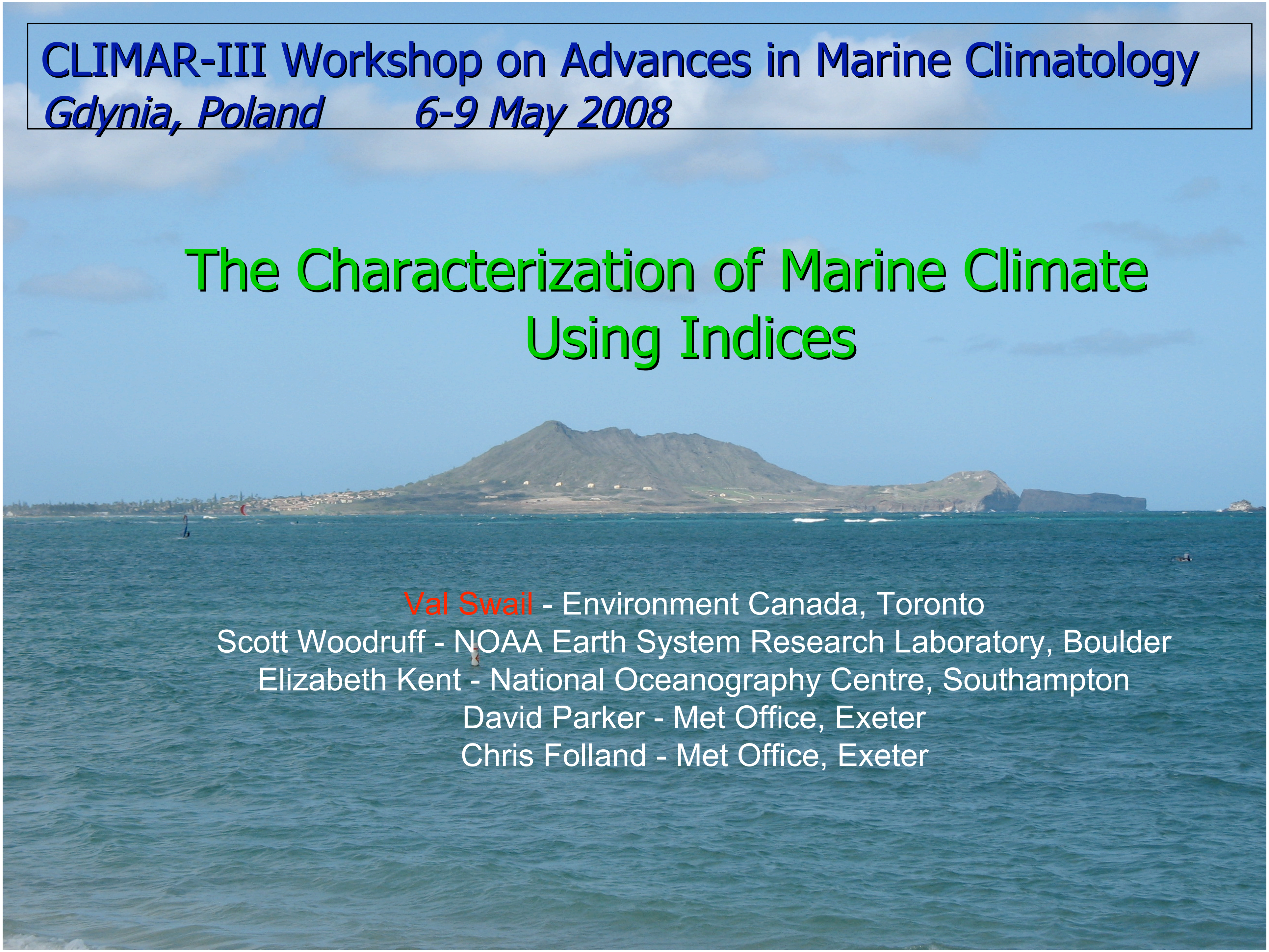

CLIMAR-III Workshop on Advances in Marine Climatology
Gdynia, Poland 6-9 May 2008
The Characterization of Marine Climate Using Indices
Val Swail - Environment Canada, Toronto
Scott Woodruff - NOAA Earth System Research Laboratory, Boulder
Elizabeth Kent - National Oceanography Centre, Southampton
David Parker - Met Office, Exeter
Chris Folland - Met Office, Exeter

OUTLINE

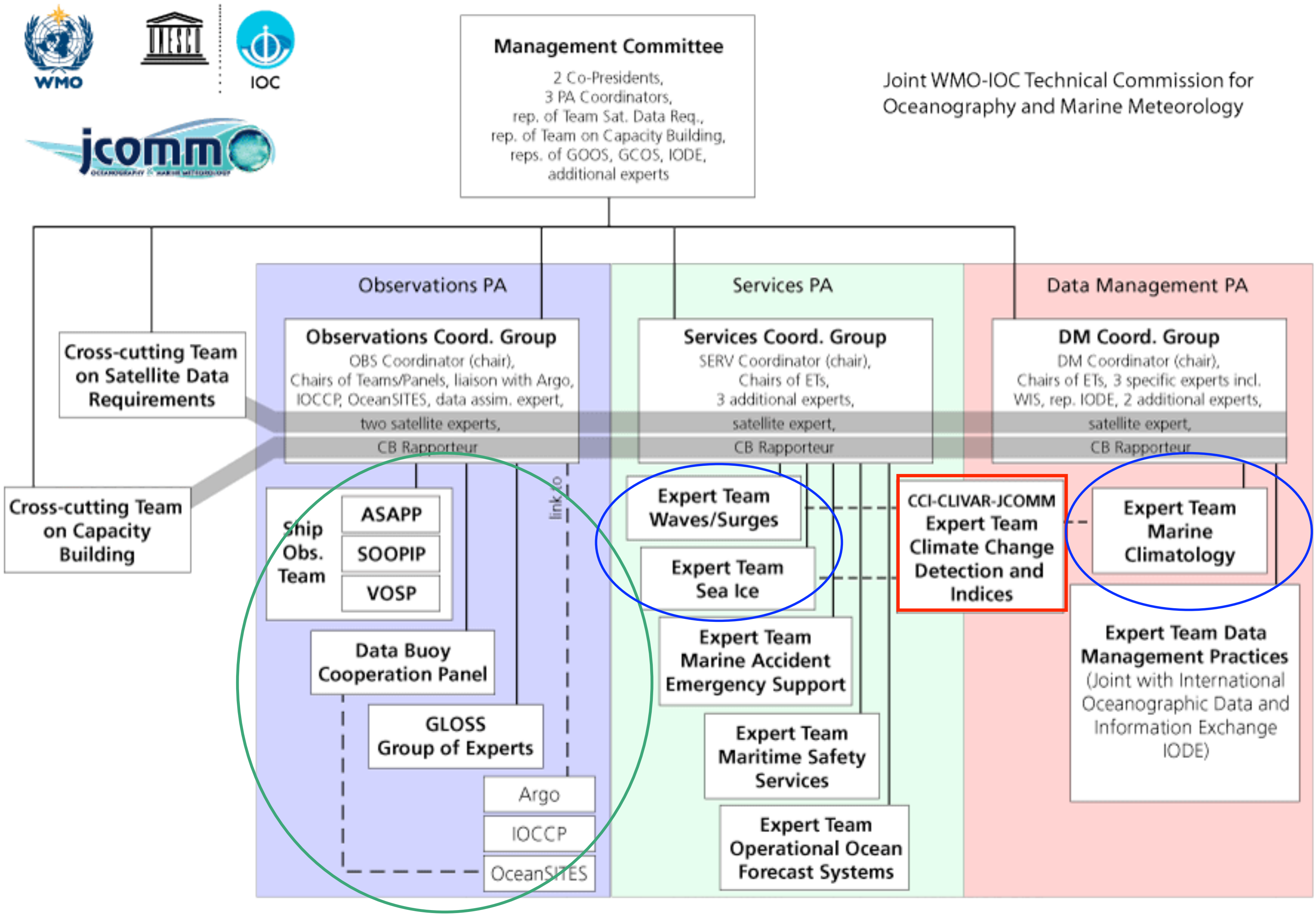
- Background
  - CLIVAR/CCl/JCOMM Expert Team on Climate Change Detection and Indices
  - Motivation
- Characteristics required from indices
- Marine Data sources suitable for indices
- Existing and Potential Marine Indices
- Enabling Mechanisms for indices development
- What Next?

Background

- Norwich November 2003 – JCOMM presentation to ETCCDMI; responsibility for marine climatology clearly identified as JCOMM
- Beijing November 2005 – CCI recommends JCOMM as full partner in split teams, ETCCDI and ETCM
- Tarragona September 2006 – ETCM-I meets; Craig Donlon as JCOMM representative
- Exeter November 2006 – JCOMM SCG-III affirms climate services as core activity
- Niagara-on-the-Lake November 2006 – ETCCDI-I meets; Val Swail, Liz Kent, Scott Woodruff, Chris Folland JCOMM representatives
- CLIMAR-III May 2008 – Marine climate indices invited presentation, Plenary discussion
- De Bilt May 2008 - ETCCDI-II meets; David Parker replaces Chris Folland on ETCCDI; report on indices discussions at CLIMAR-III

WMO
OMM

JCOMM Structure



ETCCDI – Terms of Reference

- **To provide international coordination and help organize collaboration on climate change detection and indices relevant to climate change detection;**
- **To further develop and publicize indices and indicators of climate variability and change from the surface and sub-surface ocean to the stratosphere;**
- **To encourage the comparison of modeled data and observations perhaps via the development of indices appropriate for both sources of information;**
-
-
-

FOCI ANTICIPATED FOR MARINE INDICES

- detection and attribution of climate change
- impact on marine industries (fishing, shipping, oil and gas production, tourism)
- sea-level change
- marine hazards (extreme winds and waves, harmful algal blooms, pollution)
- changes in hydrological cycle
- changes in ocean circulation
- changes in sea ice and ice bergs
- effects on coastal communities
- ocean acidification

QUESTIONS

What observational data are needed for climate change detection and attribution?

What analyses of these data can provide information useful for climate change detection and attribution?

What international coordination on data issues would improve climate change detection and attribution?

What are the indices with most impact?

How do we develop indices for inclusion in IPCC AR5 in 2013 with increased focus on extremes and regional aspects?

CHARACTERISTICS REQUIRED FROM INDICES

- Indices should cover a range of time and space scales, multi-decadal to daily, global to regional and be relevant to their target audience
- Indices should represent important impact-relevant aspects of the climate system and where possible link to the IPCC.
- It must be possible to calculate and update the indices from existing data.
- The indices must be prioritized due to limits in capacity.
- Indices can synthesize information and reduce noise by combining different components of the climate system.
- Indices should be based on homogenized and quality controlled datasets, well-understood models or reanalyses, or reliable predictions.
- Indices should have a good signal to noise ratio.
- A subset of indices should be suitable for presentation to politicians
- Common climate indices should be developed for models and observations
- Indices should be robust for detection, important and doable

