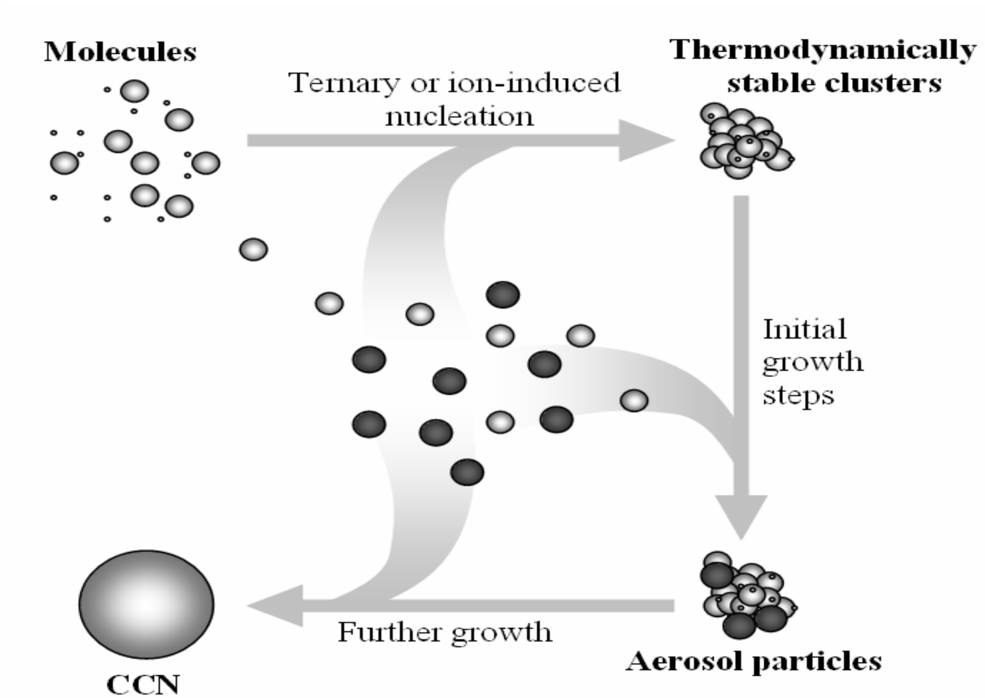
# COSMIC RAYS, AEROZOLS, CLIMAT
# Registration of the Cosmic Rays of Ultrahigh Energy

# Inerrelations between cosmic ray intension and aerozol concentration



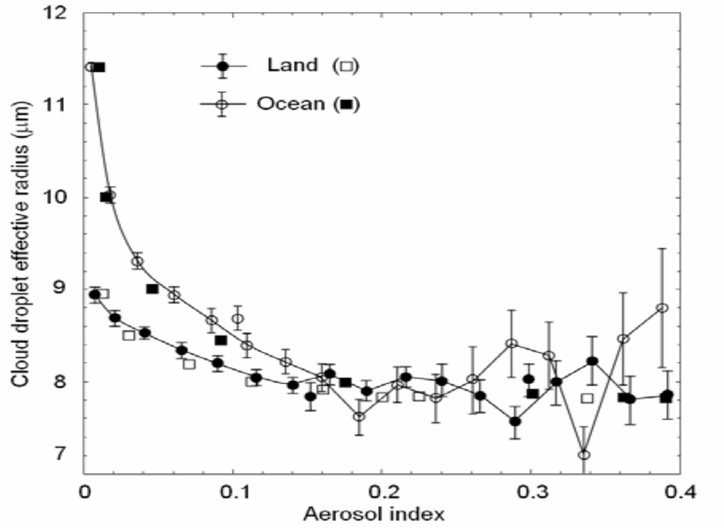
# Inerrelations between cosmic ray intension and aerozol concentration

How particles form and grow [*Kulmala*, 2003**]**:
Nucleation may involve homogeneous ternary water-sulfuric acid-ammonia mixture or may be ion-induced. The initial steps of growth include activation of inorganic clusters by soluble organic molecules, heterogeneous nucleation of insoluble organic vapors on inorganic clusters, and chemical reactions of organic molecules at surfaces of inorganic clusters. Finally, cloud condensation nuclei (CCN) form through addition of organic and sulfuric acid molecules.

