Estimation of snow/ice parameters and the effects on climate

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2. Snow/ice parameters and the effects on climate

✓Physically based snow albedo model
✓Radiative effect of aerosol deposition on snow surface

Extensions of look-up tables (LUTs)

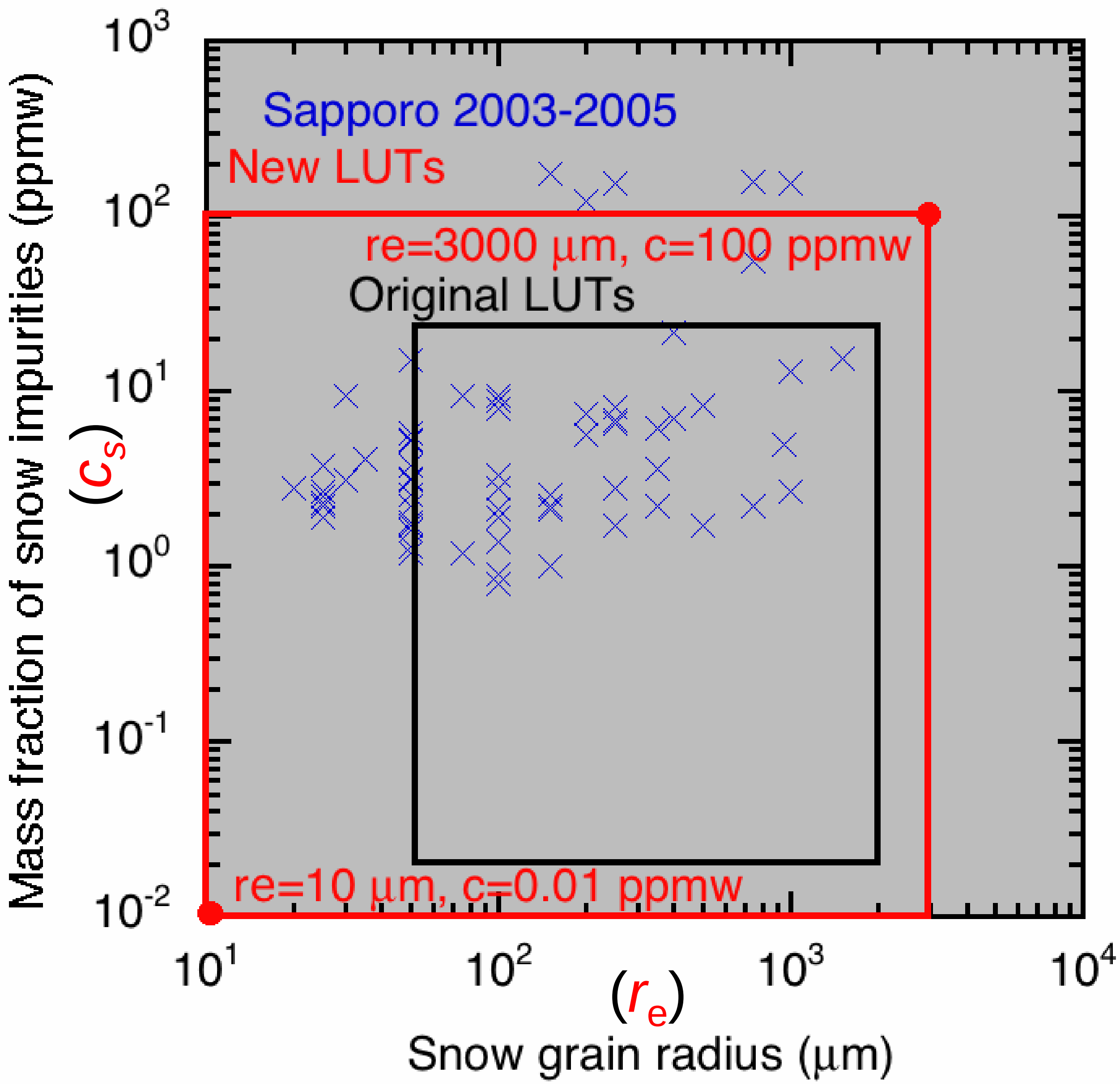
Original algorithm:

✓Extents of the original LUTs are not sufficient for both the ranges of r_e and c_s.

✓When the satellite-measured reflectance is outside the LUTs, the retrieved parameters are extrapolated.

