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World Climate Research Programme

Science Update by Global Change Research Programmes

Regional Climate Information for Decision Makers

G. R. Asrar, Sybil Seitzinger and Anne Larigauderie
Directors of WCRP, IGBP and DIVERSITAS

DIVERSITAS GLOBAL IGBP CHANGE IHDP WCRP World Climate Research Programme

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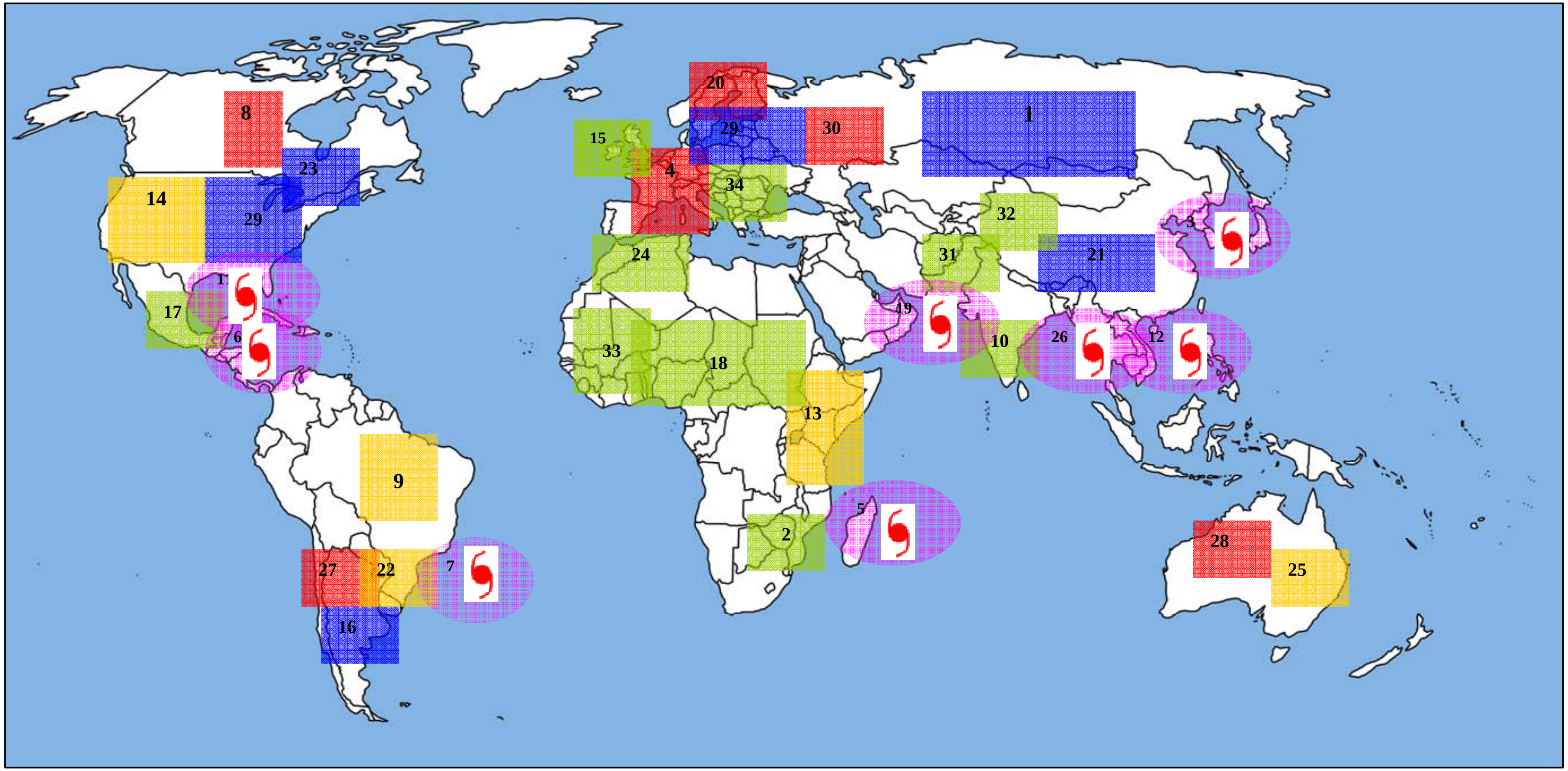
- **A major theme in our research coordination is detection and attribution of the causes and impacts of climate variability and change, especially at the regional level.**

- **This research includes for example, study of extreme events such as those observed during the past decade, including ones in 2010.**

