

‘Radiative Forcing’ Metaphor: An English-Arabic Terminological and Cultural Case Study

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Abstract: *This research studies the conceptual constructions and the manifestation of conceptual metaphors in scientific texts in the subdomain of climate change in both English and Arabic language. It also describes the influence of translation processes from English into Arabic in domain loss. For this purpose, this exploratory research presents the results of a contrastive terminological analysis, approached from the perspective of Conceptual Metaphor Theory (Lakoff and Johnson 2003) and Frame-based Terminology (Faber 2012). Reality is represented through cognitive frames or events, resulting from top-down and bottom-up processes. The analysis of conceptual and semantic information extracted from the selected corpus allows categorising reality at a multidimensional level. This case study focuses on the RADIATIVE FORCING event, a knowledge structure created originally in English on a metaphorical basis and introduced into the Arabic language via translation processes. The analysis of the Frame Elements of this event demonstrates the direct influence of translation processes from English into Arabic.*

Keywords: conceptual metaphor; corpus analysis; domain loss; frame-based terminology; radiative forcing

1. Introduction

The study of metaphor is usually related to literature and rhetoric; however, recent studies have demonstrated the presence of metaphorization processes in many scientific and technical fields. Beger and Jäkel (2015:90) claim that metaphor in scientific texts functions as a didactic tool which facilitates the transmission of information from experts to laypersons analogically, as it activates some domains at a cognitive level which enables the understanding of new domains. Studies like Ureña (2012), about metaphor in marine biology, and Boquera (2005), about metaphor in civil engineering, also show that metaphor is used in discourse to represent reality in a didactic way as well as to coin new terms (Faber 2012:41).

The main objective of this small scale, exploratory study is to carry out an analysis concerning linguistic and intercultural elements mapped through conceptual metaphor in both English and Arabic in the subdomain of climate change. Previous researchers have studied the metaphorization processes from the perspective of Frame Based Terminology (FBT) (Tercedor, Ureña and Prieto 2012; Ureña 2012). Nevertheless, this theory has not been yet implemented to study the metaphorical mapping in the subdomain of climate change in the Arabic language.

Therefore, this study would help to (1) identify the weight of cultural and intercultural elements in the formation of scientific terms and neologisms, (2)

identify the effect of translation from English, the *lingua franca*, into Arabic on domain loss, (3) assess the adequacy of FBT as a theoretical and methodological framework for the analysis and comparison of Arabic and English texts in search of metaphorical constructions and events, and (4) assess the adequacy of Sketch Engine, used in combination with a manual analysis of lexical units, in order to overcome some of the technical difficulties the Arabic language poses to this kind of tools.

For this purpose, the principles of FBT have been applied in order to study the process of metaphorization in the subdomain of CLIMATE CHANGE in both English and Arabic. More specifically, a case study on the RADIATIVE FORCING event, closely related to climate change, has been carried out to study the influence of English, the *lingua franca*, in the creation of terms which are metaphorically constructed, and the transfer of conceptual systems from English into Arabic. Through corpus analysis, FBT is applied in the extraction and codification of information from specialized texts. The results of this preliminary study would be of interest both conceptually and methodologically in this area of study.

2. Conceptual metaphor

According to Lakoff's Conceptual Metaphor Theory (CMT) (1993), metaphor is defined as a mapping between two conceptual domains. This means that there is always a degree of similarity between two domains when metaphor is used in a determined context.

Depending on the scale and complexity of this similarity at a conceptual level, Cognitive Linguistics distinguishes between image metaphor and conceptual metaphor. Image metaphor is conceptually simple and refers to metaphors which contemplate the transferred similarity from one concept in one domain into another (Faber 2012:38). Nevertheless, conceptual metaphor is more complex and productive for it emerges from the projection of a domain of experiences from one conceptual system into another (Lakoff 1993:206).

For Larson (2011) "metaphor is a key element in scientific inquiry because it enables us not only to understand one thing in terms of another but also to think of an abstraction in terms of something more concrete". For instance, recent works have studied the role of conceptual metaphor in the domain of climate change. Niebert and Gropengiesser (2013) highlight that scientific understanding depends largely on imagination; hence, metaphors are essential to understand climate change "as a bridge between experience and scientific concepts" (Niebert et al. 2013:299). They carried out a pragmatic study to analyse the understanding of climate change and global warming through the perception of the metaphor 'atmosphere is a container'.

Shaw and Nerlich (2015) also show the importance of metaphor as a cultural mechanism in the elaboration of the political and economic discourse related to global climate change governance. According to them, metaphorization processes, considered to be powerful anchoring devices, provide an interpretation

to frame novel and abstract phenomena to channel the understanding of the general public. Flottum (2017) reiterates the linguistic value of metaphor in climate change, for it has become not only a scientific debate, but also a political, cultural, social, ethical and communicational matter, behind which there are many socioeconomic and political interests.

Other studies like *Metaphors in climate change discourse* by Skinnemoen (2009) suggest which particular linguistic metaphors are used in climate change discourse, as well as their frequency of use. Based on a corpus-based analysis, the author classifies metaphor in climate change according to the following categories: ‘climate change is movement’, ‘environmentalism is movement’, ‘environmentalism is war’, ‘environmentalism is sports’, ‘environmentalism is construction’, ‘environmentalism is a game’, ‘environmentalism is a personal relationship’, ‘production of environmentally friendly energy is farming’, ‘environmentally friendly is clean and pollution is dirty’, ‘personification’, ‘the earth is a house’, etc. Other researchers also had similar classifications, such as Romaine (1996), highlighting above all, the metaphors of ‘war and peace in the global greenhouse’, ‘earth as a greenhouse’ and ‘earth is a human being’, a metaphor which coincides with James Lovelock’s Gaia Hypothesis, and the metaphor of the Earth as a self-regulating organism (Lovelock 1972). This last metaphor has produced a groundswell of debate and controversy amongst researchers during the last decades.

From a cultural perspective, Larson (2011) affirms that science is built on metaphorical foundations, and focuses on the social context of the metaphors of environmental science; the so called ‘feedback metaphor’. He considers that the way we express the natural world reflects the culture in which we live, its priorities and values, being metaphor the vehicle of this expression, leading to interpret the novel and the unknown by invoking the shared cultural context (Larson 2011:6).

