IGARSS 2023 - 2023 IEEE International Geoscience and Remote Sensing Symposium | 979-8-3503-2010-7/23/$31.00 ©2023 IEEE | DOI: 10.1109/IGARSS52108.2023.10283346

TIME-SERIES GLOBAL FLOOD MAPPING DATASETS FROM SUOMI-NPP&NOAA-20/VIIRS FOR FLOOD ANALYSIS AND MODELLING

Sanmei Li[1], Mitchell Goldberg[2], Sean Helfrich[2], Sataya Kalluri[3], William Sjoberg[3], and Donglian Sun[1],
[1]. Department of Geography and Geo-Information Science, George Mason University, Fairfax, VA, USA, 22030
[2]. NOAA National Environmental Satellite, Data, and Information Service, Silver Spring, MD 20910
[3]. NOAA JPSS Program Office, Lanham, MD, USA

Abstract

Long-term flood mapping datasets can be invaluable for historic flood investigation, flood potential or probability estimate, time series analysis and modelling, and climate change studies. With the developed flood detection algorithm and software for JPSS/VIIRS (Visible Infrared Imaging Radiometer Suite) (Li et al., 2017), in this study, VIIRS historic data since 2012 has been reprocessed from JPSS (Joint Polar Satellite System) series including Suomi-NPP (Suomi National Polar-orbiting Partnership) and NOAA-20. VIIRS global flood time series datasets have been generated and distributed by NOAA through Amazon Web Services (AWS). The derived dataset includes granule flood product, daily and 5-day composited flood products in netCDF4, geotiff and shapefile formats from 2012 to 2020. The dataset not only provides data records of historic flood events, but also shows potential in flood analysis and modelling. With the dataset, a simple application using annual composition is performed to analyze the annual change of flood extent globally and in each continent. The analysis has shown a slightly increasing trend in flood extent at a global scale, but varying in different regions.

Keywords:—JPSS, VIIRS, Time-series Flood Mapping dataset

1. INTRODUCTION

Flood, one of the costliest and most frequent natural disasters, has been predicted with increasing frequency and more extreme intensity in many climate models as a result of changing climate (Milly et al., 2002; Hirabayashi et al., 2008; Lehner et al., 2006). Validation on these models requires long-term time-series flood datasets that covers most major flood events. Because flood is generally a short-term event with widespread extent, satellite imagery plays an important role in flood mapping because they can "see" the big pictures of floodwater. Comparing to other satellite missions, satellites with moderate spatial resolution, large swath width and rapid revisit period, such as TERRA/AQUA and JPSS series including Suomi-NPP and NOAA-20, capture more flood events and derive more complete flood extent with low cost. Thus, time-series flood datasets from these satellites can be invaluable for flood investigation, planning, analysis and modelling, as well as a scientific data source for validating climate models on floods. With the support from NOAA/NASA JPSS program, an operational flood detection algorithm and software package have been developed for flood mapping from JPSS/VIIRS imagery to generate VIIRS operational flood products in near real-time, daily and 5-day composition. These products provide reliable information during major flood events globally for river forecasters and decision-makers in situational awareness, damage assessment, and flood forecasting. With the algorithm and software package, in 2022, NOAA reprocessed the VIIRS historic data since 2012 and generated a VIIRS global time-series flood dataset, which has been distributed through Amazon Web Services (https://noaa-jpss.s3.amazonaws.com/index.html#JPSS_Blended_Products/). The derived dataset includes granule flood product, daily and 5-day composited flood products in netCDF4, geotiff and shapefile formats from 2012 to 2020. This paper provides an introduction to the dataset and demonstration about a simple application of the dataset in annual fluctuation analysis of flood extent globally and in different regions, respectively.

2. DERIVATION OF THE DATASET

To derive the dataset, all the Suomi-NPP &NOAA-20/VIIRS SDR (Sensor Data Record) granules in Imager bands 1 (600~680 nm), 2 (850~880 nm), 3 (1610 nm) and 5 (1050~1240 nm) and I-band terrain-corrected geolocation data (longitude, latitude, solar zenith angles, solar azimuth angles, sensor zenith angles and sensor azimuth angles) from 2012 to 2020 have been processed. VIIRS cloud mask (JRR-CloudMask) is used to help determine cloud cover. These granules are firstly projected into an equidistant cylindrical projection, and then are applied in flood detection to generate granule flood products. The granule flood products are further divided into 136 AOIs (Area of Interest) covering the major global land between 80^{o} S and 80^{o} N in latitudes. Each AOI sizes with $15^{o} \times 15^{o}$. Fig. 1 shows a sketch of the 136 AOIs.

