Under African Skies: Hygroscopicity and the links to Visibility and Regional Haze

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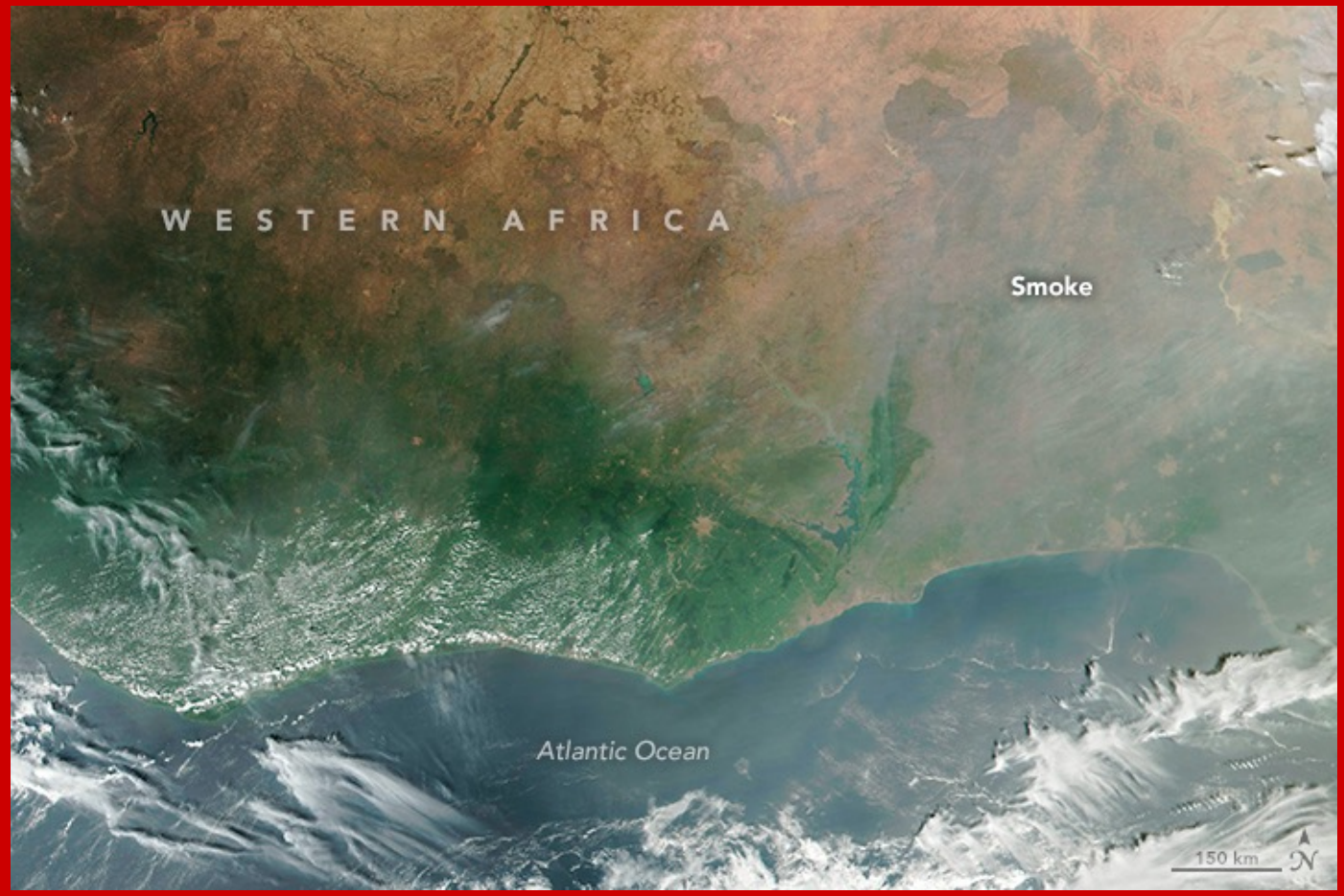
Workshop on a Pilot Design for Air Quality in Africa

