Simulations of Air-pollutants Dispersal Over Nairobi City, Kenya

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Introduction

- Urbanization is a "blessing" in disguise
- Air quality is synymous to urbanization.Poor air quality is associated with several negative effects on human health, climate and ecosystems.
- Developing nations face air quality challenge
- The city populations is highly vulnerable to the impacts air pollution
- A case study::Nairobi city, Kenya

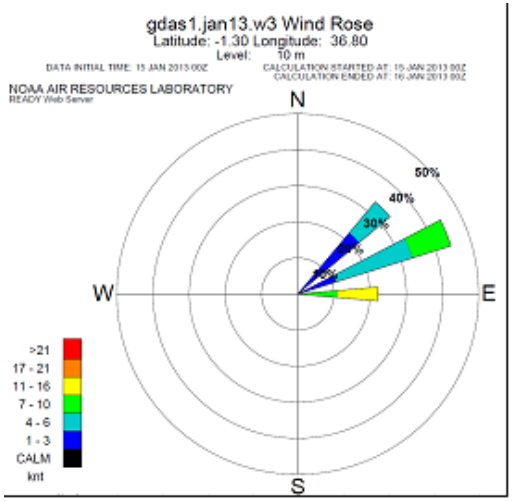
Introduction

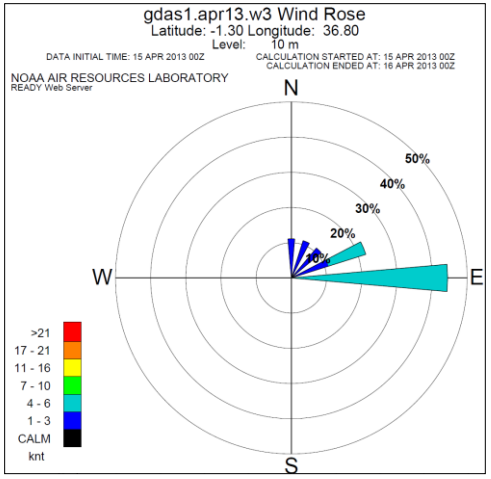
- Carbon monoxide is most widespread and the most serious for human health.
- About 50% of diseases diagonised at health facilities over Nairobi is found to be as a result of air pollution.
- Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model was used, considering a case for emission of Total Suspended Particles(TSP) into the environment.
- Wind speed over the city is about 3m/s and the wind direction is normally easterly.
- Total suspension of particles over nairobi is above WMO acceptable level(UNEP 2011)
- Ngong hills,Mathare rivers & Karura forest in northern part of Nairobi are key physical features. The Ngong hills stand towards the west, Mount Kenya towards the north and Mount Kilimanjaro further towards the south-east.

- **Emissions from Vehicles during traffic jam are source of air pollution.**
- **Dandora dumpsite located 8 km away from the city centre and occupies about 30 acres of land is potential source of pollution.**

