EcoLexicon: New Features and Challenges

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Abstract

EcoLexicon is a terminological knowledge base (TKB) on the environment with terms in six languages: English, French, German, Modern Greek, Russian, and Spanish. It is the practical application of Frame-based Terminology, which uses a modified version of Fillmore's frames coupled with premises from Cognitive Linguistics to configure specialized domains on the basis of definitional templates and create situated representations for specialized knowledge concepts. The specification of the conceptual structure of (sub)events and the description of the lexical units are the result of a top-down and bottom-up approach that extracts information from a wide range of resources. This includes the use of corpora, the factorization of definitions from specialized resources and the extraction of conceptual relations with knowledge patterns. Similarly to a specialized visual thesaurus, EcoLexicon provides entries in the form of semantic networks that specify relations between environmental concepts. All entries are linked to a corresponding (sub)event and conceptual category. In other words, the structure of the conceptual, graphical, and linguistic information relative to entries is based on an underlying conceptual frame. Graphical information includes photos, images, and videos, whereas linguistic information not only specifies the grammatical category of each term, but also phraseological, and contextual information. The TKB also provides access to the specialized corpus created for its development and a search engine to query it. One of the challenges for EcoLexicon in the near future is its inclusion in the Linguistic Linked Open Data Cloud.

Keywords: Terminology, knowledge representation, terminological knowledge base

1. Introduction

EcoLexicon (ecolexicon.ugr.es) is a multilingual visual thesaurus of environmental science (Faber, León-Araúz, and Reimerink 2014). It is the practical application of Frame-based Terminology (FBT; Faber et al. 2011; Faber 2012, 2015), a theory of specialized knowledge representation that uses certain aspects of Frame Semantics (Fillmore 1985; Fillmore and Atkins 1992) to structure specialized domains and create non-language-specific representations. FBT focuses on: (i) conceptual organization; (ii) the multidimensional nature of specialized knowledge units; and (iii) the extraction of semantic and syntactic information through the use of multilingual corpora. EcoLexicon is an internally coherent information system, which is organized according to conceptual and linguistic premises at the macro- as well as the micro-structural level.

From a visual perspective, each concept appears in a network that links it to all related concepts. The semantic networks in EcoLexicon are based on an underlying domain event, which generates templates for the most prototypical states and events that characterize the specialized field of the Environment as well as the entities that participate in these states and events. This type of visualization was selected because a semantic network is an effective representation method for capturing and encapsulating large amounts of semantic information in an intelligent environment (Peters and Shrobe 2003). The representations generated for each concept are obtained from the information extracted from static knowledge sources such as a multilingual corpus of texts and other environmental resources.

EcoLexicon currently has 3,599 concepts and 20,106 terms in Spanish, English, German, French, Modern Greek, and Russian, though terms in more languages are currently being added. This terminological resource is conceived for language and domain experts as well as for the general public. It targets users such as translators, technical writers, and environmental experts who need to understand specialized environmental concepts with a view to writing and/or translating specialized and semi-specialized texts.

2. Frame-based Terminology

Frame-based Terminology (FBT) is the theoretical approach used to create EcoLexicon. Based on cognitive semantics (Geeraerts 2010) and situated cognition (Barsalou 2008), specialized environmental knowledge is stored and structured in the form of propositions and knowledge frames, which are organized in an ontological structure.

FBT is a cognitively-oriented terminology theory that operates on the premise that, in scientific and technical communication, specialized knowledge units activate domain-specific semantic frames that are in consonance with the users' background knowledge. The specification of such frames is based on the following set of micro-theories: (i) a semantic micro-theory; (ii) a syntactic micro-theory; and (iii) a pragmatic micro-theory. Each micro-theory is related to the information in term entries, the relations between specialized knowledge units, and the concepts that they designate (Faber 2015).

More concretely, the semantic micro-theory involves an internal and external representation. The internal representation is reflected in a definition template used to structure the meaning components and semantic relations in the description of each specialized knowledge unit (see Section 5). The external representation is a domain-specific ontology whose top-level concepts are OBJECT, EVENT, ATTRIBUTE, and RELATION. The ontology is based on the conceptual representations of physical objects and processes (e.g. ALLUVIAL FAN, GROYNE, EROSION, WEATHERING, etc.). This set of concepts acts as a scaffold, and their natural language descriptions provide the semantic foundation for data querying, integration, and inferencing (Samwald et al. 2010).

