Global and regional climate changes: myths and reality

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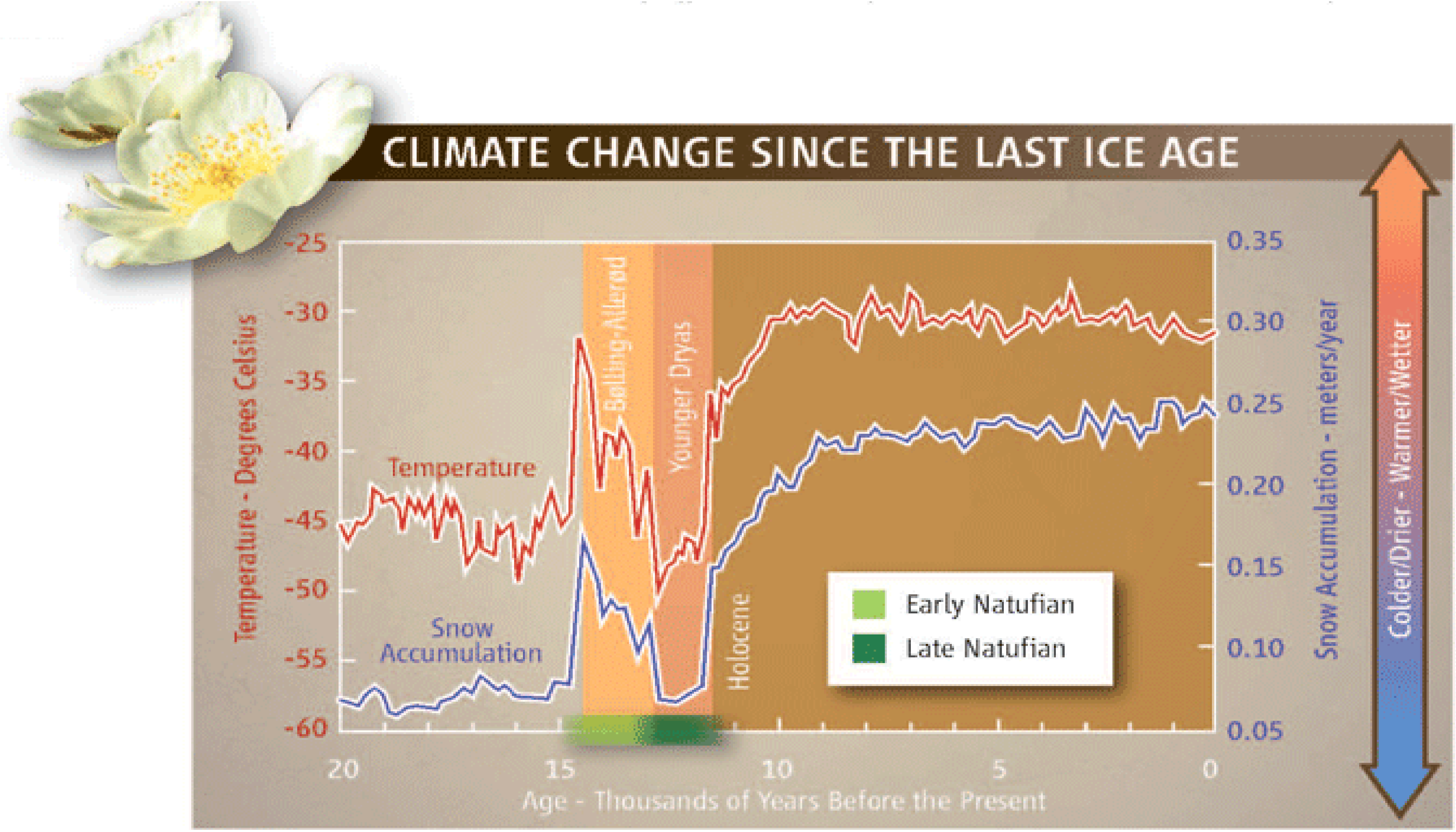
Question 1: *Where we are at the glacial-interglacial natural cycle?*

Question 2: *Has got recent climate any unique peculiarities?*

Question 3: *Is global warming still happening and if yes what is its most dengerous consequenceis?*

Reconstruction of Greenland air temperature and snow accumulation rate in winter for recent 20,000 yrs. Vertical strips point to climatic shifts (B-O event and Younger Dryas, after /Balter et al., Science, 2010/)



Sea level changes over four glacial cycles

Реконструкции изменчивости уровня Мирового океана за последние 450 тыс. лет

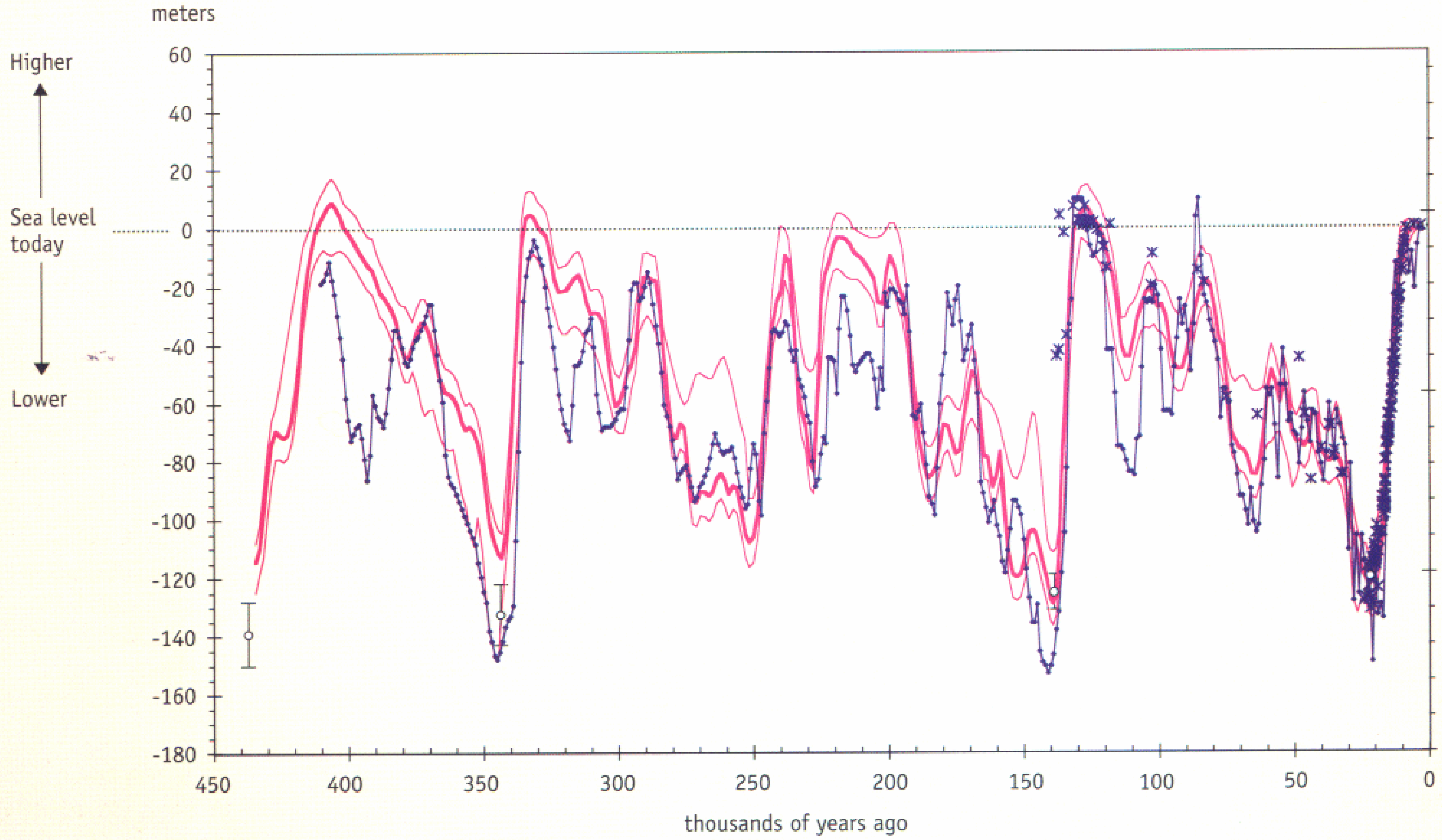
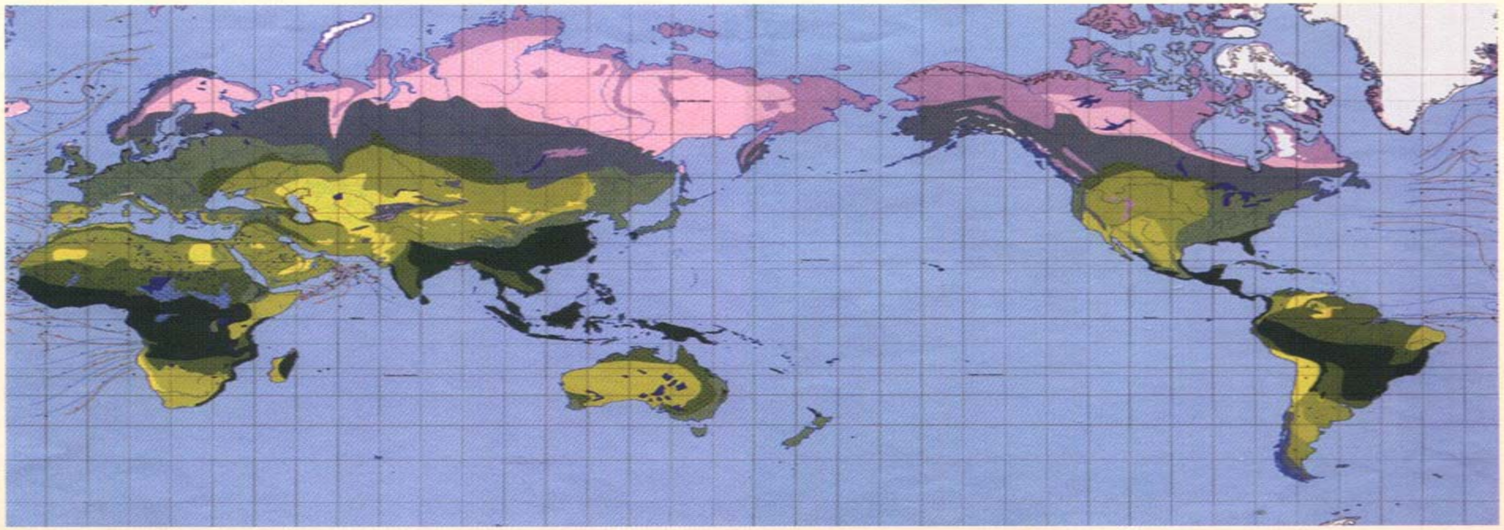


Figure ① Various estimates of how sea-level has changed over the last four glacial cycles. These were obtained from evidence of former shorelines (such as those now uplifted by Earth movement above modern sea-level, as shown on the previous page) and from changes in ocean chemistry resulting from the growth of ice sheets on the continents, which altered ocean composition. According to the reconstructions shown here, during the maximum glacial conditions (e.g. around 20-30 thousand years ago) sea-level was 120-140 m below present (shown as zero on this graph). During past warm periods (interglacials), such as 125-130 thousand years ago, sea-level was higher (by 5-10 m) because global continental ice cover was less than that of today.

source: Labeyrie et al (in preparation) in Paleoclimate, Global Change and the Future, Springer.

