

Ülle Kikas for GLOBE CC-s in Kiew, June 2011

Measurement campaign of Aerosol Optical Thickness France - Estonia

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PhD in environmental physics

SCIENTIFIC BACKGROUND FOR TEACHERS

SCIENTIFIC BACKGROUND



Atmospheric aerosol

Liquid and solid particles, size 2 nm -10 μm

Natural:

Crustal dust, fog, sea salt, volcanic, biomass burning, biogenic

Antropogenic:

smoke, black carbon - heating, burning, engines;
sulfates, nitrates - human activities, industry;
organics - transportation, industry

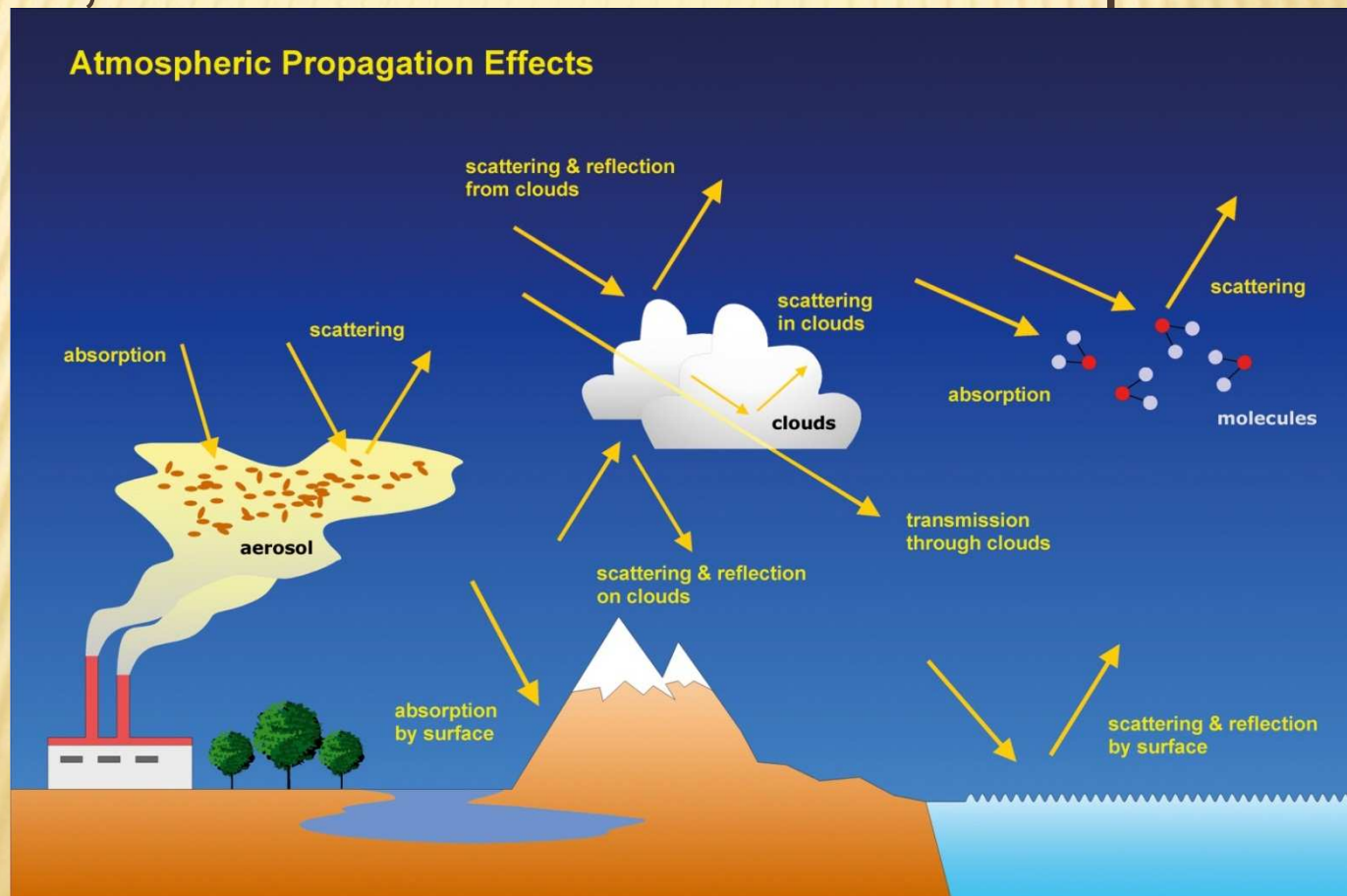


Brand meubelzaak Amsterdam



SOLAR RADIATION ATTENUATES IN THE ATMOSPHERE DUE TO

reflection, scattering and absorption on clouds, air molecules and aerosol particles



AEROSOL OPTICAL THICKNESS (DEPTH)