On the basis of the CMT, Merakchi and Rogers (2013) study the informative scientific discourse in Arabic and confirm that conceptual metaphors are used to add coherence to the scientific discourse as they “evoke the knowledge space of a particular source domain or sets of source domains” (Merakchi et al. 2013:345). They also highlight the idea that the translation of metaphor in these types of scientific texts is crucial in the intercultural and communicative act, and that translators frequently use them when they introduce new and complex concepts into the target language. According to Bordet (2016), these translation processes may lead in some cases to the standardization of the underlying conceptual constructions in the source specialized domains and a risk of domain loss in some target languages and cultures.

3. Frame-based terminology and the climate-change event

One of the modern approaches to study the conceptual constructions of specialized texts is the theory of Frame-Based Terminology (FBT) (Faber 2012), a recent cognitive approach which studies the behaviour of specialized units in texts, and their role in the transfer, communication, and representation of

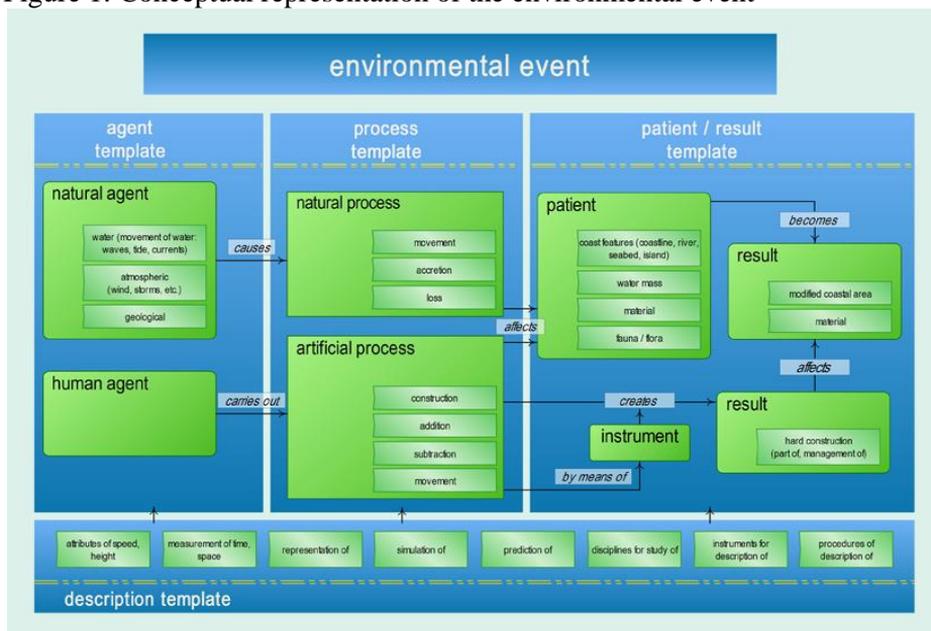
specialized knowledge. FBT focuses on the semantic and pragmatic analysis of terminological units in context as a way to represent reality through cognitive frames which result from a top-down and bottom-up analysis.

Fillmore's Frame Semantics theory (2006), which defines a 'frame' as a single coherent schematization of experience or knowledge in which lexical units can be motivated by, founded on, and co-structured with, specific unified frameworks of knowledge, or coherent schematization of experience, is an essential notion in the construction of specialized events in FBT. Each concept is delimited within a referential conceptual frame that delineates the entities, relations, and actions within their specialized domains, a scheme which also helps in the construction of terminological definitions. All of this information is extracted with the help of terminological analysis tools (López-Rodríguez, Faber, León, Prieto and Tercedor 2010), being corpus analysis the main source of paradigmatic and syntagmatic information about the term (Faber 2009:124).

According to Faber (2015:29), frames in FBT are the contexts from which the semantic, syntactic and pragmatic behaviours are specified. They provide large scale representations that link categories by means of semantic relations, for they have the advantage of emphasizing non-hierarchical as well as hierarchical conceptual relations (Faber 2015:15). These bases enable the creation of events based on lexical and syntactic relations, taking into consideration the situation in which specialized communication occurs.

The practical implementation of FBT is EcoLexicon (http://ecolexicon.ugr.es/visual/index_es.html), a multilingual terminological knowledge base where the specialized (sub)domains of the environment are conceptually represented in the form of a visual thesaurus. Here, each concept is located within a specialized frame that outlines its relation with other concepts, and provides a basis for the selection of knowledge-rich linguistic, cultural and graphical contexts (Faber 2015:15). All related entities, processes and relations in the domain of the environment are delimited within a general event-frame called the ENVIRONMENTAL EVENT, as shown in Figure 1. According to López-Rodríguez et al. (2010:57), this event describes the PROCESSES initiated by an AGENT (natural or human) which affect other entities with the function of PATIENT and produce specific RESULTS. This phenomenon can be described (DESCRIPTION) according to a group of parameters which include attributes, instruments, etc. These conceptual macro-categories and the relations linking them help articulate the other concepts of the domain. For example, the wind (NATURAL AGENT) affects PATIENTS such as coastal lines, causing a type of loss (e.g. erosion) and results in a modified coastal area. In this macro-event, the HUMAN AGENT, by means of different INSTRUMENTS, carries out ARTIFICIAL PROCESSES such as the construction of groins (ENTITY OF COASTAL DEFENSE), which at the same time affect the modified coastal line preventing and delaying erosion.