Wednesday, June 9th, 2021

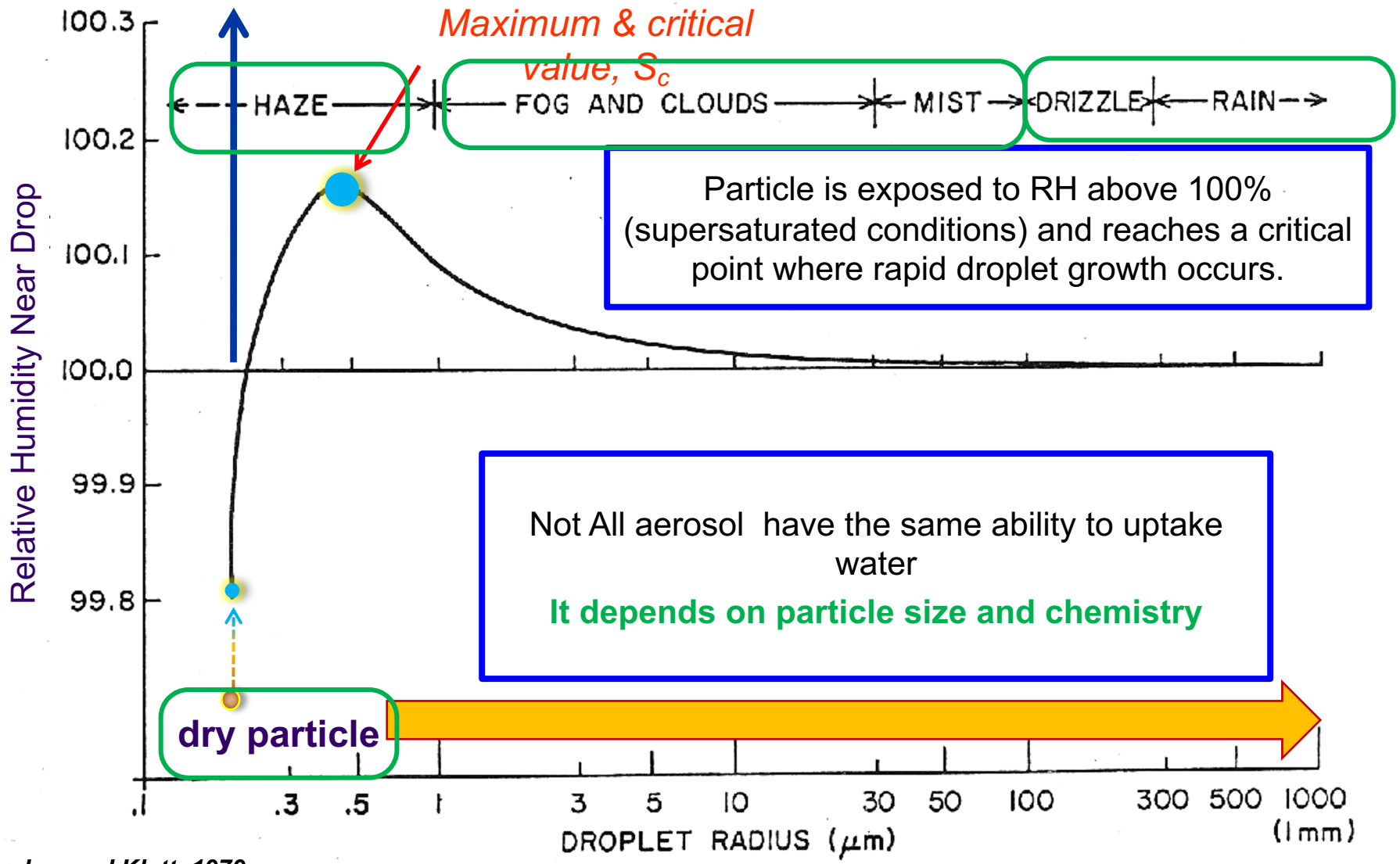
9:00am - 12:30 pm EDT

Zoom Virtual Workshop



Credit: NASA Earth Observatory, VIIRS data J. Stevens

Droplets 101



Pruppacher and Klett, 1979

