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Short Description (3-5 lines)	
The aim of this report is to explain the main ideas and discussions presented during the workshop: Climate and Health Cluster Workshop on Numerical Tools for Climate, Weather and Impact Modelling and Early Warning Systems.	
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List of Acronyms and Abbreviations

Abbreviation	Description
AI	Artificial Intelligence
AUC	Area under the ROC (Receiver Operating Characteristic) Curve
BlueAdapt	Reducing Climate Health Risks in Blue Environments: Adapting to the climate change impacts on coastal pathogens
Catalyse	Climate Action To Advance Healthy Societies in Europe
CLIMOS	Climate Monitoring and Decision Support Framework for Sand Fly-borne Diseases Detection and Mitigation
CMCC-CM3	Centro Euro-Mediterraneo sui Cambiamenti Climatici Climate Model
CMIP5	Climate Model Intercomparison Project 5
CMIP6	Climate Model Intercomparison Project 6
CORDEX	Coordinated Regional Climate Downscaling Experiment
DMP	Data management plan
ECMWF	European Center for Medium Range Weather Forecasts
ERA5	ECMWF Re-Analysis v5
EU	European Union
EWS	Early warning system
FAIR	Findability, Accessibility, Interoperability, and Reusability
FEPO	Sand Flies Extreme Population Prediction Model
GDPR	General Data Protection Regulation
GenSDM	Generative species distribution modeling approach
GLLVM	Generalized Linear Latent Variable Model
HaDEA	European Health and Digital Executive Agency
HIGH Horizons	HIGH (Heat Indicators for Global Health) Horizons: Monitoring, Early Warning Systems and health facility interventions for pregnant and postpartum women, infants and young children and health workers
IDAlert	Infectious Disease decision-support tools and Alert systems to build climate Resilience to emerging health Threats
INLA	Integrated Nested Laplace Approximation
LLM	Large Language Model
Maxent	Maximum entropy
RCP8.5	Representative Concentration Pathway 8.5
SDM	Species distribution modelling
SF	Sand fly
SFBDs	Sand fly-borne diseases
SPDE	Stochastic partial differential equation
SSP5	Shared Socioeconomic Pathway 5
TRIGGER	Solutions for mitigating climate-induced health threats
UNDRR	United Nations Office for Disaster Risk Reduction
UTCI	Universal Thermal Climate Index
WRF	Weather Research and Forecasting
WU	Wageningen University

Executive summary

The primary objective of the inaugural workshop for the Climate-Health Cluster was to focus on Numerical Tools for Climate, Meteorological, and Impact Modelling, as well as Early Warning Systems (EWS). The event aimed to foster collaboration and knowledge exchange among various projects within the cluster.

The workshop was structured into two key sessions, each dedicated to presenting methodologies and numerical models related to climate and health. The first session explored climate, meteorological, and economy-wide models, discussing aspects such as methods, data sources, and application areas. The second session focused on the use of artificial intelligence and statistics, emphasizing model validation and interpretability.

Each presentation lasted approximately 10 minutes and was followed by discussions that encouraged participants to share insights and consider potential future collaborations. The event, which included both in-person and online participants, highlighted the importance of enhancing predictive models to address complex climate and health challenges.

1. Workshop introduction

On February 21st, 2024, the Climate and Health Cluster Workshop on Numerical Tools for Climate, Meteorological, and Impact Modelling and Early Warning Systems (EWS) took place, marking a significant milestone as the inaugural workshop for the Climate-Health Cluster. With a dedicated focus on methodologies, this event aimed to foster collaboration and knowledge exchange among various projects within the cluster. The workshop served as a crucial platform for introducing the diverse range of projects within the Climate-Health Cluster. By placing a strong emphasis on methodologies, it aimed to equip participants with a deeper understanding of predictive models and early warning systems, thereby enhancing their capacity to address complex climate and health-related challenges.

This event was held at HaDEA (4th floor No 15 in COV A2), Pl. Charles Rogier 16, 1210 Saint-Josse-ten-Noode Brussels, Belgium, and was offered in a hybrid format, allowing for up to 40 in-person participants and up to 50 participants in total to attend remotely. The workshop lasted from 9:00 to 17:10 (CET), providing participants with ample opportunity to interact and delve into the presented topics. The number of participants per project, and the number of people who attended online and in person can be found in [Table 1 of Annex 1](#).

All participants, both online and in person, were provided with an information sheet and subsequently filled out a consent document for data collection and image-related matters before the event, as outlined in [Annex 2](#). All consent forms were collected for GDPR compliance purposes.

The workshop was structured into three distinct sessions, as it can be seen in the agenda, on [Annex 3](#), with each addressing specific aspects related to the projects and methodologies within the cluster. Discussions were also held during each session, fostering an interactive environment for sharing insights and exchanging ideas.

- Introductory Session: During this introductory session, projects and methodologies related to numerical approaches for climate and health modelling were presented.
- Session 1 - Climate, Meteorological, Economy-wide, and Sector-specific models within the cluster: In this session, the approaches used within each project in the cluster regarding numerical models were explored. Aspects such as research question, application area, method, scale, and data inputs were discussed. The session included a discussion on specific topics such as terminology, downscaling (numerical and statistical), and data sources.
- Session 2 - Statistical and Artificial Intelligence: During this session, the applications of statistics and artificial intelligence in the projects were explored, with a focus on the research question and whether machine learning techniques or other methodologies were employed in the process. The discussion was focused on topics such as terminology, validation, and interpretability of models, with the possibility of addressing additional topics based on the specific insights from the projects.

