Ensemble Hydrological Forecasting

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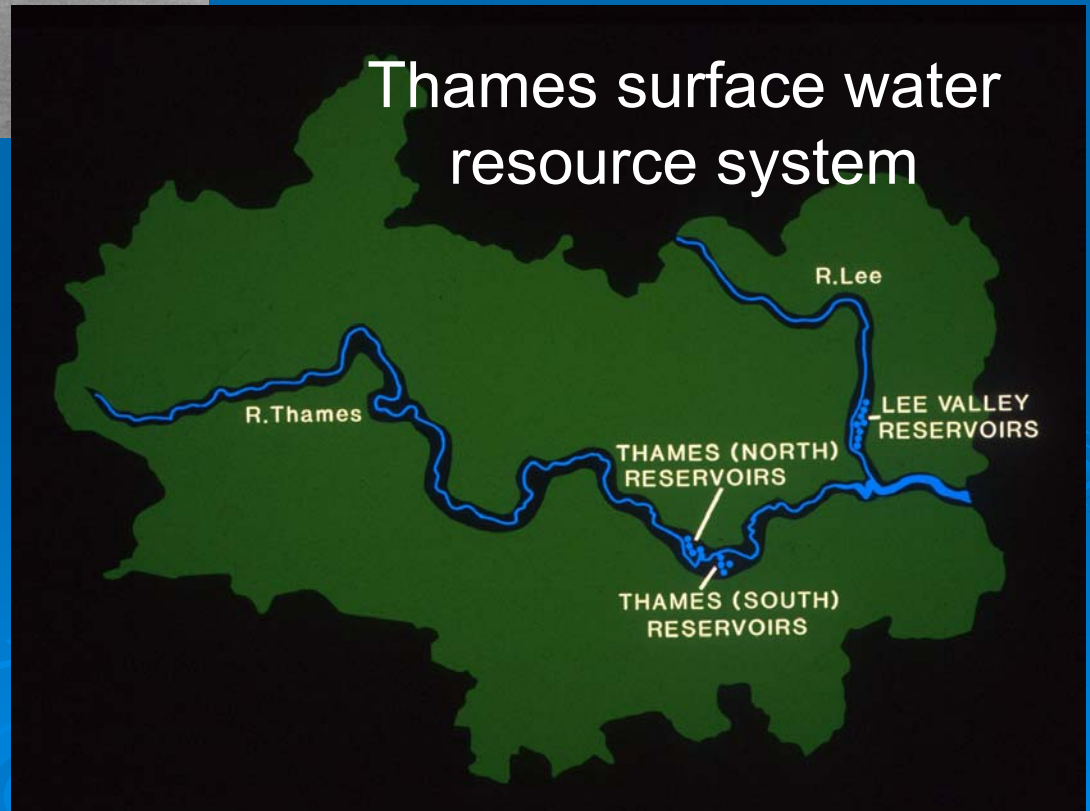
Overview

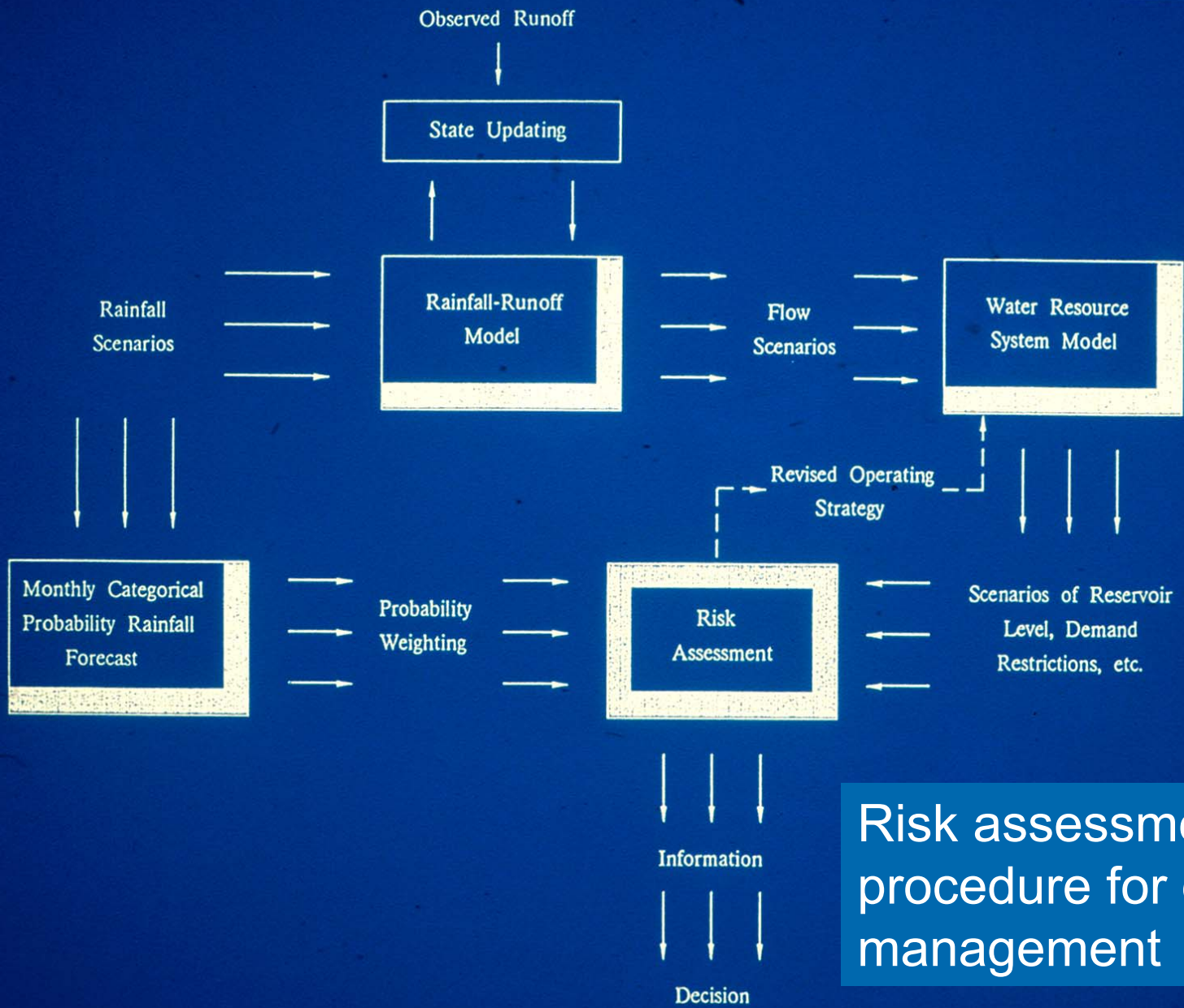➢ Drought Management

➢Flood Forecasting
- Present
- Future?

