VRAME:
Vertically Resolved Aerosol Model for Europe from a Synergy of EARLINET and AERONET data

Elina Giannakaki, Ina Mattis, Detlef Müller, Olaf Krüger

Outline

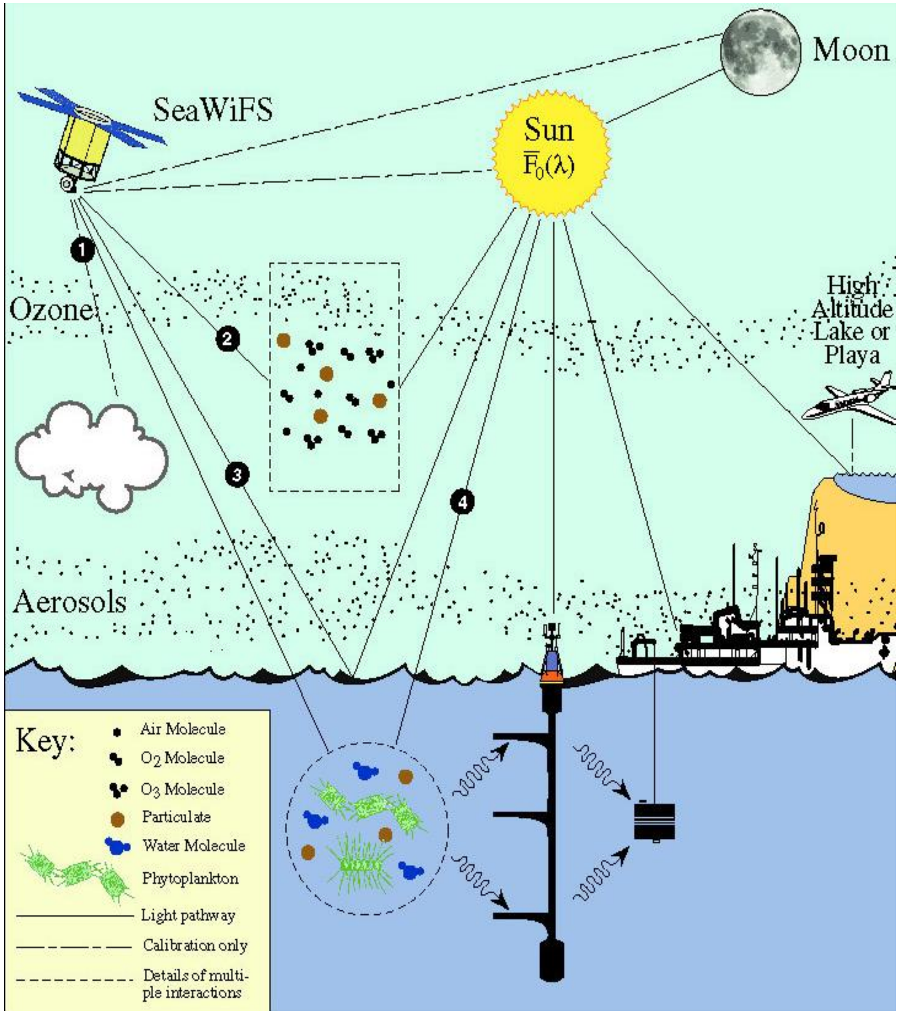
- The idea behind VRAME
- Atmospheric correction
- Development of a new aerosol model
- Activities of VRAME
- Combination of EARLINET and AERONET data

The idea behind

- Satellites monitoring the oceans in the visible range of electromagnetic spectrum
- The primary goal is to extract concentrations of marine phytoplankton

  Phyto (φυτό) +plankton (πλαγκτόν)

Satellite Ocean Color



- A satellite observes both oceans and the atmosphere
- The atmosphere is approximately 90% of the measured signal in the visible and must be accurately modeled and removed
- A 1% error atmospheric correction will result in a 10% error in water-leaving radiances

Ocean Color Retrieval

Signal

Level-0 (L0)

geolocation and calibration

Top-of-the-atmosphere calibrated radiances

Level-1B (L1B)

atmospheric correction

Water-leaving radiances

Level-2 (L2)

bio-optical algorithms

Derived bio-optical products, e.g. chl-a

Level-2 (L2)

Up to now…

- Shettle and Fenn (1979) introduced a set of basic aerosol models
  - Continental (rural and urban)
  - Maritime (oceanic and continental)

- d' Almeida *et al.* (1991) provide a more comprehensive classification
  - Maritime (clean, mineral, polluted)

SeaWiFS

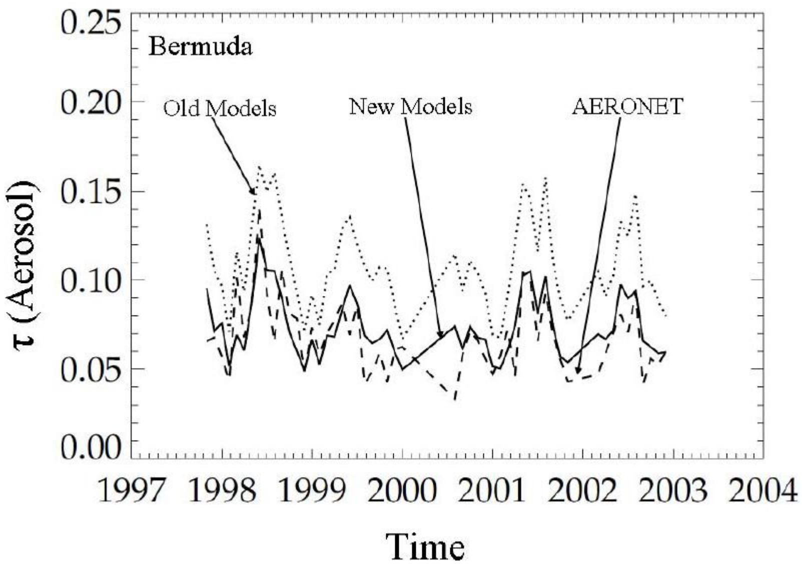
- Ocean color implementation, Gordon and Wang (1994) tropospheric, coastal, maritime and oceanic

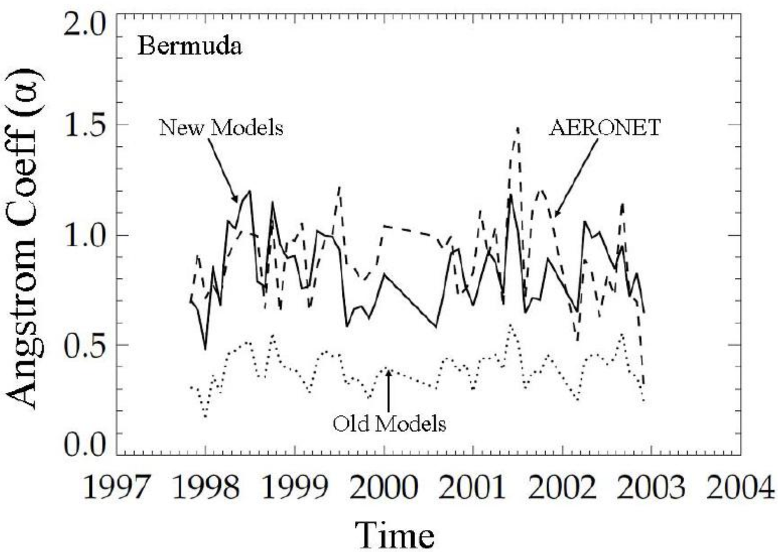
- Antoine and Morel (1999) include operational models for desert dust

MERIS

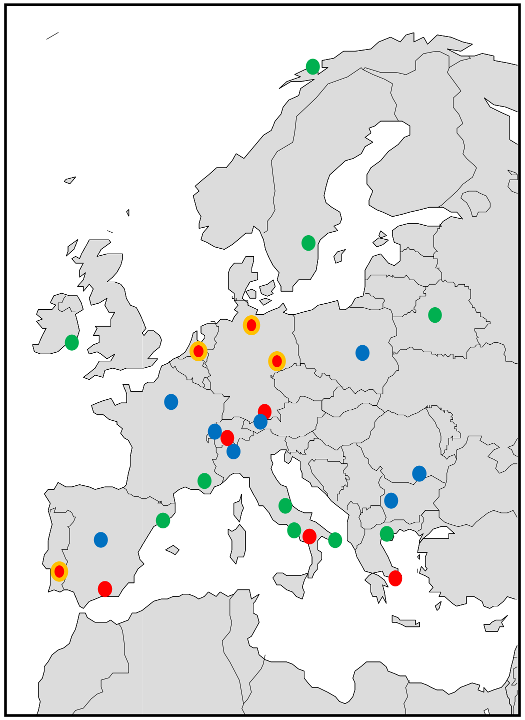
Up to now…

- New generation of aerosol models, Ahmad et al. (2010)
  - bimodal lognormal distribution
    - Eight relative humidity values (30 – 95 %)
    - Varying fine mode fraction (from 0 to 1)
    - Same spectral dependence of SSA as observed in AERONET





