MUHAMMAD AL-XORAZMIY
NOMIDAGI TATU FARG'ONA FILIALI

FERGANA BRANCH OF TUIT
NAMED AFTER MUHAMMAD AL-KHORAZMI

"AL-FARG'ONIY AVLODLARI"

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Jurnal quyidagi bazalarda indekslanadi:

Eslatma! Jurnal materiallari to'plamiga kiritilgan ilmiy maqolalardagi raqamlar, ma'lumotlar haqqoniyligiga va keltirilgan iqtiboslar to'g'riligiga mualliflar shaxsan javobgardirlar.

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Annotatsiya. Haqiqiy amaliyot shuni ko‘rsatadiki, havoning ifloslanishi dispersiya jarayonini yetarlicha aniq bashorat qilish uchun modellar ichida quyidagi omillarni hisobga olish kerak: atmosferada aerozol chiqindilarining tezligi uch yo‘nalishda o‘zgarishi; barqaror va beqaror stratifikatsiya uchun diffuziya va turbulent koeffitsiyentining o‘zgarishi; shamolning ko‘tarilishi va relyef orografiyasi; atmosfera qatlamlarida haroratning o‘zgarishi natijasida yuzaga keladigan moddalarning faza almashinuvi. Ushbu ishda ushbu omillarni hisobga olgan holda sanoat hududlarida atmosfera chegara qatlamida ifloslantiruvchi moddalar konsentratsiyasini qisqa muddatli prognozlashga qaratilgan matematik model ko‘rib chiqilgan. Ishlab chiqilgan matematik model massa va impulsning saqlanish qonuniga asoslanadi hamda ko‘chish va diffuziya tenglamasi bilan tavsiflanadi. Hisoblash tajribalarini o‘tkazish uchun hisoblash algoritmi va dasturiy ta’minoti ishlab chiqilgan. Modelni tekshirish O‘zbekiston Respublikasining Samarqand viloyatidagi mavjud tsement zavodidan chiqayotgan qattiq zarrachalarning konsentratsiyasini qisqa muddatli bashoratlashda amalga oshirildi.

Kalit so‘zlar: Model, algoritm, atmosfera, ifloslantiruvchi modda, havo sifati

Kirish. Parametrlari aniqlangan va unga mos boshlang‘ich va chegaraviy shartlarga ega xususiy hosilali tenglamalar sistemasi orqali ifodalanuvchi masalalarni yechishda massa, energiya, harakat miqdori va jarayon kinetikasining saqlanish qonunlariga asoslangan chekli ayirmali sxemalarning konservativligiga alohida e’tibor qaratish lozim.

Qo‘yilgan vazifalarni sonli yechishda quyidagilar zarur:

a) chekli ayirmali modelning konservativligini ta’minlaydigan fazoviy va vaqt qatlamlari bo‘yicha qo‘yilgan masalani integrallash bosqichlarini tanlash;

b) bashoratlovchi o‘zgaruvchilarning uzluksiz o‘zgarish sohasini diskret sohaga almashtirish;

d) obyektning matematik modelining differensial operatorlarini chekli ayirmali operatorlarga almashtirish, shuningdek, chegaraviy shartlar va boshlang‘ich kirish ma’lumotlari uchun ayirmali sxemani yozish.

Shuningdek o‘zgaruvchilarni almashtirish usuli qaysidir o‘zgarmas vaqt oralig‘ida birinchi tartibli xususiy hosiladan qutulishga yordam beradi. Bizga ma’lumki birinchi tartibli xususiy hosilani oshkormas ko‘rinishdagi chekli ayirmaga o‘tkazilgan absolyut turg‘unlik shartini ta’minlashda qiyinchilik tug‘diradi.

Adabiyotlar tahlili. [1] maqolada harakatlanuvchi chegarali sistemalarning tebranishlarini ifodalovchi to‘lqin tenglamasini yechishning analitik usuli ko‘rib chiqilgan. Chegaralarni to‘xtatuvchi va tenglamani o‘zgaruvchilarni almashtirish usuli yordamida boshlang‘ich chegaraviy masala to‘g‘ri va teskari usullar yordamida yechilishi mumkin bo‘lgan funksional ayirmali tenglamalar tizimiga keltiriladi. Chegaralar harakatining yetarlicha xilma-xil qonunlarini teskari masalani yechishdan olingan qonunlar bilan approksimatsiya qilishga imkon beradigan teskari usul tavsiflangan. Chegaralar harakati qonunlarining yetarlicha keng doirasi uchun yangi xususiy yechimlar olingan. Funksional tenglamani taqribiy yechishning to‘g‘ri asimptotik usuli ko‘rib chiqilgan. Chegaraning harakat tezligiga bog‘liq holda taqribiy usul xatoliklari baholandi. Ushbu yondashuvda [2-7] da qo‘llanilgan uslublar muvaffaqiyatli birlashtirilgan.

