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

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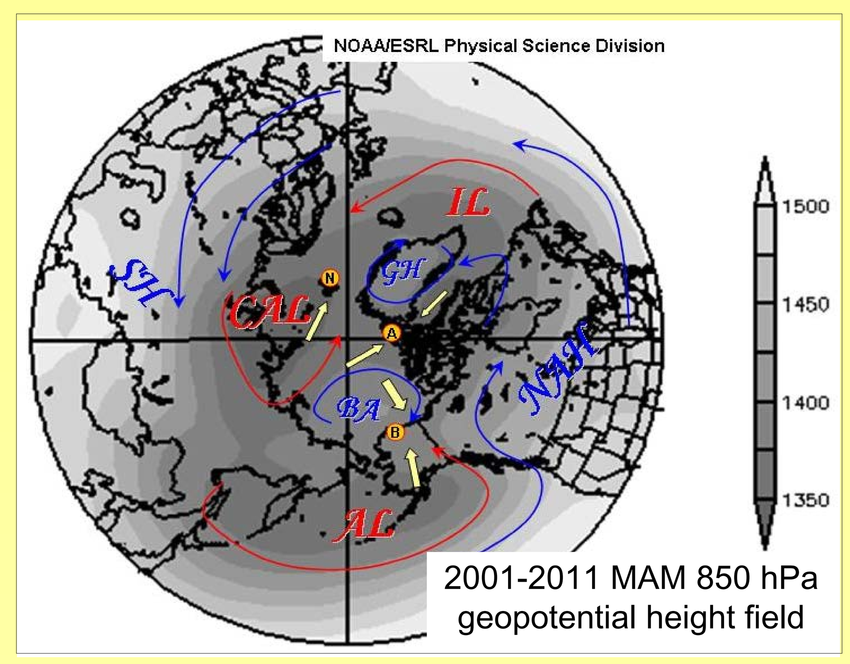
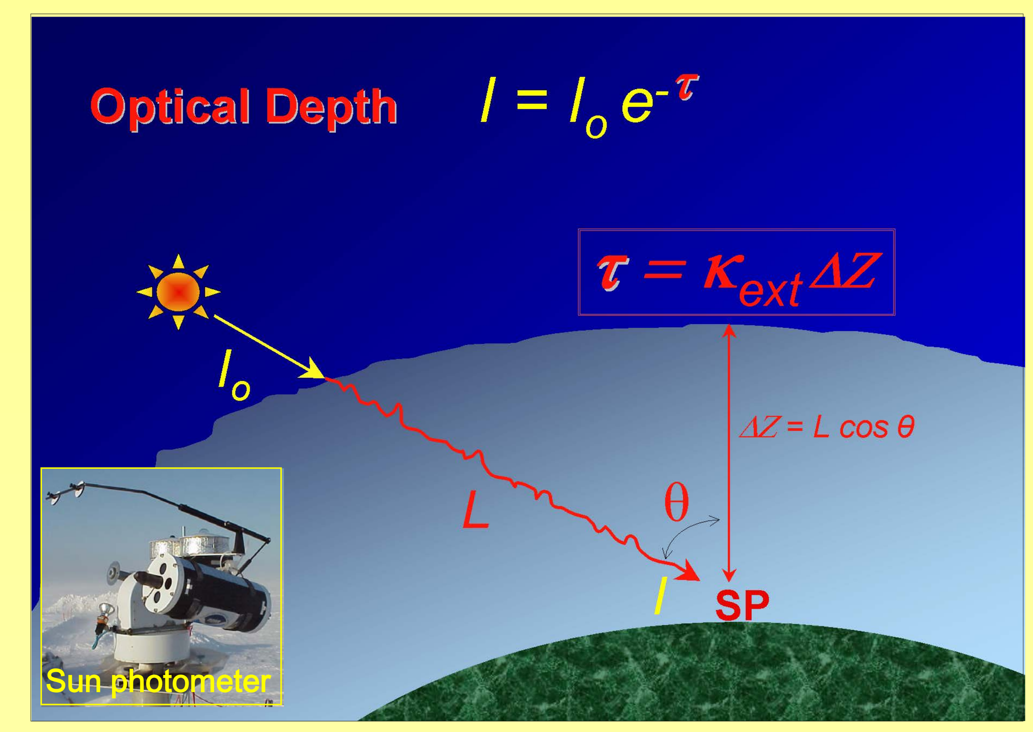
- The Arctic is sensitive to small changes in atmospheric turbidity, expressed in terms of aerosol optical depth (AOD)
- NOAA participates in the POLAR-AOD Project, to assimilate data, characterize aerosols and quantify their radiative impact on climate
- Black carbon (BC), an aerosol that contributes 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*

