The Abdus Salam International Centre for Theoretical Physics

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2210-10

MedCLIVAR Workshop on: "Scenarios of Mediterranean Climate Change under Increased Radiative Active Gas Concentration and the Role of Aerosols

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Regional climate simulations of aerosol radiative impact over the Mediterranean basin

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Regional climate simulations of aerosol radiative impact (over the Mediterranean)

F. Solmon, ICTP

Aerosol distribution is characterized by large regional gradients.

Interest of regional climate model approach to study aerosol climate interactions

- Impact of aerosol on regional and global climate via direct and indirect radiative effects

- Impact of climate and emission change on aerosol (air quality and environmental impacts).

  (on longer time scale, climatic impact via interactions with biogeochemistry)

Mediterranean region are an aerosol hot spot (cf F. Dulac presentation)

(…)

Aerosols in RegCM

- **Tracer model / RegCM3**

$$\frac{\partial \chi}{\partial t} = -\overline{V} \cdot \nabla \chi + F_H + F_V + T_{CUM} + S_\chi - R_{w,ls} - R_{w,cum} - D_{dep} + \sum Q_p - Q_l$$

Transport | Primary Emissions | Removal terms | Physico – chemical transformations

- **Particles and chemical species considered**

SO_2	SO_4^{--}	BC (soot)		OC (total organic carbon)		DUST (4 bins)				Sea salt	
Aqueous and gazeous conversion (Qian et al., 2001)		*Hydrophilic (20% at emission)*	Hydrophobic (80%at emission)	*Hydrophilic (50%at emission)*	*Hydrophobic(50%at emission)*	0.01-1 µm	1-2.5 µm	2.5-5 µm	5-20 µm	0.05-1	1-10

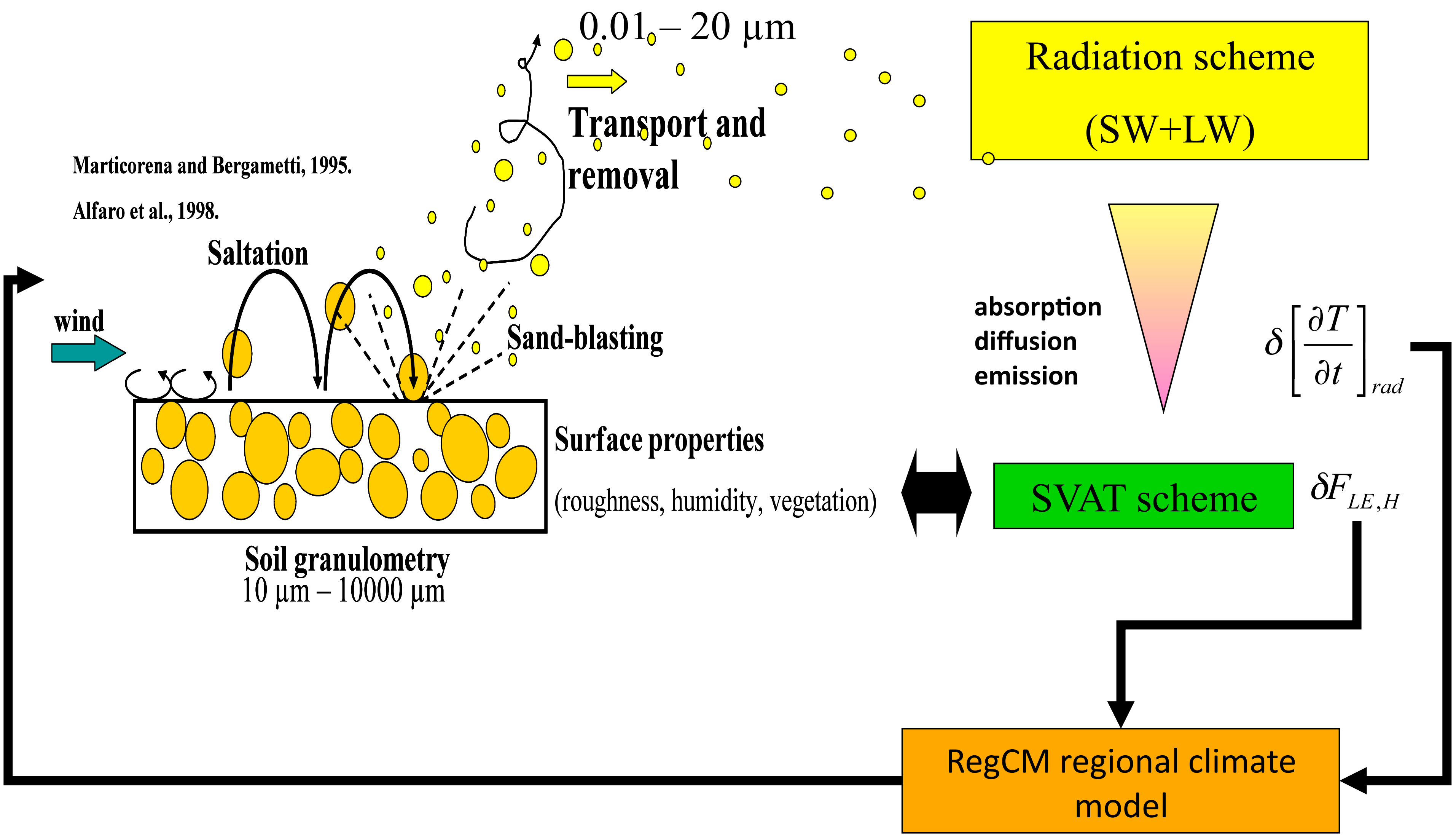
Emissions inventories

On line emissions

Oxidant fields for sulphur (MOZART climatology)

Dust aerosol on-line module in the ICTP RegCM4 model

No cloud microphysics interaction !



Spring event
(13-16 march 1998)

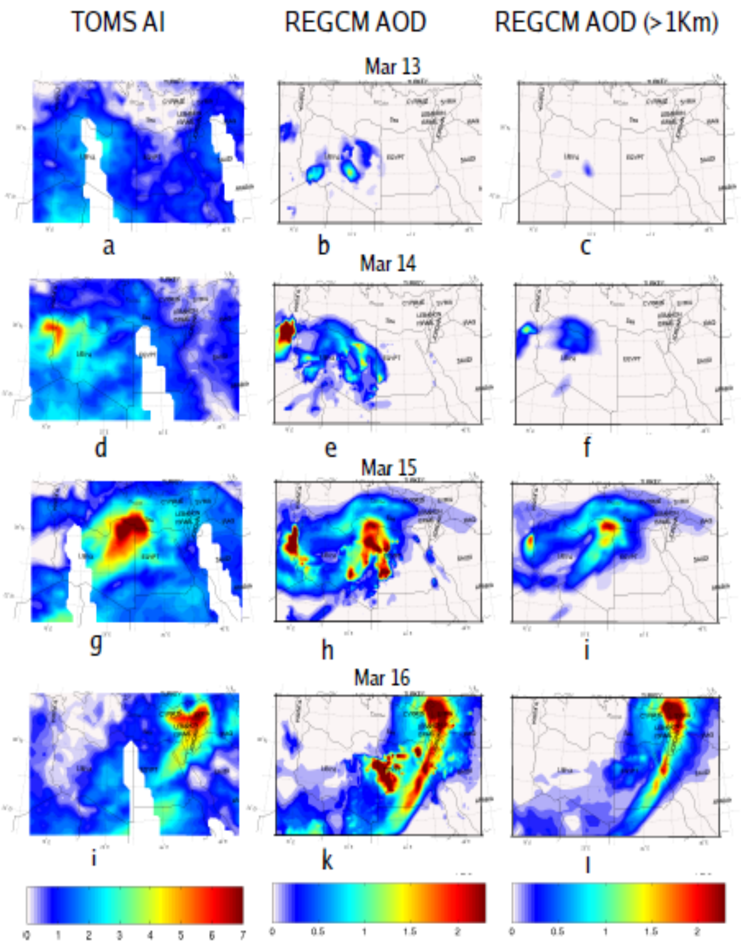
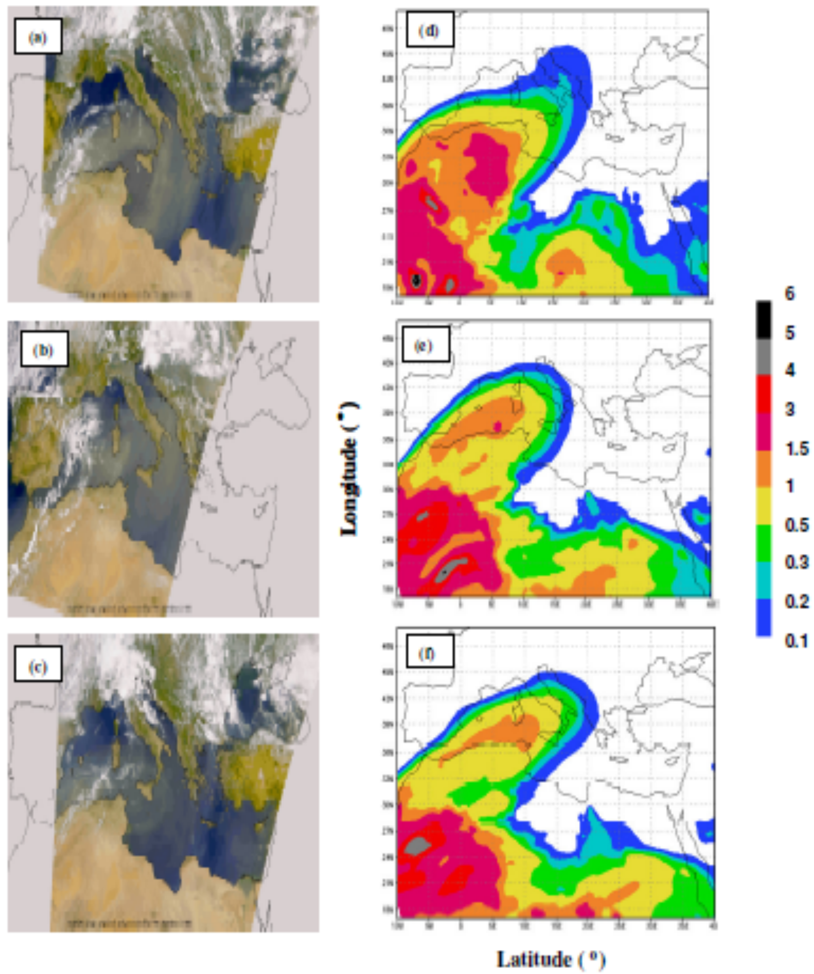


Fig. 3. Comparisons between the simulated total AOD (model band 350–640 nm), simulated AOD at height greater than 1000 m and TOMS aerosol index during the period 13–16 March 1998.

