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Transition between the dry and rainy season in Cumbayá (Ecuador): 2014 to 2015 comparison from observations at USFQ's Atmospheric Measurement Station (EMA)

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Abstract

In this work we compare the length of the dry summer season and the transition into the rainy season in Cumbayá (located in a valley east of Quito, Ecuador) between the years 2014 and 2015. Meteorological observations used for comparison are solar radiation flux density, ambient temperature, relative humidity, and precipitation. Measurements were taken continuously at Universidad San Francisco de Quito's Atmospheric Measurement Station (EMA, Spanish acronym). Data analysis shows that compared to 2014, there was a delay of almost one month for the arrival of the rainy season in 2015. In 2014 the rainy season began on 12 September, while in 2015 the first seasonal rains occurred starting 9 October. September 2015 was an extremely dry month with daytime relative humidity minima as low as 6%. In September 2015, almost 5% of the ambient temperature 10-min data points were above 26°C compared to 0.67% in September 2014. Unseasonable warm and dry conditions augmented the severity of wild fires that developed within the surrounding forests in mid September 2015.

Keywords. Quito, dry season, rainy season.

Transición entre la estación seca y lluviosa en Cumbayá (Ecuador): comparación entre los años 2014 y 2015 a partir de las observaciones de la Estación de Mediciones Atmosféricas (EMA) de la USFQ

Resumen

En este trabajo se compara la duración de la época seca del verano y la transición hacia la época lluviosa en Cumbayá (localidad ubicada en el valle oriental de Quito, Ecuador) entre los años 2014 y 2015. Las observaciones meteorológicas utilizadas para la comparación son la radiación solar, la temperatura ambiente, la humedad relativa y la precipitación. Las mediciones fueron tomadas continuamente en la Estación de Mediciones Atmosféricas (EMA) de la Universidad San Francisco de Quito. Los datos muestran que la estación lluviosa en 2015 llegó prácticamente con un mes de retraso en comparación con 2014. Así, en 2014 la estación lluviosa se inició el 12 de Septiembre, mientras que en 2015 ocurrió el 9 de Octubre. Septiembre de 2015 fue un mes extremadamente seco, con valores de humedad relativa al medio día tan bajos como 6%. Durante Septiembre de 2015 casi un 5% de valores máximos de temperatura (promedios de 10 minutos) superaron los 26°C; mientras que en Septiembre de 2014, sólo un 0.67% de los datos superó tal marca. Las condiciones extremadamente secas y calientes del mes de Septiembre de 2015 agravaron la severidad de los incendios forestales que se desarrollaron en los bosques aledaños durante ese período.

Palabras Clave. Quito, estación seca, estación lluviosa.

Introduction

In Quito (Ecuador) and its adjacent valleys, the duration of the dry season and the transition into the rainy season are critical factors that impact the development and severity of wild fires that often affect the region during the summer months. For example, in September 2015 Quito battled a serious wave of wild fires that devastated about 30 km^2 (3023.71 ha) of surrounding woods [1, 2]. Many of these events occurred within the forests that enclose densely populated towns (Puembo, Tumbaco, and Cumbayá) located across Quito's eastern valley. According to a Quito's COE report (Emergency

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Operations Council, Spanish acronym) the occurrence of fires in summer 2015 turned out to be 132% larger than in summer 2014 [1].

During the summer months, seasonal wind gusts, intense surface insolation, warm ambient temperatures, low humidity, and scarce precipitation are some of the variables that contribute with suitable conditions for wild forests to develop pervasively. At Universidad San Francisco de Quito's Atmospheric Measurement Station (EMA, Spanish acronym), environmental monitoring efforts have been started since last summer with the purpose of building an observational record of physical meteorology and air quality measurements for the region. In this work, we report a comparison between the duration of the dry season between 2014 and 2015 from meteorological observations taken at EMA (0°11'47" S, 78°26'6" W, 2391 meters above sea level). In addition, we report the appearance of the transition period towards the rainy season for both years. The variables used for comparison are ambient temperature, relative humidity, solar radiation, and precipitation. Temporal resolution of data presented corresponds to 10-minute averages for each measured quantity. Details regarding ground station instrumentation and an initial assessment of meteorological data quality can be found in [3].

