Incorporating Storage Levels into a Model for New Zealand Spot Prices

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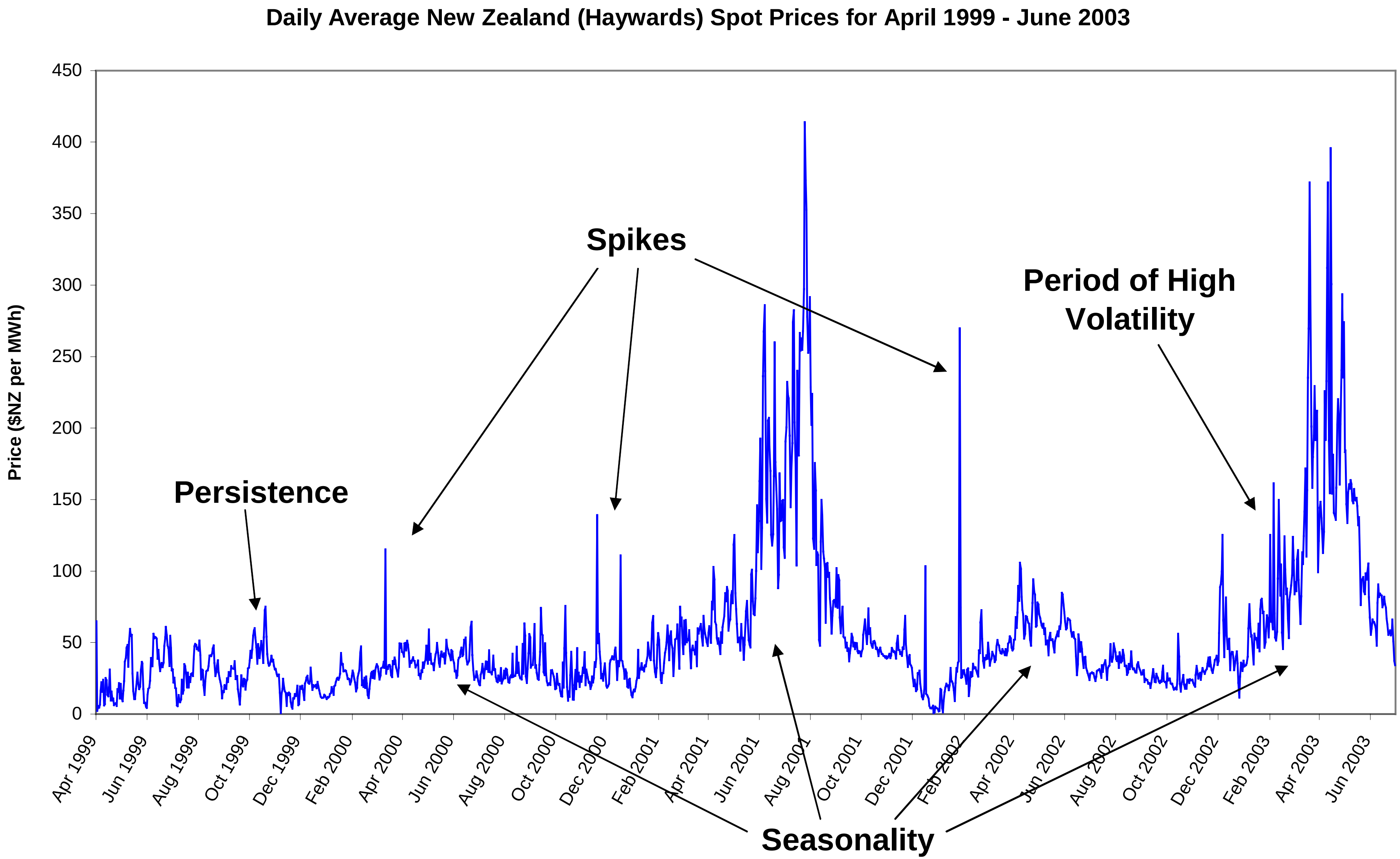
Features of Electricity Price Time Series

- Mean-reversion
- Seasonality:

- daily, weekly, and time-of-year

- Price-dependent and time-dependent (seasonal) volatility
- Occasional spikes and persistence

New Zealand Prices



Price Modelling Methods

Two main types of models:

- Bottom-up / behavioural models

  model deterministic nature of prices

- Top-down / econometric / statistical models

  better at modelling volatility

The Focus of this Research

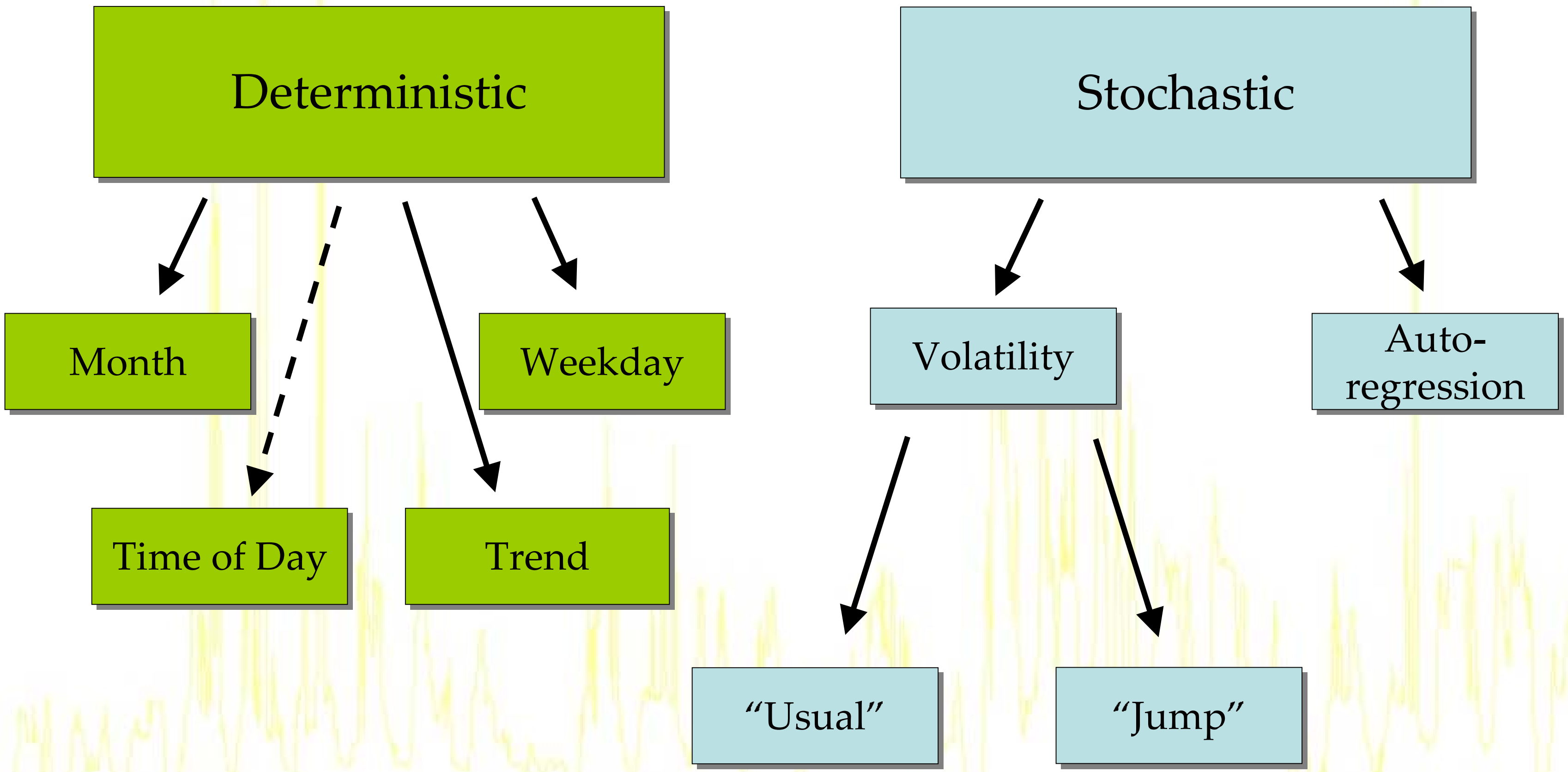
Combining the two types of models together:

- Improving existing bottom-up models to predict average price levels
- Incorporating econometric models to capture better the stochasticity of prices

This presentation focuses on the adaptation and application of one particular econometric model.

