# The Surface Ocean-Lower Atmosphere Study (SOLAS)

## SOLAS and Cape Verde scientists establish an atmosphere and ocean observatory off North West Africa

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### The tropical ocean and atmosphere

The tropics play a critical role in the Earth System. Their importance for weather and climate is exemplified by the generation of hurricanes, the significance of *El Niño* for global weather patterns and inter-annual climate variability, and the effect of tropical Atlantic sea surface temperature on rainfall in drought-threatened sub-Saharan Africa (Sahel). The tropics are truly a "weather-factory" for the planet.

The tropical atmosphere is also our planetary "waste incinerator": here, high concentrations of the OH radical are maintained, cleaning the atmosphere of pollutants as well as certain key greenhouse gases (e.g. methane). These gases are delivered from sources in the north and south and are destroyed in the tropics.

Tropical winds on western sides of continents drive upwelling of nutrient-rich subsurface waters and fuel the ocean's food chain. Eastern sides of tropical oceans sustain some of the most productive and economically important fisheries on Earth (e.g. off Peru and Mauritania). The upwelling zones of the tropical oceans are, in effect, vast, natural "fish farms".

The tropical Atlantic Ocean receives the largest input of mineral dust of the world ocean. The associated input of iron, and possibly other elements, stimulates ocean nitrogen fixation. Further, the tropical oceans play host to the key regions of low oxygen in today's ocean ("oxygen minimum zones"). Major changes to sources and sinks of important nutrients (N, P, Fe) occur when oceanic oxygen concentrations decrease below threshold levels. These spatially limited zones impact nutrient budgets, biological productivity, greenhouse gas production and $CO_2$-fixation of the global ocean. Tropical oceans are the "fertilizer plant" for the world ocean.

All these critical, natural processes in both the ocean and the atmosphere are highly sensitive to temperature, sunlight and wind, (i.e. to climate).

### Vulnerabilities

Climate change in the tropics, both natural and anthropogenic, has the potential to alter:

- the intensity and frequency of *El Niño* and the African monsoon with further consequences for climate change;
- the rate at which pollutants and greenhouse gases accumulate in the atmosphere;
- upwelling and marine food chains with consequences for food supply and, especially, the economies of coastal nations.
- the intensity and extent of oceanic oxygen minimum zones with consequences for higher trophic levels as well as for oceanic nutrient budgets

### A lack of infrastructure

Despite their significance for, and sensitivity to, global change the tropical ocean and atmosphere are remarkably little studied, especially for biological and chemical processes. Many tropical nations are unable to afford the sophisticated scientific infrastructure, equipment and training required for modern climate, ocean and atmospheric research. Even research infrastructure to study marine ecosystems remains limited for many tropical waters, despite decades of heavy fishing by richer nations. Sophisticated atmospheric measurement stations, science logistic bases and fishery research laboratories now exist throughout the richer countries of Europe, North America and Asia as well as in uninhabited ice-covered regions of the world. They remain rare in the tropics.

### Origins of the Cape Verde Observatory

Since 2002, a team of scientists from Germany, the UK and Cape Verde have been working to address this problem. The problem of lack of data and logistical difficulties for global change research in the West African coastal region was recognized in 2002 simultaneously by Doug Wallace (of the Leibniz-Institute for Marine Sciences in Kiel, and now SOLAS Chair) and Martin Heimann (of the Max-Planck-Institut für Biogeochemie in Jena). They asked the Volkswagen Foundation to


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The research boat Islandia travels between the port of Mindelo, Cape Verde, and the atmospheric observatory on São Vincente.

support a workshop to explore the potential of Cape Verde to support long-term observation. The workshop was hosted by two Cape Verde institutions and revealed a cadre of highly motivated scientists within Cape Verde's National Institute for Meteorology and Geophysics (for the atmosphere) and National Institute for the Development of Fisheries (for the ocean). The local scientists explained their needs to the visiting European scientists. The Europeans explained their needs. It became clear that European interests in global change research, and especially in long-term observation, could be compatible with Cape Verdean needs for scientific capacity with which to better understand pressures on their own fragile environment.

