Pacific Ocean monsoon, based on the hydrogen and oxygen stable isotopic data collected at the New Delhi station in the India Ocean monsoon area and the Hongkong station in the Pacific monsoon area. More importantly, the Hybrid-Single Particle Lagrangian Integrated Trajectory (shorted for HYSPLIT) is gradually being used to diagnose the sources of rainfall and simulates its transport passages (Kassomenos et al., 2010; Sadys et al., 2015), although it is mainly used to calculate and analyze the spatial diffusion of many pollutants (Yang et al., 2014; Yue & Li, 2016). Based on the backward trajectory model of HYSPLIT, we intend to use the wind direction data to calculate the contribution rate of water vapor, simulate the spatial vapor transport passages in rainy season, then demarcate the regional boundary of water vapor interaction from different sources.

Geographic profile study area

The study area is located in Yunnan and Guangxi of Southwest China, at the junction of tropical and north-subtropical. The western part of the study area, mainly refers to western Yunnan, is mainly high mountains and plateaus, with longitudinally arranged high range and deep gorges of Laobie Mountain, Nandinghe River, Bangmashan Mountain, Lancangjiang River, Wuliangshan Mountain, Babianjiang River, Amojiang River, Ailaoshan Mountain, and Yuanjiang River from west to east. Among them, Ailaoshan Mountain is a huge mountain range from northwest to southeast, with the peak elevations of more than 3100 m and nearly perpendicular to the summer monsoon flow from BOB. In contrast, the eastern region is lower in elevation and mostly hilly areas, including eastern Yunnan and Guangxi. The study area is one of the main areas where the two summer monsoon systems merge, the Indian Ocean monsoon system and the Pacific monsoon system. Relatively, the average annual temperature and precipitation are 16.88°C and 1096.32 mm in the western, while 21.53°C and 1225.49 mm in the eastern.

In view of both data availability and sites representation, 16 data collection sites all are meteorological stations, which are distributed uniformly in spatial pattern, including 10 points in Yunnan and 6 points in Guangxi (Figure 1), all close to the north Tropic of Cancer and located in 98°–112°E.

Data and methods

Data collection

Considering rainy seasons of Yunnan and Guangxi is from May to October and from April to September respectively, and the abundance and novelty of data, a year-quantum of this research was limited from April to October in the years of 2013–2016. The Global Data Assimilation System (shorted for GDAS) is the system used by the Global Forecast System model of National Center for Environmental Prediction (shorted for NCEP) to place observations into a gridded model space for the purpose of starting, or initializing, weather forecasts with observed data (Bi et al., 2011). We have downloaded wind direction data of 28 months via FTP arlftp.arlhq.noaa.gov/archives.

Data processing

The approach for vapor source identification in the present study is based on the Lagrangian framework, in which the movement of air parcels through space and time is described by backward wind trajectories reaching and particular location (Winschall et al., 2014). In the Lagrangian framework, air parcel backward wind trajectories thus provide a link between the evaporative sources of water vapor and rainfall elsewhere; thereby, it is possible to research on the changing source regions in a certain rainy-season perspective. HYSPLIT model, jointly developed by NOAA Air Resources Laboratory in the United States and the Australian Bureau of Meteorology, has online and stand-alone two versions, and the latter was used in this research. The model has two directions of forward and backward in simulation and quantitative calculation (Wang, 2014). The backward refers to the simulated trajectory before reaching the sampling sites, which meets the requirements of the present study. In this study, the GDAS wind direction data provided by NCEP is used to trace the water vapor movement in 72 hours before arriving at the 16 sample observation stations as the observation end points, using the backward trajectory of HYSPLIT model based on a single machine.

MeteoInfo is a suite of software tools, which has been developed for meteorological data...
visualization and analysis (Deshpande et al., 2016). The backward trajectory of both each month from April to October, and the whole rainy season were obtained by setting the parameters required by trajectory simulation using the MeteoInfo weather mapping software in the TrajStat plugin. There are three key steps in the process. First, enter the latitude, longitude and coordinates of the selected site. Second, select the direction of the backward trajectory. Third, set the zenith height to ensure that all trajectories are visible.