Snapshot of Extreme Events over the Past Decade



Heat waves / Extreme high temperatures

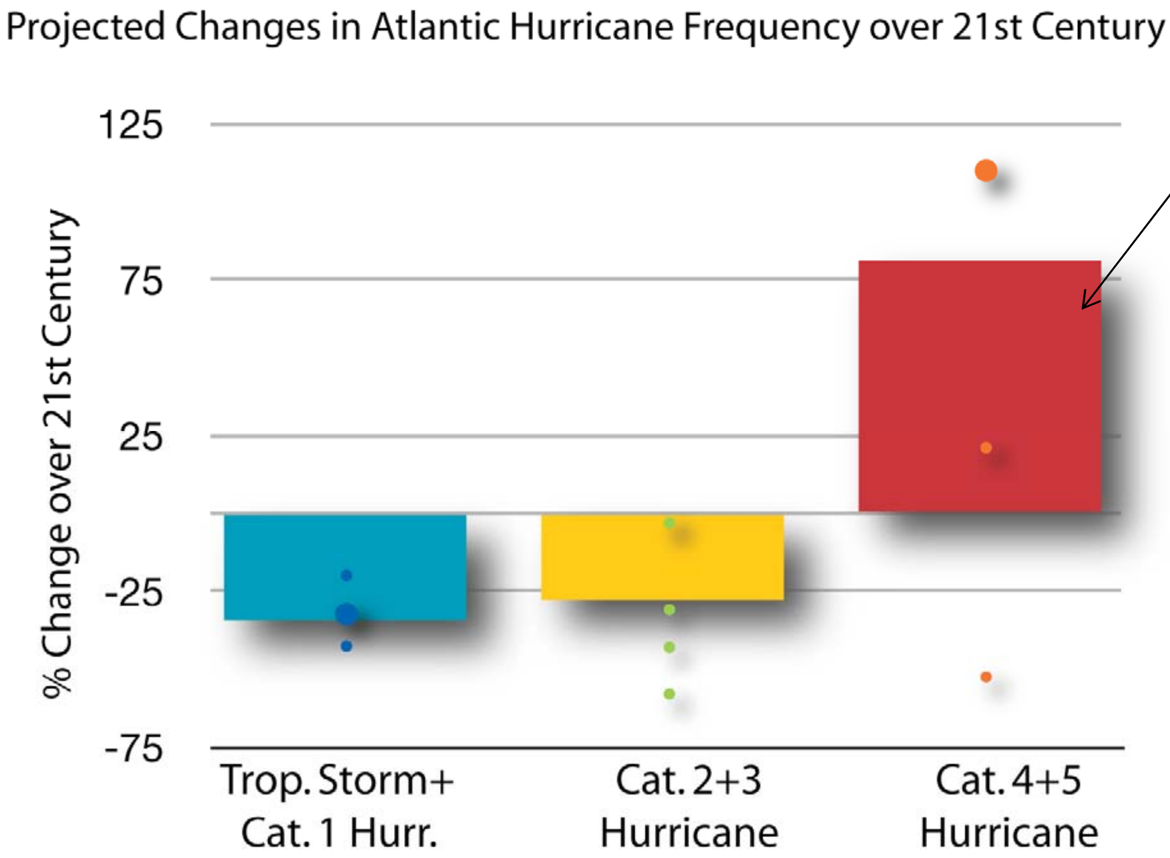
Severe or prolonged droughts

Cold waves / Extreme low temperatures / Snow storms

Tropical cyclones, hurricanes and typhoons

Intense storms / Flooding / Heavy rainfall

Atlantic Hurricanes



Cat 4+5 frequency: 81% increase, or 10% per decade

Estimated net impact of these changes on damage potential: +28%

Bars show changes for the18 CMIP3 model ensemble (27 seasons); dots show range of change across 4 individual CMIP models (13 seasons).

Bender et al., *Science,* 2010

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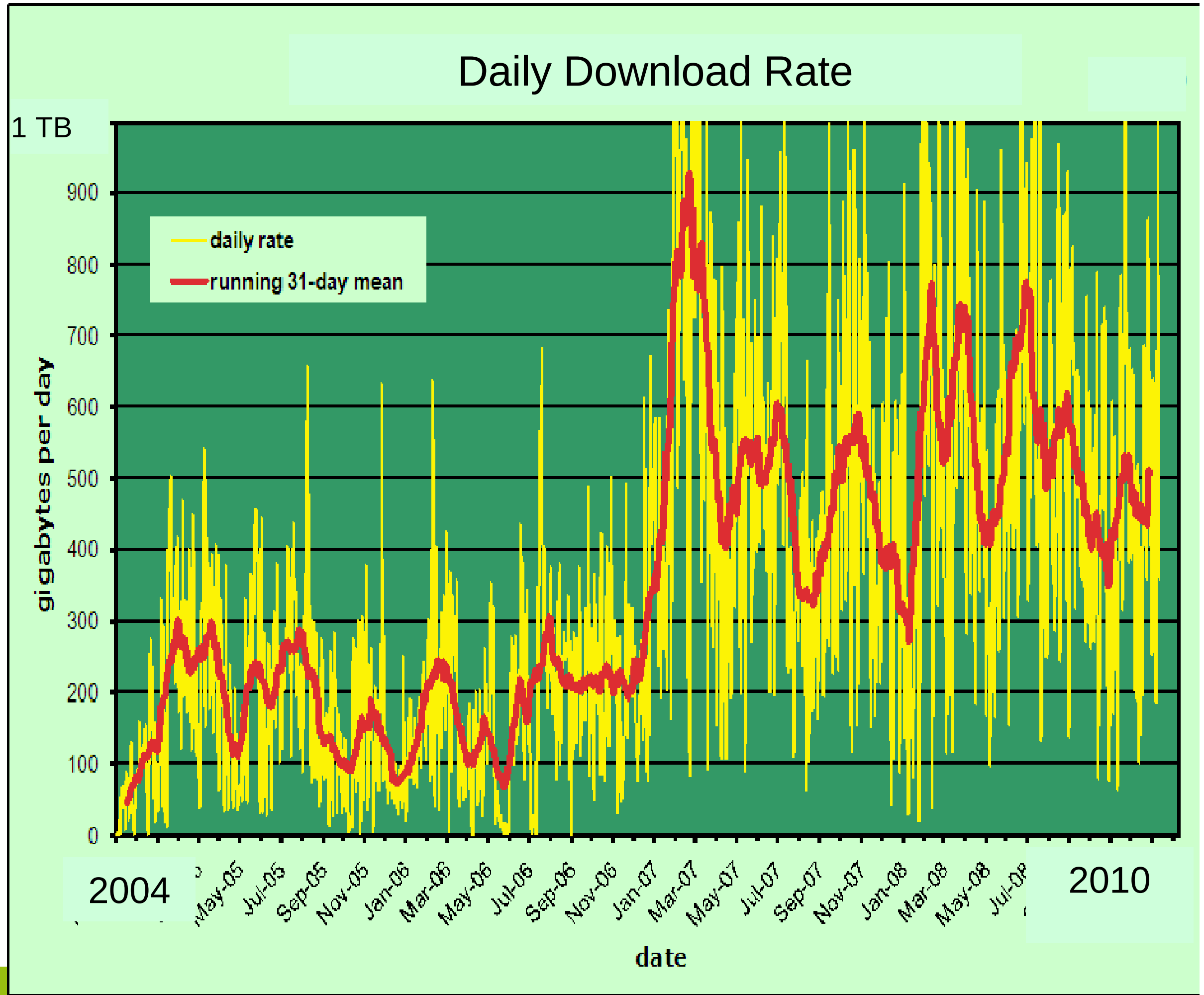
Climate Projections

Interest in CMIP3 results continues unabated!

- **More than 550 peer-reviewed publications.**
- **~1 Pbyte of data downloaded.**
- **More than 3,000 registered users.**



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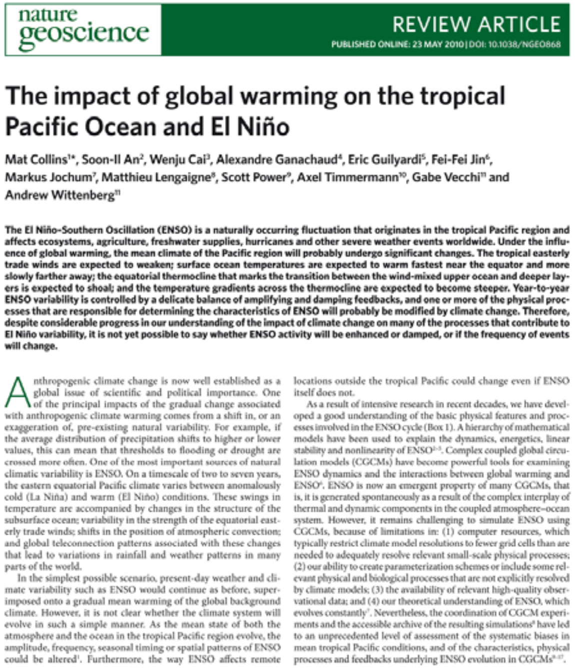
Climate Change & ENSO



nature geoscience | REVIEW ARTICLE
PUBLISHED ONLINE: 23 MAY 2010 | DOI: 10.1038/NGEO868

