# HYDALP integrating EO data with snowmelt models

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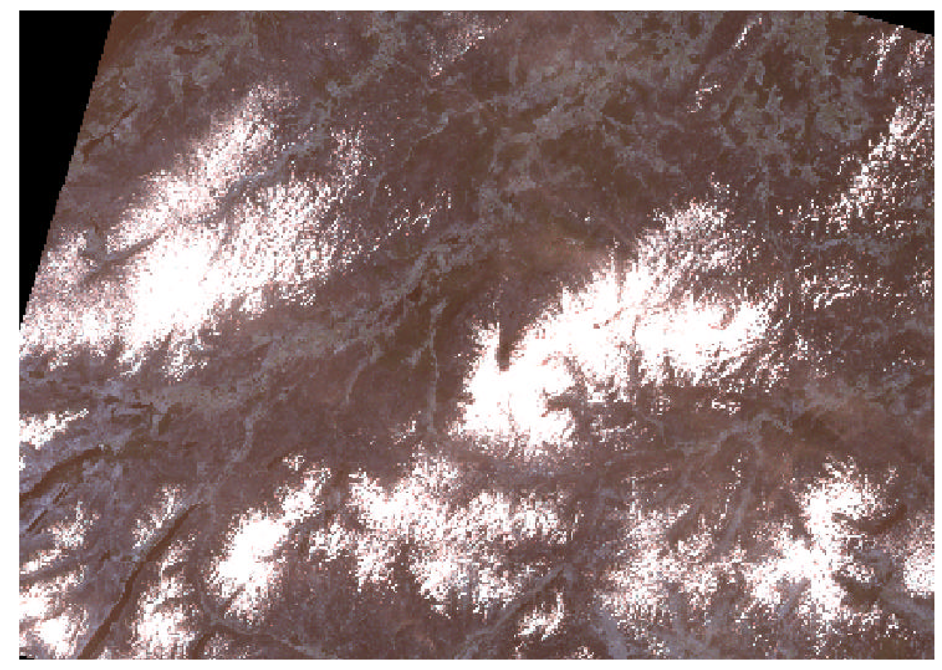
### Why model snowmelt?
Within a river catchment, a large quantity of water can stored as snow.

In catchments where hydro-electric power is generated, snow cover represents a potential source of water in addition to that contained within the artificial reservoir. An estimate of the amount of snow water available and a prediction of when it will melt will allow more efficient reservoir management and power production.

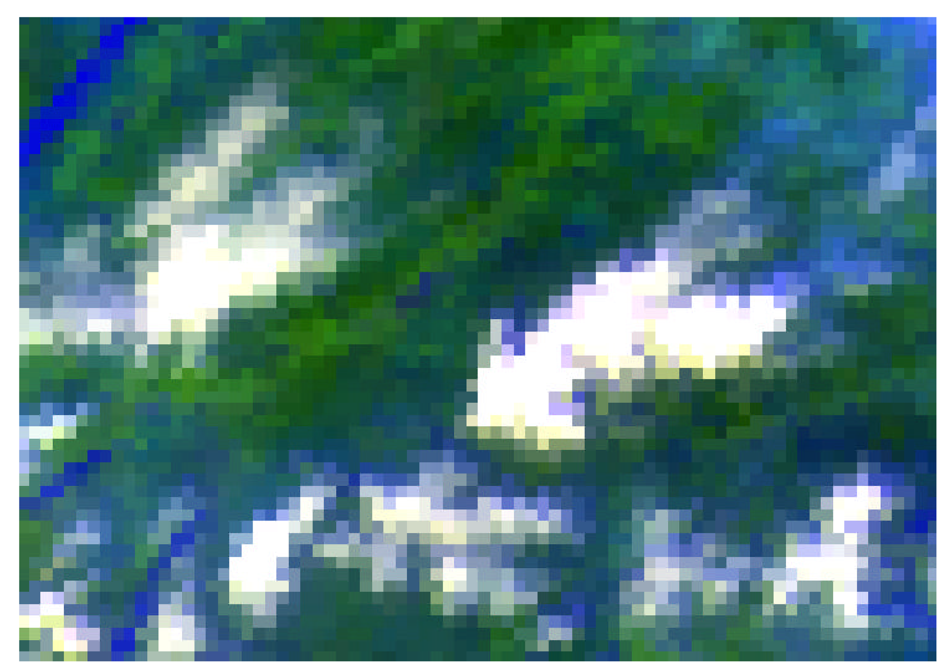
Such knowledge may also facilitate flood prediction, reducing the consequences of extreme and prolonged flooding associated with rapid snow melt.