Figure 1: Conceptual representation of the environmental event



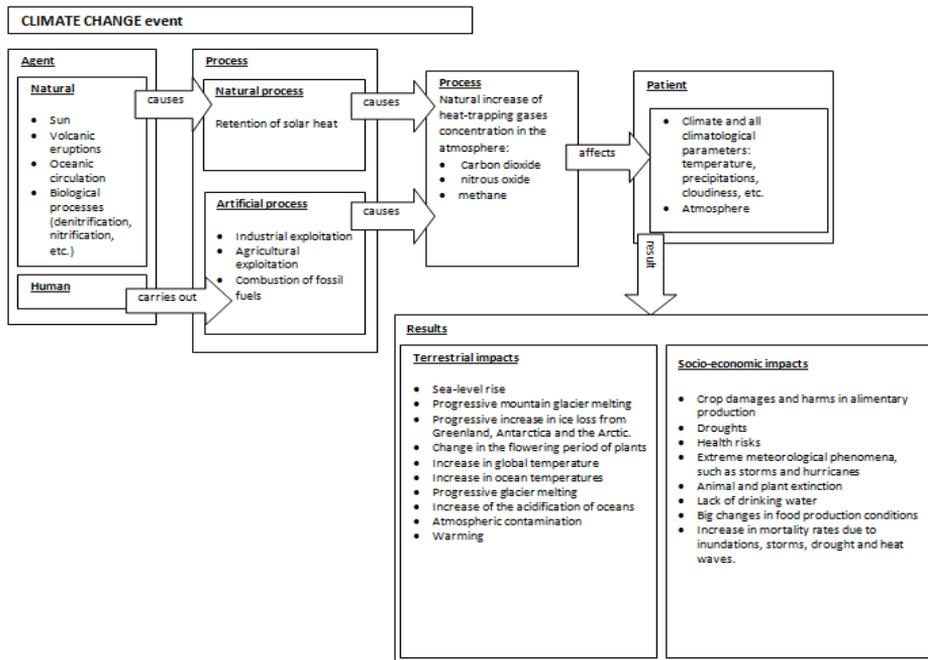
Available at EcoLexicon: <http://ecolexicon.ugr.es/en/aboutecolexicon.htm>

For the purpose of this study, the process of CLIMATE CHANGE has been integrated in this scheme as a subevent. According to Ruppenhofer, Ellsworth, Petruck and Scheffczyk (2010:9), the general process of construction of these frames is the following:

The core of the process has always been looking at corpus attestations of a group of words that we believe to have some semantic overlap, and dividing these attestations into groups. Afterward, we combine the small groups into large enough groupings to make reasonable frames at which point we may (equivalently) call the words targets, lexical units, or frame-evoking elements.

The bottom-up process was complemented with a top-down perspective, where information was extracted from dictionaries and relevant texts in the concrete specialized subdomain. With respect to the bottom-up process, lexical constructions which evoke the concept CLIMATE CHANGE were identified, as they are considered access points towards knowledge related to this subdomain in the corpus of study. The representation of this process can be observed in Figure 2, a frame that allows for the representation of interlinguistic structures that codify knowledge at a basic level (Montero 2008:4).

Figure 2: Conceptual representation of the climate change event



A NATURAL AGENT (like the sun) or a HUMAN AGENT causes a NATURAL or ARTIFICIAL PROCESS of warming, such as the combustion of the fossil fuels which emit heat-trapping gases, which affect STATES and ENTITIES (climate, atmosphere of the Earth). These states and entities have the semantic role of PATIENT and, at the same time, provoke different PROCESSES/RESULTS in ENTITIES like the sea, the glacial, etc. CLIMATE CHANGE is characterized by a series of attributes like long-term change (DURATION) and is fought by means of precautionary measures, such as the use of renewable energy sources.

4. The 'radiative forcing' event: materials and methodology

Ruiz de Mendoza (2017:307) claims that frames and frame elements can be the object of metaphorical extension, as they serve to identify a frame or frame element by the name of another frame or frame element. In this research, an approximation to metaphorization in the subdomain of CLIMATE CHANGE is carried out, with special focus on the conceptual metaphors and the effects of translation processes from English into Arabic in domain loss.

This case study applies the principles and methodology of FBT in the extraction and codification of information from a specialized, *ad hoc* corpus relating to climate change. Specifically, the study describes the concept of *radiative forcing*, a process that affects climate change. The phenomenon is defined in the online *Ecology Dictionary* (<http://www.ecologydictionary.org/>) in the following terms:

A change in the balance between incoming solar radiation and outgoing infrared radiation. Without any radiative forcing, solar radiation coming to the Earth would continue to be approximately equal to the infrared radiation emitted from the Earth. The addition of greenhouse gases traps an increased fraction of the infrared radiation, radiating it back toward the surface and creating a warming influence (i.e., positive radiative forcing because incoming solar radiation will exceed outgoing infrared radiation).

4.1 Selection and description of the corpus

The selection criteria of the corpus of this study coincide with the adequacy criteria established by Buendía and Ureña (2010), related to authority, content and design. Special emphasis was placed on the following parameters: i) text authority, ii) topic, iii) availability of articles or complete texts, iv) title of the text, and v) impact factor. However, it is worth mentioning that the compilation of the Arabic texts was complicated because of the scarcity of Arabic resources in comparison with the English ones, and the fact that it has not always been easy to evaluate the adequacy of the Arabic texts. For example, some of the texts in the Arabic corpus lack an exact bibliographic description or vital elements such as type of text, name of the event in which it was presented, etc., in spite of being extracted from prestigious websites like universities and ministries. For this reason, in general, it has not been possible to fulfil the criterion of impact factor in the case of texts originally written in Arabic.

Following these criteria, a comparable corpus was compiled with original texts in English (with a total of 240,795 tokens) and original texts in Arabic (160,437 tokens). The corpus contains specialized, semi-specialized and informative texts. The informative texts are especially relevant to this study as they contain an elevated number of conceptual metaphors thanks to their didactic function (Beger and Jäkel 2015). The English texts were selected from the textual corpus compiled in EcoLexicon, based on the topic of climate change. Other additional texts, considered especially relevant for this study were also added. As for the Arabic texts, these are written in standard Arabic and were selected from a variety of resources such as press articles, research papers, reports, textbooks, etc. It is important to highlight that the EcoLexicon corpus does not have the Arabic language yet amongst its languages.

