ARM

Atmospheric Radiation Measurement Program

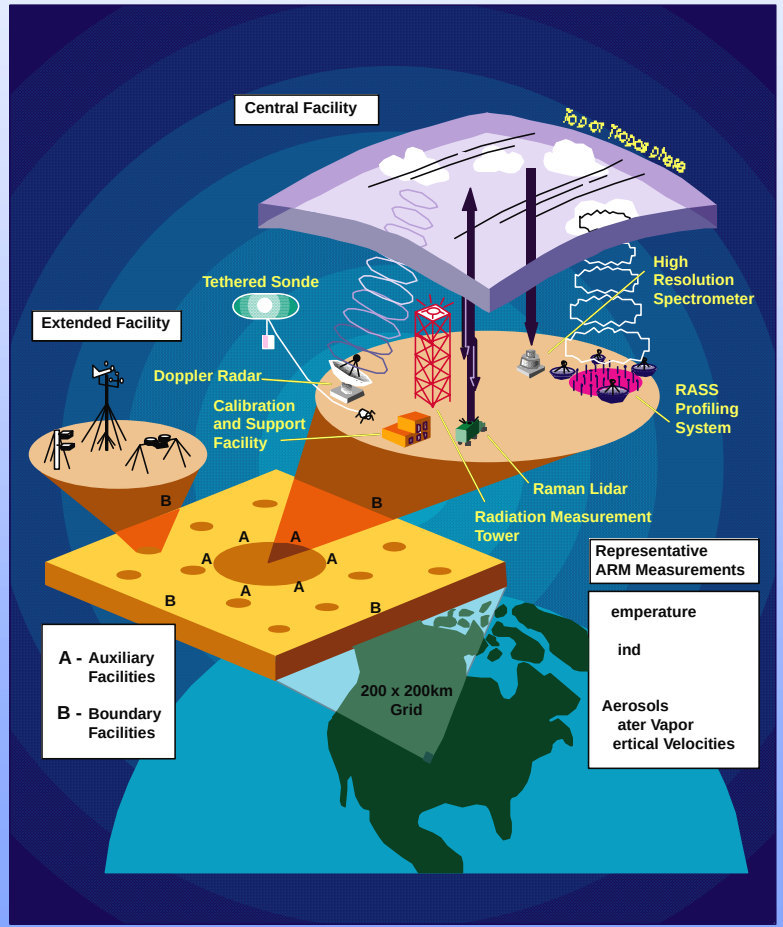
The United States Department of Energy

ARM General Objective

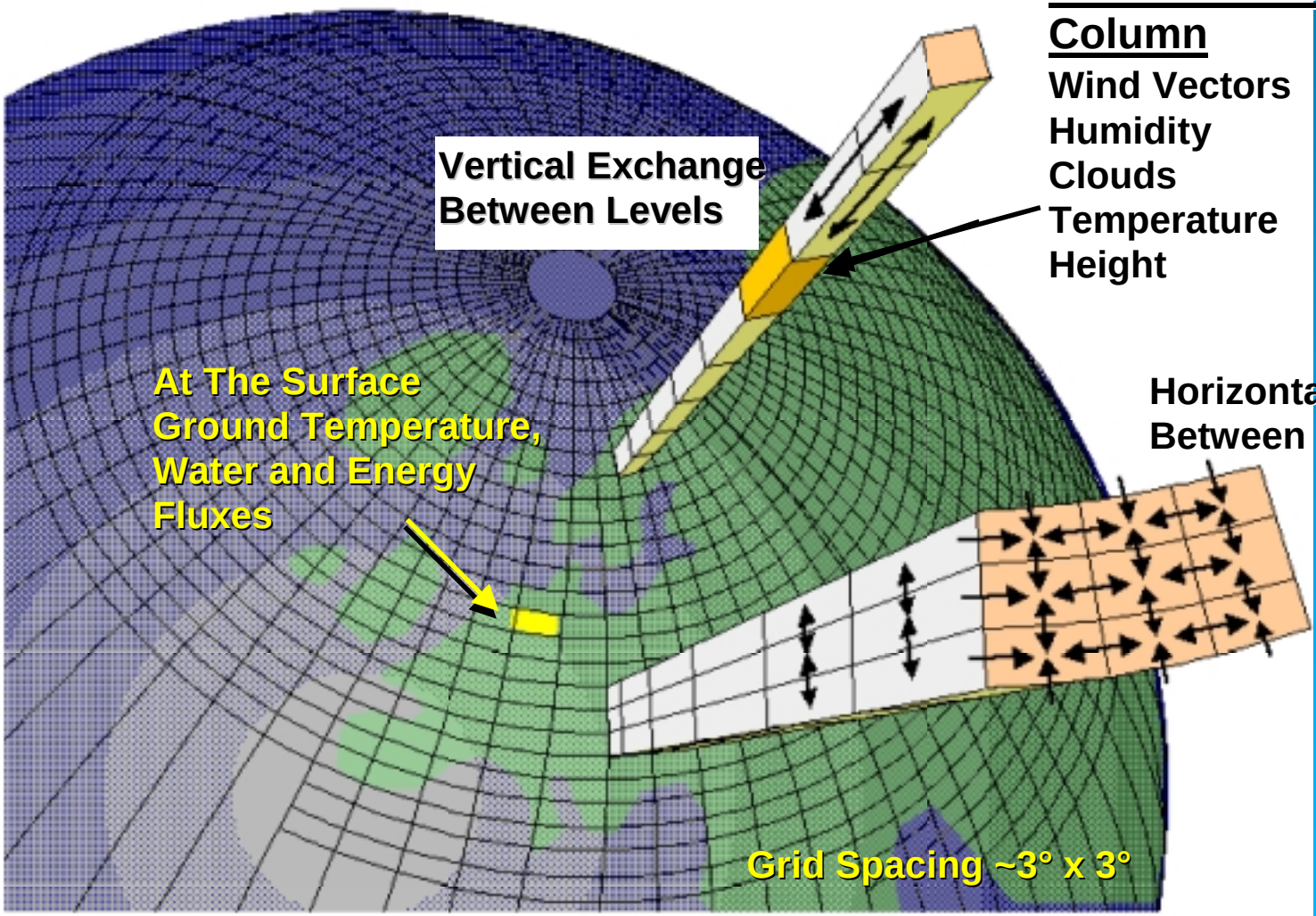
Improve the performance of General Circulation and related models of the atmosphere as tools for predicting global and regional climate change.

