Project of strategic interest NEXTDATA

Scientific Report for the reference period 01-01-2013 /31-12-2013

WP 2.5: Archive of numerical simulations and projections

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CMCC

Partners
CASPUR, CMCC, CNR-ISAC, ENEA, ICTP

1. Scheduled activities, expected results and milestones

During the second year of the project, all WP2.5 participants will contribute to the following activities: continue the production of global and regional numerical simulations targeted to the regions of interest of the project; continue the provision of the contents of the numerical data archives, with a focus on the Mediterranean area, the Alpine region and the HKKH region; initiate the implementation of high-resolution, non-hydrostatic numerical models at the local scale, for simulating climate and environmental dynamics in mountain areas with complex orography; define the configuration of high-resolution simulations for specific areas in the Alps and in HKKH; collect and prepare input and validation data; obtain the first simulation results; continue the work on stochastic downscaling to investigate future high-resolution precipitation scenarios in north-western Italy; start the activities aimed at providing a comparison between different techniques of dynamical, statistical and stochastic downscaling, in order to understand their performance and applicability limits in specific case studies; start the generation of high-resolution data archives, using spatial and temporal downscaling techniques applied to output of observations and models.

Furthermore, in the second year of the project, the activities related to the NextData "Special Projects" (or "Case Studies") have been initiated. Among them, the Special Project RECCO (Development of ensembles of regional climate change scenarios, with focus on variability, extremes and uncertainties in areas of complex topography) is carried out in the framework of WP2.5, contributing to the scope and to the objectives of the WP. A number of WP partners (ISAC-CNR, ICTP and CINECA) are involved in RECCO, and the work they have performed in the context of this subproject during the second year of NextData is illustrated and discussed in the RECCO "Special Project" report enclosed at the end of this document.

Milestone M2.5.2 (Month 24): Completion of the archiving of the global simulations.

2. Deliverables expected for the reference period

Deliverable D2.5.3: Archive of global climate simulations; information transmitted to the General Portal of the project.

3. Activities conducted during the reference period

3.1 Research activities

In the course of the second year of the project, all of the partners have contributed to the successful completion of the activities planned within the work-package. In particular, the partners have implemented and made available and accessible the climate data server, with homogeneous and coherent archiving and access protocols, which were defined during the first year of the project. This has made possible the setting of a network of data THREDDS servers, which represents the backbone of the modelled climate data archive of the NextData Project and that will be accessible from the project portal. Additionally, the partners have started the archiving of the numerical simulations listed in the census performed during the first year (Deliverable D2.5.1). At the end of the second year of the project, the archiving of the global climate simulations was completed (Deliverable D2.5.3).

During the second year of NextData, CMCC worked at the development of statistical and dynamical downscaling techniques to be applied to GCM outputs, in order to provide more spatially detailed information on the climate signal and its variability. Specifically, CMCC performed an analysis of the capability of different statistical downscaling methods to produce high-quality climate data for regions with a complex physiography. In particular, three MOS (Model Output Statistics) techniques have been considered: Analogs, Linear Scaling and Quantile Mapping. These different techniques have been calibrated, validated and tested over different Italian areas in order to make a comparison of the performances of the three methods in different contexts. Results of the research activity show that Linear Scaling method improves the representation of mean values, as expected, but has worse performance for extreme values. The MOS Analog downscaled values show a higher agreement with the observations, but this method is unable to reduce the seasonal bias if the sign of the bias changes among the different seasons. For example, RCM simulations have a negative bias in Autumn over the Po basin and a positive bias over the other seasons. The MOS downscaling, when applied to the model outputs, does not appear to be able to reduce the Autumn bias while the bias seems to be reduced in summer.

Finally, the quantile mapping method has the best scores for all precipitation indices and seasons and it clearly improves the direct output of the COSMO-CLM model. An example of the analysis performed is reported in the Figure 1, where the results for the autumn season (SON) are summarised through comparison maps for the observed dataset (left column), the COSMO-CLM model (center) and the corresponding Quantile Mapping correction (right column). Different indices have been evaluated: PRCPTOT (total precipitation), R1 (number of rainy day), and RX1DAY (maximum of daily precipitation). The seasonal values of the indices are averaged over the common period 1971-2000. Figure 1 shows an underestimation of the COSMO-CLM model especially in terms of total precipitation and number of rainy days (respectively 17% and 11% of the observed values). These biases lead to a low spatial correlation between model and observations. The Quantile Mapping downscaled values, instead, clearly outperform the uncalibrated RCM outputs for all the indices and show a higher agreement with the observations, considerably reducing the mean bias and improving the spatial correlation with observation.

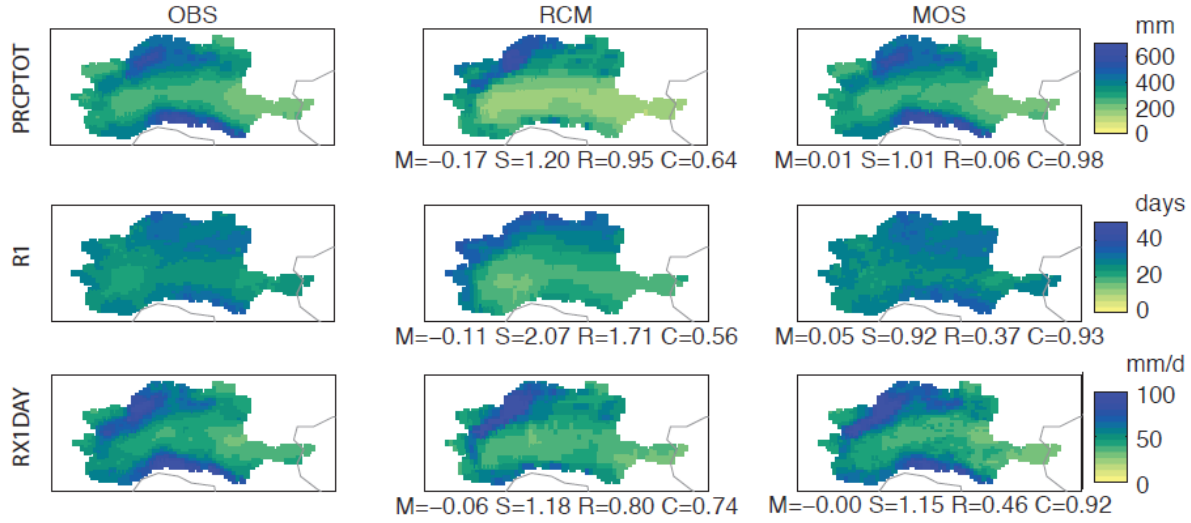

Fig. 1. Spatial distribution of the observed (left), COSMO-CLM (central) and downscaled with Quantile Mapping (right) mean values (averaged over the control period 1971-2000 for the autumn precipitation indices (from top to bottom: PRCPTOT-> total precipitation; R1->number of days with precipitation over 1 mm/day; RX1DAY-> maximum precipitation in 1 day). The spatial validation scores for the RCM and QM simulated values are given below the corresponding panels: bias (or mean error M), relative standard deviations (S), correlation (C) and centred root mean square (R). Source P1.

Figure 2 provides the comparison, over the Po river basin, for the period 1971-2000, among monthly average (top left), 50-percentile (top right), 90-percentile (bottom left) and 10-percentile (bottom right) of precipitation from observations (in black) COSMO-CLM driven by ERA-40 Reanalysis, (grey), and the precipitation statistically corrected using MOS Analogs (green), Linear Scaling (blue) and Quantile Mapping (red). Figure 3 is analog to Figure 2 but COSMO-CLM is driven by the CMCC-CM global circulation model.

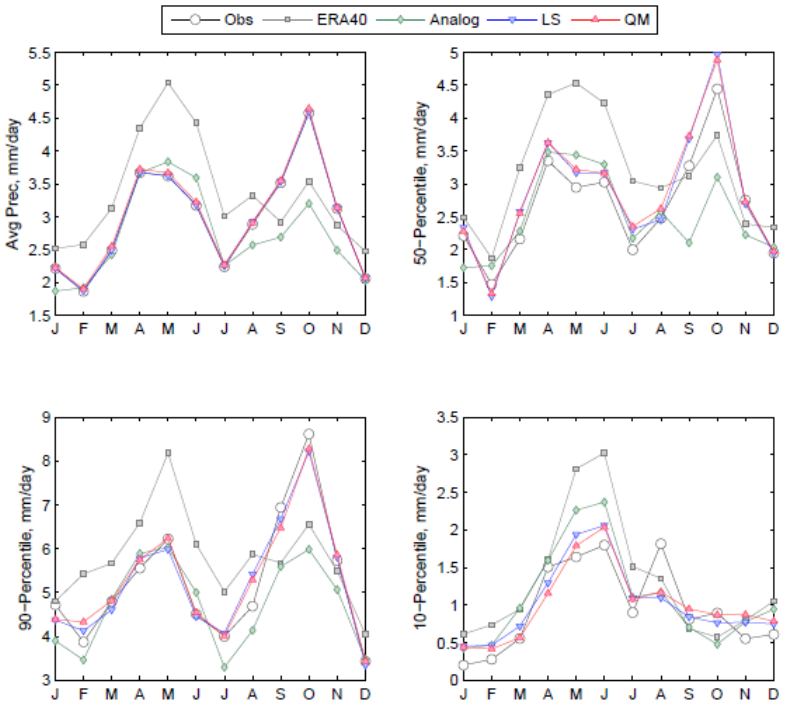

Fig. 2. Comparison of average, 50-, 90- and 10-percentile of monthly precipitation over the Po river basin in the period 1971-2000. Values have been computed from precipitation observations (black line), COSMO-CLM driven by ERA40 Reanalysis (grey), and statistically corrected fields using the Analogs (green), Linear Scaling (blue) and Quantile Mapping (red).

