

Sand and Dust Storm - The Less mentioned High- Impact Weather Event

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Outline

- Dust as an example of aerosol
- Some information about aerosol
- High Impact Weather -SDS
- Impact of SDS
- Need for SDS-WAS to do more
- Why SDS is less mentioned

Atmospheric Aerosols

- Defined as liquid or solid particles suspended in the air
- Examples
 - Smoke from wildfires and industrial activities
 - Volcanic Ash
 - Mineral dust

Atmospheric Mineral Dust

- **Mineral Dust:** Atmospheric aerosols originated from the suspension of minerals constituting the soil, being composed of various oxides and carbonates (en.wikipedia.org)
- **Human activities** lead to 30% of MD in atmosphere
- **Major sources:** Sahara (Spreads into North, Central and South America and Europe, plays a role in the nutrient inflow into the Amazon rainforest), Gobi desert (affects Asia and Western North America)

Dust (I)

- Consists of
 - tiny pieces of metal oxides (iron oxide, aluminium oxide, magnesium oxide, etc)
 - Clays
 - Carbonates such as calcium carbonate or limestone
- At any given point in time, about 20Tg of dust suspended in the air
- Dust emissions show considerable seasonal variability with max emissions during summer

Dust (II)

- Interannual variability is less pronounced, although
- Warm NAO phases and El Nino events corresponds to greater Saharan dust transport across the Atlantic

Seasonal variation in Earth's atmospheric aerosol concentrations

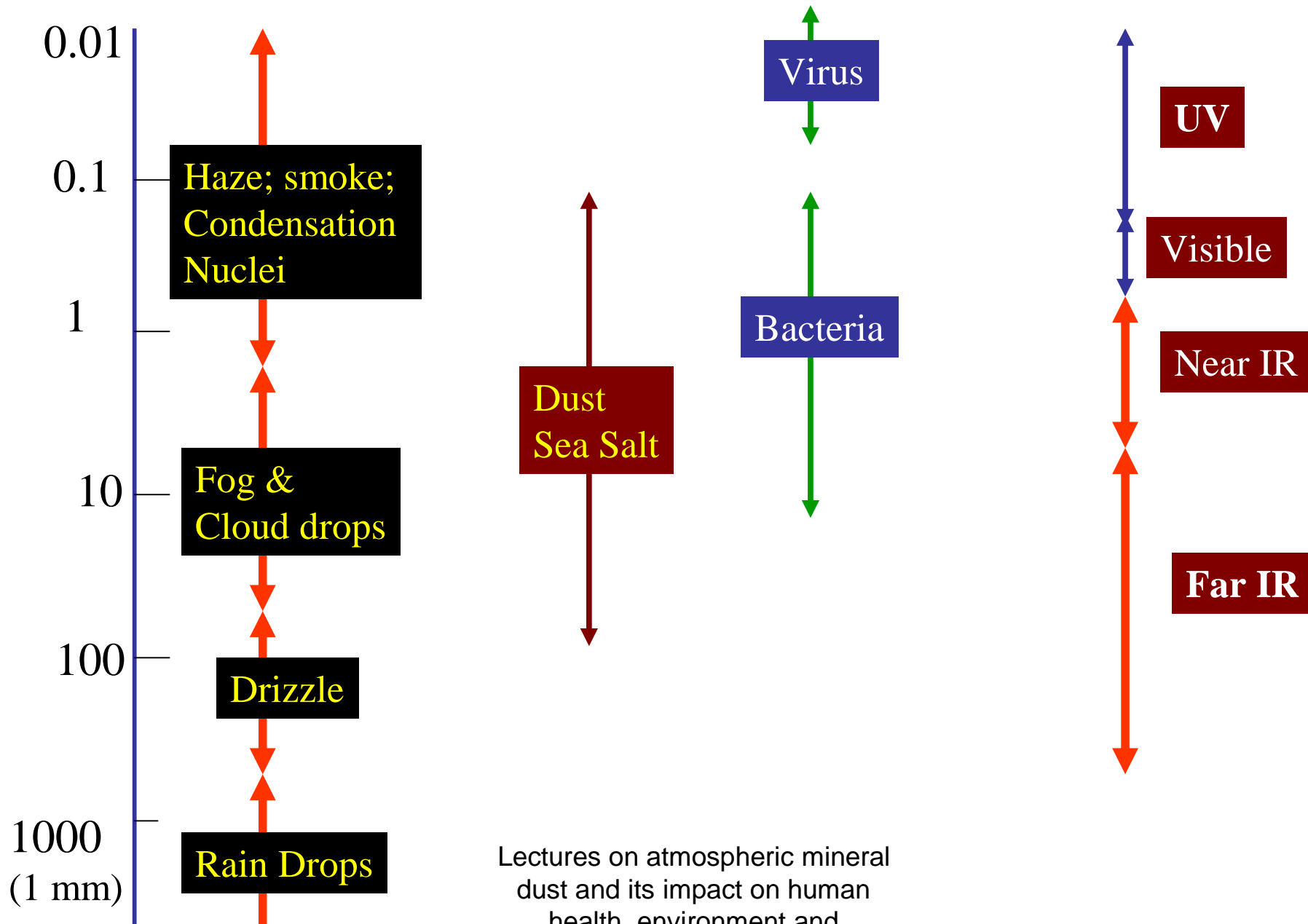
QuickTime™ and a
decompressor
are needed to see this picture.