Clear Sky – Dry Particles

Haze

Mist and Fog

Drizzle and Rain

Visibility is a function of Aerosol Number, Size and Hygroscopicity

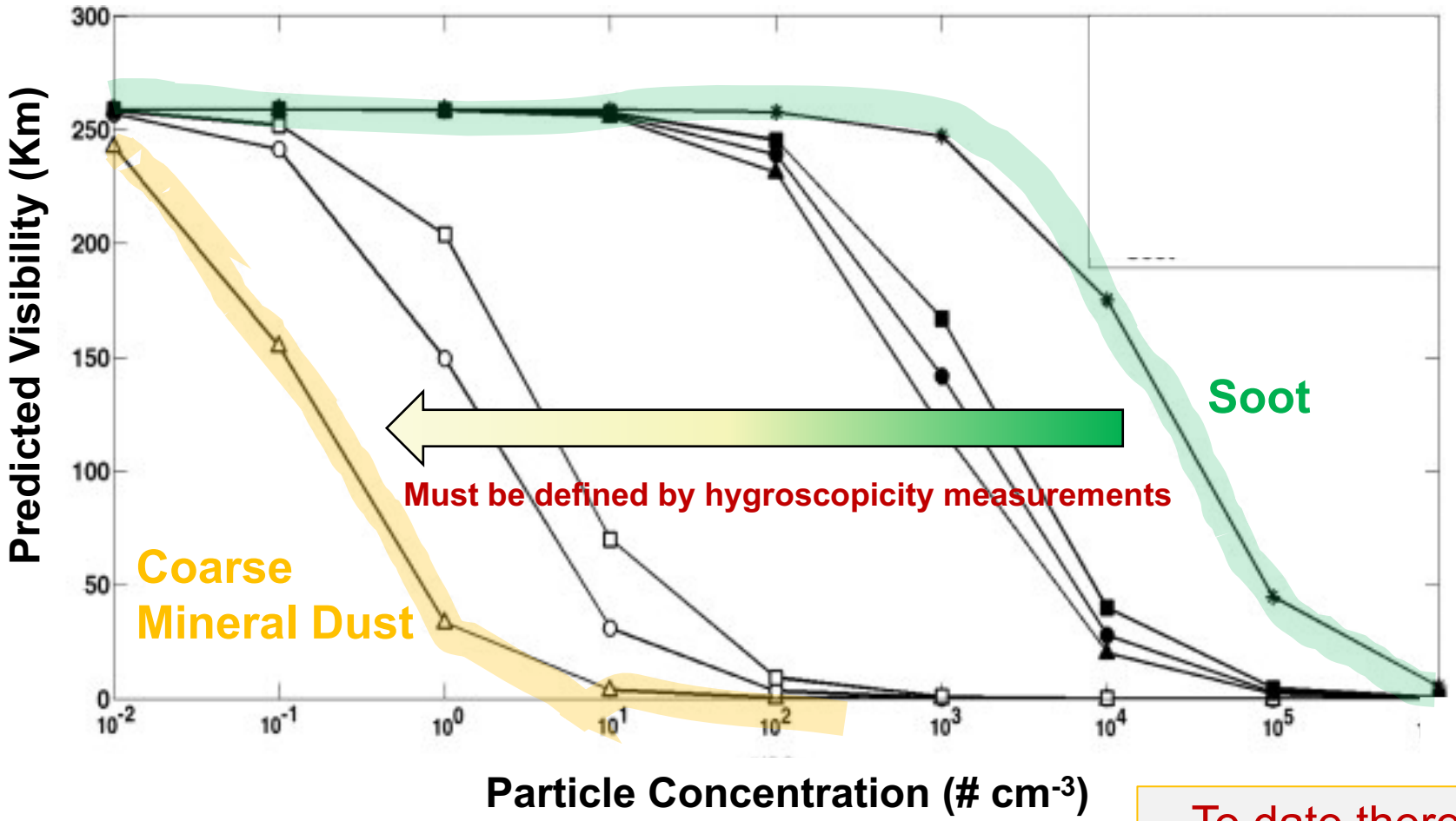


Figure 3: From Singh and Dey. Atmospheric Environment (2012)

