

Model-observation Integrated Novel studies of bioavailable Trace Element Deposition (MINTED)

SCOR WORKING GROUP PROPOSAL (April 2026)

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1. Summary

Human activities have profoundly altered the air quality and ocean health on a global scale in the Anthropocene. It is our task to quantitatively evaluate the impact of human activities on marine ecosystems through various chemical inputs to the oceans. Although the iron hypothesis has driven major advances in understanding the biogeochemical cycle of iron, Earth system models still struggle to reliably predict how atmospheric inputs of iron and other trace elements influence ocean productivity and carbon cycling. As dust emissions, wildfires, and anthropogenic aerosols continue to evolve under human pressure and climate change, this persistent knowledge gap increasingly undermines our ability to predict ocean–climate feedbacks and overall ocean health. This Working Group (WG) proposes to bring together experts from the laboratory, field observation, and modelling communities to **unravel the role of aerosol trace elements' (TEs) solubility in modulating marine biological carbon cycling.** This will be facilitated through the **novel experimental designs** targeting atmospheric TE solubility in aerosols, rainwater, and seawater, including laboratory studies, shipboard incubation, and mesocosm experiments. These approaches will **allow seamless integration of targeted processes into detailed atmospheric and ocean models.** This WG is both important and timely as the transfer of natural and anthropogenic micronutrients and toxic elements across the air-sea interface is a current research priority of large international programmes. Capacity building is central to this effort, with planned workshops combining lectures and hands-on training to foster global collaboration. A SCOR WG will facilitate the essential framework to coordinate these efforts across institutions worldwide.

2. Scientific Background and Rationale

Atmospheric deposition of aerosols represents one of the largest external nutrient sources to the open ocean, with profound implications for marine productivity, carbon sequestration, and climate feedbacks. Increased ocean stratification in the context of a warming climate is projected to decrease the internal supply of nutrients to the surface ocean, making it essential to accurately predict changes in external atmospheric inputs using a combination of observations and global numerical models. A key challenge is to estimate bioaccessibility of atmospheric nutrient supply to ocean, which varies widely between studies, creating uncertainty in how models represent this parameter. While mineral dust dominates global trace element loading, anthropogenic and wildfire aerosols often contain a large fraction of bioaccessible micronutrients due to differences in particle size, mineralogy, and solubility-enhancing reactions with acidic and organic compounds in the atmosphere and seawater. Therefore, accurately predicting the magnitude, timing, and location of aeolian deposition fluxes, along with their fate in seawater and ecosystem response, is critical. Despite this importance, current biogeochemical models show limited skill in simulating biological responses to aerosol deposition events. During major deposition episodes, most essential trace elements, including iron, are rapidly scavenged, precipitated, and exported to the deep ocean due to supersaturation, bypassing the surface mixed layer where phytoplankton reside - unless organic compounds facilitate retention and cycling. Models particularly struggle with Fe(II), which oxidizes rapidly without stabilization, forming colloidal iron that aggregates and sinks. This creates a fundamental challenge: models require organic ligands to maintain bioavailability, yet

lack mechanistic representation of their production, transport, and coupling with atmospheric inputs.

The Challenge

MINTED identified the need to establish mechanistic links between aerosol deposition and marine biogeochemistry as a key priority. Parameter tuning without process-level understanding produces models that may reproduce historical observations but fail under novel conditions, leading to uncertain projections (Meskhidze et al., 2026). Laboratory studies alone cannot replicate “real” ocean complexity, including microbial diversity, organic matter variability, and dynamic physical forcing, making coordinated observational and process-based studies essential.

A major conceptual gap exists between atmospheric and oceanic perspectives. Atmospheric scientists quantify “solubility” (dissolved fraction), whereas ocean models require “bioavailability” (what phytoplankton can assimilate). **Solubility** is operationally defined through extraction protocols, while **bioavailability** depends on biological processes such as uptake mechanisms and ligand interactions. **Bioaccessibility**, often derived from laboratory leaching, represents potential availability but does not ensure biological utilization. Previous efforts, such as WG167 (RUSTED) improved data quality and highlighted inconsistencies in solubility estimates (Shelley et al., 2024; Perron et al., 2024), while recent community discussions emphasized the urgent need to translate solubility into bioavailability within modelling frameworks (Meskhidze et al., 2026).

