# Introduction to CloudCAM

SODAR | RESOURCE MONITORING | NOISE MONITORING | CLOUD TRACKING


# company overview

- established in 2011 to develop, manufacture, market and support 3D sensors for renewable energy developers and utilities worldwide
- focus on technology support for wind and solar energy project development
- professional team of renewable energy experts
- combined knowledge and expertise of its owners:
  - Fulcrum Energy group has >10 years local & international wind energy development experience through its ownership of Epuron Pty Ltd
  - Orang-utan Engineering developed the core SODAR and telemetry platforms for extensive use in harsh and remote sites
- based in Sydney, Australia

# product offering


## compact-beam Sodar

- low cost, flexible, reliable monitoring solution
- performance verified by industry experts
- optimised for the wind energy industry

## high speed data loggers

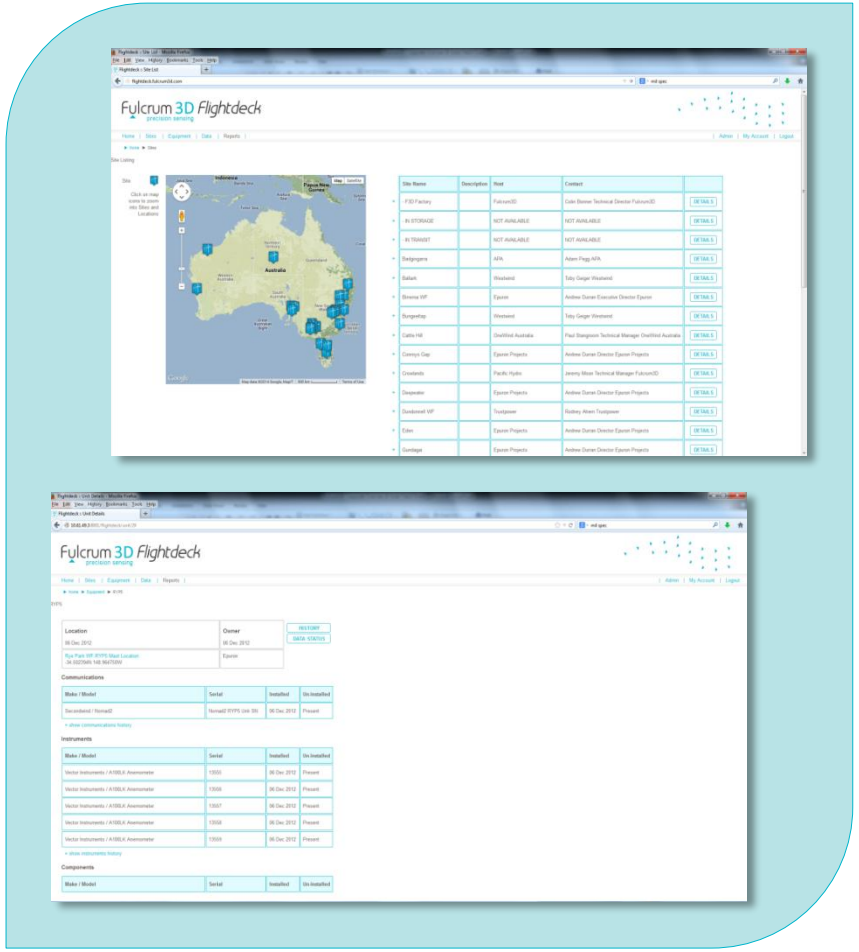
- sampling rates up to 200Hz
- uses include met masts, sonic anemometers, high speed solar monitoring
- integrated noise and weather monitoring

## CloudCam

- innovative camera-based cloud monitoring system
- tracking and prediction in development
- target prediction range from 30s to 15 minutes

# data management via *Flightdeck*

- all data can be viewed and downloaded from one location:
  - wind, solar, met, noise data
  - telemetry and location
  - operating status / faults
- data available in both raw and clean formats
- site and equipment details available at the click of a button
  - site history
  - equipment location history



# Clouds and Solar Power

# clouds have a significant impact

- when clouds block the sun, solar irradiance can drop by up to 80% in just seconds
- solar power output drops just as quickly
- this puts a significant strain on the power system the solar plant is connected to
  - other forms of generation need to immediately pick up where the solar power output dropped off