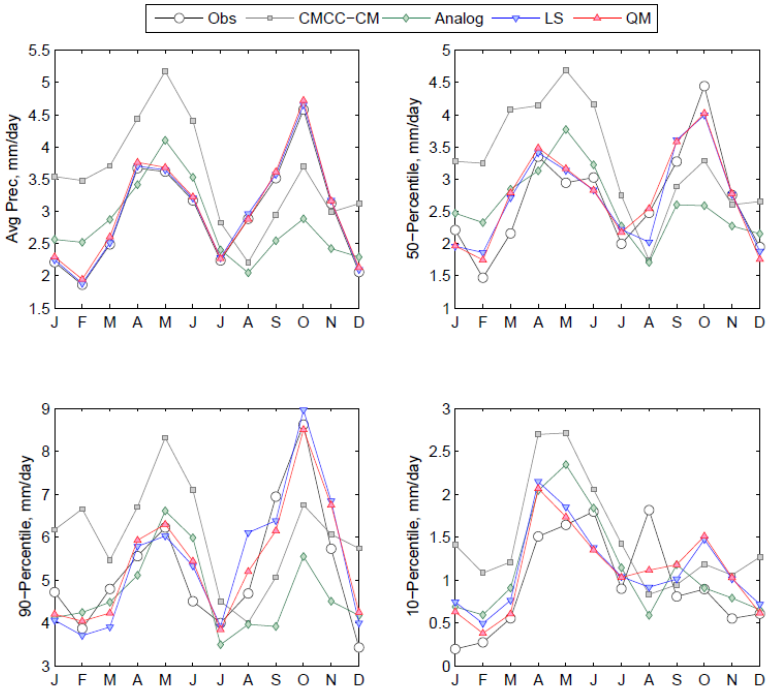

Fig. 3. Comparison of average, 50-, 90- and 10-percentile of monthly precipitation over the Po river basin in the period 1971-2000. Values have been computed from precipitation observations (black line), COSMO-CLM driven CMCC-CM (grey), and statistically corrected fields using the Analogs (green), Linear Scaling (blue) and Quantile Mapping (red).

Both Figures 2 and 3 show that the dynamically downscaled precipitations (independently from driving data) are overestimated in Spring and underestimated in Autumn, as consequence, a study of the hydrological cycle based on them will be affected by severe errors, as shown in next paragraph. The statistically corrected precipitation fields reproduce better the spring precipitation than the uncorrected ones; the MOS Analog corrected precipitation fails in reproducing the autumnal peak in precipitation while Linear Scaling and Quantile Mapping perform quite well also considering the 90- and the 10-percentiles.

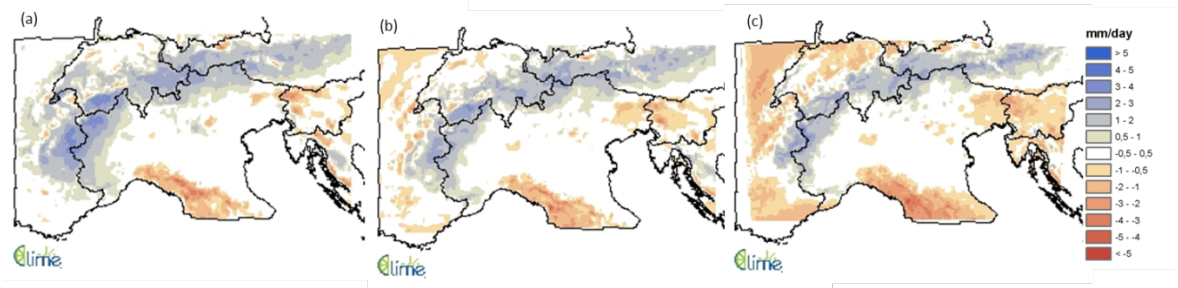

Fig. 4 Winter precipitation bias for the 3 different COSMO CLM simulations with respect to the EURO4M (Isotta et al., 2013) precipitation dataset: (a) COSMO CLM 0.125°, (b) COSMO CLM 0.0715° and (c) COSMO CLM 0.02°.

The dynamical downscaling activities performed at CMCC during the second year of NextData have focused on the implementation of a very high-resolution version of the limited area atmospheric model COSMO-CLM. Specifically, the model has been configured at a horizontal resolution of 0.02° (about 2.2 km) over Alpine region. The first test simulation was performed over the period 1979-1989 by using a double nesting approach, carrying out first a simulation

at 0.0715° driven by the ERA-Interim Re-Analysis. The main objective of this simulation is to investigate how a better representation of the orography, in a mountain area, improves the capability of COSMO-CLM to reproduce the observed climate. In addition, a better representation of orography is expected to help in simulating the snow accumulation/melting and, in general, all hydrological processes. The results were compared with two simulations at the horizontal resolutions of 0.125° and 0.0715° respectively, without the application of additional statistical downscaling. Preliminary results (Figure 4) show a capability of the highest resolution simulation to slightly improve the results over the Alpine arc in winter (Mercogliano et al., 2013). The next step requires a more accurate tuning of the parameters regulating the shallow convection scheme. New simulations at this resolution are planned in 2014.

During the same period, ISAC-CNR has performed research and a large number of numerical experiments aimed at tuning the new version 3 of the EC-Earth model. EC-Earth 3 is based on the ECMWF seasonal model cycle version 4. In its current configuration it implements IFS c36r4 for the atmosphere, H-Tessel for land surface, the NEMO v3.3.1 ocean model, and the LIM3 sea ice module. The standard reference resolution at which the tuning effort is aimed is T255 with 91 vertical levels in the atmosphere (about 80 km resolution) and ORCA1, 46 levels, for the ocean. The tuning effort has concentrated mainly on correcting biases in the overall radiative balance of the model, in particular net top-of-atmosphere and surface radiative fluxes, and biases in the hydrological balance of the model (precipitation minus evaporation balance and sea-level changes). In particular it has been found that implementing an advection mass-fixing scheme (backported from IFS c38r1) improves significantly both the radiative and the mass balance. The transport scheme in IFS is non-conservative and an extra latent heat release due to errors in the advection of humid species may lead to a signifcant contribution to the radiative balance of the model of the order of 1.3 W/m^2. Other improvements include tuning of convective entrainment parameters, the ocean surface diffusive albedo and two bug-fixes in NEMO. Overall more that 25 long experiments (between 10 and 100 years each) have been performed, for a total of more than 1350 model years of simulation. These activities have led to the definition of a new intermediate version of EC-Earth 3 which is planned to be released in early 2014.

Moreover, ISAC-CNR has performed a very high-resolution simulation for continental Europe, in the European CORDEX domain, using the non-hydrostatic Weather Research and Forecast (WRF) Model v 3.4.1, forced with ERA-Interim boundary conditions, in the period 1979-2009. This activity has been performed using computing resources provided by the LRZ Supercomputing Center. A two-way nesting subdomain partitioning has been used, where the external domain (corresponding to the Euro-Cordex domain) has been resolved at 0.11°, while an internal domain, covering most of continental Europe has been resolved at 0.036°. A preliminary series of simulations at 0.11° over the entire domain for selected years has allowed to test and study the sensitivity of the model to the choice of microphysical and PBL parameterizations. A first analysis of the model results, particularly in terms of its ability in reproducing observed precipitation extremes, particularly over the Greater Alpine Region, has been performed and model results have been compared with available high-resolution gridded data sets, in particular ERA-Interim, MERRA and CFSR reanalyses, GPCP, GPCC, EOBS and CRU datasets and the Alpine datasets HISTALP and EURO4M-APGD.

