AFRICAN DUST DEPOSITION AND OCEAN COLOUR IN THE EASTERN MEDITERRANEAN

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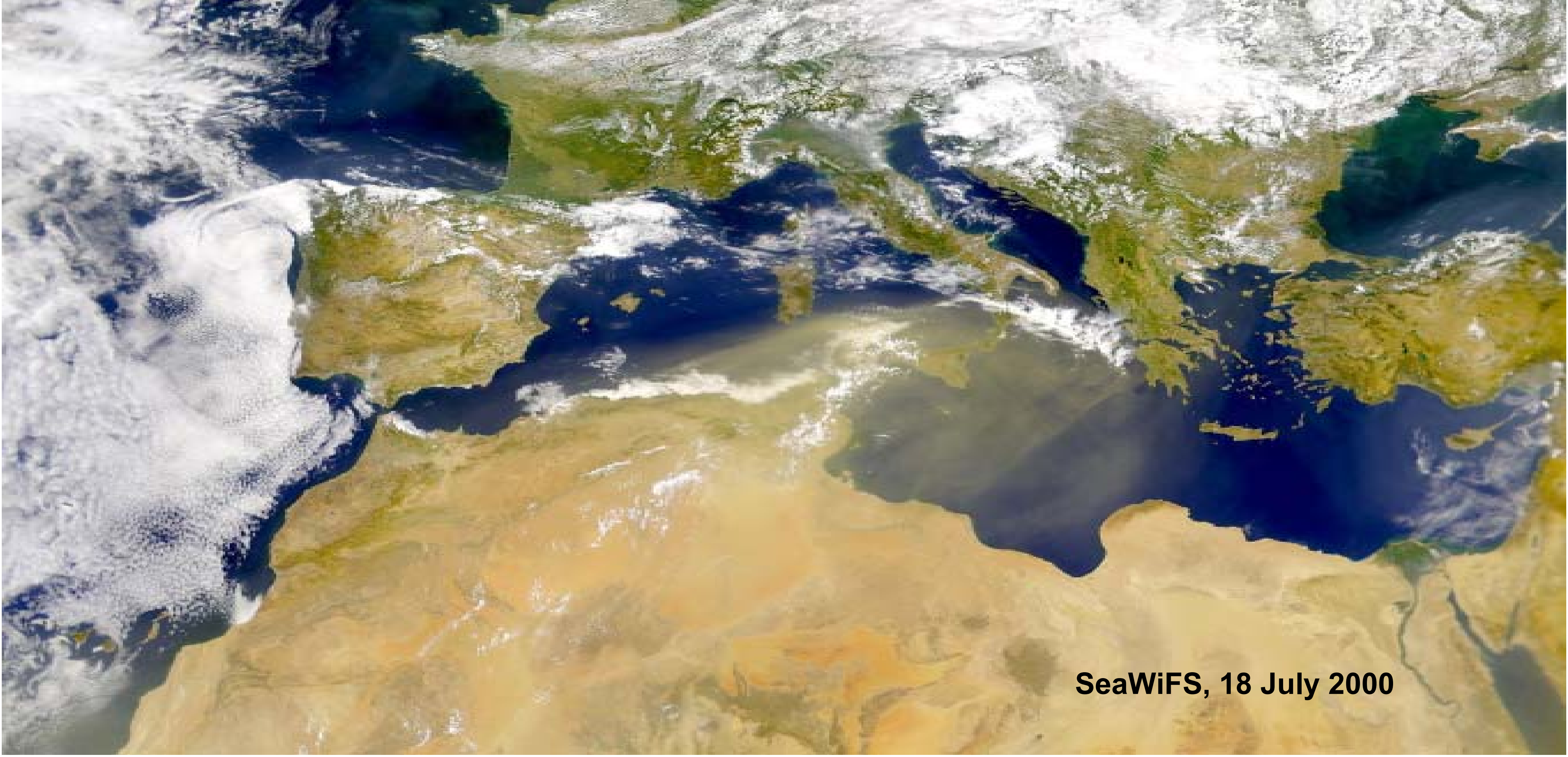


⇨ **Satellites were an essential tool for our understanding of the relative frequency and magnitude of African dust export to the Mediterranean and Europe**

- **Dust clouds are common events**
- **Total mass in a dust cloud counts in 10^5 tons**

OBJECTIVES

- ⇨ **Investigating the possible link between dust deposition and chlorophyll concentrations in areas of low productivity of the Mediterranean**

- ⇨ **Assess the potential of ocean colour satellite data to observe dust-induced phytoplankton blooms**

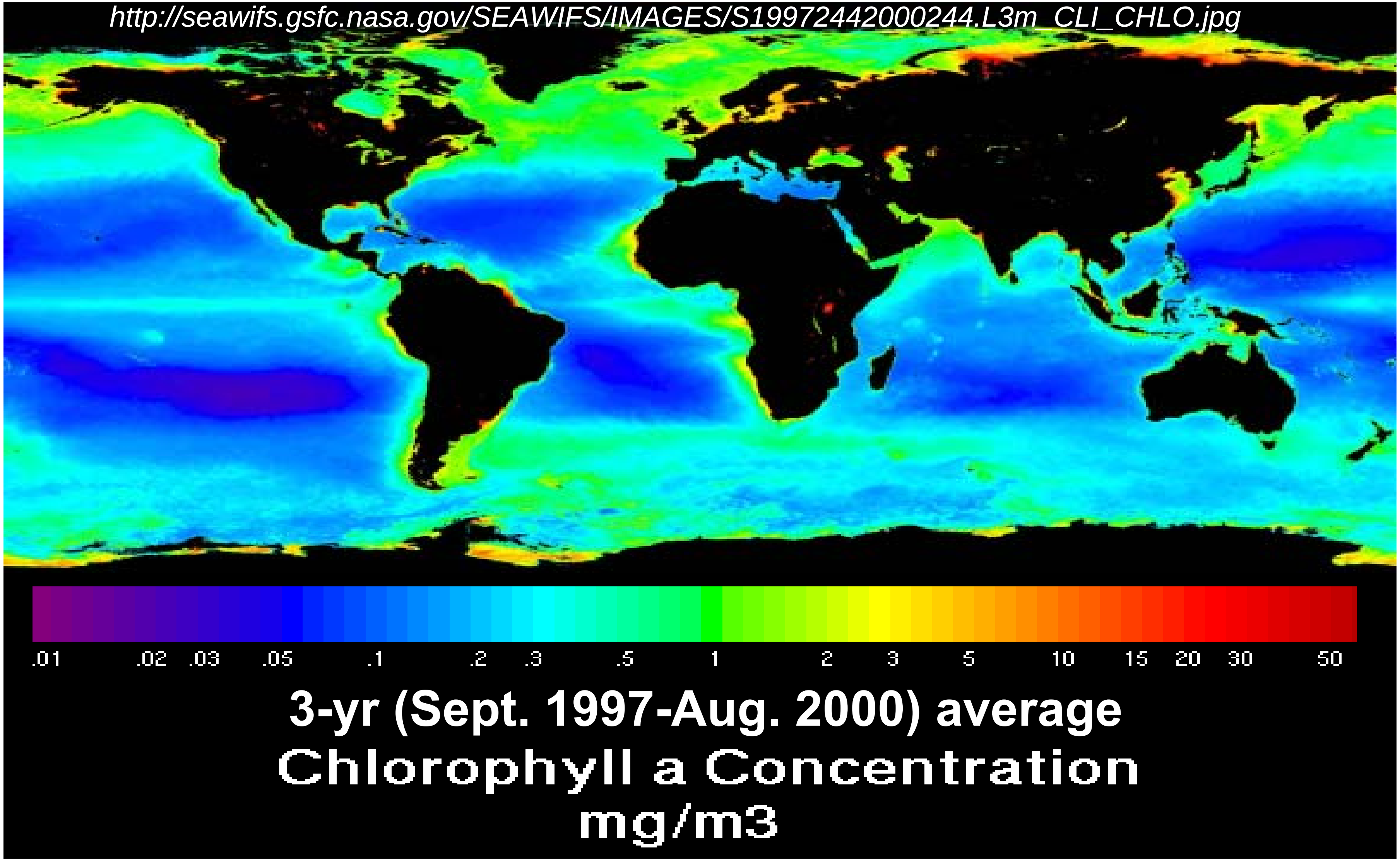
SOME FACTS (1/5)

- **Dust deposition significantly affects the chemical composition in trace metals of non-coastal surface seawater** *(e.g. Buat-Ménard and Chesselet, Earth Planet. Sci. Lett., 1979)* **and deep-sea sediments** *(e.g. Chester et al., Mar. Geol., 1979)*

- **Seeding experiments (e.g. IronEx-II,** *Coale et al., Nature, 1996;* **SOFex** *www.mbari.org/expeditions/SOFeX2002/;* **SOIREE** *http://tracer.env.uea.ac.uk/soiree/***) and microcosm experiments** *(e.g. Ridame and Guieu, 2002)* **indicate that primary productivity of oligotrophic waters is sustained by atmospheric inputs**
  - **desert dust iron**

