Toolbox module, part B –
Draft toolbox module for uncertainty assessment

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Introduction

One of the main tasks of the Work Package 8 (WP8) is to provide an uncertainty assessment for the climate impact indicators that will be accessible in the CLIPC portal (http://www.clipc.eu). The methodology for this uncertainty assessment is in detail described in the previous milestone 37 (MS37). In this MS39, the structure of the implementation of it into the CLIPC portal and the steps of the technical realisation of the implementation are demonstrated here.

The CLIPC uncertainty assessment for climate impact indicators consists of assembling and combining relevant uncertainty information, then translating the aggregated result into a *degree of confidence*. For sake of clarity, we repeat the definition of the *degree of confidence* that can be found in MS37:

Definition	For this assessment, the ***degree of confidence*** comprises not only the quantifiable fraction of uncertainty, but additionally the degree to which we trust an outcome - no matter if this outcome is a climate impact indicator derived from surface observations, re-analysis, simulations or projections describing the bio-physical or socio-economic impact of climate impact. This trust also comprises possible quantities that are deemed unknown.

The methodology of the uncertainty assessment is based on the concept of *confidence* and thus we replace the term 'uncertainty assessment' in the remainder of this milestone with 'confidence information'.

The methodology for providing confidence information developed for CLIPC is based on two main components:

- a questionnaire filled-in by experts to identify sources of uncertainty and to obtain confidence information for each selected climate impact indicator
- user engagement while developing methodology to test development steps and to determine most important components for providing confidence information

This methodology is described in detail in MS37 *(see* http://www.clipc.eu/media/clipc/org/documents/milestones/clipc_ms37_final.pdf).

Components of the confidence information

The questionnaire of MS7 helped to collect detailed information for a set of climate impact indicators. From the user consultations in cooperation with WP2 emerged that two sections are of greatest interest:

- **Confidence information**: This is given as *degree of confidence* and depends on 'evidence and agreement' of the datasets used for a selected climate impact indicator and what ‘type of method’ is used for the calculation of it. The *degree of confidence* is expressed in two ways:

   - **scale**: level of the *degree of confidence* ranging from * (low) to ****(high). The full explanation of the scale is given here in the appendix Table 2 or see: http://tiny.cc/clipc_confidence_template
   - **text**: explanation of the level of the *degree of confidence*. The text makes reference to the two categories: ‘evidence and agreement’ and ‘type of method’ but also describes limitations that are specific for the climate impact indicator and which may change the *degree of confidence*. (see: appendix Table 2 or http://tiny.cc/clipc_confidence_template)

- **Sources of uncertainty**: A list of the various sources of uncertainty that are connected with a climate impact indicator. These sources are specified in terms of their nature that means they are assigned to either ‘unpredictability’, ‘stochasticity’ or ‘incomplete knowledge’ (see: Table 2 or http://tiny.cc/clipc_confidence_template)

A comprehensive list of sources of uncertainty was compiled through the questionnaire that was developed in MS37. This questionnaire was sent out to CLIPC partners that documented in total twelve climate impact indicators. The resulting list of sources of uncertainty contained replicates because some sources of uncertainty appeared for different climate impact indicators but were differently named by the CLIPC partners. For the implementation, there was a need to harmonise these sources that were repeatedly mentioned, i.e. to define a uniform name and description.

We have grouped the sources of uncertainty depending on their original datasets: modelling, in-situ, remote sensing, bias adjustment and re-analysis. In close cooperation with the experts in the field of the respective data sets, we have compiled a list of pre-defined sources of uncertainties with a short description of each source and its characterisation. This list can be found under: http://tiny.cc/clipc_confidence_template or a copy of the list can be found in the appendix Table 1. This document was created as a ‘living’ document so that changes to the pre-defined definitions of the sources of uncertainty can be added.

The reason for the ‘living’ document is that the experts preparing climate impact indicators for the CLIPC portal will make use of the pre-defined sources of uncertainty for providing confidence information. This way they will have a chance to bring in their expertise to the definition of these sources of uncertainty during the implementation phase. GERICS will keep track of the changes. In September 2016, the portal development will be frozen. Until this point changes are possible and will be considered in the implementation of the confidence information into the portal.

Visual components of the confidence information

The CLIPC portal consists of different sections. The climate impact indicators are accessible in the section called ‘impact indicator toolkit’ (http://www.clipc.eu/indicator-toolkit, status June 2016: BETA version). The impact indicator toolkit presents tools allowing users to explore the pre-calculated climate impact indicators and to switch between different climate impact indicators. The map that displays the climate impact indicators is accompanied by a legend including visualisation options and background information for the corresponding climate impact indicator. This section is where the confidence information is located. Clicking on it leads to an overlay window with more information.

The confidence information appears in the portal in two ways. The level of the *degree of confidence* is displayed as a sliding bar on the left side. The detailed information behind the sliding bar are summarised in a so-called confidence fact sheet.

- **sliding bar**: is a type of visualisation for the confidence information. It is based on a colour bar that is designed to give an estimate of the level of the *degree of confidence*. The colours range smoothly from red to green, where as red indicates ‘low’ and green ‘high’ level of *degree of confidence*. The scale is not displayed to avoid the impression of exact values for the level of the *degree of confidence.*

  If there is no expert evaluation for a climate impact indicator available, there is the option to set the sliding bar to the field ‘unknown’.

  By clicking on the sliding bar, the user is directed to a pop-up window containing the confidence factsheet.

