

## Deliverable D2.8: Implementation of the lidar quicklook database

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## Background

The infrastructure described by this document allows the automatic generation of color map images showing the vertical resolved atmospheric aerosol contents. These images are called *quicklooks* and are generated starting from the ACTRIS/EARLINET lidar measurements. In particular two different quicklook types are supported:

- attenuated backscatter quicklooks
- volume linear depolarization ratio quicklooks

All the quicklooks are generated in Portable Network Graphics (PNG) format. The horizontal scale is always the time (UT) and the vertical scale reports always the altitude above sea level in km. The intensity of the attenuated backscatter or of the volume linear depolarization ratio at a given altitude and time is given the color code (RGB) of the corresponding pixel image.

The generation of the quicklooks has been made within the framework of the EARLINET Single Calculus Chain (SCC) which is an existing automatic tool for the analysis of EARLINET lidar data.

The automatic generation of the quicklooks is made through the following steps:

1. generation of high resolution pre-processed lidar products
2. generation of the images out of one or more high resolution pre-processed lidar products
3. implementation of a web interface allowing the external and internal users to access to the generated quicklooks and to filter them by station, lidar, time, wavelength and type.

In what it follows each of the above steps are described in details.

## 1. Generation of high resolution pre-processed lidar products

The high resolution pre-processed lidar products are generated by a new SCC module called HiRELPP (High Resolution EARLINET Lidar Pre-Processor) that is developed as part of ACTRIS-2. This module takes as input the SCC raw data file and produces in a fully automatic way pre-processed lidar data which are ready to be used for the generation of quicklook images. In particular, HiRELPP module is the high resolution version of the already existing SCC module ELPP (EARLINET Lidar Pre-Processor): all the necessary instrumental corrections are applied on the raw lidar data keeping both the time and vertical resolution as higher as possible.

The following corrections are made:

- dead-time correction
- raw error estimation
- atmospheric and electronic background subtraction
- pre-trigger correction
- trigger-delay correction
- analog and photoncounting glueing
- calculation and calibration of attenuated backscatter
- calculation of volume linear depolarization ratio

The output file of the HiRELPP module is a NetCDF 4 file where the native compression capabilities of this format are used to minimize the raw space required to store the generated products.

The calibration of attenuated backscatter allows to use always the same color scale for all the quicklooks generated by different lidar systems. The calibration constant is calculated by first performing a low resolution analysis by using ELPP and ELDA (EARLINET Lidar Data Analyzer). The calculation of the particle backscatter coefficient requires a calibration which is usually done in the aerosol-free region where the total backscatter coefficient should be equal to the molecular one. This constant is calculated by ELDA each time a low resolution particle backscatter coefficient is calculated and can be used to calibrate also the high resolution pre-processed data. The advantage of calibrating using low resolution data is that the signal to noise ratio is higher and the calibration is more accurate.

The HiRELPP module requires the presence of a MySQL database in which each generated product is logged together with all the parameters and metadata used to produce it. This allow the full traceability of the HiRELPP products.

The following tables have been created:

**Table name:** *\_hirelpp\_variable\_quantities*

**Description:** this table contains all the possible physical quantities supported by HiRELPP module.

**Columns:**

<i>id</i>	<i>int(11)</i>
<i>description</i>	<i>varchar(200)</i>
<i>short_description</i>	<i>varchar(20)</i>
<i>quicklookfilename_flag</i>	<i>char(2)</i>

**Table name:** *\_hirelpp\_variable\_types*

**Description:** this table contains all the possible variable types supported by HiRELPP module. Each variable type is identified by the wavelength, the range ID, the scatterer ID and a physical quantity (see table *\_hirelpp\_variable\_quantities*)

**Columns:**

<i>ID</i>	<i>int(11)</i>
<i>nominal_wave</i>	<i>float</i>
<i>range_id</i>	<i>int(11)</i>
<i>scatterer_id</i>	<i>int(11)</i>
<i>hirelpp_variable_quantity_id</i>	<i>int(11)</i> → <i>_hirelpp_variable_quantities.id</i>

