Seventh Framework Programme

Theme 6

Environment

# Project: 603864 – HELIX

Full project title:

**H**igh-**E**nd c**L**imate **I**mpacts and e**X**tremes

# Deliverable: 2.3

Guidance note on selection of additional experiments for Phase II of HELIX

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**Executive summary**

This short report details the discussions that have taken place concerning modelling choices for HELIX phase 2, especially the high spatial resolution climate model experiments to be performed in Work Package 3 (WP3). In addition to the original remit for this work an additional requirement, to attempt to align scenario choices with sister EU projects IMPRESSIONS and RISES-AM, has been added.

At this time the items we are able to present as decisions made include:

- The characteristics of the favoured CMIP5 experiment have been identified, and a precise model will be chosen shortly. The chosen forcing scenario will be RCP8.5.
- Time slices of length 30 years will be used, centred on the time the driving model passes a global mean surface warming of 2, 4 and 6°C above pre-industrial levels for future periods. A final decision on a near present day baseline will be made before the end of November 2014.
- Users have been consulted on the choice of climate variables through an e-mail based exercise and a final call for additions at the October 2014 HELIX assembly.
- Model simulations in WP3 will be driven by sea surface temperatures and sea ice details taken directly from a CMIP5 experiment.
- The driving scenario will also be a shared scenario with the EU sister projects.

In addition to the choice of preferred scenario discussions have considered the use of an additional new scenario engineered to reach 6°C earlier, but still with a plausible storyline. This could be made available for sensitivity testing later in the project if there is a demand.

## 1. Introduction

The HELIX project will conduct a number of new climate model experiments, with emphasis on high resolution experiments using the latest climate model set-ups. These will be produced by work package 3 and used in Phase 2 of the project to examine climate impacts in more detail at a range of specific warming levels (SWLs).

A number of face-to-face and e-mail discussions have taken place to consider a suitable choice of scenario and model set-up for these new, and computationally expensive experiments. Scientists from work packages 2 and 3 have been involved in the discussion of the physical aspects of these scenarios.

Additionally, there is a desire to have some commonality across HELIX and its two sister projects, IMPRESSIONS (http://www.impressions-project.eu/) and RISES-AM (http://risesam.eu/). Discussions with members of both projects have taken place.

This report details some of the choices that have now been made, and identifies remaining decisions that are needed before work package 3 experiments can begin. It notably draws on the output from a small workshop held at the University of Reading and involving the following participants:

- Jens Hesselbjerg Christensen (DMI/Impressions)
- Svetlana Jevrejeva (NOC Liverpool/RISES-AM)
- Klaus Wyser (SMHI/HELIX)
- Jason Lowe (Met Office/HELIX)
- Richard Betts (University of Exeter and Met Office/HELIX)
- Laila Gohar (Met Office/HELIX)
- John Caesar (Met Office/HELIX)

## 2. Overview criteria for model and scenario selection

The HELIX project needs a scenario that will cover the SWLs of 2, 4, and 6ºC, ideally during the 21st century. For this criterion we can use the analysis in report D2.1 in order to rule out a significant number of climate models and forcing scenarios.

It appears that RCP8.5 would be a good choice of forcing scenario (Figure 1). Discussion amongst the scenario intercomparison project (scenarioMIP) group, which is charged with planning policy relevant scenarios for CMIP6 and the IPCC 6th assessment (assuming that another major assessment takes place in the future) suggests this 21st century forcing level will remain the highest magnitude of forcing experiment for the foreseeable future of Coupled Model Intercomparison Project (CMIP) intercomparisons.

Another criterion is that we require a connection between phases 1 and 2 of the HELIX project. As phase 1 will use pre-existing outputs from the Inter-sectoral Impacts Model Intercomparison Project (ISIMIP) study a prudent choice would be to require the chosen model to be one of the five driving ISIMIP general circulation models (GCMs). Combining our criteria suggests a variant of the IPSL model used in CMIP5 may be a good first choice for use in work package 3 simulation.