Atmospheric models have attempted to reproduce aerosol iron solubility based on field data, yet variations among models are comparable to those arising from different experimental leaching protocols revealed by RUSTED. These discrepancies stem from differences in leaching conditions, including solution composition, pH, and reaction time. As a result, ocean models often use soluble iron as a proxy for bioavailable iron and adjust scavenging rates empirically to match observations, introducing large uncertainties in iron residence times. Furthermore, an incomplete understanding of processes such as grazing, aggregation, and particle reactivity necessitates repeated retuning of ecosystem parameters, highlighting the interconnected and non-linear nature of marine biogeochemical systems.

There is also a disconnect between the information atmospheric models can provide and what ocean models utilize. Atmospheric models can deliver source-specific information on co-deposited organic compounds, which may act as iron-binding ligands, and detailed aerosol size distributions that influence dissolution and residence time. However, ocean models typically use simplified inputs, neglecting these interactions. The situation is further complicated by co-limitation dynamics, where alleviation of iron limitation can shift ecosystems toward limitation by other nutrients such as phosphorus or manganese. Atmospheric models offer the capability to simulate multiple nutrient fluxes simultaneously, but prioritization is required based on biogeochemical relevance and data availability.

Consequently, a shift toward anthropogenic sources alter aerosol composition, bioaccessibility, and seasonal variability. Mineralogy plays a critical role in determining solubility, both during atmospheric transport and after deposition in seawater or within phytoplankton microenvironments. A coordinated Model Intercomparison Project (MIP) focusing on mineralogy and multi-trace elements represents a high-impact opportunity to quantify uncertainties, diagnose biases, and establish shared protocols and datasets. Building on frameworks such as CMIP7 and precedents like GEOTRACES and AerChemMIP, this effort can unify modelling approaches and improve process-based projections for climate assessments.

Why a SCOR proposal?

To develop a more comprehensive mechanistic understanding of the complex impact of atmospheric deposition on marine biological response, we propose (i) a suite of **novel coordinated experiments** along with (ii) a focused **modelling approach** and model evaluations. The experiments will range from laboratory work to ship-board and mesocosms incubations and will shed light on critical processes governing the behaviour of atmospheric trace elements in aerosols, rainwater, and seawater. This experimental work will **provide process-level understanding needed for integration into atmospheric and ocean biogeochemical models**. A SCOR WG allows the inter-laboratory assessment on how much of the presumed complexity is introduced by the application of inconsistent experimental approaches. For example, this can be used to evaluate the variability in biogeochemical response to a standardized atmospheric deposition. For this purpose, homogenous aerosol particles with an aerodynamic diameter of less than 10 μm (PM10) shall be generated in large quantities with an aerosol generator from parent soils mixed with other possible source materials (flyash, forest fire ashes, sea salt etc) to mimic possible natural aerosols present over the ocean. Subsequently, such homogeneous aerosols can be distributed to participating laboratories for leaching, incubation, and mesocosm experiments. These experiments can then be modified across the participating laboratories to test for specific conditions (e.g., mimicking emission events, ligand effects, the effect of bacterial respiration, phytoplankton community diversity). The outcomes from the leaching and incubation experiments can be used to improve process parameterizations in global models, which can be further constrained with atmospheric and oceanic observations.

The modelling component of MINTED will focus on evaluating models' representation of bioaccessible iron (and other trace elements) in the surface ocean, from deposition at the air-sea interface through processing in the surface mixed layer, thereby providing a key link with WG151 (FeMIP), which focused on model representation of ocean iron biogeochemistry. To establish the novel experimental design and fill the underlying gaps **between WG151 (FeMIP) and WG167 (RUSTED)**, we need SCOR's help to facilitate collaborations between different research groups across a wide range of facilities systematically.

3. Terms of Reference (ToR)

This WG aims to advance our understanding of how atmospheric aerosols influence marine biogeochemical cycles and ecosystem health in the surface ocean. Multidisciplinary teams are needed to understand aerosol sources, aging during transport, and the fate after deposition in the surface ocean. Leveraging the multidisciplinary expertise in our consortium, our aim will be achieved by addressing four main Terms of Reference (ToR).

ToR1. Facilitate inter-operability of soluble trace element experiments and analyses, with a primary focus on developing a standard homogeneous PM10 aerosol appropriate for leaching, incubation, and mesocosm experiments.

ToR2. Model-observation integrated study of the fate of soluble aerosol trace elements following deposition to the ocean surface, linking laboratory-derived solubility estimates to environmentally relevant bioavailability through process-based modeling.

