Consiglio Nazionale delle Ricerche

Ibimet ISTITUTO DI BIOMETEOROLOGIA

i confini dei modelli climatici:

nubi, suolo e parametrizzazione del mondo

teodoro georgiadis

istituto ibimet cnr bologna

Ho imparato ad amare la trincea e a disprezzare il salotto

…circa i risultati delle simulazioni con i modelli numerici di previsione del clima, egli, senza cedere alle lusinghe di allarmismi inutili, così concludeva:

"È opportuno tener presente che la capacità di modellazione del sistema climatico, nonostante gli ammirevoli progressi compiuti, ha ancora parecchie inadeguatezze. Tra queste:

- **la particolarizzazione nello spazio, la quale è alquanto modesta; una sorta di miopia che preclude, per esempio, la possibilità di rappresentare correttamente gli effetti dei maggiori rilievi terrestri;**
- **la formazione delle nubi non viene simulata applicando direttamente le leggi della fisica, bensì ricorrendo a schemi derivati dall'esperienza, i quali, anche se soddisfacenti per la previsione a breve termine, possono risultare non adatti per lo studio del clima;**
- **notevoli sono le incertezze relativamente alla quantità di energia assorbita dalle nubi, il che ha inevitabilmente ripercussioni sull'affidabilità dei risultati stessi;**
- **le influenze derivanti dalle fluttuazioni dell'attività solare non giocano ruolo alcuno nei modelli di simulazione climatica. "**

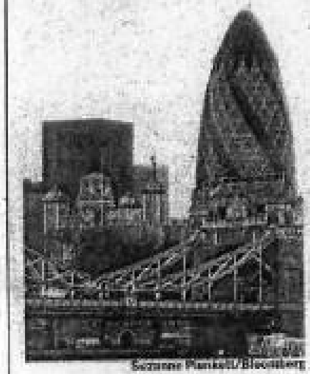
In ricordo di Sabino Palmieri
di Luigi Iafrate *(da ClimaeDintorni)*

INTERNATIONAL
Herald Tribune
iht.com
PUBLISHED BY
The New York Times
TUESDAY, FEBRUARY 6, 2007

By John Vinocur
Chirac's Iran gaffe
PAGE TWO

Chinese puzzled by reaction to a New York opera
CULTURE & MORE 8

In New York, 'size zero' models seem to be going out of style
SUZY MENKES ON FASHION 9



Suzanne Plunkett/Bloomberg

London landmark sold
The London office tower known as the Gherkin was sold for £600 million, a record for a building in the City, the main financial district. *Page 16*

2 Apples ending trademark fight

Apple Inc., the maker of iPods, and Apple Corps, which manages The Beatles' business interests, said Monday that they were ending a trademark fight over their shared name, raising speculation over a deal on downloads. *Page 13*

Microsoft rebuffs plea by Gorbachev

Microsoft on Monday rebuffed a public appeal by Mikhail Gorbachev, the former Soviet leader, for its chairman, Bill Gates, to intervene on behalf of a Russian schoolteacher charged with software piracy. *Page 13*

A Web powerhouse

Russ
new fi
charge
Yukos

Company's
a Kremlin f
extra 15-yea

By C.J. Chivers

MOSCOW: Russ brought new charge the imprisoned four oil company and on partners, opening a n tack against a Kreml
Both the former c Khodorkovsky, and l Lebedev, were charg ment and money laun lawyers said together on sentences of 15 yea
The two men have they were arrested serving eight-year s evasion and other ch yers said that they ha ified for parole late serving half of thei new charges, which a embezzling about $2 revenue, appeared chance, and opened the long saga of l Yukos.
The new criminal to put what remains o to state hands. And fo appears to be ending in an opaque mixture of criminal prosecution and energy nationalism in which it is far from

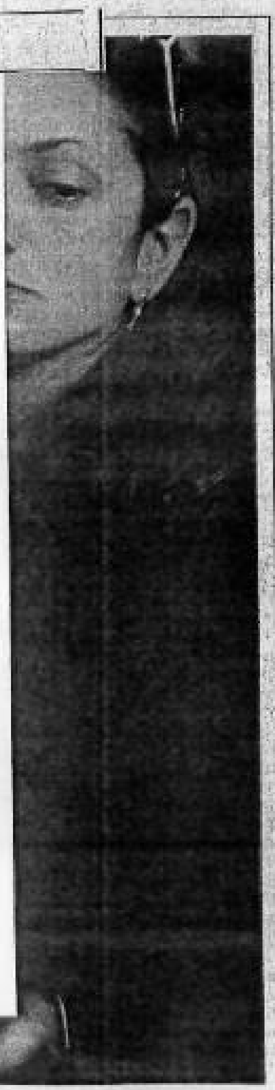
LETTERS | TO THE EDITOR

Climate change

Regarding the article "Global warming called 'unequivocal'; damage will continue for centuries" (Feb. 3): Surely we can envisage man-made contributions to climate changes. But it is not possible to understand how natural and anthropogenic contributions are causing global changes, and if these changes really have the magnitude we suppose.

Democracy is not expected to be applicable to science, so it is not important if a vast majority of scientists believe that human beings contribute to global warming. History teaches us that, in science, it is possible for even only one man alone to change our understanding of the real world.

Teodoro Georgiadis, *Bologna, Italy*



Saudis act to counter Iranian influence

Kingdom is taking aggressive role in region's conflicts

By Michael Slackman and Hassan M. Fattah

JIDDA: With three important parts of the Middle East on the boil and Iran poised to gain from them all, Saudi Arabia has abandoned its behind-the-scenes checkbook diplomacy and taken on a central and aggressive role in reshaping the region's conflicts.

On Tuesday, the kingdom will be host in Mecca to the top leaders of Hamas and Fatah, the two main Palestinian factions whose gunmen have shot, killed and kidnapped one another in recent months, in a meeting that both sides say could lead to a national unity government and reduced bloodshed.

Saudi Arabia has also increased its public involvement in Iraq and in trying to head off civil war in Lebanon. The process is shaping up as a counter-offensive to Iran's efforts to establish itself as the regional superpower, according to diplomats, political analysts and officials here and throughout the region.

"In Saudi we realized that we have to wake up," said a high-ranking Saudi diplomat who spoke on the condition of anonymity because he was not authorized to speak to the media.

The broader Saudi effort has been made in collaboration with its usual allies in the Gulf, Egypt and Jordan, but it

There are ominous signs that the earth's weather patterns have begun to change dramatically and that these changes may portend a drastic decline in food production—with serious political implications for just about every nation on earth. The drop in food output could begin quite soon, perhaps only ten years from now. The regions destined to feel its impact are the great wheat-producing lands of Canada and the U.S.S.R. in the north, along with a number of marginally self-sufficient tropical areas—parts of India, Pakistan, Bangladesh, Indochina and Indonesia—where the growing season is dependent upon the rains brought by the monsoon.

The Cooling World

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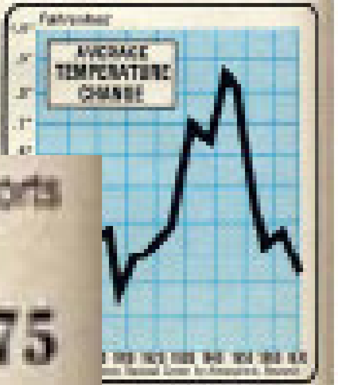

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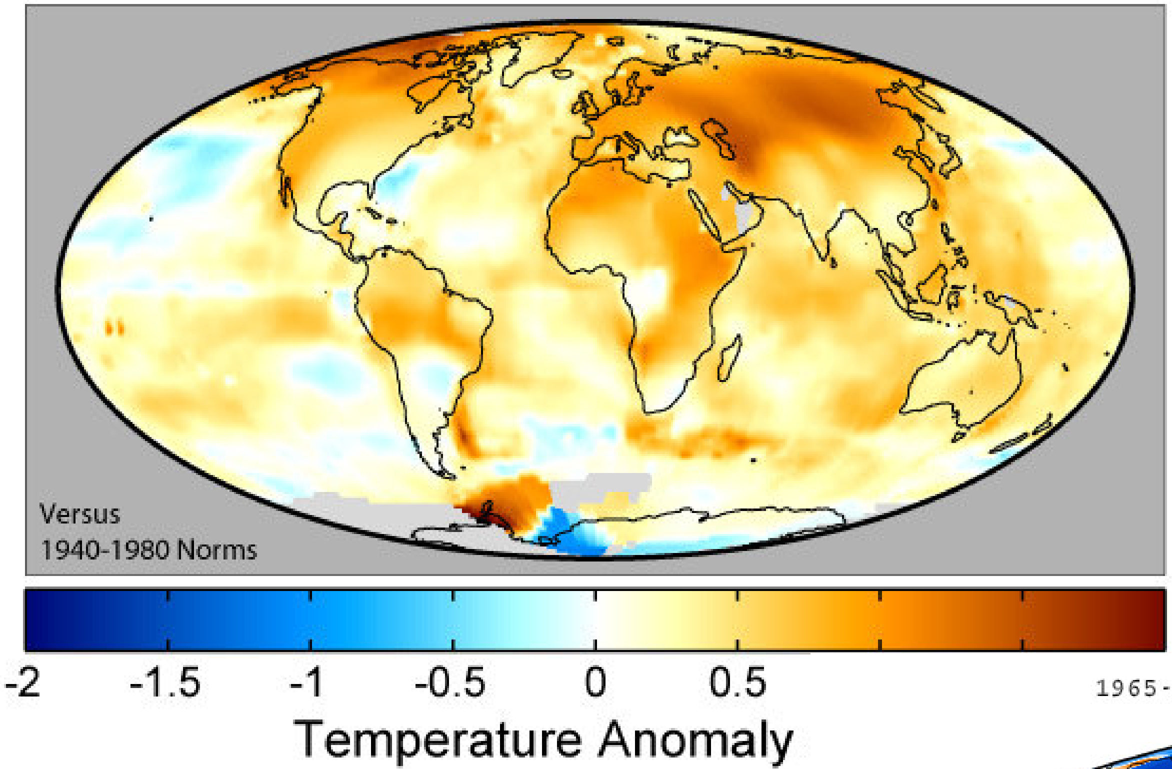
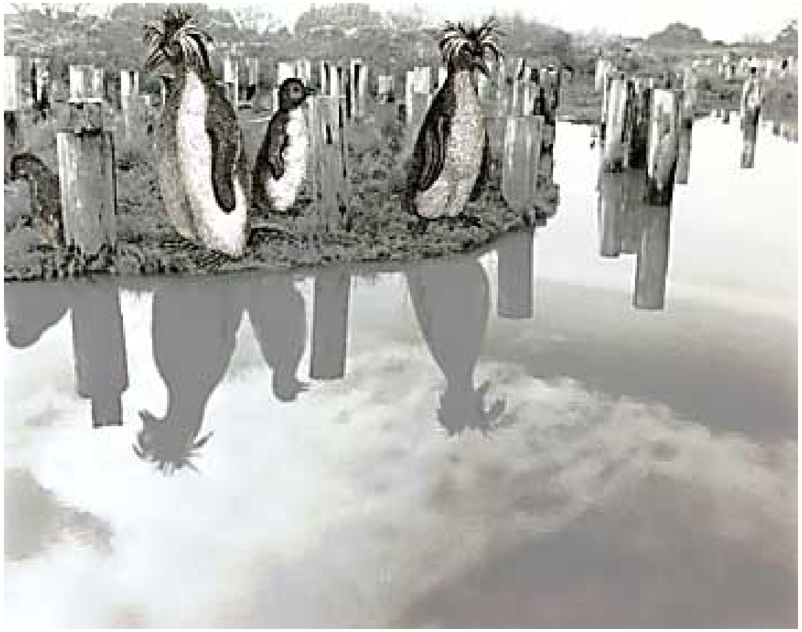
—PETER GWYNNE with bureau reports

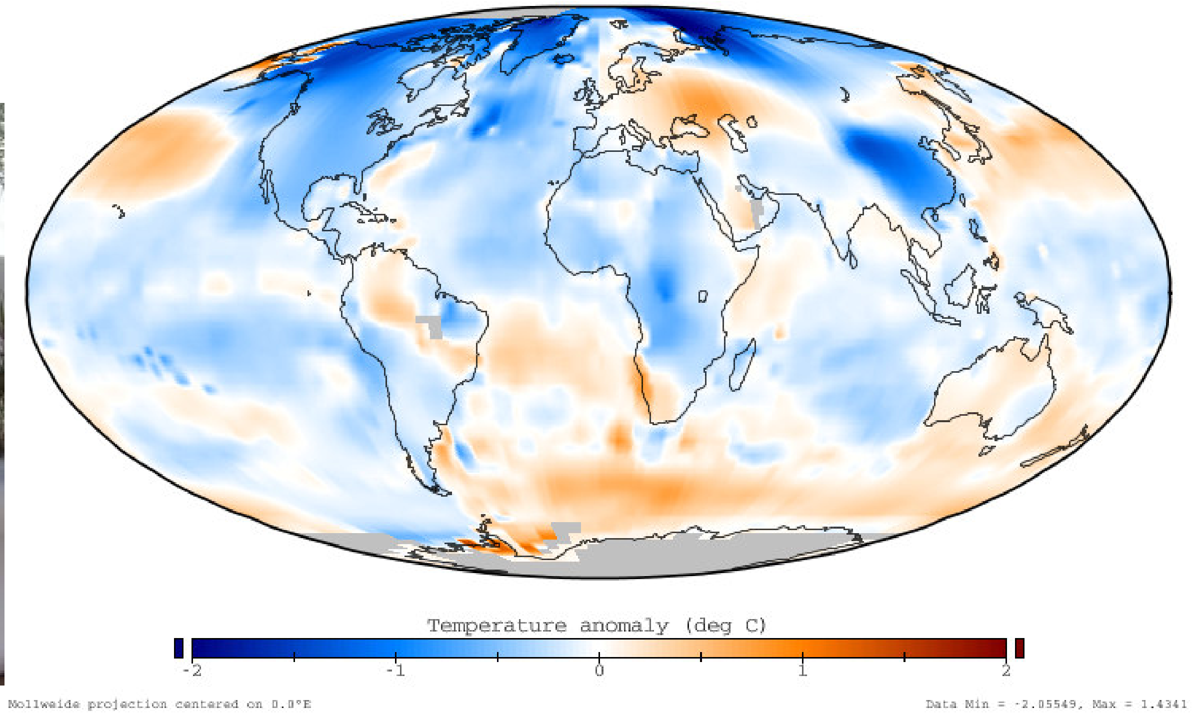
Newsweek, April 28, 1975

1995-2004 Mean Temperatures



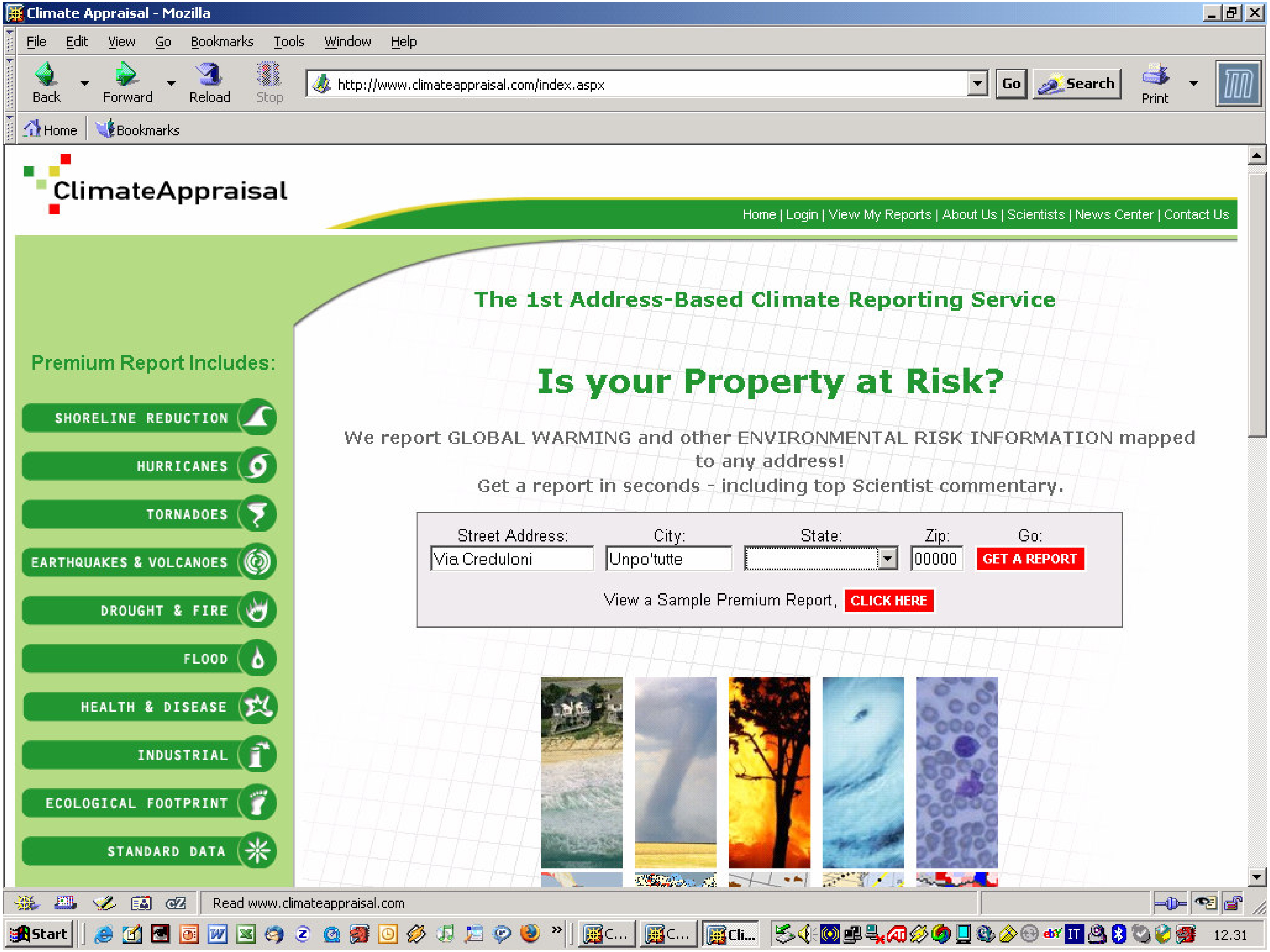


1965-1975 Mean Temperatures vs 1937-1946




BUS STOP
START
GLOBAL WARMING


23:23:10 01/04/07
800


Climate Appraisal - Mozilla
File Edit View Go Bookmarks Tools Window Help
Back Forward Reload Stop
http://www.climateappraisal.com/index.aspx
Go
Search
Print
Home
Bookmarks
ClimateAppraisal
Home | Login | View My Reports | About Us | Scientists | News Center | Contact Us
The 1st Address-Based Climate Reporting Service
Premium Report Includes:
SHORELINE REDUCTION
HURRICANES
TORNADOES
EARTHQUAKES & VOLCANOES
DROUGHT & FIRE
FLOOD
HEALTH & DISEASE
INDUSTRIAL
ECOLOGICAL FOOTPRINT
STANDARD DATA
Is your Property at Risk?
We report GLOBAL WARMING and other ENVIRONMENTAL RISK INFORMATION mapped to any address!
Get a report in seconds - including top Scientist commentary.
Street Address:
Via Creduloni
City:
Unpo'tutte
State:
Zip:
00000
Go:
GET A REPORT
View a Sample Premium Report,
CLICK HERE
Read www.climateappraisal.com
Start
12.31

Dr. Ian D. Clark, professor, isotope hydrogeology and paleoclimatology, Dept. of Earth Sciences, University of Ottawa

Dr. Tad Murty, former senior research scientist, Dept. of Fisheries and Oceans, former director of Australia's National Tidal Facility and professor of earth sciences, Flinders University, Adelaide; currently adjunct professor, Departments of Civil Engineering and Earth Sciences, University of Ottawa

Dr. R. Timothy Patterson, professor, Dept. of Earth Sciences (paleoclimatology), Carleton University, Ottawa

Dr. Fred Michel, director, Institute of Environmental Science and associate professor, Dept. of Earth Sciences, Carleton University, Ottawa

Dr. Madhav Khandekar, former research scientist, Environment Canada. Member of editorial board of Climate Research and Natural Hazards

Dr. Paul Copper, FRSC, professor emeritus, Dept. of Earth Sciences, Laurentian University, Sudbury, Ont.

Dr. Ross McKitrick, associate professor, Dept. of Economics, University of Guelph, Ont.

Dr. Tim Ball, former professor of climatology, University of Winnipeg; environmental consultant

Dr. Andreas Prokocon, adjunct professor of earth sciences, University of Ottawa; consultant in statistics and geology

Mr. David Nowell, M.Sc. (Meteorology), fellow of the Royal Meteorological Society, Canadian member and past chairman of the NATO Meteorological Group, Ottawa

Dr. Christopher Essex, professor of applied mathematics and associate director of the Program in Theoretical Physics, University of Western Ontario, London, Ont.

Dr. Gordon E. Swaters, professor of applied mathematics, Dept. of Mathematical Sciences, and member, Geophysical Fluid Dynamics Research Group, University of Alberta

Dr. L. Graham Smith, associate professor, Dept. of Geography, University of Western Ontario, London, Ont.

Dr. G. Cornelis van Kooten, professor and Canada Research Chair in environmental studies and climate change, Dept. of Economics, University of Victoria

Dr. Petr Chylek, adjunct professor, Dept. of Physics and Atmospheric Science, Dalhousie University, Halifax

Dr./Cdr. M. R. Morgan, FRMS, climate consultant, former meteorology advisor to the World Meteorological Organization. Previously research scientist in climatology at University of Exeter, U.K.

Dr. Keith D. Hage, climate consultant and professor emeritus of Meteorology, University of Alberta

Dr. David E. Wojick, P.Eng., energy consultant, Star Tannery, Va., and Sioux Lookout, Ont.

Rob Scagel, M.Sc., forest microclimate specialist, principal consultant, Pacific Phytometric Consultants, Surrey, B.C.

Dr. Douglas Leahey, meteorologist and air-quality consultant, Calgary

Paavo Siitam, M.Sc., agronomist, chemist, Cobourg, Ont.

Dr. Chris de Freitas, climate scientist, associate professor, The University of Auckland, N.Z.

Dr. Richard S. Lindzen, Alfred P. Sloan professor of meteorology, Dept. of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology

Dr. Freeman J. Dyson, emeritus professor of physics, Institute for Advanced Studies, Princeton, N.J.

Mr. George Taylor, Dept. of Meteorology, Oregon State University; Oregon State climatologist; past president, American Association of State Climatologists

Dr. Ian Plimer, professor of geology, School of Earth and Environmental Sciences, University of Adelaide; emeritus professor of earth sciences, University of Melbourne, Australia

Dr. R.M. Carter, professor, Marine Geophysical Laboratory, James Cook University, Townsville, Australia

Mr. William Kininmonth, Australasian Climate Research, former Head National Climate Centre, Australian Bureau of Meteorology; former Australian delegate to World Meteorological Organization Commission for Climatology, Scientific and Technical Review

Dr. Hendrik Tennekes, former director of research, Royal Netherlands Meteorological Institute

Dr. Gerrit J. van der Lingen, geologist/paleoclimatologist, Climate Change Consultant, Geoscience Research and Investigations, New Zealand

Dr. Patrick J. Michaels, professor of environmental sciences, University of Virginia

Dr. Nils-Axel Morner, emeritus professor of paleogeophysics & geodynamics, Stockholm University, Stockholm, Sweden

Dr. Gary D. Sharp, Center for Climate/Ocean Resources Study, Salinas, Calif.

Dr. Roy W. Spencer, principal research scientist, Earth System Science Center, The University of Alabama, Huntsville

Dr. Al Pekarek, associate professor of geology, Earth and Atmospheric Sciences Dept., St. Cloud State University, St. Cloud, Minn.

