Effect of global climate change on air temperature and precipitation in six cities in Gifu Prefecture, Japan

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Abstract. Global climate change in last decade is one of the most extensively researched and discussed topical issues affecting the environment. The question come, did global climate change will affect to the area with environmental friendly or high environment conservation such as in Gifu Prefecture. The objective of this research is to approve the evidence of effect of global climate change on local weather in Gifu Prefecture. Six cities were chosen to represented Gifu Prefecture. The results showed, maximum air temperature in all cities was increase year by year, the higher increase in Gujo city with increasing 0.1ºC/ year (R^2: 0.24), the lowest increase in Gero city 0.03ºC/year (R^2:0.067). The average of air temperature was increase except Nakatsugawa city. Precipitation in all cities was increase, and the higher increasing in Gero city. The frequency of 50 mm/h rainfall was increase in last decade, especially in Gujo city.

Keywords: Air temperature, Climate change, Extreme precipitation, Gifu Prefecture

1. Introduction

Global warming and climate change is one of the most extensively researched and discussed topical issues affecting the environment. Although there is enough historical evidence to support the theory that climate change is a natural phenomenon, many research scientists are widely in agreement that the increase in temperature in the 20th century is anthropologically related [1]. Climate change has many elements, affecting biological and human systems in different ways. The considerable spatial heterogeneity of climate change impacts has been widely studied; global average temperature increases mask considerable differences in temperature rise between land and sea and between high latitudes and low; precipitation increases are very likely in high latitudes, while decreases are likely in most of the tropics and subtropical land regions [2]

Trends in extreme meteorological events have received considerable attention in recent years due to the numerous extreme events such as hurricanes, droughts and floods observed [3]. Changes in global climate and alteration of Earth's hydrological cycle [4-6] have resulted in increased heavy precipitation with consequent increased surface runoff and flooding risk [7-8], which is likely to continue in the future [9]. Anthropogenic climate change is expected to change the distribution, frequency and intensity of precipitation and result in increased intensity and frequency of floods and droughts, with damaging effects on the environment and society [9,10,11,8,12].

Japan is one of country with more than 60% of land area was covered by forest [13-14]. Japan have highly standard in conservation for the environmental. However, because of geographic condition some disaster come and destroy many facilities in Japan. The aims of this study is to collect more information about effect of global climate change in Japan a case study in Gifu Prefecture.

2. Materials and Method

The research was conducted in Gifu prefecture in August 2018. Air temperature and precipitation data was providing by Japan Meteorological Agency (JMA) based on Automatic Weather Station measurements, the location of the Automatic Weather Station (AWS) was provided in table.1. The data uses are Air temperature and precipitation from 1 January 1988-31 August 2018 (30-year data). The characteristic of the measure location can be seen in figure 1.

