# Inflow Forecasting for Hydro Catchments

Ross Woods and Alistair McKerchar

NIWA Christchurch

# Inflows

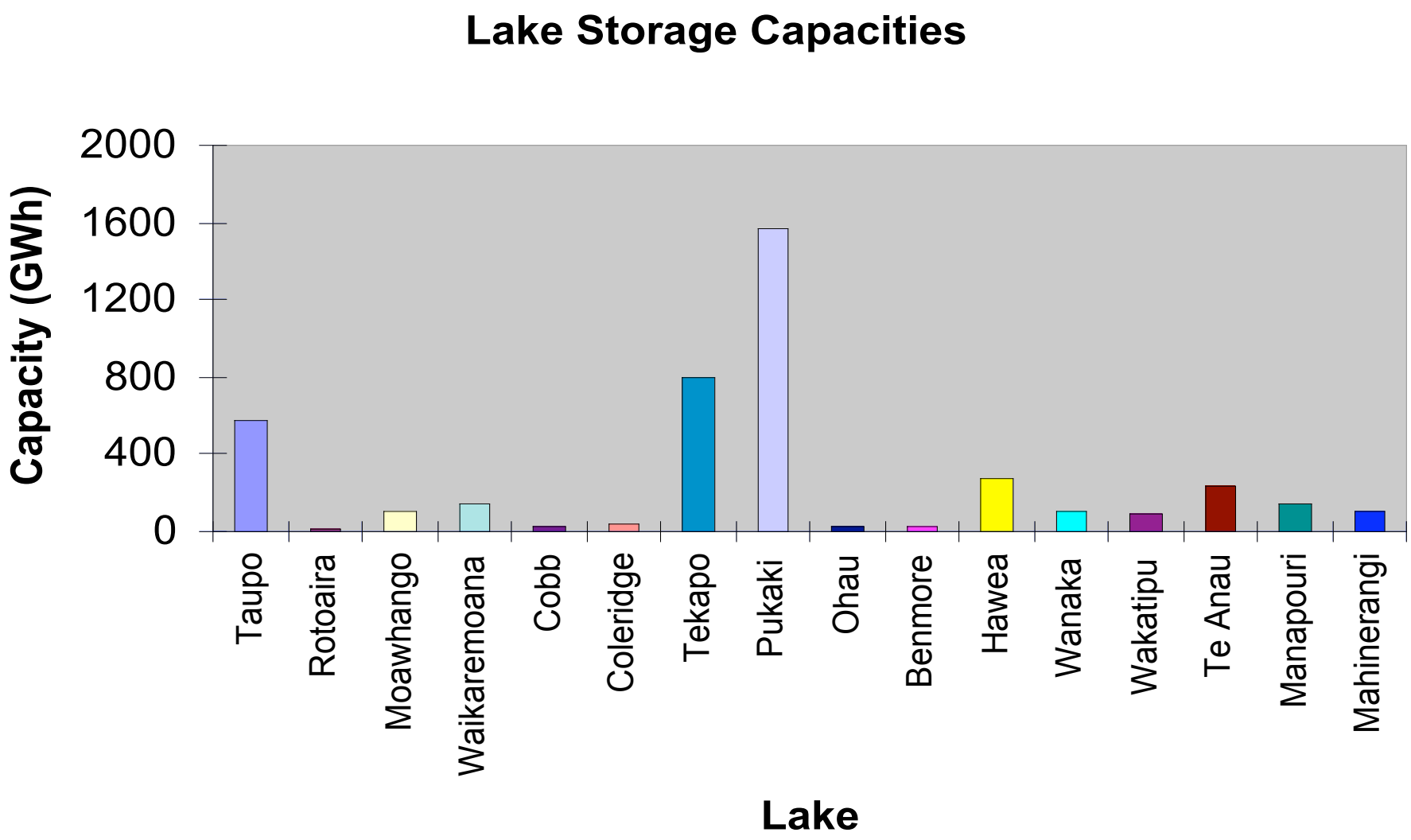
- Water flowing into hydro storages
- Usually measured by monitoring the levels and outflows from hydro storages

Inflow = Outflow + (Rate of increase of storage)

- Variable at many timescales, different from place to place
- Why make forecasts? How?

# Nearly 80 years of levels for Lake Wakatipu

# Main hydropower storages



# Forecasting for Three Timescales

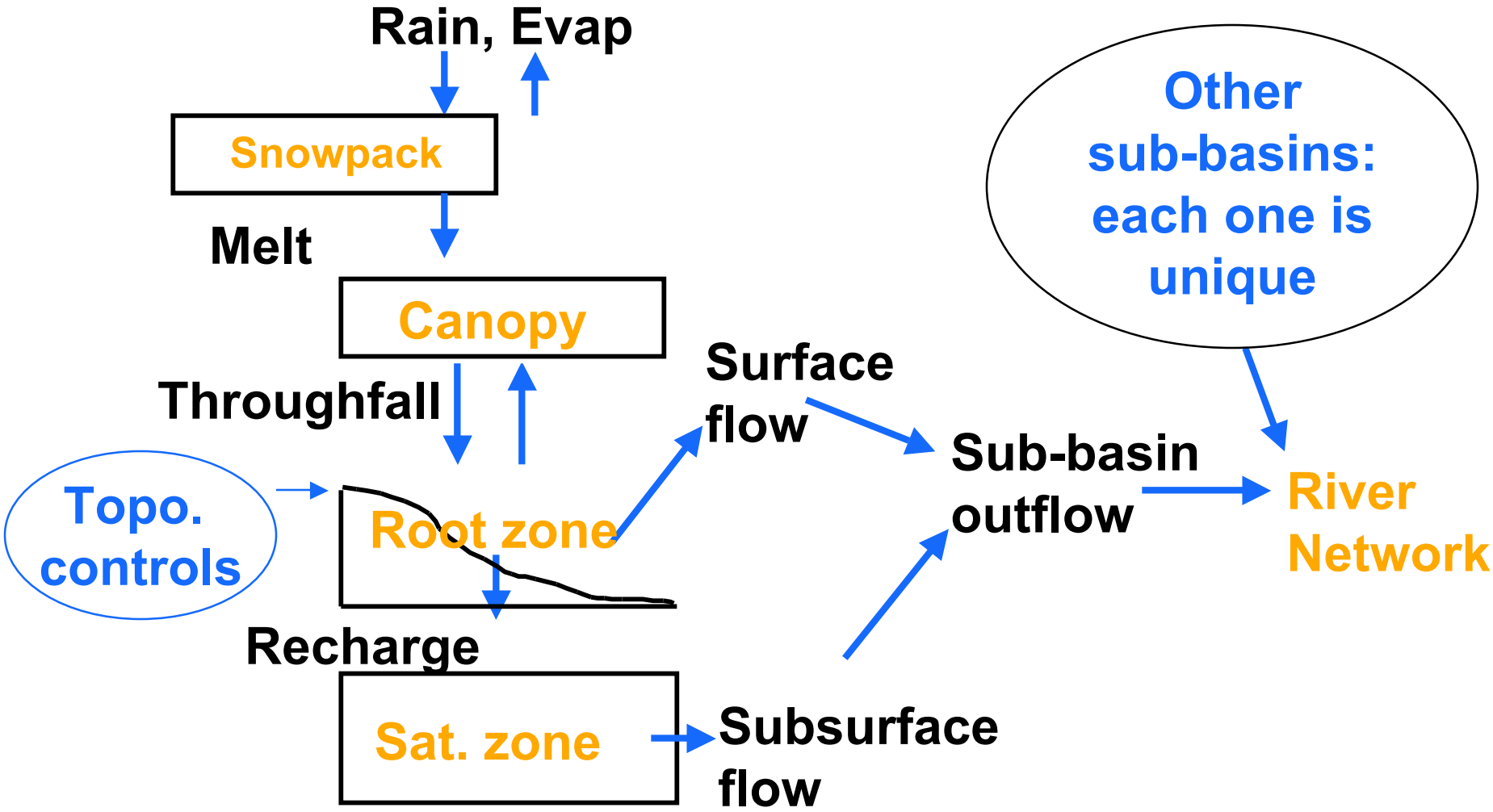
- Weather systems: 0-3 days from now
- Seasonal forecasting: 1 week to several months
- Interannual variability: Decadal-scale