A Basic Hypothesis

Electricity price series can be decomposed into:



The Model of Escribano *et al*[†]

Proposed by Escribano *et al* (2002)

Electricity spot prices are the sum of a **deterministic** component and a **stochastic** component:

$$P_t = f(t) + \tilde{X}_t$$

The **deterministic** component basically captures the trend and seasonality.

† Escribano, A., Pena, J., and Villaplana, P. (2002) *Modelling Electricity Prices: International Evidence*, Working paper, Universidad Carlos III de Madrid, 46pp

The Model of Escribano *et al*

The **stochastic** component is made up of:

- Auto-regression

  i.e. $X_t = \theta X_{t-1}$ + volatility$_t$

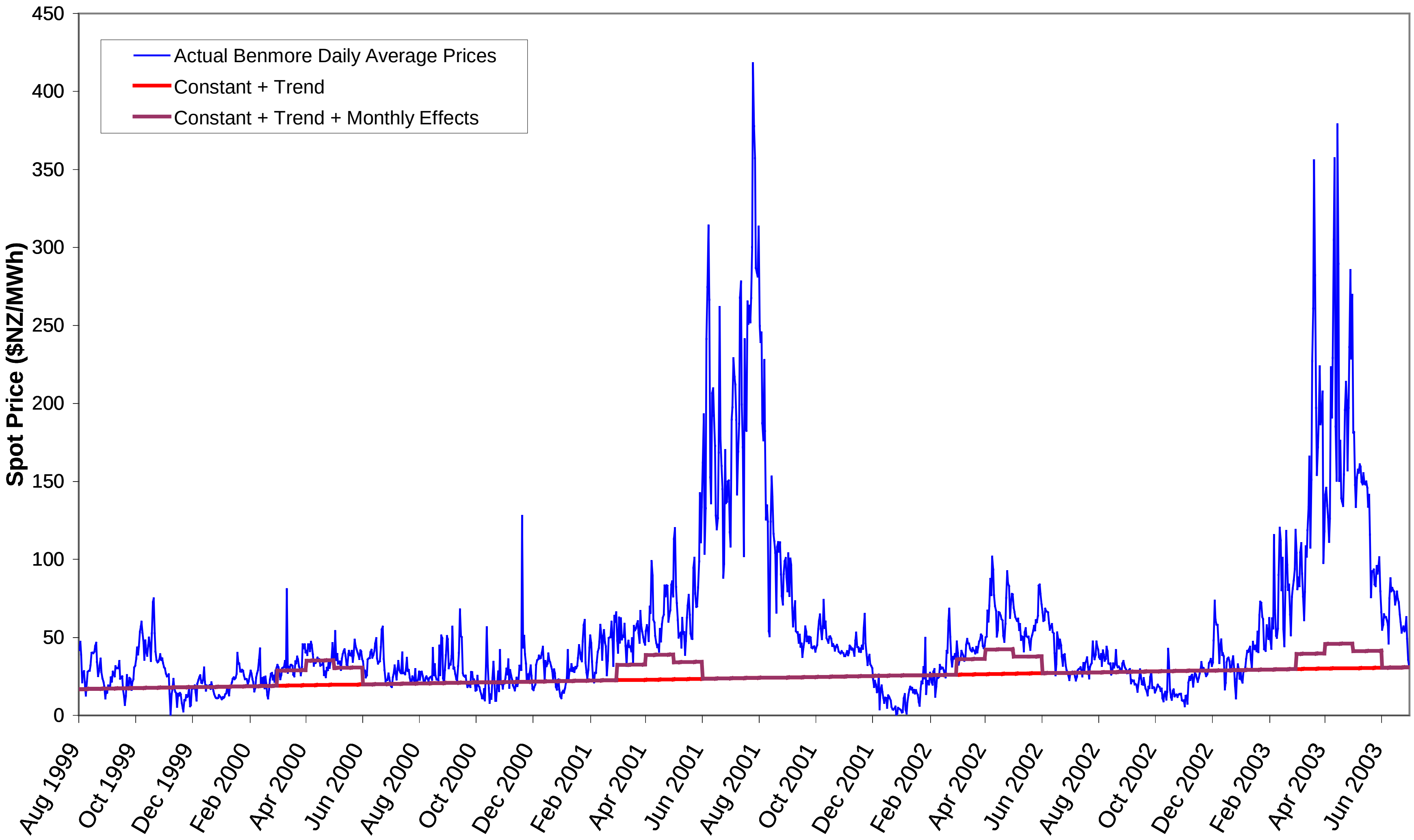
- "Usual" volatility ~ N(0, h_t)(GARCH)

- A Poisson jump process:

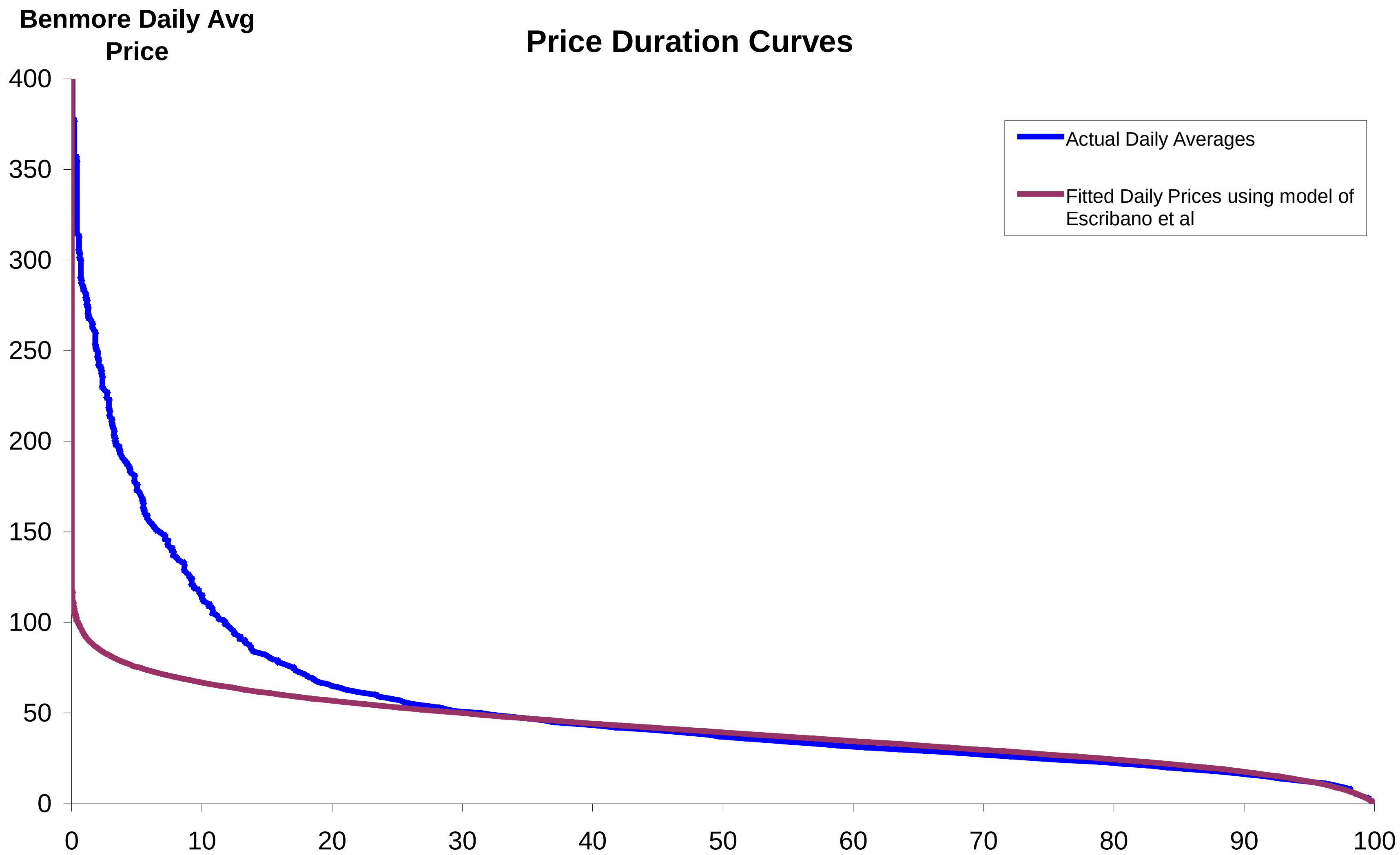
  Rate: λ_J

  Jump Size: ~ N(μ_J, σ^2_J)

Fitting NZ Electricity Prices

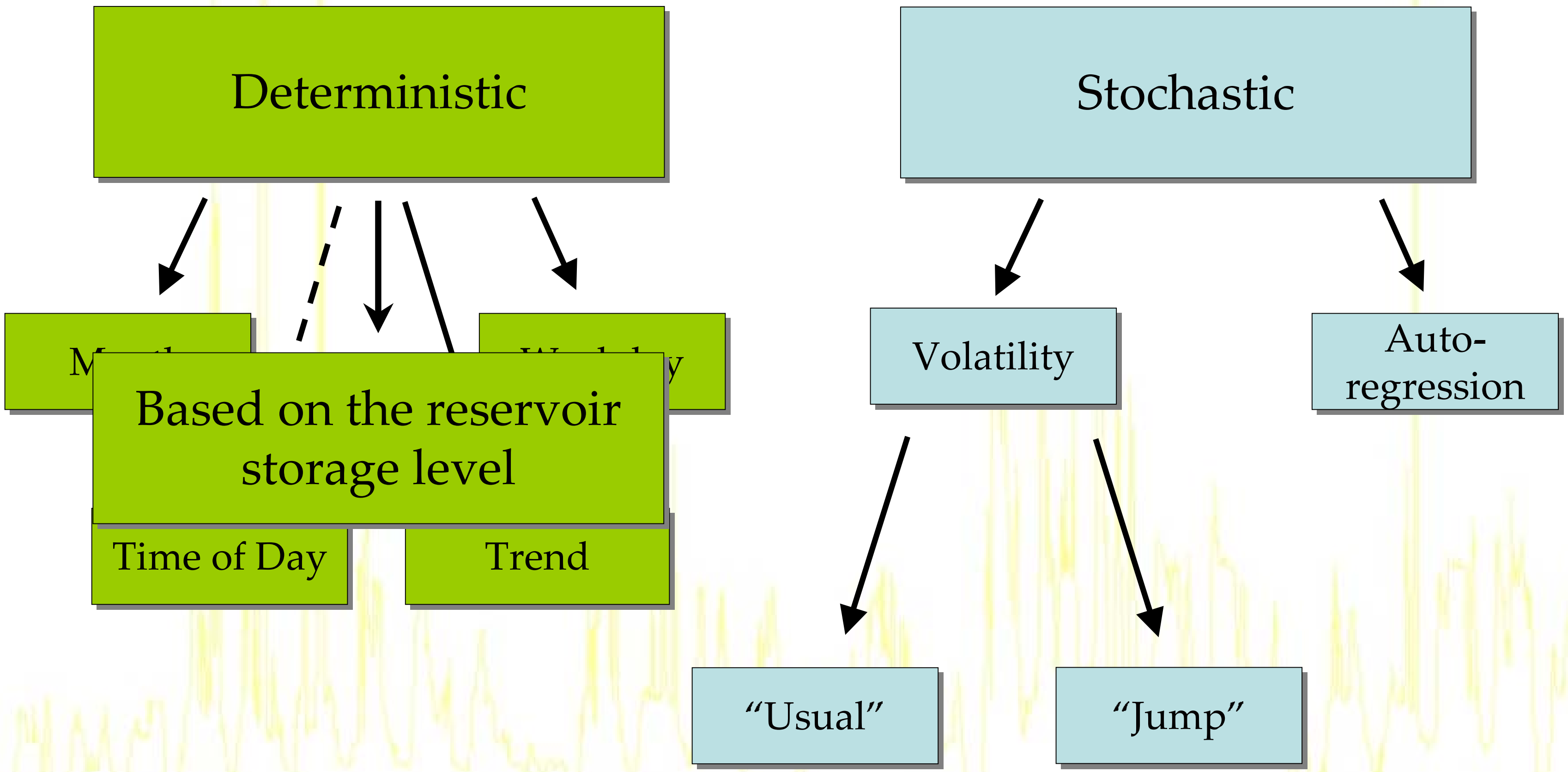


PDC Comparison



Our Basic Hypothesis

Electricity price series can be decomposed into:



The Marginal Water Value

The (simplified) hydro generator's problem is:

MAXIMISE Total value of Generation this year

SUBJECT TO S_0 + Inflows – Generation = S_T

Read (1979,1984):

The true marginal water value (MWV), ψ, represents "*the marginal value of generation foregone in the current year*", given that we have a target storage level at the end of the current year.