Drought management in the Thames Basin

Thames surface water resource system

- R.Lee
- R.Thames
- LEE VALLEY RESERVOIRS
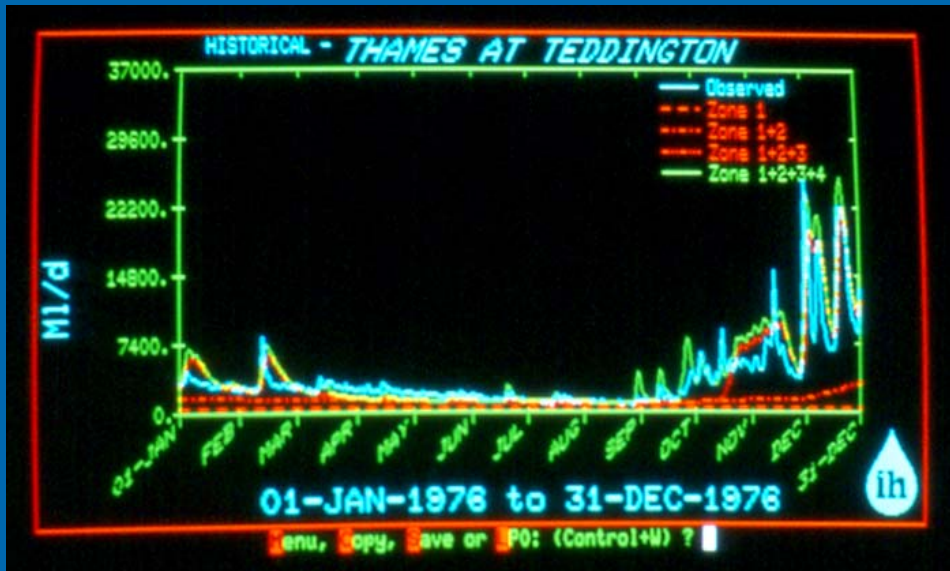- THAMES (NORTH) RESERVOIRS
- THAMES (SOUTH) RESERVOIRS

• Historical rainfall ensembles

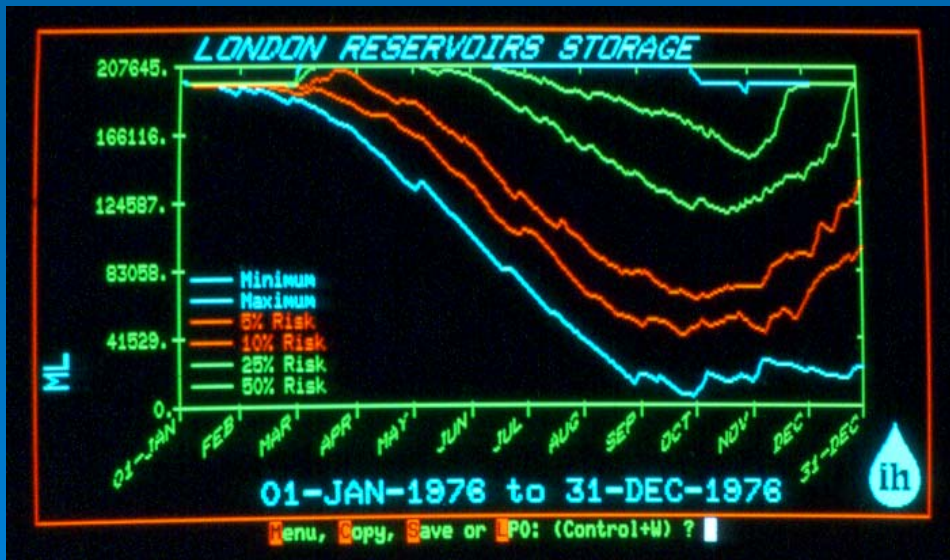• Categorical probability rainfall forecast weighting

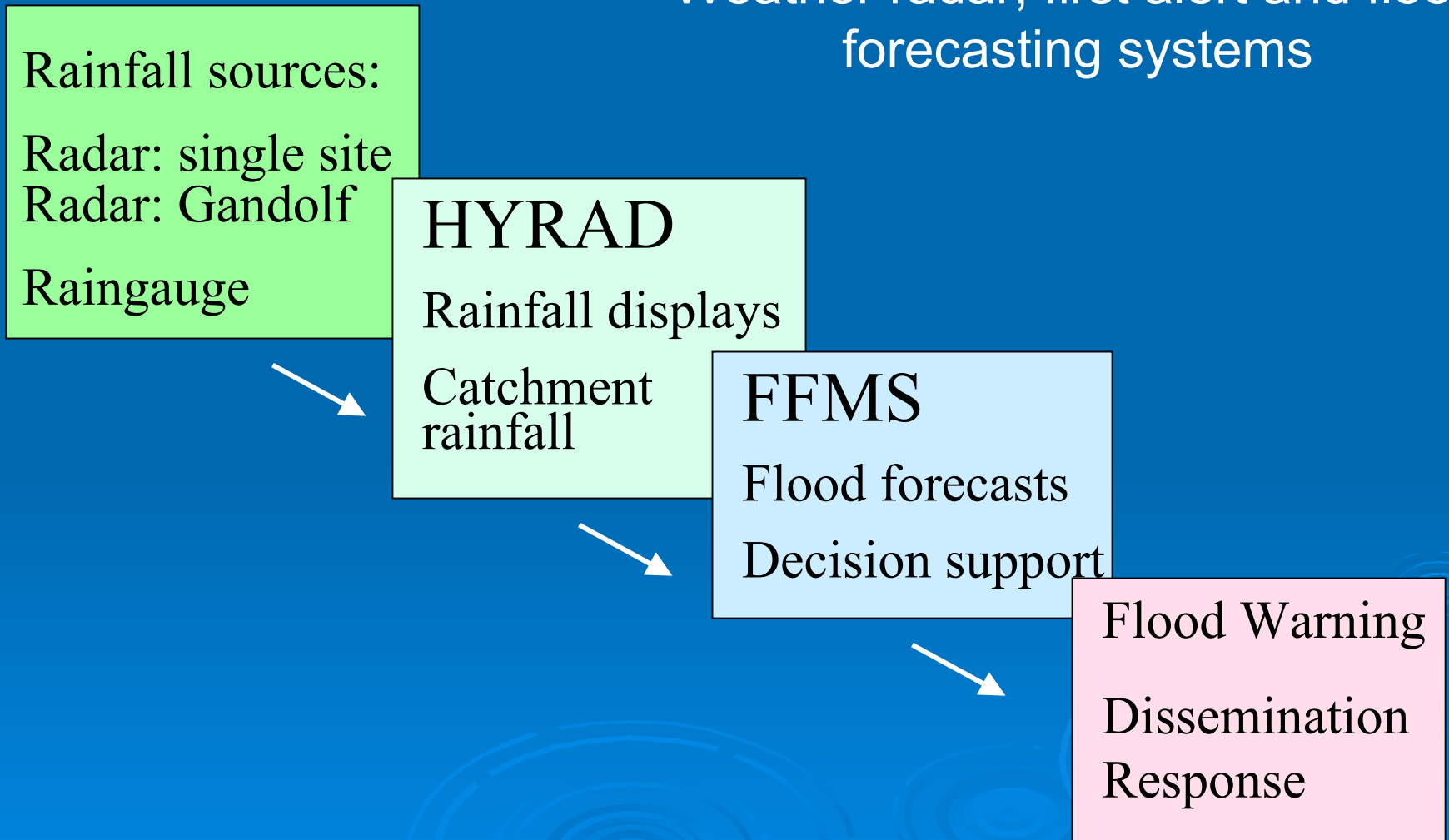Risk assessment procedure for drought management

