The construction and update of a national water resource model

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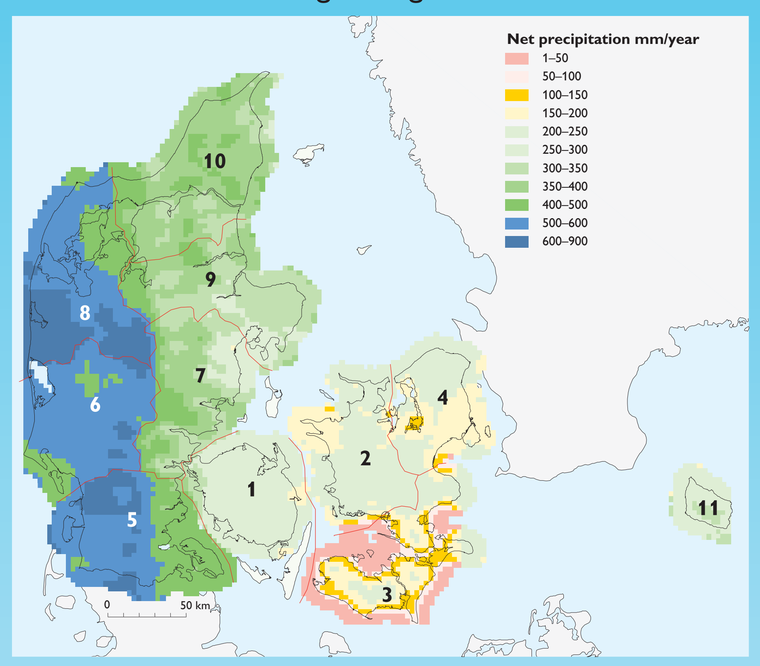
A national water resources model has been constructed for Denmark from which the exploitable resource is estimated taken into account that the extractable resource is limited by pollution of shallow aquifers and an unacceptable depletion in the stream base-flow. Compared to previous estimates of the groundwater resource based on more simplistic mass balance approaches the exploitable water resource was nearly halved by the use of an integrated hydrological model. This result clearly indicates that the groundwater system is complex and the resource difficult to evaluate without the use of integrated models describing all relevant processes of the freshwater resources.

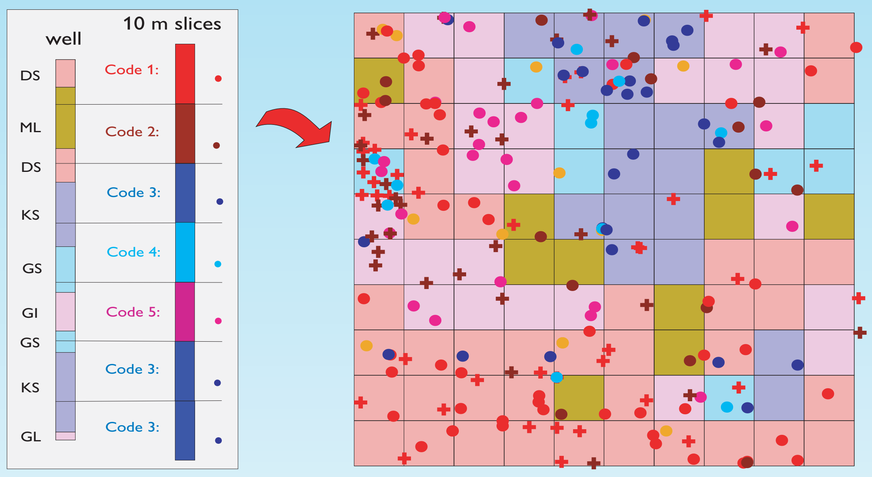
MODEL CONSTRUCTION

The 43.000 km^2 of Denmark was divided into 11 regional sub-models. For each sub-model an integrated groundwater-surface water model was constructed with a horizontal discretsation of 1 x 1 km. Net precipitation was estimated by a simple root-zone box-model, while three-dimensional groundwater flow and stream discharge was simulated by the MIKESHE/MIKE11 model system.