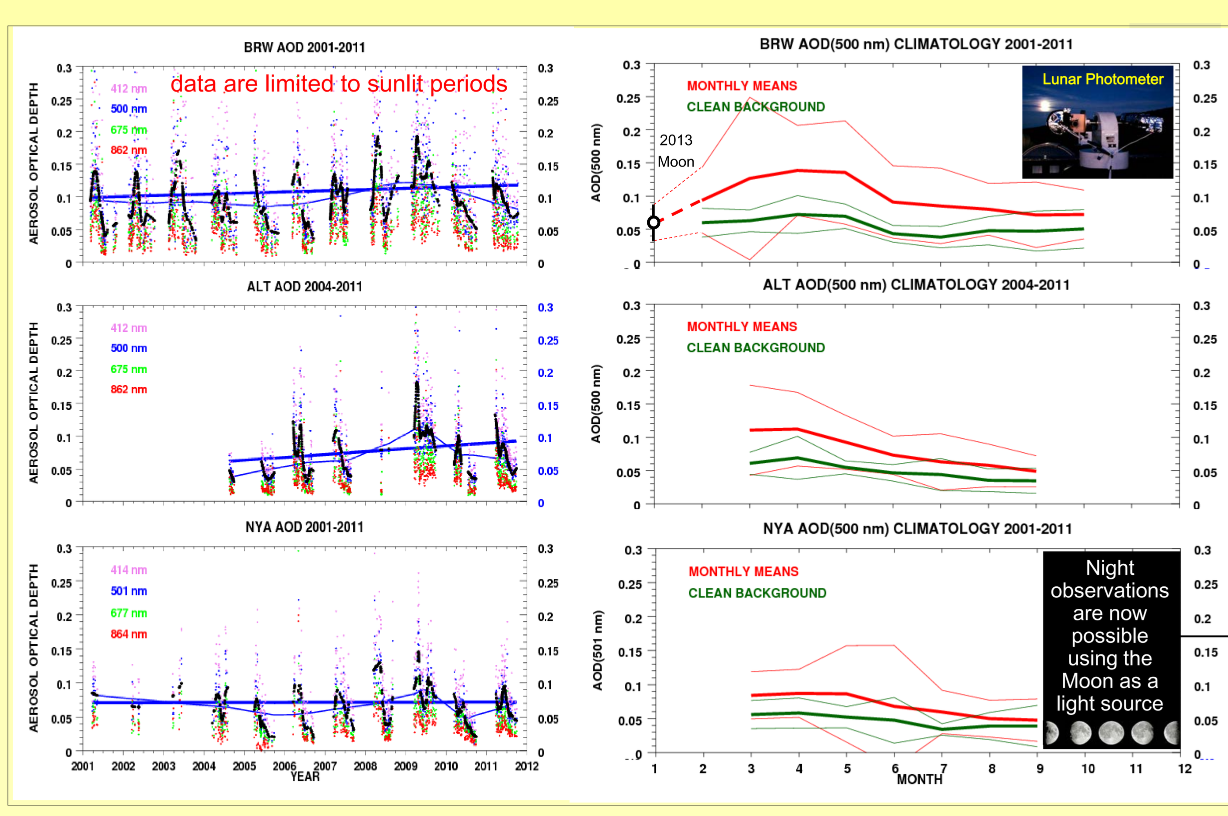



Optical depth derives from extinction of light along path, ***L***. *AOD is monitored using photometers (inset)*