Dr. Marcel Leroux, professor emeritus of climatology, University of Lyon, France; former director of Laboratory of Climatology, Risks and Environment, CNRS

Dr. Paul Reiter, professor, Institut Pasteur, Unit of Insects and Infectious Diseases, Paris, France. Expert reviewer, IPCC Working group II, chapter 8 (human health)

Dr. Zbigniew Jaworowski, physicist and chairman, Scientific Council of Central Laboratory for Radiological Protection, Warsaw, Poland

Dr. Sonja Boehmer-Christiansen, reader, Dept. of Geography, University of Hull, U.K.; editor, Energy & Environment

Dr. Hans H.J. Labohm, former advisor to the executive board, Clingendael Institute (The Netherlands Institute of International Relations) and an economist who has focused on climate change

Dr. Lee C. Gerhard, senior scientist emeritus, University of Kansas, past director and state geologist, Kansas Geological Survey

Dr. Asmunn Moene, past head of the Forecasting Centre, Meteorological Institute, Norway

Dr. August H. Auer, past professor of atmospheric science, University of Wyoming; previously chief meteorologist, Meteorological Service (MetService) of New Zealand

Dr. Vincent Gray, expert reviewer for the IPCC and author of The Greenhouse Delusion: A Critique of 'Climate Change 2001,' Wellington, N.Z.

Dr. Howard Hayden, emeritus professor of physics, University of Connecticut

Dr Benny Peiser, professor of social anthropology, Faculty of Science, Liverpool John Moores University, U.K.
Dr. Jack Barrett, chemist and spectroscopist, formerly with Imperial College London, U.K.

Dr. William J.R. Alexander, professor emeritus, Dept. of Civil and Biosystems Engineering, University of Pretoria, South Africa. Member, United Nations Scientific and Technical Committee on Natural Disasters, 1994-2000

Dr. S. Fred Singer, professor emeritus of environmental sciences, University of Virginia; former director, U.S. Weather Satellite Service

Dr. Harry N.A. Priem, emeritus professor of planetary geology and isotope geophysics, Utrecht University; former director of the Netherlands Institute for Isotope Geosciences; past president of the Royal Netherlands Geological & Mining Society

Dr. Robert H. Essenhigh, E.G. Bailey professor of energy conversion, Dept. of Mechanical Engineering, The Ohio State University

Dr. Sallie Baliunas, astrophysicist and climate researcher, Boston, Mass.

Douglas Hoyt, senior scientist at Raytheon (retired) and co-author of the book The Role of the Sun in Climate Change; previously with NCAR, NOAA, and the World Radiation Center, Davos, Switzerland

Dipl.-Ing. Peter Dietze, independent energy advisor and scientific climate and carbon modeller, official IPCC reviewer, Bavaria, Germany

Dr. Boris Winterhalter, senior marine researcher (retired), Geological Survey of Finland, former professor in marine geology, University of Helsinki, Finland

Dr. Wibjorn Karlen, emeritus professor, Dept. of Physical Geography and Quaternary Geology, Stockholm University, Sweden

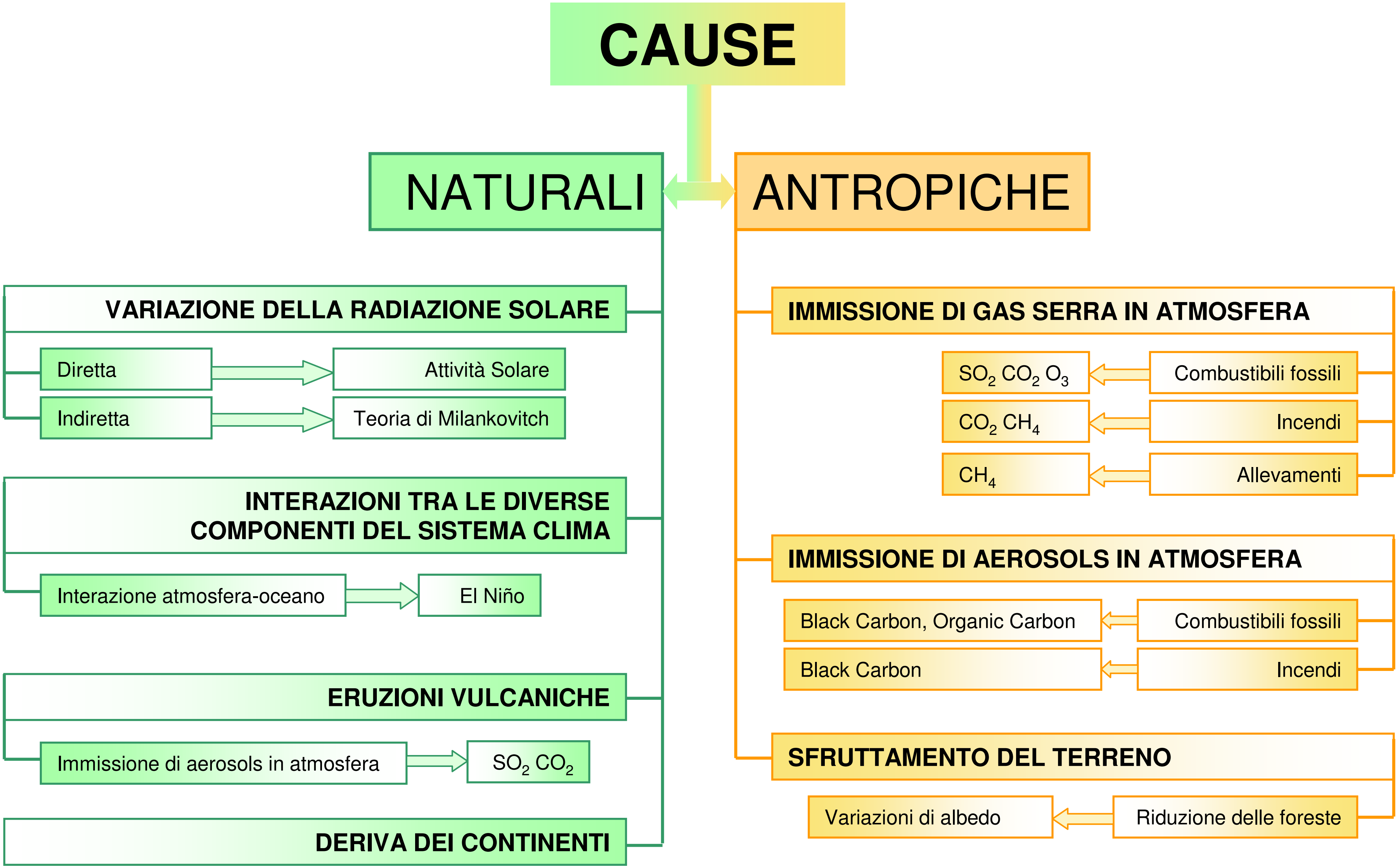
Dr. Hugh W. Ellsaesser, physicist/meteorologist, previously with the Lawrence Livermore National Laboratory, Calif.; atmospheric consultant.

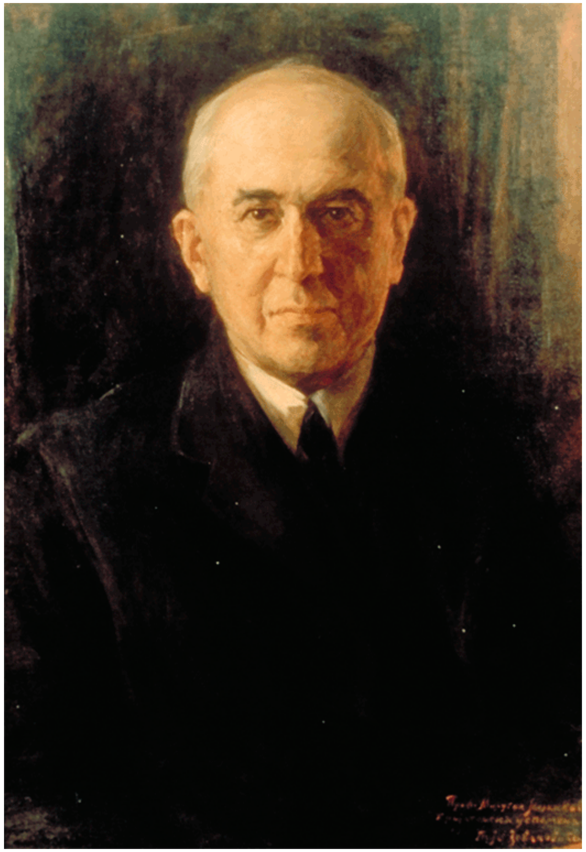
Dr. Art Robinson, founder, Oregon Institute of Science and Medicine, Cave Junction, Ore.

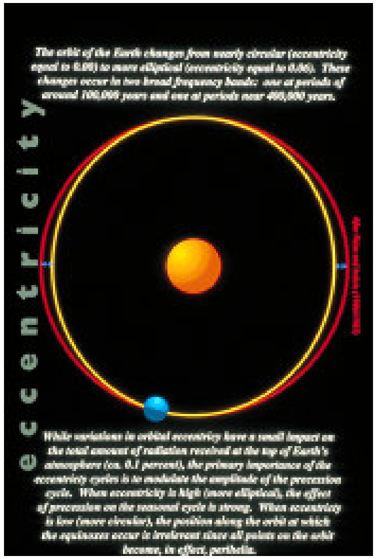
Dr. Arthur Rorsch, emeritus professor of molecular genetics, Leiden University, The Netherlands; past board member, Netherlands organization for applied research (TNO) in environmental, food and public health

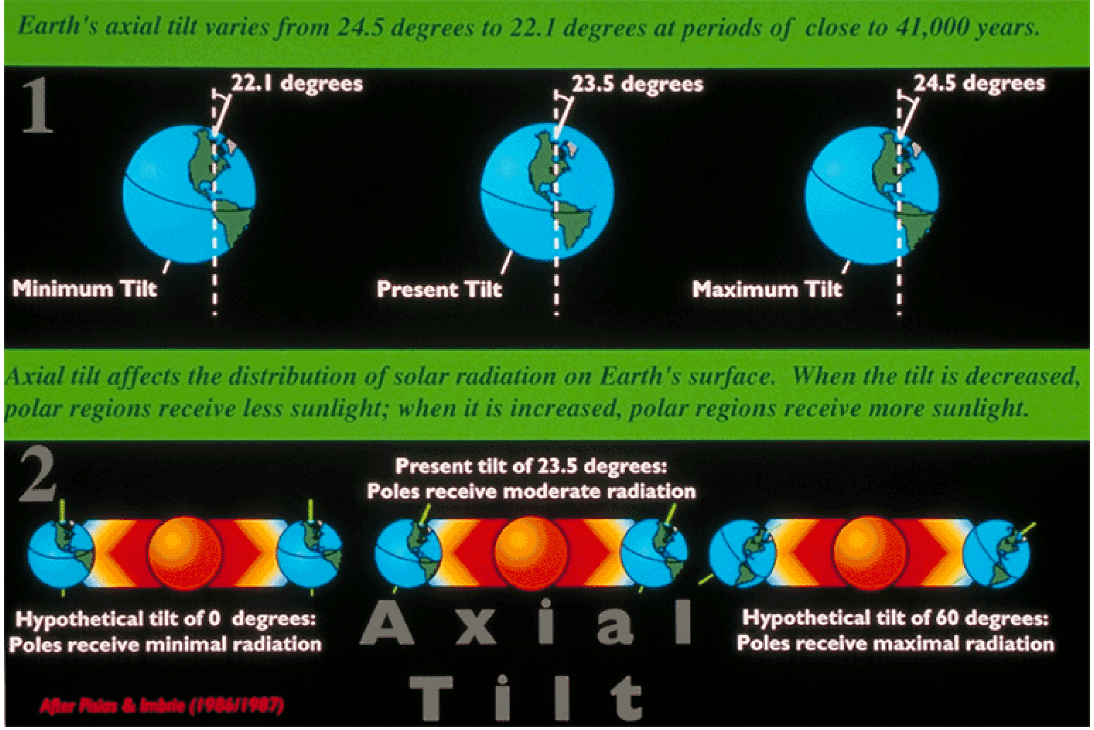
Dr. Alister McFarquhar, Downing College, Cambridge, U.K.; international economist

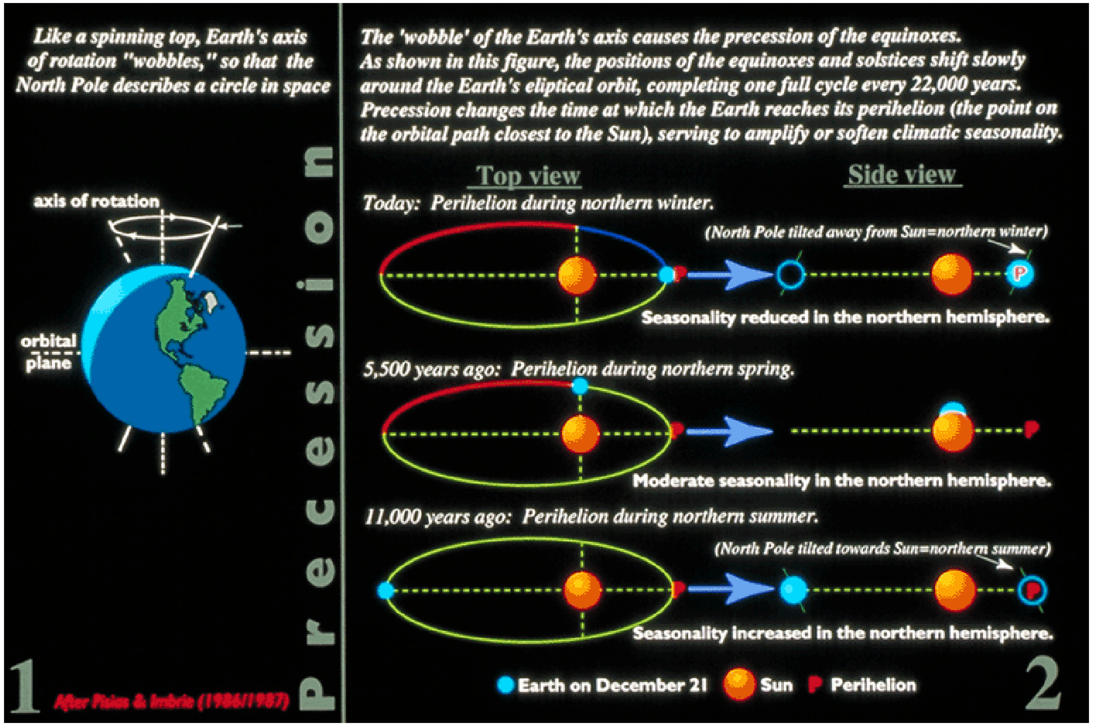
Dr. Richard S. Courtney, climate and atmospheric science consultant, IPCC expert reviewer, U.K.

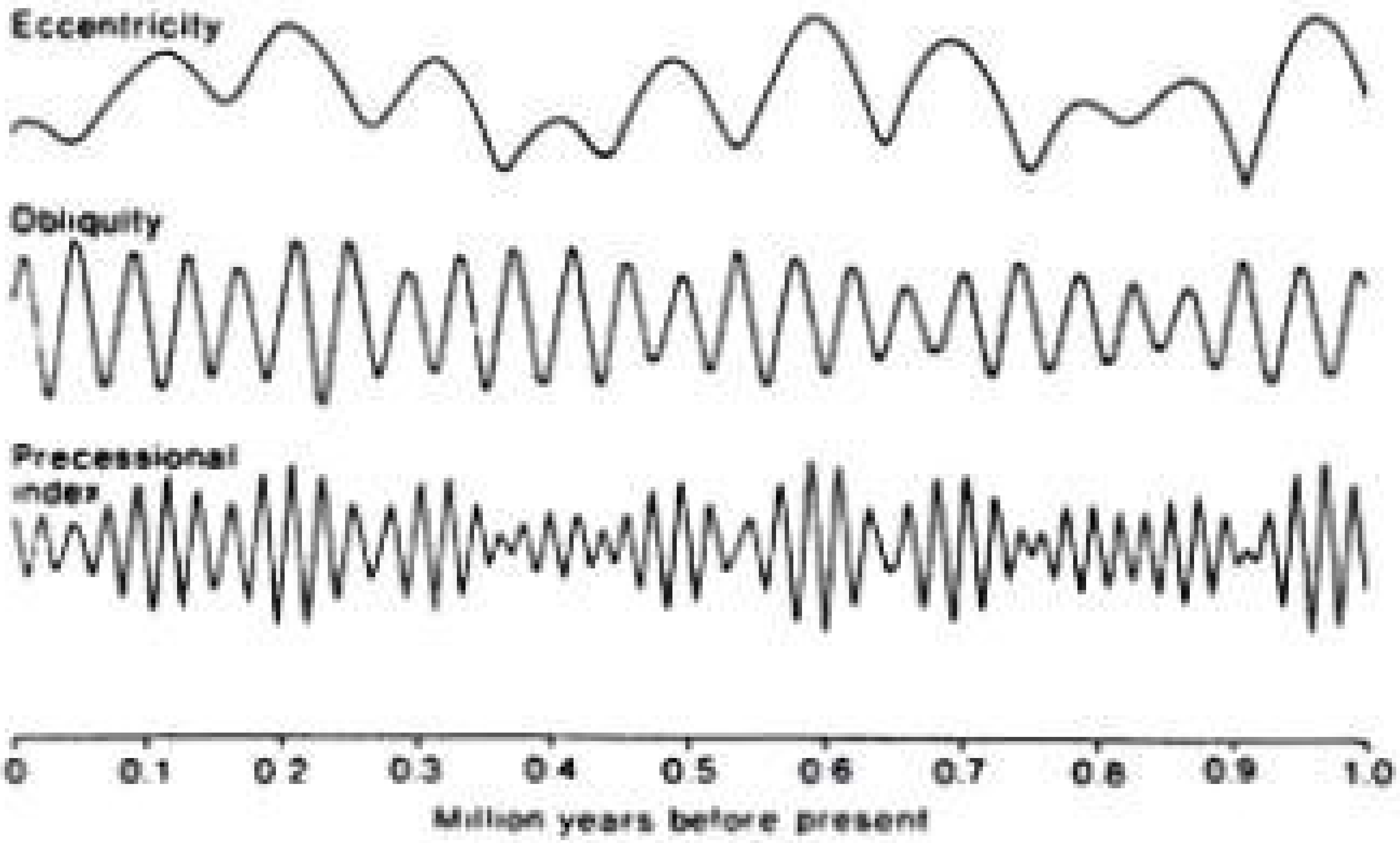

CAUSE
NATURALI
ANTROPICHE
VARIAZIONE DELLA RADIAZIONE SOLARE
Diretta
Attività Solare
Indiretta
Teoria di Milankovitch
INTERAZIONI TRA LE DIVERSE COMPONENTI DEL SISTEMA CLIMA
Interazione atmosfera-oceano
El Niño
ERUZIONI VULCANICHE
Immissione di aerosols in atmosfera
SO_2 CO_2
DERIVA DEI CONTINENTI
IMMISSIONE DI GAS SERRA IN ATMOSFERA
SO_2 CO_2 O_3
Combustibili fossili
CO_2 CH_4
Incendi
CH_4
Allevamenti
IMMISSIONE DI AEROSOLS IN ATMOSFERA
Black Carbon, Organic Carbon
Combustibili fossili
Black Carbon
Incendi
SFRUTTAMENTO DEL TERRENO
Variazioni di albedo
Riduzione delle foreste

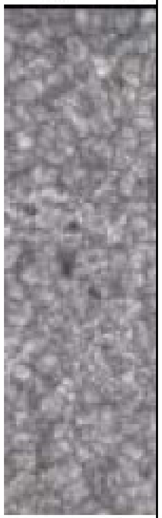


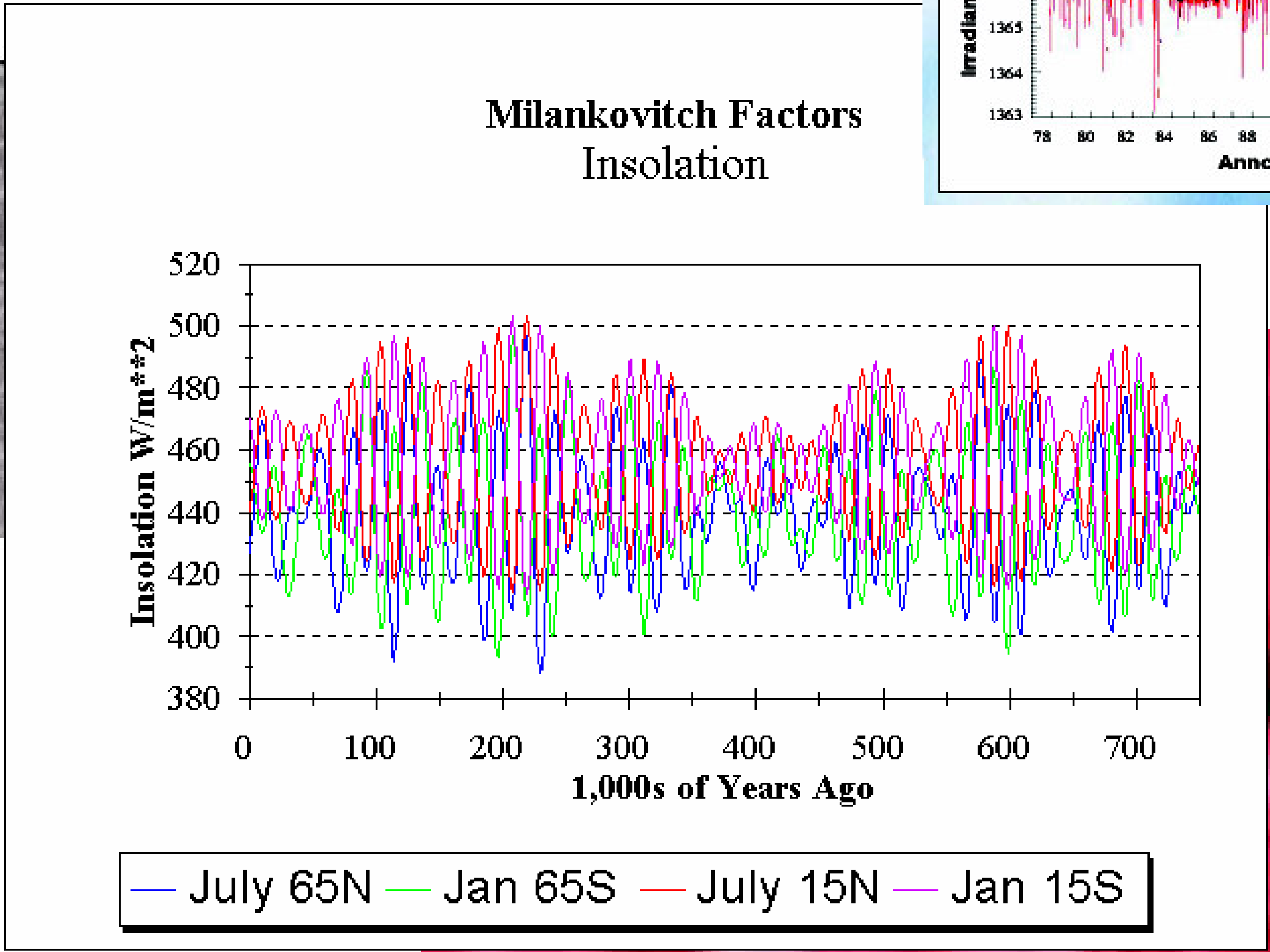

eccentricity

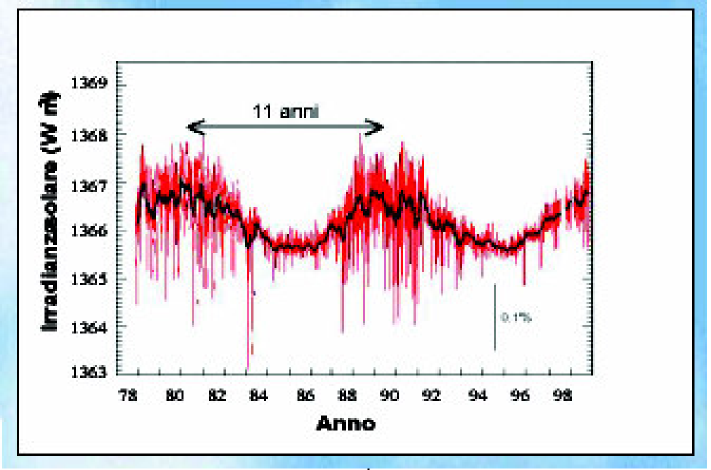

Earth's axial tilt varies from 24.5 degrees to 22.1 degrees at periods of close to 41,000 years.
1
22.1 degrees
23.5 degrees
24.5 degrees
Minimum Tilt
Present Tilt
Maximum Tilt
Axial tilt affects the distribution of solar radiation on Earth's surface. When the tilt is decreased, polar regions receive less sunlight; when it is increased, polar regions receive more sunlight.
2
Present tilt of 23.5 degrees:
Poles receive moderate radiation
Hypothetical tilt of 0 degrees:
Poles receive minimal radiation
Hypothetical tilt of 60 degrees:
Poles receive maximal radiation
Axial Tilt
After Pisias & Imbrie (1986/1987)