The syntactic micro-theory is event-based and takes the form of predicate-argument structures. The nature of an event depends on the predicates that activate the relationships between entities. According to FBT, terms and their relations to other terms have a syntax, as depicted in graph-based micro-grammars, which not only show how hierarchical and non-hierarchical relations are expressed in different languages, but can also tag corpus texts for information retrieval (León and Faber 2012).

Finally, the pragmatic micro-theory is a theory of contexts, which can be linguistic or extralinguistic. Linguistic contexts are generally regarded as spans of +5 items before and after term occurrence. They are crucial in the design stage of a terminological knowledge base (TKB) for a wide variety of reasons, which include: (i) term disambiguation; (ii) definition formulation; (iii) linguistic usage; (iv) conceptual modeling; and (v) term extraction. Such contextual information is important because it shows how terms are activated and used in specialized texts in the form of collocations and collocational patterns.

In contrast, extralinguistic contexts are pointers to cultural knowledge, perceptions, and beliefs since many specialized knowledge units possess an important cultural dimension. Cultural situatedness has an impact on semantic networks since certain conceptual categories are linked to the habitat of the speakers of a language and derive their meaning from the characteristics of a given geographic area or region and, for example, the weather phenomena that typically occur there

Based on these theoretical premises, EcoLexicon has evolved and has made significant advances since it was first created a decade ago. Section 3 explains the interface of the application, the knowledge provided to users, and the various interaction options. Section 4 describes the contextualization of knowledge to avoid information overload. Section 5 explains how natural language definitions are created according to FBT premises. Section 6 shows the search possibilities of the EcoLexicon corpus. Section 7 addresses one of the future challenges of the resource, its inclusion in the Linguistic Linked Open Data Cloud, and Section 8 draws some final conclusions.

3. User interface

Users interact with EcoLexicon through a visual interface with different modules that provide conceptual, linguistic, and graphical information. Instead of viewing all information simultaneously, they can browse through the windows and select the data that is most relevant for their needs.

Figure 1 shows the entry in EcoLexicon for FAN. When users open the application, three zones appear. The top horizontal bar gives users access to the term/concept search engine. The vertical bar on the left of the screen provides information regarding the search concept, namely its definition, term designations, associated resources, general conceptual role, and phraseology.