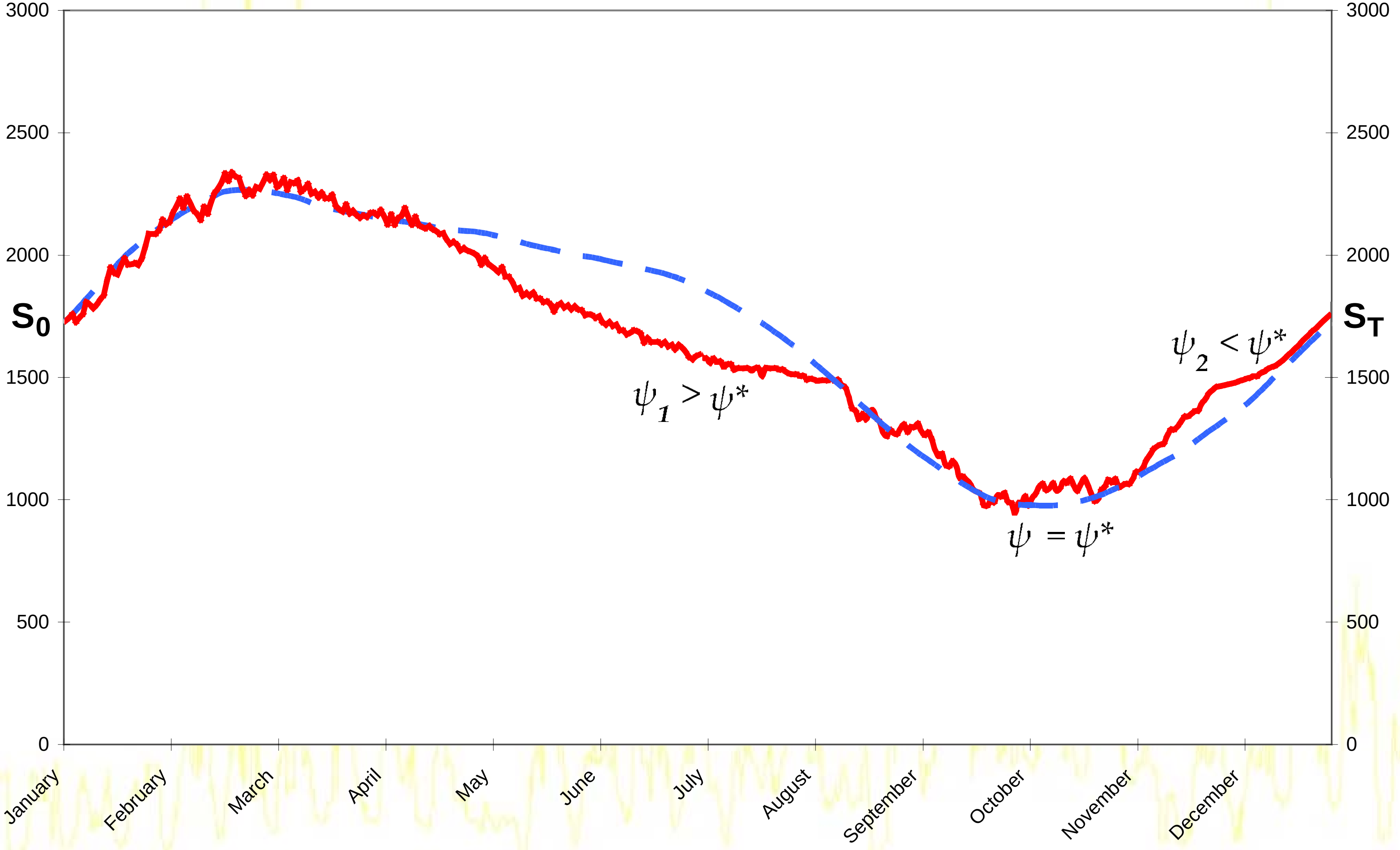
Technically, ψ^* is the shadow price on the constraint that the final storage target be met.

The Marginal Water Value

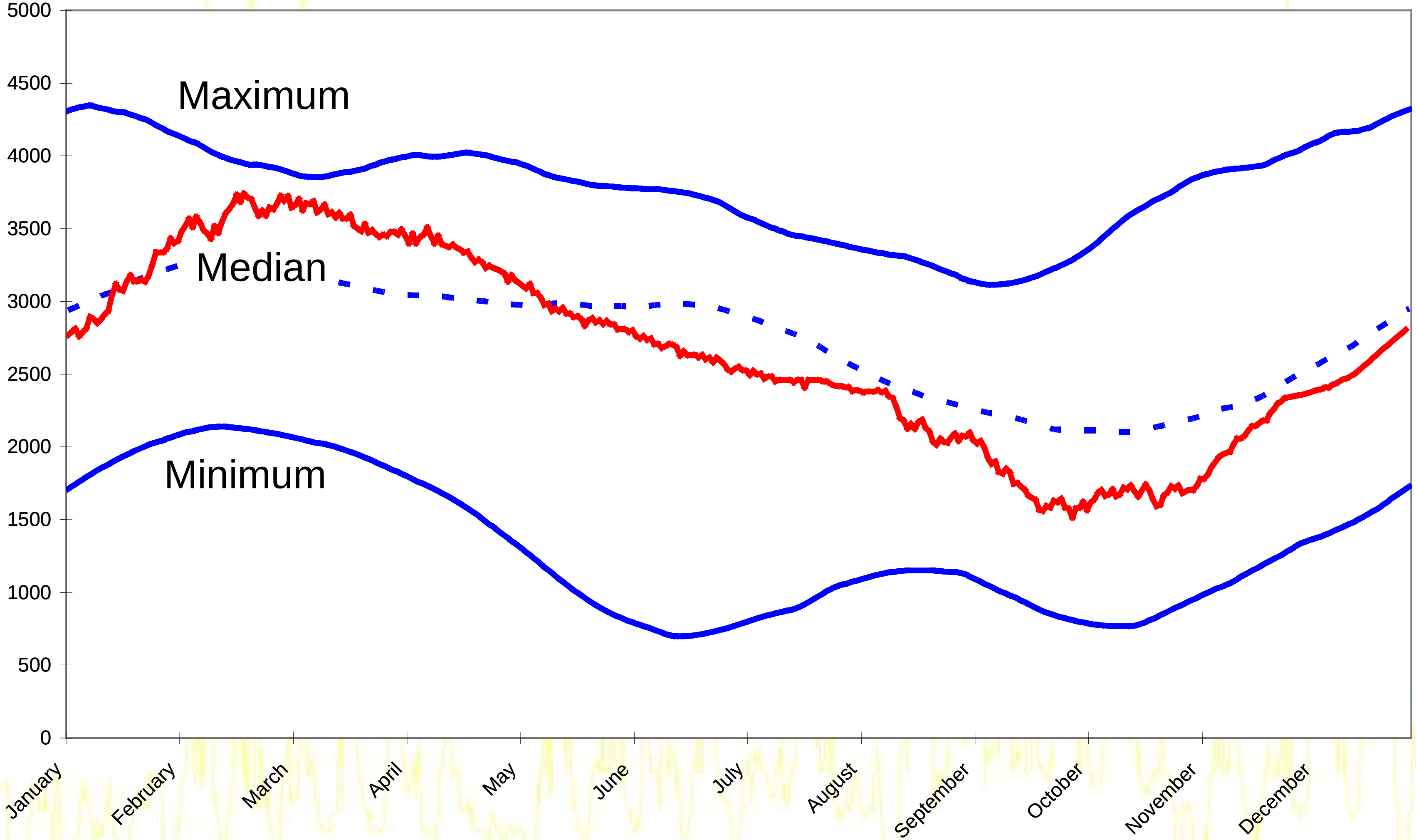
A hydro generator can be treated like a thermal generator, and water as a fuel, in that the MWV is essentially the price that water can be "bought" from the reservoir by the hydro generator.

In the absence of *uncertainty* and storage bounds, the optimal storage policy is to maintain the MWV at a constant level throughout the year.

