Analysing power system impacts using solar radiation data for Australia

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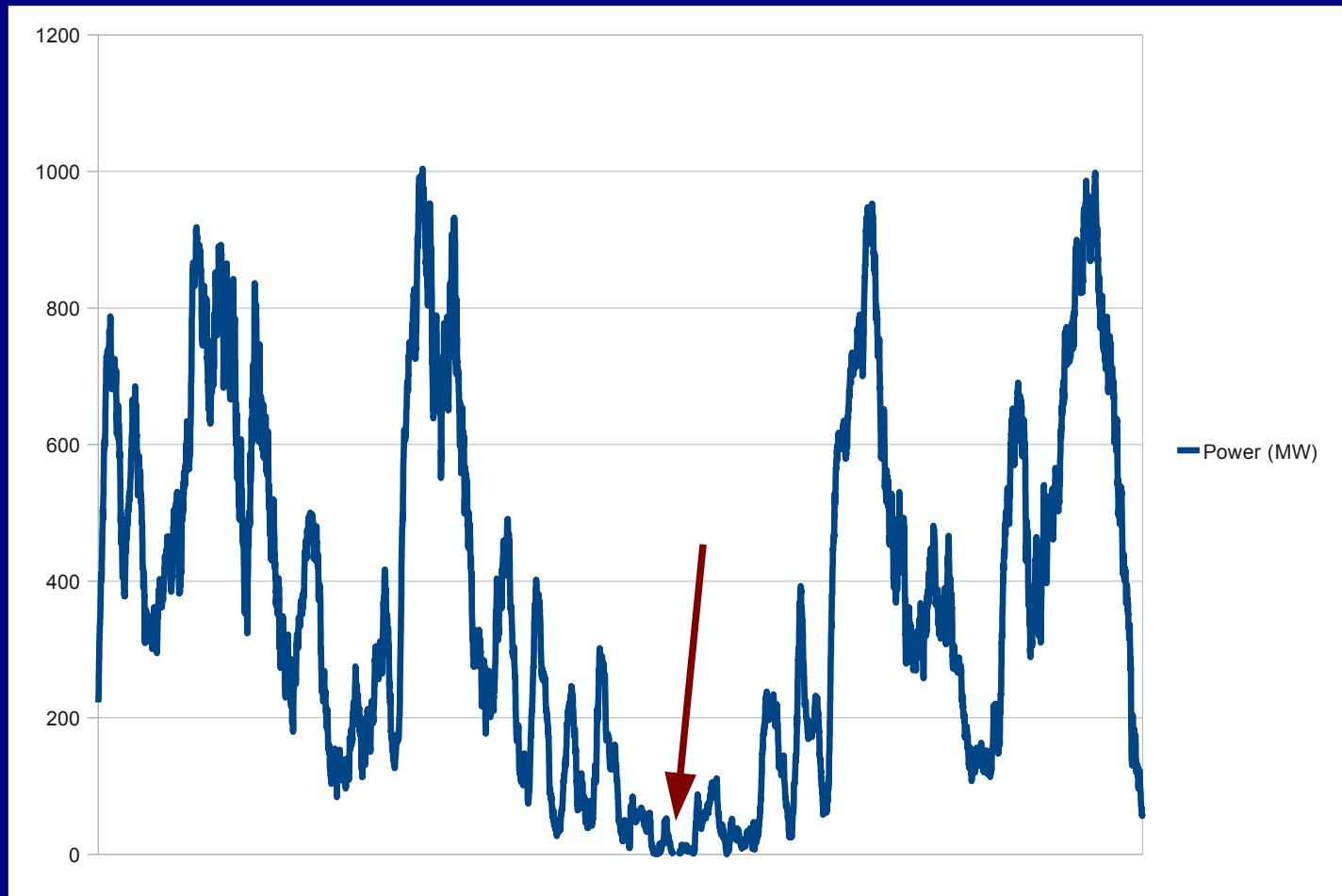Sydney, Australia