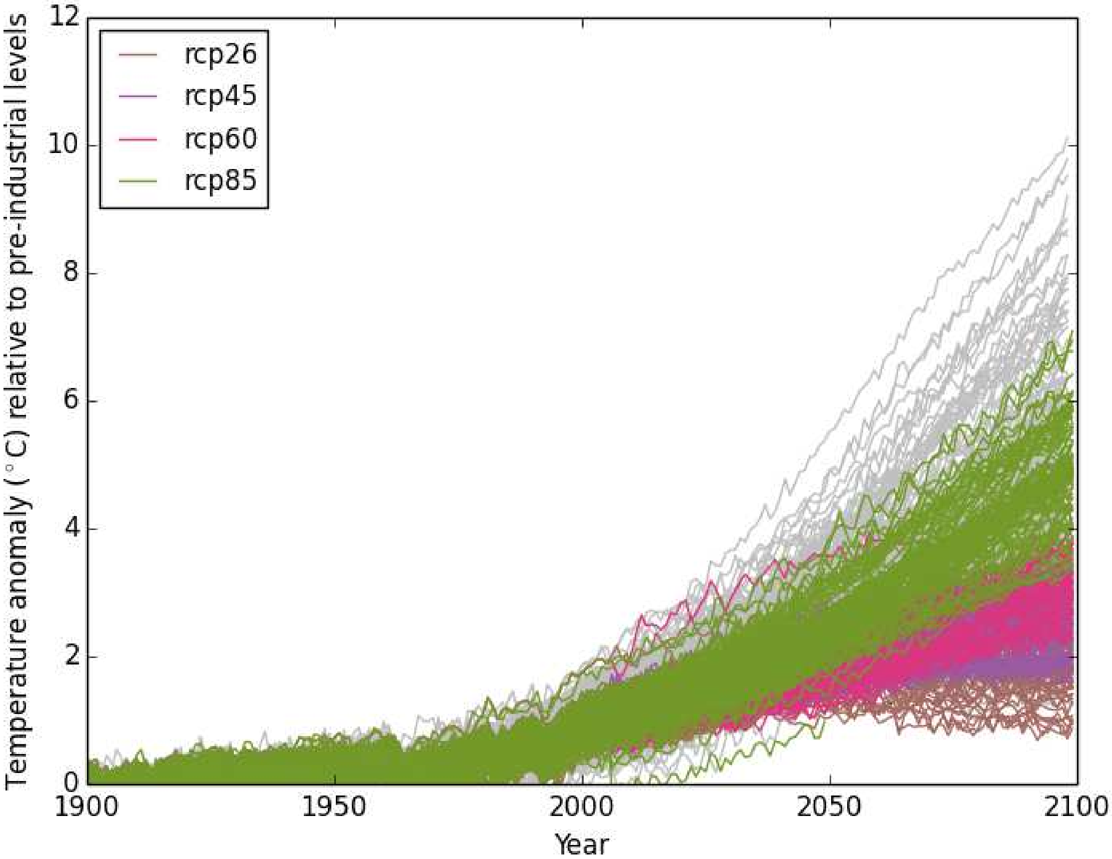


***Figure 1. Time series of GCM simulations examined in report D2.1. The CMIP5 RCP simulations are colour coded.***

The representative of the IMPRESSIONS project has stated that whilst they are interested in the time of climate change signal emergence, there is less direct relevance of the 2, 4, 6 ºC global warming levels. However, a choice of scenario that can be associated with the SSP storylines would be useful. They will not be focussing on running new climate simulations but do have access to an existing high resolution global model experiment, although this uses an idealised fixed compound rate of sea-level rise.

