Quantifying the system value of variable resource forecasting for a range of penetration levels and weather systems in South Africa

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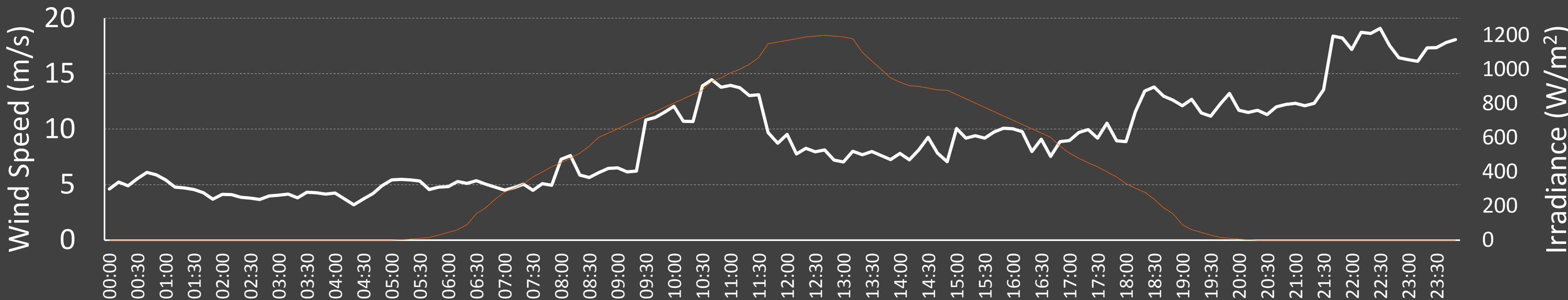
Wind Speed (m/s)
Irradiance (W/m²)
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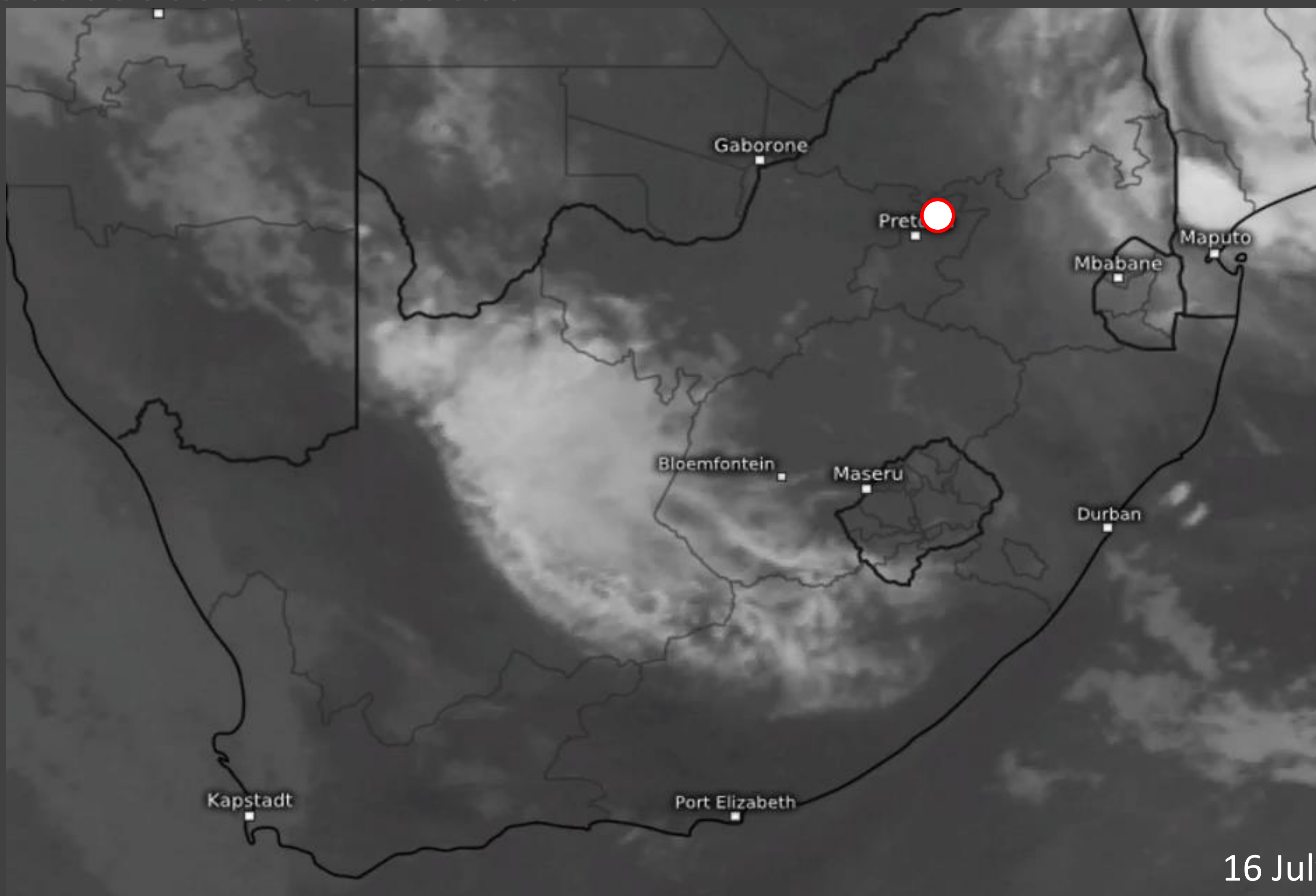
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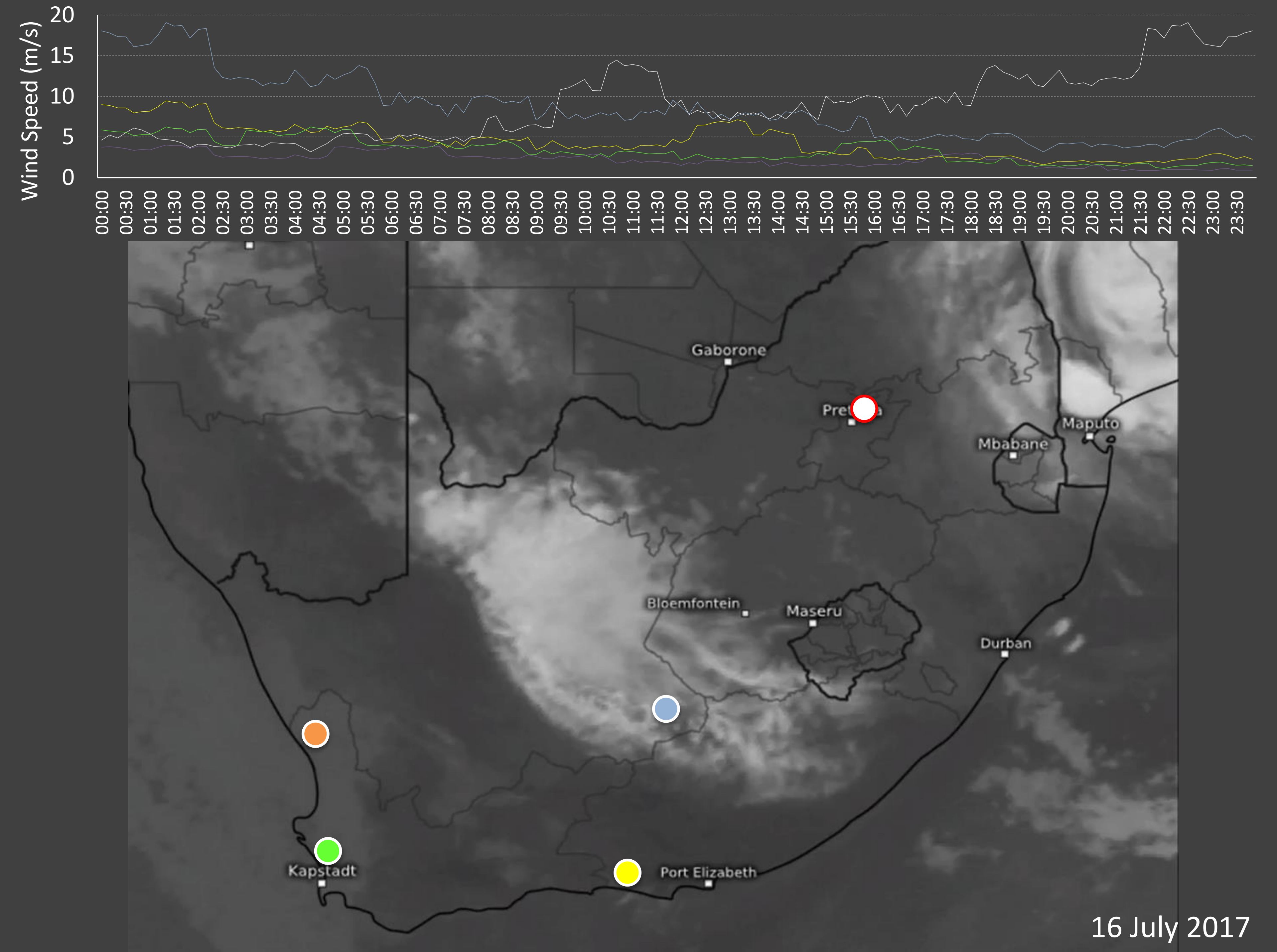
Bloemfontein
Maseru
Durban
Kapstadt
Port Elizabeth

