Applications of satellite measurements on dust-cloud-precipitation interactions over Asia arid/semi-arid region

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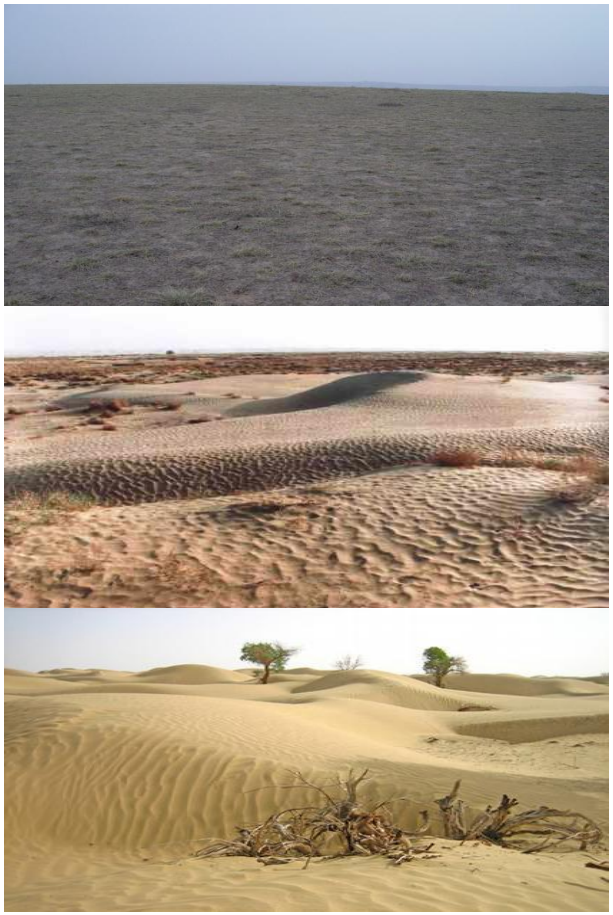
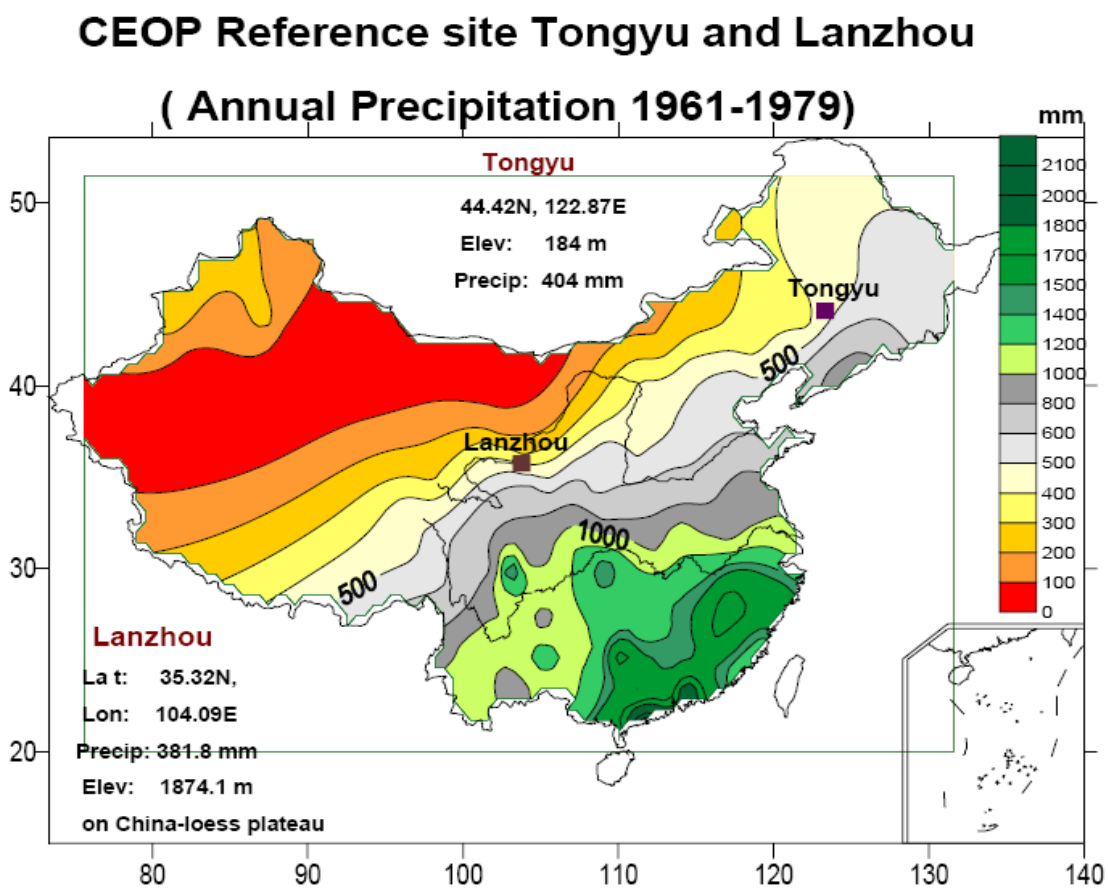
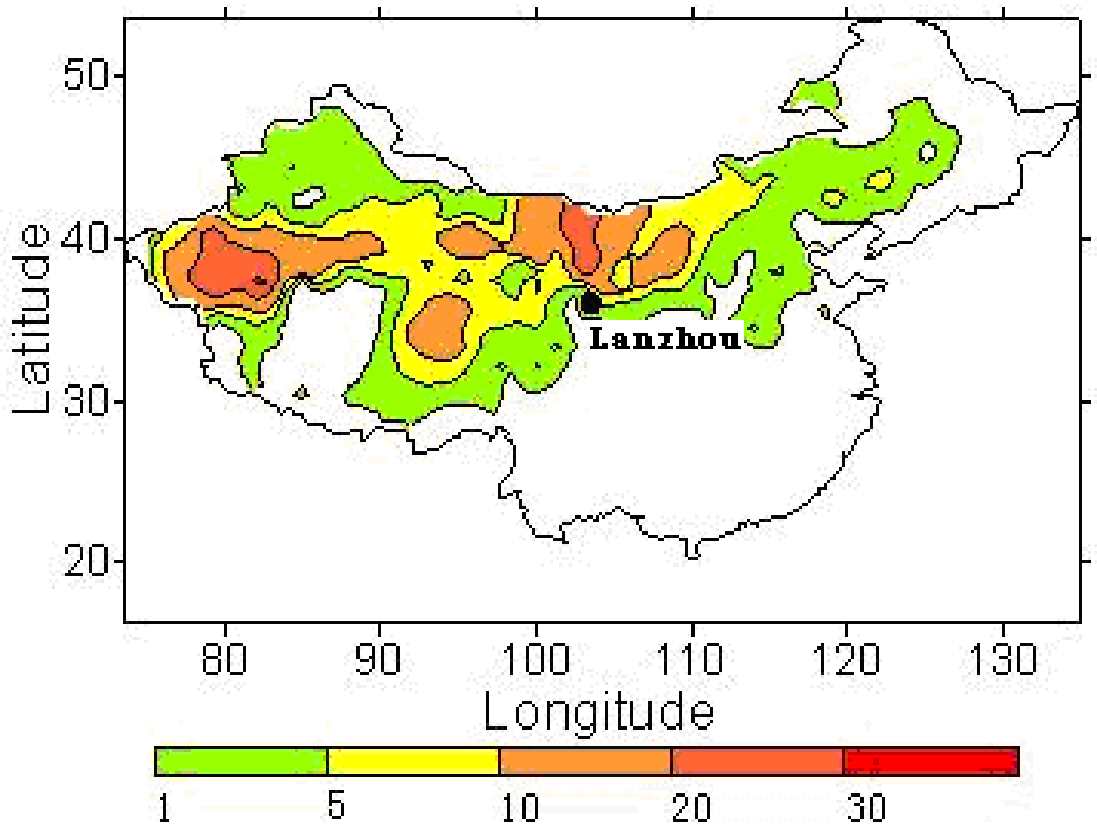
2012 AMS Meeting

Northwest China is arid/semi-arid area





This area is the a major source region of dust storm



Distribution of Dust Storm over China

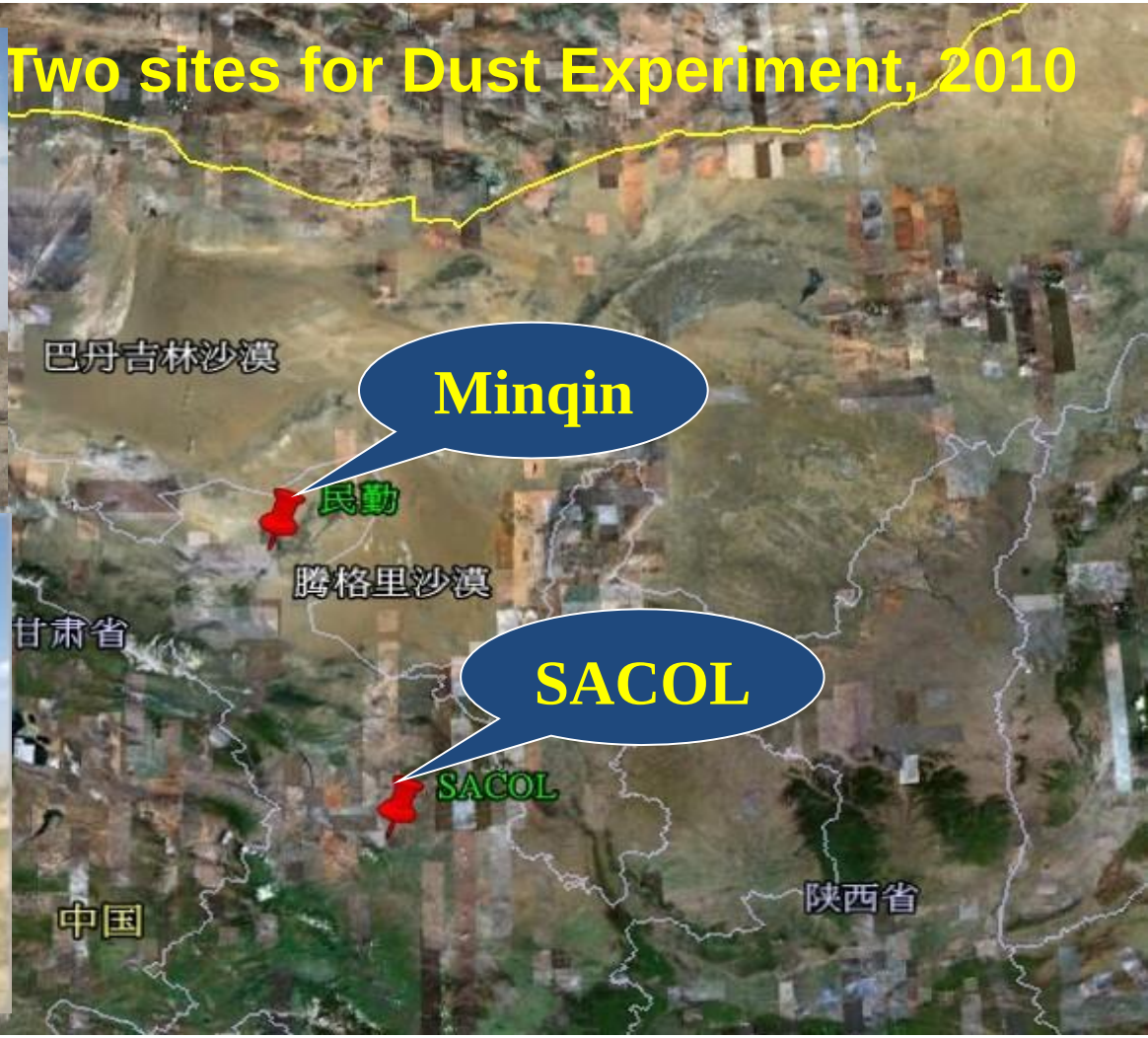
Heavy Dust Storms (April 24, 2010)

Instantly wind up to 28m/s, Visibility 0 m

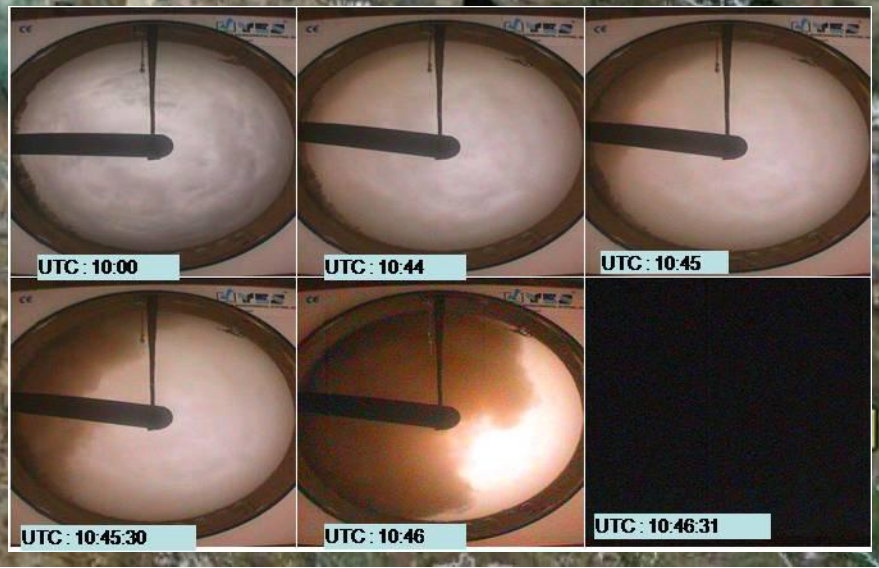
Instantly wind up to 28m/s, Visibility 0 m