**Main methods**

**Quantifying the contribution rate of water vapor passages**

First, a large number of trajectories, having been generated by simulation, are cluster analyzed to determine the main water vapor channels. Then, the water vapor contribution rate is calculated for the water vapor channels obtained by clustering, respectively. According to the Rayleigh fractionation theory and Z. H. Jiang et al. (2013), the contribution rate of water vapor passages in different geographical directions can be calculated by Equation (1).

\[
Q_s = \frac{\sum_{i=1}^{m} q_{\text{last}}}{\sum_{i=1}^{n} q_{\text{last}}} \times 100\% \quad (1)
\]

In the equation: \(Q_s\) – The contribution rate of water vapor passages in different geographical directions; \(q_{\text{last}}\) – The specific humidity at the final location of the passage; \(m\) – The number of trajectories in a vapor passage; \(n\) – The total number of trajectories.

**Least-variance clustering analysis**

In the present study, we adopted the overall spatial least-variance clustering analysis method proposed by Draxler and Hess (1998). If there are \(N\) trajectories, the spatial variance of each cluster is defined as the sum of the squares of distances between each trajectory in the cluster and the corresponding point of the cluster average trajectory. Each trajectory is an independent cluster defined as that with spatial variance being zero at the beginning. The spatial variances of any two clusters combinations were calculated when the two clusters were combined if the combination making increase in the sum of the spatial variance of all the clusters is the smallest, compared with the sum of all the clusters before combination until all the trajectories are merged into one cluster.

**Results and analysis**

**Contribution rate analysis on water vapor sources in the rainy season**

Table 1 shows the statistical data of the main wind directions and contribution rates of the water vapor source in the 16 sites during the rainy seasons in 2013–2016.

As can be seen from Table 1, the water vapor sources of 10 sites in Yunnan include BOB from the southern or southwestern or western direction, SCS from the eastern or southeastern direction and the northwestern Pacific Ocean (NPO) from eastern or northeastern or northern direction. Among them, BOB is the major source. As a whole of Yunnan, most of the water vapor from April to June came from BOB, and the water vapor in both July and August came from both BOB and SCS while the water vapor in both September and October mainly came from NPO. In terms of spatial differentiation, the rainfall in Zhenkang, Gengma, Shuangjiang, Jinggu, and Mojiang came mainly from BOB and barely from the other geographical directions while the rainfall in Honghe, Gejiu, Mengzi and Yanshan came mainly from BOB and secondly from SCS. Especially, the rainfall from SCS in July and August accounted for about 50% of total water vapor and that from NPO in September and October accounted for one third. In particular, the sampling site Funing belongs to an exception, but the same as the sites of Guangxi in the next paragraph. In a word, BOB is the most important source of atmospheric water vapor in the rainy season in western Yunnan while that in the eastern part is characteristic of water vapor sources from both BOB and SCS. According to above mentioning analysis, the barrier function of Ailaoshan Mountain may be main cause of the present pattern, who lies on the western of three sites, Gejiu, Mengzi, and Yanshan.

Water vapor source of rainfall in the six sites of Guangxi were from SCS, BOB, and NPO. Among them, SCS is the most. In April and May, water vapor mainly came from SCS. The source of rainfall from June to August was more complicated than that in Yunnan of the same period above mentioned in previous paragraph, mainly from SCS and supplemented from BOB, but there is also relatively weaker water vapor from NPO. In September and October, the intensity of water vapor transport from both BOB and SCS changed to weaken, while the water vapor transport from NPO became the protagonist. Compared with the sharp contrast of water vapors between in eastern and western Yunnan, the source difference of rainfall in Guangxi is relatively small, only showing slight decreasing trend from west to east in the proportion of water vapor from BOB.

In conclusion, both BOB and SCS were the major sources of water vapor in Yunnan and Guangxi,
respectively, and the water vapor originated from NPO contributed significantly in a temporal-spatial manner, especially in September and October, about one third. Relatively, water vapor source at the three sites of Gejiu, Mengzi and Yanshan is more complicated.

