Consiglio Nazionale delle Ricerche

NextData
un sistema nazionale per la raccolta, conservazione, accessibilità e diffusione dei dati ambientali e climatici in aree montane e marine

Project of Interest "NextData"

Research project :

Development of ensembles of regional of regional climate change scenarios, with focus on variability, extremes and uncertainties in areas of complex topography, RECCO (REgional Climate in Complex Orography)

Coordination: Silvia Trini Castelli

CNR- Istituto di Scienze dell'Atmosfera e del Clima (ISAC)

Work Pachage :
WP 1; WP 2; WP3; WP4

TITLE OF THE PROPOSED PROJECT:
Development of ensembles of regional climate change scenarios, with focus on variability, extremes and uncertainties in areas of complex topography, RECCO (REgional Climate in Complex Orography).

Project duration: 2013-2015
start date (in the first semester 2013): 1 May 2013
end date (in the second semester 2015, no later than 30 September 2015): 30 September 2015

Scientific coordinator of the proposed project:
Silvia Trini Castelli

CNR Institute coordinating the proposed project:
Institute of Atmospheric Sciences and Climate - ISAC

Participating units :

Unit 1 : Institute of Atmospheric Sciences and Climate (ISAC) - Silvia Trini Castelli and Antonio Parodi.
Unit 2 : Abdus Salam International Centre for Theoretical Physics (ICTP) - Filippo Giorgi.
Unit 3 : Cineca - Giovanni Erbacci.
Unit 4 : Institute of Methodologies for Environmental Analysis (IMAA) - Fabio Madonna.

Unit 1 (CNR coordinating Institute):
Institute of Atmospheric Sciences and Climate (ISAC)
Scientific Responsible: Silvia Trini Castelli and Antonio Parodi

ISAC-CNR (Unit of Torino) has a consolidated and internationally recognized experience in the frame of atmospheric circulation modelling at scales from the meso down to the local and microscales. A specific expertise has been acquired for the meteorological simulation in very complex and heterogeneous terrain, like the Italian Alpine areas, South America (Brazil) and Japan. ISAC also contributed to develop turbulence parameterization schemes, which were implemented in RAMS atmospheric model, in order to improve the performances of the model simulation in highly complex topography.
Also available is a consolidated expertise in the statistical analysis of extreme events and in the the study of the main sources of uncertainty in high resolution numerical modelling (with WRF model) of deep moist convective processes over complex topography areas. One of the members of the unit is also coordinator of three FP7 projects involving the use of HPC and grid computing for hydro-meteorology and climate change related research.

Unit 2:
Abdus Salam International Centre for Theoretical Physics (ICTP)
Scientific Responsible: Filippo Giorgi

ICTP has a consolidated and worldwide recognized expertise in the development and application of Regional Climate Models, and in regional climate change and uncertainties, with Giorgi being a leading international expert in the field. RegCM is the main Italian regional climate model and has one of the largest community of users Worldwide. ICTP has a unique expertise in conducting large ensembles of regional climate model scenarios and Giorgi is involved in a leadership role in major international programs, such as the COordinated Regional Downscaling Experiment (CORDEX), which would provide a strong international context for NextData.

Unit 3:
Cineca
Scientific Responsible: Giovanni Erbacci

CINECA is the Italian reference supercomputing center and it offers to all academicals and research institutions access to supercomputing facilities and data storage services. In particular, CINECA is equipped with a top 10 Tier0 class, supercomputer FERMI and is involved in national and international projects in High Performance Computing (PRACE, EUDAT among the others), training and user support. CINECA is also involved in Earth and Climate projects arising the use of state-of-the-art numerical models in national and international framework.

Unit 4:
Institute of Methodologies for Environmental Analysis (IMAA)
Scientific Responsible: Fabio Madonna

IMAA is an institute worldwide recognized for the study of atmosphere using ground based and satellite remote sensing data. IMAA has the coordination of European infrastructure research projects (e.g ACTRIS) and has strongly contributed to the design of the data processing of IASI mission. IMAA runs an atmospheric observatory equipped with the state-of-art instruments for the profiling of aerosol and clouds. IMAA is also equipped with a system for LEO and GEO satellite acquisition and data processing. In the frame of ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure Network) FP7 research project, IMAA is also involved in the evaluation and improvement of the main European mesoscale weather models made available by Cloudnet.

