CATCHMENT CHANGE NETWORK

CCN Conference 2010 - Managing an Uncertain Future: Identifying needs and opportunities for sustainable adaptation in catchment management

Water Resources Assessment in a Changing Climate – moving towards a more risk-based approach

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Main Focus: Water Scarcity

- Under Climate Change, Water Scarcity is expected to become a serious issue in the UK in the coming decades, particularly in the South East
- UKCP09 provides the latest generation of climate information for the UK: probabilistic projections of climate change based on quantification of the known sources of uncertainty.
- Key issue: How to incorporate CP09 scenarios into Water Resources Management Planning (WRMP) ?

Factors that can induce Water Scarcity

- Lack of the resource (U)
- High per capita water consumption (C)
- Inefficient usage induced by low pricing/a lack of metering (C)
- High leakage rates (C)
- Poor institutional performance (C)
- WFD and over-abstraction: environment needs more water (C)

(U: uncontrollable   C: controllable)

Sustainable Water Resources Management

- With high uncertainty over resource availability, need to focus more on controllable factors
- Supply-led approaches not sustainable in long term: water conservation and demand management (WCDM) must be implemented within a sustainable approach to managing the supply-demand balance

Water for the Environment

PHIL YEOMANS/ARNOA BURGI/CLIVE POSTLEWAITE/KEN LUCAS

The River Kennet in Wiltshire provides valuable habitat, but stretches can run dry when water is extracted

Phil Yeomans/Action for River Kennet

Dry run

Precious habitat is being threatened because of the huge volumes of water being taken out of the country's rivers

Kingfisher
Populations have been hit by water pollution, reduced fish stocks and poor river flow

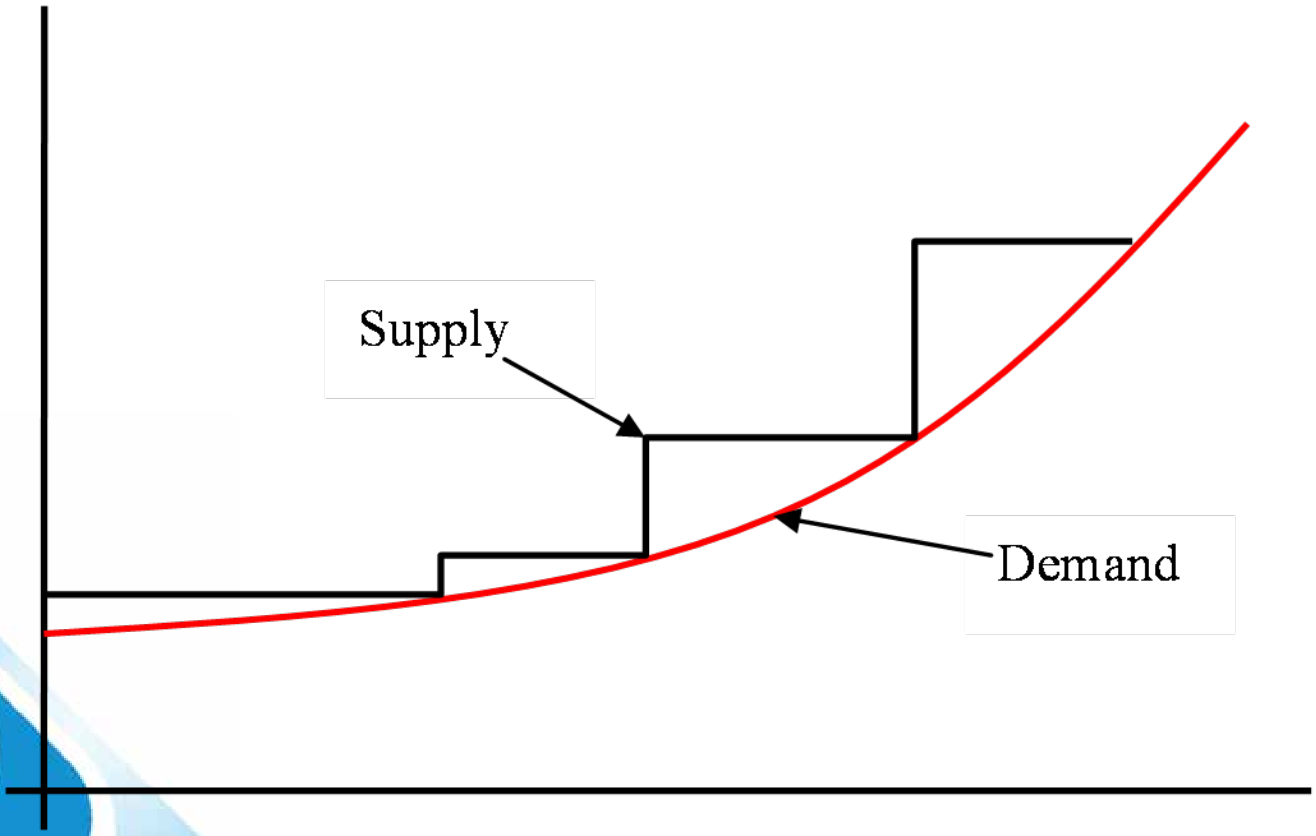
Water vole
90% decline over past two decades. Has suffered loss of river habitat