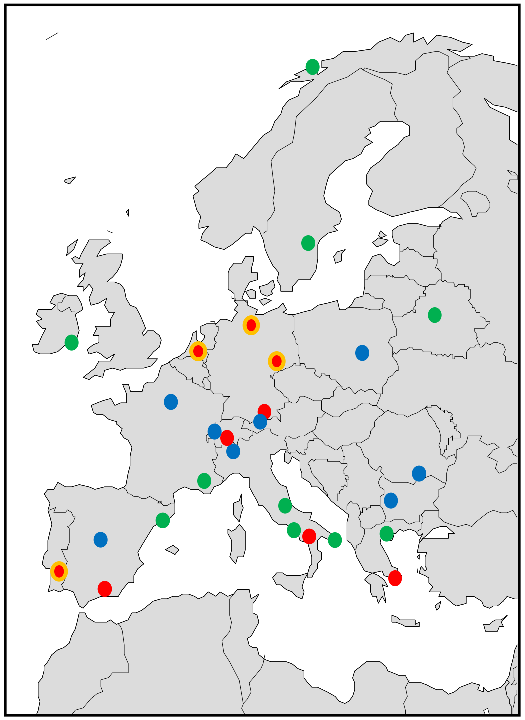
Develop a new aerosol model

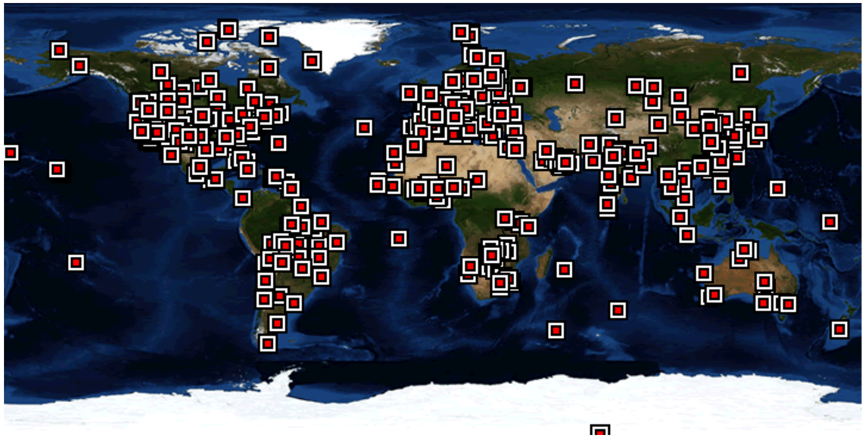


Comprehensive, quantitative and statistically significant data base

Develop a new aerosol model

- Synergy of EARLINET and AERONET datasets for VRAME





- Lidar data already finilized are only used which are included in the ESA-CALIPSO database

Develop a new aerosol model

- Synergy of AERONET and EARLINET datasets for VRAME

VERTICAL RESOLVED:
Extinction Coefficient
Single Scattering Albedo
Phase Function
Assymetry Parameter

AEROSOL TYPES:
Marine polluted
European anthropogenic pollution
Continental background aerosols
Saharan dust
Volcanic aerosols in the stratosphere
Aged and young forest fire smoke

WAVELENGTHs (MERIS):
443, 510, 560, 709, 778, 865 nm

- The first and currently primary application of the new aerosol model will be the atmospheric correction of MERIS data over the ocean

VRAME

1.

Development of the non maritime aerosol database

- Identification of aerosol layers
- Aerosol – type analysis
- Profiles of optical and microphysical properties
  - Extinction Coefficient
  - Single Scattering Albedo
  - Phase Function
  - Assymetry Parameter

As input to RT model

VRAME

1. Development of the non maritime aerosol database

2. LUT generation
   - RT calculations for individual and for the generalized EARLINET/AERONET datasets
   - The results of these calculations will be the radiances on TOA at different wavelengths and viewing geometries

VRAME

1. Development of the non maritime aerosol database

2. LUT generation

3. Sensitivity Study

   Is it possible to retrieve the aerosol type from TOA radiances?

   measurable radiances of a satellite sensor show significant differences in the presence of different aerosol types

   How profitable is the knowledge of the aerosol type?

   climatological mean aerosol data/specific aerosol type

   How profitable is the knowledge of the profile information?

   column average aerosol properties / vertical information

VRAME

1. Development of the non maritime aerosol database
2. LUT generation
3. Sensitivity Study
4. Aerosol distinction algorithms development
    - Distinguish between different aerosol types by the ratio of radiances measured in different MERIS channel

VRAME

1. Development of the non maritime aerosol database

2. LUT generation

3. Sensitivity Study

4. Aerosol distinction algorithms development

5. Validation
   - Include in-situ measurements of water leaving reflectance spectra and demonstrate if an improvement of the atmospheric correction with the new aerosol model can be achieved

VRAME

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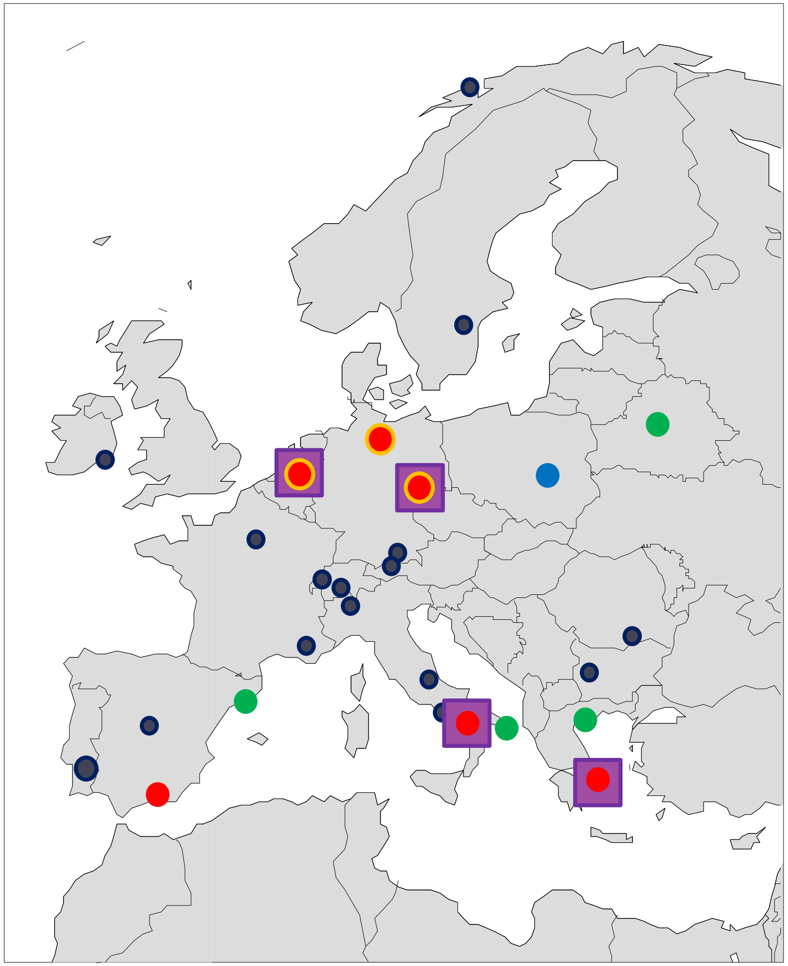
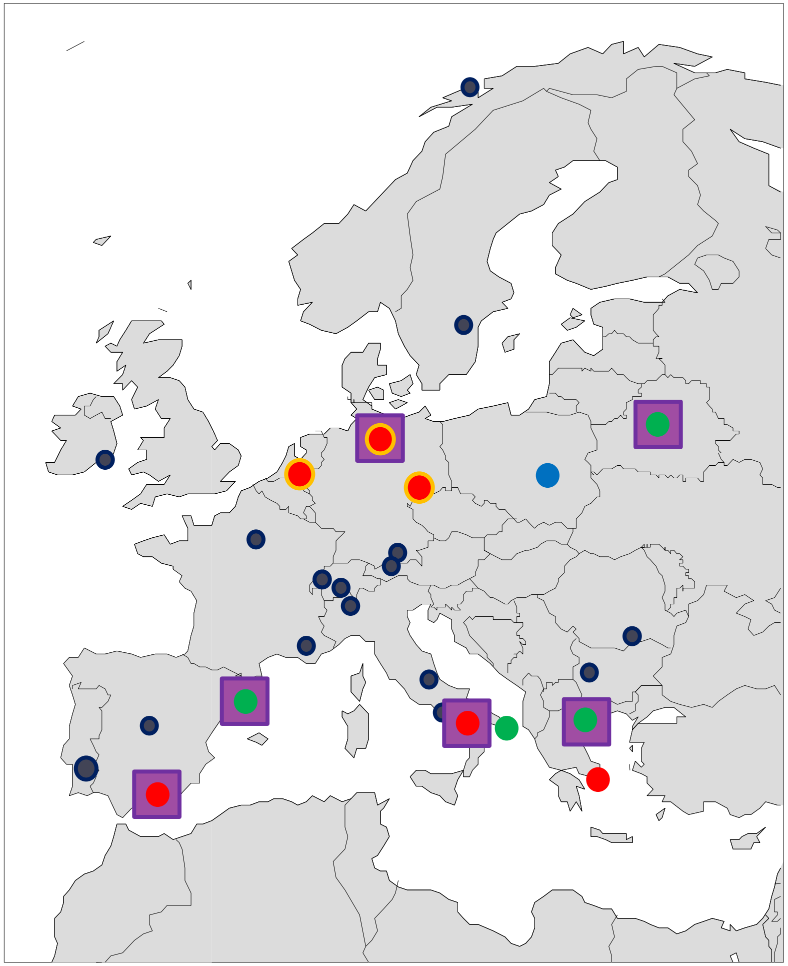
EARLINET and AERONET for VRAME



