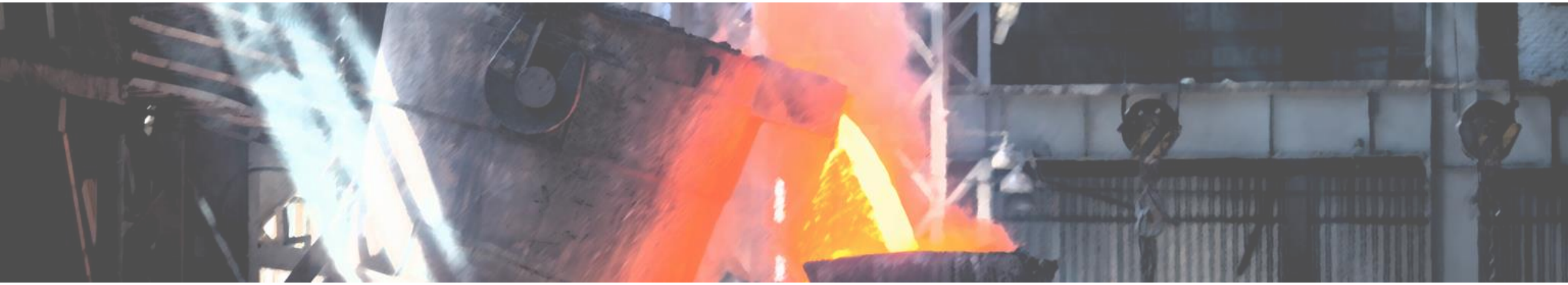
Solar Heat for Industrial Processes



The work of the PREMA project in lowering the barriers towards integrating SHIPs

Milan Swart

Pyrometallurgy Department at Mintek, RSA

14 June 2021

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

Project inspiration

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Top of FeMn smelter at Transalloys, RSA

Khi Solar One 50MW$_e$ CSP tower near Upington, RSA

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What is 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 (PREMA)

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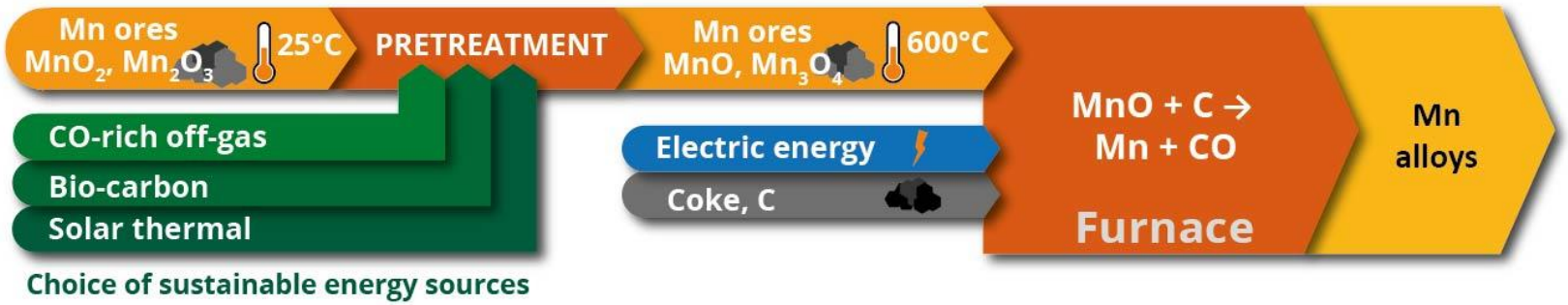
Before PREMA

After PREMA



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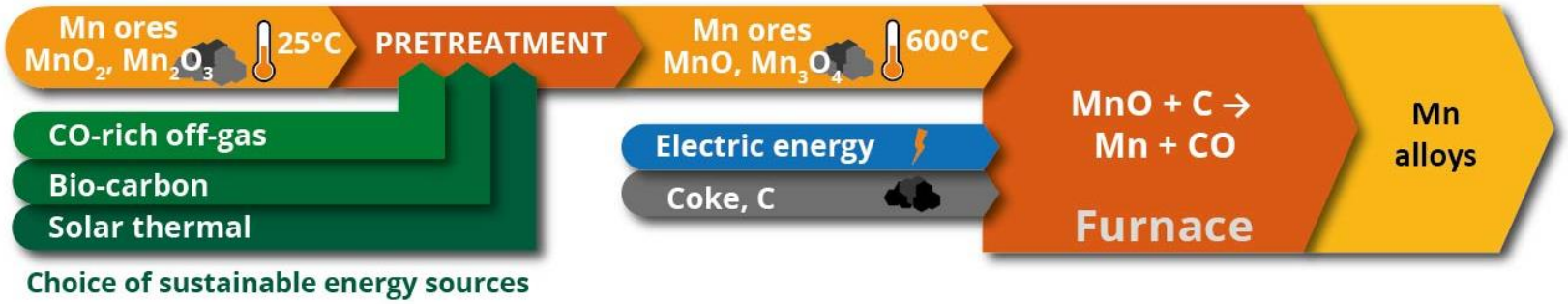
Pretreatment of Mn-ores



Advantages of two-step SAF* processing [1]:

- 20% less fossil carbon consumption
- 10% less electrical energy used
- 25% less primary energy used and 15% less CO_2 emissions
  - Improved furnace stability due to better carbon balance, very little CO_2 produced in furnace
- 10% reduction in Mn ores processing operating costs through such a flexible operation scheme

*SAF – Submerged-Arc Furnace

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CST-to-pretreatment integration concept