Masalaning qo‘yilishi. Atmosferada gazli aralashmalar va zararli moddalarning tarqalish jarayonini ifodalovchi matematik modelni quyidagicha ifodalab olamiz:

$$\frac{\partial\theta_{1,m}}{\partial t}+u\frac{\partial\theta_{1,m}}{\partial x}+v\frac{\partial\theta_{1,m}}{\partial y}+w\frac{\partial\theta_{1,m}}{\partial z}+(\sigma+\alpha)\theta_{1,m}=\delta F_{gas}-$$
$$-P_{nucl}-P_{cond}+\mu\frac{\partial^2\theta_{1,m}}{\partial x^2}+\mu\frac{\partial^2\theta_{1,m}}{\partial y^2}+\frac{\partial}{\partial z}\left(\kappa\frac{\partial\theta_{1,m}}{\partial z}\right),$$

(1)

$$\frac{\partial\theta_{2,l}}{\partial t}+u\frac{\partial\theta_{2,l}}{\partial x}+v\frac{\partial\theta_{2,l}}{\partial y}+\bar{w}\frac{\partial\theta_{2,l}}{\partial z}+(\sigma+\alpha)\theta_{2,l}=\delta F_{aer}+$$
$$+P_{nucl}-P_{cond}\,\mu\frac{\partial^2\theta_{2,l}}{\partial x^2}+\mu\frac{\partial^2\theta_{2,l}}{\partial y^2}+\frac{\partial}{\partial z}\left(\kappa\frac{\partial\theta_{2,l}}{\partial z}\right),$$

(2)

$$\frac{dw_g}{dt}=\frac{mg-6\pi\eta r w_g-0,5c\rho_z s w_g^2}{m} \qquad (3)$$

Bu yerda $\bar{w}=w-w_g$.

(1) xususiy hosilali differensial tenglamalar sistemasi uchun boshlang‘ich va chegaraviy shartlar quyidagicha:

$$\theta_{1,m}\big|_{t=0}=\theta^0_{1,m}; \qquad (4)$$

$$-\mu\frac{\partial\theta_{1,m}}{\partial x}\bigg|_{x=0}=\xi\left(\theta_E-\theta_{1,m}\right);$$
$$\mu\frac{\partial\theta_{1,m}}{\partial x}\bigg|_{x=Lx}=\xi\left(\theta_E-\theta_{1,m}\right); \qquad (5)$$

$$-\mu\frac{\partial\theta_{1,m}}{\partial y}\bigg|_{y=0}=\xi\left(\theta_E-\theta_{1,m}\right);$$
$$\mu\frac{\partial\theta_{1,m}}{\partial y}\bigg|_{y=L_y}=\xi\left(\theta_E-\theta_{1,m}\right); \qquad (6)$$

$$-\kappa\frac{\partial\theta_{1,m}}{\partial z}\bigg|_{z=0}=\left(\beta\theta_{1,m}-f_0\right);$$
$$\kappa\frac{\partial\theta_{1,m}}{\partial z}\bigg|_{z=H_z}=\xi\left(\theta_E-\theta_{1,m}\right). \qquad (7)$$

(2) хусусий ҳосилали дифференциал тенгламалар системаси учун бошланғич ва чегаравий шартлар қуйидагича:

$$\theta_{2,l}\big|_{t=0}=\theta^0_{2,l}; \quad w_g\big|_{t=0}=w^0_g; \qquad (8)$$

$$-\mu \frac{\partial \theta_{2,l}}{\partial x}\bigg|_{x=0} = \xi\left(\theta_E - \theta_{2,l}\right);$$

$$\mu \frac{\partial \theta_{2,l}}{\partial x}\bigg|_{x=Lx} = \xi\left(\theta_E - \theta_{2,l}\right); \qquad (9)$$

$$-\mu \frac{\partial \theta_{2,l}}{\partial y}\bigg|_{y=0} = \xi\left(\theta_E - \theta_{2,l}\right);$$

$$\mu \frac{\partial \theta_{2,l}}{\partial y}\bigg|_{y=L_y} = \xi\left(\theta_E - \theta_{2,l}\right); \qquad (10)$$

$$-\kappa \frac{\partial \theta_{2,l}}{\partial z}\bigg|_{z=0} = \left(\beta\theta_{2,l} - f_0\right);$$

$$\kappa \frac{\partial \theta_{2,l}}{\partial z}\bigg|_{z=H_z} = \xi\left(\theta_E - \theta_{2,l}\right). \qquad (11)$$