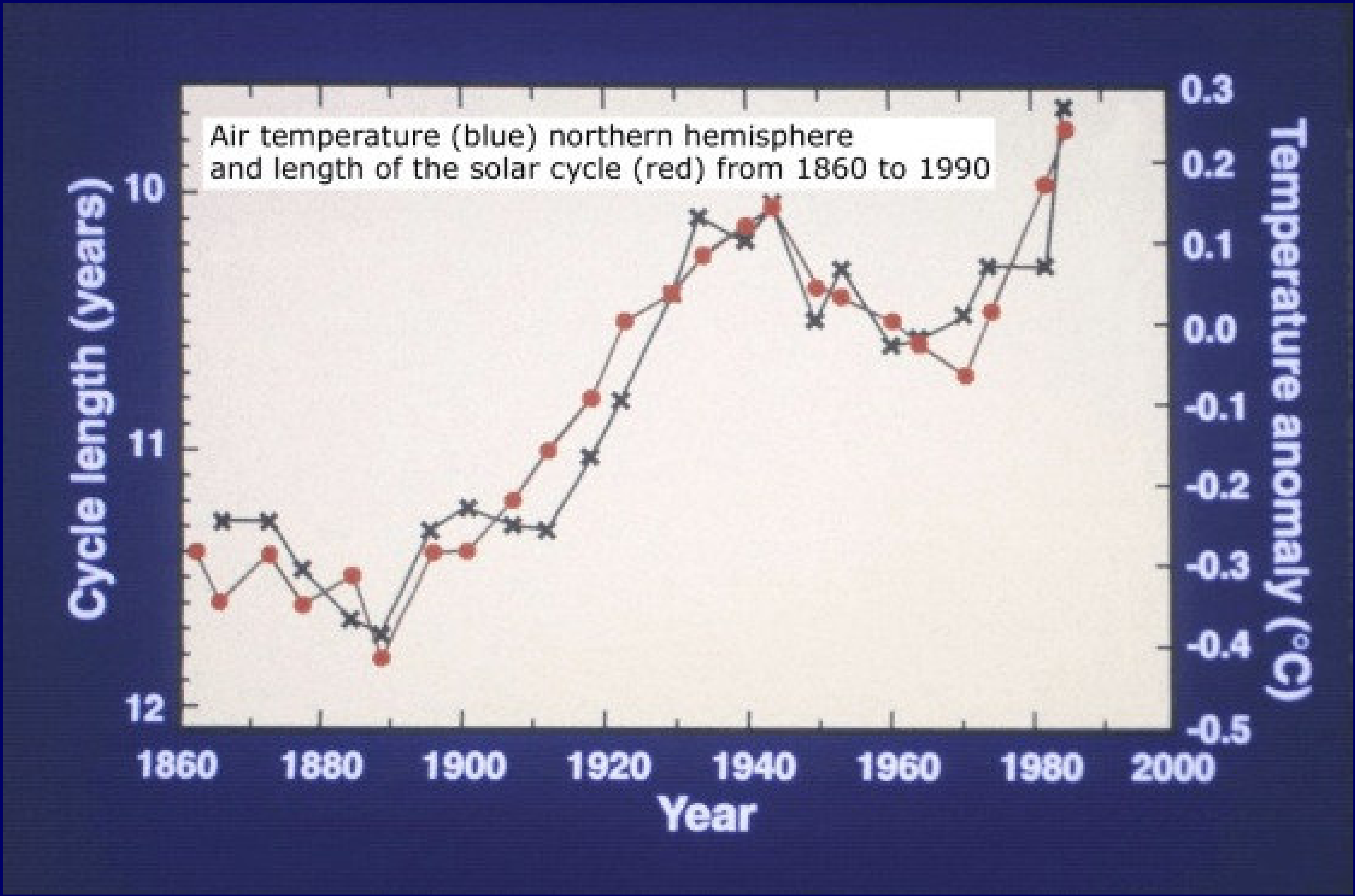

Like a spinning top, Earth's axis of rotation "wobbles," so that the North Pole describes a circle in space
axis of rotation
orbital plane
Precession
1
After Pisias & Imbrie (1986/1987)
The 'wobble' of the Earth's axis causes the precession of the equinoxes. As shown in this figure, the positions of the equinoxes and solstices shift slowly around the Earth's eliptical orbit, completing one full cycle every 22,000 years. Precession changes the time at which the Earth reaches its perihelion (the point on the orbital path closest to the Sun), serving to amplify or soften climatic seasonality.
Top view
Side view
Today: Perihelion during northern winter.
(North Pole tilted away from Sun=northern winter)
Seasonality reduced in the northern hemisphere.
5,500 years ago: Perihelion during northern spring.
Moderate seasonality in the northern hemisphere.
11,000 years ago: Perihelion during northern summer.
(North Pole tilted towards Sun=northern summer)
Seasonality increased in the northern hemisphere.
Earth on December 21
Sun
Perihelion
2


Eccentricity
Obliquity
Precessional index
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Million years before present




Milankovitch Factors
Insolation
Insolation W/m**2
520
500
480
460
440
420
400
380
0
100
200
300
400
500
600
700
1,000s of Years Ago
July 65N
Jan 65S
July 15N
Jan 15S


11 anni
Irradianza solare (W m²)
1369
1368
1367
1366
1365
1364
1363
0.1%
78
80
82
84
86
88
90
92
94
96
98
Anno



Air temperature (blue) northern hemisphere
and length of the solar cycle (red) from 1860 to 1990
Cycle length (years)
10
11
12
Temperature anomaly (°C)
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
1860
1880
1900
1920
1940
1960
1980
2000
Year

**I MODELLI
SONO QUELLE COSE A CUI NESSUNO CREDE
TRANNE CHI LI HA CREATI**

**I DATI
SONO QUELLE COSE A CUI TUTTI CREDONO
TRANNE CHI LI HA RACCOLTI**

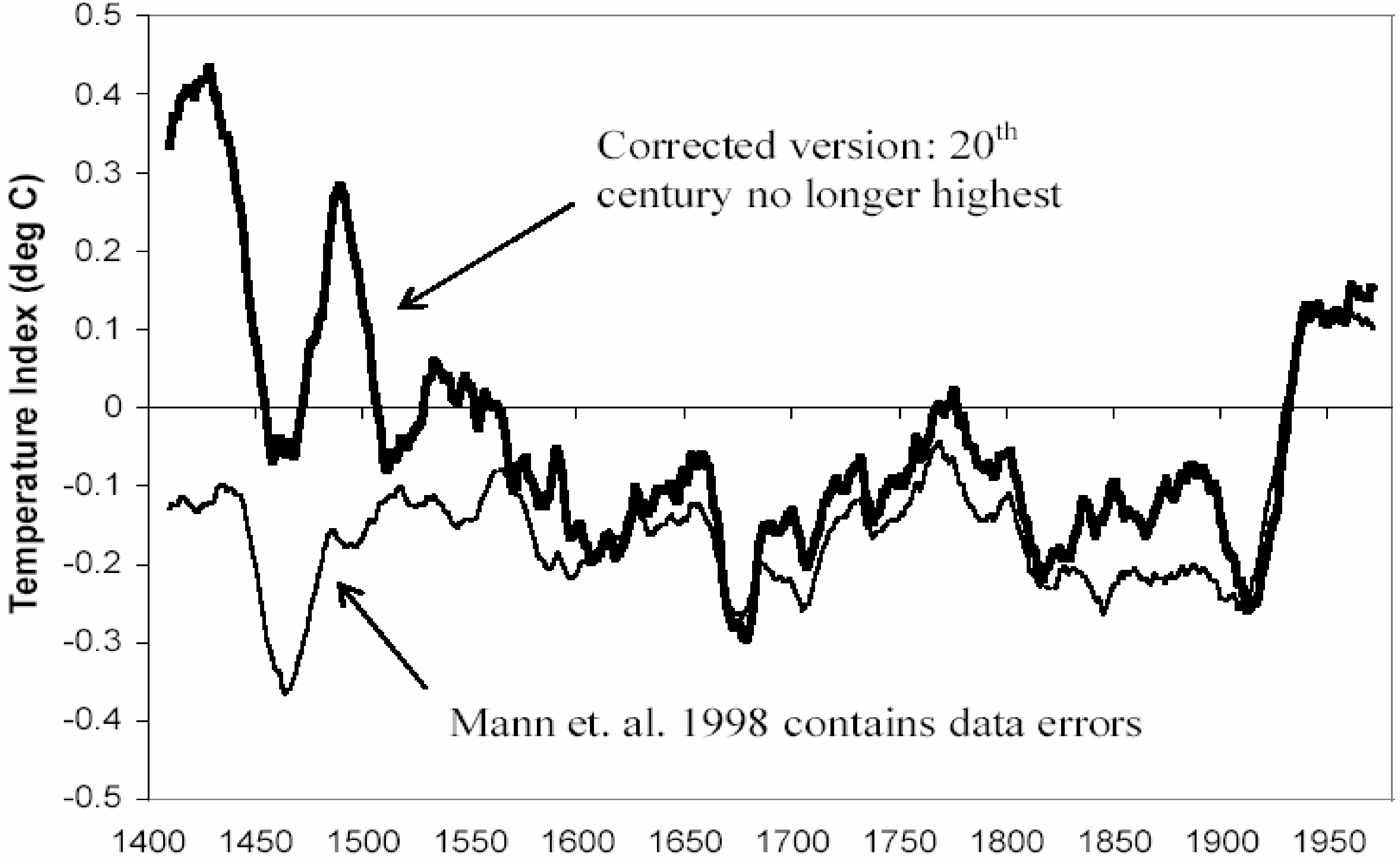
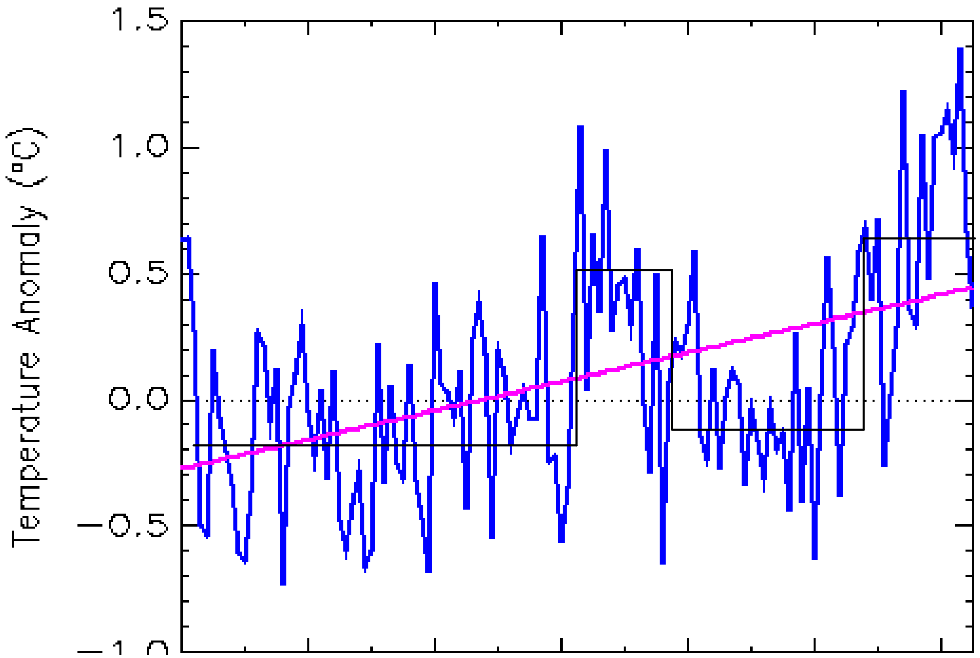
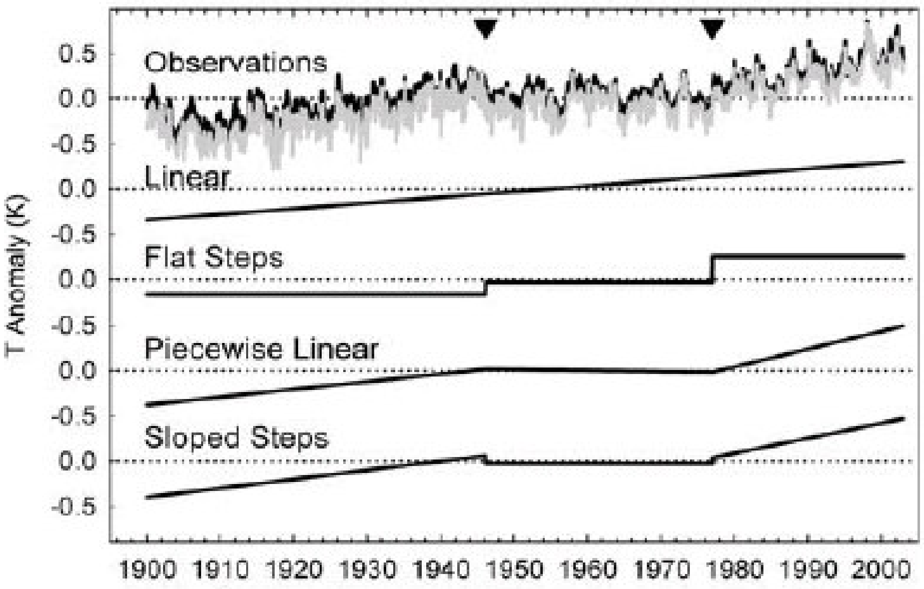


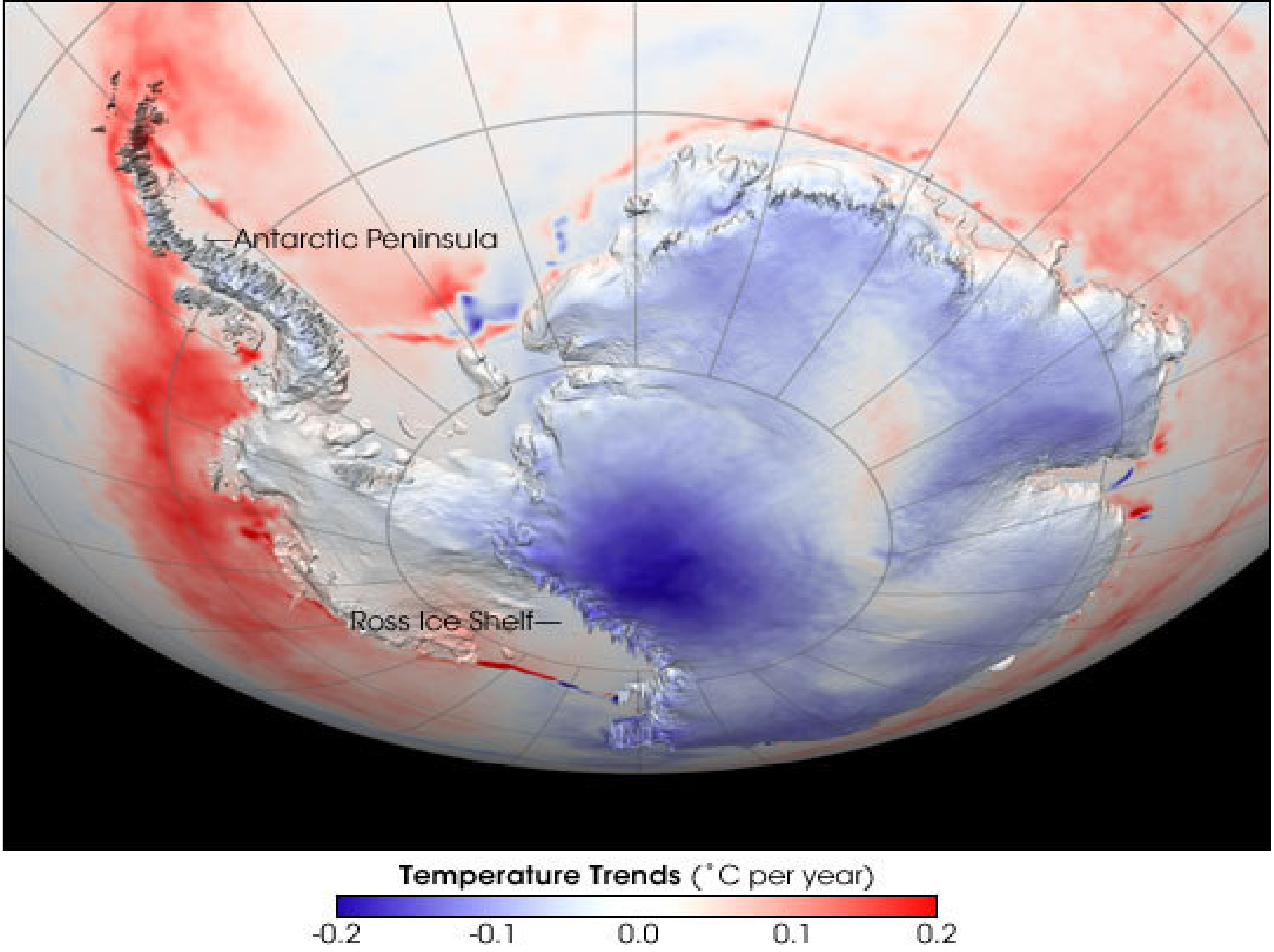
Figure 8. As Figure 7, using 20-year running mean to smooth.

1880-2006 Temperature Time Series

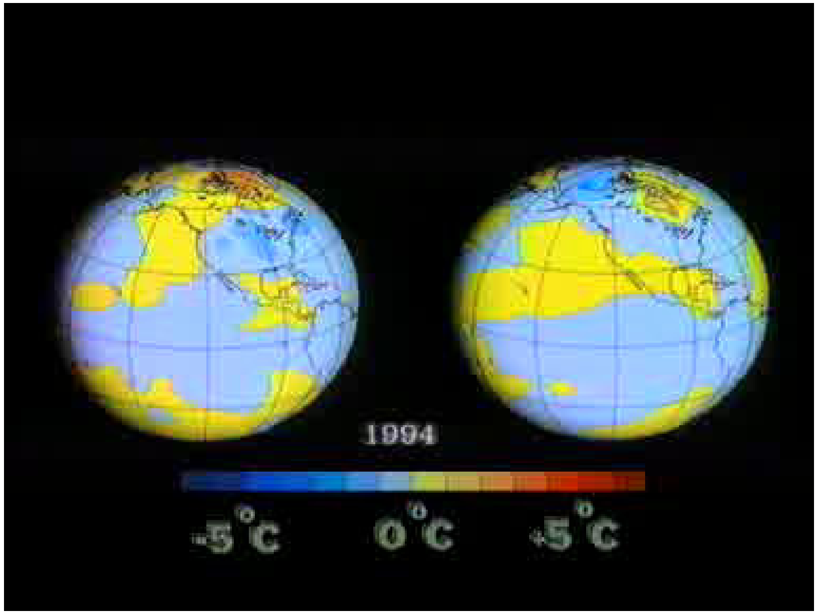
Latitude Range 35 to 45, Longitude Range 5 to 15
(from the Global Historical Climatology Network dataset)






—Antarctic Peninsula
Ross Ice Shelf—
Temperature Trends (°C per year)
-0.2
-0.1
0.0
0.1
0.2

Le rappresentazioni del mondo



Deutsches Klimarechenzentrum

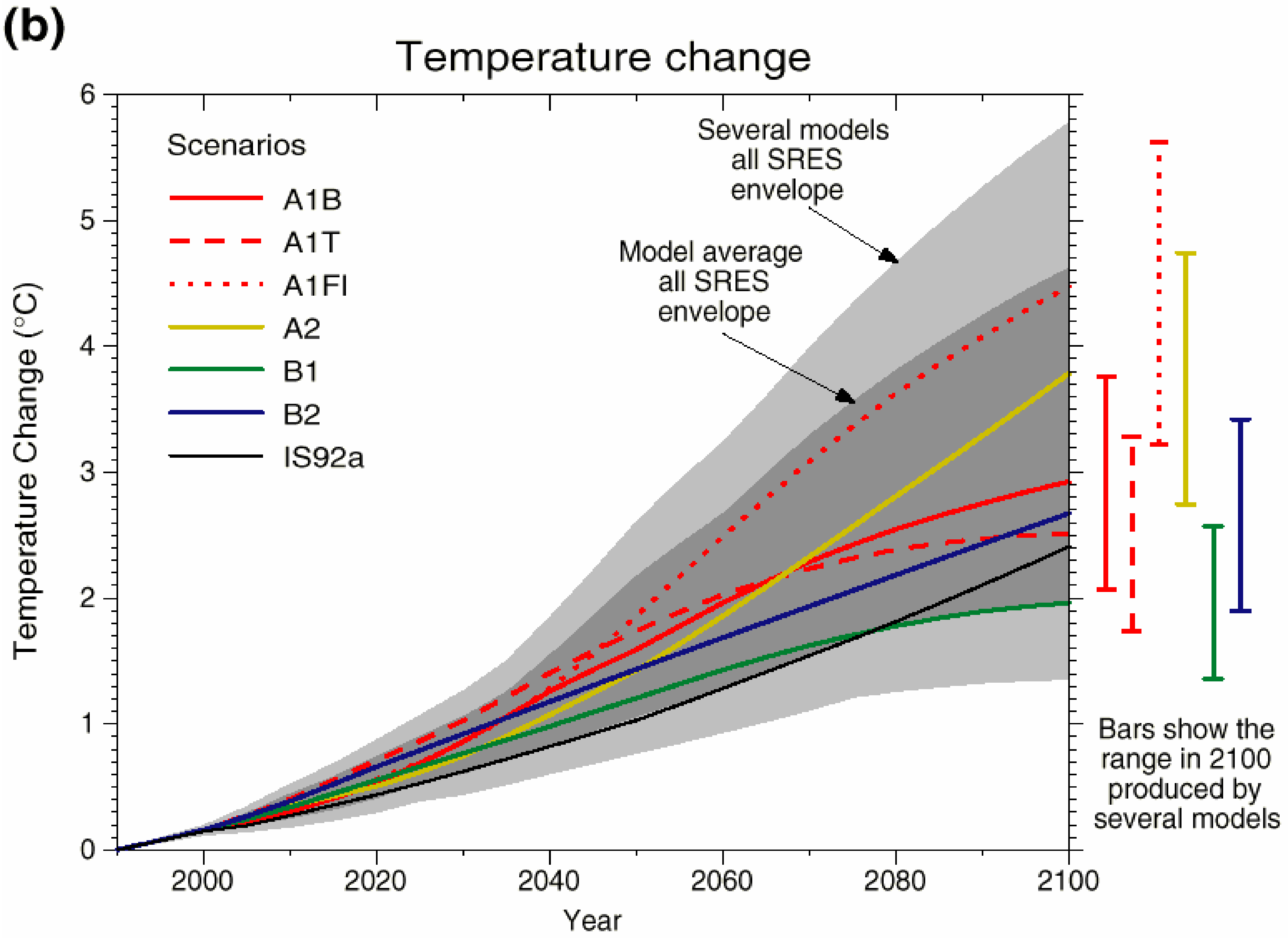
PREVISIONI
O
SCENARI?

