The Aerosol Direct Radiative Impact on the regional climate in the MEDiterranean region : the ADRIMED project

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Workshop on Observations and modeling of aerosol and clouds properties for climate studies, 12-14 Sept.

MISTRALS

ChArMEx

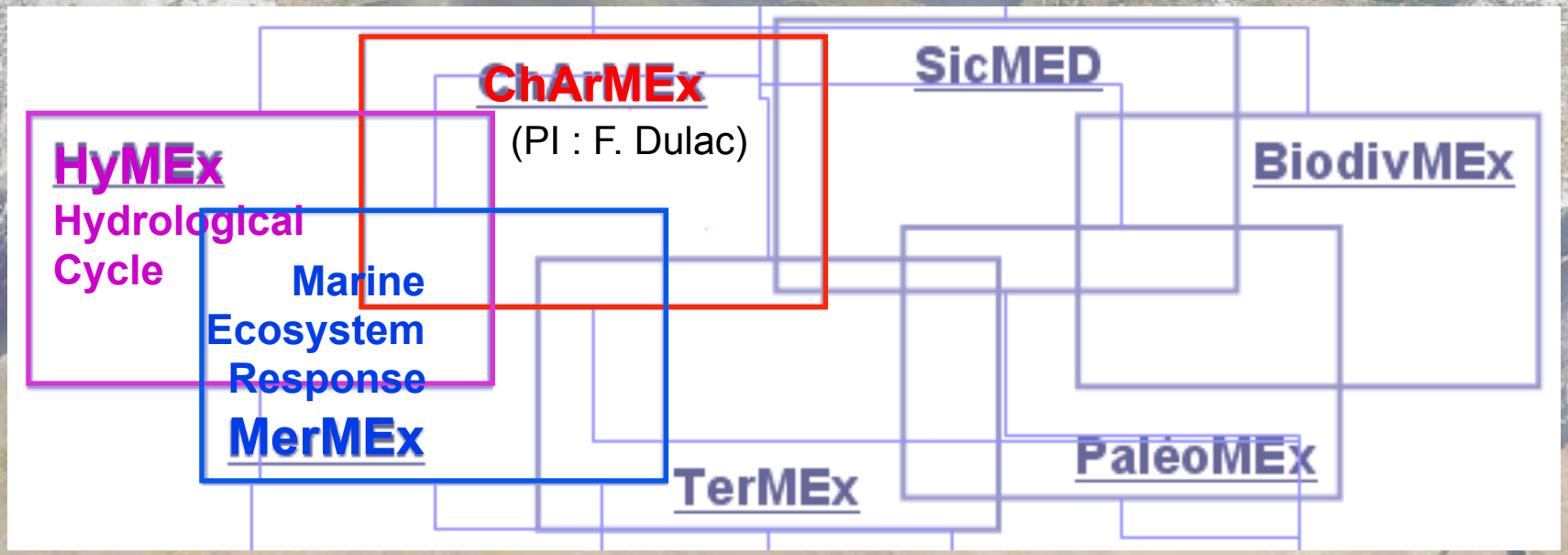
http://charmex.lsce.ipsl.fr/

MISTRALS

Mediterranean **I**ntegrated **ST**udies at **R**egional **A**nd **L**ocal **S**cales

ChArMEx is part of a new French multidisciplinary regional programme (MISTRALS) in the Mediterranean region

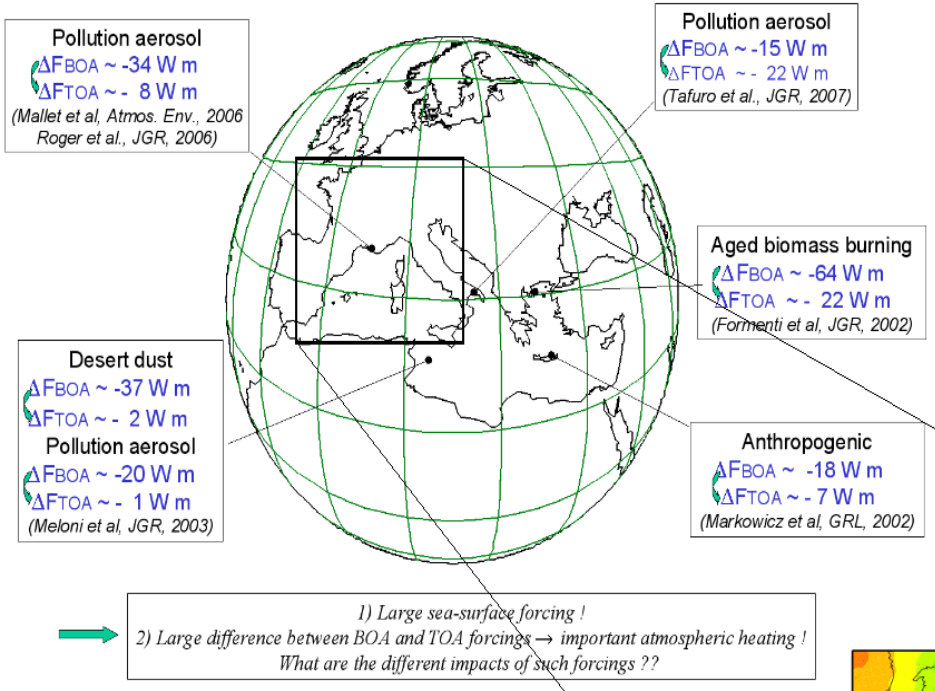
-> ChArMEx deals with short-lived tropospheric species and their impacts on the Med.



