Approaches to intercalibration/QA/QC and other network aspects of AD-Net and SKYNET systems

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Contents of this presentation

◎ Outline of calibration/QA/QC regarding the instruments of the AD-Net and SKYNET that contributes to this EarthCARE validation

◎ Summary and Comments on this theme

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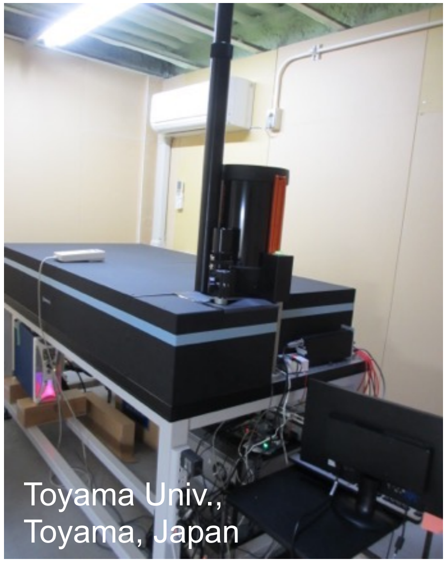
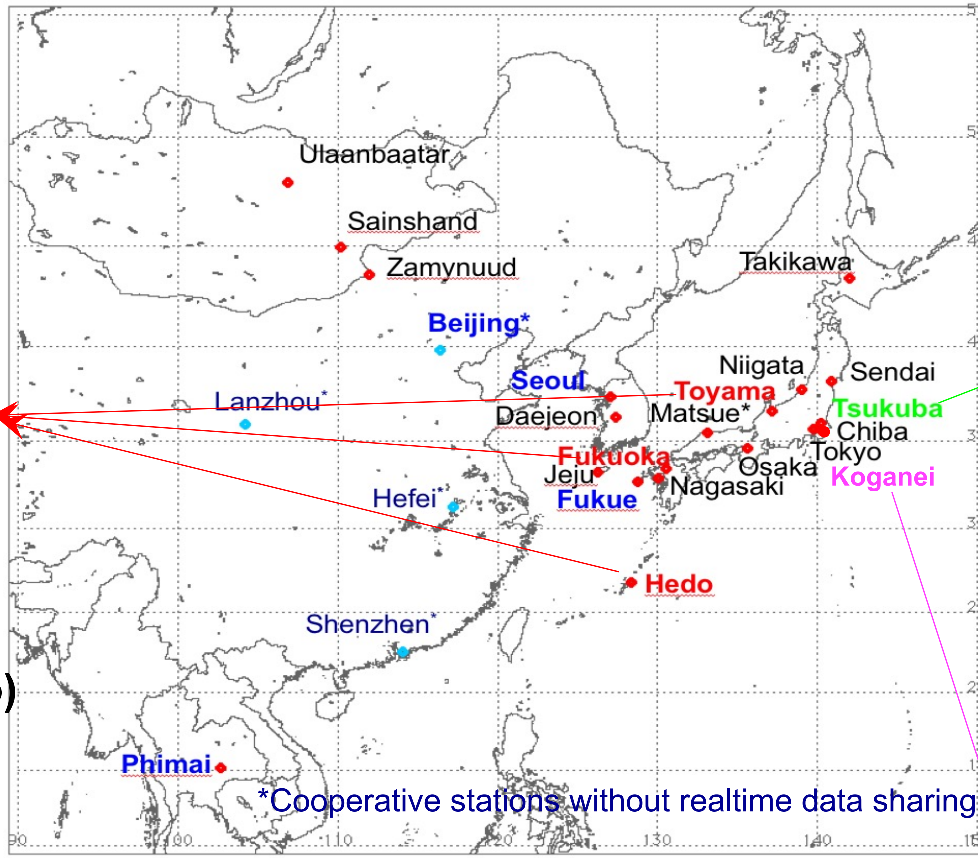
Observation products used for validation

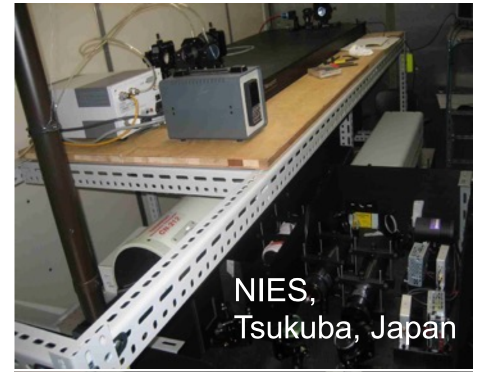
Obs. site	Lat Lon	Instrument	Parameter
Tsukuba (Rural) *stopping	36.05N 140.12E	**MRHSRL**	**α**, **β**, **δ**, **S**: 355 (Night) **α**, **β**, **δ**, **S**: 532 (Day & Night) Attenuated backscatter: 355/532/1064 (Day & Night)
Hedo (Maritime)	26.87N 128.25E	**MRL**	**α**, **β**, **δ**, **S**: 355/532 (Night) Attenuated backscatter: 355/532/1064 (Day & Night)
		Sky radiometer	AOT: 340, 380, 400, 500, 675, 870, and 1020 (Day) Angstrom exponent (Day)
Toyama (Rural)	36.7N 137.1E	**MRL**	**α**, **β**, **δ**, **S**: 355/532 (Night) Attenuated backscatter: 355/532/1064 (Day & Night)
Fukuoka (Rural-Urban)	33.52N 130.48E	**MRL =>MRHSRL (2021~)**	**α**, **β**, **δ**, **S**: 355 (Night) **α**, **β**, **δ**, **S**: 532 (Day & Night) *2021~ Attenuated backscatter: (Day & Night)
		Sky radiometer	AOT: 340, 380, 400, 500, 675, 870, and 1020 (Day) Angstrom exponent (Day)
Koganei (Urban)	35.7N 139.48E	**355 HSRL (2019~)**	**α**, **β**, **δ**, **S**: 355 (Day & Night) Attenuated backscatter: 355 (Day & Night)
Palau (Maritime)	7.34N 134.5E	**MRL (2019~)**	**α**, **β**, **δ**, **S**: 355/532 (Night) Attenuated backscatter: 355/532/1064 (Day & Night)
RV Mirai (ocean)	Ocean	**MRL**	**α**, **β**, **δ**, **S**: 355/532 (Night) Attenuated backscatter: 355/532/1064 (Day & Night)