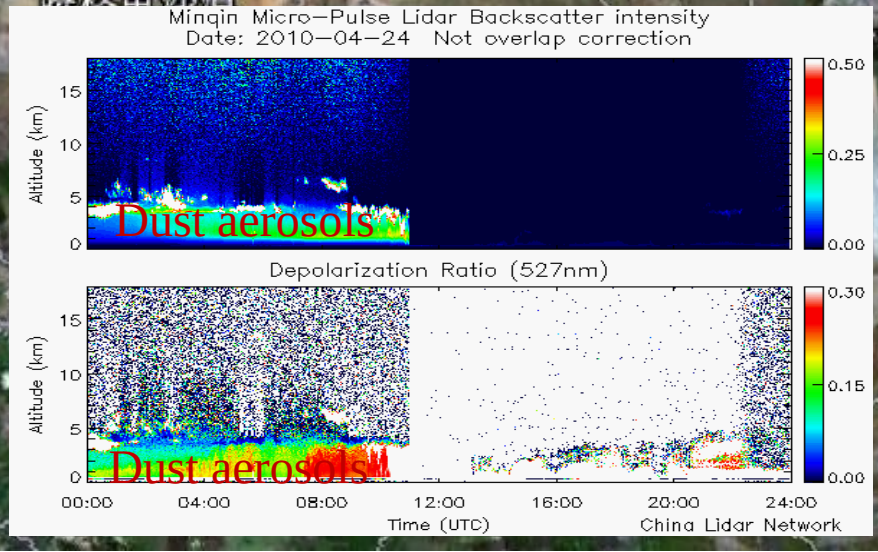
April, 24th 2010

Dust experiment

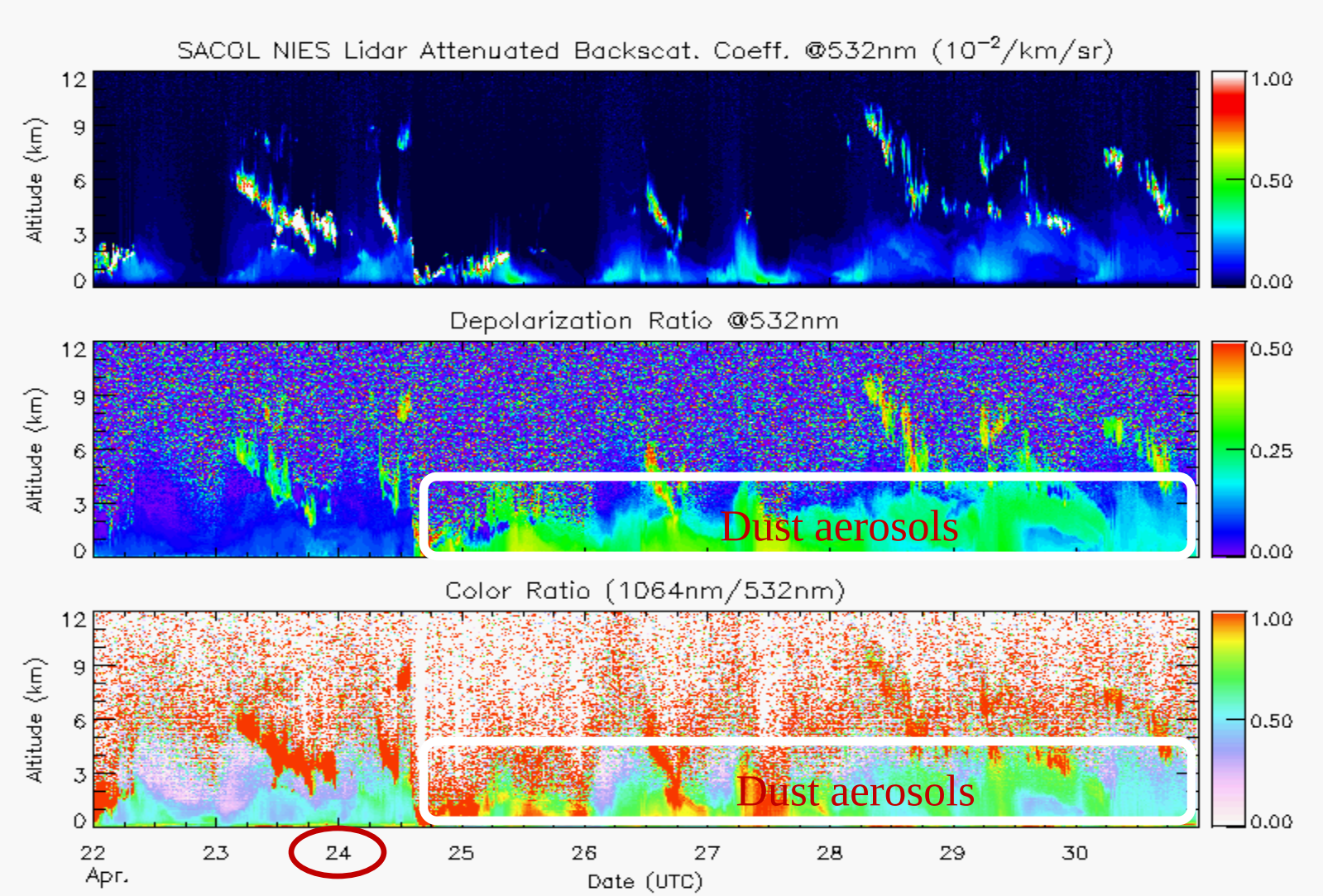


The Lidar results in Minqin

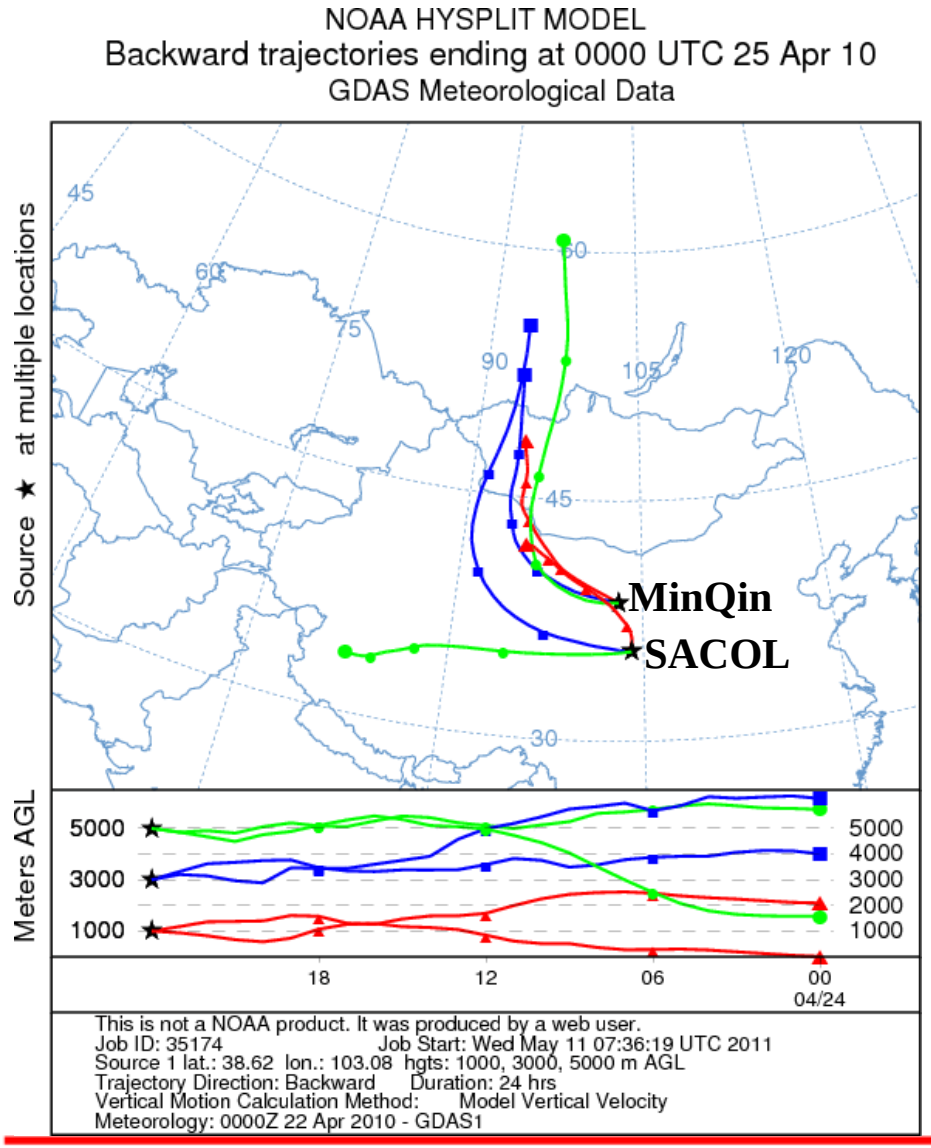




The Lidar results in SACOL

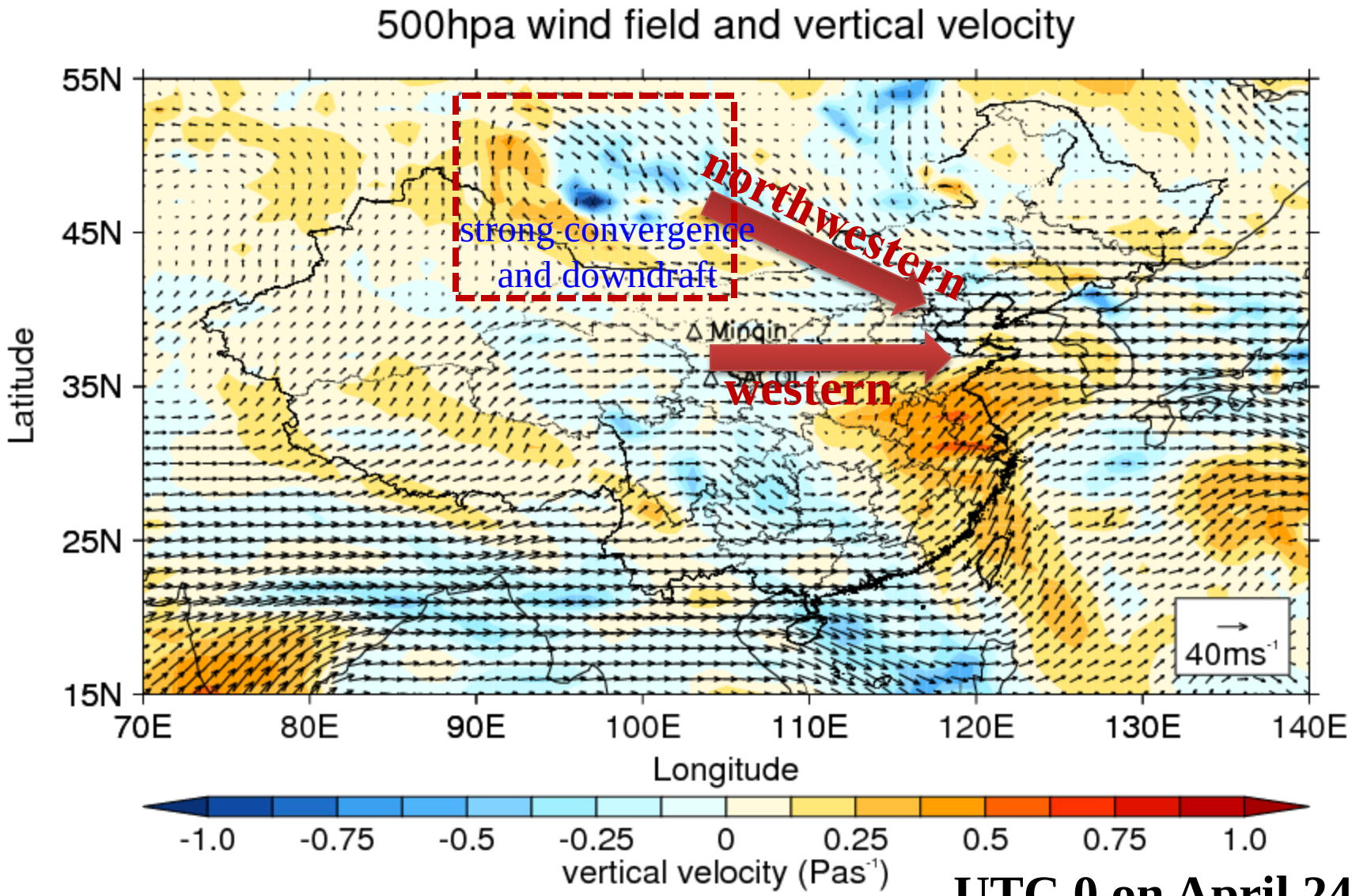


Backward Trajectories for the dusty case



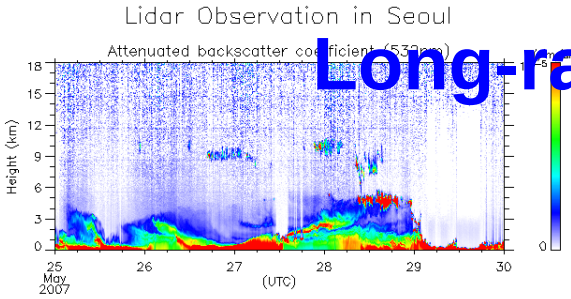
The dust aerosols transport from Minqin to SACOL.

Weather situation

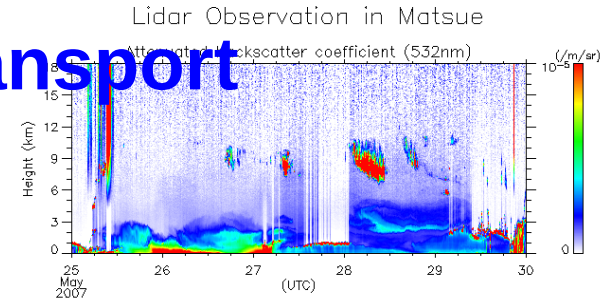


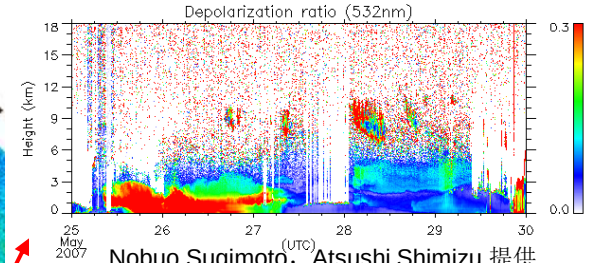
UTC 0 on April 24th

Long-range dust aerosol transport



Nobuo Sugimoto，Atsushi Shimizu 提供





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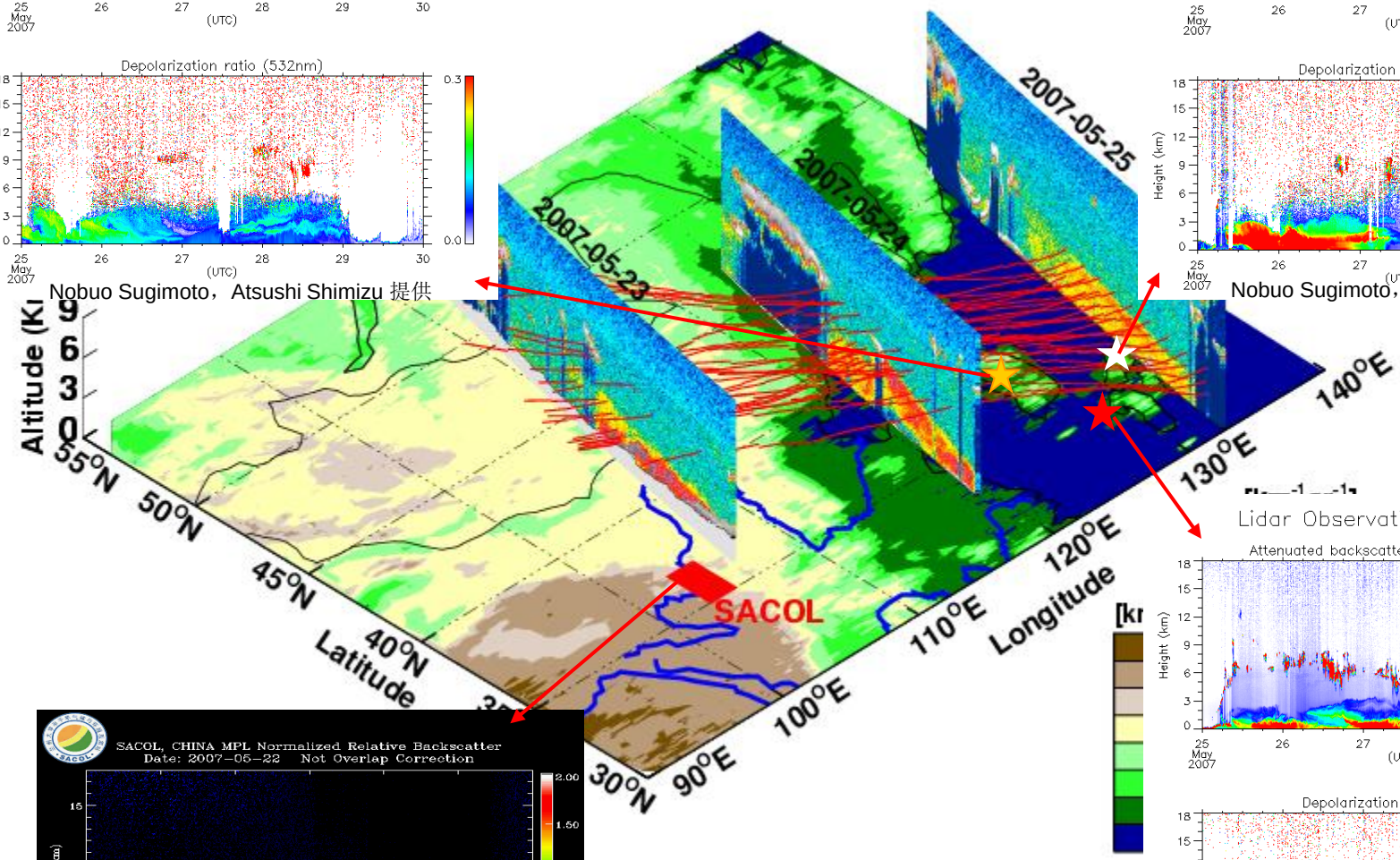
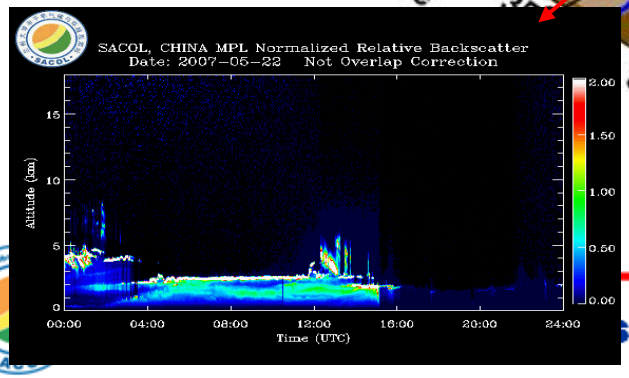
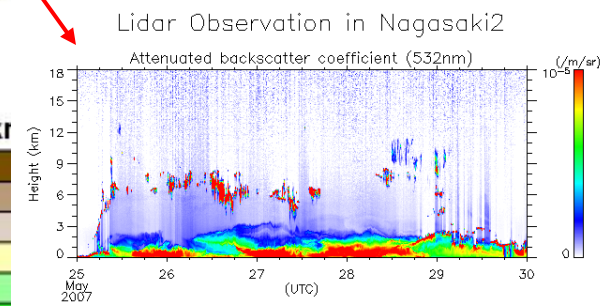
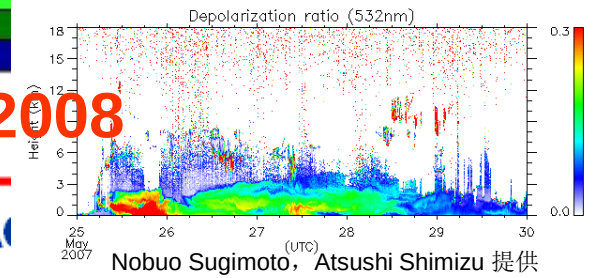






