**INCO-CT-2005- 016663**

# BEOBAL

## BEO Centre of Excellence Research Capacity Improvement for Sustainable Environment and Advanced Integration into ERA

**SSA**

**PRIORITY 6: Global Change and Ecosystems**

# Periodic Activity Report

**Period covered:** from 01.04.2006 to 31.03.2007 **Date of preparation:** 26.04.2007

**Start date of project:** 01.04.2005 **Duration:** 30 months

**Coordinator:**
Prof. D.Sc. Jordan Stamenov

**Co-coordinator and project manager:**
Assist. Prof. Dr. Boyko Vachev

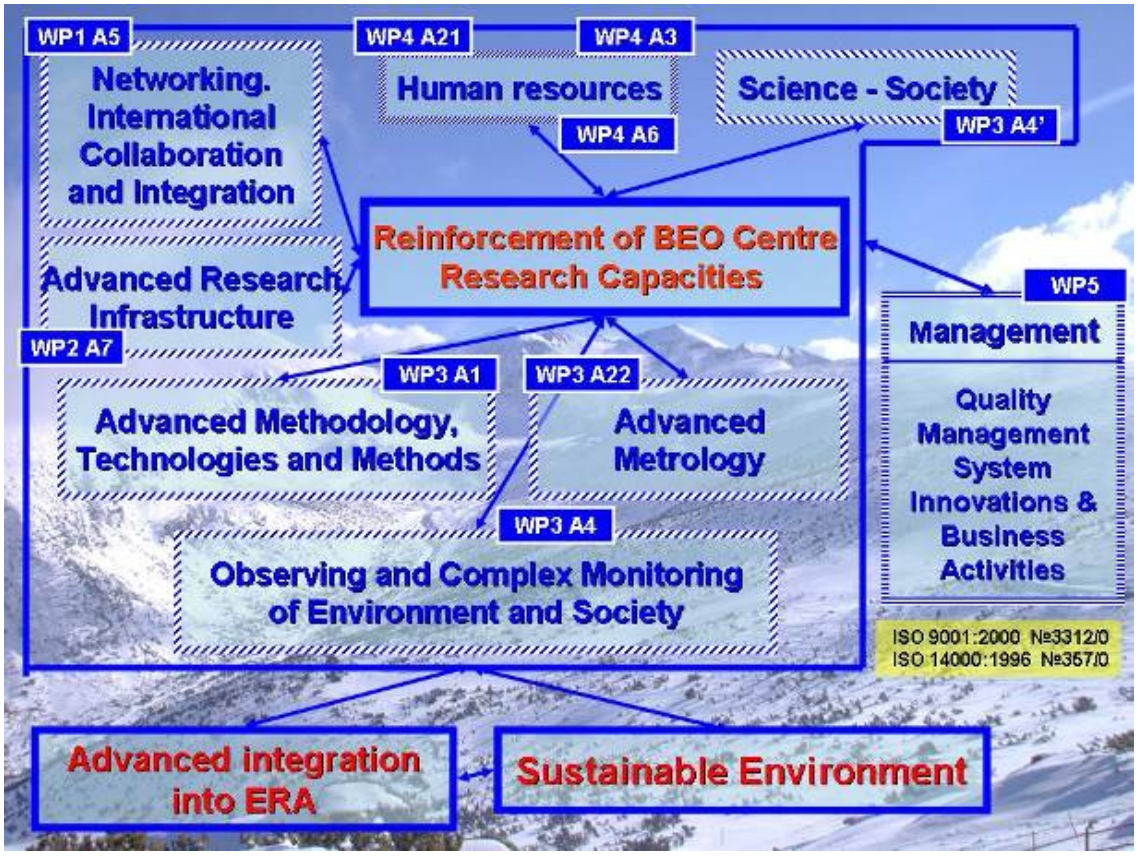
**Project coordinator organisation name**
Institute for Nuclear Research and Nuclear Energy,
Bulgarian Academy of Sciences

**Revision 1**

**"BEO Centre of Excellence Research Capacity Improvement for Sustainable Environment and Advanced Integration into ERA"**

