Centre for Energy and Environmental Markets

UNSW



Challenges in Wind Energy Forecasting

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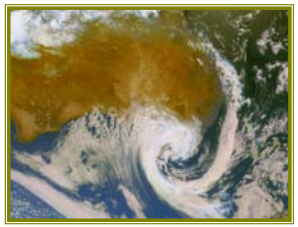
Outline

- Introduction
- Wind Farms In Australia
- Wind Statistics
- Challenges in Wind Forecasting
- Weather Systems and Events of Importance
- Preliminary Work

Introduction

- As wind power emerges as a significant component of energy markets around the world, Australia's major wind resources mean that it is well placed to harness greater wind energy within the electricity industry.
- The ability to accurately predict weather events that rapidly change wind energy production from one or more wind farms would reduce the costs of integrating wind energy into power systems and increase the commercial viability of wind energy in competitive electricity markets.
- In response to this we are working on numerous strategies to analyse and initiate a methodology to improve forecasting of events that lead to large changes in wind energy production (ie., too little or too much wind and rapid changes in wind speed and direction).

Wind Farms In Australia



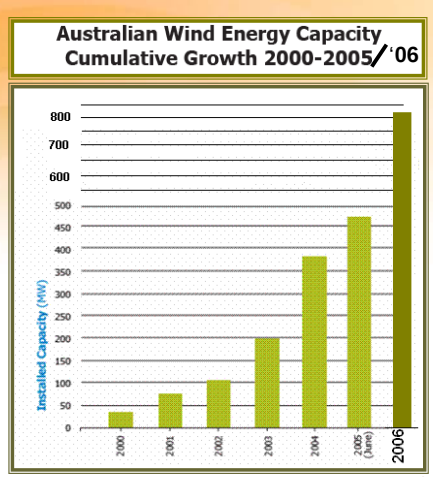


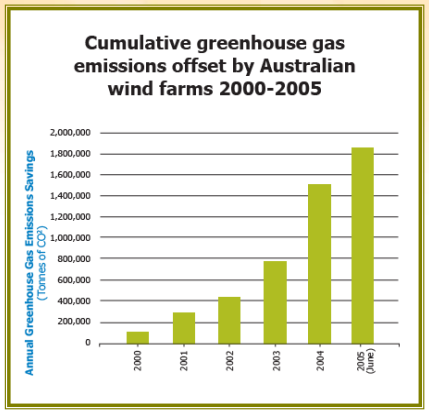

Region	Installed Under Construction
WA	199 MW
SA	388 MW 254 MW
NSW	17 MW
Vic	134 MW 192 MW
QLD	12 MW
Tas	67 MW 75 MW

Total Installed: 817MW
Under Construction: 521 MW

http://www.auswea.com.au/auswea

Wind Energy Statistics





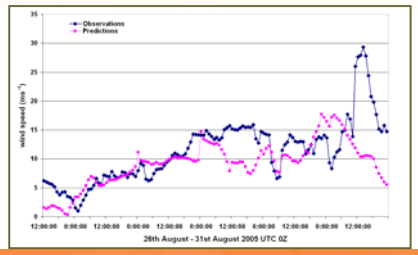
http://www.auswea.com.au/auswea/downloads/Tradewinds_report.pdf

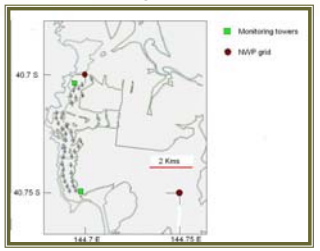
Some Challenges Faced in Wind Energy Forecasting

- There are many challenges one faces in maximising the value of wind power:
  - ***Their environmental value***
  - ***Putting them in the right place***
  - ***Operating them in the correct way***

A key challenge is forecasting!

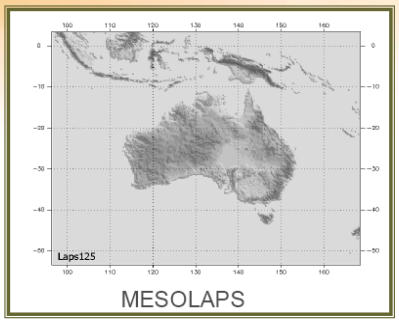
- The ability of an NWP to make an accurate/useful wind forecast: Most NWP's *are not* geared towards detailed wind predictions, especially in the context of wind power and the electricity market. **The question to answer here is are they a useful tool by themselves?**

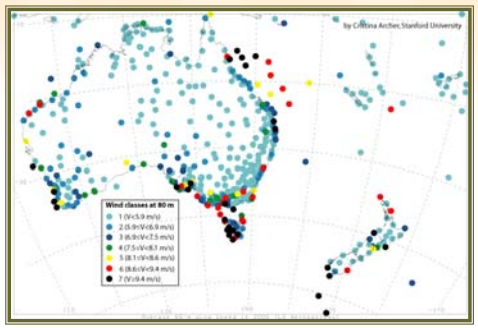




Regional and Small Scale Requirements

- There are many challenges one faces in tackling this problem and listed below are some of them:
  - **The task of distinguishing between regional and small scale forecasts.**
  - **Windfarm Placement**