Specific Goals of ARM

- Improve GCMs as tools for predicting global and regional climate change
- Improve the treatment of radiative transfer in GCMs under all conditions
- Improve the parameterization of cloud properties and cloud formation in GCMs



GCMs calculate atmospheric conditions inside each box all over the Earth and up into the atmosphere



Time Step ~30 Minutes; each grid cell is about 200 km x 200 km

The ARM Program

- Is addressing its goals through a balanced program of modeling and measurement
- Is instrumenting three primary locales for obtaining data
- Will operate each site for at least 10 years
- Is establishing education enrichment programs at each site

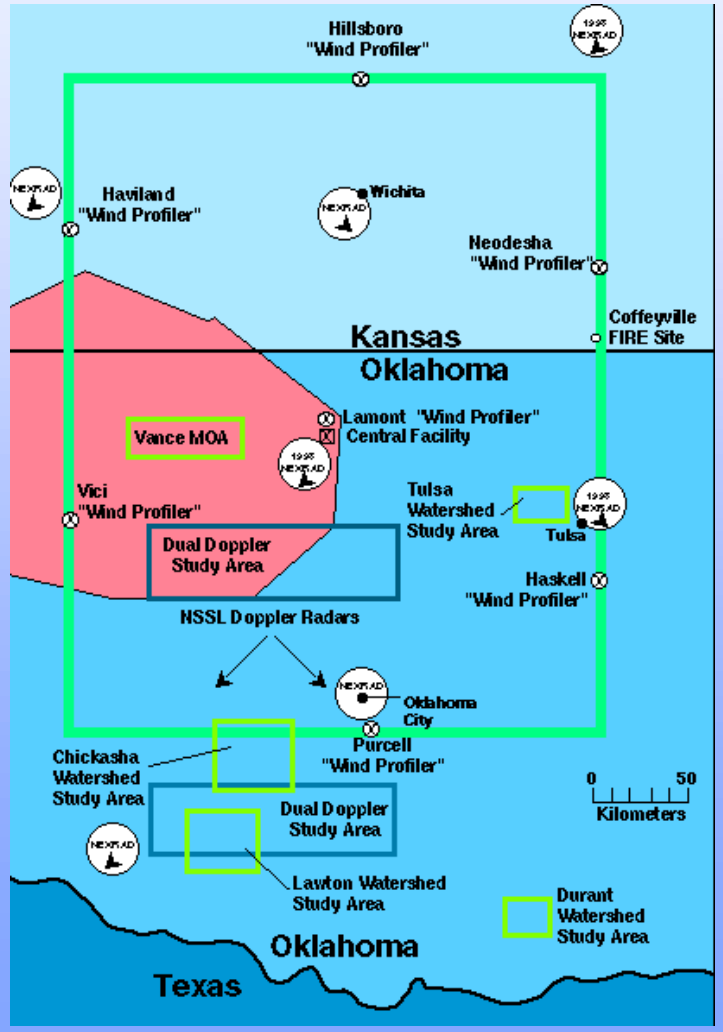
ARM Locales

Political Map of the World
North Slope of Alaska
Southern Great Plains
Tropical Western Pacific
CANADA
RUSSIA
CHINA
INDIA
BRAZIL
AUSTRALIA
North Atlantic Ocean
South Atlantic Ocean
North Pacific Ocean
South Pacific Ocean
Indian Ocean
Antarctica

Locale Development Status

- **Southern Great Plains (SGP)**
  - Operational
  - Data delivery since May, 1992
  - Regular data stream + intensive periods
- **Tropical Western Pacific (TWP)**
  - Modular (containerized) facility
  - Island-based initially
  - First site (Manus Island) operational (Oct 96)
  - Second site (Nauru Island) operational (Nov 1998)
  - Third site location under consideration
- **North Slope of Alaska (NSA)**
  - Modular facility
  - First site (Barrow) operational (July 1997)
  - Second site (Atqasuk) operation (Summer 1999)

