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Earth System Dynamics Discussions

Interactive comment on "Downscaling climate change scenarios for apple pest and disease modeling in Switzerland" *by* M. Hirschi et al.

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Reply to reviewers' comments

Reviewer 1

- P.496, L.7: Could you add some comments about the possible (or not) use of dynamical downscaling?

We actually use a combination of a dynamical and a statistical downscaling. Within the ENSEMBLES project, the GCMs were dynamically downscaled with RCMs. However, as the spatial and temporal resolution of the RCMs is not sufficient for the pest and disease models (requiring site-specific hourly weather), an additional (statistical or dynamical) downscaling is required. We added the following here:

"It is well known that the output of climate models is not suitable for direct application to impact studies. There are two major issues: low spatial (and temporal) resolution and the presence of significant biases. The latter problem also affects the sequence of weather events. Thus, a statistical or dynamical downscaling needs to be applied (Calanca et al. 2009). While a dynamical downscaling is demanding in terms of computational resources, a statistical downscaling can be achieved with relatively small resources and is thus more attractive and feasible from a climate projection end-user perspective.

Here, we developed and applied an application-specific statistical downscaling procedure based on the combination of a stochastic weather generator . . ."

- P.497, L.20: I think it would be appropriate to have here a "data" section where all available observations (meteorological but also about codling moth and fire blight) would be described once for all (instead of for example in figure legends)

We added a table on the various data sets to the Supplementary Material and referenced it in the revised version of the manuscript text.

- P.498, L.25: It would be relevant to have somewhere a listing of what analyses are available as a supplementary material and what is directly available in the paper. This could be detailed either here or at the beginning of the "results" section.

We verified that the supplementary material is referenced in the manuscript text whenever the respective analysis is mentioned. As there are no unmentioned analyses in the supplementary material, we think an additional listing is not necessary.

- P.499, L.29: the reference Fischer at al. (2011) was unfortunately not available at the moment of review.

It is available now (http://onlinelibrary.wiley.com/doi/10.1002/joc.3396/abstract).

- P.501, L.1: The calibration period should definitely be specified and commented here (cf. Also the comment on a "data" section).

We added the calibration period here.

- P.510, L.2-3: "the increase in the potential risk.." This is not very clear on the graph? Probably because of the color palette?

We added contour lines to this graph to make the non-linear increase in the risk better visible.

- Fig.6: It would have been very nice to have here the whole set of RCM-GCM combinations. That would have helped to discuss the evolution of risks commented P.510, L.3-10.

In accordance with Fischer et al. 2011, we only show the GCM-averaged model chains. These are the basis for the applied climate change signals. The averaging of RCMs that have been driven by the same GCM is done to obtain independence between the data entering the Bayesian multi-model combination algorithm (see Fischer et al. 2011).

Technical corrections

- Fig.3, bottom row (and also Fig. 8): the x-axis is not correctly positioned and make the figure a bit difficult to read at first. The zero value should be aligned with the first bar of the histogram.

We adjusted the x-axis position (and the breaks) in these figures.

Note that we exchanged the topleft panel of Figure 3: The trap observations were not taken mid-week but at the start of each week, which leads to a slight shift of the distributions (and slightly higher p-values in the topright panel). Also, we added an additional comment on the expected time delay of in-situ vs. actual flight activity (P.506, L18-20): "Note that the in situ observed first flight activity is expected to lag behind the actual flight start as the traps are only controlled weekly (i.e., actual catch during previous week) and it takes some time until the moths are captured by the traps")

Reviewer 2

- General Comments

It would have been a better approach to run all the RCM simulation through the downscaling processing and then through the impacts models rather than a mean and a high and low example as undertaken in the paper.

We agree that a downscaling of the individual RCMs with downstream impact modeling and final Bayesian estimation of the uncertainty based on the output of the impact model would have been possible as well. However, running the Bayes algorithm after the impact modeling would require observations of the occurrence of the various pest life phases over the control period, which are not available.

Also, the only contributor to the final uncertainty in the impact is defined by the uncertainty in the climate change signal (as uncertainties in the impact model are not considered here). Thus it makes sense to do the estimation of the uncertainty prior to the impact modeling. Also, beside taking into account the considered three temperature and precipitation combinations, we also analyze the full (and extended) range of the climate projection uncertainty (see Figure 6).

Moreover, the study is carried out in the framework of a national initiative to disseminate updated climate change scenarios for Switzerland (see Fischer et al. 2011 and the official CH2011 report: www.meteoschweiz.admin.ch/web/en/climate/climate_tomorrow/scenario_2011.html). One aim of our study is to demonstrate how to use these official scenarios for impact modeling. As an end-user normally does not have the resources to include a whole set of RCMs for the analysis of climate change impacts in her/his field, our paper can serve as a guideline for the usage of such aggregated multi-model scenarios. A reference to the official CH2011 report is now made in the last paragraph of the introduction section:

"In the present study we exemplify how to close the gap between climate change scenarios and impact modeling of pests and diseases on hourly time scale. It is carried out in the framework of a national initiative to disseminate updated climate change scenarios for Switzerland (see Fischer et al., 2011 and the official CH2011 report: www.meteoschweiz.admin.ch/web/en/climate/climate_tomorrow/scenario_2011.html)."

The outcomes and impacts suggested here are pushing beyond the limits 'predictability' even at seasonal scales and therefore of course with such projections at climate change time scales. I think it is not realistic to expect a regional climate model to produce a sequence of events such as those required for these impacts models. It would have been useful to look at the raw RCM output in terms of timing and sequencing of events before downscaling was applied.

Precisely the fact that "it is not realistic to expect a regional climate model to produce a sequence of events such as those required for these impacts models" motivated our choice to create input data for the impact model with the help of a stochastic weather generator. The merits of stochastic weather generators for this type of application have long been recognized, and in fact our analyses show that the presented approach is indeed capable of reproducing the phenology of the pest (see Section 3.1). Moreover, the downscaling is required prior to the impact modeling as the RCMs are not reliable on the required fine temporal scale and at specific locations. In addition, the prior application of the Bayesian multi-model combination algorithm gives a better estimation of the uncertainty in the climate change signals as compared to raw RCM output.

- Specific Comments

More discussion is need on the downscaling undertaken for the future projections from the RCMs. Exactly how was this carried out for the future runs for example was it assumed that the biases seen in the current climate runs would be seen in the future climate model runs too? Some honest discuss of the assumptions being made here needs to be discussed.

Here, we assume a constant bias, which is of course arguable (see e.g. discussion in Christensen et al., 2008 or Buser et al., 2009). The applied Bayesian framework would allow for biases to change. However, with the currently available observational and model data, it is not possible to clearly infer the development of model biases over time. Therefore, the simplest assumption, i.e. the constant bias assumption, has been chosen (see Fischer et al. 2011 for a more extensive discussion on this assumption).

We added a comment on the assumptions behind the climate projections (P.498, L.11): "Note that assumptions inherent in many climate projections are that the range of model uncertainty is fully sampled by the available model projections, and that systematic model biases do not change with time. These assumptions were also made here (for more details, see Fischer et al., 2011)"

References

Buser, C.; Künsch, H.; Lüthi, D.; Wild, M. and Schär, C. (2009). Bayesian multi-model projection of climate: bias assumptions and interannual variability. Climate Dynamics, 33, 849-868, doi:10.1007/s00382-009-0588-6.

Christensen, J. H.; Boberg, F.; Christensen, O. B. and Lucas-Picher, P. (2008). On the need for bias correction of regional climate change projections of temperature and precipitation. Geophys. Res. Lett., 35, doi:10.1029/2008GL035694.

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