**Table name:** *hirelpp\_variables*

**Description:** this table contains all HiRELPP variables that have been included in a particular HiRELPP product.

**Columns:**

<i>ID</i>	<i>int(11)</i>
<i>_product_ID</i>	<i>int(11)</i> → <i>products.ID</i>
<i>_hirelpp_variable_type_id</i>	<i>int(11)</i> → <i>_hirelpp_variable_types.id</i>

**Table name:** *hirelpp\_variable\_channels*

**Description:** this table provides all the lidar changes involved in the computation of each HiRELPP variable.

**Columns:**

<i>ID</i>	<i>int(11)</i>
<i>_hirelpp_variable_id</i>	<i>int(11)</i> → <i>hirelpp_variables.ID</i>
<i>_hoi_channel_id</i>	<i>int(11)</i> → <i>hoi_channels.ID</i>

**Table name:** *hirelpp\_products*

**Description:** this table collects all the products generated by HiRELPP module.

**Columns:**

<i>ID</i>	<i>int(11)</i>
<i>_MeasurementID</i>	<i>varchar(12)</i> → <i>measurements.ID</i>
<i>_product_ID</i>	<i>int(11)</i> → <i>products.ID</i>
<i>creation_date</i>	<i>datetime</i>
<i>filename</i>	<i>varchar(100)</i>

**Table name:** *hirelpp\_product\_options*

**Description:** this table collects options for the calculation of each HiRELPP product

**Columns:**

<i>ID</i>	<i>int(11)</i>
<i>_product_ID</i>	<i>int(11)</i> → <i>products.ID</i>
<i>min_height</i>	<i>double</i>
<i>max_height</i>	<i>double</i>

**Table name:** *hirelppexitcodes*

**Description:** this table describes all the exceptions of the HiRELPP module

**Columns:**

<i>exit_code</i>	<i>int(11)</i>
<i>description</i>	<i>longtext</i>

**Table name:** *lidar\_constants*

**Description:** this table collects all the calibration constants that have been calculated by ELDA module and are used by HiRELPP module to calibrate attenuated backscatter.

**Columns:**

<i>ID</i>	<i>int(11)</i>	
<i>_MeasurementID</i>	<i>varchar(12)</i>	→ <i>measurements.ID</i>
<i>_product_ID</i>	<i>int(11)</i>	→ <i>products.ID</i>
<i>_channel_ID</i>	<i>int(11)</i>	→ <i>hoi_channels.ID</i>
<i>filename</i>	<i>varchar(100)</i>	
<i>calibr_factor</i>	<i>double</i>	
<i>calibr_factor_sys_err</i>	<i>double</i>	
<i>calibr_factor_stat_err</i>	<i>double</i>	
<i>lidar_const</i>	<i>double</i>	
<i>lidar_const_sys_err</i>	<i>double</i>	
<i>lidar_const_stat_err</i>	<i>double</i>	
<i>detection_wavelength</i>	<i>double</i>	
<i>profile_start_time</i>	<i>datetime</i>	
<i>profile_end_time</i>	<i>datetime</i>	
<i>calibr_window_bottom</i>	<i>double</i>	
<i>calibr_window_top</i>	<i>double</i>	
<i>InscribedAt</i>	<i>datetime</i>	

## 2. Generation of quicklooks

The quicklooks are generated by a further SCC module called ELQUICK (EARLINET Lidar QUICKlooks). This module generates homogenous quicklook images out of one or more HiRELPP products.

The ELQUICK module can be configured to produce quicklook within a fixed time window. It is possible to choose different length of the time window (for example 1, 2, 6, 12, 24h and so on). Once this length is selected the different quicklooks are generated starting from the start of the hours. For example if a length of 6h is selected for each day 4 different quicklooks are generated: one starting from the 00:00 up to 06:00 the next from the 06:00 up to 12:00 the next from 12:00 up to 18:00 and finally from 18:00 to 24:00. All the HiRELPP products falling within these time windows will be included in the corresponding quicklook.