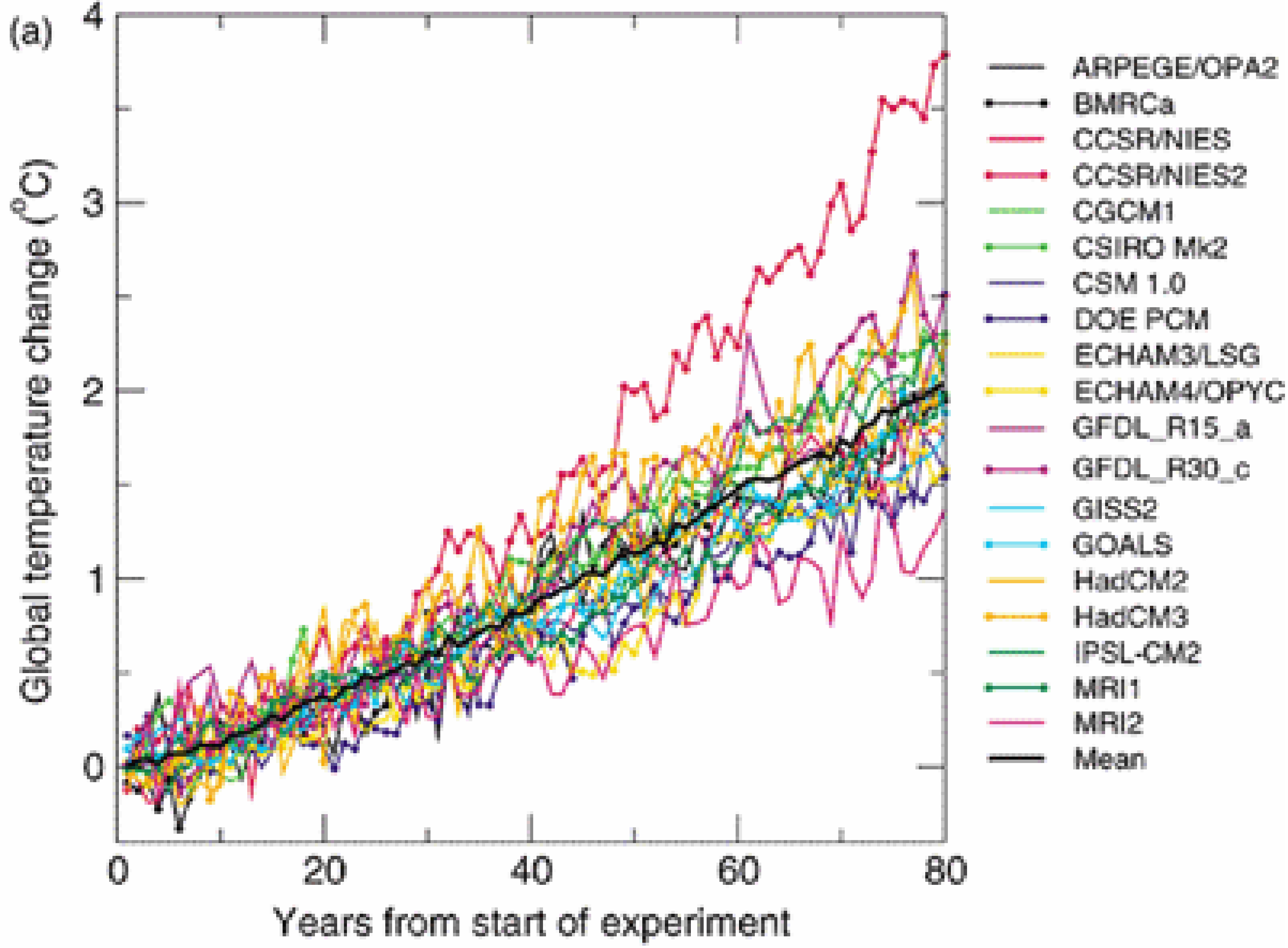
Scenari:

Sono il risultato della combinazione di una serie di interruttori
che vengono alzati o abbassati a seguito di una ipotesi.
(mi forniscono un disegno)

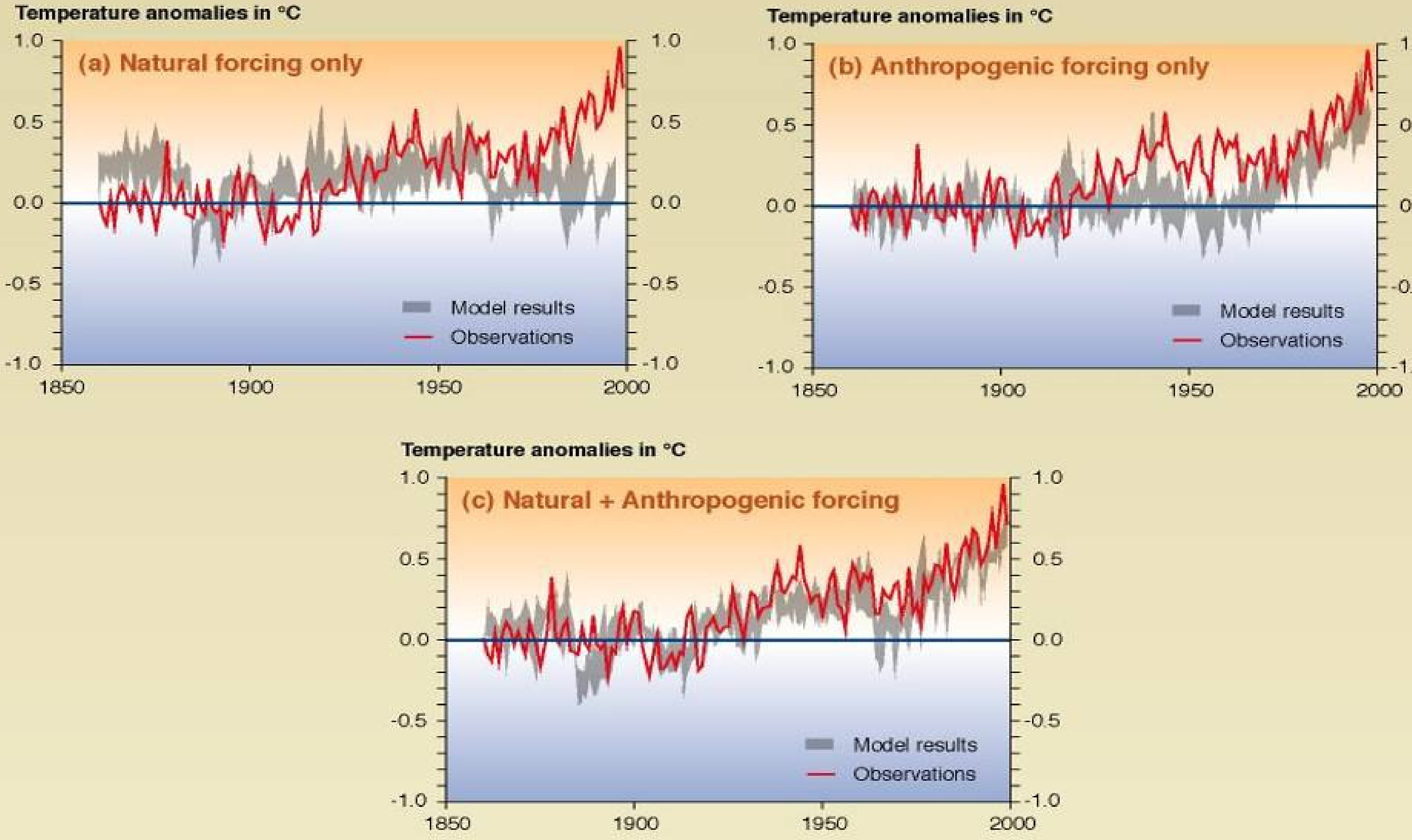
Previsioni:

Sono basate su una interpretazione fisica-matematica del funzionamento del mondo
che opera nel tempo e nello spazio basandosi su delle condizioni iniziali.
(mi forniscono una probabilita')


(b)
Temperature change
Scenarios
A1B
A1T
A1FI
A2
B1
B2
IS92a
Several models all SRES envelope
Model average all SRES envelope
Bars show the range in 2100 produced by several models
Temperature Change (°C)
Year
0
1
2
3
4
5
6
2000
2020
2040
2060
2080
2100


(a)
Global temperature change (°C)
Years from start of experiment
0
1
2
3
4
0
20
40
60
80
ARPEGE/OPA2
BMRCa
CCSR/NIES
CCSR/NIES2
CGCM1
CSIRO Mk2
CSM 1.0
DOE PCM
ECHAM3/LSG
ECHAM4/OPYC
GFDL_R15_a
GFDL_R30_c
GISS2
GOALS
HadCM2
HadCM3
IPSL-CM2
MRI1
MRI2
Mean

Comparison between model and observations of the temperature rise since 1860



An Introduction to Simple Climate Models used in the IPCC Second Assessment Report

This paper was prepared under the auspices of IPCC Working Group I.

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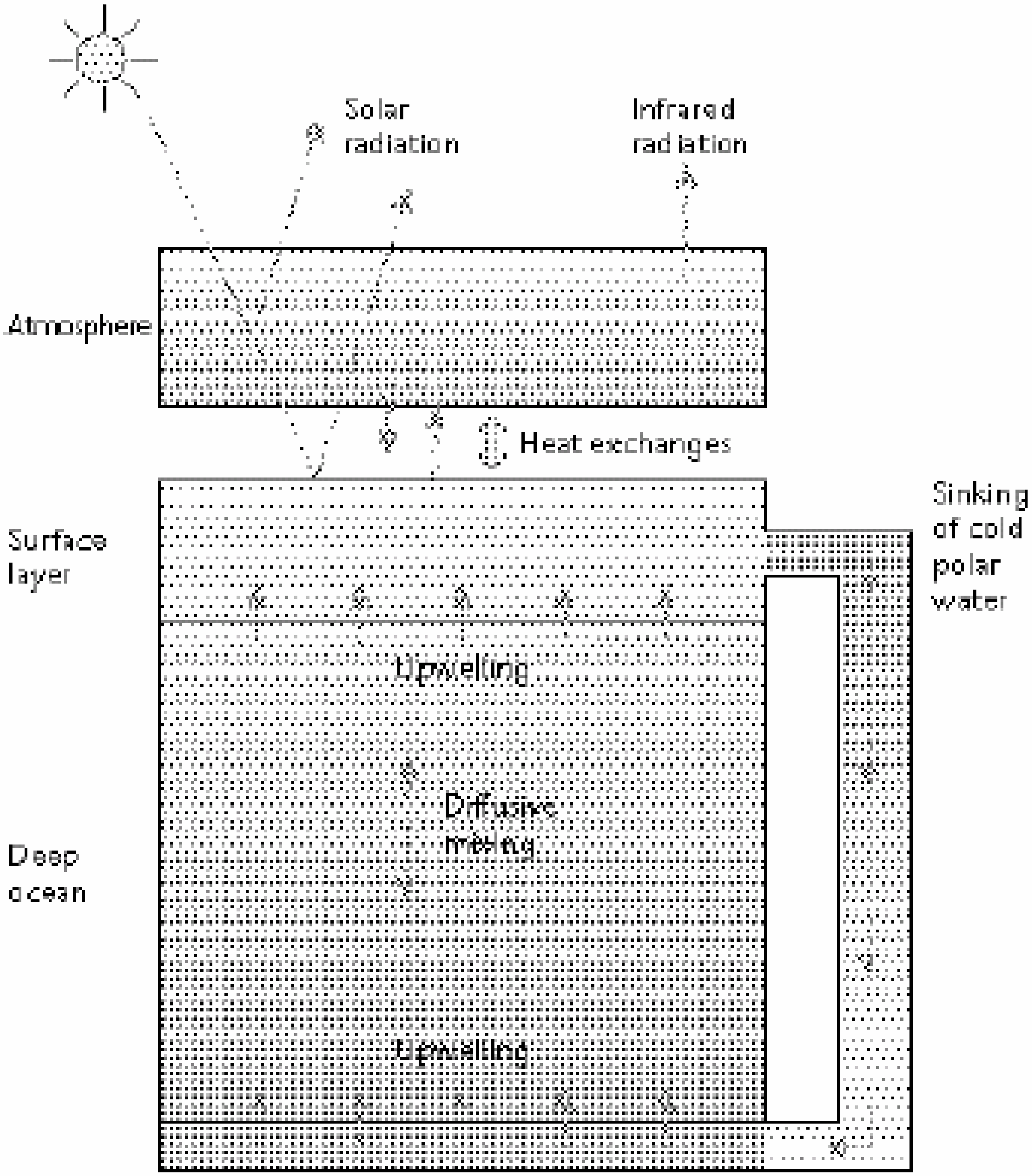
I modelli complessi tentano di rappresentare tutte le categorie di interazione dei diversi comparti e prendono cosi' il nome di AOGCMs ovvero modelli generali di circolazione con accoppiamento atmosfera-oceano. Di questi esiste una precisa gerarchia basata principalmente sulla loro dimensionalita' e sul numero di processi rappresentati:

1. **modelli atmosferici monodimensionali radiativi-convettivi;**
2. **modelli oceanici diffusivi monodimensionali;**
3. **modelli a bilancio energetico monodimensionali;**
4. **modelli bidimensionali atmosfera-oceano;**
5. **modelli tridimensionali di circolazione generale accoppiati atmosfera-oceano.**

A questa categoria appartengono gli AOGCMs che cercano di modellare esplicitamente il transfer radiativo attraverso l'atmosfera utilizzando parametrizzazioni di nubi, vapore acqueo e altri componenti minoritari, la criosfera mediante precipitazioni solide e ghiaccio marino ed il trasporto di calore e acqua dall'oceano all'atmosfera e viceversa.

Data l'estrema complessita' e l'elevato numero dei processi coinvolti, per avere accettabili risposte in termini di tempo di calcolo, i modelli utilizzano areali geografici molto estesi (tipicamente qualche centinaio di chilometri) e l'immagine del sistema che forniscono e' solo una rappresentazione a grande scala.



Solar radiation
Infrared radiation
Atmosphere
Heat exchanges
Surface layer
Sinking of cold polar water
Upwelling
Diffusive mixing
Deep ocean
Upwelling

Three-dimensional atmosphere and ocean general circulation models. The most complex atmosphere and ocean models are the three-dimensional AGCMs and ocean general circulation models (OGCMs), both of which are extensively reviewed in the SAR WGI (Chapter 5). These models divide the atmosphere or ocean into a horizontal grid with a typical resolution of 2-4° latitude by 2-4° longitude in the latest models, and typically 10 to 20 layers in the vertical. They directly simulate winds, ocean currents, and many other variables and processes characterizing the atmosphere and oceans. Both AGCMs and OGCMs have been used extensively in a stand-alone mode, with prescribed ocean surface temperatures and sea ice in the case of AGCMs and with prescribed surface temperatures and salinities, or the corresponding heat and freshwater fluxes, in the case of OGCMs. An AOGCM consists of an AGCM coupled to an OGCM, with information about the state of the atmosphere and ocean adjacent to, or at the sea surface, used to compute exchanges of heat, moisture and momentum between the two components.

Coupled Phenomena

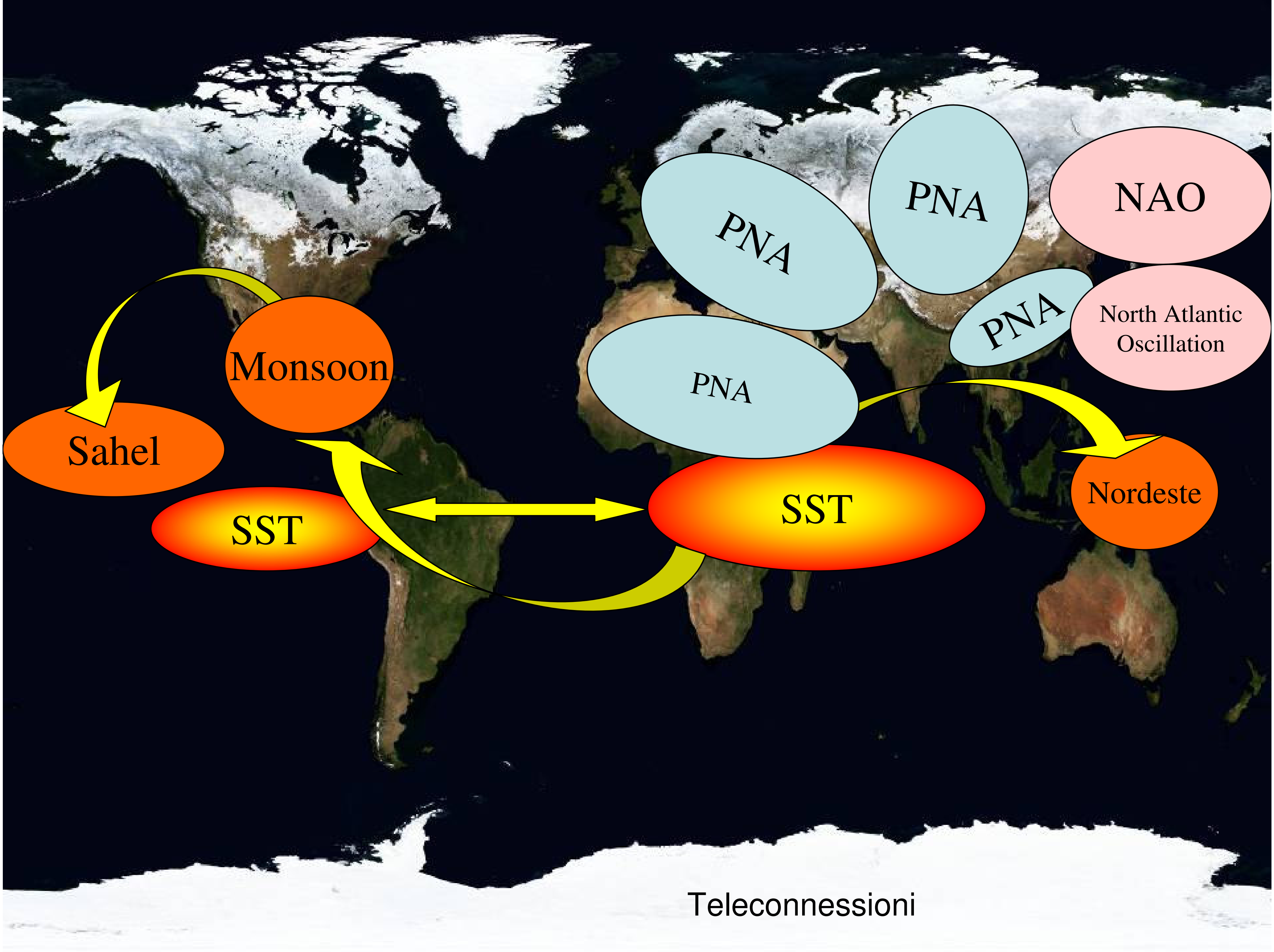
Why is there a need for considering coupled models ?
There are at least two major reasons why it is clear that realistic description of climate cannot be done without considering the atmosphere and ocean at the same time

Teleconnections

The interactions between atmosphere and oceans in the tropics dominate the variability at interannual scales. The Sea Surface Temperature affects the atmosphere generating giant patterns that extend over the planet

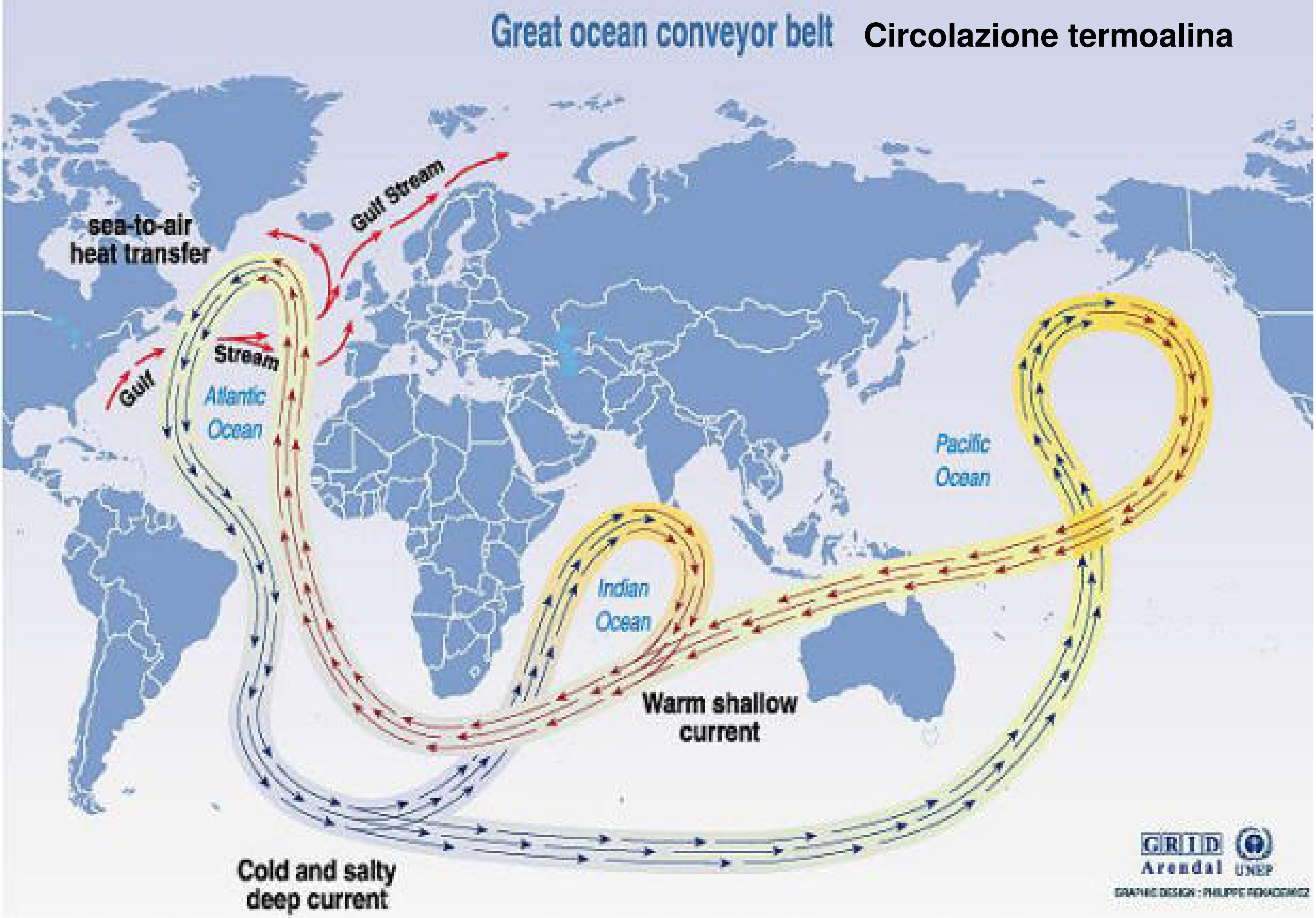
Thermohaline Circulation

The deep oceanic circulations is driven by fluxes of heat and fresh water that change temperature and salinity of the water. Dense water (cold and saline) sink deep down creating a worldwide circulation as light water (fresh and warm) upwells through the world ocean, affecting the global sea surface temperatures, which in turn change the dominant mode of climate variability through the teleconnections.

