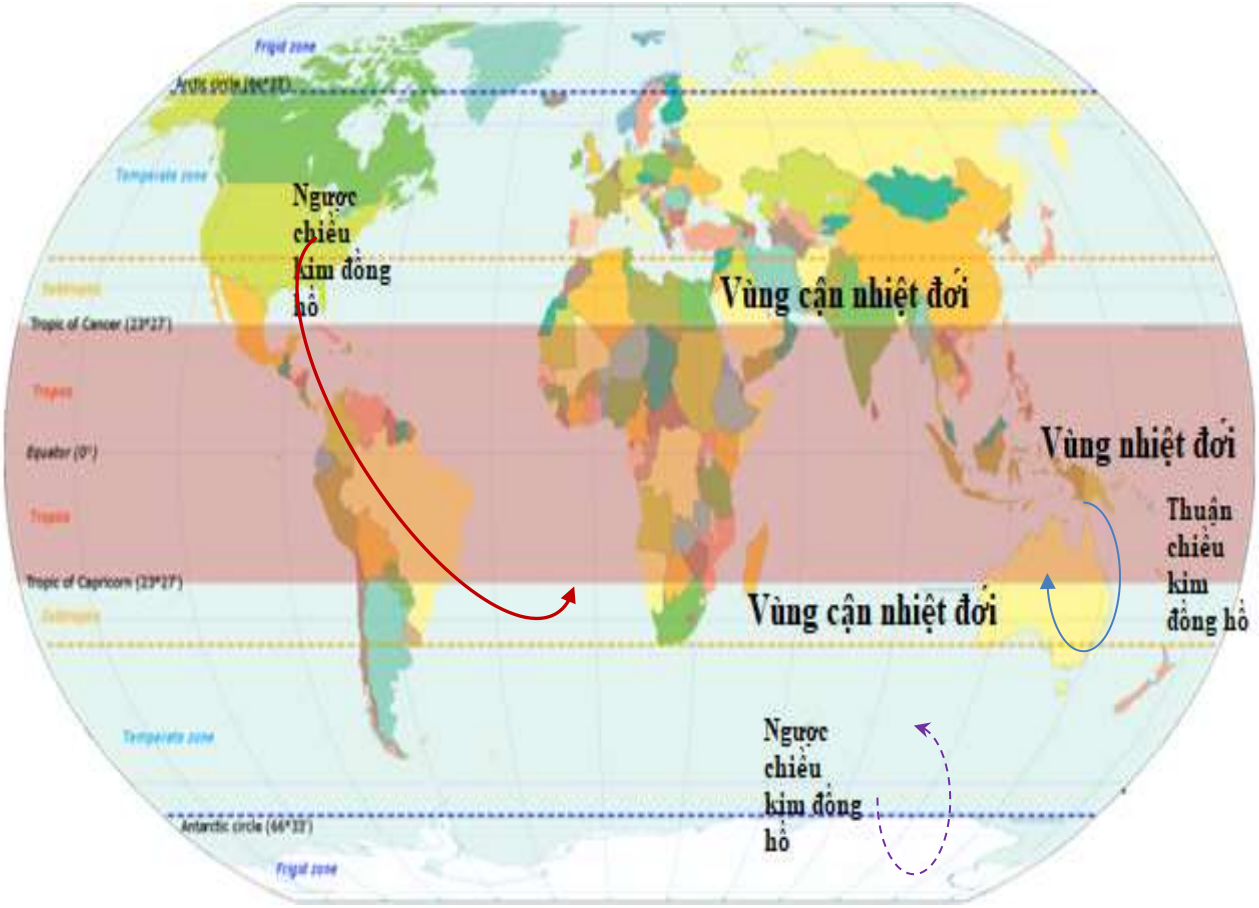
Ministry of Agriculture and Rural Development
Center for Informatics and Statistics



Negative effects of storms and heavy rains to agricultural production and prospects to use JAXA's JASMIN maps in Vietnam

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Nguyen Thi Lan Anh
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Ha Noi, 07/2022

Abstract

Vietnam situates in a specific geographical location that has many suitable factors to have heavy rains and storms, for example the the coast of 3000 km stretching from North to South, facing the Pacific Ocean (the largest ocean in the world), and its middle wide is very small with narrow plains. Behind the small and narrow plains are mountains, plateaus, and midlands. Vietnam locates almost entirely in the north of the tropical region where very strong air vortex forces usually happen.

Due to the geographical location of the regions, the Central region is most affected by heavy rains and storms, followed by the North and finally the South. The North is most affected by floods and landslides. The South is most affected by flood tide and sea level rise due to the increase of earth temperatuture.

More than 70% of Vietnam's population (more than 65 million people) is affected by different levels of storms. The average annual heavy rain and storm causes the death and more than 300 people missing. Before 2016, Vietnam had an average of 7 flash floods/year. After 2016, Vietnam has about 15 flash floods/year with more than 100 deaths/year. It is estimated that in Vietnam annually, about 400 thousand hectares of rice, crops, and fruit trees are destroyed, and more than 1 million poultry and 40,000 cattle (cows and bufalows) are death. The damage to various properties is estimated at more than $6.4 billion/year on average.

Vietnam has a disaster prevention system from the commune level up to the government/central level. The losses or damages submitted in that system are “administrative reported” figures and are compiled and “estimated qualitatively” by statisticians at each level. The “estimated” data is usually imprecise when state agencies compare them with the actual survey in fields.

This report “experimentally” uses maps of two basic indicators, precipitation, and drought, from JAXA's JASMIN maps made from June 2013 to the present. Because administrative statistics data are only compiled by year and published since 2016, this Report compares JAXA's JASMIN maps with numbers of administrative data reported for the whole country in months of frequent rainstorms namely 8, 9, and 10 in years 2016 to 2019. In addition, this Report compares JAXA's JASMIN maps with official online news in years 2020 to 2022.

Through comparison, the Report finds that the data generated by JAXA's JASMIN maps is more systematic, up-to-date, fluctuates more reasonably, reflecting more accurately changes of the weather. JAXA's JASMIN maps are consistent with news posted on Vietnam's governmental official Websites about the evolution of storms and damages caused by the storms. Because JAXA's JASMIN maps with data have been publicly available and free of charge in the past 10 years, more promotional activities are needed to bring these data to end-users.

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Abbreviation

JAXA	Japan Aerospace Exploration Agency
JASMINE	Japan Astrometry Satellite Mission for Infrared Exploration
AMIS	Agriculture Market Infor mation System
CIS	Center for Informatics and Statistics
MARD	Ministry of Agriculture and Rural Development

1. The formation of climate and types of seasons

Four seasons incluing spring, summer, autumn, and winter on earth have been formed due to 2 main reasons:

- The Earth revolves around the sun. They are always on the same plane and in the same direction from left to right (counterclockwise).
- Earth rotates on its axis and is tilted with the plane of orbit around the sun always at an angle of 23.50 degrees.

