Formulaire de dépôt de projet d'un International Research Network (IRN)

CHIMSUR

1. TYPE D'ACTION (IRN)

2. PAYS CIBLE DE L'ACTION

Argentine, Chili

3. ACRONYME ET TITRE DU PROJET

Caractérisation de l'évolution spatio-temporelle de la composition atmosphérique dans le cône Sud avec CHIMERE
Caracterisación de la evolución spacio-temporal de la composición atmosférica con CHIMere en en cono SUR **(ChimSur)**
Characterizing spatial-temporal evolution of atmospheric composition in the south cone with CHIMERE

4. EQUIPES IMPLIQUÉES FRANÇAISES ET ÉTRANGÈRES

- Laboratoire de Météorologie Dynamique : **S. Mailler**, L. Menut, R. Pennel, A. Cholakian
- Argentine, Instituto Gulich/CONAE/CONICET : **Maria Fernanda Garcia Ferreyra** ; Maximiliano Burgos, Anahí Bianco
- France/Argentine : IRL IFAECI – **Nicolas Cosentino**, Graciela Ulke, Gabriela Nicora, Facundo Orte, Juan Pallotta, Lidia Otero, Andrea Pineda Rojas, François De Vleeschouwer
- Chili : Universidad de Chile - **Nicolas Huneeus,** Mariel Opazo, Valentina Flores Aqueveque

5. RÉSUMÉ DU PROJET (15 LIGNES MAXIMUM), MOTS CLÉS

Keywords : CHIMERE model, atmospheric composition, modelling, forecast, wildfires, mineral dust

The CHIMERE model is a community model labeled by INSU/CNRS. Its development is coordinated by L. Menut (LMD) with contributions of LISA (CNRS/UPEC) and INERIS. This numerical chemistry-transport model aims at modelling atmospheric composition from urban to hemispheric scale, for purposes of research and operational air quality forecast. This tool is adapted to study the evolution of the atmospheric composition in South-America and various processes specific to that region, in collaboration with research groups in Chile (Univ. de Chile) and Argentina (IRL IFAECI, CONAE). While CHIMERE is already used by these groups for research, the IRN framework would help further development of these collaborations with several scientific and pre-operational goals such as applying CHIMERE with newly developed national emission inventories for Argentina and Chile, design an operational forecast framework capable of representing wildfire and dust plumes, train students and researchers on the latest version of CHIMERE allowing for online simulations and thus permit studies on the feedback between meteorology and pollution. The project would create new links between LMD and IFAECI, strengthen the impact of IFAECI as a research hub on atmospheric composition and spread the use of CHIMERE in the region through a workshop and a formation aimed for researchers from South American countries.

6. CONTEXTE ET HISTORIQUE DE LA COLLABORATION

Collaborations between the groups proposing the project have existed for several years. In particular, the collaboration between LMD and the University of Chile started in 2015 when the CHIMERE development group supported Dr Huneeus in his research project funded by the Chilean research funding agency. This project led to the first implementation of the CHIMERE model for Chile and resulted in Mazzeo et al. (2018). Several projects were later performed as ECOS-Sud (2018-2022), PAPILA (European project), ECOS-ANID (ongoing), including the PhD thesis of Rémy Lapere in LMD under the direction of S. Mailler and L. Menut. This collaboration has resulted

in 6 common publications so far (Mazzeo et al. 2018, Trewhela et al. 2019, Lapere et al. 2020, 2021a,b, 2023). Within the framework of these projects, Nicolas Huneeus was able to conduct a research stay in France with the CHIMERE team, and likewise members of this group team also had research stays in Chile (L. Menut and S. Mailler in 2020, R. Pennel and S. Mailler in 2023).

The collaboration has been ongoing for several years with Dr. Garcia Ferreyra, she developed her master thesis about the implementation of CHIMERE in Argentina (Garcia Ferreyra et al., 2016). In 2015 she designed the first experimental and operational air quality forecast in Argentina, with the WRF-CHIMERE-EDGAR modeling system since 2015, published by the argentinian space agency CONAE. Later on, the work of Dr. Garcia Ferreyra with CHIMERE went on during her PhD thesis, including wildfire emissions into the modeling system of CONAE, an an analysis of the impact of wildfires on air quality validation of the results using satellite and ground-based data. She has attended the formation for CHIMERE users twice (in 2018 in Palaiseau, and in 2020 online) to update her skills in the new versions of the model, and exchanges have been ongoing since. Right now, the Gulich Institute-CONAE is working on the implementation of a new version of the air quality forecast with CHIMERE by the use of the online coupling between meteorological and chemical simulations and the inclusion of wildfires and of a new local biogenic emission inventory developed by Anahí Bianco in her PhD thesis, following the supervision of Dr. Maximiliano Burgos Paci in collaboration with Dr Fernanda García.