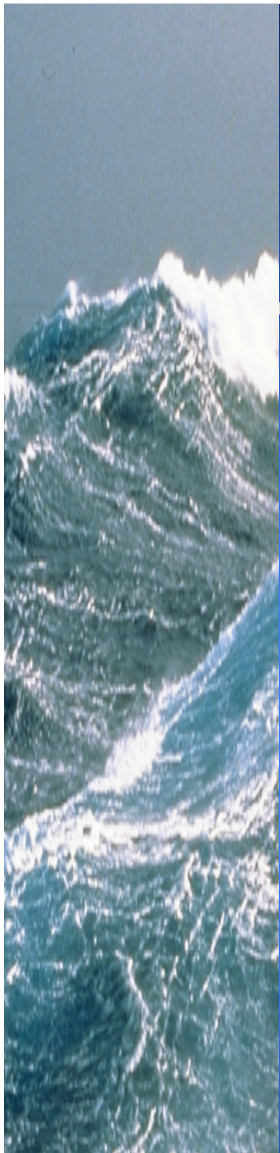
MARINE DATA SOURCES AND PROGRAMS

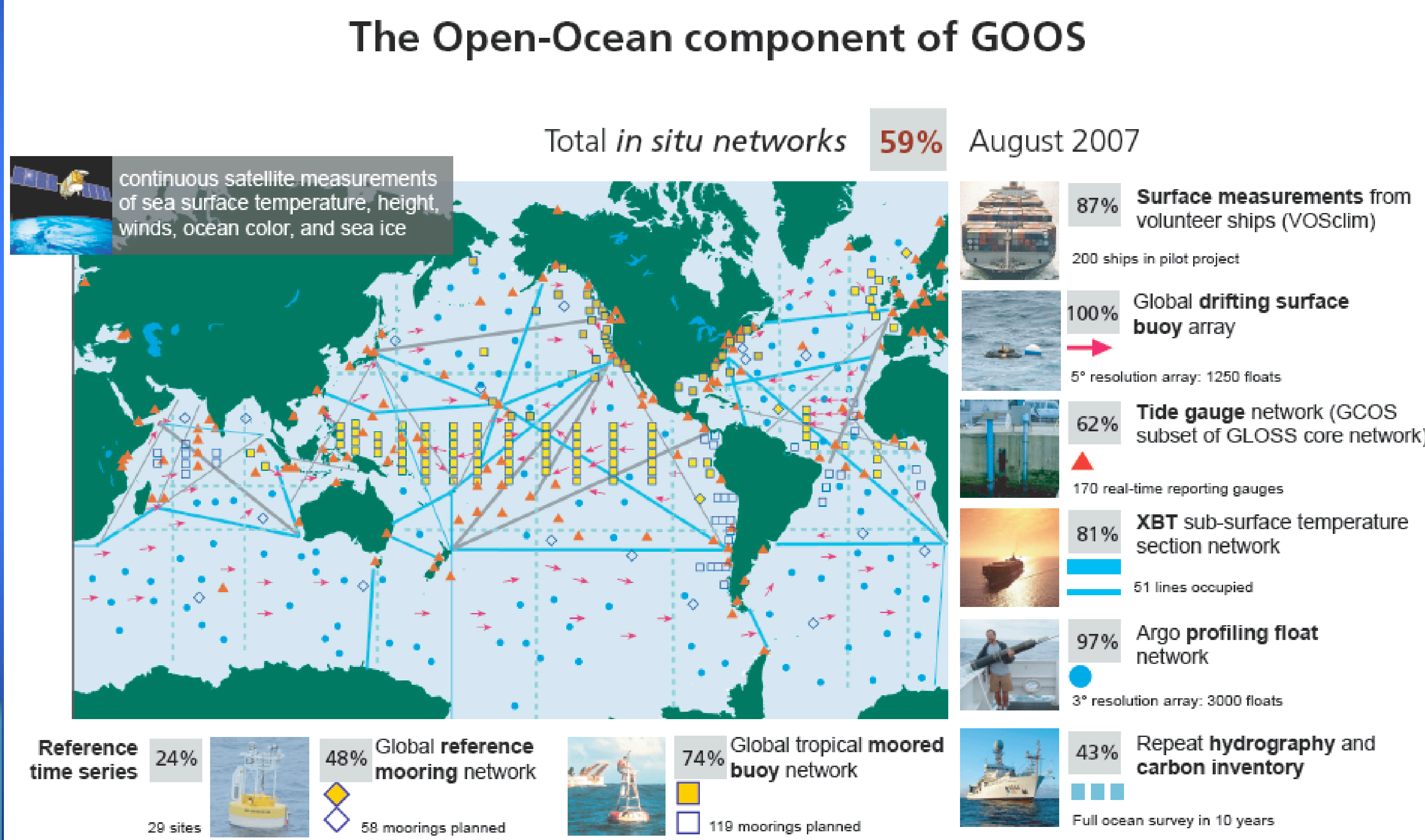
- ICOADS – ships (from 1662), moored and drifting buoys
- World Ocean Database (WOD)
- Global Digital Sea Ice Data Bank (GDSIDB)
- Permanent Service for Mean Sea Level (PSMSL)
- Derived data sets – HadISST, HadSLP, HadGOA (www.hadobs.org)
- Satellite – SST, wind, wave, ice, sea level
- Reanalyses

- Shipboard Automated Meteorological and Oceanographic System Initiative
- Global Ocean Surface Underway Data Pilot Project
- Ship Observations Team
- Data Buoy Cooperation Panel
- Argo
- Ocean Sites
- Global Sea Level Observing System
- International Ocean Carbon Coordination Project
- Global Temperature and Salinity Profile Program
- JCOMMOPS (www.jcommops.org)

Initial Global Ocean Observing System for Climate

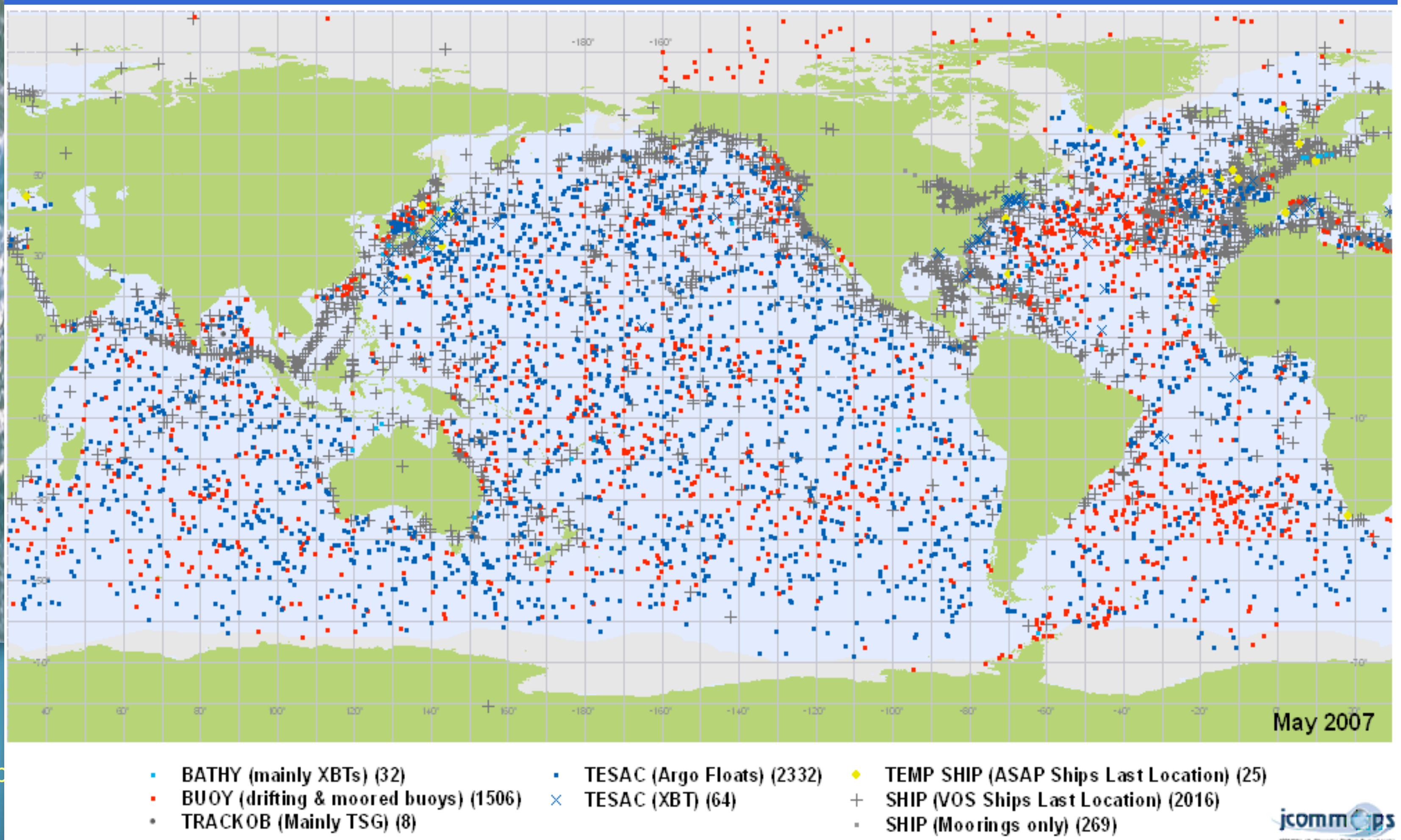
Status against the GCOS Implementation Plan and JCOMM targets



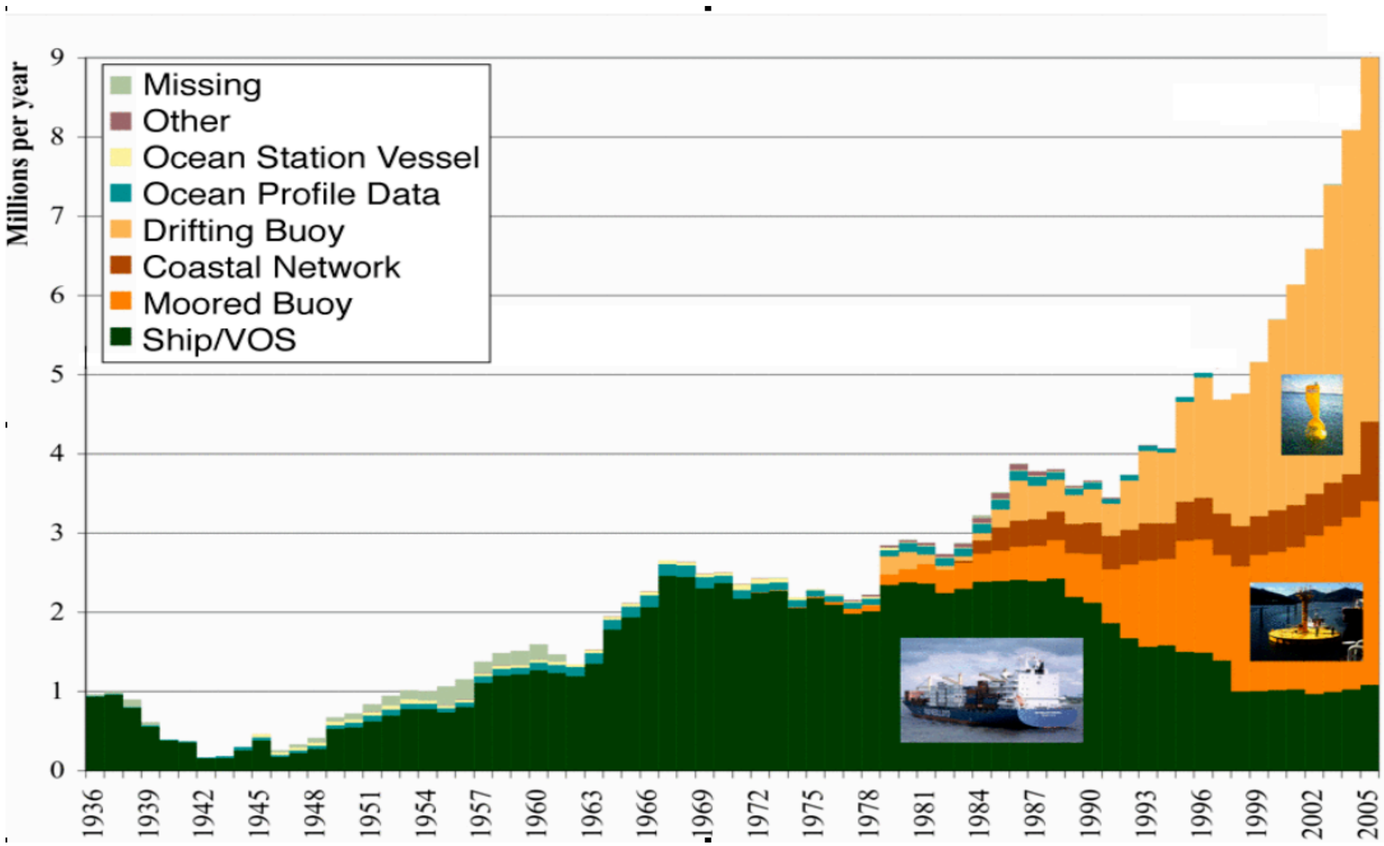


In situ observing platforms

reporting on the GTS, May 2007



Annual numbers of marine reports in ICOADS, stratified by platform type for 1936 to 2005 (Woodruff et al. 2008)



POSSIBLE MARINE INDICES

Temperature - air and sea
Humidity
Wind and wave
Storm Surge, Storm Tide, inundation zones
Sea Level
Sea Ice - global scale ice extent; regional ice extents; ice thickness and stages of development; iceberg propagation

Sub-surface – Salinity, temperature, heat content, water mass properties

Biological – HAB, coral bleaching

Atlantic Meridional Overturning Circulation strength

Some of these already exist and are operational

OOPC | State of the ocean climate | Surface indices | Pacific | Nino 3.4

http://ioc3.unesco.org/oopc/state_of_the_ocean/sur/pac/nino3.4.php

The state of the ocean climate

through estimations of key climate indices and their uncertainty

- OOPC home
- About OOPC
- Observing system
- **State of the ocean**
- Calendar
- Panel meetings
- Documents
- Contact