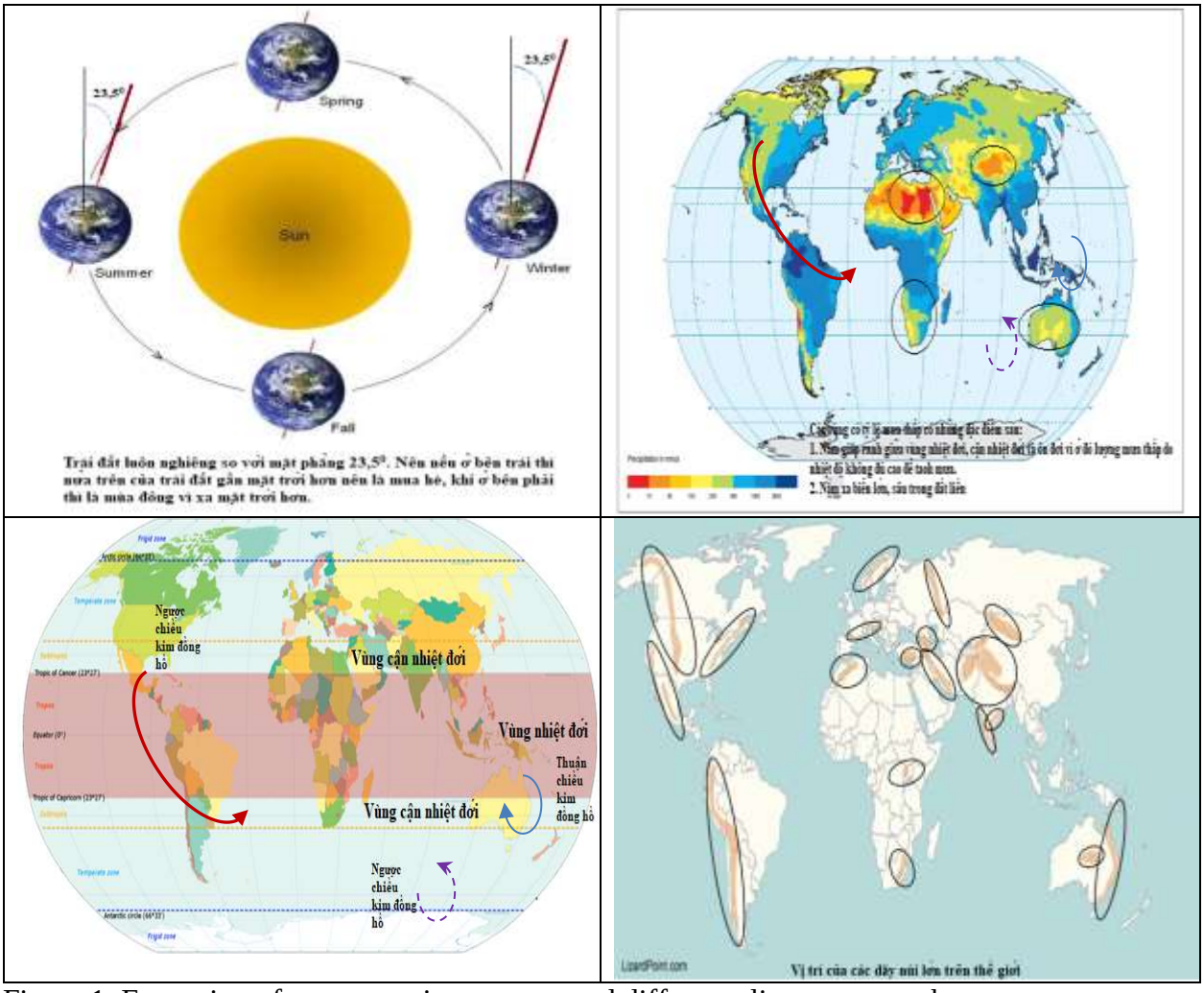


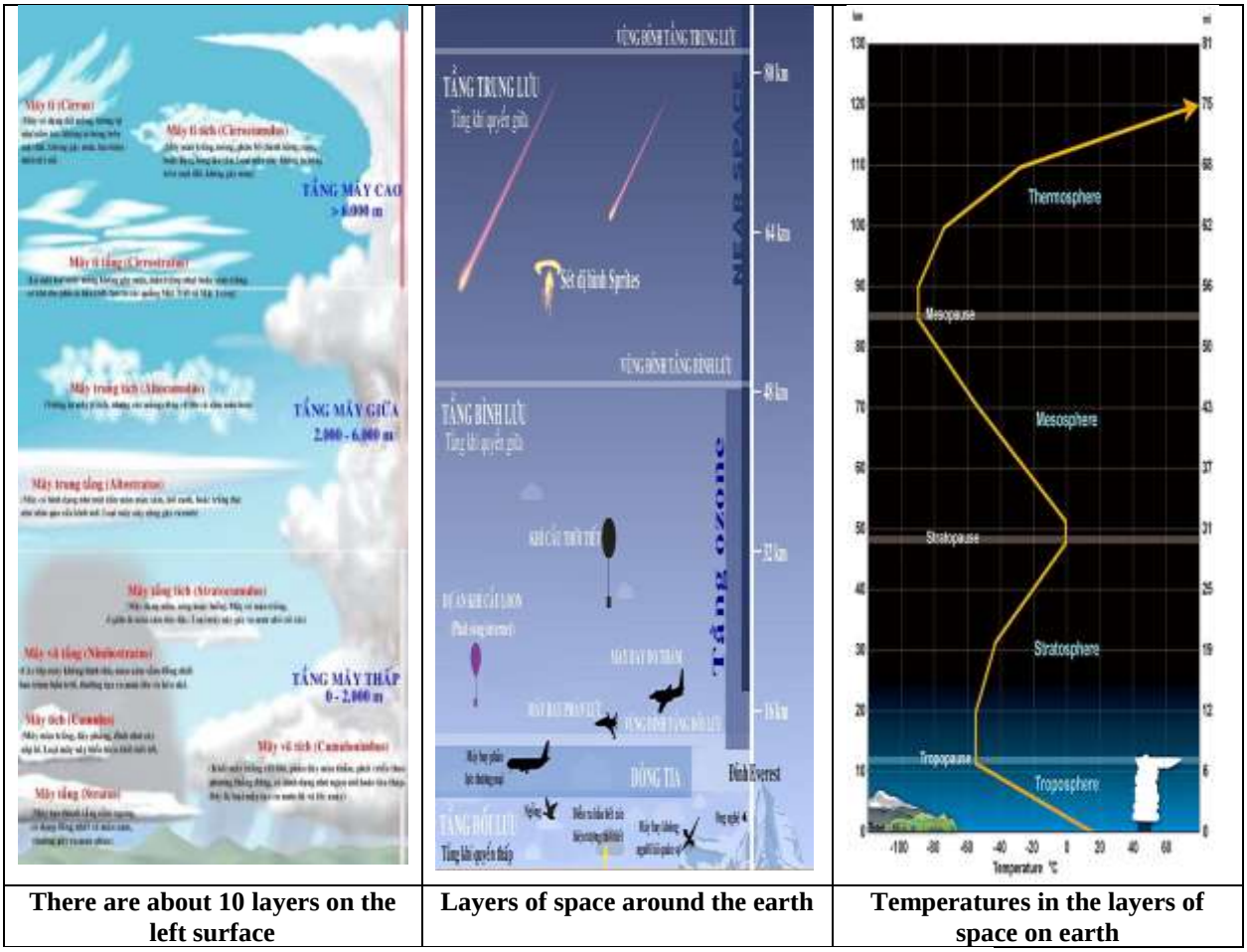
Figure 1. Formation of seasons, rains, storms, and different climates on earth

Four main climate zones including tropical, sub-tropical, temperate, and artic and some sub-climate zones including deserts have been formed because of three main reasons below:

- The closer to the equator, the closer to the sun, creating higher the temperature regions.
- The closer to seas, not covered by mountains, narrow width...creating regions with more rains and storms.
- Far to seas with large land areas and shielded by high mountains….creating regions with dry, with little rain, drought and/or desertified.

