SOLAS 2015

Ongoing Developments in the model Méso-NH for emission of primary sea salt aerosols

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Motivation

Objectives :

Caracterise the physico-chemical (concentration, size distribution, chemical composition, vieillessement, hygroscopicity) et optical properties of marine aerosols and their Direct Radiative Effect (DRE) (visible et close IR) in the Mediterranean bassin

Tools :

Experimental data from field campaigns ChArMEx (ADRIMED & SAFMED+)

Lagrangian transport and dispersion model **Flexpart** (Stohl et al., 1998)

Meteo data, AERONET/PHOTONS, satellite data (MODIS, Seviri)

Méso-NH model

Implementation of a new emission scheme of primary marine aerosols (Ovadnevaite et al., 2014) in the Méso-NH model

Step 1 : Study of the experimental data

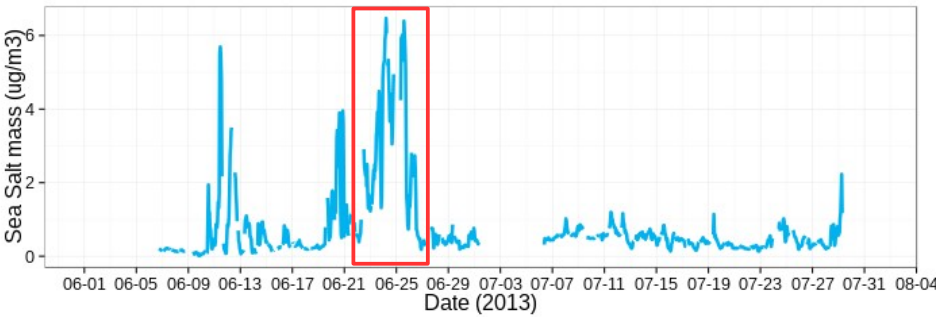
Step 2 : Méso-NH Modelling

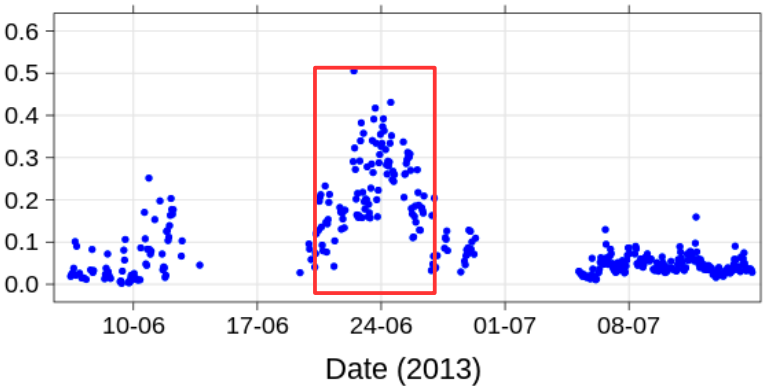
Estimate the ability of the model Méso-NH to reproduce the concentration and optical properties of marine aerosols and their effect on solar radiation

→ Case study

Case study 1
ADRIMED 22-26 June 2013

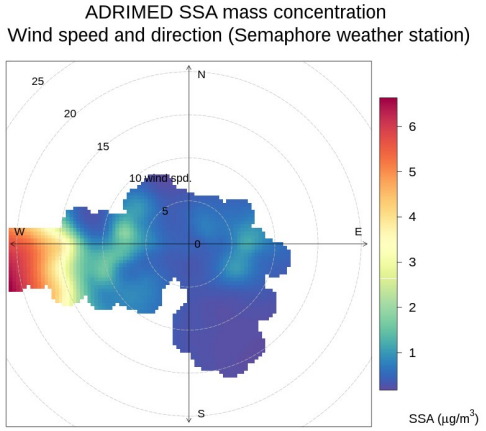
Choice of a simulation period





$[SSA]=[Cl^-] + [Na^+] + [ss\text{-}Mg^{2+}] + [ss\text{-}SO_4^{2-}] + [ss\text{-}Ca^{2+}] + [ss\text{-}K^+]$
PILS data (*LSCE*)

Ratio [SSA] (PILS) / [PM10 mass] (TEOM)



Sea salt concentration higher with **local westerly wind**

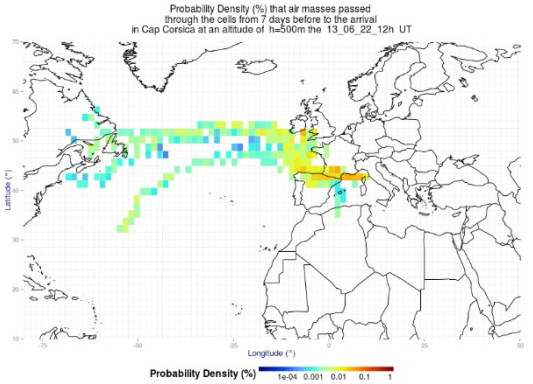
22-26 June

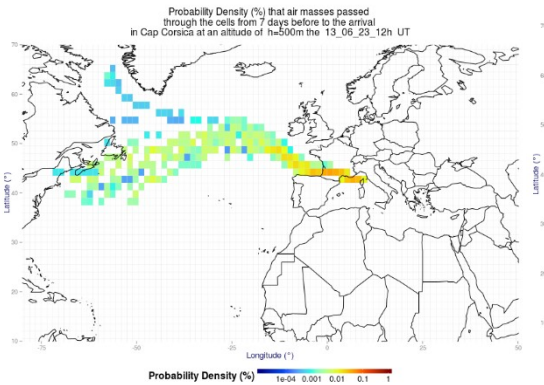
In situ measurements:
→ SSA concentration reaches **6 µg/m³**
→ SSA concentration **> 40 % mass (PM10)**

