Comments:

Dear Prof. Buongiorno,

Thank you very much for your careful checking of the manuscript and the insightful comments and suggestions. After detailed revisions, we think the paper has been improved according to your helpful suggestions. Our responses are also enclosed in the pdf file.

Q1:

The paper is well constructed and gives to readers a full view of the current status of studies regarding the , use of temperature anomalies for earthquake prediction Chapter 3,4 and 5. Nevertheless the chapter 2 need to be reviewed in order to give a full description of different parameters used to detect thermal anomalies related to seismic activity. Is misleading in this Chapter that the author indicates that satellite measurements have already proven to be able to detect thermal anomalies as precursors of seismic events (pag. 4, line 95-100) when this thesis is then refuted in Chapters 4 and 5 considering that the mechanism that produced the possible anomalies is not well understood and the measurements of temperature, gas and aerosol anomalies could not be related with enough confidence to seismic activity due also to instrumental limitation. Chapter 2 should remain the description of the possible usable parameters retrieved by satellite and used in the algorithms and approaches described in chapter 3.

Answer:

Thanks for your concerns and suggestions. In fact, based on those relatively highly cited and accepted papers which were seriously selected from many good scientific journals, we aim to review the possible precursors for pre-earthquake anomaly detection in Section 2, as well as state several frequently used anomaly detection methods in Section 3. Although these precursors and methods give us some uplifting results in which we can notice some significant anomalies prior to many earthquake cases, we still need to take some criticism and deeper insights on them in order to achieve the further aim, i.e. forecasting moderate and strong earthquakes ahead. According to our forecast practice and research there are still many issues that we have to figure out in order to achieve a more robust prediction. For example, we can find some anomalies prior to an earthquake that already happened, but when some anomalies occur we cannot predict an impending earthquake very confidently. Accordingly, we humbly point out the defects or misunderstandings in the above stated studies from the definition to data sources and several other aspects in Section 4. Besides, we list the future progresses in this field in Section 5, considering the descriptions in Section 4.

In a word, the logic of this paper goes like, Section 2 and 3 state the current study situation, then

Section 4 and 5 analyze them and try to give some suggestions on the future development and perspectives. In order to make this logic more clearly, we also add some explanations at the beginning of Section 4 as follows.

"We review the possible precursors for pre-earthquake anomaly detection in Section 2, as well as state several frequently used anomaly detection methods in Section 3. Although these precursors and methods give us some uplifting results in which we can notice some significant anomalies prior to many earthquake cases, we still need to take some criticism and deeper insights on them in order to achieve the further aim, i.e. forecasting moderate and strong earthquakes ahead. Accordingly, in this section, we humbly point out the defects or misunderstandings in the above stated studies from definition to data sources and several other aspects. "

Q2:

The author refers to a list of parameters which could be derived by satellite measurements but due to the large number of satellite data used to extract the presented parameters, I would suggest to add a table that shows the satellite missions, the possible retrieved parameter, parameter dimension, estimated accuracy and error, spatial and temporal resolution in order to permit the reader to understand the difficulties that those studies are encountering to extract significant measurements for the earthquake precursor analysis.

Answer:

Thanks for your kind advice. We have added a more comprehensive table in company with Table 1. This table is listed as follows. It contains several selected sensors which are in operation, have abundant and high-quality products, and are widely employed in remote sensing community.

Table 2 A description of different pre-seismic precursors derived from different satellites

Parameter	Satellite sensor	Spatial resolution	Temporal resolution	Precision
Brightness temperature	MODIS	1 km	4 per day	NEΔT 0.05K for band 31
	VIIRS	345 m / 750 m	2 per day	NEΔT 0.07K for band M15; NEΔT 1.5 K for band I5
	SEVIRI	2 km	15 min	NEΔT 0.25K for band IR10.8
	Himawari AHI	2 km	10 min	NEΔT 0.89K for band 14 (Da, 2015)
OLR	NOAA	2.5°	daily	–
	CERES	1°	monthly	~ 0.4 W/m^2
	AIRS	1°	monthly	~ 1 W/m^2

Air moisture	MODIS	5 km	4 per day	1.5 g/kg (Seemann et al., 2003)
	AIRS	45 km	2 per day	15%
Air temperature	MODIS	5 km	4 per day	1-2 K (Seemann et al., 2003)
	AIRS	45 km	2 per day	1 K
Trace gases	AIRS	1°	daily	0.5–1.6% for CH_4 (Xiong et al., 2008) ±0.5% for CO_2 (Maddy et al., 2008) 8%-12% for CO (McMillan et al., 2011)
Aerosol optical thickness	MODIS	3 km	4 per day	0.2 (Remer et al., 2013)
	VIIRS	6 km	2 per day	~0.05 over ocean and ~0.12 over land (Jackson et al., 2013)
SLHF	MODIS	500 m	8 days	– *
Land surface temperature	MODIS	1 km	4 per day	1 K (Wan, 2014)
	VIIRS	750 m	daily	2 K (Guillevic et al., 2014)
	SEVIRI	2 km	15 min	1–2 K (Trigo et al., 2008)
Sea surface temperature	MODIS	1 km	daily	~ 0.5 K (Kilpatrick et al., 2015)
	VIIRS	1.5 km	daily	~ 0.31 K (Tu et al., 2015)

* denotes that the precision validation of this data product cannot find.