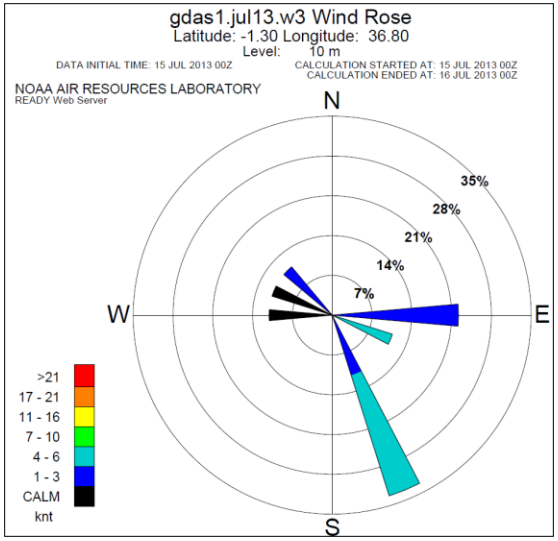
HYSPLIT MODEL

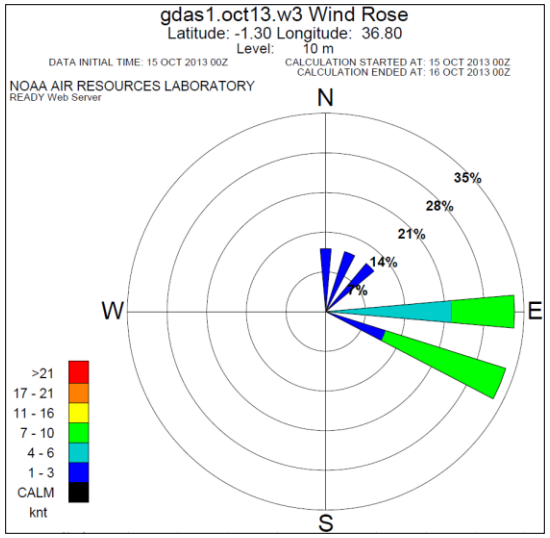
- The wind direction, forward trajectories, and concentration and distribution of pollutants was done using HYSPLIT model (Draxler and Rolph, 2013)
- The model provides an accurate representation of air pollution levels. It computes trajectories,dispersion and deposition of pollutants
- Concentrations are grid based. Calculations are performed on archive met. data runs using GDAS of NCEP. 4 runs forecasts. The model output is GRIB data format





Direction is SW and NW of city





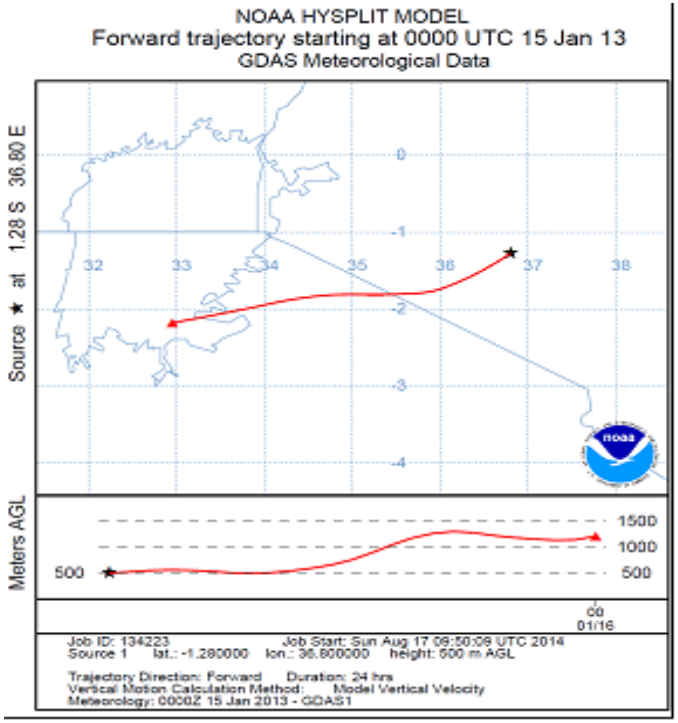
- **From wind roses, the pollutant introduced into the atmosphere over the city will be transported and dispersed to the southwest and northwest of the town.**

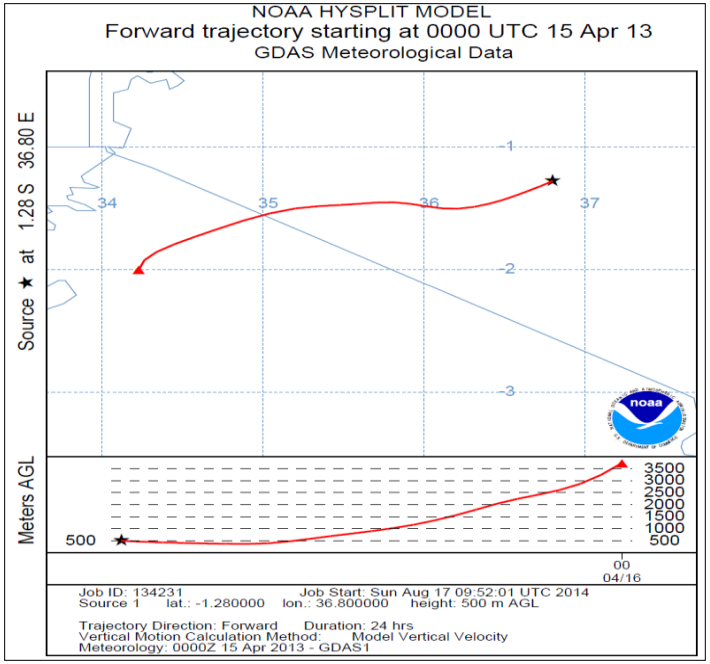
- **The dominant speed is between 4-6knots(3m/s)**