Zakey et al., 2006 (ACP)

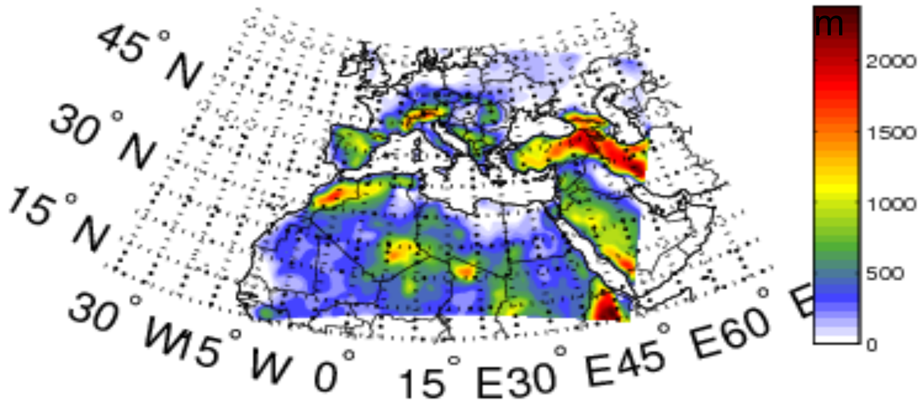
Summer event
(July 17-23, 2001)

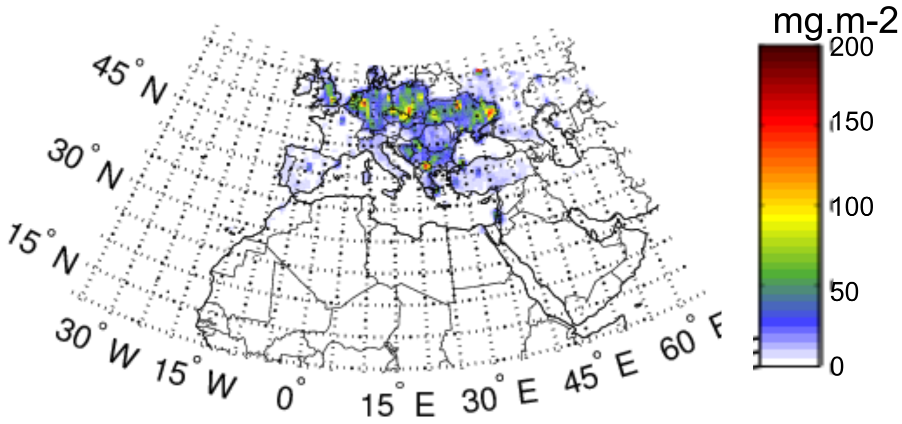
RegCM AOD



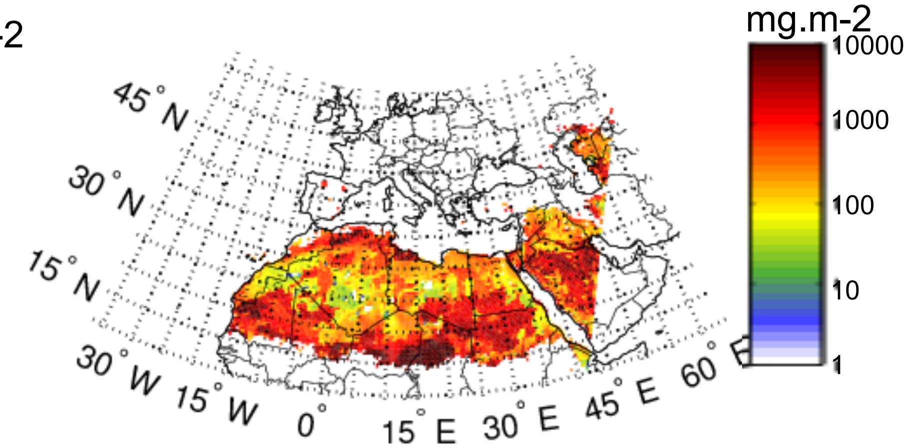
Santese et al., 2009 (ACP)

Seasonal of simulated evolution of AOD over the Mediterranean
(year 2007, 50km, ERAIM) anthropogenic + dust aerosols



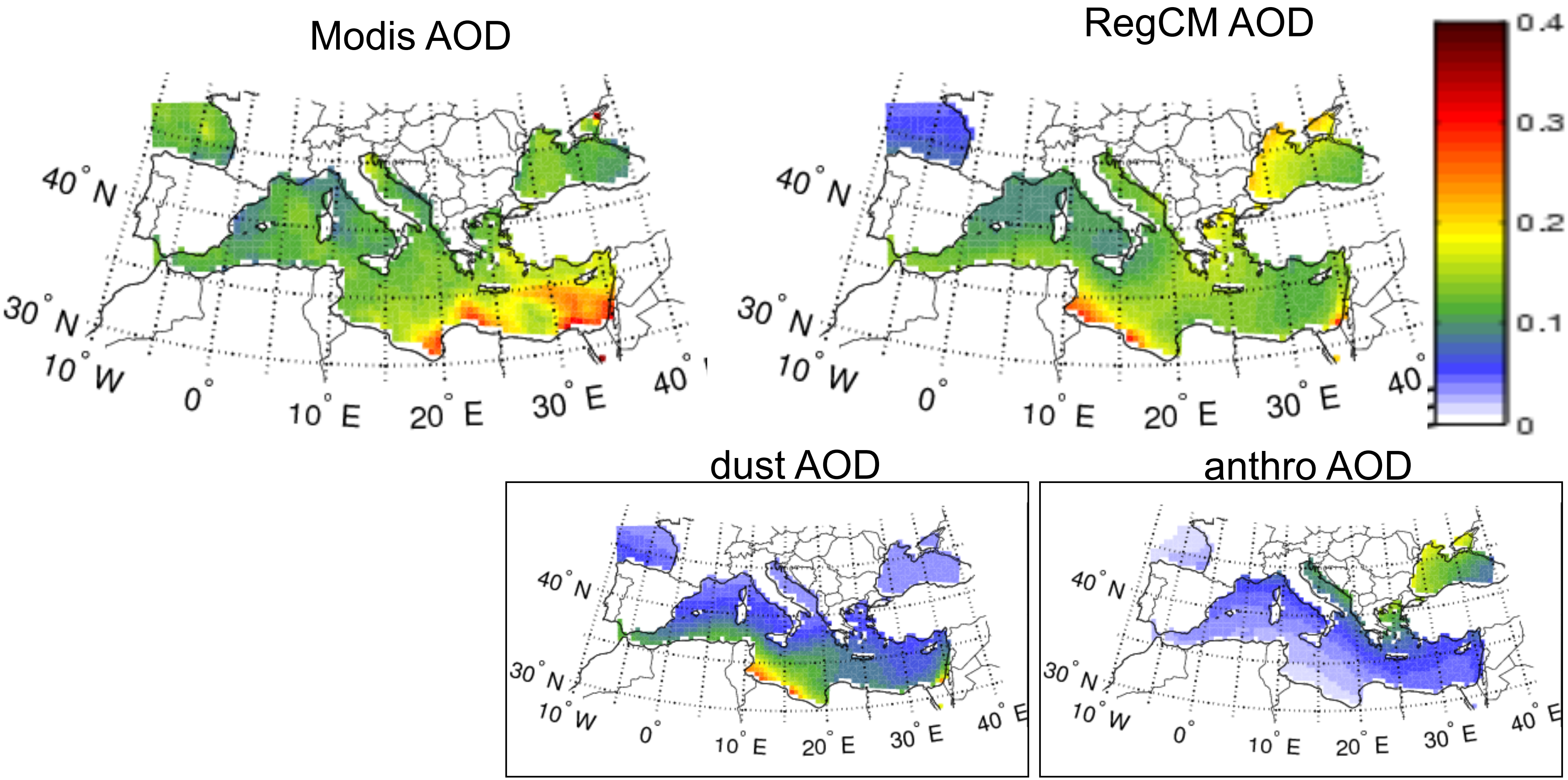


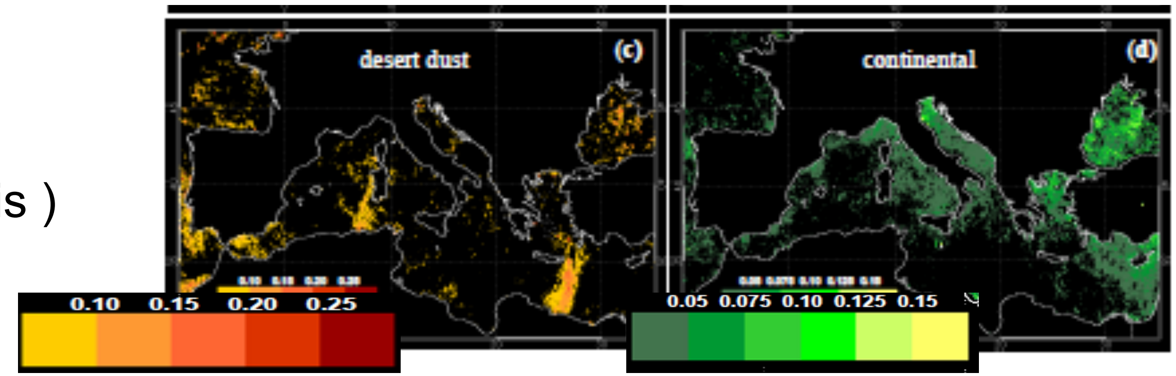
So2 emission (TNO)



dust emission (MAM)