1. GENERAL INFORMATION

Abstract of the proposed project

The project is aimed at improving the physical understanding of the changes in climatological regimes over the NextData regions of interest, with the support of their meteorological characterization. The variability and uncertainties of climate and meteorology of the interest areas (Hindu-Kush Karakorum, Alps and Mediterranean region) will be studied with a suite of regional climate models (RCMs) integrated with mesoscale meteorological models. Each modelling system will be used at different spatial scales, from regional to local, yielding a unique multi-scale modelling framework. The ICTP RegCM will produce ensembles of regional scenarios using different model configurations, resolutions, driving GCMs and greenhouse gas scenarios, which will allow a characterization of different sources of uncertainty. The WRF model will allow dynamical downscaling at the mesoscale of scenarios provided by the EC-EARTH global model. These will be compared with and integrate the ICTP RegCM ensemble. A comparison with Cloudnet mesoscale models will be also performed. RAMS will be used to perform high-resolution (cloud-resolving) simulations for specific complex topography areas to investigate relevant physical and dynamical processes. The results will be evaluated using available observations and released to the NextData databank.

Main goals of the project

An uncertainty analysis of climate scenarios will be attained through the completion of an ensemble of simulations with the ICTP RegCM. Emphasis will be on changes in climate variability, hydroclimatic regimes and extremes, and on the characterization of primary sources of uncertainty in the scenarios. This is an essential aspect for the application of the results to impact assessment studies.

A more in-depth analysis of changes in variability and extreme events, such as flood, drought, and heat waves, will be attained through the completion with the WRF model of mesoscale dynamical downscaling of emission scenarios produced with the EC-Earth global model. The focus will be on events that are the most important in determining impacts on a wide variety of sectors in environmental and health protection.

An identification and thorough analysis of critical issues related to the simulation of physical processes in very complex orography settings will be attained through high-resolution simulations with the RAMS model over the mountainous areas of the Hindu-Kush Karakorum and Italian Alps and Apennines. This goal will be achieved

on the basis of a sensitivity analysis of the model performance versus observed data. Benchmark scenarios to provide reference case studies will be delivered.

The end deliverable of the project is the inclusion of the output from these scenarios and meteorological simulations into the NextData data repository, following the NextData data format, and therefore making them available to the scientific community.

Expected results of the project

The project will result in an unprecedented set of regional climate model simulations for the Alpine and Mediterranean regions, Hindu-Kush Karakorum, and possibly other areas of interest, obtained using a chain of modelling systems operating at different scales.

The main expected results are summarized hereafter.

- Completion of an ensemble of 21st century transient scenario simulations for the Hindu-Kush Karakorum, Mediterranean (including the Alps) and possibly other regions of interest, with the ICTP RegCM with different model configurations, resolutions, greenhouse gas (GHG) scenarios and driving global models. Estimation and characterizations of the uncertainties through the analysis of the experiment ensemble.

- Completion of mesoscale dynamical downscaling of EC-EARTH future emission scenarios with the WRF model at mesoscale resolutions, for selected ten-year time-slices. Estimation and characterization of changes in variability and extreme events, such as flood, drought, and heat waves.

- Completion of high-resolution (cloud-resolving, order 1 km) simulations with the RAMS model over some specific areas of interest in the Italian Alpine and Hindu-Kush Karakorum regions, chosen on the basis of availability of observations or WRF output. Evaluation of the critical meteorological and climatic issues related to the high orographic complexity of the area.

- Delivery of the simulation database to the NextData archive. The outputs obtained from the scenario runs in regional ensemble mode (ICTP RegCM), mesoscale (WRF) and targeted high-resolution runs (RAMS) will be made available for the vulnerability, impact and adaptation (VIA) research communities operating in various sectors, such as water resources, ecosystem services, food security, health, energy, and so on.

