Researches of atmospheric air quality in Uzbekistan

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Environmental sustainability

- As a signatory to the millennium declaration, Uzbekistan is fulfilling its promises to address the challenges outlined in the Millennium Development Goals (MDG's). The government recognizes the timeliness and acuteness of these challenges in the national development context.
- As a result of collaboration of the government, a civil society and donor community eight national MDG's have been formulated, among which there is GOAL 7 - "Ensure environmental sustainability". One of GOAL 7 targets (TARGET 9) had been formulated in the following way - integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources by 2015.

Environmental sustainability

- As follows from National Report on MDG's, prepared in 2006, the condition of ecological sustainability had been included in all national strategy and plans for development.
- Strategy of the atmospheric air protection has been developed within the framework of the National Plan of Action on Environmental Protection of the Republic of Uzbekistan, on the basis of which the Government accepts the Actions Program on Environmental Protection in the Republic of Uzbekistan for 1999-2005. In particular, development and perfection of monitoring system of an environment, including atmospheric air was stipulated by this program.
- Researches in the field of atmospheric air protection are carried out according to the State scientific and technical program on the basis of grants.

Geographical situation

- The Uzbekistan is situated in the middle of Central Asia and shares its borders with
  - Kazakhstan,
  - the Kyrgyz Republic,
  - Tadjikistan,
  - Afghanistan,
  - Turkmenistan.

- Uzbekistan is located in the arid zone of Asia, between 37°and 45 ° North latitude and 56° and 73° East longitude. It's territory is 447 400 km^2.
- The area of Uzbekistan is part of the Aral Sea Basin. This basin is replenished by two main rivers: the Amu Darya and the Syr Darya.

Climate

- Uzbekistan is situated on the north border of sub-tropical and temperate climate zones. High level of solar radiation combined with relief feature and atmosphere circulation forms continental type of climate, with significant seasonal and daily air temperature fluctuations, long and hot summer, humid spring and unsteady winter.
- The average temperature in January is from –10 ° C in the north up to 0 ° C in the in July it is from 26 ° C in the north up to 32 ° C in the south.

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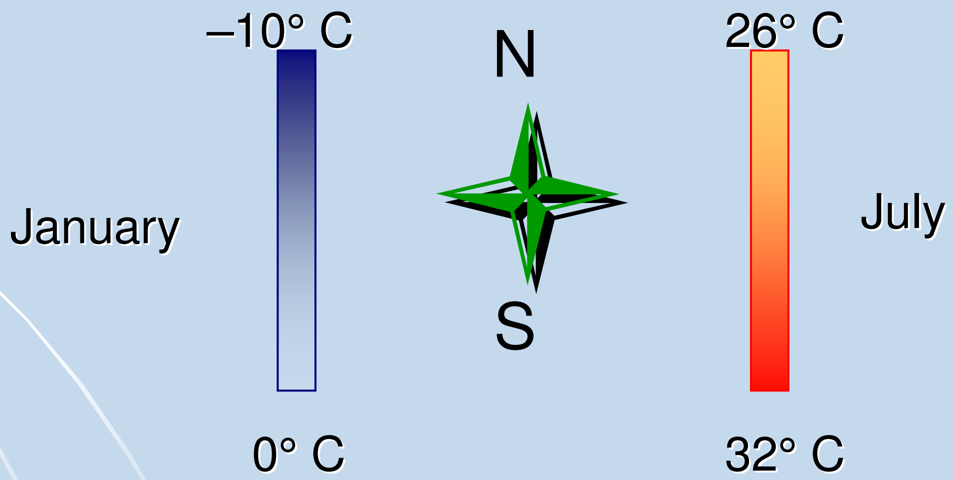


