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MEDITERRANEAN OCEAN
FORECASTING SYSTEM:
TOWARD ENVIRONMENTAL
PREDICTION

MFSTEP

Project Deliverable Report
D8

Atmospheric Forcing and Air-Sea Interaction Studies

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1) Introduction

This report describes the work performed under the scopes of deliverable 8 of WP10. This work package contains the necessary activities to create and deliver the atmospheric surface fields to the WP8 and WP9 ocean modelling community, and to define and perform the Severe Verification Period (SVP) intercomparison of atmospheric models. The aim of this sub-task (deliverable 8) is to define and document the protocols for atmospheric forecast data exchange among the partners. The IASA/AM&WFG group will utilize the nonhydrostatic SKIRON/Eta modelling system at high-resolution during the SVP and the Targeted Operational Period (TOP). IASA will make the model output available to the public through its webpage (http://forecast.uoa.gr) while the raw data will be disseminated to the project partners through a project dedicated ftp server. Similar actions will take place in the framework of the ALADIN-MFSTEP work at CHMI, as outlined below in parallel with the SKIRON part.

2) The SKIRON/Eta modelling system

The SKIRON/Eta system (Kallos, 1997, Papadopoulos et al. 2002) is based on the Eta/NCEP model. It has the unique capability to use either a "step-mountain" vertical coordinate (Mesinger 1984) or the customary pressure or sigma (or hybrid) coordinate. The current version of the Eta model is appropriately coded in order to run on any parallel computer platform (Kallos et al., 1997b). It has several unique capabilities making it appropriate for regional/mesoscale simulations in regions with varying physiographic characteristics and for simulations of the dust cycle. Some of the features of this model are summarised in the following:

- The arithmetic solution of the set of equations is performed in a grid point model using a finite difference scheme.
- It includes the option to use either the hydrostatic assumption or nonhydrostatic dynamics. In the framework of the MFSTEP project the model physics will include nonhydrostatic dynamics (Janjic et al., 2001). This is an important improvement especially for high-resolution simulations for which the non-hydrostatic processes may exert a significant influence on the meteorological fields.
- The model variables are represented on the staggered Arakawa E-grid.
- A special technique for protection from grid separation is used.
- Use of the "step-mountain" Eta vertical coordinate
- For horizontal advection the cascade process of non-linear energy toward smaller scales is under control.
- Use of a split-explicit time differencing scheme.
- Use of a 2.5 order closure scheme proposed by Mellor and Yamada for parameterization of the boundary layer.

- Use of a 2nd order closure scheme proposed by Mellor and Yamada for parameterization of the surface layer.
- Use of a viscous sublayer scheme.
- Parameterization of the surface processes using advanced schemes. A data assimilation scheme for soil temperature and soil wetness has been recently developed.
- Use of 4th order diffusion scheme in the field boundaries with diffusion coefficients dependent on the deformation and turbulent kinetic energy.
- The parameterisation of the subgrid scale convective processes is allowed to use either the modified Betts-Miller-Janjic or the Kain-Fritsch approach. Currently the model is being tested in a pseudo-operational mode using the Betts-Miller-Janjic convective parameterisation.
- The use of GFDL radiation schemes with random interaction of clouds at various levels.
- A series of pre and post processing modules for better utilization of the available input data and the model results.

The SKIRON/Eta modeling system is also including dust cycle capabilities. The hydrostatic version of the system is successfully used operationally in the University of Athens since 1997, as well as in applications of simulations of historical dust-storm events (Nickovic et al. 2001).

The computational model domain will cover the whole Mediterranean Region and part of Central Europe (Figure 1). In the horizontal, a grid increment of 0.1 degrees is applied. The coverage of each sub-area depends on the horizontal grid increment, which in our case is of about 10x10 km^2. In the vertical, 38 levels are used stretching from the ground to the model top at 25 mb (corresponding approximately to 25 km) or optionally to 50 mb (~20 km). The large number of vertical levels is expected to provide at least an adequate vertical representation of the physical processes especially within the atmospheric boundary layer.

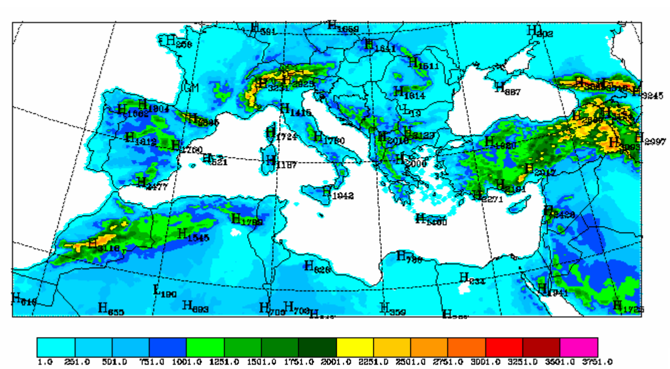

Figure 1. *The topography of the computational model domain of Skiron.*

High resolution topography, vegetation and soil data are used. The topography and vegetation data are available from USGS with a resolution of 30x30 arc sec, with the later following the SsiB classification. For soil textural class the UNEP/FAO dataset (2x2 arc min) is used after its conversion from soil type to soil textural ZOBLER classes. The model also allows the use of high resolution NCEP SST data of 0.5 degrees, high-resolution NESDIS snow and ice cover data and US Air Force snow depth analysis data. ARPEGE/ALADIN meteorological grid-point fields at a resolution of 0.25 degrees will be utilized in both SVP and TOP periods.

The high-resolution SKIRON/Eta modelling system will run parallel at the computer facilities of IASA. Specifically, a cluster of ten (10) dual-CPU nodes based on ATHLON-1900 processors will be used and has been configured in order to handle large data storage, namely a RAID 4:1 system handling approximately 350 GBYTE of data on line. The system will be exclusively available for the scope of the project. The system is connected to a high-speed network (35 Gbit/sec the slowest network section). The SKIRON/Eta modeling system will run parallel in order to achieve the highest performance.