A parallel corpus was also created (29,430 tokens in English and 36,326 tokens in Arabic), and it was adequately aligned by means of the tool *Align documents*, available in the program *TRADOS Studio 2015*. This corpus is comprised of texts which are originally written in English, extracted from *Nature* magazine (<http://www.nature.com/>), with their Arabic version, and from *Scientific American* magazine (<https://www.scientificamerican.com/>) and their translation into Arabic, available in *Al-Oloom Magazine* (<http://www.ooloommagazine.com/Home/Default.aspx>). Both magazines have an elevated *h index* according to SJR (Scimago Journal and Country Report) (<http://www.scimagojr.com/index.php>). Relevant texts from the *Integrated Regional Information Networks (IRIN)* and their Arabic official translation have

also been added. A list of the corpus texts is available upon request and can be downloaded at:

https://www.dropbox.com/s/ljkydeg6ghj0e2x/appendixes_ijaes.docx?dl=0

4.2 Identification of candidate metaphorical terms

First, the parallel corpus was analysed in order to obtain the candidate terms and its Arabic equivalents. A word list, ordered by frequency, was generated with the help of the *Sketch Engine* software. Afterwards, it was manually analysed to obtain a series of metaphorical candidate terms.

For example, one of the possible candidate terms is the lexeme 'force', which appears in the corpus with a frequency of 15 times in the form of a gerund ('forcing'), and 6 times as an adjective or a verb ('forced'), as shown in Table 1. In the online *Cambridge Dictionary*, 'force' is defined as "physical, especially violent, strength, or power". This term was selected as a candidate metaphorical term, as the previous definition is the first meaning activated at a cognitive level when reading the above mentioned word.

Table 1: List of words and its frequency

Word	Frequency
Forcing	15
Forced	6

Once the candidate terms were selected, their behaviour in context was studied in order to detect whether they in fact entailed a metaphorization process or not. In the case of the candidate term 'force', the analysis showed it frequently appeared with the lexical unit 'radiative', resulting in the term 'radiative forcing' as shown in Table 2.

Table 2: List of words which collocate with the lexeme 'force'

Collocation candidates						
		Concurrence count	Candidate count	T-score	MI	logDice
P N	<u>Radiative</u>	5	5	2.234	10.321	12.515
P N	<u>Homes</u>	3	9	1.728	8.736	11.585
P N	<u>People</u>	3	61	1.705	5.976	10.193

4.3 Conceptual representation and lexical formalization of the radiative forcing event

The lexical constructions related to the term ‘radiative forcing’ represent the lexical formalization of the RADIATIVE FORCING event. These units represent the concepts which are part of the frame, and help in the identification of its conceptual profile. In a top-down approach, some units were extracted from specialized resources such as dictionaries, encyclopaedias, etc., and this information was enriched with results obtained from corpus analysis. For example, some of the contexts retrieved from the corpus in relation to ‘radiative forcing’ are found in (1)

- (1)
- a) Calculations were performed using standard reconstructed **anthropogenic and natural radiative forcing**.
 - b) Radiative forcing is a measure of how the energy balance of the **Earth-atmosphere system** is influenced when factors that affect climate are altered.
 - c) Some aerosols cause a **positive forcing** while others cause a **negative forcing**. The direct radiative forcing summed over all aerosol types is negative.

Examples 1(a), (b), and (c) show some lexical constructions in bold which may be classified as shown in Table 3. For instance, in (a), the lexical element ‘anthropogenic (radiative forcing)’ formalizes the conceptual category HUMAN-BEING, as an AGENT of this process, while the element ‘natural (radiative forcing)’ formalizes the NATURAL AGENT. In (b), the lexical construction ‘Earth-atmosphere system’ indicates the semantic role of the ‘atmosphere’ as PATIENT. Finally, in (c), the lexical units ‘positive’ and ‘negative’, formalize the concept FORCING-BALANCE as attribute of the radiative forcing process.

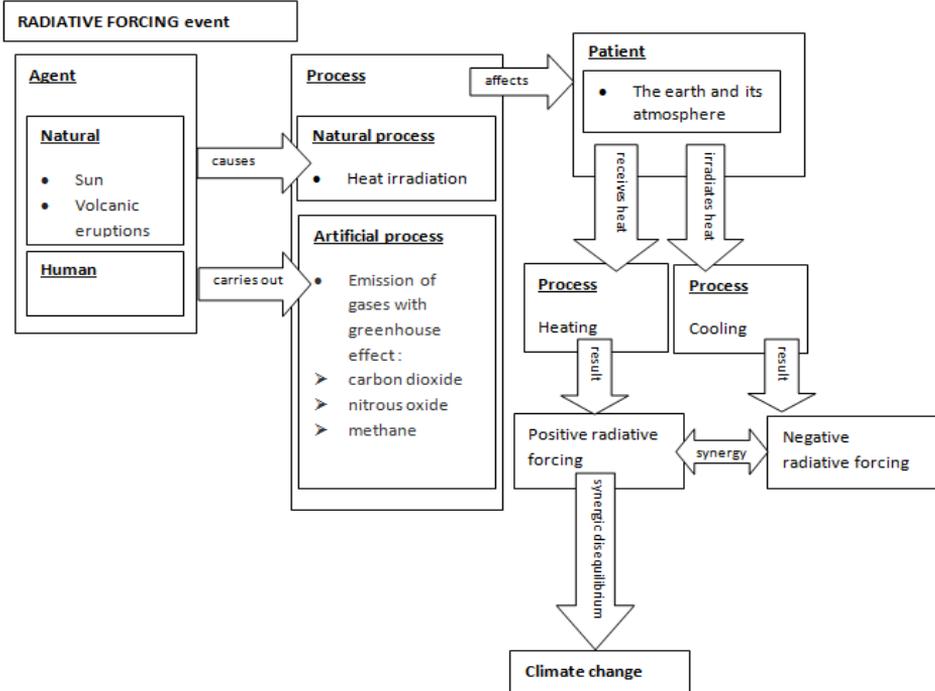
Table 3: Description of lexical concepts of 'radiative forcing'

Lexical units	Conceptual category and semantic role
anthropogenic (radiative forcing)	HUMAN BEING (AGENT)
natural (radiative forcing)	NATURAL PHENOMENON (AGENT)
Earth-atmosphere system	EARTH-ATMOSPHERE SYSTEM (PATIENT)
Positive/negative (forcing)	FORCING-BALANCE (ATTRIBUTE)

The typical conceptual patterns of the frame RADIATIVE FORCING identified through the top-down and bottom-up process provide a general

description of this phenomenon as a process of change of balance (positive or negative) of the global radiative energy of the earth and its atmosphere (patient), caused by a natural (solar or volcanic) or human agent. There is a synergic relation between the positive and the negative radiation which maintain the equilibrium of the earth's atmosphere. The positive radiative forcing produces warming while the negative radiative forcing has a cooling effect. Nevertheless, when the balance between these two opposed forcings is altered because of an increase in the positive forcing, this results in climate change. Figure 3 shows a scheme of this process or event.

