WORLD METEOROLOGICAL ORGANIZATION

Teleconnection between Asian summer monsoon anticyclone and Arctic

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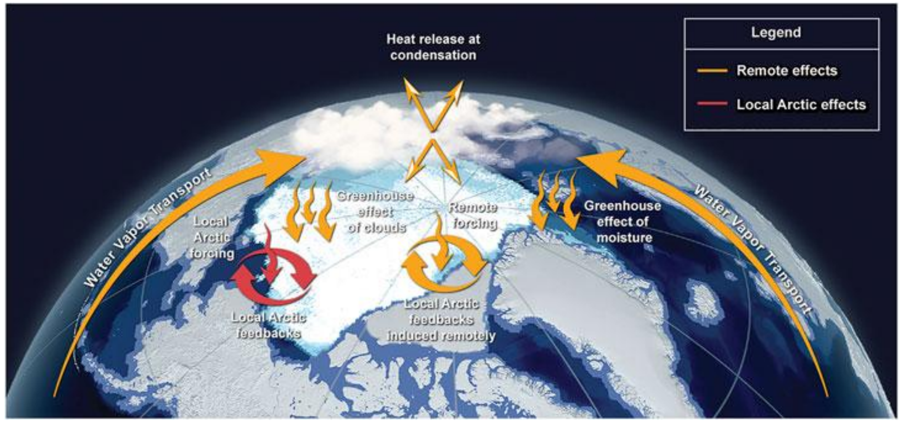
Introduction

- The summer monsoon circulation plays an important role in the long-range transport of aerosols and gases affecting radiative balance at the remote location.
- The Arctic is warming nearly four times faster than the rest of the world (1979–2021) (*Rantanen et.al 2022*).
- The link between Arctic amplification and transport of aerosol and gases from lower latitude remains elusive.



Taylor et al., 2022

- The Asian Monsoon Anticyclone (ASMA) stretches from western Africa to the western Pacific ocean. The deep convection plays an important role in the efficient transport of surface pollutants from Asia (aerosols and gases) into the UTLS (*Fadnavis et al 2024*)

- Fadnavis et al., (2024) showed, that anthropogenic aerosols from East Asia reduced seasonal mean net radiative forcing at the Arctic by -0.003 ± 0.001 W m^{-2} at the top of the atmosphere (TOA) and lead to reduction in surface temperature by -0.56 K.

- Backman et al (2021) reported that the transport of BC aerosols from the Indo-Gangetic plain in South Asia to the Arctic occurs within 7 days in the upper troposphere in summer season.

- Understanding this long-range transport into the Arctic is essential for comprehending the current and future states of Arctic climate.

TRACZILLA Lagrangian model

To estimate the percentage of trajectories, age and isentropic level of trajectories reaching the Arctic from ASMA, We use the TRACZILLA Lagrangian model

TRACZILLA is a modified version of FLEXPART that performs backward or forward trajectory analysis using reverse integration (Pisso and Legras 2008).

The age of an air parcel refers to the time elapsed since the parcel was released or originated from a specific location until it reaches its destination.