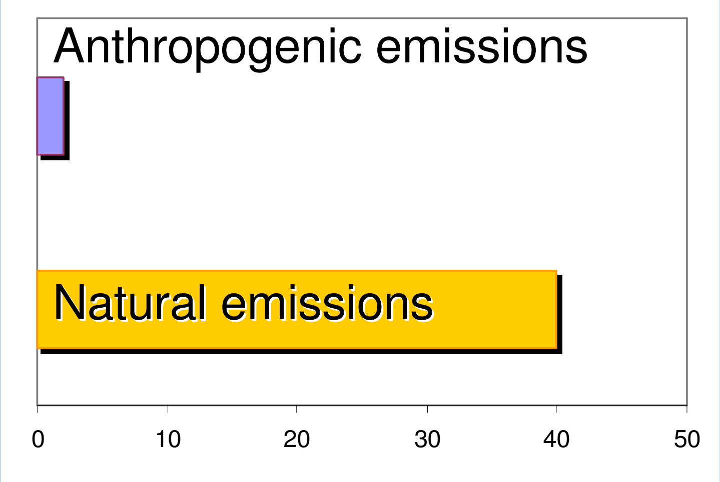
State of atmospheric air pollution

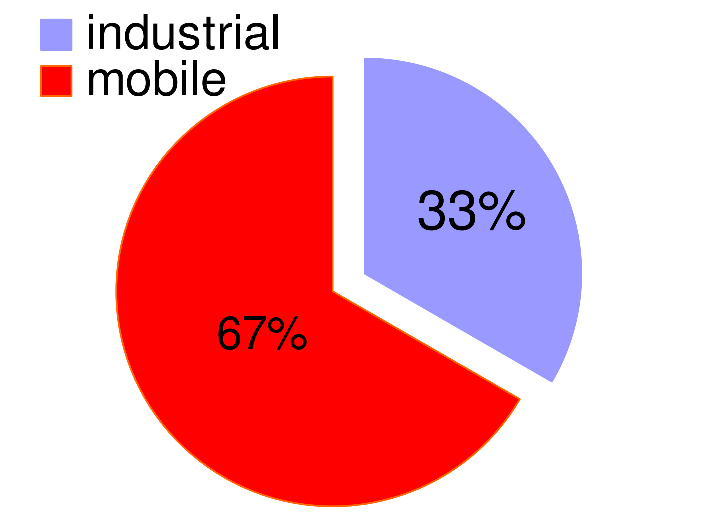
- In Uzbekistan natural and anthropogenic factors impact on atmospheric air pollution
- Natural - geographical and climatic features of the territory, exposure to natural sources of dustiness –the Kara Kum and Kyizyilkum deserts, the dried up bottom of Aral Sea from surface of which more than 40 million tons of salt is carried out to the atmosphere annually.
- Anthropogenic – pollutants emissions from the enterprises of leading industries of the Republic and transport:

in 2004 the total amount of pollutants emissions in the atmosphere amounted to 1.96 mln.tons, thus by

industrial sources -0.65 mln.tons

mobile sources – 1.31 mln.tons are emitted.





State of atmospheric air pollution

- Monitoring of atmospheric air quality is carried out by UzHydromet in 33 settlements on 60 stationary points.
- According to the monitoring data (2000-2004г.г.) excess of Maximum Admissible Concentration (1-3.3 MAC.) on dust, nitrogen dioxide, phenol, ozone was observed in five large cities of Uzbekistan.
- The contents of dust and ozone in air is influenced with natural factors of regional scale, therefore point's observations on the monitoring system are insufficient for their research and application of remote sensing methods is necessary.

The state grants

- “To develop technologies and a substantiation of remote sensing monitoring of atmospheric pollution state according to the digital satellite information “
- “To reveal physical and chemical mechanisms of ozone formation in the polluted atmosphere and a role of precursors in tropospheric ozone formation. To estimate influence of stratospheric ozone on concentration of ground odd oxygen “
- “The research of current dynamics the littoral area of the Aral Sea and ecosystems degradation in the Aral Sea region on the basis of the satellite observations and GIS-technologies”

Dust storms

- A dust storm is a transfer of big amounts of dust and sand by the strong wind leading to the considerable deterioration of the visibility.
- This phenomenon is a periodical event for Central Asia and it is quite specific for desert regions. North and the south coasts of the Aral Sea are the second major source of this phenomenon in Central Asia (the first one is situated in Central Karacum and Kopetdag foothills.
- Dust storms are a powerful natural source of dust. The storm dusts of the meso- and macro scale can be observed from the space. The synopticians divide them to two types regarding the character of their origin as follows:

  1) the storms which originate with the cold front passing

  2) the storms which originate when two baric fronts of the opposite sign encounter with of the sharp intensification of the one of them.
- The dynamics and structure of one of these storms are different.

Dust storms

- **The storms of the cold front** have several stages of their development:
- 1) formation of the storm centre at the surface,
- 2) formation of the dust cloud at the upper levels,
- 3) dust deposition with the wind weakening.
- The cloud is formed in the result of the updraft of the particles with the strong vertical flows in the field of the storm front and entrainment of the dust into the upper-air atmospheric circulation (at the levels up to 3-5 km). The storm front moves alongside with the baric formation.

- **The storms of the second type** are of stationary character
- occupy mainly the surface air layer (up to 1,5-2 km).
- The dust transfer is in the form of the dust flows directed along the wind current.

