Cloud optical properties from the SKYNET zenith observations in the visible and near infrared regions

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INTRODUCTION

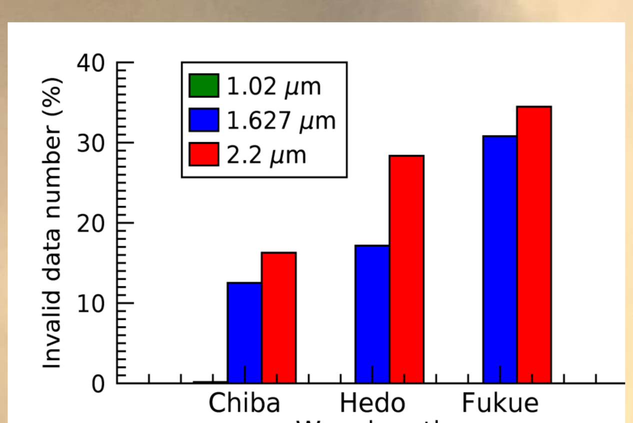
Cloud optical properties are important climate variables for determining the Earth's radiative energy balance. Cloud optical thickness (COD) and effective particle radius (Re) are the key parameters determining radiative properties of clouds such as reflection, transmission, and absorption of the solar radiation. Retrievals from geostationary and polar satellites, measuring the solar radiation reflected by clouds in the visible and near-infrared wavelengths are already provided by different sensors, however cloud optical properties can also be inferred complementarily from ground-based measurements of the transmitted solar radiation by a multispectral radiometers

METHODS

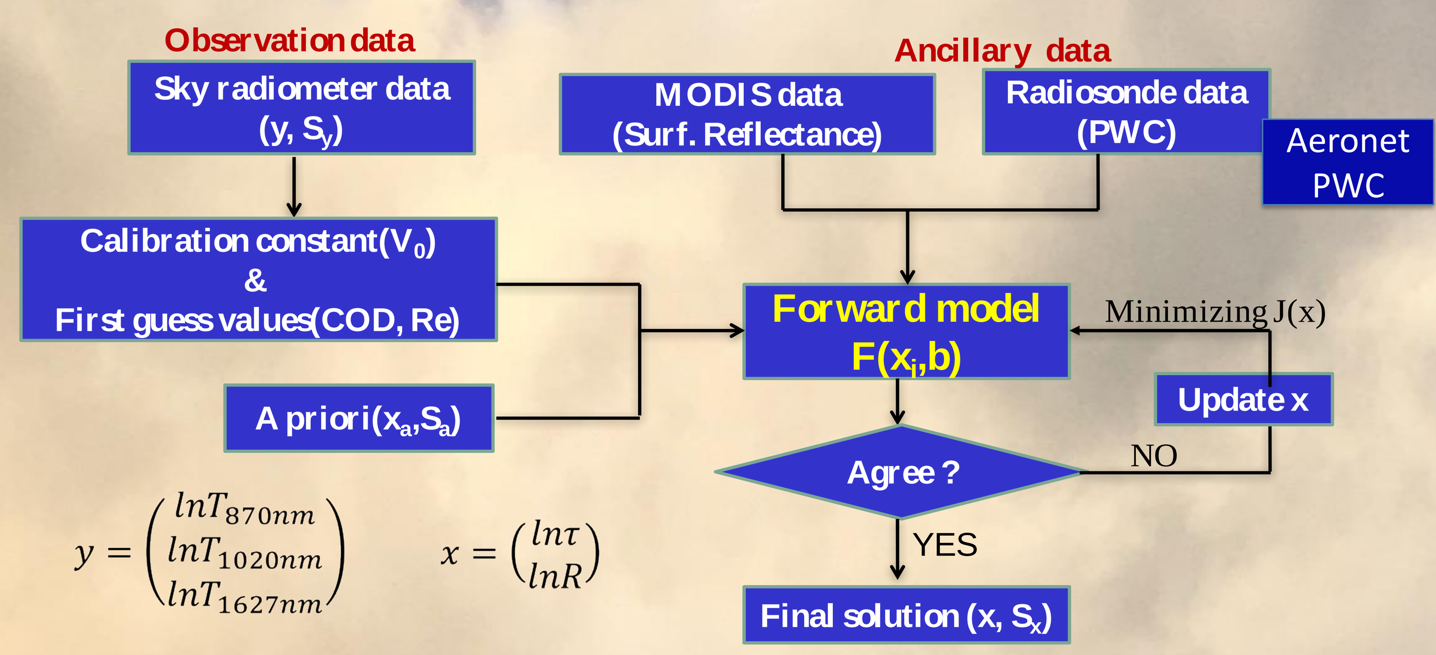
The method consists in observing non-precipitating clouds through zenith measurements of radiance at 870, 1020 and 1640 nm, performed by a PREDE-POM sun-sky radiometer, and retrieving the cloud optical properties through an iterative procedure that makes use of some input variables (columnar precipitable water vapour and surface reflectance) and the SBDART forward model for reconstructing the measured radiance