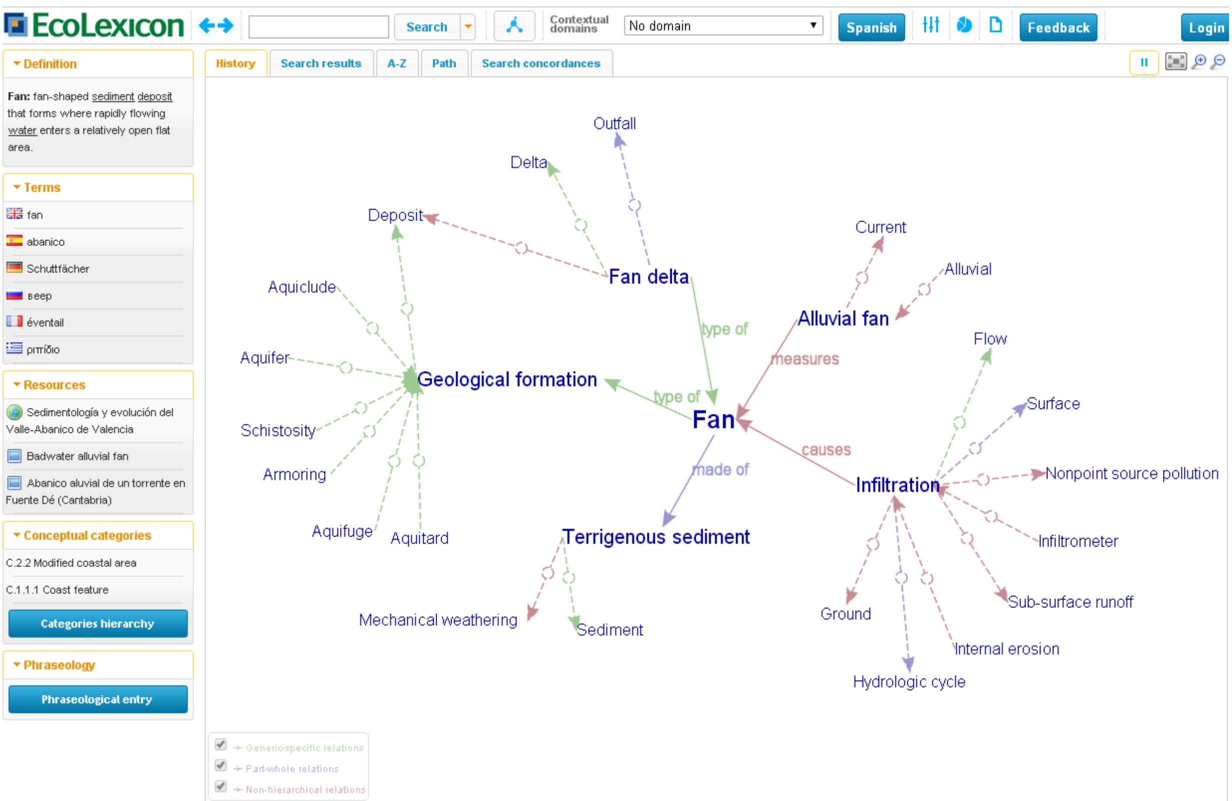

Figure 1: EcoLexicon user interface

The topmost box shows the definition of the concept. Each definition makes category membership explicit, reflects a concept's relations with other concepts, and specifies essential attributes and features (see Section 5). Accordingly, the definition is the linguistic codification of the relational structure shown in the concept map. The words in each definition also have hyperlinks to their corresponding concept in the knowledge base.

The box directly below shows the terms designating the search concept in various languages. The list is organized according to language and term type (main entry term, synonym, variant, acronym, etc.). At the left of each term is the flag of the country where the language is spoken. A click on the term provides further linguistic information regarding language, term type, gender, part of speech, and concordances.

The third box provides resources (images, documents, URLs, audiovisual material, etc.) associated with each concept/term. The fourth box shows the very general conceptual role that the concept normally has within the Environmental Event (EE). The EE is a basic template in which any environmental process is conceived of as initiated by an agent, affecting a patient (environmental entity), and producing a result, often in a geographical area. Each concept is associated with one or more conceptual categories, which are shown as a list. Also included is a *Category Hierarchy* icon, which shows the concepts in a hierarchical format in which nodes can expand or retract.

The Phraseology box is currently under construction and shows a list of verbs most commonly used with the term within different phraseological patterns. So far, this option is only available for a small number of terms, such as *hurricane* (Figure 2).

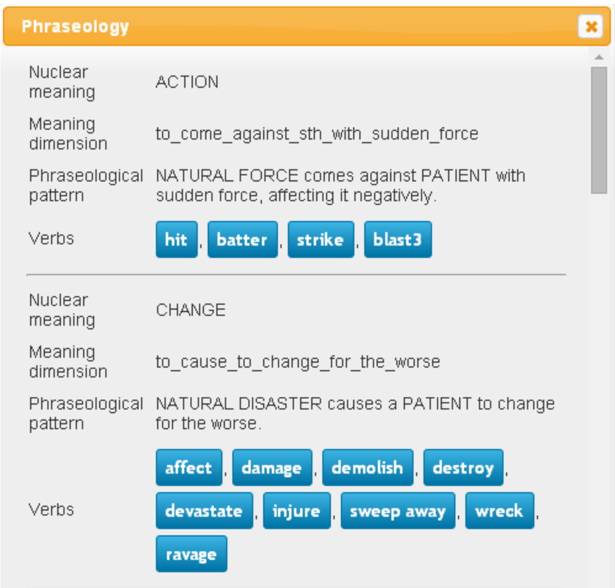

Figure 2: Phraseological information for *hurricane*

The center area has tabs that access the following: (i) the history of concepts/terms visited; (ii) the results of the most recent query; (iii) all the terms alphabetically arranged; (iv) the shortest path between two concepts; and (v) concordances for a term (see Section 6).

On the center of the screen, the conceptual map is shown as well as the icons that permit users to configure and personalize it for their needs (see Section 4). The standard representation mode shows a multi-level semantic network whose concepts are all linked in some way to the search concept, which is at its center.

When users click on any of the concepts in the map, (for example, FAN DELTA), the network rearranges itself. In this new map, FAN DELTA is at the center along with its set of related concepts (see Figure 3).