DJF 2007

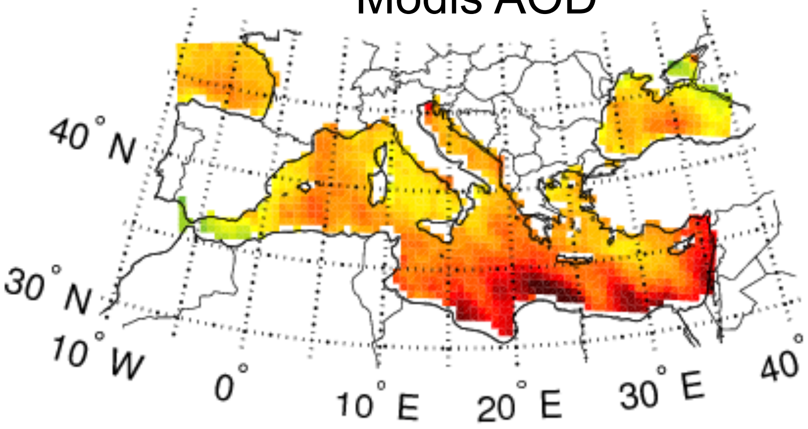




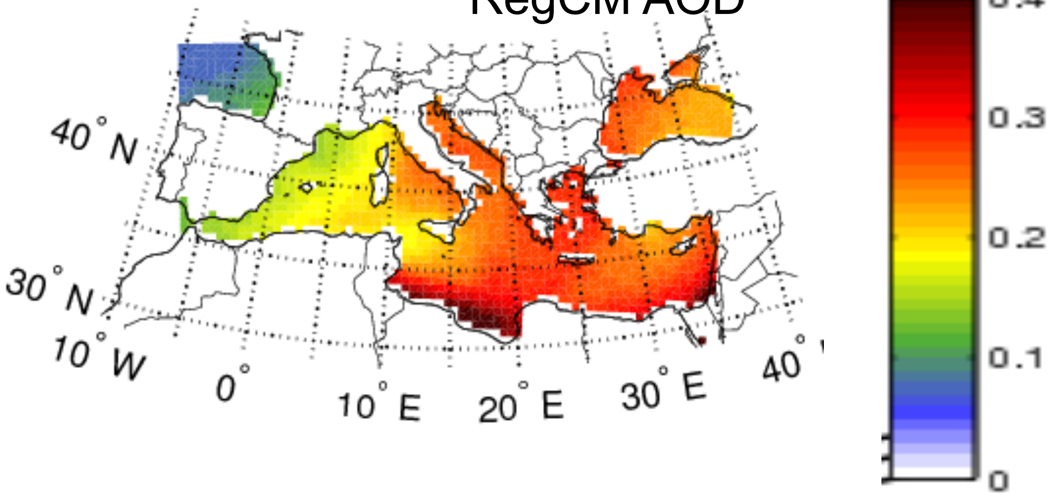
Barnaba & Gobbi, 2004
(year 2001 based on modis)

MAM 2007

Modis AOD

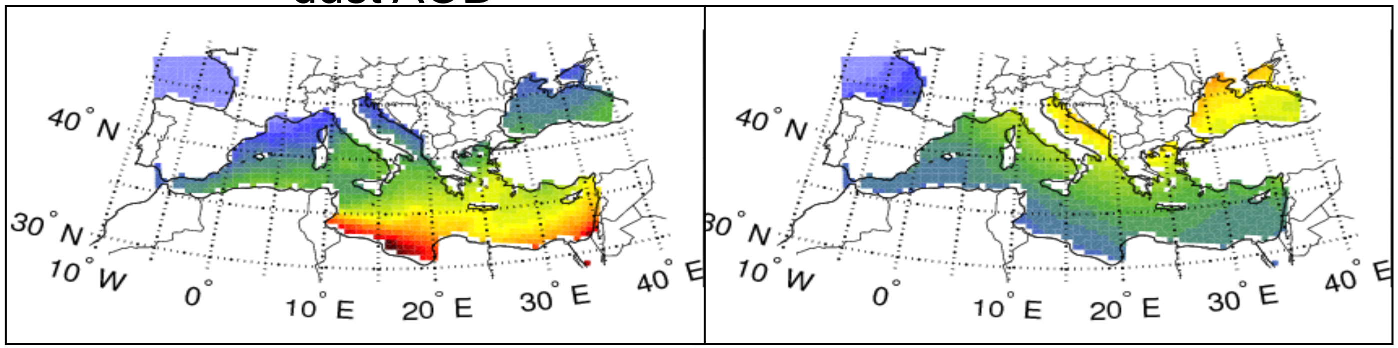


RegCM AOD

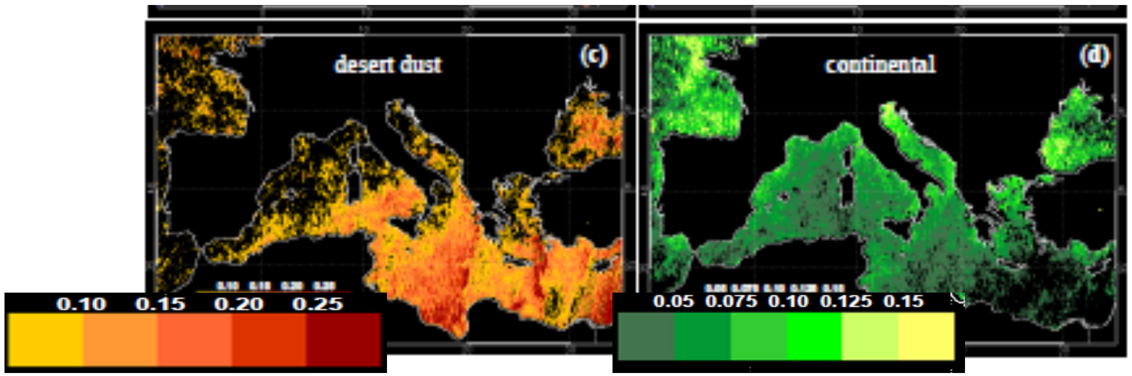


dust AOD

anthro AOD

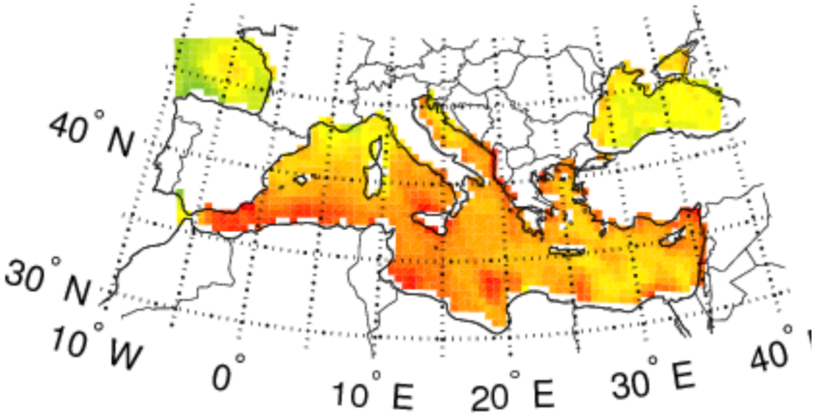


Barnaba & Gobbi, 2004
(year 2001)

