https://www.nasa.gov/multimedia/imagegallery/image_feature_2393.html

Retrieving global distribution of threshold of wind erosion from satellite data

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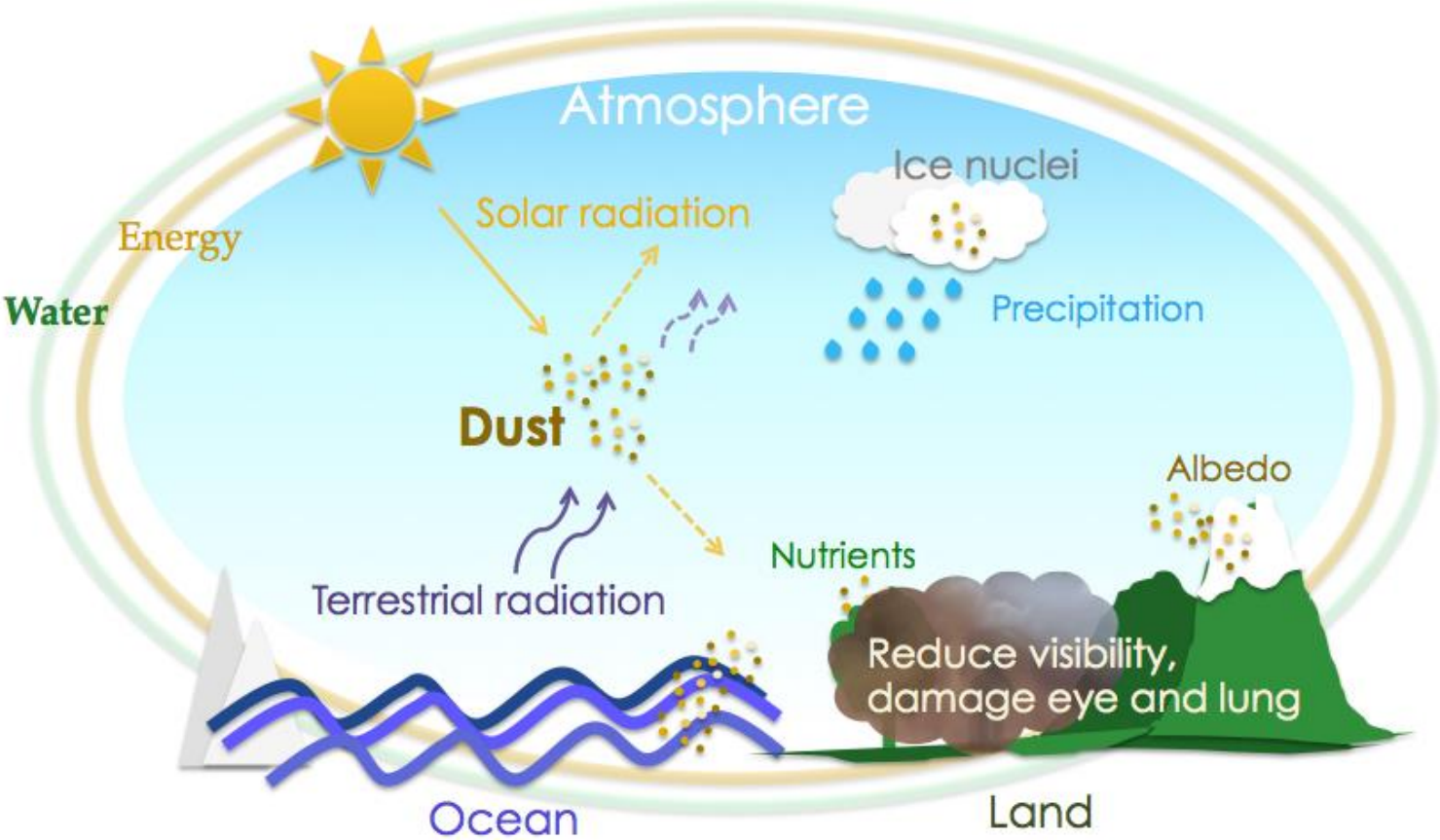
Motivation

- Dust aerosol plays important role in the climate system.
- Dust emission scheme are incorporated in many climate models to simulate the climate impacts.



Motivation

- The process of dust emission is associated with a threshold of wind erosion ($V_{threshold}$). For simplicity, a globally uniform value is widely used.
- In reality, the emission process is influenced by many land surface properties and thus varies spatially and temporally.
- Different methods have been used to study regional $V_{threshold}$, a global distribution of $V_{threshold}$ is still in

➢ **We propose a method to retrieve monthly two-dimensional $V_{threshold}$ for dry and bare surface based on high-resolution satellite products and reanalysis datasets**

Data and methods

- **Steps to retrieve $V_{threshold}$**

(1) Daily MODIS Deep Blue dust optical depth (DOD; 2003-2015) is first processed to remove the influences of non-erodible factors and unfavorable environmental conditions

a. Daily volumetric soil moisture <0.1;
b. Monthly LAI <0.3;
c. Monthly snow cover < 0.2%;
d. Monthly first-layer soil temperature > 273.15 K
e. Soil depth >15 cm.

Data and methods

- **Steps to retrieve $V_{threshold}$**

(1) Daily MODIS Deep Blue dust optical depth (DOD; 2003-2015) is first processed to remove the influences of non-erodible factors and unfavorable environmental conditions

(2) Then the cumulative frequency distribution of daily DOD is derived at each grid point for each month.