Context

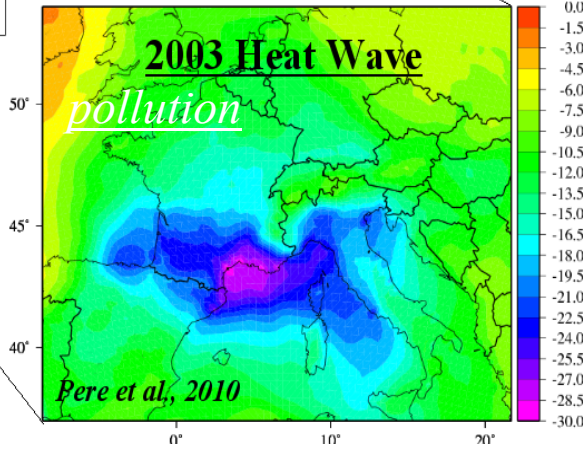
1) the Med. is characterized by a long dry and sunny summer season -> high aerosol load !
2) the main aerosol types could be observed over the Med. region,
3) aerosols are able to significantly change the Med. radiative budget

Radiative impact of aerosols over the Med. basin



1) Large sea-surface forcing !
2) Large difference between BOA and TOA forcings → important atmospheric heating !
What are the different impacts of such forcings ??

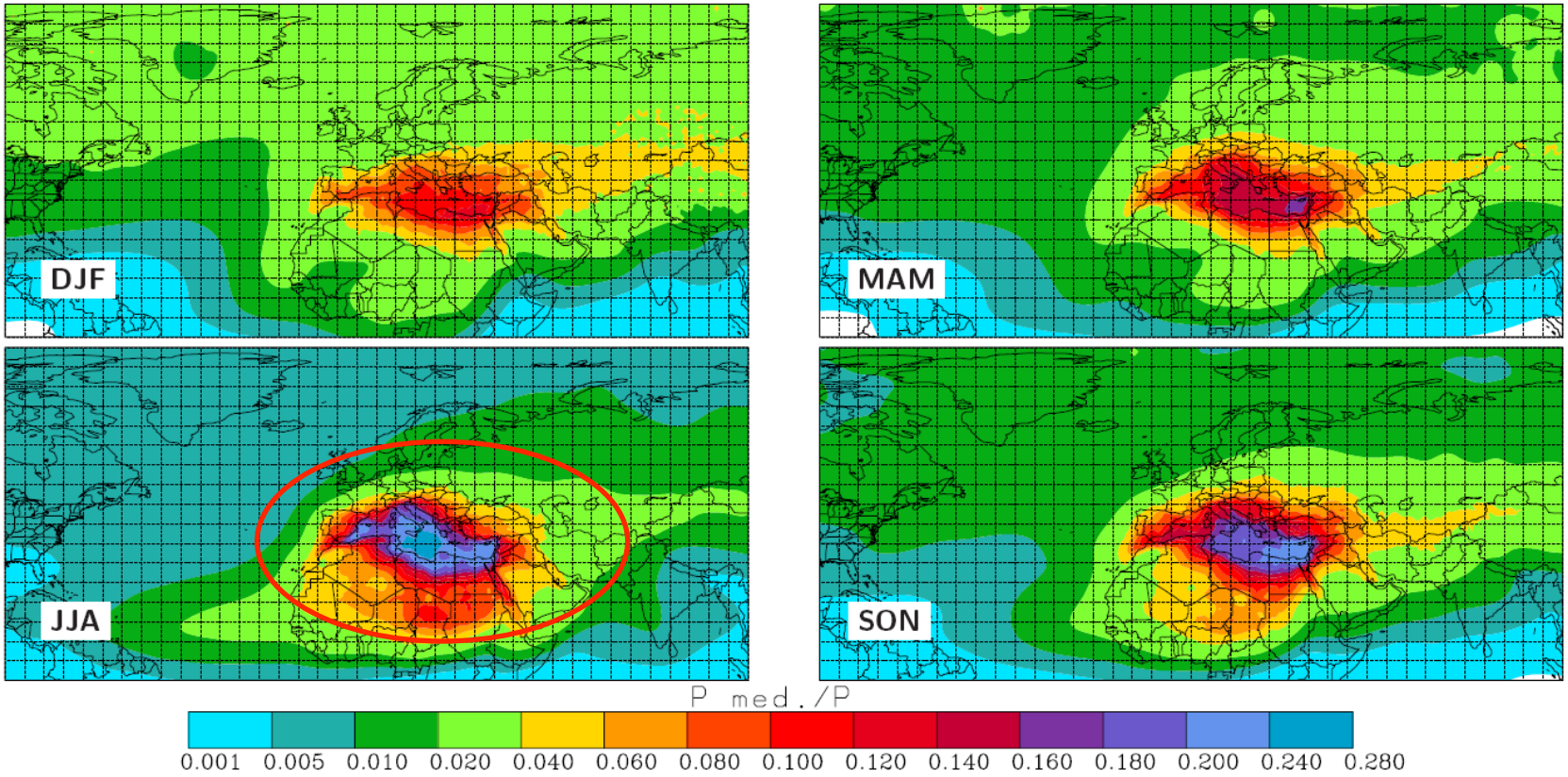
-> Sea-surface dimming associated with atmospheric Forcing for all aerosol types !



