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MEDIATION

Deliverable D5.1

Database of spatial information relevant for climate change impacts, vulnerability and adaptation assessment

responsible: PIK

Markus Wrobel, Jürgen Kropp

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Content

Abstract

Deliverable D5.1 describes the approach towards a database of spatial information as part of the MEDIATION common platform. The database is being designed against the background that for practical reasons it is most appropriate that spatial data, e.g., to be used as input for the case studies, remains at the respective sites of the various consortium members and is managed there independently. Thus, the database will be set up for (i) management of central spatial meta data and (ii) a pool of selected spatially explicit data to be made available via the common platform, e.g., respective result data generated within MEDIATION's case studies. To support intuitive representation of multi-dimensional spatio-temporal data, an interactive MEDIATION atlas is being developed.

1. Introduction

1.1 Objectives

MEDIATION (Methodology for Effective Decision-making on Impacts and AdaptaTION) aims to aid European decision making in the context of the challenges posed by the fragmented knowledge required to efficiently deal with climate change impacts, vulnerabilities and adaptation. The two central deliverable of the project will be an integrated methodology to link decision domains with appropriate methods, and an interactive common platform to make assessment methods and metrics accessible (cf. DoW, 10).

Deliverable 5.1 outlines the design of a **database of spatial information** as part of the MEDIATION common platform, as well as its integration into the envisaged platform and its relation to other central components.

1.2 The common platform

The common platform is considered to become one of this projects core deliverables. Its two central aims can be defined as follows:

1. provide its users with appropriate interactive access to a classification of typical problems to be faced in the context of climate change adaptation *and* allow the mapping of problem categories to methods and tools that are available to approach specific problem types;
2. in addition, provide an appropriate infrastructure allowing to integrate a set of case studies as illustrations of such problem – method combinations (cf. D5.2).

In order to do so, the common platform will need to rely on and make use of ingredients researched and provided by all parts of MEDIATION:

- an analysis of the adaptation decision making context (WP1);
- a toolbox of methods and metrics both for (i) assessing impacts and vulnerability (WP2) and for (ii) socio-economic evaluation of adaptation strategies including cost-effectiveness (WP3);
- the MEDIATION integrated methodology to identify and link decision domains / problem categories to tools and methods, taking into account uncertainty (WP4);
- a set of cross cutting case studies.

The final shape and features of the common platform are subject to ongoing research, being addressed by WP5 in close collaboration with all other work packages and the project's case studies.

1.3 Logical key components of the common platform

A central challenge in designing the common platform relates to the fact that basic contents as well as relevant structures (e.g., the problem categories) are to be researched throughout the project and are not at hand to develop a complete and detailed ex ante specification. Thus we start from a high level view of the common platform, distinguishing a set of logical key components - as well as central interrelations - that can be regarded as the envisaged platform's main constituting elements while being largely independent of a specific subsequent implementation. Based on this approach a set of components has been identified (Fig. 1). Note that this set of components should be considered as preliminary and does do not necessarily need to refer to actual information technological modules in a final implementation of the common platform. Rather, at this state the components serve as representatives of functionality the common platform aims to provide. Each component will need to be refined iteratively as specific structures as well as content will emerge throughout the project. For a more detailed outline and discussion of this initial framework for the common platform we refer to D5.2.

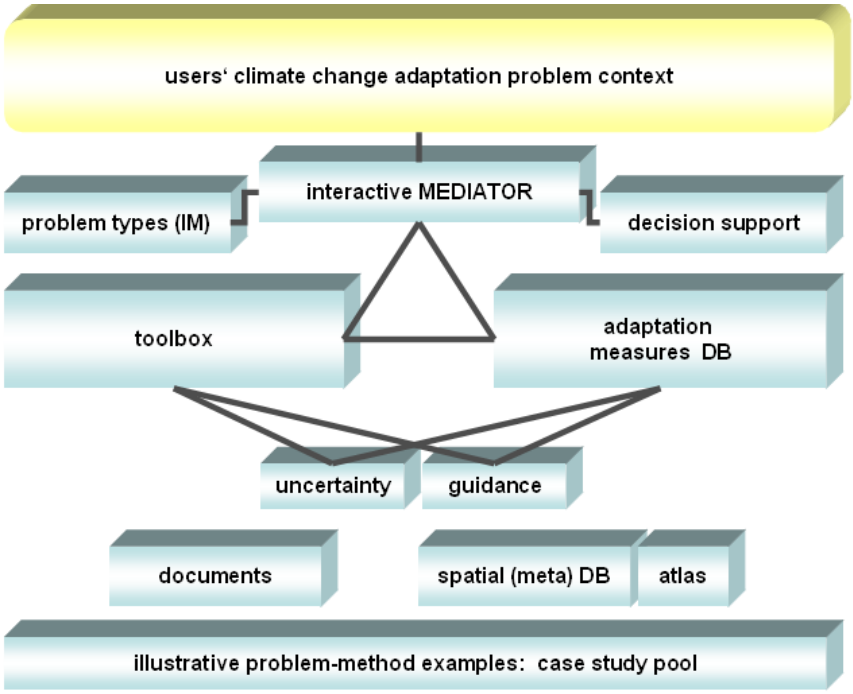

Fig. 1 – Logical key components constituting the MEDIATION common Platform

We can distinguish between the following logical key components of the common platform:

- An interactive MEDIATOR component to allow the mapping of a user's actual problem context with the content and structure provided by the common platform. This will comprise an interactive problem identification and classification facility to allow identifying specific user problems and mapping them to the problem categories as identified by the MEDIATION integrated methodology, and a problem-method-mapping facility to allow the mapping of a specific problem category to appropriate methods, tools and metrics as identified and systematized by the toolbox. The MEDIATOR component will base on the problem types that emerge from the integrated methodology and other means for decision support that will be identified within MEDIATION;
- the MEDIATION toolbox to provide a systematic overview on available tools, methods and metrics to assess climate change related impacts and vulnerabilities as well as adaptation costs;
- an adaptation measures database to hold a structured collection of options to adapt to climate change;
- a structured collection of information on uncertainty and guidance / best practices;
- a structured collection of related background documents like policy plans (literature database);
- a spatial (meta) database to document and manage spatially explicit results generated by the case studies as well as selected additional climate change background information;
- an interactive atlas including a diagram server to allow users for comfortable access to spatio-temporal data of relevance for MEDIATION, e.g., in form of interactive maps and time series diagrams. This could also include the representation of adaptation projects in their spatial context;
- a pool of case studies to act as extensible inventory of the EU-wide and region-specific case studies performed within MEDIATION, utilizing them to serve as initial illustrations for selected problem-method combinations.

This deliverable focuses on the design of the spatial (meta) database as well as on the closely related components MEDIATION Interactive Atlas and diagram server. The former relates to appropriate management of spatially explicit information in the context of the common platform, while the latter two address the part of the platform that is to provide intuitive access to spatio-temporal information.