The presentations within each session lasted approximately 10 minutes, with the order of presentations following alphabetical order:

- BlueAdapt
- CATALYSE
- CLIMOS
- HIGH Horizons
- IDAlert

- TRIGGER

Following the conclusion of the presentations in each session, there was a discussion regarding each topic. These discussions not only raised questions but also explored potential improvements or future collaborations. This interactive exchange of ideas provided valuable insights and fostered a collaborative environment among participants.

Below are the key highlights from each presentation during the introductory session:

BlueAdapt

Marc Neumann introduced BlueAdapt which stands for Reducing Climate Health Risks in Blue Environments: Adapting to the climate change impacts on coastal pathogens. He started to explain the intricate dynamics of climate warming and recent marine heatwaves, emphasizing their substantial impact on marine ecosystems. BlueAdapt's strategic location in coastal zones, situated at the interface of marine and terrestrial systems, exposes it to stressors from both the open ocean and upstream river basins. Specifically, BlueAdapt investigates how coastal pathogens are anticipated to be affected by climate change, considering their interaction with other anthropogenic pressures such as antimicrobial resistance and environmental pollution, including harmful algal blooms.

The foundation of BlueAdapt's research rests on three fundamental pillars:

- Experimental Laboratory Work: BlueAdapt conducts experimental laboratory work to understand how changes in climatic variables, such as temperature, influence pathogen behaviour.
- Field Work in Case Studies: Through fieldwork in case studies, BlueAdapt seeks to comprehend pathogen abundance in bays and estuaries, as well as patterns of human exposure.
- Modelling Work: BlueAdapt employs modelling techniques to predict pathogen transport and concentration in coastal areas.

These building blocks serve as crucial components in conducting health impact assessments and formulating policy responses. BlueAdapt's research spans both short-term strategies, such as developing predictive alert systems for bathing waters with a time horizon of hours to days, and long-term adaptation strategies to address climate change risks over the coming decades.

CATALYSE

The presentation, introduced by Cathryn Tonne, provided a brief overview of the aims and structure of CATALYSE, which stands for Climate Action To Advance HeaLthY Societies in Europe. The project seeks to address three key questions: 1) How will climate change-induced hazards (such as temperature, air pollution, allergenic pollen, wildfires) impact health in Europe 2) How can we optimize health in climate change mitigation and adaptation efforts 3) How should health systems adapt to climate change and reduce their environmental footprint.

CATALYSE involves 21 partners including academic institutions, SMEs, local agencies, and civil society partners. The main scientific activities are focused around 5 key areas:

1. The development of an indicator framework and data repository to track the health implications and actions to address climate change induced environmental hazards.
2. To comprehensively quantify the health co-benefits of European climate change policy
3. To develop innovative surveillance tools including early warning systems and predictive models

4. To understand whether framing climate change as a health issue increases engagement with climate change and fosters individual and institutional behaviour change.
5. To identify key opportunities to promote climate change adaptation and mitigation in European health care.

CLIMOS

Carla Maia presented CLIMOS, which stands for Climate Monitoring and Decision Support Framework for Sand Fly-borne Diseases Detection and Mitigation with Cost-benefit and Climate-policy Measures. CLIMOS focuses on an important vector-borne disease transmission system susceptible to climate and environmental changes. The project aims to provide a better understanding of climate and environmental drivers of SFBs to reduce model uncertainties for better prognosis of their current and potential spread. It also seeks to relate these factors to socioeconomics and provide risk assessments for various stakeholders.

CLIMOS will deliver public access interactive mapping and information services along with tangible recommendations for public and animal health. The goal is to enable and encourage public (social, environmental, and financial) preparedness. Overall, CLIMOS aims to minimize the risk of exposure to SFBs in Europe, expansion to and from currently non-endemic regions and neighbouring countries, protecting the health and well-being of its citizens from climate and environment-related risks and impacts. The project targets medical, veterinary, public and occupational health professionals, surveillance organizations, citizens, and all stakeholders responsible for monitoring and managing transmission and treatment, or those whose health is impacted or endangered by SFBs.

HIGH Horizons

Stanley Luchters presented HIGH Horizons, which stands for Heat Indicators for Global Health: Monitoring, Early Warning Systems, and health facility interventions targeting pregnant and postpartum women, infants, young children, and health workers. The project addresses the compelling evidence of the detrimental direct effects of heat on maternal and newborn health outcomes, including preterm birth, stillbirth, congenital anomalies, pre-eclampsia, maternal haemorrhage, fetal distress, and long-term impacts on children's health.

The HIGH Horizons project is a collaborative effort involving 11 partners across 10 countries in Europe and Africa, operating within both the European Union (EU) and sub-Saharan Africa. Collectively, the HIGH Horizons partners aim to:

- Quantify and monitor both direct and indirect health impacts of extreme heat through tracking indicators and studying biomarkers.
- Test a personalized Early Warning System (EWS) tailored to the needs of the target populations.
- Implement and evaluate integrated adaptation-mitigation actions in health facilities to address the identified health risks posed by extreme heat.