The setup of the nonhydrostatic SKIRON/Eta modelling system has nearly finished and all the hardware/software components are tested in a pseudo-operational mode. The performance of the model will be tested and documented extensively in the Severe Verification Period hindcasts during the following months.

3) SKIRON/Eta Output

In the framework of MFSTEP project IASA will prepare a) operational 120-hour forecasts once every week during TOP and b) 72-hour hindcasts initialized from the daily operational ARPEGE analyses of January 2003 during SVP. The output will be made available to the partners and to the public via Internet.

The model output will become available to the general public as graphics in PNG (Portable Network Graphics) format for the full computational domain. On the other hand, the raw data will be available only to the project partners in ASCII or GRIB format in the dissemination domain. The computational domain is the full model domain covering the whole Mediterranean region and part of Central Europe. The dissemination domain will cover the Mediterranean Sea east of 18°E and the Black Sea (29°N-48°N, 18°E-42°E). An example of a 120-hour forecast of the accumulated precipitation and the mean sea-level pressure field in the computational domain is shown in Figure 2. The black frame over Eastern Mediterranean encompasses the dissemination domain. The associated predicted 10m. wind field for the same time as in the previous figure appears in Figure 3. The computational domain was chosen to extend to the west much further than the western longitude of the dissemination domain (18°E) because it is well known that during all seasons synoptic systems or air-masses originating over western Mediterranean (Gulf of Genova, Atlas mountains etc.) strongly affect the weather of eastern Mediterranean (e.g. Kallos et al., 1997a).

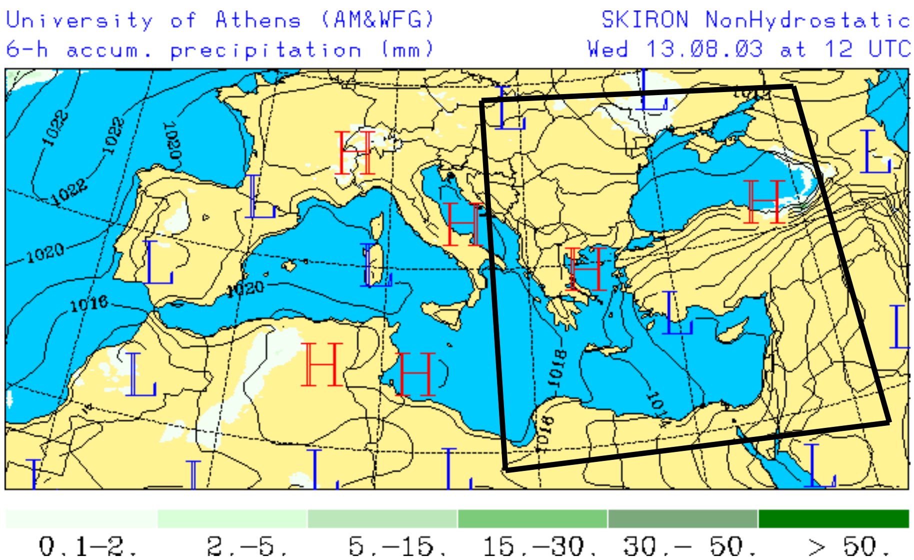

Figure 2. *120-hour forecast of the 6-hourly total accumulated precipitation and the mean sea-level pressure in the computational domain. The black frame indicates the dissemination domain. Initial time 1200UTC, 08/08/03*

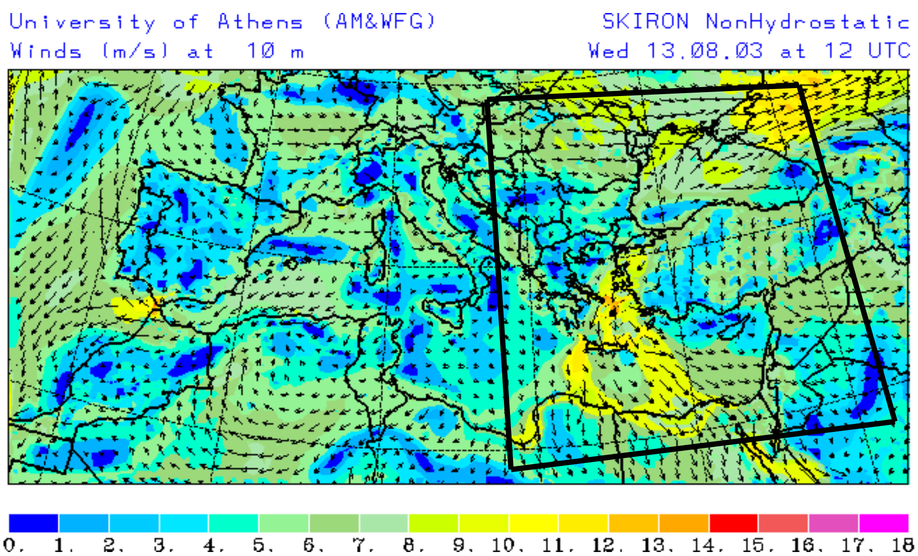

Figure 3. *120-hour forecast of the 10 m. wind field in the computational domain. Initial time 1200UTC, 08/08/03*

The meteorological fields that will become available to the project partners in the dissemination domain and will be used to force the ocean models include the 10m wind, 2m temperature, 2m specific humidity, cloud fraction, mean sea-level pressure, total accumulated precipitation, surface radiative heat flux components (shortwave downward, shortwave upward, longwave downward, longwave upward), surface latent heat flux, surface sensible heat flux, land-sea mask, and the sea-surface temperature. These fields will be available every hour from the initial time up to 120 hours in regular latitude-longitude format (0.1x0.1 degrees). The accumulated fields (e.g. precipitation) will be accumulated from the initial time. This allows the easier handling of this kind of fields by the end-user (e.g. ocean modeler).

