Dear Editor and Reviewer #1

Thank you very much for your notification regarding the reviewer's comments on our manuscript. We really appreciate the Anonymous Referee #1's time and comments which are precious to our manuscript. We have revised the entire manuscript incorporating the comments and questions by the reviewer as possible as we can. We would like to discuss in more details about the paper's aims, methodology of data analysis, and Referee #1's comments.

General discussion

First, as mentioned clearly in the manuscript the paper aims to investigate fire occurrence regimes in south central Siberia region and then evaluate how Canadian Fire Weather Indices can be used to characterize those fire regimes. The fire occurrence regimes were investigated using previous remote sensing fire data (MOD14A2 product) between 2000 and 2013. Canadian Fire Weather Indices were calculated based on historical large-scale meteorological reanalysis NCEP data between 2000 and 2013. We did not use Canadian Fire Weather Indices only to assess the fire risk and predict the fire activities in the region. Therefore, the authors can say that the validation and the accuracy in the use of large-scale Canadian Fire Weather Index have been conducted in the paper by using previous fire remote sensing data (MOD14A2 product) and large-scale NCEP meteorological data based Canadian Fire Weather Indices.

Second, the reviewer mentioned that this study lacks any statistical analysis. The authors would like to clarify methodology used in our data analysis as follows:

1) Regarding assessment of fire occurrence regime, both active fires (hotspots) and burned area from remote sensing data have been widely used to assess fire regime and/or temporal and spatial patterns of fire occurrence around the world, particular for remote regions with sparse official fire and burn data (Pricope and Binford, 2012;Oom and Pereira, 2012;Levin and Heimowitz, 2012;de Groot et al., 2012;Armenteras-Pascual et al., 2011;Hantson et al., 2013). In addition, we only used MODIS hotspots with very high confidence level (fire mask equals 9) (see (Giglio, 2010)) to assess fire regime. Therefore, active fires (or hotspots) from MODIS product were reliable data to characterize fire regime in the region.

2) In assessment of the performance of Canadian Fire Weather Indices to represent fire regime (identified in step 1 above), we used wavelet analysis approach. The authors need to confirm that wavelet analysis is one of statistical methods existing to examine relationship between two time series of ecological processes or properties (see line 4-7, page 10, and (Cazelles et al., 2008;Yates et al., 2007;Grinsted et al., 2004;Torrence and Compo, 1998). The wavelet method outperforms other time series analysis methods because of its simple assumption which not require stationary as traditional regression models (e.g. linear regression) in the data. Additionally, the wavelet coherence is similar to a traditional correlation coefficient of two datasets (R-squared) and it is used to evaluate a localized correlation of two processes in time frequency space (Grinsted et al., 2004).

As our aims, we only evaluate how large-scale Canadian Fire Weather Indices can be used to assess fire danger in other regions rather than its original application in Canada. Therefore, an assessment of historical data based performance should be sufficient to be taken into account both drawbacks and advantages for future application in fire danger assessment in other regions such as south central Siberia in this study. We really appreciate if the reviewer can explain in more details about the lacks of any statistical analysis in our paper, and thus we can improve our analysis.

Specific comments and questions

1. Page 8 Line 26: Is there any references to support your description "This moisture codes is an indicator of the relative ease of ignition and flammability of the top litter layer less than 1-2 cm in depth with typical fuel loading of 5 t ha-1".

The references (De Groot, 1998;Lawson and Armitage, 2008) have been added

2. Page 9 Line1: Any references to support your description "The Duff Moisture Coad (DMC) is a numerical rating of the average moisture content of…."

The references (De Groot, 1998;Lawson and Armitage, 2008) have been added

3. The same with the previous two questions, some references are needed to support the authors' description.

The references (De Groot, 1998;Lawson and Armitage, 2008) have been added

4. Page 9 Line 10: "It combines effect of wind and the FFMC to indicate the expected rate of fire spread." It makes me confused: "the effect of wind" presents what, and the previous description of FFMC "The FFMC fuels are affected by air temperature, wind speed, relative humidity, and rain", the FFMC is already affected by wind speed, why it cannot be used to indicate the rate of fire speed. And how to combine these two factors.