Wading birds
40% decline of snipe, lapwing and curlew. Loss of wetlands is a main cause

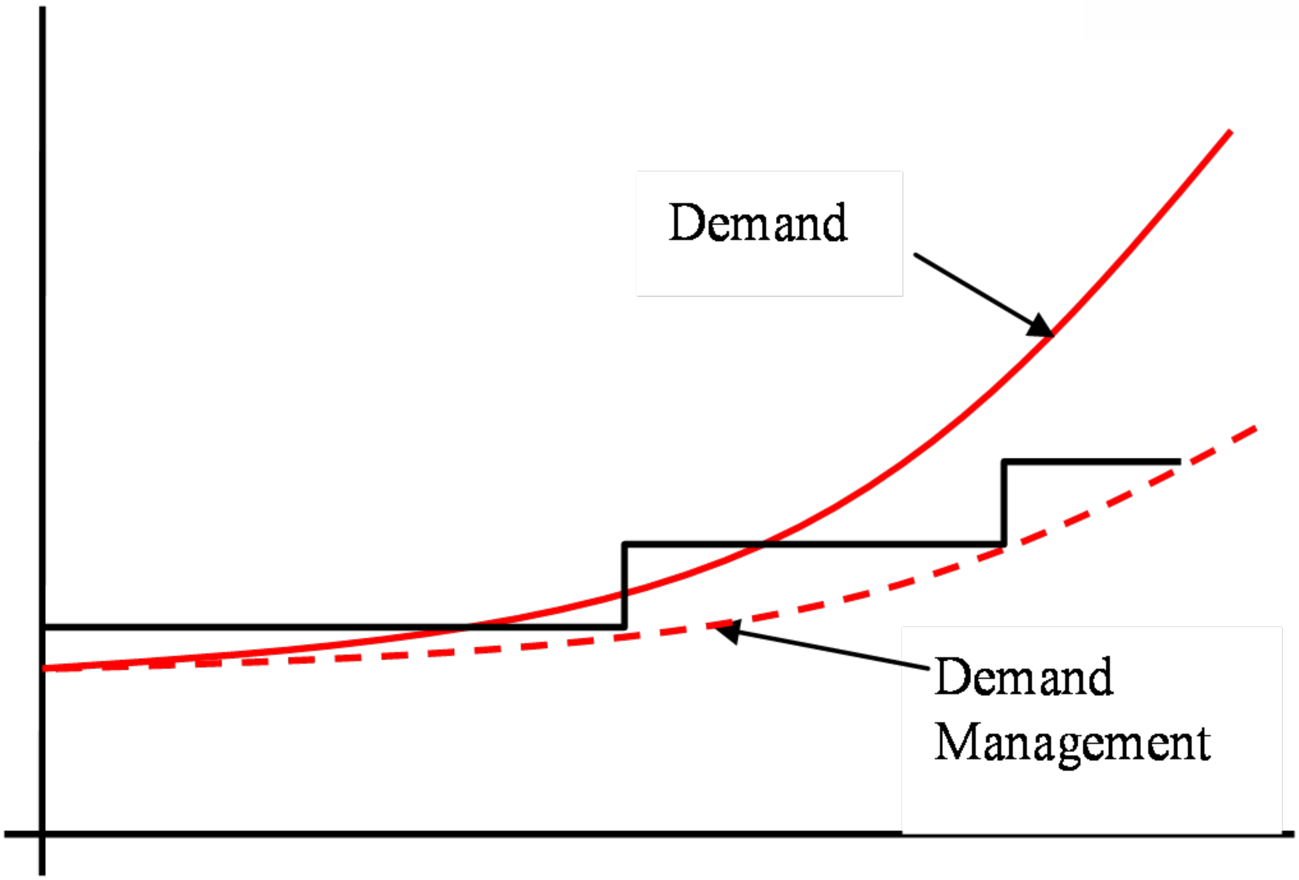
Brown trout
Populations have been wiped out in some stretches of chalk stream