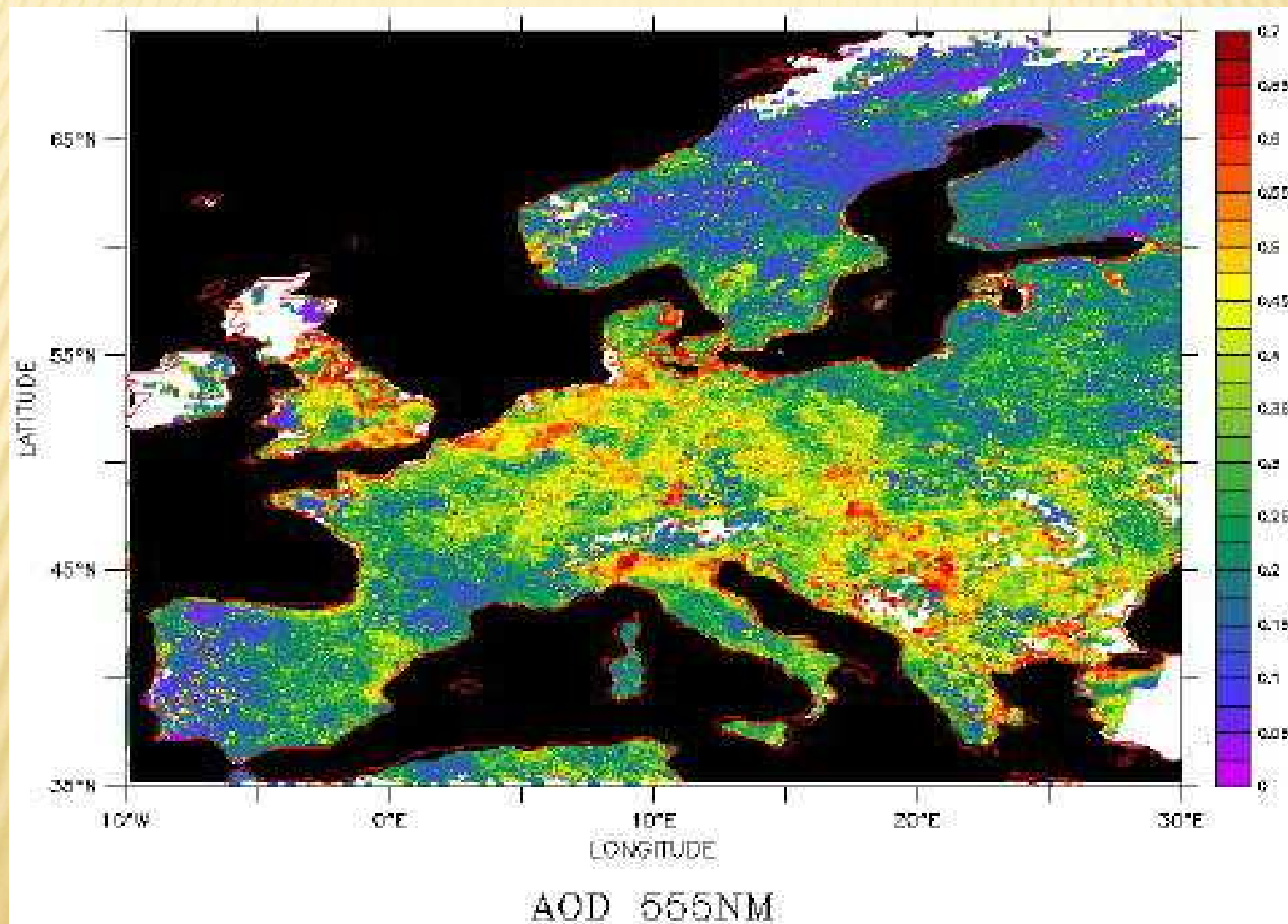
- ✘ a measure of the amount of light that aerosols scatter and absorb in the atmosphere (and generally prevent from reaching the surface).
- ✘ a measure of atmospheric transparency: the higher AOT, the smaller is transparency of the cloudfree atmosphere