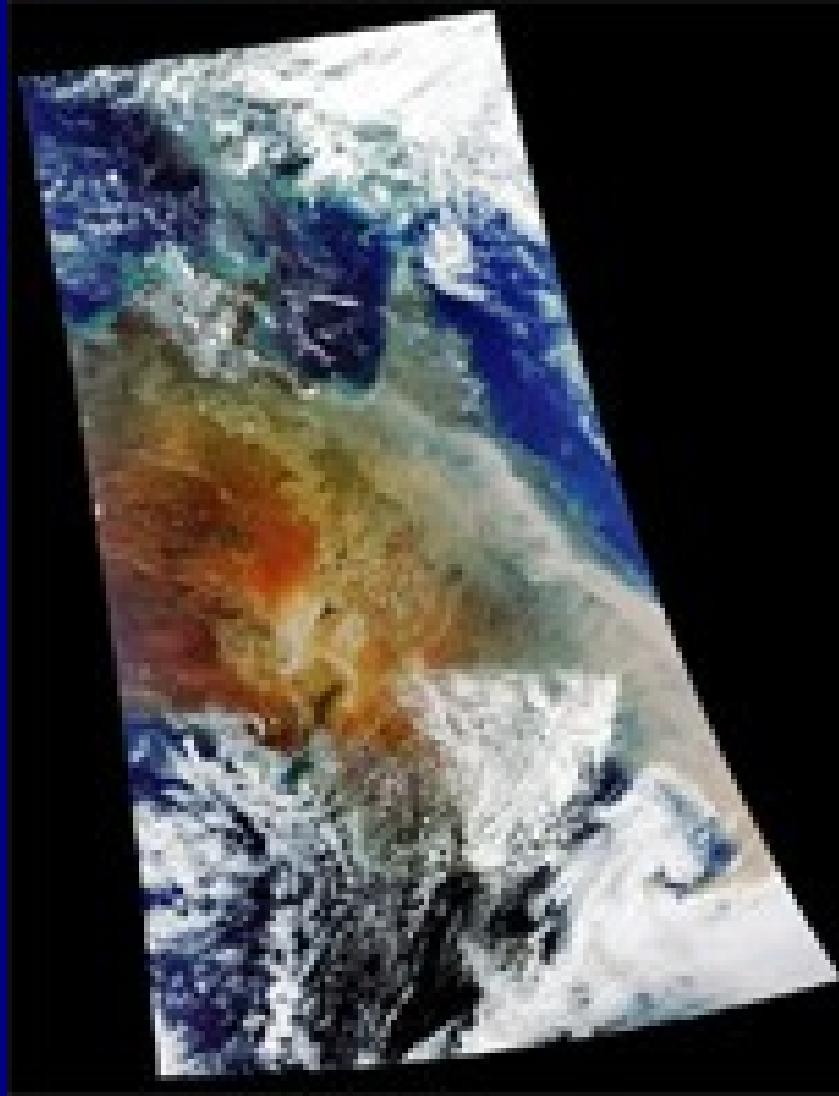# Why care about extreme events?

Source: Illawarra Mercury

Why care about extreme events?