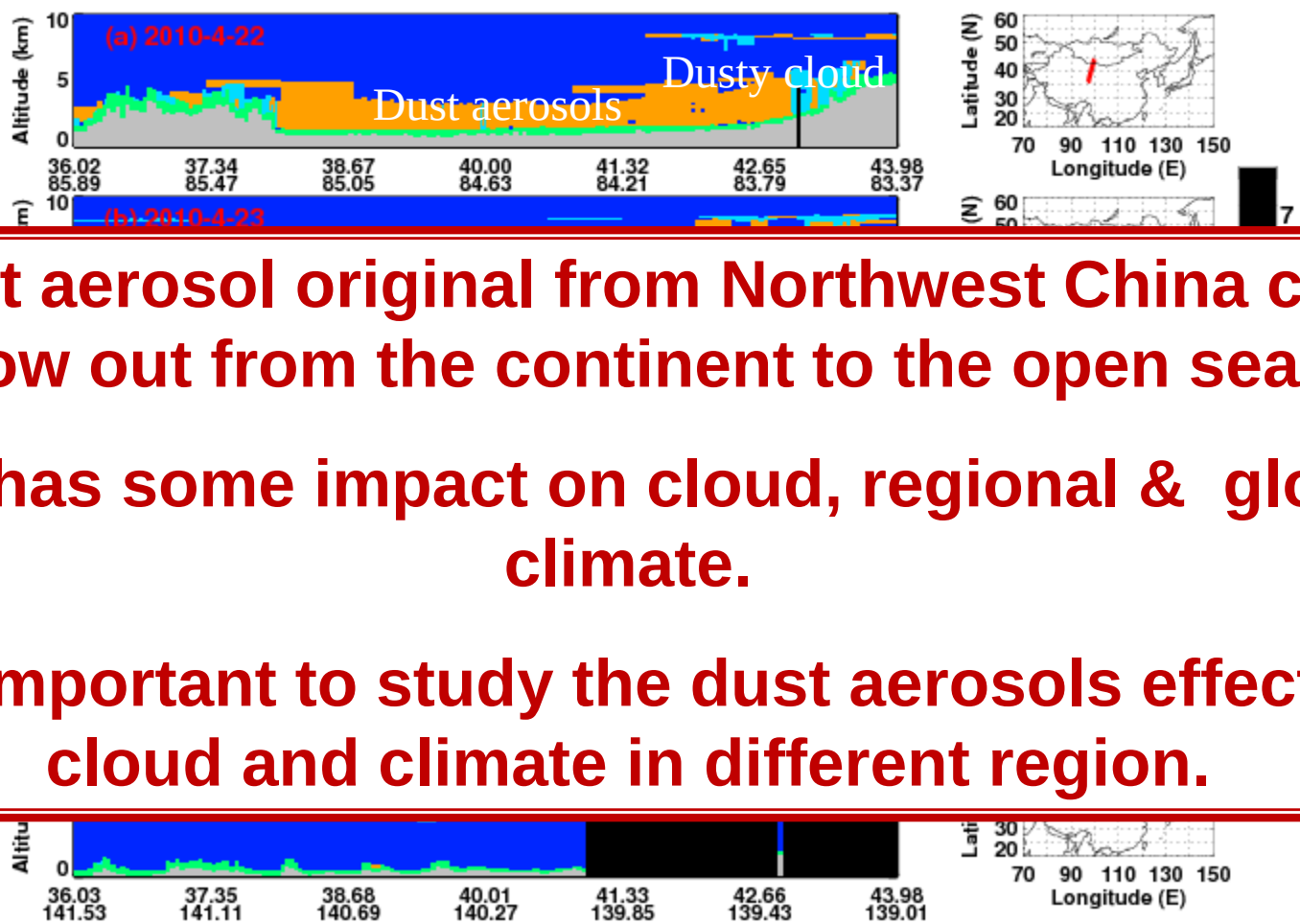


Nobuo Sugimoto，Atsushi Shimizu 提供

Huang et al., JGR, 2008

servatory & Laboratory (SA

The VFM and transmission of the dusty case

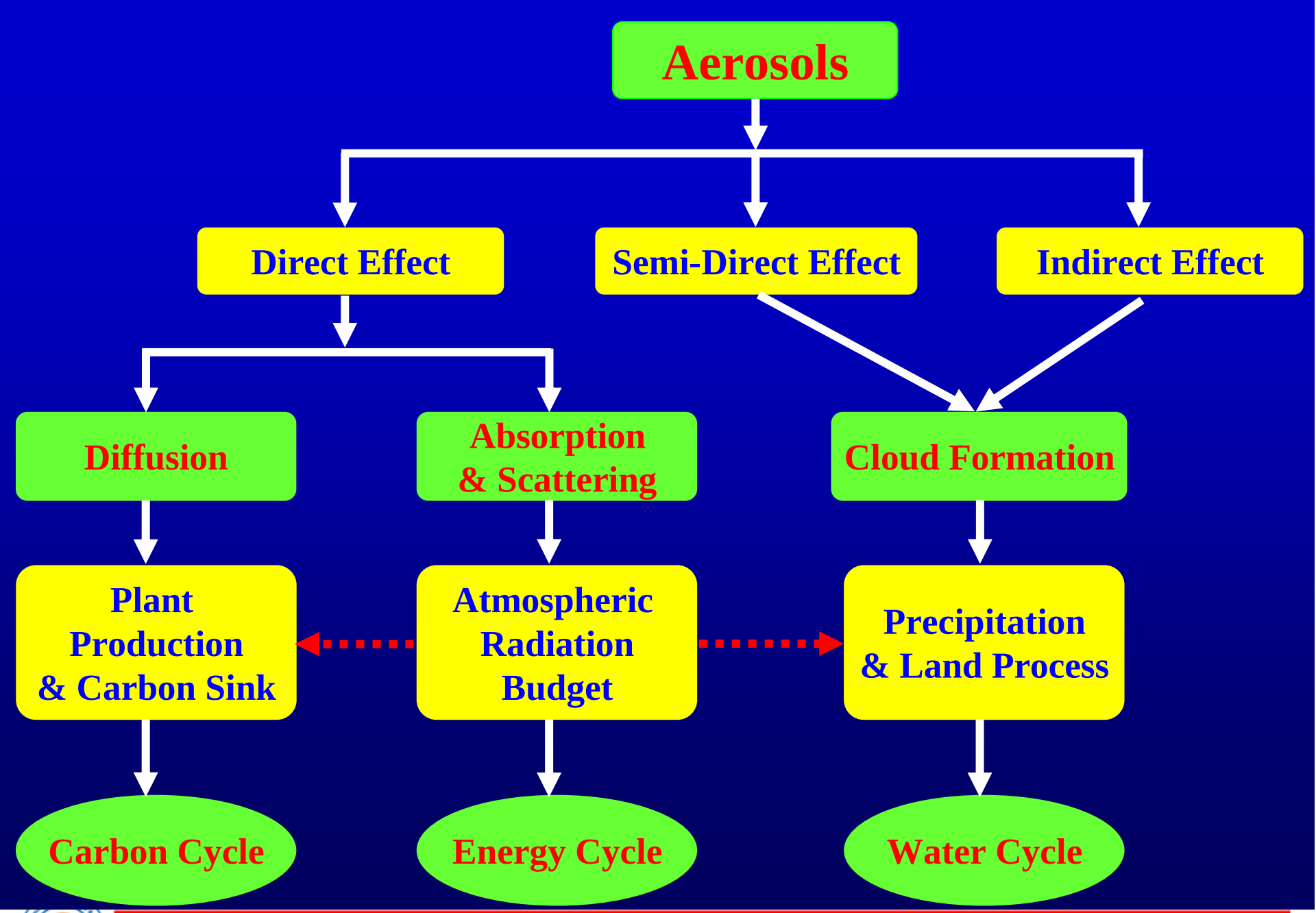


Dust aerosol original from Northwest China can flow out from the continent to the open sea,

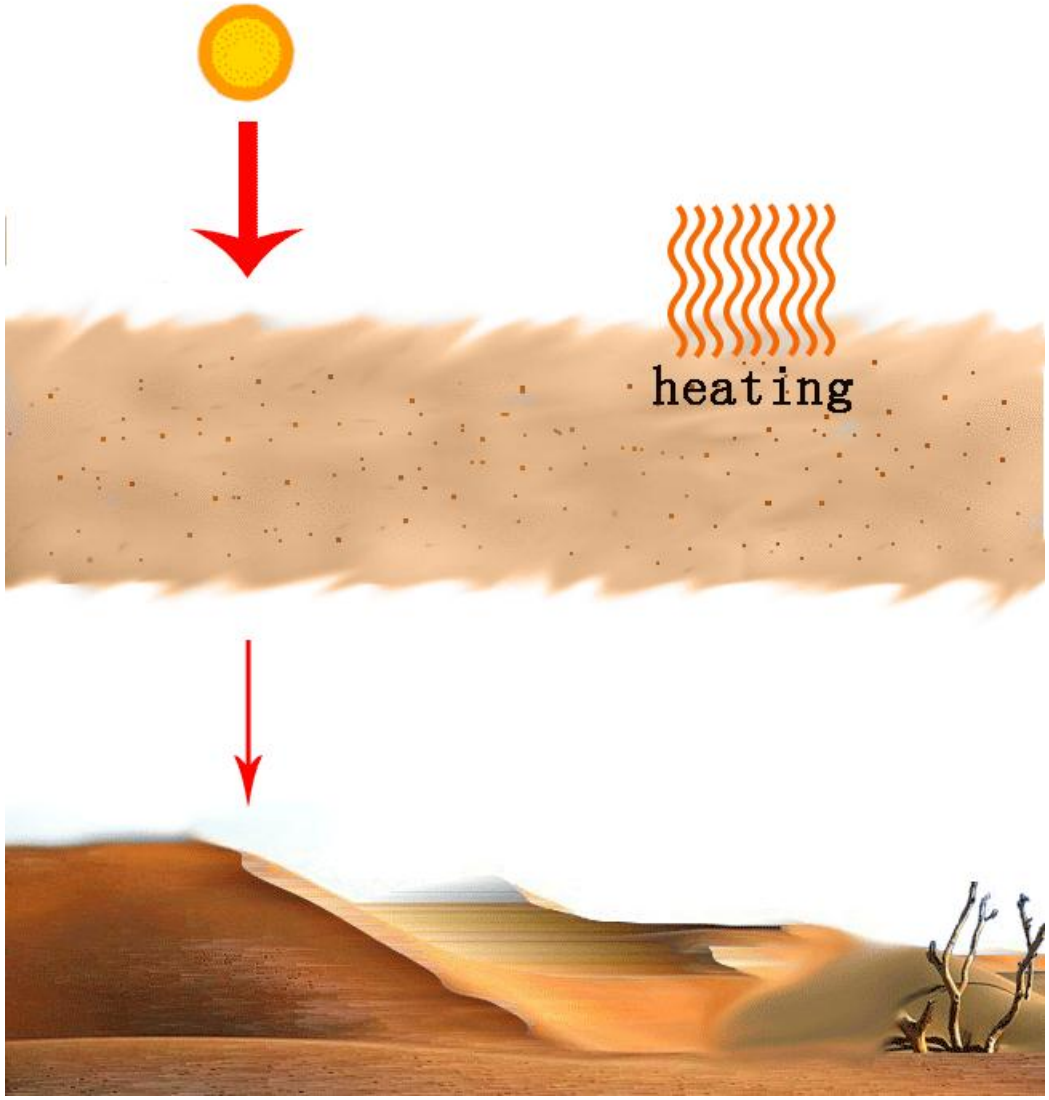
may has some impact on cloud, regional & global climate.

It is important to study the dust aerosols effect on cloud and climate in different region.

0=invalid (bad or missing data),1=clear air, 2=cloud, 3=aerosol, 4=stratmospheric, 5=surface, 6=subsurface, 7=no signal


Aerosols
Direct Effect
Semi-Direct Effect
Indirect Effect
Diffusion
Absorption & Scattering
Cloud Formation
Plant Production & Carbon Sink
Atmospheric Radiation Budget
Precipitation & Land Process
Carbon Cycle
Energy Cycle
Water Cycle

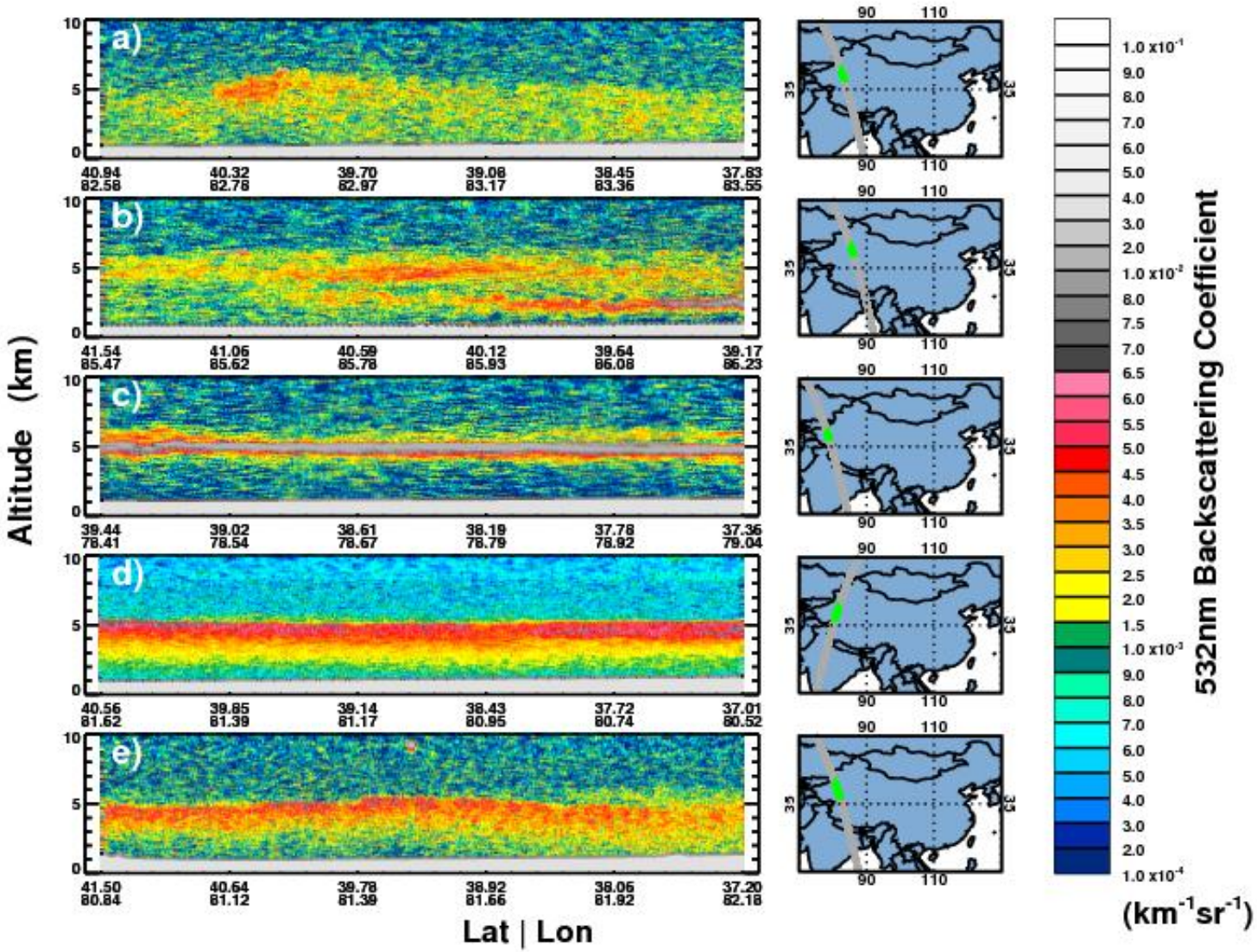
The direct dust aerosol effect



Absorb solar radiation !

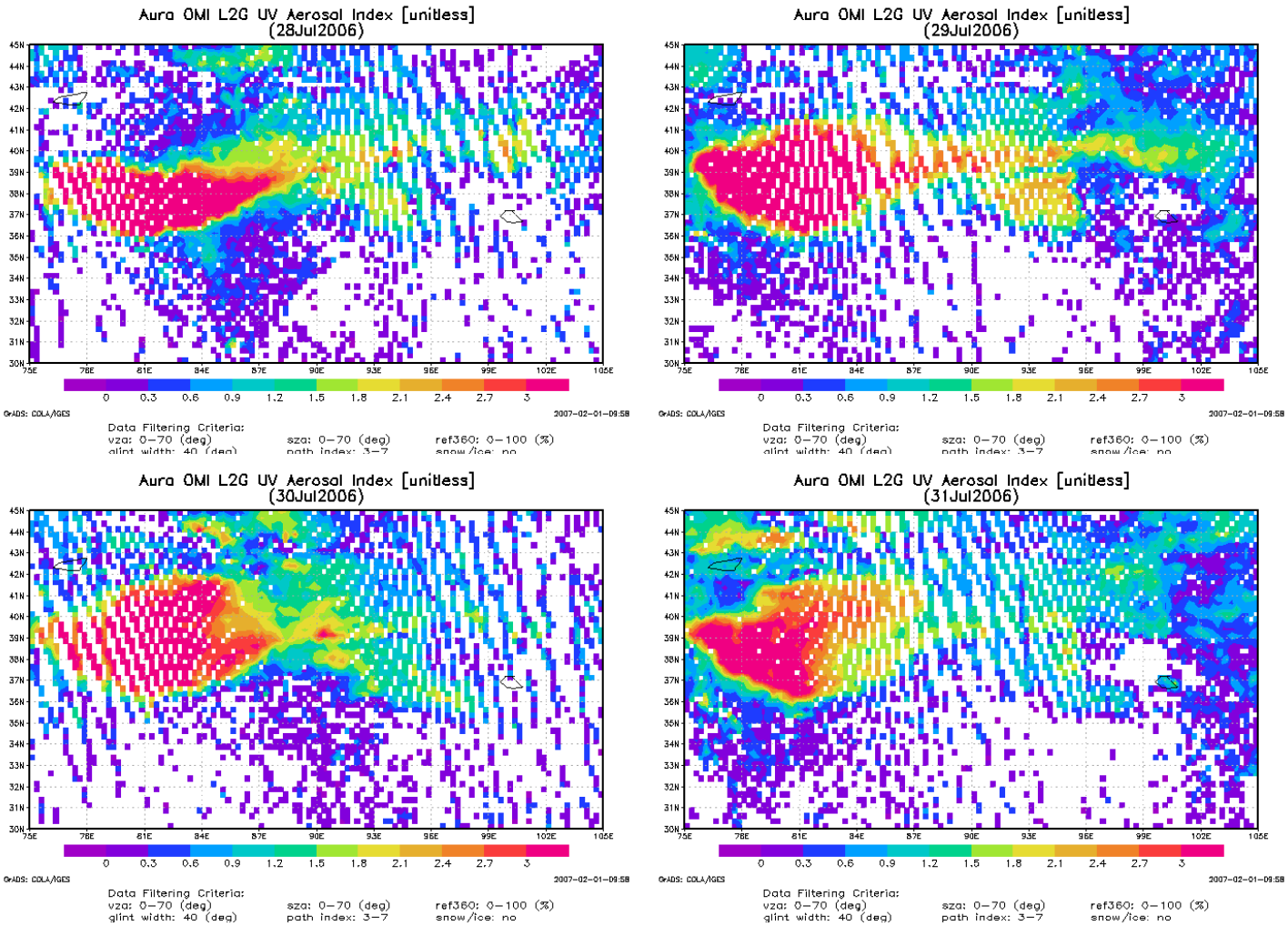
Heating Atmosphere !