ToR3. A Community Model Intercomparison Project of Atmospheric Nutrient Deposition (MIPAND) focused on developing a coordinated community effort to systematically compare and evaluate aerosol trace element deposition representations across atmospheric and oceanic models. A structured MIPAND is essential for quantifying uncertainties, diagnosing systematic biases, and accelerating progress toward robust simulations of atmospheric input-driven biogeochemical responses.

ToR4. Capacity Building, Indian Ocean monitoring station network, linking to the environmental relevance and social awareness.

The vision of MINTED is to build a strong and connected global research community that can address aerosol trace element solubility and its role in marine biogeochemical cycles. The ToR4 will focus on bridging gaps between atmospheric-science and ocean-biogeochemistry by developing a shared research framework, strengthening observational and data capabilities, and promoting collaboration across disciplines, regions, and career stages.

4. Working plan

ToR1. Facilitate interoperability of soluble trace element experiments and analyses and generate data usable in ToR2 and 3 models

A large mass of aerosol source materials (surface soil, fly ash, forest fire ashes, sea salts) will be collected without size fractionation. An aerosol generator will be used to produce large quantities of aerosol (PM10) reference materials from representative source materials to mimic natural aerosols over the ocean. The composition and size distribution of these reference PM10 materials will be characterized. The materials will then be distributed for trace element solubility studies, certified at low mass loadings representative of field-collected filter samples, and also used for joint incubation and impact studies. Distribution will be coordinated through international programs to ensure broad community access.

We will establish minimum reporting standards and metadata requirements for iron and other trace element solubility measurements (e.g., pH, ligands, contact time), ensuring

methodological flexibility while enabling intercomparison. We will also define common experimental conditions for interlaboratory comparisons to evaluate how solubility estimates from different leaching protocols relate to biological uptake and phytoplankton growth. This will help identify how variability in solubility estimates corresponds to environmentally relevant bioavailability. Based on the variability identified in ToR1, ToR2 will develop a common research framework to determine which approaches best simulate in-situ conditions.

ToR2. Develop a common research framework which facilitates knowledge transfer between the atmosphere and ocean biogeochemistry communities.

In this ToR, we will associate different leaching protocols with their best equivalent natural processes. For example, dissolution in ultrapure deionised water and seawater may represent fractional solubility in precipitation and dry deposition to the ocean surface, respectively. Additional techniques mimicking other environmental processes will also be considered. The resulting observations will be incorporated into a 1-D ocean biogeochemistry (BGC) model coupled with atmospheric chemistry model(s). We will provide reporting guidance linking experimental variability from leaching protocols to model parameters.

Establishing links between experimental approaches and in-situ equivalents will facilitate determination of trace elements, including iron, from aerosol leaches and their impacts on phytoplankton. These datasets will provide critical insight into solubility, bioaccessibility, and bioavailability following deposition.

To deliver **ToR2**, we will drive discussion on: (1) which parameters (e.g., pH, organic compounds, contact time) should be measured to connect experimental variability to model parameters; (2) how additional elements (e.g., manganese, phosphorus, copper, zinc) can improve understanding of aeolian trace element cycling. Mechanistic hypotheses will be tested using 1-D ocean BGC model(s) coupled with atmospheric chemistry model(s). Discussions will also address caveats, analytical limitations, and the use or misuse of multivariate statistics. Outputs from ToR1 and ToR2 will result in a joint publication in a special issue (e.g., AMT/ACP/AR/BG).

ToR3. Developing a community Model Intercomparison Project (MIP) of atmospheric trace nutrient deposition

ToR3 addresses key questions regarding spatial and temporal resolution requirements for atmospheric models to adequately support ocean biogeochemistry applications. It outlines a framework for a trace element MIP leveraging CMIP7 infrastructure and protocols. This includes historical simulations (1980–2023 using reanalysis meteorology) and future projections under standardized emission scenarios. A key innovation is the creation of a reference database of trace metal emissions and deposition fields, freely accessible to the broader modelling community.

Atmospheric models will generate multi-model concentration and deposition fields for validation against observational datasets. Soluble metals and organic compounds will be linked to different chemical forms (e.g., inorganic, dissolved, labile, refractory particulate iron) for comparison with ocean observations and 1-D BGC model outputs (ToR2). Validated atmospheric outputs will then drive ocean biogeochemical models from pre-industrial conditions (1750) through future scenarios, enabling assessment of ecosystem responses across temporal scales. The synthesis of outputs will produce an open-access database serving a wide range of research communities.