AOT EXPRESSES THE QUANTITY OF LIGHT REMOVED FROM A BEAM DURING ITS PATH THROUGH AEROSOL

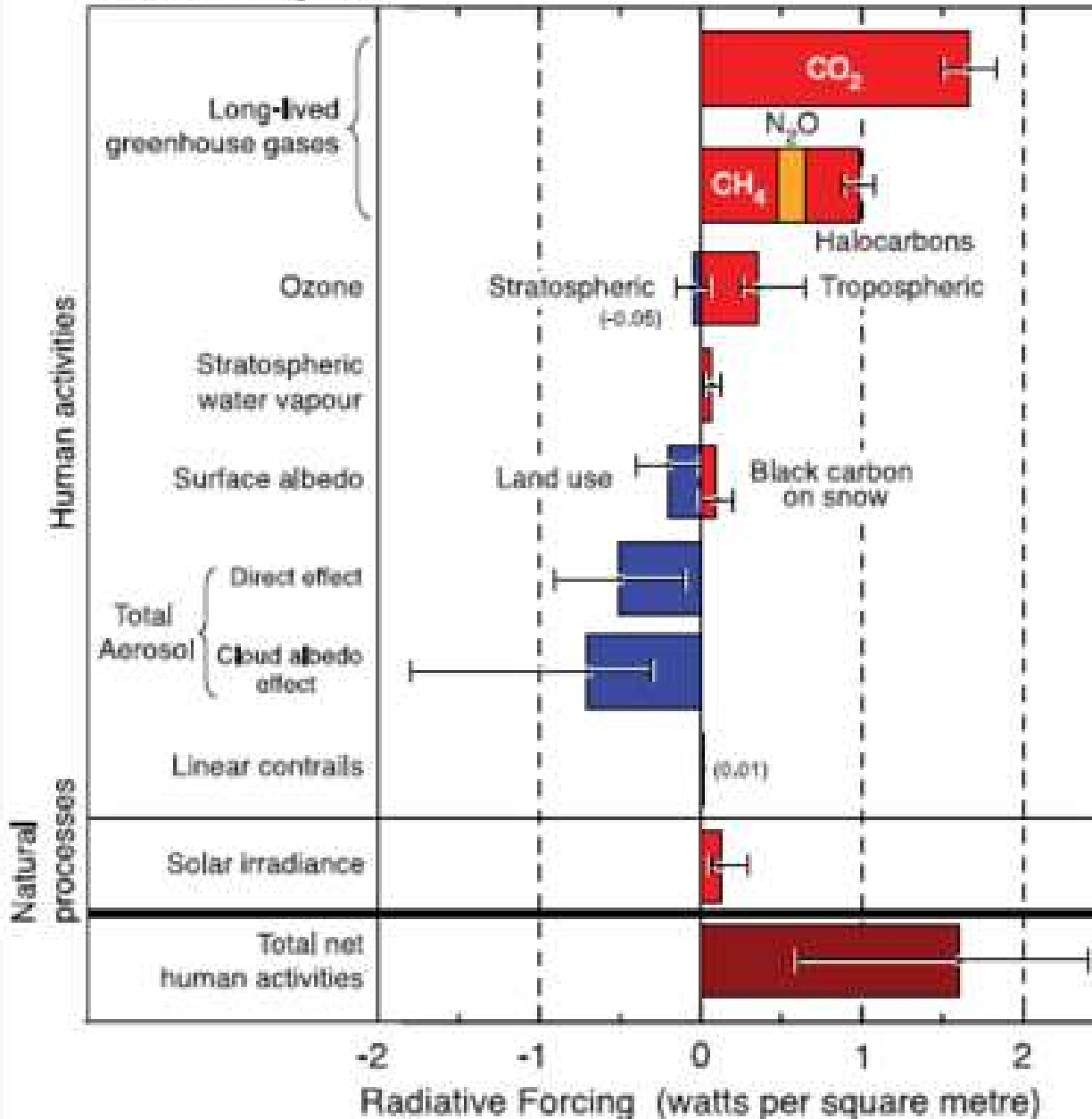
AOT	% of solar radiation reaching Earth surface
0,1	90,5%
0,2	81,9%
0,3	74,1%
0,4	67,0%
0,5	60,7%
0,6	59,9%
1,0	36,8%
2,0	8,2%
3,0	5,0%