Data and methods

- **Steps to retrieve $V_{threshold}$**

(1) Daily MODIS Deep Blue dust optical depth (DOD; 2003-2015) is first processed to remove the influences of non-erodible factors and unfavorable environmental conditions

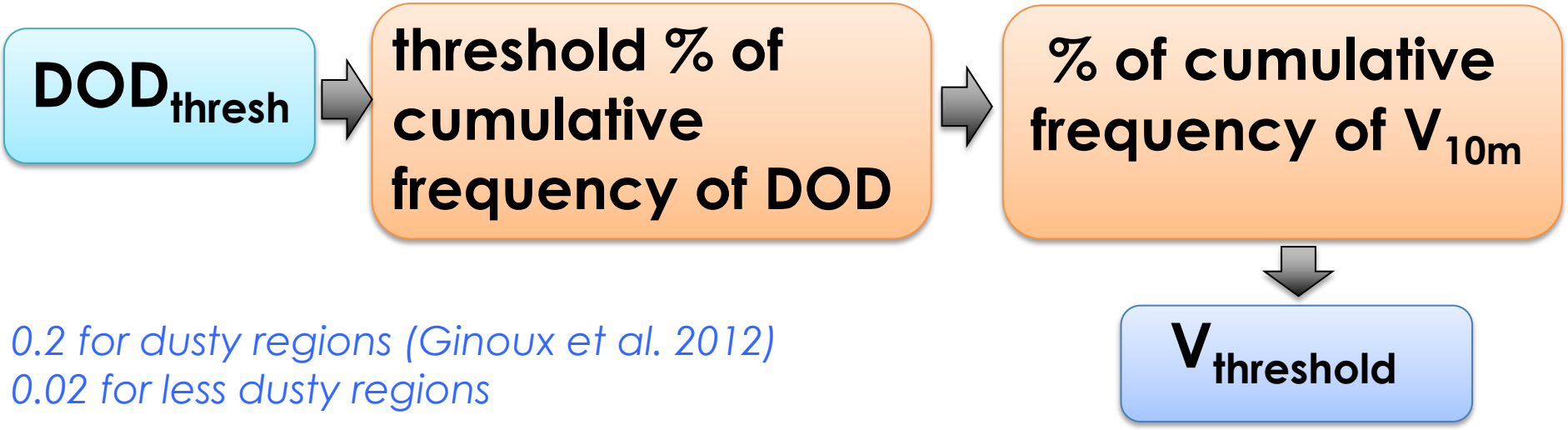
(2) Then the cumulative frequency distribution of daily DOD is derived at each grid point for each month.

(3) The cumulative frequency distribution of daily maximum surface wind from the NCEP/ NCAR reanalysis is then derived at each grid point for each month during 2003-2015.

Data and methods

- **Steps to retrieve $V_{threshold}$**

The *climatological* $V_{threshold}$ is retrieved by matching the frequency distribution of the **DOD** at certain level (i.e., DOD_{thresh}) with the frequency distribution of **surface 10 m winds** over the period from 2003 to 2015



0.2 for dusty regions (Ginoux et al. 2012)
0.02 for less dusty regions

Data and methods

- **Steps to retrieve $V_{threshold}$**

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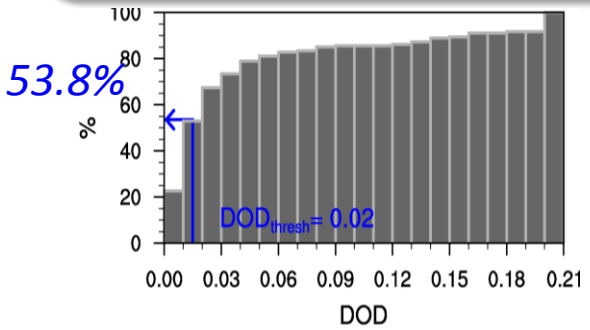
DOD_{thresh} → **threshold % of cumulative frequency of DOD** → **% of cumulative frequency of V_{10m}** → **$V_{threshold}$**