By right-clicking on a concept in the map, the user can access the contextual menu (Figure 3). This menu can be used to perform any of the following actions: (i) centering the concept; (ii) fixing a node by dragging it to a certain position; (iii) showing details of the concept (definition, associated terms, resources, etc.) by selection on the sidebar; (iv) generating a URL for direct access to the concept selected; (v) searching Google Images, Google, and Wolfram Alpha; (vi) removing a concept and its related concepts from the map. Any of these actions enhances concept representation by providing a rich quantity of conceptual information, according to the specific needs of each end user.

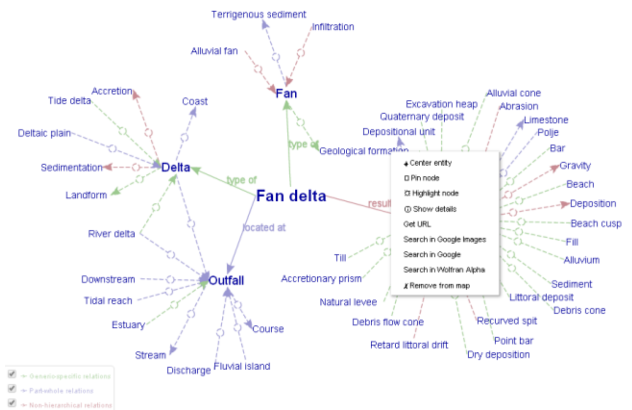

Figure 3: Conceptual map of FAN DELTA and contextual menu

EcoLexicon also includes icons to personalize concept map visualization such as *Zoom map, Zoom out map,* and *Fullscreen*. *Stop layout* deactivates the automatic arrangement of concepts in the network, thus allowing users to configure the map by dragging concepts to the desired location.

The *Settings* icon further customizes semantic networks by allowing users to establish the depth of the network, namely, its maximum conceptual level. Similarly, they can also decide whether they wish to visualize the names of all semantic relations since, by default, relation labels only appear when the relation includes the central concept. If this value is activated, all relations will have labels.

4. Information overload and multidimensionality

The scope and multidimensionality of the environmental domain, as well as the great deal of conceptual propositions represented in EcoLexicon, has resulted in an information overload problem. This problem has been solved in different quantitative and qualitative ways: (i) by letting the user filter overloaded networks by relation type, (ii) by offering a recontextualized view of concepts according to subject-field based contextual constraints, and (iii) by providing different access modes to the visualization of concepts' behaviour (network mode, tree mode, and path mode).

In the lower left-hand corner of the conceptual map (Figure 1 and 3) there is a text box that allows users to identify the three categories of conceptual relation in EcoLexicon: (i) hyponymic (*type_of*) relations; (ii) meronymic (*part_of*) relations; (iii) non-hierarchical relations (*has_function, located_at, causes, affects, result_of,* etc.). These relations, which are related to Pustejovsky's (1995) *qualia,* belong to a closed inventory that is currently being revised to make them more fine-grained and provide them with greater relational power. The checkboxes at the left of each label can be used to activate or deactivate the visualization of a certain type of relation so that it does not appear on the map. This allows users to filter overloaded networks based on relation types. Recontextualized networks can be visualized by choosing one of the contextual domains from a pull-down menu (upper ribbon in Figure 1).

This is a qualitative way to solve the information overload problem while enhancing the representation of multidimensionality. Recontextualized networks are reshaped according to how the relational behaviour of concepts varies according to perspective. Instead of representing all possible dimensions of a concept, conceptual propositions are activated or constrained based on their salience in different subject fields (León-Araúz et al. 2013).

Figure 4: Context-free overloaded network of WATER

In Figure 4, WATER appears in a context-free overloaded network – hardly meaningful to users – while in Figure 5 the same concept is framed in the Civil Engineering domain, whose network is substantially reduced.

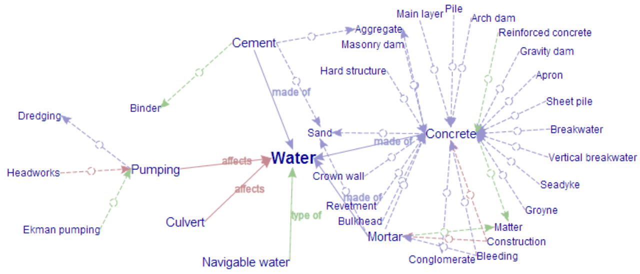

Figure 5: Network of WATER the Civil Engineering domain

Regarding the representation mode, users can also choose between a tree mode and a path mode. The tree mode generates a *type_of* hierarchy for the concept (Figure 6). In contrast, in the path mode users choose two concepts that will be the beginning and end of the path, and the application calculates and draws the shortest distance between them (Figure 7).