Ice and biome distribution 6000 years before present



Реконструкция последнего климатического оптимума и оледенения (6 и 21 тыс. лет тому наза

Ice and biome distribution at the last glacial maximum (21 000 years ago)

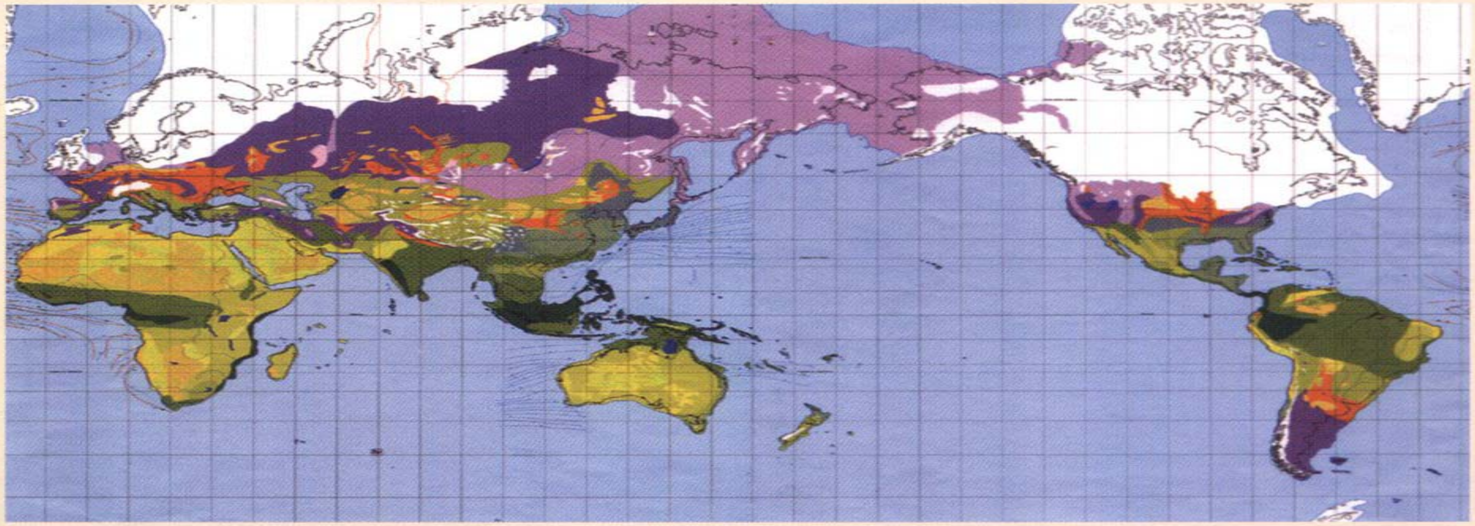
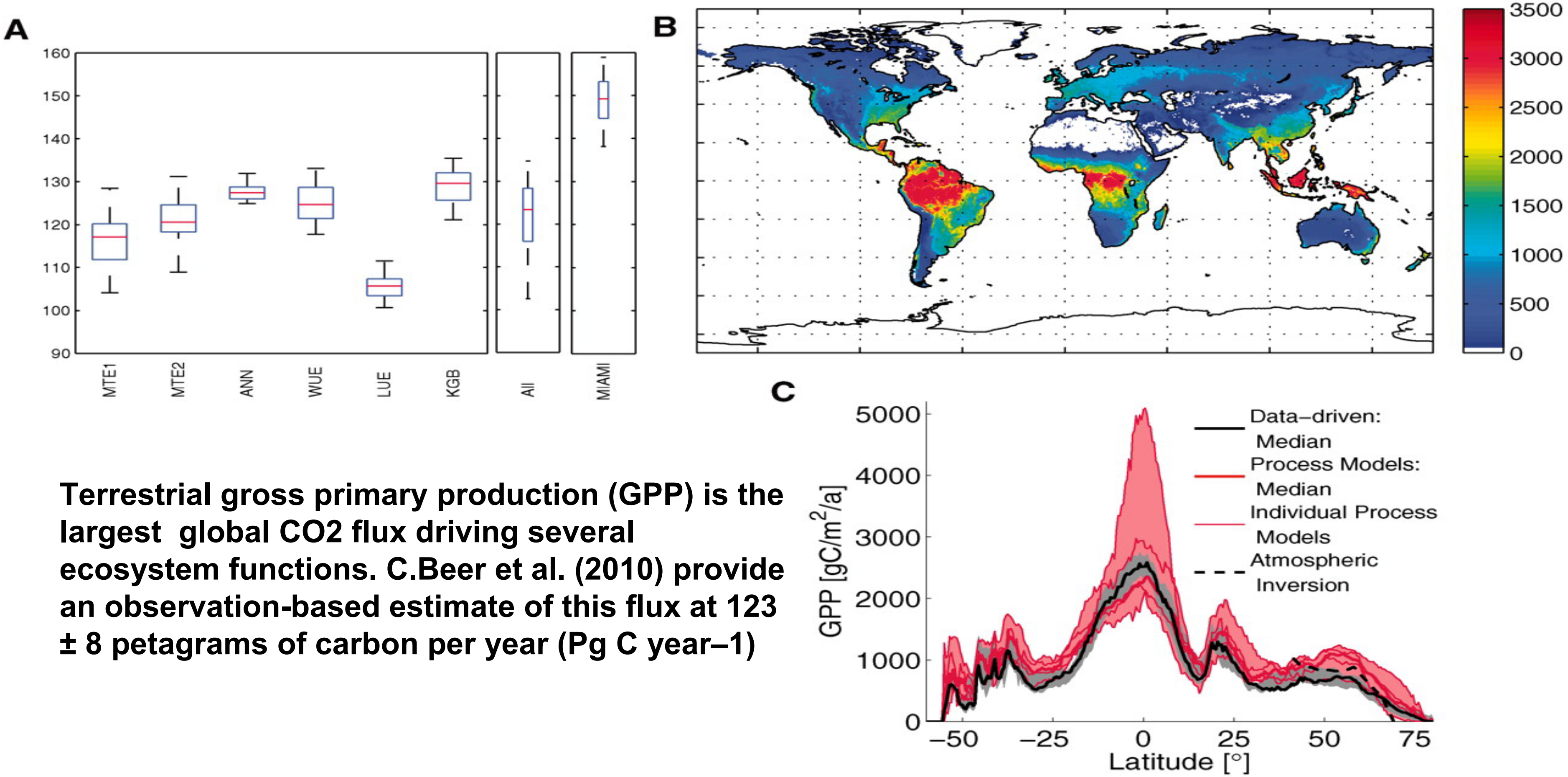


Figure ② Two reconstructions of what the world looked like during the height of the last glaciation (below) and around 6000 years ago (above). Note that the extent of sea-ice is not shown (nor is Antartica). Work is continuing on refining these maps. There is a considerable debate over the former extent of ice cover (e.g. in North West Russia) and over the character of vegetation cover in many regions (e.g. Amazonia) during glacial times. On these maps greens represent vegetation requiring more moisture and browns and yellows are aridity tolerant biomes. Purples represent tundra, taiga and step vegetation and white is ice. Full documentation is available in the original publication.

source: Petit-Maire (1999) C.R. Acad Sci Paris, Earth + Planetary Sciences, 328, 273-279.

Recent climatic epoch is characterized by additional anthropogenic forcing

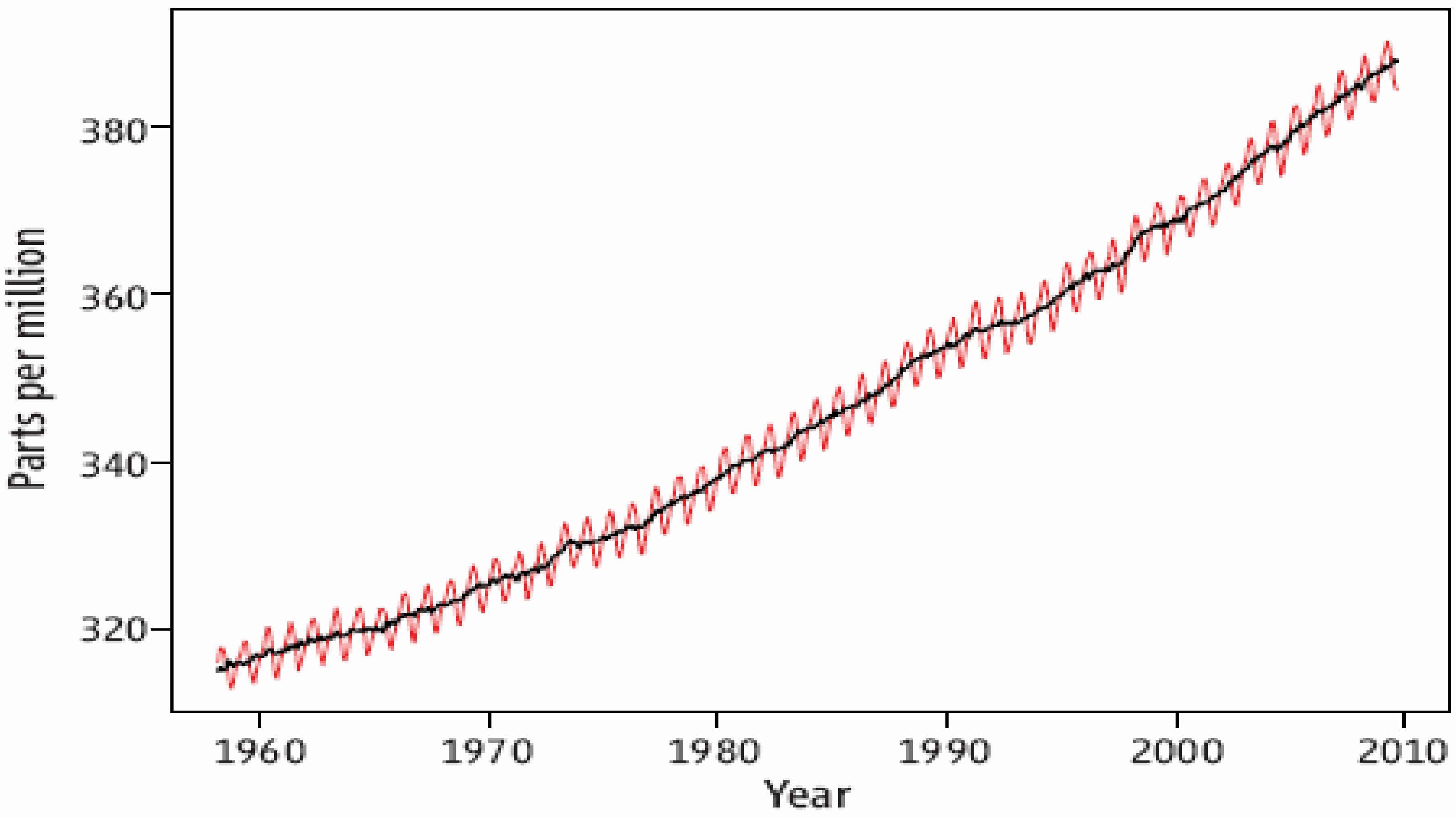
- There is extremely fast increasing of greenhouse gases (CO_2, N_2O, CH_4, clorofluorocarbons) after beginning of industrial revolution
- Typical yearly CO_2 emission now is ~ 10 Gt of C (1Gt= 10^{12} kg=10^{15}g). Ocean uptake is about 25-30% of total emission. 70 to 75% of total GHG emission increase the atmospheric GHG concentration and this warms the low troposphere (~0.75ºC/ century, IPCC report, 2007).At the same time, aerosol emission leads to cooling of the low troposphere and there are numerous feedbacks within climatic system.
- **In fact, anthropogenic forcing is essential at the multi-decadal-to-centennial scale**.
- ***Besides, there is intense interannual-to-multi-decadal natural climate variability. So, the problem is rather to separate the natural and human-induced changes than to discuss the reality of the anthropogenic warming***



Terrestrial gross primary production (GPP) is the largest global CO2 flux driving several ecosystem functions. C.Beer et al. (2010) provide an observation-based estimate of this flux at 123 ± 8 petagrams of carbon per year (Pg C year–1)

(**A**) Distributions of global GPP (Pg C year–1) for the five data-driven approaches that are most constrained by data, their combined global GPP distribution, and the GPP distribution by the Miami model. Shown are the median (red horizontal lines), the quartiles (blue boxes), and the 2.5 and 97.5 percentiles (vertical black lines), indicating the 95% confidence interval. MTE is either driven by fAPAR only (MTE1) or by both fAPAR and climate data (MTE2) (*16*). (**B**) Spatial details of the median annual GPP (gC/m2/a) from the spatially explicit approaches MTE1, MTE2, ANN, LUE, and KGB. (**C**) Latitudinal pattern (0.5° bands) of annual GPP. The gray area represents the range of the diagnostic models MTE1, MTE2, ANN, LUE, and KGB. The red area represents the range of process model results (LPJ-DGVM, LPJmL, ORCHIDEE, CLM-CN, and SDGVM). The thick lines represent the medians of both ranges. The dashed black line shows the result for northern extratropical regions from an independent diagnostic model. In this approach, we combined gridded information about the seasonal NEE amplitude based on atmospheric CO2 data and an inversion of atmospheric CO2 transport with empirical relationships between annual GPP and the seasonal amplitude of NEE derived at flux tower sites .