**INRNE 6th Framework Programme of EU project (*INCO-CT-2005-016663*)**

# BEOBAL Executive summary




The main purpose of these projects is in next years BEO Moussala to be developed as/for:

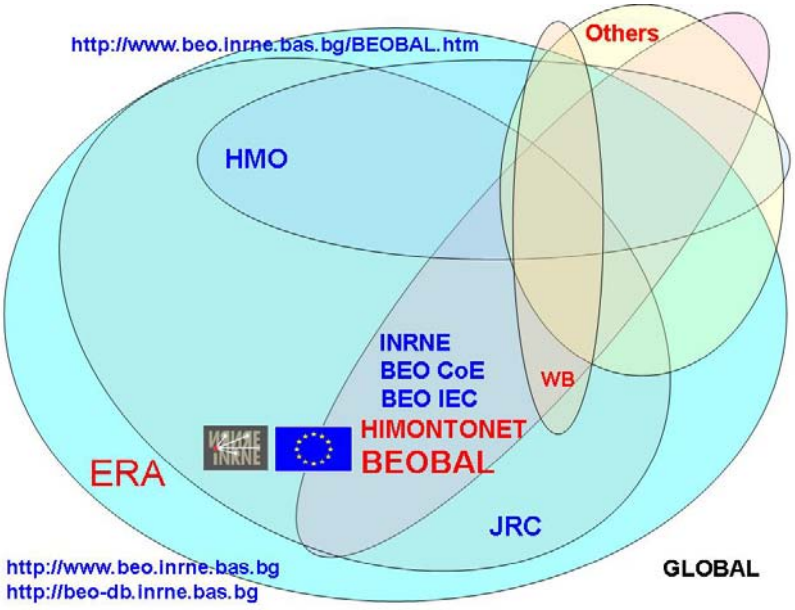
- an observatory attracting the scientists from abroad and to be included as "research infrastructure for transnational access"
- the regional station of GAW (Global Atmosphere Watch) programme of World Meteorological Organization
- implementation and development of advanced methodology, technology, methods and advanced metrology
- enhancement of observing and complex monitoring of global change and ecosystems
- diversification, broadening and enhancement of international collaboration and cooperation
- advanced Human Resources long-term management and stimulate of youth in science
- active science communication by advanced Science – Society interaction policy
- application and development of advanced management system
- reinforcement of S&T equipment and systems of BEO CoE directed to enhancement of the research infrastructure of European importance

**The basic fields of current and future work and studies at BEO Moussala and in BEO Centre of Excellence are:**

- **Global change**
- **Aero - Space weather**
- **Sustainable development**
- **Measurement devices and systems development and enhancement.**

**WP1:** ***Networking.*** *Diversification, broadening and* ***enhancement of international collaboration*** *and cooperation.* **Operational goal A1** (Networking, International Collaboration & Integration and Reinforced Research Infrastructure)

**Objectives** ***Networking. Diversification, broadening and enhancement of international collaboration and cooperation*** towards to reach real European integration.
The special attention is paid and a substantial part of work is directed to the joint activities with Balkan institutions, deepening of international collaboration, networking and integration in the space of ERA with European centers of excellence - JRC institutes (**ITU**, Karlsruhe, Germany, **IES**, Ispra, Italy, **IRMM**, Geel, Belgium), European High Mountain observatories (**HMO**), large international institutions of European and global importance like **CERN** and other leading European institutes, traditional and new INRNE partners (**INP**, Prague, Czech Republic, **INFN**, Torino, Italy, **INS**, Izmir, Turkey).