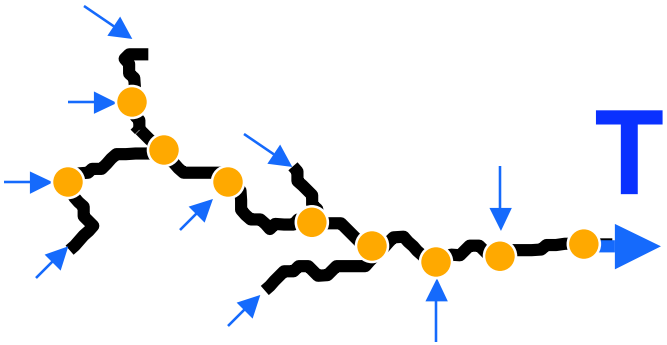
# Timescale: 0-3 days

- Why? How much electricity can we make? Flushing flows; High flow management
- What we need to know
  - What water is already in the catchment (river flows, soil water, groundwater)?
  - How will weather system affect the rainfall, snowfall and evaporative demand?
- With this information, we can use a model to calculate snow melt, runoff from land into rivers, flow along rivers to lakes
- This can be done in more or less detail …

# TOPNET - 1

- Snowpack, canopy and root-zone submodels over a shallow water table

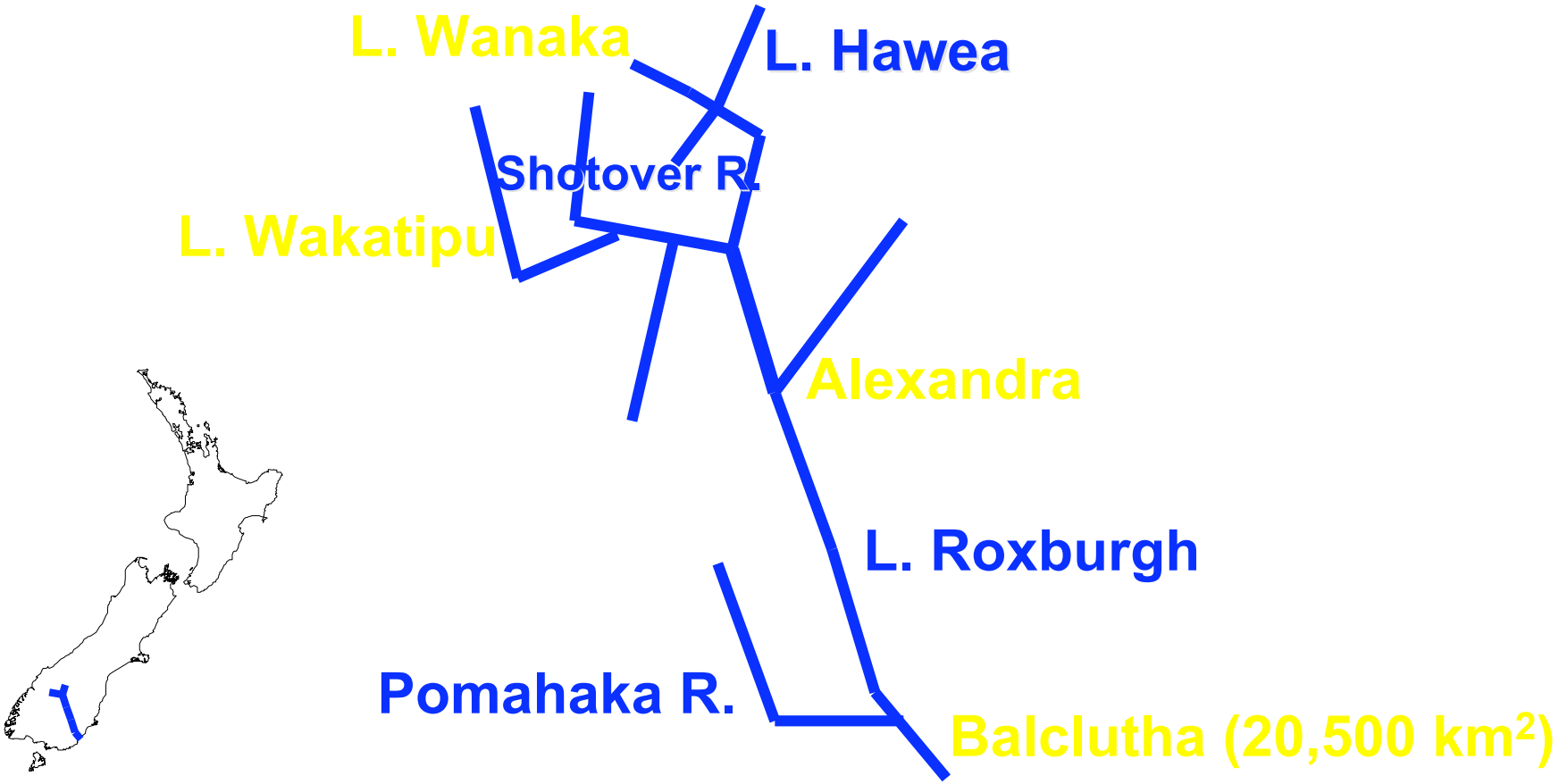




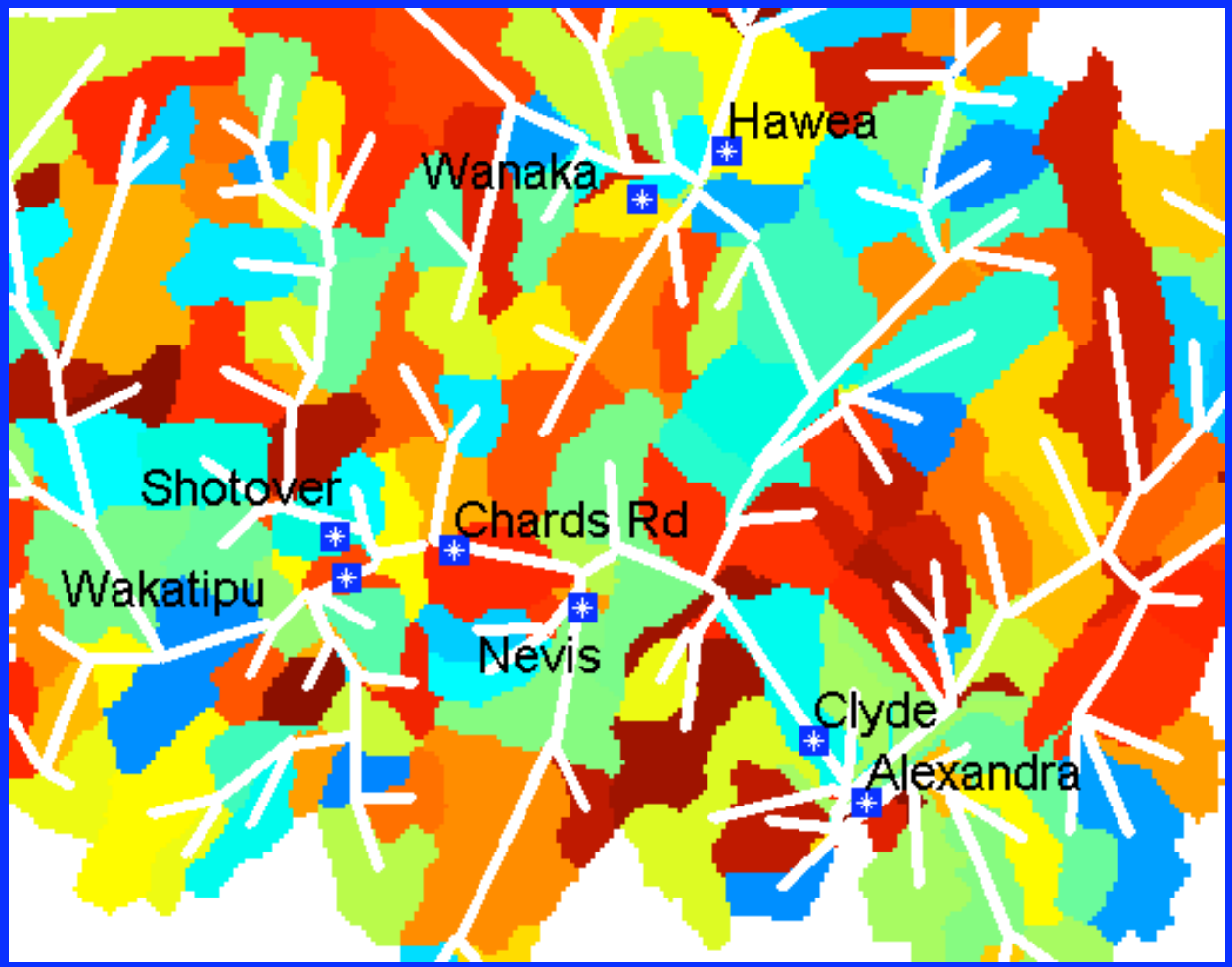
# TOPNET - 2

- Sub-basin outflows are connected to river network routing
- Model gives results for every sub-basin and every river reach, every hour

