The Abdus Salam
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2256-12

Workshop on Aerosol Impact in the Environment: from Air Pollution to Climate Change

8 - 12 August 2011

Assessing the regional radiative and climate impact of aerosol: charmex

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ChArMEx

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

Impact of aerosols on the radiative budget & regional climate in the frame of the Chemistry-Aerosol Mediterranean Experiment (ChArMEx)

M. Mallet,

F. Dulac (PI ChArMEx)

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ChArMEx

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

1) General presentation of The Chemistry-Aerosol Med. Experiment (ChArMEx)

2) The WP4 of ChArMEx -> impact on rad. budget and regional climate impact (ADRIMED project)

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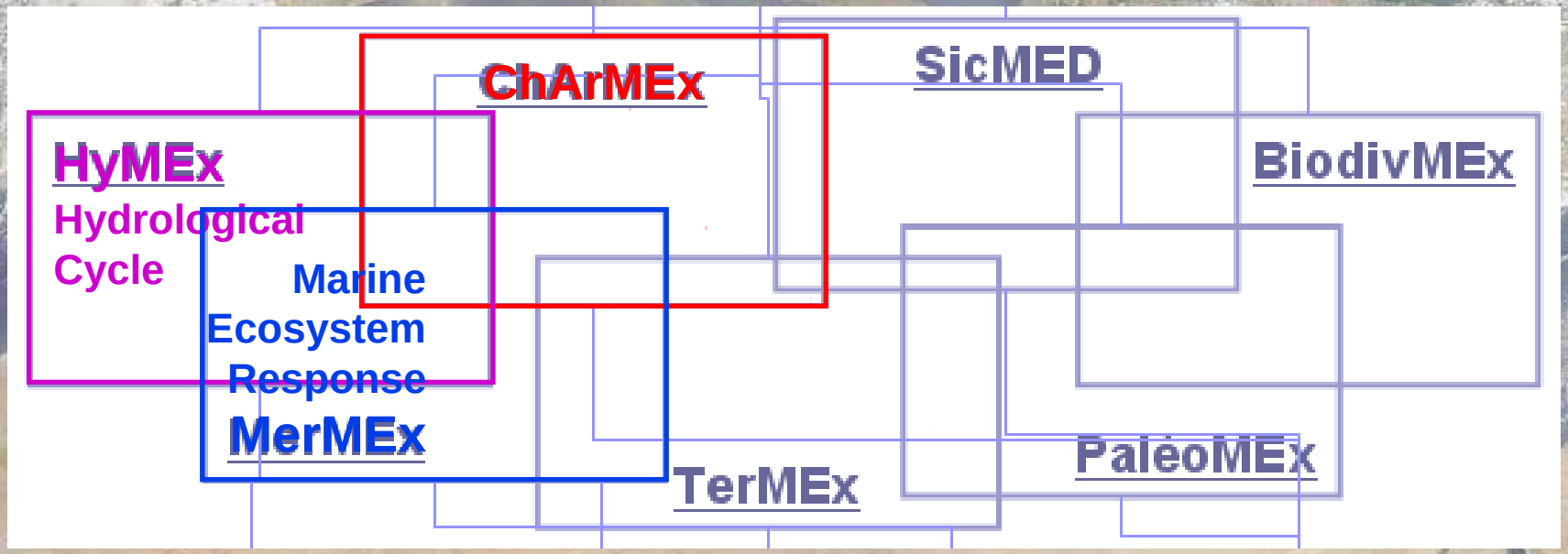
MISTRALS

Mediterranean Integrated STudies at Regional And Local Scales

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

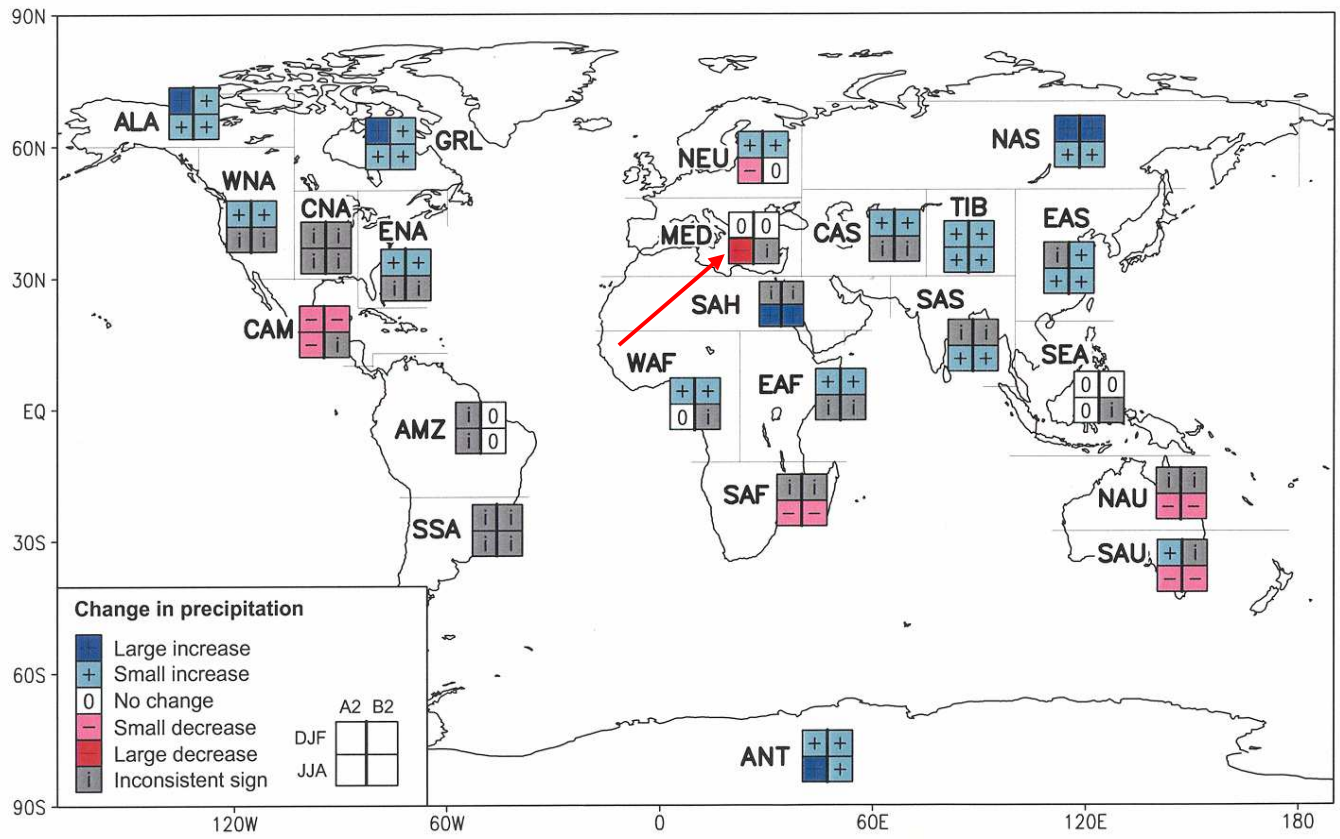
ChArMEx is the atmospheric chemistry component of MISTRALS:
-> it deals with short-lived tropospheric species and their impacts
-> it develops strong interactions with two other O-A MISTRALS actions



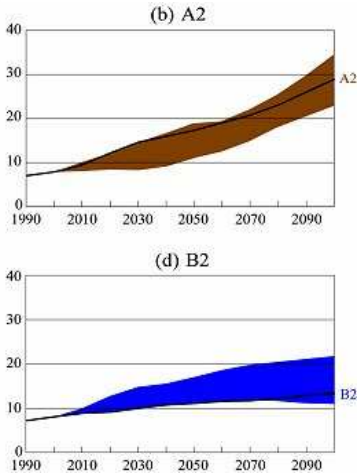
Visit MISTRALS/INSU website for the HyMEx and MerMEx programs !

The Mediterranean combines strong climate change and anthropogenic pressures

-> GCM projections for regional changes in precipitations for the A2 and B2 IPCC scenarios



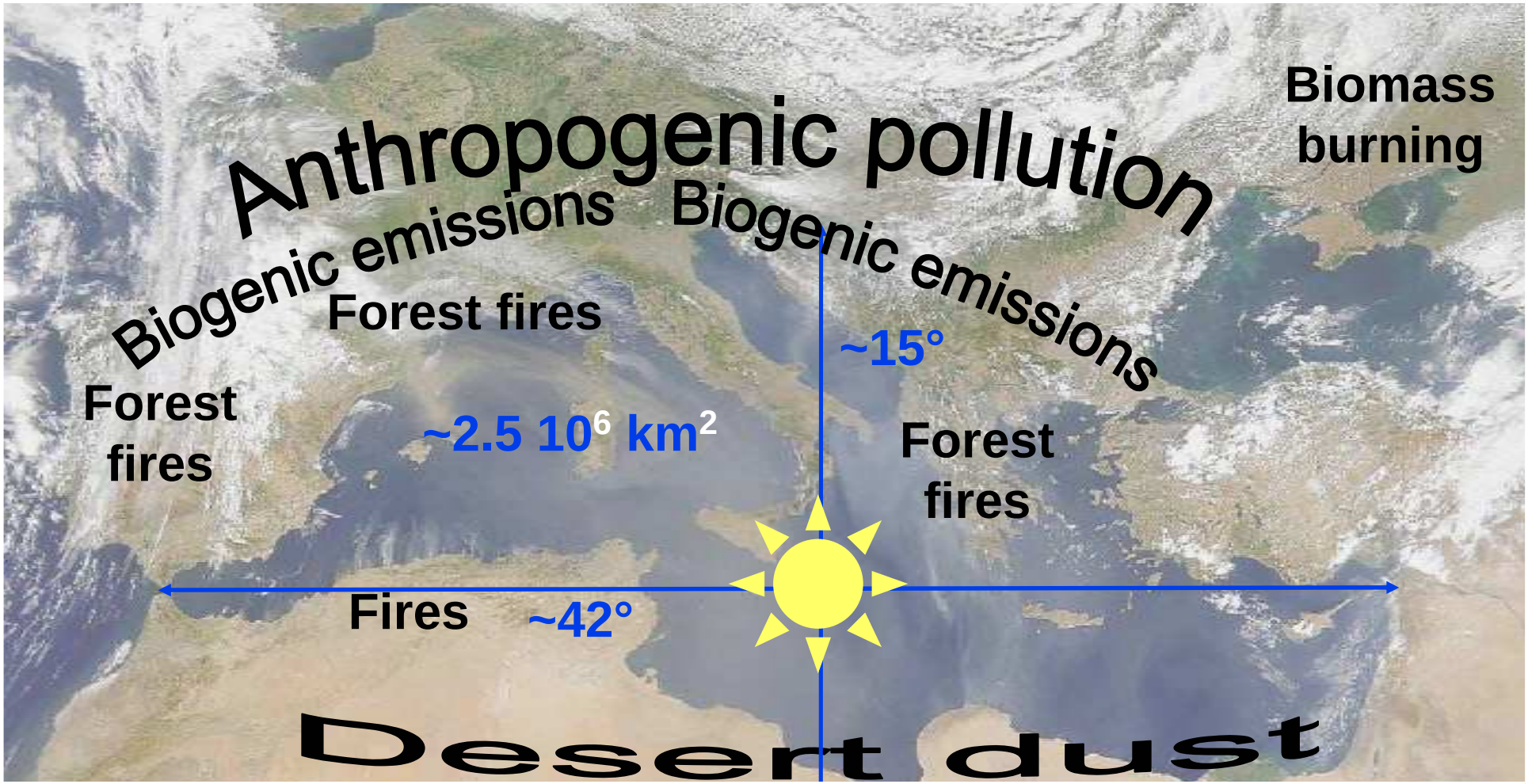
Total global annual CO_2 emissions from all sources (energy, industry, and land-use change) (in GtC/yr) for the IPCC A2 and B2 scenario groups.

