AN IMPLICIT NUMERICAL SCHEME FOR THE ATMOSPHERIC POLLUTION

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Abstract

The model relates the concentration of a polluter in the atmosphere with the field vector of wind velocity, the turbulent diffusivity vector and the rate of mass diffusion of the polluter. An implicit finite-difference method is proposed for the numerical solution of this one-dimensional advection-diffusion model.

Index Terms

Advection-Diffusion; Finite-difference Method; Turbulence; Atmospheric pollution.

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I. Introduction

THE concentration of air pollutants have in general been steadily increasing during the last two decades. To correctly gauge the impact of various sources of pollutants requires careful modeling the complex physical processes associated with the advection and diffusion of air pollution. These models are computationally demanding and require the use of stable and accurate numerical schemes, [12], [11], [13], [15]. By considering only passive pollutants in an air pollutant transport model the advection–diffusion system of equations can drive the dynamical evolution of the pollutant concentration in a similar way that this is done, for example, in water flows [1], [5], [7], [5].

Let $c(x,y,z,t)\ \mu g/m^3$ be the concentration-density of a passive polluter in the atmosphere, $\mathbf{v} = [v_x, v_y, v_z]^T\ m/s$ be the vector field of the velocity of the wind, which is given from a numerical model of weather data forecast, $\mathbf{K} = [K_x, K_y, K_z]^T$ be the turbulent diffusivity tensor and $S\ \mu g/m^3 s$ be the source of the polluter with mass release rate $q(t)$ in μ/h. Then the concentration-density c can be described from the following $3D$ advection-diffusion (AD) equation

$$\frac{\partial c}{\partial t} + \boldsymbol{\nabla}\cdot(\boldsymbol{v}\,c) = \boldsymbol{\nabla}\cdot(\boldsymbol{K}\otimes\boldsymbol{\nabla}\,c) + S(q(t)). \tag{1.1}$$

In Eq. (1.1) in order to simplify the quantity $\boldsymbol{K}\otimes\boldsymbol{\nabla}\,c$ only the diagonal terms were used. Therefore

$$\boldsymbol{\nabla}\cdot(\boldsymbol{K}\otimes\boldsymbol{\nabla}\,c) = \frac{\partial}{\partial x}\left(K_x\,\frac{\partial c}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_y\,\frac{\partial c}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_z\,\frac{\partial c}{\partial z}\right), \tag{1.2}$$

where the factors K_x, K_y and K_z can be evaluated using various methods such as to have constant values or to calculated in the numerical weather model etc.

For the unstrained term S it can be assumed that either $S = q(t)$ (locally) or the source S follows a Gaussian distribution, which depends from the distance d of the local source and expands to the grid cells as follows

$$S(d) = \frac{\partial c}{\partial t}(d) = \frac{q(t)}{2\pi\sigma_n^2 H}\ e^{-\frac{d^2}{2\,\sigma_n^2}}, \tag{1.3}$$

where H is the vertical expansion of the smog and σ_n^2 is the horizontal area of the grid cell that includes the source.

The velocity field can be available in hour intervals but a numerical scheme for Eq. (1.1) is going to need time steps in s, therefore in order to have the velocity field for all the necessary time steps there could be a linear interpolation in time.

Eq. (1.1) for the one-dimensional problem, where $c = c(x,t)$, $v = v(x)$, $K = K_x = K(x)$, $\boldsymbol{\nabla} c = c_x i$,

$$\boldsymbol{\nabla}\cdot(\boldsymbol{K}\otimes\boldsymbol{\nabla}\,c) = \frac{\partial}{\partial x}\left(K\,\frac{\partial c}{\partial x}\right) = \frac{\partial K}{\partial x}\frac{\partial c}{\partial x} + K\,\frac{\partial^2 c}{\partial x^2}$$

and

$$\boldsymbol{\nabla}\cdot(c\,\boldsymbol{v}) = \frac{\partial c}{\partial x}v + c\frac{\partial v}{\partial x},$$

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reads to the following diffusion-advection equation

$$\frac{\partial c}{\partial t}+\frac{\partial c}{\partial x}v+c\frac{\partial v}{\partial x}=\frac{\partial K}{\partial x}\frac{\partial c}{\partial x}+K\frac{\partial^2 c}{\partial x^2}+S\,;\;\; x\in(L_0,\,L_1)\;\text{ and }\; t>0. \tag{1.4}$$

Eq. (1.4) when

$v=0$, K constant without the source S reduces to the classical diffusion equation

$$\frac{\partial c}{\partial t}=K\frac{\partial^2 c}{\partial x^2}\,;\;\; x\in(L_0,\,L_1)\;\text{ and }\; t>0, \tag{1.5}$$