16 July 2017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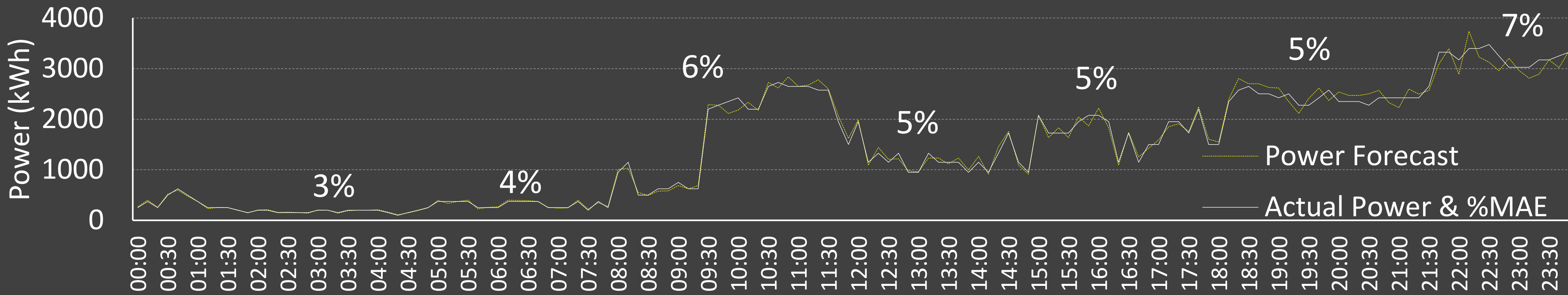
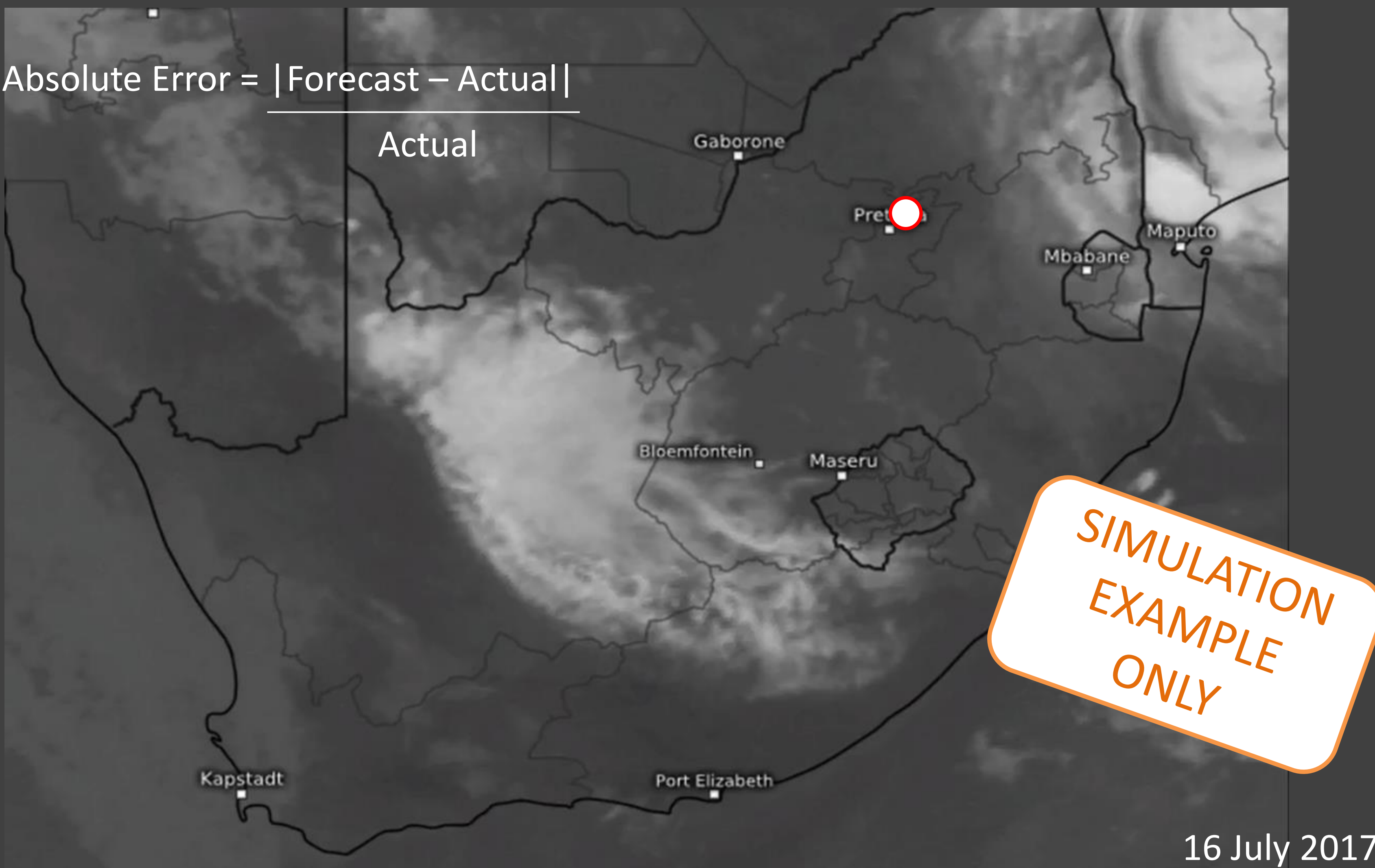


$$\% \text{ Mean Absolute Error} = \frac{|\text{Forecast} - \text{Actual}|}{\text{Actual}}$$



16 July 2017

OVERVIEW

- KEY RESEARCH QUESTIONS
- POWER SYSTEM MODELLING
- SOUTH AFRICAN CLIMATE
- ENERGY FORECASTING CHALLENGES
- RESULTS AND CONCLUSIONS

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What are we trying to achieve

Key Research Questions

QUESTION 1:

What local weather conditions are posing a challenge to VRE forecasting in South Africa?

QUESTION 2:

What is the cost impact of improved VRE forecasting on the South African Power System?

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OVERVIEW

KEY RESEARCH QUESTIONS

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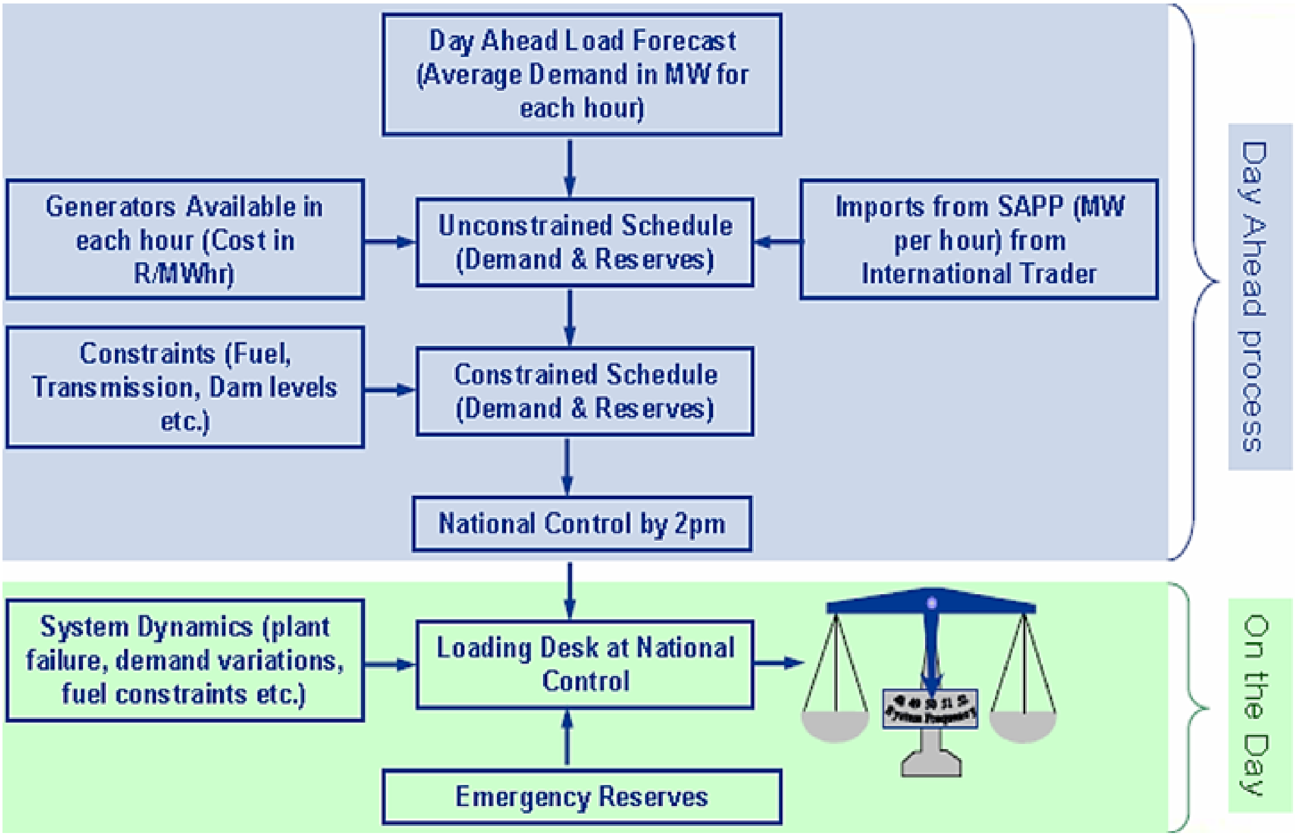
Load forecasting in South Africa