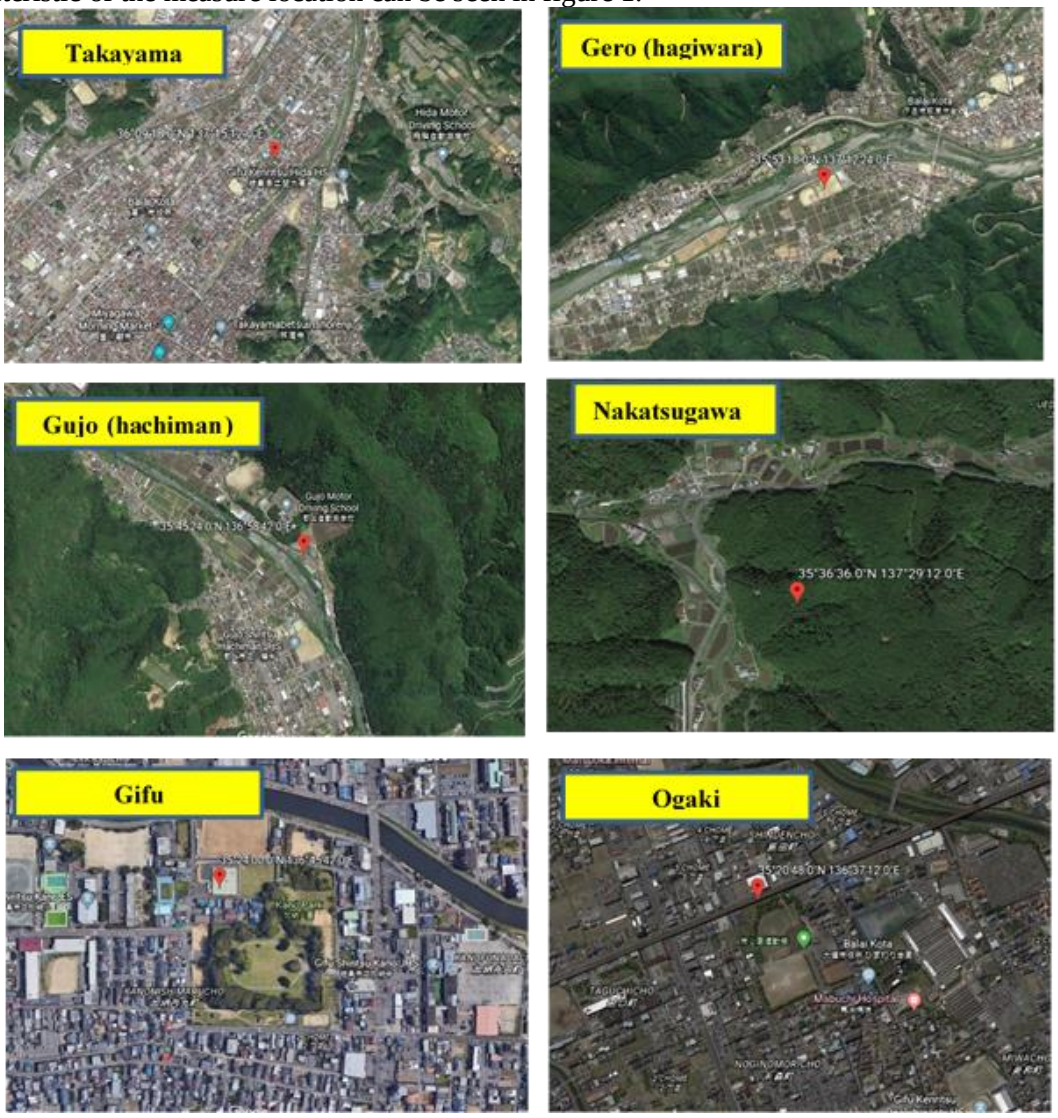

Figure 1. Map of six location of observation

Tabel 1. The coordinate of six Automatic Weather Station

Name of Station	Longitude	Latitude	Altitude (m)
Takayama	137º 15.2' E	36º 09.3' N	560
Gero (Hagiwara)	137º 12.4' E	35º 53.3' N	426
Gujo (Hachiman)	136º 58.7' E	35º 45.4' N	250
Nakatsugawa	137º 29.2' E	35º 36.6' N	378
Gifu	136º 45.7' E	35º 24.0' N	12.7
Ogaki	136º 37.2' E	35º 20.8' N	6

3. Results and Discussion

The results show figure 2 and 3, in general, the maximum air temperature in six cites was increased year by year. The highest increase was found in Gujo city with increase 0.1ºC/year (R^2= 0.24), and the lowest increase in Gero city 0.03ºC/year (R^2=0.06). In the annual average of air temperature in Gujo city was increase 0.024ºC/year and the lowest increase in Ogaki city 0.012ºC/year. However, in Nakatsugawa city the annual average air temperature was decrease with decreasing 0.0033ºC/year (R^2=0.0027).

The average 30-year annual precipitation in Takayama city 1747 mm, Gero city 2528 mm, Gujo 2728 mm, Nakatsugawa 1796 mm, Gifu 1866 mm and Ogaki 1931 mm. Figure 4 show, the highest annual precipitation is in Gujo city, and the lowest is in Takayama city. Precipitation in all cities was increase, except in Gujo city. Highest increasing was found in Gero city. 5 mm/ hour is standard from Japan Meteorology Agency for extreme precipitation. In decade 1988-1997 the higher frequency was found in Gujo with frequency 5 time, next decade in Gujo with frequency 4 time, In last decade in Gujo with frequency 7 time and 6 time in Gero city.