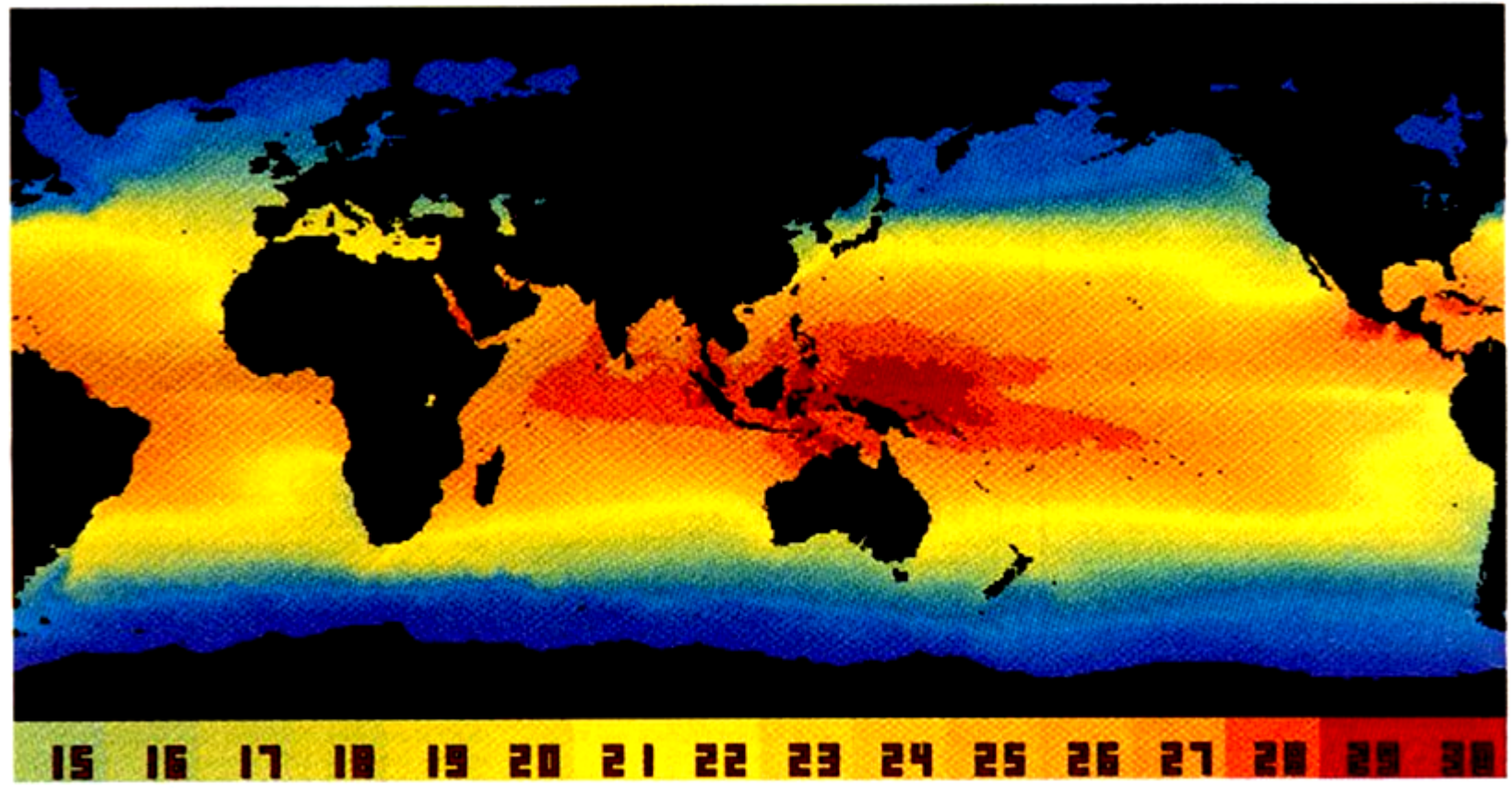
Southern Great Plains Site (SGP)



North Slope of Alaska Site (NSA)

