ALADIN-Climate: from the origins to present date

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1. Introduction

The story of ALADIN-Climate is of course much shorter than that of its NWP counterpart. It started about 10 years ago, when Janiskowa proved that a one month long simulation of ALADIN without any assimilation in the domain was possible. The model, driven by 6-hourly ARPEGE analyses at its lateral boundaries did not diverge numerically and provided acceptable meteorological situations. A few years later, three Czech institutes (CHMI, CUNI and CAS) launched a common project on climate simulation. The idea was to use ARPEGE-Climate as a driving model for IPCC climate scenarios, and possibly introduce parameterizations from the climate model better suited for this exercise: radiation code including explicitly greenhouse gases and aerosols, cloud scheme without empirical moisture profile and deep soil scheme without relaxation. The role of CNRM was to provide lateral conditions from his own scenario simulations, and routines from ARPEGE-Climate.

Once the PRUDENCE European project was finished, the partners prepared the GENIE proposal, which was later included in ENSEMBLES. The aim of this project was to go from the 50 km horizontal resolution of PRUDENCE to 20 km or even 10 km. Up to this date, the CNRM based his regional climate simulations on a variable resolution of ARPEGE (Déqué and Piedelievre, 1995). In climate simulation over Europe, it is important that the stretching factor is not greater than 3, otherwise the low resolution over the far Atlantic produces a too south storm track. As a consequence, 20 km resolution is very expensive (3 months to produce 10 years on ECMWF computer) and 10 km resolution impossible with present hardware. Therefore, CNRM decided, in order to continue participating in the European climate modelling group, to have a more active role in the design of an ALADIN-Climate model. In 2003, this was made possible, as version 4 of ARPEGE-Climate, based on cycle 24 of ARPEGE-IFS, is ALADIN compatible.

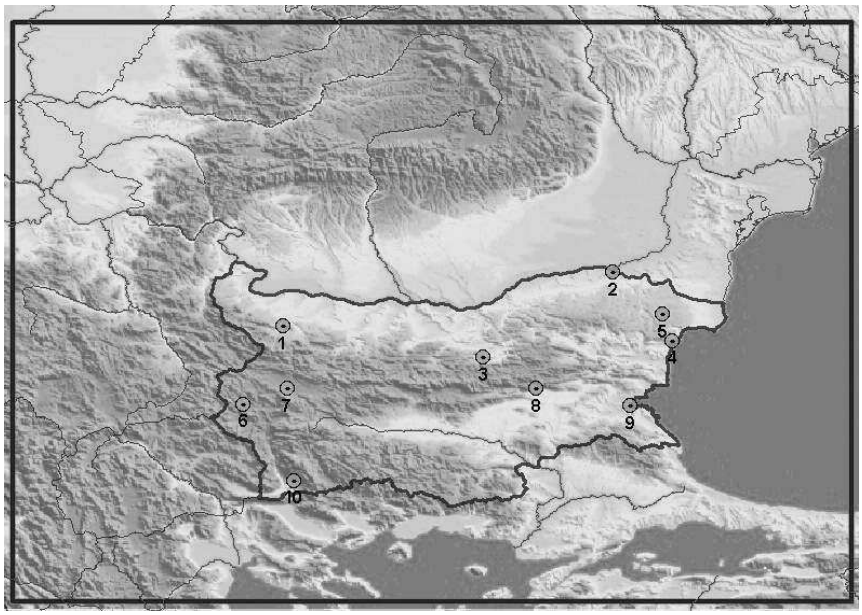
2. The ENSEMBLES project

There is an additional reason for the development of ALADIN-Climate at CNRM. A variable resolution model cannot be driven at its boundaries by observations. In ENSEMBLES, each regional model should be weighted, according to its realism to reproduce present mean climate and present climate fluctuations. This weighting will be based on an ERA40-driven simulation of each participating model. Météo-France and CUNI-CHMI are participants in this project. Météo-France will use a version directly derived from ARPEGE-Climate 4, whereas CUNI-CHMI will develop an original version based on a more recent cycle of ARPEGE-IFS. Both groups will run two 40-year runs at 50 km and 25 km resolution on a wide domain covering Europe from Greenland coast to Nile mouth. Then Météo-France is committed to provide a 100 year simulation of the 1950-2050 period driven by a GCM involved in IPCC scenarios. It is highly probable that the GCM will be ARPEGE-Climate and the scenario A1B. The geometry of ALADIN in this exercise will be the 25 km resolution over the wide European domain.