Bu yerda $\theta_{1,m},\ m = \overline{1, N_g}$ – gazli aralashmalarning atmosferadagi konsentratsiyasi; N_g – gazli aralashmalarning soni; $\theta_{2,l},\ l = \overline{1, N_a}$ – zararli moddalarning atmosferadagi konsentratsiyasi; N_a – zararli moddalarning soni; $\theta^0_{1,m}$ – gazli aralashmalarning atmosferadagi boshlang‘ich konsentratsiyasi; $\theta^0_{2,l}$ – zararli moddalarning atmosferadagi boshlang‘ich konsentratsiyasi; θ_E – masala yechimi sohasidan tashqarida zararli moddalarning konsentratsiyasi; $u,\ v,\ w$ – $x, y,\ z$ yo‘nalishlarida shamol tezligi; w_g – zarrachalarning cho‘kish tezligi; σ – zararli moddalarning atmosferada yutilishi koeffitsiyenti; $\mu,\ \kappa$ – diffuziya va turbulentlik koeffitsiyentlari; F_{gas}, F_{aer} – gazli aralashmalar va zararli moddalar manbaasining quvvati; P_{nucl}, P_{cond} – nukleatsiya va kondensatsiya operatorlari; δ – Dirak funksiyasi; f_0 – zararli moddaning yer sathidan atmosferaga tashlanish jadalligi; $c = 0.5$ – o‘lchovsiz kattalik; ρ – zarrachaning zichligi; r_z – zarrachaning radiusi; s – zarrachaning ko‘ndalang kesim yuzasi; g – erkin tushish tezlanishi; m – zarrachaning massasi; η – zarrachaning solishtirma og‘irligi.

Qo‘yilgan (1) - (11) masalalarni xususiy hosilali nochiziqli differensial tenglamalar sistemasi bilan ifodalangani uchun analitik yechim topish qiyin. Yuqoridagilarni hisobga olib, masalani sonli yechishda fazoviy o‘zgaruvchilarga nisbatan approksimatsiya tartibini oshirish maqsadida quyidagi belgilashlarni kiritamiz [8-14]:

$$\theta_{1,m} = e^{\frac{ux+vy}{2\mu}+\frac{wz}{2\kappa}}\tilde{\theta}_{1,m}; \qquad (12)$$

$$\theta_{2,l} = e^{\frac{ux+vy}{2\mu}+\frac{\overline{w}z}{2\kappa}}\tilde{\theta}_{2,l}; \qquad (13)$$

va (12) va (13) munosabatlarni mos ravishda (1) va (2) tenglamalarga qo‘yamiz, hamda o‘xshash hadlarni ixchamlashtiramiz, natijada quyidagini kelamiz:

$$\frac{\partial \tilde{\theta}_{1,m}}{\partial t} + \sigma_1\tilde{\theta}_{1,m} = \mu\frac{\partial^2 \tilde{\theta}_{1,m}}{\partial x^2} + \mu\frac{\partial^2 \tilde{\theta}_{1,m}}{\partial y^2} + \frac{\partial}{\partial z}\left(\kappa\frac{\partial \tilde{\theta}_{1,m}}{\partial z}\right) + e_1\left(\delta F_{gas} - -P_{nucl} - P_{cond}\right).$$

(14)

$$\frac{\partial \tilde{\theta}_{2,l}}{\partial t} + \sigma_2\tilde{\theta}_{2,l} = \mu\frac{\partial^2 \tilde{\theta}_{2,l}}{\partial x^2} + \mu\frac{\partial^2 \tilde{\theta}_{2,l}}{\partial y^2} + \frac{\partial}{\partial z}\left(\kappa\frac{\partial \tilde{\theta}_{2,l}}{\partial z}\right) + e_2\left(\delta F_{aer} + P_{nucl} - P_{cond}\right). \qquad (15)$$

Bu yerda

$$\sigma_1 = \frac{\kappa u^2 + \kappa v^2 + \mu w^2 + 4\sigma\mu\kappa + 4\alpha\mu\kappa}{4\mu\kappa};$$

$$e_1 = e^{-\left(\frac{ux+vy}{2\mu}+\frac{wz}{2\kappa}\right)};$$

$$\sigma_2 = \frac{\kappa u^2 + \kappa v^2 + \mu \bar{w}^2 + 4\sigma\mu\kappa + 4\alpha\mu\kappa}{4\mu\kappa};$$

$$e_2 = e^{-\left(\frac{ux+vy}{2\mu} + \frac{\bar{w}z}{2\kappa}\right)}.$$

(14) uchun boshlang‘ich va chegaraviy shartlar quyidagichadir:

$$\tilde{\theta}_{1,m}\Big|_{t=0} = \tilde{\theta}^0_{1,m}; \qquad (16)$$

$$-\mu\frac{\partial\tilde{\theta}_{1,m}}{\partial x}\bigg|_{x=0} = \xi\left(e_1\theta_E - \tilde{\theta}_{1,m}\right);$$

$$\mu\frac{\partial\tilde{\theta}_{1,m}}{\partial x}\bigg|_{x=L_x} = \xi\left(e_1\theta_E - \tilde{\theta}_{1,m}\right); \qquad (17)$$

$$-\mu\frac{\partial\tilde{\theta}_{1,m}}{\partial y}\bigg|_{y=0} = \xi\left(e_1\theta_E - \tilde{\theta}_{1,m}\right);$$

$$\mu\frac{\partial\tilde{\theta}_{1,m}}{\partial y}\bigg|_{y=L_y} = \xi\left(e_1\theta_E - \tilde{\theta}_{1,m}\right); \qquad (18)$$

$$-\kappa\frac{\partial\tilde{\theta}_{1,m}}{\partial z}\bigg|_{z=0} = \left(\beta\tilde{\theta}_{1,m} - e_1 f_0\right);$$

$$\kappa\frac{\partial\tilde{\theta}_{1,m}}{\partial z}\bigg|_{z=H_z} = \xi\left(e_1\theta_E - \tilde{\theta}_{1,m}\right). \qquad (19)$$