SOME FACTS (2/5)

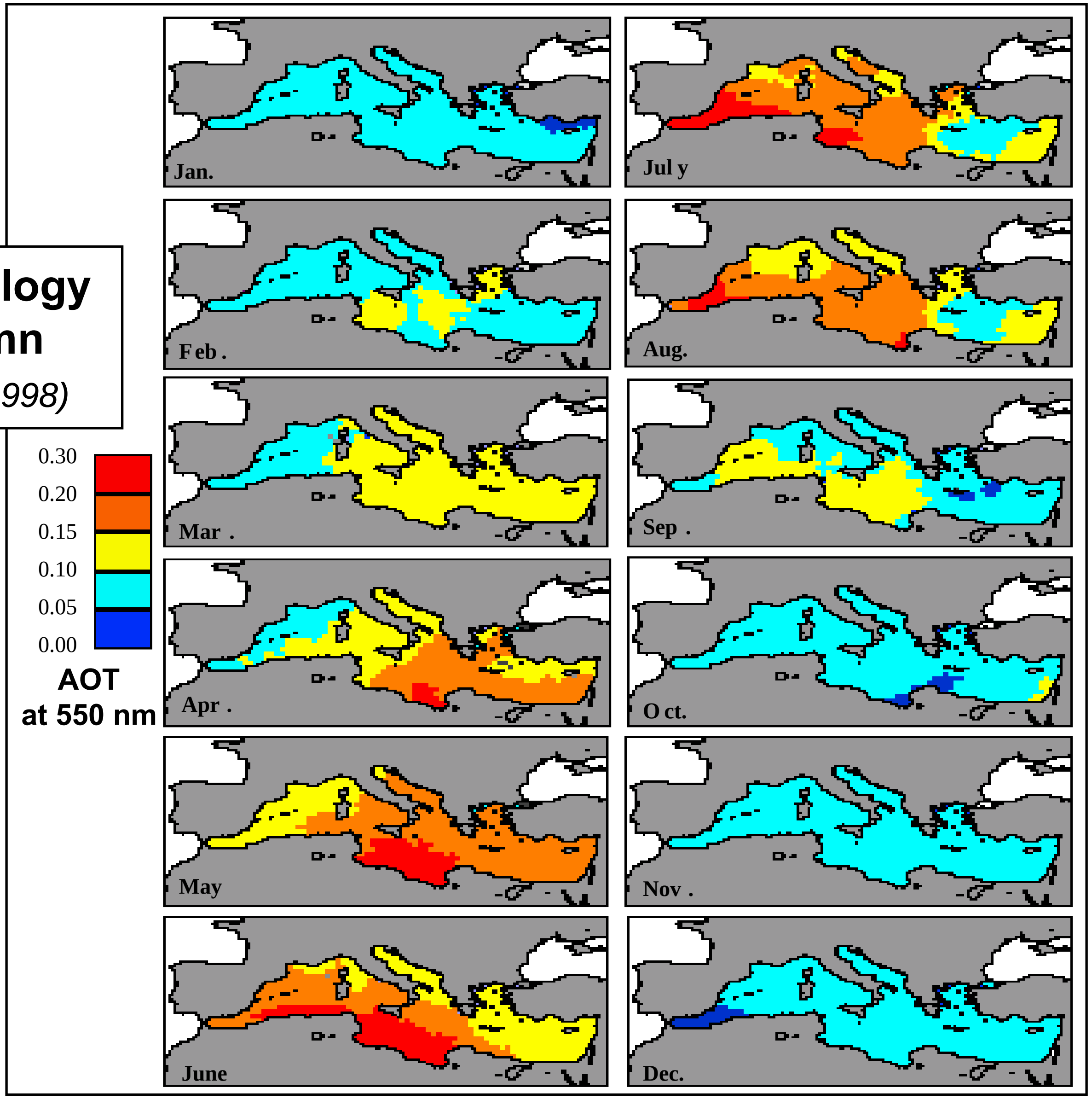
⇨ **(Eastern) Mediterranean is one of the most oligotrophic marine areas:**



SOME FACTS (3/5)

⇨ **The Med. atmosphere is heavily impacted by African dust:**

Meteosat-derived monthly climatology (1984-1994) of the aerosol column optical thickness *(Moulin et al., JGR, 1998)*



⇨ **Desert dust is the dominant aerosol both in terms of turbidity and mass**

Average column dust load is ~0.1 g m^{-2}

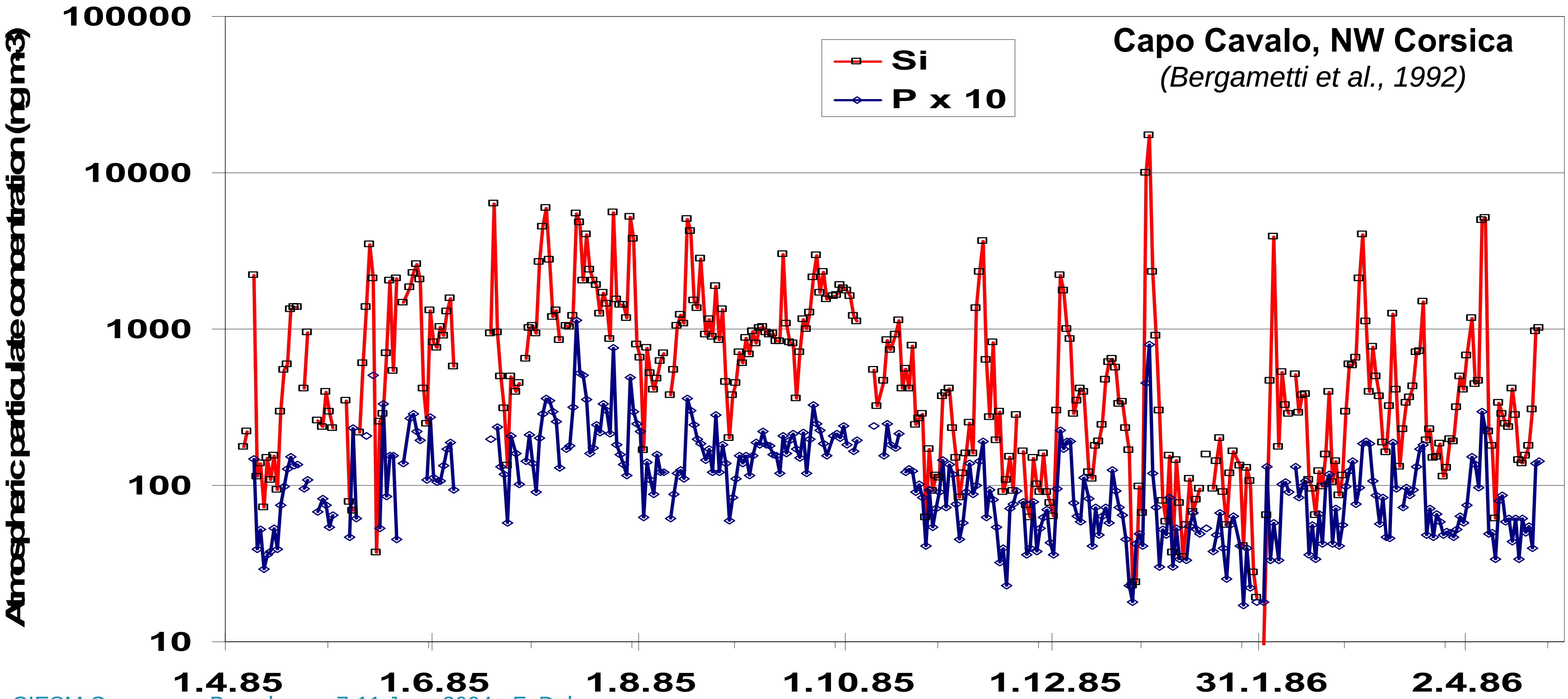
⇨ **Dust deposition: ~10 g m^{-2} yr^{-1} (*/: 4)**
(Ridame et al., 2002; Kubilay et al., Atmos. Environ., 2000)

SOME FACTS (4/5)

⇨ **In the Mediterranean, main limitation is likely phosphorus**

(e.g. Krom et al., Limnol. Oceanog., 1991)

⇨ **Saharan dust outbreaks yield frequent pulses of soluble P deposition to Mediterranean surface waters** *(e.g. Migon and Sandroni, Limnol. Oceanogr., 1999; Ridame and Guieu, 2002)*



SOME FACTS (5/5)

