Long-term measurements of solar radiation and aerosol radiative effect at Mt. Lulin (2,862m) in East Asia

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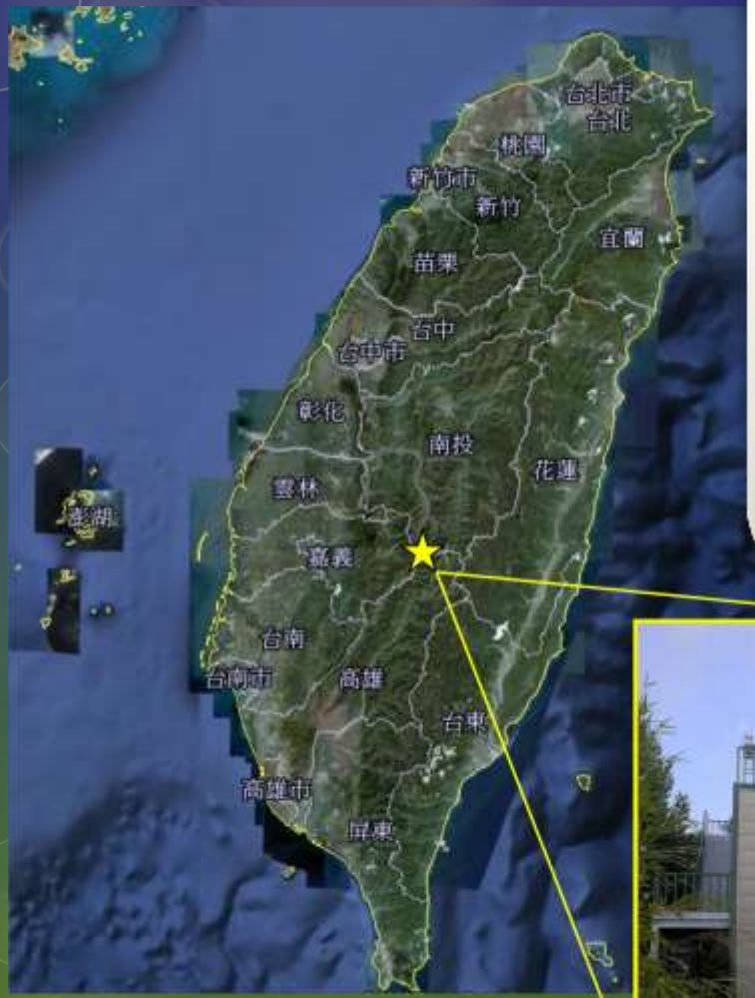
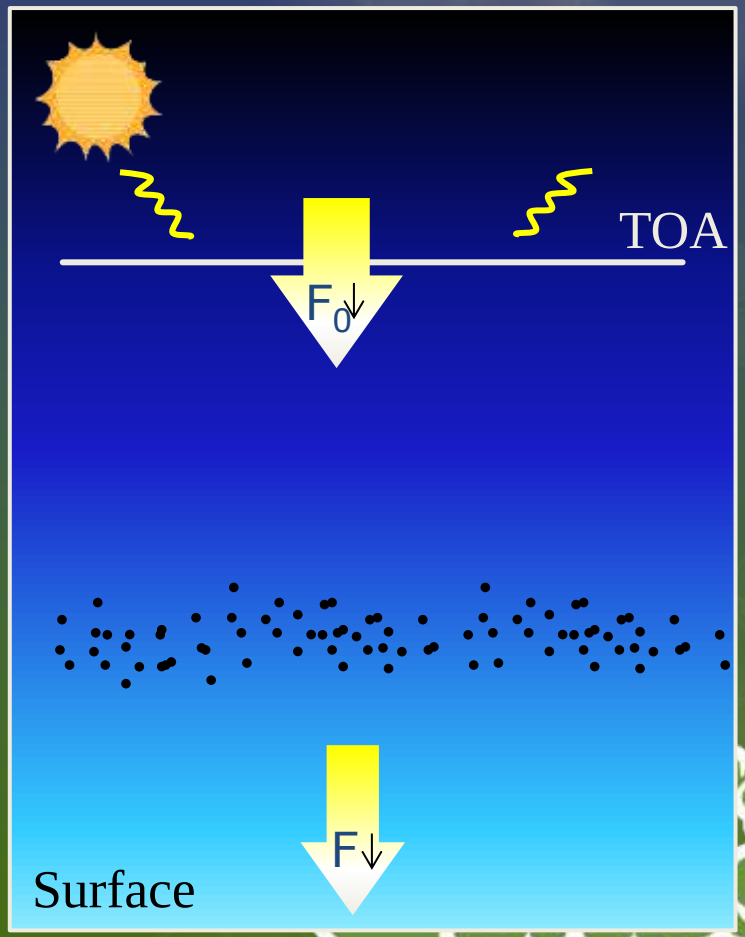


(23.47° N, 120.87° E, 2862m)

Motivation

- **How well we can estimate the direct aerosol radiative effect (DARE) based on surface measurement?**

- There are several reasons driving me to carry out this study:
  - investing an observational approach for estimating DARE
  - the DARE above PBL
  - Minimize "surface albedo" effect in DARE estimation
  - Future application for worldwide flux radiation measurements



Objectives

- This study was performed to estimate the DARE at Mt. Lulin by integrating measurements (i.e., SW broadband and AERONET sunphotometer) and a radiative transfer model (i.e., libRadtran).
- To understand the discrepancy between model simulation and observation for SW irradiances.