2. Formation of rain, storm, flood and lightning

Rains are formed by clouds. Clouds are accumulations of water vapor rising from the earth surface, for example seas, rivers, lakes and ponds. When the amount of water accumulates less, the light clouds are formed and usually at a very high position over earth surface (more than 6 km) where the temperature are around -55ºC. The water vapor accumulates for a long time, and the clouds become heavier, gradually lower altitude and move towards hotter air spaces. At the hotter spaces, ice cubes fall, and collide with the surrounding air and temperature, producing rain in the form of "water" and "ice" if the ice has not melted quickly enough.



There are about 10 layers on the left surface	Layers of space around the earth	Temperatures in the layers of space on earth

Figure 2. Atmospheric layers, cloud layers, and temperatures around the earth

Storms are formed when there are 3 conditions: temperature, humidity, and vortex forces. Therefore, the stormy area will be in the latitude range of 5 - 20 degrees on either side of the equator because:

- The temperature of above 26 degrees Centigrade (26ºC) is hot enough for seawater to evaporate quickly and form clouds.
- The Coriolis force is srong enough to vortex the clouds.

The main components of a storm include the rain bands at the outer edge, the eye of the storm in the center, and the eye wall right next to the eye of the storm. Storms are distinguished by wind speed through three main categories:

- Tropical depression: wind speed below 60 km/h

- Tropical storm: wind speed from 60 - 120 km/h
- Sea storm: wind speed over 120 km/h.

The mass of air in the vortex around a storm can be about 200 km wide, 1000 km long, and 10-12 km above the ground. The storms usually last for days, up to 2 or 3 weeks, and range in diameter from 15 km to 500 km. The travel distance of storms is usually greater than 1000 km, sometimes up to 3000 km.

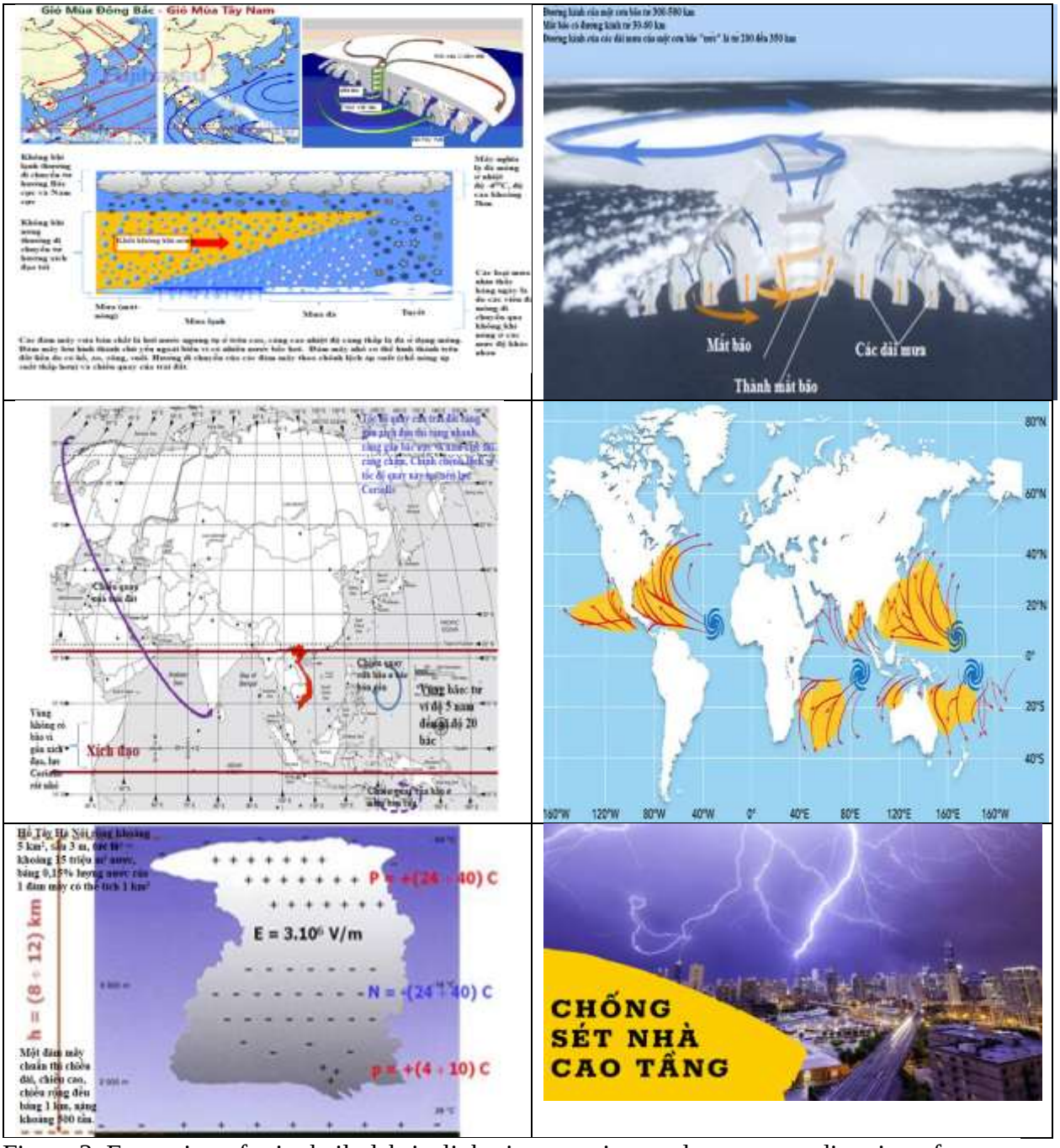


Figure 3. Formation of rain, hail, debris, lightning, rotation, and movement direction of storms

Heavy rains and storms form due to low-level clouds, usually below 2-3 km with temperatures around 0^0C, just enough to freeze in thin forms. Rain and storms move from areas of high air

pressure (thicker and denser at sea) to low pressure (thinner air inland). When entering thin air areas with soil, mountains and plains, rain and storms will weaken and disappear because there is not enough water to evaporate.

The water weight of a small rain cloud is 7 times greater than the water volume of West Lake in Hanoi. The water weight of a small storm is equivalent to more than 100 times the water volume of West Lake in Hanoi. Besides the reduced forest area, sea level rise due to increase in earth temperature, high flood-tide due to the attraction of the moon, heavy rain and storms lead to rainwater falling a lot, beyond the capacity of lakes and rivers, drainage system... leads to phenomena such as flash floods, pipe floods, mountain landslides, and landslides, in many areas.

When there is heavy rain or heavy storm, it is often accompanied by lightning. Lightning occurs due to the formation of large bulk charges. The main source of lightning is rain clouds that carry positive and negative charges in the upper and lower parts of the cloud. The mass changes are caused by the steam cooling of the upward hot air stream, creating positive and negative ions. When the potential difference at any point of the cloud reaches a critical value for the insulating properties of the air (with normal atmospheric pressure, about 3,106 V/m), that point occurs lightning.

Because the clouds of rain and storms have low altitudes, areas blocked by high enough mountains (over 2km) usually do not have rain and high temperatures, so these areas are prone to drought. Areas with little rain are often deserts, covered by high mountains, without good water storage and irrigation systems, and very few trees, and often have a drought. Drought is classified into four types: meteorological drought, agricultural drought, hydrological drought, and socio-economic drought.