$v=\mu$ constant and $K=1/Re$, Re being the Reynolds number leads to

$$\frac{\partial c}{\partial t}+\mu\,\frac{\partial c}{\partial x}=\frac{1}{Re}\,\frac{\partial^2 c}{\partial x^2}+S\,;\;\; x\in(L_0,\,L_1)\;\text{ and }\; t>0. \tag{1.6}$$

Initial conditions are assumed to be of the form

$$c\,(x,0)=f(x), \tag{1.7}$$

while boundary conditions

$$c\,(L_0,t)=g(x)\;\text{ and }\; c\,(L_1,t)=\tilde{g}(x)\,;\; t>0 \tag{1.8}$$

with f, g and $\tilde{g}$ known functions.

II. The numerical method

Finite difference schemes is a common choice for advection-diffusion equations see, for example, [9], [13], [11], [6], [2], [3], [4]. Explicit in time schemes are restricted by the well known CFL like stability restrictions that reduce substantially their computational efficiency. Our scope here is to present an implicit scheme that highly relaxes this restriction.

A. Grid and solution vector

For the numerical solution the region $\Omega=[L_0<x<L_1]\times[\,t>0\,]$ with its boundary $\partial\Omega$ consisting of the lines $x=L_0$, $x=L_1$ and $t=0$, is covered with a rectangular mesh, G, of points with coordinates $(x,t)=(x_m,t_n)=(L_0+mh,nl)$ with $m=0,1,...,N+1$ and $n=0,1,...$, so that $h=(L_1-L_0)\,/\,(N+1)$. The solution of Eq. (1.4) at the typical mesh point (x_m,t_n) is $c\,(x_m,t_n)$ which may be denoted, when convenient, by c_m^n. The solution of an approximating difference scheme at the same point will be denoted by C_m^n, while for the purpose of analyzing stability, the numerical value of C_m^n actually obtained (subject, for instance, to computer round-off errors) will be denoted by $\tilde{C}_m^n$.

Let the solution vector at time level $t=t_n=n\ell$ be

$$\mathbf{C^n}=\mathbf{C}\,(t_n)=[C_1^n,C_2^n,...,C_N^n]^T\,. \tag{2.1}$$

B. The finite-difference scheme

Eq. (1.4) using central-difference approximations for the space partial derivatives, when applied to the general mesh point (x_m,t_n) of the grid G, leads to the following system of ordinary differential equations

$$\begin{aligned}\frac{d\,C_m^n}{d\,t} \;&=\; -\frac{1}{2\,h}\left(C_{m+1}^n-C_{m-1}^n\right)v_m-\frac{1}{2\,h}\left(v_{m+1}-v_{m-1}\right)C_m^n\\ &\quad+\frac{1}{4\,h^2}\left(K_{m+1}-K_{m-1}\right)\left(C_{m+1}^n-C_{m-1}^n\right)\\ &\quad+\frac{1}{h^2}\left(C_{m+1}^n-2C_m^n+C_{m-1}^n\right)K_m+S_m^n\end{aligned}$$

for $m=1,2,...,N$, which can be written in a matrix-vector form as

$$\begin{aligned}D\,\mathbf{C}(t) \;&=\; -\frac{1}{2\,h}\text{diag}\left\{v_m\right\}\,A\,\mathbf{C}(t)-\frac{1}{2\,h}\text{diag}\left\{v_{m+1}-v_{m-1}\right\}\,\mathbf{C}(t)\\ &\quad+\frac{1}{4\,h^2}\text{diag}\left\{K_{m+1}-K_{m-1}\right\}\,A\,\mathbf{C}(t)+\frac{1}{h^2}\text{diag}\left\{K_m\right\}\,B\,\mathbf{C}(t)+\mathbf{S}^n+\mathbf{b}^n,\end{aligned} \tag{2.2}$$

where $D=\text{diag}\left\{d/d\,t\right\}$ matrix of order N and A, B are tridiagonal matrices of order N given by

$$A=\begin{bmatrix} 0 & 1 & & & & \\ -1 & 0 & 1 & & & \\ & . & . & . & & \\ & & & -1 & 0 & 1 \\ & & & & -1 & 0 \end{bmatrix}, \tag{2.3}$$

$$B=\begin{bmatrix} -2 & 1 & & & & \\ 1 & -2 & 1 & & & \\ & & . & . & . & \\ & & & 1 & -2 & 1 \\ & & & & 1 & -2 \end{bmatrix} \tag{2.4}$$

