ANTHROpogenic and natural DUST under present and future climate

A grant request from **LABORATOIRE DES SCIENCES DU CLIMAT ET DE L'ENVIRONNEMENT**
For the Climate Initiative programme of the BNP Paribas Foundation

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Description of the project

Dust storms are ubiquitous in arid and semi-arid lands, with extreme impacts upon the environment and human society both near the source and far downwind. Dust aerosols represent a serious hazard for air quality, human health, agriculture, energy production and the environment. Airborne dust has an important economic impact downwind of major source regions, particularly in some of the least developed countries in North Africa, the Middle East and Asia. Dust arises from wind erosion of uninhabited regions along with soils disturbed by human practices such as cultivation and grazing.

We propose to convene an international team of experts to improve our understanding of natural and human-created (or 'anthropogenic') dust sources, and their effect upon present and future climate, including their societal impact.

Trends in dust production during the past century are poorly known, and this lack of understanding makes it difficult to anticipate dust changes during the coming century that will accompany the rising concentration of greenhouse gases. The amount of airborne dust can change either as a result of stronger winds that raise dust from the surface or changes in the source extent. Our team has identified dust sources using satellites, and has related observed trends in dustiness to variations in vegetation (that protects the soil from erosion) and lake area. These source variations can be attributed to the changing climate along with changes in land use, associated with cultivation, for example. We propose to identify recent and future variations in both natural and anthropogenic dust sources, using combined models of land, natural vegetation and crops, along with observations and projections of future climate.

Dust impacts depend fundamentally upon the physical and chemical properties of the dust particles. For example, perturbations by dust to weather and climate through the energy and water cycles depend upon aerosol radiative forcing that is strongly related to the presence of iron oxide minerals. Current climate models represent dust assuming a globally uniform composition, despite known regional variations in the mineral composition of the parent soil. We intend, within the three years of the project, to introduce our state-of-art database of soil mineral composition and new modeling methods to account for regional variations of dust composition. This will allow the explicit representation of the effect of dust mineral variations upon the climate and societal impacts of dust. These impacts include radiative perturbations to weather along with the delivery by airborne dust of bioavailable iron and phosphorus to remote regions: micronutrients that stimulate the productivity of both terrestrial and marine ecosystems.

A strength of our proposal is the complementary expertise of our team, all of whom have made substantial contributions that address the challenges identified above. Fundamental (and unique) to our approach is the use of three well-established Earth System models (IPSL, NOAA GFDL and NASA GISS). This will allow a more reliable identification of dust impacts (and quantification of their uncertainty) than is possible with only a single model. Our project will lead to more confident projections of dust sources, erosion in agricultural areas and future climate.

Our proposal will have a significant outreach and educational component that will include the preparation of online materials and the organization of thematic workshops to transfer the knowledge produced by the project to countries in Africa, the Middle East and Asia, most affected by dust.

Project attributes

Localisation
This proposal gathers young and senior experts on mineral dust and one young leading expert on crops and agronomy from world leading climate institutions (LSCE, BSC, NASA GISS, NOAA GFDL and IIASA). The group strength relies on combined effort and complementarity expertise of its members, all of whom have published substantial contributions on these topics. The requested funding would support three postdoctoral scientists, who would be mentored by the experts.
- Postdoc 1 will further develop present and future dust sources at GFDL in Princeton and will be seconded at LMD in Paris, France.
- Postdoc 2 will determine the dust mineral composition using an innovative soil database at LSCE near Paris and at BSC (Barcelona).
- Postdoc 3 will work on Climate projections in Paris at LMD, with secondment at GISS, New York and IIASA (Laxenburg, Austria).
Sources of informations
LSCE website: http://www.lsce.ipsl.fr/en/Phocea/Vie_des_labos/Ast/ast_service.php?id_unit=52
BSC website: https://www.bsc.es/; http://www.bsc.es/earth-sciences
Sand and Dust Storm Warning Advisory and Assessment system website: http://sds-was.aemet.es/; http://dust.aemet.es
Paul Ginoux homepage: http://www.gfdl.noaa.gov/pag-homepage
LMD website: emc3.lmd.jussieu.fr/en
IIASA website: http://www.iiasa.ac.at/
NASA GISS website: http://www.giss.nasa.gov/
Major milestones 2017
M1.1: Conception and realization of the project website

