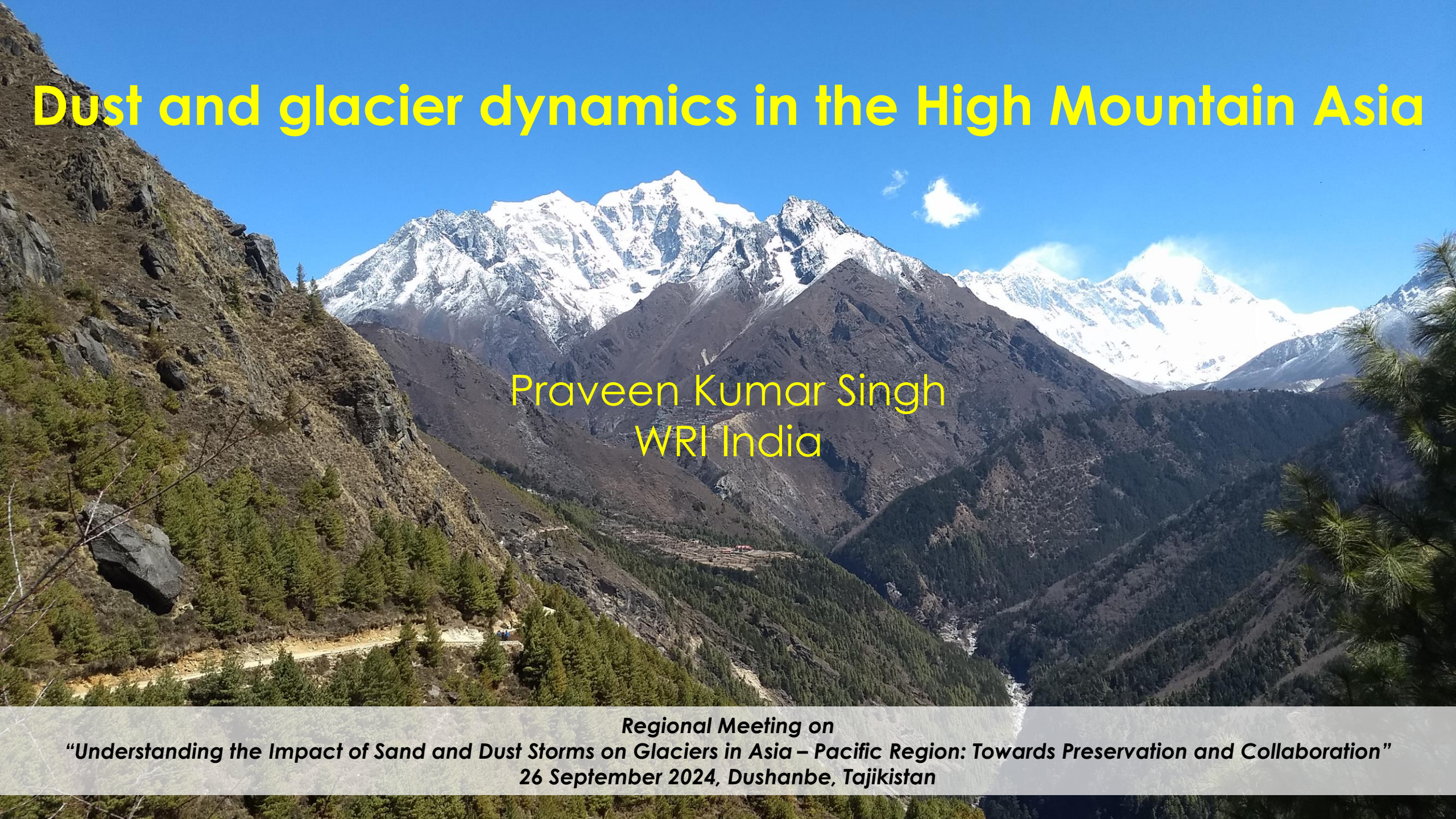
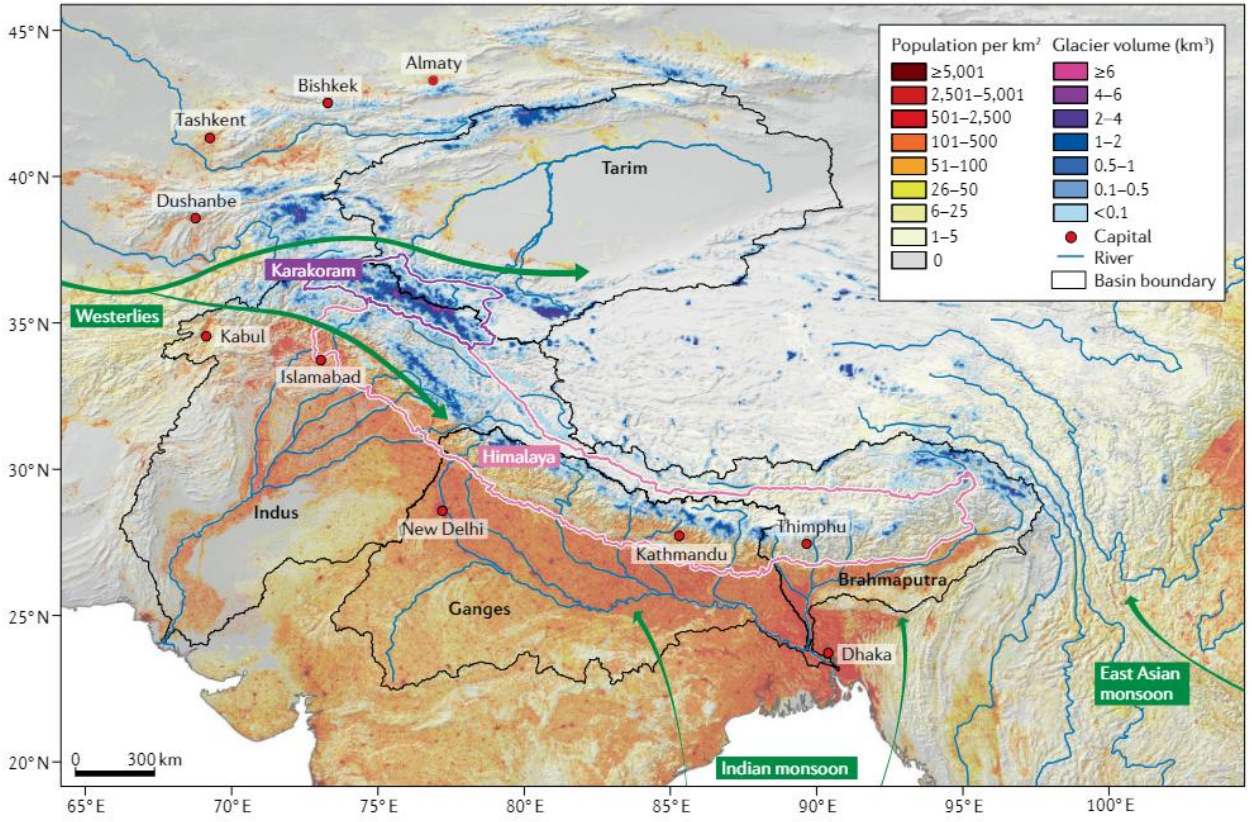
Dust and glacier dynamics in the High Mountain Asia



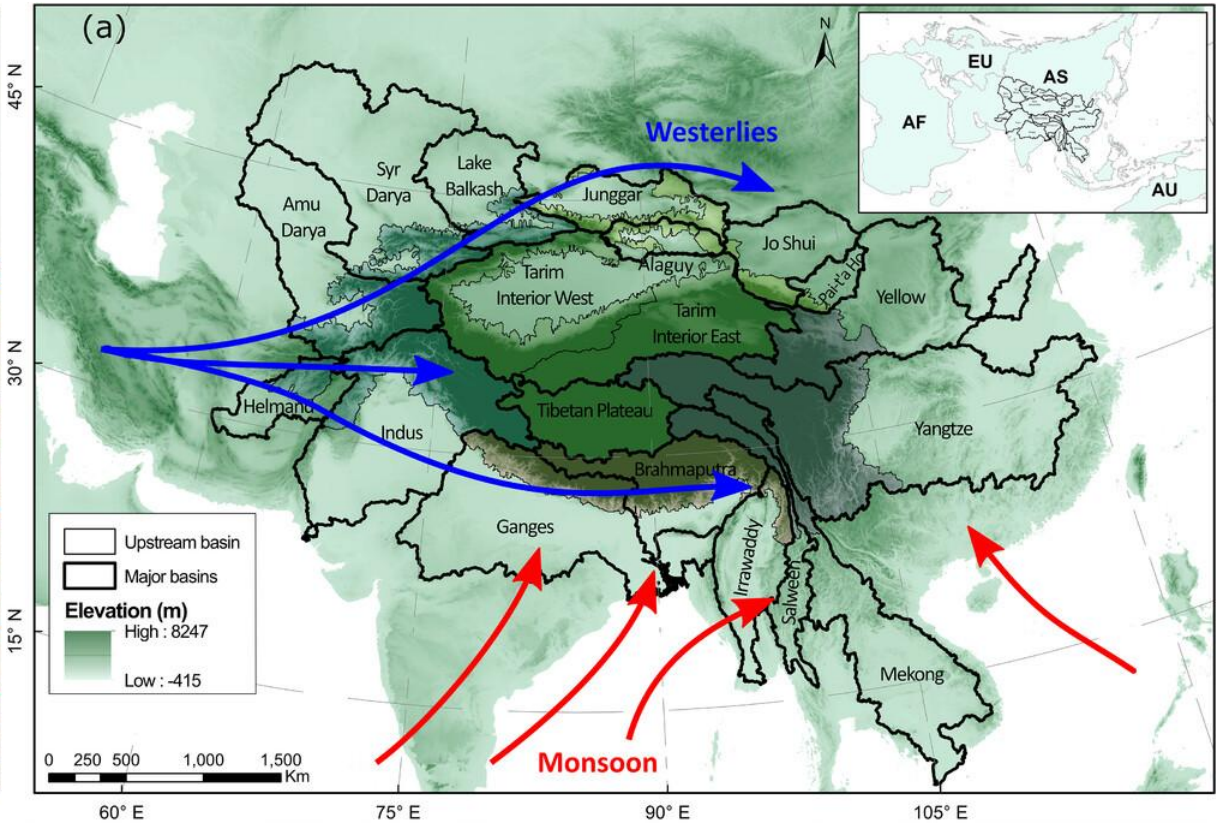
Praveen Kumar Singh
WRI India

Regional Meeting on
"Understanding the Impact of Sand and Dust Storms on Glaciers in Asia – Pacific Region: Towards Preservation and Collaboration"
26 September 2024, Dushanbe, Tajikistan