AOT CAN BE MEASURED FROM SATELLITES OR FROM SURFACE BY SUN PHOTOMETERS

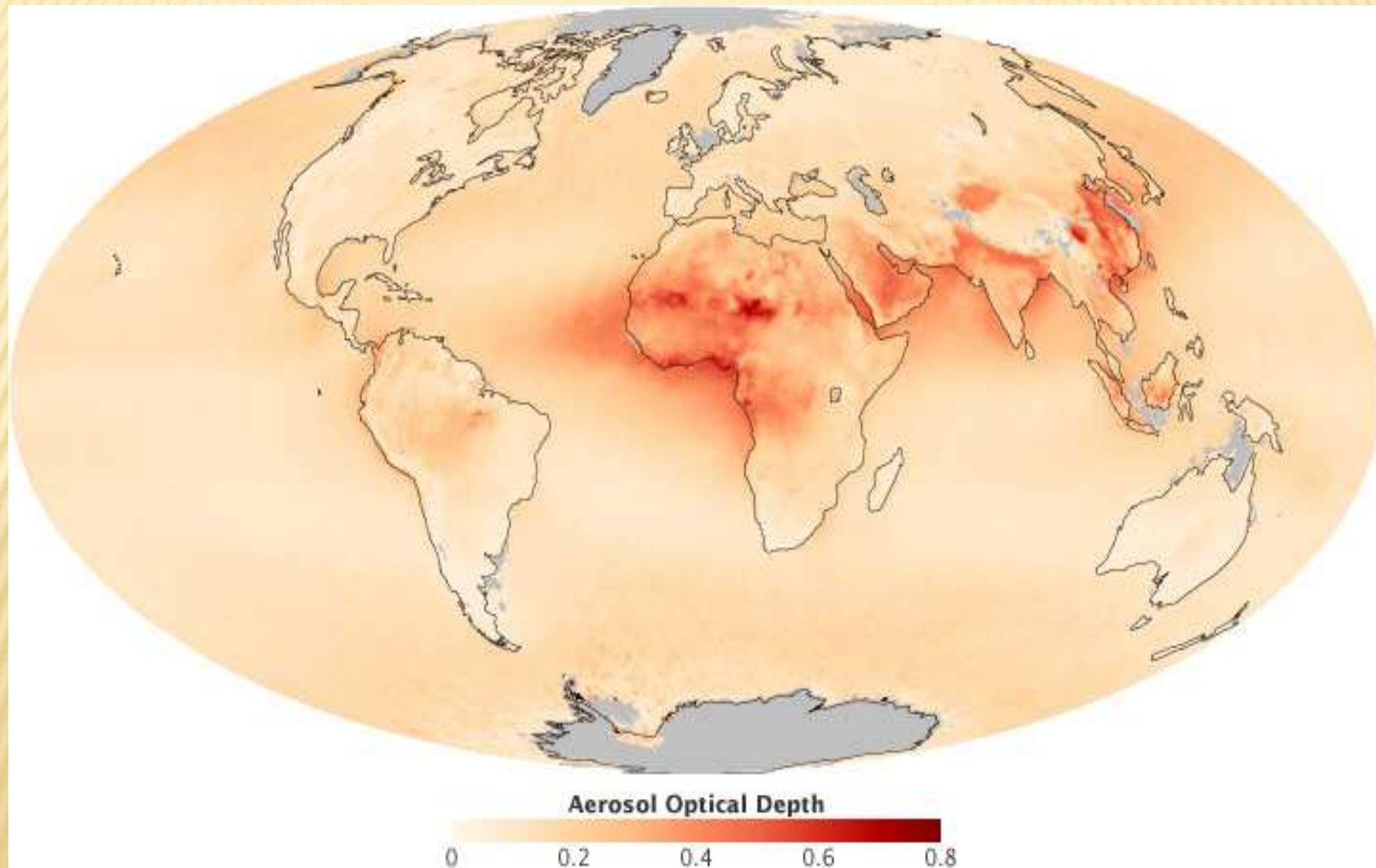


Radiative forcing of climate between 1750 and 2005

Radiative Forcing Terms



<http://earthobservatory.nasa.gov/Features/Aerosols/page5.php>



AOT VALUES AND VISUAL EFFECT

- ✘ AOT less than 0.05 - a clear sky with few aerosols and maximum visibility
- ✘ AOT around 1 - hazy conditions
- ✘ AOT above 2 or 3 - very high concentrations of aerosols.

**GLOBE / CALISP'AIR
AOT MEASUREMENT CAMPAIGN IN ESTONIA**

GLOBE / CALISP'AIR PHOTOMETEER



PREHISTORY

- ✘ Agreement of CC-S (Danielle, Karli, Kaido)
- ✘ Receiving equipment, instructions and calculation scheme from France (Danielle)
- ✘ Re-programming of the Calisph'air website for entering data from Estonian schools (FR)
<http://www.meteodesecoles.org/calisphair/>
- ✘ Teacher training in Estonia (Ülle, Karli)
 - + scientific background, measurements with sun photometer, AOT calculation, using additional data from Internet (sun elevation, see level air pressure)
- ✘ Web site of campaign: background, instructions, work sheets,
<http://www.globe.ee/globe/uurimisprojektid/?details=1&id=36>

