

# Domestic Fuel Combustion in Un-electrified Low-income Settlements in South Africa

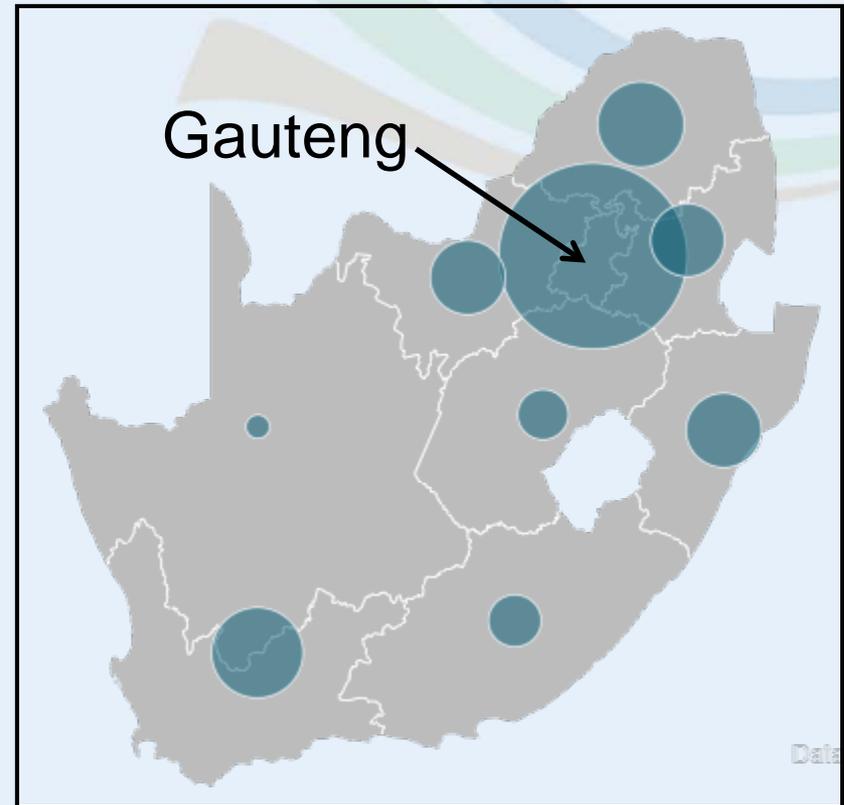
Seneca Naidoo, Stuart J. Piketh, Christopher Curtis

International Emission Inventory  
Conference 2015

San Diego

# Gauteng, SA

- Most populated
- Wealthiest
- Increasing levels of mass migration



Statistics South Africa  
2011

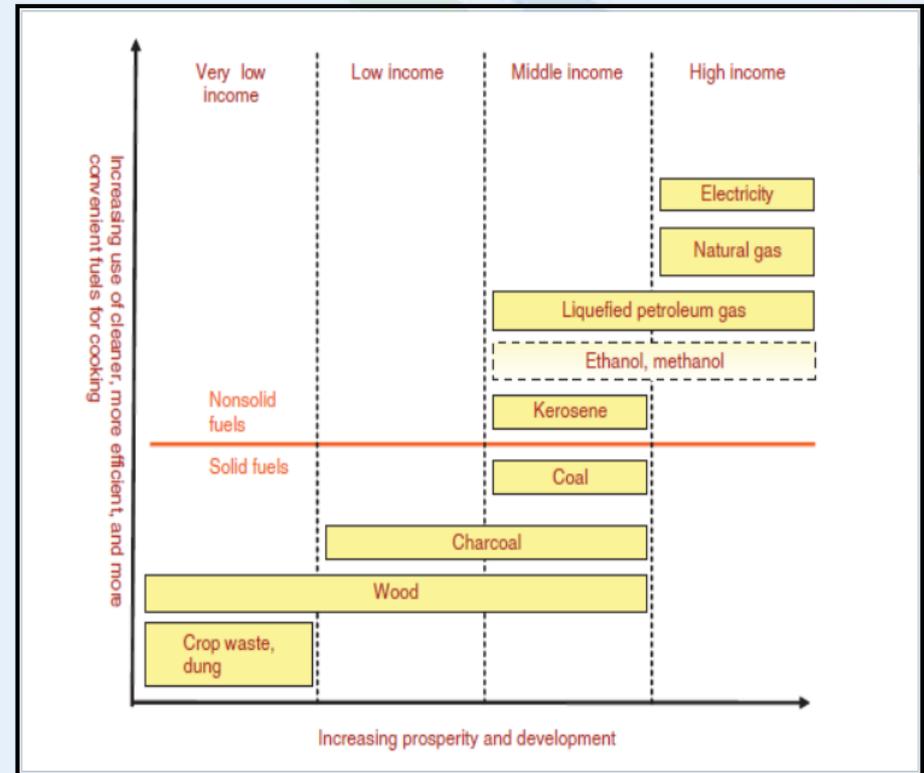
# South African Low-income Settlements

- Characterised mainly by low-income households (Balmer 2007)
- Backlog in distribution of basic services



# Domestic Fuel Combustion

- Domestic fuels
- Associated Pollutants
  - Particulate matter
  - Trace gases
  - Carbonaceous aerosols
  - Products of incomplete combustion