1.4 Database of spatial information or spatial data infrastructure?

The DoW labels the envisaged outcome of D5.1 as a "database of spatial information". Since an appropriate solution as addressed here will consist of spatial data, related meta data, and (web enabled) access interface(s) it can more precisely be described as a reduced version of a spatial data infrastructure (SDI), tailored for pragmatically needs of the common platform. To what extend meta data and spatial data will actually be managed in a specific database management system (a 'database') or based on other IT solutions is subject to the research to be undertaken within this task.

1.5 Spatial data and meta data

Spatial data can be roughly defined as data identifying the geographic location of features and boundaries on Earth (http://www.webopedia.com/TERM/S/spatial_data.html). *Meta data* is often - and somewhat imprecisely - defined as 'data about data' or 'data to describe data'. In this context we refer to meta data as data for a structured and consistent description of spatial data in the context of MEDIATION. Spatial meta data typically needs to include attributes like title, originator, quality information, spatial extent, spatial resolution, temporal reference, access information, etc. Note that the availability of a suited and consistent set of meta data is a prerequisite for efficiently identifying specific spatial datasets.

2. Spatial data in question

This deliverable describes the approach to add a "database of spatial information" to the common platform. Spatially explicit data and information are of central importance (a) as input for the research to be carried out in the MEDIATION case studies, and (b) as output that will be generated by this research. Consequently an appropriate database of such information can play a crucial role both for enhancing internal information exchange and for the outreach of MEDIATION results.

However, in order to develop a feasible and pragmatically solution tailored for the needs of the common platform, it is mandatory to come to careful decisions concerning the spatial data that can realistically be managed using such an approach, and spatial data that, although related to climate change, should be excluded deliberately. We can distinguish four main categories of spatial data that might contribute to the potential content of the common platform: (i) spatially explicit input data for tools documented in the toolbox, (ii) the project's case studies' spatially explicit input data**,** (iii) the case studies' spatially explicit output data, and (iv) other spatially explicit data of interest in the context of MEDIATION.

2.1 Input data as part of the MEDIATION toolbox

The first category refers to spatially explicit input data required by tools that will be documented in the MEDIATION toolbox, e.g., exemplary input data needed to run a specific impact model. It stands to reason that such data might be considered itself as tools (or part of tools) and thus should be part of the toolbox. Note that against the background of potentially unlimited data resources in question here, such inclusion can realistically only refer to the documentation of available, distributed data but not to a physical integration of the data itself. The ongoing research in WP2 and WP3 will show if it is feasible to provide such documentations of potential input data as part of the toolbox. If this is the case, such descriptive data should also be made available via the common platform.

2.2 The case studies' spatial input data

The second category – which can be considered as overlapping with the first one or as a subset of it – refers to the spatial data needed as input by the MEDIATION case studies to conduct their research. Central access to information on these resources can enhance the information flow between MEDIATION's case studies and work packages, and should contribute to increased consistency. On the other hand, this information is also a relevant part of documenting case studies as illustrative examples for problem-method combinations. We thus propose that respective descriptive information should also be fed into and made available via the common platform. There is a close relation between MEDIATION's case studies and the toolbox, and the tools used in the case studies will be

systematized and documented in the toolbox (cf. D2.2). Thus it will need to be clarified if the toolbox could act as a peer by providing the documentation of the case studies' input data to the common platform (cf. 2.1), or if this information will need to be provided to the common platform directly by the respective case study teams.

2.3 The case studies' spatial output data

The third category of potential content relates to spatially explicit data that will be produced as part of the results by most of the project's case studies. Spatially explicit results from the case studies will form an important part of MEDIATION's outcome that will be of interest for various users. Thus at least a selected subset of these data should be made accessible in an appropriate manner via the common platform.

2.4 Additional spatial data of interest

This fourth category refers to additional spatial data not covered by the categories sketched in 2.1, 2.2 and 2.3 that could nevertheless be of interest in the context of MEDIATION. This might include spatial data that is already online accessible, e.g., having been produced within in other EU projects, or spatial data that is not online accessible yet but could be provided by the MEDIATION partners. Since the issue of improved homogenised access to distributed spatial information of relevance in the context of climate change adaptation is to a much larger extent addressed by the upcoming Adaptation Clearinghouse for Europe (ACE), we will evaluate options to benefit from approaches taken there.

3. Estimating a realistic degree of possible integration and homogenisation

Existing spatial data. Concerning already existing spatial data (i.e. data relevant for content groups 2.1, 2.2 and 2.4) a considerably high degree of heterogeneity has to be expected. Heterogeneity can refer as well to semantic aspects (e.g., considering underlying scenarios, models, time frames, spatial extents, spatial resolutions, …) and to syntactic aspects (e.g., data formats, spatial projections, access interfaces, …). A homogenisation of these sources as well as a complete physical integration is clearly infeasible within a project like MEDIATION, since it would require extremely resource intensive and time consuming processes. An important step in this context is the European Commission's INSPIRE[2] initiative which strives to facilitate access to spatial data in Europe by building up a common infrastructure for spatial information in the European Community (cf. 5). In addition, the currently developed Adaptation Clearinghouse for Europe (ACE) should provide new opportunities for central access to distributed European information resources relevant in the context of climate change.

Spatial data to be produced within MEDIATION. MEDIATION itself should strive for a high degree of homogeneity concerning the spatial data that will be produced within the project (2.3). Note that it is currently still an open question to what degree such a homogenisation can be achieved or agreed upon across the various case studies.

Taking into account given time and resource constraints as well as the heterogeneity of existing spatial data (and possibly also of the upcoming MEDIATION spatial data products) we adhere to a strategy based on the following conclusions:

- *Data homogenisation:* within the scope of MEDIATION it is not realistic to homogenise already existing spatial data. MEDIATION should on the one hand strive to ensure that spatial data generated within its case studies should be as homogenous as possible. On the other hand it can currently not be ruled out that pragmatic issues and requirements get into the way of this goal and have to be taken into account.
- *Data integration:* due to practical constraints it is not feasible to strive for the physical integration of the spatial data characterized in 2.1, 2.2 and 2.4. However, spatial data produced *within* MEDIATION (2.3) should be made accessible centrally via the common platform.

[2] http://inspire.jrc.ec.europa.eu/

4. General approach

We follow a multi-layered approach, combining centralized meta data management with decentralized, distributed management of spatial data and central management of a selected subset of spatial data. This approach is to a large degree content independent and allows coming up with an IT infrastructure that can be easily integrated into the common platform, and that can be filled incrementally. The resulting infrastructure can act as central information source for spatial data in the MEDIATION context, and to provide integrated access to spatial explicit results of the project. Furthermore it can be extended subsequently to provide additional functionality. To facilitate location independent access it is a straightforward decision to design central parts of this infrastructure to be online accessible and web enabled.

The infrastructure (Fig. 2) will comprise a central meta data repository (4.1), distributed spatial data (4.2), and centrally managed spatial data (4.3). Comfortable and integrated access both to a set of maps depicting background information on climate change in Europe and to maps depicting the spatial explicit results of the case studies will be enabled via a web-based MEDIATION interactive atlas (7.1).