Keeling curve for monthly atmospheric CO_2 concentration at Mauna Loa Observatory, Hawaii (Science, 2009)



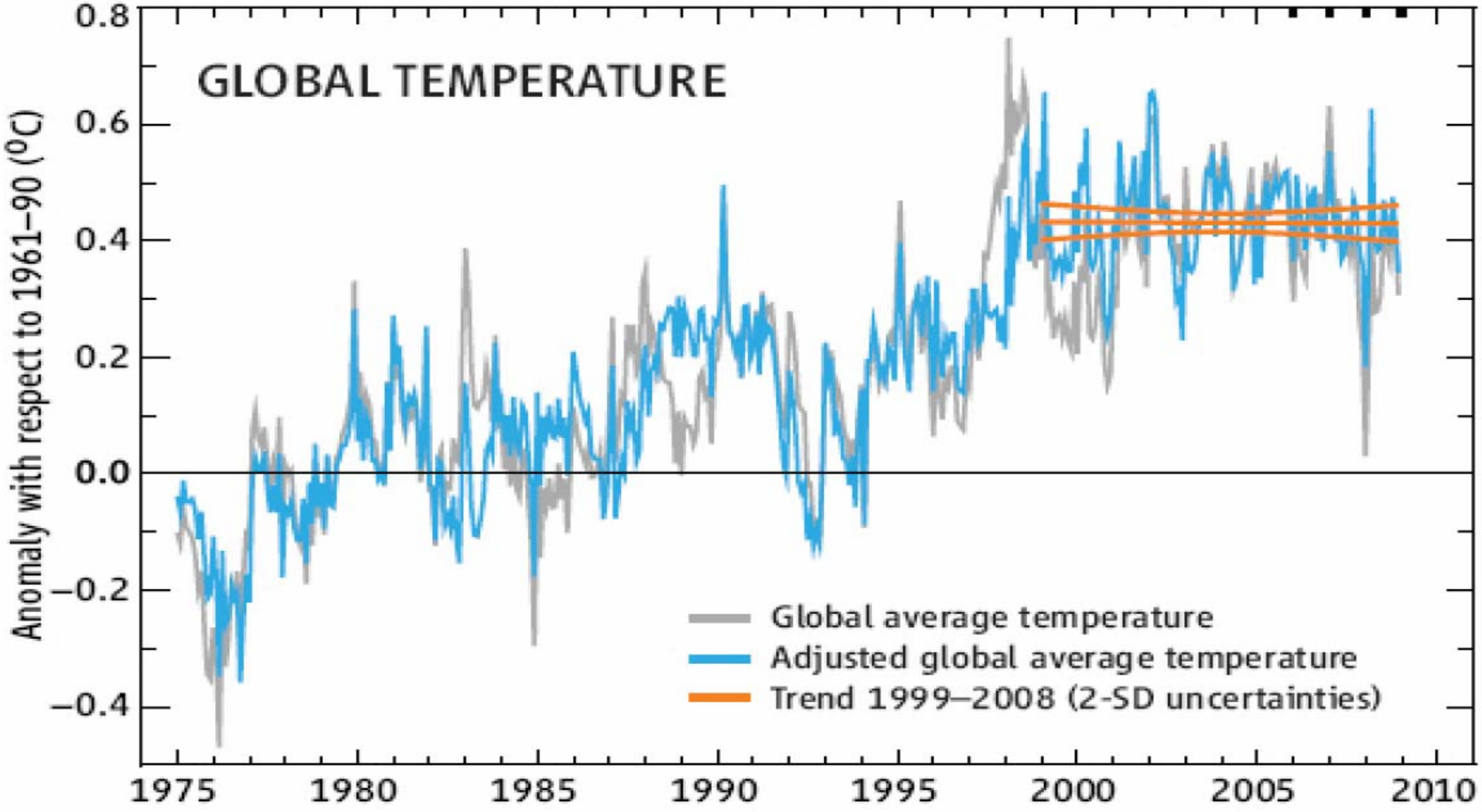
1: Is global warming still happening?

- **The skeptic argument...It's cooling**

"Global warming has stopped and a cooling is beginning. No climate model has predicted a cooling of the Earth – quite the contrary. And this means that the projections of future climate are unreliable." (Henrik Svensmark)

and skeptics have got some supporting empirical evidences !

Variability of Global Air Temperature Anomalies after 1975 (grey curve), Adjusted (to El Ninio forcing) Anomalies (blue) and Trend for the Recent Decade (orange) (Science, 2010)



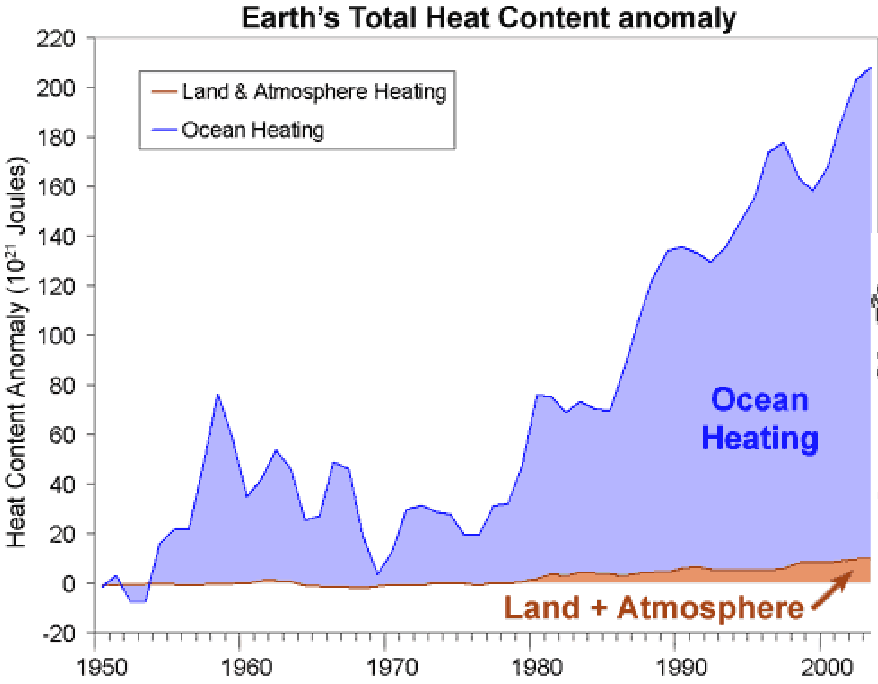
2: Is global warming still happening?

- **In fact** it necessary to consider all components of the climatic system and put attention to long-term (multi-decadal) tendencies

“Empirical measurements of the Earth's heat content show the planet is still accumulating heat and global warming is still happening. Surface temperatures can show short-term cooling when heat is exchanged between the atmosphere and the ocean, which has a much greater heat capacity than the air” (www.scepticalscience.com)

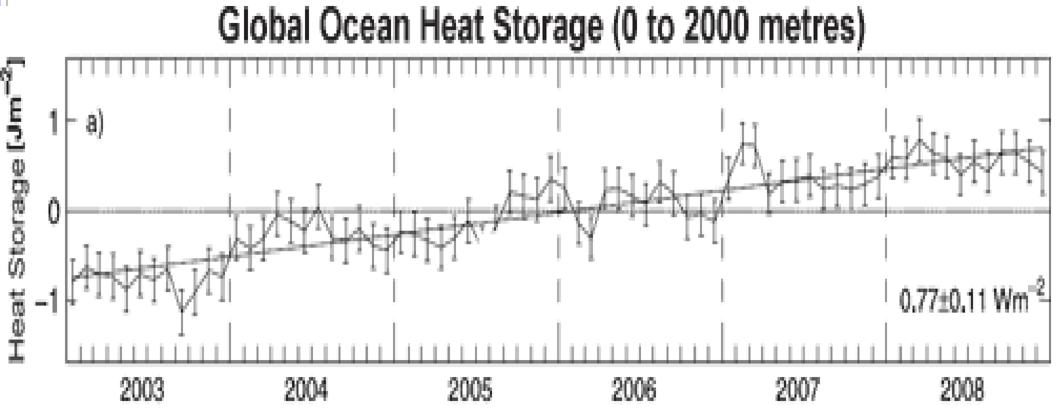
Change of Ocean Heating Rate

Total Earth Heat Content from 1950 (Murphy 2009). Ocean data taken from Domingues et al. 2008 **(Left figure)**

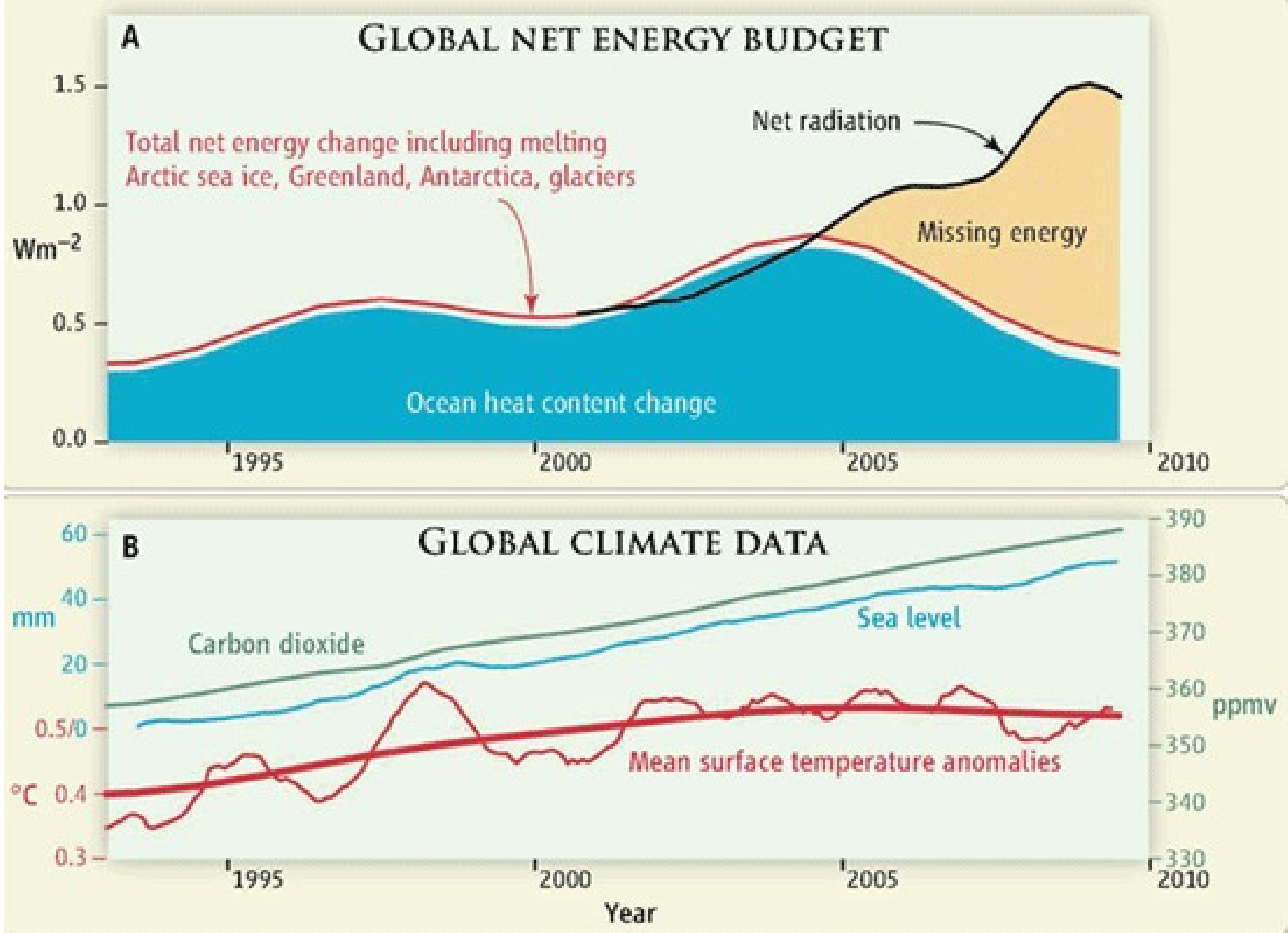


Time series of global mean heat storage (0–2000 m), measured in 108 Joules per square metre, using ARGO data (Schuckmann et al., JGR, 2009)

(Right figure)



Uncertainty of global heat heat budget of the climate system (after Trenberth, 2010)



K. E. Trenberth et al., Science 328, 316-317 (2010)

Published by AAAS

Variability of global air temperature anomalies after 1980:

Observations (CRU, black) and simple model taken into account anthropogenic effects and three natural forcing factors (orange) (Science, 2009)

tate a change in some other aspect of the system that unfolds more rapidly than the rate of change in the causative agent. An example is the unanticipated collapse of Larsen Ice Shelf B on the Antarctic Peninsula in 2002. In a period of about 1 month, an ice shelf 200 m thick disintegrated, releasing a 700 km^3 volume of icebergs to the sea. It is thought from sediment records that this ice shelf had been stable since the Last Glacial Maximum. Another involving biological systems is the enhanced success of bark beetles with warmer winter temperatures and dry summer conditions that favor the beetle's survival and diminish trees' defense systems. The result may be the massive death of trees across millions of hectacres of forest within only a few years, as with the 1990s spruce bark beetle infestation on the Kenai Peninsula.

Several recent scientific papers and reports have addressed tipping points. Lenton *et al.* (*21*) broaden this concept by defining tipping elements as subsystems of the Earth system that are at least subcontinental in scale and can be switched, under certain circumstances, into a qualitatively different state by small perturbations. The authors take into consideration equilibrium properties, threshold behavior, and critical rates of forcing, and suggest how this analysis can be of policy relevance in decision-making. A range of adverse impacts of abrupt climate change can be compared to develop cautionary strategies via a forewarning system.