M2.1: Present day quantification and localisation of anthropogenic dust sources
We will constrain a physically based dust emission scheme that is sensitive to changes in land use, vegetation, and crops using our new dust source inventory of natural and anthropogenic sources from the satellite era (Ginoux et al, 2012) and inversion modeling techniques (Escribano et al., in prep).
Foreseen outcome: 1 to 2 papers

M3: Global gridded mineralogical description of size-resolved dust distribution
We will calculate the global gridded mineral and chemical composition of emitted dust by combining our recently developed theoretical framework (Perlwitz et al., 2015, Perez García-Pando et al., 2015) with our new unique soil mineralogy dataset (Journet et al., 2014).
Foreseen outcome: 1 paper
Major milestones 2018
M4: Quantification of soluble iron deposition from natural and anthropogenic dust along with combustion aerosols.
Dust mineralogy from WP2 will allow us to constrain iron solubility changes caused by atmospheric processing. We will account for iron from combustion sources (Wang et al., 2015). Within the 3-year project, we will constrain global soluble iron deposition using the 3 ESMs (IPSL, GFDL and GISS).
Foreseen outcome: 2 papers

M2.2: Sources of dust from global croplands under land use change
We will estimate global dust mobilization from croplands using a global gridded crop model (Balkovic et al. 2014; Folberth et al. 2014). Prior compiled inventories on specific sites will serve for calibration and validation. The quantification and localisation of anthropogenic dust sources will be carried out for a landuse change scenario associated with SSP5-8.5. In addition, we will study the effect of phosphorus deposition on agricultural productivity.
Foreseen outcome: 2 papers
Major milestones 2019

M1.2: Outreach and dissemination
Relying on our collaboration with SDSWAS Regional Center in Barcelona, we will carry out a series of thematic workshops with training on the use of products and outcomes of the project. An interactive tool will be built for populations in countries affected by dust (Africa and Asia) showing how the regions of emission of natural dust versus anthropogenic dust may evolve with time depending on the land use scenario chosen and the CO_2 level.
Foreseen outcome: Final report; presentation at SDS conference

M5: Climate effects of dust
Radiative Forcing, and changes in temperature and precipitation will be computed in all three Earth System Models using caulated dust. We will focus the analysis upon the rainfall response to anthropogenic dust forcing within the Sahel region and over Southern Europe where water resources are limiting agriculture (Miller et al., 2014).
Foreseen outcome: 2 publications
Scientific interest
Current projections of airborne dust in 2100 are assigned low confidence by the Intergovernmental Panel on Climate Change in their most recent (2013) assessment of climate knowledge. A major source of uncertainty is inadequate knowledge of dust source extent due to changing cultivation and natural variations in vegetation. Projected impacts of dust are also limited by the oversimplifying assumption of uniform particle composition that affect perturbations to atmospheric radiation and climate along with the delivery of micronutrients to downwind ecosystems. African dust is associated with epidemics of meningococcal meningitis in the Sahel, and cardiovascular mortality in Southern Europe. The North American Dust Bowl is a vivid, historical example of the expansion of dust sources by human land use with disastrous impacts upon climate along with agricultural productivity and health.
International scope
The PIs and co-PIs come from three European countries and from the United States where they play significant roles in global and regional aerosol modeling, air quality and effects on agriculture. Yves Balkanski and Paul Ginoux advise the Aerosols Chemistry Modeling Intercomparison Project. Paul Ginoux leads the effort to assess the anthropogenic dust sources. Carlos Perez Garcia-Pando develops dust models and leads the group in Barcelona that makes daily forecasts of dust using regional models of Sand and Dust Storms. The SDSWAS system has built up relationships between African meteorological centers and the BSC in Spain. Ron Miller is the Deputy Director of NASA GISS and studies the climate impacts of dust. Olivier Boucher is a coordinating lead author of the IPCC 5th Assessment Report, and is ideally positioned to optimize the impact of this research with other international groups. Chris Folberth participates in the global gridded crop model inter-comparison project.
Organisation of the team and profiles involved
The team assembled for this effort consists of 11 scientists (5 young scientists and 6 senior scientists), a group to which this proposal would add 3 young scientists. To increase their potential to make progress on diverse scientific questions, each of the 3 postdocs participating in the project will work between at least two groups from two distinct countries involved in the project. This will allow a better coordination among the groups and create synergies among the diverse modelling techniques. The project will also allow leverage institute resources for creating websites tailored to the subject of the proposal. Part of this know-how was developed at LSCE within the global carbon atlas project (
http://www.globalcarbonatlas.org/?q=en/content/welcome-carbon-atlas).
Outreach
To illustrate the importance of dust and climate variations over many time scales ranging from interannual to geological, we will build up a site with an outreach section that follows a timeline. We will borrow elements from the global carbon atlas. The main results of the project will be illustrated on the same web platform.
In collaboration with the SDSWAS Regional Center, we will carry out a thematic workshop accompanied with training on the products and outcomes of the project. The main objective is to reach African/Middle-Eastern National Meteorological and Hydrological Services and national and international air quality and public health agencies.
We will focus on small segments of the general public to tailor the communication actions. Mainstream press

