Robust assessment of the expansion and retreat of Mediterranean climate in the 21st century

A. Alessandri, M. De Felice, N. Zeng, A. Mariotti, Y. Pan, A. Cherchi, J-Y. Lee, B. Wang, K-J. Ha, P. Ruti & V. Artale

Motivation: The warm-temperate regions characterized by dry summers and wet winters (Mediterranean climate, MED) are especially vulnerable to climate change. The potential impact on water resources, ecosystems and human livelihood requires a detailed picture of future changes.

The *Köppen-Geiger* bio-climatic classification method is applied to *CMIP5 MME* to assess: (i) probability of MED zones to change and (ii) MED area change under the RCP4.5 GHGs concentration scenario.

Probabilistic approach

MED Probability

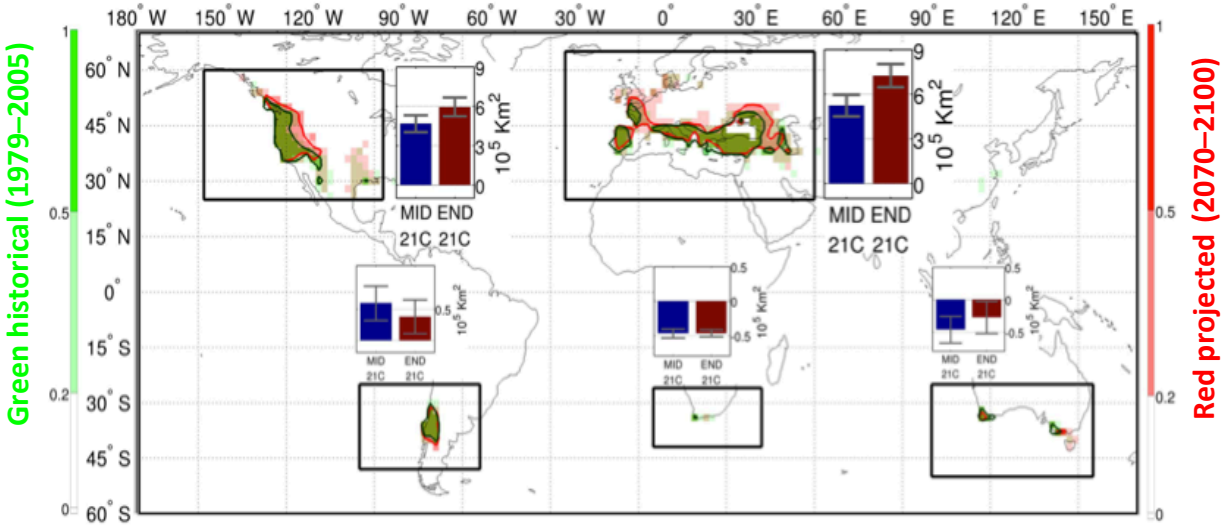
$$P_{MED}(i,j) = \frac{1}{N}\sum_{k=1}^{N}[1,0]_{i,j}^{k}$$

MED Area

$$A_{MED} = \sum_{i=1}^{Nx}\sum_{j=1}^{Ny} area_{i,j} \cdot P_{MED}(i,j)$$

N=n. CMIP5 Models
Nx=n. longitudes
Ny=n. latitudes
$area_{i,j}$=grid point area

Probability (P_{MED}) of Mediterranean climate simulated by the CMIP5 multi-models



Inset histograms are the area changes by MID (2035-2065) and END (2070-2100) 21st century

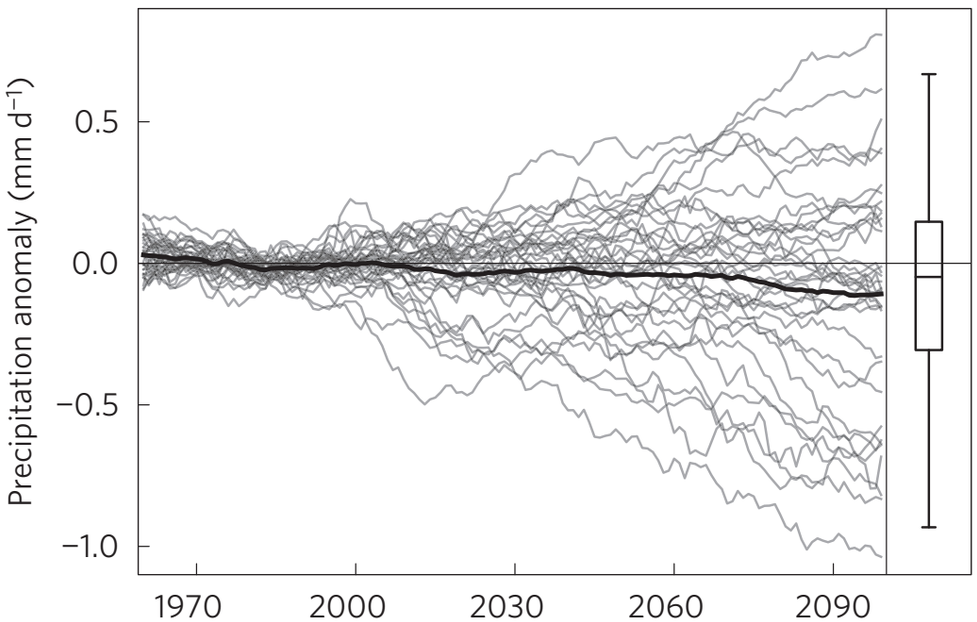
Why MED climate distribution change?

Paper at http://www.nature.com/articles/srep07211

Different reasons in different regions: e.g. increased rainfall seasonality drive northward MED expansions over humid Warm temperate regions, eastward expansions are temperature driven, poleward retreats due to rainfall reductions all year round (thermodynamic effect).

Projected strengthening of Amazonian dry season by constrained climate model simulations

Boisier, Ciais, Ducharne & Guimberteau (IPSL, France)

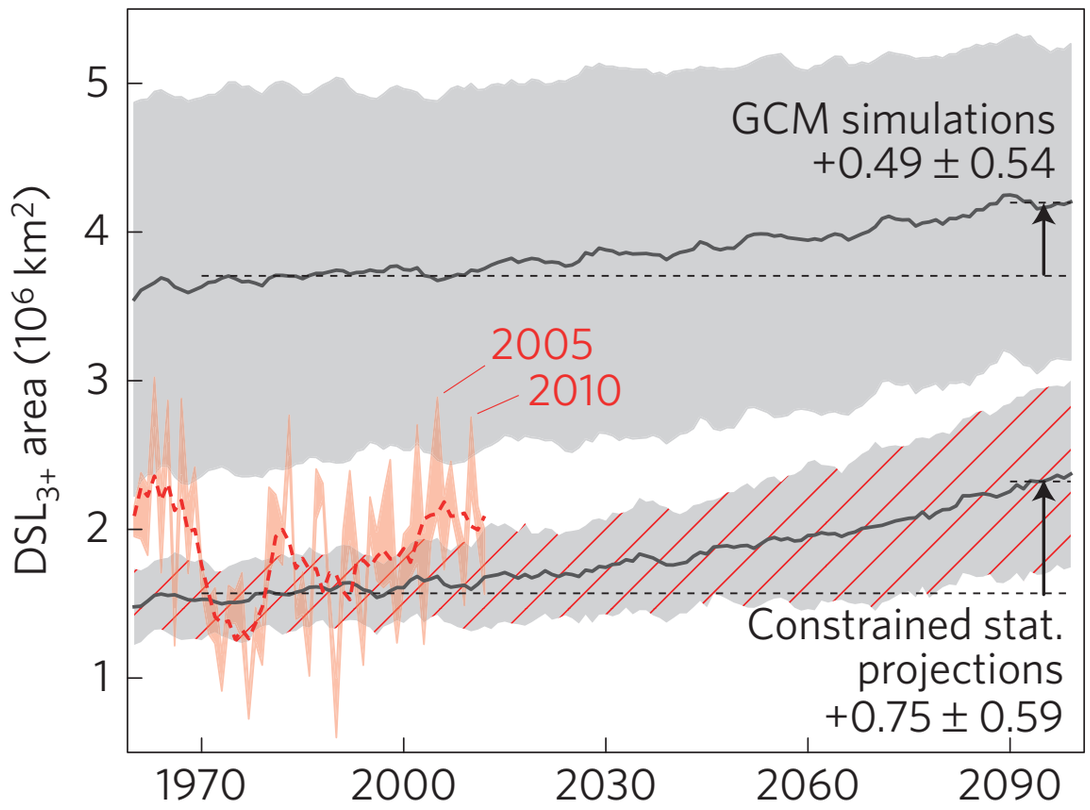


> Multi-GCM (CMIP5) projections of precipitation are very uncertain in Amazonia

We make use of an observed empirical relationship between regional precipitation (Amazonia) and large-scale circulation to constrain the GCM simulations.

- The region with savannah-like (lengthy) dry seasons is projected to expand in southern Amazonia.
- Our results confirm the dominant picture shown by GCMs, but suggest that the 'model democracy' view of these impacts can be significantly underestimated.

