Soot climate forcing via snow and ice albedos

Present by
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- Why
- How
- Result
- Summary

Importance

- Soot snow/ice albedo climate forcing is effective but always ignored
- Contribute to melting of ice and sea level rising

- Compile empirical data on BC amount in snow
- Estimate effects on snow albedo

- Calculate the forcing and simulate

BC concentration in snow

- Mechanism for collection
  - Electrostatic attraction
  - Thermophoresis
  - Diffusiophoresis

- Highly variable in space and time

BC amount in snow

Table 1. Measured BC amount and calculated visible snow albedo change

Location	Observed A_v, %	BC amount, ppbw	Calculated ΔA_v, %			
			New snow		Old snow	
			Ext	Int	Ext	Int
Arctic, 1980s	~90–97	10 (low)	0.8	1.5	2.5	4.5
		30 (mean)	1.9	3.2	6.0	9.5
NH land	~88–95	20 (low)	1.5	2.5	4.5	7.7
		60 (high)	3	5	9	14
Greenland		2 (low)	0.3	0.5	0.7	1.2
		6 (high)	0.5	0.9	1.7	3.0
Antarctica		0.2 (South Pole)	.05	0.1	0.1	0.2
		2.5 (Ross Shelf)	0.3	0.5	0.8	1.5

NH, Northern Hemisphere; Ext, external mixing; Int, internal mixing.