Lull in NEM wind power May 17-20, 2010. Data from AEMO.
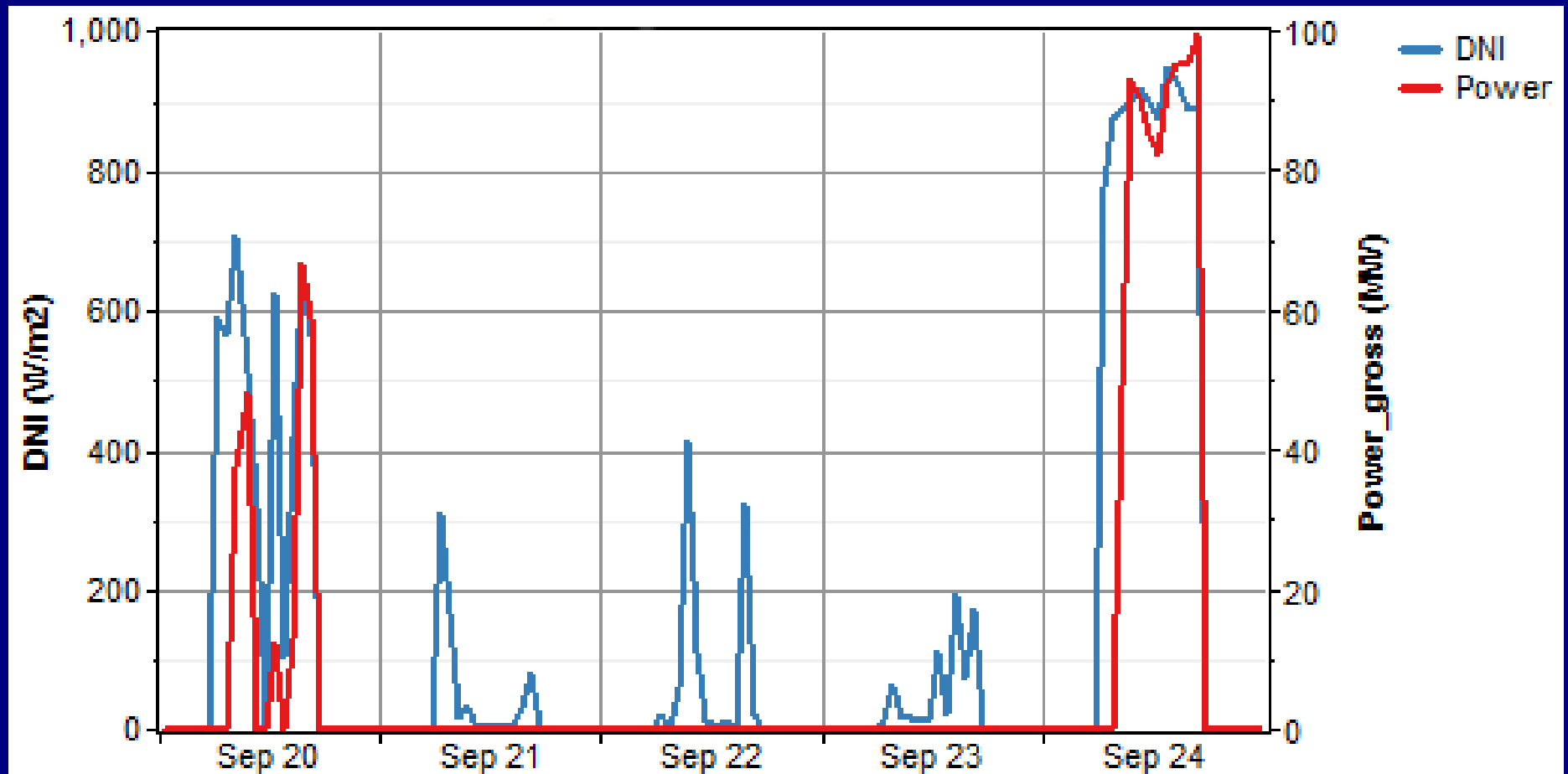
Outline

- The CST context

- Solar radiation data set

- Computational method

- Results for Australia

- More detailed results for two locations

  - Roma (Queensland), Curnamona (SA)

- Conclusions

The CST context

Aqua satellite image of dust storm over NSW. Source: Geoscience Australia

The CST context

Simulated 100MW trough plant in Cobar, NSW, September 2009

What is useful for CST planning?

- CST w/ 7+ hours storage can ride through short periods of low irradiance
  - eg. Gemasolar
- Characterising **long** low irradiance events
  - DNI < 400 W/m^2
  - How long are they?
  - When and where do they occur?
  - How frequently do they occur?

# Historical solar radiation data set

- DNI data from BoM (1998 – 2010)
- Satellite-derived
  - 5km x 5km x 1h resolution
  - 113,952 x 679 x 839 values
- DNI computed via Ridley/Boland diffuse model
- Some missing data
- PyTables used for analysis

