

Session WS-6:
Observation Needs for Climate Information, Prediction and Application

Whitepaper on:

“Capabilities of Existing and Future Observing Systems”
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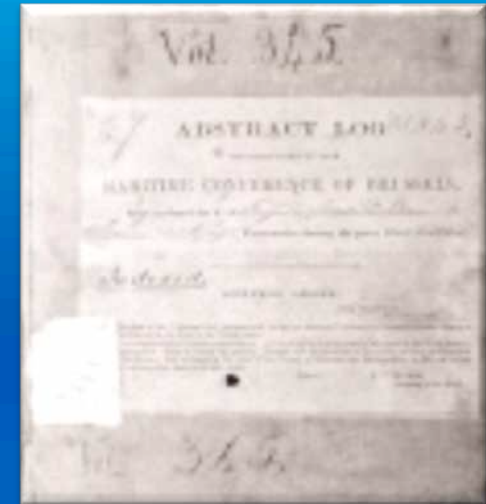
Outline

- **Introduction**
- **Essential Climate Variables - Status**
- **Systematic & Reference Observations for Climate**
- **The Role of Reanalysis & Reprocessing**
- **International Coordination & Cooperation**
- **Resilience of Observing Systems**
- **Conclusions & Recommendations**



Introduction

- **1853: 1st International Meteorological Conference, recognized need for sustained global observations**
- **1990: Second World Climate Conference, recognized need to create a Global Climate Observing System**
- **1992: Global Climate Observing System (GCOS) established**
Goal: Provide comprehensive information of total climate system involving physical, chemical, and biological observations for atmosphere, oceans, and land
 - Implementation co-sponsored by WMO, IOC/UNESCO, UNEP and ICSU
 - Guided by steering committee, support from scientific panels and secretariat
- **2003: GCOS Essential Climate Variables (ECVs) developed: key variables that meet critical needs and are feasible to observe**



Domain	Essential Climate Variables (ECVs) [As of 1-January-2009]
Atmospheric (over land, sea and ice)	<p>Surface: Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapor</p> <p>Upper-air: Earth radiation budget (including solar irradiance), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapor, Cloud properties</p> <p>Composition: Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases, Aerosol properties</p>
Oceanic	<p>Surface: Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean color (for biological activity), Carbon dioxide partial pressure</p> <p>Sub-surface: Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton</p>
Terrestrial	<p>River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Biomass, Fire disturbance</p>

Atmospheric Observations

- **Changes in atmospheric state of water are unique in the climate system**
- **Changes in natural modes of variability (e.g., El Niño, North Atlantic Oscillation) reflect changes in atmospheric circulation and storm tracks**
 - Natural variability can obscure climate change detection.
 - Climate change can occur by
 - Changes in the frequency
 - Changes in intensity
- **Multiple measurements are needed to characterize the atmosphere**
 - Temperature (frost, freezes, heat waves)
 - Clouds (type, height, optical depth, cloud droplet distribution)
 - Precipitation (amount, intensity, rate, type, drought)
 - Aerosols (size, density, distribution)



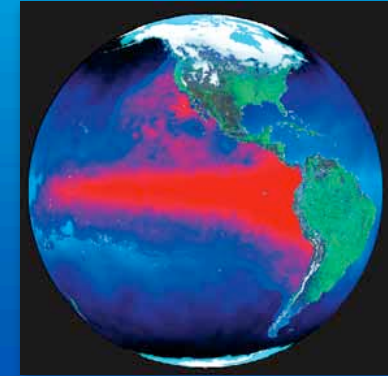
Status

- **Progress is slow in meeting today's newly evolving needs**
 - Established networks largely meet traditional needs
 - Substantial vulnerabilities exist
 - Substantial inadequacies for changes in weather and climate extremes
 - Improvement in a few developing countries, but major gaps exist



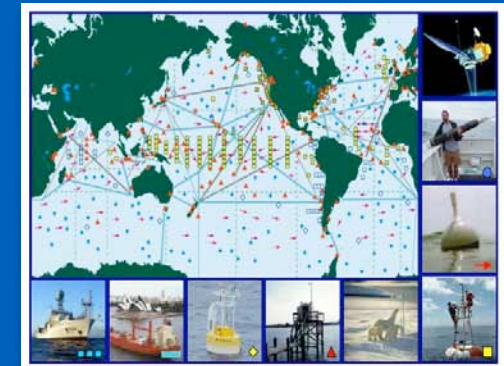
Oceanic Observations

- **Strong impact on all timescales of the climate system**
 - Teleconnections
 - Feedbacks
 - Holds most of the water in the global hydrological cycle
 - Provides the vital water that falls over land as rain and snow
 - Stores and transports large amounts of heat;
 - Possible origin of rapid climate change through alteration of deep circulation
 - Stores 50 times more carbon than atmosphere;
 - Sediments store thousands of times more
 - Has absorbed 1/3 of all carbon emitted into the atmosphere