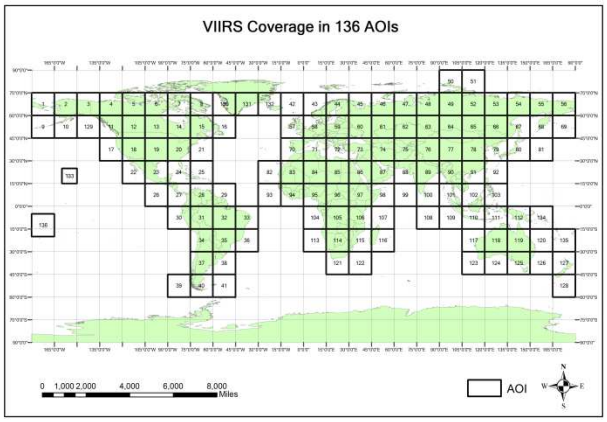

Fig. 1. Sketch of VIIRS 136 AOIs covering major global land between 80° S and 80° N in latitudes

Based on the granule flood product in 136 AOIs, daily composition and 5-day composition are applied to derive daily and 5-day composited flood products using a maximal water fraction composition method. From 2012 to 2017, there is only Suomi-NPP data, and thus the composition only uses one satellite data. From 2018 to 2020, with the availability of data from both Suomi-NPP/VIIRS and NOAA-20/VIIRS, the composition is done with the two satellites to derive the maximal clear-sky coverage. However, considering the blended results from Suomi-NPP and NOAA-20 have more clear-sky coverage than data from Suomi-NPP only, a bias is introduced when using the data for time-series flood analysis. Therefore, from 2018 to 2020, besides the composition with two satellites, the composition with Suomi-NPP only is also applied. With the process, altogether six datasets are generated and stored in netCDF4, geotiff and shapefile formats:

1) Dataset in granules from Suomi-NPP from 2012 to 2020
2) Dataset in granules from NOAA-20 from 2018 to 2020
3) Daily composited flood dataset from Suomi-NPP from 2012 to 2020
4) 5-day composited flood dataset from Suomi-NPP from 2012 to 2020
5) Daily composited flood dataset from Suomi-NPP and NOAA-20 from 2018 to 2020
6) 5-day composited flood dataset from Suomi-NPP and NOAA-20 from 2018 to 2020

3. ACCESS TO THE DATASET

The daily and 5-day composited datasets have been distributed through Amazon AWS for public access. The daily composited flood datasets in netCDF, geotiff, shapefile formats from 2012 to 2020 are available from this site: https://noaa-jpss.s3.amazonaws.com/index.html#JPSS_Blended_Products/VFM_1day_GLB/. The 5-day composited flood datasets from 2012 to 2020 are available from this weblink: https://noaa-jpss.s3.amazonaws.com/index.html#JPSS_Blended_Products/VFM_5day_GLB/. Note under these two links, from 2012 to 2017, the composited datasets are from Suomi-NPP only, and from 2018 to 2020, they are blended products from Suomi-NPP and NOAA-20.

The Suomi-NPP daily composited flood dataset in netCDF format from 2018 to 2020 can be available in this weblink: https://noaa-jpss.s3.amazonaws.com/index.html#JPSS_Blended_Products/SNPP_DECOM/.

In future, the VIIRS flood data after 2021 will also be processed and distributed for public access.

4. APPLICATIONS

The VIIRS time-series flood datasets can provide many potential applications in flood analysis and modelling. One straightforward application is to provide data records of major floods globally. With the datasets, users can check the information of historic flood events. They can also be used to analyze flood seasonal patterns or simulate flood extent and so on.