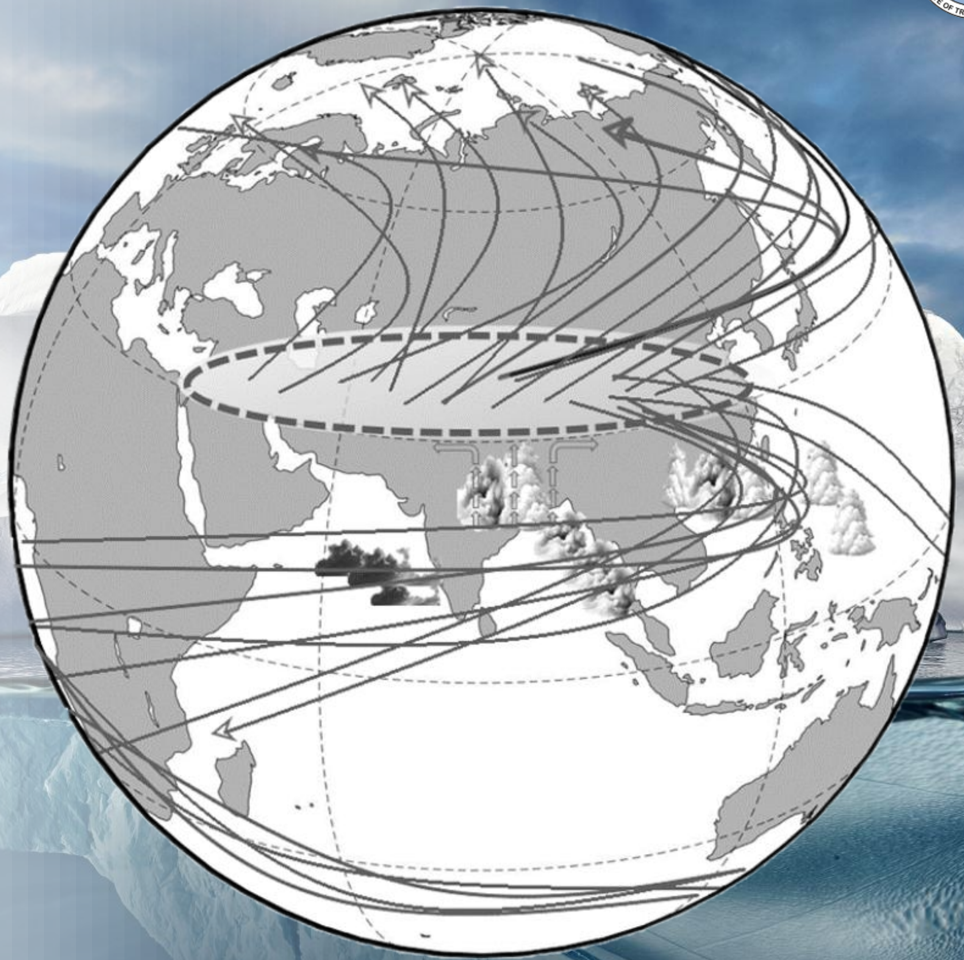
In trajectory analysis, the percentage of trajectories refers to the concentration or distribution of trajectories that reach a specific location.

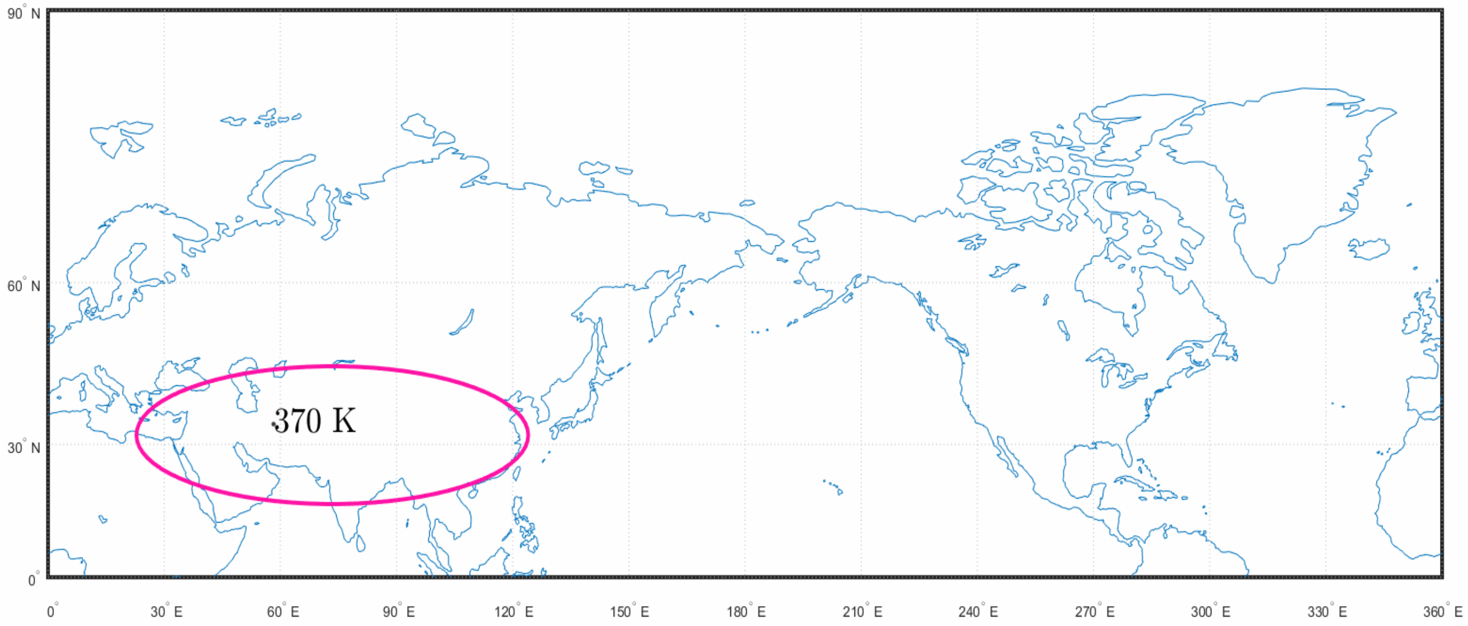
The impact level corresponds to the vertical isentropic level of the air parcel when it reaches the target.