Huang et al., ACP, 2010



CALIPSO 532nm backscattering intensity over Taklamkan Desert for: July24, 26, 29, 30, 31, 2006.

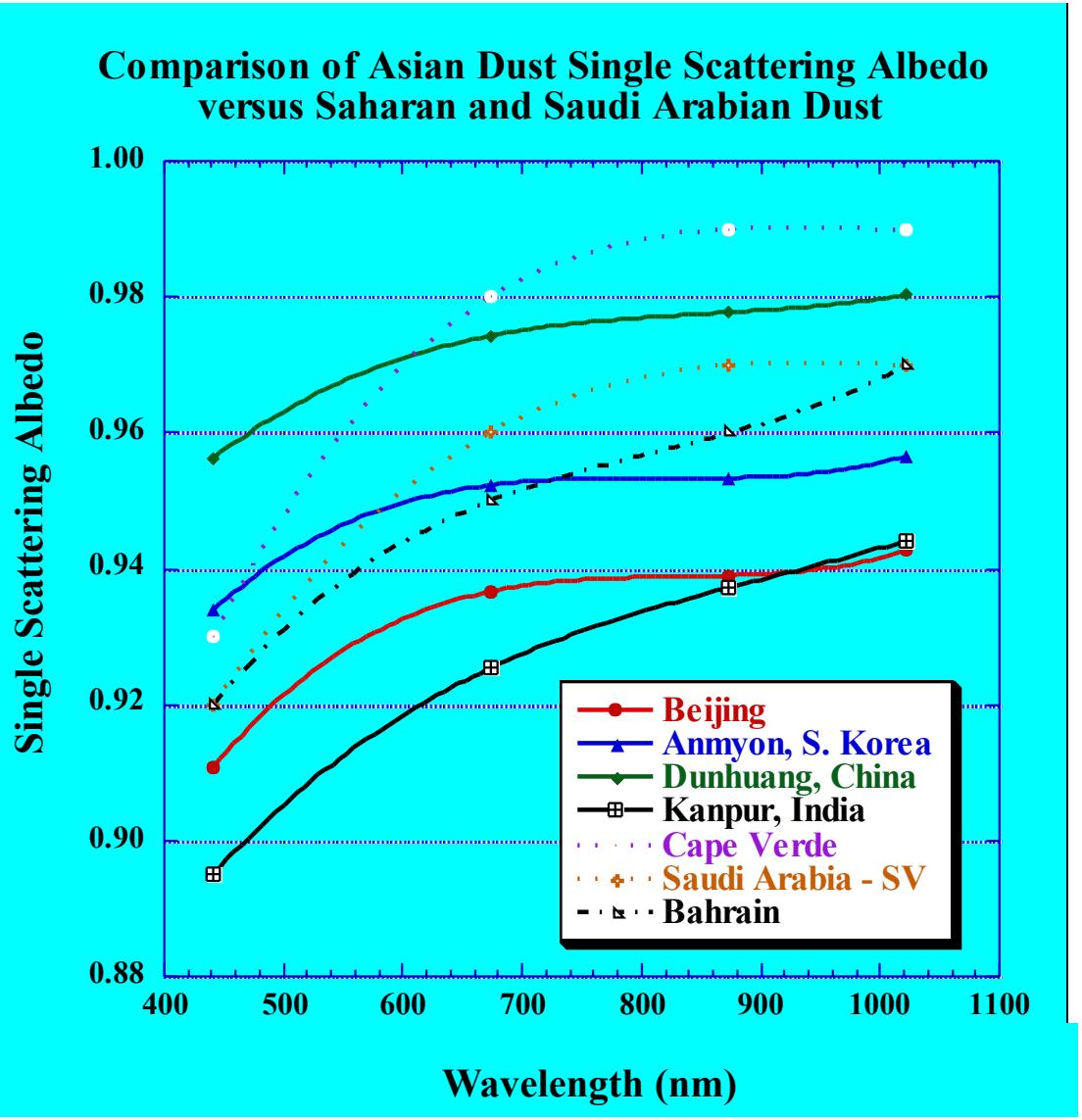
Aerosol Index derived from AURA



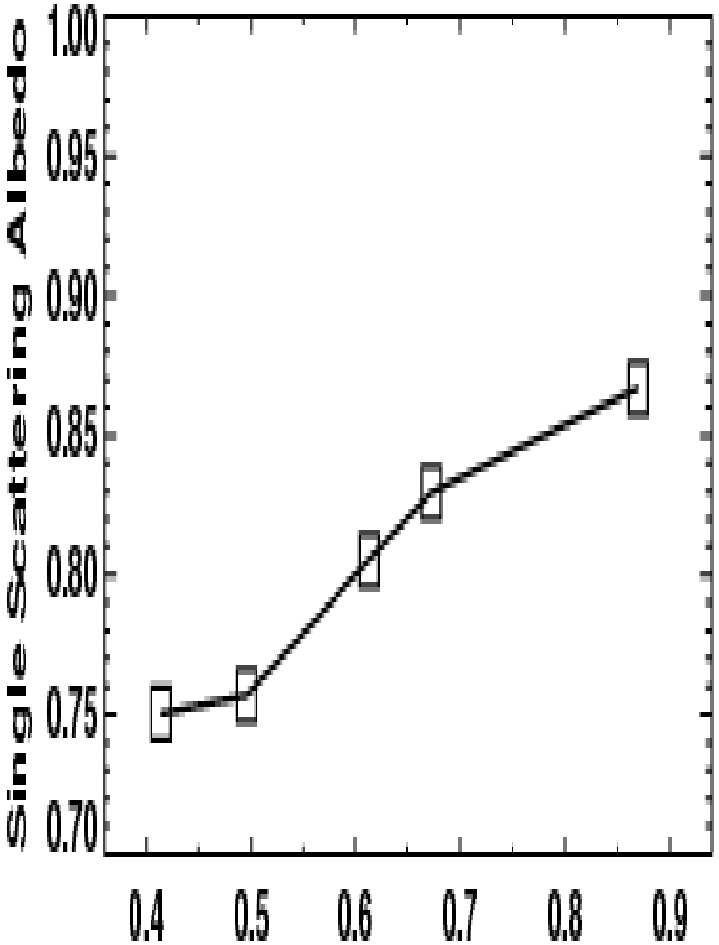
There is dust storm over Taklimakan from July 25 Aug.1, 2006

Asian Dusts are more absorbing

Ge et al., JGRL, 2010

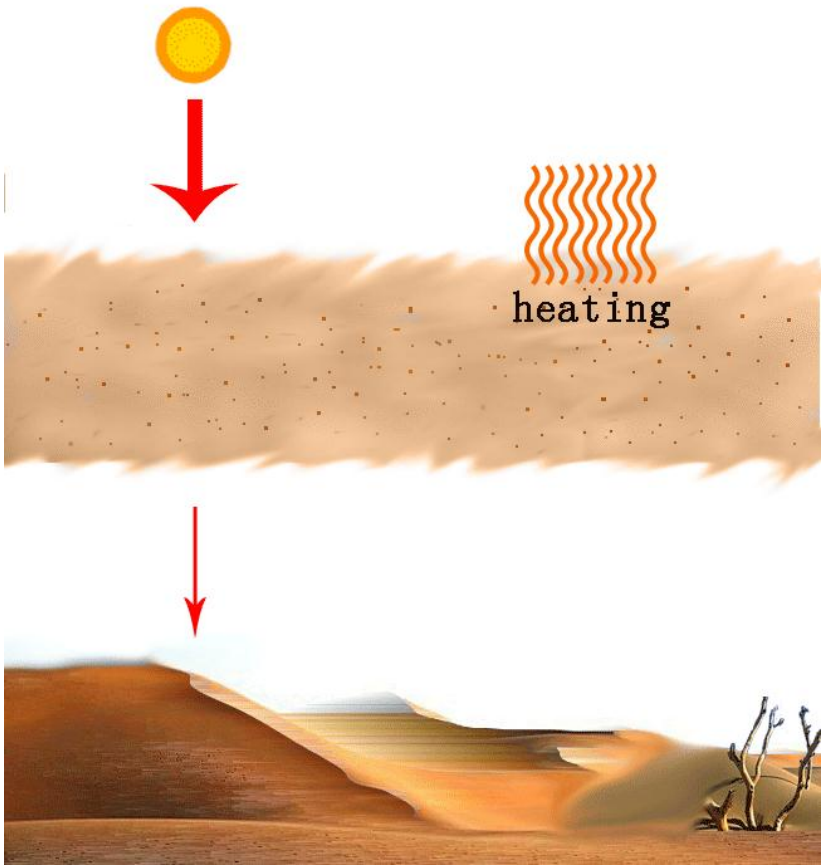


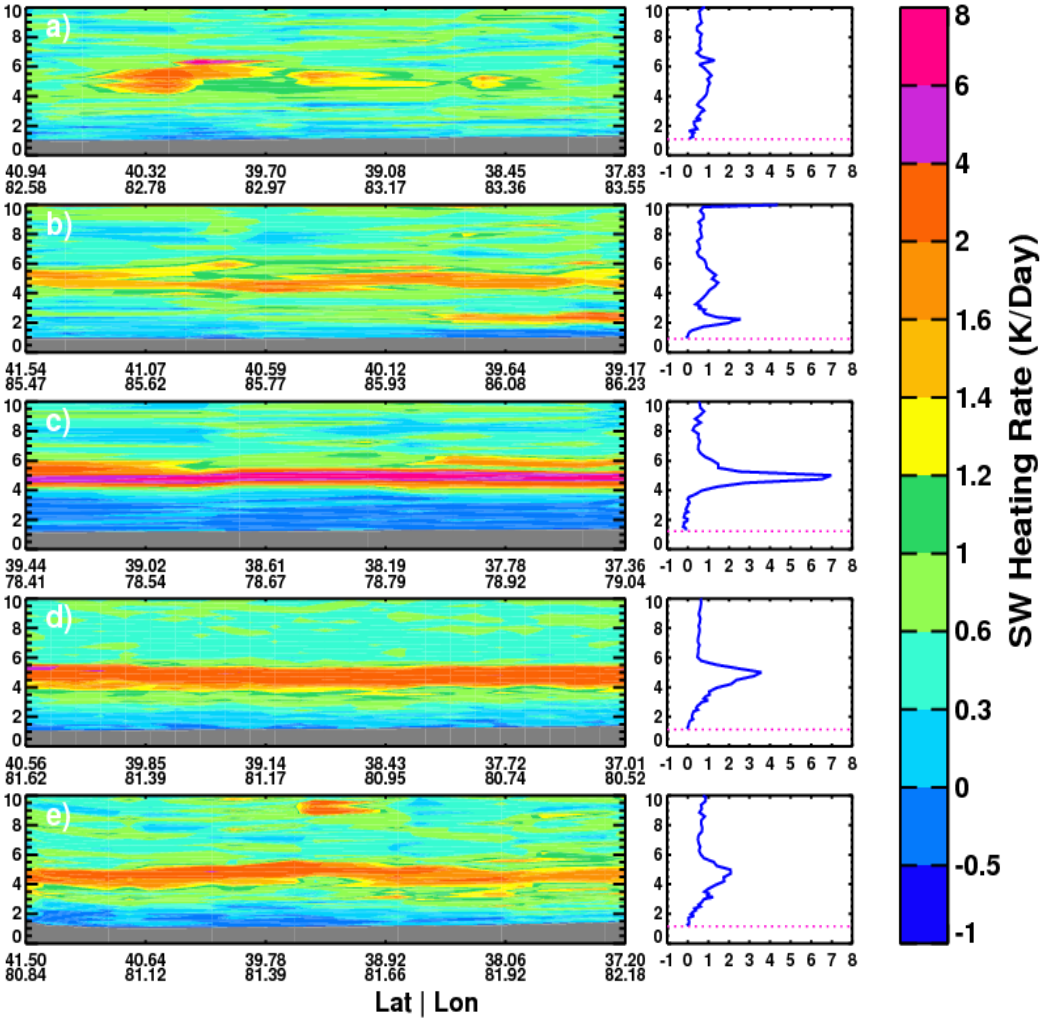
T. Eck et al 2004



Retrieved single-scattering albedo

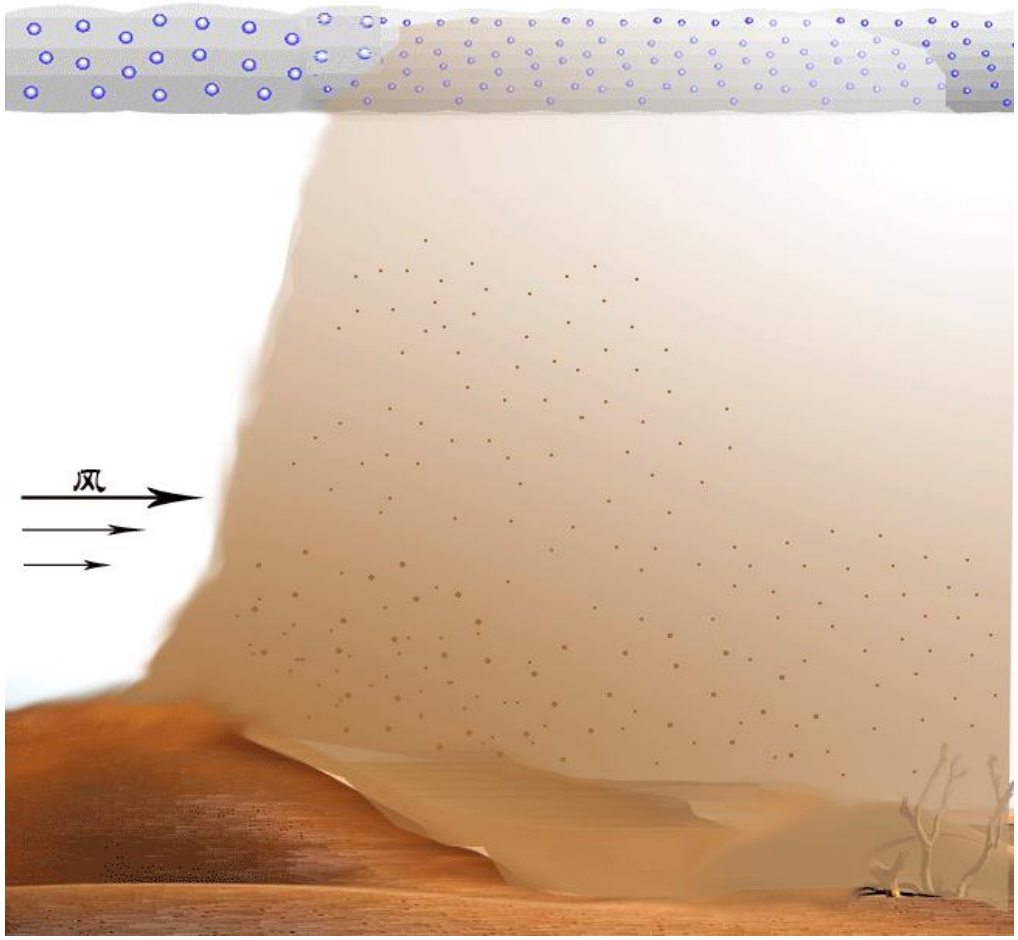
Asia dust may heat atmosphere over source region much stronger than we know before





Huang et al., ACP, 2009

Indirect aerosol effect



Higher droplet Concentration (CCN)