The third pole



High-mountain Asia population and glacier volume (Nie et al., 2021)

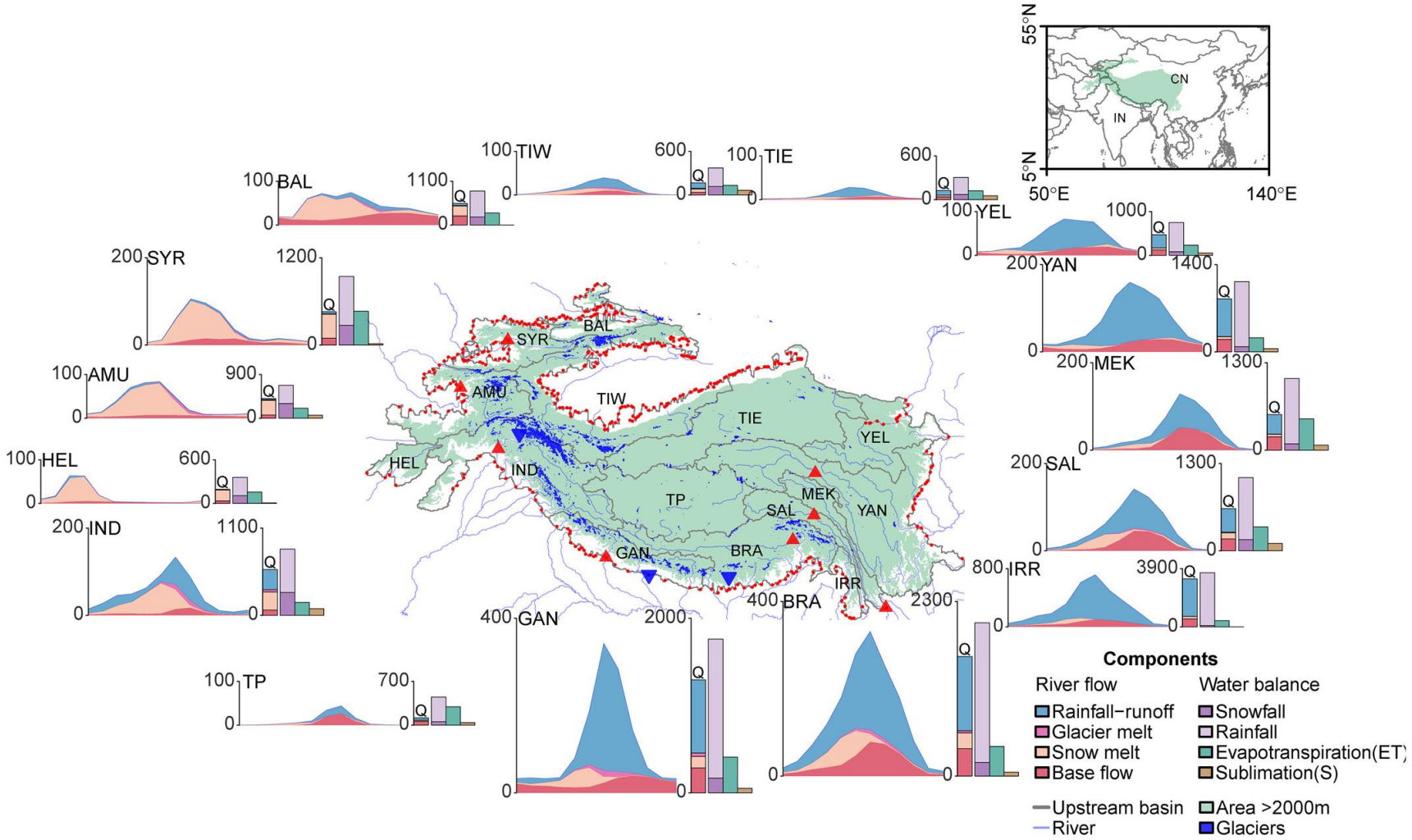


The river basins and their important moisture source (Khanal et al., 2023)

- High Mountain Asia consists of the Qinghai–Tibet Plateau and its surrounding regions, including the Karakoram, Pamir, Himalayas, and Tien Shan
- HMA hosts 131819 glaciers, covering a total area of ~99,817 km^2 (Sakai, 2019)

The water resources in the region

Contribution of snow melt is more in the total runoff

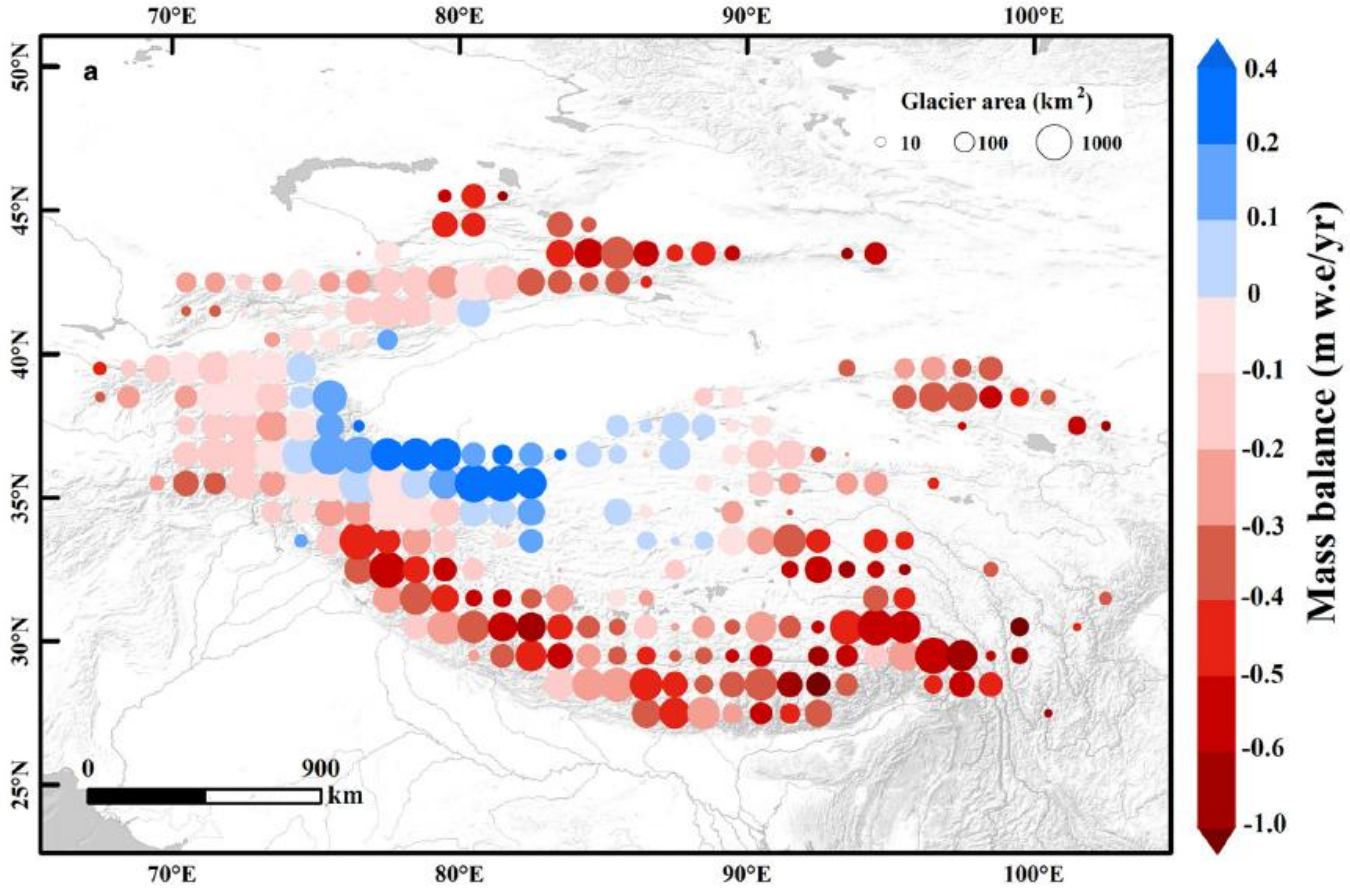


Contribution of rainfall is more in the total runoff

1985 – 2014 mean seasonal cycles of discharge and contribution of baseflow, snowmelt, glacier melt, and rainfall-runoff (Khanal et al., 2021)

Present status of glaciers

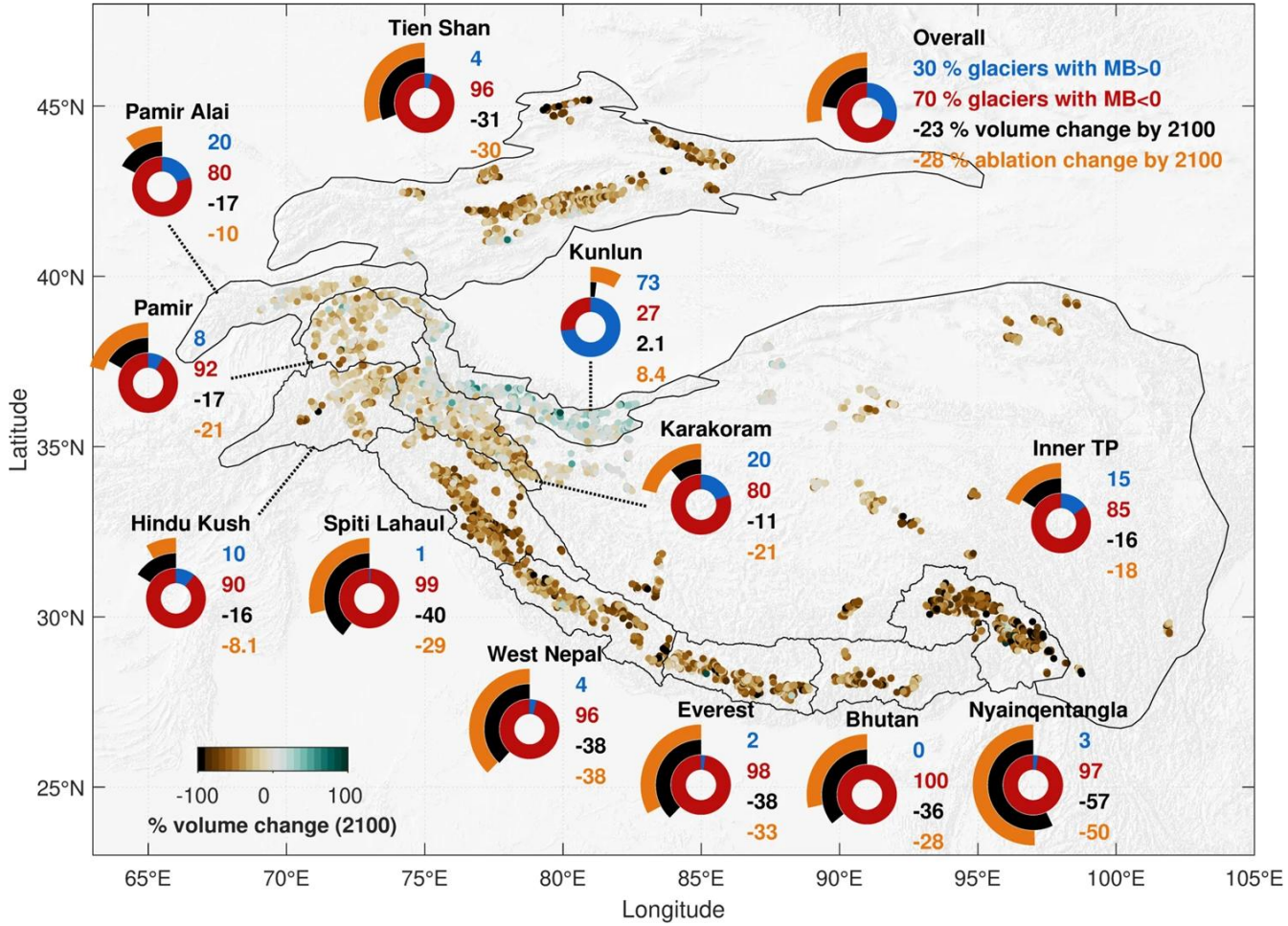
- ~−0.18 ± 0.12 m w.e. a^{-1} (−17.53 ± 11.36 Gt a^{-1}) from 2000 to 2021
- South-eastern: up to −1m w.e. a^{-1}, southern and north-eastern: ~−0.6m w.e. a^{-1}
- Hissar Alay, Pamir and West Tien Shan Mountains: −0.1m w.e. a^{-1}
- Positive trend: ~0.2–0.4 m w.e. a^{-1}