Why 2.2 μm is not used in our algorithm?

Uncertainty in measured signal increases with the increase of wavelength (AERONET sun photometer observes up to only ~ 1.6 μm)



Cloud retrieval method for sky radiometer



$$y = \begin{pmatrix} lnT_{870nm} \\ lnT_{1020nm} \\ lnT_{1627nm} \end{pmatrix} \qquad x = \begin{pmatrix} ln\tau \\ lnR \end{pmatrix}$$

T: Transmittance
τ: Cloud opitcal thickness
R: Effective radius

Sa=error covariance matrix for a priori COD and Re values

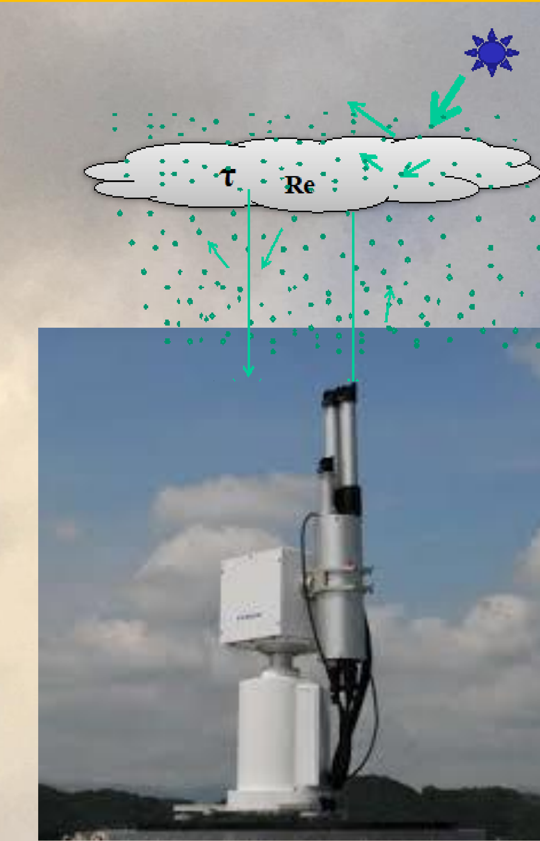
Sa and Se are with non-diagonal elements=0

(Rodgers 2000)

$$J(x) = [x-x_a]^T S_a^{-1}[x-x_a]+[y-F(x)]^T S_\varepsilon^{-1}[y-F(x)]$$

Minimization of cost function above

Se=error covariance matrix model-measurements
a) Error in calibration (1% in ln(solar calibration cost); b) 20% in surf reflectance; c) 20% in assumed PWC. the simulations with random perturbations in those parameters (100 simulation for each) are used to determine the diagonal elements of Se