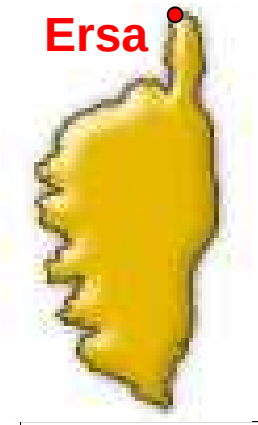


⇨ **<u>IPCC and RCM points to the Med. for the largest possible decrease in summer precipitation</u>**

"Mediterranean": the middle of lands

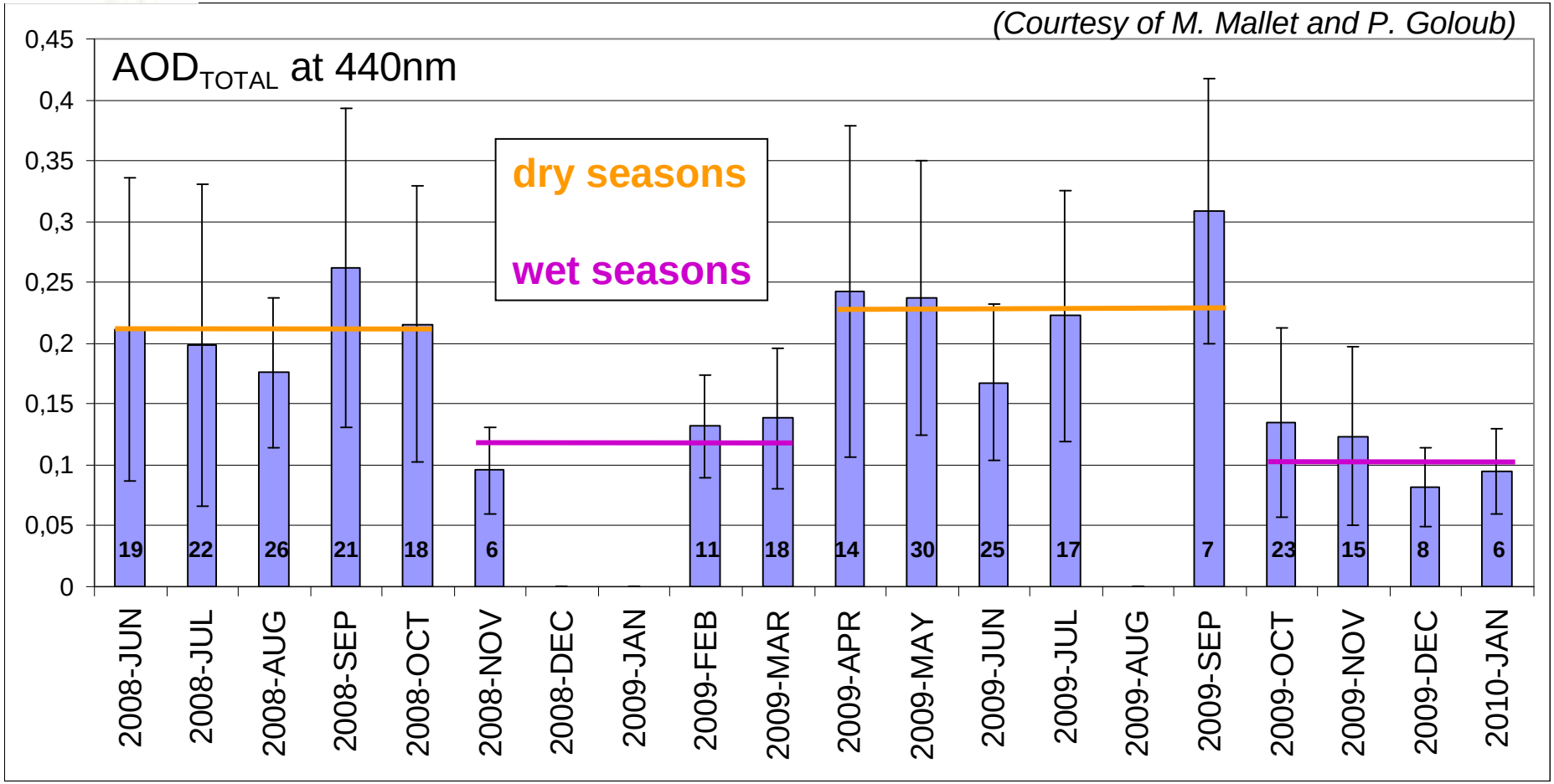
⇨ ***The long dry, hot and sunny Med dry season enhances emissions, photochemistry, continental air mass recirculation***
-> conduct to large aerosol and ozone load over the Med. !





The absence of rain in the long Med. dry season favours an aerosol max.

(Courtesy of M. Mallet and P. Goloub)

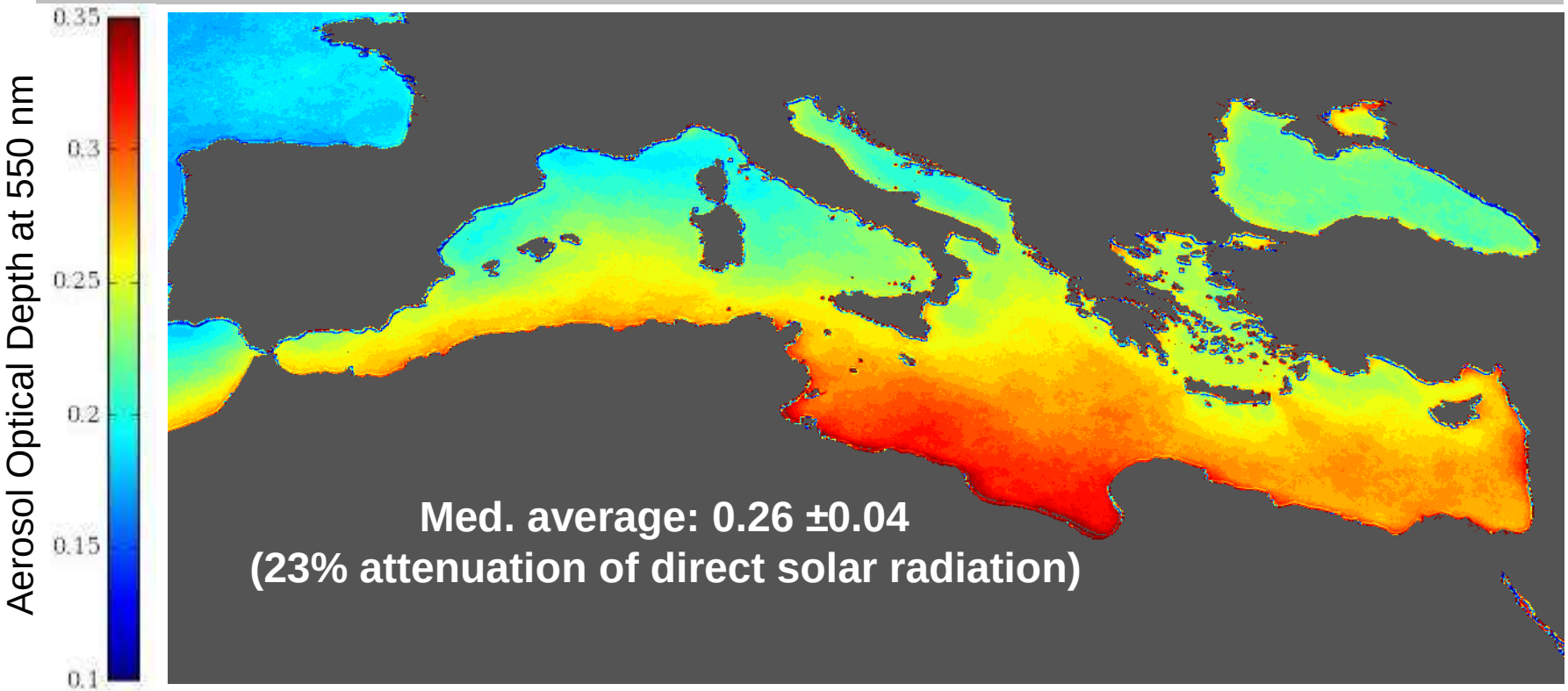


Data available at *http://aeronet.gsfc.nasa.gov/*

African dust dominates the Med. AOD

June 2005 - May 2010 average of MSG/SEVIRI-derived aerosol optical depth at 550 nm

(processed by ICARE Data Center, Lille , based on Thieuleux et al., 2005)



⇨ **Note the geographical variability between North/South**

Smoke aerosols -> another large-scale aerosol source in summer !