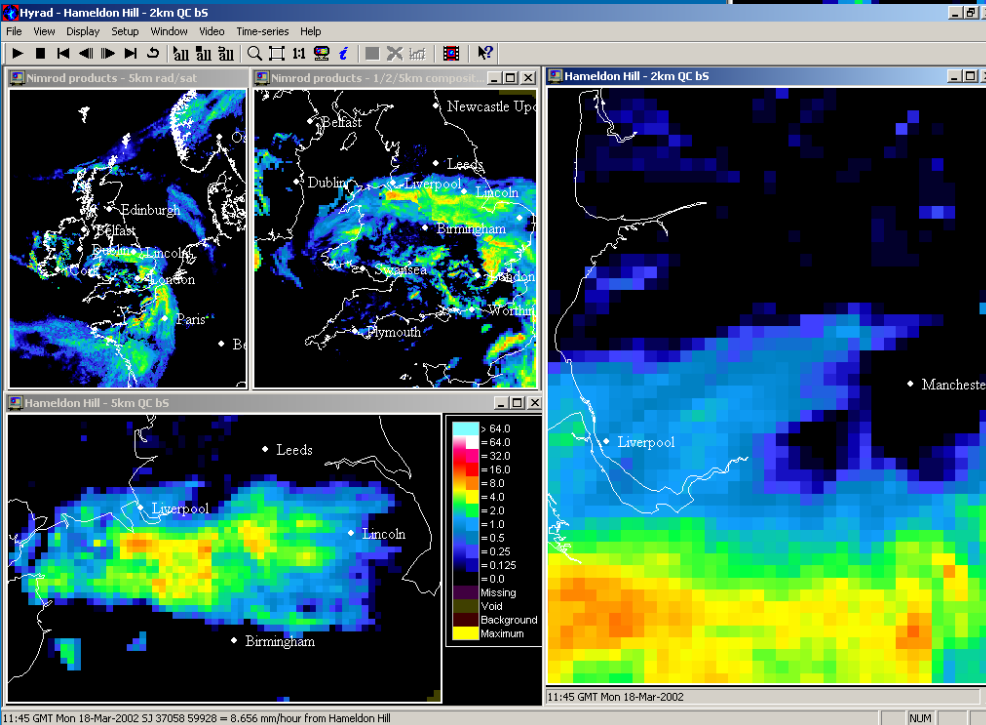Risk assessment of reservoir storage shortfall and demand restrictions

Flood Forecasting

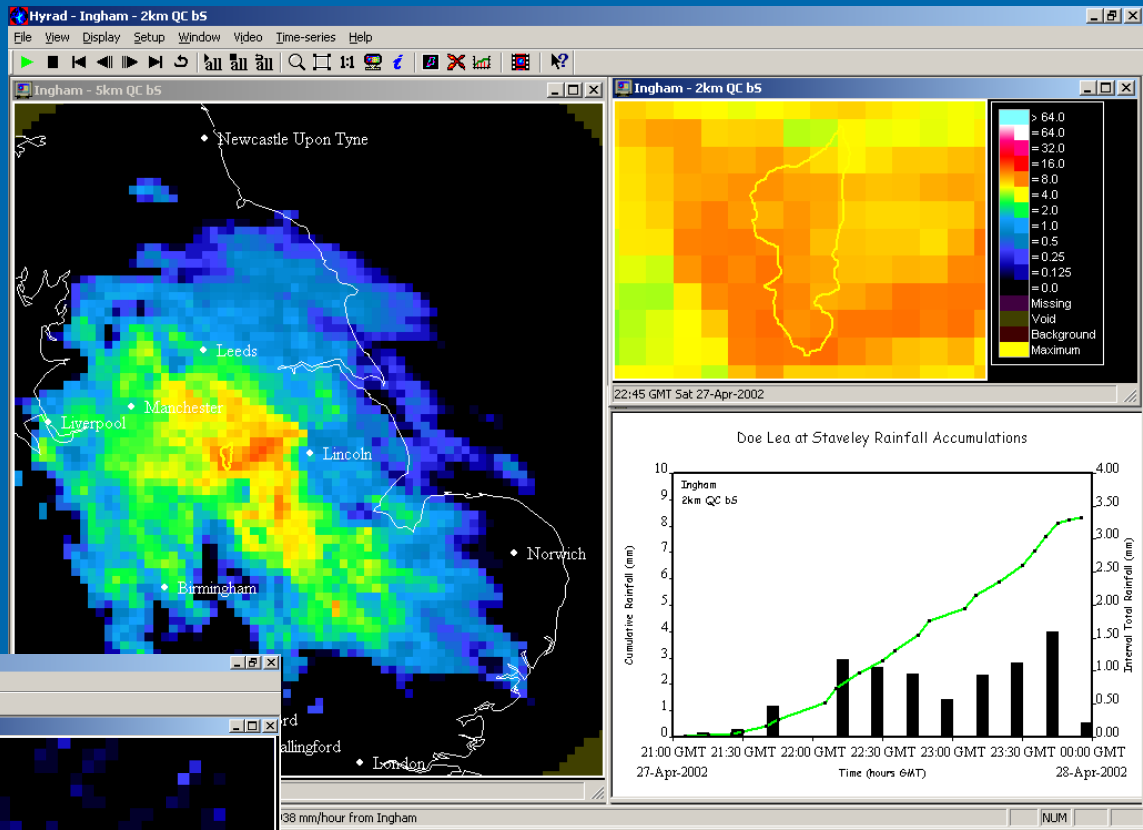Weather radar, first alert and flood forecasting systems

Rainfall sources:

Radar: single site
Radar: Gandolf

Raingauge

HYRAD

Rainfall displays

Catchment rainfall

FFMS

Flood forecasts

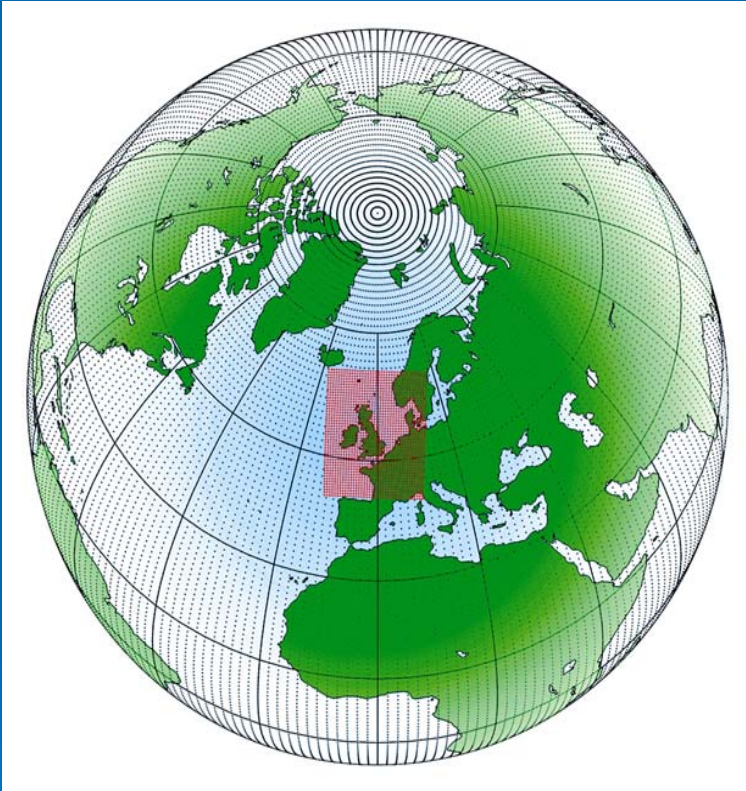Decision support

Flood Warning

Dissemination

Response

First Alert:

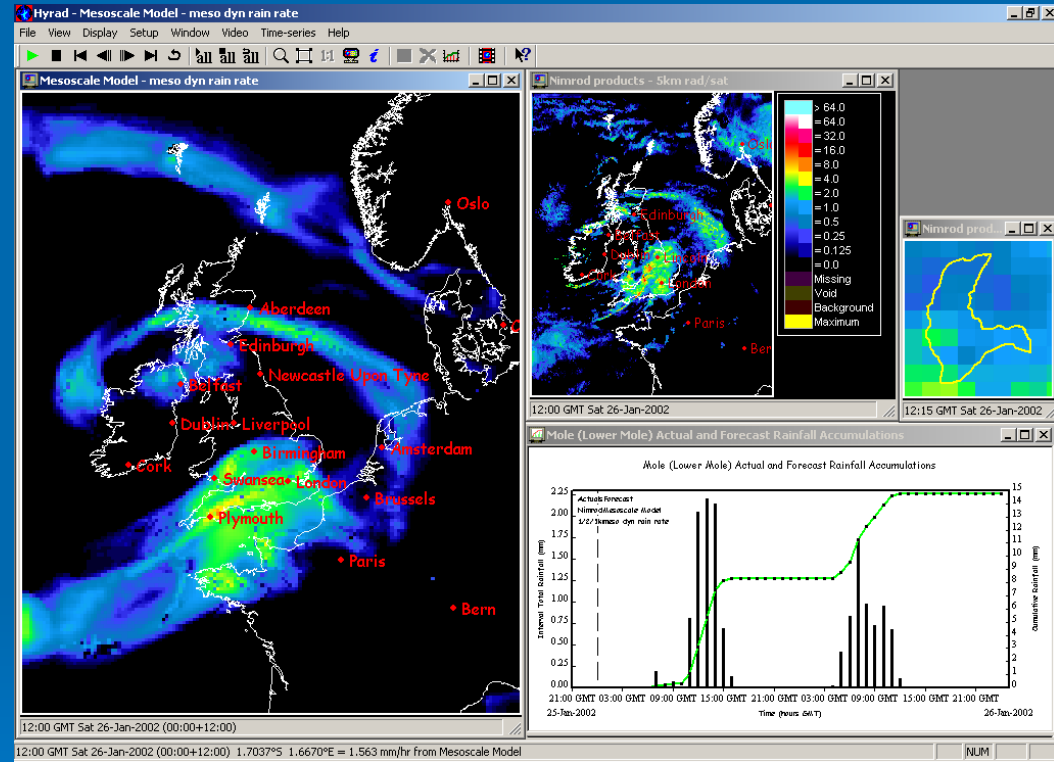Improved display of radar rainfall across scales; 0 to 6 hours, 1, 2, 5 km

HYRAD has been adopted as national standard by Environment Agency across England & Wales
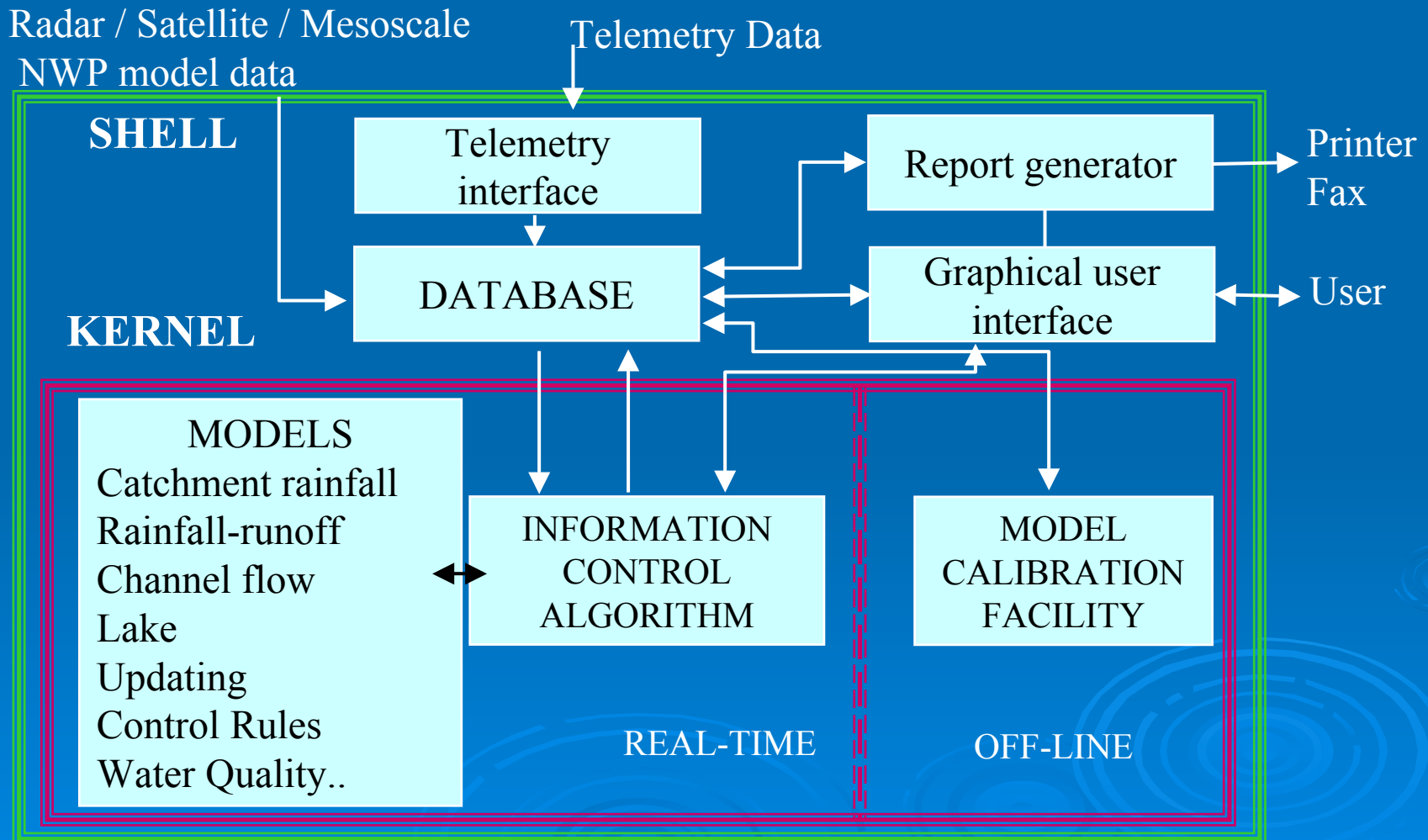
First alert warning products

Unified NWP Model grids:
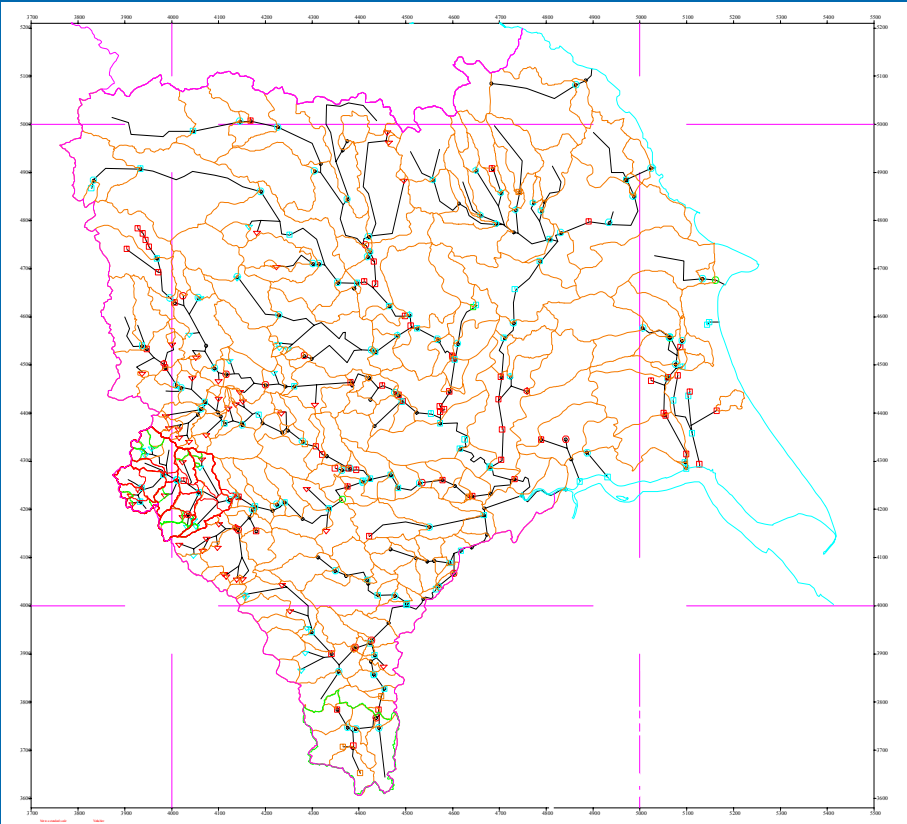global & mesoscale