Historical solar radiation data set
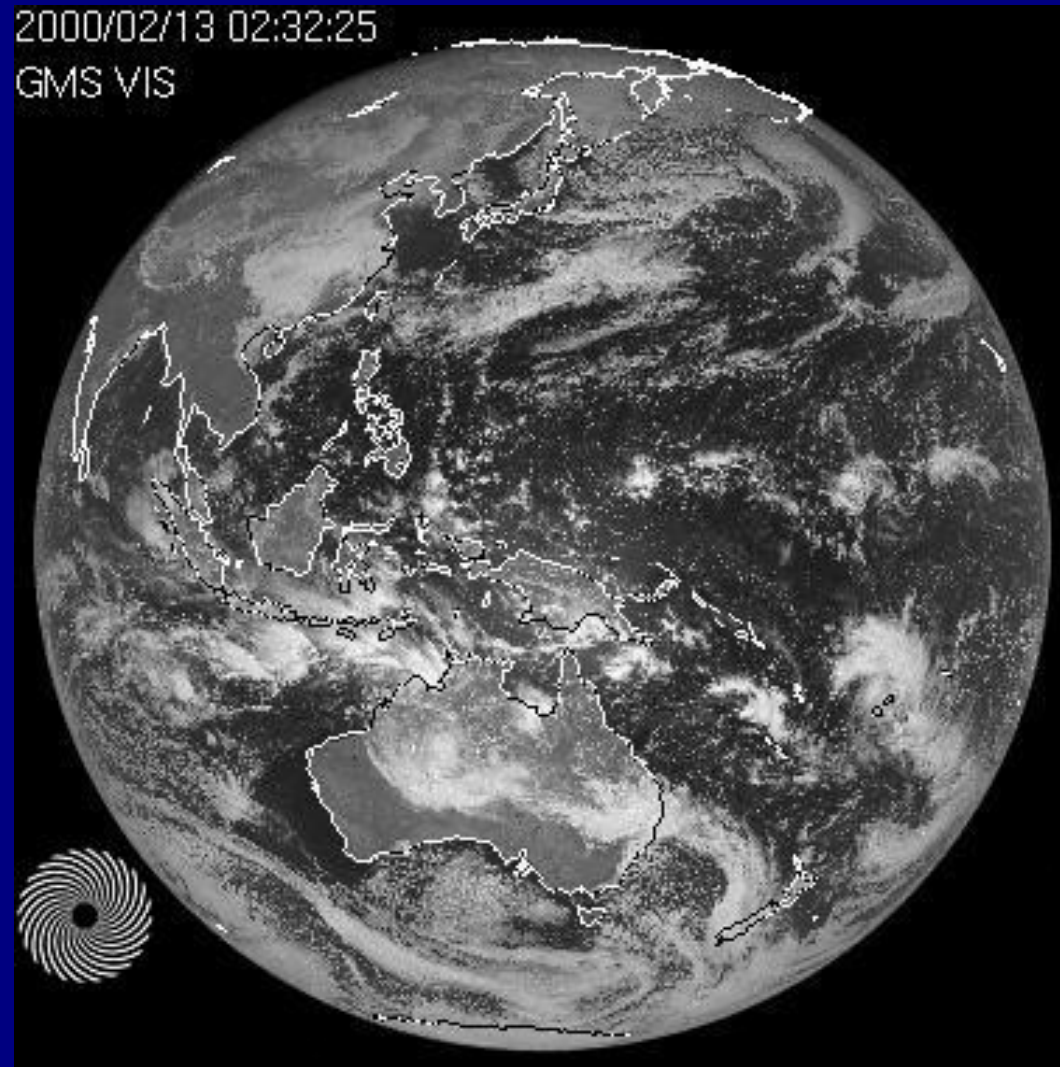
Satellite image (2am 13 Feb 2000) courtesy of Bureau of Meteorology