The six standard components of the FWI system have been divided into two categories: fuel moisture codes (FFMC, DMC, and DC) and fire behavior indexes (ISI and BUI) (Lawson and Armitage, 2008). Each moisture code is calculated in two phases – one for wetting by rain and one for drying (Van Wagner and Pickett, 1985). Since Fine Fuel Moisture Code (FFMC) indicates the moisture contents of the top litter layer on the forest floor surface, it is not only affected by temperature, relative humidity and rain (in wetting phase) but also affected by wind (in drying phase). DMC and DC indicate moisture contents of fuels in the lower layers below the forest floor surface. Thus, wind speed does not affect these two fuel moisture codes (or moisture contents) (De Groot, 1998).

On the other hand, two intermediate fire behavior indexes represent fire spread rate (ISI) and amount of available fuel (BUI). The Initial Spread Index (ISI) indicates the rate of fire spread after ignition. The speed of fire spread on the fine surface fuels will depend on wind speed and available amount of fuel (Van Wagner, 1987;Graham et al., 2004). Surface fire under conditions of strong wind and available amount of crown fuels (vines, mosses, needles, branches…) as ladders can lead to crown fire (Graham et al., 2004). According to Lawson and Armitage (2008) a relatively weak effect is felt in the daily change in the FFMC, for which wind speed chiefly affects the rate of drying fuels after rain, but a much stronger effect is built into the ISI to reflect the joint influence of wind and moisture content of fine surface fuels on a fire's rate of spread.

In other words, we can understand that wind component in the FFMC is to account for the rate of drying fuels in the top litter layer, while wind component in the ISI is to account for the rate of fire spread if fire occurs by any sources of ignition (human or lightning caused). For more details on FWI system, its components and calculation, please refer to (Van Wagner and Pickett, 1985;Van Wagner, 1987;Lawson and Armitage, 2008).

5. Page 9 Line 25: "All fire weather indices were calculated for 14 year time series over winters, except for the Drought Code (DC)." I can't understand that all indices were calculated over winters. Most of the data indicated that few fires happened in winters because of the low temperature.

Calculation of FWI components does not require calculating over winters since fire danger can be mainly observed during fire season (spring, summer and autumn in boreal ecozones). However, the study used wavelet analysis method to calibrate relationship between two time series data. Therefore, calculation of indices over winters is to achieve the consecutive data for wavelet analysis. By this way, we can also simplify the calculation of FWI indexes in which we don't have to determine exactly start and end of fire season months and don't have to restart the calculation system year by year. We did use daily accumulated precipitation during winter months (October- March) to calculate DC values over the winter. The main purpose of this is to account for overwintering issue of the DC values (Lawson and Armitage, 2008).

We agree with the reviewer that few fires happened in winters. Thus, another possible solution in the calculation of FWI indexes is that we might calculate these indexes for fire season months only (for example from April to October) and then assign low/very low values (0 possibly???) of these indexes for winter months in order to achieve consecutive data for wavelet analysis. The temporal patterns of fire weather indices in this case should be similar to our results since our results indicated very low values of fire weather indices during winter months.

6. It is difficult for me to read and understand the Fig.5 and Fig.6 because I am not very familiar with wavelet analysis. Thus, the authors can explain these two figures more in details just for me if possible.

In ecological studies, population monitoring often consists of a series of observations made at equal intervals over a period of time. Statistical procedures are often used to extract information and identify scales of pattern in the population fluctuations (Cazelles et al., 2008). Considering fire and climate records one almost always faces a composition of numerous time scales ranging from days to decades or even longer periods. Wavelet analysis developed from Fourier analysis is one of time-series analysis tools to investigate patterns of time-series data at different composition of time scales.