Extent of the 11 sub-models on top of the estimated net precipitation

Two different geological modelling approaches were used. For sub-model 1-4 the geological model was interpreted as a pre-Quaternary base overlaid by alternating sand and clay layers. In sub-models 5-11 the hydrogeology were interpreted based on borehole information by slicing all boreholes into 10 m sequences and assigning the dominant lithology for each sequence.



Hydrogeological interpretation for sub-models 5 – 11 in a 1x1 km grid

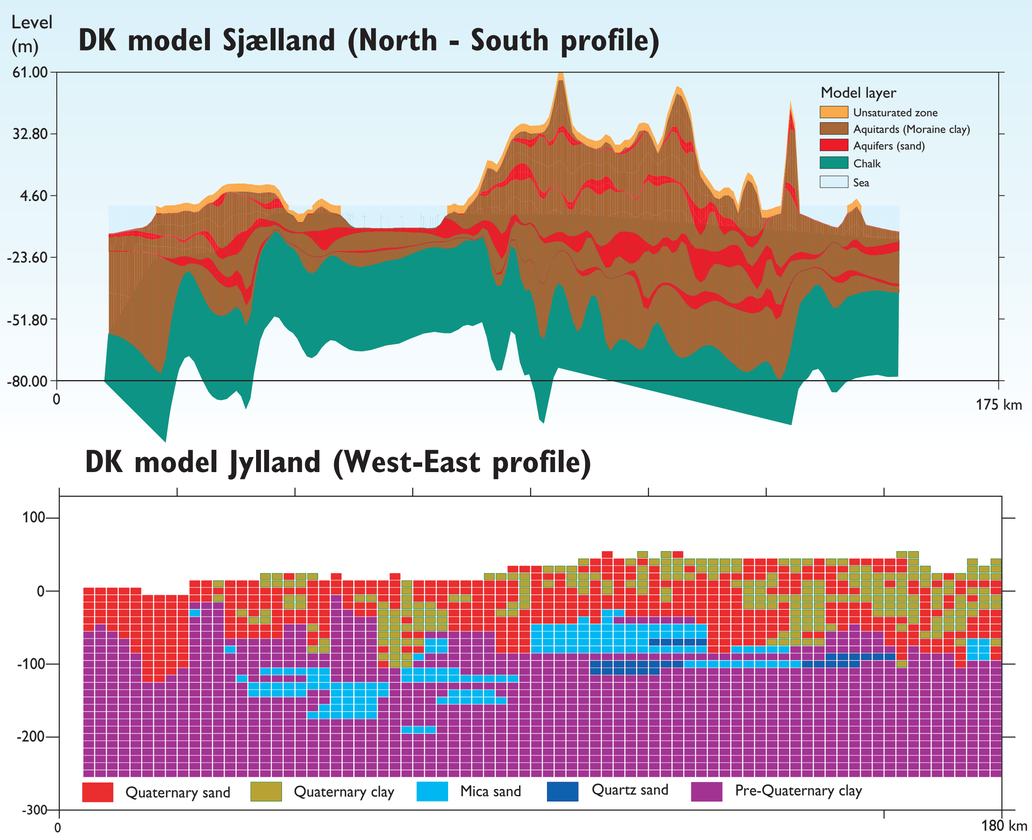
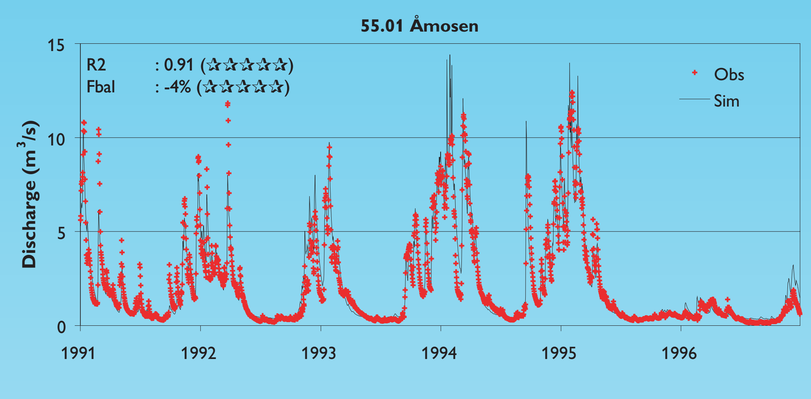