The impact of global warming on the tropical Pacific Ocean and El Niño

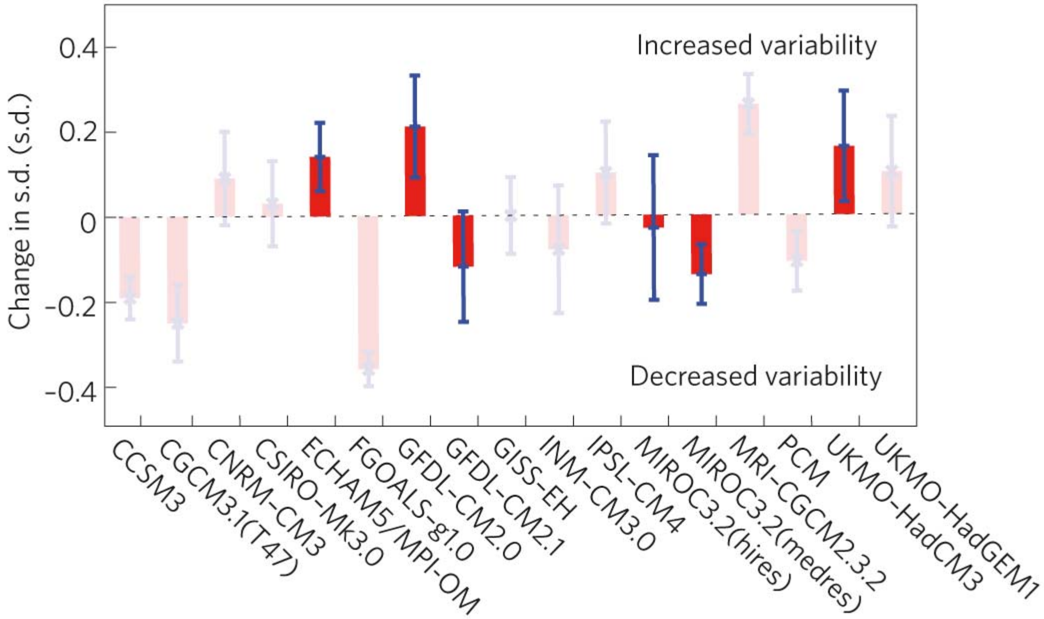
Mat Collins[1*], Soon-Il An[2], Wenju Cai[3], Alexandre Ganachaud[4], Eric Guilyardi[5], Fei-Fei Jin[6], Markus Jochum[7], Matthieu Lengaigne[8], Scott Power[9], Axel Timmermann[10], Gabe Vecchi[11] and Andrew Wittenberg[11]

The El Niño-Southern Oscillation (ENSO) is a naturally occurring fluctuation that originates in the tropical Pacific region and affects ecosystems, agriculture, freshwater supplies, hurricanes and other severe weather events worldwide. Under the influence of global warming, the mean climate of the Pacific region will probably undergo significant changes. The tropical easterly trade winds are expected to weaken; surface ocean temperatures are expected to warm fastest near the equator and more slowly farther away; the equatorial thermocline that marks the transition between the wind-mixed upper ocean and deeper layers is expected to shoal; and the temperature gradients across the thermocline are expected to become steeper. Year-to-year ENSO variability is controlled by a delicate balance of amplifying and damping feedbacks, and one or more of the physical processes that are responsible for determining the characteristics of ENSO will probably be modified by climate change. Therefore, despite considerable progress in our understanding of the impact of climate change on many of the processes that contribute to El Niño variability, it is not yet possible to say whether ENSO activity will be enhanced or damped, or if the frequency of events will change.

Anthropogenic climate change is now well established as a global issue of scientific and political importance. One of the principal impacts of the gradual change associated with anthropogenic climate warming comes from a shift in, or an exaggeration of, pre-existing natural variability. For example, if the average distribution of precipitation shifts to higher or lower values, this can mean that thresholds to flooding or drought are crossed more often. One of the most important sources of natural climatic variability is ENSO. On a timescale of two to seven years, the eastern equatorial Pacific climate varies between anomalously cold (La Niña) and warm (El Niño) conditions. These swings in temperature are accompanied by changes in the structure of the subsurface ocean; variability in the strength of the equatorial easterly trade winds; shifts in the position of atmospheric convection; and global teleconnection patterns associated with these changes that lead to variations in rainfall and weather patterns in many parts of the world.

In the simplest possible scenario, present-day weather and climate variability such as ENSO would continue as before, superimposed onto a gradual mean warming of the global background climate. However, it is not clear whether the climate system will evolve in such a simple manner. As the mean state of both the atmosphere and the ocean in the tropical Pacific region evolve, the amplitude, frequency, seasonal timing or spatial patterns of ENSO could be altered[1]. Furthermore, the way ENSO affects remote locations outside the tropical Pacific could change even if ENSO itself does not.