GCOS • GOOS • WCRP
OOPC
Ocean Observations Panel for Climate

This project realised with the cooperation of

NCDC
NOAA NESDIS
National Climatic Data Center

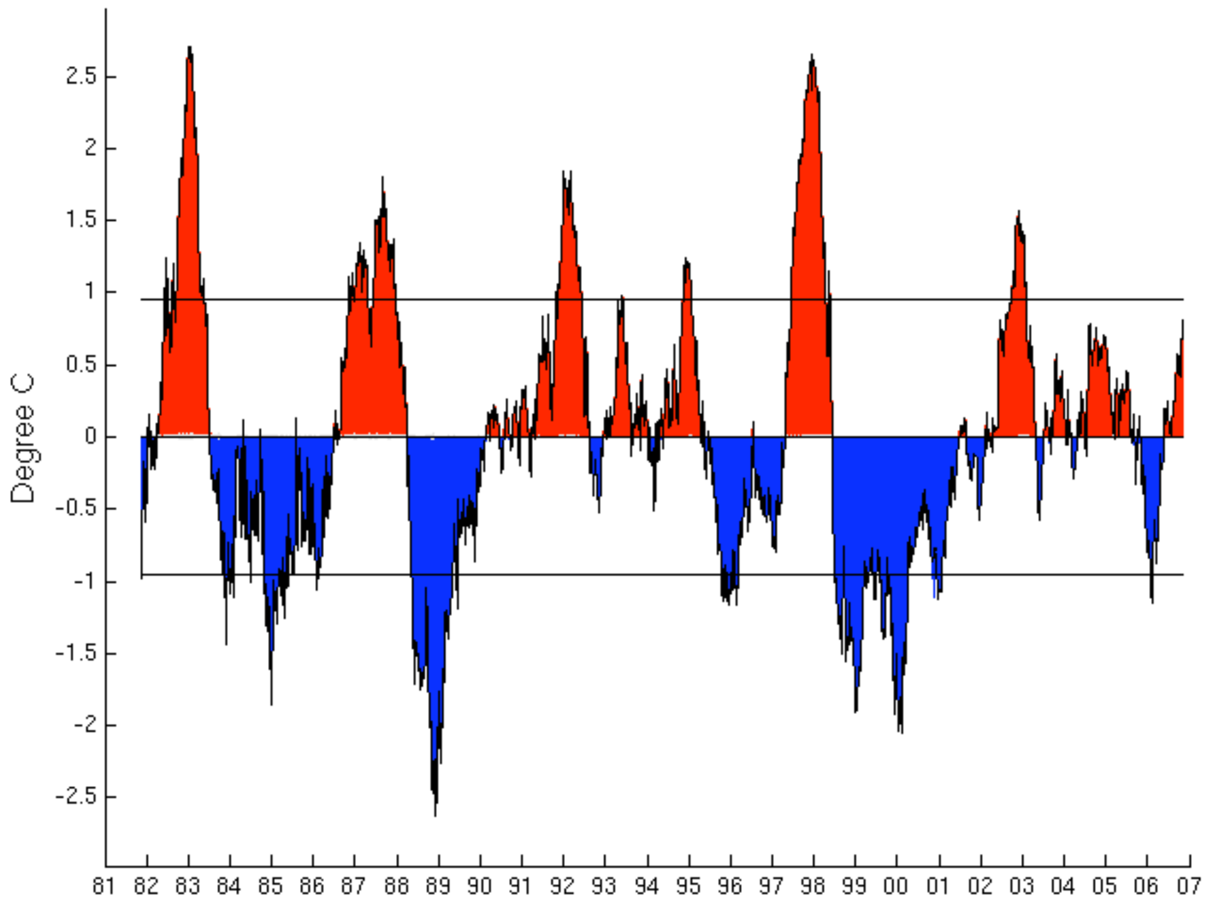
Coriolis
OCEANOGRAPHIE OPERATIONNELLE

Introduction | Overview | Atmosphere | Surface ocean | Subsurface ocean | Sea Ice

Pacific | Atlantic | Indian

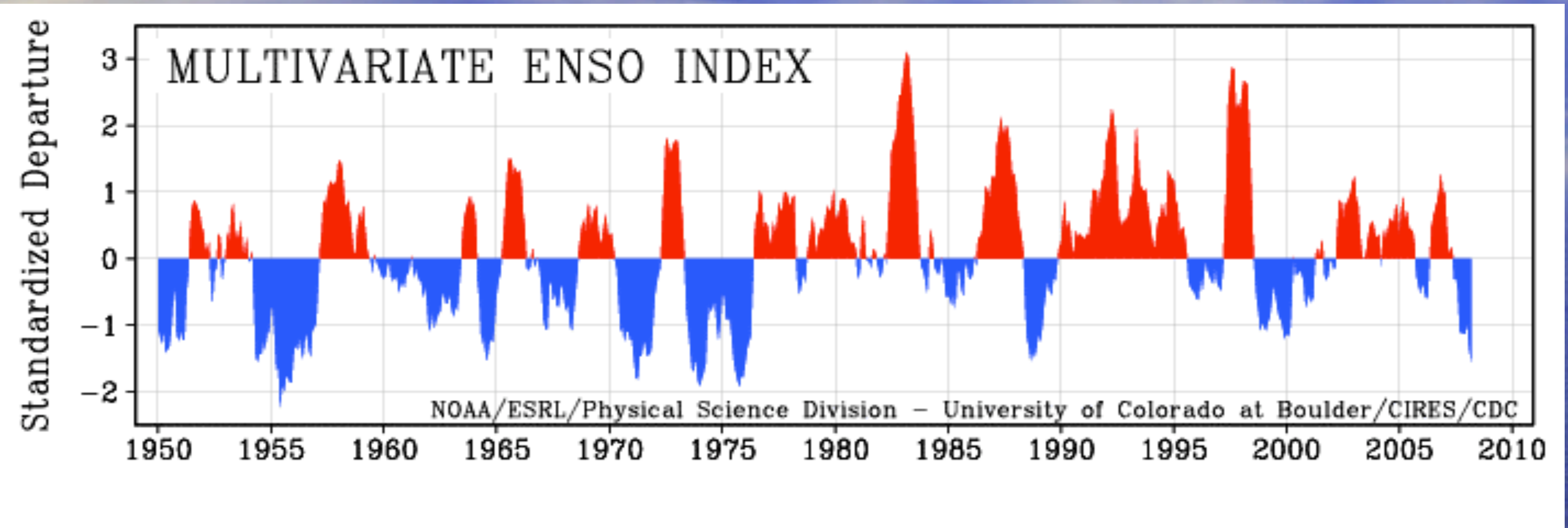
Niño1+2 | Niño3 | **Niño3.4** | Niño4

Last 2 years | Full series



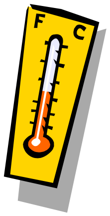
GCOS • GOOS • WCRP OOPC

Multivariate ENSO Index (MEI)



- Based on the six main observed variables over the tropical Pacific: sea-level pressure, zonal and meridional surface wind, surface air and sea temperature and total cloudiness fraction, in ICOADS.
- MEI is calculated as the first unrotated Principal Component (PC) of all six observed fields combined. Negative values of the MEI represent the cold ENSO phase, La Niña, while positive MEI values represent the warm ENSO phase (El Niño).
- http://www.cdc.noaa.gov/people/klaus.wolter/MEI/

Temperature Indices



INDEX	DESCRIPTION	Computed on
TM*	Mean of daily mean temp	Annual
TN*	Mean of daily minimum temp	Annual
TX*	Mean of daily max temp	Annual
DTR	Mean of diurnal temp range (Mean of Tmax - Tmin)	Annual
ETR*	Intra-period extreme temp (Highest Tmax - Lowest Tmin)	Annual
GD5*	Growing degree days (Sum of deg when tmean > 5°C)	Annual
GSL	Growing season length (Tmean>5°C for 5d and Tmean<5°C for 5d)	Annual
VDTR*	Mean absolute day-to-day difference in DTR (Diff bet range)	Annual
FFS*	Length of frost-free season	Annual
FFSS*	Frost free season starting date	Annual
FFSL*	Frost free season last date	Annual
SDM*	Temperature mean deviation from daily normal	Annual
SDX*	Temperature maximum deviation from daily normal	Annual
SDN*	Temperature minimum deviation from daily normal	Annual
CFD*	Max no of consecutive frost days (Tmin < 0°C)	Annual
FD	Frost days (Tmin < 0°C)	Annual
HDD*	Heating degree days (Sum of deg when Tmean < 18°C)	Annual
ID	Ice days (Tmax < 0°C)	Annual
CWDI	Cold wave duration index (max per w Tmin < 5°C below tmin normal)	Annual
CWFI*	Cold wave frequency index (no of wave: 3 days w Tmin < 10th perc)	Annual
TG10p*	Days w Tmean < 10th perc of daily mean temp (cold days)	Annual & seasonal
TN10p	Days w Tmin < 10th perc of daily min temp (cold nights)	Annual & seasonal
TX10p	Days w Tmax < 10th perc of daily max temp (cold day-times)	Annual & seasonal
SU	Summer days (Tmax > 25°C)	Annual
TR	Tropical nights (Tmin > 20°C)	Annual
HD*	Hot days (Tmax > 30°C)	Annual
CDD*	Cooling degree days (Sum of deg when Tmean > 18°C)	Annual
HWDI	Heat wave duration index (max per w Tmax > 5°C above tmax normal)	Annual
HWFI*	Heat wave frequency index (no of wave: 3 days w Tmax > 90th perc)	Annual
TG90p*	Days w Tmean > 90th perc of daily mean temp (warm days)	Annual & seasonal
TN90p	Days w Tmin > 90th perc of daily min temp (warm nights)	Annual & seasonal
TX90p	Days w Tmax > 90th perc of daily max temp (warm day-times)	Annual & seasonal

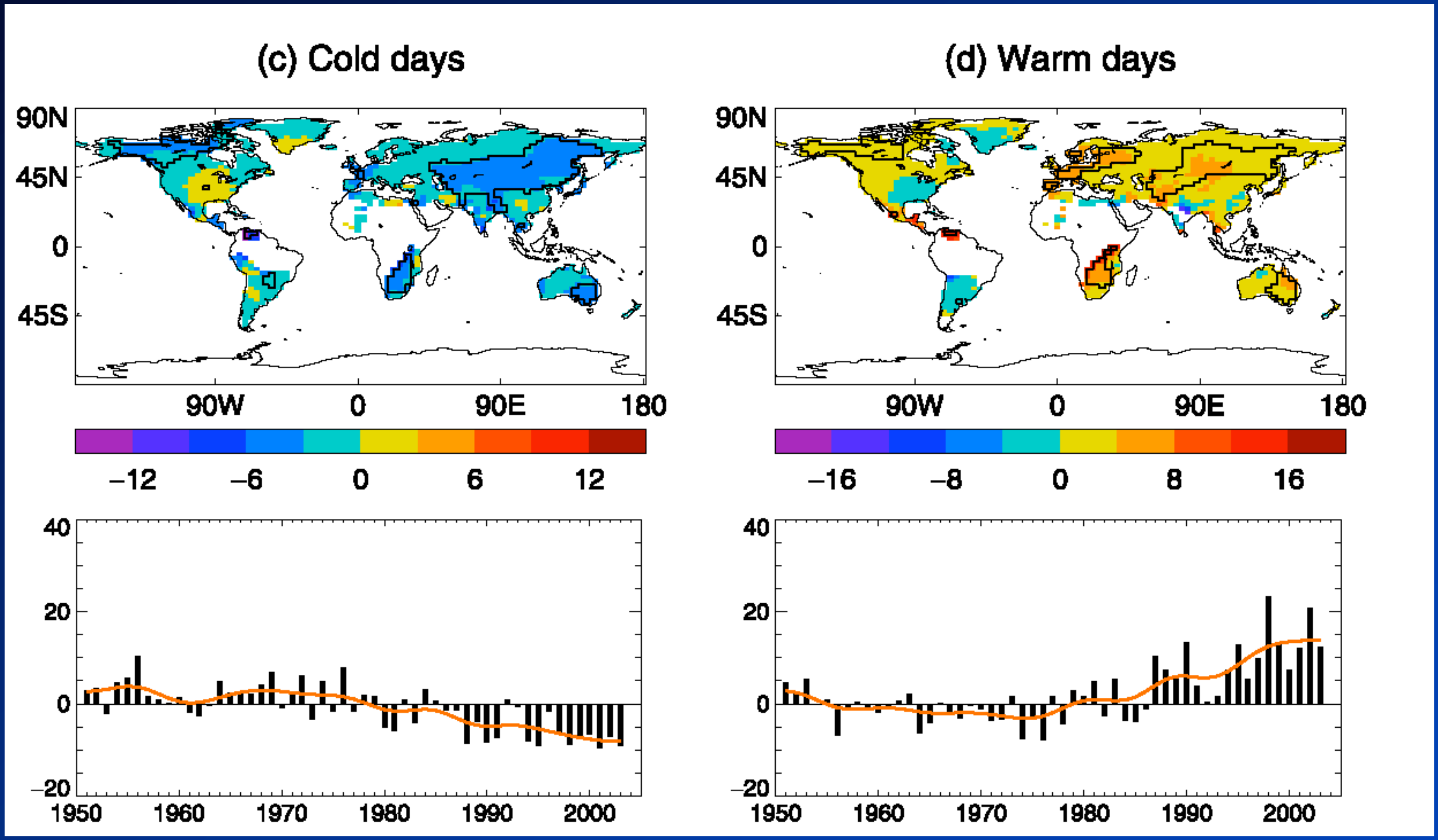
* indices different from global analysis