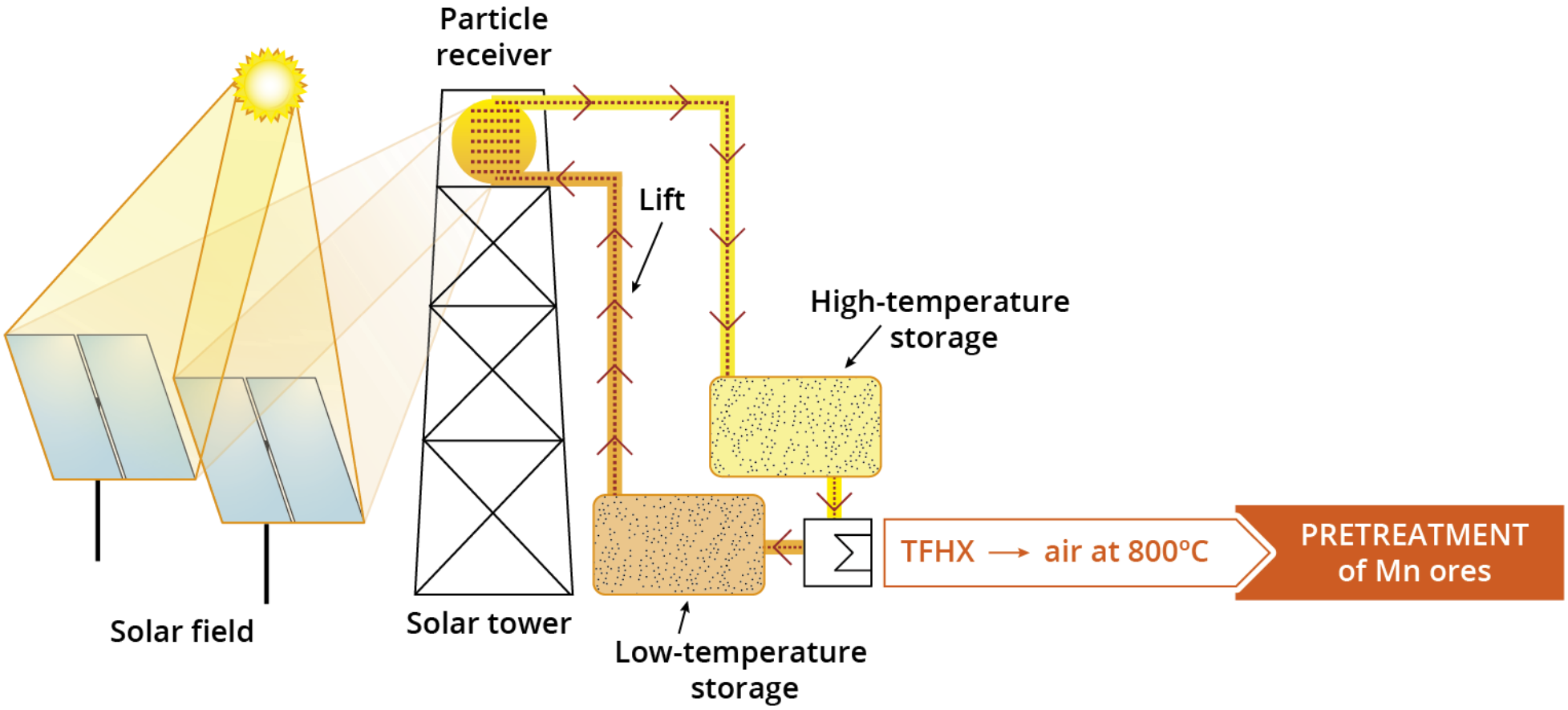

Diagram adapted with permission [2].

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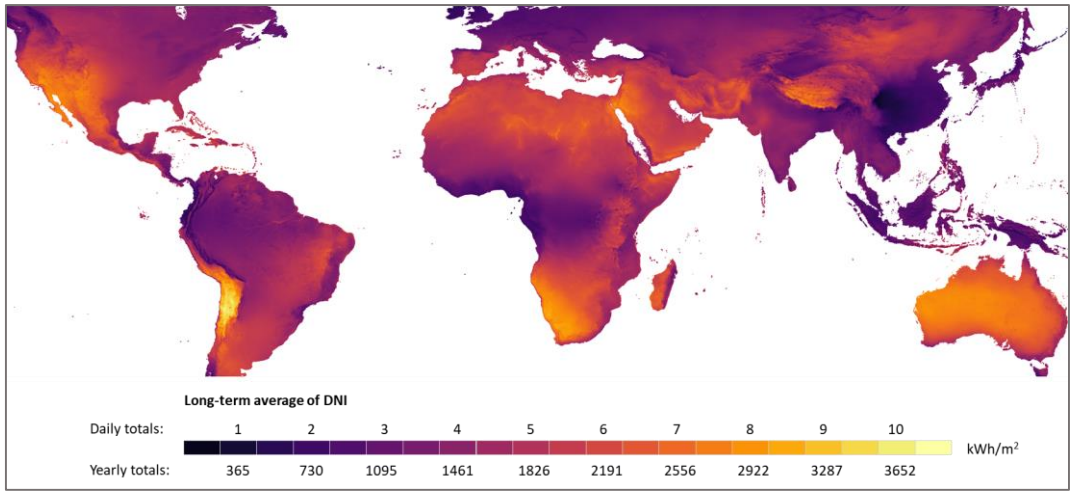
Pre-conditions for CSP

