General Insurance Seminar

Insuring Tomorrow

Actuaries Institute

17-18 November 2014 • Hilton Sydney

Recent Developments in Predicting El Nino and the Implications for Insurers

Agus Santoso, Alexander Pui, Tim Andrews

Introduction

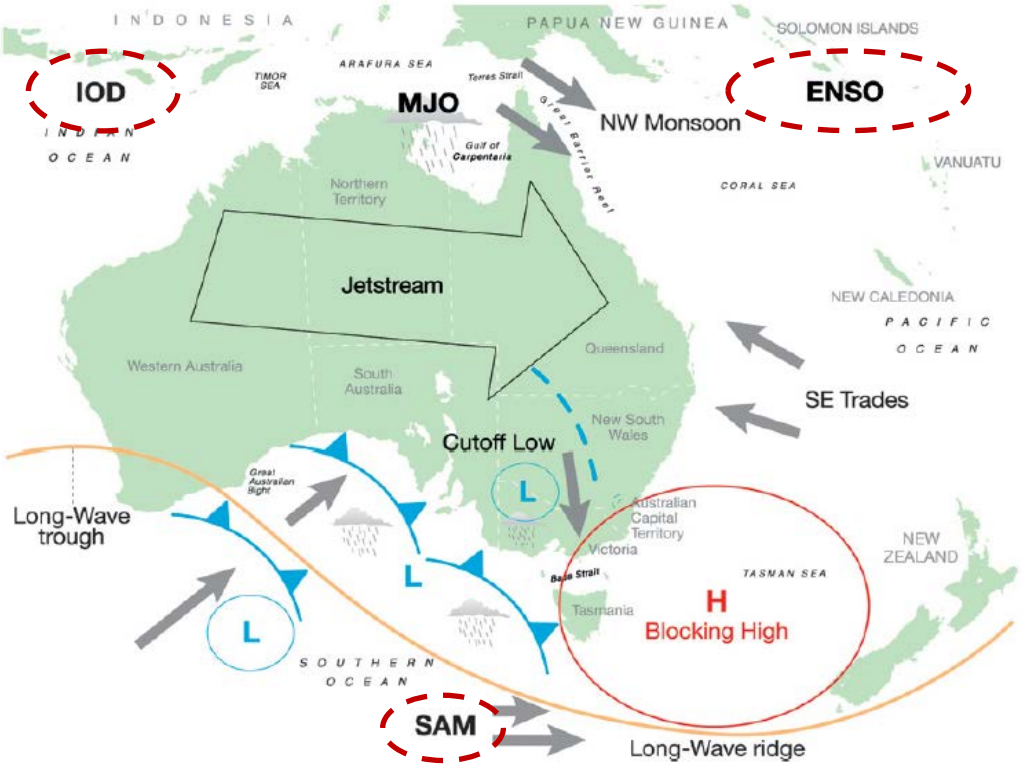
- Latest in the science
- Weather cycles and claims costs
- Implications for property insurers

Latest developments in the…

Science of Weather Cycles

Processes influencing Australian rainfall variability

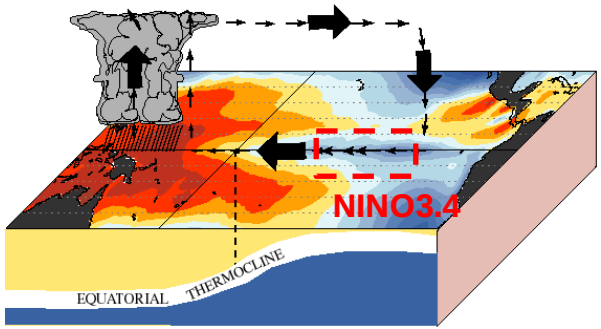
The three headed dog: **ENSO** **IOD** **SAM**



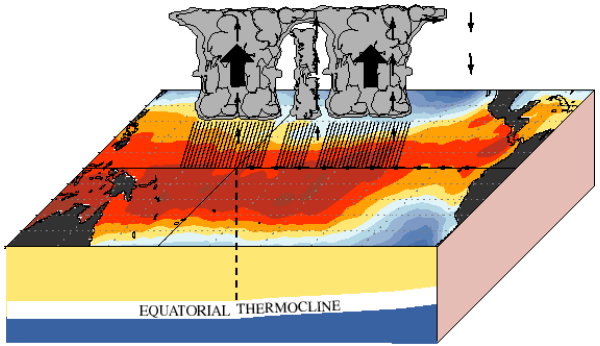
Risbey et al. 2009, Monthly Weather Review

El Nino Southern Oscillation (ENSO)

La Nina/normal condition

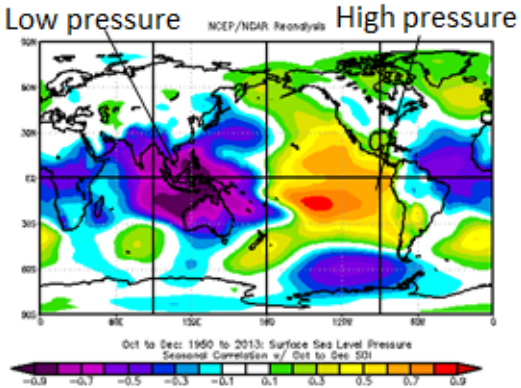


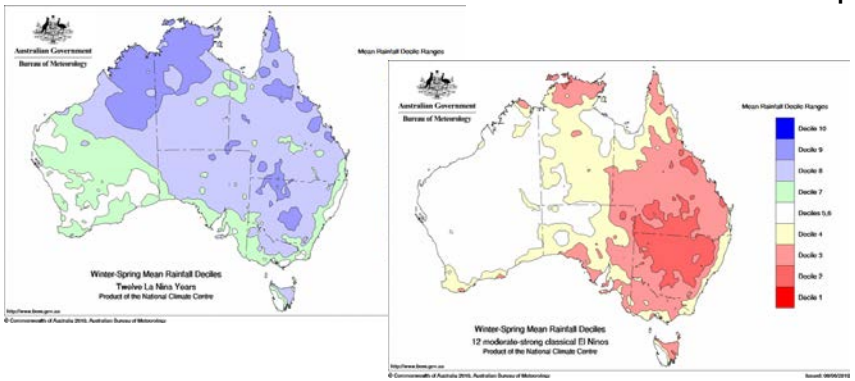
El Niño condition



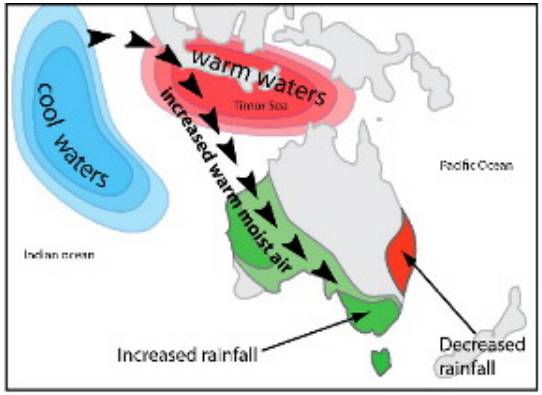
ENSO peaks in austral summer. Impacts can be significantly felt in winter and spring.

Southern Oscillation

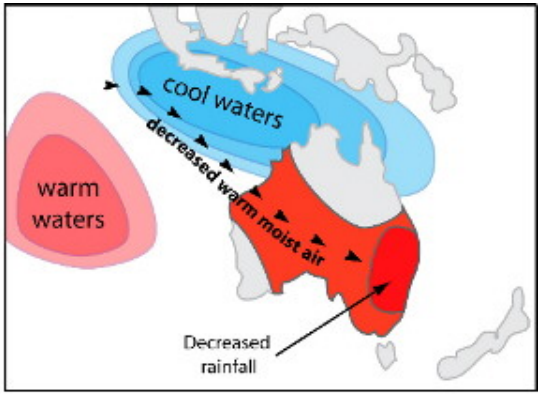




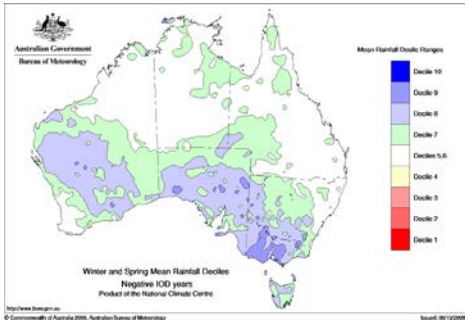
Indian Ocean Dipole (IOD)

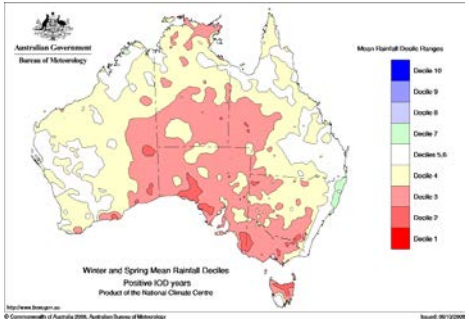


Negative phase: cool Indian Ocean water drives moist warm air and brings normal rainfall.



Positive phase: warm Indian Ocean water leads to weaker, drier winds and less rainfall.

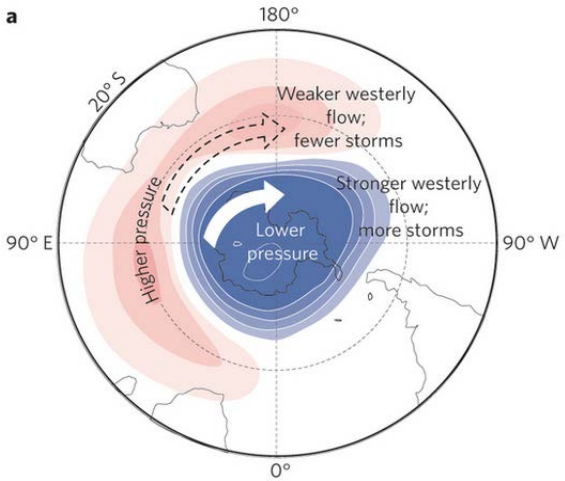




Indian Ocean Dipole develops in austral winter, peaks in spring, often co-occur with ENSO.