Super-site stations

- Cabauw, The Netherlands (2008-2009)
- Leipzig, Germany (2001-2009)
- Potenza, Italy (2006-2009)
- Athens, Greece (2008-2009)

EARLINET and AERONET for VRAME



Super-sites

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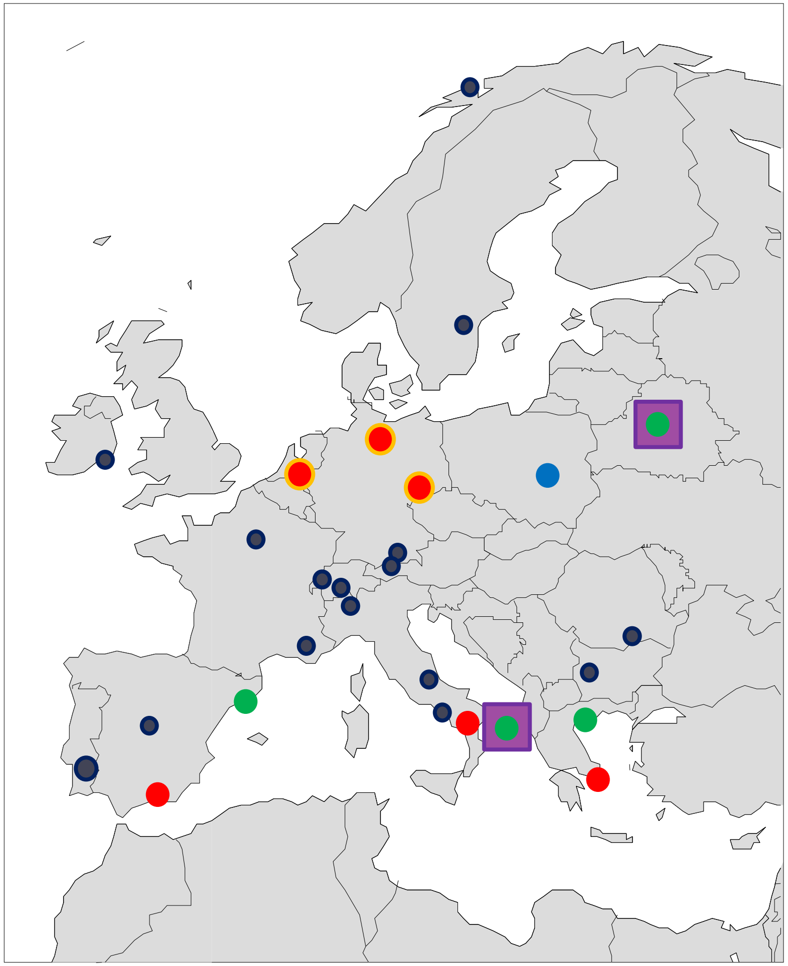
High performance

- Thessaloniki, Greece (2003-2009)
- Potenza, Italy (2004-2006)
- Barcelona, Spain (2006-2009)
- Granada, Spain (2006-2009)
- Hamburg, Germany (2006-2009)
- Minsk, Belarus (2006-2009)

EARLINET and AERONET for VRAME



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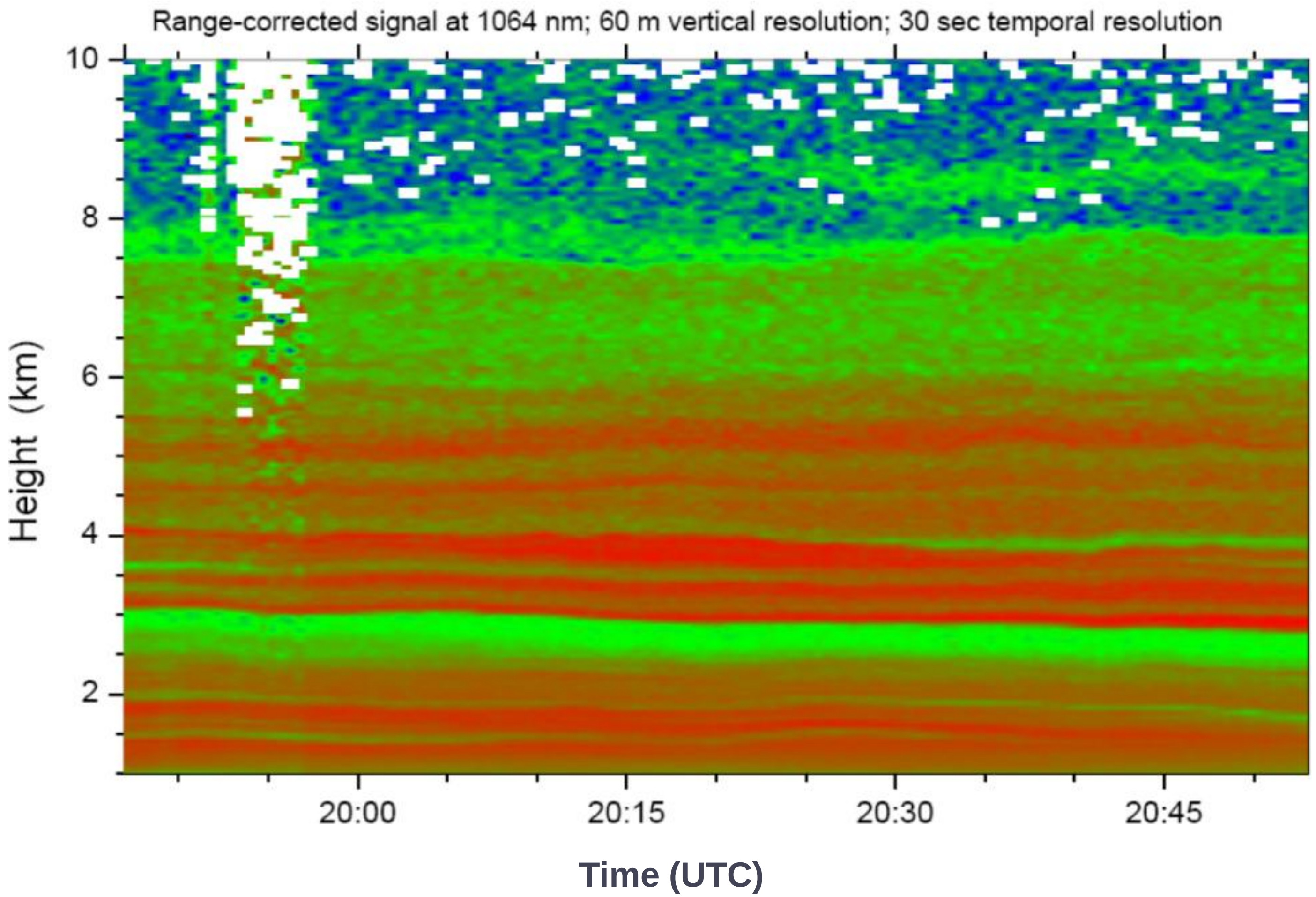
Basic stations