Methodology

Cloud

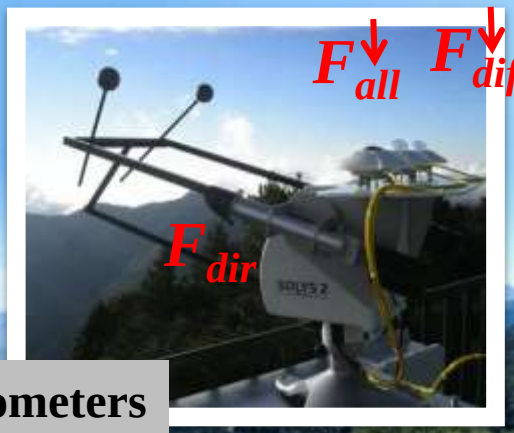
scattering

Solar radiation

Aerosol

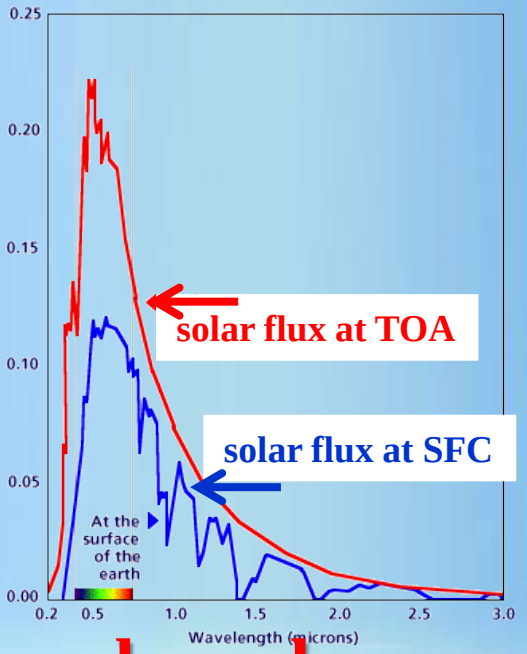
$\tau(\lambda)$, $w_0(\lambda)$, $g(\lambda)$