Glacier mass balance change between 2000 – 2021 (Fan et al., 2023)

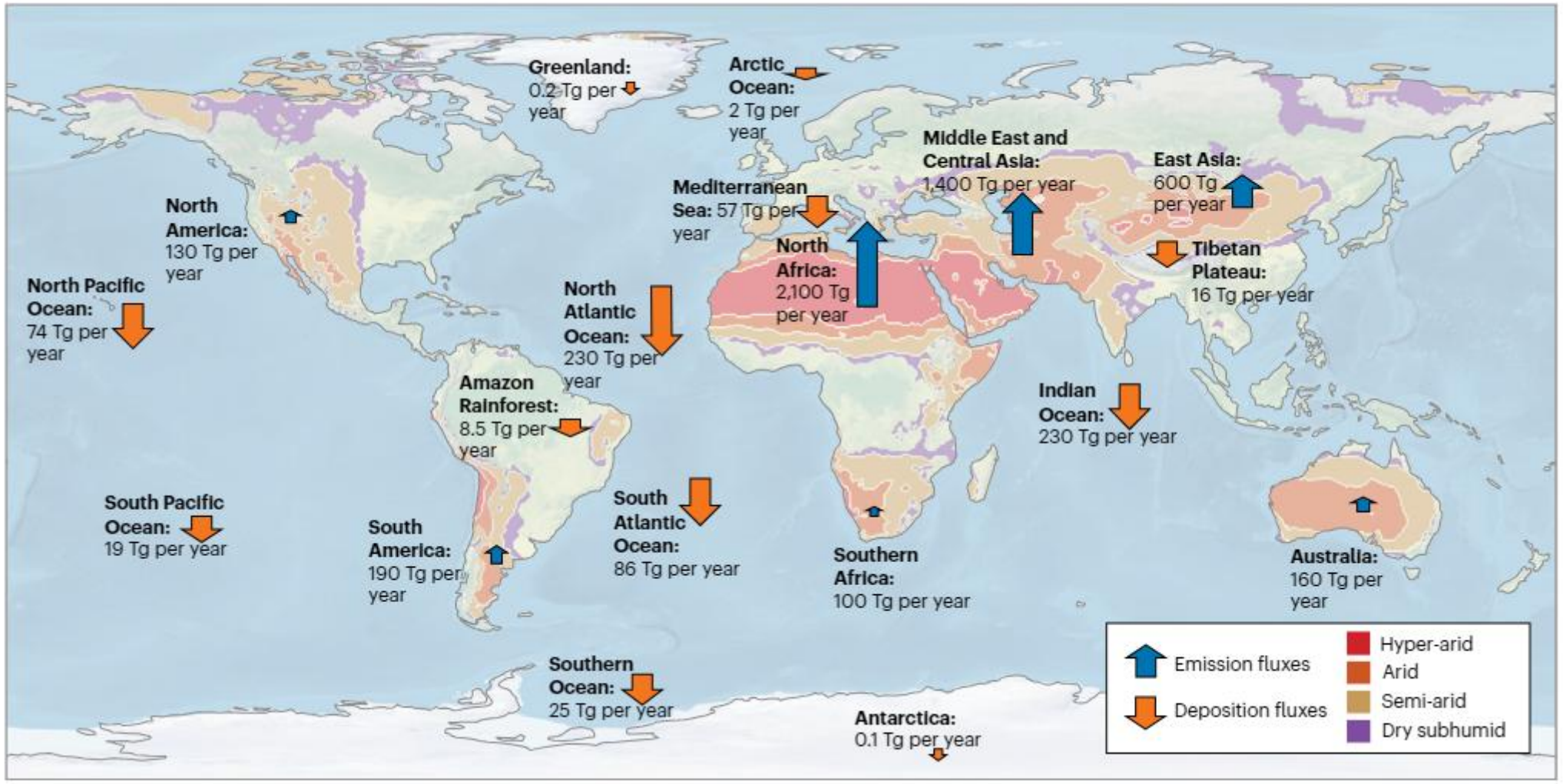
Future changes

- All subregions along the Himalaya lose at least 35% of their present-day volume by 2100.
- 10-20% for the Karakoram, Pamir Alai, Pamir, and Hindu Kush
- A volume gain of 2.1% for the Kunlun Shan



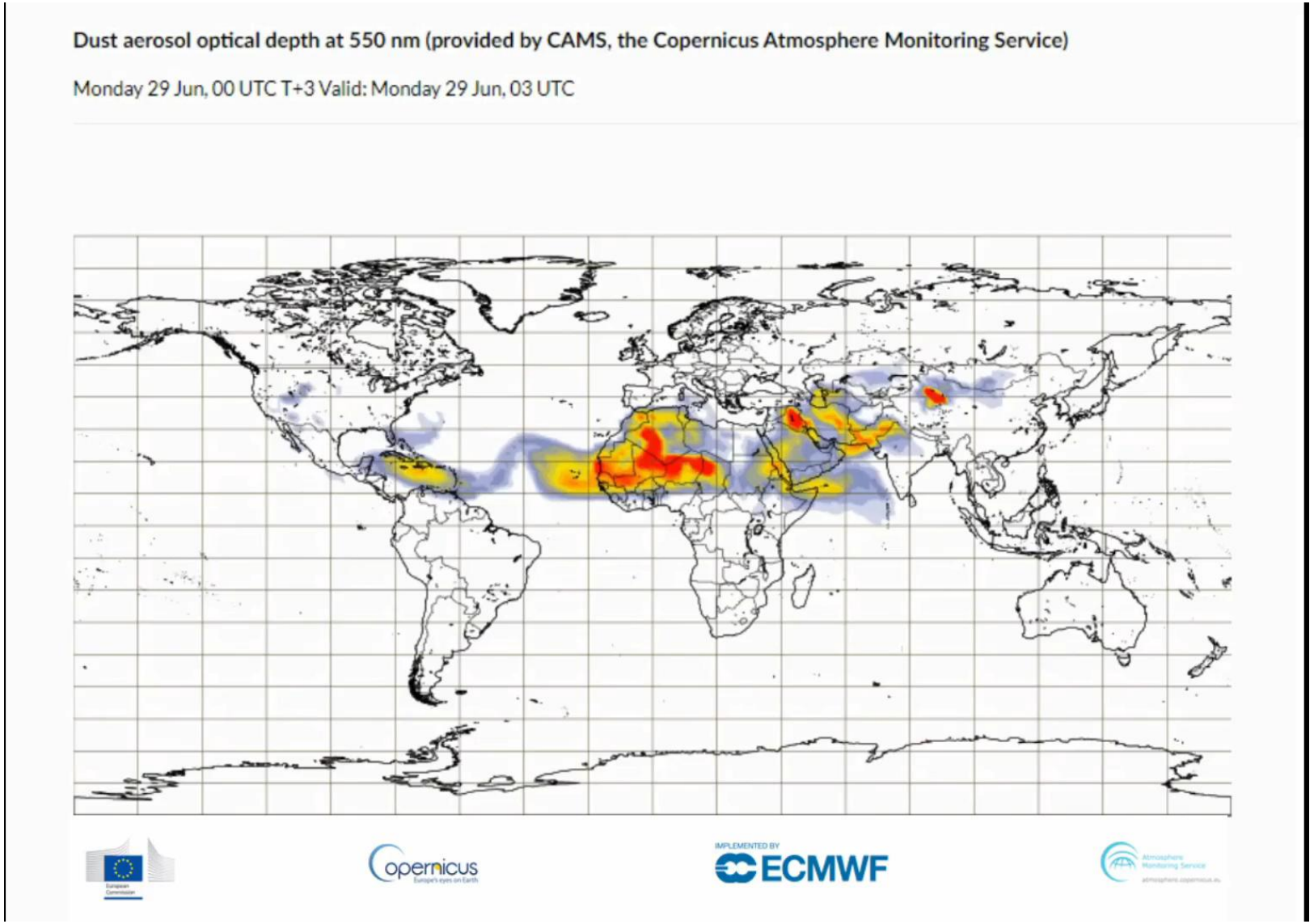
Changes in glacier volume and total ablation by 2100 implied by 2000-2016 mass balance regime (Miles et al., 2021)

