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# Why was it so hot? Australia's record heat in late spring 2014

Pandora Hope, Eun-Pa Lim, Guomin Wang, Harry Hendon and Julie Arblaster  
Australian Bureau of Meteorology

**Workshop on understanding, modeling and predicting weather and climate extremes**

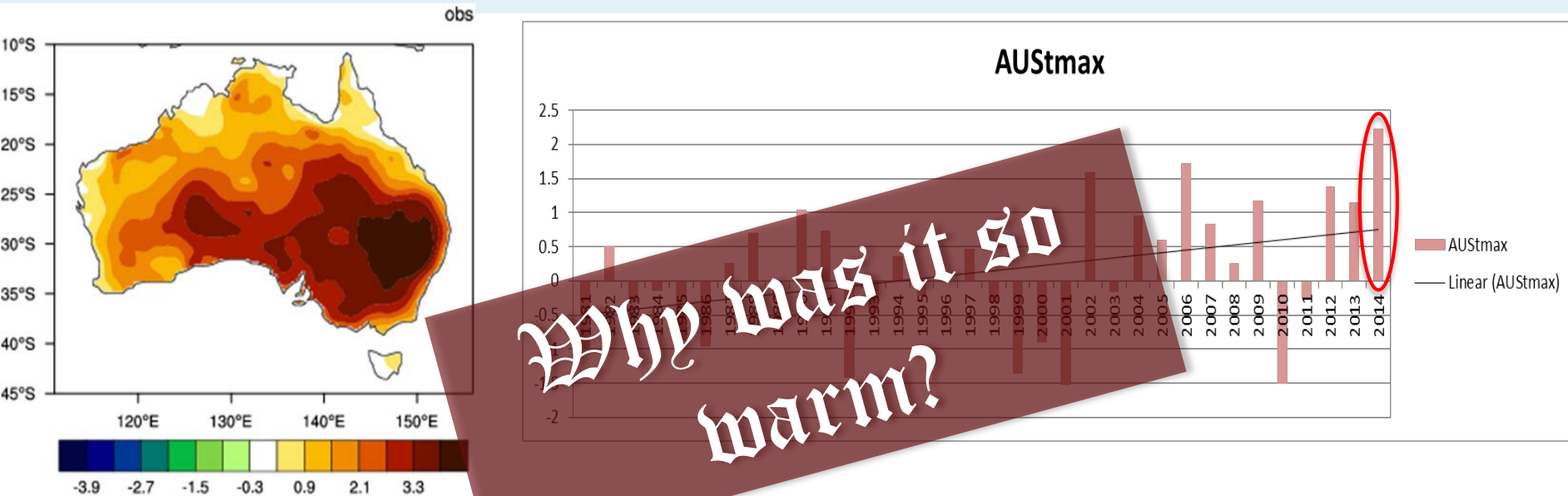
Oslo Science Park, Oslo, Norway

October 5 - 7, 2015



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# 2014: Australian warmest spring since 1910



Oct-Nov mean Tmax anomaly was  $+2.47^{\circ}$  C  
based on 1961-90 climatology

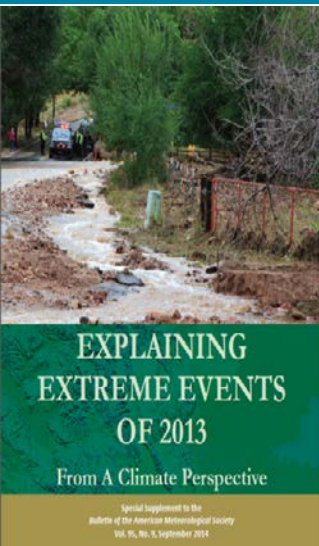
It was the warmest Oct-Nov even if the strong long-term warming trend was not present

# 32. CONTRIBUTORS TO THE RECORD HIGH TEMPERATURES ACROSS AUSTRALIA IN LATE SPRING 2014

PANDORA HOPE, EUN-PA LIM, GUOMIN WANG, HARRY H. HENDON, AND JULIE M. ARBLASTER

*The record warm Australian spring of 2014 would likely not have occurred without increases in CO<sub>2</sub> over the last 50 years working in concert with an upper-level wave train.*