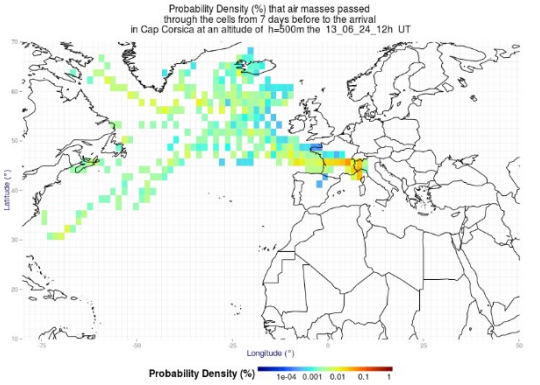
Period caracterised by **significant concentrations of sea salt aerosols** and **adapted to the objectives of this study**

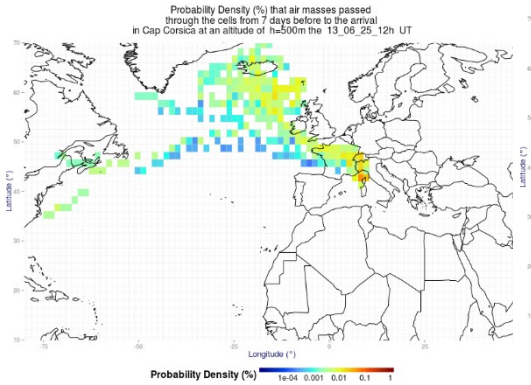
Case study 1
Air masses origins

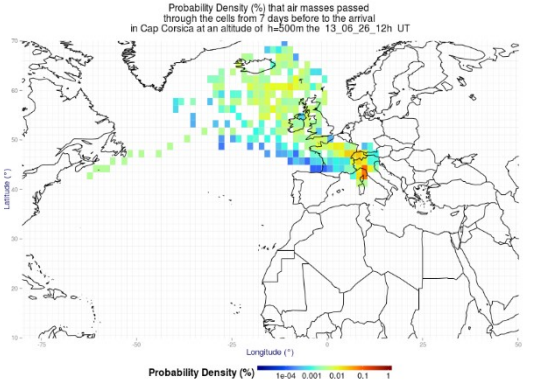
Flexpart maps









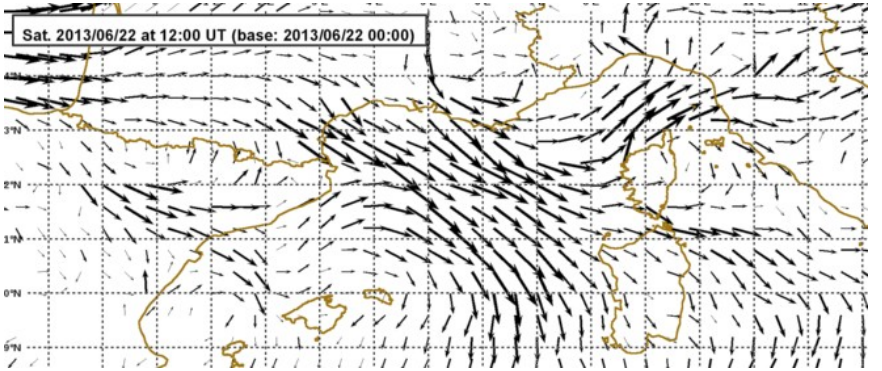


West
Gulf of Lion
North Atlantic Ocean

Time transport to Ersa:
Gulf of Lion : **few hours**
Gulf of Gascogne : **> 2 days**

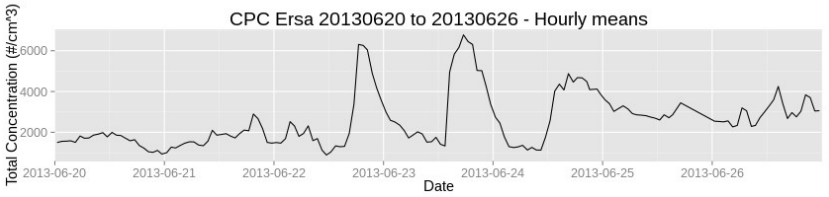
-> **P**ossible contribution of fresh sea salt (Gulf of Lion) and aged sea salt (Gulf of Gascogne and Atlantic Ocean)

Strong winds
Gulf of Lion

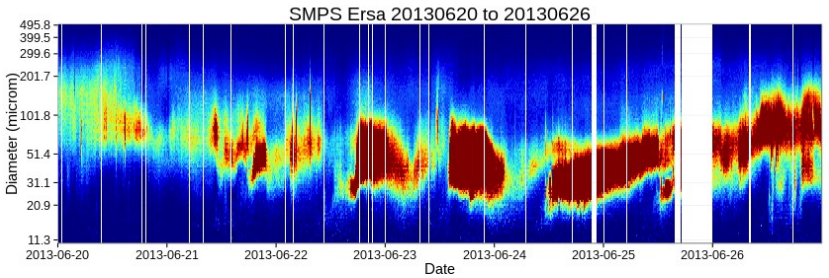


ARPEGE 22/06 12h UT forecast + 3h

Case study 1
Size distribution



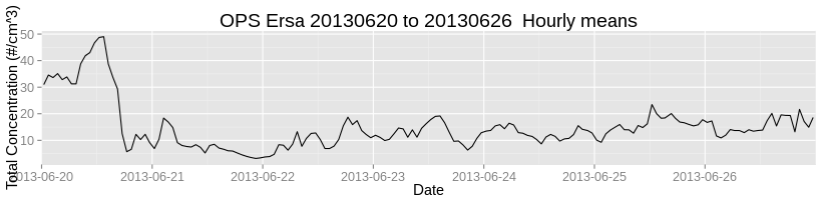
Concentration depending on aerosol sizes