Precipitation Indices

INDEX	DESCRIPTION	Comments	Computed on
P	Precipitation sum	all	Annual and Seasonal
R*	Accumulated rain (Liquid precipitation)	all	Annual and Seasonal
S*	Accumulated snow (Frozen precipitation)	all	Annual and Seasonal
S/T*	Snow to precipitation ratio	all	Annual
RR1	Days with Precipitation, Rain* or Snow* (Wet days)	> Trace	Annual
SDII	Simple daily intensity index (total / days with P, R*, S*)	> Trace	Annual
CDD	Max no of consecutive dry days	> Trace	Annual
CWD	Max no of consecutive wet days	> Trace	Annual
P10	Very wet days (P ≥ 10 mm/day)	> Trace	Annual
P20*	Very heavy precipitation days (prec ≥ 20mm/day)	> Trace	Annual
P50*	Extremely heavy precipitation days (prec ≥ 50/day)	> Trace	Annual
X1	Highest 1-day P, R* or S*	> Trace	Annual
X3*	Highest 3-day P, R* or S*	> Trace	Annual
X5	Highest 5-day P, R* or S*	> Trace	Annual
X10*	Highest 10-day P, R* or S*	> Trace	Annual
50p*	P, R* and S* days with ≥ 50th percentile (median)	> Trace	Annual
75p*	P, R and S days with ≥ 75th percentile (moderate wet days)	> Trace	Annual
90p*	P, R and S days with ≥ 90th percentile (wet days)	> Trace	Annual
95p	P, R and S days with ≥ 95th percentile (very wet days)	> Trace	Annual
99p	P, R and S days with ≥ 99th percentile (extremely wet days)	> Trace	Annual

* indicates indices different from global analysis

Changing extremes, 1951-2003 from Alexander et al (2006)

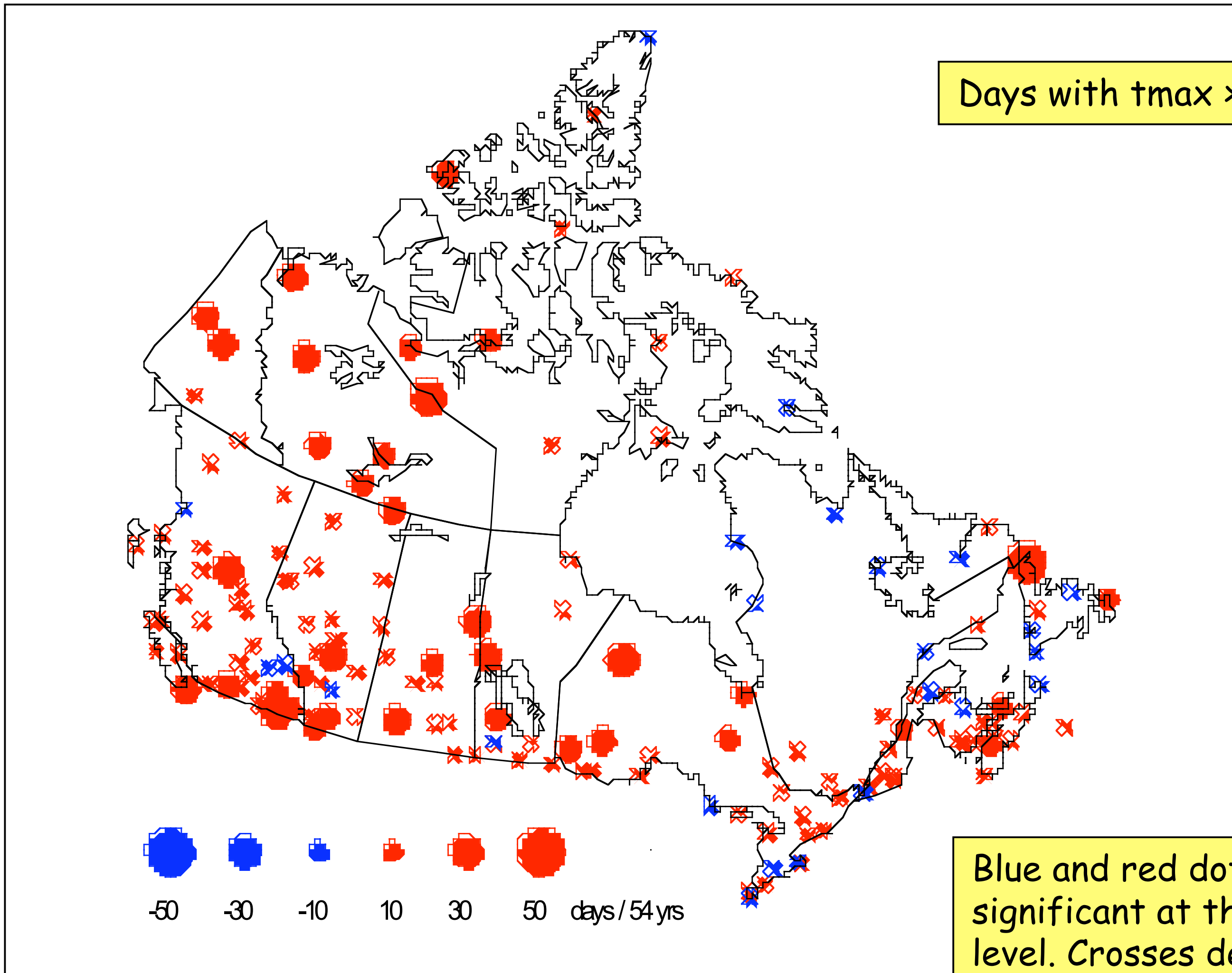


Trends in cold days (10 percentile, 1961-90) and warm days (90 percentile, 1961-90)

Hadley Centre for Climate Prediction and Research

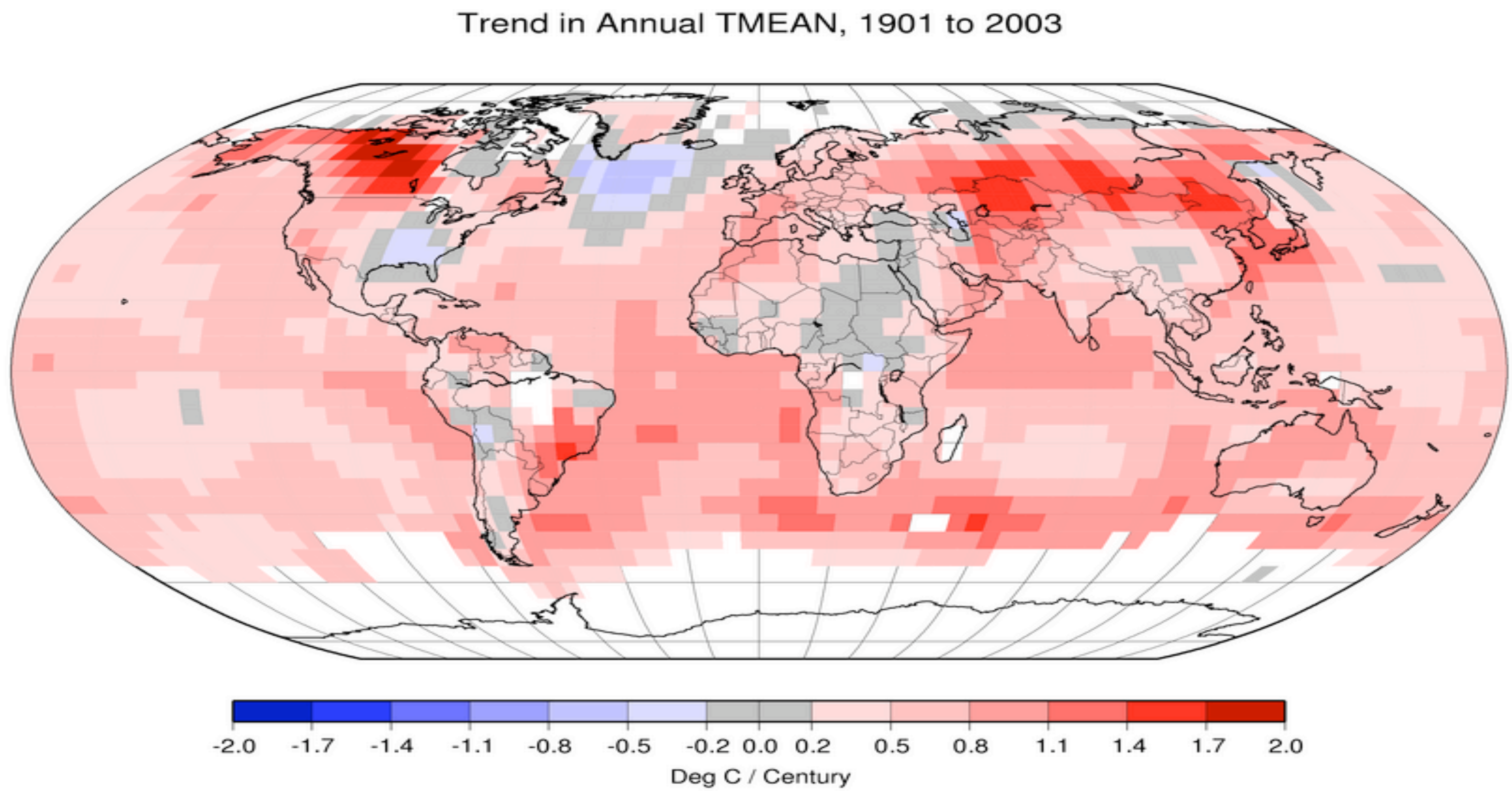
Trends in warm days
1950-2003

Days with tmax > 90th percentile



Blue and red dots indicate trends significant at the 5% confidence level. Crosses denote non-significant trends.

