The Danish National Water Resources Model (DK-model)

- Support for decision making and WFD implementation

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The National Water Resources Model (DK-model)

- Numerical hydrological model
  - 43,000 km$^2$, 7 sub-models
  - Coupled SW-GW model (MIKE SHE/MIKE 11)
  - Data from national databases
  - Hydrogeological description
    - 3D geological interpretation
  - Inverse calibration - PEST
  - Public accessible
    - Stored in national model database

(Højberg et al., 2013; Stisen et al., 2012)
Vision

• DK-model – unifying platform
  – Hydrological model and database
  – Reference for all water management related aspects at all levels
• Regularly update as new knowledge and data becomes available
• Continuous development
History

• 1996 – 2003: 1. version of the DK-model
  o Improved estimate of the national water balance (replacing simple analytical estimate)
    – Research project
    – National interpretations
    – National databases

• 2005 – 2009: Extensive model update (Højberg et al., 2013)
  – Collaboration with regional water authorities
  – Regional and local studies (> 50)

• 2010 – 2013: Various improvements based on national, regional and local scale studies
  – New geological models funded by the Danish Nature Agencies must be prepared for inclusion in DK-model
  – Collaboration between GEUS, water authorities and consultancies
Model applications

Climate change impacts and adaptations

Quantitative status
- Groundwater
- Surface water

Chemical status
- Groundwater
- Surface water

Applications
- WFD/GWD implementation
- National & regional assessments
- Basis for local studies
- Research projects

Users
- Research institutions
- National water authorities
- Regional authorities
- Municipalities
- Water companies

~25 SCI listed papers since 2003, directly or indirectly based on the DK-model (> 2 per year)
The DK-model in WFD implementation

Groundwater quantitative status e.g.:

1) Aquifer safe yield (Henriksen et al., 2008)
2) Eflows (flow quantity and quality required to sustain surface water ecosystems) (Olsen et al., 2012)
3) Terrestrial ecosystems
4) Flooding risks (coastal and hinterland) (Sonnenborg et al., 2012)

Groundwater chemical status e.g.:

1) Threshold values to protect terrestrial ecosystems
2) Threshold values to protect aquatic ecosystems and e.g. reduce risk of harmful algal blooms (Hinsby et al., 2008, 2012)
3) Saltwater intrusion. (Rasmussen et al., 2013)

Harmful Algal Bloom (Cyanobacteria)
Baltic Sea between Denmark and Germany – 25.8.2006

Foto: Klaus Hinsby, GEUS (Hinsby et al., 2008)

(Sonnenborg et al., 2012)
Quantitative status

Integrated national assessment

Decreased groundwater table:
Extraction related to natural recharge

Increased deep recharge

Reduced streamflow:
Mean flow
Eflow

Henriksen et al., 2008
Monitoring programme

- Conceptual hydrogeological model -> 3D delineation of GW bodies and link to national database on quantity and quality
  - Basis for reporting to EU
- Design of GW monitoring programme
- Estimates of water balance – quantitative status

- Interpolation and extrapolation of freshwater discharges

Windolf et al., 2007
Calculations of climate change effects on hydrology and groundwater

Several regional studies to estimate effects of CC and uncertainty related to the simulations
Risk for GW flooding or reduced recharge

Min, mean and max changes in GW levels based on analysis of 9 GCMRCM combinations

Groundwater level 2021-2050 versus 1961-1990
Changes in meter

Groundwater recharge 2021-2050 versus 1961-1990
Changes in mm/year
Results available from public portal
CC effects on N-mass fluxes

CC will generally increase stream flow

Increasing precipitation and runoff will increase nutrient loads— and hence require reduced groundwater threshold values (assuming no land use change)

(Sonnenborg et al., 2011)
Present studies: Nitrogen load to coastal areas

Development of model complex (DSS). Collaboration between national research institutes

Present studies:
- Nitrogen load to coastal areas

Basis for implementation of the WFD – 2nd cycle
- Estimates of nitrate load to Fjords and marine areas
- Estimate reduction in GW and surface water systems
- Locate optimal mitigation measures and location
- Estimate effect of mitigation measures

Funded by
- Danish Nature Agency
- Danish Environmental Agency
- Danish AgriFish Agency
New BONUS research project "Soils2Sea"

Partners from: DK (coordinator), DE, PL, RU and SE

Topic: reduction of nutrient loadings to the Baltic Sea and the impacts of climate change.
Selected references directly or indirectly using the DK-model