Strategic Plan for the BSC-CNS Earth Sciences Department (2015-2018)

# The New Earth Sciences Department of the BSC-CNS

The Department of Earth Sciences of the Barcelona Supercomputing Centre-Centro Nacional de Supercomputación (BSC-CNS), BSC-ES henceforth (bsc.es/earth-sciences), has developed since then into a reference department in the field of air quality and atmospheric composition modelling. The Climate Forecast Unit of the Institut Català de Ciències del Clima (IC3-CFU, http://ic3.cat/wikicfu/index.php/Main\_Page) was created in 2010 to evolve in a short time into one of the most active and well known groups performing research on climate prediction and services in Europe. The IC3-CFU was created and lead by Prof. Francisco J. Doblas-Reyes.

Following the designation of Prof. Francisco J. Doblas-Reyes as head of the BSC-ES, a process of merging the IC3-CFU into the BSC-ES has been requested by the BSC and by the trustees of the IC3, which is basically the Catalan Government. The Catalan Government provides some financial support to the IC3-CFU. The reason behind this merging is the aim to create a larger department with sufficient critical mass to compete with the best research groups in Earth system modelling in Europe. The new department is expected to start with at least 35 people, including technical and support staff, a new organisation and a strategic plan that will revised every two years.

The strategic plan of the BSC-ES will help the new group to have clear goals, identify the sources of funding, have an organic growth and foster the collaboration both within and outside the department. Making it public should also help attracting the much-needed young talent to contribute to its growth.

This working version of the strategic plan should receive the comments of four reviewers before being submitted to representatives of the Catalan Government to request additional funding to support the new structure of the Department. This funding is expected to at least ensure the continuous support of the four IC3-CFU positions already funded by the Government at IC3. The strategic plan will also be sent to the BSC Scientific Advisory Board, which meets in March 2015, so that they can also provide feedback on the expected near-future evolution of the Department.

# Objectives

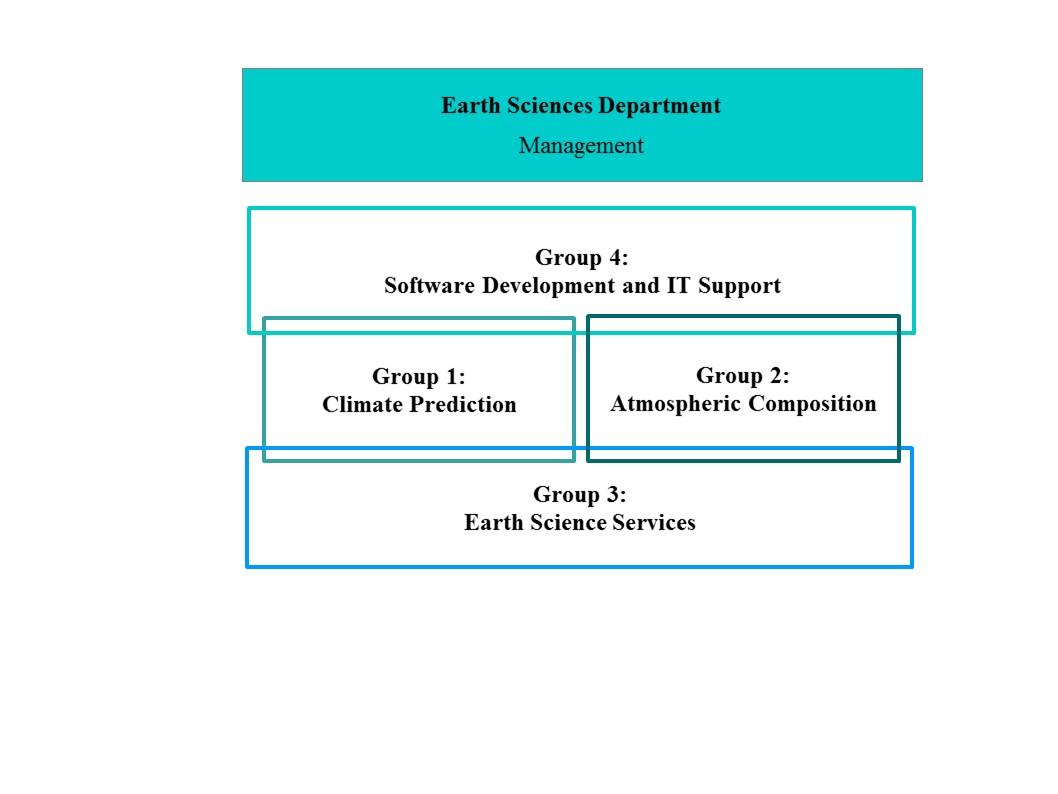
The goal of the BSC-ES is to apply the latest advances of high performance computing (HPC) and big data on Earth system modelling. The achievement of this goal aims at putting the department at the forefront of the emerging problem of environmental forecasting. This very broad and ambitious goal can be split into several more detailed aims:

* Develop a capability to include the modelling of atmospheric processes from urban to global scales, along with their impacts on weather, air quality, climate, health and ecosystems
* Implement the most efficient climate prediction system to cover time scales ranging from a month to a few decades (subseasonal-to-decadal climate prediction) at global and regional spatial scales, expanding at the same time our understanding of the climate system
* Research the impact of weather, atmospheric chemistry and climate on socio-economic sectors through the development of user-oriented services that ensure the transfer of the technology developed and the adaptation to a rapidly changing environment, especially of those highly vulnerable.
* Use cutting-edge HPC and big data technologies to increment the efficiency, portability and user-friendliness of the Earth system models developed and used, including the pre-processing and post-processing of weather, atmospheric chemistry and climate data.

# Structure

The BSC-ES is structured in four groups as illustrated in the diagram below. The department strategy includes a management layer made of the department director and the group leads that will ensure the consistency of the activities with the strategic plan and that will implement strategies to facilitate an adequate communication at all levels. This layer will facilitate the integration of the restructured department in the local and national research and services environment. The BSC-ES will make its best to play a role according to its size and resources, trying to respond to the requests of policy makers and society and supporting as much as possible the growth of a robust air quality and climate modelling Spanish community made of a set of research groups of varied characteristics. The management layer will also work towards increasing the visibility of the BSC-ES, becoming more active in the international research programme arena (GEOSS, WWRP, WCRP, Future Earth, etc).

The following table describes the main objectives and strategic goals of each one of these groups, which will be expanded in more detail in subsequent sections.



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| **Groups** | **Main objectives** | **Outline of strategic goals** |
| Climate prediction | 1.1 Development of climate prediction systems focused on sub-seasonal to decadal time scales  1.2 Exploitation of climate predictions to understand predictability mechanisms and forecast system limitations | 1.1.1 Development of climate prediction systems: improved model processes  1.1.2 Development of climate predictions systems: data assimilation and initialization  1.2.1 Forecast quality assessment: attribution and sources of predictability  1.2.2 Forecast quality assessment: diagnosis of climate forecast weaknesses |
| Atmospheric composition | 2.1 Development of modelling systems for atmospheric composition from local to global scales  2.2 Advanced research on atmospheric composition processes using modelling techniques and Earth observations | 2.1.1. Development and optimization of an online multiscale model by integrating emissions, meteorology and chemistry, from local to global scales  2.1.2. Development of modelling approaches targeting air quality in urban areas  2.2.1 Assessment of aerosol-radiation-cloud interactions and estimation of their effects on air quality, weather and climate  2.2.2 Source attribution and identification of the processes affecting air pollution over urban areas |
| Services | 3.1 Design of user-defined research to guide the fundamental science of the BSC-ES department  3.2 Development of user-interaction platforms to tailor and disseminate knowledge, tools and technology transfer  3.3 Maximisation of user and societal benefits via engagement, co-production and feedback from users to the provider | 3.1.1 Advance and tailor state-of-the-art models and data post-­processing for specific variables, timescales and resolutions, based on user-defined applications/impacts  3.2.1 Explore new data, visualisations and communication techniques to improve and stimulate use of current platforms, and develop new ones from prototypes to operational services  3.3.1 Provide guidance, training and marketing for established services to increase international visibility, and establish feedback mechanisms to evaluate their value to society and the economy |
| Software development and IT support | 4.1 Efficient use of the computational resources by the research groups  4.2 Development of HPC user-friendly software framework for Earth system modelling and the management of operational systems  4.3 Provision of data services  4.4 Guidance on the use of IT resources | 4.1.1 Provide HPC Services such as performance analysis, identification of bottlenecks and application of optimizations  4.1.2 Research on new computational methods to apply on Earth Sciences models  4.2.1 Support the development of atmospheric research software  4.2.2 Maintain and improve operational systems  4.3.1 Develop, manage and maintain a common data service framework  4.3.2 Deploy an infrastructure ready to overcome the Big Data challenge in Earth sciences  4.4.1 Design and maintain an IT infrastructure allowing the research teams the accomplishment of their objectives |