Data and methods

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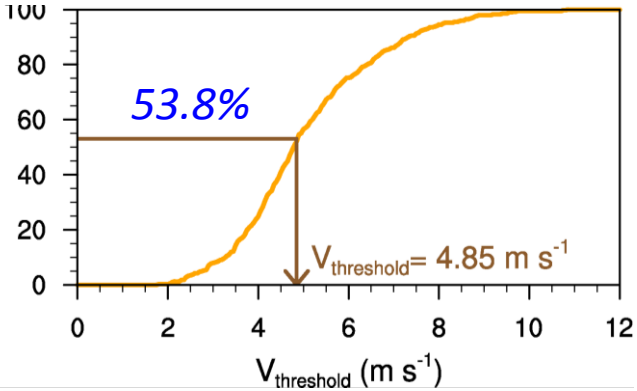
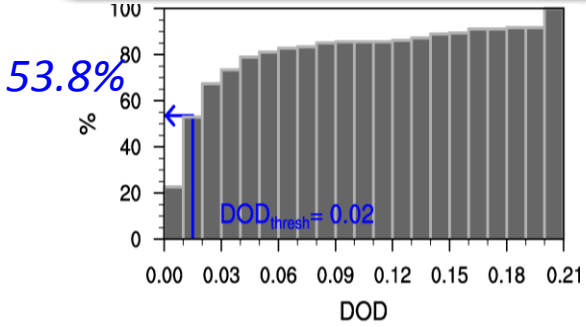
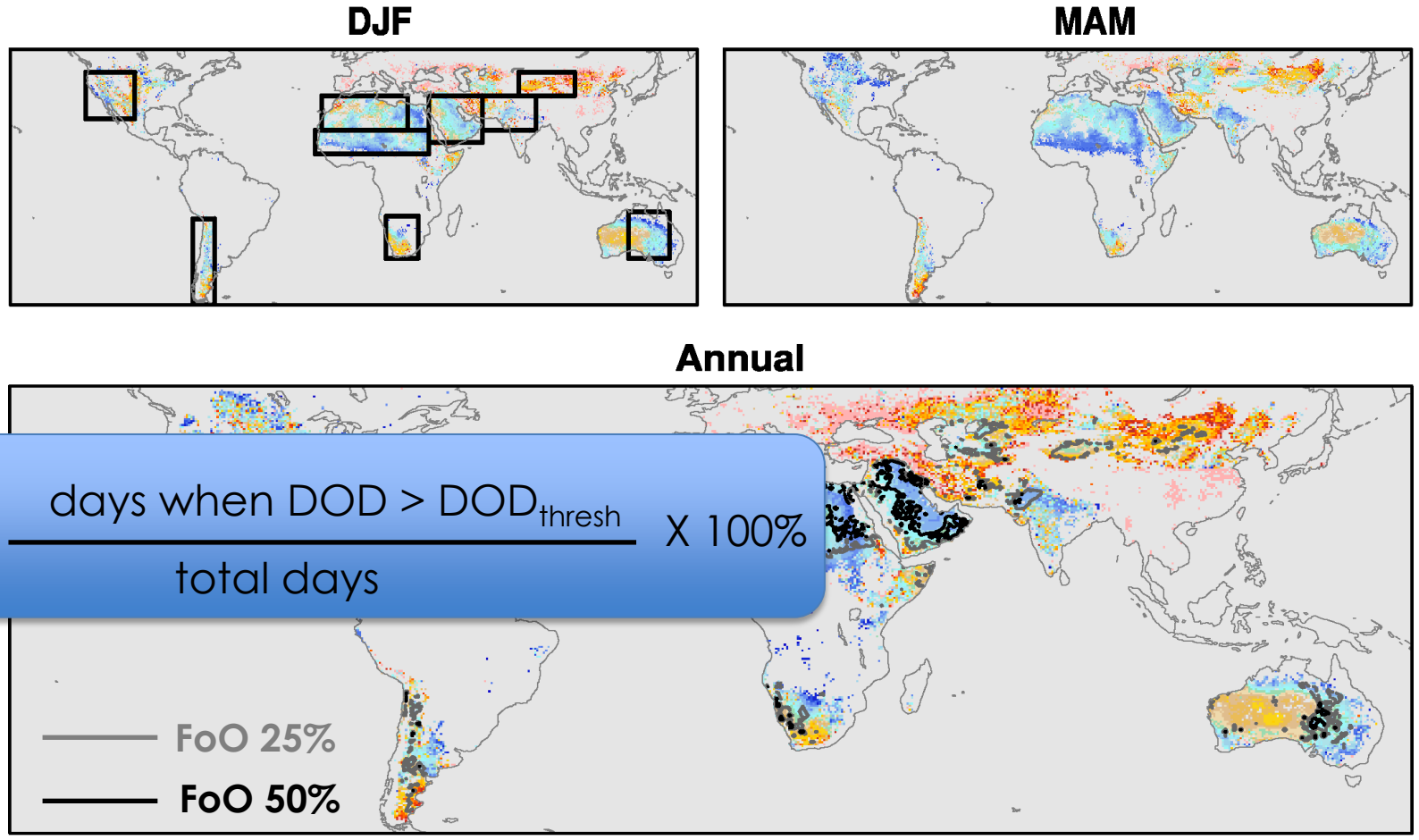


DOD_{thresh} → **threshold % of cumulative frequency of DOD** → **% of cumulative frequency of V_{10m}** → **$V_{threshold}$**



Results

- **Threshold of wind erosion ($V_{threshold}$)**



Results

- Implement $V_{threshold}$ into GFDL AM4.0/ LM4.0 model (Zhao et al. 2018a,b)

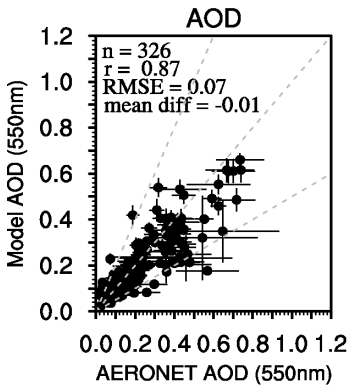
Simulations	Wind erosion threshold
Control	6 m s^{-1} over land
V_{thresh}12mn	12-month $V_{threshold}$
V_{thresh}Ann	Annual mean $V_{threshold}$

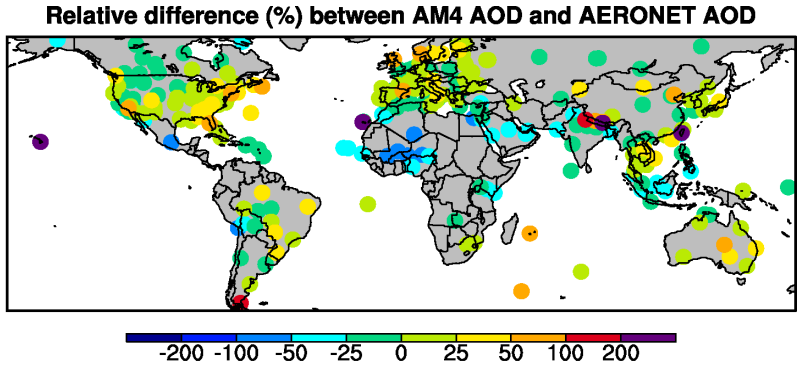
- 0.5° ×0.625°, 33 vertical layers
- Dust emission scheme: Ginoux et al. (2001) $F_p = C \times S \times s_p \times V_{10m}^2 (V_{10m} - V_t)$
- Prescribed SST and sea-ice (AMIP-type) from 1999 to 2015
- Surface winds are nudged toward the NCEP/NCAR reanalysis