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Micrometer

Aerosol Dimensions

Radiation Wavelengths



Aerosol Optical Depth

- Aerosol Optical Depth (AOD) is a quantity used to gauge atmospheric aerosol concentration
 - Values below 0.1 indicates clear skies
 - Values around 1.0 indicates fairly hazy conditions

Global Summary: Aerosol Optical Depth

Natural Aerosol = 0.07

Sea Salt

Dust

Organics

Sulfate

Anthropogenic = 0.05 to 0.07

Sulfates

Organics

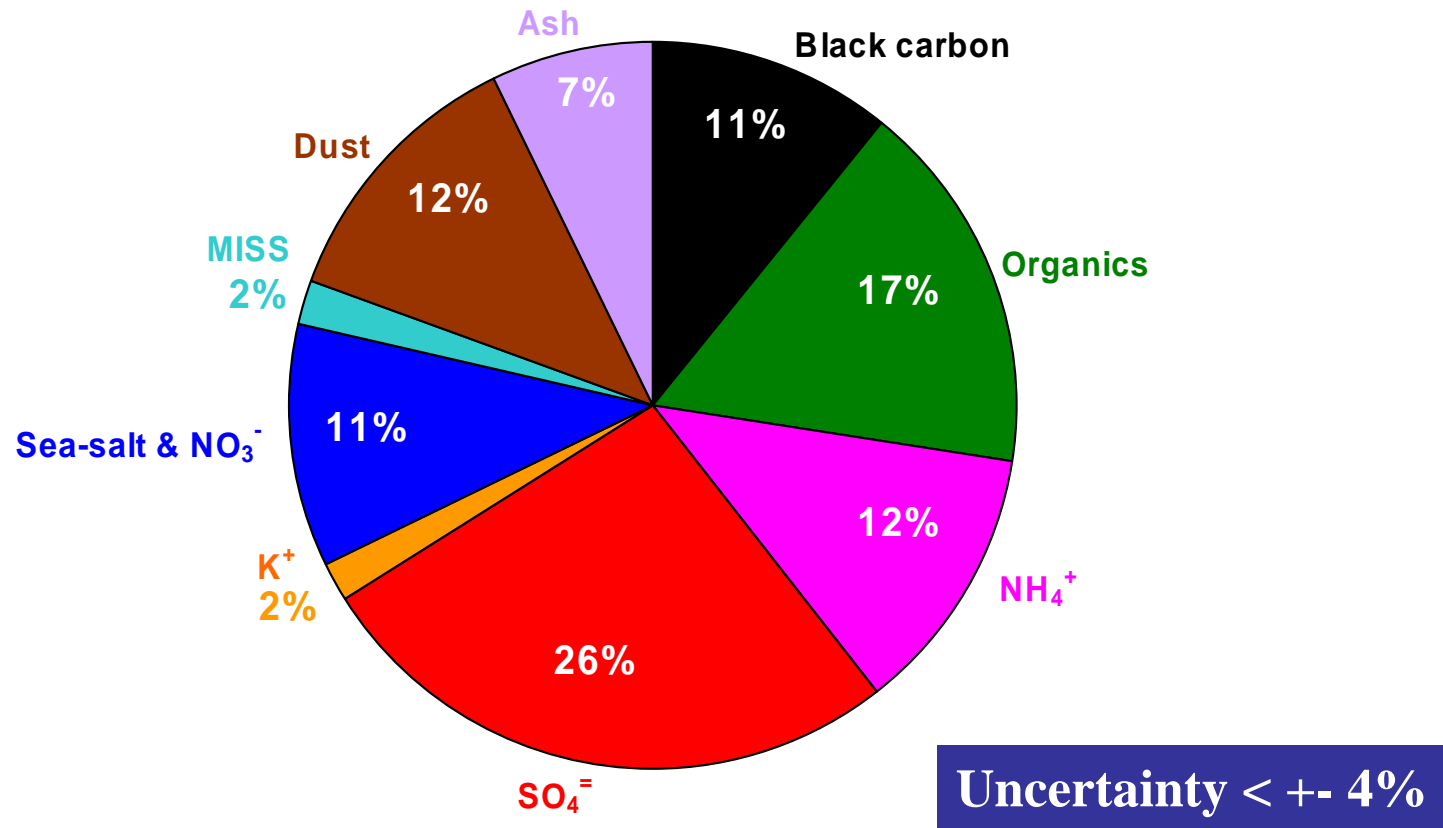
Dust

Black carbon (0.006 to 0.008)

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Ref: Ramanathan, Crutzen, Kiehl and Rosenfeld, 2001

Contribution to Aerosol Optical Depth



Ramanathan et al, 2001

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High-Impact Weather (HIW)

- **HIW:** Weather events having large impacts on society, the economy and the environment.
 - THORPEX (of WWRP) - Aims to accelerate improvements in both the accuracy and utilization of a one-day to two-week forecasts of high-impact weather.

A photograph showing a person in a green jacket and dark pants walking through a thick, orange-brown sandstorm. The person is holding a long-handled tool, possibly a shovel or a hoe, and is walking towards the right. The background is completely obscured by the dense sand, which fills the entire frame with a hazy, orange glow. The text is overlaid on the upper half of the image.

Sand and Dust Storms are Component of the Mean Distribution

A Chinese farmer walks amid a heavy sand storm in Minqin County, northwest of China's Gansu Province. Sand covered about one-eighth of China from April 14 to 18, 2006 and about 330,000 tons of sand fell in Beijing on Sunday night April 10.

Tropospheric Aerosol and Weather

- Condensation nuclei
- Cloud nuclei
 - Near surface: higher conc over land than ocean
 - Higher up: higher conc over ocean than over land
 - At 5 km: maritime-continent contrast has disappeared
- Ice nuclei
- Formation of rain
 - Amalgamation of million cloud drops into a single raindrop or precipitation particle

Effects of Dust (beneficial)

- Central and South American rainforest get mineral nutrients from the Sahara
- Iron-poor ocean regions get iron
- Dust in Hawaii increases plantain growth
- Ancient dust storm deposits known as loess are highly fertile soils (in northern China and mid-western US)

Dust impact on human health (I)

