Weather and Carbon Derivatives

Pricing Risk in the ART Market

Jon Tindall

Overview

- Background
  1. Alternative Risk Transfer
  2. Weather Derivatives
  3. Emission Markets
- Pricing and Modelling
  4. Pricing Principles
  5. Modelling the Weather
- Risk Management
  6. Managing the Weather
  7. Carbon Risk Management
  8. The Way Forward

ART Markets

What is ART?

- What is Alternative Risk Transfer?
  - Covers non-traditional risks
  - Self-insurance
  - Captives

- Areas of ART (Swiss Re definition)
  - Alternative Carriers – circumvent regulatory environments as well as taxation treatment
  - Alternative Products – Enabling the transfer of non-standard risks.

ART Markets

Types of contracts:

- CAT bonds
  - Securitised Risks
  - Weather Derivatives
  - Insurance Linked Securities (ILS)
  - Emission (Carbon) Derivatives

First securitisation took place in the US - 1988 - sale of rights to emerging profits from blocks of life policies (Cowley and Cummins 2005).

Why ART?

Some of the benefits of Alternative Risk Transfer Products:

- Increased underwriting capacity and capital for insurers;
- Broaden the cover offering;
- Portfolio diversification;
- Protection of existing cash-flows

- Generally receive a different accounting treatment.
- Allows access to a broader capital pool

Convergence of Markets

Weather Markets

ILS

- Insurance Linked Securities
  - Market born out of capacity constraints
  - Circumvent accounting treatments

- Caribbean Catastrophe Risk Insurance Facility (CCRIF)
  - Market born out of capacity constraints.
  - Circumvent accounting treatments

CAT Bonds

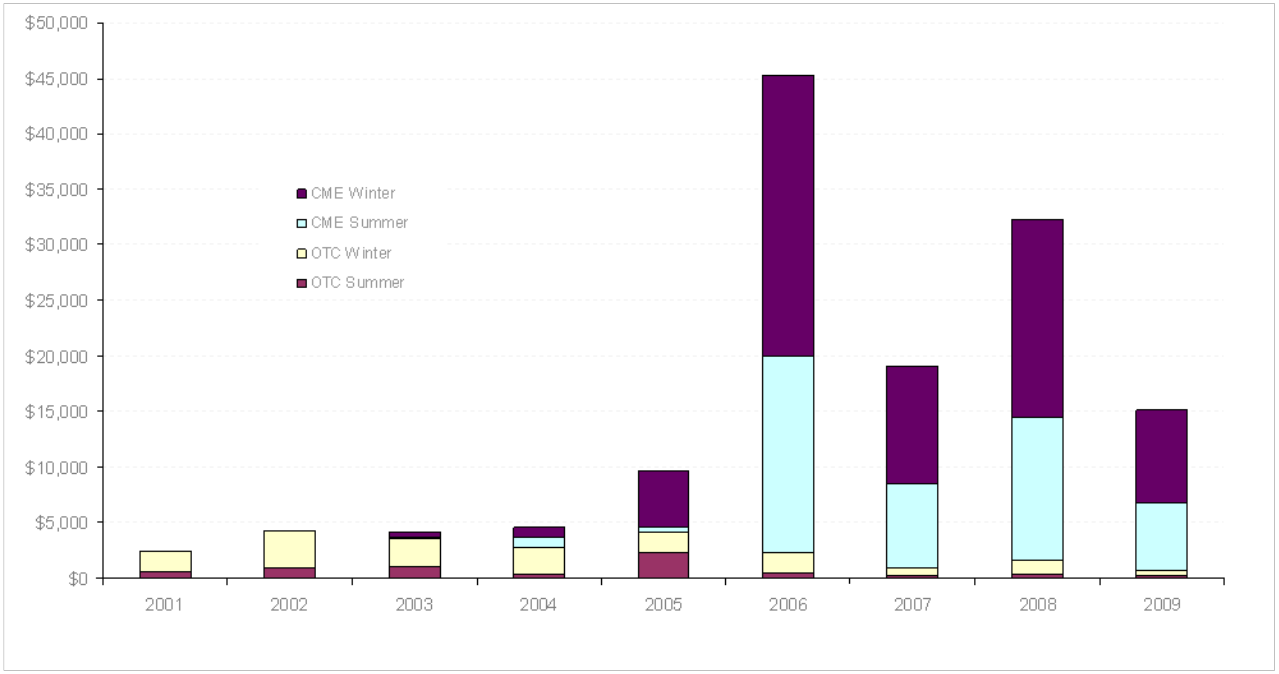
- Catastrophe bonds born after capacity constraints early 1990's
  - Hurricane Andrew - 1992
  - Northbridge earthquake - 1994