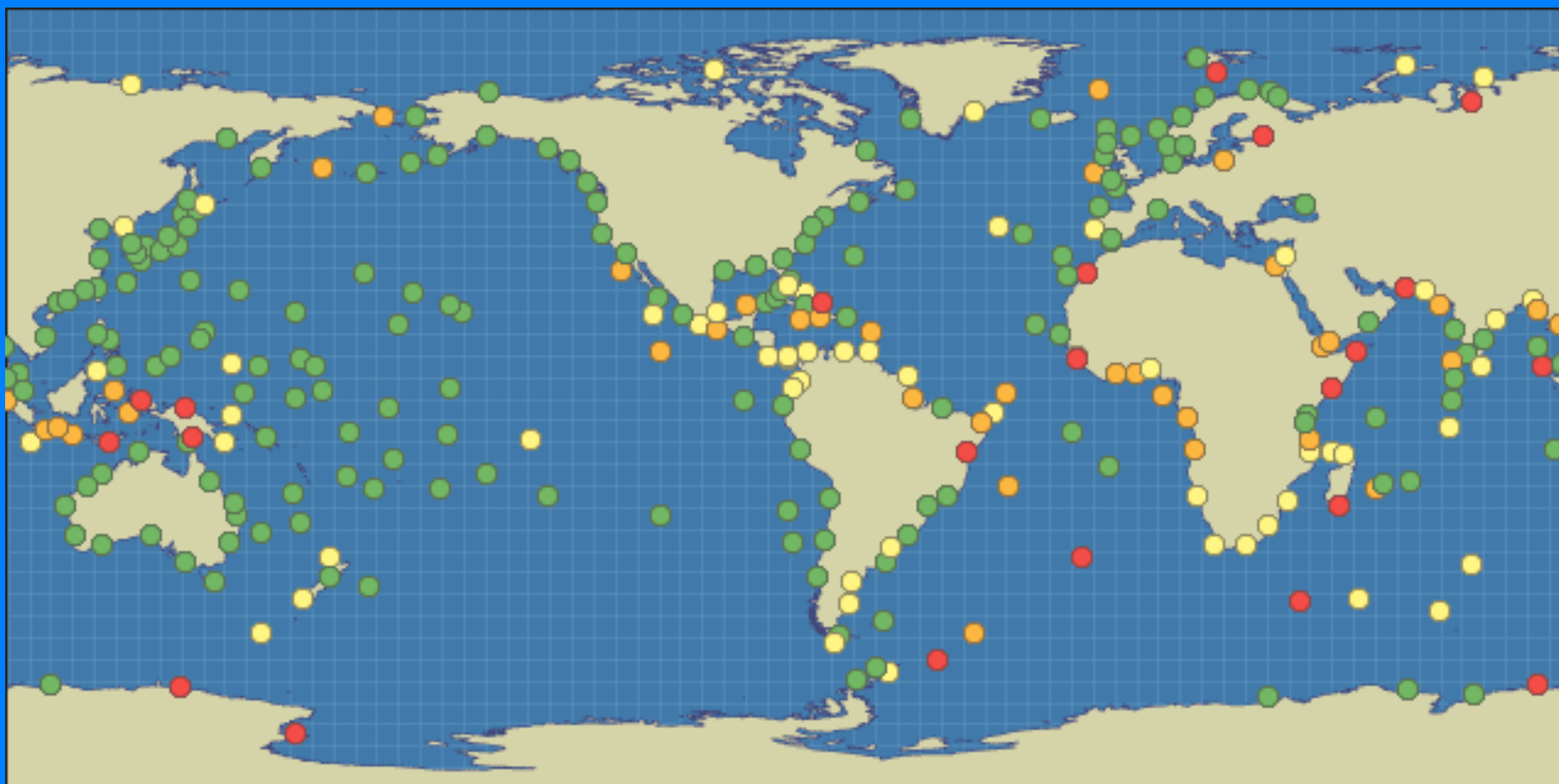
Temperature trend over 1901-2003



MCSS - Marine Climatological Summaries Scheme

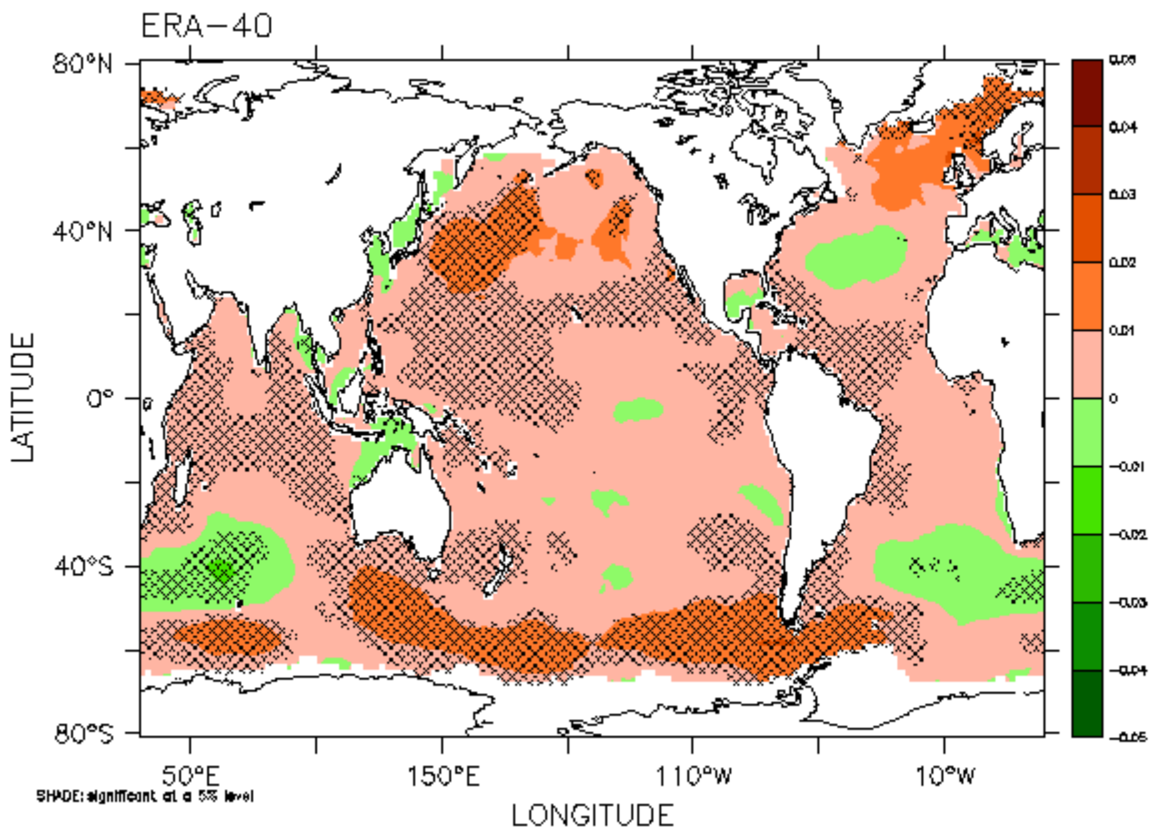
Air and dewpoint temperature - mean, stdev
Sea surface temperature – mean, stdev
Sea level pressure – mean, stdev
Wind speed – median, stdev, steadiness, dir (prevailing)
Wind speed - % ≤ 3 m/s, ≥ 11 m/s, ≥ 17 m/s
Wave height – median, stdev
Wave height - % ≤ 1.5 m, ≥ 4 m, ≥ 6 m
Wave period - % wave period ≥ 6 s; swell dir (prevailing)
Frequency tables, extremes, percentiles (5, 25, 50, 75, 95) for each month
days each month with: gales, storms, hurricane force winds
Rain, cloud, visibility, icing, weather (ww code)
Seasons defined as : DJFM, AM, JJAS, ON !!

GLOSS Network
Sea level, storm surge indices



Global Wave Climatology Atlas

S. Caires, G. Komen, A. Sterl, V. Swail



Hs January trend from 1958–2001 (m/yr)

www.knmi.nl/waveatlas

I-COADS Data Server

Search: [Go]

single data set | com-pare two

Datasets

Variables

Constraints

Output

Output Options

Previous Output

Define variable

About

Datasets > Browse by Dataset and Statistic > COADS 2-Degree Global Data > Enhanced (4.5 sigma trimming, Ship Obs + others)

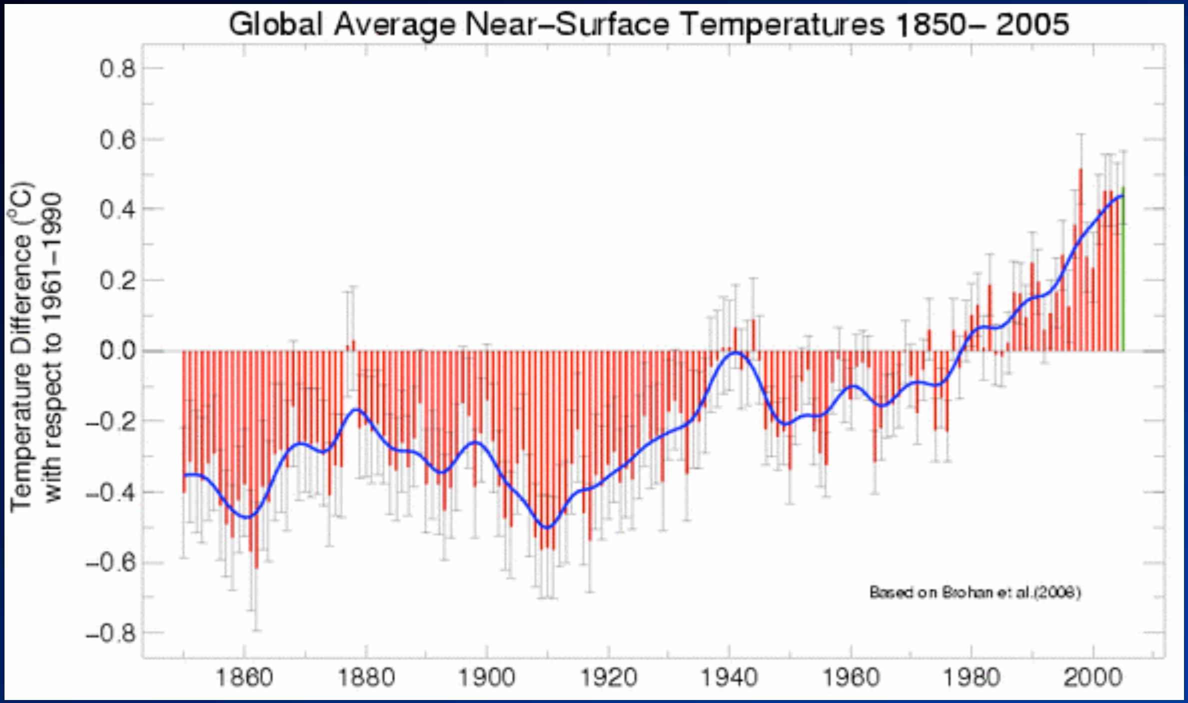
Click on a dataset to continue or an ℹ for information about a dataset. Help

Select dataset:

- 1. First Sextile
- 2. Third Sextile (Median)
- 3. Fifth Sextile
- 4. Mean
- 5. Number of Observations
- 6. Standard Deviation
- 7. Mean Day-of-Month
- 8. Fraction of Observations in Daylight
- 9. Mean Latitude (off SW corner) of Observations
- 10. Mean Longitude (off SW corner) of Observations

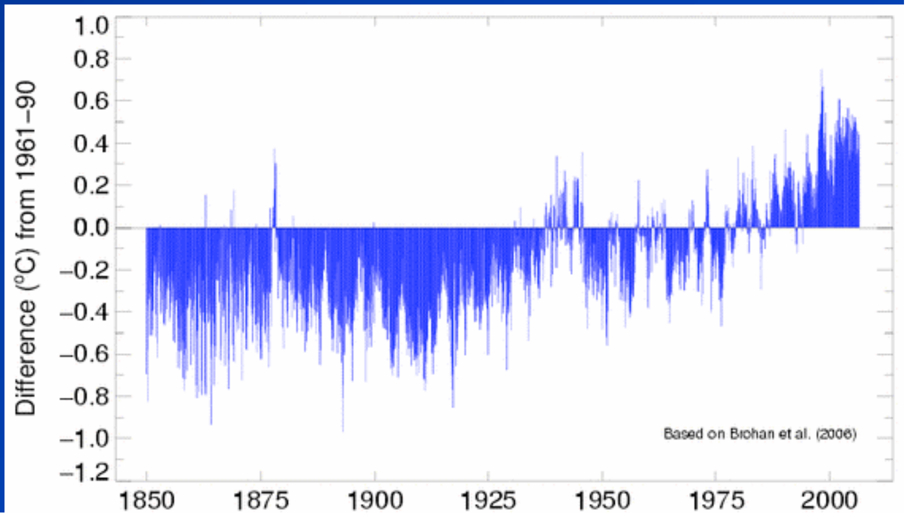
http://www.cdc.noaa.gov/coads-las/servlets/dataset