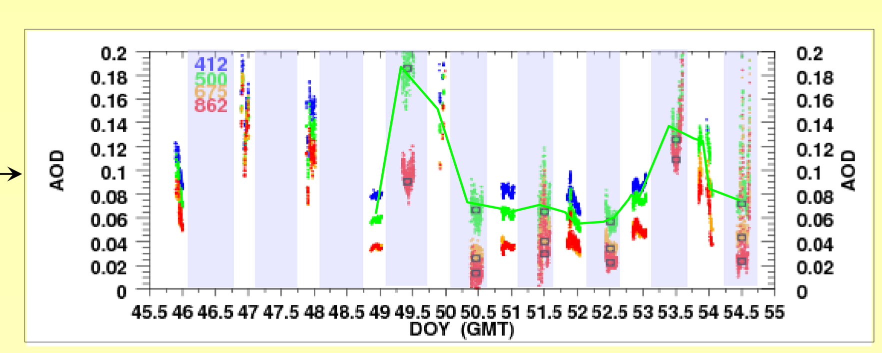
## 2. TIME SERIES CLIMATOLOGIES

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

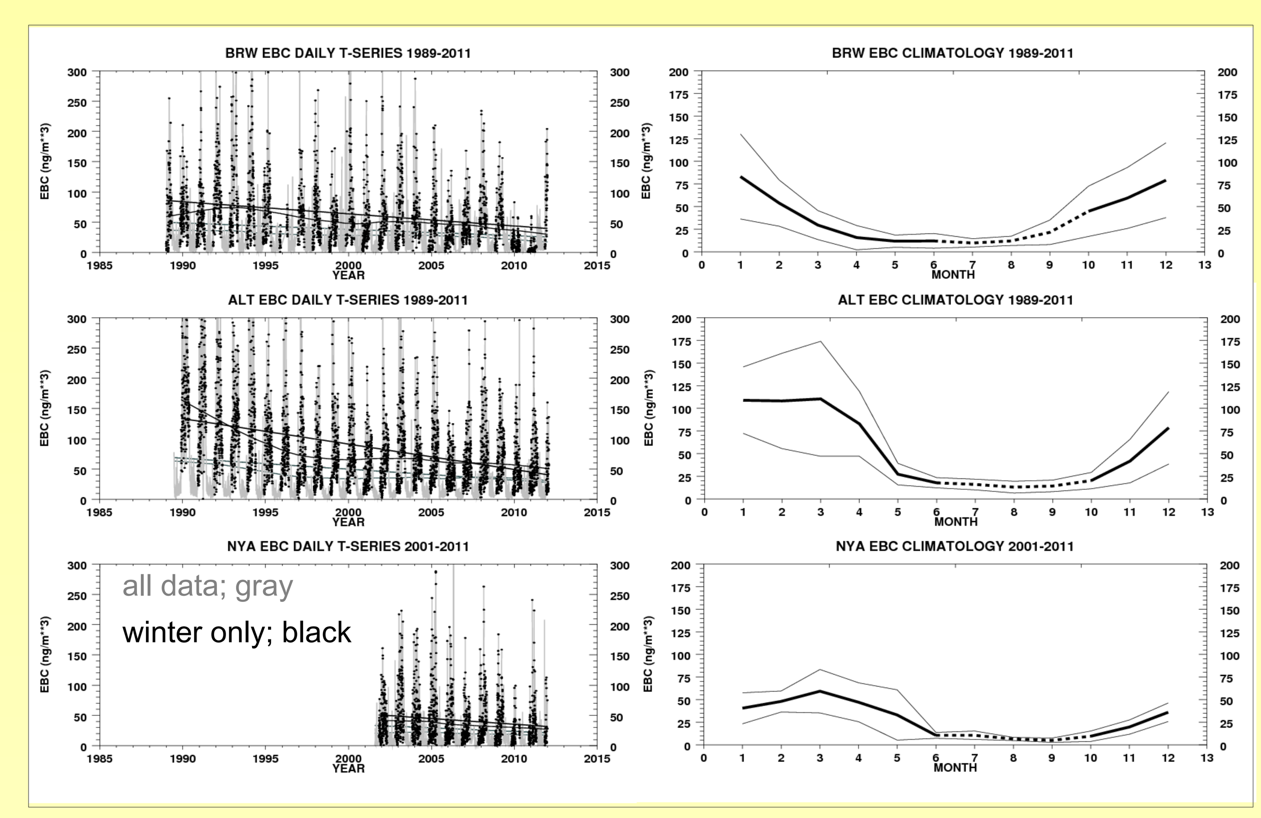
• ***EBC*** ⇔ *concentration of light-absorbing aerosol that attenuates light ≈ equal to BC (soot carbon)*