SUPPORT MATERIALS AND ISTRUCTIONS IN WEB

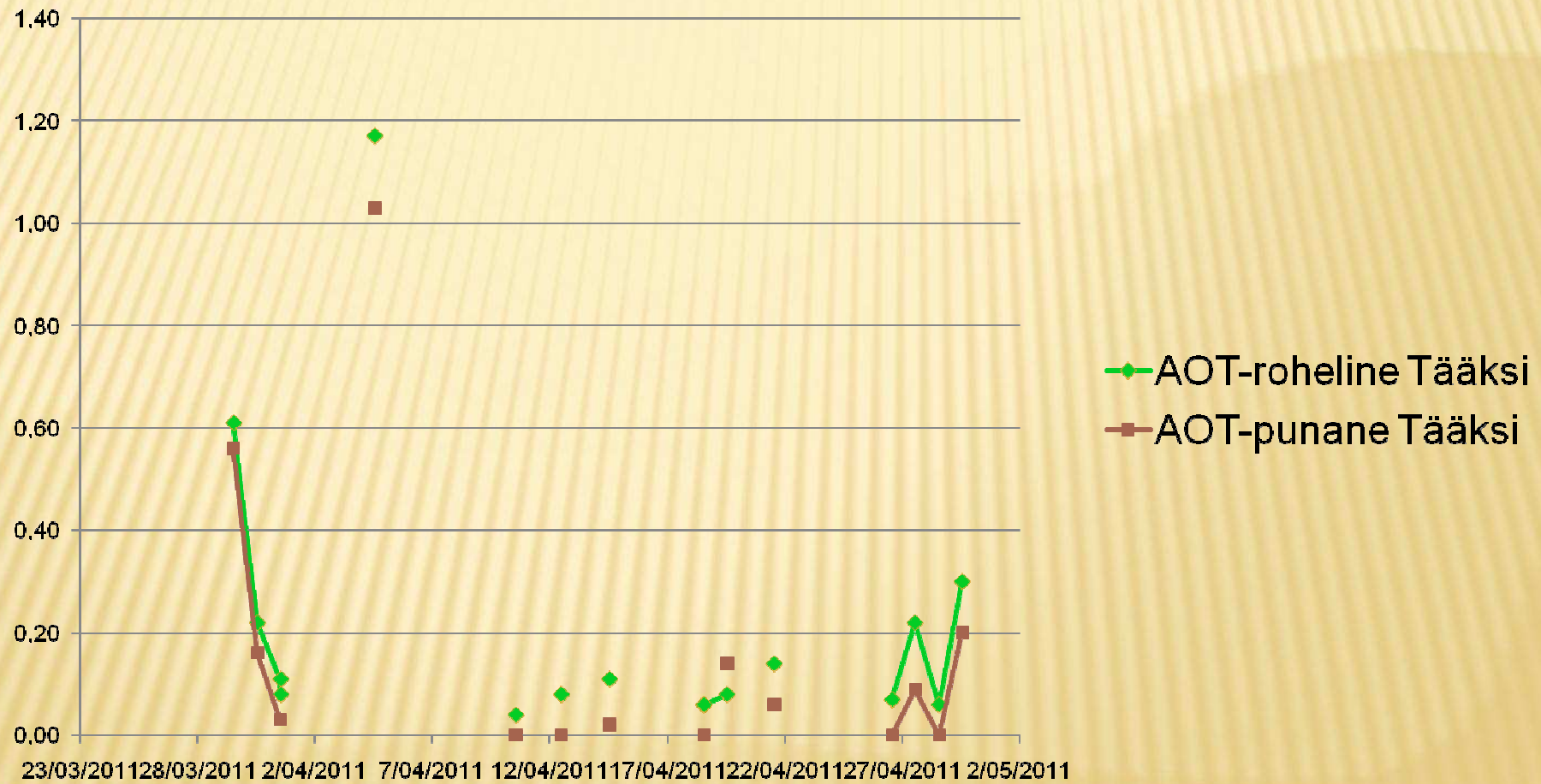
- ✘ Scientific background (ppt)
 - ✘ atmospheric aerosol
 - ✘ optical transparency of atmosphere
 - ✘ Aerosol optical thickness
 - ✘ model for measuring AOT with sun photometer
- ✘ Measurement with sun photometer (ppt, video from France)
 - ✘ Frequency, sky observation, measurement procedure, recording data
 - ✘ Geographic coordinates by GPS
- ✘ Getting additional data from Internet (ppt)
 - ✘ Calculation of sun elevation and sea level air pressure
- ✘ Data record and AOT calculation sheet (Excel file)
- ✘ Instruction for data enter

ATMOSFÄÄRI OPTILISE TIHEDUSE MÕÕTMISANDMED					Fotomeetri nr				
nädalapäev	Esmaspäev				62				
kuupäev	28.03.2011 pp/kk/aaa				Muhu Põhikool				
kellaaeg tt:mm	13:35tt:mm				Mõõtmiskoht	Eesti Saare mk Muhu v Liiva k			
õhutemperatuur	11 °C				Mõõtjad	Agnes Äkke, Emma Maltis			
koordinaadid	58,6N 23,2E								
Kõrgus merepinnast	20m								
Päikese kõrgus	34,51°				Kellaeg GMT	10:35			
Õhurõhk	1000hPa								
Õhurõhk merepinnal	1002,5hPa								
V ₀ roheline	2,46V				kollased väljad täida iga mõõtmise ajal uuesti!				
V ₀ punane	3,09V								
V roheline	1,65V								
V punane	2,9V								
AOT arvutus roheline valguse jaoks					AOT arvutus punase valguse jaoks				
kuupäev	d	28.märts	28.märts	0	kuupäev	d	28.märts	28.märts	0
Excentricité de l'orbite terrestre	ϵ	0,0167			Excentricité de l'orbite terrestre	ϵ	0,0167		
Distance Terre Soleil	R			0,9833	Distance Terre Soleil	R			0,9833
Päikese kõrgus	α		34,51		Päikese kõrgus	α		34,51	
Masse d'air relative	m			1,7651	Masse d'air relative	m			1,7651
Fotomeetri kalibratsioonikonstant roheline valguse jaoks	V ₀		2,46		Fotomeetri kalibratsioonikonstant punase valguse jaoks	V ₀		3,09	
Fotomeetri pimenäit	V _{dark}		0		Fotomeetri pimenäit	V _{dark}		0	
Fotomeetri näit roheline valguse jaoks	V		1,65		Fotomeetri näit punase valguse jaoks	V		2,9	
Valeur de la dispersion moléculaire de la lumière	a _R	0,13813			Valeur de la dispersion moléculaire de la lumière	a _R	0,05793		
Õhurõhk	P		1000		Õhurõhk	P		1000	
Õhurõhk merepinnal	P ₀		1002,5		Õhurõhk merepinnal	P ₀		1002,5	
Atmosfääri optiline tihedus	AOT			0,11	Atmosfääri optiline tihedus	AOT			0,00