Improved algorithm:

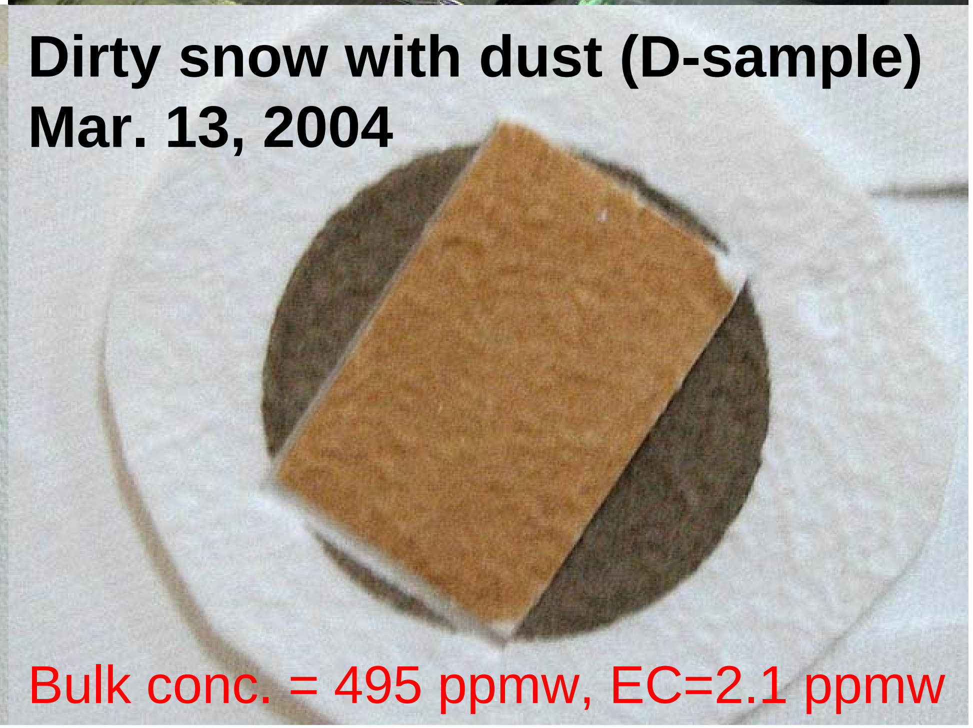
✓Impact of the extension for r_e was significant (-> latter slides).



