Assessing the impacts of climate change on UK water resources – groundwater

Steven Wade, Chris Counsell and Ralph Ledbetter, HR Wallingford Ltd
Evidence of the impacts of climate change on water resources
Preliminary results from the ARCC-Water project on groundwater impacts
Using UKCP09 for climate change impacts assessment
Challenges for future work
UK CCRA 2012

Selection of Key National Threats

UK 2012 Climate Change Risk Assessment

- Expected annual damages to properties from flooding
- Effects of floods on mental health
- Insurance costs for UK flood risks
- Summer extent affected by red band needle blight
- Overheating of buildings
- Energy demand for cooling buildings
- Forest extent affected by climate change
- Changes in species migration patterns
- Species unable to track changing climate space
- Public water supply deficits

- High consequences (negative)
- Medium consequences (negative)
- Low consequences (negative)
- High confidence
- Medium confidence
- Low confidence
Climate change plus population growth

Anticipated adaptation

• Reductions in demand will not be sufficient on their own

Planned adaptation (excluded)

• RSA

• Abstraction reform

• Demand side and supply side schemes

• Will environmental targets be achievable without stronger adaptation?

UK 2012 Climate Change Risk Assessment
Evidence – Climate change and DO

Sensitivity

Magnitude

Mid Scenario (%)

Range (Wet-Dry Scenario) (%)

Individual WRZ or small companies
The Water White Paper identifies policy priorities:

- A long term perspective
- Water scarcity and environmental damage
- Water trading
- Reducing demand for water

The 25 year planning horizon….“does not constrain companies from taking a longer term view where it is appropriate to do so…it is important that the water resources management plans are resilient to a range of potential climate scenarios and are designed with climate risks built in.”
Our approach (following the EA CC & WSP project)

- Understand sensitivity to climate
  - Vulnerability Assessment

- Climate change assessment
  - Make full use of UKCP09 or Future Flows

- Clear & consistent approach to CC
  - Headroom

- Decision making
  - Check plan is robust to range of CC scenarios

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Climate change projections

UKCP09 Rapid Assessment (5-20) → Future Flows (11) → UKCP09 (20 to 1000s)

Flow Factors

Use flow factors or climate change factors or transient climate data in models (5 to 1000s)

Hydrological / hydrogeological modelling

Water resources system modelling (LoS)

Use all scenarios (or a subset?) in water resources zone models
Trajectories of climate change impacts

Q95 based on UKCP09 scenarios
Groundwater issues (EA CC WSP project)

Groundwater DO assessment presents some difficulties

> Running lots of runs through distributed models and translating to many sources is not practical

> Intermediate vulnerability method may have limitations – similar to the former GR1 method

> However modelling recharge is straightforward using FA0 56 or similar methods

Some pragmatism and innovation needed
NERC “Future Flows” data sets for 24 groundwater observation boreholes

http://www.bgs.ac.uk/research/groundwater/change/FutureFlows/sites.html
http://www.ceh.ac.uk/sci_programmes/Water/FutureFlowsandGroundWaterLevels.html
EPSRC/ESRC-funded research into Water Resources Planning

- Ensemble of correlated, spatially coherent climatic projections for South-East
- Regional Water System Model (RWSM) using IRAS-2010
- Ensemble modelling of climate change impacts on water availability
- Demand projections – informed by customer surveys, analysis and workshops
- Multi-criteria robust decision-making to identify system vulnerabilities and test alternative strategies (demand and supply side) – RDM, Real-Options, Info-GAP
- Local studies in Anglian, Thames and Southern regions
Simple groundwater level modelling approach for 45 sites in SE England

Multiple Linear Regression
Groundwater level versus monthly recharge

Return Period Analysis
Recharge estimate based on FAO method

Estimation of future levels using UKCP09 SCPs and resampling methods
Simple groundwater level modelling
2030s Medium Emissions climate

Reduction in annual minimum level for 80% sites

% change in annual minimum groundwater level
Comparison with Future Flows modelled groundwater levels for 6 sites

Comparison with other published models shows a similar level of performance and that all models struggle with reproducing levels (and by inference DOs) in the same drought years.


Comparison of MORECS observed PET and Temperature Derived PET

- MORECS PET
- Oudin Method
- UKCP WG Method

Date:
- 1961-01-01
- 1963-01-01
- 1965-01-01
- 1967-01-01
- 1969-01-01
- 1970

PET mm month$^{-1}$
- 0
- 20
- 40
- 60
- 80
- 100
- 120

Water resources planning
Practical use of UKCP09 – PET
Water Resources Planning: Practical use of UKCP09 - Sampling methods

Annual Precipitation and Temperature Projections
UKCP09 10,000 vs LHS 100: Medium Emissions

Annual Precipitation and Temperature Projections
LHS 100 vs Sampled 20: Medium Emissions
Practical use of UKCP09 - Sampling methods based on recharge

UKCP09 2030s Medium Emissions

Median – no change
However there is a risk of a significant reduction
Conclusions on climate change and groundwater

Impacts on water resources and groundwater

> Climate change may have a significant impact on the supply-demand balance in England by the 2030s

> Groundwater impacts are evident in 80% of sites modelled in SE England; changes in average annual minima are small < 5%

> Groundwater could be an important part of adaptation to climate change; demand side measures are not enough on their own

For better assessments we need

> Improved data on source performance under drought conditions, possibly source works models

> Better access to existing EA groundwater models

> A step change in modelling speed
Conclusions
Climate change vulnerability assessment

Low vulnerability

Approach 1.1: Use 20 LHS of UKCP09 from UKWIR study 2009
- Rainfall runoff and/or groundwater modelling using perturbed data for time slices for 20 scenarios
  - Water resource modelling for 30 year time slices for perturbed data period for up to 20 scenarios

Approach 1.2: Use monthly UKCP09 flow factors (if not available) from UKWIR study 2009
- Rainfall runoff and/or groundwater modelling using perturbed data for time slices for 5 scenarios
  - Water resource modelling for 30 year time slices for perturbed data period for up to 20 scenarios

Approach 1.3: Use FF 11 RCM climate monthly factors (based on bias-corrected data)
- Rainfall runoff and/or groundwater modelling with perturbed data for time slices for 11 scenarios
  - Water resource modelling for 30 year time slices for perturbed data period for >100 scenarios

Approach 1.4: Use FF monthly flow factors or groundwater factors
- Rainfall runoff and/or groundwater modelling using perturbed data for time slices for 11 scenarios
  - Water resource modelling for 30 year time slices for perturbed data period for >100 scenarios

Approach 2.1: Use targeted sample of UKCP09 based on DI analysis
- Rainfall runoff and/or groundwater modelling using perturbed data for time slices for 20 scenarios

Approach 2.2: Use FF transient climate data
- Rainfall runoff and/or groundwater modelling with 11 transient scenarios

Approach 2.3: Use FF transient flow data and groundwater
- Water resource modelling using transient data for 11 scenarios

Approach 2.4: Use FF transient flow data and groundwater
- Water resource modelling using transient data for 11 scenarios

Medium-High vulnerability

Large investments driven by climate change

N=5-20 runs

N=11-10K runs

Vulnerability and DO assessment

Climate change assessment

Low vulnerability

Medium-High vulnerability

Large investments driven by climate change