Towards modelling the impact of atmospheric deposition on biogeochemical cycles in the Mediterranean sea with a 3D coupled dynamical-biogeochemical ocean model

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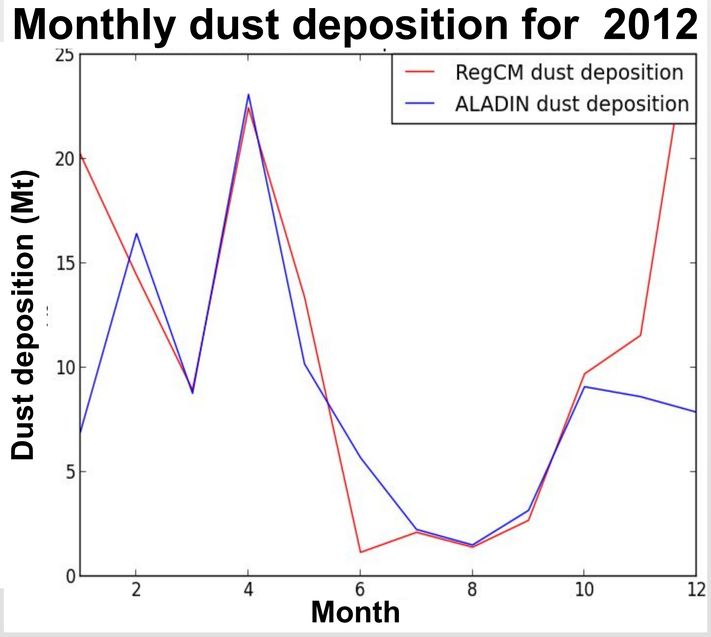
1. Presentation and objectives

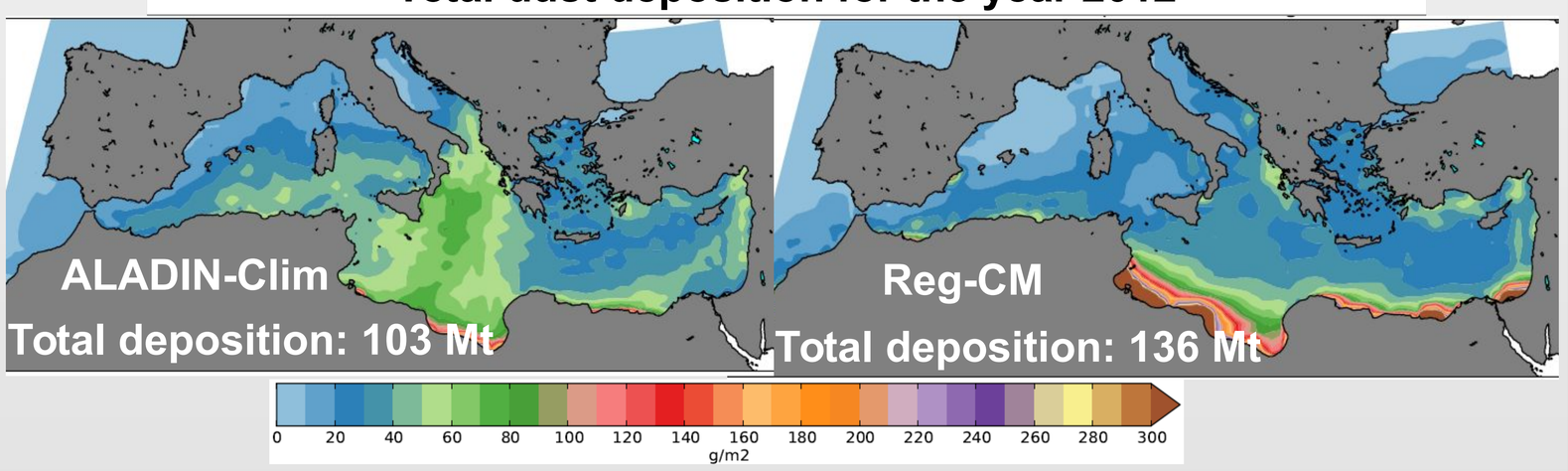
The Mediterranean basin is a hot spot of biodiversity and an area of major importance in the study of climatic changes. Atmospheric deposition is a major contributor of nutrients to the oligotrophic Mediterranean surface waters, especially through intense desert dust events. There are different atmospheric models simulating dust deposition over the basin. We show a comparison of dust deposition to the Mediterranean in 2012 from 2 regional atmospheric models: ALADIN-Clim and RegCM (Nabat *et al.* 2012) with high spatial and temporal resolutions (3 hours, 50km). We also performed decadal simulations with the coupled NEMOMED12/PISCES model and ALADIN-Clim 3-hourly forcing of dust deposition. We evaluate here the impacts of this deposition on nutrient budgets and on primary production.

