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Topic: The Remote Sensing Data Analysis for Effects of Two Selected Aerosol Particles to the Global Climate Change and Human Health: the Focus on Africa

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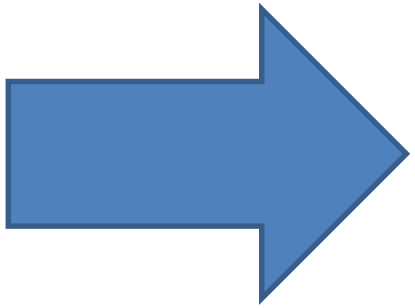
OUTILINES



- Overview;
- Materials and Methods;
- Results and discussion;
- Conclusion;
- Acknowledgments

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Overview

- The desert's dust & anthropogenic biomass burning's black carbon are associated with many effects to climate and air quality, in the tropical regions .
- In this research article,
  - the dust and black carbon affects human health by polluting the breathable air.
  - both the TWO aerosols have considerable effects on the climate change, especially on the clouds.
  - the effects of dust and black carbon (BC) on clouds formation in Africa is studied based on the respective aerosol extinction optical thickness (AOT) extinction analysed together with the sensible heat from Turbulence.
  - As part of results, the fine particulate matter, $PM_{2.5}$, an unavoidable heterogeneous mixture of both the dust and the pulverized black carbon's soot or ash, is quantitatively studied to analyse where and when $PM_{2.5}$ can endanger human health in sub-Saharan region.

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Overview (cont'd)

- The existing literature classified the same region under Meningitis Belt that is overextending.
- **Methodology:**
  - The analysed data has been collected from the second version of modern era retrospective analysis for research and applications (MERRA-2).
  - Goddard interactive online visualization and analysis infrastructure (GIOVANNI) bridged our research objectives to the data; the Geographical Information Systems (GIS) is one of the used software tools.
  - Sub-spatial and sub-temporal resolutions facilitated the focused study.

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Overview (cont'd)

- **In results:**
  - the rise and fall of the averaged sensible heat were associated to the rise and fall of averaged aerosol extinction AOT; the direct effects of the selected aerosols on the clouds are also presented.
  - Seasons with the heaviest dust's fine particulate matter ($PM_{2.5}$) are discussed and some recommendations put forward for the sustained human health in case of the highest pollution of the breathable air.
- **A recommendation:** The atmosphere is a globally shared resource; organs concerned with natural resource management to work on strategies that will mitigate the hazards due to both the desert's dust and the anthropogenic combustion's black carbon on health and on abnormal changes of the climate.

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The related literature

- The biggest deserts' dust heavily contributes to the global airborne particulates; there are many effects of dust aerosol

Hamdan, N. M., Alawadhi, H., Jisrawi, N., & Shameer, M. (2018). Characterization of fine particulate matter in Sharjah, United Arab Emirates using complementary experimental techniques. *Sustainability (Switzerland)*, *10*(4). https://doi.org/10.3390/su10041088

Varga, G. (2012). *Spatio-temporal distribution of dust storms – a global coverage using NASA TOMS aerosol measurements*. *61*(4), 275–298.

- aerosol becomes more severe to human health if it come to the particulate matter in general

Hamdan et al., 2018

Fullová, D., Ďurčanská, D., & Hegrová, J. (2017). **Impact of Asphalt Mixture Composition on Particulate Matter** Production. *Procedia Engineering*, *192*, 201–206. https://doi.org/10.1016/j.proeng.2017.06.035

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The related literature

- Besides, quantifying the Earth's energy balance is central to understanding the climate system and predicting the effects of global climate change

Ackerman, S. A., Platnick, S., Bhartia, P. K., Duncan, B., L'Ecuyer, T., Heidinger, A., … Smith, N. (2018). **Satellites See the World's Atmosphere.** *Meteorological Monographs*, *59*, 4.1-4.53. https://doi.org/10.1175/amsmonographs-d-18-0009.1

- In remote sensing:
  - aerosol optical thickness (AOT) is an extent to which aerosol (haze, smoke, dust, sea salt, etc.), obstructs the light transmission through the phenomenon of absorbing or scattering the light;
  - AOD (AOT) is distributed within a column of air to the top of the atmosphere.

Holben, B. N., Eck, T. F., Slutsker, I., Tanré, D., Buis, J. P., Setzer, A., … Smirnov, A. (1998). **AERONET—A Federated Instrument Network and Data Archive for Aerosol Characterization.** *Remote Sensing of Environment*, *66*(1), 1–16. https://doi.org/10.1016/S0034-4257(98)00031-5

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The related literature

- Apart from the desert's fine particulates, the process of biomass burning is the primary source of global air polluting particles:
  - The smoke as a gaseous aerosol broadly links with ecosystem (ie. living organisms and non-living entities like atmospheric air as well as cloud and climate).

Chen, J., Li, C., Ristovski, Z., Milic, A., Gu, Y., Islam, M. S., … Dumka, U. C. (2017). A review of biomass burning: Emissions and impacts on air quality, health and climate in China. *Science of the Total Environment*, *579*(November 2016), 1000–1034. https://doi.org/10.1016/j.scitotenv.2016.11.025

- In this research, the selected particles are the dust's fine particulate matter ($PM_{2.5}$) as well as Black Carbon (BC):

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The related literature

- Cardiovascular problems and death caused by air pollution are globally reported: more people die of air pollution than they die of acute and viral diseases.

Guo, H., Huang, S., & Chen, M. (2018). Air pollutants and asthma patient visits: Indication of source influence. *Science of the Total Environment*, *625*, 355–362. https://doi.org/10.1016/j.scitotenv.2017.12.298

- The **dust belt** (Varga, 2012) as well as the **meningitis belt** (Thomson et al., 2013) keep expanding from Africa;

Varga, G. (2012). *Spatio-temporal distribution of dust storms – a global coverage using NASA TOMS aerosol measurements*. *61*(4), 275–298.

Thomson, M. C., Jancloes, M., Foundation, C., Nickovic, S., Storm, D., & Advisory, W. (2013). *Climate Science for Serving Society*. (May 2014). https://doi.org/10.1007/978-94-007-6692-1

- Therefore, **Africa** is the selected focal research area:

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The related literature

◆Research Objectives:

- Demonstrate the direct effects of the two Selected Aerosol Particles to the Sensible Heat from Turbulence, to Cloud cover as well as to the human health, by focusing on Africa;
- To show by results the quantitative analysis of the levels of the fine particulate matter ($PM_{2.5}$) based on five subdivisions in Africa.
- To discuss both the polluting and direct link with the sustainability of the ecology.