Through these comprehensive efforts, HIGH Horizons seeks to enhance understanding, early detection, and effective response to the health challenges posed by extreme heat, ultimately contributing to improved health outcomes for vulnerable populations across Europe and Africa.

IDAlert

Joachim Rocklöv introduced the project IDAlert (Infectious Disease decision-support tools and Alert systems to build climate Resilience to emerging health Threats), presenting its objectives, organisation, intermediate results and policy engagement. The project aims to contribute to the resilience of public health concerning infectious diseases impacted by climate change. It focuses on indicator development to track developments, early warning and alert platform capacity, novel surveillance, evaluation of interventions, projections and capacity building. IDAlert is nested within the Lancet Countdown on Climate Change and Health in Europe and provides indicators through this initiative to the EEA climate and health observatory. IDAlert has six case-study areas: Sweden, Netherlands, Germany, Spain, Greece and Bangladesh.

TRIGGER

Silvana Di Sabatino introduced the TRIGGER project, which stands for soluTions foR mltiGatinG climate-induced hEalth thReats, by emphasizing its primary goal: to identify, monitor, and quantify the direct and indirect impacts of climate change-induced environmental hazards on human health. This objective is achieved through the direct collection of health, weather-climate, environmental, and socio-economic data using user-friendly tools such as sensors, simplified models, and a data hub. The project adopts a transdisciplinary approach, integrating diverse knowledge and translating it into practical tools and solutions.

To accomplish its objectives, TRIGGER conducts multicentric prospective studies, an analytical retrospective epidemiological study, and simulations with climate model chains. Additionally, innovative wearable sensors are deployed to monitor and model the impacts of environmental hazards in five demonstration labs across various climatic and socio-economic contexts in Europe. The research outcomes, including data, tools, and applications, are integrated into a novel platform known as the Climate Health Connection Hub. This platform is developed using a multidisciplinary and participatory approach, facilitating the dissemination and utilization of research findings for addressing climate and health-related challenges.

2. Session 1: Climate, meteorological, economy-wide and sector-specific models within the cluster

During the first session, each project of the cluster had the opportunity to expand the introductions to their projects with overviews of approaches and methodologies they use for numerical modelling, providing an in-depth understanding of their research questions, application areas, scales considered, and data inputs. Each presentation lasted for 10 minutes, allowing for a detailed exploration of the complexities involved.

In terms of research questions and application areas, presenters articulated the specific objectives of their projects within the broader context of climate and health modelling. This included identifying key challenges or issues that the project aimed to address, such as predicting disease outbreaks, assessing the impact of climate change on health outcomes, or understanding the dynamics of environmental factors on disease transmission. Methodology was a key focus of the presentations, with presenters elaborating on the techniques and approaches used in their projects to model climate, meteorological, economy-wide, or sector-specific factors. This involved discussing the use of mathematical models, statistical techniques, or computational algorithms to analyse complex data sets and simulate various scenarios. Scale was also addressed, with presenters discussing the spatial and temporal dimensions of their modelling efforts. This included considering whether the focus was on local, regional, or global scales, and the implications of scale for the interpretation and application of model results.

Data inputs were a critical component of the presentations, with presenters providing insights into the types of data utilized in their modelling efforts. This included meteorological data, climate projections, demographic data, health records, environmental monitoring data, and other relevant datasets. Presenters also discussed how data quality, availability, and uncertainty were addressed in their modelling framework.

Below are the summaries of key highlights covered in each presentation during the session 1:

BlueAdapt

Enrico Scoccimarro presented the session 1 effort within BlueAdapt, providing a comprehensive overview of the various types of climate models utilized, ranging from General Circulation Models to Earth System Models and Regional Models. He detailed the different sources of climate information, beginning with common data repositories such as CMIP5, CMIP6, and CORDEX, and then delved into the description of the fully coupled high-resolution CMCC-CM3 General Circulation Model. Enrico explained the tailored information provided for BlueAdapt partners, focusing on both the geographical locations (case studies) and the temporal frequency of data, encompassing raw data (e.g., temperature, precipitation, wind) and derived indicators (e.g., extreme event indicators).

He presented an initial evaluation over the European domain, comparing simulated temperature and precipitation patterns in the historical period with observations (e.g., ERA5 reanalysis).

Furthermore, Enrico described the future scenarios chosen, including the SSP5-RCP8.5 scenario characterized by high emissions and stable land use, as well as an additional scenario planned for simulation with the CMCC-CM3 model (SSP585-SSP126LU), which involves high emissions with reforestation land use change.

CATALYSE

Cathryn Tonne presented an overview of the various numerical, statistical, and AI models utilized throughout the project. These encompass scenario modelling derived from integrated assessment models, emissions modelling, and the modelling of outdoor air pollution concentrations via atmospheric models, as well as indoor modelling utilizing building physics models, which include ventilation parameters. AI applications within the project involve machine learning models aimed at predicting cycle utilization in urban areas and employing natural language processing of social media data to develop a digital surveillance tool capable of detecting instances where individuals attribute health symptoms to climate change hazards.