Figure 3: Radiative forcing event



5. Results and discussion

The contextual analysis of the lexical units which formalise the concept RADIATIVE FORCING in the corpus also helps in the identification of how the conceptualization of this process is projected in the discourse.

5.1. Metaphorical projection of radiative forcing in English and Arabic

The manual analysis of the concordances generated by Sketch Engine for the candidate metaphorical lexeme 'force' included examples like the following:

- (2) These forcings can be visualized as a tug-of-war, with positive forcings pulling the earth to a warmer climate and negative ones pulling it to a cooler state. The result is a no contest; we know the strength of the

competitors better than ever before. The earth is being pulled to a warmer climate and will be pulled increasingly in this direction as the "anchorman" of greenhouse warming continues to grow stronger and stronger. (Collins, Colman, Haywood, Manning and Mote 2007:66)

In other words, in the lexical projection in (2), the process of RADIATIVE FORCING is described as a tug of war, also called rope war, rope pulling, etc. It is a type of sport that directly puts two teams against each other in a test of strength. The teams start with the rope's centre line directly above a line marked on the ground. Once the competition starts, each team tries to pull the other one towards its own side, until the closest sign of the opposite team overcomes the central line, or when a fault is committed. In this sport, which can be conceptualized as a frame, many elements intervene, such as those shown in Table 4.

Table 4: Tug of war basic frame elements

Frame elements	
Rope (ENTITY) (PATIENT)	
First team (ENTITY) (AGENT)	Competitor of first team
Second team (ENTITY) (AGENT)	Competitor of second team
Pulling the rope (PROCESS)	
Forcing-Quantification (ATTRIBUTE)	
Forcing-Direction (ATTRIBUTE)	Right side/Left side

Some of the frame elements (FEs) which appear in Table 4 were used metaphorically in example (2) in order to conceptualize the phenomenon of RADIATIVE FORCING. This example is annotated according to these FEs in (3), where the cognitive frame shows there are two 'forcings' competing in order to change the climate of the earth: a 'positive forcing', which tries to pull the earth towards a warmer climate ('pulling the earth to a warmer climate'); and a negative forcing ('negative ones'), trying to pull the earth towards a cooler state ('pulling it to a cooler state'). There are many competitors with positive power. In this battle ('tug-of-war'), it is already known that the positive forcing ('the anchorman of greenhouse warming') is still growing, being the most powerful amongst all the rest ('continues to grow stronger and stronger') and a producer of climate change.

(3) These forcings [First team, Second team] can be visualized as a tug-of-war, with positive forcings [Forcing-Direction: right side] pulling the earth [Rope] to a warmer climate and negative ones [Forcing-Direction: left

side] pulling [Pulling the rope]it [Rope] to a cooler state [Forcing-Direction: left side]. The result is a no contest; we know the strength [Forcing-Quantification] of the competitors [First team, Second team] better than ever before. The earth [Rope] is being pulled [Pulling the rope] to a warmer climate [Forcing-Direction: right side] and will be pulled increasingly [Pulling the rope]in this direction [Forcing-Direction] as the "anchorman" of greenhouse warming [Competitor of first team] continues to grow stronger and stronger [Forcing-Quantification] (Collins et al. 2007:66)

In order to analyse whether the process of RADIATIVE FORCING is projected metaphorically in Arabic too, the first step was to identify the terms used to refer to this same concept. The analysis of the corpus allowed the identification of the term 'القسر الاشعاعي'. This term coincides with the metaphorical construction coined for the term in English. In the parallel corpus, example (4) describes the main FEs of the *tug of war* sport very clearly, and even mentions the name of the sport ('شد الحبل'). It describes the forcing factors ('العوامل') [Pulling the rope], with positive forcings ('العوامل القاسرة الإيجابية') [First team; Competitor of first team] pulling ('تشدّ') [Pulling the rope] the earth ('الأرض') [Rope] towards a warmer climate ('مناخ أكثر سخونة') [Forcing-Direction: right side], meanwhile the negative forcings ('العوامل السلبية') [Second team; Competitor of second team] trying to pull the earth ('الأرض') [Rope] towards a cooler state ('حالة أكثر برودة') [Forcing-Direction: left side].

(4) فهذه العوامل القاسرة يمكن تصورها كشّد الحبل أو صراع عنيف. فالعوامل القاسرة الإيجابية تشدّ الأرض إلى مناخ أكثر سخونة، أما العوامل السلبية فتشدها إلى حالة أكثر برودة. (Collins

Colman, Haywood, Manning and Mote 2008)

Example (5) also describes the same process by describing the RADIATIVE FORCING as a fierce struggle ('الصراع العنيف') [Pulling the rope], between two forces ('قوى قاسرة') [First Team; Second Team], a positive one ('قوى قاسرة إيجابية') [First team; Competitor of first team] leading to a warmer climate ('تؤدي إلى مناخ') [Forcing-Direction: right side] and a negative one ('قوى قاسرة سلبية') [Second team; Competitor of second team] trying to cool the climate ('تؤدي إلى') [Forcing-Direction: left side], declaring that the winner is the human induced positive forcings ('نصر حاسم لصالح القوى الناجمة عن الأنشطة البشرية التي') [Competitor of first team].

(5) إن الصراع العنيف بين قوى قاسرة إيجابية (تأثيرات تؤدي إلى مناخ أكثر دفئا) وقوى قاسرة سلبية (تؤدي إلى تبريد المناخ) يؤدي بسهولة إلى نصر حاسم لصالح القوى الناجمة عن الأنشطة البشرية التي تسبب الاحترار. (Collins et al. 2008).

