# SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

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|---|---|
| **Reporting year** | July 2013 to June 2014 |
| **Project Title:** | High Resolution Regional climate projections at 2 deg C global warming thresholds |
| **Computer Project Account:** | spsejone |
| **Principal Investigator(s):** | Colin Jones[1], Gunilla Svensson[2] David Lindstedt[1], Petter Lind[1], Patrick Samuelsson[1] |
| **Affiliation:** | [1]Swedish Meteorological and Hydrological Institute (SMHI), [2]University of Stockholm |
| **Name of ECMWF scientist(s) collaborating to the project** (if applicable) | ……………………………………………………….…… ……………………………………………………….…… |
| **Start date of the project:** | 2012-12-31 |
| **Expected end date:** | 2015-12-29 |

## Computer resources allocated/used for the current year and the previous one

(if applicable)
Please answer for all project resources

| | | **Previous year** | | **Current year** | |
|---|---|---|---|---|---|
| | | Allocated | Used | Allocated | Used |
| **High Performance Computing Facility** | (units) | 12 million | 5.5 million | 15 million | 1.9 million |
| **Data storage capacity** | (Gbytes) | 40 000 | 40 000 | 50 000 | 50 000 |

## Summary of project objectives
(10 lines max)

The primary aim is to use a new Regional Climate Model (RCM), based on the HARMONIE NWP model and assess the ability to simulate climate processes at ~6 and 2km resolution which is a necessary step for using the model to simulate climate change.
As part of the EU FP7 project HELIX we will be downscaling an ensemble of high-resolution (T511), 30-year global climate timeslices made with the global climate model EC-Earth. These timeslices use bias-corrected SSTs and Sea Ice (SIC) derived from CMIP5 coupled simulations of the same model, representative of the recent past and two 30 year periods centred on 2, 4 and 6°C global warming compared to pre-industrial conditions in the RCP8.5 CMIP5 projection. Output from EC-Earth is used to force HARMONIE on a pan-European (Euro-CORDEX) domain, employing a resolution of ~6 km, to develop a set of future warming level timeslices. The 6 km HARMONIE simulations will also be used to force smaller HARMONIE domains over sub-regions of Europe run at convection-resolving resolutions (~2km). A key aim is to develop a climate modelling capacity at 'grey-zone' resolutions ~ 3-8km and to investigate convection-resolving climate simulations.

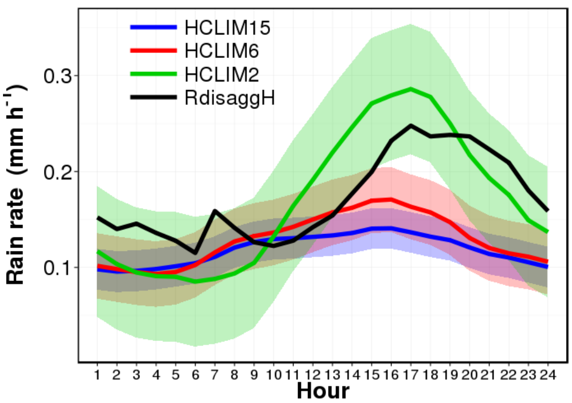
## Summary of problems encountered (if any)
(20 lines max)

All of the technical limitations in HARMONIE for application to climate time-scales are still not resolved. We are working with the representation of sea-ice in the model and have replaced the parametrization of radiation to a newer scheme which probably will reduce a negative bias in long wave radiation at the surface and make the treatment of time-varying greenhouse gases more physically consistent.
Work is also progressing to reduce output from the model, as mentioned in previous report disk space and the volume of data needed both as boundary conditions for HARMONIE and produced as output by HARMONIE in climate mode remains a serious challenge.

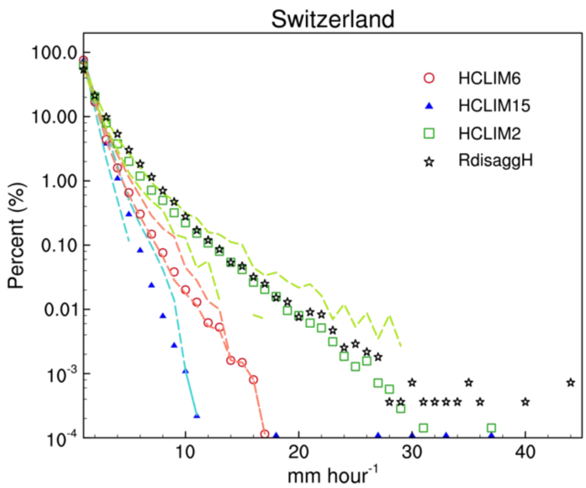
## Summary of results of the current year (from July of previous year to June of current year) This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