Session 1 showcased an exemplary product from the diverse array within CATALYSE: the Early-Warning System for allergic rhinitis presented by Mikhail Sofiev. The system was chosen due to its incorporation of several pivotal elements of interest for the cluster, including (i) machine learning technology as its foundation, (ii) environmental modelling utilizing deterministic models for meteorology, atmospheric composition, and bioaerosols, (iii) adept handling and processing of big data, and (iv) outputs directly geared towards public health applications and individual outreach.^{1[OB]}

CLIMOS

Danyang Wang presented the modelling approach for CLIMOS. In order to explain and predict the occurrences of sand flies, Wageningen University (WU) employed three species distribution modelling (SDM) techniques and tested the impacts of resolution and bias correction methods on model performance. The SDM techniques included maximum entropy (Maxent), Integrated Nested Laplace Approximation (INLA) with stochastic partial differential equation approach (SPDE) and Generalized Linear Latent Variable Model (GLLVM). Depending on available resources, they also considered employing the generative species distribution modelling approach (GenSDM), a technique recently developed within WU. Ultimately, the aim was to ensemble the outcomes of these algorithms and use the ensemble model for prediction.

The modelling procedure will consist of three steps. In the pre-processing stage, sand fly observations and environmental variables will be obtained from various data sources. Count data of sand flies will be converted to binomial data (i.e. presence-absence). The values of near-present environmental variables will be extracted at the locations of sand fly observations and will be standardized. Given the large number of candidate explanatory variables, multicollinearity is expected. Therefore, dimensionality reduction techniques will be applied to reduce the number of explanatory variables that will enter model fitting. In addition, the future scenarios of the selected variables will be obtained and standardized. In the processing phase, model will be fitted, and model evaluation statistics will be computed. Afterwards, in the post-processing phase, the best performing model will be selected based on AUC. The 'best' model will be used to make projections about the distributions of sand flies under current and under future environmental conditions. By comparing these projections, we can anticipate distribution range shifts of sand flies and species diversity changes over time.

¹ Sousa-Pinto, B., Palamarchuk, Y., Leemann, L., Jankin, S., Basagaña, X., Ballester, J., Bedbrook, A., Czarlewski, W., Almeida, R., Haahtela, T., Haveri, H., Prass, M., Henriques, T., Vieira, R., Klimek, L., Ollert, M., Shamji, M., Jutel, M., Del Giacco, S., Torres, M., Zuberbier, T., Fonseca, J., Sofiev, M., Anto, J., & Bousquet, J. (2023). From MASK-air® and SILAM to CATALYSE (Climate Action to Advance HealThY Societies in Europe). *Journal of Investigational Allergology and Clinical Immunology*, 34. <https://doi.org/10.18176/jiaci.0923>

HIGH Horizons

Chuansi Gao and Koen van der Sanden presented the session 1 for HIGH Horizons. They discussed the development and implementation of a heat and health risk warning system tailored for vulnerable groups such as pregnant and postpartum women, infants, and health workers. This system is based on a personalized ClimApp, which utilizes a mixed-method approach to determine heat health risk thresholds due to insufficient scientific evidence. Pre-determined trigger levels enable the EWS to alert impending heat health risks and provide advice, with thresholds varying based on geographical locations and individual vulnerability. Incorporating vulnerability variables allows for the personalization of the EWS, ensuring targeted advice and knowledge sharing. A comprehensive Universal Thermal Climate Index (UTCI), considering several thermal climate variables and human heat balance models, is integrated into the EWS. When heat health warnings are triggered, corresponding advice and messages are provided to users to take appropriate actions.

The EWS application is built on the Flutter framework to provide an intuitive user experience. It can be used both online and offline, automatically downloading weather now- and forecast data with internet connectivity or manually providing weather conditions offline. The ruleset for determining warnings and messages is stored locally but updated whenever an internet connection is available, allowing for the incorporation of the latest scientific insights without requiring users to download a new application version.

Moreover, the application includes built-in translation options to facilitate usage beyond English-speaking communities. This comprehensive approach ensures accessibility, usability, and adaptability of the EWS application across diverse user groups and settings.

IDAlert

In this session, Rachel Lowe presented climate and health impact modelling approaches that are being developed within the framework, which inform the creation of policy-relevant indicators and early warning systems to build resilience against emerging zoonotic diseases in Europe and beyond. The presentation also covered the post-processing steps required to feed climate information from sub-seasonal to decadal time scales into health impact models.

An early warning model framework to predict the risk of zoonotic diseases, such as leptospirosis and Lyme disease, and the data harmonization and model selection pipeline to develop probabilistic disease predictions using seasonal climate forecasts was also presented. The methodological approaches taken to quantify and communicate forecast uncertainty to end users were highlighted and plans for the development of a multi-disease early warning system in Bangladesh, one of IDAlerts key study sites were shared

TRIGGER

The efforts of TRIGGER were presented, focusing on the forecasts of climate-health indicators in the medium up to the seasonal range and the corresponding extrapolation of high-resolution city-level information via downscaling.