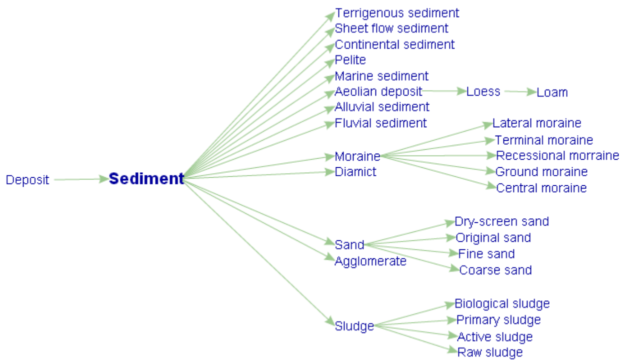

Figure 6: Tree mode of SEDIMENT

Figure 7: Path mode of HURRICANE and SAND

5. Natural language definitions

In EcoLexicon, definitions are based on the most representative conceptual propositions established by the concept in EcoLexicon. Each conceptual proposition is considered to be a feature of the concept and the representativeness of each feature is determined by the category assigned to the concept being defined. Each category has a set of representative conceptual relations that describe it, which a schematically represented in a definitional template (León Araúz, Faber, and Montero Martínez 2012: 153-154).

When applying a template to a concept, it may only inherit the relation with the defined concept in the template or activate a more specific concept than the one in the template. An example would be the template for HARD_COASTAL_DEFENCE_STRUCTURE (Table 1), which is applied to the definition of GROYNE (Table 2), a member of this category.

HARD_COASTAL_DEFENCE_STRUCTURE	
type_of	CONSTRUCTION
located_at	SHORELINE
made_of	MATERIAL

Table 1: HARD_COASTAL_DEFENCE_STRUCTURE definitional template (León Araúz et al. 2012: 156)

GROYNE	
Hard coastal defence structure made of concrete, wood, steel and/or rock perpendicular to the shoreline, built to protect a shore area, retard littoral drift, reduce longshore transport and prevent beach erosion.	
type_of	HARD COASTAL DEFENCE STRUCTURE
located_at	PERPENDICULAR TO SHORELINE
made_of	CONCRETE WOOD METAL ROCK
has_ function	SHORE PROTECTION LITTORAL DRIFT RETARDATION LONGSHORE TRANSPORT REDUCTION BEACH EROSION PREVENTION

Table 2: Definition of GROYNE after the application of the HARD_COASTAL_DEFENCE_STRUCTURE definitional template (León Araúz et al. 2012: 156)

As explained in Section 4, the multidimensional nature of the environment can cause information overload because some concepts present a high level of contextual variation. This can be prevented if the information shown is reduced according to the propositions present in specific conceptual domains. These versatile concepts, therefore, behave differently according to the contextual domain chosen. This has consequences for how these concepts are defined. In the same way that a single network becomes overloaded, a single definition cannot encompass all propositions present in the entire environmental domain and is therefore not sufficiently informative (San Martín and León-Araúz 2013).

For that reason, we are working on the creation of 'flexible definitions'. A flexible definition is a system of definitions for the same concept composed of a general environmental definition along with a set of recontextualized definitions derived from it, which situate the concept in different domains (San Martín 2016). Table 3 is an example of the resulting definitions for the entry SAND.

SAND	
Environment as a whole	Mineral material consisting mainly of particles of quartz ranging in size of 0.05-2 mm.
Geology	Sediment consisting mainly of particles of quartz ranging in size of 0.05-2 mm that is part of the soil and can be found in great quantities in beaches, river beds, the seabed, and deserts.
Soil Sciences	Unconsolidated inorganic soil component consisting mainly of particles of quartz ranging in size of 0.05-2 mm that are the result of weathering and erosion. It renders soils light, acidic, and permeable.
Civil Engineering	Natural construction aggregate consisting mainly of particles of quartz ranging in size of 0.05-2 mm that is mixed with cement, lime and other materials to produce concrete and mortar.

Table 3: Extract of the flexible definition of SAND

6. The EcoLexicon corpus

In EcoLexicon, a specialized corpus was specifically compiled in order to extract linguistic and conceptual knowledge. Then, it was classified and tagged in order to provide our users with a direct and flexible way of accessing the corpus, which is available in the *Search concordances* tab (Figure 1).