**Analysis on water vapor transport passage in each month of the rain season**

Based on GDAS global meteorological data orthographically interpolated to the projection maps with spatial resolution of 1º × 1º, this analysis on water vapor transport passage was conducted by the stand-alone model of the HYSPLIT backward trajectory with the 16 sites as the end points to trace back the water vapor trajectories before reaching the final ends. The spatial trajectories with greater similarity are attributed to the same type using the MeteoInfo clustering analysis method. Figure 2 shows the trajectories of water vapor in each month of the rainy seasons as a mean value from 2013 to 2016 in study area (Xu & Hao, 2017). A–G in Figure 2 is the backward trajectory of water vapor from April to October of rainy season, respectively.

**Table 1. The contribution rates of water vapor sources in 16 sites.**

| Stations  | Alt. (m) | Lng./Lat. (°N/°E) | Apr. (%) | May (%) | Jun. (%) | Jul. (%) | Aug. (%) | Sept. (%) | Oct. (%) | Avg. (%) |
|-----------|---------|------------------|---------|--------|---------|---------|---------|---------|---------|---------|
| Zhenkang  | 1008.4  | 98.96/23.92      | 100     | 100    | 100     | 100     | 24 S    | 76 SW   | 145W    | 48 SW   | 100SW   |
| Gengma    | 1104.9  | 99.40/23.55      | 100SW   | 100SW  | 100SW   | 22NE    | 78 SW   | 59 SW   | 41E     | 32NE    | 100SW   |
| Shuangjia | 1044.1  | 99.80/23.46      | 100SW   | 100SW  | 100SW   | 22NE    | 78 SW   | 59 SW   | 41E     | 32NE    | 100SW   |
| Jingtian  | 913.2   | 100.70/23.50     | 100SW   | 100SW  | 100SW   | 3SE     | 97 SW   | 57E     | 35SW    | 91E     | 100SW   |
| Mojiang   | 1281.9  | 101.71/23.43     | 100SW   | 100SW  | 100SW   | 3SE     | 97 SW   | 57E     | 35SW    | 91E     | 100SW   |
| Honghe    | 974.5   | 102.43/23.36     | 100SW   | 100SW  | 100SW   | 3SE     | 97 SW   | 57E     | 35SW    | 91E     | 100SW   |
| Gejiu     | 1695.0  | 103.09/23.23     | 100SW   | 100SW  | 100SW   | 5NE     | 34 SW   | 61E     | 59E     | 375W    | 63 NE   |
| Mengzi    | 1300.7  | 103.38/23.38     | 100SW   | 100SW  | 100SW   | 3SE     | 97 SW   | 57E     | 35SW    | 91E     | 100SW   |
| Yanshan   | 1561.1  | 104.33/23.62     | 100SW   | 100SW  | 100SW   | 3SE     | 97 SW   | 57E     | 35SW    | 91E     | 100SW   |
| Funing    | 685.8   | 105.63/23.65     | 465SW   | 54 S   | 92 SW   | 70SE    | 47 SW   | 34 SW   | 61E     | 59E     | 375W    |
| Debao     | 646.0   | 106.60/23.35     | 21NW    | 3S     | 92SW    | 42S     | 44S     | 40S     | 29NE    | 58SE    | 27E     |
| Pingwen   | 108.8   | 107.58/23.32     | 3SE     | 29SW   | 34S     | 265E    | 13NE    | 5E      | 33E     | 95S     | 67NE    |
| Shanglin  | 126.0   | 108.58/23.43     | 3S      | 35S    | 44SW    | 475W    | 475W    | 475W    | 475W    | 95NE    | 95NE    |
| Laibin    | 84.9    | 109.23/23.75     | 35S     | 3S     | 35S     | 44SW    | 475W    | 475W    | 475W    | 95NE    | 95NE    |
| Pingnan   | 40.0    | 110.40/23.55     | 3S      | 3S     | 35S     | 44SW    | 475W    | 475W    | 475W    | 95NE    | 95NE    |
| Wuzhou    | 114.8   | 111.30/23.48     | 3S      | 3S     | 35S     | 44SW    | 475W    | 475W    | 475W    | 95NE    | 95NE    |

**Notes:** In this table, there are eight wind directions, representative for different water vapor source. Of which, N is shorted for north, NE for northeast, E for east, SE for southeast, S for south, SW for southwest, W for west, and NW for northwest.