Climatology of AOD and DOD

- Control run

Model vs. AERONET

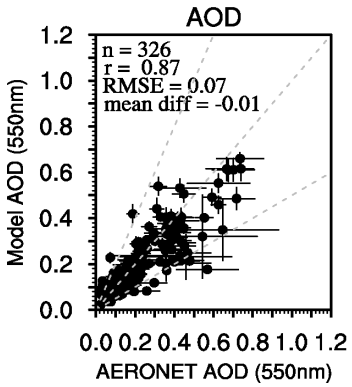


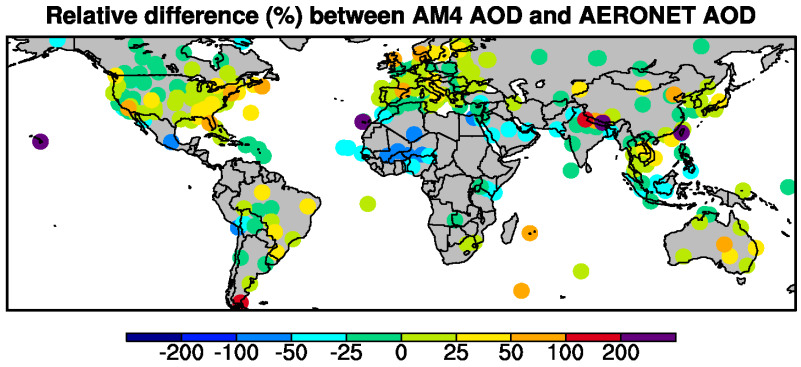


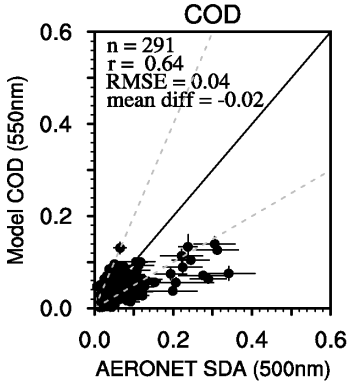
Climatology of AOD and DOD

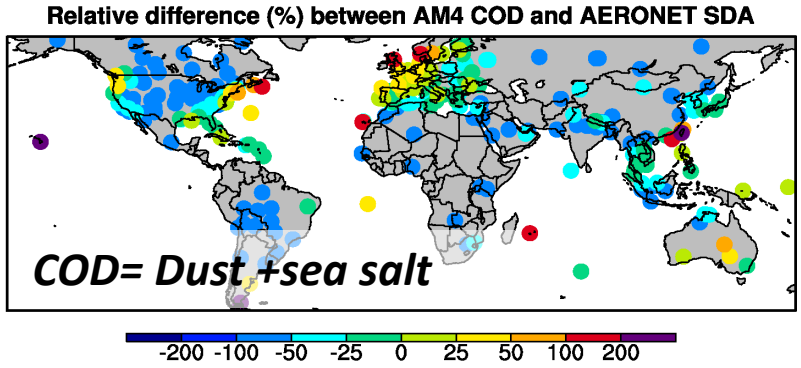
- Control run

Model vs. AERONET









Climatology of AOD and DOD

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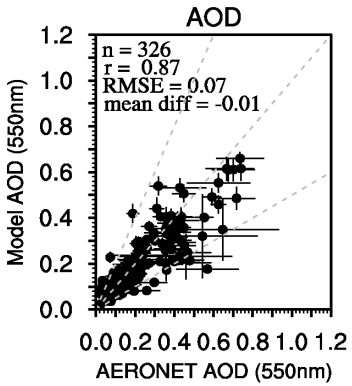
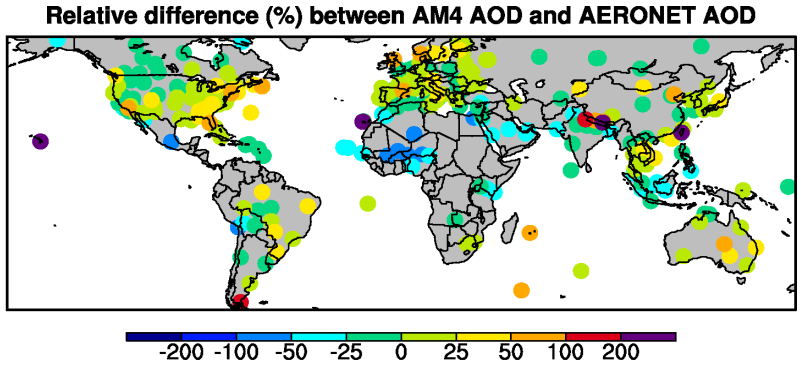
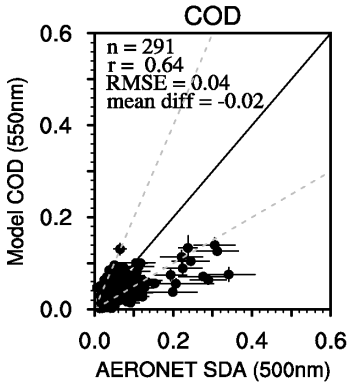
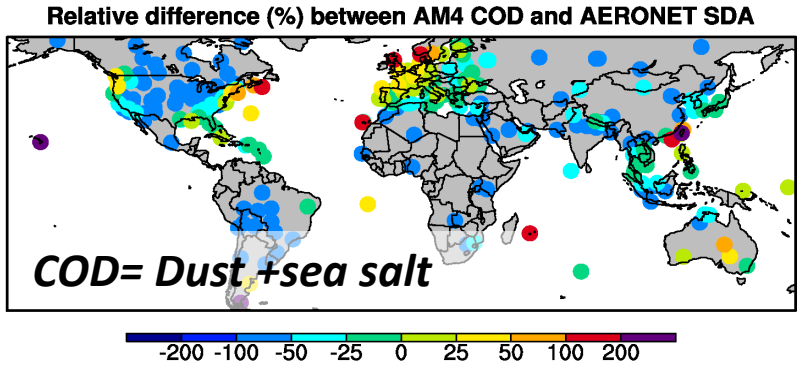
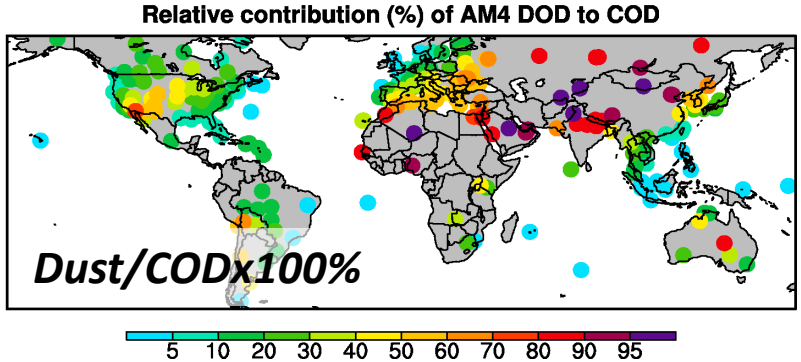
Model vs. AERONET