A recent National Science Foundation (NSF) report, *Transitions and Tipping Points in Complex Environmental Systems*, addresses

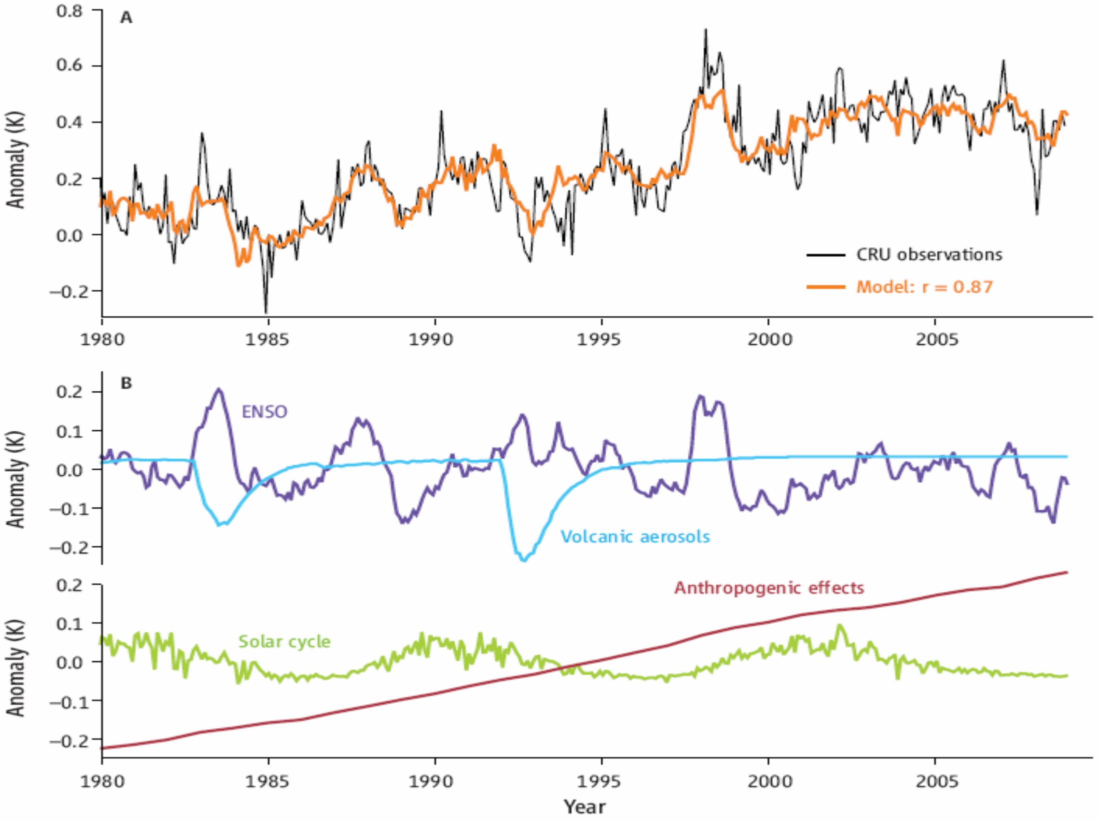


Fig. 7. Reconstructing Earth's recent climate. (**A**) Observed monthly mean global temperatures (black) and an empirical model (orange) that combines four different influences. (**B**) Individual contributions of these influences, namely El Niño–Southern Oscillation (purple), volcanic aerosols (blue), solar irradiance (green), and anthropogenic effects (red). Together the four influences explain 76% (r^2) of the variance in the global temperature observations.

lished work from an earlier period. At times

emission rate has been at or above the highest

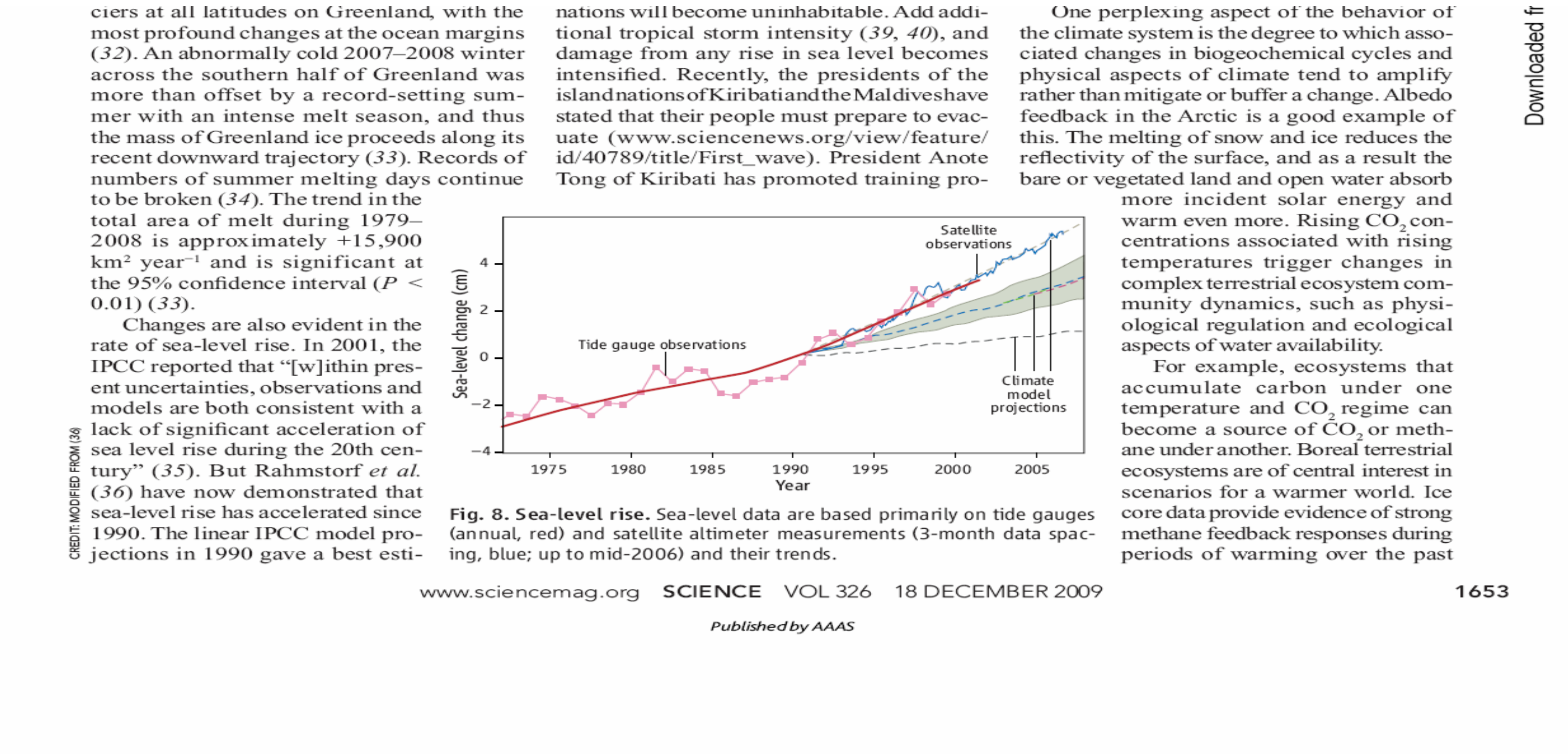
So, if one adds the decadal-scale natural modes we can conclude that

observed global climate variability for the recent climate epoch is due to slow (multi-decadal-to-centennial) anthropogenically-induced processes and superimposed natural interannual-to-multidecadal modes, such as El Ninio, North Atlantic Oscillation, Atlantic Multidecadal Oscillation, Pacific Decadal Oscillation, volcano eruptions, irradiance variability, etc.

There are three principle potential negative consequences of the *long-term* global warming

1. SEA LEVEL RISE
2. OCEAN ACIFIDICATION
3. WEATHER STATISTICS worsening (such as enhanced cyclonic activity, more numerous heat waves, etc).

Global sea level rise (SLR) acceleration occurs in 1950 - 2010 (from ~1,7 to ~3,3 mm/yr) - WHY? The principle reason is acceleration of ice sheet (Greenland and West Antarctic) degradation which is now account for ~60% of SLR



ciers at all latitudes on Greenland, with the most profound changes at the ocean margins (*32*). An abnormally cold 2007–2008 winter across the southern half of Greenland was more than offset by a record-setting summer with an intense melt season, and thus the mass of Greenland ice proceeds along its recent downward trajectory (*33*). Records of numbers of summer melting days continue to be broken (*34*). The trend in the total area of melt during 1979–2008 is approximately +15,900 km^2 year^{-1} and is significant at the 95% confidence interval ($P <$ 0.01) (*33*).

Changes are also evident in the rate of sea-level rise. In 2001, the IPCC reported that "[w]ithin present uncertainties, observations and models are both consistent with a lack of significant acceleration of sea level rise during the 20th century" (*35*). But Rahmstorf *et al.* (*36*) have now demonstrated that sea-level rise has accelerated since 1990. The linear IPCC model projections in 1990 gave a best esti-

nations will become uninhabitable. Add additional tropical storm intensity (*39*, *40*), and damage from any rise in sea level becomes intensified. Recently, the presidents of the island nations of Kiribati and the Maldives have stated that their people must prepare to evacuate (www.sciencenews.org/view/feature/id/40789/title/First_wave). President Anote Tong of Kiribati has promoted training pro-

One perplexing aspect of the behavior of the climate system is the degree to which associated changes in biogeochemical cycles and physical aspects of climate tend to amplify rather than mitigate or buffer a change. Albedo feedback in the Arctic is a good example of this. The melting of snow and ice reduces the reflectivity of the surface, and as a result the bare or vegetated land and open water absorb more incident solar energy and warm even more. Rising CO_2 concentrations associated with rising temperatures trigger changes in complex terrestrial ecosystem community dynamics, such as physiological regulation and ecological aspects of water availability.

For example, ecosystems that accumulate carbon under one temperature and CO_2 regime can become a source of CO_2 or methane under another. Boreal terrestrial ecosystems are of central interest in scenarios for a warmer world. Ice core data provide evidence of strong methane feedback responses during periods of warming over the past

Fig. 8. Sea-level rise. Sea-level data are based primarily on tide gauges (annual, red) and satellite altimeter measurements (3-month data spacing, blue; up to mid-2006) and their trends.

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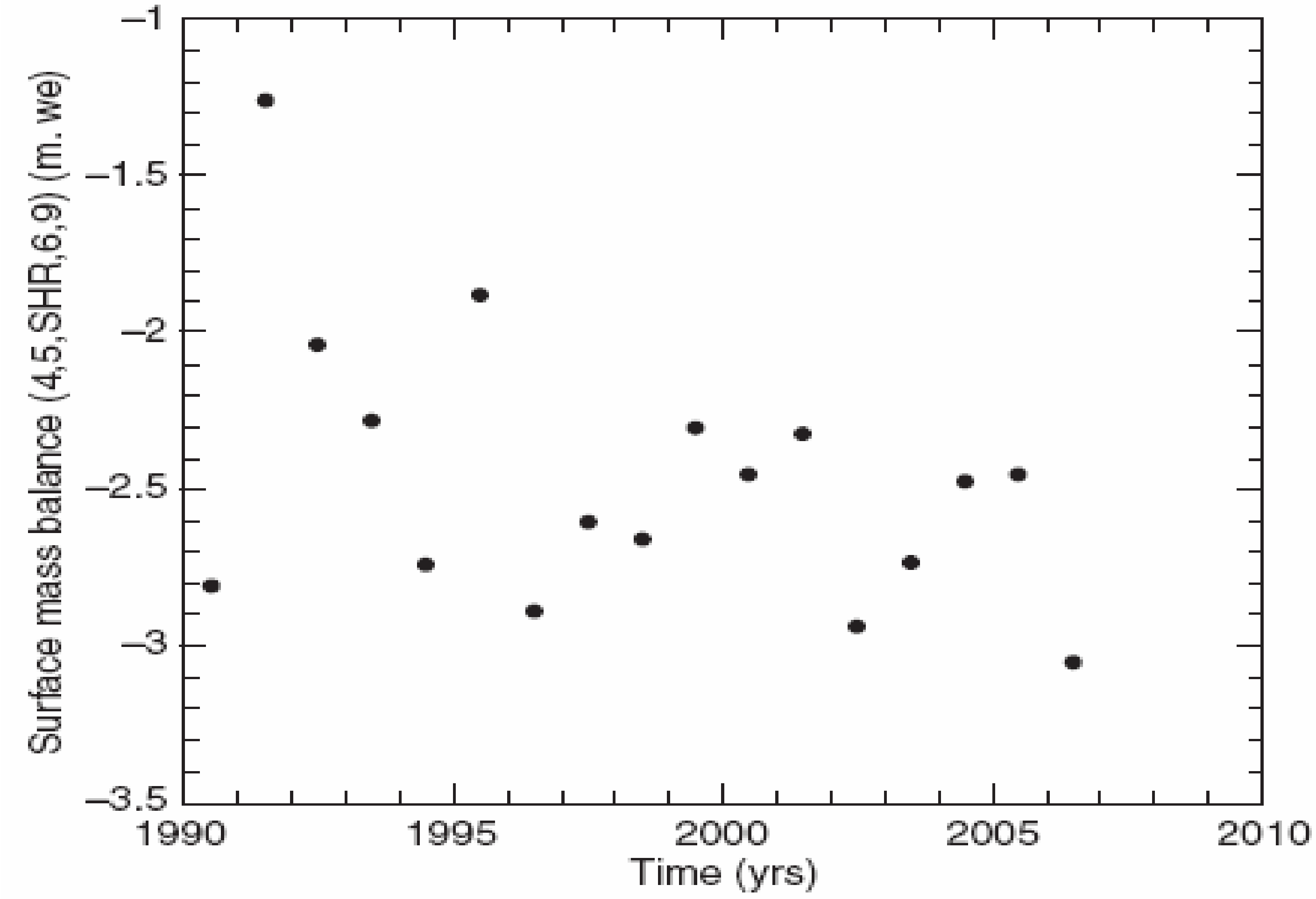
Increasing of ablation rate of Greenland Ice (Science, 2008)



insertion

The annual surface mass balance in the ablation zone of the K-transect (see insertion) over the 17 years. “m.we” – meter water equivalent

SLR for 1992 to 2009 varies in the World Ocean from ~ -10 to 15 mm/yr (Science, 2010)