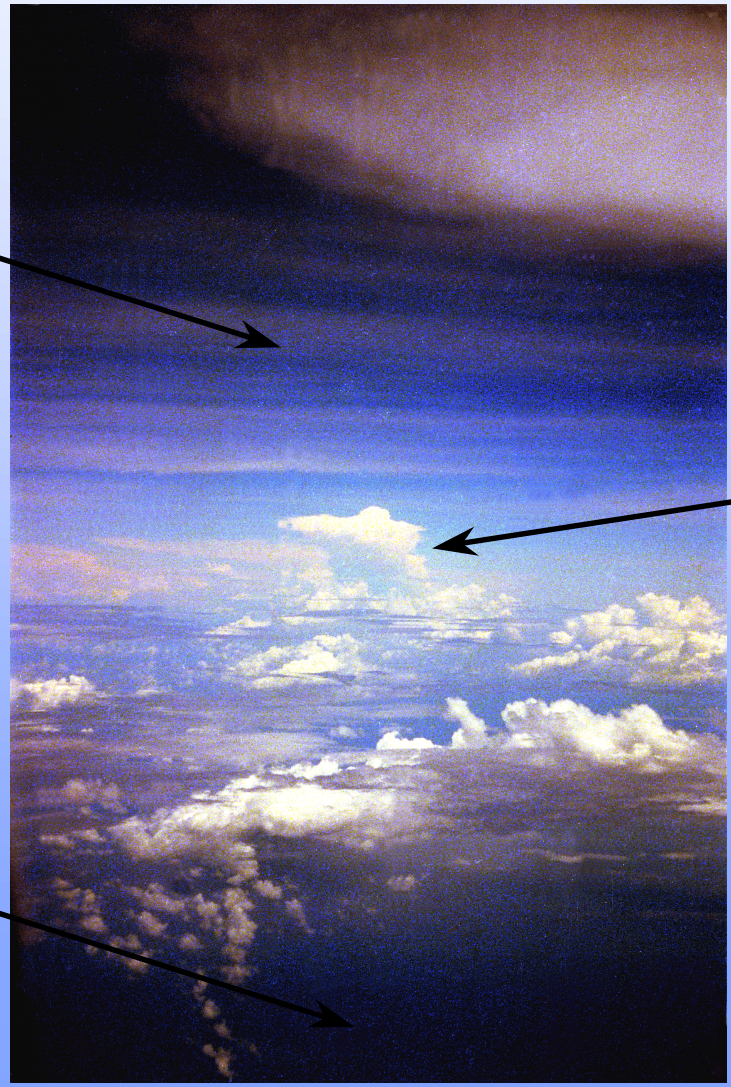
Tropical Western Pacific Site (TWP)

Pacific Warm Pool - sea surface temperatures highest in the world

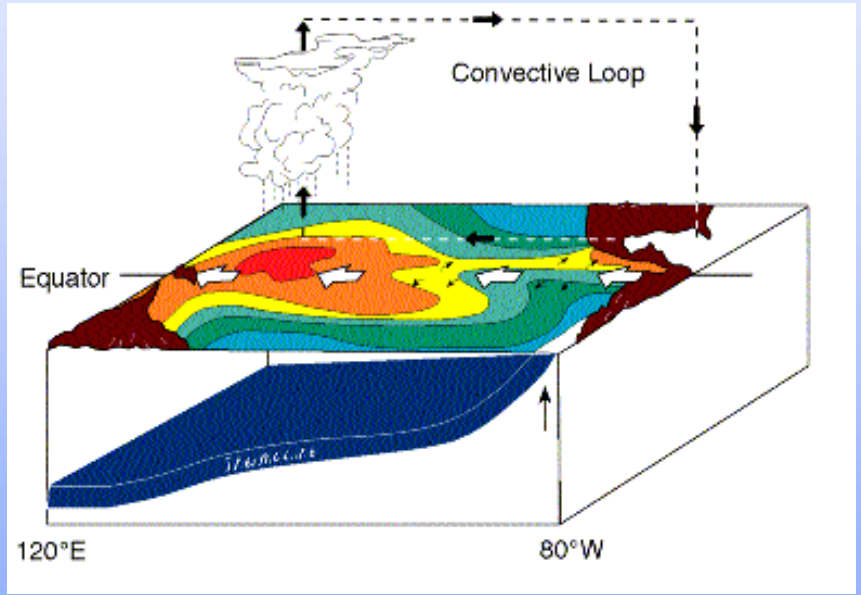


The warm pool is a driver for much of the global climate systems, pumping heat and moisture into the atmosphere