The Marginal Water Value



Modelling the MWV



Modelling the MWV

Key issue:

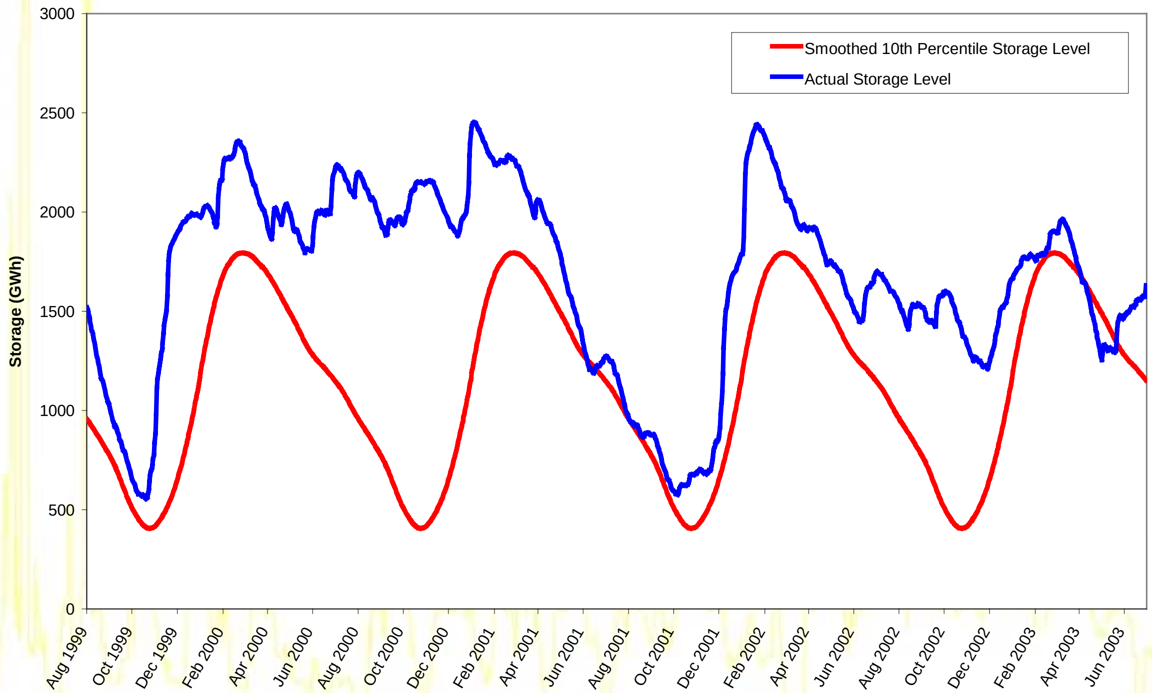
The storage envelopes must be time-dependent

e.g. A water shortage at the end of winter is much less serious than at the start of winter

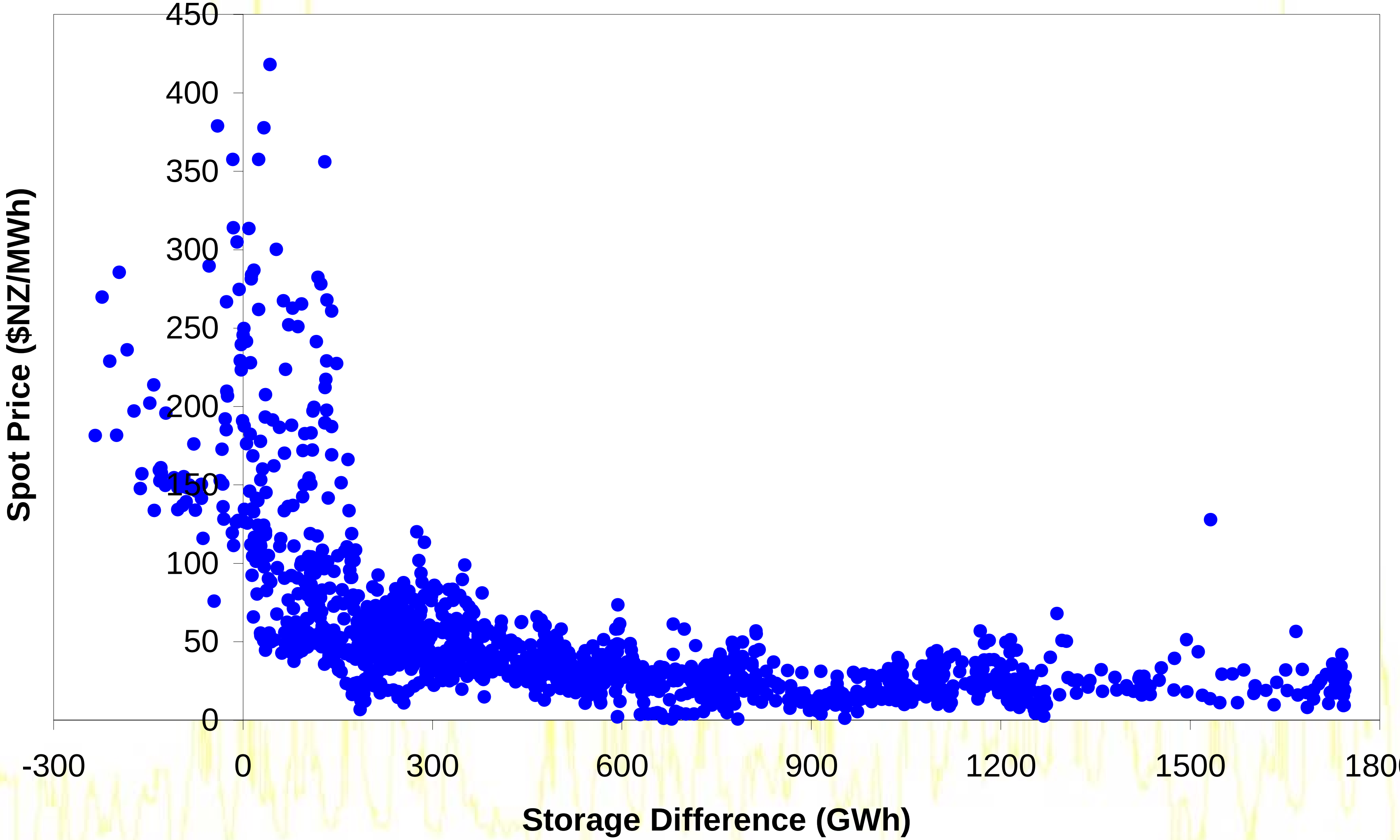
Also, the MWV curve flattens out for high levels of storage, and is steeper the less water you have. Therefore, the values of water at lower relative levels of storage are the important ones to model.