Collaboration between IRL IFAECI and LMD on air quality has started in the framework of a project LEFE-CHAT 2014-2017 with Graciela Ulke and Sylvain Mailler. Various attempts of continuing this collaboration have been hindered by lack of funding, including 2 rejected ANR projects. However, with the progress made in CONAE in the operational use of CHIMERE and the strengthening of IRL IFAECI, the situation is now ripe to retake this collaboration and include the expertise of IFAECI for the in situ measurements. In this project, IFAECI brings expertise in air quality (Graciela Ulke, Andrea Pineda Rojas), mineral dust (N. Cosentino, F. De Vleeschouwer), and teledetection (Lidia Otero, Facundo Orte). All this expertise gives a fertile ground for collaboration with the air quality modellers in LMD.

7. DESCRIPTION DU PROJET SCIENTIFIQUE

Over the last decades, air pollution has caused significant adverse impact on human health in south America and in the world. In fact, according to the Panamerican Health Organization, air pollution is the main environmental risk to public health in the Americas (https://www.paho.org/es/temas/calidad-aire). Gaining insights into the spatial and temporal dynamics of atmospheric composition is crucial in assessing the impact of human-induced activities and nautral phenomena on air quality. By comprehending this impact, we can develop integrated policies that effectively address both climate change and air quality concerns, ultimately reducing unintended consequences and promoting a healthier environment.

In addition to anthropogenic activities and their associated emissions, the south cone of South America (ie. Chile and Argentina) have also important natural emissions with a potentially an important impact in both air quality and climate. On one hand, the region has an important fire activity in the region with wildfires ranging from tropical rainforest in northern Argentina, to boreal ecosystems in Patagonia and the forests of southern Chile. On the other hand, the south cone has important sources of mineral dust in the Patagonian region in southern Argentina and other arid and semi-arid regions. Dust emitted in this region can be advected over large distances over the south-American cities and the Southern Oceans (Cosentino et al., 2021), in which they represent source of nutrients (Cosentino et al., 2020). The presence of large salt-lakes and their massive and sporadic emissions of salt and dust/salt particles in the atmosphere is another phenomenon that is specific of this region. Finally, eruptions from from volcanoes neighbouring the Chile-Argentina border can have impacts from the regional to the hemispheric scale (Ulke et al., 2016, Mailler et al. 2017), but have scarcely been studied with full chemistry-transport models, including the physico-chemical processes in the plume.

Global studies examining atmospheric composition focus mostly on the Northern Hemisphere, and regional studies focus on Northern Hemisphere regions such as US, Europe or Asia. To the best of our knowledge, limited amount of studies have focused on examining the evolution of the atmospheric composition in South America and much less for the south cone. The current proposal aims to adapt and apply the CHIMERE model to capture and characterize the different natural and anthropogenic processes that modulate the spatio-temporal evolution

of atmospheric composition in the south cone. Additionally, to apply CHIMERE with newly available emission inventories for Chile and Argentina to develop highly accurate air quality simulations for Argentina and Chile, and assess the strength and possible limitations of these new inventories regarding air quality modeling in the this region.

8. VALEUR AJOUTÉE DE LA COLLABORATION INTERNATIONALE POUR ATTEINDRE LES OBJECTIFS DU PROJET

Partners bring expertise and knowledge of local specificities in each region, new state-of-the-art emission datasets, in situ observational data and experience on the use of satelllite data and spatial analysis. The benefits for all the partners in the project rely on the complementarity between all of them. LMD brings model development expertise and the knowledge to include new processes in the CHIMERE air quality model. Instituto Gulich and Universidad de Chile bring new high-resolution emission datasets they have built in the framework of the PAPILA project. Universidad de Chile brings experience in the use of CHIMERE for regional air quality simulations in Chile, and the knowledge of the regional air quality processes, while Grupo Gulich also brings his pre-operational forecast platform built with CHIMERE.

This project, built around the CHIMERE model (LMD) and the collaboration hub around IRL IFAECI will put together these two forces (a state-of-the-art chemistry transport model, national community tool of INSU, and IFAECI, an International Research laboratory that federates Franco-Argentinian expertise). This way, the development and regional influence of IFAECI will benefit from the increased activity in this network around atmospheric composition modelling, while LMD and more generally INSU will benefit from the spread of the community tool CHIMERE and the opportunity to perform research on new regions. With the geophysical knowledge brought by U. Chile, Instituto Gulich, better representation of wildfire and dust processes in CHIMERE can be reached.