To be published in:  
BAMS special issue:  
"Explaining extreme events of 2014 from a climate perspective"



1. FAR analysis from tables (Lewis et al. 2014)
2. FAR analysis using coupled seasonal forecasts
3. Regression analysis (Arblaster et al. 2014)
4. Analysis of synoptic situation

EXPLAINING EXTREME  
EVENTS OF 2012 FROM A  
CLIMATE PERSPECTIVE

Editors

Thomas C. Peterson, Mark P. Alexander, Peter A. Stott, and Stephen C. Hering

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# The role of increasing CO<sub>2</sub> in the extreme high T<sub>max</sub> of late spring 2014

## coupled seasonal forecast system

POAMA is an atmosphere-ocean coupled system:

- Atmospheric model: **Bureau's Atmospheric Model v3**  
(~250km x 250km x 17 vertical levels)
  - Ocean model: **Australian Community Ocean Model 2**  
(200km x 50-150 km x 25 vertical levels)
- coupled by **Ocean Atmosphere Sea Ice Soil** (OASIS, Valcke et al. 2000)

It is the system for operational seasonal forecasts at the  
Australian Bureau of Meteorology

# The role of increasing CO<sub>2</sub> in the extreme high T<sub>max</sub> of late spring 2014

Forecast Initialisation:

Realistic atmosphere and land initial conditions generated from ALI (Hudson et al. 2010 Clim. Dyn.)

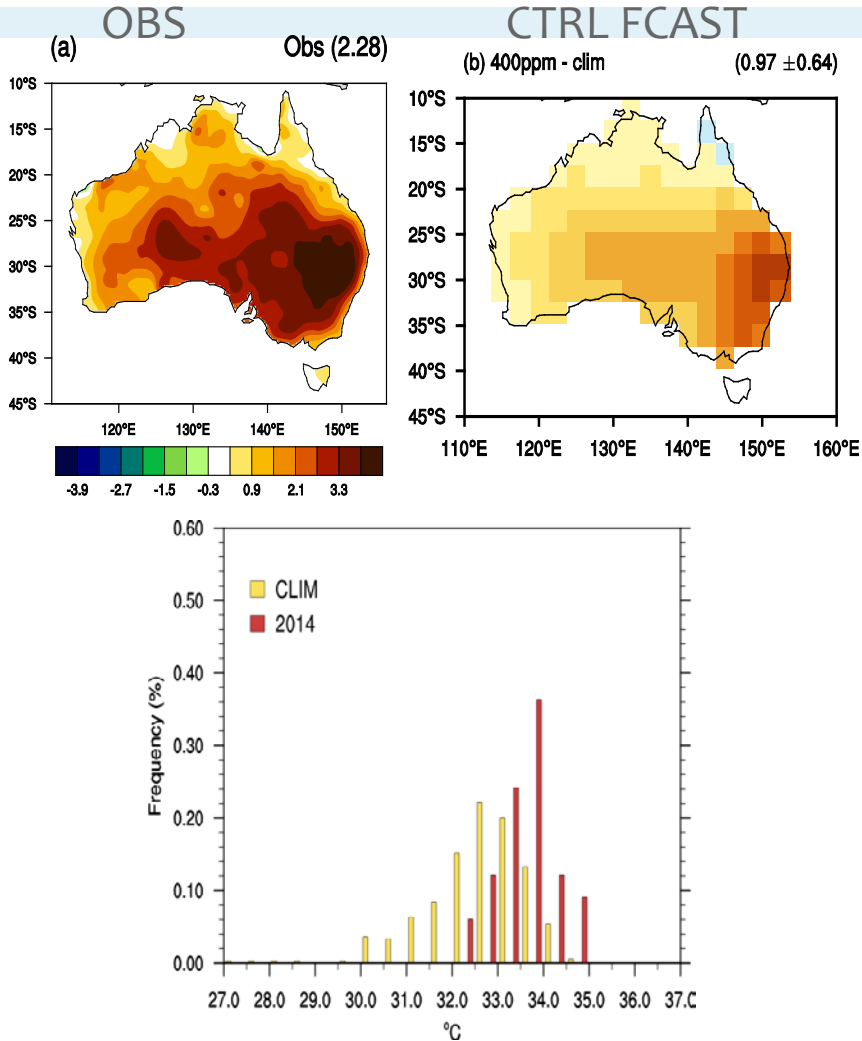
Realistic ocean initial conditions generated from PEOODAS (Yin et al. 2011 Mon. Wea. Rev.)

