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## FINAL REPORT OF NOPA ACTIVITIES

**Project Title:** Numerical methodologies applied to Solar and Wind Energy Resource Assessment

**Partner Institutions:**

Brazilian Institute for Space Research (INPE) and  
Carl Von Ossietzky Universität (University of Oldenburg)

**Brazilian Coordinator:** Dr. Enio Bueno Pereira (from INPE)

**German Coordinator:** Dr. Detlev Heinemann (from Un of Oldenburg)

**Process number:** 002/2011.



December, 2013.

## 1. INTRODUCTION

Brazil and Germany have set ambitious targets in order to effectively address the challenges associated with climate change and promote sustainable development using natural resources. In this context, both countries have intensified efforts to reduce the environmental impacts of energy consumption and promote the commercial exploitation of renewable energy resources like solar and wind energy in order to meet the growing energy demand due to the Brazilian social and economic development with a sustainable and clean approach. The NoPa program is a joint collaboration among CAPES and DAAD in order to support scientific partnership between Brazilian and German research institutions.

Taking into consideration the increasing share of solar and wind resources to the Brazilian energy matrix, it is required to get better knowledge of climate and weather impacts on the electricity generation and distribution system as well as the operation of solar and wind power plants. Information on spatial and temporal availability and variability of these energy resources is required, not only to operate the Brazilian energy system but to evaluate and develop new energy policies and incentives programs to boost the solar and wind energy market in Brazil.

This project was developed by the research team of the Renewable Energy Resource Assessment Laboratory of the Brazilian Institute of Space Research (LabRen/INPE) together with Energy Meteorology research group from Carl Von Ossietzky Universität. The activities aimed at evaluating the impacts of the climate changes on the solar and wind energy resources in the predominant tropical conditions in Brazil, and at improving numerical methodologies to estimate and forecast the energy resources in short and long-term by using climate models and stochastic approaches.

The term *Energy Meteorology* is relatively new and it is characterized by its interdisciplinarity. It comprises studies in the interface between the energy sector, the meteorological sciences, and the decision sector at government level as well as the stakeholders in the private sector of the society. As the solar and wind energy exploitation worldwide is showing an increasing tendency, the technology for resource assessment and forecasting is becoming more and more important to plan, operate the electricity system in



a sustainable and secure way. The energy sector is requiring more consistent and reliable meteorological tools and services to keep up with the technical and security challenges to meet the energy demand. This technology and capacity building is becoming more important in Brazil because of its large territorial extension encompassing different typical climate conditions. The German experience shows that tools for estimate and short-term power forecast have a significant contribution to the energy market. A growing number of small businesses is providing the energy and climate forecasting service to the energy sector and become an integral part of the energy industry in Germany.

The focus of this NoPa program was to support capacity building through PhD students, and joint researches between the two partners. Two Brazilian students visited Oldenburg in order to developed part of their doctorate research at the Carl Von Ossietzky Universität under supervision of Dr. Detlev Heinemann. Besides that, one Brazilian investigator had a short stay (20 days) in Germany to exchange knowledge in radiative transfer modeling applied to solar radiation assessment in 2012. Three workshops were developed during the two-year period to disseminate the research activities and to bring new partners interested in framing a new proposal for a research to be presented to energy companies from both countries seeking for a long-term support. Two of the workshops were held in Brazil and the third was held in Germany.

This document presents a brief description of the activities developed by INPE during the NoPa project. The next topic will describe the INPE participation in the workshops. The section 3 presents the research activities of two Brazilian PhD students in Germany. The section 4 presents a short description of the 20-day mission accomplished by Dr. Fernando Ramos Martins at the University of Oldenburg.

## 2. INPE-UN. OLDENBURG WORSHOPS

Three workshops were carried out during the NoPa project. The kick-off meeting was held in February 2012 at INPE in São José dos Campos and aimed at promoting the integration between the research groups from both institutions. Five investigators from the Energy Meteorology at University of Oldenburg team came to Brazil and were engaged in lectures and round discussions together with Brazilian students and professors from several interested Brazilian institutions: INPE, the Federal University of Alagoas, the Federal



University of Brasilia, and the Federal University of Itajubá. Approximately twenty people participated in the three-day event that allowed an interesting opportunity to discuss the basic concepts and approaches of the meteorological science applied to the energy sector. The German experience was presented and compared to the activities under development by the participating Brazilian institutions. The goals and the agenda for the INPE-Un. Oldenburg activities in the framework of the NoPa project were proposed, discussed and established in the last day of the workshop. The Annex 1 presents the main achievements from the kick-off meeting.