# Detailed Description of the Research Groups

## Climate prediction

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| **Strategic goals** | |
| The Climate Prediction Group aims at developing a climate prediction capability for time scales ranging from a few weeks to a few decades into the future (sub-seasonal to decadal climate prediction) and from regional to global scales. This objective relies on expanding our understanding of the climate processes through a deep analysis of the strengths and weaknesses of state-of-the-art climate forecast systems in comparison with the most up-to-date observational datasets, and on exploiting these detailed analyses to refine the representation of climate processes in our climate forecast systems and their initialization. We will contribute to near-operational climate prediction exercises: on decadal (<http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/decadal-fc>) and on seasonal (<http://www.arcus.org/search-program/seaiceoutlook>) time scales.  ***1.1.1 Development of climate prediction systems: toward more realistic model processes***   * Inclusion and/or testing of new model components (biogeochemistry, vegetation, aerosols, sea ice) or sub-grid cell parameterizations (ocean mixing, sea ice and snow cover surface scheme…) to account for additional potential predictability sources. * Tuning of sub-grid cell parameterisations to reduce the climate prediction drift and improve the prediction skill. * Generation of ground-breaking high resolution climate predictions and assessment of the added-value from such a resolution increase (from 0.25 down to 0.08 degrees for the ocean, 40 to 25 km for the atmosphere).   ***1.1.2 Development of climate prediction systems: data assimilation and initialisation***   * Use of a large set of ocean and atmospheric reanalyses (physical combination of observational data and model equations) and generation of in-house ensemble sea ice reconstructions to obtain a large variety of initial conditions (IC) for climate predictions to be compared in their merits and caveats * Comparison of the performance of various initialisation techniques (full-field and different variants of anomaly initialisation). * Assessment of the benefits of weakly coupled observational data assimilation (through nudging and Ensemble Kalman Filter) in obtaining initial conditions.   ***1.2.1 Forecast quality assessment: attribution and sources of predictability***   * Assessment of the performance of state-of-the-art climate forecasts using multifaceted forecast quality assessment in the presence of climate drift for a large range of variables (continental temperatures and precipitation, tropical cyclones, heat waves, ocean circulation, sea ice conditions …). * Production of sensitivity experiments (to new model components, initial conditions, radiative forcings, resolution) to highlight sources of skill (land surface and sea ice initialization, volcanic, natural and anthropogenic aerosols, snow cover ...) and estimate the contribution of these sources to the prediction skill * Detailed analysis of successful climate predictions for attribution purposes (extreme events, recent global warming hiatus, Arctic summer sea ice lows and Antarctic winter sea ice highs) and sensitivity experiments to highlight the causes for success.   ***1.2.2 Forecast quality assessment: diagnosis of climate forecast weaknesses***   * Investigation of the mechanisms leading to climate prediction drift and the relations between the drift and the prediction skill. * Investigation of the causes for particular missed climate events in forecasts. * Feedbacks toward climate forecast system development: information about the sources of model errors and suggestions of ways to improve the model quality | |
| **Resources** 2010-2014 | **Resources** 2015-2018 |
| **1.a.** Currentnumber of members: **9 = 8 early career scientists** (Virginie Guemas, Louis-Philippe Caron, Chloé Prodhomme, François Massonnet, Omar Bellprat, Martin Ménégoz, Eleftheria Exarchou, Neven Fuckar) **+ 1 PhD student** (Danila Volpi)  **1.b.** Core funding available: **2 early career scientists + 1 PhD student**  **1.c**. Total funding captured: **3,537,787 €**  **1.d.** Computing resources (in millions of core-hours per year): **~20** | **1.a.** Number of members required to achieve the objectives: **12 = 1 group leader + 8 early career scientists + 3 PhD student** (450,000 €/year, paid by the core funding and projects)  **1.b.** Core funding needed: **1 group leader, 2 early career scientists** and **1 PhD student** (160,000 €/year)  **1.c.** Total funding needed: 500,000 €/year (personnel + travel, publications, etc)  **1.d.** Computing resources (in million of core-hours per year): ~**50** to handle increases in model resolution and ensemble size |
| **Indicators** 2010-2014 | **Indicators** 2015-2018 |
| **1.e.** National/EU/international/private grants: 273,000 €/year awarded: **14** (**EU-FP7 projects:** CLIM-RUN, QWeCi, DENFREE, SPECS, PREFACE, EUCLEIA / **Marie-Curie fellowship:** INCLIDA / **ESA fellowship:** VERITAS / **MINECO projects:** RUCSS, PICA-ICE / **MINECO PhD grant** / **private RPI project** / **French ANR project:** MORDICUS)  **1.f.** National/EU/international/private grants submitted: **9** (**H2020:** PRIMAVERA, CHANCE, IMPREX / **Marie Curie fellowships:** Javier Garcia-Serrano and François Massonnet / **1 ESA CMUG proposals** / **MINECO projects:** RESPONS / **private Fundacion Biodiversidad:** HACE / **French ANR project:** POLARIS)  **1.g.** National and international collaborators: **20** (SMHI, KNMI, Météo-France, LOCEAN, Univ. Reading, Univ. Exeter, ECMWF, MPI, AWI, CPTEC, NOAA, CMCC, Complutense University of Madrid, CERFACS, MetOffice, UQAM, ENEA, UCL, Univ. Washington, NSIDC)  **1.h.** Peer-reviewed publications: **54 + 2 high-impact** (see full list at http://ic3.cat/wikicfu/index.php/Publications)  **1.i.** Other publications: **8** (see full list at http://ic3.cat/wikicfu/index.php/Publications) | **1.e.** National/EU/international/private grants required: ~15 to cover 6 early career scientists and 2 PhD students, i.e. **290,000 €/year** plus **50,000 €/year** for travel, publications, ...  **1.f.** New collaborators targeted: **3** (NERSC, INRIA, University of Bergen)  **1.g.** Peer-reviewed publications expected: **60** |
| **Commitments** 2010-2014 | **Commitments** 2015-2018 |
| **1.j.** Project deliverables  **1.k.** Contribution to the EC-Earth consortium via tuning of the model, provision of initial conditions, testing of new components or parameterisations | **1.h.** Project deliverables  **1.i.** Contribution to the EC-Earth consortium via tuning of the model, provision of initial conditions, testing of new components and/or parameterisations  **1.j.** Participation in steering groups of international panels such as WCRP core projects and working groups |