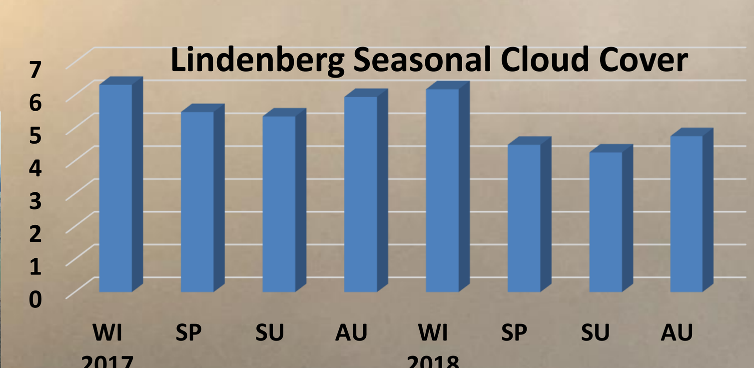


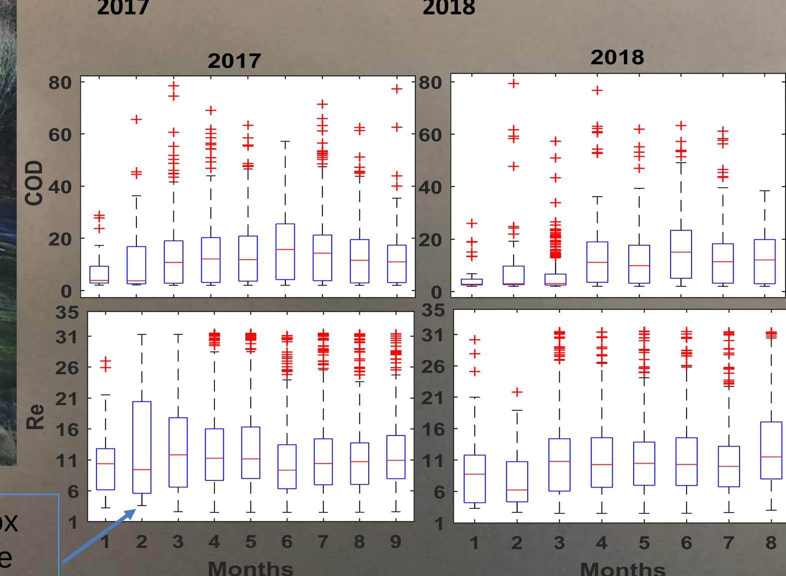
PREDE-POM 02 model performing zenith measure

The method has been applied to two PREDE-POM 02 measurements located at two ESR/SKYNET site (www.euroskyrad.net) : Lindenberg (Germany) and Burjassot (Spain)

RESULTS Lindenberg Observatory, Germany

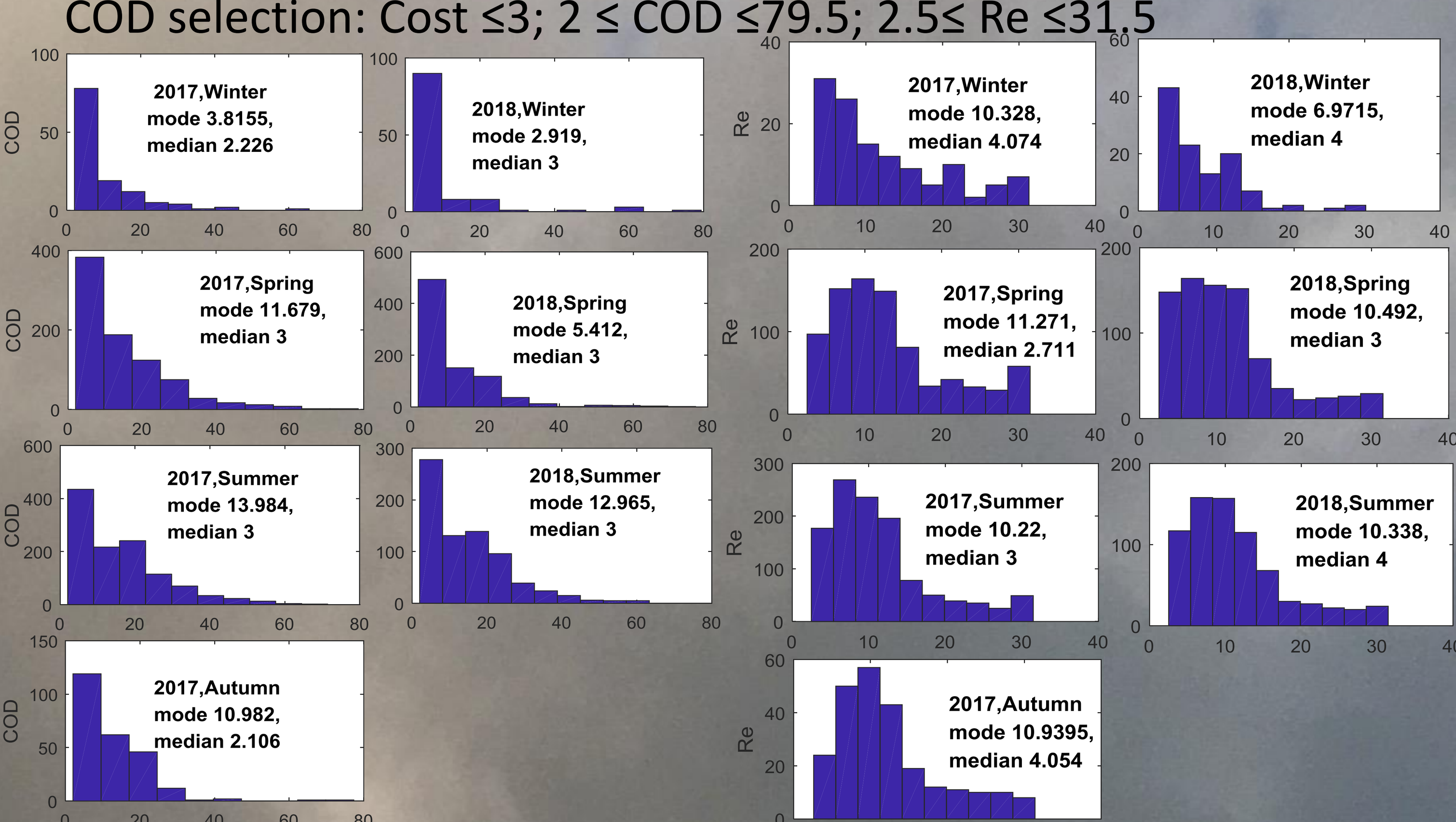
On each box, the central mark indicates the median, and the bottom and top edges of the box indicate the 25th and 75th percentiles, respectively. The whiskers extend to the most extreme data points not considered outliers, and the outliers are plotted individually using the '+' symbol





