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# INVESTIGATION OF AEROSOL AND CLOUD SUBTYPES PRESENT AT HIGHER ALTITUDES OVER THE HIMALAYAN FOOTHILLS

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## INTRODUCTION

- Improved characterization of vertical and regional distribution of aerosols (of both anthropogenic and natural origin) are crucial to completely understand the aerosol-climate interaction.
- The variability in aerosol vertical distribution is due to the combined effects of emissions, vertical lifting strength and boundary layer-troposphere/troposphere-stratosphere exchanges, atmospheric transport through air mass trajectory as well as their removal processes over a region.
- Aerosol and cloud vertical distributions, their subtypes as well as the aerosol-cloud interaction over the Himalayan foothills covering the northeastern south Asia (22-30°N; 88-98°E) are investigated in the present study using multiple satellite observations (Figure 1).

**Keywords:** Aerosol subtypes, Cloud subtypes, Aerosol distribution, Aerosol-cloud interaction, North-East India.

## STUDY REGION:

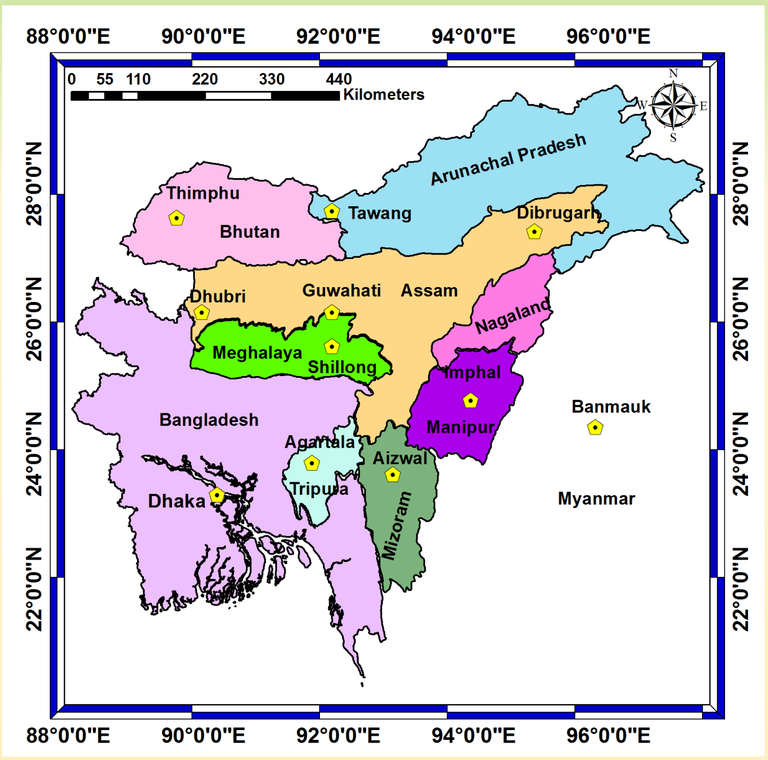


*Figure 1: Study locations (yellow pentagon) over northeastern south Asia.*

## RESULTS AND DISCUSSION

### Vertical Profiles of Aerosols and their Subtypes

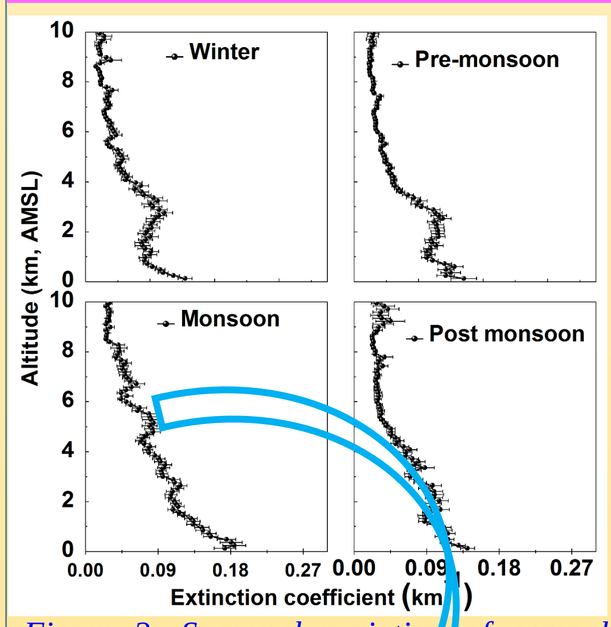


*Figure 2: Seasonal variation of aerosol extinction coefficient over the study region.*

- Seasonal variability in aerosol extinction profiles with distinct elevated aerosol layers (EALs) have been observed (Figure 2).
- Monsoon season exhibits EALs at higher altitudes (up to ~7.4 km at Banmauk) than rest of the seasons (Figure 3). This is attributed to the strong ascending motion due to overturning Walker and Hadley circulation.