- Market hit by GFC fallout
  - New issues dried up
  - Still about 10bn.
  - Lehman security issue

Lehman Brothers

- Market hit by Lehman Brothers fallout
  - Sponsored 4 CAT bonds
  - 2 failed, others
- Lehman acted as a TRS counterparty – considered to be risk free
- Improved capital backing and collateralisations
  - US Treasury debt
  - Multi-party collateralisations

Weather Derivatives



- Market peaked in 2006 – Hedge fund interest
- Suffered from the GFC fallout

Carbon Markets

Kyoto Protocol

- UN Developed Protocol
  - 1997
  - 136 signatories, only one major contributor outstanding

- 'Flexibility' Mechanisms

International Emission Trading (IET) –emissions traded between Annex I countries.

Joint Implementation (JI) –allows Annex 1 countries to offset their emissions by investing in emission reduction projects in other Annex 1 countries. Bio-sequestration and geo-sequestration projects.

Clean Development Mechanism - (CDM) – emission reduction projects in non-Annex 1 countries - produce Certified Emission Reductions (CER's)

Recent Scandals

Carbon markets in Europe have experienced several recent setbacks

Phishing scam – February 2010:

- An estimated 250,000 permits were ‘stolen’ from 6 German organisations.
- Inadvertently handed over company details that enabled third parties to steal their emission permits.

Recycled CER scandal – March 2010:

- The Hungarian government unintentionally sold 2 million recycled CER’s onto the market.
- Certificates had already been used to meet compliance targets by Hungarian companies.
- Trading suspended on most European exchanges.

Modelling and Pricing

Pricing

Traditional Black-Scholes assumptions:

- A traded underlying asset that can be used to create a hedge, i.e. sold short.
- Log-normal distribution.

Other methods must be found for the pricing of these contracts:

- Alternative BS framework.
- Martingale approach.
- Numerical simulation.

Pricing Fundamentals

GHD's -Generalised Hyperbolic Distributions

$$f_x = \frac{\chi^{-\lambda}\left(\sqrt{\chi\delta}\right)^{\lambda}}{2K_{\lambda}\left(\sqrt{\chi\delta}\right)} x^{\lambda-1} e^{[-\frac{1}{2}(\chi x^{-1}+\delta x)]}$$

Black '76 Model

$$dX_t = \mu.dt + \sigma.dW_t$$

$$X_t = X_0.e^{[(\mu-\frac{1}{2}\sigma^2)(t-t_0)+\sigma W_{t-t_0}]}$$

Pricing Risk

- Analytic Solutions
  - General don't exist
  - Restricted applicability – assumptions
  - Modifications to Black-Scholes framework

- Numerical Solutions
  - Parametric / Non-parametric
  - Easy to perform given computing power

Numerical Methods

‘Burn’ Analysis:

- No assumptions needed re: the process dynamics;
- No parameters to be estimated;
- Agreement on price.

Monte Carlo Simulations:

$$\mathbf{E}[f(X_t)] = \frac{1}{N} \cdot \sum_{i=1}^{N} f(\overline{X}(t, \psi_i))$$

- Model dependant;
- Data intensive.

Alternative Black-Scholes

- Futures Price:

$$Y_t = X_t . e^{r(T-t)}$$

- Process s.d.e:

$$dY_t = y[(\mu - r)dt + \sigma dW_t]$$

- Modified Black-Scholes p.d.e:

$$\frac{dV_t}{dt} = rV - \frac{1}{2}\sigma^2 y^2 \frac{d^2 V}{dy^2}$$

- Solution:

$$V(y,t) = BS(ye^{-r\tau}, t, r, \sigma)$$
$$= e^{-r\tau} . BS(y, t, 0, \sigma)$$

Modelling Temperature

Temperature Modelling Process:

- De-trend data;
- Choose functional form for seasonal fluctuations;
- Estimate the parameters, including mean-reversion;
- Simulate the process;
- Analyse residuals.

