Study on the Advances in Atmospheric Aerosol Remote Sensing Inversion

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Abstract. With the development of urban industrialization, atmospheric aerosol pollution has become increasingly serious and has become the focus of atmospheric research. As a scientific, rapid and wide-ranging monitoring method, remote sensing technology is widely used in atmospheric research. The four main research contents of aerosol optical thickness (AOD), aerosol concentration, particle size spectrum and aerosol and air pollution were expounded from the mechanism of atmospheric radiation transmission, and the research progress of aerosol remote sensing inversion at home and abroad was analyzed. And the advantages and disadvantages of various inversion methods. Finally, the current problems and research trends of atmospheric aerosol inversion are discussed and forecasted.

Introduction

Aerosol is an important parameter for studying air pollution. It affects the radiation balance of the geogas system and is an important factor in climate change research. At the same time, aerosol information is also one of the important parameters of atmospheric correction of satellite remote sensing images. Only by obtaining the atmospheric aerosol property parameters equivalent to the pixel scale can the atmospheric effect correction of the pixel by pixel be realized, and the complete quantitative determination can be realized. Remote sensing analysis and inversion. Aerosols are also closely related to other environmental issues and have a unique impact on the physical health of humans and other organisms. Atmospheric aerosol research has become one of the research hotspots in the international academic community. Satellite remote sensing can provide information about aerosol distribution over a wide background. Researchers have successively proposed methods for acquiring aerosol parameter information by means of satellite remote sensing. The author summarizes and evaluates the aerosol remote sensing inversion method, and discusses the existing problems and development directions in the field.

Aerosol Remote Sensing Inversion Method

Sensors currently used for aerosol remote sensing can be classified into the following categories based on characteristics such as solar radiation spectrum, angular distribution, and polarization information reflected by aerosols: Using reflectance spectral intensity information such as EOS-MODIS, ADEOS-OCTS/ GLI; use angular distribution to reflect spectral information, such as EOS-MISR, ADEOS-POLDER; use reflection spectral polarization information, such as POLDER (Polarization and Directionality of Earth. s Re flectances), EOS-EOSP (Earth Observing Scanning Polarimeter).

It can be divided into four categories: single-channel remote sensing and multi-channel remote sensing, contrast reduction method, multi-angle multi-channel remote sensing, and polarization characteristic remote sensing.

Single channel remote sensing and multi-channel remote sensing. Griggs found that the solar radiation value reflected vertically above the ocean surface increases linearly with the change of aerosol optical thickness. Based on this linear relationship, a single channel inversion method for offshore aerosol optical thickness is established. However, this method is limited to low-reflectivity surfaces such as the ocean, and this linear relationship is not well established because the local table reflectance is large. The single-channel method uses visible light channels to invert and analyze

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aerosols in the atmosphere, and successfully used to study the distribution of troposphere and stratospheric aerosols over the ocean. Multi-channel remote sensing is most common in establishing two-band modes using visible and near-infrared bands. Durkee et al. used the first and second channels of the AVHRR radiometer to measure the aerosol optical thickness in the atmosphere. They used satellites to receive between visible and near-infrared light in clear, cloudless and calm seas. The amount of radiation is considered to be mainly caused by the scattering caused by the aerosol, and it is assumed that the radiation intensity observed by the satellite is a single scattering. Therefore, for solar radiation, the Rayleigh scattering caused by gas molecules can be regarded as a constant and negligible, but the scattering caused by cloud droplets and aerosols cannot be ignored. Under this assumption, it is verified that the radiation intensity received by the satellite has a nearly linear relationship with the aerosol optical thickness. At present, the more popular algorithm for inverting terrestrial aerosols using reflectance spectral intensities is the Dark dense vegetation method. Kaufman (1997) and other large-scale aircraft test data obtained in the densely reflective low-reflectivity surface area of the mid-infrared channel (2. 13 Lm) and red (0. 66 Lm), blue (0. 47 Lm) visible channel reflectivity The existence of linear correlations and successful application to MODIS terrestrial aerosol inversion. The dark dense vegetation method is mainly based on the darker underlying surface of the red and blue bands, and the inversion of the path radiation of the aerosol is obtained. If the refractive index of the aerosol, the single scattering albedo, the spectral distribution, etc. are known, the aerosol can be estimated. Information such as load (optical thickness) and particle size spectrum. Applying the algorithm to MODIS data aerosols, the main idea of inversion is based on the lower reflectivity of the surface in the mid-infrared channel (2.3L) reflectivity with red (0.66 Lm), blue (0.47 Lm) visible light The statistical relationship between the channels (Kaufman, 1998), using the reflectivity of the mid-infrared channel (2. 13 Lm) to determine the dark pixels present in the red (0. 66 Lm), blue (0.47 Lm) channels, And estimate the reflectivity of dark pixels in the red and blue channels; use the global aerosol distribution information, and select the appropriate dynamic aerosol model, apply the radiative transfer model (such as MODTRAN, HITRAN, 6S, etc.) to calculate the radiation transmission lookup table inversion Calculation. This method can only be used for dark pixels with a lower reflectivity of Q2. 13Lm 0.15 and requires a priori or hypothetical knowledge such as aerosol type. Since the reflectivity of the land surface is usually high and the distribution of dark pixels is small, the application range and accuracy of the method are largely limited.