SCHOOLS PARTICIPATING IN ESTONIA

- × Valga PK
- × Vormsi PK
- × Narva HG
- × Muhu PK
- × Tallinna
Tehnikagümnaasium
- × Paide G
- × Tääksi PK
- × Viljandi Paalalinna G
- × Kilingi-Nõmme G
- × Audentes
- × Tartu Hiie (HEV)
- × Kääpa PK

AOT DATA FROM TÄÄKSI BASIC SCHOOL

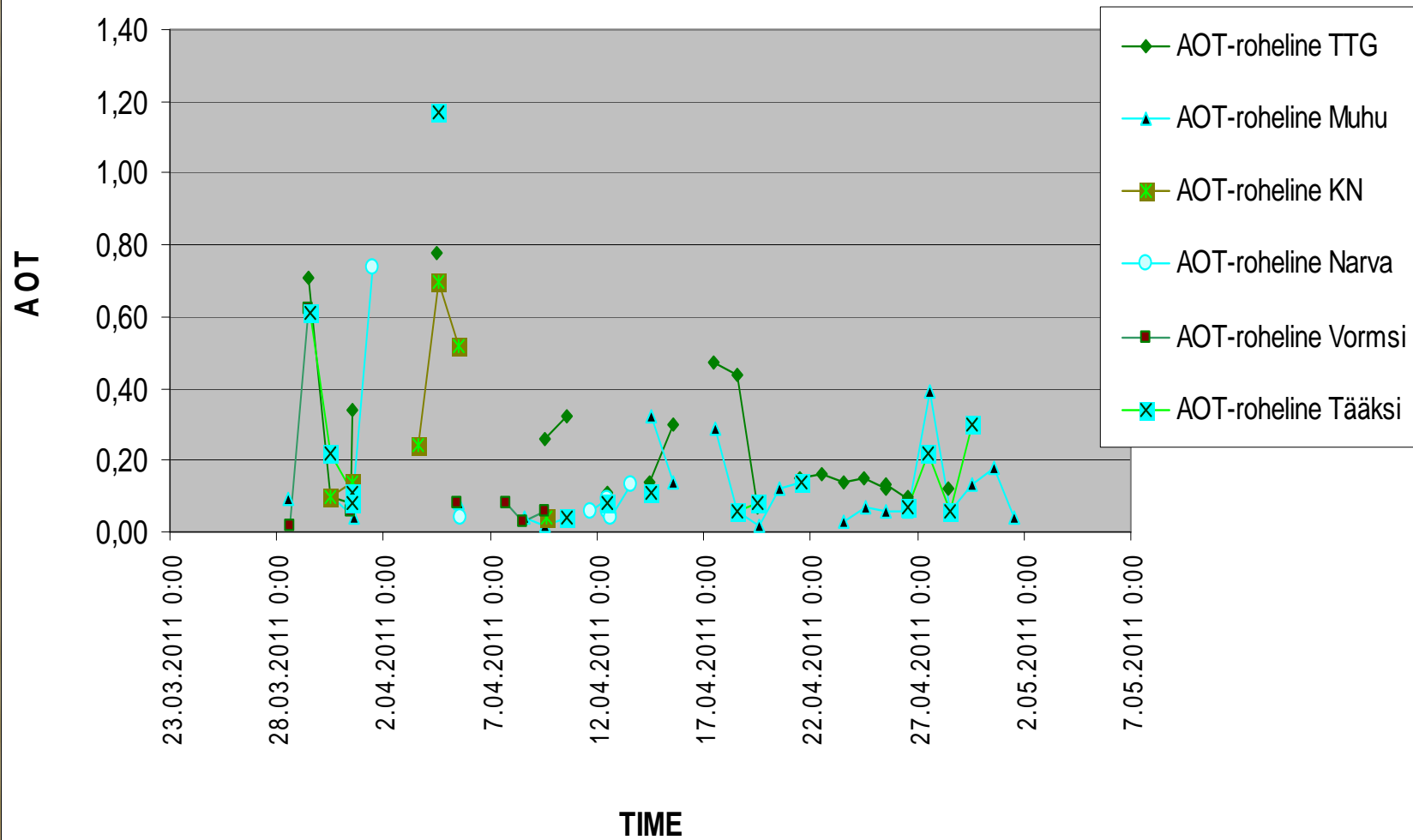


RESULTS

Period: 28 Mar–9 Apr–5 May

- 8 schools around the country got agreeable results
 - AOT_{green} 0,02 – 1.17
 - AOT_{red} 0.00 – 1.03
- 2 schools measured substantially higher AOT-s
- 2 schools' got unreliable data
- School data were in the same range with AERONET data from Tõravere, Estonia (58N, 26E)