(15) uchun boshlang‘ich va chegaraviy shartlar quyidagichadir:

$$\tilde{\theta}_{2,l}\Big|_{t=0} = \tilde{\theta}^0_{2,l}; \qquad (20)$$

$$-\mu\frac{\partial\tilde{\theta}_{2,l}}{\partial x}\bigg|_{x=0} = \xi\left(e_2\theta_E - \tilde{\theta}_{2,l}\right);$$

$$\mu\frac{\partial\tilde{\theta}_{2,l}}{\partial x}\bigg|_{x=L_x} = \xi\left(e_2\theta_E - \tilde{\theta}_{2,l}\right); \qquad (21)$$

$$-\mu\frac{\partial\tilde{\theta}_{2,l}}{\partial y}\bigg|_{y=0} = \xi\left(e_2\theta_E - \tilde{\theta}_{2,l}\right);$$

$$\mu\frac{\partial\tilde{\theta}_{2,l}}{\partial y}\bigg|_{y=L_y} = \xi\left(e_2\theta_E - \tilde{\theta}_{2,l}\right); \qquad (22)$$

$$-\kappa\frac{\partial\tilde{\theta}_{2,l}}{\partial z}\bigg|_{z=0} = \left(\beta\tilde{\theta}_{2,l} - e_2 f_0\right);$$

$$\kappa\frac{\partial\tilde{\theta}_{2,l}}{\partial z}\bigg|_{z=H_z} = \xi\left(e_2\theta_E - \tilde{\theta}_{2,l}\right). \qquad (23)$$

(14) – (23) masalalarni vaqt va fazoviy o‘zgaruvchilarga nisbatan yuqori tartibli approksimatsiyani qo‘llagan holda oshkormas ko‘rinishdagi chekli ayirmani qo‘llaymiz va quyidagi natijalarni olamiz.

Masalaning sonli yechimi va uning natijalari. (14) xususiy hosilali differensial tenglamalar sistemasining Ox yo‘nalish uchun yechimi:

$$a_{1,m,i,j,k}\tilde{\theta}^{n+1/3}_{1,m,i-1,j,k} - b_{1,m,i,j,k}\tilde{\theta}^{n+1/3}_{1,m,i,j,k} + c_{1,m,i,j,k}\tilde{\theta}^{n+1/3}_{1,m,i+1,j,k} = -d_{1,m,i,j,k}.$$

$$a_{1,m,i,j,k} = \frac{\mu}{\Delta x^2};$$

$$b_{1,m,i,j,k} = \frac{3}{\Delta t} + \sigma_1 + \frac{2\mu}{\Delta x^2}; \quad c_{1,m,i,j,k} = \frac{\mu}{\Delta x^2};$$

$$d_{1,m,i,j,k} = \left(\frac{3}{\Delta t} - \frac{2\mu}{\Delta y^2} - \frac{\kappa_{k-0,5} + \kappa_{k+0,5}}{\Delta z^2}\right)\tilde{\theta}^n_{1,m,i,j,k} + \frac{\mu}{\Delta y^2}\tilde{\theta}^n_{1,m,i,j-1,k} + $$
$$+ \frac{\mu}{\Delta y^2}\tilde{\theta}^n_{1,m,i,j+1,k} + \frac{\kappa_{k-0,5}}{\Delta z^2}\tilde{\theta}^n_{1,m,i,j,k-1} + \frac{\kappa_{k+0,5}}{\Delta z^2}\tilde{\theta}^n_{1,m,i,j,k+1} +$$
$$+ \frac{1}{3}e_1\left(\delta_{i,j,k}F_{gas} - P_{nucl} - P_{cond}\right).$$

$$\alpha_{1,m,0,j,k} = \frac{4\mu c_{1,m,1,j,k} - b_{1,m,1,j,k}\mu}{3\mu c_{1,m,1,j,k} - a_{1,m,1,j,k}\mu + 2\Delta x\xi};$$

$$\beta_{1,m,0,j,k} = \frac{d_{1,m,1,j,k} + 2\Delta x\xi c_{1,m,1,j,k}e_1\theta_E}{3\mu c_{1,m,1,j,k} - a_{1,m,1,j,k}\mu + 2\Delta x\xi}.$$

$$\tilde{\theta}^{n+1/3}_{1,m,N,j,k}=\frac{2\Delta x e_1\xi\theta_E}{2\Delta x\xi+\left(\alpha_{1,m,N-2,j,k}\alpha_{1,m,N-1,j,k}-4\alpha_{1,m,N-1,j,k}+3\right)\mu}-$$
$$=-\frac{\left(\beta_{1,m,N-2,j,k}+\alpha_{1,m,N-2,j,k}\beta_{1,m,N-1,j,k}-4\beta_{1,m,N-1,j,k}\right)\mu}{2\Delta x\xi+\left(\alpha_{1,m,N-2,j,k}\alpha_{1,m,N-1,j,k}-4\alpha_{1,m,N-1,j,k}+3\right)\mu}.$$