Solar radiation comparison

Summertime solar radiation measurements are depicted in Fig. 1 for July, August and September 2014 (top panel), and 2015 (bottom panel). Plotted 10-min data (in green) and the corresponding diurnal profile (black line) reveal that on average July 2015 was considerably cloudier compared to the clearer skies in July 2014. Advancing towards the equinox, solar radiation around noontime was more intense for the months of August and September 2015 when compared to the previous year. For example, between 11h00 and 14h00, solar radiation measurements above 1100 W m^{-2} in 2015 correspond to 1.4% of the data points in August and 3.2% in September, whereas in 2014 the same percentages are 0.92% and 2.2%, correspondingly.

Ambient temperature comparison

Ambient temperature measurements for July, August and September are plotted against the hour of the day in Fig. 2 for 2014 (top panel), and 2015 (bottom panel). In July 2015 there was larger abundance of cloudiness (previous section). As a result, July 2015 was a cooler month than July 2014, as depicted by the diurnal profile curves (blue solid lines) for every case. Thus, in July 2015 the average temperature maximum was 23.4°C with a narrower diurnal profile curve and larger data dispersion around it. In contrast, in July 2014 the mean temperature maximum was 24.3°C, the diurnal profile curve had a wider peak, and 10-min points were more compact around the mean. On the other hand, as the surface received more intense insolation during August and September 2015 when compared to 2014 (previous section), ambient temperatures were accordingly higher. On average, temperature maxima were 25°C and 26°C on August and September 2015, respectively. In contrast, average temperatures for the same moths in 2014 were 23.3°C and 24°C. The percentage of 10-min temperature points above 26°C between 11h00 and 15h00 in August and September 2015 were 1.5% and 4.8%. However, in 2014 there were no 10-min data points above 26°C in August, while in September only 0.67% of the data was above the 26°C-mark.

Relative humidity comparison

Regarding relative humidity, dry conditions in summer 2014 were observed since July. As shown in the top panel of Fig. 3, July 2014 had drier days and remarkably drier nights than the following months, whereas September 2014 was more humid. In addition, the first rain occurred on 12 September 2014 (more details in the next section). In contrast, there was more dispersion of relative humidity data points around noontime in July 2015 when compared to the following months in the same year. Hence, in 2015 dry conditions started in August and intensified considerably towards the end of summer. For example, in September 2015 the average daytime relative humidity minimum was 25% with a couple of days when values dropped dramatically and reached values as low as 6% (Fig. 3 bottom panel, September). It was during this time period when wild fires developed in a very intense fashion. Precipitation recorded at EMA during September 2015 was practically absent (only 3.1 mm for the monthly total, more in the next section) as opposed to what happened the previous year.

Precipitation comparison

A comparison of the monthly precipitation totals for the months of June through October 2014 and 2015 is presented in Table 1. June and October have been included in this comparison in order to identify the length of the summertime and the transition from the dry into the rainy season on both years. Fig. 4 depicts total monthly precipitation curves obtained with data in Table 1. In this analysis the initiation of the rainy season has been identified on the first day of rain within the month when considerable total precipitation occurred immediately after the previous dry summer months. Hence, in

Month	**Cumulative precipitation (mm)**	
	2014	**2015**
June	11.6	6.2
July	-	13.8
August	0.7	-
September	89.7 (*)	3.1
October	126.7	116
Onset of rainy season	September 12th	October 9th

(*) There was partial loss of data at the EMA site during this month. Hence, the precipitation total for September 2014 was obtained in part with measurements from a nearby monitoring station operated by the City's network [4].

Table 1: Monthly precipitation totals in mm for June through October taken at EMA during 2014 and 2015.