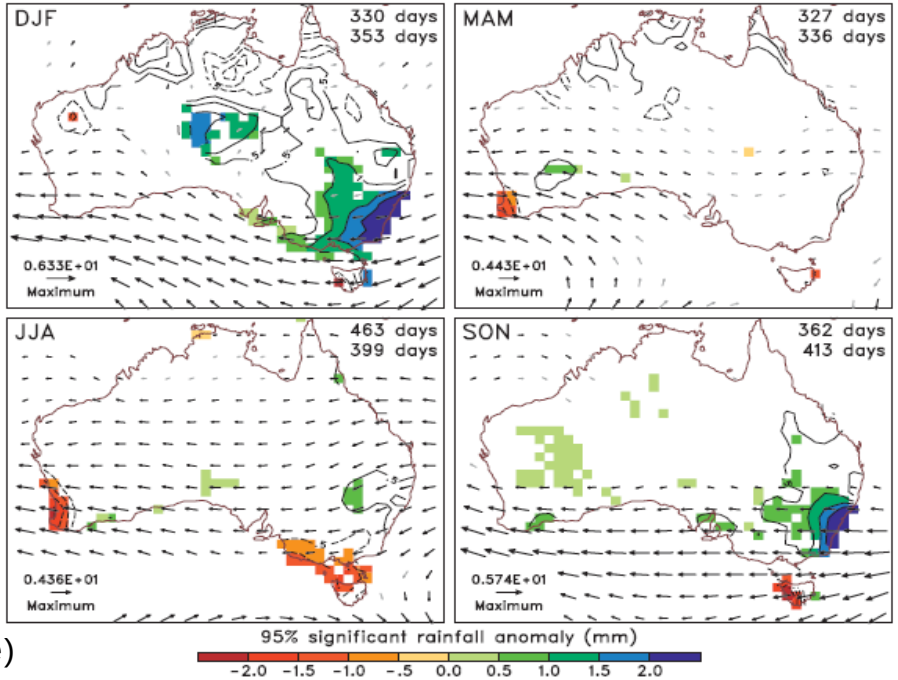
The positive phase of the IOD causes drier conditions

Southern Annular Mode (SAM)



Schematic from Jones (2012, Nature Geoscience)

Positive phase of the SAM: southward shift of the westerly (west-to-east) wind belt



Rainfall impact varies with season

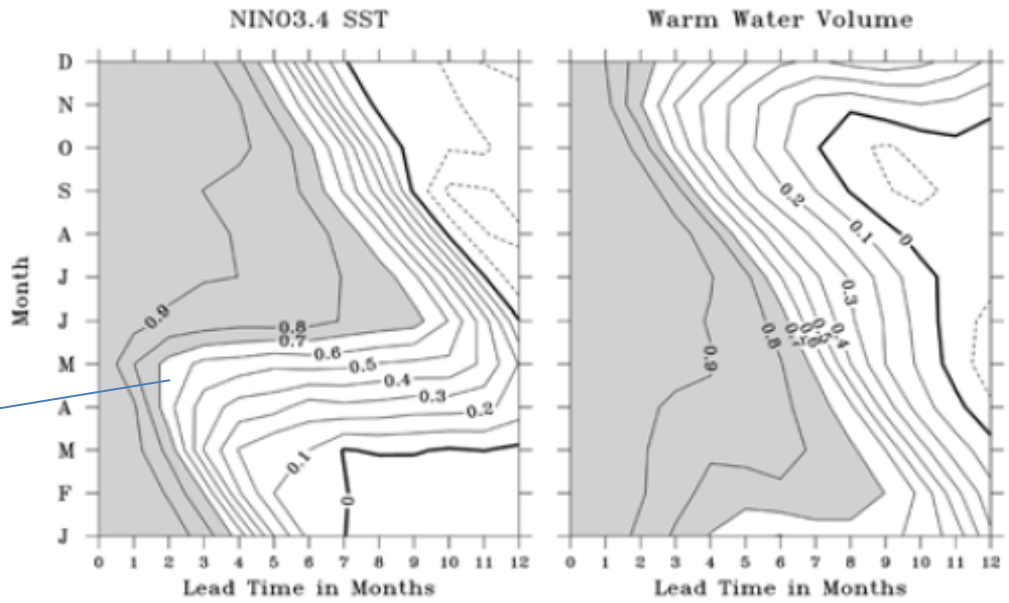
Hendon et al. (2007, J. Climate)

ENSO – highest potential for predictability

- ENSO: can be predictable 2-3 seasons in advance
- IOD: 1 season
- SAM: 1-2 weeks, but could potentially be longer due to its correlation with ENSO

Pacific Warm Water Volume: An ocean memory for ENSO predictability

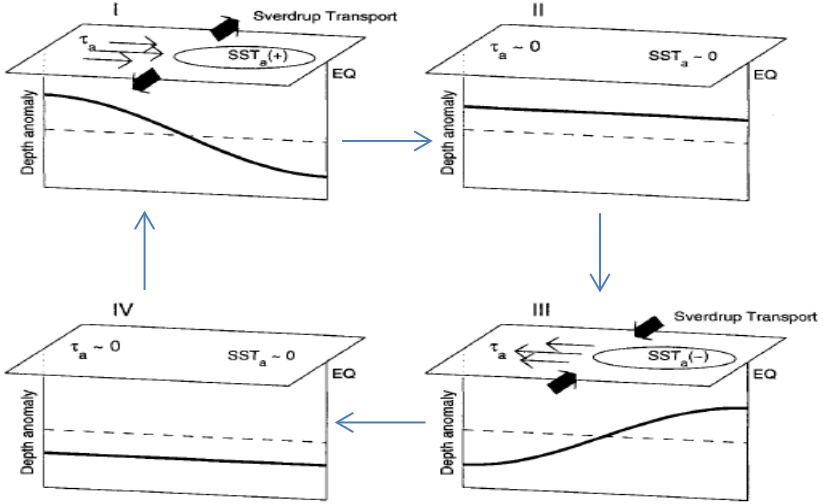
Autumn Predictability Barrier



McPhaden (2003, Geophys. Res. Lett.)

Deterministic part of ENSO: The Recharge Oscillator

El Nino

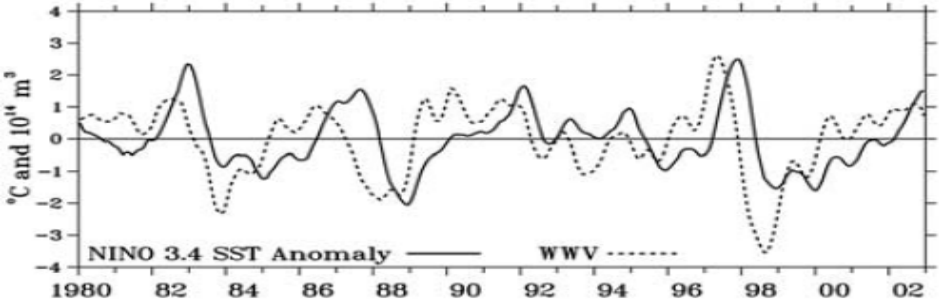


Recharge

Discharge
of warm water volume (WWV)

La Nina

Schematic from Meinen and McPhaden, 2000, J. Climate



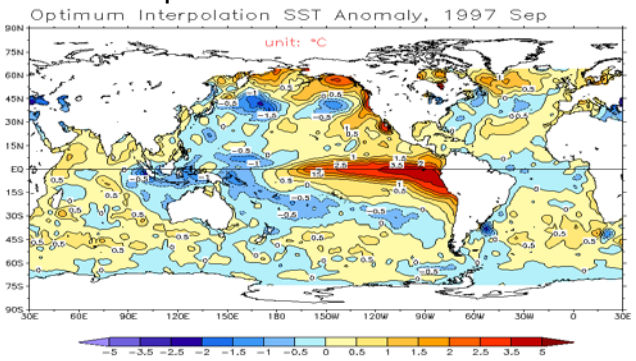
WWV leads NINO3.4
WWV has no autumn barrier
Source for ENSO predictability

McPhaden (2003, Geophys. Res. Lett.)