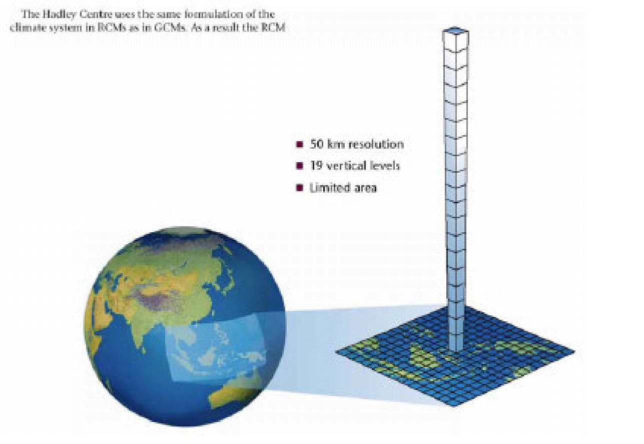


Teleconnessioni

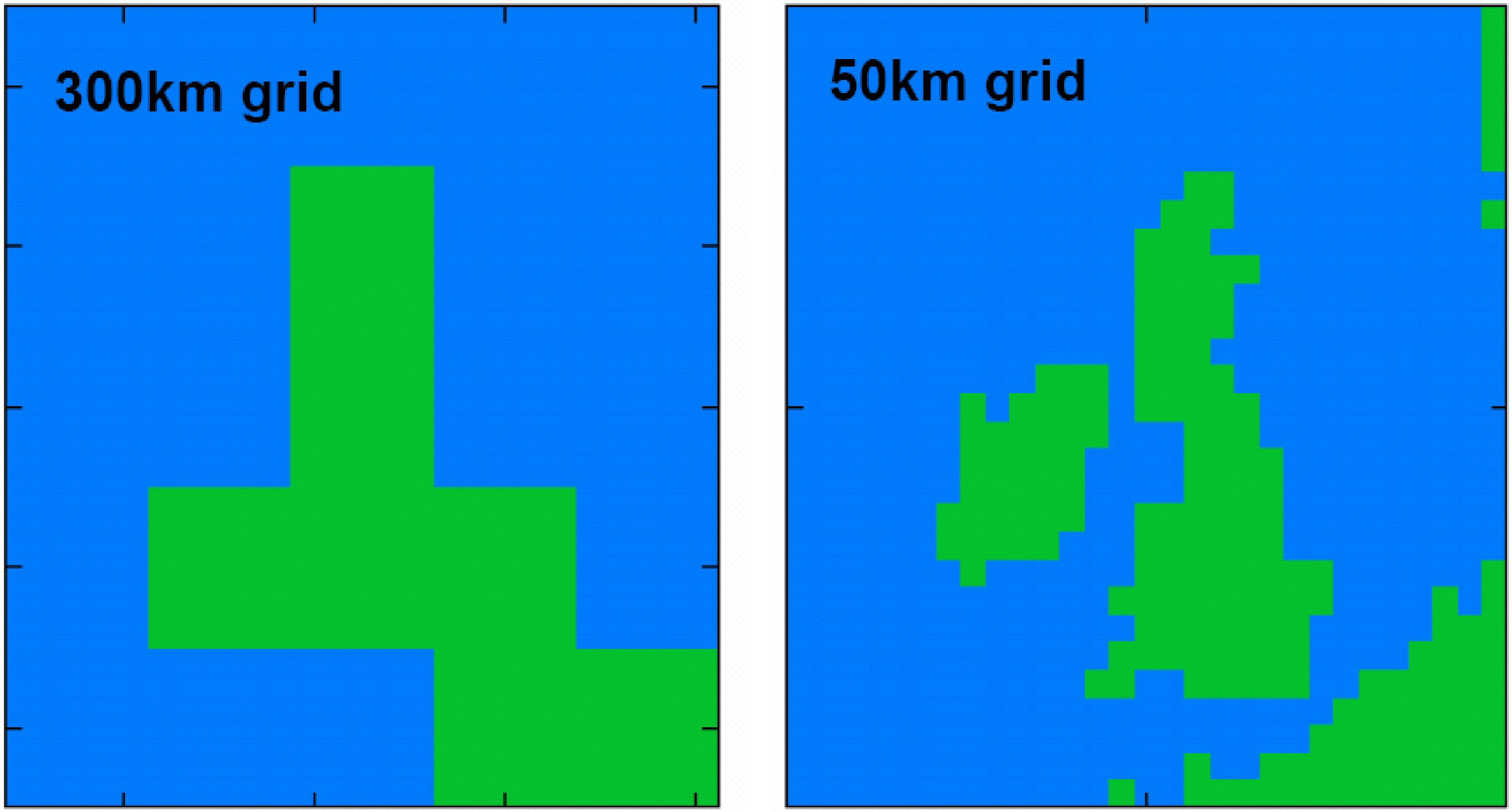
Circolazione termoalina



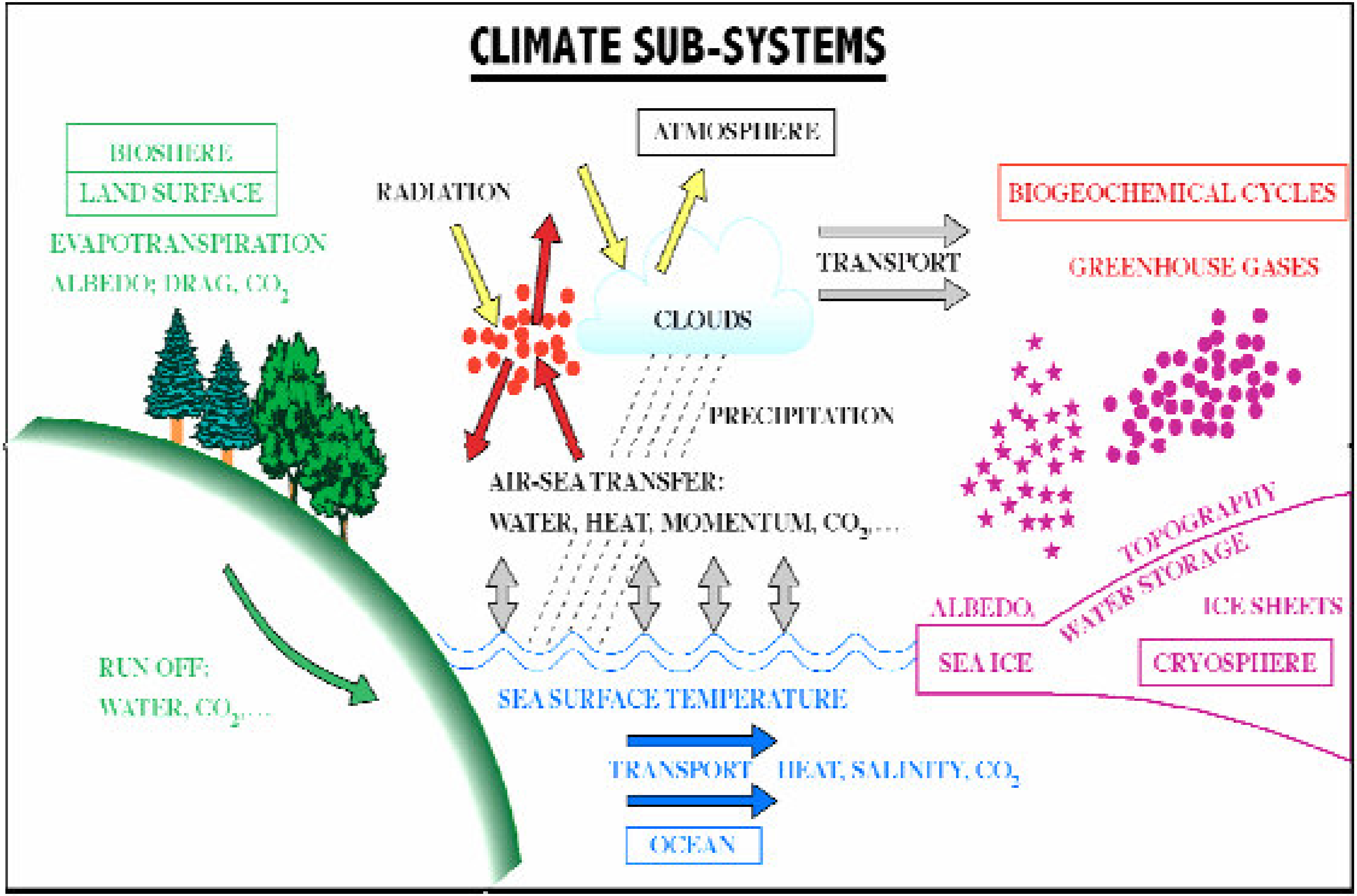
Source: Broecker, 1991, in Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.



CELLE DI 200-300 KM DI LATO

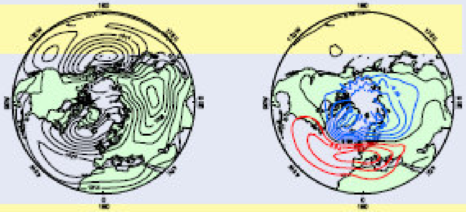

300km grid
50km grid

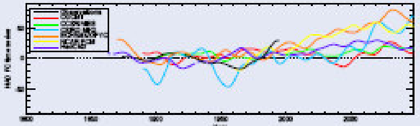
Simple Models	*Complex Models*
Generally produce zonally- or globally-averaged results, and only for temperature and temperature changes, not for other variables such as rainfall.	Simulate the past and present geographical variation of temperature, as well as other variables of climatic interest such as rainfall, evaporation, soil moisture, cloudiness, and winds; and provide credible continental scale changes of at least some of these variables.
Cannot simulate possible changes in climatic variability as output consists of the climate change signal only.	Have the potential to simulate changes in important modes of interannual variability (e.g., *El Niño)* as well as mean values.
The effects of physical processes are approximated based on globally- or zonally-averaged computations with low temporal resolution.	Many physical processes are directly simulated, necessitating the use of a short time-step but allowing resolution of the diurnal cycle.
Climate sensitivity and other subsystem properties must be specified based on the results of complex models or observations. These properties can be readily altered for purposes of sensitivity testing.	Climate sensitivity and other subsystem properties are computed based on a combination of physical laws and sub-grid scale model parametrizations.
Sufficiently fast that multiple scenarios can be simulated, and that runs with a wide range of parameter values can be executed. Can be initialized in a steady state at little computational cost.	Computational cost strongly limits the number of cases that can be investigated and the ability to initialize in a steady state.
Useful for sensitivity studies involving the interaction of large-scale climate system components.	Useful for studying those fundamental processes which can be resolved by the model.
Analysis is easy because simple models include relatively few processes. Interpretation of simple model results may give insights into the behaviour of more complex models.	Model behaviour is the result of many interacting processes, as in the real world. Studies with complex models indicate what processes need to be included in simple models and, in some cases, how they can be parametrized.
One-dimensional models cannot simulate climatic surprises, for example sudden ocean circulation changes. Two-dimensional ocean models can give some insight into such changes.	AOGCMs can simulate major changes in ocean circulation but the timing and nature of such changes may not yet be reliable.


CLIMATE SUB-SYSTEMS
ATMOSPHERE
BIOSHERE
LAND SURFACE
RADIATION
BIOGEOCHEMICAL CYCLES
EVAPOTRANSPIRATION
ALBEDO; DRAG, CO_2
TRANSPORT
GREENHOUSE GASES
CLOUDS
PRECIPITATION
AIR-SEA TRANSFER:
WATER, HEAT, MOMENTUM, CO_2,…
TOPOGRAPHY
WATER STORAGE
ALBEDO,
ICE SHEETS
RUN OFF:
WATER, CO_2,…
SEA ICE
CRYOSPHERE
SEA SURFACE TEMPERATURE
TRANSPORT
HEAT, SALINITY, CO_2
OCEAN

Observations

UKMO sea level pressure analyses 1873-1995 (Jones, 1987; Basnett & Parker, 1997)





Smoothed time series showing the NAO indices from the greenhouse gas forced simulations, when their SLP fields are projected onto the corresponding control run NAO patterns. Observed NAO time series is also shown.

Statistics given for each model

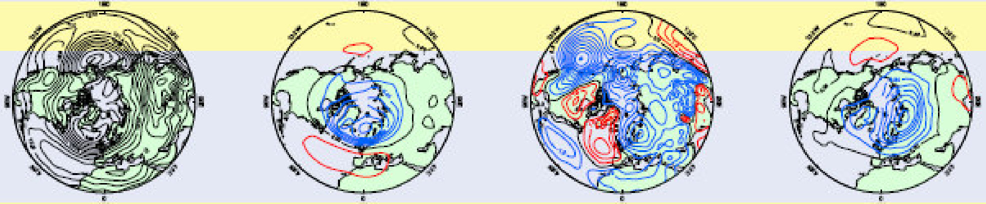
pattern: pattern correlation between observed and simulated mean SLP

% con: percentage of Atlantic SLP variability explained by EOF1 during the control (observed value is 40%)

% g1: percentage of Atlantic SLP variability explained by EOF1 during the g1 simulation

CGCM1

Canadian Center for Climate Modelling and Analysis, Canada. Model and simulations described by Flato *et al.* (2000).

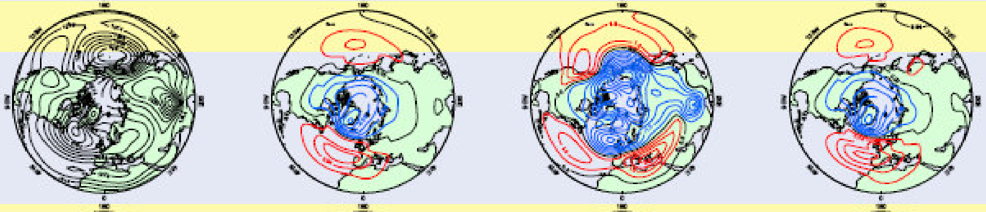


CGCM1

pattern: 0.79
% con: 56
% g1: 42

CCSR/NIES

Center for Climate Research Studies and National Institute for Environmental Studies, Japan. Model and simulations described by Emori *et al.* (1999).

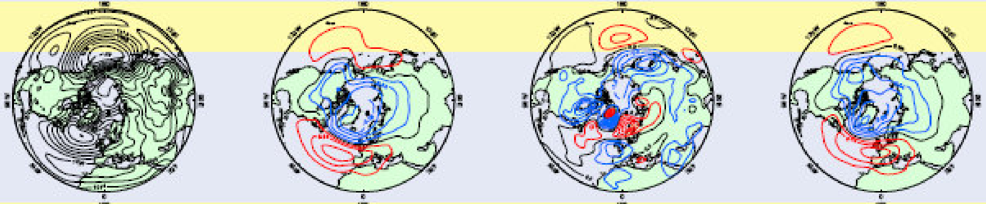


CCSR/NIES

pattern: 0.76
% con: 66
% g1: 71

CSIRO MK2

Commonwealth Scientific and Industrial Research Organisation, Australia. Model and simulations described by Gordon & O'Farrell (1997).

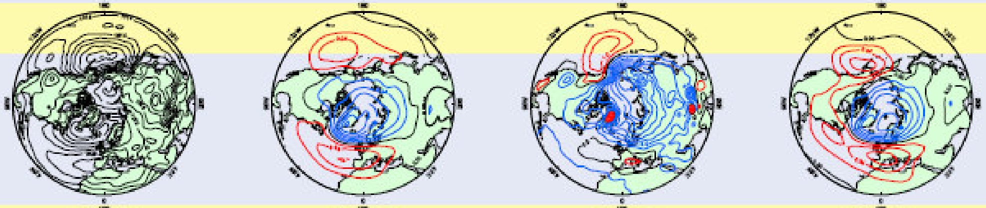


CSIRO MK2

pattern: 0.81
% con: 40
% g1: 42

ECHAM4/OPYC

Deutsches Klimarechenzentrum DKRZ, Germany. Model and simulations described by Bacher *et al.* (1998).

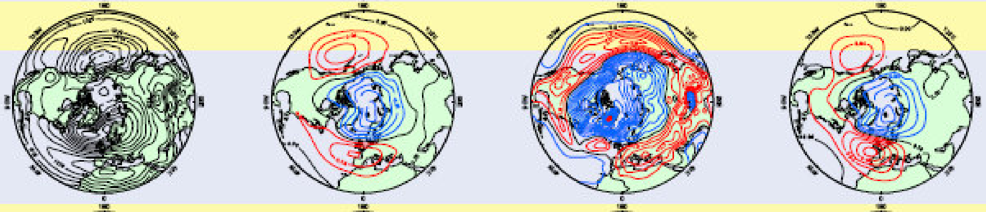


ECHAM4/OPYC

pattern: 0.88
% con: 55
% g1: 47

NCAR PCM

National Centre for Atmospheric Research, USA. Model and simulations described by Washington *et al.* (2000).

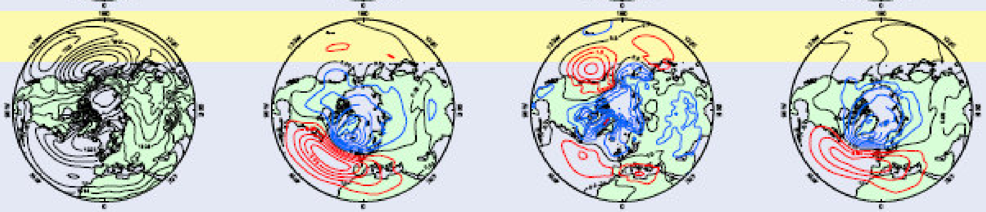


NCAR PCM

pattern: 0.85
% con: 53
% g1: 50

HadCM3

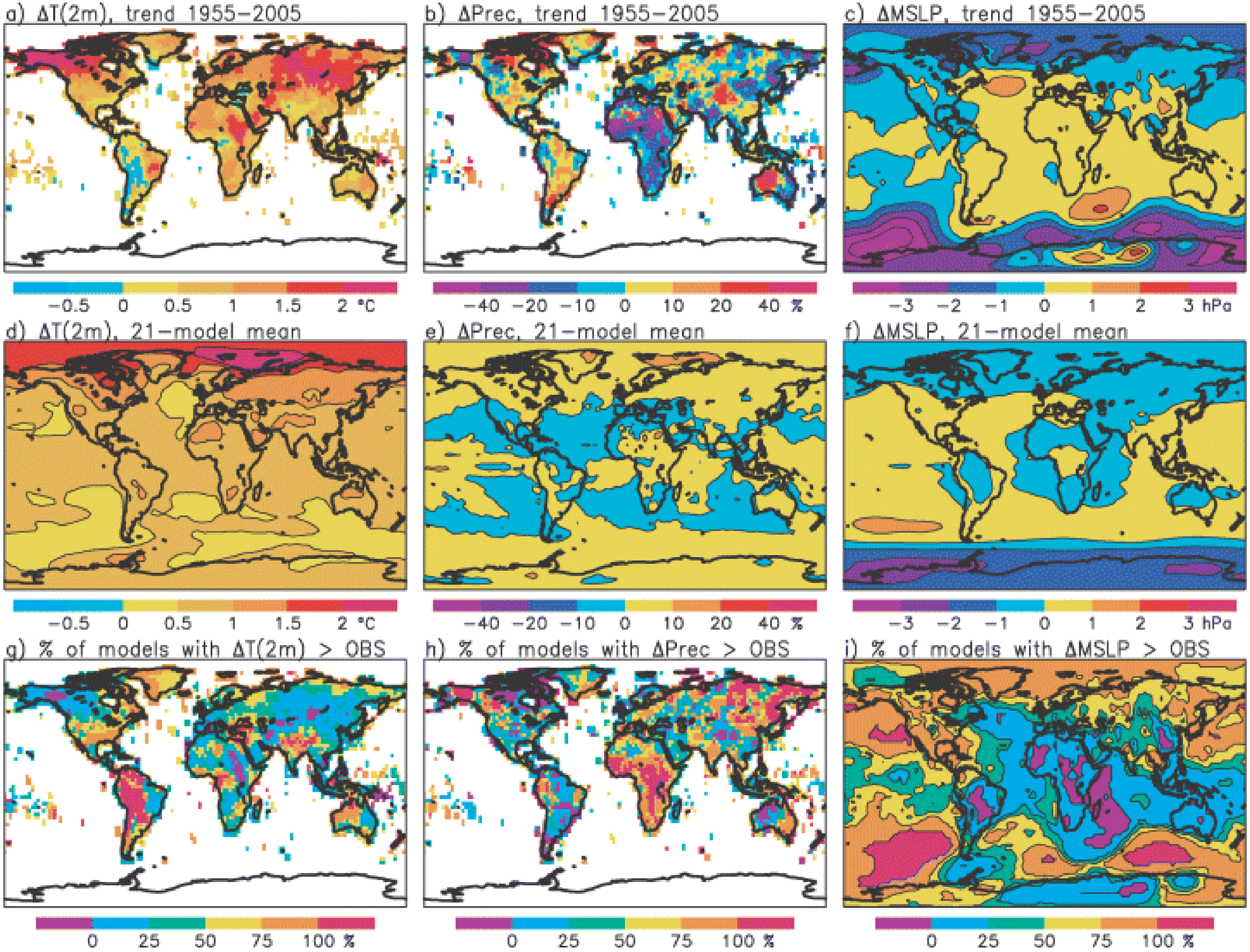
Hadley Centre for Climate Prediction and Research, UK. Model and simulations described by Gordon *et al.* (2000).