releases will be prepared for general media, and partner institutions will disseminate the discoveries of the project to enrich the public's scientific knowledge.

Project timeframe

ANTHRODUST will be a three-year project organized around 5 work packages. WP1 publicizes the societal consequences of dust presence. WP1 will be conducted in parallel to the other WPs.

WP2 will be devoted to the present day quantification and localisation of anthropogenic dust sources, WP3-WP4 will constrain dust mineralogy, chemical composition, and soluble iron content in models, and WP5 will calculate the climate effects of dust. WP2 and WP3 will be most active in years 1 and 2 of the project to feed intermediate outputs to WP4 and WP5.

WP1 will have a constant workload throughout the three-year project. The workload emphasis will progressively shift from WP2/WP3 to WP4/WP5 during the 36-month project.

Impact of the fundings

We envision the participation of 3 postdocs, who will work in at least two groups involved in the project. This scheme is designed to create an unprecedented synergy among the 6 international groups that are working on assessing anthropogenic and natural dust contributions and their effects on climate. At the same time the 3 postdocs will benefit from an excellent and comprehensive training period.

Synthesis

Our team shares the ambitious long-term goal of quantifying the natural and anthropogenic contributions to airborne dust along with both the climate and economic response under present and future climate. Within the proposed three-year period, the team will merge their complementary expertise and state-of-art knowledge to identify variations in both natural and anthropogenic dust sources while representing regional variations in the dust composition. These innovative products will be used to calculate both climate and societal impacts of dust.

A unique aspect of the proposal is the use of three well-established Earth System models (IPSL, GFDL and NASA GISS). This will quantify the impact in a more rigorous and complete way than is possible by using one model only.

The outreach actions will help countries affected by ubiquitous dust in Africa, the Middle East and Asia to better apprehend the relationships between dust, water limitation and agriculture.

Project team

Wang, Rong

Scientist

CNRS-LSCE

Global inventories of soluble iron from dust and from combustion. Global deposition fields of total and sobluble iron

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BALKANSKI, Yves

Senior researcher

CNRS- Laboratoire des Sciences du Climat et de L'Environnement

Yves Balkanski will ensure an efficient communication and exchange between the groups. He will supervise the work on aerosol mineralogy, heterogeneous chemistry and nutrient availability described in WP2, 3 and 4.

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Boucher, Olivier

Directeur de Recherches

Laboratoire de Meteorologie Dynamique

Olivier Boucher will supervise the work on inverting the global sources of dust. He will collaborate with Y. Balkanski in the realisation of the dust simulation for present day and the SSP5-8.5 future scenario.

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Miller, Ron

Scientist

NASA, Goddard Institute for Space Studies

Ron Miller will work on the dust/climate interactions and analyze changes in temperature and precipitaiton associated with dust.