**Study visits: 11**

**1** in UFS Schneefernerhause, Zugspitze and Hochenpeissenberg Observatory, Germany; **2** in INP and Tien-Shan, Kazakhstan; **3** in INS, Izmir, Turkey; **2** in JFJ, Interlaken, Switzerland; **2** in INR and NUARC, Kiev, Ucraine; **1** in ITU JRC, Karlsruhe, Germany,
During these visits BEOBAL project has been presented. As a result several protocols, memorandums and agreements have been signed, and agreements for collaboration, joint research and exchange of information have been reached.Special regional task was directed to the activities with **Neighbor countries and Turkey** (see table 1).
**Joint work programme with the JRC institutes** (in the framework of NUSES initiative and BEOBAL project) (see table 1)
**Bilateral cooperation and joint cooperative agreements with European HMO** (in the framework of HIMONTONET, BEOBAL, ACCENT, EUSAAR and other EU projects and initiatives) (see table 1).
Deepening of international collaboration, networking and integration in the space of ERA with **large international institutions of European and global importance and INRNE traditional and other new partners**. (see table 1)
**2** project proposals **for FP7 have been submitted** and **2** are **in stage of preparation** (in **Research Potential, Ideas, Science and Society and Security** calls) with BEOBAL partners.

| Title/Subject | Date | Participant/ Lecturer/ Visitor | Content/Work | Main Output |
|---|---|---|---|---|
| UFS, DWD Hochenpeisenberg Observatorium, DE | 23.07-05.08.06 | S.Mavrodiev | Series of seminars have been made, BEOBAL project has been presented and consideration of obtained models for temperature., CO2 atmosphere conc., number of world earthquakes as function of global temperature | agreements for collaboration, joint research and exchange of information have been reached; prepared joint presentation for GEIA 2006 Open Conference |
| Tyan-Scan, Kazachstan | | J.Stamenov, I. Kirov | BEOBAL project has been presented and agreements for collaboration, joint research and exchange of information have been reached | Proposal from Kazachstan part has been made for methodological assistance for formation of Euro – Asian Astrophysical Centre |
| JFJ, Switzerland | Sep 2006 | J.Stamenov, B.Vachev | BEOBAL project has been presented with a poster and new joint project for HMO has been agreed to be presented in FP7 inauguration exhibition | Joint project for HMO has been prepared; new contacts have been made |
| INR, UNRAC, Kiev, Ucraine | 14-20.01.2007 | S.Mavrodiev, B.Vachev | BEOBAL project has been presented and agreements for collaboration, joint research and exchange of information have been reached. | Two bilateral agreements have been signed. Joint project proposals for FP7 have been discussed |
| ITU, Germany | 25.02 – 3.03.07 | A.Strezov | The implementation of an electronically cooled (Stirling-cooled) High Purity Germanium detection system with integrated nuclide identification and training at the laboratories of ITU for measure. of nucl. mat. samples | Development the cooperation in performing joint analysis of samples by the request of the Bulgarian state of those data which are relevant for determination of potential routs of illicit materials to be measured at ITU |
| INS, Izmir, Turkey | 2006-2007 | A.Damianova | Discussions and definition of the areas of collaboration and preparation of proposals for joint research projects in the area of environmental investigations | Two agreements have been signed with the Department of Physics, Ege University, Turkey in the field of environmental ecological studies and use of mineral sorbents zeolites. |
| INRNE, Sofia - IRMM, JRC, Geel, Belgium | | B. Slavchev, U. Waetjen | 1 Ph.D. student 12 months specialisation and BEOBAL and continuation of discussions about the training seminar organisation and thematic | Ongoing 12 month Ph.D. student specialisation |
| INRNE, Sofia - IES, JRC, Ispra, Italy | | A. Nishev, M. de Cort | Realisation of two 3 months visit in IES; discussion of future training seminar; | Continuation of EURDAP fruitful collaboration |
| POST_HAFS Jungfraujoch&Gornegrad, Switzerland | 28.11-04.12.2005 | I. Penev | Continuation of Discussion of the technology for measurement of airborn radioactive elements towards harmonization of measuring methods inside possible future collaboration. | BEO is included in collaboration "RING OF FIVE", European Trace Survey Station for Monitoring Airborn Radioactivity |
| Post__Hochenpeissenberg Observ. DE+ JFJ | 2006-2007 | Ch. Angelov | Recommendation for BEO to join EMEP network - initial steps were made; Partic. in Europe air sampling campaign, leaded by NILU, NO. | Participation in a joint European sampling compaign, results of analysis are expecting |
| Monte Cimone research station, IT, Hochen-paissensberg, DWD, DE, others, Lomnitsky Stit HMO, Slovakia | 21-25 March .2007 | P. Bonasoni, W. Fricke, K. Kudela | Exchange of experience, join field work, new methods and general organization of work of MC Research station. + future activities + BEOBAL; agreements for joint work in the field of ozone and aerosols studies, complex GAW observing, ecotoxicology studies and neutron studies. | Joint project proposals and activities in the field of quality assurance, aerosols and greenhouse gases measurements and studies.<br>INRNE BEO CoE FP7 proposal REGBEOBAL with participation of these three HMO. |
| INP, Prague, Czech Republic; | 2006 -2007 | F. Spurny | Discussion of the first results from the application of new method for 14C estimation and LIULIN Let spectrometer device calibration and implementation | Start of exploitation of similar installation for 14C measurement LIULIN exploitation |
| INRNE – CERN, Switzerland | Dec. .2006 | P. Konstantinov, E. Puncheva | Discussion of continuation of CERN – INRNE joint work in the field of implementation of GRIN technologies | Implementation of joint CERN – INRNE – Ministry of Education and Sciences GRID activities |
| INRNE – INFN, Torino, Italy | 2006-2007 | A. Zanini | Discussions of first results and future activities in estimation of neutron flux with use of MCNP. Adjustment of w. progr. of visits of A. Mishev in INFN, Torino + joint project FP7 proposals: + REGBEOBAL + RDD (SEC call), Science communication activities | Adjustment of work plans of common activities 2006-2007<br>Preparation of new INRNE BEO CoE FP7 proposal REGBEOBAL with participation of Testa Gridjia HMO and INFN, Italy; 2 FP7 proposals – 1 in SEC and 1 in SiS calls |
| EUSAAR,ACCENT FP6 | 2006-2007 | J. Stamenov, B. Vachev, P.Ivanov, Ch. Angelov | INRNE joint ACCENT NoE as associate partner. Continuation of work in EUSAAR NWAs; technical and audit visit to BEO Moussala | Participation in workshops, exchange of know – how |
| ALOMAR observatory, Norway | | I. Angelov, E. Malamova, J. Stamenov, M. Gausa | Atmospheric transparency; previous collaboration has been discussed and | a new joint project proposal has been prepared |

