

A characterization of Arctic aerosols and their forcing of the surface radiation budget



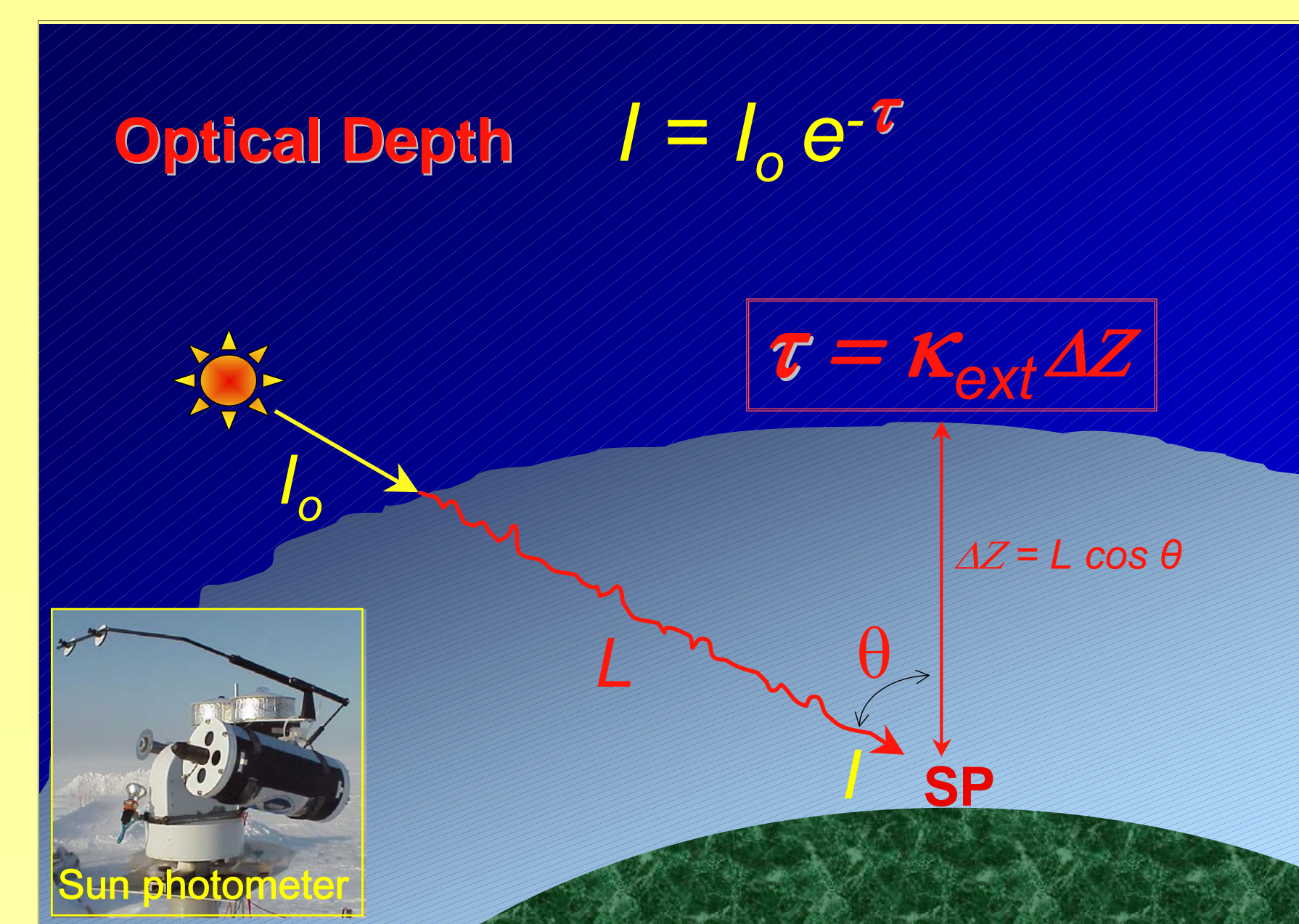
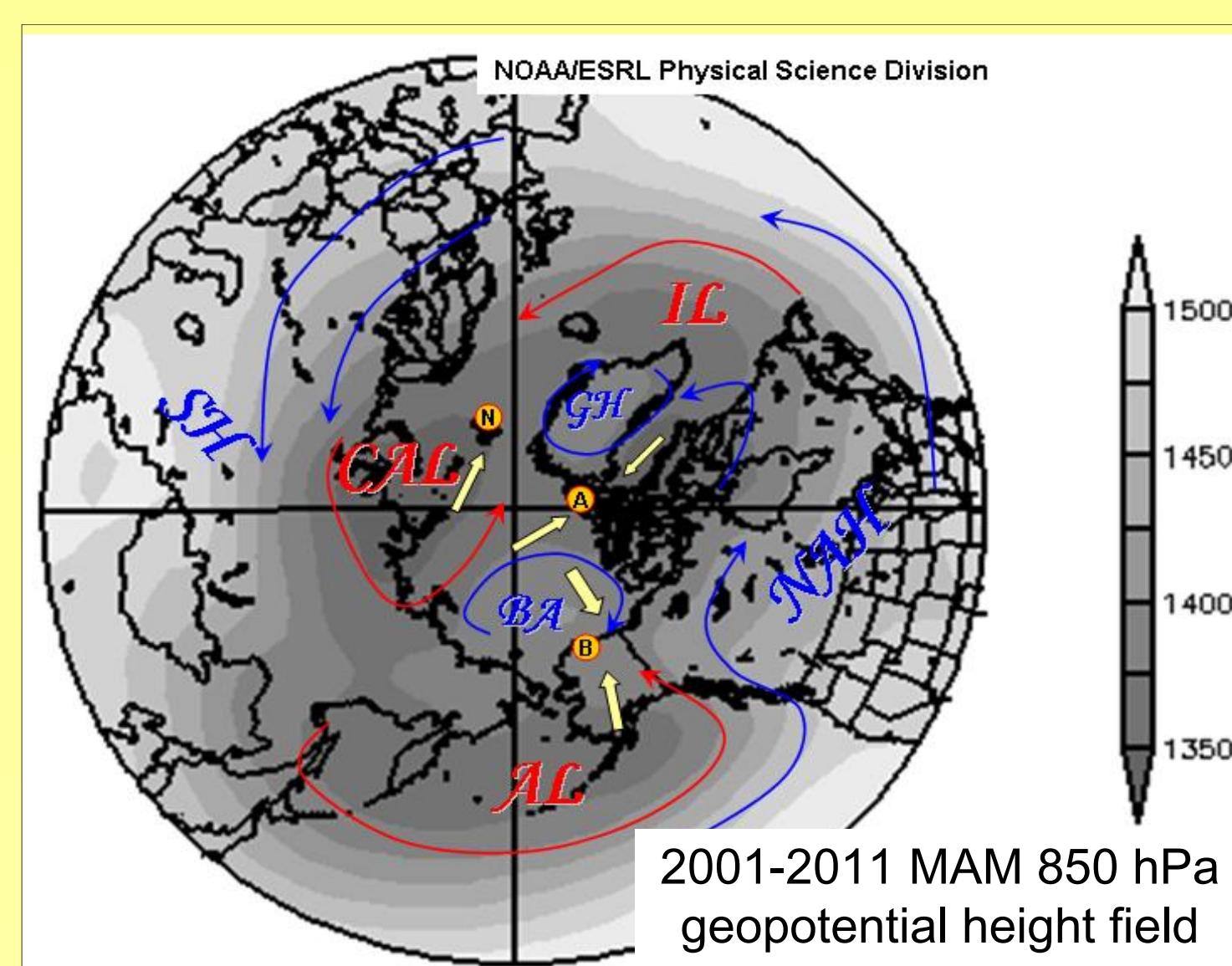
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- The Arctic is sensitive to small changes in atmospheric turbidity, expressed in terms of aerosol optical depth (AOD)
- NOAA participates in the POLAR-AOD Project, to assimilate data, characterize aerosols and quantify their radiative impact on climate
- Black carbon (BC), an aerosol that contributes to global warming, is also monitored at co-located Global Atmosphere Watch stations in the Arctic
- We present climatologies of AOD and equivalent BC for three stations within the network and demonstrate how Arctic aerosols radiatively cool the surface