Our method of estimation

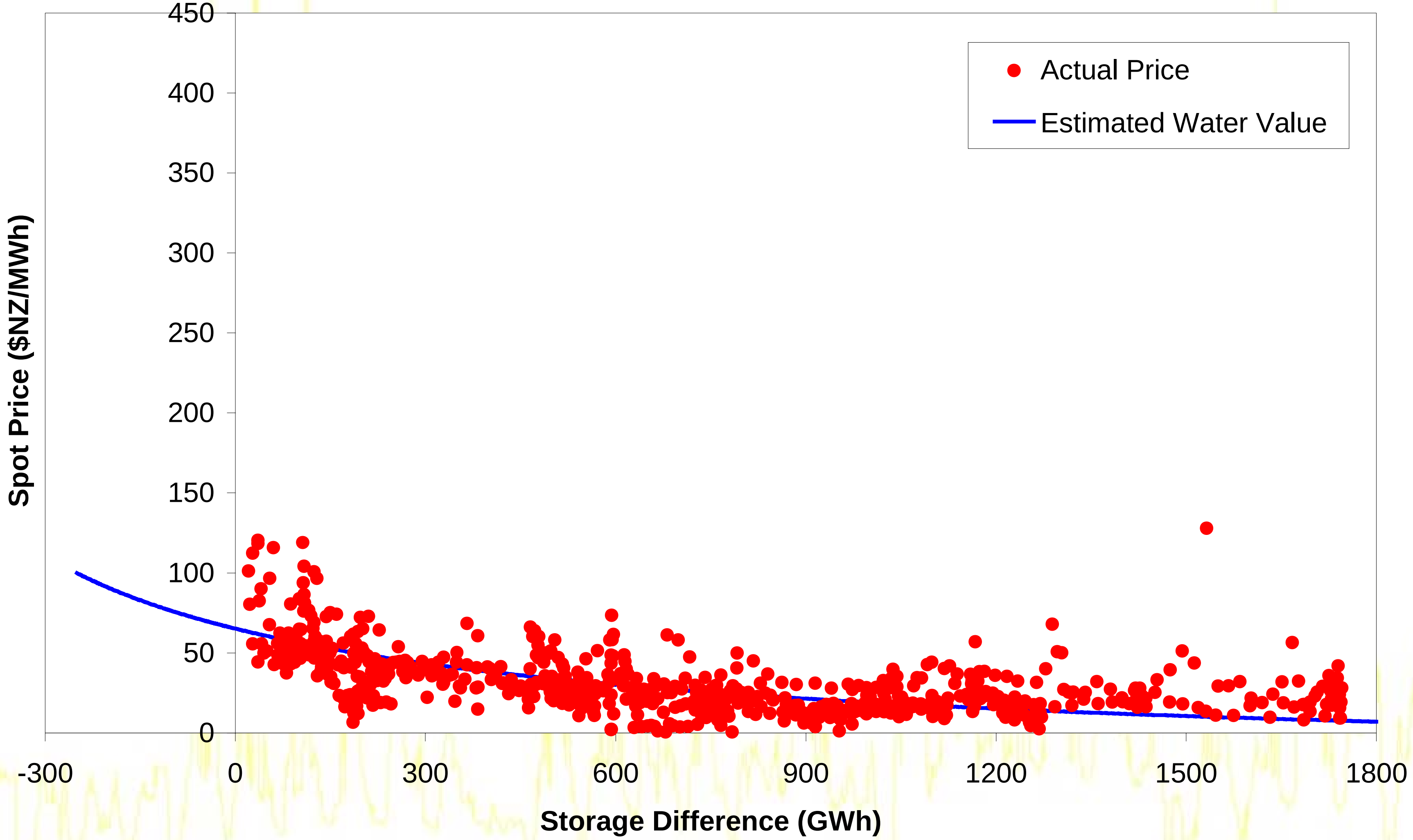
The spot price may be related to the difference between the storage level and the 10th percentile of daily storage levels over the past 30 years:



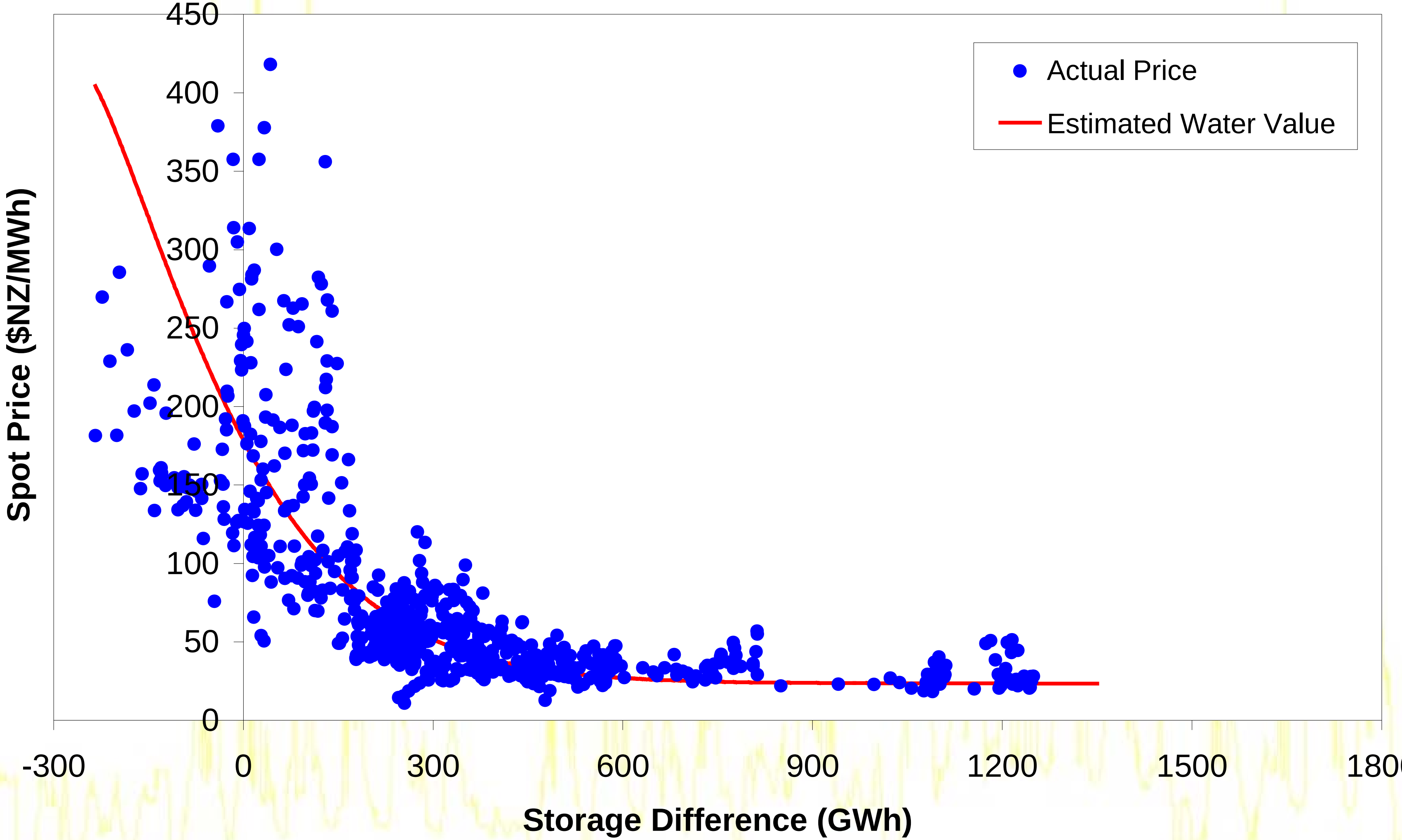
Price versus Storage Difference



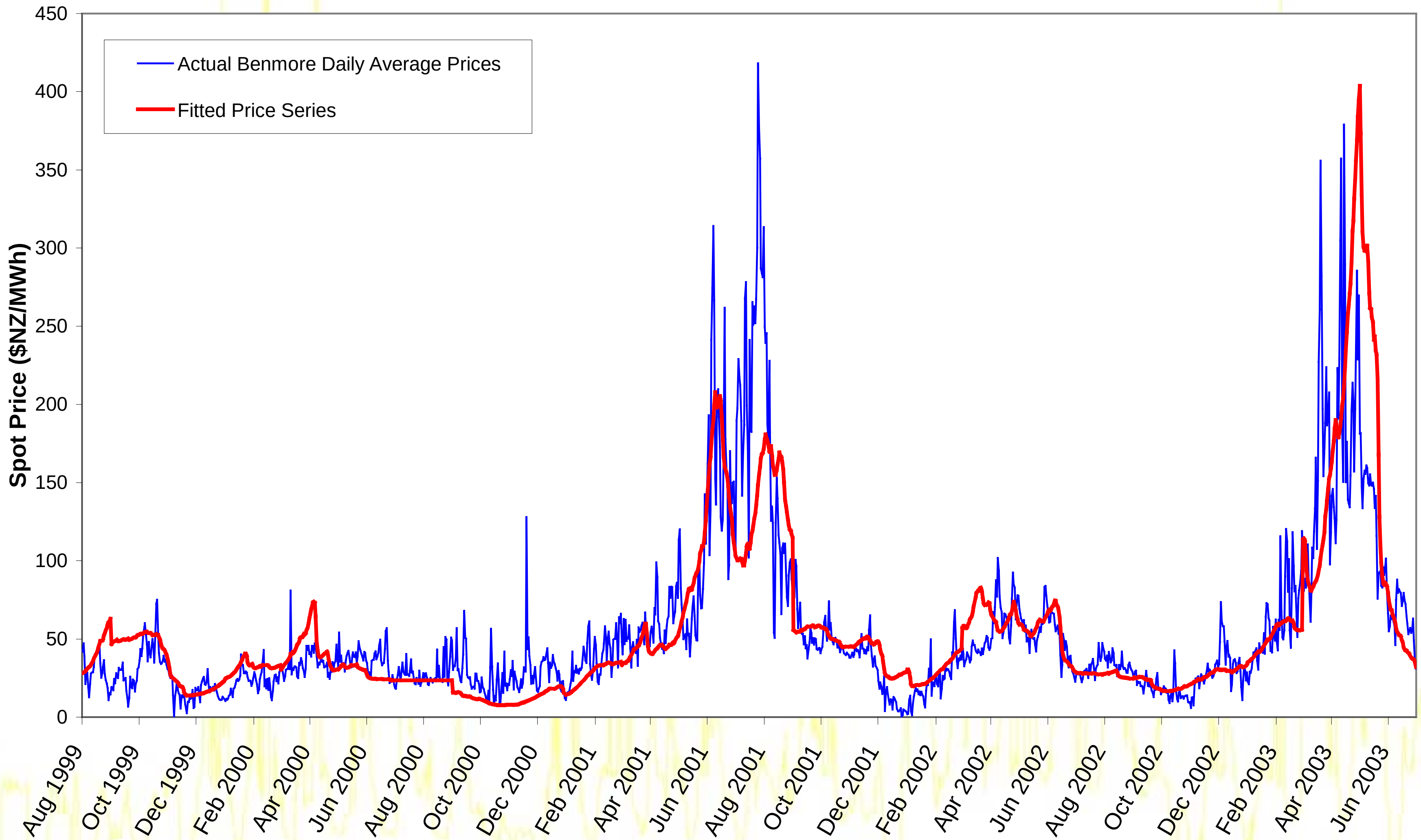
Spring & Summer



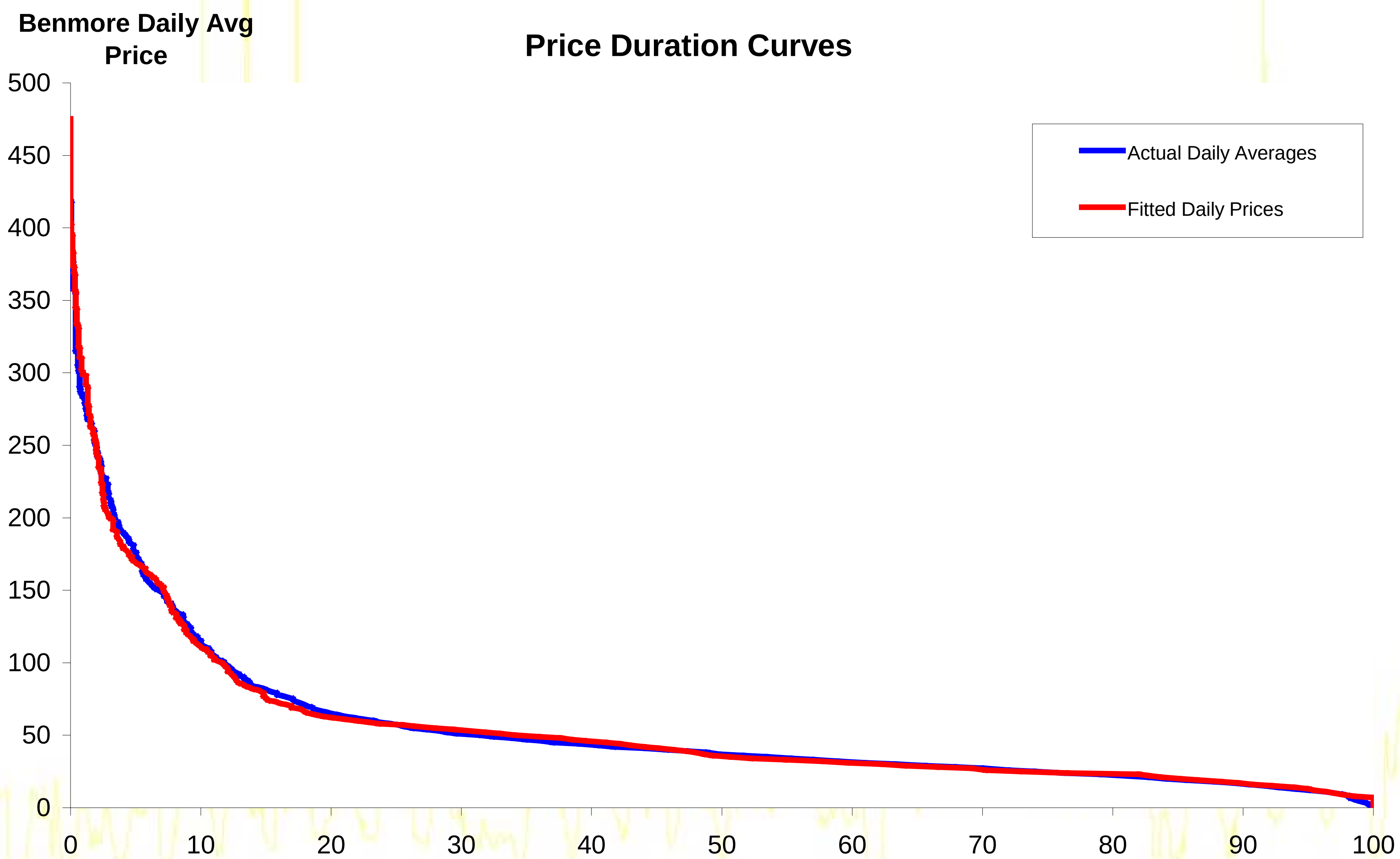
Autumn & Winter



Fitted to the NZ Price Series



NZ Price Duration Curve



The Price Model

Replace the linear step function from Escribano *et al* with the function for the *estimated* water value.

