Towards a Generalisable Methodology to Limit the Effects of Soiling for Heliostats Sited Near a Ferromanganese Smelter

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PREMA - Energy efficient, primary production of manganese ferroalloys through the application of novel energy systems in the drying and pre-heating of furnace feed materials

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 820561

CONTENT

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INTRODUCTION

- PREMA – Energy efficient, primary production of manganese ferroalloys through the application of novel energy systems in the drying and pre-heating of furnace feed materials
- CO_2 rich off-gas, bio carbon, and **CST-generated heat** will be used for **ore pretreatment**
- **Particle receiver** (CentRec®) + **Tower** / **HelioPod** (STERG)

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BACKGROUND

- The future of concentrating solar technologies relies <u>partly</u> on their application expansion to industries outside of power generation > **Metallurgical processes** > **Sintering and pre-heating of furnace feed materials**

- Investigations conducted by Lubkoll et al. (2018)[1] found:
  > Expected **LCOH** for **CST process heat** range(389 R/MWh_t to 474 R/MWh_t)
  > Expected **LCOH** for **Diesel burners**, range(563 R/MWh_t to 1107 R/MWh_t)
  > 33% total CO2 emission reduction

(1) – M Lubkoll, S A C Hockaday, T M Harms, T W von Backstrom, L Amsbeck, and R Buck, "Integrating solar process heat into manganese ore pre-heating", Proceedings of the South African Solar Energy Conference (SASEC), 2018.

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BACKGROUND

- PREMA: Pre-heating of MN-alloys upstream of furnace
  > Particles heated to in range 800 °C to 1000 °C (TES)
  > Transported and used to heat air to 700 °C
  > Air used to heat Mn-ore to 600 °C in shaft-kiln (CF-HX)

- Overarching goals:
  > CO_2 Emission reduction (direct and indirect)
  > Mn-alloys sector more flexible, sustainable, and attractive
  > 'Cleaning' a dirty process

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PROBLEM

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SCOPE OF WORK

- **Location** > Transalloys ferromanganese smelter
- Assess the feasibility of using CST through **solar resource characterisation** at ferromanganese smelter site
- Develop methodology that is generally applicable

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EXPERIMENTAL WORK AND METHODOLOGY

- Soiling study
- Dust deposition study
- Atmospheric Boundary Layer **(ABL) flow** characterisation
- Computational Fluid Dynamics **(CFD)** of characteristic atmospheric conditions

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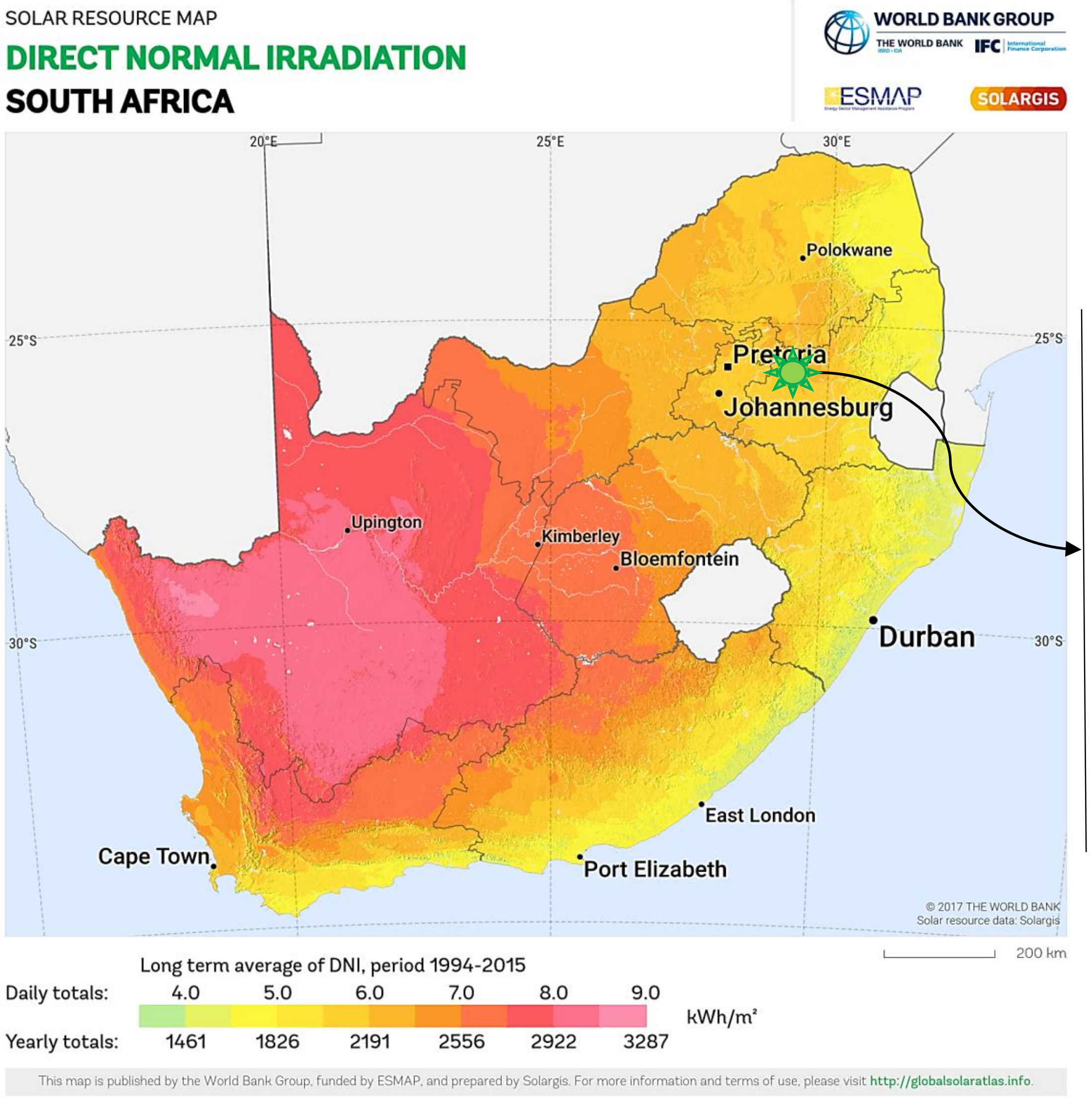
SCOPE / Location