Seasonal Trends

Fourier series to model seasonal component:

$$T_{Seasonal} = \varepsilon\alpha_0 + \sum_i \alpha_i .Sin(\gamma t + \phi) + \sum_i \beta_i Cos(\lambda t + \theta)$$

- A first order series is sufficient to capture seasonal pattern.

Combining this with the linear trend we obtain:

$$\overline{T} = a + b.t + \alpha .Sin(\gamma t + \phi) + \beta Cos(\lambda t + \theta)$$

Mean Reversion

- Weather variables do not rise or fall without bound
- Reverts to the seasonal, trended average.

Mean-reversion component:

$$\frac{dX_t}{dt} = -\omega.(X_t - \overline{X})$$

where ω represents the strength of the mean reversion.

- Mean reversion strength depends on several factors – most significantly latitude.

Modified OU-process

Ornstein-Uhlenbeck (OU) process:

$$dX_t = \omega(\overline{X} - X_t).dt + \sigma.dW_t$$

Modified OU process:

$$dT_t = \left[\omega(\overline{T} - T_t) + \frac{d\overline{T_t}}{dt}\right]dt + \sigma.dW_t$$

$$e^{\omega.s}$$

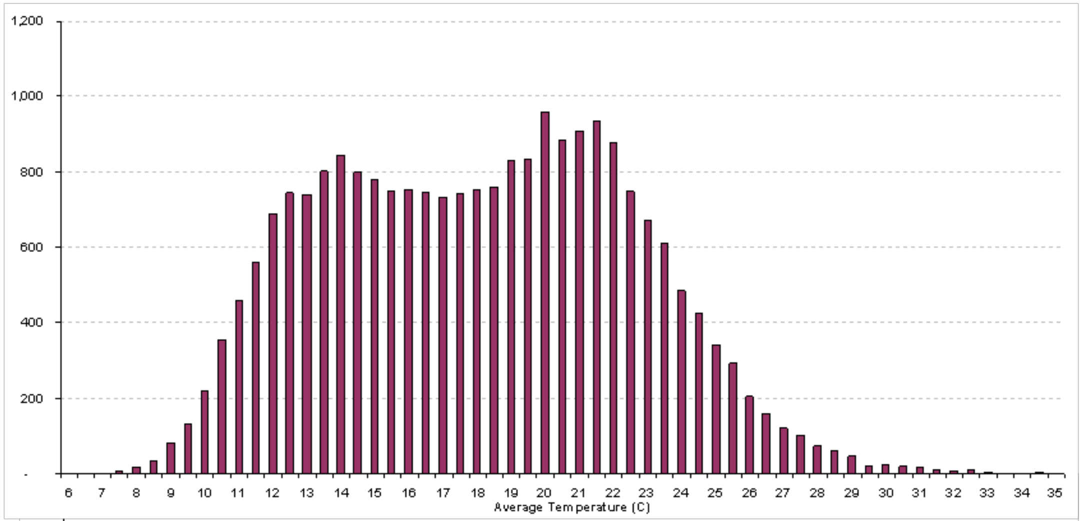
Which has a solution via an integrating factor,

$$X_t = \overline{X}_t + (X_0 - \overline{X}_o).e^{-\omega\Delta t} + \int_s^t e^{-\omega\Delta t}.\sigma_\tau dW_\tau$$