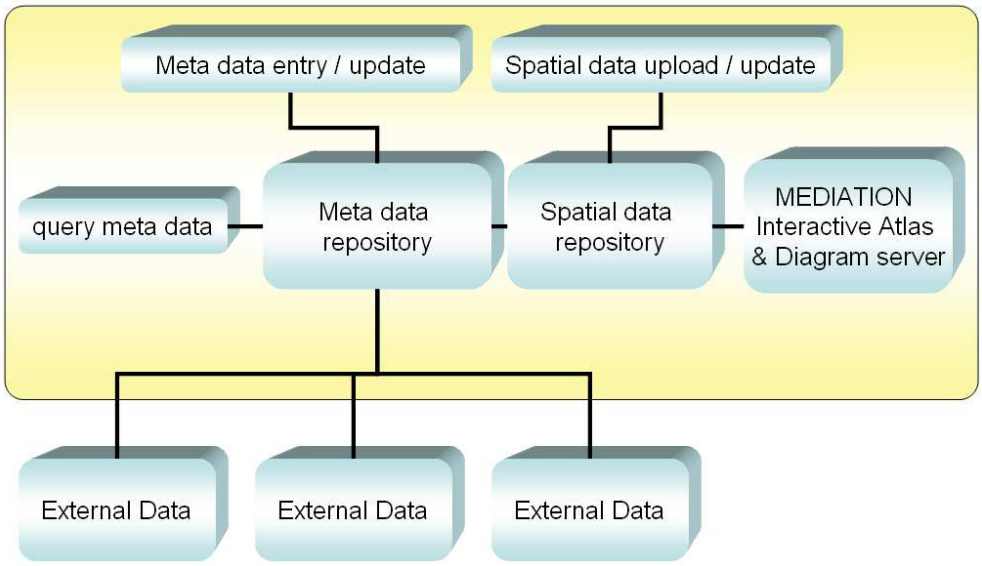

Fig. 2 – Components comprising MEDIATION's spatial data infrastructure

4.1 Central meta data repository

The core component will be a central meta data repository. It will be used to document in a structured and consistent manner the spatial data resources relevant for MEDIATION. As discussed in sec. 2, it will need to be defined if meta data describing input data for tools in general and for those tools used in the case studies should be best considered as part of the toolbox and be managed there. Spatial data itself will by default reside distributed at the various consortium partners' sites and be managed there independently. Selected data sets can subsequently be integrated into a central data repository to provide increased access functionality.

The collected meta data will provide the basis to allow requirement driven identification of specific spatial data sets and to provide necessary access information. Previous experiences in comparable contexts show that the process of defining and agreeing upon a concise set of meta data can be both complex and time consuming. We can draw upon several existing de facto meta data standards for spatial data that have emerged (like NASA DIF, US FGDC or ANZLIC), which have been harmonized 2003 into the ISO 19115 Geographic Information Metadata standard**;** and notably on the set of meta data attributes defined by the EC's INSPIRE initiative to homogenise meta data for European spatial data. Note that meta data definitions can consist of large sets of attributes to allow concise description of all possible aspects of spatial data. To ensure ease of use, a sufficient subset suited for MEDIATION has to be identified.

4.2 Distributed spatial data

While the meta data for data description of data as characterized in 2.1, 2.2 and 2.4 will be collected and stored centrally, the spatial data itself is kept by default at its distributed locations, e.g., at the sites of the various MEDIATION partners and is managed independently. The central meta data repository will facilitate orientation on this distributed data pool without imposing any need for data migration where this is not feasible. Note that while the chosen approach has the advantage of restricting main efforts on providing effective access to suited meta data, it does neither dissolve existing data or interface heterogeneities, nor does it strive to provide any processing functionality on the distributed data.

4.3 Central spatial data repository

Together with a central meta data repository and distributed spatial data, a central spatial data repository is proposed as a third component of the common platform's spatial database. Selected spatial data sets, namely the spatial explicit output data produced by the project's various case studies, can step by step be integrated into this central repository in order to provide enhanced access functionality like interactive mapping (sec. 7). The combination of distributed data management with the option to transfer selected data subsequently to a central repository will allow MEDIATION to start straight forward by documenting relevant data sources, as well as to progress subsequently to higher degrees of functionality.

5. INSPIRE compliant spatial meta data

In order to be compliant with the ongoing initiative to establish an infrastructure for spatial information in Europe we propose to base the definition of the spatial meta data set for MEDIATION on a set of respective meta data attributes adhering to the requirements of the Infrastructure for Spatial Information in the European Community (INSPIRE)[3]. The Commission Regulation (EC) No 1205/2008 of 3 December 2008 (Commission Regulation, 2008) prescribes a set of meta data attributes which we consider to be adequate to provide the basis for MEDIATION's purposes. The set of meta data elements prescribed by INSPIRE appears to be small enough to allow for sufficiently uncomplicated meta data gathering; on the other hand it covers all major aspects that need to be addressed in documenting spatial data in the context of MEDIATION. INSPIRE defines 10 main categories of spatial meta data (Table 1) and a set of meta data elements or attributes (Table 2). The European Commission also provides a web-based prototypic INSPIRE meta data editor (a multi-level form allowing to enter meta data and to export it into an XML file that can be stored on the user's computer), and a web-based meta data validator (allowing to upload a meta data file and to validate it)[4].

Reference	category
1.	Identification
2.	Classification of spatial data and services
3.	Keyword
4.	Geographic location
5.	Temporal reference
6.	Quality and validity
7.	Conformity
8.	Constraint related to access and use
9.	Organisations responsible for the establishment, management, maintenance and distribution of spatial data sets and services
10.	Metadata on metadata

Table 1 – Overview on the INSPIRE meta data categories

[3] http://inspire.jrc.ec.europa.eu/

[4] Both tools are available online under http://www.inspire-geoportal.eu/index.cfm/pageid/342

Reference	metadata element
1.1	Resource title
1.2	Resource abstract
1.3	Resource type
1.4	Resource locator
1.5	Unique resource identifier
1.7	Resource language
2.1	Topic category
2.2.	Spatial data service type
3	Keyword
4.1	Geographic bounding box
5	Temporal reference
6.1	Lineage
6.2	Spatial resolution
7	Conformity
8.1	Conditions for access and use
8.2	Limitations on public access
9	Responsible organisation
10.1	Metadata point of contact
10.2	Metadata date
10.3	Metadata language

Table 2 – Overview on the INSPIRE meta data elements for spatial data sets and spatial data set series

As a next step, we will evaluate how this basic set of meta data attributes or elements defined by INSPIRE needs be extended to meet specific MEDIATION requirements, e.g., to relate spatial meta data to toolbox resources, to case studies, or to the categories of problem types that the integrated methodology will emerge. Additionally, options for meta data synergies with the upcoming ACE as well as with FP7 partner projects like CLIMESAVE and RESPONSES will need to be taken into account.

6. Central functionality

This section outlines functionality foreseen with respect to the handling of spatial meta data and data in the context of the common platform.

6.1 Entries to the central meta data repository

The first set of functionality refers to entering, changing and deleting the entries for the central meta data repository. These functionalities need to be restricted to members of the MEDIATION project and should be provided location independent.