## Atmospheric composition

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| **Strategic goals** | |
| The Atmospheric Composition Group will keep developing an online chemical weather prediction system, the NMMB/BSC Chemical Transport Model (**NMMB/BSC-CTM**), whose unified non-hydrostatic core allows to consider problems involving from global to local scale processes including telescoping nesting capabilities. The group aims to develop the model for meso- and microscale air quality applications and global atmospheric chemistry studies. Furthermore, the group has established the **CALIOPE** air quality system (“CALIdad del aire Operacional Para España”) that provides short-term forecasts at high resolution over Europe and Spain, with a special focus over main Spanish urban areas, thanks to the in-house emission model **HERMESv2**.**0**. One of the priority tasks consists in maintaining and improving the CALIOPE systemthrough the integration of the NMMB/BSC-CTM model in the current operational system based on WRF and CMAQ and the extension of the HERMESv2.0 capabilities.  ***2.1.1 Development and optimization of an online multiscale atmospheric model by integrating emissions, meteorology and chemistry from local to global scales***   * Improvement of the mineral dust module through implementation of new emission schemes, parameterizations related to convective small-scale processes, and dust mineralogical composition. * Coupling of processes determining aerosolsʾ physical, chemical and optical properties with gas-phase chemistry in order to study aerosol-radiation-cloud interactions. * Development of an ensemble-based data assimilation system to improve model initial conditions, generate analysis products, and provide an estimation of uncertain model parameters through the integration of ground-based and satellite observations.   ***2.1.2 Development of modelling approaches targeting air quality in urban areas***   * Integration and evaluation the NMMB/BSC-CTM model into the CALIOPE system. * Enhancement of the HERMESv2.0 model through its expansion to the global scale, the implementation of new sources, pollutants and methodologies, the update of the activity data and the increase of the model flexibility to perform source apportionment studies. * Combination of air quality mesoscale simulation at street canyon models to accurately reproduce the fine details of dispersion of pollutants along streets in urban environment.   ***2.2.1 Assessment of aerosol-radiation-cloud interactions and estimation of their effects on air quality, weather and climate.***   * Study of the impact of aerosol-radiation-cloud interactions upon weather forecasts and regional climate, including sensitivity analysis to aerosol shape, chemical composition, size and optical properties, and the integration of Earth observations. * Quantify the contribution of small-scale dust storms (i.e. haboobs ) to the global and regional dust aerosol budget. * Assessment of the impact of aerosols (and in particular, mineral dust and black carbon) on human health and ecosystems in collaboration with experimental groups. * Perform regional mineral dust simulations to obtain climatological reference values describing the spatial and temporal (monthly, seasonal and annual) distribution of airborne dust both near the Earth’s surface and in upper levels.   ***2.2.2 Characterization of sources and processes affecting air pollution over urban areas.***   * Determination the origin of air pollution problems in terms of source attribution and/or areas by means of source apportionment and source sensitivity techniques. * Description of air pollution dynamics as a function of typical synoptic conditions over the Iberian Peninsula. * Assessment of the impact of air pollutants on human health over urban areas in collaboration with experimental groups. | |