Sun photometer



radiometers

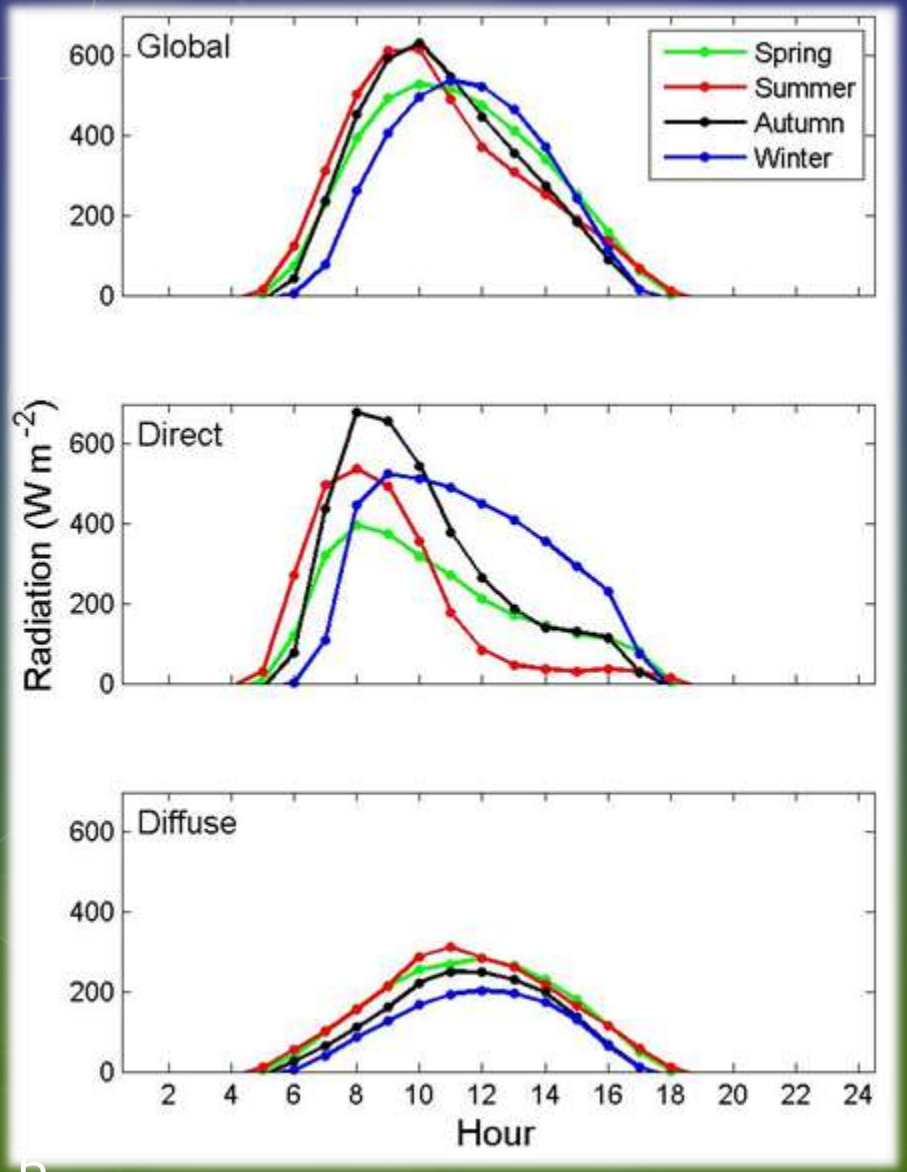
libRadtran model

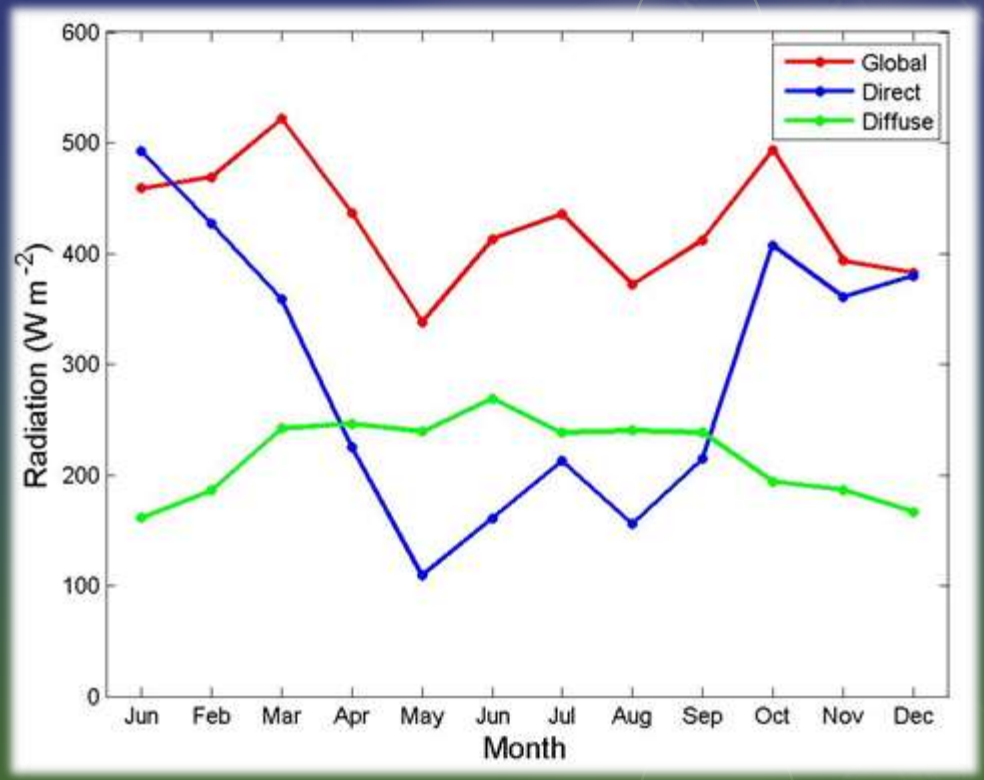


clear-sky

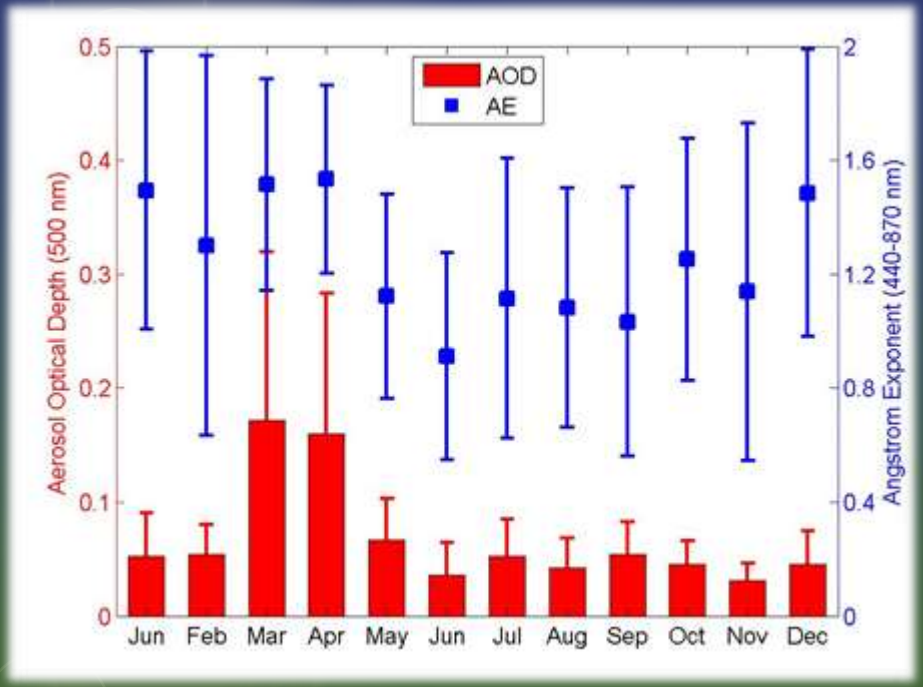