### The HYDALP project and snowmelt runoff prediction
HYDALP is using two existing snowmelt models SRM* and HBV**. to estimate snow runoff. Both these models use satellite images or aerial photographs to provide information on the area of snow. HYDALP aims to develop automated image processing techniques to permit near real-time forecasting and will be testing the models within the Spey catchment in Scotland.

### How the models work
SRM, for example, divides the catchment into zones representing a 300-500 m elevation band. The runoff from each zone is calculated from the area covered by snow, the mean daily temperature and the degree day factor. If it is known how the snow covered area decreases during the spring, then a seasonal forecast can be made.



Landsat TM - good spatial but poor temporal resolution



AVHRR - poor spatial but good temporal resolution

## Estimating snow covered area

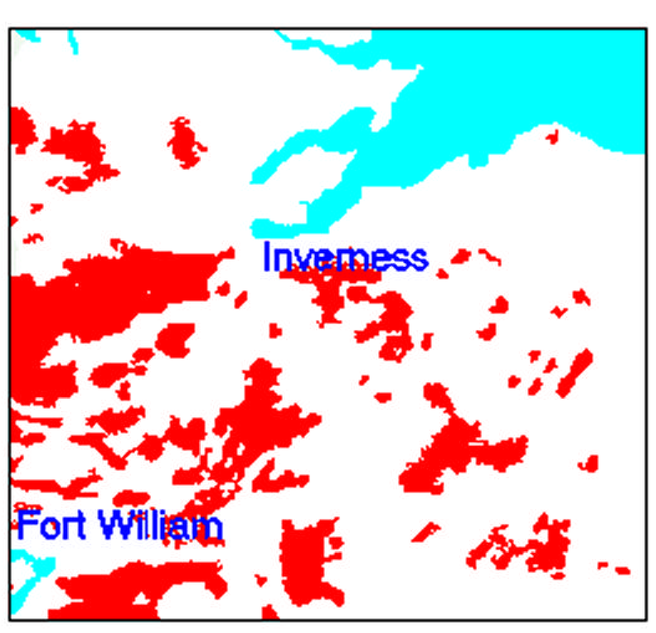
When good images are available, Earth Observation (EO) data can be used to identify the location of snow.

Landsat TM imagery can provide an estimate of the area of snow with a spatial resolution of about 30m. However, since Landsat TM overpasses occur only every 16 days and many images are of limited use due to cloud cover, then often only one or two useful images are available during a winter season.

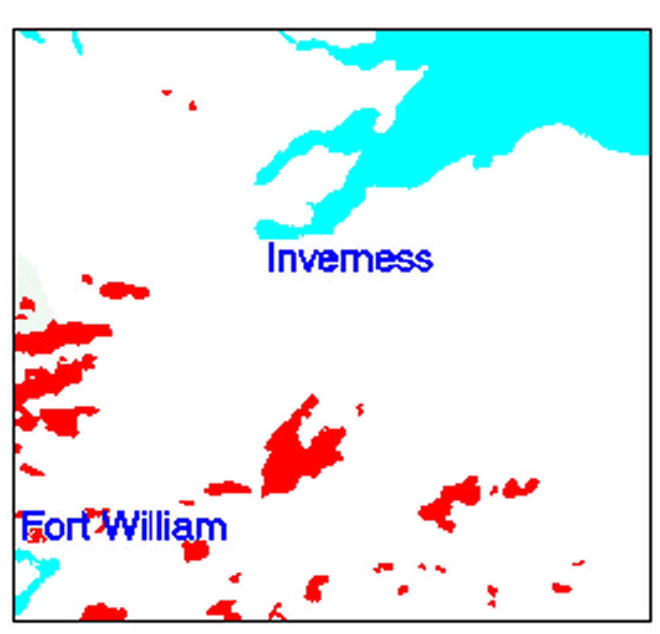
NOAA AVHRR overpasses occur several times per day, allowing data collection on any cloud free day during the winter. While this temporal resolution is excellent, the spatial resolution of 1.1km is rather poor.