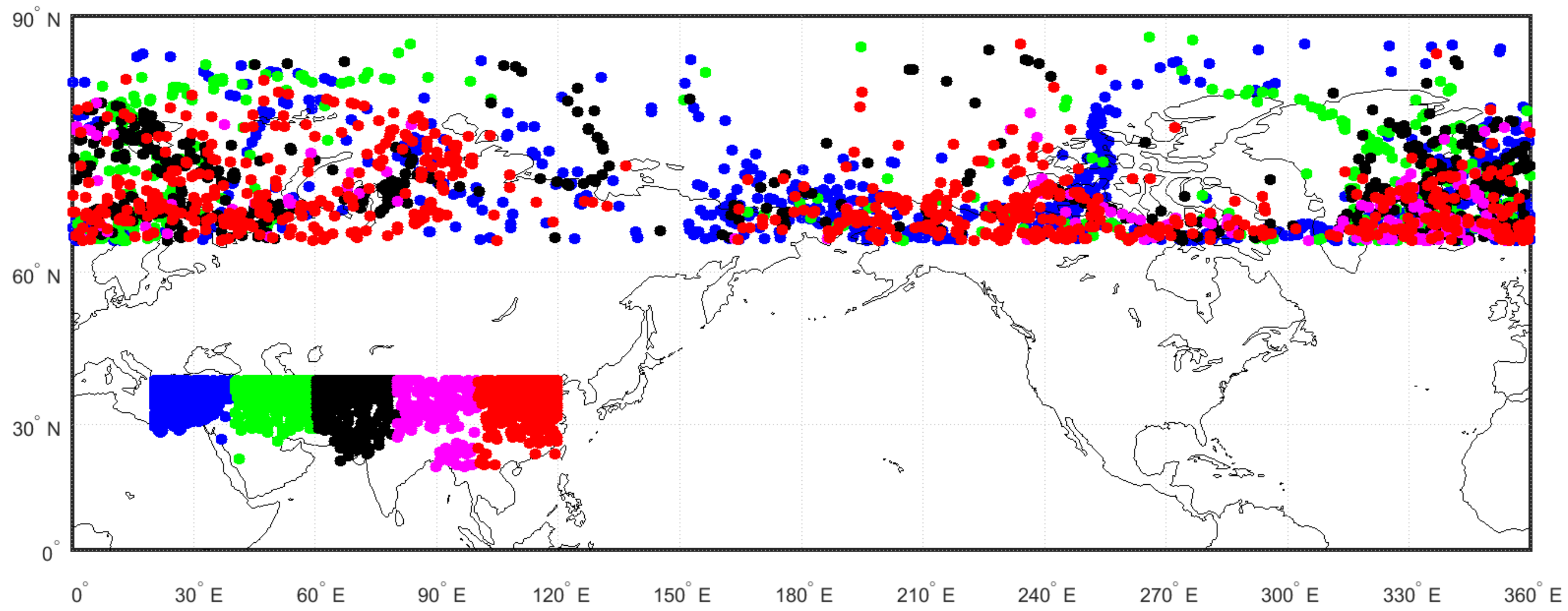
This trajectory analysis helps us to track their movement, study transport processes, and assess their impact on various regions.