See Boisier et al. (Nature Clim. Change, 2015)

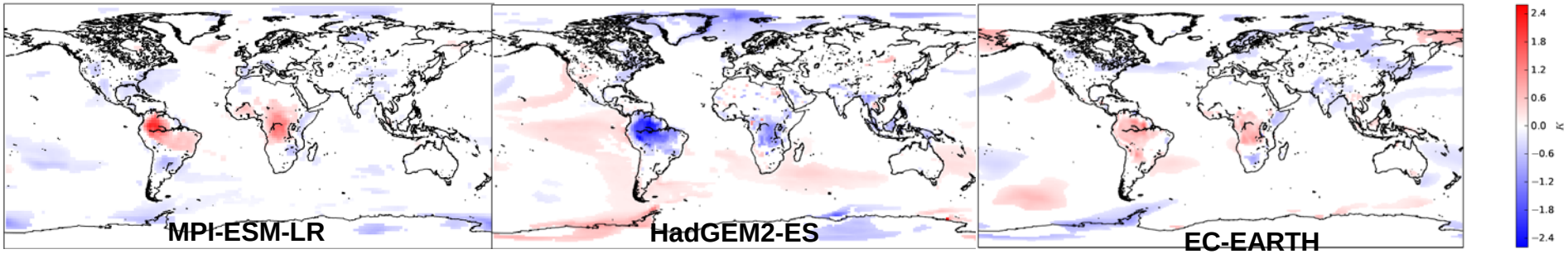


Biogeophysical effect of large-scale tropical deforestation in three Earth System models

Victor Brovkin, Thomas Pugh, Eddy Robertson, Sebastian Bathiany, Almut Arneth, and Chris Jones

- Previous deforestation experiments were performed with prescribed SSTs-> ocean feedbacks were not included
- Effects of tropical deforestation (23S -23N) in high CO_2 world (2100) are studied with 3 coupled models

Changes in annual SAT, K



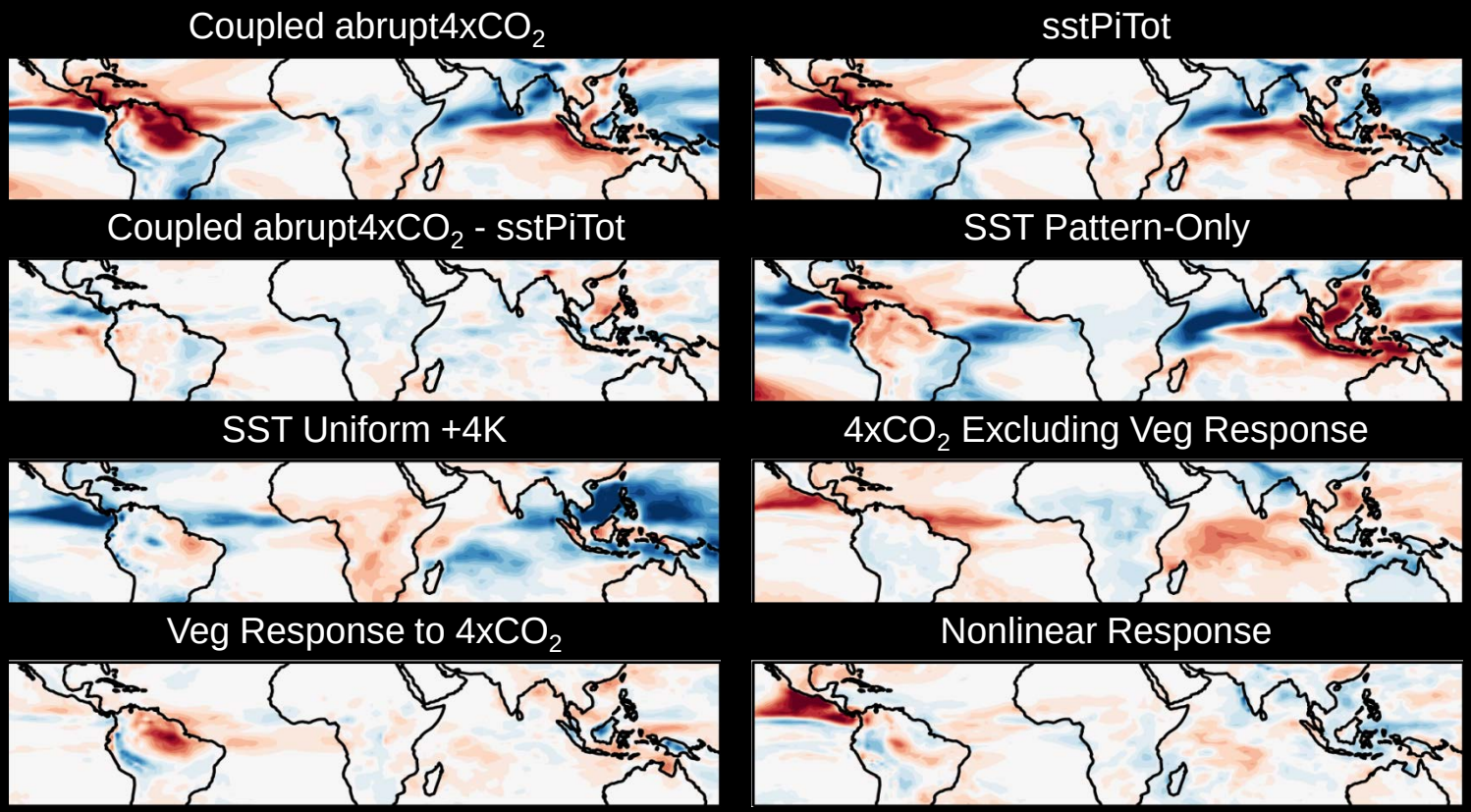
RESULTS

- All models show negligible effect on global temperature, with a potential for a slight cooling trend
- Global temperature response is different from experiments with fixed SSTs
- Regional cooling simulated by HadGEM2-ES requires further investigation
- Large-scale deforestation experiments with ESMs are insightful and planned for CMIP6 models in LUMIP

Understanding processes and uncertainty in regional climate change

Rob Chadwick (Met Office), Hervé Douville (CNRM) and Chris Skinner (U. Michigan)

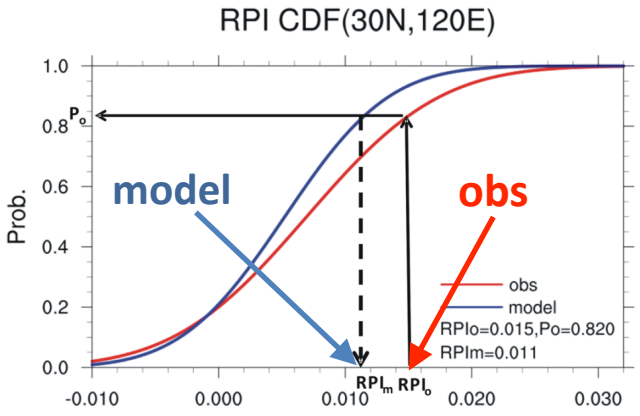
Annual Precipitation Change HadGEM2



Present and Future Projected Changes of Asian Summer Monsoon Evolution and Intensity in CMIP Models

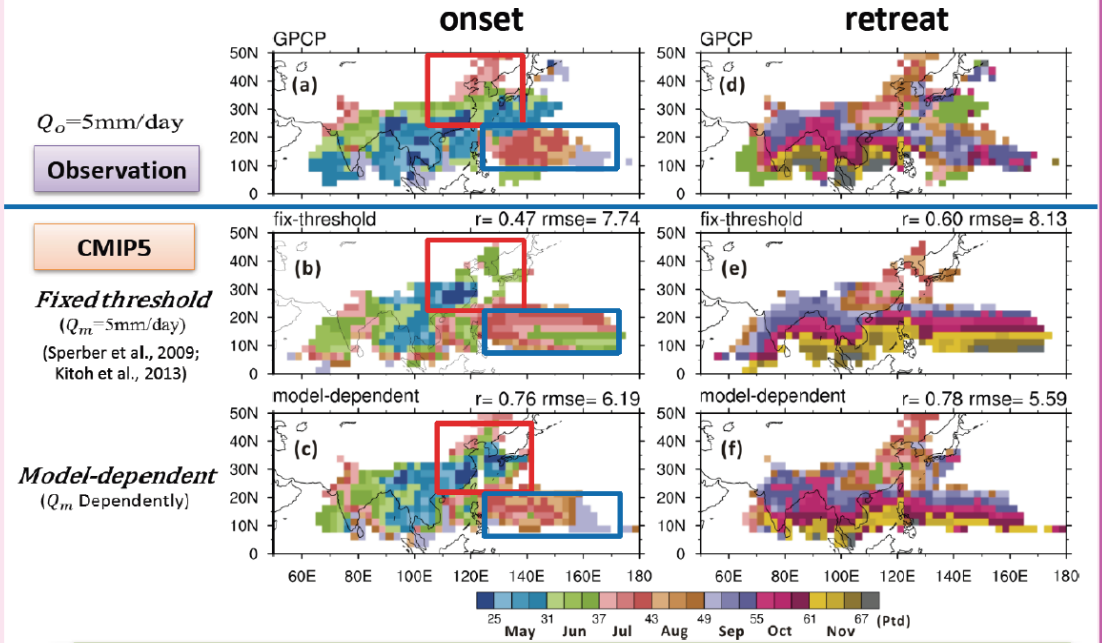
C.T. Chen[1], Y.S. Tung[2], P.C. Hsu[3].
[1]National Taiwan Normal University, Department of Earth Sciences, Taipei, Taiwan.
[2]National Science and Technology Center for Disaster Reduction, TCCIP, Taipei, Taiwan.
[3]Nanjing University of Information Science and Technology, College of Atmospheric Science, Nanjing, China.