4) ALADIN-MFSTEP modeling and assimilating system

4.1) INTRODUCTION

For the purpose of fulfilling the objectives of Work Package 10 of MFSTEP, a special configuration of the ALADIN NWP system will be run in dedicated mode on the SX6 computer of CHMI-Prague. The basic constraints of the TOP final set-up will be the following: (i) running a permanent ALADIN pseudo data assimilation cycle in full coupling with the 4D-Var long-cut-off cycle of the ARPEGE global NWP system of Météo-France in Toulouse (6 hour updating frequency in both cases, coupling every three hours, hourly output frequency for the atmosphere-ocean coupling data); (ii) once a week on Wednesday 00 UTC, launch of a 5 day ALADIN adaptation forecast coupled with a special run of ARPEGE based on the above-mentioned assimilation cycle (same conditions of coupling and production as above); (iii) an option will be considered in which SST results from the OGCM would enter the step ‘i’.

The system will be run on a 589 x 309 domain with a mesh size of 9.508 km (5591 x 2928 km^2 hence). The projection will be a Lambert tangential one (reference point 46.47N-2.58E) and the centre of the domain will be at 41.95N-9.81E. There will be 37 vertical levels irregularly spaced in the so-called ‘hybrid-eta’ coordinate of Simmons and Burridge (1981), the top one being at 5hPa and the bottom one at about 17 meters above the surface. The elliptic spectral truncations will be E299/159 (linear-grid) for the forecasting model and E83/44 for the filtering part of the so-called blending procedure. The time-step will be of 400 seconds.

The post processing will be done on a lat/lon grid of 0.1 degree in each direction with limits at 19W, 37E, 30N and 48N (561 x 181 points hence).

4.2) DYNAMICAL PART

The ALADIN Hydrostatic Primitive Equations (HPE) dynamics is the transcription to the Limited Area Modelling (LAM) world of the IFS/ARPEGE global one, jointly developed by ECMWF and Météo-France. The jump from the spherical geometry to the tangential plane one is accomplished following the idea of Machenhauer and Haugen (1987) which allows to keep all the advantages of the spectral approach at minimum overhead costs (see Geleyn, 1998). The vertical discretisation is the one advocated by Simmons and Burridge (1981). The semi-implicit, semi-Lagrangian two-time-level time-marching scheme is quite close to the one described in Ritchie et al. (1995), Simmons and Temperton (1997), Ritchie and Tanguay (1996) and Hortal (2000), with two ARPEGE/ALADIN enhancements: the implicit treatment of the Coriolis term as proposed by Rochas (see Temperton, 1997) and an analytical (rather than interpolated) computation of the coordinates of the origin point of the trajectories. This scheme allows the use of the so-called 'linear grid' (see Côté and Staniforth, 1988), i.e. a reduction to its minimum of the spectral aliasing problem, as well as very efficient time steps (Courant numbers down to 23 m/s).

For the reasons explained in McDonald (1998), the orography (still of 'envelope' type for the time being, see below) is fitted like for a classical quadratic grid, but applying the method of Bouteloup (1995) spectacularly reduces the Gibbs effects over sea.

The horizontal diffusion is implicit linear and fourth-order with a divergence damping factor of five. The e-folding time of the smallest wave for vorticity, vertically scaled temperature and moisture is set proportional to the model mesh-size with a ratio of 12.3 m/s in the linear-grid case. This value is the one for the surface and the effect increases with height in inverse proportion to pressure.

The lateral coupling of the LAM is of the Davies (1976) type and its interaction with the semi-implicit procedure is performed at no additional cost thanks to the suggestion of Radnoti (1995).

Beside the HPE version, there exists a non-hydrostatic fully compressible version of ALADIN (Bubnova et al., 1995) following the suggestion of Laprise (1992) to keep the HPE continuity equation unchanged through the use of a hydrostatic-pressure-based vertical coordinate. However, this will not be used in the basic MFSTEP set-up, owing to its very small impact at 10 km of mesh-size.

4.3) PHYSICAL PARAMETRISATION PART

Radiation computations

The basic scheme is adapted from Geleyn and Hollingsworth (1979) and Ritter and Geleyn (1992) and simplified enough for being able to describe the interactions soil-radiation and clouds-radiation at each time step. The three main 'compromise' hypotheses for speeding-up the calculations are the following:

- only one spectral interval in the solar as well as in the thermal range, but consideration of all active gases as well as of the separation between liquid- and ice-cloud components;
- grey body assumption (i.e. linear monochromatic behaviour) for all effects except gaseous absorption (but multiple scattering is treated without approximation, even in the thermal domain, thanks to a delta-two-stream computation with a choice between random and maximum-random (unused) overlap hypothesis for cloud geometry);
- the interaction between line absorption of gases and two-stream 'adding' method as well as the saturation effects of the former are treated via the diagnostic estimation of a 'minimum' gaseous optical depth for all remaining effects, once (i) absorption of parallel solar radiation in the solar domain and (ii) so-called 'cooling to space' and 'exchange with surface' terms in the thermal domain have been treated exactly.

The diagnostic schemes for the 'radiative' clouds link the cloudiness to the production of stratiform and convective precipitations, and to the existence of inversions. The scheme is based on the following principles:

- cloudiness functionally depends (with different parameters for the stratiform and convective contributions to a single amount) on the diagnosed liquid- ore ice-water-content; the functional dependency is one of those proposed by Xu and Randall;
- the contribution is obtained from the rate of generation of convective precipitation at the previous time step in one case;
- in the other case, one estimates the instantaneous super-saturation of the air properties averaged along a certain delta-theta thickness below, with respect to the local saturation state multiplied by a 'critical relative humidity' vertical profile (tuned with two parameters only);

the partition between ice and liquid state depends only on temperature with a progressive transition below 0°C.