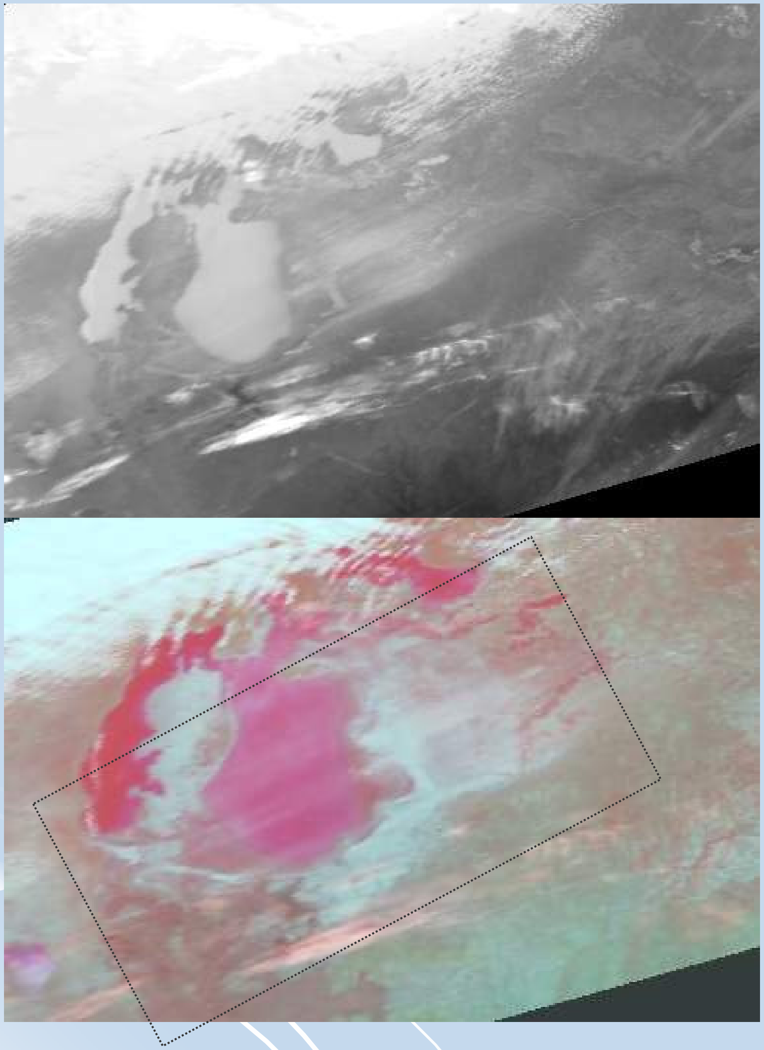
In the conditions of Aral Sea region the first type on storms prevails.

Dust storms

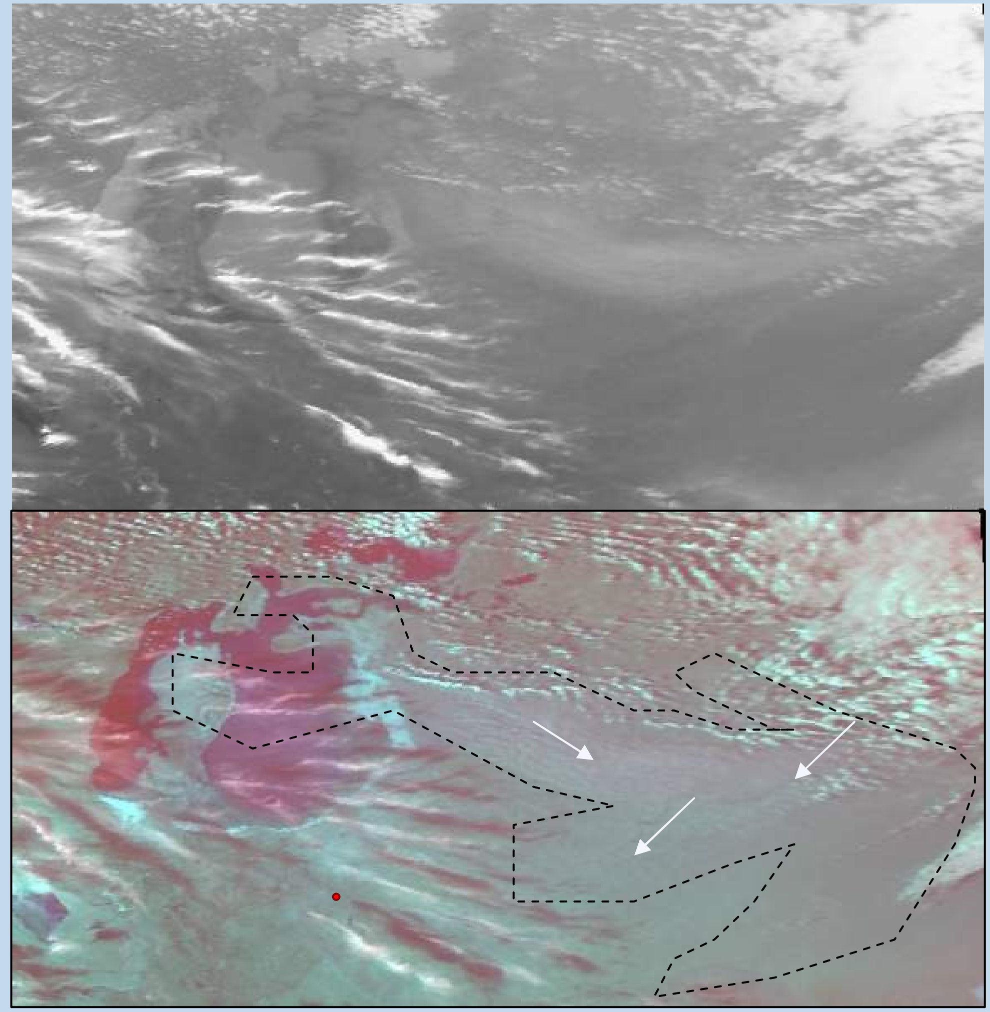
- Basing on the information of the data base and of the archive of the digital satellite information of NOAA system received with AVHRR equipment of "Meteoinfosystem" information and technical administration of Uzhydromet the images with the dust storm events in the studied region were received.