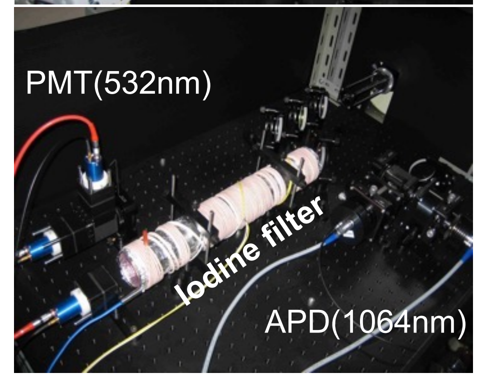
AD-Net



MRL
(Fukuoka, Toyama, Hedo)







MRHSRL
(Tsukuba)

- ✓2β(532,1064)+1δ(532) Mie lidar
- ✓1α(532)+2β(532,1064)+1δ(532) Raman
- ✓2α(355,532)+3β(355,532,1064)+2δ(355,532) Raman (MRL)
- ✓2α+3β+2δ Raman-HSRL (MRHSRL)
- ✓ 1α(355)+1β(355)+1δ(355) HSRL

355nm HSRL
(Koganei)

MRL data processing and calibration

Calibration

Measurements (7ch)
ΔT＝15min ΔZ＝6m (Elastic channel)
ΔT＝15min ΔZ＝7.5m (Raman channel)

Integration
ΔT＝15min ΔZ＝30m (Elastic, Raman)

Calibration

1064nm
Calibrate signal using signal scattered by cloud
＊use 1064nm signal to detect cloud layer [Shimizu etal. 2004]

532/355nm
Calibrate elastic and Raman signals using signals measured under clean condition and signals for aerosol free layer (around 6km).

Geometrical form factor
Evaluate using measured Raman signals and theoretically computed Raman signals. [Xie etal 2008]

Depolarization (off-line)
Calibrate using linear polarizer sheet directed at a ±45°
(Freudenthalter etal. 2016)

Attenuated backscatter (7ch)
ΔT＝15min ΔZ＝30m (Elasctic, Raman)

Optical Prop. retrieval

Attenuated backscatter β_{atn} (7ch)
ΔT＝15min ΔZ＝30m (Elastic, Raman)

Cloud layer detection
(Use β_{atn} at 1064nm)

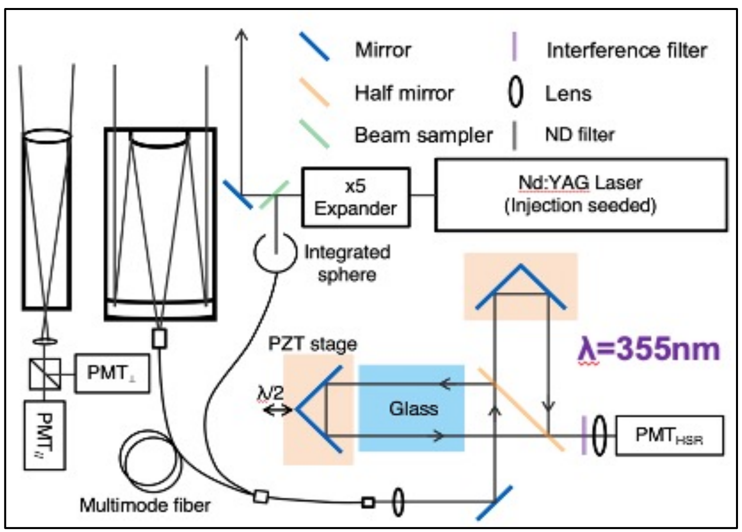
Retrieval of Aerosol & Cloud optical properties

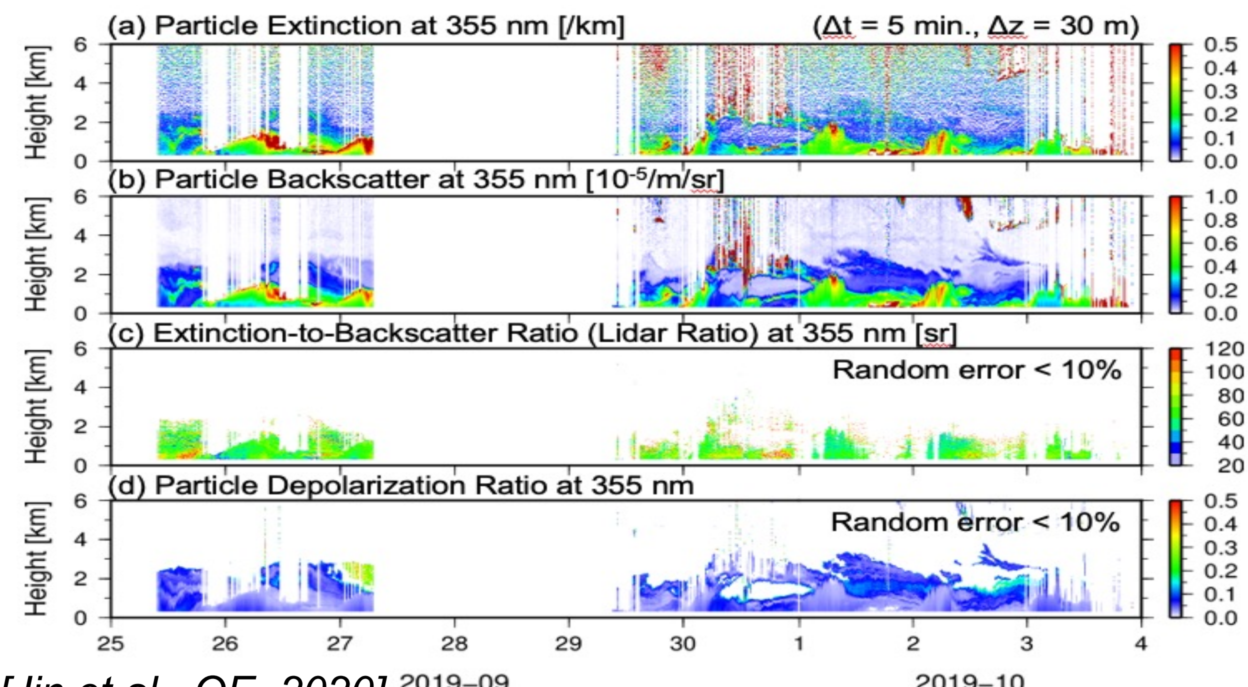
Particle optical properties (POP)
Moving average
ΔT＝±30min, ΔZ＝±60m
✓Extinction（355,532)
✓Backscatter (355,532,1064)
✓Depolarization（355,532)