Dust sources and sinks



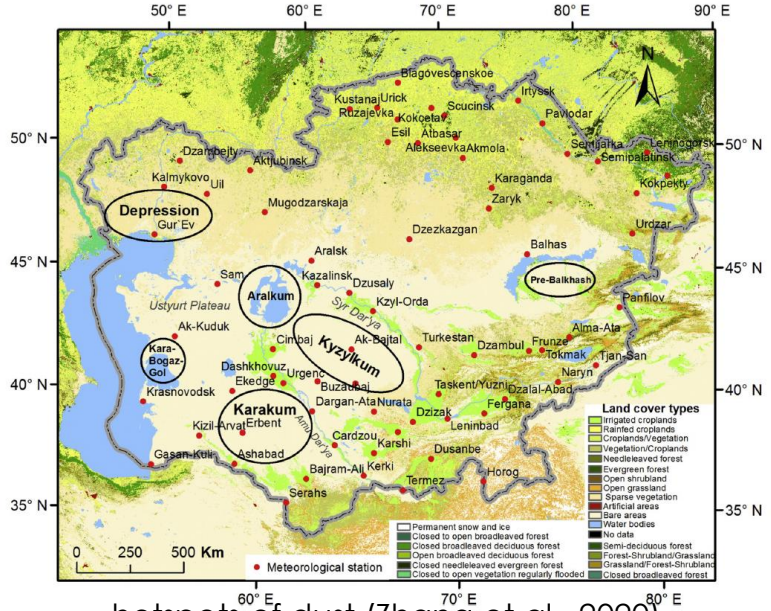
Sources and sinks of dust in the global dust cycle (Kok et al., 2023)

Dust storms

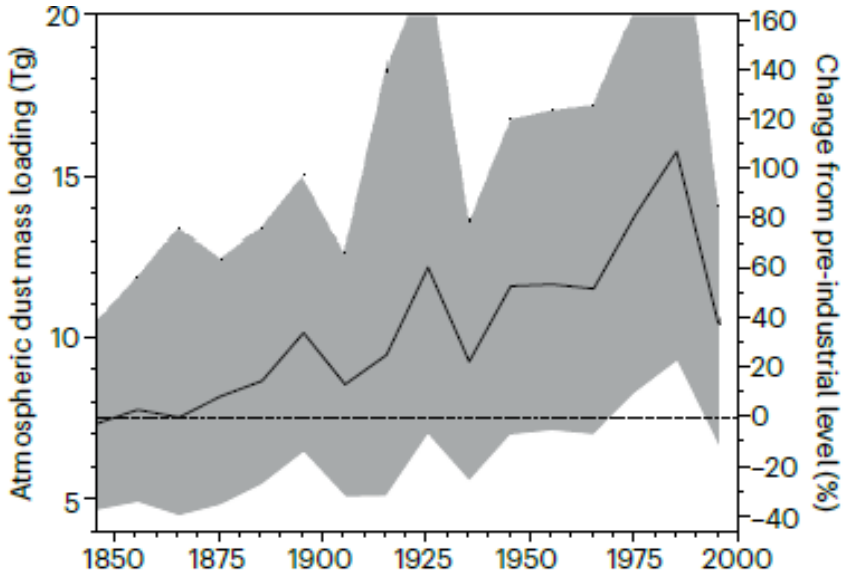

Dust aerosol optical depth at 550 nm (provided by CAMS, the Copernicus Atmosphere Monitoring Service)
Monday 29 Jun, 00 UTC T+3 Valid: Monday 29 Jun, 03 UTC
opernicus
IMPLEMENTED BY
ECMWF

Dust storms in the Central Asia

- Central Asia are characterized by a continental climate with ***long dry summers, strong winds, a scarcity of vegetation cover, a lack of moisture in the soil, relatively low air humidity, atmospheric droughts, and frequent and strong winds throughout the whole year***
- *Anthropogenic factors such as* ***unsustainable methods of land use, excessive water uptake, secondary use of water and soil salinization, deforestation and unsustainable farming practices that contribute to soil erosion***
- The hotspots of dust storm activity are in Kazakhstan (areas surrounding the desiccated **Aral Sea**, known as the **Aralkum Desert**, **Saryesik Atyrau Desert** to the south of **Lake Balkhash** and **Muyunkum Desert** to its western end), Turkmenistan (**Karakum Desert**), Uzbekistan (**Kyzylkum Desert**), **west of Mongolia and northwest China** (Tarim Basin, Taklimakan and Gurbantunggut Deserts)
- Several atmospheric parameters such as El Nino-Southern Oscillation (ENSO), Arctic Oscillation and North Atlantic Oscillation (AO/NAO), and Siberian High (SH) can directly and/or indirectly influence dust activity over Central Asia.
- Recent studies highlighted the role of Caspian Sea-Hindu Kush Index over the dust storm activity in the Central Asia.

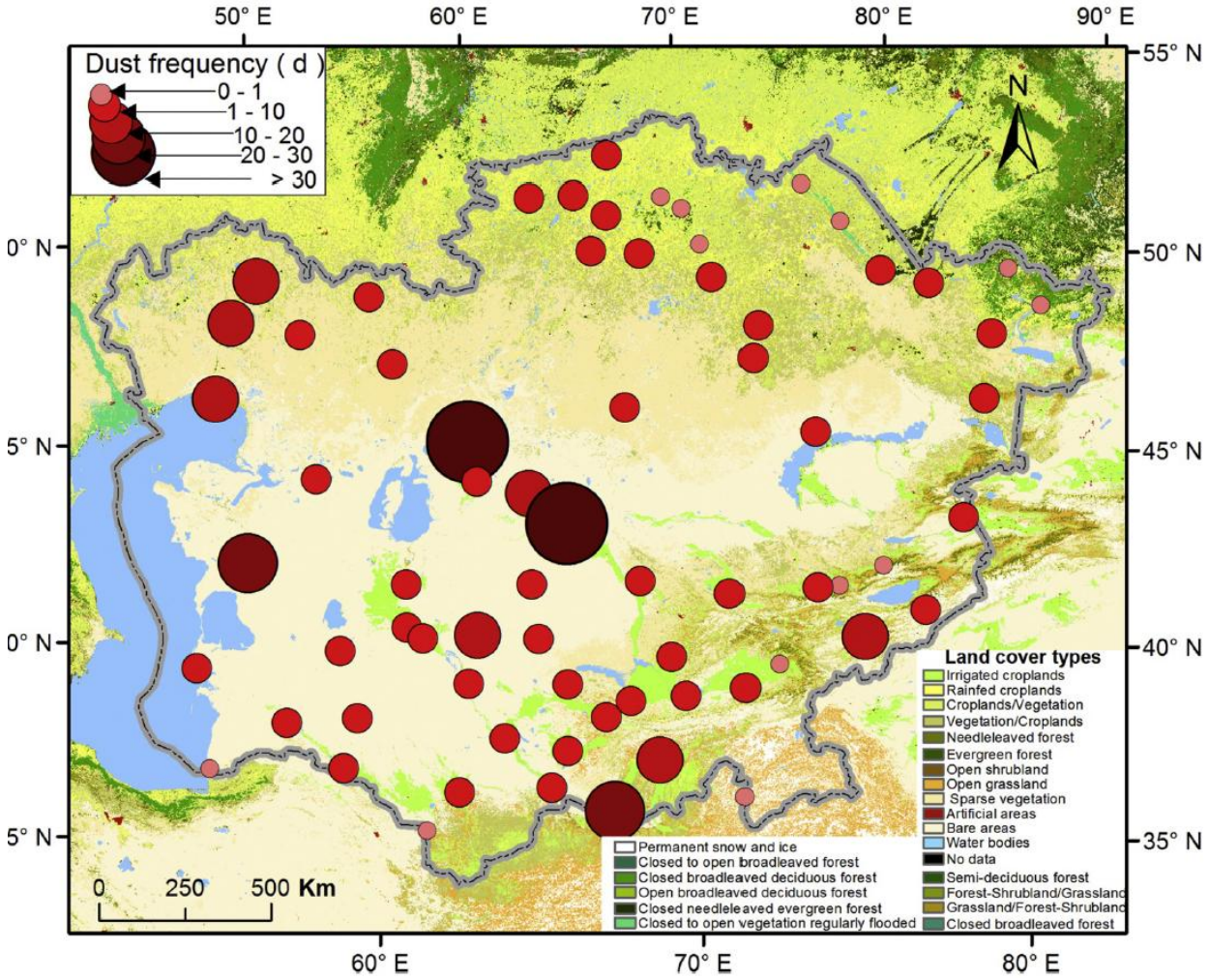


hotspots of dust (Zhang et al., 2020)

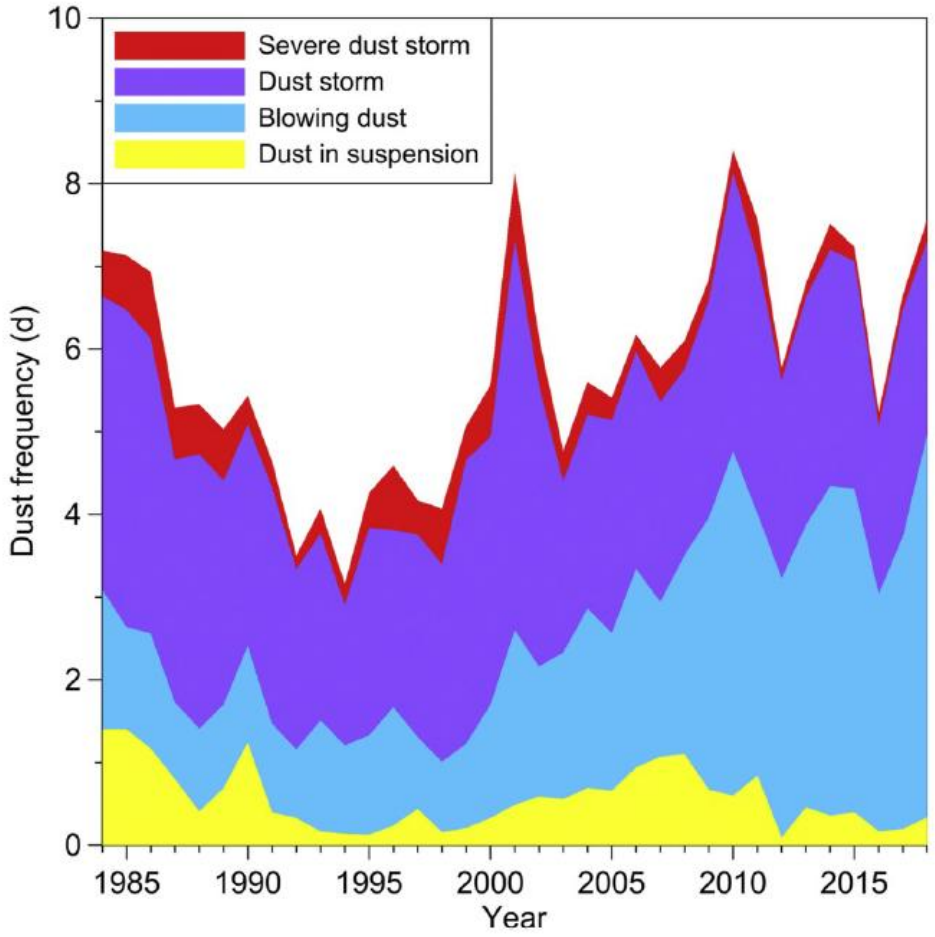


Atmospheric dust mass loading changes since pre-industrial times (Kok et al., 2023)