One is currently considering a new structure for the radiative computations in which the clear sky gaseous computations, the cloud/aerosol sub-model and the delta-two-stream solver would be considered as three independent parts, this allowing more flexibility and a different view of the 'radiative time stepping problem'. The benefits of this action will very likely be included in the MFSTEP pre-TOP phase, pending successful testing.

Turbulent vertical diffusion and PBL

The common scheme for the surface and upper-air exchanges is designed according to Louis (1979) and Louis et al. (1981), with the shallow convection incorporated according to Geleyn (1987) and recently modified to cure a tendency to an on/off behaviour in time and along the vertical. For the past four years a big effort (still on-going) has been made to improve the coefficients' dependency on the Richardson number in case of stable situations. Two (positive) critical Richardson numbers (each with a potentially modulated vertical profile) have been introduced. The first one deals with the enhancing effect on fluxes of sub-grid inhomogeneities and the second one with the difference in the effect of such inhomogeneities between the thermal and momentum parts of the calculation.

A retuning of the 'mixing length' vertical profile was applied during this work and it is intended to make it dependent at some stage on the time- and space-dependent height of tropopause and PBL depth, the latter computed according to Ayotte.

The residual gusts when the wind is weak near the sea surface and the situation is unstable are treated via a stability-dependent enhancement of the result of the basic Charnock formula, in the spirit of the work of Miller. An enhancement to the moist convective case, inspired by the ideas of Redelsperger is currently considered as well as the possibility to distinguish between roughness lengths for momentum and for heat over sea (as it is already the case over land). These improvements, if successfully tested, ought to find their ay in the pre-TOP or TOP phases of MFSTEP.

The 'anti-fibrillation' scheme of Bénard et al. (2000) is activated. Extending the idea of Girard and Delage, it introduces an over-implicit treatment only when and where the linear local full stability analysis estimates it necessary in order to get a pre-chosen degree of 'smoothness' of the solution. In order to avoid getting 'space-sliced' patterns in place of time oscillations, a constraint of vertical monotonicity was recently imposed on the resulting over-implicit factor. Since this scheme, by construction, cannot handle the type of shallow convection parameterisation via turbulent exchange coefficients' enhancement used in the package, the above-mentioned modification of the shallow convection scheme had to be introduced to harmonise the whole treatment.

Specific diagnostics for the boundary layer are (in a broad sense and to be adapted to MFSTEP specificities during the SVP):

- interpolated values in the SBL (generally towards the measurement heights);
- PBL height (up to now computed with a Richardson number offset, soon to be replaced by the above-mentioned adaptation of Ayotte's method);
- maximum gust wind speed, either through a link with the dynamical roughness and the surface friction velocity or as the wind at the top of the PBL;
- CAPE and moisture convergence (several algorithmic options for each of them) computations for the instantaneous diagnostic of convective risk, especially in diagnostic mode with a frequent near-surface-analysis update.

Mountain drag scheme

It describes in a broad sense the influence of unresolved orography on the higher levels of the atmosphere in a way adapted from Boer et al. (1984) for the linear 'gravity wave drag' part (with full use of the Lindzen (1981) saturation criterion for applying the Eliassen-Palm theorem) and from Lott and Miller (1997) for the 'form drag' low level part. An optional (yet unused) parameterisation of the sub-grid scale so-called 'lift' effect exists, following Lott (1999). Some additional effects are taken into account for the following aspects:

- influence of the anisotropy of the sub-grid orography on the direction and intensity of the stress, according to Phillips;
- use of averaged wind and stability low level conditions (and smooth return to the true profiles above the averaging depth) in order to get a surface stress as independent as possible of the model's vertical discretisation;
- amplifying or destructive resonance effects parameterised according to the work of Peltier and Clark, as well as dispersion effects in case of upper-air neutrality;
- the linear and non-linear potential instabilities of this complex scheme are preventively eliminated at the time of computation of the integrated effects (except for the 'lift' case that is currently an independent piece of parameterisation put in the scheme's code only for convenience).

The whole scheme is currently under review with the aim to abandon the associated envelope orography and to replace its volume effect by a better tuned form drag and by the use of a revised version of the lift effect (that would then cease to be independent of the scheme's backbone). This is very likely to be part of the standard set-up at the SVP stage of MFSTEP.

Deep convection

This parameterisation is surely the one that has received most attention in the evolution of the considered physics package. Contrary to the general tendency in other NWP groups, most of the attention has been paid to the formulation of the entrainment and to its consequences and not to the closure assumption, still of the Kuo-type, even if its practical implementation has also gone more complex than in the 80's.

The original scheme is the mass-flux-type one from Bougeault (1985), modified for the numerical stability according to the Appendix of Geleyn et al. (1982). In its current version it encompasses the following refinements:

- the Kuo-type closure has been made dependent on the horizontal resolution according to the ideas of Bougeault and Geleyn since the dynamical part of the moisture convergence is here modulated by a factor depending on the mesh size and that goes to zero for a vanishing one;

- a very simple microphysics to avoid 'deep convection' from too shallow clouds; this follows the proposal formulated in the Appendix of Arakawa and Schubert;

- it is forbidden to have deep convection when absolute dry convection is active;

- a comprehensive treatment of the vertical transport of horizontal momentum that includes the recirculation by the mass-flux in the Schneider and Lindzen sense, the effect of lateral entrainment and the effects of pressure difference between the cloud and its environment following the proposal of Gregory; the 'non-hydrostatic' part of the moist adiabat ascent/descent computations are treated in conformity with Gregory's underlying hypotheses;

- a provision for cancelling the computations when the potential for convective rain at the surface makes it unlikely for the ascent to reach the lifting condensation level;

- a vertically varying detrainment rate with a constant component plus a dependency on the buoyancy decrease in the upper part of the cloud;