ToR4. ToR4 will ensure active participation of Early Career Researchers (ECRs) by supporting experiments, analyses, and model simulations, and involving them in discussions, outputs, and leadership roles in workshops and conference sessions. Community building will be central, including workshops, conference sessions, and training activities at international meetings such as Goldschmidt and SOLAS Open Science Meetings. Strong links will be maintained with international programs (e.g., SOLAS, GEOTRACES), and efforts will improve communication through shared terminology and guidance documents. ECRs will be actively involved throughout, with opportunities for training, collaboration, and leadership.

We plan five WG meetings. To optimize resources, the first and final meetings will be online, while three meetings will coincide with international events in hybrid format. An ECR-dedicated workshop and symposium will be held in Japan and/or South Africa.

Months 1-12:

A call for aerosol trace element data contributions will be issued, alongside mining of existing repositories and setup of atmospheric model simulations.

November 2026, an initial online WG meeting will finalize ToR1–4 plans, including preparation and distribution of reference materials in early 2027. A data use protocol, similar to GEOTRACES, will be established to support database development. Reference emission datasets and meteorological inputs will be distributed to atmospheric modelers. A workshop in the Indian Ocean region will assess observational capacity, facilities, and training needs.

2027: A full WG meeting at the SOLAS Open Science Conference will introduce the WG, report early progress, and refine tasks. Standardized protocols aligned with frameworks such as GEOTRACES and AerChemMIP will be developed, including harmonized emissions, common experimental scenarios, benchmark datasets, and quality control procedures.

Months 13-24:

A full WG meeting at the 2028 Goldschmidt Conference, alongside the Iron at the Air-Sea Interface Workshop, will present progress and refine objectives. Additional support will be

sought from initiatives such as Africa-Japan Collaborative Research (AJ-CORE). Atmospheric models will generate historical simulations (1980-2023 using reanalysis meteorology) and future projections (using standardized emission scenarios), validated against datasets from ToR1 and ToR2, including mineralogy, dissolution, incubation, and mesocosm studies.

Months 25-36:

A full WG meeting in South Africa will host workshops, lectures, and hands-on training to support an Indian Ocean monitoring network. Public outreach will raise awareness of atmospheric nutrient deposition impacts on marine ecosystems in collaboration with AJ-CORE. Validated atmospheric outputs will drive ocean biogeochemical simulations from pre-industrial to future conditions, with outputs contributing to an open database accessible to broader communities such as FeMIP.

Months 37-48:

Final meeting will synthesize results and coordinate publication of a synthesis paper.

Database online release on existing data repositories such as GEOTRACES and GRANTS

Data through [RUSTED](#) and [tooltip](#)

1. Deliverables

ToR1 will characterise the biogeochemical reactivity of TE from different aerosol source materials (e.g., dust and ash) to inform source-specific representations of TE solubility and composition. **ToR1** will create mechanisms for the rapid dissemination of methodological advances and lessons learned from interlaboratory comparisons.

ToR2 will create coupled atmospheric-ocean model testbeds that allow atmospheric models to deliver enhanced information (e.g., source attribution, size distributions, organic aerosol composition, and bioaccessible iron fraction) to ocean biogeochemical models at scales and temporal resolutions relevant to biological response. **ToR2** will develop consensus definitions for solubility, bioaccessibility, and bioavailability through cross-community dialogue and dedicated working groups, with clear operational criteria for each term. The investments in methodological harmonization would transform our ability to translate atmospheric iron and other nutrients' solubility measurements into the bioavailability parameters that ocean biogeochemical models use.

ToR3 will create an atmospheric dry and wet deposition database for the use of ocean BGC and Earth system models that allow from preindustrial, present, and future simulations for diverse research communities such as FeMIP, beyond the core MIP participants. Atmospheric model output will be validated against observed atmospheric concentrations and measured deposition fluxes, while ocean models will be evaluated with seawater trace element concentrations.

ToR4 will help to establish long-term time series observations at representative locations that capture both atmospheric deposition and ocean biogeochemical responses at appropriate temporal resolution, with collocated atmospheric and oceanic sampling strongly preferred where logistically feasible for the Indian Ocean monitoring station network. **ToR4** will create frameworks that foster sustained dialogue between atmospheric and ocean scientists to align measurement approaches with ecological questions.

- Paper publication in a special issue (e.g., AMT/ACP/AR/BG)
- Revision of the GEOTRACES aerosol cookbook with aerosol leaching protocols for specific processes
- Establishment or strengthening of regional observational networks, particularly in the Indian Ocean, helping to address current data gaps.
- A series of international workshops, training activities, and conference sessions, including events focused on early career researchers.