Illustration of the results from the two approaches used in the geological interpretation

MODEL CALIBRATION

A five year period was used for inverse model calibration, followed by a five year validation period. Mean hydraulic heads and daily stream discharges were used as calibration targets. The performance categories (stars) were established from observation uncertainties and literature studies. The target for the calibration and validation was that the aggregated score within each sub-model should be in the middle category (three stars) or better for all three performance indicators



Example of observed and simulated stream discharge in the Åmosen creek on Sjælland

Performance Indicator	Excellent (5 points)	Very good (4 points)	Good (3 points)	Poor (2 points)	Very poor (1 point)
RMS (m)	< 4	4 – 6	6 – 8	8 – 10	> 10
R^2	0.85	0.65 – 0.85	0.50 – 0.65	0.20 – 0.50	< 0.20
F_{bal} (%)	< 5	5 – 10	10 – 20	20 – 40	> 40
Performance category	☆☆☆☆☆	☆☆☆☆	☆☆☆	☆☆	☆

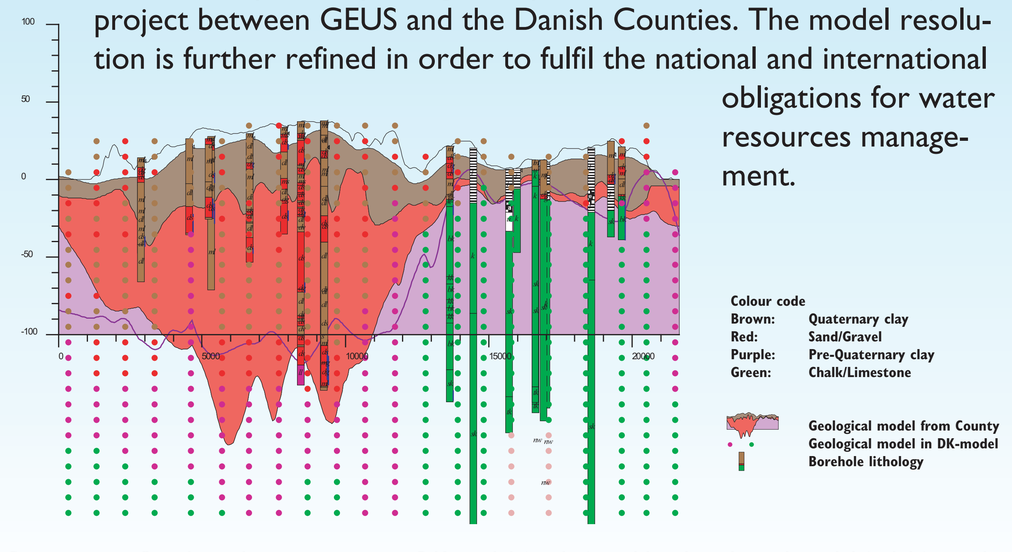
Model performance criteria and five performance intervals used to categorise the performance level of a given model

EXPLOITABLE RESOURCE

The total exploitable groundwater resource for Denmark is estimated to be 1.0 x 109 m3/year. The study demonstrated large spatial variation, where overexploitation mainly occurs around the larger cities and areas with coarse sandy soils in Western Jylland due to irrigation demands, see also Henriksen et al., 2006.

MODEL UPDATE

Since the construction of the geological model on which the DK-model is based, extensive geological mapping has been carried out by the Danish Counties, which is presently being incorporated in the DK-model in a joint project between GEUS and the Danish Counties. The model resolution is further refined in order to fulfil the national and international obligations for water resources management.



Comparison of geological interpretation in DK-model (circles) and local geological model (solids), used to update the geological model in the DK-model

FUTURE PERSPECTIVES

The vision is to provide an ongoing process in which the national water resources reference model is gradually updated and adapted as more knowledge becomes available from the continuing geological mapping, the national monitoring program and research activities. For a consistent estimate of the water resource the national water resources model will provide the overall hydrogeological framework at all levels for the water resource management, i.e. from a national overview to the definition of actions plans at a local level, where the national water resources model can act as the off-set for more detailed model studies.

LITERATURE

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