MODIS-derived episodes of large forest fire plumes affecting the western Med.
(Pace et al., JGR, 2005)

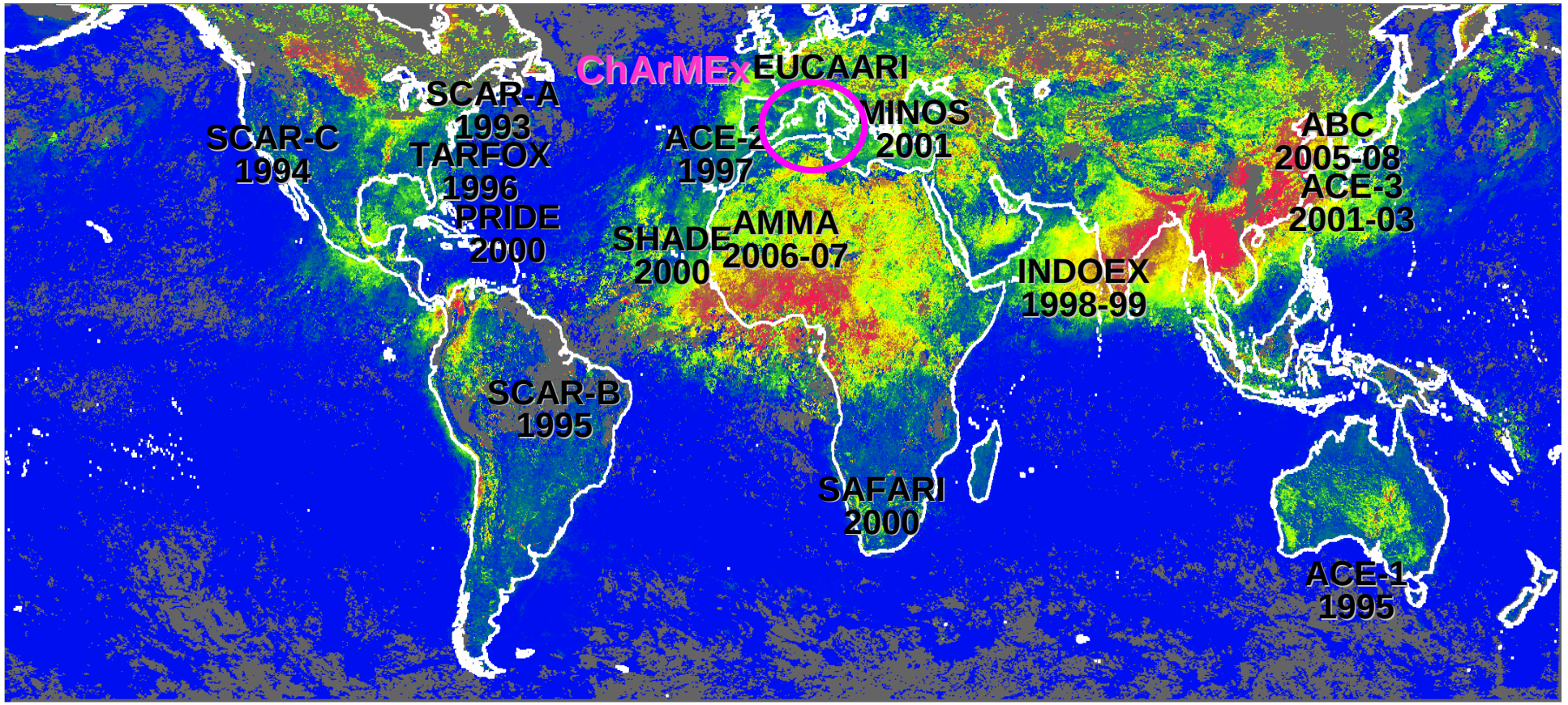
Year	Period	AOT_{550}
2000	20-23 July	0.21±0.04
2001	25-29 July	0.24±0.09
2002	27-30 July	0.16±0.15
2003	8-12 July	0.22±0.06
	4-14 August*	0.21±0.04
2004	15-17 August	0.11±0.05

*heat wave

⇨ The summer 2003 heat wave favoured fires and high concentrations of carbonaceous aerosols over the Med.

Chemistry/aerosol-climate interaction studies are based on regional experiments

⇨ *in spite of important aerosol & gases load, the western Med. has been neglected up to now !*



0 Polder Aerosol Index (March 1997) 0.5

POLDER Data: CNES/NASDA

A favorable context…

- The remote Mediterranean atmosphere offers the best combined possibilities
  - to follow very diverse polluted continental air masses over the basin using satellites (clear sky), background monitoring (observatories) and field campaigns (proximity)
  - to constrain chemistry-transport and chemistry-climate models used for simulating all relevant dynamical and chemical processes
- In addition, the oligotrophic Mediterranean waters offers the best opportunity to use atmospheric and marine biogeochemical models to study atmos. deposition impact
- MISTRALS offers a major opportunity for regional multidisciplinary approaches necessary to improve our knowledge of the “Med. system” (-> ChArMEx-HyMeX-MERMEX)

ChArMEx general scientific objectives

⇨ **1. Assessing the present state of the Mediterranean atmospheric environment**

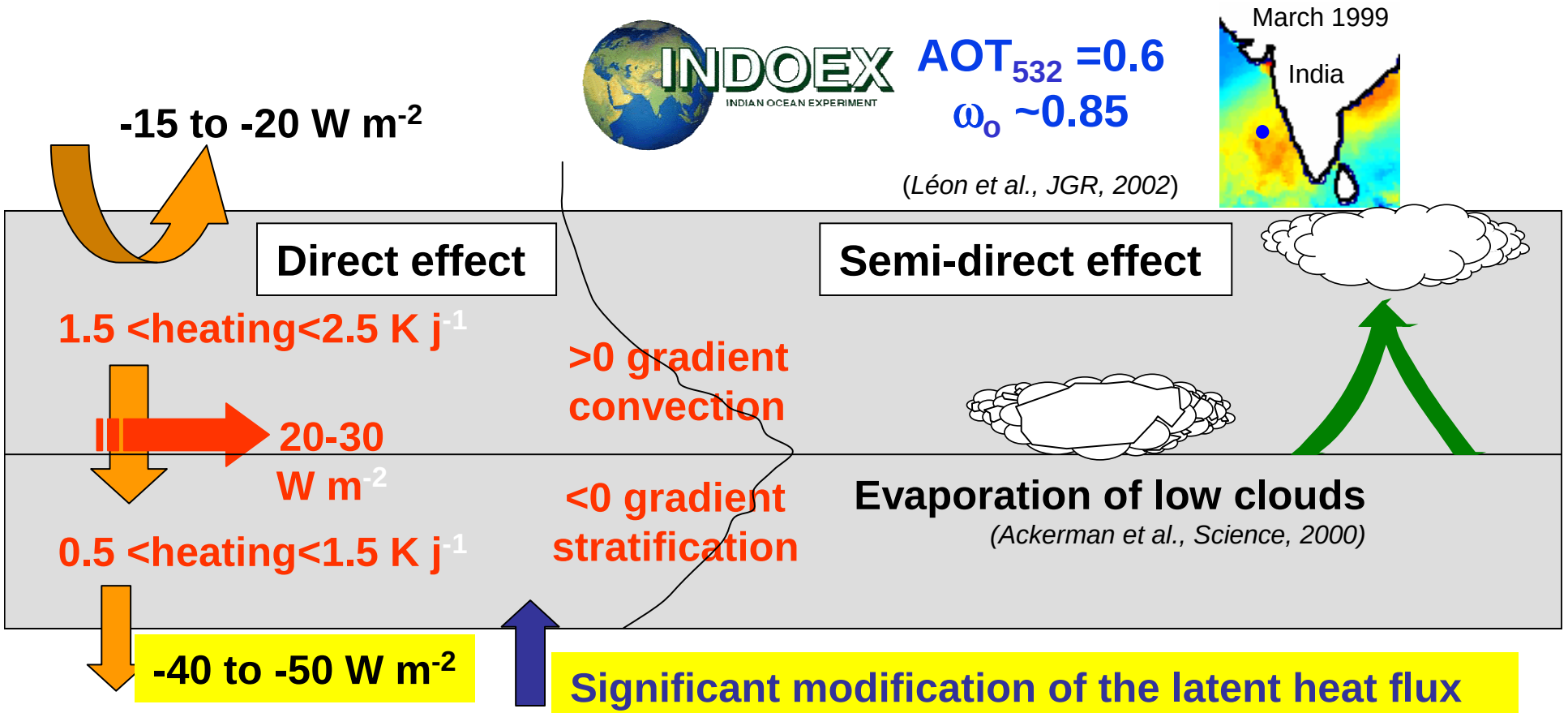
- **Sources and budgets of aerosols and precursors of secondary species?**
- **Chemical and dynamical processes?**
- **Atmospheric deposition?**

⇨ **2. Quantifying the impacts of aerosols and reactive gases**

- ***On the Mediterranean radiative budget and regional climate (SST, evaporation, atmospheric heating, cloud cover, heat waves, photochemistry/oxidizing capacity) --> WP4 (ADRIMED project)***
- **On the surface air quality (long range vs regional contributions)**
- **On the marine surface ecosystems (role of deposition, perturbation of incident radiation)**

⇨ **3. Predict future evolution of these budgets and impacts in the context of climate change and increasing anthropogenic pressure**

Challenge 1: quantifying the impact of antropogenic and natural aerosols on the Med. regional climate : illustration from INDOEX

