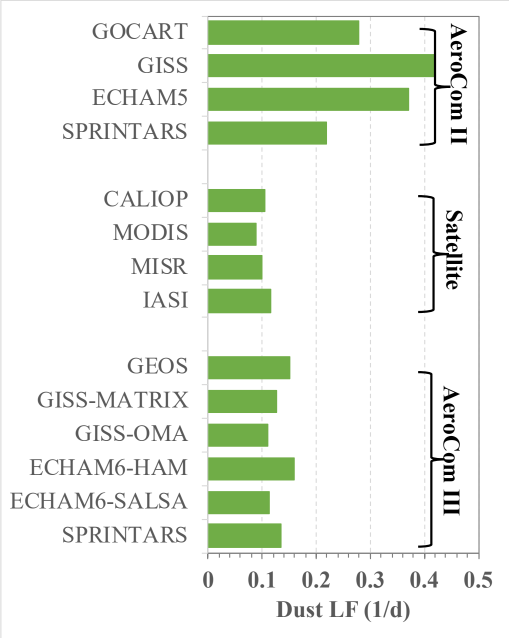



- AeroCom II is 2000-2005 average (Kim et al., 2014)
- Satellite & AeroCom III are for 2010



# Way forward

- Collect some basic information about parameterizations of dust processes (size, gravitational settling, wet removals, precipitation, etc)

- Extend model evaluations by using
  - ❑ Surface $PM_{10}$ observations
  - ❑ Dust vertical profiles from CALIOP
  - ❑ Other experiments (e.g., HIST, UTLS, etc.) to investigate interannual variations (2007-2016)