The second workshop occurred during the IV Brazilian Congress for Solar Energy (CBENS) held in September 2012 in the city of São Paulo. The Annex II presents the workshop rationale and its agenda. The event aimed at disseminating the research activities related to solar and wind resource assessment and forecasting developed by INPE and Un. Oldenburg in order to meet the information demands from the Brazilian energy sector. Invited lectures from the Federal University of Santa Catarina and of the Empresa Pesquisas Energéticas presented the energy market point of view about the required data and information from the energy meteorological researches and services.

The third workshop was held in Bremen as part of DEWEK 2012 – the most important meeting for wind energy community in Europe. The event was very similar to the one held in São Paulo and it presented the same goals but focused on the German wind energy researchers and energy entrepreneurs interested in information on wind energy in Brazil. The Annex 3 presents a short description and agenda of the German workshop.

A fourth workshop will occur in Recife during the first week of December. This meeting will be focused in planning a long term research proposal involving INPE, the Federal University of São Paulo, the Un. of Oldenburg and CHESF (Energy Company of São Francisco). This proposal will focus in regional evaluation of solar energy resource for a concentrated solar power plant located in Northeastern region of Brazil. The discussions during this meeting are expected to be important to define the goals, approaches and methodologies of the new project for the next two or three years.



### 3. PhD. STUDENT ACTIVITIES AT UN. OF OLDENBURG

Two Brazilian PhD students went to the University of Oldenburg in Germany for a four-month period in order to develop part of their doctorate research under supervision of Dr. Detlev Heinemann:

- Marcelo Pizzuti Pes - his doctorate research is focused in the frequency distribution of extreme wind and its relationship with climate variability in Brazil.
- Francisco José Lopes de Lima – his PhD. research aims at developing a short-term forecast approach using numerical weather prediction models together with neural network refinement for Northeastern region of Brazil.

#### 3.1 Doctoral Exchange Activities developed by MSc. Marcelo P. Pes (process no. BEX 4406/13-3)

His activities were accomplished from May 28<sup>th</sup> until September 30<sup>th</sup>. His research aims at evaluating the influence of extreme wind frequency distribution on wind power generation in Brazil. Besides that, he intends to investigate if there is any change in extreme wind frequency distribution as a consequence of global climate change.

The wind power generation was almost insignificant in Brazil by 2005. However, currently there are around 80 wind farms in commercial operation or planned to start running by 2014. The operation license for these wind farms are endorsed for next 20 years and it may be extended for another 20 years. Some recently published studies (Sailor and Hart, 2008; Breslow and Sailor, 2001; Lucena et al, 2008 and Pereira et al., 2011) demonstrated that the wind resources would change in some regions as a consequence of future climate scenarios established in IPCC reports. These changes can have a significant impact in the wind energy power plants once wind power is proportional to the cube of wind speed. Moreover, the capacity factor of wind power plants may also suffer negative impacts due to extreme wind events. The wind turbine requires a threshold wind velocity to start and stop operating in order to avoid damage to the wind turbine. Thus, the changes in trends of the extreme wind speed and frequency should be considered in the medium and long term in order to evaluate the economic feasibility of investments in wind energy. Few research results were published evaluating future scenarios of wind resources in Brazil. Nevertheless, the topic is still open because of the uncertainties associated with climate model outputs. Up to date there are no published scientific study regarding the extreme winds frequency distribution and their impact on wind power generation in Brazil. Thus, the key issue of his PhD research is to evaluate any trends in wind regimes and correlating them with



meteorological and climate phenomena. The extreme winds frequency distribution was determined by using historical time series of ground data acquired in several Brazilian airports. The second goal is to evaluate how this information can be used to forecast the impact of climate variability in the wind energy resources and wind energy generation.

Multivariate statistical techniques are being employed to evaluate temporal trends in historical meteorological data acquired at Brazilian airports. Mesoscale climate models are being used to evaluate the correlation between climate events and trends in observational data. Refinement methods will be applied to mesoscale model outputs in order to reduce uncertainties in wind forecasts. Finally, the climate variability influence on wind power generation will be investigated using IPCC data for future climate scenarios.