# How particles form and grow

- Primary inoculate centers – ions (cosmic rays), ternary (water-sulfuric acid-amonia mixture), soil particles
- Growth: geterogeneous nucleation, diffusion driven aggregation (fractals)
- Formation of CCN
- Condensation of droplets

# Interrelation between cloud droplet radius and aerosol index




- Effect of aerosol on cloud droplet: mean cloud droplet effective radius (CDR) as a function of aerosol load [Breon et al., 2002]. The two curves show the mean CDR as a function of aerosol index (AI) for land (lower curve) and ocean (upper curve). The error bars represent the confidence level of the mean value, i.e. , where *n* and $\sigma$ are the number of CDR measurements within the bin and their standard deviation [Breon et al., 2002]. The empirical dependence CDR=*f* (AI) of type (1) for land (■) and ocean (□) is also represented
- .

$$AI = \left[ \frac{1}{(0.6 r_{eff} - 4.385) r_{eff}} - \frac{\eta}{r_{eff}} \right]^{1.429}, \quad \eta = \begin{cases} 0, & over \quad ocean, \\ 0.63, & over \quad land, \end{cases}$$

# Fractal Properties of Atmospheric Aerosols

Experimental data and some theoretical and model approaches

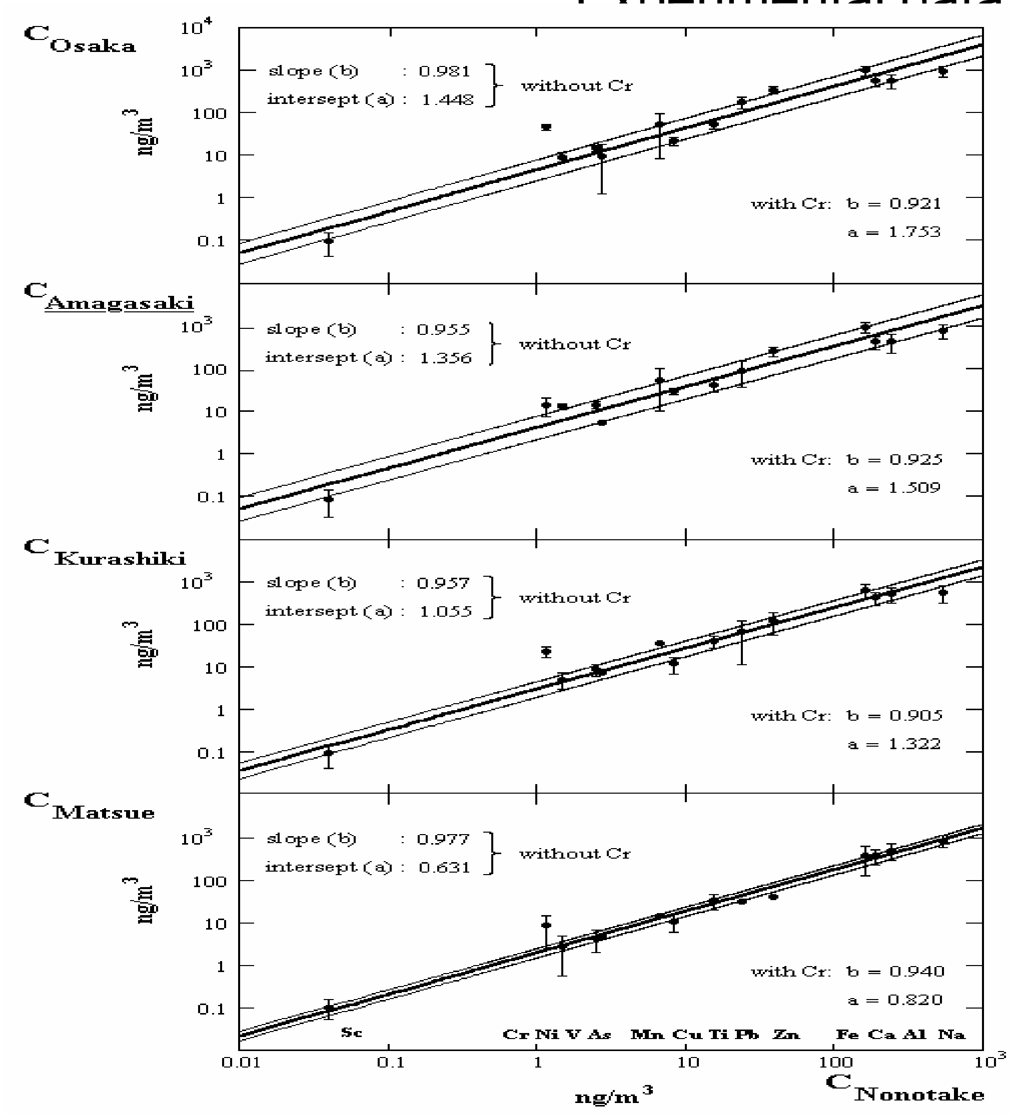
## Experimental data from Antarctica, Slovenia, Ukraine, Japan