- **confidence factsheet**: is a popup window containing detailed information on the degree of confidence (see Figure 1). The upper section is dedicated to the confidence information, i.e. a description of the *degree of confidence* in words. This is a free text written by the expert. The second section contains a list of sources of uncertainty complied by the expert from the list of pre-defined list of sources of uncertainty (see Table 1). If needed, additional sources are added. The sources of uncertainty are separately listed for climate and non-climate data. Only the names of the sources of uncertainty are shown. Detailed information appears by sliding over it. The sources of uncertainty are displayed in the format of a table whereas the sources of uncertainty are the rows and the columns indicate three categories about the nature of the source of uncertainty: ‘unpredictability’, ‘stochasticity’ and ‘incomplete knowledge’. The sources of uncertainty are assigned to one of the categories by a tickmark. All terms used in this section are explained in the glossary that becomes visible by sliding over the term.

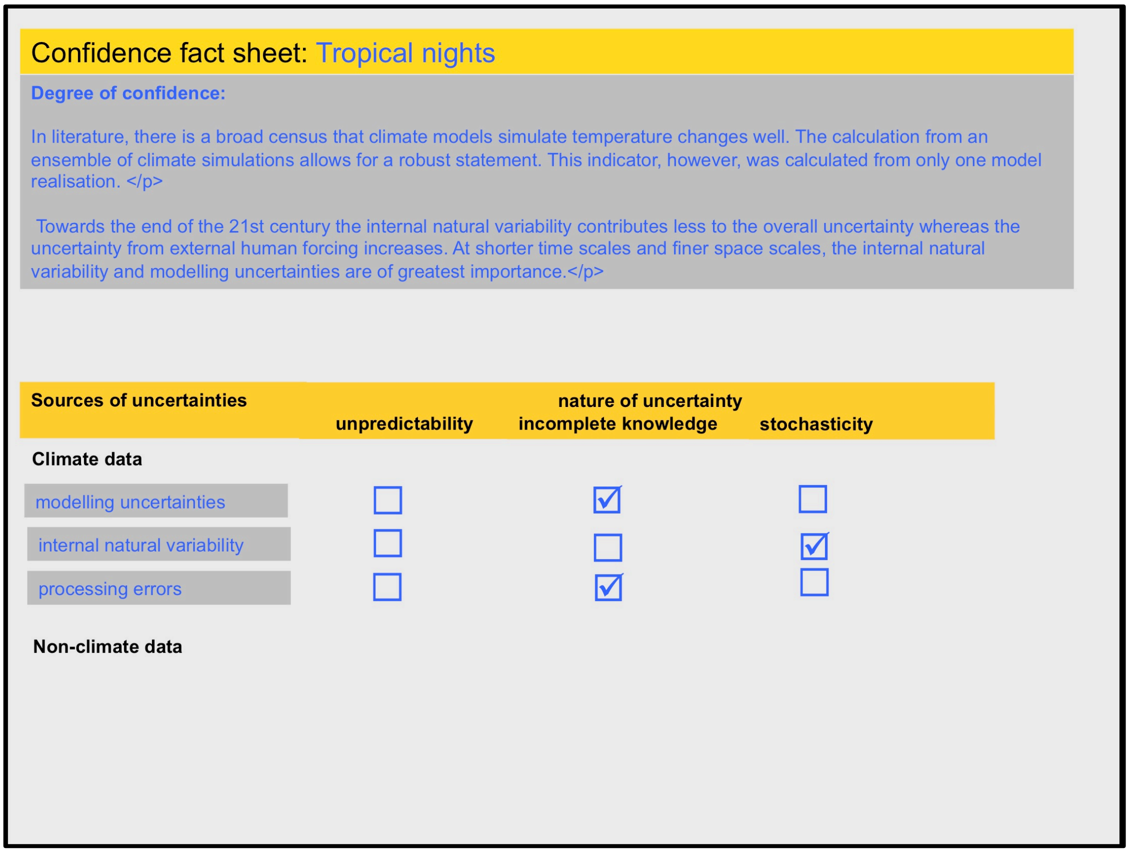

Figure 1: Sketch of the structure how the confidence fact sheet will be presented in the CLIPC impact indicator toolkit. This example shows the entries for the indicator 'tropical nights' in blue, see for more information the section 'Demonstration of the implementation' and Table 3.

Technical realisation of the confidence information

The confidence information for each climate impact indicator is managed through a web-based Content Management System (CMS). This CMS (see Figure 2) and the visualisation and design of the CLIPC indicator toolbox were set up by WP3.