Contrast reduction method. The relative aerosol optical thickness is inverted using the Blurring effect of different phase images in the same region. The method obtains the relative aerosol optical thickness of the same-named pixel in the same region of different phases, which has the advantage that it can be applied to the terrestrial region where the dark pixel does not exist, and has the disadvantage that it is difficult to find a small time interval and no aerosol distribution. Or a reference image of the aerosol optical thickness is known, so the relative value of the optical thickness obtained by the inversion cannot be converted into an absolute value. This method was successfully applied to Mapper (TM) and AVHRR for aerosol studies on dry surface atmospheres. Multi-angle multi-channel remote sensing. The multi-angle multi-channel remote sensing inversion method extends the above-mentioned single-channel and multi-channel and contrast-reduced remote sensing inversion methods. Mar tonchik and Diner proposed the MISR aerosol parameter inversion method in 1992. There are 2 different methods used on land. If dark dense vegetation exists, combined with multi-angle observation, the dark dense vegetation with low surface reflectivity is used to invert the aerosol parameters. If it does not exist, the surface and atmospheric signals are separated by spatial contrast and angular change information of the observed signals to obtain aerosol parameters of the observed area. Above the ocean, the observed radiation of the satellite mainly depends on the aerosol scattering phase function. Multi-angle remote sensing provides more detailed information to establish an aerosol model over the ocean, improving the accuracy of aerosol optical thickness inversion. In recent years, multi-angle observations provide a new method for terrestrial surface physical parameters and aerosol inversion. With the advent of new multi-angle sensors such as ATSR-2, POLDER, and MISR, new qualitative and quantitative inversion methods for remote sensing aerosols have been further developed with improved accuracy. Xue and Yu used ATSR multi-angle observation data to build a model of remote sensing aerosols, which was applied to England and achieved good results.

The spatial variability of aerosols makes it increasingly important to use satellite remote sensing to observe the nature, distribution and changes of global and regional aerosols. Aerosol remote sensing inversion on the ocean using NOAA/AVHRR data has been operational and has achieved good accuracy and effectiveness. However, the correction of the atmospheric effects of nearshore water is still a problem. It has been thought in the past that satellite aerosol remote sensing only applies to underlying surfaces that are as dark as ocean surfaces. Until recent years, the emergence of various high-calibration precision and high-spectral resolution sensors has made remote sensing of terrestrial aerosols possible. The key to terrestrial aerosols is how to obtain information from aerosols by removing the contribution of the underlying surface from the top of the atmospheric reflection signal. Due to the terrestrial surface heterogeneity, the reflection values of solar short-wave radiation vary greatly depending on the target. To invert the aerosol on the land surface, or to assume that the surface reflectance is known, or to select a special band, a special target, or the polarization characteristics of the surface reflected light is known, the polarization caused by atmospheric molecular scattering is accurately excluded, and the polarization characteristic is measured. . But so far there is no better universal terrestrial aerosol remote sensing algorithm. Therefore, terrestrial aerosol remote sensing is still a difficult and hot topic in international research.

Development Trend of Aerosol Remote Sensing Inversion

With the continuous development of remote sensing technology, many achievements have been made in atmospheric monitoring and inversion of aerosol optical properties, but also face some challenges and difficulties, such as high albedo aerosol inversion in Beijing, aerosol type (Accurate determination of aerosol scattering and absorption, establishment of aerosol inversion models with universal applicability, treatment of surface reflectivity, and the like. In the future, the trend of aerosol remote sensing inversion should be broken in the following three aspects. (1) Aerosol remote sensing inversion combined with ground monitoring and ground-based remote sensing monitoring. Such as multi-wave photometer, canopy meter, wireless sensor, laser radar, drone, etc., which will greatly improve the remote sensing speed and inversion accuracy. (2) Establish an aerosol inversion model based on radiation transfer theory. At present, the more common inversion methods of aerosols (such as aerosol concentration) are based on empirical formulas established by statistical models. The physical meaning is not clear enough and the applicability is not strong. Therefore, it is necessary to study the scattering and absorption mechanism of particles with different shapes and sizes from the theory of atmospheric radiation transmission, so as to establish an aerosol inversion system with universal applicability and clear physical meaning. (3) Improve the accuracy of the determination of the aerosol model. The selection of the aerosol model has a great influence on the accuracy of aerosol inversion. Therefore, it is very important to determine the aerosol model. The aerosol model can be improved by long-term ground observation or a more reasonable aerosol model. Precision.

Remote sensing of polarization characteristics. The advantage of using remote sensing to invert aerosols from space is that polarized radiation is less sensitive to surface reflectance and extremely sensitive to the effective particle size and refractive index of aerosol particles. With this method, the aerosol optical thickness and the effective particle size of the aerosol particles can be simultaneously inverted. Lv Daren's Major Project of the Chinese Academy of Sciences (KZ951-B1- 415) Under the influence of human activities, the Inner Mongolia typical grassland ecology) The monitoring and basic process of climate interactions in the study of terrestrial aerosols for quantitative remote sensing, using polarized and polarized radiation Joint inversion method, and correspondingly developed polarization radiation transmission algorithm. However, due to the non-uniform and non-spherical nature of the aerosol particles, the polarization characteristics of the aerosol are inconsistent with the properties of the uniform spherical particles assumed by the method, and the influence of the surface polarization characteristics limits the application of this method.

Conclusion

Atmospheric aerosols are a mixture of particles suspended in the Earth's atmosphere that affect not only global climate change, but also the quality of the atmospheric environment and human health. At present, the study of atmospheric aerosol has become one of the hot spots of international research. The research progress of remote sensing inversion of aerosol parameters is introduced. The methods of inverting aerosol parameters using satellite remote sensing data are summarized. The various assumptions in the method are analyzed, and the existing problems and developments in the field are analyzed. Directions are explored.

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