The effects on snow albedo

- Mie scattering
- A multiple scattering approximation
- BC absorption

  ext or int,shape,voids,uncertainty in optical constants and refractive index

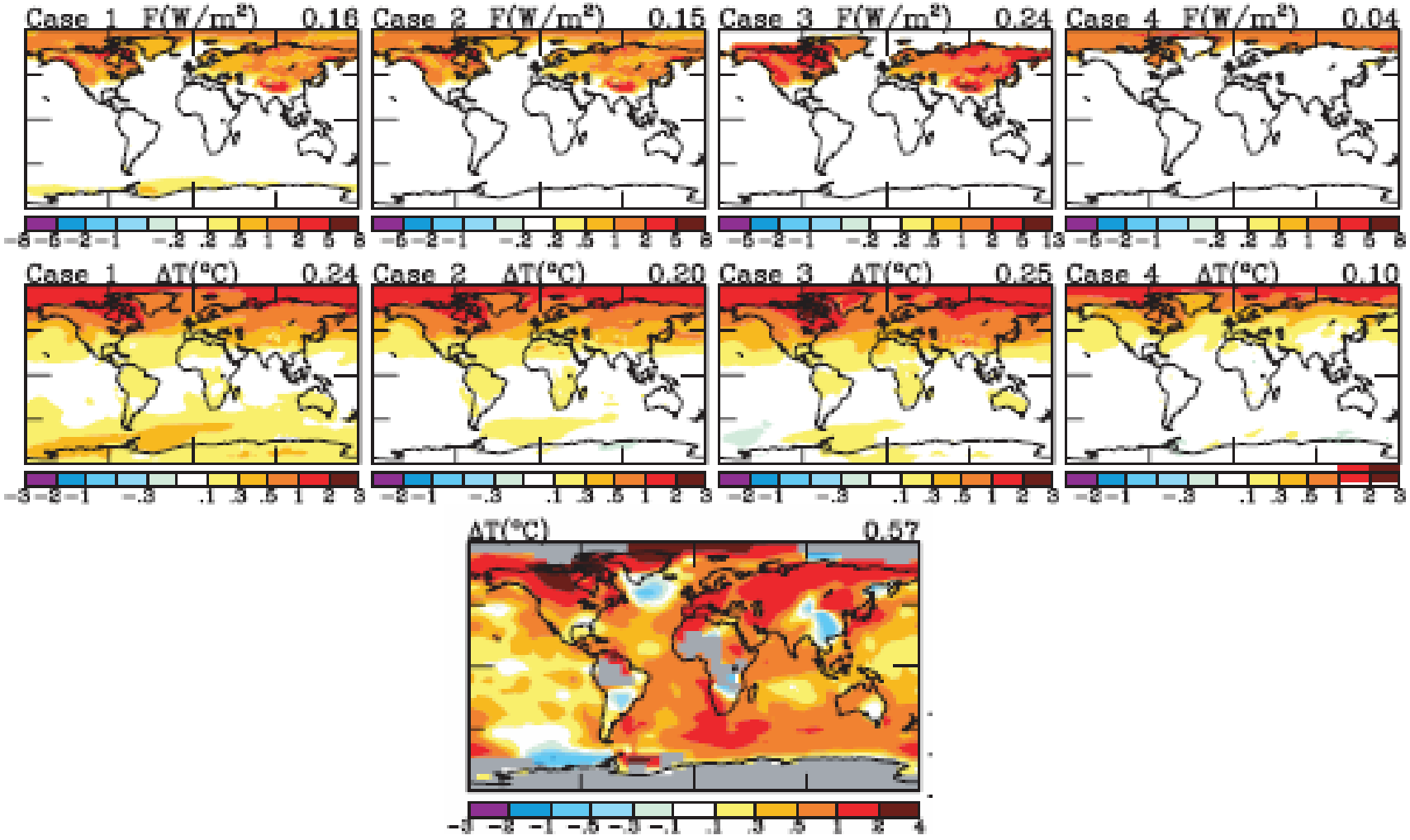
Albedo Change

Table 2. Specified snow and ice albedo changes

Experiment	Arctic, %	NH land, %	Antarctica, %	Rest of SH, %
Case 1	2.5 (vis λ)	5 (vis λ)	0	1 (vis λ)
Case 2	2.5 (vis λ)	5 (vis λ)	0	0
Case 3	0	5 (all λ)	0	0
Case 4	2.5 (all λ)	0	0	0

NH, northern hemisphere; SH, southern hemisphere.

Climate forcing and simulation



Seasonal Change

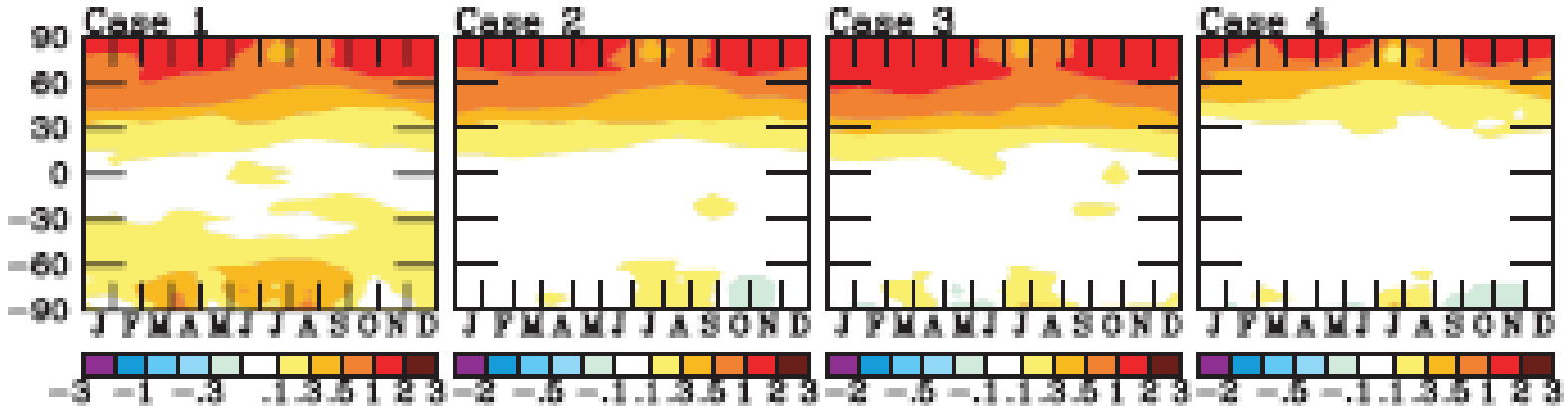
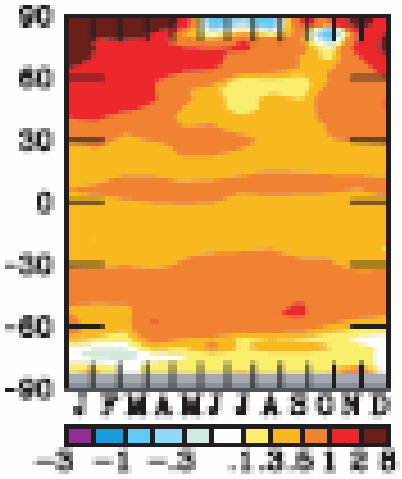


Fig. 2. Equilibrium T_s (°C) response to the snow/ice albedo forcings of Fig. 1 as a function of month and latitude.