1. INTRODUCTION



Long-range transport of aerosols influences the Arctic climate.

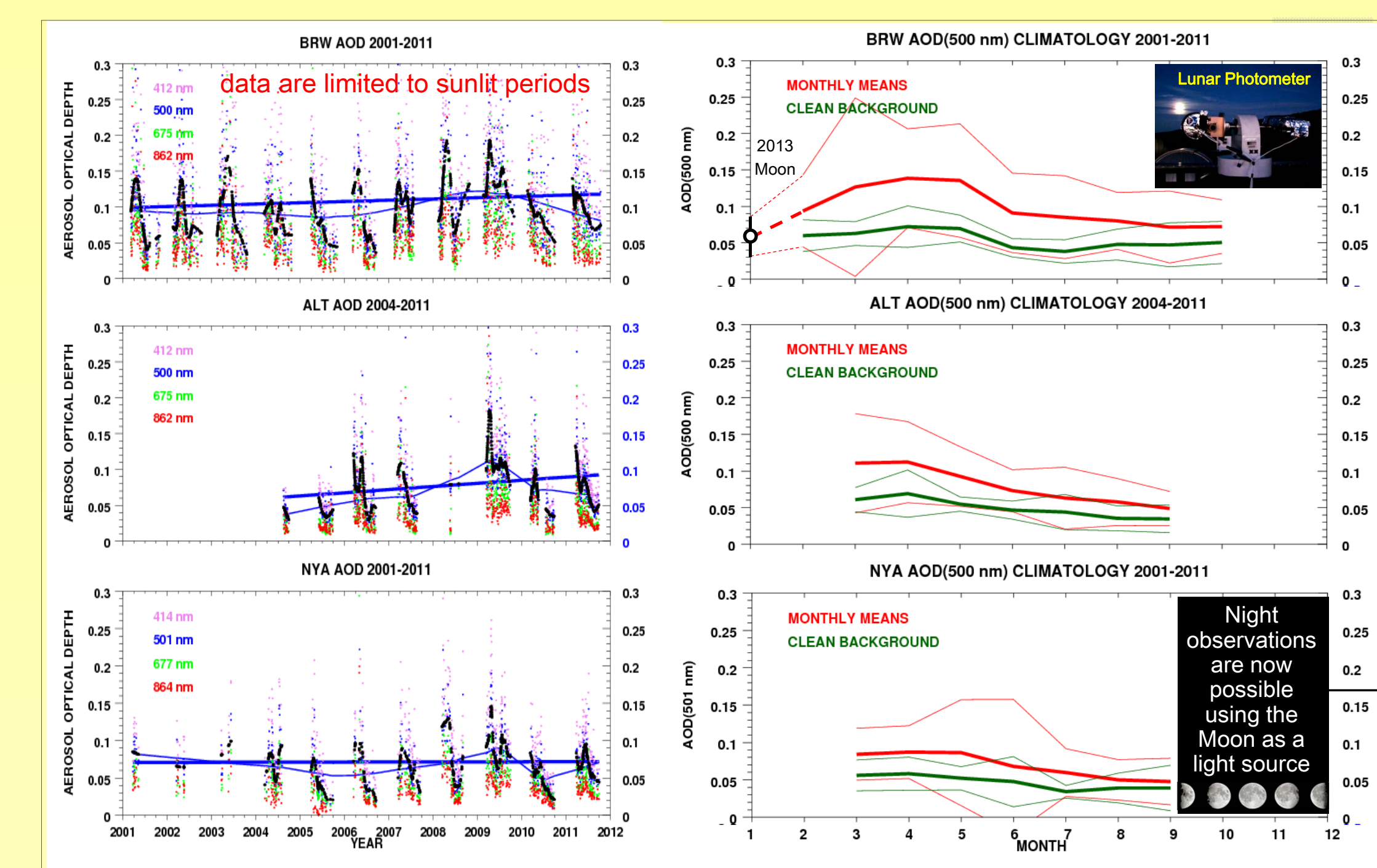
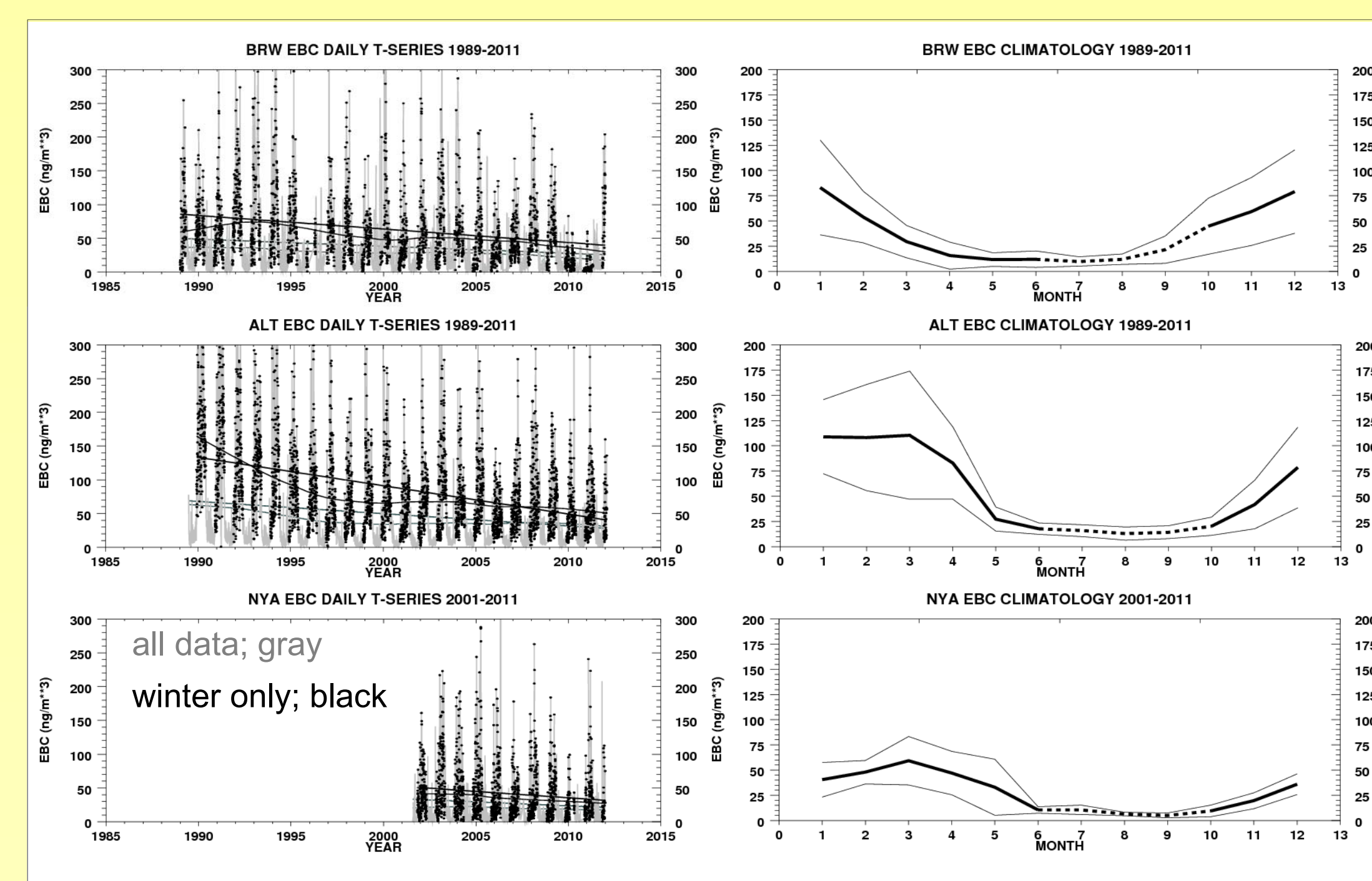