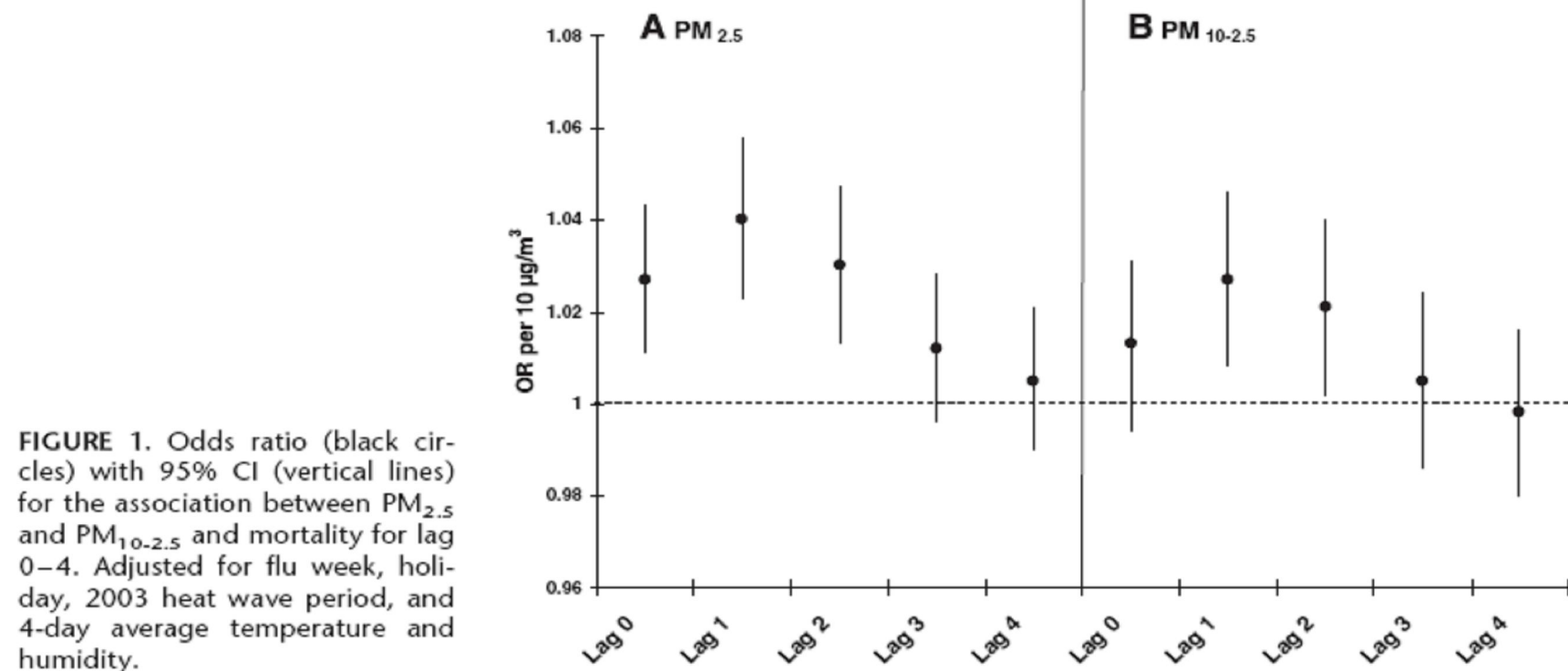
- Both dust storm (DS) and normal (N)PM_{2.5} has biphasic effects on cell proliferation, namely, stimulated cell proliferation in human lung fibroblasts at lower concentrations and inhibited it at higher concentrations
- The organic and inorganic extracts from PM_{2.5} (DS) and PM_{2.5} (N) significantly inhibited the proliferation in human lung fibroblasts at concentrations corresponding to their mass contents in PM_{2.5} samples (Deng et al., 2007)

Dust impact on human health (II)

- Effect on human health of breathing dust
- Increase the spread of disease across the globe (virus spores on ground blown into air by storm with minute particles acting like urban smog or acid rain)