- Visibility is reduced with higher particle concentrations
- Coarse mode and larger particles (like mineral dust) require fewer concentrations to reduce visibility
- Non-hygroscopic small and accumulation particles (like fresh soot) are less likely to swell
- As particles age they can increase hygrosocopicity, and then droplet growth is a function of RH

To date there have been little to no in-situ ground based hygroscopicity measurements on the African continent

Particle hygroscopicity can be inferred from the RH dependence on visibility

Credit: WSJ Singapore Haze Aug 28, 2016

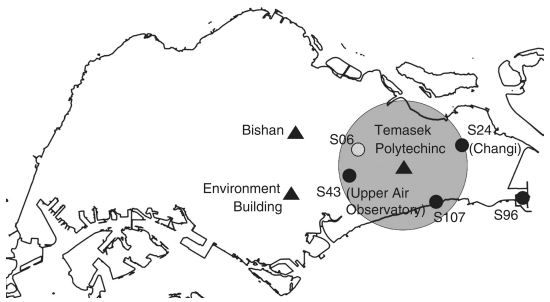


Figure 3. Lee et al 2016. Atmospheric Science Letters

The aerosol source and location matters

- A study in Singapore found that aged biomass burning, likely had increased hygroscopic lead to decreased visibility and poor regional air quality *Lee et al, 2016*