- ⇨ **Atmospheric deposition of dissolved P likely supports summer new production in the NW Mediterranean** *(e.g. Bergametti et al., J. Atmos. Chem., 1992; Ridame and Guieu, Limnol. Oceanog., 2002; Migon et al.'s poster)*
- ⇨ **0.5 g m^{-2} is a common dust deposition flux in the Med.** *(Loÿe-Pilot and Martin, ADAM book, Guerzoni & Chester Eds., 1996)*
- ⇨ **It corresponds to an average input of ~2 µmoles m^{-2} of DIP** *(Ridame and Guieu, 2002)*
- ⇨ **Assuming a Redfield ratio C:P of 106:1, this implies a new production of about 2.5 mg C m^{-2}**
- ⇨ **Assuming a 20-m mixed layer, we can expect a chlorophyll increase of ~0.20 mg Chl m^{-3}**
- ⇨ **Microcosm exp. in the NW Med. indicate a time lag of 48 h** *(Ridame and Guieu, 2002)*
- ⇨ **Dust impact could be detected in ocean colour data**

OUR STRATEGY

⇨ **A combined analysis of**

- **ocean colour satellite-derived data and**
- **dust deposition model-derived data**
- **co-located in space and time**

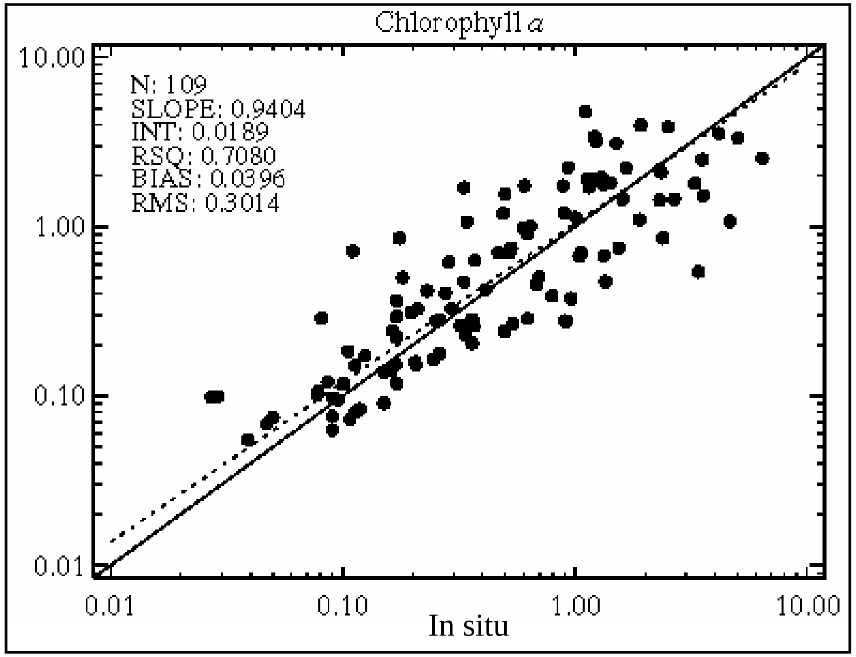
⇨ **A statistical approach using**

- **multi-year daily data (selected period: 1998-2000)**
- **several locations along the main track of dust clouds**

SATELLITE DATA

⇨ **Standard level-3 SeaWiFS products** *(http://seawifs.gsfc.nasa.gov/SEAWIFS.html)*

- **Chlorophyll-a validation:**
- **Radiance in the visible and near-IR channels**

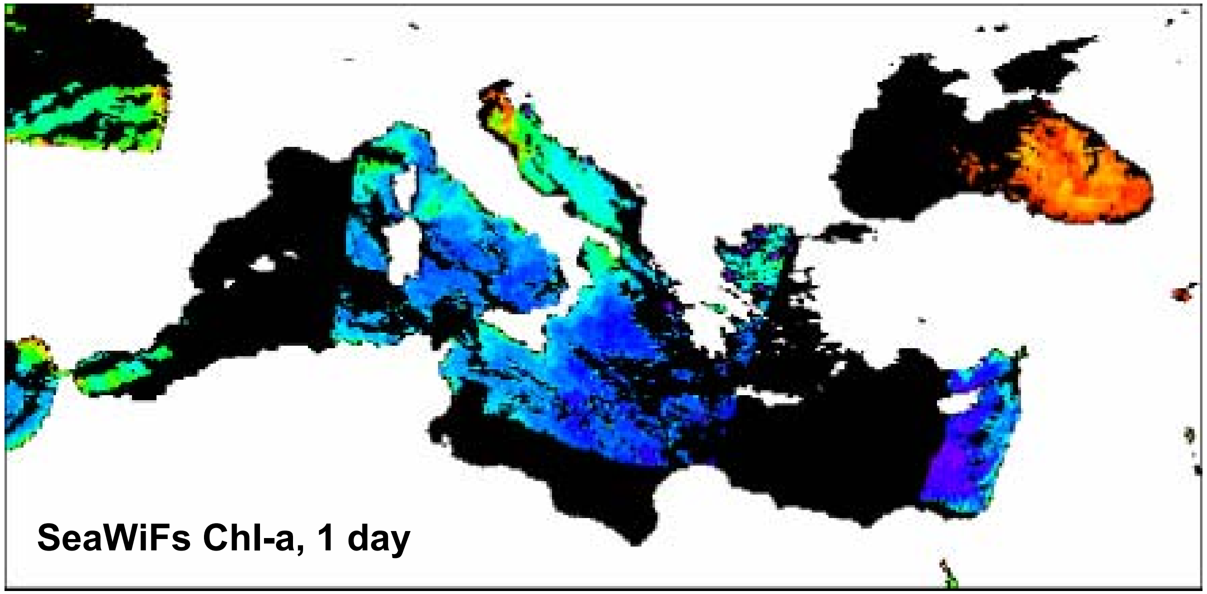


⇨ **Modified spectral matching aerosol algorithm** ***(Moulin, Gordon et al., JGR, 2001)***

- Aerosol optical thickness at 865 nm
- Angström exponent

⇨ **9 km x 9 km resolution, daily results**

- partial coverage due to clouds, high aerosol load, and shift between successive orbits:

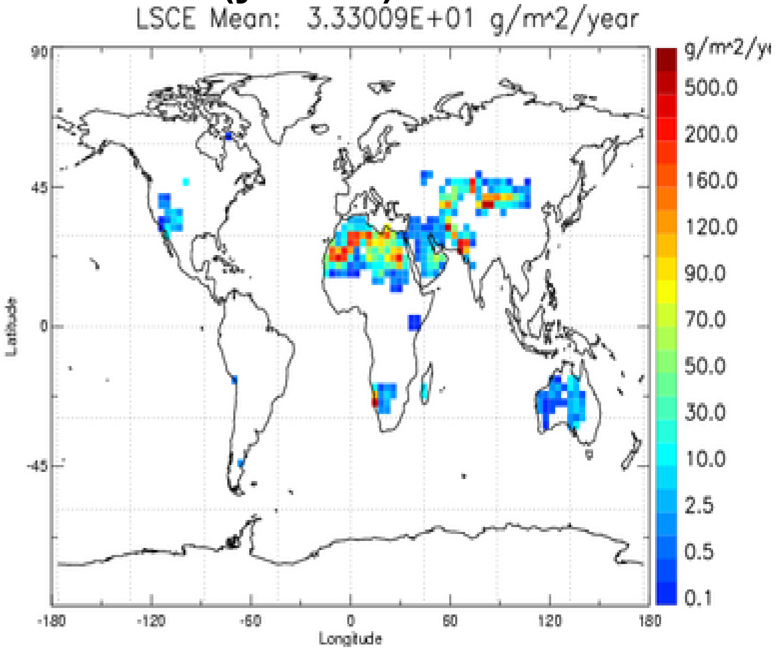


MODEL DATA

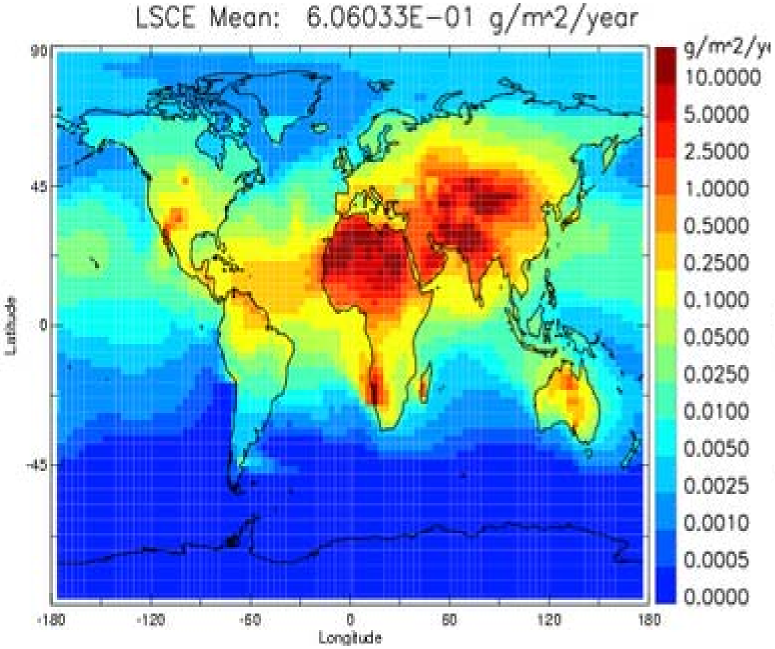
⇨ **Simulation of the daily dust deposition flux with a global Atmospheric Chemistry-Transport Model : LMDZ-INCA**