Benefits for the Argentinian part : to obtain a new operational air quality forecast including local and transboundary wildfires impacts on air quality; to consolidate the forecast that is of interest for the Environmental Ministry in Argentina and to evaluate modeling outputs using ground and satellite-based data in order to understand forecasting bias for rutinary and special events simulations. On the other hand, the possibility to be in close contact with CHIMERE developers would increase the modeling community and therefore modeling quality and analyses opportunities. IFAECI is structured around the personnel, resources, and infrastructure of CIMA (Centro de Investigacion del Mar y de la Atmosfera), but also includes investigators affiliated to other Argentine laboratories of the CONICET, the University of Buenos Aires, the National Meteorological Service, the National Hydronaval Service, the National Ministry of Defense and the National University of the North East, allowing access not only to computing laboratories but also to operational services/tools and various instruments for observing terrestrial, atmospheric and marine phenomena including Lidar Facilities (G. Nicora's group). Moreover, the current IFAECI informatic capacities hosted at CIMA allow the analysis of datasets of different sizes. The big data handling capability is supported by the available storage systems including a small high-performance computer to realise numerical experiments (such as low- to medium-resolution numerical simulations of the regional climate, case study-based experiments of high-resolution numerical weather prediction and data assimilation, and medium- to low-resolution ocean numerical simulations).

ChimSur wil therefore benefit of the entire IFAECI facility and infrastructure to organize the activities of the project. Moreover, ChimSur will use IFAECI as a nexus to build up collaborations not only in Argentina but as well in South America.

The collaboration between U. Chile and LMD has been focused in general to understand the dispersion of urban pollutants in Central Chile and in exploring the transport of this pollution to the andean cryosphere and trying to understand its mechanism. This new collaboration would allow the chilean group to expand the possible applications of CHIMERE. Specifically, this collaboration could significantly contribute to adapt CHIMERE to simulate the dust cycle in northern Chile. Something the group from U. Chile has been working without success so far. A successful representation of the dust cycle in northern Chile would allow to apply the model to estimate

the impact of dust on solar power plants. Additionally, simulations have been mainly centered in winter periods, when most of the pollution occurs. However, this collaboration could also contribute to include the emission of forest fires in future Chimere simulations and therefore be able to apply the model also in summer months with important fire activity.

9. DESCRIPTION DES ACTIVITÉS PRÉVUES DANS LE CADRE DU PROJET ET CALENDRIER

DESCRIPTION DES ACTIVITÉS

Activities in the project will be performed in collaboration between the French groups and the Chilean/Argentinian groups.

1. **Use CHIMERE with the newly available national emission inventories.** High resolution inventories of the anthropogenic emissions from Argentina, Chile and the entire subcontinent have been developed in national and international projects (including project PAPILA). To develop their use in CHIMERE, they need to be adapted to the requirements of the emiSURF preprocessor. This will be done within the first two years of the project.
2. **Add wildfires emissions to the operational forecast system with CHIMERE.** Wildfires occurs frequently in Argentina and Chile in summer and winter depending on the dry season. While some fires are controlled, or related to the agricultural activities, others can acquire huge dimensions, putting in risk human life and health. Fire emissions affect directly air quality up to hundreds of kilometers downwind. This is the reason why adding them to the anthropogenic emissions would improve air quality forecasting that is being produced by Gulich-CONAE in the region. New CAMS global fire emissions, estimated from near-real time satellite fire detection, is going to be used as input to the model as boundary conditions (including emissions from Amazonian fires) and within the simulation domain.
3. **Process studies in South-America** : As mentioned, a new biogenic emission inventory is being prepared for Argentina. This new inventory will increase spatial resolution and update the data. Its incorporation to the modeling input will be assessed as a contribution to the total emissions and impacts to air quality. With respect to mineral dust aerosols, a dataset of spatially resolved dust sources for southern South America is being prepared, which combines satellite information with in situ monitoring based on an array of passive dust traps, to derive seasonality of emissions as well as mass flux estimates for some sources. These revised dust sources will be incorporated into CHIMERE. Also, recent estimations of volcanic ash mass emitted during recent Patagonian eruptions, as well as of emitted grain size distributions (Bia et al., 2022), will serve as input for the simulation of volcanic emissions from CHIMERE.
4. **Spread the use of CHIMERE in South-America.** A combined scientific workshop + formation will be organized in either Chile or Argentina. This workshop will aim at gathering scientific contributions from all the subcontinent, including contributions from students & young researchers, and exchange knowledge on observing and modeling air quality in the South Cone and more generally in South-America. The user's technical formation, to held just before/after the workshop to control travel expenses, will aim at inviting forecasters and researchers from various countries and propose them a hands-on formation on the last version of the CHIMERE model for their purpose (both operational and scientific). This workshop will be held in the final two years of the project to be able to look for additional funding and to use the network built in the first years of the project.