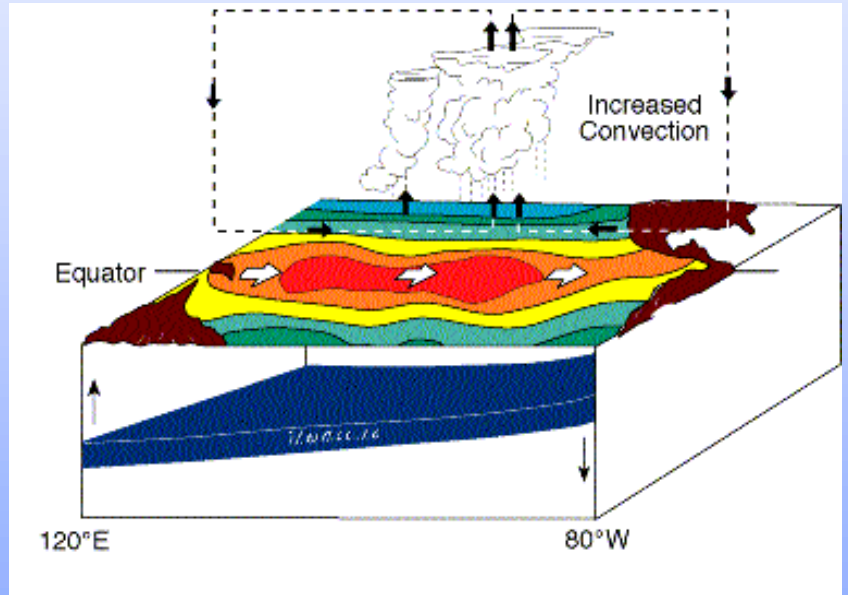
Deep Convection



El Niño Southern Oscillation



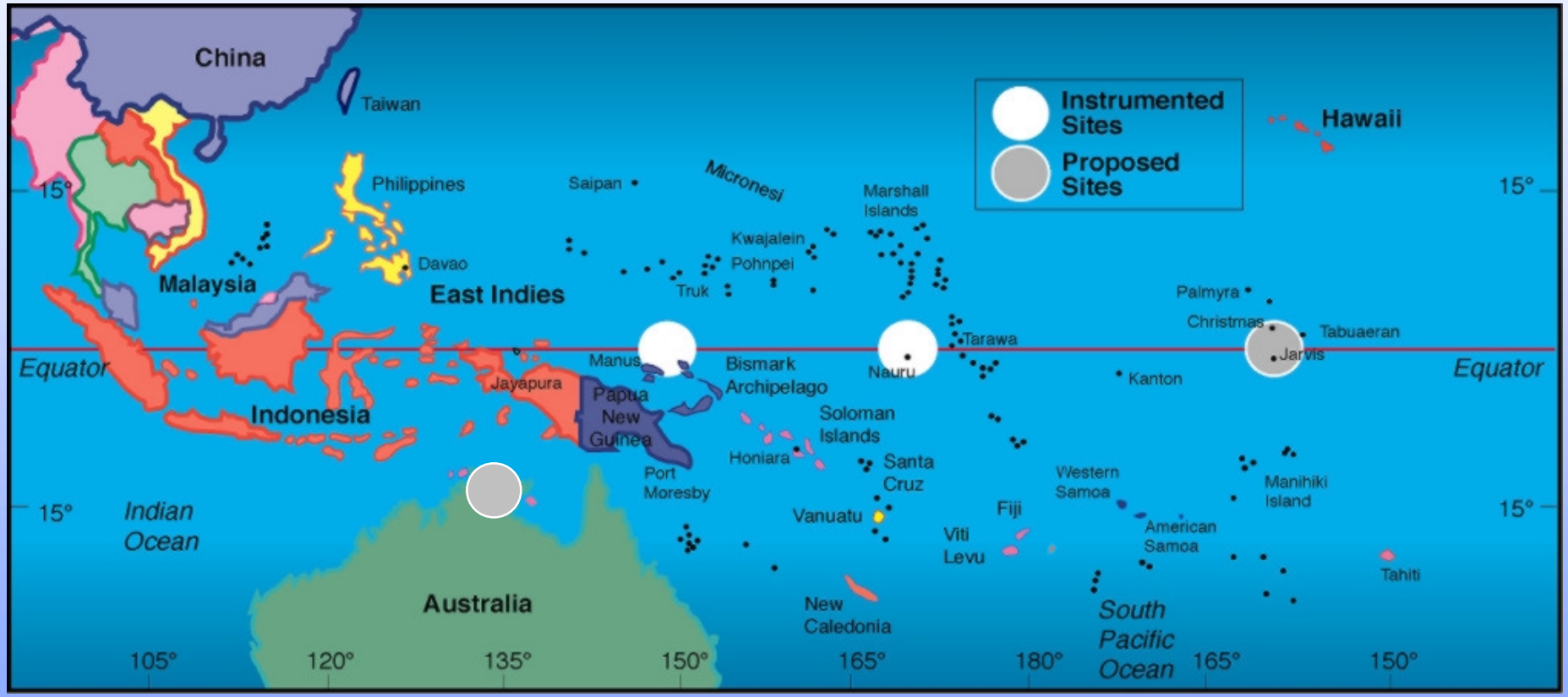
Normal Conditions



El Niño Conditions

Source: www.pmel.noaa.gov/toga-tao/el-nino-story.html

TWP Siting Strategy

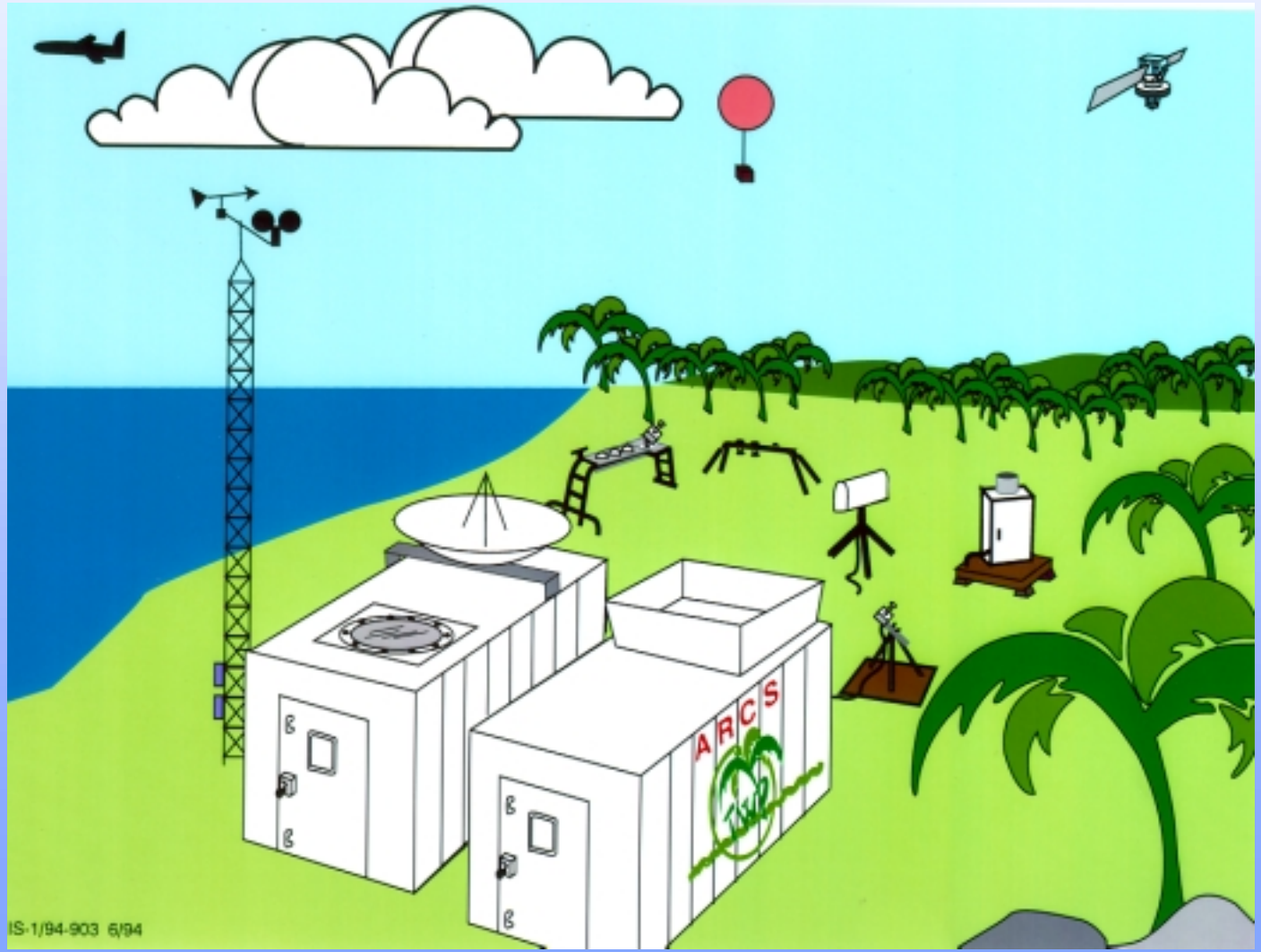


Collaborative work with host countries to operate state-of-the-art instrumented climate research sites across the warm pool

Installing and Operating Sites and Instruments in Remote Locations