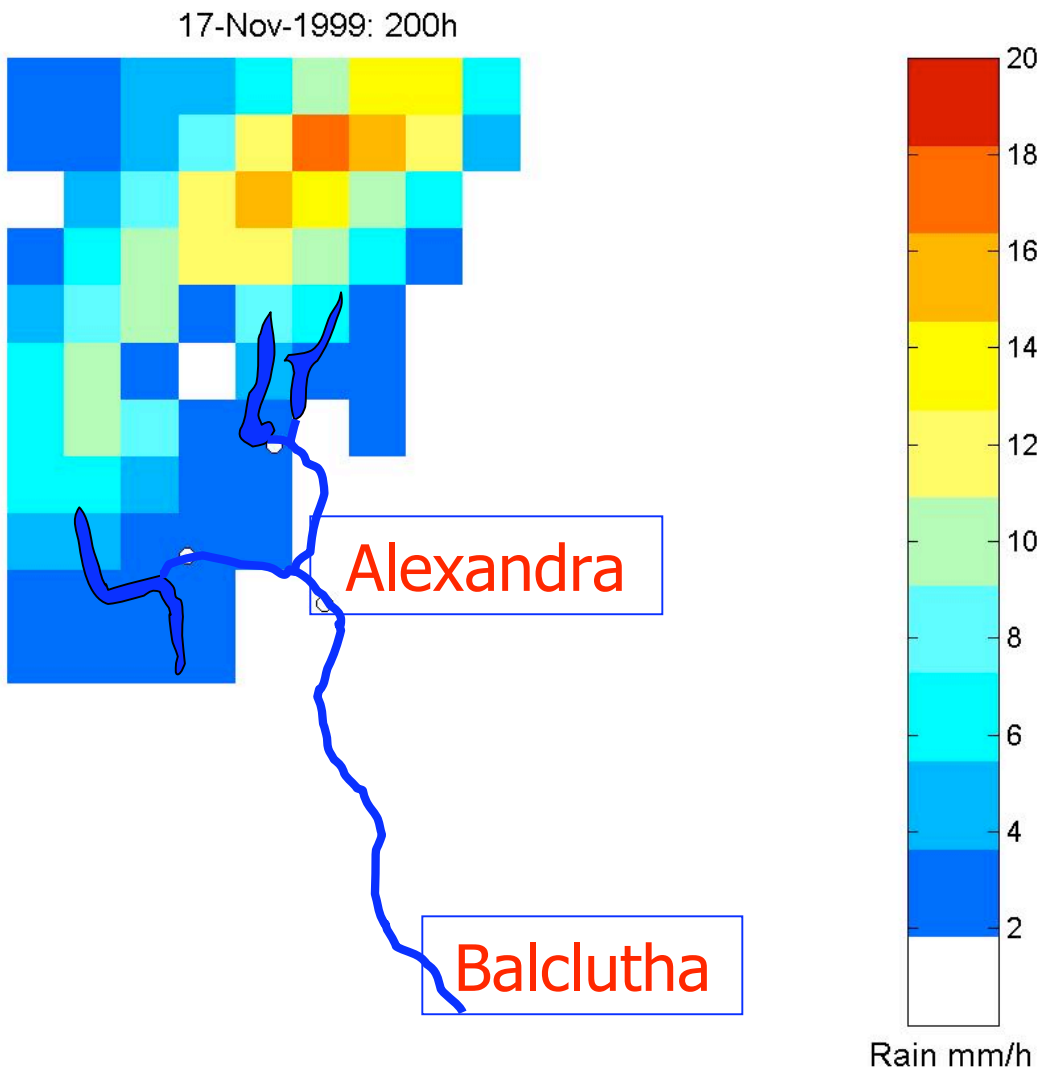
# The Clutha River Catchment



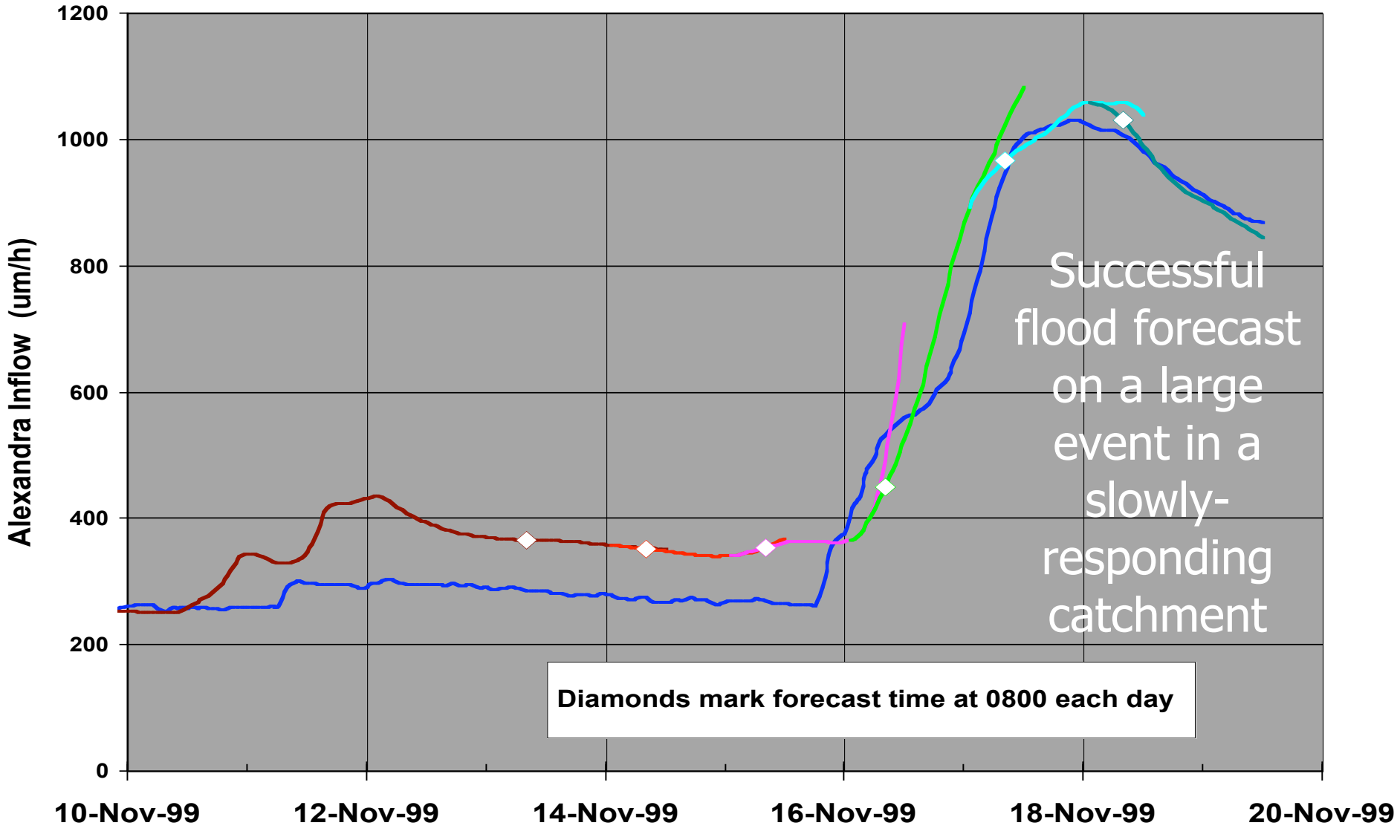
# The Catchment Model



# RAMS Rainfall Forecasts over Clutha Catchment



# Real Time Forecasts for Alexandra - Nov. 1999 using RAMS forecast on 20 km grid



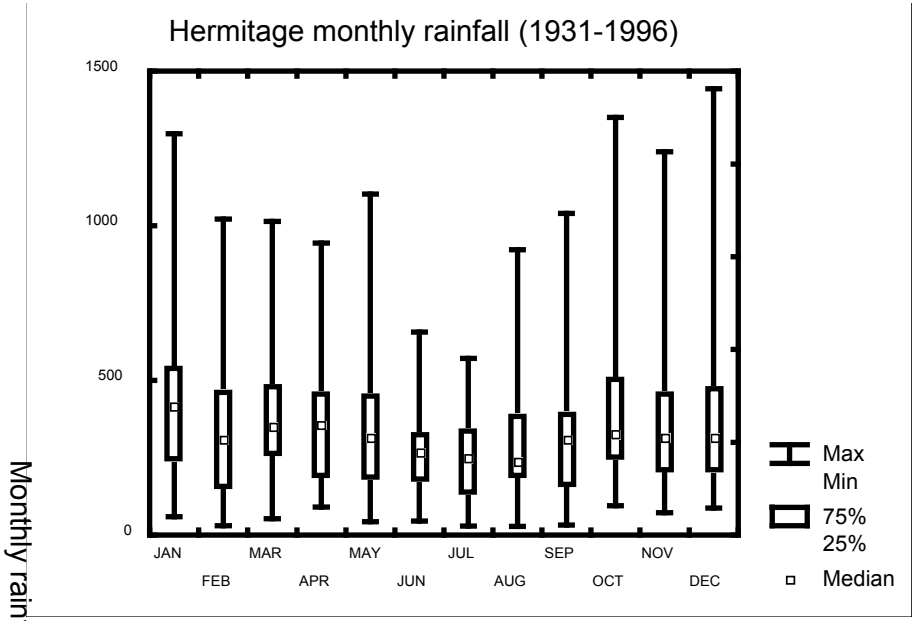
# Next Generation of Forecasts

- Operational Forecasting for catchments, with linked weather and hydrology models
- Operational Forecasting for Regions, with linked weather and hydrology models

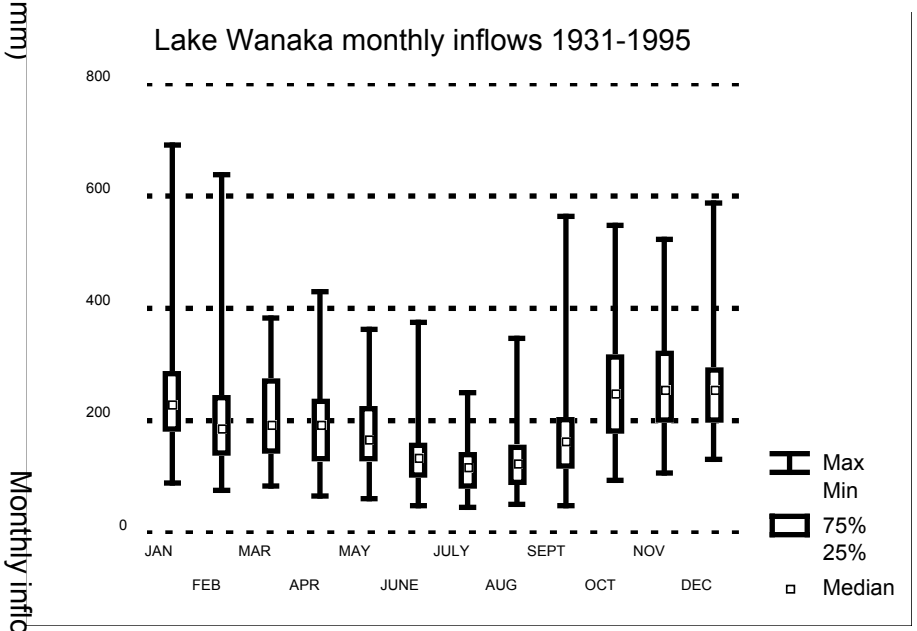
# Timescale: 1 week – 6 months

- Why? Is there a hydro drought coming? When do we need pre-empt with thermal?