33 member ensemble forecasts initialised on the 21st , 25th and 28th of September 2014 & verified for October and November mean climate

CO<sub>2</sub> concentration was set to **400 ppm** ~ 2014 level (NOAA Mauna Loa CO<sub>2</sub> data)



# POAMA forecasts for high Tmax of late spring 2014



POAMA skilfully predicted spatial pattern of this warm event

extremity (i.e. ~ 60% chance for 1° C (1σ) warmer & 10% chance for 2° C (2σ) warmer than normal)

Ensemble mean forecast underestimated the magnitude of the anomalous warming



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# Experiment to detect the impact of enhanced CO<sub>2</sub> on T<sub>max</sub> 2014

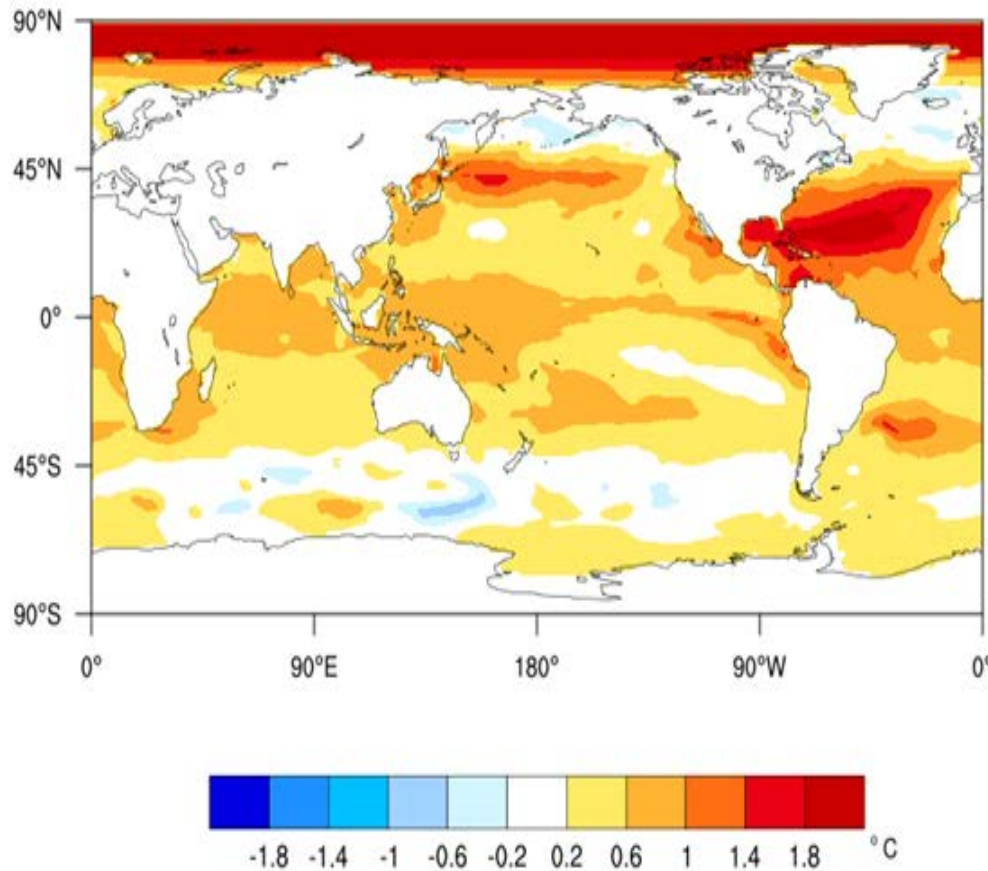
POAMA was run with the same conditions as those for the control forecast except for

lowering the CO<sub>2</sub> concentration from 400 ppm to 315 ppm (value of 1960)

removing the ocean imprint of enhanced CO<sub>2</sub> since 1960 from the full ocean initial conditions (T, S)