Also, Tables 5 to 8 show some of the similarities in the lexical constructions in both English and Arabic and their correspondence with the FEs of the *tug of war* frame, which underlie the lexical projections of the RADIATIVE FORCING phenomenon. For instance, in Table 5, both English and Arabic formalizations include examples which highlight the semantic role of the climate as the PATIENT of the radiative forcing process. The lexical constructions

‘climate forcing’ and ‘الشدّة المناخيّة’ and ‘قاسرة للمناخ’ represent this relation and underlie the similarity between the ‘climate’ and the FE *rope*.

Table 5: Metaphorical projections of the FE Rope

English formalizations	Arabic formalizations	tug of war Fes (PATIENT)
‘climate forcing’	‘قاسرة’، ‘الشدّة المناخيّة’ ‘للمناخ’	Rope

Both languages also contain lexical elements which highlight the similarity between the AGENT in the radiative forcing event and the FE *team* in the *tug of war* event. Table 6 shows examples where the lexical unit ‘forcings’ and the construction ‘the dominant forcing’, which correspond to ‘الآثر’ and ‘القاسر المهيمن’ and ‘مؤثرات قاسرة للمناخ’ in Arabic, all represent the FEs *First team* and *second team*. Also, reference to the NATURAL and HUMAN AGENTS of radiative forcing is found in the constructions ‘natural radiative forcing’ and ‘human-induced forcing mechanisms’ in English, and ‘القسر الاشعاعي الطبيعي’ and ‘اليات قاسرة للمناخ من صنع الانسان’ in Arabic, which point to the FEs *competitor of firstteam* and *competitor of second team*.

Table 6: Metaphorical projections of the FE Team

English formalizations	Arabic formalizations	tug of war Fes (AGENT)
‘forcings’	‘مؤثرات قاسرة للمناخ’	First Team; Second Team
‘the dominant forcing’	‘الآثر القاسر المهيمن’	First Team
‘human-induced forcing mechanisms’	‘اليات قاسرة للمناخ من صنع الانسان’	Competitor of First team/Second team
‘natural radiative forcing’	‘القسر الاشعاعي الطبيعي’	Competitor of First team/Second team

In Table (7), examples in English and Arabic show the similarity between both languages in using the FE *pulling the rope*. The lexical construction ‘pulling the earth’ in English correspond to ‘تشدّ الأرض’ in Arabic and reflect the semantic role of PROCESS.

Table 7: Metaphorical projections of the FE Pulling the Rope

English formalizations	Arabic formalizations	tug of war Fes (PROCESS)
'pulling the earth'	'تشد الأرض'	Rope pulling

Finally, other examples from the parallel corpus reflect the similarity between the attribute DIRECTION in both English and Arabic. Such similarity is noticed through examples like 'positive forcing' and 'negative forcing' and their Arabic equivalents 'قوى قاسرة إيجابية' and 'قوى قاسرة سلبية'. These examples can be observed in Table 8, and correspond to the FE *forcing-direction*. Also, an attribute quantifying forcing is found in the constructions 'watts per square meter' in English, and 'واط في المتر المربع' in Arabic. These correspond to the FE *forcing-quantification*. Finally, the terms 'net positive radiative forcing' and its equivalent in Arabic 'القسر الاشعاعي الايجابي الصافي' also reflect the FE *forcing-Quantity* and *forcing-direction*.

Table 8: Metaphorical projections of the FEs Forcing-Direction and Forcing-Quantification

English formalizations	Arabic formalizations	tug of war Fes (ATTRIBUTE)
'positive forcing'	'قوى قاسرة إيجابية'	Forcing-Direction (right side)
'negative forcing'	'قوى قاسرة سلبية'	Forcing-Direction (left side)
'watts per square meter'	'واط في المتر المربع'	Forcing-Quantification
'net positive radiative forcing'	'القسر الاشعاعي الايجابي الصافي'	Forcing-Quantification and Forcing-Direction

In sum, all of these examples show the similarity between the English and Arabic constructions, and prove they are understood in terms of the *tug of war* FEs. These findings are in line with Skinnemoen (2009), who points to the metaphor 'environmentalism is sports', as one of the most common metaphors in climate change discourse. However, it is also noteworthy that this metaphorical projection can be observed in example (6), extracted from the Arabic comparable corpus, that is, texts originally written in this language. It can be observed that the RADIATIVE FORCING process is described in terms of an anthropomorphic activity which has the tug of war ('شد الحبل') sports as the source domain.

(6) العامل او "المعامل" المستخدم عادة لقياس درجات الاحترار هو التأثير (القسر) الاشعاعي. و هو الفرق بين طاقة اشعة الشمس القادمة عبر الغلاف الجوي و طاقة الحرارة و الاشعة المنعكسة

منه. ستؤدي غازات وجسيمات الغلاف الجوي , تحت ظروف مختلفة , الى احترار (تأثير اشعاعي ايجابي) او تبريد (تأثير اشعاعي سلبي). (Al-Najjar: 2008)

In example (6), the term 'القسر الاشعاعي' appears between brackets as an alternative to 'التأثير الإشعاعي'. In this example, RADIATIVE FORCING is defined as the difference between the coming solar radiation ('طاقة اشعة الشمس القادمة') [First team] and the salient radiation ('الاشعة المنعكسة منه') [Second team], from or towards the atmosphere of the earth ('الغلاف الجوي') [Rope]. This implies that the gases and corpuscles ('غازات و جسيمات') [Competitor of first team] may produce warming ('احترار') [Forcing-Direction: right side] or cooling ('تبريد') [Forcing-Direction: left side]. This means that the dimension of warming ('درجات الاحترار') [Forcing-Quantity] is reflected through the RADIATIVE FORCING.

It is evident that the construction of the term 'القسر الاشعاعي' in Arabic is based on the metaphor created originally in English, the *lingua franca*, and the source of creation of new concepts in scientific and technical language. Apart from that, it can also be observed from the previous examples that the terminological constructions which lexicalise the RADIATIVE FORCING event in Arabic form part of the previously described metaphorical frame. This indicates the direct influence of English in the conceptual construction of this term in Arabic.