- The procedure of formation of the image with the dust storm is as follows.
  - From the "Dust Storms" data base the events with the dust storms with the cloudiness point less than 6 are sampled.
  - The images where the orbits and time are in the best correspondence with the selected events are sampled.
  - In ERDAS IMAGINE after conversion of file and after geometric and (if needed) radiometric correction the image in the 4th and synthesized images in the 1st, 2nd and 4th bands are singled out. The decoding of the image is made.

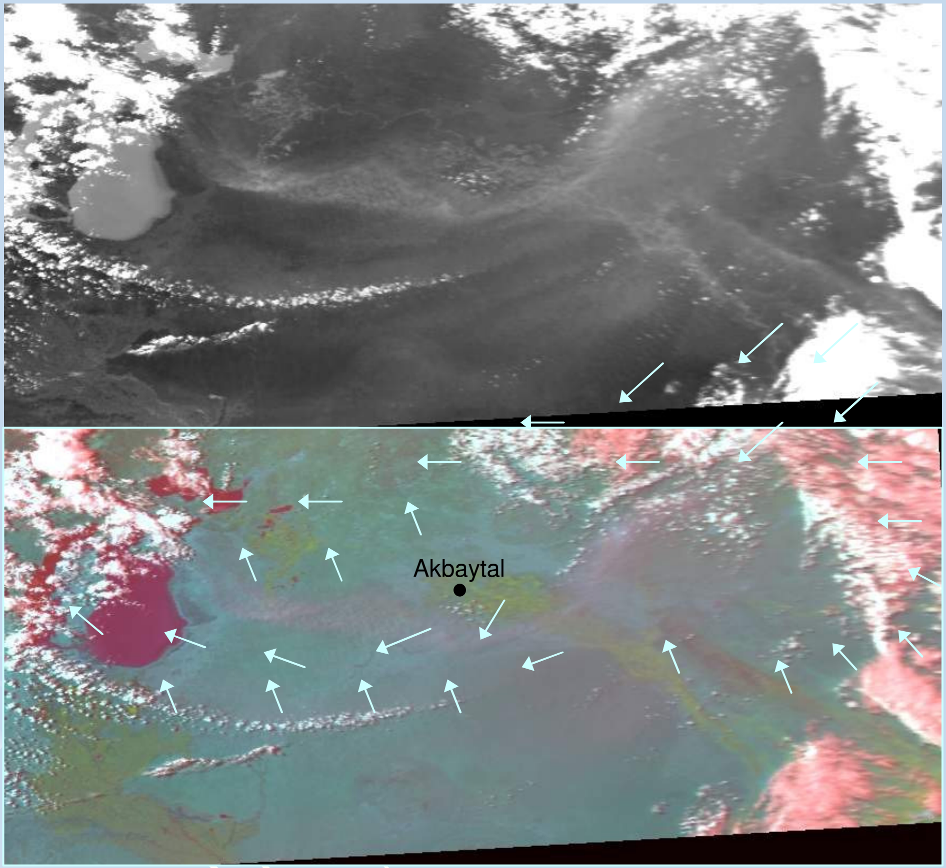
- The area of the dust storm can be estimated with a standard procedure ERDAS IMAGINE



Dust storm 09 04 2002
(NOAA-12, 08h 17m GT)
a)- 4th channel
б)-1,2,4 channels



Dust storm 12 03 2002
(NOAA-12, 12h 41m GT)
a)- 4th channel
б)-1,2,4 channels



10 06 2001 (NOAA-14, 1247 GT)
a)- image in 4-th channel
б)-1,2,4 channel

The range of the dust storm events is within tens thousand square kilometers.

For the evaluation of the mass of dust uplifted to the air during the dust storm it is necessary to know the concentration of the dust particles and their distribution with the elevation.

The dispersion value and peculiar features of chemical composition of the dust particles depend on the region.

The theory of diagnosis of atmospheric aerosol

- Prof. Arushanov has developed the theoretical principles of the diagnosis of atmospheric aerosol by the brightness characteristics of "the underlying surface-atmosphere" system relayed from the board of the satellite.

- Two approaches compose the basis of the theoretic work outs:

– semi-empiric technique ,

– method based on the solution of the inverse problem according to A.Tikhonov

Semi-empiric theory

- Semi-empiric theory of diagnosis of atmospheric aerosol is based on the definition of the optimum conditions with which the highest sensitivity of satellite measurements towards the aerosol content in atmosphere is supported.

The main equation $M = F\,[f(I_\lambda, \tau)]$,

Where M - aerosol mass in the vertical atmospheric column, g/m^2.

