Aerosols Radiative Forcing in Western Trans-Himalayas

Why in News

Recently, a study by **the Aryabhatta Research Institute of Observational Sciences (ARIES)** has found that **radiative forcing of aerosols** i.e. effect of anthropogenic aerosols is much higher over the high altitudes of western trans-Himalayas.

- **ARIES,** Nainital is an autonomous research institute under the Department of Science and Technology (DST), Ministry of Science and Technology.
- The Trans-Himalayas Mountain Region is located to the north of the Great Himalayas which consists of **Karakoram, Ladakh, Zaskar and Kailash mountain ranges.** It is also called the Tibet Himalayan Region because most of the part of these ranges lies in Tibet.

Key Points

- **Aerosol Radiative Forcing (ARF) :**
  - The study analysed the **variability of aerosol optical, physical and radiative properties** from January 2008 to December 2018 and the role of fine and coarse particles in **Aerosol Radiative Forcing (ARF)** assessment.
  - The ARF values at top of the atmosphere were mostly low over Hanle and Merak.
    - **ARF** is the **effect of anthropogenic aerosols on the radiative fluxes** at the top of the atmosphere and at the surface and on the absorption of radiation within the atmosphere.
    - Hanle and Merak, situated in Ladakh are the part of **Indian Astronomical Observatory (IAO).**
  - **Change in Temperature:**
    - The study shows that monthly-mean atmospheric radiative forcing of aerosols leads to heating rates of **0.04 to 0.13 degree celsius per day.**
    - Further, the temperature over the Ladakh region is increasing **0.3 to 0.4 degree celsius per decade** from the last 3 decades.

- **Aerosol Optical Depth (AOD):**
  - The observations show that the **Aerosol Optical Depth (AOD)** exhibited a distinct seasonal variation with higher values (0.07) in May and lower (0.03) in winter months.
  - **AOD** is a measure of how **light is absorbed or reflected by airborne particles** as it travels through the atmosphere.
    - If aerosols are concentrated near the surface, **an optical depth of 1 or above** indicates very **hazy conditions.**
    - An optical depth, or **thickness, of less than 0.1** over the entire atmospheric vertical column is considered clean.
- **Angstrom Exponent (AE):**
  - The lower values of **Angstrom Exponent (AE)** in spring indicated dominance of coarse-mode dust aerosols.
  - **The Angstrom Exponent** is a parameter that describes **how the optical thickness of an aerosol typically depends on the wavelength** of the light.
- **Composition of Air:**

  Pure and polluted dust exhibited fractions between 16% and 23%, with a low frequency of less than 13% of absorbing aerosols, denoting weak influence of **anthropogenic aerosols** and **Black Carbon** over the trans-Himalayan sites.

Significance of the Study

- The atmospheric aerosols **play a key role in the regional/global climate system** through scattering and absorption of incoming solar radiation and by modifying the cloud structure.
- The transport of **light-absorbing carbonaceous aerosols and dust from the polluted Indo-Gangetic Plain and desert areas over the Himalayas** constitutes a major climatic issue due to severe **impacts on atmospheric warming and glacier retreat.**
- This heating over the Himalayas facilitates the **"elevated-heat pump"** that strengthens the temperature gradient between land and ocean and modifies the atmospheric circulation and the monsoon rainfall.
- A deep scientific study of **aerosol generation, transport, and its properties have important implications in the mitigation of climate change.**
- The study can help better **understand the aerosol optical and microphysical properties** and improve the **modelling of aerosol effects in view of aerosol-climate implication** via modifications in atmospheric warming and changes in the snow/glacier albedo over the trans-Himalayan region.

Background

- Measurements of aerosol optical and microphysical properties started during the last decade at the **Indian Astronomical Observatory (IAO) at the high altitude background sites of Hanle and Merak in the trans-Himalayas** under the frameworks of **Aerosol Radiative Forcing over India (ARFI)** and **Astronomical Site Survey program of Indian Institute of Astrophysics (IIA),** Bangalore.
- The **Indian Astronomical Observatory,** located near **Leh in Ladakh,** has one of the world's highest located sites for optical, infrared and gamma-ray telescopes.
- In addition to this, few in-situ measurements of carbonaceous aerosols and ionic species have also been performed at Himansh Observatory (Spiti Valley) in the western Himalayas.

Aerosol

- Aerosols are defined as a combination **of liquid or solid particles suspended** in a gaseous or liquid environment.
- In the atmosphere, these particles are mainly situated in the low layers of the **atmosphere (< 1.5 km) since aerosol sources** are located on the terrestrial surface.
- However, certain aerosols can still be found in the stratosphere, especially volcanic aerosols ejected into the high altitude layers.
- The origin of atmospheric aerosols is either **natural or the result of anthropogenic activities.**
    - **Natural sources of aerosols** include sea salt generated from breaking waves, mineral dust blown from the surface by wind, and volcanoes.
    - **Anthropogenic aerosols** include sulfate, nitrate, and carbonaceous aerosols, and are mainly from fossil fuel combustion sources.
    - **Significance:**
        - Reflect **more energy from the sun back to space.**
        - In remote places with cleaner air, the effect of aerosol particle formation on clouds is found to be much larger.
        - Affect the atmospheric chemical composition.
        - Can **reduce visibility.**
        - Have important impacts on **air quality and human health** (e.g. aerosols can cause damage to heart and lungs).
        - Serve as nuclei for cloud droplets or ice crystals in ice clouds.

Way Forward

Despite the large progress in quantifying the impact of different aerosols on radiative forcing, it still remains one of the **major uncertainties in the climate change assessment. Precise measurements of aerosol properties** are required to reduce the uncertainties, especially over the oceans and high altitude remote locations in the Himalayas.

Source: PIB