- What we need to know for inflow forecasts:
  - How much rainfall/snowfall?
  - What temperatures?
- No deterministic answers: uncertainty is central. Aim to reduce the uncertainty
- This can be done in more or less detail …

# Seasonal Patterns




**Hermitage monthly rainfall**




**Lake Wanaka monthly mean inflows**

NIWA
Taihoro Nukurangi

# The Past as a guide to the Future

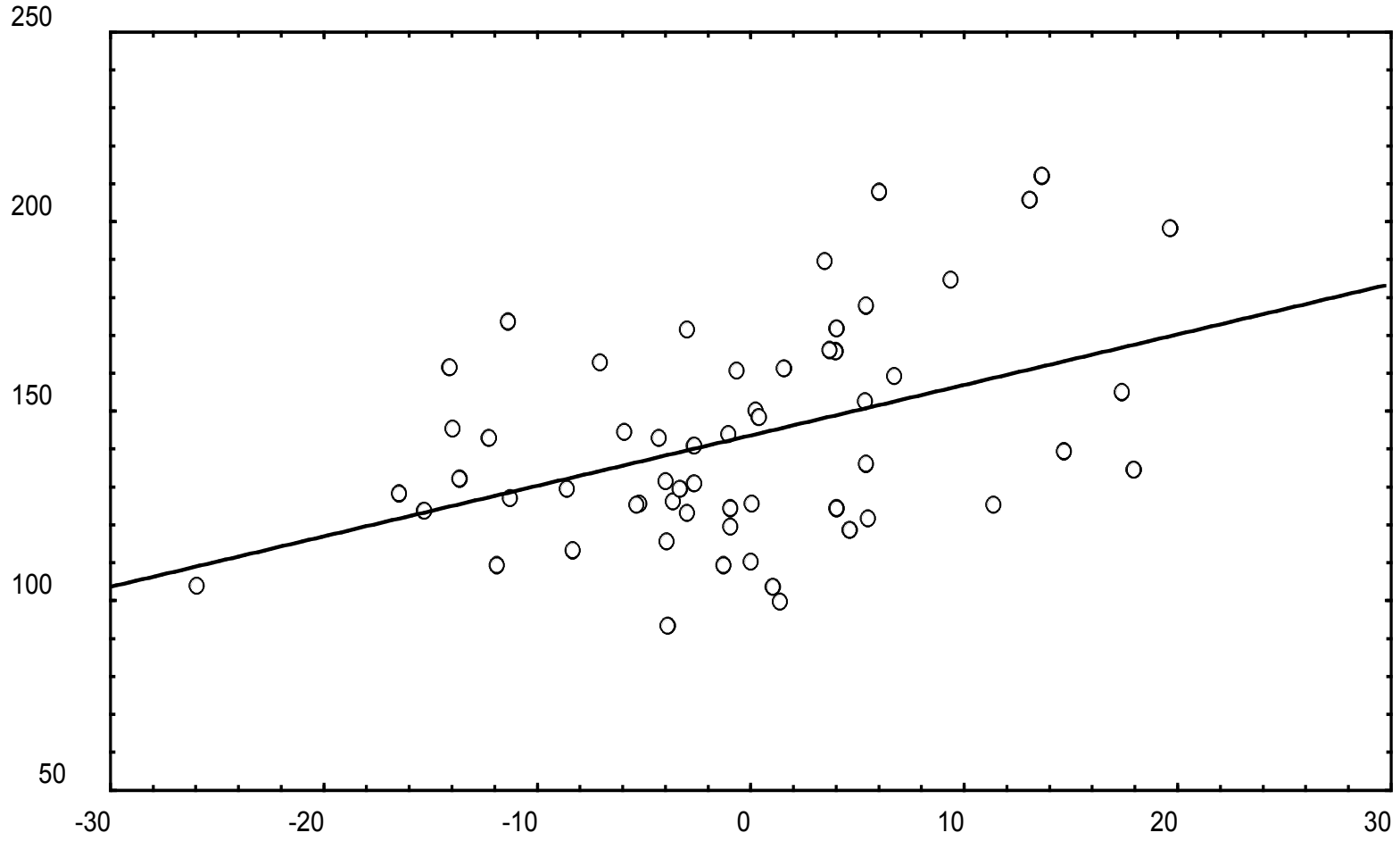
1. It is common to forecast the performance of energy systems over the next season by starting from the current lake storage, and then using weekly inflow sequences from each of the last 70 years of inflows. This lets us sample the variability of inflows at this time of year.