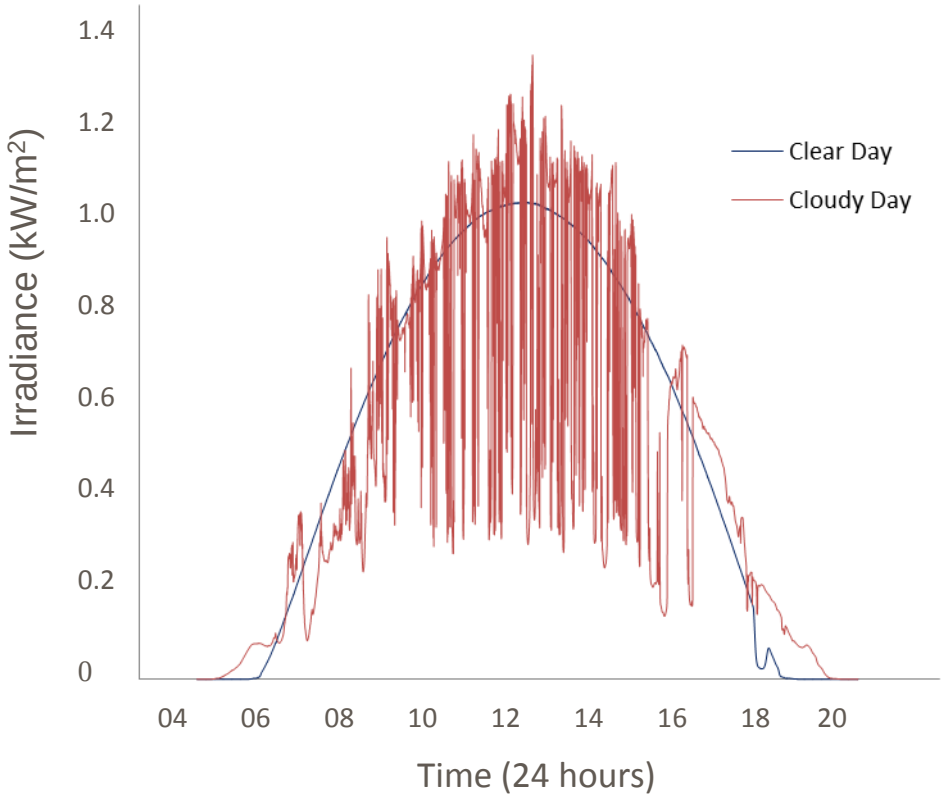



Image courtesy of Epuron 2014

# cloud impacts depend on the system type

off-grid:

- small off-grid diesel power stations with small, medium or high penetration of solar
  - e.g. Epuron's TKLN Project
- larger off-grid townships with high levels of distributed (rooftop) solar
  - E.g. Alice Springs, Carnarvon

grid connected:

- large centralised solar power stations connected to major grids
  - e.g. AGL's 100MW solar power station
- significant levels of distributed solar power generation
  - e.g. >1GW rooftop solar spread across the Sydney region

each of these applications has different management requirements related to geographic coverage, detection or prediction timescales, accuracy and cost.