The Advanced Research Weather Research and Forecasting Model (WRF), version 3.3.1, has been used to explore its ability in reproducing extreme hydro-meteorological phenomena over the most complex topography region of the Hindu-Kush-Karakorum. In particular

experiments were performed to explore the atmospheric conditions that characterized the most intense days of 2010 Pakistan flood (26-31 July, 2010). Two domains were used, one with a 14 km grid spacing and the other, nested in the former, at 3.5 km resolution, in a two-way nesting mode. The vertical coordinate was discretized in 42 levels, with 10 levels in the lowest 2.5 km. A higher number of layers near the surface was used to better resolve the atmospheric flow over the complex orography of the simulated mountainous region and its associated convective activity. The turbulent parameterization employed in the simulations is the Mesoscale 1D scheme, and the planetary boundary layer scheme is the Yonsei University (YSU) one. The boundary and initial conditions for the experiments were provided by the ERA-Interim reanalysis Project at its native resolution, namely 0.7° (~78 km). A set of model simulations was performed employing different convection and microphysics configurations, and the model was tested with different initialization days. The best configuration was selected through a comparison with the observations in terms of daily rainfall, columnar water vapor content, wind speed and direction. Model outputs have been compared with rainfall depth observations, radio sounding data, geostationary/polar satellite images and cloudsat observations.

We analyzed properties of precipitation in the Hindu-Kush Karakoram Himalaya (HKKH) region as simulated by thirty-two state-of-the-art Global Climate Models (GCMs) participating in the Coupled Model Intercomparison Project Phase 5 (CMIP5). To this end historical CMIP5 model simulations have been downloaded and collected at ISAC and compared with the Climate Research Unit (CRU) and Global Precipitation Climatology Centre (GPCC) precipitation data in the period 1901-2005. Future precipitation from CMIP5 models has been downloaded and analyzed for the two Representative Concentration Pathways (RCP) RCP 4.5 and RCP 8.5 scenarios. Further research has been dedicated to explore the main sources of moisture for winter precipitation in the Hindu-Kush Karakoram (HKK), analyzing the links between evaporation, tropospheric winds, sea surface temperatures, precipitable water and the NAO index over an area extending approximately from the Mediterranean to the Indian subcontinent. To this end, ECMWF ERA20cm reanalysis data for surface pressure and zonal winds have been downloaded and collected at ISAC-CNR.

An application of the RainFARM stochastic downscaling model to satellite precipitation measurements (TRMM, 25 km resolution) over the Karakoram area has been started. In fact, few and sparse in-situ rain gauges are still available for the mountainous regions of Northern Pakistan, and their measurements are strongly biased by altitude (since rain gauges are mainly located in valley floors, at lower elevations than those where maximum precipitation occurs). Therefore, the application of the downscaling procedure to coarse-scale satellite measurements can be thought of as an effective way to obtain high-resolution synthetic precipitation estimates for poorly gauged regions. We compared the statistical properties (such as the shape of the precipitation power spectrum and probability density functions, PDFs) of the downscaled TRMM precipitation fields with the few observations available for this area, provided by the Pakistani meteorological Department (PMD) and the Water and Power Development Authority (WAPDA). We performed our analysis on a seasonal basis and focusing on the time periods1998-2012. The downscaled TRMM precipitation PDFs agree better with the station-based observed precipitation PDFs than the precipitation PDFs from the original TRMM data, in terms of amplitude distribution and its capability to represent precipitation extremes.

In the second year of the project, according to the planned work, ENEA has continued the activity of climate simulations with its regional coupled model implemented over the

Mediterranean area. Thus, new regional coupled simulations have been produced in order to analyse the low frequency variability over the Mediterranean basin both in terms of weather regimes and of oceanic circulation. Specifically, these simulations are aimed at exploring the natural variability of the basin and its role in modulating the trends associated to the anthropogenic global warming. A publication illustrating the results is in preparation. Furthermore, the partner has made available and accessible the archives of numerical simulations as described in the census performed during the first project year (Deliverable D2.5.1).

Besides, ENEA has deepened the analysis of its climate simulations over the Mediterranean area, investigating the capability of the model to reproduce the statistics of the observed weather regimes at local scales, by comparing the model output against SYNOP weather stations data provided by Italian Air force.

Finally, ENEA in collaboration with ISAC-CNR, has investigated how a combination of dynamical and statistical (stochastic) downscaling might improve the simulated climate signal at local scale, especially for precipitation. The results of this analysis have been published in a paper on the Journal of Hydrometeorology.

3.2 Applications, technological and computational developments

All of the principal partners (CASPUR-CINECA, CMCC, ENEA, ISAC-CNR) have implemented and made available THREDDS servers to access to the climate numerical simulation data listed in the census performed during the first year of the project and included in the deliverable D2.5.1. Furthermore, the partners have started the archiving of the global climate simulations as illustrated in the project deliverable D2.5.3, where detailed information on how to access the data are provided.

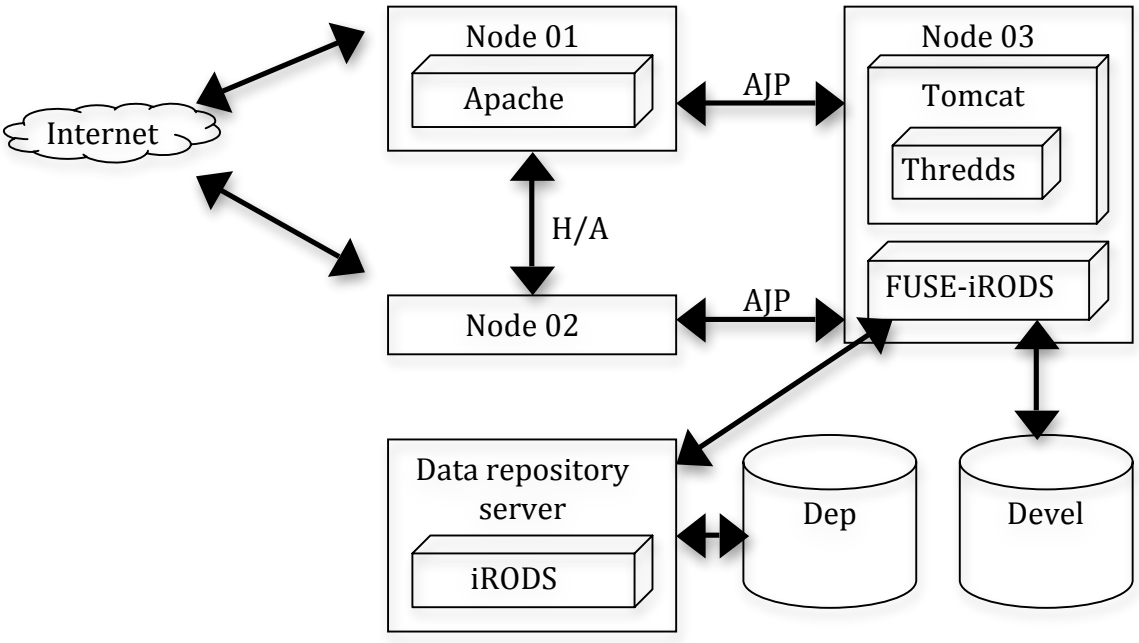

Fig. 5. Scheme of the THREDDS Server installed at CINECA. This scheme reflects the structure of the server installed at the centers partner of the WP.

The THREDDS data server installed at CINECA (http://nextdataproject.hpc.cineca.it/thredds) is based on a Frontal End Cluster (FED) composed by Intel Xeon E5530 bi-processor 2.4 Ghz quad-core nodes. In particular, as shown in Figure 5, nodes 01 and 02 support the web server Apache[1], which, by means of a AJP protocol, is connected to node 03, where the servlet container Topcat[2] (Version 7) is installed along with the THREDDS server (TDS, version 4.3). The TDS has been configured to allow the data access via OpeNDAP, OGC WMS, OGC WCS and HTTP protocols. Besides, NetCDF Subset and ncISO services have been installed.

At CMCC, the implementation of the limited area model COSMO-CLM at very-high resolution (~2 km) has required a substantial effort to optimize the parallelization of the code in order to improve its computational performances. Furthermore, a number of post-processing and diagnostic tools have been developed to make an effective evaluation of the simulation results. Additionally, a preliminary activity concerning the use of remote sensing products for snow detection has been performed, with the aim of reproducing large scale snow distribution and extension in Northern Italy over the last decade (2003 - 2013). 500 m resolution daily snow maps of ten years have been processed, highlighting the annual trends of snow accumulation and snowmelt for the whole Alpine region. This study will be integrated with measurements of snow depth and estimations of snow density, in order to assess the inter-annual fluctuations of snow water equivalent stored in the Po river basin.