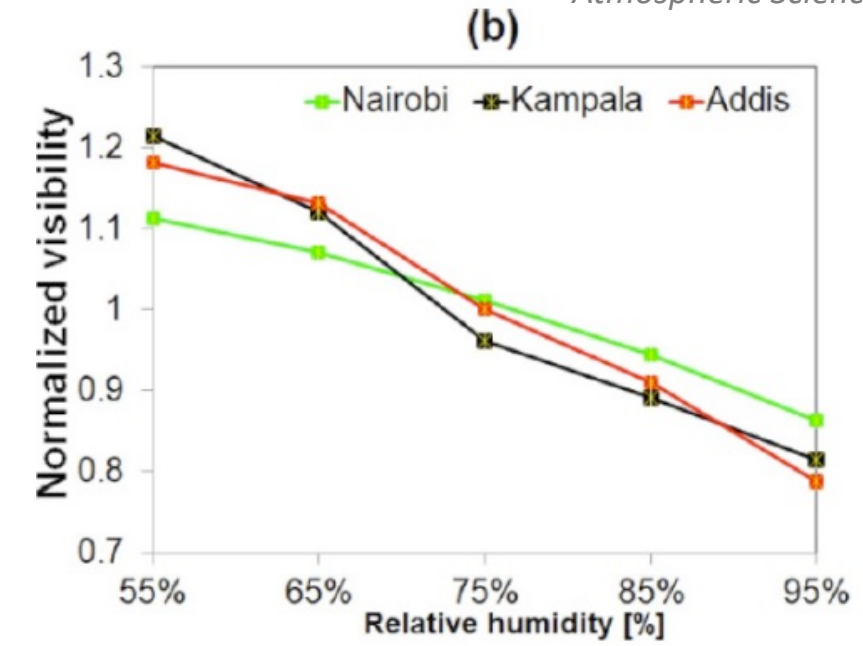


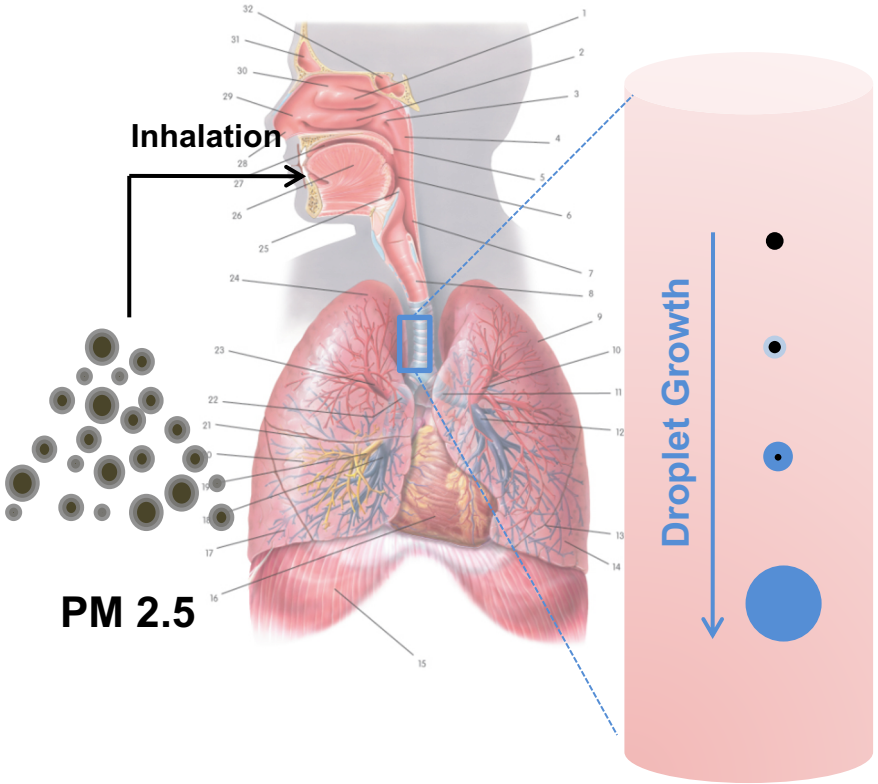
Figure From Singh, Avis and Pope. Environmental Research Letters (2020)

The duration of study also matters

- Visibility in the 3 East African Urban areas is likely reduced by less hygroscopic aerosol composition. *Singh et al. 2020*
- The estimated hygroscopicity decreases over decades indicating that the aerosol in the study is becoming less hygroscopic in East African urban areas.

Because in-situ measurements are not collected, short-term variability (daily/ weekly/seasonal) due to changes in particle hygroscopicity are unknown

Particle size and Hygroscopicity are critical to understand aerosol deposition



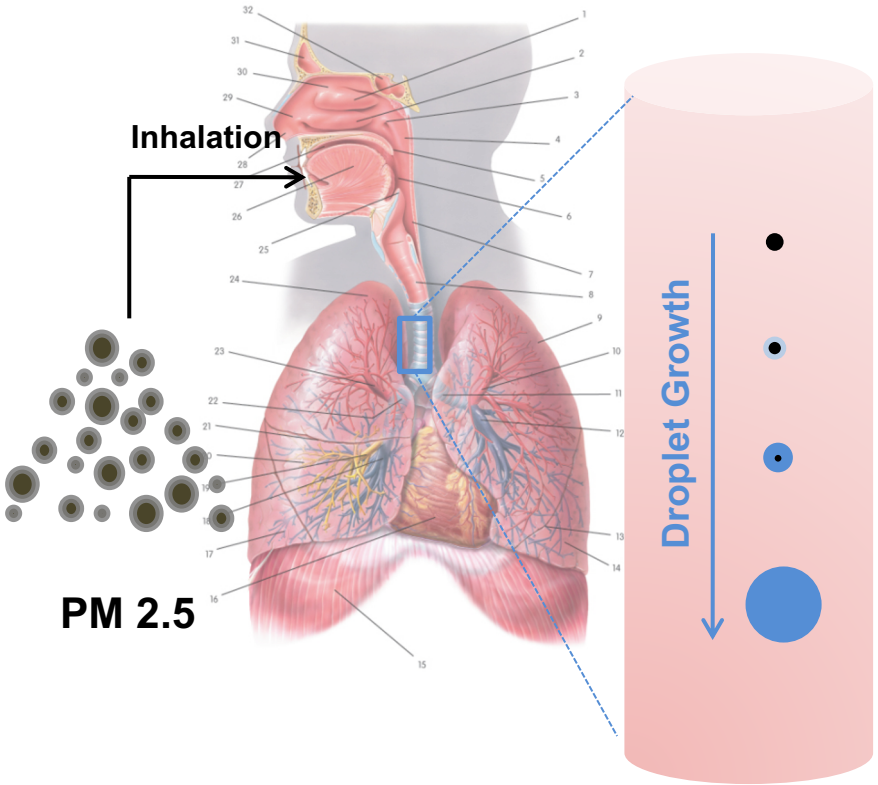
Enhanced Condensational Growth of Particles affects lung deposition rates