- **Add a new meta data entry.** Allows for distributed entry of meta data to document relevant spatial data. The meta data may refer to either external data or data that is made available via the central spatial data repository. The creator of a meta data entry receives the role of the owner of the respective entry, granting the right to subsequently update or delete this entry.
- **Derive a new meta data entry from an existing one.** Past experiences in designing interfaces for meta data entry show that users often prefer to ‘re-use’ already available meta data entries to derive new ones in order to reduce input required, rather than re-entering similar attribute values all over again. Thus, in addition to create a new meta data entry ‘from the scratch’, it should be possible to create a new meta data entry by deriving it from a user selectable existing meta data entry and subsequently changing only the necessary attribute values. This functionality should not necessarily be restricted to entries owned by the person that wants to derive a new entry..
- **Update an existing meta data entry.** Enables a user to update attribute values of existing meta data entries, e.g., in order to change already entered information or to correct typos. Updating a meta data entry requires ownership for the respective entry.

- **Delete an existing meta data entry.** Enables a user to completely remove an existing meta data entry from the meta data repository. Similar to updating, deleting a meta data entry requires ownership for the respective entry.

It is considered to additionally provide a basic role back functionality to allow access to previous versions of subsequently changed meta data entries.

6.2 Entries for the central spatial data repository

This set of functionality refers to entering, updating and deleting entries for the central spatial data repository. Again, these functionalities will be restricted to the members of the MEDIATION project.

- **Upload a new spatial data set.** Allows for adding a new data set to the central spatial data repository. In addition, respective meta data will have to be entered. The user who uploads a spatial dataset receives the role of the owner of the respective entry, granting the right to subsequently update or delete this entry.
- **Upload a new version of an already uploaded spatial data set.** Allows for exchanging an already uploaded spatial data set against a new version of this data set. Uploading a new version of a dataset will require ownership for the respective dataset.
- **Delete an already existing spatial data set.** This will enable users to delete an existing data set entry from the central spatial data repository. Deleting a dataset will require ownership for the respective dataset.

Note that, as opposed to the handling of meta data entries, it is not envisaged to provide any role back functionality for data sets. For practical reasons, the central spatial data repository will be designed to enable central access to selected datasets for representing them to the users of the common platform or for download, its aim is not to act as storage for different versions of spatial datasets.

6.3 Filtering meta data entries

This set of functionality refers user selectable filtering of the data documented in the central meta data repository. Since it does not affect content, filter functionality can be in principle made available to all users of the common platform.

- **Filter meta data entries.** Allows to flexibly filter the entries in the central meta data repository. Filter criteria can potentially include all meta data attributes and combinations of those attributes.
- **Interrelate with the case study pool.** Allows to identify those entries in the central meta data repository that relate to a specific case study, and vice versa. This will enable to identify programmatically any case study that has used or generated a specific spatial data set, as well as the spatial data used by or generated within a specific case study, respectively.
- **Interrelate with the toolbox.** Allows to identify those entries in the central meta data repository that relate to a specific tool documented in the toolbox, and vice versa. According functionality would enable to programmatically identify tools documented in the toolbox that require a specific spatial data set as input or that have been used to generate a specific spatial data set.

Note that while direct filtering of the spatial meta data is straight forward, interrelating it with the case studies and with the toolbox will depend both on the design of the toolbox and of the integrated methodology and will require additional meta data elements to express the respective interrelations.

6.4 Linking to external spatial data from selected meta data

Access functionality to distributed external spatial data documented in the MEDIATION central meta data repository will naturally be limited and depend on existing web-enabled access interfaces. Ideally such data will be online accessible via other sites, and the meta data will provide the required information allowing a user to directly link to the respective data access interface. If this is the case, the common platform will where possible provide direct hyperlinking from selected meta data to a remote site that gives access to the documented data.

6.5 Accessing centrally stored spatial data from selected meta data

As opposed to the limited forms of access that can be established to distributed external data, the common platform will provide advanced forms of access to data that has been uploaded into its central spatial data repository. The following forms can be distinguished:

- **Data display using maps.** Will allow to interactively visualise user selectable spatial data on maps. This functionality will be provided by a web-based interactive MEDIATION atlas (7.1).
- **Data display using diagrams.** Will allow to interactively visualize user selectable spatio-temporal data using suited types of time series diagrams. This functionality will be provided by a web-based diagram server coupled to the interactive atlas (7.3).
- **Data download.** In principle, download of data in the central spatial data repository can be enabled via the common platform. It needs to be agreed upon with the consortium members whether such a functionality should be enabled for all or only for selected datasets, and if it should be generally available or only for specific users.

7. Advanced access interfaces for spatial data

In order to support comfortable and vivid representations of spatio-temporal data, we will integrate both a web-based interactive MEDIATION atlas and a coupled diagram server into the common platform.

7.1 Towards a web-based interactive MEDIATION atlas

We propose to design and integrate a web-based interactive MEDIATION atlas as one of the core components of the common platform. The aim of such an atlas would be to provide intuitive and integrated access both to (a) a set of climate, risk and vulnerability maps, and (b) to the spatial explicit output that will be produced by MEDIATION's case studies.

The advent of concepts towards rich internet applications, e.g., Ajax (Garret, 2005), has extended the classical, synchronous client-server paradigm of the web and also enabled a new quality of web mapping (Haklay et al., 2008). Today various information technologies are at hand to develop interactive web-based mapping facilities based on standards and open source software, e.g., Open Geospatial Consortium's (OGC)[5] OpenGIS Web Map Service Interface Standard (WMS)[6], the open source software API OpenLayers[7], and UMN MapServer[8]. These technologies enable an approach that could base on centrally managed spatial data, provided via a single, central WMS; additionally, distributed WMS can be used, allowing for integrating maps from different sources on the fly, respectively. To be made available via a centrally managed WMS, spatial data needs to be provided in a common format like raster or shape, together with basic setup information, e.g., defining projection and colour mapping.

In addition, a variety of APIs is available from major companies to develop interactive web-based 2D-maps (e.g., Google Maps[9], Bing Maps (Microsoft)[10], ArcGIS Web Mapping (ESRI)[11]). Furthermore, APIs for digital globes are available (e.g., Google Earth[12], NASA World Wind[13], TerraExplorer[14]); for a comparison of digital globes see Aurambout and Pettit (2008).

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[5] http://www.opengeospatial.org/

[6] http://www.opengeospatial.org/standards/wms

[7] http://openlayers.org/

[8] http://mapserver.org/

[9] http://maps.google.de/

[10] http://www.bing.com/maps/

[11] http://www.esri.com/software/arcgis/web-mapping/index.html

[12] http://www.google.com/earth/index.html

[13] http://worldwind.arc.nasa.gov/java/

Interactive maps can be considered as state of the art in displaying spatially explicit climate change related data. The MEDIATION interactive atlas will be designed to provide the following set of user functionalities:

- **Extensibility.** The Atlas will be developed such that it can be easily extended by additional maps. This will comprise a setup mechanism that will allow to integrate maps without reprogramming if the data is provided in an appropriate format.
- **Content selection.** Will allow the user to select data from MEDIATION's central spatial data repository to be displayed in the atlas. This will, e.g., comprise the selection of specific variables, scenarios, and time slices. Depending on the data available, various types of temporal aggregations (e.g., for seasons) could additionally be made available.
- **Map interactions.** Will enable typical map interactions like zoom in, zoom out, and panning.
- **Content comparison.** Will enable the user to intuitively compare data, e.g., for different time slices or different scenarios. This can comprise, e.g., options to generate and display difference maps (e.g., to compare a future projection with a baseline) or to display more than one map at once. Such and similar functionalities can also provide useful means to represent inherent uncertainties, e.g., by presenting output generated by several models or for different scenarios simultaneously.