# existing solutions aren't good enough

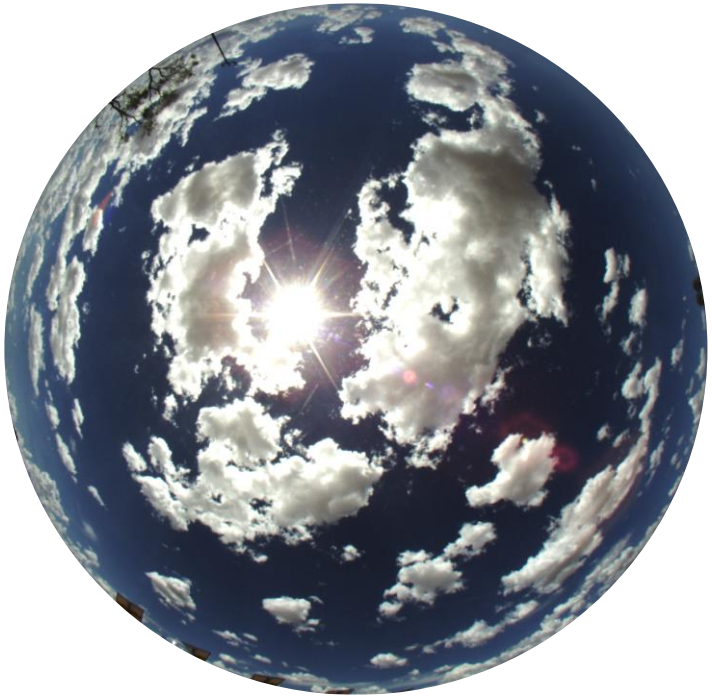
| approach | advantages | disadvantages |
|---|---|---|
| **reduce solar penetration (max 10% solar)** | • minimal capital cost<br>• avoids battery / storage capital and O&M costs | • high diesel generation costs<br>• low penetration<br>• un-utilized solar resource |
| **fast response energy storage (batteries, flywheels)** | • increased solar penetration (~30% of energy)<br>• minimize fuel costs<br>• reduced greenhouse gas emissions | • energy storage systems (batteries) required<br>• high capital cost<br>• high ongoing O&M costs<br>• limited solar power contribution |
| **competing cloud detection / prediction systems** | • minimal capital cost | • low cloud detection rates<br>• poor accuracy for multilevel cloud & spontaneous cloud formation |

# The CloudCAM System

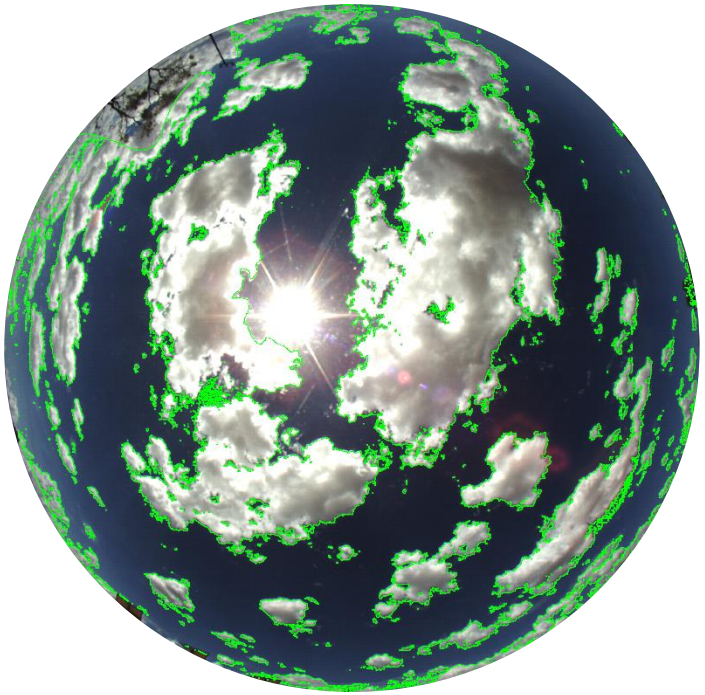
# introduction to CloudCAM

- CloudCAM tracks and predicts cloud movements at solar power stations
- this enables users to know in advance the:
  - timing of cloud events (time to onset as well as duration)
  - impact of cloud events (magnitude of change in irradiance and solar power output)
- this information can be integrated with solar power control systems to manage the fluctuations:
  - solar power output can be controlled
  - local storage can be used effectively (batteries, flywheels)
  - alternate generators can be started / stopped as required
- as a result, more solar power can be used in the system
  - greater fuel, cost and greenhouse gas savings

