IMPETUS: Improving Predictions of Drought for User Decision Making

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WP2: Forecasting droughts and water scarcity, and methods to support decision-making

- Improve our ability to predict future drought and water scarcity...in the range of months to decades
- Consider the drivers of water demand
- Develop methods to support stakeholder decision-making
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• Improve our ability to predict future drought and water scarcity…in the range of months to decades
• Consider the drivers of water demand
• Develop methods to support stakeholder decision-making
• Droughts are multifaceted: meteorological drought; agricultural (soil moisture) drought; surface water and groundwater drought to be considered
People and Institutions

NCAS, Reading
Len Shaffrey
Rowan Sutton
Pier Luigi Vidale

CEH
Christel Prudhomme
Bob Moore

BGS
Chris Jackson
John Bloomfield

Engineering and Geoscience, Southampton
Ben Anderson

Engineering, Newcastle
Hayley Fowler

SHES, Reading
Anne Verhoef
Hannah Cloke
Liz Stephens
Walker Institute
Nigel Arnell
Ben Lloyd-Hughes

Physics, Oxford
Tim Woollings
Antje Weisheimer
Tim Palmer
InSIS, Oxford
Steve Rayner

Project Partners:
IMPETUS is a 4-year project that aims to improve the forecasting of UK drought on monthly to decadal timescales, which will lead to the development of improved decision-making processes.
Task 1.1 Assessing stakeholder needs and current approaches

Initial discussion with key stakeholders (drought forecasting and planning)

Operational forecasting: Hydrological Outlooks projects (Met Office, EA, BGS and CEH) and the ECMWF-led European Flood Awareness System report to the European Drought Observatory

Need for precipitation forecasts for input into operational water supply models

Need for soil moisture forecasts for agricultural planning

At the start of IMPETUS initiate wider stakeholder engagement: other water supply companies, DEFRA, DECC, EA, Natural England, UKWIR, Knowledge Transfer Networks (WSKEP, ESKTN, FSKTN), financial, health, and retail sectors etc...
Task 1.2 Co-producing decision-relevant drought metrics

- Where stakeholder needs identified then co-produce decision-relevant drought metrics

- Stakeholders’ use of probabilistic forecasts (Hannah Clokes’s work in flood forecasting, Demerrit et al. (2010; 2012); Liz Stephens’ Leverhulme fellowship).

Task 1.3 Documenting the stakeholder engagement process

- Oxford InSIS: Understanding the wider opportunities and constraints that are likely to influence the usability of drought forecasts

- Rayner et al. (2005), “Forecasts are for wimps”
WP2 Meteorological Forecasts of Drought

Task 2.1/2.2 Assessing meteorological forecasts for drought

2003 Summer surface temperature anomaly from Left) observations Centre) System 3 and Right) Improved ECMWF CY33r1 seasonal forecasts Units: K. (Weisheimer et al. 2011).

- Current skill limited, but improvement in model resolution and land surface processes have to lead to increases in skill in monthly to seasonal forecasts
- Monthly to seasonal forecast skill: Met Office (Glosea5) and ECMWF (S4)
- Seasonal to decadal forecast skill: NCAS HiGEM, Met Office and CMIP5
- Particular focus on past UK droughts and drought onset, maintenance and termination and the role of the land surface and anti-cyclonic blocking
Task 2.3 Meteorological drivers of drought and improving climate models

Understand meteorological drivers of past UK droughts:

- North Atlantic sea surface temperatures (Sutton and Dong, 2012)
- Arctic sea ice loss (Petrie et al., 2013)
- Aerosol (Booth et al., 2012)
- Extratropical-tropical interactions (Cassou, 2012)
- Role of stratosphere (e.g. Ineson and Scaife, 2009)

Investigate the role of resolution in high-resolution (150km, 60km, 25km) UPScale HadGEM3 and ATHENA ECMWF IFS (180km, 60km, 20km) model experiments

Differences in summer rainfall for periods when the North Atlantic Ocean is warm (1996-2009) and when it is cold (1964-93). (Sutton and Dong, 2012)
Task 3.1 Evaluating and improving land surface schemes

- Evaluate JULES (Met Office) and H-TESSEL (ECMWF) land surface schemes
  - Focus on processes such as the spring drying of soils and the role of improved parameterisations (e.g. plant water stress, Egea, Verhoef and Vidale, 2011)