Minimum COD median in February, corresponding to the smallest particles

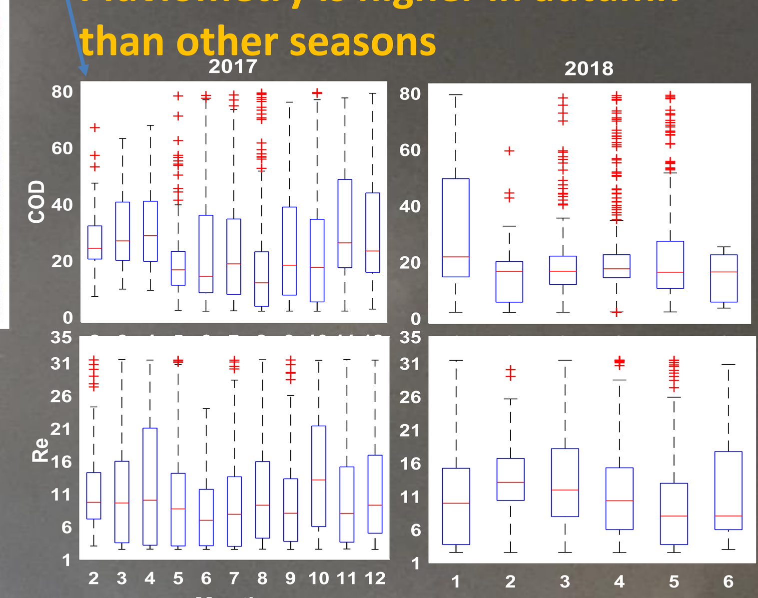
COD selection: Cost ≤3; 2 ≤ COD ≤79.5; 2.5≤ Re ≤31.5