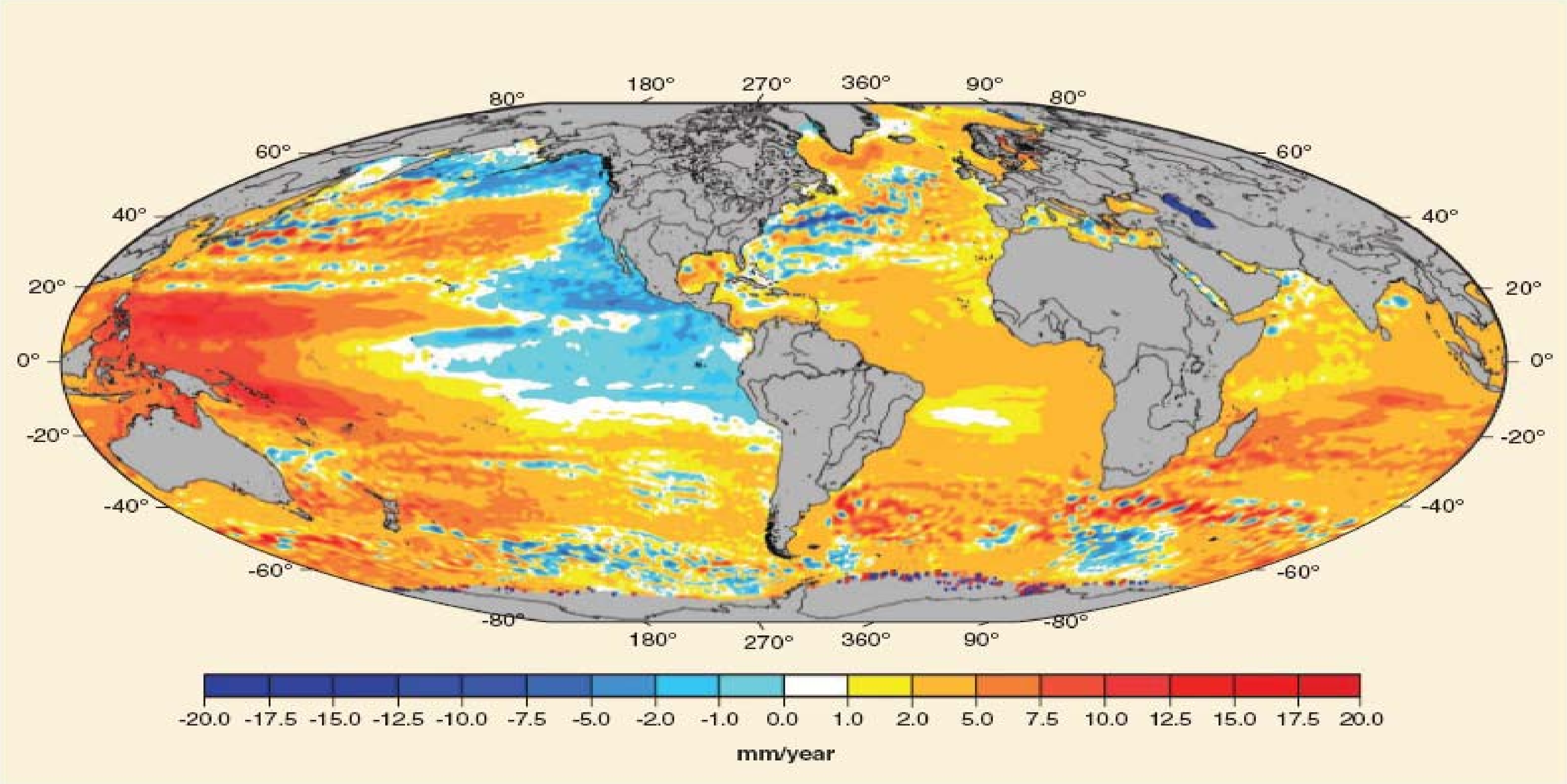


Fig. 2. Regional sea-level trends from satellite altimetry (Topex/Poseidon, Jason-1&2, GFO, ERS-1&2, and Envisat missions) for the period October 1992 to July 2009 (*48*).

Most vulnerable coastal zones for expected SLR in XXI century (30-180 cm/century)

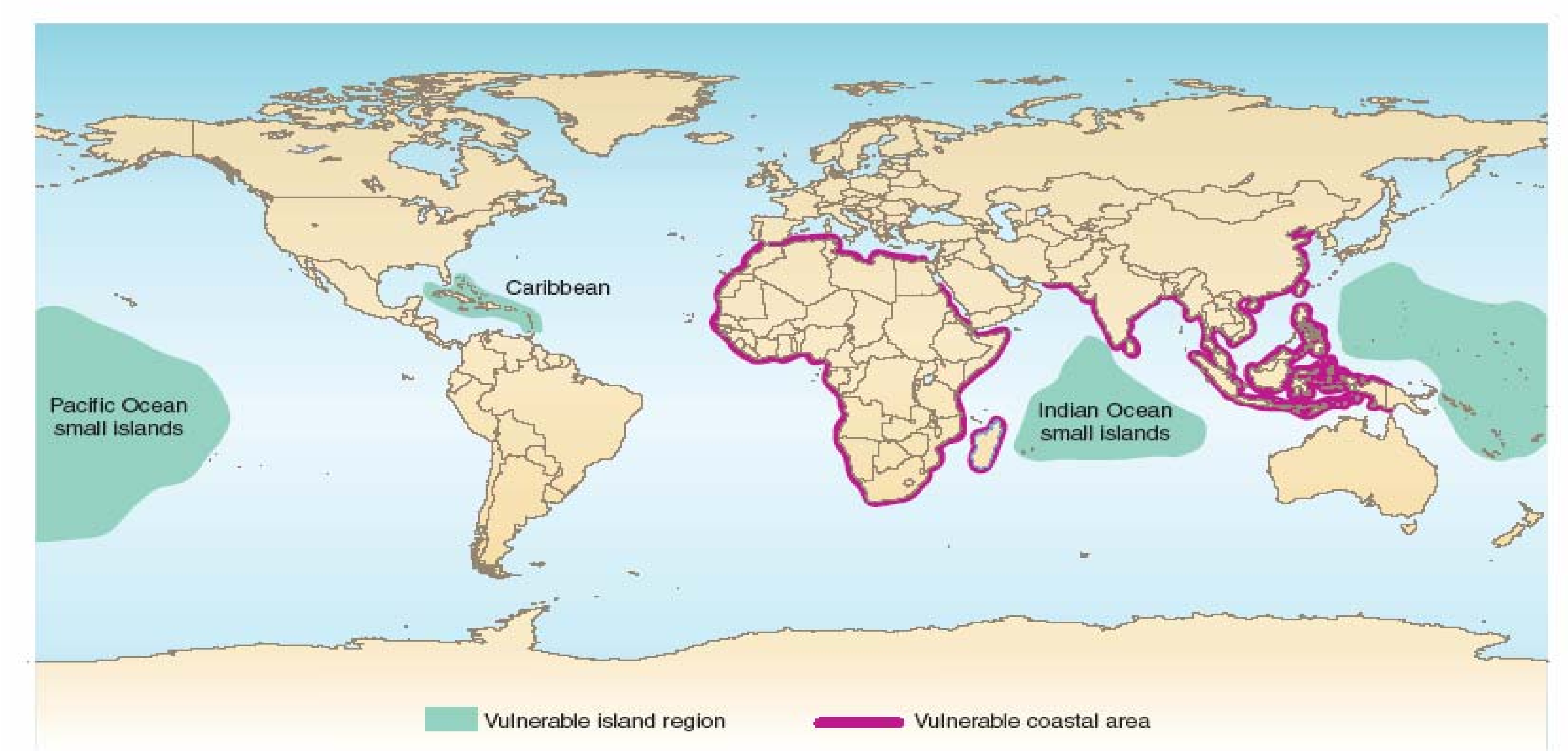
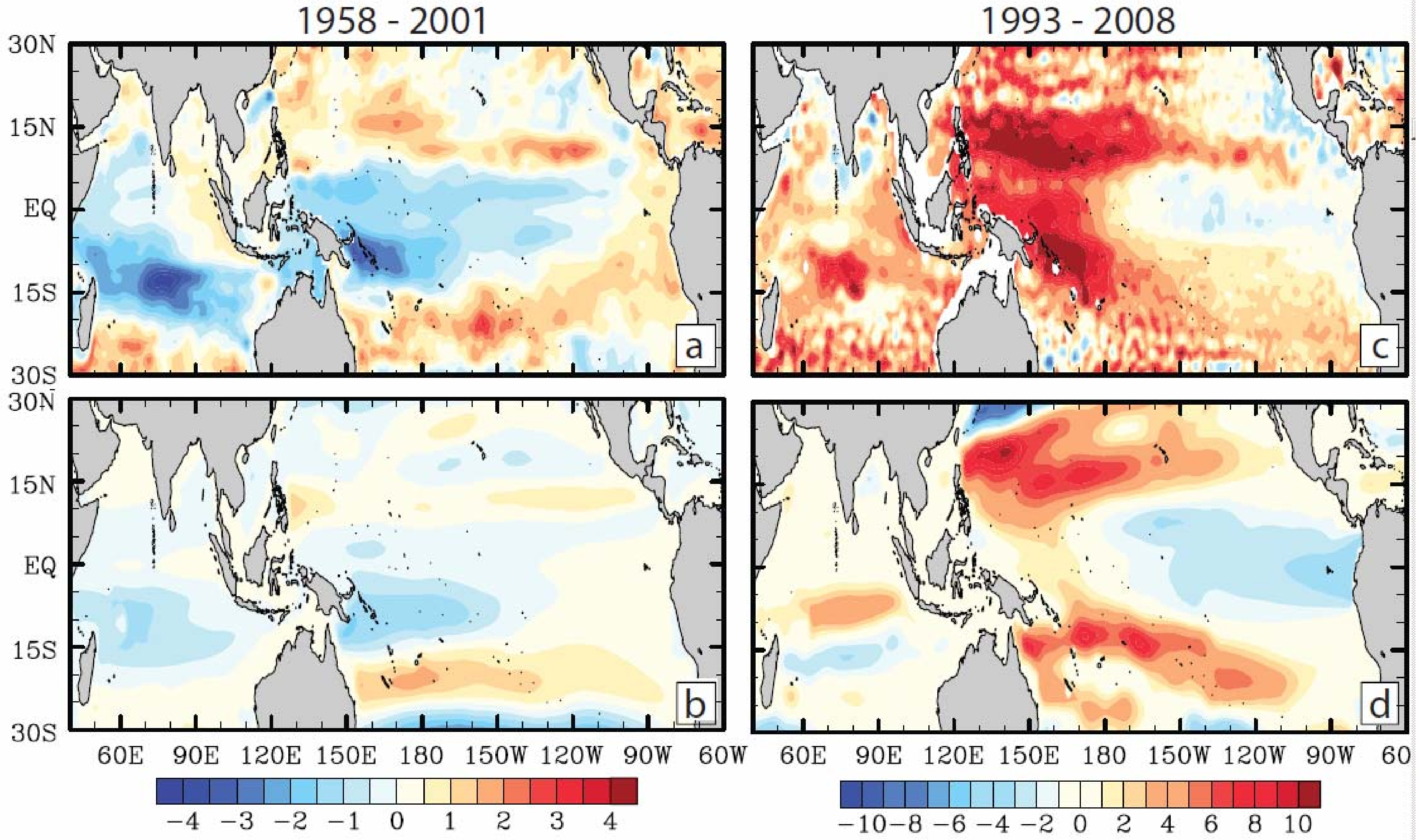
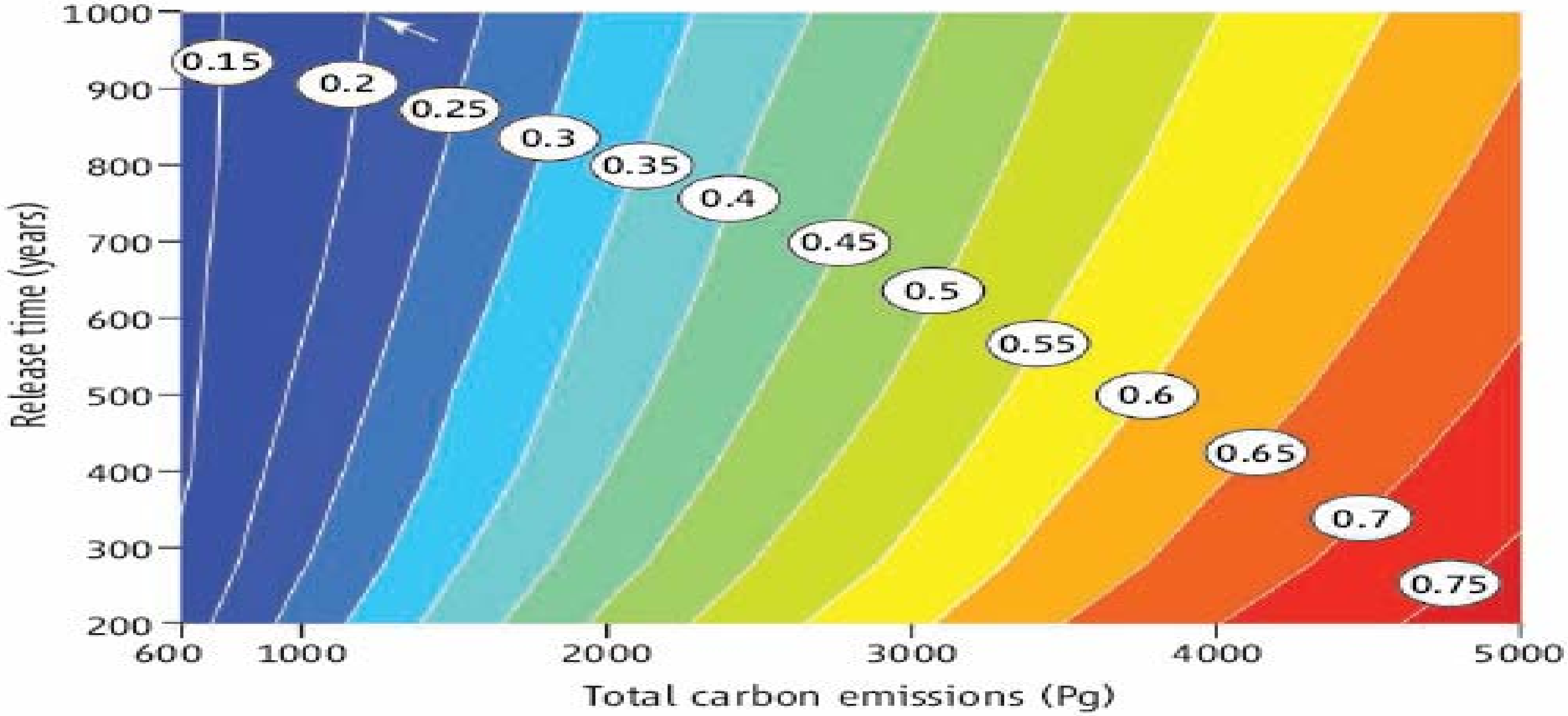