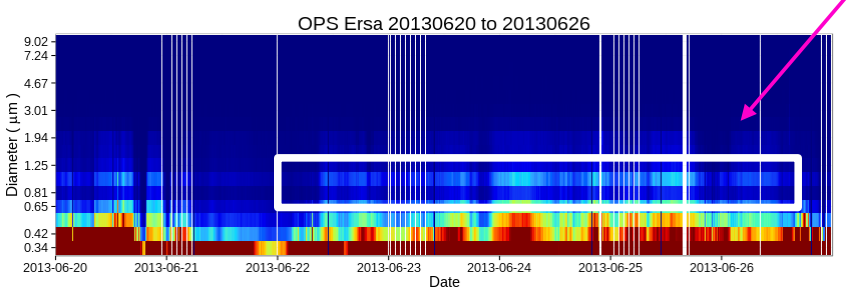


SMPS size distribution → High contribution of fine and accumulation modes from the 22nd to the 26th of June

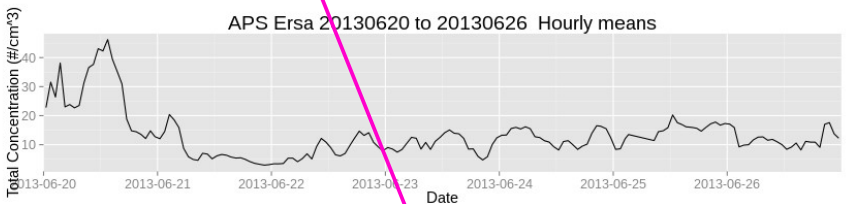
10 - 500 nm

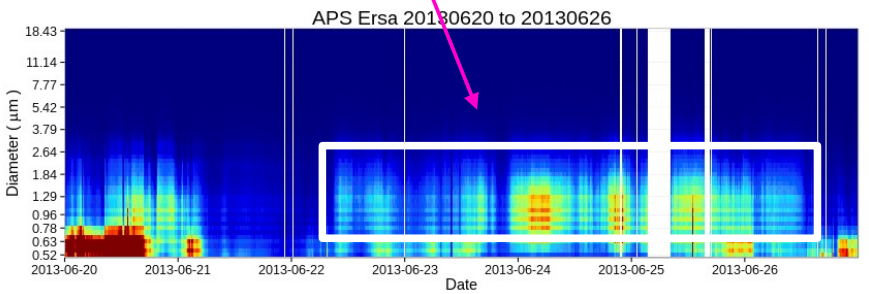
OPS & APS → Coarse mode from the 22nd to the 26th of June → Probably SSA and/or Dust