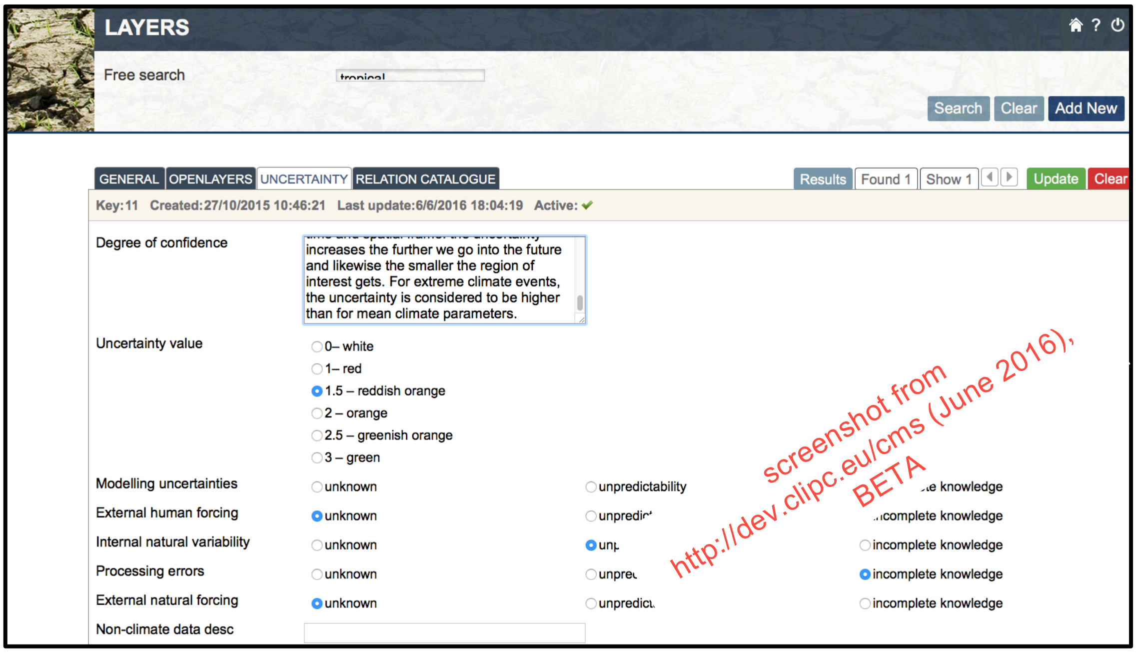

Figure 2: Screenshot of CMS where the confidence information is added to be presented at the CLIC indicator toolkit.

The confidence information is added separately for each climate impact indicator into the CMS. The description of the *degree of confidence* is copied as text into the CMS, the level for the sliding bar can be selected from a pre-defined list of values that is used to visualise the sliding bar. The pre-defined sources of uncertainty (see above) are available in the CMS and can be selected by a ‘click’. Additional sources of uncertainty can be manually added by a text field and be assigned to the three categories (unpredictability’, ‘stochasticity’ and ‘incomplete knowledge’).

Workflow for the implementation of confidence information

The implementation of the confidence information for a respective climate impact indicator consists of a chain of several steps designed as a workflow in Figure 3. First CLIPC partners (WP6-8) produce a climate impact indicator and fill in a template with the corresponding confidence information (described in detail below). While the climate impact indicator is prepared for visualisation at the CLIPC indicator toolkit by WP3-4, the confidence information is pasted into the CMS by GERICS. Once the climate impact indicator appears in the CLIPC indicator toolkit, the confidence information will be by validated by SYKE and GERICS.

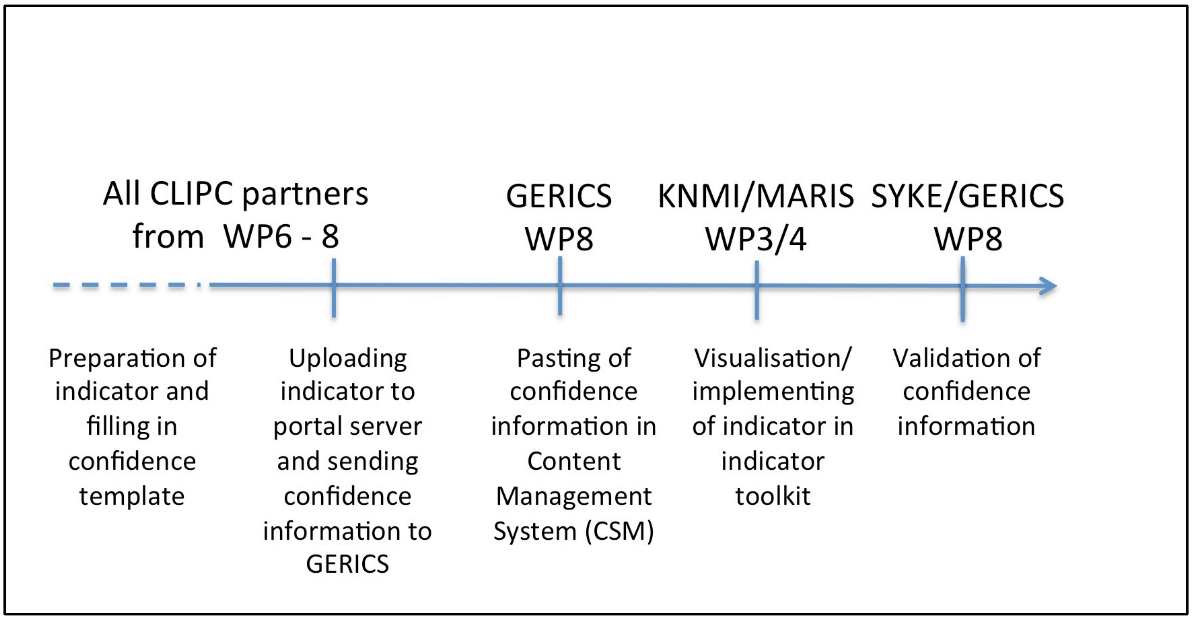

Figure 3: Workflow for producing a climate impact indicator to the appearance with confidence information at the CLIPC indicator toolkit.