Fig. 3. Several regions are vulnerable to coastal flooding caused by future relative or climate-induced sea-level rise. At highest risk are coastal zones with dense populations, low elevations, appreciable rates of subsidence, and/or inadequate adaptive capacity.

Linear sea level trend (mm per year): a-ocean reanalysis output; b-simulated by shallow water model forced by ERA40 output; c-satellite altimeter data; d- b-simulated by shallow water model forced by operational ECMWF output (IPRC Climate, v.10, No.1, 2010)

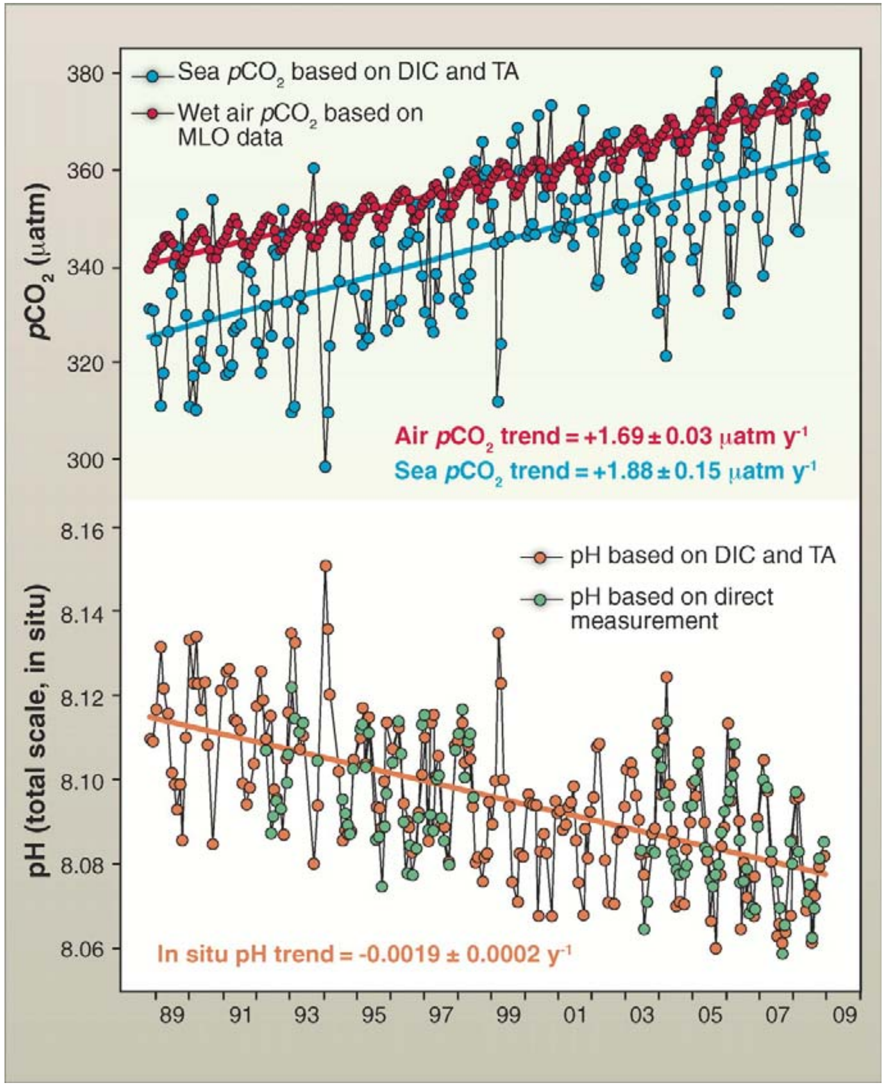


Surface ocean pH decline vs total carbon emissions and release time. Dangerous level is 0.2 to 0.3 per century (Science, 2008)



Surface ocean pH decline. The white contour lines illustrate the expected maximum pH decrease of average surface ocean waters in the future (in pH units) as a function of total anthropogenic CO_2 emissions (in petagrams of carbon, 1 Pg = 10^{15} g) and release time (in years, see supporting online material). For example, if humans release a total of 1200 Pg C over 1000 years, surface ocean pH will drop by about 0.2 units (arrow).

Variability of air/water pCO$_2$ and pH in the North tropical Pacific: 1988-2008

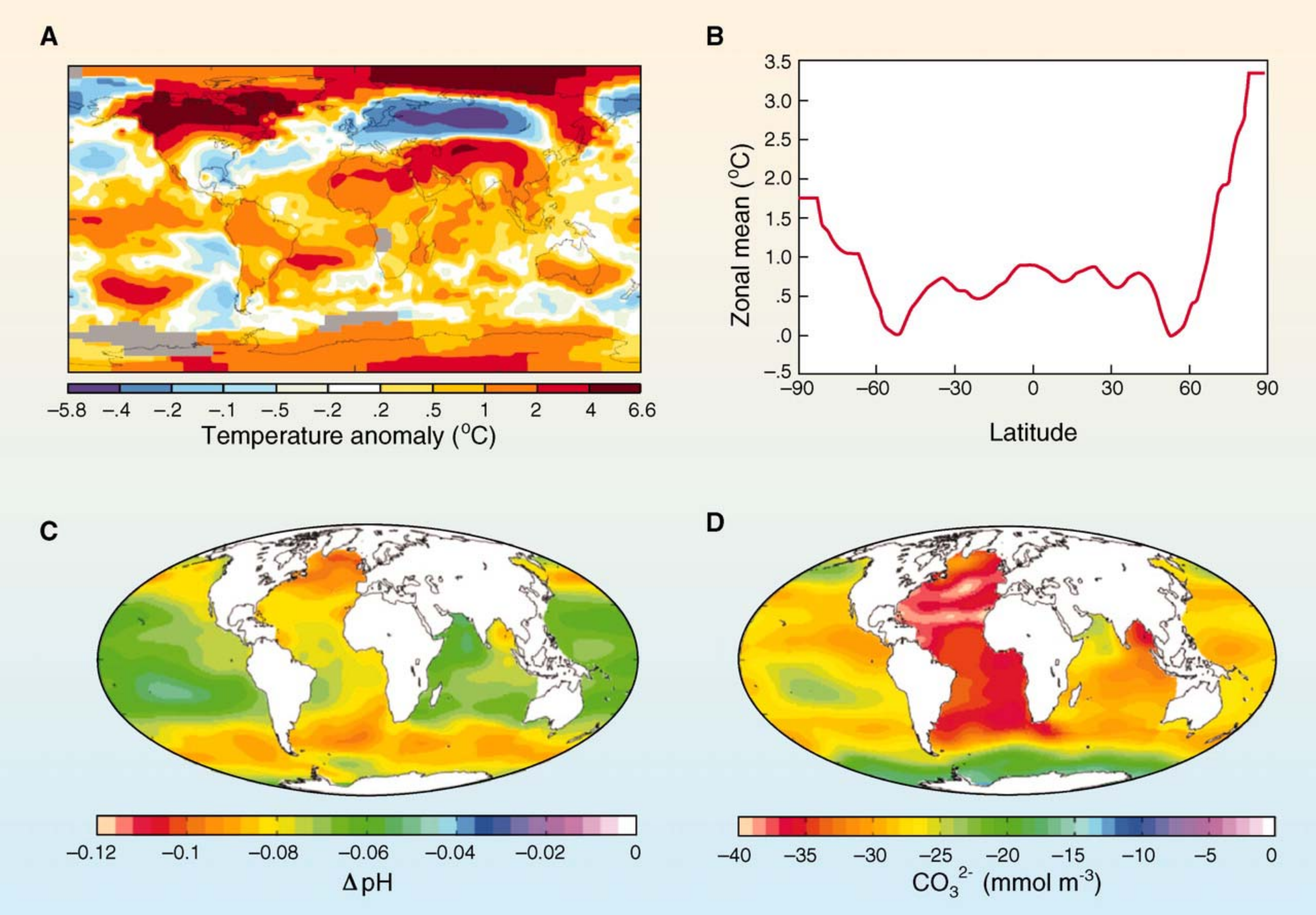


Time series of (**top**) atmospheric CO2 and surface ocean *p*CO2 and (**bottom**) surface ocean pH at the atmospheric Mauna Loa Observatory (MLO) on the island of Hawai‘i and Station ALOHA in the subtropical North Pacific north of Hawai‘i, 1988–2008.
After (Science, 2010)

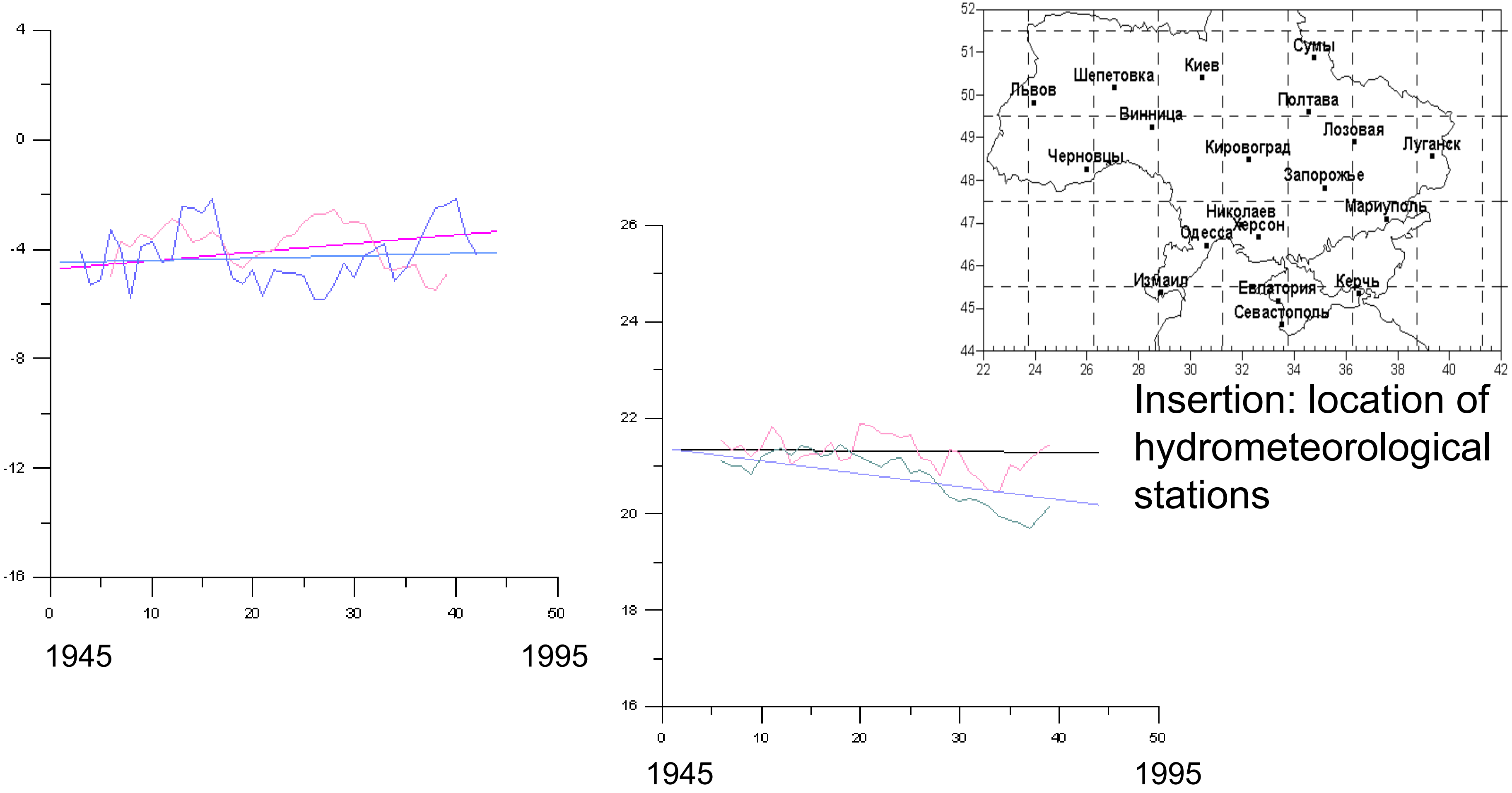
In situ pH trend is about

-0.2 per century

Recent changes in ocean temperature, acidity, and carbonate ion concentration. (**A**) Surface temperature anomaly for January 2010 relative to the mean for 1951–1980. (**B**) The same data presented in (A) as a function of latitude. (**C**) Estimated change in annual mean sea surface pH between the pre-industrial period (1700s) and the 1990s. (**D**) Estimated change in annual mean sea surface carbonate ion concentration between the pre-industrial period (1700s) and the 1990s. [Science, 2010]