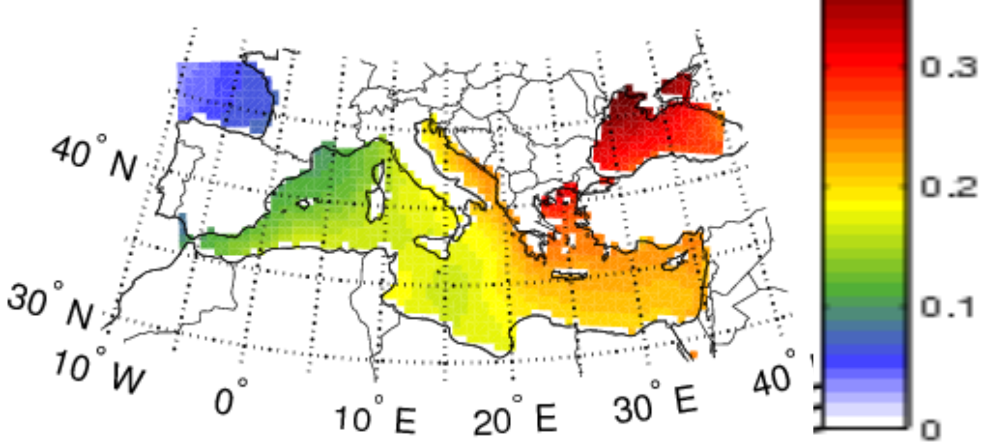


JJA 2007

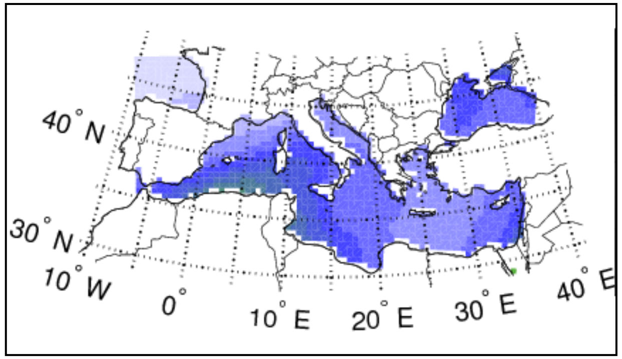
Modis AOD



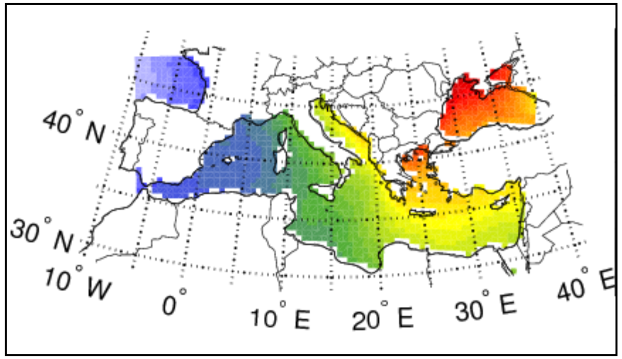
RegCM AOD



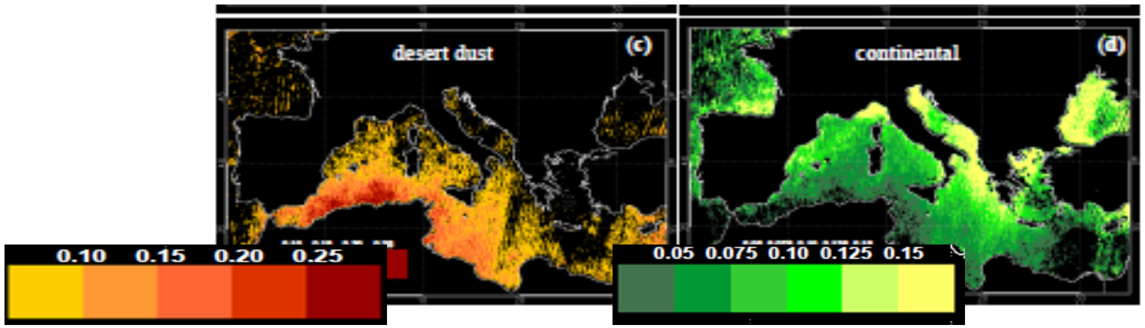
dust AOD



anthro AOD

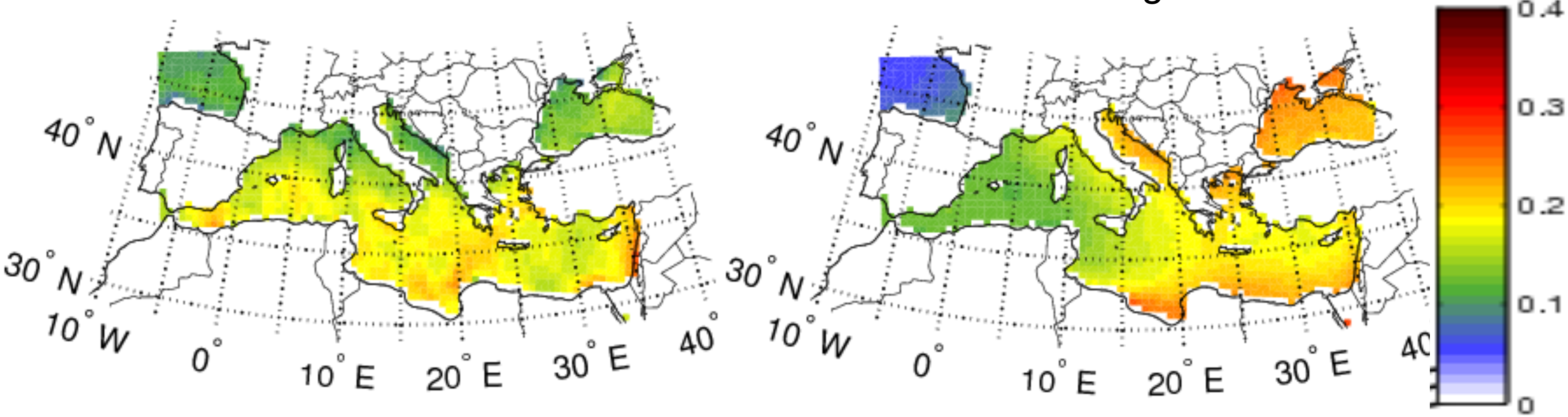


Barnaba & Gobbi, 2004
(year 2001)

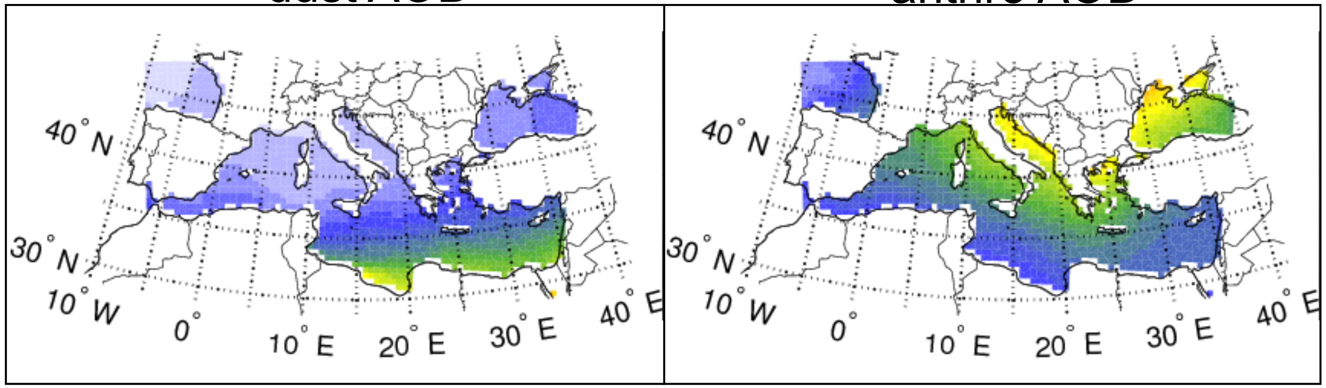


SON 2007

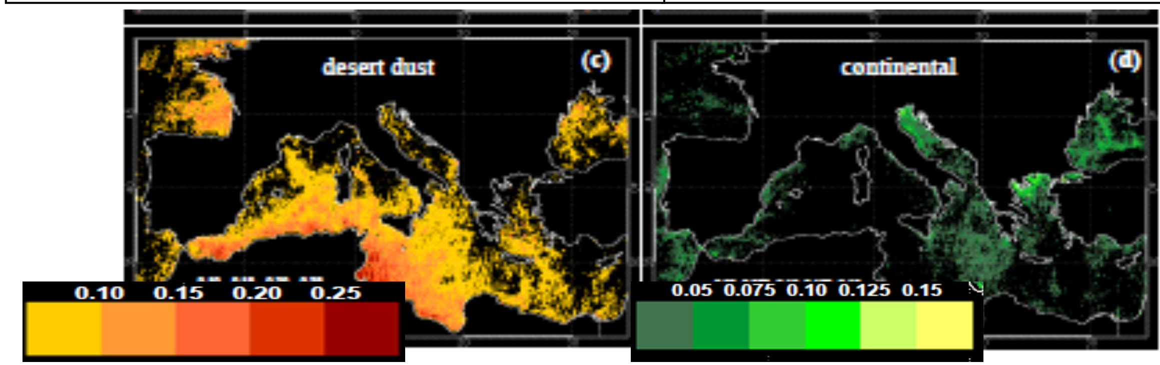
Modis AOD | RegCM AOD



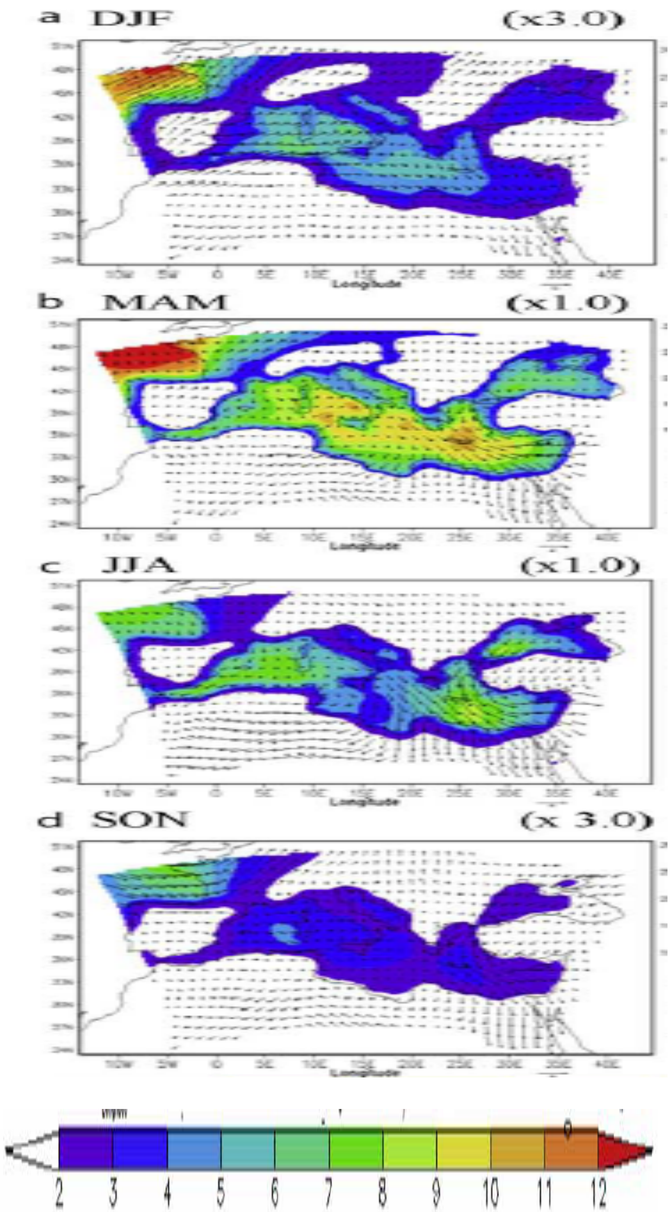
dust AOD | anthro AOD



Barnaba & Gobbi, 2004
(year 2001)