Transalloys ferromanganese smelter, Emalahleni, Mpumalanga

DNI levels of approximately 2140 kWh/(m^2 a)

> 2000 kWh/(m2 a)

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SCOPE / Solar resource characterisation

- Relocation of Vanrhynsdorp SAURAN station in progress …

Measurements
Global horizontal irradiance [W/m²]
Direct normal irradiance [W/m²]
Diffuse horizontal irradiance [W/m²]
Air temperature [°C]
Barometric pressure [mbar]
Relative humidity [%]
Rainfall [mm]
Wind speed and wind direction [m/s]
Wind direction [°]

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SCOPE / Dust background

- Impact of solar field Operation & Maintenance (O&M) is high, around 8%[2] of LCOE for CSP
  > if too much cleaning required could be financially unfeasible!
  > Workaround if HelioPods are used, **handwashing feasible**
  > Current norms range from **7 day to 20 day cycles**

- Thermal energy loss of **1.2% for each 1%[3] reflectivity drop** (as percentage of clean mirror)

(2) – K Lovegrove and W Stein, "Concentrating solar power technology: Principles, developments and applications", Elsevier, 2012.

(3) – F B J Anglani, W Dekker, "CFD modelling of a water-jet cleaning process for concentrated solar thermal CST systems", Third Southern African Solar Energy Conference (SASEC), 2015.

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SCOPE / Industrial dust

- Dust is any particulate matter lightweight enough to be suspended, and heavy enough to settle out of airstream via gravity over time