2. Dust model intercomparison

Monthly dust deposition for 2012

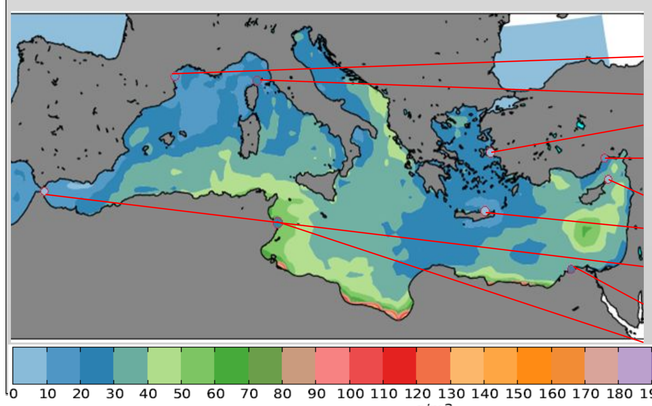


Total dust deposition for the year 2012



Models display comparable deposition amounts. There is a marked S-to-N decreasing gradient for deposition in RegCM. Spatial and temporal trends are relatively comparable between the 2 models. Deposition is weaker in winter (NDJ) and wet deposition is predominant in ALADIN-Clim. The intense deposition along the southern coasts observed in RegCM is mainly due to dry deposition of big particles (>1 µm).

The comparison of ALADIN-Clim deposition simulation with observations from the ADIOS campaign (June 2001-May 2002; Guieu *et al.*, 2010) shows that the model overestimates deposition, but values are in the same order of magnitude.



Station	Dust Dep. Flux g m^{-2} yr^{-1}
France, Cap bear	11
France, W Corsica	28
Greece, Lesbos	6
Turkey, Akkuyu	10
Cyprus	4
Greece, Crete	9
Morocco	7
Egypt, Alexandria	21
Tunisia, Mahdia	24

(calculated assuming 7% Al)

(Guieu et al., 2010)

3. Atmosphere as a major nutrient source

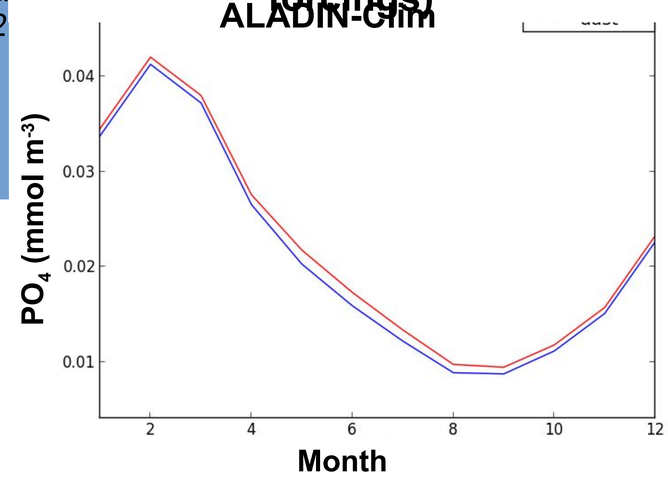
Atmos. contribution to nutrient inputs

Atmospheric contribution to the total nutrient input	This work 2012	This work 1983	*Krom et al. 2010*	*Bergametti et al. 1992*
NO_3	40-60	25-75	60	/
PO_4	5-40	0.1-15	28	36

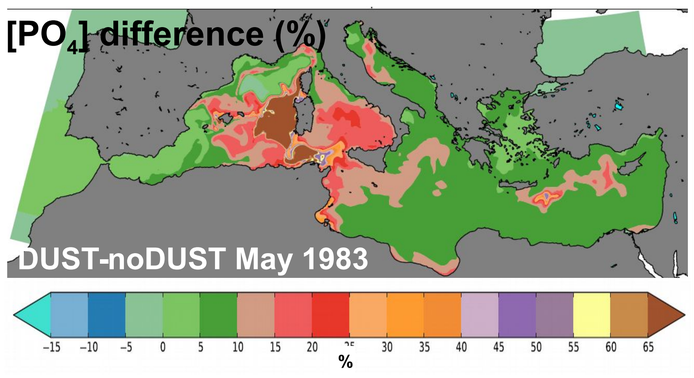
The table shows that atmospheric deposition is a major NO_3 source (simulation from INCA model) and a significant source for PO_4 (simulation from ALADIN-Clim). The range of values we found with these simulations are in agreement with literature values.