Trajectories with greater similarity are attributed to the same type using the MeteoInfo clustering analysis method. Figure 2 shows the trajectories of water vapor in each month of the rainy seasons as a mean value from 2013 to 2016 in study area (Xu & Hao, 2017). A–G in Figure 2 is the backward trajectory of water vapor from April to October of rainy season, respectively.

In the early summer monsoonal period including April and May, the rainfall was mainly from BOB in Yunnan, as shown in Figure 2a and b, via two passages. One passage was through the Indian Peninsula via the Arabian Sea to the south section of the Himalayas Mountain, entering in Yunnan from western direction. The other one was from BOB to the

---

**EUROPEAN JOURNAL OF REMOTE SENSING**

**RETRACTED**

**RETRACTED**

**RETRACTED**

**RETRACTED**
northeast, crossing the Indochina Peninsula into Yunnan from southwest direction. In April, the rainfall at all sites of Yunnan came by these two water vapor transport passages. The rainfall of Guangxi was mainly from SCS, NPO, with the former as the major source. Especially in May, the water vapor was all from SCS while in April from NPO mainly.

In the middle summer monsoonal period including June and July, the atmospheric water vapor of Yunnan still mainly came from BOB via the passage passing Indochina Peninsula. As shown in Figure 2(c), the water vapor transport trajectory was the most typical in Yunnan in June, with almost of the atmospheric water vapor from BOB in the west sites of Yunnan, especially Zhenkang, Gengma, Shuangjiang, and Jinggu. The atmospheric water vapor in the East sites of Yunnan mainly came from BOB, and SCS as a supplement. Compared to June, Yunnan sites in July were fully influenced by

---

Figure 2. The backward trajectory of each month in rainy season from 2013 to 2016 (the figures from April to October.)
summer monsoon from SCS. Whether in June or July, the rainfall of Guangxi was dominantly from SCS. In addition, there was also a large proportion from NPO, accounting for about 10%.

From Figure 2(e–g), in the late summer monsoonal period of August to October, we have seen that water vapor source of western Yunnan was mainly BOB from the southwestern. Although water vapor source of eastern Yunnan was still mainly BOB in August, NPO from the northeastern was more powerful than that in the middle monsoonal period. Especially in eastern Yunnan, water vapors of September or October were basically from NPO. More prominently, the rainfall passages of Guangxi in August were almost equally from NPO and SCS, while that in September and October was mainly from NPO and barely from SCS, despite being the nearest in all water vapor sources.

In brief, the rainfall of western Yunnan was mainly from BOB in the early and middle summer monsoonal season, while that of eastern Yunnan and Guangxi was mainly from SCS. Even though in the eastern of study area, atmospheric water vapor from BOB also accounted for a high proportion during the middle summer monsoonal season. To almost sampling sites, we can say that BOB is the main source of atmospheric water vapor, generally. While in the late summer monsoonal season, the rainfall of western Yunnan is characteristic of water vapors from both BOB and NPO, while the water vapor of eastern Yunnan and Guangxi were dominantly from NPO.

There is an interesting thing about backward trajectory of difference month in the eastern region of study area. Water vapor trajectories more come from the south in April, May, June, and July while more come from the north in August, September and October. Although the precipitation in the study area is mainly affected by SCS and BOB, the influence of NPO is also significant, especially in the eastern. We think July is the exchanging period of beginning NPO. But there is less affected by NPO in the western.

Demarcation of the two major water vapor affecting areas

According to these mean data of each site from April to October based on GDAS, the Lagrange-based HYSPLIT model was applied to simulate the backward trajectory of water vapor, as shown in Figure 3, which is a summary of the contents of the seven subgraphs in Figure 2. It shows the average results of backward trajectory of the rainy season from 2013 to 2016. It can be seen that water vapor source of sites in western Yunnan, such as Zhenkang, Gengma, Shuangjiang, Jinggu, Mojiang, and Honghe, mainly is BOB from the southern direction, while the water vapor of Funing, the easternmost site of Yunnan, contributed largely to both easterly and southeasterly flows. That is to say that the water vapor of Funing was not from BOB. The trajectories of Gejiu, Mengzi and Yanshan, lied between Honghe and Funing, were rather complicated. And two water vapor sources from the southwesternly and southeasterly were rather high proportion, but neither was absolute advantaged. Thus, it is concluded that Gejiu, Mengzi, and Yanshan may be the interaction zone between the water vapors from BOB and SCS. As shown above, we can have concluded that the more warm-humid southwest currents from BOB may cross the Ailaoshan Mountain and interact with water vapor from SCS nearby these three sites. To some extent, the barrier effect of Ailaoshan Mountain on water vapor movement of these two oceanic flows is one of the causes.