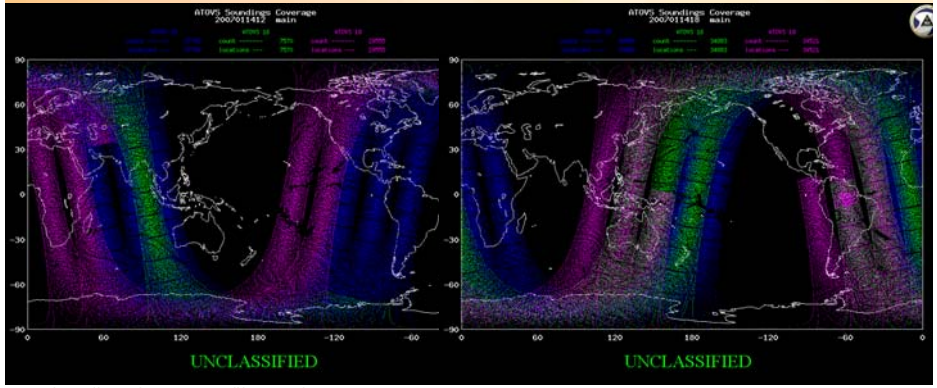




▪ Archer, C.L., and Jacobson, M.Z. (2005), Evaluation of global wind power, J. Geophys Res., vol 110, D12110.

Data and Forecast Horizon

- Access to data: **Will additional data sources contain any information of use to forecasting for the wind energy sector?**



▪https://www.fnmoc.navy.mil/PUBLIC/

What is the Best Model to Use?

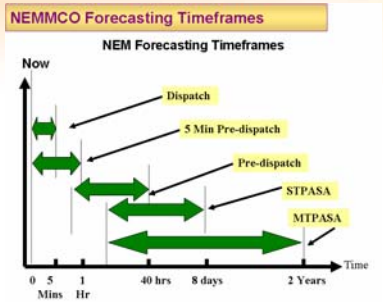
- **What type of models will be the most advantageous to use?**
  - WLAPS looks promising
  - besides a typical NWP could The Air Pollution Model (TAPM) provide a more useful forecast [1]?
- **What type of statistical methods/corrections could improve forecasts?**
- **Will forecasting techniques used for dust storms, wind events related to fires [2] be able to help predict timing of sudden wind changes?**

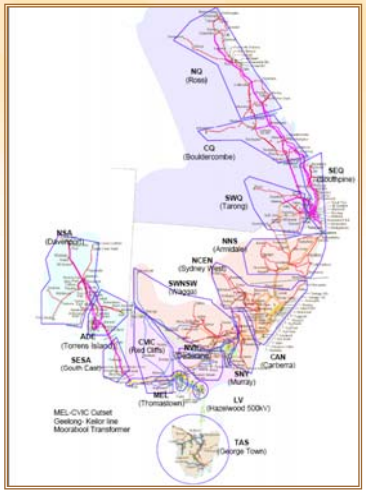
[1] Craine, S., Massie, R., vander Schoor, K., Cohen, W., Bateman, B., Peterson, J., and Langford, S. (2004), Wind Resource Atlas for Southern Australia. *Wind Engineering*, **28**, 4, pp. 355-366.

[2] Huang, X. and Mills, G.A. 2006. Objective identification of wind change timing from single station observations. BMRC Research Report No. 120, Bur. Met. Australia.

The National Electricity Markets Requirements

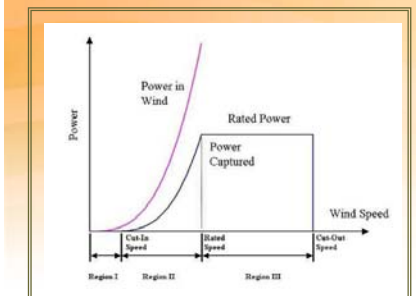
- The National Electricity Market Management Company (NEMMCO)'s regional aggregation requirements leads us to ask: **What is the best way to produce a forecast that can incorporate individual and aggregated wind farms for the NEM forecasting timeframes?**





AWEFS functional requirements ROI from NEMMCO website http://www.nemmco.com.au/

The Power Curve

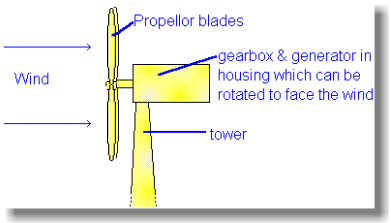


An example Power curve showing the cut-in and cut-out speeds:
Region I: 5ms^{-2}
Region II: rated power at ~15ms^{-1}
Region III: Cut out Speed 25ms^{-1}