6. Capacity Building

Our vision is that this WG will bridge existing knowledge gaps in our understanding of aerosol solubility targeted by **WG167 (RUSTED)** and the role of atmospheric deposition in marine biogeochemical Fe cycles targeted by **WG151 (FeMIP)**. The proposed work is designed to build a common research framework that facilitates knowledge transfer from atmospheric science and ocean biogeochemistry communities and stimulate new research proposals and collaborations between established and early-career scientists around the world. This goal is reflected by the proposed multidisciplinary membership, which is diverse in terms of gender, career stage, and geographical representation. We have Full and Associate Members from countries that are developing their scientific capacities, such as India, Argentina and South Africa, who also conduct research in regions that are traditionally understudied. During the term of the WG, we are committed to creating at least one opportunity for the members, or early career researchers (ECRs) from their labs, to pursue a POGO-SCOR Fellowship and/or SOLAS summer school at an institution with the appropriate analytical and/or computing capabilities. The Indian Ocean monitoring station network of ToR4 is an ideal candidate for a POGO-SCOR Fellowship. We anticipate that future POGO-SCOR Fellowship opportunities resulting from this WG will promote training and capacity building and result in new collaborations well past the conclusion of the WG.

In-person networking remains vital for generating new ideas and forging new connections. During the first year, we will take advantage of travel funding to allow Associate Members from developing/emerging countries and ECRs to attend SCOR WG meetings. The WG will encourage early-career members to chair and host a discussion session at the SOLAS Open Science Conference related to the group's topic, as well as provide mentoring for them, thus aiding their career development.

During the second year, we propose to deliver a session and workshop on trace elements at the air-sea interface in conjunction with the 2028 Goldschmidt Conference with the support from the Tokyo Metropolitan Government and Iron at the Air-Sea Interface Workshop. We will host a symposium for the public, which aims to foster greater awareness and progress on these issues. By inviting international professionals who are actively engaged in advancing diversity and inclusiveness, we hope to inspire public audiences to reflect on and embrace the essential principles on the impact of human activities on marine ecosystems through various chemical inputs to the oceans. This will be publicised in advance via social media.

During the third year, hosting the workshop in a country where logistically feasible for the Indian Ocean monitoring station network is timely. The Indian Ocean has long been identified as understudied and a priority for further research. The Indian Ocean is of great interest because throughout the year it receives large inputs from the atmosphere from the various dust source regions proximal to the northern basin, which include the Arabian Peninsula, Africa and Asia. Anthropogenic aerosols from industrial pollution and biomass burning on the surrounding continents are also prevalent, and evident in the brown haze that lingers over the Arabian Sea, Bay of Bengal and southern tropical Indian Ocean. There are specific questions about how the supply of trace elements from the atmosphere impacts carbon and nitrogen cycles. The dominant controls on primary production in the Arabian Sea (i.e., zooplankton grazing versus iron limitation) remains an active research topic. Furthermore, the Indian Ocean is a globally important denitrification zone, and it also appears to be a region where nitrogen fixation rates are significant, although patchy and very much under discussion. Running a workshop in this region will have great benefit to the host institution as it will turn the international spotlight onto this under-studied region. The workshop will give the institution the opportunity to showcase its research facilities and provide students and ECRs with networking and mentorship opportunities from international experts working at the air-sea interface.

The AJ-CORE consortium will provide co-sponsorship and additional funding for this workshop. A key component of the project will involve building rich multimedia profiles of the researchers involved - especially early-career scientists from disadvantaged or underrepresented communities. These profiles will not only highlight their academic paths and personal motivations but also explore the cultural and institutional environments that shape their scientific inquiry. By presenting researchers as individuals with stories, aspirations, and values, we humanize environmental science and inspire future generations, particularly young students, to pursue careers in Earth system sciences.

Our goal is that this WG will produce a strong peer network that will facilitate global knowledge transfer and collaborations outlasting the term of this WG.

7. Working Group composition

This WG has 10 Full and 10 Associate Members that bring together state-of-the-art expertise in experimental methods for the assessment of aerosol trace element solubility, Earth system modelling, biogeochemical modelling and aerosol composition, which will guide key requirements and shape future directions. The Full Members are responsible for the successful

delivery of the objectives of the ToRs. The associate members will provide valuable inputs from complementary fields. Our full membership represents 10 countries, including two Global South middle-income economies (South Africa, Argentina) and one lower income economy, emerging/developing country (India), and has three early-career members.

