

GREENHOUSE 2011

Climate Observations as a Basis for Climate Science

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4 April 2011



Why do we observe weather and climate?

- To understand variability in weather (and climate)
- To enable us predict the weather (and climate)
- We have been observing weather and climate globally for well over a century



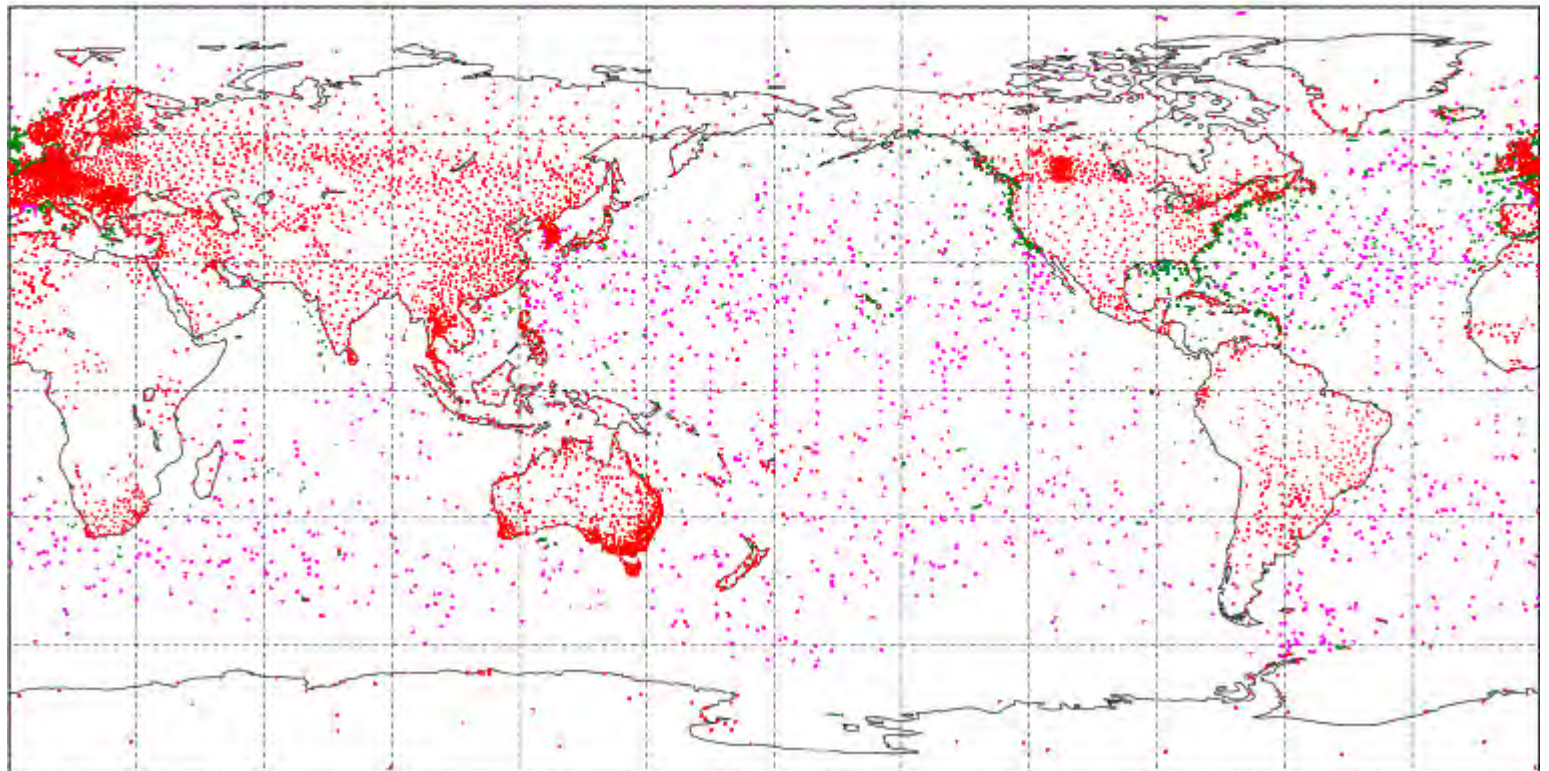
Data assimilation defines the initial state . . .