In the first part of the presentation, it was described the operational chain set up in TRIGGER to deliver forecasts of climate-health indicators from the ECMWF (European Centre for Medium-Range Weather Forecasts) prediction model up to 10 days into the future. This chain targeted multiple health hazards such as heatwaves, cold spells, UV radiation, pollution, and allergenic pollens, delivering daily indicators forecasts to the medical partners located at the TRIGGER climate-health connection labs. It was showcased

the successful prediction of the early January cold spell and its potentially detrimental cold-related health impacts for one of the TRIGGER labs.

The second part of the presentation covered the analysis of hybrid (statistical-dynamical) seasonal forecasts developed by the University of Bologna, based on the C3S multi-model hindcast for the period 1993-2016. The results demonstrated that the hybrid forecast outperformed the dynamical one, revealing skillful predictions of extreme heat in summer for many European regions.

Finally, the methodology to downscale climate predictions and projections up to the resolution of 500m using the WRF model was discussed. The setup for the climate-health connection hub in Bologna was presented and discussed, providing insights into the process of extrapolating high-resolution city-level information through downscaling. This comprehensive presentation provided attendees with a detailed understanding of TRIGGER's efforts in forecasting climate-health indicators and downscaling high-resolution climate data.

Following the presentations, there was a dedicated time for discussions, during which various topics were explored in depth. During the discussion of session 1, a debate arose regarding each project's understanding of the definition and objectives of an EWS. Daniel San Martín from CLIMOS directly cited a definition of an EWS provided by the United Nations Office for Disaster Risk Reduction (UNDRR). The definition states:

"An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events.".

This definition sparked an exchange of ideas, with other project coordinators expressing their agreement and noting that the definition encompassed all necessary aspects and goals for an effective EWS. However, it was suggested that jointly developing a comprehensive typology of Early Warning Systems would be beneficial to unify criteria and promote a more holistic understanding. Furthermore, the discussion identified several vulnerable areas within the projects' scopes. Additionally, common areas where projects could mutually benefit from each other's insights were highlighted, fostering a collaborative learning environment and maximizing the impact of individual initiatives within the broader context of the cluster. It was also noted during the discussion that there is a need to explore further the topic and terminology related to the Early Warning Systems, possibly through the creation of a joint paper or research initiative aimed at deepening the understanding and effectiveness of EWS within the cluster and sharing of knowledge and experiences of cluster's scientific synergies related to the EWSs.

Overall, the discussions following the presentations provided valuable insights into the diverse perspectives and approaches within the cluster, highlighting opportunities for collaboration, knowledge exchange, and collective learning to address complex climate and health-related challenges.

3. Session 2: Statistical and Artificial Intelligence

Session 2 of the workshop, titled "Statistical and Artificial Intelligence," delved into the utilization of statistical and artificial intelligence approaches within the cluster. This session provided an opportunity to explore how these advanced techniques are applied in climate and health modelling, focusing on areas not covered in Session 1. Presenters discussed the specific research questions and application areas addressed by their projects, along with the methodologies, scales, and data inputs employed.

During this session, participants engaged in discussions regarding key synergies and uncertainties across different models and approaches. Various topics were suggested for discussion, including terminology, validation, and interpretability of models. These topics aimed to foster a deeper understanding of the methodologies used and the challenges encountered in employing statistical and artificial intelligence techniques in climate and health research.

The discussion session provided a platform for participants to exchange insights and ideas, promoting collaboration and shared learning across projects within the cluster. Additionally, participants had the opportunity to raise additional topics based on their project-specific insights, further enriching the discussion and contributing to a comprehensive exploration of statistical and artificial intelligence approaches in the context of climate and health modelling.

Below are the key highlights from each presentation during the session 2:

BlueAdapt

During Session 2, Peter Robins presented on behalf of the BlueAdapt project, focusing on case studies in coastal regions. He showcased the application of the Delft3D model for predicting pathogen dispersal in these areas. Peter provided insights into the progress made in modelling the Conwy estuary, an idealized estuary case study, and discussed the parameterization of the Delft3D model for simulating faecal bacteria in the Rijnland coast and inland waters. His presentation highlighted the importance of modelling techniques in understanding and predicting the dynamics of pathogens in coastal environments, contributing to the broader goals of the BlueAdapt project in addressing climate and health-related challenges.

CATALYSE

Session 2, presented by Joan Ballester, highlighted the development of a small-area heat-cold-health early warning system within Catalonia as part of the CATALYSE project. This system integrates high-resolution weather forecasts with small-area epidemiological models applied to disaggregated health data to issue warnings of health risks and impacts for population subgroups. The initiative is being carried out in coordination with local meteorological and public health partners, aiming to codesign the tool and better address the needs of public health authorities and key stakeholders.

CLIMOS

Majid Soheili presented insights from the CLIMOS project, focusing on the application of a machine learning method. Majid introduced a prediction model named FEPO (Sand Flies Extreme Population Prediction), specifically designed for forecasting the population of sand flies, the primary carriers of Leishmania disease. FEPO addresses the challenge posed by the highly skewed observations of sand fly populations, which are common in extreme event prediction problems requiring an early warning system to mitigate side effects.