Historical solar radiation data set

Direct normal irradiance 2000-02-13 02UT
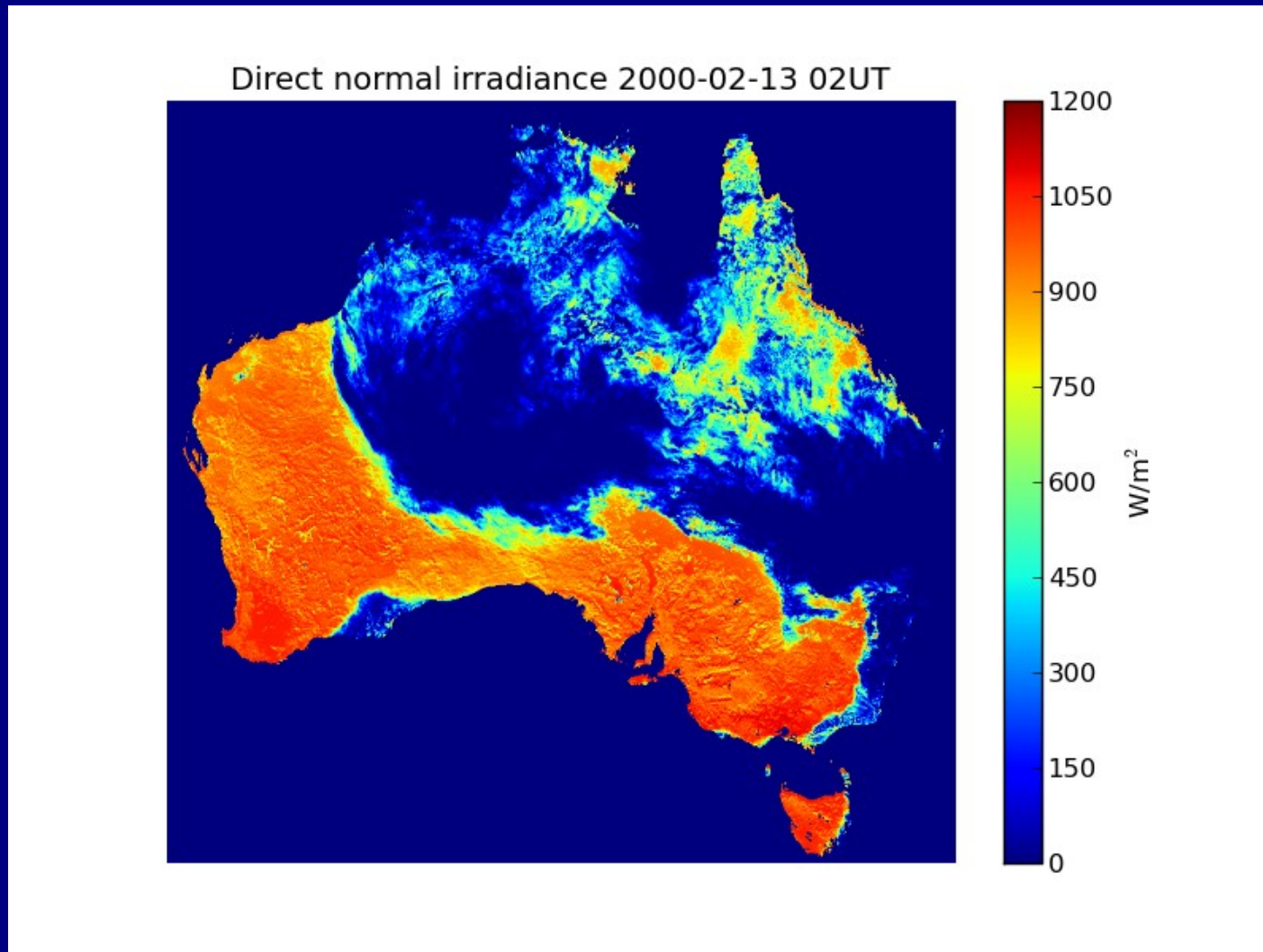
