Analysis of spatio-temporal distribution characteristics and fog forming conditions of Zhejiang coast in recent ten years

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Abstract. Based on the hydrometeorological observation data of Zhejiang coastal observation station from 2009 to 2018, the temporal and spatial distribution characteristics and fogging conditions of sea fog along the coast of Zhejiang Province were analyzed in this paper. The result shows that the average annual fog day along the coast of Zhejiang Province is 112 days according to the situation that the sea fog occurs as long as there is one station along the coast of Zhejiang Province. The fog season is from March to June and the sea fog occurs in the middle of the night and early in the morning. The spatial distribution of sea fog along the coast of Zhejiang Province is more in the middle of the two ends and the average annual fog days of each station are in the range of 19.2-82.0 days. Under the condition of fog, most of the relative humidity in Zhejiang coastal area is greater than or equal to 90%, the average temperature difference between gas and water is -0.5 - 2.1℃, and the direction of fog wind is mainly eastward. More than 93.6% of the sea fog occurs under the condition that the wind force is less than or equal to level 5. There are four main types of weather situation affecting the occurrence of sea fog in coastal areas of Zhejiang Province, including inverted trough type, low pressure sea exit type, weak cold air type and high-pressure sea entry type. When the continuous sea fog process occurs, the weather situation usually goes through the high-pressure sea entry type, the inverted trough type and the low pressure sea exit type. The wind direction will change with the variation of weather situation and the wind force will be less than or equal to 4 levels. When the wind is greater than level 5, the wind changes from west to southwest, and the sea fog tends to dissipate. Thick fog or strong fog occurs mainly in the middle of the night, early in the morning and around the evening.

1. Introduction
Fog is a large number of water droplets or ice crystals suspended in the near ground layer, which is the main factor affecting visibility [1]. Sea fog refers to fog generated at sea or on the coast or island area under the influence of the sea [2]. Sea fog occurs when horizontal visibility is less than 1 km. There are many types of sea fog, such as advection fog, mixed fog, radiation fog, topographic fog [2] and evaporation fog at sea. The sea fog affecting the coast of Zhejiang Province is mainly advection fog, radiation fog and front fog, among which advection fog is the most common [1], that is, warm air flows through the cold sea surface to produce fog [2]. The study of the formation conditions of sea fog is generally aimed at advection fog [2-4]. Since the type of fog is not distinguished at the time of observation, all the fog observed in the coast is statistically analyzed as a sea fog [5].

The fog is a strong and severe weather phenomenon [6]. The heavy fog results in low visibility of the near-ground floor, which is a high risk for aviation, road traffic, and marine shipping. The sea fog occurring along the coast, directly affects the navigation of ships and the production of coastal
industry, fisheries, agriculture and so on. According to the International Maritime Organization, 70% of maritime accidents are caused by sea fog. Therefore, the sea fog is called gentle knife' [7]. As shown in [7-16], the study of sea fog in the Yellow Sea is more systematic and comprehensive, while the study of sea fog along the coast of the East China Sea [17] is relatively few. The data used in the analysis of sea fog along the coast of Zhejiang Province are mainly concentrated before the 1990s, or in small areas such as Zhoushan [18-20], Ningbo [21].

Therefore, based on previous studies, this paper made use of the real-time observation visibility data of several marine observation stations along the coast of Zhejiang Province in the past 10 years. This paper has a relative advantage in the degree of data updating and data continuity. Moreover, this paper summarized the characteristics and laws, which provides a better reference for the warning service of coastal sea fog in Zhejiang Province.

2. Data and methods

In this paper, the real-time observation data of Xiaoqushan, Beilun, Dachen, Kanmen, Wenzhou and Shipeng observation stations along the coast of Zhejiang Province from 2009 to 2018 (shown in Figure 2-1) were selected for research and analysis. The observation data (as shown in Table 2-1) include visibility, wind direction, wind speed, water temperature, air pressure and relative humidity. Air temperature, air pressure and humidity are sometime missing. Because the observed records do not distinguish the types of fog, the correlation analysis in this paper is aimed at all processes of sea fog.

According to the contents of effective visibility and fog observation in the tenth part of the Seaside observation Code, it is considered that the visibility less than 1 km is the occurrence of fog, and it is defined that a time visibility less than 1 km, is recorded as a fog day. The duration of the fog is from the beginning to the end of the fog. In a sea fog occurrence process, the fog interruption is not more than 3 hours and it is considered that the sea fog continues. Sea fog duration days is the days of continuous appearance of sea fog [14]. The standard of fog season: when the relative frequency of monthly fog days (monthly fog days/annual fog days) is more than 10%, that month is fog season [5].