This project will contribute to strengthen considerably the NextData data archive, making it an invaluable source of climate data for VIA studies. Furthermore, results of the comparison between the simulations at the different scales and observations will be archived and released as a contribution to the NextData repository and as benchmark studies for the model validation in highly complex topography in support of observational net planning.

Role of the different units

Unit 1:
ISAC-CNR will perform WRF and RAMS meso- to local-scale simulations.
WRF dynamical downscaling of EC-EARTH emission scenarios for different times-slices in the future will be produced. The reference WRF model configuration will be identified with a set of control runs for the period 1996-2005 using both ERA-Interim global and EC-Earth datasets.
RAMS high-resolution simulations will be produced for the area of the Hindu-Kush Karakorum. Runs in the Italian Alps will focus on the assessment of physical and numerical aspects related to the complexity of the topography and atmospheric circulation. RAMS and WRF simulations will be analysed and compared also to observations, the outputs and the data analysis will be delivered to the NextData archive.

Unit 2:
ICTP will carry out and analyse ensembles of regional simulations using the model RegCM in its latest version RegCM4 over all interest areas. The model will be run following the CORDEX domain specifications, i.e. using 50 km grid spacing over large domains. This will allow the completion of a large ensemble of simulations with different model configurations, driving GCMs and GHG scenarios, estimated to be of the order of several tens of 21st century runs (1970-2100), which will allow an exploration of different sources of uncertainty. High-resolution (10-20 km) time-slice scenario simulations will also be performed over the Mediterranean region. The model output will be delivered to the NextData archive.

Unit 3:
CINECA will provide access to its supercomputing facilities (FERMI among the others, equipped with 163840 cores) to Units 1 and 2 of the project. The access will be realized using standard channels (ISCRA calls and CINECA user support) together with a fixed amount of core hours devoted to the project simulations. CINECA SCAI group will give support for the compilation, linking and setup of numerical models onto CINECA HPC architectures and a first-aid assistance for the construction of a workflow of the entire simulation process. Limited assistance will be due for application-specific problems and performance bottlenecks.

Unit 4:
IMAA-CNR will provide in-situ data, and when required ground based and satellite remote sensing observations, to cross-check the outcome of the modelling activities. The output of weather hydrostatic mesoscale models will be made available for comparison with the WRF output. IMAA remote sensing data and in-situ data used for the model evaluation activities will be made available on the NextData archive.

2. DETAILED PROJECT DESCRIPTION

State of the art and motivations

Changes in climate variability and extremes, from droughts to intense precipitation events, can have an enormous impact in terms of hydrogeological risk, availability of water resources, human health, food security and ecosystem conservation (e.g. [1]). The frequency and intensity of extreme hydroclimatic events, such as flood and droughts, is expected to increase with global warming (e.g [1]), however key challenges in understanding hydroclimatic changes are represented by the improvement of the modelling of severe hydro-climatic events, particularly in complex terrains, and by a robust characterization of uncertainties in climate scenarios. This requires on the one hand high spatial and temporal resolution and, on the other, large ensembles of experiments. One approach to achieve both these goals is to run ensembles of regional climate model (RCM) simulations over specific areas of interest driven by different Global Climate Models (GCMs) and greenhouse gas (GHG) concentration scenarios along with very high resolution mesoscale simulations in complex terrains. Such approach meets the strategy elaborated by the World Modelling Summit for Climate Prediction [2] to improve climate prediction, the leading idea being that climate and weather are a seamless problem, and the use of numerical weather forecasting methods can help us to quantify and reduce uncertainty in climate projections [3].
Of specific interest for the NextData Project, mountain regions are considered as "sentinels of change" in terms of both climate response and related impacts, therefore it is crucial to perform meteorological and long term climate simulations that can be accurate enough to correctly represent the atmospheric and environmental processes in complex topography settings. Our multi-scale regional modelling approach thus offers an optimal framework to investigate hydroclimatic changes in mountain environments. Ensembles of RCM simulations at intermediate resolution (e.g. RegCM4 at 20-50 km grid interval) can be used to identify the effects of mountain systems on the regional scale change signals and characterize related uncertainty sources. Mesoscale and cloud resolving models, driven by global meteorological fields (such as ECMWF and NCEP analyses or different GCMs), representing the synoptic-scale influence, and run at very high resolutions (from 10 down to 1 km), can then be used to simulate the influence of topography on flow fields, such as

valley and slope winds. Compared to previous projects (e.g. PRUDENCE and ENSEMBLES) which employed ensembles of RCMs run at a single resolution, our multi-scale model approach can provide the basis for a much more detailed analysis and in depth understanding of relevant processes and feedbacks.