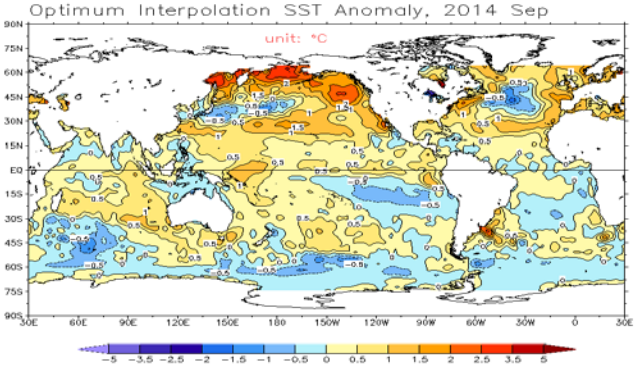
El Nino Development

Temperature at sea surface

Super El Nino 1997

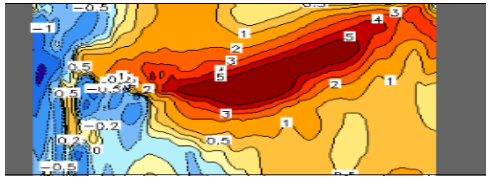


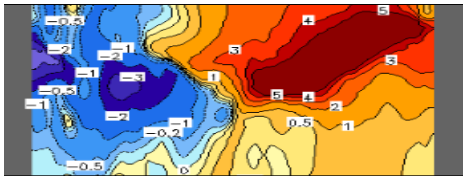
2014



Temperature in ocean interior along equator

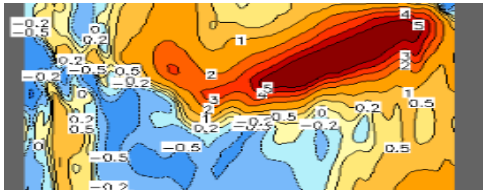
April 1997

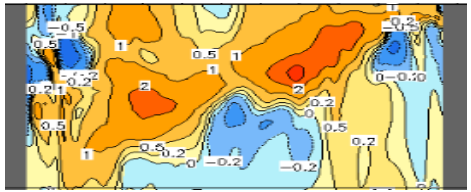




September 1997

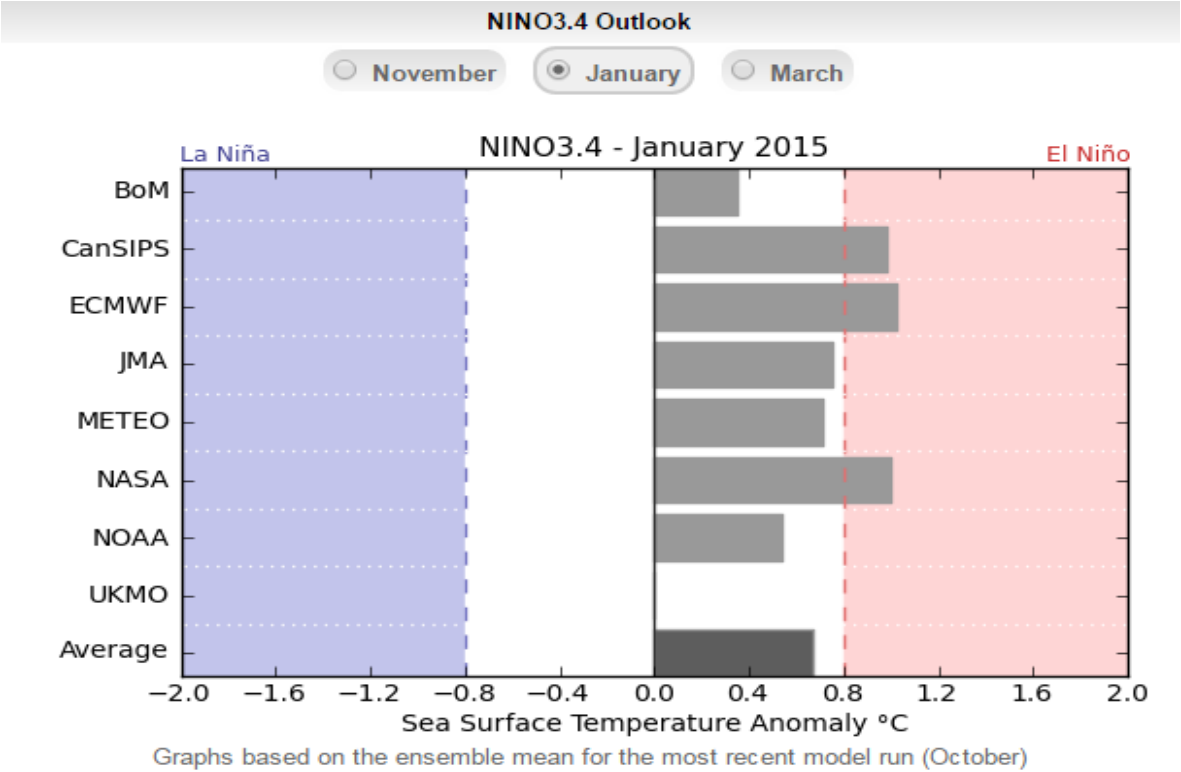
April 2014





September 2014

Current BOM Model Forecasts



http://www.bom.gov.au/climate/ahead/model-summary.shtml#tabs=Pacific-Ocean

Improved forecasting

- **Better models**
- **Better observations: more data (real-time)**
- **Better initialisation methods (data assimilation)**

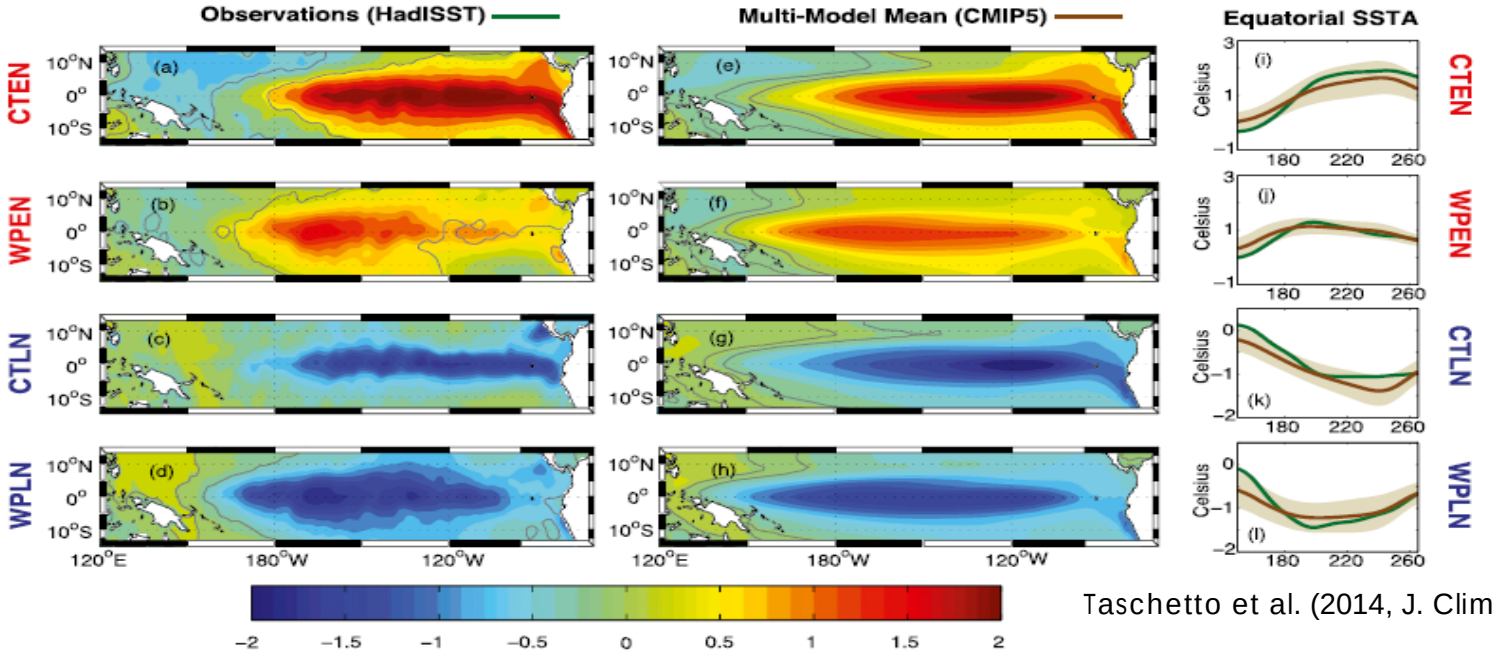
Note:

- Prediction becomes more accurate with shorter lead times
- It is easier to predict stronger events than weak/neutral. This is dependent upon the mean climate. In most recent decade (since 2000), ENSO variability is weaker and forecasts become less accurate (Barnston et al. 2012).

More on El Nino predictability:

theconversation.com/dont-dismiss-a-2014-super-el-ni-o-just-yet-30720
theconversation.com/drought-in-store-as-el-ni-os-western-cousin-to-grow-stronger-27826
theconversation.com/are-we-heading-for-a-worrying-super-el-ni-o-26090

Better ENSO simulation in climate models



Taschetto et al. (2014, J. Climate)

TABLE 2. Summary of criteria employed for the ENSO classification for observations and CMIP5 models, using the standardized DJF Niño-3 and Niño-4 indices. Years refer to January–February. For further details see text.

Event	Criteria	Years selected in observations
Cold tongue El Niño	Niño-3 > 1.0 and Niño-3 > Niño-4	1966, 1973, 1983, 1987, 1992, and 1998
Warm pool El Niño	Niño-4 > 1.0 and Niño-4 > Niño-3	1958, 1969, 1988, 1995, 2003, and 2010
Cold tongue La Niña	Niño-3 < −1.0 and Niño-3 < Niño-4	1950 and 1985
Warm pool La Niña	Niño-4 < −1.0 and Niño-4 < Niño-3	1956, 1971, 1974, 1976, 1989, 1999, 2000, 2001, 2008, 2011, and 2012

ENSO response to greenhouse warming?

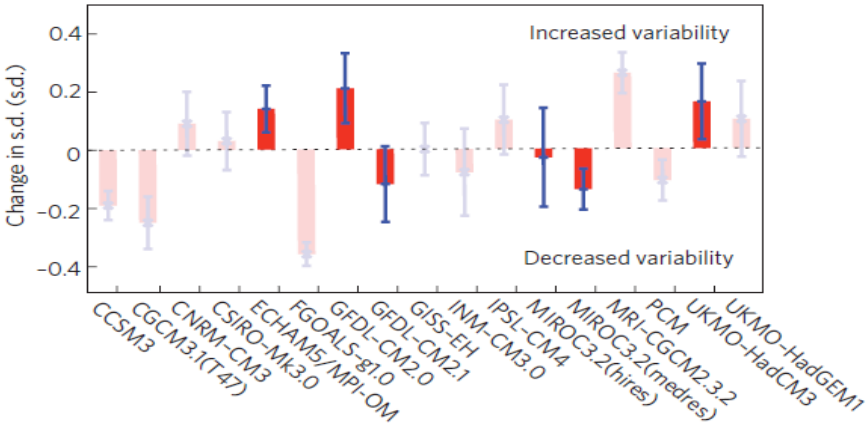
nature geoscience
REVIEW ARTICLE
PUBLISHED ONLINE: 23 MAY 2010 | DOI: 10.1038/NGEO868

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]

No clear picture

Some models show a decrease, some an increase in ENSO intensity



Lack of consensus despite robust projections of the background climate:

- **More "El Nino-like" in the Pacific: Weakened Walker Circulation *(e.g., Vecchi et al. 2006, Nature)***
- **More positive IOD-like in the Indian Ocean *(e.g., Cai et al. 2013, Nature Geoscience)***
- **More positive SAM-like southward shift of the extra-tropical westerly jet *(e.g., Arblaster and Meehl 2006, J. Climate)***