12 hour ahead rainfall forecast from
Mesoscale Model, Nimrod radar actual
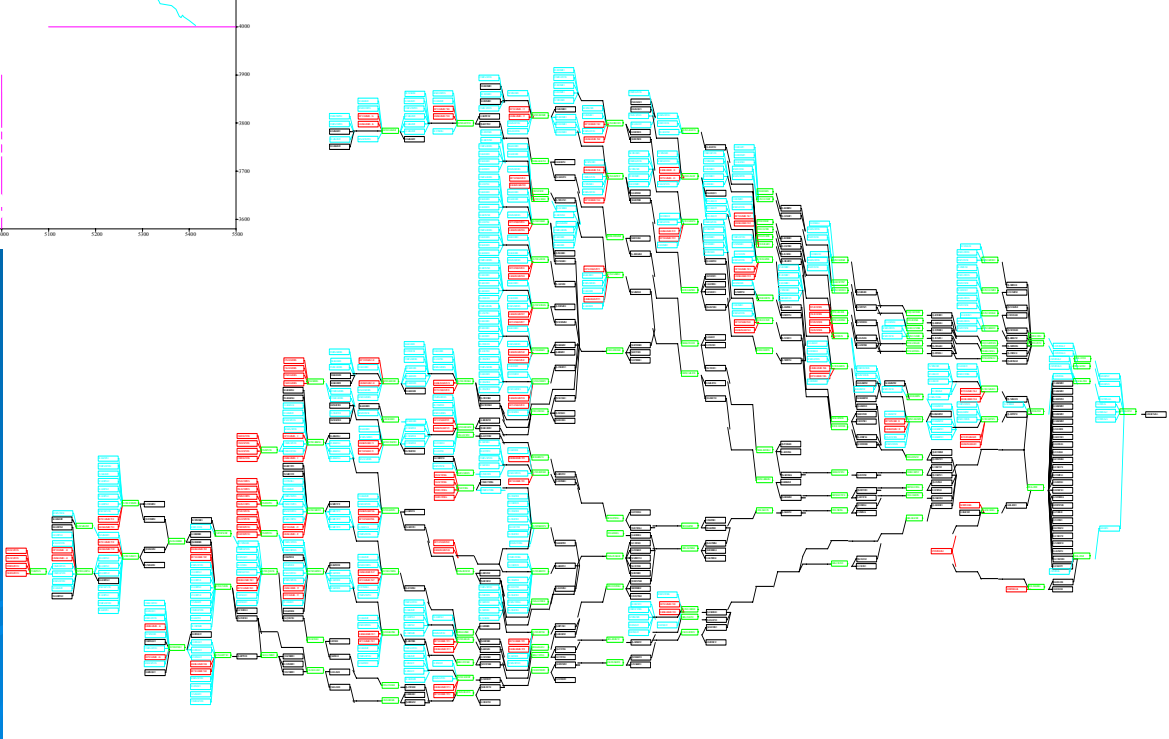and catchment hyetograph

12 km, 0 to 2 days

Flow Forecasting & Modelling System (FFMS) Design
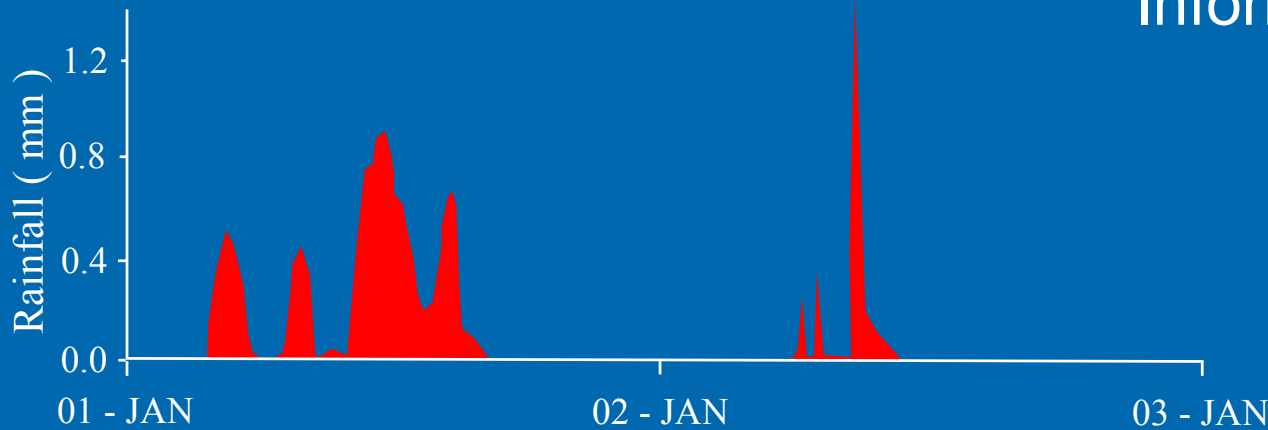
Model Network configuration
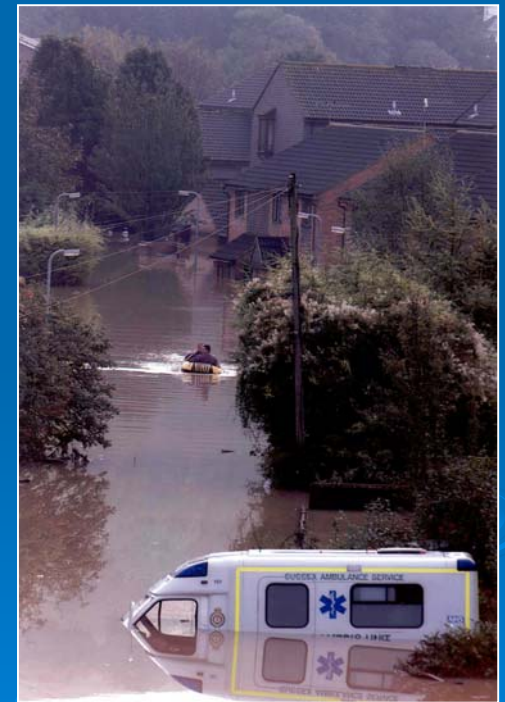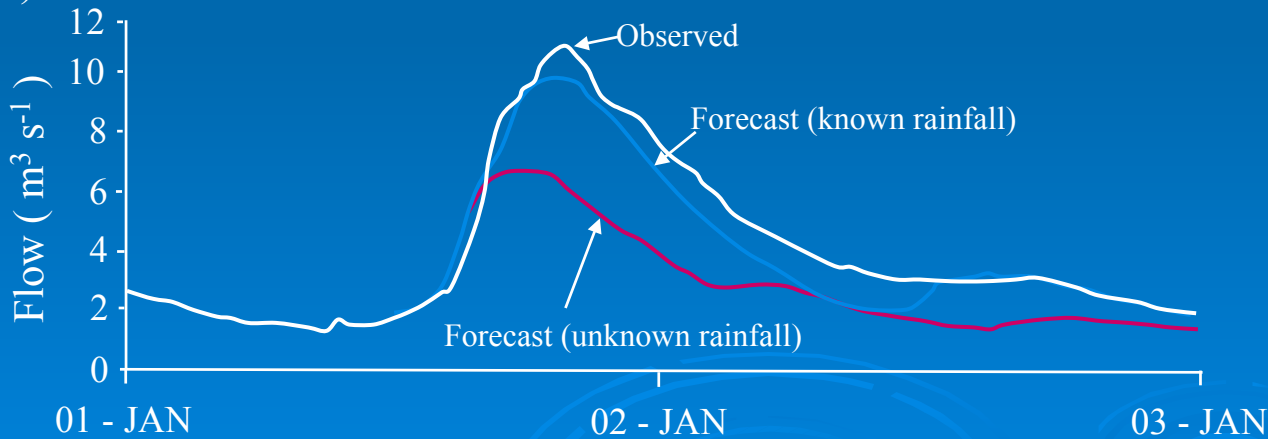
Propagation of uncertainty ?