(15) xusussiy hosilali differensial tenglamalar sistemasining *Ox* yo‘nalish uchun yechimi:

$$a_{2,l,i,j,k}\tilde{\theta}^{n+1/3}_{2,l,i-1,j,k}-b_{2,l,i,j,k}\tilde{\theta}^{n+1/3}_{2,l,i,j,k}+c_{2,l,i,j,k}\tilde{\theta}^{n+1/3}_{2,l,i+1,j,k}=-d_{2,l,i,j,k}.$$

$$a_{2,l,i,j,k}=\frac{\mu}{\Delta x^2};$$

$$b_{2,l,i,j,k}=\frac{3}{\Delta t}+\sigma_2+\frac{2\mu}{\Delta x^2};\quad c_{2,l,i,j,k}=\frac{\mu}{\Delta x^2};$$

$$d_{2,l,i,j,k}=\left(\frac{3}{\Delta t}-\frac{2\mu}{\Delta y^2}-\frac{\kappa_{k-0,5}+\kappa_{k+0,5}}{\Delta z^2}\right)\tilde{\theta}^{n}_{2,l,i,j,k}+\frac{\mu}{\Delta y^2}\tilde{\theta}^{n}_{2,l,i,j-1,k}+$$
$$+\frac{\mu}{\Delta y^2}\tilde{\theta}^{n}_{2,l,i,j+1,k}+\frac{\kappa_{k-0,5}}{\Delta z^2}\tilde{\theta}^{n}_{2,l,i,j,k-1}+\frac{\kappa_{k+0,5}}{\Delta z^2}\tilde{\theta}^{n}_{2,l,i,j,k+1}+$$
$$+\frac{1}{3}e_2\left(\delta_{i,j,k}Q+P_{nucl}-P_{cond}\right).$$

$$\alpha_{2,l,0,j,k}=\frac{4\mu c_{2,l,1,j,k}-b_{2,l,1,j,k}\mu}{3\mu c_{2,l,1,j,k}-a_{2,l,1,j,k}\mu+2\Delta x\xi};$$

$$\beta_{2,l,0,j,k}=\frac{d_{2,l,1,j,k}+2\Delta x\xi c_{2,l,1,j,k}e_2\theta_E}{3\mu c_{2,l,1,j,k}-a_{2,l,1,j,k}\mu+2\Delta x\xi}.$$

$$\tilde{\theta}^{n+1/3}_{2,l,N,j,k}=\frac{2\Delta x e_2\xi\theta_E}{2\Delta x\xi+\left(\alpha_{2,l,N-2,j,k}\alpha_{2,l,N-1,j,k}-4\alpha_{2,l,N-1,j,k}+3\right)\mu}-$$
$$=-\frac{\left(\beta_{2,l,N-2,j,k}+\alpha_{2,l,N-2,j,k}\beta_{2,l,N-1,j,k}-4\beta_{2,l,N-1,j,k}\right)\mu}{2\Delta x\xi+\left(\alpha_{2,l,N-2,j,k}\alpha_{2,l,N-1,j,k}-4\alpha_{2,l,N-1,j,k}+3\right)\mu}.$$

(14) xusussiy hosilali differensial tenglamalar sistemasining *Oy* yo‘nalish uchun yechimi:

$$\bar{a}_{1,m,i,j,k}\tilde{\theta}^{n+2/3}_{1,m,i,j-1,k}-\bar{b}_{1,m,i,j,k}\tilde{\theta}^{n+2/3}_{1,m,i,j,k}+\bar{c}_{1,m,i,j,k}\tilde{\theta}^{n+2/3}_{1,m,i,j+1,k}=-\bar{d}_{1,m,i,j,k}.$$

$$\bar{a}_{1,m,i,j,k}=\frac{\mu}{\Delta y^2};$$

$$\bar{b}_{1,m,i,j,k}=\frac{3}{\Delta t}+\sigma_1+\frac{2\mu}{\Delta y^2};\quad \bar{c}_{1,m,i,j,k}=\frac{\mu}{\Delta y^2};$$

$$\bar{d}_{1,m,i,j,k}=\left(\frac{3}{\Delta t}-\frac{2\mu}{\Delta x^2}-\frac{\kappa_{k-0,5}+\kappa_{k+0,5}}{\Delta z^2}\right)\tilde{\theta}^{n+1/3}_{1,m,i,j,k}+\frac{\mu}{\Delta x^2}\tilde{\theta}^{n+1/3}_{1,m,i-1,j,k}+$$
$$+\frac{\mu}{\Delta x^2}\tilde{\theta}^{n+1/3}_{1,m,i+1,j,k}+\frac{\kappa_{k-0,5}}{\Delta z^2}\tilde{\theta}^{n+1/3}_{1,m,i,j,k-1}+\frac{\kappa_{k+0,5}}{\Delta z^2}\tilde{\theta}^{n+1/3}_{1,m,i,j,k+1}+$$
$$+\frac{1}{3}e_1\left(\delta_{i,j,k}F_{gas}-P_{nucl}-P_{cond}\right);$$