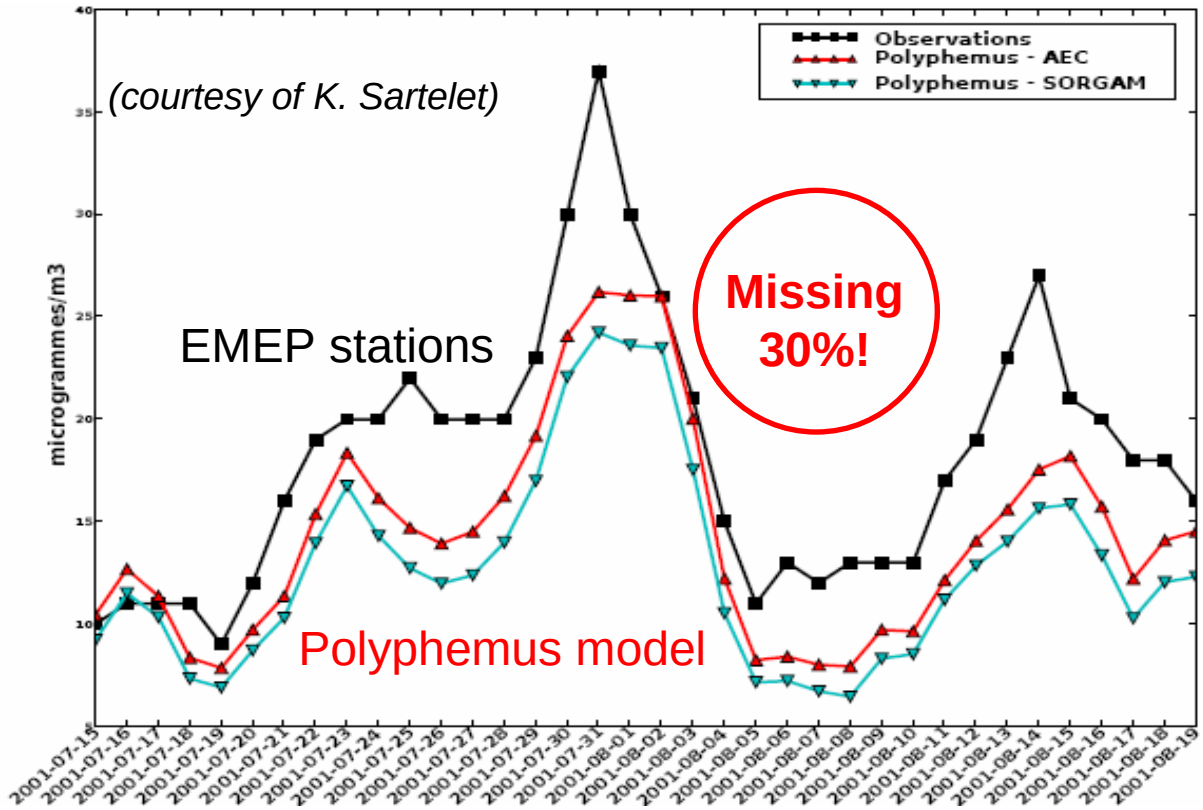


Significant modification of the latent heat flux (-20% over the 4-month dry season!) -> impact on the regional hydrological cycle *(Ramanathan et al., JGR, 2001)*

⇨ *ChArMEx : Modifications on the rain distribution in the Med. region during the dry season ? -> WP4 -> strong connexion with HyMex*

Challenge 2: simulating atmospheric PM air quality

⇨ **Under-estimation of simulated daily PM10 over Europe in summer**



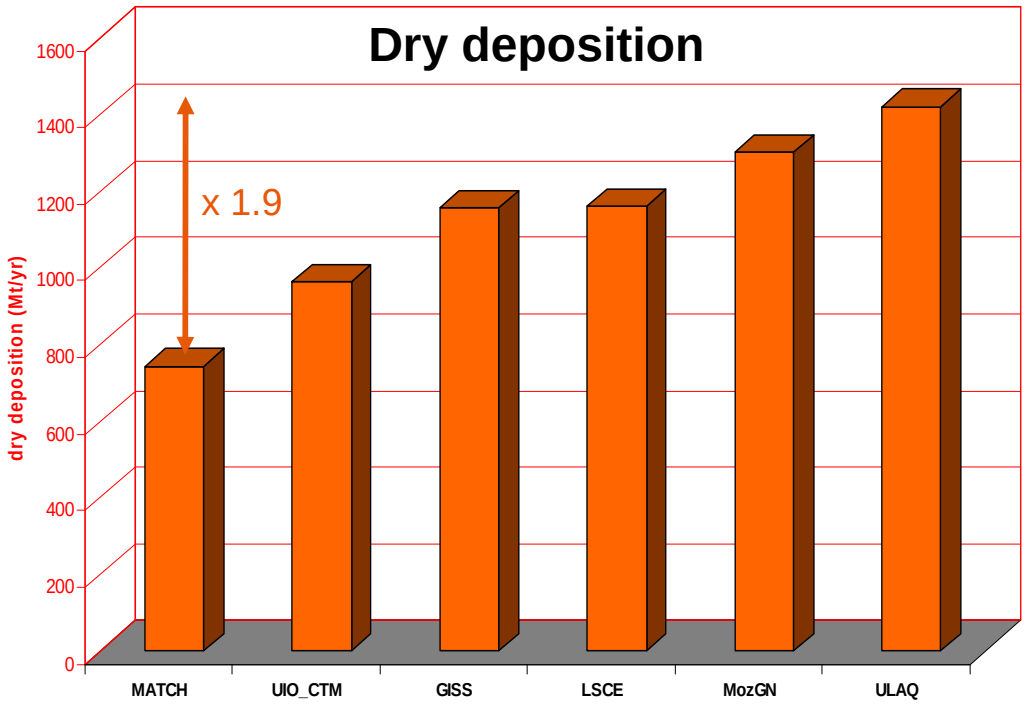
⇨ **Uncertain biogenic and dust emissions**

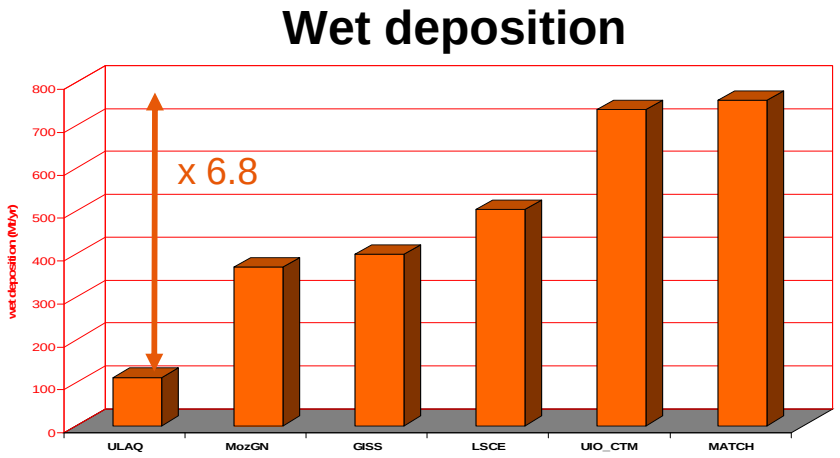
⇨ **Fires not taken into account** (~810 000 ha in Europe during JJA 2007)

⇨ **Organic chemistry to be documented (isoprene and VOCs…)**

Challenge 3: quantifying atmospheric deposition and its biogeochemical impact

Global dust aerosol model intercomparison with prescribed mass fluxes, injection height and emitted particle size





Adapted from AEROCOM (Aerosol Model Comparison; http://dataipsl.ipsl.jussieu.fr/cgi-bin/AEROCOM/; Textor et al., Atmos. Chem. Phys., 2006 and 2007)

⇨ *The huge model variability in deposition is a critical problem to address atmospheric input to surface waters.*

⇨ *In-situ obs. will be used to constrain numerical model ! -> strong connexion with MerMEX*

ChArMEx general strategy

⇨ **A multi-scale exp. and model. integrated strategy**

- **3 levels of in situ field observation:**
  - **LOP: Long-term Observation Period (5-10^{+} yr)**
    - **Trends and interannual variability**
    - **a networked background observatories with basic chemical and radiative parameters**
  - **EOP: Enhanced Observation Period (2-3 yr)**
    - **daily to seasonal variability**
    - **continuous monitoring incl. detailed chem.**
  - **SOPs: Special Observation Periods (field campaigns)**
    - **detailed process studies at the regional scale**
    - **lagrangian and column type observations**
    - **intensive campaigns, extensive measurements, airborne means**
- **Spaceborne (MODIS, PARASOL, CALIOP,…) remote sensing**
- **Chemistry-transport and chemistry-climate modelling**

ChArMEx Scientific Work Packages

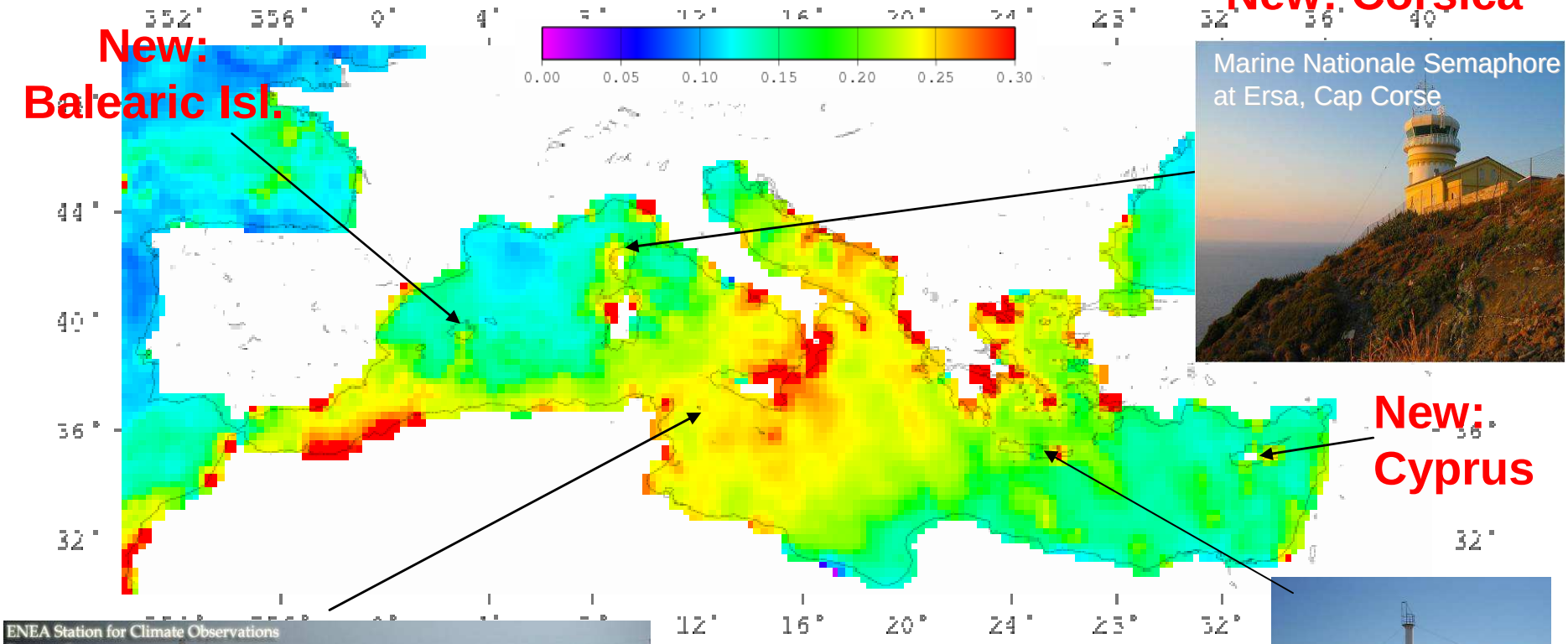
WP	Short title	Title	French co-leaders	International co-leaders
WP 1	**Sources**	**Emission inventories and source apportionment**	**C. Liousse, N. Marchand**	**X. Querol (ES)**
WP 2	**Ageing**	**Atmospheric processing of reactive gases and aerosols**	**A. Borbon, K. Sartelet, J. Sciare**	**C. Reeves (UK), H. Schlager (DE)**
WP 3	**Transport**	**Impact of long-range and vertical transport on air quality**	**J.-L Attié**	**S. Arnold (UK), U. Dayan (IL), G. Kallos (GR)**
WP 4	**Radiation**	**Radiative budget and climate impact**	**M. Mallet**	**L. Alados-Arboledas (ES), G. di Sarra (IT), W. O'Hirok (CY)**
WP 5	**Deposition**	**Atmos. deposition to the sea of compounds of biogeochemical interest**	**K. Desboeufs, E. Pulido-Villena,**	**I. Hedgecock (IT), A. Tovar-Sanchez (ES)**
WP 6	**Trends**	**Recent trends and variabilities in trace species over the Mediterranean region**	**P. Ricaud**	***To be identified***
WP 7	**Future**	**Modelling the future of the Mediterranean atmospheric chemistry and its impacts**	**V.-H. Peuch, I. Coll**	***To be identified***