Feasibility study for black carbon analysis with EC/OC Instrument

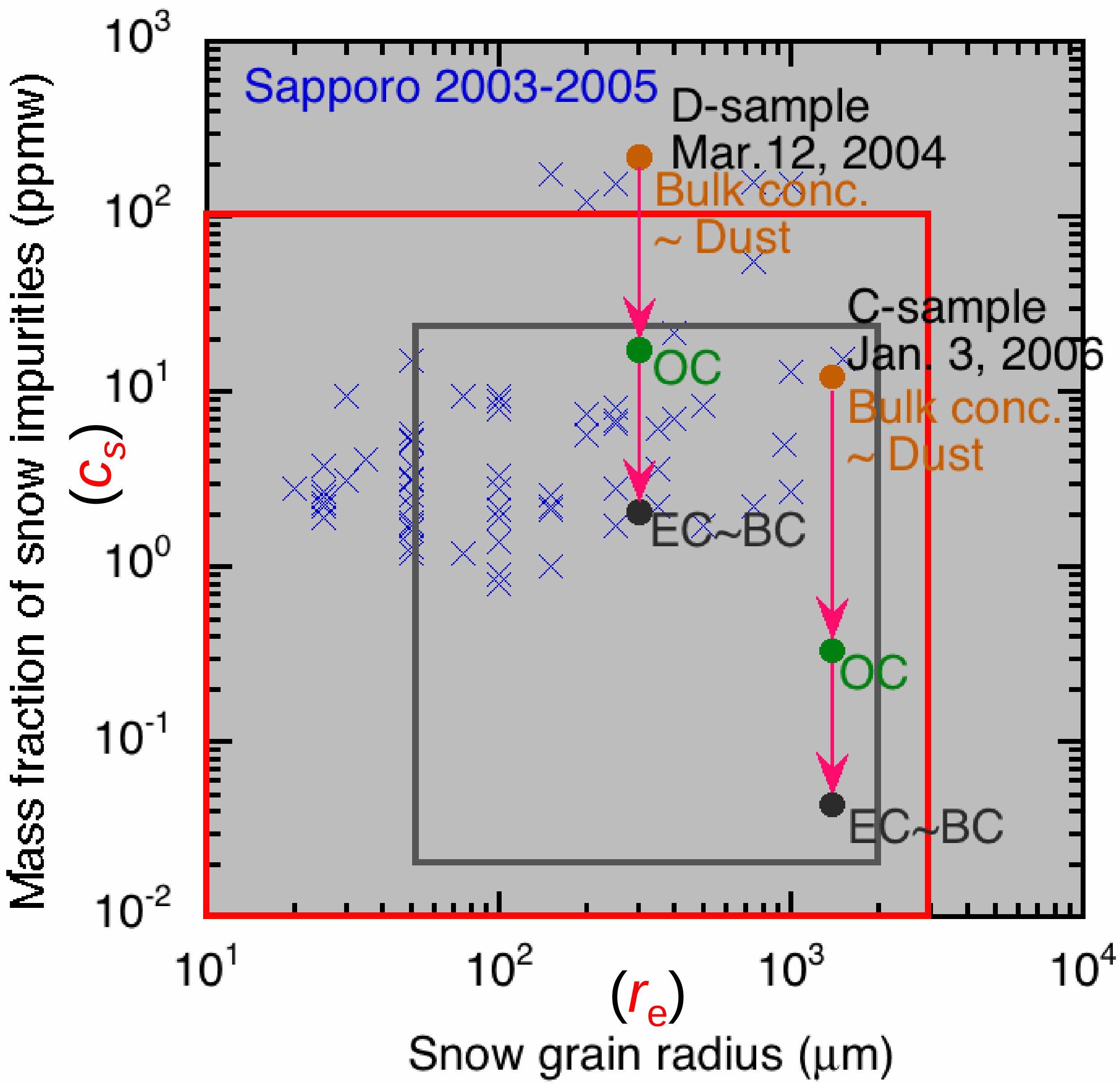
✓Thermal/Optical method

✓Test result suggests EC(~BC) /OC components could be successfully measured from clean and dirty snow samples.



Black carbon (soot) analysis

- ✓Thermal/Optical method
- ✓Test result suggests EC(~BC) /OC components could be measured from clean and dirty snow samples.
- ✓The extended LUTs are expected to cover the actual ranges of c_s.



Retrievals of R_e and C_s with LUTs calculated by non-spherical ice particles

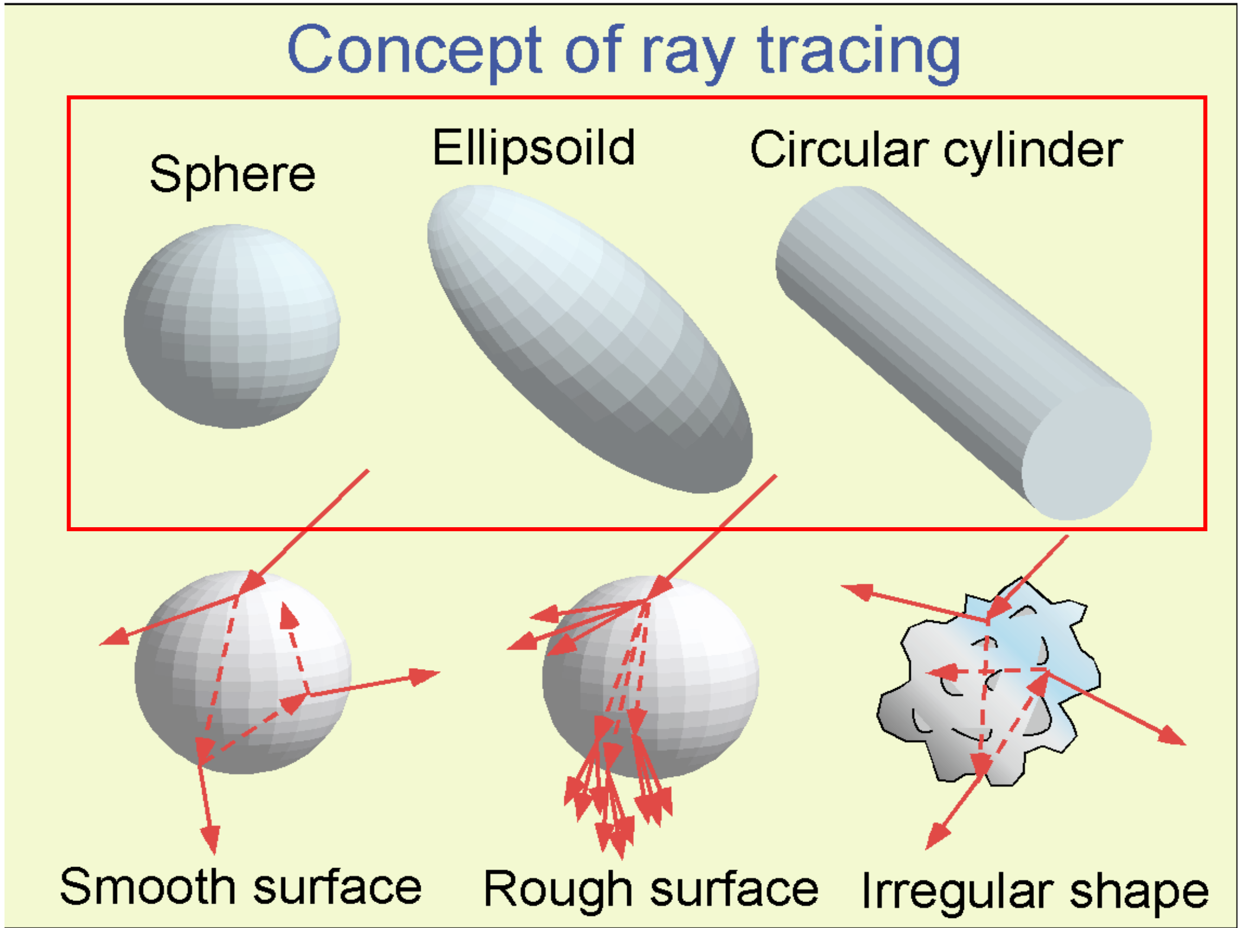
✓Aspect ratio is fixed to be 5 for non-spherical ice particles based on the comparison in HDRFs between the calculation and field measurements.