Located in the middle of the subtropical zone, the coastal area of Zhejiang is between 27° 02’~ 31° 11’ north latitude. With four distinct seasons, Zhejiang coastal, belongs to monsoon humid climate. The seasonal division shows that winter is from December to February of the following year, spring is from March to May, summer is from June to August and autumn is from September to November. The daily variation is divided into 6 periods of day: 5:00-8:00, 9:00-12:00, 13:00-16:00, 17:00-20:00, 21:00-24:00 and 01:04:00.

Table 2-1 Data description of Zhejiang coastal observation station

| station  | the length of the data | air temperature, air pressure, humidity missing measurement |
|----------|------------------------|-------------------------------------------------------------|
| Xiaoqushan | 2009.1.1-2018.12.31    | ———                                                         |
| Beilun   | 2009.1.1-2018.12.31    | 2.1-5.31, 2010                                              |
| Dachen   | 2009.6.13-2018.12.31   | 9.1-10.31, 2009; 2.1-5.31, 2010                             |
| Kanmen   | 2009.1.1-2018.12.31    | 2.1-4.30, 2010                                             |
| Wenzhou  | 2009.6.1-2018.12.31    | 9.1 -10.31, 2009; 2.1 -4.30, 2010                          |
| Shipeng  | 2009.2.1-2018.12.31    | 9.1 -10.31, 2009; 2.1 -4.30, 2010                          |
3. Temporal and spatial variation characteristics of sea fog along the coast of Zhejiang Province

3.1. Time variation characteristics

3.1.1. Interannual variation  According to the six stations along the coast of Zhejiang Province, as long as there is one site where sea fog occurs, there is sea fog occurring. The analysis shows that the average fog day in Zhejiang coastal area is 112 days, but the interannual difference is significant, with a maximum of 150 days in 2012 and 65 days in 2017 (as seen in Figure 3-1). In addition, the interannual differences of each site are also significant (Table 3-1), taking Xiaoqushan and Dachen as examples. The fog day of Xiaoqushan was 38 days in 2011 and only 2 days in 2015. The fog day of Dachen was 109 days in 2010 and 54 days in 2017. In addition, in 2010, Beilun, Dachen, Kanmen have the most fog days. The reason for this large interannual variation is closely related to the anomaly of atmospheric circulation and water temperature [1].
3.1.2. Seasonal variation Sea fog occurs along the coast of Zhejiang all the year round. From Table 3-2, it is seen that the occurrence time of coastal sea fog is mainly concentrated in spring, accounting for 40.9% of the whole year., followed by summer and winter, which account for 25.3% and 21.5%, respectively. The rate of sea fog in winter is basically the same as that in summer. Sea fog occurs least in autumn, accounting for only 12.5%.

| Season | Spring | Summer | Autumn | Winter |
|--------|--------|--------|--------|--------|
| %      | 40.9%  | 25.3%  | 12.5%  | 21.5%  |

Coastal fog days have significant monthly changes (as shown in Fig. 3-2 and Table 3-3). March to June are the fog seasons along the coast of Zhejiang Province, especially from April to June. October is the least foggy month of the year.

The above results are basically consistent with those obtained by Hou et al[1].

![Figure 3-2 The average number of foggy days per month in Zhejiang coastal, 2009 to 2018 (Unit: day)](image)

Table 3-3 Monthly variation and monthly average about the fog days in Zhejiang coastal, 2009 to 2018

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Monthly average (day) | Percentage (%) |
|------|------|------|------|------|------|------|------|------|------|------|----------------------|----------------|
| 1    | 1    | 7    | 2    | 14   | 14   | 10   | 3    | 7    | 7    | 8    | 7.3                  | 6.7            |
| 2    | 8    | 16   | 12   | 17   | 18   | 11   | 7    | 5    | 3    | 5    | 10.2                 | 9.4            |
| 3    | 2    | 14   | 8    | 16   | 13   | 13   | 10   | 12   | 8    | 14   | 11.0                 | 10.1           |
| 4    | 7    | 18   | 20   | 23   | 25   | 18   | 12   | 25   | 14   | 15   | 17.7                 | 16.2           |
| 5    | 1    | 21   | 21   | 17   | 25   | 20   | 16   | 17   | 8    | 13   | 15.9                 | 14.6           |
| 6    | 11   | 22   | 23   | 17   | 22   | 12   | 17   | 10   | 13   | 4    | 15.1                 | 13.9           |
| 7    | 9    | 18   | 6    | 9    | 3    | 9    | 6    | 3    | 4    | 2    | 6.9                  | 6.3            |
| 8    | 9    | 6    | 3    | 6    | 10   | 4    | 4    | 3    | 5    | 5.6              | 5.1            |
| 9    | 5    | 7    | 4    | 6    | 2    | 2    | 7    | 1    | 3    | 4.1              | 3.8            |
| 10   | 2    | 9    | 3    | 3    | 3    | 2    | 3    | 7    | 1    | 3.7              | 3.4            |
| 11   | 7    | 5    | 10   | 4    | 4    | 6    | 5    | 3    | 4    | 5.8              | 5.3            |
| 12   | 4    | 6    | 5    | 12   | 5    | 5    | 5    | 3    | 8    | 5.9              | 5.4            |