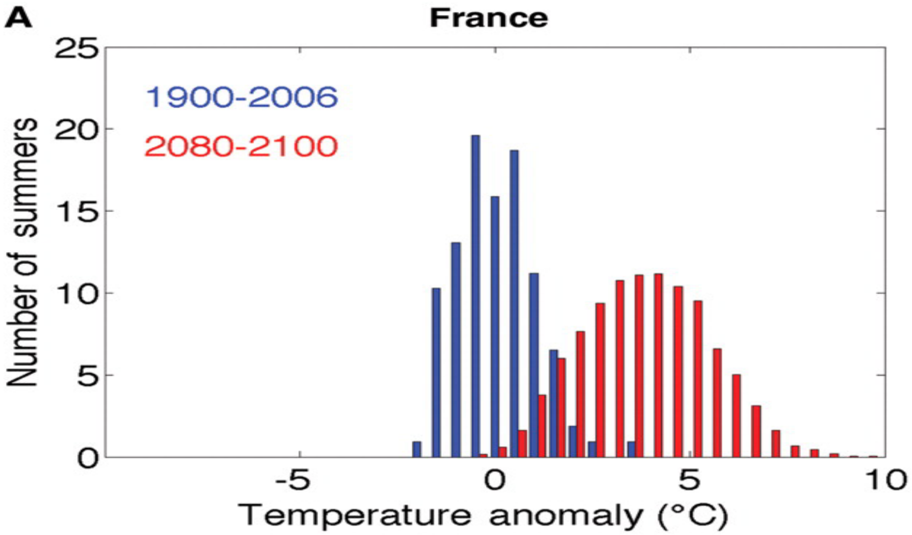


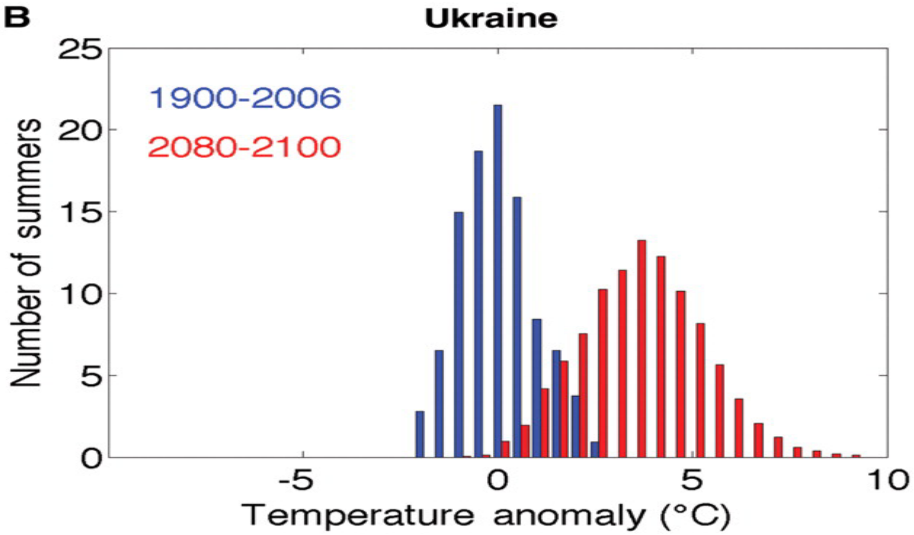
Air temperature variability over Ukraine in January (Celsus degrees, left panel) and July (right) for the second part of 20 century. Red curves – GFDL CM 2.1 simulation, blue curve – observations averaged over routine network (insertion).



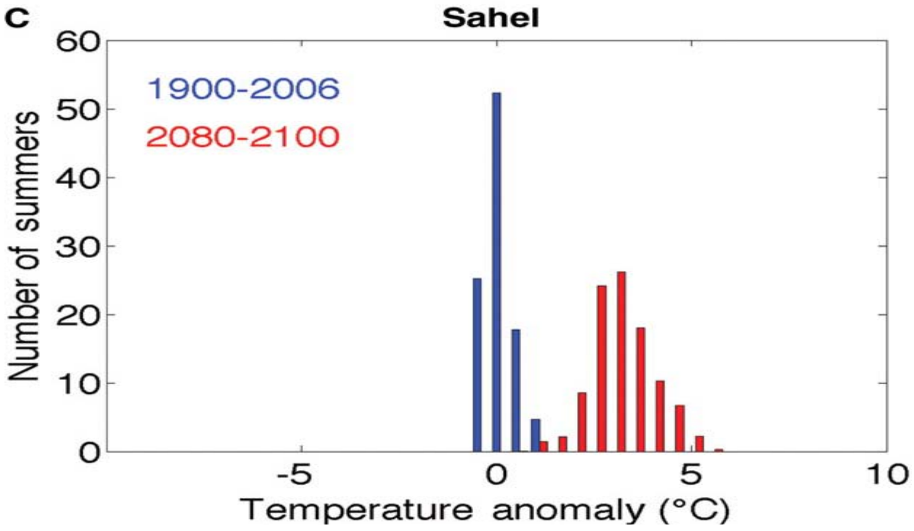
Insertion: location of hydrometeorological stations

Histograms of observed (blue) and predicted for 2080-2100’s (red) summer air temperature regional anomalies (Science, 2009)

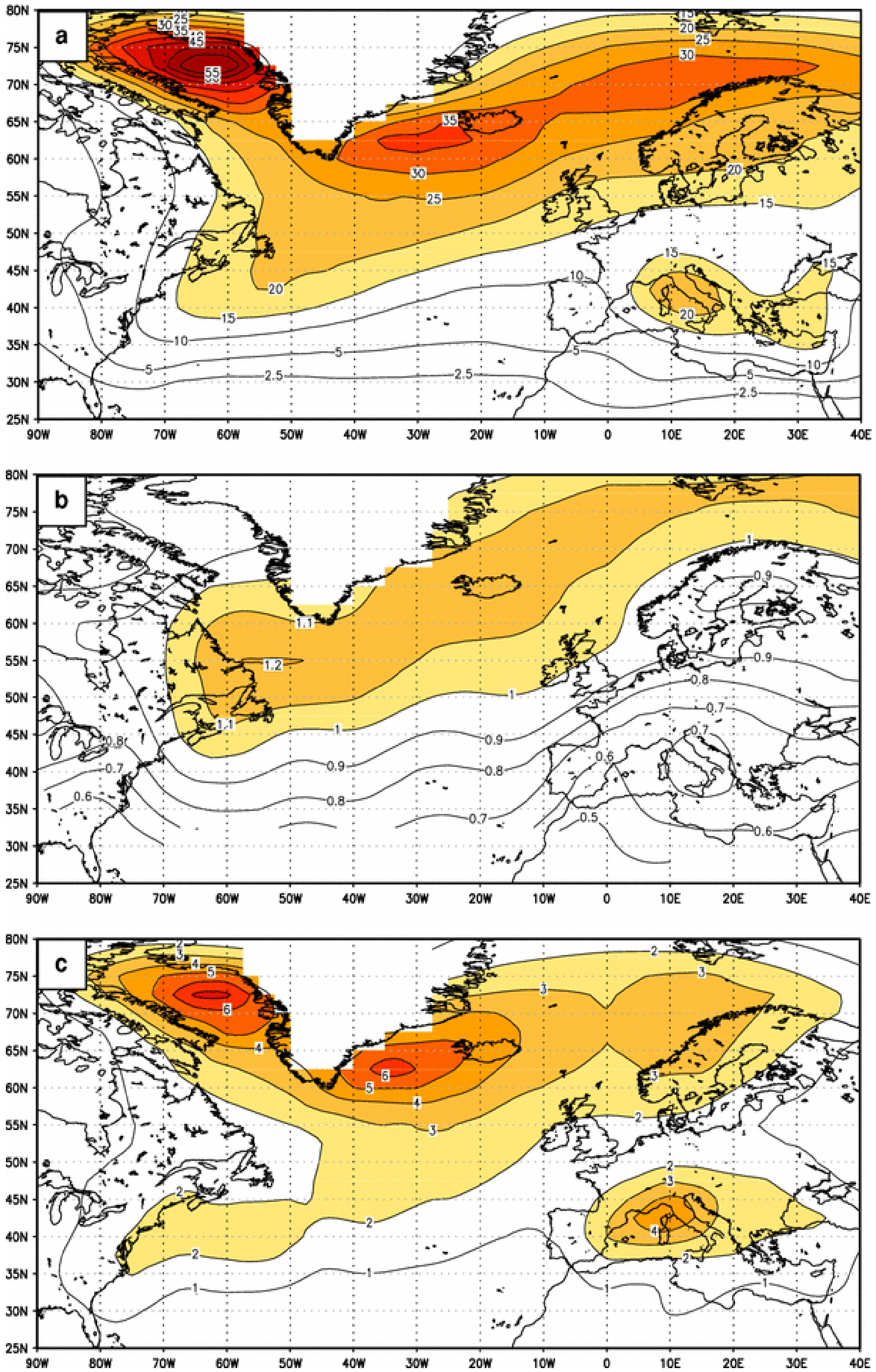




Histogram of summer (June, July, and August) averaged temperatures (blue) observed from 1900 to 2006 and (red) projected for 2090 for (**A**) France, (**B**) Ukraine, and (**C**) the Sahel. Temperature is plotted as the departure from the long-term (1900–2006) climatological mean. The data are normalized to represent 100 seasons in each histogram.
In (A), for example, the hottest summer on record in France (2003) is 3.6°C above the long-term climatology.
The average summer temperature in 2090 is projected to be 3.7°C greater than the long-term climatological average, and there is a small chance it could be 9.8°C higher.



Average characteristics of Winter cyclones for 1957-1998 гг. (Pinto et al, 2009)



Number of winter days when cyclones have been observed within rectangular areas 2,5 by 2,5 degrees