Sea salt aerosol emission scheme (Zakey et al.,2008)



mg/m2

Maximum burden (and AOD) in fall / winter

Application of RegCM to the of study regional aerosol climate impact…

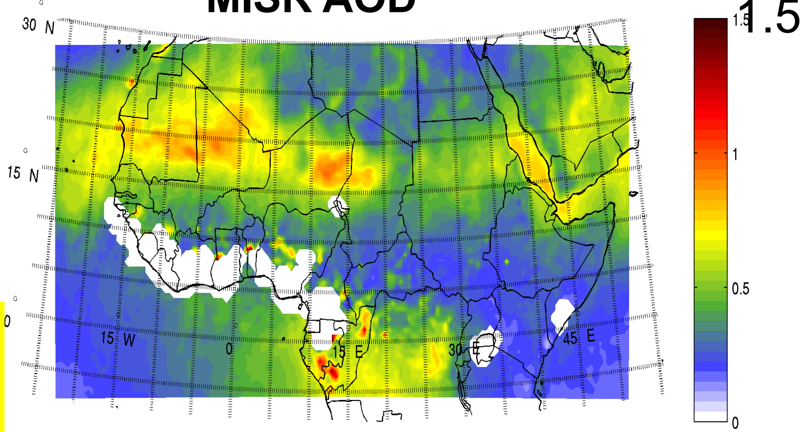
An example over west Africa

Dust radiative forcings

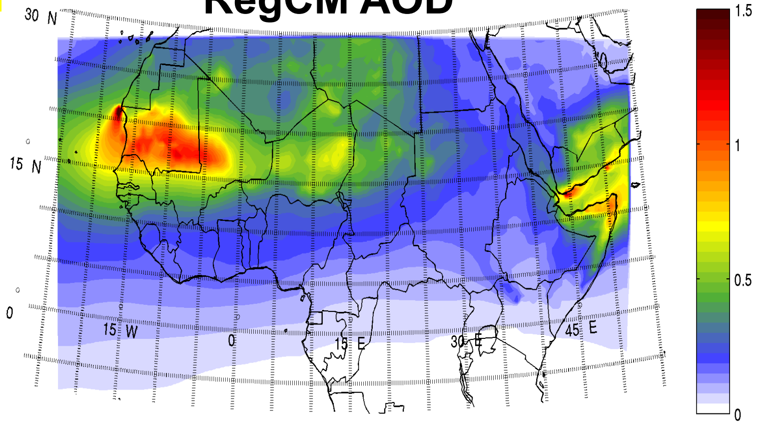
JJA

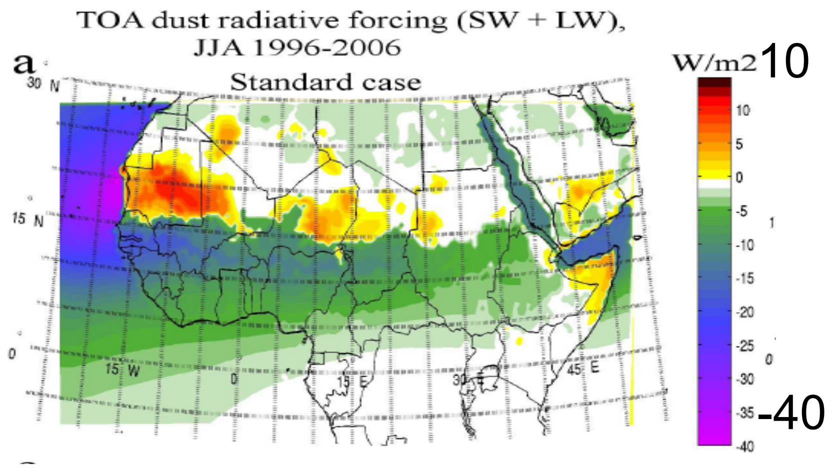
(2000-2006)

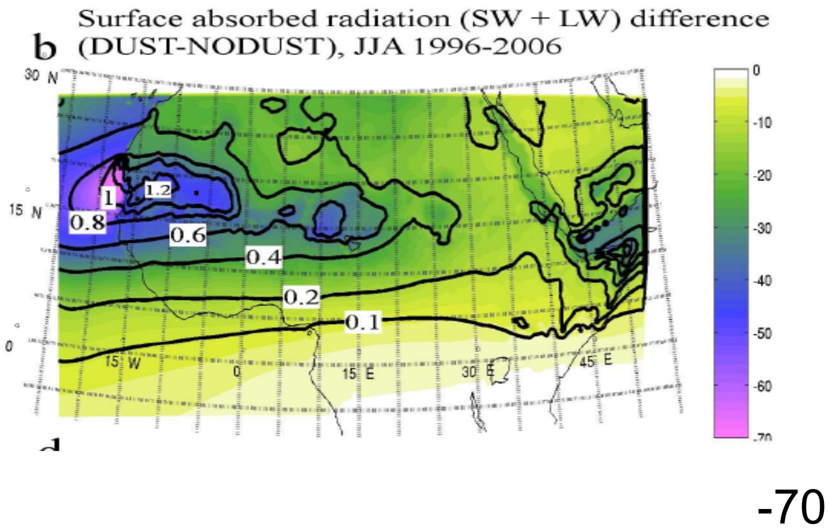
MISR AOD



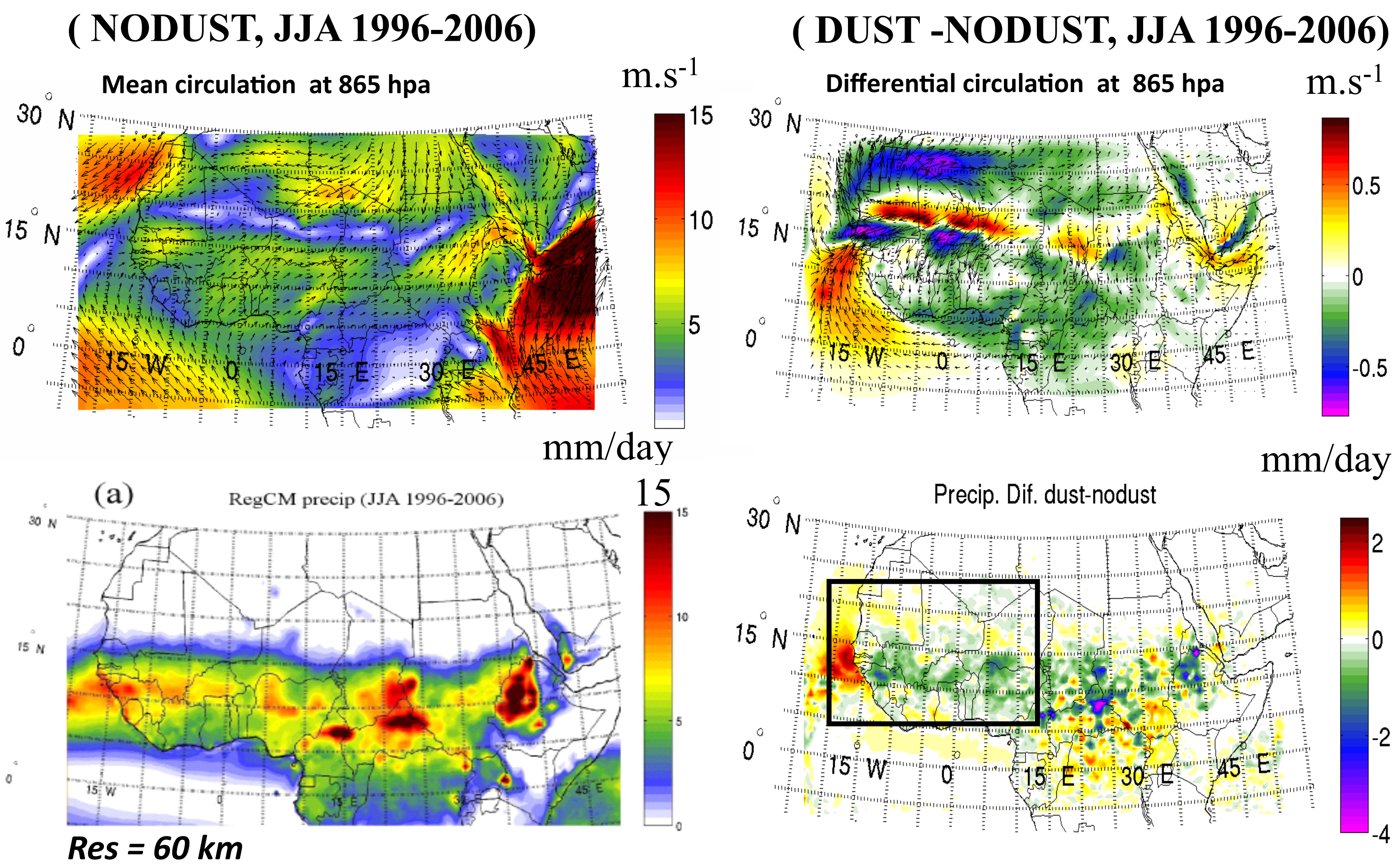
RegCM AOD







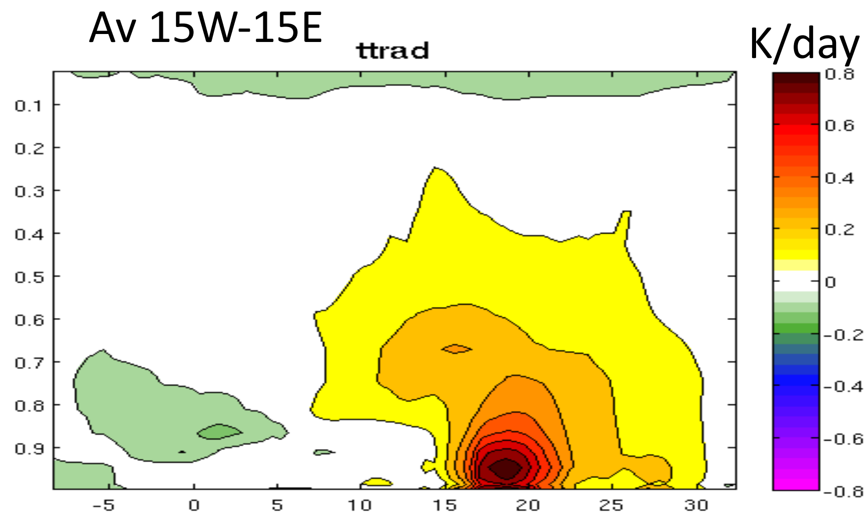
Compares well with Li et al., 2004
(TOA) : -35 W/m2/AOD ,(SRF) -65 W/m2/AOD