Flood forecasting and warning

What ifs?
Informal ensembles

a) Rainfall

Rainfall (mm)

1.2

0.8

0.4

0.0

01 - JAN   02 - JAN   03 - JAN

b) Flow

Flow (m³ s⁻¹)

12
10
8
6
4
2
0

Observed

Forecast (known rainfall)

Forecast (unknown rainfall)

01 - JAN   02 - JAN   03 - JAN

Area-wide flow modelling

Land path

River path

Surface flow

Return flow

Sub-surface flow

River Seine at Paris
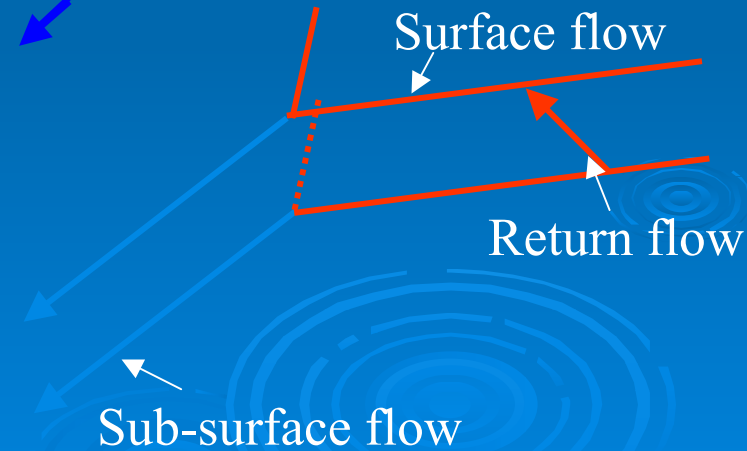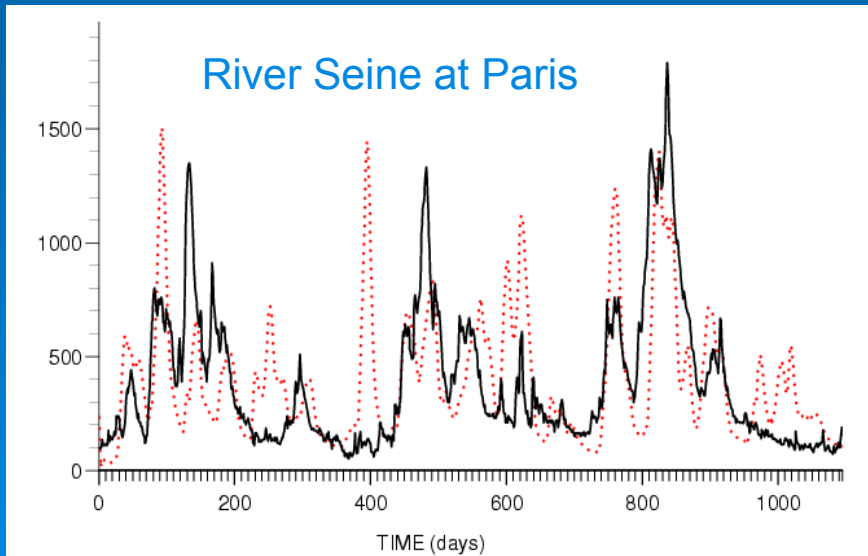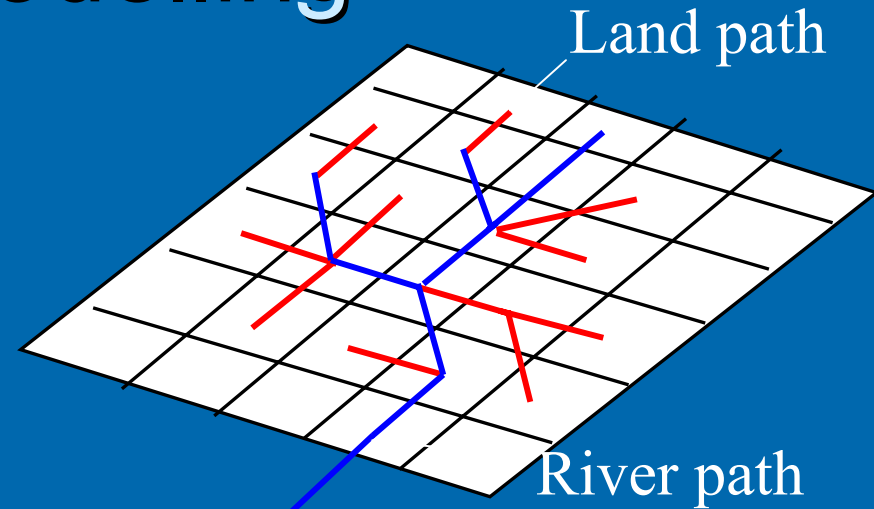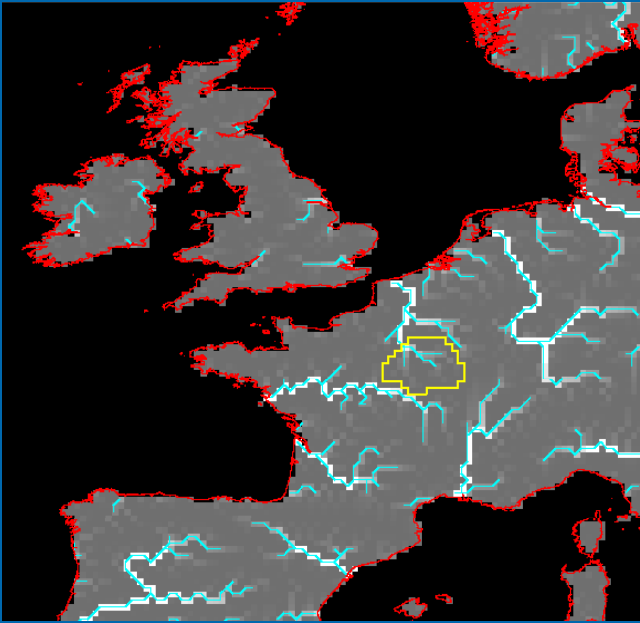
Area-wide Hydrological Grid Model with rainfall ensembles