A representative of the RISES-AM project noted that it has only one work package dealing with physical changes, and it is considering impacts on coasts especially for high-end sea-level rise cases. They are especially keen on information on regional climate change patterns in the Mediterranean, Black Sea and Baltic Sea regions. Their current aim is to use an RCP4.5 baseline then to focus on changes under the RCP8.5 scenario. They also require uncertainties for worst case (– 5% probability), which is likely to be taken as a 1.8m 'upper limit' scenario at 2100 based on RCP8.5. There is a small component on storm surges, which could make use of high resolution driving data.

A common aim for all three projects is to focus on the period up 2100 for most of the high resolution modelling and impacts work. This will not be a problem for the 4ºC SWL, but may be a challenge for the 6ºC level.

As there is an interest in uncertainty, in addition to a common preference scenario and model pair several other scenarios (of the order of 5) that reach all the SWLs up to 6ºC will also be considered for analysis, although high resolution experiments based on them will not be carried out.

**Decision:** Adopt a common scenario based on RCP8.5 and a single GCM for use in any shared analysis between the projects and for HELIX high resolution runs.

**Future action:** Following the HELIX workshop in October 2014, the authors of this report will identify the preferred model (and 4 or 5 secondary choices) and check that the model s not an outlier in terms of temperature or precipitation in the HELIX focus regions. Additionally some comparison with similar work in IMPRESSIONS will be considered, along with the sensitivity to the choice of pre-industrial period. To be completed by end November 2014.

**Future action:** HELIX will make available driving data to the other two projects, including 10m winds and PMSL globally, from the high resolution experiments. To be completed when model runs are finished and analysed.

### 3. Do we need to make an "artificial" even higher scenario?

It is noted that even those CMIP5 RCP8.5 simulations whose global average near surface warming reaches 6ºC, typically only reach this level late in the 21st century. It is also noted that economic growth and population scenarios above those used in the integrated assessment model that produced RCP8.5 could possibly be achieved. The conclusion is that a new scenario, which reaches the 6ºC SWL earlier in the century, could be justified.

There are several ways to construct a higher scenario and a companion storyline. The physical component could make use of existing runs that have a stronger response to a given forcing than the CMIP5 models, such as the upper part of a Met Office Hadley Centre perturbed parameter ensemble. An alternative would be to make use of a simple climate model compared with pattern-scaling, or similar approaches, to produce an artificial scenario. Further work in WP2 deliverable D2.4 and D2.5 will be needed to understand if this could be credibly achieved for climate variables of interest. The socio-economic storyline would need to draw on existing literature values for extreme population and GDP growth, and use established values for future energy intensity of GDP and carbon intensity of energy.

Whilst the production of this "earliest possible" 6ºC scenario would be relevant to the issues of HELIX it is not currently a deliverable so further discussion will be needed to see if it might be a useful communication aid.

### 4. Discussion of baselines and time-slices

The new high resolution model simulation in HELIX will be run as atmosphere only time-slices. Based on previous work options of 10, 20 or 30-year slices have been considered. The central estimate of 20 years has the advantage of being similar in length to the averaging periods used in the recent working group 1 component of the IPCC 5th assessment. However, the longer 30 year time-slice offers better sampling of longer period variability and for applications wanting 20 year samples a sub-set could easily be used. Slices greater than 30 years are not being considered because of the steep rate of change of climate in the RCP8.5 experiments. One particular challenge will involve the warmest SWL time-slice, because the time this is encountered is quite near to the end of the century and, for some driving model choices, the end of the time-slice might go beyond the end of the 21st century. Further consideration of this is needed.

A near present day baseline must be selected as one of the time-slices, so that impacts calculations can express the changes relative to present day. The earlier IMPACT2C project (http://impact2c.hzg.de/) uses a present-day baseline with the observed temperature change prior to this being added on to give changes from pre-industrial time for presentation purposes. There are several options for this period, with examples in the literature, including 1961-1990, 1981-2010, 1986-2005. It is noted that baselines after 2005 would include part of the future scenario period for the RCP experiments, which is a complexity that should ideally be avoided.