- The power of the wind is the cube of the wind speed.
- The Wind Power Formula:

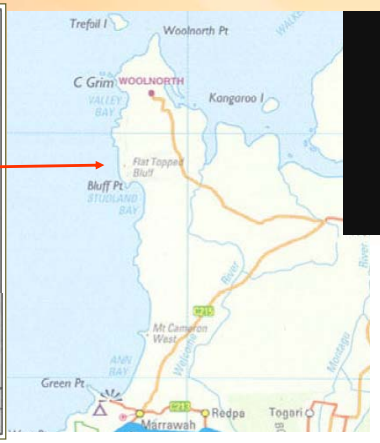
$$P = \frac{1}{2}\rho v^3 \pi r^2$$

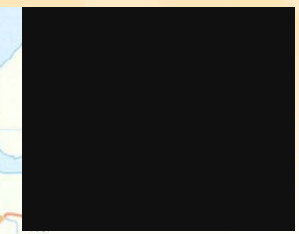
- Where P = Power in Watts
- **ρ** = density of dry air in kgm^{-3}
- r= radius of the rotor in metres
- V = velocity in ms^{-1}

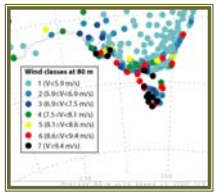


http://home.clara.net/darvill/altenerg/wind.htm

Woolnorth Wind Farm in Tasmania







http://www.hydro.com.au/Documents/Corporate/Woolnorth1.mpg

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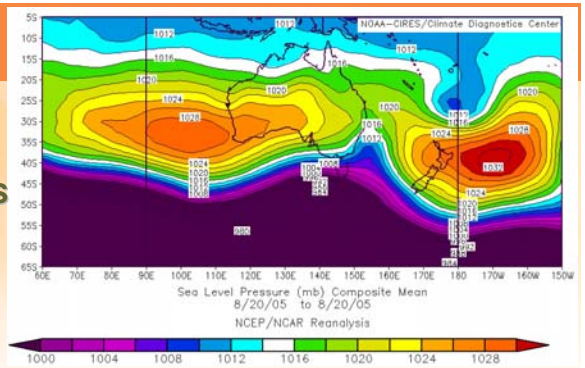
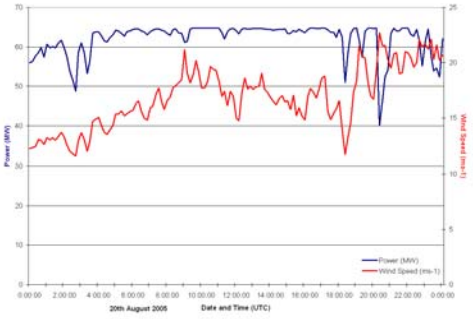
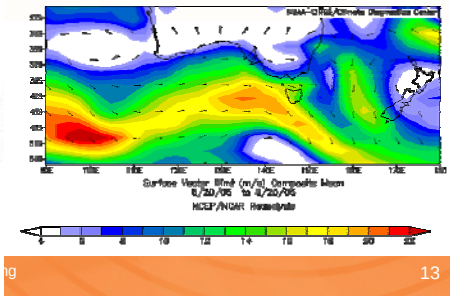
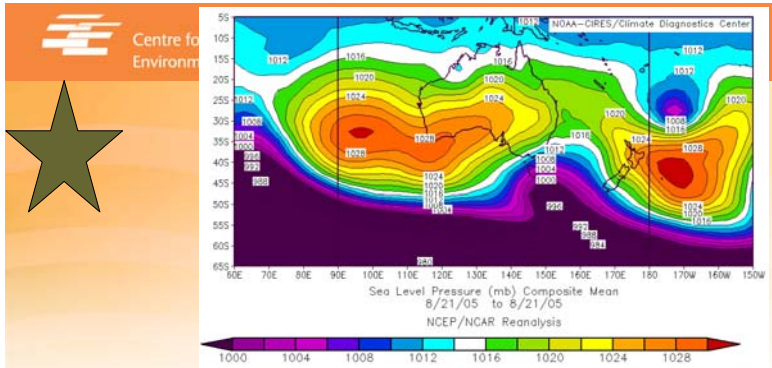
Synoptic Features Identifiable with Large Swings

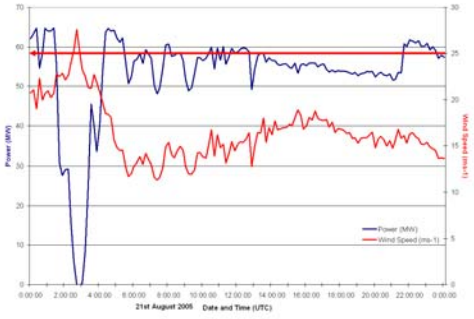
- Cold Fronts
- Troughs
- Unstable low pressure systems