The major issue demanding a great effort was related to observational data quality. The first step, and maybe the most important, is the quality control of the ground data from the meteorological stations operating in Brazilian airports. Most of the time was spent in developing codes to evaluate extreme events of winds. Codes to get Weibull and GEV distribution parameters were implemented and preliminary results are not conclusive yet. During his stay in Germany, Mr. Marcelo participated in the International Conference of Energy and Meteorology with financial support of German partner. His final activities report was submitted to CAPES in October 2013 in order to conclude his 4-month fellowship as part of NoPa program (Annex 4). His PhD thesis is due to second semester of 2014, but the research cooperation between the both parts, the Brazilian student and the German research team continue in order to discuss the final results and new proposals for Post-doc Research.

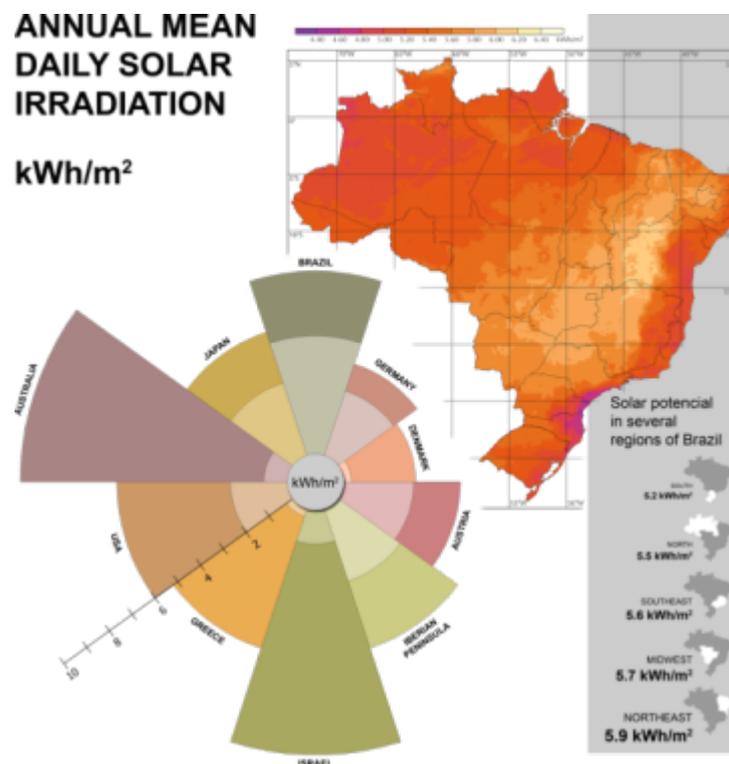
### 3.2 Doctoral Exchange Activities developed by MSc. Francisco Lima (process no. BEX 4404/13-0)

His research aims at prediction of solar radiation using atmospheric models and statistical refinement. His activities were accomplished from May 28<sup>th</sup>. until September 30<sup>th</sup>.

In contrast with other renewable energy sources (wind, biomass, and small hydroelectric plants) that have incentives and supporting policies from Brazilian government, the share of solar energy in energy matrix is coming far behind. Figure 1 presents a relative comparison between solar energy resources in Brazil and in countries where the solar energy market is far more advanced, such as Germany and countries in the Iberian Peninsula. It also shows the mean annual solar resources for each of the five Brazilian geo-political regions. Besides the large annual solar irradiation, the seasonal and inter-annual variability are low due to the fact that

much of the Brazilian territory is located in a tropical region. Earlier studies have pointed out that the solar technology could be cost-effective all over Brazil. Previous publications demonstrated that PV power plants in the Amazon region, concentrated solar power plants (CSP) in the semi-arid area of Northeastern region, and water heating in Southern and Southeastern of Brazil are technically viable (Martins et al., 2008).

Despite the great solar resource and high value that can be attributed to grid-connected PV systems in commercial areas of urban centers in Brazil, the installed PV capacity is meager and restricted to universities and research institutes. According to the Brazilian Ministry of Mines and Energy, the solar installed capacity is still only 8MW.



**Figure 1.** Mean annual range of the solar resources in Brazil compared to other countries (source, Pereira et al., 2006).

In addition, several energy companies are now evaluating the economic feasibility and planning to operate new solar power plants (PV, concentrated PV and CSP) in the Brazilian Northeastern and Mid-West regions. INPE is preparing the revised edition of Brazilian Atlas for Solar Energy in order to deliver more accurate information on solar energy resource to the energy sector.