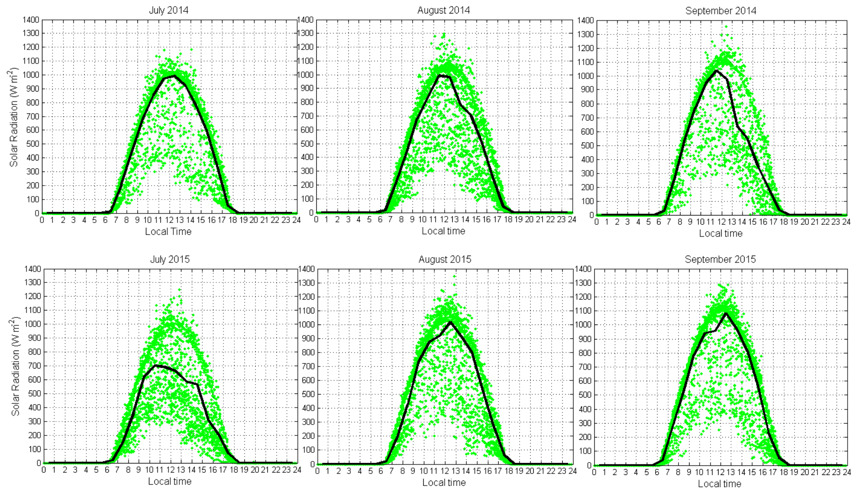

Figure 1: Solar radiation measurements for July, August and September taken at EMA during 2014 (top panel) and 2015 (bottom panel). Green points are 10-min data. Black solid line depicts the diurnal profile obtained with the hourly median.

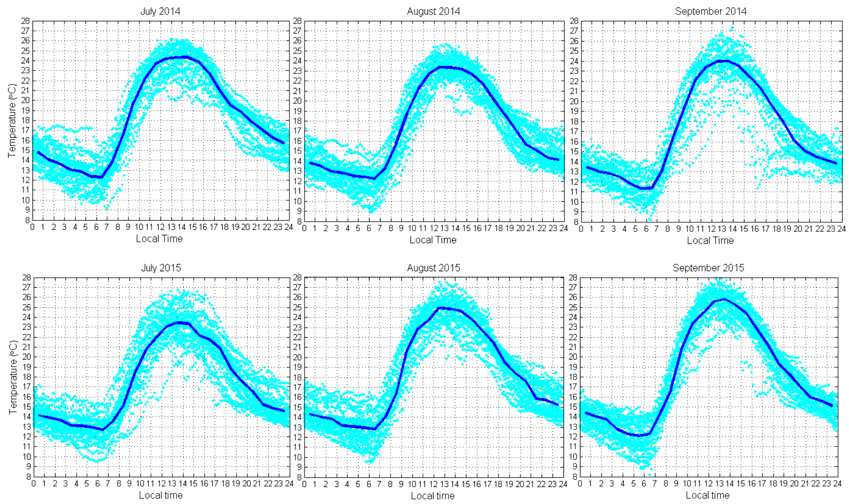

Figure 2: Ambient temperature observations for July, August and September taken at EMA during 2014 (top panel) and (2015) bottom panel. Cyan points are 10-min data. Blue solid line depicts the diurnal profile obtained with the hourly mean.