***Table 1***

**WP2:** ***Reinforcement of S&T equipment and systems of BEO CoE***

**Operational goal A2 (**Networking, International Collaboration & Integration and Reinforced Research Infrastructure)

**Objectives** Reinforcement of S&T equipment and systems of BEO CoE directed to ***enhancement of the research infrastructure*** of European importance, connected with: global change observing, ecosystems monitoring, technological and natural risks (study, early detection and control) widely using new information technologies and platforms. The improving of systems for ***observing and complex monitoring*** in attempt to realize adequate management towards to reach sustainable environment. ***Improving BEO Moussala to a regional GAW station***, creating and improving by this way South - East European part of this network, joining ERA.

**Upgrading and renewal of S&T equipment: 12**

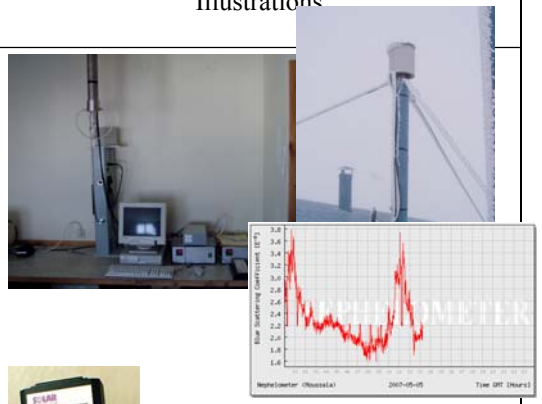
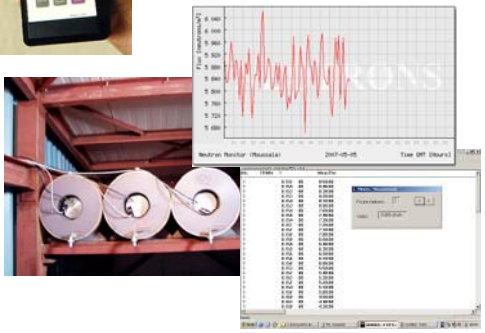
The following equipment is delivered and it is at stage of testing and measurements:

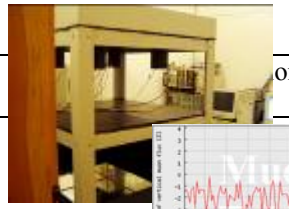
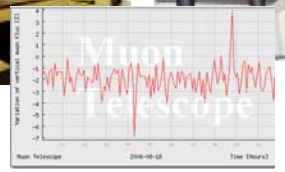
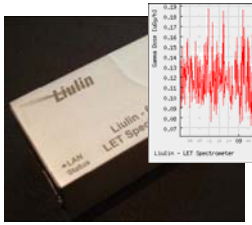
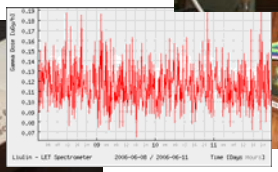
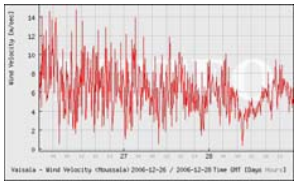
- Aerosol instruments (according GAW requirements)
  Integrated nephelometer for determination of integral light-scattering coefficient of aerosol - nephelometer
- Inlet to nephelometer
- Condensation particle counter (will be delivered)
- Rn analyser
- Alpha spectometer
- Equipment for monitoring of aerosols radioactivity
- Gas analyzer for measurement of CO2 (will be delivered)
- Ozonometr (will be delivered)
- Software to Gamma probe
- Small portable equipment and complectation to the existing system
- New meteorological equipment (will be installed)

The following equipment and systems are in operation:

- Air quality monitoring system (NOx, CO, SO2, O3 analyzers, portable calibrator and data acquisition system);
- Systems for cosmic particles, radioactivity detection and complex environment monitoring
  Gamma background probe;
  Neutron detector;
  Muon telescope;
  Modernized set of portable small devices for complex environmental monitoring (new gamma spectrometer)
- Modernized computer network;
- Improved automatic weather station (new wind sensor);
- Upgraded system for uninterruptible emergency power supply;
- Improved equipment for radioaerosols research
- Improved and modernised video control and observing system
- Modernised electricity supply, thunder protection, transport and other technical infrastructure systems, ect.