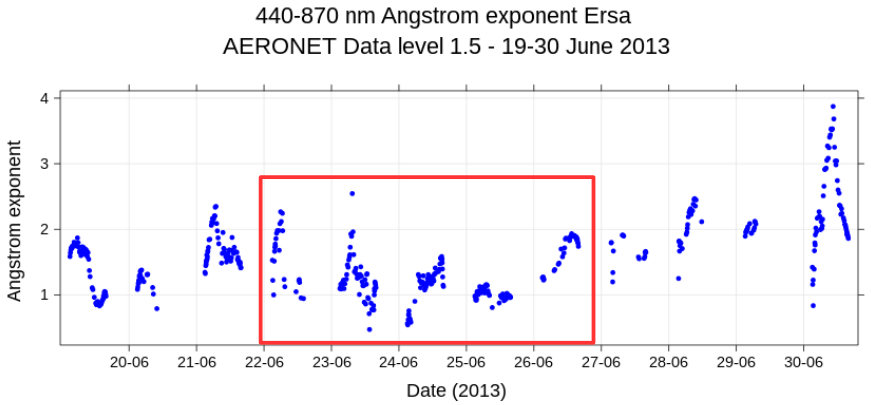
300 nm - 10 µm
Dry





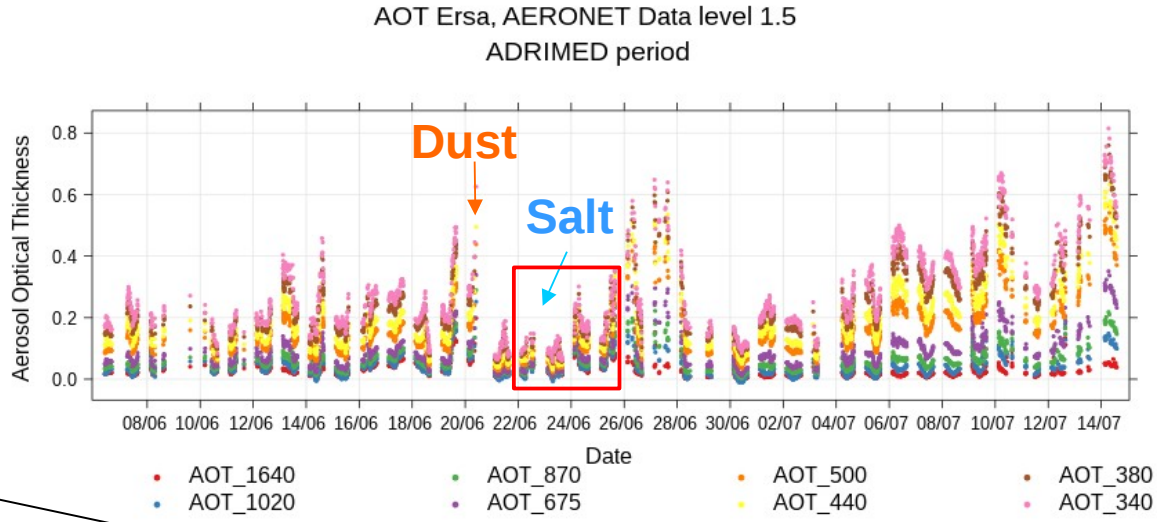
500 nm - 20 µm
ambiant RH

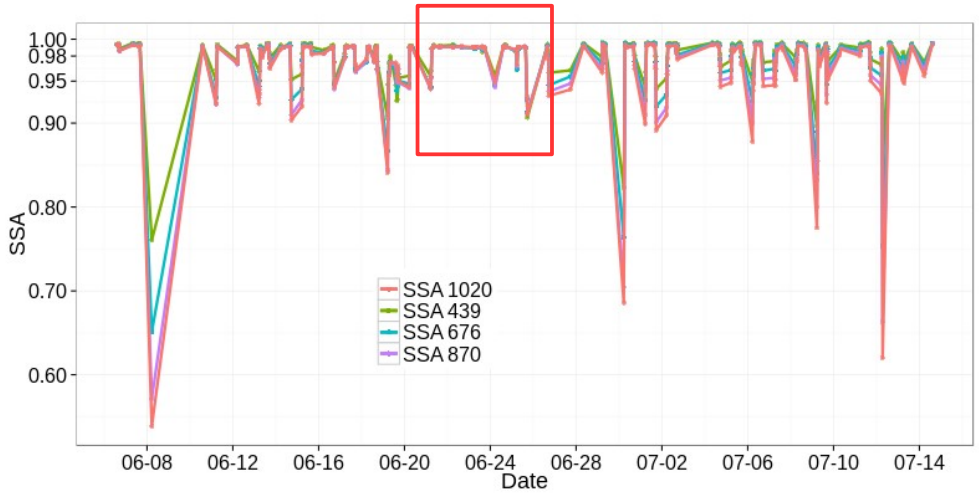
AERONET



Optical Depth : Indication of particle concentration in the atmospheric column
Values encountered in clean remote ocean:
~ 0,1 for calm winds
↑ 0,4 for v=18m/s

Angstrom exponent (α): Ratio of extinction at two different wavelengths
Indication of aerosol sizes
→ α(salt) < 1
→ α close to 1, aerosol mixing