# Experiment to detect the impact of enhanced CO<sub>2</sub> on T<sub>max</sub> 2014



Ocean imprint of enhanced CO<sub>2</sub>

Difference of two 30 yr long runs of POAMA with 400 ppm and 315 ppm CO<sub>2</sub>

This ocean response to the CO<sub>2</sub> change from 1960 to 2014 was removed from the 2014 September ocean initial conditions (i.e. POAMA started with colder ocean state)



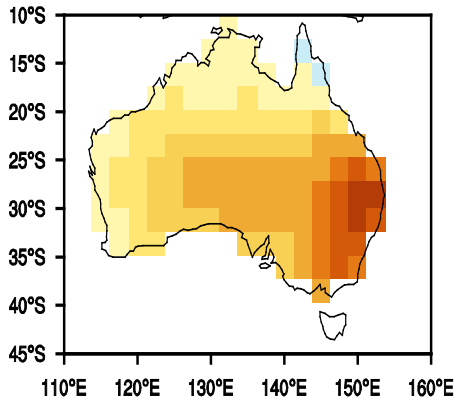


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# Experiment to detect the impact of enhanced CO<sub>2</sub> on Tmax 2014

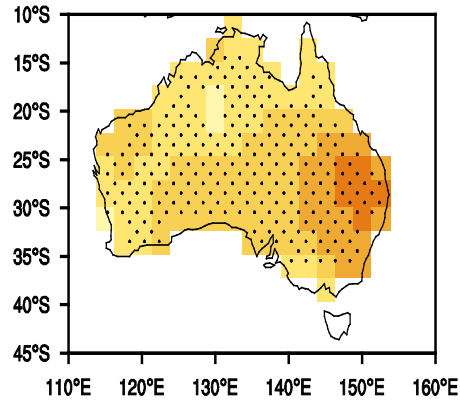
CTRL-Climatology

(b) 400ppm - clim (0.97 ± 0.64)

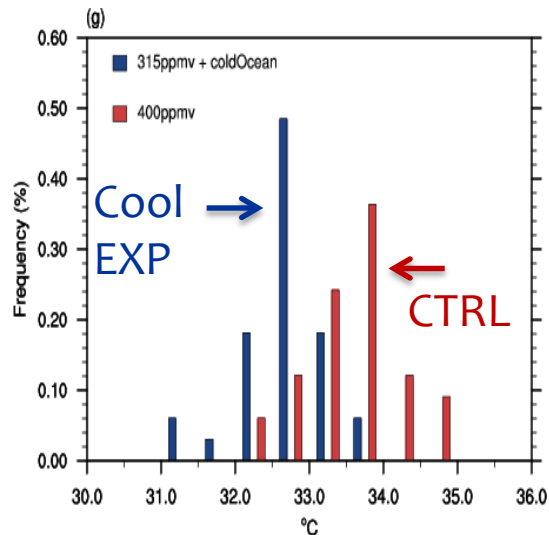


CTRL - EXP

(e) 400ppm - (315ppm + coldO) (0.92 ± 0.55)



Significant difference in Tmax forecasts between the control (with 400 ppm CO<sub>2</sub> + obs Ocean I.C.) and the experiment (with 315 ppm CO<sub>2</sub> + cold Ocean I.C.)