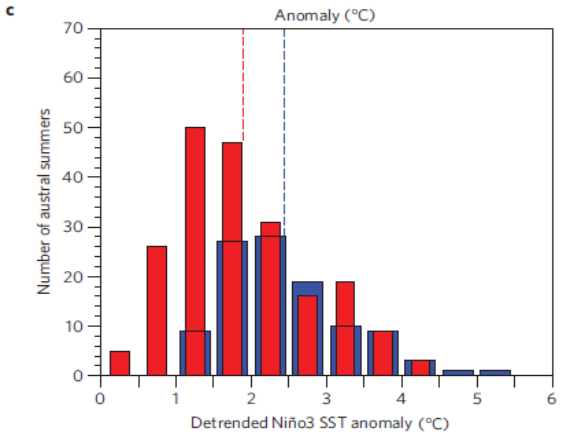
Recent developments

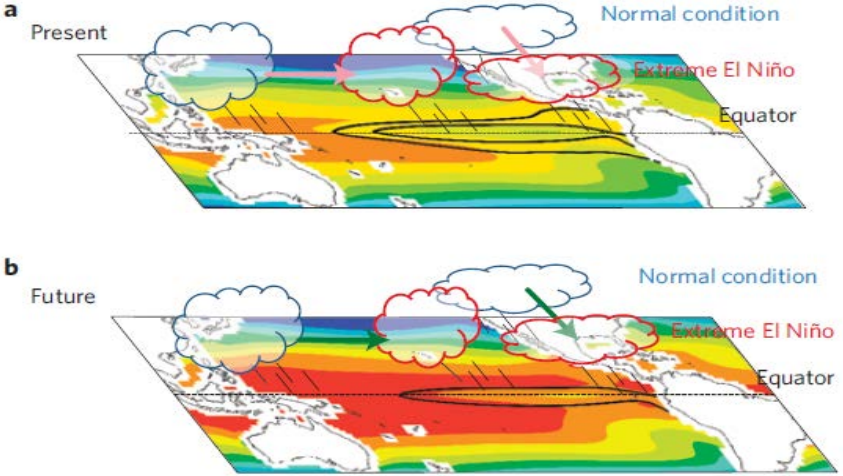
nature climate change LETTERS
PUBLISHED ONLINE: 19 JANUARY 2014 | DOI: 10.1038/NCLIMATE2100

Increasing frequency of extreme El Niño events due to greenhouse warming

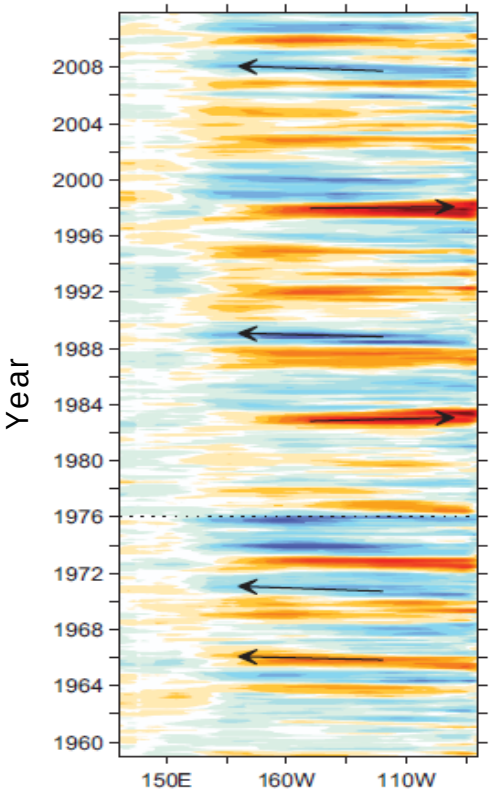
JAN 2014

Wenju Cai[1,2]*, Simon Borlace[1], Matthieu Lengaigne[3], Peter van Rensch[1], Mat Collins[4], Gabriel Vecchi[5], Axel Timmermann[6], Agus Santoso[7], Michael J. McPhaden[8], Lixin Wu[2], Matthew H. England[7], Guojian Wang[1,2], Eric Guilyardi[3,9] and Fei-Fei Jin[10]





Sea surface temperature anomalies along equatorial Pacific



Super El Nino 1997

Super El Nino 1982

Pre-76: Symmetric Propagation
Both warm and cold anomalies propagate westward.

LETTER

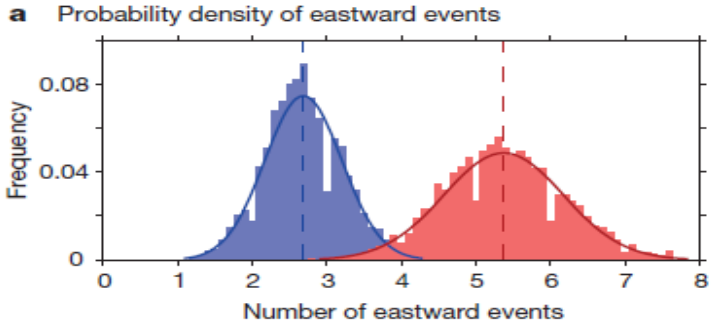
doi:10.1038/nature12683

Late-twentieth-century emergence of the El Niño propagation asymmetry and future projections

Agus Santoso[1], Shayne McGregor[1], Fei-Fei Jin[2], Wenju Cai[3], Matthew H. England[1], Soon-Il An[4], Michael J. McPhaden[5] & Eric Guilyardi[6,7]

NOV 2013

West to East propagation is a characteristic of Super El Nino. Such occurrences are projected to double in the future.



Santoso et al. 2013, Nature

LETTER Cai and Santoso, et al., 2014, Nature

doi:10.1038/nature13327

Increased frequency of extreme Indian Ocean Dipole events due to greenhouse warming

Wenju Cai[1,2], Agus Santoso[3], Guojian Wang[2,1], Evan Weller[1], Lixin Wu[2], Karumuri Ashok[4], Yukio Masumoto[5,6] & Toshio Yamagata[7]

How about La Nina?

....stay tuned!

ENSO prediction for pricing?

Kalista launches "ENSO-based Parametric Cover"

Kalista Global, a boutique insurance and reinsurance services company with a focus on the Insurance-Linked Securities, Catastrophe Bond and Alternative Reinsurance sectors has partnered with Bermuda-based New Grange brokers to launch an innovative type of parametric index-based insurance weather cover. The new product is called "EPC", or "ENSO-based Parametric Cover", and functions by utilizing sea surface temperatures taken from the ENSO (El Nino Southern Oscillation) cycle index, developed by the National Oceanic and Atmospheric Association, as the basis for payout.

The relationship between...

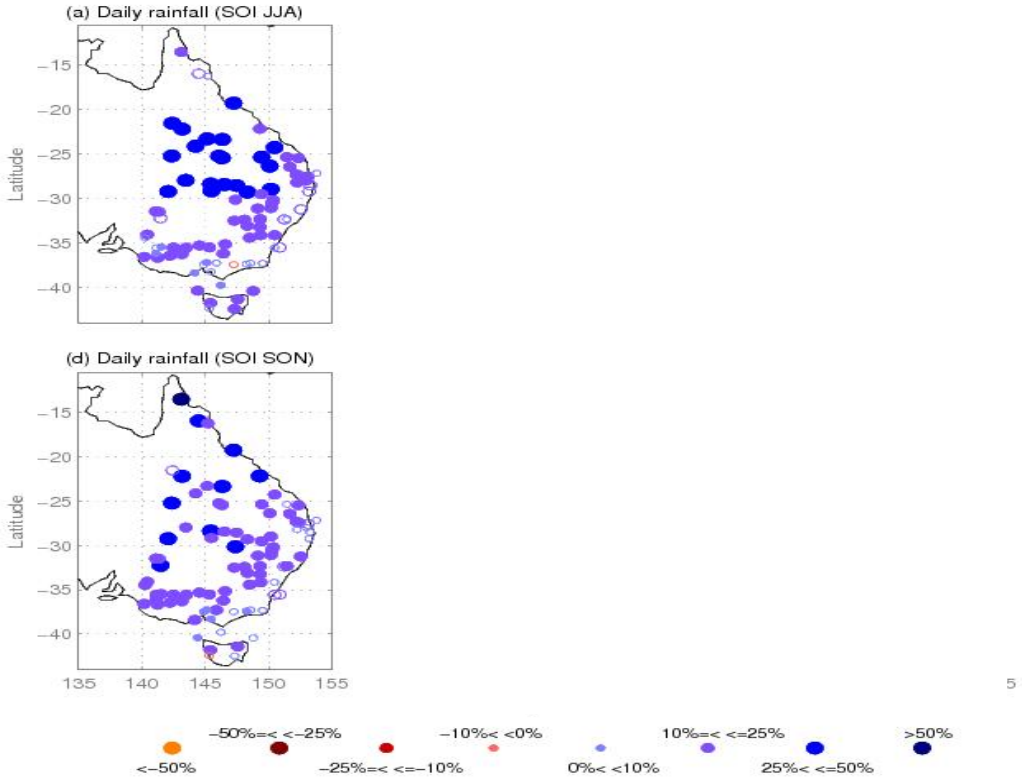
Weather Cycles and Claim Costs

Impact of ENSO on Australian Rainfall

Total Rainfall | No. Wet Days | Rainfall per Wet Day

Winter (JJA)