- an entrainment rate that (i) varies from higher values at the bottom to lower ones at the top alike the proposal of Gregory and Rowntree, (ii) is dependent on a first estimate of the integrated buoyancy and (iii) encompasses the 'ensembling entrainment' concept (i.e. the clouds inside a grid-box that survive at a given height have a higher buoyancy than the averaged one below, because they entrained less in their lower part) in its consequences on the profiles;

- parameterisation of downdrafts via quasi-symmetric computations for the ascending and descending motions following Ducrocq and Bougeault; the additional differences are a geometric modulation of the mass flux to avoid its convergence in the sole lowest model level and constant entrainment/detrainment rates along the vertical, contrary to the description in the last two bullets, valid only for updrafts;

- in the closure assumption for the downdraft part, precipitation fluxes' creation replaces moisture convergence but Bougeault's main closure coefficient (ratio of mass flux to buoyancy) has been constrained to remain smaller for downdrafts than for updrafts in order to avoid a runaway feedback when a shallow moist unstable layer caps a deep dry and well-mixed PBL; to alleviate the consequences of this 'security' in terms of surface fluxes a compensating 'unorganised' sub-cloud evaporation term is incorporated following a relaxation method.

Stratiform precipitation scheme

There is neither storage of the liquid and solid phases in the clouds, nor consideration of partial cloudiness, but a revised Kessler (1969) method is used for computing precipitation evaporation, melting and freezing. A ratio of the falling speed for the two types of precipitation allows distinguishing two aspects in the liquid/ice partition:

- formation that follows the same partition as the one used in the radiative diagnostic cloud scheme;

- evolution for the falling parts that takes into account the past 'history' of the falling fluxes, even if those are diagnosed under a (time-step by time-step updated) stationarity assumption.

Parameterisations of the soil processes

This is based on the ISBA scheme described by Noilhan and Planton (1989) and by Giard and Bazile (2000). Some modifications have been added to the scheme for taking into account the freezing-melting effects of the soil water at different levels. The research version of the same scheme is well known through the participation to the various international inter-comparisons (PILPS, SNOWMIP, …).

4.4) 'PSEUDO DATA ASSIMILATION' PART

Upper air blending

The initial conditions for a Limited Area Model (LAM) may basically be obtained either by interpolating the initial conditions of the driving model to the LAM grid (dynamical adaptation mode) or by an independent data analysis/assimilation procedure in the LAM (data assimilation mode). The smaller the size of the LAM domain is, the more the dynamical adaptation mode is appropriate since the analysis of larger scales over a small domain becomes more and more questionable (Berre, 2000). If one wants to avoid the dilemma between the two above-mentioned basic solutions, an appropriate treatment of the larger scales may be achieved by applying a so-called blending technique where the fields of the driving model and of the LAM are selectively combined in function of the scales resolved by each model. This technique is used in ALADIN in order to keep the 4DVar ARPEGE results for the long waves, well resolved by the global model, and to combine them with the short-range meso-scale ALADIN forecast. The meso-scale part of the ALADIN solution (itself denoted as 'guess'), unresolved by ARPEGE, should thus be kept in the initial conditions. In other words the blending is a meso-scale analysis without observations, where the long-wave part of the spectra is analysed by ARPEGE and where the short-wave part of the spectra relies on its own ALADIN guess. The hypothesis is that the short-wave guess is more realistic and closer to the truth (thanks to the balance with the fine-mesh surface forcing) than the short-wave result obtained simply by interpolating the ARPEGE analysis.

The determination of the smallest scales still well captured by the analysis of ARPEGE is based on the resolution of the ARPEGE analysis increments and also on the resolution of its deterministic forecast. This scale limit, together with the size and resolution of the ALADIN domain provides a first estimate of the 'blending truncation' within the ALADIN spectra. A smooth transition between the ARPEGE and ALADIN spectra, around the blending truncation, is implicitly obtained by the Digital Filter Initialisation (DFI) method (Lynch et al., 1997). The digital filter is applied on both ARPEGE and ALADIN fields at the low spectral resolution of the blending truncation in order to obtain a filtered large-scale decrement, to be then added to the high resolution guess. The blending truncation and DFI settings are the tuning parameters of the system. The tuning criteria is to keep realistically active structures both in the initial and +6h forecasts states, together with realistic physical fluxes in the early hours of the forecast (thus taking care of the spin-up problem). Beside the smooth transition between the spectra, the digital filter offers the advantage to balance the final blending increment when adding the meso-scale ALADIN information to the large-scale part. This is ensured by the properties of the digital filter incremental initialisation, gently creating a good balance of mass and wind fields in the initial condition blended state. Any use of an external initialisation can thus be avoided.

Surface blending

DFI blending of the upper-air dynamical variables can be completed by a blending of soil variables, where the interpolation procedure transports the surface analysis increments instead of the surface analysis itself. The initial values of the surface variables in ALADIN are obtained by adding the interpolated ARPEGE surface analysis increments to the ALADIN guess. To avoid a divergence of the cycle, a weak relaxation toward the ARPEGE analysis is applied. The surface blending may easily separate the treatment of the soil and sea surfaces (a useful property in the MFSTEP case) and it can be combined with an independent surface analysis scheme (solution currently in testing phase).

5) ALADIN-MFSTEP output method and products (so-called *Full*POS package)

*FullP*OS is a powerful and sophisticated post-processing package. It is intended to be used for operation and research as well.

*FullP*OS has two main parts : the vertical interpolations, then the horizontal interpolations. In between, a spectral treatment is sometimes possible for the dynamic fields.