# Fractal Properties of Atmospheric Aerosols

- Nucleopore filters
- Sampling in different region of the Earth (Antarctica, Slovenia, Ukraine)
- Neutron activation analysis (Kyiv and Ljubljana reactors)
- Data from Japan (23 years every mounth)

# Element content of aerozols

Experimental data



# Element content of aerozols

## Experimental data

- (i) the elemental content of atmospheric aerosols is practically the same and does not depend on the recording location at least for most widespread elements;
- (ii) the linear relation (on a logarithmic scale) of different pairs of experimental samples of element concentrations in atmospheric aerosols indicates the statistically significant power mass growth of the *i*–th element in atmospheric aerosol, thus substantiating the assumption about the fractal nature of the genesis of atmospheric (secondary) aerosols, so

$$C_{i1} = a_i (C_{i2})^b$$

- or more correctly
- , $\frac{C_{i1}}{C_r} = a_i' \left( \frac{C_{i2}}{C_r} \right)^b$
- where Cr is some reference concentration;
- (iii) those elements which depart from linear dependence, are different in their genesis, which indicates the technogenic nature of their sources;
- (iv) the multicomponent properties of atmospheric (secondary) aerosol point to their being a non-homogeneous fractal, or, what is the same, a multifractal.
- (v) the model of linear regression is satisfactory for all pairs of data obtained in different regions of the Earth.

# Element content of aerozols

## Experimental data

- It can be considered as the low of linear correlation dependence between the components of two-dimensional (at the Earth surface) random variable $\left( u = \frac{\ln C_{1i} - \langle \ln C_{1i} \rangle}{\sigma}, v = \frac{\ln C_{2i} - \langle \ln C_{2i} \rangle}{\sigma} \right)$. It is well known from the probability theory that the components of the two-dimensional normal distribution

$$P(\ln C_{1i}, \ln C_{2i}) = \frac{1}{2\pi\sigma_1\sigma_2\sqrt{1-r^2}} \exp\left[ -\frac{1}{2(1-r^2)} \left( u^2 + \upsilon^2 - 2ru\upsilon \right) \right]$$

- where *r* is the correlation coefficient,is connected by the linear correlation dependence. In other words, the parameters of two-dimensional normal distribution is connected by the equations of direct linear regression

$$\ln C_{1i} - \langle \ln C_{1i} \rangle = r \frac{\sigma_1}{\sigma_2} \left[ \ln C_{2i} - \langle \ln C_{2i} \rangle \right]$$

- and inverse linear regression.The components of two-dimensional normal distribution have also normal distribution

$$P(\ln C_i) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left\{ -\frac{1}{2\sigma^2} \left[ \ln C_i - \langle \ln C_i \rangle \right]^2 \right\}$$

or

$$P(C_i) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left\{ -\frac{1}{2\sigma^2} \left[ \ln C_i - \langle \ln C_i \rangle \right]^2 \right\}$$

# Back to fractals

It is interesting to note that the occupation numbers pij of multifractals have also log-normal distribution (if one can approximate the spectrum of fractal dimensions *f*($\alpha$) by parabola

$$P(p_{ij}) = \exp\left(\mu - \frac{1}{2}\sigma^2\right) \cdot \exp\left[-\frac{1}{2\sigma^2}\left(\ln p_{ij} - \mu\right)^2\right]$$

where $\mu = \ln p_0, \quad \sigma^2 = 2\ln\frac{1}{p_0 N_{D_0}} \quad \ln p_0 = \alpha_0 \ln\frac{1}{l} \quad \ln N_{D_0} = -D_0 \ln\frac{1}{l}$