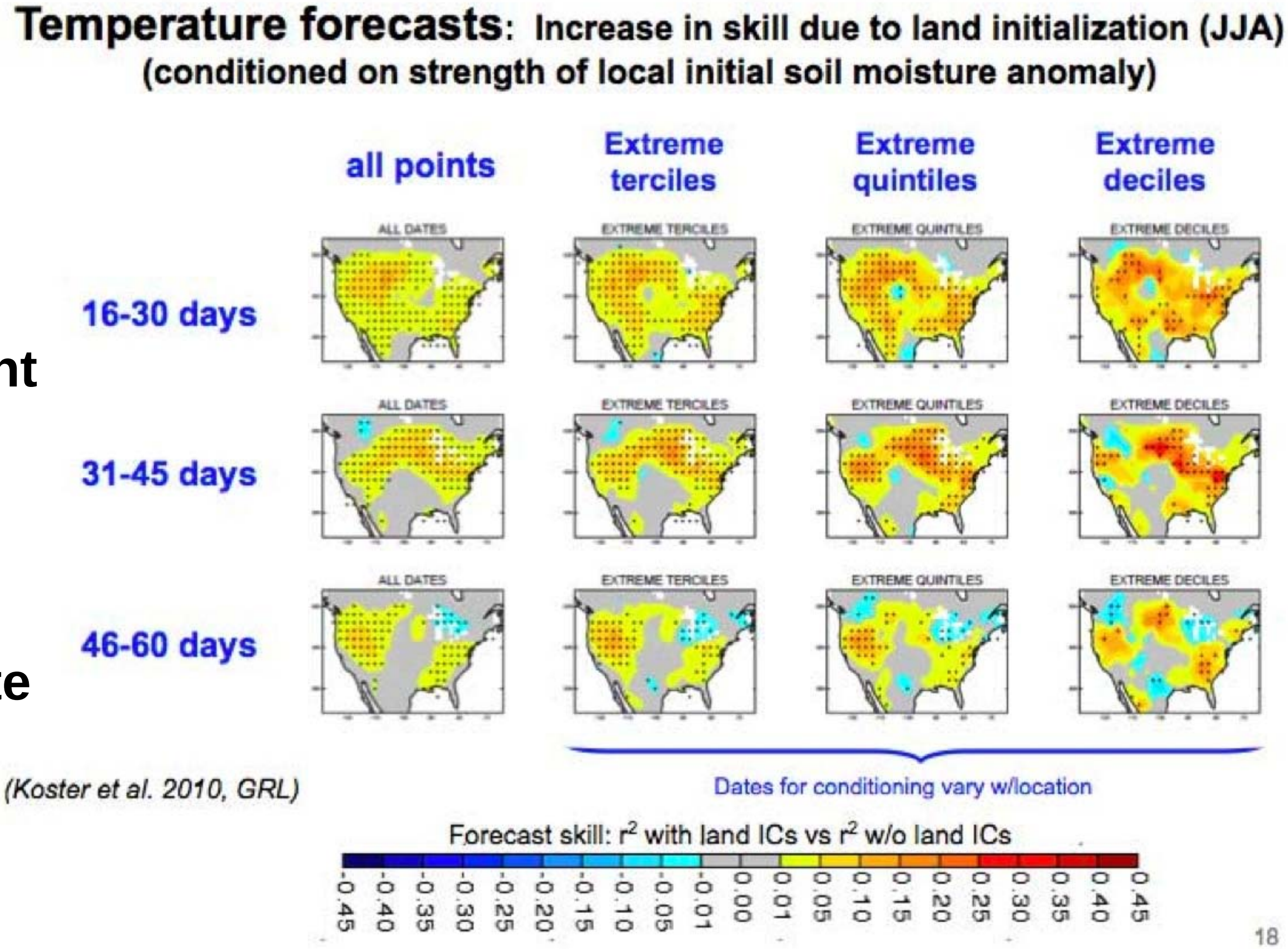
As a result of intensive research in recent decades, we have developed a good understanding of the basic physical features and processes involved in the ENSO cycle (Box 1). A hierarchy of mathematical models have been used to explain the dynamics, energetics, linear stability and nonlinearity of ENSO[2-5]. Complex coupled global circulation models (CGCMs) have become powerful tools for examining ENSO dynamics and the interactions between global warming and ENSO[6]. ENSO is now an emergent property of many CGCMs, that is, it is generated spontaneously as a result of the complex interplay of thermal and dynamic components in the coupled atmosphere–ocean system. However, it remains challenging to simulate ENSO using CGCMs, because of limitations in: (1) computer resources, which typically restrict climate model resolutions to fewer grid cells than are needed to adequately resolve relevant small-scale physical processes; (2) our ability to create parameterization schemes or include some relevant physical and biological processes that are not explicitly resolved by climate models; (3) the availability of relevant high-quality observational data; and (4) our theoretical understanding of ENSO, which evolves constantly[7]. Nevertheless, the coordination of CGCM experiments and the accessible archive of the resulting simulations[8] have led to an unprecedented level of assessment of the systematic biases in mean tropical Pacific conditions, and of the characteristics, physical processes and feedbacks underlying ENSO evolution in CGCMs[9-17].



It is not yet possible to say whether ENSO activity will be enhanced or dampened, or if its frequency will change, despite considerable progress in understanding of climate change on many processes that contribute to El Nino variability.