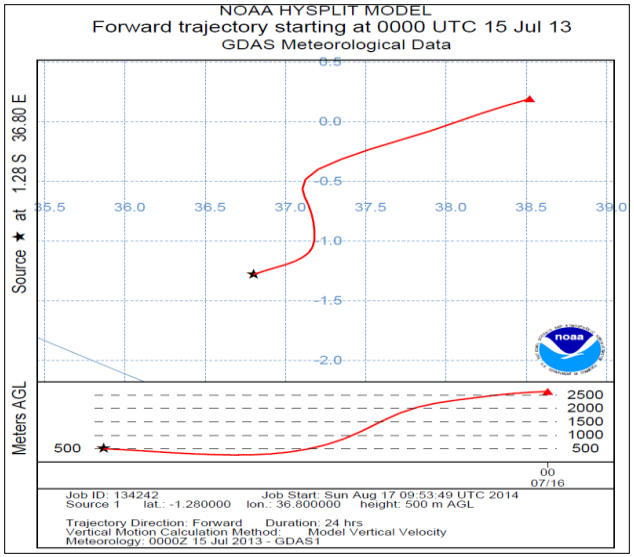
- **However, urbanization is likely to reduce wind speed over the cities (Ongoma et al., 2013). This poses a threat on the future of the air quality over the city.**

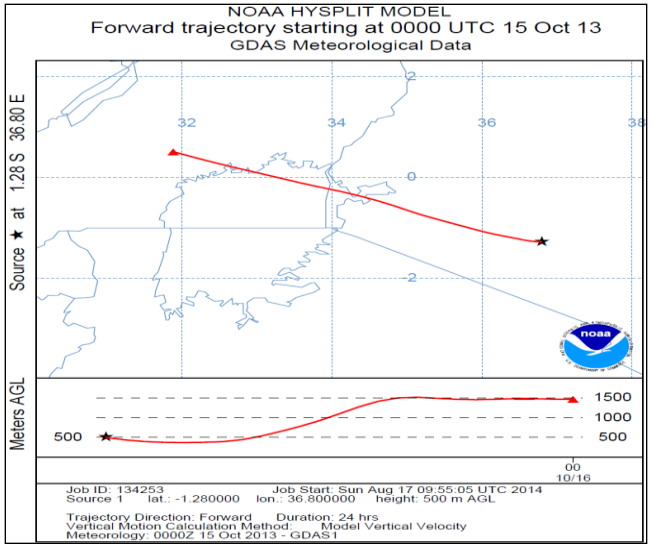
- **Forward trajectories for the MAM,DJF ,JJA OND seasons were simulated.**

- **The transfer of pollutants emitted over the city is generally observed to be in the western side of the city except for the cold season during which the flow from the city is towards the north east.**


NOAA HYSPLIT MODEL
Forward trajectory starting at 0000 UTC 15 Jan 13
GDAS Meteorological Data
Source ★ at 1.28 S 36.80 E
Meters AGL
1500
1000
500
500
00
01/16
Job ID: 134223 Job Start: Sun Aug 17 09:50:09 UTC 2014
Source 1 lat.: -1.280000 lon.: 36.800000 height: 500 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 15 Jan 2013 - GDAS1