- Belsk, Poland (2006-2009)
- Lecce, Italy (2006-2009)

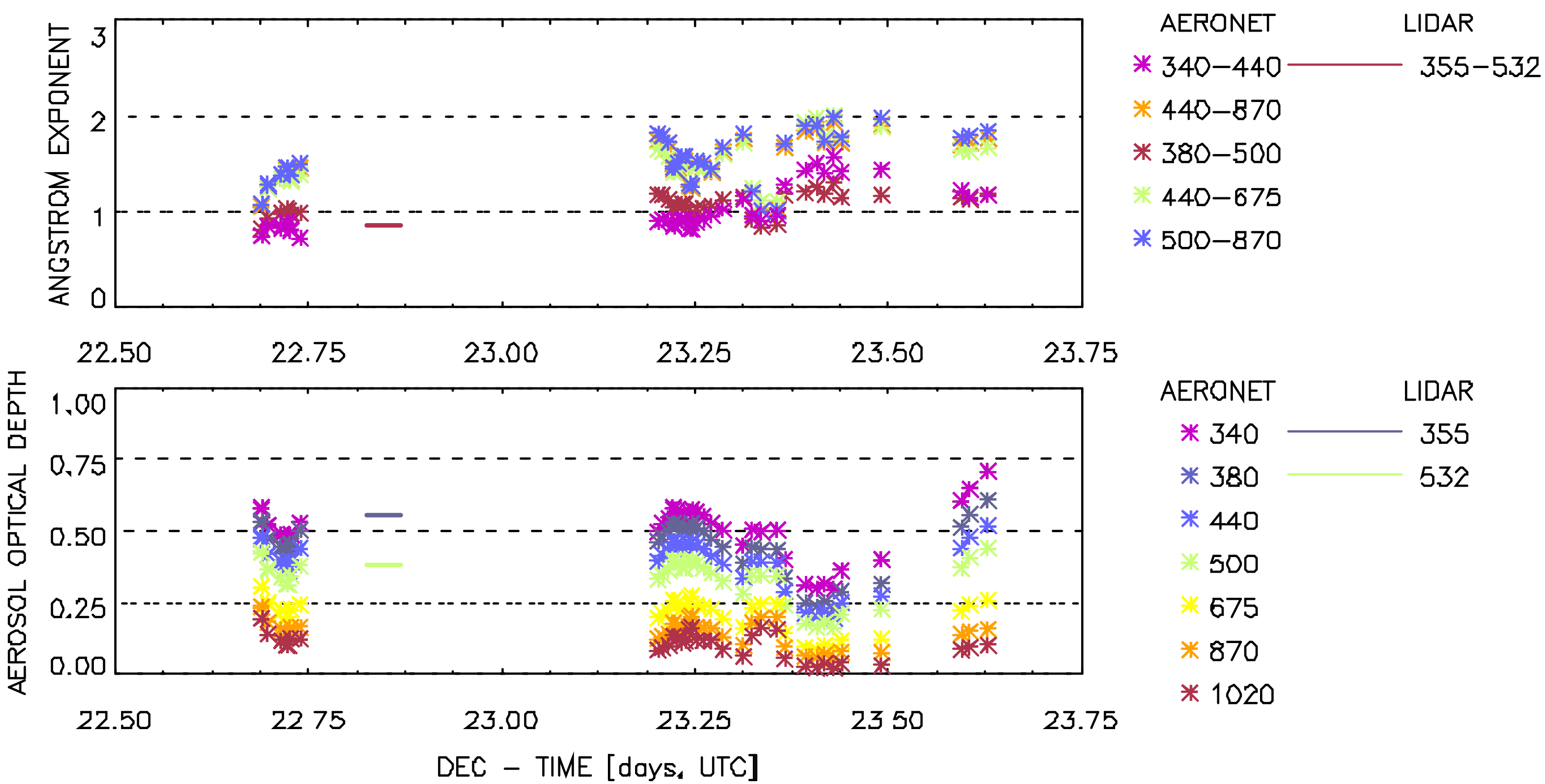
EARLINET and AERONET for VRAME

	Super-sites
	Cabauw, The Netherlands
22 July 2004: Smoke / Anthropogenic	Leipzig, Germany
	Potenza, Italy
	Athens, Greece
	High performance
10 June 2010: Anthropogenic	Thessaloniki, Greece
	Potenza, Italy
	Barcelona, Spain
	Granada, Spain
	Hamburg, Germany
	Minsk, Belarus
Leipzig as only bp at 532 nm	**Basic stations**
	Belsk, Poland
	Lecce, Italy

