



Seventh Framework Programme

Theme 6

Environment



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Full project title:

**High-End cLimate Impacts and eXtremes**

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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:

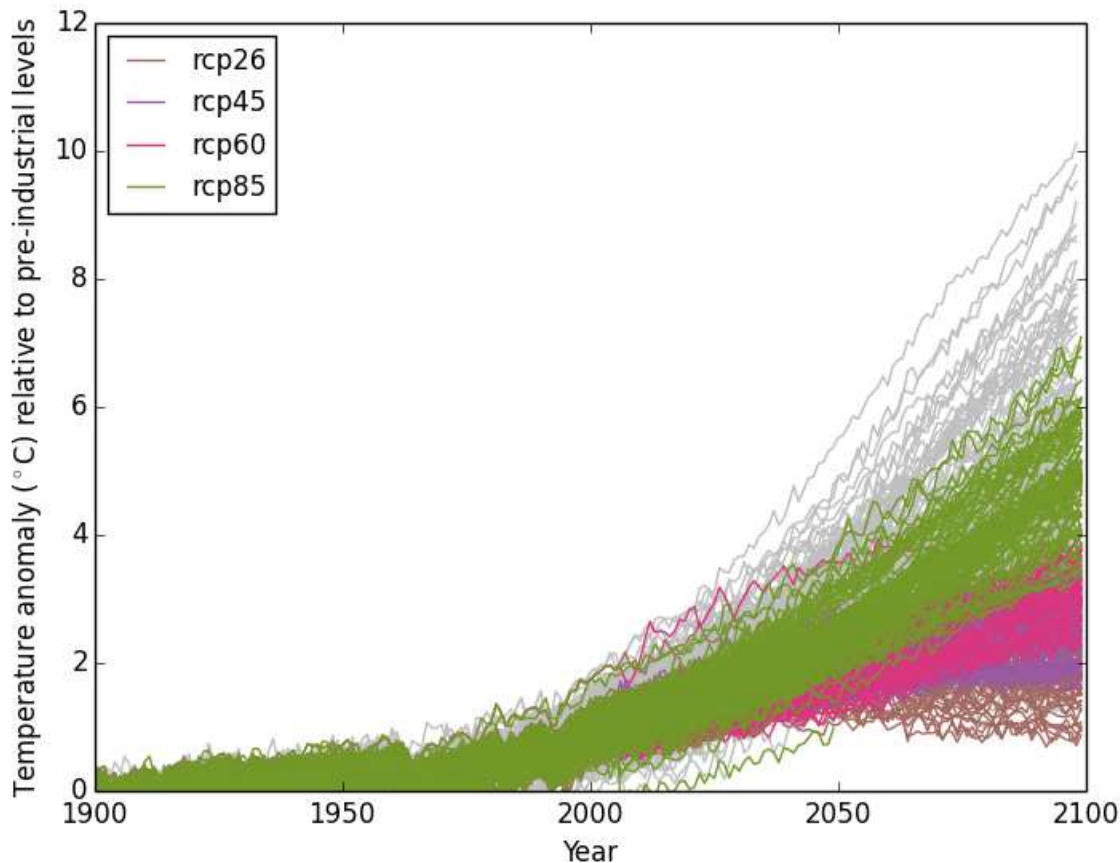
- Jens Hesselbjerg Christensen (DMI/Impressions)
- Svetlana Jevrejeva (NOC Liverpool/RISES-AM)
- Klaus Wyser (SMHI/HELIX)
- Jason Lowe (Met Office/HELIX)
- Richard Betts (University of Exeter and Met Office/HELIX)
- Laila Gohar (Met Office/HELIX)
- John Caesar (Met Office/HELIX)

## 2. Overview criteria for model and scenario selection

The HELIX project needs a scenario that will cover the SWLs of 2, 4, and 6°C, 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 °C 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 4°C SWL, but may be a challenge for the 6°C 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 6°C 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 is 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 6°C, 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 6°C 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” 6°C 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 21<sup>st</sup> 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.

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