Foreseen Contribution of the proposed research. The research proposed here will contribute to improve long term hydroclimate projections by (1) characterizing the uncertainties in climate scenarios; (2) improving the physical understanding of processes in very complex and heterogeneous regions; (3) providing reference databases of simulations to the NextData archive for further elaboration and investigation (ref. NextData WP2.5); (4) integrating the observational activities underway in NextData (ref. WP1.1 and WP1.2) with the data from the simulations and with available long-term observations in the areas of interest; (5) identifying new infrastructure or new possible measuring sites on the basis of ad-hoc assessment studies (ref. WP1.1)
We will focus mainly on two regions where significant impacts of climate change are expected and where modeling is particularly challenging due to the formation of intense and complex meteorological structures or to rich and complex topography:

1) The Hindu-Kush-Karakorum – Himalaya range (HKKH), with a focus on changes in winter precipitation over the western Himalayas and Karakorum associated with the passage of western weather patterns, as well as changes in summer monsoon precipitation. This region is exceptionally exposed to future impacts of climate change, also due to the presence of numerous glaciers which feed rivers and sustain water resources for almost a billion people [4,5]. It is also a region where GCMs have traditionally had difficulties in accurately reproducing regional climate patterns, so that a significant understanding of underpinning problems can be achieved through the use of RCMs and mesoscale models.

2) High-altitude zones in Italy, in both the Alps and Apennines, and the Mediterranean area at large, with a focus on severe hydro-meteorological phenomena over complex topography. This region represents another 'hot-spot' of climate change [6]. It is located at the interface between the African deserts and the Alpine range, it is characterized by complex orography and it is exposed to the influx of cyclonic activity from the Atlantic and to local cyclogenetic processes [7]. Historical data show recent changes in the frequency and intensity of precipitation events, with a shift towards a hotter and dryer climate characterized by episodes of increasingly intense precipitation. The assessment of similar changes in future climate scenarios is paramount to evaluate impacts on the delicate Mediterranean and Alpine ecosystems and on a region characterized by an already great exposure to hydrogeological risks.

During the course of the research, other sensitive mountainous regions in South America and Africa might be considered.

Proposed methodology. Based on the previous considerations, this project adopts a multi scale, multi model approach, starting from regional scale RCMs and downscaling to very fine scale mesoscale models. The overarching goal of the project is to characterize, and improve the physical understanding of the changes in the hydroclimatological regimes of these regions forced by increased 21st century GHG concentrations, from the regional to the local scale. This is achieved through the use of a set of different regional modelling suites, RegCM, WRF and RAMS, driven by different GCMs (e.g. EC-Earth, HadGEM, MPI-ESM, GFDL).
Output from different global model simulations, or from downscaled regional simulations, will be used to drive the RCMs, thereby providing an ensemble required for uncertainty analysis. The RegCM modelling system driven by different GCMs will be used to produce ensembles of climate simulations at the regional scale. The WRF non-hydrostatic model will be driven by the outputs of EC-Earth for dynamical dowscaling at the mesoscale. RAMS will then be used at cloud resolving scales as a numerical tool for the investigation of the physical and dynamical processes in the areas under consideration. The availability of long records of surface observations and satellite data in the Mediterranean area will be an original contribution and an additional value of the project.

The research already pursued in this field by the proponents, the expertise acquired and the results obtained from previous work in several areas or relevance, briefly cited in the following section and supported by the referenced publications (among others), constitute a solid basis to guarantee the feasibility of the project work.

