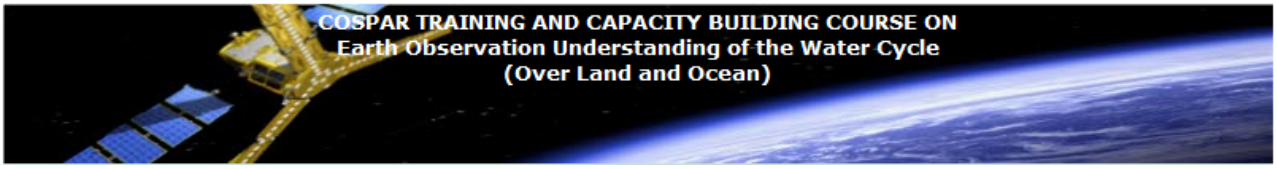

Fundação Cearense de Meteorologia e Recursos Hídricos (FUNCEME)
(Ceara's Foundation* for *Meteorology and Water Resources)

Fortaleza, Ceará, Brazil, 01 – 12 November 2010

http://www.funceme.br/eos.cospar

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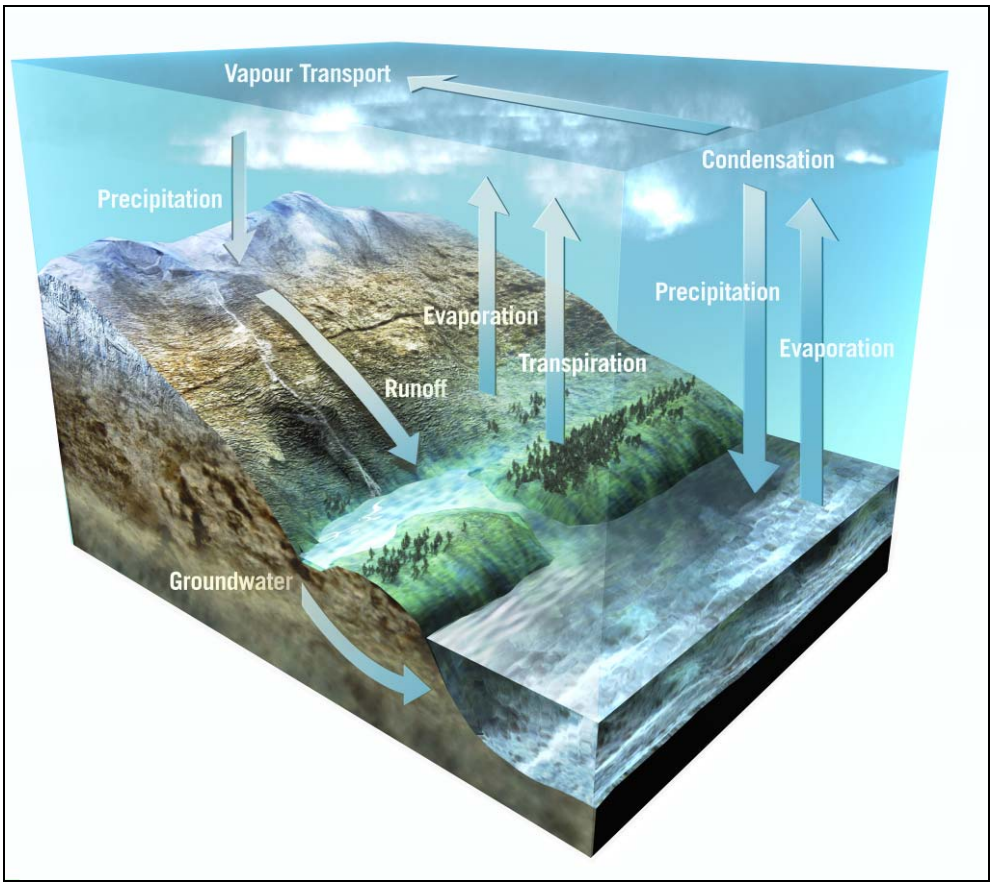
July 2010

1. Introduction

Water is the source of all life on Earth. The distribution of water, however, is quite varied; many locations have plenty of it while others have very little. Water exists on Earth in the three phases, namely solid (ice), liquid and gas (water vapour). Oceans, rivers, clouds, and rain are in a frequent state of change (surface water evaporates, cloud water precipitates, rainfall infiltrates into the ground, etc.). However, the total amount of the Earth's water does not change. The circulation and conservation of Earth's water is called the *Hydrologic Cycle* (WW2010, 2009).



The Water Cycle (ESA, 2009a)

Water is essential for life, for generating hydroelectric power and meeting irrigation and domestic requirements. Water-resources assessment and forecasts are needed to plan water storage, agricultural activities and urban development. Measurements of hydrological variables are essential for the effective management of water resources and exchange of hydrological data. Accurate and reliable data are essential for formulating integrated water resources management strategies. Warning systems are vital for protection against ocean-generated natural hazards such as natural disasters, tsunamis and hurricane-induced storm surge (WMO, 2009).

Although the soil only holds a small percentage of the total global water budget, soil moisture plays an important role in the global water cycle. However, in-situ measurements of soil moisture are sparse but, if we are to better our understanding of the water cycle so that the forecasting of climate, weather and extreme-events can be improved, more data are urgently required. The same is true for data on ocean salinity. There are few historical measurement data, and only a small fraction of the ocean is currently sampled on any regular basis. Salinity and temperature determine the density of seawater, and in turn density is an important factor driving the currents in our oceans. Ocean circulation plays a crucial role in moderating the climate by, for example, transporting heat from the Equator to the poles. Ocean salinity is therefore one of the key variables for monitoring and modeling ocean circulation (ESA, 2009b).