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The related literature

- A research question:
  - **when and where exactly**, in a selected region, can the dust, and the black carbon affect the sustainability of ecosystem in attenuating the clouds? what about the quantity of breathable fine particulate matter in the focal region?

2. Materials and Methods

2.1. The research data source

2.2 Research Method’s Roadmap

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2.1. The research data source

- The raw and data for this research was collected via MERRA-2,
  - an online model which directly assimilates the remote sensing data from the MODIS and the advanced very high-resolution radiometer, AVHRR.
  - MERRA-2 is thus equipped by the update algorithm ….. thus, an acknowledgeable model of the Goddard earth sciences and information services center (GES-DISC) since January 1980 (Rienecker et al., 2011).

GES DISC (2019). Giovanni, the Bridge between Data and Science, version 4.28 [text]. Retrieved from https://giovanni.gsfc.nasa.gov/giovanni/ (last visited in 14 November, 2019).

Rienecker, M. M., Suarez, M. J., Gelaro, R., Todling, R., Bacmeister, J., Liu, E., … Woollen, J. (2011). MERRA: NASA's modern-era retrospective analysis for research and applications. *Journal of Climate*, *24*(14), 3624–3648. https://doi.org/10.1175/JCLI-D-11-00015.1

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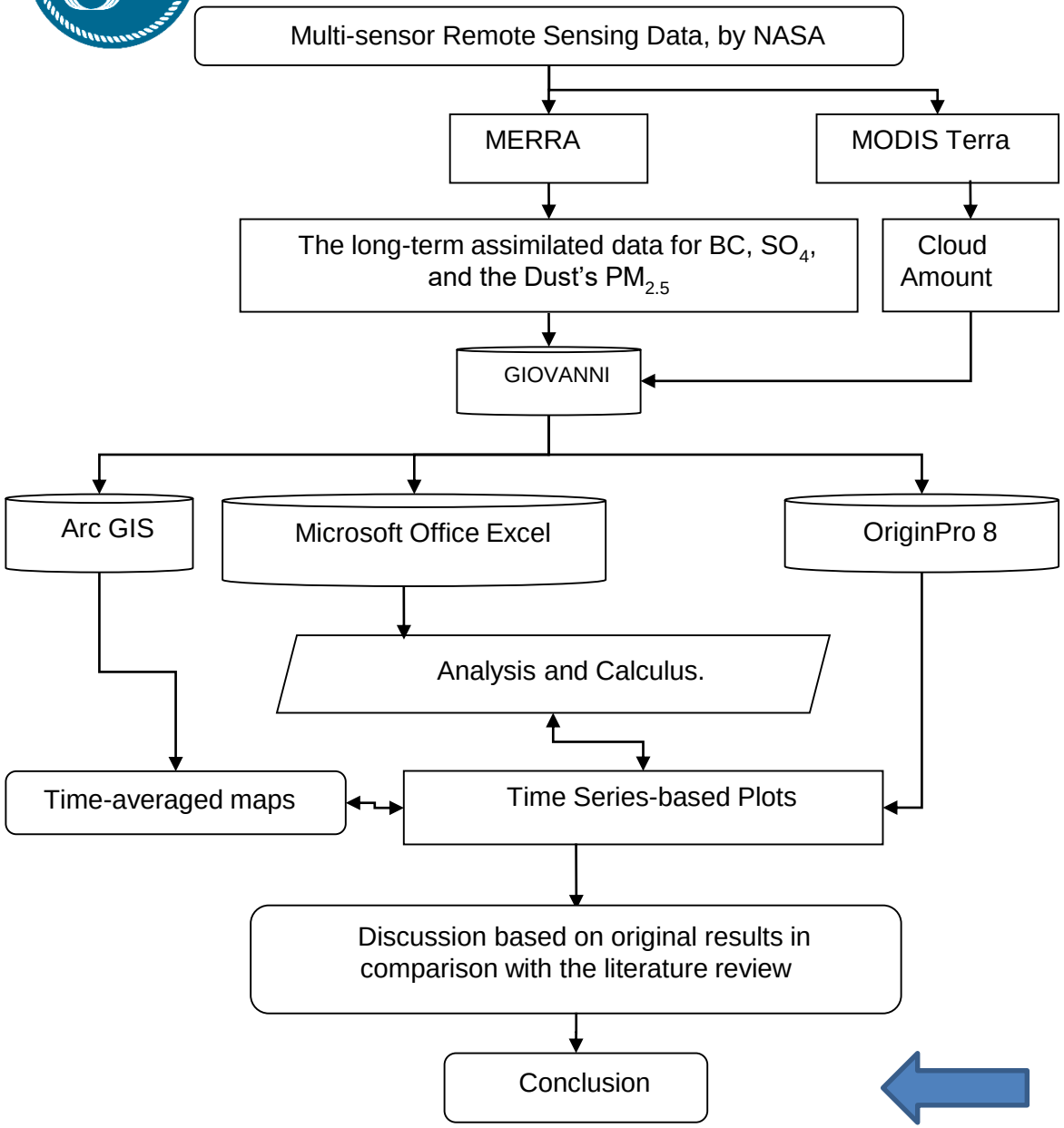
2.2 Research Method's Roadmap



- GIOVANNI: Goddard Interactive Online Visualization ANd aNalysis Infrastructure (GES-DISC, 2019) bridged the research needs to the NASA data and science;
- further data treatment has been necessary for most of the presented results in this research.
- Arch GIS, Excel and Origins: Software tolls utilized to treat the data

Figure 1: The research roadmap

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Results and discussion

- 3.1. Results in the entire Africa;
- 3.2. Results based on sub-spatial resolutions in Africa;
- 3.3. Discussion.

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Results and discussion

- Throughout in the manuscript, the abbreviated seasons are used as:
  - **DJF (December, January, and February)**: the winter in the northern hemisphere;
  - **MAM (March, April, and May)**: the northern hemisphere’s spring season.
  - **JJA (June, July, and August)**: the northern hemisphere's summer;
  - **SON (September, October, and November)**: the northern hemisphere's autumn season.