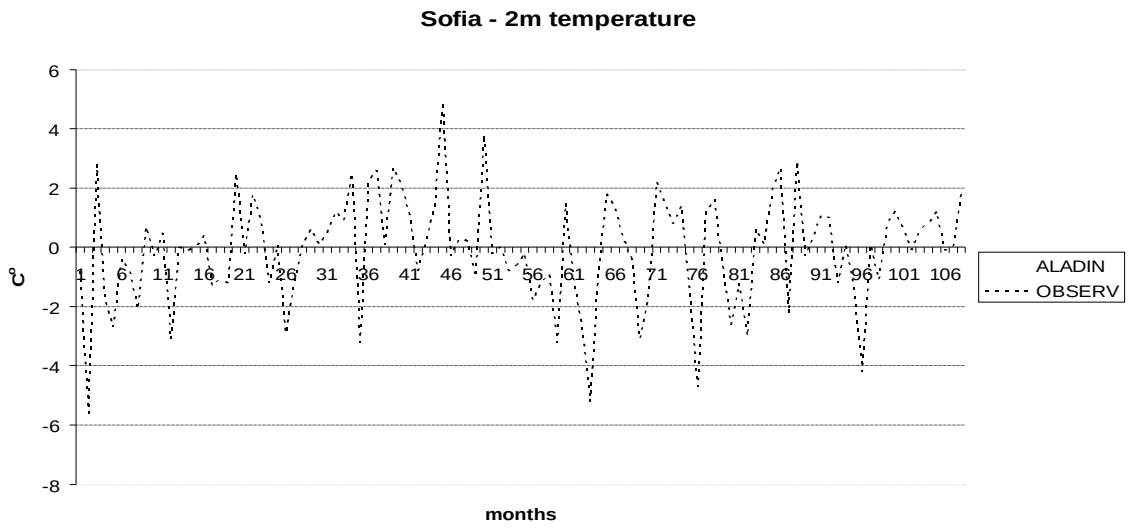
3. Application to the Bulgarian domain

Downscaling of a global model with a certain LAM needs some preliminary experiments. That is necessary for evaluation of the method feasibility. The ERA40 data was used as boundary conditions during the integration of ALADIN-Climate in the period 1990-1999. The model resolution was 12 km. The observations were taken from synoptic stations, representative for different micro-climatic regions in Bulgaria. The domain and stations are shown bellow.