3. Damage of heavy rains and storms to life and agricultural production in Vietnam

Vietnam is located in the tropical belt in the northern hemisphere, with a coastline of nearly 3,000 km from North to South, facing the Pacific Ocean, the largest ocean on earth. The width of the country is narrow. The plains are narrow and long.Except for the Mekong Delta region, behind the narrow plains are mountains, plateaus, and midlands. Therefore, Vietnam is one of the few countries in the world that suffers from almost all types of natural disasters, especially heavy rains and storms. The Mekong Delta is located near the equator, with few mountains, so it is less affected by heavy rains and storms but is greatly affected by sea level rise and flood tide.

Vietnam has an average of 5 - 6 storms and 2 - 3 tropical depressions every year. There might be up to 12 storms and tropical depressions in a year. Storm season normally starts in June and ends in late November or the first half of December. Storms most often occur in August, September, and October. The average direction of storms also varies by season. From January to May, storms are less likely to affect Vietnam. From June to August, storms often affect the Northern region. From September to November, storms mainly affect the Central and Southern regions.

Figure 4. Map of mountains and plains of Vietnam

Due to the geographical location, heavy rains and storms have the most influential to the Central region, followed by the North and finally the South . More than 70% of Vietnam's population (more than 65 million people) is affected by natural disasters. From 2000 to 2020, natural disasters in Vietnam killed more than 13,000 people (more than 300 deaths and missing every year), and property damage was estimated at more than 6.4 billion USD (1-1.5% of GDP). The average damaged area of rice, crops, and fruit trees is about 400,000 ha/year. More than 30,000 hectares of aquaculture are damaged on average per year. More than 1 million poultry and 40,000 cattle are damaged anually.

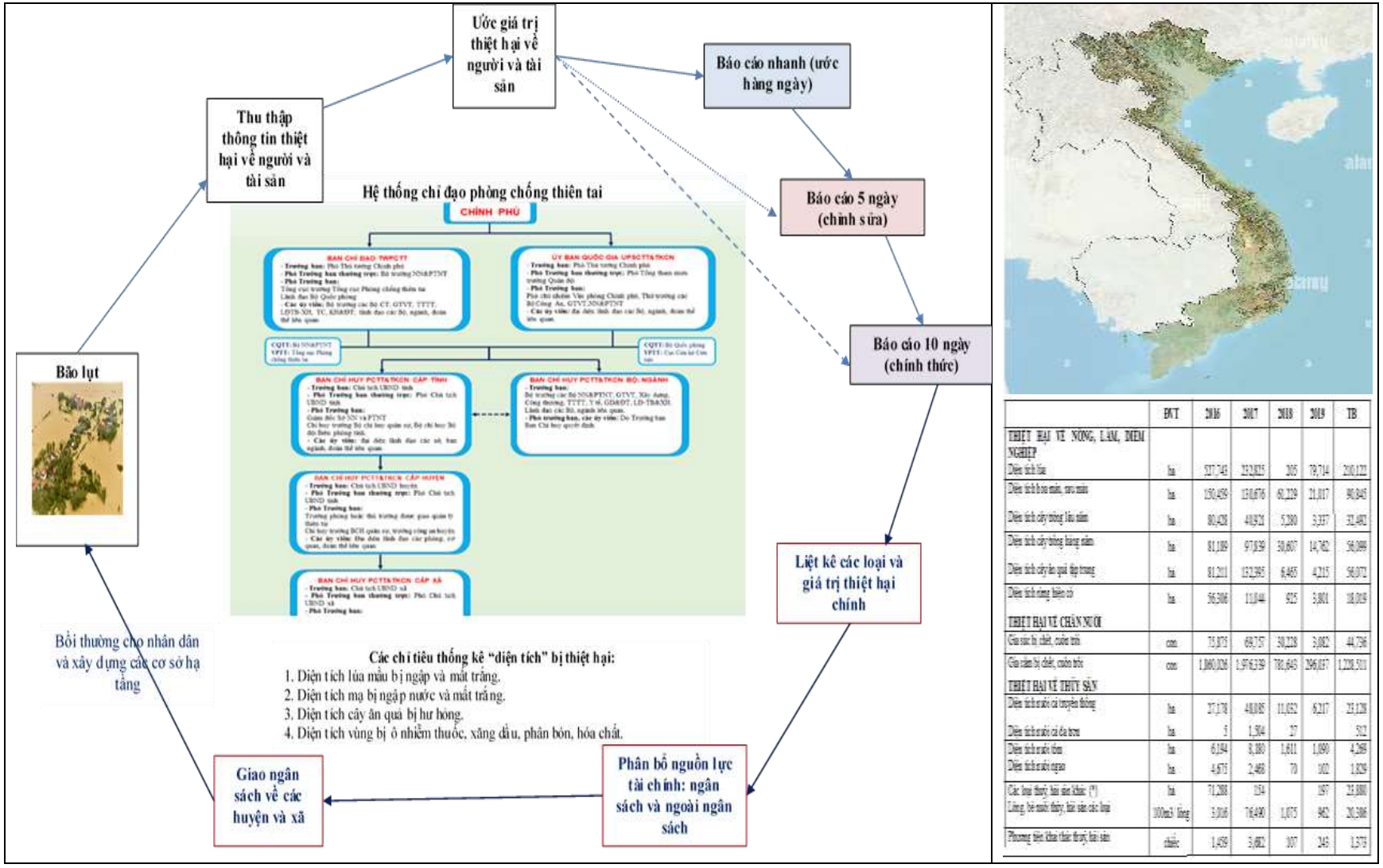
Figure 5. Some pictures of flood types in Vietnam

Flash floods and landslides occurred in most of the mountainous and midland provinces. From 1953 to 2000, there were 448 flash floods and landslides (an average of 7 events/year). From 2000 to 2015, there were 250 flash floods and landslides (an average of 15-16 events/year), killing 779 people and injuring 426 people. In 2018, in the northern mountainous provinces, there were 14 flash floods and landslides, killing and injuring 82 people (accounting for 70% of the total number of deaths and injuries caused by flash floods and landslides across the country). Flash floods and landslides happen every year and tend to increase.

Figure 6. Some pictures of floods, mountain landslides, landslides, and droughts in Vietnam

4. Disaster prevention management system and damage statistics in Vietnam

Vietnam has built a disaster prevention system from the government (central level) to the commune level (grassroots level) to respond to abnormal weather phenomena. By design, administrative data and reports are updated continuously with a frequency of 1 day, 5 days, and 10 days. The current disaster prevention system is based on "estimates" data with nearly 100 different indicators, including 4 indicators of areas. According to the assessment of state management agencies, these estimates have very low accuracy, especially in terms of "area", many indicators are difficult to estimate, for example "number of fallen power poles", “number of houses collapsed”, “value of damage”. The Ministry of Agriculture and Rural Development is increasing the application of different technologies to better predict, prevent and support damages, including remote sensing technology.