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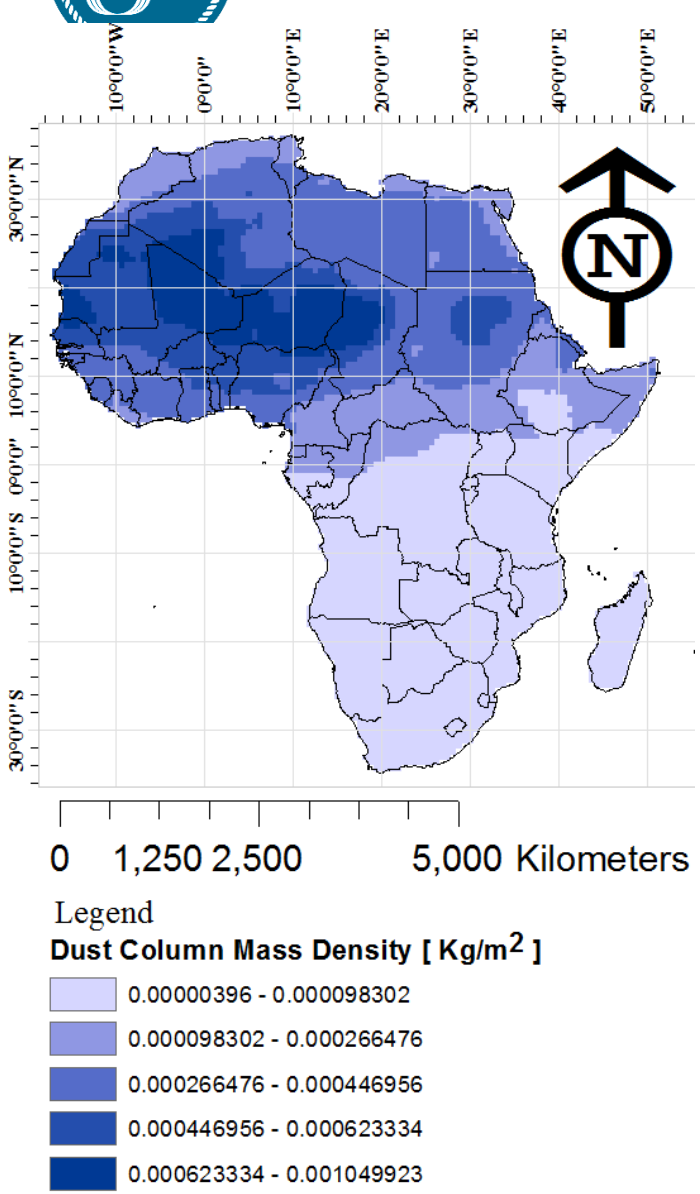
3.1. Results in the entire Africa



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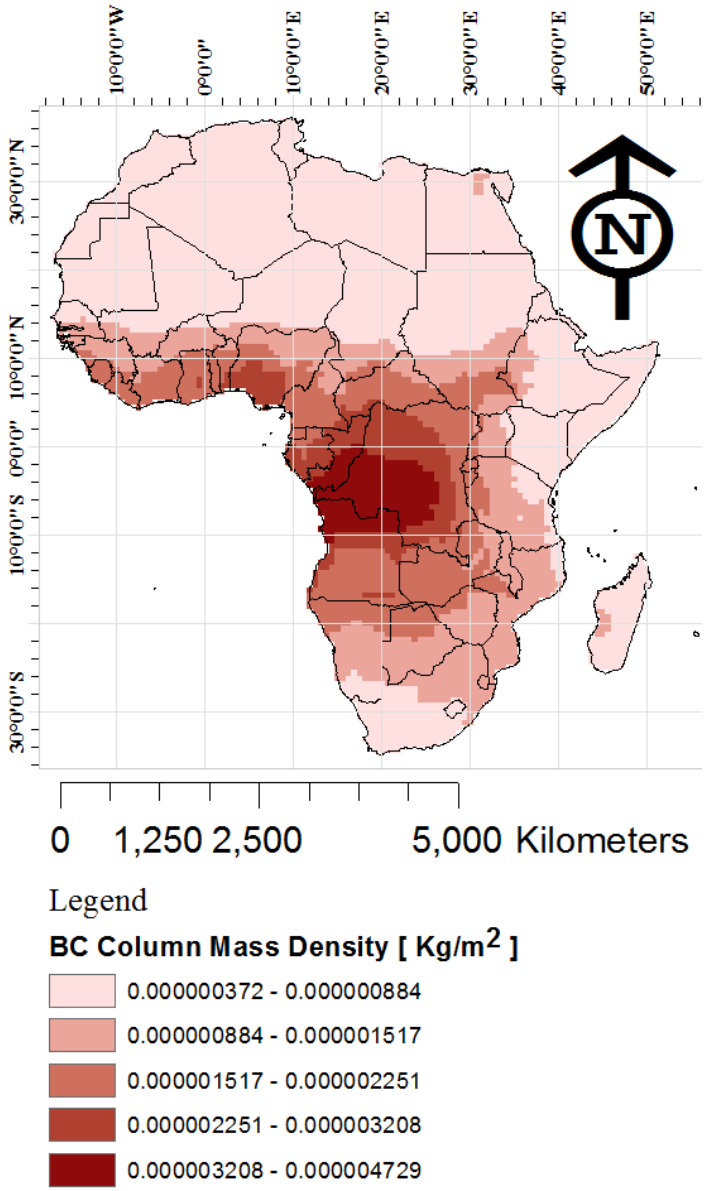

(b)

Figure 2: The Africa time averaged Map for the Column Mass Density, from January 2000 to September 2019:

(a)Dust aerosol;

(b)Black Carbon aerosol

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3.1. Results in the entire Africa (Cont.)