Visit ChArMEx web page http://charmex.lsce.ipsl.fr for more informations

ChArMEx proposes a network of atmospheric background Mediterranean stations

Summer (JJA) 2007 aerosol optical depth at 865 nm from PARASOL

(courtesy of D. Tanré, J.-L. Deuzé and F. Ducos)



New: Balearic Isl.

New: Corsica

New: Cyprus

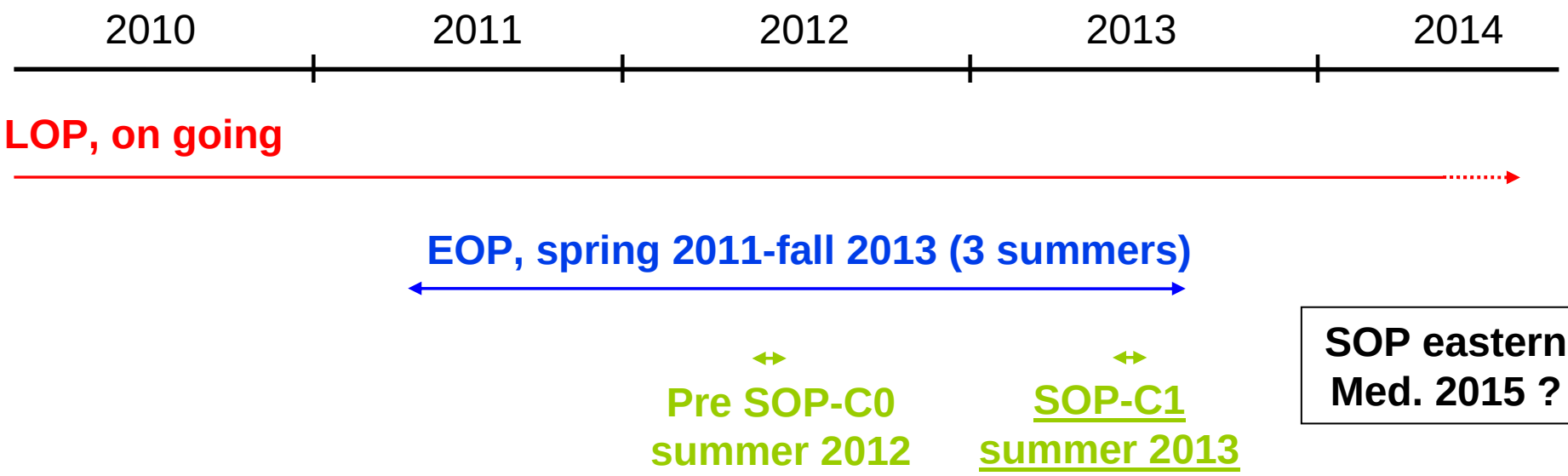
Lampedusa

Finokalia

+ existing background observatories (e.g. PAES, IAGOS…)

ChArMEx 2010-2014 operation planning

2011-2012: new infrastructure for the Corsica observatory



Main option for summer SOP: 6 weeks from late june (dust) to early august (fires)

- ⇨ **Joint EOP with HyMeX and MERMEX**
- ⇨ **ChArMEX SOPs in alternance or joint with HyMeX-MERMEX SOPs**

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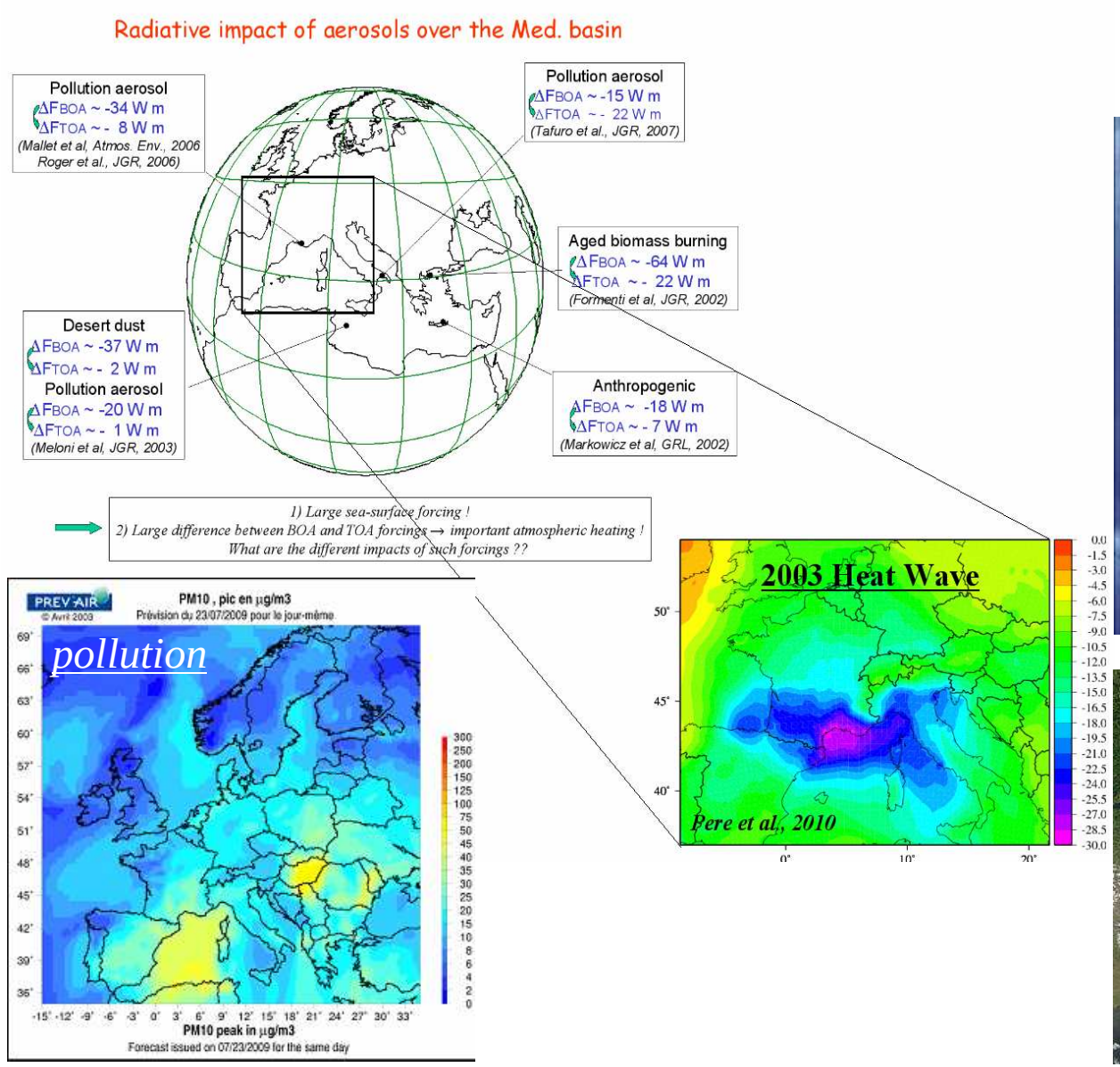
http://charmex.lsce.ipsl.fr/

-> WP4 work package : Aerosol direct Forcing and Regional Climate impact

The ANR ADRIMED project

Context (1)

The different Med. aerosols have a large impact on the Med. radiative budget
-> Sea-surface dimming + Atmospheric Forcing for all aerosol types !