[Nishizawa et al., JQSRT, 2017]

355nm HSRL

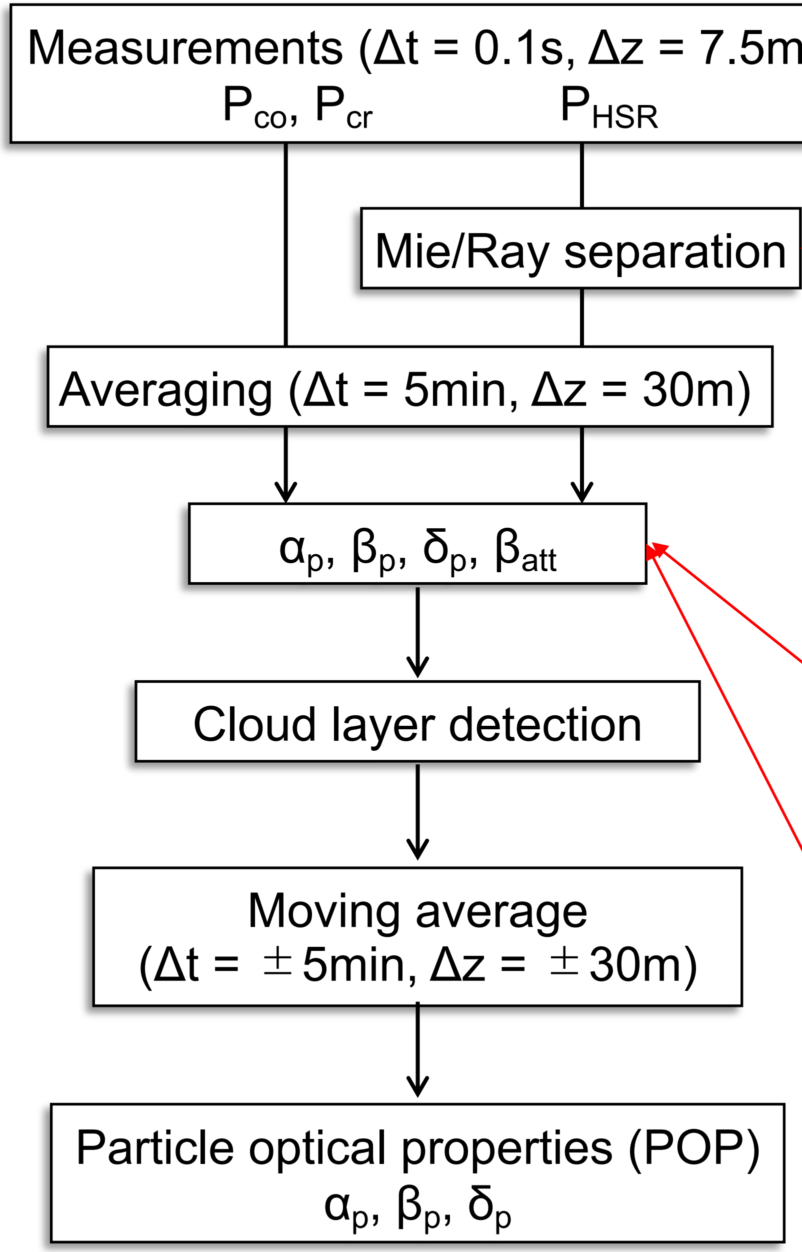
Specification of HSRL using a scanning interferometer	
Laser	Injection-seeded, Q-switching Nd:YAG laser (Continuum Surelite I-10)
Wavelength	355 nm
Pulse energy	100 mJ
Beam div.	0.1 mrad (after x5 beam expander)
Repetition rate	10 Hz
Receiver	Takahashi μ-210 (Dia. = 21cm), Smaller telescope (Dia. = 5cm)
Field-of-view	0.5 mrad (21cm telescope), 1 mrad (5cm telescope)
Interferometer	Michelson interferometer, FSR = 2.4 GHz Scanning speed: 1 Hz
Detector	Photomultiplier (Licel PM-HV-R9880)
Acquisition	160MSPS ADC (AVALDATA ADO-1616-STD)





[Jin et al., OE, 2020]

355nm HSRL data processing and calibration



Mie / Rayleigh separation

✓ Using scan data, profile data are separated into Mie and Rayleigh components (here, data for calibration such as aerosol-free data is not required). [Jin et al. 2020]

