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Study on the Highly Pathogenic Avian Influenza Epidemic Using Land Surface Temperature from MODIS Data

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***Abstract* - The pandemic disease of avian influenza, which was first recognized in Italy in 1878, outbreaks in most temperate regions such as Southeast Asian, resulting in the death of a paramount number of birds and chicken, even probably infecting the human being, so it is of particular concern.**

Because the virus of HPAI, i.e. H5N1 is largely dependent on the habitat or the surrounding environment, analysis of the correlation between the land surface temperature (LST) in the infected area of HPAI epidemic and the outbreak of HPAI is becoming more and more pressing. In this paper we successfully verify that there are strong correlation between LST and HPAI. Except that, it is true that the outbreak of HPAI is characterized by the vicinity to the river.

This paper mainly addressed the concern about the connection between LST and the infected area associated with the outbreak of HPAI, moreover, It also expounded on the vicinity of river to affected area played a important role in the prevalence of HPAI.

Ⅰ. INTRODUCTION

The pandemic disease of avian influenza, which was fist recognized in Italy in 1878, outbreaks in most temperate regions such as Southeast Asian, resulting in the death of a paramount number of birds and chicken, even probably infecting the human being, so it is of particular concern. Highly pathogenic strains of avian influenza virus, for example H5N1, have crossed from birds to humans and are known to cause fatal disease [1].

Land surface temperature (LST) has be spreadly used in many fields for its wide coverage on the earth, while the traditional meteorological data can only stand for the in situ circumstance at that location. Because the H5N1 virus for high pathogenic avian influenza (HPAI) can only exist in the limited temperature ranges, we have done some preliminary work on the correlation between LST and HPAI.

Sea surface temperature anomalies has been seen as an important indicator of epidemics such as forecast rift valley fever in Kenya [2]. Meteorological land surface temperature data interpolated to a grid was used to monitoring the trypanosomiasis in space and time [3][4]. Likewise, that is true for LST. Now we will testify this in the following paragraph.

Through our work on the retrieval algorithm of LST using Moderate Resolution Imaging Spectroradiometer (MODIS) data, developed by Xue et al.[1], we found that there are rather higher temperature in the infected area than the neighbouring area, and the infected area usually were adjacent to the rivers or brooks using the buffering in GIS, therefore we can draw some conclusion that there are some correlation between LST, vicinity and the outbreak of HPAI in the lower reaches of Yangtze River, which broke out in spring of 2004, then spread to almost the whole country.

The paper was organized like the following. Firstly, we retrieved the LST using our algorithm from remote sensing MODIS data, which is very important for the spatial heterogeneity in the infected area. Accounting for the traditional meteorological temperature measurement can only represent in situ situation, remotely sensed data, can represent the large true conditions in the epidemic site in short time. Secondly, by means of buffering function in Arc/Info GIS, it is clear shown that the vicinity to the water body like river in the infected area plays an important role in the transmission and outbreak of HPAI.

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Finally, we choose China HPAI cases data of 2004 in lower reaches of Yangtze River as studying objects. Based on the LST data we statistically draw preliminary conclusion that the case of HPAI often outbreaks in region of higher LST.

II. STUDY AREA

The study area is in and around Anhui Province which is located in southeastern China, at a latitude of 29^0N, longitude of 122^0E at the right bottom corner, and a latitude 35^0 N, longitude of 113^0 E (Figure 1).The general topography of the study area consists of the Yangtze River Delta with prominent ridges usually less then 200m in height.

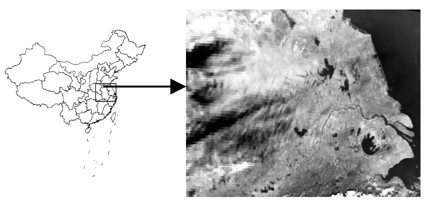

Figure 1. The rectangle on the left shows the location of the study area within PR China, while the image acquired on February 4, 2004 from MODIS data on the right illustrates the working area)

III. DATA AND METHODS

A Preprocessing of MODIS data

MODIS, which has 36 spectral bands of moderate resolution that cover the wavelength range from 0.4 to 14 μ m, has spatial resolution of 250, 500, 1000m respectively, and a swath of 2330 km.

We acquired the MODIS level 1B data of 1km resolution that over passed the study area by ordering from Land Processes Distributed Active Archive Center [3].

Accounting for the detailed information like cloud and HPAI cases in the study area, we choose the MODIS Terra data between Jan.31-Feb.10 as the objects to radiation and geometric correction. After that, we registration the object image with a map as the same projection type with the map, then mosaic the different images achieved at 5 minutes interval, finally we get the image including our study area, which is show in figure1.