Detailed description of the project, including the work plan, deliverables and milestones (explicitly indicating the activities of the different years)

WP1 RegCM modelling activities
The ICTP will utilize the latest version of the regional modelling system RegCM (RegCM4, [8]) to carry out and analyze an ensemble of 21st century simulations over domains covering the regions of interest mentioned above. Each domain will follow the CORDEX specifications, i.e. a grid spacing of 50 km over a large domain encompassing the interest region. For each region multiple model configurations (i.e. multiple physics options), multiple GCMs and multiple GHG concentration scenarios will be run and analysed. The driving GCM fields will be obtained from the recently completed CMIP5 (Coupled Modeling Intercomparison Project 5) ensemble of global model simulations. Additional high resolution time-slice simulations (10-25 km grid spacing) will be performed over the Mediterranean area and possibly over sub-regions of the Hindu-Kush Karakorum. The analysis will include the evaluation of the model performance in reproducing present day climate statistics and the assessment of GHG induced changes, with focus on hydroclimatic variability and regimes, extremes and underlying sources of uncertainty. These activities build upon and continue current work performed under the first year of NextData. Data from the

GAW-WMO global network (WP1.2) will be used to complement available global and regional datasets (e.g. CRU, UDEL, APRHODITE, TRMM, APCP) in the model analysis. Specifically, the activities carried out will be:

Months 1-8 (05/2013 – 12/2013): Completion of the analysis of the runs already carried out during the first year of NextData, consisting of 14 scenario runs for the Mediterranean domain (2 GCMs, 2 scenarios, 7 model configurations), 6 scenario runs for the South America and central American domains (2 GCMs, 2 RegCM configurations, 2 scenarios), and 5 scenario runs for the South Asia domain (2 GCMs, 2 RegCM configurations, 2 scenarios). Each scenario simulation extends from 1970 to 2100. The activities also include the completion of a high-resolution simulation (1970-2050) over the Mediterranean region. Relevant data will be then transferred to the NextData archive.

Deliverable: Data transferred and analysis completed (M8).
D1.1. Report describing the data transferred to the NextData Archive;
D1.2. Report summarizing the main findings from the analysis of the available simulations. In addition, eventual publications deriving from this work will be attached.

Months 9-20 (01/2014 – 12/2014): Completion of additional simulations (more GCMs, more model configurations) for the Mediterranean and South Asia domains, possibly complemented by additional runs for the South America, Central America and Africa domains. The set of new simulations will be discussed within the NextData consortium and finalized by the end of M8.

Deliverable Completion of additional simulations (M20).
D1.3: Report describing the additional simulations completed and eventual results from a preliminary analysis of these experiments.

Months 21-29 (01/2015 – 09/2015); Analysis of additional simulations completed as part of D1.3 and transfer to the NextData archive following the NextData protocol.

Deliverable: Analysis and transfer completed (M29).
D1.4. Report describing the new data transferred to the NextData Archive;
D1.5. Report summarizing the main findings from the analysis of the new simulations. In addition, eventual publications deriving from this work will be attached.

WP2 WRF modelling activities

The Weather Research and Forecasting (WRF) Model is a next-generation mesoscale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs. WRF is suitable for a broad spectrum of applications across scales ranging from meters to thousands of kilometres.

WRF has been widely used by the proposing group for hydro-meteorological research applications [9, 10,11].

RCP 4.5 emission scenario produced with the EC-Earth climate model will be downscaled using WRF model to characterize changes in the amplitude of the probability distribution of precipitation intensities, of the length of dry periods and of the duration of precipitation events. The data produced by the project will be useful also for following climate impact studies in the focus areas, providing a high resolution climatology for a full set of atmospheric variables.

The proposed choice of numerical domains is summarized hereafter. We will focus on two different study regions simulated at 0.11 degree resolution: the EURO-CORDEX domain, and the South Asia CORDEX domain. Two second-level, convection-permitting resolution nested domains will resolve the Great Alpine area, and Hindu Kush – Karakorum - Himalaya (HKKH) area, respectively, at 0.04 degree resolution. This project will require to perform control runs, forced by ERA-Interim re-analysis and EC-Earth climate model, and 2 scenario time-slices (in the RCP 4.5 emission scenario produced with the EC-Earth climate model), all for 10 model years each, on the domain grids specified above.