Status

- **Significant progress made in implementing ocean observing system for climate as recommended in GCOS Implementation Plan**
- **Current Status: 60 percent of global ocean observing system completed.**
 - Gaps in deep ocean and high latitudes still exist
 - Very limited progress in establishing national institutions for sustaining climate quality ocean observations
- **Reassessment of networks to be done at OceanObs '09 in late September 2009**



Terrestrial Observations

- **Land provides humans with vital resources (e.g., food, fibre, forest, water)**
- **Changes in water storage, carbon storage, and land cover (e.g., deforestation) affect climate change and variability**
- **Critical components of the hydrological cycle include:**
 - Precipitation
 - Evapotranspiration
 - Snow
 - Glaciers
 - Frozen ground
 - Soil moisture
 - Groundwater
 - Lake levels
 - River discharge
- **All terrestrial observations have considerable spatial and temporal variability**



Status

- **Progress defining internationally accepted standards for ECVs**
- **Establishing several Global Terrestrial Networks (e.g., Glaciers, Hydro, and Permafrost)**
- **Understanding the hydrological and carbon cycles are crucial**
 - Uncertainty is still too large in closing these cycles
- **Surprisingly, large observational gaps still exist**
 - Where the greatest number of people live

Satellite Observations

- **Satellite-based observations have progressed greatly since the early 1960s**
- **Proven capability to monitor many aspects of the Earth system, including:**
 - evolution of El Niño events
 - weather phenomena
 - natural hazards
 - vegetation cycles
 - the ozone hole
 - top-of-atmosphere radiation
 - sea ice and ice sheets weather
 - coastal zones and algal blooms
 - deforestation and forest fires
 - distributions of water vapour, clouds and aerosols

Status

- **Space agencies responsive to the needs expressed by GCOS through the Committee on Earth Observation Satellites (CEOS)**
- **CEOS (2006) identified 59 actions covering key climate-related observations of atmosphere, oceans, and land**
- **Creation of Climate data records (CDR) from satellite observations are now in progress**



Reference Observations

- **Increased emphasis on detecting climate trends**
- **Reference observations needed to answer the question: “How has the climate changed in the past 50 years and more?”**
- **They provide anchor points for existing networks**
 - calibrating satellite data
 - validating data products
- **Reference quality in-situ networks are needed to**
 - Address inadequate in-situ measurements
 - Help transition between non-overlapping satellite missions



Status

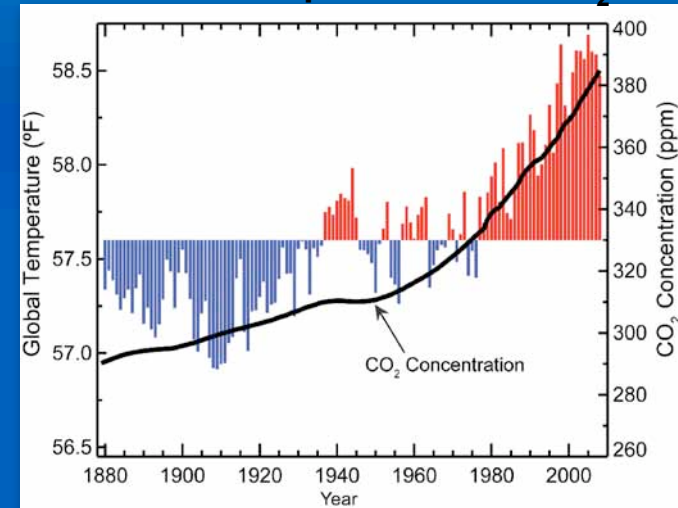
- **GCOS Reference Upper Air Network (GRUAN) is making some limited progress**
- **Climate Absolute Radiance and Refractivity Observatory (CLARREO) is a key element of a climate observing strategy – launch in 2017**



Reanalysis

- **First generation of atmospheric reanalyses carried out in Europe and the USA**
 - Are widely used
 - Are considered extremely valuable
- **Integrated datasets, no time-dependent biases, required for:**
 - Model development
 - Model verification
- **Atmospheric model analyses provide a physically consistent set of observations**
 - More continuity and infrastructure required

Global Temperature and CO₂



Status

- **Significant advances in reanalysis of ocean data**
 - Promising developments in sea ice, Arctic, reanalysis
 - Developing atmosphere-ocean data assimilation
- **New developments in land surface reanalysis**
- **International cooperation is vital and needs to grow**