The presentation delved into the intricacies of FEPO, highlighting its capacity to accurately predict sand fly populations, particularly in extreme scenarios. Majid discussed the techniques employed by FEPO and emphasized its ability to handle extreme situations in sand fly population dynamics. To evaluate the model's efficacy, various measurements were discussed, and a comprehensive assessment of FEPO was conducted.

Furthermore, Majid presented the outcomes of FEPO for a specific region, Murcia, Spain, demonstrating the practical application of the model. This showcased FEPO's potential impact on predicting and managing the risk of Leishmania disease in real-world scenarios, emphasizing its importance in contributing to the goals of the CLIMOS project in addressing climate and health-related challenges.

HIGH Horizons

In Session 2, Jørn Toftum shared insights from the HIGH Horizons project, which focuses on developing and implementing a heat and health risk warning system for vulnerable groups such as pregnant and postpartum women, infants, and health workers. The presentation highlighted the development of a personalized EWS, based on ClimApp, which provides tailored advice to the above vulnerable groups for coping with outdoor thermal exposures based on user-specific input and current weather conditions.

Jørn discussed the challenges associated with predicting indoor temperatures, emphasizing the importance of accurate forecasts for ensuring the well-being of individuals spending significant amounts of time indoors. To address this challenge, the HIGH Horizons project developed a machine learning algorithm capable of predicting indoor temperatures using simple and easily observable properties of the building state, such as window openings and thermostat settings. The algorithm was trained using data from measurements in dwellings and advanced simulations.

While the model's performance is acceptable in temperate climates, Jørn noted the need for additional data in warmer climates to improve the accuracy of temperature predictions. He highlighted the project's collaboration with other initiatives, such as the ClimApp project, to leverage data and enhance the prediction algorithm.

IDAlert

Bruno Carvalho presented some of the machine learning and AI applications currently being applied in the IDAlert project. Bruno described the extreme gradient boosting method, which is being applied in the development of two indicators: leishmaniasis and West Nile virus. The indicators track the climatic suitability for these diseases at subnational level for Europe, based on open-source epidemiologic, climatic, and environmental data.

Both indicators are part of the European Lancet Countdown on Health and Climate Change report and are currently being adapted to subseasonal to seasonal timescales. The leishmaniasis indicator is a successful collaboration between two cluster projects, IDAlert and CLIMOS. Bruno also presented the AI methods being developed for Tick Report, a citizen science project led by the Swedish Veterinary Agency. Neural networks are being trained to identify tick species in pictures uploaded by citizens. It currently has good accuracy in identifying the native *Ixodes ricinus* ticks, and it is regularly being improved as more data is supplied.

TRIGGER

Fredrik Wetterhall presented the TRIGGER project's latest research, focusing on exploring the relationship between climate change and health as evident in existing policies and public perceptions. The presentation showcased the outcomes of an experimental approach that utilized Large Language Models (LLM) and generative AI techniques. These advanced methodologies significantly improved the project's ability to identify and interpret implicit and explicit connections between climate hazards and health impacts within European climate policies. The presentation also highlighted the application of similar methodologies based on LLMs to analyse social media data, providing valuable insights into public perceptions of climate stress. This innovative approach offered a unique perspective on understanding the public's sentiment regarding this critical issue. Overall, these research activities demonstrated TRIGGER's commitment to employing innovative methodologies and generating insights into the complex intersections of climate change and health.

Following the completion of the presentations, the workshop transitioned into a discussion phase where participants engaged in insightful dialogue on various pertinent topics. Suzana Blesic from CLIMOS raised a question to Trigger regarding the potential integration of complex network modelling into their approaches. Furthermore, the importance of adhering to the FAIR principles when collecting data was emphasized, ensuring that data is Findable, Accessible, Interoperable, and Reusable. Transparency and accessibility of collected data, as well as sharing results with contributors, were underscored as essential practices.

Another crucial point that emerged during the discussion was the recognition of the significant gap in artificial intelligence expertise, especially concerning new European regulations and emerging regulatory trends. Proactive approaches and strategies were highlighted as necessary to address this challenge and promote responsible development of artificial intelligence in the climate and health domains. Furthermore, expertise in geolocating tweets was highlighted, showcasing its potential contribution to sentiment analysis in the context of One Health. Possible collaboration opportunities between TRIGGER and this specific field were explored, emphasizing the importance of interdisciplinary collaboration within the group.

4. Closing discussion

Once the different sessions concluded, a final discussion ensued, providing an invaluable opportunity for participants to engage in a comprehensive exploration of various pertinent topics that had emerged throughout the workshop. During this discussion, considerations were raised regarding the utilization of ECMWF data and the expressed willingness to share, albeit with noted restrictions and challenges in harmonizing them, particularly concerning metadata and regulatory aspects, which have evolved significantly in recent years with the implementation of GDPR. The evolving nature of data spaces, akin to a data marketplace, was mentioned, highlighting the prevalent scenario where many projects are purchasing non-open data. Suzana Blesic from CLIMOS advocated for a transparent and standardized approach to data sharing, akin to climate data practices, and proposed a common harmonization and homogenization process within the cluster. Rita Araujo, the EC Policy Officer emphasized the importance of identifying barriers to data sharing within data spaces. Raman Preet from IDAlert highlighted the complexities in data sharing across countries due to normative and political reasons, suggesting collaboration not only in data but also in open-access scripts. Discussion revolved around the importance of having a clear idea of the required data for sharing, with BlueAdapt members citing the sharing of models in CMIP as a positive example where sharing the models has provided opportunities for better collaboration between different research groups.

