Influence of Weather and Air Quality Conditions on the Physiological response to cold weather stress: Impact on Asthma exacerbation in Miami Dade, Florida

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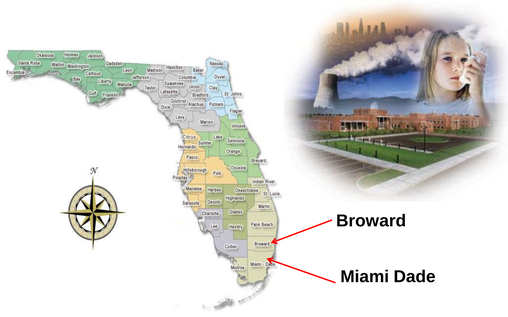
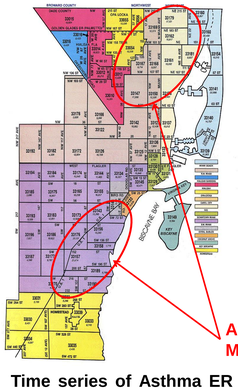
Abstract

Human Health is affected by a complex and coordinated action of many factors: Atmospheric, physiological, and behavioral; placing humans into different scenarios of sensible stress, that immediately impact the response of human beings to these external forcing. Asthma, a respiratory disorder characterized by airways inflammation and shortness of breath is an example of a human response to adverse environmental conditions modulated by the genetic predisposition of each individual. Florida Asthma Consortium (FAC) provided the asthma database for Miami Dade and Broward from January 2005 to December 2011, showing the number of visits to Emergency Rooms. Additionally, a comprehensive weather database obtained from WeatherBug (Earth-network) including outdoor temperature (T), humidity (H), barometric pressure (P), wind direction (θ_w) and speed (v_w) as well as the values of maximum and minimum and the range of all these variables has been created. Environmental Protection Agency stations in Miami Dade provided information about Ozone and Particulate Matter over the same time frame. As a result, a seasonal pattern emerged, with a maximum appearing around the middle of December and a minimum around the middle of March every year for five years of analysis. The inclusion of weather indexes facilitates the understanding of the obtained correlations and helps to predict possible outbreaks of asthma.

Health Data



The information about the number of Emergency Room (ER) visits due to Asthma was provided by the Florida Asthma Consortium (FAC) and covers years from 2005 through 2011 on daily basis. A breakdown by zip codes is also included in order to determine possible geographical spots.

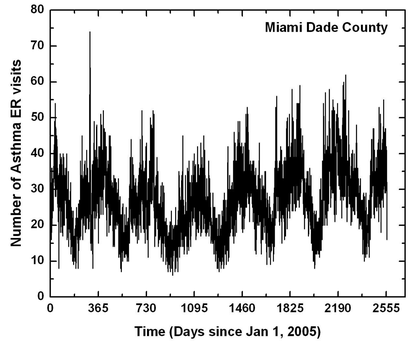


Features of Circled Areas

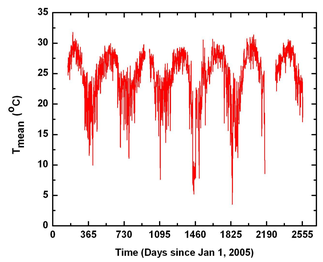
- **Very close to highly transited roads and/or Expressways**
- **High motor load, due to connecting bridges**
- **Low income population**
- **Predominant ethnicity African – American**

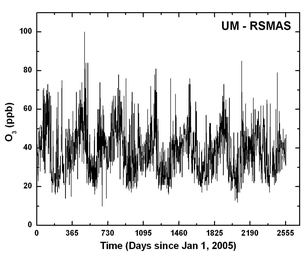
Areas of major incidence within Miami Dade County

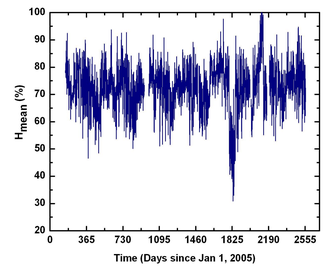
Time series of Asthma ER visits in Miami Dade County from January 2005 to December 2011. It is noteworthy the maxima happening between December and January every year.