3.1.3. Diurnal variation Sea fog occurs at all times along the coast of Zhejiang Province, but the occurrence period of sea fog is from mainly 1:00 to 8:00. The highest probability of sea fog occurs from 5 o'clock to 8 o'clock, followed by 1 o'clock to 4 o'clock (as shown in Fig. 3-3), and the least sea fog occurs at 13 o'clock to 13 o'clock. Taking Beilun as an example, the proportion of sea fog at 5 to 8
o'clock is 30.1%, 1 to 4 o'clock is 28.7%, 13 to 16 o'clock is only 7.0%. Because the sea fog data observed by Xiaoqushan are only 8:00, 14:00 and 20:00, the time distribution is different from that of other stations. The duration of sea fog is uncertain. Generally speaking, the probability of lasting 2 to 6 hours is large, but for strong dense fog with visibility less than 50 meters, the probability of lasting 8 to 14 hours is higher [21].

3.2. Spatial distribution characteristics

As far as the distribution of fog is concerned, the coast of Zhejiang Province is a relatively foggy area. From north to south, sea fog occurs on behalf of the shore section of each site (Fig. 3-4). On the whole, there is a trend that there are two more ends in the middle (from Figure 3-4). The annual average fog days of the stations along the coast of Zhejiang are 12.9-82.0 days. The maximum annual average fog day of Dachen station is 82.0 days, and the annual average fog day of XiaoQushan is only 12.9 days. This conclusion is basically consistent with the results of Hou et al. [1], although the data used by the two are different. The spatial distribution of sea fog along the coast of Zhejiang Province is mainly closely related to the distribution of current along the coast of Zhejiang Province [1].

Dachen Station (also called Island Station), located in the middle of Zhejiang coastal area, is located at the intersection of Taiwan warm current and East China Sea coastal current, and sea fog is often formed in this cold sea area. In addition, the island also has more fog than its sea area, so Dachen Station has more fog than other stations.

4. Analysis of fog forming conditions

Because of the different properties of sea fog, the physical mechanism in the process of formation is not the same. But there are many similarities in the physical process of condensation of fog, such as turbulence effect in condensation process, radiation effect, collision and settlement of liquid water droplets. However, any kind of fog is produced under certain environmental background, including atmospheric circulation condition, water vapor condition, cushion surface condition and so on. Fog can be generated at the boundary layer only when the environmental conditions are configured [11].
This paper studied the main climatic conditions affecting the formation of sea fog, including relative humidity, wind direction and wind speed, air-water temperature difference, atmospheric circulation situation and so on.

4.1. Relative humidity
When fog occurs, warm and wet air flow is more active, air humidity is larger. Most of the fog that occurs in the early hours of the morning and at night occurs when the air is in or near saturation. But at noon, fog occurs when the relative humidity is as low as 88% [22]. Table 4-1 shows that in most cases, the sea fog along the coast of Zhejiang Province appears above 90% relative humidity, and the other small parts of the sea fog can also become fog when the relative humidity is below 80%, which is highlighted in the Shipeng station. Shipeng station stands at the southernmost end of Zhejiang coastal area, leaning towards the north of the South China Sea. The study results of He et al. [23] on the coastal sea fog in the northern South China Sea show that the atmospheric humidity over the northern part of the South China Sea decreases in the years with more sea fog days, while the atmospheric humidity over the northern part of the South China Sea increases in the years when the number of sea fog days is less. This result can prove that sea fog still occurs when the relative humidity of stone bang is low.