$\mathbf{C}^n=[S_1^n,S_2^n,...,S_N^n]^T$ a vector of order N and

$$\begin{aligned}\mathbf{b}^n \;\; &= \;\; [b_1^n,\, b_2^n,\, ...,\, b_N^n]^T \left[\left\{ \frac{1}{2\,h}\, v_1 - \frac{1}{4\,h^2}\,(K_2-K_0) + \frac{1}{h^2}K_1 \right\} C_0^n \right. \\ & \left. ,0,...,0,\, \left\{ -\frac{1}{2\,h}\, v_N + \frac{1}{4\,h^2}\,(K_{N+1}-K_N) \; + \frac{1}{h^2}K_N \right\} C_{N+1}^n \right]^T \end{aligned} \tag{2.5}$$

the vector of the boundary conditions also of order N.

Using the recurrence relation

$$\mathbf{C}\,(t+\ell) = \; e^{\ell\, D}\; \mathbf{C}\,(t)\,, \;\; t=\ell,\, 2\,\ell, ... \tag{2.6}$$

in which the matrix-exponential term is replaced with the $(1,0)$ Padé approximant of the form

$$e^{\ell\, D} \;\approx (I-\ell\, D)^{-1}\,, \tag{2.7}$$

where I the identity matrix of order N, finally leads to

$$(I-\ell\, D)\; \mathbf{C}\,(t+\ell) = \mathbf{C}\,(t)\,. \tag{2.8}$$

Let $r=\ell/h$ and $p=\ell/h^2$. Eq. (2.8) using Eq. (2.2) leads to the following linear system

$$\begin{aligned} & \left[I + \frac{r}{2}\text{diag}\,\{v_m\}\,A + \frac{r}{2}\text{diag}\,\{v_{m+1}-v_{m-1}\} \right. \\ & \left. -\frac{p}{4}\text{diag}\,\{K_{m+1}-K_{m-1}\}\,A - p\,\text{diag}\,\{K_m\}\;B \right] \mathbf{C}(t+\ell) \\ & -\ell\,\mathbf{S}^{n+1} - \ell\,\mathbf{b}^{n+1} = \mathbf{C}(t), \end{aligned} \tag{2.9}$$

which, when the notation of the grid G is used, gives

$$\begin{aligned} & \left[\frac{r}{2}\,v_m - \frac{p}{4}\,(K_{m+1}-K_{m-1}) - p\,K_m \right]\; C_{m+1}^{n+1} + \left[1 + \frac{r}{2}\,(v_{m+1}-v_{m-1}) + 2\,p\,K_m \right]\; C_m^{n+1} \\ & + \left[-\frac{r}{2}\,v_m + \frac{p}{4}\,(K_{m+1}-K_{m-1}) - p\,K_m \right]\; C_{m-1}^{n+1} - \ell\,S_m^{n+1} - \ell\,b_m^{n+1} = C_m^n \end{aligned} \tag{2.10}$$

for $m=1,2,...,N$.

C. The stability analysis

Following the Fourier method of analyzing stability it is considered a small error of the form

$$Z_m^n = C_m^n - \tilde{C}_m^n \tag{2.11}$$

with

$$Z_m^n = e^{\alpha n \ell} e^{i\beta m h} \;\; ; \;\; i=\sqrt{-1}, \tag{2.12}$$

where α is complex number and β is real. Then the von Neumann necessary criterion for stability requires the following condition to be satisfied

$$\left| e^{\alpha\,\ell} \right| \leq 1 + \ell\,\mathcal{S}, \tag{2.13}$$

where $\mathcal{S}$ a non negative constant independent of ℓ and h.

Let

$$\mathcal{S} = \max_{m=1,2,\ldots,N} \; S_m^n \;; \;\; n=0,1,... \tag{2.14}$$

Then $\mathcal{S}$ obviously satisfies the required condition for the constant on the right-hand side of In. (2.13). Eq. (2.10) when the last two terms on the right-hand side, because of (2.13), are omitted, otherwise the problem is without a source, using Eqs. (2.11)-(2.12) after canceling both sides by $e^{\alpha n \ell} e^{i\beta m h}$ leads to

$$\Big\{\Big[\frac{r}{2}\,v_m-\frac{p}{4}\,(K_{m+1}-K_{m-1})-p\,K_m\Big]\;e^{i\beta h}\;+1+\frac{r}{2}\,(v_{m+1}-v_{m-1})$$
$$+2\,p\,K_m+\Big[-\frac{r}{2}\,v_m\;+\frac{p}{4}\,(K_{m+1}-K_{m-1})-p\,K_m\Big]\;e^{-i\beta h}\Big\}\,e^{\alpha\ell}=1$$