The design of appropriate interactive user interfaces is not trivial (Shneiderman 1998), and specific solutions including appropriate visualisation (Nocke et al., 2008) are required to make the complex data in the context of climate change accessible to the user (Wrobel et al., 2008). Designing web-based applications poses specific challenges for user-interface design (e.g., Nielsen, 1999; Krug, 2006), and web-based mapping introduces its own usability challenges (e.g., Newman et al., 2010; Haklay and Zafiri, 2008). Thus, the interactive MEDIATION atlas, as well as the common platform as a whole, will be developed in an iterative manner based on prototypes, allowing to obtain feedback in early stages of development for ongoing refinement.

PIK will design and implement the interactive MEDIATION atlas. We have started to develop a prototype that combines multiple interactive maps that can be either coupled or decoupled. In coupling mode, both panning and zooming of all maps are synchronized programmatically, so that the task of adjusting all maps to an identical spatial extent is considerably facilitated. In this mode, various dimensions of spatio-temporal data can be comfortably compared for a user selectable spatial extent, e.g., to compare multiple time slices (Fig. 3), scenarios, model projections (Fig. 4) or variables (Fig. 5). In the decoupled mode, each map can be panned and zoomed independently, thus allowing to view overview and detail simultaneously by selecting different zoom levels, or to display details for different regions at the same time (Fig. 6). The prototype is implemented to evaluate and demonstrate functional options that can extend features typically used in the context of web-based mapping of climate change related data. The current version utilizes the Google Maps API, but can be adapted to other APIs like OpenLayers. Note also that the figures show sample data to demonstrate the prototype's functionality.

A second prototype, using the OpenLayers API (which again is only one of several options), focuses on tracking state in a web-based environment to explore options for advanced undo/redo-functionality for user interactions. In addition, it makes use of the JQuery[15] and the JQuery UI[16] API to enable rearrangement of components on a web page. Size and position of a set of coupled interactive maps can be adjusted at runtime, allowing each map to be dragged and resized using the mouse (Fig. 7).

[14] http://www.skylineglobe.com/SkylineGlobe/corporate/home/index.aspx

[15] http://jquery.com/

[16] http://jqueryui.com/

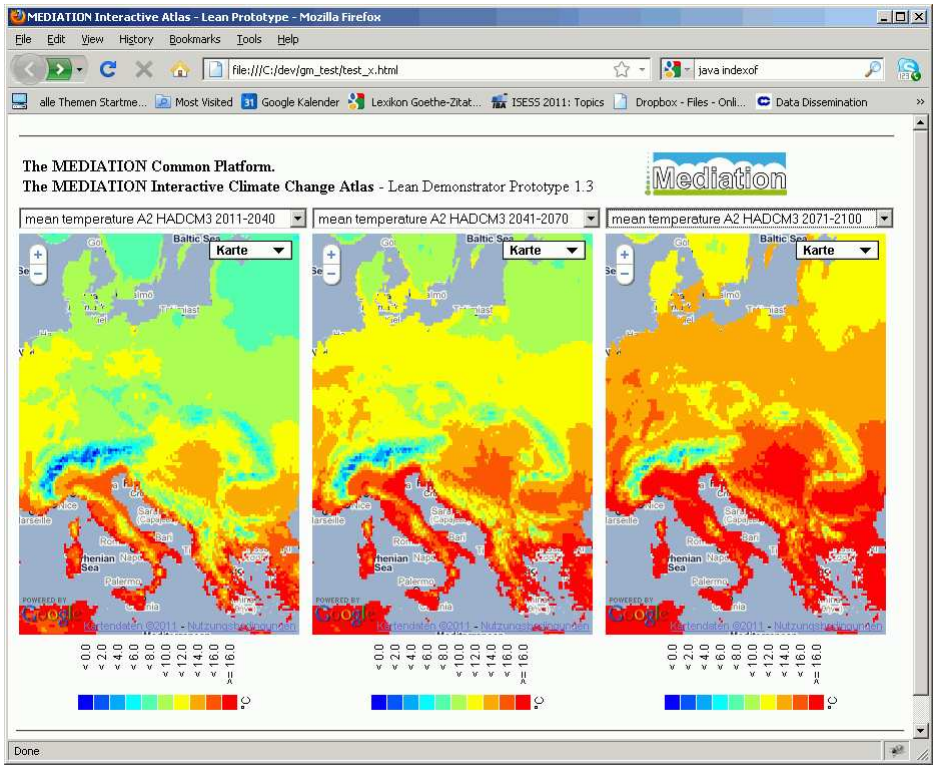

Fig. 3 – Simultaneously representing multiple time slices: 2011-2040, 2041-2070 and 2071-2100 for mean temperature projected by HADCM3 under A2 (atlas prototype, screenshot)

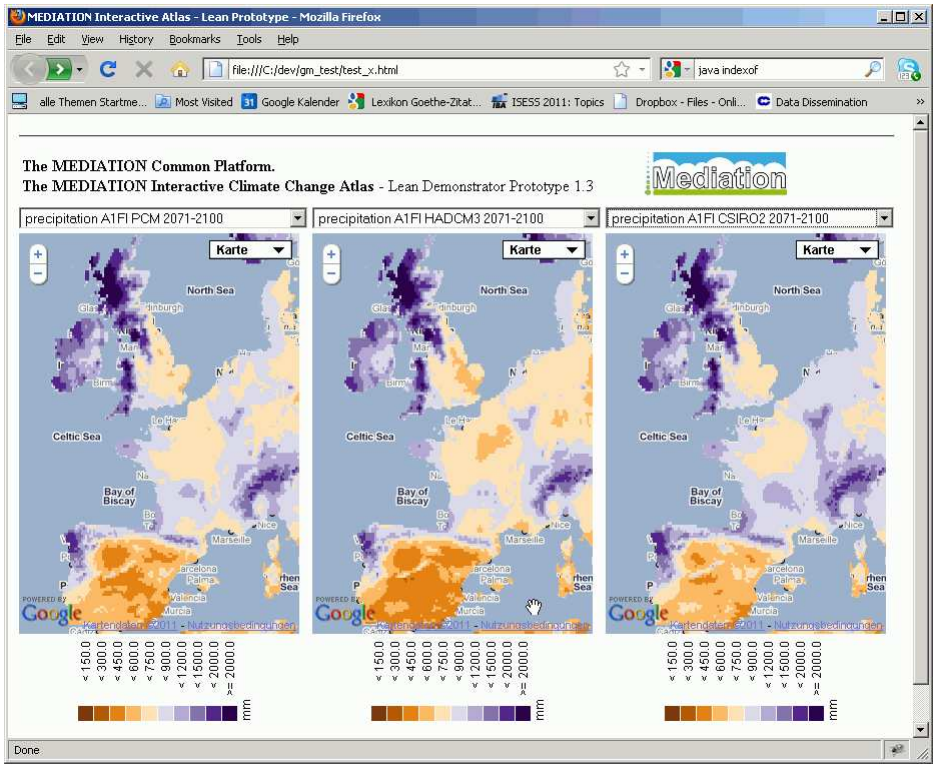

Fig. 4 – Simultaneously representing projections from multiple GCMs: precipitation under A1FI, projected by PCM, HADCM3 and CSIRIO2 (atlas prototype, screenshot)