Furthermore, this is the appropriate moment to investigate and develop a suitable methodology to provide short-term forecast of solar irradiance taking into consideration the typical climate



and environment features of each Brazilian region. There are several elements pointing out that the solar generation would grow in near future, the reliable short-term forecasts will be required for planning and managing the new solar plants and the electricity distribution.

Mr. Francisco is using remote sensing data acquired by automatic weather stations operated by INPE and by the Brazilian Institute for Meteorology (INMET) to validate solar radiation forecasts and estimates provided by mesoscale models, like WRF, running with different setups for numerical parameterization of physical processes. The following activities were developed during his stay at Un. of Oldenburg:

- Quality evaluation of solar irradiation data acquired at INMET ground sites using similar criteria established for BSRN sites (Baseline Surface Radiation Network);
- Analysis of data provided by WRF outputs and ECMWF Meteorological Products;
- Numerical implementation of two Clear-Sky models required to reduce bias presented by solar radiation forecasts provided by WRF and ECMWF outputs.

All the research activities were conducted at the Energy Laboratory (ENERGIELABOR), located within the University of Oldenburg. Mr. Francisco is preparing an article to be published in a scientific journal describing the proposed methodology and presenting the preliminary results. The final results will be ready at the beginning of 2015 when he is supposed to conclude and present his PhD thesis to the graduate program in Meteorology at INPE.

During his stay in Germany, Mr. Francisco participated in the 2<sup>nd</sup>. International Conference on Energy & Meteorology held in France from 25 to 28 June 2013, presenting preliminary results obtained during his research activities. In addition, lectures and seminars have significantly contributed to his research activities in Germany. His final activities report (Annex 5) was submitted to CAPES in October 2013 in order to conclude his 4-month fellowship as part of NoPa program.

#### 4. FIELD MISSION ACTIVITIES AT UN. OF OLDENBURG

Dr. Fernando Martins was visiting the Energy Meteorology team at the Un. of Oldenburg for 20 days in November 2012, just after his participation in DEWEK Conference in Bremen. This short stay was an opportunity to discuss different methodologies for satellite image processing in order to get cloud cover data required as input data in radiative transfer models used for solar energy assessment. Although, each institution has its own radiative transfer model – INPE uses



the BRASIL-SR model and Un. of Oldenburg uses the HELIOSAT model – the cloud cover data required by both models are obtained in a quite similar way from satellite images.

However, some issues concerning typical climate features make more difficult to get reliable cloud cover data for some areas in Brazilian territory. The discussions and interactions with German team was very helpful to improve image manipulation and to refine the numerical procedures used for cloud cover determination.

New approaches are being investigate as a result of the information exchange during his stay in Germany and preliminary results were published in two Brazilian events: International Symposium of Climatology and Brazilian Conference for Remote Sensing. The advances in cloud cover determination are in use to prepare the 2<sup>nd</sup> edition of the Brazilian Atlas for Solar Energy to be published next year by INPE.

## 5. CONCLUSIONS

The key goals of the NoPa project between INPE and Un. of Oldenburg were the knowledge exchange and capacity building in both sides. The first objective was fully achieved. INPE team organized three meetings in Brazil in collaboration with Energy Meteorology research group of University of Oldenburg. Fourth event was held in Germany. Energy stakeholders and entrepreneurs, decision makers from government and non-government organizations, investigators and professors from other universities and research institutes have participated and contributed for the discussions in order to prepare a more comprehensive proposal for a future research collaboration starting in 2014. The research proposal may be submitted for a grant at the beginning of 2014.

The second goal was partially completed. The initial expectation was that at least four students would travel to Germany as trainees at the University of Oldenburg during the project. However, several difficulties made it impossible to reach. Two of the students did not complete all the requirements necessary to get authorization from the graduate program coordination at INPE to develop part of their doctorate research in Germany. They were not able to attend the qualification exams and Thesis proposal analysis in time to be eligible for this travel program before the end of the NoPa project.

Nevertheless, the other two students did manage to get this permission and have performed their research activities here in Brazil and in Germany successfully and several products will be prepared as a result of their effort and enthusiasm.



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The new research proposal is been prepared involving INPE, University of Oldenburg, CHESF, other partners from Brazilian universities and German entrepreneurs interested in contribute to the renewable energy market in Brazil. Probably, the major product of the NoPa program, supported by CAPES and DAAD, will be the collaboration network linking Brazilian researchers and German institutions and organizations interested in solar and wind energy technologies development and in the perspectives of the market in Brazil.