Aerosol **No aerosol**

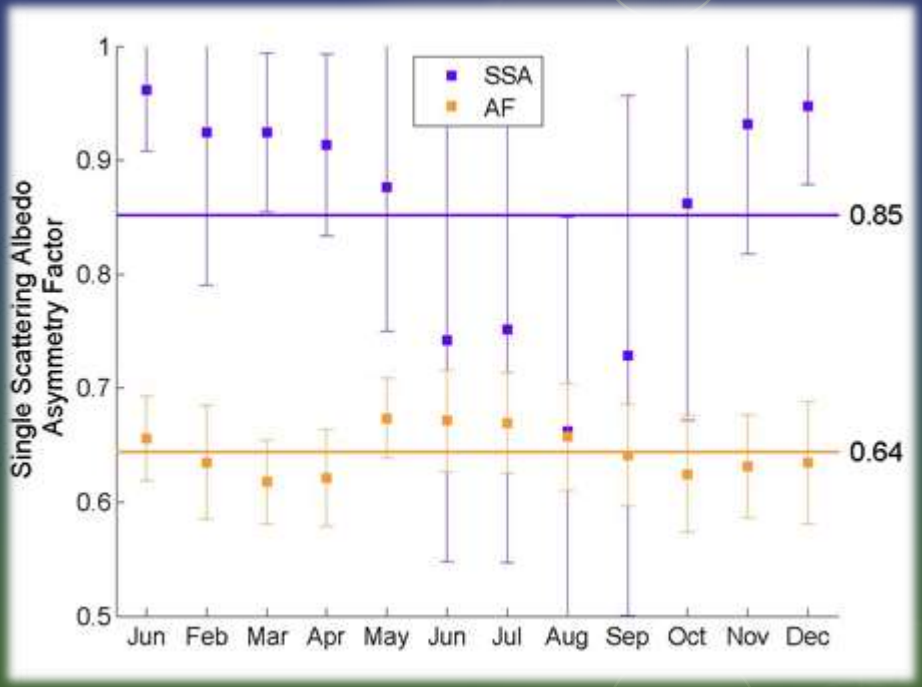
Long-term solar radiation (2010-2014)



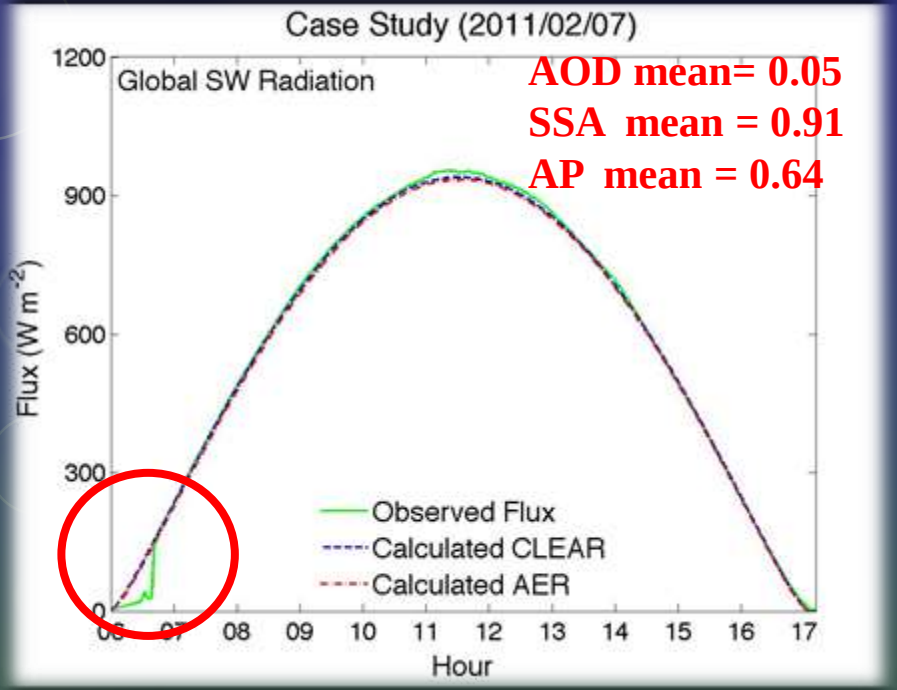


Long-term aerosol optical properties (2010-2014)