*FullP*OS is a post-processing package containing many features. The following is just a small list of the main available features :

- Multiple fields from the dynamics, the physics, the cumulated fluxes or the instantaneous fluxes
- post-processing available on any pressure level, height (above output orography) level, potential vorticity level, potential temperature level or model level
- Multiple latitudes X longitudes output subdomains, or one gaussian grid with any definition, or one grid of kind 'ALADIN', with any definition
- Multiple possible optimisations of the memory or the CPU time used, through specific I/O schemes, vectorisation depth, distribution and various other segmentations.
- Possible spectral treatment for all the fields of a given post-processing level type

- Customization of the names of the post-processed fields
- Support for computing a few other fields without diving deeply into the code of *FullP*OS
- Ability to perform post-processing in-line (ie : during the model integration) or off-line (out of the model integration)
- Ability to make ARPEGE or ALADIN history files, starting from a file ARPEGE or a file ALADIN (processes "927", "E927" and "EE927")

*FullP*OS is a non-independent software: it is designed to serve specifically the ARPEGE/ALADIN post-processing.

To get a post-processing fully consistant with the model itself, *FullP*OS software has been completely embedded inside the ARPEGE/aladin software, in order that it can (and it should !) re-use model operators. The reliability of this concept has been ensured by the existence of a previous internal post-processing software (currently pointed out by the name of its leading subroutine : POS). However the target of this previous internal software was limited to vertical pressure interpolations for a few specific fields to be written out as spherical harmonics, while *FullP*OS is designed to be a comprehensive post-processing tool.

*FullP*OS is also designed to serve both operations (which implies : high efficiency to be run in real time situation) and research (which means : the ability to process various elaborated fields on various grids and vertical levels).

This section will list the processes that have taken part in the elaboration of *FullP*OS . Presented prior to the architecture of the software, it should help understanding the conception of the code.

- Dynamical fields should be post-processable on pressure levels (P), potential vorticity levels (P_v), isentropic levels, eta levels including other definitions than the model originating eta levels, and on height levels above a given orography (z).
- Fields post-processed on P, P_v should be interpolated vertically first, then horizontally. In between, it should be possible (as an option) to fit the fields in spectral space (to remove the numerical noise induced by the vertical interpolations). For a few specific fields (like geopotential, medium sea-level pressure, ...) for which the formulation of vertical interpolation induces potential inconsistancies, a filter in spectral space should be optionally performed.

- Fields post-processed on eta and z levels should respect the profile of the boundary layer ; therefore they should be interpolated horizontally first, then re-ajusted with respect to the orography of the target grid.
- To ensure the inter-consistancy of fields interpolated on eta or z levels, only the model primitive variables (U, V, T, q, P_s currently) should be horizontally interpolated : the other fields should be recomputed from the interpolated model primitive variables.
- Fields on horizontal surfaces should be homogenous ; in other words the small scale information should not pollute the interpretation of the output fields. This means that the fields which are composed of derivatives (like vorticity, divergence, vertical velocity as the integral of the divergence, but also any field on P_v levels) should be filtered in a spectral space of homogeneous resolution. The intensity of this filter should depend of the output grid resolution.
- Physical fields from the model, including cumulated fluxes and instantaneous diagnostics, should be post-processable : their interpolations require often specific treatments, like the land/sea aspect (only points of the same nature should serve the interpolations), the control of the validity domain for the output values (for instance : the interpolated land/sea mask should be either 0. or 1.), or the interdependencies of the post-processed physical fields (for instance : deep soil temperature should be interpolated as its anomaly with respect to surface temperature, which implies to interpolate surface temperature prior to deep soil temperature).
- It should be possible to interpolate "physico-dynamic" fields : these are fields defined on a surface and computed with model physical surface fields as well as upper air dynamic fields (CAPE is one of them). If computed on the model originating grid, this should be easy (because the environment is then very similar to the model gridpoint environment), but if computed on another grid, this implies to interpolate horizontally almost all the model pronostic fields (upper air as well as surface).
- While doing bogussing, to prevent from getting "walls" at the border of the bogussing area, the target grid should get only the interpolated increments from the source fields.
- It should be possible to use climatology data in order to interpolate with a better accuracy a few surface fields ; instead of a straightforward interpolation, we would interpolate the anomaly of a field with respect to the climatology, or even : we would impose the whole climatology field if it is a constant field (land-sea mask for instance).
- In case of gridpoint outputs on a complete ALADIN grid, the extension zone should be computed as well, taking into account the realism of the physical fields.

- In the initial design, horizontal interpolations had to be quadratic exclusively.
- Wind-related fields (like vorticity, divergence, etc) should be computed from the wind components so that all these fields are consistent.

Beside the scientific aspects, various technical aims have been achieved :

- it should be possible to post-process during the model direct integration ("in-line post-processing") as well as after ("off-line post-processing"), both solution giving the same results. This implies that *FullP*OS should not be a specific ARPEGE/ALADIN configuration but a package which could be called inside the direct model temporal loop, and that the packing of fields in history files should be considered.
- *FullP*OS should benefit, as the model does, from the (super)computer hardware architecture, that is : the memory distribution today and probably OPEN-MP tomorrow.
- *FullP*OS should be cheap.
- *FullP*OS should be modular and should not spread itself all over the code *FullP*OS users interface should be ergonomic. This should not mean that the users interface should be restricted to a limited number of namelists parameters, but rather that the namelists should be easy to set, with meaningful parameters.
- *FullP*OS should stick to the ARPEGE/ALADIN interfaces standards : namelists parameters for the users interface and ARPEGE/ALADIN files for the I/O data.
- the list of post-processing fields, levels and horizontal domains per post-processing time range should be flexible.
- The horizontal output format has been restricted to : either one gaussian grid, or one ALADIN grid, or a set of LATLON grids, or one definition of spectral coefficients.
- One should be able to pack each post-processing field on a tunable specific number of bits.

6) FTP and WEB Servers

The SKIRON/Eta output produced during TOP and the archived SVP-WP10 meteorological fields will be disseminated through ftp procedures and the IASA/AM&WFG web page. IASA together with the other partners involved in the atmospheric modeling will have the responsibility to distribute their own weekly forecasts to the interested project partners.