*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.).

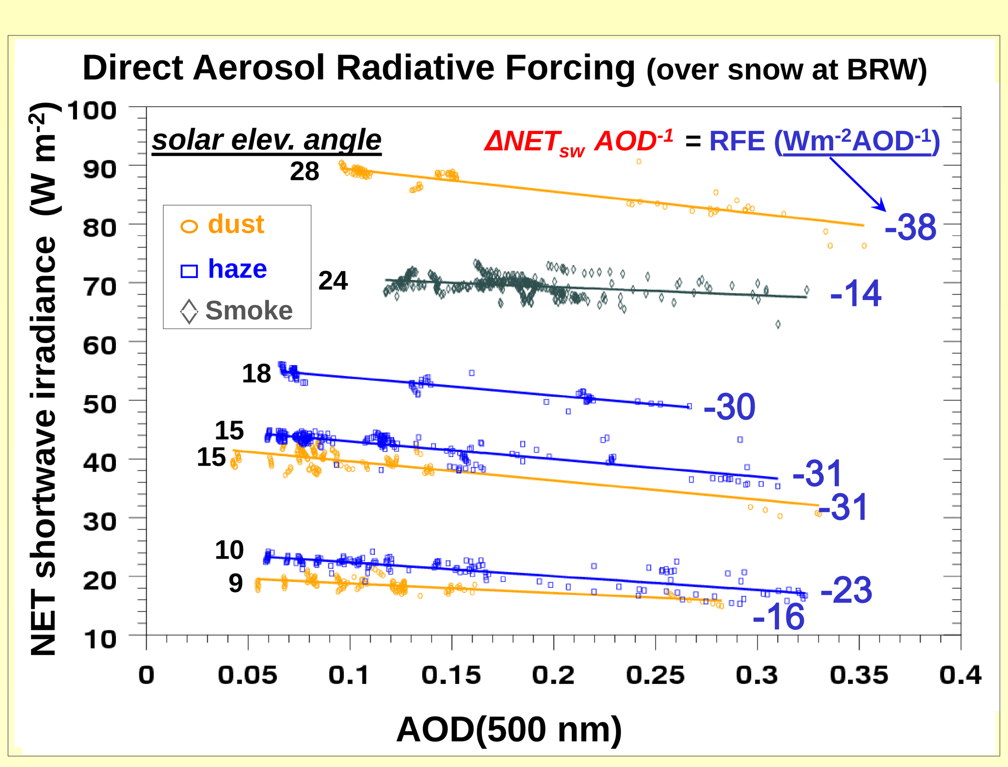


Diurnal AOD at BRW, 17-25 February 2013. *nighttime values derived from lunar calibrations*