| **Resources** 2010-2014 | **Resources** 2015-2018 |
| **2.a.** Current number of members: **12 = 5 researchers** (Oriol Jorba, Sara Basart, Marc Guevara, Enza Di Tomaso, Antonis Gkikas) + **5 PhD students** (Victor Valverde, Lorenzo Fileni, Lluís Vendrell, Vincenzo Obiso, Michele Spada) + **2 associates** (Maria Gonçalves, Maria Teresa Pay)  **2.b.** Core funding available to maintain this group: **3 =** **1 researcher** (Oriol Jorba) + **2 PhD students** (Michele Spada, Lorenzo Fileni) (120,000 €/year)  **2.c**. Total funding captured: **3,700,000 €**  **2.d.** Computing resources (in millions of core-hours per year): **2** | **2.a.** Number of members required to achieve the objectives: **15 = 1 group leader, 7 researchers, 6 PhD students, 1 associate** (480,000 €/year, paid by the core funding and projects)  **2.b.** Core funding needed: **1 group leader and 2 PhD students** (100,000 €/year)  **2.c.** Total funding neded: 550,000 €/year (personnel + travel, publications, consumables, etc)  **2.d.** Computing resources (in millions of core-hours per year): **20** |
| **Indicators** 2010-2014 | **Indicators** 2015-2018 |
| **2.e.** National/EU/international/private grants awarded: **20** (**EU-FP7 projects**: IS-ENES, IS-ENES2, APPRAISAL, FIELD\_AC, ACTRIS / **National projects**: Severo Ochoa, NMMB-gas, NMMB-aerosol, NMMB-radiative forcing, COVARIANCE, integrated action Portugal-Spain, CALIOPE, ATMOS, Consolider SyeC / **EU-Marie-Curie fellowship**: Antonis Gkikas / **National PhD grant**: Vincenzo Obiso / **Catalan projects:** AGAUR SGR (GReCT), MeteoCAT (ESCAT) / **Private grants**: IBERDROLA PhD grant (Victor Valverde), BSC-La Caixa PhD grant (Lluis Vendrell) )  **2.f.** National/EU/international/private grants submitted: **10** (**EU-LIFE project**: SAME / **EU-H2020**: ACTRIS2, NUC-DSS / **National project**: Sara Basart / **AXA grant**: Delia Arnold / **Catalan grant**: Maria Teresa Pay/ Clim-Dev Africa, **CONACYT project**: Mexico Regional Climate, Health impact assessment)  **2.g.** National and international collaborators: **38**  **2.h.** Peer-reviewed publications published in international journals: **54** (see full list at http://www.bsc.es/earth-sciences/publications-and-communications)  **2.i.** Other publications: **7** (see full list at http://www.bsc.es/earth-sciences/publications-and-communications) | **2.e.** National/EU/international/private grants required: enough to cover **450,000 €/year**  **2.f.** New collaborators targeted: **5** (CREAL, CSIC, NILU, University of Brescia, KIT, EM)  **2.g.** Peer-reviewed publications expected: 60 **+ 1 high-impact** |
| **Commitments** 2010-2014 | **Commitments** 2015-2018 |
| **2.j.** MoU with NOAA/NCEP/EMC on NMMB/BSC-CTM model developments  **2.k.** Participation in AQMEII-Phase2, HTAP/AQMEII-Phase3, COST Action ES1004 EuMetChem, EURODELTA III and Charmex  **2.l.** Participation FAIRMODE (4 WG) | **2.h.** MoU with NOAA/NCEP/EMC on NMMB/BSC-CTM model developments  **2.i.** Participation in FAIRMODE (4 WG) |