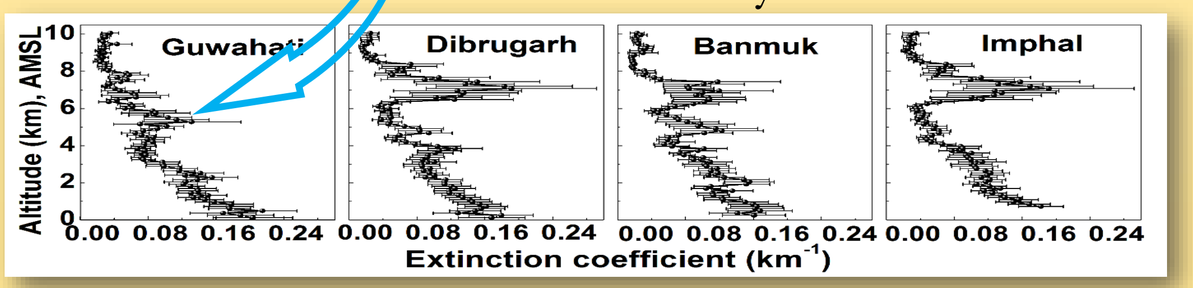


*Figure 3: Elevated aerosol layers (EALs) over selected location during the monsoon.*

- Background maritime, dusty marine (MC) and clean continental (CC) are prevalent during winter and post monsoon in the atmospheric column.
- Occurrence of dust, polluted dust, and elevated smoke aerosols are significant in the EALs in all the seasons (Figure 4). Sizable amount of CC aerosols are also found in the EALs during monsoon.