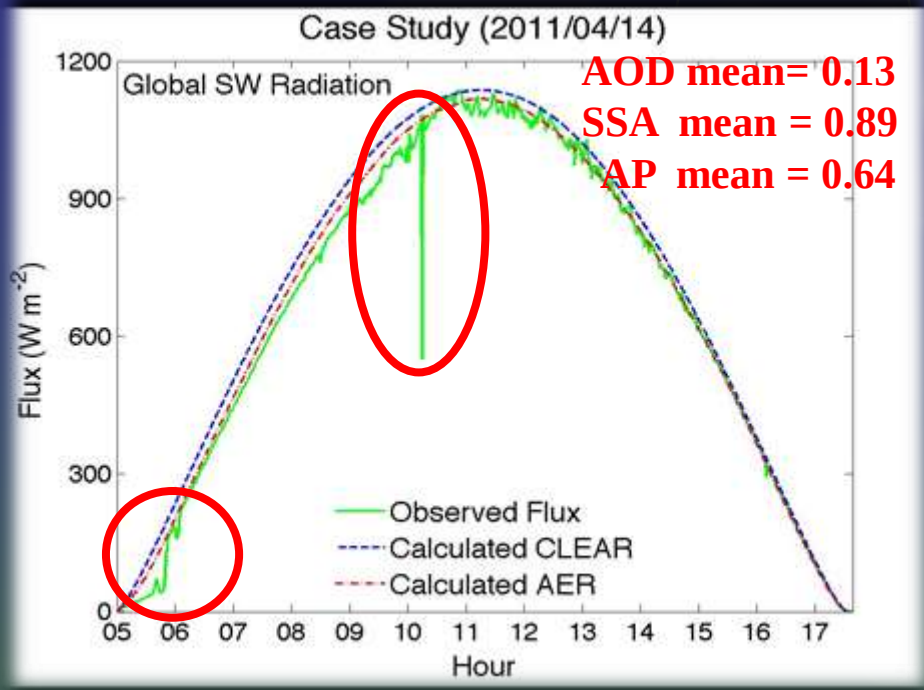




Clear-sky condition and low AOD

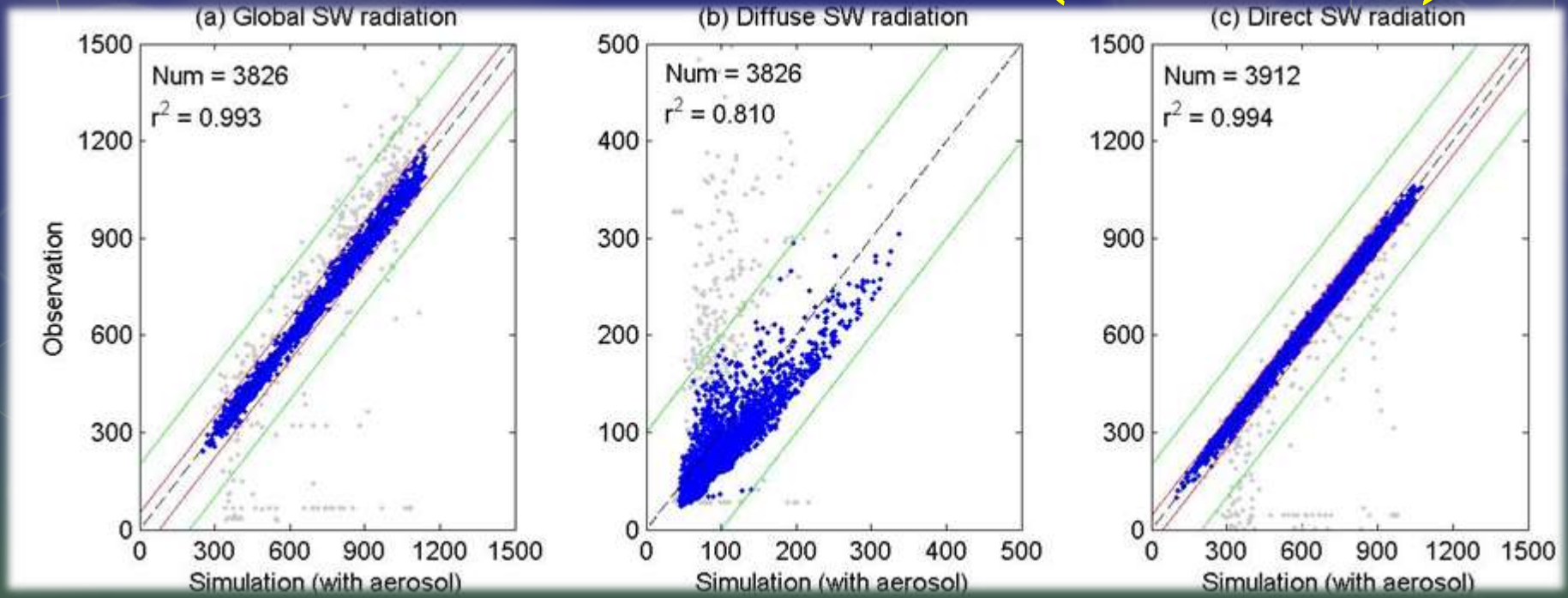


Partial-cloud condition and high AOD



	Case 1 (2011/02/07)			Case 2 (2011/04/14)		
	Global	Diffuse	Direct	Global	Diffuse	Direct
$F^{\downarrow}_{obs}$	577.7	39.3	542.7	652.8	83.4	576.2
$F^{\downarrow}_{mod}$(no aerosol)	576.6	43.6	534.7	690.6	45.3	647.2