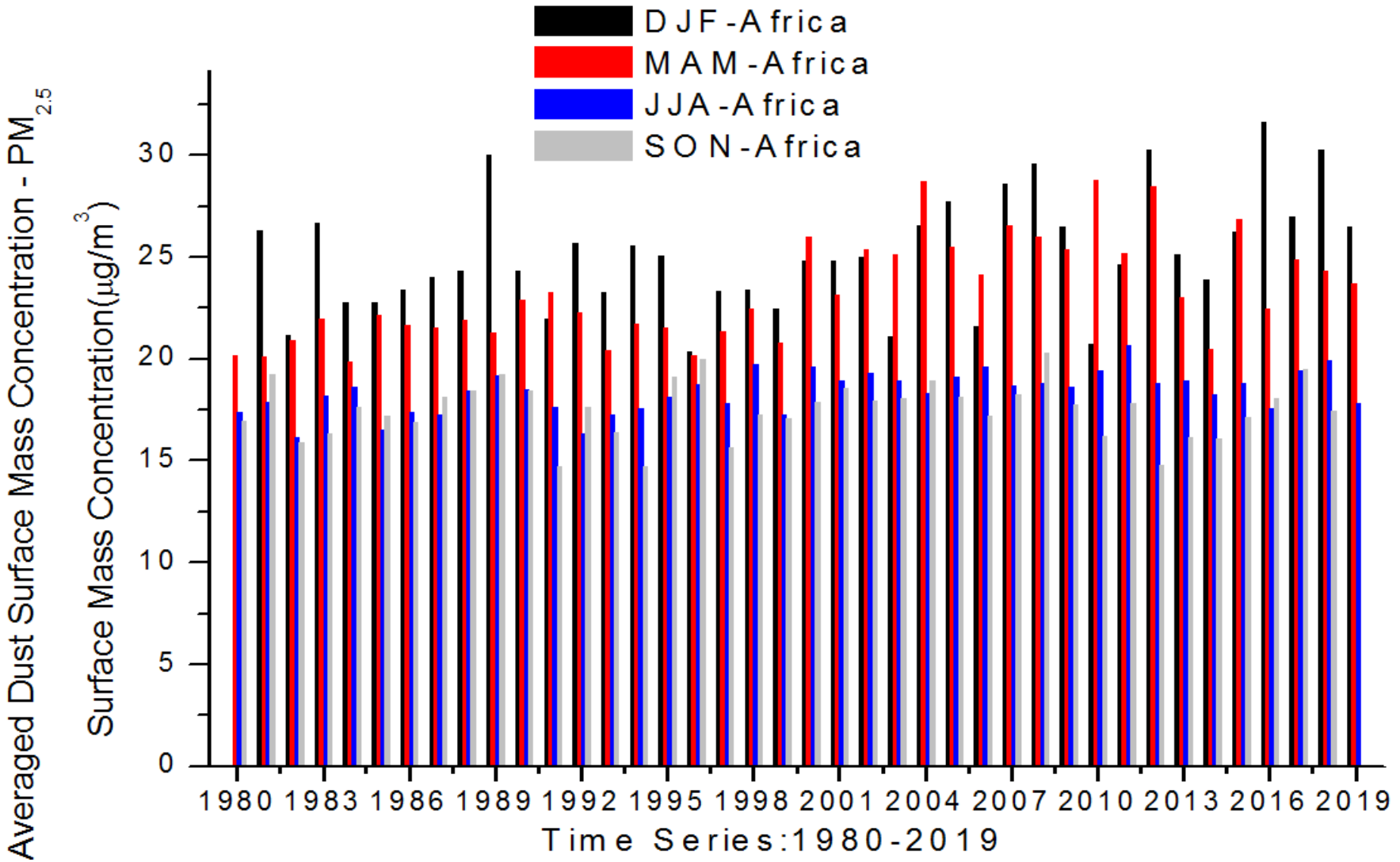

Figure 3. The long-term and averaged time-series of the Surface Mass Concentration in the entire Africa for: (a) the Dust's PM 2.5 monthly,

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3.1. Results in the entire Africa (Cont.)

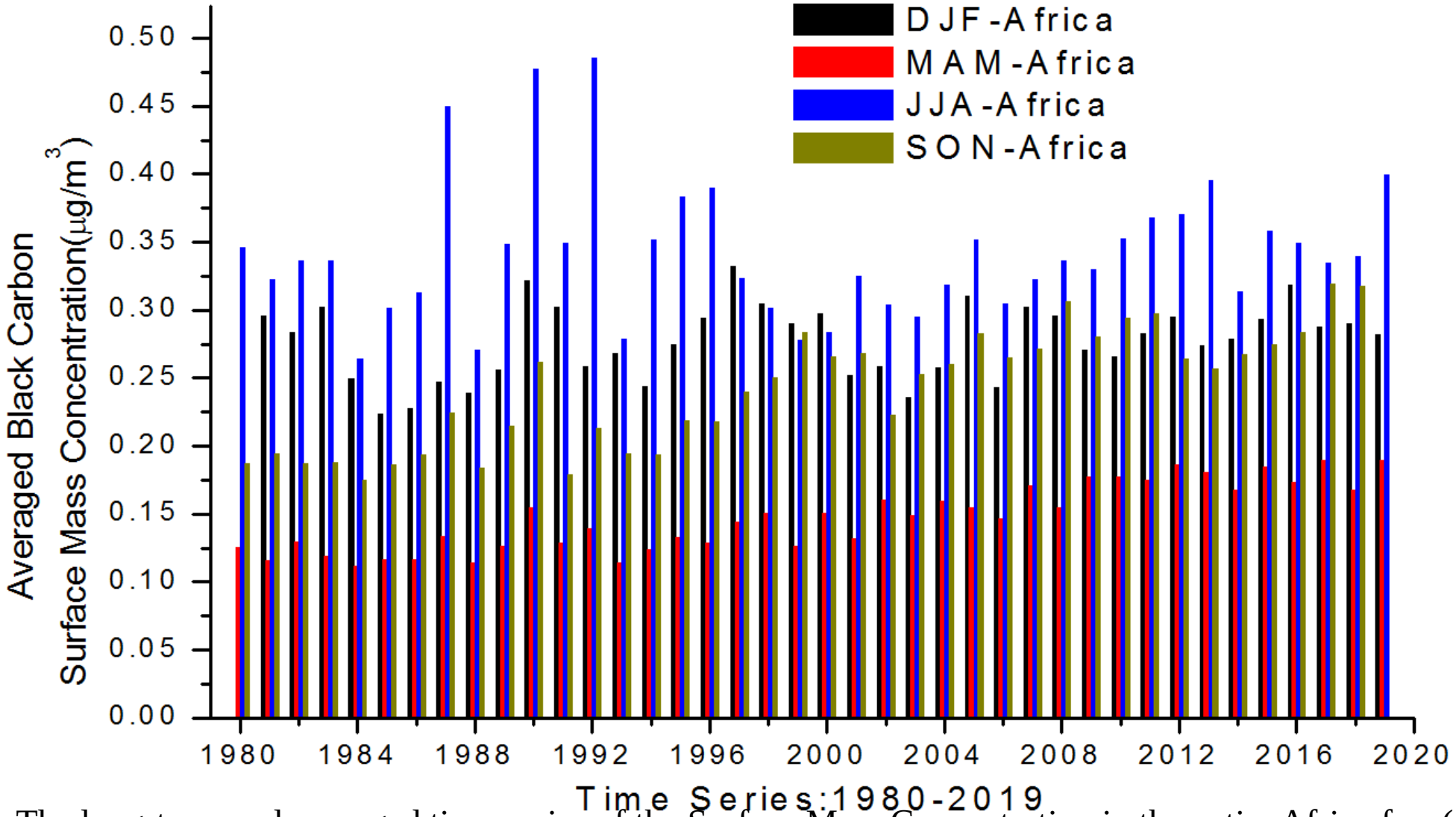

Figure 3. The long-term and averaged time-series of the Surface Mass Concentration in the entire Africa for: (a) the Dust's

(b) Black Carbon

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3.2. Results based on sub-spatial resolutions in Africa

- With knowledge of the African physical Geography as well as climates, five sub-regions had been created and those are described:
  - 15º W, 9.5º E, (4-14)º N for the West Africa;
  - 10º W, 52º E, (24-40)º N for the North Africa and neighbourhood;
  - (9.5-30)º E, 10º S, 14º N for Central Africa;
  - (11-35)º E, (10-35)º S for the South Africa;
  - (30-52)º E, 28º S, 12º N for East Africa.