- **Resolution: 1.84° latitude x 2.25° longitude resolution**
- **Forced by ECMWF ERA-40 reanalysis**
- **Dust emissions based on soil characteristics and surface wind speed, dust size distribution up to 20 µm, size dependent dry and wet deposition processes** *(see Guelle et al., JGR, 2000)*

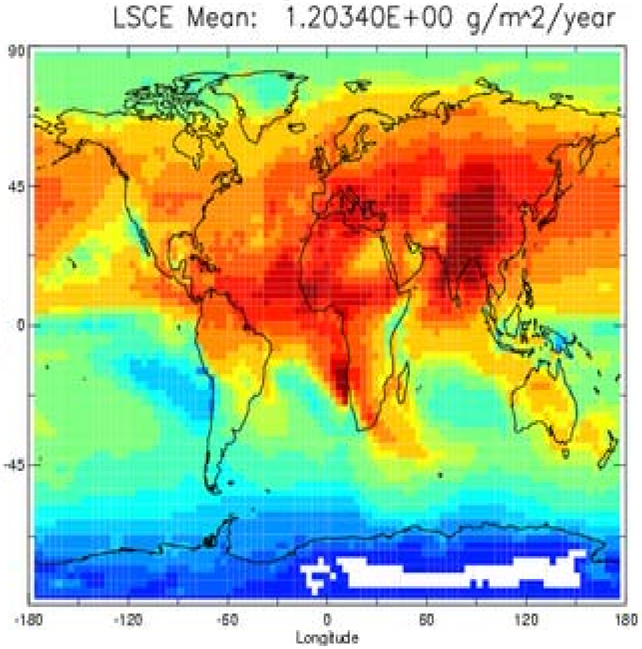
Results (yr 2000): Dust emissions



Sedimentation



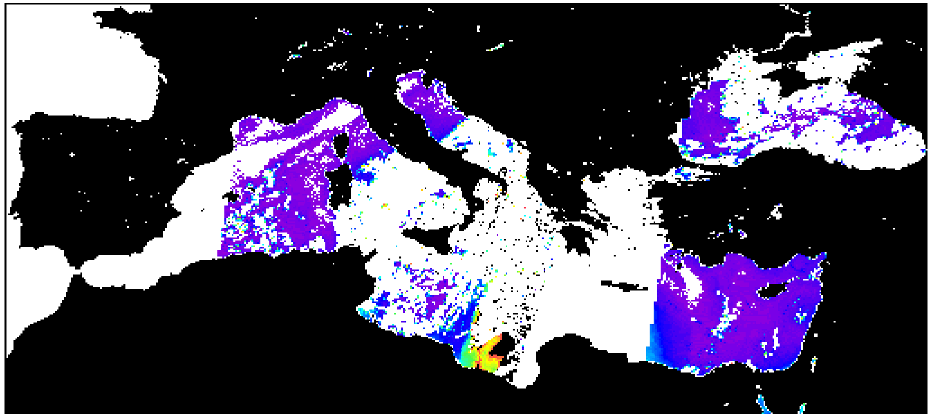
Wet deposition



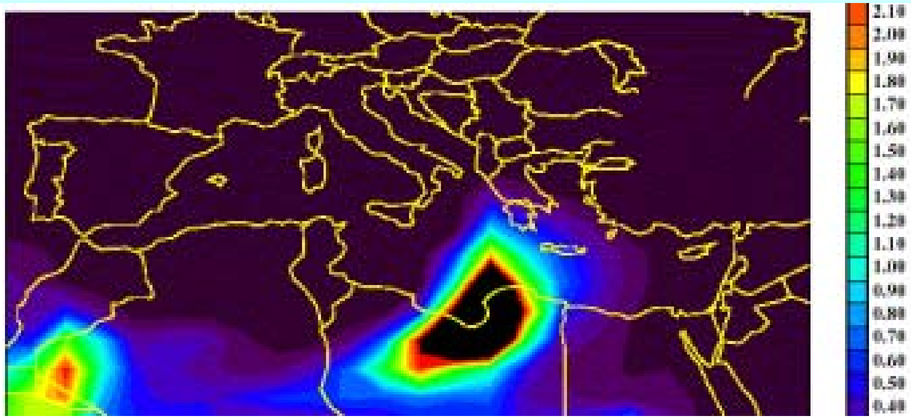
(http://nansen.ipsl.jussieu.fr/cgi-bin/AEROCOM/)