# cloud detection

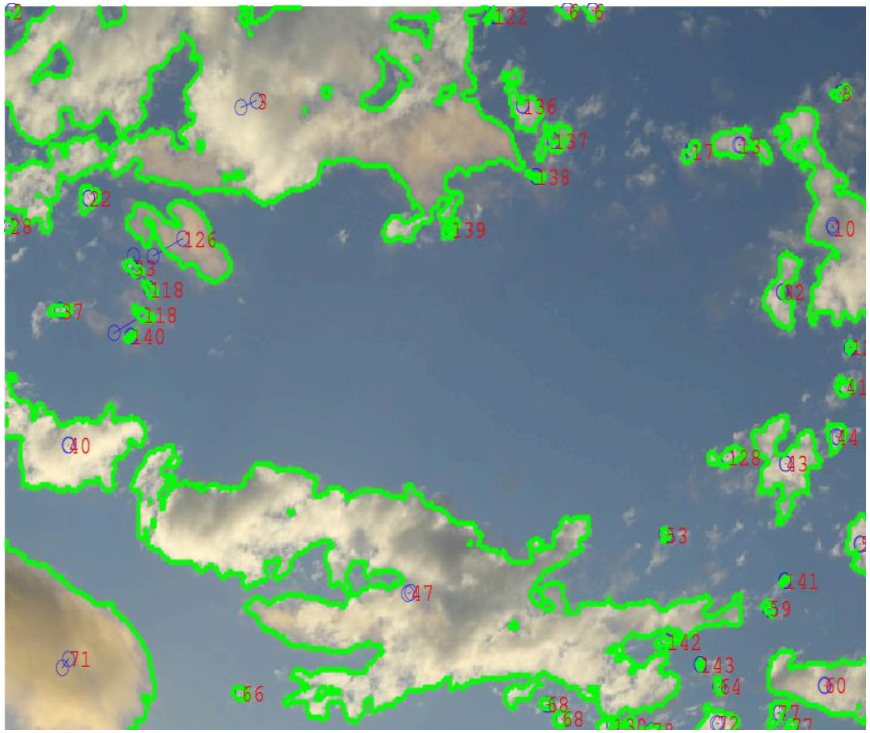


*CloudCAM image*



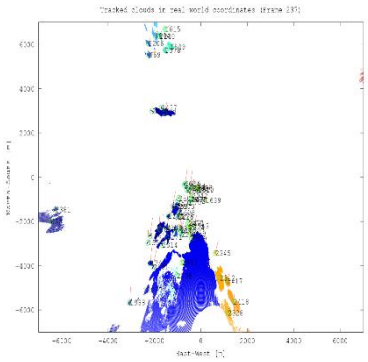
*CloudCAM image with cloud detection overlay*