Instead of using fixed criteria of local evolution of climatic pentad rainfall, we use the CDF of normalized RPI to find the model criteria corresponding to observation to minimize effect from model biases.



$$\mathrm{RPI} = \frac{P - \overline{P_{Jan}}}{P_{total}}$$

Fixed-threshold and Model-dependent Criteria Comparison

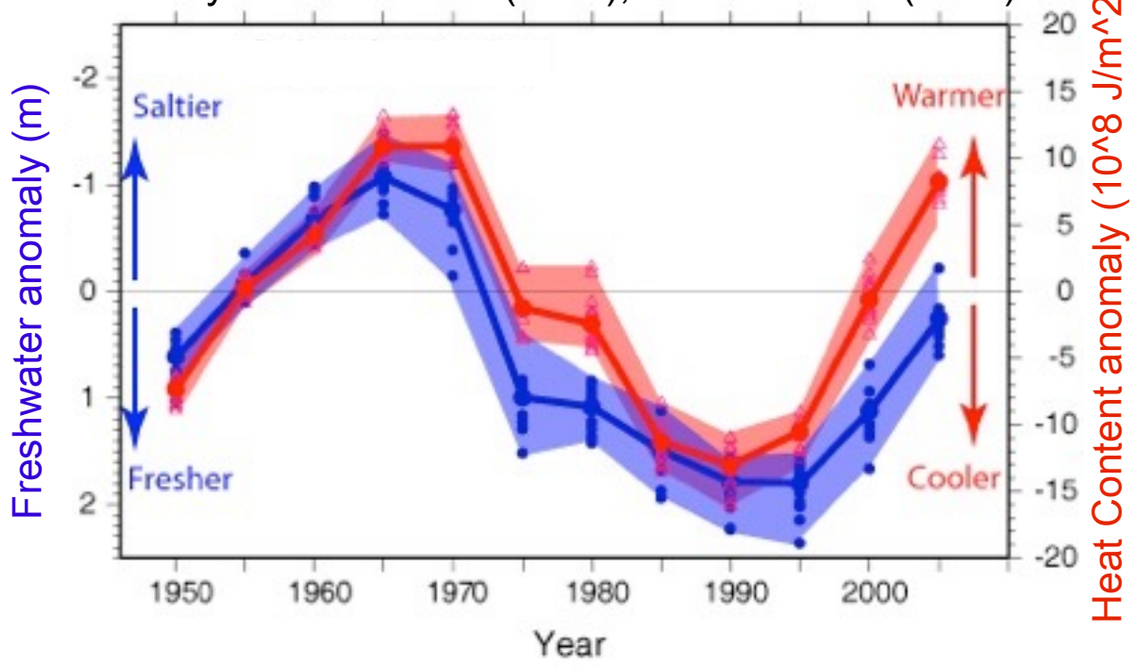


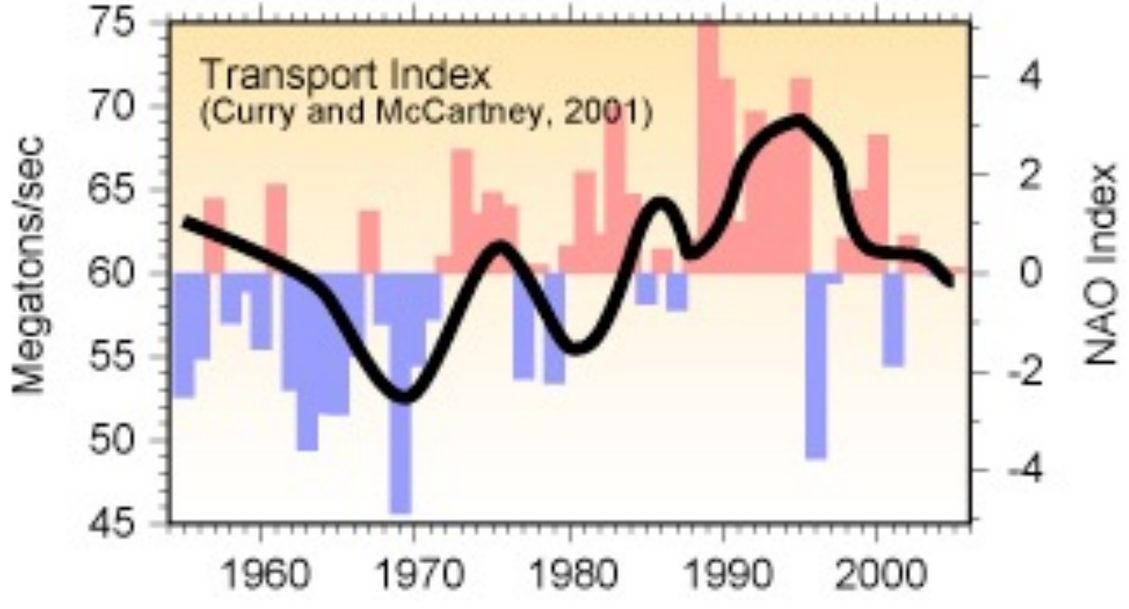
Using model dependent RPI bias correction, the regional onset timing improved over NE Asia and NW Pacific.

Friday, Oct. 23, Session 5, Poster no. 5

Observations and hindcast simulations suggest that from early 1970s to mid-1990s the subpolar gyre became fresher while the gyre and meridional circulation intensified.

Curry and Mauritzen (2005), Peterson et al (2006)





This is opposite to the relationship of freshening causing a weakened circulation most often reproduced by climate models.

Jungclaus et al. (2005), Msadek and Frankignoul (2009)

Do these two configurations coexist but dominate on different time scales?

CMIP5 intercomparison of freshwater budget and circulation in the North Atlantic

Julie Deshayes, Ruth Curry and Rym Msadek

Journal of Climate (27), 3298-3317, DOI 10.1175/JCLIM-D-12-00700.1

A mid-Holocene constraint for future projections (of the North Atlantic Oscillation)?

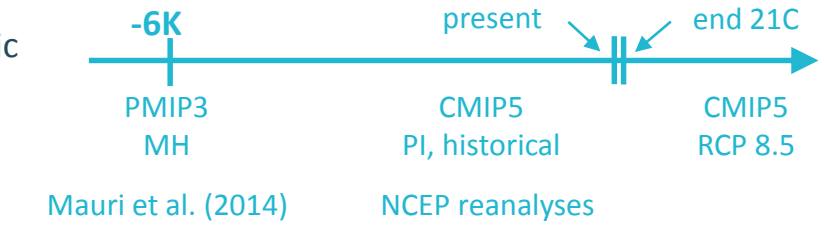
Alina Găinuşă-Bogdan, Didier Swingedouw, Pascal Yiou, Julien Cattiaux, Francis Codron

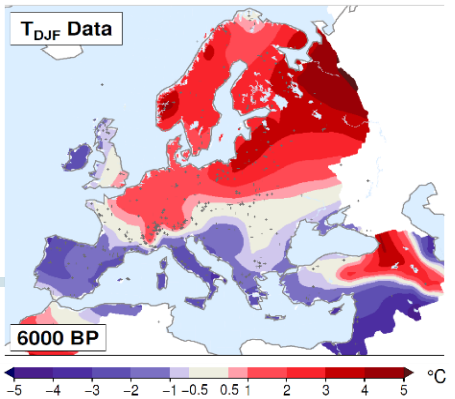
Poster #7

- Future projections of winter NAO – little agreement between models
- Mid-Holocene (MH) winters – characterized by conditions typical of NAO+

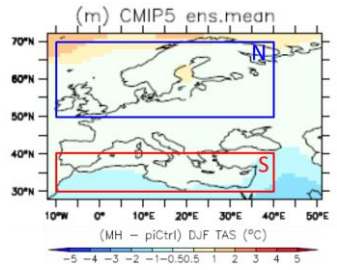
⇨ Can we use MH European winter temperature reconstruction to constrain future CMIP5 projections of winter NAO?