Months 1-12 (05/2013 – 04/2014): Preliminary test runs will be performed to find a reference configuration, using only the 0.11 degree resolution domain, both for the EURO-CORDEX domain, and the South Asia CORDEX domain. The control runs for the period 1996-2005 using ERA-Interim reanalysis and using the historic EC-Earth control run will be produced for both areas using 0.11 and 0.04 domains. Evaluation and analysis of the control runs will be undertaken.

Deliverable: Preliminary tests and control runs (M12).

D2.1. A report on the analysis of the preliminary simulations will be delivered, with illustrative examples, identifying the critical issues related to simulations in the two study regions. The outputs from the simulations will be elaborated and stored in archives, then made available for the intercomparison foreseen in WP4 activity.

Months 13-24 (05/2014 – 04/2015): The scenario simulations (RCP 4.5) will be run for the timeslices 2041-2050 and 2071-2080. The set of simulations will be discussed within the NextData consortium and the first part of analysis performed.

Deliverable: Future emission scenarios runs (M24)

D2.2. The outputs from the simulations will be elaborated and stored in archives, then made available for the intercomparison foreseen in WP4 activity. A preliminary report on the scenarios simulations will be produced.

Months 25-29 (05/2015- 09/2015)

The second part of the analysis will be performed and the modelling output will be delivered to the NextData database.

Deliverable: Analysis and transfer completed (M29).

D2.3. The conclusive analysis of the work performed will be included in the comprehensive report (see Deliverable *D4.1* in WP4)

WP3 RAMS modelling activities

Several studies [12,13,14,15,16] proved that in highly complex orography certain terrain-induced meteorological processes cannot be captured at resolutions coarser than 1-km. WP3's goal is to run high-resolution simulations in the HKKH area, in order to:

1. perform a sensitivity analysis for identifying which key physical and numerical issues are fundamental to improve the reproducibility of the meteorology, and therefore the climatology, in such complex topography;
2. establish focused benchmark studies for the validation of non-hydrostatic atmospheric circulation models in highly complex topography, providing archives of data for the comparison between predicted and observed meteorological fields;
3. characterize the local meteorology for identifying locations of specific interest where to install measuring stations.

Simulations will be performed with the RAMS [17,18] non-hydrostatic model. RAMS can simulate the atmospheric flow from local and regional to synoptic scales, including: hydrostatic and non-hydrostatic mode, two-way interactive grid nesting, terrain-following coordinates stretched in vertical, nudging system, a set of -numerical schemes -boundary conditions -parameterisations for physical processes. In its latest version a true Cartesian grid structure (ADAP) is available, where the apertures of the grid cell faces are adapted to topography that would block the flow. ADAP technique allows dealing with arbitrarily steep and even overhanging topography, enabling simulations with very high resolution. Alternative turbulence closure models were implemented and tested in RAMS [14,19,20,21], to provide a better description of the flow structures at high resolution in complex terrain.

Simulations will be run on a domain approximately 100x100 km2, with a resolution of about 1 km, for a total period of some months, reproducing the seasonal variability of the meteorology in the area. Simulation outputs will be compared with an ensemble of ground daily data, temperature, precipitation, wind, pressure, humidity etc, collected by ground stations between altitudes of 3000 m and 8000 m. Comparisons with WRF runs at larger resolution (WP2) are planned. Specific information on the sites where new monitoring stations are planned to be installed may be inferred by the analysis.

The simulations will be tailored so to contribute to the studies related to the installation of new infrastructure and the upgrade of existing monitoring stations in the sites of interest (WP 1.1 in NextData).

Months 1-8 (05/2013 – 12/2013): definition of the areas and time periods of interest in the Italian Alps and HKKH regions; collection of -appropriate input topographical/meteorological data for high-resolution runs - available observed data; configuration of the simulations and preliminary tests in the Alps.