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Konstantinos, Tsigaridis

Scientist

NASA, Goddard Institute for Space Studies

Expertise on heterogeneous chemistry and on the effect of the mineralogy on optical parameters

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Chaney, Nathaniel W.

Scientist

Princeton University

N. W. Chaney is key in the development of the 250m satellite data that will be used with the LM4 dunamic vegetation modeltoderive and simulate high resolution dust sources and plumes for this proposal.

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Elena, Shevliakova

Senior Climate Modeler

Princeton University

E. Shevliakova is leading the dynamic vegetation land model used in the project (LM3 and the LM4 under development). They are actually developing an initialization of LM4 using 250m satellite data that are clustered into 10-100 clusters per grid cell.

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Folberth, Christian

Research Scholar

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS (IIASA)

Chris Folberth (IIASA) will contribute global crop model simulations based on the Environmental Policy Integrated Climate (EPIC; formerly Erosion Productivity Impact Calculator) model.

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Albani, Samuel

Marie Curie Fellow

Department of Earth and Atmospheric Sciences, Cornell University

Samuel Albany will be in charge of assessing the deposition fields from the different models and compare them with the observations from the database that he developed (Albani et al., 2015).

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Perez Garcia Pando, Carlos

Team leader

Barcelona supercomputing center

C. Perez will participate in the determination of the anthropogenic fraction of the dust through simulations. He will cooperate with Y. Balkanski on the mineralogy of dust.

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Ginoux, Paul

Senior scientist

National Oceanic and Atmospheric Administraion

Analysis of satellite data to separate the anthropogenic from the natural dust. Simulations of dust under present and future climate conditions.

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Budget of the project

- Budget entered
- Budget group by account
- Budget group by year

Spendings

Marie Curie Fellowship *800 In-kind support*	2017	88,950.00€
500000 hours of computer time from GISS *800 In-kind support*	2017	15,500.00€
400000 hours of computer time from BSC *800 In-kind support*	2017	8,000.00€
500000 hours of computer time from GFDL *800 In-kind support*	2017	15,500.00€
500000 hours of computer time GENCI *800 In-kind support*	2017	15,500.00€

Fundings

PostDoc 1 * *500 Grant requested from the BNP Paribas Foundation*	2017	48,900.00€
10% overheads on overall project from CNRS * *500 Grant requested from the BNP Paribas Foundation*	2017	26,668.00€
Conferences including travel * *500 Grant requested from the BNP Paribas Foundation*	2017	25,000.00€
web site creation and deployment * *500 Grant requested from the BNP Paribas Foundation*	2017	40,000.00€
3 publications *		

1 person-month consolidated salary, R. Miller, GISS *800 In-kind support*	2017	11,000.00€
1 person-month consolidated salary, P. Ginoux, GFDL *800 In-kind support*	2017	11,000.00€
1 person-month consolidated salary, C. Folberth, IIASA *800 In-kind support*	2017	13,375.00€
66% consolidated salary, Scientist, BSC *800 In-kind support*	2017	32,000.00€
30% consolidated salary, C. Perez Garcia Pando, BSC *800 In-kind support*	2017	30,000.00€
20% consolidated salary, O. Boucher LMD *800 In-kind support*	2017	20,784.00€
30% consolidated salary, Y. Balkanski LSCE *800 In-kind support*	2017	33,207.00€
Marie Curie Fellowship *800 In-kind support*	2018	88,950.00€
500000 hours of computer time from GISS *800 In-kind support*	2018	15,500.00€
400000 hours of computer time from BSC *800 In-kind support*	2018	8,000.00€
500000 hours of computer time from GFDL *800 In-kind support*	2018	15,500.00€
500000 hours of computer time GENCI *800 In-kind support*	2018	15,500.00€
1 person-month consolidated salary, E. Shevikalova, GFDL *800 In-kind support*	2018	11,000.00€
1 person-month consolidated salary, C. Folberth, IIASA *800 In-kind support*	2018	13,375.00€
66% consolidated salary, Scientist, BSC *800 In-kind support*	2018	32,000.00€
30% consolidated salary, C. Perez Garcia Pando, BSC *800 In-kind support*	2018	30,000.00€
20% consolidated salary, O. Boucher LMD *800 In-kind support*	2018	20,784.00€