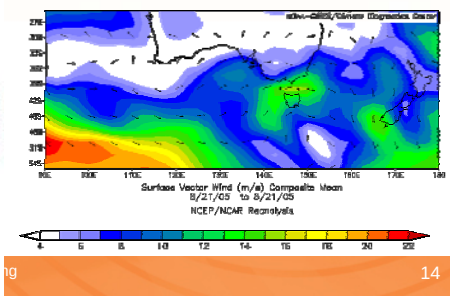


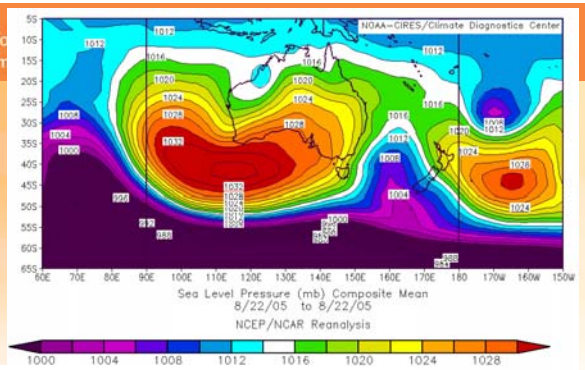


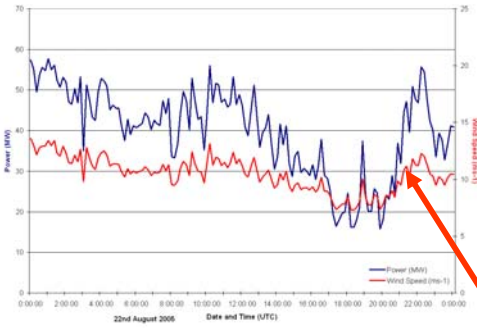


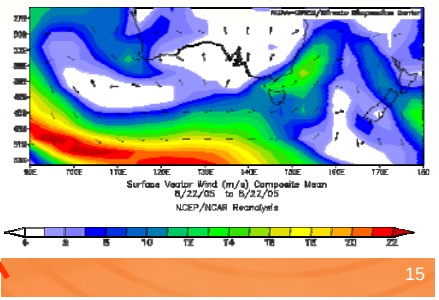


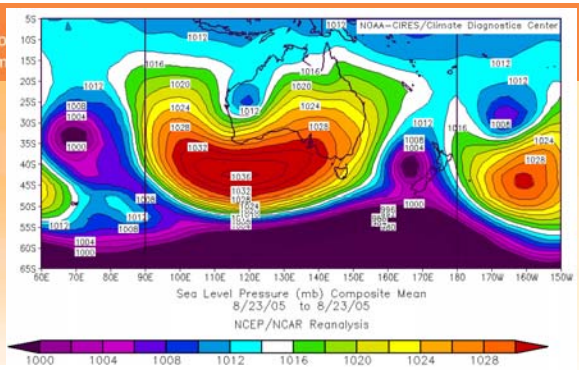


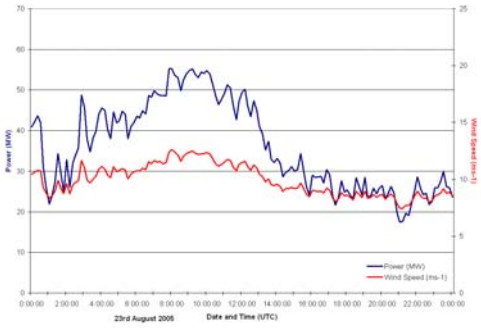


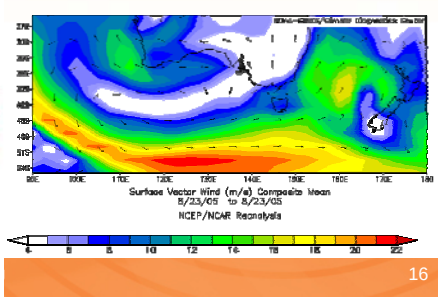


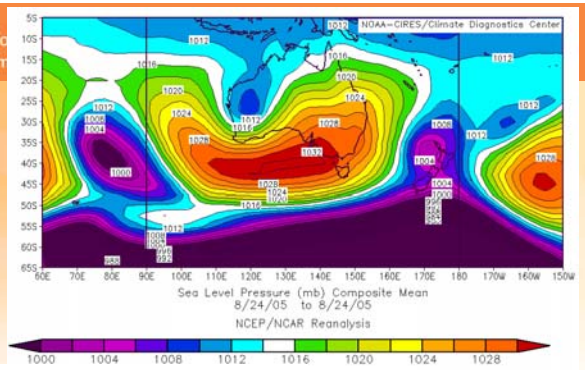








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8/24/05 to 8/24/05
NCEP/NCAR Reanalysis
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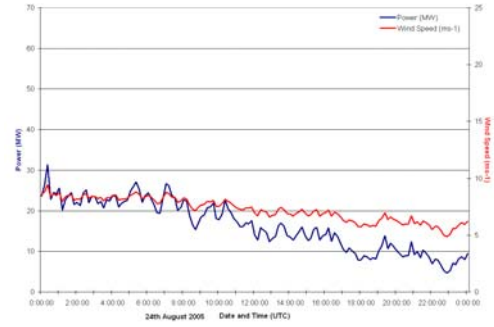
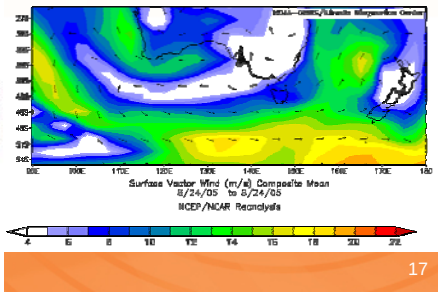
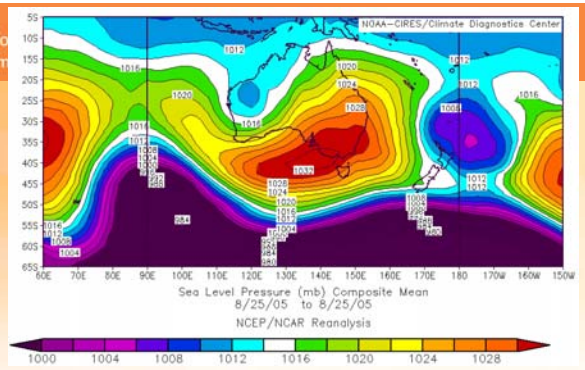

Power (MW)
Wind Speed (ms-1)
24th August 2005
Date and Time (UTC)


Surface Vector Wind (m/s) Composite Mean
8/24/05 to 8/24/05