***Table 2***

| Type of equipment | Status, Date | Functional characteristics (specification) | Tender procedure | Data transfer | Illustrations |
|---|---|---|---|---|---|
| **TSI 3563** Integrated nephelometer for mesuring of integral light-scattering coefficient of aerosol **Inlet** to the integrated nephelometer | In operation at BEO Moussala since 21-th of February 2007. | Measurements of light scattering coefficient and back-light scattering coefficient of aerosols are provided by TSI Integrating Nephelometer model 3563. TSI Integrating Nephelometer is designed specifically for studies of direct radiative forcing of the Earth's climate by aerosol particles.The light-scattering coefficient is a highly variable aerosol property. Integrating Nephelometer measures the angular integral of light scattering that yields the quantity called the *scattering coefficient*, which is used in the Beer-Lambert Law to calculate total light extinction. Model 3563 includes three-wavelength and back-scatter features – wavelengths 450 nm (blue); 550 nm (green) and 700 nm (red). | Tender procedure with direct negotiation; GAW requirements and standards and 3 recommendations of leading experts Direct negotiation | On screen and database output, Web integration |  |
| **Gas analyser CO12** | Delivery Jun 2007 | Gas analyser for measurement CO2 production of Environnement | No tender, 3 offers | On screen and database output, Web integration | |
| **MICROTOPS II** ozonometer | Delivery Jun 2007 | **MICROTOPS II** is a 5 channel hand-held ozonometer for measuring total ozone column; Optical channels: 305.5 ±0.3 nm, 312.5 ±0.3 nm, 320.0 ±0.3 nm, 936 ±1.5 nm, 1020 ±1.5 nm, 10 nm; Resolution: 0.0001uW/cm² on 305nm channel; Dynamic range: >300,000; Viewing angle 2.5° Precision 1-2%; Nonlinearity max 0.002% FS; Operating environment 0 to 50°C, no precipitation; Computer interface RS-232C Power source 4xAA Alkaline batteries Weight 21 oz (600 grams) Size 4"W x 8"H x 1.7"D (10x20x4.3 cm) | No tender, 3 offers | On screen and database output, Web integration |  |
| **CPC** + neutralizer radioactive source (Am241) | Delivery Jun_Jul 07 | CPC- Condensation particle counter. Optical counter of aerosols | Direct negotiation | On screen and database output, Web integration |  |
| **SNM15** **Neutron detector** | Neutron detector in test operation from march 2007 | 2 modules of 3 SNM-15 detectors SNM -15 detector: Dimensions 2mx15 cm diameter Filled with $BF_3$ enriched to 90% with $B^{10}$ (pressure 1.2 atm); High voltage regime 2000-2200 V Moderator tube – 240x40 cm cylinder, approximately 200 litters of glycerine; Data acquisition system - 6 channels of individual counters; 1 channel integrated sum.; Maximal counting rate 30 000 counts/s for each channel | No tender, direct negotiation | | |
| **Improvement** of equipment for radioaerosols measurements | regular operation | El. motor - 3kw, 3 phases; House for el. motor, 140x80x90cm, material - special isolation against noise and vibrations; Air turbine - 3000t/minp capacity - 1200$m^3$/h, possibility for reduction till 300-400$m^3$/h Filter device, 50x50cm, filter material ФПП-15 Effectiveness for aerosols in the frame 0.2 - 5mkm more then 95% House for filter device, steel 80x80x80cm Air flow meter Testo 435-2 | No tender | |  |
| **Small portable devices** El.An. balan. JD400–2B multip.. meter "Sension 156"; DR 2800 spectrophotometer | regular operation | Sension 156" – pH meter for measurement of pH, conductivity, dissolved oxygen, salinity, total dissolved solids; DR 2800 spectrophotometer: wavelength range – 340-900 nm; accuracy - ± 1.5nm; resolution – 1 nm; calibration – automatic; spectral bandwidth - ≤ 8nm; date storage – 500 measured values | No tender | |   |