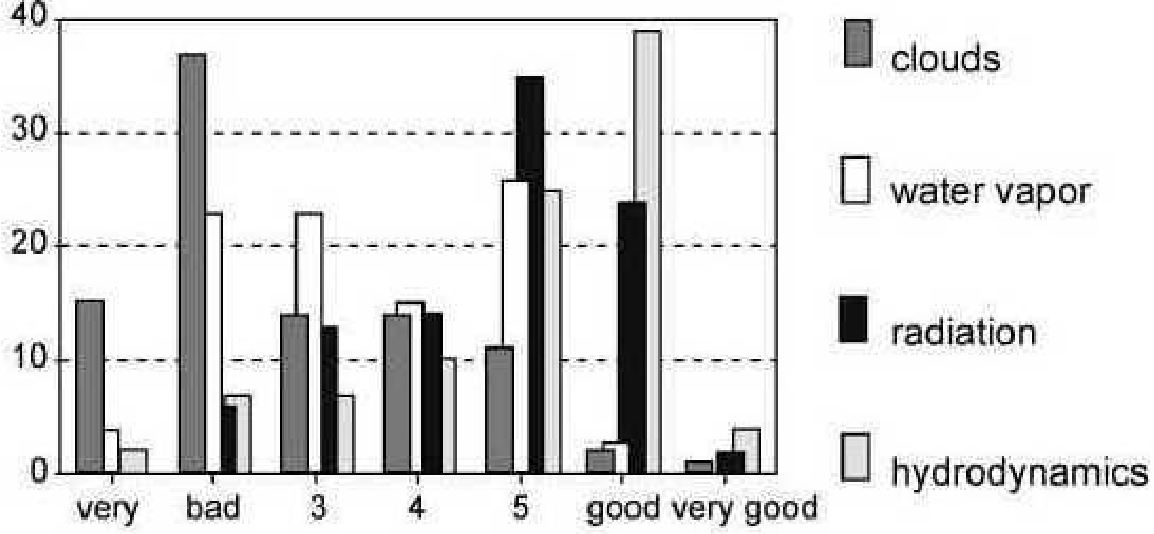


HadCM3

pattern: 0.67
% con: 44
% g1: 48

Fig. 6. Comparison between observed and simulated linear trends in annual mean climate from 1955 to 2005. (a)–(c) Observed changes in annual mean temperature (left; in °C/50 yr), precipitation (middle; per cent/50 yr) and mean sea level pressure (right; hPa/50 yr); (d)–(f): 21-model mean changes; (g)–(i): percentage of models with the change exceeding the observed change. (da Raisanen 2006 Tellus v.59°)





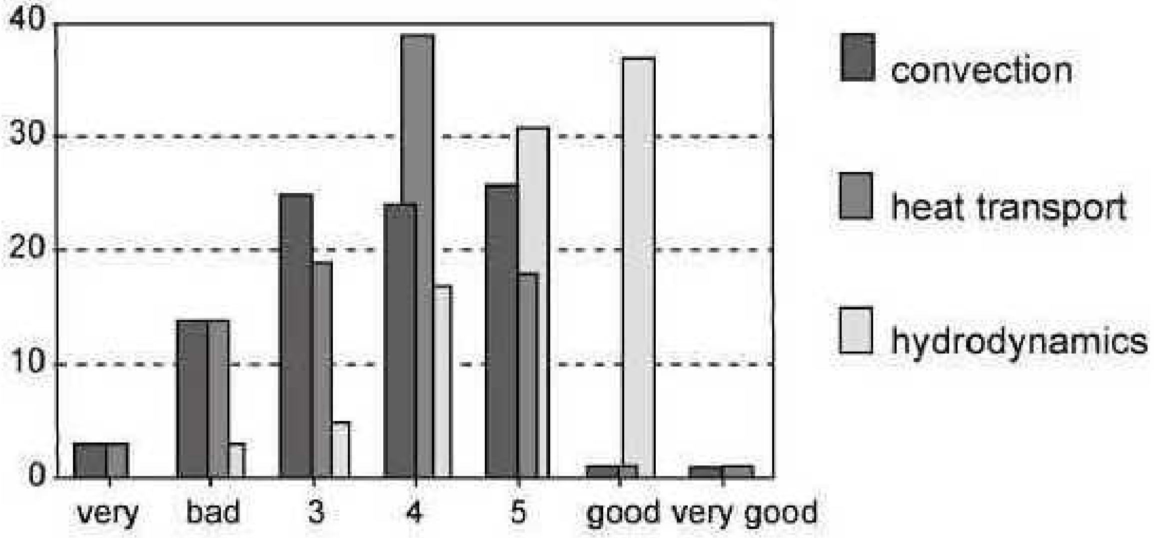


*Figure displays the outcome of a survey among 104 climate modellers, who have been asked to assess the skill of contemporary climate models in the end of the 1990s in describing a number of processes (**Bray and von Storch, 1999**). They were requested to respond a 7-graded scale, varying between "very good" and "very bad". For obvious reasons, the response "very good" is almost never heard. Hydrodynamics, i.e. the implementation of the laws of conservation of mass and momentum, is considered to be well reproduced. However, thermodynamic processes, related to convection or clouds, are assessed by many experts as being insufficiently represented. Of course, this assessment is partly reflecting the wish of modellers to continue their work in improving their models, but the outcome of the survey is also a strong evidence that models really need to be improved.*

The year 2100 is likely to be at least as different from the present as the present is from 1900. Emissions rates in 2100 are not only unknown, but unknowable because we do not know what the future holds for global population, income, energy efficiency and sources of energy.

Dr Manabe also made another important observation:

'Models that incorporate everything from dust to vegetation may look like the real world, but the error range associated with the addition of each new variable could result in nearly total uncertainty'.

This would certainly represent a paradox: The more complex the models, the less they tell us!

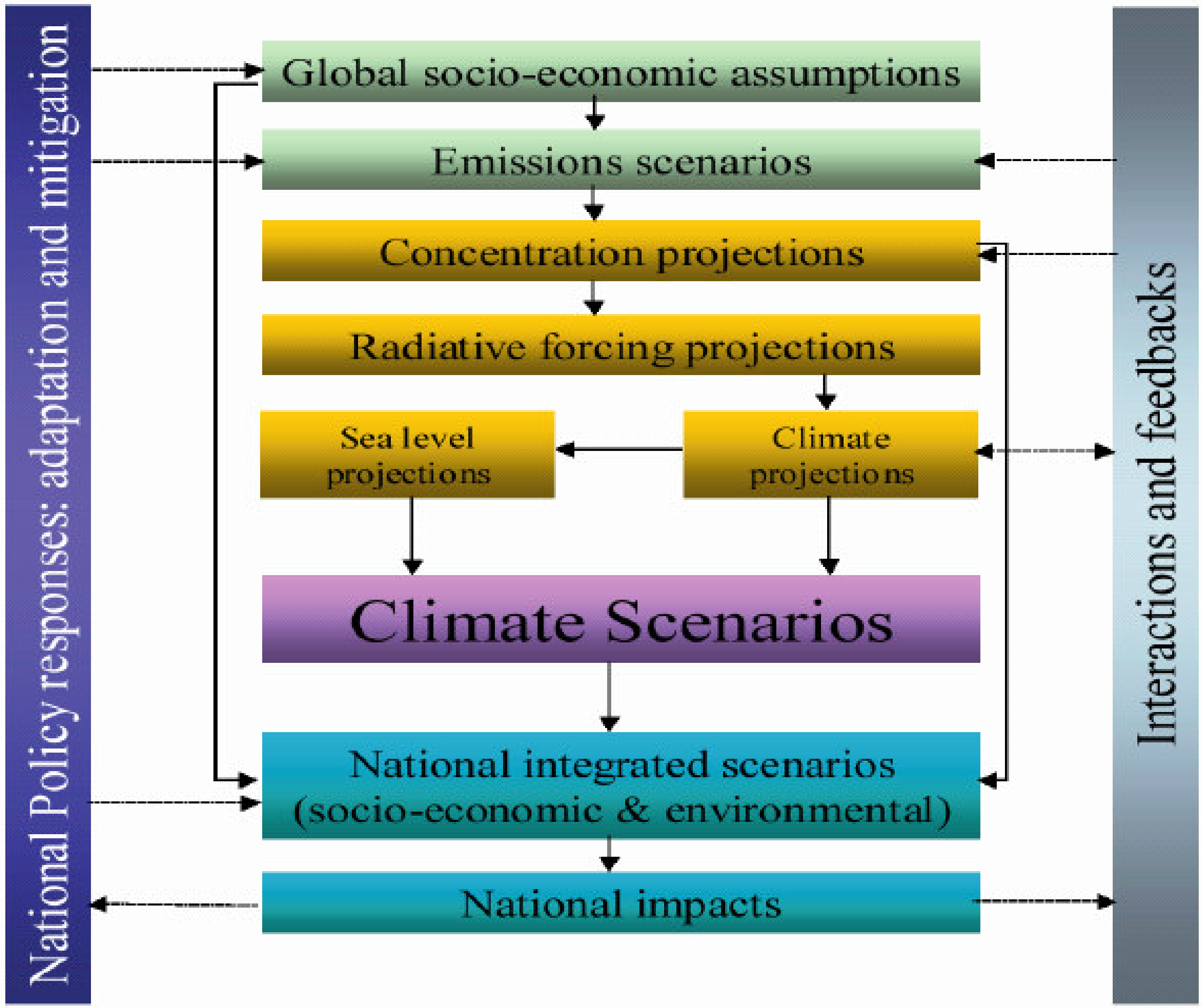
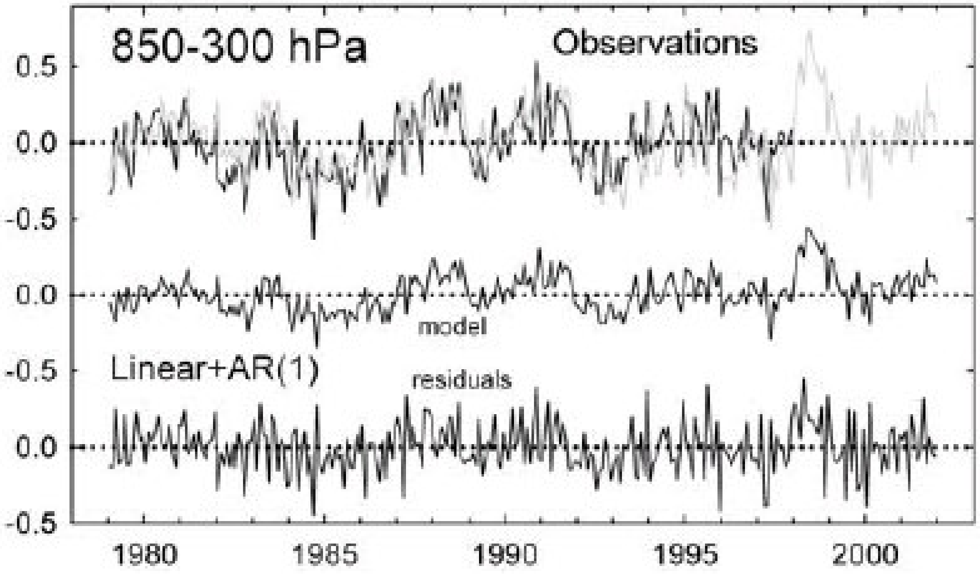

National Policy responses: adaptation and mitigation
Global socio-economic assumptions
Emissions scenarios
Concentration projections
Radiative forcing projections
Sea level projections
Climate projections
Climate Scenarios
National integrated scenarios (socio-economic & environmental)
National impacts
Interactions and feedbacks

Table 1. Best Statistical Models to Describe Global Temperature Changes for Each Atmospheric Level[a]

Level	Censored	Period	ΔT_{lin}	N_b	Best Model	ΔT_1	Second-Best Choice	ΔT_2	ΔS, %
Surface	no	1900–2002	0.66	2	Sloped Steps plus AR(0)	0.87	Piecewise Linear plus AR(0)	0.87	4.3
850–300 hPa	no	1958–2001	0.52	1	Sloped Steps plus AR(2)	0.32	Sloped Steps plus AR(1)	0.32	0.9
100–50 hPa	no	1958–2001	−1.81	6	Sloped Steps plus AR(1)	−1.82	Sloped Steps plus AR(2)	−1.82	2.1
100–50 hPa	yes	1958–2001	−1.9	6	Linear plus AR(1)	−1.90	Linear plus AR(2)	−1.90	2.6
MSU2	no	1979–2001	0.13	0	Linear plus AR(1)	0.13	Flat Step plus AR(1)	0.00	0.7
MSU4	no	1979–2001	−1.13	4	Sloped Steps plus AR(2)	−0.88	Sloped Steps plus AR(0)	−0.88	10.5
MSU4	yes	1979–2001	−0.99	4	Flat Steps plus AR(1)	−0.83	Linear plus AR(1)	−0.99	8.1
850–300 hPa	no	1979–2001	0.14	0	Linear plus AR(1)	0.14	Linear plus AR(2)	0.14	0.3
100–50 hPa	no	1979–2001	−1.67	4	Sloped Steps plus AR(1)	−1.18	Sloped Steps plus AR(2)	−1.18	3.9
100–50 hPa	yes	1979–2001	−1.48	4	Linear plus AR(1)	−1.48	Linear plus AR(2)	−1.48	5.7

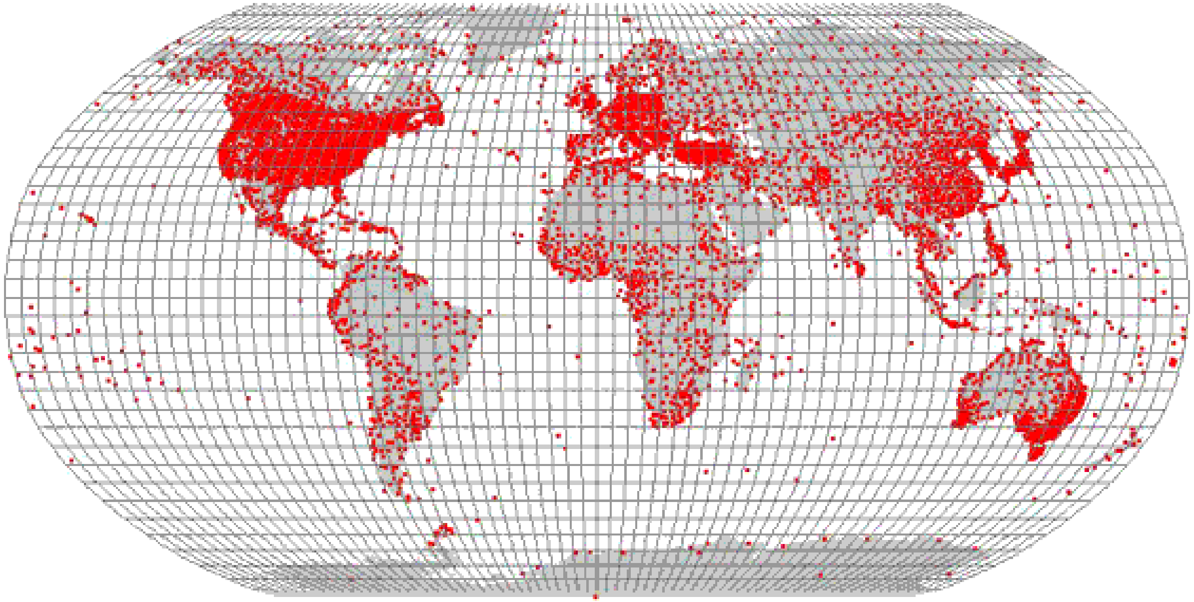
[a]Also shown are second-best statistical models and net temperature change (K) from each (ΔT_1 and ΔT_2) over the data period. Results are based on the Schwarz Bayesian Information Criterion, $S(q)$. Also shown are the net temperature change (K) from the linear model (ΔT_{lin}), the number of breakpoints (N_b) identified in the time series, and the percentage difference in $S(q)$ between the two best models ΔS. If "volcanically perturbed" periods have been excluded from the analysis, the table entry for "censored" is "yes." MSU is microwave sounding unit, and AR(1) and AR(2) are first- and second-order autoregressive models, respectively.



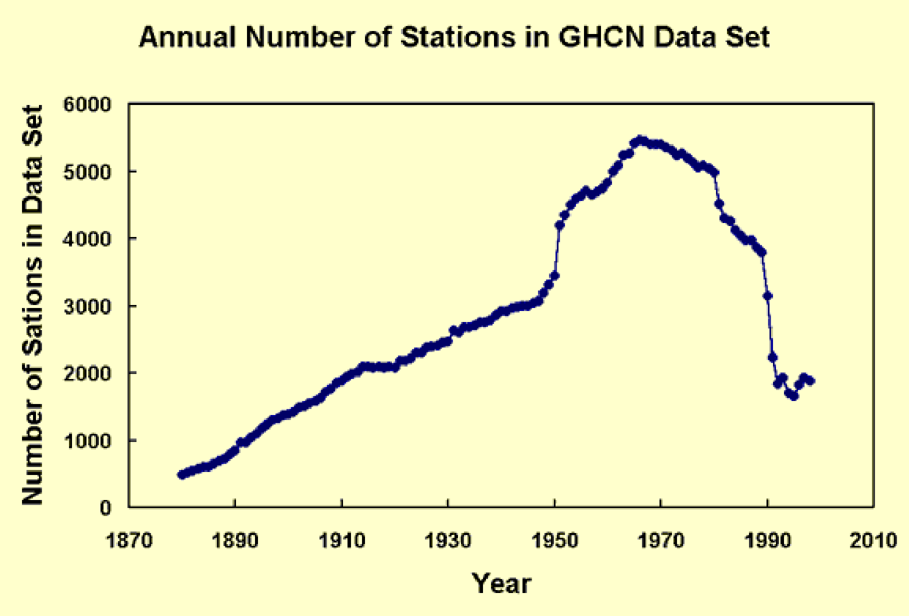
SEIDEL AND LANZANTE: ALTERNATIVE TEMPERATURE CHANGE MODELS

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 109, D14108, doi:10.1029/2003JD004414, 2004

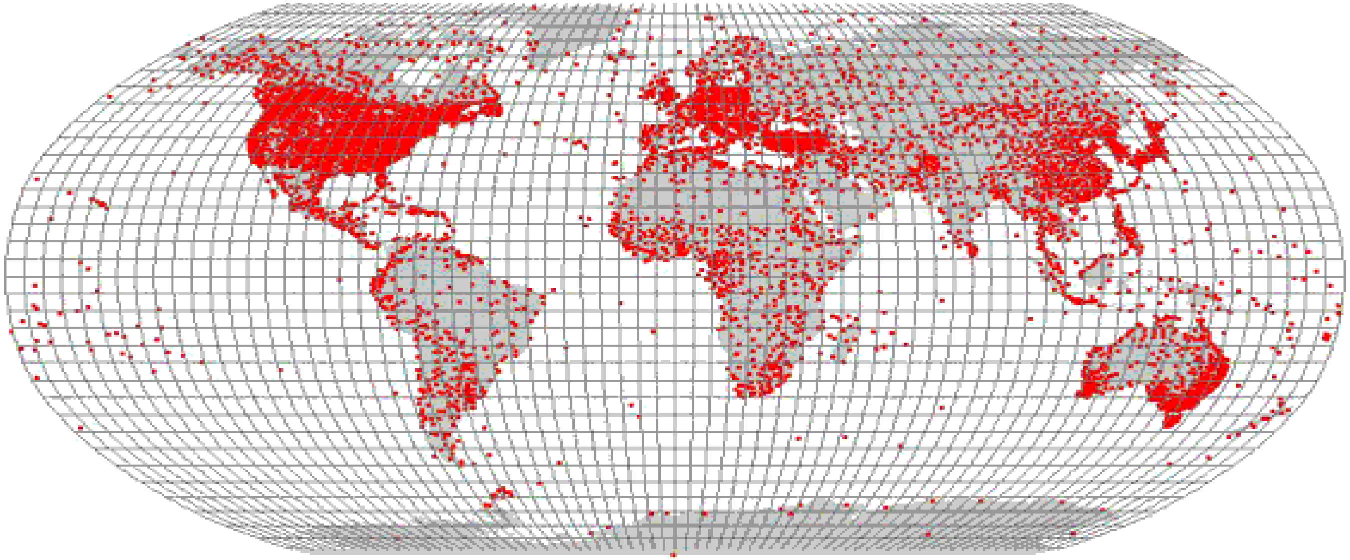
GHCN Temperature Data Set Station Locations



Station locations are indicated by the individual red circles that are superimposed on top of the 5° latitude by 5° longitude grid boxes to which they belong.

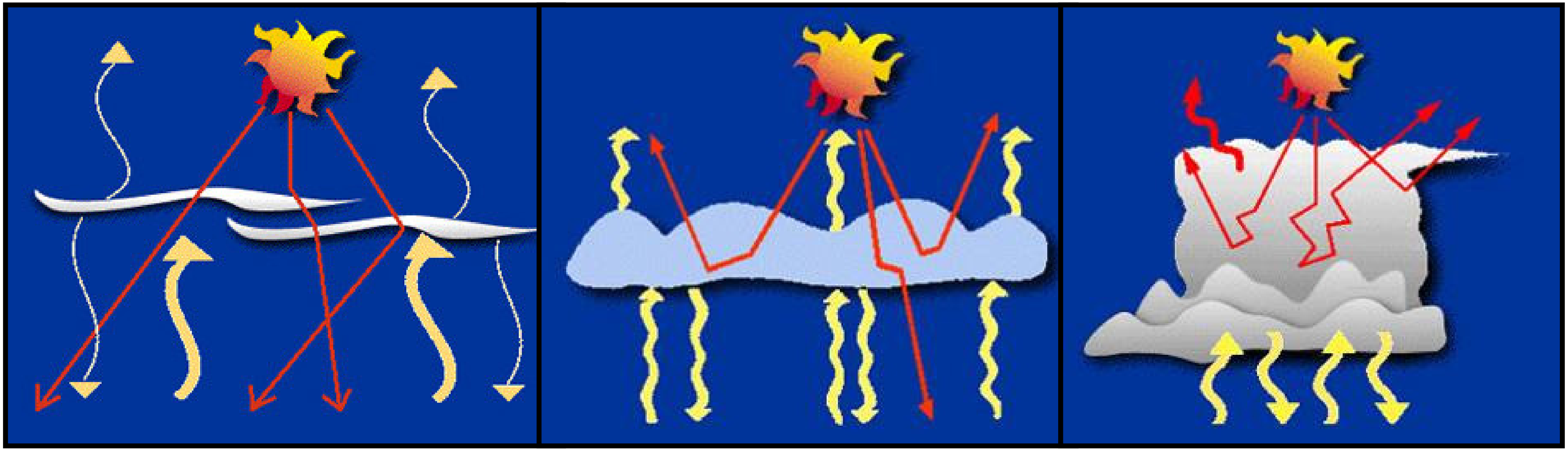


GHCN Temperature Data Set Station Locations



Station locations are indicated by the individual red circles that are superimposed on top of the 5° latitude by 5° longitude grid boxes to which they belong.

PROPRIETA' DELLE NUBI



Cirri: nubi alte e sottili.

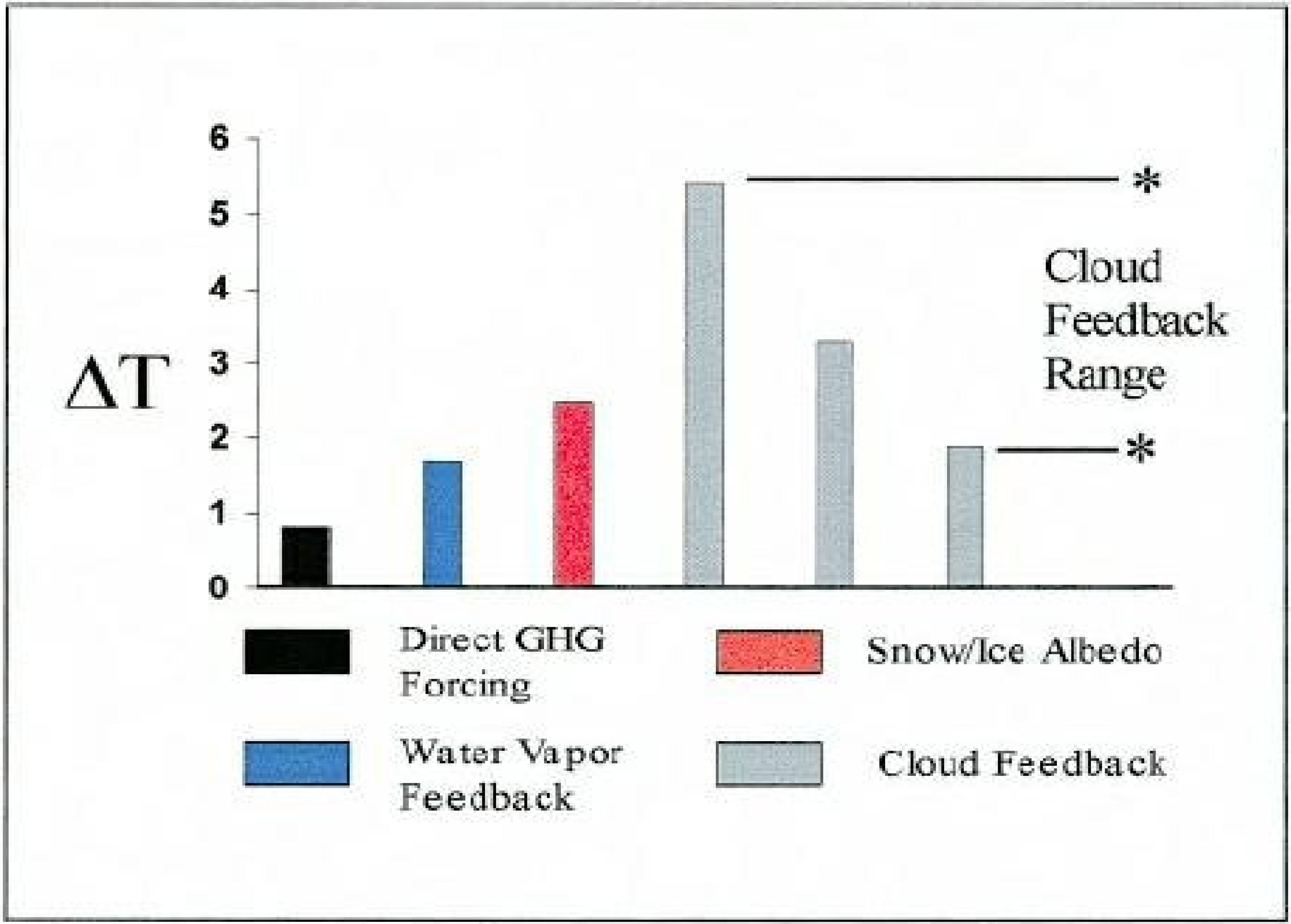
Tendono a scaldare la superficie.