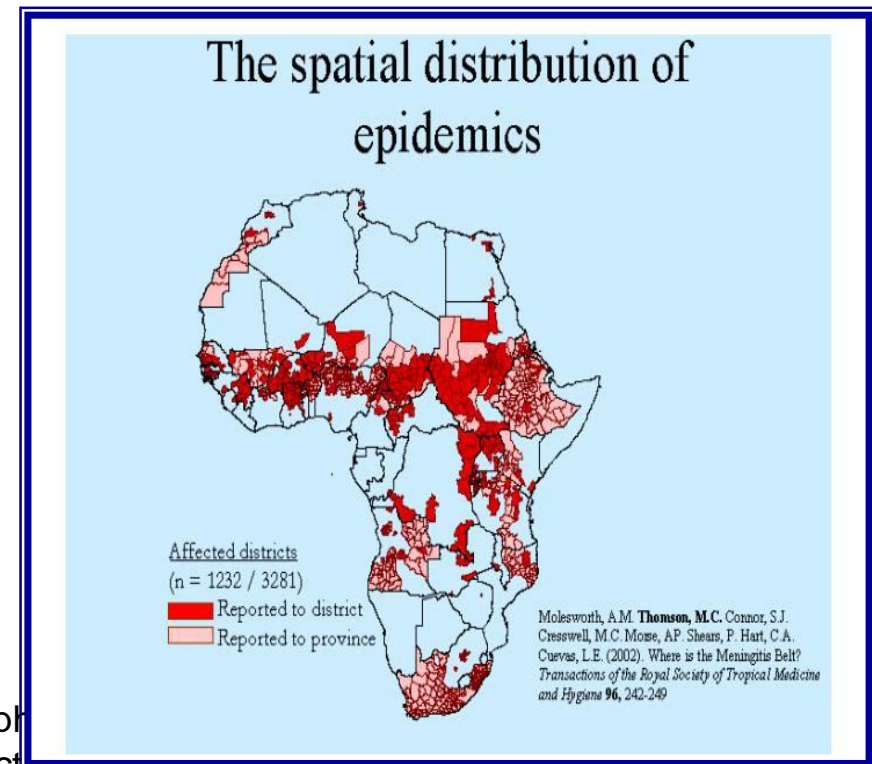
Coarse Particles From Saharan Dust and Daily Mortality

This study demonstrates that Sahara dust outbreaks increase daily mortality in **Barcelona, Spain**. The effects of short-term exposure to PM_{10-2.5} on daily mortality are stronger during Saharan dust days than non-Saharan dust days.