Observed warming over several decades has been linked to changes in the large-scale hydrological cycle such as: increasing atmospheric water vapour content; changing precipitation patterns, intensity and extremes; reduced snow cover and widespread melting of ice; and changes in soil moisture and runoff. Precipitation changes show substantial spatial and inter-decadal variability. Over the 20th century, precipitation has mostly increased over land in high northern latitudes, while decreases have dominated from 10°S to 30°N since the 1970s. The frequency of heavy precipitation events (or proportion of total rainfall from heavy falls) has increased over most areas (*likely*). Globally, the area of land classified as very dry has more than doubled since the 1970s (*likely*). There have been significant decreases in water storage in mountain glaciers and Northern Hemisphere snow cover. Shifts in the amplitude and timing of runoff in glacier- and snowmelt-fed rivers, and in ice-related phenomena in rivers and lakes, have been observed (*high confidence*) (Bates et al., 2008).

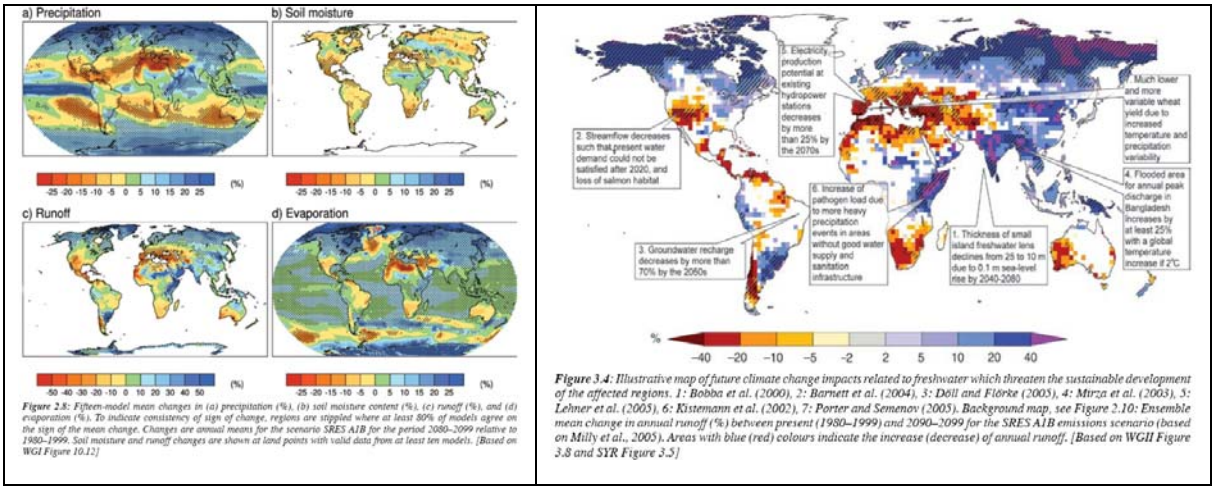
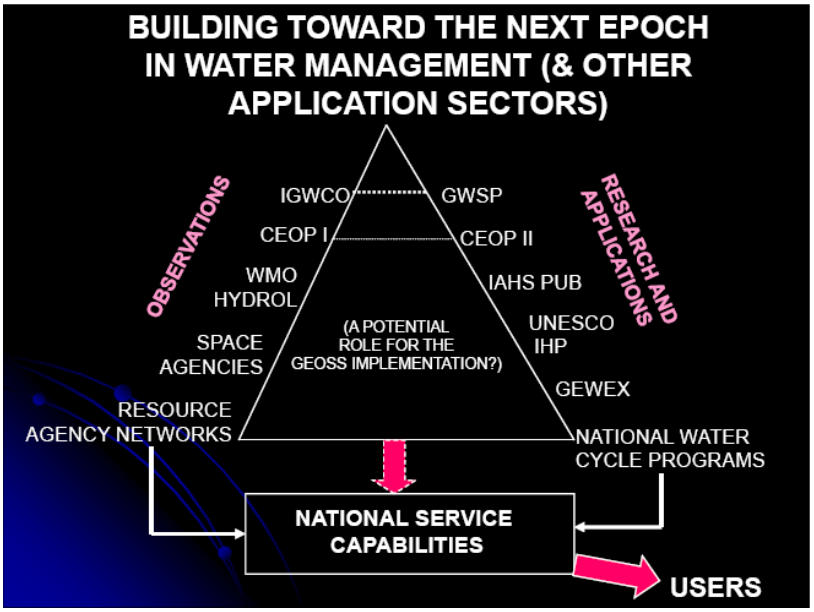


Figure 2.8: Fifteen-model mean changes in (a) precipitation (%), (b) soil moisture content (%), (c) runoff (%), and (d) evaporation (%). To indicate consistency of sign of change, regions are stippled where at least 80% of models agree on the sign of the mean change. Changes are annual means for the scenario SRES A1B for the period 2080–2099 relative to 1980–1999. Soil moisture and runoff changes are shown at land points with valid data from at least ten models. [Based on WGI Figure 10.12]

Figure 3.4: Illustrative map of future climate change impacts related to freshwater which threaten the sustainable development of the affected regions. 1: Bobba et al. (2000), 2: Barnett et al. (2004), 3: Döll and Flörke (2005), 4: Mirza et al. (2003), 5: Lehner et al. (2005), 6: Kistemann et al. (2002), 7: Porter and Semenov (2005). Background map, see Figure 2.10: Ensemble mean change in annual runoff (%) between present (1980–1999) and 2090–2099 for the SRES A1B emissions scenario (based on Milly et al., 2005). Areas with blue (red) colours indicate the increase (decrease) of annual runoff. [Based on WGII Figure 3.8 and SYR Figure 3.5]

Left: Fifteen-model mean annual changes in precipitation, soil moisture, runoff and evaporation for scenario SRES A1B for the period 2080-2099 relative to 1980-1999 (http://www.ipcc.ch/pdf/technical-papers/ccw/chapter2.pdf). Right: Illustrative map of future climate change impacts related to freshwater which threaten the sustainable development of the affected regions (http://www.ipcc.ch/pdf/technical-papers/ccw/chapter3.pdf) (Bates et al., 2008)

Through its broad base of scientific researchers and experts on the various components of the hydrologic cycle, the *Integrated Global Water Cycle Observation* (IGWCO) theme has contributed actively to each of the Water Tasks contained in the GEO (*Group on Earth Observation*) Work Plan. These contributions in the form of strategic guidance, coordination, and gap analysis have been instrumental to the development of the water segment of the *Global Earth Observation System of Systems* (GEOSS) as it seeks to attain the targets of developing an integrated, sustained operational global water cycle observation system and increase the use of Earth Observations with respect to integrated water resource management by 2015 (GEO, 2009)



