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CliPick – Climate change web picker. A tool bridging daily climate needs in process based modelling in forestry and agriculture

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Abstract

Aim of study: Climate data is a need for different types of modeling assessments, especially those involving process based modeling focusing on climate change impacts. However, there is a scarcity of tools delivering easy access to climate datasets to use in biological related modeling. This study aimed at the development of a tool that could provide an user-friendly interface to facilitate access to climate datasets, that are used to supply climate scenarios for the International Panel on Climate Change.

Area of study: The tool provides daily datasets across Europe, and also parts of northern Africa

Material and Methods: The tool uses climatic datasets generated from third party sources (IPCC related) while a web based interface was developed in JavaScript to ease the access to the datasets

Main Results: The interface delivers daily (or monthly) climate data from a user-defined location in Europe for 7 climate variables: minimum and maximum temperature, precipitation, radiation, minimum and maximum relative humidity and wind speed). The time frame ranges from 1951 to 2100, providing the basis to use the data for climate change impact assessments. The tool is free and publicly available at http://www.isa.ulisboa.pt/proj/clipick/.

Research Highlights: A new and easy-to-use tool is suggested that will promote the use of climate change scenarios across Europe, especially when daily time steps are needed. CliPick eases the communication between climatic and modelling communities such as agriculture and forestry.

Keywords: AGFORWARD; CORDEX; ENSEMBLES; Forest growth; IPCC; process based modelling.

Supplementary material: (Figure S1) accompanies the paper on FS website.

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Introduction

Climate change impact is a transversal assessment in different studies. However, there is often a complex pathway, usually requiring programming skills, from the need to the usage of climate data for different kind of modeling purposes. For example, forest process based growth modeling can require yearly, monthly or daily climate inputs for a specific location (Fontes *et al*., 2010; Luedeling *et al.*, 2016) but climate datasets are usually available in geographic information systems grid formats and not at daily time steps (e.g. Hijmans *et al*., 2005; Perry & Hollis, 2005).

Most of the climate models and simulations are developed by different scientific communities (e.g. astrophysics, biology) that have different methodological pathways of delivering scientific results, causing a gap in knowledge interchange. For example the most common format used by climate modelers to exchange data is the network common data format (NetCDF) which is a binary file containing array-oriented scientific data that ease data exchange between climate modelers (Rew & Davis, 1990). Another common characteristic of climate datasets is their large size. Even with binary formats, the large areas (e.g. European scale, including oceans) and the time span (often 100 years in future) delivers an amount of information that needs to be mined to use for other modeling areas requiring simpler and easy access data.

Currently, there are no tools available that simultaneously satisfy 1) European coverage, 2) daily data for a given point location, 3) generated climate with process based models where climate variables are related to each other in the simulations, as opposed to some climate generators, 4) where the data is consistent with reports sent to International Panel on Climate Change (IPCC) allowing follow up assessments with this data to be consistent with IPCC scenarios, 5) containing historical representations and future scenarios of the same simulations to allow consistent impact assessments, 6) with an API to serve climate relatively fast to other tools over internet and 7) with a user friendly web-interface.

The tool here proposed, called CliPick, provides the above characteristics, delivering climate files ready to be processed by other models, in particular forest process based models, usually requiring a simple, text file. The tool is set initially to deliver climate files for models such as YieldSAFE (van der Werf *et al*., 2007) but given the common nature of climate needs by biological modeling, the climate variables provided for these models can be used for a wide range of models (see e.g. Fontes *et al*., 2010; Luedeling *et al*., 2016).

Climate data sources

The COordinated Regional climate Downscaling EXperiment (CORDEX) is currently the biggest international effort to produce regional climate change information at continental scale with a resolution reaching 12 km (Giorgi *et al*., 2009; Jacob *et al*., 2014). At the date of this publication, CliPick provides climate simulations from the Regional Atmospheric Climate Model (RACMO) simulated by the Koninklijk Nederlands Meteorologisch Instituut (KNMI), showing a remarkable quality on the representation of European precipitation (Katragkou *et al*., 2015; Kotlarski *et al*., 2014; Prein *et al*., 2015). The datasets were retrieved through the Earth System Grid Federation (ESGF) computation platform (http://esgf.llnl.gov/).

Numerous climate variables are simulated by these models but only a small number of variables are needed for process based forest modeling (and other biological processes). Furthermore, the daily simulation results are gridded data (e.g. Europe) in binary format (NetCDF) for one variable in blocks of 5 years with approximately 450 MB.

The original data has, therefore, been transformed in two ways in CliPick. First, by creating a file for each grid point with the full timeframe available for a particular scenario (e.g. 2006-2100) where several climate variables were gathered (minimum and maximum temperature, precipitation, radiation, relative humidity, evaporation and wind speed) and, secondly, at the same time, the original units of temperature (Kelvin), precipitation (kg m^{-2} s^{-1}) and radiation (W m^{-2}) were converted to Celsius, mm and MJ m^{-2} respectively. A further monthly calculation is done at user request. In no way the data is interpolated.