DNI > 1600 kWh/m^2



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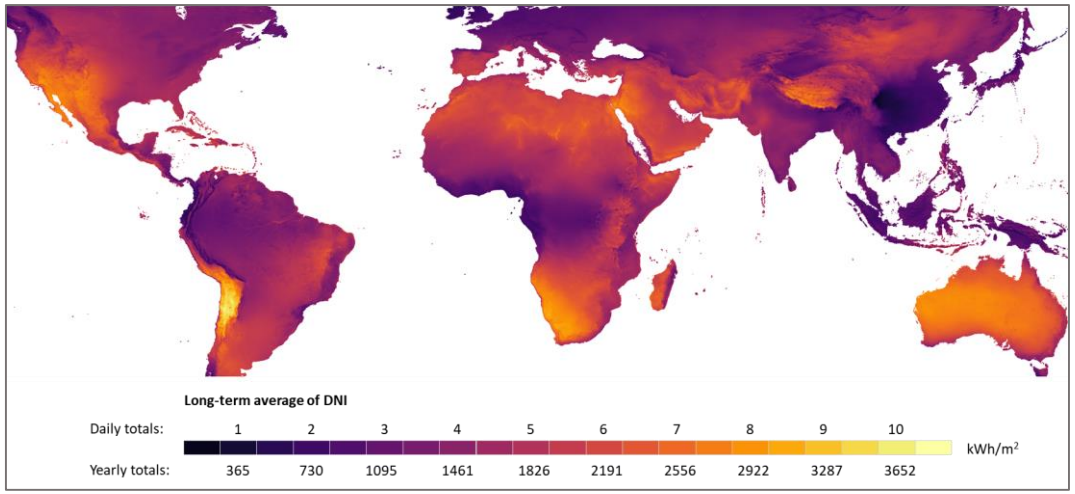
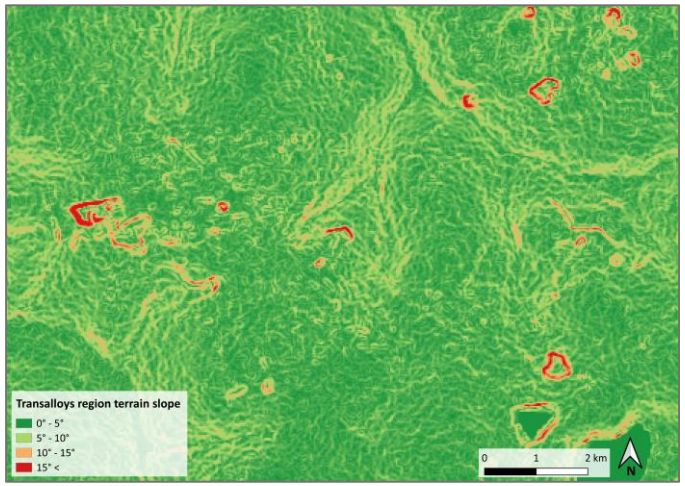


Terrain slope less than 5°, and free horizons



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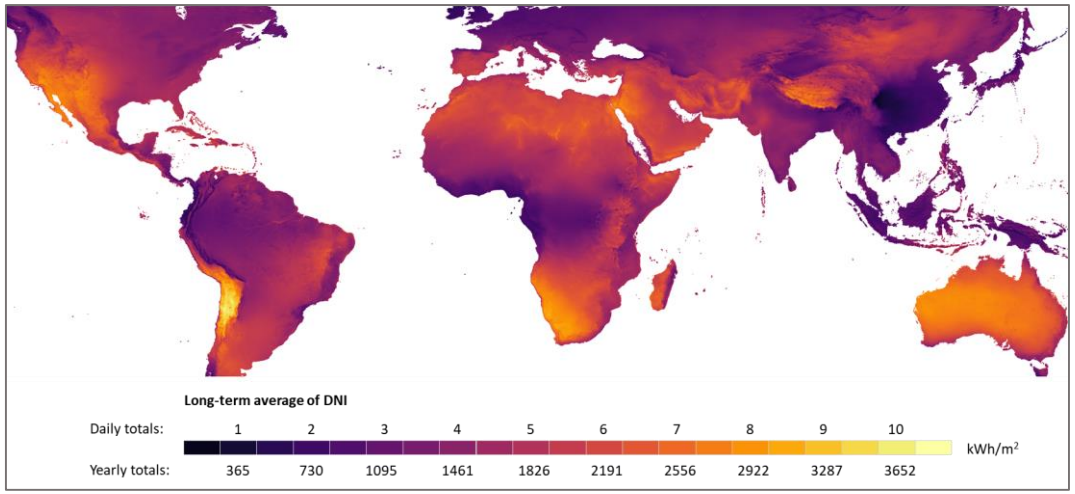