Enio Bueno Pereira

Coordenador



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## Annex 1 – Achievements from NoPa Project Kick-off Meeting in São José dos Campos-SP, Brazil , 2012



Project Title: **German-Brazilian Research Network on Energy Meteorology: Supporting the Energy Future (“Energy Meteorology”)**

### 1- Introduction

This report summarizes the activities carried out during the Kick-off Meeting of the NoPa Project “Energy Meteorology” at The National Institute for Space Research-INPE in São José dos Campos- SP-Brazil, from 03 to 05 April 2012.

As originally planned, this meeting followed the introductory visit of the Brazilian partners of the NoPa project in Oldenburg, where they became more acquainted with the research work done at the university and at its Wind Institute ForWind, besides being introduced to all Oldenburger researchers that are actively involved in the collaboration.

At the kick-off Meeting in São José dos Campos participated the following researchers from the NoPa project team **from the University of Oldenburg**:

Dr. Detlev Heinemann, Dr. Elke Lorenz, Constantin Junk, Michael Schmidt and Dr. Rejane Moraes-Duzat

#### **From INPE’s NoPa-project team participated:**

Dr. Enio Pereira, Dr. Fernando Martins, Dr. Gilberto Fish, Francisco J. L. de Lima, André R. Gonçalves, Marcelo Pizutti Pes, Lucia C. Pinto, Roque dos Santos, Márcio Ceconi, Rafael C. Chagas, Alexandre Dumas Jr., Luciana M. de Moura and Dr. Jean Omato.

#### **Invited Speakers:**

Dr. Marco Ianniruberto from the Institute of Geosciences, University of Brasilia and Dr. Roberto Lyra from the Atmospheric Science Institute, Federal University of Alagoas



## 2-Activities

**03.04.2012- Tuesday**

The first day was dedicated to presentations concerning Wind Energy Research. During the day the following presentations were made:

**“General view of INPE and INPE Researches Concerning Renewable Energy”**- by Dr. Enio Pereira, the leader of the research group “Energy meteorology” at INPE/CCST.

**“Preliminary Results for Climate Change influence on Brazilian wind energy resource and Wind Resources in Hydro Reservoirs”**- by Dr. Fernando Martins from INPE/CCST.

**“Atmospheric Boundary Layer Research at the Institute of Aeronautical and Space “-IAE/CTA”** – by Dr. Gilberto Fisch, IAE/CTA

**“Evaluation of wind potential offshore in NE Brazil using multi-satellite Blended Sea Wind product “**- by Dr. Marco Ianniruberto\* and Felipe Mendonça Pimenta \*\* University of Brasilia, Institute of Geosciences, Brasilia and \*\*Federal University of Rio Grande do Norte, Department of Geophysics, Natal

**“Mesoscale Wind Assessment”**- by Dr. Roberto Lyra, Atmospheric Science Institute, the Federal University of Alagoas.

**“Diagnose of spatial smoothing of wind power variability and forecast in Europe”** - by Lueder von Bremen, ForWind -Center for Wind Energy Research of the Universities Oldenburg, Hannover und Bremen, presented by Constantin Junk from ForWind

**“Wind Farm Power Assessment using a Simple Model”** - by Hugues Ambroise, Forwind, presented by Michael Schmidt from ForWind

**“Large-eddy simulation (LES) of intra wind farm flows”**- by G. Steinfeld and B. Witha , Forwind - Universität Oldenburg, presented by Michael Schmidt from ForWind

**“Defining Favorable Places for Wind Farms with a Statistical Metric”** - by Nicole Stoffels, Forwind -University of Oldenburg, presented by Constantin Junk from ForWind.

### **Open Lecture:**

**Energy Meteorology: Meteorological Tools and Information in Support of Renewable Energies-** Detlev Heinemann, Energy Meteorology Group & ForWind, Institute of Physics, University of Oldenburg

### **Presentation of INPE’s students:**



- André Rodrigues Gonçalves: Presentation of his MSc. Thesis: **Statistical Downscaling of ETA-Model Wind Forecasts applied to Wind Power Generation at Northeastern Brazil**  
Applicability of his topic: Wind Farm Competitiveness in the Energy Market and electrical Grid Management

-Marcelo Pizzuti Pes: PhD Student in Earth Science System; Topic: **Impacts of the Variations and Climate Changes on the Extreme Winds and its Effects in Brazilian Energetic Sector**

-Lucia I. C. Pinto: PhD- Student in Meteorology; Topic: **Wind Energy Assessment in Tropical Regions.**

#### **04.04.2012- Wednesday**

##### **Technical visit to INPE's second campus in Cachoeira Paulista -SP**

-Visit to the Centre for Weather Forecast and Climate Studies - CPTEC/INPE where the participants were introduced to CPTEC different activities/facilities related to the NoPa project.