The back end

About one hundred thousand files (one file for each coordinate of the datasets with 12 km resolution) per climate scenario, with all seven climate variables, were pre-processed with the help of the European Grid Infrastructure. The result enables fast retrieval time, without server processing when user requests data, becoming user friendly not only for the web interface, but also for integrations of CliPick in different model implementation that need access to climate data.

The front end

To facilitate the provision of data CliPick was developed as a web based interface. The interface uses the application programming interface (API) of Google Maps and the JavaScript libraries of DOJO 1.7.5 (http://dojotoolkit.org/) and JQuery 3.1.1 (http://jquery.com/) as client side programming, while asynchronous javascript and XML (AJAX), eases the communication between the user inputs and instructions for server requests to access the data.

There are three steps to use CliPick clearly evidenced in the web interface (Figure 1). In Step 1, the user selects the date range from 1st January 1951 up to 31st December 2100, depending on the dataset selected, while date limits are in accordance to the source datasets. User can also select the time step (monthly or daily) and the format (sequence of variables) for the output files.

In Step 2, the user selects a location for which the data is going to be retrieved. The data is extracted for the nearest grid point (25 km and 11 km resolution in AR4 and AR5 respectively) using the icon provided. It is important the user understands that the location selected will likely provide the same data within a 5 km radius because, in AR5 datasets, the resolution is 12 km. It is also important to understand that, because of the resolution of the data, locations near particular geomorphological structures (e.g. mountains, coastline)

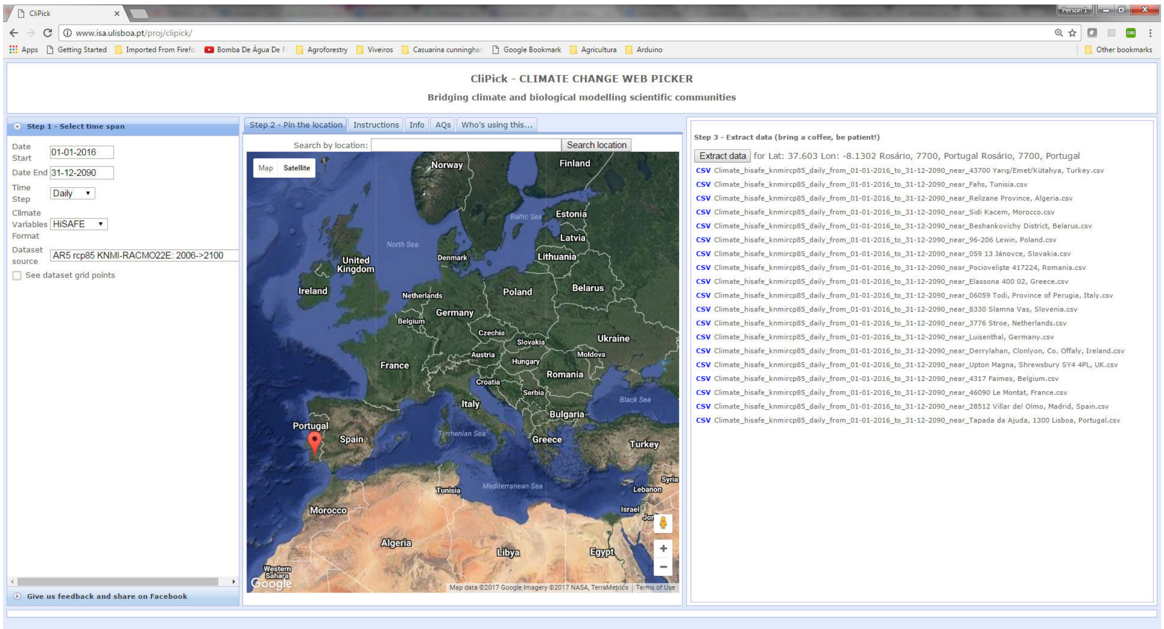

Figure 1. Screenshot of CliPick front-end. Three steps will result in a link to download of a comma separated value text file.

may retrieve data which is not representative of a location.

In step 3, the HTTP request is made, building a link to a text file that can be downloaded. The name of the file is named according to the previous steps chosen.

Accessibility through HTTP requests

The most intuitive way to access CliPick data is the web interface providing a link to download the data. However the architecture of CliPick was built to deliver data in different ways. Another option to the online user-friendly tool is to programmatically access the data. Any programming language can access CliPick as long as it provides HTTP Requests routines.

A routine to request data to CliPick via a small program in python is given in Fig. S1 [supplementary]. To run this script you just need: 1) to install a free python interpreter (www.python.org); 2) a simple text editor (e.g. http://notepad-plus-plus.org/), and; 3) to save your files with an extension ".py" and run the program (see details in comments in Fig. S1 [supplementary]).

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