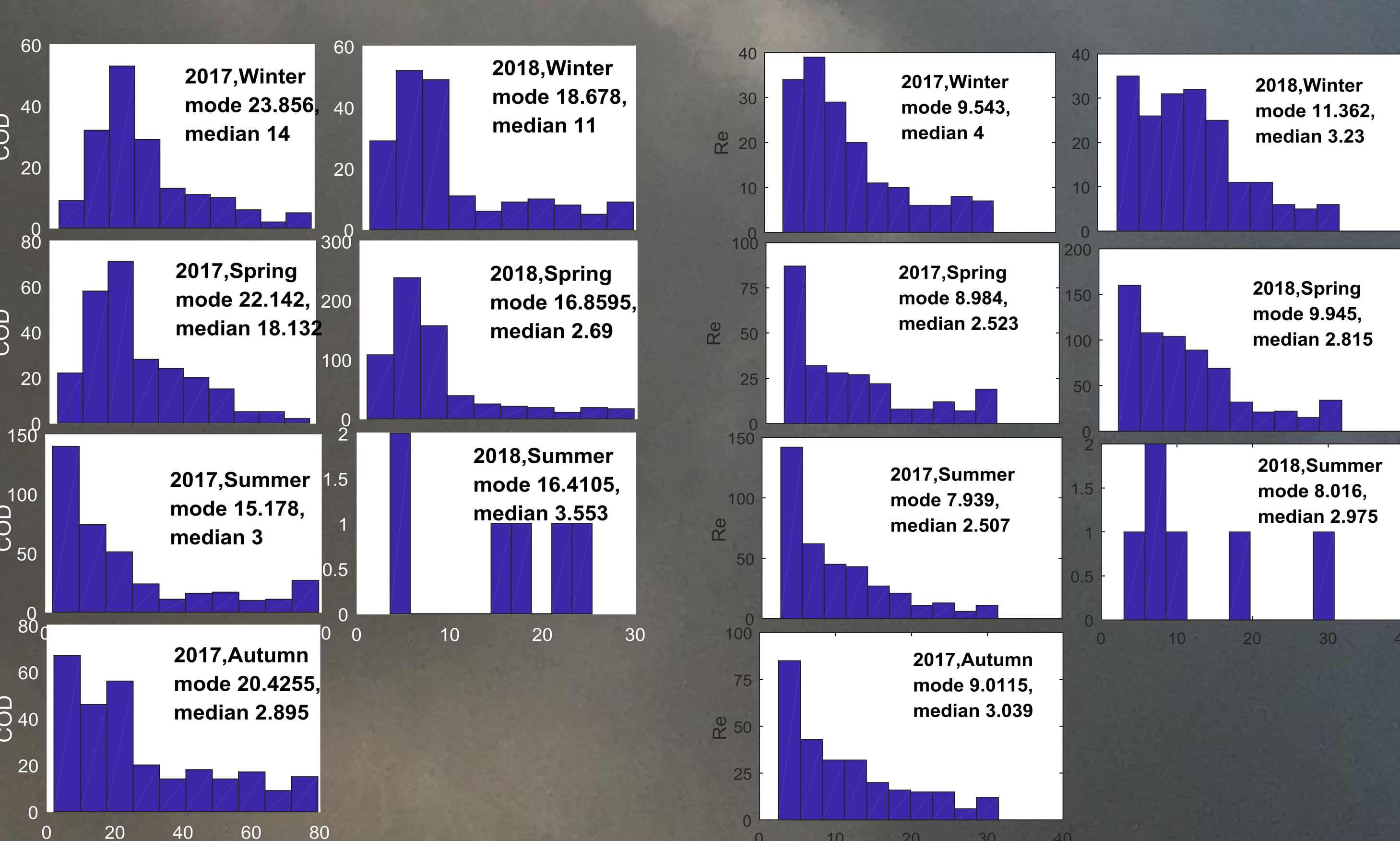
Minimum COD Mode in Winter for both the years
Re Mode always within 10.2-11.2 μm, with the exception of Winter 2018 with the smallest particles (7 μm); Particles larger and COD smaller than in Burjassot ; smaller COD in 2018

Burjassot, Valencia, Spain

Burjassot is 10km east from the coast, so it is frequently affected by low maritime clouds.
Pluviometry is higher in autumn than other seasons



2017: the higher is COD medians the larger are the particles



Minimum COD Mode in Summer for both the years, Maximum in Winter
Minimum Re Mode in Summer (8 μm), Maximum in Winter
Particles smaller and COD greater than in Lindenberg ; smaller COD in Win and Spr 2018

FUTURE STEPS: A sensitivity study of the methodology to input parameters and wavelengths selection
A comparison of the products against other available methodologies (AERONET, Satellites, Cloud Radar)

REFERENCES

Khatri, P., et al;, 2017,Proceedings of 19th EGU General Assembly, Vienna, Austria, EGU2017–6727; Khatri, P., et al.(2018), doi:10.2151/jmsj.2018-036
Campanelli M., et al. , Atmospheric Environment, Vol.48, pp. 33-45, 2012.;