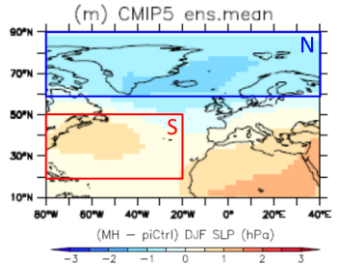
- Focus: Europe, North Atlantic
- Simulations
- Observational data

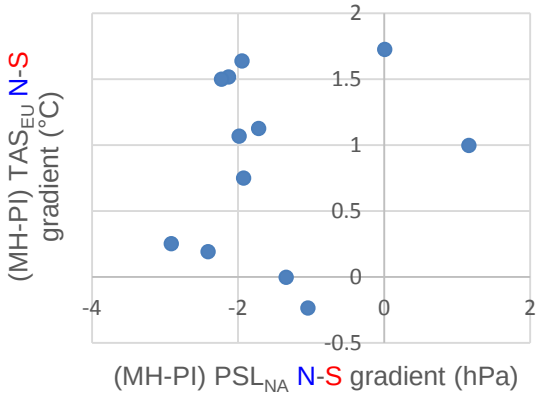




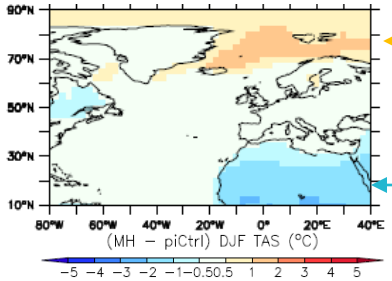
Mid-Holocene winter temperature anomalies as reconstructed from pollen data. Figure from Mauri et al. (2014).



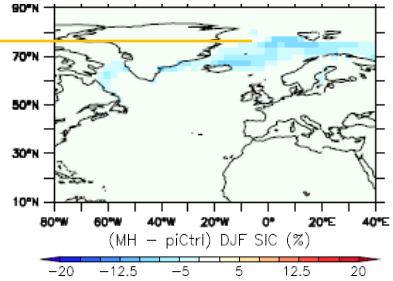




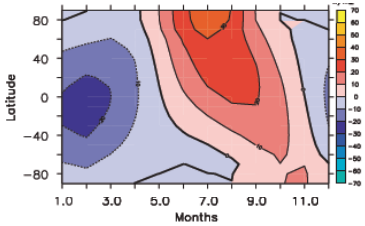
Δ temperature



Δ sea ice cover



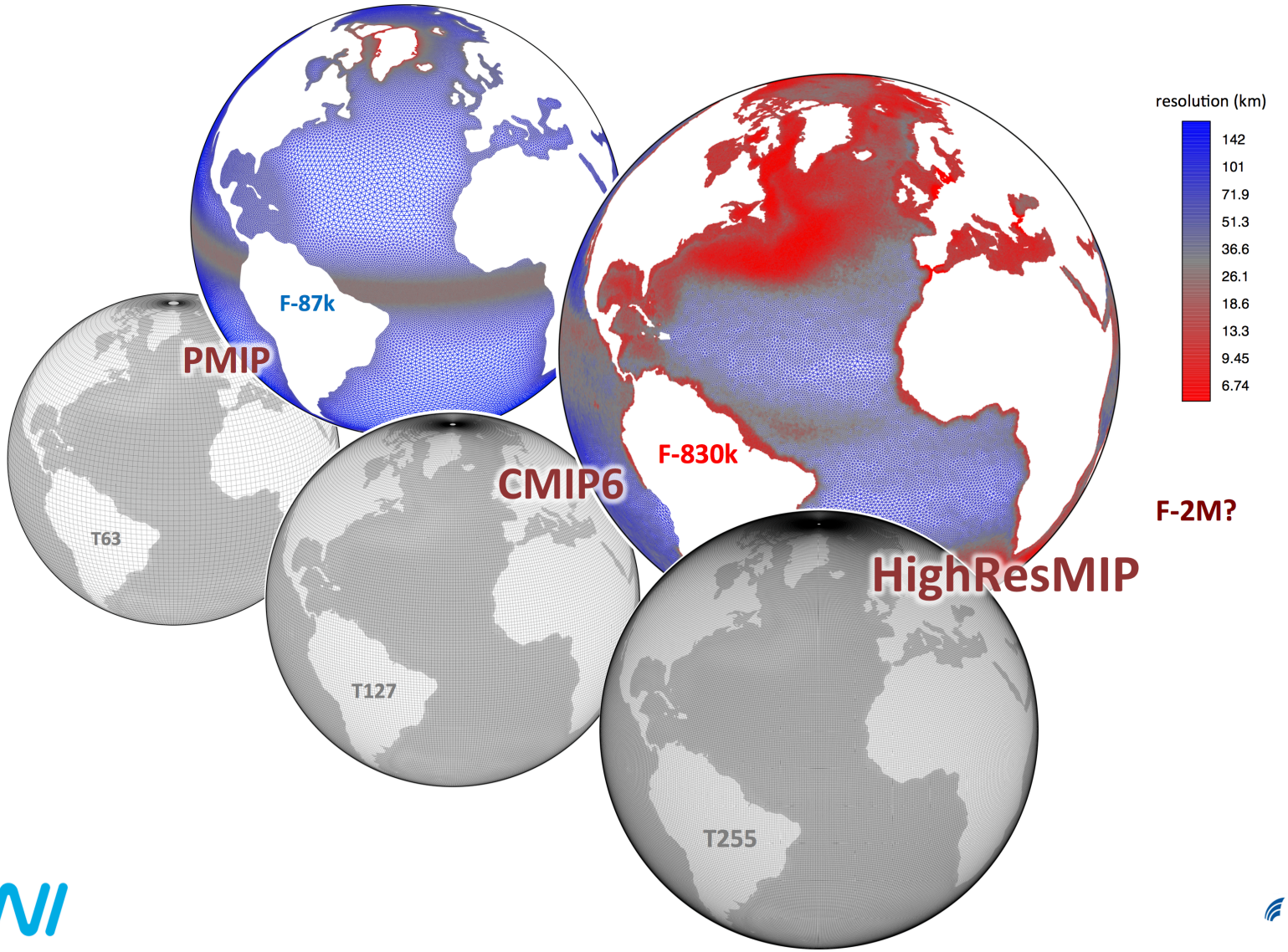
radiative forcing



MH-PI insolation (Wm^{-2}) at the top of the atmosphere as a function of latitude and month. Figure from Swingedouw et al. (2009).

Multi-resolution modeling with AWI-CM in CMIP6

Tido Semmler, Dmitry Sidorenko, Thomas Rackow, Helge F. Goessling, Dmitry Sein, Qiang Wang, Sergey Danilov, Thomas Jung, Gerrit Lohmann



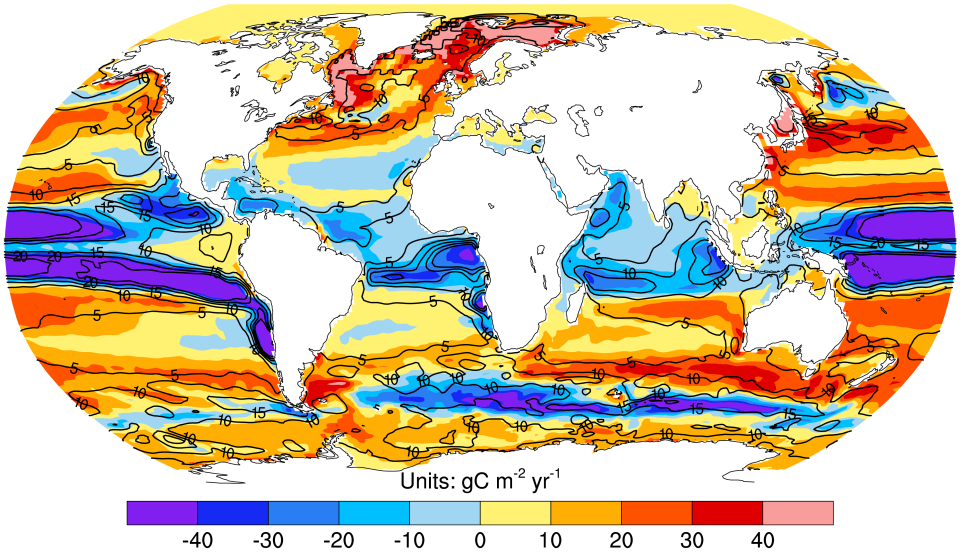
Decadal predictions of the oceanic carbon uptake

HONGMEI LI, TATIANA ILYINA, WOLFGANG MÜLLER

Max Planck Institute for Meteorology

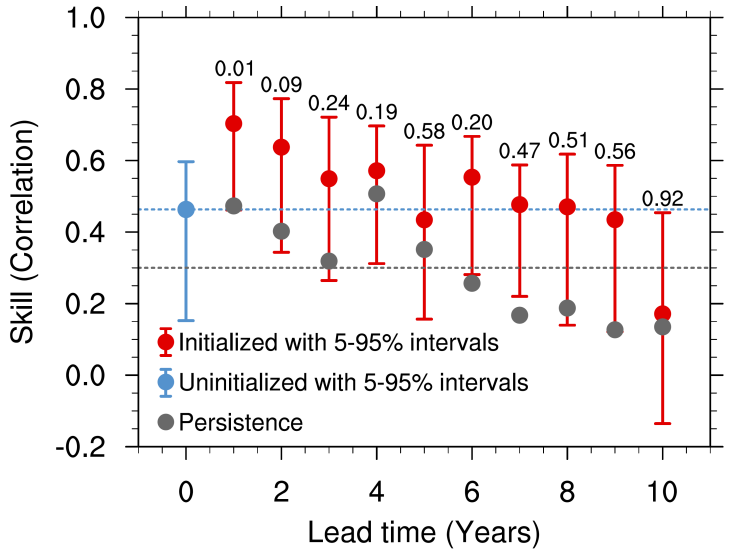
Is the global oceanic carbon uptake predictable?