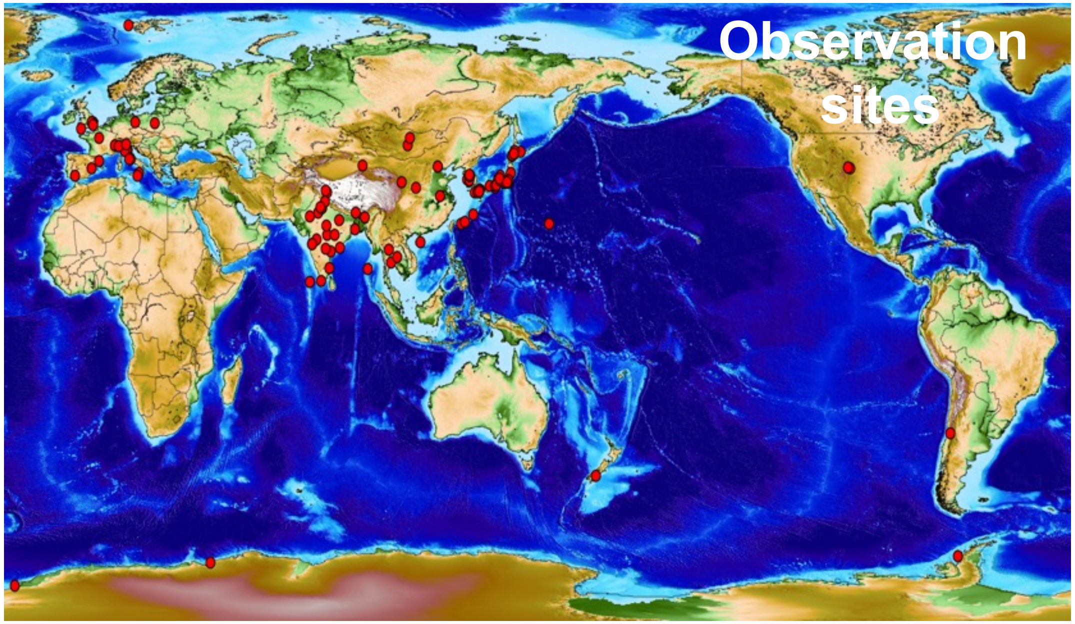
Depolarization (off-line)

✓ Calibrate co-pol/cross-pol using a linear polarizer sheet directed at a ±45° (Freudenthaler et al. 2016)

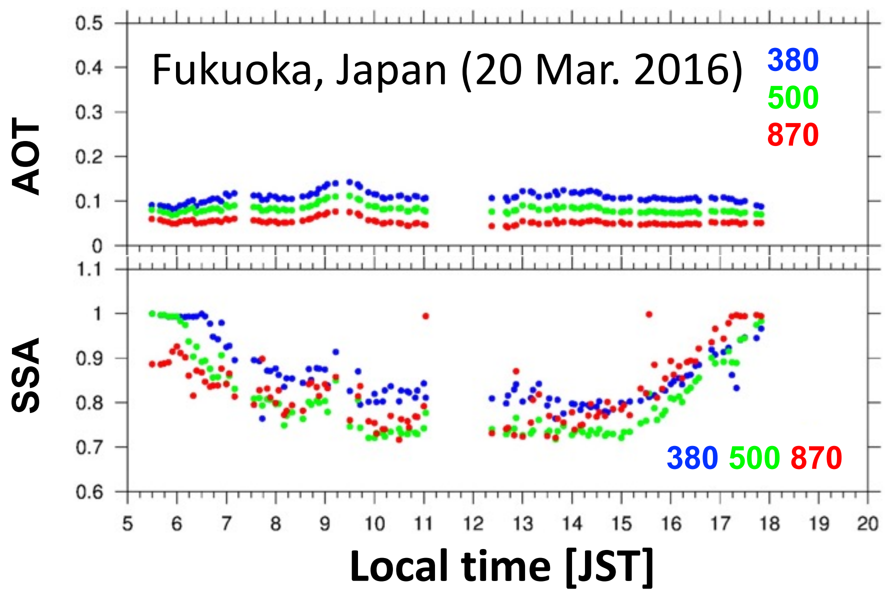
Geometric form factor

✓ Calculate the factor using range-corrected signals and computed attenuated backscatter profiles

SKYNET



AOT, SSA measured by skyradiometer



Skyradiometer (by Prede co, Japan)