Meningitis

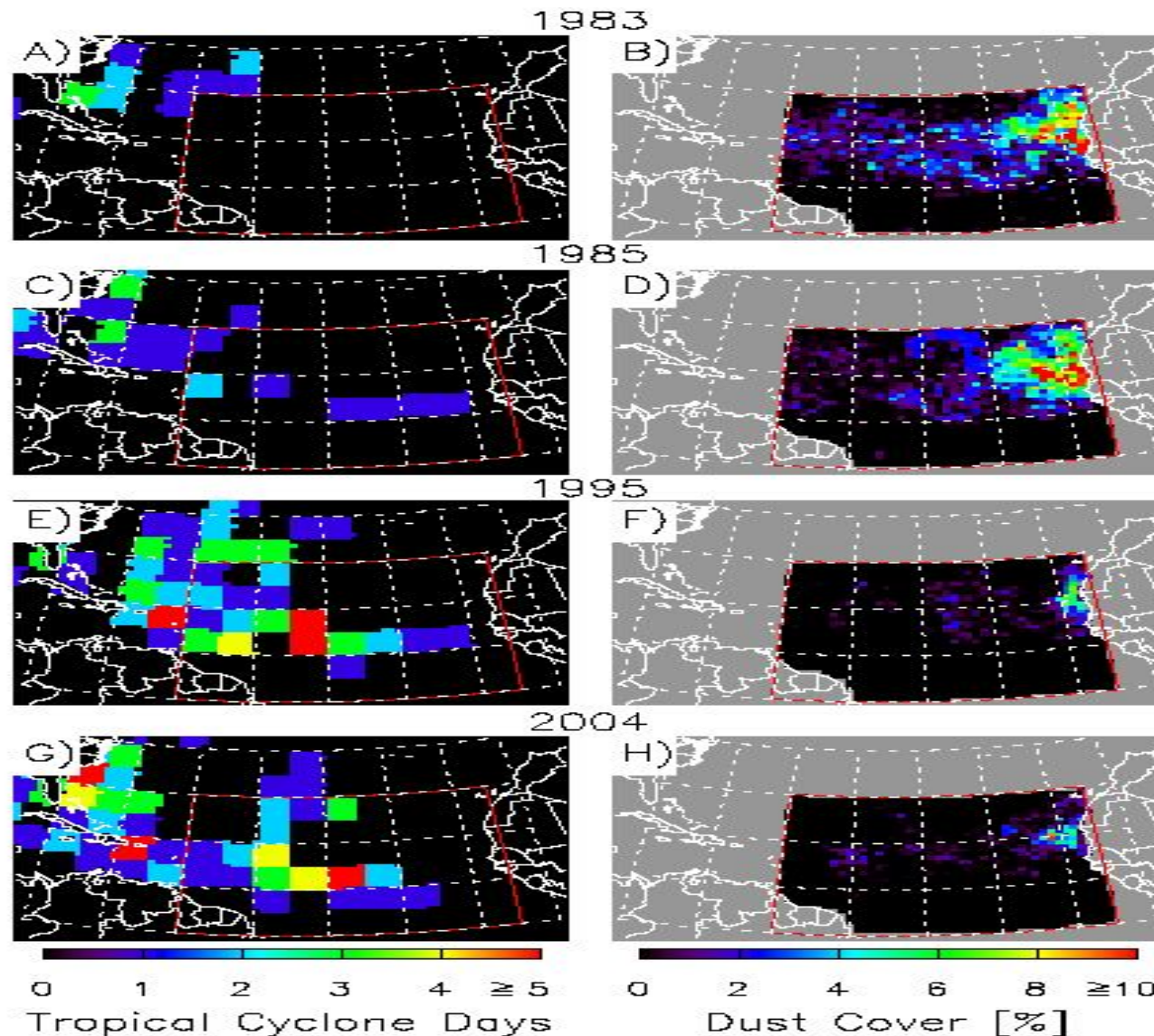
- Meningitis in sub-Saharan belt is one of the most feared epidemic diseases in Africa
- High fatality rates; brain damage
- Epidemics 1996-7 example: 250,000 people affected, 25,000 fatalities
- High probability that meningitis is associated with sand and dust weather
- WMO SDS-WAS is a partner in the International Meningitis Environmental Risk Information Technologies (MERIT) project.



Impact of Dust storm on Economy

- Causes soil loss from dryland - preferentially removes organic matter and nutrient-rich lightest particles, thereby reducing agric productivity
- Causes damage to crop plants
- Clouds and rain
- Reduced visibility -affecting air and road transport

SDS IMPACTS: Dust and Tropical Storms



There is a link between Atlantic tropical cyclone activity and African dust outbreaks *Evan et al., 2006 JRL*. Increased % of dust cover in the Eastern Atlantic has a decreased number of tropical cyclones. A hypothesis: **cyclogenesis and cyclone evolution is reduced in the presence of sand and dust aerosol.** **MORE RESEARCH NEEDED**

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Impact of Dust storm on Environment (I)

- **Drought:** 1930's Dust Bowl in the central US was caused by SST induced rainfall reductions amplified by elevated dust concentrations
- **Snowmelt:** Major dust storms in America's Southwest cause snowpack in the nearby mountains to become "dirty". This reduces the snow's albedo causing it to melt faster
- **Nutrient:** Mineral dust deposition shown to "fertilize" ocean surfaces, potentially stimulating algal blooms, as well as forests such as the Amazon

