BALTEX Survey on

Biogeochemical Modelling Activities in the Baltic Sea Basin

Model Name	INCA-N (Integrated Nutrients in Catchments-Nitrogen)
Model Description	The dynamic INCA-N (Integrated Nutrients in Catchments–Nitrogen) model integrates hydrology and N processes (Whitehead et al. 1998, Wade et al. 2002a; Wade 2004). The model is semi-distributed meaning the land surface is not described in detail, but rather by the land-use classes in sub-basins. The sources of N include atmospheric deposition, leaching from the terrestrial environment and direct discharges. The terrestrial N fluxes are calculated in up to six user-defined land use classes. The river flow model is based on mass balance and uses a multi-reach description of the river system. Within each reach, the flow variation is determined by a non-linear reservoir model. The point source inputs of N can be added as parameters when they are daily averages for the whole simulation period.
State Variables	The mass balance equations for NO_3-N and NH_4-N in the soil and groundwater zones are solved simultaneously with the flow equations. The key N processes that are solved in the soil water zone are nitrification, denitrification, mineralization, immobilisation, N fixation and plant uptake of inorganic N in six land use classes. It is assumed that no biochemical reactions occur in the groundwater zone. In the rivers the key N processes are nitrification and denitrification.
On a scale between 1 and 10, please classify your model	1 Biogeochemical cycling, matter fluxes 2 3 4 5 INCA, semi-distributed catchment scale model 6 7 8 9 10 Ecosystem functioning
Dimension (0D, 1D, 2D, 3D)	2D
Modeled Area (Marine, terrestial, combined)	Terrestrial and river
Coupled to hydrological component	The hydrologically effective rainfall (HER) is used to drive the N through the catchment system and N can enter the river system by the lateral flow through the surface soil layers or by the vertical movement and transport through the groundwater zone. The hydrology within the sub-catchments is modelled using a simple two-box approach, with reservoirs of water in the reactive soil zone and in the deeper groundwater zone. HER can be derived from a more detailed hydrological model. In Finland we have used Watershed Simulation and Forecast System, which is in an operational use. It is a version of HBV-model.
Suited for climate change sensitivity studies	Yes, processes are moisture and temperature dependent
Publications	Granlund, K., K. Rankinen and A. Lepistö. 2004. Application of the INCA

	model in a small agricultural catchment in southern Finland. Hydrology and Earth System Sciences **8**(4): 717-728. Rankinen, K., A. Lepistö and K. Granlund. 2002a. Hydrological application of the INCA (Integrated Nitrogen in CAtchments) model with varying spatial resolution and nitrogen dynamics in a northern river basin. Hydrology and Earth System Sciences. **6**(3): 339-350. Rankinen, K., A. Lepistö and K. Granlund. 2002b. Sensitivity of the INCA model to N process parameters and hydrological input. Integrated Assessment and Decision Support proceedings of the 1st biennial meeting of the International Environmental Modelling and Software Society. 24.-27. June 2002, University of Lugano, Switzerland. **1**: 317-321. Rankinen, K., A. Lepistö and K. Granlund. 2004. Integrated nitrogen and flow modelling (INCA) in a boreal river basin dominated by forestry: scenarios of environmental change. Water, Air and Soil Pollution: Focus **4**: 161-174. Rankinen, K., K. Granlund and I. Bärlund. 2004. Modelling of seasonal effects of soil processes on N leaching in northern latitudes. Nordic Hydrology **35**(4-5): 347-357. Rankinen, K., T. Karvonen and D. Butterfield 2004. Developement of a simple model for predicting soil temperature in snow covered and seasonally frozen soil. Hydrology and Earth System Sciences **8**: 706-716. Rankinen, K., Ö. Kaste and A. Lepistö. 2004. Adaptation of the Integrated Nitrogen Model for Catchments (INCA) to seasonally snow-covered catchments. Hydrology and Earth System Sciences **8**(4): 695-705. Rankinen, K., H. Lehtonen and I. Bärlund. 2004. Assessing the Effects of Agricultural Change on Nitrogen Fluxes Using the Integrated Nitrogen CAtchment (INCA) Model. Complexity and Integrated Resources Management, Transactions of the 2nd Biennial Meeting of the International Environmental Modelling and Software Society, Manno, Switzerland, iEMSs, 2004. Rankinen, K., T. Karvonen and D. Butterfield. 2006. Application of the GLUE methodology in estimating the parameters of the INCA-N model. the Science of the Total Environment **365**: 123-139. Rankinen, K., K. Kenttämies, H. Lehtonen and S. Nenonen. 2006. Nitrogen load predictions under land management scenarios for a boreal river basin in northern Finland. Boreal Environment Research **11**: 213-228. Rankinen, K. 2006. Analysis of inorganic N leaching in a boreal river basin in northern Finland. Doctoral dissertation, Helsinki University of Technology, Laboratory of Water Resources. http://lib.tkk.fi/Diss/2006/isbn9512280760 Whitehead, P. G., E. J. Wilson and D. Butterfield. 1998. A semi-distributed Integrated Nitrogen model for multiple source assessment in Catchments (INCA): Part I-model structure and process equations. the Science of the Total Environment **210/211**: 547-558. Wade, A., P. Durand, et al. 2002. Towards a generic nitrogen model of European ecosystems: New model structure and equations. Hydrology and Earth System Sciences **6**(3): 559-582. Wade, A. J. 2004. Errata in INCA-N equations to simulate nitrogen storage and transport in river systems [Hydrol. Earth Sys. Sci., 6, 559-582]. Hydrology and Earth System Sciences **8**: 858-859.
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Web Site	http://www.aerc.rdg.ac.uk/welcome.php

Remarks

The model will be used in Eurolimpacs-project (EU 7) for climate change studies.
http://www.eurolimpacs.ucl.ac.uk/index.php