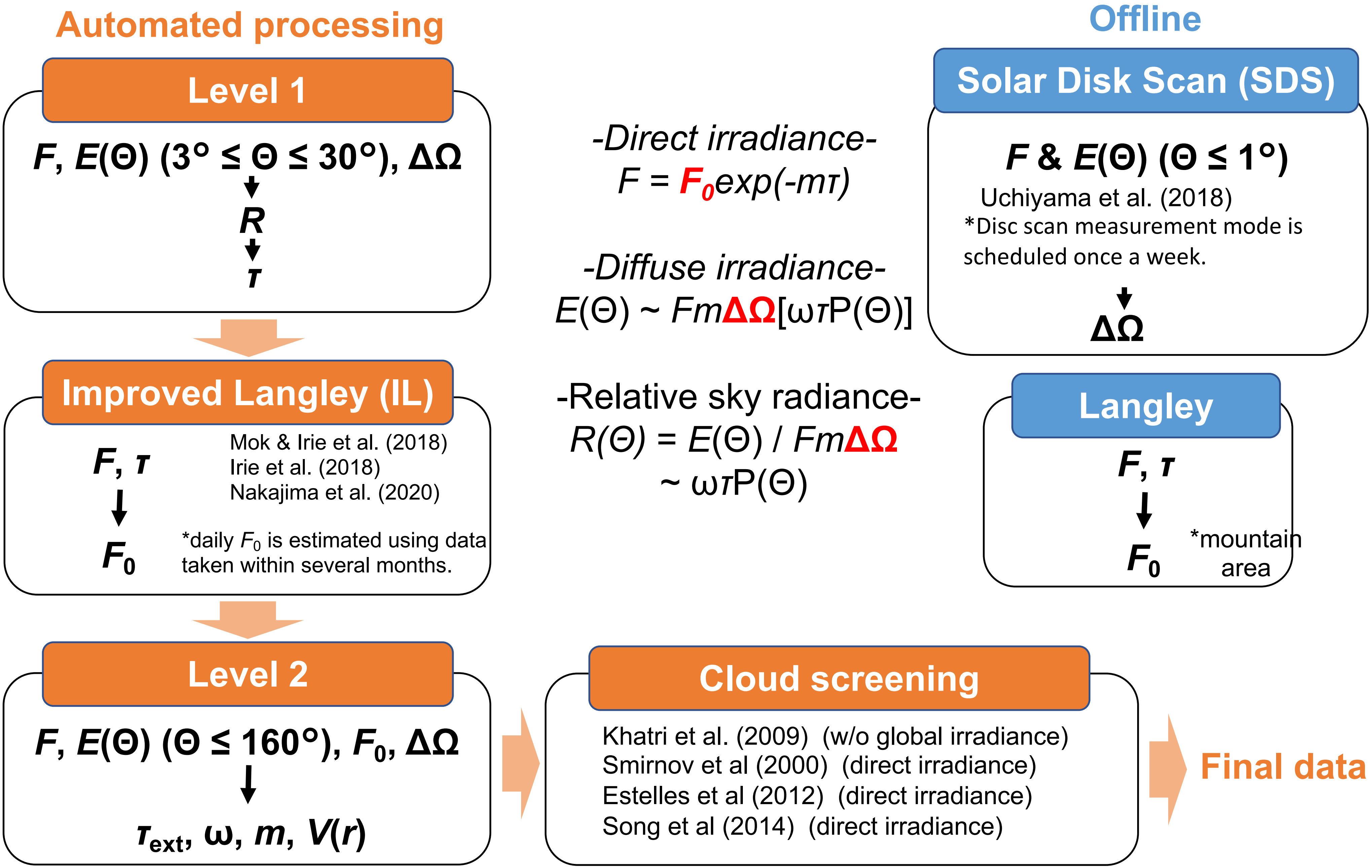
✓Sun-scanning sunphotometer

✓Measured wavelengths:
315, 340, 380, 400, 500, 675, 870, 940, 1020, 1627, 2200nm

✓Data recorded every 10~15min

✓Derived parameters:
AOT, **Angstrom exponent, SSA, Size distribution, Refractive index**

Skyradiometer data processing and calibration



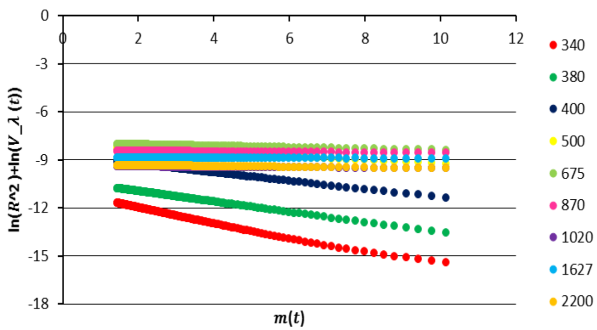
Mountain calibration activity

◎**Period:** Oct. 27-Nov. 5, 2016

◎**Place:** Mauna Loa (MLO), Hawai'i, USA

◎**Purpose:**

Direct calibration of the Chiba-U's master sky radiometer by the Langley method for all channels, including cloud channels.



Summary and Comments

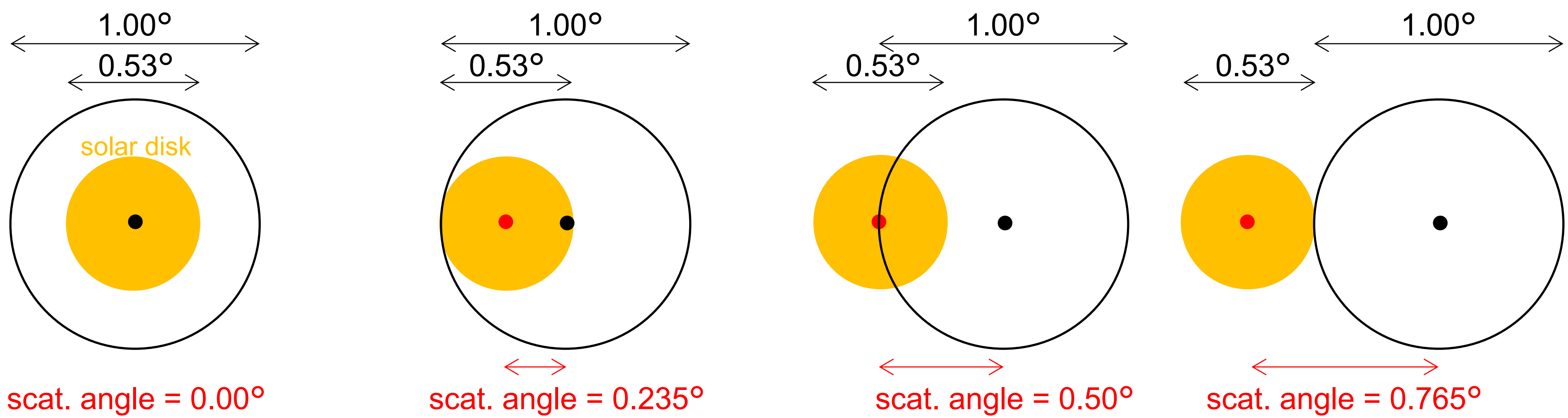
AD-Net

- ✓ Calibration using operational data is performed regularly, however, calibration measurement of depolarization is performed annually.
- ✓ We strives to keep data quality through regular maintenance about a year (replacement of consumables, alignment adjustment, polarization calibration, etc)
- ✓ The status of the instrument is constantly monitored via the data sent over the network.
- ✓ Data screening of products extracted by Raman lidar and HSRL observation is under consideration.