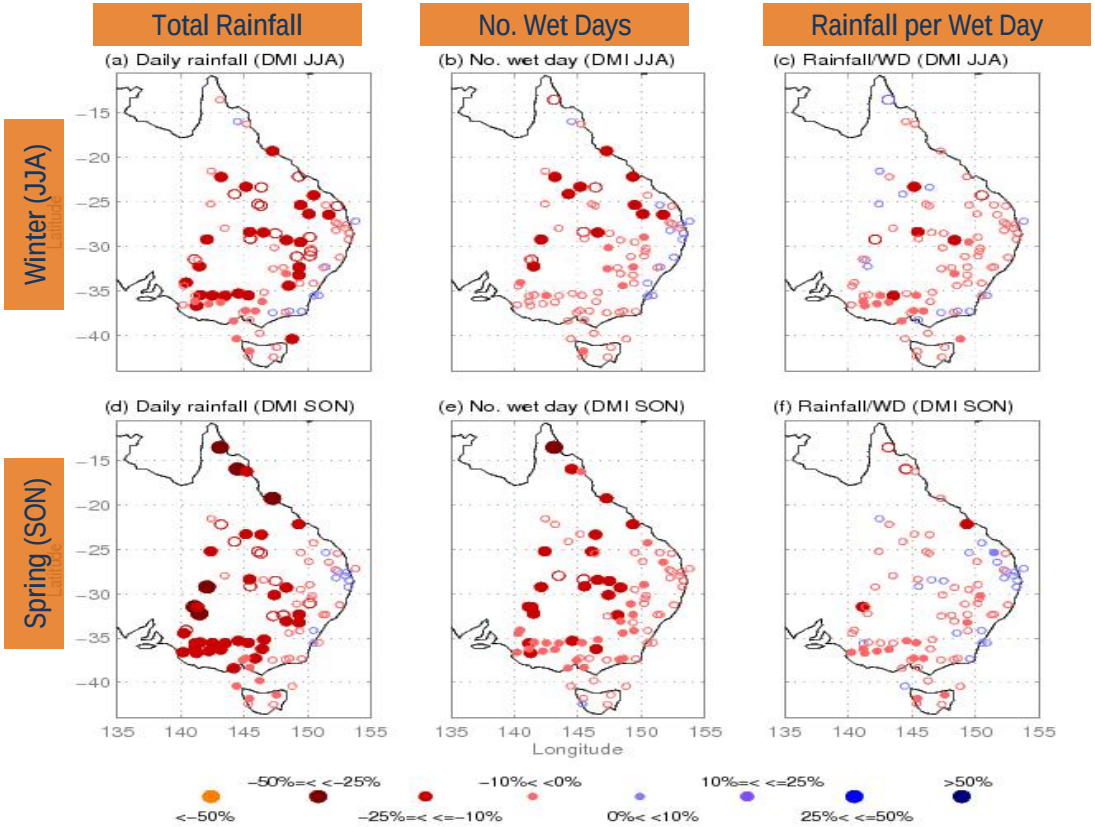
Spring (SON)



Changes in daily rainfall variables corresponding to +1 SD change in normalised SOI for JJA (top row) and SON (bottom row).

Source: Pui et al. 2012, *Impact of ENSO, IOD, and SAM on Rainfall Characteristics in East Australia. Mon. Wea. Rev.*, **140**, 1665–1682.

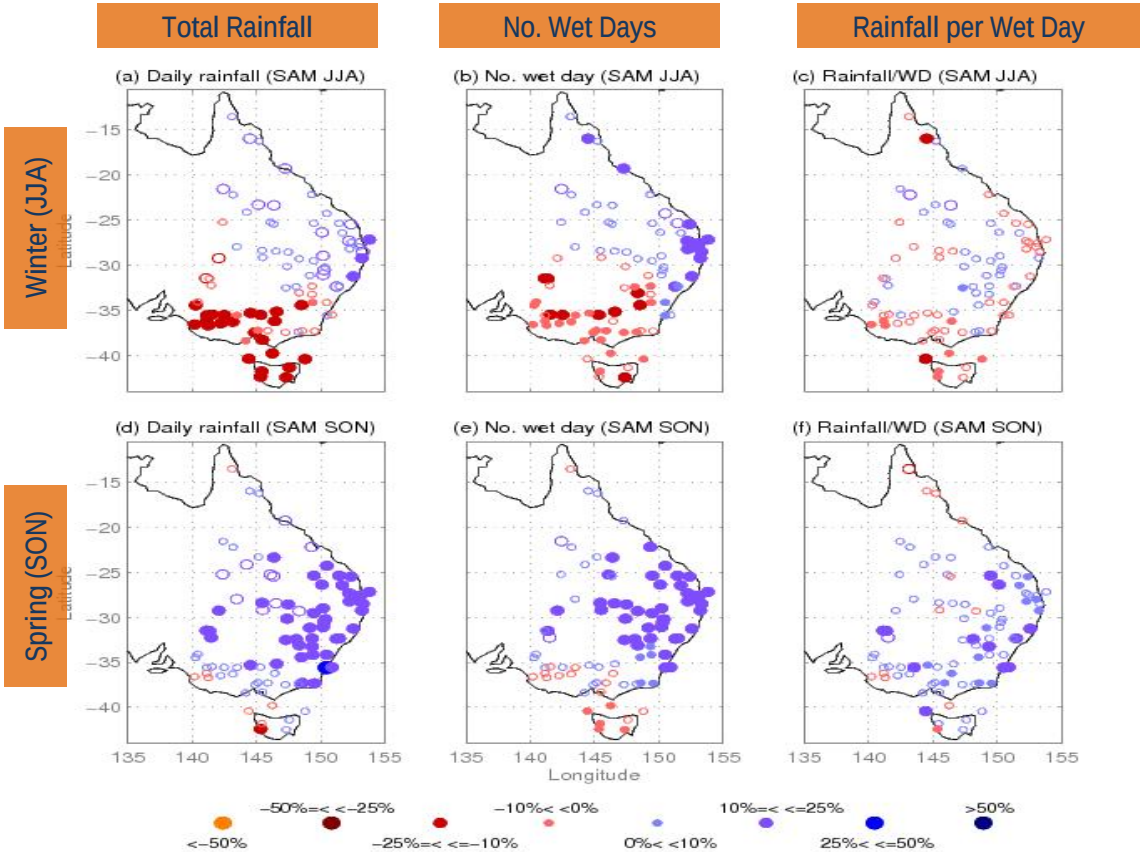
Impact of IOD on Australian Rainfall



Changes in daily rainfall variables corresponding to +1 SD change in normalized DMI in JJA (top row) and SON (bottom row).

Source: Pui et al. 2012, Impact of ENSO, IOD, and SAM on Rainfall Characteristics in East Australia. Mon. Wea. Rev., ***140****, 1665–1682.*

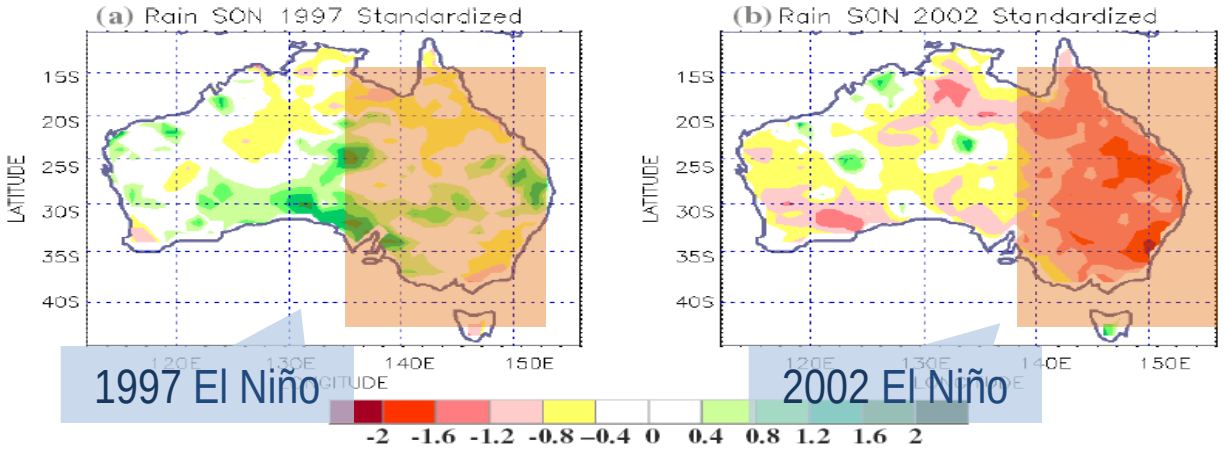
Impact of SAM on Australian Rainfall



Changes in daily rainfall variables corresponding to +1 SD change in normalized SAM index in JJA (top row) and SON (bottom row).

Source: Pui et al. 2012, Impact of ENSO, IOD, and SAM on Rainfall Characteristics in East Australia. Mon. Wea. Rev., ***140****, 1665–1682.*

Not all ENSO events are equal



1997 El Niño

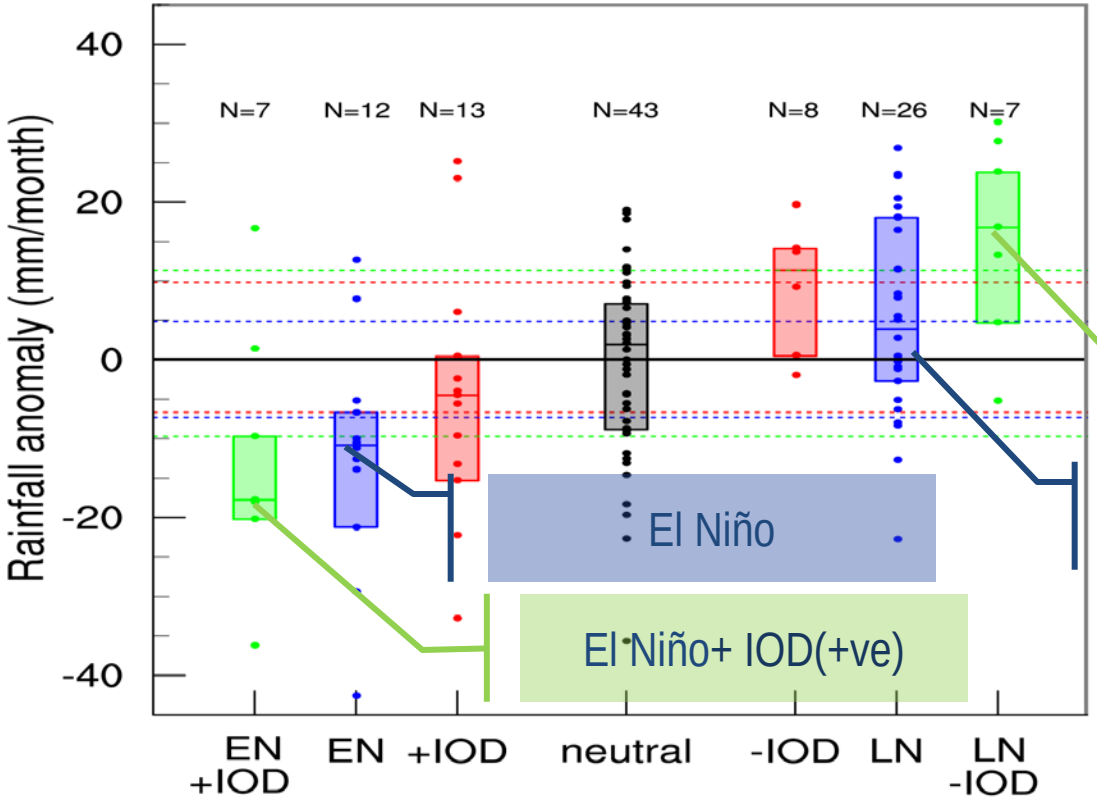
2002 El Niño

Differences in rainfall response according to position of maximum SSTAs.