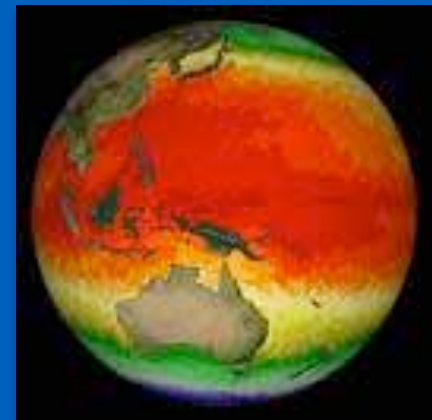
Reprocessing

- **Much more work is needed to take advantage of observations already made**
 - To improve knowledge of what has happened and why
 - To make climate predictions
- **Broader engagement of the scientific community is needed to**
 - Assess derived data products
 - Refine the algorithms for the generation of these products
- **Robust collection, management and homogenization of observed data needed**
- **Better coordination of common standard algorithms, are required for:**
 - Comparisons
 - Assessment of results
- **Reanalysis is increasingly valuable for monitoring, research, and applications.**



Status

- **Some reprocessing efforts underway**
 - Emphasis on the construction of climate data records
- **More algorithm development**
- **Increased computing power required**
- **More integration with satellite data is required**



International Centers

- Reliable analyses benefit from globally standardized, preserved, and accessible data
- Data collection, monitoring, storage, and redistribution have been undertaken by centers around the world
- International data centers have been established for many ECVs, but not all

GOSIC
Global Observing Systems Information Center

Home | About GOSIC | GCOS | GOOS | GTOS | Data Registry | Search | Publications | Acronyms | Contact Info

Facilitating Access to Global Observing Systems Data and Information

The GOSIC Portal provides convenient, central, one-stop access to data and information identified by the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS) and their partner programs, such as the Global Atmosphere Watch (GAW) and regional observing systems, such as the GOOS Regional Alliances (GRA). [More information on the GOSIC and the GOSIC Portal](#)

Updated July 13, 2009

Access Data, Metadata & Data Products	<ul style="list-style-type: none"> • GCOS - Global Climate Observing System • GAW - Global Atmosphere Watch • GTOS - Global Terrestrial Observing System • GOOS - Global Ocean Observing System • GRA - GOOS Regional Alliances • Maps and Google Earth(TM) Products
Search Tools	<ul style="list-style-type: none"> • Data Registry (search for data and metadata) • Portals (search for metadata in NASA's Global Change Master Directory (GCMD)) • Data Access Matrices (provides quick access to data download by program or theme) • Text Search • Publications (search by observing system, year or title keyword/cross referenced by GCOS, GOOS, GTOS, GAW, WMO and UN ID) (1985 to present)
Information	<ul style="list-style-type: none"> • Data Flow Diagrams • Meeting Calendars: GCOS - GOOS - GTOS • Publications/Documents: GCOS - GOOS - GTOS - GAW - GOSIC • Data Management Plans: GCOS/GOOS/GTOS - GCOS - GOOS - GTOS - GAW • Strategic Plans: GOOS - GAW - GCOS/GOOS/GTOS • Review the scientific and technical basis for the design of GCOS - GOOS - GTOS - GOSIC - GCOS/GOOS/GTOS • Scientific Panels • Climate Change News Feed (from the Ocean United web site) • Related Links • Disclaimer

GOSIC is supported and hosted by the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC), and the U.S. GCOS Program on behalf of the global observing community.

URL: <http://gosic.org>

Data Access

Information about Atmospheric, Oceanic, and Terrestrial Observing Systems

Goal: Easy access to data across multiple data centers

International Coordination

- **GCOS requires global, regional, and national coordination mechanisms**
- **GCOS Secretariat and Steering Committee have long called for appointment of national GCOS coordinators and committees. They can:**
 - Act as national advocates for sustainable climate observing systems
 - Provide a national focus to coordinate reporting to UNFCCC and communication with GCOS Secretariat
 - Help GCOS Monitoring Principles (GCMP) identify priorities of potential donor agencies and sources of funding for activities
 - Promote adherence to GCMP and other standards for climate observations
 - Facilitate identification and provision of climate data to international data centers
- **In all but 16 countries there are no GCOS national coordinators**
- **Coordination at regional level is equally important;**
 - Facilitates harmonized action to address common issues,
 - Only one Regional Coordinator exists (*i.e.*, Pacific Islands)