Stratocumuli: nubi basse e spesse.

Tendono a raffreddare la superficie.

Cumulonembi: nubi profonde e convettive.

Non riscaldano e non raffreddano la superficie.


ΔT
6
5
4
3
2
1
0
*
*
Cloud Feedback Range
Direct GHG Forcing
Snow/Ice Albedo
Water Vapor Feedback
Cloud Feedback

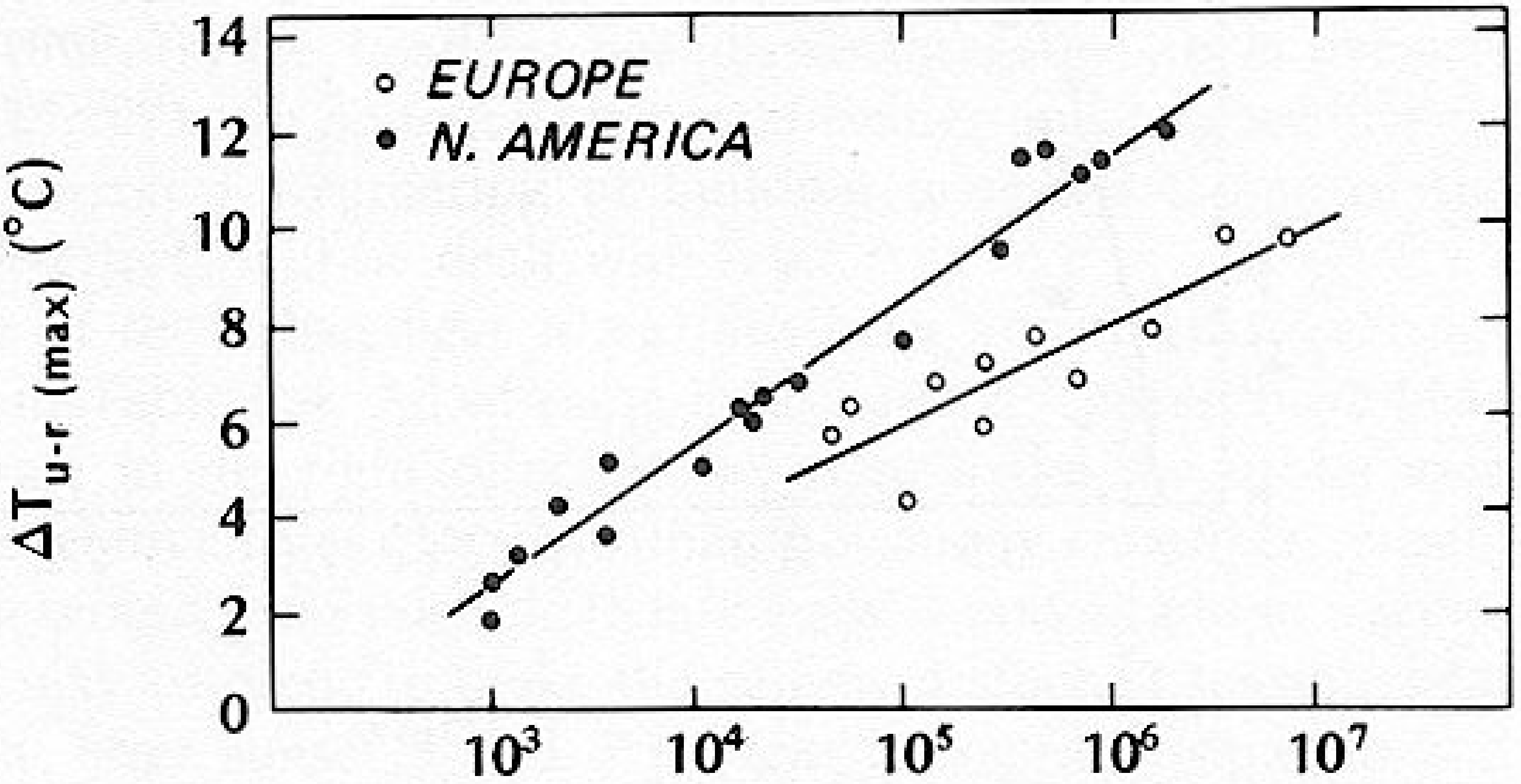
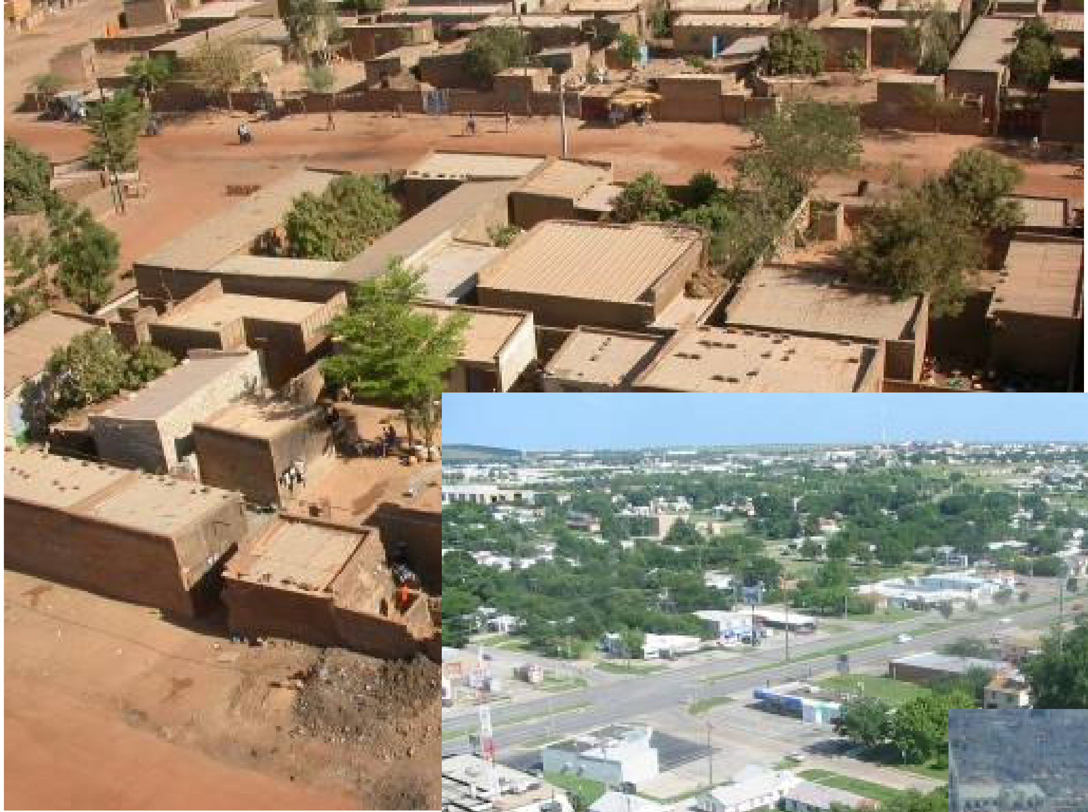
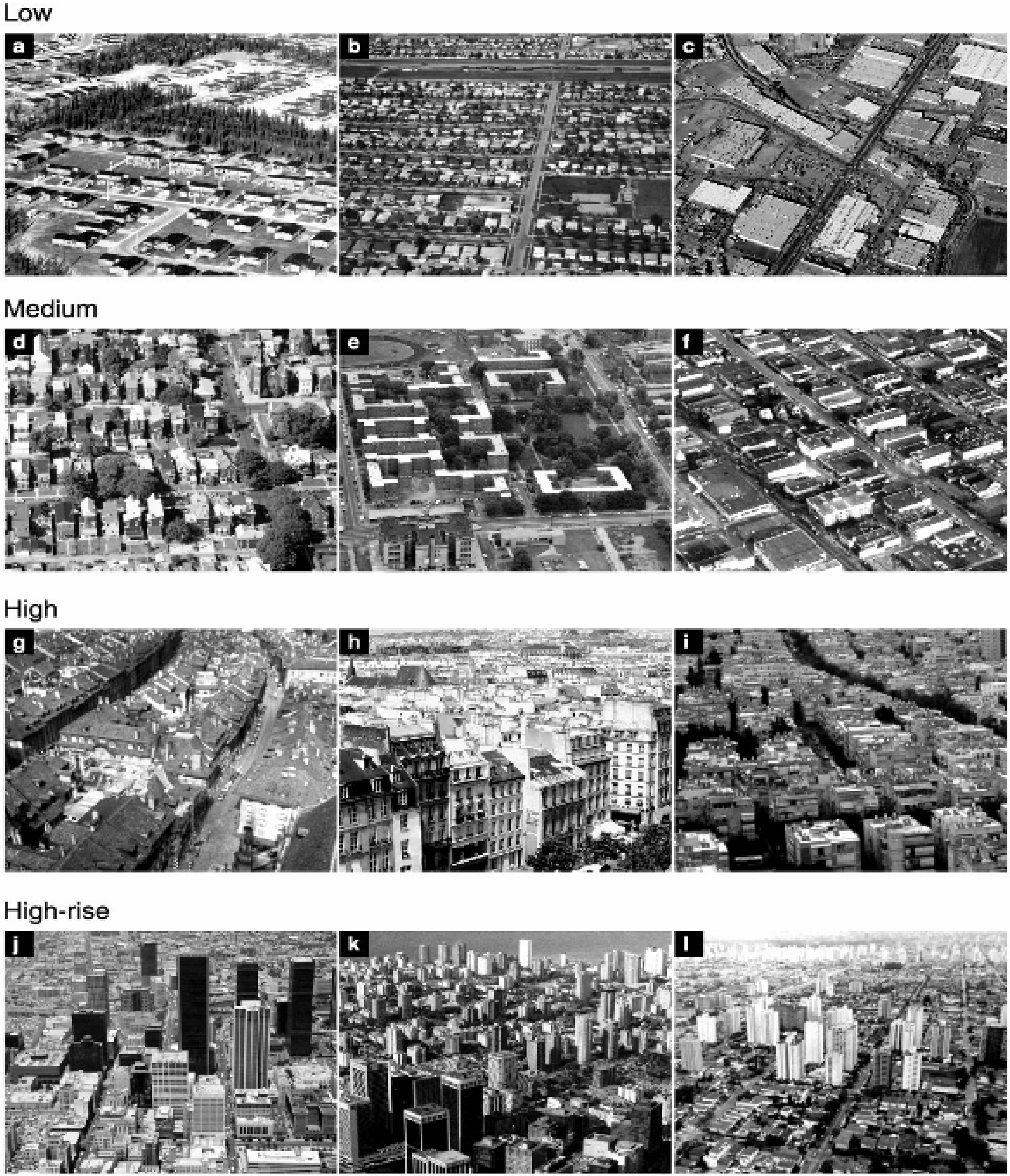


Figure 8.15 Relation between maximum observed heat island intensity ($\Delta T_{u-r(max)}$) and population (P) for North American and European settlements (modified after Oke, 1973).

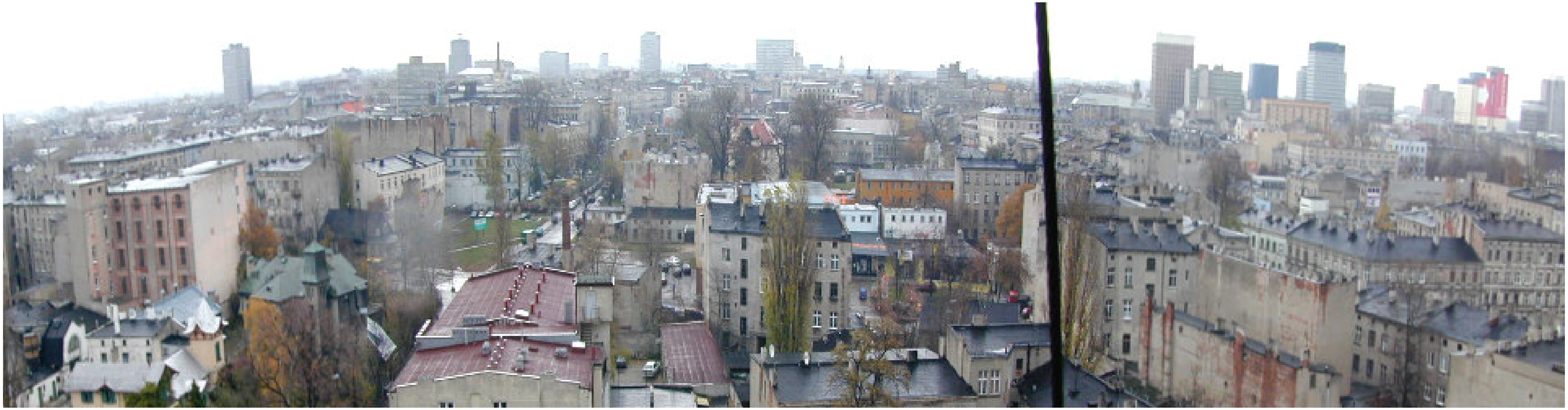


Changes in surface morphology
Changes in surface cover
Additional anthropogenic sources of heat, water, other gases and particulates



Wind flow

- **Dispersion**
- **Flux partitioning**
- **BL height**
- **Air quality**
- **Surface runoff**
- **Solar access**
- **Radiative cooling**



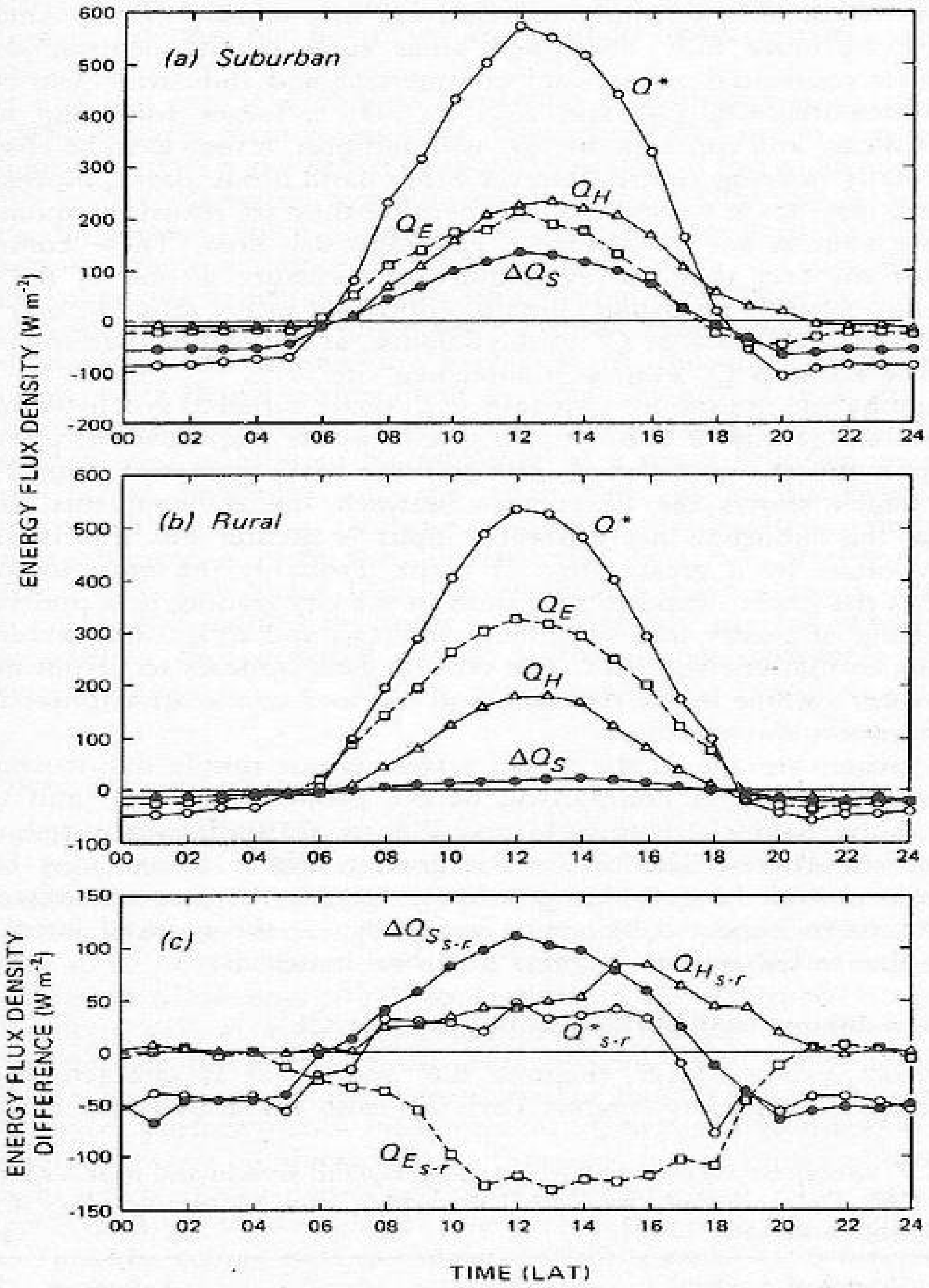

(a) Suburban
(b) Rural
(c)
Q*
Q_H
Q_E
ΔQ_S
$\Delta Q_{S_{s-r}}$
$Q_{H_{s-r}}$
Q^*_{s-r}
$Q_{E_{s-r}}$
ENERGY FLUX DENSITY (W m^{-2})
ENERGY FLUX DENSITY DIFFERENCE (W m^{-2})
TIME (LAT)

Figure 3a: Typical Daily Summer Rural Energy Balance

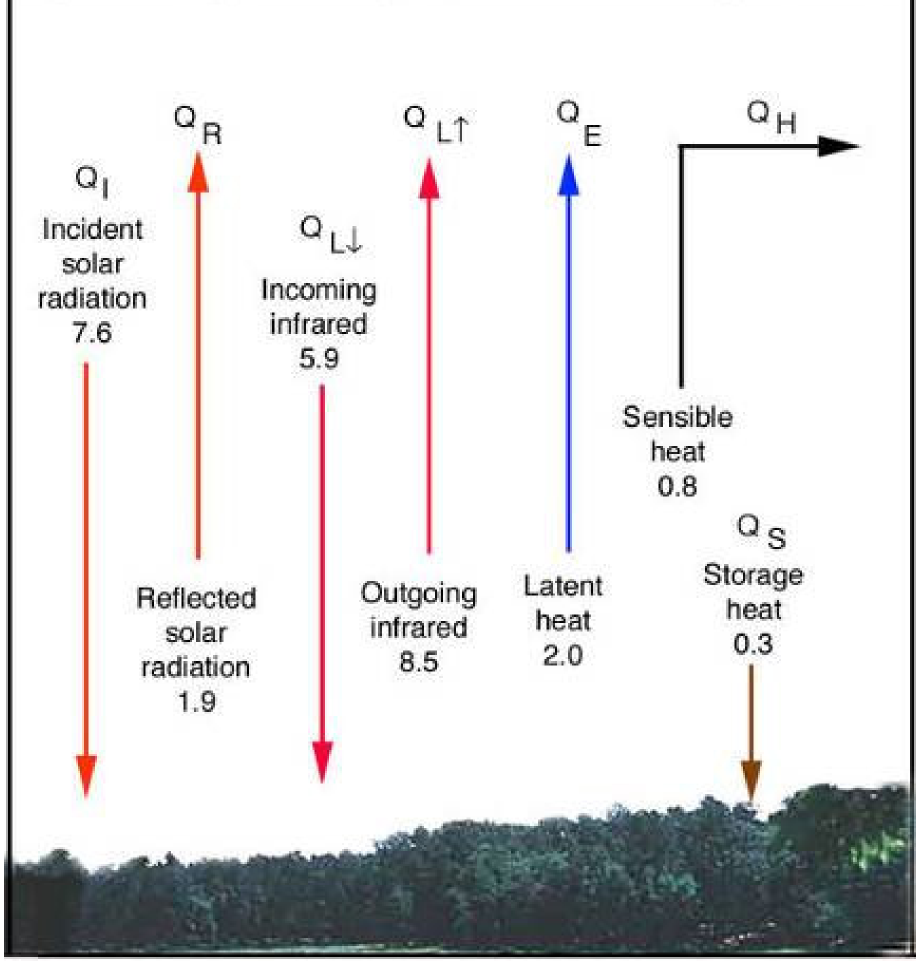
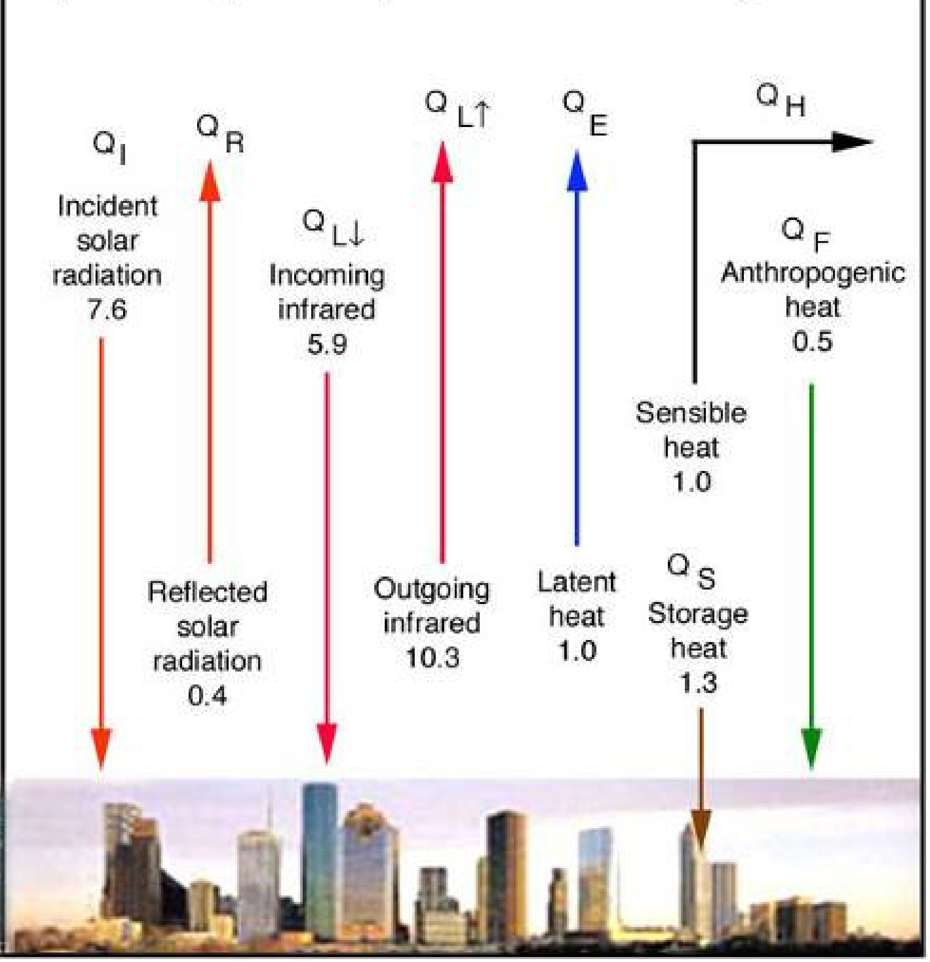


