

An Integrated Meteorological /Hydrological Model for the Mawddach Catchment, North Wales

by

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Abstract

This project makes a study of meteorological and hydrological processes operating in the Mawddach river catchment of North Wales, with the objectives of recommending catchment management options to reduce the severity of flooding and to produce a design for a high resolution flood forecasting model for the catchment.

An array of rain gauges installed across the catchment has allowed the detailed mapping of rainfall distributions. Two patterns are identified, with axes of high rainfall running NW-SE and N-S respectively. Within these zones, the locations of rainfall maxima do not necessarily correspond with the highest altitude. The approach direction of weather systems and the funnelling of air flows along deep valleys appear to control rainfall distribution.

A series of flood events are examined, particularly the convective squall line storm of 3 July 2001 and the period of intense frontal rainfall of 3-4 February 2004. Modelling of rainfall is carried out using the MM5 meteorological model. It is found that frontal rainfall can be forecast to a high degree of accuracy. Convective thunderstorm events are less predictable, and different convective physics schemes within the MM5 package had differing degrees of success in forecasting the July 2001 Mawddach storm.

The catchment is an area of hard, low permeability Palaeozoic rocks. Thick deposits of glacial and periglacial materials are locally present, particularly in valleys. Experiments to monitor hillslope throughflow and runoff show that these superficial deposits play a crucial role in controlling the antecedent conditions necessary for saturation-excess flood events.

Deep blanket peat is found at a number of upland sites in the catchment. Watertable monitoring indicates that older peat has a low water storage capacity, with saturation possible within a few hours of heavy rainfall. Areas of young *Sphagnum* peat can act as regulating reservoirs for flood water, and should be conserved.

Field monitoring of river bed temperatures shows that resurgence of groundwater can occur in the deep river valleys of Coed y Brenin during storm events. However, resurgence occurs after the flood peak has passed and is not thought to influence the severity of flooding.

Flood scenarios for the town of Dolgellau are investigated, including the effects of continued gravel deposition in the River Wnion. Gravel supply should be controlled through planting of native broadleaf woodland on riverbanks of (peri)glacial materials. A flood reduction scheme is proposed, with establishment of wet woodland and creation of a flood interception basin in the lower Wnion valley.

Field monitoring of river and tidal flows at the head of the Mawddach estuary indicates no additive effect of river flood and tidal peaks. Flooding at the head of the estuary is generally caused by river flows. Further reclamation of salt marsh could worsen upstream flooding.

A new hillslope model has been written which allows for changing antecedent soil moisture conditions. The model generates a soil distribution based on the HOST (hydrology of soil types) scheme. A flood forecasting system is developed by combining the hillslope model with MM5 and existing river routing and floodplain modelling components. The system operates by a combination of parallel and distributed processing, to produce forecasts within an operationally useful timescale.

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Declaration

This work has not been previously accepted in substance for any degree and is not being concurrently submitted in candidature of any degree. This thesis is the result of my own investigations, except where otherwise stated. Other sources are acknowledged by references in the text. A bibliography is appended.

I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

Signed (candidate)

Date

Signed (supervisor)