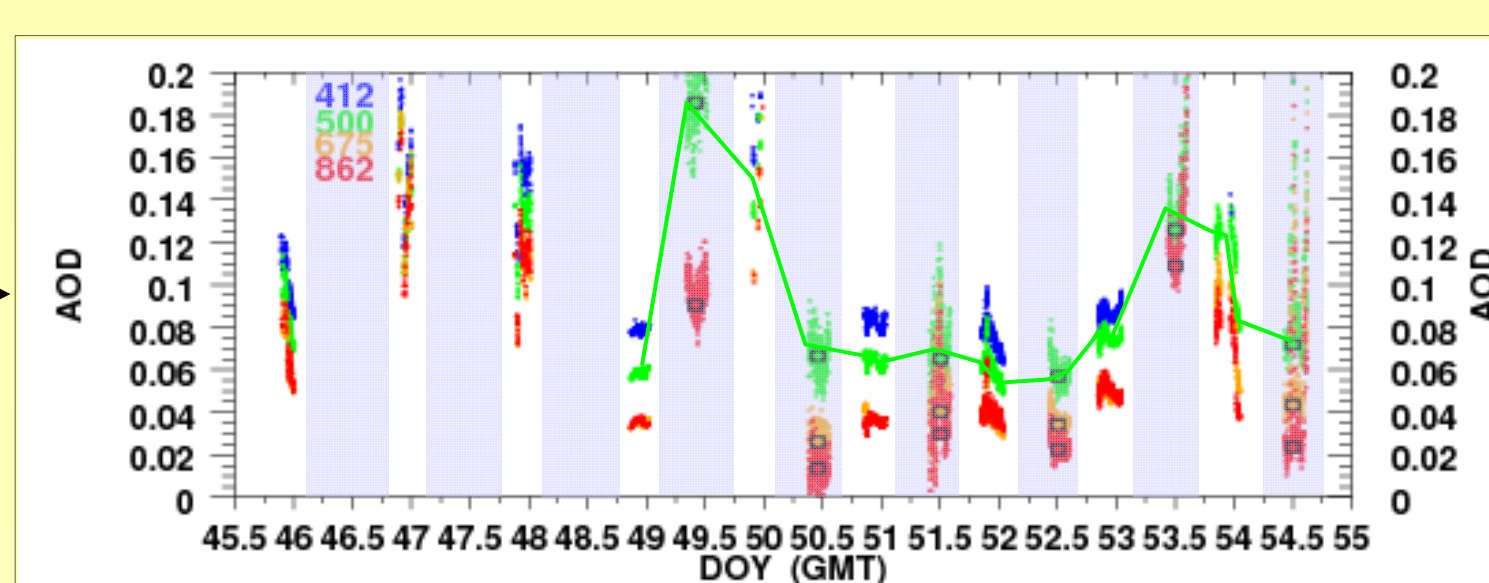
The dispersion of aerosols to observing sites depends on large-scale circulation patterns. B; Barrow, A; Alert, N; Ny-Alesund

