A contribution of an insurance foundation to the study of urban heat waves and their societal impact

Rationale
Climate change implies new risks and challenges for insurance industries. Among its prospective activities the MAIF Foundation is supporting researches in climate change, societal impact, risk prevention and adaptation. According to climate models for the XXI century, summer warming trends might increase the occurrence, intensity and duration of heat waves. Fig.1. Those are especially deadly in cities due to surfaces characteristics, anthropogenic heat and pollutants, e.g. the extreme 2003 heat wave in western Europe, Fig.2, has resulted in 4,867 heat related deaths in the Paris region, Fig.3. Urban heat stress and vulnerability studies require high spatial resolution meteorological observation that is unavailable from synoptic weather stations located in parks or airports Fig.4, away from the built environment Fig.5.

Objectives
Using time series satellite thermal IR images:
- to observe the urban surface temperature gradients
- to produce thermal indices and anticipate urban heat stress
- to implement health alert systems

Data and results
- 85 NOAA AVHRR images, Jul.20 Aug.20 2003, 1 km resolution
- albedo, vegetation index & radiant surface temperature
- 1 SPOT4 HRV image, Jul.13 2003, 20m resolution
- albedo, vegetation index & land use classification
- Public health data: heat stress and mortality (IVS)

![Fig.1: Heat waves, mean number of days / Year > 30 °C (Beniston et al., 2007; DMI)](image)

![Fig.2: Temperature anomaly June-Aug. 2003 vs. 1988-2003, in-situ and satellite observation (NOAA).](image)

![Fig.3: Air temperature and mortality, June 25 - Aug.19, 2003 (IVS). Heat wave of 9 consecutive days: August 4-13 2003. High minimum temperatures > 4867 heat related deaths](image)

![Fig.4: The Paris weather station in a Park.](image)

![Fig.5: The Paris built environment](image)

![Fig.6: Land Surface Temperature during the August 4-13 2003 heat wave at times of satellites pass. The composite thermal infrared images are built from a 50 NOAA AVHRR image series.](image)

![Fig.7: Land cover classification of Paris from a SPOT-4 HRV image, July 13 2003.](image)

![Fig.8: Mean diurnal cycle of Surface Temperature at given locations, from 50 NOAA-AVHRR image series. Aug.4 -13, 2003.](image)

![Fig.9-10: Influence of Vegetation on Surface Temperature.](image)

![Fig.11: Thermal conditions for 482 persons over 65. For each location, a thermal index is produced and integrated into a conditional logistic regression model to estimate the spatial variability of risk factors and to implement the health alert system.](image)

![Fig.12: Vulnerability - Surface Temperature thresholds.](image)

![Fig.13: Summertime satellite surveillance and near real time website to inform local public and authorities on extreme urban surface temperature and related heat stress.](image)