7.1 Full Members

Name	Gender	Place of work	Expertise relevant to the proposal
1 Akinori Ito (co-chair)	M	JAMSTEC, Japan	Integrated researcher of the model with laboratory measurements and field observations. Lead instructor.
2 Garima Shukla (co-chair)	F	Leibniz Institute for Tropospheric Research (TROPOS), Germany	Early Career. Aerosol chemical composition, aerosol pH and liquid water content, source attribution, and reanalysis products.
3 Prema Piyusha Panda (co-chair)	M	Stellenbosch University, South Africa	Early Career. Aerosol TE solubility, biogeochemistry, and Southern Hemisphere aerosol.
4 Andrew Bowie	M	University of Tasmania, Australia	Biogeochemical cycling, aerosol TE solubility, Southern Hemisphere aerosols. Contributed to GEOTRACES IDP, GEOTRACES SSC co-chair (2018-2020), and member of GEOTRACES exec.

5 Clarissa Baldo		Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA), France	Early Career. Aerosol composition, mineralogy, solubility, dissolution kinetics, biogeochemistry. High Latitude and Southern Hemisphere aerosol.
6 María Gonçalves Ageitos	F	Universitat Politècnica de Catalunya (UPC) / Barcelona Supercomputing Center (BSC), Spain.	Earth system models, dust modelling (with a focus on mineralogy and its Earth system impacts, including ocean biogeochemistry).
7 Nicholas Meskhidze	M	North Carolina State University, USA	Aerosol dissolution, reaction kinetics
8 Nicolás J. Cosentino	M	CIMA-IFAECI, Argentina	Present-day Southern Hemisphere dust cycle. Lab experiments on aerosol/sediment TE solubility. Earth system and ocean biogeochemistry modeler.
9 Tung-Yuan Ho	M	Academia Sinica, Taiwan	Biogeochemical cycling, biological response to atmospheric deposition
10 Ying Ye	F	Alfred Wegener Institute, Germany	Ocean iron modelling (0D and 1D Fe speciation models, 3D ocean biogeochemistry and Earth system model with a focus on marine biological carbon pump)

7.2 Associate Members

Name	Gender	Place of work	Expertise relevant to the proposal
1 Alex Baker	M	University of East Anglia, UK	Aerosol TE solubility, biogeochemical cycling. GESAMP WG38 co-chair, contributed to GEOTRACES IDP, FeMIP associate member.
2 Ashwini Kumar	M	CSIR-National Institute of Oceanography, India	Biogeochemical cycles, aerosol TE solubility, Sr and Nd isotopes
3 Cecile Guieu	F	Laboratoire d'Océanographie de Villefranche, France	Biological response to atmospheric deposition and biogeochemical cycling. Co-Chair of the SOLAS SSC. Contributed to GEOTRACES IDP.
4 Clifton Buck	M	Skidaway Institute of Oceanography, University of Georgia, USA	Aerosol TE composition and solubility. Contributed to GEOTRACES IDP.
5 Douglas Hamilton	Non-binary	North Carolina State University, USA	Earth System models, wildfire and dust aerosols
6 Holly Winton	F	Victoria University of Wellington, New Zealand	Aerosol chemical composition, biomarkers, dust provenance, TEs in ice

			cores. SOLAS national representative.
7 Mingjin Tang	M	Guangzhou Institute of Geochemistry-CAS, China	Aerosol TE solubility
8 Morgane Perron	F	GESAMP WG38, France	Aerosol TE solubility, Southern Hemisphere aerosols, biogeochemical cycles.
9 Stelios Myriokefalitakis	M	National Observatory of Athens (NOA), Greece	Earth system modelling, atmospheric composition, multiphase chemical processes
10 Susanne Fietz	F	Stellenbosch University, South Africa	Biogeochemical cycling, biological response to atmospheric deposition. GEOTRACES SSC, national representative (2018-2023).

8. Working Group contributions

Akinori Ito (co-chair)

Atmospheric scientist, model developer, and integrated researcher with laboratory measurements and field observations, focusing on Fe cycle. Lead instructor at the 10th SOLAS Summer School.

Garima Shukla (co-chair)

Early career, aerosol chemistry, chemical composition, particle acidity and its association with liquid water content, source attribution, and reanalysis products.

Prema Piyusha Panda (co-chair)

Early career, Aerosol composition of atmospheric deposition and marine biogeochemical cycles, with a primary focus on the Southern Hemisphere oceans through shipboard expeditions and coastal monitoring stations at Sadhana Bay, the west coast of South Africa.