SKYNET

- ✓ Calibration using operational data is performed regularly.
- ✓ We strives to keep data quality through regular maintenance (generally, about a year) (replacement of consumables, alignment adjustment, etc)
- ✓ The status of the instrument is constantly monitored via the data sent over the network.
- ✓ Intercalibration using “a master instrument” calibrated by the Langley method in mountain observation has been conducted occasionally.
- ✓ A data center (International SKYNET data center) is being constructed to aggregate all skynet data, centrally analyze it, generate and publish standard products [Nakajima et al. 2020] (this standard products will be used for the EarthCARE validation). Data screening of products is under consideration.

Simple relationship between solar disk and SVA



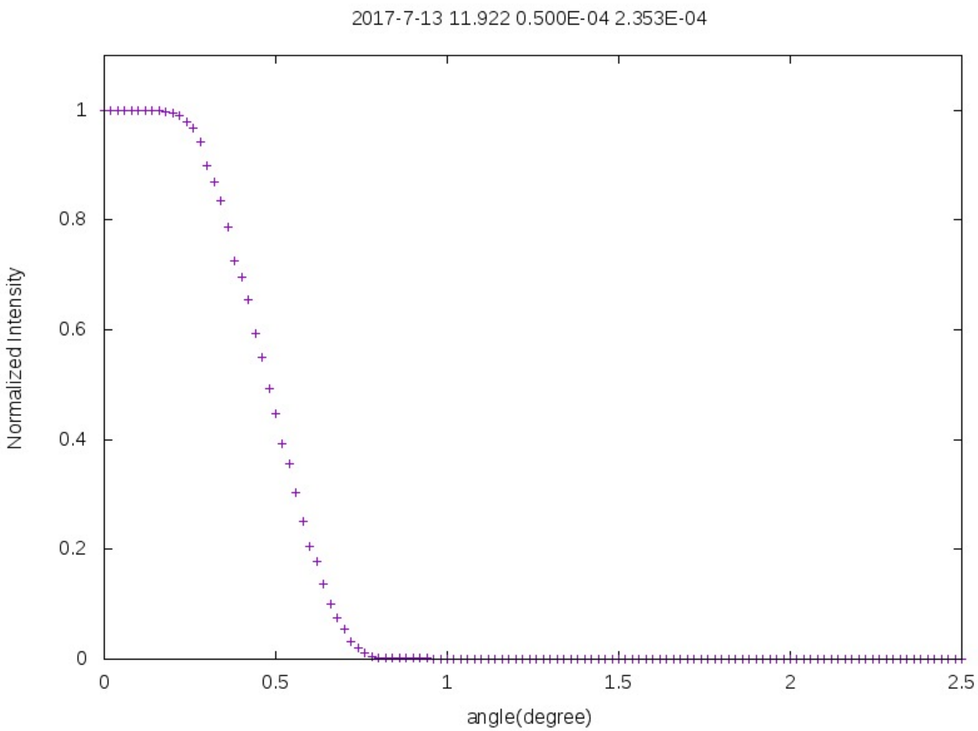
$$\Delta\Omega = 2\pi(1 - \cos\theta) = 0.239 \text{ msr}$$

$\Delta\Omega$: solid view angle

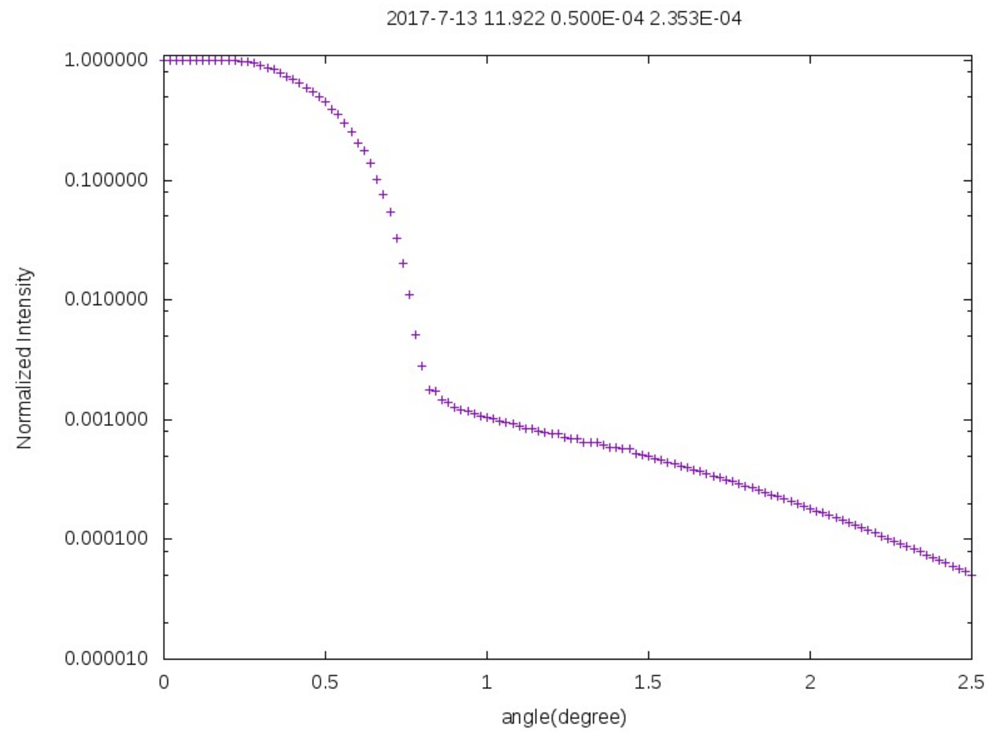
θ: half angle of circular cone (=1.00°/2)