otherwise

$$\Big\{i\;\Big[r\,v_m^n-\frac{p}{2}\,(K_{m+1}-K_{m-1})\Big]\;\sin\beta h+1\;+\frac{r}{2}\,(v_{m+1}-v_{m-1})+2\,p\,K_m\,(1-\cos\beta h)\Big\}\,e^{\alpha\ell}=1$$

and finally to the following *stability* equation

$$\Big\{i\;\Big[r\,v_m-\frac{p}{2}\,(K_{m+1}-K_{m-1})\Big]\;\sin\beta h+1\;+\frac{r}{2}\,(v_{m+1}-v_{m-1})+4\,p\,K_m\sin^2\frac{\beta h}{2}\Big\}\;\xi=1, \tag{2.15}$$

where $\xi=e^{\alpha\ell}$ is the amplification factor.

- Eq. (2.10) for the diffusion problem given by Eq. (1.5) becomes

$$\xi=\left(1+4\,p\,K\sin^2\frac{\beta h}{2}\right)^{-1}. \tag{2.16}$$

  Since p, $K>0$, condition (2.7) is always satisfied, so the method is unconditionally stable.

- Eq. (2.10) for the advection-diffusion problem given by Eq. (1.6) becomes

$$\xi=\left(i\,\mu\,r\,\sin\beta h+1+\frac{4\,p}{Re}\sin^2\frac{\beta h}{2}\right)^{-1}. \tag{2.17}$$

  so

$$\left|\xi^2\right|\quad=\quad\frac{Re^2}{\left(2\,p+Re-2\,p\cos\beta h\right)^2+\mu^2\,r^2\sin^2\beta h}\leq\left(1+\frac{4\,p}{Re}\right)^{-2}. \tag{2.18}$$

  Then condition (2.7) is always satisfied and the scheme is, again, unconditionally stable.

III. Numerical results

In this section, numerical results are presented based on the scheme presented above. In all the test problems presented below free outflow boundary conditions are implemented.

The first test problem has an analytical solution with $S=0$. The analytical solution is that of a Gaussian pulse of unit height centered at $x_0=1$m in a region bounded by $0\leq x\leq 6$ and is given by

$$C(x,t)=\frac{1}{\sqrt{4t+1}}\;e^{-\frac{(x-x_0-ut)^2}{K(4t+1)}}, \tag{2.19}$$

where u is the velocity and K the (constant) diffusion coefficient in the x direction. The values of the various parameters used are $D=5\cdot 10^{-3}m^2/s$ and $u=0.8m/s$. The space step and time step are taken to be $h=0.02m$ and $l=0.01s$ respectively. The distribution of the Gaussian pulse at $t=5$s is computed using the presented numerical scheme and compared with the concentration distribution obtained using the exact solution in Fig 1, where we can see that the numerical solution follows very closely the exact one.

For the next test problem we assume an area of length $L=200m$ and we impose a constant velocity $u=1m/s$ with the diffusion coefficient $K=5\cdot 10^{-2}m^2/s$. The value of $h=0.1m$ and $l=0.2$s. A pollutant source is placed at $x=50m$ with a constant emission rate $S=u_sq_s$, where $u_s=20m/s$ the gas exit speed and $q_s=0.1\mu g/m^3$ the source concentration rate. The results are presented in Fig.2 where the advection of the pollutant can be seen at four different times.

For the same problem we assume initially that $u=0$ for the first 50s and that $K=5\cdot 10^{-1}m^2/s$. After 50s the (wind) velocity changes to $u=1m/s$ in the positive direction. In Fig. we can see the effect of diffusion for the first 50s, the concentration is increased locally and spreads in both directions. Then it is advected in the positive direction.

In the next problem we assume the existence of two sources located at $x=150m$ and $x=300m$ respectively in an area of 1000m. The second source has now $q_s=.05\mu g/s$. We use $K=0.1m^2/s$, $h=0.2m$ and $l=0.01s$ In Fig.4 we can see the evolution of concentration in the domain, by time $t=180s$ the two source have contributed to an increase in the concentration to a maximum value of $3\mu/m^3$ which gradually propagates in the rest of the domain.

For the last test case a more realistic case is presented. Assuming a domain of $L=50km$ with $u=1m/s$ and $K=10^3m^2/s$ (a typical value of the daily atmospheric boundary layer). A source is placed at $x=25km$ based on Eq. (1.3) with $H=1m$, $\sigma_n=h$ and $q(t)=2\mu/m^3$. The computational parameters used where $h=25m$ and $l=1s$. The effect of the diffusion can be clearly seen in Fig.5 as it is dominant in this case. The concentration hasn't reach its peak value even after five hours but has spread in all the half domain in the positive direction.