It is also possible to select different color palette (for example black and white, rainbow, and so on).

The ELQUICK module requires the presence of a MySQL database in which each generated product is logged together with all the parameters and metadata used to produce it. This allow the full traceability of the ELQUICK products.

The following tables have been created:

**Table name:** *quicklook\_timelength*

**Description:** this table contains all the possible timelength that can be used to produce ELQUICK products

**Columns:**

<i>id</i>	<i>int(11)</i>
<i>value</i>	<i>varchar(200)</i>

**Table name:** *\_color\_palette*

**Description:** this table contains all the possible color palette that can be used to produce ELQUICK products

**Columns:**

<i>id</i>	<i>int(11)</i>
<i>description</i>	<i>varchar(200)</i>

**Table name:** *elquick\_products*

**Description:** this table collects all the products generated by ELQUICK module.

**Columns:**

<i>id</i>	<i>int(11)</i>	
<i>_hoi_lidar_version_id</i>	<i>varchar(12)</i>	→ <i>hoi_lidar_versions.ID</i>
<i>_elquick_product_option_id</i>	<i>int(11)</i>	→ <i>elquick_product_options.ID</i>
<i>start_time</i>	<i>datetime</i>	
<i>stop_time</i>	<i>datetime</i>	
<i>generation_time</i>	<i>datetime</i>	
<i>filename</i>	<i>varchar(200)</i>	

**Table name:** *elquick\_product\_options***Description:** this table collects options for the calculation of each ELQUICK product**Columns:**

<i>id</i>	<i>int(11)</i>
<i>_hirelpp_variable_type_id</i>	<i>int(11)</i> → <i>_hirelpp_variable_types.id</i>
<i>altitude_min</i>	<i>double</i>
<i>altitude_max</i>	<i>double</i>
<i>color_min</i>	<i>double</i>
<i>color_max</i>	<i>double</i>
<i>_color_palette_id</i>	<i>int(11)</i> → <i>color_palette.id</i>
<i>timelength_threshold</i>	<i>float</i>
<i>_time_length_id</i>	<i>int(11)</i> → <i>_quicklook_timelength.id</i>

**Table name:** *hirelpp\_elquick\_products***Description:** this table links the HiRELPP products with a single ELQUICK product**Columns:**

<i>id</i>	<i>int(11)</i>
<i>_hirelpp_product_id</i>	<i>int(11)</i> → <i>hirelpp_products.ID</i>
<i>_elquick_product_id</i>	<i>int(11)</i> → <i>elquick_products.ID</i>
<i>quicklook_ok</i>	<i>int(11)</i>

**Table name:** *elquick\_excluded\_types***Description:** this table collects all the HIRELPP variable types that should be not considered for the quicklook generation for a particular lidar configuration.**Columns:**

<i>ID</i>	<i>int(11)</i>
<i>_hoi_system_id</i>	<i>int(11)</i> → <i>hoi_system.ID</i>
<i>_hirelpp_variable_type_id</i>	<i>int(11)</i> → <i>_hirelpp_variable_types.ID</i>

**Table name:** *elquickexitcodes***Description:** this table describes all the exceptions of the ELQUICK module**Columns:**

<i>exit_code</i>	<i>int(11)</i>
<i>description</i>	<i>longtext</i>

The following picture shows the relationship between all the SCC Database tables (described above) involved in high resolution pre-processed lidar products and quicklooks generation :