Example of solar disk scan

Linear scale

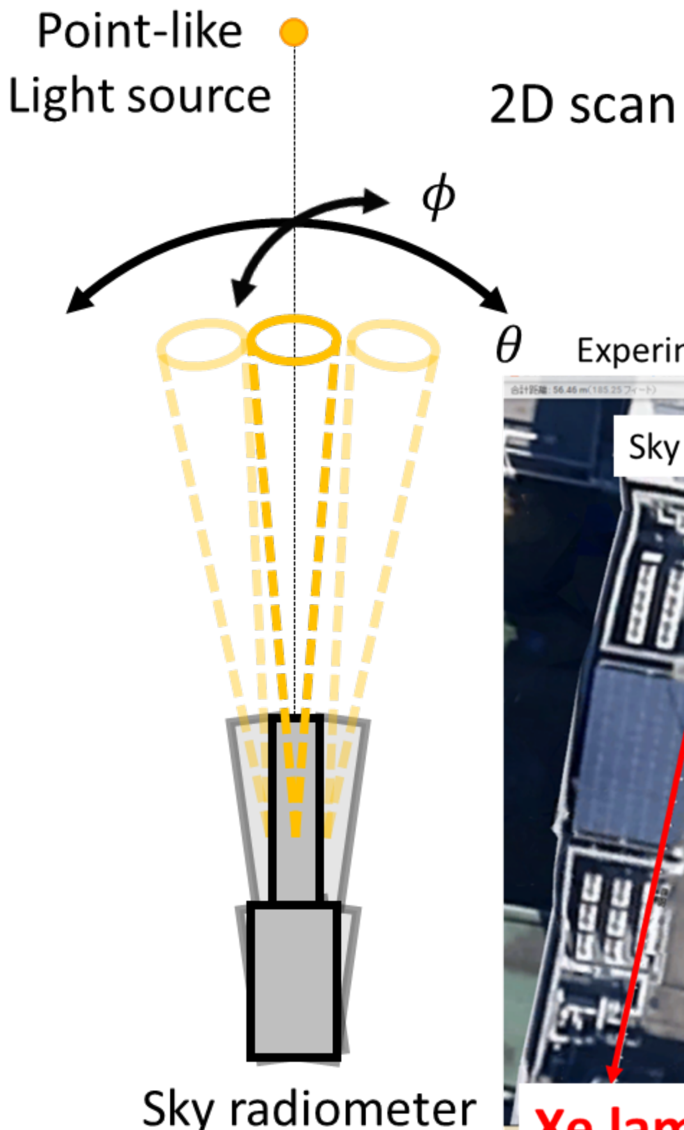


Log scale

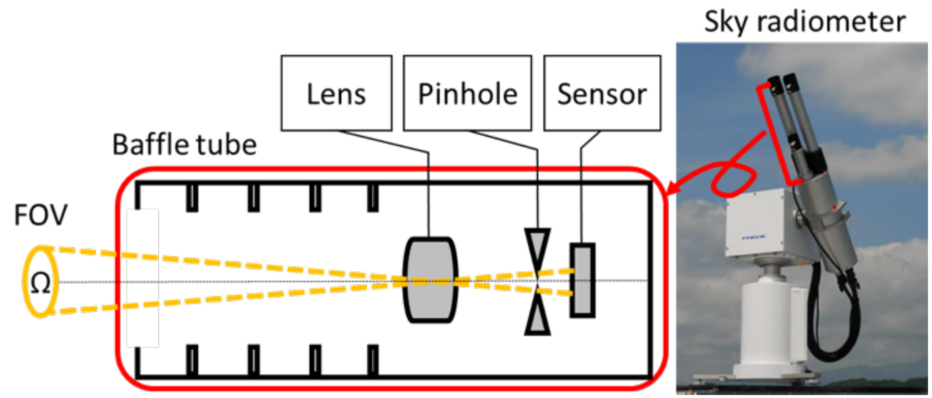


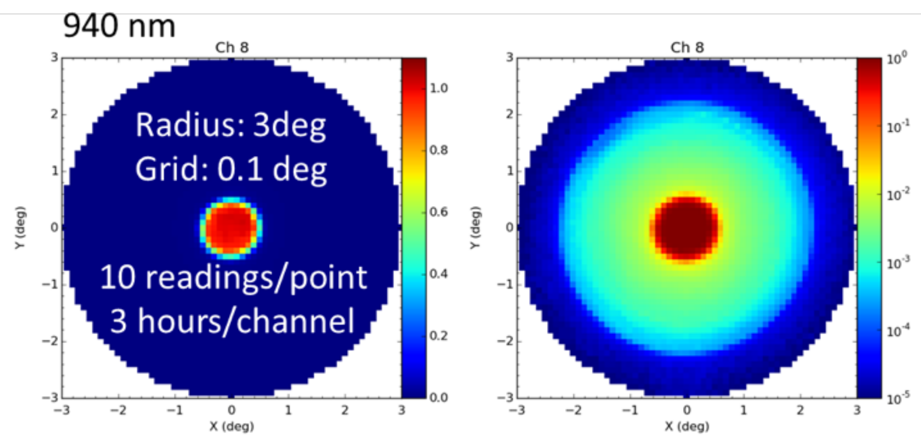
Scattering angle

Far lamp method: Experiments for Solid View Angle



Experiment at Chiba U





Idea of Improved Langley method

$$\ln F = \ln F_{\mathrm{TOA}} - m\tau$$

$$\ln F = \ln \frac{F_0}{r^2} - m\tau$$

$$\ln Fr^2 = \ln F_0 - m\tau$$

$$F_0^* = Fr^2 \exp(m\tau)$$

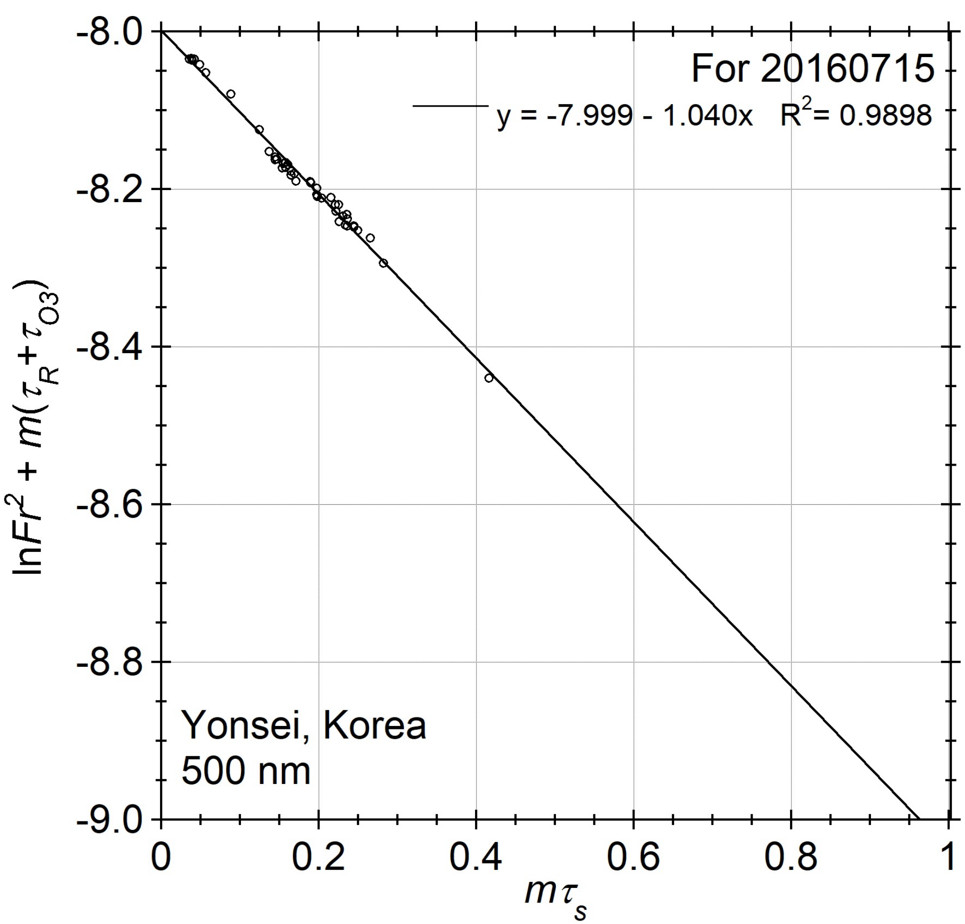