Based on these above-mentioned, we retrieve LST using the split-window algorithms developed by Xue et al.[5]. The detailed flow chart of preprocessing of MODIS data is showed in Fig.2.

B Case data of HPAI

The case data of HPAI were achieved from the website of Ministry of Agriculture of China [4]. The time ranges from January 31 to February 10.

For the convenience of the following buffering function, we thought the case data as point features and built up a point feature class in Arc/Info GIS software, which was positioning at the centroid of the infected county.

C the Retrieving Algorithm of LST

In the paper, we chose thermal infrared band 29(8.4-8.7 μ m),band 31(10.78-11.28 μ m)and band 32(11.77-12.27 μ m), but not including band 30, accounting for band 30 has strong ozone absorption effects. Through the combination band 29 and 31, band 29 and 32 respectively, we can get the formula:

$$T_{s,1}= A_{0,1} +A_{1,1}T_1+ A_{2,1}T_2 \qquad (1)$$

$$T_{s,2}= A_{0,2} +A_{1,2}T_2+ A_{2,2}T_3 \qquad (2)$$

The key issue for our algorithm is to choose and adjust the local split window coefficients range. In order to enhance the accuracy, we firstly classified the infected area using k-means unsupervised classification methods as a separate band, and detailed information, including the validation of the algorithm using the in situ temperature data from the observation climate data is mentioned in [5].

For the cloud cover on the infected area, we make a composite image, which is shown in fig.3 as a base map, using the MODIS data of 11 days between January 31 and February 10. The base map in Figure 3 is from emissive band 9 of MODIS data.

D the Buffering of the river

Fig.3 is the overlay map of river, infected area and the emissive band 9 of MODIS data, we can see five infected area clearly on it using Arc/Info GIS software's overlay function.

IV. RESULTS AND DISCUSSION

In this part, we mainly expound on the results and make some discussion based on them. The results from the above method and data are threefold:

Firstly, we get the mean LST in the infected area using the retrieval algorithm mentioned above, which is shown in figure 4. The figure is a density slice map of LST image for your convenience.

Secondly, we confirm that there are strong correlation between the river and the outbreak of HPAI through the buffering of river on a radius of 50 km, because 4 of 5 infected area, which is shown in figure 5, are in the buffering area of river.

Thirdly, we draw a preliminary conclusion that the outbreak of HPAI happens often in the higher LST region through statistics of LST in the vertical and horizontal profile in the infected area. Figure 6 and Figure 7 showed the horizontal (i.e., longitude direction) and vertical profiles(i.e., latitude direction) respectively. For the composite image was synthesized from a time series, We use the mean LST of the infected area to reflect the truth.

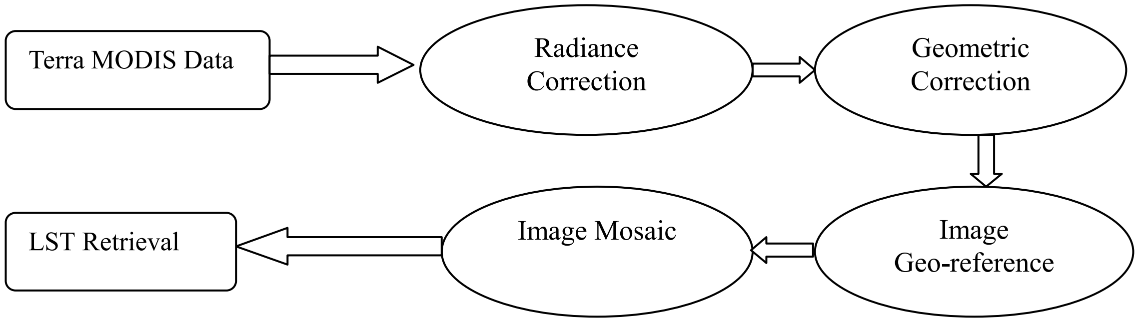

Figure.2 The flow chart of preprocess of MODIS data

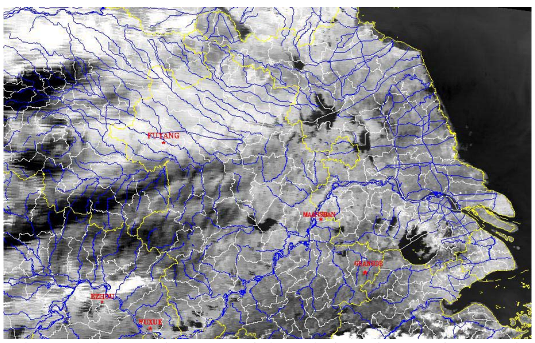

Figure.3 the Overlay map of river, infected area of HPAI(the red is the infected counties) and MODIS data

The above-mentioned results were got from a typical infected area of HPAI, and only the preliminary conclusions, which accuracy and feasibility are going to be validated in our later work.