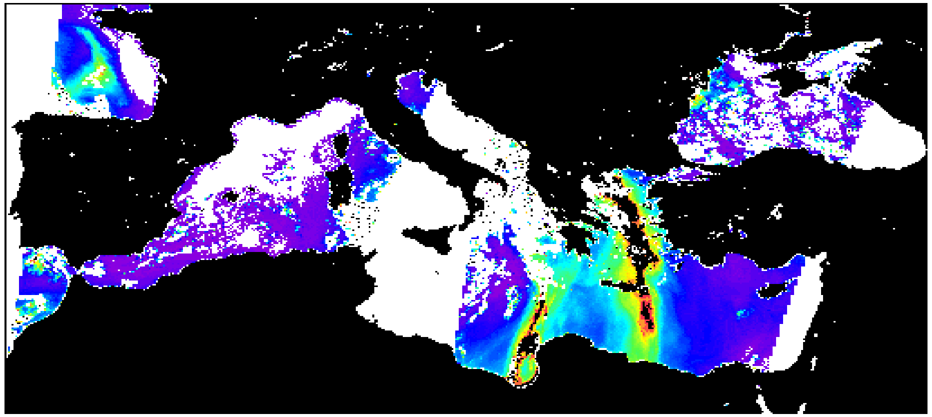
VALIDATION OF TRANSPORT

SeaWifs 865nm radiance

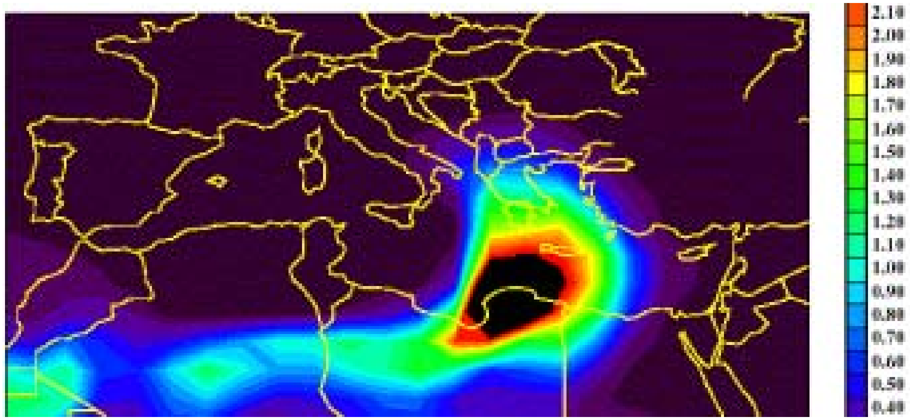


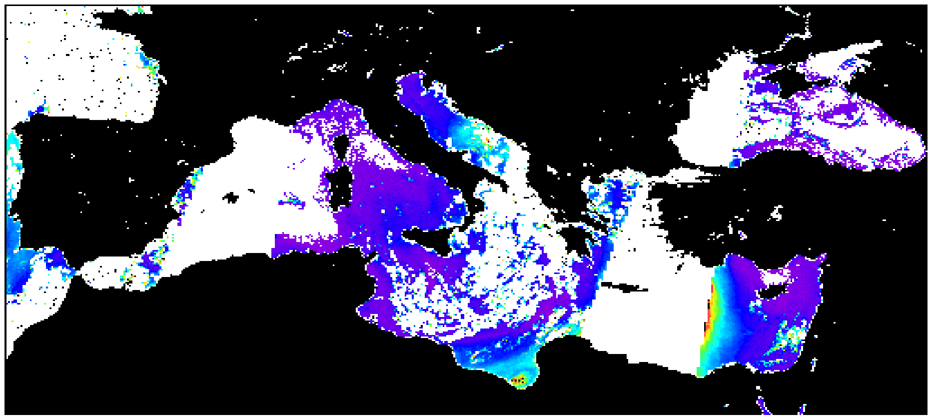
Sep. 9, 2000



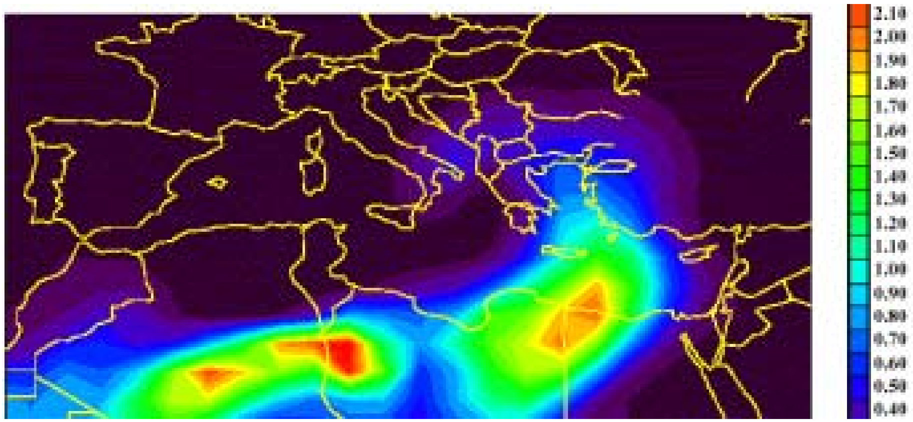


Sep. 10





Sep. 11



LMDZ-INCA aerosol optical thickness

VALIDATION OF DEPOSITION

⇨ **In progress for LMDZ-INCA**

- **AEROCOM aerosol model intercomparison and evaluation programme**

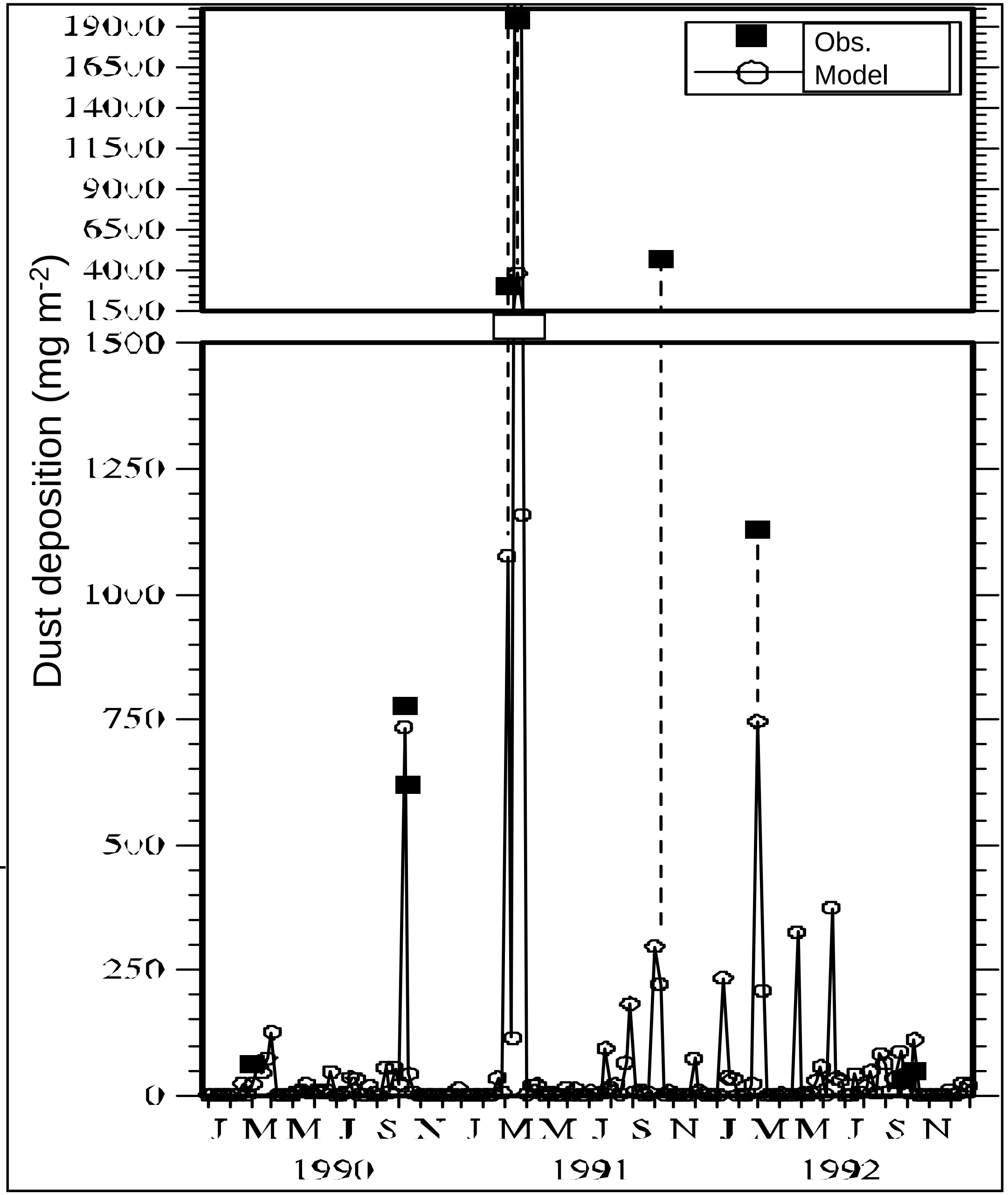
  http://nansen.ipsl.jussieu.fr/cgi-bin/AEROCOM/

⇨ **Results from our former similar model (TM2Z) were found reasonable**

(Guelle et al. JGR, 2002)

- **ex. of red rains in NE Spain:**

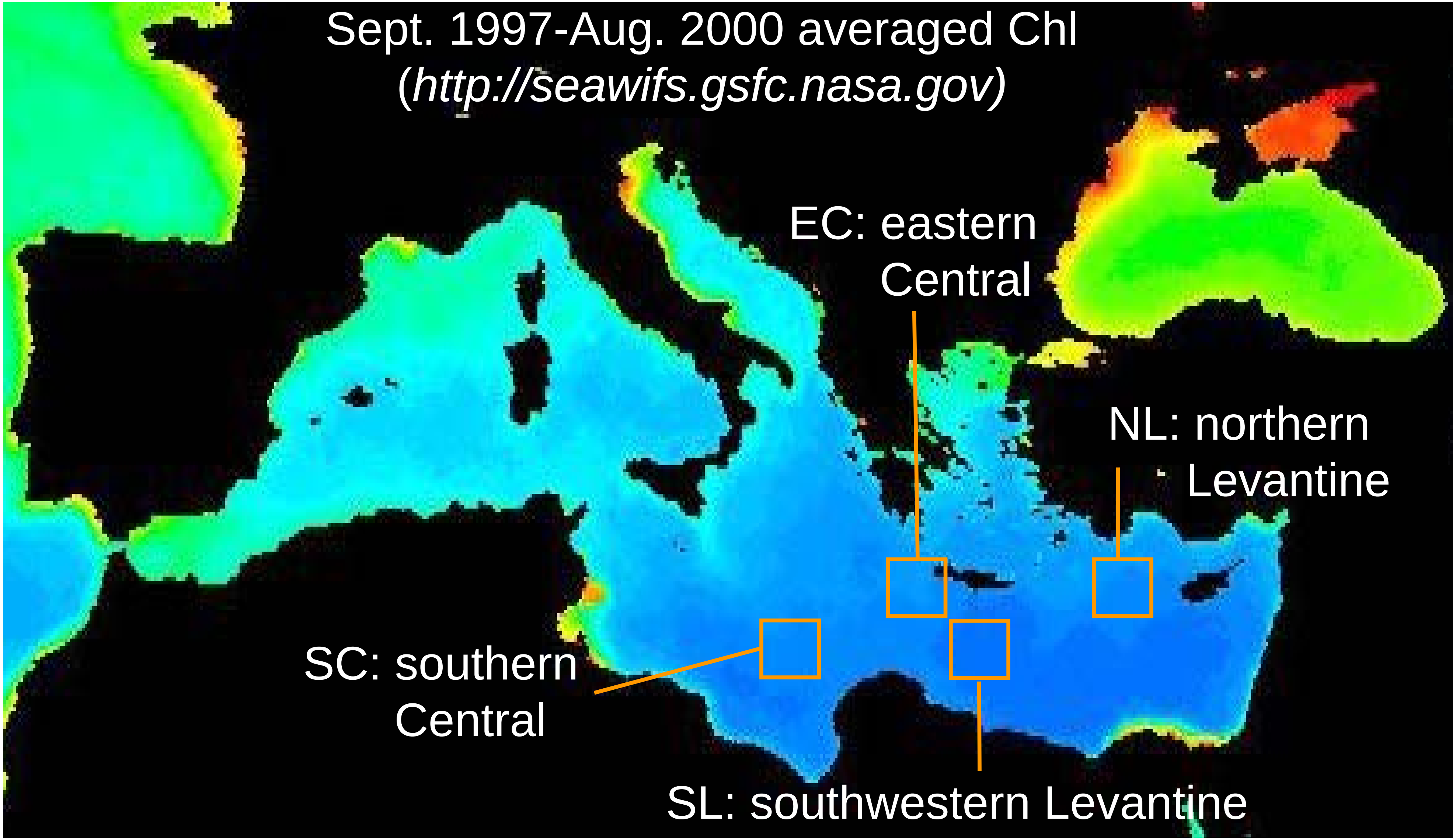
  the October 1991 case mismatch was due to a one order of magnitude underestimation of rainfall by ECMWF



