Aerosol Effects on Heating in the Asian Monsoon Tropopause Layer

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The ATAL as represented by MERRA-2



Aerosols enhance heating near the monsoon tropopause where clear-sky shortwave heating is weakest



Why focus on clear-sky shortwave?

- Direct forcing on diabatic heating
- Aerosol-ice cloud interactions within ATAL largely unknown
- Clouds below ATAL enhance aerosol effects

Based on MERRA-2 aerosols:

ATAL effects on radiative heating peak at about 0.2K/d, with daily mean effects near 0.1K/d



ATAL effects depend primarily on composition: aerosol type



testing ATAL composition

testing ATAL height

ATAL shortwave heating effects are comparable to those of monsoon anomalies in ozone and water vapor



In addition to large variability, discrepancies across aerosol analysis and forecast products lead to large uncertainties

Simulated effects on clear-sky SW heating range from 10-70%



Constraints on optical properties also weak

Could this impact vertical transport 50

- Trajectory simulations using MERRA-2 indicate that transit times between 370K and 380K average around 20 days within the monsoon anticyclone
- Total diabatic heating in this region is ~0.5-1K/day





- Daily-mean ATAL effects of ~0.1K/day represent ~10-20% of total heating
- Subtracting these effects from MERRA-2 heating would lengthen transit times by as much as 5 days
- Implications for, e.g., troposphere-tostratosphere transport of short-lived halogenated species that contribute to ozone depletion

How do aerosol effects couple to cloud and dynamical fields?



ACAM AeroCom experiments target the effects of Asian aerosols on the monsoon system in global models:

- BASE: all emissions
- ANTO: no anthropogenic emissions
- EASO: as ANTO but only over East Asia
- SASO: as ANTO but only over South Asia
- VOLO:
 no volcanic emissions

anthropogenic aerosols from all sources weaken the monsoon anticyclone



How can aerosols influence the upper-level anticyclone?



Garny and Randel 2013

Summary

- Aerosols enhance radiative heating near the monsoon tropopause, where clear-sky shortwave heating is weakest
- In additional to large day-to-day variability, discrepancies across aerosol analysis and forecast products lead to large uncertainties (10-70%) in the magnitude of ATAL radiative effects
- Radiative heating effects based on MERRA-2 are comparable to those of monsoon anomalies in ozone and water vapor
- ATAL effects could reduce transit time through the tropopause layer within the monsoon anticyclone, a key source of pollutants to the global stratosphere
- We are investigating coupling with clouds and dynamical fields using the ACAM/UTLS set of AeroCom model experiments: combined, aerosol effects weaken the upper-level anticyclone





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