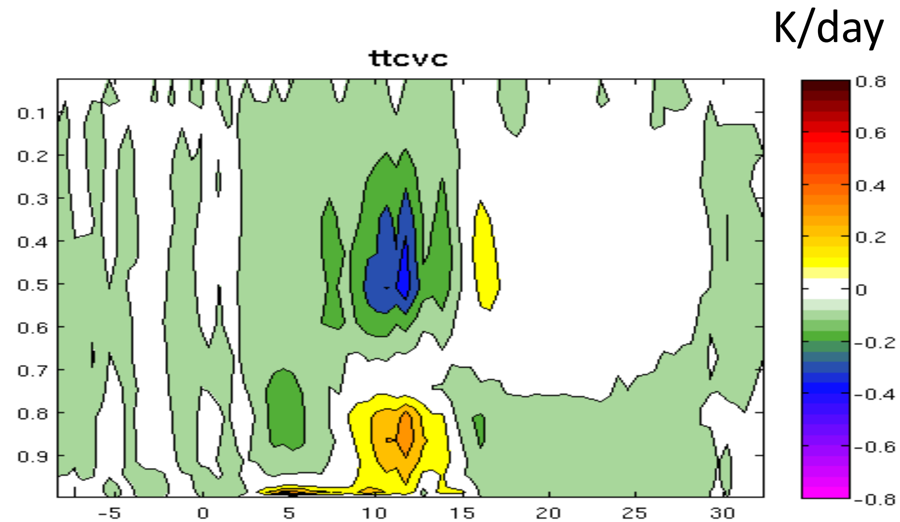

(NODUST, JJA 1996-2006)
(DUST -NODUST, JJA 1996-2006)
Mean circulation at 865 hpa
m.s-1
Differential circulation at 865 hpa
m.s-1
30° N
15° N
0°
15 W
0
15 E
30 E
45 E
15
10
5
0.5
0
-0.5
mm/day
(a)
RegCM precip (JJA 1996-2006)
15
mm/day
Precip. Dif. dust-nodust
2
0
-2
-4
Res = 60 km

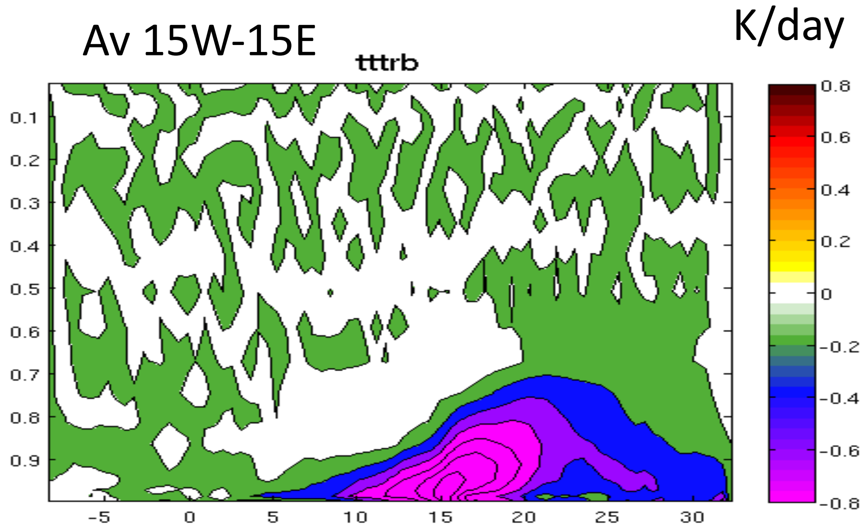
Dust perturbation :

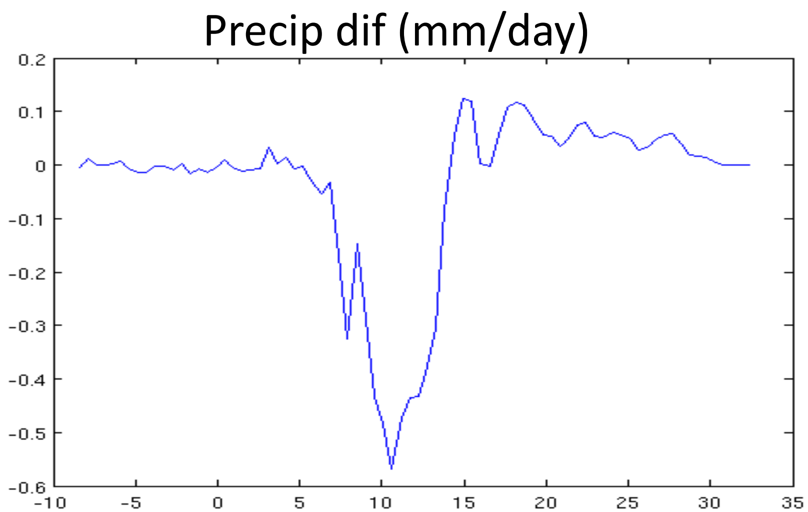
$$\frac{\partial T}{\partial t} = \left[\frac{\partial T}{\partial t}\right]_{adv} + \left[\frac{\partial T}{\partial t}\right]_{adb} + \left[\frac{\partial T}{\partial t}\right]_{conv} + \left[\frac{\partial T}{\partial t}\right]_{rad} + \left[\frac{\partial T}{\partial t}\right]_{trb} + \left[\frac{\partial T}{\partial t}\right]_{cond/prc}$$

$$\delta\left[\frac{\partial T}{\partial t}\right]_{rad} = \left[\frac{\partial T}{\partial t}\right]_{rad}^{dust} - \left[\frac{\partial T}{\partial t}\right]_{rad}^{nodust}$$







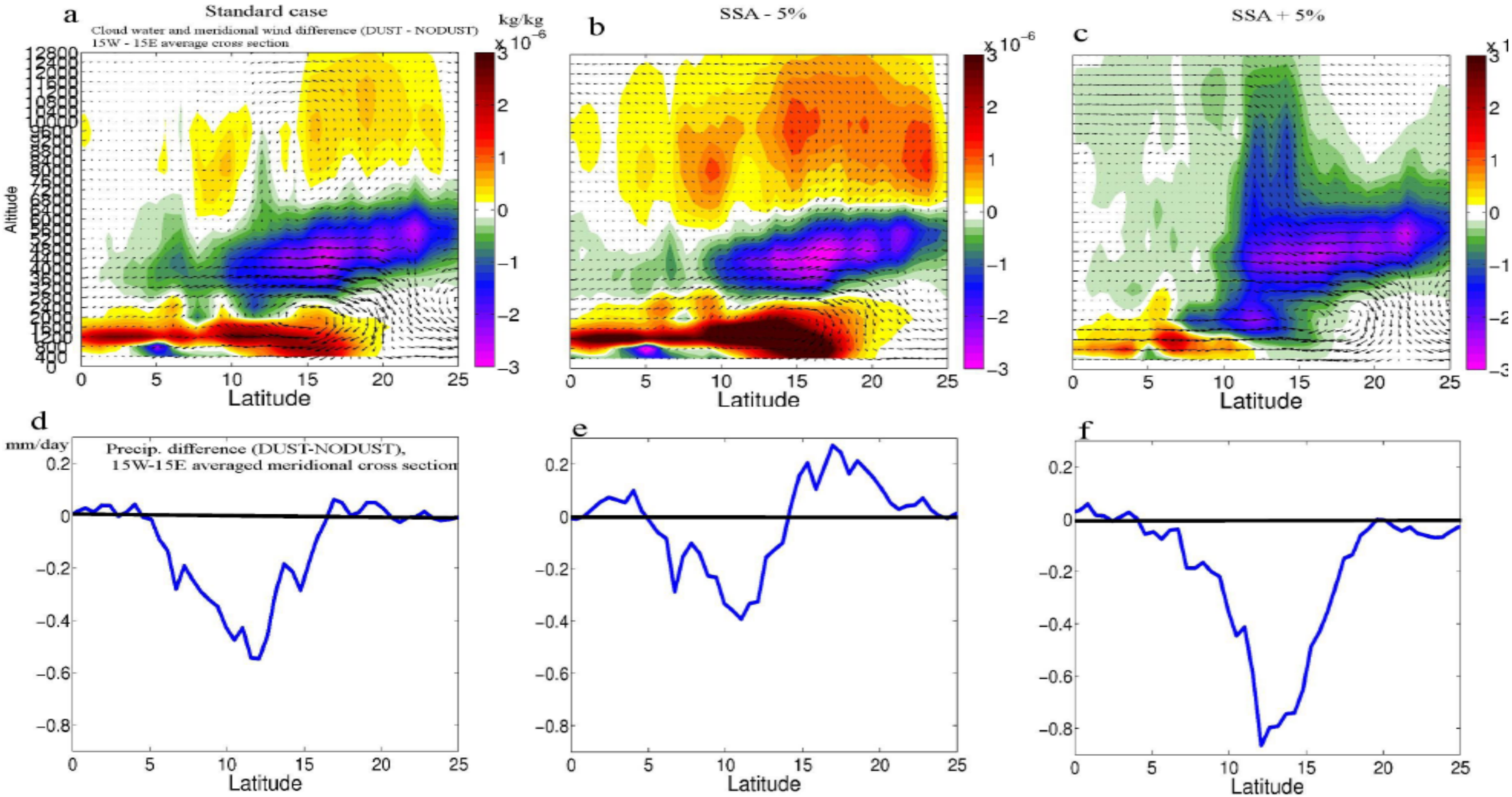


The importance of resolving regional gradients of cooling/heating rates

Climate sensitivity to dust absorption properties

Variability of measured values of dust SSA values (mineral composition, coating, aerosol size distribution ..) : impacts on the climatic response ?