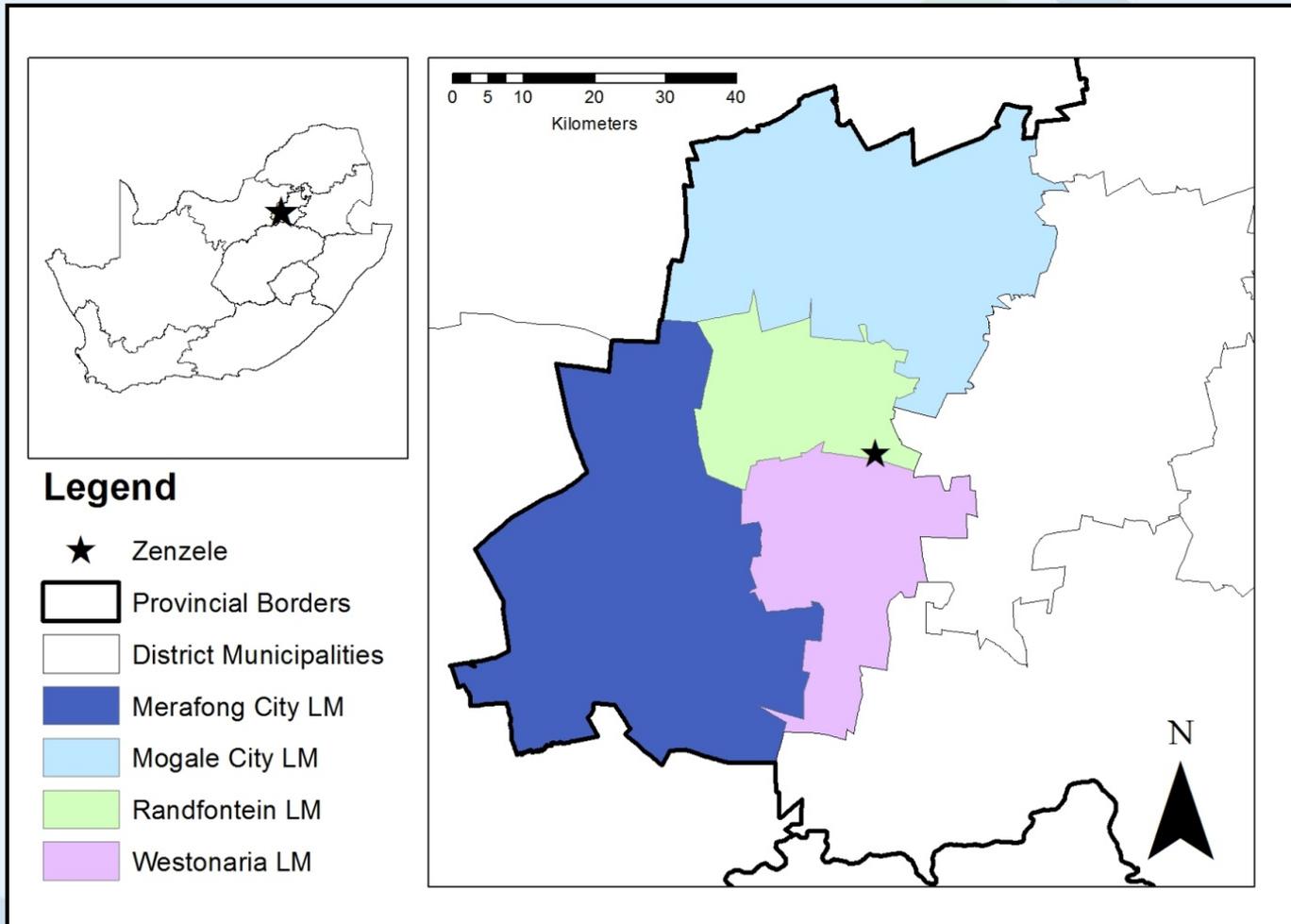


Rehfuess *et al.*  
2011

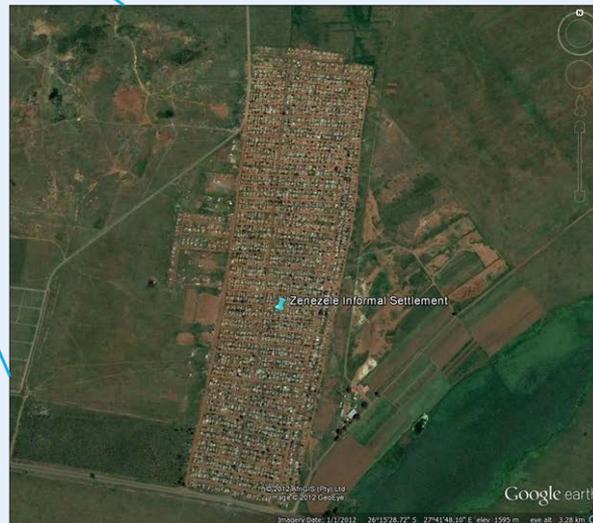
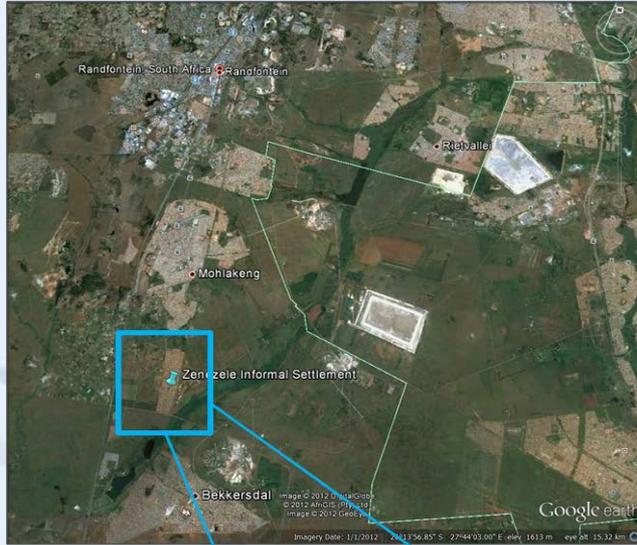
# Research

- Identify fuels most commonly burnt during winter
- Quantify emissions generated from domestic combustion processes
- Examine the potential of being able to relate the emissions from one site to another with similar characteristics