Figure 3b: Typical Daily Summer Urban Energy Balance



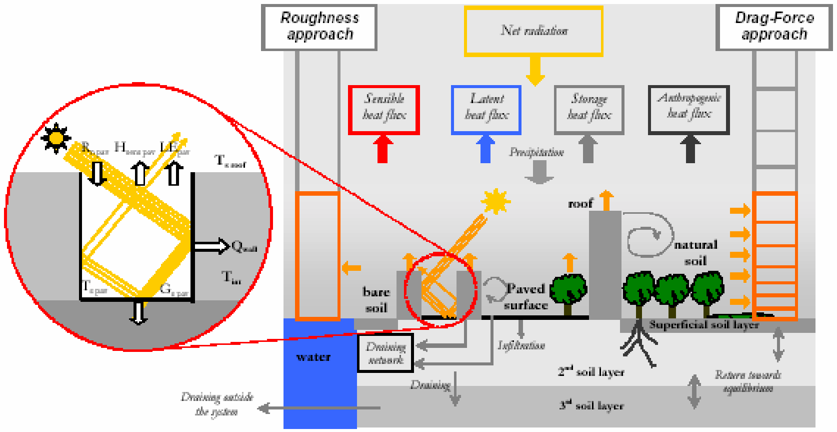
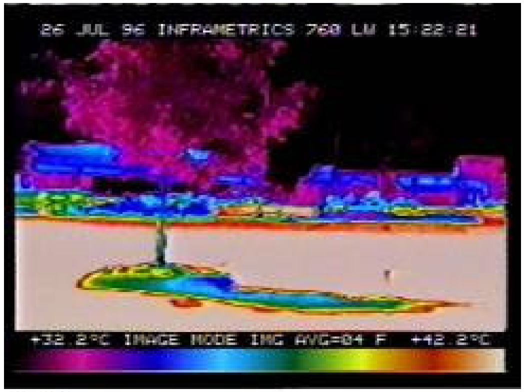
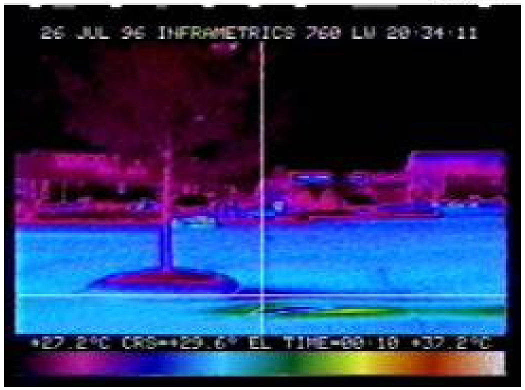


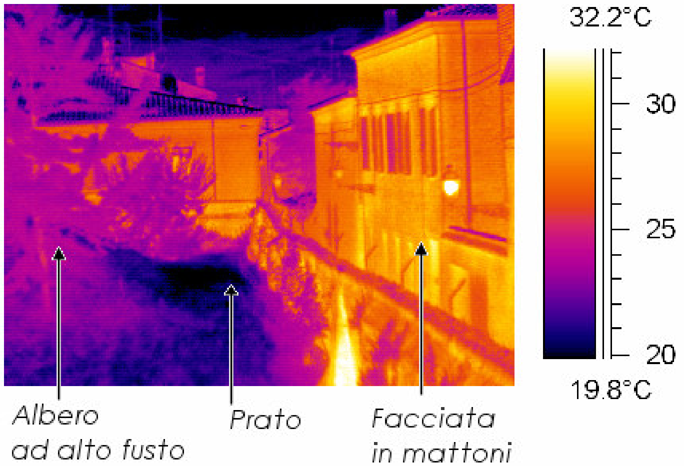
Figure 1. Scheme of the new MM5 canopy parameterization, DA-SM2-U, using the drag-force approach with the soil model SM2-U(3D), compared with the roughness approach.

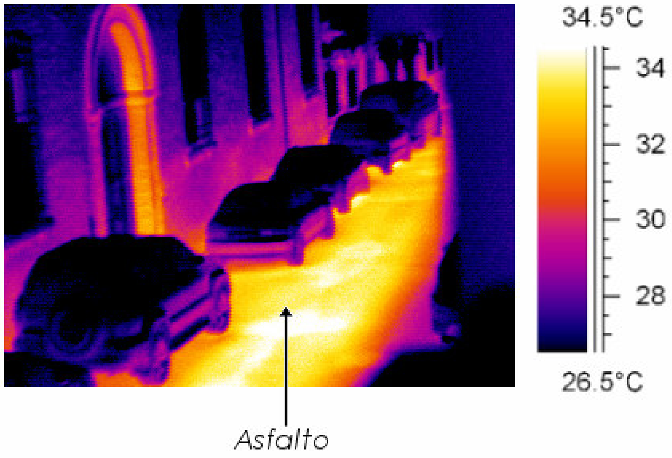


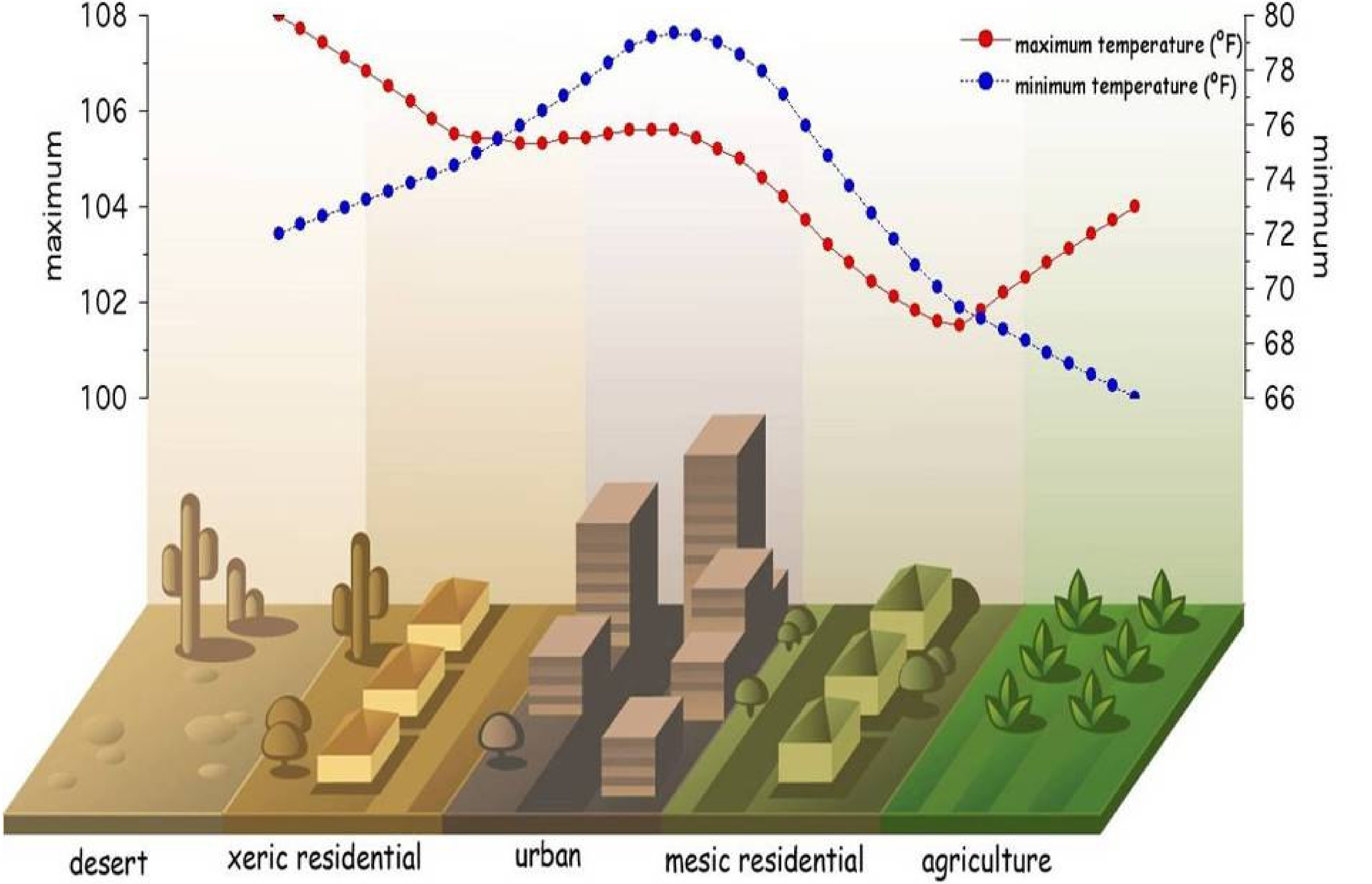
Day

Night








108
106
104
102
100
maximum
80
78
76
74
72
70
68
66
minimum
maximum temperature (°F)
minimum temperature (°F)
desert
xeric residential
urban
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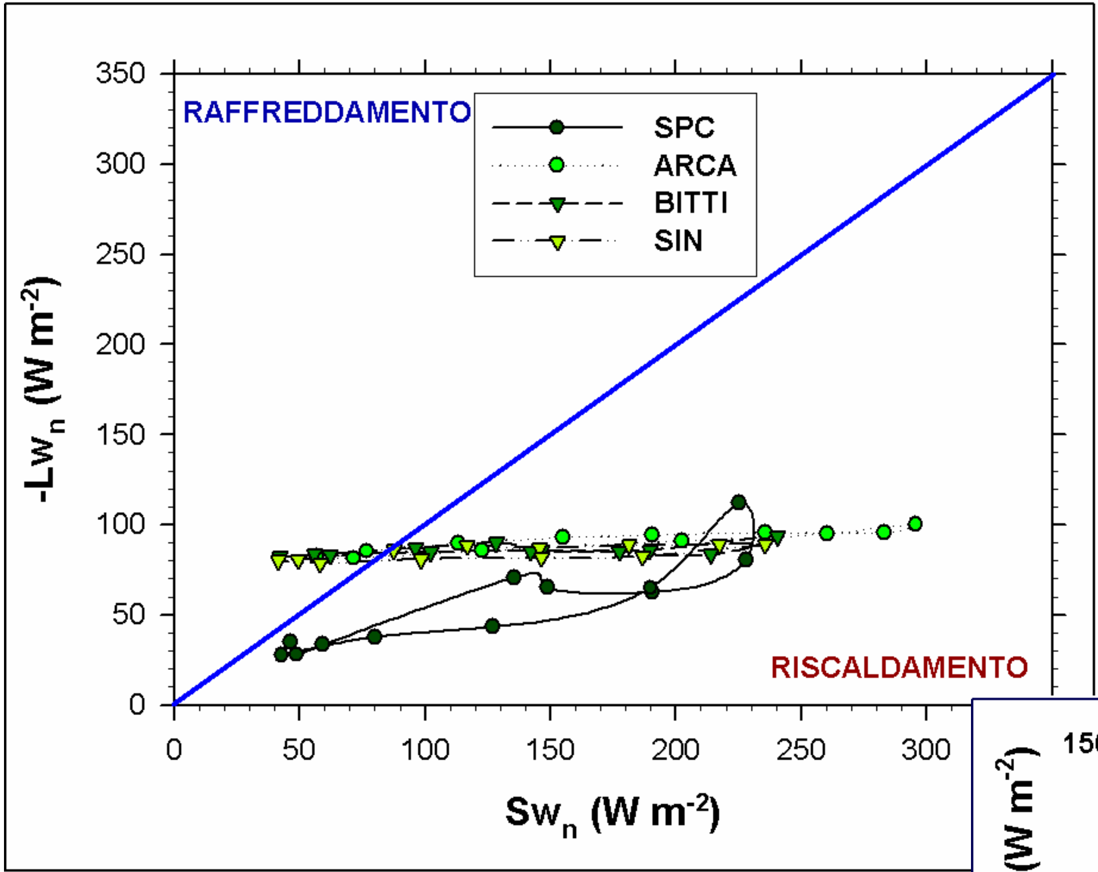
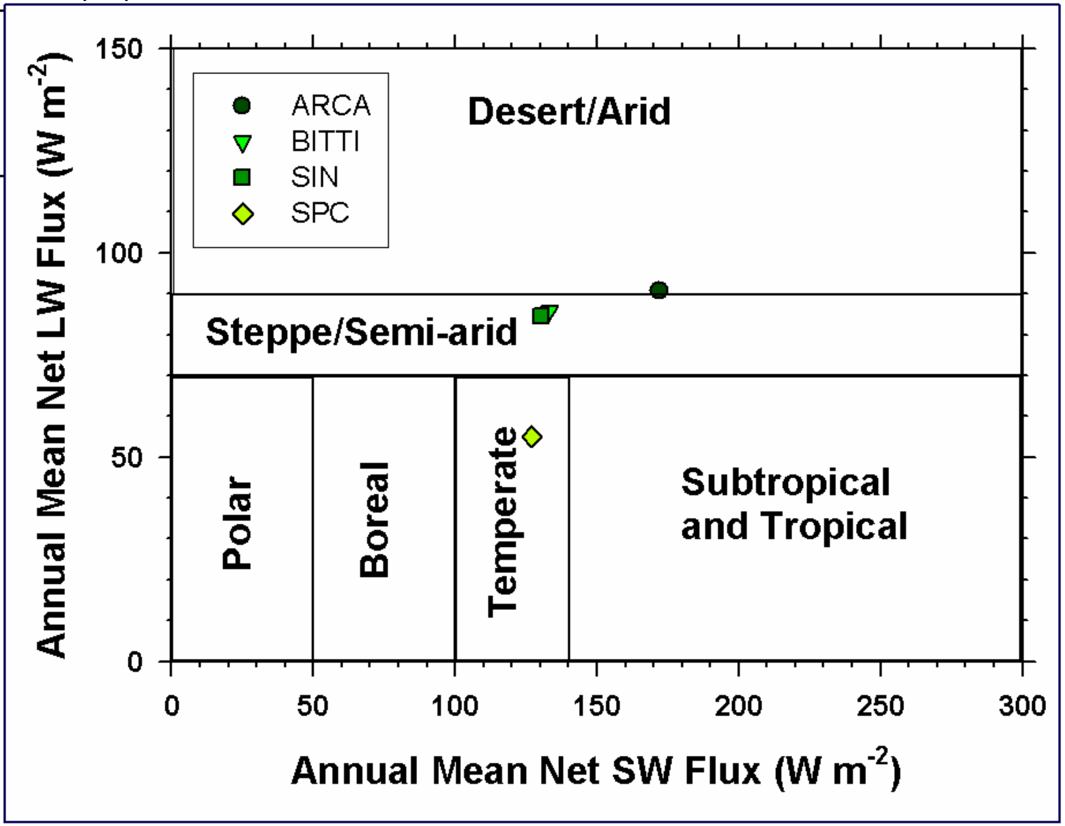
agriculture



RAFFREDDAMENTO
RISCALDAMENTO
SPC
ARCA
BITTI
SIN
$-Lw_n$ (W m^{-2})
Sw_n (W m^{-2})
0
50
100
150
200
250
300
350



ARCA
BITTI
SIN
SPC
Desert/Arid
Steppe/Semi-arid
Polar
Boreal
Temperate
Subtropical and Tropical
Annual Mean Net LW Flux (W m^{-2})
Annual Mean Net SW Flux (W m^{-2})
0
50
100
150
200
250
300

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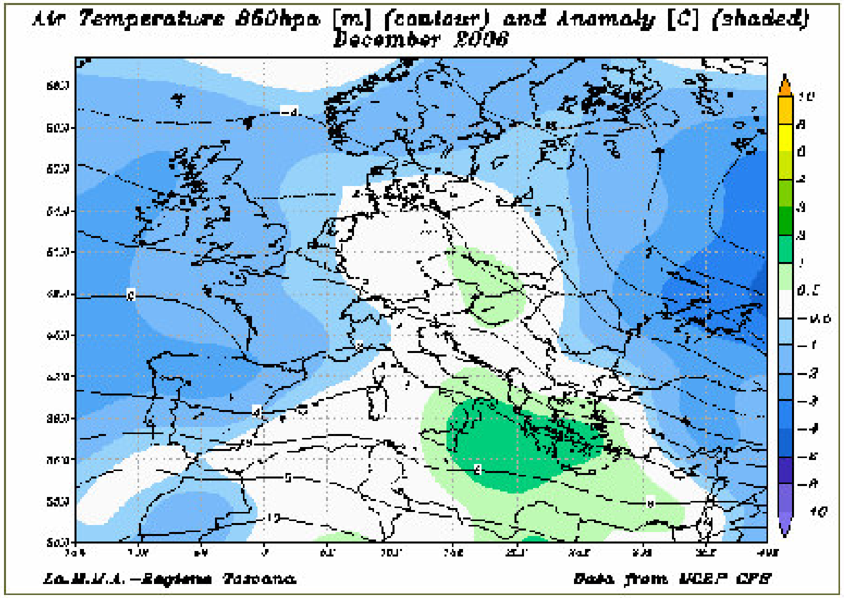

Last Update: 18-09-2006

CFS (NCEP Climate Forecast System): a coupled ocean-atmosphere model. The atmospheric part is a low-resolution version of the operative model GFS (Global Forecast System) while the oceanic component is the version 3 of GFDL Modular Ocean Model (MOM3). CFS run on initial conditions of 7 days ago obtained from NCEP/NCAR Reanalysis-2 (for the atmosphere) and from GODAS (for the sea). Results are produced for the partial first month and for the nine following months (here are represented only the 3 following months).

CCCMA (Canadian Centre for Climate Modelling and Analysis): based on a second generation global circulation model. Results derive from a 6-member ensemble (derived from the 6 days ago). SST's anomalies are constant over the three months of the forecast (current month and the following two). Model run over a Gaussian grid with 97x48 grid-point, with an approximate resolution of 3.75x3.75.

References:

- Saha,S. et al: The NCEP Climate Forecast System, 2005 (Accepted for publication in J.Climate)
- McFarlane,N.A. et al: The Canadian Climate Centre second-generation general circulation model and its equilibrium climate. J.Climate,5,1013-1044

For further information on the models:

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IBIMET CNR Seasonal Weather Forecast

This site is devoted to the presentation of the research activities carried on by the Institute of Biometeorology (IBIMET) of the National Research Council (CNR) in the domain of Seasonal Weather Forecast. The site, conceived as a work in progress, present the last updates of the on-going development and validation activities.

IBIMET issues monthly seasonal forecast based on different methodologies for the following target areas:

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- Models Outlook

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- Analogues method
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Seasonal forecasting methodologies and results presented in these pages have to be considered as experimental products, derived from innovative procedures and algorithms, that need to be further validated and improved.
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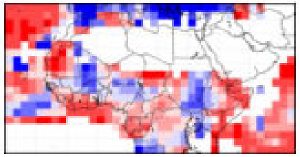
Seasonal Products:

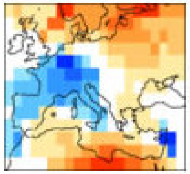
Seasonal Forecast for North Africa and Sahel

Analogue Algorithm Forecast



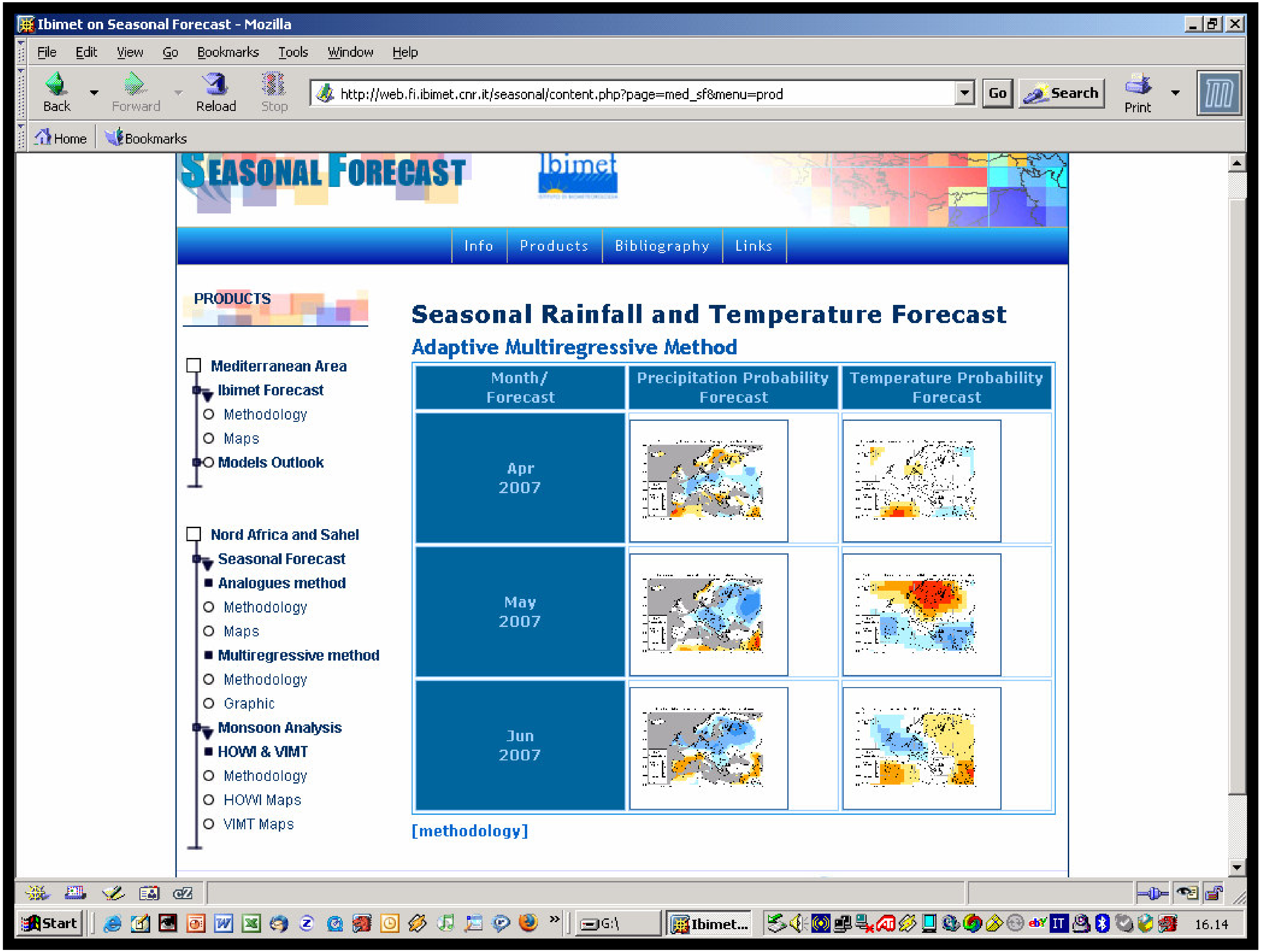
Seasonal Forecast for Europe and Mediterranean

Adaptive Multiregressive Method



Monsoon Analysis

HOWI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The actions that we take on climate change should be robust to (i) the diversity of scientific perspectives, and thus also to (ii) the diversity of perspectives of the nature of the consensus. A consensus is a measure of a central tendency and, as such, it necessarily has a distribution of perspectives around that central measure (*1*). On climate change, almost all of this distribution is well within the bounds of legitimate scientific debate and reflected within the full text of the IPCC reports. Our policies should not be optimized to reflect a single measure of the central tendency or, worse yet, caricatures of that measure, but instead they should be robust enough to accommodate the distribution of perspectives around that central measure, thus providing a buffer against the possibility that we might learn more in the future (*2*).

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