$$\bar{\alpha}_{1,m,i,0,k}=\frac{4\mu\bar{c}_{1,m,i,1,k}-\bar{b}_{1,m,i,1,k}\mu}{3\mu\bar{c}_{1,m,i,1,k}-\bar{a}_{1,m,i,1,k}\mu+2\Delta y\xi};$$

$$\bar{\beta}_{1,m,i,0,k}=\frac{\bar{d}_{1,m,i,1,k}+2\Delta y e_1\bar{c}_{1,m,i,1,k}\xi\theta_E}{3\mu\bar{c}_{1,m,i,1,k}-\bar{a}_{1,m,i,1,k}\mu+2\Delta y\xi};$$

$$\tilde{\theta}^{n+2/3}_{1,m,i,M,k}=\frac{2\Delta y e_1\xi\theta_E}{2\Delta y\xi+\left(\bar{\alpha}_{1,m,i,M-2,k}\bar{\alpha}_{1,m,i,M-1,k}-4\bar{\alpha}_{1,m,i,M-1,k}+3\right)\mu}-$$
$$-\frac{\left(\bar{\beta}_{1,m,i,M-2,k}+\bar{\alpha}_{1,m,i,M-2,k}\bar{\beta}_{1,m,i,M-1,k}-4\bar{\beta}_{1,m,i,M-1,k}\right)\mu}{2\Delta y\xi+\left(\bar{\alpha}_{1,m,i,M-2,k}\bar{\alpha}_{1,m,i,M-1,k}-4\bar{\alpha}_{1,m,i,M-1,k}+3\right)\mu}.$$

(15) xusussiy hosilali differensial tenglamalar sistemasining *Oy* yo‘nalish uchun yechimi:

$$\bar{a}_{2,l,i,j,k}\tilde{\theta}^{n+2/3}_{2,l,i,j-1,k}-\bar{b}_{2,l,i,j,k}\tilde{\theta}^{n+2/3}_{2,l,i,j,k}+\bar{c}_{2,l,i,j,k}\tilde{\theta}^{n+2/3}_{2,l,i,j+1,k}=-\bar{d}_{2,l,i,j,k};$$

$$\bar{a}_{2,l,i,j,k}=\frac{\mu}{\Delta y^2};$$

$$\bar{b}_{2,l,i,j,k}=\frac{3}{\Delta t}+\sigma_2+\frac{2\mu}{\Delta y^2};\quad \bar{c}_{2,l,i,j,k}=\frac{\mu}{\Delta y^2};$$

$$\bar{d}_{2,l,i,j,k}=\left(\frac{3}{\Delta t}-\frac{2\mu}{\Delta x^2}-\frac{\kappa_{k-0,5}+\kappa_{k+0,5}}{\Delta z^2}\right)\tilde{\theta}^{n+1/3}_{2,l,i,j,k}+\frac{\mu}{\Delta x^2}\tilde{\theta}^{n+1/3}_{2,l,i-1,j,k}+$$
$$+\frac{\mu}{\Delta x^2}\tilde{\theta}^{n+1/3}_{2,l,i+1,j,k}+\frac{\kappa_{k-0,5}}{\Delta z^2}\tilde{\theta}^{n+1/3}_{2,l,i,j,k-1}+\frac{\kappa_{k+0,5}}{\Delta z^2}\tilde{\theta}^{n+1/3}_{2,l,i,j,k+1}+$$
$$+\frac{1}{3}e_2\left(\delta_{i,j,k}F_{aer}+P_{nucl}-P_{cond}\right);$$

$$\bar{\alpha}_{2,l,i,0,k}=\frac{4\mu\bar{c}_{2,l,i,1,k}-\bar{b}_{2,l,i,1,k}\mu}{3\mu\bar{c}_{2,l,i,1,k}-\bar{a}_{2,l,i,1,k}\mu+2\Delta y\xi};$$

$$\bar{\beta}_{2,l,i,0,k}=\frac{\bar{d}_{2,l,i,1,k}+2\Delta y e_2\bar{c}_{2,l,i,1,k}\xi\theta_E}{3\mu\bar{c}_{2,l,i,1,k}-\bar{a}_{2,l,i,1,k}\mu+2\Delta y\xi};$$

$$\tilde{\theta}^{n+2/3}_{2,l,i,M,k}=\frac{2\Delta y e_2\xi\theta_E}{2\Delta y\xi+\left(\bar{\alpha}_{2,l,i,M-2,k}\bar{\alpha}_{2,l,i,M-1,k}-4\bar{\alpha}_{2,l,i,M-1,k}+3\right)\mu}-$$
$$-\frac{\left(\bar{\beta}_{2,l,i,M-2,k}+\bar{\alpha}_{2,l,i,M-2,k}\bar{\beta}_{2,l,i,M-1,k}-4\bar{\beta}_{2,l,i,M-1,k}\right)\mu}{2\Delta y\xi+\left(\bar{\alpha}_{2,l,i,M-2,k}\bar{\alpha}_{2,l,i,M-1,k}-4\bar{\alpha}_{2,l,i,M-1,k}+3\right)\mu}.$$