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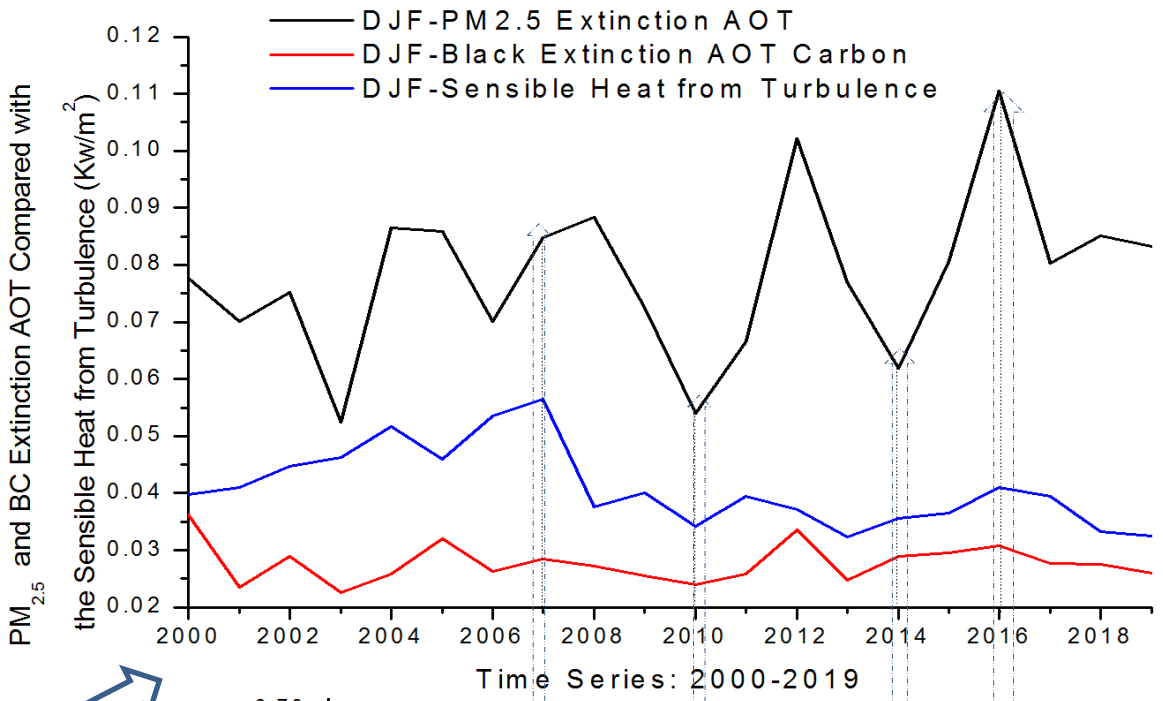
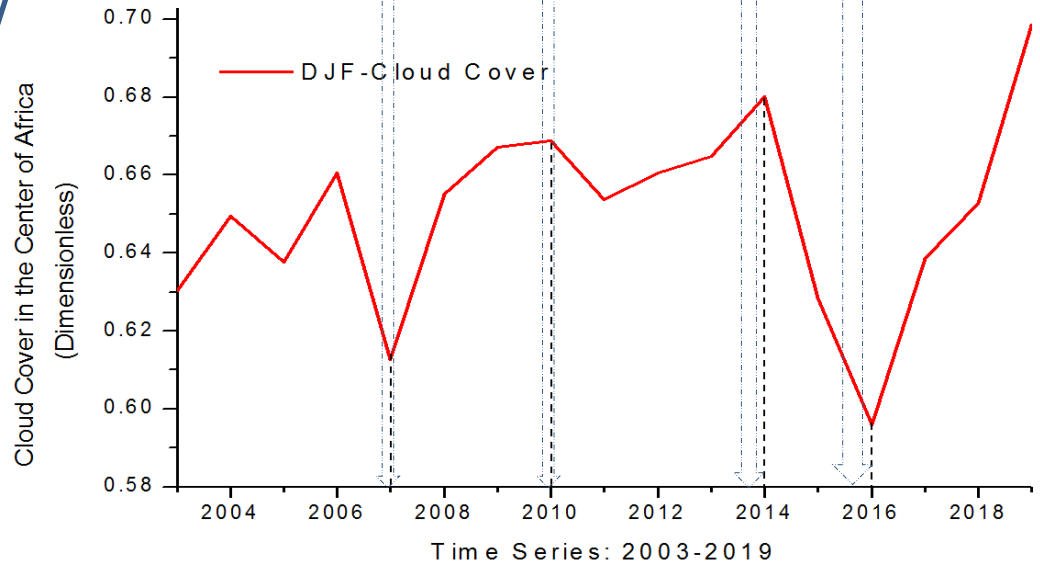
3.2. Results based on sub-spatial resolutions in Africa

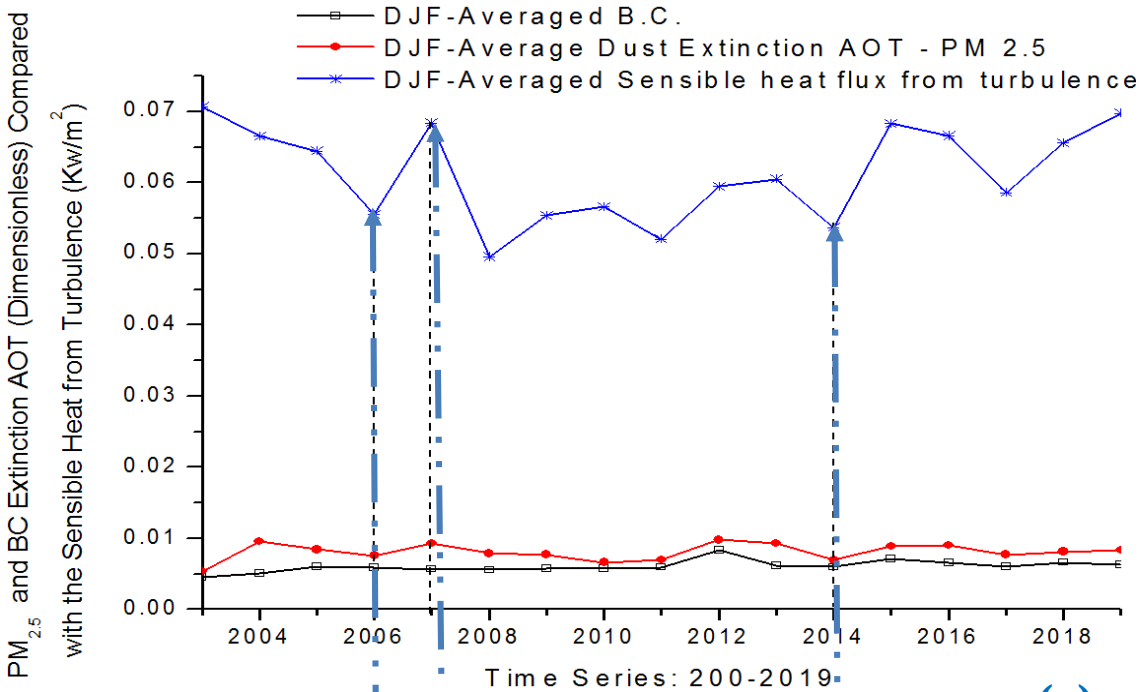


(a)