# Study Site

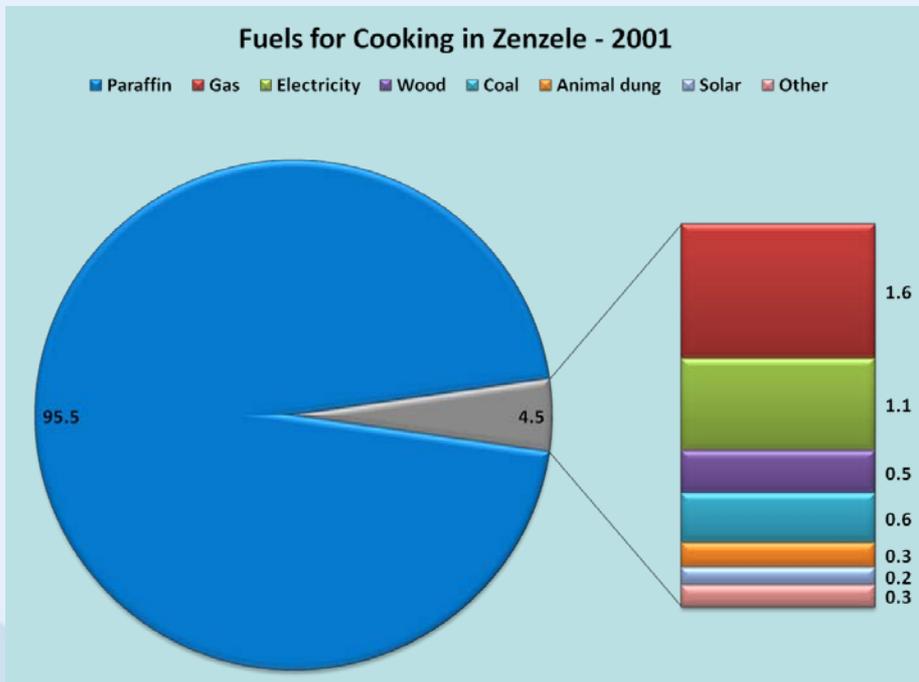


# Zenzele

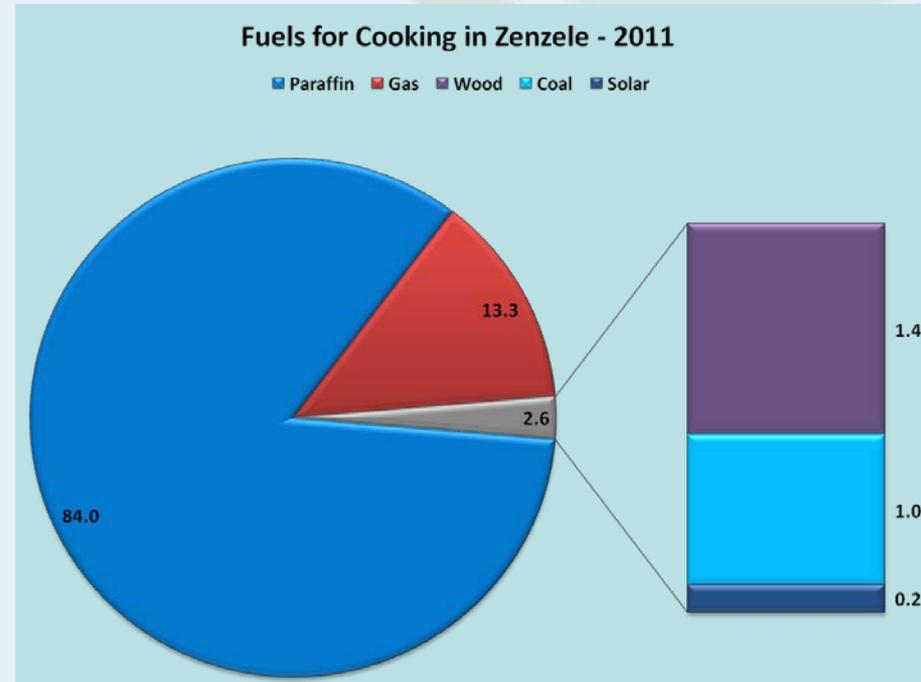


# Cooking in Zenzele (Census 2001 and 2011)

Total number of households 2380



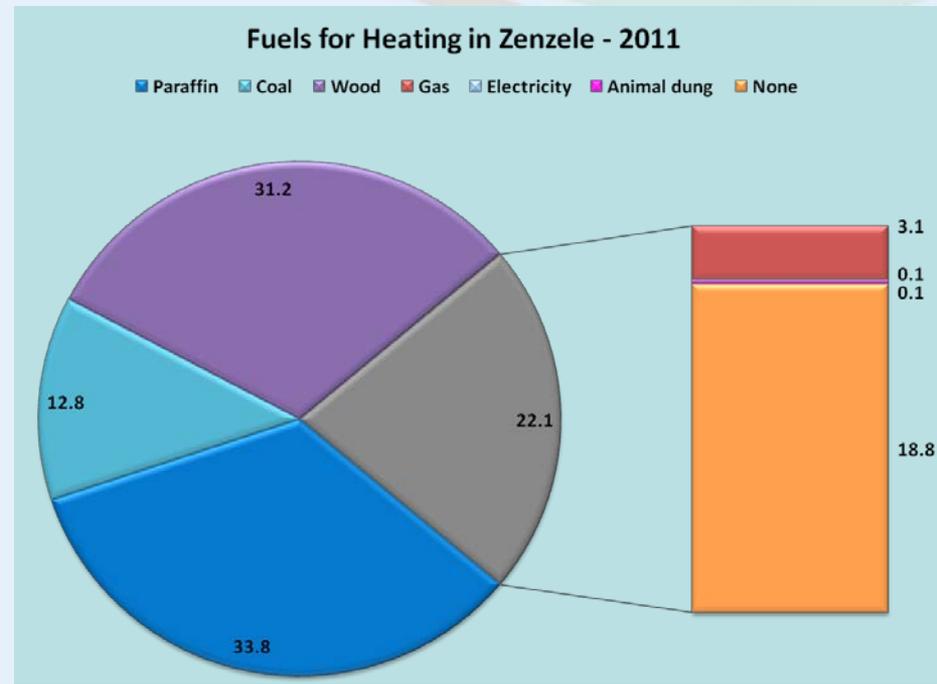
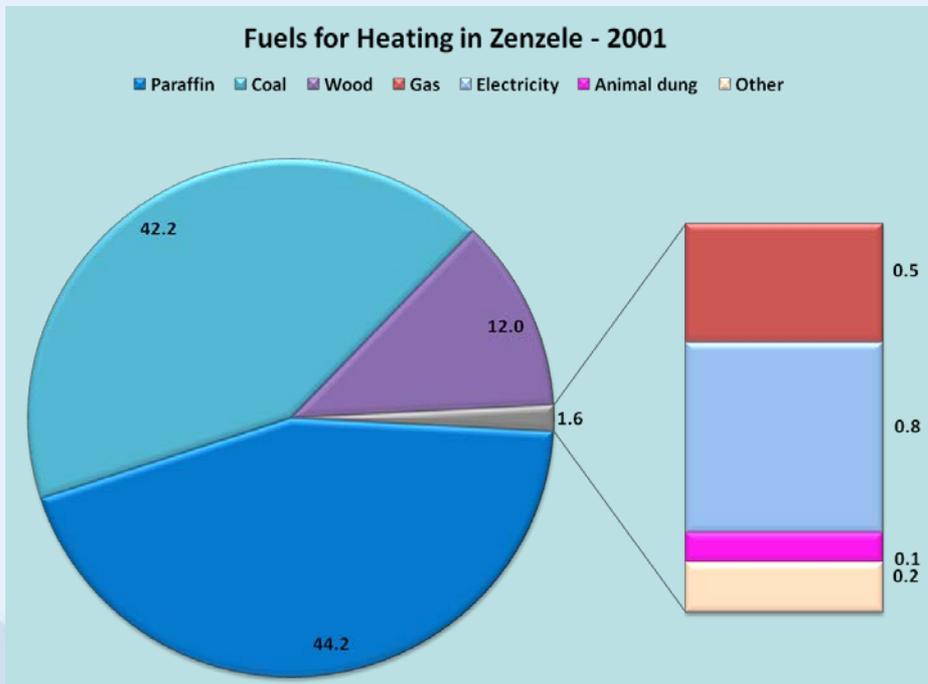
Total number of households 2168



# Heating in Zenzele (Census 2001 and 2011)

Total number of households 2380

Total number of households 2168



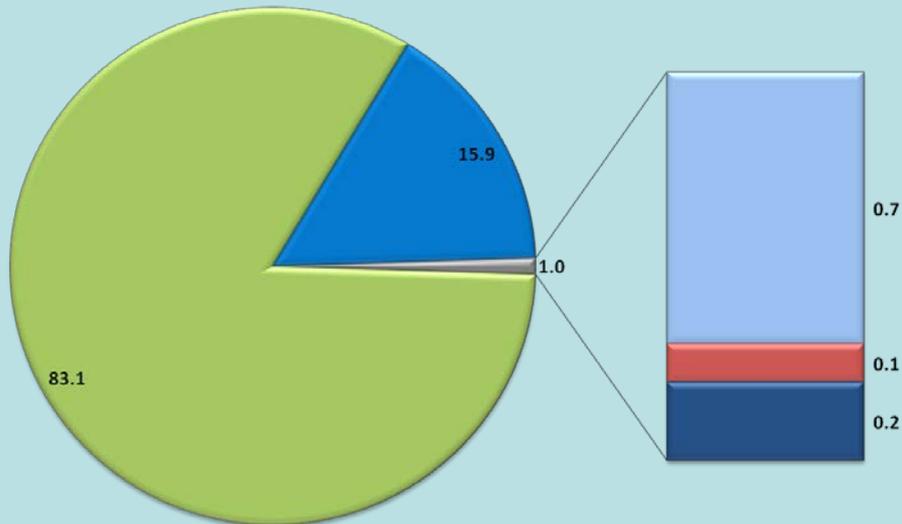
# Lighting in Zenzele (Census 2001 and 2011)