Currently, the corpus has more than 50 million words and each of its texts has been tagged according to a set of XML-based metadata (Figure 8). These tags contain information about the language of the text, the author, date of publication, target reader, contextual domain, keywords, etc. Some of them are based on the Dublin Core Schema (<dc>) and some others have been included based on our own needs (<eco>).

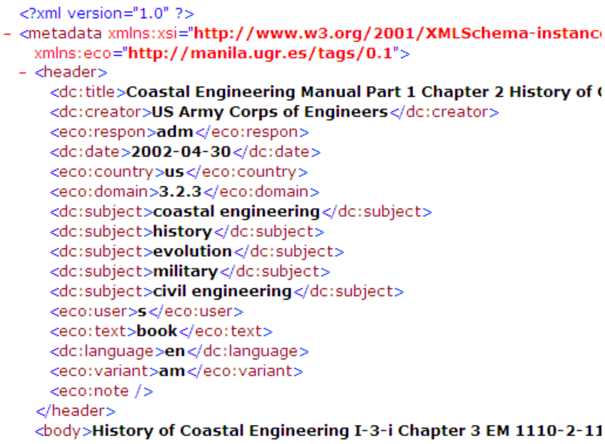

Figure 8: Corpus metadata

This allows constraining corpus queries based on pragmatic factors, such as contextual domains or target reader. In this way, users can compare the use of the same term in different contexts. For instance, Figure 9 shows the concordances of *sediment* in Environmental engineering texts, while Figure 10 shows the concordances of the same term in an Oceanography context. In the same way, in Figures 11 and 12 the query for *sand* is constrained according to expert and lay settings respectively.

Furthermore, in the future, the corpus will be expanded and annotated with a POS tagger in order to enable richer queries.