	ĐVT	2016	2017	2018	2019	TB
THIỆT HẠI VỀ NÔNG, LÂM, DIÊM NGHIỆP						
Diện tích lúa	ha	527,345	252,825	205	79,714	210,122
Diện tích hoa màu, rau màu	ha	150,456	134,676	61,229	21,017	91,845
Diện tích cây công nghiệp lâu năm	ha	80,428	40,852	5,200	3,337	32,482
Diện tích cây công nghiệp hàng năm	ha	81,189	97,859	38,607	14,742	58,099
Diện tích cây ăn quả tập trung	ha	81,211	152,395	6,465	4,215	56,072
Diện tích rừng bị cháy	ha	56,506	11,044	925	3,801	18,019
THIỆT HẠI VỀ CHĂN NUÔI						
Gia súc bị chết, cuốn trôi	con	73,873	69,757	30,228	3,002	44,790
Gia cầm bị chết, cuốn trôi	con	1,000,026	1,974,539	781,645	296,037	1,228,561
THIỆT HẠI VỀ THỦY SẢN						
Diện tích nuôi cá truyền thống	ha	37,178	48,085	11,652	8,217	25,283
Diện tích nuôi cá đặc trưng	ha	5	1,504	37		512
Diện tích nuôi tôm	ha	6,184	8,180	1,611	1,060	4,259
Diện tích nuôi ngao	ha	4,675	2,468	70	102	1,829
Các loại thủy hải sản khác (*)	ha	71,288	154		197	23,880
Lồng bè nuôi thủy hải sản các loại	100m3 lồng	3,016	76,400	1,075	962	20,366
Phương tiện khai thác thủy hải sản	chiếc	1,459	3,482	107	245	1,573

Figure 7. Vietnam's Disaster Prevention System

5. Current status of application of remote sensing/mapping technology in agriculture in Vietnam

5.1. Current status of technology application to collect agricultural statistics

Agricultural statistics mainly uses the method of collection through administrative reports or statistical surveys. The administrative statistical system is usually built from the village level up to the central level (usually a ministry agency). The form of collection is through report forms, accompanied by questions or statistical indicators. This administrative system operates regularly, reporting frequency is usually once a month. In collected indicators, there are indicators on damages caused by natural disasters such as "area of rice completely lost", and "area of forest completely lost".

Statistical surveys (population and sample) are usually done periodically, quarterly, annually, every 2 years, every 5 years, or every 10 years. The method also uses questionnaires and online forms.

Statistical surveys or administrative reports have been using information technology such as online websites, smartphones, and mobile messages to send and receive questions and answers, gradually reducing the use of paper copies and face-to-face interviews.

5.2. Current status of application of remote sensing/mapping technology in agricultural statistics

The General Statistics Office (under the Ministry of Planning and Investment) and the General Department of Irrigation (under the Ministry of Agriculture and Rural Development) use “simple” technologies to measure hydrometeorology for example water levels in rivers and lakes, roads; rainfall in different regions… It seems that these agencies have not used remote sensing technology to measure the area of crops, weather conditions of regions in Vietnam.

The Center for Informatics and Statistics (CIS), under the Ministry of Agriculture and Rural Development, has collaborated with AFSIS (Food Security Organization for Southeast Asia) monthly since 2014 in many activities, including writing the “Rice outlook” report, which describes changes in rice area in Vietnam and causes of the changes. CIS occasionally use the JASMIN’s precipitation monitoring map to see whether the descriptions or explanations in the”Rice outlook” report make sense or not.

The Japan Aerospace Exploration Agency (JAXA) also collaborated with CIS, with funding from the Asian Development Bank (ADB) to provide the results of remote sensing on rice production and yield in Thai Binh sample province from 2015-2019. The results have also been published in many national and international conferences and research journals. However, after the project ended, no further relevant activities were carried out.

Since October 2018, CIS has cooperated with the Center for Space Technology Application (under the Vietnam Space Center, the Academy of Science and Technology of Vietnam) on the comparison of rice area data according to administrative and remote sensing reports for provinces in the Mekong Delta. This remote sensing data is also sent monthly to the Department of Crop Production (under the Ministry of Agriculture and Rural Development).

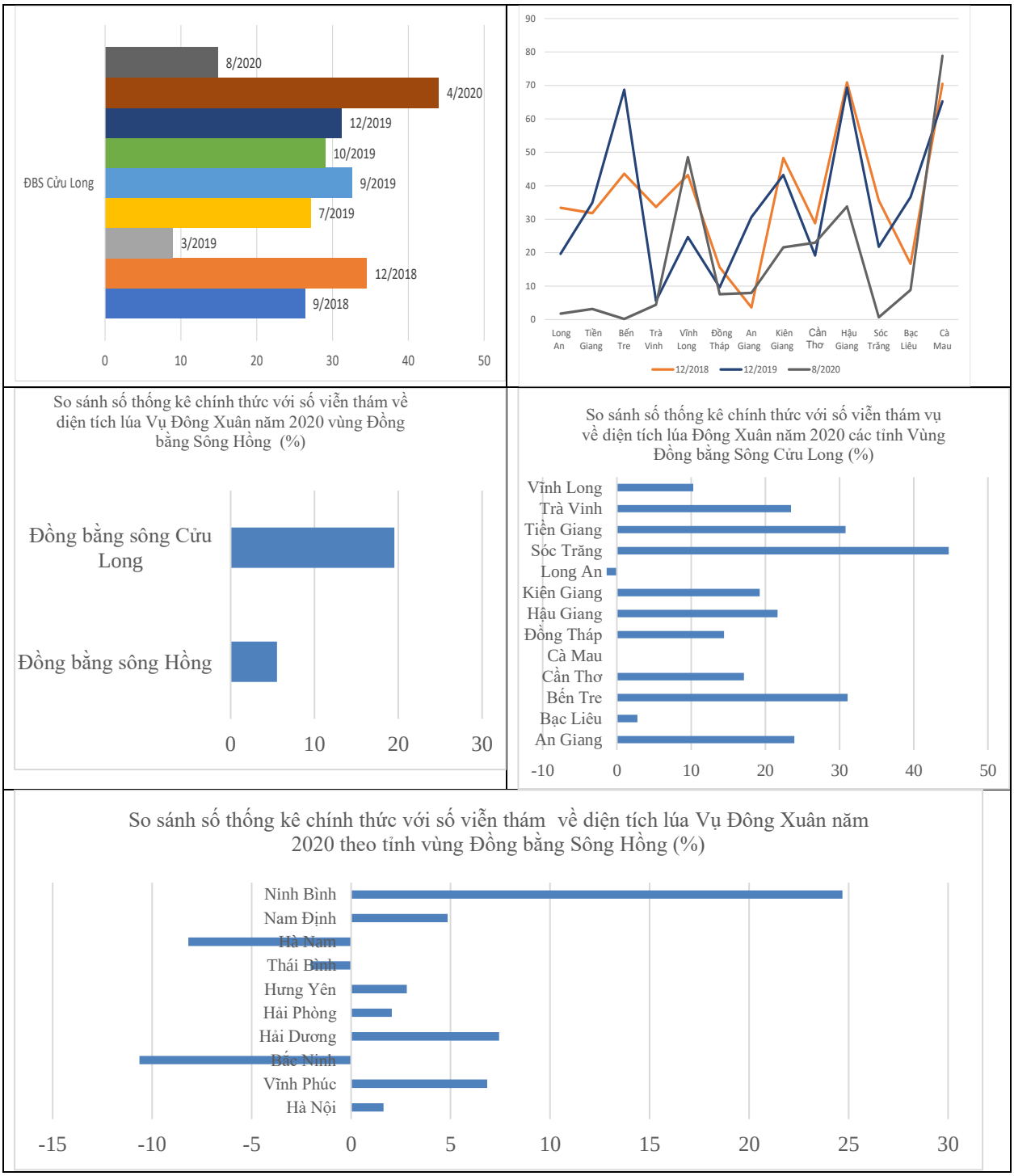


Figure 8. Comparison of remote sensing numbers of the Center for Space Technology Application and the number of administrative reports of the Center for Informatics and Statistics

From June 2021, with the introduction of CIS, the Space Technology Application Center started providing rice data and maps to the private company named AGROMONITOR about agriculture, forestry, fishery market information. From July 2021, with the introduction of CIS, the Center for

Space Technology Application began to provide rice data and maps to the Department of Agriculture and Rural Development of Hung Yen province.