We have been evaluating the overall performance of HARMONIE for present climate conditions, using the Euro-CORDEX domain (Fig. 1 in attached paper). HARMONIE has been run at two resolutions (15km and 6.25km) over the Euro-CORDEX domain, driven by ERA-interim lateral and surface boundary conditions, for the period 1997-2008 inclusive. The coarser resolution version allows us to compare HARMONIE performance to our present RCM (RCA4) and to other European RCMs run in Euro-CORDEX at an equivalent resolution forced by ERA-interim. The two HARMONIE resolutions allow us to assess benefits accruing from the increased resolution in a common model. After the overall performance was established we investigated to what extent the higher resolution provides an improved representation of higher order regional climate statistics such as intense precipitation events. Results from these simulations have been submitted to Tellus A and a copy of the paper which is in review is attached to this report.

HARMONIE contains of a number of physics packages, specifically developed for different resolution ranges. In this project we concentrate on the ALARO physics, nominally developed for grey-zone resolutions (~3-10km) and the AROME physics, applicable to convection-permitting resolutions (~1- 3km). We have begun assessing the performance and added-value of going to convection-resolving resolutions, within the HARMONIE configuration, concentrating on summer season precipitation over the Alps. We choose the Alps due both to the extreme topographic forcing of precipitation and because a well-documented, high-resolution observed precipitation data set is available for model evaluation. We have run HARMONIE, on the full Euro-CORDEX domain, for 7 summer seasons (May-September inclusive) spanning a range of representative summer precipitation outcomes over the Alps. HARMONIE is run at the two resolutions; 15km and 6.25km, with the output from the 15km model used in a double-nesting step to force an inner HARMONIE domain at 2km resolution centred on the Alpine region. This interior domain is run for the same 7 summer seasons twice, using either ALARO or AROME physics. Such an experiment protocol allows us to evaluate simulated precipitation statistics in the 3 HARMONIE versions; 15km, 6.25km and 2km (the latter forced by the 15km HARMONIE) over the common Alpine region. Furthermore, testing both ALARO and AROME in the 2km domain allows an assessment of the relative benefits of both schemes at high resolution, contrasting this with the importance of physics consistency across the lateral boundaries of the small Alpine domain, with ALARO physics used in the 15km driving model. This set of simulations is now completed and analysis begun, looking at precipitation variability, rain spell duration and the diurnal cycle of precipitation across the range of model resolutions. First results show an improvement in several aspects when using explicit treatment of deep convection. Well known behaviours of parametrized convection such as too much light rain "drizzle" and early onset of the diurnal cycle is improved where the phase and amplitude is closer to local high resolution observations. We envisage submission of an article on this subject early in 2015.




*Diurnal cycle of precipitation in Switzerland for HARMONIE-Climate (HCLIM) at 3 resolutions: 15 km (blue), 6km (red) and 2 km (green, AROME). Black is high-resolution gridded observations.*




*Empirical probability density functions of rainfall for HCLIM at 3 resolutions contrasted to observations in black. The stippled lines are the 95% confidence intervals.*

## List of publications/reports from the project with complete references

Lindstedt, David., Lind, Petter., Jones, Colin. and Kjellström, Erik.: *A new regional climate model operating at the meso-gamma scale; performance over Europe*. Tellus A 2014 (in review)

Petter Lind., David Lindstedt., Colin Jones., and Erik Kjellström.*: The benefit of convection permitting horizontal resolution in a climate model for the representation of summer precipitation in the Alp region. (In preparation)*

### Oral presentations and posters

*The benefit of convection permitting horizontal resolution in a climate model for the representation of summer precipitation in the Alp region.*
Petter Lind, David Lindstedt, Colin Jones, and Erik Kjellström
http://meetingorganizer.copernicus.org/EGU2014/EGU2014-13319.pdf

*Pan-European climate simulations using the HARMONIE limited area model - the benefit of ”grey zone” horizontal resolution for precipitation and its extremes.*
Petter Lind, David Lindstedt, Colin Jones, and Erik Kjellström
http://meetingorganizer.copernicus.org/EGU2014/EGU2014-13239.pdf

Very high-resolutions climate runs over Europe; an evaluation
David Lindstedt, Petter Lind, Colin Jones, and Erik Kjellström
http://cordex2013.wcrp-climate.org/posters/P1_43_Lindstedt.pdf

## Summary of plans for the continuation of the project

(10 lines max)

Due to delays in the project and technical issues we are still working to get a model version for multi-decadal simulations. Towards the end of 2014 and during 2015 the intended, high-resolution HARMONIE timeslices for Europe, forced by EC-Earth data, will be started. Depending on progress made with these timeslices we also aim to apply the same HARMONIE 6.25km configuration using both ERA- interim and EC-Earth boundary data to East Africa. Here we aim, in particular, to study potential changes in the precipitation variability, drought and flood risks, at specific warming levels.