Corresponding hourly grid of estimated DNI values
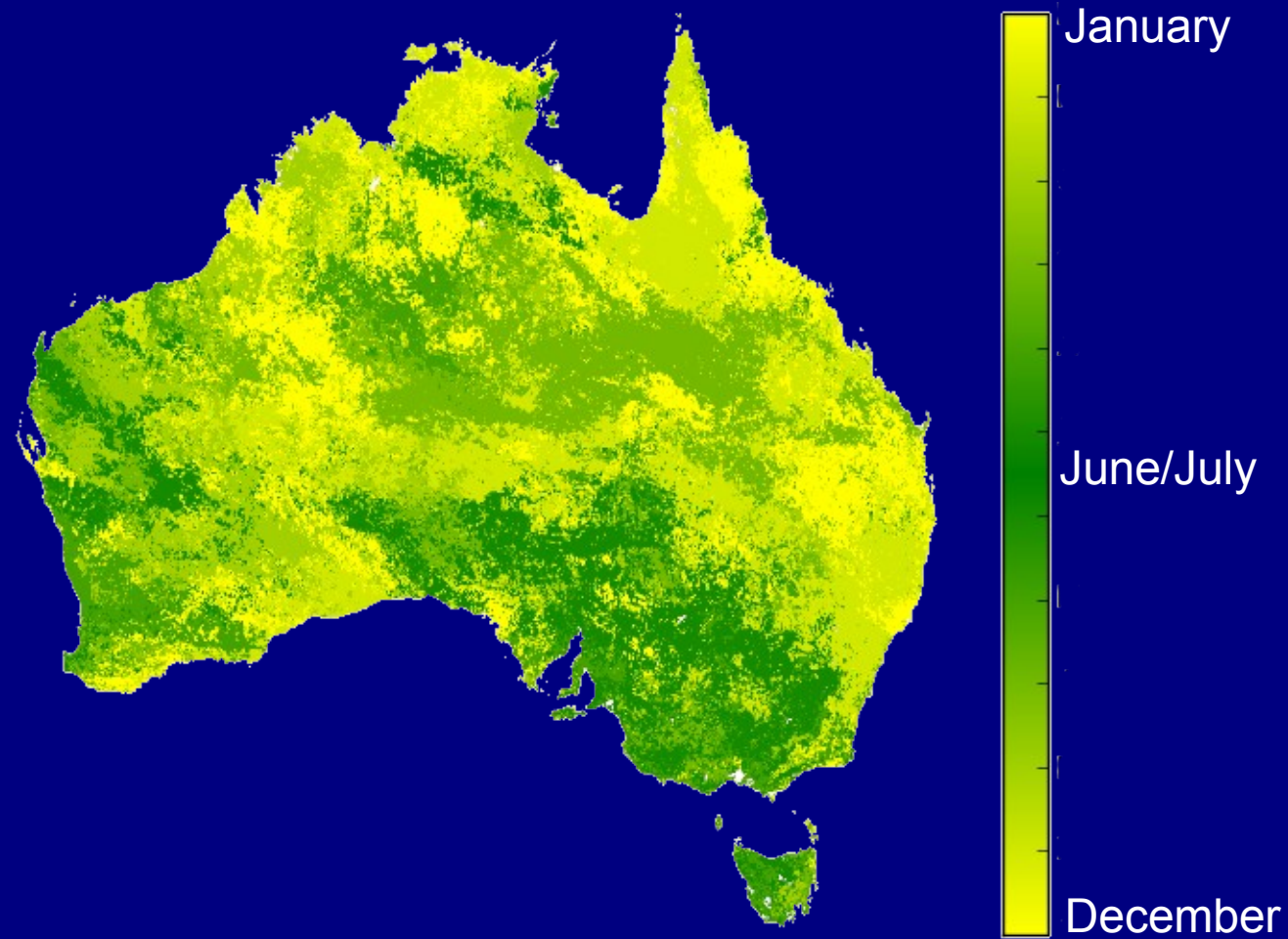
Computational method