Optical depth derives from extinction of light along path, L . AOD is monitored using photometers (inset)

2. TIME SERIES CLIMATOLOGIES

AOD (left) and equivalent BC (EBC) (right) vary in time and space; both peak in winter or spring and show marked summer minima.

EBC \Leftrightarrow concentration of light-absorbing aerosol that attenuates light \approx equal to BC (soot carbon)



Left; time series of daily mean spectral AOD at BRW, ALT and NYA (500 nm, fitted and smoothed), and right; 500 nm monthly climatologies of means and background (± 1 Std. Dev.).

Diurnal AOD at BRW, 17-25 February 2013. nighttime values derived from lunar calibrations

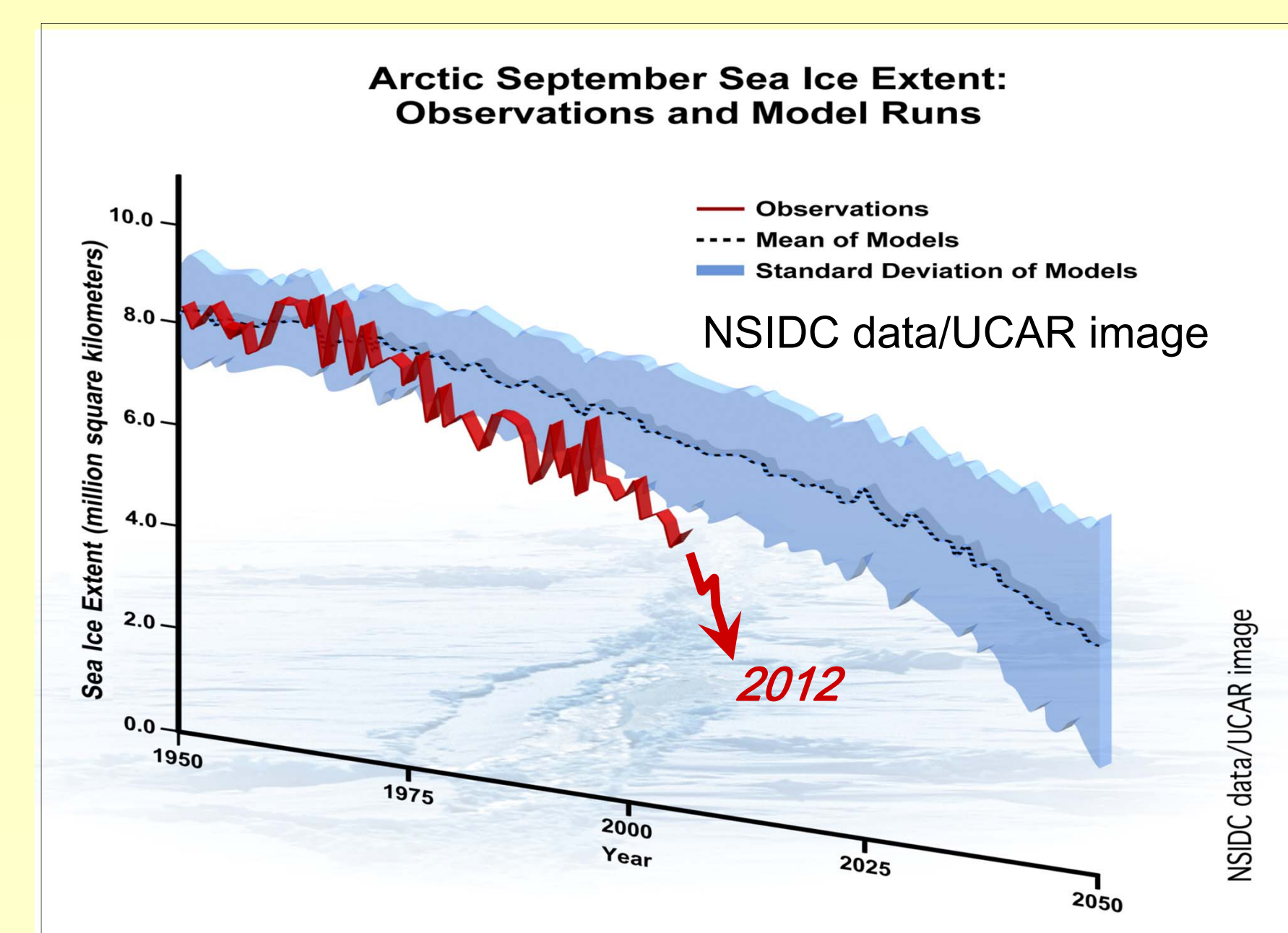
Left; time series of daily mean EBC at BRW, ALT and NYA (fitted and smoothed), and right; derived monthly means (± 1 Std. Dev.); summer data are prone to large errors (dashed).