We point out that in all computations the value of the time step is highly increased when compared to other explicit schemes usually presented in the literature.

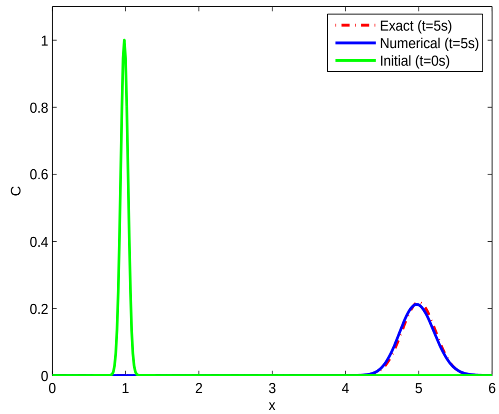

Fig. 1. Test Problem 1: Evolution of a Gaussian pulse (comparison with exact solution))

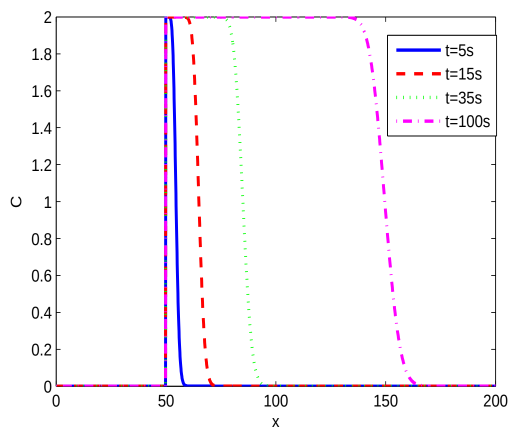

Fig. 2. Test Problem 2: Evolution of pollutant concentration from a source ($u = 1$ and $K = 5 \cdot 10^{-2}$)

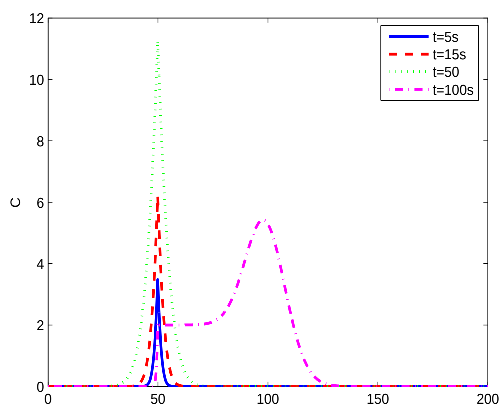

Fig. 3. Test Problem 3: Evolution of pollutant concentration from a source ($u = 0$, for the first 50s, and $K = 5 \cdot 10^{-1}$)