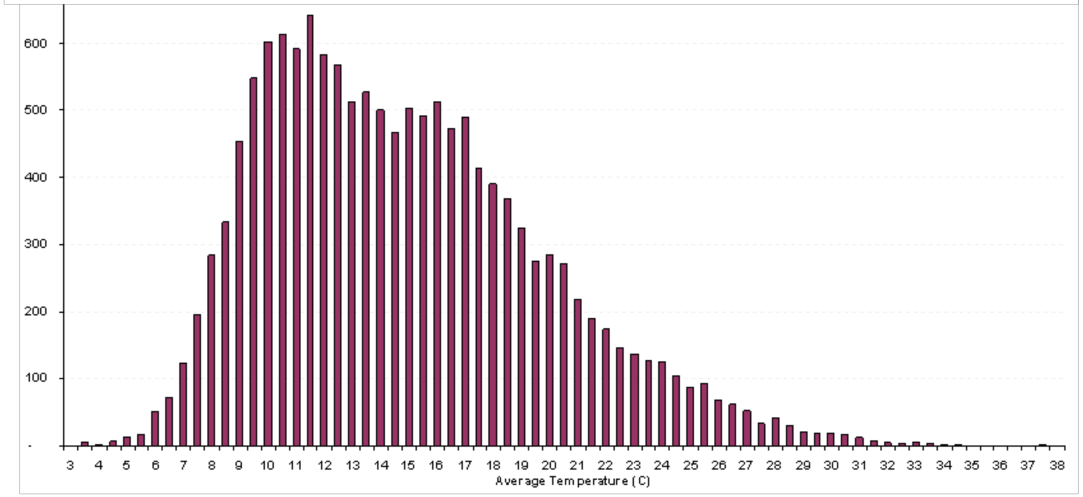
5th Financial Services Forum
Renovating the Financial System
Institute of Actuaries of Australia
2010
13 and 14 May 2010 – SYDNEY

Temperature Distribution – Syd. & Melb.