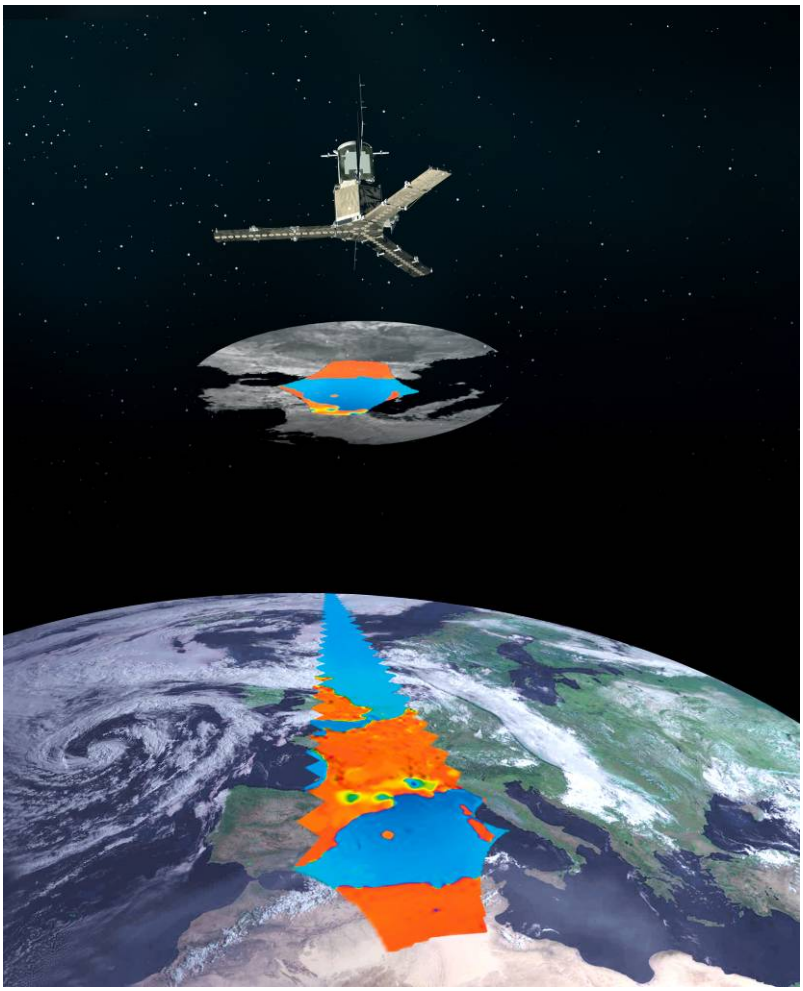
The IGOS-P Global Water Cycle Observations Theme (IGWCO) and its Potential Contributions to GEO (Lawford 2004)

This educational project refers to the organization of a *COSPAR Training and Capacity Building Course* in the field of Earth Observation in order to improve our understanding and observations of the Water Cycle from space. The activity is framed within the Scientific Commission A on *Space Studies of the Earth's Surface, Meteorology and Climate*, and more specifically within Sub-Commissions A2 on *Ocean Dynamics and Productivity* and Sub-Commission A3 on *Land Processes and Morphology*. The timely coincidence of the end of the ESA SMOS (*Soil Moisture and Ocean Salinity*) Mission *Commissioning Phase* only a few months before the Training Course makes it appropriate to dedicate a special attention to the different SMOS land and ocean products. SMOS is a new *ESA Earth Opportunity Mission* within the *ESA Living Planet Programme* whose launch was fully successful on 2nd November 2009. Besides, the production of the first data is developing smoothly during this first significant period of the mission (Kerr et al., 2009). Therefore, November 2010, one year after SMOS launch, is timely to develop the training of scientists to learn about remote sensing of soil moisture and ocean salinity.

Artist's impression of SMOS (ESA, 2009b)

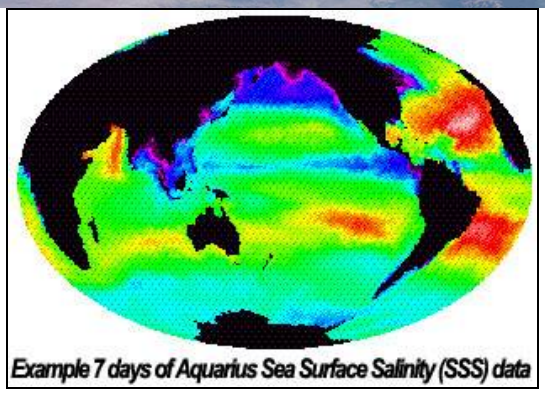
SMOS, ESA's Water Mission (ESA, 2009b), has been designed to observe soil moisture over the Earth's landmasses and salinity over the oceans. Soil moisture data are urgently required for hydrological studies and data on ocean salinity are vital for improving our understanding of ocean circulation patterns. As well as demonstrating the use of the new radiometer, the data acquired from this mission will contribute to furthering our knowledge of the Earth's water cycle. The data acquired from the SMOS mission will lead to better weather and extreme-event forecasting, and contribute to seasonal-climate forecasting.

An important aspect of this mission is that it will demonstrate a new measuring technique by adopting a completely different approach in the field of observing the Earth from space. A novel instrument has been developed that is capable of observing both soil moisture and ocean salinity by capturing images of emitted microwave radiation around the frequency of 1.4 GHz (L-band). SMOS will carry the first-ever, polar-orbiting, space-borne, 2-D interferometric radiometer. But the development of the SMOS mission not only addresses the intricate process of building a novel instrument. It also requires long-term work in the field in order to study the effects on the signal in detail. The chosen orbit will result in global coverage every three days, which is required to track the quick-drying period on land after rainfall. This novel measuring technique means that SMOS is the first-ever space borne mission that will provide global maps of soil moisture and ocean salinity.