Traczilla Lagrangian model

- Geographical Domain: 20 - 120E, 20 - 40N
- Grid Size: 0.5° x 0.5°
- Frequency: Every 3 hours
- Duration: 1st June to 30th September
- Timeframe: Forward in time for 120 days
- Trajectories are launched at 370K
- Data Source: Wind Data and Radiative Heating Rates from ERA-5
- El Niño years: 2002, 2006, 2009, 2015
- Normal years: 2001, 2003, 2005, 2013




370 K
90° N
60° N
30° N
0°
0°
30° E
60° E
90° E
120° E
150° E
180° E
210° E
240° E
270° E
300° E
330° E
360° E



- The primary outflows to the Arctic occur from the western and eastern flanks of the Asian Monsoon Anticyclone (ASMA).

- **TRACZILLA Forward Trajectory Analysis:** Approximately 11% of trajectories reached the Arctic out of all trajectories launched from ASMA.
- We geographically divide the Arctic into four subdivisions to trace the percentage of trajectories, age and isentropic levels.

Region	Lat	Lon
Greenland Norwegian Barent Sea (GNB)	65- 90 N	25°W–50°E
Russian Coastline	65-90 N	50^{0}E-180^{0}E
Beaufort Gyre	65-90 N	0^{0}W -120^0 W
Baffin Bay	65-90 N	120^0 W-25^0 W