SELECTED LOCATIONS

⇨ **Focus on 4 model grid cells in oligotrophic and non-coastal areas:**

- **~580 SeaWiFS pixels are averaged within each model grid cell**



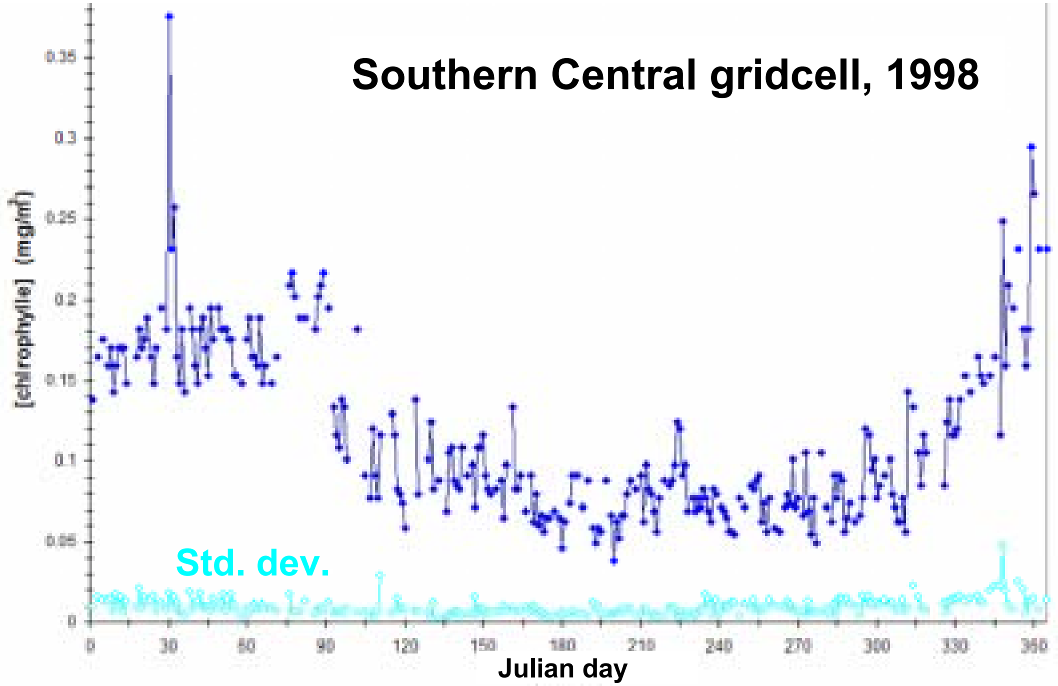
CHLOROPHYLL DATA PROCESSING

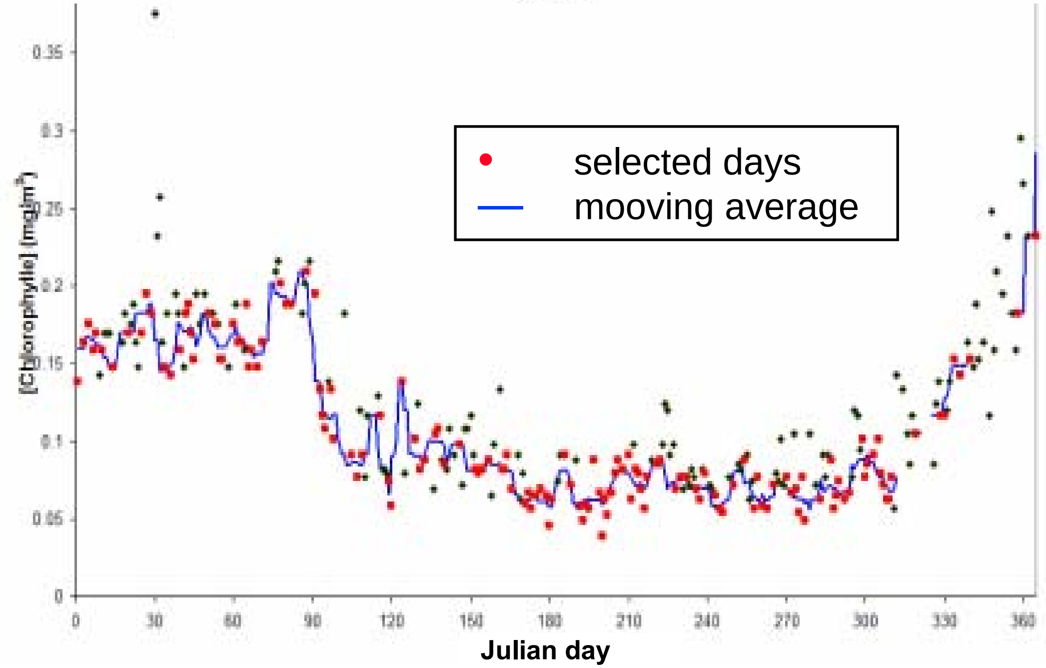
⇨ **Filters**

- **AOT>0.5**
- **>25% of pixels available in the gridcell**
- **40-50% of days finally missing**