The provision of the confidence information will be done by means of a template with instructions (see appendix Table 2) that is designed to collect the confidence information for each climate impact indicator that will be displayed in the CLIPC indicator toolkit. Beside some information about the author, the template collects information for the sliding bar (level of the *degree of confidence*), and for the confidence fact sheet (description of the *degree of confidence* and the sources of uncertainty).

The template will be distributed via different channels. It will be sent to the CLIPC partners that documented the selection of twelve climate impact indicators for MS37. The implementation of the confidence information for these climate impact indicators will be described in the forthcoming Deliverable 8.4 "Uncertainty assessment of impact indicators". For additional climate impact indicators, the template and instructions will be documented in the forthcoming Deliverable 7.3 "Implementation of existing and new climate impact indicators, consistency check and interpretation guidelines" where the whole workflow and instruction for publishing climate impact indicators in the CLIPC indicator toolkit will be in detail described.

Demonstration of the implementation

The climate impact indicator 'tropical nights' - defined as number of days where the daily minimum temperature is above 20 °C - is used for the demonstration how the confidence information is visualised in the CLIP indicator toolkit (BETA Version). The climate impact indicator 'tropical nights' was calculated based on a dataset consisting of one climate model (ICHEC-EC-EARTH /KNMI-RACMO22E) for the time period 1950 – 2005.

Following the workflow in Figure 3, the confidence information for the climate impact indicator ‘tropical nights’ was filled in the template and can be found here: Table 3. The visualisation of it in the CLIPC indicator toolkit is presented in Figure 4 and Figure 5.

For all other climate impact indicators already present in the CLIPC indicator toolkit, the scheme of the provision of confidence information is implemented but there is temporarily no confidence information available yet. This is indicated by the sliding bar set to ‘unknown’. When clicking on it, the popup window with the confidence fact sheet opens with the message that there is no confidence information available (see Figure 6 and Figure 7). For the forthcoming Deliverable 8.4 is planned to collect and to provide the confidence information for at least twelve climate impact indicators.

Please note that the CLIPC portal is still under development so that the screenshots demonstrate the current state (June 2016) of the implementation of the confidence information but not the final state. The technical CLIPC portal development will be finished in September 2016.

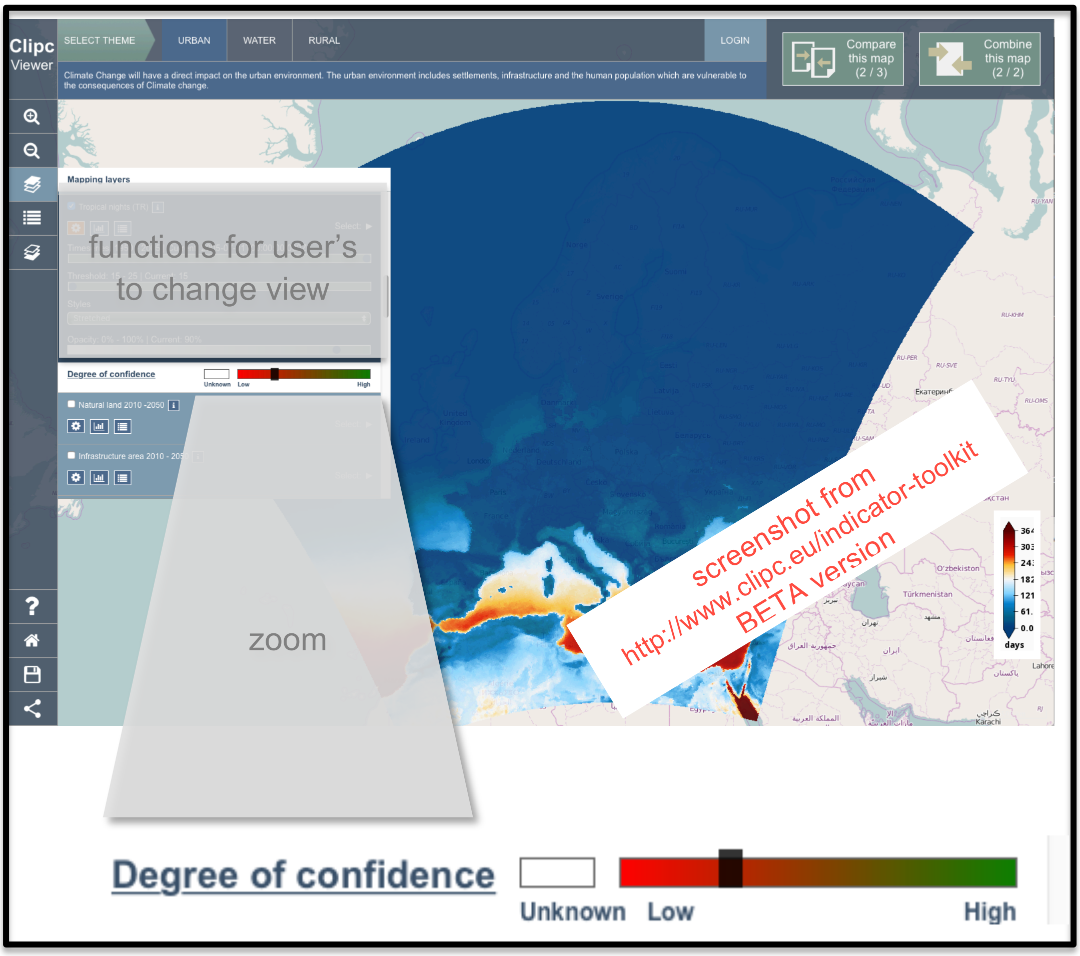

Figure 4: Demonstration of CLIPC indicator toolkit and sliding bar. This demonstration shows the climate impact indicator 'tropical nights' (status June 2016, BETA-version) . On the left hand side the confidence information is summarised in the sliding bar. The level is based on the confidence information documented in Table 3. By clicking on the sliding bar, the confidence fact sheet opens, see Figure 5.