Concerns were raised regarding continents where data sharing reluctance exists, stemming from various contexts such as data from minors. Suggestions were made for reorganizing the cluster structure, with Maria Maia from CLIMOS asserting that it is well-organized within working groups. The EC Policy Officer stressed the significance of the Data Management Plan (DMP), acknowledging the challenges in medical and health data sharing and highlighting opportunities for data homogenization across individual DMPs within the cluster. Maria Maia noted that in CLIMOS, representatives are involved in all packages, staying informed of cluster activities through meetings and a shared SharePoint folder. Raman Preet expressed confidence in the cluster's functionality and suggested collaboration between working groups for effective dissemination.

The need to balance well-defined deliverables with research activities was raised, with concerns regarding administrative burdens. Suggestions were made to reduce the number of deliverables to allow more time for networking and other tasks. Maria Maia encouraged reading the scientific strategy for new workshop ideas. The EC emphasized that strategic planning of cluster activities would be key to the success of the cluster during its lifetime, while BlueAdapt expressed eagerness to coordinate the cluster. Raman Preet assured that working group coordination is progressing well.

5. Next steps

Following the productive discussions and valuable insights gained from the workshop, the Climate and Health Cluster is ready to take proactive steps forward.

Our focus will be on leveraging the momentum and collaboration fostered during the event to propel collective efforts forward. Looking ahead, the emphasis will be on implementing a cohesive plan that integrates the diverse expertise and methodologies showcased by participating projects. This involves working closely together, sharing knowledge, innovating, and collaborating to address key research gaps in climate and health modelling. A commitment to fostering an inclusive environment where different perspectives and ideas are welcomed is paramount. By embracing diversity and interdisciplinary collaboration, we believe the quality and impact of research outcomes can be significantly enhanced. One of the priorities will be establishing clear and transparent protocols for sharing data to facilitate effective collaboration. The aim is to ensure that data-sharing practices are open, accessible, and user-friendly for all stakeholders involved, thus maximizing the impact of research.

In addition, collaboration will extend to the production of scientific papers. Working together to publish findings will not only enhance visibility and credibility but also facilitate knowledge dissemination and contribute to the advancement of climate and health research. In that regard, a discussion on the initiative to write a paper on EWS terminology will continue during the next planned cluster meeting.

In summary, the Climate and Health Cluster is enthusiastic about the journey ahead. With collaboration, innovation, and a commitment to making a positive impact, there is ability and common purpose to address pressing climate and health-related challenges and contribute meaningfully to improving global health and well-being.

Annex 1: List of workshop participants

Table 1: All workshop attendees, indicating their project and mode of attendance (online or in-person)

Project	Number of participants	In person	Online
IDAlert	12	11	1
CLIMOS	11	8	3
BlueAdapt	6	4	2
HIGH Horizons	12	9	3
CATALYSE	6	3	3
TRIGGER	7	5	2
Other (HaDEA)	2	2	0
Other (RTD)	1	1	0

Annex 2: Workshop consent form

WORKSHOP INFORMATION SHEET

The European Climate-Health Cluster – Thematic Workshop 1



The Climate-Health Cluster is a **Horizon Europe cooperation** between 6 European research and innovation projects. The 6 projects include: BlueAdapt, CATALYSE, CLIMOS, HIGH Horizons, IDAlert, and TRIGGER. The projects collaborate to increase the societal and policy impact of EU-funded research linked to climate, health and policy.

The specific objectives of the cluster are to:

- 1) Promote and disseminate climate change and health research from a OneHealth perspective;
- 2) Raise awareness of the health impacts of climate change, and the costs and benefits of mitigation and adaptation interventions;
- 3) Maximise the communication and dissemination of results through our networks;
- 4) Contribute to evidence-based decision-making and stronger EU and global policies; and
- 5) Build capacity around climate change and health research.

The Climate-Health Cluster will connect to significant initiatives in climate change and health to provide scientific evidence and policy-related advice to contribute to a more resilient Europe, and beyond. The Cluster will collaborate with researchers and academia, climate and environment professionals, policymakers, policy experts, funding agencies, NGOs, healthcare providers, patient organisations, the healthcare industry, civil society and citizens.

Today's workshop is part of the clusters planned activities to contribute to the success of the objectives outlined above. Therefore, the workshop, the presentations, and discussions that follow are considered a form of primary data collection. The content of the workshop may be used in a number of ways to achieve the goals of the European Climate and Health Cluster. This may include inclusion of content in future presentations, project reports, white papers, policy briefs, blogs and other cluster outputs. All published outputs will be available publicly, through open-source repositories.

All pre-published research materials produced as part of the workshop will be stored on the secure Climate and Health Cluster Sharepoint, only accessible by cluster personnel.