Impacts on Rainfall are different

Source: Wang, G., and H.H. Hendon, 2007: *Sensitivity of Australian rainfall to Inter-El Nino variations.* J. Climate, **20**, 4211-4226.

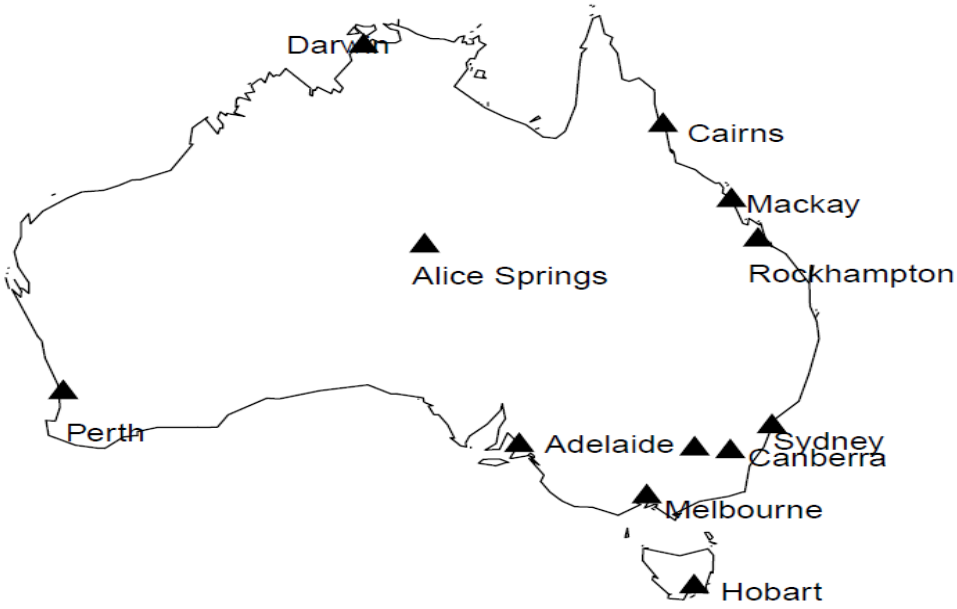
Interaction between climate modes



Mean SE Australian Rainfall anomalies for different ENSO/IOD categories for the June –October Period

Source: Ummenhofer et al. 2009 *'What causes southeast Australia's worst droughts?'* , Geophysical Research Letters, vol. 36, pp. 1-5.

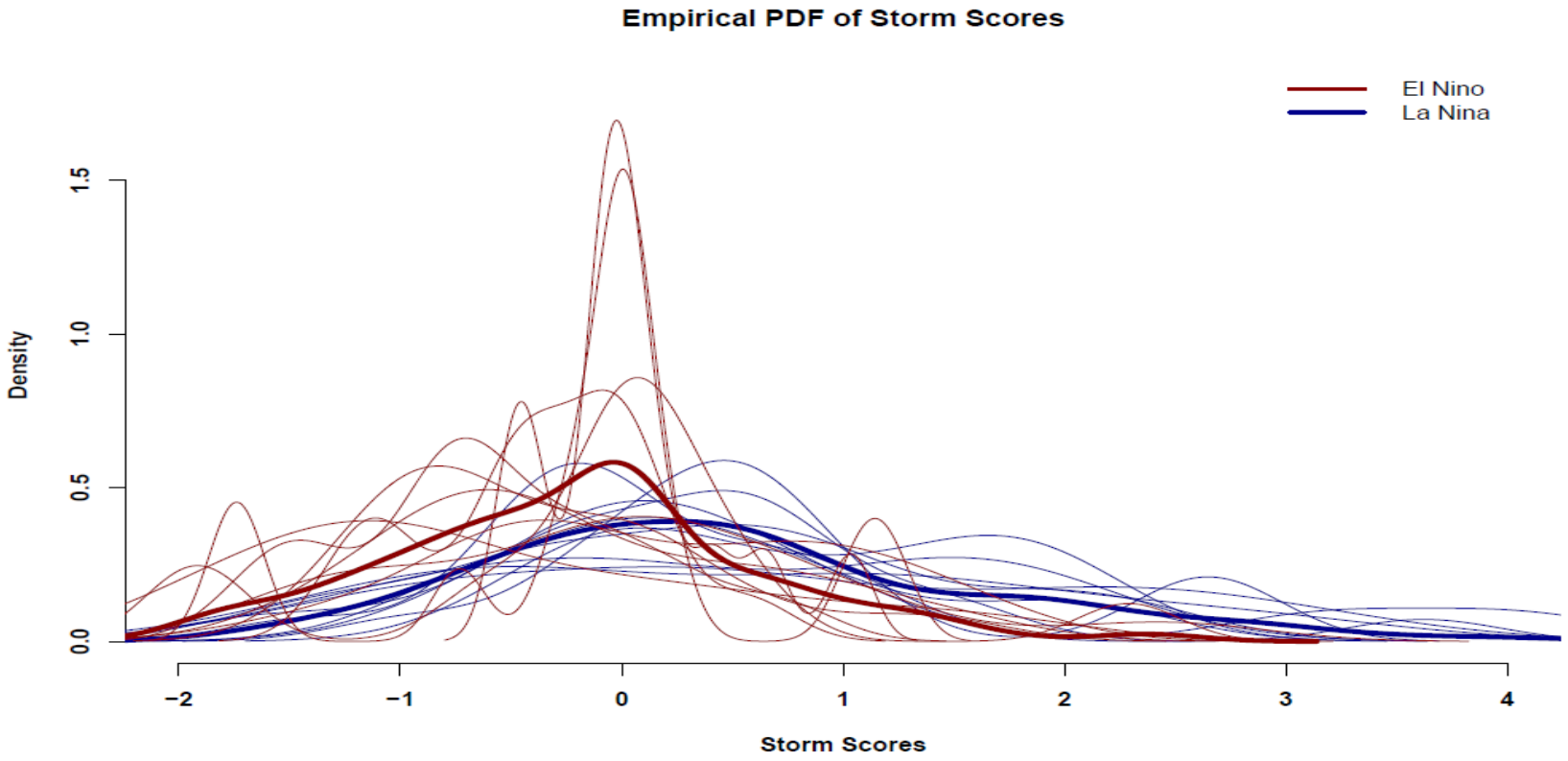
ENSO and weather related claims costs



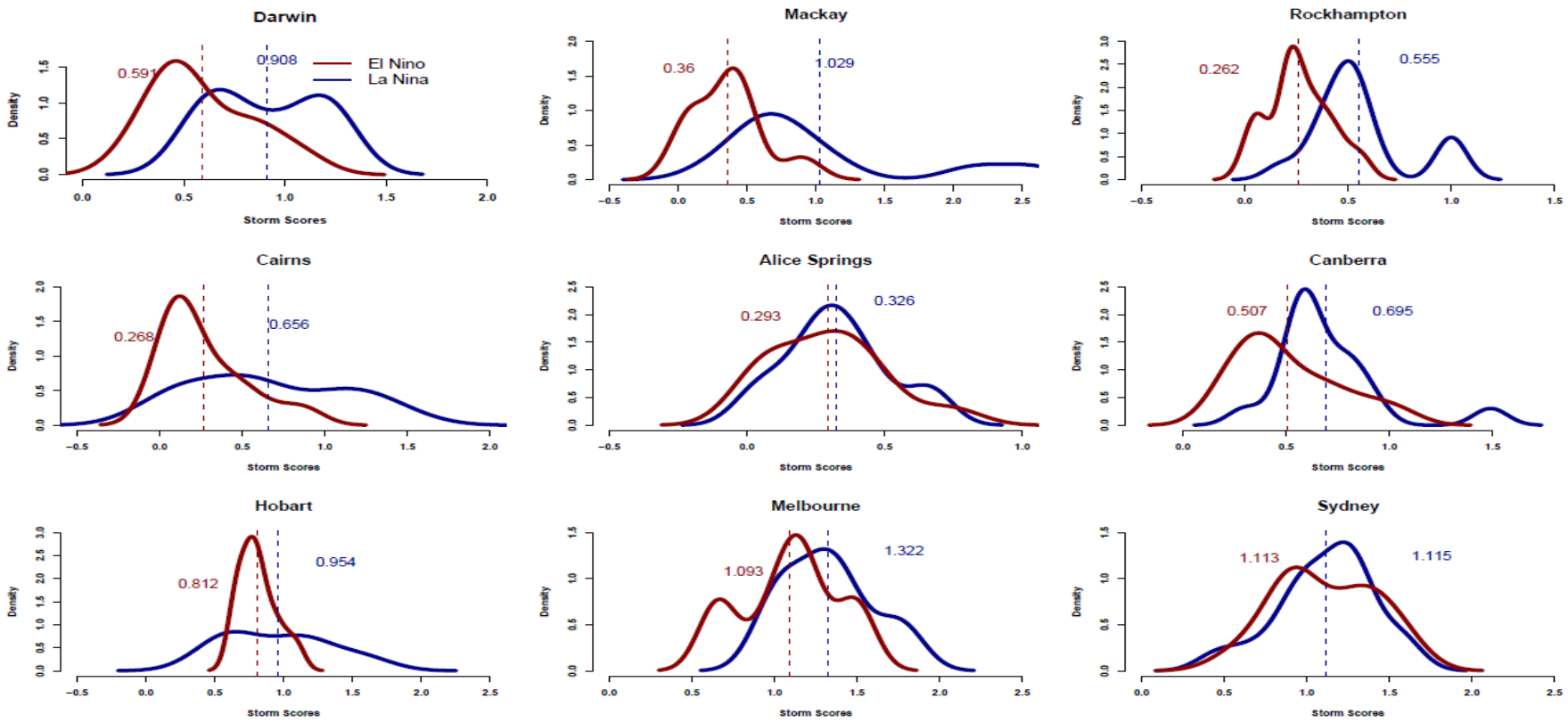
- Storm Score Analysis
- Derived from daily peak wind gust, rainfall, and associated claims cost (non cat)
- One weather station per location in open area – records date from 1950s till present