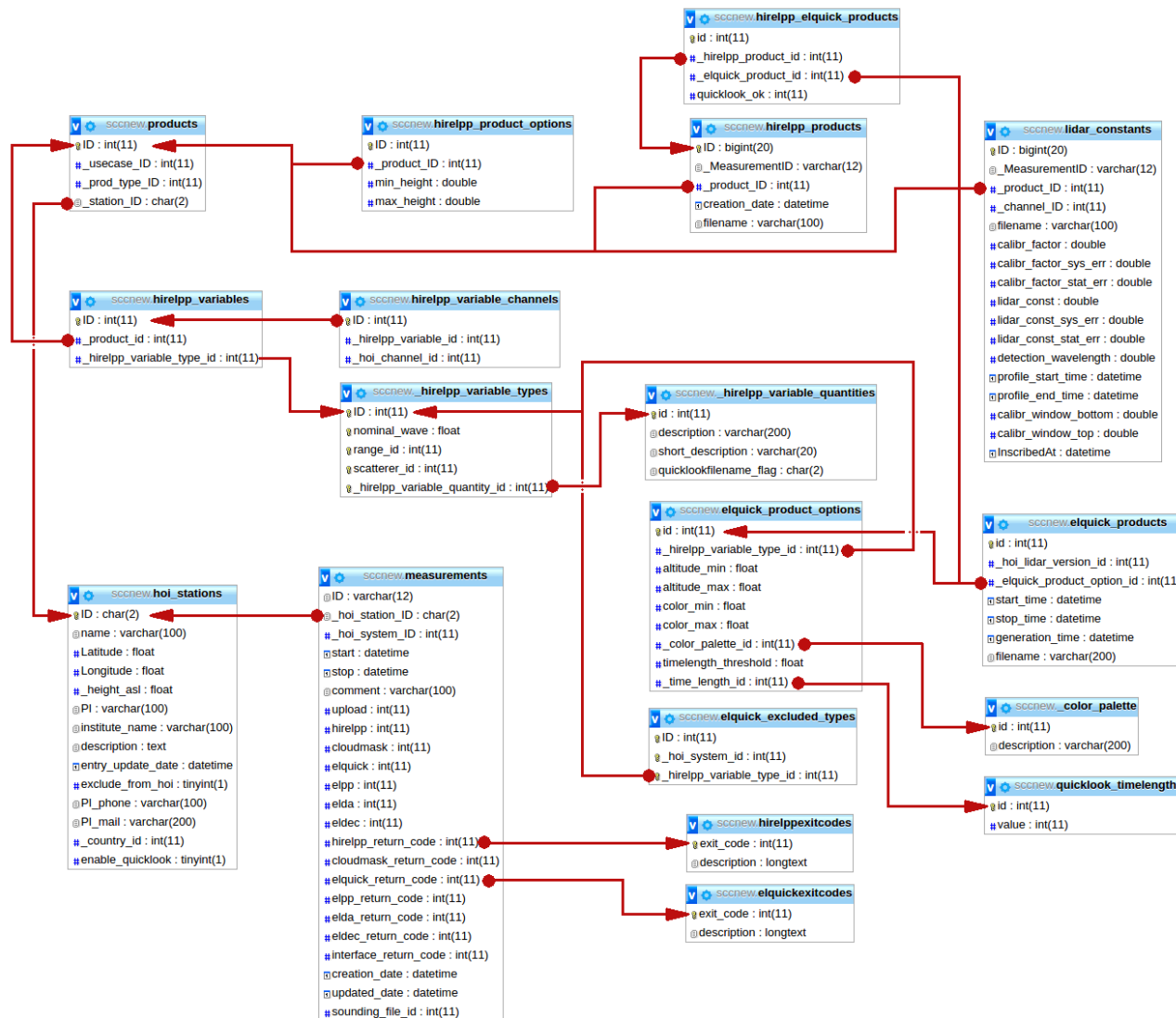


Figure 1 - Relationship between the SCC Database tables involved in high resolution pre-processed lidar products and quicklooks generation.