River life threatened by water company 'greed'

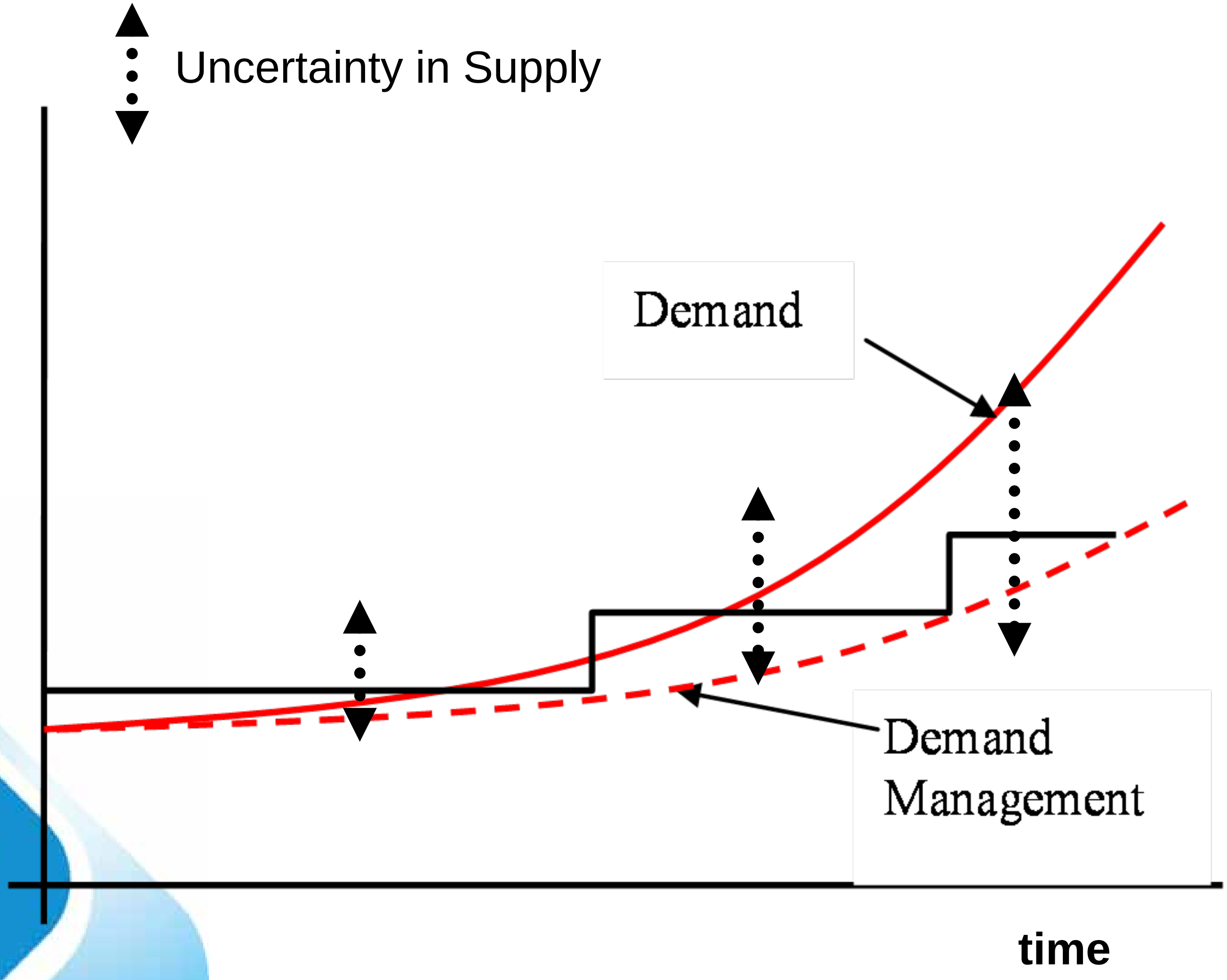
THE SUPPLY-DEMAND BALANCE: SUPPLY SIDE DETERMINISTIC



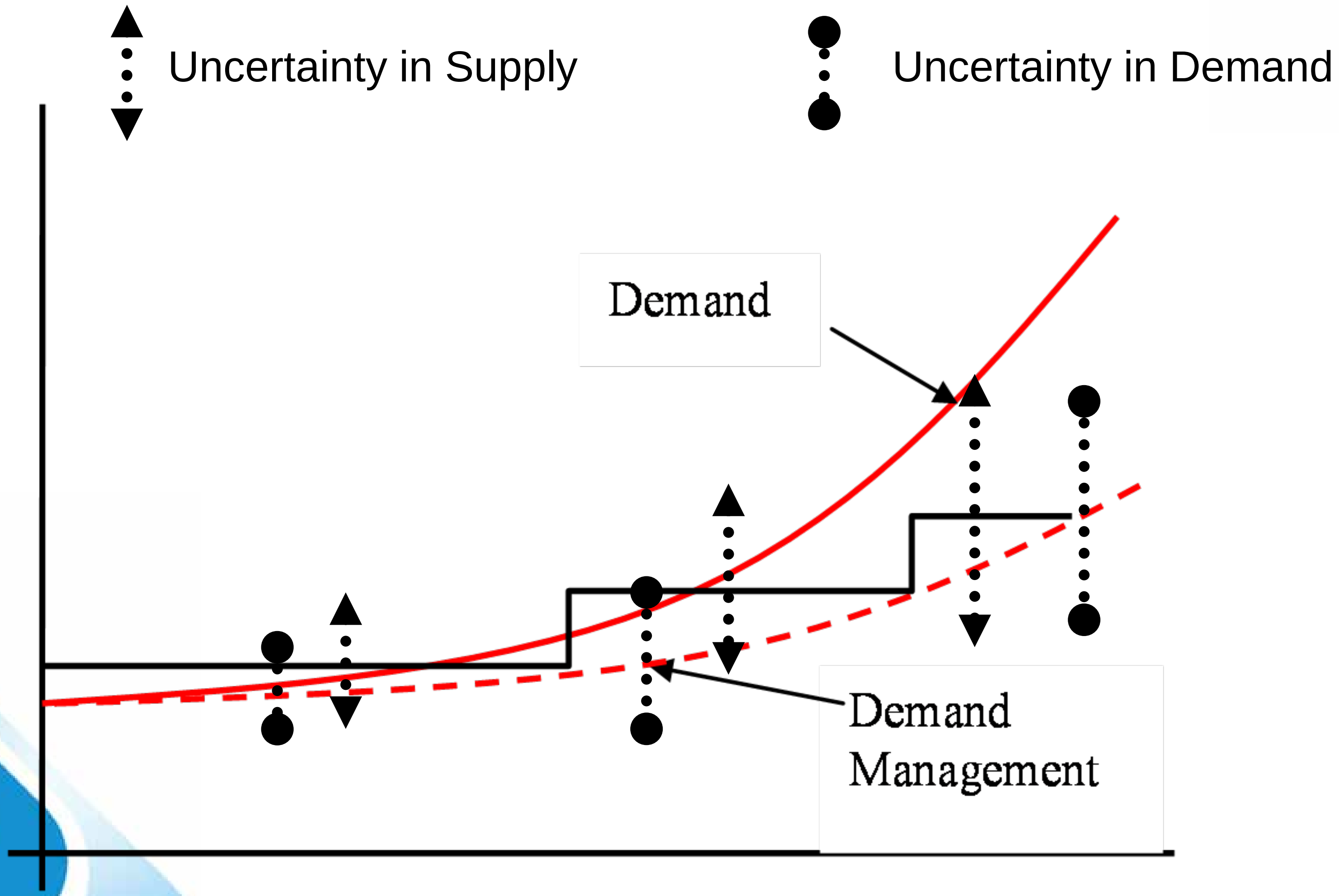
THE SUPPLY-DEMAND BALANCE: TWIN- TRACK DETERMINISTIC



THE SUPPLY-DEMAND BALANCE: SUPPLY UNCERTAINTY



THE SUPPLY DEMAND BALANCE: TWIN-TRACK WITH UNCERTAINTY



Water Resources Assessment in a Changing Climate: the Stationarity Issue

Science 1 February 2008:
Vol. 319. no. 5863, pp. 573 – 574

CLIMATE CHANGE:
Stationarity Is Dead: Whither Water Management?

P. C. D. Milly, Julio Betancourt, Malin Falkenmark, Robert M. Hirsch, Zbigniew W. Kundzewicz, Dennis P. Lettenmaier, Ronald J. Stouffer

Water Resources Assessment in a Changing Climate: the non-stationarity issue

- Stationarity assumes statistical equilibrium: a past record is assumed to be representative of the future within the limits of sampling variability
- In a changing (transient) climate, stationarity is arguably not a tenable assumption
- Long term statistics (mean,variance, probabilities, return periods) not definable: a function of the unknown form of nonstationarity