This is particularly important in catchments such as the Spey where steeply sloping terrain allows for variations in excess of 500m within a 1.1km x 1.1 km area, so that some parts of the pixel may contain snow, yet others be snow free

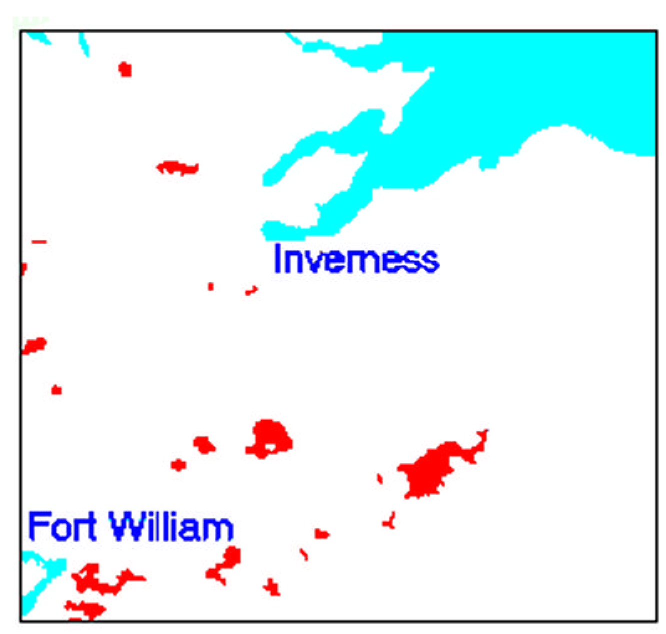
It would be beneficial, therefore, to be able to estimate what proportion of a pixel is occupied by snow.
The IMAGINE sub-pixel modeller (Applied Analysis Inc. 1998) was used to do this and has been discussed elsewhere (Benham *et al.* 1998).



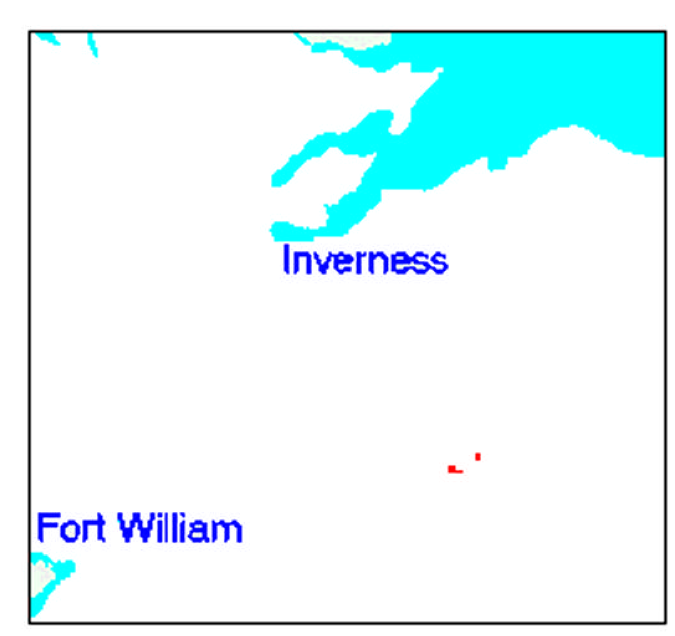

Early January




Mid February




Early April




Late April

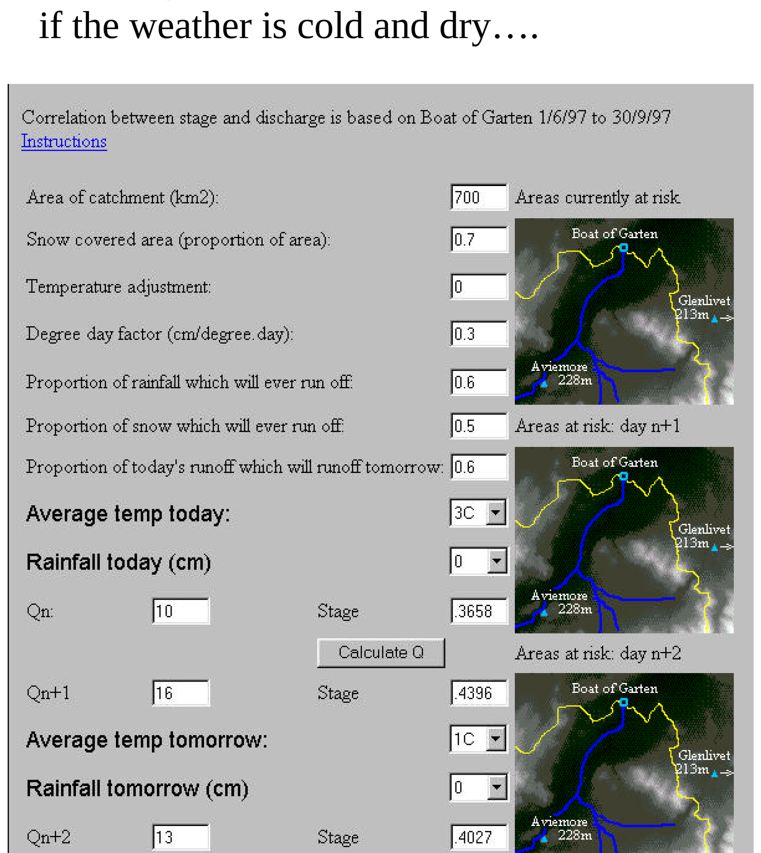
Change in snow covered area during early 1997 (derived using AVHRR full pixel classification)‡.