Frequency of the dust events

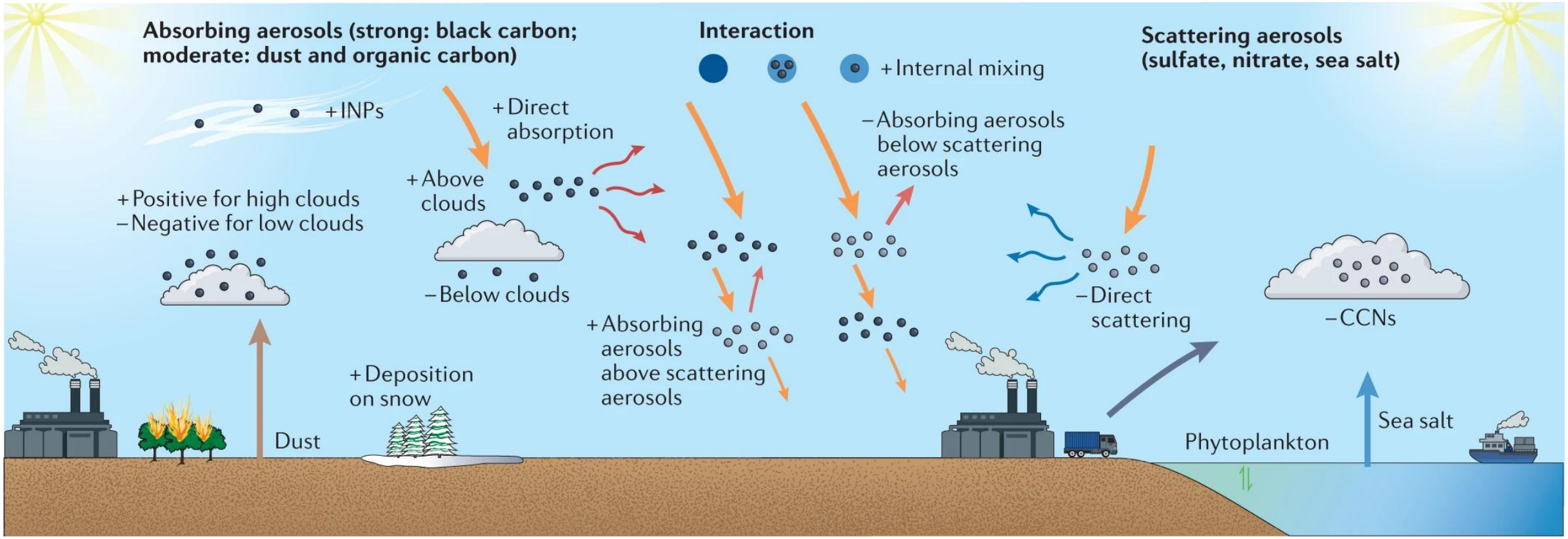


Spatial distribution of annual average dust event frequency from 1984 to 2018 in Central Asia (Zhang et al., 2020)



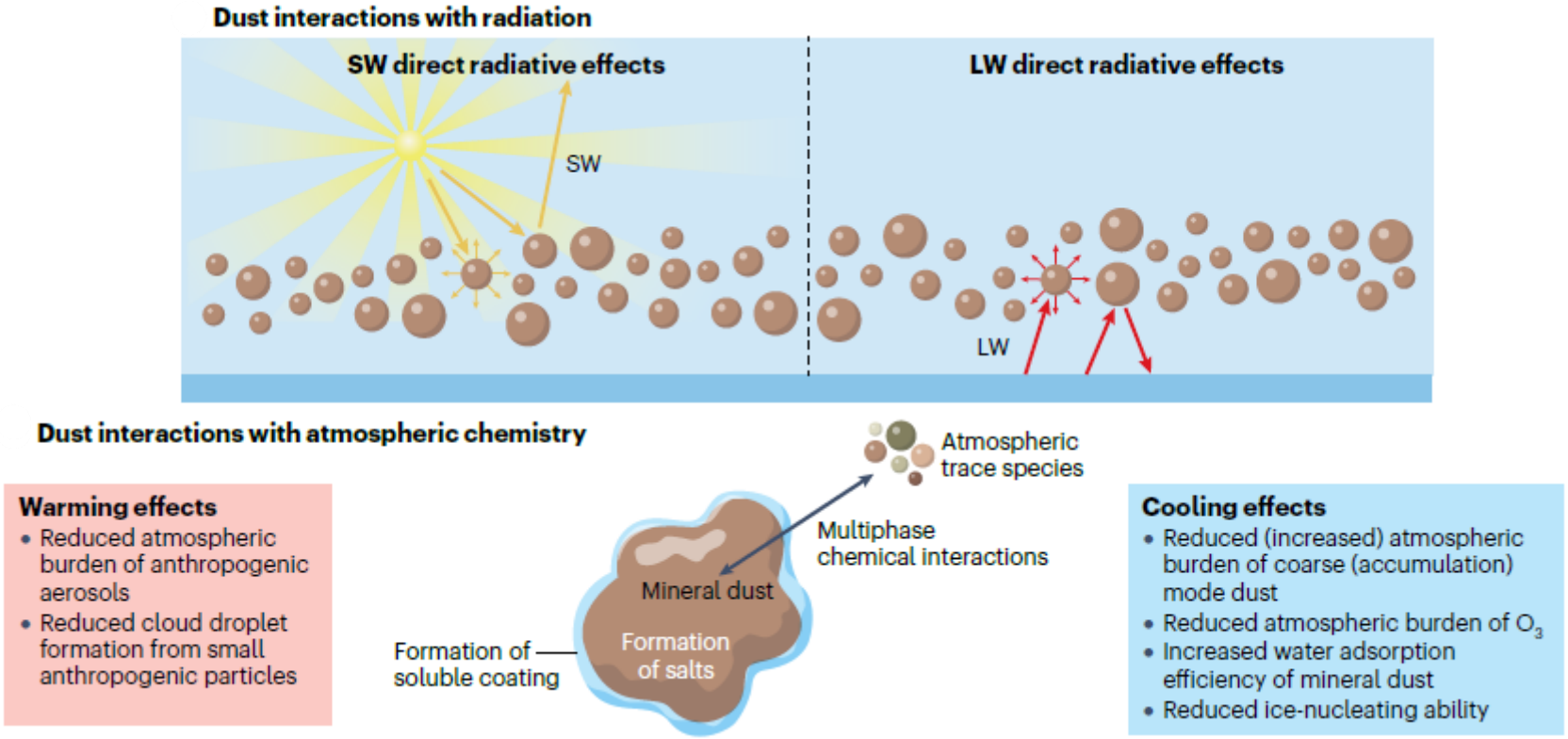
Dust event frequency over Central Asia (1984–2018) (Zhang et al., 2020)

Absorbing vs scattering aerosols



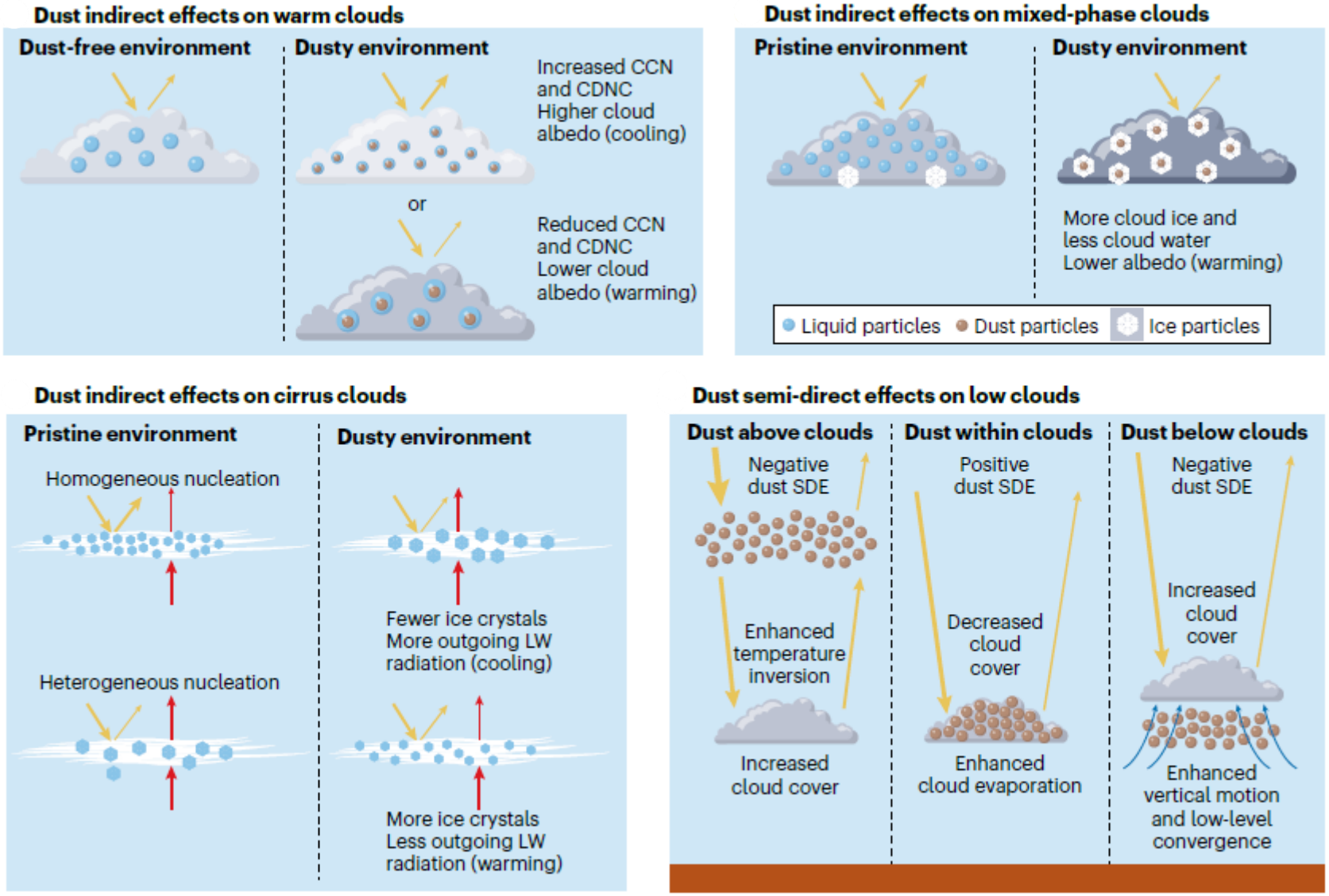
(Li et al., 2022)