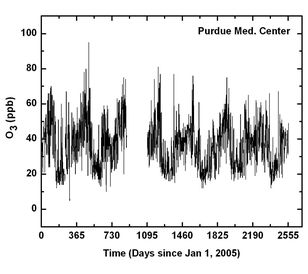


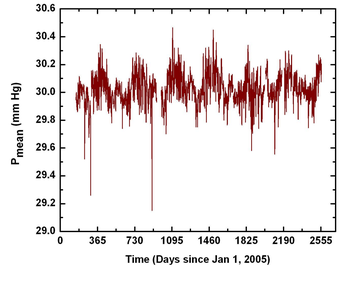
Weather and Air Quality Data



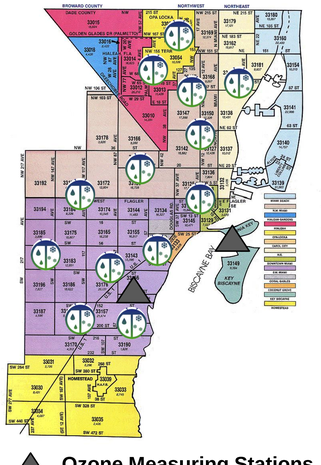




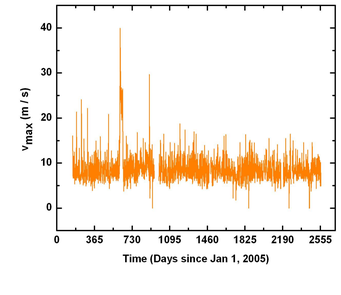




WeatherBug Stations

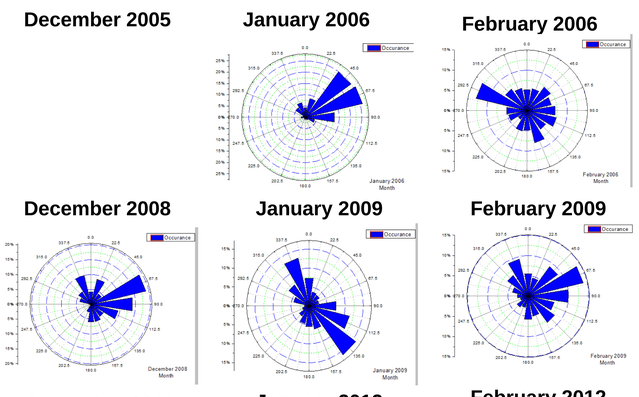


Ozone Measuring Stations



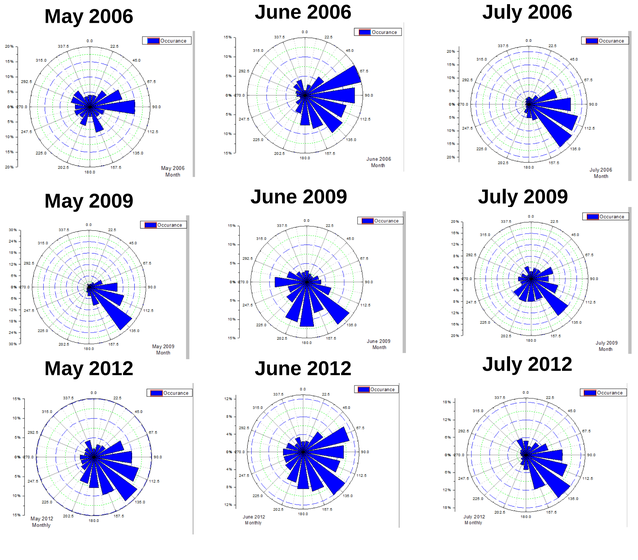
Prevailing Winds Over the Years

December – February 2006, 2009, 2012 (Month data)



Prevailing Winds Over the Years

May – July 2006, 2009, 2012 (Month data)



Correlations between the number of cases and the given set of variables

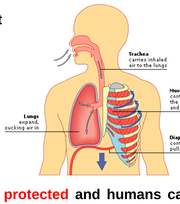
	Tmax	Tmin	ΔT	Tmean	dT/dt	ΔT/Tmean
Pearson (r)	- 0.524	- 0.529	0.357	- 0.531	- 0.122	0.487
P - value	0.000	0.000	0.002	0.000	0.306	0.000
Kendall - τ	- 0.325	- 0.301	0.159	- 0.311	- 0.122	0.264
P - value	0.000	0.000	0.048	0.000	0.132	0.002
Spearman - ρ	- 0.485	- 0.463	0.224	- 0.475	- 0.148	0.375
P - value	0.000	0.000	0.059	0.000	0.215	0.001

	ΔP	Pmean	dP/dt	ΔP/Pmean	ΔH	Hmean	dH/dt	ΔH/Hmean
Pearson (r)	0.367	- 0.021	0.082	0.42	0.452	- 0.213	- 0.015	0.445
P - value	0.002	0.862	0.491	0.000	0.000	0.073	0.899	0.000
Kendall - τ	0.269	0.008	0.045	0.291	0.282	- 0.052	0.006	0.264
P - value	0.001	0.922	0.579	0.000	0.000	0.521	0.938	0.001
Spearman - ρ	0.388	0.001	0.063	0.415	0.402	-0.091	0.003	0.373
P - value	0.001	0.996	0.600	0.000	0.000	0.445	0.979	0.001

The Acclimatization Thermal Strain Index – ATSI

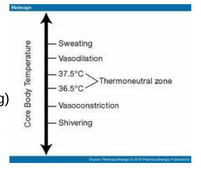
(following ideas suggested by C.R. de Freitas and E.A. Grigorieva
International Journal of Biometeorology (2009) 53: 307 – 315)

Q = C + E --- Respiratory Heat Exchange, Forced Convection
C – Dry heat flux
E – Evaporative (latent) heat flux
ATSI = 100 (Q_{hN} – Q_t) / Q_{hN}
Q_{hN} – heat exchange in place computed from Normals
Q_t – heat exchange in place computed at moment t
ATSI < 0 cold strain



The respiratory organs are not protected and humans can do nothing to prevent the ambient air entering into the body's core area, the lungs, through airways

Q = C + E
C = 1.17 x 10^{-3} M (T_{core} – T) A
E = 2.3 x 10^{-3} M (e_a – e) A
M – Metabolic heat rate (W / m^2)
A – DuBois body area (m^2)
T_{core} – Body core temperature (ºC)
T – ambient air temperature (ºC)
e – vapor pressure of ambient air (mm Hg)
e_a – vapor pressure of core air (mm Hg)
M = 90 W / m^2 person standing relaxed
e_a = 44 mm Hg
T_{core} = 37 ºC



Why negative thermal loading is so relevant?

- **Keystone in the etiology of acute respiratory diseases.**
- **Respiratory heat losses above the norm (15 W – effective heat loss) lead to high frequency of respiratory diseases in children.**
- **High heat losses from respiratory organs make it easier for pathogenic micro-flora to penetrate the protective barrier of lungs and may be the reason for increased morbidity.**