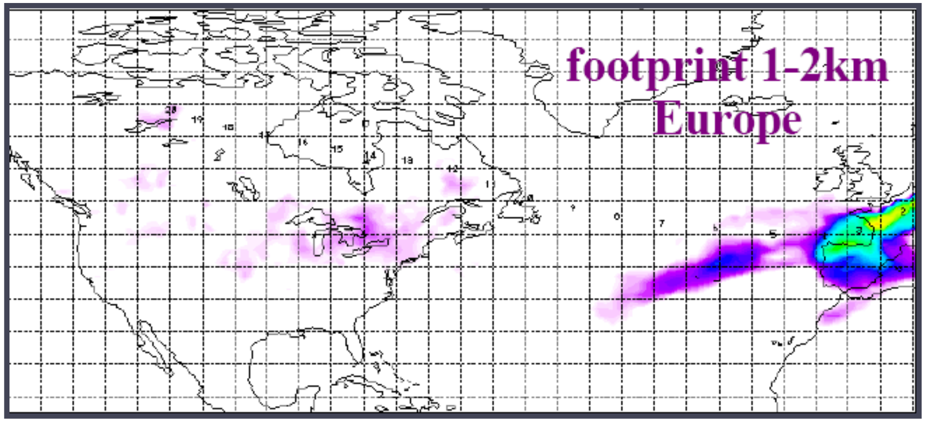
Leipzig, 22 July 2004

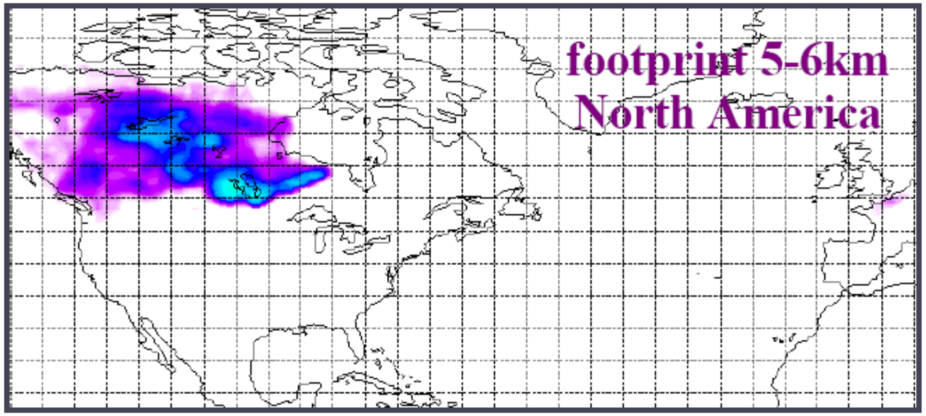


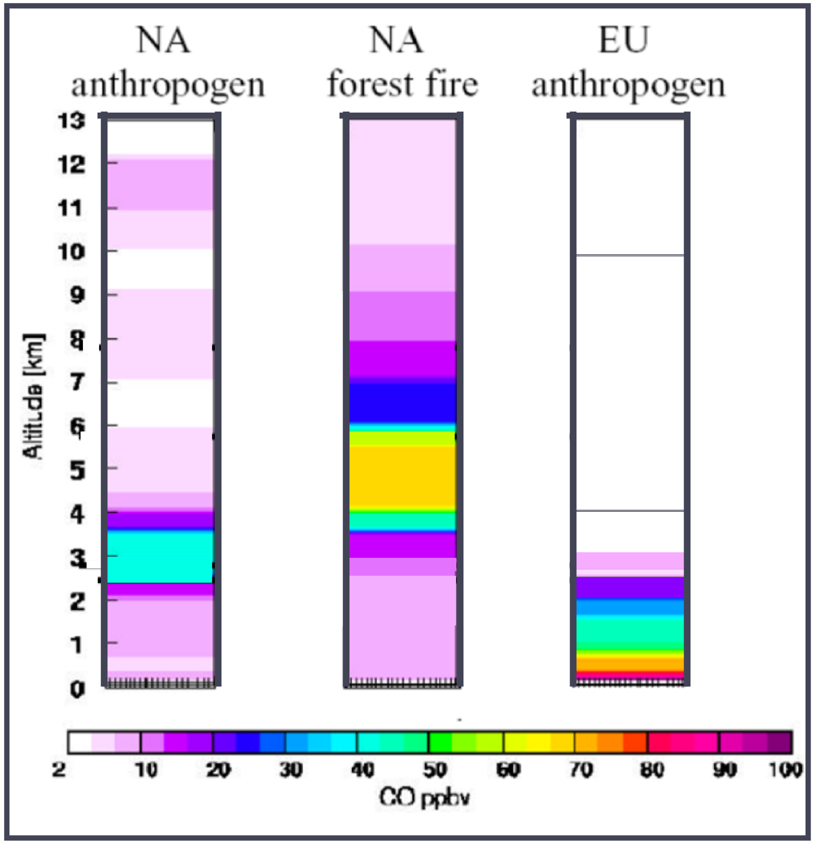
Consistency of two datasets



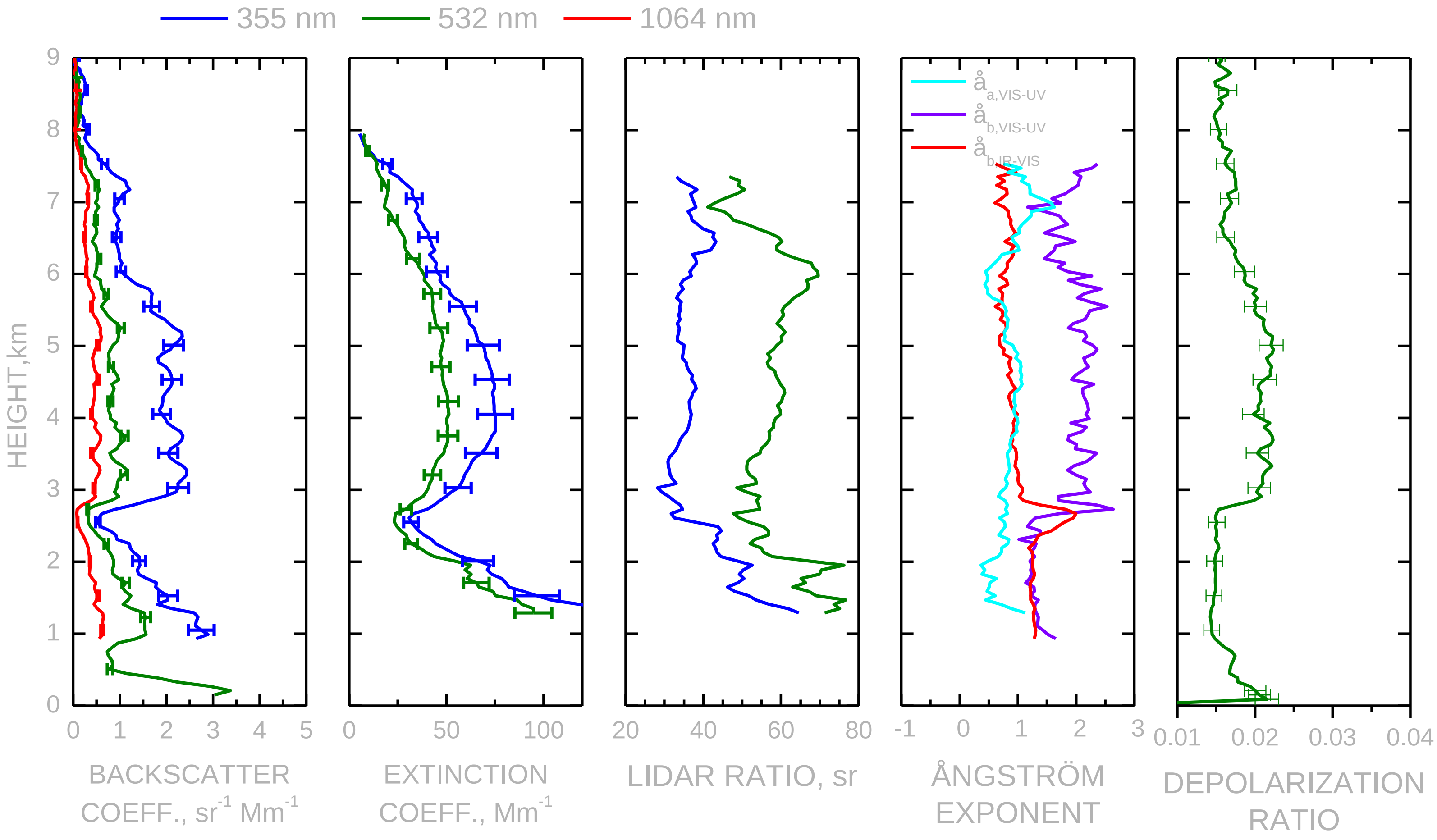
Aerosol Type, 22 July 2004







The optical profiles, 22 July 2004



Extinction Coefficient

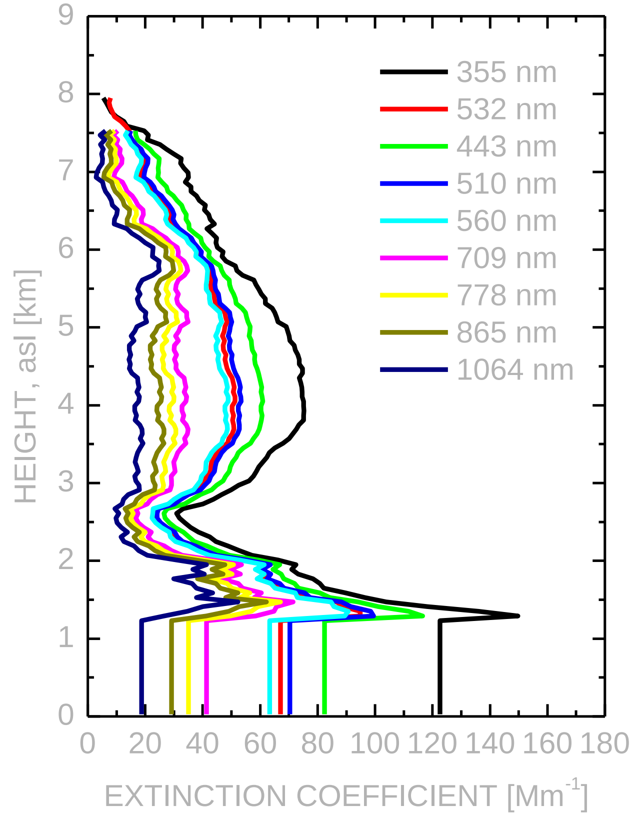
WAVELENGTHs (MERIS channels):
443, 510, 560, 709, 778, 865 nm

443,510 and 560 nm

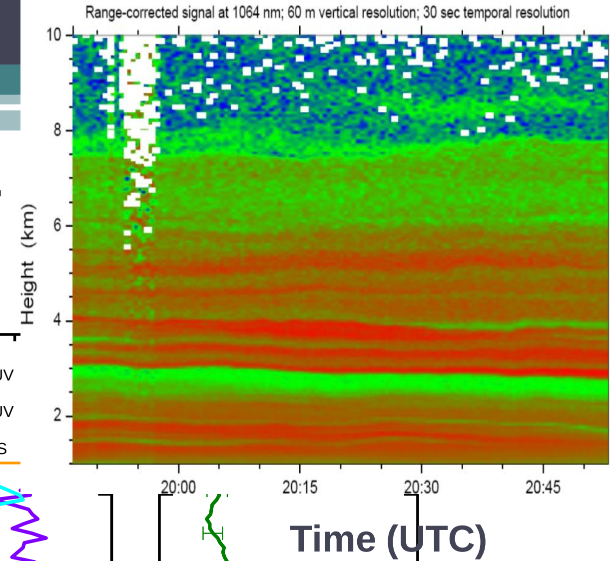
- Aerosol Extinction Coefficient at 532 nm [LIDAR]
- Ångström exponent between 355/532 nm [LIDAR]