-CPTEC computational infrastructure: Super computer Cray XT6 and other computer resources to be utilized in research work.

-Presentation of a lecture on Climate models – by Marcos Sanches

-Introduction to Computational resources – by Wander Mendes

-Visit to The Laboratory of Meteorological Instrumentation – LIM/ INPE/CPTEC and the SONDA network - presented by Celso Thomaz and Silvia Pereira

#### **05.04.2012 -Thursday**

The last day was dedicated to presentations concerning solar energy research and discussions of the details of the activities to be carried out in the cooperation; the definition of common research themes and the needs for new research efforts, including the discussion of themes/topics for Brazilian and German student's qualifications in the frame of the project (Msc, PhD, etc.).

In the morning sessions the following presentations were made:

**“Energy Meteorology at the University of Oldenburg”**- Dr. Elke Lorenz, Energy Meteorology Group, Institute of Physics, University of Oldenburg

**“PV power forecasting: operational and commercial applications”**- Dr. Elke Lorenz, Energy Meteorology Group, Institute of Physics, University of Oldenburg

**INPE PhD-students presented their preliminary plans for PhD-research to be developed at INPE:**

**“Forecast of short-term Solar Radiation in Brazil”** -Francisco José Lopes de Lima- INPE PhD-student in the Post-Graduate Course in Meteorology.



PhD-research topic: Investigate the short term variability of the solar radiation in the region where solar resource is large in order to provide reliable information to the energy sector to manage electricity generation and distribution.

**“Comparison of solar data provided by NWP models running at INPE”** - Maria Francisca Velloso - INPE PhD-student in the Post-Graduate Course in Earth Science System.

PhD- research topic: Investigate the performance of NWP models running short term variability of the solar radiation in the region where solar resource is large in order to provide reliable information to the energy sector to manage electricity generation and distribution.

### **3- Outlook (further project’s activities and Capacity Building)**

The afternoon was dedicated to discussions concerning future work and topics for the exchange of students and researchers in the frame of the NoPa project.

It has been agreed that the following topics would be pursued in this cooperation, with regard to:

#### **Wind Energy:**

- Short term forecast
  - Extreme winds and their influence on wind power generation (This should also be the topic of the research work of a PhD-student of INPE in 2012 in Oldenburg.)
- Establishment of an open methodology to wind assessment at fine resolution for wind applications
- Long-term forecast and wind variability due to climate variability (seasonal and climate change)
  - Extreme winds and their influence on wind generation (INPE)
- Marine boundary layer (in the long term cooperation with the University of Oldenburg)
  - In cooperation with the University of Brasilia(UNB) and the Federal University of Alagoas (UFAL) whose representatives have been invited to this event.

#### **Solar Energy:**

- Irradiance satellite models
  - Improvement on Cloud Cover Index
  - Improvement on smoke identification
  - Direct solar irradiance
  - GOES/METEOSAT comparison
  - Aerosol parameterization comparisons
  - Spectral assessment
- Short-term forecast
  - Global and Mesoscale models comparisons
  - Statistical methods and ANN comparisons for post-processing
  - Cloud motion vectors
  - Uncertainty information
- Long-term forecast and solar variability due to climate variability (seasonal and climate change)
- Forecasting of solar Energy and its applications
- Solar energy assessment and Photovoltaic power prediction



### **Long term cooperation**

- Solar climatology

### **Solar and Wind and Hydro resources**

- Solar and wind complementarity
  - Optimize solar and wind generation
  - Spatial temporal correlation analysis
- Spatio-temporal balancing (smoothing) effects

A proposal for a PhD-project intended for an INPE student in cooperation with the University of Oldenburg was discussed. The proposal has been prepared by Dr. Lüder von Bremen and his team from ForWind. The proposal has as title “**Potential of Wind and Solar power deployment to retain Hydro Power**” and deals with the production of wind and solar power and its combination/balancing with hydro-electric power to meet demand in urban areas of Brazil.

The proposal was well accepted by both parties but it is still necessary to find a PhD-student with the right profile to carry out such work, since it also involves expertise in hydro-electric energy production. Finally, it has been decided that the project coordinators and researchers from INPE and the University of Oldenburg would contact colleagues and professionals working in the hydro-electric field in other Brazilian Universities and/or Research Institutes, in order to find the best solution to this matter.