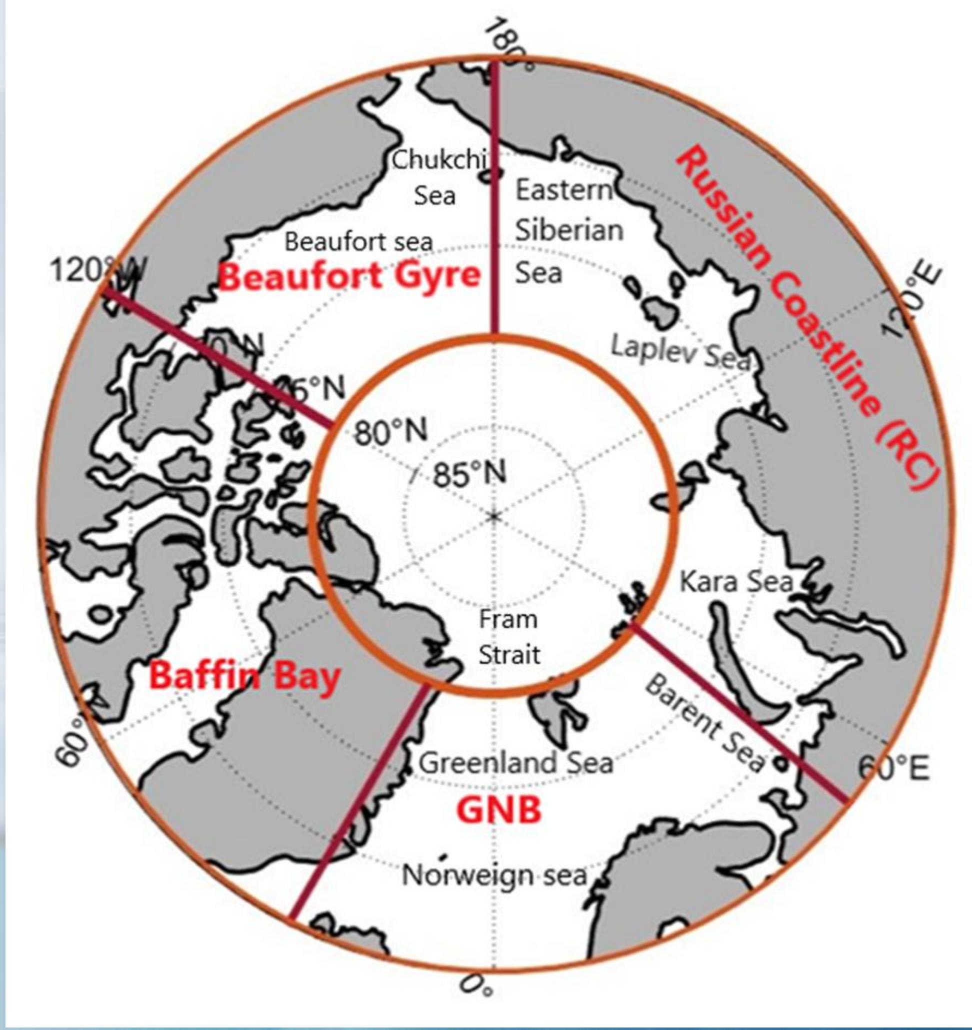


Fig 5: Study Area

Result and Discussion

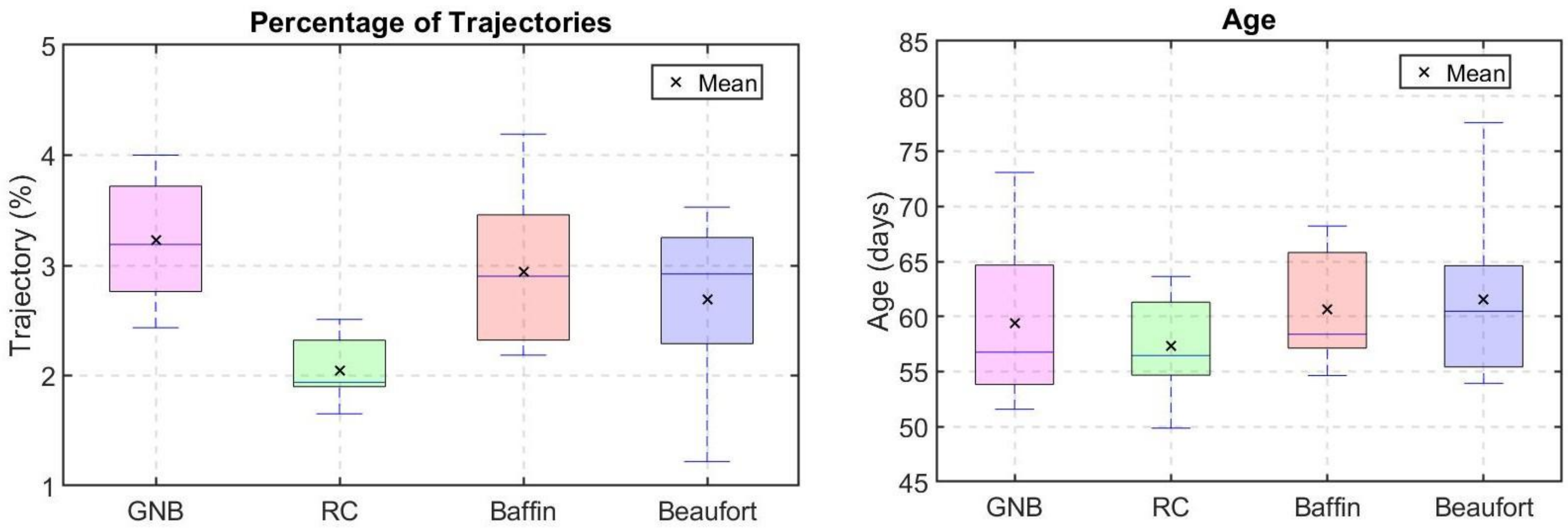


Fig 6: Age and percentage of trajectories reaching the Arctic from the ASMA.

- Maximum percentage of trajectories reach the GNB region, while the minimum in the Russian Coast (RC).
- Trajectories take more time to reach the Beaufort region, whereas they take less time to reach the RC.