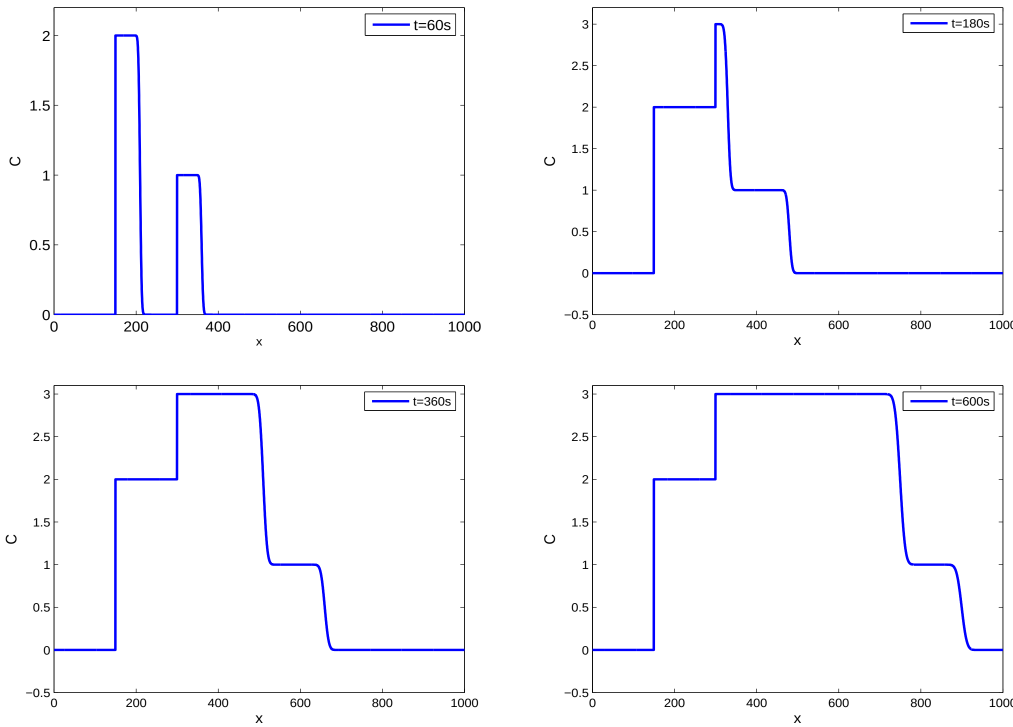

Fig. 4. Test Problem 4: Evolution of pollutant concentration from two sources

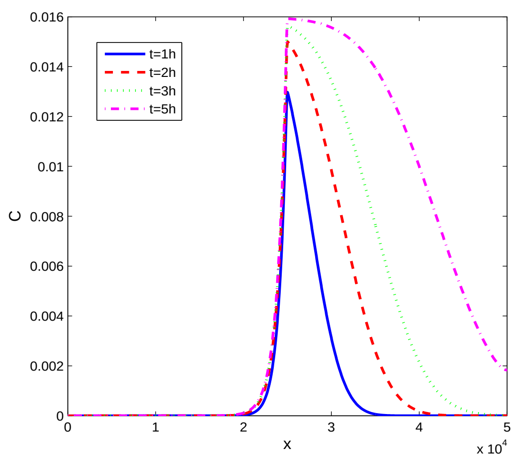

Fig. 5. Test Problem 4: Evolution of pollutant concentration from a source ($K = 10^3 m^2/s$)

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KREMIZIS A., KONSTANTINIDI I., PAPADAKI M., KERAMIDAS G. and GRIGORIADOU M.
Greek Wordnet extension in the domain of Psychology and Computer Science

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Minisymposium: INFORMATION SYSTEMS ENGINEERING

HARAMIS G.E., SOUBENIOTIS D., FOTIADIS T. and HATZITHOMAS L.
Structured systems development

FOUNTOUKIS S.G. and HARAMIS G.E.
Towards an efficient reliable and low cost integrated information system in the organization

CHASSAPIS C., SPYRIOUNI D., THEODOROU D. and PETROPOULOS J.
Computer simulation and analysis methodology for the detection of nanostructure in amorphous polymers and elucidation of its effect on diffusion phenomena therein

DIMITRANTZOU A., LIAKOPOULOU G., FOTOPOULOU G., VALTSIS N., DAMASKOS G., KARAKITSIOS I. and ZAXAROPOULOS A.
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SPATHOULAS G. and VENNOU P.
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HATZITHOMAS L. and FOTIADIS T.
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MOUE A.S.
A famous heat engine and the information theory

CONSTANTOPOULOU C., ANDRAS CH. and DELIGIAURI A.
The power of Internet and the reflection of Information Technology in the daily Greek Press

KOSMOPOULOS A.
Challenging e-democracy: An overview of regulatory and legal implications with regard to ICT's

SIMAIOFOROS TH.-A.
Genesis and Generation: The mathematical and philosophical theory of Timaios of Lokros

Minisymposium: NON-LINEAR PHYSICAL PHENOMENA: SOME RECENT STUDIES

FAMELIS I. TH., EHRHARDT M. and BRATSOS A.
A discrete Adomian decomposition method for the discrete nonlinear Schrodinger equation

BRATSOS A., PAPAKOSTAS T., FAMELIS I., DELIS A. & NATSIS D.
An implicit numerical scheme for the atmospheric pollution

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KOUTRAS V., PLATIS A. and GRAVVANIS G.
Software rejuvenation on a grid computing environment for higher availability based on approximate inverse preconditioning

CASTAIN R.
Whither the Grid? Future directions and issues

PATIL A., NORVIK C., POWER D. and MORRISON J.
Implementing fine and coarse grained payment mechanisms using WebCom

CHOUHAN P., PATIL ARCH., PATIL AD. and MORRISON J.
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PARASHAR M. and PIERSON J.-M.
When the Grid becomes pervasive: A vision on pervasive grids

SANCHEZ A., MONTES J., GUEANT P. and PEREZ M.
Lessons learnt from cluster computing: How they can be applied to grid environments

VINTER B.
The grid taken literally

VAFOPOULOS M., GRAVVANIS G. and PLATIS A.
New directions in computing on demand (CoD)