Australian BoM ACCESS-G Accepted observations coverage
Surface 20110322 0000 UTC
Total number of obs = 26076

16741 synop land

2721 synop ship

6614 buoy



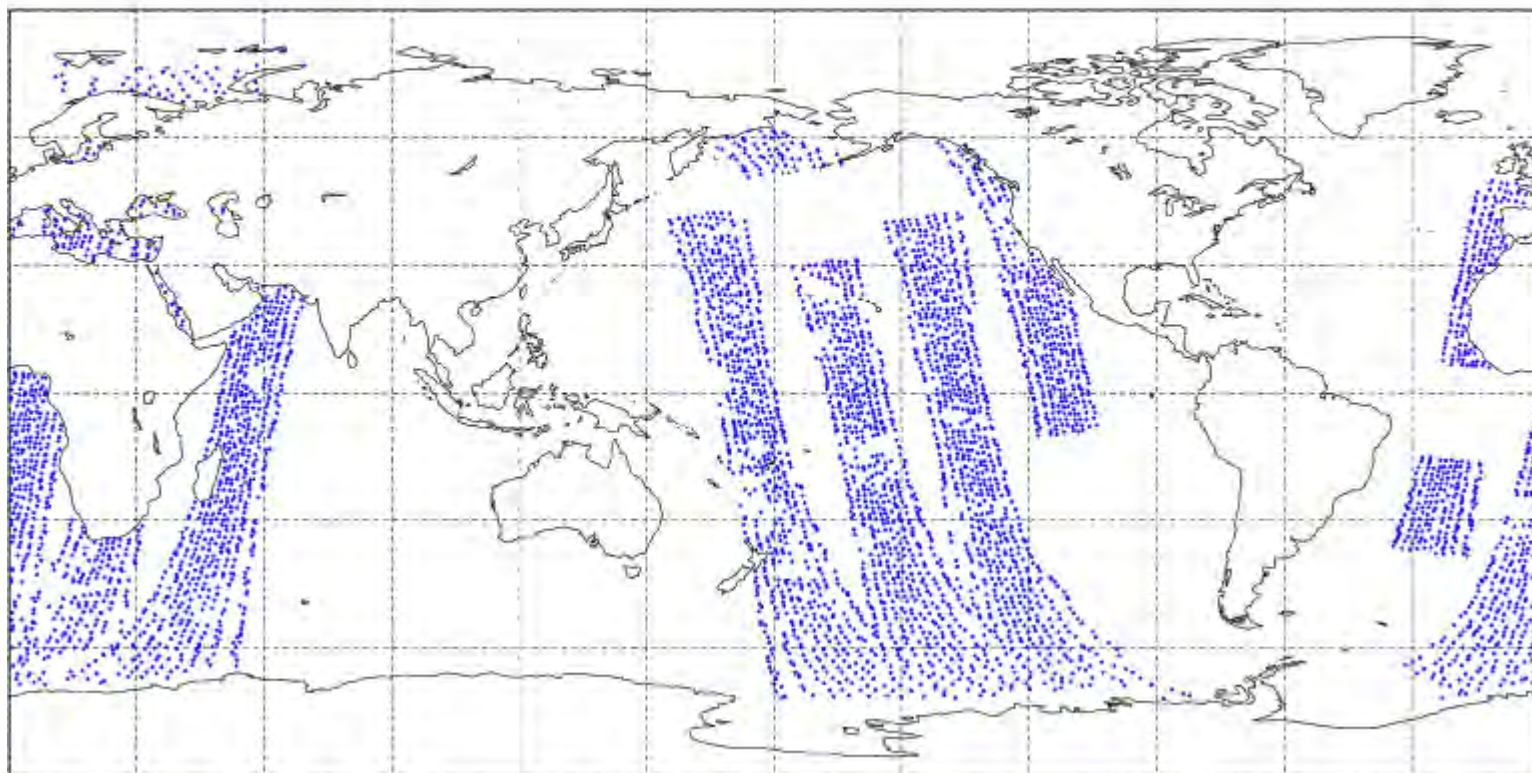
Issue time 05UTC 22 Mar 2011



Australian Government
Bureau of Meteorology

.. and the more observational data we assimilate ...

Australian BoM ACCESS-G Accepted observations coverage
AIRS 20110322 0000 UTC
Total number of obs = 4193



Issue time 05UTC 22 Mar 2011



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. . . . the better the forecast