Total number of households 2168

Total number of households 2168

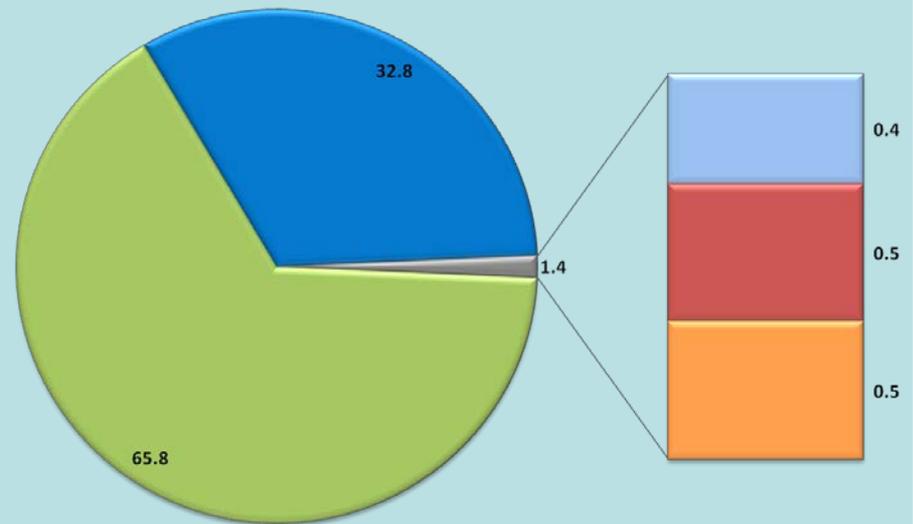
Fuels for Lighting in Zenzele - 2001

■ Candles ■ Paraffin ■ Electricity ■ Gas ■ Solar

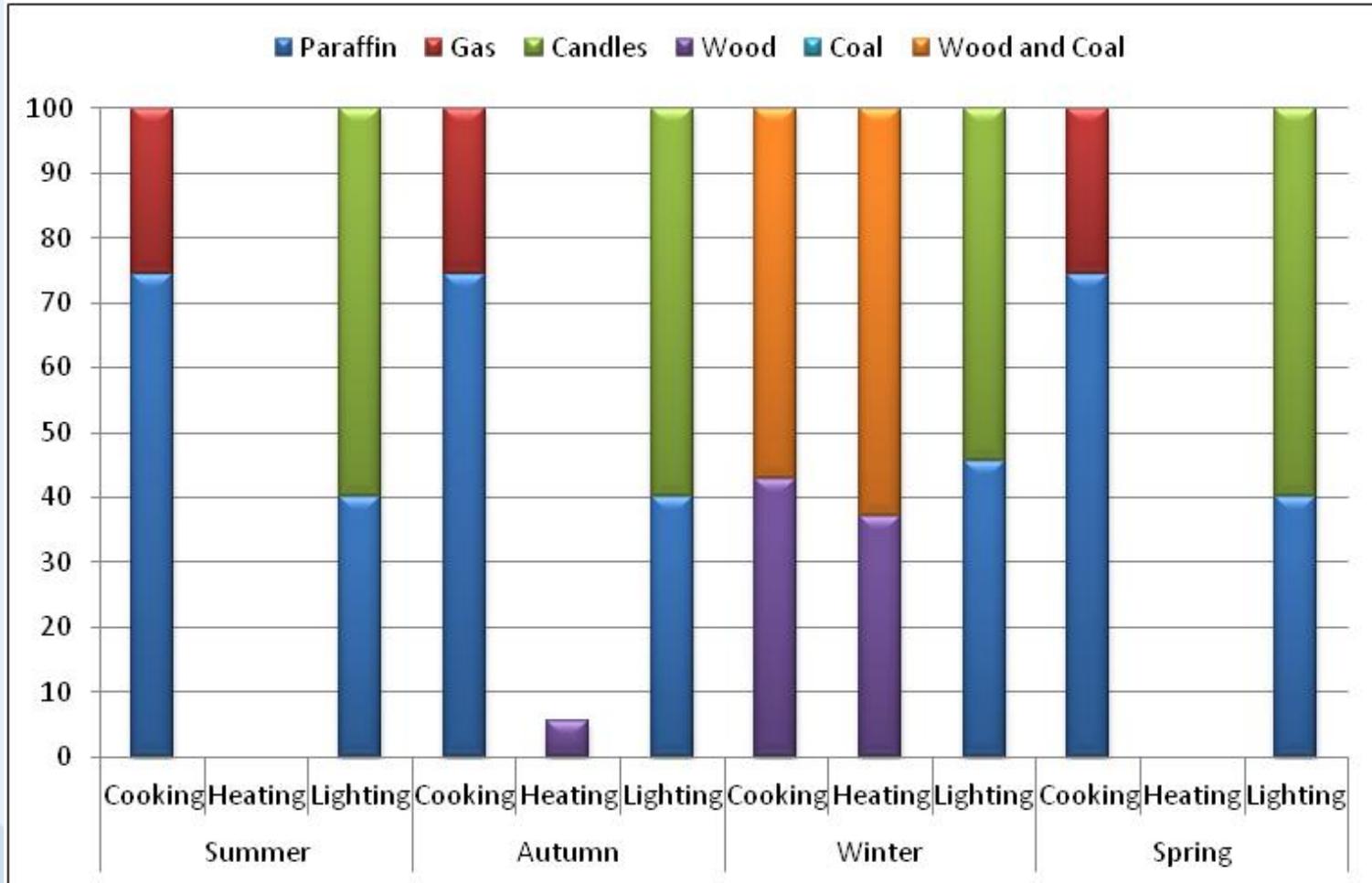


Fuels for Lighting in Zenzele - 2011

■ Candles ■ Paraffin ■ Electricity ■ Gas ■ None



# Questionnaires



# Responses to Questionnaires

- Electricity preferred for convenience
- Coal and wood burnt infrequently during warmer months – paraffin, gas and candles most commonly used
- Coal and wood burnt simultaneously
- Temperature and cost will prompt shift to solid fuel use
- Multi-functional nature of wood and coal (Scorgie 2003)