The air temperature in six cities cannot be comparable, because of different in distance and altitude. In this case in general air temperature was increased. The main factor that is the most affected air temperature in six cities is surface characteristic or land characteristic [15]. In Gujo, the increasing the timber industry will decrease the forest area, with change the land cover will increase the temperature. Converting the forest to non-forest will increase the albedo and increase the solar radiation to reach soil surface. With increasing the albedo and solar radiation the ground temperature will increase, the consequence of this phenomenon is the snow will melt faster.

There is a direct influence of global warming on precipitation. Increased heating leads to greater evaporation and thus surface drying, thereby increasing the intensity and duration of drought. However, the water holding capacity of air increases by about 7% per 1°C warming, which leads to increased water vapor in the atmosphere. Hence, storms, whether individual thunderstorms, extratropical rain or snow storms, or tropical cyclones, supplied with increased moisture, produce more intense precipitation events. This increases the risk of flooding. The atmospheric and surface energy budget plays a critical role in the hydrological cycle, and also in the slower rate of change that occurs in total precipitation than total column water vapor. With modest changes in winds, patterns of precipitation do not change much, but result in dry areas becoming drier (generally throughout the subtropics) and wet areas becoming wetter, especially in the mid- to high latitudes: the ‘rich get richer and the poor get poorer’. This pattern is simulated by climate models and is projected to continue into the future. Because, with warming, more precipitation occurs as rain instead of snow and snow melts earlier, there is increased runoff and risk of flooding in early spring, but increased risk of drought in summer, especially over continental areas. However, with more precipitation per unit of upward motion in the atmosphere, i.e. ‘more bang for the buck’, atmospheric circulation weakens, causing monsoons to falter. In the tropics and subtropics, precipitation patterns are dominated by shifts as sea surface temperatures change, with El Niño a good example [8]