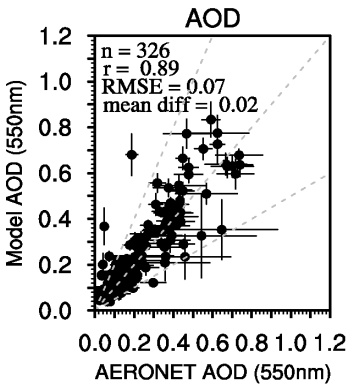


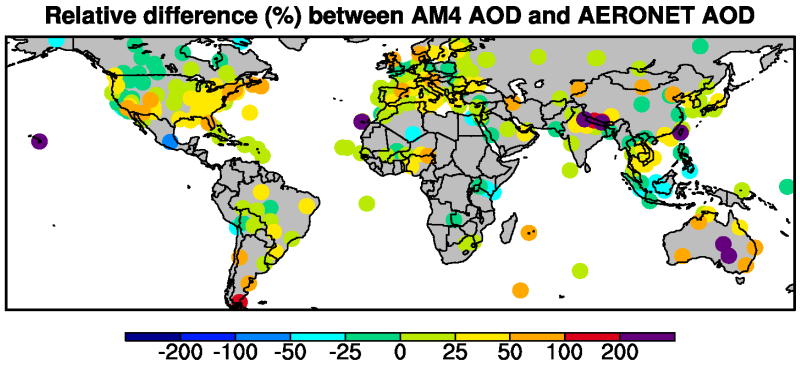


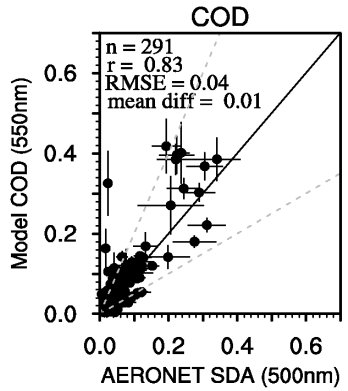
Climatology of AOD and DOD

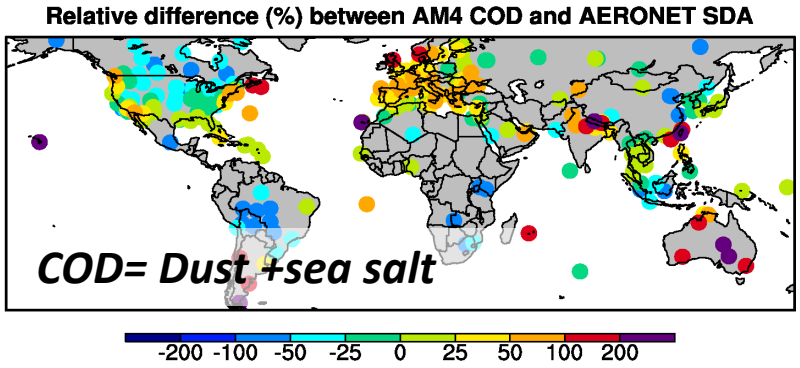
- V_{thresh}12mn

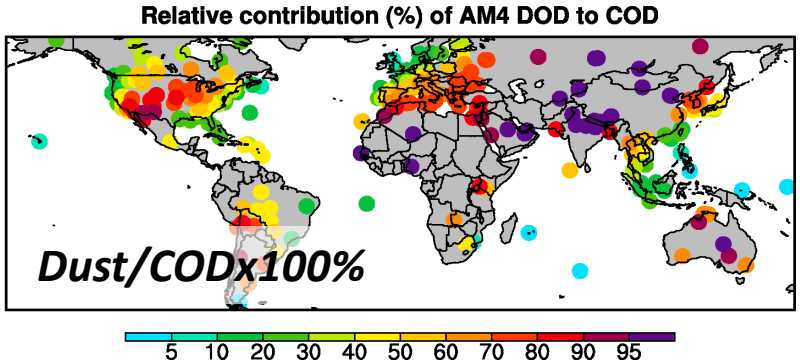