- Both NSA and TWP depend on an “ARCS” concept -- semiautonomous laboratories that are designed, developed and tested before installing at the remote site.
- Remote sites are operated in collaboration with local or regional assistance.
- Similar instruments are used throughout ARM to ensure consistency in data flows and high quality data

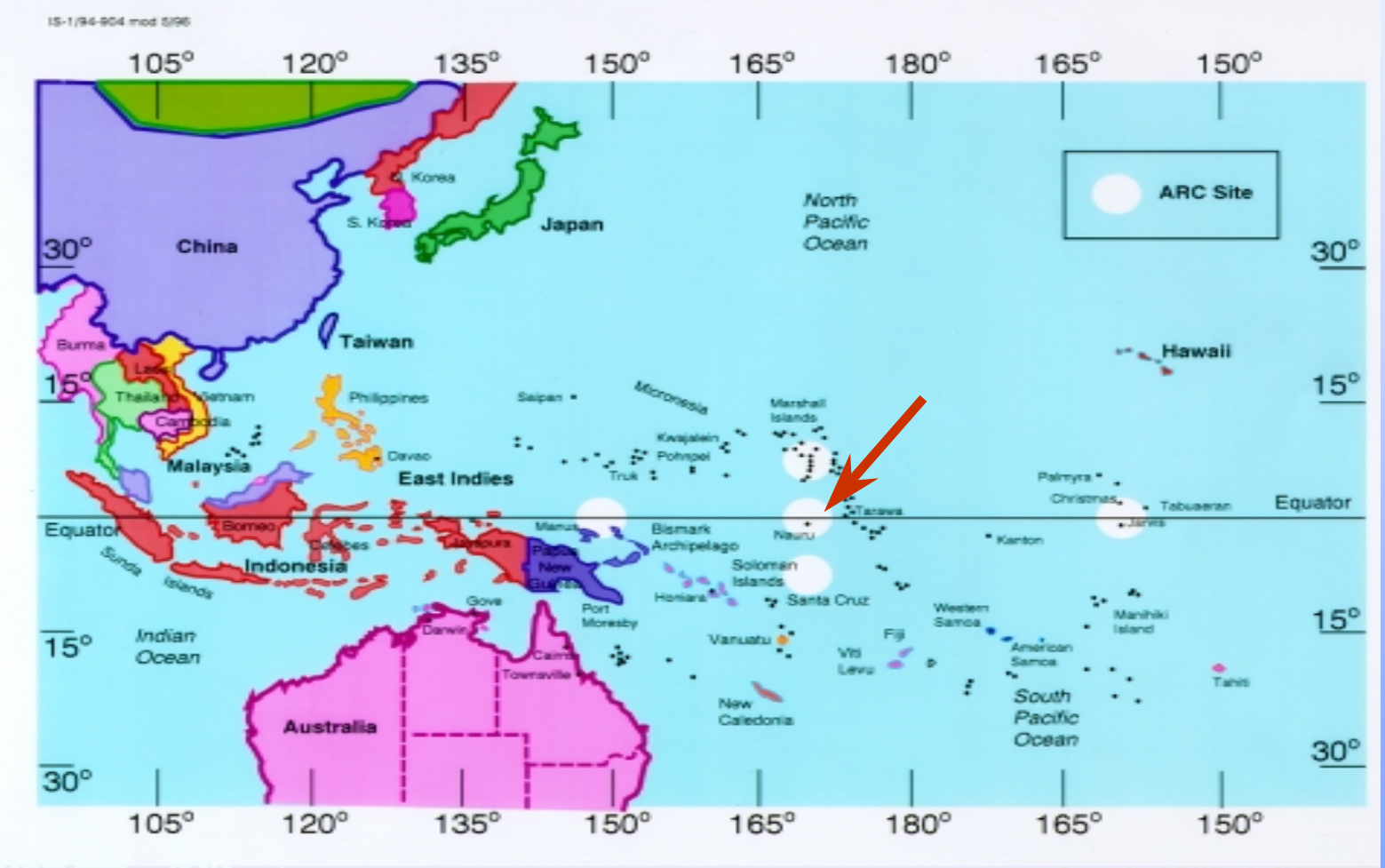
Atmospheric Radiation and Cloud Station (ARCS) Concept