Q3:

Chapter 2 needs to be more coherent with the following Chapters that are giving a correct critical review of this fascinating research aimed to the understanding the complex interaction between Earth interior and surface phenomena. The author may consider focusing only on temperature anomalies excluding satellite retrievals of columnar gas content anomalies due to the emissions in the fault zones. I strongly believe that this is not a suitable parameter if satellite measurements are considered since current satellites measure CO2/CO columnar concentrations with very coarse spatial resolution and therefore with very low chance to detect appreciable variations on localized areas. Volcanic emitted CO2 which shows high concentrations and is continuously emitted is mostly not detected by current satellite missions due to the high concentration in the atmosphere and the quick dispersion. Fault areas could discharge gases but the direct measurement of an anomalous concentration in the atmospheric column over the possible earthquake area by current satellites missions is not credible.

Answer:

Thanks for your concerns. We will explain the reasons one by one.

Firstly, as we said in the response to question 1, Section 2 selectively describes several pre-earthquake precursors which has been proposed in advance and then accepted by some other scientists. We aren't intended to introduce any novel precursor but to review the related parameters which will be further discussed in the following contents. And the credibility of trace gases require to be validated as we said in Section 4 and 5.

Secondly, the trace gases derived from satellite data always have low spatial resolution (like 1°), therefore they cannot indicate the regional anomalous variations that should use satellite data with higher resolution. This situation is very similar to the usage of OLR data that also have low spatial resolution. From the point of view of many papers using satellite derived trace gases or OLR data, they present high relationship between the anomalous areas and the location of an earthquake. Therefore it seems that low spatial resolution is not a very serious problem. CO_2 and some other trace gases are believed to induce local greenhouse effects. Therefore, they are indeed thermal anomaly related parameters.

Thirdly, central volcano even shield volcano is somehow like a point emission source, while its counterpart fault is always like a line or area source when considering their relative areas. Although the emission of volcano is more intensive, just as you said, its limited concentration area and quick dispersion can hardly be captured by satellites with the coarse spatial and temporal resolutions. As for trace gases which induced by fault movements, they are often long-lasting and large-existing, though with lower concentration. Meanwhile the temporal resolution of data acquirement can be 1 - 2 per day. The data can capture the variations of trace gases in every day, thus the transient changes of gas concentration may also be recorded. Therefore, they might be caught by some scientists, just as described in Section 2.3 "Atmospheric trace gases".

In the Section 5, we also point out that with the assistance of in-situ measurements in specific places. Ground measurements of trace gases are also used in the earthquake monitoring, and trace gases retrieved from remote sensing data can be considered as the extension of the ground measurements.

Last, the advance of sensor in the future could provide higher spatial resolution and accuracy. The remotely sensed trace gases data with higher spatiotemporal resolution and accuracy might provide more useful information for the earthquake prediction.

In conclusion, trace gases can be the possibility in earthquake monitoring, and could be a candidate precursor as other precursors for now despite with many limits that hinder the application of monitoring seismic activities.

Q4:

A final comment which may be added to the Chapter 5 is to strengthen the consideration that the studies on the analysis of thermal anomalies are of high scientific interest but at the moment this study could not bring any practical use for the earthquake risk reduction or alert. I appreciate the very clear statement on fact that we need to improve satellite instruments capabilities in terms of accuracy and spatial/temporal resolution. This review may stimulate the development of specific experiments which will help the understand more about the interactions between faults movements and the variation of surface parameters which could be detected by satellites observations.

Answer:

Thank you for your appreciation. As you suggested, we modified the last paragraph (in the red) in Section 5 as follows.

"Yet still, further efforts on satellite pre-seismic anomalies are required to study the physical mechanism, new satellite data, and anomaly detection approaches. Although various techniques with different measurements and approaches have been used in this field for decades and show the potential and possibility for the recognition of seismic precursors, no any technique has the full ability to forecast imminent strong earthquakes in a short-term (e.g., a few weeks) or long-term (e.g., several years) for now. And current pre-seismic anomalies monitoring techniques from optical satellite observations could also not forewarn the earthquake or reduce the seismic risk in the practice. Despite the difficulties in pre-seismic anomaly monitoring, previous studies have shown that to some extent, a link exists between various anomalies and seismic activities. Therefore, the practicality of the anomaly detection in earthquake monitoring could be advanced from many perspectives based on existing research foundations. The anomalies which might be induced by seismic activities theoretically should be contained in the temporal and spatial distributions of satellite spectral information. Thus, the researches on the pre-earthquake anomalies monitoring from satellite platforms are of high scientific interest with the rapid development of remote sensing technology. Analyzing the correlation between various anomalies and seismicity provides a promising way for short-term earthquake prediction and accelerates the present capability on seismic hazard assessment and early warning. "

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