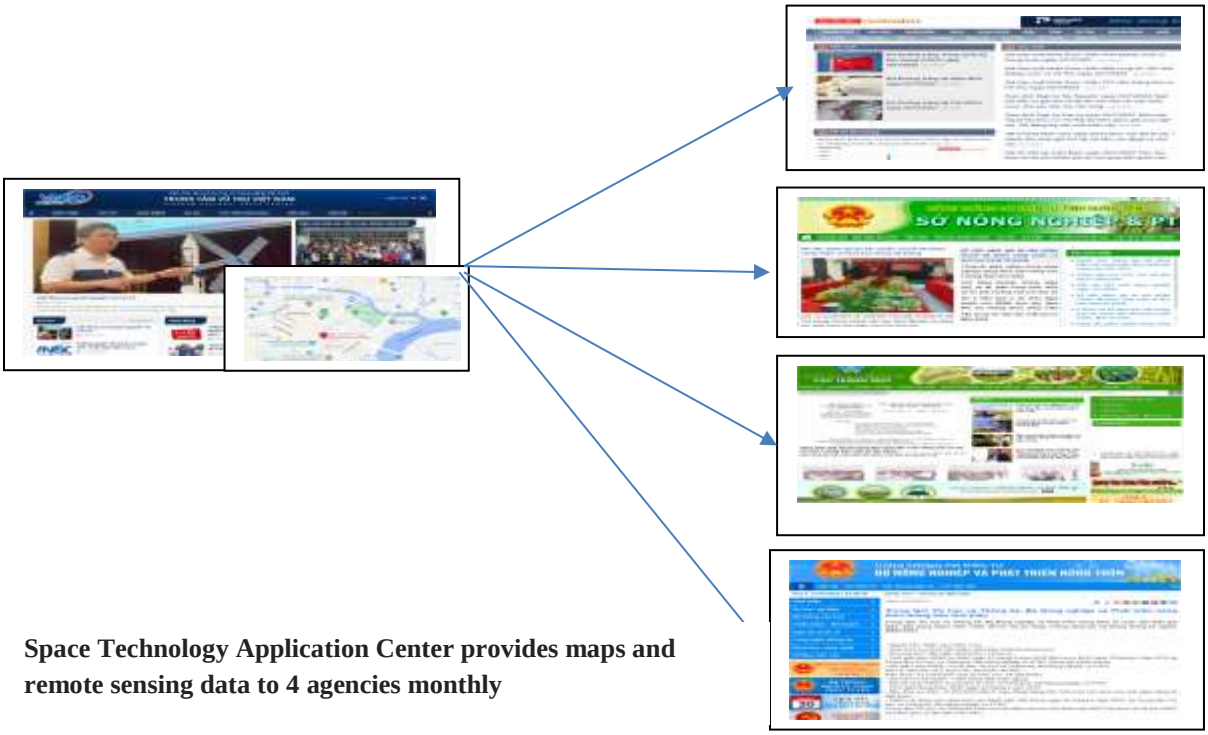


Figure 9. Remote sensing units of the Center for Space Technology Application

6. Using JASMIN's remote sensing map "testing" for the case of Vietnam

6.1. Introduction to JASMIN

JASMIN is a mapping system produced by JAXA from June 2013 to present on climate and weather to serve the needs of FAO for agricultural market monitoring. This system includes about 6 main indicators on climate, updated every 2 weeks for East Asia, Southeast Asia, and South Asia.

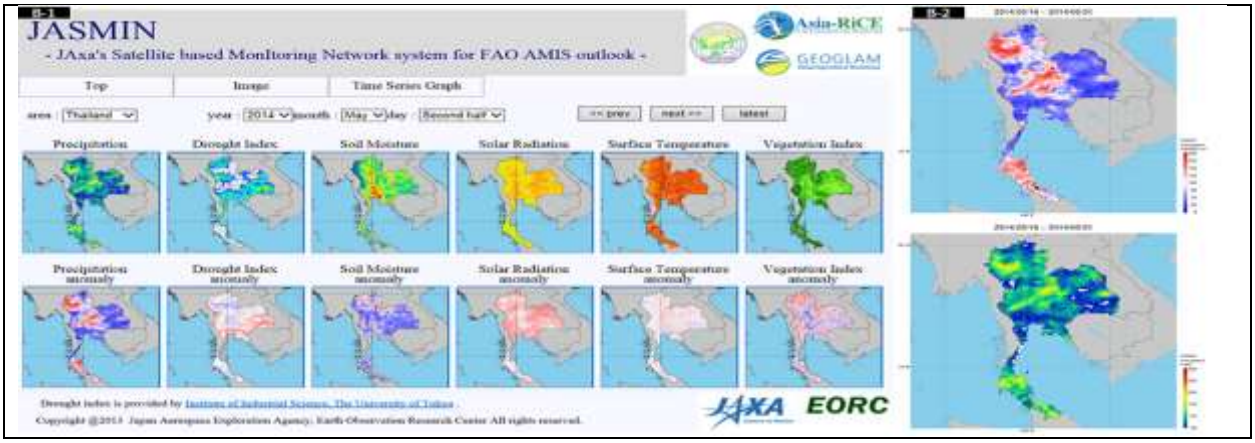


Figure 10. Map and Data Website of JASMIN

6.2. Use JAXA JASMIN map/data test and compare with administrative numbers, online news

Currently, remote sensing tools have not been widely used in disaster damage statistics. In March 2021, the Vietnam Space Center started working with the General Department of Disaster Prevention and Control, but the results are currently unclear. The Center for Informatics and Statistics used the rainfall data from JAXA's JASMIN map and compared with that data from the General Statistics Office (GSO). The result isshown as below.