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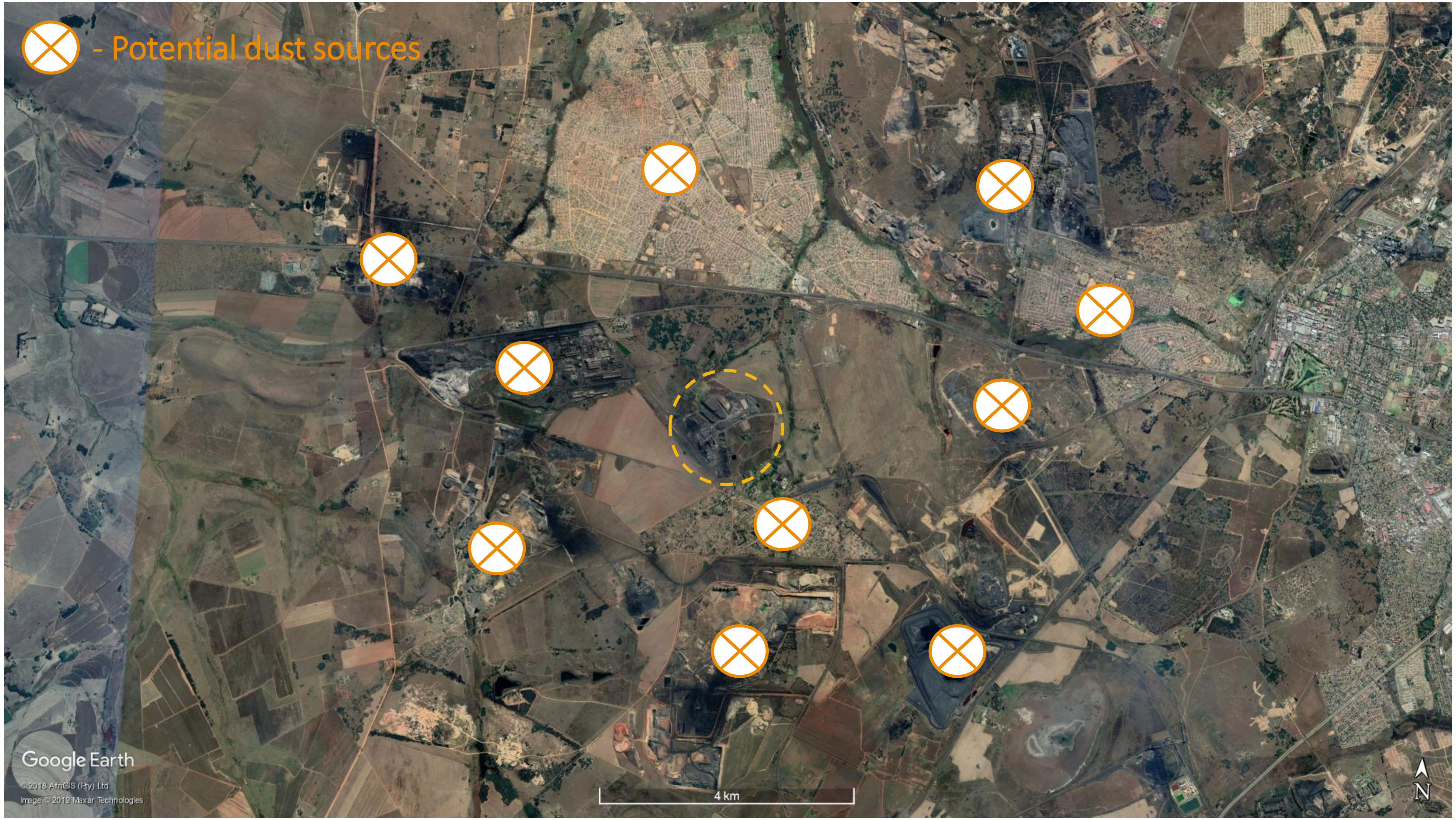
SCOPE / Industrial dust