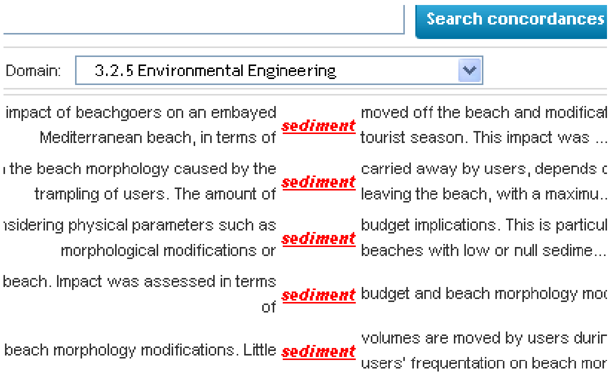

Figure 9: Concordances of *sediment* in Environmental Engineering

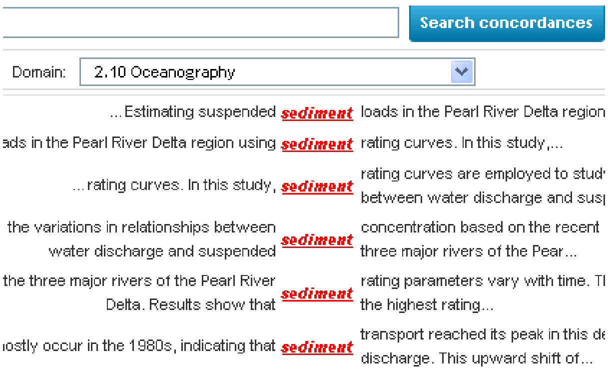

Figure 10: Concordances of *sediment* in Oceanography

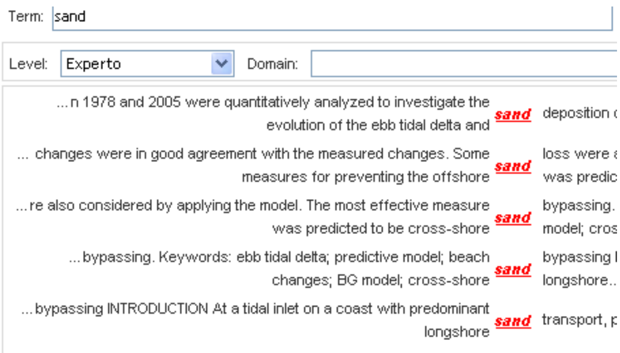

Figure 11: Concordances of *sand* in expert-to-expert texts

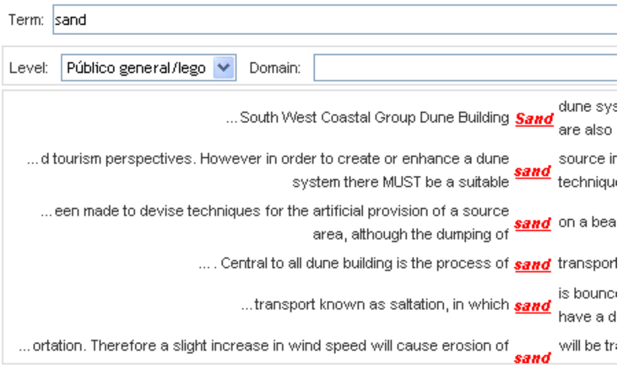

Figure 12: Concordances of *sand* in expert-to-lay texts

7. EcoLexicon-LD

Apart from annotating the corpus, expanding the phraseological module, and creating flexible definitions for all versatile concepts, one of the major challenges in EcoLexicon is to integrate the resource in the Linguistic Linked Open Data Cloud (León-Araúz et al. 2011a, 2011b).

Linked Data is an important initiative for creating a shared information space by publishing and connecting structured resources in the Semantic Web (Bizer et al. 2008). However, the specification of semantic relationships between data sources is still a stumbling block.

First of all, the TKB was converted to an RDF ontology in order to link it to other resources and provide the ways in which other resources can be linked to EcoLexicon. Thus, in the near future EcoLexicon will be available in three ways, as depicted in Figure 13: (i) the web application, as it is currently presented; (ii) another web application where EcoLexicon-LD can be browsed by humans; and (iii) a SPARQL endpoint.

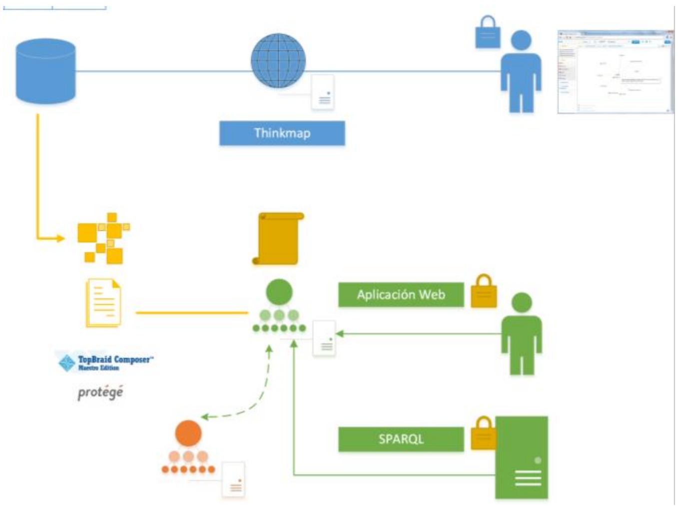

Figure 13: Access to EcoLexicon-LD

After that, a linking algorithm was designed in order to automatize the mappings between DBpedia and EcoLexicon (Figure 14).

Instead of mapping one-to-one manual correspondences between the entities contained in each of the resources, the matching algorithm performs sense disambiguation by exploiting the semantics of each data set. The data categories that are used from EcoLexicon are those related to linguistic variants, multilingual choices and semantic relations, which are mapped against the properties in DBpedia containing text.

Therefore, the first step in the data linking process is the comparison of the string of all English variants in EcoLexicon with the *rdfs:label* property of DBpedia. Since these strings may match various entries in DBpedia and lead to erroneous mappings, disambiguation is then performed by comparing other multilingual equivalents.