Australian BoM ACCESS-G Accepted observations coverage

Satwind

20110322 0000 UTC

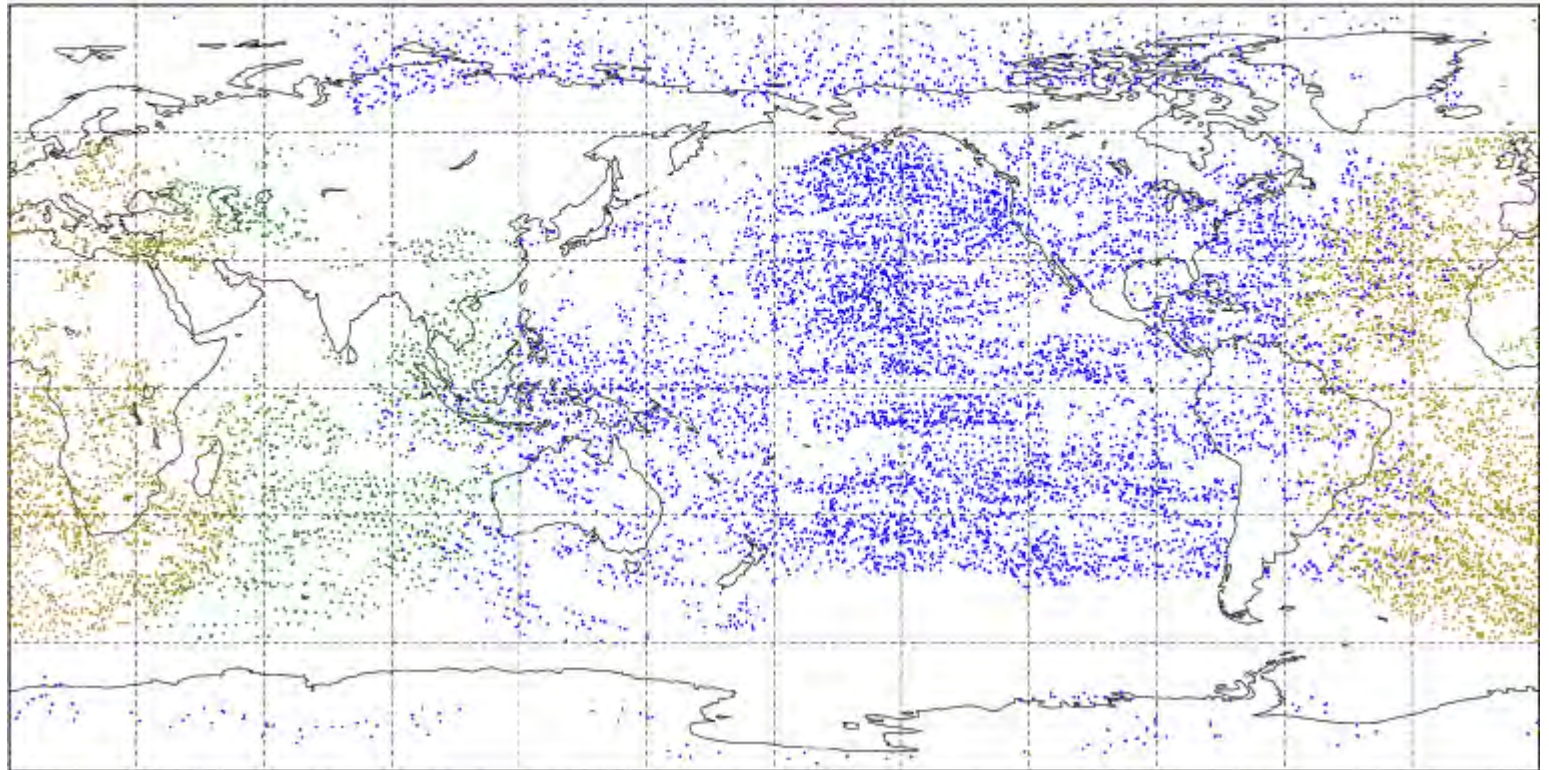
Total number of obs = 13376

8150 GOES

1188 ESAC

0 JMA

4038 MSG



Issue time 05UTC 22 Mar 2011



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. . . . the better the forecast