Source: Andrews and McNab *'Storm Insurance Costs: How have weather conditions impacted recent profitability?'* , 2005

ENSO impact on East Coast Storm Scores



ENSO impact: Individual stations

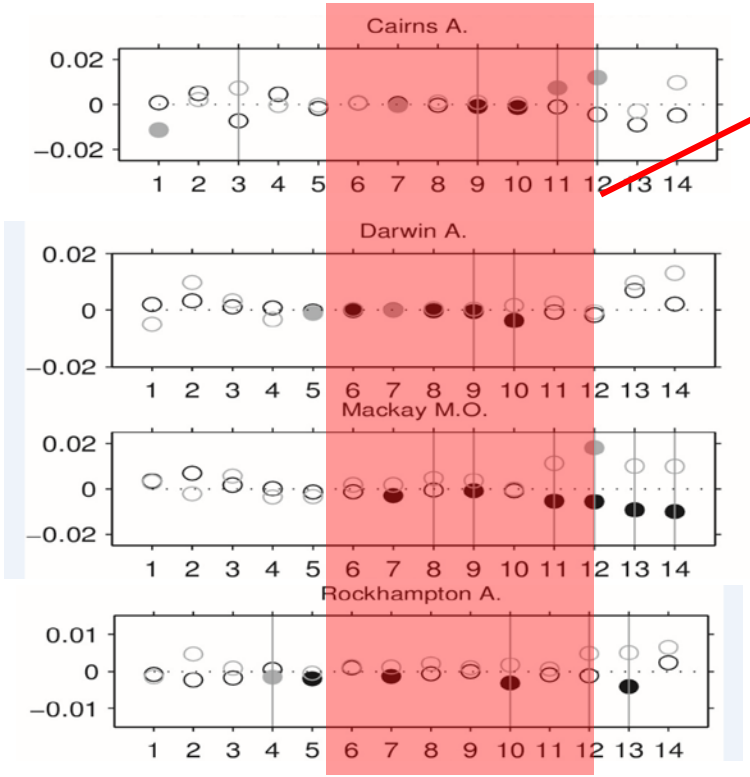


ENSO impact: Individual stations significance

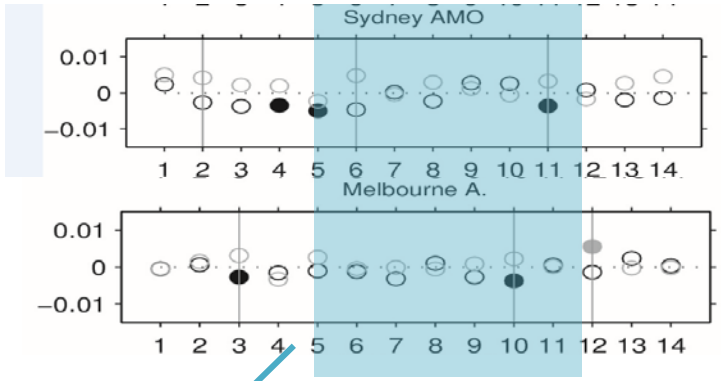
Station	El Nino	Neutral	La Nina
Sydney	1.113	1.018	1.115
Cairns	0.268	0.339	0.656
Canberra	0.507	0.652	0.695
Rockhampton	0.262	0.382	0.555
Melbourne	1.093	1.114	1.321
Hobart	0.812	0.719	0.954
Alice Springs	0.293	0.273	0.326
Mackay	0.360	0.579	1.029
Darwin	0.591	0.574	0.908

- Sydney and Melbourne not significantly different between opposite ENSO phase
- Impacts in NE Qld more pronounced
- Neutral phase results closer to El Nino at most stations, or even lower than El Nino phase (i.e. non linear response)

ENSO impact: Monthly



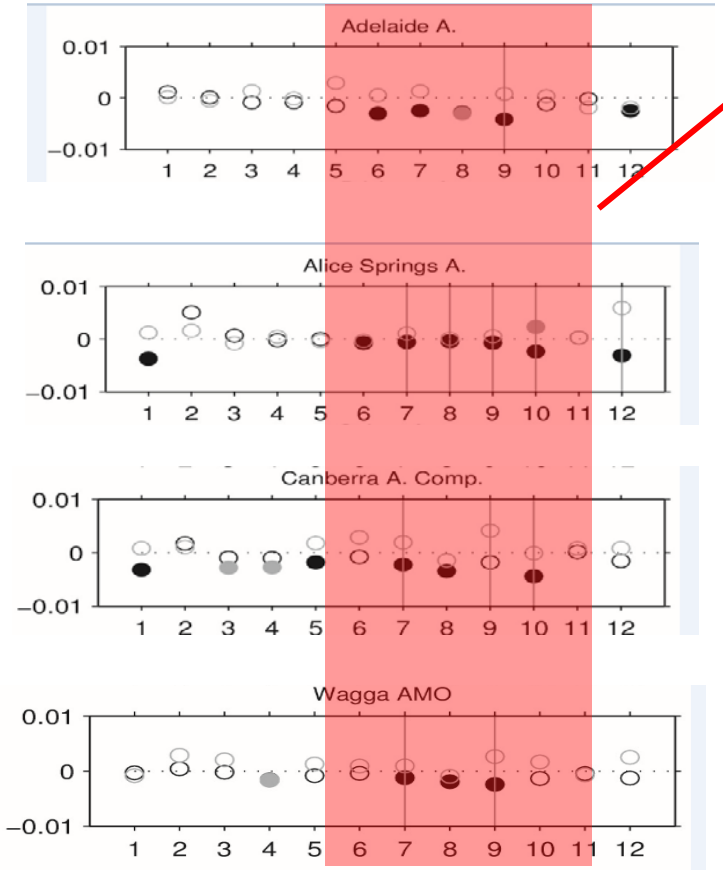
Greater impact in NE Aust



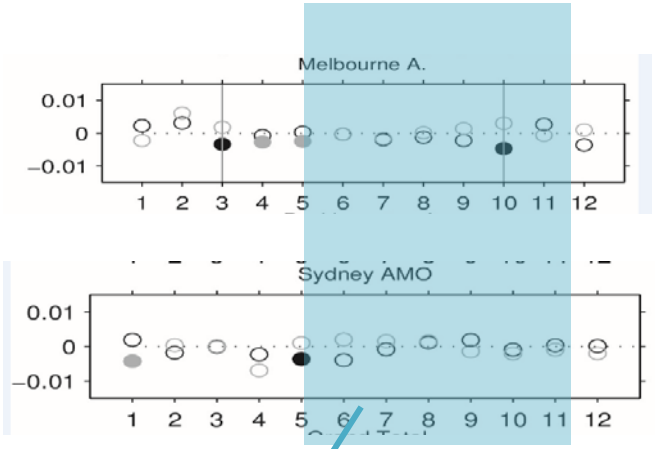
Less pronounced impact in SE Aust

- El Nino (SS from mean)
- El Nino (not SS from mean)
- La Nina (SS from mean)
- La Nina (not SS from mean)
- SS btw El Nino and La Nina

IOD impact: Monthly



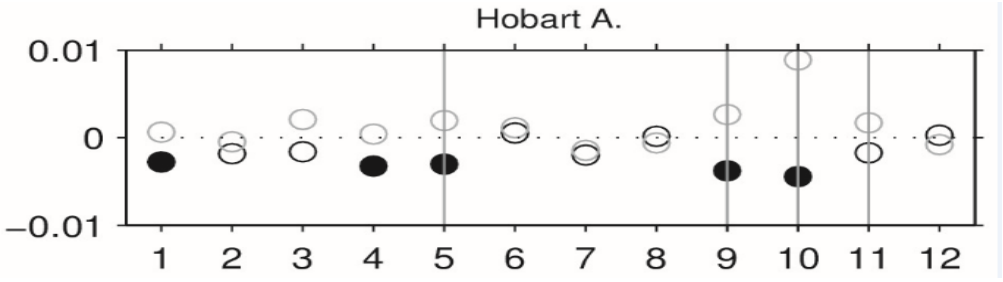
More pronounced impact in inland/SE Aust



Less pronounced impact closer to coast

- +IOD (SS from mean)
- +IOD (not SS from mean)
- -IOD (SS from mean)
- -IOD (not SS from mean)
- SS btw +IOD and - IOD

SAM Impact



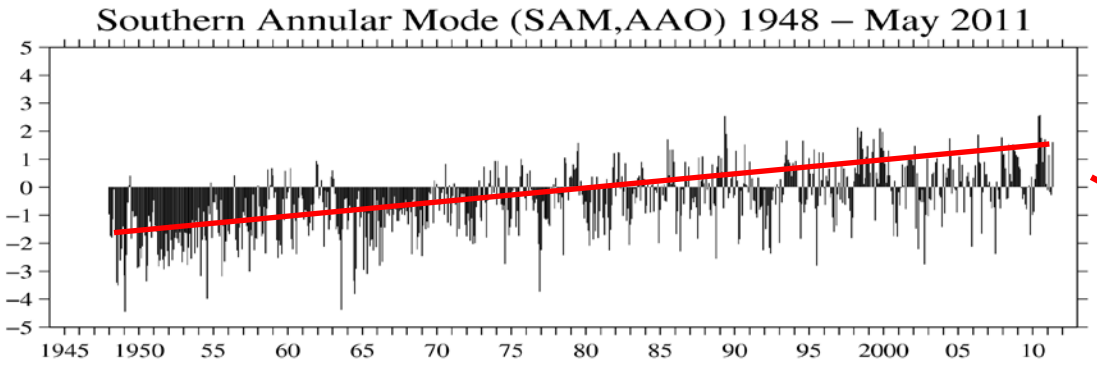
+ SAM (SS from mean)

+ SAM (not SS from mean)

-SAM (SS from mean)

-SAM (not SS from mean)

SS btw +SAM and La Nina



Increasing +SAM trend

Leading PC of NCEP – NCAR reanalysis sea–level pressure anomalies, 20–90°S, for 1979–2010.
The spatial pattern was then projected onto the entire record,
and the time series standardized with respect to 1979–2010.