a

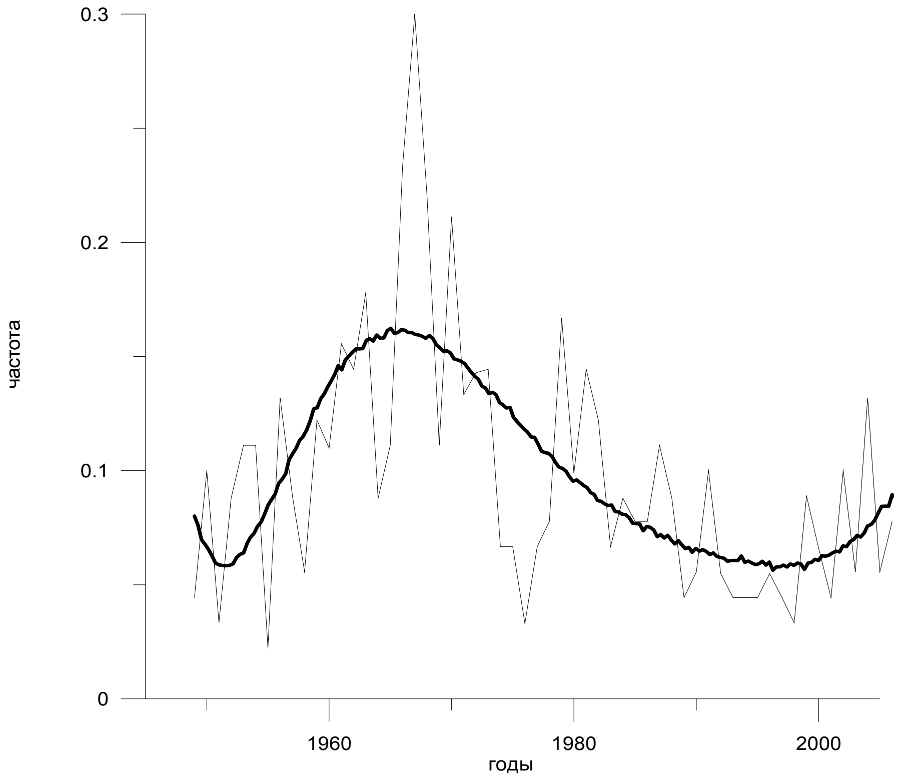
Average intensity of winter cyclones

b

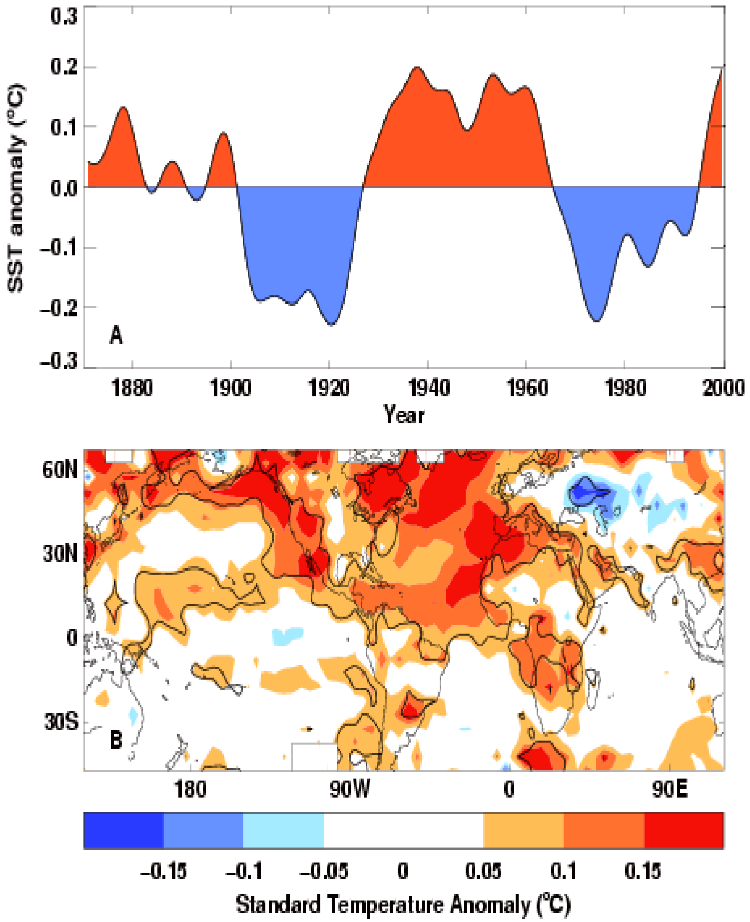
Average number of winter cyclogenesis events

c

Atlantic multidecadal oscillation (AMO) and its impact on the statistics of Black sea cyclones

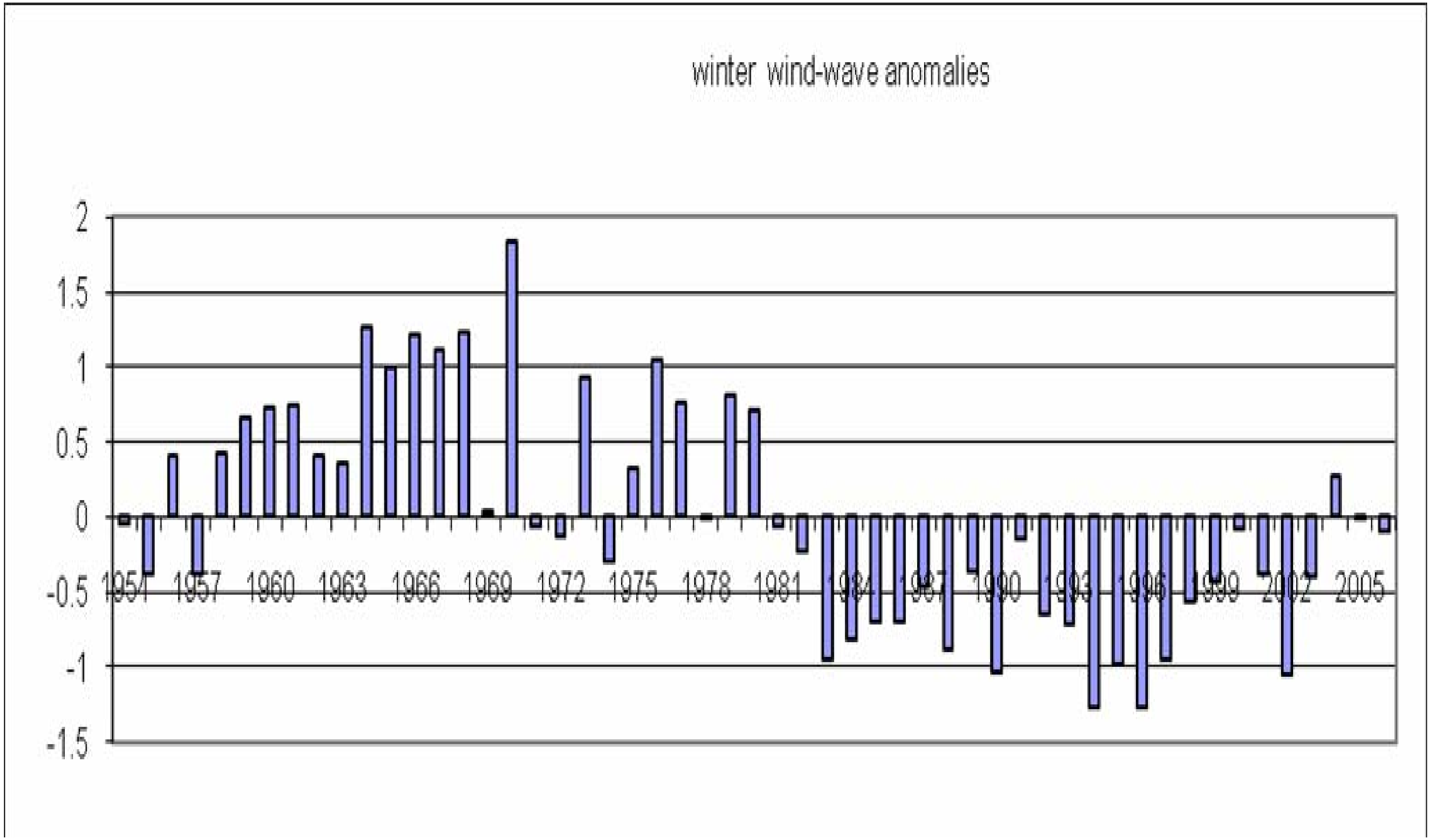


Year-to-year frequency of winter Black sea cyclones (thin curve) and approximation polynomial best fit function (thick) for 1950 to 2006 (Polonsky et al., 2007),

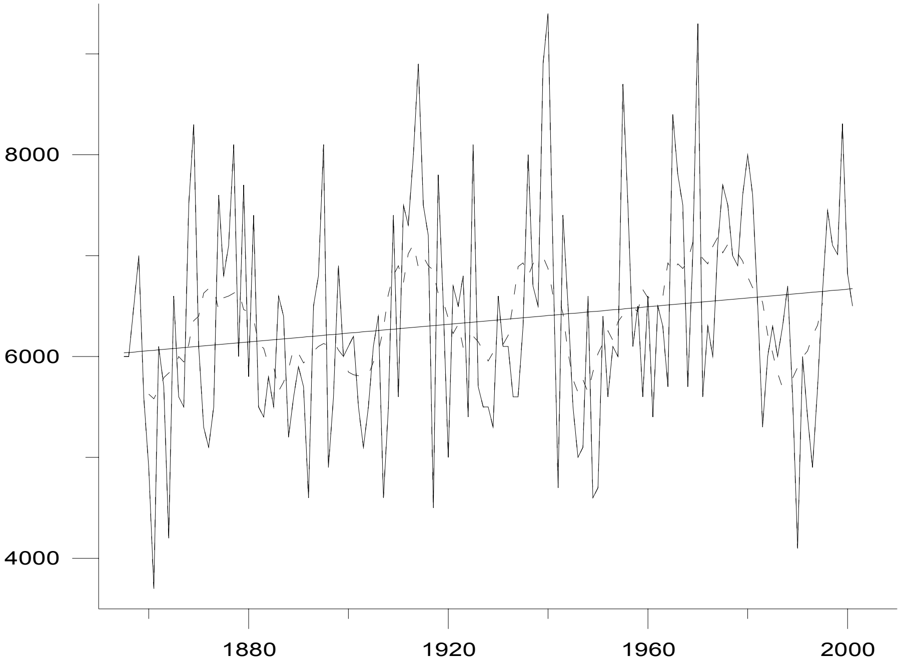


AMO index (SST anomalies in the North Atlantic) (A) and SAT anomalies when positive AMO index anomaly is at maximum (B) (Knight et al., 2006)

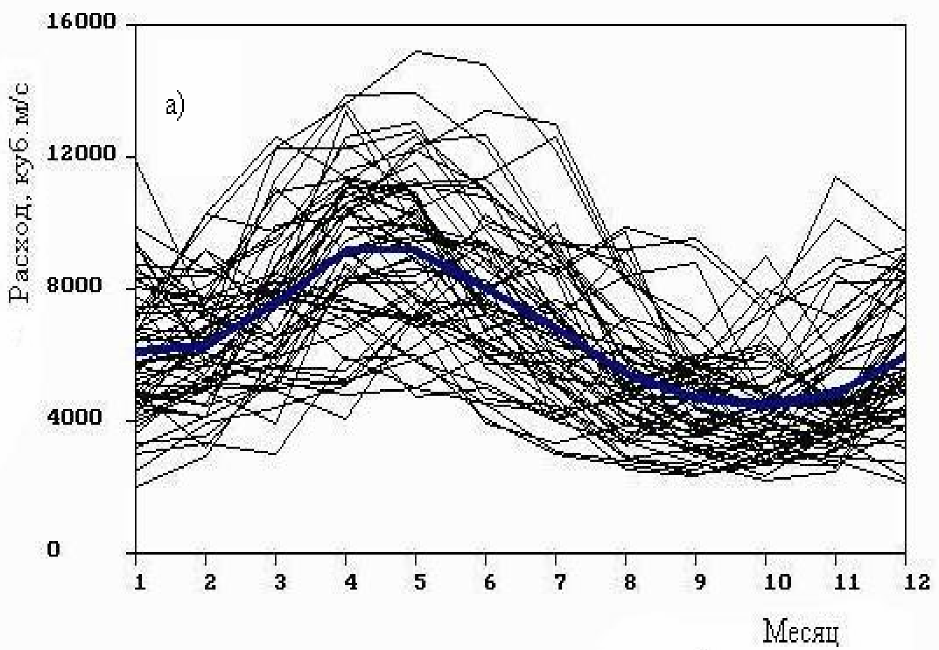
Wind wave height anomalies at the c. Chersones in winter of 1954-2006. (Polonsky et al., 2009)



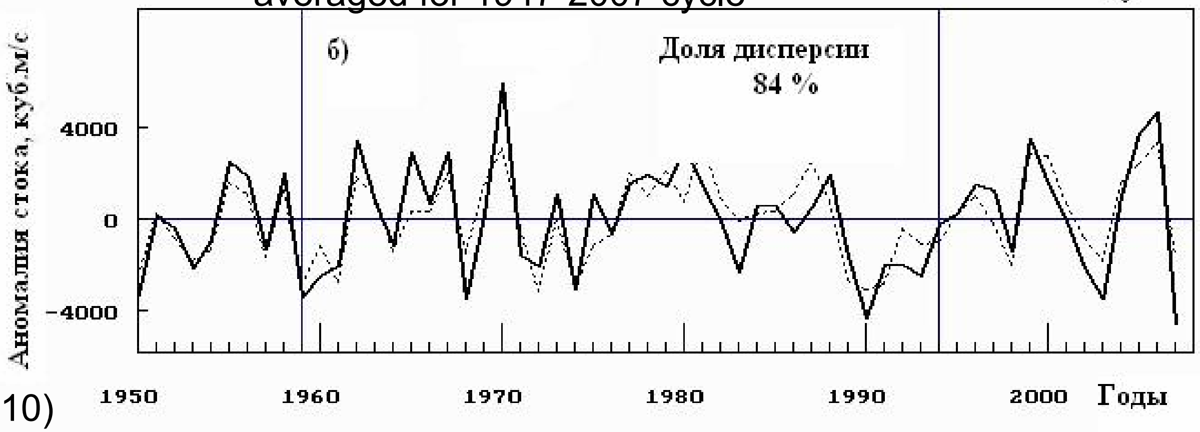
Interannual variability of Danube discharge as function of variability of the coupled system



Annual Danube discharges, cub m per sec (solid curve), Decadal-scale variability (dashed) and linear trend



Seasonal cycle of Danube discharge for each year and averaged for 1947-2007 cycle



Danube May discharge anomalies: Solid curve – observation; dashed curve – forecast using atmospheric indices for January-March and neutron Network technique (Polonsky et al., 2010)

Conclusions

- *The observed global and regional climate variability is due to slow (multi-decadal-to-centennial) human-induced processes and natural interannual-to-interdecadal modes. Anthropogenic warming is accompanied in general by enhanced precipitation and Black sea river discharge. Typical (r.m.s.) interannual-to-interdecadal anomalies of January air temperature and precipitation in the Eastern Europe and Black/Mediterranean sea region are of about 3-4°C u 2-3 mm. At the same time there are twofold (or even more) intense quasi-periodical anomalies and catastrophic events (without any visible relation to the global warming).*
- *The regional simulation (and projection) of the climate change and variability using even the best models are not reliable. The state-of- the-art coupled models are not able to reproduce adequately the recent climate variability and change over Ukraine.*