I_λ - spectral radiance

τ- optical thickness

- Numerical simulation made with the account of the multiple dispersion and absorption with ozone has revealed that the relationship between the brightness I_λ, derived by the data of AES over the water surface, from the aerosol optical depth τ is approximately presented by the linear function

$$I_\lambda = \xi_1 + \xi_2\,\tau,$$

where ξ_1, ξ_2 are empiric coefficients.

Semi-empiric theory

The relationship is rightly for the aerosol distributed

with the size following the Yung Law (ν=4),

with the particles radius from 0,04 up to 20 µm,

complex refraction index of n=d-mi*=1,5-0,02i with the error about 1,5%.

Basing on the derived empirical relationships we have the following:

$$\frac{M_A}{M_B} = \frac{\tau_A}{\tau_B}$$

$$M_V = \Re b_M,$$

Where $M_{A,B}$ – aerosol mass in the vertical atmospheric column

$\tau_{A,B}$ - aerosol optical thickness ,

M_V - aerosol mass in volume unit,

b_M - volume dispersion coefficient on Mi* particles

$\Re$ - empirical coefficient ($\Re$=40),

The aerosol content in the atmosphere can be reconstructed by the data from the polar-and-orbital AES of NOAA type using the measurement data on the wave length of 0,67 and 0,64 µm, respectively.

For the linear relationships and the angle coefficients should be derived with the account of the regional conditions and conditions of survey. With this the accuracy of algorithm of radiometer calibration is the most important theoretic factor.

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The inverse problems solution

Rather precise quantitative estimations of the aerosol content in the atmosphere can be derived on the base of theory of radiation transfer in the dispersing atmosphere on the base of the inverse problems solution according to A.Tikhonov.

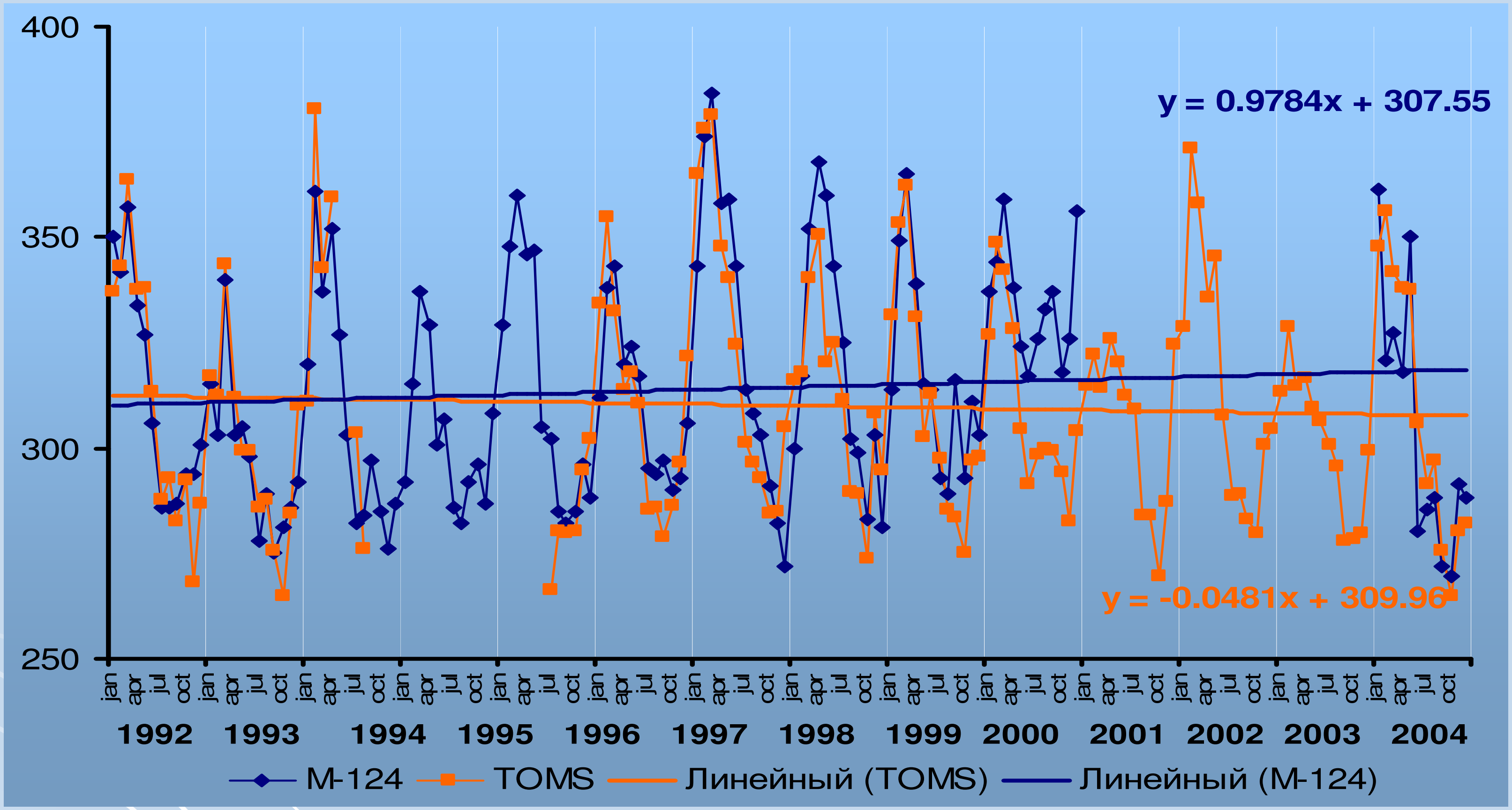
In the framework of our studies prof. Arushanov proposed the following for the solution of the main problems:

- The model of atmosphere was selected.
- Methods of normalization were selected correctly.
- The problem of the brightness profiles of the daytime and twilight horizon was solved for the reconstruction of parameters of the upper atmosphere composition (stratosphere and lower mesosphere).
- The assessment of informational content of radiometric data with the different survey conditions was made.

The total column ozone

- The researches of the total column ozone (TCO) over Uzbekistan for the last 10 years have been carried out using the TOMS data. The satellite and ground observations have been analyzed, long-term trends have been obtained.
- The research objects were follow:
- Assessment of seasonal variations in the total column ozone over Uzbekistan.
- Comparison of ground observations and Satellite data (TOMS).
- Assessment of the long-term trend of total column ozone over Uzbekistan.
- Spatial distribution of total column ozone over Uzbekistan

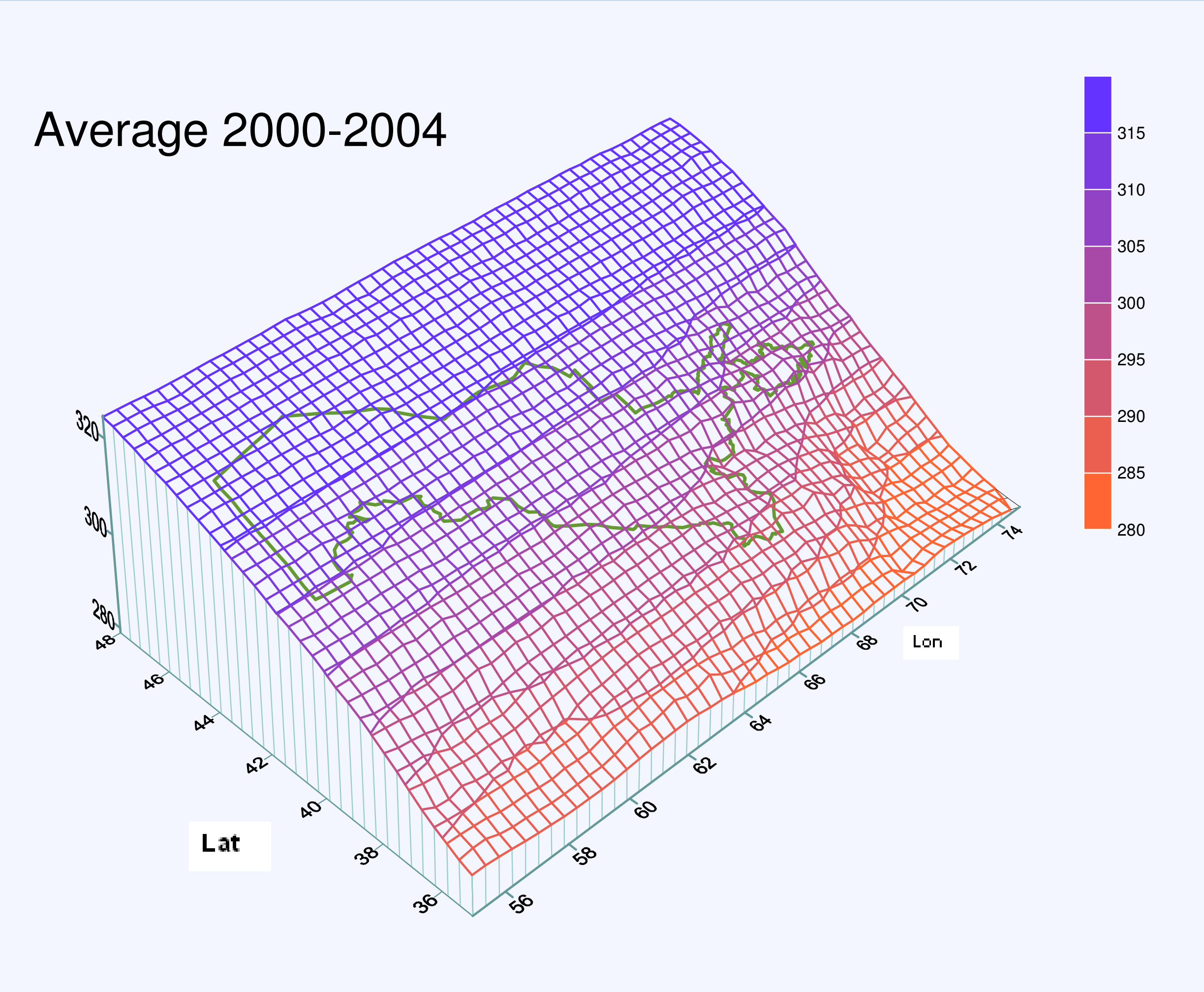
Long-term trend of total column ozone (DU) over Tashkent between ground data and satellite