# cloud identification

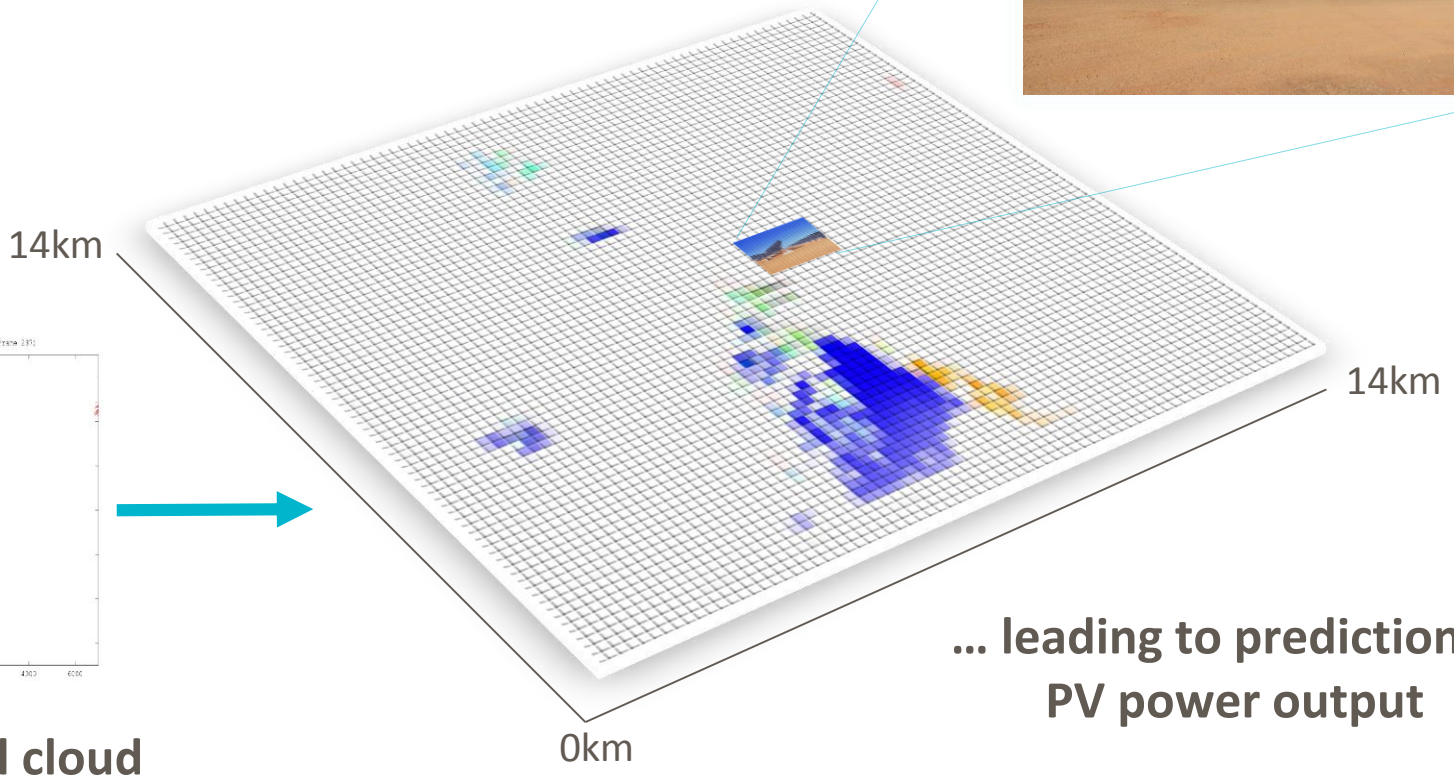


- each cloud is separately identified
- individual cloud tracking and prediction
  - cloud **growth / shrinkage**
  - cloud **disappearance & re-emergence** where multi-layered clouds exist
- individual cloud characterisation
  - determine its individual solar “blocking factor”
  - predict the magnitude of impact when it passes the sun