BUT, the unspoken assumption is that each of the last 70 years is equally likely in the next 3 months. Once we are in a strong El Nino or La Nina, some years are much more likely than others.

2. Some energy system models use auto-regressive models to forecast streamflows: on average these might be useful, but extreme seasons have a different persistence structure

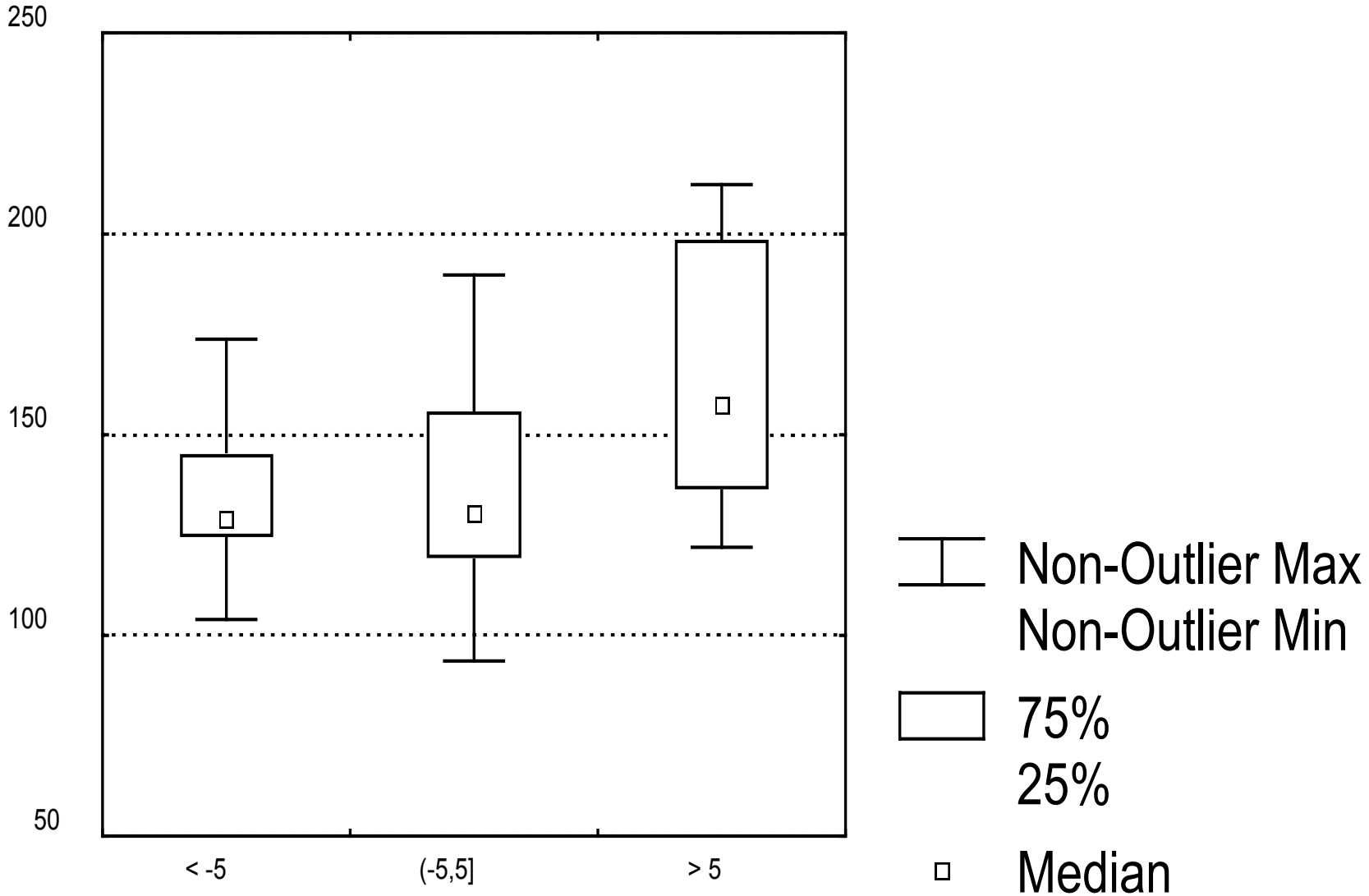
3. Use “ENSO”-streamflow or rainfall-streamflow forecasting