PETSOUNIS K.
Introduction to Data Analysis and Parallel Computing with MATLAB

Minisymposium: RECENT INNOVATIONS IN BUSINESS

AND INDUSTRIAL STATISTICS

PSARAKIS S., KIANI M. and PANARETOS J.
Contribution to monitor the standard deviation of a quality characteristic

ZAMBA G., TSIAMYRTZIS P. and HAWKINS D.
Bayesian statistical process control: An application to syndromic surveillance

MYTALAS G. and ZAZANIS M.
Quality inspection and cycle times in Manufacturing systems

ANTZOULAKOS D., KOUTRAS M. and RAKINTZIS A.
A new start-up demonstration test

KASKAVELIS E. and ARVANITIS A.
Process monitoring and fault detection using multivariate statistical process control –Case study from ELVAL aluminium DC casting process

BERSIMIS F., BERSIMIS S. and PSARAKIS S.
Multivariate control charts: A comparative study

NIKOLOPOULOS C, and YANNACOPOULOS A.
Optimal advertising policy in stochastic environments

SACHLAS A., PAPAIOANNOU T. and BERSIMIS S,
Controlling non-normal multivariate processes using information theoretic control charts

TSIPTSIS K.
Data mining in the framework of analytical CRM

PSARAKIS S., PANARETOS J. and KIANI M.
A control chart for monitoring process variability

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KARAGIANNOPOULOS M., ANYFANTIS D., KOTSIANTIS S. and PINTELAS P.
Feature selection for regression problems

TSIRIDIS D., ZAHARAKIS I. and KAMEAS A.
The role of indirect communication in emerging collective behaviours

KANELLOPOULOS D.
Intelligent multimedia adaption for universal multimedia access

LAZARINIS F.
Adding adaptive behaviour using information retrieval techniques to Greek e-shop search engines

TZELEPIS D. and TAMPAKAS V.
Using text mining techniques for analysing financial reports

*Minisymposium:*ADVANCED TOPICS IN COMMUNICATIONS

JIAYUE HE, MUNG CHIANG and REXFORD J.
Don't optimize existing protocols, design optimizable protocols

DONG-WON SHIN, CHONG E.K.P. and SIEGEL H.J.
Multi-postpath-based lookahead multiconstraint QoS routing

CHERUBINI G.
Reliable resynchronization of sequential decoders

MANIKAS A., ELISSAIOS G. and EFSTATHOPOULOS G.
A signal-subspace steering vector beamformer robust to pointing errors

GURCAN M., WELIWITEGODA D. and CHANDRA G.
Minimum distance improvement method for sequential detectors

PAPAZOGLOU P., KARRAS D. and PAPADEMETRIOU R.
Efficient Simulation methodologies for wireless multimedia communications systems

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PSILLAKI M., TSOLAS I. and MARGARITIS D..
Evaluation of credit risk based on firm performance

PAPADEMETRIOU R., OSBORN A. and CHALVATZIS I.
MagLab- An Intelligent Management Learning Environment

ANGELIDIS T. and TESSAROMATIS N.
Beta and specific risk forecasting: Implications for portfolio Management

LIPITAKIS A. and PHILLIPS P.
E-business strategies and adaptive algorithmic schemes

TSERKEZOS D. and THANOU E.
Portfolio Management: An investigation of the implications of measurement errors in stock prices on the creation, management andevaluation of stock portfolios, using stochastic simulations

ZAPRANIS A. and ALEXANDRIDIS A.
Modelling temperature time-dependent mean reversion with neural networks in the context of derivatives pricing

FRANGOS N., VRONTOS S. and YANNACOPOULOS A.
A computational approach for the calculation of value at risk using a partial differential equation

Contributed Papers

COMPUTATIONAL MATHEMATICS
AND ITS APPLICATIONS

SUN W., WU J. and ZHANG X.
Nonconforming spline collocation methods in irregular domains

DEMETRIOU I.C. and LIPITAKIS E.A.
Least squares data fitting by using the signs of divided differences

APOSTOLOPOULOU M., SOTIROPOULOS D. and BOTSARIS C.
A curvilinear method for large scale optimization problems

GRAPSA T.N. and MALIHOUTSAKI E.N.
A Newton's method without direct evaluation of nonlinear function values

NIKOLOPOULOS C.V. and ZOURARIS G.
Numerical solution of a non-local elliptic problem modelling a thermistor with a finite element and a finite volume method

ZOURARIS G.E.
A linearly implicit Finite Element method for a Klein-Gordon-Schrodinger type system

LI F.-L., HU X.-Y. and ZHANG L.
Left and right inverse eigenpairs problem for the symmetrizable matrices