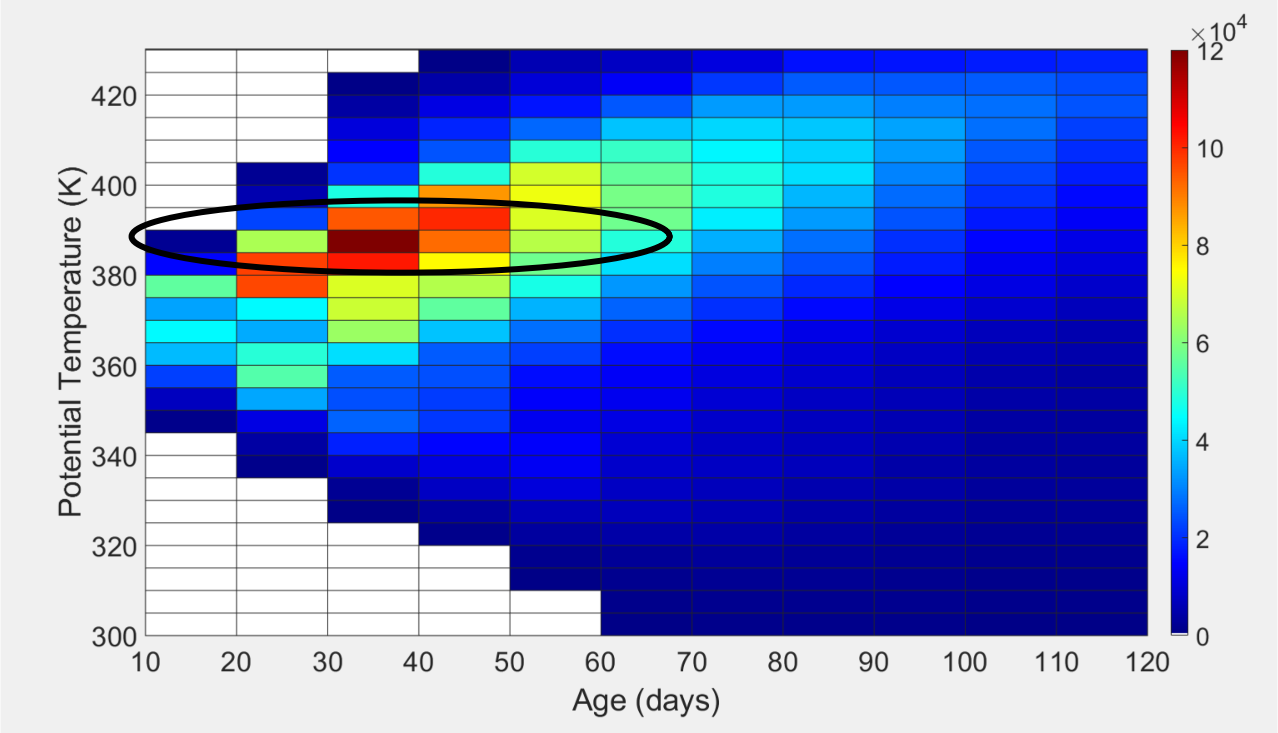
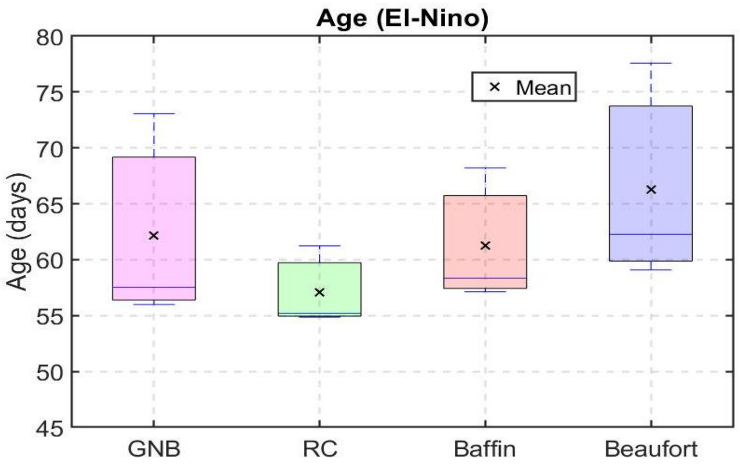


Fig 7: Histogram of the isentropic level versus age of the air parcel reaching the Arctic

- The maximum number of trajectories reach the Arctic at an isentropic level of 380–395 K.