## Web-side management

The web-side management has been implemented in the well known **LAMP** (Linux Apache MySQL Php) architecture :

- **Linux Server** : the server that hosts the website on which runs a Slackware linux distro.
- **Apache Webserver** : web server platform developed by the Apache Software Foundation. It is the most popular modular web server platform that can run on different OS and is capable, among other things, of advanced networking functionalities and security control functions.
- **MySQL database** : it is the open-source most popular RDBMS (Relational Database Management System) database. It is based on the query language SQL (Structured Query Language). In this case the RDBMS is the one of the **SCC (Single Calculus Chain)** – the main analysis tool for Lidar products within the EARLINET network.
- **PHP (Personal Home Page)** : it is an interpreted programming language mainly used to develop server-side web applications.

## Web-graphic design

The Web-graphic design has been implemented by using the following technologies:

- **HTML 5 (HyperText Markup Language 5)** : it is a markup language used for structuring and presenting content on the World Wide Web. It is the fifth and current version of the HTML standard. It is recommended from the W3C (World Wide Web Consortium).
- **CSS3 (Cascading Style Sheets 3)** : used for HTML documents indentation. It tells the browser how the content should be displayed in browsers and other user agents that need to display it.
- **Javascript** : it is a high-level, dynamic, untyped, and interpreted run-time language. it is used on the client web side in order to create interactive and dynamic effects.
- **jQuery** : it is a cross-platform JavaScript library designed to simplify the client-side scripting of HTML. It is used, above all, to manage web pages animations and events.
- **Bootstrap** : is the most popular HTML, CSS, and Javascript framework for developing responsive, mobile first projects on the web.

## HTML Layout

The website HTML layout is a classical three columns + header + footer layout. It has been managed to create a responsive layout, using the Bootstrap API, so that the site content will adapt itself depending on the device on which it is visualized. The organization of HTML contents has been implemented according to W3C standards so that the website is highly accessible. Moreover the main SEO (Search Engine Optimization) rules have been respected so that it is optimized for the search engines. Last but not least the cross-browser compatibility has been preserved for the nowadays most used browsers.

### Web Interface interactivity

The Web Interface guides the user along all the steps of the operations to be carried out. In particular, the messages that the interface provides the user are clear, transparent and reassuring. In order to achieve a user-friendly interface it is described to the user the type of interaction, and what will get through each step. The main features of the developed web interfaces can be summarized as follows:

- Each operation has a guidance system that, at any time, informs the user what he/she has already done, what is being done and what must still be done. Every user action returns feedbacks. The feedback has been developed to be clear and accurate.
- The data collection form are distributed, if necessary, on multiple pages. Each page asks the user data of a specific logical area.
- In the case of complex forms, during each operation, the data is saved as the user enters them. Avoiding that, if an error occurs, the user has to start from scratch.
- The buttons have consistent names along the action that the user performs. Therefore, depending on the action performed, each button has a semantic meaning.
- If the user makes a mistake in filling out a form, an error message will block the access to the next step. The error messages are structured so as to be clear and precise, in order that the user can correct and continue.

### Quicklook Web interface

The Quicklook web interface allows viewing color maps of the range corrected signal relative to the channels of the various systems of the EARLINET stations.

The web interface has been implemented with the PHP language interacting with the **SCC** database through the SQL query language. It consists of a calendar in which, by default, is displayed the most recent month with measurements, within which are shown the days when the systems have acquired data.

The following picture shows the relationship between all the SCC Database tables involved in the Quicklook web interface:

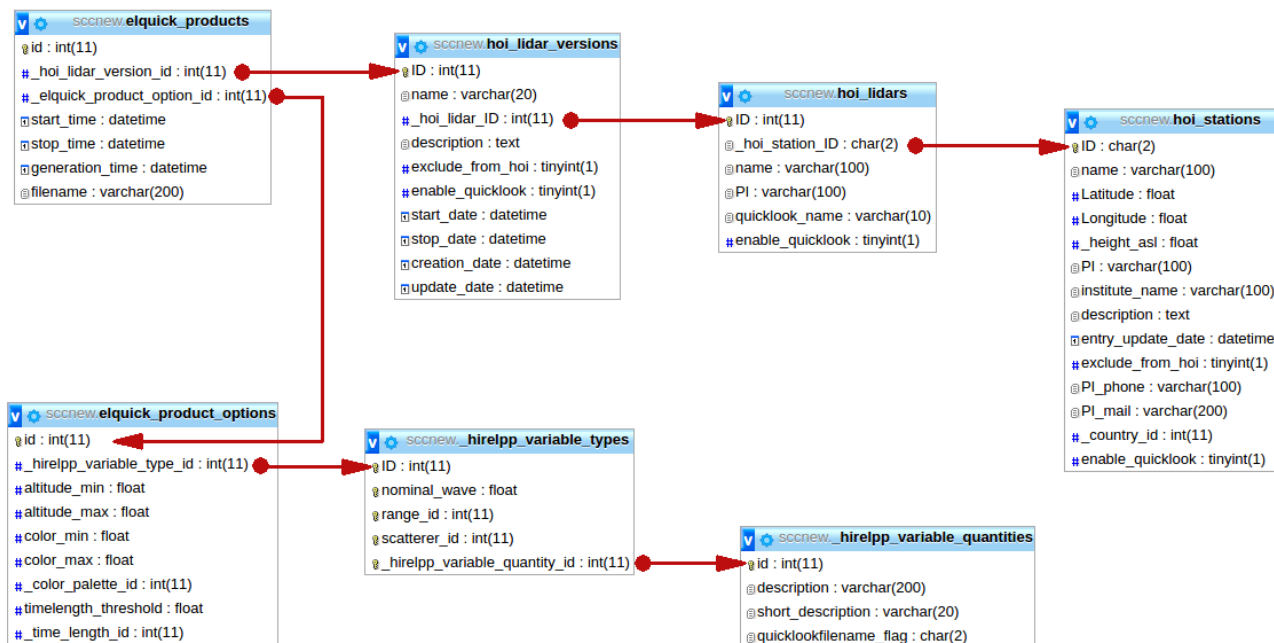


Figure 3 - Relationship between the SCC Database tables involved in the Quicklook web interface.

The user interacts by selecting one or more days and/or one or more systems he/she wants to be displayed.