**Decision:** Adoption of 30-year time-slices as best compromise for the work package 3 experiments.

**Future action:** Discussion on the topic of near-present day baseline to take place at HELIX workshop in October 2014 with any follow up immediately after the meeting via e-mail. IMPRESSIONS and RISES-AM to also consult members on this choice. Decision to be made by end of November 2014.

### 5. Choice of climate variables

As the new high resolution global atmospheric model simulations of work package 3 need to be useful for a range of impact model applications in HELIX it is important that members of other work packages be consulted. Such a consultation was carried out by e-mail in spring 2014. Additionally, the modelling teams involved have experience from previous experiments. Based on this the default list for the Met Office Hadley Centre simulations is shown in appendix 1. A further final last call for variables will be made at the HELIX workshop in October 2014.

As some regional climate model experiments are planned in HELIX a decision is needed on storing high temporal resolution three dimensional boundary conditions from the high resolution global experiments for later use by regional climate model studies. These add an overhead in terms of model run time and storage of output. It is not planned to store these boundary conditions for all high resolution model runs, but it will be done for at least one global model experiment. This will be reviewed once the costs of storage are fully considered.

**Future action:** Lock-down climate variable list after final call.

**Future action:** Finalise decision on providing regional boundary conditions for additional global model runs.

### 6. Data sharing issues

A data policy has been developed for HELIX and WP3 experiments should follow this where possible. It is recommended to store a copy of the high resolution global model data locally at the centres running the models for all experiments in a format chosen by the modelling groups involved. Additionally, a "CMORised" version of the data will be produced and distributed. Discussions are under way as to how to distribute this within HELIX.

With respect to sharing data with IMPRESSIONS and RISES-AM, large data transfers are not envisaged. Methods developed for sharing data within HELIX can be applied to the other projects.

A suitable contact has or is being identified for each of the EU projects. These are John Caesar for first instance in HELIX and Marianne Sloth Madsen for IMPRESSIONS. RISES are in the process of identifying a suitable contact.

**7. Potential model set up – based on Met Office Hadley Centre choices**

The Met Office intends to use a version of the HadGEM3 climate model, run in atmosphere-only mode. Most experiments will be at a spatial resolution of N216 (around 60km) with a smaller number at higher resolution of N512 (around 25km). This can be compared with the EC-Earth model that will be run by the SMHI group, which has a spatial resolution of T511 (which corresponds to around ~40km).

For the Met Office set up we propose that we require at least one N512 baseline and time slice. Then, in order to estimate 50-year return period events, we would expect to need at least 100 years to produce a sample. This will be done using four 30-year time-slices with the more affordable N216 set-up. The runs proposed are shown in the table below. This is for illustration and may be subject to change.

| Model resolution | Scenario | Number of ensemble members |
|---|---|---|
| N512 | Present day | 1 |
| N512 | RCP8.5 6ºC SWL | 1 |
| N216 | Present | 4 |
| N216 | RCP8.5 6ºC SWL | 4 |
| N216 | RCP8.5 4ºC SWL | 1-4 |
| N216 | RCP8.5 2ºC SWL | 1-4 |

**8. Conclusion**

This report summarises current thinking on the set up choices for the forthcoming high resolution global atmospheric climate model experiments in HELIX. It reports on choice of driving scenario, and model from which sea surface temperatures will be drawn, length of time-slices, choice of pre-industrial baseline and list of variables.