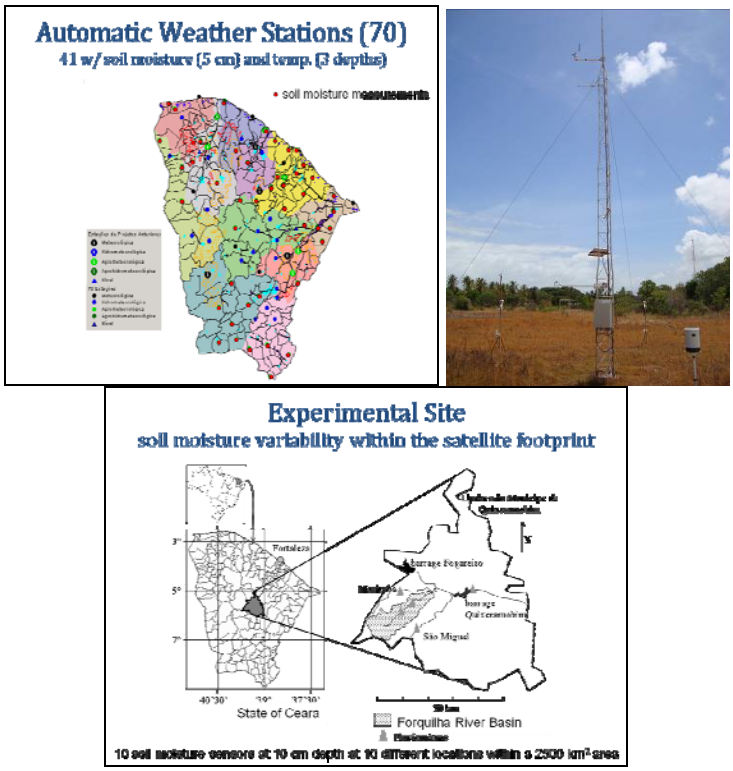
SMOS measurement principle (ESA, 2009c)

Contemporary/follow-up missions of SMOS will be NASA AQUARIUS and SMAP (*Soil Moisture Active and Passive*). On the one hand, AQUARIUS is a focused satellite mission to measure global sea surface salinity. After its 2010 launch, it will provide the global view of salinity variability needed for climate studies. The AQUARIUS/SAC-D mission is being developed by NASA and the *Space Agency of Argentina* (*Comisión Nacional de Actividades Espaciales, CONAE*). On the other hand, SMAP, currently planned for March 2013, will provide global measurements of soil moisture and its freeze/thaw state. These measurements will be used to enhance understanding of processes that link the water, energy and carbon cycles, and to extend the capabilities of weather and climate prediction models.



Left: Artistic rendition of the SMAP spacecraft (NASA, 2009a). Right: Example of 7 days of AQUARIUS Sea Surface Salinity data (NASA, 2009b)

The three scientists proposing this *COSPAR Training and Capacity Building Course* in reality represent and are backed up by a significant number of scientists who are involved in Water Cycle scientific activities, some of them in the different development phases of SMOS, AQUARIUS and SMAP. The ambition is to organize an advanced training course in South America, Europe and Asia (e.g., India and China). The first occurrence of this event, and object of this proposal, would take place in Brazil, at FUNCEME (*Fundação Cearense de Meteorologia e Recursos Hídricos- Ceara's Foundation* for *Meteorology and Water Resources,* http://www.funceme.br). The selection of FUNCEME as host institution for the first course is not casual. Besides the name of the institution itself which shows its motivation for hydrological resources in a semiarid area, their satellite receiving and processing stations for geostationary and polar-orbit satellites and their significant deployment of measuring stations in the whole State of Ceará, FUNCEME holds one of the teams that will study soil moisture variability in an area of the size of the SMOS footprint in Northeast Brazil with the objective of contributing to the validation of SMOS.



Left: Automatic Weather Station network from FUNCEME in the State of Ceará, Brazil. Center: Example of one of the agro/hydro/meteorological stations. Right: Experimental site being prepared for SMOS validation activities

The University of Valencia, Spain, plays also a significant role in soil moisture studies and land product validation activities of SMOS. It runs two robust meteorological stations that are used for validation of satellite remote sensing data and products. The *Valencia Anchor Station* is showing its capabilities and conditions as a *reference validation site* in the framework of low spatial resolution remote sensing missions such as CERES, GERB and SMOS. The *Alacant Anchor Station* is trying to be a *reference site in studies on the interactions between desertification and climate*. Both stations separated at a distance of about 180 km are actually twin stations, their representative areas have similar land use and soil types, but they are located in two different climatic zones: the average annual precipitation is about 450 mm in the *Valencia Anchor Station* area and about 250 mm in the *Alacant Anchor Station* area. The parallelism between both *Anchor Stations* and the fact that one of them is under water-stressing conditions make it appropriate to define a *Water Cycle Observatory* where to study and compare meteorological parameters and surface fluxes of radiation, energy and water (http://nimbus.uv.es and http://www.uv.es/elopez/). Besides this, the *Valencia Anchor Station* area, being reasonably homogeneous at this large scale under consideration, has been chosen by the SMOS Mission as a primary validation site during the *Mission Commissioning Phase*, before attempting more complex areas. It is a site where Level 2 land products will be validated for typical representative Mediterranean Ecosystem conditions with the sound contribution of CESBIO and INRA_Bordeaux SMOS scientists. The organization of the Course and its actual development will be an opportunity to transfer the expertise of the SMOS core team in charge of validating Level 2 products to Brazilian, Argentinean and other South-American scientists from the region.

ESA is significantly represented in the Course organization through the *Earth Observation Applications Department* and the *Education and Training Department*.

ESA viewing tools and other tool boxes will be used in the course to facilitate the use of remote sensing data (ESA, 2009d, Crapolicchio et al., 2009).