Eskom's existing load forecasting model



SANEDI Forecasting Seminar Presentation by Eskom, 2017

System optimisation and impact of short-term load forecast, Du Plessis, L, Eskom, 2007

Load forecasting in South Africa

Eskom's existing load forecasting model

$$Y_i = \alpha + \gamma X1_i + \delta X2_i + \theta X3_i + \zeta X4_i + \eta X5_i + \eta X6_i + \varepsilon$$

Where:

Yi = Hour i forecast, i = 1,2,……, 168

X1i = Day type and seasonality

X2i = Weather variable

X3i = Public events

X4i = Holidays

X5i = Anomalies

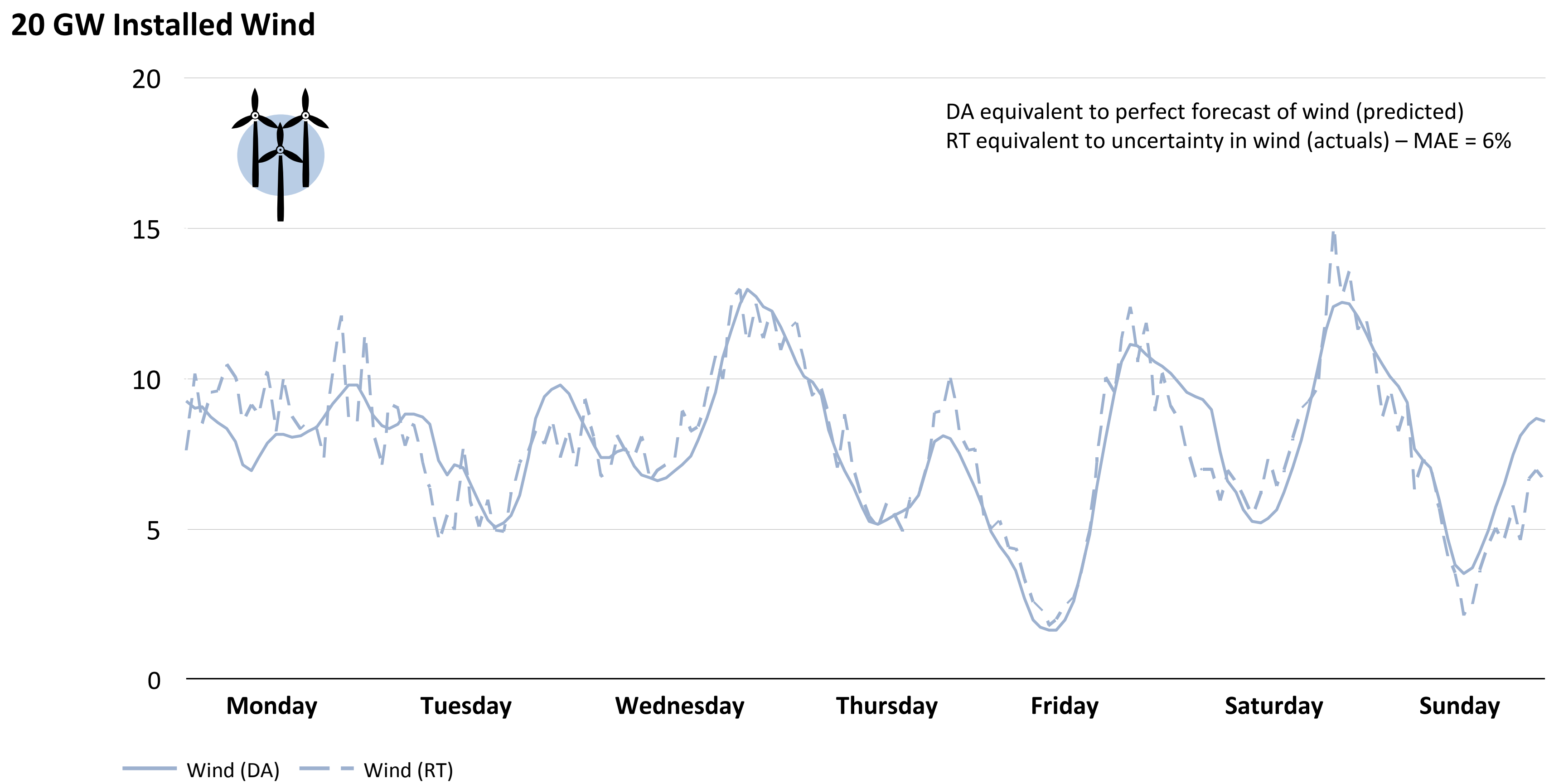
X6i = Change in profile

Increasing significance since this term includes the IPP's contribution

Now need to establish relationship between existing load forecasting methodology and variable resource forecasting

SANEDI Forecasting Seminar Presentation by Eskom, 2017
System optimisation and impact of short-term load forecast, Du Plessis, L, Eskom, 2007

Wind uncertainty in real-time requires different system dispatch – with associated costs



Note: DA = Day-ahead, RT = Real-time

Sources: CSIR analysis

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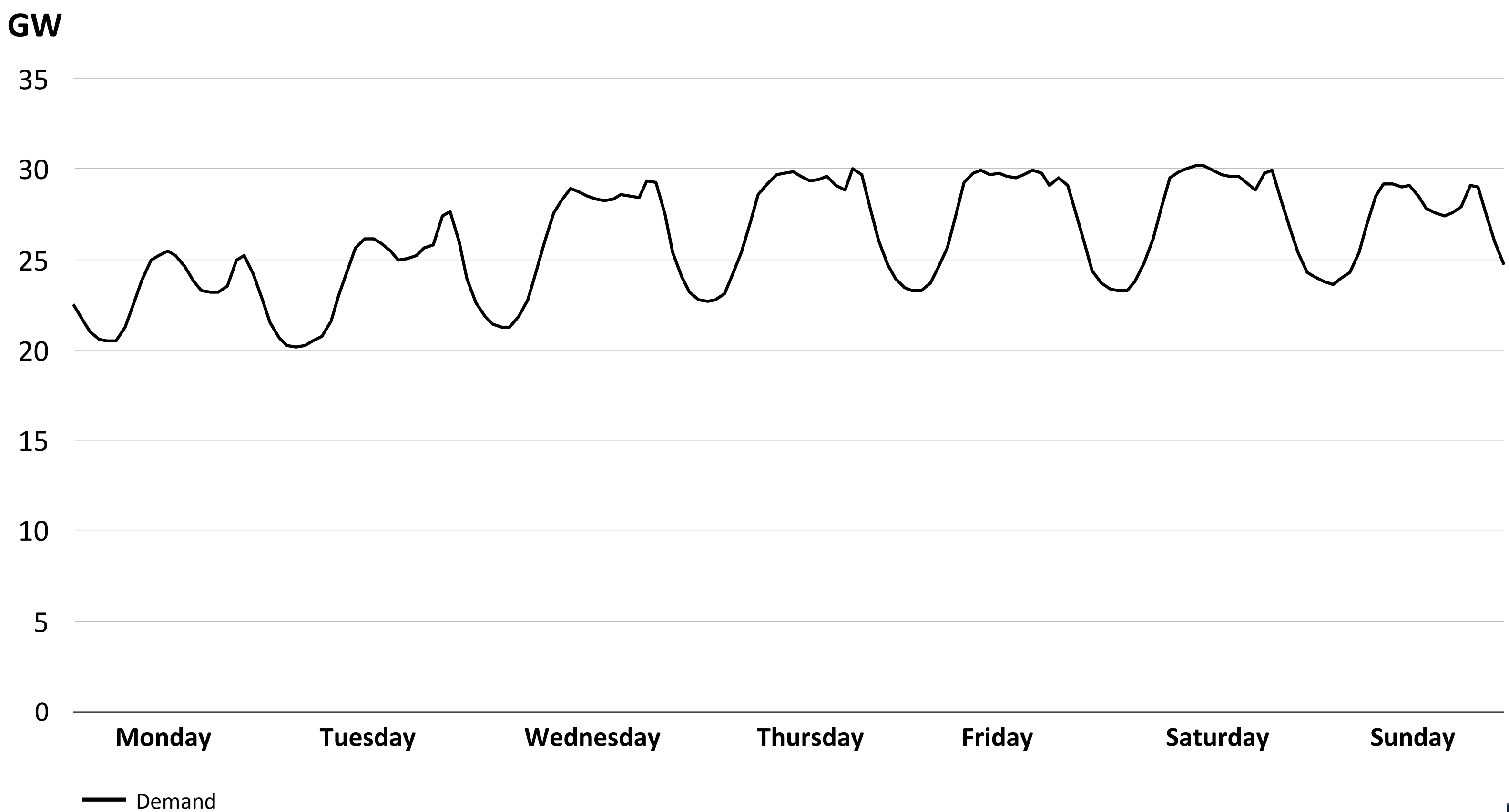
Wind uncertainty results in different residual demand – worsened at high penetration levels