Ⅴ. CONCLUSION

In conclusion, the outbreak and prevalence of HPAI are indeed related to the LST and the vicinity to the river, which were verified by the results in this paper. Meanwhile, it is a new efficient method to make use of LST to analyze and predict the outbreak and prevailing of HPAI.

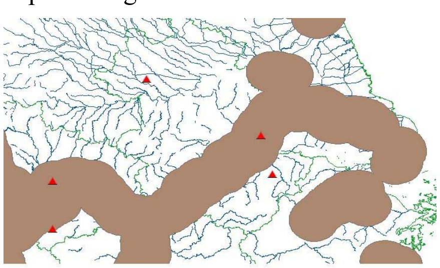

Figure 4. Buffering of river in infected area

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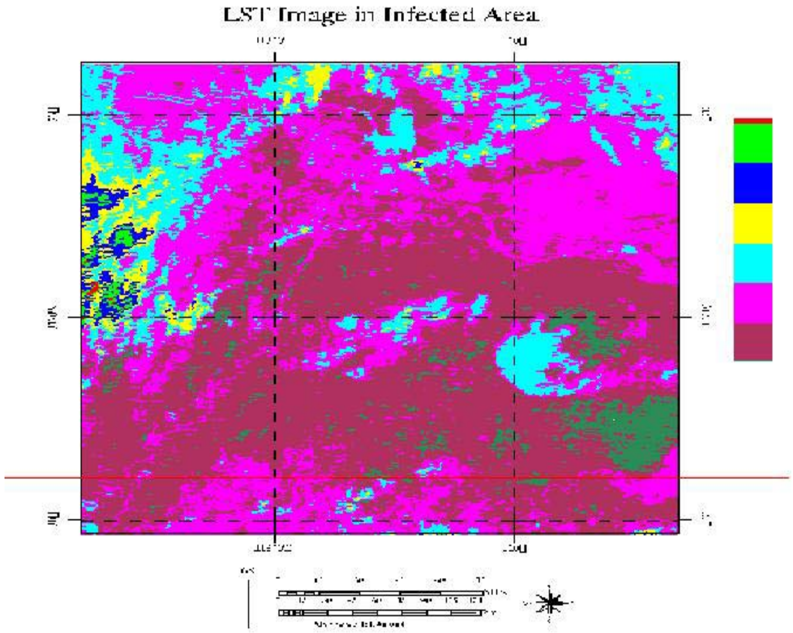

Figure 5. Density slice pap of LST in infected area

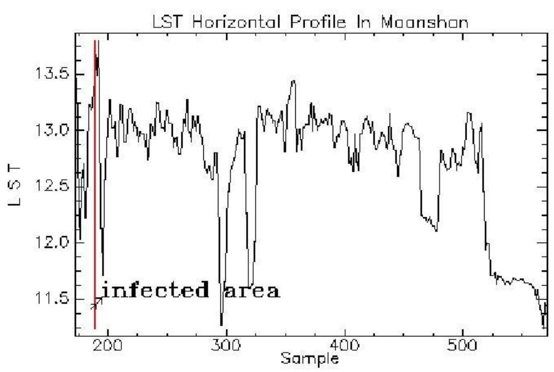

Figure 6. LST horizontal profile map in Maanshan infected area (the red line presents the centroid of infected area)

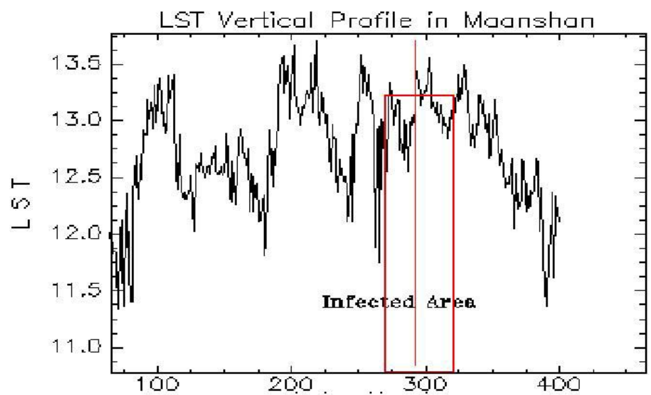

Figure 7. LST vertical profile map Maanshan infected area (the red rectangle presents the infected area)

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