2. Objectives of the COSPAR TRAINING AND CAPACITY BUILDING COURSE ON *EARTH OBSERVATION UNDERSTANDING OF THE WATER CYCLE*

COSPAR Training and Capacity Building activities are intended to enhance the scientific capability of developing countries by meeting the following objectives:

(i) to increase knowledge and use of public archives of space data in order both to broaden the scope of research programmes in developing countries and also to ensure that scientists in them are aware of the full range of facilities which are available to them and which are also used by scientists in the developed countries,
(ii) to provide highly-practical instruction in the use of these archives and the associated publicly-available software so that participants on returning home can readily incorporate them into their research programmes, and
(iii) to foster personal links between participants and experienced scientists attending the workshops to contribute to reducing the isolation often experienced by scientists in developing countries.

This activity certainly contributes to the objectives mentioned above, more specifically in the field of Earth Observation where only a reduced number of activities have been developed so far in the framework of COSPAR (2009). The proposers frankly believe that the significance of Water Cycle Studies, the current applications in this subject from AVHRR-NOAA (*Advanced Very High Resolution Radiometer*) and SeaWiFS/MODIS (*Sea-viewing Wide Field-of-View Sensor*)/(*Moderate Resolution Imaging Spectroradiometer*), CBERS (*China-Brazil Earth Resources Satellite*) and LANDSAT, and the pioneering character of SMOS, SMAP and AQUARIUS as global space missions, all will make this activity a paradigm of knowledge transfer and capacity building from experienced satellite Earth Observation scientists to highly motivated scientists from developing countries. Thus, the specific objectives of the Course are:

(i) to provide in-depth knowledge of Earth Observation remote sensing concepts, principles, methodologies, and applications
(ii) to examine and demonstrate the utility of remote sensing methodologies in real world situations, especially those related to the estimation of soil moisture in semi-arid regions and sea surface temperature, ocean colour and sea surface salinity in tropical regions
(iii) to facilitate the end-to-end process from satellite direct acquisitions to both land and ocean products of different Level from 1 to 4, according to the mission product type specifications. Of special significance will be the application to SMOS data and products through the familiarization with the extensive suite of software tools already available
(iv) to form highly trained personnel in cutting-edge technology by facilitating the acquaintance with a pioneering and avant-garde remote sensing mission.

3. Programme

The programme includes scientific and technical lectures related to the remote sensing process, sensors, calibration, validation and algorithm development, tutorials and specific aspects of the ESA SMOS Mission, NOAA and SeaWiFS/MODIS Missions, as well as of the forthcoming NASA SMAP and AQUARIUS missions. The emphasis will be on the practical hand-to-hand characteristics of these missions. The preliminary contents of the Course are:

Programme Contents

(i) General Introduction on Water Cycle Study Guidance
- a. The Water Cycle Processes. The Earth's Water Balance
- b. The Global Water Cycle
  - Terrestrial Water Cycle and the Impact of Climate Change
  - The Ocean Component of the Global Water Cycle
  - Key Remote Sensing Hydrological Observations

(ii) Introducing Satellite Remote Sensing
- a. Remote Sensing Systems. The Remote Sensing Process
- b. Interaction of Electromagnetic Radiation with Natural Surfaces. Radiative Transfer Processes
- c. Remote Sensing in the Solar and Thermal parts of the Electromagnetic Spectrum

(iii) Digital Image Processing Techniques
- a. Preprocessing
  - Radiometric Correction
  - Geometric Rectification
- b. Image Enhancements
- c. Spectral Transformations
- d. Atmospheric Corrections
- e. Image Classification Techniques

(iv) Statistical Data Analysis
- a. Data Analysis Concepts
- b. Spatial analysis of environmental data

(v) Physical Principles in Microwave Radiometry
- a. Passive Microwave Systems
  - Microwave Emission Models
  - Land-surface Applications
  - Oceanographic Applications
- b. Radar Systems
  - Radar Altimetry
- c. Microwave Scatterometry
  - Microwave Scatterometry over Ocean Surfaces
  - Microwave Scatterometry over Land Surfaces

(vi) Remote Sensing Applications for Land and Ocean
- a. Land Applications

- Earth Radiation Balance, Precipitation, Vegetation Dynamics
- Studies on the Spatial Variability of Soil Moisture in Semiarid Northeast Brazil

b. Ocean Applications
- Sea Surface Temperature, Ocean Colour, …
- Studies on the Spatial Variability of Ocean Salinity, Salinity Gradients, …

(vii) Validation of Remote Sensing Data and Products

a. Land Products
   i. CBERS, LANDSAT, MODIS, NOAA, SMOS, …
   ii. NDVI, Soil Moisture, Vegetation Water Content

b. Ocean Products
   i. NOAA, SeaWifs, SMOS, …
   ii. Sea Surface Salinity

(viii) Assimilation of Remote Sensing Data and Products in Numerical Prediction Models

4. Organizing Committee

- Ernesto Lopez-Baeza (UVEG, Climatology from Satellites Group, Spain), Chair
- Jérôme Benveniste (ESA-ESRIN, Earth Observation Applications Department, Italy), Co-Chair
- Antonio Geraldo Ferreira (FUNCEME, Brazil), Co-Chair

- Philippe Richaume / Fraçois Cabot (CESBIO), SMOS Data Coordination
- Almudena Velazquez (UVEG, now at RMIB, BE), Practical Classes Coordination

- Pierre-Philippe Mathieu (ESA-ESRIN, Earth Observation Science and Applications, Italy)

- Meiry S. Sakamoto (FUNCEME, Brazil), Education Activities Coordination
- Silvia Helena Barbosa (FUNCEME, Brazil), Secretary
- Maria Albenisa Gadella (FUNCEME, Brazil), Secretary

5. Advisory Committee

- Jean-Louis Fellous, COSPAR Executive Director
- Jordi Font (ICM, SMOS Co-PI, Salinity)
- Laura Frulla (CONAE, Argentina. Director for Applications)
- Nadine Gobron (ISPRA, Italia. COSPAR Scientific Commission A Chair)
- Yann H. Kerr (CESBIO, France. SMOS PI)
- Eni Njoku (JPL, USA, SMAP Project Scientist)
- Tom Jackson (U.S. Department of Agriculture, USA. SMAP/SDT Cal/Val Working Group Lead)
- Gary Lagerloef (President of Earth and Space Research, USA. AQUARIUS PI)
- Luiz Augusto Machado (CPTEC/INPE Coordinator, Brazil)