Andrew Bowie

Biogeochemistry of trace elements in the Southern Ocean and Antarctica, with projects addressing key research questions related to atmospheric dust deposition and solubilities, ocean iron fertilisation, physico-chemical speciation of trace elements and their isotopes, and the role of ocean dynamics on chemical and biological marine processes.

Clarissa Baldo

Early Career. Atmospheric scientist investigating aerosol properties, processes, and their impacts on climate through laboratory experiments and field observations. Their research focuses on physicochemical properties, including composition and mineralogy, and on atmospheric processes controlling nutrient solubility and dissolution kinetics, particularly for natural and anthropogenic particles in the Southern Hemisphere and high latitudes.

María Gonçalves Ageitos

Atmospheric composition scientist, particularly interested in aerosols and their interactions with the Earth system. Her research includes the development and application of atmospheric and Earth system models, focusing on mineral dust and its effects on radiation, clouds, and biogeochemical cycles.

Nicholas Meskhidze

Atmospheric scientist and model developer with expertise in integrating laboratory measurements, field observations, and numerical modeling to investigate the atmospheric iron cycle. His research spans iron mobilization, organic interactions, sunlight-driven transformations, and remote sensing of aerosol deposition, while fostering cross-disciplinary collaboration through international workshops on the air–sea interface.

Nicolás J. Cosentino

Mineral dust aerosol researcher with expertise on in-situ and satellite aerosol monitoring, total and soluble trace metal lab determinations on aerosol and dust source sediment samples, paleo-reconstruction of past dust fluxes, and Earth system (CESM2) and ocean biogeochemical (cGENIE, MARBLE-CESM2) modelling. His research is focused on the Southern Hemisphere dust cycle.

Tung-Yuan Ho

Marine biogeochemist focusing on anthropogenic and lithogenic aerosol deposition impacts on trace metal cycling in the northwestern Pacific Ocean. Applies elemental and isotopic analyses

to trace sources and transformations, and investigates bioavailability of aerosol-derived metals using model phytoplankton to understand biological uptake and surface ocean cycling.

Ying Ye

Ocean biogeochemistry modeller with expertise in developing parameterisations for iron–ligand binding based on laboratory and field observations and kinetic models. Experienced in constraining external iron sources and assessing impacts on the biological carbon pump using models from 0D to Earth system scale, with contributions to FeMIP.

Alex Baker

Aerosol chemistry, trace element fractional solubility. Impact of aerosol on ocean biogeochemistry. GESAMP WG38 co-chair also contributed to GEOTRACES IDP.

Ashwini Kumar

Aerosol chemistry, Aeolian dust characterization using geochemical tools, including radiogenic isotopes Sr and Nd. Total and soluble trace element composition and fluxes over the Indian Ocean.

Cecile Guieu

Marine biogeochemist, external inputs of nutrients to the ocean and their impact on biota: experimental approaches. Minicosm facility available for a joint experiment.

Clifton Buck

Chemical oceanographer with a focus on characterization of aerosol chemical composition, fractional solubility, and deposition. Leader of atmospheric characterization on U.S. GEOTRACES missions since 2013.

Douglas Hamilton

Atmospheric scientist and Earth System modeller with expertise in natural aerosols and their changing influence on climate and biogeochemical cycles through the Anthropocene. Led the development of an intermediate complexity iron aerosol module for the latest version of the Community Earth System Model.

Holly Winton

Aerosol chemical composition, Atmospheric iron fertilisation, Antarctic dust provenance, novel ice core proxies, impact of trace elements on primary production, biogeochemical cycles.

Mingjin Tang

Atmospheric chemist with interest in 1) sources, processes and fractional solubility of aerosol trace elements; 2) atmospheric multiphase chemistry and microphysics of aerosol particles; 3) atmospheric chemistry of mineral dust aerosol.

Morgane Perron

Atmosphere biogeochemist with an interest in the air-sea transfer of trace elements and nutrients. Focus on source apportionment and the identification of relevant atmospheric tracers based on field samples. Link between laboratory-based concentration and solubility data and ocean solubility and bioavailability.

Stelios Myriokefalitakis

Atmospheric scientist and model developer (TM4-ECPL/TM5-MP, EC-Earth3, and IFS-COMPO), focused on aerosol dissolution and aqueous-phase chemistry and data conversion with a standard code for exchanging climate data called "Climate Model Output Rewriter" (CMOR).