| Station   | Percentage of relative humidity | Xiaoqushan | Beilun | Dachen | Kanmen | Wenzhou | Shipeng |
|-----------|--------------------------------|------------|--------|--------|--------|---------|---------|
|           | ≥80                            | 99.40%     | 99.30% | 99.80% | 99.00% | 99.90%  | 80.10%  |
|           | ≥90                            | 96.50%     | 86.50% | 97.90% | 93.70% | 99.60%  | 73.40%  |

4.2. Gas-water temperature difference
Wang [2] thought that the average temperature difference between gas and water in the fog caused by advection cooling fog off the coast of China is 0.5 ℃ ≤ (ta-tw) ≤ 3 ℃ (where Ta is temperature, tw is water temperature). When (ta-tw)>5℃ or (ta-tw)<-0.1℃, fog cannot be formed. Under the condition of fog, the range of gas-water temperature difference between the six observation stations along the coast of Zhejiang Province (Table 4-2) is different. Taking Xiaoqushan as an example (ta-tw), the temperature is 9.3 ℃ ~ 8.4 ℃, (ta) is the temperature, (tw) is the water temperature. The mean value of (ta-tw) is from 2.1℃ to 0.5℃, decreasing from north to south. Therefore, the threshold of gas-water temperature difference at each station in Zhejiang coastal area is beyond the range given by Wang Binhua, which indicates that the coastal area of Zhejiang Province is not only affected by advection cooling fog, but also affected by other types such as advection evaporation fog, radiation fog, topographic fog and so on.

| Station   | Gas-water temperature difference | Gas-water temperature average |
|-----------|--------------------------------|------------------------------|
| Xiaoqushan| -9.3~8.4                        | 2.1                          |
| Beilun    | -4.4~5.8                        | 1.5                          |
| Dachen    | -4.1~8.3                        | 1.5                          |
| Kanmen    | -13~7.3                         | 1.4                          |
| Wenzhou   | -5.3~6.3                        | 0.9                          |
| Shipeng   | -12.5~10.6                      | -0.5                         |

4.3. Wind speed and direction
All the wind directions along the coast of Zhejiang Province can be fogged, and the main wind directions of fog at different observation stations are different (Fig. 4-1 ~ Fig. 4-6). The main wind direction of Xiaoqushan is N-NNW, and the main wind direction of Beilun is SE-SSE, the main wind direction is NNE-NE, the main wind direction is SSW-SW, the main wind direction is ENE-E, the main wind direction is SW-WSW; Wenzhou, the main wind direction is NE-E, and the main wind direction is WNW-NW; stone, the main wind direction is NE. Generally speaking, the probability of
fog formation in wind direction with east component is significantly higher than that in other wind directions. This shows that the water vapor condition is the key to the formation of sea fog along the coast of Zhejiang Province, and the wind with east component is beneficial to blow the wet air to the coast.

From the point of view of wind speed grade (Table 4-3), 93.6% or more of the sea fog at Zhejiang coastal stations appears under the condition that wind speed is less than or equal to 5. The wind power of Xiaoqushan Station and Dachen Station is concentrated in 2 and 4 levels, while that of other stations is concentrated in ≤ 3 level. This is due to the fact that Xiaoqushan and Dachen are isolated island stations, which are closer to the wide sea area and slightly larger than the coastal stations. It is generally believed that when the average wind speed is greater than 10m/s, it is easy to cause the fog to dissipate. However, the results show that even if the wind velocity is greater than or equal to 5(10.8m/s), there is still sea fog, but the proportion in the formation of sea fog is very small. In this case, the fog generally does not last for a long time, it might be quickly invaded with the low cold air, the coastal area is open, the underlying surface is smooth, resulting in a significant increase in the north wind and wind. At this time, it is too late to change the inversion characteristics of the atmospheric junction, and it will take some time for the main body of the cold air in the middle and upper levels to arrive. Therefore, the sea fog can be maintained during this period [6].

4.4. Circulation situation
The formation of coastal sea fog in Zhejiang depends on the specific marine environment and weather
conditions under certain weather conditions. By looking up the surface map from 2009 to 2018, it can be seen that the coastal sea fog in Zhejiang Province mainly occurs in the following four types of weather situations. The first type is Inverted trough type (Fig. 4-7). This kind of weather system often occurs in winter and spring, and sea fog of this type usually occurs at the top of inverted trough, with southeast or easterly winds blowing along the coast. The second type is the low-pressure sea exit type (Fig. 4-8), which occurs in all seasons, but mainly in early summer and winter and spring. This type of sea fog usually occurs in the front of the cold front, with southwest winds blowing along the coast. The third type is weak cold air type (Fig. 4-9). Sea fog might be formed in this type of weather system except in summer, and northeast wind is dominant along the coast. The fourth type is high pressure entry type (Fig. 4-10). This type mainly occurs at the end of winter and spring. When the high-pressure center moves eastward into the sea, the coast of Zhejiang is at the bottom or back, and the southeast or northeast wind blows along the coast. This conclusion is the same as that of Hou et al.[1].