Context

-> The Med. area is an important source of moisture for summer precipitation

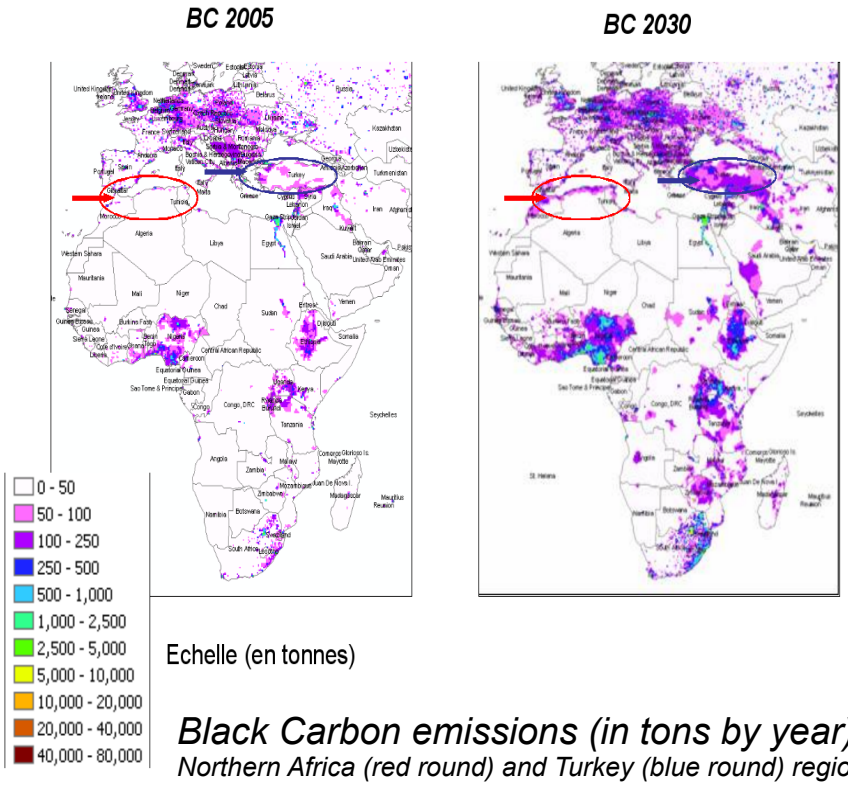
Impact of the sea-surface aerosol forcing on SST ? ocean-atmos. fluxes ?



Fraction of precipitated water that evaporated inside the Mediterranean basin by different seasons (DJF, MAM, JJA and SON). Schicker et al. ACP (2010)

Context

Increase of anthropogenic emissions in the next future…



Black Carbon emissions (in tons by year) in 2005 and 2030 (courtesy of C. Liousse).
Northern Africa (red round) and Turkey (blue round) regions are indicated.

Northern Africa together with Turkey *display important expected changes in 2030 compared to 2005,*

Anthropogenic emissions, in addition to heat waves and biomass burning events, should contribute ***to increase significantly the aerosol load in the next future.***

ADRIMED objective :

➢ Reg. Clim. Model (RCM) simulations including updating optical properties to study how feedbacks from Direct Rad. Forcing do reinforce the large regional precipitation decrease predicted by climate models.