ARCS Measurements

- Surface meteorology
- Surface radiation balance
- Vertical structure of atmosphere
- Column water
- Cloud properties
- Aerosol optical depth

Republic of Nauru



Operations began in November 1998 in collaboration with the Nauruan Department of Island Development and Industry (IDI).

Nauru Island

Nauru Site Installation

Nauru ARM Site

Met Tower

Optical Rain Gage

Remote Balloon Launcher (RBL)

Remote Balloon Launch

Sky Radiation Instruments (SKYRAD)

Solar Tracker Instruments

Ground Radiation Instruments

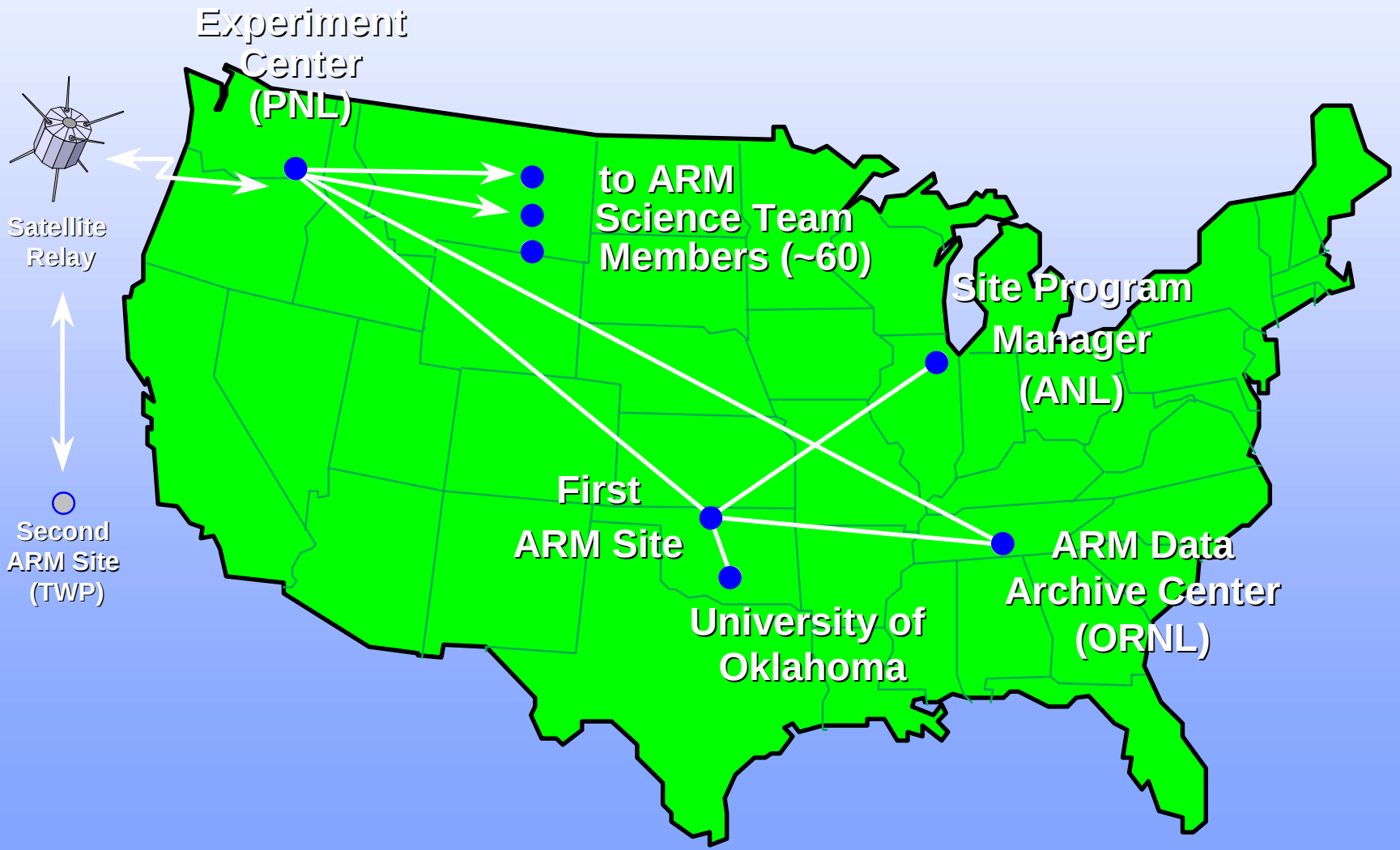
Ceilometer

Cloud Lidar

Cloud Radar

Whole Sky Imager (WSI)

