AVHRR Observations of the Aerosol Indirect Effect

for Summertime Stratiform Clouds in the Northeastern Atlantic

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Aerosol Direct Effect

Aerosols interact directly with solar radiation.
Views of Denver with and without aerosols. (March 20 and 22, 2004)

Aerosol Indirect effect

Fewer CCN = Less reflective
More CCN = More reflective

Usually assume constant liquid water

Images courtesy of NASA

Cloud Lifetime Effect (AIE – 2)

Smaller droplets lead to suppressed drizzle.
Clouds persist longer and may have greater horizontal extent.
Does liquid water remain constant?

Photo: Maryellen Kinhan
Implications for Climate Change

The global mean relative forcing of the climate system for the year 2000, relative to 1750

Source: IPCC 2001

New look at the IPCC Chart

Treat the estimates on the IPCC chart as means and standard deviations

- Reported errors treated as 1.0, 1.5, or 2.0 standard deviations
- Various assumptions of Gaussian, log-normal, or box errors

New look at the IPCC Chart

Divide into aerosol and non-aerosol components

Boucher and Haywood, 2001

Example of Satellite Data

Visible Image

NOAA / AVHRR
Summary of Retrieval Method

Satellite Observations

- Clear
- Cloudy

Radiative Transfer Model (Aerosols)

Look-up Table

Radiative Transfer Model (Clouds)

Look-up Table

Aerosol or Cloud Properties of Pixel

Example of Retrieved Properties

Four Months of Data

- More aerosol to the east (and north)
- Droplets smaller to the east

Correlation between $\tau_a$ and $R_e$

Polluted clouds have Smaller droplets
Correlation between $\tau_a$ and $\tau_{\text{cloud}}$

- Thicker clouds to the east
- Polluted clouds are optically thicker ($\tau = n\sigma z$)

Correlation between $\tau_a$ and LWP

- LWP = $2/3 \, R_e \, \tau_{\text{cloud}}$
- Polluted clouds lose liquid water

A look at smaller regions

- Partially alleviate issue of large-scale gradient
- Focus on effect of available water

Comparison of Smaller Regions

- Small Aerosol Burden – 47.5N, 17.5W
- Wet

- Large Aerosol Burden – 42.5N, 12.5W
- Dry
Take-home message

- Measuring the Aerosol Indirect Effect is crucial for predicting climate change
- But we need to understand Cloud Liquid Water, which does not remain constant
- Available moisture may govern magnitude of Aerosol Indirect Effect