Collins et al., Nature Goesciences, 2010

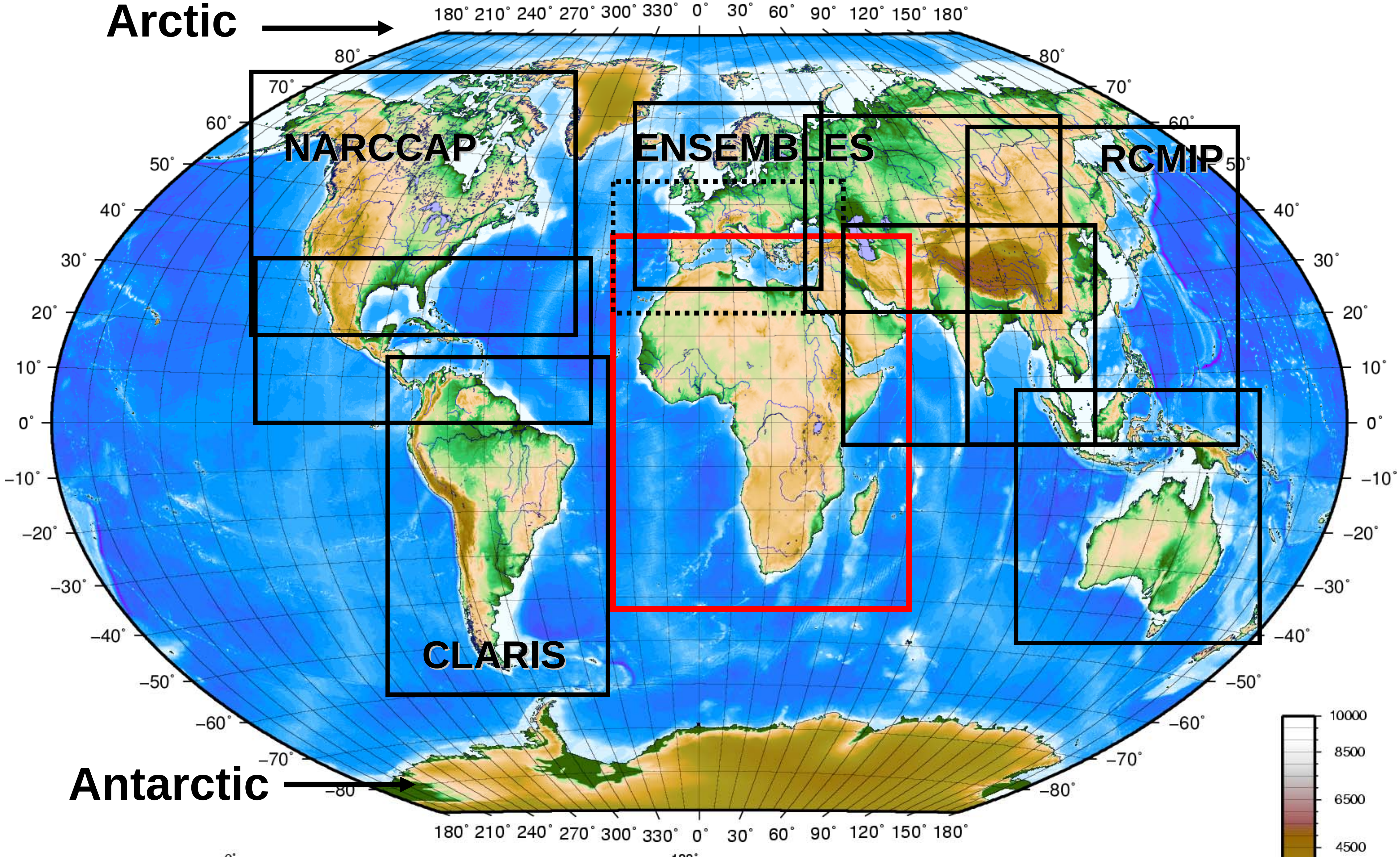
Seasonal Climate Prediction



(Koster et al. 2010, GRL)

The results highlight the potential usefulness of improved observational networks for climate prediction.

WCRP Regional Climate Project: CORDEX



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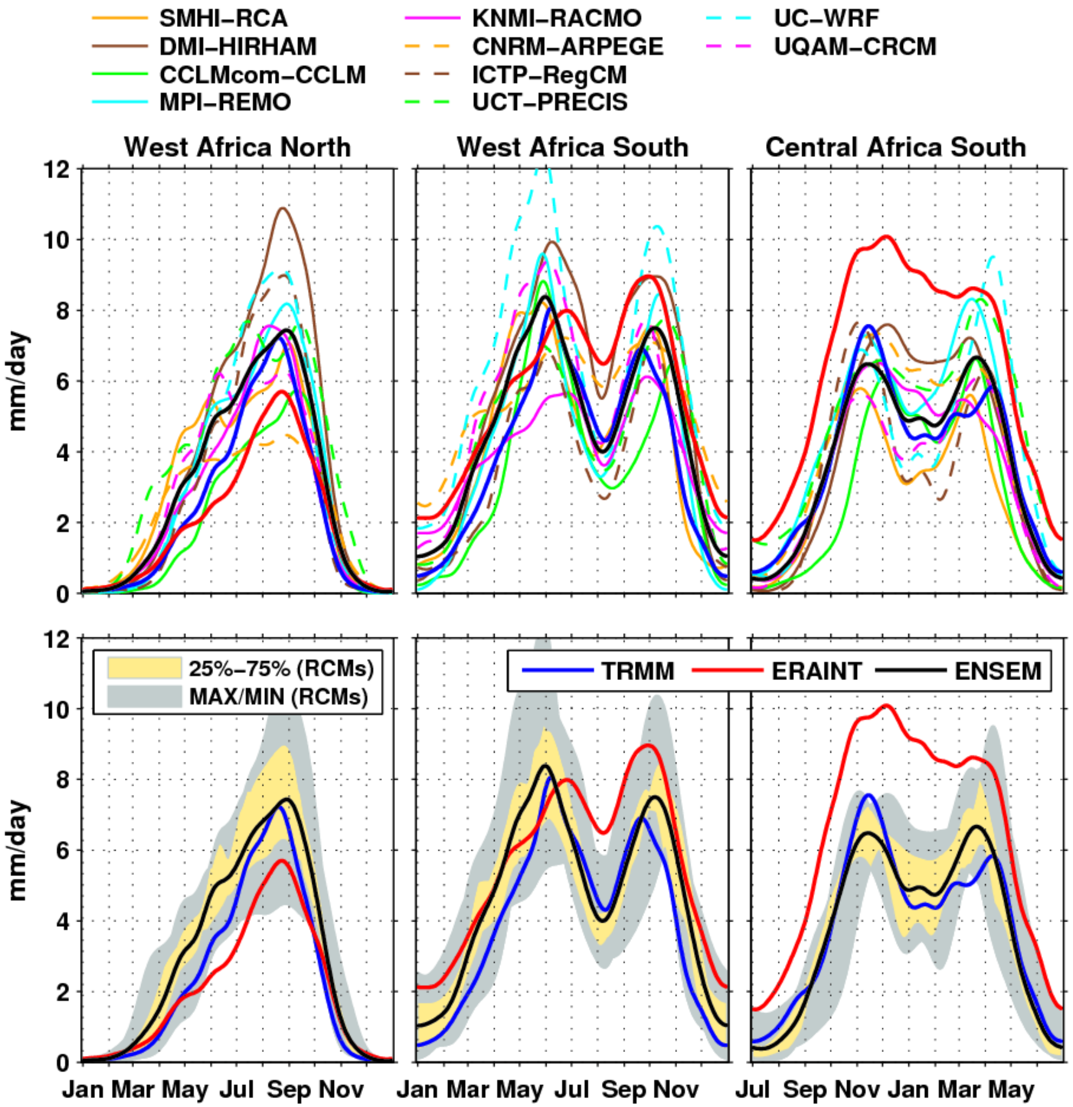
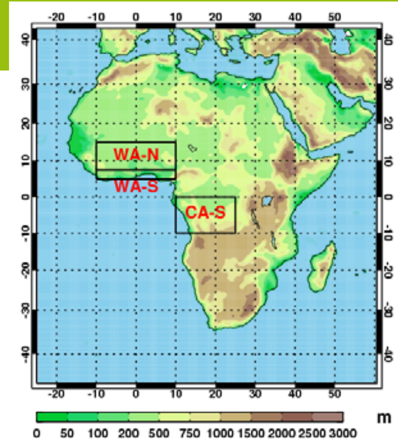
Regional Climate Prediction





Annual cycle of precipitation simulated by 10 Regional Climate Models (RCMs) for three African regions compare very well with satellite observations (TRMM) and reanalysis.