**Appendix 1: Standard hi-res run diagnostics**

| STREAM/ | STASH/ | FC | DESCRIPTION |
|---|---|---|---|
| apm | 24 | 16 | SURFACE TEMPERATURE AFTER TIMESTEP |
| apm | 409 | 8 | SURFACE PRESSURE AFTER TIMESTEP |
| apm | 1201 | 186 | NET DOWN SURFACE SW FLUX: SW TS ONLY |
| apm | 1207 | 200 | INCOMING SW RAD FLUX (TOA): ALL TSS |
| apm | 1208 | 201 | OUTGOING SW RAD FLUX (TOA) |
| apm | 1235 | 203 | TOTAL DOWNWARD SURFACE SW FLUX |
| apm | 2201 | 187 | NET DOWN SURFACE LW RAD FLUX |
| apm | 2205 | 206 | OUTGOING LW RAD FLUX (TOA) |
| apm | 2207 | 205 | DOWNWARD LW RAD FLUX: SURFACE |
| apm | 3217 | 178 | SURFACE HEAT FLUX W/M2 |
| apm | 3234 | 180 | SURFACE LATENT HEAT FLUX W/M2 |
| apm | 3236 | 16 | TEMPERATURE AT 1.5M |
| apm | 4203 | 99 | LARGE SCALE RAINFALL RATE KG/M2/S |
| apm | 4204 | 118 | LARGE SCALE SNOWFALL RATE KG/M2/S |
| apm | 5205 | 98 | CONVECTIVE RAINFALL RATE KG/M2/S |
| apm | 5206 | 119 | CONVECTIVE SNOWFALL RATE KG/M2/S |
| apm | 5216 | 90 | TOTAL PRECIPITATION RATE KG/M2/S |
| apm | 8208 | 106 | SOIL MOISTURE CONTENT |
| apm | 8223 | 122 | SOIL MOISTURE CONTENT IN A LAYER |
| apm | 8231 | 1530 | LAND SNOW MELT RATE KG/M2/S |
| apm | 8234 | 1532 | SURFACE RUNOFF RATE KG/M2/S |
| apm | 8235 | 1533 | SUB-SURFACE RUNOFF RATE KG/M2/S |
| apm | 16202 | 1 | GEOPOTENTIAL HEIGHT ON P LEV/P GRID |
| apm | 16222 | 8 | PRESSURE AT MEAN SEA LEVEL |
| apm | 26001 | 1902 | RIVER WATER STORAGE M2 |
| apm | 26002 | 1904 | GRIDBOX OUTFLOW KG/S |
| apm | 26003 | 1903 | GRIDBOX INFLOW KG/S |

| | | | |
|---|---|---|---|
| apm | 26004 | 1901 | RIVER OUTFLOW KG/M2/S |
| apm | 30201 | 56 | U COMPNT OF WIND ON P LEV/UV GRID |
| apm | 30202 | 57 | V COMPNT OF WIND ON P LEV/UV GRID |
| apm | 30205 | 95 | SPECIFIC HUMIDITY ON P LEV/UV GRID |
| apm | 30207 | 1 | GEOPOTENTIAL HEIGHT ON P LEV/UV GRID |
| apm | 30211 | 0 | UU ON P LEV/UV GRID |
| apm | 30215 | 0 | UQ ON P LEV/UV GRID |
| apm | 30222 | 0 | VV ON P LEV/UV GRID |
| apm | 30225 | 0 | VQ ON P LEV/UV GRID |
| apm | 30301 | 1335 | HEAVYSIDE FN ON P LEV/UV GRID |
| apm | 30428 | 0 | dry mass col int u*q per unit area |
| apm | 30429 | 0 | dry mass col int v*q per unit area |