At this point, the international connectedness of modern science played a key role. A new SOLAS initiative in the UK (funded by the Natural Environment Research Council) was considering establishment of a long-term field site. Dr. Lucy Carpenter of the University of York and Dr. Phil Williamson of the University of East Anglia had heard about the workshop in Cape Verde and decided to visit the island of São Vicente, Cape Verde, themselves. They recognized that this island location was ideal for the needs of UK SOLAS. The UK initiative could be combined with a new German research initiative SOPRAN (Surface Ocean Processes in the Anthropocene) which is funded by the Federal Ministry of Education and Research (www.sopran.pangaea.de). The Cape Verde Observatory was more or less born at that time with trilateral support from Germany, the UK and Cape Verde linked via support from a European Union project (www.tenatso.com).

## What is the Cape Verde Observatory?

The Observatory has an atmospheric and an oceanic site, both based on or near the island of São Vicente. The atmospheric site, the "Cape Verde Atmospheric Observatory Humberto Duarte Fonseca", named in honor of a Cape Verdean climatologist of the last century, was selected on the windward side of the island on an ancient lava field, close to the ocean. Here, steady NE trade winds bring air directly from the ocean to the measurement systems without risk of land-based contamination. A road was built, power lines and a 30m high sampling tower were constructed. Custom laboratories housed within shipping containers, were installed. There are presently five container labs on the site, contributed by groups from the Universities of York and Leeds, the Max-Planck-Institute in Jena and the Leibniz-Institute for Tropospheric Research in Leipzig. The labs house a wide variety of sophisticated instrumentation that makes continuous measurements of trace gases, greenhouse gases and aerosols as well as meteo-

Photo credit: Ally Lewis, University of York

Cape Verde Atmospheric Observatory "Humberto Duarte Fonseca" on the island of São Vicente, Cape Verde.

rological parameters. A wind turbine was recently installed to supplement the power supply for the site.

The ocean site is located 40 nautical miles "upwind" of the atmospheric site in a water depth of 3700 m. It is now visited regularly with the small Cape Verde research vessel *Islandia*, which has been completely rebuilt for the task. Continuous measurements are made from an oceanographic mooring which was established in June 2006 as well as from unmanned gliders and floats deployed around the mooring. Every few days these autonomous platforms come to the surface and relay their most recent data via satellite to shore before returning on their mission. The mooring and autonomous systems provide long-term data for basic parameters such as temperature, salinity, chlorophyll fluorescence, turbidity, dissolved oxygen and dissolved $CO_2$. More complex biological and chemical measurements rely on water sampling from the *Islandia*. Samples are returned to a newly-equipped laboratory ashore for processing.

Both sites are being developed to support visits of scientists interested in studying tropical atmospheric and oceanic processes in the context of a long-term data set. The sites are also nested within international observation programmes such as the Global Atmospheric Watch and OceanSITES.

## Training, education and capacity building

The Observatory has already trained and employed four Cape Verdean site-managers and technicians. Increasingly, Cape Verdean scientists are becoming involved in site operations and the associated science. In 2007, the Observatory hosted a major atmospheric research campaign involving long-term stays by scientists from Europe and North America. Research vessels from the USA, Netherlands, Germany, France and the UK now sample the ocean site and visit it regularly. Efforts are underway to finance graduate training opportunities for Cape Verdean Masters and PhD students in the context of the scientific projects associated with the Observatory. The project partners view the long-term commitment to science in the region as an excellent opportunity for capacity building: not just for Cape Verdeans but also for other West African nations. The key is to establish long-term scientific interests and capabilities which sustain a commitment from international scientists to work closely with their regional partners. In addition to development of education, consideration is being given to use of the port of Mindelo and Observatory-associated facilities as a logistics centre for the support of international research activities in the region (e.g. research vessel support).

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