# ground-level solar irradiance prediction (30s to 15 min)

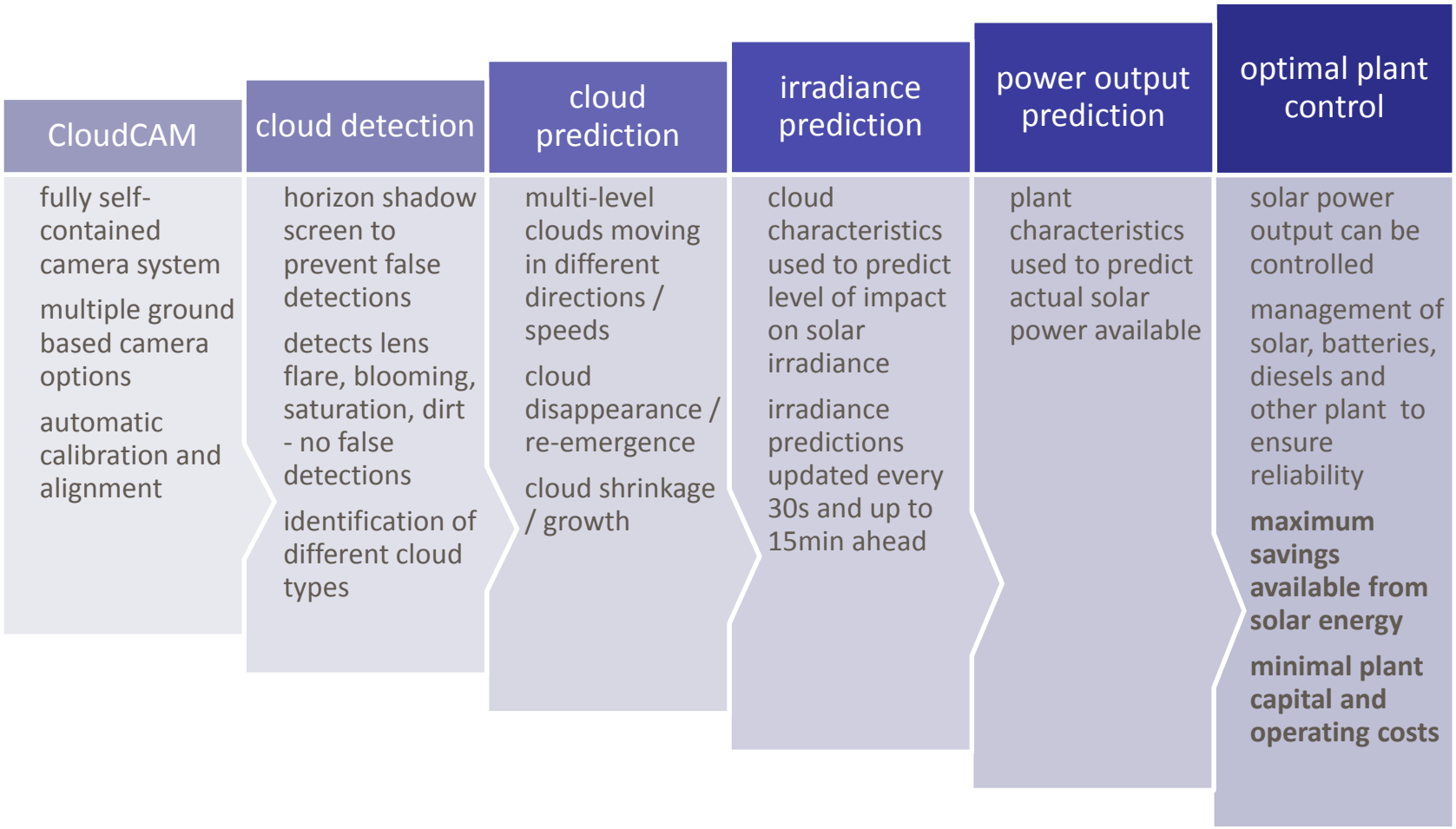


**ground-level cloud shadow map**




**… leading to prediction of PV power output**

# CloudCAM system



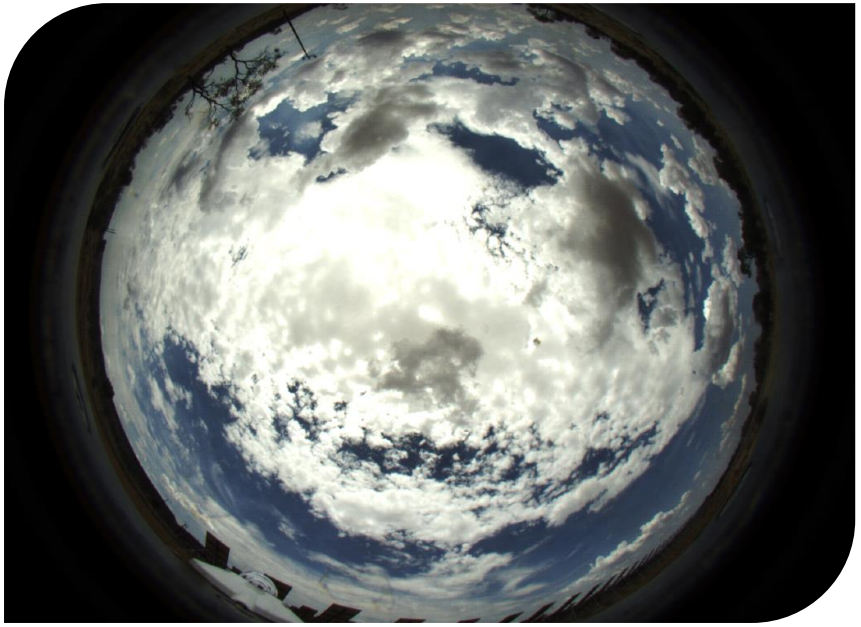
# CloudCAM

- fish-eye camera with 360/180deg sky coverage
- low cost cloud detection
- sampling rate >1s
  - typical sampling rate 5s
- system comes with integrated power supply, communications and weather sensors (pyranometer, temperature, pressure, humidity, rainfall…)
- **available now**

*CloudCAM installed at Uterne Solar Power Station, NT*

# CloudCAM – advanced system

- currently under development
- improved **near-horizon performance**
  - Important for centralised / tracking PV systems
- improved **multi-layer cloud detection** and **prediction**
  - independent tracking of different levels / types of cloud
- ideal for high reliance integrated systems where greatest prediction accuracy is required