Courtesy of C. Jones, Sweden Met. Center

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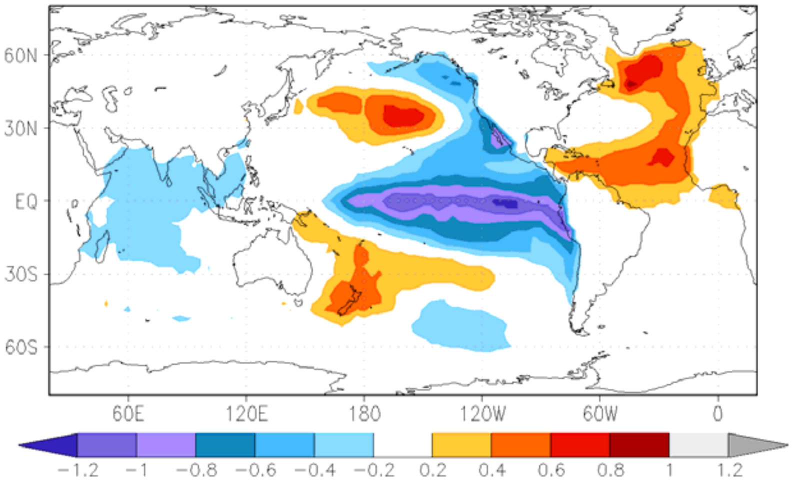
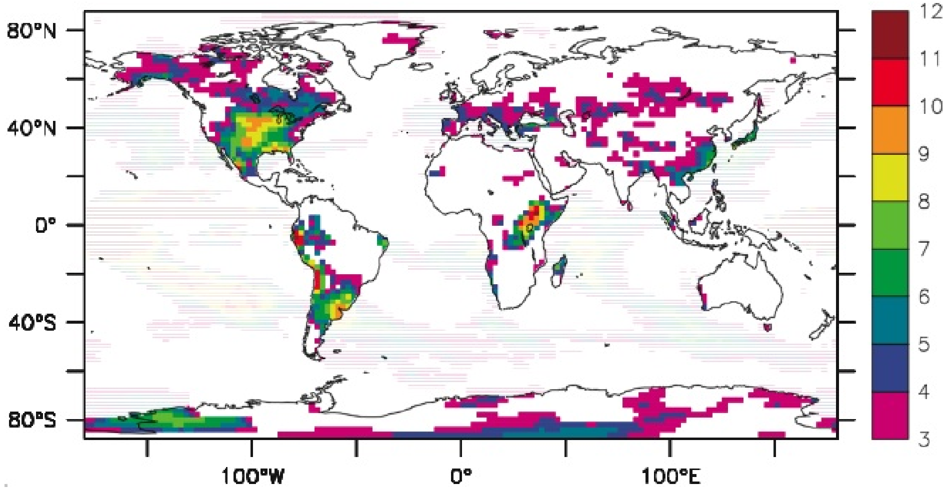
Droughts in a Changing Climate

Climate Model Evaluation Project (DRICOMP)



SSTA patterns

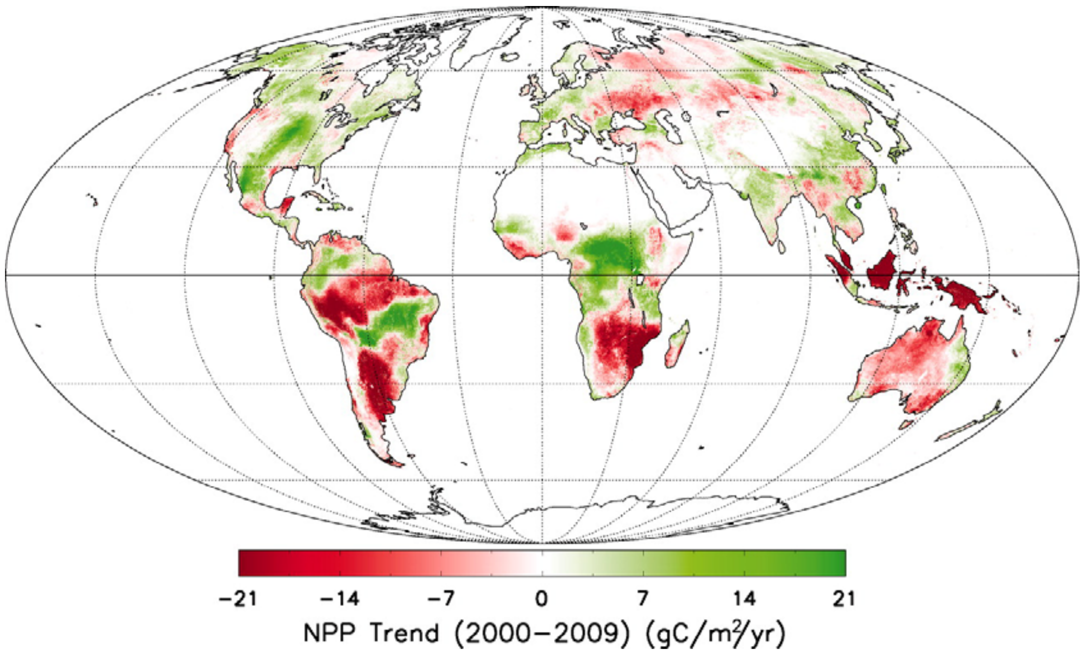


Implications for future global droughts.

Courtesy of Kirsten Findell (GFDL-NOAA-USA)

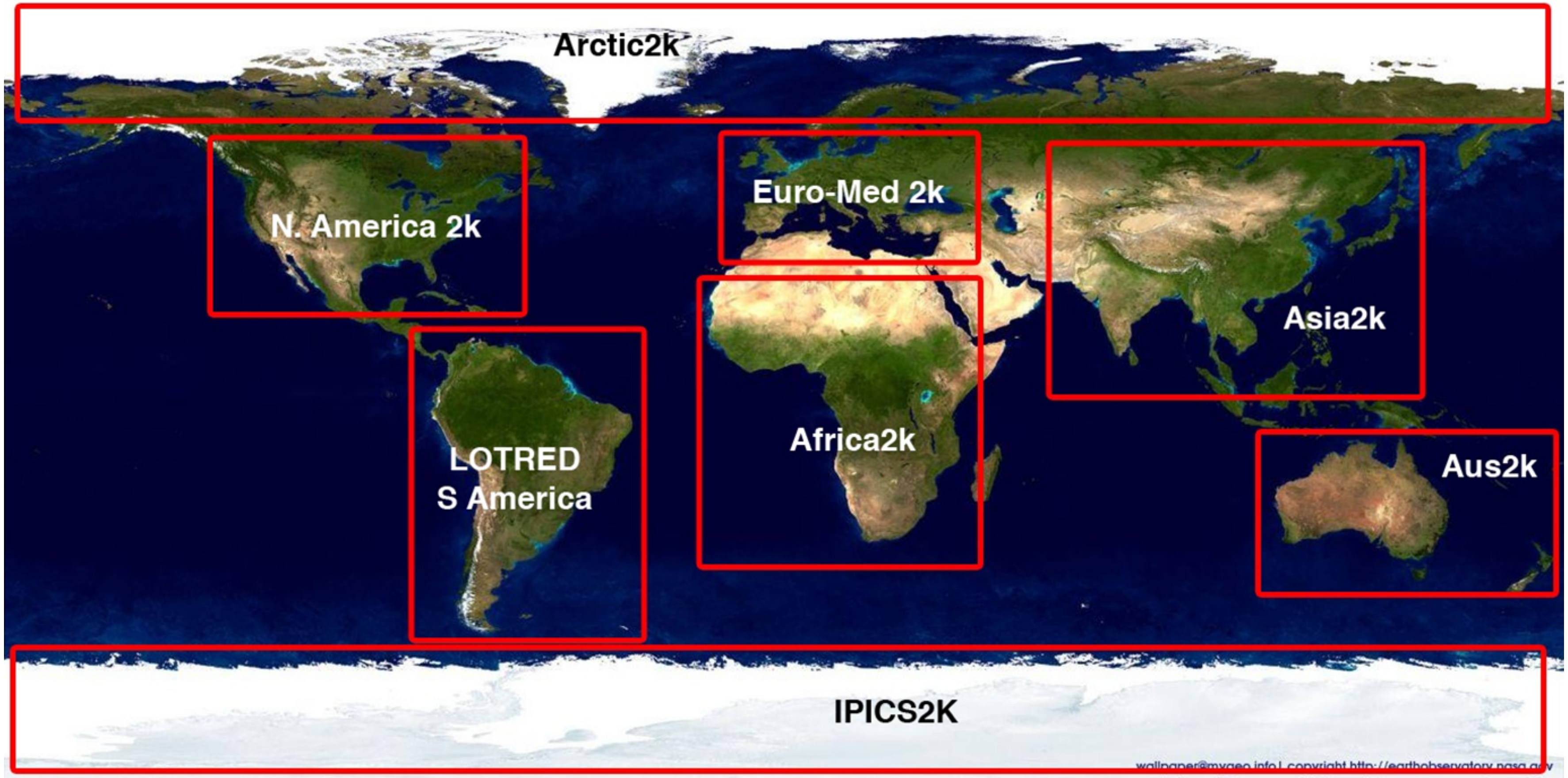
Regional and Decadal Trends in Terrestrial Ecosystems Net Primary Production