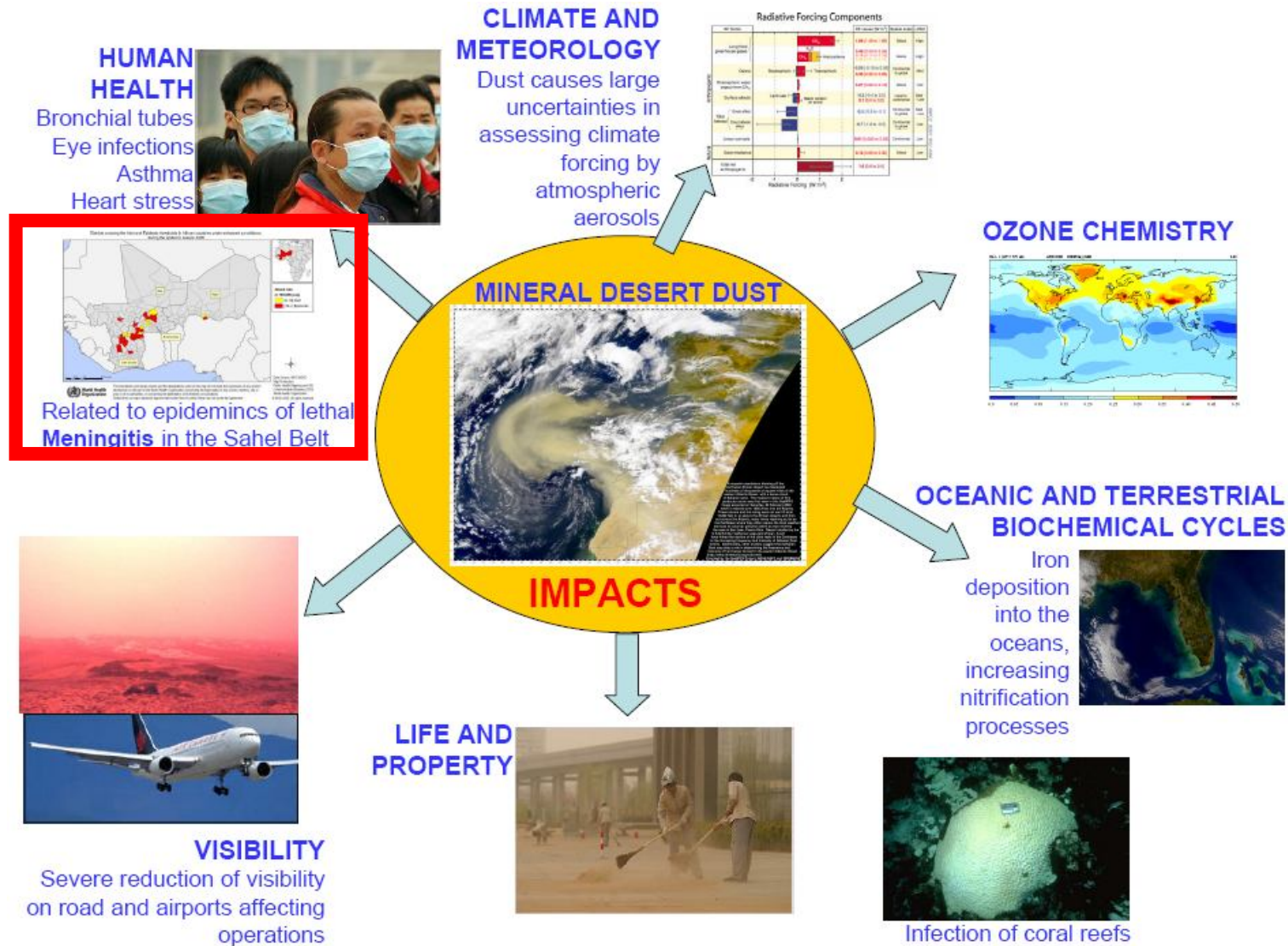
Impact of Dust storm on Environment (II)

- **Atlantic Sea Surface Temperatures and Hurricane Season Intensity:**
 - Net effect of “dust plume” (from Sahara Desert into the Atlantic Ocean) is unclear
 - Reduced amount of sunlight on ocean surfaces, results in decreased ocean surface temperatures. Higher sea surface temperatures strengthen hurricanes
 - When the SAL, sits over the Atlantic’s main hurricane development region, there is less deep convection and more vertical wind shear, factors that discourage tropical cyclone formation

Impact of Dust storm on Environment (III)