It has also been decided that the project coordinators and researchers from both sides will begin to start with the preparation for the integration of industrial partners in the project, having in mind the preparation of a broader project proposal at the end of this project. For this, first contacts with ANEEL, EPE, CEPEL and Brazilian Utility companies will be made, especially to invite Brazilian professionals from the energy industry to participate in the first NoPa workshop in November in Germany. The support from the GIZ-team in Brazil will be extreme valuable in this point. It is intended to schedule a first meeting with GIZ in Rio de Janeiro in June 2012.

Concerning the organization of workshops and seminars in the frame of the project, there was lunched the idea to try to organize an “Energy meteorology” session at the “IV Brazilian Solar Energy Congress (IV CBENS) and V ISES Latin American Conference (V ISES-CLA)” in São Paulo, in September, 2012, as well as to couple the First NoPa- workshop in Germany to the “German Wind Energy Conference DEWEK 2012” in November 2012 in Bremen. Following this meeting, the project leaders and coordinators are supposed to make the necessary contacts to concretize these plans.



Kick-off Meeting at INPE in April 2012 in Sao José dos Campos-SP, Brazil ( back row, 1 to r : Marcelo P. Pes, Constantin Junk, Detlev Heinemann, Michael Schmidt, Francisco L. de Lima, Fernando Martins; Middle row, 1 to r :Rejane Moraes-Duzat, Maria Francisca Velloso, Elke Lorenz; front row: Enio Pereira)



Annex 2.

**IV BRAZILIAN SOLAR ENERGY CONGRESS - CBENS  
V ISES LATIN AMERICA CONFERENCE – ISES-CLA  
18 a 21 de setembro de 2012**

**SPECIAL SECTION – ENERGY METEOROLOGY**

**Rationale:**

Both, Brazil and Germany have set themselves ambitious goals in order to effectively tackle the challenge of climate change and to follow a more sustainable path in the use of natural resources. In this context the energy sector has always played a vital role and both nations are working and planning to reduce energy consumption, improve energy security and to increase the share of renewable energy sources in their energy matrix. Taking into consideration these issues, the Centre for Earth System Science of Brazilian Institute for Space Research (CCST/INPE) and Institute of Physics of University of Oldenburg are collaborating on a scientific project to exchange knowledge and technology in Energy Meteorology.

The increasing contribution of renewable energies to the global energy supply makes weather and climate a factor of great importance for planning and operation of energy systems. Especially the resource's variability in space and time is a matter of large concern. Energy Meteorology as a rather new applied and interdisciplinary research field addresses these needs and describes the interface between the energy supply system and the meteorological conditions and its interactions.

The Energy Meteorology group at Oldenburg University is a research group addressing this new field of R&D and is contributing since approx. 15 years to this field. The group accrued from the renewable energy research in Oldenburg and consists of more than 20 researchers working on both solar and wind power meteorology. The Energy Meteorology group was one of the first of its kind and is still the only German university group in that area. The group is both developing fundamental methods and providing applied tools in close co-operation with industry.

The Renewable Energy Team at the Brazilian Institute for Space Research (INPE) has been newly established and similarly aims at investigating the influence of meteorological aspects and climate variability on renewable resources of energy. The Renewable Energy Team is part of the Center for Earth Science System (CCST) that focuses on providing the required knowledge to improve and support the sustainable development of emerging economies, particularly Brazil.

The main focus of this collaboration regards to capacity building. Through this collaboration, both institutions are working together to provide scientific methods for the generation of energy-specific meteorological information and its integration in new tools for planning and control of energy systems. Currently, especially in regions with large shares of wind and solar energy in the electricity supply, products like solar and wind power forecasts and user-specific data for resource assessment, show already a substantial value in the energy market.



**Title:**

*“Meteorological Tools to support the integration of solar and wind resources in the energy matrixes of Brazil and Latin America”*

**Date:** September 20<sup>st</sup>, 2012

**Goals:**

- Increase the energy sector’s awareness on meteorology tools and technology to support planning and operation of solar and wind energy plants;
- Perceive the R&D demand from the energy sector concerning meteorological data, tools and services to support planning and operation of solar and wind power plants;
- Create a collaborative network including research institutes, government organizations, industry and energy companies to work together in capacity building and technology development to support the integration of solar and wind energy in energy matrix in Brazil;
- Create opportunity to discuss and prepare R&D international collaboration including institutions from other Latin American countries.