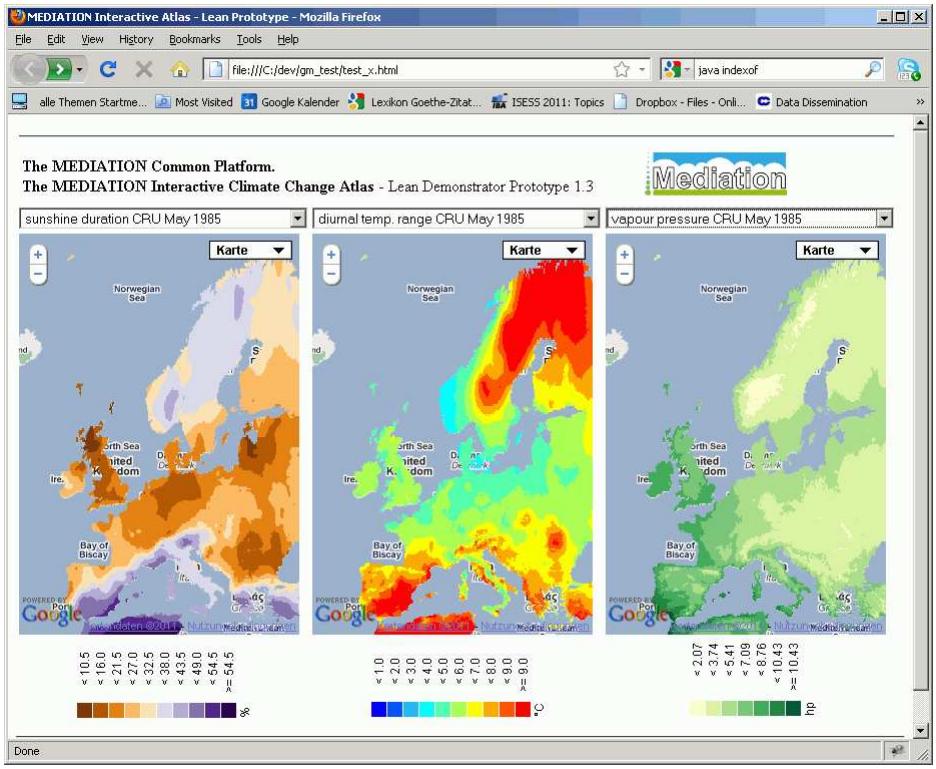

Fig. 5 – Simultaneously representing multiple variables from a CRU dataset: sunshine duration, diurnal temperature range and vapour pressure (atlas prototype, screenshot)

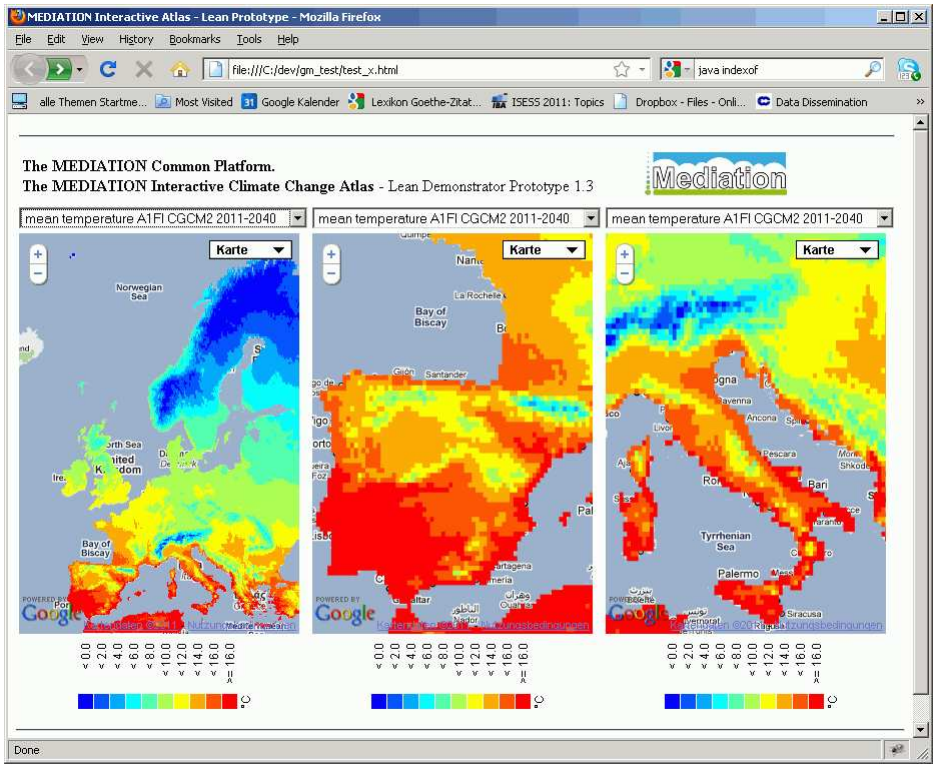

Fig. 6 – Simultaneously representing multiple spatial references:
mean temperature projected by CGCM2 (atlas prototype, screenshot)

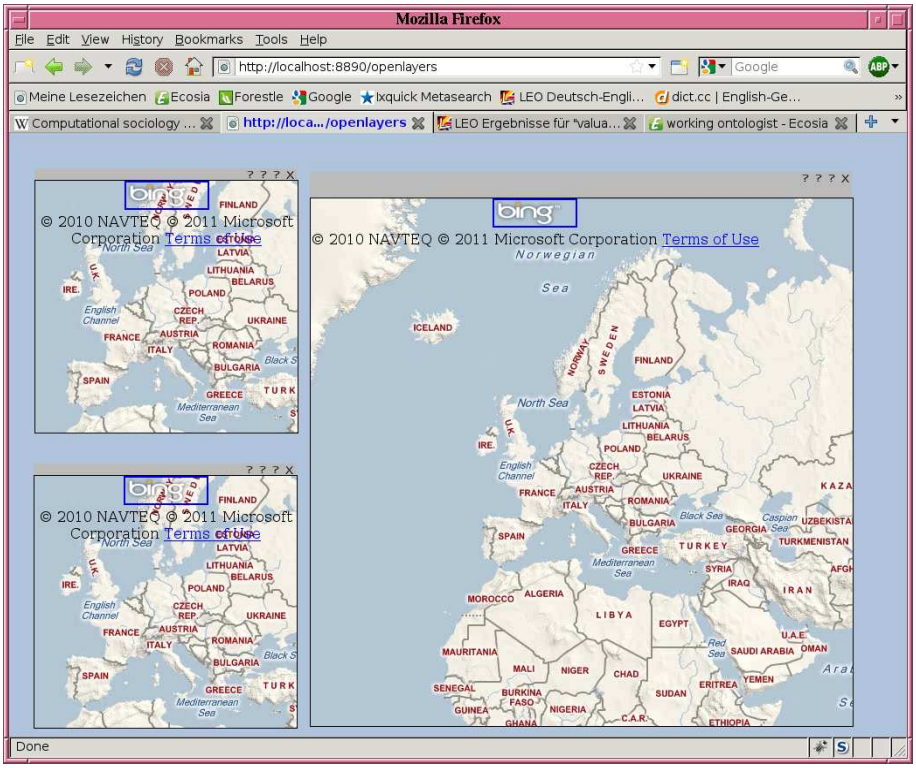

Fig. 7 – Prototype allowing to drag and resize coupled maps on a web page (screenshot)