3. RADIATIVE FORCING

Left; A measure of NET_{sw} vs. AOD_{500} is used to develop parameterizations of RFE.

Right; Observed vs. modeled Arctic sea ice decline since 1950.

What are the relative contributions of surface cooling by atmospheric aerosols versus warming due to BC deposition?



Arctic Sea ice has declined more rapidly than projected. Warming by BC is thought to be a contributing factor.

Will mitigation of BC slow Arctic warming?

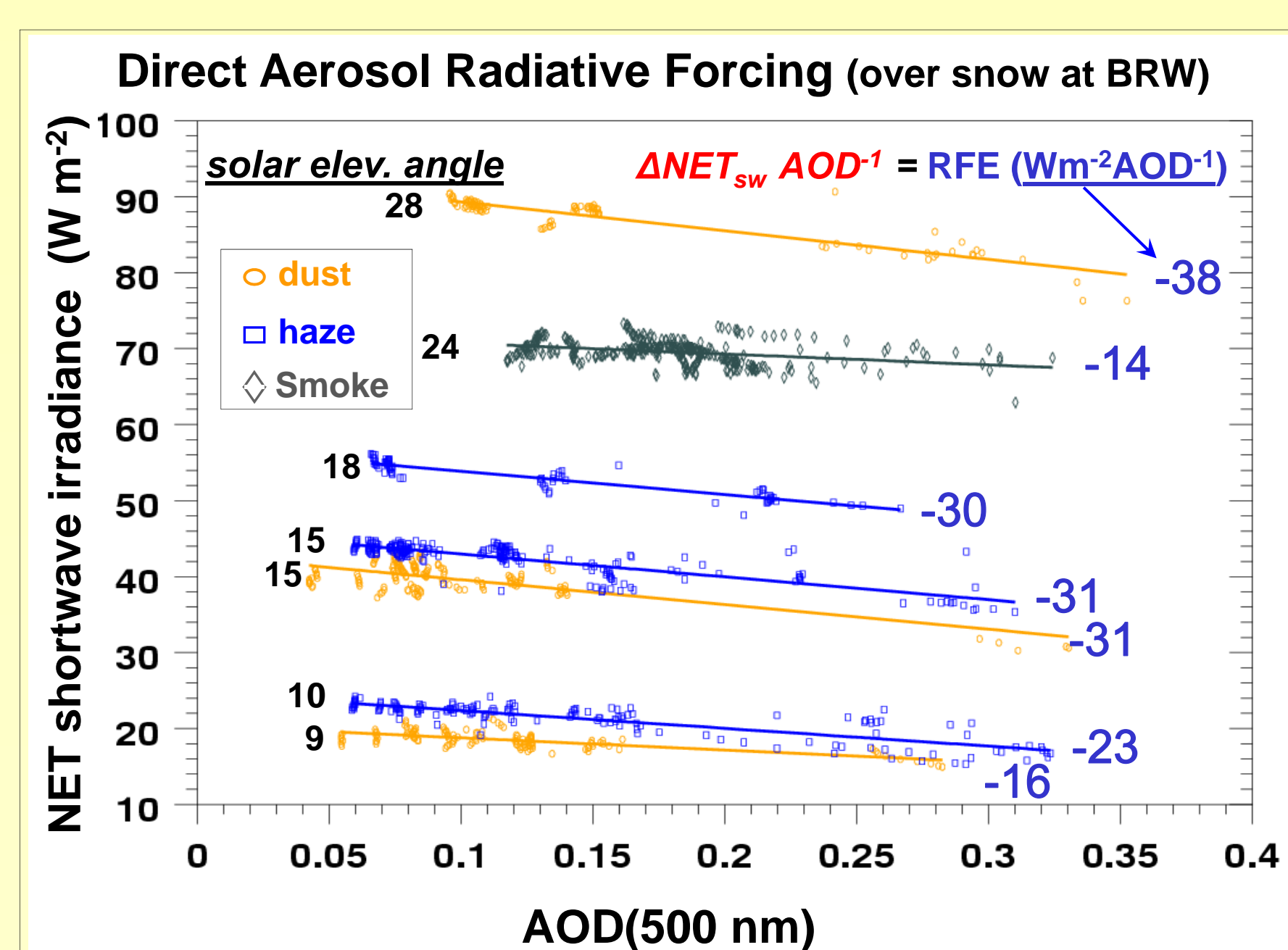
Conclusions:

