

Urban climate and air quality in tropical cities

Per Jonsson

Abstract

Although Africa is the least urbanized continent in the world, the rate of urbanization is unprecedented. City authorities are faced with the problem of providing inhabitants with services and infra structure, which in turn has negative effects on the urban environment. Urban growth is also known to be accompanied by inadvertent modifications of local climate and air quality. Both of these urban properties and their interactions are investigated in three cities located in sub-Sahara Africa: Dar es Salaam (Tanzania), Ouagadougou (Burkina Faso) and Gaborone (Botswana). The cities differ in terms of population size (0.2-2.5 million), location (coastal/inland), latitude (7-24 °N/S), elevation (50-1000 m a.s.l) and consequently, in climate characteristics.

Field measurements included urban/rural sampling of temperature and suspended particulate matter (SPM) on seasonal and diurnal time scales. Mobile intra-urban measurements of temperature, relative humidity, SPM and longwave incoming radiation were conducted in three different areas of each city, i.e. the city center, a green residential area and a traditional residential area.

All cities have an urban heat island (UHI) with seasonal variation. The highest mean nocturnal UHI intensities, of up to 4.5 °C (Ouagadougou), occur in the dry season, which can be attributed to seasonal changes in climate and rural substrate properties (i.e. soil moisture and albedo). It is shown that the processes which govern UHI development can be summarized by the seasonal variation in specific humidity. Clarity in seasonal and diurnal UHI patterns increases away from large water bodies. Intra-urban temperature differences of up to 4 °C were found in Gaborone while differences were less obvious in the other cities. Water availability is of great significance to intra-urban temperature differences in the absence of low sky view factors.

Concentrations of SPM in Dar es Salaam were lower during the wet season due to precipitation and lower frequencies of calms. The city is generally more polluted during both seasons in comparison to a rural site. Morning and night peaks in SPM concentrations were found in inland Ouagadougou and Gaborone, while no night peak was evident in coastal Dar es Salaam. This difference is attributed to inland stability and coastal instability associated with the sea and land breeze. The inland cities have large intra-urban differences in SPM concentrations. This is mainly due to unpaved roads, but also their proximity to arid environments. Although extreme concentrations of SPM (24 hr mean of up to 2400 $\mu\text{g m}^{-3}$ in Ouagadougou) were observed, no enhancing effect on longwave incoming radiation was detected. This indicates that the urban radiation balance is unaffected by suspended particles of natural origin.

Keywords: Tropical, Africa, urban heat island, longwave incoming radiation, suspended particulate matter, urban/rural, intra-urban, seasonal variations, diurnal variations, Dar es Salaam, Ouagadougou, Gaborone.