# Fractal Properties of Atmospheric Aerosols

- Connection between element content of aerosols and multifractals
- Model assumption on aerosol formation
- Diffusion aggregation of single particle – fractal
- Diffusion aggregation of different particles – multifractal
- Conclusion about standard of pure air

# Back to cosmic rays

- Our knowledge about cosmic rays forms not only our ideas of Earth climate, but in general our concept of Universe
- We Know that:

1. CR is universal phenomenon and play sufficient energetic role in Universe.
2. Main part of CR has Galactic origin with small modulation by solar CR.
3. Main source of GCR are supernova stars

# GCR of ultrahigh energy

- 1 particle/100yr km*2 sr
- Several events with energy >E20 eV were detected by usual methods
- CR of 3.E20 eV has the age not exceeding E8yr due to interaction with photons of relict radiation
- In our Galactic there are no such obvious objects which can accelerate protons to such energy

# Radiomethod of CR detecting

- Cherenkov radio tail and geomagnetic radiation induced by air shower -30-50 MG
- Showers in dense matter – 1-10 MG:
- $\delta$- and excess electrons of the shower – 0.5 MG
- Transition radiation due to transition of shower from air to sea water – 5 MG
- Preliminary Antarctic results
- Main question – is detecting signal due to cosmic ray or this is a noise

# Radiomethod of CR detecting

- Bremsstrahlung radiation
- Single or double reflection from ionosphere
- Lateral wave
- Beveridge antenna at Antarctic station
- «Master-signal»?
- Pulse shape?
- Good analog-digital [A/D] converter
- Coincident signals of two or more antennas (Bolgarian, Russian or another stations)
- Monte Carlo simulation

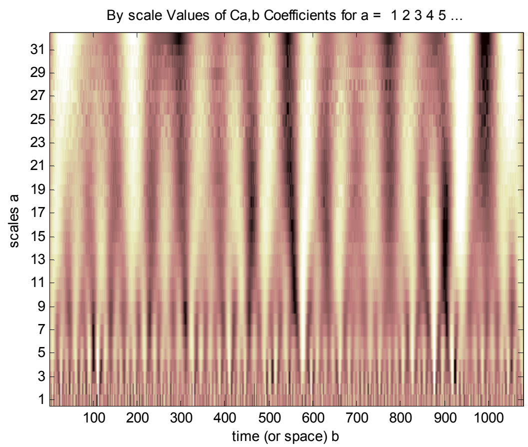
# Statistics of Cosmic Ray

- CR detection is random process
- Poisson Statistics
- Generalized Poisson statistics (Neimann type – two cascade process)
- Processing of the known results (BEO Mussala Cherenkov detector)