Central Africa

(b)



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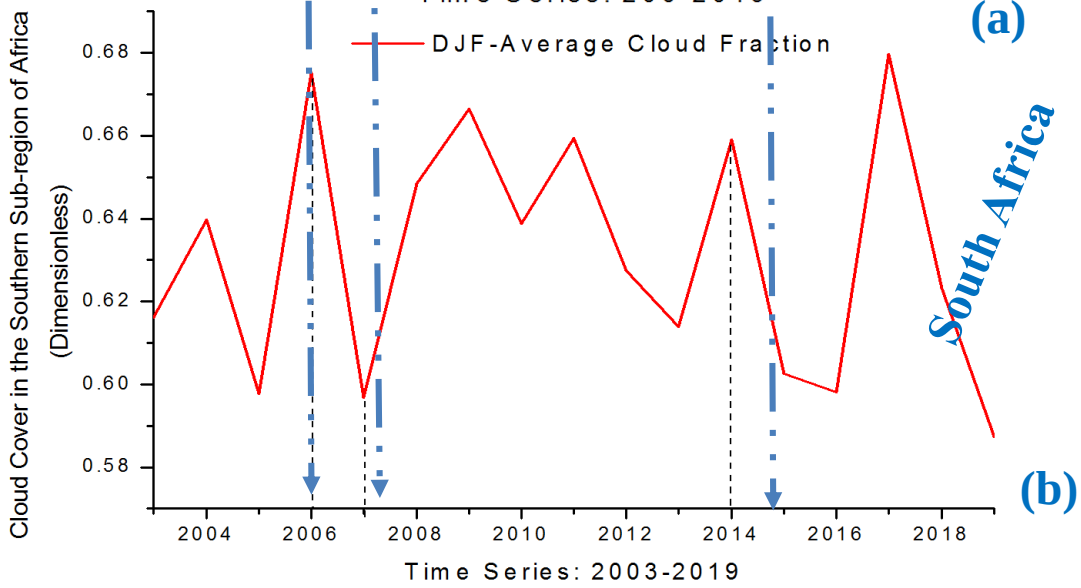

South Africa

(b)

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3.3. Discussion

- The dust storm's particulate matter has been reported as an agent of pulmonary tuberculosis (Wang et al., 2016) and the dry desert's dust an agent to Meningococcal meningitis (Agier et al., 2017, p. 108-109).

Wang, Y., Wang, R., Ming, J., Liu, G., Chen, T., Liu, X., … Cheng, G. (2016). **Effects of dust storm events on weekly clinic visits related to pulmonary tuberculosis disease in Minqin, China.** *Atmospheric Environment*, *127*, 205–212. https://doi.org/10.1016/j.atmosenv.2015.12.041

Agier, L., Martiny, N., Thiongane, O., Mueller, J. E., Paireau, J., Watkins, E. R., … Broutin, H. (2017). Towards understanding the epidemiology of Neisseria meningitidis in the African meningitis belt: a multi-disciplinary overview. *International Journal of Infectious Diseases*, *54*, 103–112. https://doi.org/10.1016/j.ijid.2016.10.032

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3.3. Discussion

- In this research, the quantitative results in Table 1 show that the dust's fine particulate matter ($PM_{2.5}$) in all the 5 sub-regions, the annually-averaged mass concentration of the dust's $PM_{2.5}$ is significantly greater than the mean concentration of 25µg/m^3 (Chen et al., 2017).

Chen, J., Li, C., Ristovski, Z., Milic, A., Gu, Y., Islam, M. S., … Dumka, U. C. (2017). A review of biomass burning: Emissions and impacts on air quality, health and climate in China. *Science of the Total Environment*, *579*(November 2016), 1000–1034. https://doi.org/10.1016/j.scitotenv.2016.11.025

Table 1: The seasonal surface mass concentration (µg/m^3) of the dust's $PM_{2.5}$, in the focal region of interest

	West-Africa				North-Africa				Central-Africa			
TIME	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
2000	66.8	54	9.4	21.1	25.3	40.9	39.1	33.3	34.4	24.6	6.1	11.3
2001	69	38.8	9.3	26.9	29.1	39.8	39.1	33.4	31.6	21.1	5.9	12.0
2002	67.2	46	9.7	21.4	28.9	43.3	38.9	33.3	32.7	23.8	6.4	11.9
2003	45.1	43.2	9.1	18.3	31.3	42.8	37.6	35.5	23.3	25.9	6.2	11.2
2004	74.2	60.7	10	25.7	34.2	46.5	36.6	34.1	35.6	36.3	6.6	14.4
2005	75.6	44.8	9.5	23.7	36.4	43.9	38.6	33	34.2	26.2	6.7	12.5
2006	36.9	47.9	11.8	25.2	33.5	40	40.4	30.3	26.3	26.1	6.9	12.2
2007	84.6	54.1	8.4	26.1	31.6	44	39.4	32.3	35.4	27.7	5.7	13.4
2008	85.2	44.9	7.9	29.4	32.3	47.8	40.7	37.4	38.4	22.7	5.0	12.8
2009	59.1	42.2	9.2	25.2	39.1	42.3	37.3	31.6	29.9	27.9	6.1	12.7
2010	37.2	56	10.6	16.8	38.6	47.8	38.3	33.6	22.1	26.1	6.3	9.0
2011	58.8	37.8	12.2	22	34.4	42.9	40.3	31.5	28.7	25.5	12.2	12.7
2012	77.1	53.9	9.2	15.6	34.7	43.2	36.8	28.3	40.0	30.0	6.2	9.6
2013	57	25.4	8.4	16.5	33.2	46.1	38.9	30.3	32.0	20.1	5.6	10.5
2014	52.3	29.5	8.8	17	31.6	36.8	37.5	31.6	27.0	19.4	5.4	10.3
2015	62.9	54.5	11	24.2	34.3	38.7	37.8	30.3	33.6	33.7	6.5	11.0
2016	108.3	29	7.9	28.5	28	40.2	36.2	31.4	46.1	21.8	5.2	13.0
2017	67.2	41.3	14.1	36.5	30.8	41.8	36.3	30.5	36.8	27.1	9.4	17.5
2018	85.1	39.7	14.4	24.3	37	46.4	37.8	32	36.4	26.0	7.1	11.4
2019	63.6	41.3	10.9	N/A	32.4	39	35.1	N/A	37.0	25.5	6.1	N/A

Table 1: The seasonal surface mass concentration ($\mu g/m^3$) of the dust's $PM_{2.5}$, in the focal region of interest

3.3. Discussion

Thus, the region is heavily polluted by the dust's $PM_{2.5}$, extremely high in the DJF seasons of the West, north and Central African sub-regions of interest.