- Susanne Meckelenburg (ESA-ESRIN, SMOS Mission Manager)
- Antonio Divino Moura (Director of INMET, Brazil. 3rd Vice-President WMO)
- Luis Parente Maia (LABOMAR, Coordinatior, Brazil)
- Luiz Drude de Lacerda (LABOMAR/INCT-TMOcean (General Coordination, Brazil)
- Carlos Artur Sobreira Rocha (.Tecnology Institute of the Information and Communication – Director)
- Francesco Sarti (ESA-ESRIN, Scientific Coordinator of the Education and Training Activities in Earth Observation)
- Eduardo Savio Martíns (FUNCEME, Brazil. President)
- Peter van Oevelen (Maryland, USA. Director of International GEWEX Project Office)
- Peter Willmore (University of Birmingham, UK. COSPAR Capacity Building Committee, Chair)

6. Teaching Staff and Keynote Contributions

See: http://www.funceme.br/eos.cospar

7. Lecture Format

The training course is composed of theoretical lectures and practical laboratory hands-on classes where the students will continuously be using remote sensing images.

In general, morning classes will be dedicated to common topics (land and ocean)from a theoretical point of view, where as afternoon classes, generally dedicated to practical classes, may also be structured as parallel and/ocean activities when required.

8. Host Institution

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FUNCEME (*Ceará Foundation on Meteorology and Water Resources*) is a regional institute located in the city of Fortaleza, State of Ceará, Brazil, that develops activities in four areas, namely meteorology, oceanography, environmental resources and water resources. FUNCEME has contributed to different development actions, through regional climate and weather forecasts, for environmental planning and analysis, resource monitoring, technology transfer, and has provided support to civil defense, agricultural production, water resources management and more. Visit FUNCEME's website at http://www.funceme.br to know more details about the institution.

9. Contact Scientists for this Activity

- Antonio Geraldo Ferreira (FUNCEME), FUNCEME's scientific advisor, geraldo_cospar@funceme.br
- Ernesto Lopez-Baeza (University of Valencia, Climatology from Satellites Group, COSPAR related scientist, Vice-Chair of Sub-Commission A3 on *Land Processes and Morphology*). ernesto.lopez_cospar@funceme.br
- Jérôme Benveniste (European Space Agency – ESRIN, Earth Observation Applications Department, COSPAR related scientist, Chair ofSub-Commission on *Ocean Dynamics and Productivity*). jerome.benveniste_cospar@funceme.brº

10. Compliance of this Proposal with a COSPAR Capacity-Building Activity

Missions Involved and Data to be Used
Data from operational missions, specifically from NOAA, CBERS, LANDSAT and SeaWiFS/MODIS missions will be used throughout the course. SMOS data and products, both from land and ocean, will also be used during the activity. Furthermore, the group of teachers will be able to use data from the different mission stages, namely Level 1 (obtained by applying the instrument calibration and the image reconstruction), Level 2 (defined according to the surface type, land or sea, and containing geophysical parameters), and higher Level 3 and Level 4 product maps on specified grids.

Most of the missions involved are operational (AMSR-E, ASAR, ASCAT, CEBERS, CERES, GERB, LANDSAT, MERIS, MODIS, NOAA-AVHRR, PALSAR, SeaWiFS, SMOS, etc.) and currently providing data and elaborated products. These missions are well known to the scientific community for their significance in Earth Observation. Specifically, SMOS, ESA Water Mission, represents a direct response to the current lack of global observations of soil moisture and ocean salinity which are needed to further our knowledge of the water cycle and to contribute to better weather and extreme-event forecasting as well as seasonal-climate forecasting. Direct observations of these two significant parameters, namely, soil moisture and ocean surface salinity, will definitely improve parameterizations of numerical models. In this sense, certainly the SMOS mission is expected to be producing exciting results. Concerning SeaWiFS and MODIS, both have given researchers an unprecedented view of the biological engine that drives life on Earth - the countless forms of plants that cover the land and fill the oceans. FUNCEME has a SeaWiFS reception system. The *Advanced Very High Resolution Radiometer* (AVHRR), operating on the *Polar Orbiting Environmental Satellites* (POES) of NOAA, is the direct descendent of the longest-lived and most influential series of Earth observing satellites ever launched. The current generation AVHRR has evolved into a highly accessible data collection system with a wide range of applications in meteorology, climatology, oceanography, and the study of land surfaces. The impressive growth of applications continues with increasing emphasis on regional and global environmental issues, due to AVHRR's unique position as a provider of daily global coverage of digital imagery from two satellites, truly synoptic views, calibrated thermal data, low cost of direct-readout stations and of data from NOAA. FUNCEME has a NOAA reception system as well. The Chinese and Brazilian CBERS satellite has a set of sensors or instruments - WFI (*Wide Field Imaging Camera*), CCD (*Imaging High Resolution Camera*), IRMSS (*Infrared Multispectral*

Scanner) and HRC (*High Resolution Panchromatic Camera*) with high potential applications in significant areas such as deforestation and fire control in the Amazon Region, water resources monitoring, urban growth, soil occupation, education and several other applications
(http://www.cbers.inpe.br/?hl=en&content=introducao)
Regional Character of the Activity
NOAA (sea surface temperature, SST) and SeaWiFS/MODIS (ocean colour) data are contributing to the development of sound research and applications (ex. el Niño, Fisheries, Climate Monitoring, etc.) in the whole South American region. SMOS will certainly bring valuable information concerning soil moisture and ocean salinity as well. This kind of information will also allow for the analysis of these parameters in a synoptic way and at different spatial scales. On the one hand, this type of information, associated, for example, to SST, will provide a better understanding of the ocean dynamics around the Brazilian coast. On the other hand, the soil moisture information will improve the results generated, for example, by the hydrological model actually running at FUNCEME, the host institution, and at other research institutes in Brazil that also run hydrological and climate forecast (global and regional) models.

