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Receiving and Processing of Direct Broadcast Satellite Data for Regional Air Quality and Weather Forecast Researches: Case study in Shanghai, China

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Regional air quality monitoring and weather forecasting have strict requirements on the temporal and spatial characteristics of several important atmospheric variables. A source of such information, and one that comprises a relatively large spatial coverage of real-time observations, is satellite remote sensing using direct broadcast (DB) technology for data capture.

A current research theme in weather and air quality forecasting is the assimilation of both satellite and weather station data into numerical models of atmospheric transport. This paper introduces the applications of DB data and related techniques - including retrieval, assimilation and visualization - applied to regional air quality and weather forecasting researches in the greater Shanghai area.

In May 2010 a DB satellite remote sensing receiving station was built atop an 18-storey building at East China Normal University (ECNU). It consists of X and L band receivers that capture real-time remotely sensed data from several sensors aboard different low earth orbit (LEO) satellites, these satellites including TERRA, AQUA, NOAA-16 to 18, FY-1D and METOP-A. It can also receive data from next generation satellites after simple upgrades provided that they broadcast their data directly using X or L band. These missions include FY-3, NPP and METOP-B. In addition to real-time satellite data reception, a rapid data processing system is needed for real-time applications.

A DBPS (Direct Broadcast Processing System) system was developed based on the IMAPP (International MODIS/AIRS Processing Package) from SSEC (Space Science and Engineering Center) of University of Wisconsin-Madison. It is primarily a fast retrieval system for MODIS and AIRS level 1B data, and is designed to rapidly generate a range of key atmospheric, land-surface and sea-surface parameters. These include atmospheric products like aerosol optical depth (AOD), cloud physical parameters and total precipitable water (TPW) - three critical inputs for atmospheric and trajectory models used in air quality monitoring and regional weather forecasts.

In our application we employ DBCRAS (Direct Broadcast CIMSS Regional Assimilation System), a regional assimilation system designed for direct broadcast remote sensing data. DBCRAS assimilates MODIS cloud top pressure (CTP) and TPW products to calculate a 72-hour regional weather forecast.

The visualization tool McIDAS is used to produce animations of synthetic atmospheric variables including temperature, humidity and wind, for our region of interest, namely the greater Shanghai area. McIDAS is also used to animate the dispersion of aerosol for our air quality research. An empirical model was developed to translate satellite AOD retrievals in the greater Shanghai area to PM10-based on-station measurements. Validation of the applications of DB data in air quality monitoring and weather forecasting for this region is still in progress. However it is already clear that real-time acquisition and fast processing of DB data make a significant contribution to regional atmosphere-related researches and applications when compared to using weather station and PM10 data in isolation.