7.2 Content for the MEDIATION atlas

PIK will provide a reduced set of risk maps for this interactive atlas, e.g., maps depicting SPI based drought frequency and SPI based drought severity. Additionally, to provide a set of basic climate information for the atlas, it is envisaged to produce and integrate a set of climate maps based on a high resolution data set (ca. 20 × 20 km) from the regional climate model CLM that is available via the World Data Center in Hamburg (daily values, 1960-2100, one GCM (ECHAM5), scenarios A1B and B1)[17]. Based on this data, it is planned to provide homogenised maps, depicting changes in average temperature and precipitation as well as related to the Koeppen climate classification (Gerstengarbe and Werner, 2009; Rubel and Kottek, 2010).

Furthermore it is envisaged to produce maps for a set of indices like the number of summer days (days with T_{max} >25 °C), the number of hot days (days with T_{max} > 30 °C), the number of tropical nights (days with T_{min} > 20 °C), the number of number of wet days (prec >= 1mm), the number of frost days (T_{min} < 0 °C) or the number of ice days (T_{max} < 0°C). Additional candidates for indices relate to extreme events like heat waves (Frich et al., 2002; Alexander et al., 2006; Tebaldi et al., 2006), drought (McKee et al., 1993; Byun and Wilhite, 1999; Frich et al., 2002; Alexander et al., 2006, Krysanova et al., 2008) or heavy rain (Grieser and Beck, 2002; Frich et al., 2002; Alexander et al., 2006).

Other European datasets that could be based on include data from FP5 project PRUDENCE[18] and FP6 project ENSEMBLES[19], as well as from the Tyndall Center, e.g., the TYN SC 1.0 dataset[20] (10' × 10' spatial resolution, 2001-2100, 4 GCMS (CGCM2, CSIRO mk 2, DOE PCM, HadCM3), four SRES emissions scenarios (A1FI, A2, B2, B1). We will also discuss with CLIMSAVE to align on data sets that could be used to produce maps for the MEDIATION atlas.

[17] http://cera-www.dkrz.de/WDCC/ui/SearchByName.jsp?query=clm

[18] http://prudence.dmi.dk/

[19] http://ensembles-eu.metoffice.com/

[20] http://www.cru.uea.ac.uk/cru/data/hrg/timm/grid/TYN_SC_1_0.html

In addition it is envisaged to integrate a selection of maps available from other sources. A set of promising candidates identified so far is constituted by European scale vulnerability maps that are currently produced within the project ESPON-Climate[21], potentially also together with other maps that will be available via the ESPON Database 2013[22] (the current ESPON projects are scheduled to terminate in the first half of 2011). We will discuss with the MEDIATION partners to decide which other maps that are already available via different projects or institutions should and can be integrated into the MEDIATION atlas, e.g., risk / damage maps concerning flood risk and crop risk produced in the ADAM project[23], or maps from the pools of EEA and JRC.

7.3 Diagram Server

While maps are very beneficial to display spatially explicit information, they have their inherent limitations in representing changes over time. Thus, it is planned to additionally provide a diagram server that can deliver time series diagrams out of spatio-temporal data on the fly. The diagram server can be operated stand-alone, but also be coupled with interactive maps in order to select special references (Fig. 8). Thus it can be easily combined with the MEDIATION interactive atlas.

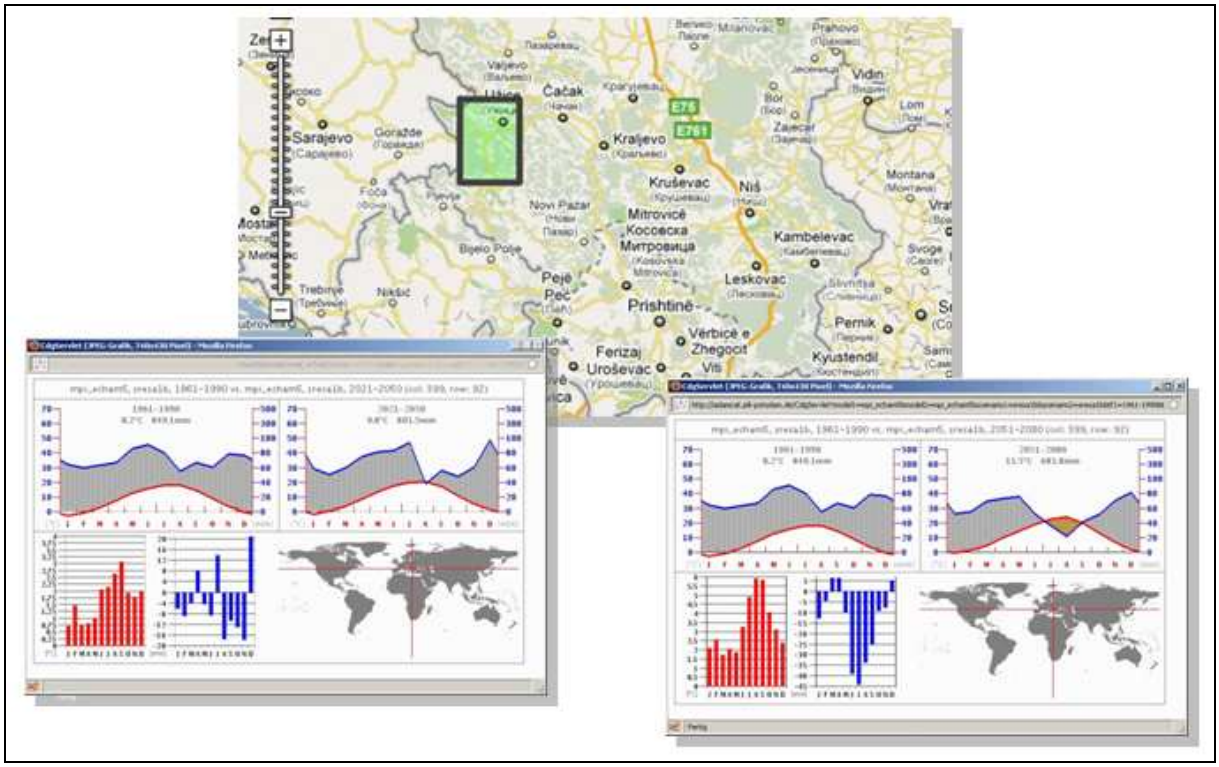

Fig. 8 – Example of a user interface combining diagram server and interactive map to enable access to time series data on regular grids. Selected data is displayed for multiple time slices using combinations of Walter climate diagrams and monthly difference plots.