The tuning of EC-Earth 3 has required a new implementation and optimization of the model on the Supermuc machine at LRZ, Germany. A series of optimization speedup experiments has been performed in order to determine the optimal configuration in terms of cores allocated to the different model components (http://www.to.isac.cnr.it/ecearth3/scaling.html). A wide range of post-processing tools has been implemented to allow the analysis of the model results. In particular a set of post-processing scripts developed in the framework of the Hiresclim PRACE project has been adapted and implemented to provide output directly in netcdf format for a selected number of standard model variables. A performance index (PI) computation tool based on Reichler and Kim (BAMS 89, 2008), developed by the EC-Earth consortium for EC-Earth v2 has been adapted and optimized by ISAC-CNR for EC-Earth v3. The tool provides standard PI indices for model simulations by comparison with a set of reference datasets. The AMWG diagnostic suite, originally developed by NCAR and further adapted by the EC-Earth consortium, also in collaboration with ISAC-CNR, has been implemented operationally for EC-Earth runs and allows to obtain a wide range of plots comparing model output climatology with a wide range of standard reference observational datasets. We created a set of diagnostic time-series plotting routines for the atmosphere and we implemented diagnostic plotting routines for the ocean developed by the EC-Earth consortium. All post-processing diagnostics (AMWG plots, PI tables, global average tables for selected variables, atmospheric and oceanic time series) are computed and are available soon after the completion of each run, on a set of dedicated web pages on a server at ISAC-CNR (http://sansone.to.isac.cnr.it/ecearth/diag).

The high-resolution simulations with WRF have been post-processed by storing a set of selected variables at frequencies recommended and defined by the WRF-Cordex community (http://www.meteo.unican.es/wiki/cordexwrf/OutputVariables). To this end an existing post-processing tool written in NCAR Command Language (NCL) has been greatly expanded and adapted for the WRF-Cordex output data. The output netcdf files follow closely the recommended CORDEX output format. The main surface variables are available at 3hr intervals. Overall the post-processed output of the 30 year ERA-Interim forced simulation

occupies about 11 TB. These data are currently stored at LRZ and will be transferred to ISAC-CNR machines and to the project portal in the current year.

Monthly precipitation datasets from CMIP5 models for the historical period and for the RCP 4.5 and RCP 8.5 scenarios have been downloaded and stored on ISAC-CNR servers, together with observational datasets CRU and GPCC for the period 1901-2005.

3.3 Formation

Marco Turco (CMCC) has attended the Summer School on "Climate Change and the Mountain Environment" from 18 to 28 June, 2013 (http://www.to.isac.cnr.it/aosta/).

Pierfrancesco Da Ronco (CMCC) has attended the conference "High Summit 2013 - International Conference on Mountains and Climate Change" from 23 to 25 October, 2013 (www.highsummit.org).

Supervision of a Ph.D., starting in January 2013, of the "Scuola di Dottorato in Scienze della Natura e Tecnologie Innovative" of the University of Torino.

Supervision of a Ph.D. starting in March 2013 of the "Scuola di Dottorato in Fluidodinamica" of the Politecnico di Torino.

Supervision of a first cycle degree thesis (Univ. of Torino) on historical climate modeling with the Plasim climate model.

Supervision of a second cycle thesis ("Laurea Magistrale" – Univ. of Torino) on Predictability in Climate System Models.

Co-Supervision of a second cycle thesis ("Laurea Magistrale - Environmental Engineering - Sustainable Development and Risk Management – Univ. of Genova) on High-resolution non-hydrostatic simulations of extreme rainfall events: the case of Pakistan flood 2010.

3.4 Dissemination

Summer school "Climate Change and the Mountain Environment", Valsavarenche, Valle d'Aosta (Italy), 18-28 June, 2013, Course XXI of the Alpine Summer School**.** The course has seen the participation of 22 lecturers and of 33 students (http://www.to.isac.cnr.it/aosta_old/aosta2013/index.htm).

CISM Advanced course, The Fluid Dynamics of Climate. Coordinators: A. PROVENZALE, K. FRAEDRICH, International Centre for Mechanical Sciences, Udine, Italy, 26-30 August,2013.

M. TURCO: Seminar on "Forest fires under climate change in a Mediterranean environment (Catalonia, NE of Spain)" at CIMA RESEARCH FOUNDATION, Savona, Italia, 5 maggio 2013.

3.5 Conferences, Workshops, Meetings

R. VEZZOLI, P. MERCOGLIANO, S. PECORA, E. ZENONI: Impact simulations of climate change on hydrological extremes in the Po basin. *EGU 2013*, Vienna (AT)

P. MERCOGLIANO, E. BUCCHIGNANI, M. MONTESARCHIO, A. L. ZOLLO: Very high resolution simulations with COSMO-CLM over Alpine space: benefits versus costs. *CORDEX 2013*. http://cordex2013.wcrp-climate.org/parallel_B4/B4_07_engelbrecht.pdf

M. TURCO, A.L. ZOLLO, R. VEZZOLI, C. RONCHI, and P. MERCOGLIANO. Daily precipitation statistics over the Po basin: observation and post-processed RCM results. *First Annual Conference of the Italian Society of Climate Sciences (SISC)*, Lecce 2013.

International meeting with EC-Earth contributors/users, Lisbon, Portugal, 16-17 April, 2013.

European Geosciences Union, General Assembly 2013, Vienna, Austria, 7–12 April 2013:

- The 2010 Pakistan floods: high-resolution simulations with the WRF model (F. VITERBO, A. PARODI, L. MOLINI, A. PROVENZALE, J. VON HARDENBERG, e E. PALAZZI (oral).

- Western weather patterns and winter precipitation in the Hindu-Kush Karakoram L. FILIPPI, E. PALAZZI, J. VON HARDENBERG, e A. PROVENZALE (poster).

- Snow cover changes in the Hindu-Kush Karakoram Himalaya S. TERZAGO, J. VON HARDENBERG, E. PALAZZI, e A. PROVENZALE (poster).

International Conference on Regional Climate - CORDEX 2013, 4-7 November 2013 in Brussels, Belgium:

- The 2010 Pakistan floods: high-resolution simulations with the WRF mode (F. VITERBO, A. PARODI, VON HARDENBERG J., PROVENZALE A.) (poster).

- Impact of different microphysics parameterizations on dynamical downscaling with WRF for the EURO-CORDEX domain (A. PIERI, J. VON HARDENBERG, A. PROVENZALE, A. PARODI) (poster).

- Stochastic rainfall downscaling of a regional climate model over North-Western Italy (D'ONOFRIO D., PALAZZI E., VON HARDENBERG J., PROVENZALE A., CALMANTI S.) (poster).

4. Results obtained during the reference period

4.1 Specific results (Data libraries, Measurements, Numerical simulations, etc)

- Archive of post-processed outputs from WRF simulations for the Euro-CORDEX domain, at 0.036° resolution, in the period 1979-2009, forced by ERA-Interim boundary conditions. The data are currently stored at LRZ, Germany and will be transferred to ISAC-CNR machines and to the portal in the course of the current year.
- Copy of monthly precipitation data for 32 models from the CMIP5 archive, stored at ISAC-CNR.
- Sea-level pressure and zonal winds data from the ERA-20cm archive by ECMWF, stored at ISAC-CNR.
- Diagnostic output (AMWG, PI tables, global average tables for selected variables, atmospheric and oceanic time series) for EC-Earth v3 tuning runs, available from a public web server at ISAC-CNR (http://sansone.to.isac.cnr.it/ecearth/diag).

The database of climate simulations produced by ENEA, after the harmonization during the first year of activity, has been made available (experimentally) directly from NextData data Portal. Moreover, new regional simulations obtained by using PROTHEUS coupled system (atmospheric model RegCM3.1+hydrological scheme IRIS+ Oceanic component MEDMIT) have been finalised (Artale et al, 2010). More in details:

i) PROTHEUS simulation ERA-INTERIM: Lateral Boundary conditions from ERA-INTERIM for the 19-year period 1982-2010(Simmons et al, 2006). The global Reanalysis has been produced assimilating observations into a global circulation model. The 6 hourly data are reported on a regular grid with a horizontal resolution of .75 degree. With the same boundary conditions a similar stand alone simulation with RegCM3.1 atmospheric model has been performed.

ii) PROTHEUS simulation CNRM-CM5-RF: Same model configuration employed for simulation driven by ERA-INTERIM global Reanalysis system. The lateral boundary conditions for the atmosphere (1971-2005) are taken from the CNRM-CM5-RF (run r1i1p1) global simulation (run3) included in the CMIP5 experiment.

iii) PROTHEUS simulation CNRM-CM5-RCP45: Same as the previous one but the lateral boundary conditions are taken from the CNRM-CM5-RCP45 (run r1i1p1) global simulation (2006-2095).

The standard outputs are saved every 6 hours and then post-processed, interpolated over pressure levels (from original vertical sigma-levels) and finally converted in NETCDF files.

The configuration employed for the atmospheric component has a uniform 150x160 horizontal grid spacing of 30 km on a Lambert conformal projection. In that configuration, the disk space required is about 25 Gigabyte/year.