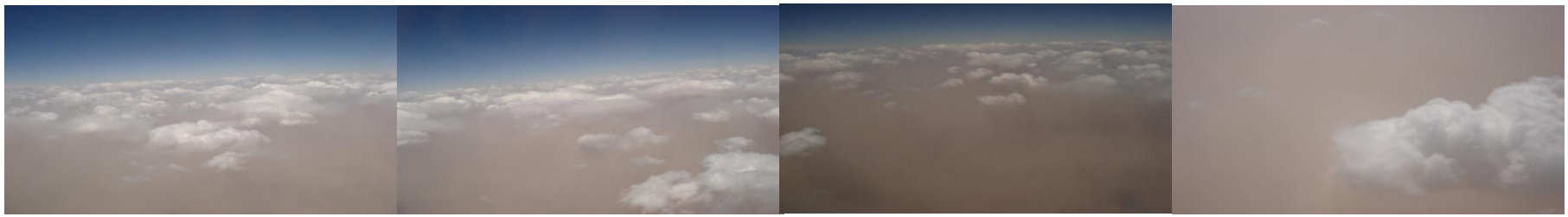
Smaller droplets

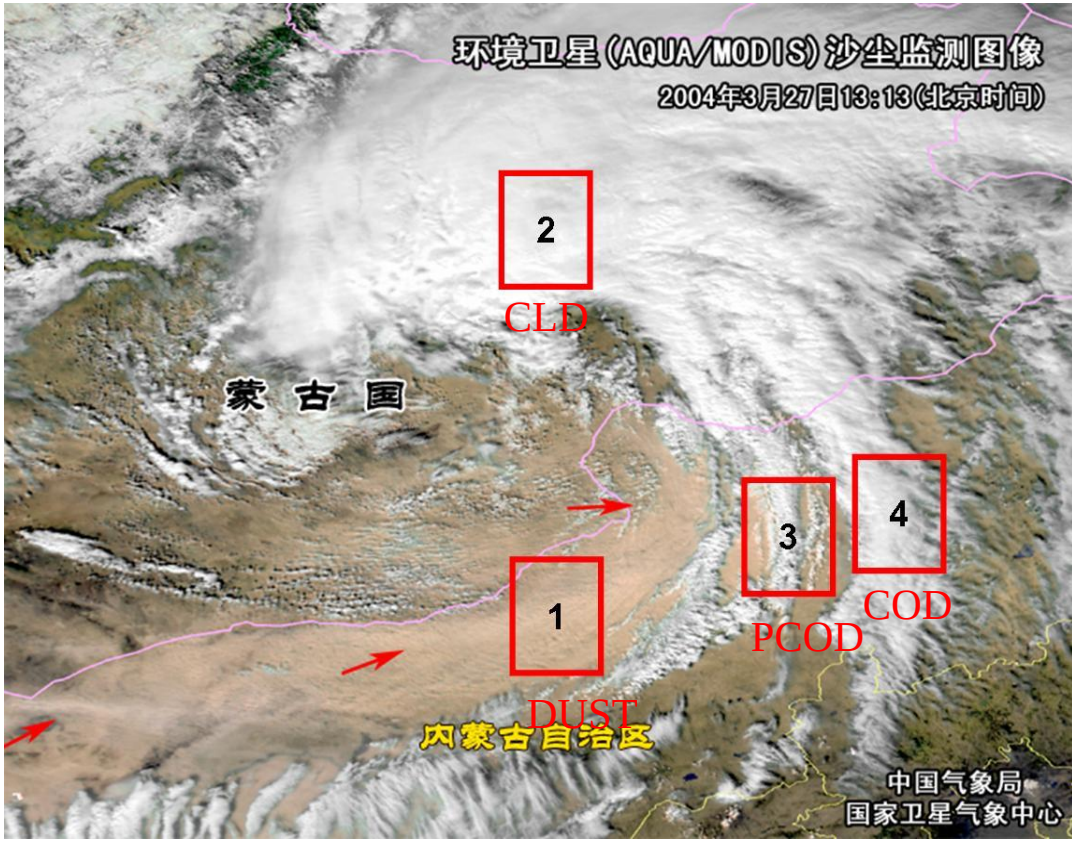
Lower Precipitation rate

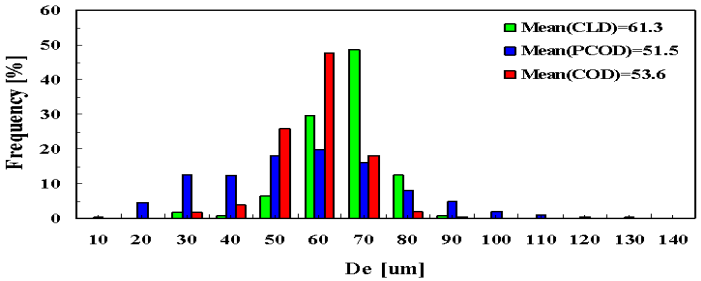
Clouds longer lived

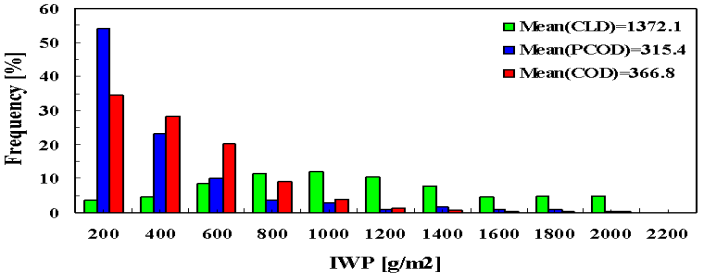
More reflective cloud (Cooler climate)

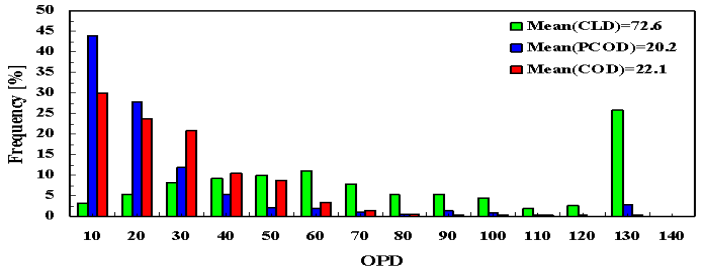
Case Study: March 27, 2004





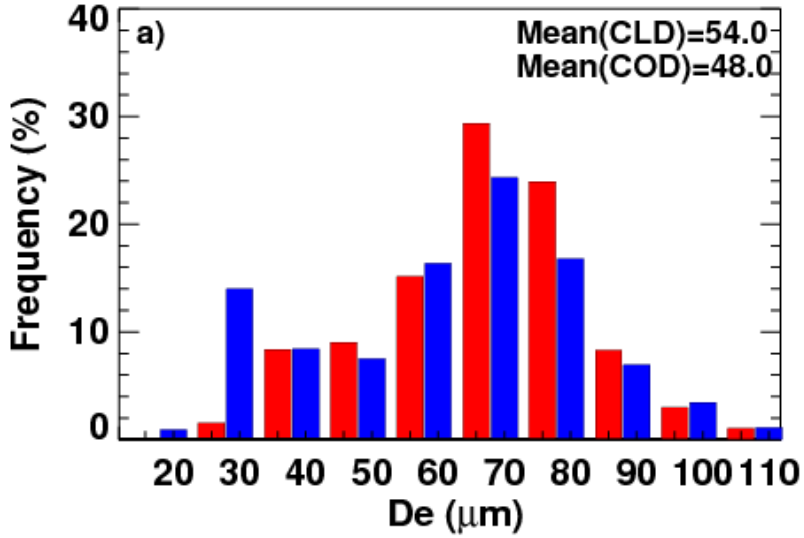


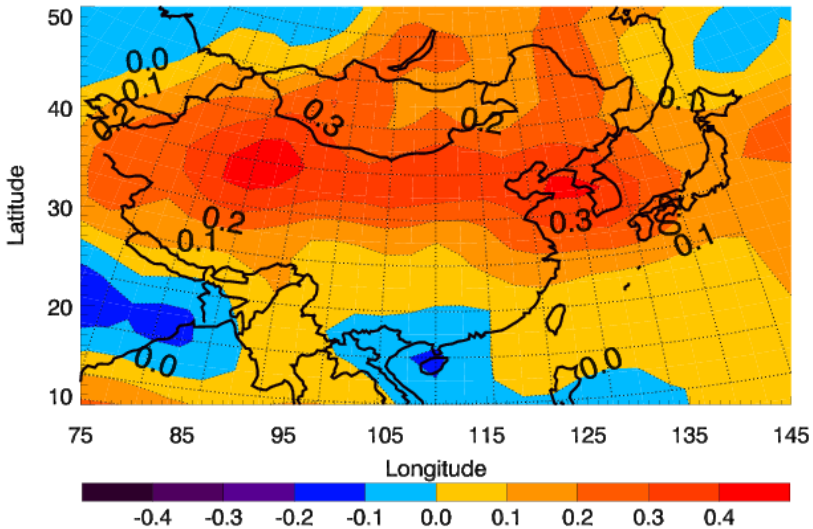




Satellite Data Analysis: Indirect Effect of Dust Aerosol

Reduce the ice diameter and increase high cloud cover
Huang et al., GRL, 2006a

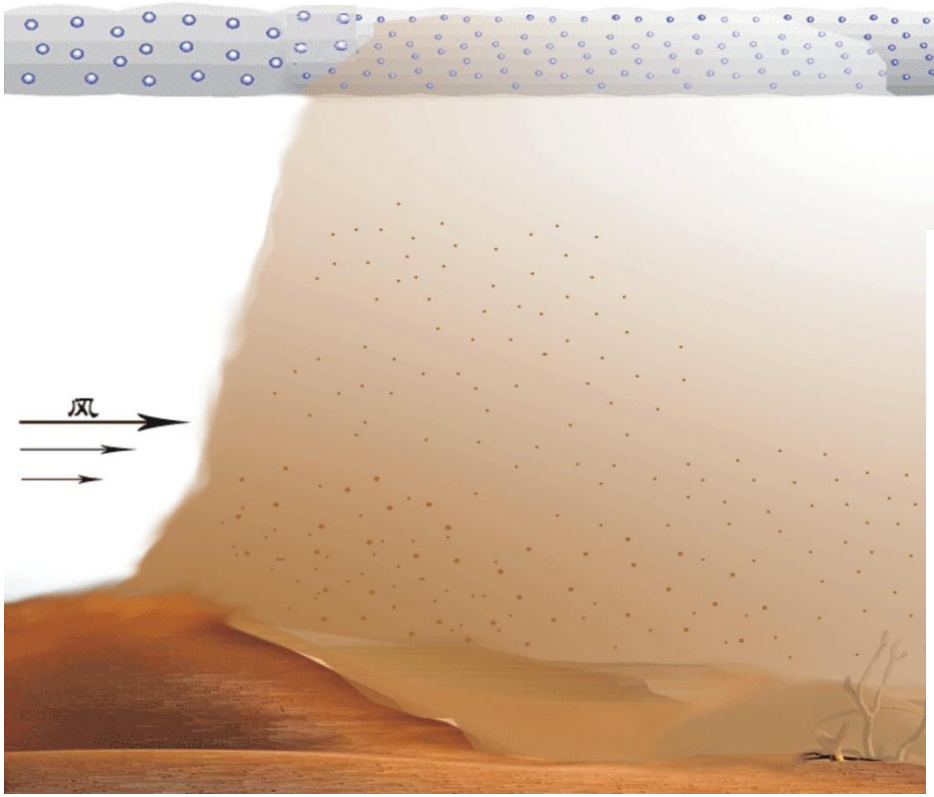


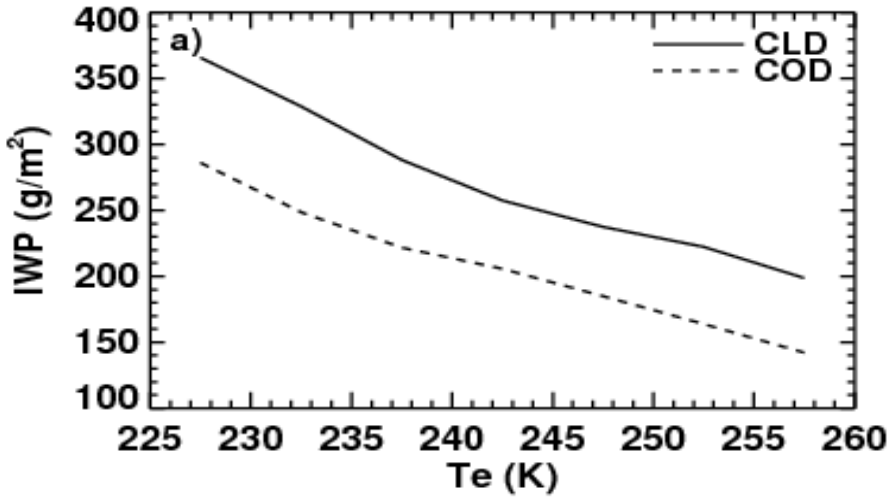


Comparison of ice cloud diameter over the dust-free cloud (CLD) and clouds over the dust (COD) region.

Correlation between Taklamagan dust storm index and ISCCP high cloud amount.

Dust indirect effect was evidenced by observation

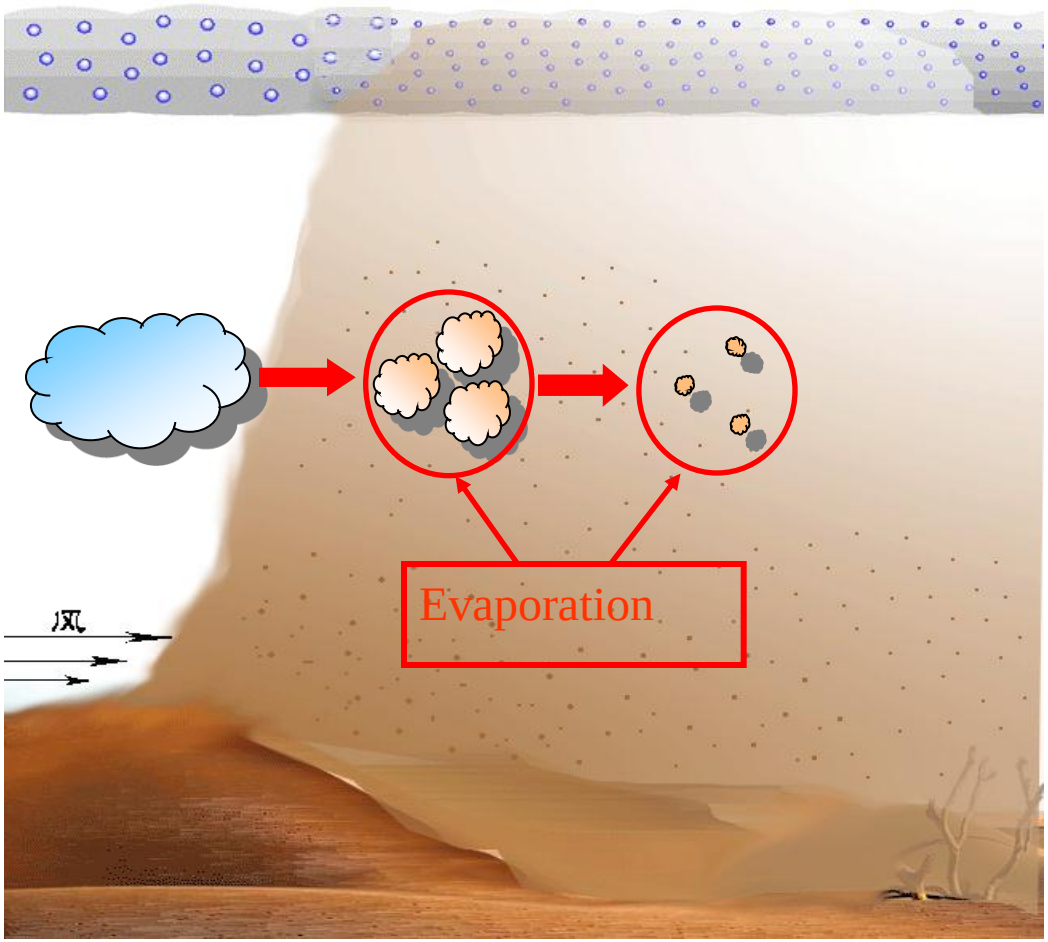




Huang et al., GRL, 2006a

Dust Aerosol, as Cloud condensation nuclei (CCN), can change cloud microphysical property, cloud fraction and cloud lifetime, thus can indirectly influence the radiation budget of the earth-atmosphere system.

The semi-direct aerosol effect



Absorb solar radiation

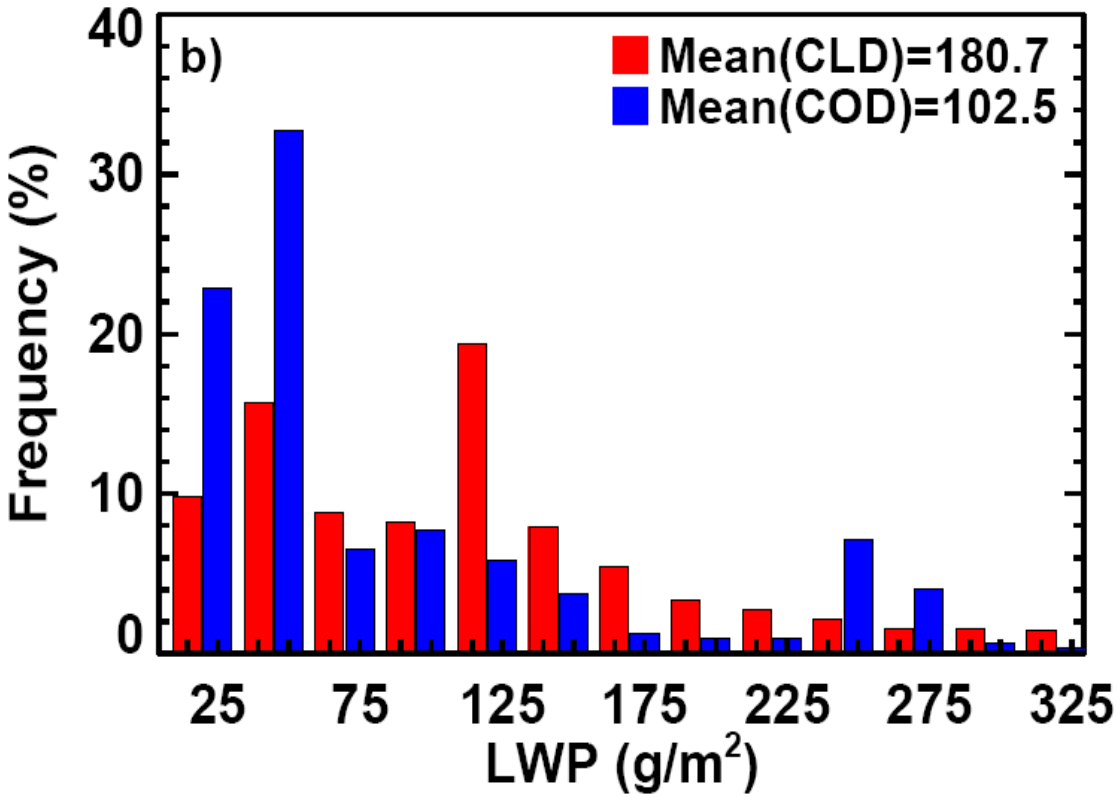
Evaporation of the cloud!