Deliverable: Data collection and preliminary tests. (M8)
D3.1. A report on the analysis of the preliminary simulations will be delivered, with illustrative examples, identifying the critical issues related to simulations in complex topography.

Months 9-24 (01/2014- 04/2015): elaboration of the test runs and analysis of the key items for high-resolution runs (resolution; turbulence; input data etc); simulations in the HKKH area for different months representative of the seasonal variability; comparison with observations and WRF outputs and analysis.

Deliverable: Completion of additional simulations (M24)
D3.2. A report discussing the specific results of the simulations performed in the different areas will be delivered.

The outputs from the simulations will be elaborated and stored in archives, then made available for the intercomparison foreseen in WP4 activity.

Months 25-29 (05/2015- 09/2015): elaboration of the data archive containing the simulation outputs, the data analysis and comparison; delivery to NextData database; publications of the results.

Deliverable: Analysis and transfer completed (M29).
D3.3. The conclusive analysis of the work performed will be included in the comprehensive report (see Deliverable *D4.1* in WP4).

The outputs from WP3 simulations will be integrated with the outputs from WP1 and WP2 runs and the results from WP4 intercomparison, then stored in archives and delivered to NextData repository (see Deliverable *D4.2* in WP4)

WP4 Evaluation and joint analysis of simulation results

Over common study regions and time-slices an intercomparison will be carried out between the RegCM and WRF dynamical downscaling results for a range of variables and statistics (means, interannual and seasonal variability and extremes; daily, 12/6-hourly rainfall projections for 50th and 95th quantiles). The WRF results will be compared with the RAMS simulations in the common subareas through graphical and statistical analyses. All simulations will be compared to observed data where available. Results obtained for the Apennines will also be compared with remote sensing observations [22,23]. The purpose of the intercomparison will be to identify the added value of increased resolution, particularly in terms of representation of dynamical processes in complex topography regions, and to explore methods to account for such processes in climate projections (e.g. regression techniques).

Deliverables (M29): Intercomparison analysis and final database
D4.1. Comprehensive report detailing the comparison between observed and simulated fields. Discussion of the critical and particular aspects related to the topographical complexity of the different regions.
D4.2. Datasets of observations (from meteorological stations and satellite) and predicted fields publicly available as benchmark studies for NextData community.

Timetable of deliverables

Deliverable	WP number	Nature	Delivery date (Month)
D1.1	1	report, data	8
D1.2	1	report	8
D3.1	3	report	8
D2.1	2	report, data	12
D1.3	1	report	20
D2.2	2	data	24
D3.2	3	report, data	24
D1.4	1	report, data	29
D1.5	1	report	29
D2.3	2	report, data	29
D3.3	3	report, data	29
D4.1	4	report	29
D4.2	4	report, data	29

Cited references

[1] Giorgi F, et al., 2011. Higher hydroclimatic intensity with global warming. Journal of Climate, 24: 5309-5324.

[2] Shukla, J., et al., 2009: Strategies: Revolution in climate prediction is both necessary and possible: A declaration at the World Modelling Summit for Climate Prediction, Bulletin of the American Meteorological Society 90.2, 175-178.

[3] Shapiro, M. A., et al., 2010. An Earth-system prediction initiative for the twenty-first century. Bull. Amer. Meteor. Soc, 91, 1377-1388.

[4] Akhtar, M., Ahmad, N., and Booij, M. J., 2008. The impact of climate change on the water resources of Hindukush–Karakorum–Himalaya region under different glacier coverage scenarios. Journal of Hydrology, 355(1), 148-163.

[5] Hewitt, K., 2005. The Karakoram anomaly. Glacier expansion and the 'elevation effect,' Karakoram Himalaya. Mountain Research and Development, 25(4), 332-340. [6] Giorgi F, 2006. Climate change Hot-Spots. Geophysical Research Letters, 33: L08707, doi: 10.1029/2006GL025734

[7] Giorgi F ,Lionello P, 2008. Climate change projections for the Mediterranean region. Global and Planetary Change, 63:90-104.

[8] Giorgi F, et al., 2012: regCM4: Model description and preliminary tests over multiple CORDEX domains. Climate Research, 52:7-29.