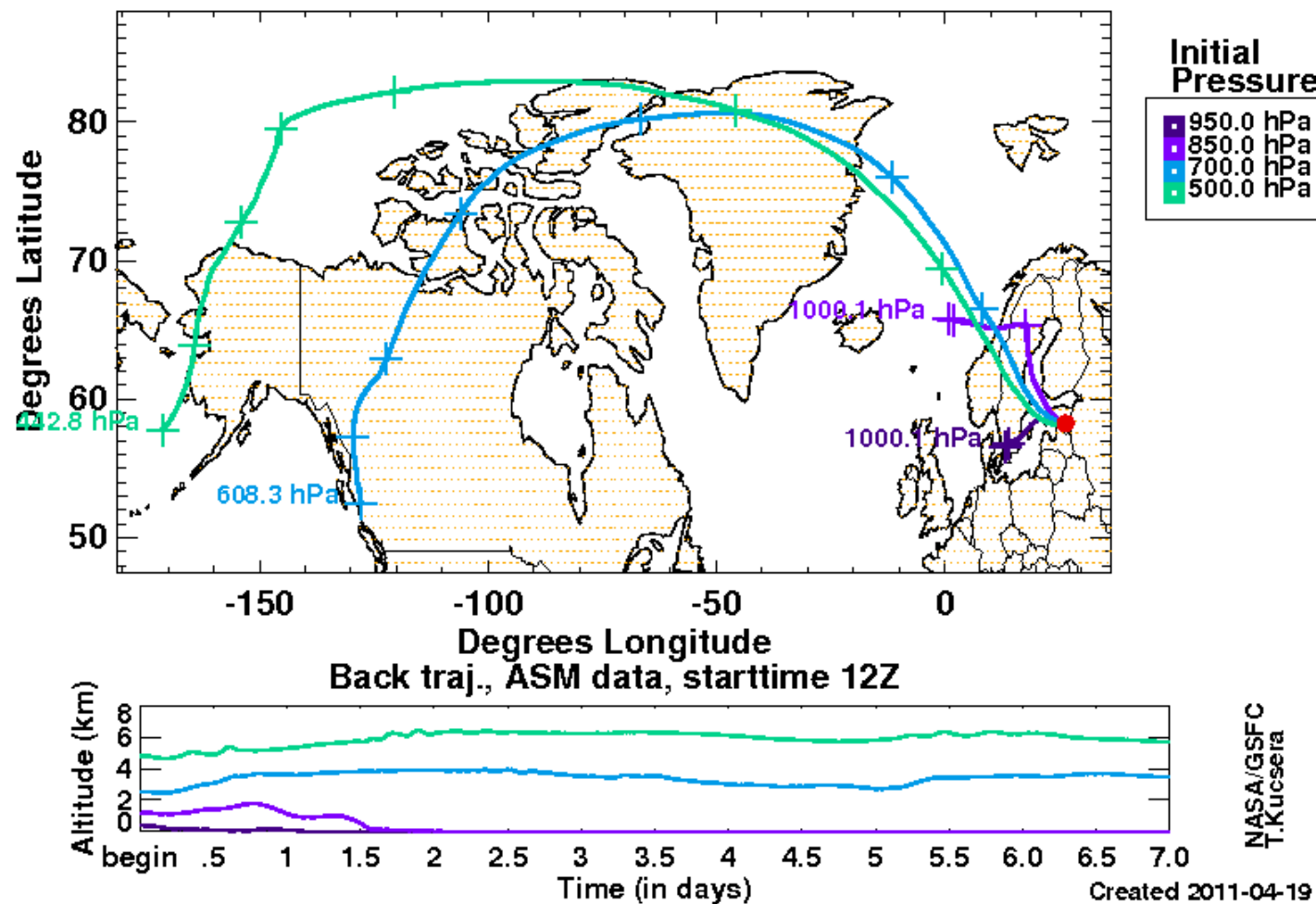
Variation of AOT-green in Tallinn, Narva, Muhu, Vormsi, Kilingi-Nõmme, Tääksi