PO_4 concentrations are significantly higher in surface (map shows % difference in [PO_4] between DUST and noDUST simulations) especially during spring and summer months. The Mediterranean basin is mainly P limited but there are also significant differences in [Si] and [Fe].

[PO_4] in the first 10 m (1983 forcings) ALADIN-Clim



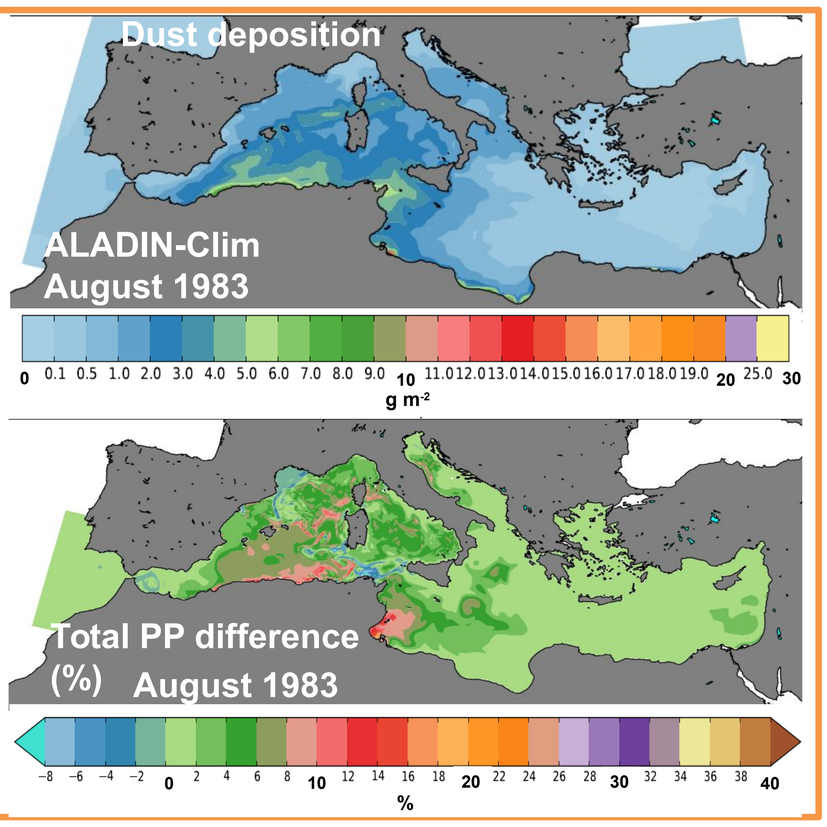
[PO_4] difference (%)



4. Impacts on primary production

We observe a significant enhancement (up to 20%) of surface primary production in areas of high deposition. This difference in primary production is mainly due to nanophytoplankton (accounting for more than 90% of Mediterranean's primary production).

The biggest changes in primary production occur where dust deposition is the highest during the month. Primary production enhancement is significant during the summer months (from June to September). During this period the Mediterranean Sea is stratified: deposition brings available nutrients to the depleted surface.



5. Preliminary conclusions

- **Impacts of dust deposition on nutrient budgets: +40-70% PO4, +100% Fe,+60-80% Si**
- **Impacts of dust deposition on primary production: +20% on the regions of high deposition**

6. Future work

- Particle export effects (*ballast effect*), explicit representation of bacterial loop (Guieu *et al.,* 2014)
- Simulations with variable N/P ratio
- Integration of anthropogenic aerosols

References:

Guieu,C., Loÿe-Pilot ,M-D., Benyahya ,L., Dufour, A., **Spatial variability of atmospheric fluxes of metals (Al, Fe, Cd, Zn and Pb) and phosphorus over the whole Mediterranean from a one-year monitoring experiment: Biogeochemical implications,** Mar. Chem., 120,164-178, 2010.

Guieu, C., Dulac, F., Ridame C. and Pondaven, P., **Introduction to project DUNE, a DUst experiment in a low Nutrient, low chlorophyll Ecosystem,** Biogeosci., 11, 425–442, 2014.

Nabat, P., Solmon, F., Mallet, M., Kok, J.F. and Somot, S., **Dust emission size distribution impact on aerosol budget and radiative forcing over the Mediterranean region: a regional climate model approach**, Atmos. Chem. Phys. Discuss., 12, 17835–17886, 2012.

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