(14) xusussiy hosilali differensial tenglamalar sistemasining *Oz* yo‘nalish uchun yechimi:

$$\bar{\bar{a}}_{1,m,i,j,k}\tilde{\theta}^{n+1}_{1,m,i,j,k-1}-\bar{\bar{b}}_{1,m,i,j,k}\tilde{\theta}^{n+1}_{1,m,i,j,k}+\bar{\bar{c}}_{1,m,i,j,k}\tilde{\theta}^{n+1}_{1,m,i,j,k+1}=-\bar{\bar{d}}_{1,m,i,j,k};$$

$$\bar{\bar{a}}_{1,m,i,j,k}=\frac{\kappa_{k-0,5}}{\Delta z^2};$$

$$\bar{\bar{b}}_{1,m,i,j,k}=\frac{3}{\Delta t}+\sigma_1+\frac{\kappa_{k-0,5}+\kappa_{k+0,5}}{\Delta z^2};$$

$$\bar{\bar{c}}_{1,m,i,j,k}=\frac{\kappa_{k+0,5}}{\Delta z^2};$$

$$\bar{\bar{d}}_{1,m,i,j,k}=\left(\frac{3}{\Delta t}-\frac{2\mu}{\Delta x^2}-\frac{2\mu}{\Delta y^2}\right)\tilde{\theta}^{n+2/3}_{1,m,i,j,k}+\frac{\mu}{\Delta x^2}\tilde{\theta}^{n+2/3}_{1,m,i-1,j,k}+$$
$$+\frac{\mu}{\Delta x^2}\tilde{\theta}^{n+2/3}_{1,m,i+1,j,k}+\frac{\mu}{\Delta y^2}\tilde{\theta}^{n+2/3}_{1,m,i,j-1,k}+\frac{\mu}{\Delta y^2}\tilde{\theta}^{n+2/3}_{1,m,i,j+1,k}+$$
$$+\frac{1}{3}e_1\left(\delta_{i,j,k}F_{gas}-P_{nucl}-P_{cond}\right);$$

$$\bar{\bar{\alpha}}_{1,m,i,j,0}=\frac{4\kappa_0\bar{\bar{c}}_{1,m,i,j,1}-\bar{\bar{b}}_{1,m,i,j,1}\kappa_0}{3\kappa_0\bar{\bar{c}}_{1,m,i,j,1}-\bar{\bar{a}}_{1,m,i,j,1}\kappa_0-2\Delta z\beta};$$

$$\bar{\bar{\beta}}_{1,m,i,j,0}=\frac{\bar{\bar{d}}_{1,m,i,j,1}\kappa_0+2e_1\Delta z\bar{\bar{c}}_{1,m,i,j,1}f_0}{3\kappa_0\bar{\bar{c}}_{1,m,i,j,1}-\bar{\bar{a}}_{1,m,i,j,1}\kappa_0-2\Delta z\beta};$$

$$\tilde{\theta}^{n+1}_{1,m,i,j,L}=\frac{2\Delta z e_1\xi\theta_E}{2\Delta z\xi+\left(\bar{\bar{\alpha}}_{1,m,i,j,L-2}\bar{\bar{\alpha}}_{1,m,i,j,L-1}-4\bar{\bar{\alpha}}_{1,m,i,j,L-1}+3\right)\kappa_L}-$$
$$-\frac{\left(\bar{\bar{\beta}}_{1,m,i,j,L-2}+\bar{\bar{\alpha}}_{1,m,i,j,L-2}\bar{\bar{\beta}}_{1,m,i,j,L-1}-4\bar{\bar{\beta}}_{1,m,i,j,L-1}\right)\kappa_L}{2\Delta z\xi+\left(\bar{\bar{\alpha}}_{1,m,i,j,L-2}\bar{\bar{\alpha}}_{1,m,i,j,L-1}-4\bar{\bar{\alpha}}_{1,m,i,j,L-1}+3\right)\kappa_L}.$$

(15) xususiy hosilali differensial tenglamalar sistemasining *Oz* yo‘nalish uchun yechimi:

$$\bar{\bar{a}}_{2,l,i,j,k}\tilde{\theta}^{n+1}_{2,l,i,j,k-1}-\bar{\bar{b}}_{2,l,i,j,k}\tilde{\theta}^{n+1}_{2,l,i,j,k}+\bar{\bar{c}}_{2,l,i,j,k}\tilde{\theta}^{n+1}_{2,l,i,j,k+1}=-\bar{\bar{d}}_{2,l,i,j,k};$$

$$\bar{\bar{a}}_{2,l,i,j,k}=\frac{\kappa_{k-0,5}}{\Delta z^2};$$

$$\bar{\bar{b}}_{2,l,i,j,k}=\frac{3}{\Delta t}+\sigma_2+\frac{\kappa_{k-0,5}+\kappa_{k+0,5}}{\Delta z^2};$$