Variability during El-Niño and Normal years



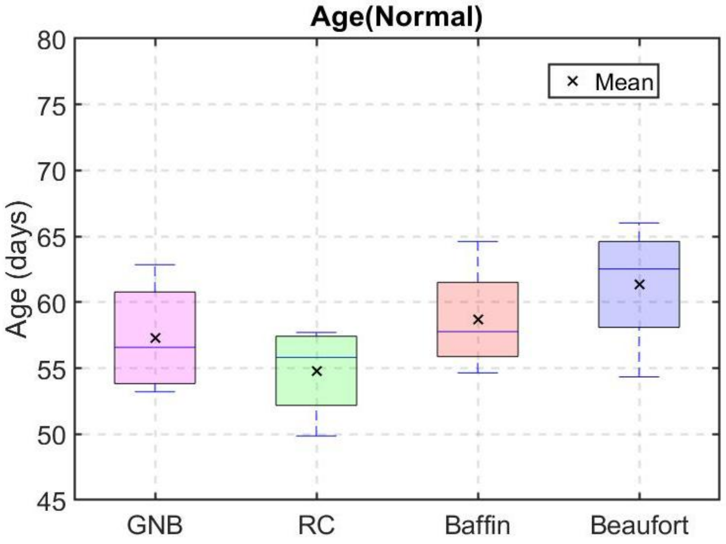


Fig 8: Age of the air parcel to reach the Arctic during El-Nino and normal years.

- Trajectories takes more time to reach the Arctic during El-Nino years as compared to normal years.

- During El-Niño years, trajectories take 4 to 5 days longer to reach GNB and Beaufort and 2 to 3 days longer to reach RC and Baffin region.

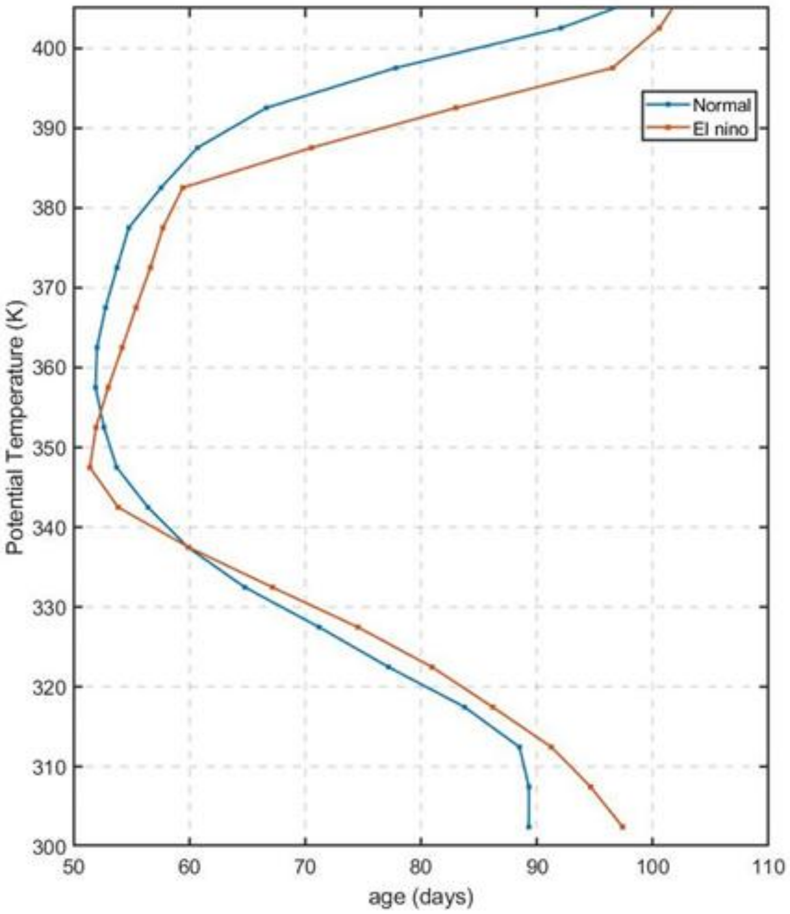


Fig 9: Average age and corresponding isentropic level variability during El Niño and Normal years.

- Most of the trajectories reaching 350 to 385 K take only 55 to 60 days, whereas those above 390 K and below 325 K take longer to reach the Arctic.

Conclusion

- The percentage of trajectories entering the Arctic is highest in the GNB region and lowest along the Russian Coastline.

- The transport time for air parcels to reach the Arctic is shortest time for the Russian Coastline (56 days) and longest time for the Beaufort Gyre (63 days).

- During El-Nino years, trajectories take more than 4 days reach the Arctic as compared to normal years.

- The maximum number of trajectories reach the Arctic at an isentropic level of 380–395 K.

Thank you