Aerosol-cloud interactions over major urban clusters of China using MODIS satellite data

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Introduction

City clusters are among the most dynamic and rapidly growing regions of China. Several such clusters have emerged in the past two decades and are still evolving. Here, we study 3 urban clusters: (1) the Yangtze River Delta urban cluster (YRD), (2) the Pearl River Delta urban cluster (PRD), and (3) the Beijing-Tianjin-Hebei urban cluster (BTH), which are the most rapidly growing. (figure 1, left).

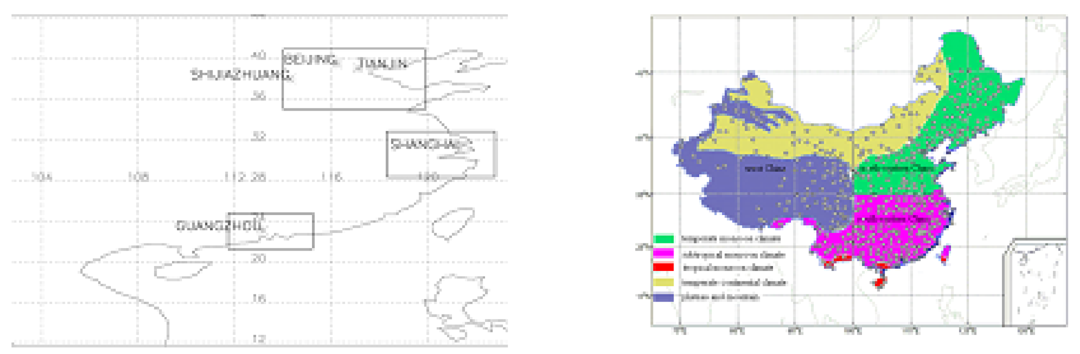

Figure 1: The 3 major urban clusters in China (left), distribution of climate regions in China (right, adopted from Song et al, 2011).

Aerosols are known to impact the formation, optical properties, and life cycle of clouds (Ackerman et al. 2000, Andreae et al. 2004, Kaufman et al. 2005b, Kim et al. 2003, Koren et al. 2004, Koren et al. 2005, Penner et al. 2004, Ramanathan et al. 2001, Rosenfeld 2000, Rosenfeld et al. 2002, Schwartz et al. 2002). It is important to understand and quantify the microphysical impact of both natural and anthropogenic aerosols on clouds, in order to understand and predict climate change (Anderson et al. 2003, Forest et al. 2002, Knutti et al. 2002).Therefore, it is essential to use satellite-based observations to observe potential aerosol effects on the micro and macro-physical properties of clouds (Myhre et al. 2007). In this work, we study the aerosol-cloud relations over 3 selected regions in China. The region of China was separated in 5 climatic zones which are primarily influenced by the Asian monsoon systems and the Tibetan Plateau, to investigate aerosol - cloud interactions under different synoptic regimes over these 3 major urban clusters (figure 1, right). For that purpose, we used a decade (2003 - 2013) of MODIS observations from Terra and Aqua satellites. The relationships that were studied were mainly between the aerosol optical depth at 550 nm (AOD_{550}) and cloud cover (CC), cloud water path (CWP) and water vapor (WV).

Methodolody

For the scope of this work, data from MODIS Terra and Aqua level-3 dataset (1 x 1 degree) were used for the period 2003 - 2013 over the 3 urban clusters in China. In particular, we used Aerosol Optical Depth at 550nm (AOD_{550}), Cloud Cover (CC), Cloud Water Path (CWP), Water Vapor for clear conditions (WVclear) and Water Vapor for cloudy conditions (WVcloudy).

Locally weighted scatter smoothing (Lowess) method with a span of 10% of the total data was used to treat the AOD_{550}-CC, AOD_{550}-CWP, AOD_{550}-WVclear and AOD_{550}-WVcloudy data over the regions. We used only AOD_{550} - cloud parameter data with AOD_{550} values up to 0.6, to exclude misinterpretation of dust as clouds by MODIS, according to Myhre et al. (2007).

Results & Discussion

Over all urban clusters and in all seasons, CC is found to increase with AOD_{550} (figure 2). Regarding the AOD_{550} - CWP relations, the results from Terra and Aqua are not very consistent (figure 3), since Aqua CWP retrievals are somewhat higher than the Terra ones for all regions (figure 3). Therefore, we cannot infer clearly about AOD_{550} and Cloud Water Path relationship without further investigation. Water Vapor is found to increase over BTH urban cluster and to decrease over YRD urban cluster with increasing aerosol load, both for clear and cloudy conditions (figures 4,5). For cloudy conditions over PRD, WV is found to decrease with increasing aerosol load (figure 5), but we cannot conclude for clear conditions, since Terra and Aqua's results differ greatly (figure 4).