Probability products?
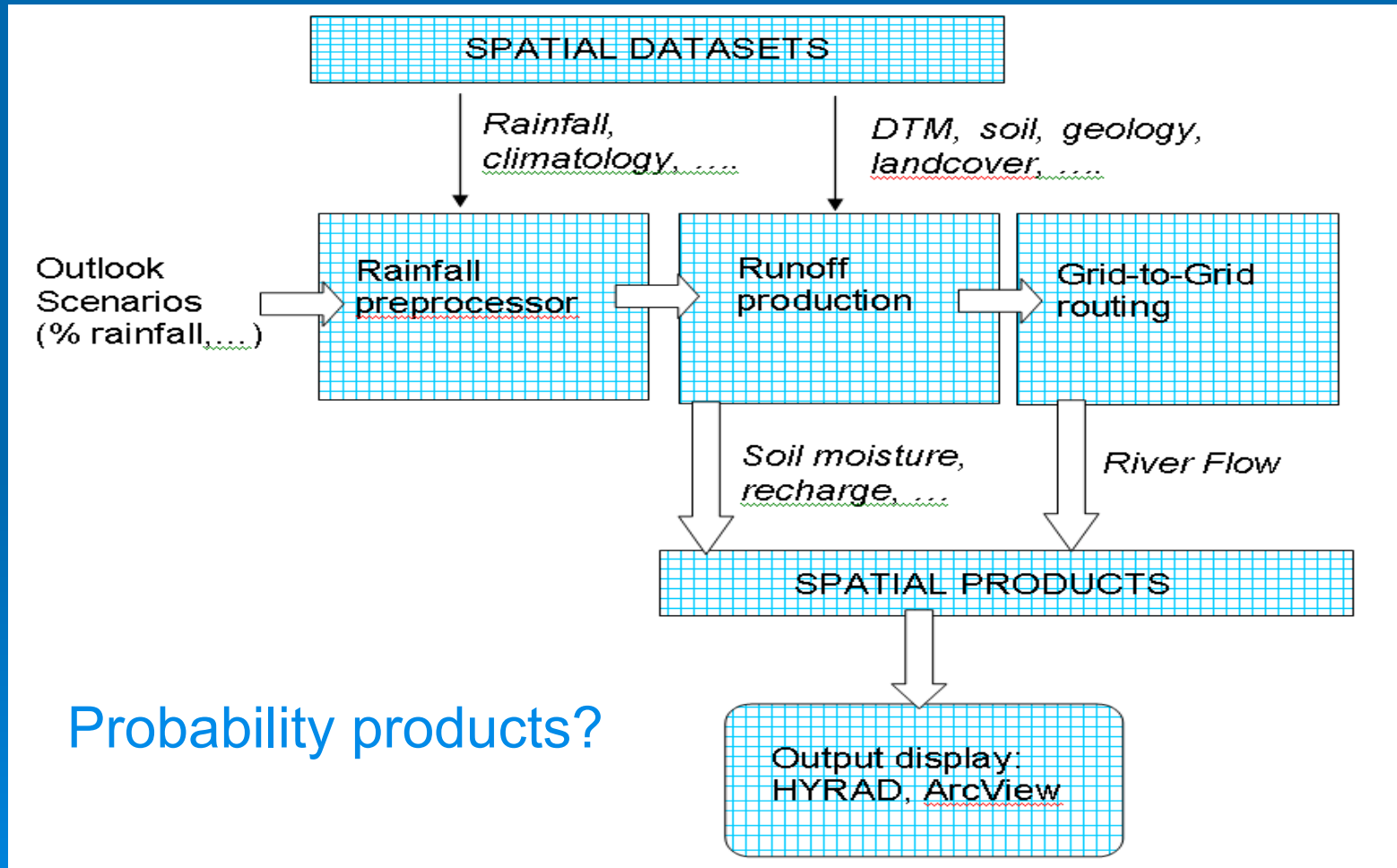
STochastic Ensemble Prediction System

➢ Model design

- Cascade framework to model dynamic scaling behaviour

- merging extrapolation nowcasts with NWP forecast
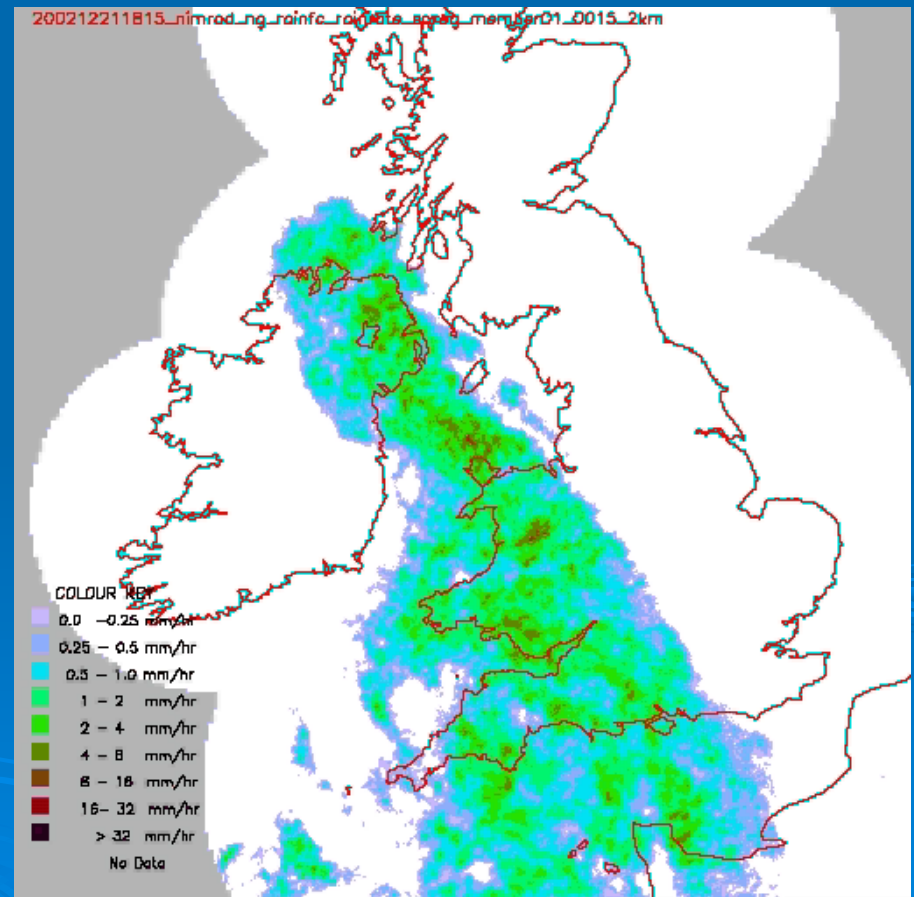
➢ Sources of uncertainty / error

- diagnosed velocity fields

- Lagrangian temporal evolution

- NWP forecast

- *initial state - radar inferred rain rate*

➢ Forecast evolution

- blends extrapolation, NWP and noise cascades

- stochastic noise
  - replaces extrapolated features beyond their life times
  - introduces features unresolved by NWP

- 100 member ensemble

➢ Stochastic noise progressively dominates the forecast from the smallest scales upwards.

➢This process is arrested by the NWP forecast.