| Type of equipment | Status, Date | Functional characteristics (specification) | Tender procedure | Data transfer | |
|---|---|---|---|---|---|
| Moun telescope; | Regular operation Aug, .2006 | Threshold of energy 1 GeV<br>Zenith angular interval ± 25°<br>All others angular Intervals 0 … 45 °<br>Standard error/hour 0.5%<br>Total effective detect area 1m2 | No tender, direct negotiation | On screen and database output, Web integration is realise |    |
| Rn low level analyzer; | Test operation Feb 2007 | Air aspiration flow-rate – adjustable from 0,5 to 2,5 L $min^{-1}$;<br>Filter rotation velocity : fixed – 1 rph or 1 rp12h<br>PC controlled – adjustable from 1 rph to 1 rp24h;<br>Alpha-spectrometry detectors – surface barrier detectors, 30 $mm^2$;<br>SSNT detectors – Kodak LR 115; Air aspiration time – unlimited;<br>Temperature range (without heating) – from 0 to $50^0$ C | No tender, Direct negotiation | Web based interface |  |
| α-spectrometer; | In operation Mar 2007 | ADC – type Wilkinson, 4 K channels; Nonlinearity < 0,25 %; Interface – USB; Max. counting rate – 5000 $s^{-1}$; Detector surface – 450 $cm^2$; Measured resolution ($^{241}$Am): 17 keV with PIPS detector; 22 keV with surface barrier detectors. | No tender, 3 offers | On screen and digital output |  |
| **Liulin - 6MB** Modernization of set of portable small devices for complex environmental monitoring | Regular operation June.2006 | **Hi - Tech Gamma spectrometer with wide range, incl. space application**<br>- Dose range: 0.093 nGy – 1.56 mGy;<br>- Flux range: - 0.01 – 1250 part/cm2s;<br>- Energy loss range: - 0.0407 – 20.83 MeV;<br>- Pulse height analysis range: - 9.25 mV – 5.0 V;<br>- LET range: 0.135 - 69.4 keV/μ;<br>- Temperature range: -20oC - +40oC;<br>- Power consumption at normal operation: not more than 150 mA from 12 V<br>- Spectrometer dimensions: 84x40x40 mm; weight 0.12 kg; | No tender, direct negotiation; recommen-dations of leading experts; wide international cooperation | Web based interface |    |
| **Vaisala WINDCAP® Ultrasonic Wind Sensor WS425** Improvement of automatic weather station | Regular operation from Nov 2006 | **Wind speed**<br>Measurement range: serial output: 0...65 m/s (0...144 mph, 0...125 knots); analog output: 0...56 m/s (0...124 mph, 0...107 knots)<br>Starting threshold: virtually zero<br>Delay distance: virtually zero<br>Resolution: 0.1 m/s (0.1 mph, 0.1 knots, 0.1 km/h)<br>Accuracy (range 0...65 m/s): ± 0.135 m/s (±0.3 mph, ±0.26 knots) or 3% of the reading, whichever is greater<br>**Wind direction**<br>Measurement range: 0...360°<br>Starting threshold: virtually zero<br>Delay distance: virtually zero<br>Resolution: 1°<br>Accuracy (wind speed over 1 m/s): ±2° | No tender, direct negotiation (improving of existing Vaisala automatic weather station) | Software adjustment; software integration is made |    |
| **Vaisala** data logger + new detectors of temperature and pressure | Regular operation Jul 2007 | The QLI50 Data Logger acts as interface between sensors for meteorological and other parameters and the computer. It performs automatically measuring commands to 20 Voltage and 10 Current inputs with 16-bit A/D converter with digital filters for analog signals, and 8 bit I/O port for digital signals. QLI50 is designed to work in harsh ambient condition and has built EMI (electromagnetic interference) and ESD (electrostatic discharge) protection. | No tender, direct negotiation (improving of existing Vaisala automatic weather station | On screen and database output | |

**WP3** ***Advanced methodology, technology, methods, metrology, observing and complex monitoring.***
***Science – society interactions.*** **Operational goal A3, (Networking, International Collaboration & Integration and Reinforced Research Infrastructure), Operational goal C (Advanced Science – Society Interaction policy)**

**Objectives:** ***Implementation and development of advanced methodology, technology, methods and advanced metrology, observing and complex monitoring*** in the field of Global change and ecosystems and their regional and European projections and components including: impact and mechanisms of greenhouse gas emissions and atmospheric pollutants from all sources on climate, ozone depletion and carbon skins, towards to improve predictions and forecasts; operational forecasting and modelling, global change observing systems; especially environmental radioactivity, monitoring and assessment of technological and natural hazard and risks.
***Advanced metrology development and implementation*** in the field of global change observing, environmental radioactivity and radioecology, radiochemistry and radionuclide analysis, based on the close collaboration with JRC institutes. ***Observing and complex monitoring*** of Global change processes and ecosystems in attempt to realize adequate management towards to reach sustainable environment. ***Advanced Science – Society Interaction policy*** towards to reach not only dissemination of the obtained research results but to succeed in the active communication and dialogue with the public organizations, government and NGOs. ***Improving responses to socio-economic needs of the country.***

**Exchange of personnel and of results and joint experiments**: **1**
**1** visit to UFS Schneefernerhause, Zugspitze and Hochenpeissenberg Observatory;

**Visits for research activities: 6**
(visits for joint research activities to BEO Centre of Excellence of scientists from leading European institutions, BEOBAL partners, EU and Balkan countries)
**2** from ALOMAR, Norway, **3** from INR, UNAS, Kiev, NUARC, Kiev, NOPU, NUARC, Odessa, Ukraine, **1** from INS, Izmir, Turkey