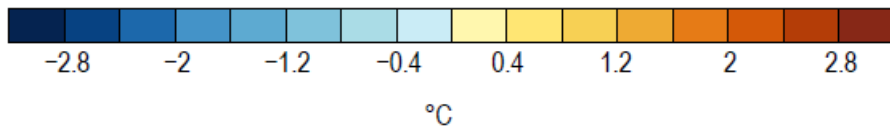
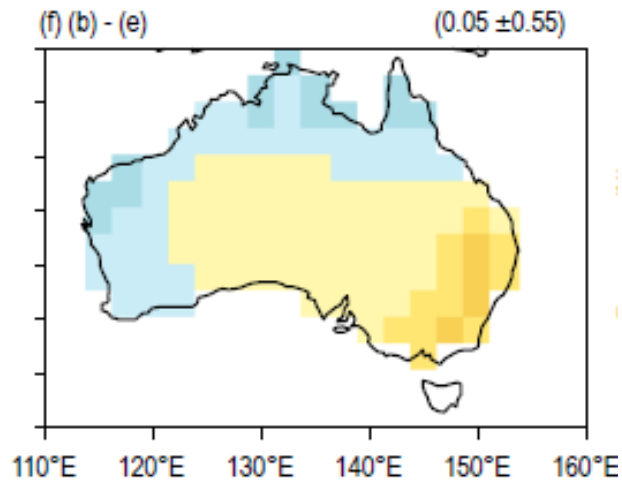


Warming due to the change of CO<sub>2</sub> explains most of the warm anomaly predicted by POAMA control forecast except for the warming over the far south east



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# Experiment to detect the impact of enhanced CO<sub>2</sub> on T<sub>max</sub> 2014



Forecast heat anomaly from 'cool' experiment

The atmospheric conditions of spring 2014 would likely have been conducive to warm conditions in 1960

Particularly in south east



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# Why was it so warm in late spring 2014?

From other analysis (see poster):

- high geopotential height anomaly over Australia
- SAM, ENSO contributed only a small amount
- antecedent Australian soil moisture contributed, particularly in south east
- Global warming contributed strongly



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# Why was it so warm in late spring 2014?

*Hope et al. (2015) found that the record warm Australian spring of 2014 would likely not have occurred without increases in CO<sub>2</sub> over the last 50 years working in concert with an upper-level wave train.*



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# Thank you

Pandora Hope, Eun-Pa Lim, Guomin Wang, Harry Hendon and Julie Arblaster

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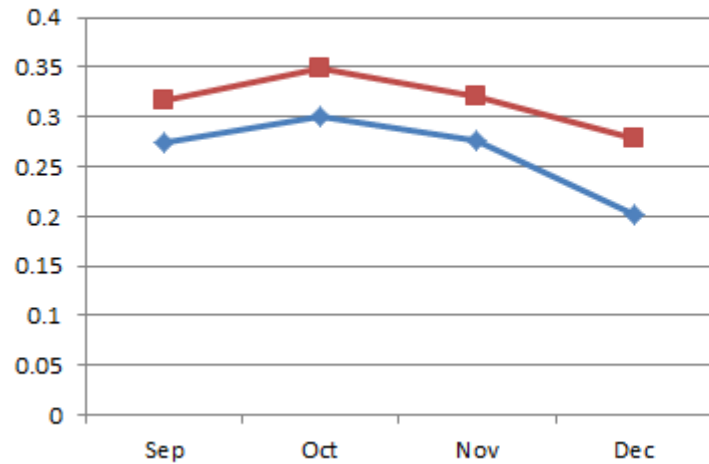
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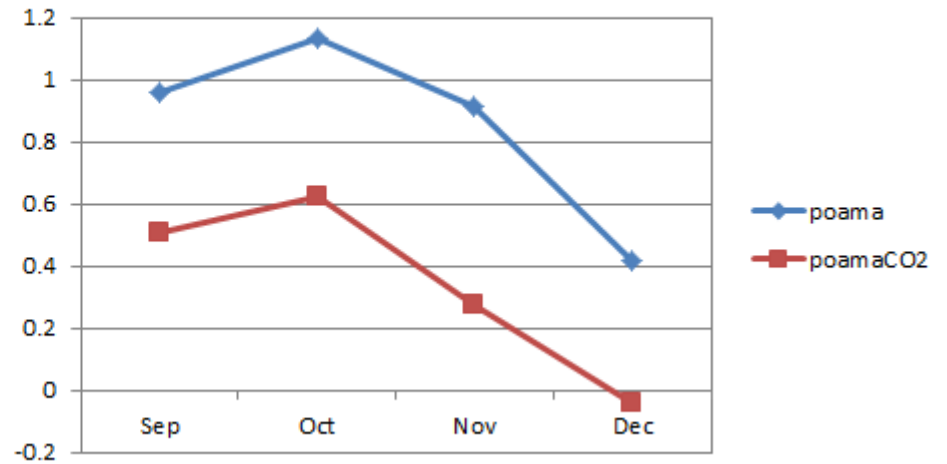
October 5 - 7, 2015