✓Grain radius is defined for the equal V/A ratio sphere to non-spherical ice particle.

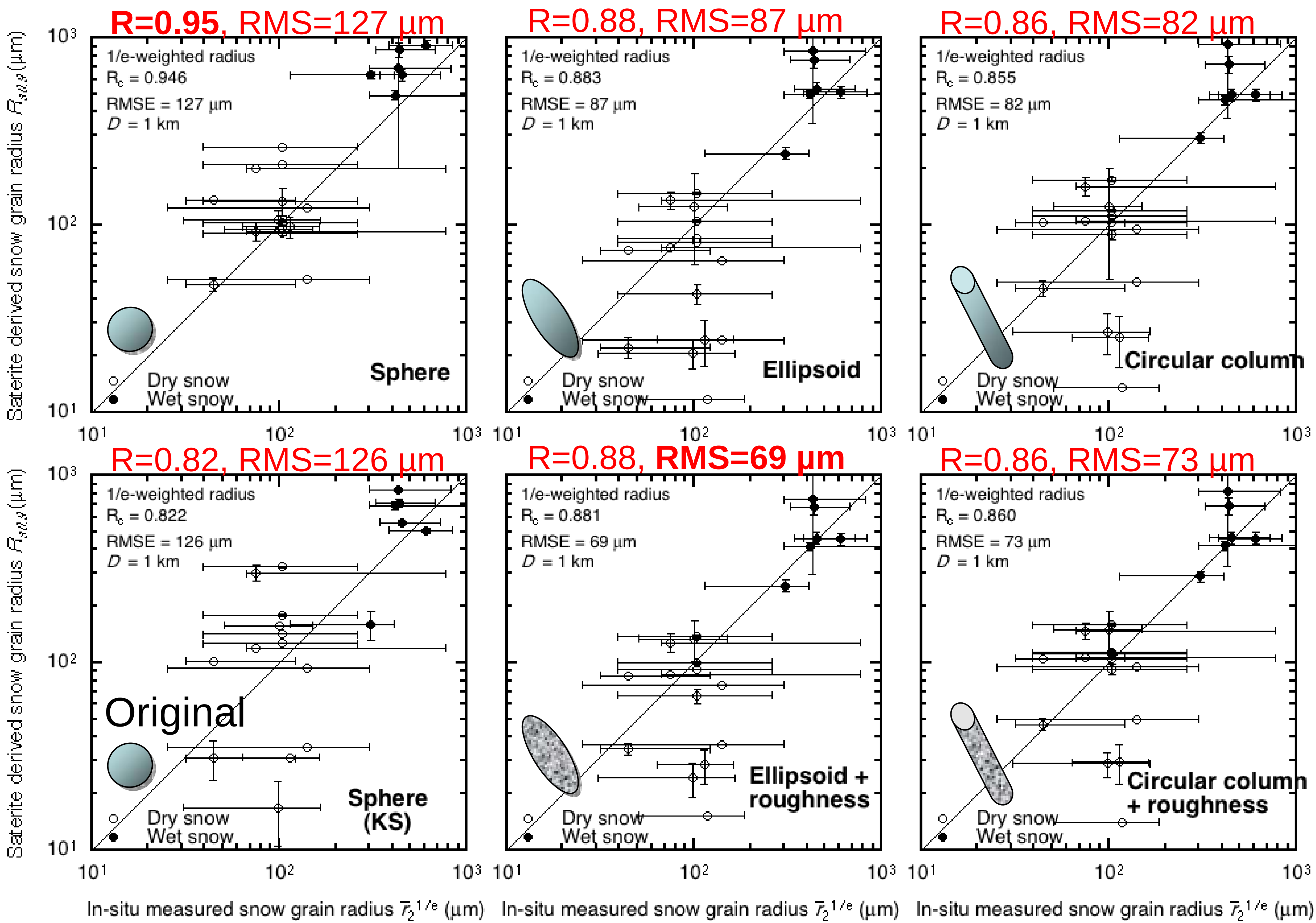
Other improvement:

✓Two-dimensional-spline interpolation in LUTs

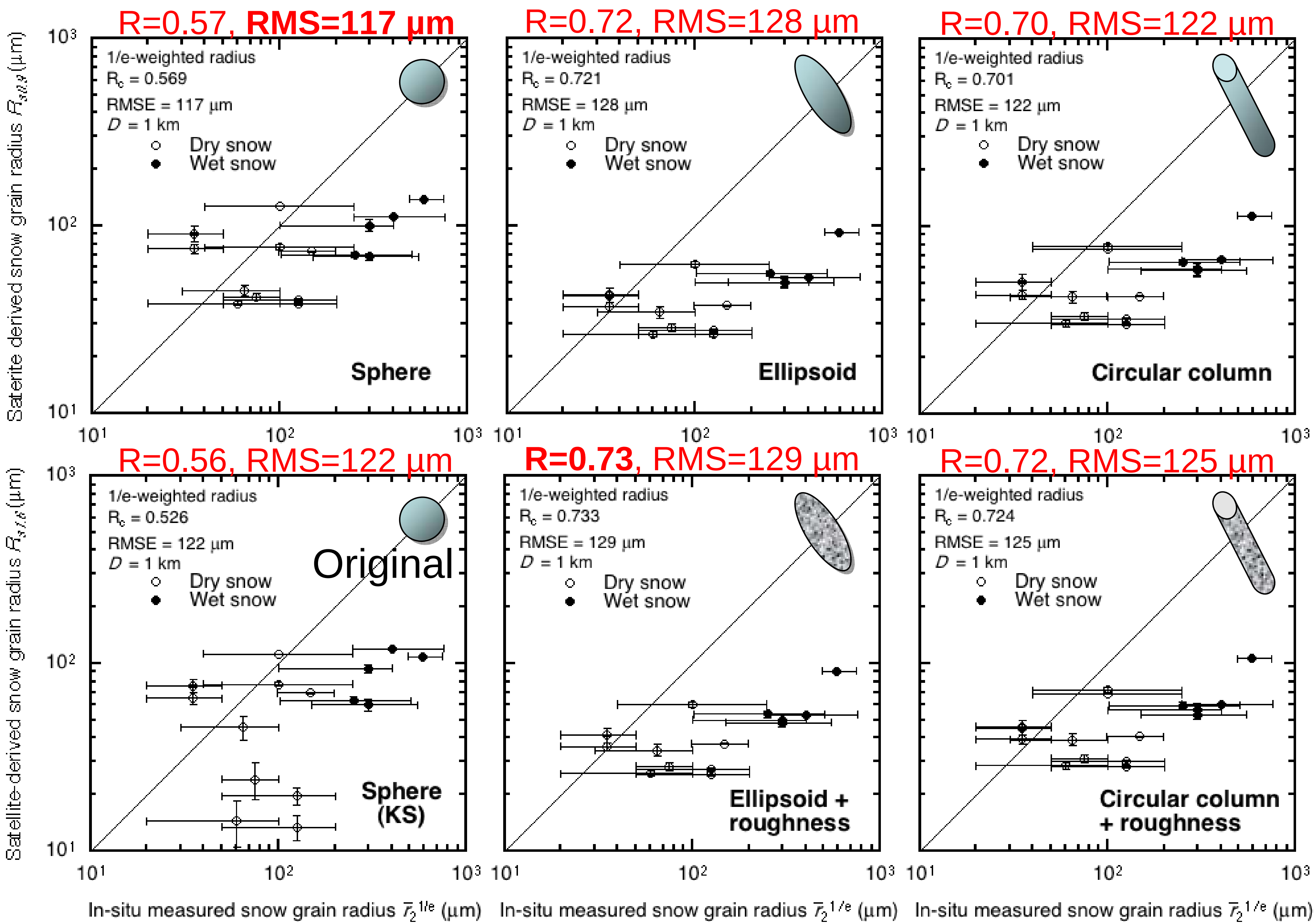
Tanikawa et al. (2006)