From original time-series data (Fig 2, data were collected in each 8-day composite), wavelet transform analysis decomposes signal (the time series) into harmonic components that are localized in both frequency and time (Grinsted et al., 2004). This can be regarded as a partition of the variance of the series into it different oscillating components with different time scales (periods). Peaks (e.g. dark red color in Fig. 5) in the wavelet spectrum indicate which time scales (periods) are contributing the most to the variance of the series. Since the original time-series data had been collected in the basis of time interval of 8-days composite (e.g. counted total number of fire and averaged climatic variables in each 8 days), the time scales (periods) showing in the Y axis were by 8-day composite. In this manner, we can look at changes (fluctuations) of fire occurrence and climate variables in each smallest time scale of 8 days and up to the maximum time scale of 8*n days. The smaller the scale factor (Y axis values), the more "compressed" the wavelet (see http://www.mathworks.com/help/wavelet/gs/continuous-wavelet-transform.html#bsotdjj-1 for more explanation on the concepts of wavelet transform), and thus the more detail changes of time series can be extracted. For example, looking at scales (periods) smaller than or equal 8*8 days in figure 5a, only several peaks (dark red color region within thick black contour indicating the 5% significance level) of fire occurrence have been identified in 2002, 2003, 2006, 2008, 2011, and 2012. If we back to original dataset in Table 1 and Fig 2, these years were abnormal fire years with very high number of fires compared with other years between 2000 and 2013. In contrast, the larger the scale factor, the more stretched the wavelet, and thus the coarser changes of time series data can be interpreted. For example, looking at scales of 8*40 days not only extreme fire years but also low severity fire years can be identified. In this larger scale, we couldn't separate exact extreme fire years from normal fire years, but we might identify the period (including several years, e.g. 2001-2004 & 2010-2012 in fig 5a) in which fire activity is dominant compared with other periods. Similar interpretation is for other time series data and wavelet transforms in Fig 5. For the time series data with slight fluctuations (similar patterns) from year-to-year such as FFMC (Fig 2b & Fig 5b), it is hard to exactly observe which year was severe year of that moisture code using any scales. However, the cyclic variation of this index from year to year was clearly detected using large scales at 32*8 days to

64*8 days scales. This is because of that peaks or values of data in each individual year was not significantly different from the general pattern of data in the entire 13 years period (e.g. see original data in Fig 2a and 2b, clearly several peaks were identified in Fig 2a but not in Fig 2b).

We added more detail interpretation of Fig 5 in the section 3.2.1.

An important field in time series analysis is multivariate analysis to see how different variables depend on each other. Wavelet cross spectrum and wavelet coherency has been developed for this purpose. Wavelet cross spectrum describes the common power of two processes without a normalization to the single wavelet power spectrum, and thus it can produce mis-leading results in relation of two time series (Maraun and Kurths, 2004). For example, if continuous wavelet transform of fire occurrence is locally flat (no peak) in year n and the climatic variables exhibit strong peaks at that time, this can produce peaks in the wavelet cross spectrum, which may have nothing to do with any relation of two time series. Therefore, we did not use wavelet cross spectrum for significance testing the relation between fire occurrence and fire weather indices. In this case, wavelet coherency that is similar as traditional correlation models of two dataset has been used to detect significant interrelation between two time series. However, wavelet cross spectrum can be used to estimate the phase difference between two time series. Fig 6a, for example, was the result of combining wavelet power spectrum of fire occurrence and FFMC showing in Fig 6a and Fig 6b respectively (see equation (4) in page 12). The results showing in fig 6 were similar to traditional correlation coefficients of two dataset but they were localized in different time frequency space. In other words, different decomposition levels of two time series resulted in different levels of correlation between two time series. Because fire weather indices are often used to predict fire danger in fire management, the suitable (or best) fire weather indices should represent (or have consistent patterns with) real fire occurrence patterns. Thus wavelet coherence in Fig 6 will help to find which indices at which time scales can be used to reflect fire activities in the study area, particular in the identification of extreme fire years. See section 3.2.2 and section 4 for detail interpretation and discussion of fig 6 and its relation to fig 5 as well as the original dataset in fig 2.