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3.3. Discussion (Cont'd)

	East-Africa				South-Africa			
TIME	JJA	SON	JJA	SON	JJA	SON	JJA	SON
2000	4.5	4.6	3.7	2.5	1.6	1.8	2.1	2.1
2001	5.1	4.0	3.5	2.6	2.4	1.5	1.8	1.7
2002	5.1	3.8	4.0	2.7	2.2	1.3	1.8	1.8
2003	3.7	4.6	3.8	2.7	1.6	1.5	1.8	2.0
2004	5.2	5.1	3.7	2.7	2.7	2.4	1.9	1.8
2005	4.6	3.7	3.9	2.8	2.2	1.7	1.6	1.9
2006	4.3	4.4	3.8	2.6	2.0	1.6	1.9	1.8
2007	5.8	4.3	3.5	3.3	2.6	1.8	1.9	2.2
2008	7.3	4.6	4.0	3.6	2.2	1.3	1.6	2.1
2009	5.4	5.0	3.9	2.9	2.2	1.5	1.9	1.8
2010	4.5	4.5	3.8	3.2	2.0	1.5	1.9	2.0
2011	5.6	4.3	6.3	3.5	2.0	1.3	1.9	2.1
2012	7.8	6.6	4.5	3.0	2.7	1.8	1.9	2.0
2013	5.6	4.1	4.3	2.9	2.6	1.7	1.8	2.0
2014	5.7	3.3	3.9	2.8	2.1	1.6	1.9	1.9
2015	5.8	4.8	4.1	2.7	2.7	1.6	1.6	2.0
2016	6.5	3.8	3.8	3.2	2.7	1.7	1.7	1.9
2017	5.5	4.5	4.9	3.4	2.3	1.5	1.5	1.7
2018	6.8	4.9	5.3	2.9	2.4	1.8	2.1	1.9
2019	5.2	4.3	3.9	N/A	2.5	1.8	1.7	N/A

Table 1: The seasonal surface mass concentration ($\mu g/m^3$) of the dust's $PM_{2.5}$ in the focal region of interest

3.1. Results in the entire Africa (Cont.)

- From the results in Table 1, the surface mass concentration of the dust's fine particulate matter $PM_{2.5}$, are undoubtedly dangerous, especially in the world's dust belt and surroundings; say the West, north and Central Africa sub-regions.

Dust-Belt and Meningitis Belt are illustrated below:

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Results and discussion

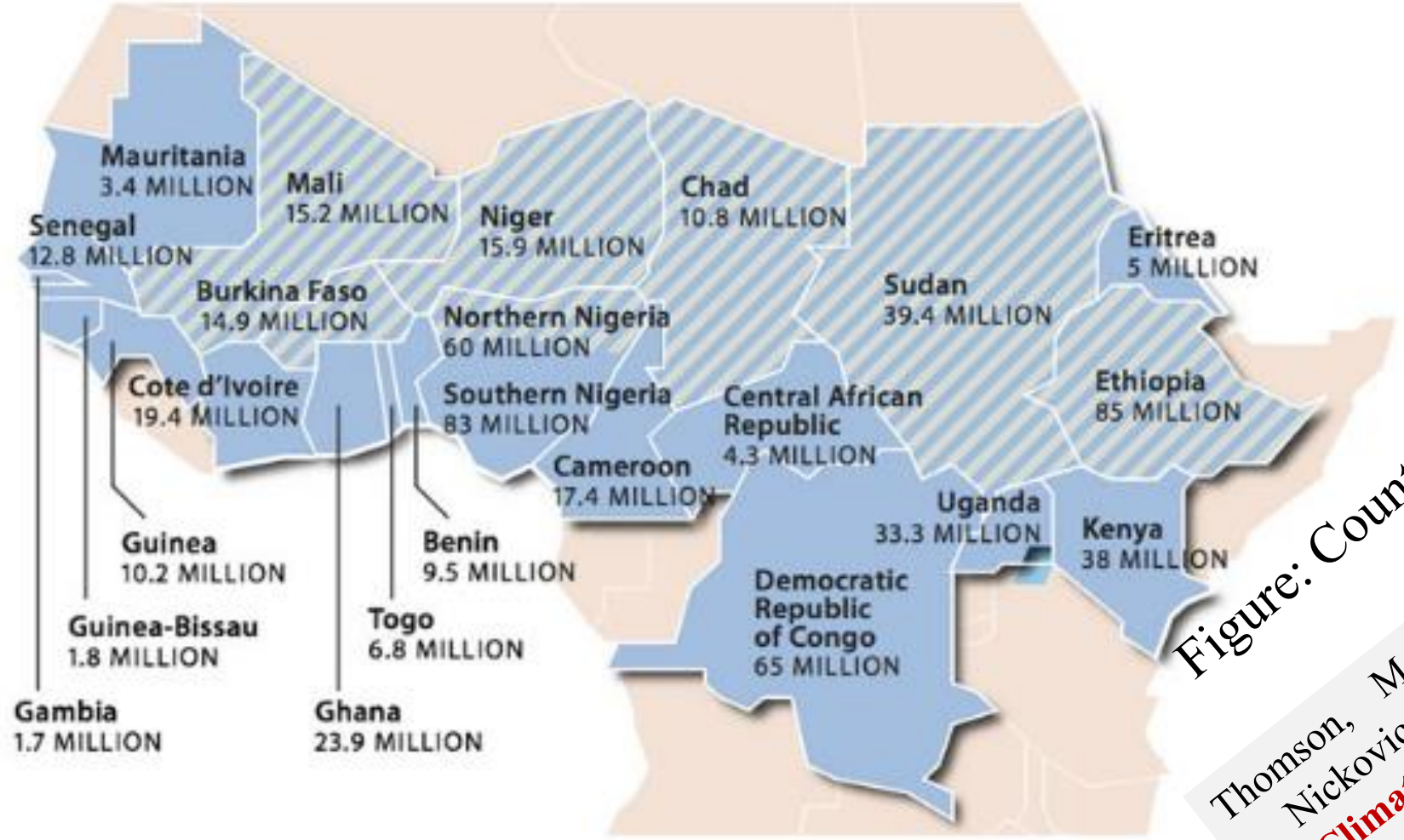

Figure: Countries of the '**Meningitis Belt**'