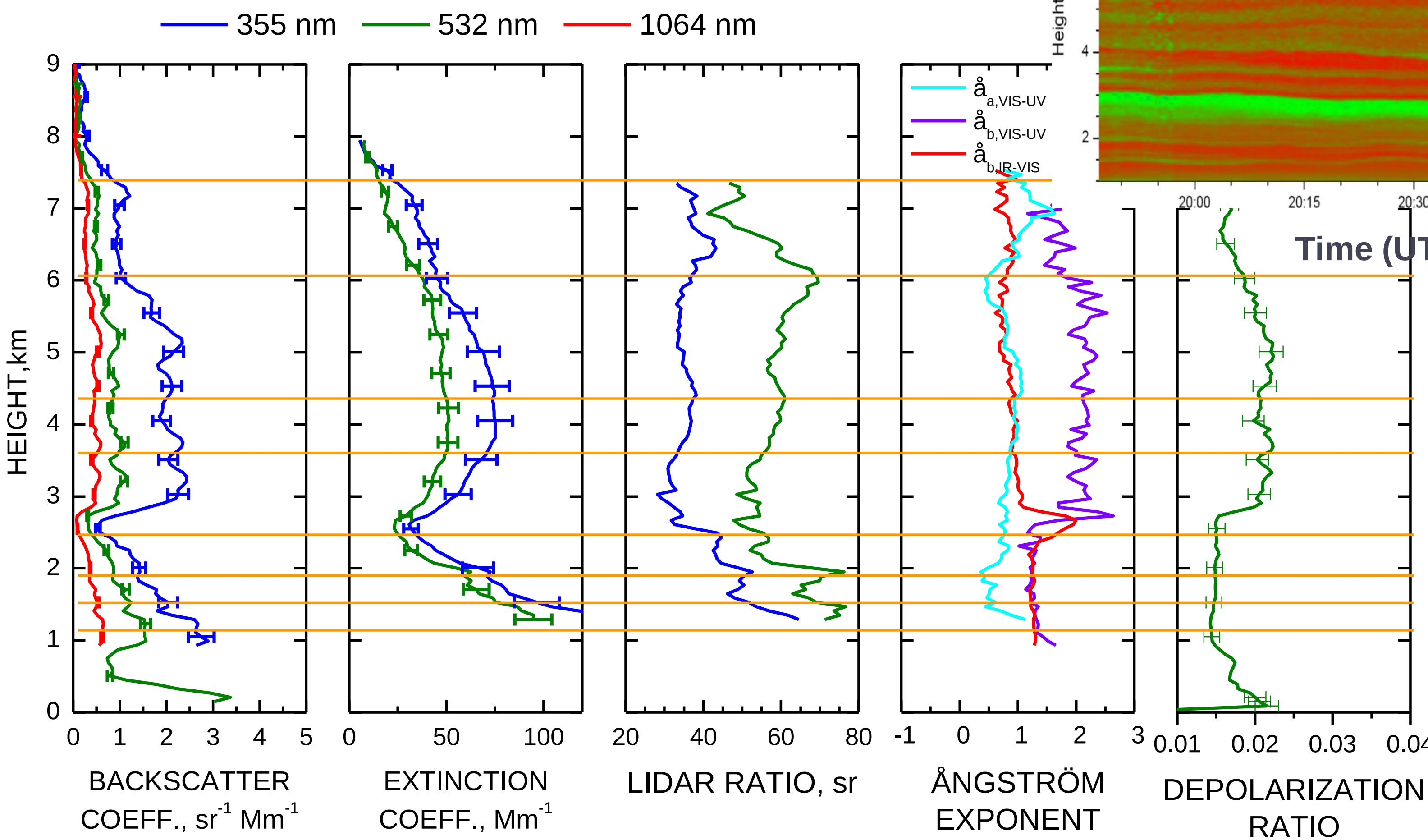
709,778 and 865 nm

- Aerosol Extinction Coefficient at 532 nm [LIDAR]
- Ångström exponent between 500/870 nm [CIMEL]



The optical profiles, 22 July 2004



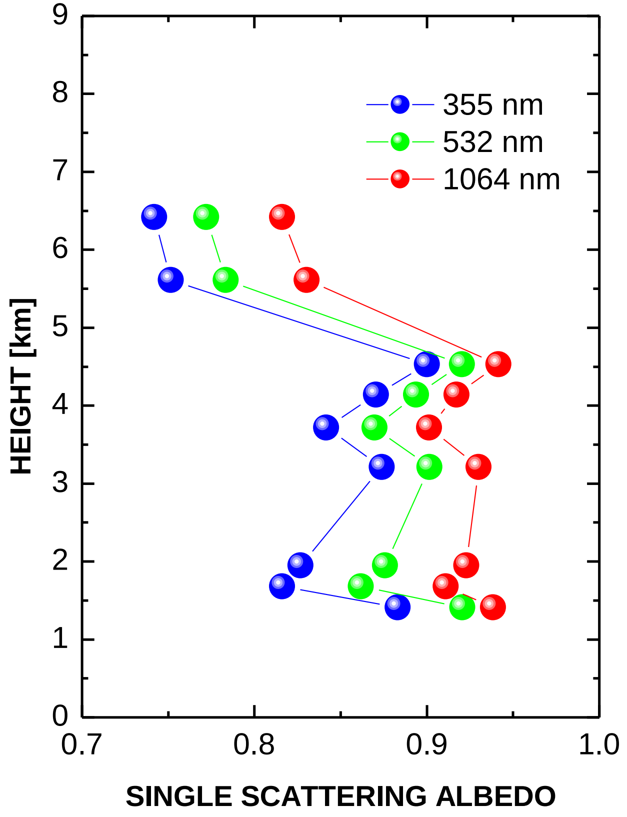


Single Scattering Albedo

WAVELENGTHs (MERIS channels):
443, 510, 560, 709, 778, 865 nm

With inversion of optical properties [3 backscatters and 2 extinctions] we retrieve the profile of SSA for 355, 532 and 1064 nm