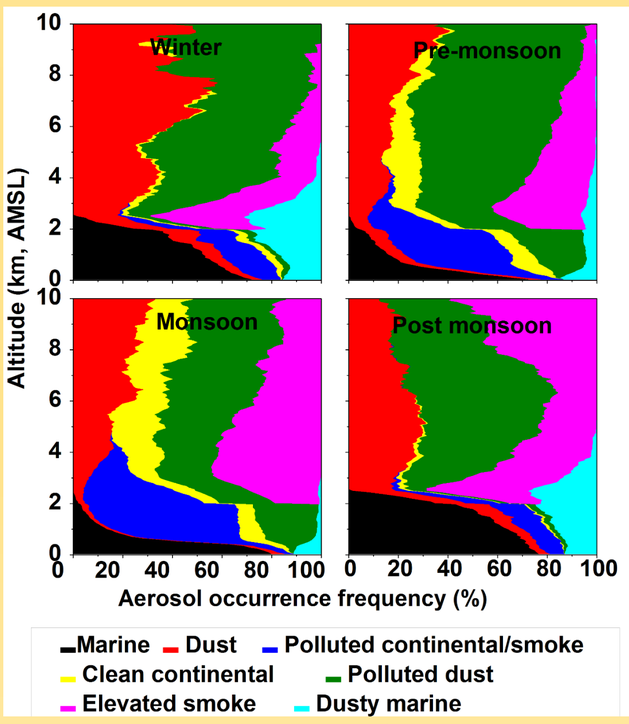


*Figure 4: Seasonal variation of aerosol subtypes.*

### Vertical Profiles of Cloud Subtypes

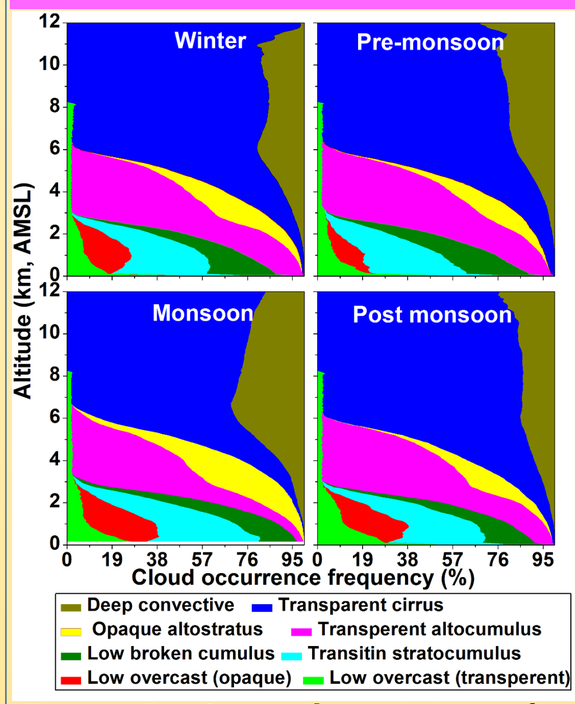


*Figure 5: Seasonal variation of cloud subtypes.*

- Seasonal variability of cloud subtypes occurrence frequency is observed.
- The high clouds: transparent cirrus and deep convective clouds (DCCs) are prevalent during monsoon season.
- In total cloud occurrence frequency single peak only is observed with peak frequency in monsoon.

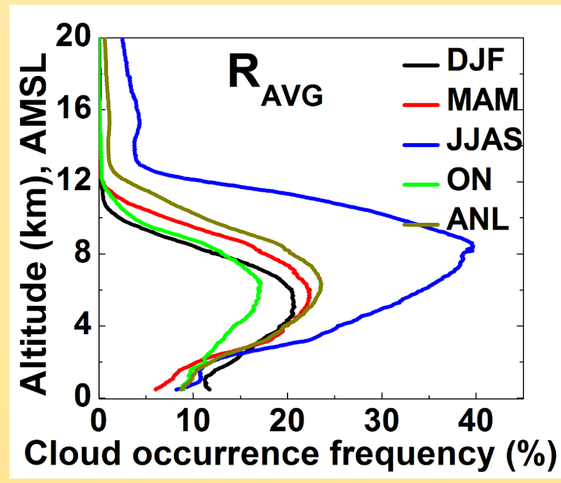


*Figure 6: Vertical profiles of total cloud occurrence frequency.*

### Effect of Aerosols on Cloud

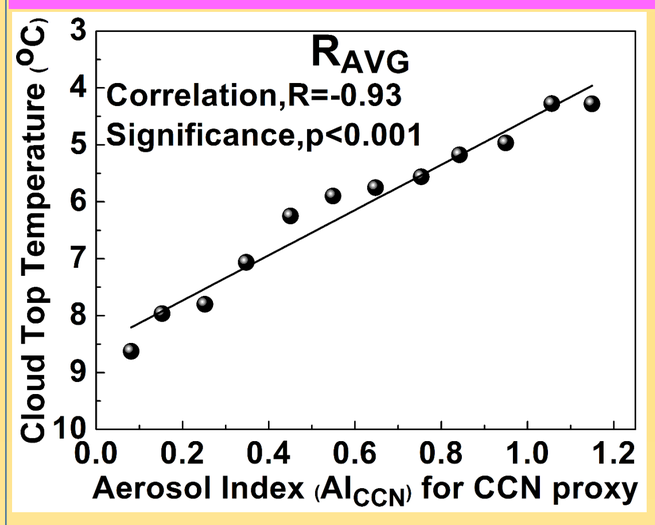


*Figure 7: Correlation of cloud top temperature (CTT) and cloud condensation nuclei (CCN) proxy for warm clouds.*

- Significant ($p<0.001$) negative correlation is observed between CTT and $AI_{CCN}$ for warm (liquid) clouds, suggesting the presence of invigoration for liquid clouds.
- Cloud inhibition is observed in case of mixed phase/ice clouds due to semi direct effect by dust, polluted dust, elevated smoke.

- Distinct seasonality in aerosol profiles as well as EALs are observed.
- High cloud occurrence frequency is maximum over the region.
- In total cloud occurrence frequency Single peak is observed.
- Cloud invigoration/ inhibition is observed in warm cloud/ mixed-phase or ice clouds.

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