In the context of the common platform the diagram server will offer the following core functionalities:

- **Extensibility.** The diagram server will be designed such that it is extensible to additional spatio-temporal data. Furthermore, new diagram functionalities can be added.
- **Content selection.** Allows the user to select data from MEDIATION's central spatial data repository to be displayed via diagrams. This will comprise the selection of specific variables as well as of spatial and temporal references.

[21] http://www.espon-climate.eu/

[22] http://www.espon.eu/main/Menu_Projects/Menu_ScientificPlatform/espondatabase2013.html

[23] http://adam-digital-compendium.pik-potsdam.de/risk-damage-maps/

- **Content comparison.** Enables the user to compare data, e.g., for different time slices, models or scenarios, by generating and combining diagrams for different time slices and difference plots (for an example see Fig. 8).

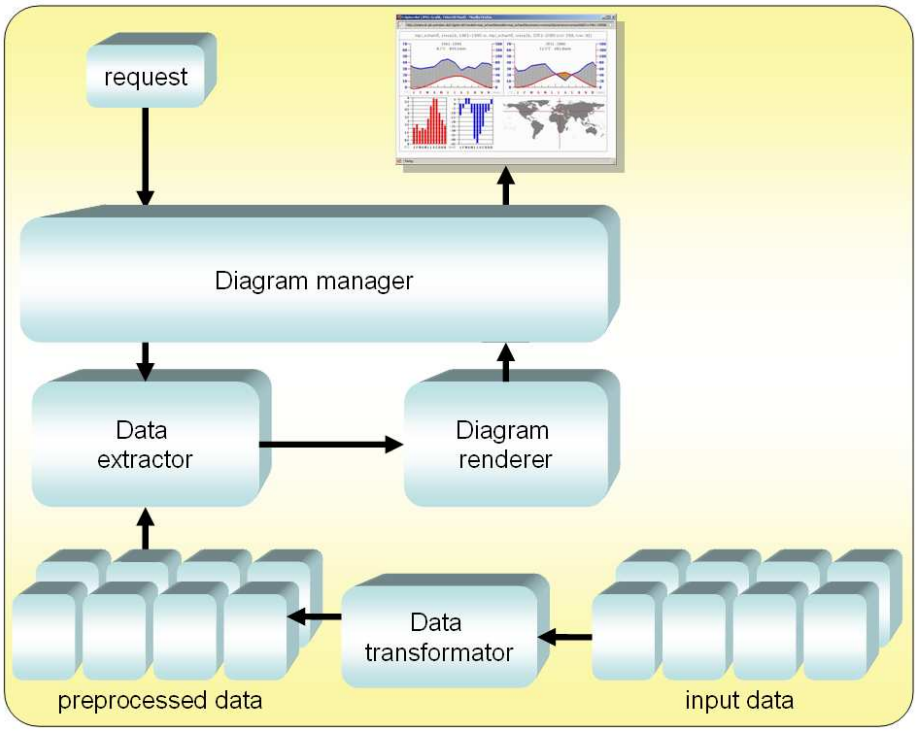

Fig. 9 – Diagram server architecture

A diagram server can in principle operate on the same spatial data used to generate maps for the interactive atlas. Note however that requirements may differ concerning the temporal resolution of data provided for the common platform: while it may be sufficient to base on temporally aggregated spatial data (e.g., 30 yrs averages) to provide maps, it is evident that data with a finer temporal resolution (e.g., monthly or annual) is needed to generate meaningful visual representations of time series. In addition, it might be necessary to pre-process multi-dimensional spatio-temporal data in order to enable responsive on-the-fly data extraction and diagram generation without imposing tedious delays on the interaction performance (Fig. 9).

7.4 Concerning a list of European spatial data sources

It is beyond the scope of MEDIATION to provide comprehensive integrated access to the distributed sources providing spatial data on Europe. Nevertheless, a centrally accessible, searchable list of such sources is considered a valuable asset and might form an attractive part of the common platform. We will evaluate if access to such information can be provided via the currently developed Adaptation Clearinghouse for Europe (ACE). As an alternative, PIK is planning to hire a student assistant to collate a list of web-accessible sources for spatial data. This list could then be made available via the common platform in form of a searchable collection (e.g., by sector and spatial extent), allowing to hyperlink to the respective sources.

8. Open questions and outlook

This document outlined MEDIATION's approach towards developing a spatial database as one of the core components of the envisaged common platform. Open questions in this context that deserve further attention refer to the following issues:

Data ownership. It still needs to be identified whether spatial data presented or provided via the common platform should be generally freely accessible or different access rules / access restrictions need to be applied, e.g., to handle data that has not been published yet.

Meta data granularity. An appropriate and pragmatic level of meta data detail concerning the description of case study input data and tool input data in general needs to be identified together with WP2 and the case studies.

Designing appropriate user interfaces. A central challenge refers to the design of appropriate user interfaces to access and represent spatial data in the context of the common platform. It is planned to collect user feedback based both on prototypes for the components outlined in this deliverable (see below) as well as on rapid prototyping of the overall common platform. Since information technologies for web-based user interfaces and web-based mapping constitute a rapidly evolving field, we will in parallel evaluate options that current IT developments can provide for the aim of the common platform.

Consistency of case study maps and other maps for the atlas. It needs to be clarified to what extend additional climate change related maps provided in the interactive atlas should base on the same data being used as input data in the case studies. This might contribute to a consistent overall picture, but could also reduce the information to be provided (for the issue of consistency across case studies see also D5.2).

Type of spatial resolutions for the interactive atlas. It needs to be decided whether maps provided via the interactive atlas, e.g., representing case study output, should be restricted to a specific type of spatial resolution, namely either to grid cells or to administrative boundaries like the NUTS system, or if data of both types should be presented to the user. While model output is often available on grids, e.g., from GCMs or impact models, data for administrative boundaries might be more appropriate for informing decisions. Note that available web mapping technology can display both types of resolutions.

Adaptation Clearinghouse for Europe. The current developments towards establishing an Adaptation Clearinghouse for Europe (ACE) as a central entry point for climate change related information in Europe provide also new opportunities for the common platform. We thus will work towards identifying potential linkages and synergies with the ACE.

Initial prototypes of components outlined in this deliverable (meta data repository, spatial data repository, interactive MEDIATION atlas and diagram server) will be available in the first half of 2011. In parallel, drafts for the design of the user interface of the overall common platform will be developed. Subsequently these prototypes will be evaluated, improved and refined iteratively. It is foreseen to timely base on selected case studies as pilots to further identify and elaborate respective requirements (see also D5.2), as well as to obtain sample input data and initial versions of spatio-temporal data generated in these case studies to subsequently extend and refine the components for handling spatial data in the context of the common platform.

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