Linear approximation to estimate the desired wavelengths

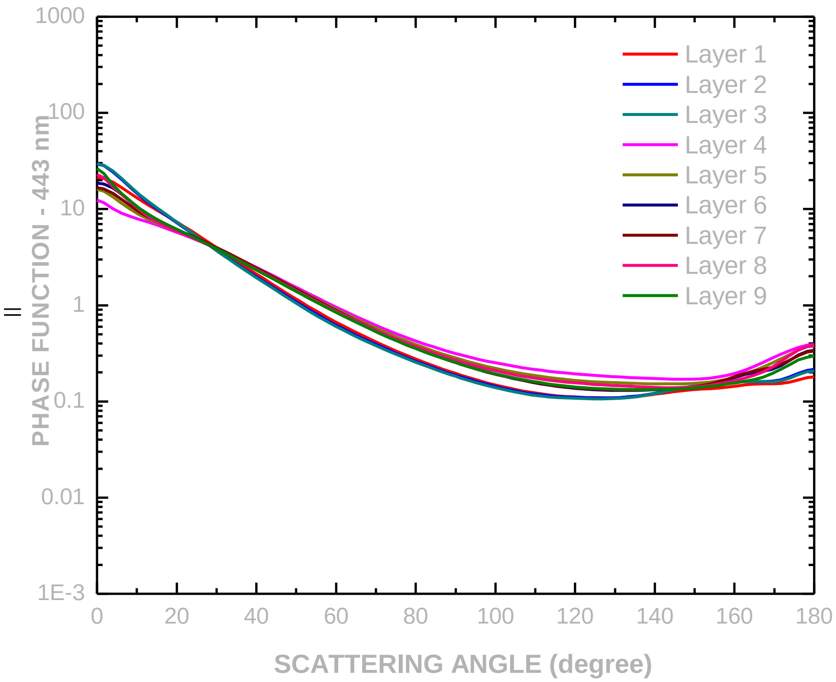


Phase Function and Asymmetry Parameter

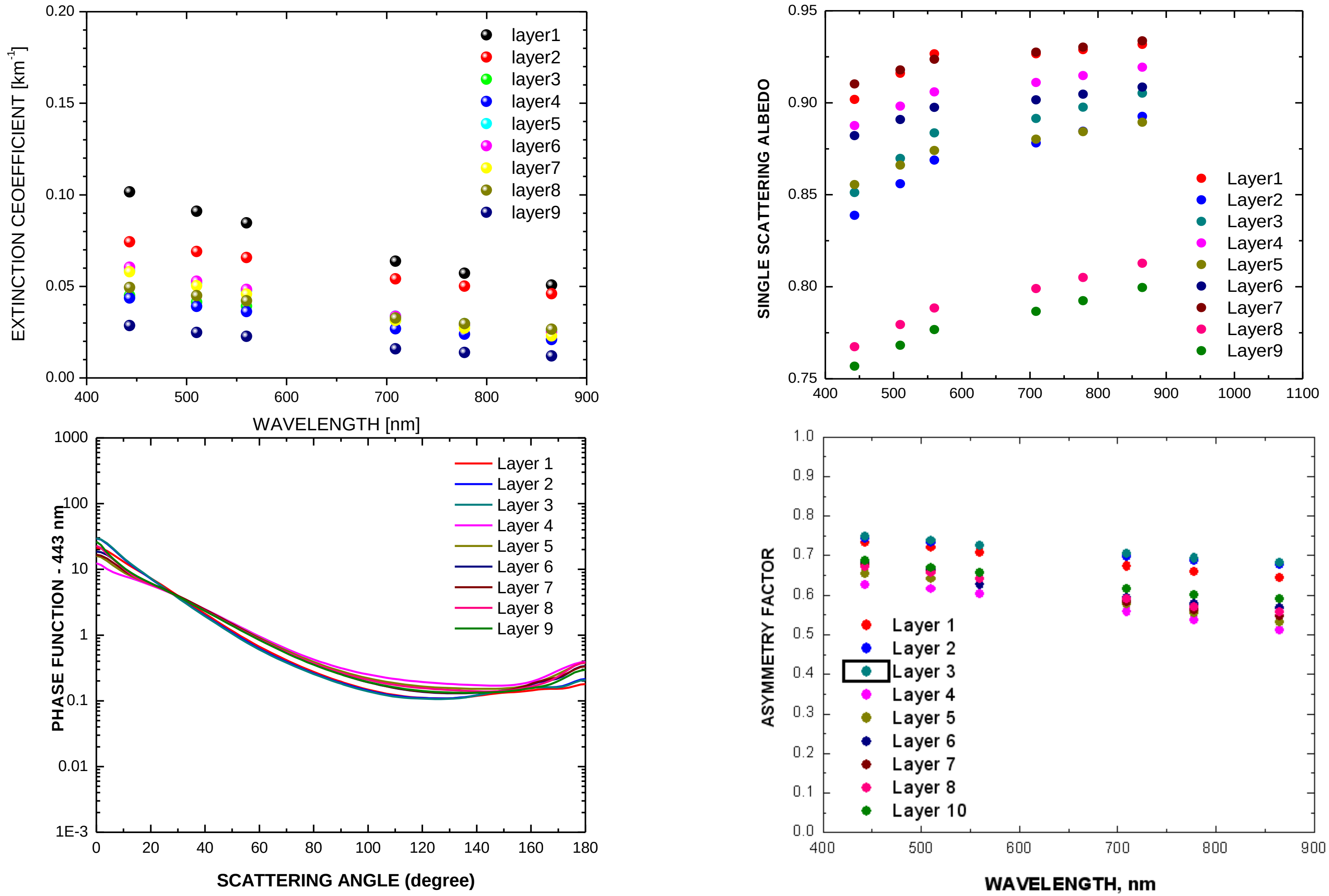
Refractive index and size distribution from inversion algorithm are used in a Mie code to find the phase function in several wavelengths for each layer

Then the asymmetry parameter is being calculated:

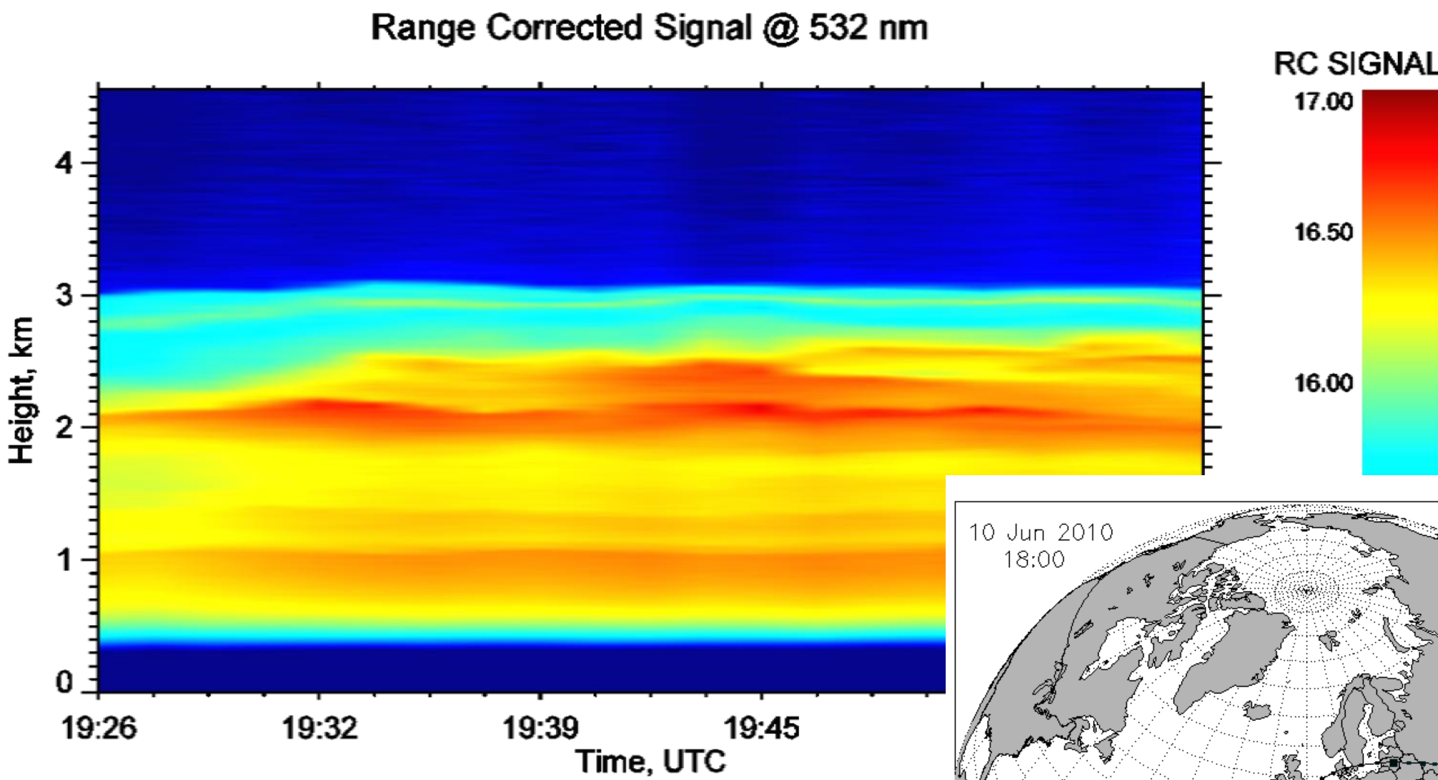
$$g = \frac{1}{2}\int_{-1}^{1} P(\cos\vartheta)\cos\theta d\cos\theta$$