- Radiative forcing by Arctic aerosols varies greatly over time and space, depending on their type, rates of emission, transport and deposition, varying solar geometry and surface albedo
- Concentrations of EBC have decreased markedly at BRW, ALT and NYA since the 1980s; AOD has increased slightly
- During sunlit periods, cooling by Arctic aerosols more than offsets warming attributed to the deposition of BC on snow
- Mitigation of BC may not slow Arctic warming because reductions in co-emitted species result in less cooling (warming)

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Ref: Stone et al. (2013); (to be submitted)

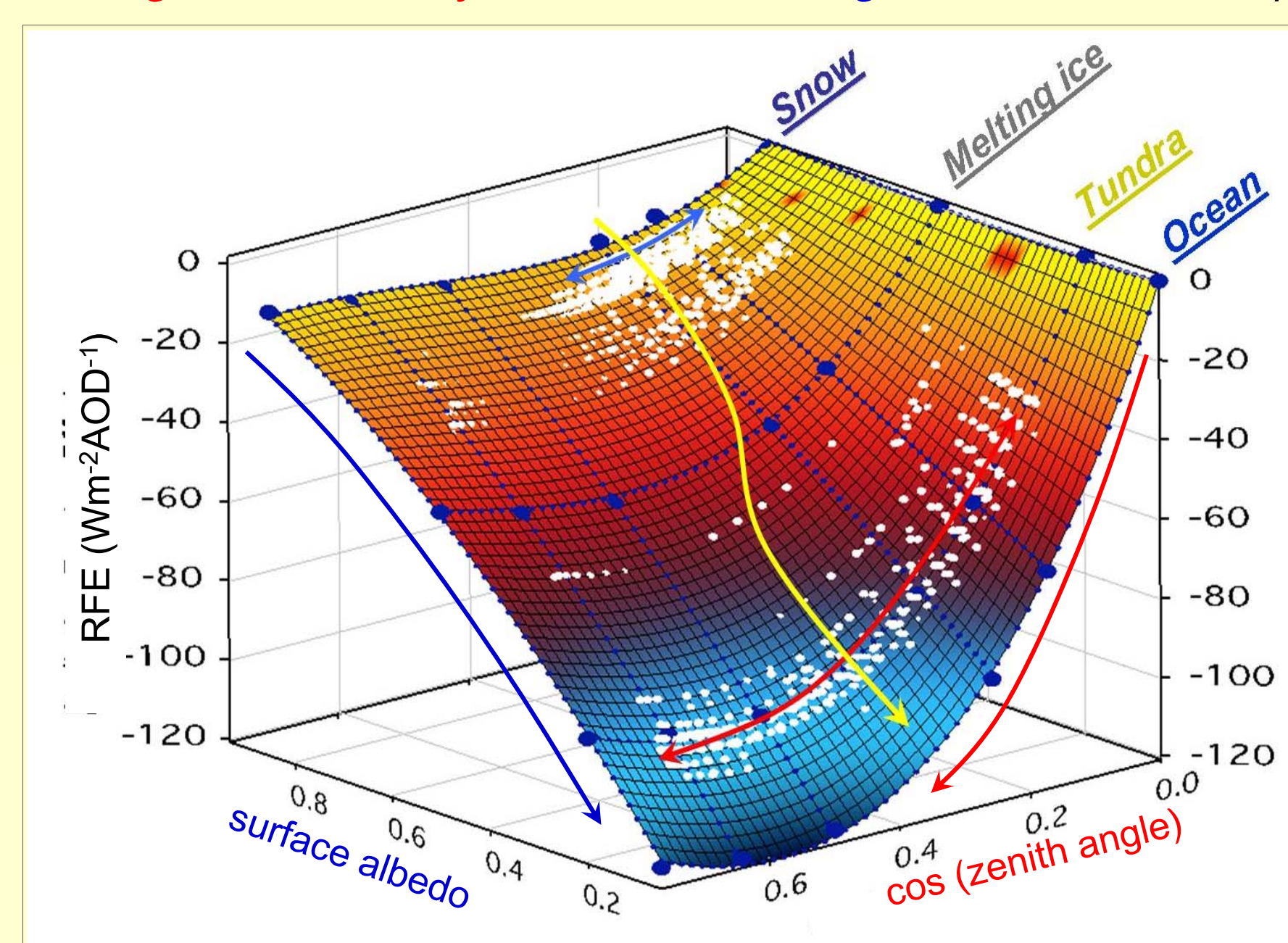
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Radiative Forcing Efficiency (RFE) is defined as the change in net shortwave irradiance (NET_{sw}) per unit AOD at 500 nm.