•Reduce low cloud cover

•Warm the climate as low clouds scatter solar radiation back to space.

Semi-Direct Effect of Dust Aerosol

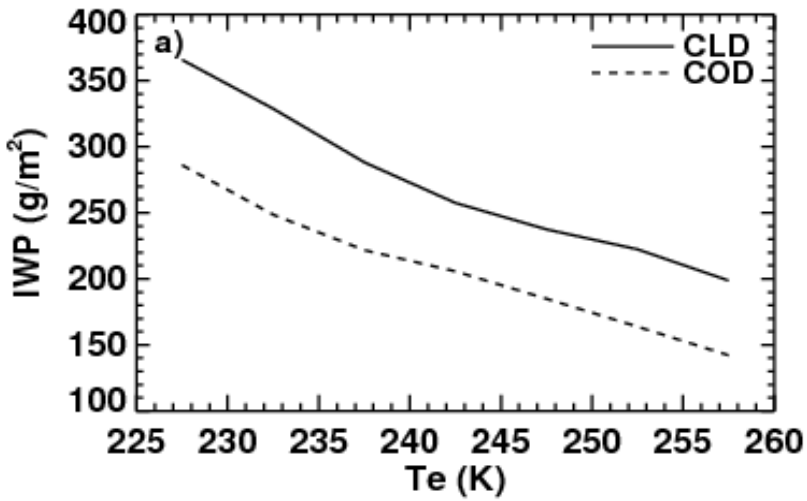
Reduce low cloud water Path
Huang et al., GRL, 2006b

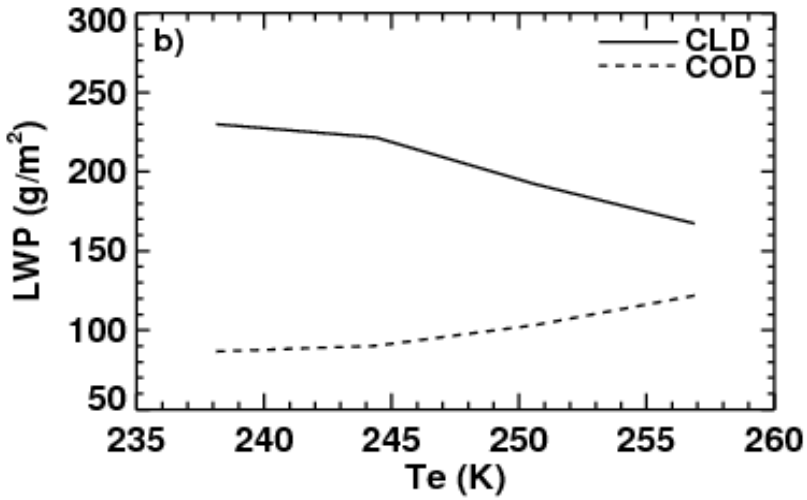


Comparison of low cloud water path over the dust-free cloud (CLD) and clouds over the dust (COD) region.

Semi-Direct Effect of Dust Aerosol

Reduce low cloud water Path
Huang et al., GRL, 2006b

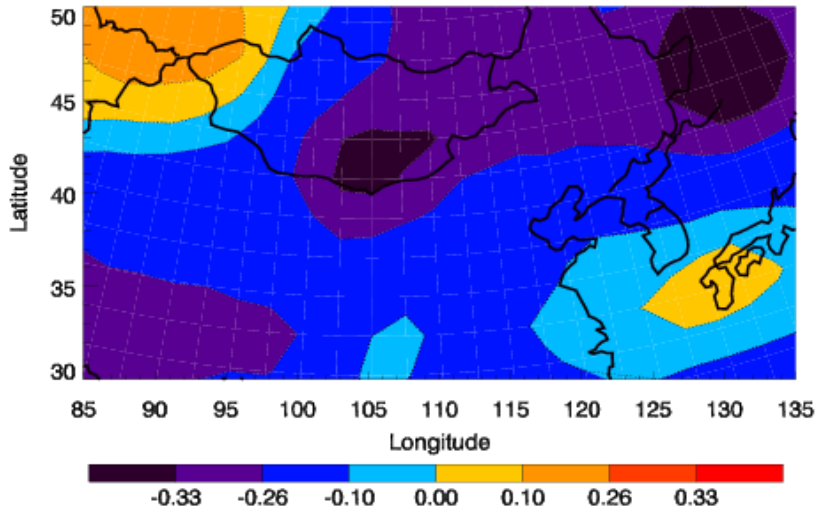




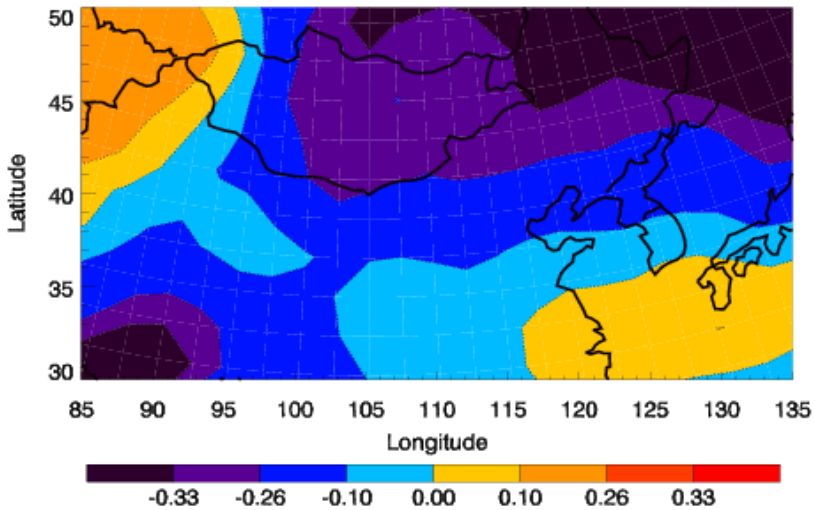
Comparison of the cloud water path for dust-free with cloud over dust region as a function of effective cloud top temperature *Te*
for (a) IWP, (b) LWP.

Semi-Direct Effect of Dust Aerosol

Reduce low cloud water Path
Huang et al., GRL, 2006b

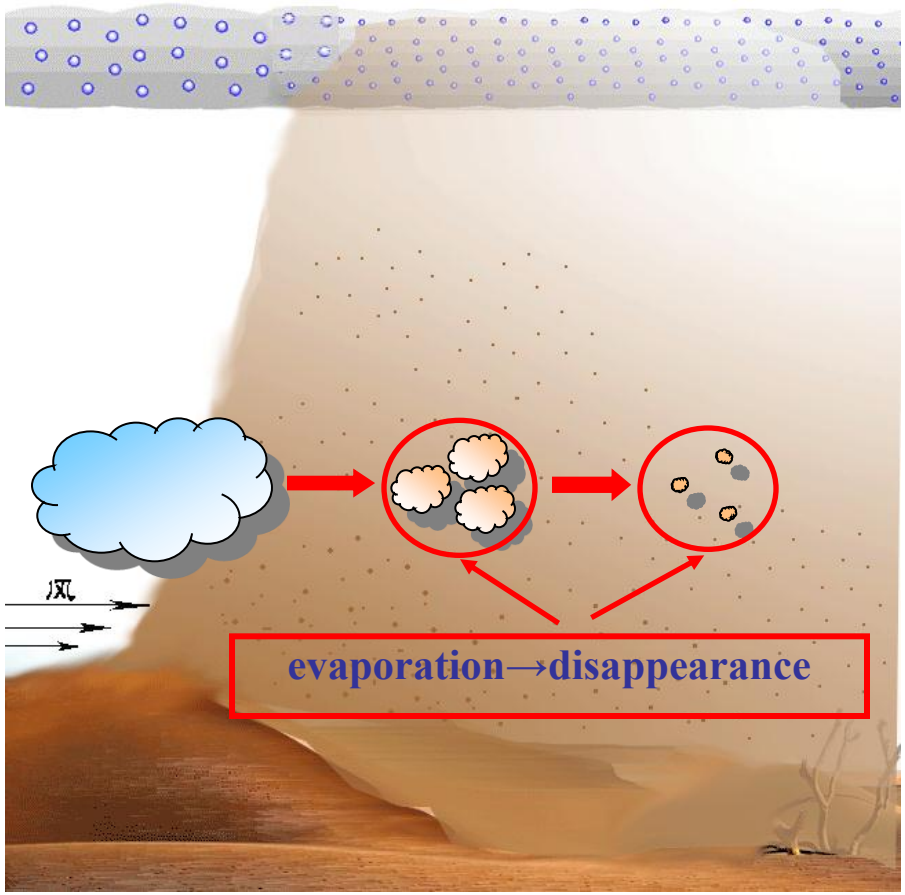


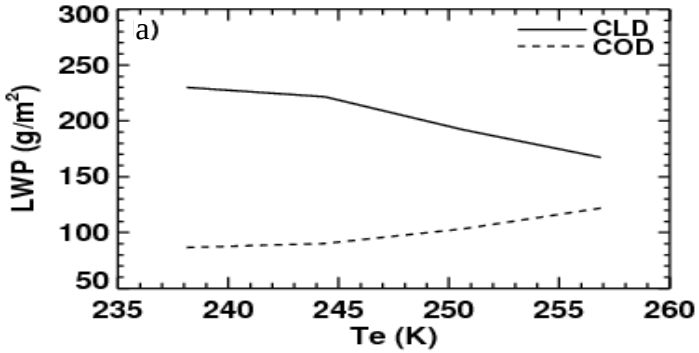
Correlation between dust storm index & ISCCP cloud optical depth.

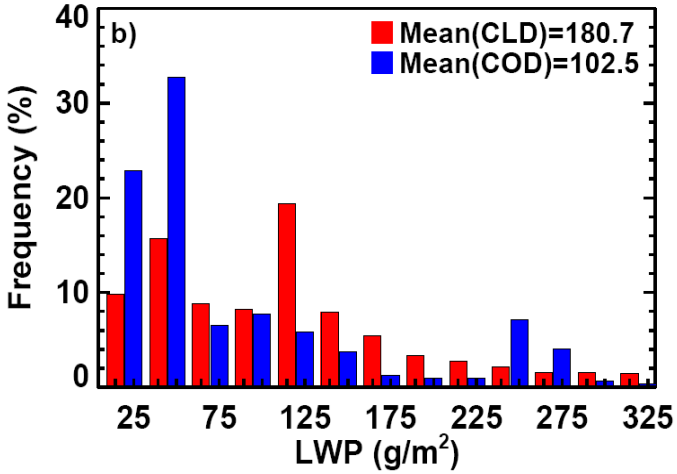


Correlation between dust storm index and ISCCP low cloud total water path

Semi-direct effect may contribute to arid climate



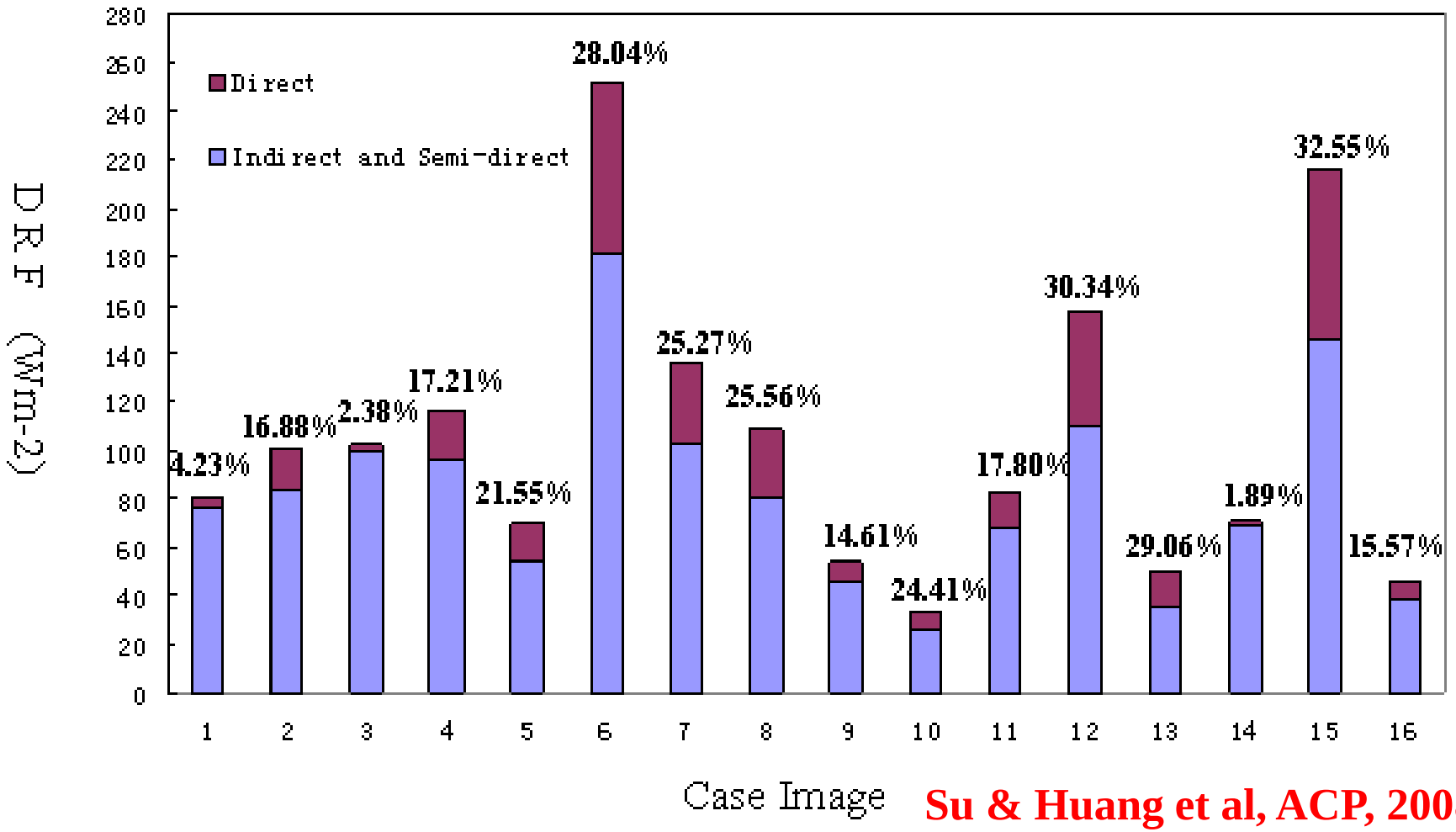




Huang et al., GRL, 2006b

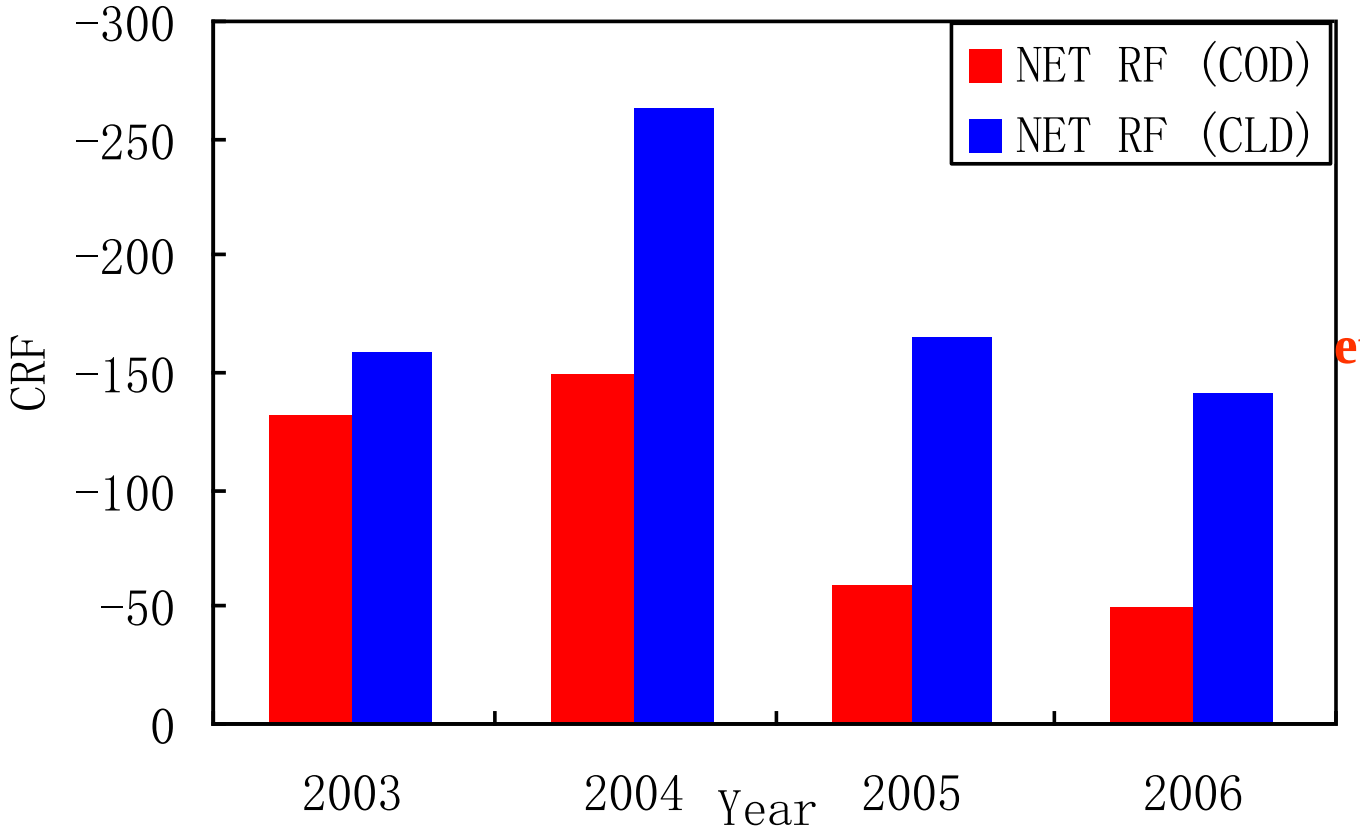
Dust Aerosols' semi-direct effect can increase droplet evaporation, reduce liquid water path by 49.8%, lead to less precipitation.