**Proposal for Event Programme:**

1. Opening Lecture: The INPE/Un. Oldenburg Collaboration Project.  
Time Schedule – 09:00 – 09:15.
2. Lecture 1: The actual scenario and future perspectives for solar energy in Brazil.  
Speaker: Juarez C. Lopez. Empresa de Pesquisa Energética (EPE).  
Time Schedule – 09:15 – 09:45.
3. Lecture 2: The main barriers for solar deployment in Brazil.  
Speaker: Ricardo Rüther – Instituto Ideal  
Time Schedule – 09:45 – 10:15.
4. Lecture 3: Applied Research on Renewable Energy Resources at CCST/INPE.  
Speaker: Enio Bueno Pereira  
Time Schedule – 10:15 - 10:45.
5. Lecture 4: Applied Research on Wind Energy Forecast.  
Speaker: Lueder von Bremen – FORWIND and Uni. Oldenburg  
Time Schedule – 10:45 – 11:05.
6. Lecture 5: Applied Research on Solar Energy Forecast.  
Speaker: Detlev Heinemann.  
Time Schedule – 11:05 – 11:25.
7. Debate: Meteorological Tools and reliable data needs to support solar and wind energy integration in Brazilian energy matrix  
Moderator: Fernando Ramos Martins  
Time Schedule – 11:30 – 12:00.



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Annex 3. Short description and agenda of the Bremen Workshop of NoPa project involving INPE and Un. Of Oldenburg.

## DEWEK Side Event



**8<sup>th</sup>. November 2012 13:30 – 18:00** Room Roselius

### Workshop

## **Meteorological Tools and Services to support the Grid Integration of Wind Power and other Renewable Energies**

The workshop focuses on extending the development and improvement of meteorological tools and services to support the planning and operation of electric energy systems based on fluctuating wind and solar power. Besides the discussion of general aspects and current operational issues of wind and solar power integration the workshop aims at an exchange of the German and Brazilian situation within this context and to promote the dialogue between partners from industry and science from both countries. In detail, the workshop will

- exchange and share knowledge on the development of energy meteorology (EM) services,
- discuss products like solar and wind power forecasts and user-specific data for resource assessment and their value in the respective energy markets,
- strengthen the cooperation on EM between Brazil and Germany,
- bring together stakeholders from industry and science from both countries.

Who should attend?

Professionals from industry and science interested in

- tools and services from energy meteorology for an optimization of the grid integration of wind and solar power
- exchanging the German and Brazilian experience in wind and solar power generation.

The program:

13:30 – 13:45 Welcome and presentation of the NoPa Project

*Detlev Heinemann, University of Oldenburg*



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- 13:45 – 14:05 “Actions of EPE concerning the Integration of Wind and Solar power in the Brazilian Energy Matrix“  
Juarez C. Lopes, Eletrobrás Energy Research Company (EPE)
- 14:05 – 14:25 “Future of Wind Energy in Brazil: Market and Technology aspects”  
*Elbia Melo, Brazilian Association of Wind Energy (ABEEolica)*
- 14:25 – 14:45 “Operational Status of Large Scale Integration of Fluctuating Power in the German Transmission Grid“  
*Christian Schulz, TenneT TSO GmbH*
- 14:45 – 15:00 Open Discussion
- 15:00 – 15:30 Coffee Break
- 15:30 – 15:50 “The Vision of a Utility Company concerning Generation and Connection of Renewable Energy Sources to the Grid in Brazil”  
*Alcides Codeceira, Companhia Hidroelétrica de São Francisco (CHESF)*
- 15:50 – 16:10 “Integration of Photovoltaic Power in the Distribution Grid”  
*Bernhard Ernst, SMA Technology AG*
- 16:10 – 16:30 “Experience with a Commercial Wind Power Forecasting System“  
Hans-Peter Waldl, Overspeed GmbH & Co.KG
- 16:30 – 16:50 “Energy Meteorology Research in Brazil”  
*Enio Pereira, National Institute for Spatial Research (INPE/CSST)*
- 16:50 – 17:10 “Photovoltaic Power Prediction“  
*Elke Lorenz, University of Oldenburg*
- 17:10 – 18:00 Open Discussion

The workshop is held as part of the Program „New Partnerships: Linking Academic and Technical Cooperation between Brazil and Germany“ (NoPa).

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