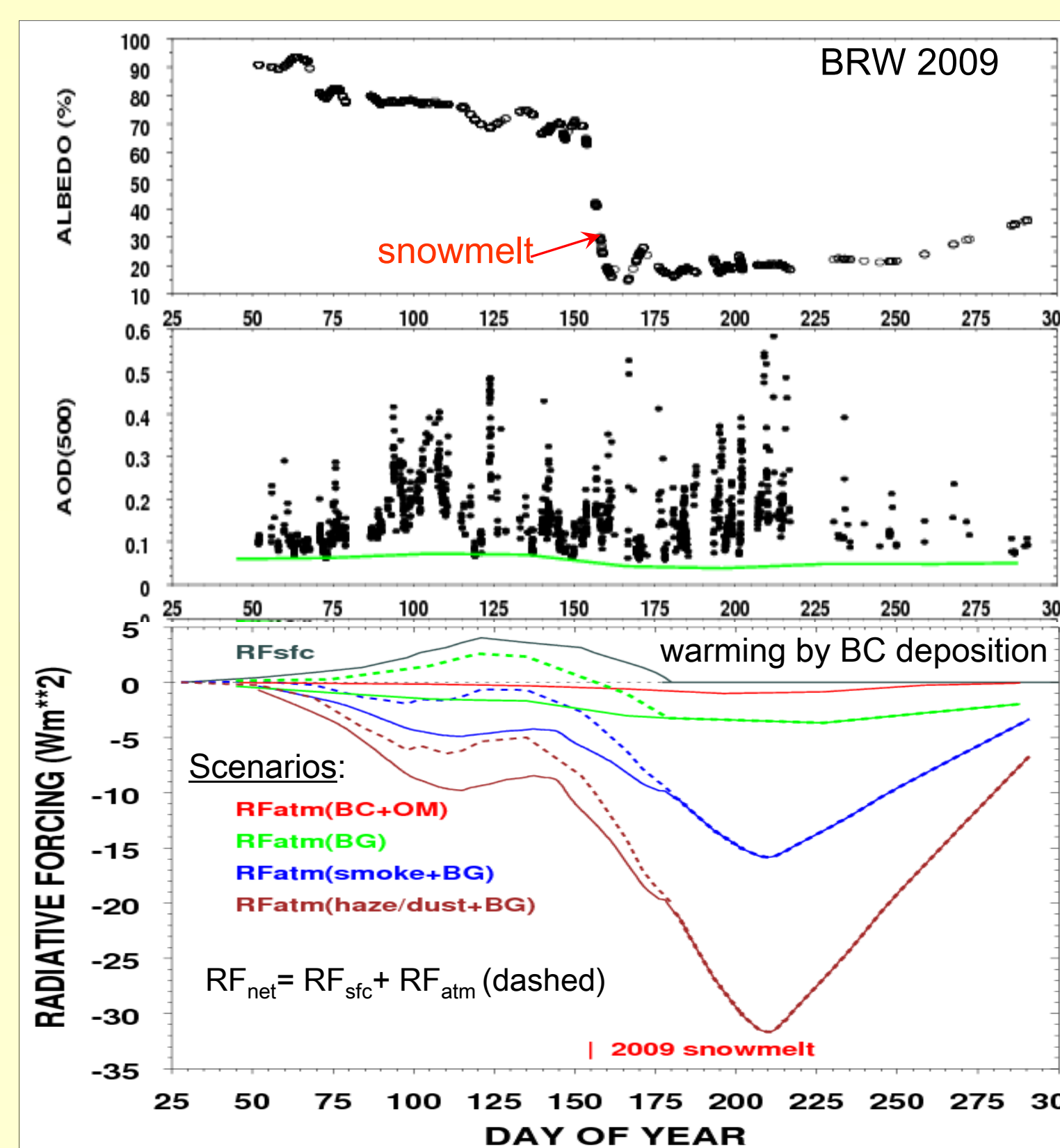
Arctic aerosols radiatively cool the surface

Increasing solar intensity and/or decreasing albedo increases |RFE|



RFE is parameterized to account for seasonal variations of solar geometry and surface albedo; an example for smoke.

4. EVALUATIONS



Evaluations of RF (= RFE*AOD) scenarios for measured albedo (top) and AOD (middle). Cooling by aerosols offsets warming by BC dep