GACP 2nd YEAR ACCOMPLISHMENT REPORT

Title: Estimate the Indirect Aerosol Effect and Retrieval of Related Parameters from Satellite Measurement

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Goals:

The goals of this project are 1) Develop algorithm for quantitative evaluation of cloud susceptibility from satellite remote sensing; 2) twelve years of cloud property data that include optical thickness, column number concentration of water clouds, and column susceptibility; 3) Analyze cloud and aerosol property data to quantitatively relate changes of cloud properties to changes of aerosol abundance. The aerosol property data will be obtained from the products of the science team.

ACCOMPLISHMENT

1) *Near-global survey of cloud column susceptibility*

A new parameter, cloud *column* susceptibility, is introduced to study the aerosol indirect effect, which describes the aerosol indirect effect more directly without assuming how cloud droplet size will respond to changes of droplet number concentration [Han et al., 2000]. Figure 1 shows that, between the two approaches that used to retrieve cloud column susceptibilities, the one that makes no assumption of constant liquid water content leads to smaller, even negative cloud column susceptibilities. This finding is consistent with results of model studies and observations. Model studies show that cloud top warming or cloud base cooling can lead to reduced boundary-layer mixing, which restricts the supply of water vapor and results in a thinning of cloud layers [e.g., *Lilly*, 1968; *Bougeault*, 1985; *Turton and Nicholls*, 1987]. When more CCNs are activated into cloud droplets the total droplet surface area, and thus evaporation, increases due to a greater droplet concentration and smaller average size of the droplets. The increased evaporation at cloud base leads to a greater decoupling between the cloud and the subcloud layers that causes a reduction of cloud liquid water [*Ackerman et al.* 1995]. Another mechanism may lead to desiccation of clouds due to aerosol-cloud interaction is by enhanced solar absorption [e.g., *Ackerman and Toon*, 1996]. Calculations based on results from the observation during the 1998-1999 Indian Ocean Experiment (INDOEX) show that fractional cloud coverage might be reduced by 25% to 40% due to heating by aerosol absorptions [*Schwartz and Buseck*, 2000]. The results of this survey suggest that using constant liquid water content in models may lead to significant overestimation of the aerosol indirect effect.

2) *New approach to distinguish cloud from dust*

In order to estimate the aerosol indirect effect, it is critical to distinguish clouds from aerosols using satellite data. Current techniques used to construct aerosol or cloud climatologies have difficulties in discriminating aerosols and clouds. This drawback limits the credibility when these climatologies are used, especially when they are used for studies of aerosol-cloud interactions. Based on model calculations

and satellite data analysis, this study describes a technique to discriminating dust from clouds over ocean areas using AVHRR data. The results show that this technique is most successful when relatively thick dust storms are presented.

References

Ackerman, A. S., O. B. Toon, and P. V. Hobbs, 1995: Numerical modeling of ship tracks produced by injections of cloud condensation nuclei into marine stratiform clouds. *J. Geophys. Res.*, **100**, 7121-7133.

Ackerman, A. S., and O. B. Toon, 1996: Unrealistic desiccation of marine stratocumulus clouds by enhanced solar absorption. *Nature*, **380**, 512-515.

Bougeault, P., 1985: The diurnal cycle of the marine stratocumulus layer: A higher-order model study. *J. Atmos. Sci.*, **42**, 2826-2843.

Han, Q., W. B. Rossow, J. Chou, and R. M. Welch, 2000: Near-Global Survey of Cloud Column Susceptibilities Using ISCCP Data. *Geophys. Res.*, **27,** *[in press]*

Lilly, D. K., 1968: Models of cloud-topped mixed layers under a strong inversion. *Qua. J. Roy. Meteor. Soc.* **94**, 292-309.

Turton, J. D., and S. Nicholls, 1987: A study of the diurnal variation of stratocumulus using a multiple mixed layer model. *Qua. J. Roy. Meteor. Soc.* **113**, 969-1009.