With the changing climate, extreme flood events become very common nowadays. Widespread floods have been a severe threat to the safety of human lives and properties. For government agencies and decision-makers, it is important to know whether there are any trend signals on these increasing flood events. A reliable time-series flood dataset from VIIRS may help derive such information. With an annual composition in observed flood times pixel-by-pixel, an annual composited flood dataset can be generated to calculate global or regional annual flood areas or percentage of flood areas. Percentage of flood area (P) and percentage of weighted flood area (P_w) are defined to compare the annual flood extent in globe and continents, respectively:

$$P = \frac{\sum_{i=0}^{n} p_i \times f_i}{\sum_{i=0}^{n} p_i} \times 100\%, \quad (1)$$

$$P_w = \frac{\sum_{i=0}^{n} p_i \times F_i}{\sum_{i=0}^{n} p_i} \times 100\%, \quad (2)$$

Where, p_i is pixel's area, f_i is pixel's annual maximal flood water fraction, n is total flood pixels, $F_i = \sum_{j=0}^{m} W_j$ is the pixel's total observed flood times weighted by floodwater fractions, m is total observed flood times, and. W_j is floodwater fraction ($0.0 \leqslant W_j \leqslant 1.0$).

The percentage of flood area (P) reflects average total flood extent, and the percentage of weighted flood area (P_w) somehow reflects flood intensity (frequency or lasting period). By calculating the two indices globally and in different regions from 2012 to 2020 using the Suomi-NPP/VIIRS time-series flood datasets, some trend and fluctuation signals may be demonstrated. Fig. 2 presents a plot of percentage of global flood area (P) from 2012 to 2020, and Fig. 3 is a plot of percentage of weighted global flood area (P_w) from 2012 to 2020. In Fig. 2, although percentages of global flood area in each year remain similar,

there is still a very slight increasing trend that can be found. In Fig. 3, with the percentage of global weighted flood area, which counts in observed flood times by accumulating floodwater fractions, the increasing trend is more apparent from 2012 to 2020. This might indicate over the similar flood plains, floods occur more frequently or with larger intensity.

The trend of regional flood areas, however, varies substantially from the two indices. Here, globe is divided into seven regions: Africa, East Asia, Central-west Asia, Europe, North America, Oceania and South America. From the results shown in Fig. 4, Africa, East Asia and North America show slightly increasing percentages of flood area, and the rest regions do not show any trend but fluctuate year by year. From the percentage of weighted global area (Fig. 5), only East Asia and North America show a slightly increasing trend.

Although the VIIRS time-series datasets show some trend information on flood areas, the 9-year period is still too short for long-term analysis related to climate change. This application is more a demonstration on how to use the data than analysis about climate change. In future, with more data processed for flood mapping, such as the 20-year MODIS dataset, more significant signals in global flood extent can be detected from time-series analysis.

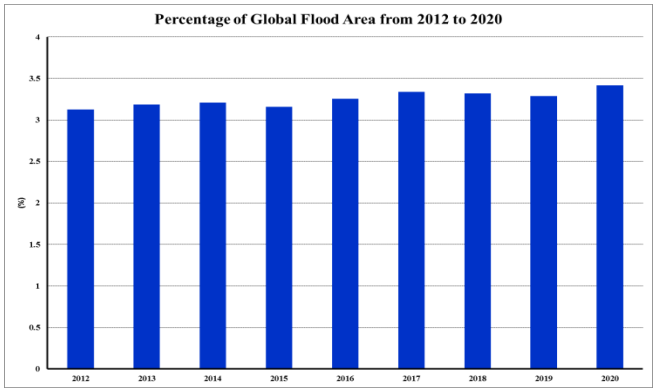

Fig. 2. Time series of percentage of global flood area (P_w) from 2012 to 2020

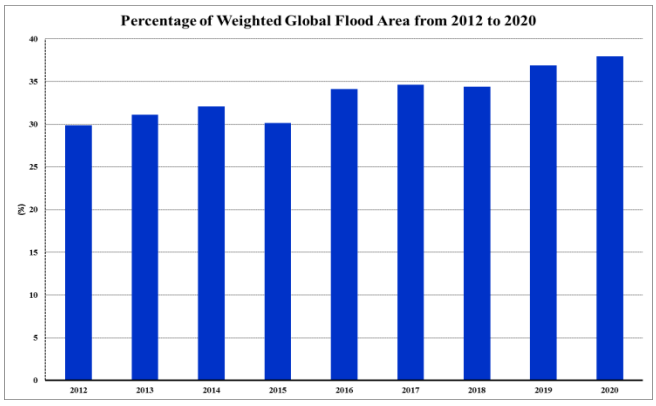

Fig. 3. Time series of percentage of weighted global flood area (P_w) from 2012 to 2020