C-uptake in the MPI-ESM decadal prediction system



- magnitude of interannual variability is close to the climatological mean state.

Prediction skill of the N. Atlantic SPG C-uptake



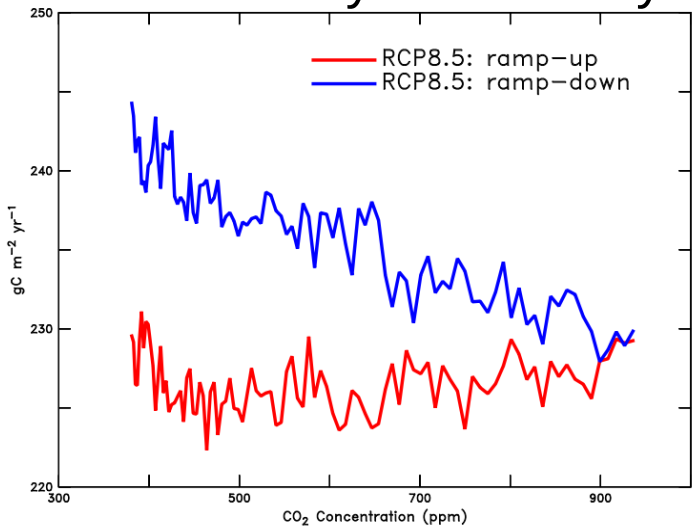
- potential prediction skill of up to 4 years is attributed to the improved physical state of the ocean (Li et al., in review)

A more productive, but different, ocean after mitigation

Jasmin G. John, Charles A. Stock, John P. Dunne

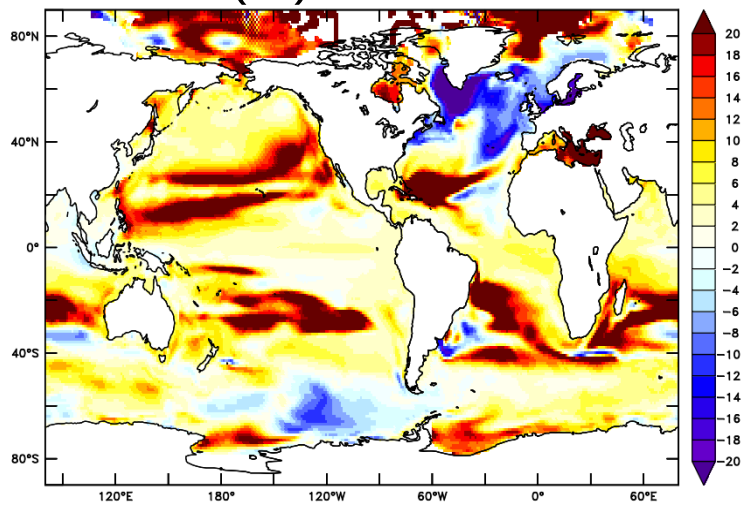
NOAA/GFDL

Net Primary Productivity

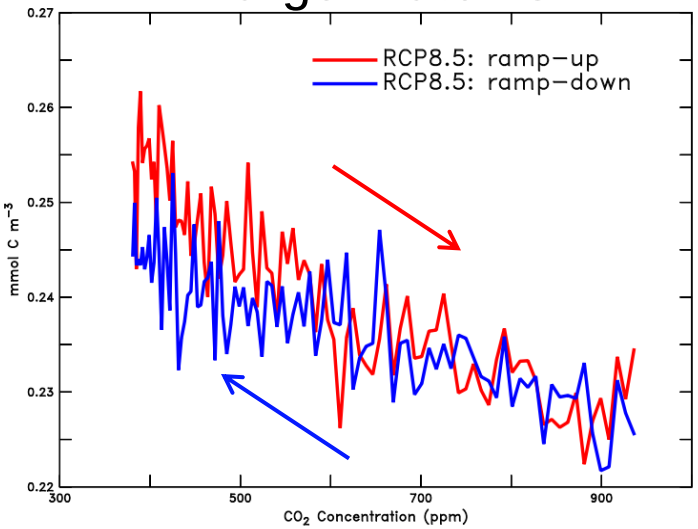


ΔNPP (%)

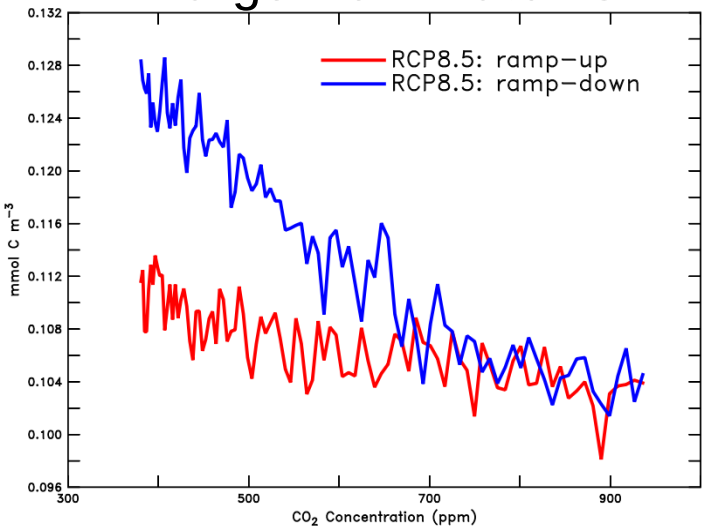
2146-2195 vs 2006-2055



Large Diatoms



Large Non-Diatoms

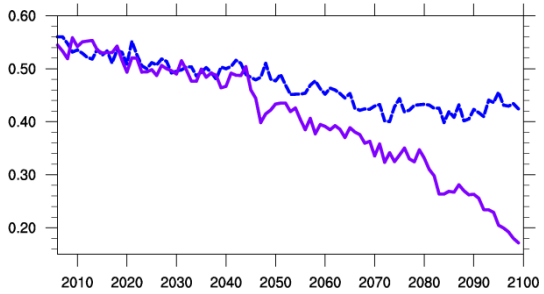


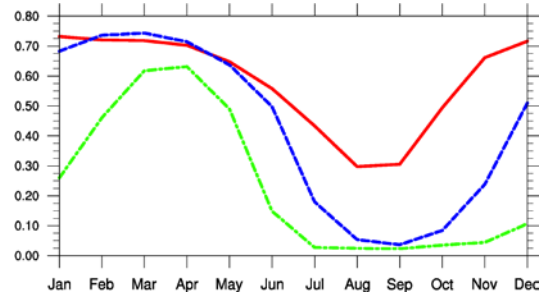
Future Arctic Sea Ice and Climate Projections from RCP Scenarios

Johan Lee, Young-Hwa Byun, Kyung-On Boo, Hyunsuk Kang, and Chun-Ho Cho
National Institute of Meteorological Sciences, Korea Meteorological Administration

Based on the RCP climate change scenarios which had been produced by NIMS using HadGEM2-AO

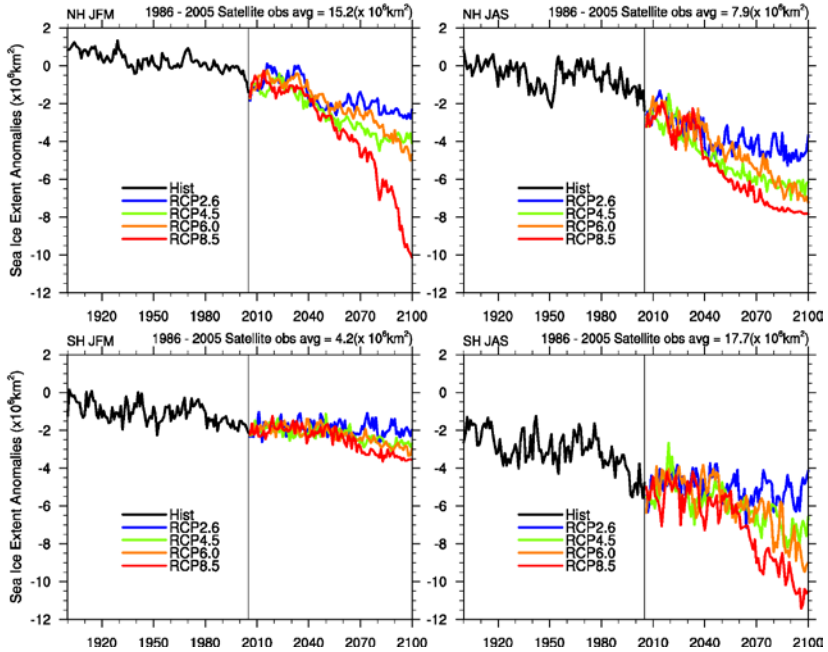
- the sea ice and the climate changes over the "Arctic" region in the future studied
- analysis with multi model results needed for reducing uncertainties
- base information to improve sea ice process in the coupled model for CMIP6