*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



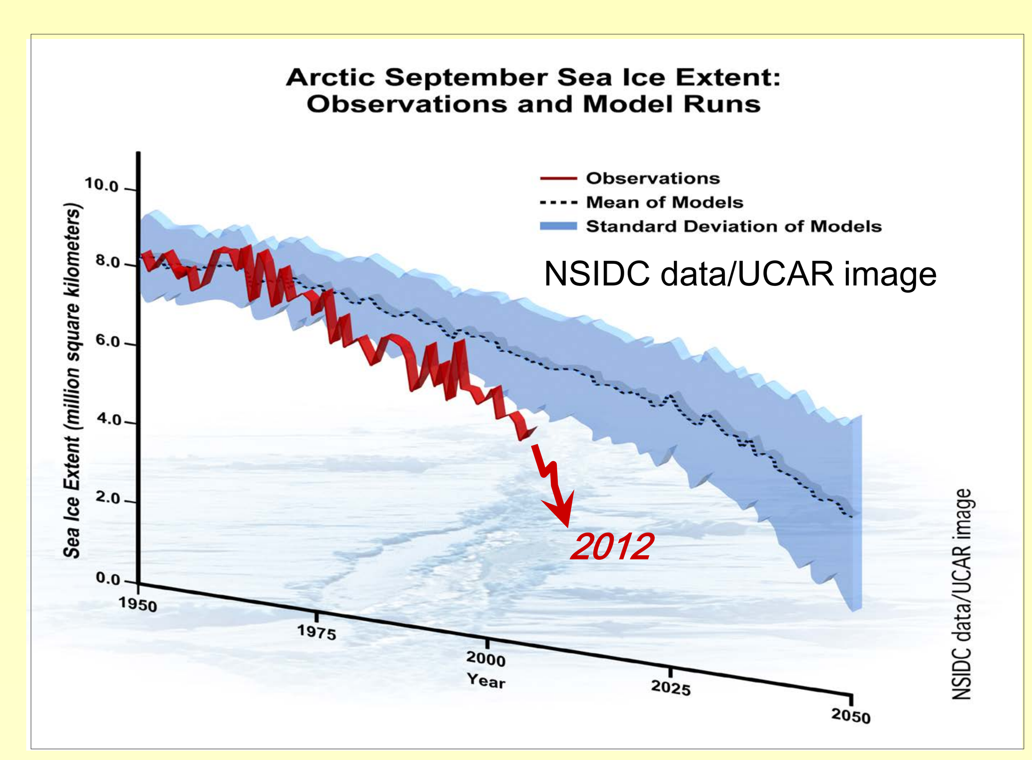

Radiative Forcing Efficiency (RFE) is defined as the change in net shortwave irradiance ($NET_{sw}$) per unit AOD at 500 nm.

• ***Arctic aerosols radiatively cool the surface***

*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.

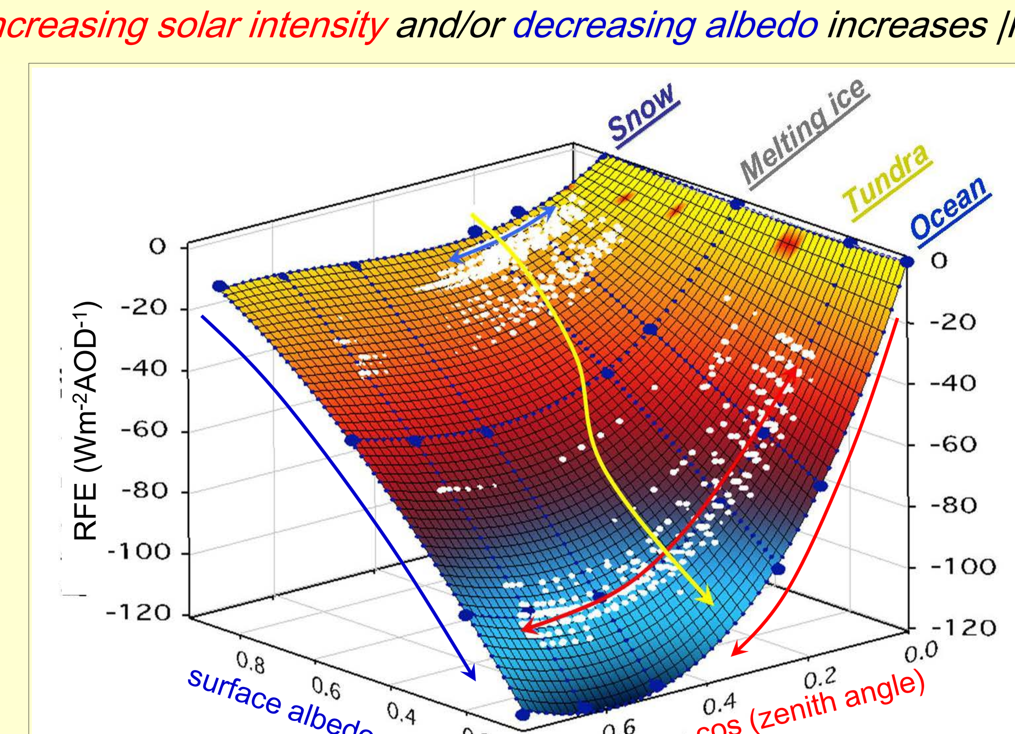
• ***What are the relative contributions of surface cooling by atmospheric aerosols versus warming due to BC deposition?***