Australian BoM ACCESS-G Accepted observations coverage

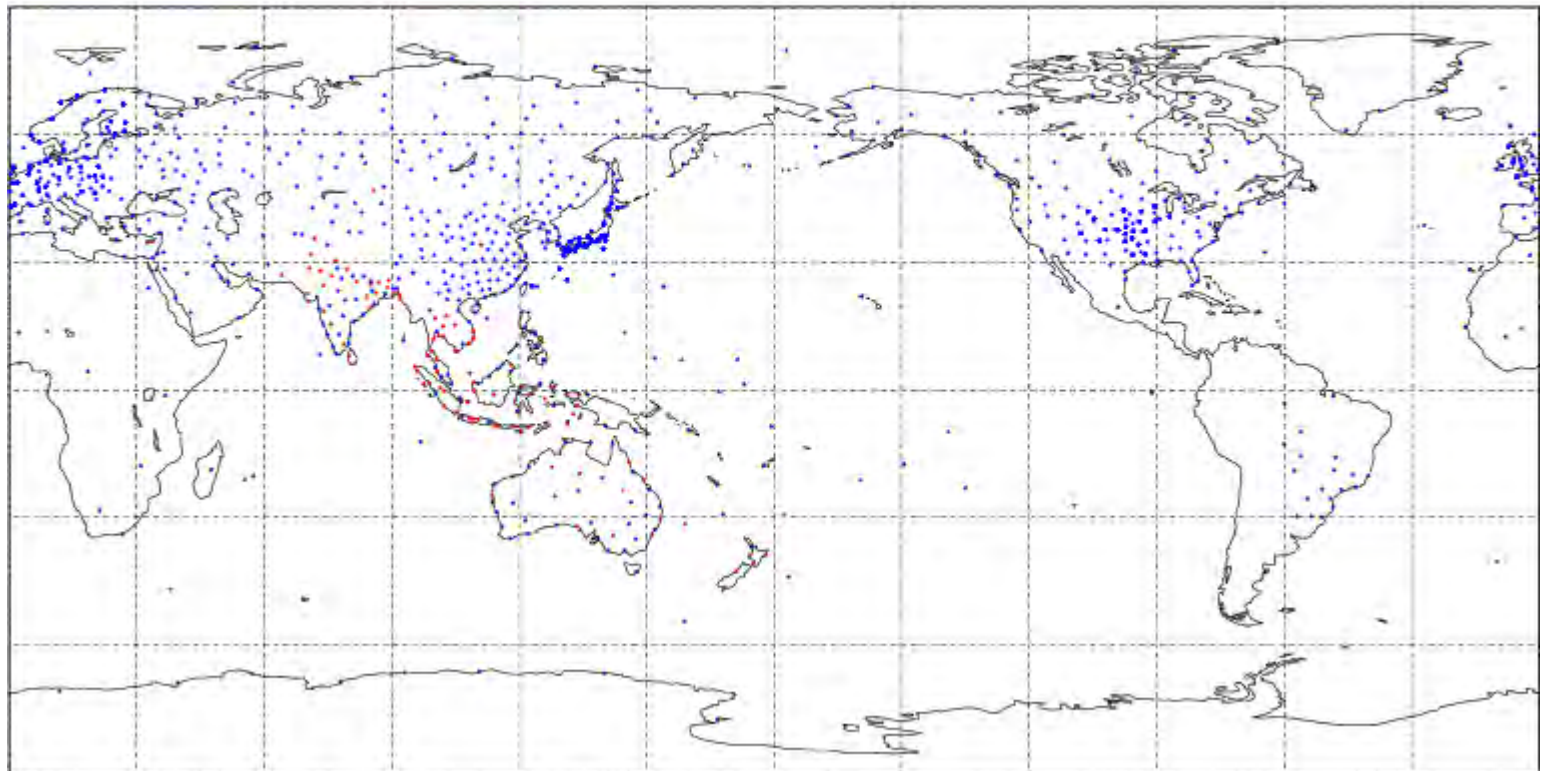
Sonde

20110322 0000 UTC

Total number of obs = 1321

631 temp

103 pilot



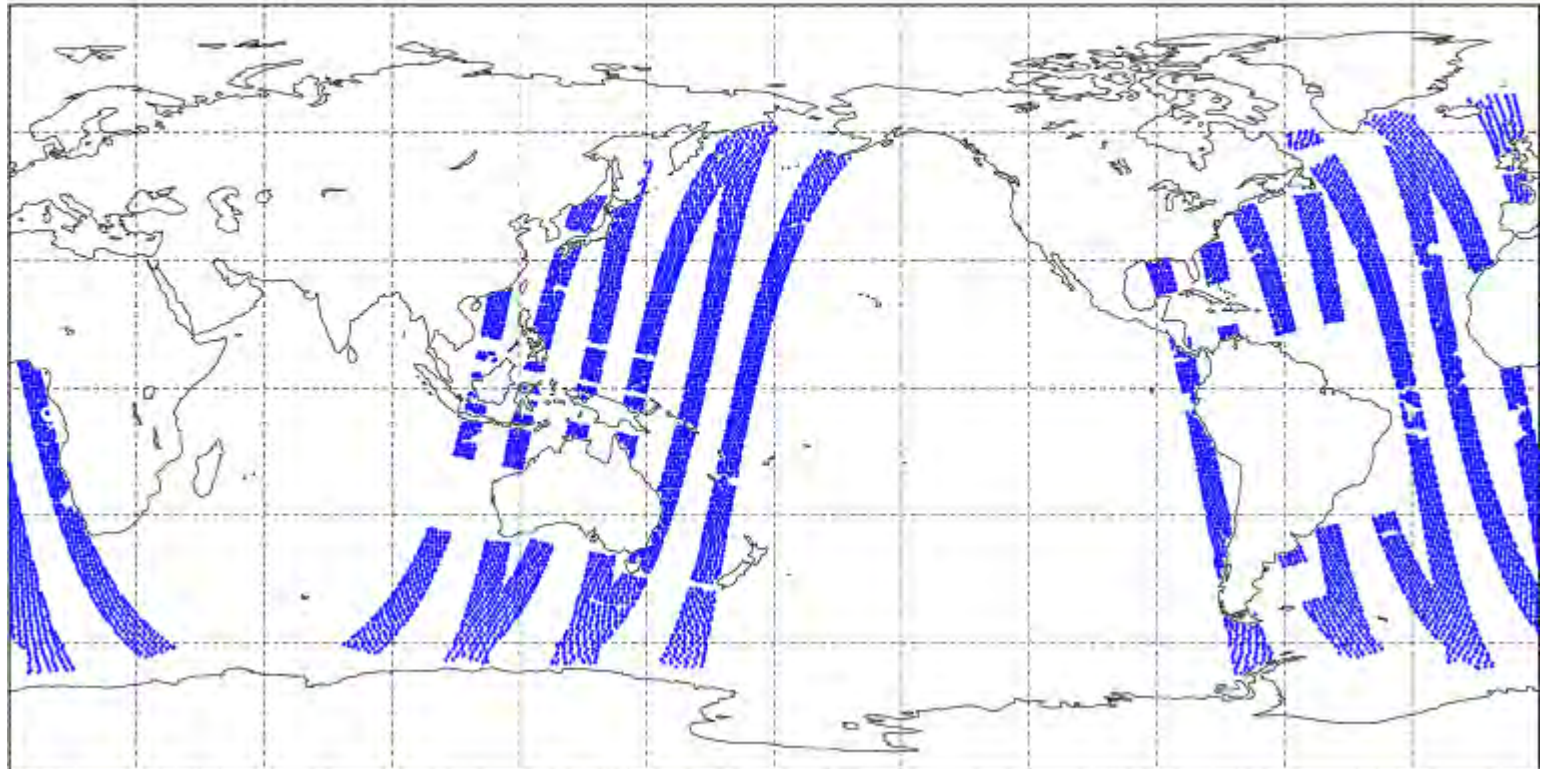
Issue time 05UTC 22 Mar 2011



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. . . . the better the forecast

Australian BoM ACCESS-G Accepted observations coverage
Scatwind 20110322 0000 UTC
Total number of obs = 8606