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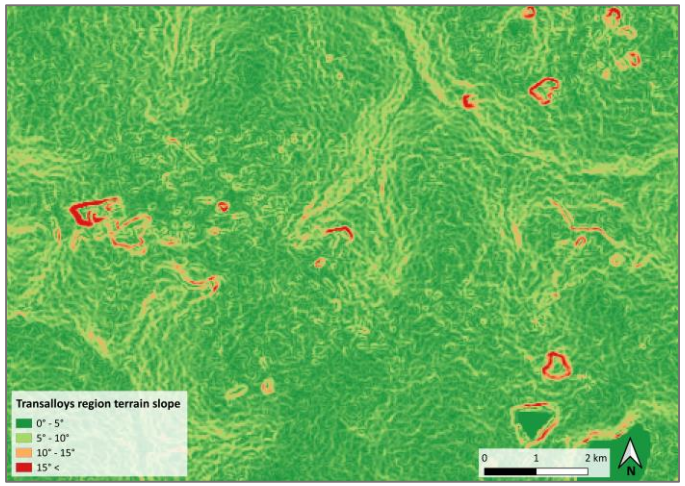
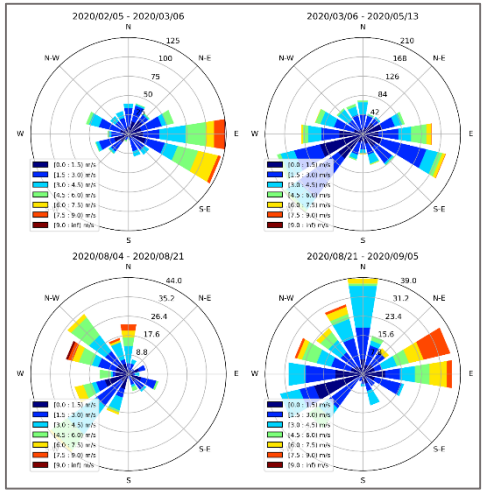
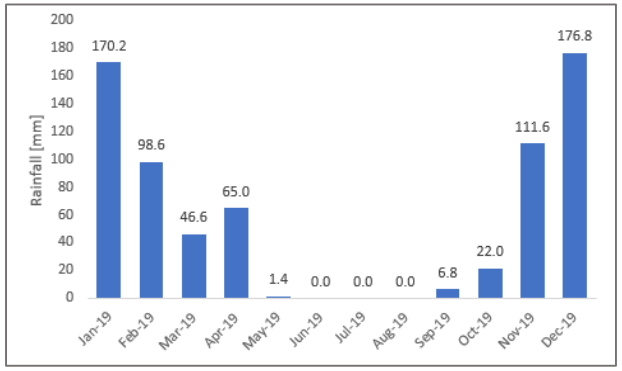


Impacts of other environmental conditions





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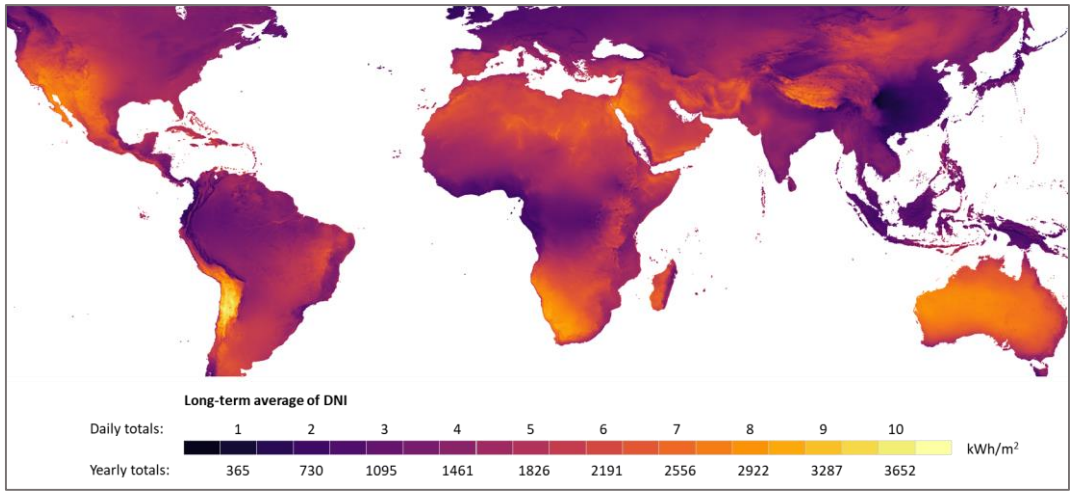

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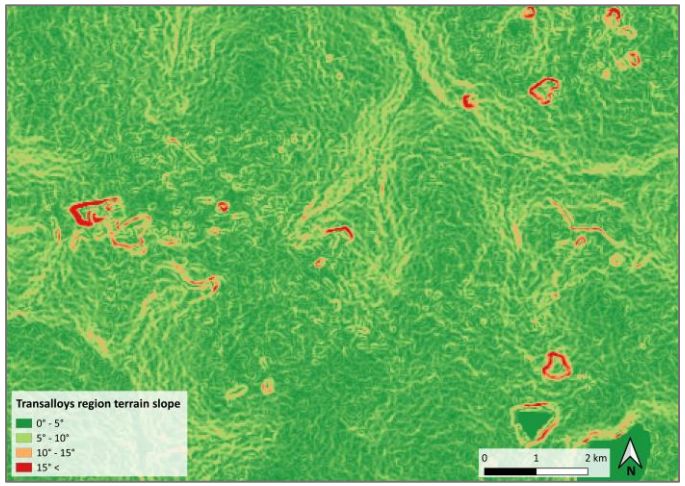

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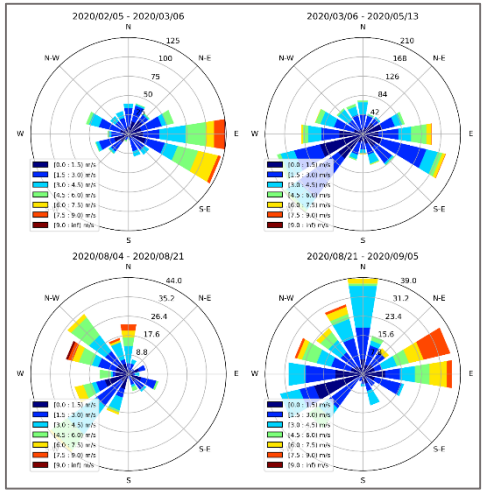