- ## Needs to be fast
  - "Embarrassingly" parallel problem
- ## Method:
  - Initialise 2 working matrices: **C**, **M**
  - For each hour:
    - $\text{C} = (\text{C} + \text{B}) \circ \text{B}$ (increment if $b_{i,j}$ is 1, reset if 0)
    - $\text{M} = \max(\text{M}, \text{C})$
- ## Two result matrices:
  - Maximum duration, starting hour number

How long are the longest events?
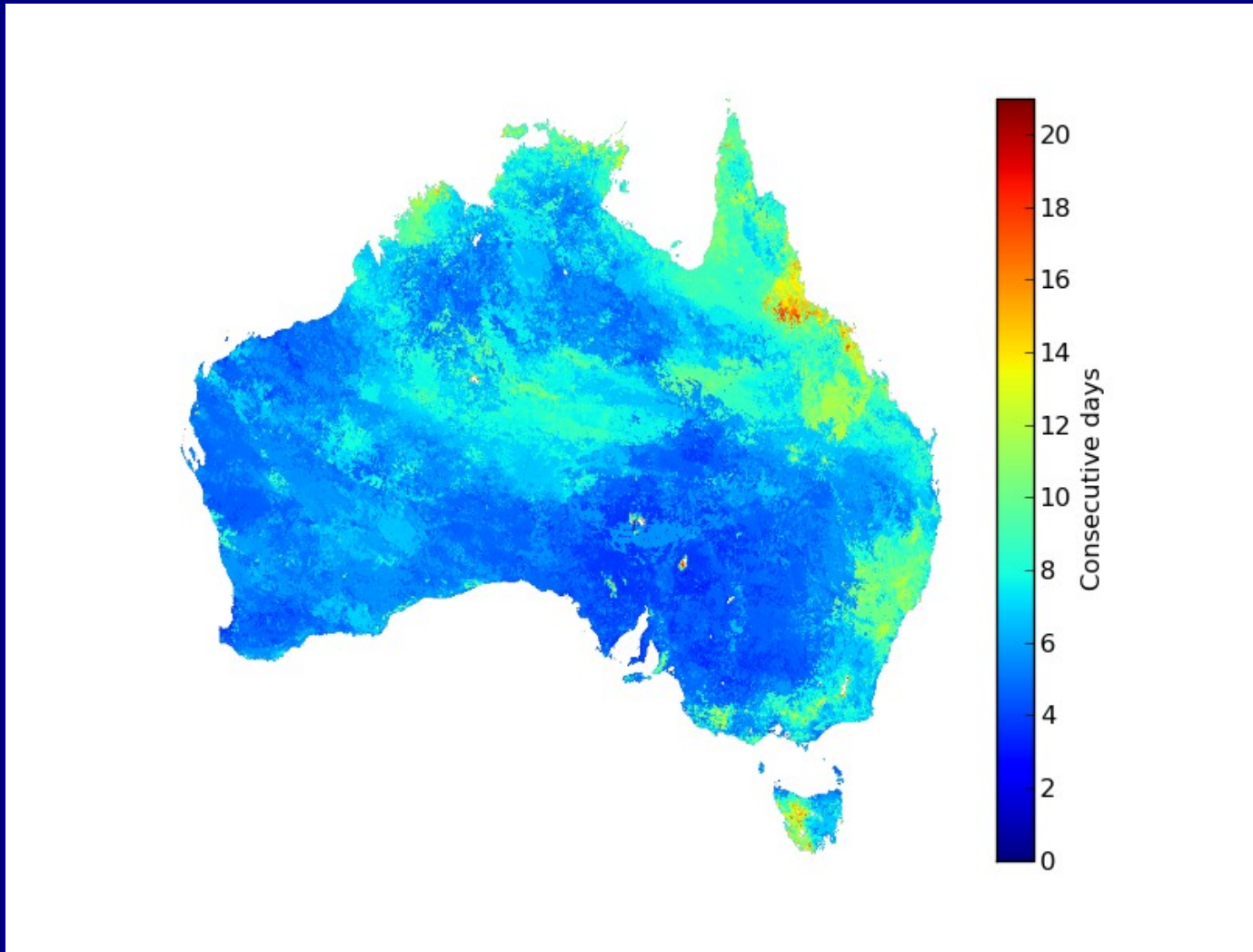
Longest events typically last 4 to 8 days across Australia

When do the longest events occur?