NOAA HYSPLIT MODEL
Forward trajectory starting at 0000 UTC 15 Apr 13
GDAS Meteorological Data
Source ★ at 1.28 S 36.80 E
Meters AGL
3500
3000
2500
2000
1500
1000
500
500
00
04/16
Job ID: 134231 Job Start: Sun Aug 17 09:52:01 UTC 2014
Source 1 lat.: -1.280000 lon.: 36.800000 height: 500 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 15 Apr 2013 - GDAS1


NOAA HYSPLIT MODEL
Forward trajectory starting at 0000 UTC 15 Jul 13
GDAS Meteorological Data
Source ★ at 1.28 S 36.80 E
Meters AGL
2500
2000
1500
1000
500
500
00
07/16
Job ID: 134242 Job Start: Sun Aug 17 09:53:49 UTC 2014
Source 1 lat.: -1.280000 lon.: 36.800000 height: 500 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 15 Jul 2013 - GDAS1


NOAA HYSPLIT MODEL
Forward trajectory starting at 0000 UTC 15 Oct 13
GDAS Meteorological Data
Source ★ at 1.28 S 36.80 E
Meters AGL
1500
1000
500
500
00
10/16
Job ID: 134253 Job Start: Sun Aug 17 09:55:05 UTC 2014
Source 1 lat.: -1.280000 lon.: 36.800000 height: 500 m AGL
Trajectory Direction: Forward Duration: 24 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 0000Z 15 Oct 2013 - GDAS1

The pollutant is observed to be transported **beyond** 100 m

Season	Dates/Data
DJF	January 15, 2013
MAM	April 15, 2013
JJA	July 15, 2013
OND	October 15, 2013

Season	Direction	Prevailing wind Speed (knot)
Hot Season	ENE	4 – 6
Long Rain	ENE	4 – 6
Cold season	ESE	4 – 6
Short Rains	ESE	7 – 10

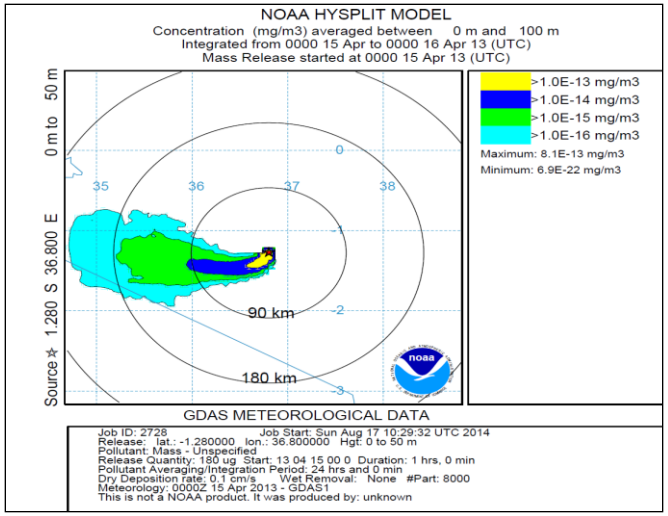
Wind Speed and Direction over Nairobi, wind have easterly component