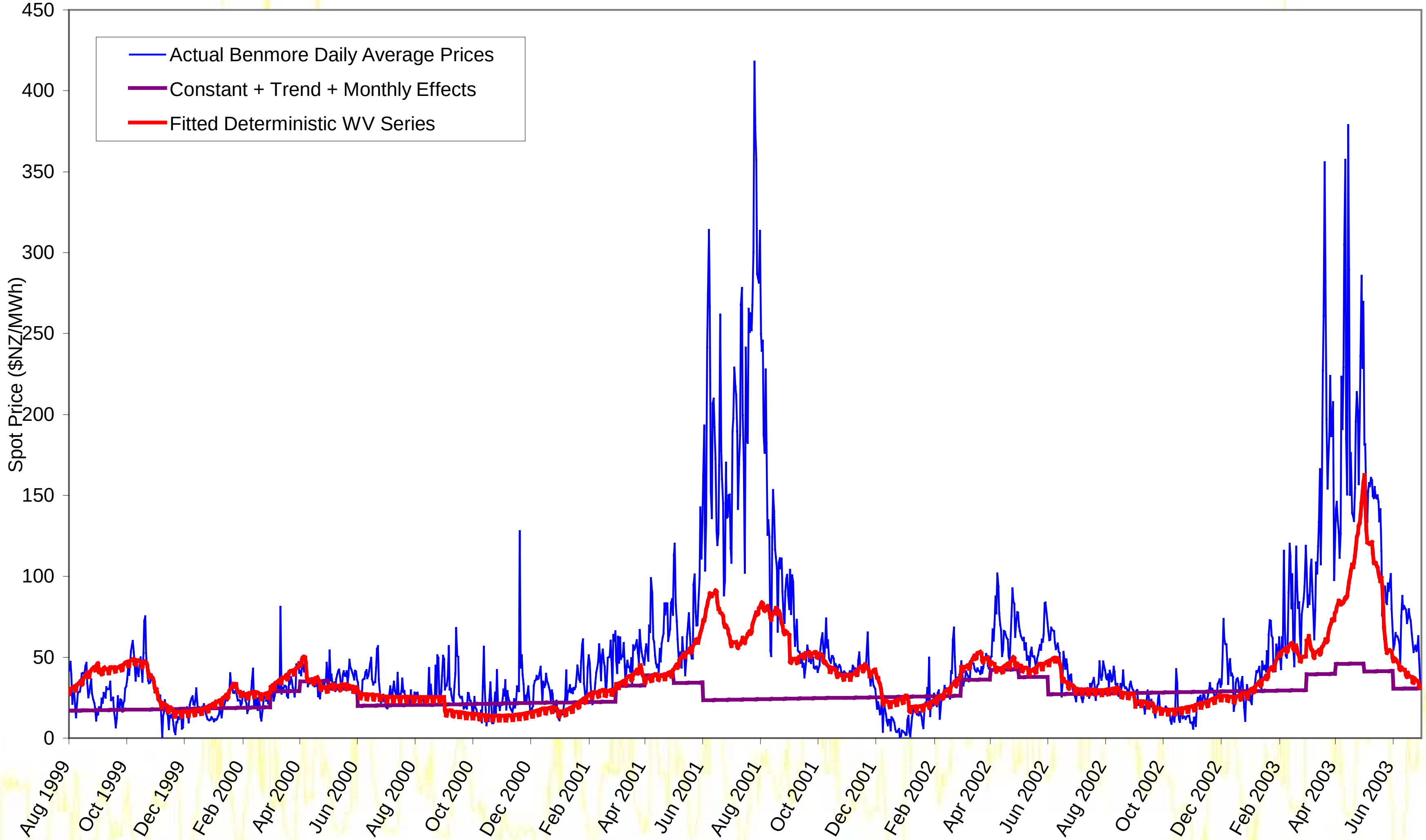
$$P_t = WV_t + \tilde{X}_t$$

where

$$WV_t = f\,(\,Storage\ Difference\,)$$

$$WV_t = c + w\,\boldsymbol{e}^{x(\,y+SD_t\,)^z}$$

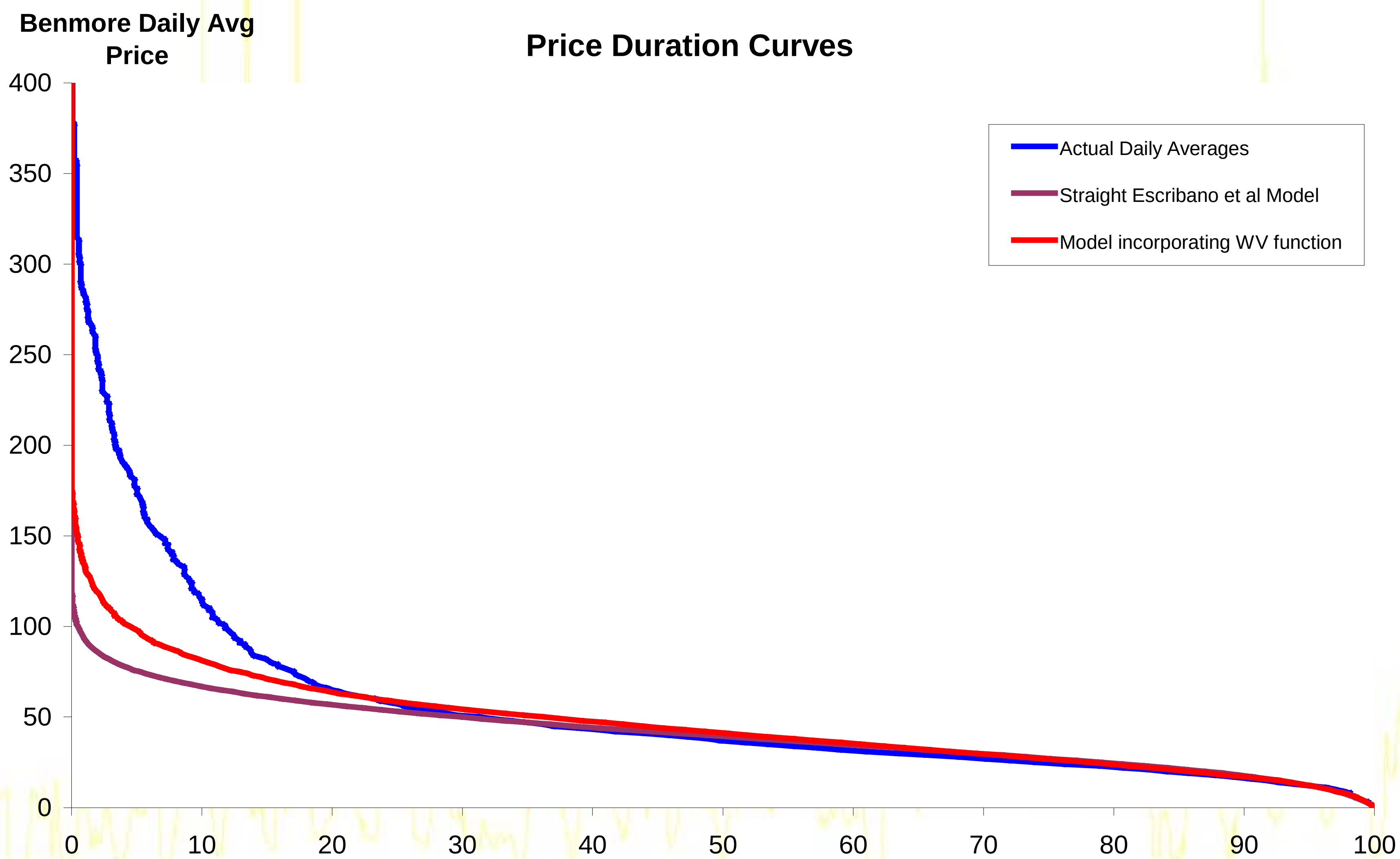
Fitted to New Zealand Prices



Fitted to New Zealand Prices

	Escribano *et al*	Water Value
Mean reversion parameter	0.92	0.86
Cold season jump probability	7.8%	8.2%
Cold season jump mean	17.26	17.96
Cold season jump variance	307.79	249.45
Warm season jump probability	6.3%	5.6%
Warm season jump mean	10.37	12.10
Warm season jump variance	351.33	383.02

Fitted to New Zealand Prices



Further research

Improving the model for the **deterministic** component:

- Incorporating load into a half-hourly model

Improving the model for the **stochastic** component:

- Changing the jump distribution
- Using the storage level as a driver for volatility