ADRIMED will address the following scientific questions :

(1)

-What is the physico-chemical-optical properties of the main "Mediterranean aerosols" (mineral dust, anthropogenic from Megacities and smoke aerosols) ?

-What is the possible mixing of aerosols over the basin and impact on optical properties (focus on absorption processes) ?

radiative effects

(2)

- What is the aerosol direct radiative forcing (at local and regional scales) at the surface, TOA & into the atmosphere (SW & LW) ?

- What is the associated diabatic heating rate (SW & LW) ?

climatic impacts

(3)

- Investigate how the modifications of the radiative budget due to aerosols affect the sea-surface evaporation fluxes, dynamical processes and the Med. hydrological cycle (focus during the dry season) and water budget (for present and future) ?

1) Strategy -> Surface Obs. over 2 (Ersa & Lampedusa) super-sites

• **Aerosol Physical properties :** fine (DMA) and coarse (GRIMM) number size ditribution

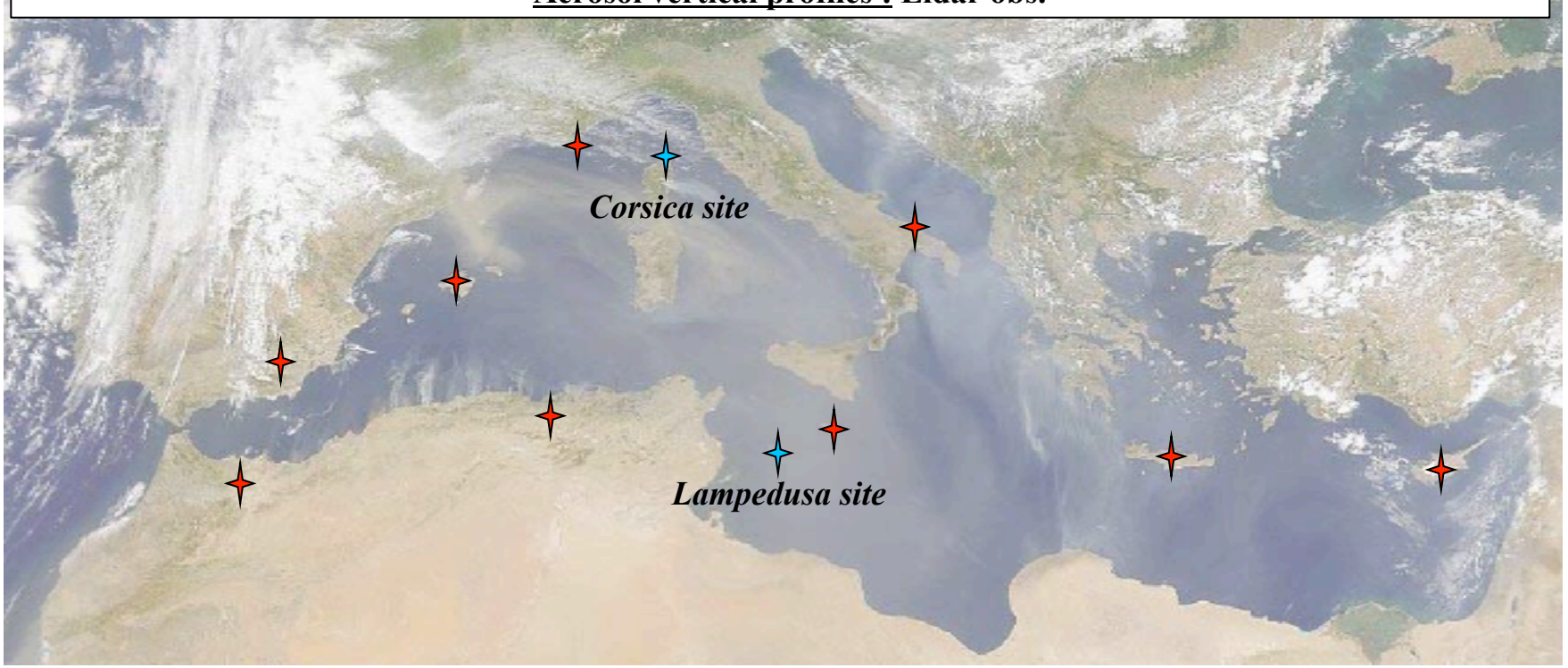
• **Aerosol Chemical properties :** concentration of the main aerosol species (BC, OC, sulfate, nitrate,…) : DKTI filters + AMS

• **Aerosol Optical properties :** 1λ CAPS (total extinction, only Corsica), 3λ nephelometer (scat.), 7λ aethalometer (abs.), PSAP (abs.), AER./PHOTON (whole-column averaged 4λ AOD, 4λ AODabs., 4λ SSA, vol. size distrib.)