ARM Data Distribution



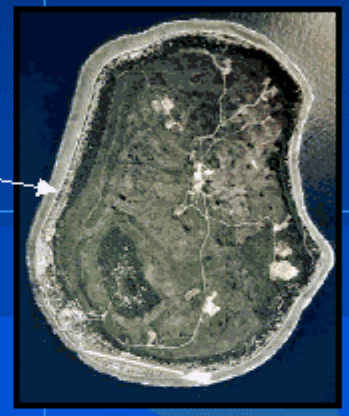
Campaigns and Intensive Observation Periods (IOPs)

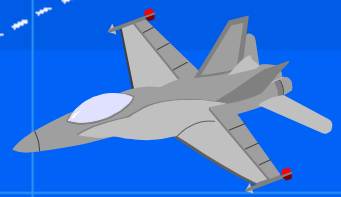
- All sites have times for focused experiments and increased observations.
- International collaborations are often a key factor in IOPs.
- Arctic -- SHEBA campaign was sponsored by NSF and Office Naval Research; ARM participated.
- Pacific -- Nauru99 was sponsored by ARM and NOAA, with Japan and Australia as key collaborators.

Nauru99 Field Campaign
June - July 1999

ARM
Atmospheric Radiation Measurement

Nauru 99 Field Experiment





Nauru

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163
164
165
166
167

TAO Buoy Chain

ARM Education Outreach Program

- ARM Program mandates an education outreach program for each site.
- Education outreach must be relevant to the needs of the local and regional communities.
- Content and management of the program has been determined by the Education Project Director.
- Starting in FY2000, the Education Outreach Program is now integrated across all 3 sites.

Education Outreach Plan

- Focus on basic science, climate, climate change, and effects relevant to the region.
- Enrich primary, secondary and college science programs in the region.
- Collaborate in the development and implementation of a regional science curriculum.

Education Outreach Elements

- Visits to Schools
- Newsletters, TV and radio interviews, videos
- Web sites
- Classroom Activity Guides
- Curriculum Development
- Teacher Workshops for curriculum implementation
- ***INTEGRATION ACROSS ALL SITES*** for increased resources and opportunities for teachers and schools

Work Year 2001-2002

- 3 teacher workshops in TWP
- Workshops evaluations improved
- NSA scoping meetings with teachers, school board, local groups
- Start preparing a museum kiosk on climate issues and ARM program for the local Heritage Center in Barrow Alaska
- Teacher enrichment grants started - NSA
- SGP visit to start collaborations
- Third curriculum volume for TWP on environment
- New lesson activities for all sites

Curriculum Workshops

Nauru

Nov. 98

PNG - May 99

- *Port Moresby*
- *Manus*

ARM Education Website

Hey Kids...
Meet
PROFESSOR POLARBEAR!

Developed for
KIDS
and
TEACHERS!

Check out our
Scavenger
Hunt !!

ARM Program's

EDUCATION CENTER

About ARM
Take a look at who we are and what we do.

Global Warming
The facts for beginners or brainers

Ask a Scientist
Got big questions? We've got big answers.

Question of the Week
Professor Polarbear's pick of the week

Lesson Plans
A little help for teachers.

Try Our Quiz!
Global warming
What do you know?

Cool Sites!!!
Lesson plans & tools
Cool education links

Related News
Global news
Great reports

Outreach Sites
Take a trip to one of our education sites!

http://www.arm.gov/docs/education/

ARM Education Website

Causes of climate change and effects of carbon dioxide on the environment.

Look at the following sections for more details!

- ***Global Beginners***

  If you are not sure what global warming means, this is the place to start.

- ***Global Thinkers***

  You have given global warming some thought and would like to know more -- this section is for you.

- ***Global Experts***

  This section is for those who have spent considerable time studying global warming.

http://www.arm.gov/docs/education/warming/

ARM Education Website

The following lessons were first printed as part of the ***Curriculum Modules for the Pacific Schools*** - Climate Change and Sea Level.

Most materials [links are highlighted] are aimed at the **middle school grade level**, but many can be modified by the teacher to be more or less difficult, as desired.
The lessons typically require some background information which is also included. The lessons contain the **objective**, **materials** needed, **important points** to understand, **preparation** steps, and **procedures**.

The lessons will give students:
1. A basic understanding of the composition and structure of the atmosphere.
2. An understanding of the role played by atmospheric pressure and temperature.
3. An understanding of the natural and enhanced greenhouse effects and their implications.

Examples of topics: Air Density and Temperature, Air Pressure, Winds, etc…

http://www.arm.gov/docs/education/tlessons/