- Global NPP decrease
- SH decrease - drought
- Impact on terrestrial Carbon sink



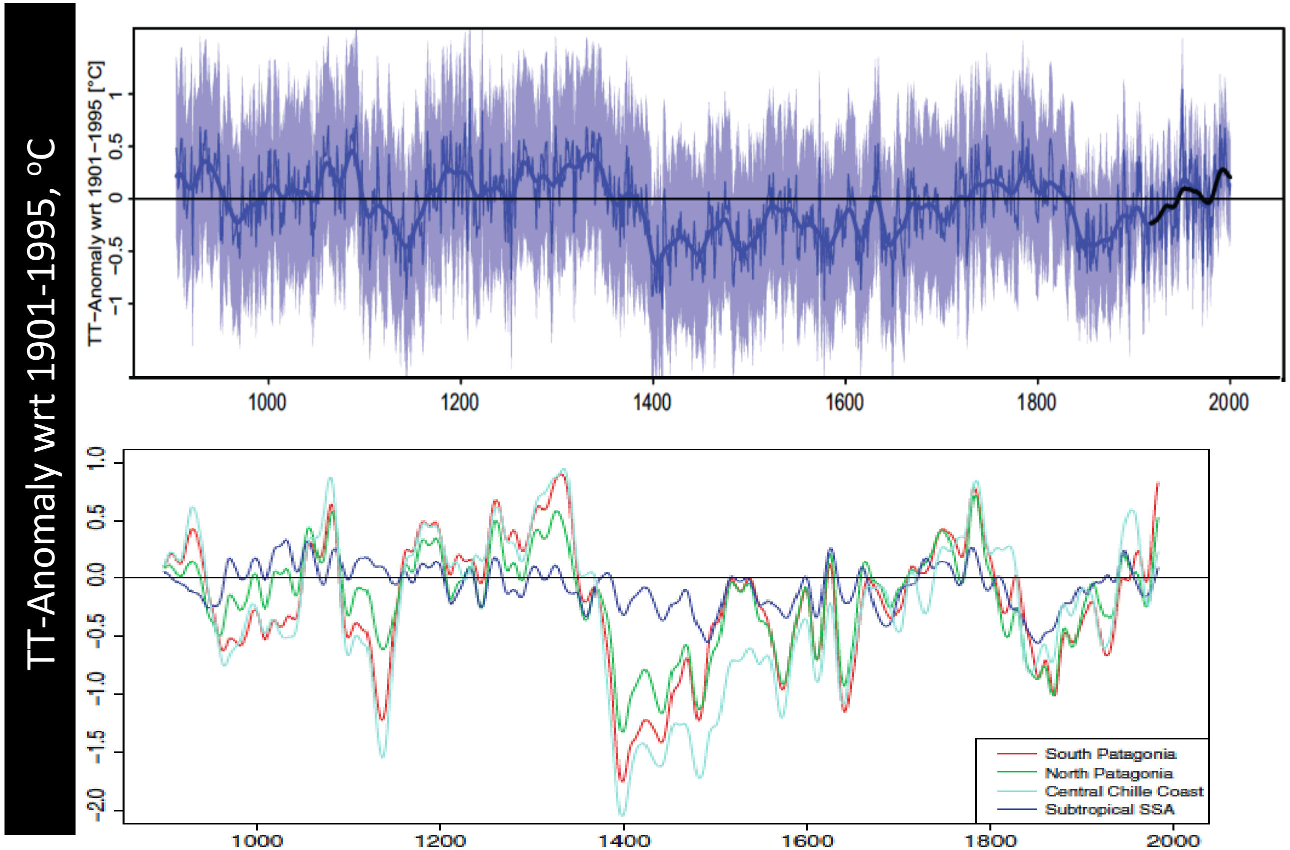
Terrestrial NPP Trends (2000 – 2009)

Regional & Decadal Paleo-Records



Regional and sub-regional climate of southern South America

Villalba et al. 2009 Palaeo-3 (special issue)



Amazon Forest Tipping Point!