**Conference activities 1**
BEOBAL Project Conference, Giuletchitza, 21-25 Mar. 2007, Bulgaria
More then **60** participants from **8** countries, **14** HMO, universities, institutes. See details at:

http://www.beo.inrne.bas.bg/BEOBAL/BEOBAL_Conference.htm

**Science communication:**

- Improvement of BEO web sites and development of BEOBAL web page

http://www.beo.inrne.bas.bg

http://beo-db.inrne.bas.bg

http://www.beo.inrne.bas.bg/BEOBAL.htm

- **2** CD, electronic, **2** web sites and **1** web page and other publications
- **2** Public lectures
- **5** Posters
- **5** Exhibitions, including Sofia realisation of the world exhibition during the XX Olympic Games in Torino, Italy "High Mountain Research Stations – a Window to the Universe"
- Media activities – 2 video films
- 3 volumes of OM2 multi volume series – 2 (10 and 11)devoted for BEOBAL training seminars and 1 (12) with the proceedings of BEOBAL conference.

**WP4:** ***Improvement of Human Resources.*** **Operational goal B (Advanced Human Resources long-term Management)**

**Objectives:** ***Advanced Human Resources long-term management*** reaching and preserving European qualification level and creating the best home for young scientist, additionally attracting young scientist from other countries

**Description of work** Young students from Bulgaria will be attracted to work in the BEO Integrated environmental centre preparing PhD and Post doc studies devoted to the global change and environmental problems. Plan for a regular improvement of qualification level will be realized among the basic staff of the BEO CoE and BEO IEC.

The objective of this WP will be achieved primarily by the use of PhD (post doc) form of qualification, in the institutes – partners, INRNE and institutes and universities from BEO IEC, by use also of activity 2 (visiting fellows -hosting scientist from aboard for teaching and training activities) and activity 3 training for Ph.D. students and/or post-doctoral researchers

**Hosting scientist from abroad for teaching and training activities: 2**

Within the framework 6 training seminars have been organized:

- Cosmic rays,Aerosols, Climate (1 lecturer, INR, UNAS, Kiev, Ukraine)
- Solar particle phenomena (1 lecturer, IEP, SAS, Kosice, Slovakia)

For details about BEOBAL training seminars see:

http://www.beo.inrne.bas.bg/BEOBAL/BEOBAL_events.htm

and BEOBAL web page

http://www.beo.inrne.bas.bg/BEOBAL.htm

**Short stays for specialization: 7**

**2** visit to INS., Izmir, Turkey, **2** visits in JFJ, HMO, Bern, Switzerland; **1** visit to INP, Prague, Czech Republic, **2** visits to CERN, Switzerland.

**Young researcher's specialization: 2**

**2** specialisations in the institutes of Joint Research Centre of European Commission
**1** in IRMM, Geel, Belgium, 8 month of 12 months specialisation, started from August, 2006.
**1** in IES, Ispra, Italy. (2x3 months)


Institute for Nuclear Research and Nuclear Energy
BEO Centre of Excellence
BEOBAL FP6 project
training seminar
19 – 20 Feb 2007
"Solar particle phenomena into magnetosphere"
26 Jul 2006
"Global climate - cosmic rays – clear air standard. Aerosols"
Environmental monitoring seminar is organised in the framework of INRNE BEOBAL FP6 EC project INCO-CT-2005-016663
For information:
Boyko Vachev, tel.: +(359) 2 9746310,
vachev@inrne.bas.bg
http://www.beo.inrne.bas.bg

## Cosmic Rays, Aerosols, Climate

**Prof. D.Sc. Volodimir Pavlovych, Institute of Nuclear Research, National Ukrainian Academy of Sciences, Kiev, Ukraine**

- Cosmic Rays, Aerosols, Climate. Registration of the Cosmic Rays of Ultrahigh Energy






## Solar particle phenomena into magnetosphere

**Prof. D.Sc. Karel Kudela, Department of Space Physics, IEP SAS, Kosice, Slovak Republic**

- Trajectories of energetic particles in the magnetosphere
- CR tramsmissivity in variable magnetosphere
- Solar particle penetration into magnetosphere
- Cosmic rays and space weather: direct and indirect relations