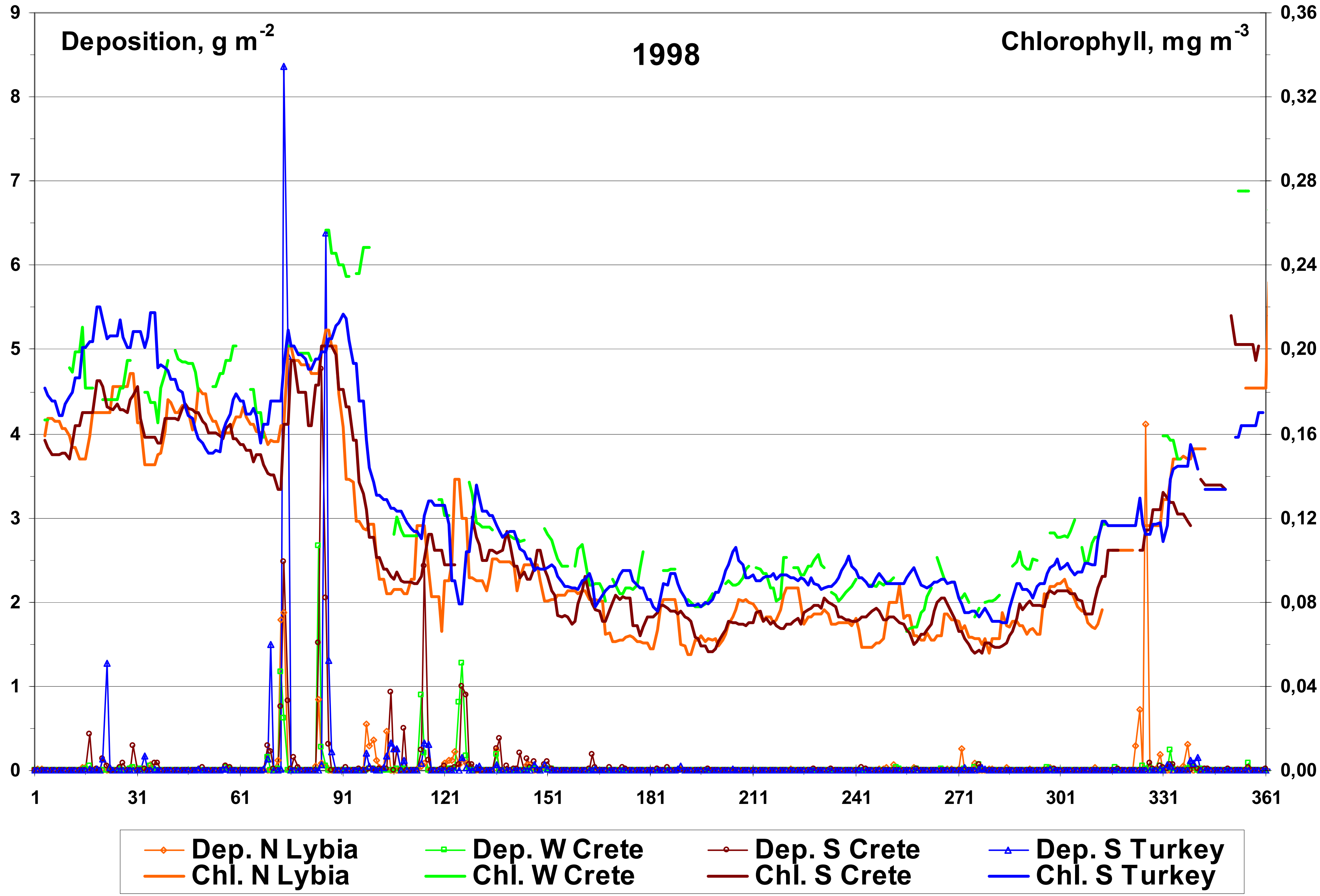
⇨ **7-d mooving average**

- **smoothing and filling gaps**

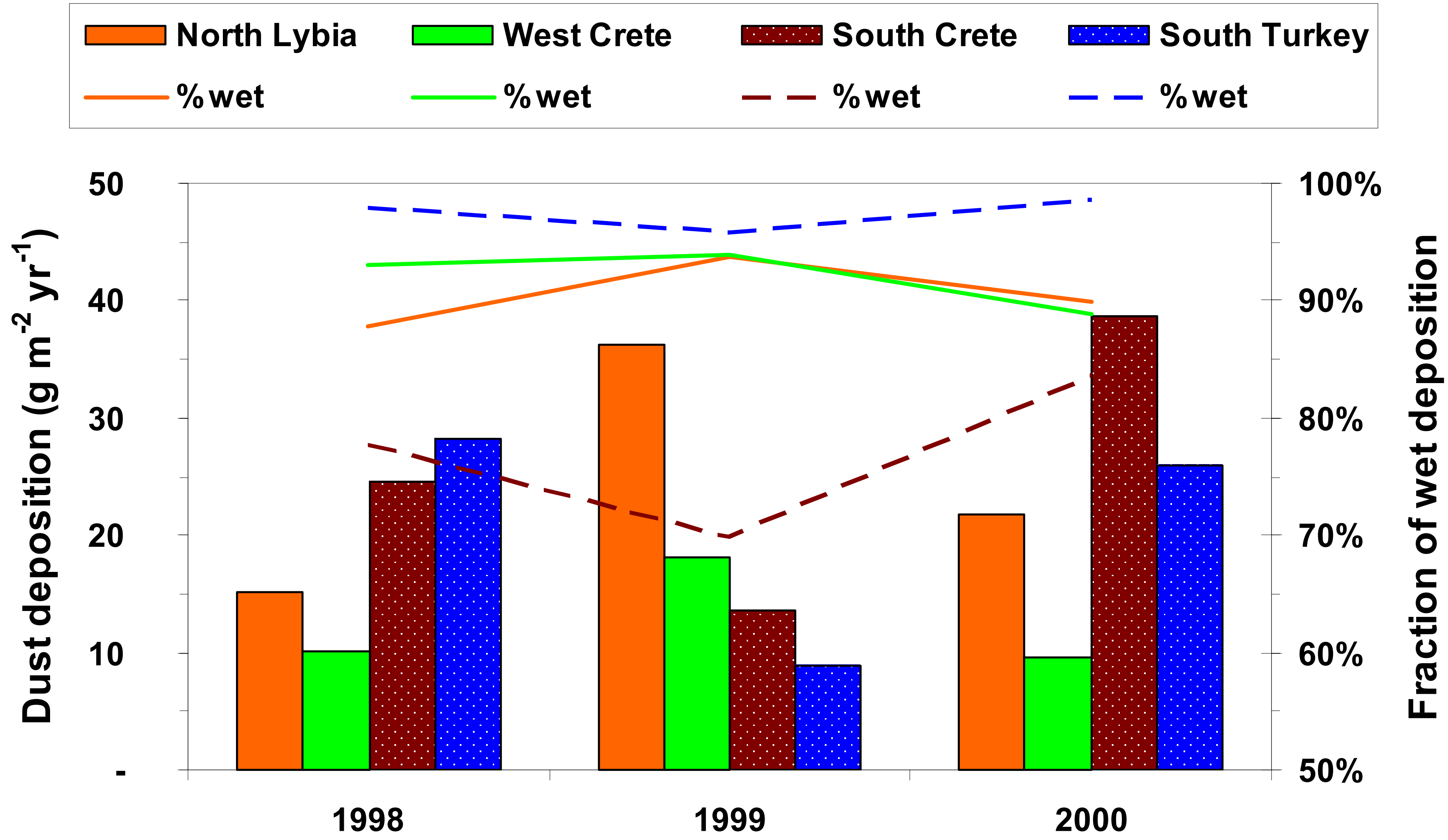




OVEVIEW OF RESULTS FOR 1998



SUMMARY OF RESULTS: 1.DEPOSITION



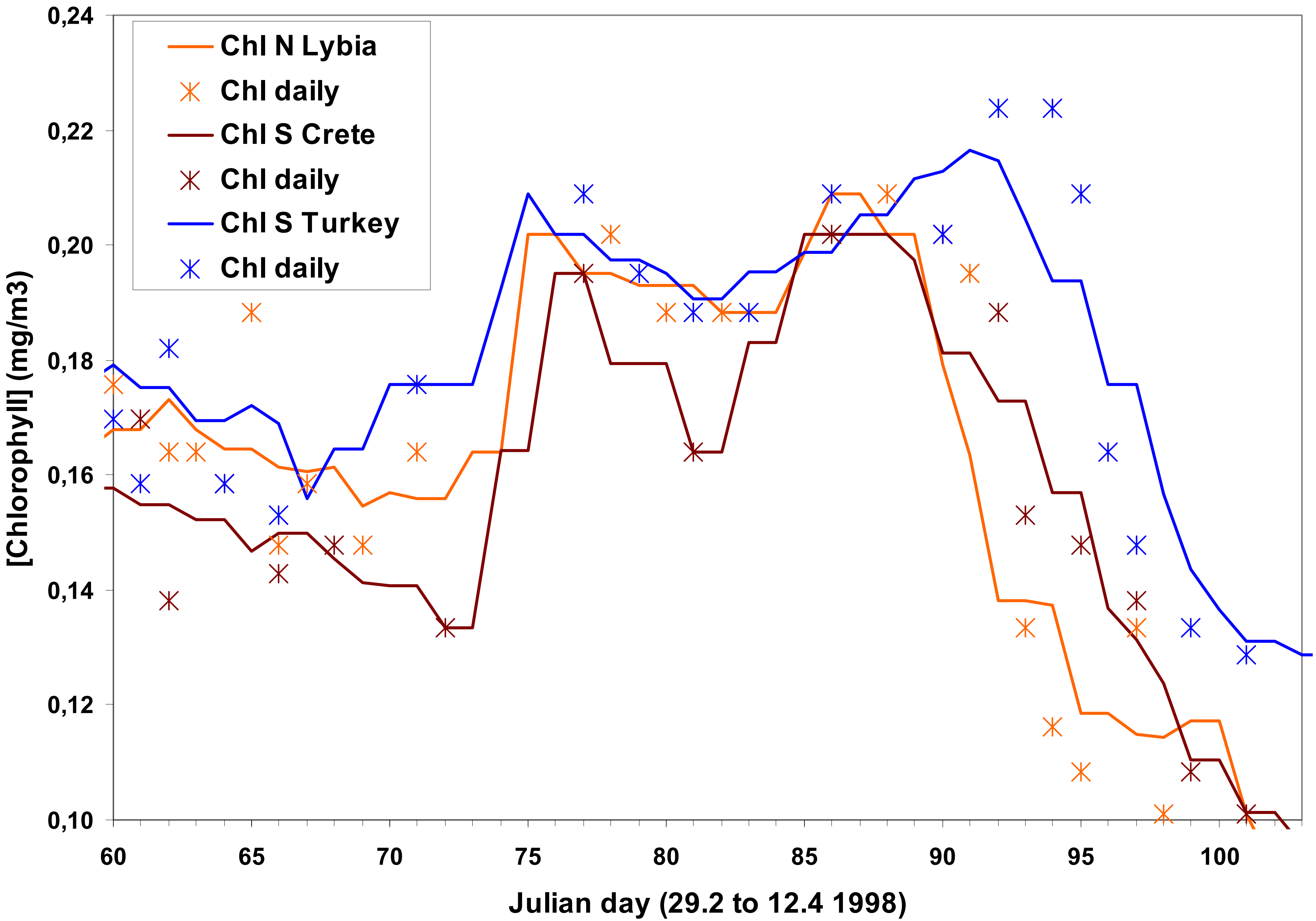
⇨ **Dust deposition range: 9-39 g m^{-2} yr^{-1} (35-160 µmol DIP m^{-2} yr^{-1})**
Wet fraction: 70-99 %