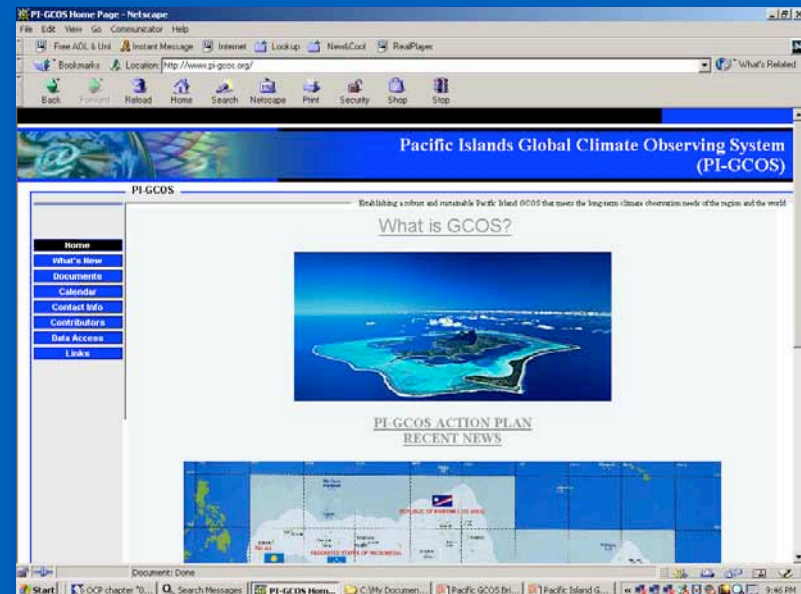
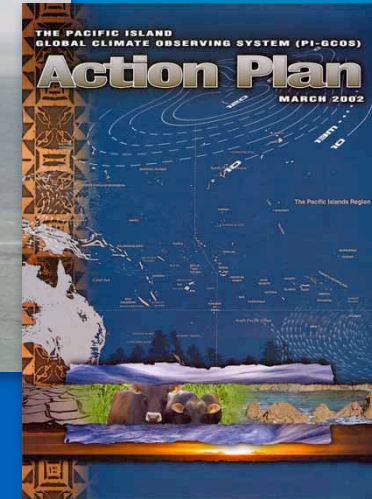
Capacity Building Status

- **Technology transfer and local training are important ways to improve the quality of climate-related observations**
- **GCOS Cooperation Mechanism assists in the improvement of global observing system infrastructure in developing countries**
- **GCOS Secretariat implemented a Regional Workshop Programme between 2000 and 2006 to help regions identify gaps and deficiencies in their climate observing networks**
 - Regional Action Plans developed to address highest priority needs



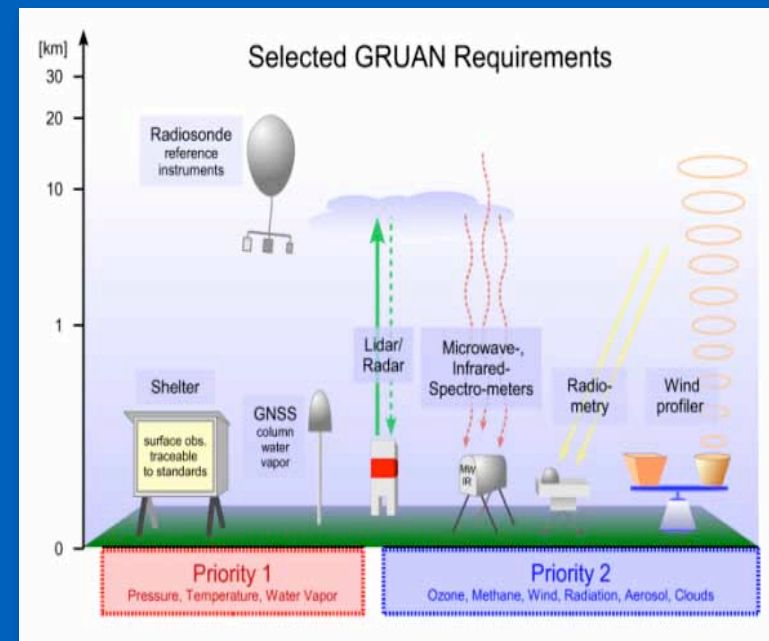
Regional Programs

- **Great potential, some successes**
 - 10 regional workshops, 2000-06
 - Regional Action Plans created for each region
 - Pacific Islands a model for other regions
 - Keys to success include grass roots leadership
 - Assistance from developed nations key
- **ClimDev Africa has great potential for success to further GCOS in Africa**
- **Need to develop local observations to better monitor extremes**