5. Analysis of continuous sea fog weather process
Two consecutive sea fog processes, 28-30 April 2013 and 11-13 February 2016, were selected for analysis. For these two processes, one occurs in the fog season, the other occurs in the winter, the duration is 3 days, the effect is wide.

5.1. Continuous sea fog process in fog season
The sea fog process in April 2013 took place during the fog season. The sea fog process was observed at Beilun, Dachen, Kamen and Shipeng stations (Table 5-1). The minimum visibility is less than 0.1 km, and the thick fog mainly occurs at 1:00-8:00 and 17:00-20:00. The wind speed is concentrated in 2-4 degree, and Dachen Station has a 6-level wind (11.8m/s) of 1 hour. With the change of weather situation, the wind direction changes with the change of weather situation. SE-S is the main wind direction when fog starts, and SW-W is the main wind direction when fog dissipates. The cases of relative humidity $\geq 83\%$ and relative humidity $< 90\%$ occurred at night. The air-water temperature
difference between Beilun, Dachen and Kanmen is basically the same, and the negative difference between water temperature and air temperature appears.

Table 5-1 Continuous sea fog process in April 2013

| Station | Time period       | Lasting days (day) | Minimum visibility (km) | Gas-water temperature difference(℃) | Fog rises wind speed(m/s) | Fog rises wind direction(°) | Fog dispersal wind speed(m/s) | Fog dispersal wind direction(°) | Relative humidity (%) |
|---------|-------------------|--------------------|-------------------------|-------------------------------------|---------------------------|-----------------------------|-------------------------------|-------------------------------|----------------------|
| Beilun  | 20:00 on 29th-03:00 on 30th | 2                  | 0.2                     | 2.5~4.3                             | 3.0                       | SE                          | 3.2                           | SE                            | 89-92                |
| Dachen  | 16:00 on 28th-11:00 on 30th | 3                  | 0.1                     | 2.7~4.3                             | 4.7                       | S                           | 11.8                          | SW                            | 90-93                |
| Kanmen  | 00:00 on 28th-09:00 on 30th | 2                  | 0.1                     | 2.3~4.3                             | 2.5                       | SE                          | 5.7                           | W                             | 100                  |
| Shipeng | 02:00 on 29th-07:00 on 30th | 2                  | 0.4                     | -0.2~2.9                            | 0.7                       | W                           | 4.3                           | SW                            | 83-100               |

From the point of view of the ground situation (Fig. 5-1 ~ Fig. 5-3), the coastal area of Zhejiang Province was first affected by the southwest air flow at the back of the high pressure on the 28th, but the wind force was not strong. With the warm and wet air flow at high altitude, there was sea fog along the coast. With the eastward movement of the high pressure, the ground trough began to develop on the 29th, and then a low pressure went out to sea on the 30th, and formed a front. Therefore, the fog has experienced the process of high-pressure sea entry, inverted trough and low pressure going out of the sea, and the duration was longer than that of the general sea fog. Around noon on the 30th, the sea fog began to dissipate. As can be seen from figure 5-4, the new round of cold air affects the coastal areas of Zhejiang Province south, and the pouring of cold air brings about a relatively dry cold air flow in the north. Therefore, the air-water temperature difference decreases, the relative humidity decreases, the wind direction changes, and the sea fog process dissipates.

![Figure 5-1 08:00 BJT 28 apr](image1)
![Figure 5-2 08:00 BJT 29 apr](image2)
![Figure 5-3 08:00 BJT 30 apr](image3)
![Figure 5-4 08:00 BJT 1 may](image4)
5.2. Continuous sea fog process in winter

The sea fog process in February 2016 occurred in winter. The sea fog process was observed at three stations in Dachen, Kanmen and Wenzhou (Table 5-2). The minimum visibility is less than or equal to 0.1 km, and the dense fog occurs at 0:00-9:00, followed by 17:00-20:00. Dachen wind speed is concentrated in 2-5 degree, and there is 6-degree wind for one hour (11.3m/s). The wind speed of Canmen, Wenzhou is less than or equal to 3 degree. The wind direction changes with the change of weather situation, the wind direction varies from station to station when the fog rises, and the wind direction changes to SW-W when the fog is dispersed. The relative humidity is larger than or equal to 90%. The temperature difference between gas and water in Dachen, Kanmen and Wenzhou decreases from north to south.