# Lake Taupo Natural Spring Inflows 1935-1992

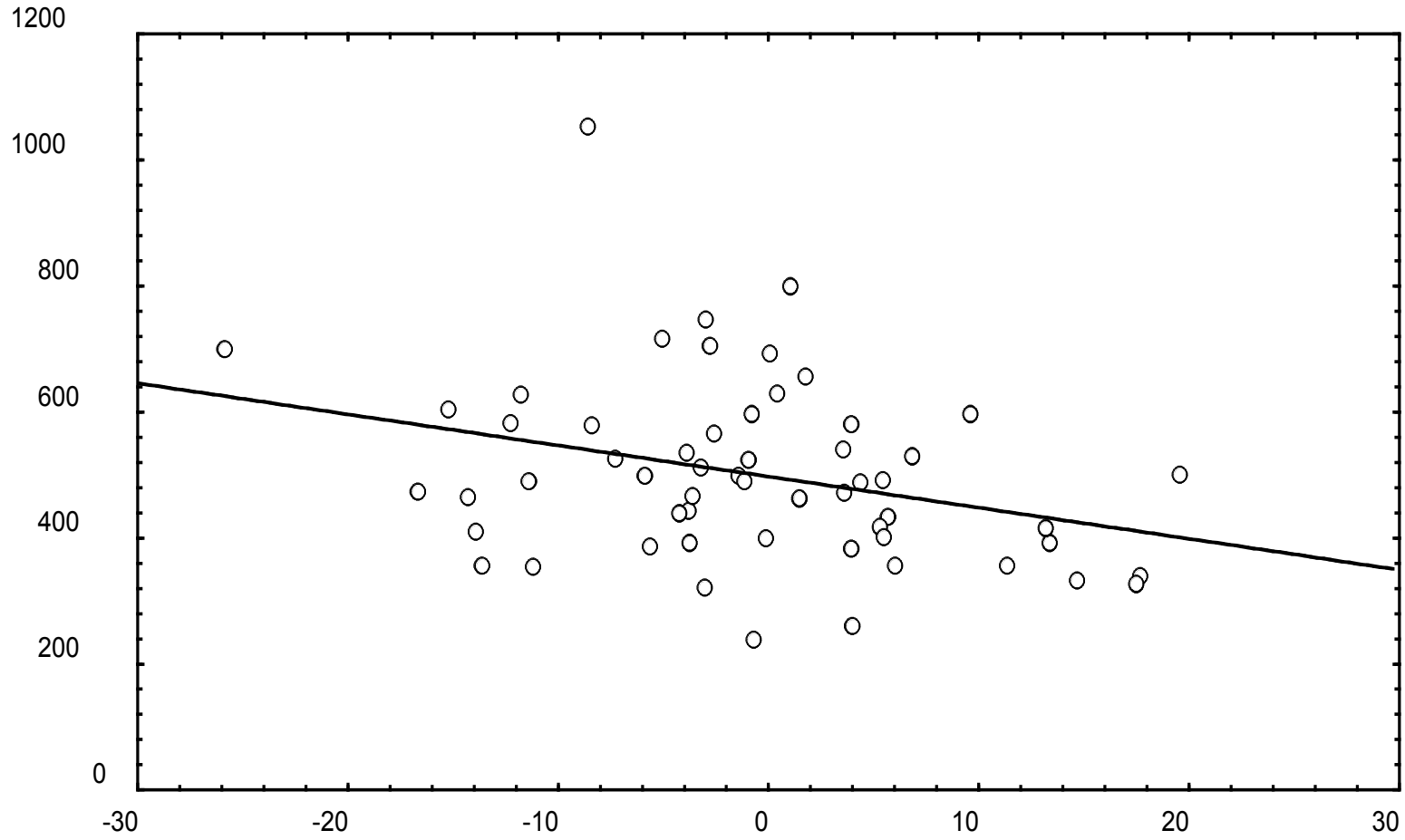



NIWA
Taihoro Nukurangi

# Lake Taupo natural spring inflows 1935-1992

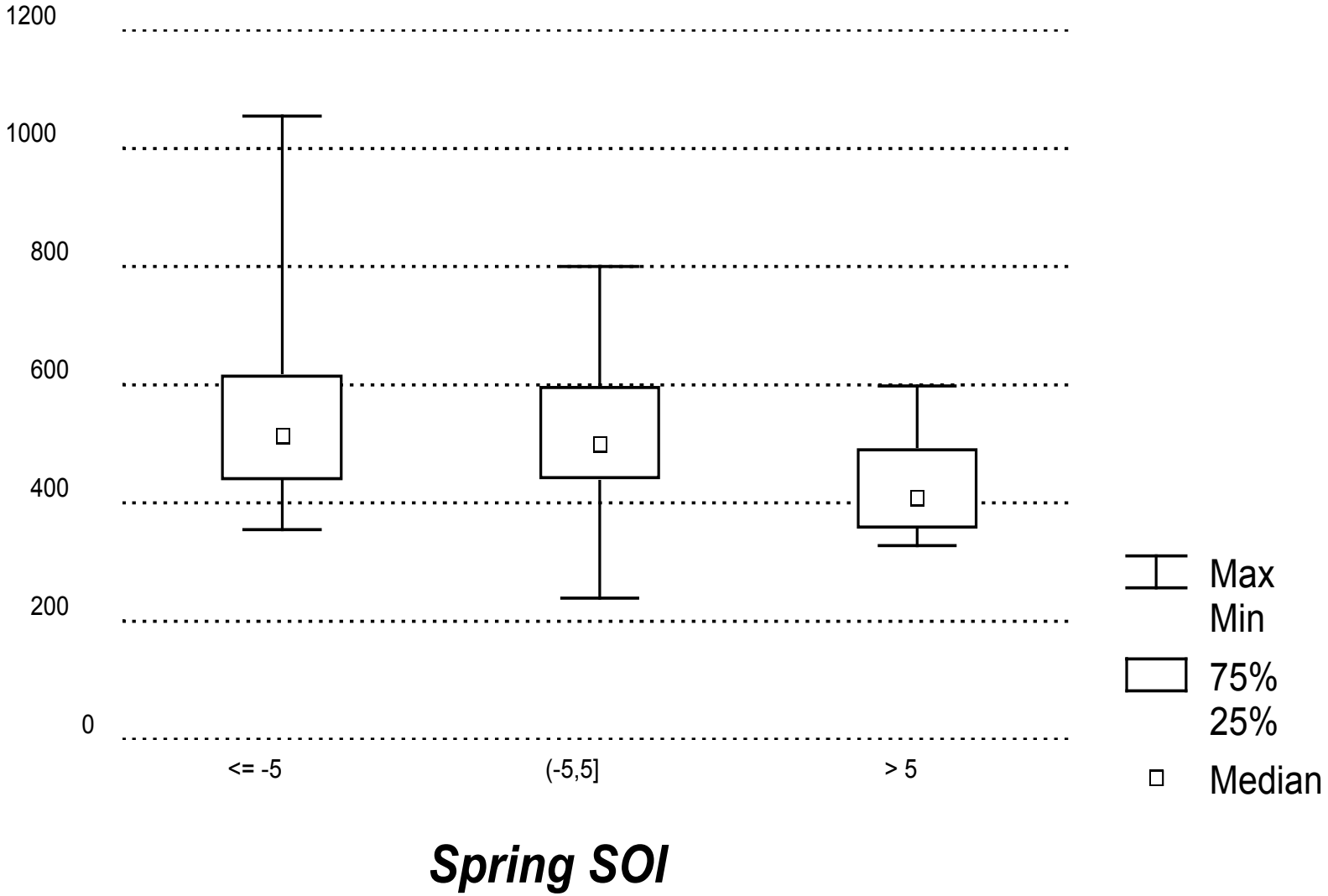


# Clutha lakes summer inflow vs spring SOI




NIWA
Taihoro Nukurangi

# Clutha lake summer inflows vs spring SOI




NIWA
Taihoro Nukurangi

# NIWA National Climate Centre and National Centre for Water Resources

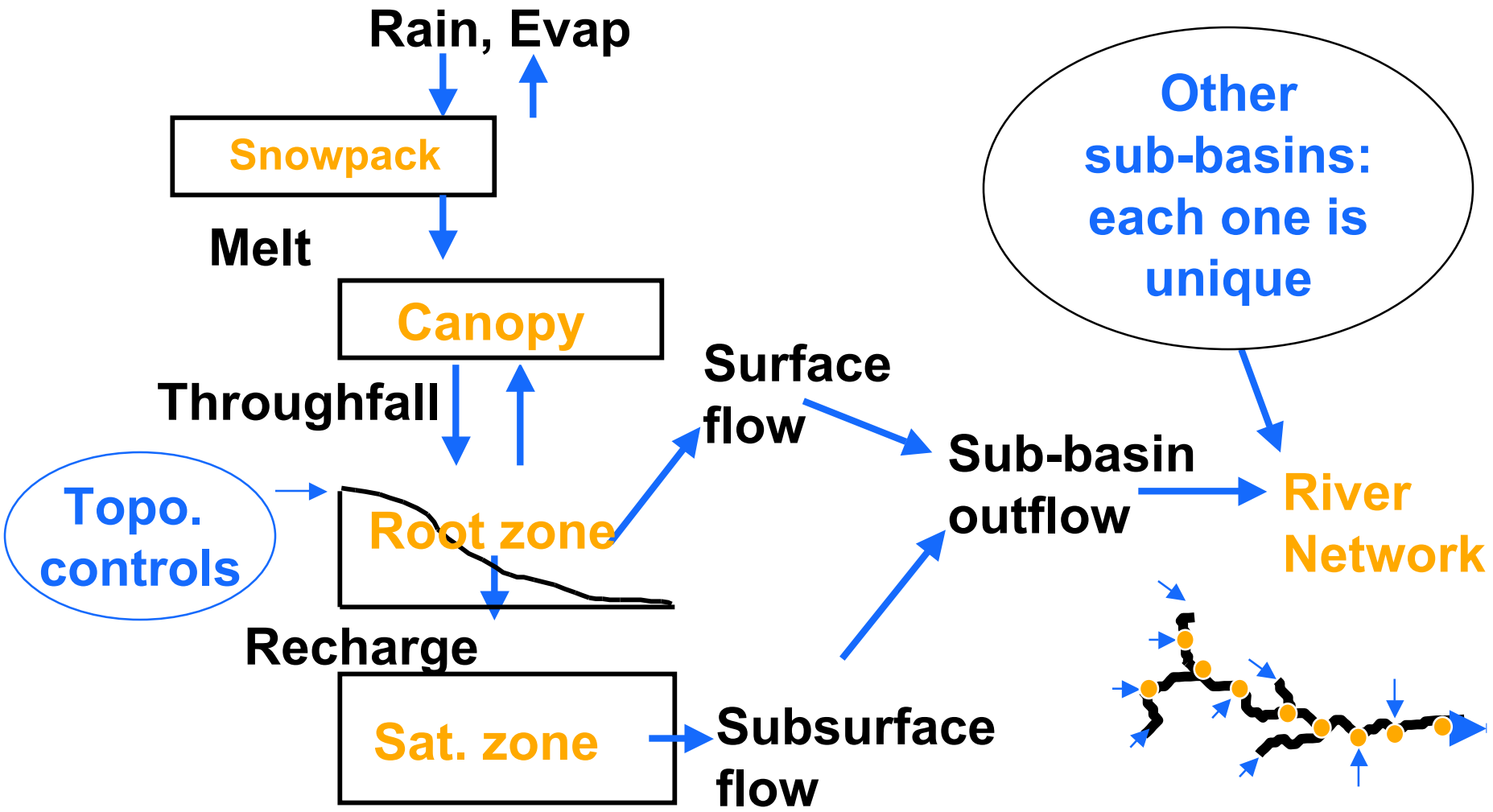
- Forecasts each month of the streamflows for the coming 3 months www.niwa.co.nz/ncc
- Based on: climate forecasts, current status of river flow and soil moisture, expert knowledge and statistical analysis of past data.