## Developing a simplified version of an 'SRM like' model for use on the Internet

A simplified version of a model similar to SRM has been developed using Javascript for distribution via the World Wide Web. Examples of the model outputs are given below which indicate the effect of various climate scenarios on runoff and flood risk.

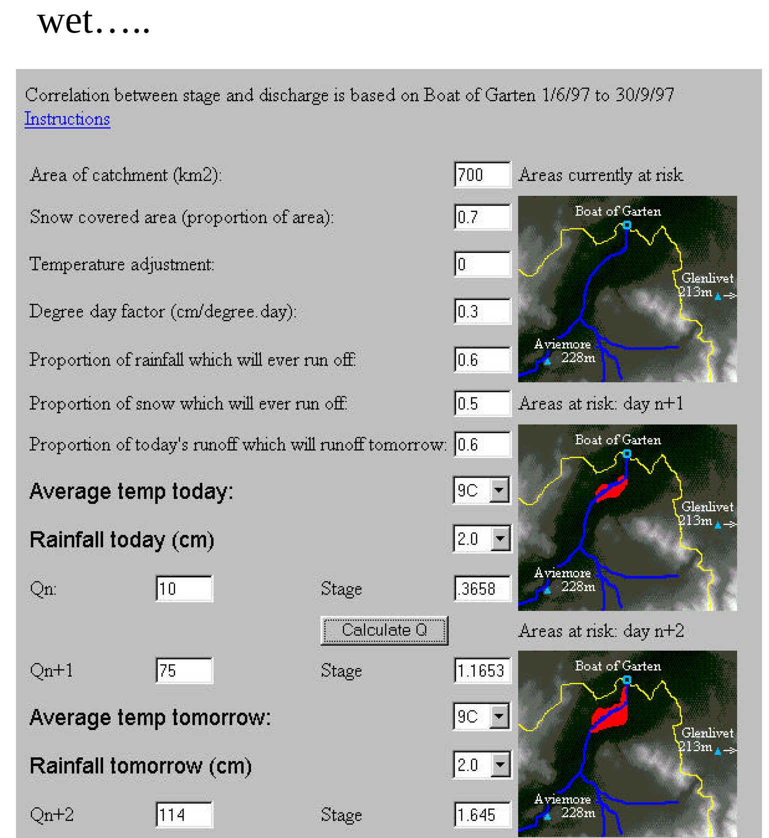
**Note:** Currently this is a prototype, but will be further developed in the near future. All comments are most welcome

For the given snow covered area:
if the weather is cold and dry….



Conclusion: no flooding occurs.

On the other hand, if the weather is warm and wet…..



Conclusion: extensive flooding occurs.

### Is sub-pixel better than full pixel classification?
Benham *et al.* (1998) found that, for a whole AVHRR image of more than 3000 km², the total area of snow estimated by the sub-pixel classifier was similar to that estimated using an unsupervised full pixel classification, although some errors in estimating the location of snow were found. As such little improvement was achieved.

Within small catchments (10km²), however, the increased accuracy would be of greater importance, provided that accurate image registration could be achieved.

### Where next?
Although the sub-pixel classifier provides information on the amount of snow within a pixel, no information is available as to *where* the snow will be. If this was known then the snow could be allocated to a particular elevation allowing further refinement of the snowmelt model.

### Further information
Further information about the HYDALP project can be found at http://bamboo.mluri.sari.ac.uk/hydalp/

### References
**Applied Analysis Inc. (1998)** IMAGINE sub pixel Classifier™ V8.3 User's Guide, version 1.4.2
**Benham, T., Wright, G., Dunham, R., Wright, R. and Miller, D. (1998)** NOAA AVHRR Sub-pixel snow classification. *Erdas UK Users Group Meeting*, Cambridge. September 1998
**Martinec , J. (1975)** Snowmelt-Runoff model for stream flow forecasts *Nordic Hydrol.* 6(3) 145-154

*SRM - snowmelt runoff model developed by Martinec (1975)
** HBV developed by Swedish Meteorological and Hydrological Institute
‡ (Derived with the collaboration of the BNSC Scottish Snow Cover Project at the University of Dundee.)