Global temperature



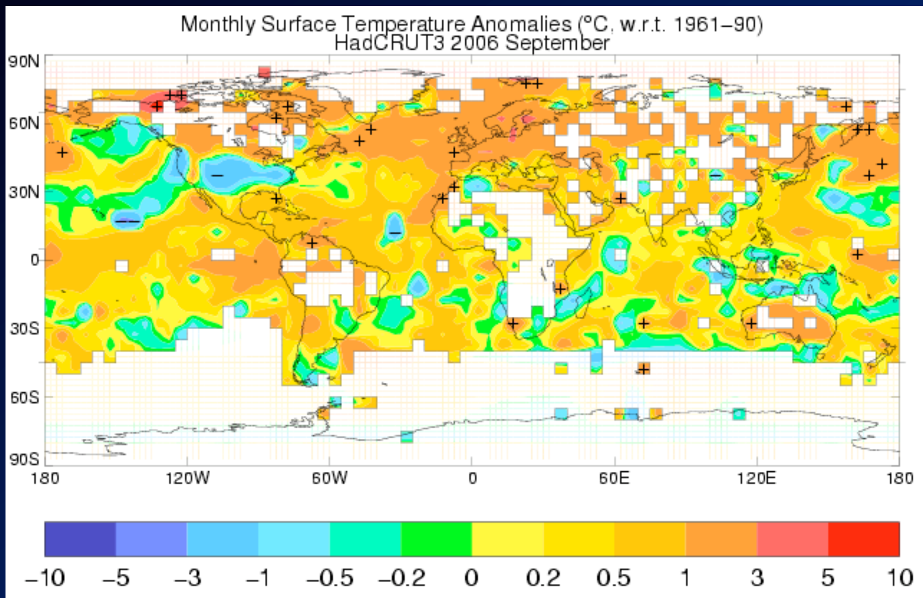
Annual Anomalies and uncertainties 1850-2005

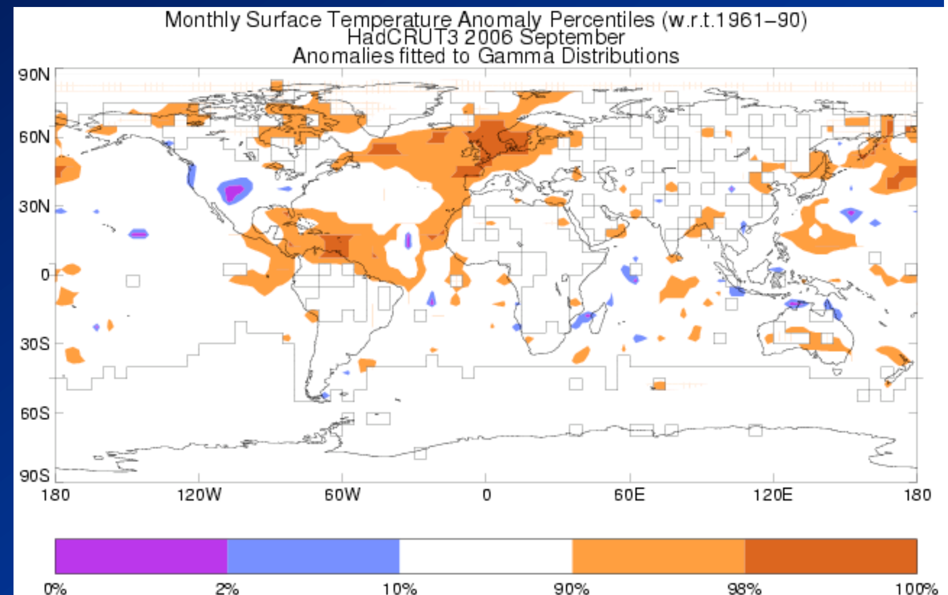
Monthly anomalies: 1850 – Jul 2006



Hadley Centre for Climate Prediction and Research

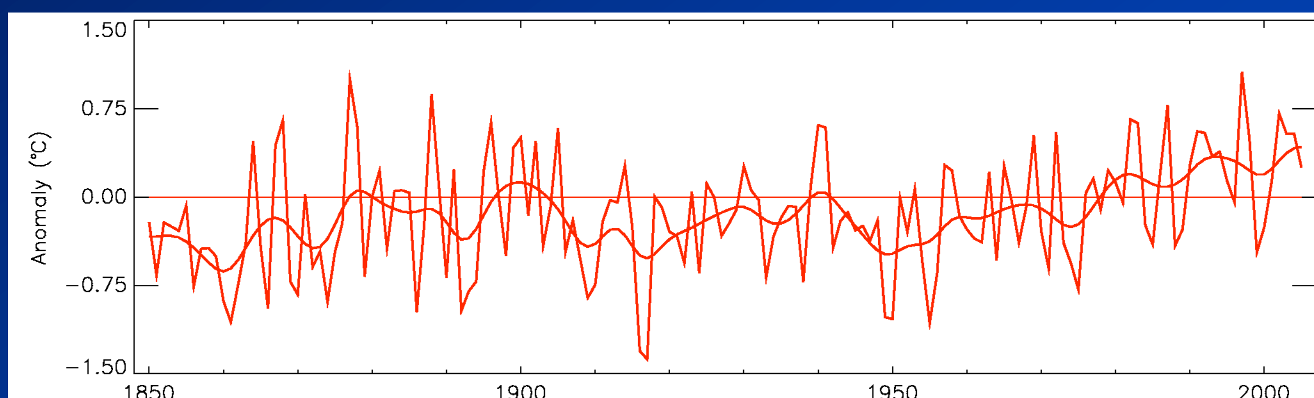
Monthly Surface Temperature Sept. 2006





Anomalies

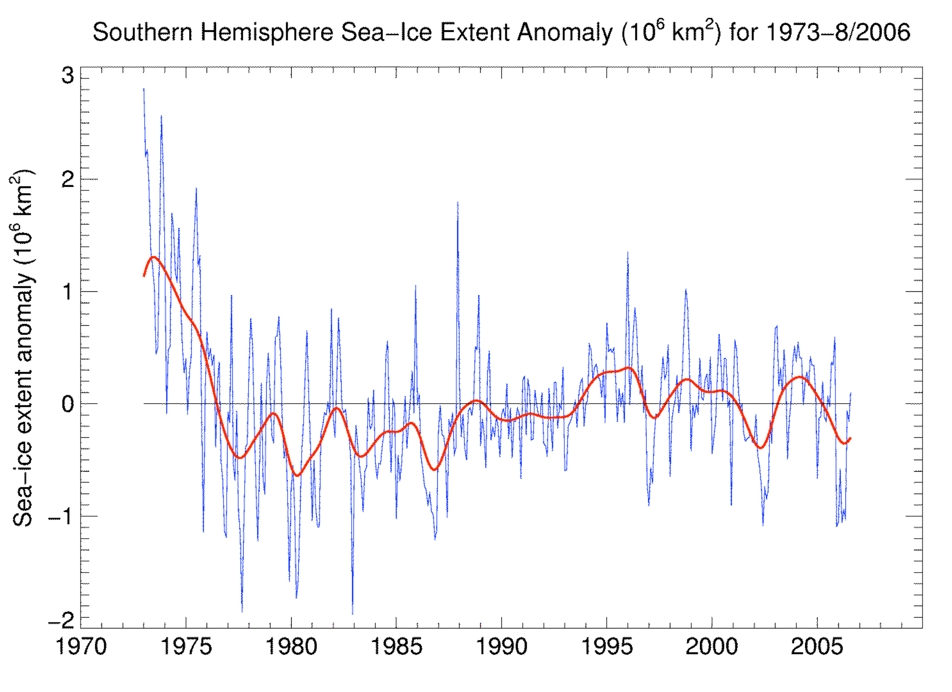
Percentiles



Tropical Central and EastPacific SST Anomalies, 1850–2005

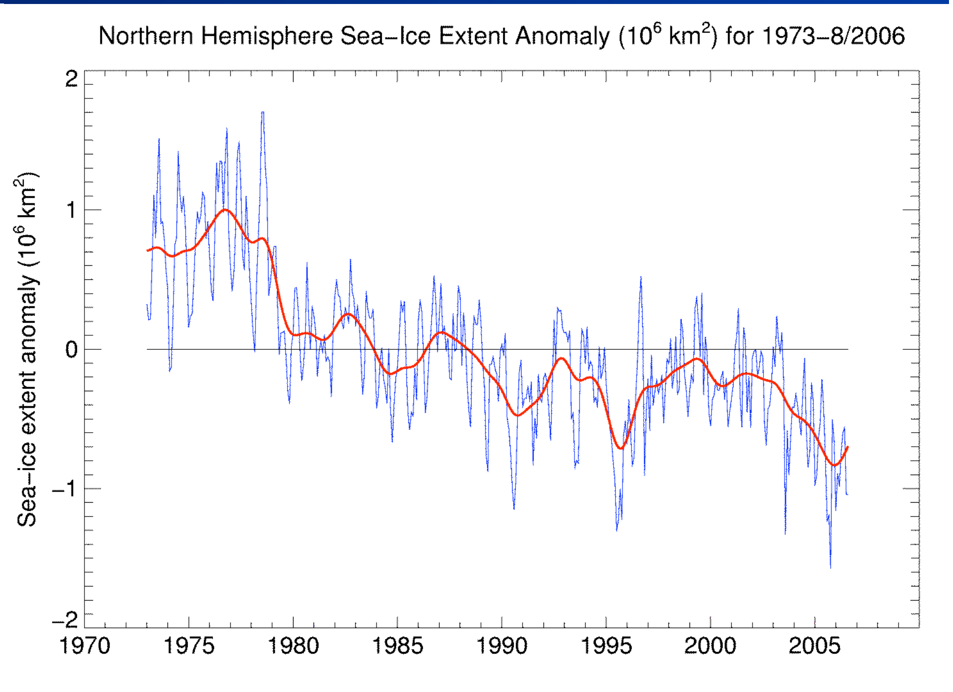
Annual sea-ice extent changes, 1973-2006 (updated from IPCC, 2001)

Antarctic sea-ice



Not declining since 1976

Arctic sea ice



Retreating until late1990s.

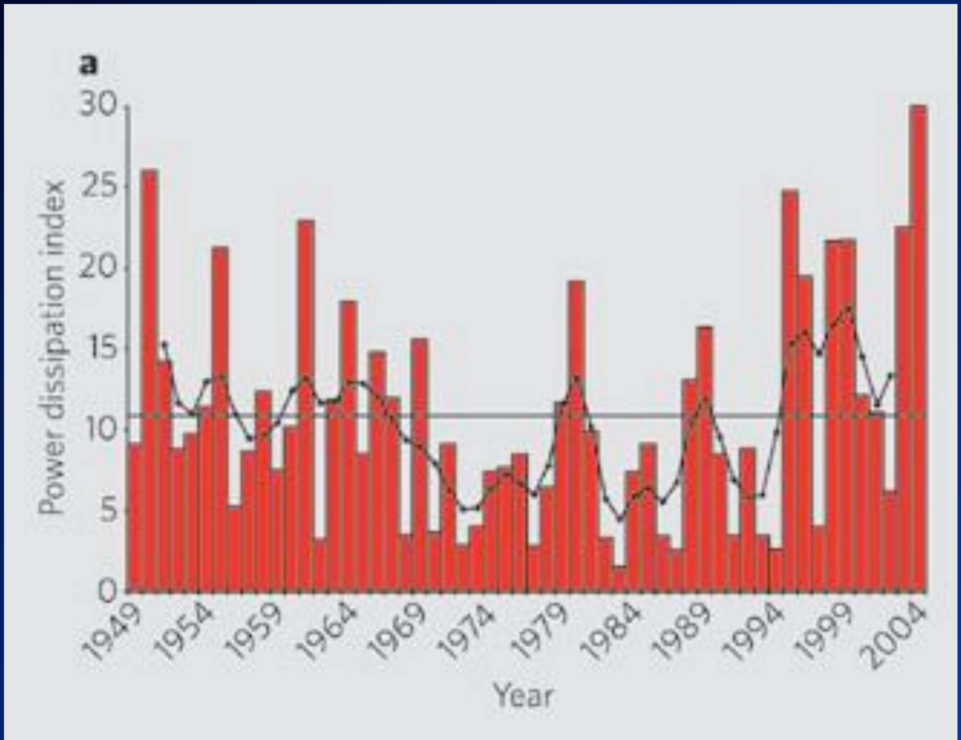
Little retreat 1998-2003

2006 record low *so far*

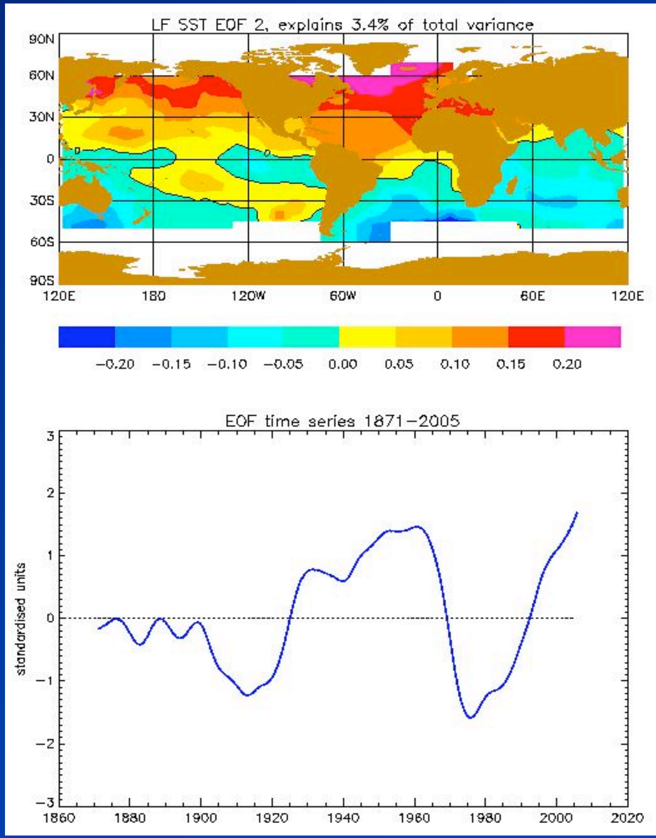
Hadley Centre for Climate Prediction and Research