- **Atlantic Sea Surface Temperatures and Hurricane Season Intensity cont'd:**
 - More dust means more nuclei for cloud formation, a necessary ingredient for tropical cyclone development
- Reduced visibility (aircraft and road transport)
- Reduced sunlight reaching the surface
- Increased cloud formation increasing the heat blanket effect

Mineral Dust Impacts



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SDS-WAS Need to do more

- African Scientists
 - Azores high ridging over NA certain threshold pressure 1035mb over Morocco : Ghana will experience haze
 - High pressure center relaxing (1025mb) - 1016 isobar will move northward to lat 20N (Ghana/Nigeria)
 - ITD isobar 1015 moves to about 1012, ITD will be in the sea and the whole country will under harmattan
 - Sudden movement of ITD from lat 8 (for 3 days) to lat 10, expect rain in the middle part of Ghana (in Jan/Feb
- End-users???

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Sources of dust data

- Aeronet data
- Visibility data
- MISR Aerosol data
- Outputs from model simulation
- MSG?

Research and Applications related to impacts (I)

- **Research**
 - **1979-2010 simulations with the dust models to provide modeled daily dust concentration levels**
 - **Intensive validation against observations (sun photometers, satellites)**
 - **Understanding the role of dust in relation to other environmental and climatic variables. Studying the relationship of dust events with humidity, winds, temperature., etc.**
 - **Careful analysis of the different sources and pathways of dust**

Research and Applications related to impacts (II)

- **Weather/Meningitis relationship.**
 - **Google funded UCAR project (do a brief write-up on this)**
- **Sylwia (IRI) deploying dust samplers in Niger (Niamey), Ghana (Navrongo) and a city in Senegal. Looking for money to install one in Ethiopia**
 - **Filters to be changed once a week and analyzed for composition and concentration**
 - **Will have AWS attached to dust samplers**
 - **Sampling period (i) Dec 2010 - April 2011, (ii) 8 weeks in wet season**
 - **Sampler output to be compared to satellite and model products**

High-Impact Weather Events mentioned more often

- Flood
- Drought
- Prolonged dry spells
- Frequent wet spells?
- Excessive temperature

Why is SDS less mentioned (I)? Is it because

- Flood and drought can occur everywhere while SDS are limited to some geographical regions (e.g. Sahel)?
- Even within a country where SDS occurs, it is common in some parts? For example in Mali, SDS is common in Timbuktu, Gao and Kidal but not in Sikasso
- People do not see most of the impacts of SDS to be immediate?
 - With flood or drought you lose the crops completely
 - With SDS not all the crops may be damaged

Why is SDS less mentioned (II)? Is it because

- People do not link SDS directly to the food we eat or the water we drink?
- Some farms have crop cover?
- There are instances of wind shelter?
- The impact of SDS is less dramatic than the impact of say flood or drought?

Why is SDS less mentioned (III)? Is it because

- In known regions for SDS, it happens every year and people know about the short-term consequences?
- Researchers can not convince funding agencies about the dramatic impact of SDS?
- Few researchers are studying impacts of SDS?

Thank you for listening

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Atmospheric Aerosol and Radiative Balance

The atmospheric aerosol affects the radiative balance:

- 1. By scattering and absorbing incoming solar radiation**
- 2. By scattering and absorbing solar radiation reflected from the surface**
- 3. By influencing the formation and lifetime of clouds via the droplet concentration and co- agulation, and in the case of clouds colder than 0deg C, by influencing ice crystal formation**
- 4. By scattering and absorbing outgoing infrared radiation in the clear atmosphere.**
- 5. By influencing clouds as in 3 and thereby the outgoing infrared radiation**

Severe, Extreme & HIW

- **Severe Weather:** In general, any destructive storm, but usually applied to severe local storms in particular, that is, intense thunderstorms, hailstorms, and tornadoes (AMS Glossary)
- **Extreme Weather:** Includes weather phenomena that are at the extremes of the historical distribution, especially severe or unseasonal weather (e.g. of extreme temperatures: heat waves, cold waves). Commonly based on an event's climatological distribution