⇨ **Different transport regimes in the central and eastern basins**

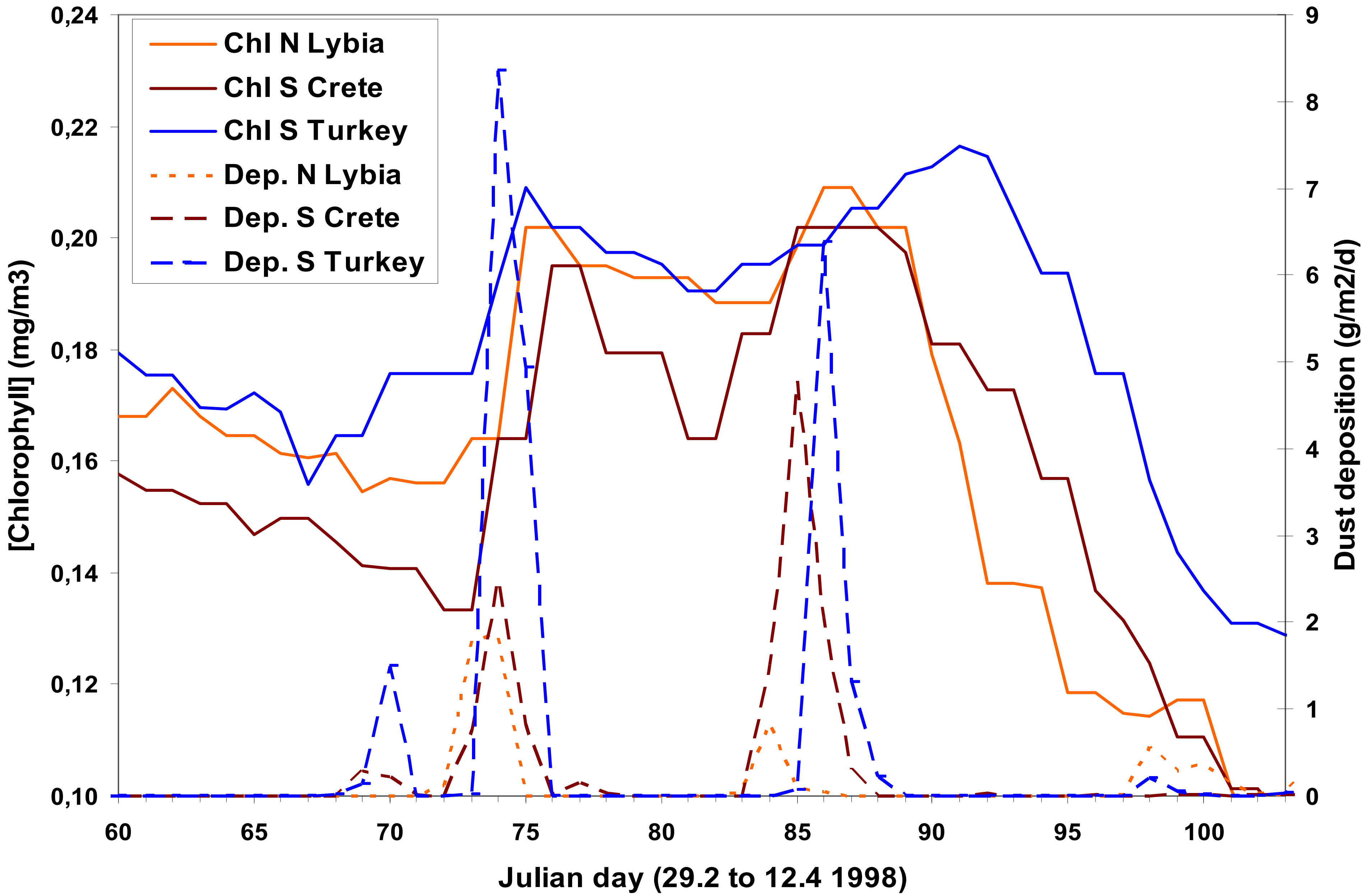
SUMMARY OF RESULTS: 2.CHLOROPHYLL

STATION	Number of verified events with deposition >0.5 g m^{-2}	ΔChl ($mg\ m^{-3}$)	Δt between min and max Chl (days)	Unverified deposition events
North Lybia	10	0.010-0.033	1-4	2
West Crete	9	0.010-0.033	1-4	4
South Crete	14	0.014-0.070	2-5	1
South Turkey	12	0.018-0.080	1-5	1

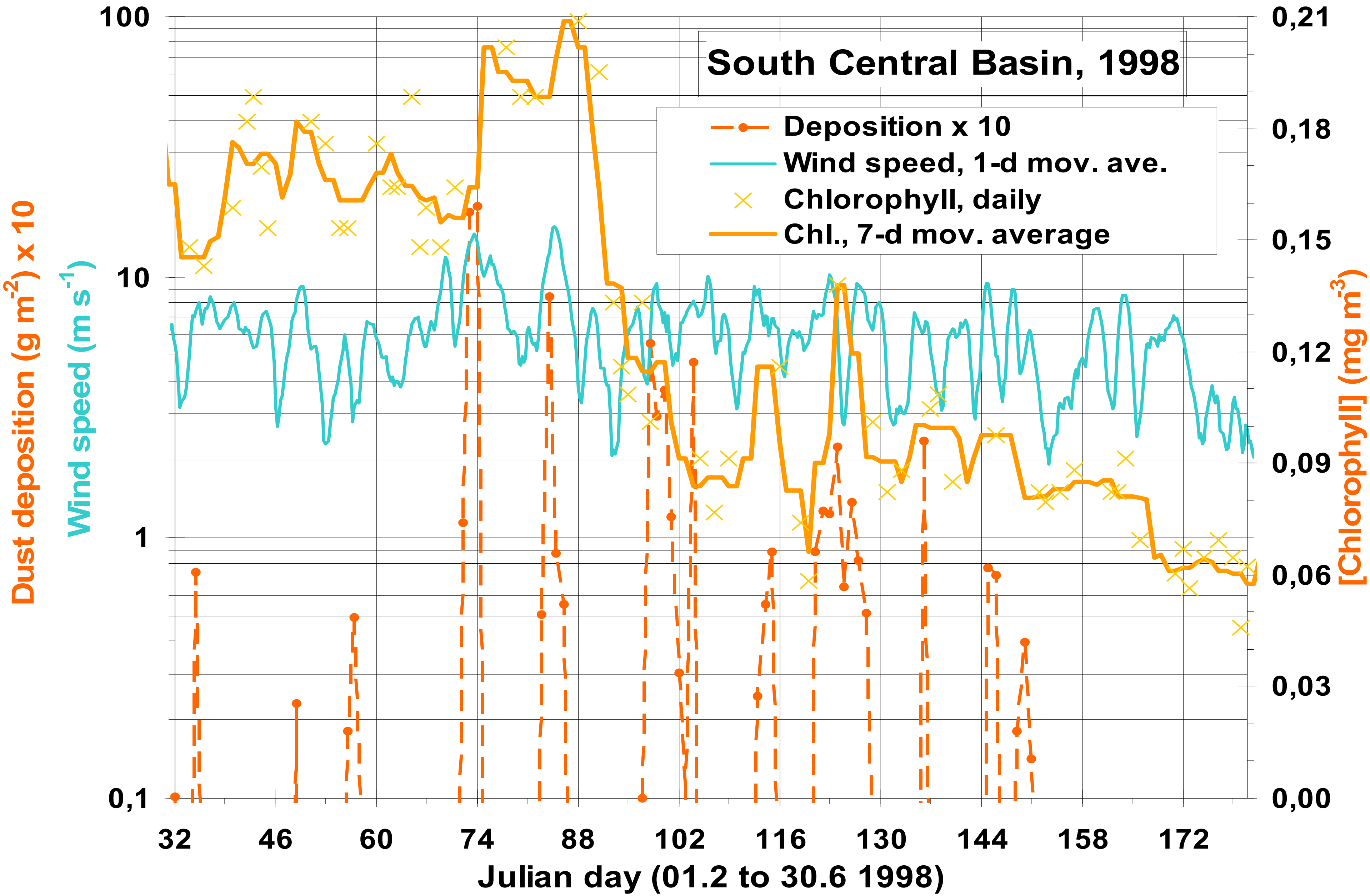
FOCUS ON MARCH 1998 (1/2)



FOCUS ON MARCH 1998 (2/2)



DUST DEPOSITION IS ASSOCIATED WITH THE HIGHEST WINDS (>30 km h^{-1})



CONCLUSIONS (1/2)

1. **We have statistical evidence that a small positive step (0.01-0.08 mg Chl m^{-3}) in satellite-derived surface chlorophyll follows events of mineral dust deposition generally within 1-2 d in the central and eastern Mediterranean**

2. **This is smaller, but remains compatible, with what we expect assuming that the dust-derived soluble P is stimulating the primary production**

3. **However, there is also evidence that the increase in primary production cannot be attributed (only) to atmospheric deposition of dust, because**
   - **wind peaks are associated with high dust deposition events**
   - **same type of Chl peaks are observed without evidence of dust event**
   - **deposited dust particles could also produce such a >0 bias in satellite Chl in oligotrophic waters** *(Claustre et al., GRL, 2002)*

CONCLUSIONS (2/2)

4. This work shows that dust deposition impact on chlorophyll is not great enough so that satellite chlorophyll can be used standalone to assess it

5. Finally, it leaves open the question to apportion respective impacts of
   - surface mixed layer deepening
   - desert dust deposition
   - pollution-derived P deposition

   } on the primary production

   - deposited dust — on bio-optics

PERSPECTIVES

1. **Use the 1D coupled dynamical-biogeochemical model ORCA-PISCES (coll. LODyC-Paris)**
   - **2 groups of phytoplankton, co-limitation by Fe, Si, P**
   - **any information welcome on nutrient and other marine data in our studied areas**

2. **Take into account both dust and anthropogenic P emissions in the aerosol transport model**
   - **on going development of the regional (1°x1°) chemistry-transport model CHIMERE (coll. LISA-Créteil)**

3. **Estimate bio-optic effects (coll. LOV-Villefranche/Mer)**