Sydney

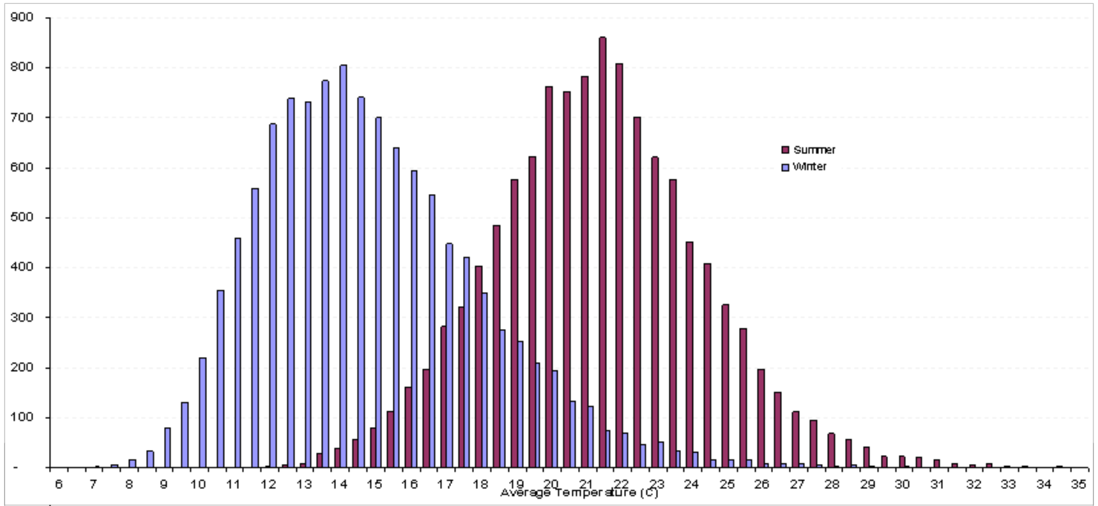


Melbourne

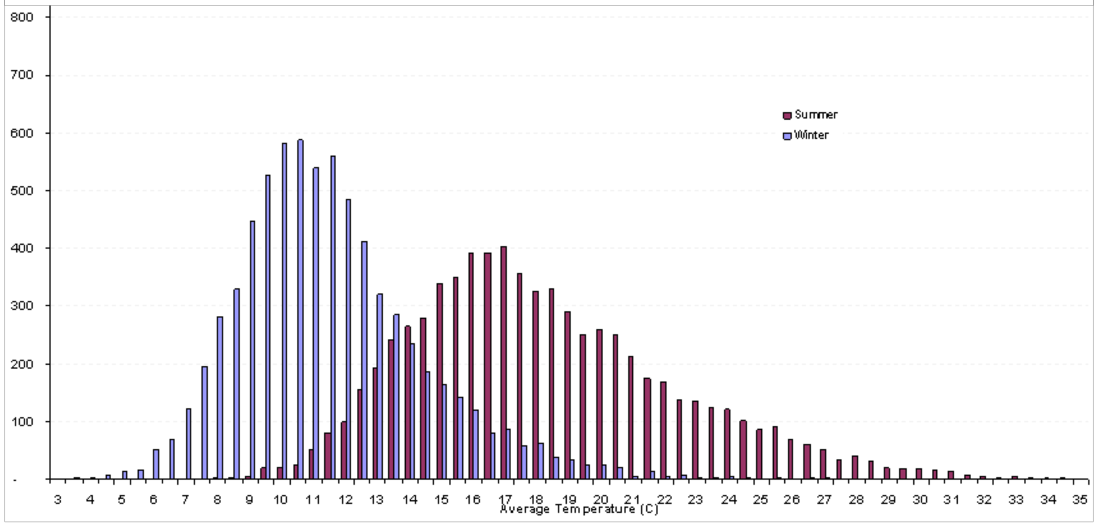


Temperature Distribution – Syd. & Melb.