CALENDRIER

Year 1 : Adaptation of CHIMERE's preprocessor emiSURF to the Argentinian and Chilean inventories. Kickoff meeting en Buenos Aires (1 week, ~10 persons)

Year 2 : two visits France -> Chile -> Argentina. Air quality simulations with CHIMERE including the new inventories, process studies.

Year 3 : WORKSHOP + formation (~50 persons) + CHIMERE formation (in Córdoba, BA or Santiago : 10k€ for organisation + 30k€ for travel expenses from France and project partners). Funds will be necessary to invite speakers/participants to the formation. We also foresee a postgraduate to PhD level course at the UBA to train young scientists to CHIMERE.

Year 4 - Year 5 : Process studies (mineral dust, wildfires), collaboration for the implementation/upgrade of forecast applications with CHIMERE.

10. PARTICIPATION D'ÉTUDIANT(E)S ET /OU JEUNES CHERCHEURS ET CHERCHEUSES AUX ACTIVITÉS DU PROJET

The scientific coordinators from Instituto Gulich and from IFAECI are both young Researchers :

Fernanda Garcia has defended her PhD thesis only recently, about modeling and satellite monitoring in Argentina. She continues to develop this subject in the CONAE and Instituto Gulich. **Nicolás Cosentino** has obtained his PhD thesis in 2017 and has recently joined IFAECI as a permanent CONICET researcher. He specializes in the dynamics and composition of mineral dust aerosols emitted from southern South America, using both observational and modelling techniques. His research in general is highly alligned with the objectives of this project.

Anahí Bianco, project participant at Instituto Gulich, is working on her PhD thesis to obtain a new Argentinian biogenic emissions inventory by the use of the MEGAN model, and the validation of her results using satellite data by means of the inclusion of those emissions as inputs in CHIMERE.

For the Workshop and the formation, attention will be payed to invite a significant proportion of Young Researchers.

11. QUALITÉ SCIENTIFIQUE DES ÉQUIPES

LMD, a part of IPSL, is a highly recognized laboratory for atmospheric studies. Within LMD, the InTRo group is specialized in regional model development, including the CHIMERE chemistry-transport model. In this project, the LMD team is composed of two researchers and two engineers, covering a large spectrum of knowledge and experience in the field of atmospheric composition modelling.

University of Chile is the main Chilean state institution in public higher education, funded in 1842. The research team participating in the proposal has implemented the modeling system WRF-CHIMERE for the metropolitan region of Santiago that resulted in the publications of Mazzeo et al. (2018) and Trewhela et al. (2019). Nicolas Huneeus has also actively participated in the studes that resulted in Lapere et al. (2020, 2021a, 2021b). Furthermore, the group from University of Chile has collaborated closely with the LMD team in the past years. Using the CHIMERE model, an assessment report for policy-makers was prepared on air pollution in central and south Chile. This report was led by N. Huneeus and can be downloaded from https://www.cr2.cl/contaminacion/.

The Gulich Institute belongs to the National University of Córdoba and the argentinian space agency CONAE. It is a research and postgraduate Institute with main focus on environmental applications using satellite and geospatial data, and space systems; its CONAE dependance puts it close to national and regional operational and managing institutions as the National Environmental Ministry which has an special interest for air quality operational monitoring and applications. On the other hand, the academic activities are linked to other local researchers. Air quality along with hydrometeorology studies for natural disasters have been developed since 2012 ; its educational and research activities promote the use of satellite data and modeling in the region.

IFAECI (https://ifaeci.cima.fcen.uba.ar, https://www.ifaeci.cnrs.fr/) is an International Research Laboratory formed by a network of 77 investigators from the Argentinean and French scientific institutions (CNRS, CONICET, IRD, UBA) and is located in Buenos Aires. The general goal of IFAECI is to strengthen France-Argentina scientific collaboration on a research agenda oriented to better understand, simulate and predict climate variability and change, as well as their impacts in southern South America and its surrounding oceans. Climate variability is interpreted as encompassing the full multi-scale nature of the problem including phenomena ranging from mesoscale, synoptic, intraseasonal, interannual, to longer timescales. The network of researchers belonging to different institutes of the Argentine scientific system provide the ability to access complementary infrastructure.