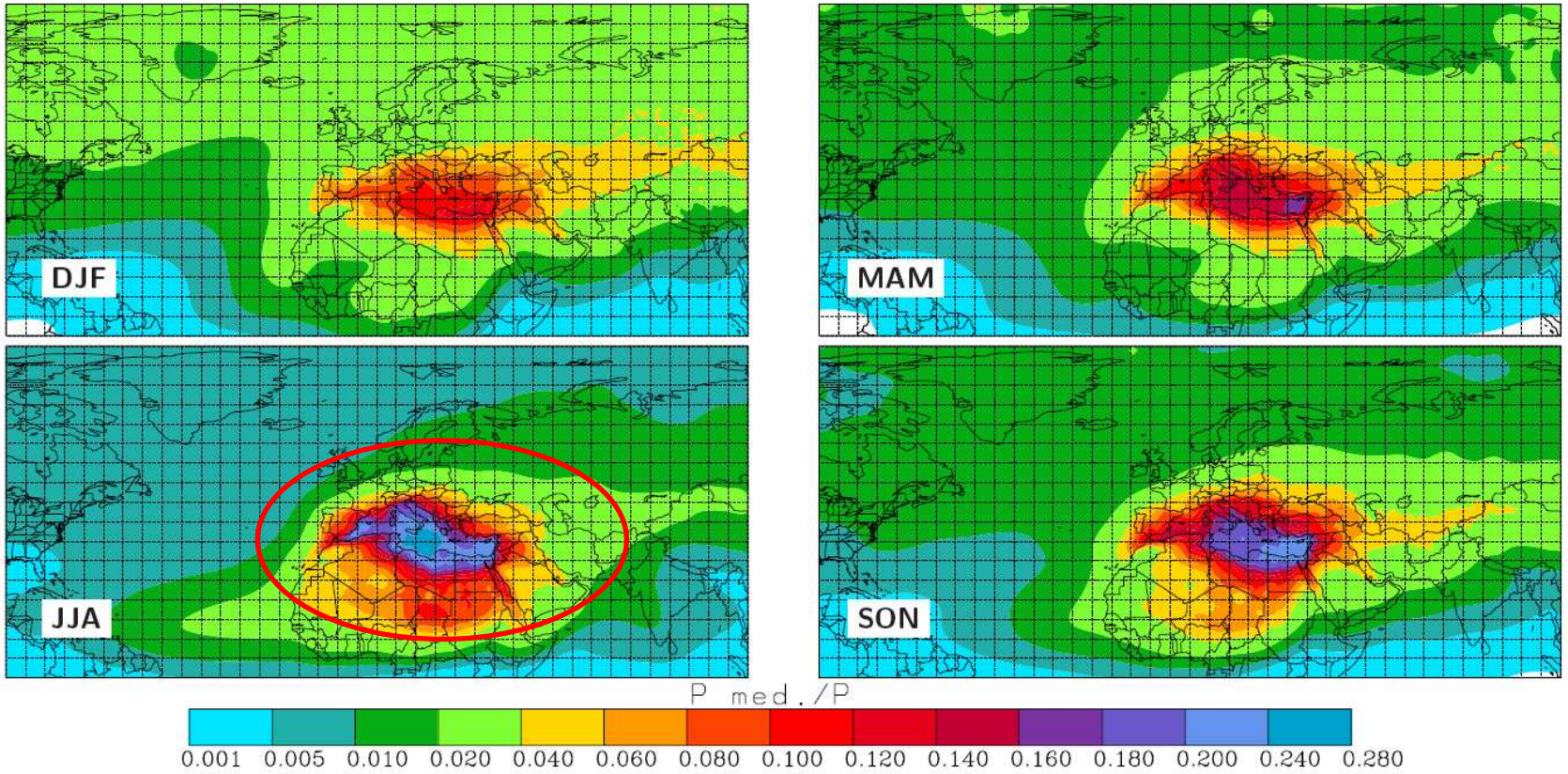


Context (2)

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

-> The local Med evaporation has a central role in the local precipitation

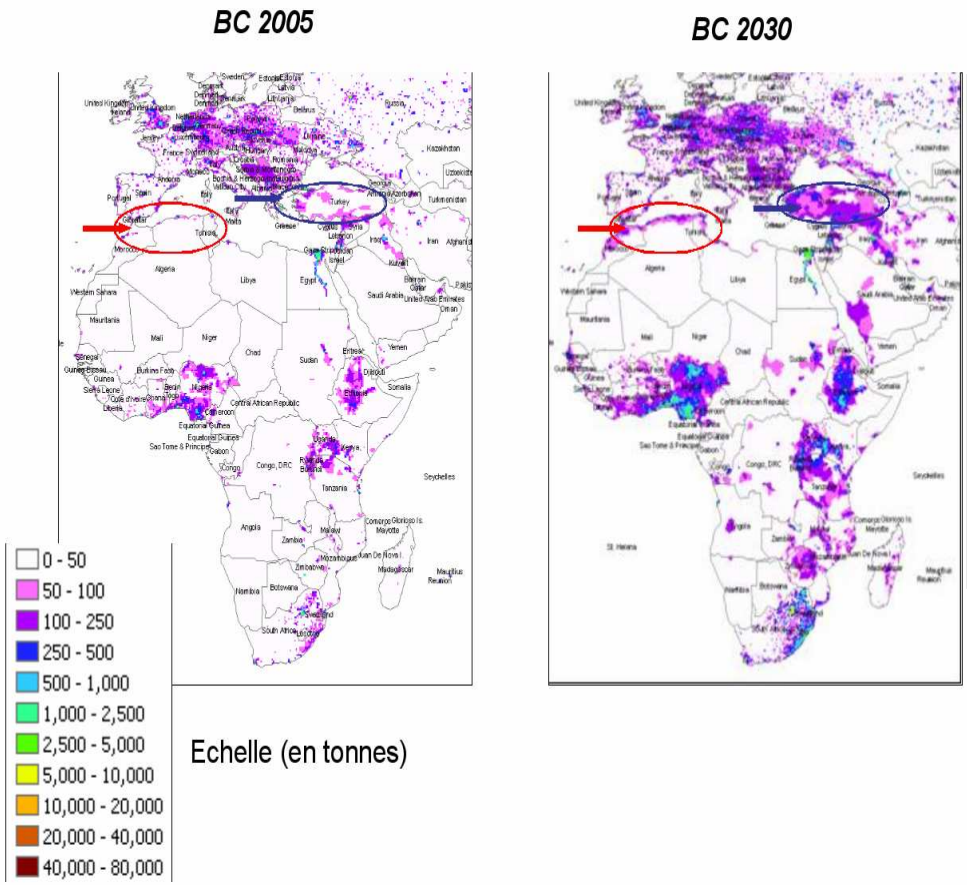
Impact of the sea surface Aerosol Direct Forcing ?



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

Context (3)

Increase of anthropogenic emissions in the next future…



Scenario projections of anthropogenic aerosols indicate a large increase of particulate anthropogenic emissions,

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

These specific anthropogenic emissions, in addition to heat waves and biomass burning events, should contribute ***to increase significantly the aerosol load over the basin 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.

WP4 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) ?

radiative effects

2)

- What is the aerosol and gases radiative forcing (at local and regional scales) at the sea-surface, TOA & into the atmosphere (SW & LW) ?
- What is the associated diabatic heating rate (SW & LW) ?

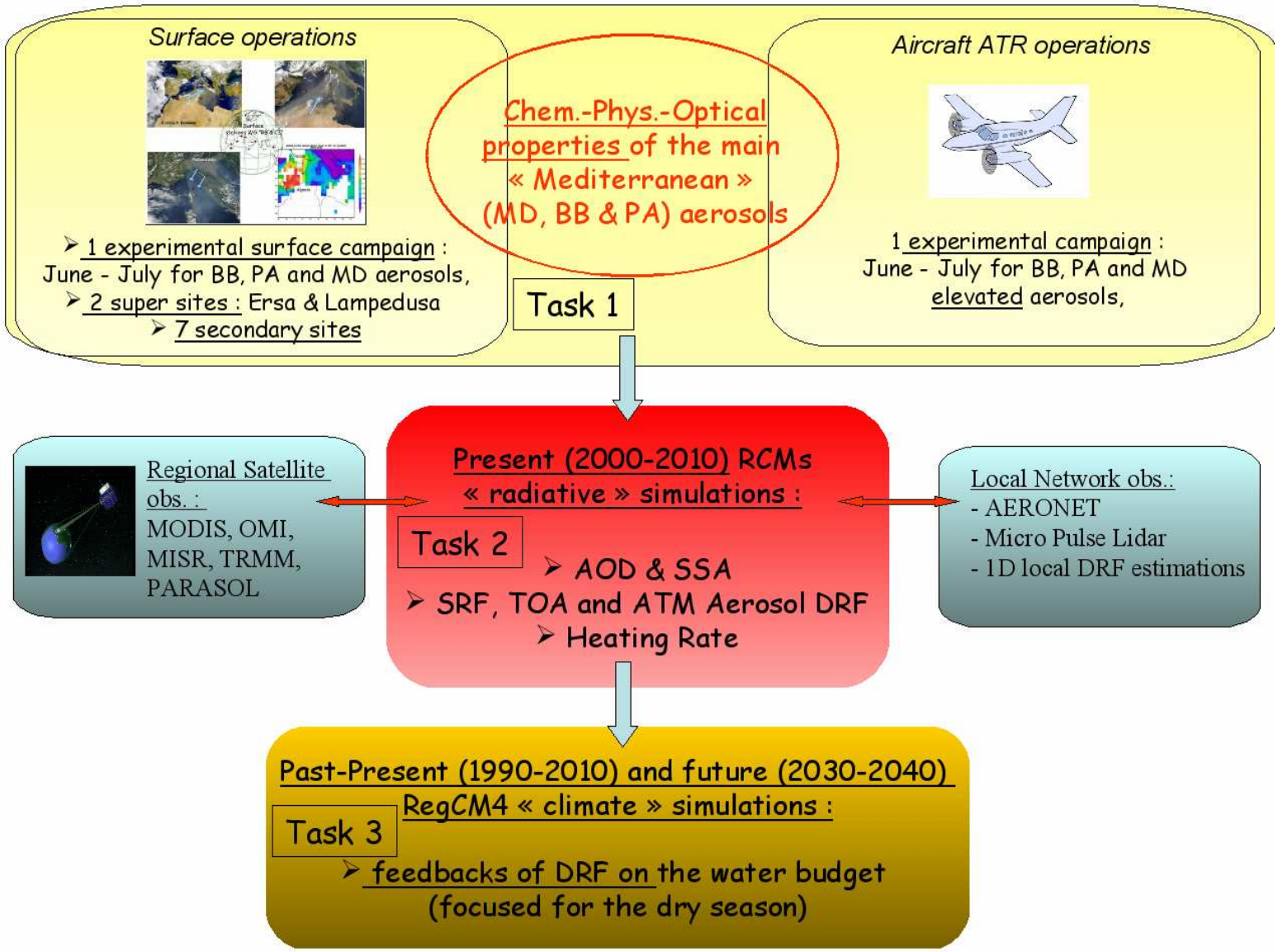
impacts

3)

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

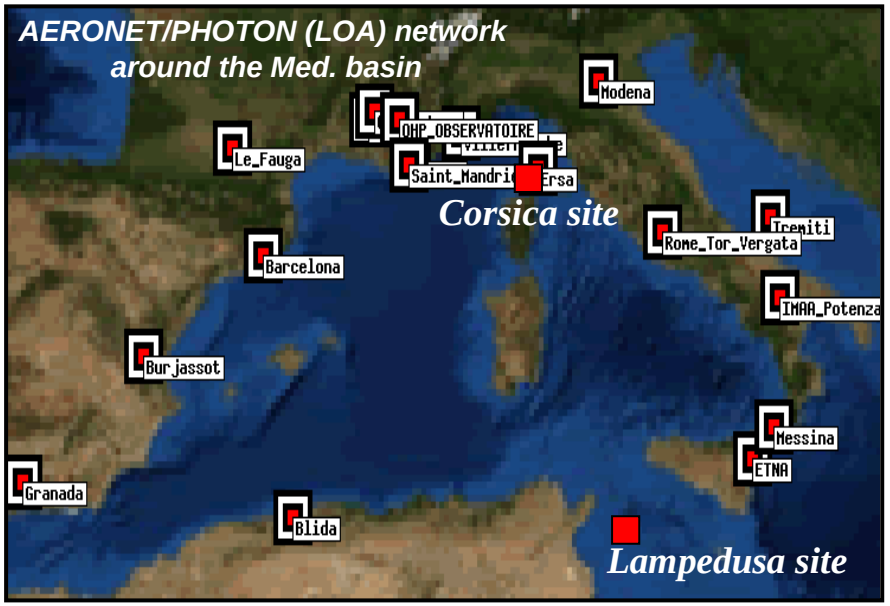
→ ***high connexion with HymeX TTM3 !***