Sydney

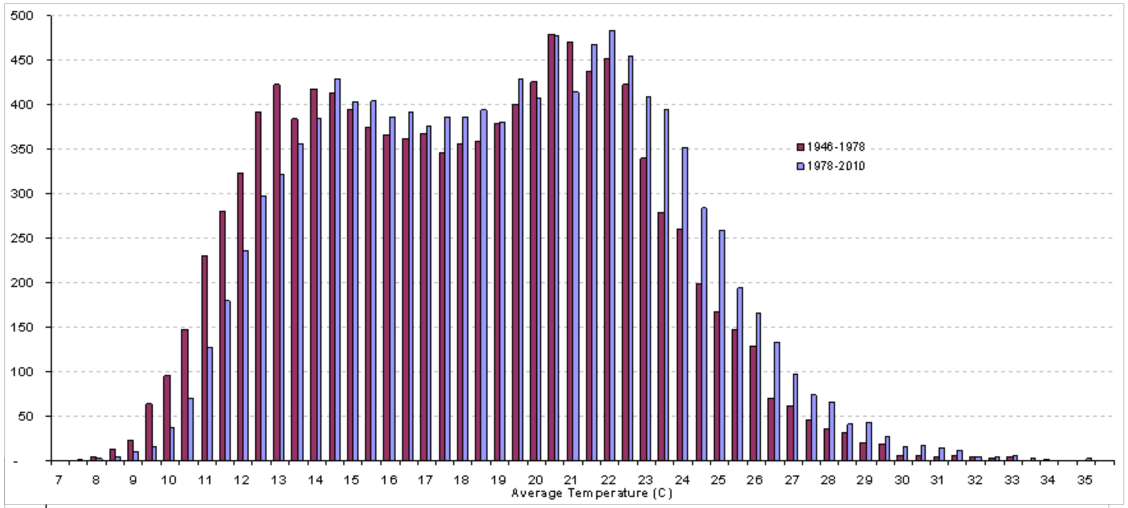


Melbourne

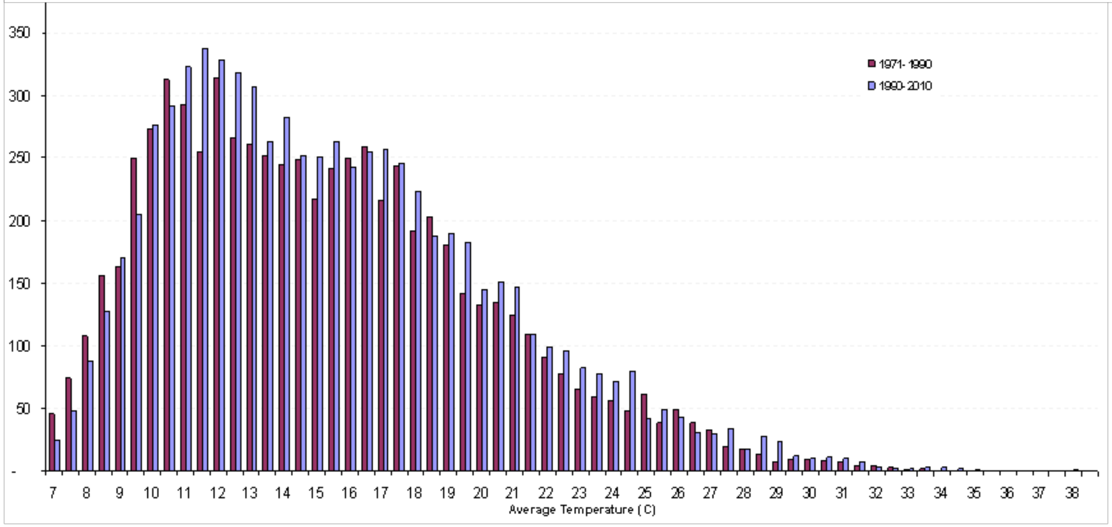


Changes over time – Syd. & Melb.