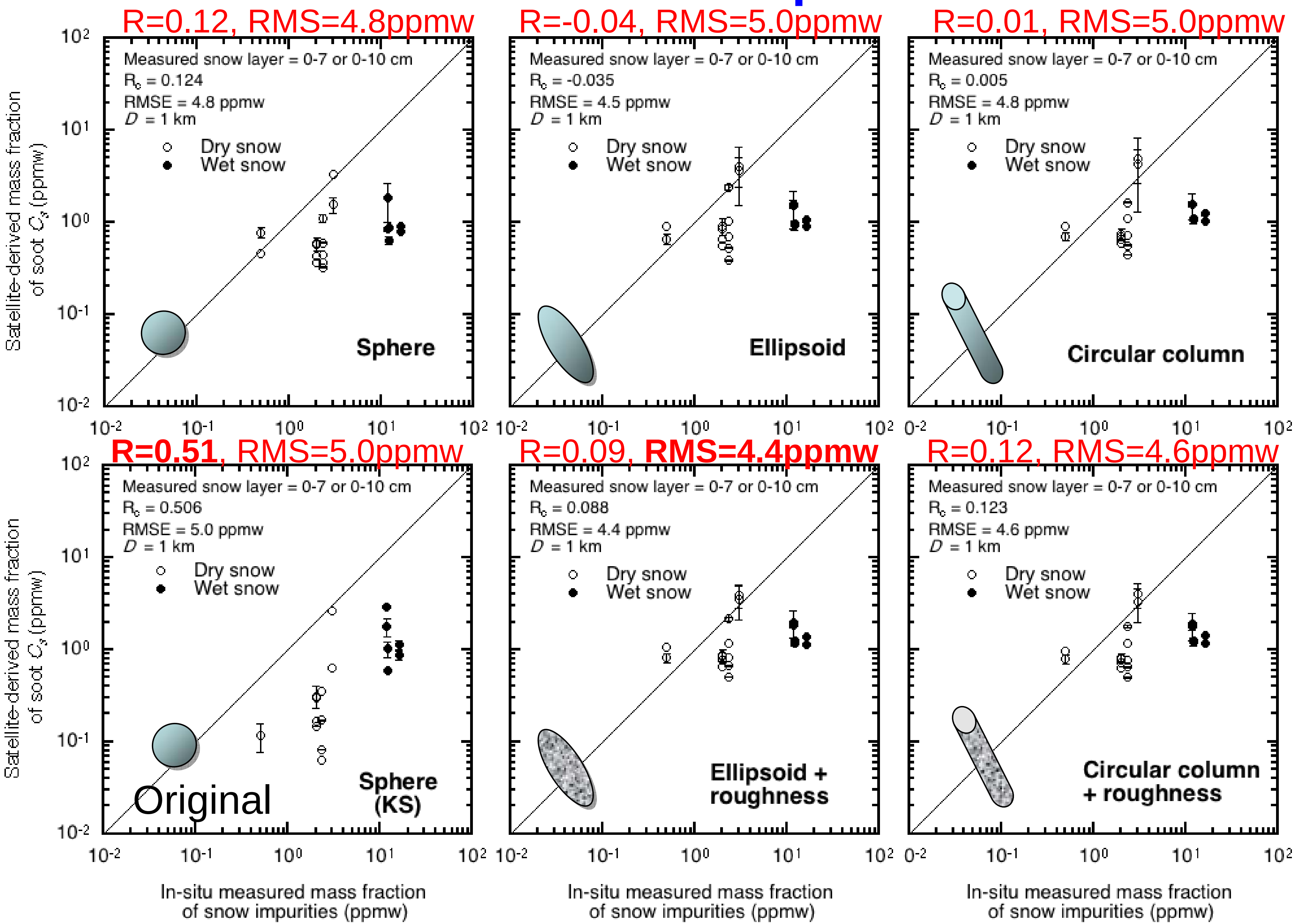
Snow grain radius from Chs. at λ = 0.46 and 0.865 μm



Snow grain radius from Chs. at λ = 1.64 μm



Mass fraction of snow impurities as soot



Summary-1

- ✓ Look-up tables were extended to the actually variable ranges for r_e and c_s as soot.
- ✓ Feasibility study for BC analysis suggested EC(~BC) /OC components could be measured from clean and dirty snow samples using EC/OC instrument.
- ✓ Retrievals using non-spherical ice particles for snow grain size were improved, while the accuracy was not improved for snow impurities. -> The detailed analyses are needed using the validation data of BC concentration (not bulk concentration).

Snow albedo process in land-surface model of GCM

Present: Snow albedo is parameterized by air temperature, snow surface temperatures, and elapsed time after snowfall (*Empirical model*).

↓

Snow albedo strongly depends on snow grain size (r_e) and concentration of snow impurities (c_s), which process is called *snow aging*.