4.2 Publications

M. TURCO, A.L. ZOLLO, C. RONCHI, C. DE LUIGI, P. MERCOGLIANO: Assessing gridded observations for daily precipitation extremes in the Alps with a focus on northwest Italy, *Nat. Hazards Earth Syst.* Sci., 13, 1457-1468, doi: 10.5194/nhess-13-1457-2013, 2013.

D'ONOFRIO, D., PALAZZI, E., VON HARDENBERG, J., PROVENZALE, A. and CALMANTI, S., 2013: Stochastic rainfall downscaling of climate models, *Journal of Hydrometeorology*, doi: 10.1175/JHM-D-13-096.1.

PALAZZI E, VON HARDENBERG J, PROVENZALE A (2013): Precipitation in the Hindu- Kush Karakoram Himalaya: Observations and future scenarios. *J Geophys Res* 118:85–100, doi: 10.1029/2012JD018697.

PARODI A., VON HARDENBERG J., PROVENZALE A.: Emergence of large-scale patterns in moist atmospheric convection, in preparation.

PIERI A., VON HARDENBERG J., PARODI A., PROVENZALE A.: Do precipitation rates from non-hydrostatic simulations agree with data? A view from the WRF model over Europe. In preparation.

S. CALMANTI, A. DELL'AQUILA, F. MAIMONE, V. PELINO: Evaluation of climate patterns in a regional climate model over Italy using long-term records from SYNOP weather stations and cluster analysis. Under review (Minor revision) on *Climate Research*.

DI BIAGIO V., CALMANTI S, DELL'AQUILA A. and RUTI PM.: Northern Hemisphere winter mid latitude atmospheric variability in CMIP5 models. Under review (Minor revision) on *Geophysical Research Letters.*

4.3 Availability of data and model outputs (format, type of library, etc)

The data made available to the project partners and users are included in project deliverable D2.5.3 (Archives of global climate simulations; transmission of information to the General Portal).

The above described simulations are available on the original grid as well as onto the MED-44i regular grid, defined in the framework of CORDEX (see www.medcordex.eu for more details). On this domain the data have been post-processed following the CORDEX convention. These data will be available in the next period as daily and monthly means with the following naming convention.

VariableName_Domain_GCMModelName_CMIP5ExperimentName_CMIP5EnsembleMember_RCMModelName_RCMVersionID_Frequency[_StartTime-EndTime].nc

The data from the pre-existing simulations (see Deliverable 2.5) are already available on line experimentally from the NextData Portal.

4.4 Completed deliverables

In the course of the first year project the partners have completed the project Deliverables:

D2.5.3 (Archives of global climate simulations; transmission of information to the General Portal).

5. Differences between planned and performed activities/results/deliverables

No significant differences have occurred during the second year between the planned activities and those actually performed. The Deliverable 2.5.3 has been postponed to the beginning of the third year to include all simulations which were not completed in 2013.

6. Expected activities for the following reference period

In the course of the third year of the project, all of the WP2.5 partners will continue the main activities of numerical simulation data archiving and new simulation production according to the WP work plan. Specifically, the following activities will be continued and completed:

- completion of the climate model output archiving with the regional simulations, particularly those focusing on the Mediterranean area, Alpine region and the region HKKH. The data will be made available and accessible via the THREDDS server.
- Analysis and evaluation of the COSMO simulations at 2.2 km over the Alpine region and the Po valley domain through the comparison with other RCM and/or COSMO model configurations at coarser horizontal resolutions, and with observational datasets
- Continue the comparison of dynamical and statistical downscaling methods to generate the precipitation at sub daily time scale over different areas according to data availability.
- Downscaling with WRF at high resolution of a EC-Earth RCP 4.5 projection over the European domain and analysis of scenarios output variables in particular over the Alpine region and comparison with available observational archives.
- Set up of a final tuned version of EC-Earth 3 at T255 resolution and corresponding analyses and diagnostic outputs.

- Development of the application of the RainFARM downscaling technique for the downscaling of satellite observations in poorly gauged and high-altitude regions.
- Analysis and assessment of the simulated low frequency variability over the Euro-Mediterranean basin.
- Organize meetings (at least two) of the project researchers, in order to discuss climate scenario experiments, and the distribution and use of the numerical data.

Project of strategic interest NEXTDATA

Scientific Report for the reference period 01–05–2013 / 31–12 2013

Special project
RECCO
Development of ensembles of regional climate change scenarios, with focus on variability, extremes and uncertainties in areas of complex topography.

WP Coordinator: Silvia Trini Castelli
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Collaborators:

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1. Scheduled activities, expected results and Milestones (as indicated in the Executive Plan)

The program of RECCO project is organized in Units and Working Packages (WP), depending on the different modelling activities, which will merge in the conclusive and comprehensive WP4 "Evaluation and joint analysis of simulation results".

In this first report, the description of the activities is thus structured by Unit and WP.

Unit 1, ISAC-CNR, WP2.

WRF modelling activities: this WP is expected to 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. The RECCO project requires 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.

Milestone and Deliverable:
Preliminary tests and control runs

Unit 1, ISAC-CNR, WP3.

In the framework of RAMS modelling activities, we plan to perform a sensitivity analysis to identify key physical and numerical issues that are fundamental to improve the reproducibility of the atmospheric circulation in such highly complex topography. Further we will pursue 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, collection of available observed data and configuration of the simulations and preliminary tests in the Alps.

Milestone and Deliverable:
Elaboration of a database collecting already available simulation outputs and results from preliminary runs. Analysis and discussion of the results.

Unit 2, ICTP, WP1.

For the special project RECCO, ICTP is expected to carry out the following activities:

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.

Milestone and Deliverable:
Data transferred and analysis completed.

Unit 3, CINECA, all WPs

The CINECA Supercomputing Consortium is the only one in Italy, following the fusion of CILEA and CASPUR, and it is one of the largest ones in Europe.

CINECA is involved mainly for the use of the supercomputing power required to perform the activities of the partners ISAC-CNR and ICTP. Additionally, CINECA provides support towards ordinary and specialized numerical models which are the core business of simulation activity.

Unit 4, IMAA-CNR,all WPs

IMAA-CNR contributes to the project with an across-the-board approach, and in the reference period it is expected to collect and elaborate in-situ data, ground-based and satellite remote sensing observations, and to cross-check the outcome of the modelling activities. IMAA remote sensing data and in-situ data to be used for the model evaluation activities will be provided to the other partners and made available in the NextData Archive.

2. Deliverables expected for the reference period

Unit 2, ICTP; WP1

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.

Unit 1, ISAC-CNR, WP3.

D3.1. A report containing the review of the critical issues for high-resolution and complex-terrain simulations and for the analysis of the preliminary runs.

3. Activities which have been actually conducted during the reference period

3.1 Research activities

Unit 1, ISAC-CNR, WP2.

Part 1 WRF reference configuration identification: the WP2 research activities during the first year focused on the identification of the WRF model best configuration for the reproduction of rainfall statistics over the European area. To achieve that goal a target year was adopted, namely 1979, representing the initial year of the ERA-Interim dataset, and different model configurations were tested.

The region of study used for model integration is the EURO-Cordex domain (Jacob et al., 2013), defined as an equidistant longitude / latitude projection with rotated North Pole, extending approximately in the range 22W-45E longitude and 27N-72N latitude (Figure 1). In this region, two different reference areas have been identified: the largest one, called the Inner European Region (IER), covers most of Europe and it has been adopted for higher resolution two-way nested model simulations with spatial resolution 0.04. The second, smaller region coincides with the Greater Alpine Region (GAR), extending in the range 4E-19E in longitude and 43N-49N in and it is adopted to compare model runs with observations over this part of Europe with complex topography.

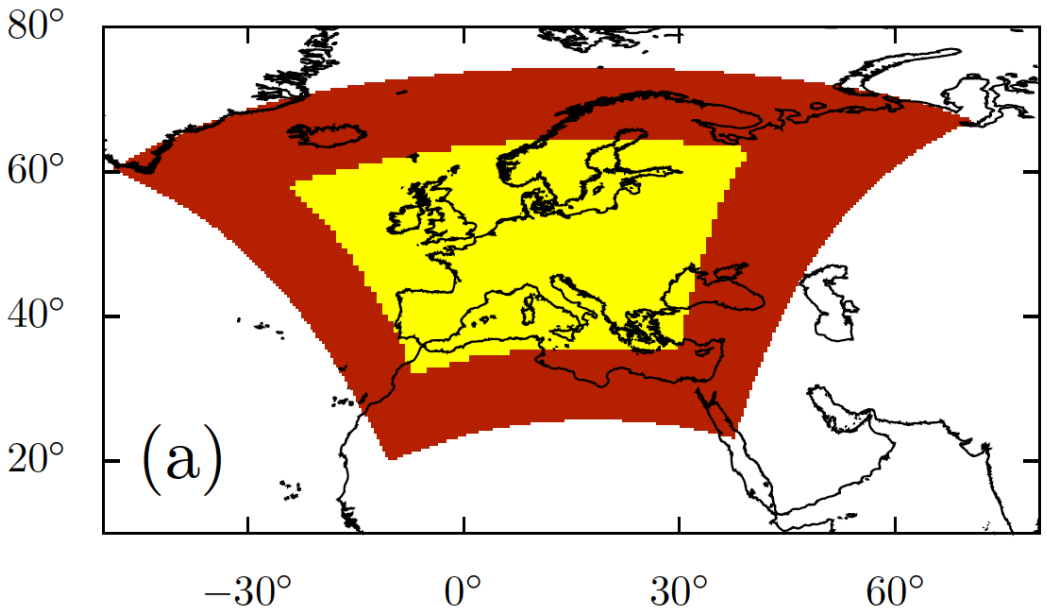

Fig. 1. The Euro-CORDEX domain (0.11, red) and the Inner European Region (0.04, yellow) used for the high-resolution integration.