IASA has setup an ftp server that will be dedicated to the dissemination of the SKIRON/Eta output. Its IP address is 195.134.91.8 and the interested partners can be provided with a username and a password after request. The filename convention of the grib files will be MFSTEP_CENTER_TTDDMMYY_XXX.grb where TT, DD, MM and YY are the time, date, month and year (respectively) of the initial time and XXX is the forecast time (in hours). CENTER corresponds to the originating center, e.g. MF, IASA, CHMI. For example the file MFSTEP_IASA_00140803_102.grb corresponds to the 102 hours forecast of IASA from 0000 UTC, 14 August 2003. Its valid time is 0600 UTC, 18 August 2003. The forecasts will remain in the server for a week until they are replaced by the new 5-day forecast. All the forecasts of IASA will be archived. Information about any changes in the structure of the directories of the ftp server and in the available files will be provided in a frequently updated README file.

The SKIRON/Eta model output will also be available to the public as graphics through the AM&WFG/IASA web page (http://forecast.uoa.gr). The main page of the AM&WFG/IASA appears in Figure 4. At the moment this page runs in test mode and it can accessed through http://wwwforecast.mg.uoa.gr. In September 2003 it will become the operational web page of the group and it will make the output of MFSTEP-WP10 freely available to the public.

The home page of MFSTEP-WP10 can be accessed through the “Active Projects” section of the main page. In the Active Projects section, the user may find links to MFSTEP-WP10 and to other EC Funded programs such as ANEMOS, AUTOHAZARD-PRO, MERCYMS, and others. The link to MFSTEP-WP10 leads to the web page appearing in Figure 5. In the MFSTEP-WP10 web page the user may find information about the MFSTEP project, links to other workpackages through the main project web page (http://www.bo.ingv.it/mfstep/), and information about the objectives, findings, innovative aspects and partners of WP10. Moreover, a link will connect the user with the SKIRON/Eta output page (Figure 6).