Here seems a confusing thing need to be explained. There are more vapor trace lines of both western and eastern stations while fewer of middle stations. It may be that the least-variance clustering analysis leads to this phenomenon. However, it does not affect the results, because the main concern of this study is the proportion of lines rather than the number of lines themselves.

Following the above methodology involving the identification of the location of the changing between water vapor sources, the identified moisture source for each sampling site can be ascribed to any of the three sources of water vapor, including BOB, SCS and NPO. As for regional demarcation acted by the warm-humid currents of summer monsoon in China, researchers have conducted many relevant studies. Some of their research results are similar to ours. For example, Qiang et al. (1998), having based on the calculation of water vapor currents, had concluded that eastern Yunnan was the intersection of the two summer monsoons. Because it was firstly affected by the summer monsoon from the Pacific ocean at the early monsoonal season while from both the Indian Ocean and the Pacific ocean at the middle monsoonal season. Hu et al. (2011), having selected Ailaoshan Mountain as the research object and based on the spatial demarcation of atmospheric water vapor in rainy season, had quantified the correlation between the regional topography and the confluence of monsoons. And at last it concluded that the interaction region between the Indian summer monsoon and the Pacific summer monsoon varies with the two monsoons development process. Our previous

Figure 3. The backward trajectory of average value from 2013 to 2016.
studies also showed that Ailaoshan Mountain could not only block the northern cold air in winter from entering the mountainous areas in southwest China, but also was one of the main factors determining the influence scope of Indian Ocean monsoon and Pacific monsoon (Hao & Wang, 2016). Significant variations in the climate and vegetation near Gejiu and Mengzi also implied that the regions could be one of boundary lines of regional demarcation, some or certain geographical elements.

Conclusions
In this study, we research on atmospheric water vapor sources in Yunnan and Guangxi during the rainy season of April to October. We not only quantified the contribution rates of different geographical directions to the rainfall of 16 sites, but also simulated the water vapor transport path based on backward trajectory analysis of HYSPLIT modeling. At last, the research tried to explore the boundary zone influenced by the two warm-humid air currents controlling the wet or dry condition during the rainy season. The following conclusions can be drawn. First, water vapor of Yunnan in the rainy season of the years from 2013 to 2016 mainly came from BOB, especially in the early and middle summer monsoonal periods. And atmospheric water vapor from SCS and NPO had significant temporal-spatial influences in the late summer monsoonal period. Second, water vapor of Guangxi in rainy season from 2013 to 2016 was mainly from SCS, and as a supplement from BOB. In addition, water vapor from NPO also accounted for a certain percentage. Third, three sampling sites, Gejiu, Mengzi, and Yanshan in the eastern Yunnan, are in the demarcation zones affected by warm-humid air currents during the whole rainy season, mainly due to the blocking effect of Ailaoshan Mountain. The warm-humid southwest current from BOB may cross Ailaoshan Mountain and interact with water vapor from SCS in Gejiu, Mengzi, and Yanshan. In a word, this research will play an important role to define the influence circle of different water vapors, including the North Pacific Moisture, the South Sea Moisture, and the Bay of Bengal Moisture, and to revise the present climatic regionalization and reconstruct palaeoenvironment.

Disclosure statement
No potential conflict of interest was reported by the authors.

Funding
This work was supported by the Project of College Innovation Research Team for Science and Technology of Henan under Grant (number 18IRTSTHN008); the National Natural Science Foundation of China under Grant (number 41371105).