This slide shows monthly average TCO values based on ground and TOMS measurements for same period for Tashkent station. The increase trend at ground data is higher than that at TOMS. TCO at **ground data** increases at the rate of **0.78 DU/year**, **TOMS data** – decreases at the rate of **–0.57 DU/year.**

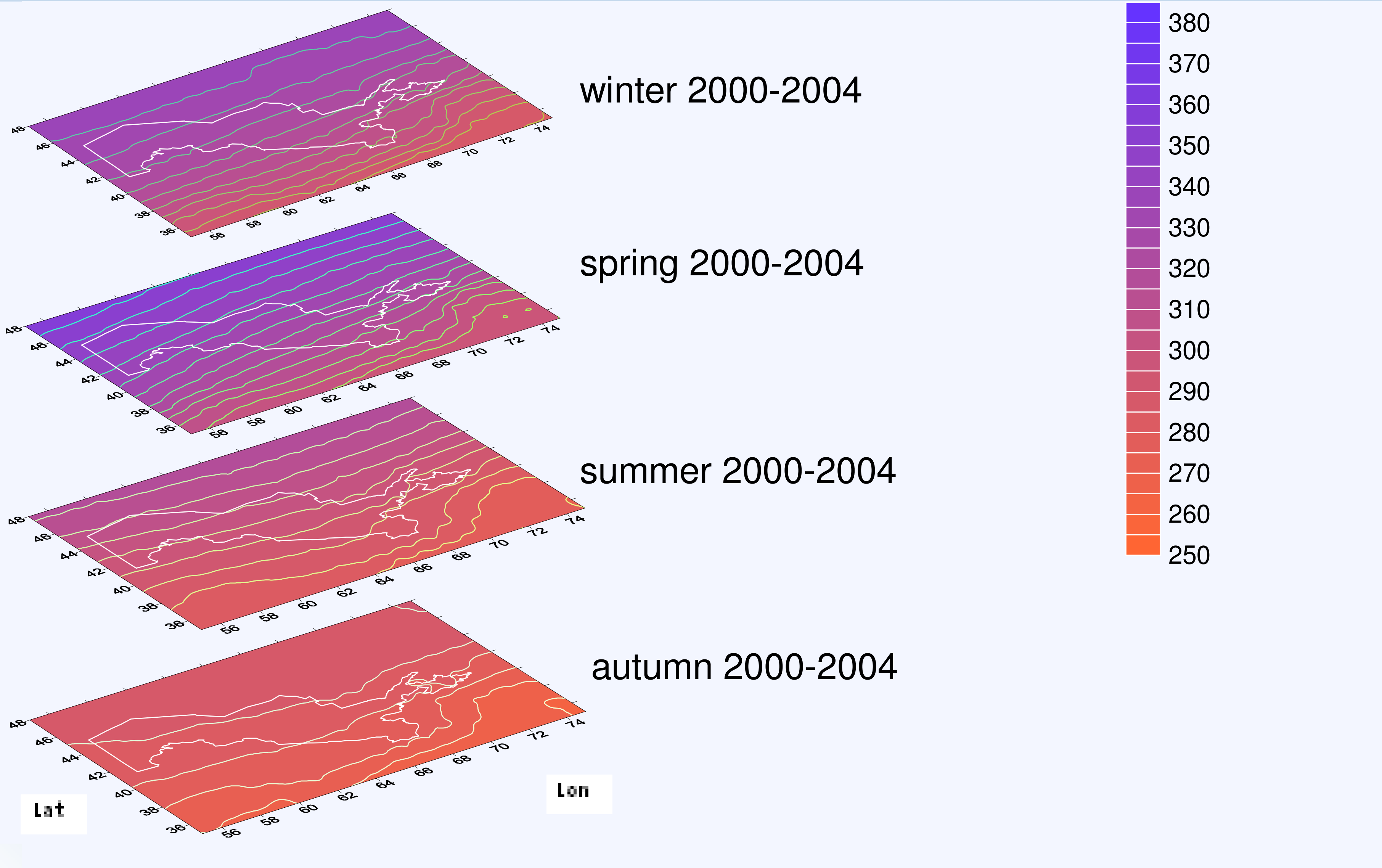
Distribution of total column ozone (DU) over Uzbekistan

This is map of distribution of average for all years TCO values over Uzbekistan, We can see, that TCO varies from 295 DU to 320 DU over the Republic.



Increase of 25 DU observed toward to the north, could be explained by transport of ozone from tropical zones to poles.
TCO distribution during different seasons over Uzbekistan we can see the following.