$F^{\downarrow}_{mod}$(aerosol)	570.6	61.7	510.4	666.3	101.7	566.3
$\Delta F^{\downarrow}_{mol-obs}$(aerosol)	-7.1 (-1.2%)	22.4 (57.0%)	-32.3 (-6.0%)	13.5 (2.1%)	18.4 (22.0%)	-9.9 (-17.2%)

Observation vs. Simulation (2010-2014)



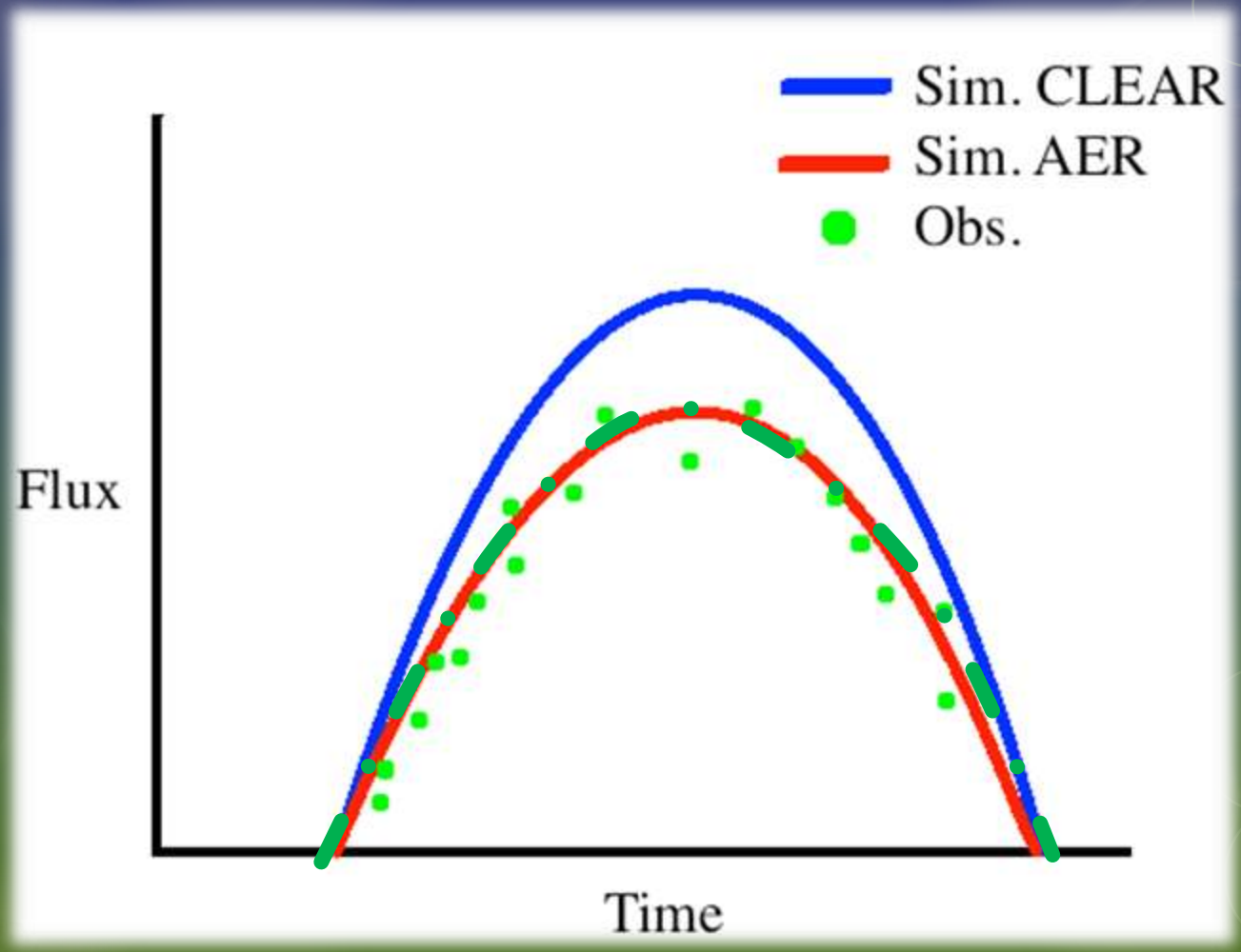
Instantaneous values when AERONET data available