NCEP/NCAR Reanalysis


NOAA–CIRES/Climate Diagnostics Center
Sea Level Pressure (mb) Composite Mean
8/25/05 to 8/25/05
NCEP/NCAR Reanalysis
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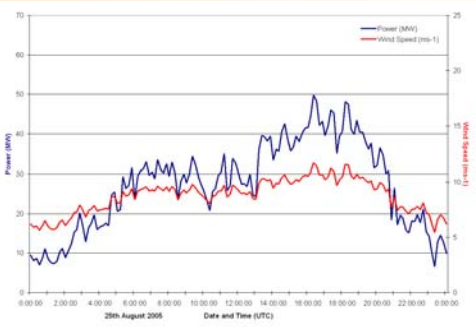
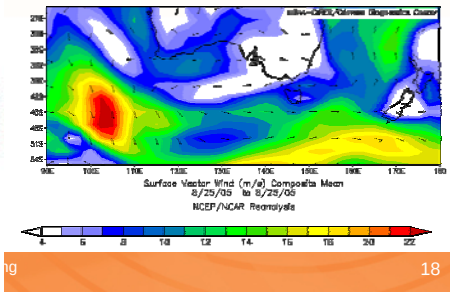

Power (MW)
Wind Speed (ms-1)
25th August 2005
Date and Time (UTC)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8/25/05 to 8/25/05
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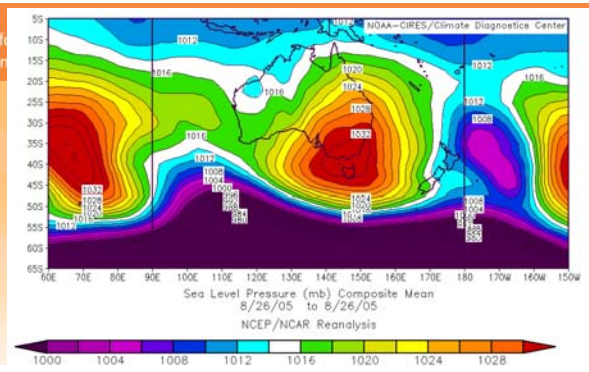
NOAA–CIRES/Climate Diagnostics Center
Sea Level Pressure (mb) Composite Mean
8/26/05 to 8/26/05
NCEP/NCAR Reanalysis
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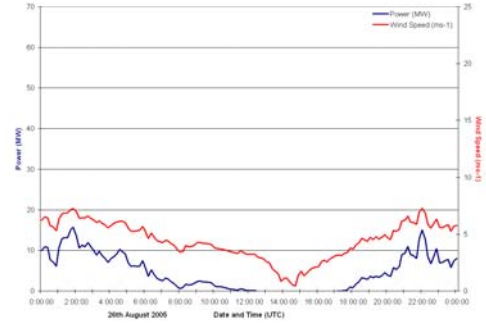
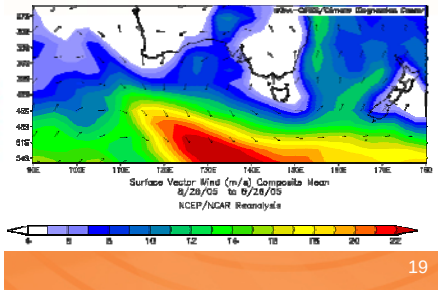