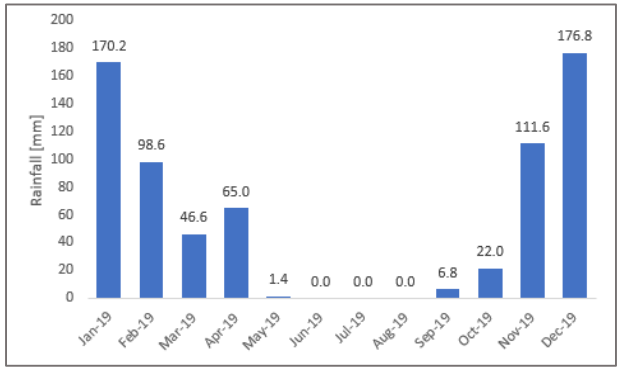

- Many other conditions and infrastructure needs must be met for a CSP project to be feasible, [3][4][5] – are all excellent resources

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Pre-conditions for CSP

Long-term average of DNI

Daily totals:	1	2	3	4	5	6	7	8	9	10
Yearly totals:	365	730	1095	1461	1826	2191	2556	2922	3287	3652

kWh/m^2

Data from the Global Solar Atlas 2.0 [6]

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Technology Integration Barriers

Challenge

Energy conversions

Technology dispatchability

Soiling of heliostats

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Technology Integration Barriers

Challenge	PREMA
Energy conversions	Trickle Flow Heat Exchanger (particle-to-air)
	Shaft kiln-based Heat Exchanger (air-to-ore)
Technology dispatchability	Mobility demonstration of HelioPod technology
Soiling of heliostats	Development of dust management protocol

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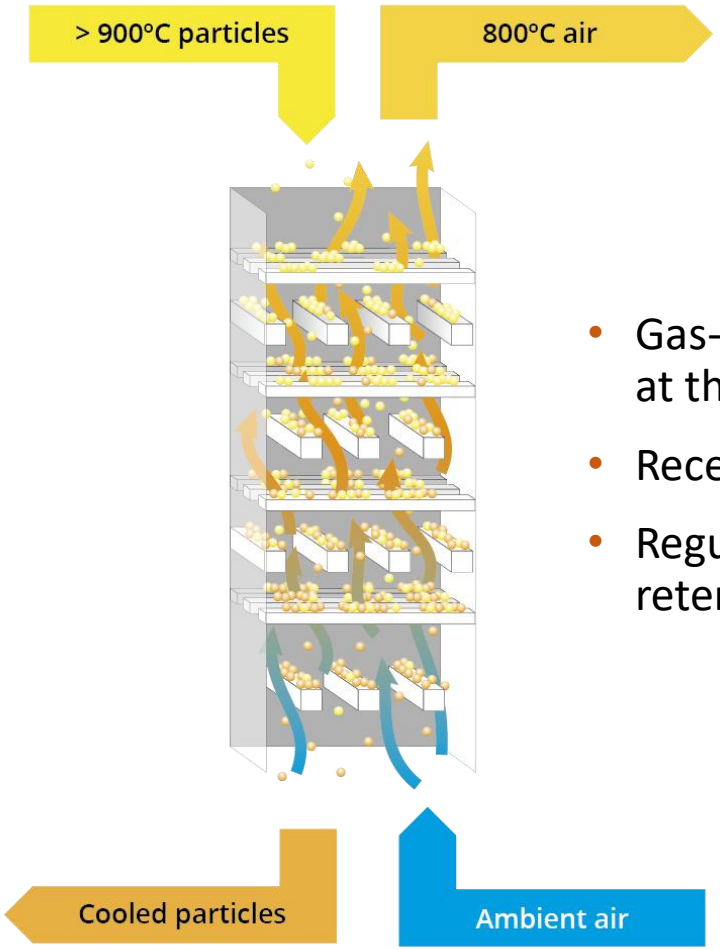
TFHX technology



- Gas-particle trickle flow direct contact heat exchanger (TFHX) under development at the DLR, Germany [7]
- Receives hot particles at upwards of 900°C from the receiver
- Regularly arranged packing structures with flat surfaces found to have best particle retention, expecting highest potential for heat transfer and high-power densities

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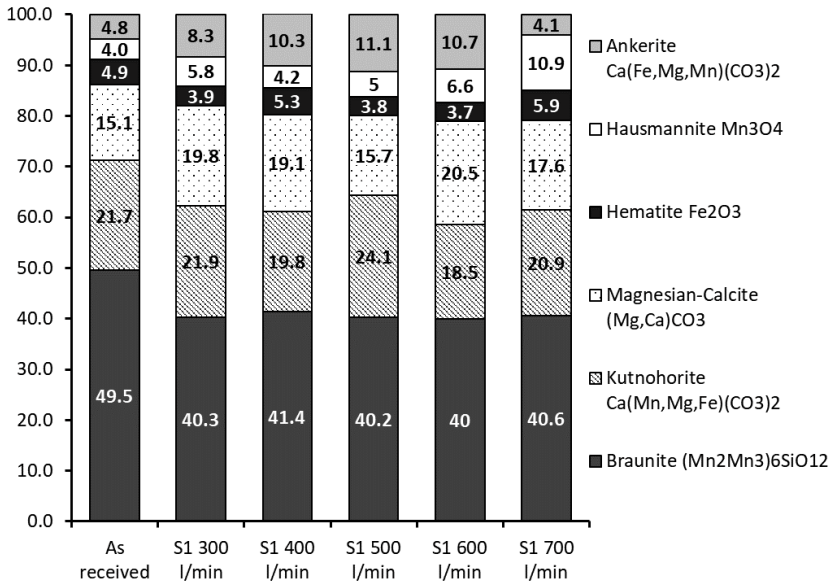
Ore pre-heating with air