Sources: CSIR analysis

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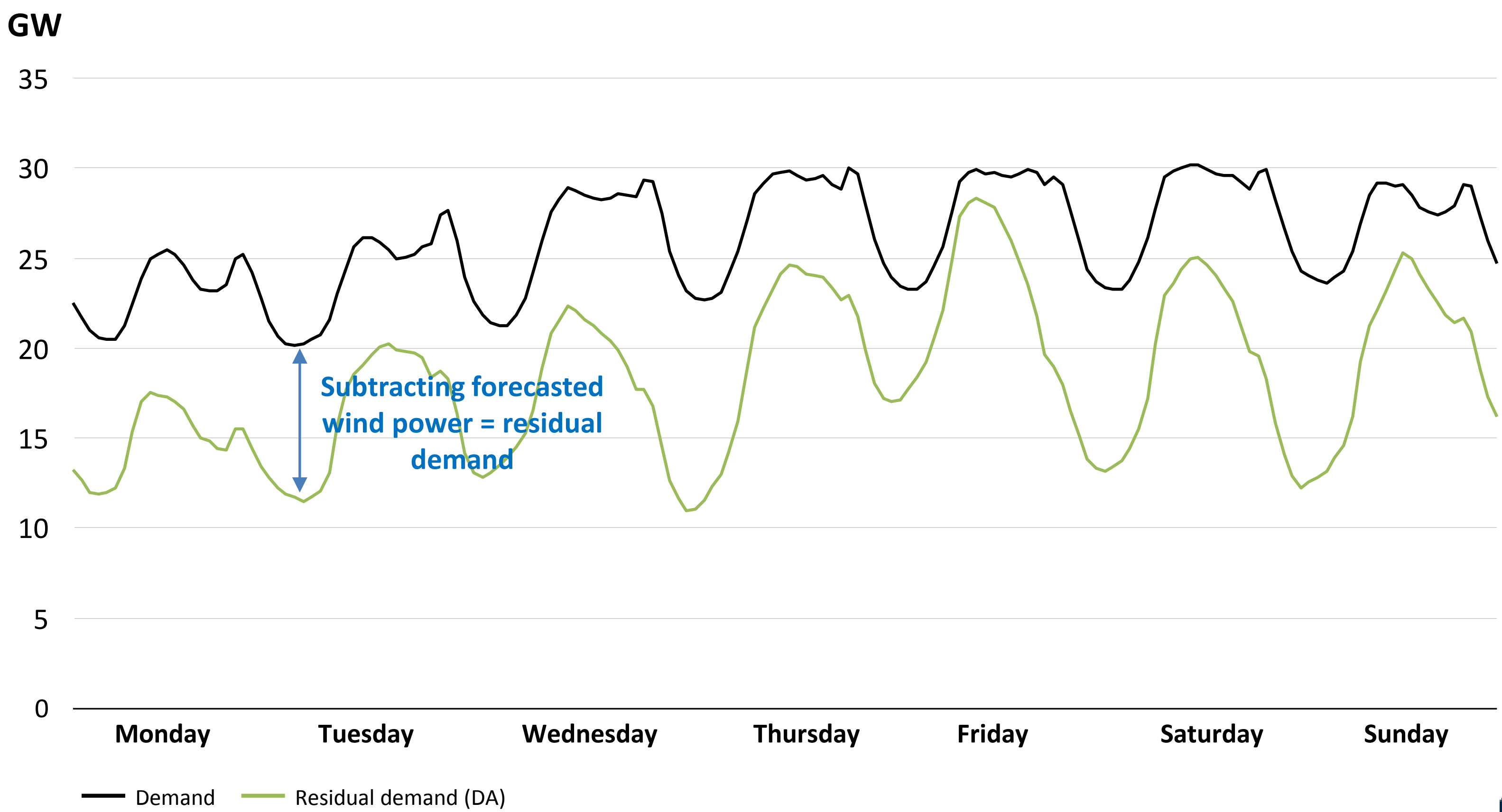
Wind uncertainty results in different residual demand – worsened at high penetration levels