MAKROGLOU ATH. and KONSTANTINIDES D.
Second order Volterra integro-differential equations arising in ultimate ruin theory: An overview combined with numerical treatment

TYRTYSHNIKOV E., OSELEDETS I and ZAMARASHKIN N.
A new paradigm for construction of structured preconditioners

HADJIDIMOS A. and TZOUMAS M.
Using Extrapolation for the solution of the linear complementary problem

NOUTSOS D.
On Stein-Rosenberg type theorems for nonnegative splittings

VASSALOS P., NOUTSOS D. and SERRA CAPIZZANO S.
The conditioning of FD matrix sequences coming from semi-elliptic differential equations

SIFALAKIS A., FULTON S., PAPADOPOULOU E. & D SARIDAKIS Y.
On the iterative analysis of the generalized Dirichlet-Neumann map for Elliptic PDE's

FINANCIAL COMPUTING AND METHODOLOGIES

MANSINI R., OGRYCZAK W. and GRAZIA SPERANZA M.
Tail Gini's risk measures and related linear programming models for portfolio optimization

BARTKOWIAK A.
Comparing the distribution of the WIG20 and S&P500 index

PEFFERLY R.J.
Government debt collection metrics in the Estonian Market

LISGARA E.G. and ANDROULAKIS G.S.
An applied methodology for the prediction of time series' local optima

COMPUTER MATHEMATICS, PROGRAMMING
AND SOFTWARE APPLICATIONS

VOUDOURIS D., SAMPSON M. and PAPAKONSTANTINOU G.
Variable reordering for reversible wave cascades

PANAGOPOULOS I., PAVLATOS C., DIMOPOULOS A. and PAPAKONSTANTINOU G.
Hardware solution of a first-order Diophantine equation

SAMPSON M., VOUDOURIS D., KALATHAS M. & PAPAKONSTANTINOU G.
A Quantum algorithm for finding minimal exclusive-or expressions for incompletely specified Boolean functions

TSELEPIS I., BEKAKOS M., NIKITAKIS A. and LIPITAKIS E.A.
MD5 hash algorithm hardware realization on a reconfigurable FPGA platform

SALAMANOS N., ALEXOGIANNI E. and VAZIRGIANNIS M.
AD-SHARE: An advertising method in P2P systems based on reputation management

COMPUTING & ALGORITHMIC METHODOLOGIES
WITH APPLICATIONS

VERGINIS D.G.
Confidence intervals for nonparametric quantile estimators

HARHALAKIS S., SAMARAS N. and FRAGIADAKI E.
An extended evaluation of a collection of TCP congestion control algorithms

HARHALAKIS S., SAMARAS N. and FRAGIADAKI E.
An improved method for experimental evaluations of TCP congestion control algorithms

MARGARIS A., SOURAVLAS S., KOTSIALOS E. & ROUMELIOTIS M.
WinSPT- A software tool for speech signal processing

LIPITAKIS A.
Adaptive algorithmic methods and dynamical singular perturbation techniques for e-business problems and strategic management methodologies

BIO-INFORMATICS, SIMULATION AND
INFO-MEDICAL APPLICATIONS

ANDREADIS I., SPYROU G., ANTARAKI A., GIANNAKOPOULOU G., KOULOHERI D., ZOGRAFOS G., NIKITA K. and LIGOMENIDES P.A.
Combining SVM and rule based classifiers for optimal classification in breast cancer diagnosis

VALAVANIS I., SPYROU G. and NIKITA K.
Investigating the structure of protein similarly networks both on sequence and structure level

PARALLEL & DISTRIBUTED COMPUTING
AND APPLICATIONS

DENIS C., JEZEQUEL F. and SCOTT N.S.
High performance computation: Numerical music or numerical noise?

VIOLENTIS J., KOUTRAS V., PLATIS A. and GRAVVANIS G.
Asymptotic availability of an electrical substation via a semi-Markov process computed by generalized approximate inverse preconditioning

MICHAILIDIS P.D. and MARGARITIS K.G.
Parallelization of multiple string matching on a cluster platform

SOURAVLAS S., KOTSIALOS E., MARGARIS A. & ROUMELIOTIS M.
On simulating parallel algorithms with VHDL

DYNAMICAL SYSTEMS AND PROGRAMMING MODELS

BENMAKROUHA F. and HESPEL CH.
Validation of a particular class of dynamical systems

BENMAKROUHA F. and HESPEL CH.
Generating formal power series and stability of bilinear systems

PRANEVICIUS H. and SUTIENE K.
The effect of copula on scenario tree structure

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