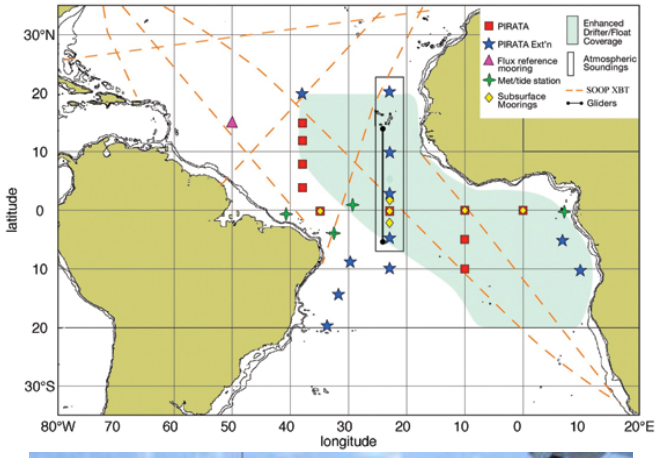
One direct application of ocean salinity data is to understand the *South Atlantic Warm Pool (SAWP)* dynamics over the continent. Due to its closeness to populated areas along Northeast Brazil, SAWP is believed to have a direct influence on the regional climate, dictating how severe flooding episodes can be. Another application refers to biogeochemical studies over the continental shelf.

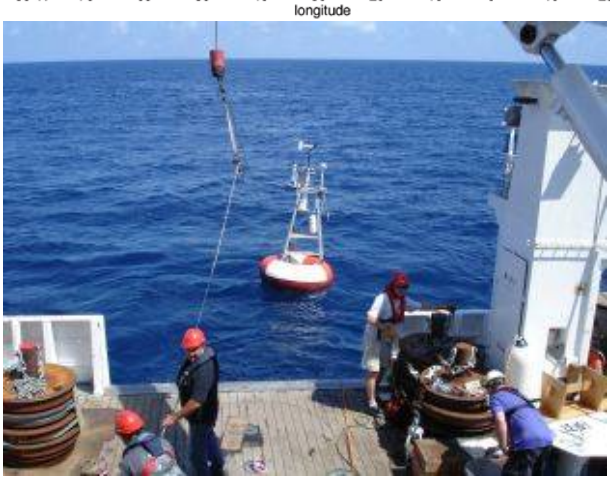
Since SMOS, ESA's Water Mission, will provide a uniform dataset to improve our understanding of the water cycle, another direct application at a regional level will be related to climate and weather forecasting. SMOS data will definite help to improve South American climate and weather forecasting model results.

SMOS will bring real opportunities to the Brazilian and Latin American scientific community to use information on soil moisture and ocean salinity at different space/time scales. In particular, the Amazonia is an optimal study area for vicarious calibration activities. Soil moisture data are urgently required for hydrological studies, and data on ocean salinity are vital for improving our understanding of ocean circulation patterns around Brazilian littoral, for example. Thus, we believe that this training Course will allow for the development of inter-institutional and multidisciplinary research that requires this type of information generated by satellites orbiting the Earth. As a consequence, the Course will strengthen cross-country knowledge and expertise among

- Brazilian institutions: e.g., FUNCEME, University of Bahia (UFBA), *National Institute for Space Research* (INPE), *Federal Rural University of Pernambuco* (UFRPe), LABOMAR (Marine Science Institute linked to the *University Federal of Ceará*, Fortaleza, Brazil).
- European institutions: e.g. *ESA*, *Centre d'Etudes Spatiales de la BIOsphère* (CESBIO), *Satellite Climatology Group* (University of Valencia), Institute for Marine Science (ICM, Barcelona, Spain), *Institut de Recherche pour le Développement* (IRD), *Institut Français de Recherche pour l'Exploitation de la Mer* (IFREMER).
- North-American institutions: e.g., *NASA*, *NOAA*, *JPL, U.S. Department of Agriculture*, *Center of Amospheric Sciences.*

At the above institutions there are scientific groups (e.g., FUNCEME, LABOMAR, UFBA, UFPE, INPE, University of São Paulo – USP, running global and regional climate/ocean models (coupled or stand-alone) within the Tropical Atlantic. FUNCEME and INPE are Brazilian institutions directly involved in the *Pilot Research Moored Array in the Tropical Atlantic* (PIRATA) Project, which can provide ocean data for the SMOS validation phases. Note that the PIRATA project is a joint effort between different institutions in Brazil, France and the United States to collect oceanic and meteorological observations in the tropical Atlantic. See their respective sites (http://www4.funceme.br/funceme/projetos/principal-pirata), (http://www.ifremer.fr/ird/pirata/) and (http://www.pmel.noaa.gov/pirata/).





