SEASONAL EVALUATION OF TEMPERATURE INVERSION OVER CAIRO

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This work presents the utilization of remotely sensed data to evaluate the seasonal the temperature inversion over Cairo-Egypt during a complete year (September 2004 - September 2005). This area suffers from annual increased suspended Particulate Matter (PM) associated with temperature inversion mainly during autumn and spring. The existence of temperature inversion is associated with an increase of the concentration of the trapped suspended PM, which contributes to the so-called “Black or Dark Cloud”. This work investigates two types of temperature inversion, (i) the Ground Temperature Inversion (GTI) and (ii) the Subsidence Temperature Inversion (STI). The GTI is associated with a rapid decrease in the ground surface temperature and simultaneous existence of warm air in the lower troposphere. It develops at dusk and continues until incident solar radiation warms the surface the following day. Pollutants emitted during the night are caught under this “inversion lid”. The STI forms when a warmer air mass moves over a colder air mass. This inversion develops with a stagnating high-pressure system (generally associated with fair weather) and higher water vapor content. Under these conditions, the pressure gradient becomes progressively weaker so that winds are light. These light winds greatly reduce the transport and dispersion of pollutants.

The temperature inversion phenomenon was simulated using the fifth generation of the Penn State NCAR Mesoscale Model (MM5). The simulation incorporates three levels nesting with grid spacing of 81km, 27km, and 9km to ensure accurate model results. The topology used employs the Shuttle Radar Topography Mission (SRTM) data. Monthly averaged vegetation coverage data, obtained from NOAA series satellite data, updates the model lower boundary conditions replacing the model defaults. Both the land use and the vegetation categories follow the United States Geological Survey (USGS) categorization. The temperature gradient was calculated using finite differencing to identify the temperature inversion layers.

The following results present data extracted from the MM5 solver and from ground observations. The GTI strength and PM_{10} concentration increased during winter months (December, January, and February) when the solar and ground heat fluxes were minimal. In addition, strong anti-correlation coefficients were obtained between the ground heat fluxes and the GTI strength (0.8) and inversion-lifetime (0.81) respectively. This was consistent with the fact that the GTI development strongly depends on the ground heat fluxes and forms more readily over the Nile Delta and the vegetated areas as shown in Figure 1. Furthermore these affected areas contribute to airborne particular matter resulting from burning of agricultural waste. Figure 2 compares the vertical temperature profile and satellite observations at North of Egypt during STI existance. Figure 3 compares the daily average of GTI strength and PM_{10} concentrations during April, 2005 at Cairo International Airport. The correlation between the PM_{10} concentrations and the GTI strength is excellent as seen in figure with a correlation coefficient of (0.87). The monthly average of PM_{10} over Cairo is shown in Figure 4 and is compared to the monthly inversion strength average. During the peak season, November 04-May 05, the PM_{10} concentration and the inversion strength are highly correlated. During the other months the PM_{10} concentrations levels represents their background values and may not correlate with the numerical simulations results.

The simulation results showed also that the STI develops at higher frequencies and strength during the months September, October, April and May compared to the other months. Figure 5 presents the frequency distribution in hours for the STI strength from September 2004 to September 2005 over Cairo. The figure shows that the STI strength increases during the warm season and decreases during cold season. Figure 6 compares the STI strength and the STI elevation during the simulation period. The results indicate that the higher strength and lower elevation of STI increases the PM concentrations. This confirms that the temperature inversion plays a strong role in the air pollution episodes, “Black cloud”, and in the Khamasin sand storms (in March and April).