References
Bi, L., Jung, J. A., Morgan, M. C., & Marshall, J. F. L. (2011). Assessment of assimilation ASCAT surface wind retrievals in the NCEP global data assimilation system. Monthly Weather Review, 139(11), 3405–3421. https://doi.org/10.1175/2011MWR3399.1
Deshpande, R. D., Medha, D., Virendra, P., Kumar, H., & Gupta, S. K. (2016). Water vapor source identification for daily rain events at Ahmedabad in semi-arid western India: Wind trajectory analyses. Meteorological Applications, 22, 754–762. https://doi.org/10.1002/met.1515
Draxler, R. R., & Hess, G. D. (1998). An overview of the HYSPLIT_4 modeling system of trajectories, dispersion and deposition. Austalian Meteorological Magazine, 47, 295–308. https://www.researchgate.net/publication/23906109_An_overview_of_the_HYSPLIT_4_modelling_system_for_trajectories
Eslami, A., Kaviani, B., Amini, M., & Akbari, K. (2014). The use of geographical information system (GIS) to query the endangered lily [Lilium ledebourii (Baker) Bioss.] species for planting and restoration in the northern part of Iran. Indian Journal of Geo-Marine Sciences, 43(10), 1927–1938. https://xueshu.baidu.com/usercenter/paper/show?paperid=1a2ba77e90a95cbba0ebab9040fb83f91&site=xueshu_se
Hao, C. Y., & Wang, L. C. (2016). Regional clustering for ecological geographical parameters based on SOFM model. Environment and Pollution Technology, 27(5), 265–267. https://www.researchgate.net/publication/299393136_Regional_clustering_for_ecological_geographical_parameters_based_on_SOFM_model
Hao, C. Y., Wu, S. H., & Li, S. C. (2007). Measurement of climate complexity using permutation entropy. Geographical Research, 26(1), 46–52. https://kns.cnki.net/kXXReader/Detail?TMESTAMP=637374888987122500&DBCODE=CJFD&TABLENAME=CJFDTOTAL-QXXB201302012.htm
Hu, J. M., He, D. M., & Li, Y. G. (2011). Discussion on monsoons’ interfacing around Ailaoshan through analyzing regional variation of wet season rainfall. Advances in Earth Science, 26(2), 183–192. https://doi.org/10.11867/j.issn.1001-8166.2011.02.0183
Jiang, X. W., Li, Y. Q., & Wang, X. (2009). Water vapor source identification for daily rain events at Ahmedabad in semi-arid western India: Wind trajectory analyses. Meteorological Applications, 22, 754–762. https://doi.org/10.1002/met.1515
Jiang, X. W., Li, Y. Q., & Wang, X. (2011). Water vapor transport characteristics during the Meiyu period over China and its relationship with drought and flood in Yangtze River Basin. Journal of Geographical Sciences, 19(2), 153–163. https://doi.org/10.1007/s11442-009-0153-6
Jiang, Z. H., Ren, W., Liu, Z. Y., & Yang, H. (2013). Analysis of water vapor transport characteristics during the Meiyu over the Yangtze-Huaihe River valley using the Lagrangian method. Acta Meteorologica Sinica, 71(2), 295–304. http://en.cnki.com.cn/Article_en/CJFDTOTAL-QXXB201302012.htm
Kassomenos, P., Vardoulakis, S., Borge, R., Lumbreras, J., Papaloukas, C., & Karakitsios, S. (2010). Comparison of statistical clustering techniques for the classification of modeled atmospheric trajectories. Theoretical and Applied Climatology, 102, 1–12. https://doi.org/10.1007/s00704-009-0233-7
Li, L. P., Zhang, K. M., Luo, T., & Fu, X. H. (2014). An analysis of the drought and flood hazard characteristics and risks during the pre-rainy season in South China. Natural Hazards, 71(2), 1195–1213. https://doi.org/10.1007/s11069-013-0692-0
Ma, F. B., Xiao, Z. N., & Li, C. (2009). The relationship between annual precipitation and Asian monsoon activity in Yunnan province. *Science and Technology Information, 16*(2), 591, 588. https://kns.cnki.net/KXReader/Detail?TIMESTAMP=637374898030872500&DBCODE=CJFD&TABLNAMESPACE=CJFD2009&FileName=KJXX200902508&RESULT=1&SIGN=TSLB%2bYqvdXTYyG%3d