Successful small-scale demonstration of preheating



- The expected reactions are being observed
- Thermal decomposition of certain phases leads to reduced CO_2 emissions

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Mobility demonstration of small-scale heliostat field

- Investigating an ESCO* model
- Modeling work [8]:
  - 30MWe SAF, 40 t_{ore}/h, preheated to 600 °C
  - Requires 13.6 MWth preheater

*ESCO – Energy service as company

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Mobility demonstration of small-scale heliostat field

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  - 30MWe SAF, 40 t_{ore}/h, preheated to 600 °C
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Implication

- 0.16 km^2 footprint (16 towers)
- 14 hours storage
- 25,530 heliostats
- 35% cost saving

*ESCO – Energy service as company

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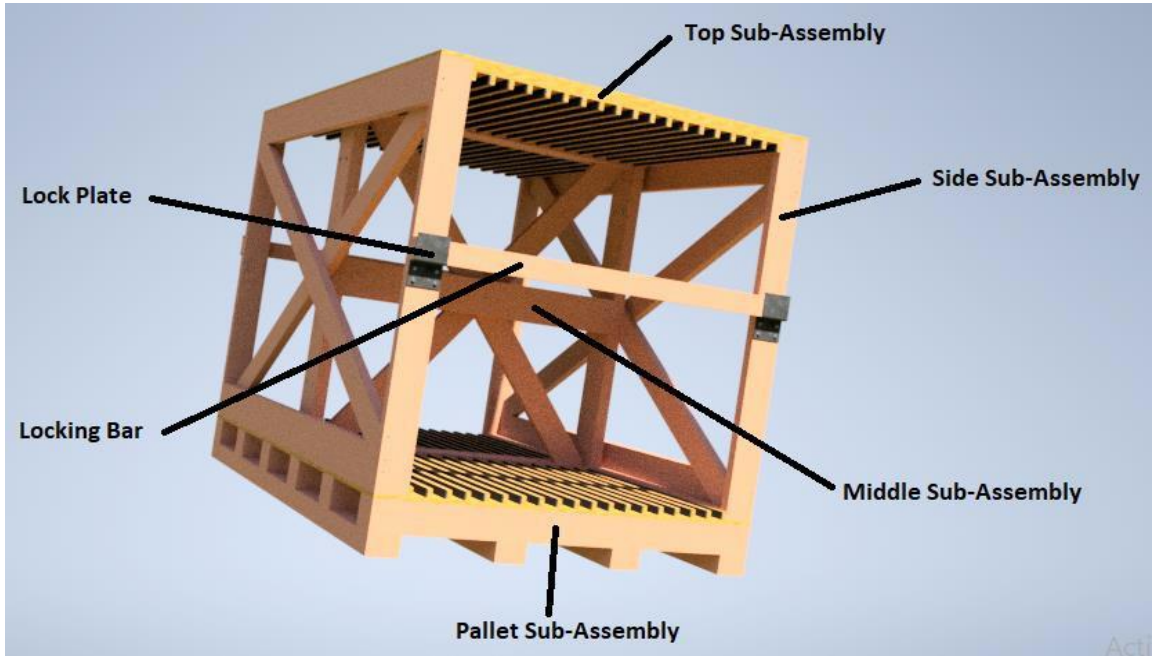
Mobility demonstration of small-scale heliostat field

HelioPOD transport



- 1,22 million USD – field cost (1716 heliostats)
- 40,000 USD – OPEX per year
- 32,000 USD – per relocation

Work underway at Stellenbosch University

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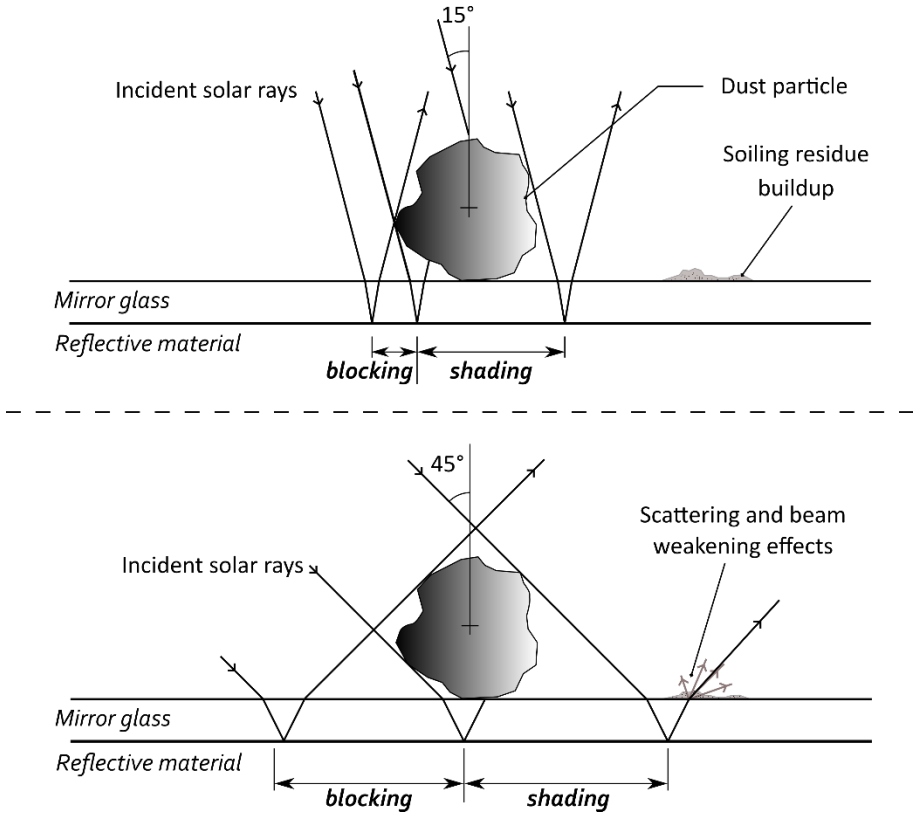
Industrial dust