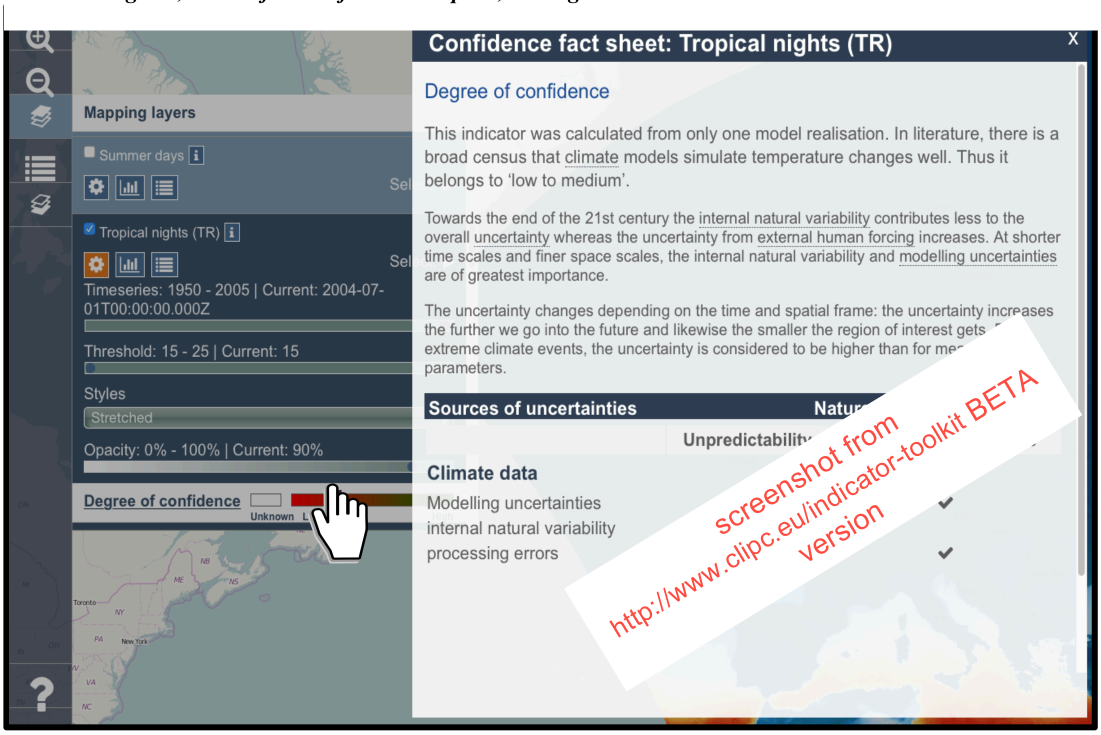

Figure 5: Demonstration of the confidence fact sheet. By clicking on the sliding bar, the visitor opens a popup window. The content of the confidence fact sheet is based on the confidence information documented in Table 3.