General view of the ChArMEx WP4 (ADRIMED project)



WP4 Strategy -> Obs. over 2 (Ersa & Lampedusa) ground-based super-sites

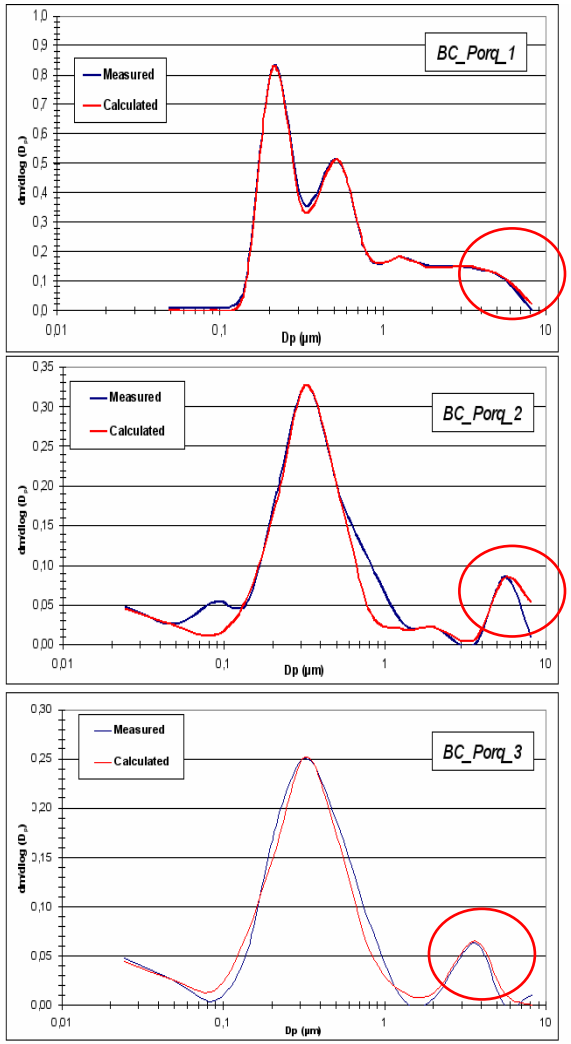
- **Aerosol Physical properties :** fine (DMA) and coarse (GRIMM) number size ditribution
- **Aerosol Chemical properties :** concentration of the main aerosol species (BC, OC, sulfate, nitrate,…) : DKTI filters
- **Aerosol Optical properties :** 3λ nephelometer (scat.), 7λ aethalometer (abs.), PSAP (abs.), AER./PHOTON (whole-column averaged AOD, SSA, vol. size dis.)



- (**Aerosol mixing properties :** HTDMA (external or internal) VTDMA (coating) & MEB (study of core and shell properties))

- **Radiative fluxes :** pyranometer (SW), pyrgeometers (LW)
- **Aerosol vertical profiles :** Lidar obs.

WP4 in-situ obs. will be used for « updating » aerosol optical properties used in RCMs over the Med. -> example for BC particles

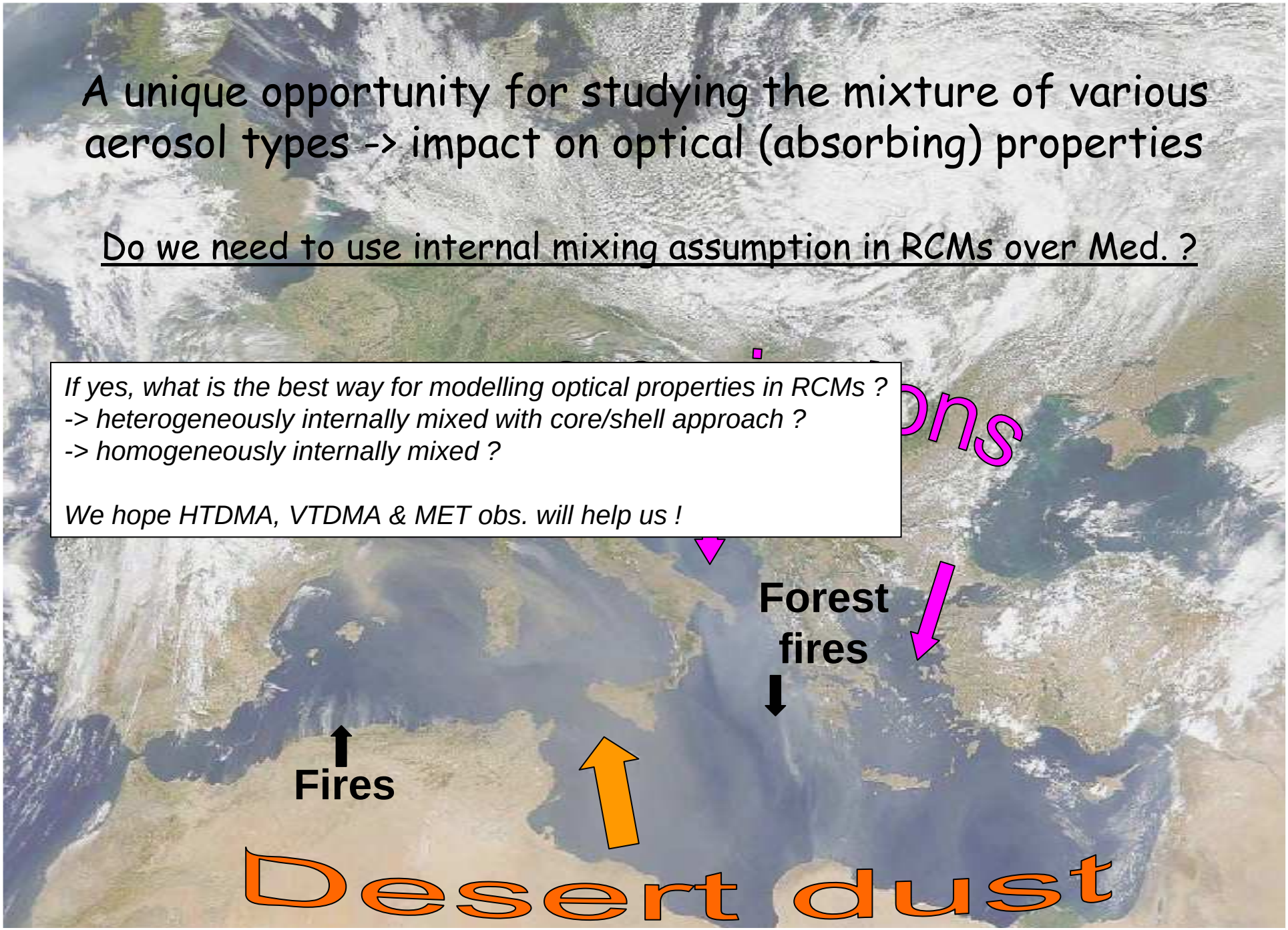


Recent observations indicate that the presence of fine *and coarse BC modes* leads to lower « bulk » BC Mass Ext. Efficieny -> 6 m^2g^{-1} (SW)

Such observations should be consolidated in the frame of the WP4

Improvements of BC optical properties in RegCM4

Mallet, Gomes, Solmon et al., Atmos. Res., 2011


A unique opportunity for studying the mixture of various aerosol types -> impact on optical (absorbing) properties
Do we need to use internal mixing assumption in RCMs over Med. ?
If yes, what is the best way for modelling optical properties in RCMs ?
-> heterogeneously internally mixed with core/shell approach ?
-> homogeneously internally mixed ?
We hope HTDMA, VTDMA & MET obs. will help us !
Forest fires
Fires
Desert dust

WP4 Strategy -> Aircraft operations during SOP summer 2012 (or 2013)

1) Aircraft observations onboard the ATR-42 :

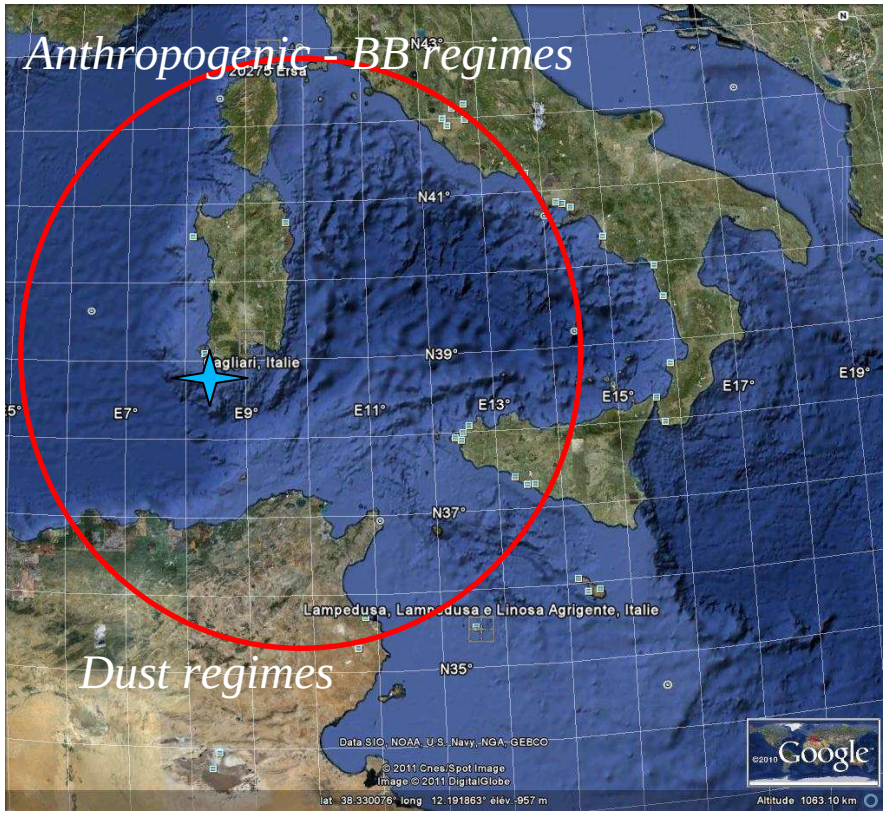
- Aerosol physical properties : PCASP, SMPS and GRIMM
- Aerosol chemical composition and mixing : AMS, SP2, impactor sampling,
- Aerosol optical properties : PSAP, aethalomete 7λ, TSI Nephelometer 3λ and PLASMA
- Upwards and downward SW & LW fluxes : Pyranometers and Pyrgeometers