# Stoves

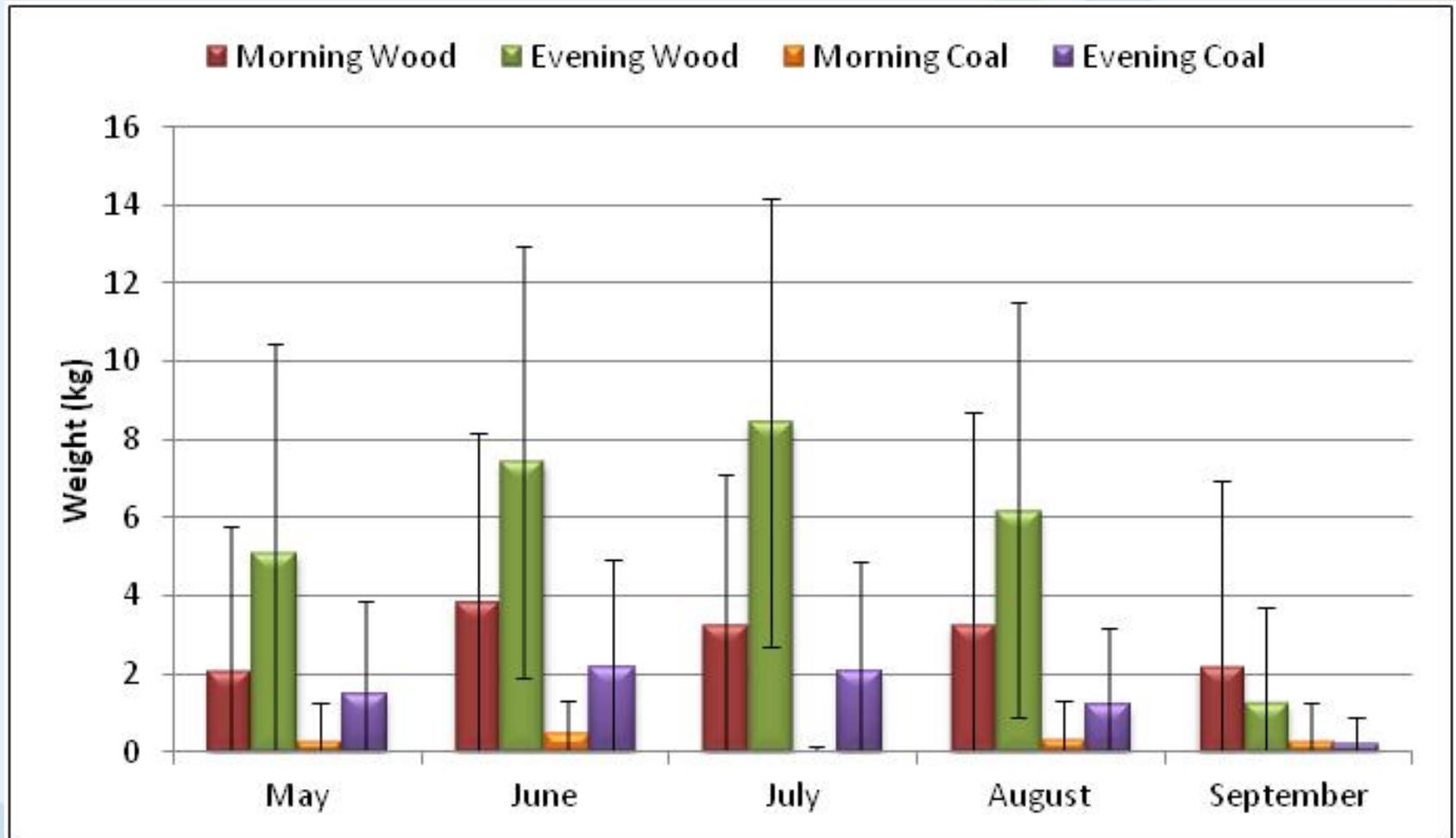


# Field Study

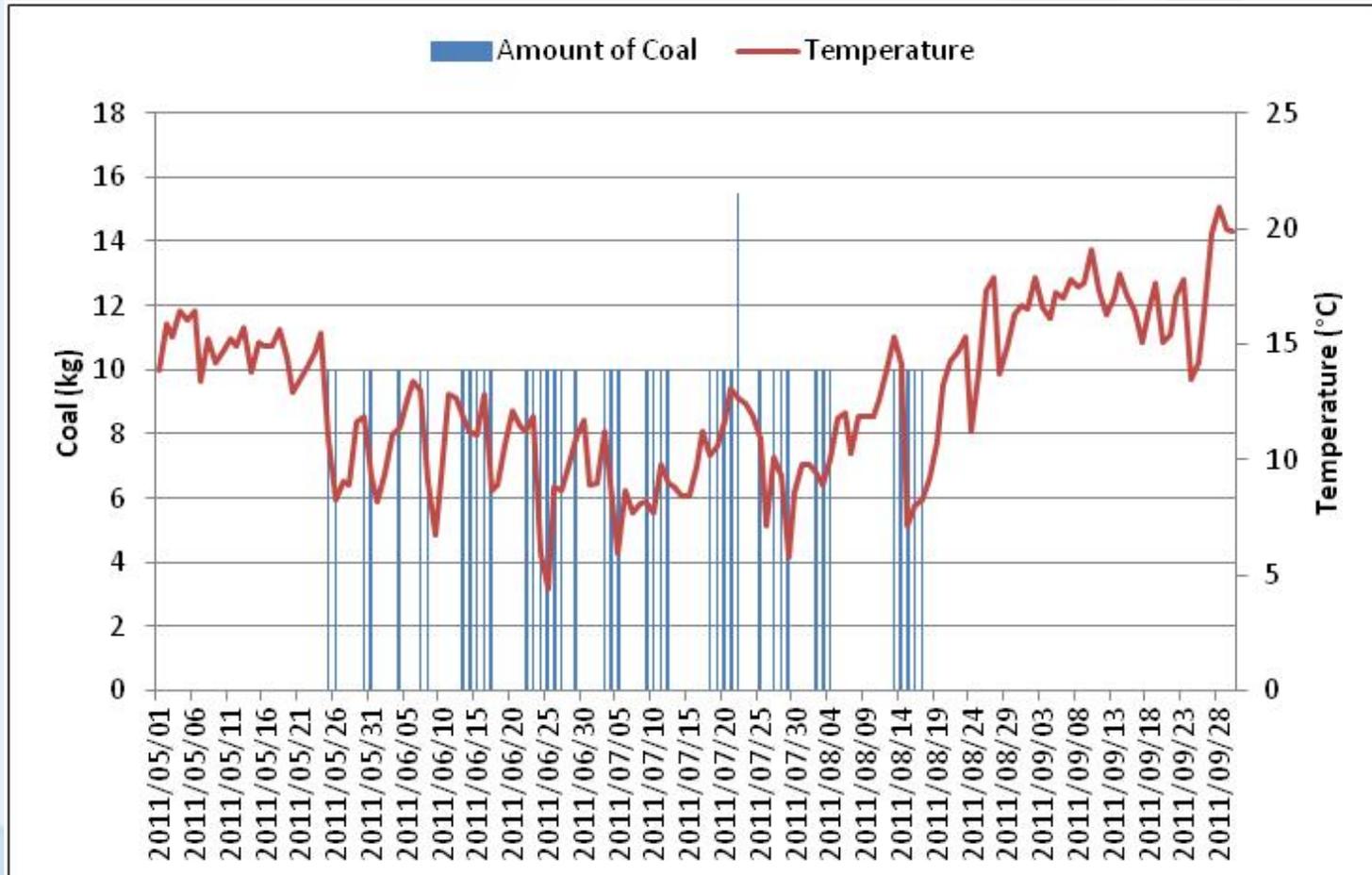
- 15 households
- Weigh amounts of wood and coal
- May 2011 to September 2011