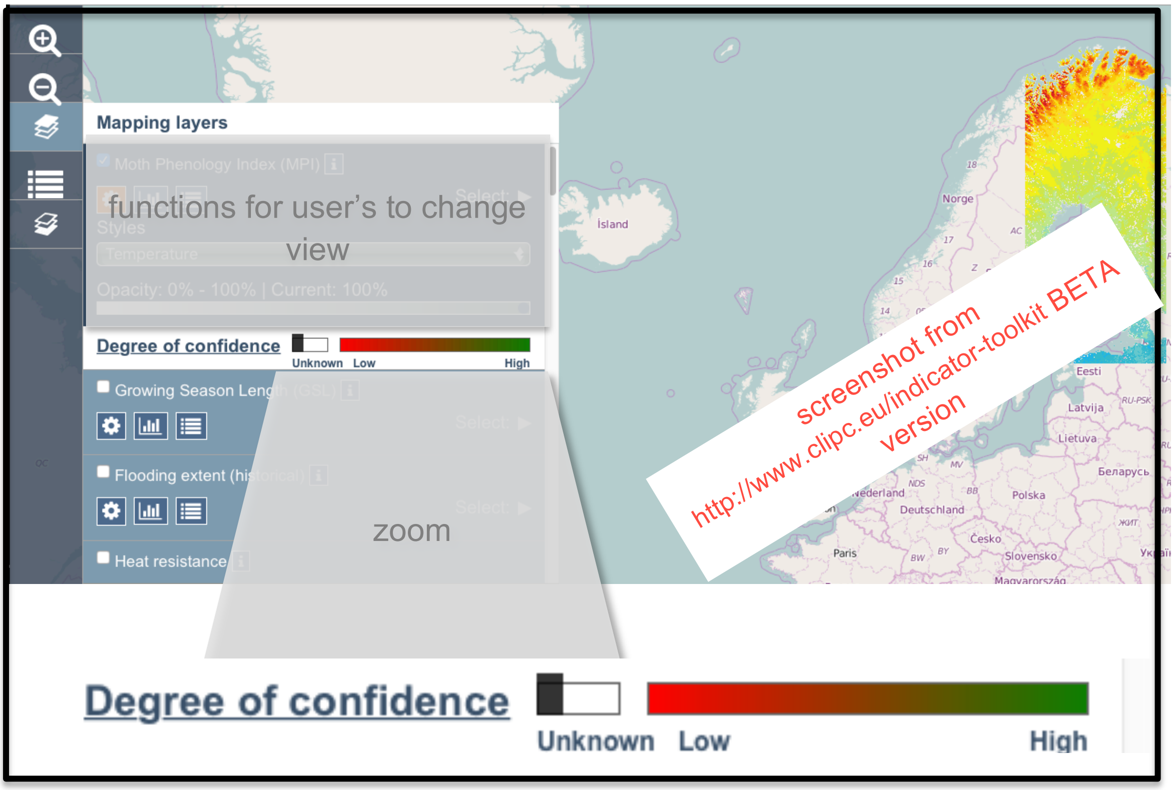

Figure 6: Demonstration of sliding bar if no confidence information is available for a climate impact indicator. The sliding bar is set to 'unknown'. When clicking on it, the confidence fact sheet opens, see Figure 7.

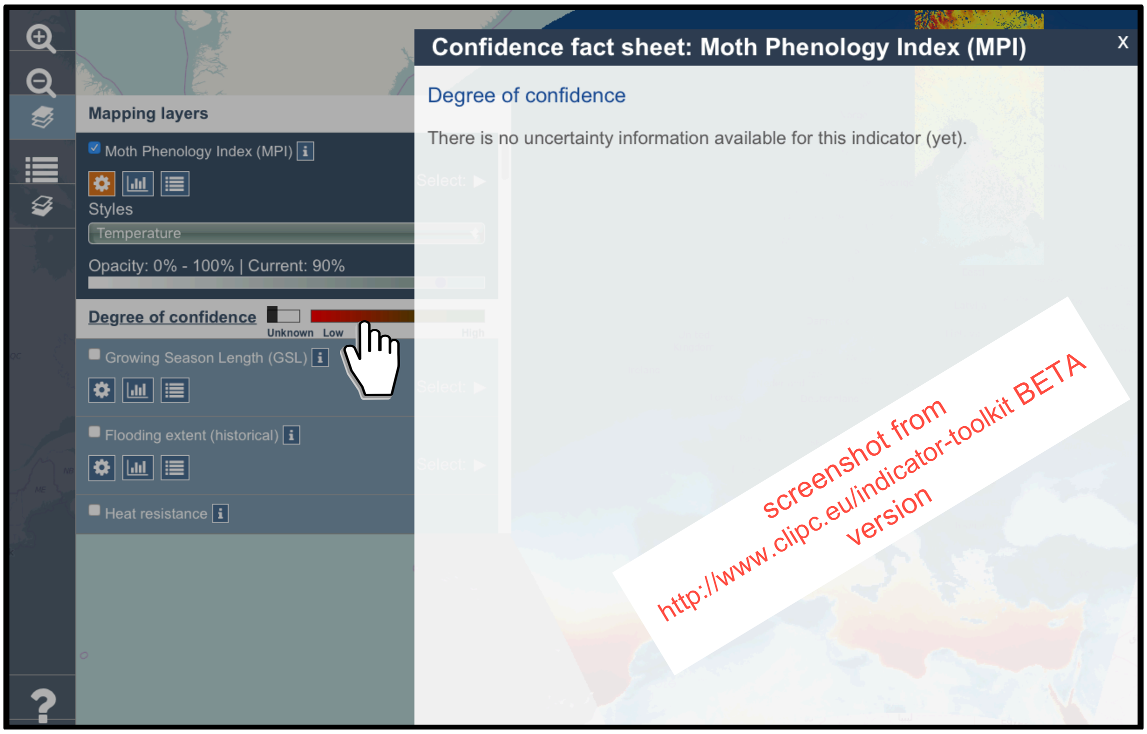

Figure 7: Demonstration of confidence fact sheet if no uncertainty assessment is available. The confidence fact sheet opens with the disclaimer that no information is available.

Summary and implementation plans

The methodology of providing confidence information for pre-calculated climate impact indicators is based on a questionnaire and user consultations as presented in MS37. By the means of the user consultation the most important features (confidence information and sources of uncertainty) were extracted and used for the implementation in the CLIPC indicator toolkit. In cooperation with WP3, the concept and visualisation for the confidence information (sliding bar and confidence fact sheet) has been implemented in the BETA-version of the CLIPC indicator toolkit.

For an example climate impact indicator, 'tropical nights', the confidence information was collected, documented and implemented. For all other climate impact indicators the feature for the confidence information are available but with a disclaimer that the information is not available yet.

For the next steps, the confidence information will be collected for the twelve climate impact indicators documented in MS37. The CLIPC partners will be asked to follow the workflow presented here and to fill in the confidence template so that a selected set of climate impact indicators will be completely implemented in the CLIPC indicator toolkit by September 2016. The content will be documented in the forthcoming Deliverable 8.4 "Uncertainty assessment of impact indicators".

Appendix

Table 1: Preliminary list of pre-defined sources of uncertainties for the documentation of the degree of confidence for climate impact indicators in the CLIPC indicator toolkit. The list can be found online and comments are welcome: : http://tiny.cc/clipc_confidence_template.