Thomson, M. C., Jancloes, M., Foundation, C., Nickovic, S., Storm, D., & Advisory, W. (2013). **A Climate and Health Partnership to Inform the Prevention and Control of Meningoccocal Meningitis in Sub-Saharan Africa: The MERIT Initiative**. *Climate Science for Serving Society*. (M 2014). https://doi.org/10.1007/978-94-007-6692-

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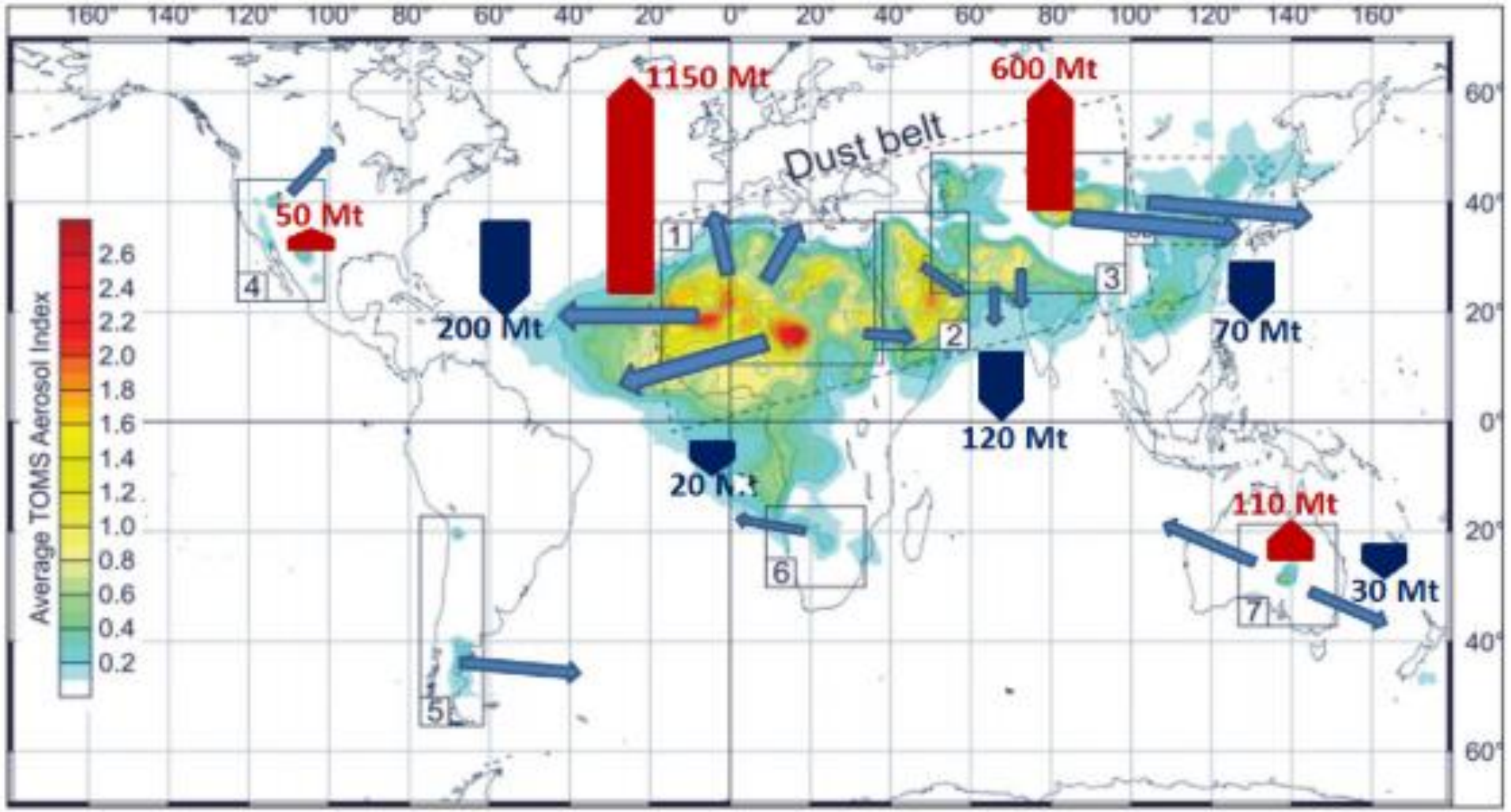
Results and discussion



Main routes of desert dust transport (light blue arrows) and locations of the major dust sources: **(1) Sahara; (2) Arabia; (3) Asia; (4) North America; (5) South America; (6) Southern Africa; and (7) Australia,**

Varga, G. (2012). **Spatio-temporal distribution of dust storms – a global coverage using NASA TOMS aerosol measurements.** *61(4), 275–298.*

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Conclusion and recommendations

- The results presented in different formats in this research demonstrated the effects of aerosols on climate change by directly attenuating the cloud amount and increasing the sensible heat energy whenever the aerosols volumes had increased.

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Conclusion and recommendations

- An important point to mention, and which can be projected to further research is that the Winter (DJF) and spring (MAM) of the west, North and Central Africa has been characterized by the heaviest surface mass concentration of dust's fine particulate matter.
- Over the 19 years, the quantities of $PM_{2.5}$ is throughout beyond the tolerably recommended quantity of 25µg/m^3, in those sub-regions (West, Centre and North) further investigations are recommended to demonstrate how it can be linked with the Sub-Saharan meningitis belt.

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Conclusion and recommendations

- Governmental and inter-governmental organs would better invest in further investigations and research works, which would help to mitigate numerous hazards caused by the desert's dust, the most notable is the fine particulate matter.
- Increased research in this area would provide enough information and related results to readers, inhabitants and scientific researchers who may make the documentation and develop models and systems for the human respiratory duct's health care.

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5. Acknowledgments

- We acknowledge both the University of Rwanda and Qingdao University, to have supported this research in different ways.
- The highly acknowledged are the efforts made by the team of GES DISC, who contributed to enrich GIOVANNI with the useful and resourceful research tools;
- many thanks to NASA and fellow scientists for the supportive data that are made available online.

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5. References

- 26 References, in total, have been documented for this research Paper

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END OF PRESENTATION

- Thank you for your audience;

QUESTIONS ARE WELCOME!