↓

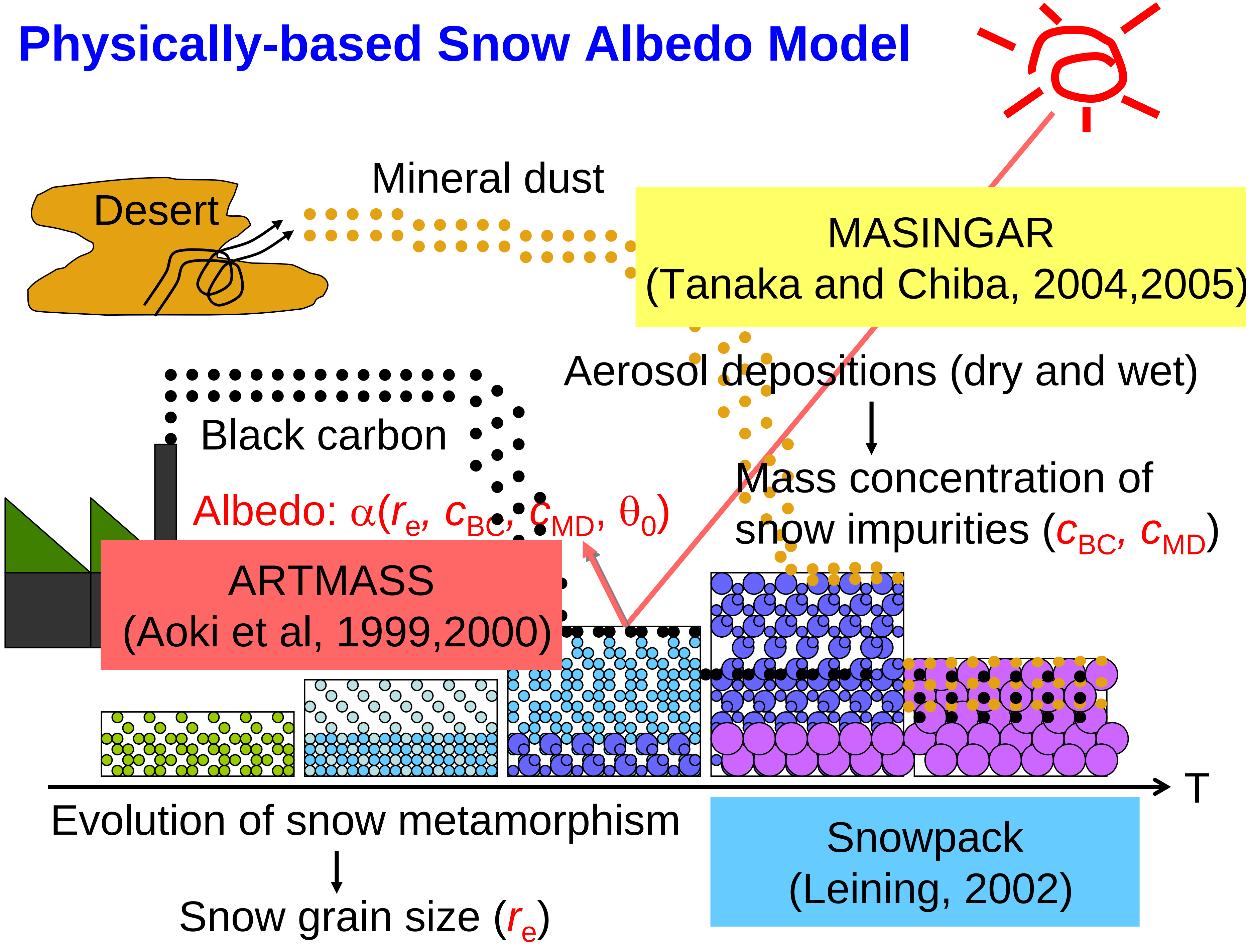
Next generation: r_e and c_s should be treated as predictors in GCM. (*Physically-based model*)

↓

✓r_e should be calculated by heat budget in snowpack
✓c_s should be calculated from production, transportation, and deposition of atmospheric aerosols as source for c_s.