• **Aerosol mixing properties :** HTDMA (external vs internal), VTDMA (coating)

• **Radiative fluxes :** pyranometer (SW), pyrgeometers (LW)

• **Aerosol vertical profiles :** Lidar obs.



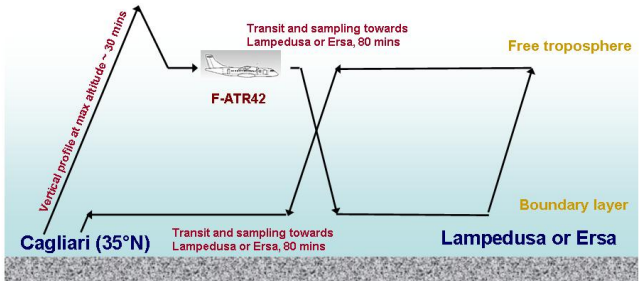
1) Aircraft operations for Special Obs. Period (SOP)

Aircraft observations onboard the ATR-42 :

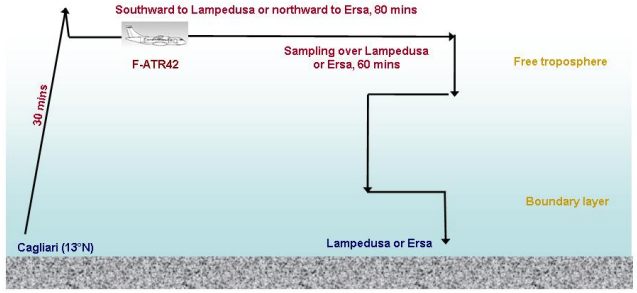
- Aerosol physical properties : PCASP, SMPS and GRIMM,
- Aerosol chemical composition and mixing : AMS, SP2, impactor sampling,
- Aerosol optical properties : PSAP, 7λ aethalometer, 3λ Nephelometer and PLASMA,
- Upwards and downward SW & LW fluxes : Pyranometers and Pyrgeometers,

2 flights configurations

Scientific objective : regional characterisation



Scientific objective : Aerosol characterisation and optical/radiative closure



-> ATR-42 will be based in Cagliari (Sardignia)
-> Period : June-July 2013

Possible collab. with MET-Office (J. Haywood) group -> BAe-146

In-situ obs. will be used for updating optical properties in RCM

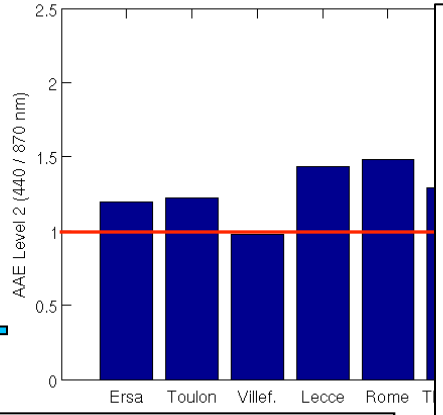
-> optical properties of black carbon aerosols ?
-> are organics purely scattering over Med. ?

Absorbing Ang. Exp. is higher than 1 (typical BC) for most of Med. sites
-> contribution of C_{brown} to the absorption ?

Table 1. Number distribution characteristics and optical properties (at 380 and 550 nm) for the four carboneaceous types considered in the study. r_0 = 'dry' modal radius, σ = standard deviation, ρ_p = particle density, m = refractive index, σ_{ext} = dry extinction cross section, α hygroscopic growth parameter, $f_{rh=0.8}$ = hygroscopic growth factor at 80% relative humidity