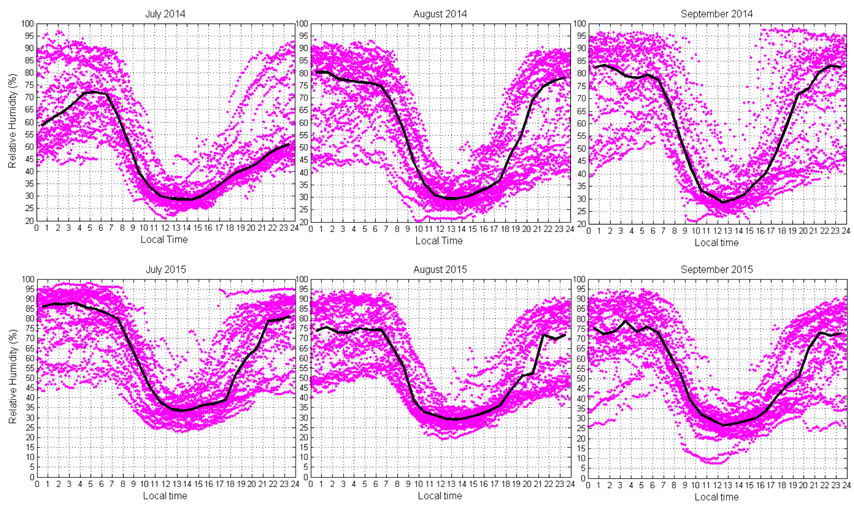

Figure 3: Relative humidity measurements for July, August and September taken at EMA during 2014 (top panel) and 2015 (bottom panel). Magenta points are 10-min data. Black solid line depicts the diurnal profile obtained with the hourly mean.

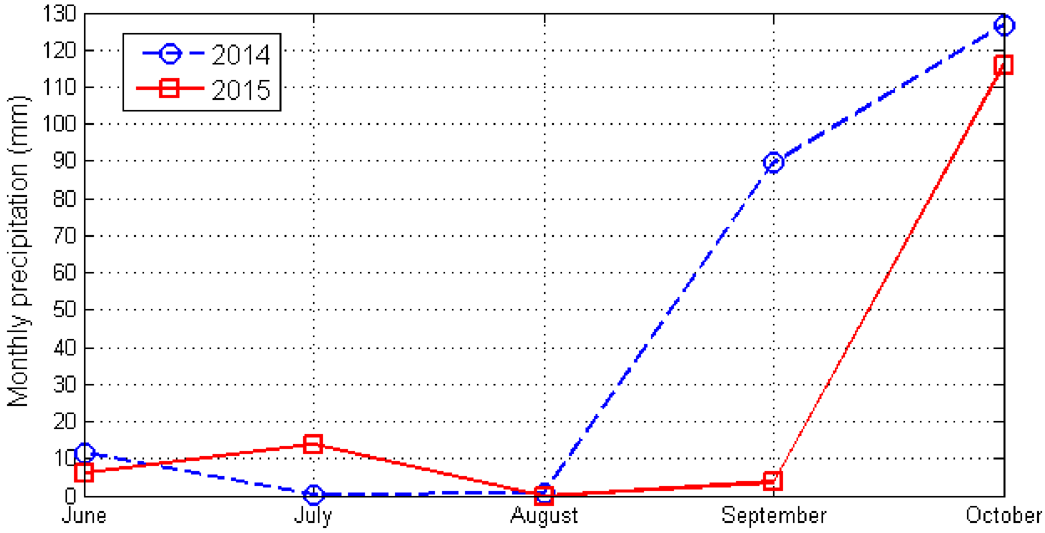

Figure 4: Cumulative monthly precipitation collected at the EMA site from June to October 2014 (blue dashed line with circles) and 2015 (red line with squares).

2014 the rainy season began on September 12th, while in 2015 the rainy season began on October 9th.

Summary

Data analysis shows that in 2014 the rainy season began on September 12th, after three months of scarce precipitation. During this time period, June 2014 was partially dry, while July and August 2014 were dry. In contrast, June and July 2015 were partially dry, while August was dry, and September 2015 was an extremely dry month. Thus, the rainy season in 2015 began on October 9th, after four months of scarce rainfall and almost a month later than in 2014. Additionally, September 2015 was unseasonably warm with almost 5% of the daytime temperature maxima surpassing 26°C, while in September 2014 only 0.6% of the temperature maxima surpassed the same mark. Such dry and warm conditions during September 2015 along with summertime wind gusts (not analyzed in this report) favored the pervasiveness of wild fires that devastated a considerable area of woods that surround Quito's eastern valley.

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