Back trajectories of air help to explain AOT variation

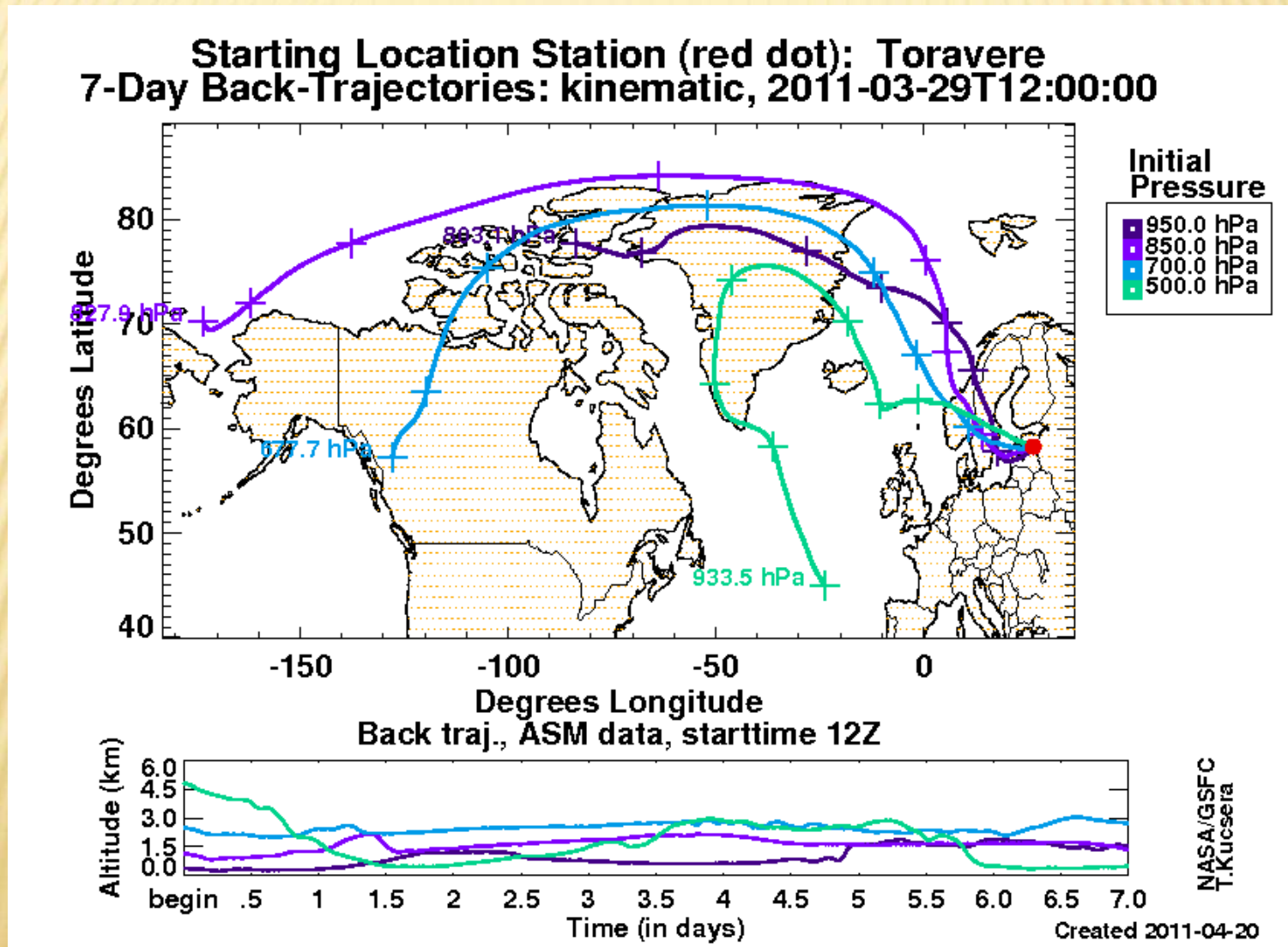
28 Mar: clean air from Arctic area → AOT_{green} below 0.09

Starting Location Station (red dot): Toravere
7-Day Back-Trajectories: kinematic, 2011-03-28T12:00:00



Back trajectories of air help to explain AOT variation

29 Mar: could air from Arctic mixed with warm air from Atlantics → $AOT_{green} 0,71$



WHAT STUDENTS HAVE LEARNED

- ✘ Aerosol is an important component of air which effects transfer of solar radiation
- ✘ How radiation interacts with medium (aerosol)
- ✘ Why green light attenuation is always higher than red light attenuation
- ✘ How solar beam moves through atmosphere
- ✘ How to get solar angle for a certain geographic location and time
- ✘ How to measure with sun photometer and GPS
- ✘ How to use Excel for simple modeling

SUMMARY OF THE CAMPAIGN

- ✘ Campaign was successful
- ✘ Protocol is challenging for experienced GLOBE teachers
- ✘ Suitable for high-school students
 - + Measurement with sun photometer easy and fun, but
 - + scientific background and calculation model rather sophisticated
- ✘ The calculation model (developed in France in addition to traditional GLOBE protocol) is useful
 - ✘ enables more learning, not only measurement practice
 - ✘ enables to develop students' ICT skills

SUMMARY: PROBLEMATIC ISSUES

- ✘ AOT is extremely variable, there is almost no measure what result is right or wrong
- ✘ Interpretation of AOT values is complicated
 - ✘ requires additional data: local meteo, back trajectories, satellite images: Teachers should learn more!
 - ✘ collaboration with experts is needed
- ✘ Longer training is necessary for less experienced teachers
- ✘ Photometers
 - ✘ Red sensor of photometers is not enough sensitive?