SSA ~0.95 (fine dust) | **SSA ~0.90** | **SSA ~0.99**



The importance of the interactive ocean

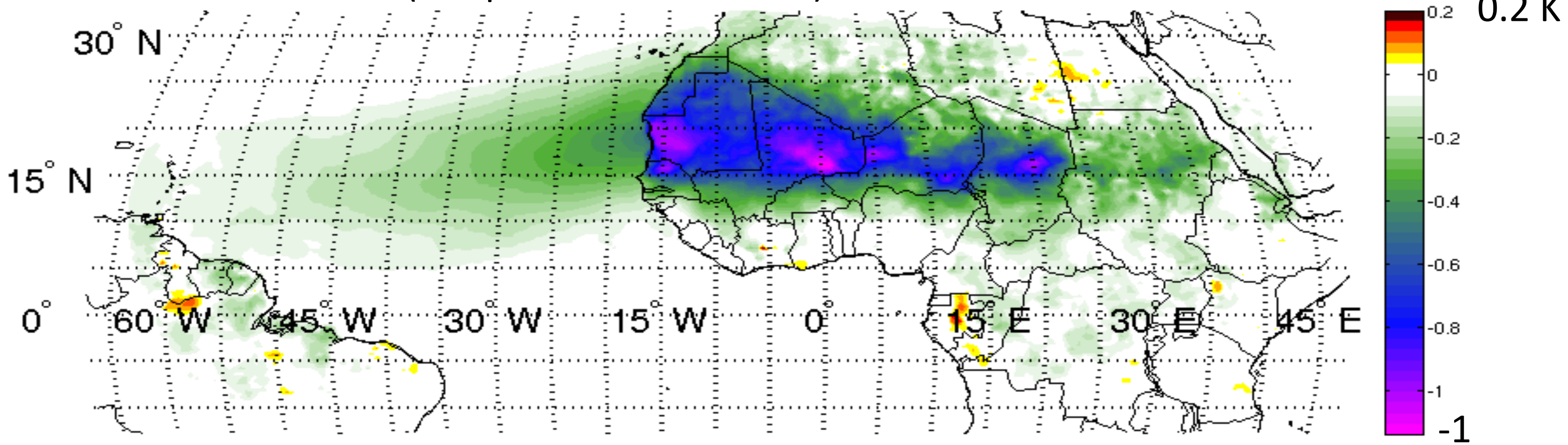
In standard configuration SST are prescribed

Simple experiment : SST* = SST - 0.8 x AOD

as a result of less SW absorbed in ocean mixed layer due to dust extinction

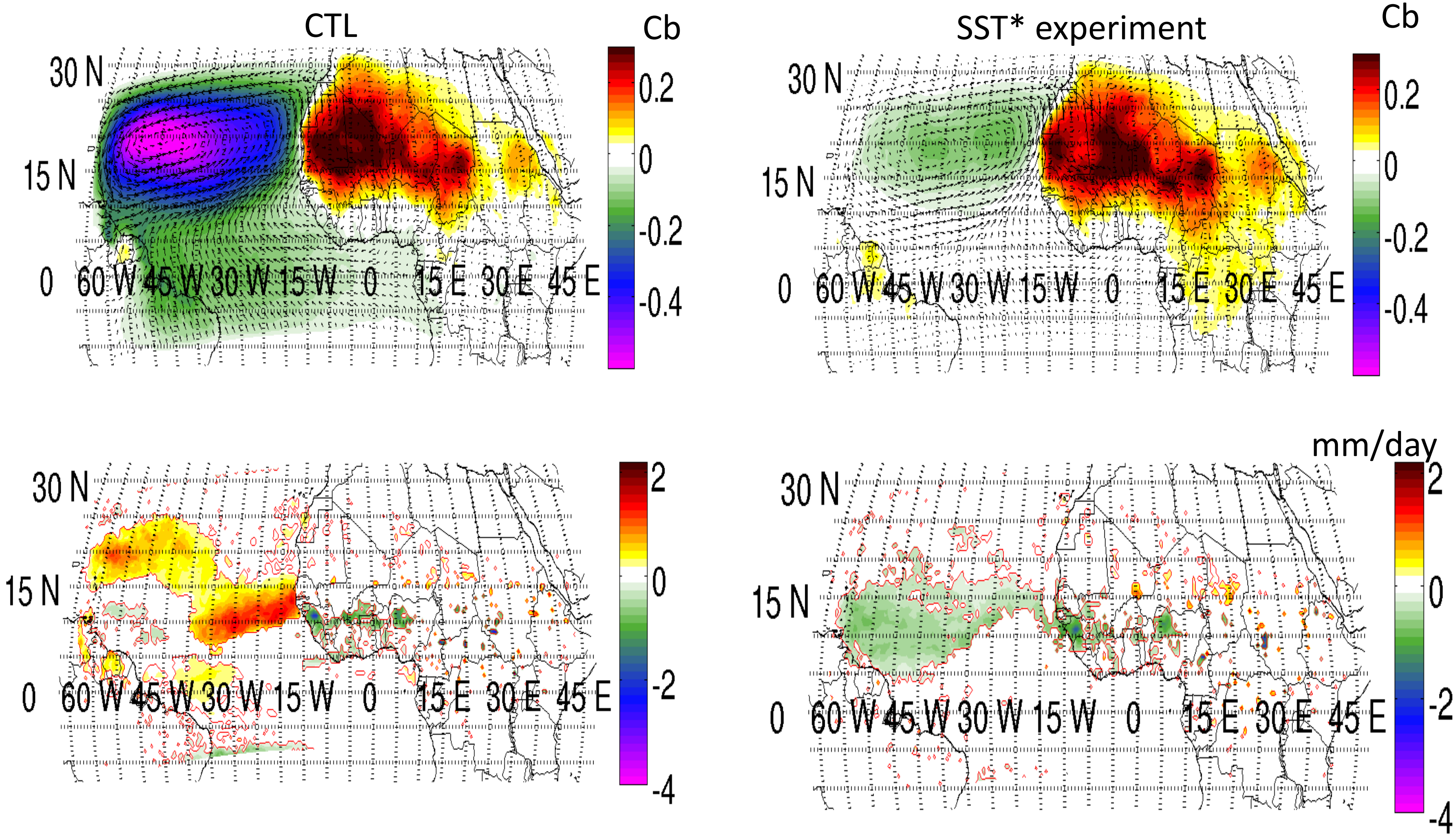
(consistent with ***Avila et al., 2007***, ***Evan et al., 2009***, ***Yoshioka et al.,2007 studies using observation and coupled ocean models***)

T2m (temperature difference) JJA 85-06



Limits of the hypothesis: during dust storm SST anomaly is applied 'instantaneously'

JJA 85-06



Needs coupled ocean !

Local, regional and remote impacts

Aerosol forcing can trigger local (e.g summer convection/ see breeze) , regional and large scale feedbacks .

Problem of boundary conditions in regional model

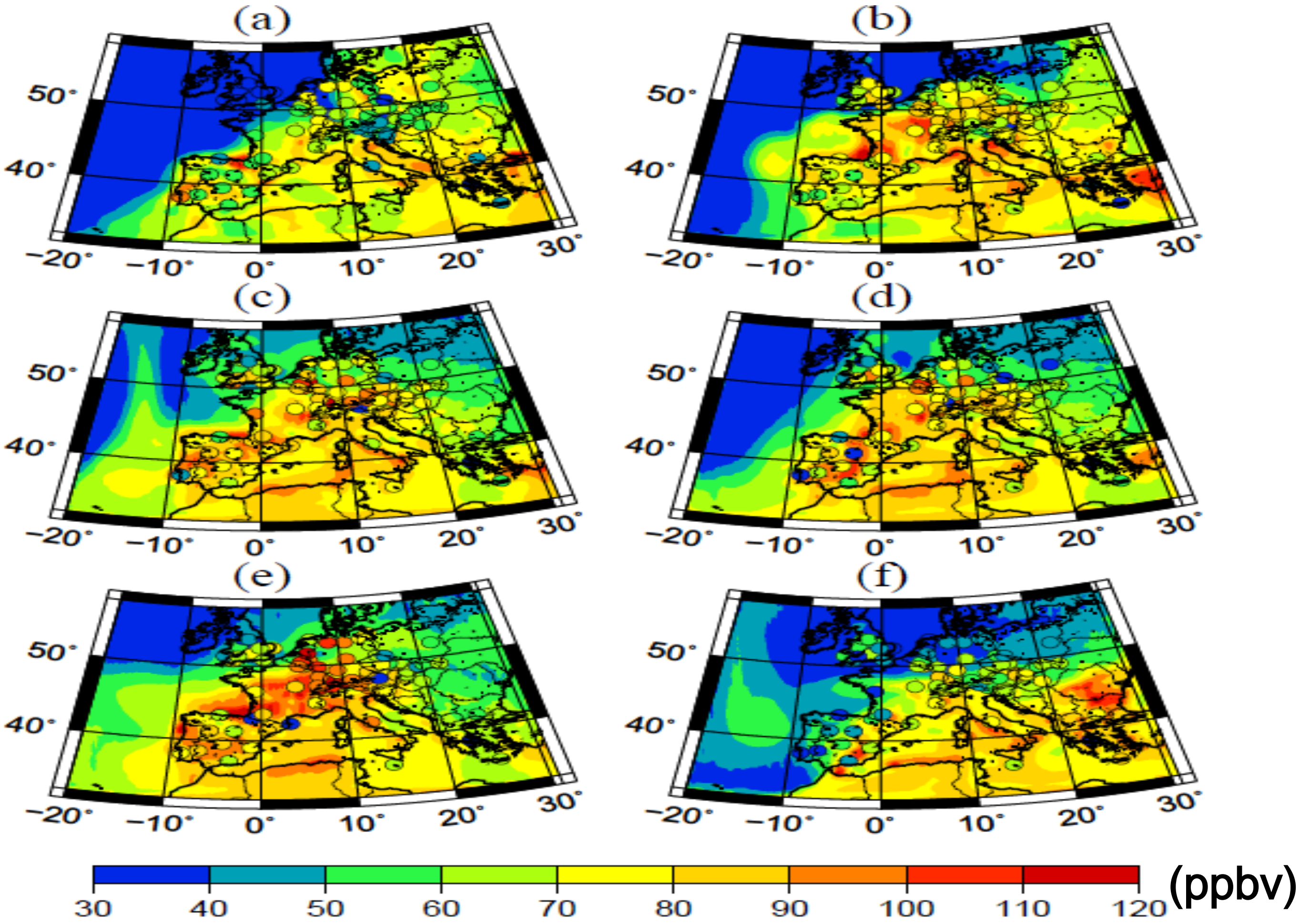
Importance of assessing if a given anomaly induced by aerosol is robust when testing e.g. various domain size. Needs a synergy between GCM and RCM approach (or quadruple coupling!) .

Relevance for Mediterranean regions.