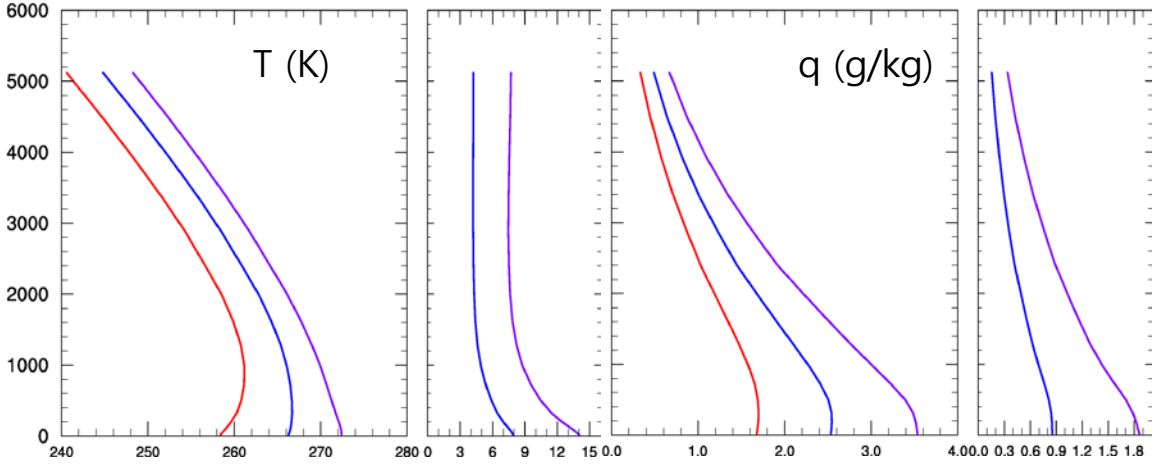
- Ice reduction greater in summer than in winter (seasonally ice covered state in summer)
- Sea ice concentration decreases continually (blue: RCP 4.5, scarlet: RCP 8.5)
- Sea ice reduction in summer, and late recover in the autumn (red: HIST, blue: RCP 4.5, green: RCP 8.5

Simulated Anomalies in Sea Ice Extent for the 20th and 21st centuries for Winter and Summer Hemispheres



Mean temperature and humidity (SON) over the Arctic ocean

- Increases of the heat and moisture transfer from the ocean (relatively warm and saturated) with reduced sea ice cover
- Overall increases of the temperature and humidity through the lower troposphere by GHGs and increased convective activities over the Arctic

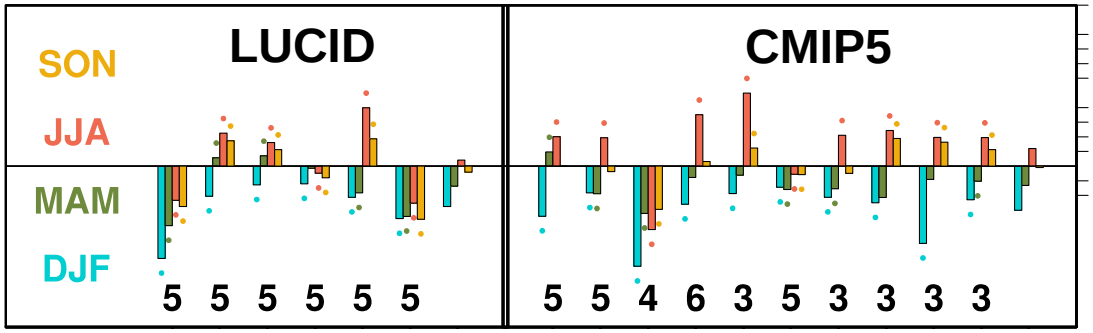


The biogeophysical effects of land-cover changes on mean and extreme temperature in temperate regions from 1850 to present

Quentin Lejeune[1], Edouard L. Davin[1], Sonia I. Seneviratne[1]
[1]Institute for Atmospheric and Climate Science, ETH Zürich, Switzerland

Few CMIP5 models ran simulations forced only with land-cover changes (LCC)

[1] We use a method to reconstruct the impact of LCC on climate in all-forcings simulations
[2] We demonstrate that it works well for albedo, LH, and both seasonal mean and extreme temperatures
[3] Models agree on a cooling effect of LCC in DJF and for cold extremes, but show a stronger disagreement than previous studies for JJA and warm extremes



ETH zürich

Abstract N°12

Slowdowns and accelerations of surface global warming due to tropical Pacific internal variability: A multi-model intercomparison

H. Tatebe, K. Lestari, Y. Kosaka, and Y. Imada

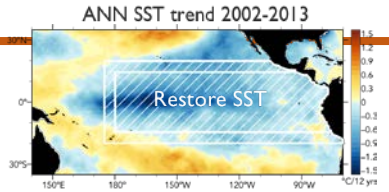
BACKGROUND

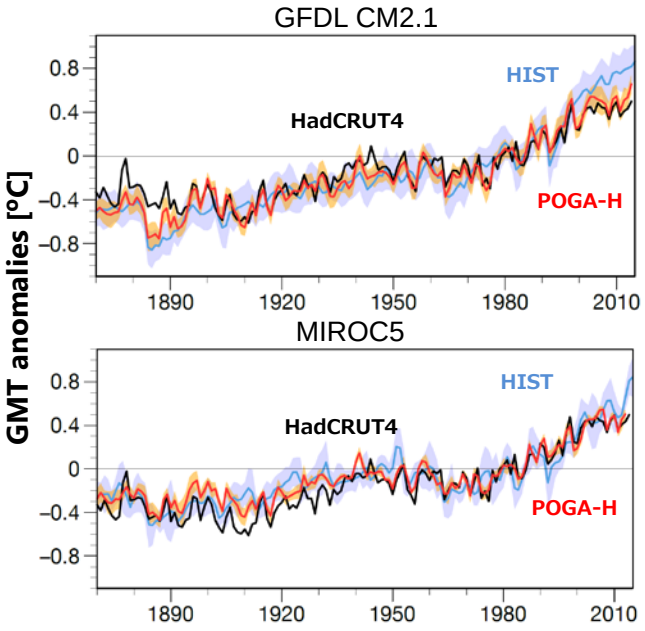
Global-mean temperature (GMT) trend in this century is

- Slower than in the 1980s-1990s
- Slower than the ensemble mean of CMIP5 historical and RCP simulations

Kosaka and Xie (2013)

- A 2-parameter CGCM exp. (restored tropical Pacific SST variability) called **POGA** exp.
- Radiative-forced warming+GMT decrease due to recent tropical Pacific cooling → Current hiatus





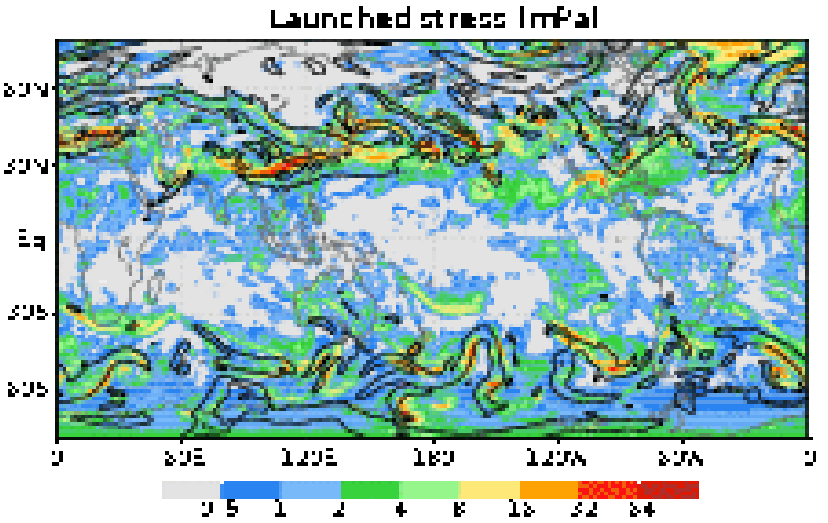
- In this study,
  - We extended the POGA experiment from the late 19th century to present using two AOGCMs (GFDL CM2.1 and MIROC5).
  - We assess uncertainty of the tropical Pacific influence on global climate.
- Both models represented accelerations and deceralations of global warming due to tropical Pacific decadal warming and cooling from the late 19th century to present.
- By compareing the POGA results with sets of CMIP5 historical experiment,
  - We quantified contribution of tropical decadal variability to individual acceleration and hiatus events of global warming since late 19th century.
  - We show that there is some uncertainty of the tropical Pacific influence on global climate between the two models.