According to Bordet (2016), this situation leads to domain loss. For this reason, the author considers that these transfer processes impoverish the conceptual systems of specialized language, and prevents the growth of scientific languages at cultural and conceptual levels. Nevertheless, Montero, Fuertes-Olivera and García (2001:692) argue that, in the case of scientific and technical translation, the use of loans in the transfer of terms may act as a fertilizer of communication techniques in other languages, and in many cases it is more adequate than the creation of artificial and new terminology in the native language.

In light of these two contradictory positions, consideration should be given to the extent to which the influence of English in the Arabic language is considered as a risk of domain loss and scientific acculturation. On the one hand, English is the dominant language in science and technology at the international level, and it promotes the expansion of knowledge world-wide. On the other hand, although Arabic is not a minority language, it is necessary to take into consideration the lack of resources and scientific production in the Arab world in comparison with the developed countries. According to the World Bank's reports, the Arab world countries still lag behind in education and, consequently, it suffers a lack of scientific and technical creation.

5.2. Limitations of the study

One of the limitations of this study relates to the scarcity of resources in the Arabic language, as mentioned. The multilingual knowledge base EcoLexicon has not yet included Arabic amongst its languages, therefore, the corpus used in this case study was compiled *ad hoc*. In general, it has not been possible to fulfil the

criterion of impact factor in the case of texts originally written in Arabic, in spite of being extracted from prestigious websites like universities and ministries.

Another source of difficulty refers to the terminological analysis program. Sketch Engine works better with the English corpus than the Arabic one, as it does not always recognise the lexical units and the derivations from the same root in Arabic. Some of the word counts may vary according to the preciseness of the annotation carried out by the program. This difficulty is due to the wide range of affixes which may be added to a simple root in Arabic in order to obtain different words, and to the lack of vocalisation in the Arabic texts or '*Tashki:l*', which also creates an obstacle in the process of corpus annotation.

Finally, it should be noticed that this is a small scale exploratory study used to analyse if FBT is a useful methodology to analyse and compare Arabic and English texts in search of metaphorical constructions and events, and if the use of Sketch Engine combined with a manual analysis of lexical units can help overcome some of the technical difficulties the Arabic language poses to this kind of software.

6. Conclusions

Previous studies have analysed the importance of conceptual metaphor in the subdomain of climate change, and have demonstrated its discursive role in the promotion of political and economic interests. These researches have approached the issue from different theoretical and methodological frameworks in order to analyse metaphor in a wide range of texts. In this work, a multidisciplinary research is carried out in a language combination which still lacks a full body of literature, provided that there are very few comparative studies on the metaphorization processes in Arabic and English in the field of climate change.

In this exploratory study, for the first time the principles of Frame-based Terminology have been applied in order to study the process of metaphorization in the subdomain of CLIMATE CHANGE in both English and Arabic. With this objective, a case study on the RADIATIVE FORCING subevent has been implemented to study the influence of English, the *lingua franca*, in the creation of terms which were metaphorically constructed, and the transfer of conceptual systems from English into Arabic. The conceptual metaphor of RADIATIVE FORCING described in this study coincides with one of the most common metaphors in climate change discourse, 'environmentalism is sports', as classified by Skinnemoen (2009).

The results of the analysis suggest metaphorization is a prolific method in the creation of new terms in scientific language, and that very frequently, the translation and conceptual transfer of these terms from English, the *lingua franca*, are used in order to create new terms in many languages, Arabic amongst them. As a matter of fact, the creation of the term 'القسر الإشعاعي' in Arabic results from the transmission of the metaphorical frame of this concept from English into Arabic. The analysis of terminological concordances extracted from the corpus showed similarities in the lexical formations of the concept RADIATIVE

FORCING in both English and Arabic. This implies that the same metaphorical elements are used in the process conceptualization.

For this reason, in the present moment of the development of the Arabic language, it could be said that thanks to the processes of specialized translation, the Arabic language is expanding its “horizons” at a scientific level; a statement which can be validated or refuted in the subdomain of CLIMATE CHANGE as the study deepens. The implications of these findings would be of great value for translators and linguists training, as well as for language planning in the Arabic language.

Notes

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Appendixes

1. Examples from the English Parallel Corpus in Sketch Engine – ‘radiative forcing’ query

Example 1: Parallel corpus - English

Parallel Corpus, English

fuels. Climate scientists use a concept called **radiative forcing** to quantify the effect of these increased concentrations on climate. **Radiative forcing** is the change that is caused in the global energy forcing induces cooling. We can determine the **radiative forcing** associated with the long-lived greenhouse larger than the best estimate of the natural **radiative forcing** caused by changes in solar activity. This . This increased certainty of a net positive **radiative forcing** fits well with the observational evidence of that human activities have caused a positive **radiative forcing** and that the climate has actually changed, can

2. Examples from the English Parallel Corpus in Sketch Engine – 'القسر' / الإشعاعي query

Example 2: Parallel corpus - Arabic

Parallel Corpus, Arabic

من أجل التقدير الكمي ل تأثير forcing radiative يستخدم علماء المناخ مفهوم يدعى القسر الإشعاعي . هذه التراكيز المتزايدة في المناخ و القسر الإشعاعي هو التعبير الذي يطرا على التوازن في طاقة الكرة الأرضية ب النسبة الى فترة ما قبل التصنيع . ويمكننا تمديد القسر الإشعاعي المرافق ل غازات الدفيئة ، اذا ما استمرت فترة طويلة ، ب دقة ب العة . ل اننا نعلم تراكيزها في الجو وتوزعها المكاني والخصائص الفيزيائية ل كفاعلها مع الإشعاع ف في افضل تقديرنا ، يفوق المكون البشري ب نحو عشر مرات افضل تقييم ل القسر الإشعاعي . الطبيعي الناتج عن تغيرات في النشاط الشمسي ان تزايد درجة اليقين ل القسر الإشعاعي الايجابي الصافي يتوافق جيدا مع ادلة مراقبة الاحترار و التي ب تناقضها فيما بقي . على الرغم من الثقة العالية ب ان الانتظمة البشرية قد احدثت مؤثرات اشعاعية ايجابية قاسرة ، و ان ؟ المناخ قد تغير فعلا ، ف هل يمكن الربط بين هاتين الحقيقتين ؟