$$\ln Fr^2 = \ln F_0 - m(\tau_{\mathrm{non-aerosol}} + \tau_{\mathrm{aerosol}})$$

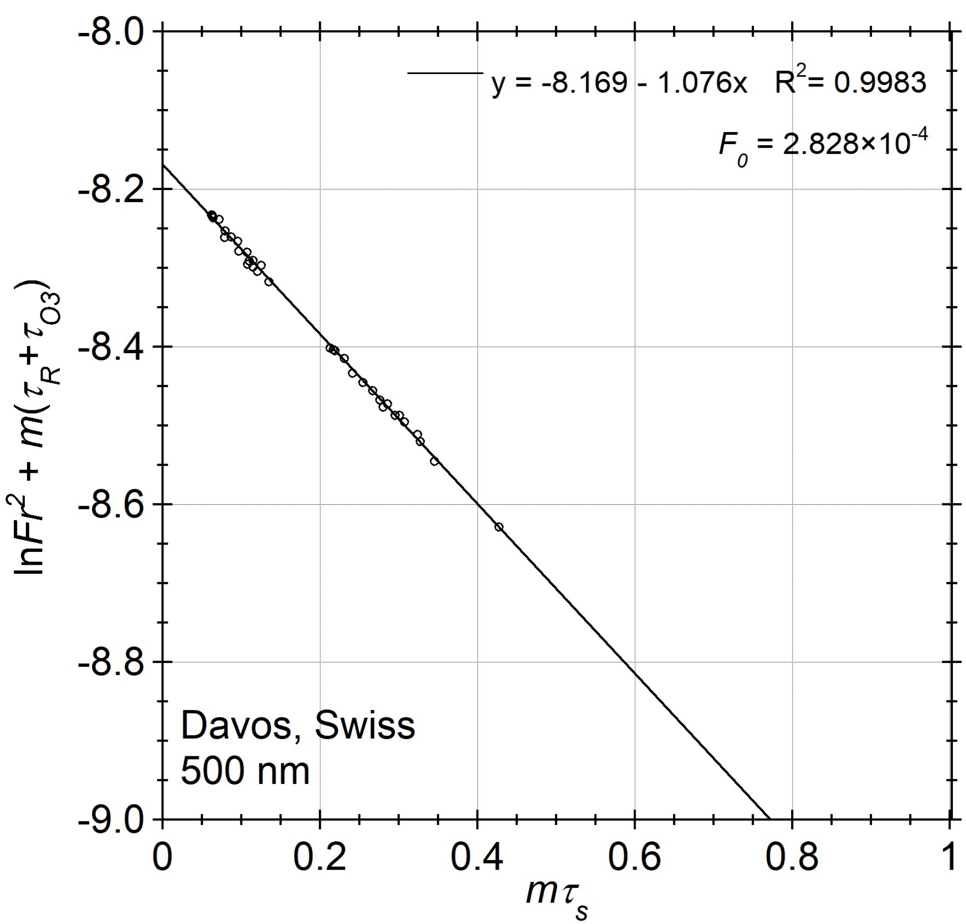
$$\ln Fr^2 = \ln F_0 - m(\tau_{\mathrm{non-aerosol}}) - m\tau_{\mathrm{aerosol}}$$

$$\ln Fr^2 = \ln F_0 - m\tau_{\mathrm{non-aerosol}} - m\frac{\tau_s}{\omega}$$

$$\underbrace{\ln Fr^2 + m\tau_{\mathrm{non-aerosol}}}_{y} = \ln F_0 - \frac{1}{\omega}\underbrace{m\tau_s}_{x}$$

Example of results: Improved Langley method





Evaluation of F_0 derived by IL method