[9] Parodi, A., and K. Emanuel, 2009: A theory for buoyancy and velocity scales in deep moist convection. J. Atmos. Sci., 66, 3449–3463.

[10] Parodi, A. and Tanelli, S., 2009: Influence of turbulence parameterization on high resolution numerical modeling of observed tropical convection during NASA TC4 field campaign, Journal of Geophysical Research-Atmospheres, 115, D00J14, doi:10.1029/2009JD013302).

[11] Parodi, A., Foufoula-Georgiou, E., and Emanuel, K., 2011: Signature of microphysics on spatial rainfall statistics. Journal of Geophysical Research, 116(D14), D14119.

[12] Gohm, A, Zängl, G, Mayr, GJ (2004) South Foehn in the Wipp Valley on 24 October 1999 (MAP IOP 10): verification of high-resolution numerical simulations with observations. Mon Wea Rev 132: pp. 78-102.

[13] Schicker I., Seibert ., 2009. Simulation of the meteorological conditions during a winter smog episode in the Inn Valley. Meteorol Atmos Phys 103, 211–222

[14] Trini Castelli S., Morelli S., Anfossi D., Carvalho J., Zauli Sajani S., 2004: Intercomparison of two models, ETA and RAMS, with TRACT field campaign data. Environmental Fluid Mechanics, 4, 157-196.

[15] Trini Castelli S., Belfiore G., Anfossi D., Elampe E. and Clemente M., 2010: Modelling the meteorology and traffic pollutant dispersion in highly complex terrain: the ALPNAP alpine space project, International Journal of Environment and Pollution, 44, 235-243

[16] Arnold, D., D. Morton, I. Schicker, P. Seibert, M. W. Rotach, K. Horvath, J. Dudhia, T. Satomura, M. Müller, G. Zängl, T. Takemi, S. Serafin, J. Schmidli, S. Schneider, 2012. High Resolution Modelling in Complex Terrain. Report on the HiRCoT 2012 Workshop, Vienna, 21-23 February 2012. BOKU-Met Report 21, 42 pp. ISSN 1994-4179 (Print), ISSN 1994-4187 (Online).

[17] Pielke, R.A., W.R. Cotton, R.L. Walko, C.J. Tremback, W.A. Lyons, L.D. Grasso, M.E. Nicholls, M.D. Moran, D.A. Wesley, T.J. Lee and J.H. Copeland, 1992: A comprehensive meteorological modeling system – RAMS. Meteorol. Atmospheric. Phys., 49, 69–91.

[18] Cotton, W. R., R. A. Pielke, Sr., R. Walko, G. E. Liston, C. J. Tremback, H. Jiang, R. L. McAnelly, J. Y. Harrington, and M. E. Nicholls, 2003: RAMS 2001 - Current status and future directions. Meteor. Atmos. Phys, 82, 5-29.

[19] Trini Castelli S., Ferrero E., Anfossi D., 2001: Turbulence closures in neutral boundary layers over complex terrain. Boundary-Layer Meteorology, 100, 405-419.

[20] Trini Castelli S., Ferrero E., Anfossi D., Ohba R., 2005. Turbulence closure models and their application in RAMS. Environmental Fluid Mechanics, 5, 169-192.

[21] Trini Castelli S., Hara T., Ohba R and Tremback C.J., 2006: Validation studies of turbulence closure schemes for high resolutions in mesoscale meteorological models. Atmospheric Environment, 40, 2510-2523.

[22] Di Tomaso, E., F. Romano, and V. Cuomo, 2009:,Rainfall estimation from satellite passive microwave observations in the range 89 GHz to 190 GHz, J. Geophys. Res., 114, D18203, doi:10.1029/2009JD011746.

[23] Madonna, F., Amodeo, A., Boselli, A., Cornacchia, C., Cuomo, V., D'Amico, G., Giunta, A., Mona, L., and Pappalardo, G., 2011: CIAO: the CNR-IMAA advanced observatory for atmospheric research, Atmos. Meas. Tech., 4, 1191-1208, doi:10.5194/amt-4-1191-2011.