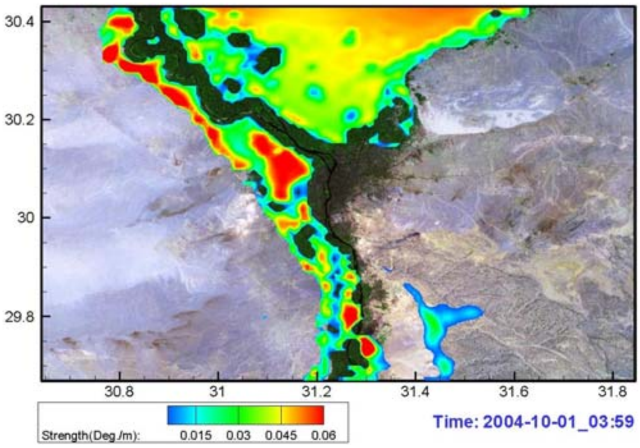

Figure 1 GTI strength distribution over Greater Cairo area

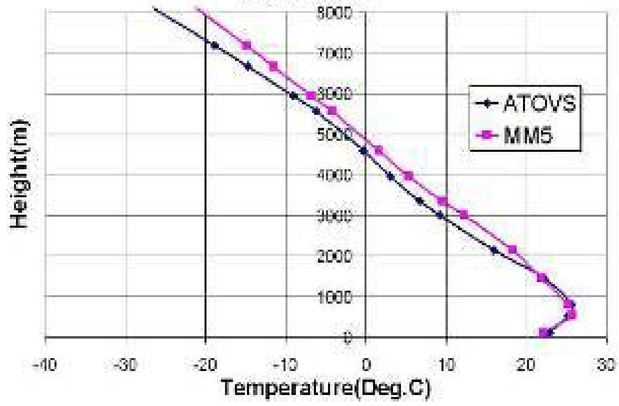

Figure 2 Comparison between vertical temperature profile and satellite observations at North of Egypt during STI exictance

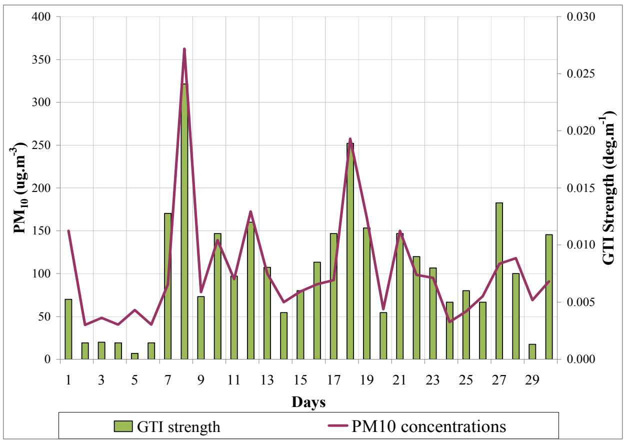

Figure 3 Comparison between PM_{10} concentration and GTI strength during April, 2005

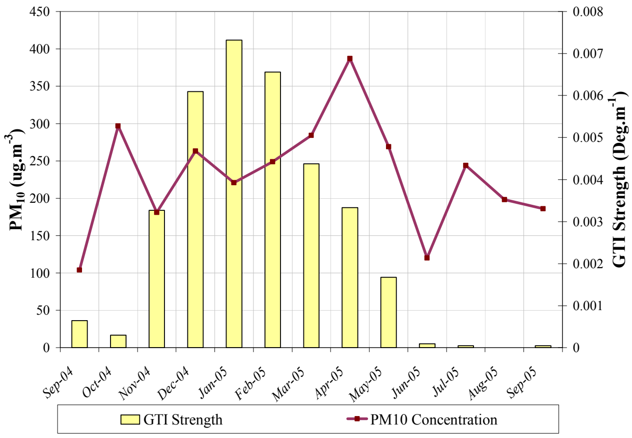

Figure 4 Comparision between monthly average of PM_{10} concentrations and GTI strength

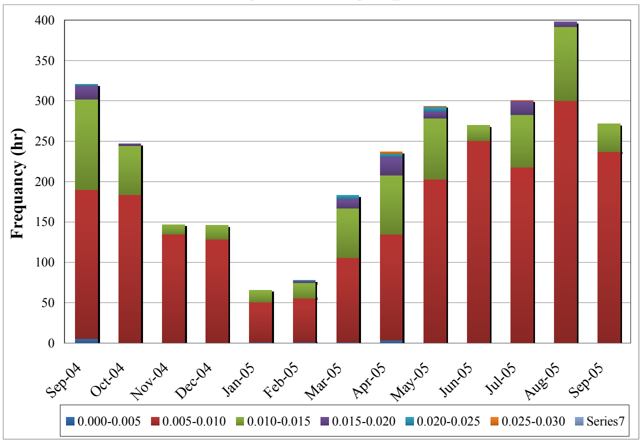

Figure 5 Frequency distribution for the STI strength over Cairo for complete year

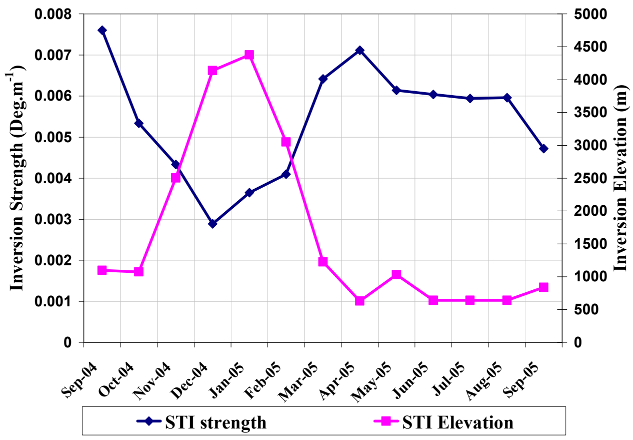

Figure 6 The STI strenght and inversion elevation over Cairo