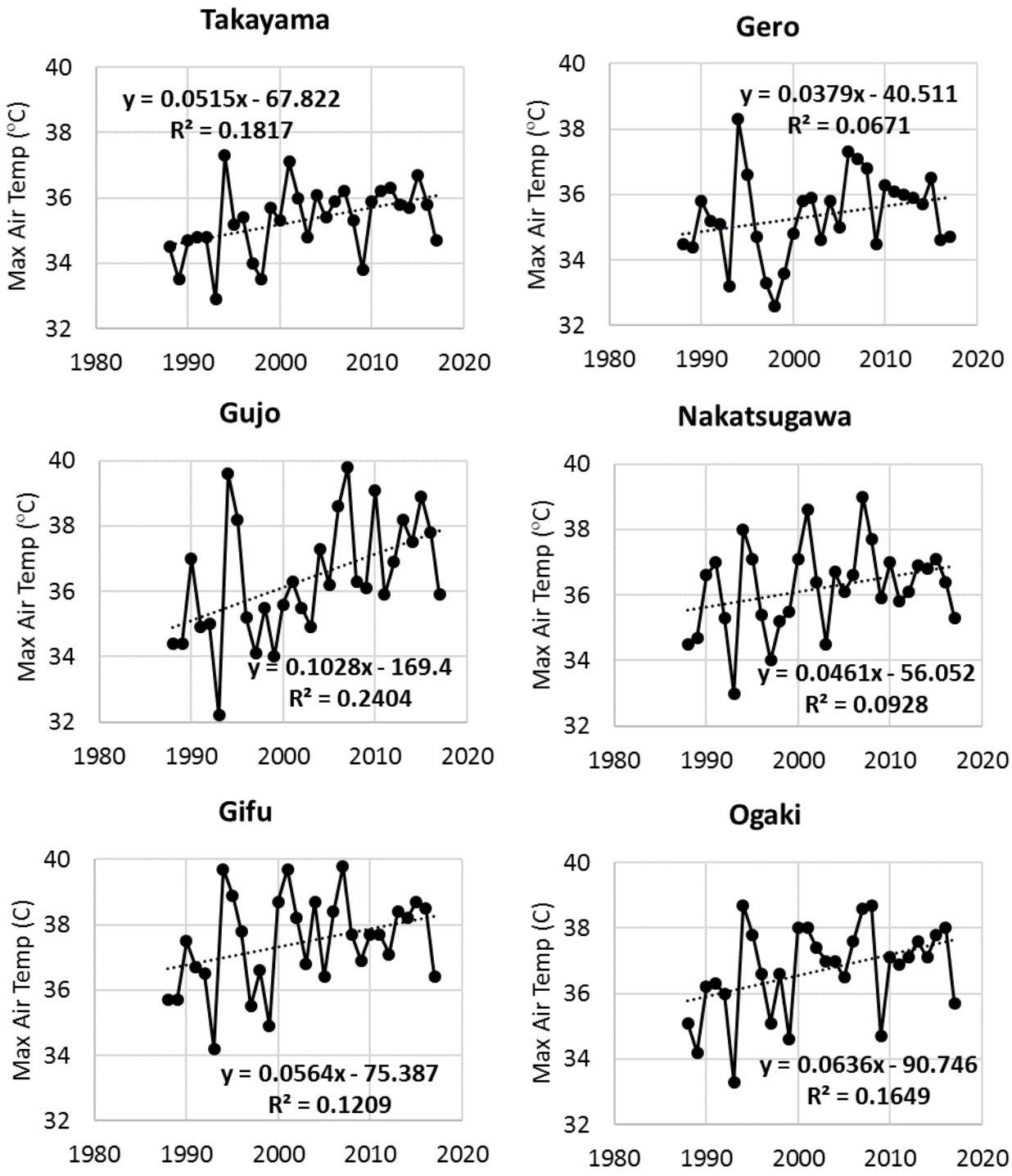

Figure 2. Maximum air temperature in six cities in Gifu Prefecture.