Stochastic parameterization of gravity waves from fronts and convection

Francois Lott and Alvaro De La Camara, Poster 14, Friday Morning

Objective: Relate the non-orographic GWs to their sources
Test in GCM and implement for CMIP6
Test realism against in situ observations.

Method: Stochastic sampling of the unresolved GWs spectra. Sources related to well understood physical. For the front the spontaneous emission theory (Lott et al. 2010, 2012, 2015)



Launched GWs stress amplitude, and $\left\|\vec{\nabla} T\right\|$ at 600hPa:

Spontaneous adjustment predict a wave stress in close Analytical form:

$$F \approx \frac{\rho g^2}{f \theta^2 N^3} \left(\rho q' \sigma_z\right)^2 \frac{e^{-\pi \frac{N}{\Lambda}}}{4}$$

PV anomaly

Characteristic depth of the PV anomaly

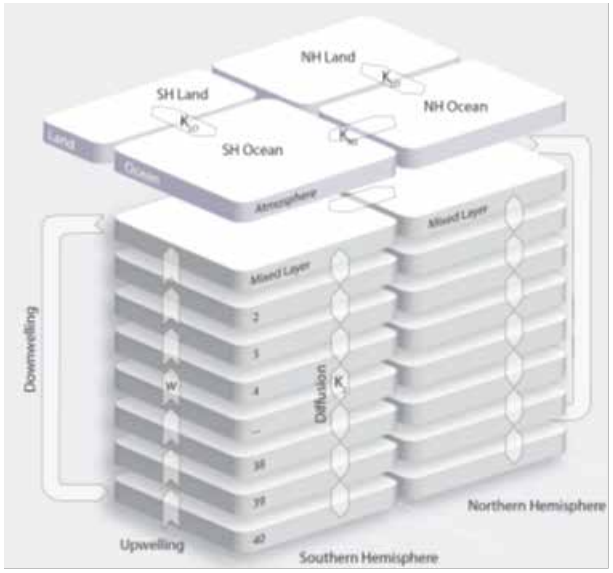
The waves predicted come from frontal zones

The drag predicted by the theory has about the right amplitude. The parameterization is opérational in LMDz for CMIP6.
Tests done on the QBO, SSWs, SH final warming day...

Probabilistic uncertainty assessment of multi-centennial sea-level rise projections consistent with climate targets

Alexander Nauels, Malte Meinshausen, Katja Lorbacher, Matthias Mengel

MAGICC with CMIP5 OCN



SLR MODULE

THERMAL EXPANSION

GLOBAL GLACIERS

GREENLAND SMB

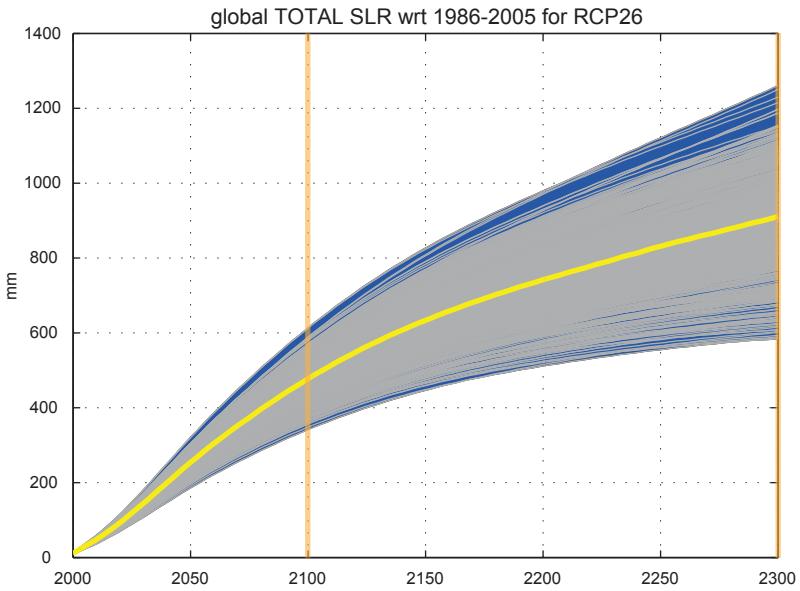
GREENLAND SID

ANTARCTICA SMB

ANTARCTICA SID

LANDWATER STORAGE

long-term global SLR response



- Future impacts of sea-level rise (SLR) from global warming call for a robust assessment of uncertainties associated with multi-centennial sea-level projections.
- Hence, we have developed a sea-level emulator that is calibrated against long-term process-based model results for all major sea-level components.
- The emulator is part of an updated version of the SCM MAGICC and calibrated with CMIP5 Θ.
- Due to the computational efficiency of the model, we are able to run large ensembles in probabilistic setups, analyze scenario specific long-term SLR responses, and investigate model related uncertainties.

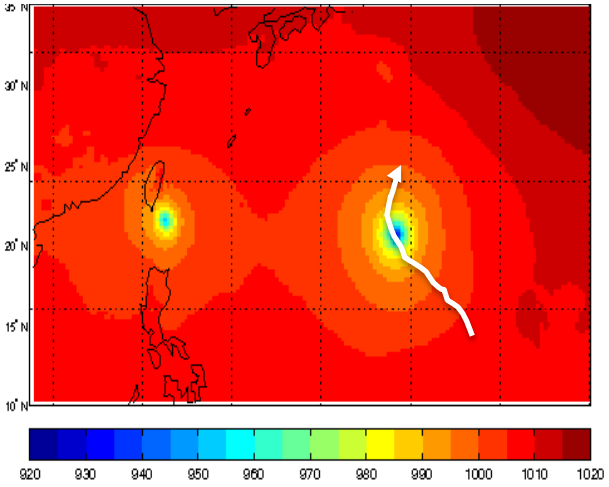
TROPICAL CYCLONES-OCEAN INTERACTION IN A HIGH RESOLUTION GCM: THE ROLE OF THE COUPLING FREQUENCY

Enrico Scoccimarro[1,2], P.G. Fogli [2], S. Gualdi[1,2],S. Masina[1,2], A. Navarra[1,2]

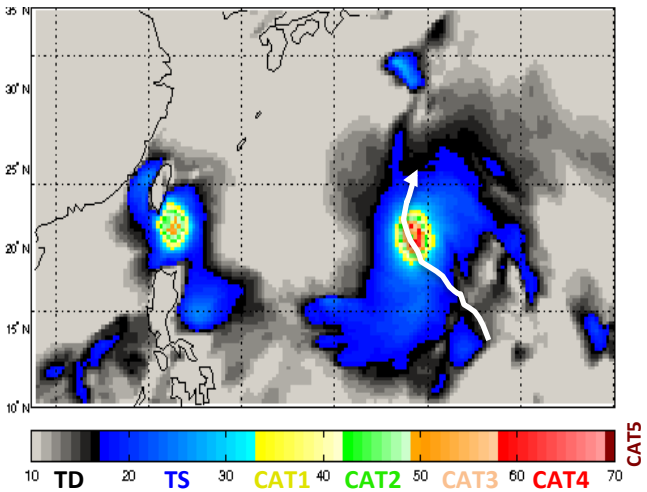
[1]INGV - Istituto Nazionale di Geofisica e Vulcanologia, Bologna, Italy [2]CMCC - Centro Euro-Mediterraneo sui Cambiamenti Climatici, Bologna, Italy

A simulated CAT5 Typhoon in a 25 km CGCM (6 hourly snapshot)

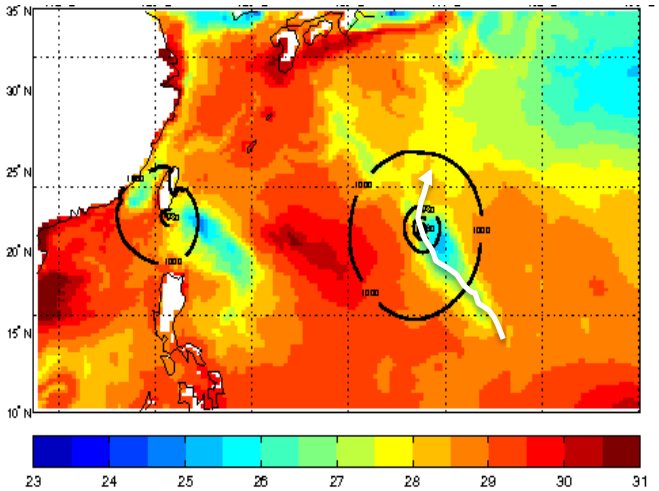
SLP [hPa]