	Global SW Flux	Diffuse SW Flux	Direct SW Flux
$F^{\downarrow}_{obs}$	659.0	74.4	590.4
$F^{\downarrow}_{mod}$(aerosol)	676.4	92.7	590.1
$\Delta F^{\downarrow}_{mol-obs}$(aerosol)	17.4 (+2.6%)	18.3 (+24.6%)	-0.3 (-0.1%)

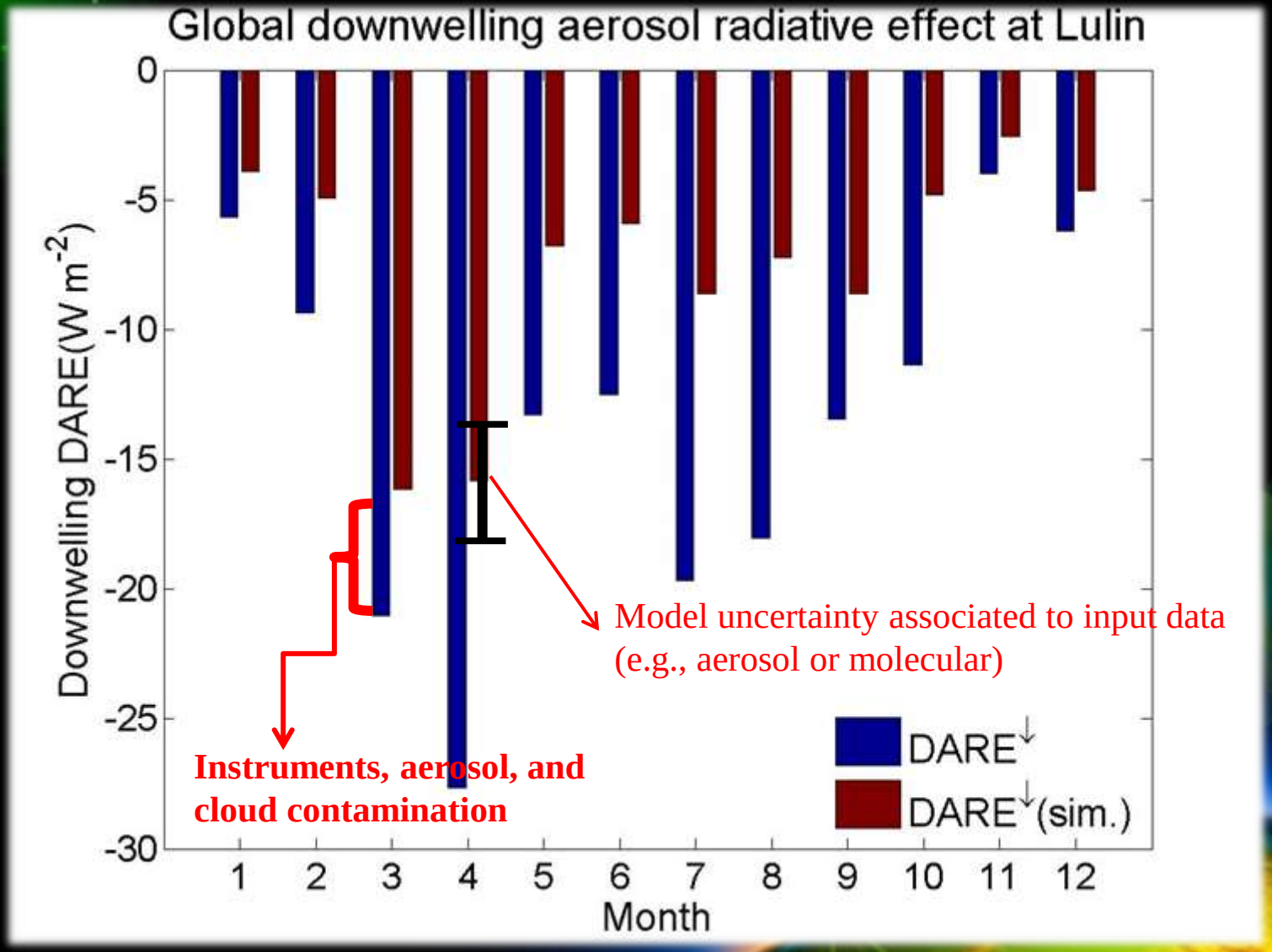
Uncertainty analysis on global SW flux

Item	Uncertainty (%)	Note
Incoming Solar Radiation	± 0.1%	
Molecular	-0.2%~0.3% (H_2O) ±0.2% (O_3)	based on ± 10% sensitivity test
Aerosol	±0.3 % (AOD) ± 0.3% (AP) ± 1.2% (SSA)	based on ± 10% sensitivity test
Surface albedo	-0.1% ~0.5%	
Cloud contamination	**Unknown**	
Instrument uncertainty	< 10 W m^{-2} **(± 1.5%)**	