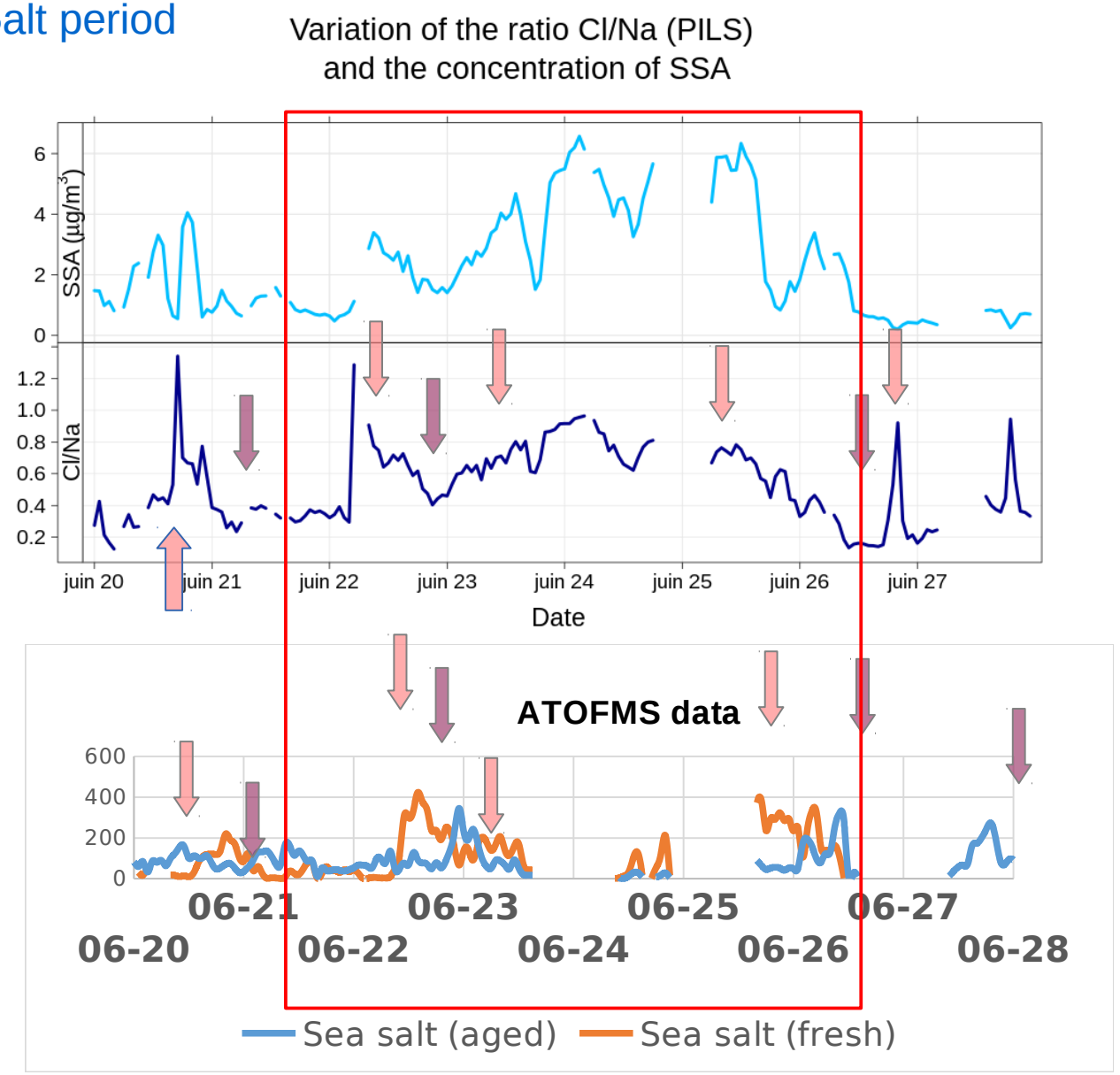




Single Scattering albedo (SSA) :
SSA=Scattering/Extinction
SSA → 1 : Scattering → Sea salt
SSA → 0 : Absorption
→ SSA close to 1

Case study 1
Ageing of salt

Salt period



ATOFMS data, Jovanna Arndt., univ of Cork

Chlorine reacts with gazeous species : HNO_3, HSO_4^{2}

Ratio of sea water:

Cl / Na = 1.8

(*Seinfeld and Pandis, 1998*)

→ Indication of sea salt ageing

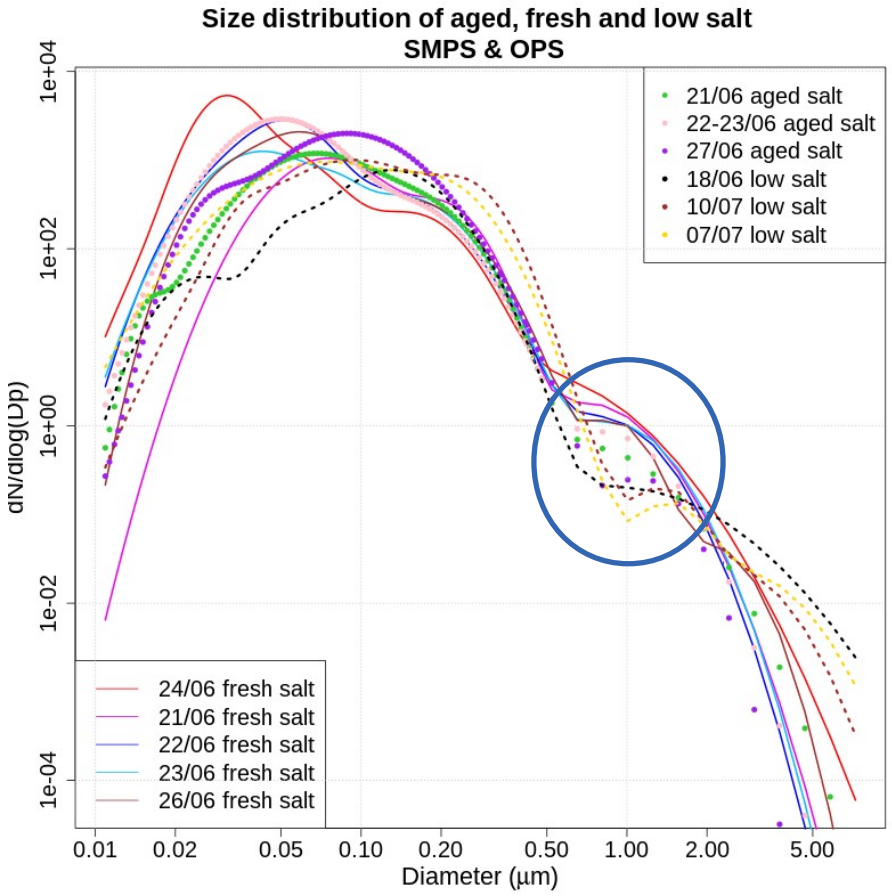
During the episode
→ ratio between **0.2 et 1.2**

Fresh salt

Aged salt

Tendancy for aged and fresh sea salt.
Good agreement between the two instruments

Case study 1
Relation size/ageing of sea salt



Fitting method :
-Mean of size distribution for each period
-Sum of 3 to 5 lognormal modes

→ **N**o distinction of caracteristic modes for fresh sea salt and aged sea salt among the size distribution of all the particules

→ But differences of size distribution between air masses containing fresh and aged sea salt and those nopt containing sea salt :

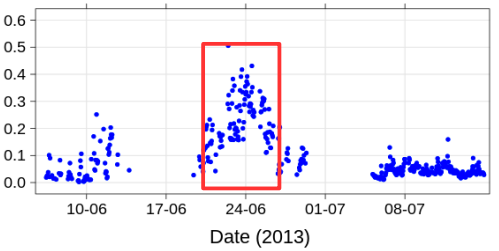
A mode appears around 1 µm except for one case (27/06 aged salt, corresponding to the end of the salt episode). The number of particles in this mode is lower for aged salts than fresh salts.