Sources: CSIR analysis

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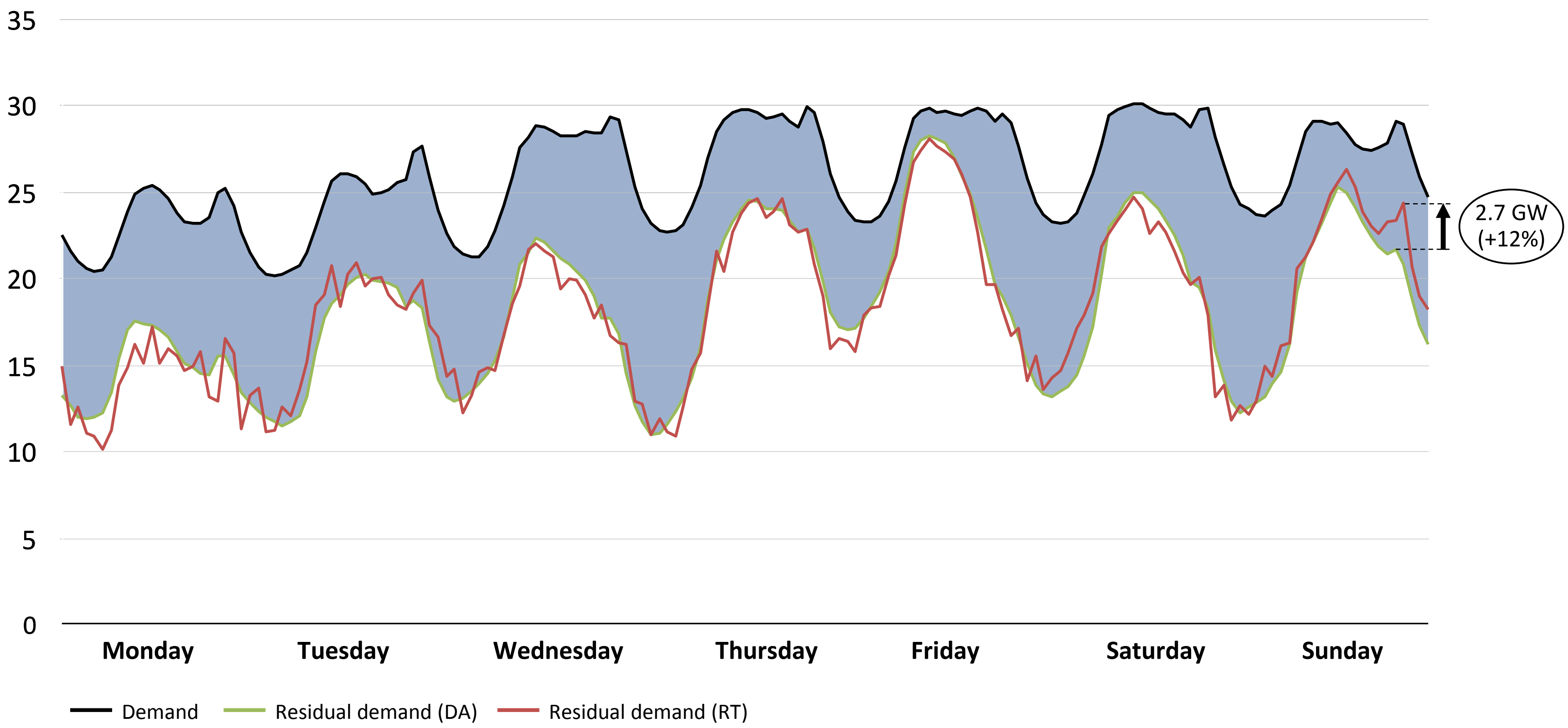
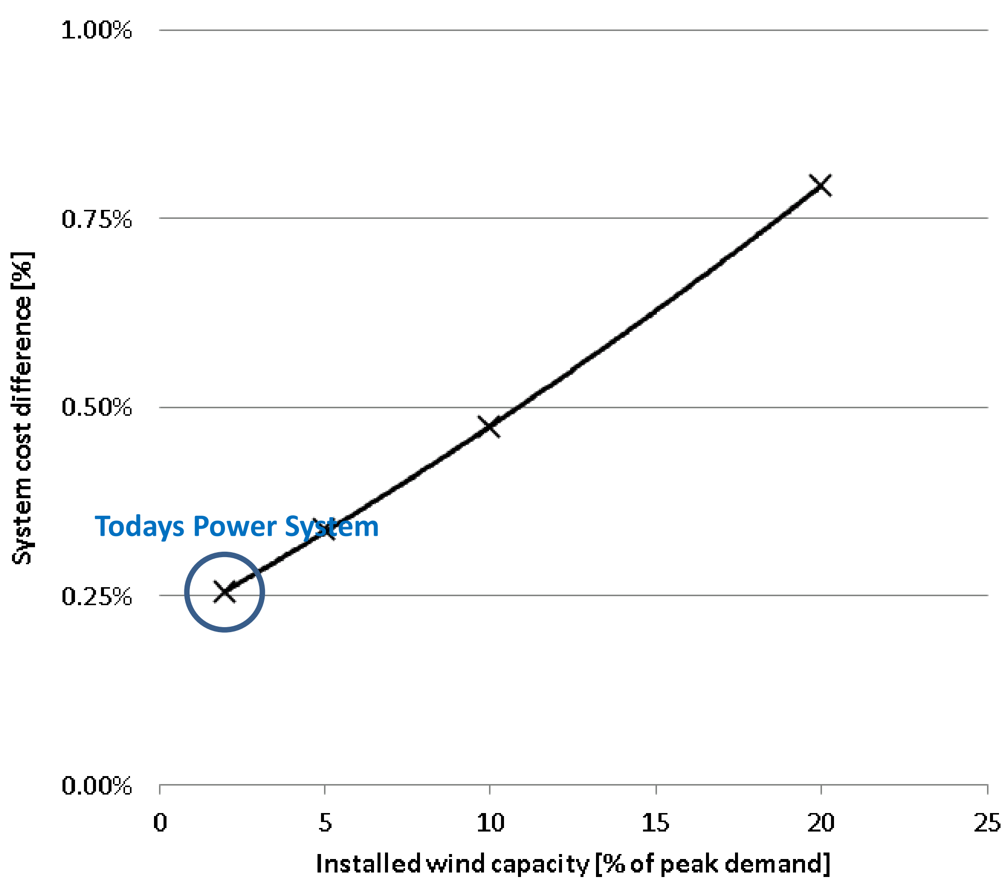
Wind uncertainty results in different residual demand – worsened at high penetration levels



Sources: CSIR analysis

Value of an improved wind forecast is already notable at low wind penetration – increases with increasing wind penetration

Relative cost difference with perfect foresight and forecast uncertainty



For the wind forecast uncertainty, range of VRE penetration and system setup assumed[1], a system the size of South Africa with an improved forecast could save:
≈0.25-0.80% or ≈ 200-500 R-million/yr of production costs[2].

[1] Can be provided on request.
[2] Could change depending on energy mix at higher VRE penetrations as well as other uncertainty (other VRE and demand forecast). Should be investigated further to fully capture and understand value.

Sources: CSIR analysis

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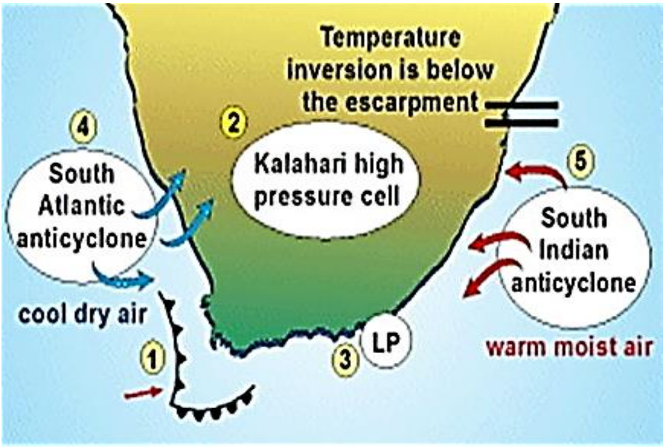
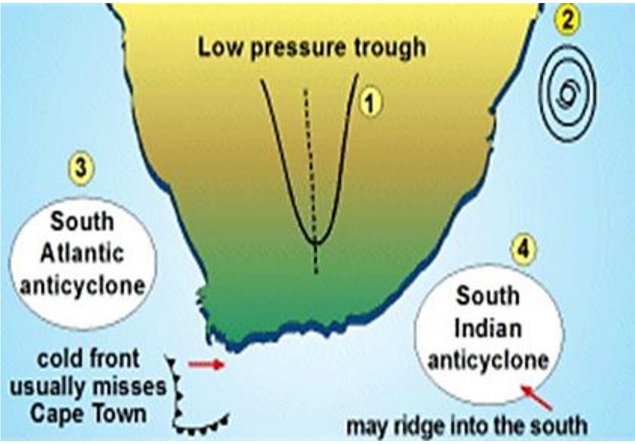
Several Major Climate Influencers

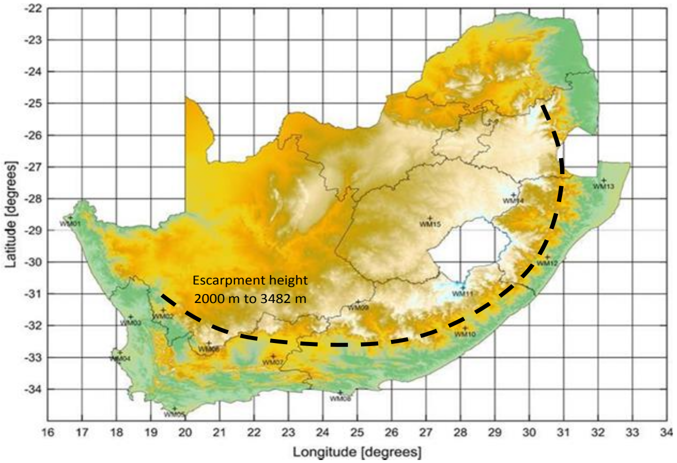
South African Climate



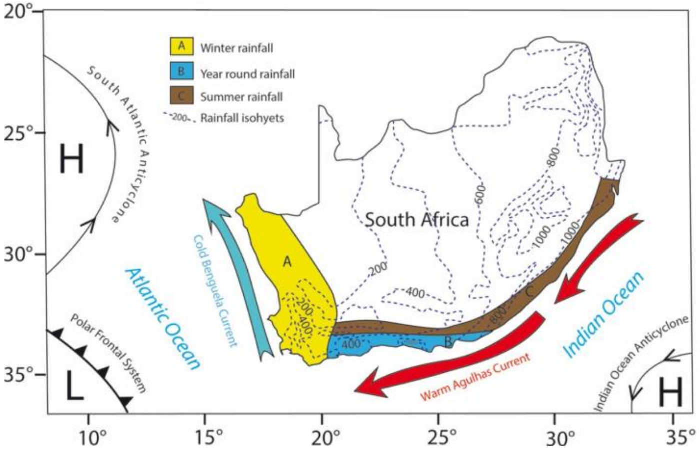
Winter – April to September



Summer – October to March



Escarpment



Ocean Currents

Dynamics of late Cenozoic aeolian deposition along the South African coast: a record of evolving climate and ecosystems, http://sp.lyellcollection.org/content/388/1/353
South Africa terrain elevation (SRTM+, NASA version 3)
Warren, M., Climatology – a South African Perspective, http://slideplayer.com/slide/10180352/, accessed May 2018