Dust sources [9]

- 34% - Extraction and hauling emissions
- 30% - Furnace emissions
- 13% - Tapping emissions
- 8% - General smelter
- 7% Sinter production
- 8% - Fugitive dust

Reflectance losses no more than 0.8% per day

- Reflectance ~83.8% after 2-weeks



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Dust sampling at Transalloys

One of four sampling sets stationed around the smelter

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Industrial dust

Soiling experiment at Transalloys, Emalahleni, South Africa

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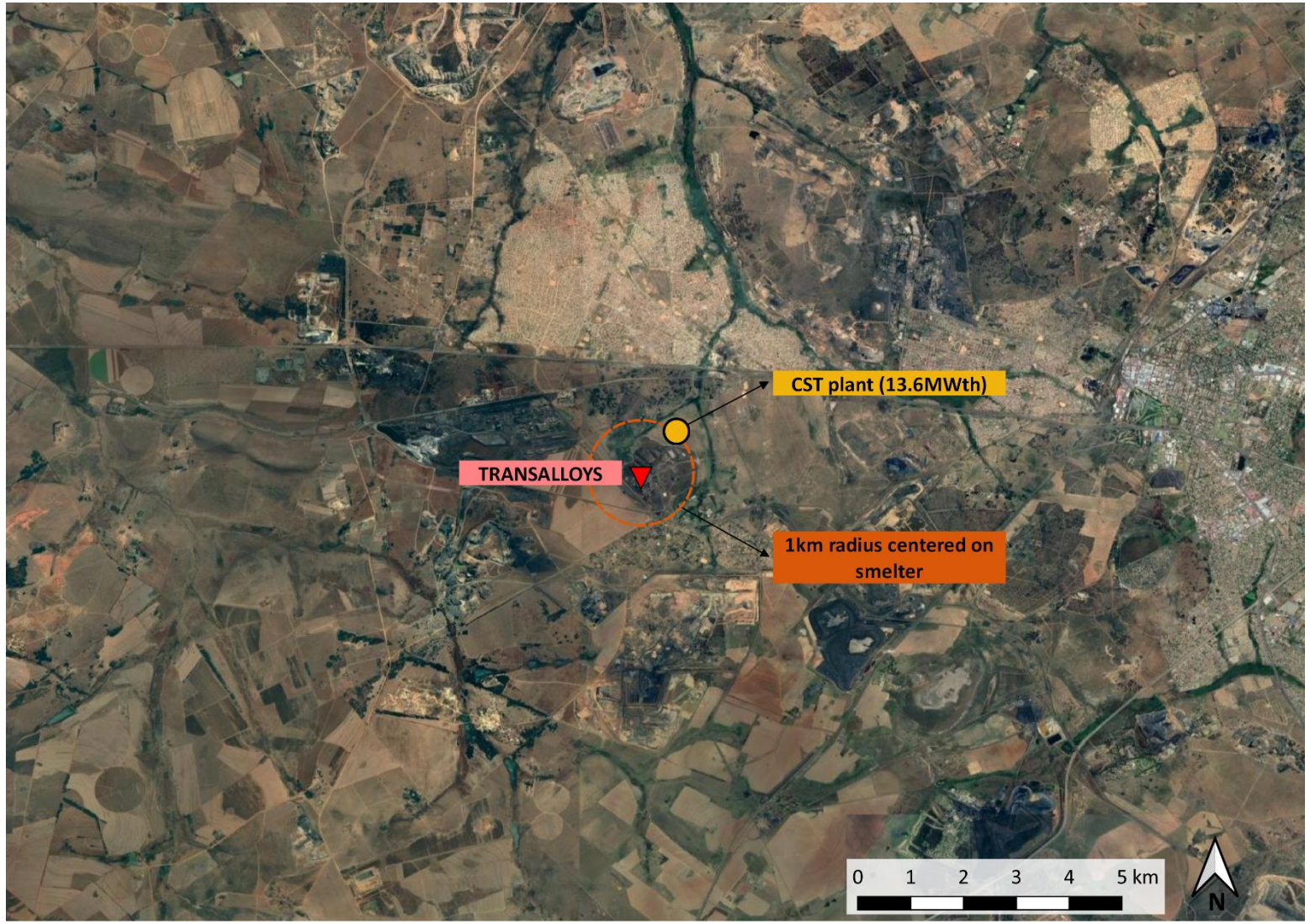
Industrial dust



Soiling experiment at Transalloys, Emalahleni, South Africa

- Given a limit of 1km from receiver to pretreatment unit, where is the ideal location to situate a CST plant?
- Notice the coal fields and other industrial operations!