Date

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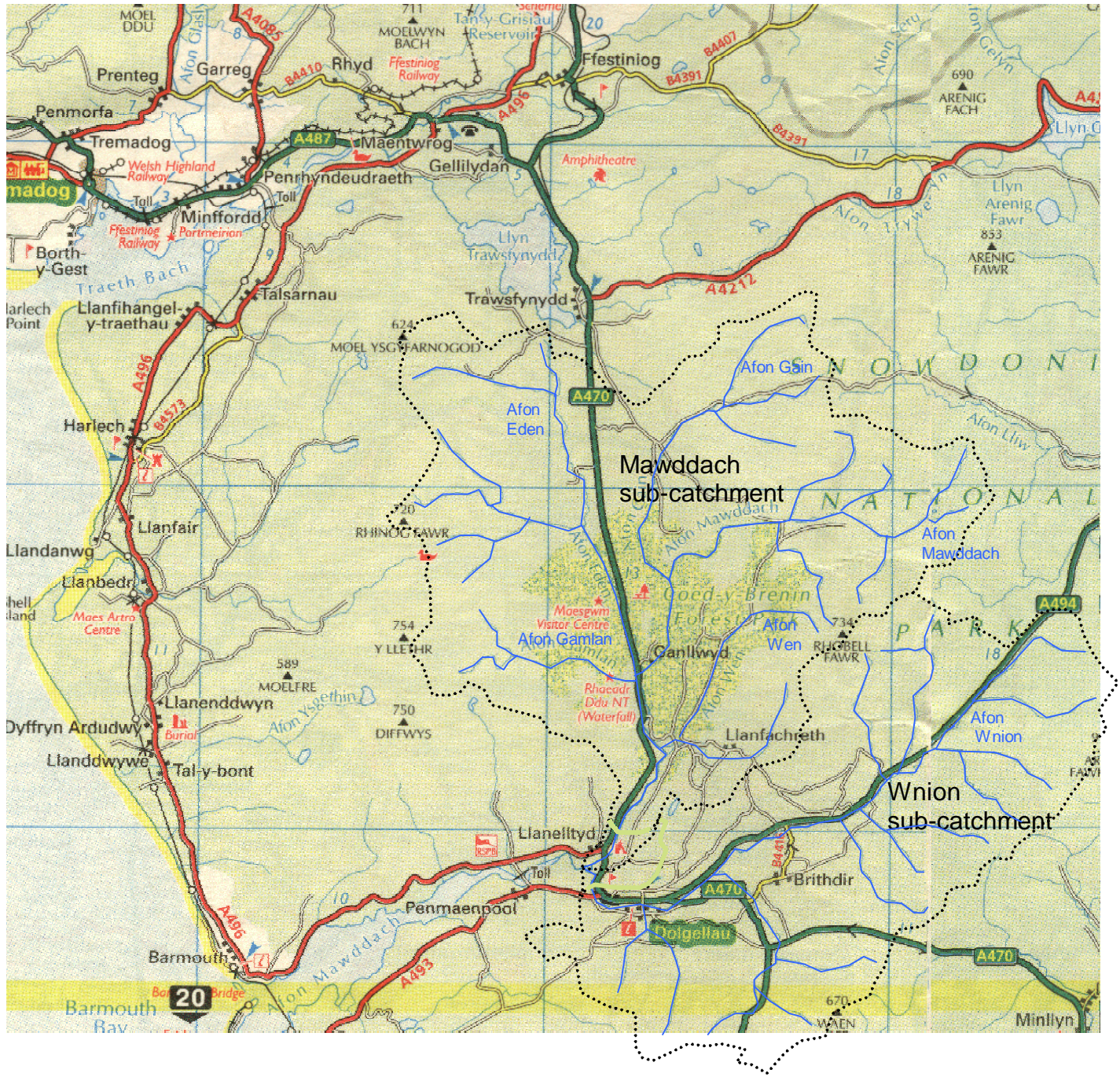


Figure i. Mawddach-Wnion catchment location map

Publications related to the project:

- Hall G. and Cratchley R., 2005. Modelling frontal and convective rainfall distributions over North Wales. Proceedings of the 2005 WRF/MM5 User's Workshop, National Centre for Atmospheric Research, Boulder, Colorado.
- Hall G. and Cratchley R., 2005. The role of forestry in flood management in a Welsh upland catchment. Proceedings of the 45th Congress of the European Regional Science Association, Amsterdam.
- Hall G. and Cratchley R., 2006. Sediment erosion, transport and sedimentation during the July 2001 Mawddach extreme flood event. In: Sediment Dynamics and the Hydromorphology of Fluvial Systems. IAHS publication 306.
- Hall G. and Cratchley R., 2006. Coupling of MODFLOW with the MM5 mesoscale meteorological model for real-time input of high resolution rainfall events in a mountainous area. In: Managing Groundwater Systems. International Groundwater Modelling Center, Colorado.
- Hall G. and Cratchley R., 2006. A hydrological study of Waen y Griafolen blanket bog, North Wales. Proc. International Conf. on Hydro-ecology. Carlsbad, Czech Republic.
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- Hall G. and Cratchley R., 2007. Mechanisms of flooding in the Mawddach catchment. In: Hydrology and Management of Water Resources in Celtic Countries. IAHS publication 310 (in press)
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