Met Office

Changes in North Atlantic Hurricanes



Version of the related Atlantic Multidecadal Oscillation

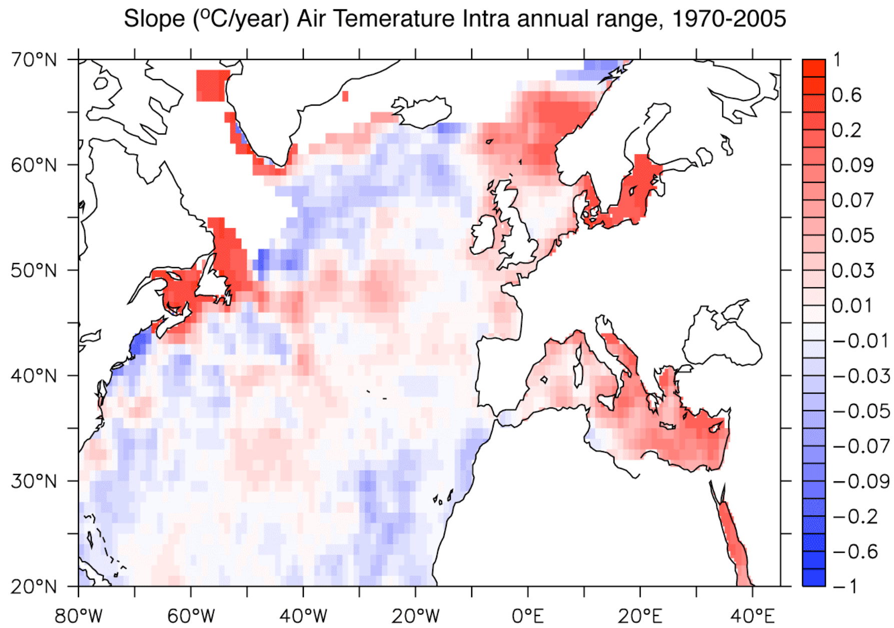


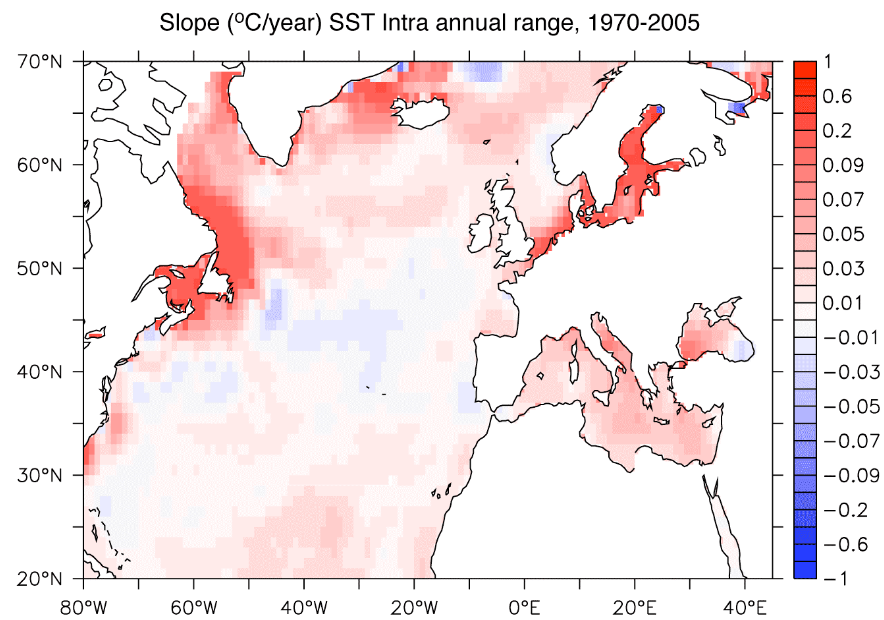
Variation in hurricane activity

Revised PDI *(Landsea, 2005, Nature)*

Decadal link with North Atlantic AMO sea surface temperature shown by *Goldenberg et al, Science, (2001)* and by *Knight et al, GRL, (2006)*

Trends in intra annual daily temperature range



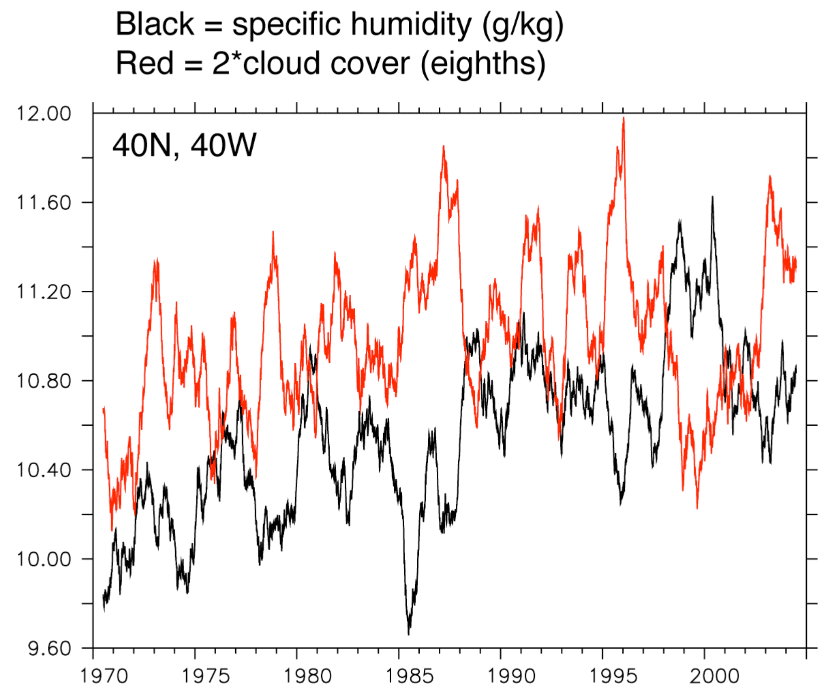


ICOADS

National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

Clouds and/or humidity?

- 365-day running mean cloud cover (x2) and specific humidity
- Long-term trend increasing in both variables
- On shorter time-scales changes in cloud cover anti-correlated with changes in humidity



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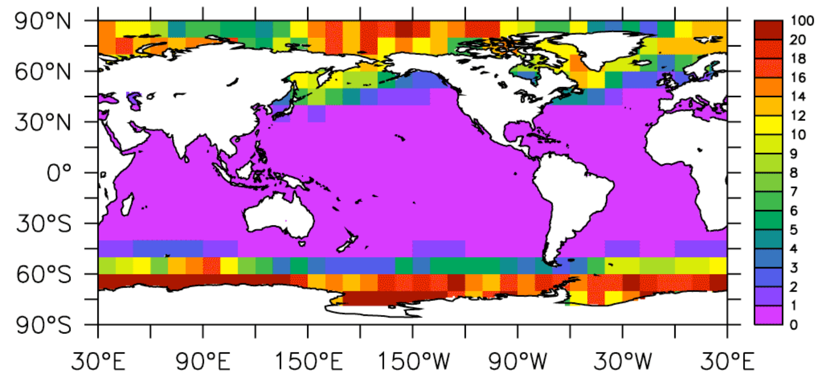
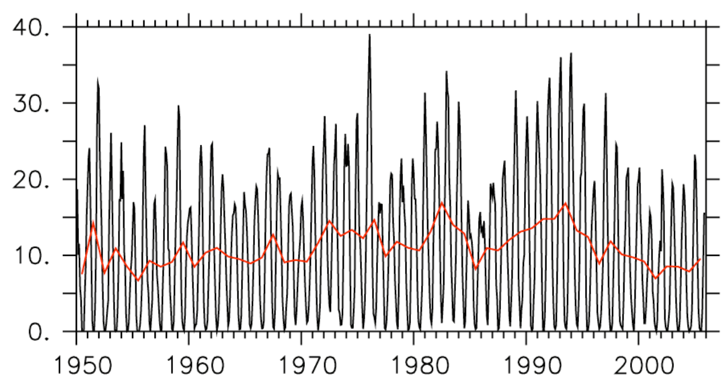
Index based on ship weather codes?

% reports indicating solid precipitation



mean % reports indicating solid precipitation, 70-50W, 60-70N



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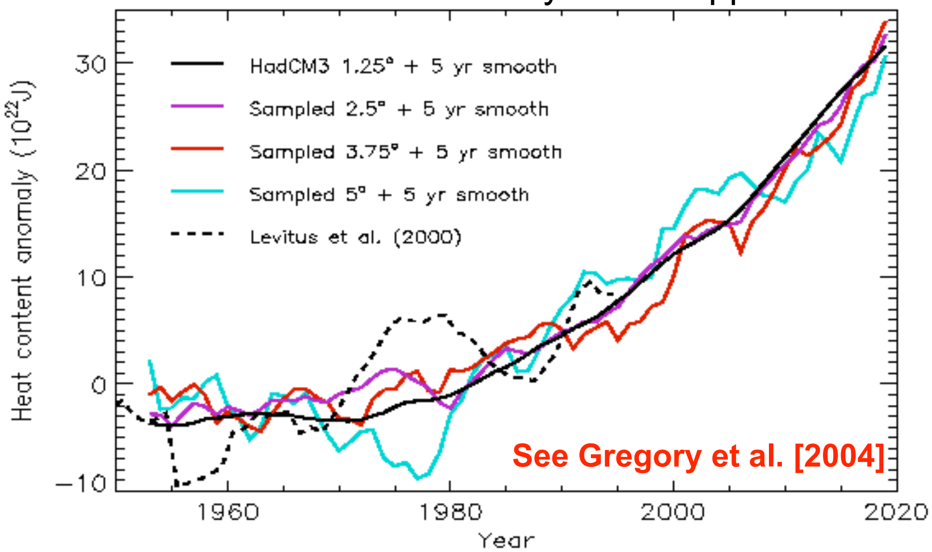
Background: ocean heat uptake

Heat content for Anomaly for the upper 300m



Questions:

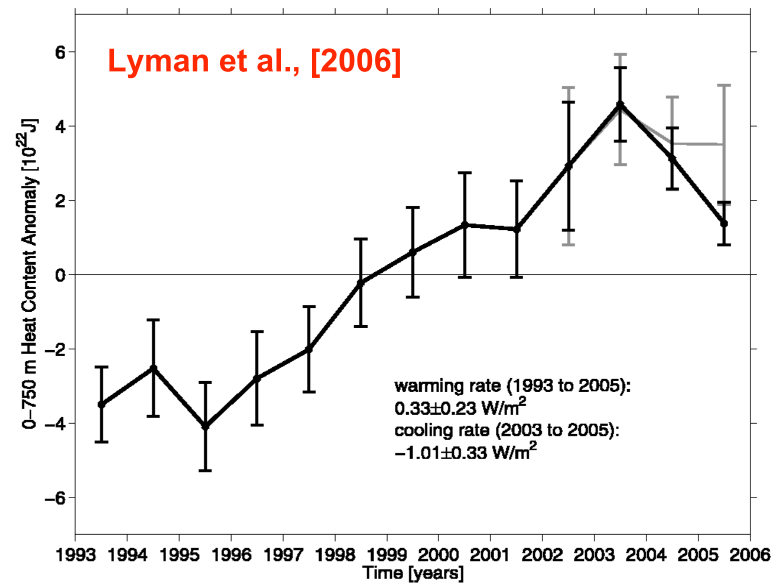
(i) What is the rate of oceanic heat uptake? (trend?)

(ii) Is the decadal variability seen in the observations (but not the models) real?

To address these questions we require:

(i) Comprehensive error estimates for observed time series.