## Services

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| **Strategic goals** | |
| Knowledge and technology transfer, via tailored services, is essential to bridge the gap between science and its end users. Services are developed both in-house (weather forecasting, climate predictions, atmospheric composition) and via non-profit projects in collaboration with public administrations (e.g. the WMO Sant and Dust Storm Warning Advisory and Assessment System for North Africa, Middle Eas and Europe Regional Center, SDS-WAS NAMEE RC, and the Barcelona Dust Forecast Center, BDFC). This group will facilitate the interpretation and application of research coming from the BSC-ES to advance sustainable development in key sectors such as energy, urban development, infrastructure, transport, health and agriculture. The overall aim is to demonstrate an ongoing value of atmospheric composition, weather forecasting and climate prediction services to society and the economy. End users will remain at the centre of the process, to ensure that outcomes are both useful and usable, and this will affect the group activities by including:   * User-defined research, to advance and guide state-of-the-art research in the BSC-ES. * User-interaction platforms, to tailor and disseminate knowledge and technology. * Estimates of user and societal benefits, to establish feedback and evaluate the service value.   ***3.1 Design of user-defined research to guide the fundamental science of the BSC-ES department***  **3.1.1 Advance and tailor state-of-the-art models and data post­processing for specific variables, time scales and resolutions, based on user-defined applications/impacts**  Weather forecasting and climate prediction services will   * Evaluate renewable energy supply via wind power predictions over sub-seasonal to seasonal time scales with full post-processing of the outcome. * Extend to solar, hydro power and energy demand predictions over all timescales (weather and climate) using a multi-model approach; Extend predictions to risk and vulnerabilities; Translate knowledge into the agricultural sector (e.g. wine).   Atmospheric composition services will   * Implement multiscale modelling for air quality management and forecasting. * Adapt the most recent version of the BSC-ES air quality forecasting system for implementation abroad from global to local scales. * Implement micro-scale models (< 1km) to resolve problems in urban environments and better assess heavily trafficked hotspots with high hourly peak values. * Provide different indicators to better assess the impact of air quality on human health and ecosystem exposure. * Provide mineral dust forecasts for solar radiation management based on the developments implemented as part of the SDS-WAS NAMEE RC and BDFC. * Maintain the global alert system for sand and mineral dust storms for SDS-WAS NAMEE RC and BDFC to ensure the continuity of both centres. * Definition of an early warning system for dust storms based on pictograms and colour-coded maps.   ***3.2 Development of user-interaction platforms to tailor and disseminate knowledge, tools and technology transfer***  **3.2.1 Explore new data, visualisations and communication techniques to improve and stimulate use of current platforms, and develop new ones from prototypes to operational services**  Weather forecasting and climate prediction services will   * Perform a full evaluation of the visualisation of renewable energy supply using wind power predictions over sub-seasonal to seasonal timescales for individual forecast systems. A collaboration with end users whose decisions are influenced by wind power supply and with data visualizers will be started to develop a decision support tool prototype. * Develop a prototype of climate service and transform it into an operational service with an initial focus on the wind power sector, but with a sufficient flexibility to extend scope. * Training to further user understanding of climate predictions, and in particular the interpretation of the concepts of reliability, skill and probabilistic predictions inherent to climate forecasts.   Atmospheric composition services will   * Maintain and improve the current platforms that provide air quality services: the CALIOPE air quality forecast system disseminated via the web and Apps for tablets and smart phones. * Provide short term mitigation plans and warnings in forecast mode to relevant institutions. * Provide emission datasets for Spain to be used by air quality modellers based on the HERMES model. * Explore data visualization and communication to adapt to the needs of energy industries, infrastructure and agriculture sectors. * Contribute to an integrated tool for airlines and flight operators to prevent and mitigate the impact of aerosols (e.g. mineral dust over deserts) in flights. * Maintain and continue the dissemination of the global alert system for sand and mineral dust storms based on the SDS-WAS NAMEE RC and BDFC.   ***3.3 Maximisation of user and societal benefits via engagement, co-production and feedback from users to the provider***  **3.3.1 Provide guidance, training and marketing for established services to increase international visibility, and establish feedback mechanisms to evaluate their value to society and the economy**  Weather forecasting and climate prediction services will   * Establish feedback mechanisms between the energy sector user and the provider to assess the value of the climate predictions issued. * Provide guidance information and training to the energy sector on the use of energy supply and climate demand predictions in their decisions. * Ensure adequate co-production of the climate predictions service between users (primarily energy managers such as EDF and consultancies such as Vortex) and providers (primarily BSC-ES) throughout the development process. * Extend energy-related user groups and develop more advanced feedback mechanisms, such as professional workshops, online tools, co-designed projects/initiatives, etc.   Atmospheric composition services will   * Provide guidance on air quality and mineral dust management to public administrations and companies (e.g. for road transport and industrial emissions). * Explore the needs of users in order to implement integrated modelling systems for human health and ecosystem assessments. * Explore user needs to develop extended versions of the CALIOPE platforms. * Establish feedback mechanisms with energy companies, met offices, universities and research centres. * Provide guidance on mineral dust mitigation to public administrations and companies. * Promote transfer of knowledge in the framework of the SDS-WAS NAMEE RC such as trainings and workshops to provide information about the mineral dust services. | |
| **Resources**  2010-2014 | **Resources** 2015-2018 |
| **3.a.** Current number of members: **8** (2 Phd, Verónica Torralba, Aida Pinto; 2 services managers, Melanie Davis and Albert Soret; 1 Junior postdoc, Nube González; 3 researchers, Gustavo Arévalo, Valentina Sicardi, Enric Terradellas, who is associated from AEMET).  **3.b.** Core funding available to maintain this group: **3** **1 PhD student + 1 service manager + 1 senior postdoc + 1 junior postdoc** (145,000 €/year)  **3.c**. Total funding captured: 600,000 €  **3.d.** Computing resources (in millions of core-hours per year): **4** for the operational CALIOPE and NMMB/BSC-Dust forecast and real-time decadal predictions | **3.a.** Number of members required to achieve the objectives: **17 = 1 technical manager + 2 services managers + 1 communication and marketing support officer + 2 researchers + 6 junior postdocs + 2 PhD students + 1 associate from AEMET**  **3.b.** Core funding needed: 2 service managers, 2 senior postdocs, 1 PhD student (190,000 €/year), with an in-kind contribution from AEMET of 50,000 €/year  **3.c.** Total funding needed: 600,000 €/year  **3.d.** Computing resources (in million of core-hours per year): **15** to support the increase in resolution in all systems |
| **Indicators** 2010-2014 | **Indicators** 2015-2018 |
| **3.e.** National/EU/international/private grants awarded: **33** (**EU-FP7 projects**: CLIM-RUN, EUPORIAS, SPECS, NEWA / **MINECO projects**: RESILIENCE / AGAUR grant: ARECS / **Private**: KFC, Climate KIC / **Institutional**: AEMET-BSC WMO dust center agreement in phases / **Private companies**: 23 contracts  **3.f.** National/EU/international/private grants submitted: **6** (**H2020**: PRIMAVERA, IMPREX, STOMP / **Private**: Asian Development Bank, BBVA, AQFS-Mexico); funding pending 1,128,110 €  **3.g.** Academic/private collaborators/networks: 57 **Academic**: SMHI, KNMI, Meteo-France, CMCC, ENEA, Met Office, CENER, DTU, Forwind, MeteoSwiss, Leeds University, Oxford University, PIK, DHMZ, ADB, APCC / **Networks**: EERA, European Energy Research Alliance, ECSP, (European) Climate Service Partnership, EU COST-WIRE project, CSP, ICEM, International Conference for Energy Meteorology / **Private**: Vortex, EDF, AWS Truewind, E.ON, Natural Power, EWEA, European Wind Energy Association  **3.h.** Peer-reviewed publications: **4**  **3.i.** Other publications: **2** | **3.e.** National/EU/international/private grants required: ~12 projects plus substantial private funding from service users to cover the non-core positions, i.e. ~400,000 €/year  **3.f.** New collaborators/networks/service users targeted: **13** (EDF trading, Fahrenheit Insurance, Iberdrola, Endesa, 3 Tier, Accenture Insurance, GE, GLGH, DTU, NERC, IBM; Networks: TP Wind, GWEA)  **3.g.** Peer-reviewed publications expected: **20**  **3.h.** New services: weather and atmospheric composition forecasting and climate predictions for energy, atmospheric forecast for airlines and flight management |
| **Commitments** 2010-2014 | **Commitments** 2015-2018 |
| **3.k.** Project deliverables  **3.l.** For SDS-WAS NAMEE RC: HPC Access for daily operational dust forecasts and an updated dust model, 4 people involved (2 BSC + 2 AEMET)  **3.m.** For BDFC: daily high-resolution dust predictions.  **3.n.** Daily global aerosol predictions for International Cooperative for Aerosol Prediction. | **3.i.** Project deliverables  **3.j.** Continuation of previous commitments  **3.k.** Service provision and support for end users |