PREMA

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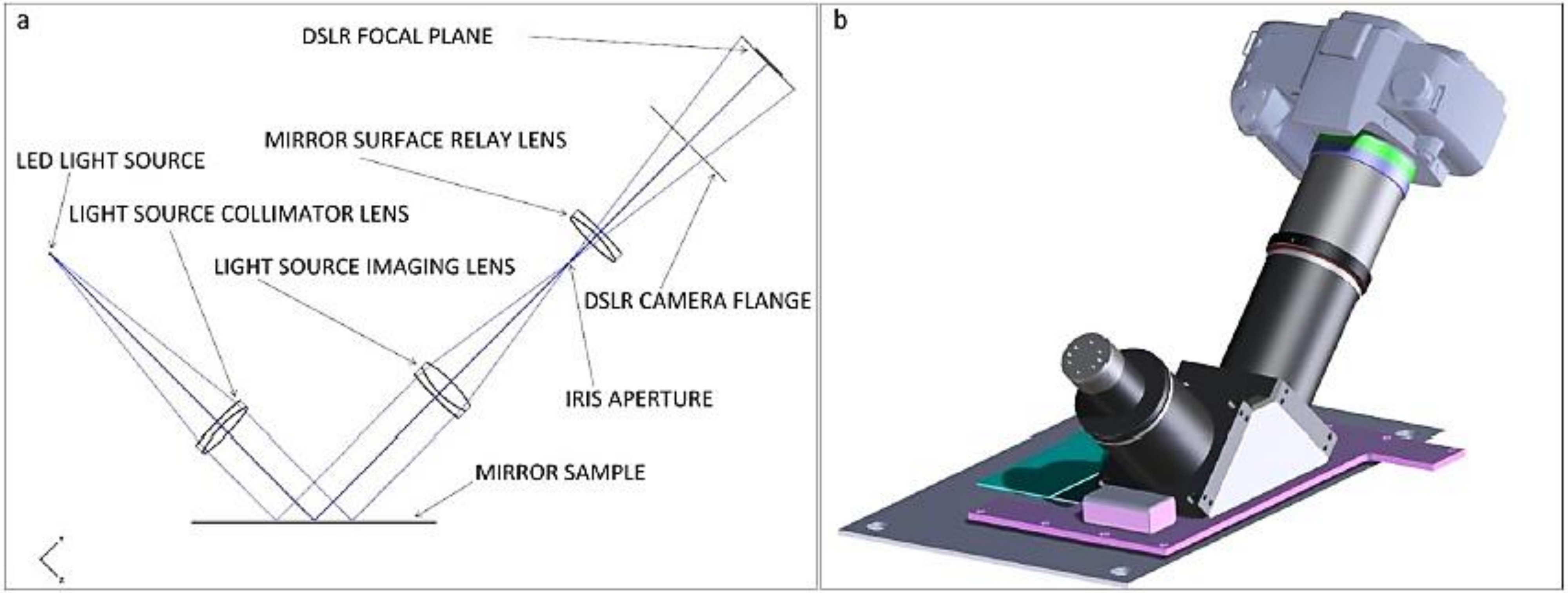
SCOPE / Mirror reflectivity measurements



(a) DSLR-Based Contamination Camera Optical Layout | (b) CAD View of DSLR-Based Dust Camera

Griffith, Derek & Vhengani, Lufuno & Maliage, M. (2014). Measurements of Mirror Soiling at a Candidate CSP Site. Energy Procedia. 49. 1371 - 1378. 10.1016/j.egypro.2014.03.146.

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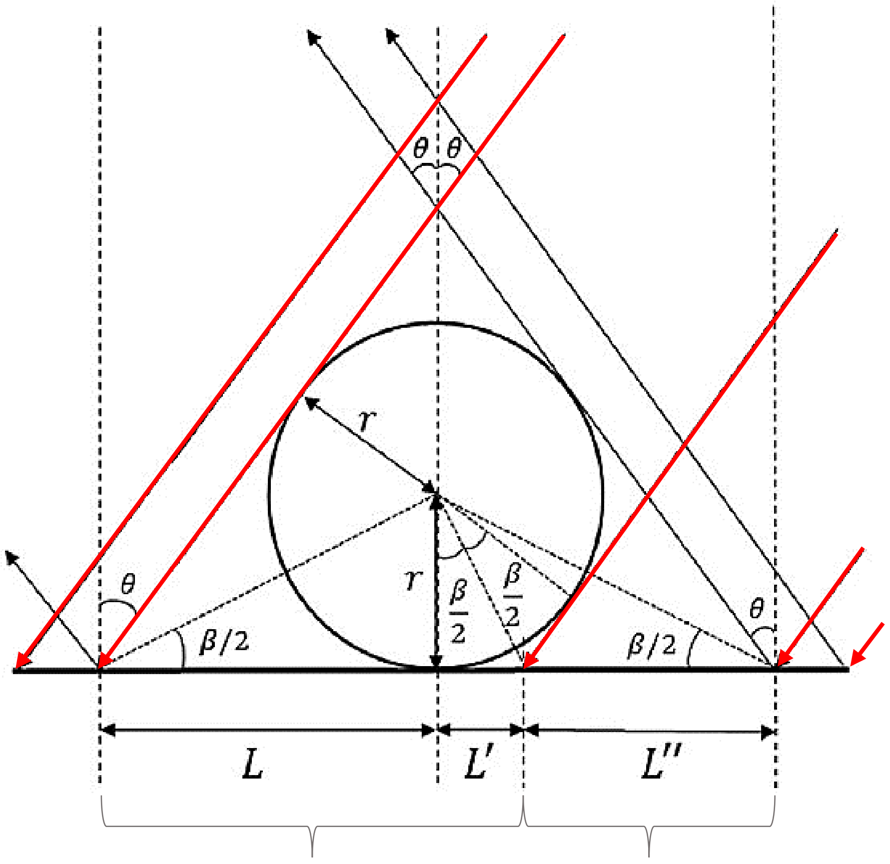
SCOPE / Soiling



G Picotti, P Borhesani, G Manolini, M E Cholette, and R Wang, "Development and experimental validation of a physical model for the soiling of mirrors for CSP industry application", Solar Energy 173, 2018, pp1287-1305.