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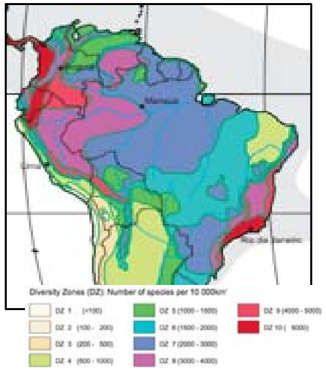
Biodiversity Status

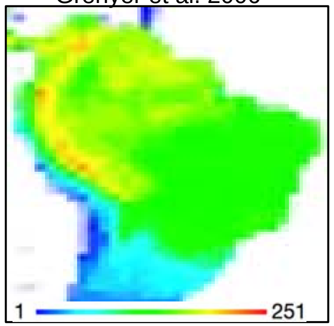
Vascular Plants

Barthlott et al. 2005



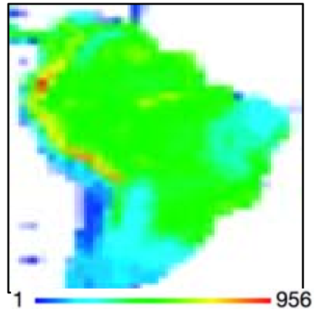
Mammals

Grenyer et al. 2006



Birds

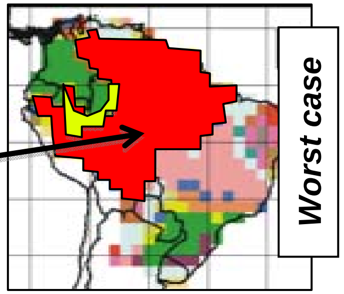
Grenyer et al. 2006



Species Number (/10,000 km²)

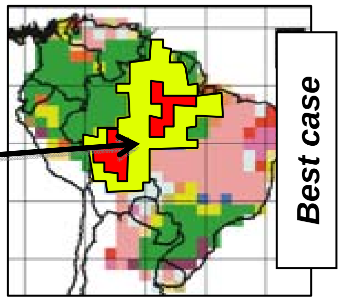
2075

Humid Tropical Forest Dieback (=red)



Climate Change ≈3.2° C + 50% Deforest + Fire

Fate of Tropical Forest Uncertain (=yellow)

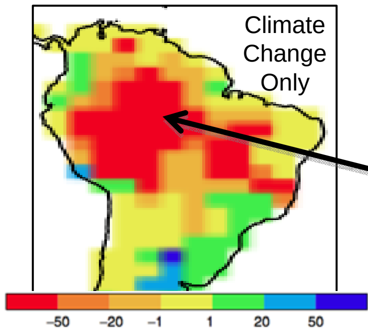


Biome shifts

Climate Change ≈1.6° C

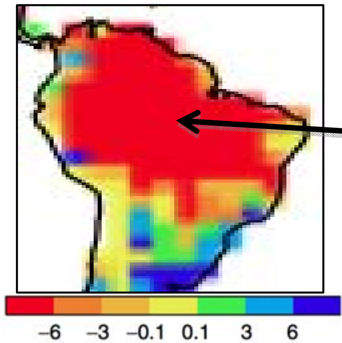
World Bank 2010

2099



Tree cover change

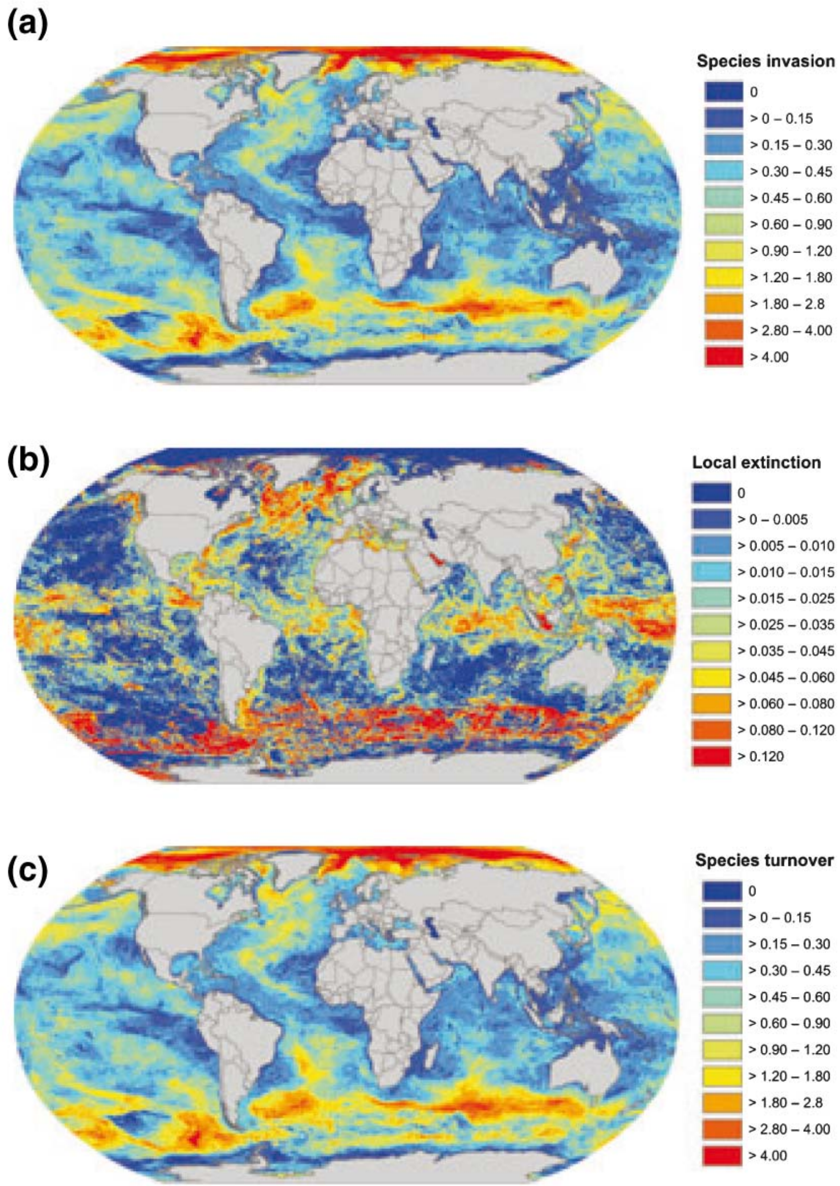
Tropical Forest Dieback (=red)



Total C change (Pg C)

Massive C loss to atmosphere (=red)

Sitch et al. 2008



SHIFTS IN THE DISTRIBUTION OF SPECIES, SPECIES GROUPS AND BIOMASS DUE TO CLIMATE CHANGE

Turnover of marine fish and invertebrate species by 2050

Shifts in the distribution of fish due to ocean warming could lead to a large turnover of species especially in the tropics and high latitudes. This could lead to major upheavals of local to global fisheries.

Source: Cheung et al. 2009 Fish and Fisheries. See also Leadley et al. 2010 CBD, Periera et al. 2010 Science.

IPCC SRES A1B scenario.

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Summary

Research Priorities Include;

Quantify and communicate uncertainties in climate change information/knowledge;

A major focus on regional and intera-seasonal to inter-annual, and decadal climate prediction/projection;

Promote and enable timely, reliable, and easy to access climate information and knowledge for adaptation planning, mitigation strategies, and assessing risks of climate variability and change; and

Support education, training and development of next generation of climate experts.

Essential Pillar of Global Framework for Climate Services

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