(ii) Ocean climate indices with a high signal-to-noise ratio and small uncertainties.



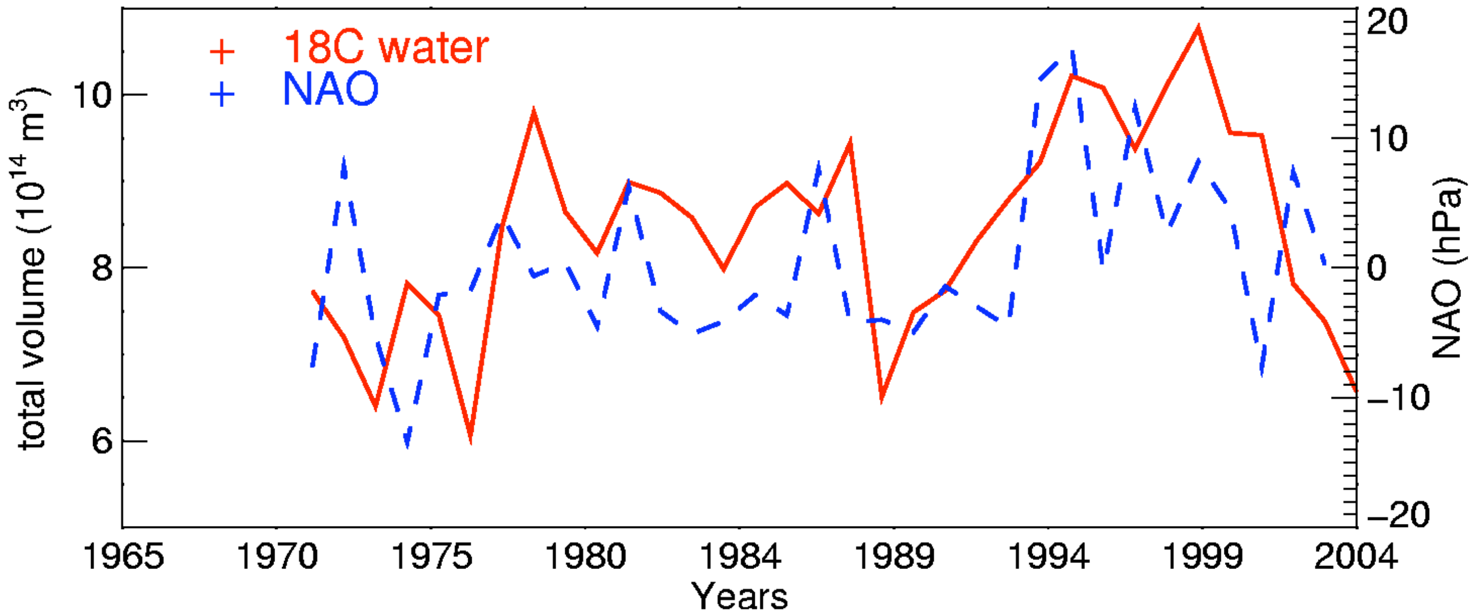
HadGOA: monitoring water masses

Met Office

Eighteen Degree Water (subtropical mode water (STMW)) volume in the North Atlantic

(defined as volume of water with temperature between 18.5 C and 17.5 C in the subtropical North Atlantic).

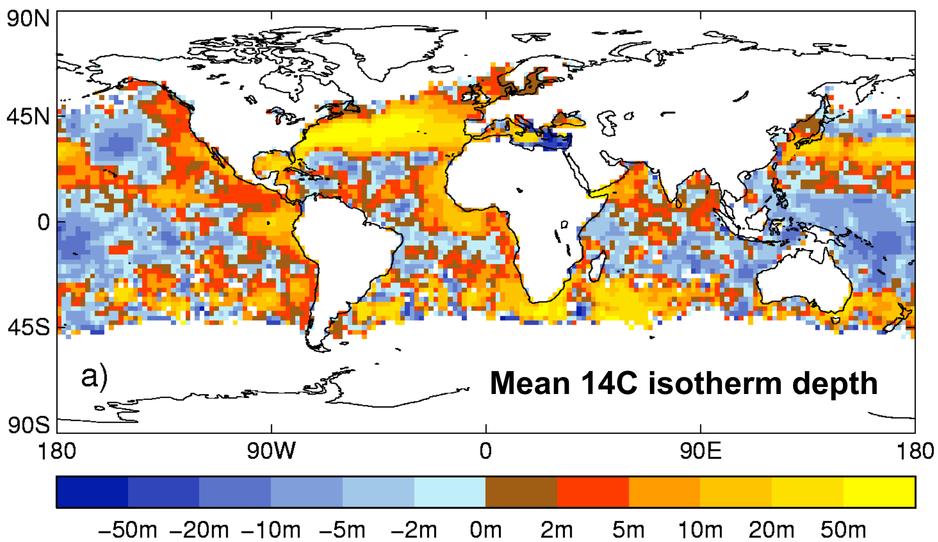
CO_2 Uptake (Bates et al).



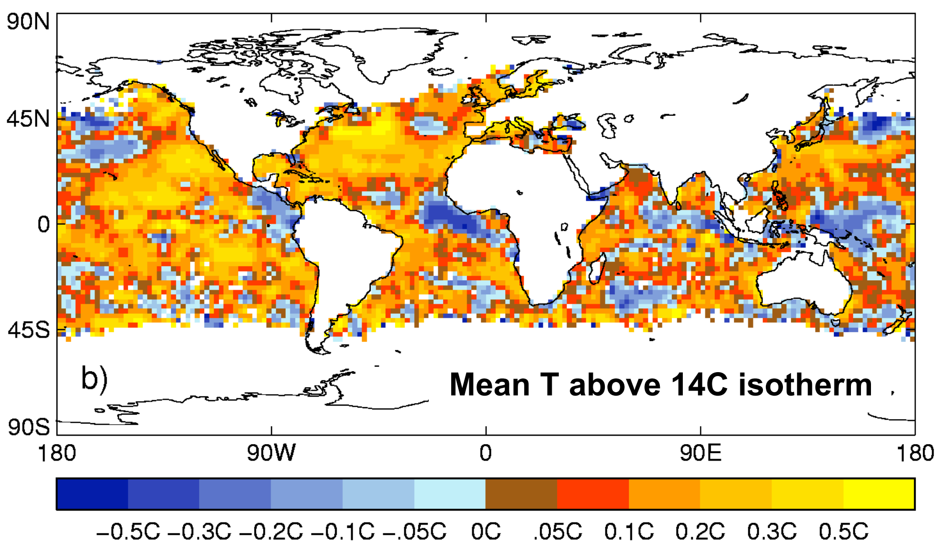
Correlated with the NAO at lag 6 yrs (NAO leads the EDW) r=0.36 for 'winter' (Feb, Mar, Apr) after Kwon & Riser, 2004

Source: HadGOA

Changes in mean T and isotherm depths



1985-2004 minus 1961-1980



- **Deepening of isotherms in N. Atlantic associated with change in phase of NAO.**
- **Large areas of slight shoaling and smaller areas of large deepening**

- **Wide-spread warming signal.**
- **Less prone to aliasing from changes in ocean circulation than z-levels.**
- **Greater insight into underlying physical mechanisms**

OOPC | State of the ocean climate | Subsurface indices | Bermuda-Labrador Basin transport index

http://ioc3.unesco.org/oopc/state_of_the_ocean/sub/berm_lab_trans.php

The **state of the ocean** climate

Towards a measure of **our ability to observe the ocean** through estimations of key climate indices and their uncertainty

- OOPC home
- About OOPC
- Observing system
- **State of the ocean**
- Calendar
- Panel meetings
- Documents
- Contact

GCOS • GOOS • WCRP

OOPC

Ocean Observations Panel for Climate

This project realised with the cooperation of

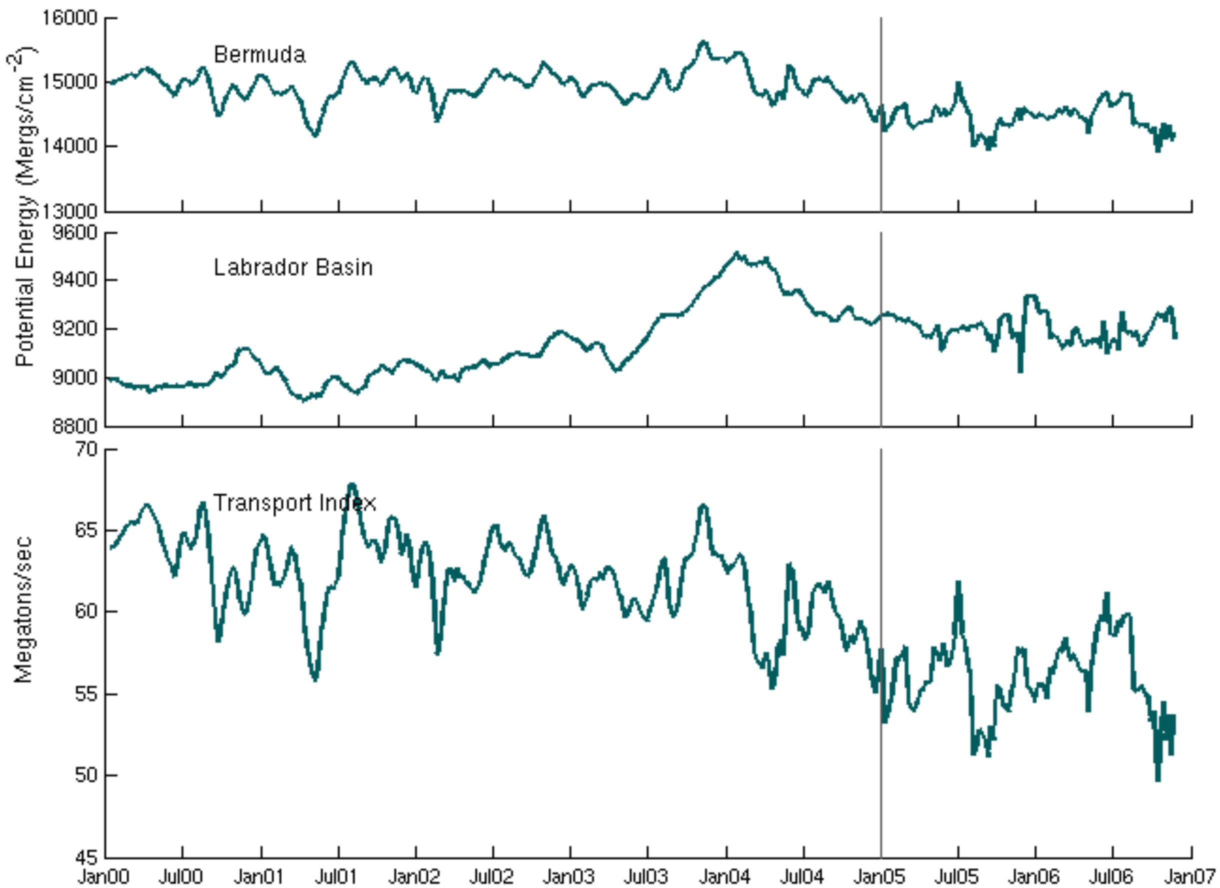
NCDC NOAA NESDIS National Climatic Data Center

Coriolis

Introduction | Overview | Atmosphere | Surface ocean | **Subsurface ocean** | Sea Ice

Bermuda-Labrador Basin Transport Index

Last 2 years | Full series



GCOS • GOOS • WCRP OOPC

Enabling Mechanisms

ICOADS - Critical and critically under-resourced

JCOMM Expert Teams
- Wind Waves and Storm Surges
- Sea Ice
- Marine Climatology
  - Task Team on the Marine-meteorological and Oceanographic Summaries (TT-MOCS)

Engage expertise within the CLIMAR community to assist in the development and production of marine indices

Liaise with other groups interested in marine indices such as the AOPC and OOPC

WAY FORWARD

- **Investigate how to expand the range of useful and homogeneous climate change indicators available for the ocean including information from both the ocean surface and subsurface**
- **Consider how these might be used in IPCC 5AR (2013)**
- **To engage with other JCOMM Programme Areas as appropriate, and the broader marine climate community in the development, calculation and maintenance of marine indices**
- **Use CLIMAR-III to promote marine indices, with a presentation and Plenary discussion**
- **Report back on progress to the 3rd ETCCDI meeting in May 2008, with a proposal as appropriate for further development of marine climate indices**
- **Aim for presentations at MARCDAT-III (2010) and CLIMAR-IV (2012) that have answers instead of questions**