500 Grant requested from the BNP Paribas Foundation	2017	7,500.00€
PostDoc 3 * *500 Grant requested from the BNP Paribas Foundation*	2017	48,900.00€
PostDoc 2 * *500 Grant requested from the BNP Paribas Foundation*	2017	48,900.00€
PostDoc 1 * *500 Grant requested from the BNP Paribas Foundation*	2018	48,900.00€
10% overheads on overall project from CNRS * *500 Grant requested from the BNP Paribas Foundation*	2018	26,667.00€
Conferences including travel * *500 Grant requested from the BNP Paribas Foundation*	2018	25,000.00€
Year 2 outreach actions and meeting with international visibility * *500 Grant requested from the BNP Paribas Foundation*	2018	24,000.00€
Adding functionalities to web site * *500 Grant requested from the BNP Paribas Foundation*	2018	8,000.00€
4 publications * *500 Grant requested from the BNP Paribas Foundation*	2018	10,000.00€
PostDoc 3 * *500 Grant requested from the BNP Paribas Foundation*	2018	48,900.00€
PostDoc 2 * *500 Grant requested from the BNP Paribas Foundation*	2018	48,900.00€
PostDoc 1 * *500 Grant requested from the BNP Paribas Foundation*	2019	48,900.00€
PostDoc 2 * *500 Grant requested from the BNP Paribas Foundation*	2019	48,900.00€
PostDoc 3 * *500 Grant requested from the BNP Paribas Foundation*	2019	48,900.00€
12 months cost for Postdoc 1 in foreign laboratory * *500 Grant requested from the BNP Paribas Foundation*	2019	20,000.00€
12 months cost for Postdoc 2 in foreign laboratory * *500 Grant requested from the BNP Paribas*	2019	20,000.00€

30% consolidated salary, Y. Balkanski LSCE *800 In-kind support*	2018	33,207.00€
30% consolidated salary, Y. Balkanski LSCE *800 In-kind support*	2019	33,207.00€
20% consolidated salary, O. Boucher LMD *800 In-kind support*	2019	20,784.00€
30% consolidated salary, C. Perez Garcia Pando, BSC *800 In-kind support*	2019	30,000.00€
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1 person-month consolidated salary, P. Ginoux, GFDL *800 In-kind support*	2019	11,000.00€
1 person-month consolidated salary, R. Miller, GISS *800 In-kind support*	2019	11,000.00€
500000 hours of computer time GENCI *800 In-kind support*	2019	15,500.00€
500000 hours of computer time from GFDL *800 In-kind support*	2019	15,500.00€
500000 hours of computer time from GFDL *800 In-kind support*	2019	15,500.00€
400000 hours of computer time from BSC *800 In-kind support*	2019	8,000.00€
500000 hours of computer time from GISS *800 In-kind support*	2019	15,500.00€
Total Spendings		**799,998.00€**

* Non confirmed funding

Foundation		
12 months cost for Postdoc 3 in foreign laboratory * *500 Grant requested from the BNP Paribas Foundation*	2019	20,000.00€
2 publications * *500 Grant requested from the BNP Paribas Foundation*	2019	5,000.00€
Report publication with SDS groups * *500 Grant requested from the BNP Paribas Foundation*	2019	4,000.00€
Adding functionalities to web site * *500 Grant requested from the BNP Paribas Foundation*	2019	8,000.00€
Year 3 outreach actions and meeting with international visibility * *500 Grant requested from the BNP Paribas Foundation*	2019	24,000.00€
Conferences including travel * *500 Grant requested from the BNP Paribas Foundation*	2019	25,000.00€
10% overheads on overall project from CNRS * *500 Grant requested from the BNP Paribas Foundation*	2019	26,666.00€
Printing costs of the final report * *500 Grant requested from the BNP Paribas Foundation*	2019	14,397.00€
Total Fundings		**799,998.00€**