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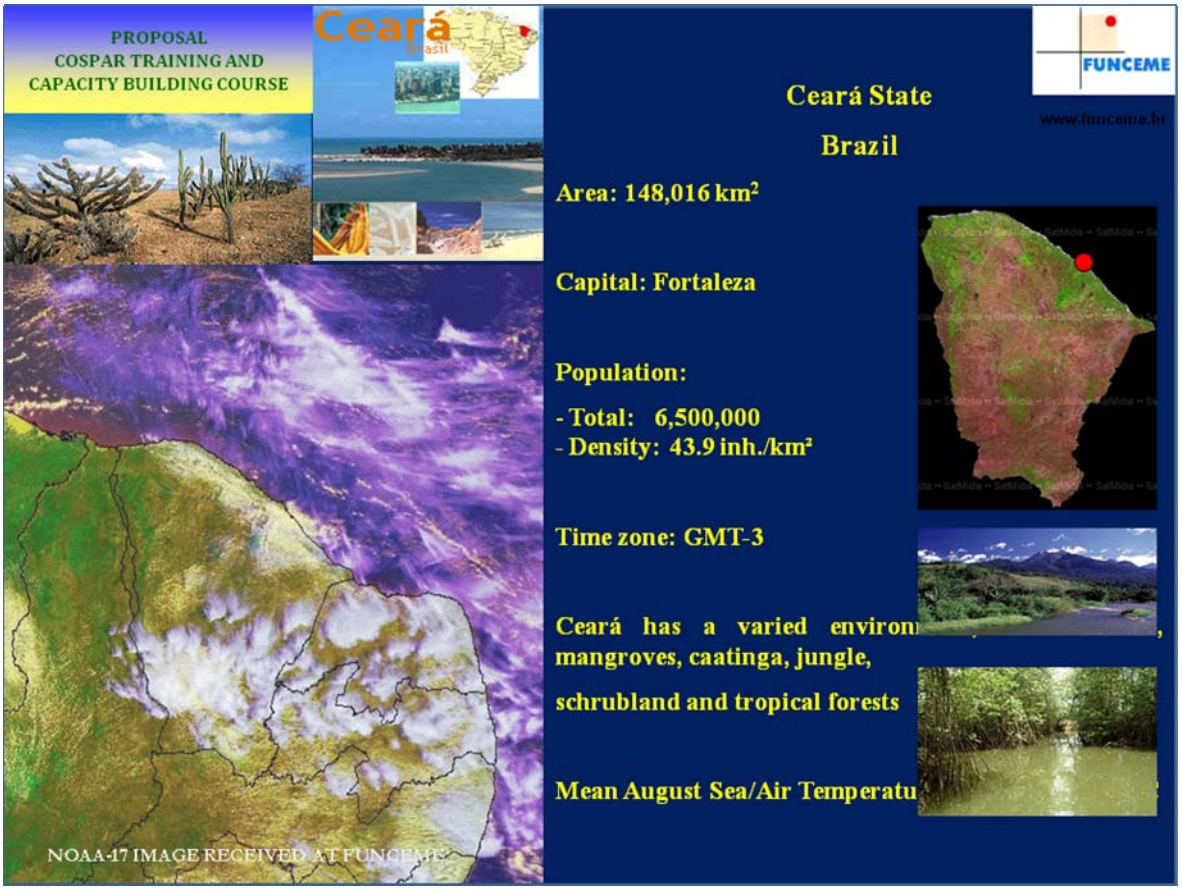
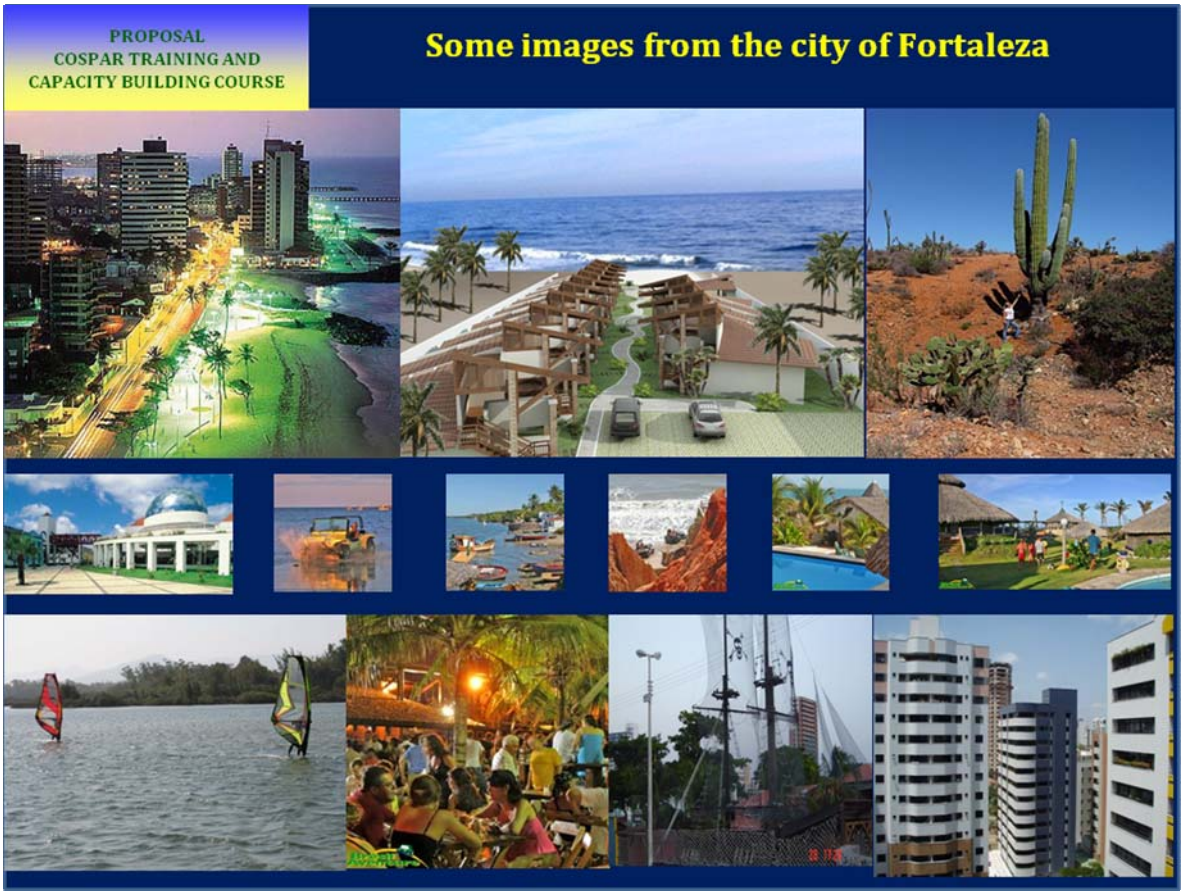

PROPOSAL
COSPAR TRAINING AND
CAPACITY BUILDING COURSE
Ceará
Brasil
FUNCEME
www.funceme.br
Ceará State
Brazil
Area: 148,016 km²
Capital: Fortaleza
Population:
- Total: 6,500,000
- Density: 43.9 inh./km²
Time zone: GMT-3
Ceará has a varied environ
mangroves, caatinga, jungle,
schrubland and tropical forests
Mean August Sea/Air Temperatu
NOAA-17 IMAGE RECEIVED AT FUNCEME


PROPOSAL
COSPAR TRAINING AND
CAPACITY BUILDING COURSE
Some images from the city of Fortaleza