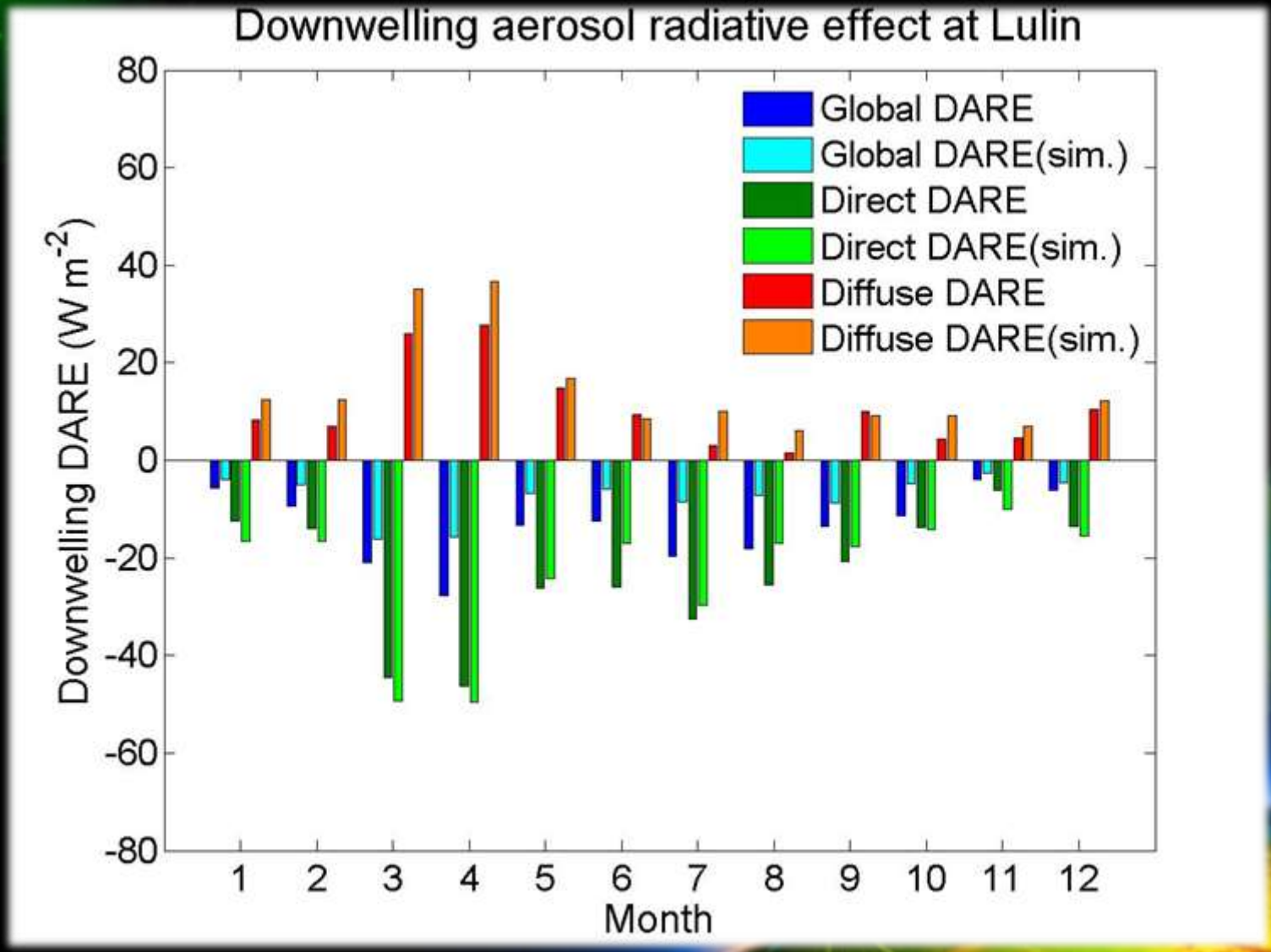
Concept of DARE estimation



Downwelling DARF at Mt. Lulin



DARE for three components



Conclusions

- A reasonable agreement between observation and simulation of downwelling radiation flux for clear-sky condition, implying the model can represent solar radiation at the surface for the mountain site.
- In general, model overestimate SW fluxes, and turns out model underestimate the DARE.
- The observational results show that the annual mean downward shortwave DARE at Lulin for the three component of solar fluxes:

	Global	Diffuse	Direct
DARE (Wm^{-2})	-13.5	10.6	-23.5


Thank you!
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