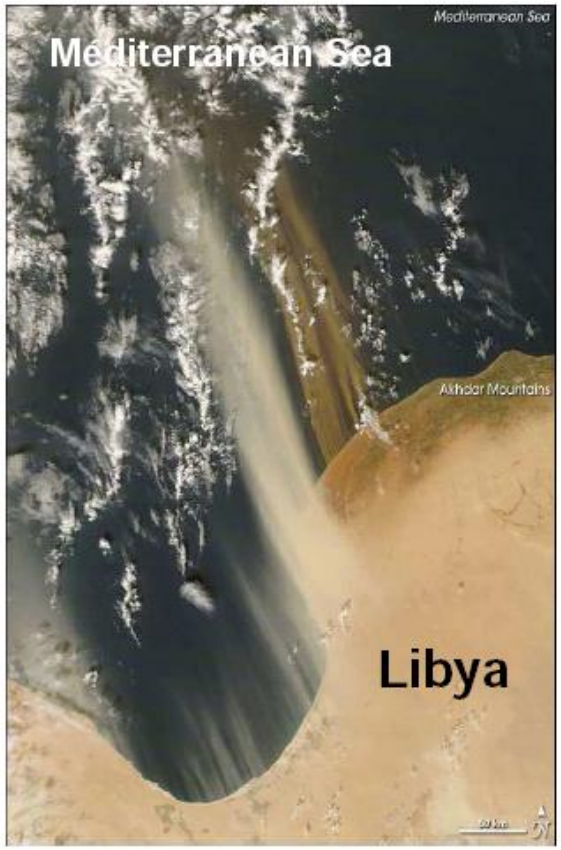
Species	r_0 (μm)	σ	ρ_p (g cm^{-3})	$m=n-ik$ 380–550 nm	σ_{ext} (m^2 g^{-1}) 380 nm	σ_{ext} (m^2 g^{-1}) 550 nm	α	$f_{rh=0.8}$
BC_{hb}	0.0118	1.7	1.5	1.87–0.569i	14.6	9.6	0	0
BC_{hl}	0.03	1.9	1.5	1.87–0.569i	20.2	12.1	0.2	1.37
OC_{hb}	0.06	2.	1.7	1.55–0.005i	6.1	2.7	0	0
OC_{hl}	0.1	2.	1.7	1.55–0.005i	9.8	4.9	0.25	1.49

Solmon et al. Tellus, 2006



Improvements of OC refractive index (imag. part ≠ 0) ?

-> optical properties of dust aerosols vs chemical composition ?



Source NASA

A unique opportunity for studying the mixture of various aerosol types -> impact on optical (absorbing) properties

Do we need to use internal or external mixing assumption in RCM over Med. ?

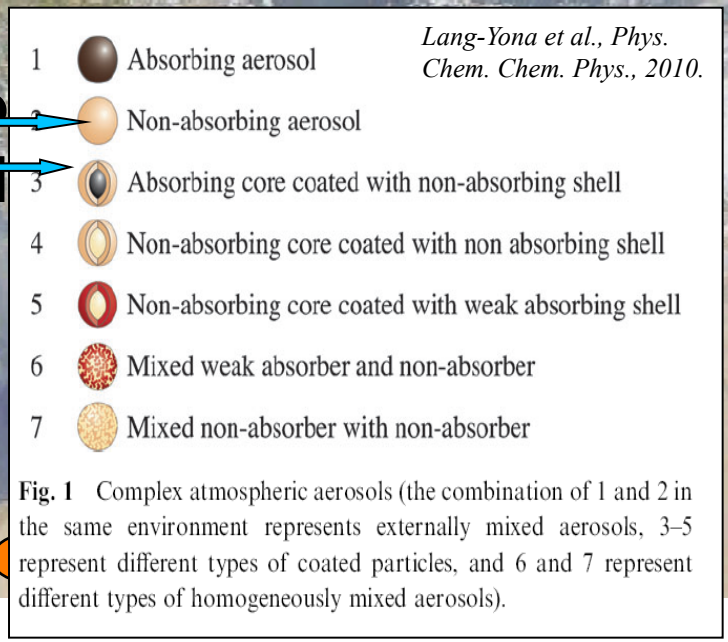
European emissions

What is the best way for modeling aerosol optical properties ?
-> homogeneously internally mixed ?
-> heterogeneously internally mixed with core/shell approach ?
-> complete external mixing ?

HTDMA, VTDMA will be used

Fires

Desert

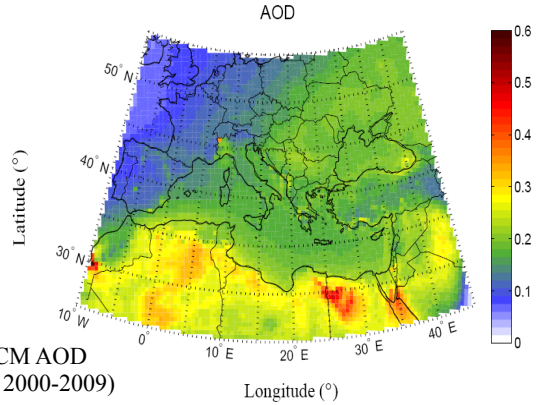


Lang-Yona et al., Phys. Chem. Chem. Phys., 2010.

Fig. 1 Complex atmospheric aerosols (the combination of 1 and 2 in the same environment represents externally mixed aerosols, 3–5 represent different types of coated particles, and 6 and 7 represent different types of homogeneously mixed aerosols).