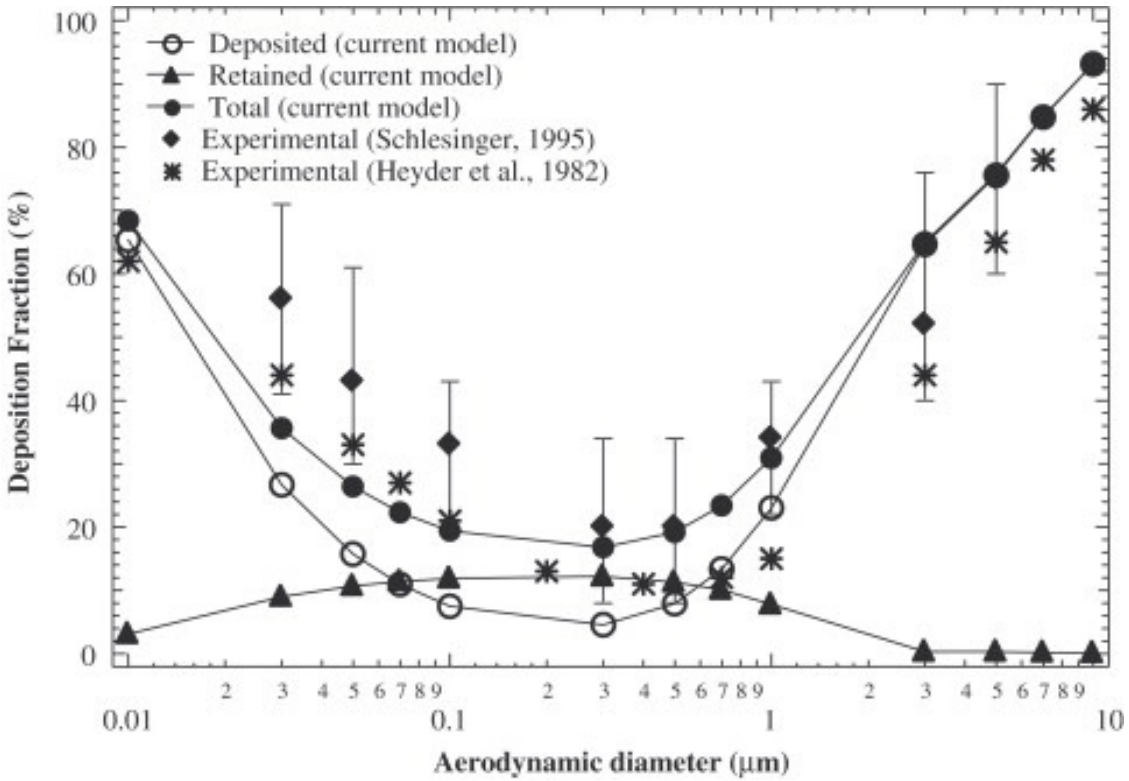
instantaneous values in the supersaturated range (up to 104% RH) (Longest and Xi, 2008; Varghese and Gangamma, 2009; Longest et al., 2010)

At large RH, enhanced condensational droplet growth (ECG) may occur, droplets may form (Longest et al., 2010)

dry particles will effectively behave as cloud condensation nuclei (CCN) within the respiratory system

Particle size and Hygroscopicity are critical to understand aerosol deposition

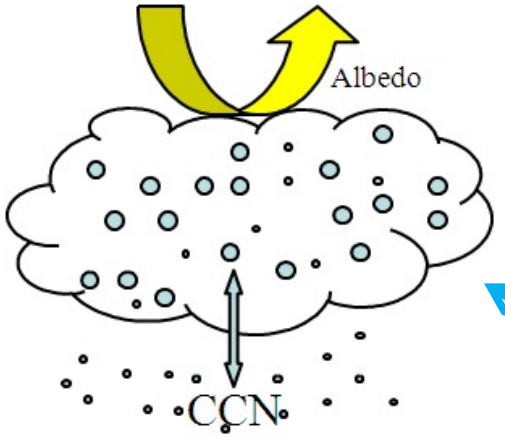




Hygroscopicity affects droplet growth and the deposition rates of particles in the upper respiratory tract