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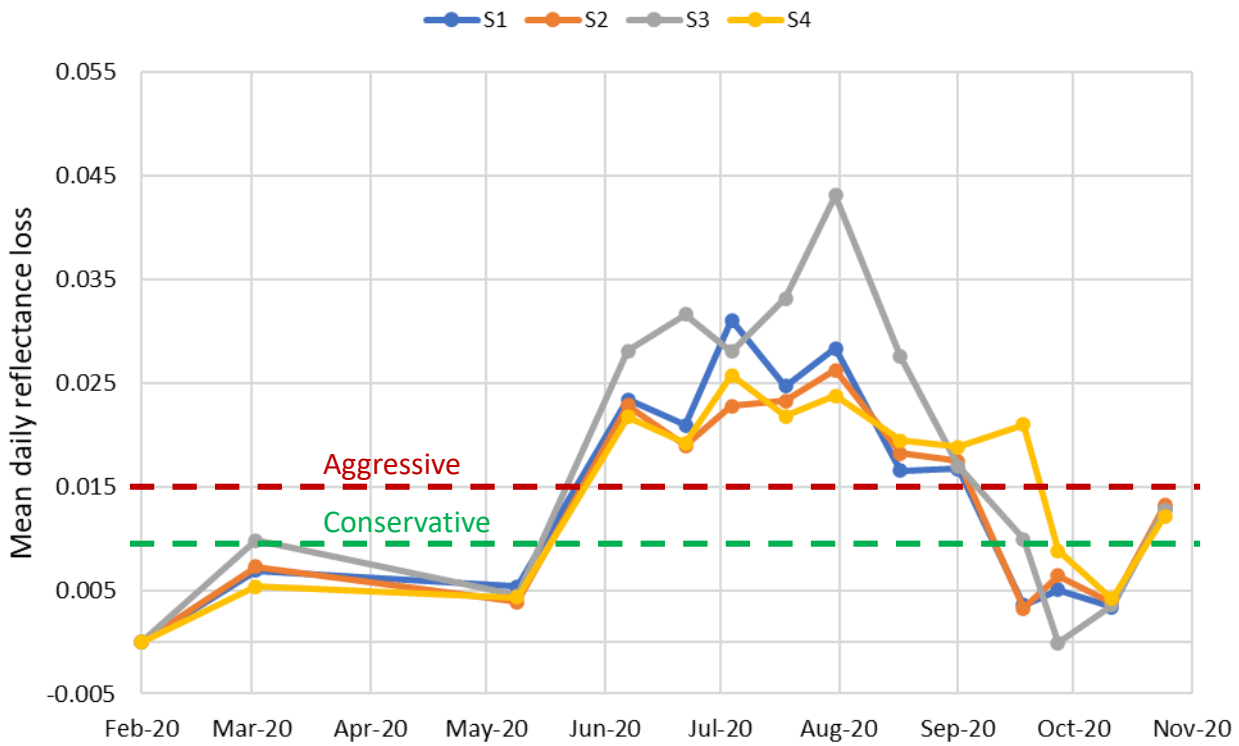
Recorded soiling rates

- Clear seasonal trend observed
- Positional dependance relative to plant
- Acceptable rates of soiling observed during rain season



Sample sets S1 – S4 at different location around smelter

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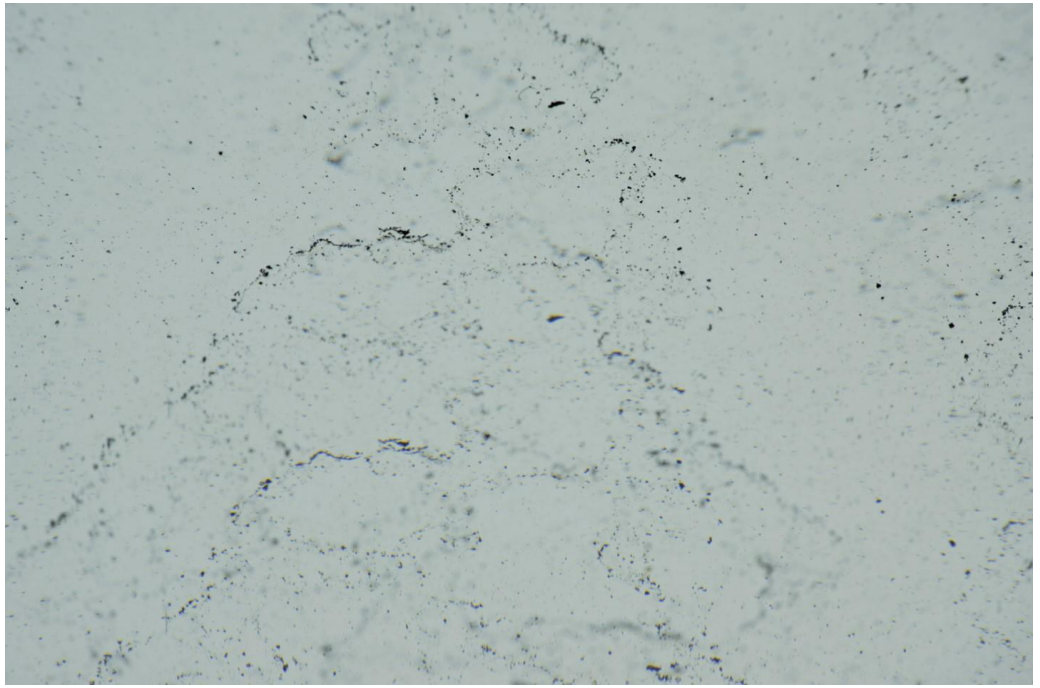
Mirror Dust Data

Sample from S3 04-21/08/2020
(extreme soiling over 2-week period)



Sample from S1 01-15/10/2020
(very little soiling over 2-week period!)

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Partners

SINTEF

Universiteit iYunivesithi Stellenbosch University 100 1918·2018

Transalloys

Metso:Outotec

NTNU
Norwegian University of Science and Technology

MINTEK

IETU

HZDR

Ferroglobe
Mangan Norge AS

eramet

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

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Thank you! Questions?

Direct discussions to milans@mintek.co.za or quinnr@mintek.co.za

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