# Monthly

## global mean T

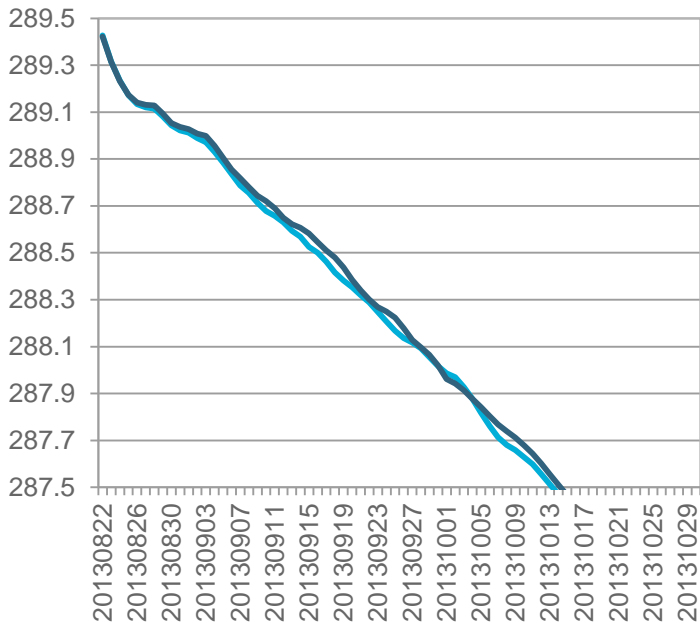


## global mean OLR

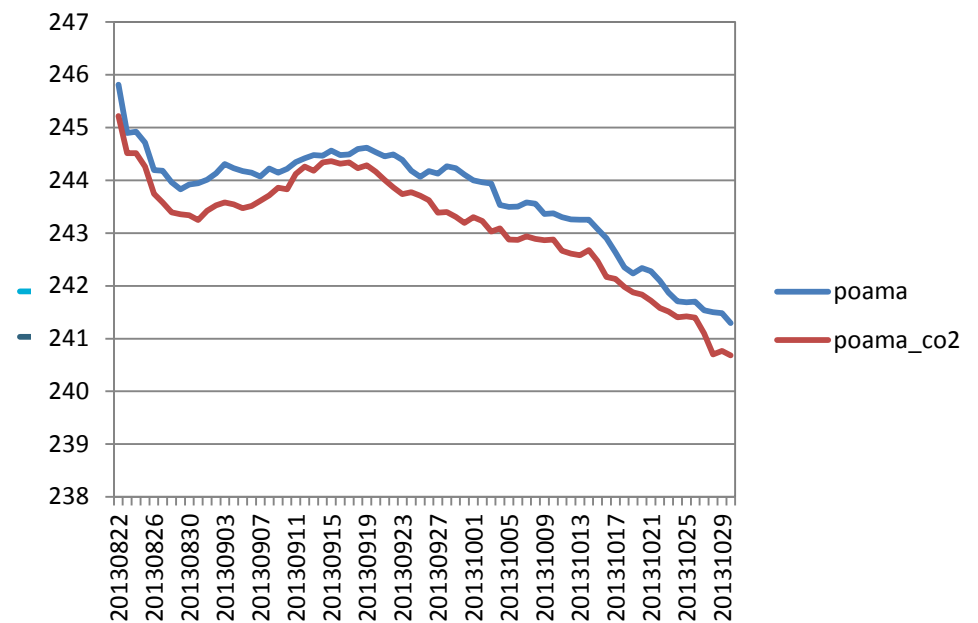


# Daily

## global mean surface air

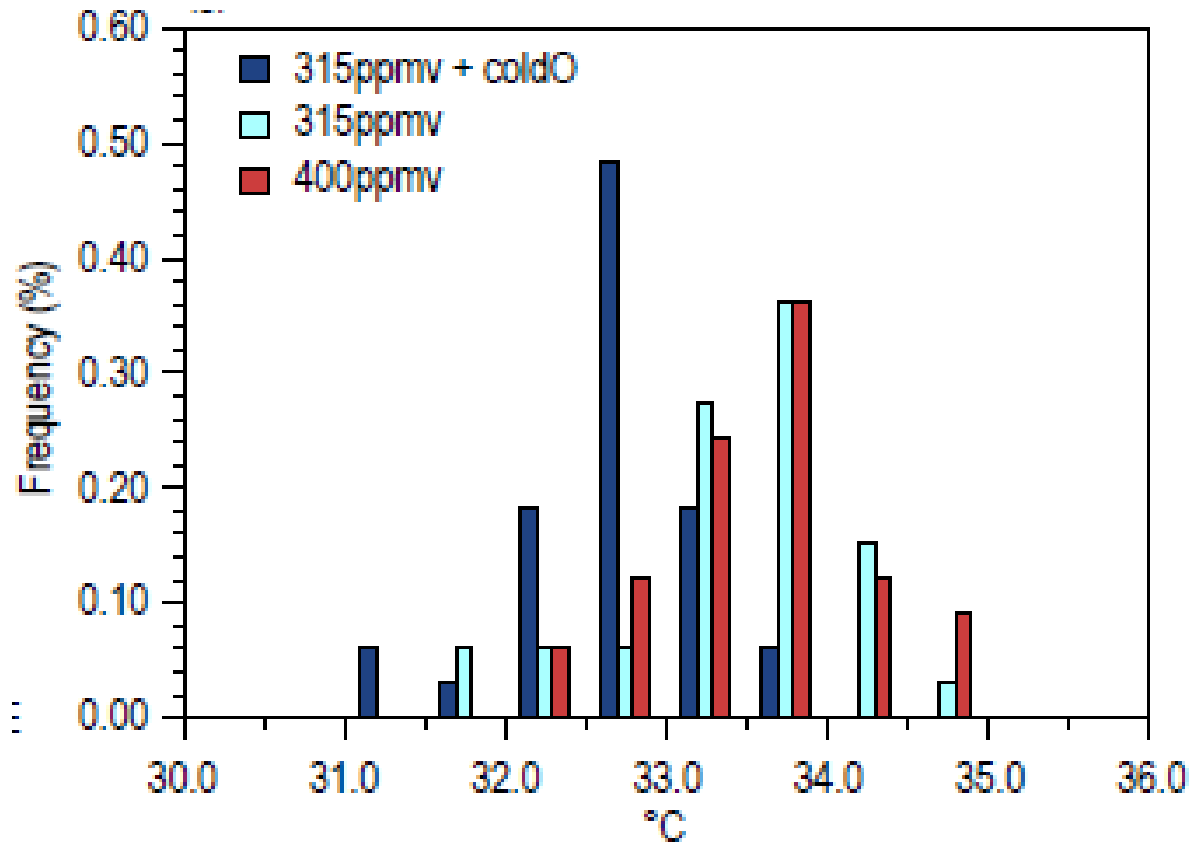