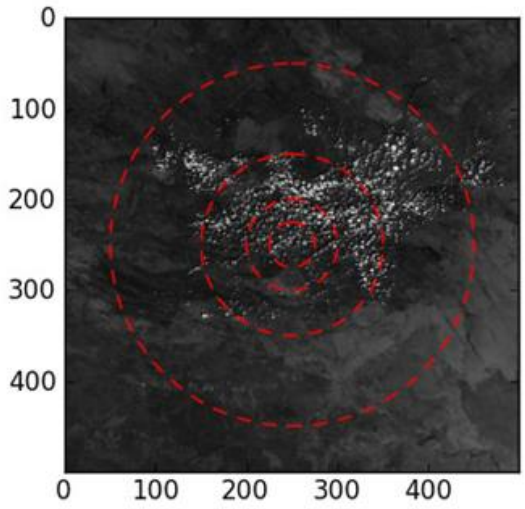


# two complementary methodologies

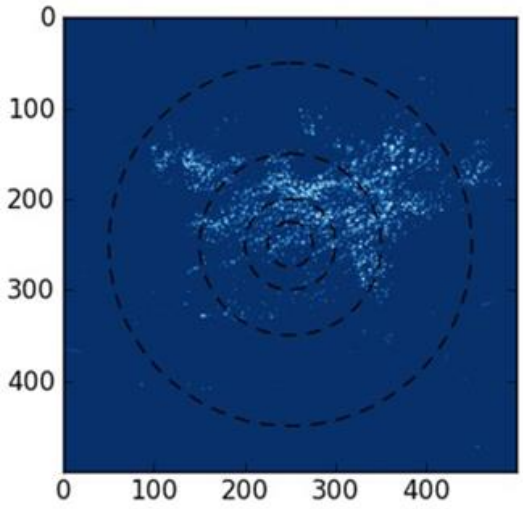
- **CloudCAM**
  - ground-based camera system
  - high spatial (m) and temporal (s) resolution
  - low geographic coverage (kilometres)
- **applications:**
  - highly accurate “nowcasting”
  - short term predictions over defined areas
    - 10s to 15min predictions
  - ideal for off-grid / centralised power station applications

- **CloudSAT**
  - satellite-based system
  - high geographic area (country / continental)
  - limited geographic resolution (1-4km per pixel)
- **applications:**
  - supplements and enhances ground-based view, seeing “over the horizon”, to provide longer-term predictions
  - allows prediction over large areas e.g. cities or states