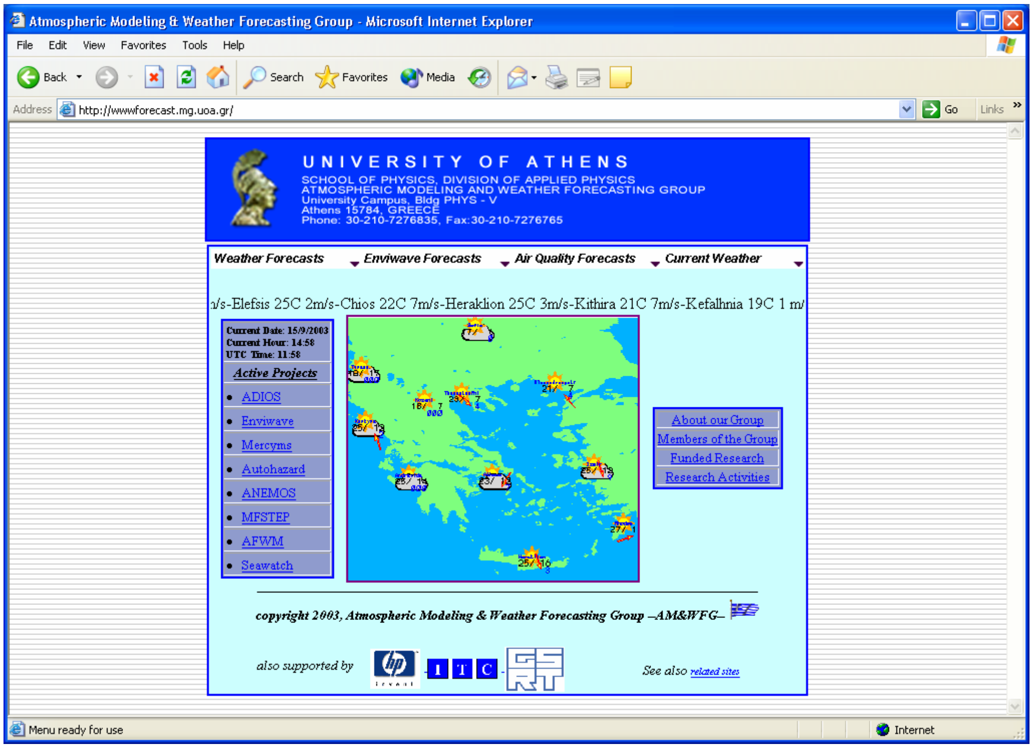

Figure 4. *The AM&WFG/IASA web page*

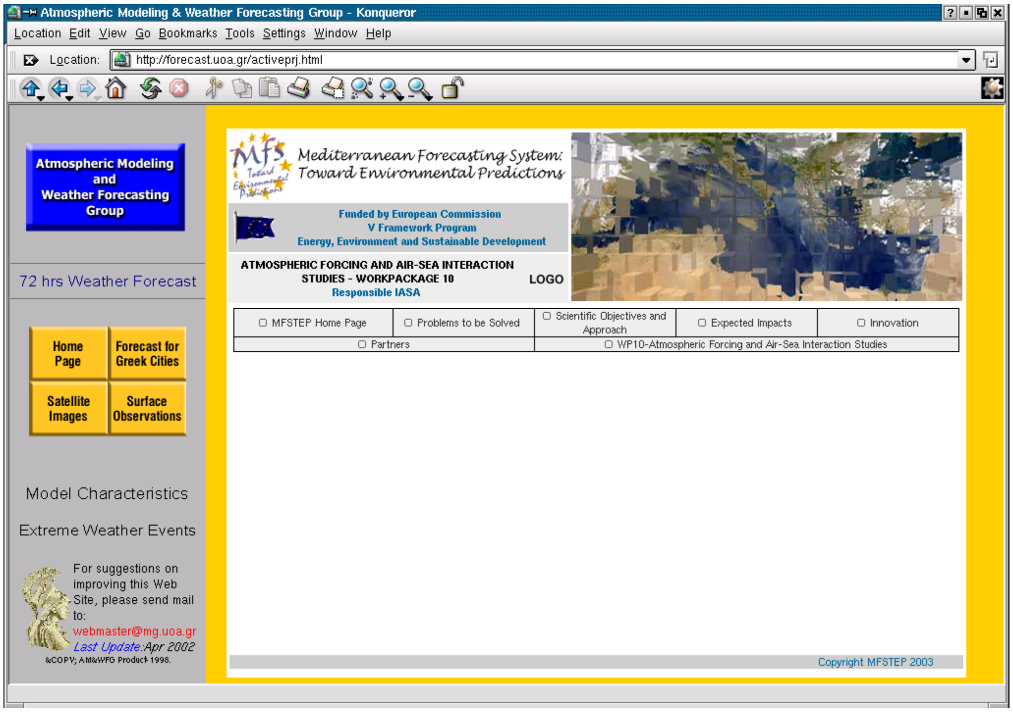

Figure 5. *The home page of MFSTEP/WP10 within the AM&WFG/IASA web page*

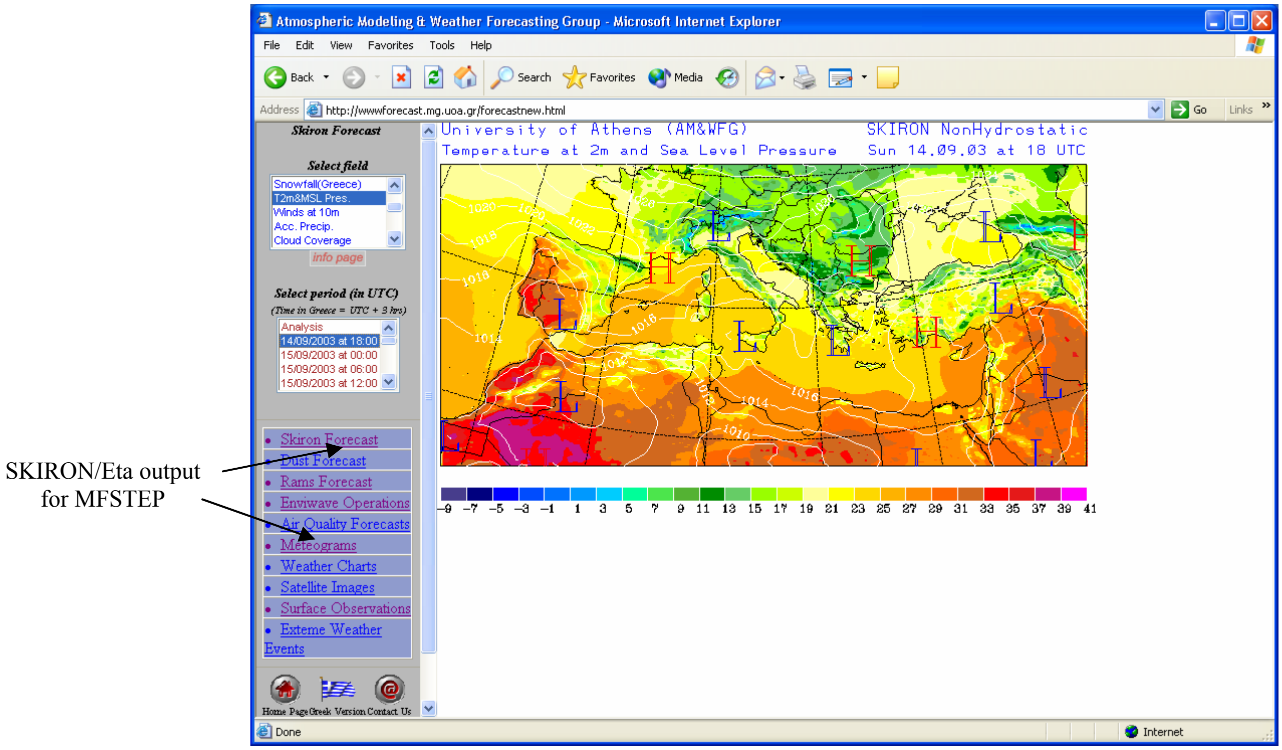

Figure 6. *An example of the SKIRON/Eta output within the AM&WFG/IASA web page*

The MFSTEP-WP10 web page with the SKIRON/Eta output (Figure 6) will make available to the public a number of fields as graphics in the computational domain. Some of the available fields are the 10m wind, the mean sea-level pressure, the accumulated precipitation, the 2m temperature, the cloud fraction, the SST etc. Moreover, under the link "Meteograms" on the left frame of the web page the user will be able to find meteograms with 5-day forecasts of basic fields (e.g. 2 m. temperature, 10m. wind etc.) for a selected number of coastal locations in eastern Mediterranean. Finally, in the web page of Figure 6 AM&WFG/IASA makes available a number of forecasts from other EC and Greek Funded projects (see the menu on the left frame of Figure 6). This allows the accessibility of the project to increase since the visitors of the AM&WFG/IASA web page through other projects will have the opportunity to access MFSTEP. In needs to be noted that the web page of AM&WFG/IASA is very popular with approximately 4500 visitors daily from whom only 45% are from Greece.

CHMI will provide the outputs of ALADIN/MFSTEP model via its ftp distribution server ftp.chmi.cz. Interested partners will be provided by the user name and password. The products are also planned to be uploaded to IASA when IASA provides to CHMI the access to a reception server.

The name convention of outputs will follow the description given by IASA. The standard version of the outputs will be the grib-like ascii file. All outputs will be archived on the main archiving device of CHMI.

7) Future Work

The works planned for the second half of 2003 are the finalization of the system automation, the finalization of the tests, the production of the SVP hindcasts and the verification of the model, and finally the distribution of high resolution forecasting products to the partners at the required format (grib outputs and graphics).

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