Power (MW)
Wind Speed (ms-1)
26th August 2005
Date and Time (UTC)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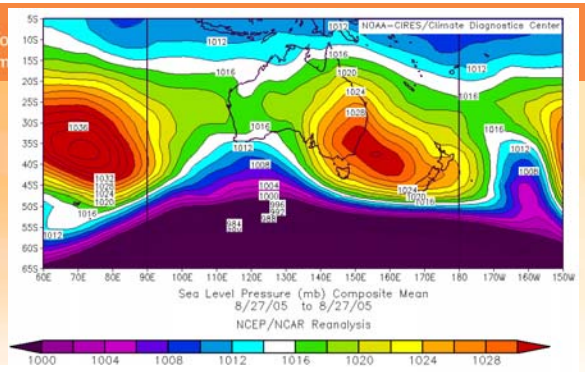
8/26/05 to 8/26/05
NCEP/NCAR Reanalysis


NOAA–CIRES/Climate Diagnostics Center
Sea Level Pressure (mb) Composite Mean
8/27/05 to 8/27/05
NCEP/NCAR Reanalysis
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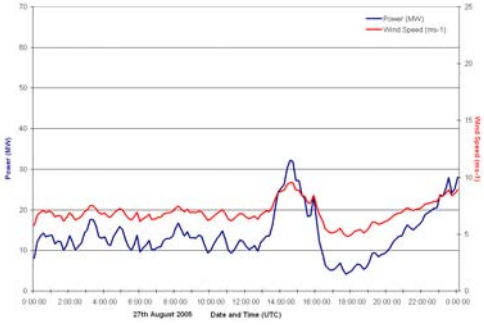
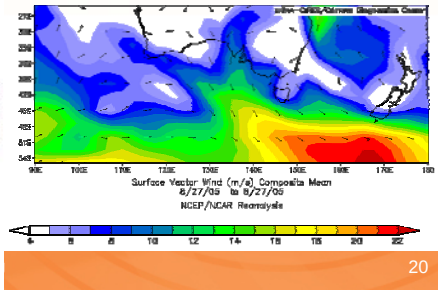

Power (MW)
Wind Speed (ms-1)
27th August 2005
Date and Time (UTC)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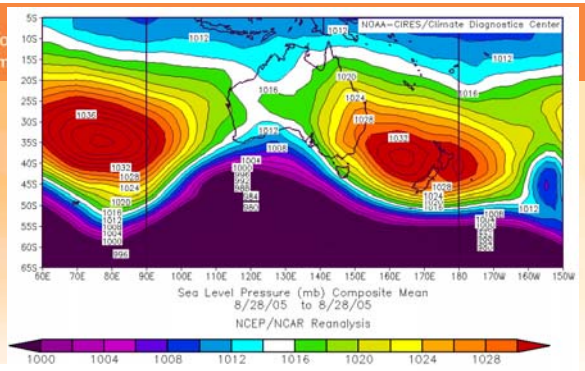
NCEP/NCAR Reanalysis


NOAA–CIRES/Climate Diagnostics Center
Sea Level Pressure (mb) Composite Mean
8/28/05 to 8/28/05
NCEP/NCAR Reanalysis
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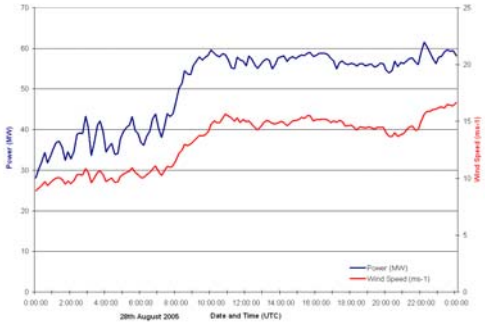
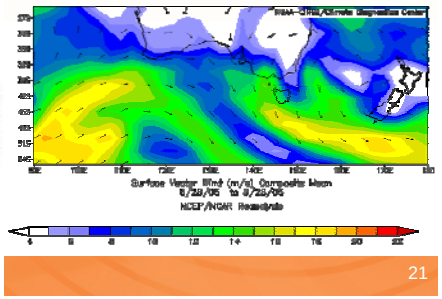

Power (MW)
Wind Speed (ms-1)
28th August 2005
Date and Time (UTC)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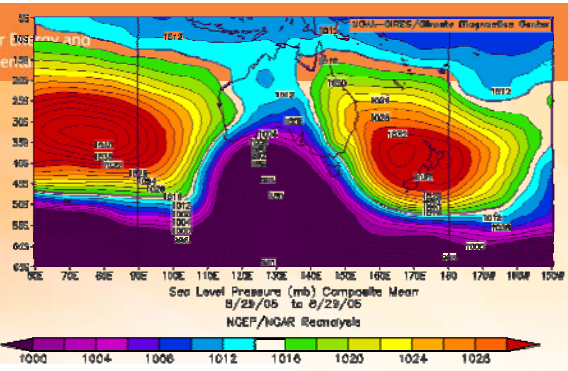
8/28/05 to 8/28/05
NCEP/NCAR Reanalysis