Issue time 05UTC 22 Mar 2011



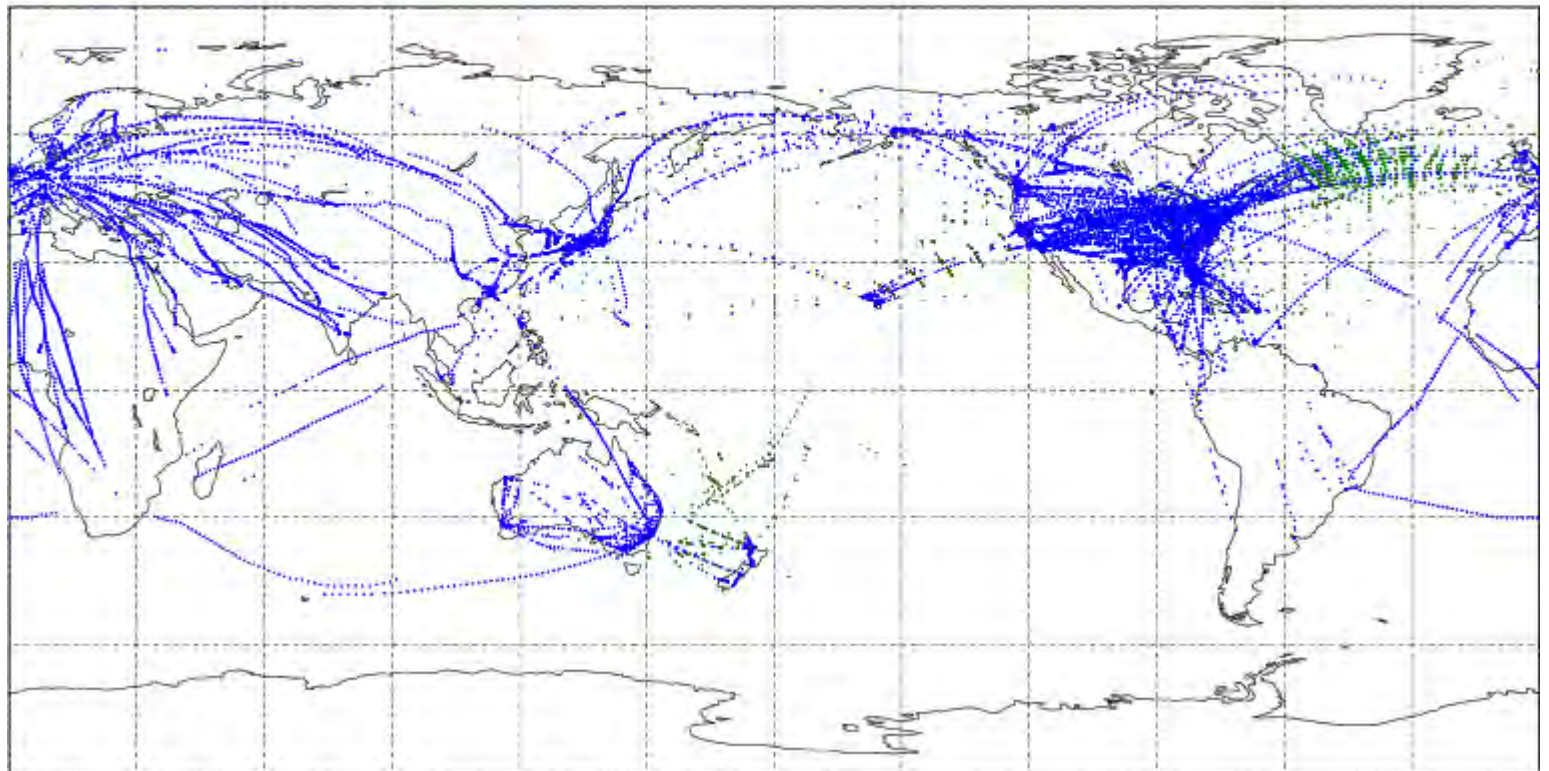
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. . . . the better the forecast

Australian BoM ACCESS-G Accepted observations coverage
Aircraft 20110322 0000 UTC
Total number of obs = 17361