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UKCP09 – Probabilistic projections

- For all 25 x 25 km UK land grid squares and some aggregated regions, including administrative areas and river basin areas;
- For three future scenarios of greenhouse gas emissions (labelled as Low, Medium and High)
- For the period 2010-2099, using seven overlapping 30-year time-slices that move forwards in decade steps (i.e. 2010–2039, 2020–2049, etc. until 2070–2099)
- As projected climate change (i.e. change relative to the 1961-1990 baseline period) and as projected future climate (i.e. absolute future climate values)
- At different probability levels e.g. 10% (very unlikely to be less than), 50% (central estimate), 90% (very unlikely to be greater than)

CP09 Weather Generator

- Developed by University of East Anglia and Newcastle University
- Based on a stochastic model that simulates future time series of weather variables for the different (stationary) time slices
- Fitted to UK historical 5km gridded data for the period 1961-1995 to provide a baseline model
- Statistical measures within the weather generator are then perturbed according to the UKCP09 probabilistic projections to generate time series for future time slicess.

Use of CP09/WG probabilistic projections

- Need for risk-based analyses of the supply demand balance, emerging water scarcity conditions, and of adaptation and mitigation strategies
- Issues that need attention:
  - Lack of interannual variability in CP09 probabilistic projections
  - Spatial correlation in the context of regional/national strategies.

Long-term Climatic Variability and Stationarity

"Before the assumption of hydrologic non-stationarity is accepted, the ability to cope with the uncertain impacts of global warming on water management via the operational assumption of hydrologic stationarity should be carefully examined."

"The **strategy of wait-and-see** ie delaying the making of important, expensive and essentially irreversible capital investments could serve water managers well in coping with the uncertainties regarding climate change."

Matalas (1997)