| | | | |
|---|---|---|---|
| aps | 24 | 16 | SURFACE TEMPERATURE AFTER TIMESTEP |
| aps | 409 | 8 | SURFACE PRESSURE AFTER TIMESTEP |
| aps | 1201 | 186 | NET DOWN SURFACE SW FLUX: SW TS ONLY |
| aps | 1207 | 200 | INCOMING SW RAD FLUX (TOA): ALL TSS |
| aps | 1208 | 201 | OUTGOING SW RAD FLUX (TOA) |
| aps | 1235 | 203 | TOTAL DOWNWARD SURFACE SW FLUX |
| aps | 2201 | 187 | NET DOWN SURFACE LW RAD FLUX |
| aps | 2205 | 206 | OUTGOING LW RAD FLUX (TOA) |
| aps | 2207 | 205 | DOWNWARD LW RAD FLUX: SURFACE |
| aps | 3217 | 178 | SURFACE HEAT FLUX W/M2 |
| aps | 3234 | 180 | SURFACE LATENT HEAT FLUX W/M2 |
| aps | 3236 | 16 | TEMPERATURE AT 1.5M |
| aps | 4203 | 99 | LARGE SCALE RAINFALL RATE KG/M2/S |
| aps | 4204 | 118 | LARGE SCALE SNOWFALL RATE KG/M2/S |
| aps | 5205 | 98 | CONVECTIVE RAINFALL RATE KG/M2/S |
| aps | 5206 | 119 | CONVECTIVE SNOWFALL RATE KG/M2/S |

| | | | | |
|---|---|---|---|---|
| aps | 5216 | 90 | TOTAL PRECIPITATION RATE | KG/M2/S |
| aps | 8208 | 106 | SOIL MOISTURE CONTENT | |
| aps | 8223 | 122 | SOIL MOISTURE CONTENT IN A LAYER | |
| aps | 8231 | 1530 | LAND SNOW MELT RATE | KG/M2/S |
| aps | 8234 | 1532 | SURFACE RUNOFF RATE | KG/M2/S |
| aps | 8235 | 1533 | SUB-SURFACE RUNOFF RATE | KG/M2/S |
| aps | 16202 | 1 | GEOPOTENTIAL HEIGHT ON P LEV/P GRID | |
| aps | 16222 | 8 | PRESSURE AT MEAN SEA LEVEL | |
| aps | 26001 | 1902 | RIVER WATER STORAGE | M2 |
| aps | 26002 | 1904 | GRIDBOX OUTFLOW | KG/S |
| aps | 26003 | 1903 | GRIDBOX INFLOW | KG/S |
| aps | 26004 | 1901 | RIVER OUTFLOW | KG/M2/S |
| aps | 30201 | 56 | U COMPNT OF WIND ON P LEV/UV GRID | |
| aps | 30202 | 57 | V COMPNT OF WIND ON P LEV/UV GRID | |
| aps | 30205 | 95 | SPECIFIC HUMIDITY ON P LEV/UV GRID | |
| aps | 30207 | 1 | GEOPOTENTIAL HEIGHT ON P LEV/UV GRID | |
| aps | 30211 | 0 | UU ON P LEV/UV GRID | |
| aps | 30215 | 0 | UQ ON P LEV/UV GRID | |
| aps | 30222 | 0 | VV ON P LEV/UV GRID | |
| aps | 30225 | 0 | VQ ON P LEV/UV GRID | |
| aps | 30301 | 1335 | HEAVYSIDE FN ON P LEV/UV GRID | |
| aps | 30428 | 0 | dry mass col int u*q per unit area | |
| aps | 30429 | 0 | dry mass col int v*q per unit area | |
| | | | | |
| apj | 3236 | 16 | TEMPERATURE AT 1.5M | |
| apj | 5216 | 90 | TOTAL PRECIPITATION RATE | KG/M2/S |
| | | | | |
| apb | 16222 | 8 | PRESSURE AT MEAN SEA LEVEL | |
| apb | 30207 | 1 | GEOPOTENTIAL HEIGHT ON P LEV/UV GRID | |

| | | | | |
|---|---|---|---|---|
| apd | 03217 | 178 | SURFACE HEAT FLUX | W/M2 |
| apd | 03234 | 180 | SURFACE LATENT HEAT FLUX | W/M2 |
| apd | 08023 | 93 | SNOW MASS AFTER HYDROLOGY | KG/M2 |
| apd | 01201 | 186 | NET DOWN SURFACE SW FLUX: SW TS ONLY | |
| apd | 01235 | 203 | TOTAL DOWNWARD SURFACE SW FLUX | |