→ Deposition during transport

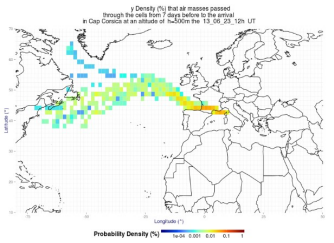
→ **M**eso-NH

Conclusion In situ results

Period 22 – 26 June : NaCl > 40 % PM10 mass

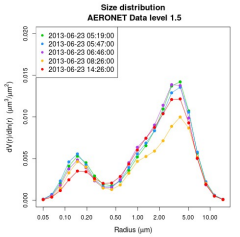


Air masses from the West (Lion Gulf, Atlantic Ocean)



Coarse Mode :

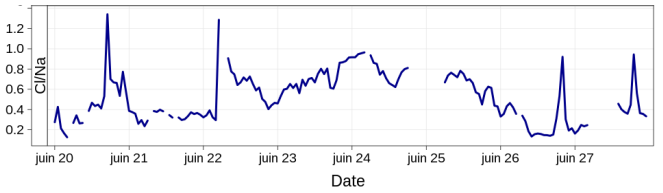
- Instrumental (APS – OPS)
- AERONET (scattering particles, low AOD)



→ **Significative mass concentration of Sea salt aerosol particles**

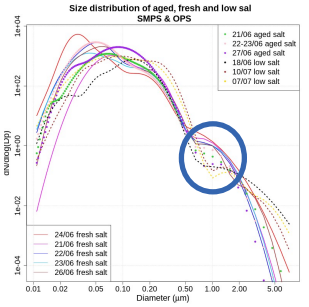
Ageing :

- Sea salt aerosols rather aged
- Good agreement between PILS and ATOFMS

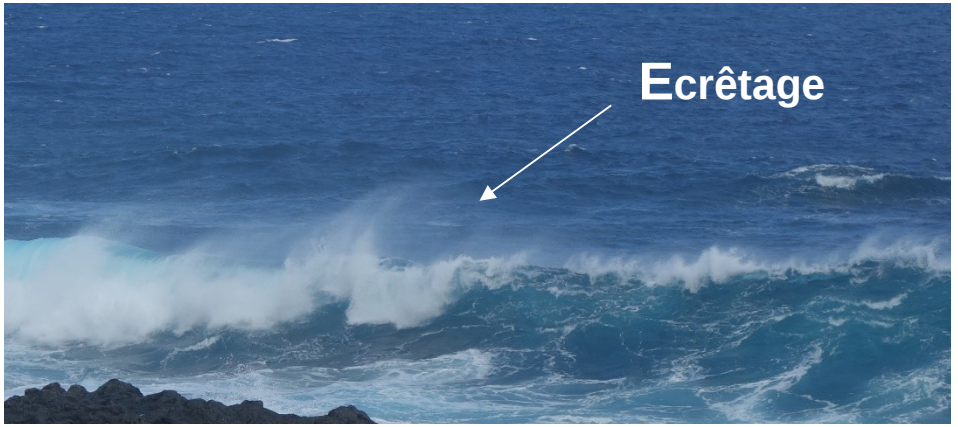


Size distribution :

- Specific mode for sea salt aerosols

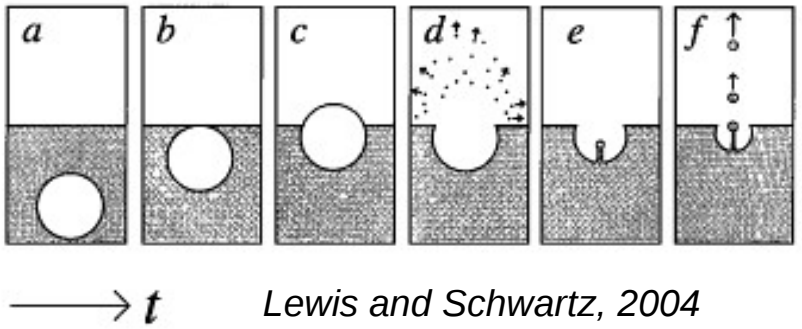


Production of marine aerosols



Particules > 10 µm
Wind > 8-10 ms^{-1}

Couverture moutonneuse
(Whitecap)



Lewis and Schwartz, 2004

d. **F**ilm drops
R < 1 µm

f. **J**et drops
R > 1 µm

Emission **of marine aerosols** depends mainly on **wind speed**. But also on **SST**, **salinity** and **sea state**

Méso-NH : Schéma de génération de sels marins primaire (NaCl)

- Previous schemes :
  - Schulz et al., 2004
  - Vignati et al., 2001

F (Wind speed)
3 aerosol modes

Disadvantages :

- Only take into account wind speed

→ Effects of SST and sea state neglected

- Size spectrum does not take into account smallest particles

- New scheme :
  - Ovadnevaite et al., 2014

F (wind, salinity, SST, Hs)
5 aerosol modes

Ovadnevaite et al., 2014

→ **M**odes determined from filed measurements (in situ & North Atlantic cruises)