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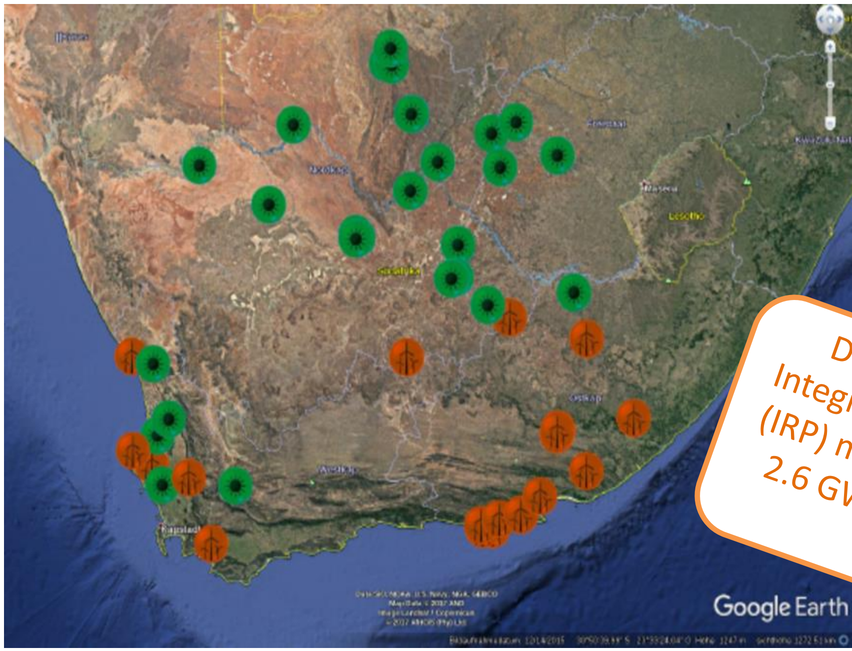
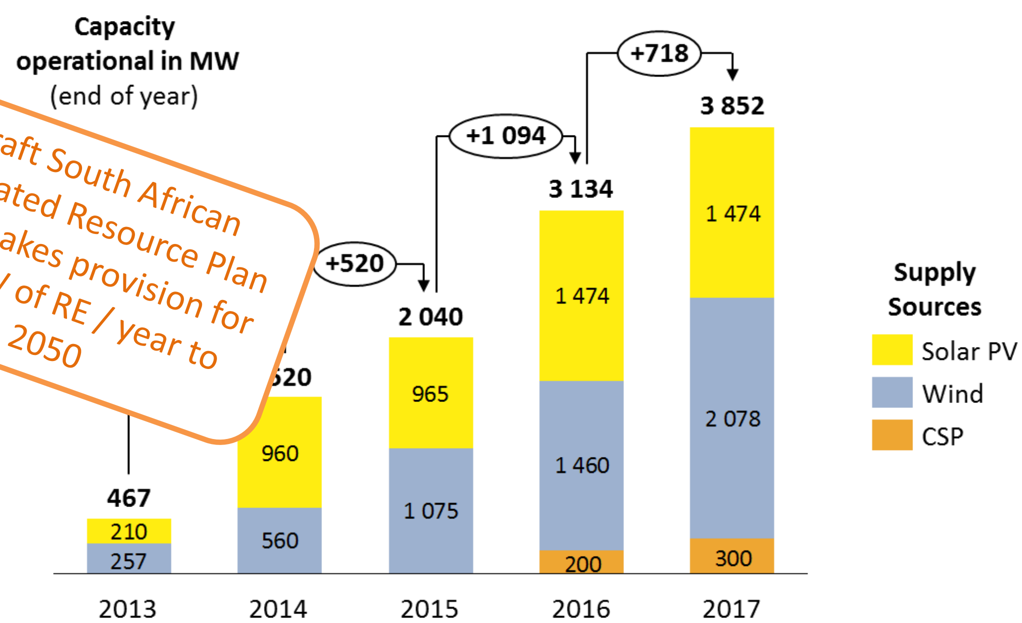
South Africa has 3.8 GW of Installed VRE

Local variable renewable energy (VRE) installed capacity



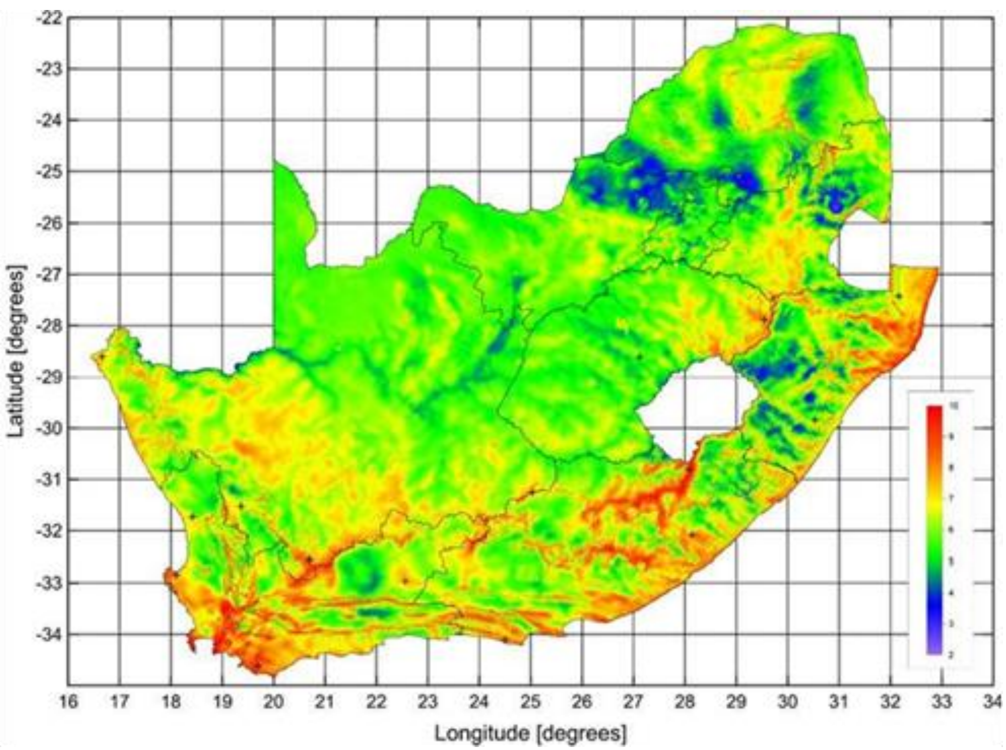
Draft South African Integrated Resource Plan (IRP) makes provision for 2.6 GW of RE / year to 2050

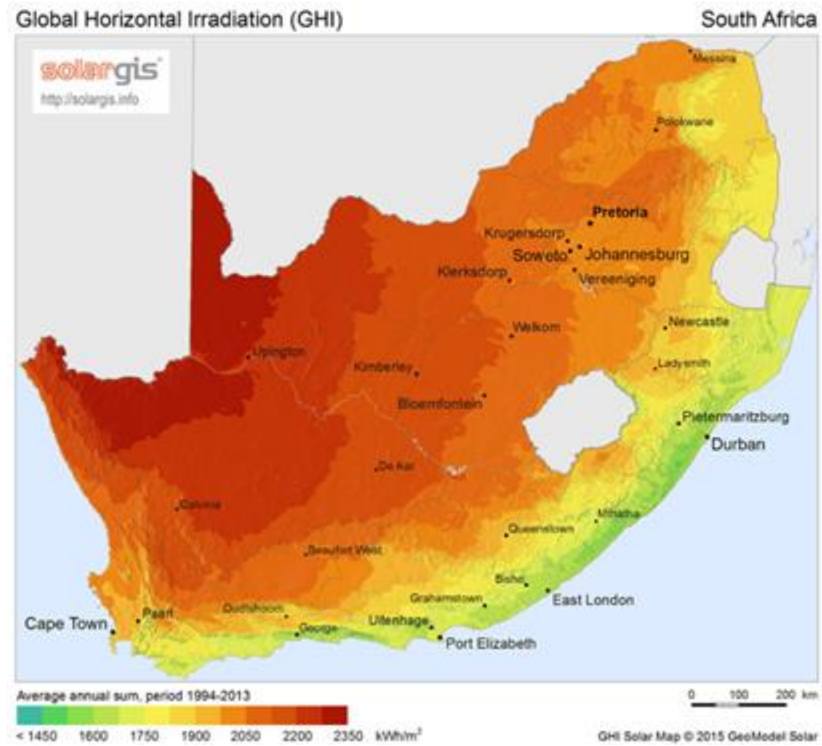


CSIR Energy Centre Analysis, Statistics of utility-scale solar PV, wind and CSP in South Africa in 2017, February 2018
CSP: Concentrated Solar Power , Lange, M., Evaluation of forecasts, meteorological characteristics in South Africa and lessons learned, Workshop presentation, Eskom, Nov 2017