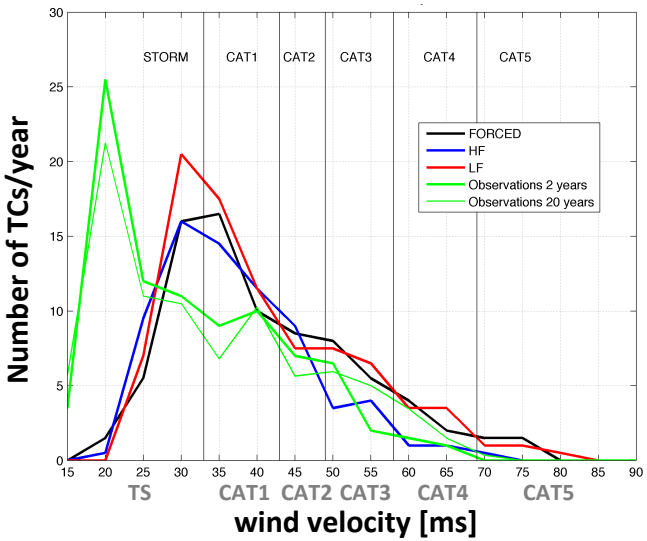
10m wind [m/s]



SST [°C]



The role of the ocean–atmosphere coupling frequency

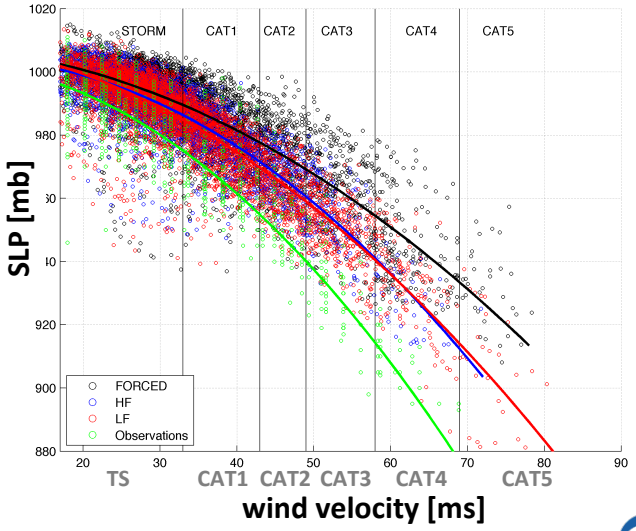


forced run (atm only)

hourly atm-oce coupling

daily atm-oce coupling

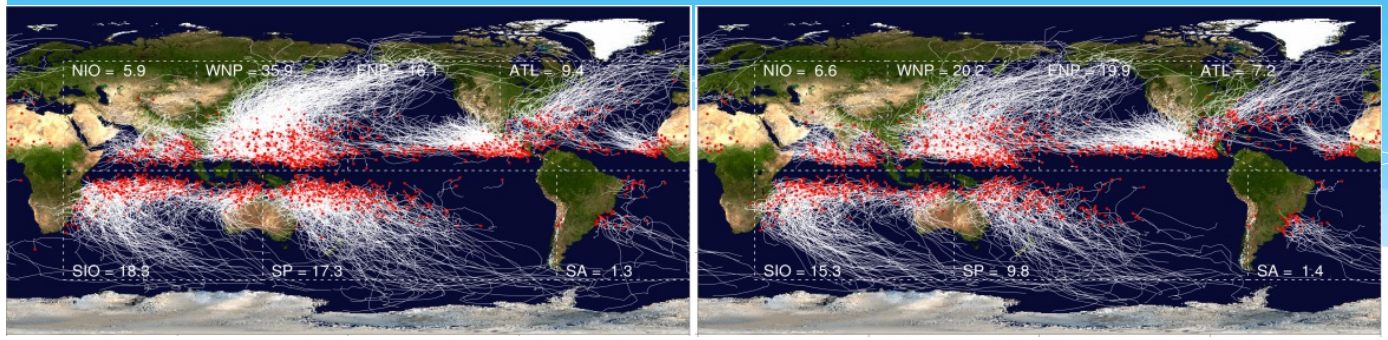
IBTraCS obs



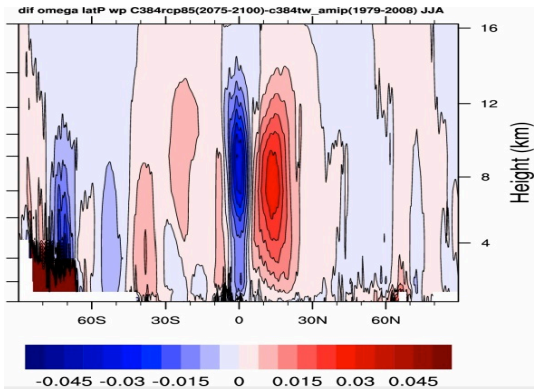
Processes Leading to the Projected Reduction of Tropical Cyclone Activity in the Western North Pacific

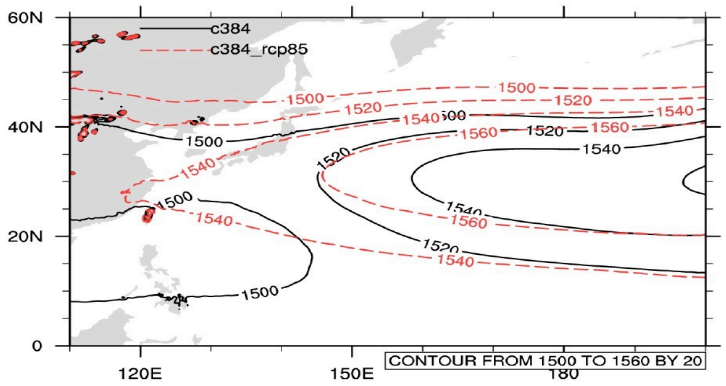
Chia-Ying Tu[R], Huang-Hsiung Hsu[R], Ping-Gin Chiu[R], Shian-Jiann Lin[G]

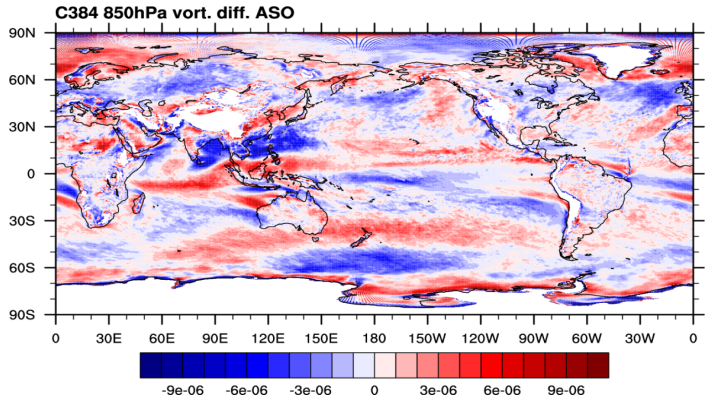
R - RCEC, Academia Sinica, Taiwan
G - GFDL, NOAA, U.S.A.



- ***GFDL HiRAM (C384~23km) for AMIP-type time-slice simulations.***
- ***HadiSST for the present (1979-2008) and SST ensembles (28 CMIP5 CGCMs under RCP8.5) for the future (2074-2100) experiments.***
- ***Equatorward contraction of convection and the corresponding anomalous subsidence enhance anti-cyclonic response in the Asian monsoon trough (cyclonic) region.***
- ***Westward extension of the subtropical anti-cyclone.***







Sulphate aerosol impacts on 20th century multidecadal climate variability

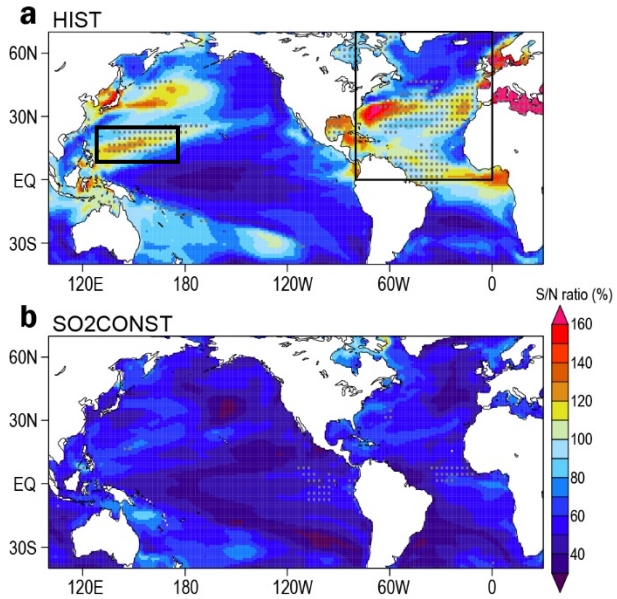
M. Watanabe, C. Takahashi, T. Tanaka, T. Tatebe, M. Ishii & M. Kimoto
Atmosphere and Ocean Research Institute, University of Tokyo

- We show, using MIROC5.2 ensemble attribution experiments, a robust increase in decadal/multidecadal SST variance due to changes in sulphate aerosols in the 20th century.
- Forced decadal variance is weakened in CMIP5 RCP compared to historical runs, suggesting an impact of sulphate aerosols in CMIP5 as well, and that the decadal variability is increasingly generated by internal processes in the future.

S/N ratio in decadal SST variance

MIROC5.2 historical (5 member)

MIROC5.2 constant SO_2 (5 member)



CMIP5 historical 1931-2000

CMIP5 RCP4.5 2031-2100