81% dusty cloud warming effect is contributed by indirect/semi-direct effect, 19% from direct effect



Su & Huang et al, ACP, 2008

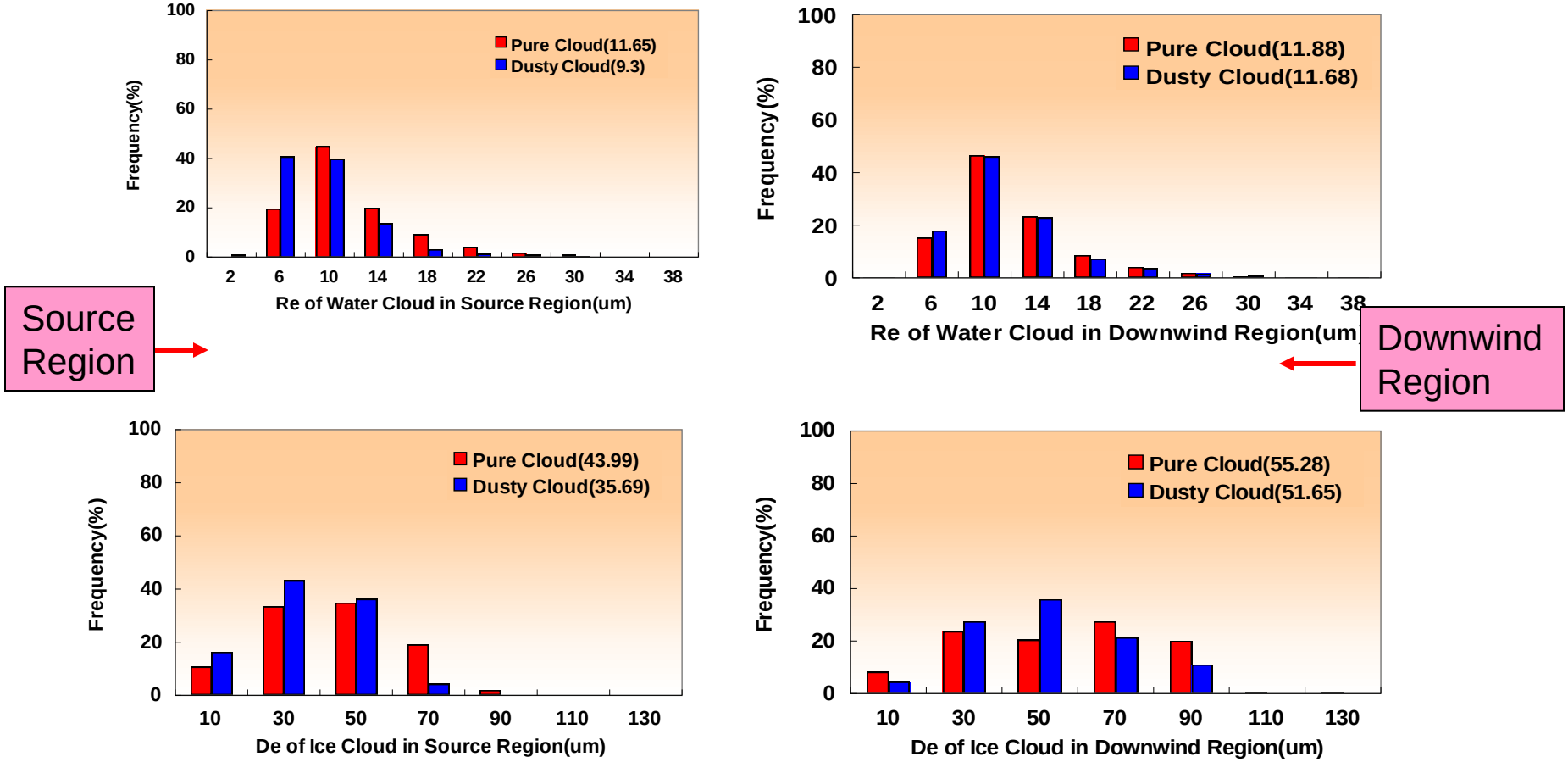
Dusty cloud reduced net TOA cloud cooling effect by 40% and may lead to warm atmosphere.



Su & Huang et al, ACP, 2008

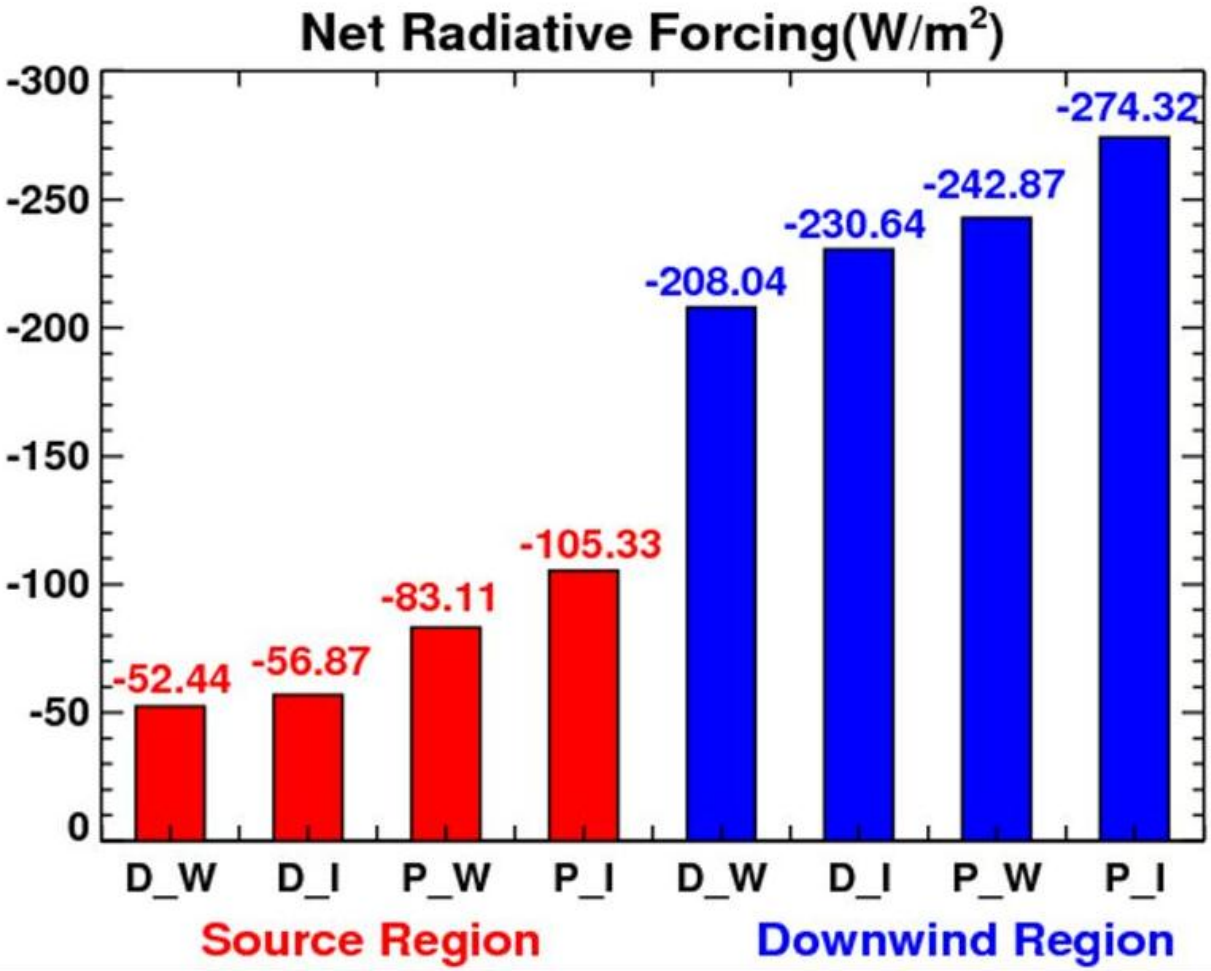
Comparison of the annual mean net radiative forcing at the TOA.

Dust aerosol reduce cloud particle size in both source & downwind region but much significant in source region



Wang & Huang et al., JGR, 2010

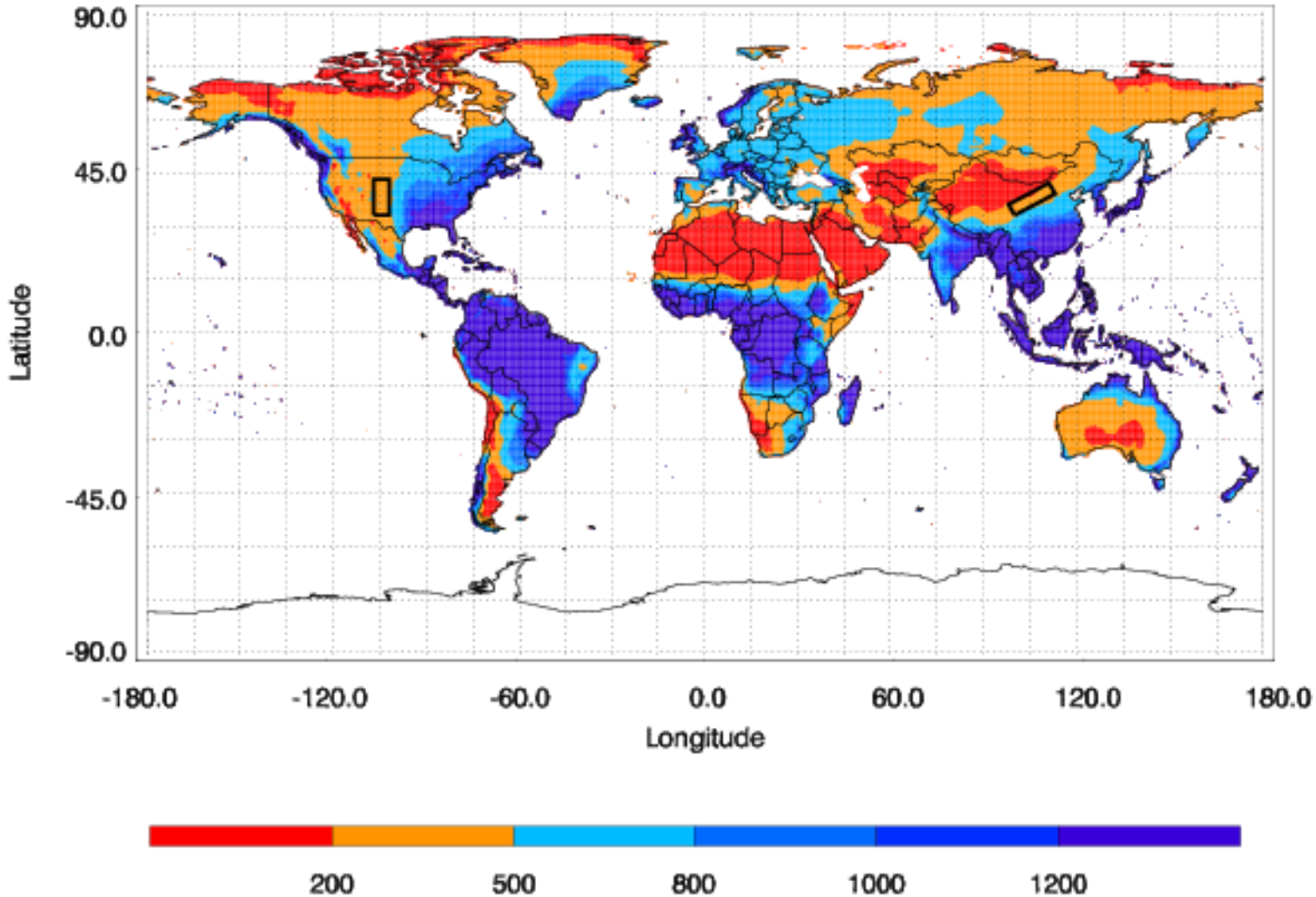
Dusty cloud reduce net TOA cloud cooling effect in both source & downwind region but much significant in source region



D— Dusty
P — Pure

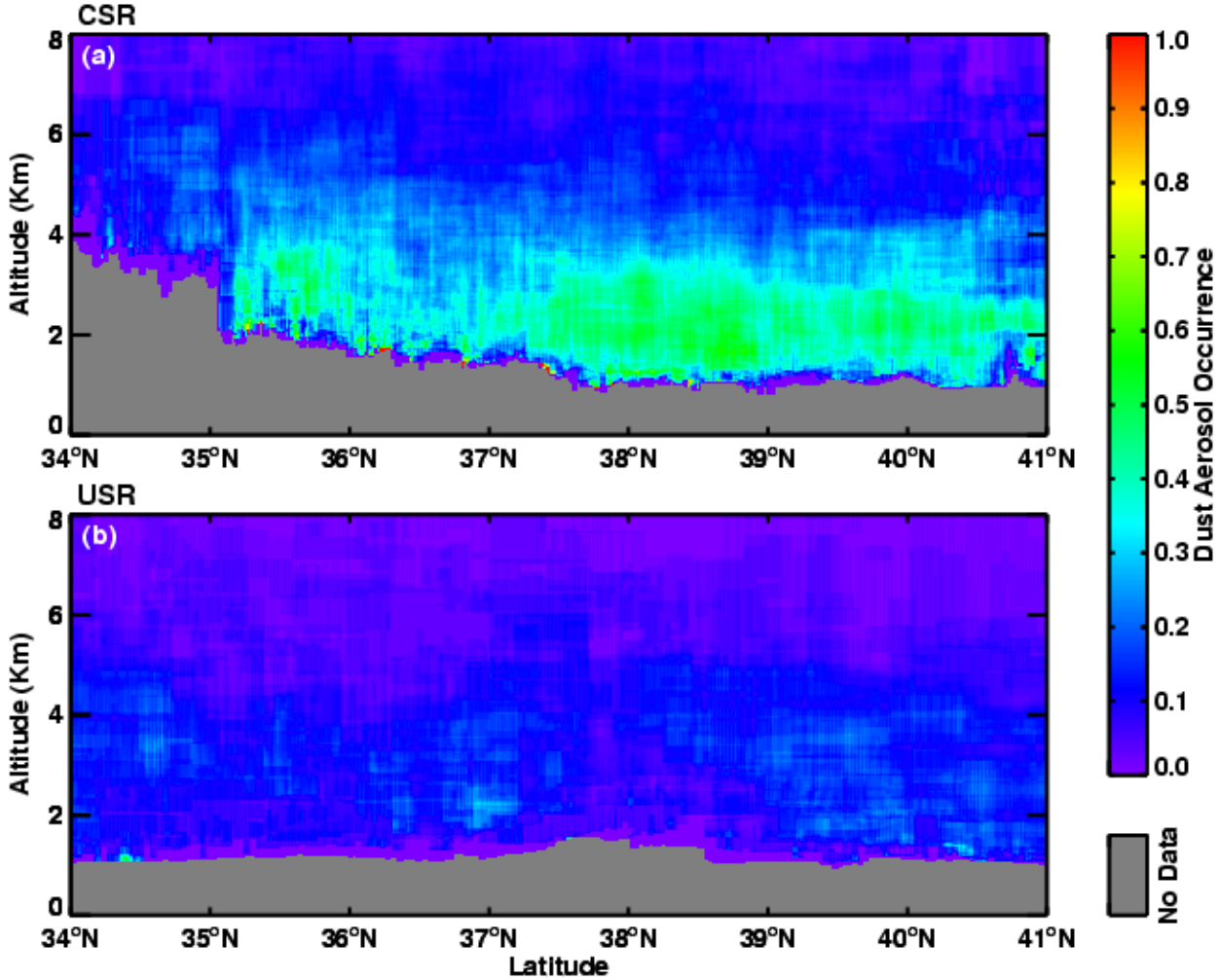
W — Water
I — Ice

Wang & Huang et al., JGR, 2010



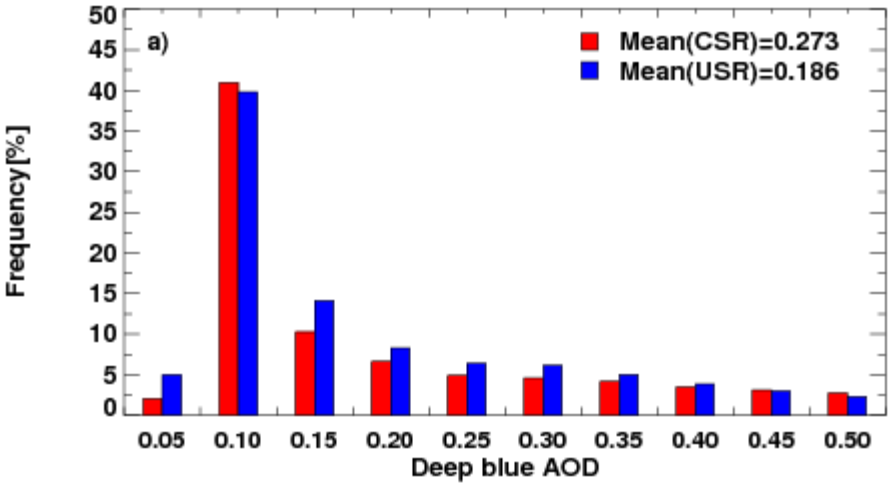
Global precipitation distribution. The black rectangles denote the semi-arid regions over China (CSR) and over the USA (USR)