Model precipitation and its statistics are compared with different observational and reanalysis datasets available for 1979: on the reanalysis side we considered the ERA-interim dataset (Dee et al., 2011), the Modern Era Retrospective analysis for Research and Applications (MERRA; Rienecker et al., 2011); the Climate Forecast System Reanalysis (CFSR); Saha et al. (2010) and Wang (2011); on the observational side, instead, the Global Pre cipitation Climatology Project merged precipitation dataset (GPCP; Adler et al., 2003); the Global Precipitation Climatology Centre datatset (GPCC); the Climatic Research Unit dataset (CRU) and the European high resolution gridded data set E-OBS (Haylock et al., 2008). It is worth to mention that for the GAR area, we also consider the HISTALP precipitation dataset (Auer et al., 2007) and the more recent high-resolution Alpine precipitation gridded dataset (EURO4M- APGD) developed by Meteo Swiss in the framework of the EURO4M collaborative project (Isotta et al., 2013).

The WRF numerical experiments adopted grid spacing ranging from 0.44° to 0.04° and different possible parameterizations related to microphysics, convection and planetary boundary layer phenomena aiming at identifying a suitable configuration allowing the most satisfactory reproduction of rainfall statistics for the chosen grid spacing. Hereafter a summary of the option used is given:

Microphysics schemes. Three different microphysics schemes have been considered: the WRF Single-Moment 6-Class Microphysics Scheme (WSM6, Hong and Lim, 2006), the Thompson et al. (2004) microphysics closure and the Morrison and Gettelman (2008) scheme. These are all 6-class schemes which consider vapor, rain, snow, cloud ice, cloud water and graupel. Additional sensitivity tests have been implemented using the Thompson microphysics. We also examined the impact of changes in the parameter related to the number of cloud droplets, the Ntc parameter, and a modification of the collision efficiency for rain collecting cloud water in the Thompson scheme.

Convection parameterization schemes and grid spacing. Two different convection parameterization schemes have been considered: Kain-Fritsch CAPE removal time scale closure (KF; Kain and Fritsch, 1990) and the Betts-Miller-Janjic adjustment type closure (BMJ; Betts, 1986) schemes. A set of simulations, with grid spacing equal to 0.44° and 0.11° over the EURO-CORDEX domain has been then performed and evaluated. Subsequently these results

have been compared also with a high-resolution run with explicit convection at a resolution of 0.04° ≈ 4 km, two-way nested in the aforementioned 0.11° grid spacing runs.
Planetary boundary layer parameterization. Two different PBL schemes were considered: the Yonsei University (YSU) scheme (Hong et al., 2006) and the Mellor-Yamada-Janjic (MYJ) scheme (Mellor and Yamada, 1982). The MYJ PBL scheme is a 1.5-order (level 2.5) local turbulence closure model which uses the prognostically calculated turbulent kinetic energy to determine vertical mixing while YSU is a first-order nonlocal scheme.

Part 2 WRF control runs. A set of control runs for the period 1979-2009 using ERA-Interim reanalysis and the optimal WRF model configuration derived from part 1 research is currently on going at the LRZ supercomputing center, Garching, Germany, in the framework of the Gauss-EXPRESS project.

Unit 1, ISAC-CNR, WP3.

In this first phase of RAMS modelling activities, a thorough review of the specialized literature on high-resolution simulations in highly complex terrain was conducted. This allows to identify the critical aspects of performing simulation of the atmospheric circulation in very inhomogeneous topographical conditions. The main issues that proved to be critical and need further assessment are:

- Grid resolution: to simulate the subgrid-scale phenomena, in particular the variations of the surface properties influencing the local meteorology, fine grid resolutions (order 1 km) should be used. Coarser resolution is not sufficient to reproduce appropriately atmospheric processes in complex terrain with a highly variable surface.
- Nesting technique: improvements in the agreement between predictions and observations appear on the finest grids with respect to the coarse ones, thanks to the nesting process.
- Topography smoothing: smoothing algorithms that depend on the grid resolution may not properly resolve the strong observed fluctuations in the meteorological fields.
- Initial and boundary conditions: mesoscale simulations are very sensitive to initial and boundary conditions, a preliminary sensitivity analysis is generally needed for properly configuring the simulations.
- Initial and nudging input fields: the assimilation of local observed data can contribute to improve the performance of the simulations but needs to be treated with attention, in particular when the observational net is limited in the considered domain, since it may affect the fields also in other parts of the domain that should not be influenced.
- Initial soil values (temperature, humidity): lack of observed data and information on the soil thermo-dynamical variables is one of the limits which can affect the performances of the numerical models, particularly in winter; also, not yet optimal information is available on snow coverage.
- Turbulence parameterization: the boundary-layer assumption, generally adopted in mesoscale models, prevents accounting for horizontal contributions to the horizontal strain rate, while they can have important effect in non-homogeneous conditions.
- Parameterizations: preliminary sensitivity tests are generally needed for the specific application in order to use the most appropriate parameterizations, like for radiation schemes, microphysics, convections, boundary layer etc.
- Computational aspects: compilers, compiler options, hardware and its system software, rounding errors algorithms etc., may influence the model outcome.
- Numerical issues: the choice of the discretization scheme with regard to accuracy, stability and computational cost, the impacts of implicit and explicit diffusion and

problems associated with coordinate systems have to be accounted for.

Thanks to the analysis of results from the literature, it will be possible to establish the guidelines for the sensitivity analysis to carry on with RAMS simulations in the framework of the RECCO project.
As a second activity, past RAMS simulations in the Italian Alps, performed in the Frejus and Brenner areas, were collected and a database is under preparation. In next months, these runs will be further analyzed to provide specific guidelines for RAMS configuration to be used in other areas of interest for NextData, such as the HKKH. In particular, we plan to perform preliminary tests in areas where new observations are collected for Nextdata, in the Italian Alpine area and the HKKH area. In this framework, input datasets useful for at high-resolution simulations were identified and are going to be considered:
http://eros.usgs.gov/elevation-products;
http://eros.usgs.gov/land-cover;
http://bioval.jrc.ec.europa.eu/products/glc2000/glc2000.php
http://due.esrin.esa.int/globcover/

Unit 2, ICTP; WP1.

Research activities during the NextData reference period have mostly focused on the analysis of a series of scenario simulations with RegCM4 at 50 km resolution completed over 5 CORDEX domains, and on the completion of a new 12 km resolution scenario run over the Mediterranean region.

The CORDEX runs, which are part of the CORDEX RegCM hyper-MAtrix (CREMA) experiment, covered the Africa, Mediterranean, South Asia, Central America and South America CORDEX domains. Runs were carried out with different driving GCMs, greenhouse gas concentration pathways (RCP4.5 and RCP8.5) and different RegCM physics configurations (convection and land surface schemes). The analysis covered different aspects of the simulations. A series of papers was produced as part of this analysis, contributing to a Special Issue of Climatic Change currently under way. The different papers of this special issue (see “Publications”) covered the following topics:

Analysis of the biases and changes in the full ensemble of driving global and nested regional runs. (Coppola et al., 2014) This work showed that the models exhibit a good performance in simulating climate characteristics over the domains of interest.

Analysis of extreme temperature and precipitation events over the different domains (Giorgi et al., 2014, Figure 2). This work showed the added value of the regional model in simulating such events and an increase in heat waves and precipitation extremes associated with global warming.

Analysis of changes in monsoon precipitation regimes over the Africa domain (Mariotti et al., 2014). It showed a prevailing late onset and early retreat of the monsoon leading to a narrowing and intensification of the monsoon precipitation season.

Analysis of changes in the summer monsoon precipitation over the India sub-continent (Dash et al., 2014), which showed a general decrease of monsoon rain in line with observed trends over the main central India crop regions.