Sea Level Pressure (mb) Composite Mean
8/29/05 to 8/29/05
NCEP/NCAR Reanalysis
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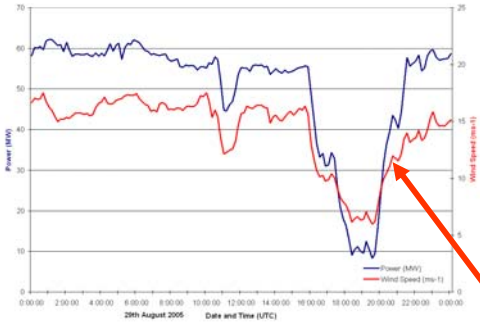
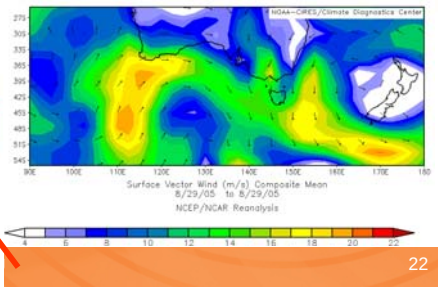

Power (MW)
Wind Speed (ms-1)
29th August 2005
Date and Time (UTC)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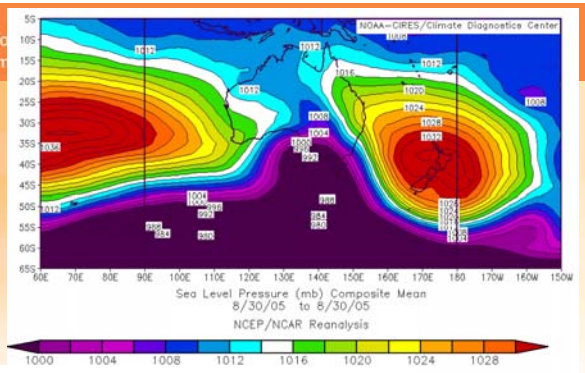
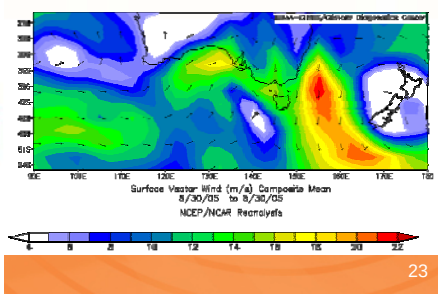
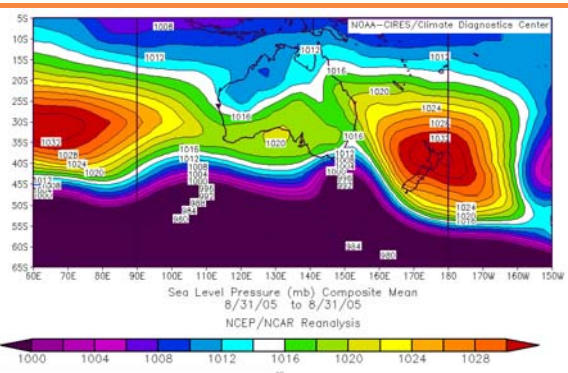
8/29/05 to 8/29/05
NCEP/NCAR Reanalysis

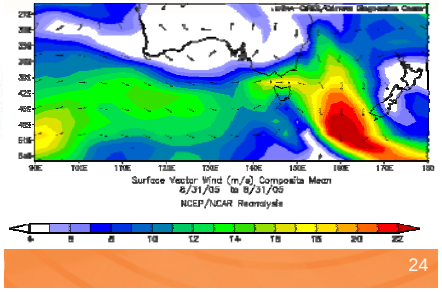

NOAA–CIRES/Climate Diagnostics Center
Sea Level Pressure (mb) Composite Mean
8/30/05 to 8/30/05
NCEP/NCAR Reanalysis
1000 1004 1008 1012 1016 1020 1024 1028


Power (MW)
Wind Speed (ms-1)
30th August 2005
Date and Time (UTC)


Surface Vector Wind (m/s) Composite Mean
8/30/05 to 8/30/05
NCEP/NCAR Reanalysis


NOAA–CIRES/Climate Diagnostics Center
Sea Level Pressure (mb) Composite Mean
8/31/05 to 8/31/05
NCEP/NCAR Reanalysis
1000 1004 1008 1012 1016 1020 1024 1028


Power (MW)
Wind Speed (ms-1)
31st August 2005
Date and Time (UTC)