Name of source*	**Description***	**Nature of source***			**Guidance help: it is indicated the source applies for type of underlying data**				
	**If you capture any mistakes or errors, please inform Juliane (juliane.otto@hzg.de)*	**Unpredictability**	**Stochasticity**	**Incomplete knowledge**	**modelling**	**in-situ**	**remote sensing**	**bias adjustment**	**re-analysis**
external natural forcing	Externally forced climate variations may be due to changes in natural forcing factors, such as solar irradiance or volcanic aerosols.	yes			**x**			**x**	
internal natural variability	Is an inherent part of the Earth climate system and arise from chaotic non-linear processes in the climate system which lead to stochastic variations in climate parameters.		yes		**x**			**x**	
external human forcing	It stems from many possible trajectories that future emission rates of greenhouse gases and aerosol precursors might take, and from future trends in land use.	yes			**x**			**x**	
modelling uncertainty	This comprises all uncertainties resulting from incomplete understanding and representation of the system modelled, including chosen parameters in models and algorithms. This can also include uncertainty from imperfect calibration, the choice of statistical techniques and missing or simplified processes in the algorithms used to retrieve a geophysical quantity from the signal detected by a satellite sensor.			yes	**x**		**x**	**x**	
processing uncertainty	Any steps taken in the transformation from raw data to an end product. This includes homogenisation, averaging, interpolating, computing indices/trends etc.			yes	**x**	**x**	**x**	**x**	**x**
measurement uncertainty	This includes the precision of the instrument, and inhomogeneity due to changes in the observing system over time, and any bias of one observing system or sensor versus another. Related to satellite measurements, the position of the sensor plays a role which can lead to errors of the retrieved value. Moreover, the instrument calibration and ageing of the instrument lead to additional uncertainties.			yes		**x**	**x**		
temporal sampling uncertainty	Missing data at the hourly, daily and monthly scales are very common. This will affect any analyses of daily/monthly/seasonal/annual maxima and minima, as well			yes		**x**			

	as averages.								
spatial representativeness	Any region of the Earth is unlikely to be evenly or densely sampled. Stations may also drop in and out over time. Regional averages can only represent the stations they are made up of. The comparison of data measured at ground stations with data collected by satellites may introduce scaling errors. The coarser the grid cell of the remotely sensed data, the more of this variability is lost. This may lead to scaling errors between remotely retrieved and in-situ observations.			yes		**x**	**x**		
sampling uncertainty	Temporal and spatial sampling characteristics will vary depending on the type of orbit, the width of the instrument swath and its field-of-view. For example a single sensor might provide an under-sampled view in space and time and thus, the measurements may or may not capture the true variability of the observed quantity. The position of the sensor which is related to the viewing geometry plays can also lead to errors of the retrieved value.			yes			**x**		
signal contamination	Depending on the quantity of focus, atmospheric effects like clouds or aerosols, or unwanted signals from the Earth's surface can significantly influence or alter the retrieved signal. For example, for optical data, a robust surface image classification can be very challenging, given the fact that approximately 50% of the Earth is covered by clouds at any time.		yes				**x**		
data assimilation uncertainty	The changing mix of observations, and biases in observations and models, can introduce spurious variability and trends into reanalysis output. Variables relating to the hydrological cycle, such as precipitation and evaporation, should be used with extreme caution. More information: https://climatedataguide.ucar.edu/climate-data/atmospheric-reanalysis-overview-comparison-tables			yes					**x**
calibration uncertainty	The choice of the calibration period introduces uncertainty. The length but also the choice of years for the calibration relate to the relationship which is build between observation and simulation data. This issue is related to the non-			yes				**x**	

	stationarity of the bias - it can be changing over time. Statistical methods, however, assume stationarity of biases over time. Therefore, there is a need to maximise the calibration period in order to reduce this part of the uncertainty.								
observational constraints	Observational constraints, and therefore the reliability of the output, can considerably vary depending on the location, time period, and variable considered.			yes				**x**	**x**

Table 2: Instructions and guidelines for template to collect confidence information for climate impact indicators.

Steps:	
1. Download this file as .xlsc to your computer: Go to 'File', select 'Download as'.	
2. Rename according to the proofed DRS (point 2 and 3 of instructions upload impact indicators).	
Example DRS: <VariableName>_<package>_<institution>_<model>_<CMIP5ExperimentName>_<CMIP5EnsembleMember>_[IndicatorRealisation_][<RCMName>_<RCMVersionID>_<domain>_] [<BcName>_<BcObsName>_<BcRefPeriod>_] <frequency>_<StartTime-EndTime>_ [<Reference_period>_][tile-nnnnn].nc --> tr_icclim-4-1-2_SMHI_ICHEC-EC-EARTH_historical_r1i1p1_SMHI-RCA4_v1_EUR-11_yr_19500101-20050107.xlsx	
3. Then start filling in all blue-highlighted fields of the sheet 'Template....' . Make use of the predefined sources of uncertainties under the sheet 'Predefined sources of uncertainty'. A full description of each field is given below in the guidelines.	
4. Send the completed file to GERICS (Juliane, juliane.otto@hzg.de) and MARIS (Peter, peter@maris.nl).	
If you want to see a final template filled in for the indicator 'tropical nights', you can find it under the sheet called 'Example'. The implementation of this information can be found under http://www.clipc.eu/indicator-toolkit, choose 'tropical nights' and click on the 'degree of confidence'.	
Guidelines	
Author, email:	Please indicate your name and email address
Name of indicator	Please provide the name of the indicator (as given under http://tiny.cc/clipc_indicator_workflow).
Definition	Please provide the definition of indicator
DRS	Please provide the Data Reference System (DRS) for this indicator. This needs to correspond to the file name.