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

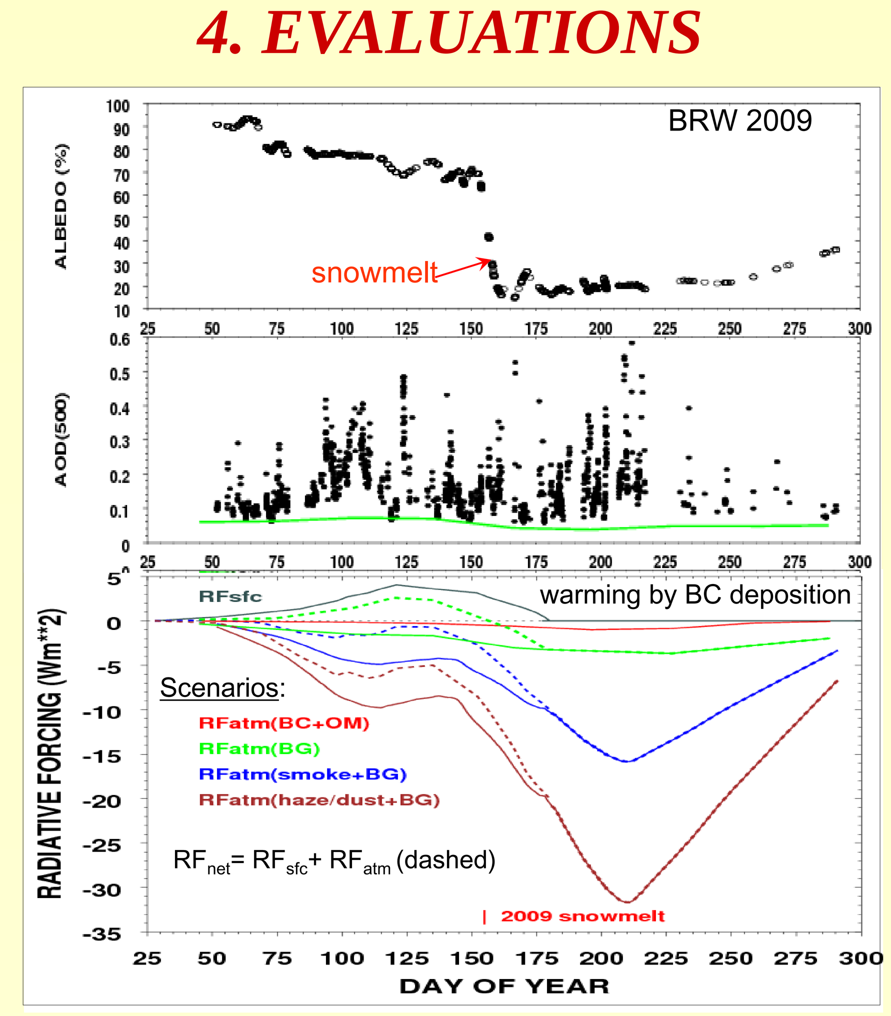
• ***Will mitigation of BC slow Arctic warming?***

*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 $BC_{dep}$***

### 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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