S.A. has world class wind & solar resource

Renewable energy resource maps





Interim (5 km) High-Resolution Wind Resource Map for South Africa, Metadata and further information, SANEDI, Oct 2017; Global Horizontal Irradiation Map, Solargis, http://www.sapvia.co.za/sa-solar-irradiation-maps/, accessed May 2018;

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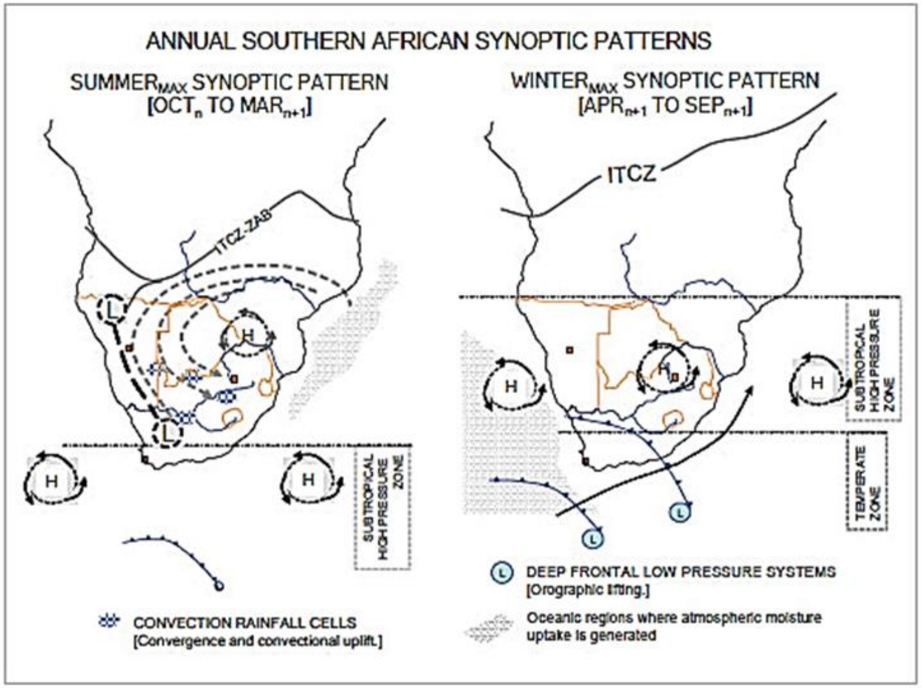
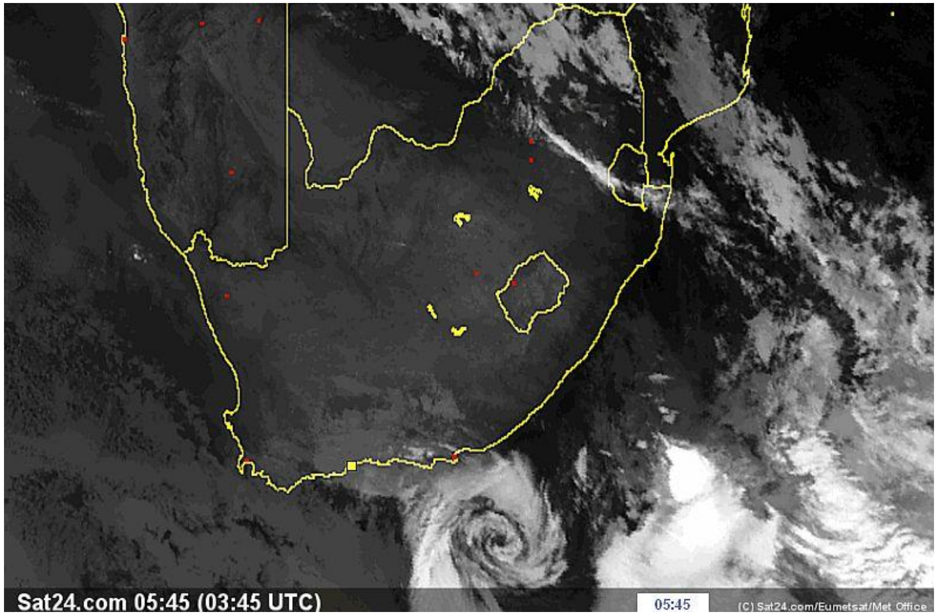
Mid Latitude Cyclones (MLC's)

Challenging Weather Systems to Forecast





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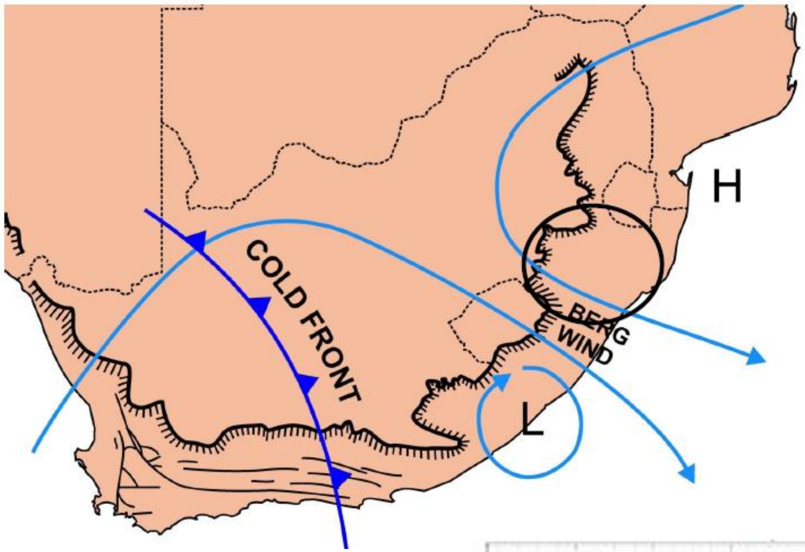
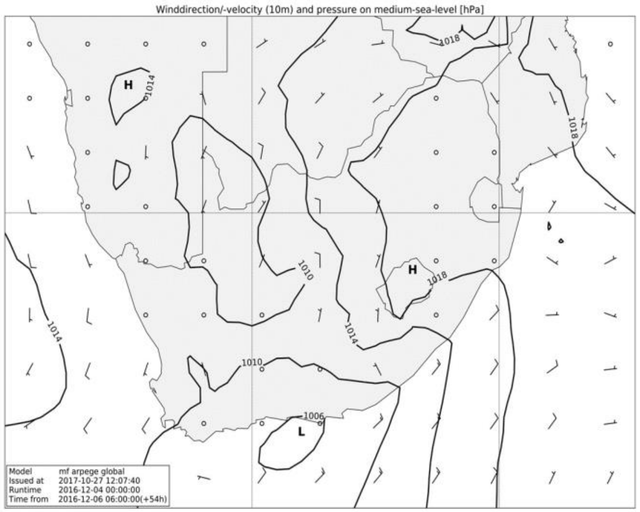
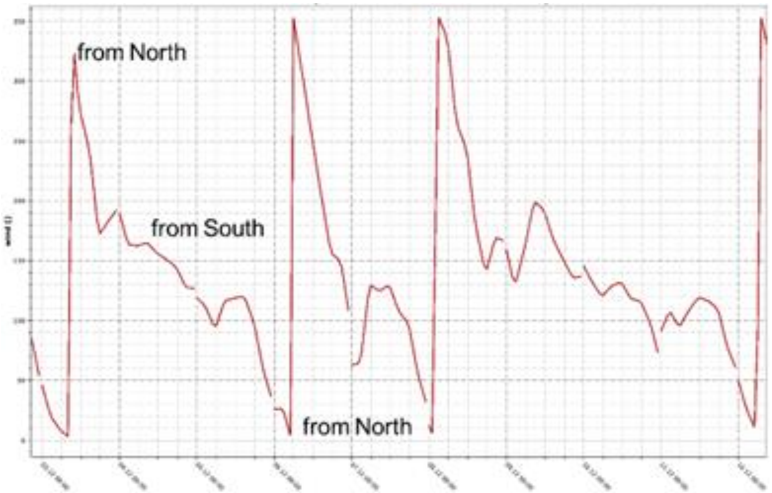
van Wyk, E., van Tonder, GJ., Vermeulen, D., Characteristics of local groundwater recharge cycles in South African semi-arid hard rock terrains - rainwater input, Water SA vol. 37 n.2 Pretoria Apr 2011