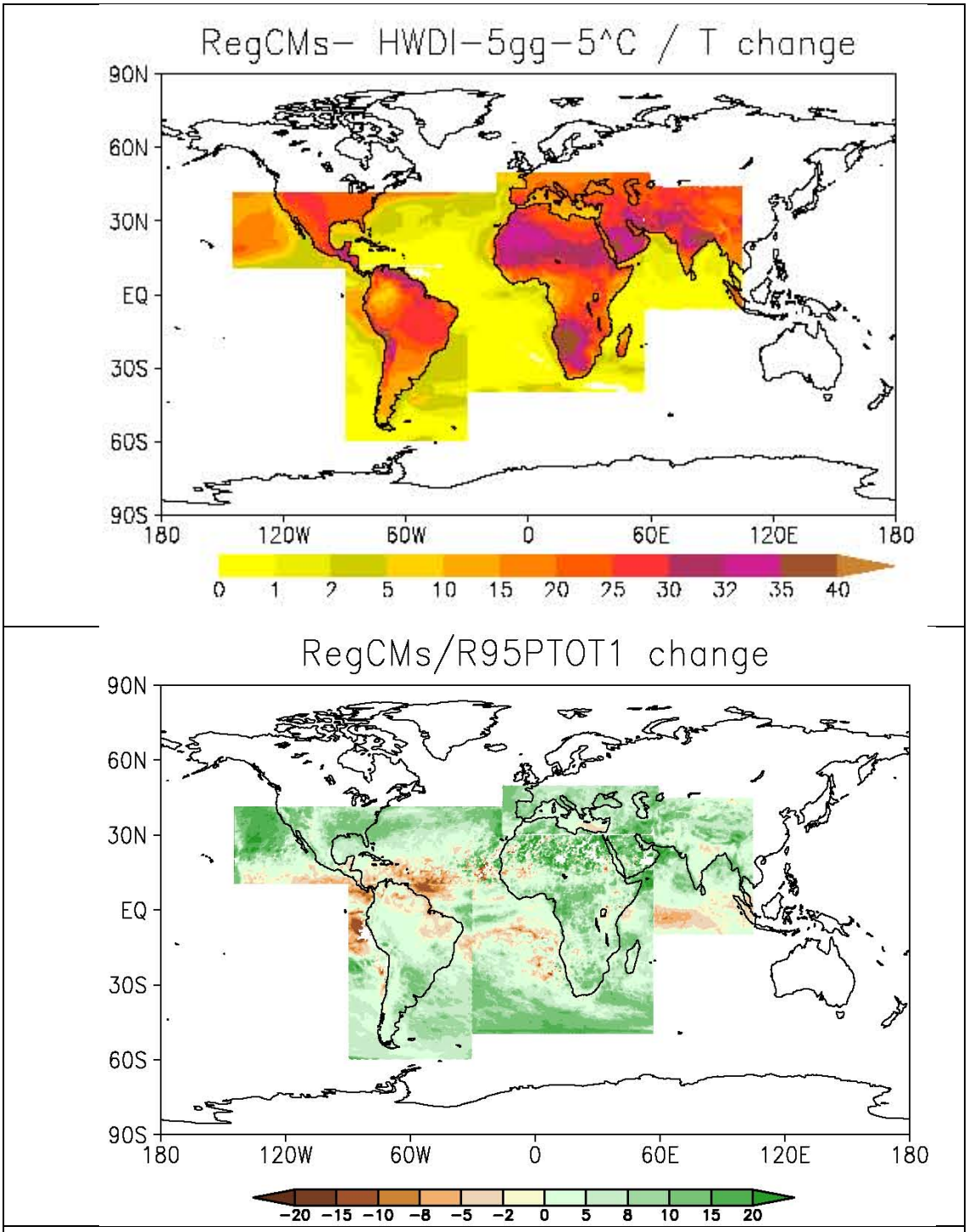

Fig. 2. Upper panel: Ensemble average change in the occurrence of heat waves over the five domains of the CREMA ensemble of RegCM4 scenario simulations (RCP8.5). Units are number of days per year per degree of warming. Lower panel: Ensemble average change in the ninety-five percentile of precipitation over the five domains of the CREMA ensemble of RegCM4 scenario simulations (RCP8.5). Units are % of present day value.

Analysis of changes in interannual variability (Fuentes-Franco et al., 2014) and tropical storm statistics (Diro et al., 2014), showing both a strong sensitivity of the model simulation of tropical storms on physics schemes and driving GCM and a decrease in number but increase in intensity of storms over the Atlantic region.

Analysis of the effects of El Nino (Da Rocha et al., 2014) and land-atmosphere interactions (Llopart et al., 2014) on the climate change signal over the South America continent.

Application of the Factor Separation method to a large ensemble of scenarios over the Mediterranean region in order to investigate the relative importance of different aspects of the model configuration in determining the climate change signal (Torma et al., 2014). This study illustrated the usefulness of the FS technique to study the importance of different sources of uncertainty in climate projections.

In general, these experiments indicated a strong sensitivity of the simulated climate change signals on the model physics schemes, thus providing a substantial contribution to the uncertainty of the simulated signals and further stressing the need of large ensembles to characterize these uncertainties.

Finally, during the reference period, the analysis of the high resolution Mediterranean scenario simulation was also initiated and is currently under way.

Unit 4, IMAA-CNR, all WPs

IMAA-CNR has:

- processed ground based and satellite remote sensing observations of clouds and precipitation and it is ready to make all the data available to the project partners (mostly already publicly available from other international databases of the observations networks in which IMAA is participating).
- finalized retrieval of clouds and rain rate from satellite observations.
- performed routine evaluation of the main European mesoscale weather models (ECMWF, MetOffice, MeteoFrance, ….).

3.2 Applications; technological and computational aspects

Unit 1, ISAC-CNR, WP3.

The latest version of RAMS6.0 was downloaded and its modification for including the most updated routines for the turbulence parameterization elaborated in past year at ISAC-CNR Torino is in process.

Unit 2, ICTP; WP1.

The horizontal and vertical parallelization of the model has been completed, this version allowed us to increase the resolution of the model up to 12km while keeping reasonable computational wall times.

The coupling with the MIT GCM ocean model has been completed in September 2013. From November 2013, a new coupling with the latest version of Community Land Model (CLM4.5) has been started; this coupling requires another substantial change in the parallelization of the code.

Unit 3, CINECA

CINECA is '"Hosting member" of European research infrastructure (PRACE) and is involved in a large number of European community projects. The computing infrastructure that has been used for the activities of this project includes one of the TOP500 architectures in the world (FERMI), which is characterized by a high number of cores for more “challenging” applications and a new machine (EURORA) which is able to guarantee high performance computing power to a very low energy consumption and is considered the prototype of the future architectures towards exascale Computing.

EURORA is a commodity cluster and is composed by 64 compute nodes. Each node contains two Intel Xeon Sandy bridge and 2 "accelerators" to support the computation: either 2 Intel Xeon Phi (MIC) or 2 NVIDIA K20S.
This cluster (or the equivalent cluster suitable for technical computing, namely PLX, based on similar processors) can be used for computational simulations of medium and small size, like RAMS .
RAMS is the limited area model used by CNR ISAC for simulations carried out under the project, with particular emphasis for all those characterized by a complex orography and high / very high spatial resolution. RAMS, currently at Release 6.0, has been developed over the years to adapt to the evolution of architectural "supercomputer". In particular, with regard to more computational aspects, it was parallelized using the standard MPI (Message Passing Interface), which transformed it into a code of computationally efficiency and portable on the majority of today's supercomputers ("clusters " in memory distributed models or MIMD).
For this kind of activity, all the aspects which are related to the parallelization of ROMS (scalability, speed-up, efficiency, I O) have been considered and addressed, for now, through simple benchmarks on the cluster EURORA (or PLX).
The next steps, once the "fine-tuning" of the model on the machine has been finished, will cover studies of "sensitivity analysis" that will involve the use of the model in a "farm-wise" manner on the geographical areas of interest for the project

3.3 Formation

Unit 1, ISAC-CNR, WP3.
An associate researcher will start officially to collaborate to the project under a granted position in March 2014. In these previous months the researcher is being trained on the specific use of RAMS at high resolution and is studying the related literature.

Unit 2, ICTP; WP1.
A student was invited to ICTP for a period of 8 months to carry out the tests with the new version of the model under the supervision of ICTP scientific staff.

3.4 Dissemination

The RegCM model is a free and public code and it is maintained for community use. The outputs from the CORDEX simulations are available for community use, particularly for impact studies.

3.5 Participation in conferences, workshops, meetings

The preliminary results of WRF simulations (WP2) have been presented to the International Conference on Regional Climate - CORDEX 2013 (Bruxelles, 4-7 November 2013).