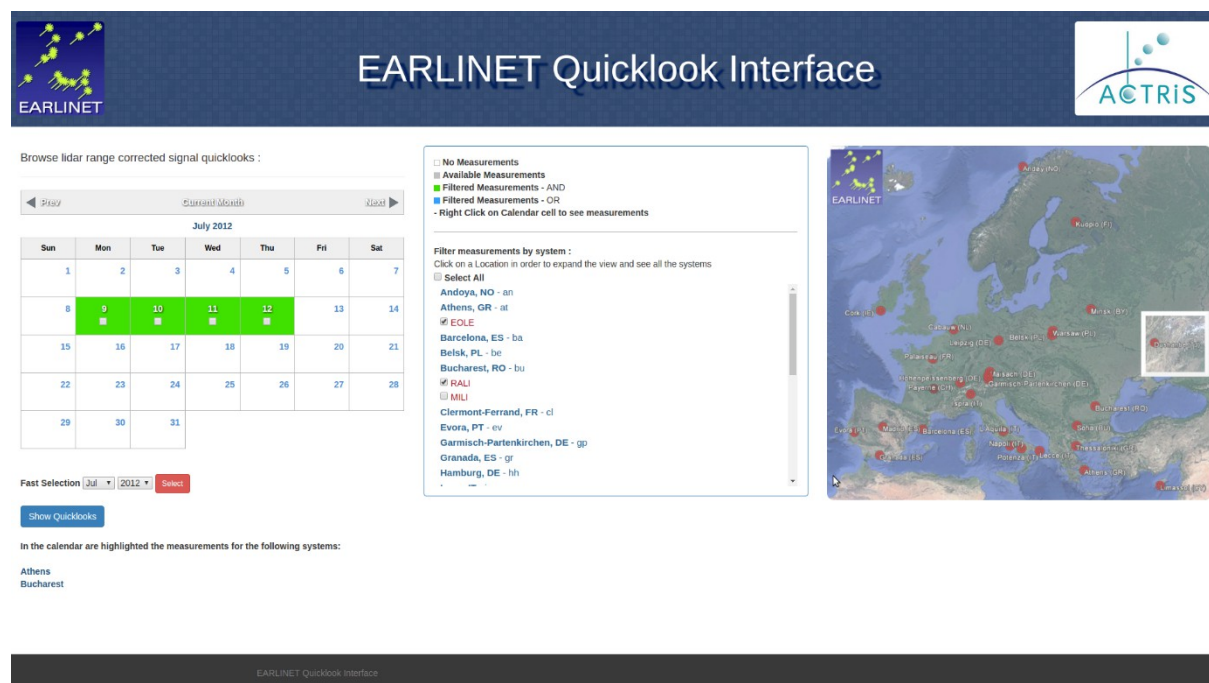


Figure 4 – User measurements selection.

After making the request, by pressing a submit button, the service dynamically displays a series of vertical summary tabs. Each tab represents the user selected days.

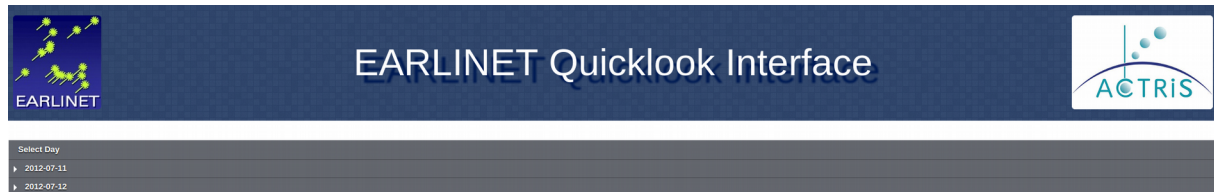


Figure 5 – User selected days.

Within each tab are displayed the quicklook previews if available.