16069 amdar

1292 airep



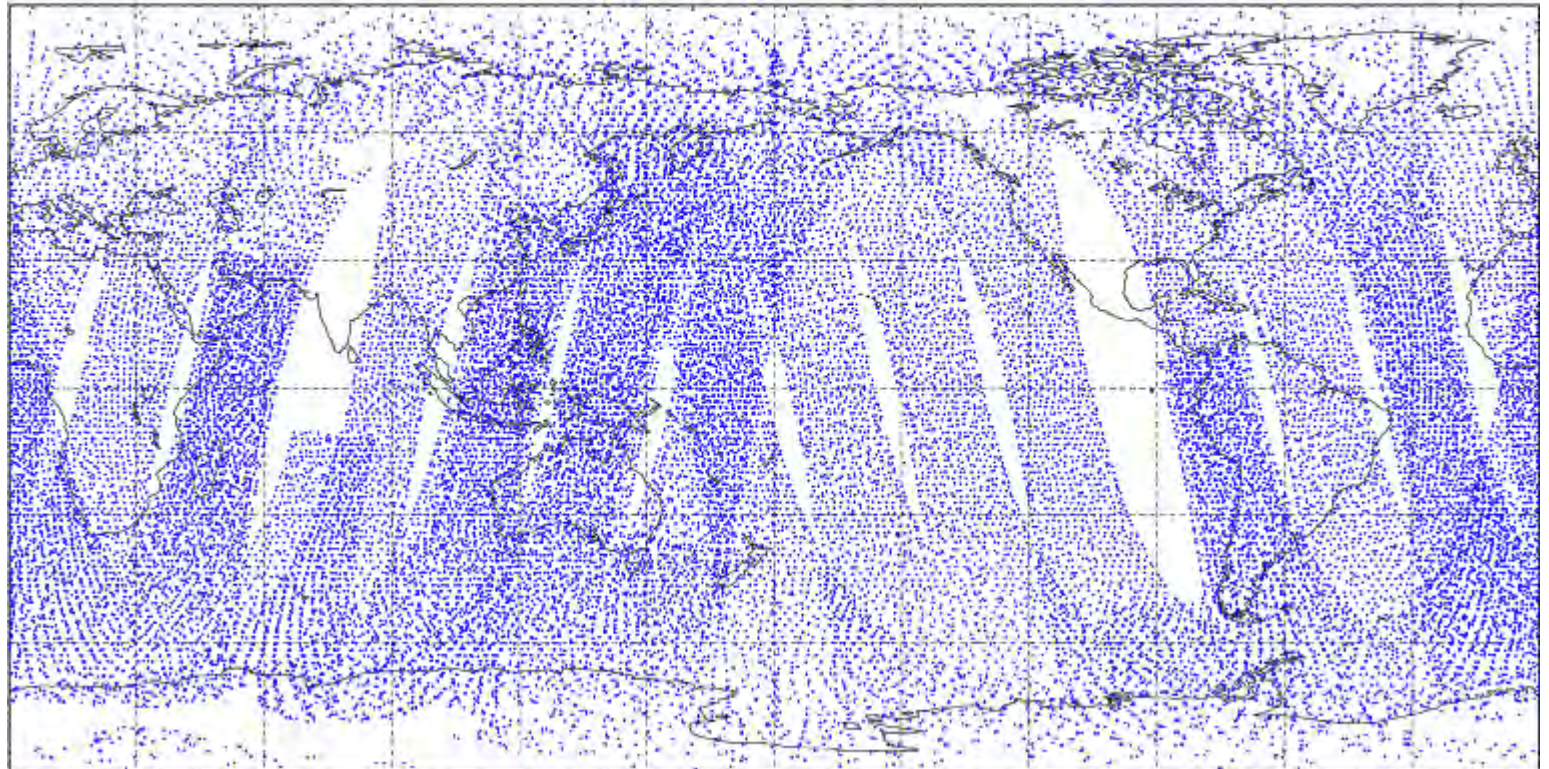
Issue time 05UTC 22 Mar 2011



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Australian BoM ACCESS-G Accepted observations coverage
ATOVS 20110322 0000 UTC
Total number of obs = 30925