# Average Consumption



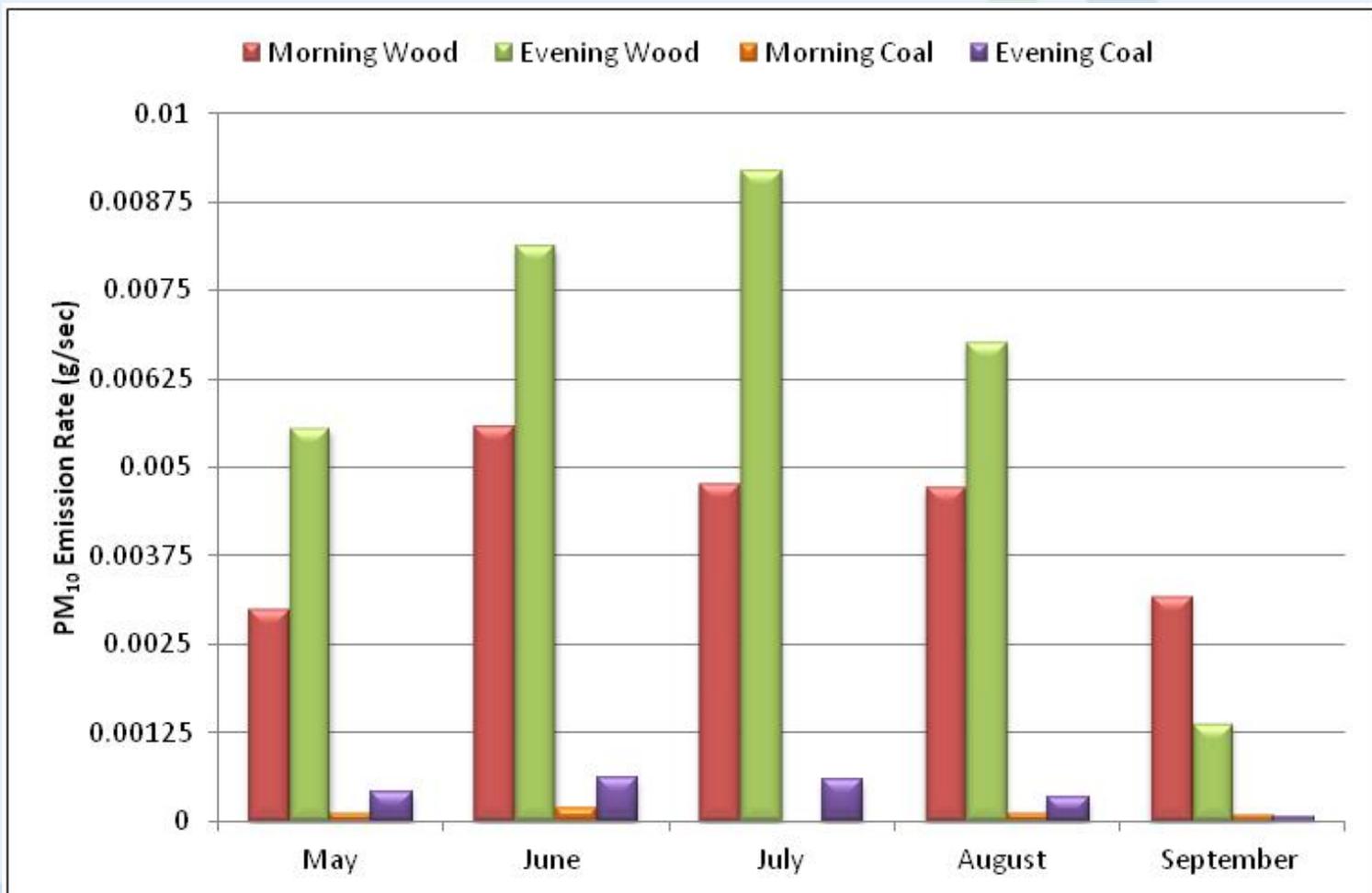
# Total Consumption of an Individual Household



# Factors Affecting Consumption

- Accessibility of wood
- Relative cost of wood and coal
- Supply of fuel
- Time yielding the maximum benefit