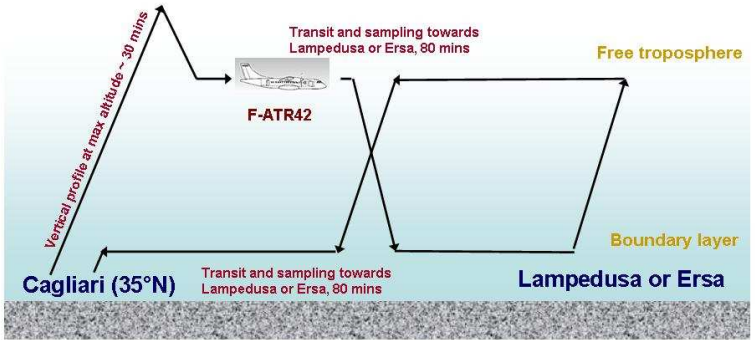
2) Aircraft observations onboard the F20 :

- Aerosol optical properties : OSIRIS
- Radiative fluxes : CLIMAT, MICROPOL
- Aerosol profiles : LNG Lidar

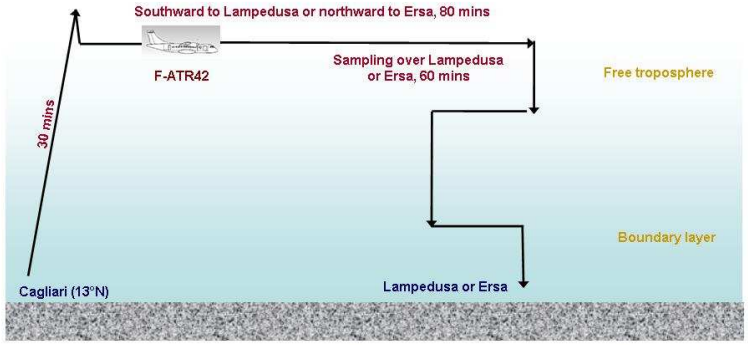
Aircraft operations during the ADRIMED project

Scientific objective : regional characterisation





Scientific objective : Aerosol characterisation and optical/radiative closure



- *ATR-42 will be based in Cagliari (Sardignia)*
- *17 days + 24 hours of ATR-42 flights are funded*

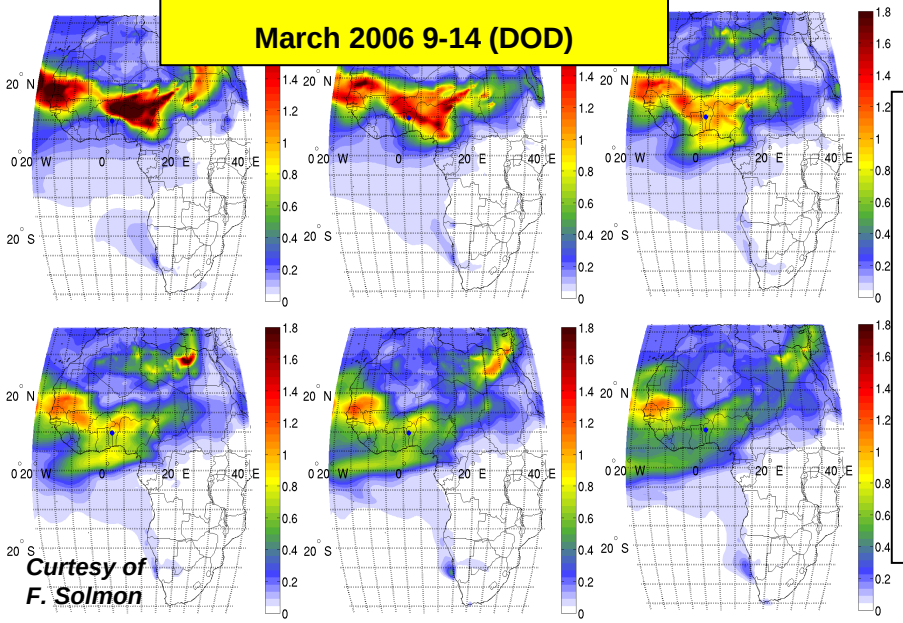
WP4 Strategy -> Regional Climate Modeling exercices & interaction with ICTP (RegCM4)

Regional Climate Models (RCMs) including

« aerosol-radiations » SW & LW interactions

AMMA example - DUST event

March 2006 9-14 (DOD)



long-term (present & futur) regional climate simulations

1) RegCM4 - dust
(-> post-doctoral position ADRIMED, collab. F. Solmon)

***2) RegCM4 - dust coupled with an** oceanic modeling system …to be discussed…*

3)** Sea-Atmos. Med. Mod : **ALADIN
-> complete ocean-atmopshere coupling
*but **<u>without dust scheme for the time</u>***
(-> PhD MF: P. Nabat, resp. S. Somot, coll. F. Solmon)

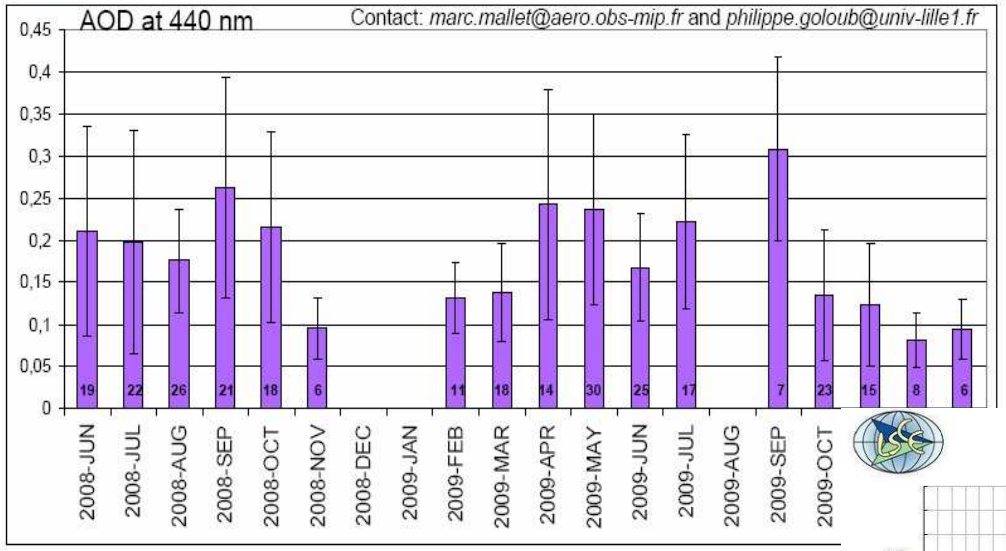
<u>Objectives :</u>

1) Aerosol Direct Radiative Forcing (ADRF) <u>at the regional</u> scale
2) Feedbacks of ADRF on the sea surface evaporation fluxes and SST over the Mediterranean basin
3) Impact of ADRF on the water cycle and precipitation pattern (focus on the North Africa) for present and future (WP 1 ChArMEx « emissions ») climate

Visit ChArMEx web page http://charmex.lsce.ipsl.fr

Monthly average of the Aerosol Optical Depth at 440 nm at Ersa (43.00°N, 09.36°E, alt. 80 m)

(the number of days with measurements is given for each month)



Data available at http://aeronet.gsfc.nasa.gov/cgi-bin/type_one_station_opera_v2_new?site=Ersa&nachal=2&lev

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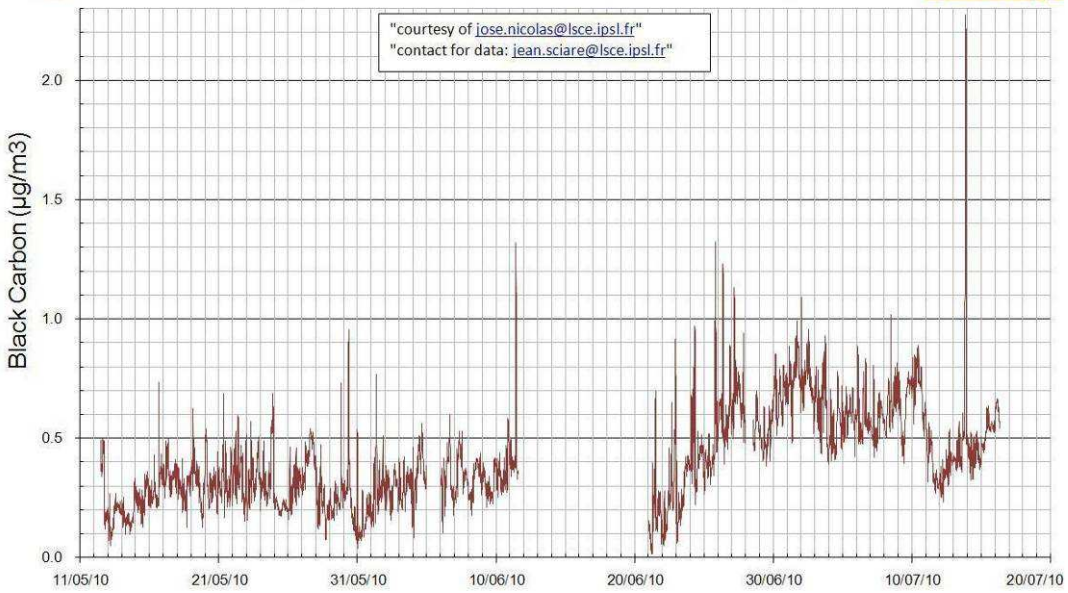
Hourly average of Black Carbon at Ersa
Aethalometer 1 lambda (880 nm)



Collaborations is welcome !

Thank you !