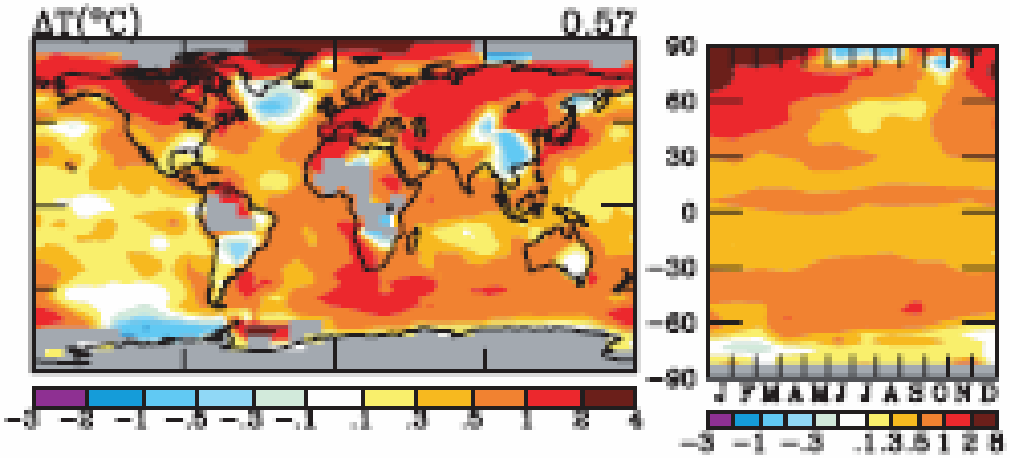
Efficacy

Table 3. Climate forcings and their efficacies

Experiment	Forcing, W/m²		Response,	Efficacy		
	F_i	F_a	ΔT, °C	E_i	E_a	F_c, W/m²
2× CO_2	4.05	3.63	2.57	1.00	1.00	3.63
Case 1	0.17	0.16	0.24	2.22	2.12	0.34
Case 2	0.16	0.15	0.20	1.97	1.88	0.28
Case 3	0.23	0.24	0.25	1.71	1.47	0.35
Case 4	0.04	0.04	0.10	3.94	3.53	0.14

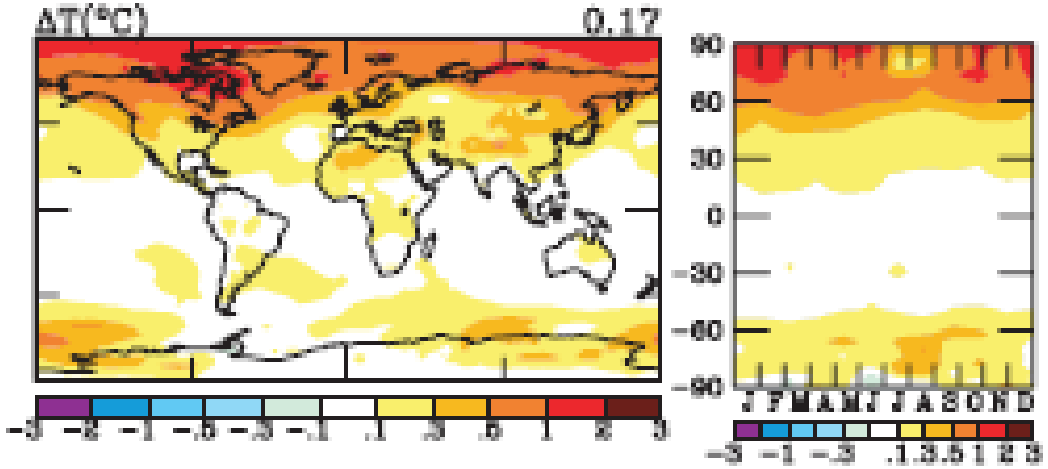
$E=Ts/T_{co2}$ $Fe=Fa*Ea$

Transient Simulation



<--observed

Simulated -->



Summary

- Melting ice and sea level rise
- A climate forcing of 0.3 W/M2
- Efficacy is about 2

- Uncertainty