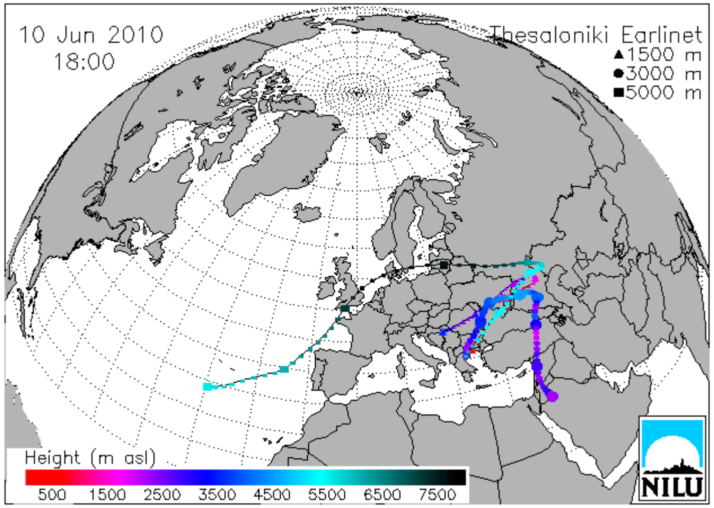


The results: Input for RT model

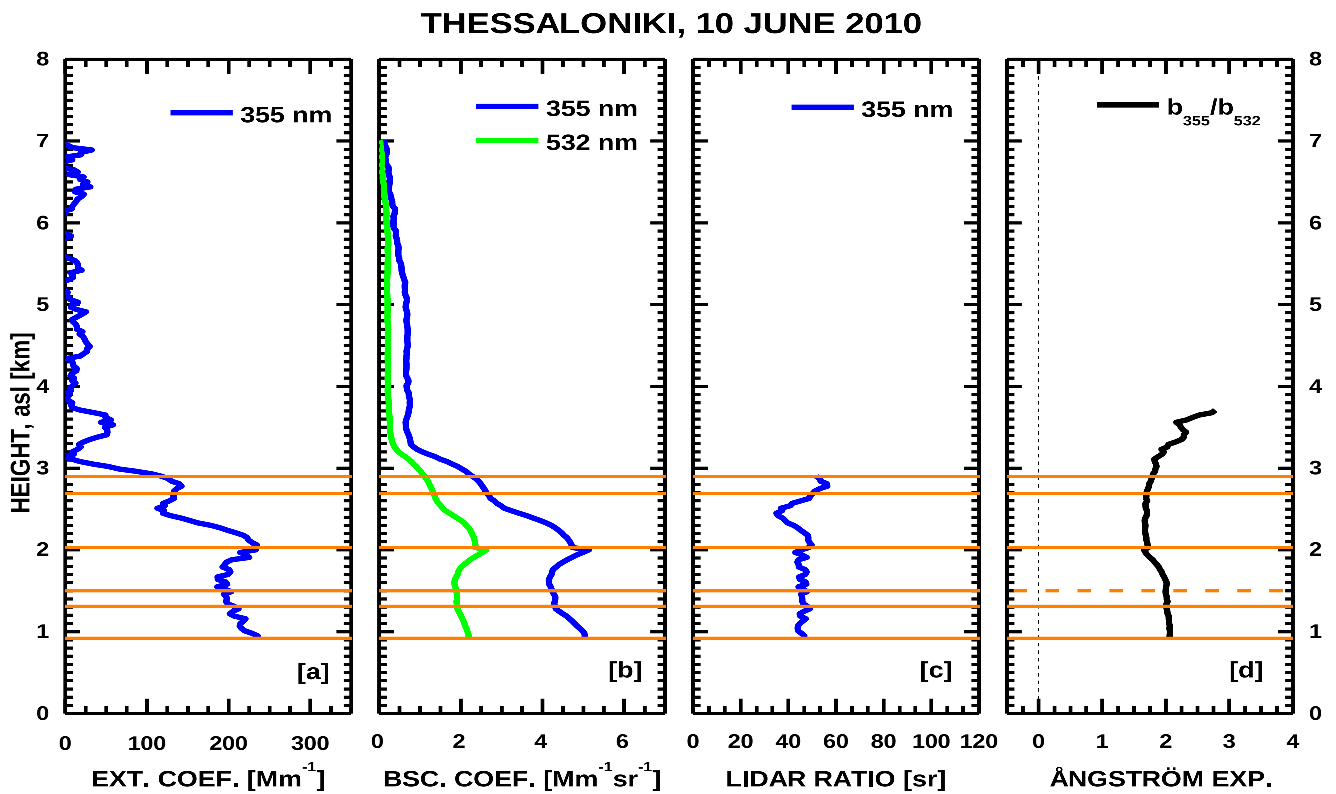


Thessaloniki, 10 June 2010





The optical profiles



Additional assumptions to reach MWL stations

Following Balis et al. (2009) the missing information in lidar profiles are approximated with the synergy of sunphotometer data:

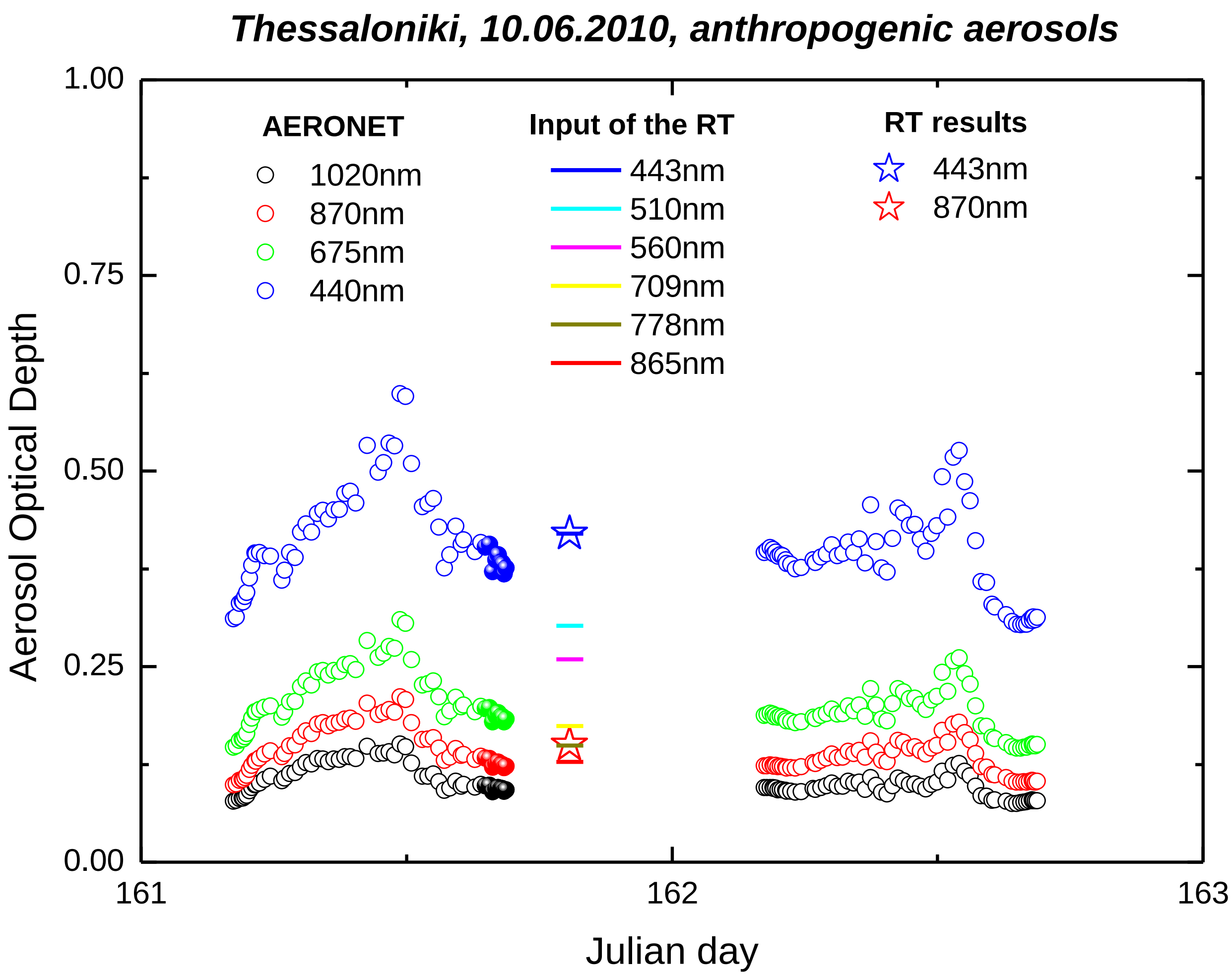
$$LR_{355} = LR_{532} \Rightarrow a_{532}$$

CIMEL

$$\frac{A^{layer}_{355/532}}{A^{layer}_{532/1020}} = \frac{A^{total}_{355/532}}{A^{total}_{532/1020}} \Rightarrow a_{1020}$$

In this way the inversion algorithim is being applied and the sequence of the previous steps could be applied

Consistency check



Leipzig, 22 July 2004 as basic station

Apply the information of backscatter contribution to the total backscatter into the total aerosol optical depth to retrieve extinction coefficients at several layers and several wavelengths

Assume same microphysical properties though column

Summary

- A 1% error in atmospheric correction will result in a 10% error in water-leaving radiances

- The main objective of VRAME is to develop a dynamic, vertically resolved aerosol model to be delivered to the sattelite community for accurate atmospheric correction.

- With the synergy of AERONET and EARLINET data a dynamic aerosol model will be developed

- Different assumptions need to be introduced for each group of dataset

Thank you for your attention