- 4 km resolution
- 6 hour forecast
- 100 members

Towards probabilistic hydrological forecasting

➤ Uncertainty in rainfall input dominates (Moore, 2002)

➤ Ignore other error sources eg. rainfall-runoff model

➤ Ensemble of river flow from ensemble of rain accumulation

➤ Underestimates total uncertainty (Krzyztofowicz, 2001)

Case study: 21 December 2002
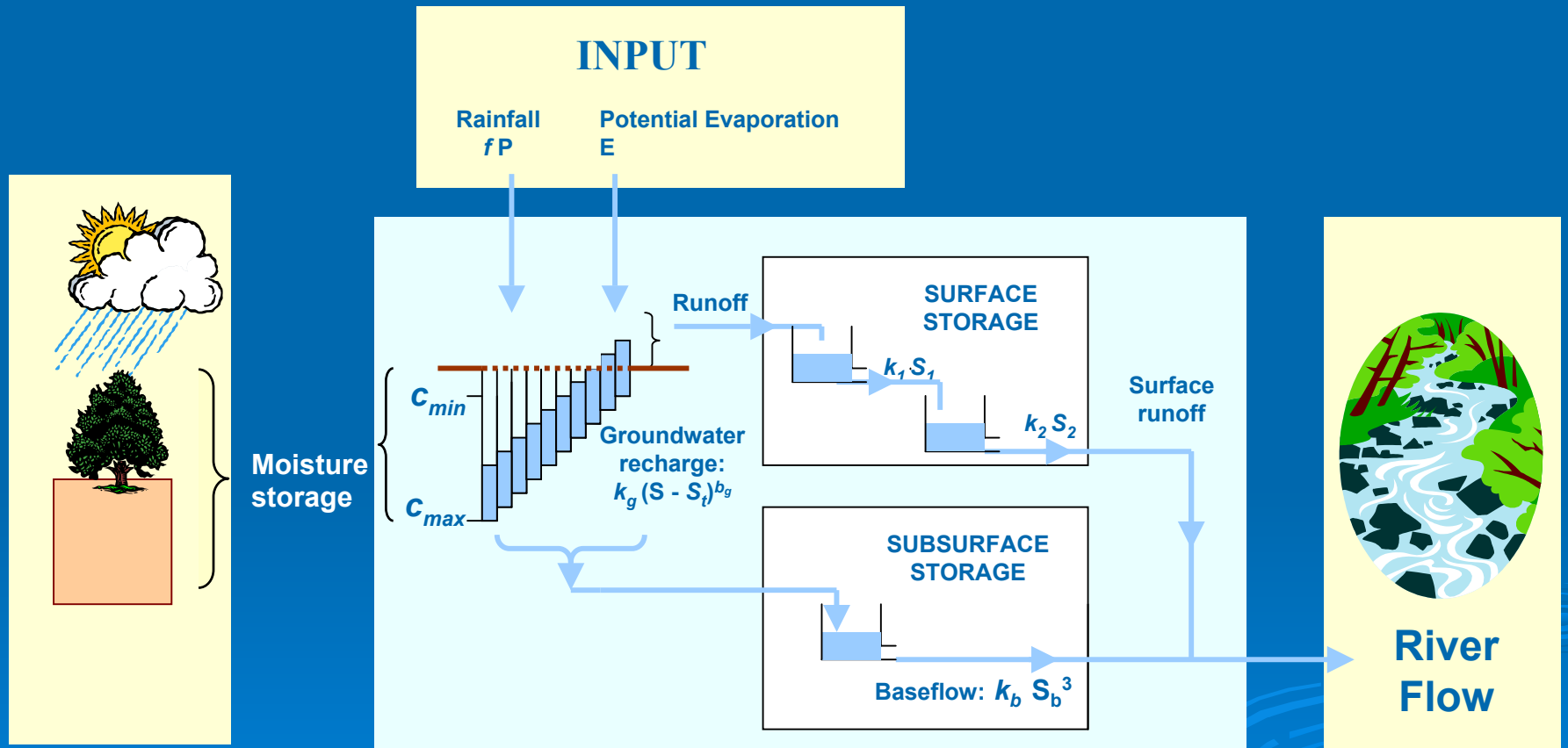
➢ Catchment

- River Mole, 142 km^2, S.E. England

➢ Rainfall forecast

- STEPS 100 member ensemble (no NWP)
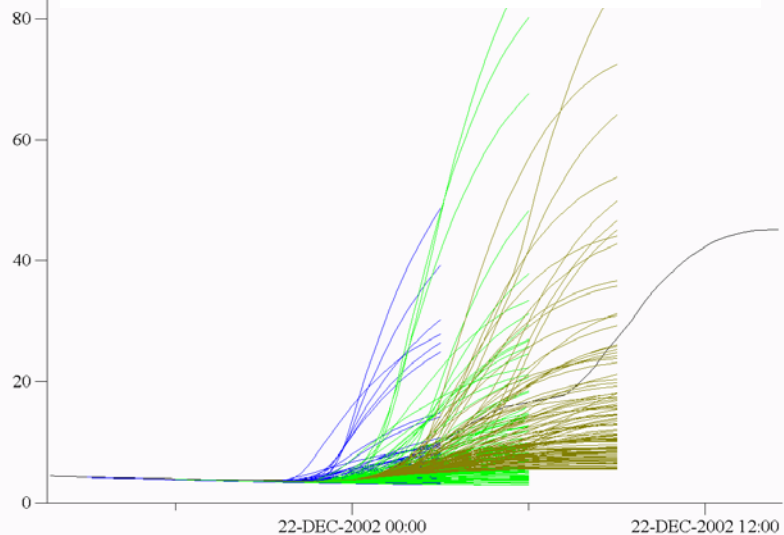- 15 minute accumulation
- range 6 hours

➢ River flow forecast

- Probability Distributed Model (PDM)
- Calibrated using radar data
- Forecasts from 3 time origins
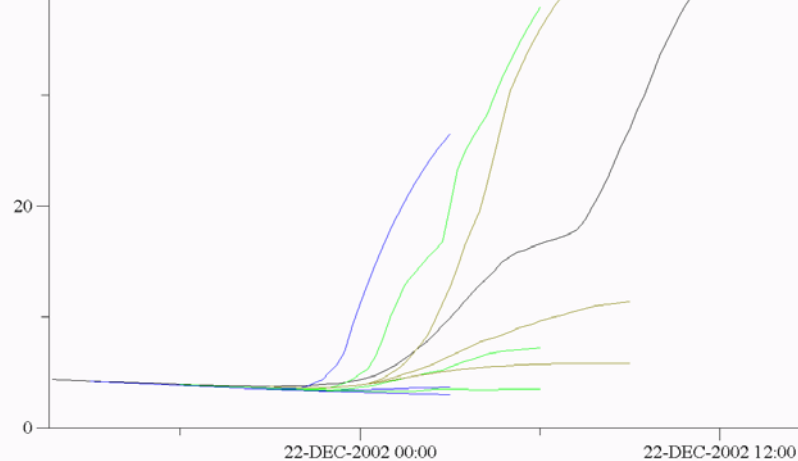- Forecast range extended using zero rainfall
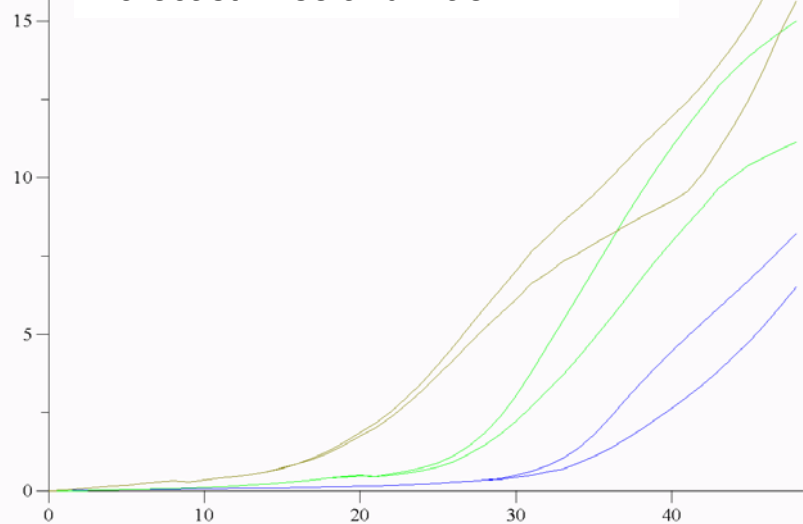
Probability Distributed Model

Forecast flow ensemble

5%, median, 95% points of flow forecast

Forecast rmse and mae

Probability Flood Forecasts from radar rainfall nowcast ensembles

CEH/Met Office/Australian Bureau of Meteorology collaboration

August 2002
European floods