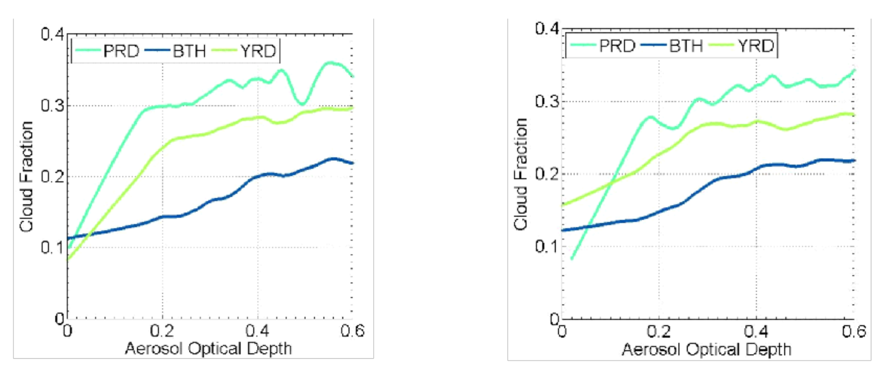

Figure 2: CC as a function of AOD_{550} from Aqua (left) and Terra (right) over the 3 major urban clusters in China for the period 2003-2013 (PRD: Pearl River Delta urban cluster, BTH: Beijing-Tianjin-Hebei urban cluster, YRD: Yangtze River Delta urban cluster).

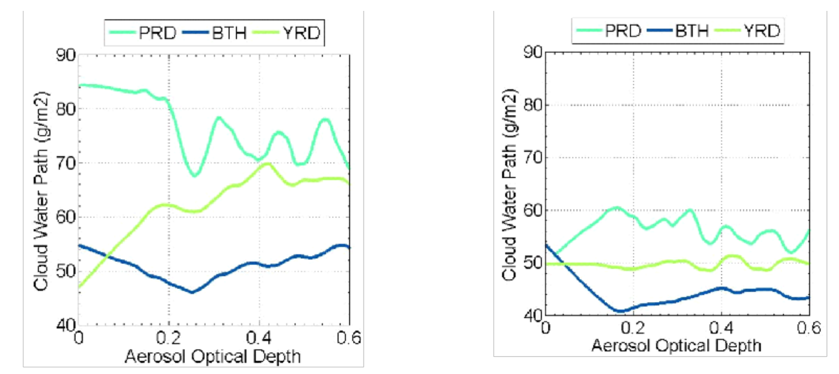

Figure 3: Same as figure 2 but for AOD_{550} - CWP.

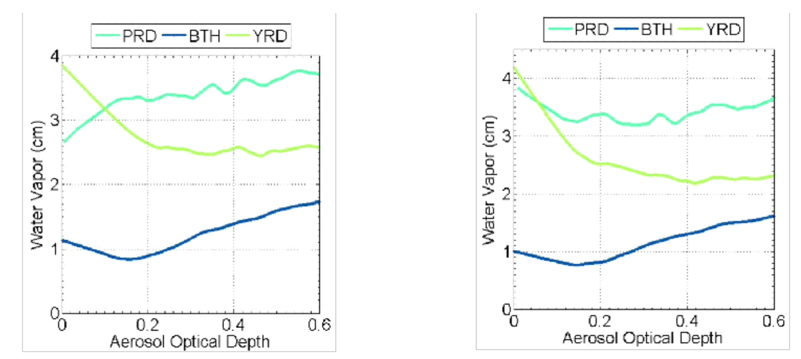

Figure 4: Same as figure 2 but for AOD_{550} - WVclear.

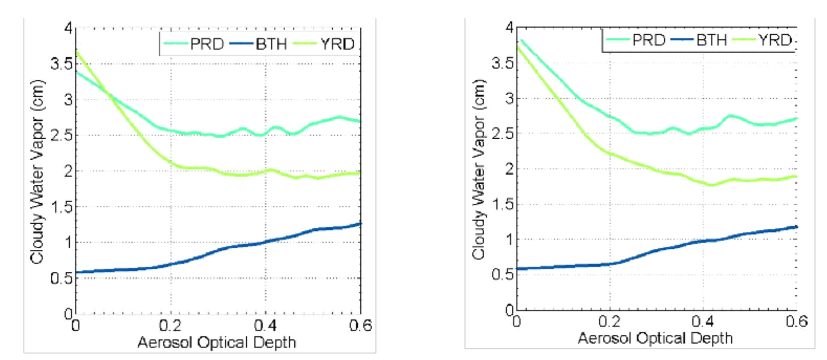

Figure 5: Same as figure 2 but for AOD_{550} - WVcloudy.

Acknowledgments

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