Sydney

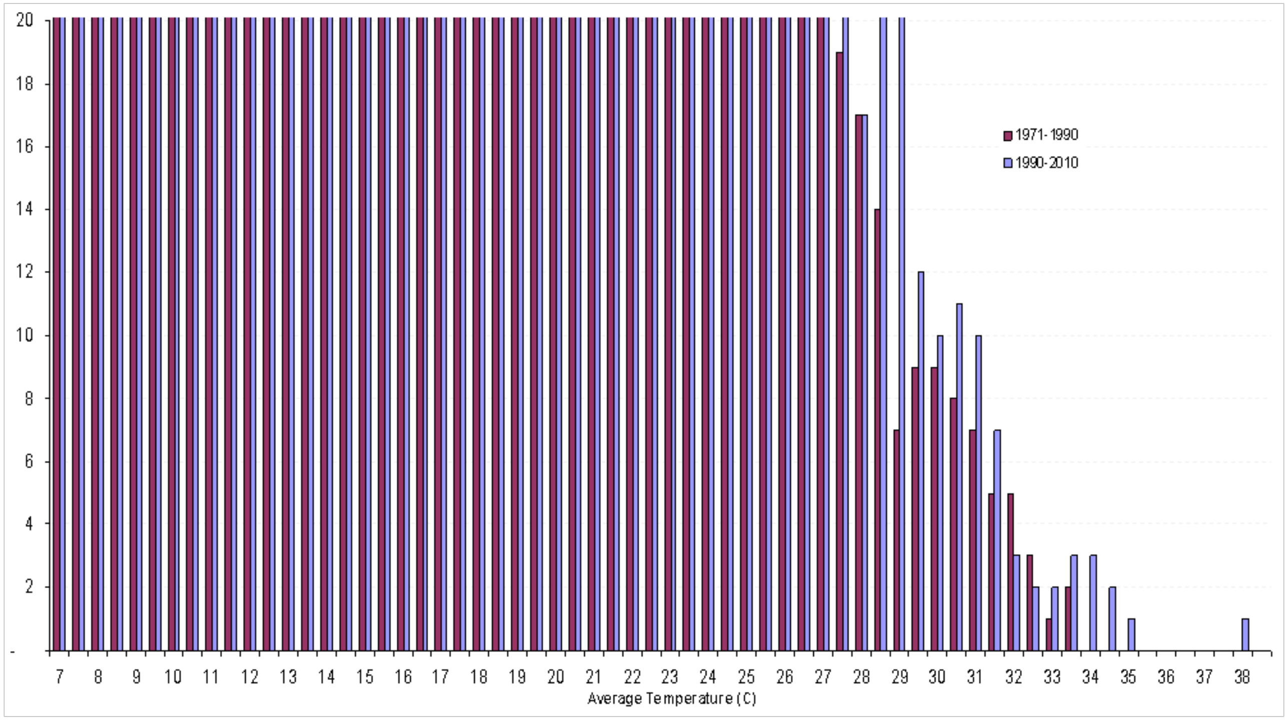


Melbourne

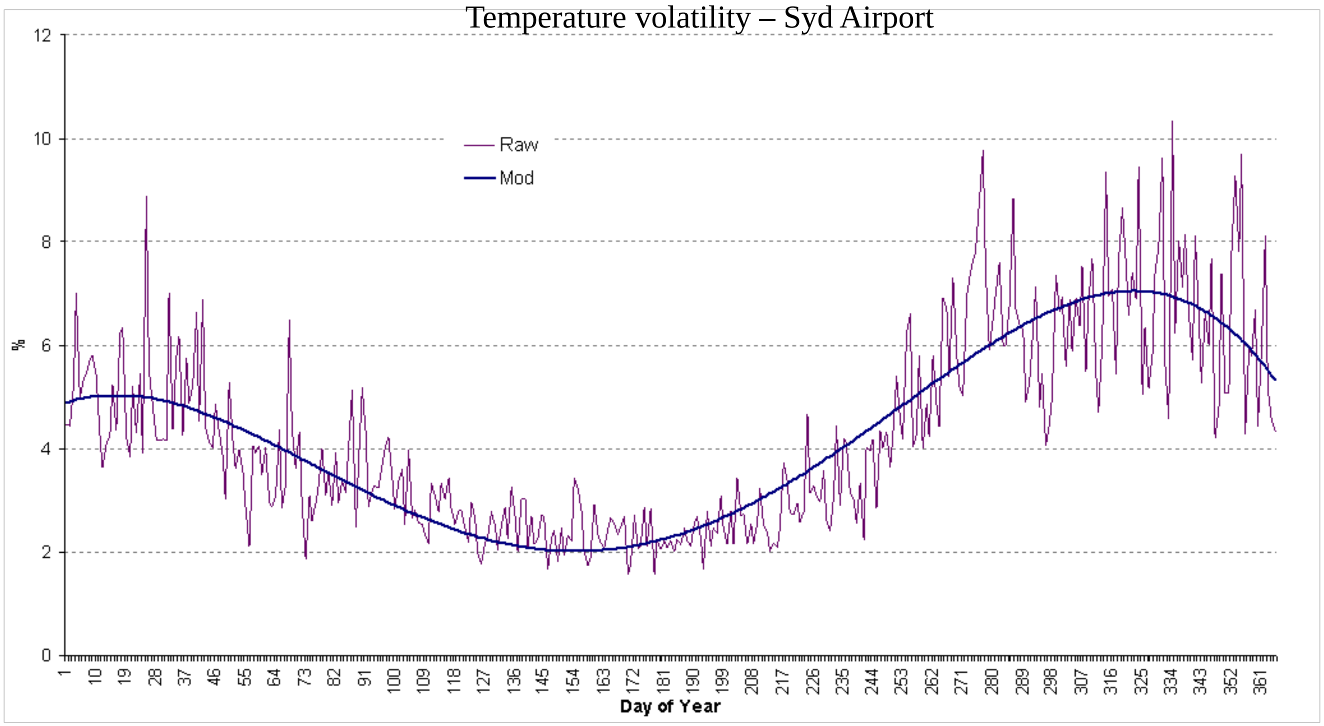


Changes over time – Syd. & Melb.

Melbourne



Heteroscedasticity



- Clear seasonal volatility pattern
- Fit via polynomial

Pricing Example

- CDD option - January

Period:	January
Measure:	Cumulative CDD
Exercise Prices:	170 / 180 / 190 / 200 CDD's
Tick::	$100,000 /CDD
Location:	Sydney Airport (Kingsford Smith)