Distribution of total column ozone (DU) over Uzbekistan



Thank you

for attention!

Atmosphere model:

appendix

- The main scattering agents : a molecular component and aerosol; absorbing components - ozone.
- The atmospheric column - concentric spherical layers with borders at heights z_j (j=0 … n),

  (z_o=R - the Earth radius),

  $\Delta z_j=(z_{j+1} - z_{j})$ - thickness j- layer.
- Density dependence on height – exponential
- Scattering indicatrix of a molecular component -Rayleigh
- Scattering indicatrix of an aerosol undertakes for ensemble of particles with distribution of the sizes under law Yung with parameter ν=3.
- Coefficient of aerosol attenuation - function of the corresponding length of a wave.
- The section of scattering molecular component is set by the formula
- .

Atmosphere model:

appendix

- The section of scattering molecular component is set by the formula

$$\sigma_{s1}=2{,}68(10\lambda)^{-4{,}22}\cdot 10^{-15}$$

- The section of absorption of ozon and nitrogen dioxide (M a l c h o v H. L. Standard models of stratospheric constituents and radiative phenomena for inversion simulation.- M I T Aeronomy Program Int. Rep. NAER 7-1,1971.-102p)

- The vertical optical thickness of j- layer :

$$\Delta\tau v_j(\lambda) = \sum_k \int_{z_j}^{z_{j+1}} \beta_k(z,\lambda)dz = \sum_k \frac{\Delta z_j(\beta_{k,j+1})}{\ln(\beta_{k,j})}$$

Where (k=1,2,…4)

$$\beta_k(z,\lambda)=\rho_k(z)[\sigma_{sk}(\lambda)+\sigma_{\alpha k}(\lambda)],$$

$\sigma_{sk}, \sigma_{\alpha k}$- the sections of molecular scattering and absorption; $\sigma_{s1}=\sigma_{s4}=\sigma_{\alpha 1}=\sigma_{\alpha 4}$

- Optical thickness from $z=z_0$ to $z=z_i$ $\Delta\tau v_j(\lambda) = \sum_{0}^{l-1}\Delta\tau v_j$

- Spectral distribution of solar constant $F(\lambda)$ (M a l c h o v H. L. ,1971.)

The geometry of measurement of a brightness field

appendix

- The geometry of measurement of a brightness field of is determined by three characteristics: zenith angle of Sun ψ_z, an azimuth of sight line $\theta_{z,}$ hight h or tangential height of of sight line

- The geometry of daily horizon: $0^o \leq \psi_z, \leq 80^o$
- twilight $88^o \leq \psi_z, \leq 95^o$
- glancing route : $0^o \leq \psi_z, \leq 120^o$

The equation of the transfer

appendix

- The stationary and monochromatic radiation field
- Polarization and refraction are't taking into account
- In the point M - conditions of the local thermodynamic equilibrium
- The equation of the transfer ofE-field radiation :

$$\frac{1}{\varrho}\frac{\partial I_\lambda}{\partial s} = k_\lambda B_\lambda(M) - (k_\lambda + \sigma_\lambda) I_\lambda + \frac{\sigma_\lambda}{4\pi}\int_\Omega I_\lambda(M, r') f_\lambda(M, r, r') d\Omega,$$

I_λ – intensity of radfiation, proportionate to initial value $I_{0\,\lambda}$ (*M*,r) in the point *M*, traversed path ds, atmospheric densityr(*M*);

k_λ -mass adsorbtion coefficient for λ;

B_λ(M) – Planc function;

σ_λ - mass scattering coefficient;

f_λ - Scattering indicatrix;

$f\,\lambda$ (M,r/,r)/4π - scattering probability by medium ofradiation quantumизлучения from direction **r'**, to one **r** to unit of space angle Ω, In the point M

The solution of the inverse problem

appendix

- At the passive probing and formal problem definition solution of this problem is solution of Fredgolm equation equation of 1 type

$$f(x) = \int_a^b G(x, y)\varphi(y)dy, \quad c \le x \le d,$$

- To be suppose, that *G(x,y)* - integral equation kernel, and function *f(x)* –spectral intensity of outgoing radiance observed from satellite in limit number of spectra intervals $x_1, x_2, \ldots, x_m$. have known
- *φ(y)* -unknown quantity, profile of meteorological parameters

- equation is accumulated to **f=A** φ, where **A** - matrix mxn, , **f**= $|f1, f2, \ldots, fm|^T$ – measurements vector (T- transposition sing)
- $\varphi = |\ \varphi_1, \varphi_2, \ldots, \varphi_n|^T$ **-** unknown vector of meteorological parameters in the points $y_1, y_2, \ldots, y_n$.
- *Elements* a_{ij} of matrix *A* are

$$a_{ij} = G(x_i, y_j)\, \Delta y_j \omega_j ,$$

ω_j – quartet weights, corresponding to levels j

The direct solution of this system is impossible (detA~0). Methods of stable solution (A.Tikhonov) based with the regard of a priori data about φ.