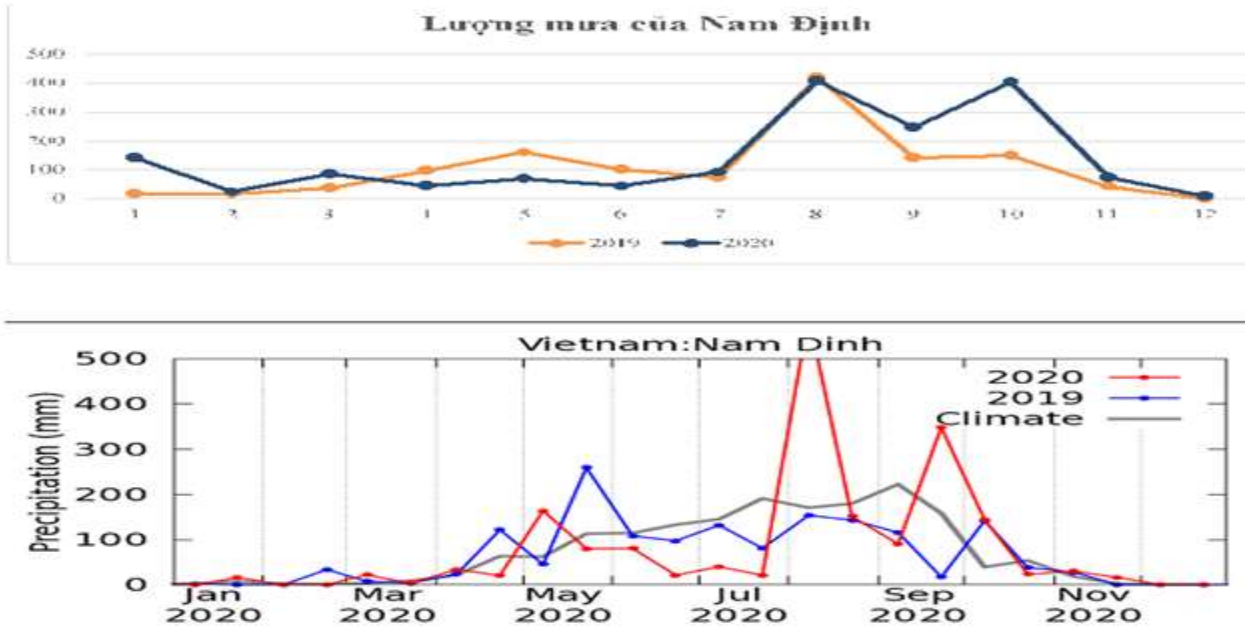
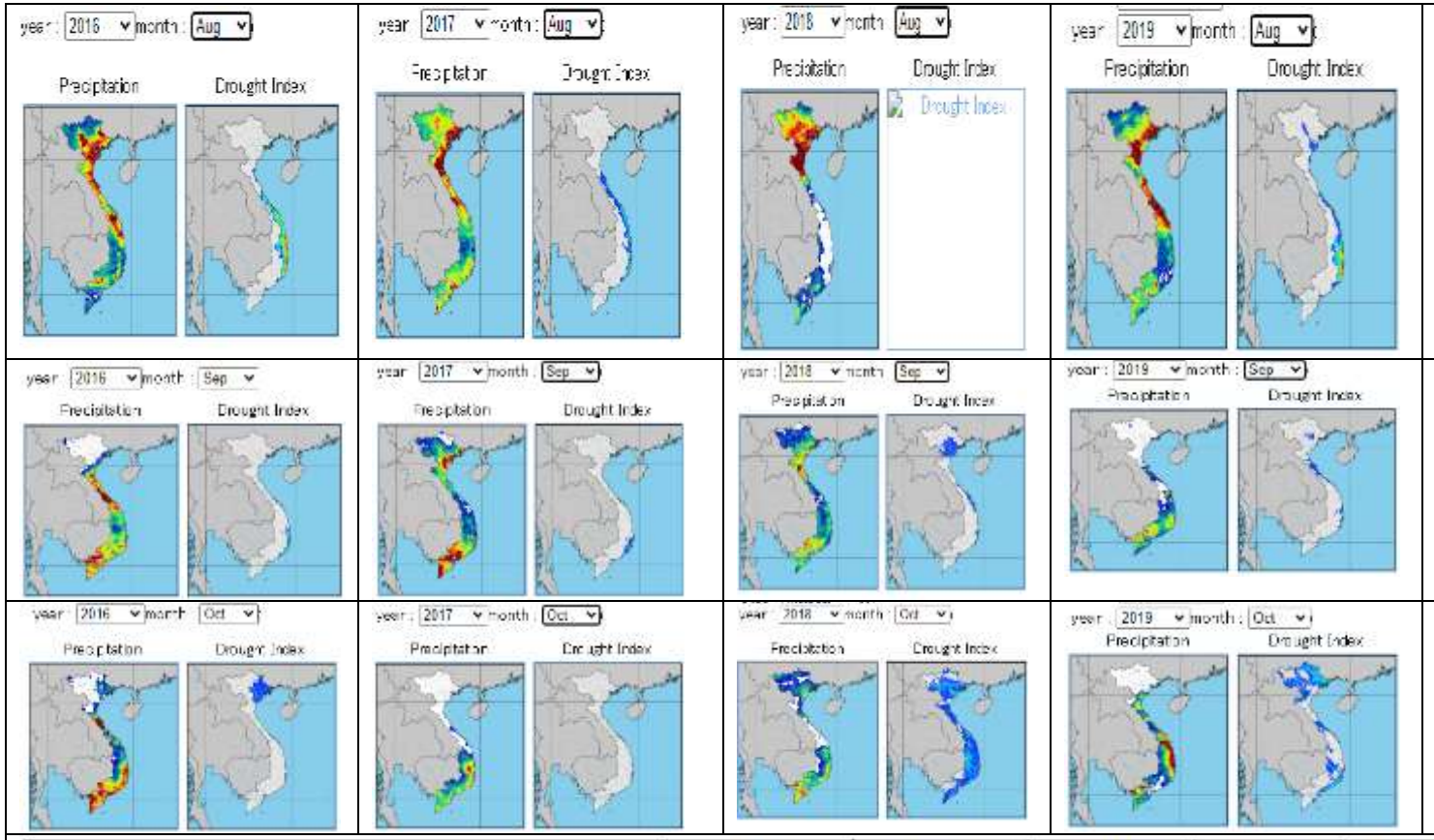


Figure 11. Comparison rainfall data between GSO and JASMIN map

The figure above shows the difference in rainfall data between the statistics of GSO and statistics using remote sensing technology. Specifically, with GSO data, the highest average amount of rainfall in Nam Dinh province was recorded in August and October 2020 with a total rainfall of 400mm. However, with remote sensing images in August 2020, the total rainfall of Nam Dinh is over 500mm. Compared with reality and online news, in August 2020, Vietnam suffered the No. 4 storm that directly affected the Northern region. JAXA's JASMIN map is more reasonable because it clearly sees the difference in "rainfall" between 2020 and 2019 and coincides with the news of the official newspapers reporting on storms and floods.



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Diện tích lúa	ha	327,743	232,825	205	79,714	210,122
Diện tích hoa màu, rau màu	ha	130,459	130,676	61,229	21,017	90,845
Diện tích cây trồng lâu năm	ha	30,428	40,921	5,280	3,337	32,492
Diện tích cây trồng hàng năm	ha	81,189	97,839	30,607	14,762	56,099
Diện tích cây ăn quả tập trung	ha	81,211	132,395	6,465	4,215	56,072
Diện tích rừng hiện có	ha	56,306	11,044	925	3,801	18,019
THIỆT HẠI VỀ CHĂN NUÔI						
Gia súc bị chết, cuốn trôi	con	75,875	69,257	30,228	3,082	44,736
Gia cầm bị chết, cuốn trôi	con	1,860,026	1,976,339	781,643	296,037	1,228,511
THIỆT HẠI VỀ THỦY SẢN						
Diện tích nuôi cá truyền thống	ha	27,178	48,085	11,032	6,217	23,128
Diện tích nuôi cá da trơn	ha	5	1,504	27	6,217	512
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Các loại thuỷ, hải sản khác (*)	ha	71,288	154	154	197	23,880
Lồng, bè nuôi thủy, hải sản các loại	100m3/ lồng	3,016	76,490	1,075	962	20,386
Phương tiện khai thác thuỷ, hải sản	chiếc	1,459	3,682	107	243	1,373

Các số liệu thống kê hành chính về "thiệt hại" tăng giảm rất "sốc", lúc có và lúc không có. Các số liệu hành chính cũng ít cập nhật công khai trên website đúng định kỳ để người đọc có thể tự tổng hợp và tự kiểm tra được

Figure 12. Comparison of JASMIN rainfall and drought maps with administrative data on disaster damage in August, September, and October in 2016, 2017, 2018 and 2019