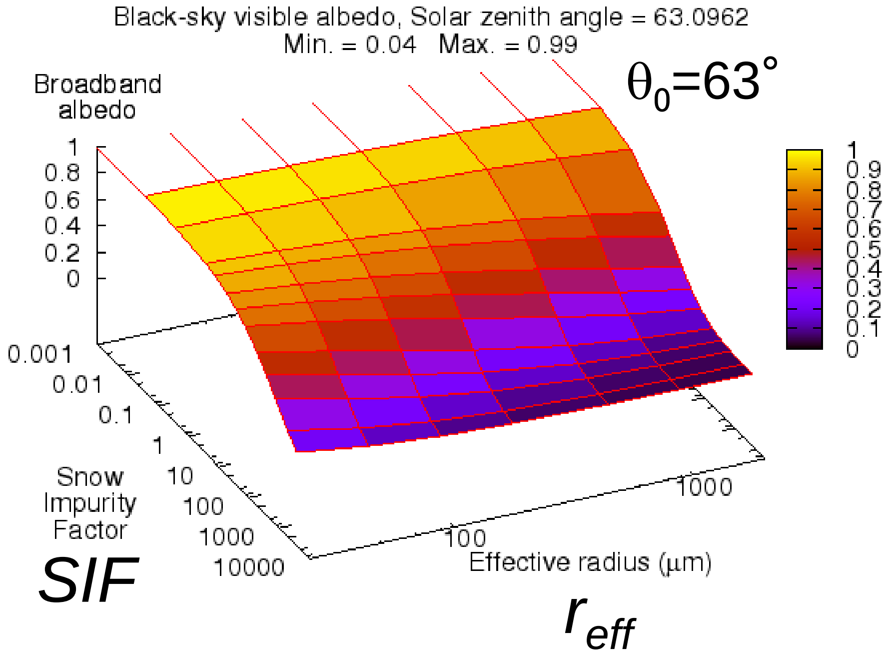
↑

Validation with satellite snow products

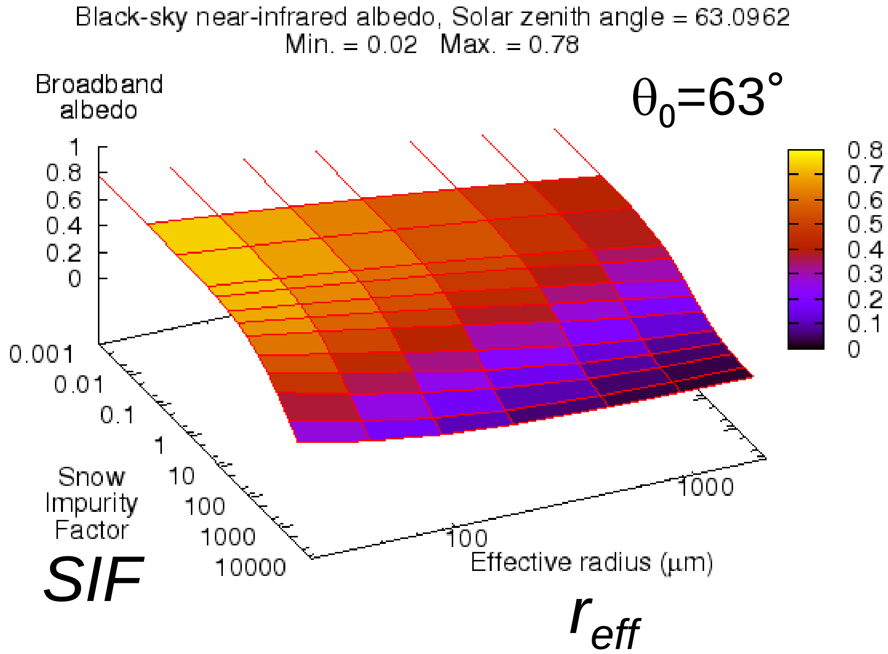

Physically-based Snow Albedo Model
Mineral dust
Desert
MASINGAR
(Tanaka and Chiba, 2004,2005)
Aerosol depositions (dry and wet)
Mass concentration of
snow impurities (c_{BC}, c_{MD})
Black carbon
Albedo: $\alpha(r_e, c_{BC}, c_{MD}, \theta_0)$
ARTMASS
(Aoki et al, 1999,2000)
T
Evolution of snow metamorphism
Snow grain size (r_e)
Snowpack
(Leining, 2002)

Black-sky albedo as functions of *SIF and r_{eff}*

Visible albedo



Near-infrared albedo



Climate simulation with aerosol transport model MASINGAR

✓Simulation period : Spin up in three months and the calculation during four years. The latter three years are analysed.

✓No data assimilation

✓Dry and wet depositions

✓Dust and black carbon

✓Horizontal resolution: T42 (~2.8° ×2.8°)

✓Vertical resolution: 30 atmospheric layers (surface ~ 0.8 hPa)

✓Calculation condition

- Control run : Depositions of BC and MD
- No *SIF* : No depositions of BC and MD
- BC run : Depositions of only BC
- Dust run : No depositions of only MD

Tanaka et al. (to be submitted)

Summary-2

- ✓ Quasi-physically-based snow albedo model depending on r_e and *c* was developed and incorporated into aerosol transport model MASINGAR.
- ✓ Snow impurity factor (*SIF*) is introduced to calculate the effects of BC and dust which have the different light absorption.
- ✓ TOA radiative effect of aerosol (BC + dust) depositions on snow surface was comparable to the aerosol direct or indirect effect.
- ✓ The contribution due to BC is approximately half of the total radiative effect.
- ✓ Satellite snow products will be used to validate the simulation with MASINGAR.