If you would like to withdraw consent at any stage, you can contact the Current Climate and Health Cluster Coordinator – Carla Maia - CarlaMaia@ihmt.unl.pt

WORKSHOP INFORMED CONSENT FORM

This form will be issued and signed in two copies, one for the participant and one for the project management files.

Terms of consent	Yes	No
I confirm that I have read the information sheet explaining the purpose of the cluster and workshop and have had the opportunity to ask questions about the project.		
I confirm that my participation is voluntary and consent to data collected from me to be used for a Climate and Health Cluster deliverable, which will be publicly available in open access repositories.		
I consent to the activity I participate in and understand any data will only be used for the Climate and Health Clusters sake.		
I consent to have the name of my organisation stated for this research.		
I consent to the project team contacting me, if required, as a follow-up to the research/engagement activity.		
I consent to project researchers' use of my anonymised responses OR		
I consent to the use of my name and responses in project deliverables.		
I consent that my picture is taken, and video recorded during the event (if applicable) and used for dissemination activities or others within the context of the project. Photographic, audio or video recordings may be used for the following purposes: • Conference presentations, educational presentations, or courses • Communication/dissemination purposes (e.g., social media posts, blogs, website) • Project presentations • Project reports, white papers, policy briefs, scientific articles		
If necessary, I consent to audio recording for future content analysis, exclusively by the project team and for the project purposes.		
I consent the project to register me to the cluster newsletter.		

Participant's name	
Organisation	
Climate-Health Project	
Signature	
Date: DD/MM/YYYY	

Annex 3: Agenda of First thematic workshop of the EU Climate-Health Cluster



Climate and Health Cluster Workshop on Numerical tools for climate, meteorological, and impact modelling and early warning systems (EWS)

Rationale:

First workshop for the Health Cluster, with the purpose of introducing projects and focusing on methods in particular.

Objectives:

- To share methods and research approaches within the Cluster with respect to predictive models and EWS
- To provide insights into potential synergies and opportunities for shared learning across projects within the Health Cluster.
- To identify key research gaps related to methods

Date: 21-02-2024

Time: 9:00-17:10 (CET)

Location: HaDEA (4th floor No 15 in COV A2). [Pl. Charles Rogier 16, 1210 Saint-Josse-ten-Noode](#)
Brussels, Belgium & Online

Online meeting link:

<https://econf.webex.com/econf/j.php?MTID=m7c0db69f70ff227e36fcebb29f5cfb86>

Format: Hybrid (up to 25 in person & up to 50 in total) - partners already in Brussels for the RTD meeting will attend in person and all other partners can attend remotely.

Welcome: **Dr. Stephane Hogan** - Head of Unit for Health Research at HaDEA

Discussion chairperson:

- Introduction: **Daniel San Martín**
- Session 1: Climate, meteorological, economy-wide and sector-specific models within the cluster: **Suzana Blesic**
- Session 2: Statistical and Artificial Intelligence: **Fredrik Wetterhall**
- Closing discussion: **Sergio Natal**

09:00 - Welcome(5m): Dr. Stephane Hogan - Head of Unit for Health Research at HaDEA

09:05 – 10:05 - Introduction (1:00h)

Introduction to the projects and methodologies – numerical approaches to climate and health modelling (10 min each project- 60 min)

Order of presentations:

- BlueAdapt
- CATALYSE
- CLIMOS
- HIGH Horizons
- IDAlert
- TRIGGER

10:05 – 10:35 - Coffee break (30 min) - @ HaDEA cafeteria (1st floor, in COV A1)

10:35 – 12:15- Session 1: Climate, meteorological, economy-wide and sector-specific models within the cluster (1:45h)

10 min explaining approaches within each project in the cluster with respect to numerical models

- what is the research question, application area
- what is the method, scale, data inputs

Discussion session 1- topic tbc e.g. what are key synergies, uncertainties across models

Specific topics to be discussed:

1. Terminology
2. Downscaling (numerical and statistical)
3. Data sources

Order of presentations:

- BlueAdapt
- CATALYSE
- CLIMOS
- HIGH Horizons
- IDAlert
- TRIGGER

Lunch (12:30-13:30) @ HaDEA cafeteria (1st floor, in COV A1)

13:30 – 15:30 - Session 2: Statistical and Artificial Intelligence (2h)

Please note: It is likely that projects will be at different stages, and therefore projects are invited to give an overview of their project's status with regard to AI deliverables. For this reason, the focus of this session is flexible, however some guidance is provided below.

10 min explaining where these approaches are used and how (not for the topics covered in session 1)

- what is the research question, application area
- what is the method, scale, data inputs

Discussion session 2- topic tbc e.g. what are key synergies, uncertainties across models

Suggested topics to be discussed:

1. Terminology
2. Validation and interpretability of models
3. Additional topics can be brought forward on the day, depending on project specific insights

Order of presentations:

- BlueAdapt
- CATALYSE
- CLIMOS
- HIGH Horizons
- IDAlert
- TRIGGER

15:30 – 16:00 - Coffee break: 30 min - @ HaDEA cafeteria (1st floor, in COV A1)

16:00 – 17:00 - Closing discussion (1h)

Identifying cross-cutting issues, synergies, research gaps and next steps

17:00 – 17:10 - Farewell and closing remarks (10 minutes)