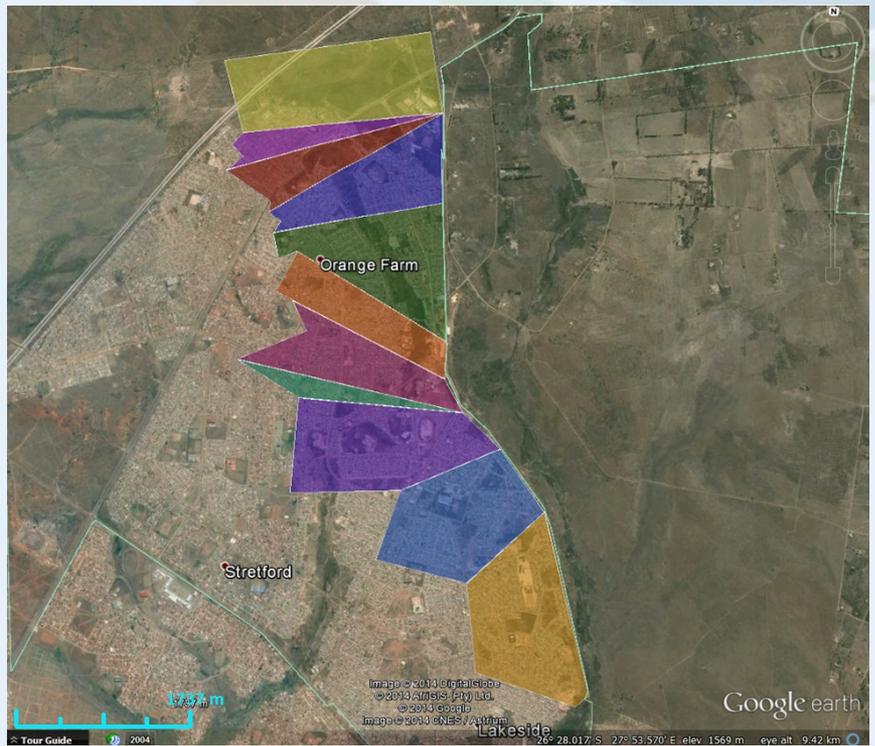
# Emission Estimates



# Dispersion Modelling

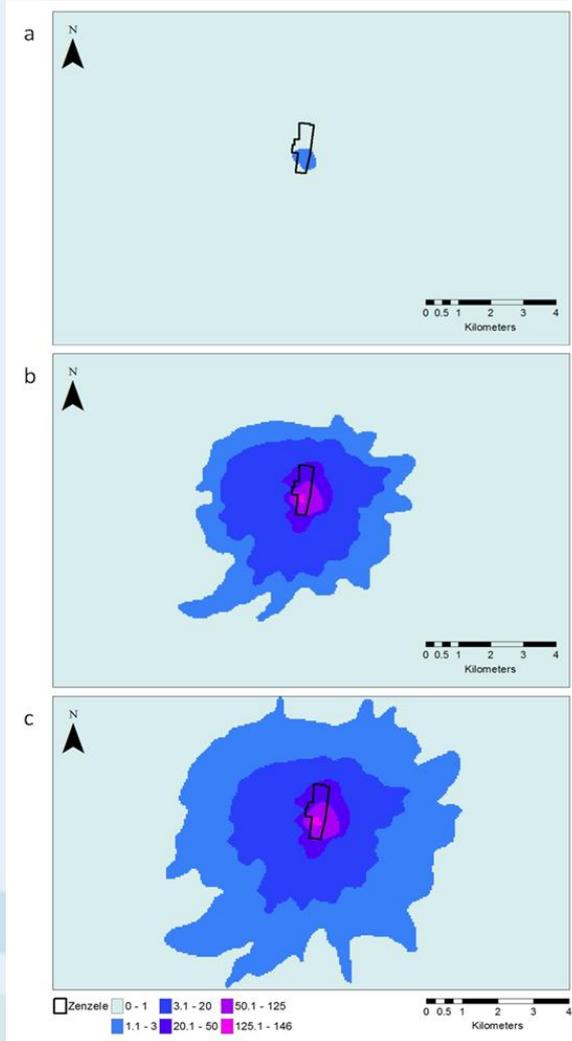
- CALPUFF : assess the dispersion and fate of pollutants from Zenzele and Orange Farm
- Atmospheric dispersion potential : stable conditions ; no rainfall
  - surface and elevated inversions common occurrence which decreases the depth of the mixing layer, inhibiting the dispersion of pollutants.
- Preparation of input data for CALPUFF
  - based on 7-hr burning period per day

# Zenzele and Orange Farm

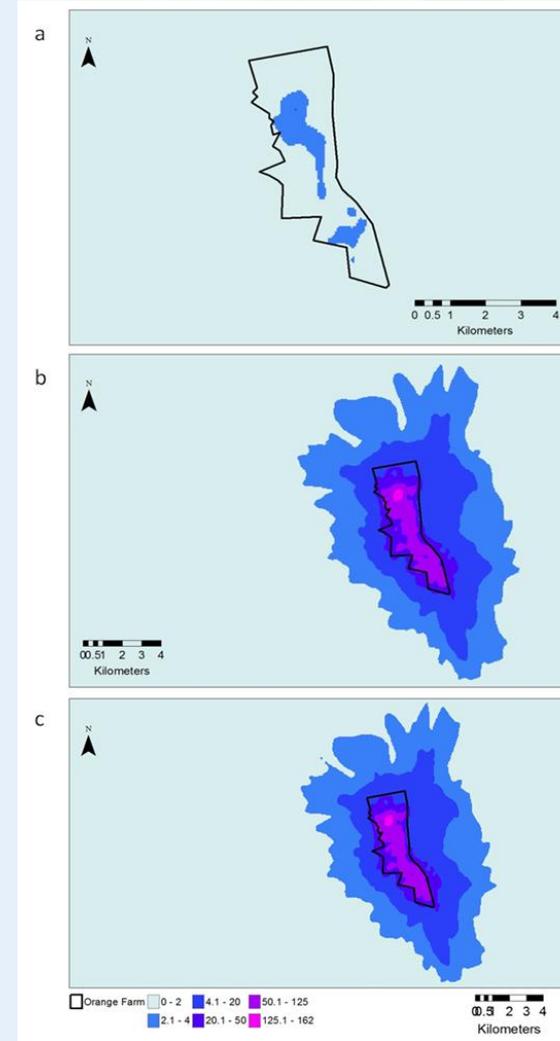


# Maximum Averages Daily SO<sub>2</sub> Concentrations

Zenzele



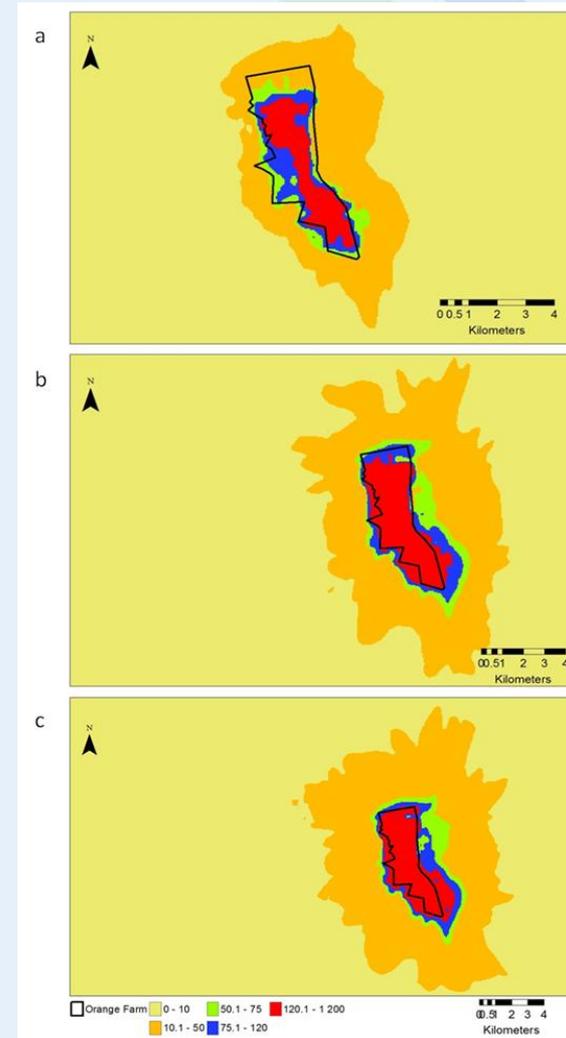
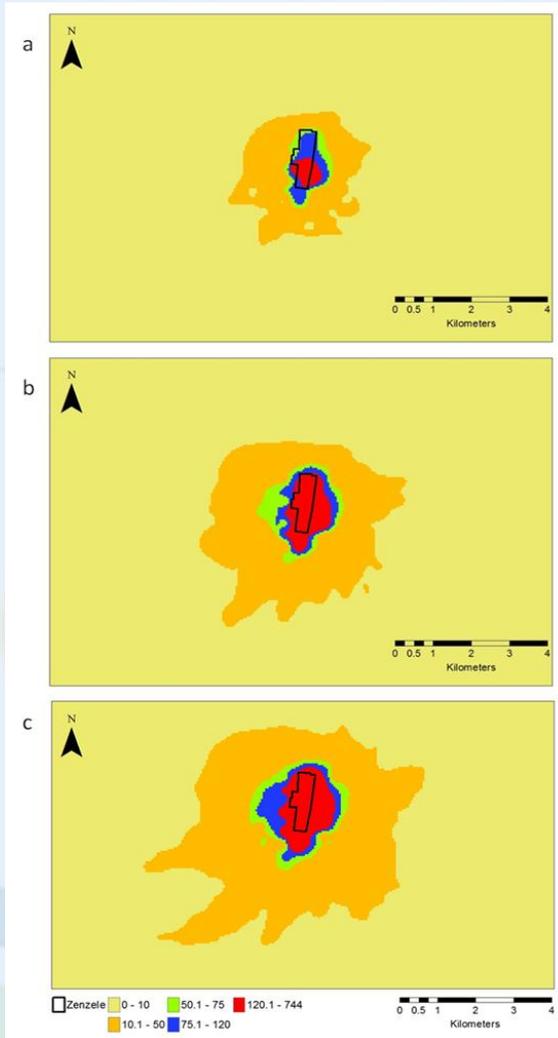
Orange Farm