## Software development and IT support

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| **Strategic goals** | |
| The Software Development and IT Support Group is a multidisciplinary team with different IT profiles that interacts closely with all the other groups of the Department. The group has among its tasks providing help and guidance to the scientist with the technical of their work and developing a framework for the most efficient use of HPC resources. In order to improve the use of the variety of computing resources available at the BSC and in other HPC institutions, a solid software development, profiling and optimisation area will be created to provide feedback to Earth system modellers around Europe on how to improve their codes in the career towards exascale computing. Last but not least, the development of a framework to disseminate the outputs generated in the BSC-ES among the research and services community will be pursued. This area will take advantage of the unique environment of the BSC where research in Big Data is becoming a priority.  **4.1.1 Provide HPC Services such as performance analysis, identification of bottlenecks and application of optimizations**   * Collaborate with other BSC departments, especially Computer Sciences, to use state-of-the-art programming models and profiling tools to prepare the next generation of Earth sciences models for developing exascale HPC systems.   **4.1.2 Research on new computational methods to apply on Earth Sciences models**   * Collaborate with external Earth system modelling teams to implement and test new computational methods that allow the use of new platforms such as heterogeneous architectures.   **4.2.1 Support the development of atmospheric research software and contribute to its maintenance**   * Interact with model developers and HPC support teams to develop and deploy a software stack to run generic Earth system models on a wide range of HPC facilities.   **4.2.2 Maintain and improve operational systems**   * Collaborate with the other three groups to satisfy their needs for the development and efficient running, including the design of appropriate workflows, of the BSC-ES operational air quality, weather and climate forecast systems.   **4.3.1 Develop, manage and maintain a common data service framework**   * Develop, manage and maintain a common data service framework to collect, standardize and distribute any type of data to both internal and external users of the research and services community. * Implement locally and contribute to the development of international standards for data storage and exchange, with special interest in data in NetCDF and GRIB formats.   **4.3.2 Deploy an infrastructure ready to overcome the Big Data challenge in Earth sciences**   * Improve the capability for processing Big Data volumes for the analysis of Earth system simulations. * Improve the outcome to society of user-friendly data visualization products * Study new approaches to address the I/O challenges of the new generation of high-resolution, highly parallelized Earth system models.   **4.4.1 Design and maintain an IT infrastructure allowing the research teams the accomplishment of their objectives**   * Maintain an IT infrastructure that ensures an efficient working environment for the development of the BSC-ES research and services, including the provision of sufficient storage to reduce this specific vulnerability of the department. * Provide and guide the department groups to use a collaborative framework and good coding practices (code version control, testing suites, style guides) to improve the work efficiency, the integration of newcomers and the sharing of the tools. * Develop and ensure a continuous training to IT members and earth sciences users to use resources in the most efficient way. | |
| **Resources** 2010-2014 | **Resources** 2015-2018 |
| **4.a.** Currentnumber of members: **12.5 =** **8.5** (Muhammad Asif, Francesco Benincasa, Pierre-Antoine Bretonnière, David Carrió, Miguel Castrillo, Oriol Mula-Valls, Domingo Manubens, Nicolau Manubens (part time), Kim Serradell) + **1 postdoc** (Georgios Markomanolis) + **1 PhD student** (Oriol Tintó) + **2 students** (Carles Carmona, Xavier Yepes)  **4.b.** Core funding available to maintain this group: **2 engineers** (80,000 €/year)  **4.c**. Total funding captured: **400,000 €**  **4.d.** Computing resources (in millions of core-hours per year): **1** | **4.a.** Number of members required to achieve the objectives: **15** (7 engineers, 4 postdocs, 4 PhD students)  **4.b.** Core funding needed: **4 engineers** (160,000 €/year)  **4.c.** Total funding needed: 600,000 €/year (personnel + travel + infrastructure)  **4.d.** Computing resources (in million of core-hours per year): ~**1** |
| **Indicators** 2010-2014 | **Indicators** 2015-2018 |
| **4.e.** National/EU/international/private grants awarded: **2** (**FP7 projects:** IS-ENES, IS-ENES2)  **4.f.** National/EU/international/private grants submitted: **3** (**H2020 projects:** CHANCE, ADVITAM, ESiWACE)  **4.g.** National and international collaborators: **2** (Meteo-France, Univ. Barcelona)  **4.h.** Number of releases of software versions: **7** (5 Autosubmit and 2 s2dverification) | **4.e.** National/EU/international/private grants needed to maintain the group: **8**  **4.f.** New collaborators targeted: **10**  **4.g.** Number of external users of software developed in the group: **25** |
| **Commitments** 2010-2014 | **Commitments** 2015-2018 |
| **4.i.** User support both internally and externally (s2dverification, Autosubmit)  **4.j.** Maintenance of an operational dust data modelling catalogue | **4.h.** User support both internally and externally (s2dverification, Autosubmit)  **4.i.** Maintenance of an operational dust and air quality modelling catalogue  **4.m.** Dissemination of Earth system data |