The hygroscopicity of complex aerosol, needs to be characterized to understand particle deposition in the respiratory system and the effects of poor air quality

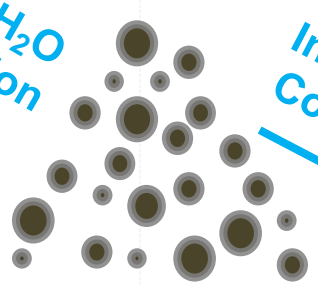
Linking Climate, Air Quality Health:



Aerosols impact cloud formation and climate.

Ambient H_2O Condensation

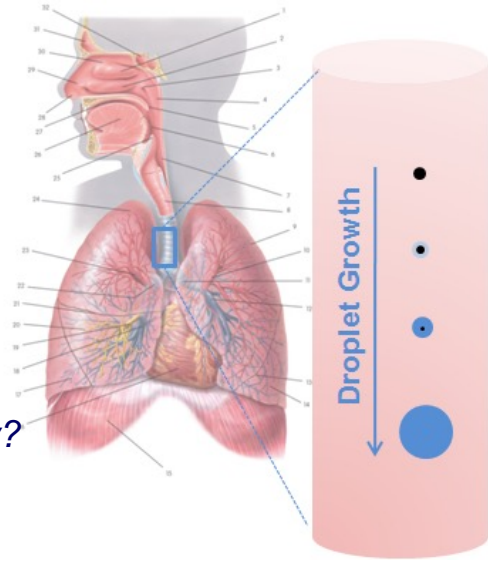
Inhalation H_2O Condensation



Particulate Matter (PM)

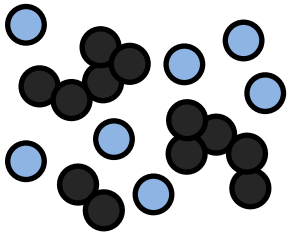
Composition? • Sources? • Emission Rates? • Toxicity? • Number Concentration? • Particle Size? Deposition

Aerosol droplet growth affects lung deposition rates and human health

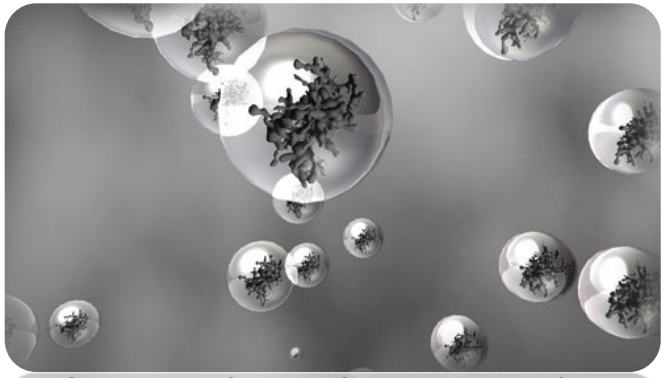


The ability of aerosol to uptake water (hygroscopicity) has the potential to impact both climate and health

Hygroscopicity measurement are needed in Africa

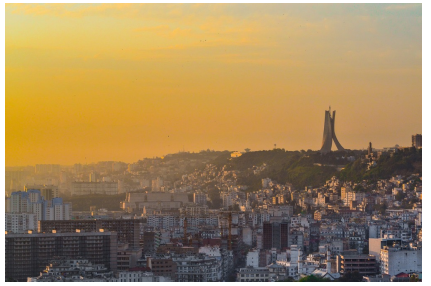


Condensation →



Source: NASA : *Black Carbon Cloud Droplets (artist rendition)*

Kigali, Rwanda Credit: Sean J on Flickr



Algiers, Algeria Credit:

(1) Provide Quantitative and Fast Measurement Techniques for Real-World Sources

Librevelle, Gabon

Accra, Ghana

(2) Characterize Changes in Physical and Chemical Properties that can alter perceived Hygroscopicity of sources

Gaborone, Botswana