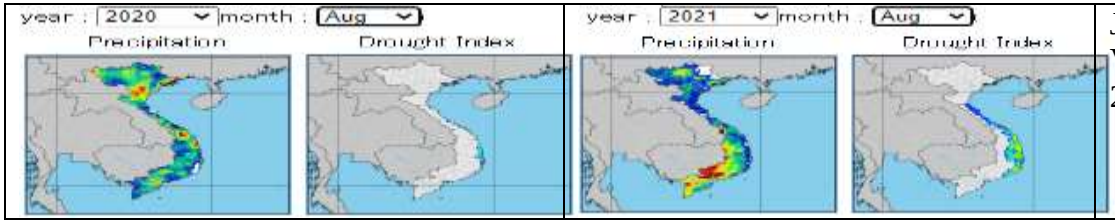
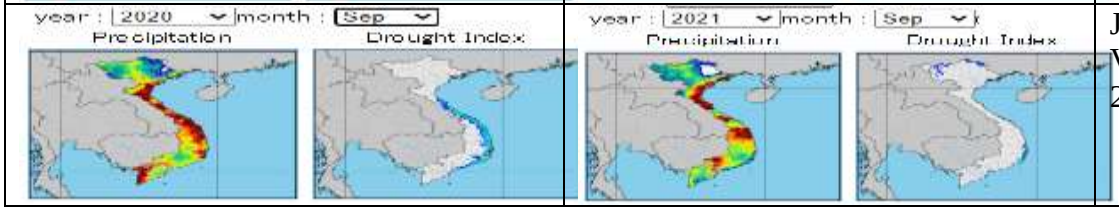
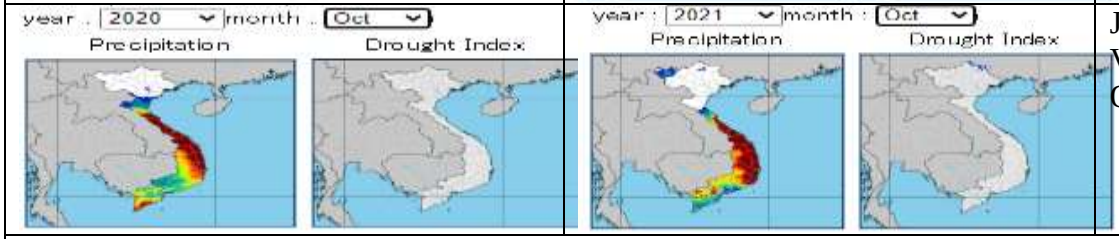
		JAXA's map accurately reflects online news in Vietnam with little rain in August and September 2020 and 2021.
		JAXA's map accurately reflects online news in Vietnam with unusually heavy rain in September 2020.
		JAXA's map accurately reflects online news in Vietnam with very heavy and unusual rain in October 2020 and 2021.
The flood in the Central region in 2020 (also known as the double flood, historical flood) is a storm and flood throughout Central Vietnam, starting from the late night of October 6–early morning of October 7, and lasting until December 1, 2020, mainly in the North Central region including Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, and Thua Thien Hue; a part of the South Central region including Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen provinces, and North Central Highlands. During October and November, tropical depression circulation, monsoon, and tropical cyclone formed and continuously fluctuated in the East Sea. Starting with two waves of low pressure and storm Linfa in just one week, the historic flood of 2020 was complicated with many low pressures and big storms in October such as typhoon Nangka, storm Saudel, and storm Molave; then in November with storm Goni, storm Etau, storm Vanco, heavy rainfall poured into the area, causing many localities in the Central region to be flooded on a large scale. The flood water rose in many places, dividing the areas. During the first flood from October 6 to 13, the central provinces were seriously affected from damage to facilities and infrastructure, to damage to people and property, adversely affecting people's lives. The second flood from October 16, the Central region continues to be affected by a new tropical depression in the process of turning into a storm with cold air, constantly receiving heavy rains and prolonged flooding. In some central regions, the water level exceeded the historical record in 1979, and 1999, setting a new record for natural disasters, storms, and floods. The third flood occurred on October 25, with two storms making landfall, especially the severe storms of typhoon Molave on October 28 and 29, causing enormous damage. This was followed by the fourth flood on November 6, causing upheaval in the whole Central region, especially shifting the location to the South Central region. The floods in Central Vietnam in 2020 are considered a new historical flood, set at alarming level IV- the dangerous and very high-risk natural disaster level in Vietnam, affecting far-reaching and damaging effects, causing damage to the whole region, destroying, delaying, and pushing back the socio-economic of Central Vietnam, especially in localities such as Quang Binh, Quang Tri, Thua Thien Hue, Da Nang, Quang Nam, and Quang Ngai, which were not long ago hot spots of the second wave of COVID-19 pandemic in Vietnam.		

Figure 13. Comparison of JASMIN rainfall and drought maps with online news published by mainstream newspapers in Vietnam for the months of August, September, and October in the years 2020 and 2021

7. Conclusion

Vietnam has a geographical location that converges many factors, which are very suitable for natural disasters related to heavy rain and storms such as the long coastline from north to south, facing the Pacific Ocean (the largest ocean in the world). The width is narrow plains. Behind the narrow plains are mountains, plateaus, and midlands. Vietnam is located almost entirely in the north of the sea and has a tropical climate, where there is a very large air vortex force. Vietnam has a lot of heavy rain, from 9 to 12 big storms/year. Therefore, more than 70% of Vietnam's population (more than 65 million people) is heavily affected by heavy rains and storms, with an average depth and disappearance of over 300 people per year. On average, in the last 5 years, property damage is estimated at more than 6.4 billion USD/year. Before 2016, Vietnam had an average of 7 flash floods per year. From 2016 to now, Vietnam has an average of about 15 flash floods per year with more than 100 deaths. The average damaged area of rice, crops, and fruit trees is about 400,000 ha/year. More than 30 thousand hectares of aquaculture are damaged on average per year. More than 1 million poultry and more than 40,000 cattle are damaged on average per year.

Vietnam has a disaster prevention system from the commune level up to the government level. The losses submitted in that system are “administrative” figures and are compiled and “estimated” by statisticians at each level. State management agencies consider the "estimated" data to be inaccurate when compared with the actual survey and application of "sample" testing technology. Vietnam is increasing the use of remote sensing technology to estimate the damage caused by natural disasters, specifically the General Department of Natural Disaster Prevention and Control from March 2021. Currently, the Vietnam Center for Space Technology Application has provided remote sensing data and maps but has only focused on the rice area for a private company (Agromonitor) since June 2021 and a Department of Agriculture and Rural Development (Hung Yen Province) from July 2021. The Center for Informatics and Statistics is also storing monthly remote sensing data on the area for rice from October 2018 to the present.

This report uses experimental maps of two basic indicators, namely rainfall and drought, made by JASMIN of JAXA from June 2013 to the present. Since administrative statistics are only compiled by year and published since 2016, this report compares data from JAXA's JASMIN map with the data from administrative reports for the whole country in the frequent stormy months including August, September, and October, from 2016 to 2019. Through comparison, the report finds that data observed by JAXA's JASMIN map is more systematic, up-to-date, reflecting more accurately the fluctuations of the weather. Finally, JAXA's JASMIN maps are more consistent with information posted on official websites about the evolution of storms and damage caused by natural disasters in Vietnam. Because JAXA's JASMIN maps have been made available online and free of charge since June 2013, a lot of promotional activities are needed to make the maps and accompanying data available to users.