| Station | Time period          | Lasting days (day) | Minimum visibility (km) | Gas-water temperature (℃) | Fog rises wind speed(m/s) | Fog rises wind direction (°) | Fog dispersal wind speed(m/s) | Fog dispersal wind direction (°) | Relative humidity (%) |
|---------|----------------------|--------------------|-------------------------|---------------------------|--------------------------|-----------------------------|-----------------------------|-------------------------------|-----------------------|
| Dachen  | 08:00am 11th-12:00pm 13th | 3                  | 0.1                     | 2.0~8.3                   | 0.6                      | SE                          | 11.3                        | SW                            | 90-93                 |
| Dachen  | 08:00am 11th-10:00am 13th | 3                  | 0.1                     | 1.8~7.3                   | 0.1                      | NNE                         | 6.2                         | SW                            | 98-100                |
| Wenzhou | 21:00pm 11th-12:00pm 13th | 3                  | 0.1                     | 1.4~5.4                   | 2.8                      | W                           | 8.4                         | W                             | 100                   |

From the ground situation (Fig.5-5 to Fig.5-7), the coastal 11 days of Zhejiang Province are affected by the air flow from the rear of the high-pressure rear section. The wind is not large, and the high-altitude warm-wet air flow is fitted, and the sea fog appears on the coast. With the eastward shift of high pressure, the 12th surface trough began to develop. Then on the 13th, the situation of low pressure went out to sea, and the front was formed, and the coastal area of Zhejiang was in front of the cold front. Then on the 13th, the situation of low pressure went out to sea, and the front was formed, and the coastal area of Zhejiang was in front of the cold front. Therefore, the fog has undergone high-pressure sea-to-sea, reverse-trough and low-pressure out-to-sea processes. The duration is longer than the normal sea fog process. The fog began to dissipate before and after noon on 13th. It can be seen from Figure 5-8 that the new round of strong cold air affects the coast of Zhejiang Province southward, the cold air is poured in, the wind force along the coast of Zhejiang increases rapidly, and the process of sea fog dissipates.
In conclusion, when a continuous sea fog occurs and the duration is long, it is generally affected by several weather conditions. The process of sea fog studied in this paper has experienced three weather situations: high pressure sea entry type, reverse trough type and low-pressure sea exit type. The wind direction will change with the change of weather situation, and the wind will be less than 4 level. When the wind degree is greater than 5, the wind changes from west to southwest, and the sea fog tends to dissipate.

6. Conclusions

(1) As long as there is one site where sea fog occurs, there is sea fog occurring along the coast of Zhejiang Province. The results show that the mean fog day in the coast of Zhejiang is 112 days, and the interannual variation is significant. The seasonal variation is also very sharp. Sea fog occurs mostly in spring, and the fog season is from March to June. The diurnal variation is obvious, and the sea fog occurs in the middle of the night to the early morning. The spatial distribution of sea fog along the coast of Zhejiang Province is less in the middle of the two ends. The average fog day of each site is 19.2 days and 82.0 days, and the maximum number of stations on the average fog day is the big old station.

(2) Under the condition of fog, most of the relative humidity in Zhejiang coastal area is greater than or equal to 90%, but sea fog also occurs when the relative humidity is less than 80%. The range of gas-water temperature difference is wide, the average value is within the range of \(-0.5 \sim 2.1^{\circ}C\). The sea fog affecting the coast of Zhejiang Province is not only the advection cooling fog. All the wind directions along the coast of Zhejiang Province can form fog, and the probability of fog formation in the wind direction with eastward component is obviously higher than that in other wind directions. 93.6% and more of the sea fog occurred at the level 5 wind turbine.

(3) There are four main types of weather situation affecting the occurrence of sea fog in coastal areas of Zhejiang Province, including inverted trough type, low pressure sea exit type, weak cold air type and high-pressure sea entry type.

(4) When the continuous sea fog process occurs, it usually goes through the process of high pressure entering the sea, inverted trough and low pressure going out to sea. The wind direction will change with the variation of the weather situation and the wind will be less than 4 levels. When the wind appears is 5, the wind changes from west to southwest, and the sea fog tends to dissipate. Thick fog or strong fog occurs mainly in the middle of the night-early in the morning and around the evening.

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