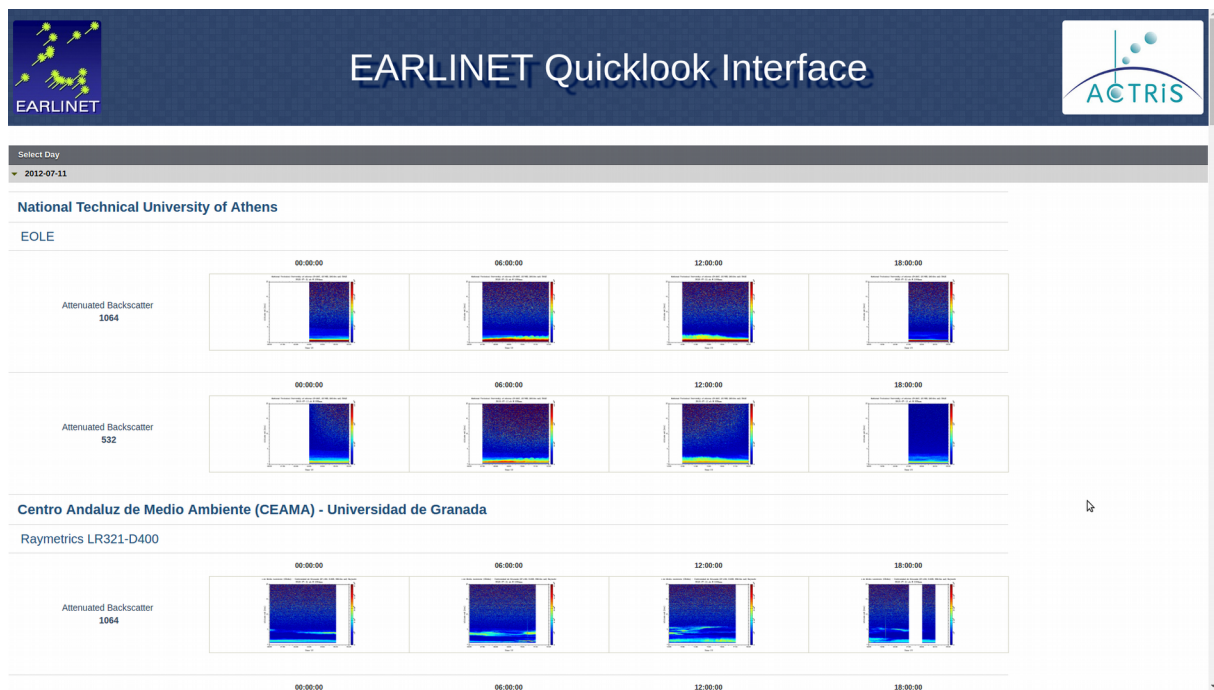


Figure 6 – Quicklook preview for user selected days.

By clicking on the quicklook preview the user will be redirected on a new page that will display the selected quicklook and other info related to the quicklooks available for the other station in the same time range and same quicklook type.

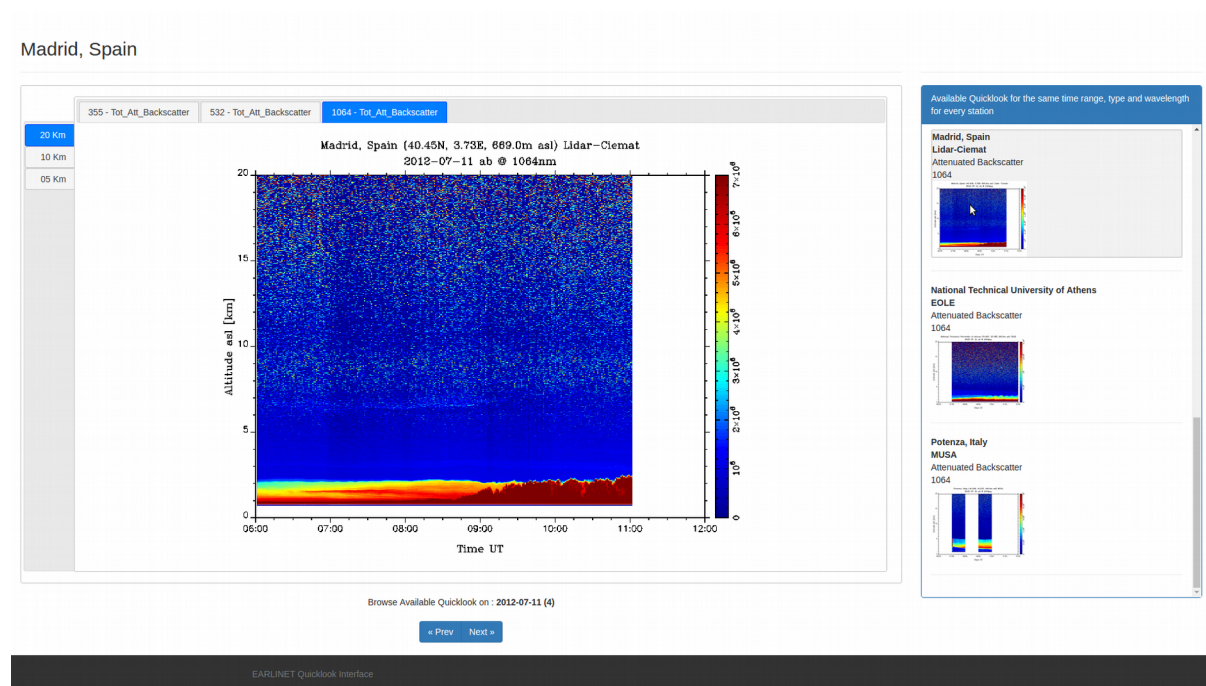


Figure 7 – User selected quicklook.

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