Starting month of longest low DNI events
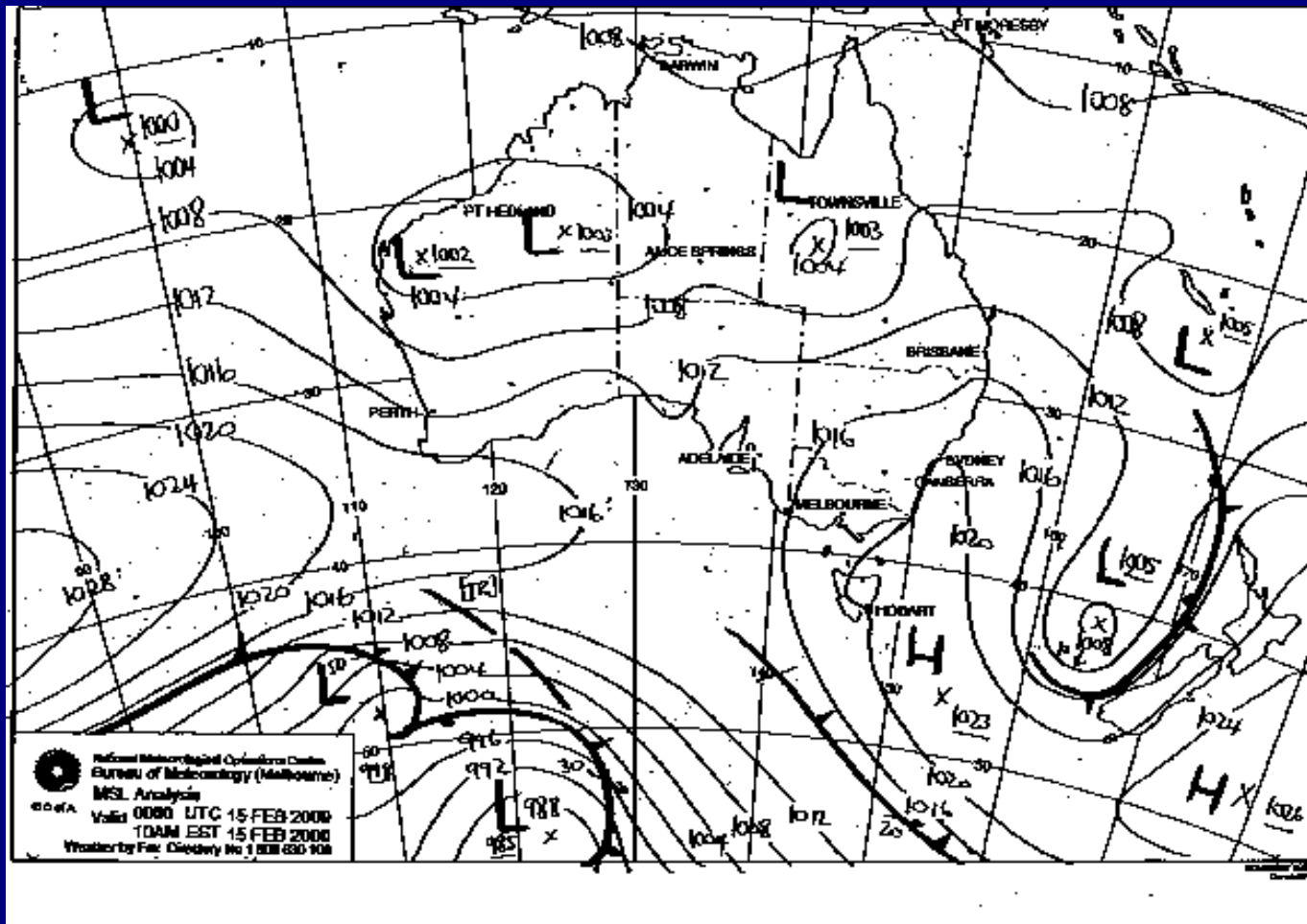
Roma 10 longest events

Map courtesy of Google Maps

Roma 10 longest events

Start (UTC)	End (UTC)	Hours	Days
2000-02-12	2000-02-18	139	6
2008-01-14	2008-01-20	138	
2010-02-27	2010-03-05	136	
1998-12-29	1999-01-03	134	
2010-09-16	2010-09-21	115	5
1998-04-13	1998-04-17	113	
2000-04-22	2000-04-26	113	
2000-11-13	2000-11-17	111	
2010-01-03	2010-01-07	110	
2000-11-07	2000-11-11	109	

MSLP map for 15 Feb 2000

Tropical Cyclone Marcia (category 1) in Indian Ocean

Curnamona 10 longest events

Map courtesy of Google Maps

Curnamona 10 longest events

Start (UTC)	End (UTC)	Hours	Days
1998-07-31	1998-08-04	89	4
2007-01-17	2007-01-20	83	
1999-03-24	1999-03-27	71	3
2004-05-31	2004-06-30	66	
2000-03-18	2000-03-20	65	
2006-07-13	2006-07-15	65	
2007-03-18	2007-03-21	65	
2004-07-22	2004-07-24	64	
2005-07-06	2005-07-08	64	
2010-02-01	2010-02-03	64	

Conclusions

- Some very long low irradiance events
  - No CST output for 5+ days
  - Storage to ride through clearly uneconomic
  - Storage insufficient to provide system security
- North/south diversity useful
  - Longest northern events in summer
  - Longest southern events in winter
- Diversity comes at a cost: poorer DNI in south

Acknowledgements

- Australian Solar Institute
- Intersect Australia
- NCI National Facility

Questions?