3. Examples from the English Comparable Corpus in Sketch Engine – 'radiative forcing' query

Example 3: Comparable corpus - English

Query radiative, forcing 101 (346.00 per million)

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file649628...	the warming pro- portional to the associated	radiative forcing	. An assessment based on the available
file649628...	of reproducing the true diurnal cycle of	radiative forcing	at Coral Bay, we used the photosynthetically
file649628...	being uncertain11, 12, stabilizing	radiative forcing	at 2020 levels through SRM reduces the risk of
file649628...	air temperature following a unit change in	radiative forcing	(degrees Celsius, per watts per square meter, ?
file649628...	history and climate state. See climate,	radiative forcing	. Climate System (or Earth System) The five
file649628...	gases. See radiation, infrared radiation,	radiative forcing	. Fossil Fuel A general term for organic
file649628...	, solar radiation, longwave radiation.	Radiative Forcing	A measure of the influence of a particular
file649628...	by reflecting away solar radiation (negative	radiative forcing). General Circulation Models which
file649628...	Constraints on	radiative forcing	and future climate change from observations
file649628...	concentrations in the atmosphere and the	radiative forcing	effects by aerosols are not well constrained,
file649628...	density function for the present-day total	radiative forcing	, giving 1.4 to 2.4 W m-2 for the 5-95 per cent
file649628...	constraints on the climate sensitivity, on the	radiative forcing	and on the future warming that arise from the
file649628...	this by using the reconstructed and projected	radiative forcing	of all major forcing components in combination
file649628...). To illustrate the relationship between	radiative forcing	, climate sensitivity, ocean mixing and the
file649628...	ocean heat uptake. Figure 1: Relation between	radiative forcing	, climate sensitivity, and modelled
file649628...	oceanic warming. Figure 1: Relation between	radiative forcing	, climate sensitivity, and modelled
file649628...	reconstructed anthropogenic and natural	radiative forcing	. Each dot indicates one model simulation. The
file649628...	is mainly hampered by uncertainties in the	radiative forcing	components and temperature data rather than by
file649628...	uncertainties arise from uncertainties in	radiative forcing	. The global-mean indirect aerosol forcing,
file649628...	after 1980, indicating that either the assumed	radiative forcing	is not correct, or part of the observed

4. Examples from the Arabic Comparable Corpus in Sketch Engine – 'الإشعاعي' query

Example 4: Comparable corpus - Arabic

هذه المحصلة . ويدعي عدم التوازن ب (الدفء الإشعاعي) . و صليبا " ف ان اعلى الغلاف الجوي هنا ، هو اعلى الداخلية او الراجعة اختلافات في التوازن الإشعاعي عن طريق تأثيرها على الاشعة الشمسية المنعكسة او التغيير المناخي الإشعاعي الشمسي يقدر التأثير الإشعاعي الناتج عن التغييرات في الإشعاع الشمسي منذ عام (في شمال امريكا و اوروبا . و عند ما يتغير التأثير الإشعاعي ، يستجيب النظام المناخي على فترات زمنية مختلفة . ما قد نعلم ل الالف السنين . ان اي تغيير في التوازن الإشعاعي ل الارض ، ب ما في ذلك زيادة غازات الدفيئة او ، حيث يتفاعل النظام المناخي ل اعادة التوازن الإشعاعي . الرصد المناخي بدأ يقاس درجة الحرارة منذ الكربون خلال المائة عام الاخيرة ، وتغيرها الإشعاعي . و من المؤكد ان ثنائي اكسيد الكربون الناتج عن حرق هو الغاز الهم بين غازات الدفيئة من حيث تأثيره الإشعاعي . ويقدر التأثير الإشعاعي ل د ب 1.46 وات / 2م و ب 1.46 الدفيئة من حيث تأثيره الإشعاعي . ويقدر التأثير الإشعاعي ل د ب 1.46 وات / 2م و ب ذلك ف هو يمثل 60 ٪ من د 1.46 وات / 2م و ب ذلك ف هو يمثل 60 ٪ من مجموع التأثير الإشعاعي ل غازات الدفيئة جميعها . و تعادل الكمية الكلية ل الجوى خلال 1000 عاما " الاخيرة ، و التأثير الإشعاعي ل د ، و ياتي حوالي نصف غاز الميثان الذي يطلق الى من عينات من القبة الجليدية . و يعادل التأثير الإشعاعي ل غاز الميثان اليوم ، حوالي 0.48 وات / 2م . و هذا ، حوالي 0.48 وات / 2م . و هذا يعادل 20 ٪ من التأثير الإشعاعي ل كامل غازات الدفيئة . لقد ارتفع تركيز غازا تركيز اكسيد النيتروز في الغلاف الجوي ، وتغيره الإشعاعي . يراج اكسيد النيتروز من الجوب واسطة التفاعلات " يقدر ب 0.15 وات / 2م و هو يعادل 6 ٪ من التأثير الإشعاعي ل كامل غازات الدفيئة . الكلوروف كربون CC اترج إشعاعي موجب قدره 0.35 وات / 2م . ويختلف التأثير الإشعاعي ل الأوزون كثيرا " من منطقة ل اخرى ب اختلاف مناطق

previous > ان محصلة الإشعاع في اعلى الغلاف الجوي تساوي الصفر . ويؤدي اي تغير في الإشعاع الشمسي ، او في الاشعة تمت الحرارة التي يتغير هذه المحصلة . ويدعي عدم التوازن ب (الدفء الإشعاعي) . و صليبا " ف ان اعلى الغلاف الجوي هنا ، هو اعلى طبقة السترووسفير ، و لذلك ل ان طبقة السترووسفير تتأثر على مدى اشهر حتى تغير في التوازن الحراري ، بينما توازن السترووسفير مع سطح

next <