$$\bar{\bar{c}}_{2,l,i,j,k}=\frac{\kappa_{k+0,5}}{\Delta z^2};$$

$$\bar{\bar{d}}_{2,l,i,j,k}=\left(\frac{3}{\Delta t}-\frac{2\mu}{\Delta x^2}-\frac{2\mu}{\Delta y^2}\right)\tilde{\theta}^{n+2/3}_{2,l,i,j,k}+\frac{\mu}{\Delta x^2}\tilde{\theta}^{n+2/3}_{2,l,i-1,j,k}+$$
$$+\frac{\mu}{\Delta x^2}\tilde{\theta}^{n+2/3}_{2,l,i+1,j,k}+\frac{\mu}{\Delta y^2}\tilde{\theta}^{n+2/3}_{2,l,i,j-1,k}+\frac{\mu}{\Delta y^2}\tilde{\theta}^{n+2/3}_{2,l,i,j+1,k}+$$
$$+\frac{1}{3}e_2\left(\delta_{i,j,k}F_{aer}+P_{nucl}-P_{cond}\right);$$

$$\bar{\bar{\alpha}}_{2,l,i,j,0}=\frac{4\kappa_0\bar{\bar{c}}_{2,l,i,j,1}-\bar{\bar{b}}_{2,l,i,j,1}\kappa_0}{3\kappa_0\bar{\bar{c}}_{2,l,i,j,1}-\bar{\bar{a}}_{2,l,i,j,1}\kappa_0-2\Delta z\beta};$$

$$\bar{\bar{\beta}}_{2,l,i,j,0}=\frac{\bar{\bar{d}}_{2,l,i,j,1}\kappa_0+2e_2\Delta z\bar{\bar{c}}_{2,l,i,j,1}f_0}{3\kappa_0\bar{\bar{c}}_{2,l,i,j,1}-\bar{\bar{a}}_{2,l,i,j,1}\kappa_0-2\Delta z\beta};$$

$$\tilde{\theta}^{n+1}_{2,l,i,j,L}=\frac{2\Delta z e_2\xi\theta_E}{2\Delta z\xi+\left(\bar{\bar{\alpha}}_{2,l,i,j,L-2}\bar{\bar{\alpha}}_{2,l,i,j,L-1}-4\bar{\bar{\alpha}}_{2,l,i,j,L-1}+3\right)\kappa_L}-$$
$$-\frac{\left(\bar{\bar{\beta}}_{2,l,i,j,L-2}+\bar{\bar{\alpha}}_{2,l,i,j,L-2}\bar{\bar{\beta}}_{2,l,i,j,L-1}-4\bar{\bar{\beta}}_{2,l,i,j,L-1}\right)\kappa_L}{2\Delta z\xi+\left(\bar{\bar{\alpha}}_{2,l,i,j,L-2}\bar{\bar{\alpha}}_{2,l,i,j,L-1}-4\bar{\bar{\alpha}}_{2,l,i,j,L-1}+3\right)\kappa_L}.$$

Xulosa. Shunday qilib, qattiq chang zarrachalarini atmosferada ko‘chish va tarqalish jarayoniga asosan quyidagilar ta’sir qilishi aniqlandi: shamol tezligining gorizontal komponenti, u zararli zarrachalarning tarqalish maydonini ortganda shamol yo‘nalishiga mutanosib ravishda ortadi; yutilish koeffitsiyenti ortishi bilan atmosferada zararli moddalar konsentratsiyasi kamayadi, o‘z navbatida bu parametr havo massasining namligiga bog‘liq. Kichik o‘lchamli zarrachalarning vertikal ko‘chishiga asosan turbulentlik koeffitsiyenti ham ta’sir qiladi.

Atmosferaning 10 dan 250 m gacha bo‘lgan balandlikdagi sirt qatlamida bu parametr ayniqsa tez o‘sishini aniqladik. Shuningdek, cho‘kish tezligi asosan turbulentlik koeffitsiyenti, shamol tezligining vertikal tashkil etuvchisi, zarrachalar o‘lchami va zichligiga bog‘liqligi aniqlandi.

Ko‘rib chiqilayotgan hudud atmosferasida zararli moddalar konsentratsiyasining maksimal to‘planishini yoz mavsumida, yutilish koeffitsiyenti nolga yaqinlashganda ko‘rish mumkin.

Matematik apparatning GAT bilan integratsiyasi ko‘rib chiqilayotgan jarayonlarni vizual kuzatish va bashorat qilish, noqulay ekologik vaziyatning atrof-muhitga ta’sirini baholash va tabiatni muhofaza qilish tadbirlarining samaradorligini baholash imkonini beradi. Bu bizga turli xil ekologik jarayonlarning ijtimoiy-iqtisodiy jihatlarini juda aniq baholash imkonini beradi: atmosferadagi ifloslanishning tarqalishi, tuproq eroziyasi, cho‘llanish va boshqalar.

Olingan natijalar asosida tavsiyalar shakllantirildi va tegishli qarorlar qabul qilish uchun O‘zbekiston Respublikasi Ekologiya va atrof-muhitni muhofaza qilish davlat qo‘mitasining Samarqand viloyati bo‘limiga taqdim etildi.

Foydalanilgan adabiyotlar

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