→ **D**ependence to Re_{Hw} different for each mode

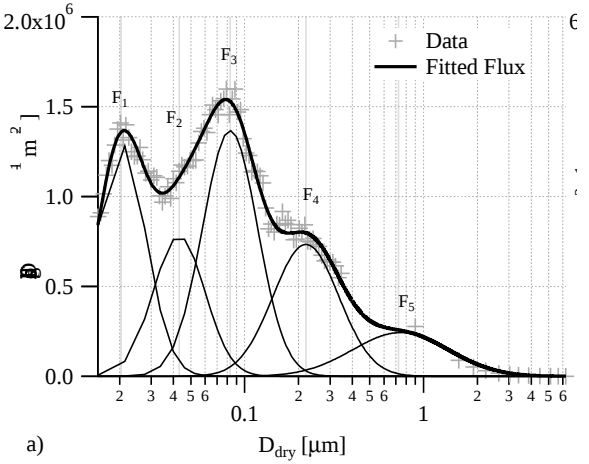
$$Re_{Hw} = u_* H_s / \nu_w$$

H_s : Significative height of wind waves (**ECMWF**)

ν_w : Viscosity of sea water (F(SST))

Why this parametrization ?

- Possible inclusion of sea state
- Size Spectrum more complete (submicron and supermicron)
  - → Direct and indirect radiative effect
- Anticipation for future high resolution coupled models



Ovadnevaite et al., 2014

Emission flux in fonction of marine aerosols sizes

Méso-NH simulations
ADRIMED

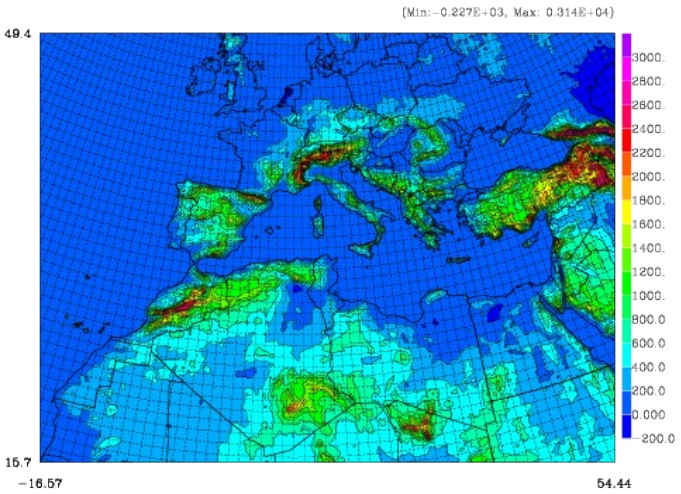
1st simulation

- 12 to 27 June period
  - Salt Episod from 22 to 26 June
  - Dust Episode from 16 to 20 June
- 64 vertical levels
  - 30 levels below 1000 m
  - 1st level at 10m
- 3 nested domains

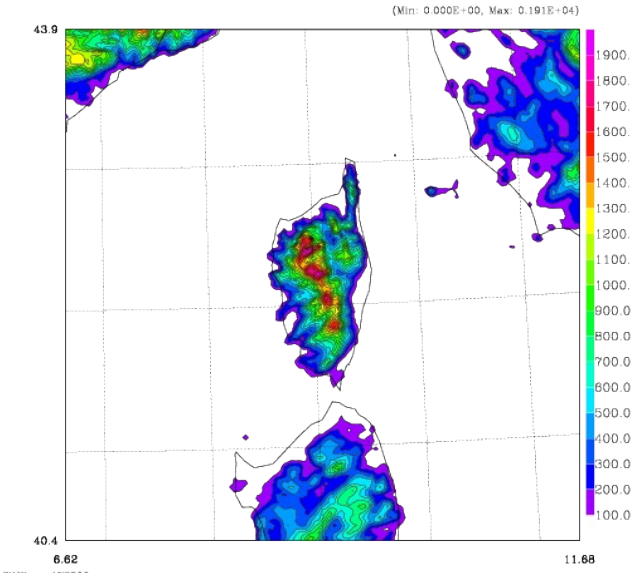
Meteorological forcings :
- ECMWFanalyzes every 6h
- Horizontal resolution: 0,125°

Schemes DUST et SALT (Tulet et al., 2005) activated

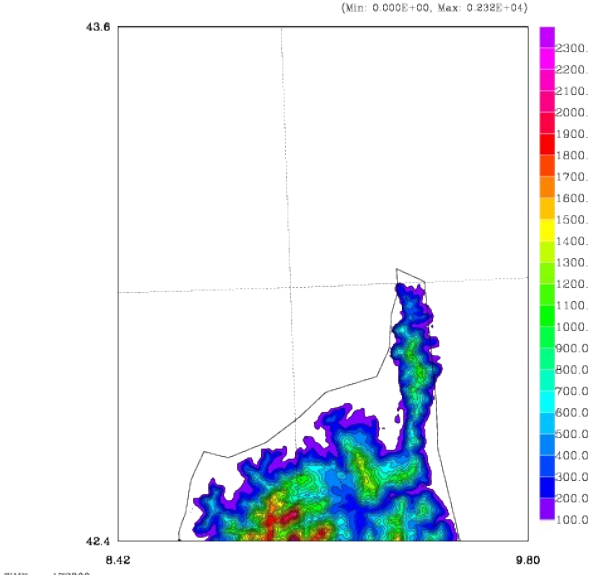
1 moment : Variation of the concentration only (Standard deviation & median radius fixed)