Dust in the climate system



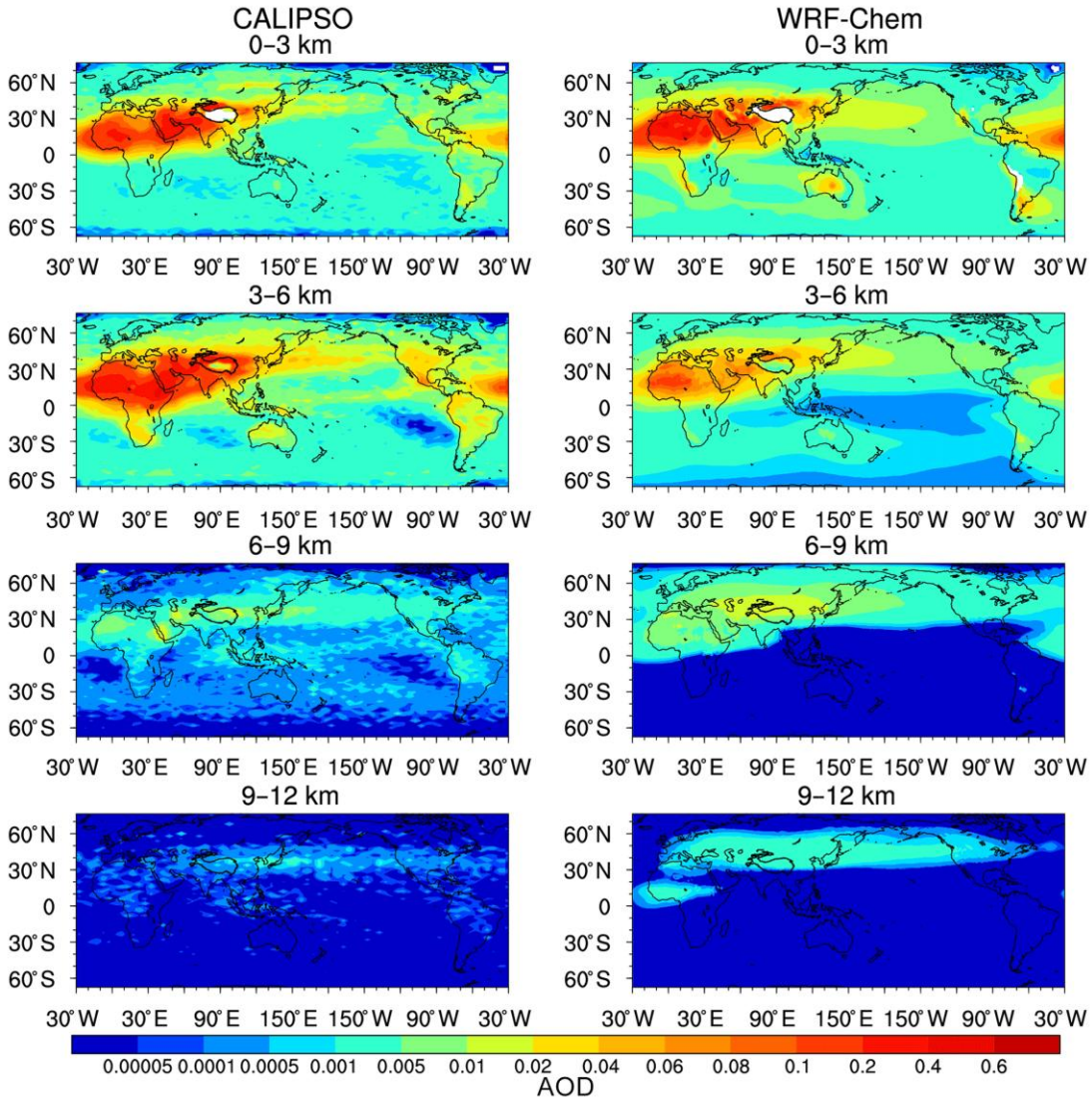
(Kok et al., 2023)

Dust in the climate system



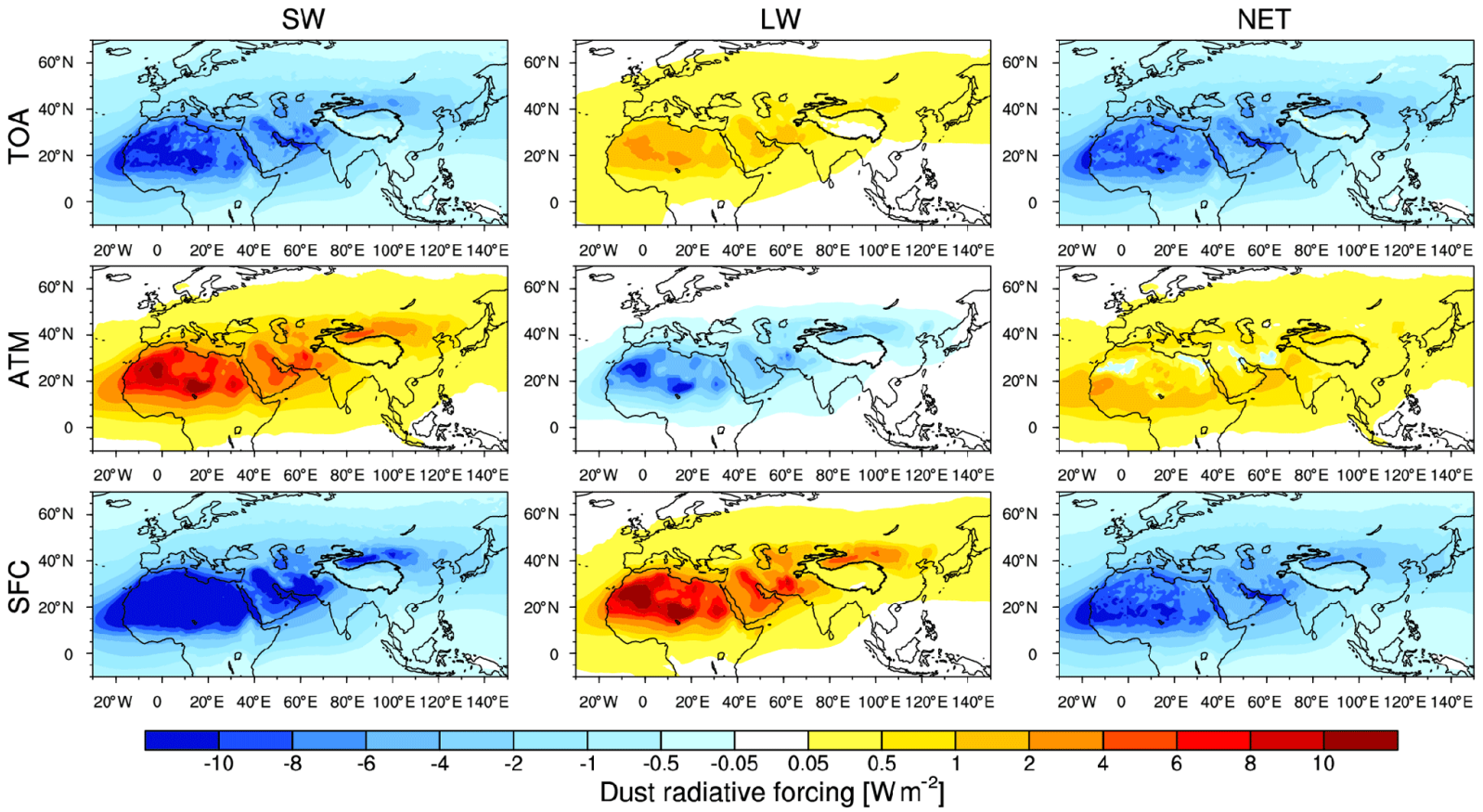
(Kok et al., 2023)

Vertical and spatial distribution



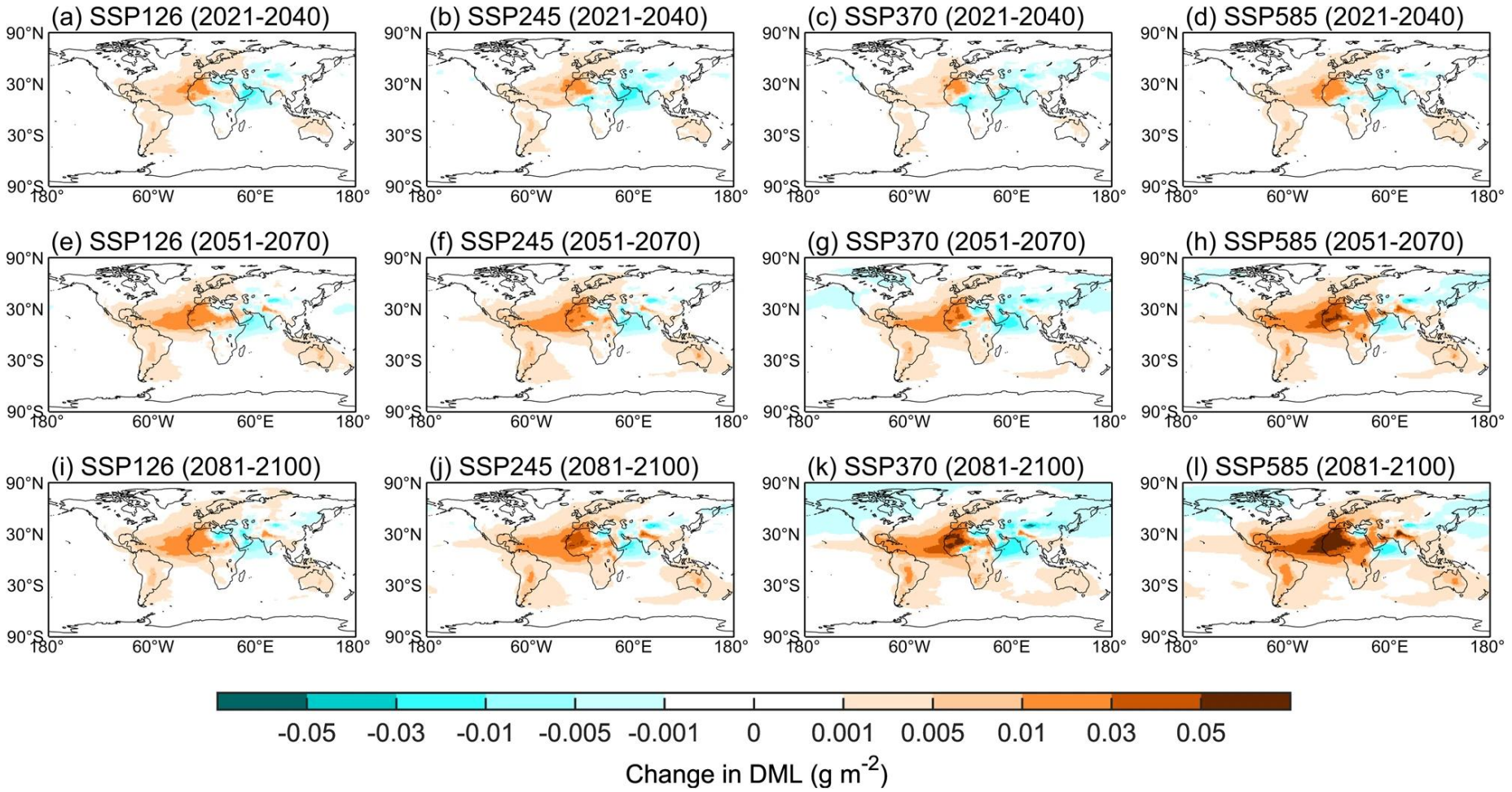
(Hu et al., 2020)