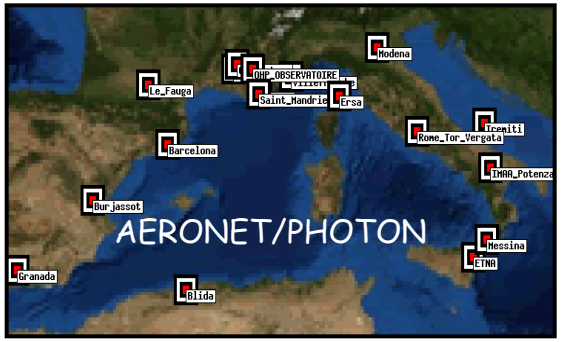
2) RCM simulations of radiative properties & Direct Rad. Forcing (SW & LW)

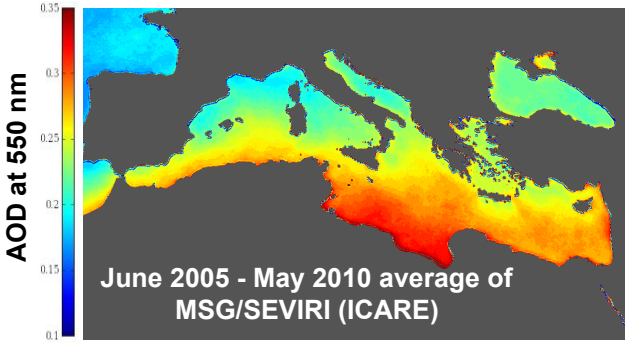
1) Simulation of Rad. Properties



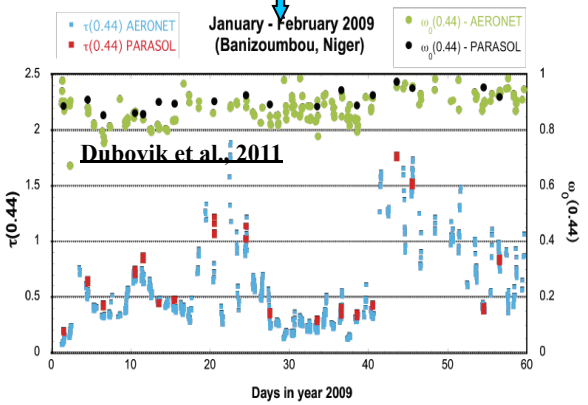
1) *Good region (clear-sky, marine surface, diff. aerosol types) for testing new remote-sensing techniques !*

2) *Good AERONET/PHOTON network*



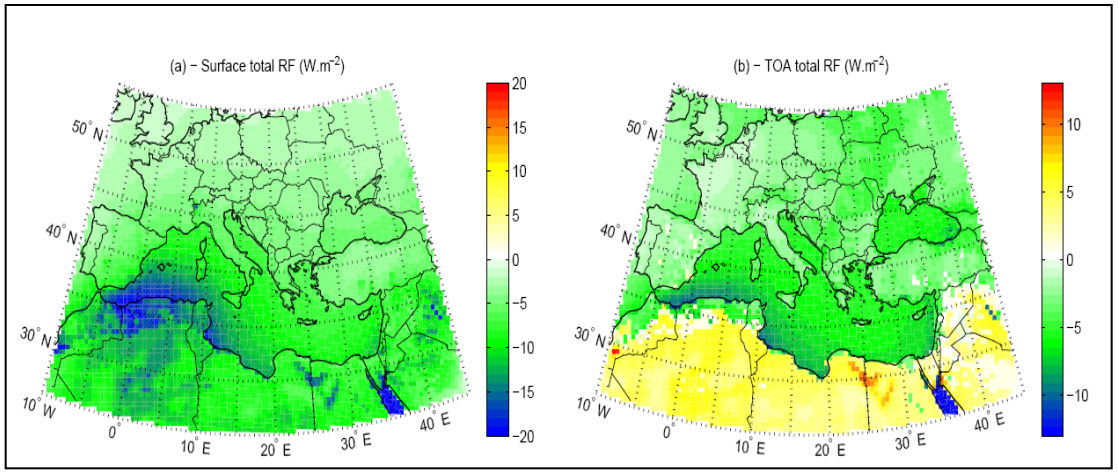


SSA should also be evaluated using recent.developments
(collab. O. Dubovik, D. Tanre (LOA) / PARASOL)



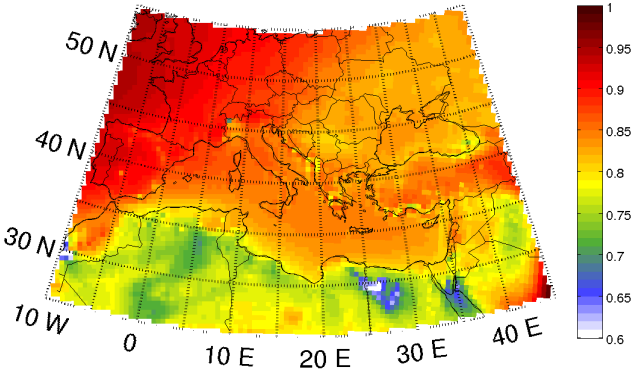
…but also…
MISR SSA -> Kahn et al., 2010
OMI SSA -> Torres et al.