Surface Vector Wind (m/s) Composite Mean
8/31/05 to 8/31/05
NCEP/NCAR Reanalysis

Comparing NEMMCO Power Demand in August to the Output from Woolnorth

- An interesting question to ask is: **During peak demand times (Figure 2), would the wind power from Woolnorth have been available at peak times?**

Figure 1: Power and wind speed over a 24 hour period

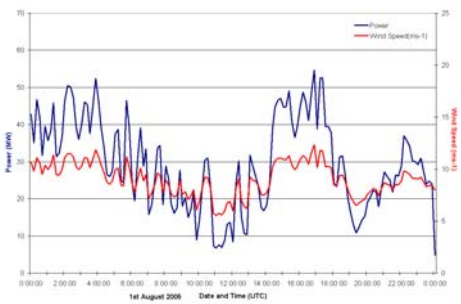
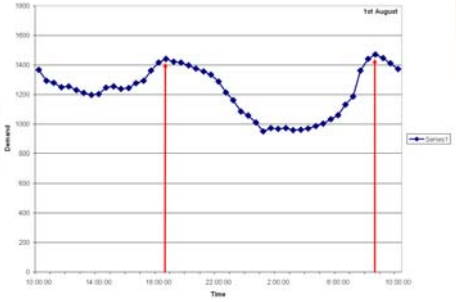
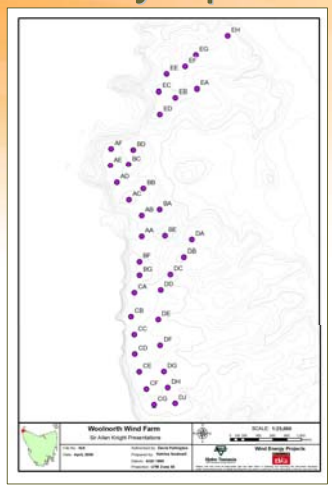


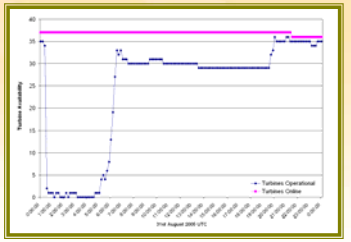
Figure 2: 30 minute power demand for Tasmania

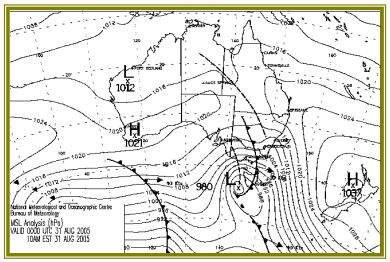


demand data for Tasmania http://www.nemmco.com.au/

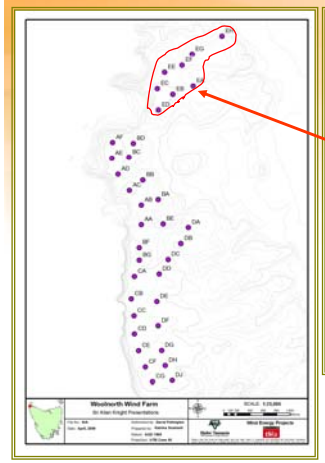
Turbine Availability Compared to Synoptic Situation

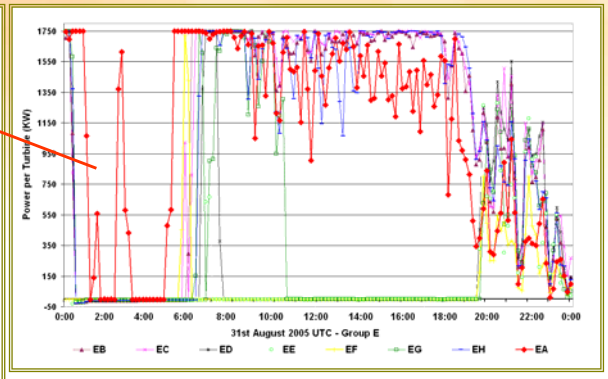






Turbine Availability Compared to Synoptic Situation – Group E





Wind direction is SW - W

Future Directions to Solve some of the Wind Forecasting Challenges

We are attempting to answer some of these questions:

- Initial work has been on classifying what synoptic weather events are correlated to rapid changes in wind power.
- On a smaller scale, how did the position of the turbines affect the amount of wind power it produced.
- Will a bias correction help the NWP forecast?
- **I have been concentrating on the Woolnorth wind farm, and have acquired 5 years of minute observational data from Cape Grim. I am hoping to be able to correlate some of the wind farm observations at Woolnorth with the data from Cape Grim to see if there is some sort of pattern or a way to produce a type of forecast.**
- **Conducting a sensitivity study on the effectiveness of different NWP/mesoscale models in predicting sudden changes in wind speed and direction.**

Acknowledgements

- MSLP and maps available from Bureau of Meteorology website: www.bom.gov.au
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