Berg Winds

Challenging Weather Systems to Forecast







de Villiers, M., Roll cloud on the South African east coast, Weather vol. 66, Issue 2, Jan 2011
Lange, M., Evaluation of forecasts, meteorological characteristics in South Africa and lessons learned, Workshop presentation, Eskom, Nov 2017

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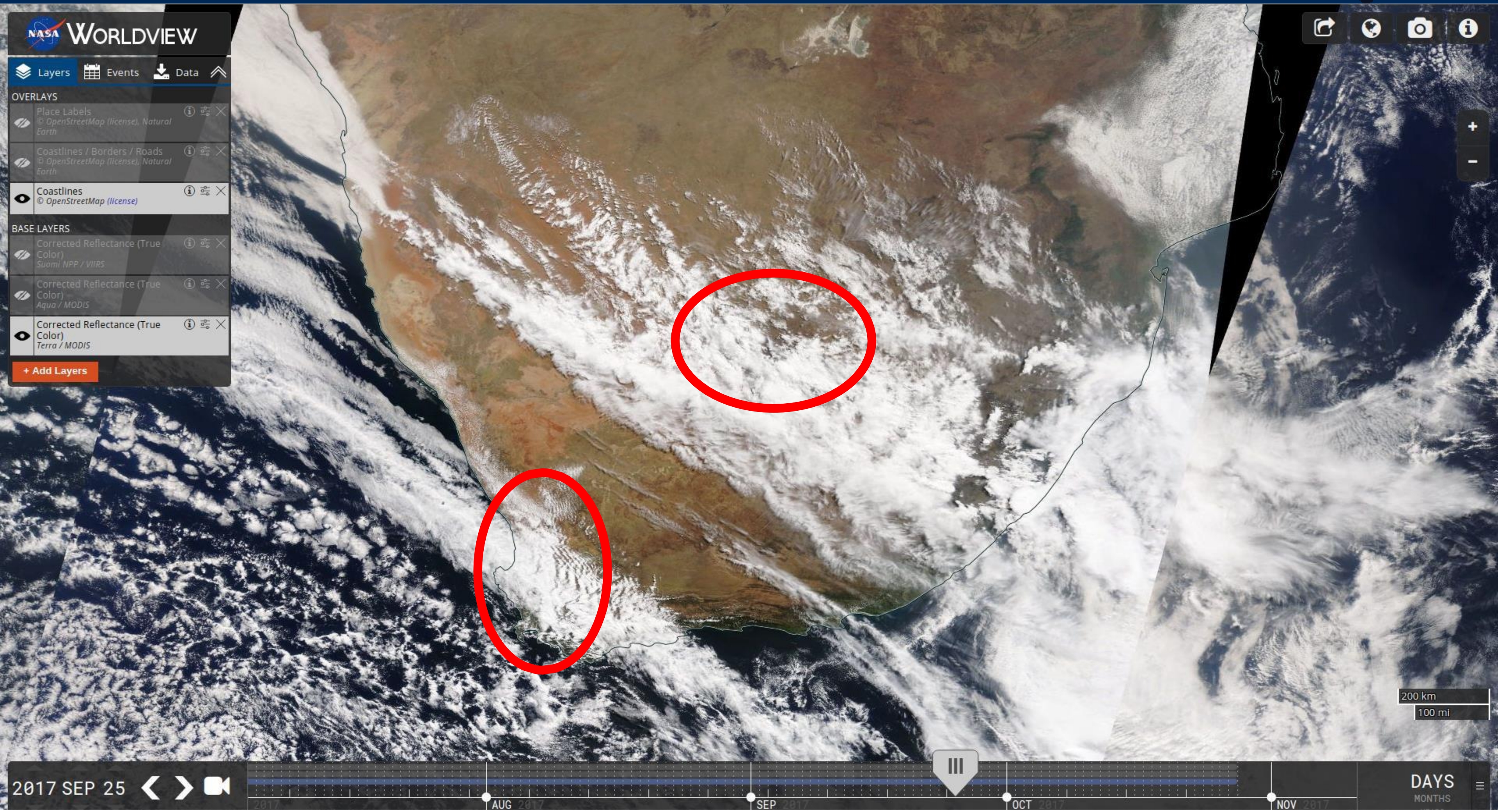
Challenging Weather Systems to Forecast

Cloud build up on the West coast and interior and Low Level Jet formation (LLJ)



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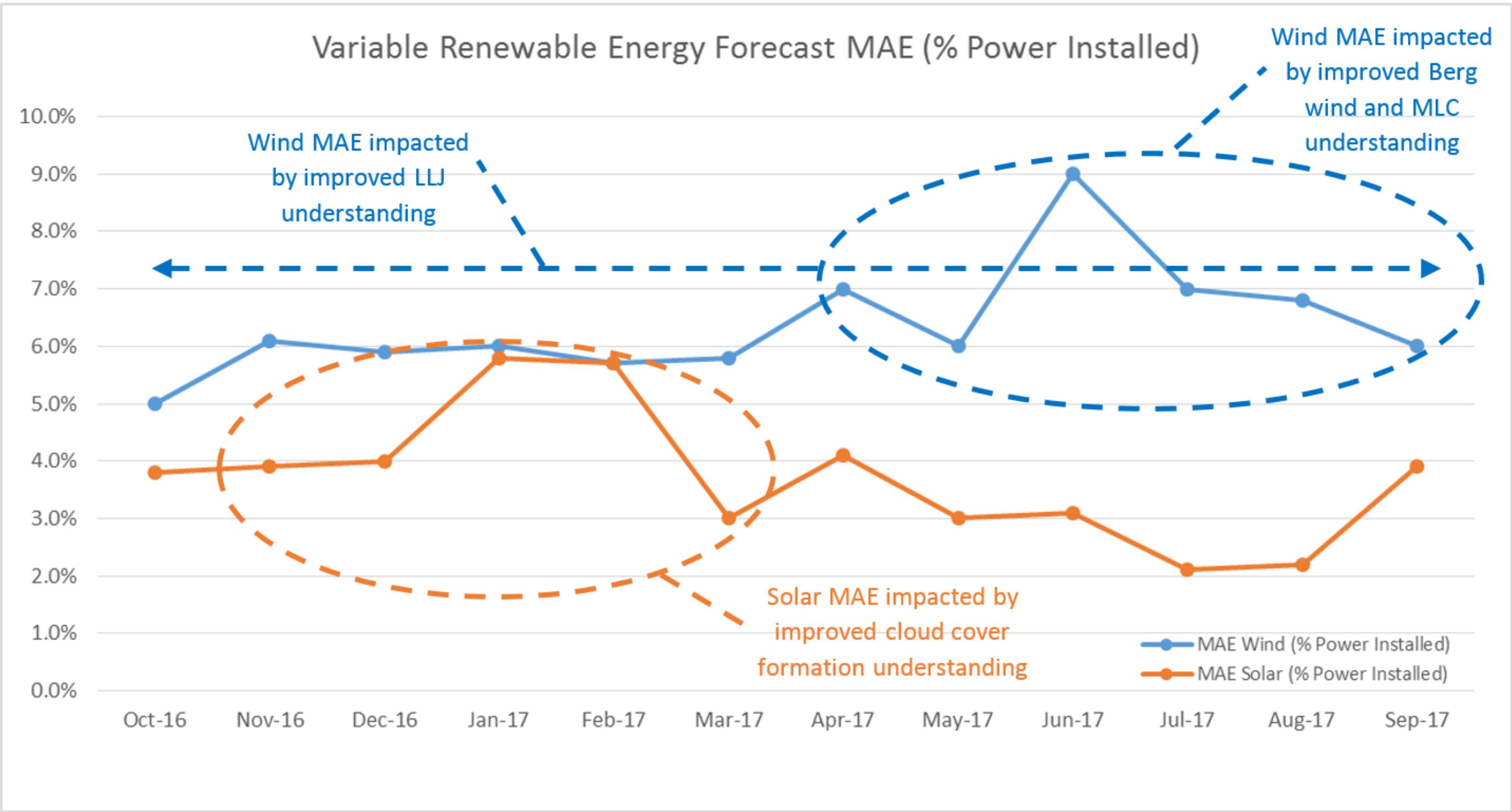
Means by which VRE forecasts in South Africa can be improved



Lange, M., Evaluation of forecasts, meteorological characteristics in South Africa and lessons learned, Workshop presentation, Eskom, Nov 2017

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Conclusion and Future Work

- Power system analysis supports the business case for accurate forecasting
- Results show high VRE penetration cost saving in excess of USD 125 million per annum by reducing error
- Analysis of SA power system confirms alignment with international norms
- Forecasting improvement requires detailed understanding of local weather anomalies and systems with best of breed international methods
- CSIR embarking on a project to develop a localised System operator VRE forecasting model

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Thank you

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