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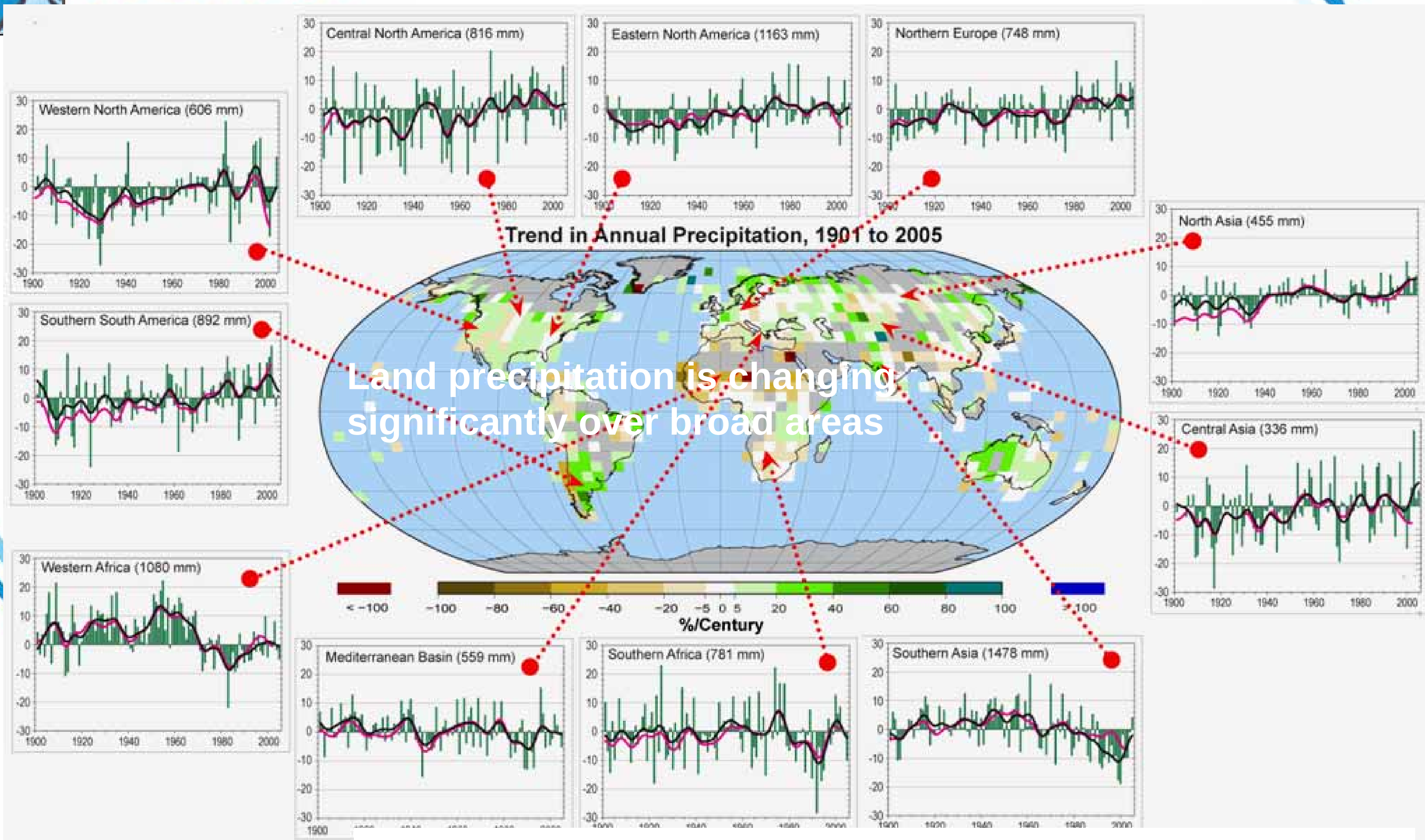
Land precipitation is changing significantly over broad areas



Smoothed annual anomalies for precipitation (%) over land from 1900 to 2005; other regions are dominated by variability

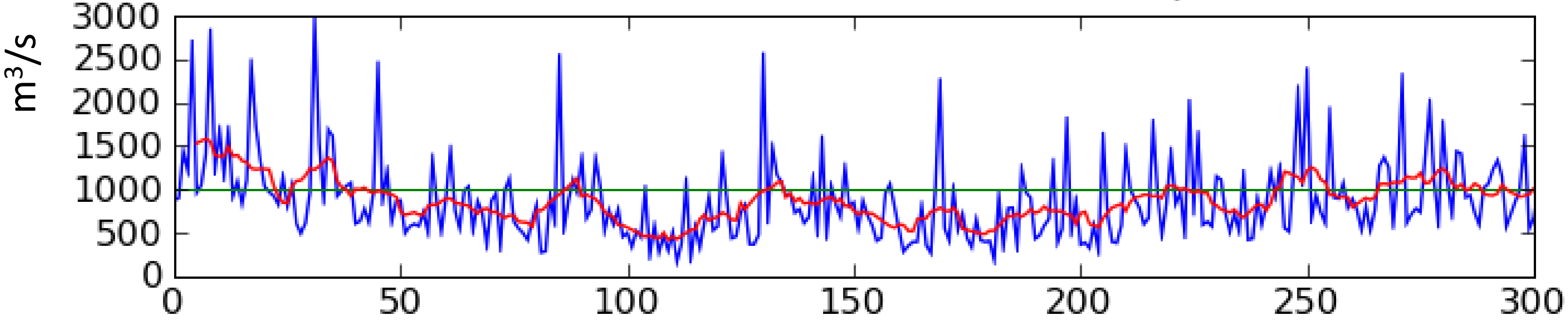
Long-term Climatic Variability and Stationarity

