Innovative technologies for scientific wetland management, conservation and restoration

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Abstract Innovative technologies are being developed within the SHYLOC project, which is partly funded by the European Commission’s Space Technology programme under the 4th Framework Programme, to provide improved tools for wetland modelling and satellite-derived information for wetlands that can be used for calibrating hydrological models. The project comprises three main components: (a) a software tool, SHYLOC, that uses a unique method to combine Landsat-TM images with digitized drainage or irrigation ditch networks to determine surface water storage; (b) a coupled hydrological and hydraulic modelling system that can incorporate hydraulic boundary conditions commonly associated with wetlands; and (c) a comprehensive hydro-meteorological database for four wetland sites in England and Greece. Preliminary results are promising. The SHYLOC software and the coupled hydrological/hydraulic modelling package have been completed and are being applied to the project test sites. There is a correlation between space-borne and ground based measurements of ditch water levels, and water balances are being prepared for two of the wetland sites.

Key words coupled MIKE SHE/MIKE 11 modelling package; ditch water levels; Elmley Marshes (north Kent, England); Landsat TM; nonlinear regression; SHYLOC; water level recorders; wetland hydrological modelling

INTRODUCTION

According to Mitsch & Gosselink (1993) hydrology is probably the single most important determinant of the establishment and maintenance of specific types of wetlands and wetland processes. Moreover, as the central concept of hydrology, the water balance has a unique position in wetland management, conservation, and restoration. A detailed wetland water balance, both spatially and temporally, is a sound
foundation upon which to base wide-reaching decisions that include resolving conflicts between development and conservation (Gilman, 1994; Hollis, 1996). Frequently, however, little is known about historical hydrological conditions within wetlands, such as water levels and extent of inundation. This paper describes how new integrated technologies are being developed to improve wetland hydrological modelling and to provide data derived from satellite imagery that would otherwise be rare and which can be used for calibrating hydrological models.

HYDROLOGICAL MODELLING

In wetlands, water storage rather than flow dominates the water balance, and they are often characterized by complex hydraulic boundary conditions (e.g. sluices, pumping systems, earth dams). Kaiser et al. (1997) and Al-Khudhairy et al. (1999) found that the deterministic, fully distributed, and physically-based hydrological model MIKE-SHE (DHI, 1993) was capable of modelling wetlands but that hydraulic features such as pumps needed careful handling. Coupling MIKE-SHE with the hydraulic model MIKE 11, and using the Danubian Lowland between Bratislava and Komárno as a test site, was found to improve the representation of hydraulic features (Refsgaard & Sørensen, 1997). One objective of the SHYLOC (System for Hydrology and Land Observation for model Calibration) project is to permanently couple these two models, thus creating a better tool for wetland modelling. This coupled system is being applied to two of the SHYLOC test sites, and preliminary results show that this approach is able to provide a more complete representation of the hydrology of the wetlands, yielding improved predictive capabilities.

REMOTE SENSING FOR HYDROLOGICAL MODELLING

The SHYLOC software uses a unique method (Shepherd et al., 2000) to combine Landsat-TM images with digitized networks of drainage or irrigation ditches to determine surface water storage (Calaon et al., 1999). The ability of SHYLOC to provide calibration data for wetland hydrological models is being examined for an English test site, the Elmley Marshes (north Kent, England). The site is an area of scientific and conservation interest where the needs of conservation must be balanced with those of farming, and where ditch water levels need to be kept high and to flood at regular intervals in order to maintain the wetland ecosystem. SHYLOC generates estimates of satellite-derived wet ditch widths. Functional relationships are then established between these wet ditch widths and water levels measured using automatic water level recorders (pressure transducers and data loggers) and stage boards.

SHYLOC was applied to control areas around three stage boards, and an automatic water level recorder installed in the Elmley Marshes. Nine Landsat-TM images were subjected to geometric and atmospheric correction. Nonlinear regression relationships were established between satellite-derived wet ditch widths and observed ditch water levels (Fig. 1). The relationships derived for the stage boards are notably different from that for the automatic water level recorder. The dominant reasons include the different cross-sections of the ditches in which the stage boards are installed compared to the
Exponential combined with polynomial curve order 2: \( y = a \exp(bx + cx^2) \)

![Graph showing the regression of observed ditch water levels for control sections around three stage boards and a pressure transducer with satellite-derived wet ditch widths. Each point is determined from a single Landsat TM image and observed ditch water level.](image)

**Fig. 1** The regression of observed ditch water levels for control sections around three stage boards and a pressure transducer with satellite-derived wet ditch widths. Each point is determined from a single Landsat TM image and observed ditch water level.

ditch in which the automatic water level recorder is located, and the position of both stage boards and pressure transducer within the ditch system.

**CONCLUSIONS**

Nine Landsat TM images and simultaneous ground-based ditch water levels were used to show that a relationship can be derived between satellite-derived wet ditch widths and observed water levels. Results suggest that for ditches where surface water level data are available, ditch water levels can subsequently be estimated from satellite data alone. Future work involves determining how well the time series of remote sensing measurements analysed with SHYLOC compares with calculations from the coupled hydrological/hydraulic model applied to the Elmley Marshes.

**REFERENCES**