Model vs. AERONET



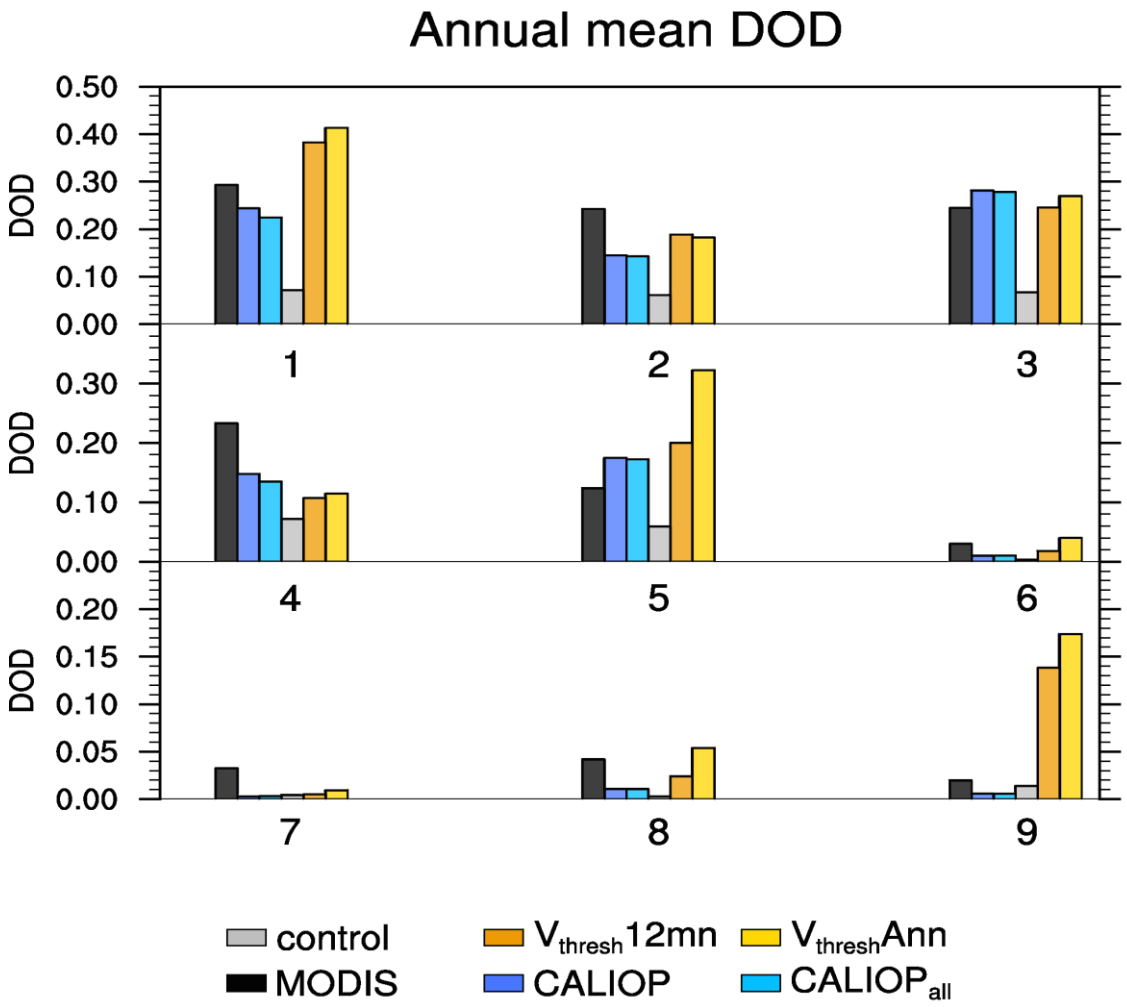








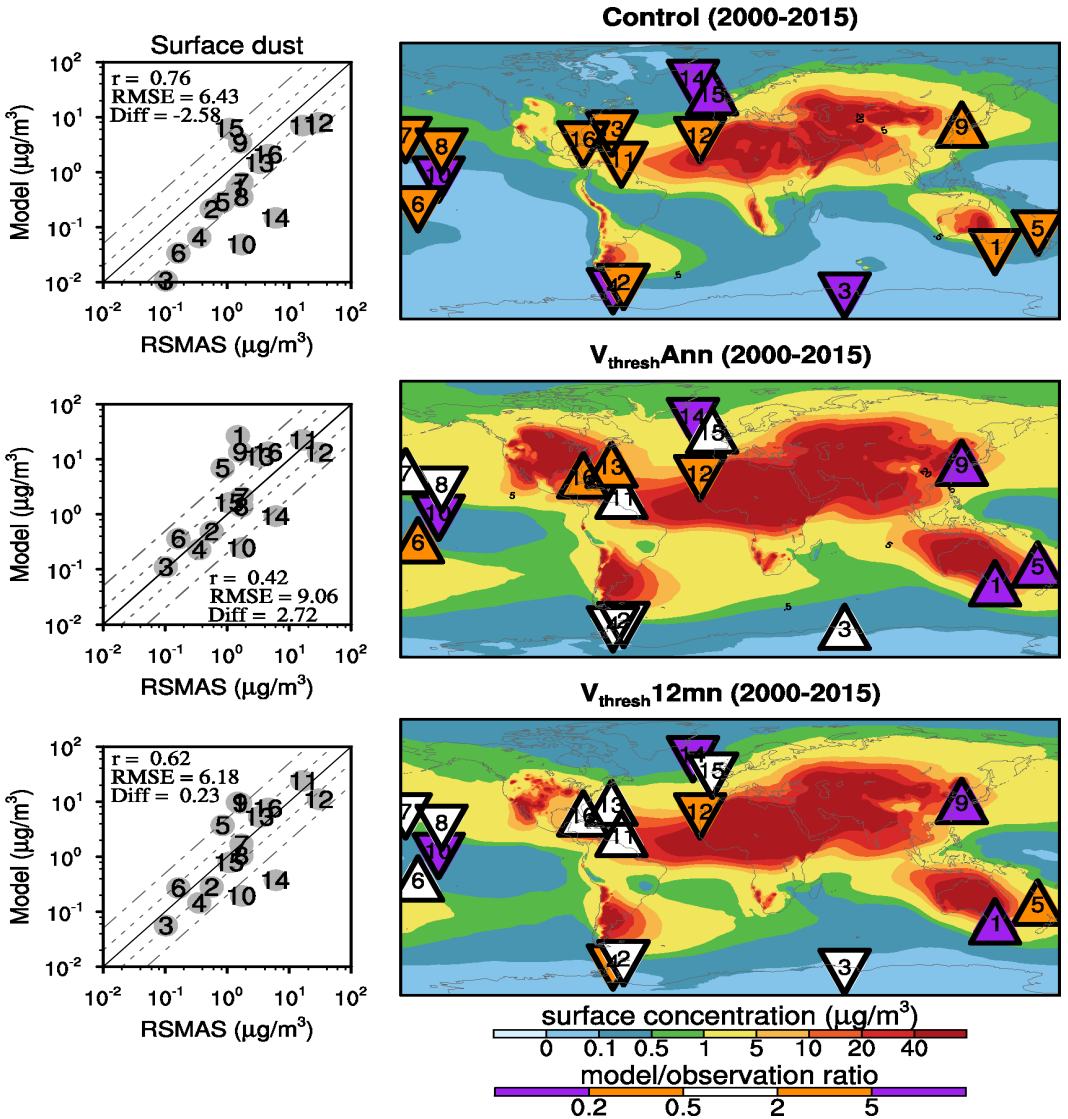
Climatology of AOD and DOD



1) Sahel 2) Sahara 3)Arabian Peninsula
4) N. China 5) India 6) US
7) S. Africa 8) S. America 9) Australia