- The climate has always been variable; the variability is evident in longer records
- We expect increasing climatic variability as a result of climate change
- There are stationary stochastic processes that exhibit a wealth of irregular low frequency features/long term persistence eg
  - Fractional Gaussian noise (long memory)
  - ARMA(1,1) (long memory)
  - Shifting mean models (no memory)

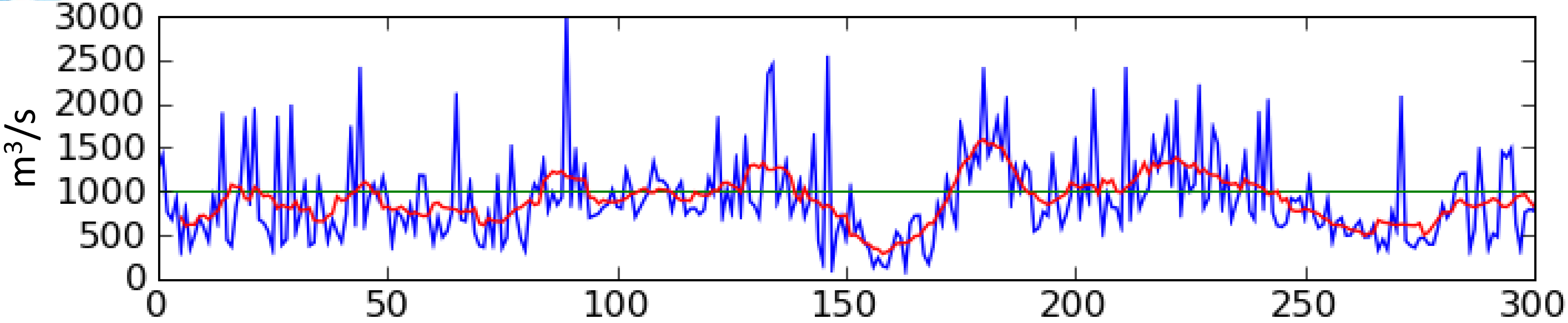
- The range of variability exhibited in finite samples (eg N= 50 years) is always less than the full range of population variability

Long-term Climatic Variability and Stationarity

ARMA(1,1) $X_t = \phi X_{t-1} + \varepsilon_t - \theta\varepsilon_{t-1}$ $\rho=0.2$ $\phi=0.95$ $\theta=0.84$



Shifting Mean $X_t = M_t + \varepsilon_t$



Long-term Climatic Variability and Stationarity

- How might **Proactive** (invest now) and **Reactive** (wait and see) water resources investment strategies compare under highly variable but stationary flow regimes?

.....some guidance on how to deal with the adaptation investment problem under climate change....?

- Can be explored using Monte Carlo simulation experiments with stationary stochastic flow models

Risk-based Assessment of Adaptive Strategies for Implementing Twin-Track Approach

- Reactive (wait-and-see) approach necessitates high level of adaptability/flexibility
- Use stationary stochastic models to explore investment strategies under increasingly variable climates
- Combine with historical data and CP09 ensemble information using Bayesian approach?
- Reactive (adaptive) versus proactive strategies: assess robustness across emissions scenarios and increasing levels of climatic variability

Main Activities in First Year

1. CCN Water Scarcity Focus Area Workshop

"Water resources assessment in a changing climate"

Wednesday 10th February 2010

2. Preparation of paper to be submitted to CIWEM Journal

3. Development of risk-based framework for WRMP

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CIWEM Paper

Introducing UKCP09 into Water Resources Planning

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Thank you for your attention.

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