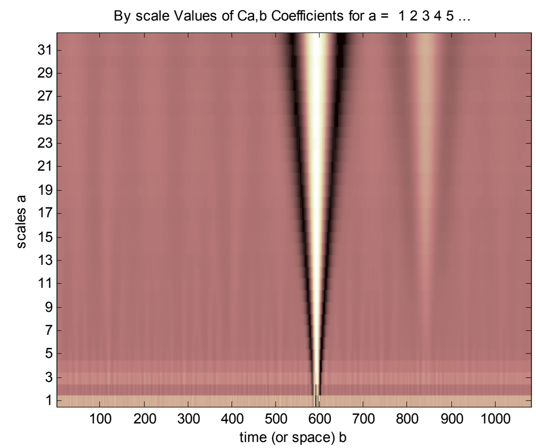
# Statistics of Cosmic Ray

## Cherenkov detector – wavelet analysis

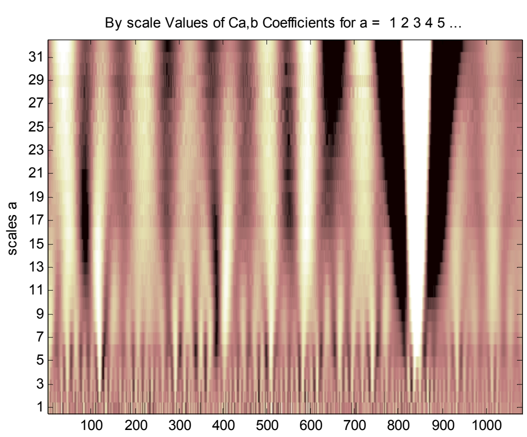
### Artificial Poisson process



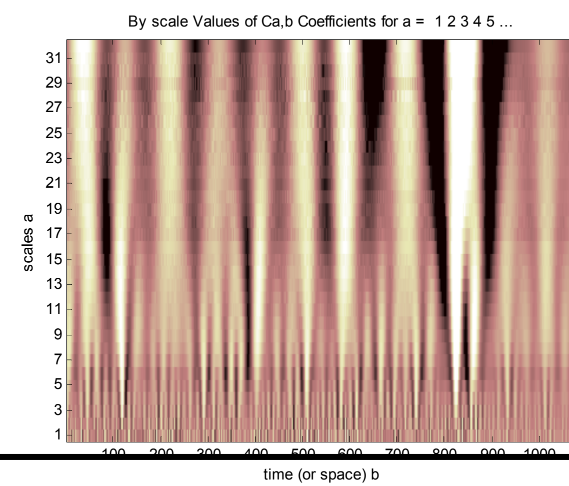

### Data of Zenith experiment (July 2006)




### Experiment improved by Poisson (600c)

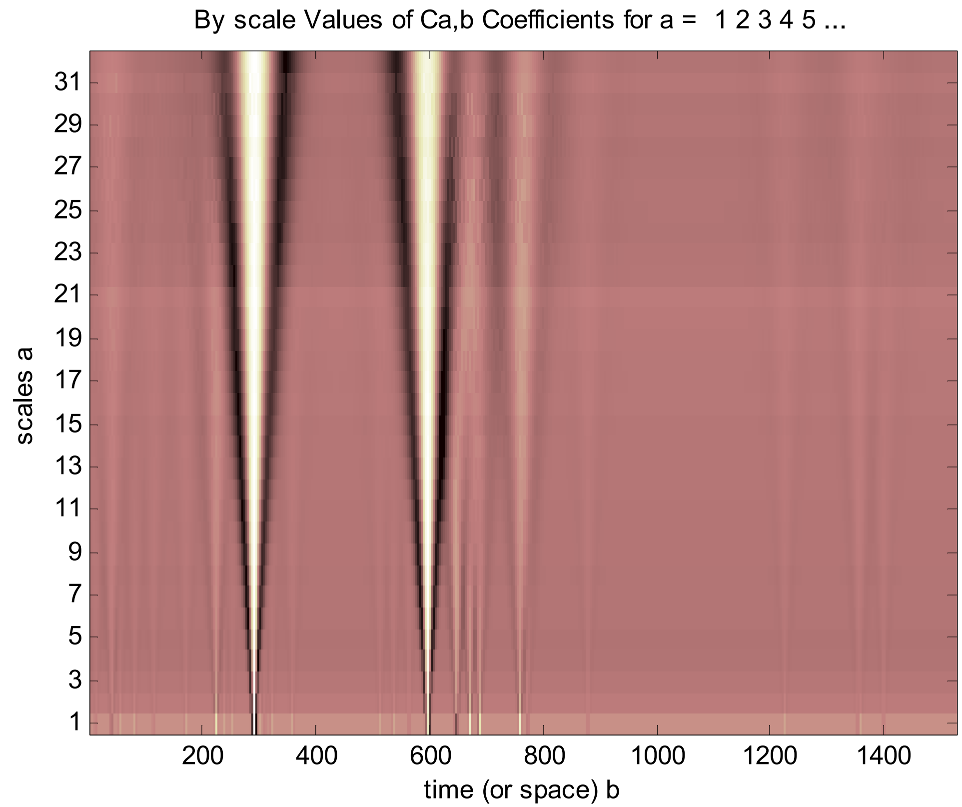



### Experiment improved by Poisson (600,800c)



# Statistics of Cosmic Ray

## Cherenkov detector – wavelet analysis of lake reflected signal



# Conclusion

- Many unknown question
- Invitation for collaboration