Degree of confidence	Please indicate the level of the 'degree of confidence'. The level will be used for summarising the 'degree of confidence' in the form of a colour bar. **** – 4 stars (high) *** – 3 stars ** – 2 stars * – 1 star (low) The degree of confidence ranges from low to high and depends on how much evidence and agreement is there and what type of method is used for the calculation of the indicator: ****: we understand the underlying processes, we can give good numerical assessments, strong evidence in multiple references. We used state-of-the-art methods to calculate the indicator (for example for indicators derived from modelling data: an ensemble of climate simulations, and in the case of impact models, an ensemble of impact models were used) ***: we are reasonable confident in our analysis, evidence provided in moderate number of references. We used widely accepted methods to calculate the indicators (i.e. an ensemble of climate simulations is used, but only one impact model). **: new evidence could have a substantial impact on our assessment, although no major surprises are expected. Evidence in a small number of references. We used less accepted (or former pioneer) methods to calculate	This field is very **important**. Describe in words why you choose this level of the 'degree of confidence'. The structure of the text: <evidence and agreement> <jugdement about method> <any other important aspects, i.e. limitations, conditions that may change the degree of confidence> There is no word limit.	

	the indicator (i.e. more than one climate simulation is used but not a whole ensemble and only one impact model is used). *: we have very limited understanding of the processes or possibilities. Resilience to unexpected occurrence is called for. Evidence provided in unpublished (unverified) reports or few observations. We used a controversial method for the calculation (i.e. only one climate simulation and one impact model is used).				
Sources of uncertainties	**Description**	**Unpredictability** …is caused by the variable behaviour of human beings or social processes. It differs from 'incomplete knowledge' because it concerns what 'we cannot know' and therefore cannot be reduced or changed by further research. 'Unpredictability' is therefore non-reducible.	**Stochasticity** … is an inherent property of the system and it describes the degree to which the system's evolution is not predictable, even given perfect understanding of the system. For example, it refers to the evolution of the climate system that is due to chaotic behaviour or (quasi-)random events. This source of uncertainty is non-reducible**.**	**Incomplete knowledge** …arises from the imperfection of our knowledge. It concerns what 'we do not know' at this moment but might know in the future, if sufficient time and resources are available to perform additional research or collect more data. 'Incomplete knowledge' is therefore reducible.	For the implementation in portal: Please indicate with 'yes' if source was copied from http://tiny.cc/clipc_ua_main_sources
Climate data					
Fill in the sources of uncertainties that belong to the underlying climate data of your indicator. The main sources of uncertainties related to five data sets (modelling, in-situ, remote sensing, bias adjusted, re-analysis) are summarised under the					

sheet 'Pre-defined sources of uncertainties'. Please check if sources apply for this indicator. The columns G-K may help you to identify the sources of uncertainties depending on the underlying data used for your indicator. If this is the case, copy the appropriate fields: name, description, nature. For any other sources of uncertainty, please give the name of the source of uncertainty, a short description and indicate with 'yes' or 'no' if this source belongs to either 'unpredictability', 'stochasticity', or 'incomplete knowledge'.	
Non-climate data	
Fill in the sources of uncertainties that belong to the underlying non-climate data of your indicator. Follow the steps above.	

Table 3: Demonstration of template for confidence information filled in for climate impact indicator 'tropical nights' with DRS : TR_EUR-11_ICHEC-EC-EARTH_historical_r1i1p1_KNMI-RACMO22E_v1_day.nc.

Author, email:	Juliane Otto, juliane.otto@hzg.de				
Name of indicator	Tropical nights				
Definition	Number of days per year where the daily minimum temperature is above 20 °C				
DRS	tr_icclim-4-1-2_SMHI_ICHEC-EC-EARTH_historical_r1i1p1_SMHI-RCA4_v1_EUR-11_yr_19500101-20050107				
Degree of confidence	** – 2 stars	In literature, there is a broad census that climate models simulate temperature changes well. The calculation from an ensemble of climate simulations allows for a robust statement. This indicator, however, was calculated from only one model realisation. </p> Towards the end of the 21st century the internal natural variability contributes less to the overall uncertainty whereas the uncertainty from external human forcing increases. At shorter time scales and finer space scales, the internal natural variability and modelling uncertainties are of greatest importance.</p>.			
Sources of uncertainties	**Description**	**Unpredictability**	**Stochasticity**	**Incomplete knowledge**	**predefined (copied)**
Climate data	text	yes/no	yes/no	yes/no	
internal natural variability	Is an inherent part of the Earth climate system and arise from chaotic non-linear processes in the climate system which lead to stochastic variations in climate parameters.		yes		yes
modelling uncertainty	This comprises all uncertainties resulting from incomplete understanding and representation of the system modelled. This can also include uncertainty from imperfect calibration, the choice of			yes	yes

	statistical techniques and missing or simplified processes in the algorithms used to retrieve a geophysical quantity from the signal detected by a satellite sensor.				
processing uncertainty	Any steps taken in the transformation from raw data to an end product. This includes homogenisation, averaging, interpolating, computing indices/trends etc.			yes	yes
Non-climate data	Text	yes/no	yes/no	yes/no	
no	no	no	no	no	no