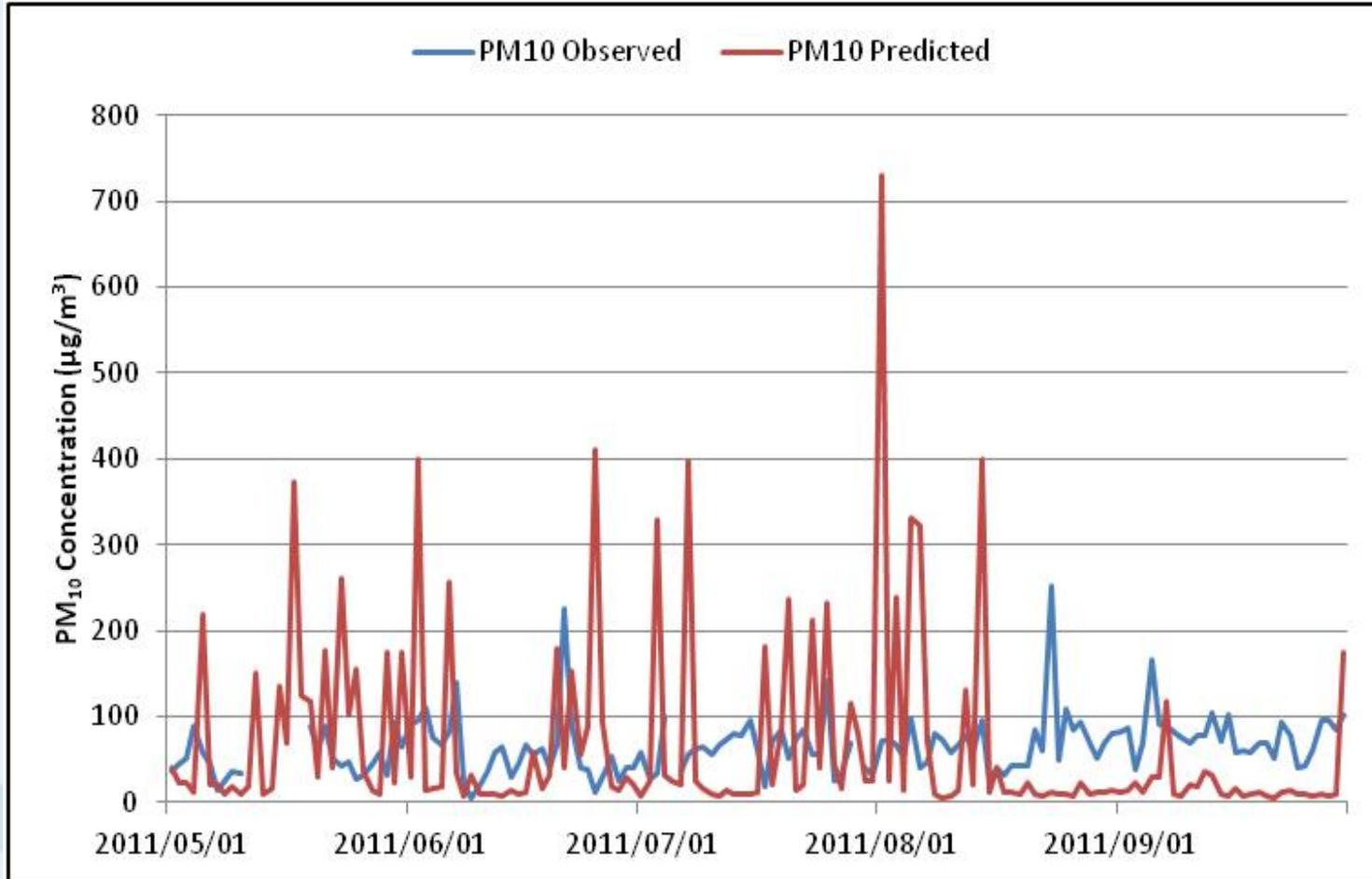
# Maximum Averages Daily PM<sub>10</sub> Concentrations

Zenzele

Orange Farm



# Observed VS Predicted 24-hr Average Concentrations



# Conclusion

- Electricity - often affordability outweighs convenience
- Winter – more than one fuel source
  - Morning: wood
  - Evening: wood and coal simultaneously
- Dangers associated with the use of hand-built stoves and imbaulas
- Seasonality, price, availability and cultural aspects – major influences
- Largest peaks in fuel use occur after large drop in temperature
- Significant seasonal variations

# Conclusion (cont.)

- Emission rates higher during colder months and evenings
- Labour and fuel intensive fires – evenings
- Predicted CALPUFF concentrations of SO<sub>2</sub> and PM<sub>10</sub> – exceeds SA NAAQS limit value and WHO AQ guidelines
  - Zenzele: 10 X higher than SA NAAQS limit value and 15 X higher than WHO guideline
  - Orange Farm: 16 X higher than SA NAAQS limit value and 24 X higher than WHO guideline
- Variations in Observed and Predicted concentrations – no background concentrations in CALPUFF only 7 hour burning period

# Limitations and Recommendations

- Limitations
  - Lack of good quality domestic burning data for South Africa
  - Representative sample size
  - Lack of standardised South African emission factors for domestic fuel combustion
- Recommendations
  - Verify and revise emission factors
  - important to have an understanding of the social and cultural dynamics surrounding domestic fuel combustion in low-income settlements.

# Acknowledgements

- South African Weather Service
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- Prof. Christopher Curtis
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# Thank You