Vertical and spatial radiative forcing



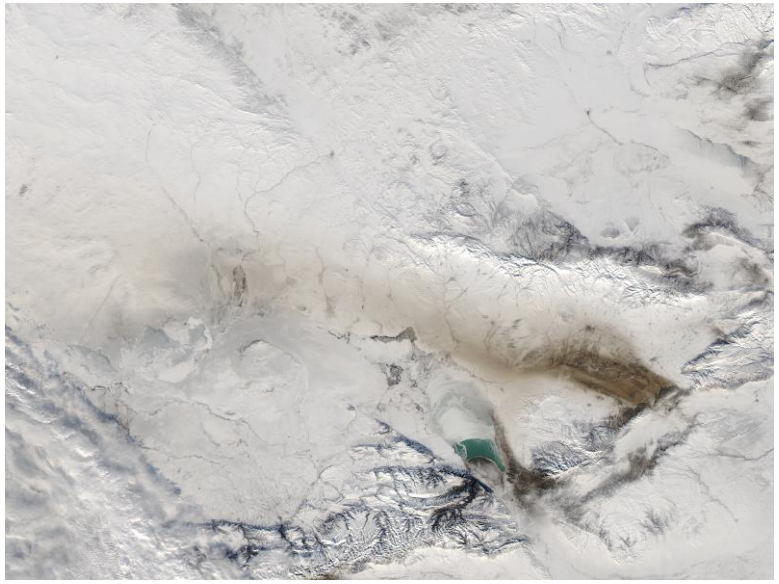
(Hu et al., 2020)

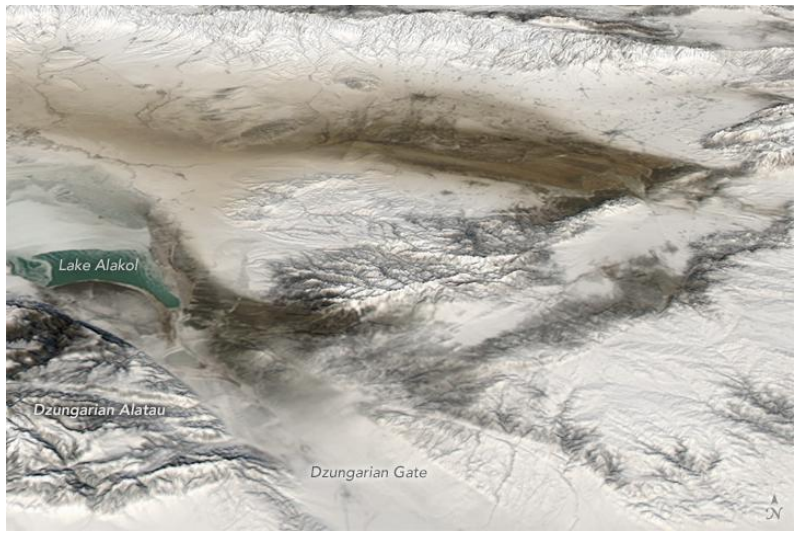
Future dust distributions

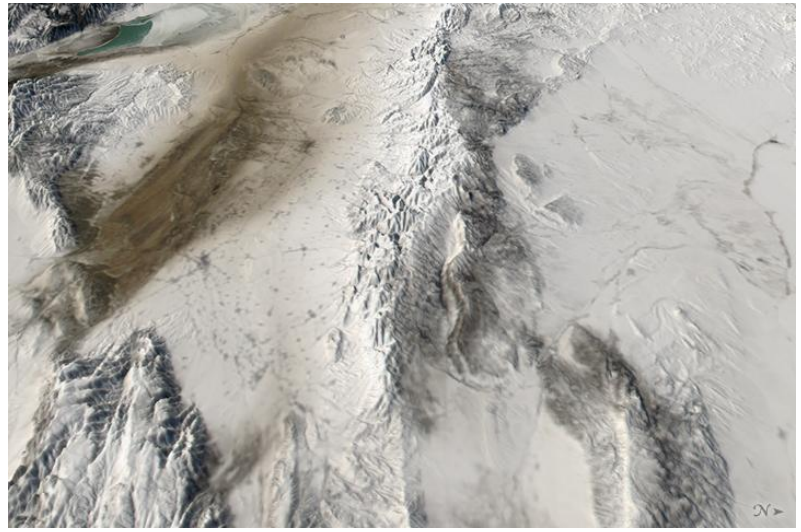


(Liu et al., 2024)

Dust on snow





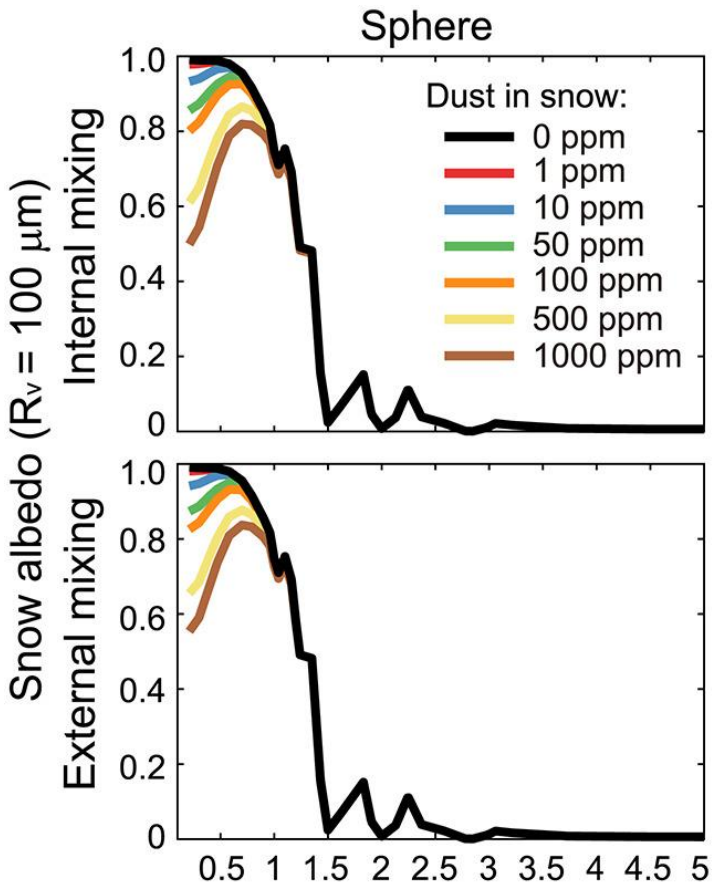


Dust layers over the snow in 2016 seen from MODIS (NASA)

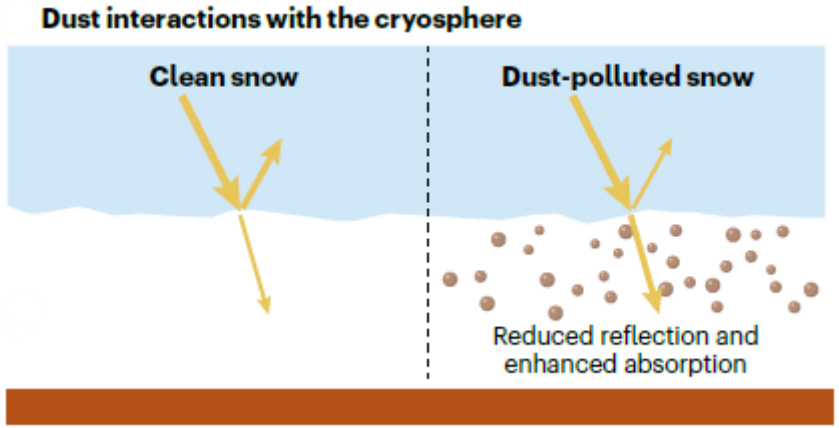


Glacier surface darkening (Zhang et al., 2020)

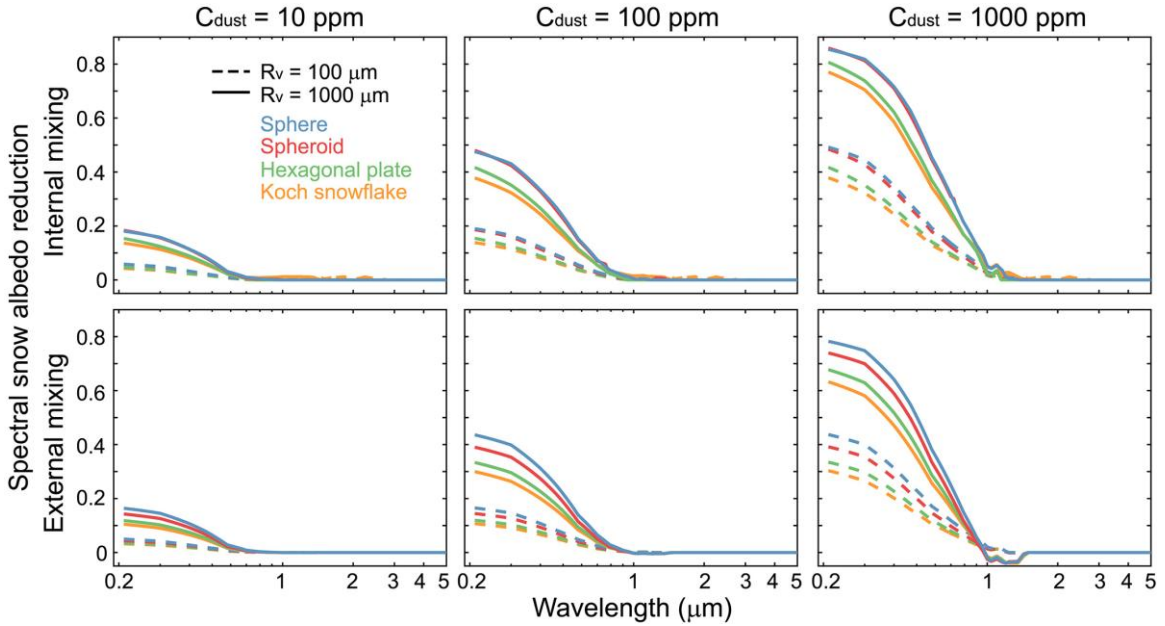
Reduction of the snow albedo and radiative forcing