Climatology of surface dust concentration

- Model vs. RSMAS stations

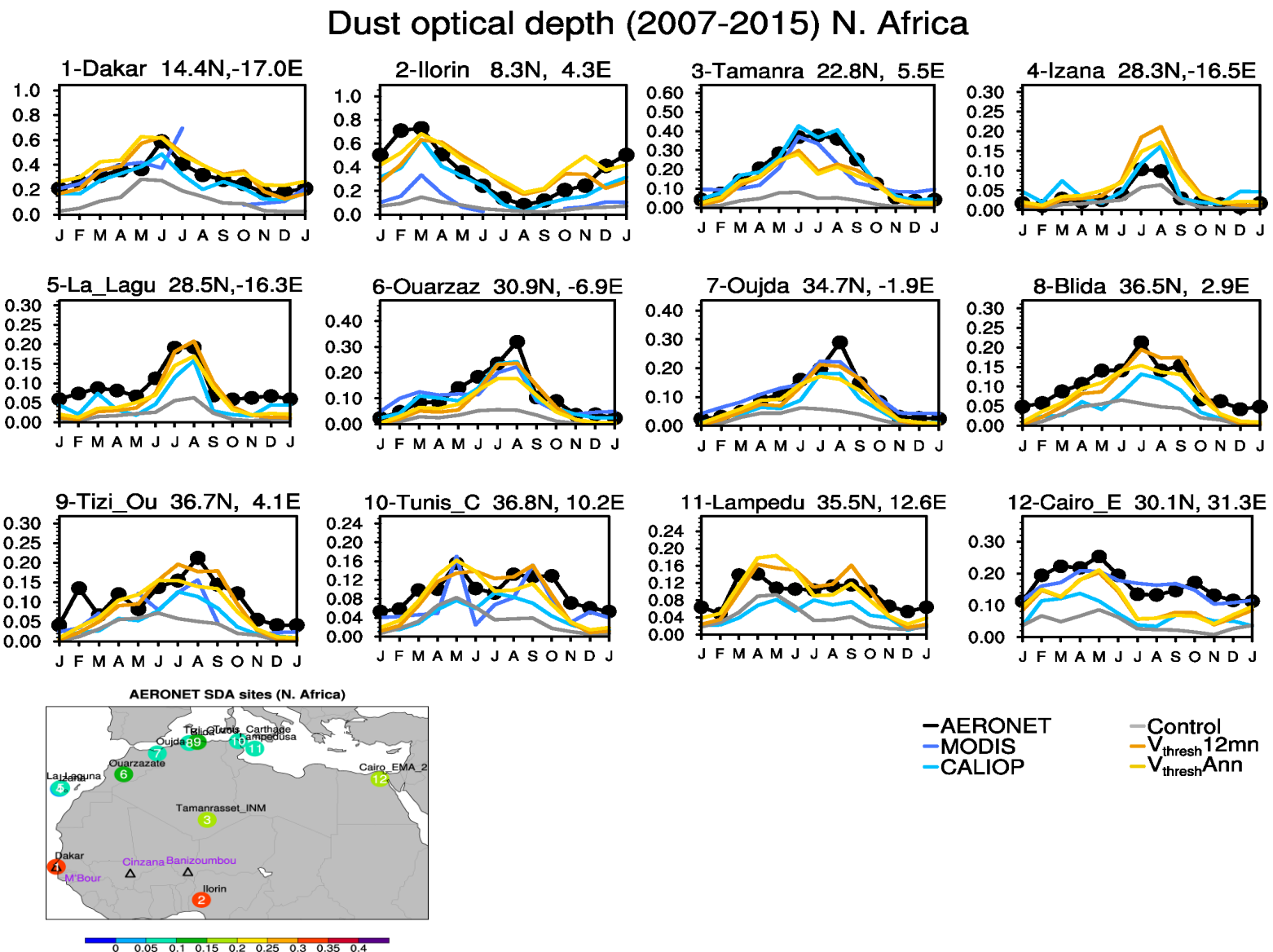


Control run

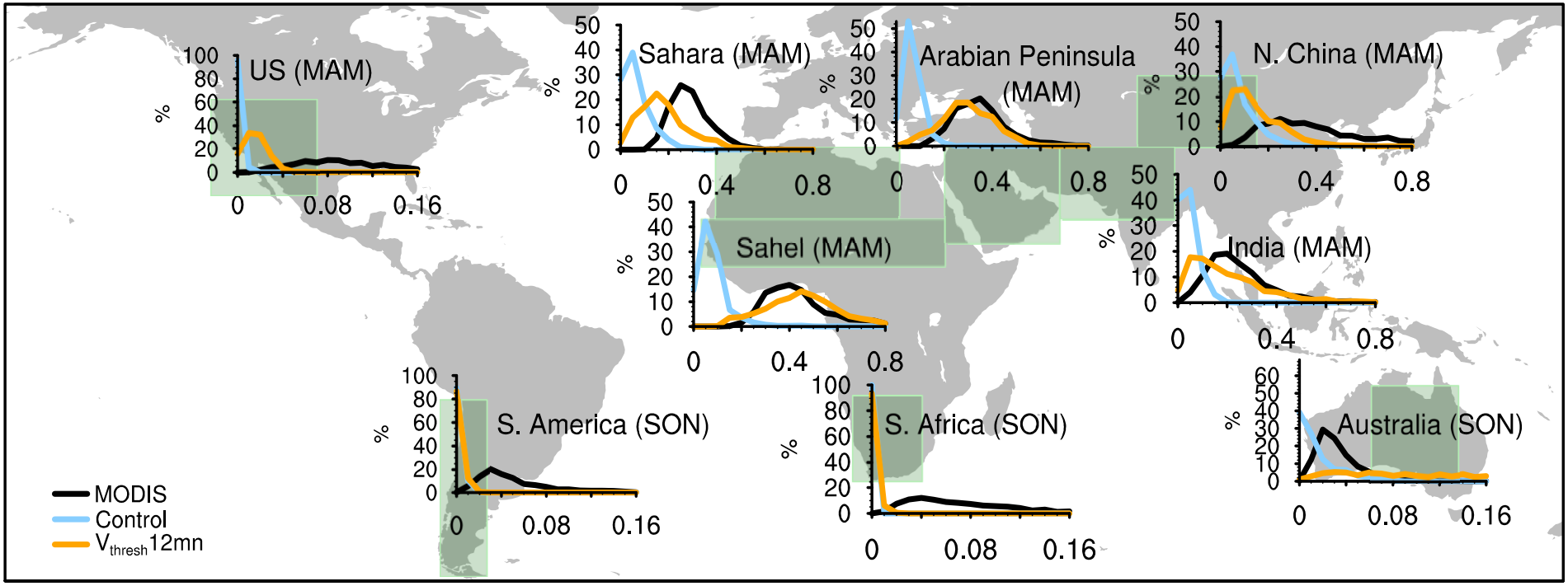
V_{thresh}Ann

V_{thresh}12mn

Seasonal Cycle



Frequency of DOD in the model and from MODIS



Uncertainties

- Biases in the satellite products are inherited in the derived DOD frequency distribution
- DOD frequency is derived based on daily records over 13 years-- some temporal dust sources may not captured
- Influences of soil properties such as soil cohesion, particle size, and particle compositions on the threshold of wind erosion are not explicitly examined here

Summary

- Using high-resolution MODIS Deep Blue **DOD** and **surface wind speeds**, along with other land surface factors, a time-varying two-dimensional threshold of wind erosion ($V_{threshold}$) over dry and bare surface is developed.
- This climatologically monthly $V_{threshold}$ is then incorporated into the GFDL AM4.0/ LM4.0 model. The climatology, seasonal cycle, and distribution of DOD are better captured over the "dust belt" (i.e. North Africa and the Middle East) than those with the default globally constant threshold.
- Simulations with time-varying $V_{threshold}$ also perform better than a constant annual-mean threshold of wind erosion.
- This global $V_{threshold}$ can be retrieved under different resolutions and may help improve the climatology and seasonal cycle of dust simulation as well as dust forecasting in other models.

Acknowledgement

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Thank you all☺

Data and methods

Over dry and bare surface

threshold % of cumulative frequency of DOD (53.8%)

% of cumulative frequency of V_{10m} (53.8%)