## global mean OLR



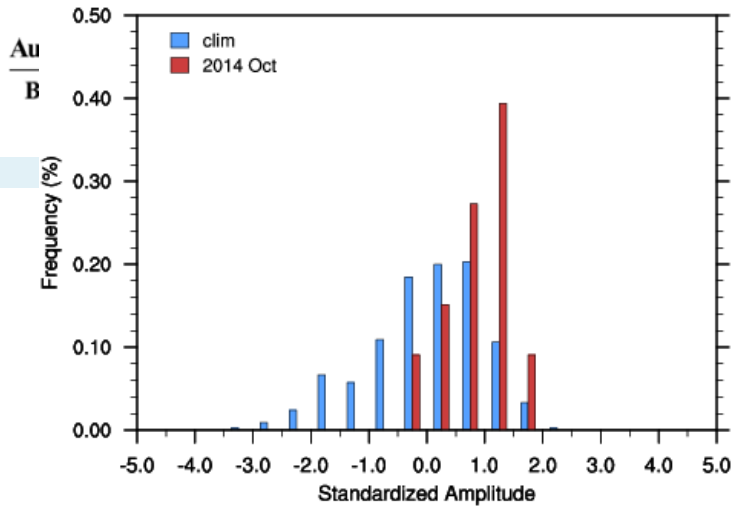


# Experiment to detect the impact of enhanced CO<sub>2</sub> on T<sub>max</sub> 2014



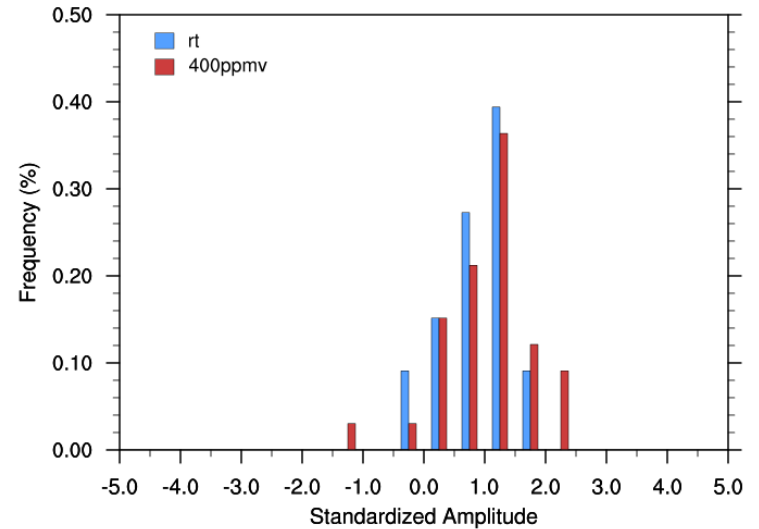
# ACCSP: Attribution of extremes – Spring 2014

Oct Tmax POAMA FCSTs at LT1

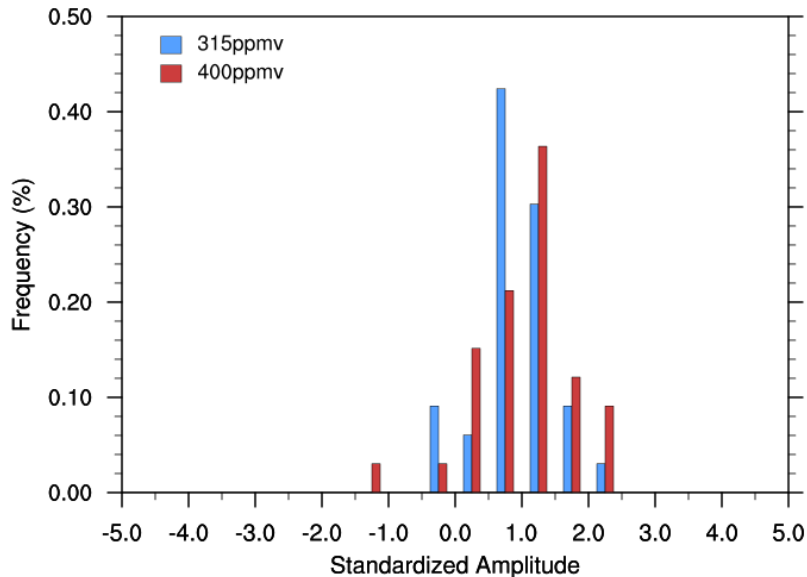


Guomin,  
Eunpa,  
Harry,  
Pandora,  
Julie

Oct Tmax POAMA FCSTs at LT1



Oct Tmax POAMA FCSTs at LT1



Oct Tmax POAMA FCSTs at LT1