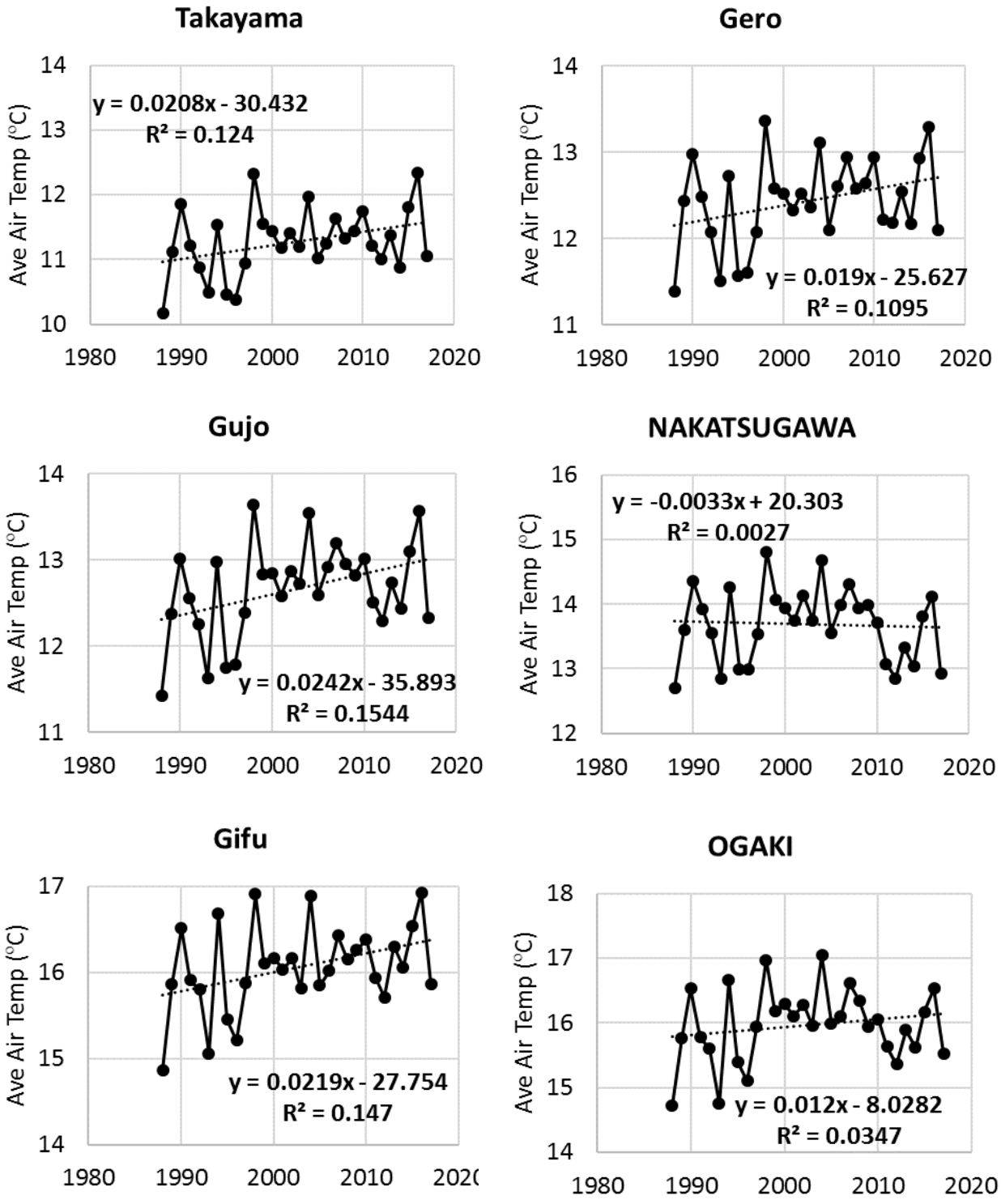

Figure 3. Average air temperature in six cities in Gifu Prefecture

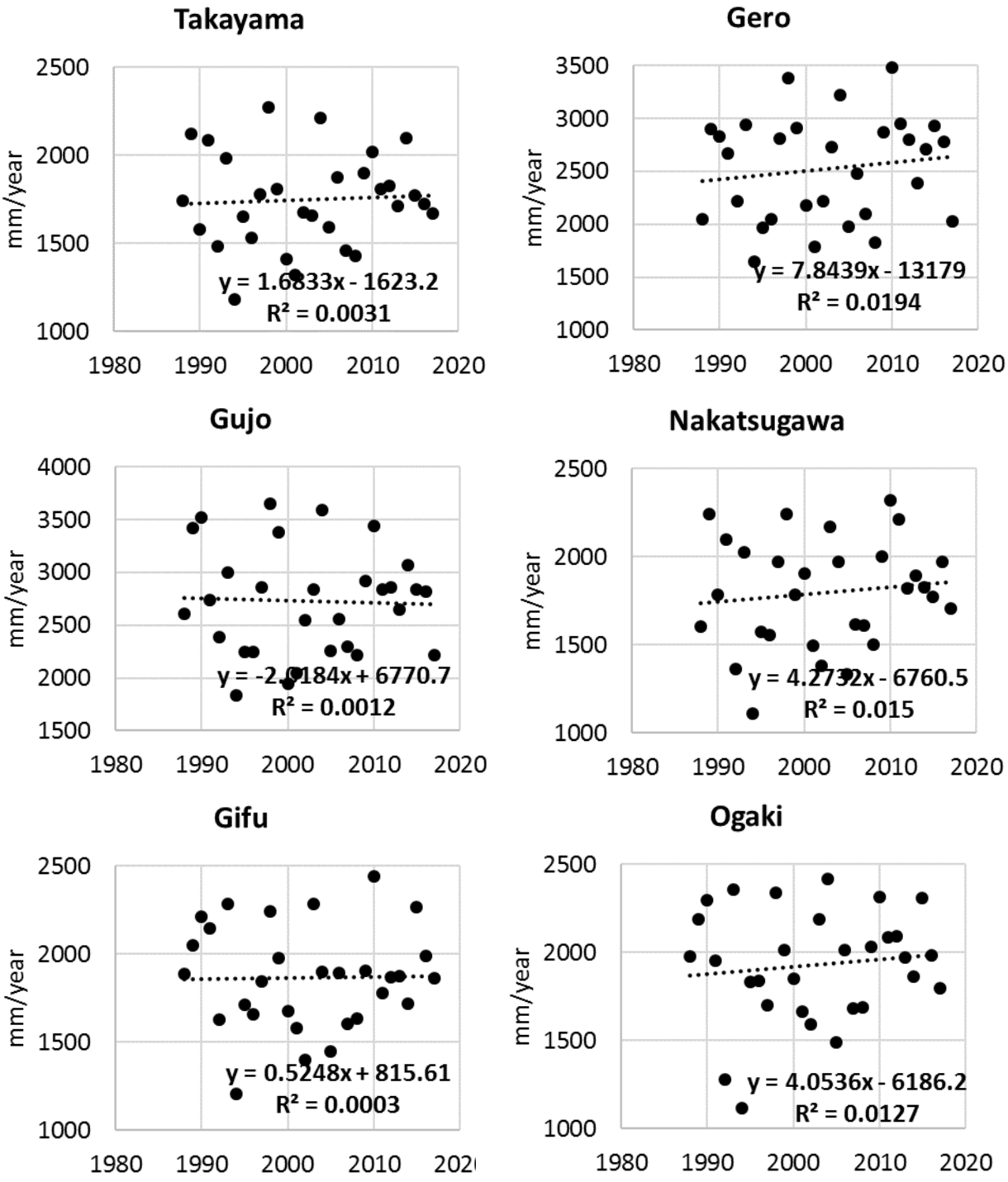

Figure 4. Annual precipitation in six cities in Gifu Prefecture

Table 2. Frequency of 50mm/hour precipitation 1988-1997

	Takayama	Gero	Gujo	Nakatsugawa	Gifu	Ogaki
1988	0	0	0	1	0	0
1989	0	0	0	0	0	0
1990	0	1	4	0	0	0
1991	0	0	0	0	0	0
1992	0	0	0	0	1	0
1993	0	0	0	0	0	0
1994	0	0	0	0	0	0
1995	0	0	0	0	0	0
1996	0	0	0	1	0	0
1997	0	1	1	0	1	0
Total	**0**	**2**	**5**	**2**	**2**	**0**

Table 3. Frequency of 50mm/hour precipitation 1998-2007

	Takayama	Gero	Gujo	Nakatsugawa	Gifu	Ogaki
1998	0	0	1	0	0	0
1999	0	0	1	0	0	0
2000	0	0	0	1	0	0
2001	0	0	0	0	0	0
2002	0	1	0	0	0	0
2003	0	0	0	0	0	0
2004	1	0	1	0	0	2
2005	0	0	0	0	0	0
2006	0	0	0	0	0	0
2007	0	0	1	0	1	0
Total	**1**	**1**	**4**	**1**	**1**	**2**

Table 4. Frequency of 50mm/hour precipitation 1998-2007

	Takayama	Gero	Gujo	Nakatsugawa	Gifu	Ogaki
2008	0	0	0	0	0	0
2009	0	0	1	0	0	0
2010	0	1	1	1	0	0
2011	0	0	0	0	0	0
2012	1	0	2	0	0	0
2013	0	0	1	0	1	1
2014	1	0	1	0	0	0
2015	0	1	0	0	0	0
2016	0	2	1	0	0	0
2017	0	0	0	0	0	0
2018	1	2	0	0	0	0
Total	**3**	**6**	**7**	**1**	**1**	**1**

Consistent with previous research, that the wet areas become wetter, and dry and arid areas become more so. In addition, the following general changing pattern is emerging: (a) increased precipitation in high latitudes (Northern Hemisphere); (b) reductions in precipitation in China, Australia and the Small Island States in the Pacific; and (c) increased variance in equatorial regions. The changes in the major ocean currents also appear to be affecting precipitation patterns. For example, increased intensity and frequency of El Nin˜o and ENSO seem associated with evidence of an observed ''dipole'' pattern affecting Africa and Asia, although this time series is too short so far. But the changing pattern calls for renewed efforts at adaptation to climate change, as the changing precipitation pattern will also affect the regional availability of food supply [16]

The evidence of effect of the global climate change was found in Gifu prefecture there are increasing air temperature and extreme rainfall. Consistent wet areas become wetter, especialy seen in Gujo and Gero city

4. Conclusions

The conclusion of this research is maximum air temperature in all cities was increase year by year, the higher increase in Gujo city with increasing 0.1ºC/ year (R^2: 0.24), the lowest increase in Gero city 0.03ºC/year (R^2:0.067). The average of air temperature was increase except Nakatsugawa city. Precipitation in all cities was increase, and the higher increasing in Gero city. The frequency of 50 mm/h rainfall was increase in last decade, especially in Gujo city. Gujo city have strongly affected by climate change.

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