Summary of Main Findings

- ENSO remains the leading driver of rainfall variability
- ENSO has most potential for predictability (up to 9 months in advance)
- GCMs project more frequent extreme El Nino and +ve IOD events
- Climate modes exert their influence by impacting FREQUENCY rather than SEVERITY of events
- Weather Based Claims experience is consistent with RF analysis:
  - ENSO impacts stronger in the NE Qld, but not in coastal SE Aus
  - SE Aust stronger 'noise' component (EC Lows/ coastal troughs/southerly busters)
  - SAM impacts Hobart in winter months, and likely to dry due to +SAM trend.

Impact on Insurers…

What it means for insurers

Summary of possible uses

Improving profitability	• Difficult for direct policies • May be opportunities for R/I programme (and for R/I coys)
Variable perils budget	• No, if budgeted profit intended to reflect level of underlying profitability of business
Capital requirements	• Adds volatility that can be built into capital modelling
Premium Liabilities	• Unnecessary complexity and adds unhelpful volatility to capital base
Technical Pricing	• If pricing on basis of past experience, knowledge of cycle will assist interpretation of experience
Explaining periods of high catastrophes	• It was useful after 2011 and 2012 to show that higher costs had cyclical element, not indicative of upwards trend
Allowance in catastrophe models	• If no, then multiple events in a year understated • PML may be understated if cycle impacts on size

Improving Profitability

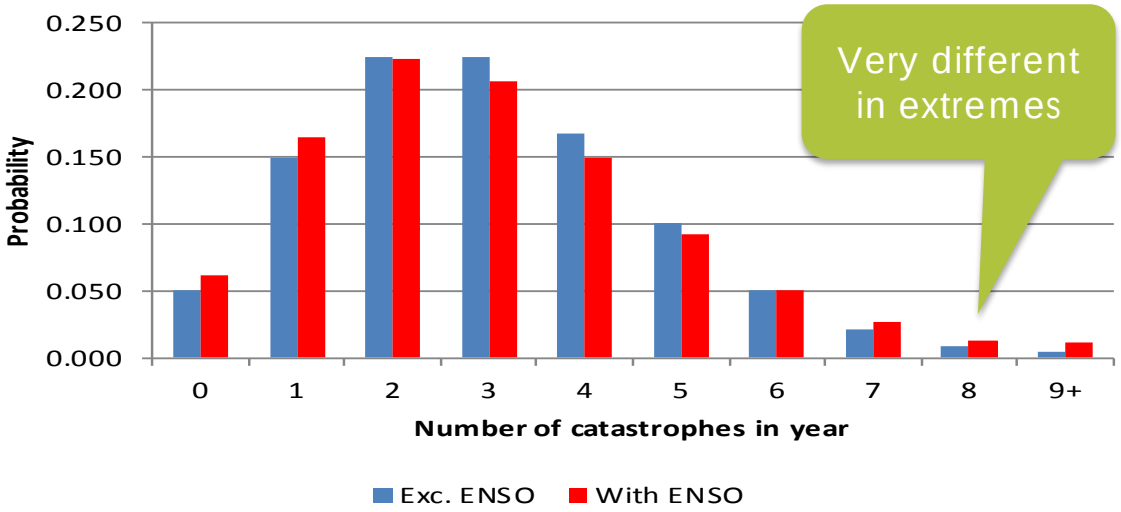
- 2012 paper – direct writer with perfect knowledge
  - 0.2% improvement in COR
  - but smaller portfolio
- May be opportunities relating to reinsurance programme
  - eg. lower retentions in La Nina
- Equally reinsurers may look to exploit

Allow for in Premium Liabilities

- Overly theoretical
- Unnecessary complexity
- Can't vary premiums to reflect phase in cycle
- Adds unhelpful volatility to capital base

Impact on Cat Models

- Important to recognise ENSO in assessing value of sideways programme

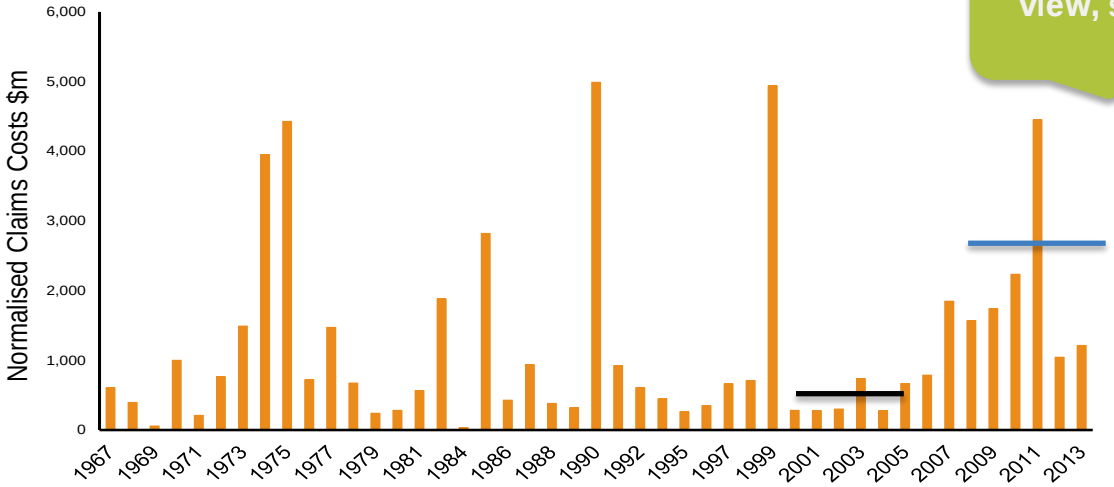


- Does not impact PML calculation
  - Unless catastrophes in La Nina periods are larger
  - Second order effect in context of model uncertainties

Budgeting for cat costs

- Cost vary significantly year to year

Taking a "medium term" view, say 5 years, is also too volatile



- Appropriate to take long term view (20+ years)
- Applies more critically to pricing

Budgeting for cat costs

- Cycle predictions
  - Some evidence extreme states of cycle could be predicted 6-18 months out
- Variable budgeting
  - Potential to respond to prediction in budget allowances
  - For listed insurers difficult to explain guidance to markets. Better approach may be informing investment market of potential for higher cat activity when approaching a certain phase
  - For unlisted insurers this approach may be more feasible
  - What's the cost of getting it wrong?

Budgeting for cat costs

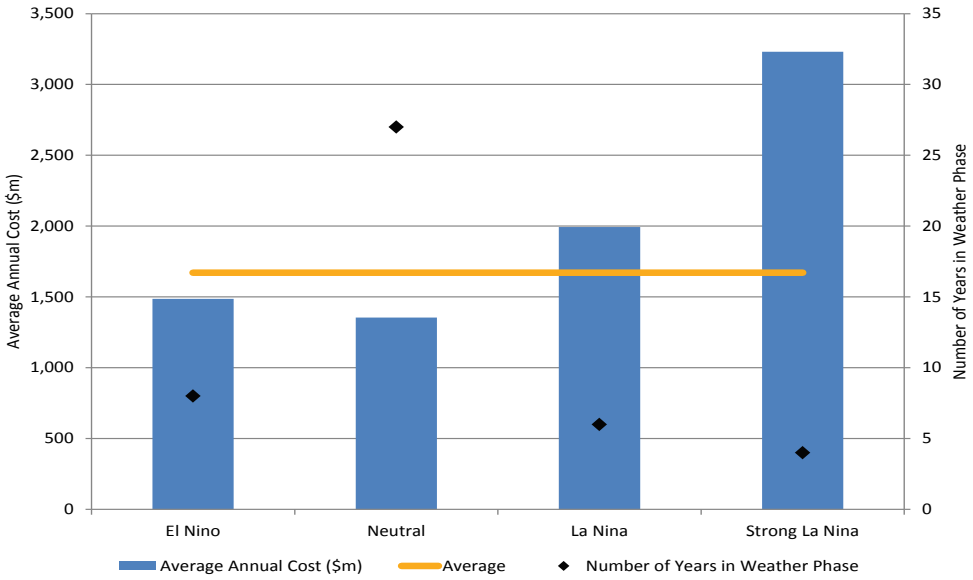
- Multi-year peril budgets?
- Investment markets
  - Attempt to see through catastrophe results to understand underlying margins
  - Possible for market to not recognise underpricing of peril covers
    - Heightened as insurers at varied levels of sophistication in peril based risk selection
  - Role for insurers to educate markets on financial impact of weather

Implications for capital

- Multi-state nature of weather means profit volatility is greater than history may suggest
- "Tail" outcomes are different enough that capital modelling results could be materially impacted when considered in light of risk appetites
- Reinsurance strategy can be considered in light of ENSO predictions
  - Works better for December renewals

Trend vs Cycle

- Role for insurers to educate reinsurance markets
- Putting experience in the context of the cycle phase
  - True deterioration versus natural variability



Final remarks

Wrap-up