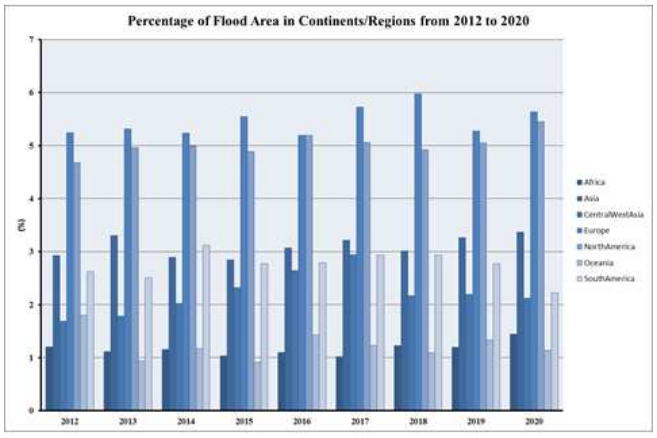

Fig. 4. Time series of percentage of global flood area (P_w) from 2012 to 2020 in seven regions

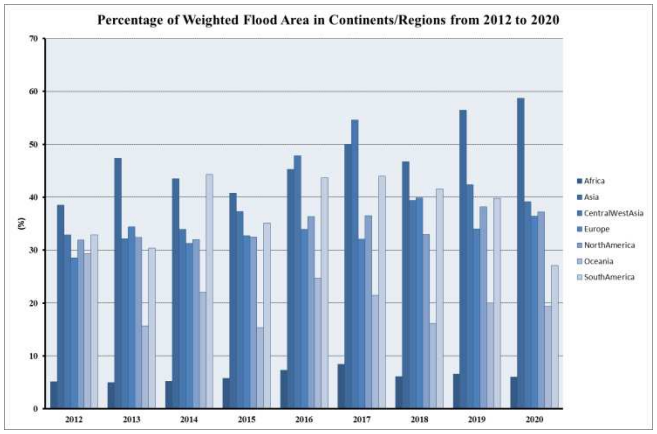

Fig. 5. Time series of percentage of weighted global flood area (P_w) from 2012 to 2020 in seven regions

5. SUMMARY

Overall, VIIRS global time-series datasets from 2012 to 2020 have been derived and distributed for public access through Amazon AWS:

1) With the developed operational Suomi-NPP&NOAA-20/VIIRS flood mapping algorithm and software package, VIIRS historic data from 2012 to 2020 has been reprocessed for flood mapping. Altogether six flood mapping datasets flood datasets have been generated in netCDF, geotiff and shapefile formats.
2) The VIIRS global daily and 5-day composited flood datasets are distributed through NOAA Amazon AWS and user can access these datasets through the following sites: https://noaa-jpss.s3.amazonaws.com/index.html#JPSS_Blended_Products/VFM_1day_GLB/ (daily composition);

https://noaa-jpss.s3.amazonaws.com/index.html#JPSS_Blended_Products/VFM_5day_GLB/ (5-day composition), and https://noaa-jpss.s3.amazonaws.com/index.html#JPSS_Blended_Products/SNPP_DECOM/ (Suomi-NPP daily composition from 2018 to 2020),

3) The datasets show potential in flood analysis and modelling. A simple application by using the data to detect time series signals of flood extent indicates a slightly increasing trend globally, but varying in different regions from 2012 to 2020.

6. REFERENCES

[1]. Hirabayashi, Y., Kanae, S., Emori, S., Oki, T. and Kimoto (2008). Global projections of changing risks of floods and droughts in a changing climate, Hydrol. Sci. J. 53, 754–772.

[2]. Lehner, B., Döll, P., Alcamo, J., Henrichs, T. & Kaspar, F (2006). Estimating the impact of global change on flood and drought risks in Europe: A continental, integrated analysis, Climatic Change 75, 273–299.

[3]. Milly, P., Wetherald, R., Dunne, K. and Delworth, T (2002). Increasing risk of great floods in a changing climate, Nature 415, 514–517.

[4]. Li, S., Sun, D., Goldberg, M.D., Sjoberg, W., Santek, D., Hoffman, J.P., DeWeese, M., Restrepo, P., Lindsey S., Holloway, E., 2017. Automatic near real-time flood detection using Suomi-NPP/VIIRS data. Remote Sensing of Environment 204, 672-689.