Resilience of Observing Systems

- **Building resilience of observing systems for all ECVs**
- **Cross calibrate all space based observations with reference observing systems. *Examples:***
 - CLARREO – Satellite system
 - GRUAN – In situ based system
 - Critical to maintaining data continuity should there be a major system or instrument failures, e.g., Orbiting Carbon Observatory
- **Multiple platform approach is crucial for both planning for the potential loss of an observing system and avoiding unknown biases in climate monitoring**
- **How well are we doing?**
 - Globally
 - Near-global
 - Regionally



Current Atmospheric ECV Resilience [2009]

Green – 3 or more measures; Yellow – 2 or more measures; Orange – 1 measure; Red – No measures

ECV	Global	Near Global	Multi-Regional	Regional
Surface Air Temperature				
Precipitation				
Surface Air Pressure				
Surface Radiation Budget				
Surface Wind Speed & Direction				
Surface Water Vapor				
U/A Water Vapor				
Earth Radiation Budget (including TSI)				
U/A Temp (including MSU radiances)				
U/A Wind Speed & Direction				
Cloud Properties				
Carbon Dioxide				
Methane				
Ozone				
Other Long-Lived Greenhouse Gases				
Aerosol Properties				

Current Oceanic ECV Resilience [2009]

Green – 3 or more measures; Yellow – 2 or more measures; Orange – 1 measure; Red – No measures

ECV	Worldwide	Near Worldwide	Multi-Regional	Regional
Sea Surface Temperature				
Sea Surface Salinity				
Sea Level				
Sea State				
Sea Ice				
Surface Current				
Ocean Color				
Carbon Dioxide Partial Pressure				
Sub-Surface Temperature				
Sub-Surface Salinity				
Sub-Surface Current				
Nutrients				
Carbon				
Ocean Tracers				
Phytoplankton				

Current Terrestrial ECV Resilience [2009]

Green – 3 or more measures; Yellow – 2 or more measures; Orange – 1 measure; Red – No measures

ECV	Worldwide	Near Worldwide	Multi-Regional	Regional
River Discharge	Orange	Orange	Orange	Orange
Water Use	Red	Red	Orange	Orange
Ground Water	Red	Red	Orange	Orange
Lake Levels	Orange	Orange	Orange	Orange
Snow Cover	Yellow	Yellow	Yellow	Yellow
Glaciers and Ice Caps	Yellow	Yellow	Orange	Orange
Permafrost	Red	Red	Orange	Orange
Albedo	Yellow	Yellow	Orange	Orange
Land Cover (including Vegetation Type)	Yellow	Yellow	Orange	Orange
FAPAR	Yellow	Yellow	Orange	Orange
Leaf Area Index	Yellow	Yellow	Orange	Orange
Biomass	Red	Red	Red	Red
Fire Disturbance	Yellow	Yellow	Yellow	Yellow

Future Prospects and Concerns

Resilience of Observing Systems

- **Coordinated future planning needs more attention**
- **Resilience of the measurement of many ECVs are likely to get worse**
 - Problems & needs in developing countries need to be addressed
- **Difficult to anticipate problems in satellite observing**
 - Launch failures
 - On-Orbit failures
- **Inadequate overlap and dual operation of observing systems**
- **Need continued priority for key reference observing systems e.g.,**
 - GRUAN
 - CLARREO
- **Risk of gaps in the satellite records over the next 10-20 years**
- **Spotty maintenance of in-situ networks leads to:**
 - Problems with reanalysis and reprocessing
- **Observation continuity is key to climate record in jeopardy**
 - Planned redundancy is critical



Summary

- **Long-term, high-quality, calibrated, and un-interrupted observations are the foundation for global climate services**
 - Economies and societies increasingly affected by climate variability and change
- **Since the 1990s, some observing network degradation has been halted**
- **New observing systems have been established**
 - But a number of past concerns remain
 - New requirements have emerged
- **Many established observing systems have yet to implement the GCOS Climate Monitoring Principles**



Conclusions

- **Enhancements are still needed for many observing systems**
 - Filling gaps in coverage, improving measurement accuracy where needed
 - Establishing key networks of reference observations using absolute calibration and high operating standards (GCMP)
 - Failure to fully observe climate ECVs seriously compromises our ability to mitigate and adapt to climate variability and change
- **Climate Services would be well served by assessing the resilience of ECV monitoring for both the present and future states**
 - Future assessments should look beyond current systems
 - Address **existing and new** observing systems including:
 - Related instrument lifetimes
 - Likelihood of instrument degradation
 - Stability of observing platform



**Climate Services will require sustained and dedicated
observing system support**

**Without these investments we will be ill-prepared to make
informed and better decisions**

Merci - Any Questions??

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