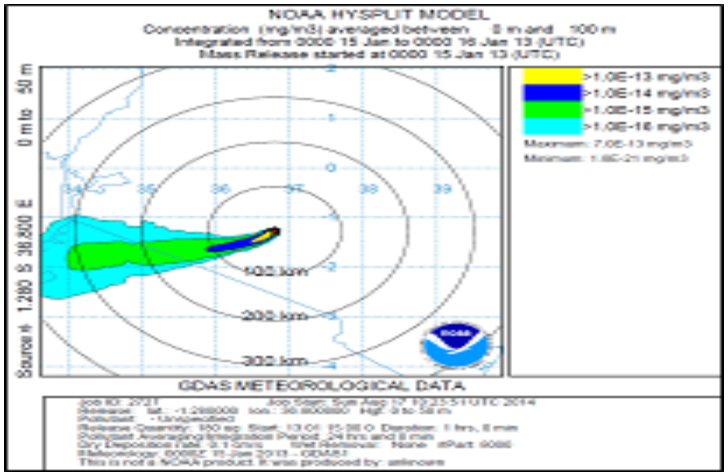
Simulations of Pollutants based on TSP

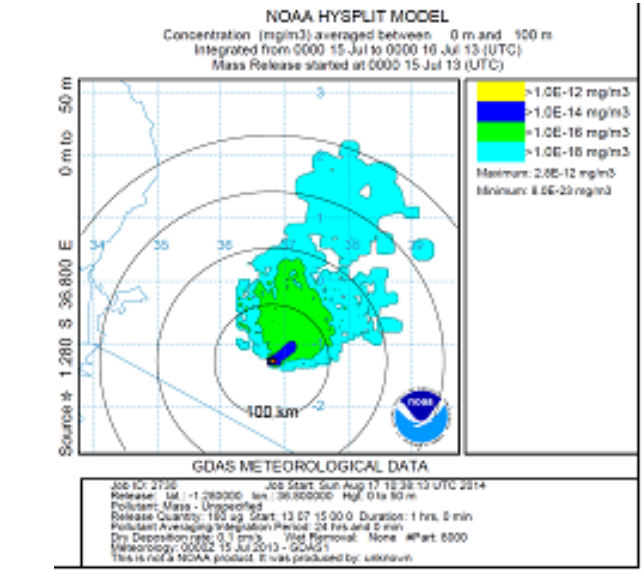
- The pollutant release quantity was 180µg/m^3 starting at 00 UTC for duration of 1 hour. The dry deposition rate was 0 cm/s at height was 10 m; the pollutant is observed to be transported beyond 100 m throughout the year.

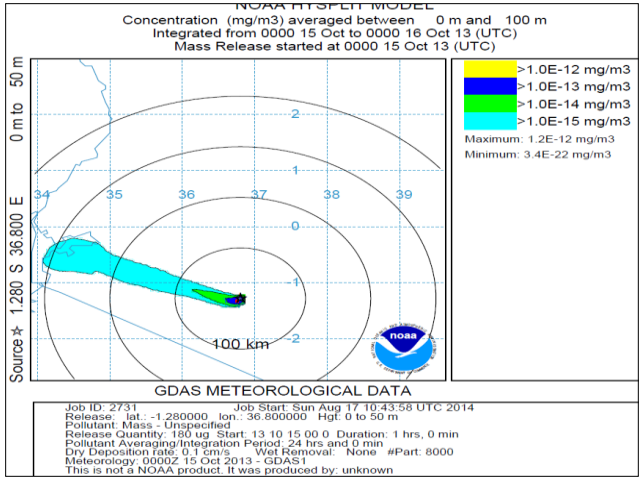
Season	Centre line concentration (in mg/m^3) at the ground level downwind at a distance of:					
	10 km	20 km	30 km	40 km	50 km	60 km
Hot Season	$1X10^{-13}$	$1X10^{-13}$	$1X10^{-13}$	$1X10^{-13}$	$1X10^{-14}$	$1X10^{-13}$
Long Rain	$1X10^{-13}$	$1X10^{-13}$	$1X10^{-13}$	$1X10^{-14}$	$1X10^{-14}$	$1X10^{-14}$
Cold season	$1X10^{-14}$	$1X10^{-14}$	$1X10^{-14}$	$1X10^{-14}$	$1X10^{-14}$	$1X10^{-16}$
Short Rains	$1X10^{-13}$	$1X10^{-13}$	$1X10^{-14}$	$1X10^{-14}$	$1X10^{-14}$	$1X10^{-14}$

Simulations of TSP









- **Pollutants are NE direction and further dispersed during hot season than cold season.**

Conclusion/Summary

- The concentration of pollutants in the atmosphere is high during the rainy season, leading to high possibility of occurrence and collection of polluted rain water over the city during rainy season.
- Nairobi city are mainly predominant of easterlies flows
- As a result, pollutants will mainly be transported to the southwest and northwest of the town.
- The pollutants are dispersed beyond 100 km within one hour
- A consultative planning process that accounts for climatology is key for city development
- The Govt needs to evaluate Quality of water over city during rainy season