Spendings	
800 In-kind support	799,998.00€
Total Spendings	**799,998.00€**

Fundings	
500 Grant requested from the BNP Paribas Foundation	799,998.00€
Total Fundings	**799,998.00€**

Spendings	
2017	294,816.00€
2018	283,816.00€

Fundings	
2017	245,868.00€
2018	240,367.00€

2019	221,366.00€	*2019*	313,763.00€
Total Spendings	**799,998.00€**	**Total Fundings**	**799,998.00€**

Our organisation

LABORATOIRE DES SCIENCES DU CLIMAT ET DE L'ENVIRONNEMENT

Creation year :1998

Laboratoire du Climat et de l'Environnement (LSCE) belongs to CNRS-IPSL is a consortium of 5 laboratories working on global environmental issues, including research on the climate system & biogeochemical cycles. IPSL employs over 300 permanent researchers, 200 technical and administrative staff and over 450 PhD students and post-docs spanning 30 different nationalities. One of the main research missions of IPSL is to contribute to a better understanding of the interactions between human activities in the Earth System, and the environment and climate dynamics at different time scales. IPSL coordinates the cooperative development of the French IPSL-CM Earth System Model that participated to all CMIP & IPCC exercises, with ~100 researchers and engineers involved. This Earth System Model includes interactions between the physical climate system (as simulated by the atmospheric and ocean GCMs LMDZ and NEMO), the land surface component (ORCHIDEE), aerosols and chemistry (INCA) and marine biogeochemistry (NEMO-PISCES). Many of these model components are developed in-house and will be used in the project. The scientific excellence of IPSL is illustrated by the annual publication of over ten papers in the highest profile journals such as Nature, Nature Geoscience, Nature Climate Change, PNAS and Science and over 700 peer-reviewed papers in A-ranking international journals. The IPSL researchers contributing to Earth system modeling and global biogeochemical cycles and relevant to this proposal, are pivotal players in global climate and biogeochemistry modeling and are heavily involved in international projects / programs of IGBP and WCRP.

Web site :
http://www.ipsl.fr

Organisation :
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Project leader

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Organisation :CNRS- Laboratoire des Sciences du Climat et de L'Environnement
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Contribution to the project :

Yves Balkanski will ensure an efficient communication and exchange between the groups. He will supervise the work on aerosol mineralogy, heterogeneous chemistry and nutrient availability described in WP2, 3 and 4.

Main area of research

Study of aerosol/climate interactions
Heterogeneous chemistry
Mineralogy of aerosols
Inclusion of biogeochemical cycles in an Earth System Model
Evaluation and intercomparison of models

Awards

- Cited among The world most influential scientific minds in 2014 and Highly cited Researchers in 2015 by Thomson-Reuters

Main publications

Wang, R., Y. Balkanski, ..., Influence of anthropogenic aerosol deposition on the relationship between oceanic productivity and warming, Geophys. Res. Lett., 42, doi:10.1002/2015GL066753, 2015.
Wang, R., Y. Balkanski, ...: Sources, transport and deposition of iron in the global atmosphere, Atmos. Chem. Phys., 15, 6247-6270, doi:10.5194/acp-15-6247-2015, 2015.
Wang, R., Y. Balkanski, ..., Closure of the global atmospheric phosphorus budget, Nature Geoscience, 8, 48-54, doi 10.1038/ngeo2324. 2015.
Hauglustaine, D. A., Y. Balkanski, et al., A global model simulation of present and future nitrate aerosols and their... JGR 2014
Journet, E., Y. Balkanski, and S. P. Harrison,: A new data set of soil mineralogy for dust-cycle modeling, Atmos. Chem. Phys., 14, 3801-3816, doi:10.5194/acp-14-3801-2014, 2014.
Ginoux, et al. (2012), Mixing of dust and NH3 observed globally over anthropogenic dust sources, Atmos. Chem. Phys., 12, 7351-7363, doi:10.5194/acp-12-7351-2012.