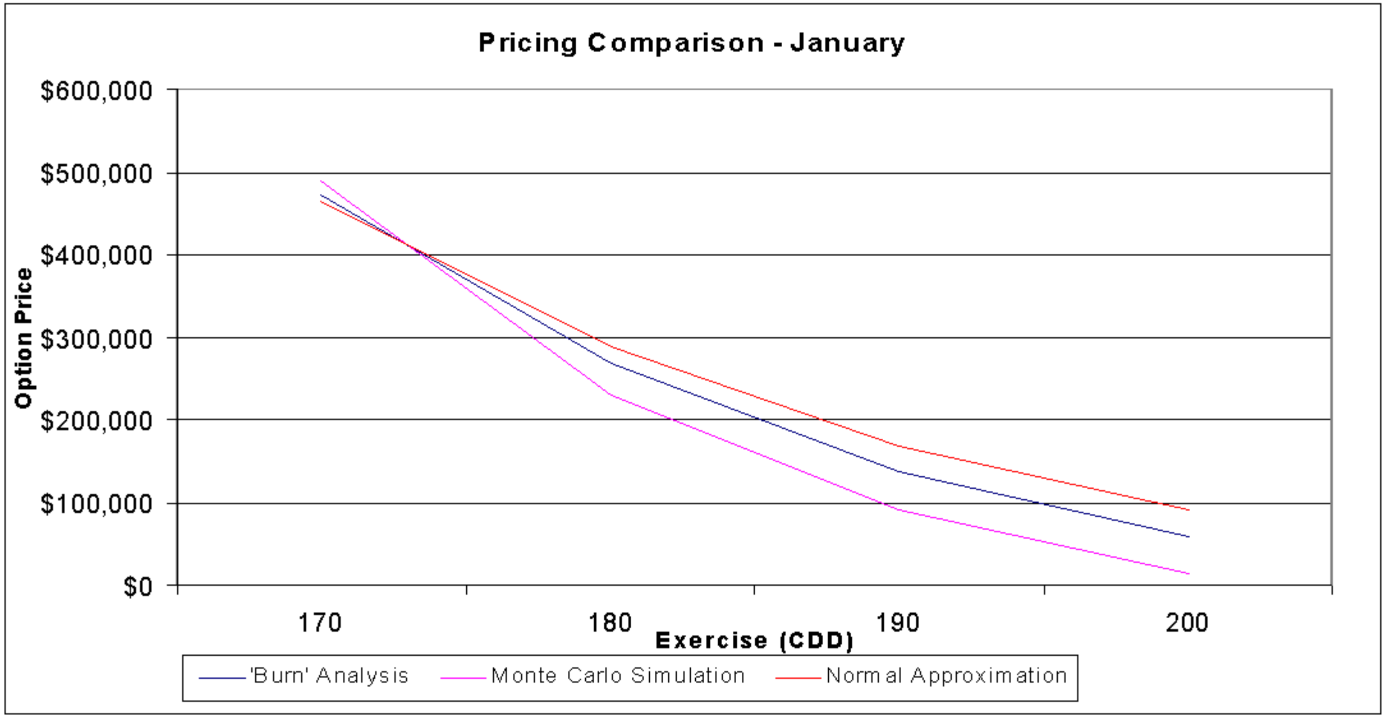
- Pricing via:
  1. Normal approximation.
  2. 'Burn' analysis – 66 years of data.
  3. Monte Carlo simulations

Pricing Example

Sydney Airport
January

	Exercise (CDD)			
Method	170	180	190	200
'Burn' Analysis	$473,306	$268,763	$137,865	$59,582
Monte Carlo Simulation	$489,044	$230,479	$90,848	$13,990
Normal Approximation	$463,670	$288,627	$167,993	$91,012

Pricing Example



- Diverge when option further ‘out-of-the’ money
- Burn Analysis is nearly the average of the other two.

Carbon Prices

Carbon Prices

- Prices collapsed during the GFC.
- Market has stabilised – recent signs of a recovery

Inefficient Market

- Phase 1 Certificates – May 2006 – traders discovered the market was 'long'
- Informational inefficiencies, political risk – difficult to apply time series analysis

Where to from here?

- New Markets:
  - Securitisation of Insurance cashflows
  - Australian weather market practically non-existent – primary industry based economy.
  - Must promote to seek out suitable counter-parties.
  - Improve product design – reduce basis risk.
- New Interest:
  - Hedge funds – attracted to immature market.
  - Diversification tool – minimal correlation to debt and equity markets.
  - Weather-based indexed insurance contracts.

Questions ?

Thankyou

Jon Tindall

jon.tindall@finity.com.au