- Forecasts developed as the probability of "Above normal", "Normal" and "Below normal" flows. In the long run each of these occurs 33% of the time. So random guesses have 33% hit rate. We have had 40-45% hit rate over the last 3 years
- www.niwa.co.nz/ncwr - water quality, quantity, lakes, groundwater, …

# Next Steps

- Develop new methods for forecasting climate
  1. Statistical weather generators
  2. Regional climate models
- Both of these are ways to generate many sequences of daily rain and temperature for the coming season (conditioned on the current ocean-atmosphere status – ENSO etc)
- Either way, we need to convert these climate forecasts to inflows: can use the same model as for the 0-3 day forecasting.

# Topnet

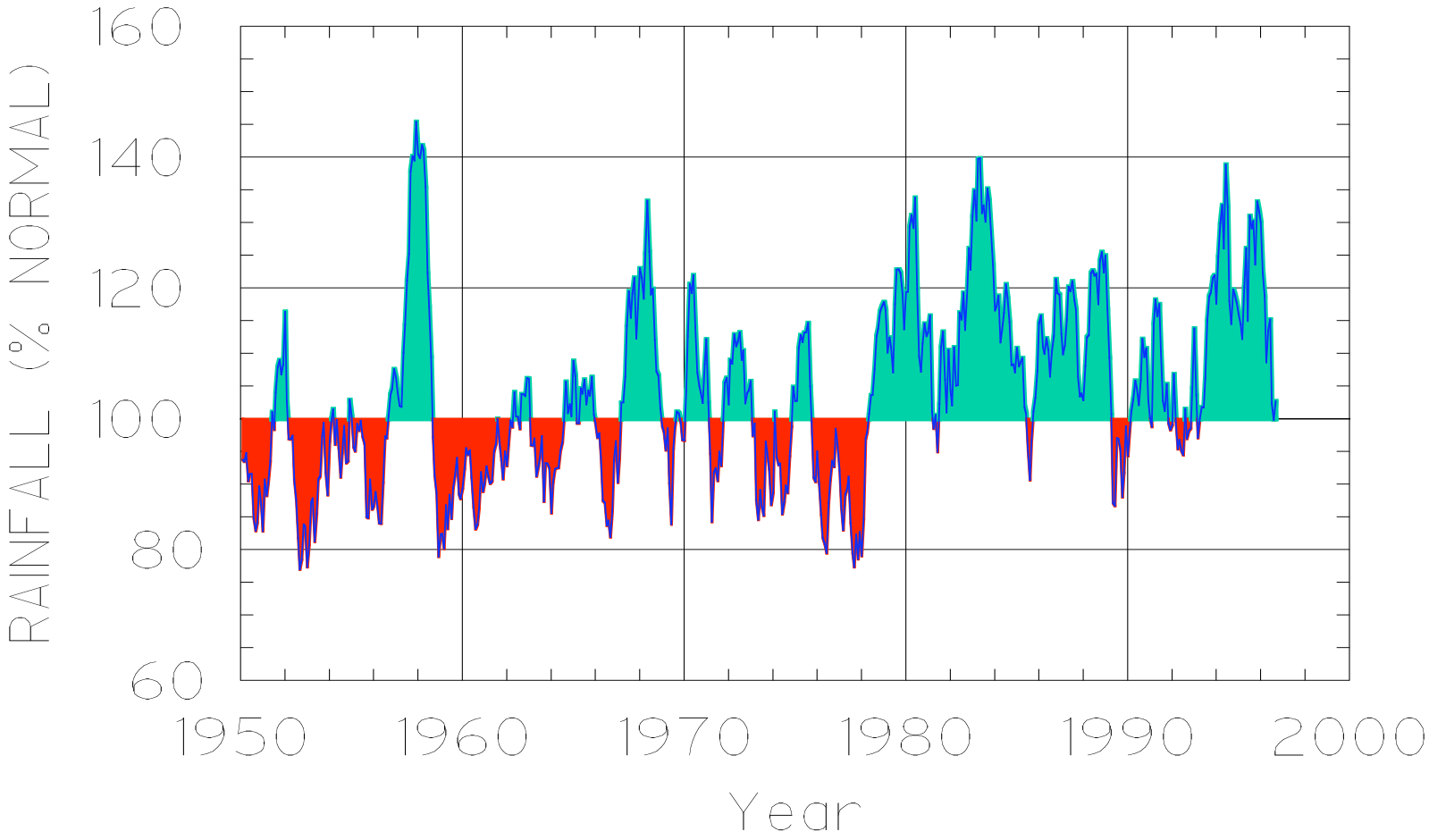
- Example of Regional Modelling in Northland