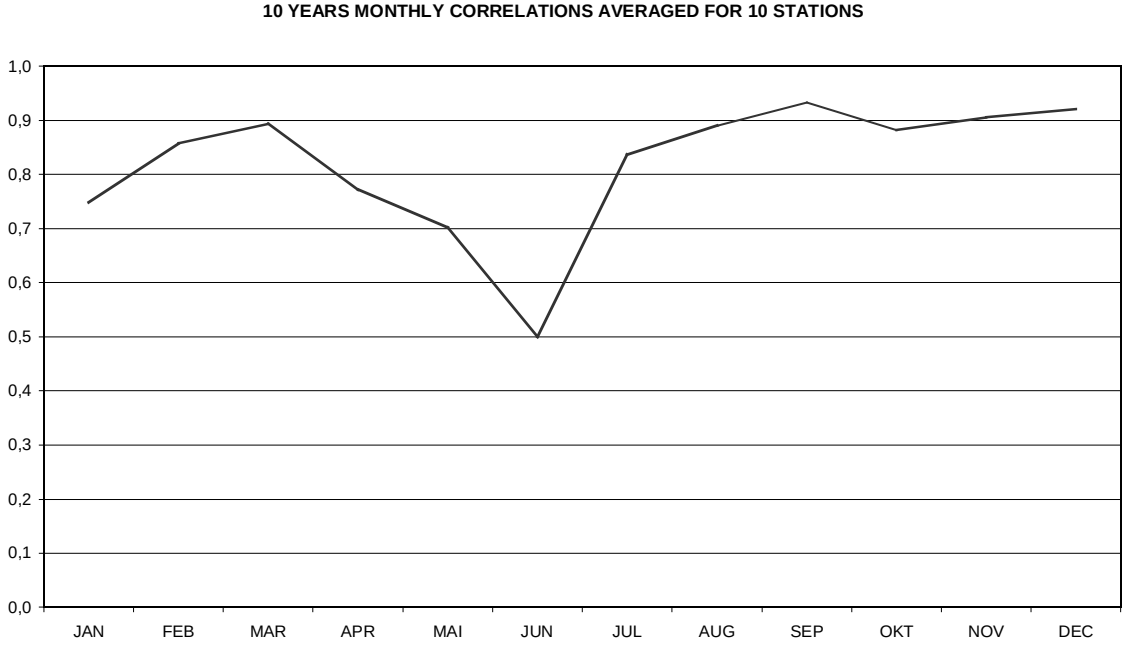
DOMAIN AND LOCATION OF THE SYNOPTIC STATION



The following example of model results and observed monthly mean temperatures shows smoother variability of the model comparing with observation. Similar behavior was recognized for all stations.



Averaged for all 10 stations correlation coefficient varies with months. May and June are the most problematic in this experiment.



Finally we can conclude that the 'jump' up to 10 times' finer resolution (~120 km for ERA40 data and 12 km for the model) is possible. Downscaling over small domain gives reasonable and more detail temperature field even with big increasing of resolution.

4. Bilateral cooperation

ALADIN has been from the beginning subject to bilateral research projects. At present, two project concern ALADIN-Climate. A project started two years ago between France and Bulgaria. The theme is the design of small size high resolution domains with the ARPEGE-Climate physics. Indeed, contrary to the NWP physics, the

parameterizations of the climate version are developed at 250 km resolution, and tested up to 50 km resolution in the stretched geometry. On the other hand, they have proved to be robust in multi-year integrations. The climate group of CNRM is indebted to NIHM for his contribution in the formation of climate modellers to the tips and tricks of ALADIN. A second project between France and Romania will start in 2006 and concerns the introduction of spectral nudging in ALADIN-Climate. Indeed, running a LAM in multiyear simulation is a challenge to numerics, as the solution imposed at the lateral boundaries is not a natural solution of the system of equations. The two ways to circumvent this flaw is either to use a small domain, so that the LAM is enough constrained, or to add a constraint on the large waves inside the domain to maintain the consistency between the centre and the boundaries.

5. Perspective: the CECILIA project

In December 2004, a meeting organized in Prague by Halenka in the framework of the MAGMA Centre of Excellence resulted in the creation of an informal group including modellers from Czech Republic, Bulgaria, Romania, Hungary, Austria, Italy (ICTP), Denmark (DMI) and France (Météo-France). A response to an European-Commission call for proposal was coordinated by Halenka in October 2004 with the acronym CECILIA. At time of writing, CECILIA has passed the first step of the review process, but we don't know whether CECILIA is definitely accepted. In any case, a community on climate modeling of eastern and central Europe is born. In this project, complimentary to ENSEMBLES, country-wide domains of ALADIN and RegCM will be prepared at 10 km resolution. Thirty-year simulations (1961-1990, 2021-2050 and 2071-2100) driven by 50 km-resolution versions of ARPEGE-Climate (global variable resolution) and RegCM (wide ENSEMBLES domain over Europe) will be carried out. As a validation, an ERA40-driven simulation will also be performed. The project also includes statistical downscaling, extreme events analysis, and impacts on air quality and forestry.

6. Perspective: a coupled model for the Mediterranean Sea

The Mediterranean climate and the Mediterranean Sea should be studied with regional ocean-atmosphere coupled models (Somot, 2005). Indeed high resolution and air-sea coupling are often essential in Mediterranean climate processes (cyclogenesis, open-sea deep convection, …). ALADIN-Climate (resolution of 20 km) associated with a Mediterranean version of the ocean model OPA (10 km) and forced by ERA40 (or by a climate model) lateral boundary conditions will be a well dedicated Atmosphere-Ocean Regional Climate Model (AORCM) to study Mediterranean climate. This regional coupling will be tested in the framework of the French ANR-CICLE project in the next three years. Regional process studies as well as interannual and climate change studies will be completed in comparing the regional coupled approach to the more classical forced approach.

References:

Déqué M, Piedelievre JP (1995) High-Resolution climate simulation over Europe. Clim Dyn 11:321-339

Somot (2005) Modélisation climatique du bassin méditerranéen : variabilité et scénarios de changement climatique. PhD thesis. Univ. Paul Sabatier, Toulouse, 333 pp. (in French)