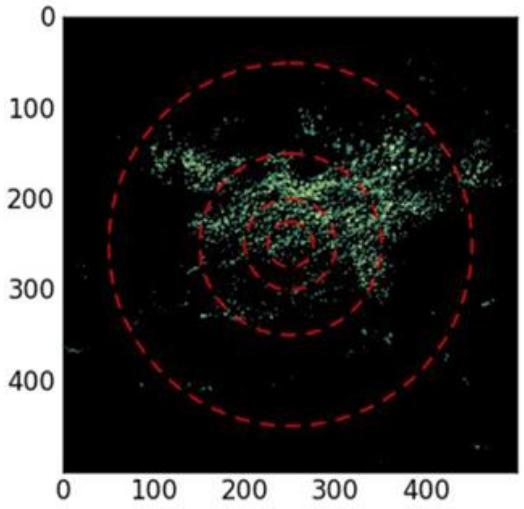
# CloudSAT: satellite image analysis




*satellite image*




*cloud detection*

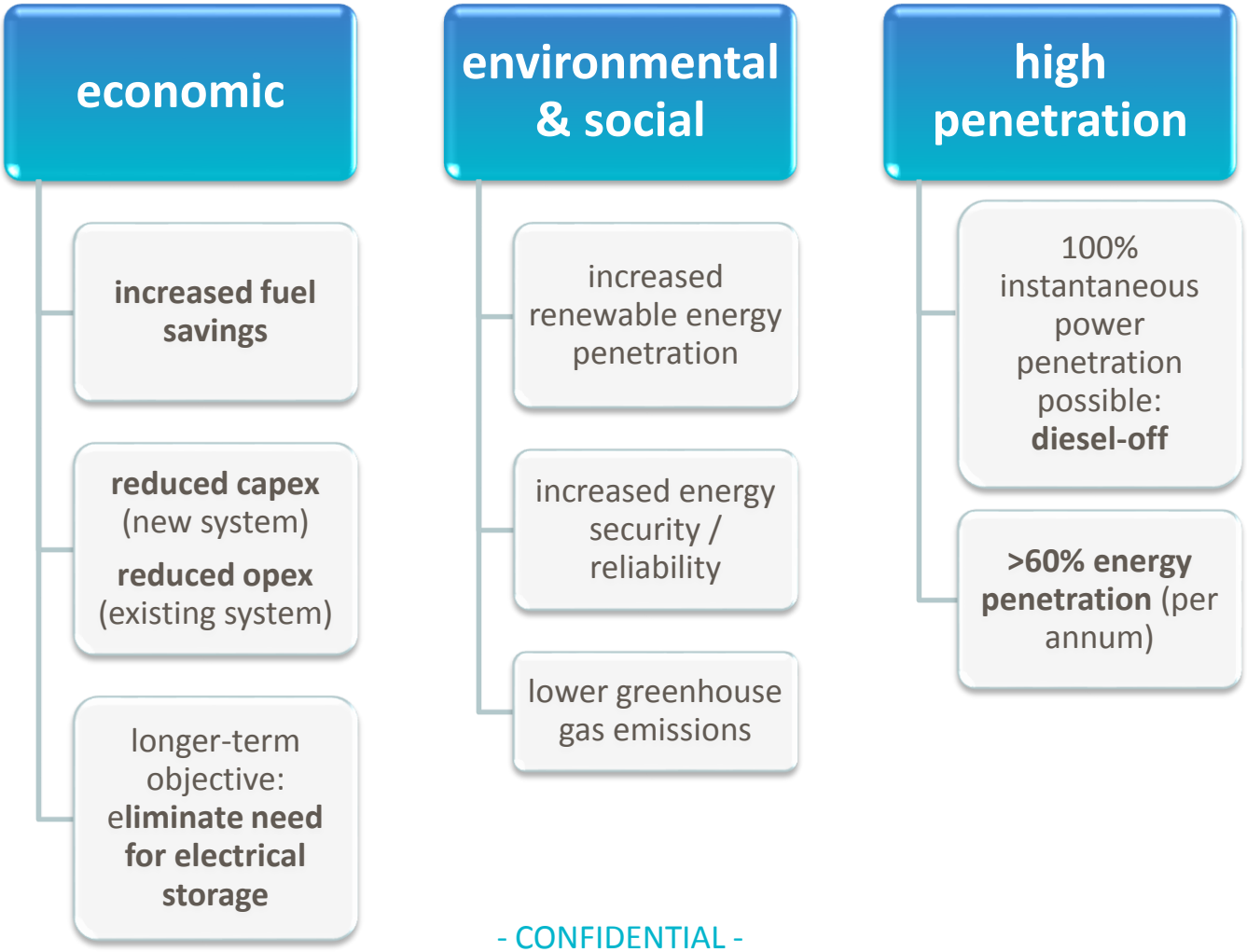



*light , medium & thick cloud detection*

- (left) raw satellite image shows cloud cover over the area
- (centre) algorithm removes background land features to reveal clouds only
- (right) clouds categorized as being either light, medium or thick

(axes scales in km; radial circles centred on Alice Springs have radii 50, 100, 200 and 400 km respectively)

# advanced irradiance prediction - benefits



# CloudCAM applications

- **low cost site assessment**
  - determining cloud patterns
  - assisting with plant sizing / design
  - characterisation of clouds for future cloud control systems
- **“nowcasting”**
  - detection of clouds within a defined distance from site
  - likelihood of an event in next period
- **“forecasting”**
  - based on predicted time to and significance of a cloud event

Image courtesy of Epuron 2014

# CloudCAM is available now

- applications
  - resource assessment, nowcasting, forecasting cloud events
- standard inclusions:
  - mounting hardware, solar power supply, communications
  - temperature, humidity, irradiance sensors (pyranometer)
- optional extras
  - additional weather sensors (rain, pressure, wind, PV reference cell etc.)
  - control system integration
  - support services (site analysis, reporting etc)
  - CloudSAT integration

Fulcrum 3D
precision sensing

Uterne Solar Power Station, Alice Springs
Image courtesy of Epuron 2014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