On going developments in RegCM
(relevant to charmex, hymex, medcordex)

- On line Gas phase chemistry / ozone / improved inorganic aerosol / secondary organic aerosol

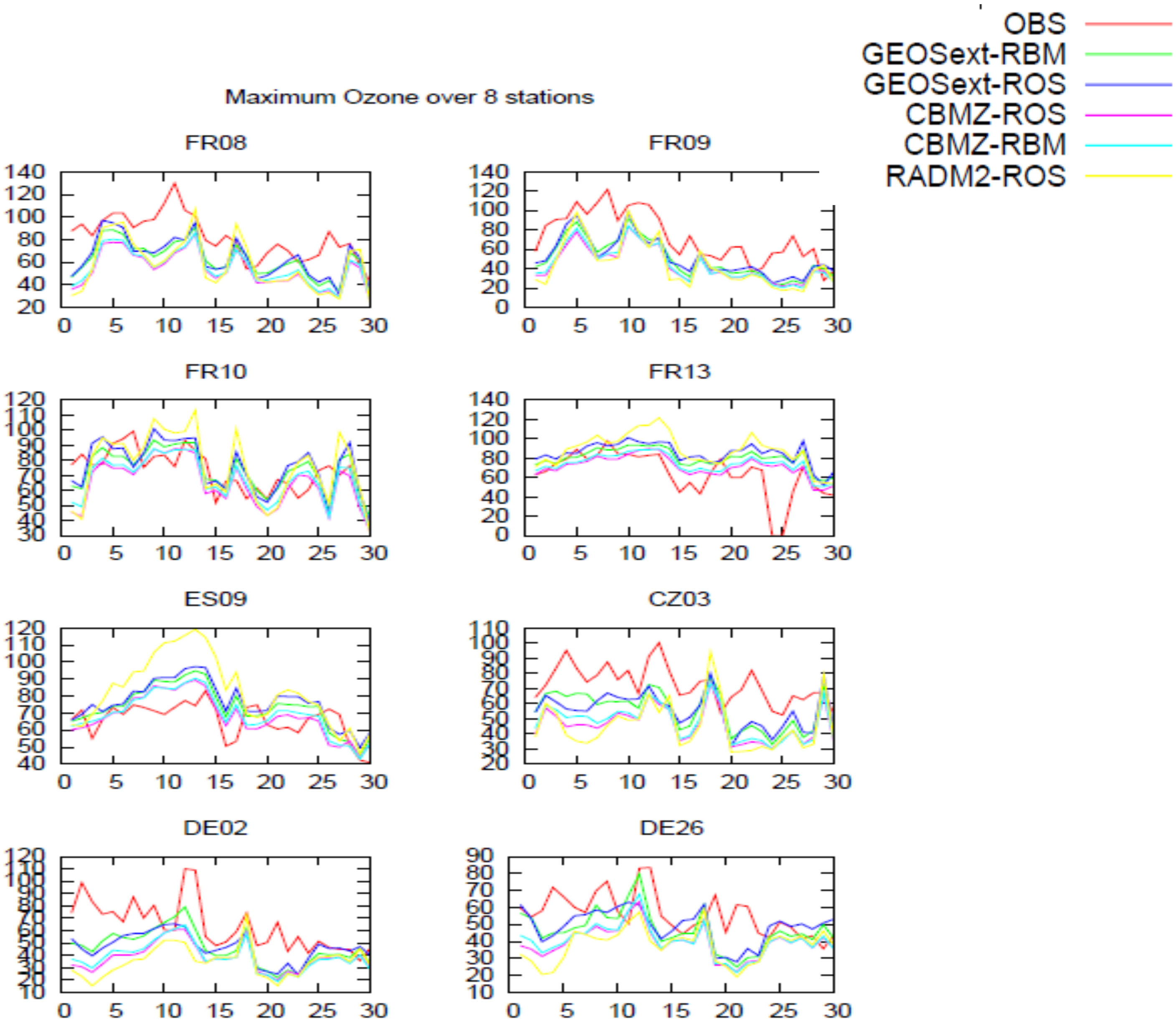
Simulation of the evolution of ozone concentration during Aug 2003 heat wave

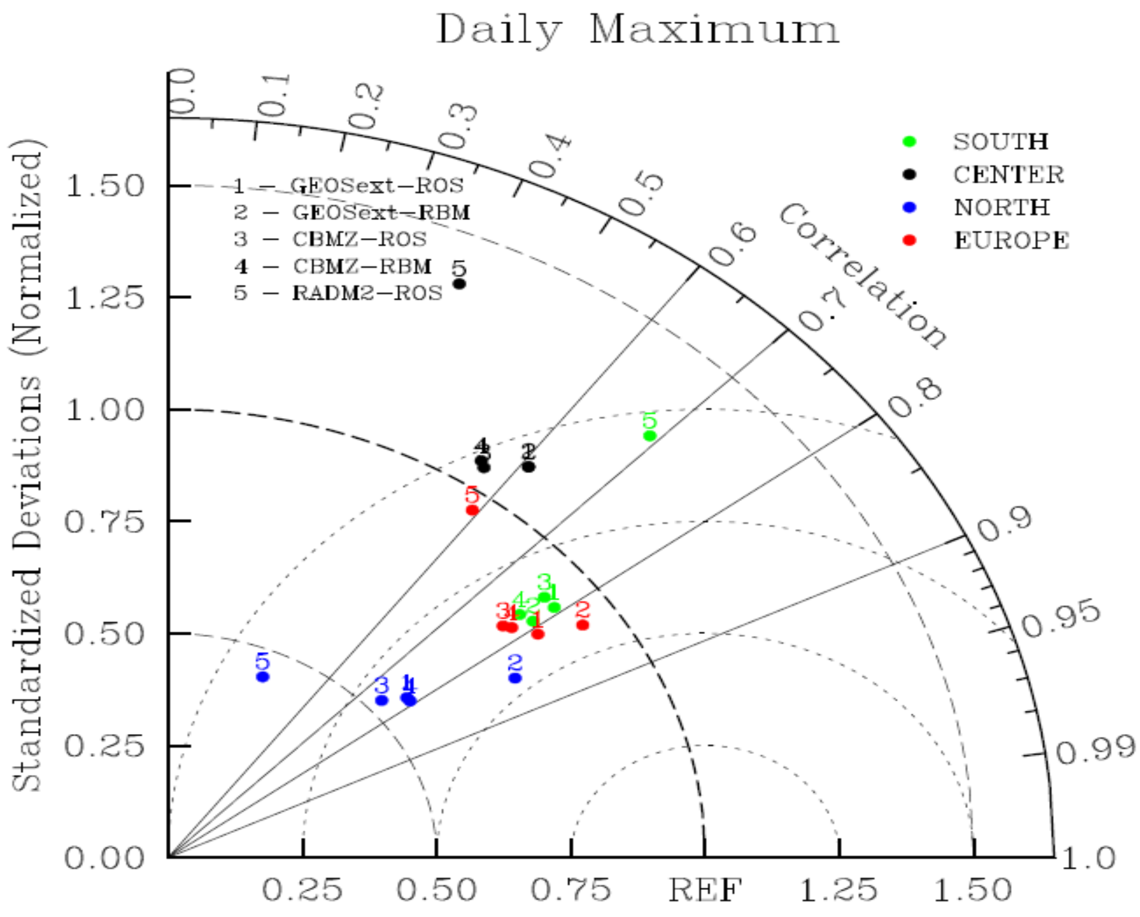


Each panel displays a concentration field in (ppbv) at 14 h UT.
(a) 1-August,
(b) 4-August,
(c) 8-August,
(d) 10-August,
(e) 12-August,
(f) 16-August.

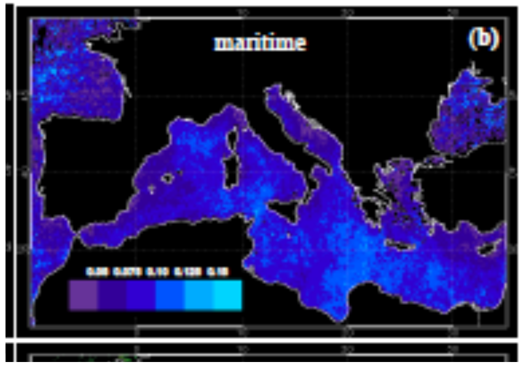
- Indirect effects

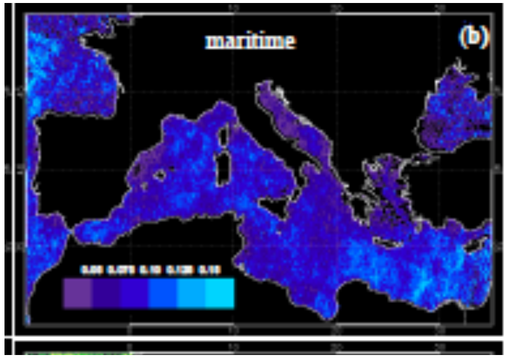
Thank you

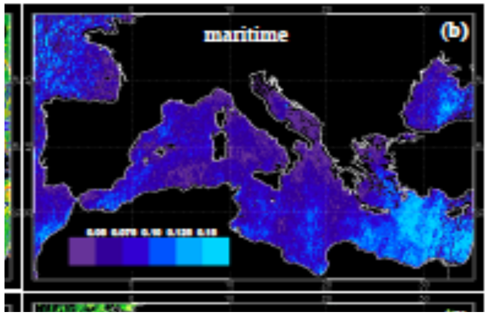

OBS
GEOSext-RBM
GEOSext-ROS
CBMZ-ROS
CBMZ-RBM
RADM2-ROS
Maximum Ozone over 8 stations
FR08
FR09
FR10
FR13
ES09
CZ03
DE02
DE26

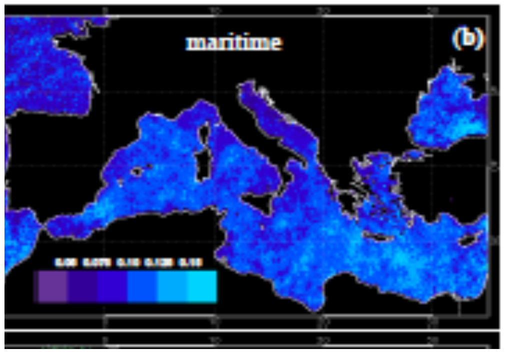


Daily Maximum
Standardized Deviations (Normalized)
Correlation
1 – GEOSext–ROS
2 – GEOSext–RBM
3 – CBMZ–ROS
4 – CBMZ–RBM
5 – RADM2–ROS
SOUTH
CENTER
NORTH
EUROPE
0.00
0.25
0.50
0.75
1.00
1.25
1.50
REF
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0.95
0.99
1.0


maritime
(b)


maritime
(b)


maritime
(b)


maritime
(b)