Task 3.3 Exploring links between land surface and groundwater

- Is surface heterogeneity at subcatchment scales important for deep drainage (and also for runoff and soil moisture)?
- Develop a 1km version of H-TESSEL and use a 1km version of JULES
- Enable us to directly link JULES and H-TESSEL with MODFLOW groundwater models.
Task 3.2 River flow modelling

- Assess ability of PDM, Grid2Grid, GWAVA and CATCHMOD (used by EA) river flow models to capture drought given observed meteorological inputs

- Focus on onset, maintenance and termination of drought (recovery from low river flows)

Observed and simulated river flows from the Grid2Grid model for the Tay at Ballathie and the Ribble at Samlesbury
Task 3.2 Groundwater modelling

IMPETUS will assess R-Groundwater and EA MODFLOW distributed groundwater models (in addition water supply companies also use MODFLOW models) across a wider range of aquifers.

If time allows, assess more complex models, e.g. the Thames TIM model developed by BGS in conjunction with Thames Water.
Task 4.1 Developing a domestic demand model

Much work on long-term demand forecasting, but much less on how people respond during droughts.

Build on the ARCC-Water and SPRG Water survey projects

Use microsimulation techniques to produce a spatially disaggregated domestic water demand model for Southeast England

Data sources include the SPRG Water Practices Survey and the Living costs and food survey (other data sources will also be sought).
Task 5.1/5.2 Combining hydro-meteorological forecasts

• Evaluate combined drought forecasts by driving hydrological and land surface models with meteorological forecasts.

• Assess uncertainty using statistical tools e.g. Cloke et al. (2010)

Task 5.3 Combining water demand and hydro-meteorological forecasts

• GWAVA: combines water availability, irrigation and water demand (from WP4)

• Address questions of where and when is agricultural and domestic water demand important during drought

Map of change in probability (%) of hosepipe ban implementation in any given year for 2050s, relative to baseline of 1980-2000.

• UK application = 0.1° resolution = ~9km x ~6km
• Boundaries represent water management regions (pooling of water resources)
• Results absent of management intervention
WP6 Working with stakeholders

• Synthesise forecasts for stakeholders

• Stakeholder workshops based on re-forecasts of past droughts - how might stakeholders have responded if drought forecasts were available?

• Reports on IMPETUS progress for the EA, Met Office and ECMWF

• Fact Sheets for stakeholders (e.g. What is a probabilistic forecast?)

• Statement of drought forecasting capability for stakeholders
Attached Project Studentships

Three project studentships proposed:

*Dynamical atmospheric drivers of drought:* University of Oxford: Tim Woollings (Oxford), Brian Hoskins and Mike Blackburn (Reading), Adam Scaife (Met Office)

*Representing uncertainty in land surface hydrology for seasonal forecasting:* University of Reading: Hannah Cloke, Anne Verhoef (Reading), Florian Pappenberger (ECMWF), Antje Weisheimer (Oxford)

*Probabilistic drought forecasting using GLAMSS statistical models:* University of Newcastle: Hayley Fowler (Newcastle)
Interdisciplinary team capable addressing broad definition of drought

Bringing together meteorological, land surface, river flow, groundwater and water demand forecasts to produce drought forecasting framework

Use outcomes from the successful WP1 project and provide models and forecasts for successful WP3 projects

Stakeholder engagement important to IMPETUS
• Identified clear needs from water and agricultural sector
• Both ECMWF and the Met Office involved
• Social science insights into stakeholder engagement
• Develop the science underpinning operational forecasting: Hydrological Outlooks and EFAS reporting to the EDO
• First project meeting in late November/early December (tbc)

• Three PhD studentships have just started

• Successfully recruited for the initial three post-doctoral positions (one more position to start in Southampton in 2015)

• First stakeholder event provisionally planned for March 2015 in conjunction with WP1 and DRIVER
Start with a climate model to produce monthly to decadal forecasts of precipitation and soil moisture.
Use meteorological forecast to drive surface water and groundwater models
For water scarcity, we need to also consider water resources and demand.
Drought and Water Scarcity Forecasting

Meteorology 30%

Soil Moisture 15%

Surface Water 15%

Groundwater 10%

Water Resource 5%

Water Demand 10%

Plus 10% on stakeholder engagement and 5% on improving land surface-subsurface links