7. Page 15 Line 15: "The calculation of average phase angle at scales of 8- 16 months indicated the time lag of 3 months between FWI and fire activity in the study area." Why does this phenomenon exist? Was it affected by any factors? In my opinion, it has not any necessary *relationship between each other. So the authors should provide more proof to support your description.*

As mentioned in the discussion section that the calculation of the fire weather indices started in early April after snow has essentially left the area with the use of default spring initial values of three moisture codes (FFMC = 85, DMC = 6, DC =15) (Lawson and Armitage, 2008;Van Wagner and Pickett, 1985). The values of the fire weather indices were low during spring due to high moisture content in the fuels caused by snowmelt and then increased gradually due to a decrease of soil and fuels moisture after spring (water in soil and fuels left). The fire weather indices reached the maximum in autumn as it is a dry season. This pattern of fire weather indices in south central Siberia was exactly the same as that of Canadian boreal forest. However, the fire activity in south central Siberia region was primary in spring with the peak in May (Table 1 and Fig. 3) and mainly caused by human activities (up to 87% of fires in Russia and Siberia) (Mollicone et al., 2006;Achard et al., 2008;de Groot et al., 2012). This aspect reveals the performance of Canadian fire weather indices in south central Siberia that is not similar as original application in Canada in which lightning fires occur most frequently during summer months in Canada (de Groot et al., 2012;Stocks et al., 2003). In other words, Canadian fire weather indices might be more suitable for the areas such as Canadian boreal forest in which climatic and weather conditions play important role in defining fire activity, while the indices are less suitable for the areas with human-caused fire activity such as Siberian forest. In this context, other physical mechanisms such as vegetation types, topography and human activities should take into account in coupling with fire weather indices in the prediction of fire danger in Siberian study areas.

8. Page 15 Line 16: "other reasons" present "what reasons".

The authors couldn't find this in Page 15 Line 16. Page 15 Line 16 is the sentence in question 7 above.

9. Page 16 Line 20: "Artic Oscillation Index (AOI)" appears for the first time, thus the authors should give the definition of "AOI".

The definition of AOI was given and explained in Page 16 Line 23 to Line 26: “As the AOI quantifies the difference in atmospheric pressure between the northern middle and high latitudes…”

10. Page 17 Line 17: “with higher their values”, what does the authors want to express?

Higher values of DMC, ISI, BUI and FWI indicate higher number of fires in south central Siberia (in the observation of critical periods of fire activity using small scales of 8 days to 8 months data). The authors revised the sentence to make it clearer.

11. Page 18 Line 15: “data not shown”, why don’t the authors show the data? Maybe the authors should show the results to support your point.

The analysis of drivers of large burned areas in south central Siberia has been conducted in another our research paper, and we just want to mention the result that elevation and density of resident places in south central Siberia are more important than fire weather indices in determining area burned. This is to confirm and discuss the performance of Canadian fire weather indices in determining burned area, such as in Mediterranean (Dimitrakopoulos et al., 2011), China (Tian et al., 2012).

12. Several sentences of the paper that confuse me must be revised. Page 18 Line 8: “This argument of the phase …” Page 19 Line 2: “The annual patterns…”

The authors revised these sentences to make them clearer expression.

13. The authors use six indices to assess the fire risk, but it doesn’t present the expression of them. Thus, I recommend the authors to list the expressions (or formula) in a table.

In the section 2.3, the authors explained the FWI components and how they are measured. The calculation of those components are very complicated and based on various steps and equations. For detail expression of them, the reader can refer to (Van Wagner and Pickett, 1985) and (Lawson and Armitage, 2008)

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