Pang, H. X., He, Y. Q., Zhang, Z. L., Lu, A. G., Gu, J., & Zhao, J. D. (2005). δ18O in monsoon precipitation and the origin of precipitation. *Chinese Science Bulletin, 50*(20), 2263–2266. https://doi.org/10.1360/982004-363

Qiang, X. M., Ju, J. H., & Zhang, H. H. (1998). A diagnostic analysis of the summer monsoon in Yunnan. *Journal of Yunnan University, 20*(1), 75–79. http://en.cnki.com.cn/Article_en/CJFDTOTAL-YNDZ2004000000000.htm

Ruan, Y. F., Liu, Z. F., Yao, Z. J., & Wang, R. (2018). Temporal and spatial of precipitation delta O-18 and controlling factors on the pearl river basin and adjacent regions. *Advances in Meteorology, (2)*, 155–165. https://doi.org/10.1155/2018/1419326

Sadys, M., Kennedy, R., & Skjoth, C. A. (2015). An analysis of local wind and air mass directions and their impact on Cladosporium distribution using HYSPLIT and circular statistics. *Fungal Ecology, 18*(18), 56–66. https://doi.org/10.1016/j.funeco.2015.09.006

Tang, X., Chen, B. D., Liang, P., & Qiang, W. H. (2010). Definitions and features of the north edge of Asian summer monsoon. *Acta Meteorologica Sinica, 24*(1), 83–89. https://doi.org/10.1029/2009RS004194

Tian, H., Guo, P. W., & Lu, W. S. (2004). Characteristics of vapor inflow corridors related to summer rainfall in China and impact factors. *Journal of Tropical Meteorology, 20*(4), 401–408. http://d.wanfangdata.com.cn/periodical/tqxxb2004000000000.htm

Wang, Y. Q. (2014). MeteoInfo: GIS software for meteorological data visualization and analysis. *Meteorological Applications, 21*(2), 360–368. https://doi.org/10.1002/met.1345

Winschall, A., Pfahl, S., Sodemann, H., & Wernli, H. (2014). Comparison of Eulerian and Lagrangian moisture source diagnostics—the flood event in eastern Europe in May 2010. *Atmospheric Chemistry & Physics Discussions, 13*(14), 6605–6619. http://connec tion.ebscohost.com/c/articles/93249335/comparison-eulerian-lagrangian-moisture-source-diagnostics-flood-event-eastern-europe-may-2010

Xu, C. Y., & Hao, C. Y. (2017). Research on vegetation spatial heterogeneity in Local Domain-Range-gorge Region of Yunnan Province, China. *Bulgarian Chemical Communications, 49*, 192–197.

Xu, X. D., Tao, S. Y., Wang, J. Z., Chen, L. S., Zhou, L., & Wang, X. R. (2002). The relationship between water vapor transport features of Tibetan Plateau monsoon “Large Triangle” affecting region and drought flood abnormality of China. *Acta Meteorologica Sinica, 60*(3), 259–265. http://en.cnki.com.cn/Article_en/CJFDTOTAL-QXXB2002030000.htm

Yang, H., Jiang, Z. H., Liu, Z. Y., & Zhang, Q. (2014). Analysis of climatic characteristics of water vapor transport based on the Lagrangian method: A comparison between Meiyu in the Yangtze–Huaihe River region and the Huabei rainy season. *Chinese Journal of Atmospheric Sciences, 38*(5), 965–972. http://en.cnki.com.cn/Article_en/CJFDOTAL-DQXK201405012.htm

Xue, J., & Li, Q. P. (2016). Study on the moisture source of rainstorms in Sichuan Basin by the Lagrangian methods. *Journal of Tropical Meteorology, 32*(2), 256–264. http://en.cnki.com.cn/Article_en/CJFDOTAL-RDQX201602012.htm

Zhou, C. Y., Li, Y. Q., Li, W., & Chen, L. X. (2005). Climatological characteristics of water vapor transport over eastern part of Qinghai-Xizang Plateau and its surroundings. *Plateau Meteorology, 24*(6), 880–888. http://en.cnki.com.cn/Article_en/CJFDOTAL-GYQX200506005.htm