Evaluation of CMIP6 AOD over the Middle East North Africa (MENA) region

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BACKGROUND

- Approximately 75% of the global aerosol burden is attributed to dust aerosols originating from the Middle East North Africa (MENA) region.
- Couple Model Intercomparison Project phase 6 (CMIP6) act as a vital tool in comprehensive investigations of aerosol characteristics that provide wide spatial and temporal coverage.
- Regional evaluations of the CMIP6 model simulated Aerosol Optical Depth (AOD) exclusively over the MENA region are limited.
- It is essential to investigate how the CMIP6 models simulate AOD over the MENA region.

DATA SETS

- CMIP6 (study period: 2001-2014 for historical, 2040-2050 for future projections)

Model	Spatial Resolution
ACCESS-CM2	1.875^0 x 1.25^0
ACCESS-ESM1-5	1.875^0 x 1.25^0
AWI-ESM-1-1-LR	0.9^0 x 0.9^0
EC-Earth3-AerChem	3.0^0 x 2.0^0
GFDL- CM4	1.25^0 x 1.0^0
GFDL-ESM4	1.25^0 x 1.0^0
INM-CM4-8	1.50^0 x 2.0^0
INM-CM5-0	1.50^0 x 2.0^0
IPSL-CM6A-LR	1.26^0 x 2.5^0
MPI-ESM1-2-HR	1.875^0 x 1.875^0
MPI-ESM1-2-HAM	1.875^0 x 1.875^0
MRI-ESM2-0	1.125^0 x 1.125^0

- MERRA-2 Reanalysis, MODIS for model evaluation

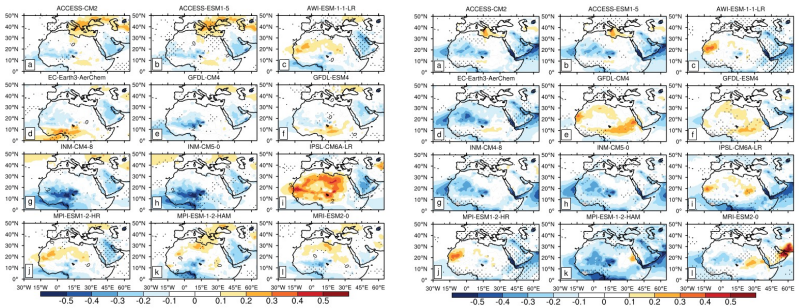

Fig. 2: AOD bias between individual CMIP models and MODIS AOD for MAM and JJA

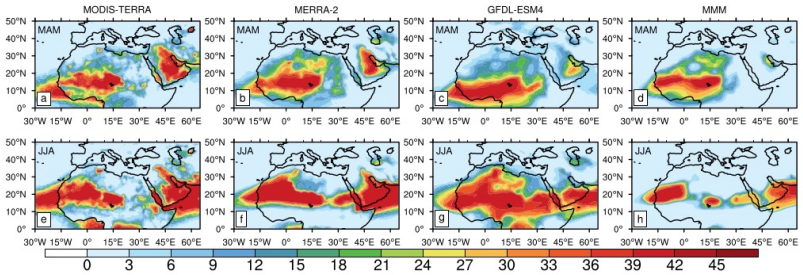

Fig. 4: Number of occurrences (NoO) when monthly AOD is >0.4, obtained from MODIS, MERRA2, GFDL-ESM4, and MMM over the MENA region.

- The difference in the NoO for AOD >0.4 patterns between the MMM and the GFDL-ESM4 can be due to the structural differences in aerosol schemes employed in the individual CMIP6 models .

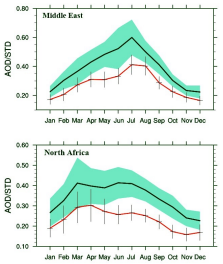

Fig. 3. Monthly Climatology of MODIS(black line) and CMIP6 Multi-Model mean AOD (red line).

- The individual CMIP6 models show large diversities in the spatial distribution of AOD with many models failing to capture key features of AOD over the MENA region.
- The GFDL-ESM4 model simulates the spatiotemporal distribution of seasonal AOD better than the MMM in comparison with reanalysis and satellite observations.
- The different driving factors that make GFDL-ESM4 outperform MMM are the ability to simulate DOD, prevailing wind patterns and direction, and soil moisture accurately.
- A comparison of MMM AOD of high, medium, and low emission scenarios for JJA (2040-2050) reveals no significant change.
- The changes in the NoO are consistent with AOD changes with GFDL-ESM4 simulation showing the highest value in the SSP5-8.5 emission scenario, followed by SSP2-4.5 and SSP1-2.6 respectively for both seasons.

RESULTS

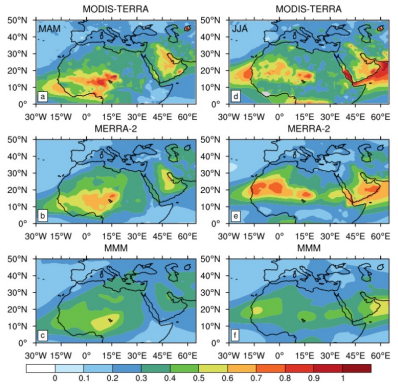

Fig. 1: AOD seasonal climatology from MODIS, MERRA-2 and CMIP6 Multi-model mean (MMM)

- The AOD values obtained from the MMM are consistently 0.2 to 0.3 units lower than those observed by MODIS and MERRA-2 over hotspot regions

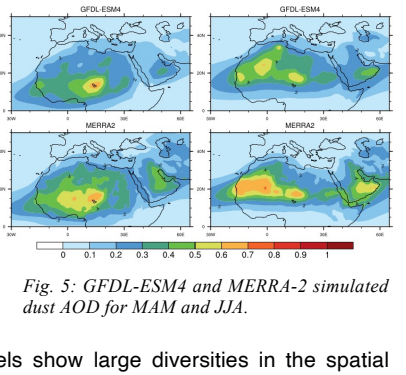

Fig. 5: GFDL-ESM4 and MERRA-2 simulated dust AOD for MAM and JJA.

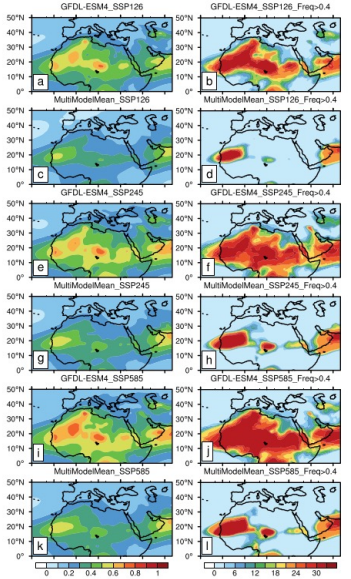

Fig. 6: Spatial AOD and NoO when monthly AOD is >0.4, obtained from GFDL-ESM4 and MMM for different emission scenarios.

CONCLUSIONS

- The MMM from CMIP6 models doesn't have to be the best way of representing the aerosol scenario.
- Studying the AOD distribution of individual CMIP6 models before using the MMM may be a better approach before investigating the climate impact of aerosols.