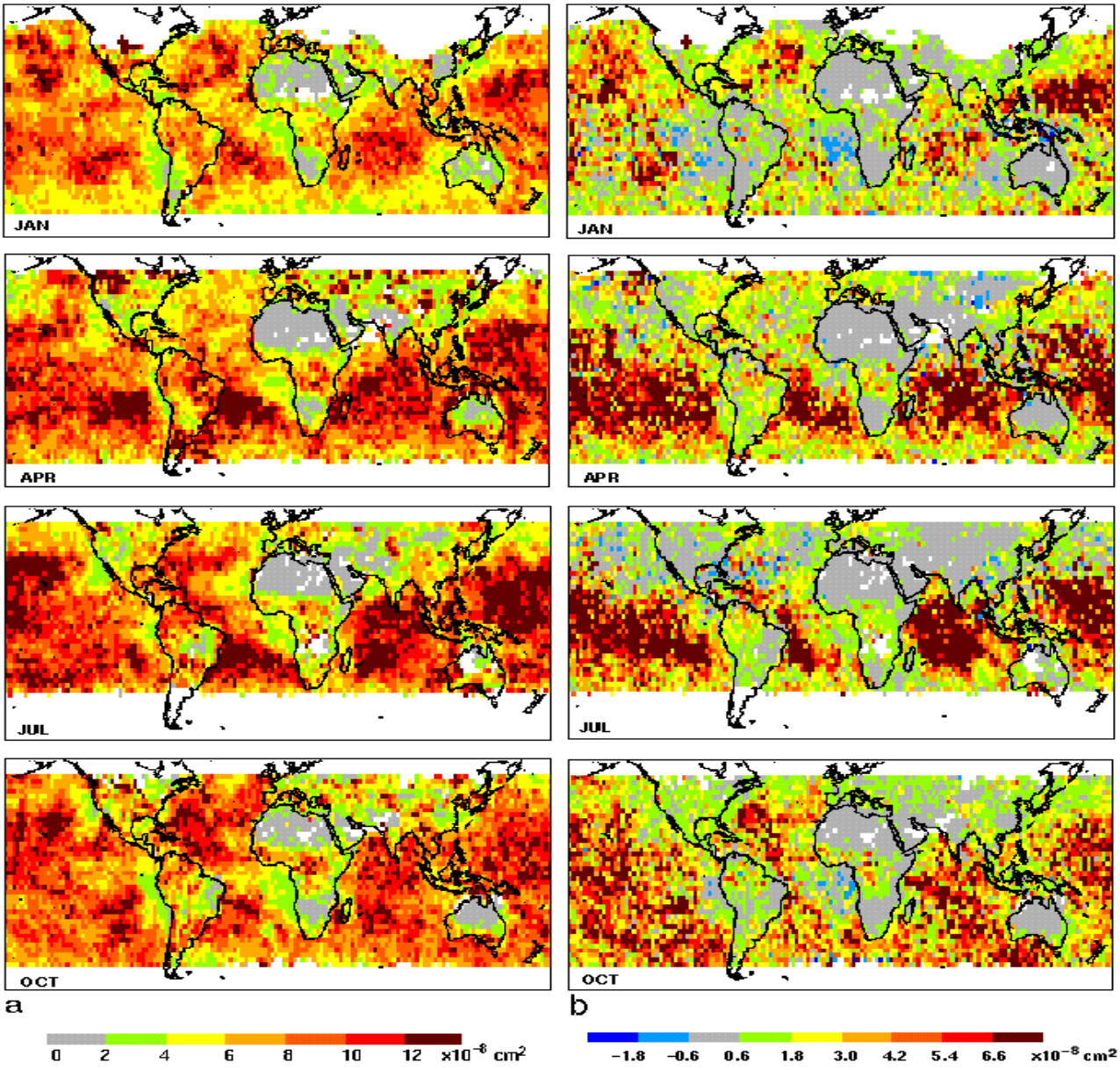

Figure 1. Cloud column susceptibility retrieved from NOAA-9 data of 1987 (a) with the assumption of constant liquid water content, (b) without the assumption of constant liquid water content. Note that different color bars are used in order to show the detailed patterns.

GACP 3rd YEAR STATEMENT OF WORK

In agreement with model studies and in situ measurements, the result of cloud column susceptibility reveals that aerosol-cloud interaction may lead to two different changes in cloud properties, i.e., increase or decrease cloud albedo, even for thin clouds (τ<15). What still kept unknown is the percentage of these two different results and the spatial and temporal variations. In order to answer this question, we plan to process twelve years of ISCCP data to retrieve cloud column susceptibility.

When more evidences showing that holding cloud liquid water content to be constant overestimates the aerosol indirect effect, one has to find out the behavior of cloud liquid water content during the aerosol-cloud interactions. We will estimate the behavior of cloud liquid water during the aerosol-cloud interactions in a near-global scale, which will be helpful in model studies of the aerosol indirect effect.

GACP BIBLOGRAPHY

a. Refereed papers

Han, Q. Y., W. B. Rossow, J. Chou, and R. M. Welch, 2000: Near-global survey of cloud column susceptibility using ISCCP data. *Geophys. Res. Letts.* [in press]

Han, Q. Y., W. B. Rossow, J. Chou, and R. M. Welch, 1998a: Global survey of the relationship of cloud albedo and liquid water path with droplet size using ISCCP. *J. Climate*, **11**, 1516-1528.

Han, Q. Y., W. B. Rossow, J. Chou, and R. M. Welch, 1998b: Global Variation of Droplet Column Concentration in Low-level Clouds. *Geophys. Res. Letts.* **25**, 1419-1422.

b. non-refereed papers

Han, Q., W. B. Rossow, J. Chou, and R. M. Welch, 2000: Retrieval of cloud column susceptibilities of water clouds using satellite data. *Preprints, the 10th Conf. On Satellite Meteorology and Oceanography*, 9-13 Jan, 2000, Long Beach, *CA, 326-329.*

Han, Q., W. B. Rossow, J. Chou, K-S Kuo, and R. M. Welch, 1999: Observed Effects of Cloud Droplet Concentration on Albedo for Low-Level Clouds Using Satellite Data. *Preprints, the 22nd General Assembly of the International Union of Geodesy and Geophysics, 18-30, July 1999*, Birmingham, UK.

Han, Q. Y., J. Chou, and R. M. Welch, 1998: Towards monitoring the aerosol indirect effect from space. *Proceedings of the 18th CERES Science Team Meeting*, Sep, 15-17, 1998, Stony Brook, New York, NY.