2) Regional simulation of summer surface and TOA DRF



RegCM DRF (JJA period 2000-2009) curtesy P. Nabat & F. Solmon

RegCM4 SSA Mean 2000/2009

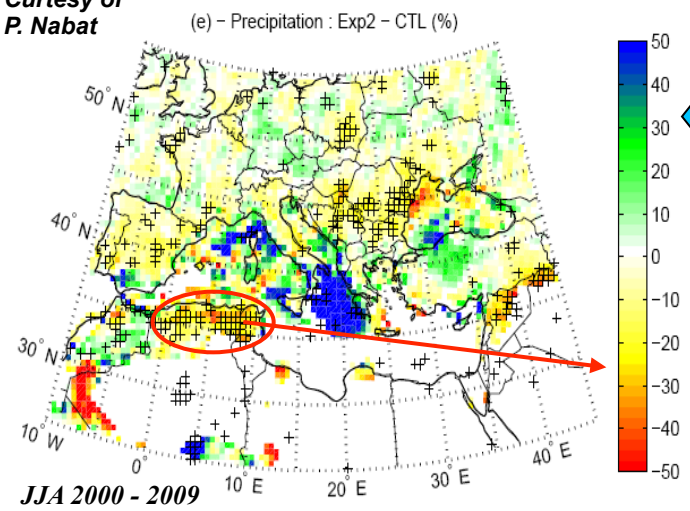


3) Regional aerosol climatic impacts

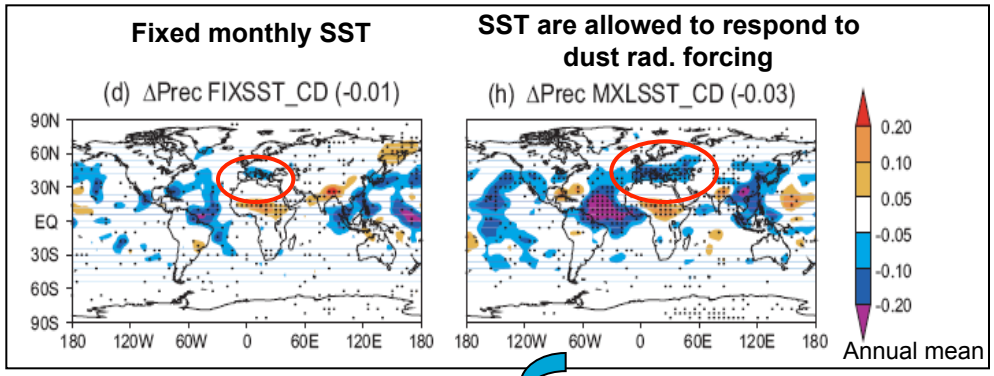
Regional Climate Models (RCMs) including aerosol schemes and particles SW & LW interactions

long-term (present & futur) regional climate simulations

Curtesy of P. Nabat



1) RegCM4.2 atmospheric model including complete aerosol scheme (–> dust, OC, BC, SS, Sulfate : external hyp.) *(Solmon et al.)*
→ *no ocean – atmos. coupling*



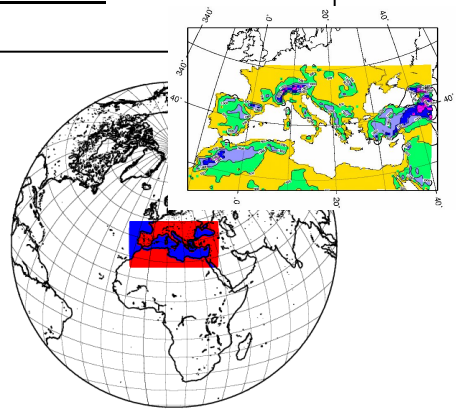
Yue et al., ACP, 2011

ΔPrec over Med. seems to be very sensible to the dust <-> SST coupling !

3) Sea-Atmos. Med. CNRM Model : ALADIN-Climat V5 *(Somot et al.)*
-> ocean – atmos. coupling ***but without interactive aerosol scheme for the time***

Up-to-now aerosols are global low resolution 2D monthly-mean (Tegen et al.) for 5 species

Interactive aerosol scheme will be used



Collaborations (remote sensing, in-situ observations & modeling group's) are welcome !

Thank you for your attention !