He et al., 2019

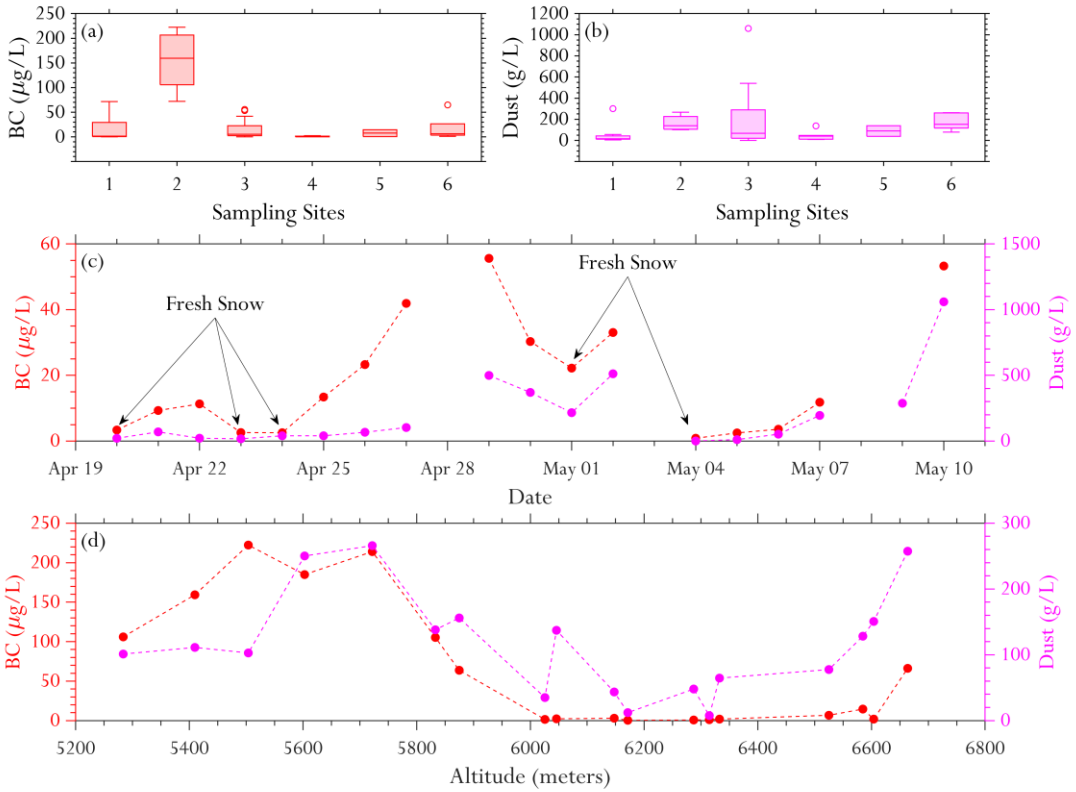


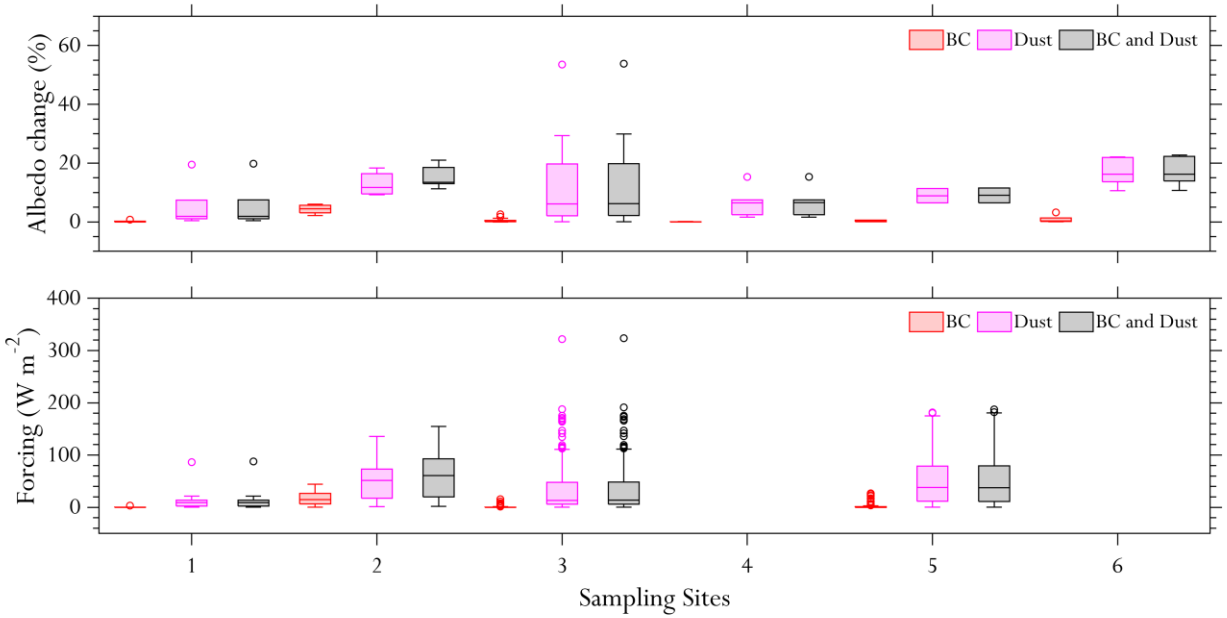
(Kok et al., 2023)



He et al., 2019

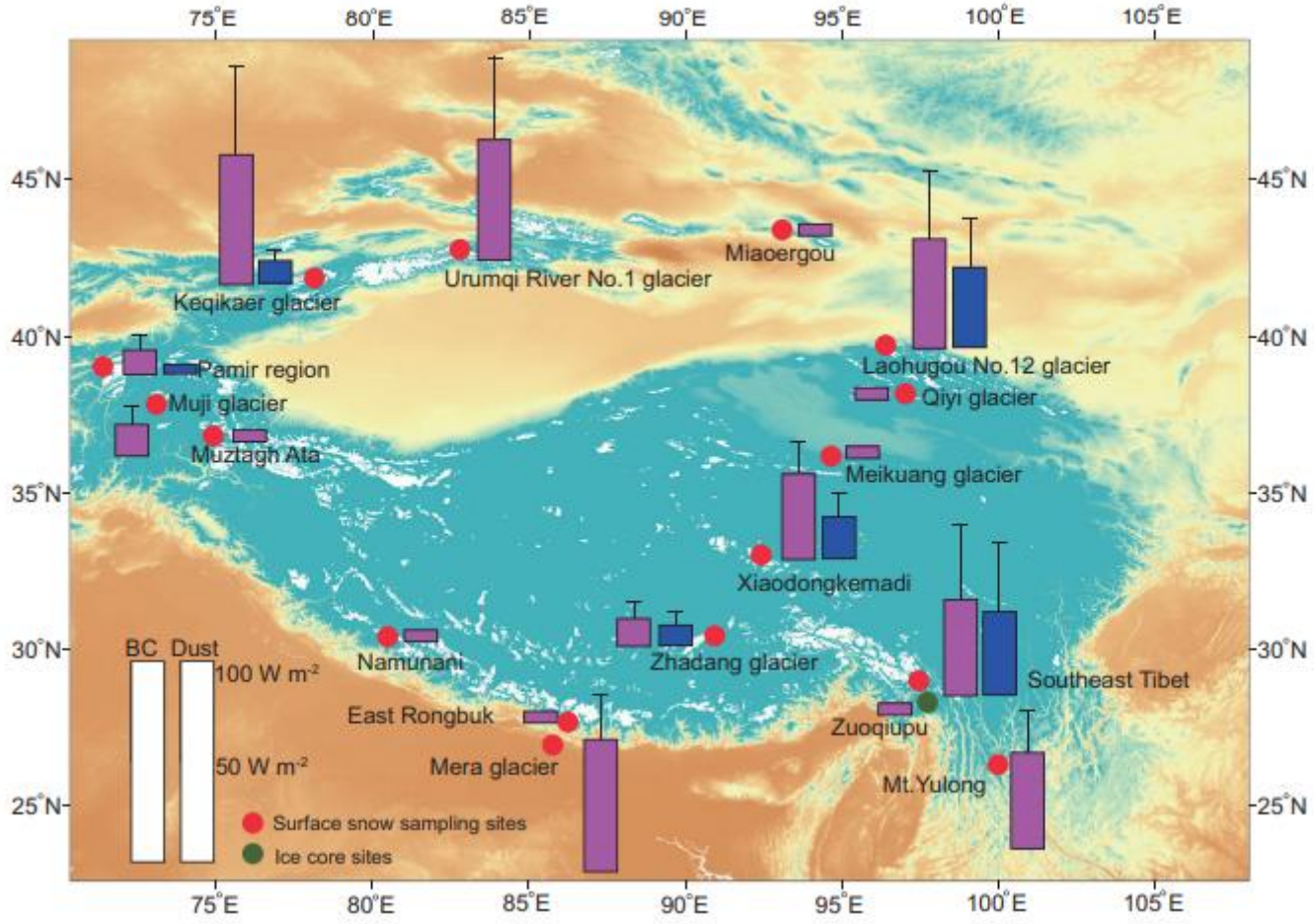
Reduction of the snow albedo and radiative forcing





Singh et al., unpublished

Current Status



Kang et al., 2019

Challenges in monitoring & Regional cooperation

- Sand and Dust Storm (SDS) forecasting and early warning system
- Coordination between the agencies at the national level
- Long term plan for the High altitude monitoring and related infrastructure
- Scientific knowledge and funding

- Establishment of a regional control, command and data centre
- A regional plan for monitoring, and developing infrastructure
- A transparent data sharing policy


Thank you
• Asian and Pacific Centre for the Development of Disaster Information Management (APDIM)
• Committee of Emergency Situations and Civil Defense, Government of Tajikistan
• WRI India