Susanne Fietz

Environmental geochemist; laboratory experiments and field observations on atmospheric inputs of trace metals into the ocean and impact on phytoplankton.

9. Relationship to other international programmes and SCOR Working groups

SCOR Working Groups: By bringing a modelling community focusing on improving solubility for aerosols and bioavailability for phytoplankton representation in atmospheric and ocean models, respectively, **our WG (MINTED) will bridge the gap between WG151 (FeMIP) and WG167 (RUSTED)**. We will contact the chairs to discuss possible collaboration.

GESAMP WG38 (Atmospheric Inputs to the Ocean): This group was formed in response to concern about the impact of atmospheric deposition on ocean chemistry, biology, biogeochemistry, and climate. This group has recently advanced knowledge of how changes in atmospheric acidity are likely to impact the dissolution of aerosol TEs. Close communication with this group will be facilitated through the co-chairs of GESAMP WG38 (Maria Kanakidou and Alex Baker).

GEOTRACES, SOLAS and SIBER (Sustained Indian Ocean Biochemical, Biogeochemical, and Ecological Research): The deliverables from all four ToRs will benefit these communities, e.g., the recommendations for handling aerosol Fe and TE solubility data (ToR1&2 deliverable). The database will be of particular interest to these communities, as it will provide quality-assured TE solubility data from these programs, alongside auxiliary information, to numerical modelers. The sensitivity study (ToR3 deliverable) will be of interest to the SIBER program, especially. We anticipate inviting SOLAS and SIBER to co-sponsor our workshop-lecture series. These organisations recognise the importance of improving the representation of soluble Fe in models. Full and associate members are currently serving, or have served, on GEOTRACES and

SOLAS committees. A SCOR WG will promote greater collaboration between these programmes.

IIOE-2: We anticipate close communication and collaboration with IIOE-2 participants to leverage their data and guide future research directions in the region (ToR4 deliverable). This programme will be approached for co-sponsorship of the workshop-lecture series.

International Global Atmospheric Chemistry and Global Atmosphere Watch programmes of the World Meteorological Organization (WMO) and NASA's Plankton, Aerosol, Cloud and ocean Ecosystem (PACE) program: The database will be of use to these programmes who are interested in the impact of aerosol metals (especially Fe) on air quality, weather and climate.

UN Decade of Ocean Science for Sustainable Development: The WG will be submitted for endorsement as an Ocean Decade Action as the workshop-seminar series address Priority Challenges 5 (Unlock ocean-based solutions to climate change) and 9 (Skills, knowledge and technology for all) directly, and Priority Challenges 1 (Understand and beat marine pollution) and 7 (Expand the global ocean observation system indirectly). In addition, the discussions of this WG will provide recommendations for future research questions on the flux of essential and potentially toxic TEs across the air-sea interface, thus addressing Priority Challenges 1 and 5. Publication in open-access journals addresses Priority Challenge 9.

10. Key References

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Appendix

Key Publications of Full Members of relevance to this Working Group (5 each)

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Glossary

ASLO – Association for the Sciences of Limnology and Oceanography

ECR – Early Career Researcher

Eos – The science news magazine published by the American Geophysical Union (AGU)

GEOTRACES - An international study of the marine biogeochemical cycles of trace elements and isotopes

GESAMP - Group of Experts on the Scientific Aspects of Marine Environmental Protection. Advises the United Nations on scientific aspects of marine environmental protection.

Fe – Iron

ICP-MS – Inductively-coupled plasma – mass spectrometry

IIOE-2 – Second International Indian Ocean Expedition (2015-2025)

NIO, India – National Institute of Oceanography, India

POGO – SCOR Fellowship - This programme is designed to promote training and capacity building leading towards a global observation scheme for the oceans, jointly funded by POGO and SCOR

RUSTED – Reducing Uncertainty in Soluble aerosol Trace Element Deposition (the proposed SCOR WG)

SIBER – Sustained Indian ocean Biogeochemistry and Ecosystem Research. The long-term goal is to improve understanding of the role of the Indian Ocean in global biogeochemical cycles and the interaction between these cycles and marine ecosystem dynamics. IIOE-2 is a major component of SIBER.

SOLAS – Surface Ocean Lower Atmosphere Study. Aims to understand the key biogeochemical-physical interactions and feedbacks between the ocean and atmosphere in order to understand and quantify the role that ocean-atmosphere interactions play in the regulation of climate and global change.

SWOT analysis - Strengths, Weaknesses, Opportunities, and Threats. A strategic planning and management technique.

TE – Trace elements

WG – Working Group