15 * 15 km



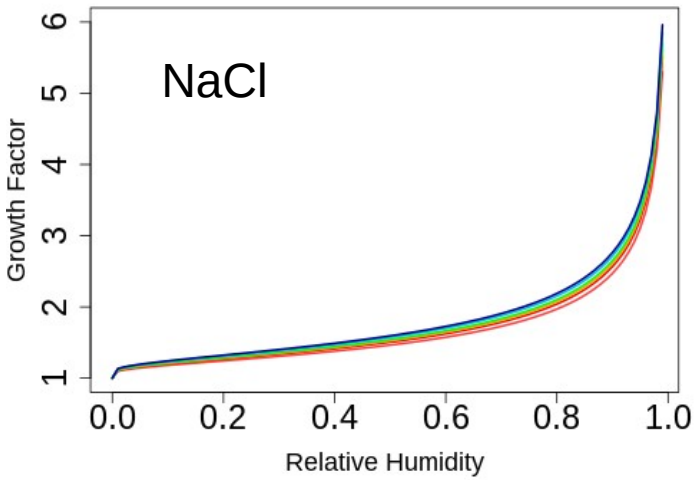
3 * 3 km



0,5 * 0,5 km

Developments ongoing

- Inclusion of significant height of wind waves by Méso-NH
- Hygrosocopic growth of marine aerosols for radiative properties (DRE)
  - Gerber, 1984



At RH=80 %
Growth factor ~ 2

Surface (RH=80 %) = 4 x Surface (r_{dry})
→ Impact Optical properties

Perspectives

- **Simulation ADRIMED** :
  - Simulation with marine aerosols emission in the whole domain **VS** Simulation with emission in the mediterranean basin only
    - → Respective contribution of Atlantic Ocean and Mediterranean sea on sea salt concentration measured in Ersa
  - Inclusion of the organic fraction of marine aerosols
    - → Parameterization ?
    - → Hygroscopic growth of aerosols (↓ hygrosocopic abilities of sea salt when organic fraction ↑)
    - → Optical properties and indirect radiative effect
- **Second case study** : SAFMED+ measurement campaign
  - Atmospheric dynamic ≠
    - Moderate wind and long distance transport (ADRIMED)
    - Strong Mistral (SAFMED+)


Questions ?

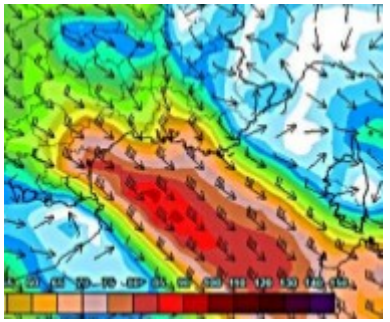
Cas d'étude
SAFMED+ Juillet 2014

Vols instrumentés ATR 42 : 10/07/2014

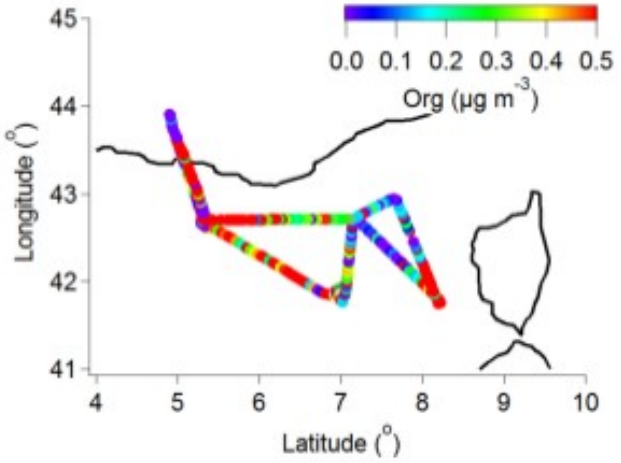
Mesures de la distribution de taille des aérosols et de leur composition chimique

Cas d'étude très différent: Cas typique de Mistral fort sur le bassin Méditerranéen

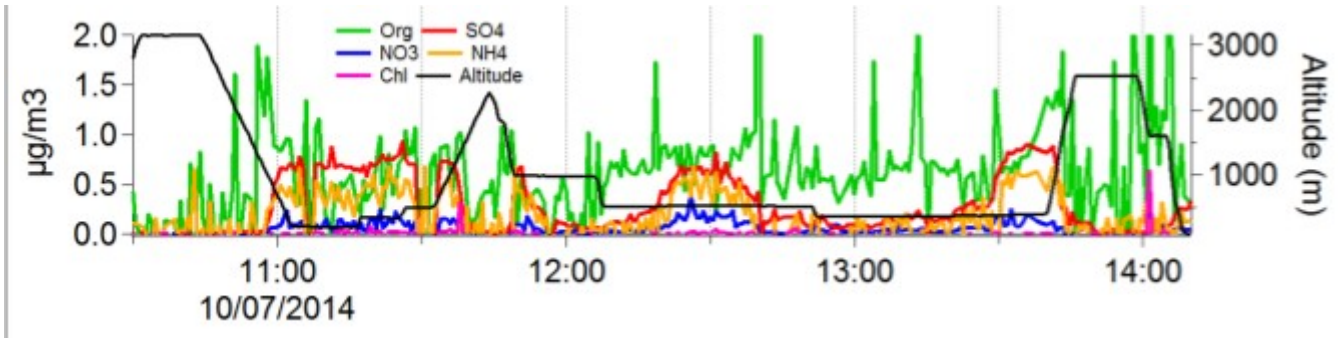
Complémentaire du cas ADRIMED -> Vent modéré et transport longue distance



Vitesse du vent



Plan de vol
Cas de vent fort (v ↑ 90km/h)



Altitude du vol
→ descend dans la couche limite marine

Données du LAMP

→ **P**ossibilité de suivre la trajectoire avion avec Méso-NH