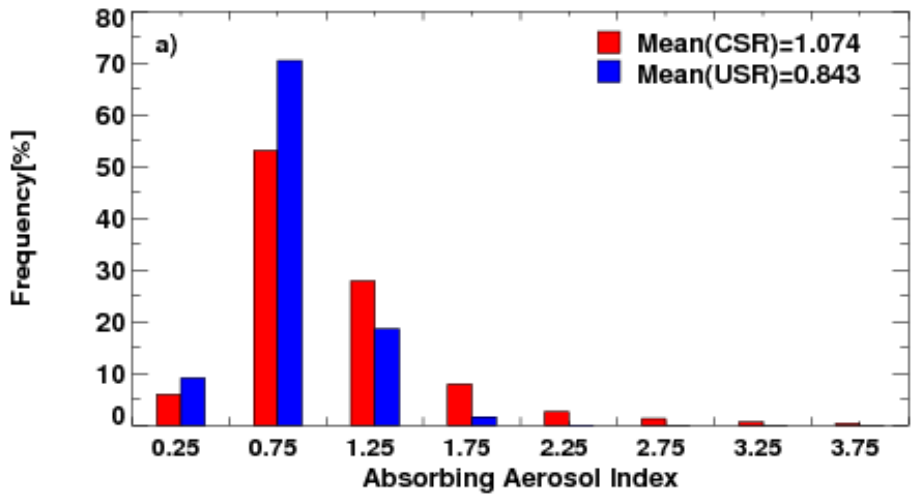
Huang et al., ACP, 2010

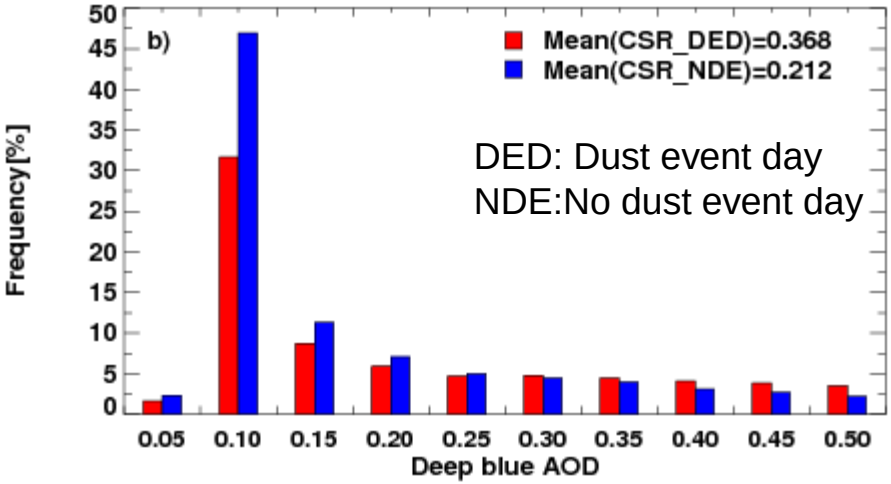


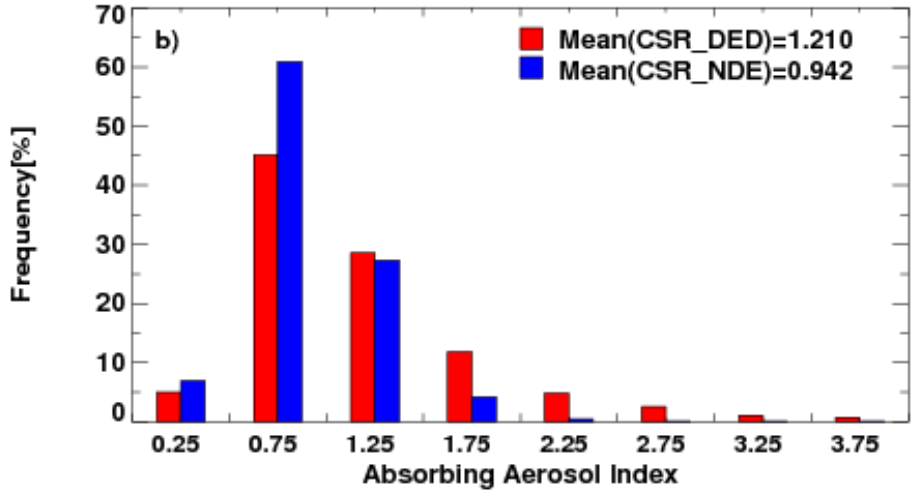
Comparison of vertical structure of dust aerosol occurrence from CALIPSO over (a) China Semi-arid Region (CSR) and (b) US Semi-Arid Region (USR)

Huang et al., ACP, 2010



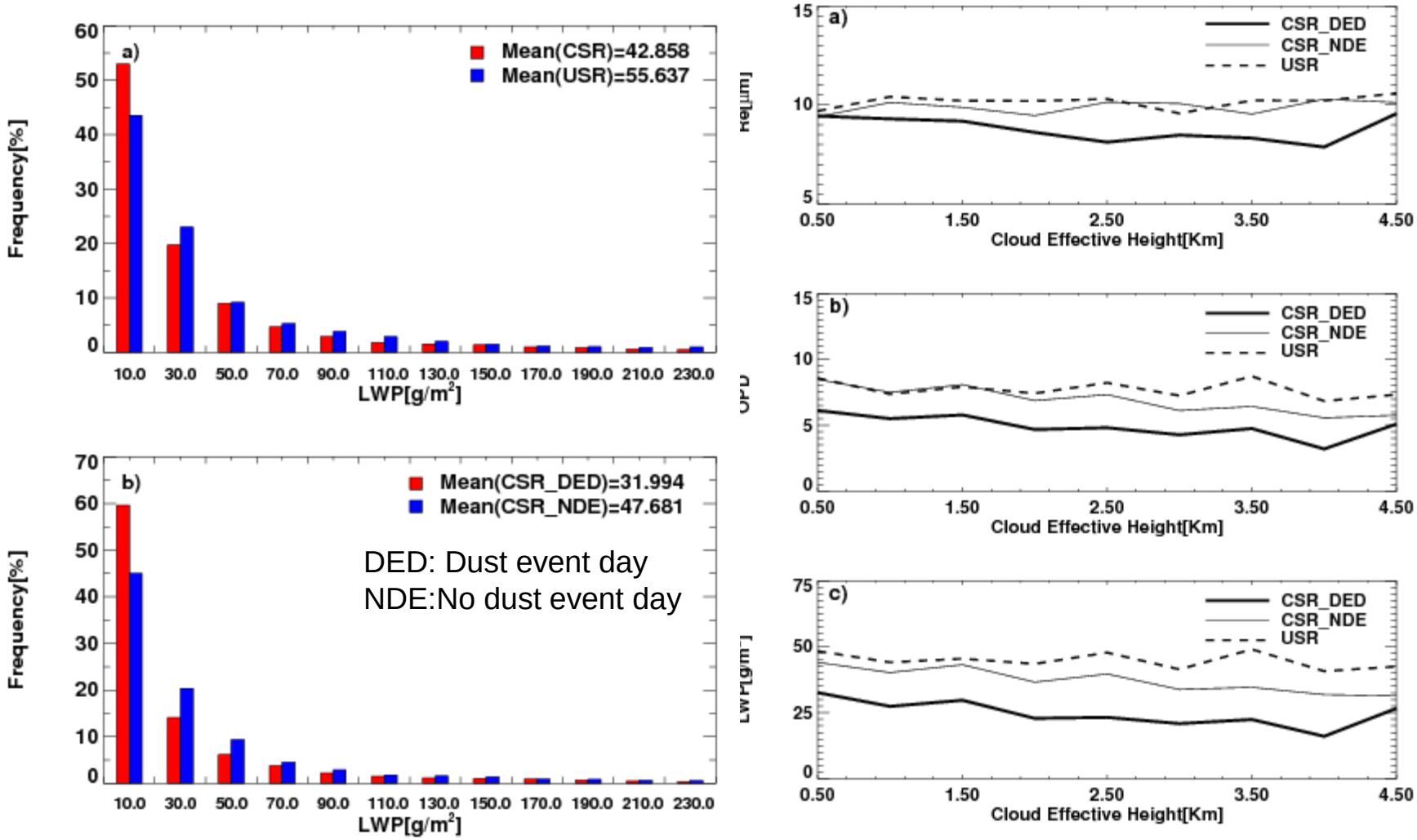






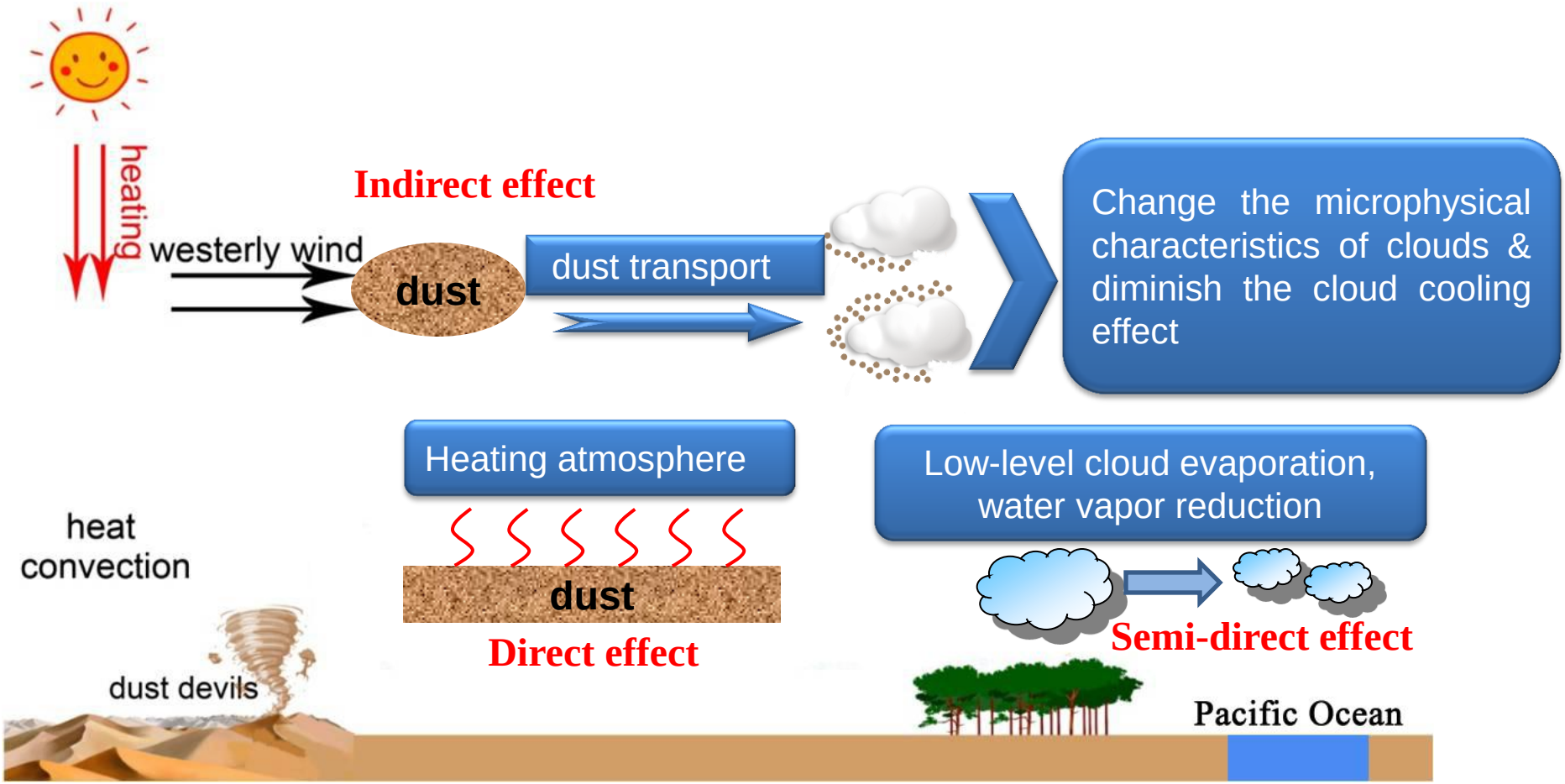
Comparison of aerosol optical depth (left) and absorbing aerosol index (right) over China Semi-arid Region (CSR) and US Semi-Arid Region (USR)

Huang et al., ACP, 2010

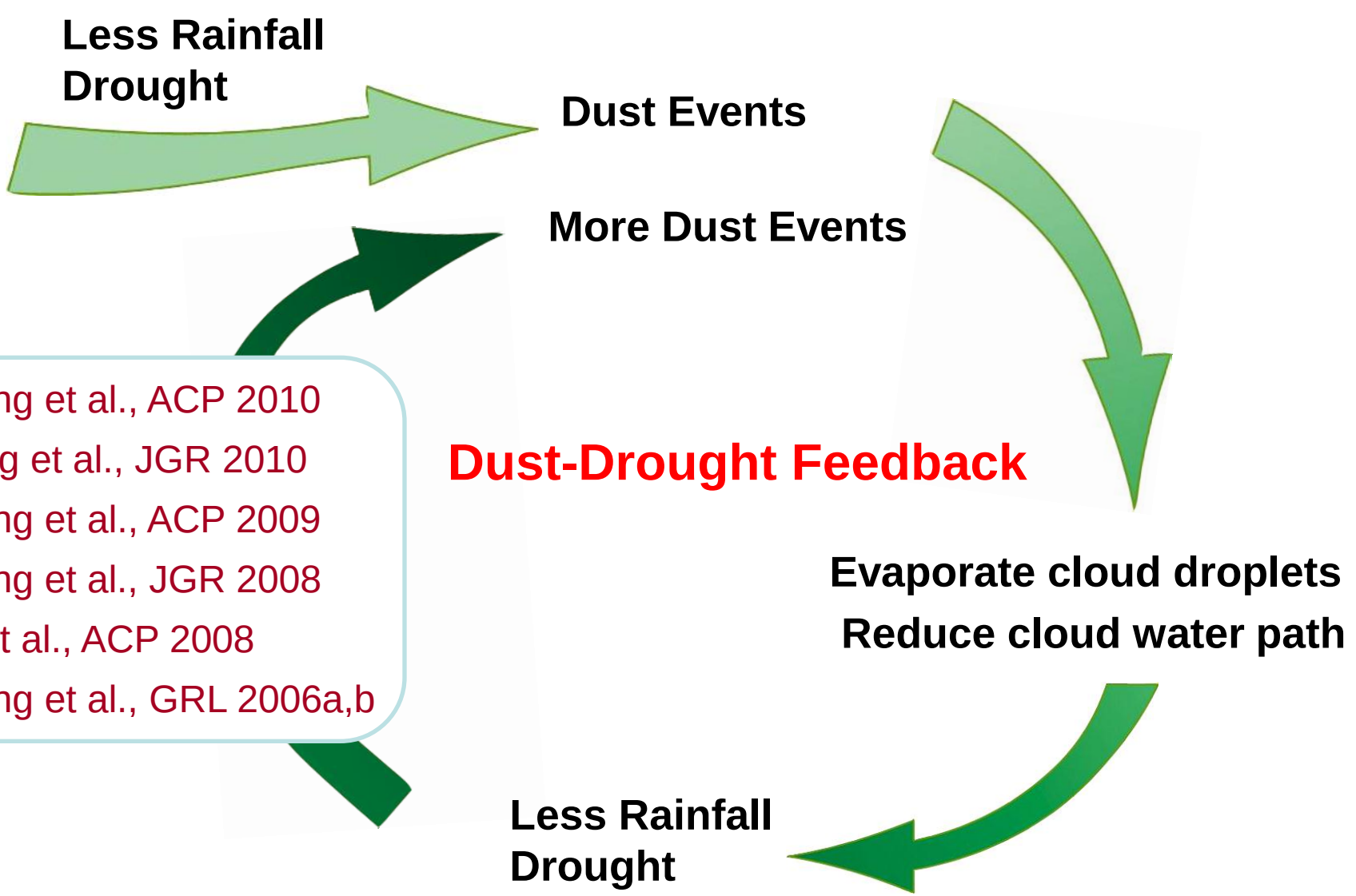


Comparison of cloud properties over China Semi-arid Region (CSR) and US Semi-Arid Region (USR)

Dust aerosols effect on cloud



Summery and Discussion



Huang et al., ACP 2010
Wang et al., JGR 2010
Huang et al., ACP 2009
Huang et al., JGR 2008
Su et al., ACP 2008
Huang et al., GRL 2006a,b

Summery and Discussion:

- The absorption of Asian dust aerosol can cause:

  heating atmosphere

  evaporate cloud droplets

  reduce cloud water path and optical depth

  reduce cloud-cooling effect

  lead to warm local climate

  lower precipitation rate

- More field cloud/aerosol observation need to understand the their effect on climate and hydrological cycle.

Thank you for your attention!