Modelling Activities To Support Extended Hydrological Predictions

Narendra Kumar Tuteja
6 April 2009
Outline of the presentation

- The role of new Water Division of the Bureau
- Australian Water Resources Information System – AWRIS
- Water Forecasting Services Branch and its role
- Flood forecasting and warning services
- Extended hydrological predictions services (main focus of the presentation)
The Bureau’s new functions – Commonwealth Water Act 2007

• Issuing standards for water data measurement and transmission

• Aggregating all water information and make it freely available via the web, with value-added analyses

• Conducting regular national water resource assessments

• Producing an annual national water account

• Providing regularly updated water availability forecasts
Water Information System

- AWRIS
- End to end coverage of water data & information
Our vision...

Australia is better equipped to manage water scarcity and flood risk through ready access to high quality water information provided by the Bureau of Meteorology.

Led by...

Dasarath Jayasuriya, Jim Elliott and Neil Plummer
Water Forecasting Services Branch

- Flood Forecasts
- Flow Forecasts
- Seasonal Predictions
- Climate Change Projections

Decisions
- Emergency Response
- River Operations
- Water allocations
- Supply Planning

Time
- 1-72 hours
- 7-10 days
- 3-12 months
- Multi years

Flood Forecasting & Warning
Extended Hydrologic Predictions
Flood Forecasting & Warning

- Current system:
  - Flood forecast and warning (system evolved since the 1960s)
  - ~ 300 forecast locations
  - Event based hydrologic modelling (URBS/Hymodel)

- System improvements:
  - Pilot of new operational forecasting system – FEWS (Flood Early Warning System)
  - WIRADA research to support improved (continuous) modelling and other improvements
Flood Early Warning System (FEWS)

- Used by UK Environment Agency and elsewhere in Europe; being adopted by USNWS; many others
- Can be tailored to specific needs of forecasting agency
- Enables use of range of models and multiple data inputs
- Initial scoping work by CSIRO in Hunter Valley (NSW)
- Pilot study underway with BoM flood forecasters in Queensland
- Stage 1 completed by June 2009
WIRADA Research and Development – Short term

- Introduce continuous streamflow forecasting – improve flood forecasting and support short-term flow forecasting
- Physically-based spatially distributed hydrological modelling
- Model development to include:
  - Capability for flash flood forecasting
  - Quantifying forecast uncertainty
  - Incorporating hydrometeorological data (radar, QPF) as well as soil moisture data from remote sensing
Extended Hydrological Predictions – Key Result Areas (KRAs)

- **KRA1** – Better ‘seasonal’ water availability predictions
  - monthly out to a year
- **KRA2** – Better ‘long-term’ water availability predictions
  - next 10 to 30 years
- **KRA3** – Informing policy and servicing specialised user needs
- **KRA4** – A better place to work
  - A safe, healthy, productive and enjoyable place to work
KRA1 – Better ‘seasonal’ water availability predictions

• Seasonal predictions using a combination of two approaches
  – Seasonal hydrological predictions using statistical approach (Bayesian Joint Probability or BJP)
  – Seasonal hydrological predictions using dynamic approach

• Research support
  – WIRADA
  – CAWCR
  – Bureau of Meteorology
  – University sector
  – eWater CRC
Seasonal hydrological predictions - statistical

- Development of the BJP modelling approach (WIRADA; Wang et al.)
- Peer review
  - Journal (WRR), conference papers, internal review
- Operationalisation of the BJP approach (Bureau; Perkins et al.)
  - 12 comprehensive sub-projects with the aim of one pilot catchment in every jurisdiction
Seasonal hydrological predictions – dynamic

From Plummer et al. (2009)

~ 15 projects to develop this capability for 2 to 4 valleys across the continent.

Seasonal predictions using dynamic modelling
(Predictions at specified locations decided a-priori)

Evaluation of the seasonal predictions estimated from dynamic modelling
(Uncertainty assessment through total error analysis and advanced updating using data-model assimilation techniques)

Testing and validation of the hydrology model
(Conditional parameterisation and optimisation based on – dry/ wet years, ENSO/IOD/SAM/MJO and best predictors from the statistical BJP approach)

Specification of the catchment hydrology model
(Initial implementation of the lumped rainfall–runoff models and progressively moving towards physically based hydrological models)

Downscaled seasonal climate predictions
(Statistical downscaling models)

Seasonal climate predictions – hindcast datasets
(POAMA 1.5)

Seasonal climate predictions into the future
(POAMA 1.5/2.1)

Historical climate data
(AWAP/ SILO)
Catchment runoff generation and discharge processes

Storage in vegetation and soil
- Interception
- Litter storage
- Root zone
- Deep soil

Runoff concentration
- $P$ net
- $I = 0$
- $f_{sat} = f(\theta)$
- $g_{r,\text{recharge}}$
- $q_b$
- $q_{s1}$
- $q_{s2}$
- $q_i$

River discharge
- $f(\theta)$

Discharge routing in large river systems
- Urban areas (high direct runoff & clearly defined storage)
- Storage in river bed and floodplains
- Percolation
- Regulated rivers
- Unregulated rivers
- $Q_{routed}$
## Land surface hydrology – key differences

<table>
<thead>
<tr>
<th></th>
<th>Climate Science</th>
<th>Hydrology Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale (km(^2))</td>
<td>(10^4) to (10^5)</td>
<td>(10^2) to (10^3)</td>
</tr>
<tr>
<td>Lateral connectivity</td>
<td>Not necessary</td>
<td>Necessary</td>
</tr>
<tr>
<td>Lower BC (soil domain)</td>
<td>Free drainage</td>
<td>Specified head, flux or gradient</td>
</tr>
<tr>
<td>Topography</td>
<td>Not included</td>
<td>Included</td>
</tr>
<tr>
<td>Calibration – generated runoff</td>
<td>Residual term</td>
<td>Inverse modelling</td>
</tr>
<tr>
<td>Calibration – routed runoff</td>
<td>Not needed</td>
<td>Inverse modelling</td>
</tr>
</tbody>
</table>
Review of the physically based hydrologic modelling approaches in Australia

- Extended Hydrological Predictions Group, Water Division initiative with input from CSIRO, DPI Vic and Universities (Newcastle, UNSW, Melbourne, Macquarie and UWS)

- Hillslope hydrology theme
  - 3PG, CLASS, SGS, CAT, HFE expt.

- Catchment hydrology theme
  - FCFC, CLASS, CAT, Macaque, LUCICAT, CATSALT, RHESSys, BC2C

- Bushfire theme
  - Experimental and (stochastic) modelling approaches

- Uncertainty analysis (BATEA)
Hillslope hydrology theme (3PG/3PG+; Landsberg and Waring, 1997)
Concluding remarks

• Focus in the Forecasting Services Branch
  – Flood forecasting and warning
    • Further improvement in the current operational services
    • Supported by research under WIRADA
  – Extended hydrological predictions
    • Initial focus on seasonal predictions
    • New business area and early days......
    • Supported by research under WIRADA, CAWCR, BoM, University Sector and eWater CRC
Thank you…

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