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SCOPE / Dust deposition & Reflectivity study

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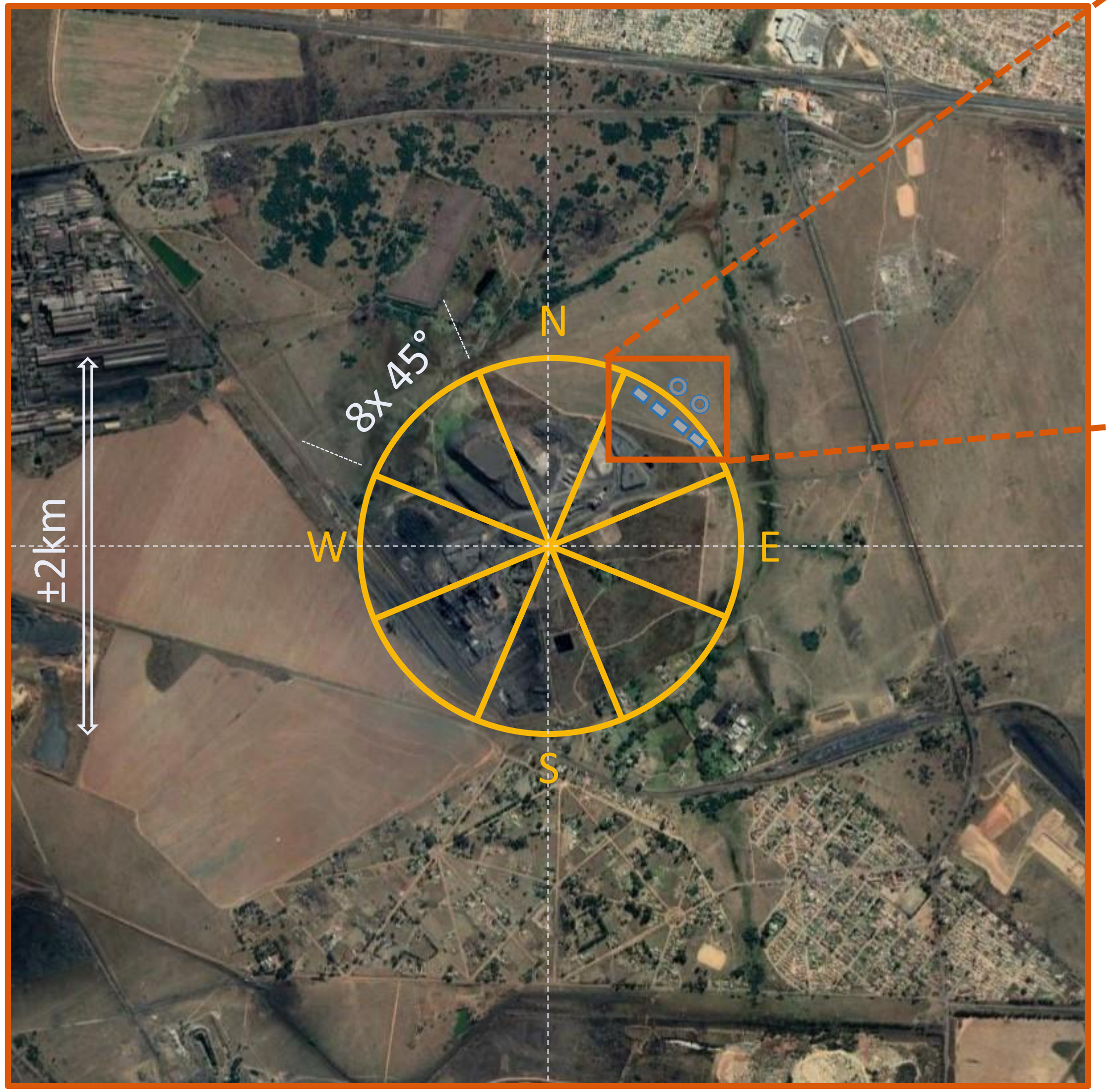
SCOPE / Experimental layout



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