# Timescale: Interannual

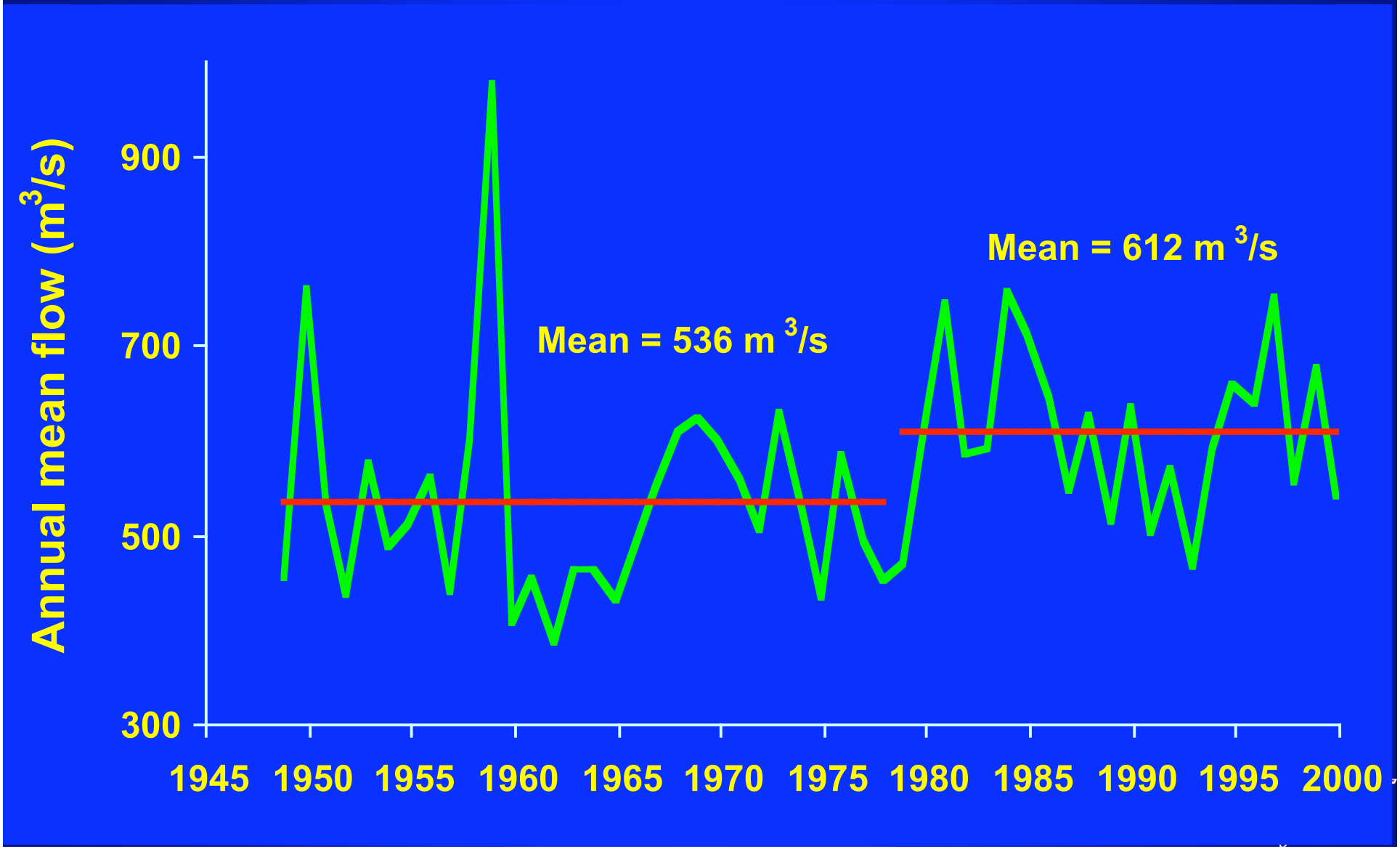
- Why? Investment in new generation; Assessing the expected performance of existing system
- Fact: Inflows can be very different from one decade to another
- Up to 15% changes in South Island
- Inflow differences caused mainly by rainfall variability. This is *climate variability* (as opposed to *climate change*: e.g. rise in temperature & rain in west and south of South Island by 2050)
- Rainfall differences are caused by slow changes in ocean-atmosphere circulation, called Interdecadal Pacific Oscillation (IPO, PDO)
- 1945-1977, 1978-1999?, 1999?-

# South Island West Coast Rainfall



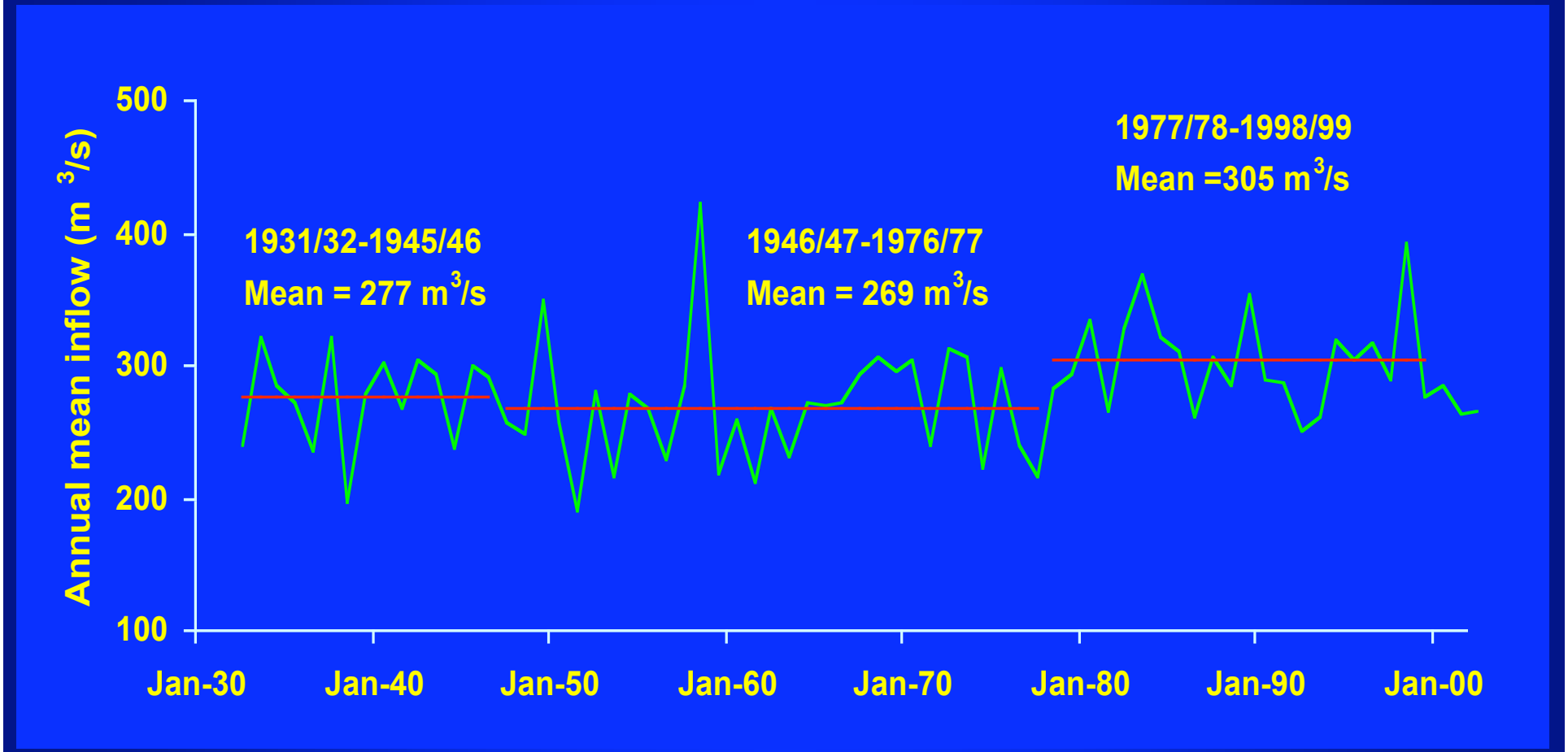
# Clutha River at Balclutha 1947/48 to 1998/99

(data courtesy Contact Energy Ltd)



# Lake Te Anau inflow, 1931/32 to 2001/02

(data courtesy FRST, Meridian Energy Ltd & The Market Place)




NIWA
Taihoro Nukurangi

# Summary

- 0-3 days: weather system forecasting and a model of catchment processes
- 1 week – 6 months: Effects such as ENSO can shift the distribution of inflows far from the “typical” distribution
- Interdecadal: Differences between decades of order 15% - be careful which years of data you use!
- For these inflow forecasts to be useful, we need better links with energy system modellers, esp for advice on how best to communicate inflow forecasts