Researchers from IFAECI include Nicolás Cosentino, who has experience with monitoring and modelling of mineral dust aerosol emissions, dynamics, and climatic triggers in South America. François De Vleeschouwer is also a specialist in mineral dust studies, particularly in South America and surrounding oceans and islands, both for the present-day and paleo (i.e., Holocene) dynamics. Andrea Pineda Rojas has extensive experience in the study of air quality in the Metropolitan Area of Buenos Aires (AMBA) through the development and implementation of air quality models of varying complexity. Graciela Ulke has specialized in pollen and biomass burning aerosol monitoring, with a focus on their impacts on air quality in the city of Buenos Aires. The group of G. Nicora develops remote sensing equipment and use this instrumentation to monitor atmospheric processes to understand them and/or to provide comprehensive descriptions of several atmospheric phenomena impacting in the region (e.g. volcanic monitoring and ash dispersion, air pollution, etc.). In particular it participates to observation networks dedicated to a Social Management System for Atmospheric Environmental Risks in South America. (http://www.savernet-satreps.org) and the AErosol RObotic NETwork (https://aeronet.gsfc.nasa.gov/). Facundo Orte has experience in teledetection and ground-based monitoring applied to volcanic ash aerosols. Finally, Juan Pallotta and Lidia Otero are LIDAR specialists, and have participated in the Latin American Lidar Network (LALINET) for aerosol research.

12.BUDGET PRÉVISIONNEL ET SOURCES DE FINANCEMENT

Postes de dépenses :	**Budget prévisionnel par an :**
Missions	10k€ x 2 : visit of French researchers to Argentina 12k€ : travel expenses for French, Argentinian and Chilean project members for the Kickoff meeting 25k€ : travel expenses for French CHIMERE developers, Argentinian and Chilean project members and South-American guests for the Workshop (speakers) and for the CHIMERE formation (students, young researchers)
Etudes de terrain	-
Organisation de réunions/ colloques	10k€ (Workshop), 5k€ (Kickoff meeting)
Autres (20% max.)	Publications (8k€ max)
Demande totale annuelle moyenne	80k€ sur 5 ans, **16k€/an en moyenne**

Nicolas Huneeus and Valentina Flores will apply to the Chilean research funding agency to the call for international cooperation (to be submitted in July 2023) with LMD around the CHIMERE tool (https://anid.cl/concursos/concurso-de-fomento-a-la-vinculacion-internacional-para-instituciones-de-investigacion-convocatoria-2023/). If approved, this Chilean project would constitute a Chilean counterpart to the present IRN and permit funding of the travel expenses of the Chilean participants but would also allow to invite researchers of other countries (south america and/or europe) to participate in the workshop for instance.

Nicolás Cosentino has applied to two projects that, if funded, may each fully finance travel expenses for himself for the kickoff meeting. These projects are a PICT-2022-TA-GRFT1 (lead PI, submitted to Agencia I+D+i, Argentina) and a project proposal to OBVI (co-PI, submitted to Schmidt Futures, USA).

13.PPST (PROTECTION DU POTENTIEL SCIENTIFIQUE ET TECHNIQUE)

No specific concern. The CHIMERE model is open-source and widely available, the project will follow an open-science policy for the publication of articles, code and datasets.

ANNEXES

Publications :

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3. Orte F., Wolfram E., Luccini E., D' Elia R., Lusi A., Pallota J., Nollas F., Carmona F., Papandrea S., Cabezas M., Carbajal Benítez G. and Mizuno A. (2022). Saver-Net UV-total solar irradiance monitoring network in Argentina. Revista Meteorológica 47: e016. https://doi.org/10.24215/1850468Xe016
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8. Lara Sofía Della Ceca, Francesca Barnaba, Maria Fernanda García Ferreyra, Alexei Lyapustin, Alexandra Chudnovsky, Lidia Otero, Hebe Carreras. Satellite-based view of the aerosol spatial and temporal variability in the Córdoba región (Argentina) using over ten years of high-resolution data. ISPRS Journal of Photogrammetry and Remote Sensing, https://doi.org/10.1016/j.isprsjprs.2018.08.016(2018).
9. Cosentino NJ, Ruiz-Etcheverry LA, Bia GL, Simonella LE, Coppo R, Torre G, Saraceno M, Tur V, Gaiero DM, Does satellite chlorophyll-a respond to southernmost Patagonian dust? A multi-year, event-based approach.Journal of Geophysical Research: Biogeosciences 125(12), e2020JG006073, doi:10.1029/2020JG006073
10. Bia GL, García MG, Cosentino NJ, Borgnino L, Dispersion of arsenic species from highly explosive historical volcanic eruptions in Patagonia. Science of the Total Environment 853, doi:10.1016/j.scitotenv.2022.158389.