1. Get all ECOLEXICON concepts $C = \{c_1, ..., c_i, ..., c_n\}$
2. For each c_i in C
2.1. Search in DBPEDIA resources $D = \{d_1, ..., d_j, ..., d_m\}$ such that c_i.rdfs:label == d_j.rdfs.label (exact match @en)
2.2. if |D| == 0
    # No match, end procedure
2.3. if |D| == 1
    # Match
    $R = \{d_1\}$
2.4. if |D| > 1
    # Disambiguation required
    2.4.1. Search in ECOLEXICON $T^{ci} = \{t_1, ..., t_k, ..., t_p\}$ such that t_k is a term of c_i (any language)
    2.4.2. For each d_j in D
        2.4.2.1. Search in DBPEDIA $L^{dj} = \{l_1^{dj}, ..., l_l^{dj}, ..., l_q^{dj}\}$ such that l_l^{dj} == d_j.owl:sameAs (any language)
    2.4.3. Select $D^{max} = \{d_j\}$ such that max($|T_{ci}$ intersection $L_{dj}|$
    2.4.4. if $|D^{max}|$ == 1
        # Match
        $R = \{d_j\}$
    2.4.5. if $|D^{max}| > 0$
        # Disambiguation required
        2.4.5.1. $Tc_i = Tc_i \cup Tc_i^*$ such that c_{i*} is associated to c_i in ECOLEXICON and lemmatized
        2.4.5.2. For each $d_{j'}$ in D^{max}
            2.4.5.2.1. $X^{dj'} = \{x_1, ..., x_s, ..., x_t\}$ such that (x_s == dj'.rdfs:comment ||
            x_s == dj'.dbpedia-owl:abstract)
            and lemmatized
        2.4.5.3. Select $D^{max\_text} = \{d_{j'}\}$ such that
        max (| Ti intersection $X^{dj'}$ |)
        2.4.5.4. $R = D^{max\_text}$

Figure 14: Linking algorithm

Nevertheless, in those cases in which polysemy also occurs at a cross-linguistic level – or no multilingual choices are available – semantic information comes into play. If any term belonging to the same contextual domain of the search concept appears in any of the text-related DBpedia properties (i.e. *rdfs:comment*; *dbpedia-owl:abstract*, etc.), then concepts are considered equivalents (Figure 15).

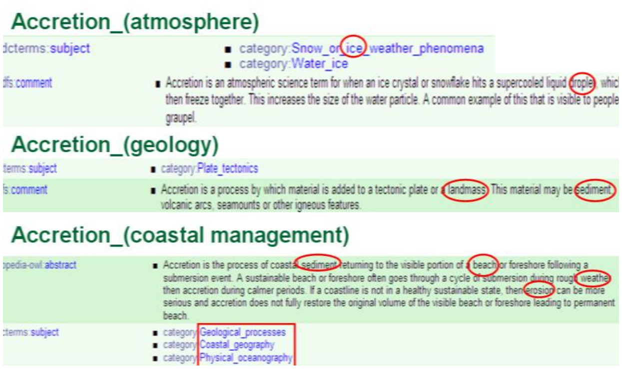

Figure 15: DBpedia dataset for ACCRETION

The final step will be to provide access to EcoLexicon-LD, where any registered user will be able to validate and evaluate the reliability of each link (Figure 16).

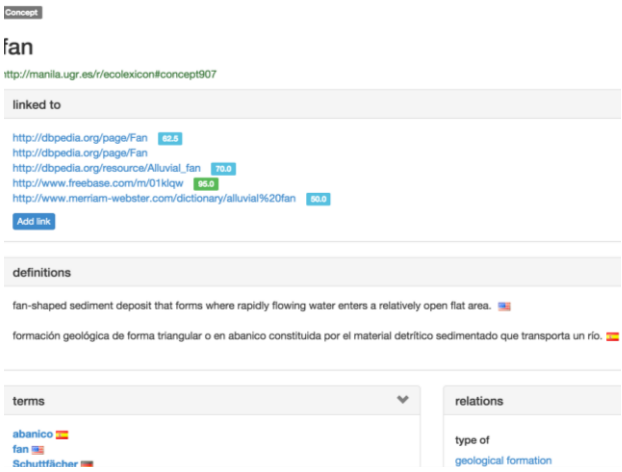

Figure 16: EcoLexicon-LD validation form

This will allow for the development of a validation protocol, from which new conclusions could be drawn for the future linking of new resources and the improvement of the algorithm.

8. Conclusion

In the past decade, EcoLexicon has evolved and made significant advances in the representation of environmental knowledge. As well as the specialized domain the TKB represents, it must grow and adapt to new scientific advances. Apart from adding new conceptual knowledge and improving the already existing modules, e.g. adding phraseological information to all entries of the TKB, we have been able to broaden our scope by giving access to contextualized networks, a specialized corpus on the environment, and to other web-related options such as Google images and Wolfram Alpha. The next challenge is to improve the reusability of all this coherently organized knowledge. One way we envision to this end is linking EcoLexicon to other knowledge bases in the Linguistic Linked Open Data Cloud.

9. Acknowledgements

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