From the 4th to 7th November 2013 Filippo Giorgi, Laura Mariotti, Gao Xuejie, Ramon Fuentes Franco and Ismaila Diallo attended to the International Conference on Regional Climate – CORDEX 2013 in Brussels

Filippo Giorgi attended NextData-RECCO meeting in Torino (3 July, 2013).

Laura Mariotti attended the NextData-WP2.5 meeting in Bologna (19 September, 2013) and in Rome (12 November, 2013).

Silvia Trini Castelli organized the NextData-RECCO meeting in Torino (3 July, 2013), attended NextData-WP2.5 meeting in Bologna (19 September, 2013) and NextData meeting in Rome (12 November, 2013).

PieroLanucara attended the NextData-RECCO meeting in Torino (3 July, 2013) and the NextData meeting in Rome (November 12, 2013).

Fabio Madonna attended the NextData-RECCO meeting in Torino (3 July, 2013).

4. Results obtained during the reference period

4.1 Specific results (Data libraries, Measurements, Numerical simulations, etc)

Unit 1, ISAC-CNR, WP2

An illustrative example of the first part of the results for WP2 simulations is presented hereafter. Concerning the annual rainfall rate, Table 1 reports its average over the Inner European Region and limited to land surfaces, for the different numerical experiments and the different observational datasets. The table also reports the percentage difference between the precipitation averages from the simulations and the average from the CRU dataset. It is clear that all the numerical simulations produce precipitation values which are significantly larger than those indicated by the observational datasets. The simulation using the BMJ parameterization (c4ei) and its counterpart at high-resolution (h1e4) are the only two with less that 30% excess precipitation with respect to the gridded data.

Tab. 1. Annual rainfall rate averages (arr) for (a) the different observational datasets and (b) the different WRF configurations used in the present study. The rightmost column reports the percentage difference from the CRU dataset.

(a)

Dataset	arr [mm.day^{-1}]
cfsr	2.89
cru	2.09
eobs	1.75
erai	2.24
gpcc	2.16
gpcp	2.51
merra	2.06

(b)

Run	arr [mm day^{-1}]	Excess
c1ei	2.78	33.2%
c2ei	2.83	35.4%
c3ei	2.92	39.8%
c4ei	2.65	26.9%
c1fi	2.89	38.4%
c1gi	2.84	35.8%
c1hi	2.81	34.7%
c1li	2.91	39.4%
cmjy	2.77	32.9%
h1e4	2.63	26.1%

Unit 1, ISAC-CNR, WP3.

The analysis following the literature review for simulation at high resolution in complex terrain allowed identifying the main critical issues and outlining the guidelines for the following sensitivity analysis to be carried on with of RAMS model in the Italian Alps/Apennines and HKKH areas.

Unit 2, ICTP; WP1.

A new simulation over the Mediterranean at 12km of resolution has been completed at the end of December 2013. Data from the CREMA experiment runs are being assembled and transferred onto the NextData aArchive.

Unit 3, CINECA, all WPs.

Literature review for computational aspects of RAMS model. Preliminary benchmarks on CINECA clusters (EURORA and PLX).

Unit 4, IMAA-CNR, all WPs

Collection of the following databases:

- Ground based observations of Essential Climate Variables for the study of aerosol, clouds, precipitation and radiation (available since 2004).
- Output of the main European mesoscale weather models retrieved over the IMAA-CNR Atmospheric Observatory (CIAO), in cooperation with Cloudnet (www.cloud-net.org).
- Systematic in-situ radiosounding providing vertical profiles of PTU and wind along with their uncertainty budget obtained using the GRUAN data processing (GCOS Upper-Air Reference Network).
- Rain rate estimation retrieved for all AMSU overpasses over Italy since 2011 (possible extension to earlier data) available for the project activities.

4.2 Publications

Unit 2, ICTP; WP1.

Articles have been submitted for the special on "*Climate Change*" (about 8 items) on the first results and analysis of the CORDEX simulations. Items are in the final approval stage, the special issue should be released by 2014.

Another publication has been submitted to *Atmospheric Science Letters*.

Submitted to *Climatic Change Special Issue* 2014:

The bias and climate change signal in the Phase I CREMA ensemble (COPPOLA et *AL.*).

Changes in extremes and hydroclimatic regimes in the CREMA ensemble projections (GIORGI et AL.).

Seasonal and intraseasonal changes of African monsoon climates in 21st century CORDEX projections (MARIOTTI et AL.).

Projected Seasonal Mean Summer Monsoon over India and Adjoining Regions for the 21st Century (DASH et. AL).

Changes in inter-annual variability of precipitation over Southern Mexico and Central America from RegCM4 CORDEX projections and their relationship to Sea Surface Temperature (FUENTES FRANCO et AL.).

Tropical cyclones in a regional climate change projections with RegCM4 over the CORDEX Central America domain (DIRO et AL.).

Interannual variability associated with ENSO: present and future climate projections of RegCM4 for South America-CORDEX domain (DA ROCHA et AL.).

Climate change impact on precipitation for the Amazon and La Plata basins (LLOPART et AL.)

Submitted to *Atmospheric Science Letters*:

Assessing the contribution of different factors in regional climate model projections using the Factor Separation method (Torma et al.).

Unit 1, ISAC-CNR; WP2.
PIERI A., J. VON HARDENBERG, A. PARODI AND A. PROVENZALE, Do precipitation rates from non-hydrostatic simulations agree with data? A view from the WRF model over Europe, submitted to *Journal of Hydrometeorology*, 2013

Unit 4, IMAA-CNR
E. RICCIARDELLI, D. CIMINI, F. DI PAOLA, F. ROMANO, AND M. VIGGIANO, A statistical approach for rain class evaluation using Meteosat Second Generation-Spinning Enhanced Visible and InfraRed Imager observations, *Hydrology and Earth System Sciences*, in review.

4.3 Availability of data and model outputs (format, type of library, etc)

Unit 1, ISAC-CNR; WP3. Output from selected RAMS simulations in RAMS-specified HDF5format, to be adjusted to NectCDF format established in NextData protocol

Unit 2, ICTP; WP1. Output from the CORDEX simulations are in NetCDF format following the NextData protocol.

Unit 4, IMAA-CNR, all WPs. All the data are available on both the IMAA-CNR data archive and on the open access databases of the observing networks in which IMAA-CNR is actively participating (Cloudnet, AERONET, EARLINET, GRUAN, …). Data are in NetCDF format.

4.4 Completed deliverables

The following deliverables are currently in preparation (there was a delay due to the late arrival of NextData funding in 2013):

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.

D3.1. Report discussing the critical issues for high-resolution and complex-terrain simulations and the analysis of the preliminary RAMS runs.

5. Comment on differences between expected activities/results/deliverables and those which have been actually performed.

Unit 1, ISAC-CNR.

Since the budget for RECCO project was available at the end of September 2013, it was not possible to activate research grants before the end of 2013. This implied a delay in the actual model simulation activity, which will be mostly performed by young researchers for training and formation purposes. The runs with the RAMS model will start in the first months of 2014 and any delay will be compensated with the contribution of the new associate researcher which is going to be hired.

Unit 2, ICTP.

The collection of the data on the archive has not been completed yet; the post-process phase is still ongoing. In the following Table 2 a list of the simulations on the NextData Archive is reported.

Table 2. *Unit 2, WP1.* Summary of the experiments that have been transferred to the NextData Archive; all runs at 50km of horizontal resolution.

Domain	**Boundary conditions (GCMs)**	**period**
Africa	HadGEM scenarios: RCP4.5, RCP8.5	1970-2100
Africa	MPI ECHAM6 scenario RCP8.5	1970-2100
Central America	HadGEM scenarios: RCP8.5	1970-2100
South America	HadGEM scenarios: RCP8.5	1970-2100
Mediterranean	HadGEM scenarios: RCP8.5	1970-2100
Mediterranean	MPI ECHAM6 scenario RCP8.5	1970-2100

6. Expected activities for the following reference period

Unit 1, ISAC-CNR, WP2

One scenario time slice (10 years) over the European area will be produced with the WRF model using as forcing the RCP 4.5 emission scenario provided by the EC-Earth climate model

Unit 1, ISAC-CNR, WP3

Further elaboration of the test runs and analysis of the key items for high-resolution applications; first RAMS simulations in the Italian Alpine and HKKH areas.

Unit 2, ICTP; WP1.

Completion of additional simulations for the Mediterranean and South Asia domains.

Unit 3, CINECA

The next steps, once the fine-tuning of the RAMS model on the machines has been finished, will be sensitivity analysis studies in which the model will be used in "farm-mode" for the areas of interest of the project.

Unit 4, IMAA-CNR, all WPs

- provide satellite, ground based and in situ observations of the atmosphere thermodynamics and the related retrieved products.
- provide rain gauge data for the CIAO station and for the whole network available in Basilicata region (data provided by the regional agency ALSIA) for the validation of model output over the Apennines region.
- identify observations and products relevant for the modelling activities.

References

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