Issue time 05UTC 22 Mar 2011

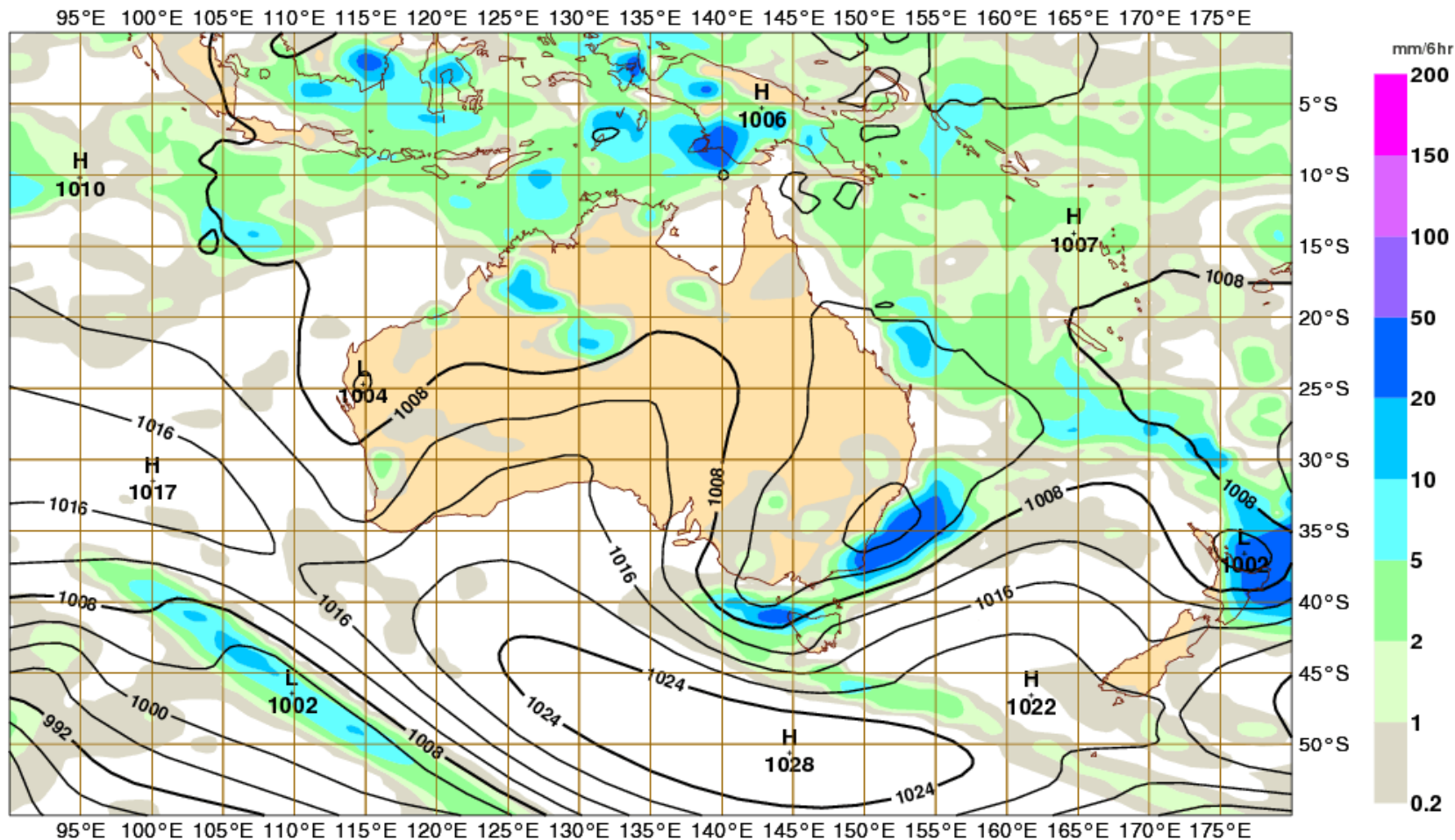


Australian Government
Bureau of Meteorology

This is why we observe weather and climate

MSLP / Precip (06 hourly)
Valid 18UTC Mon 21 Mar 2011

ACCESS-Global
t+006



Mon Mar 21 17:22:17 2011 mslpPrecip.py ACCESS_G 20110321 12Z (Australia)



Australian Government
Bureau of Meteorology

[Bureau Home](#) > [Tropical Cyclones](#) > [About](#) > [Warnings](#) > [Track Map](#) > Tropical Cyclone Forecast Track Map Sample

Tropical Cyclone Forecast Track Map Sample

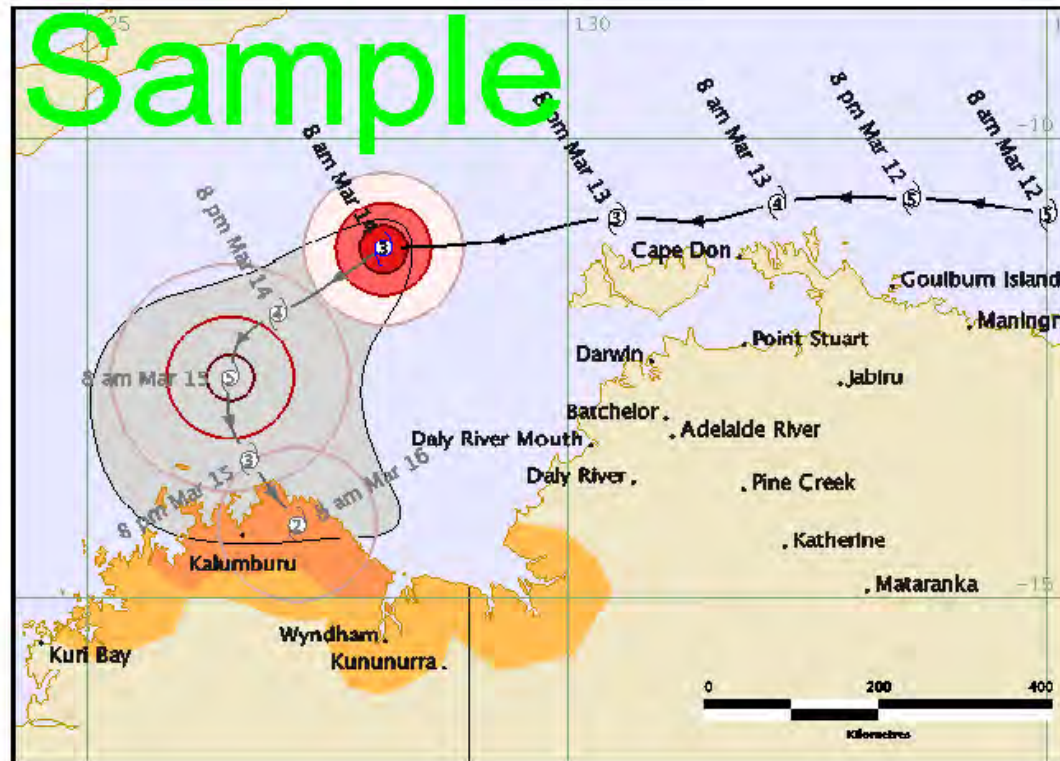
[About tropical cyclone warning services](#) | [Preparation & safety](#) | [About tropical cyclones](#) | [FAQs](#)

AUSTRALIAN BUREAU OF METEOROLOGY
TROPICAL CYCLONE WARNING CENTRE PERTH

Sample TROPICAL CYCLONE FORECAST TRACK MAP

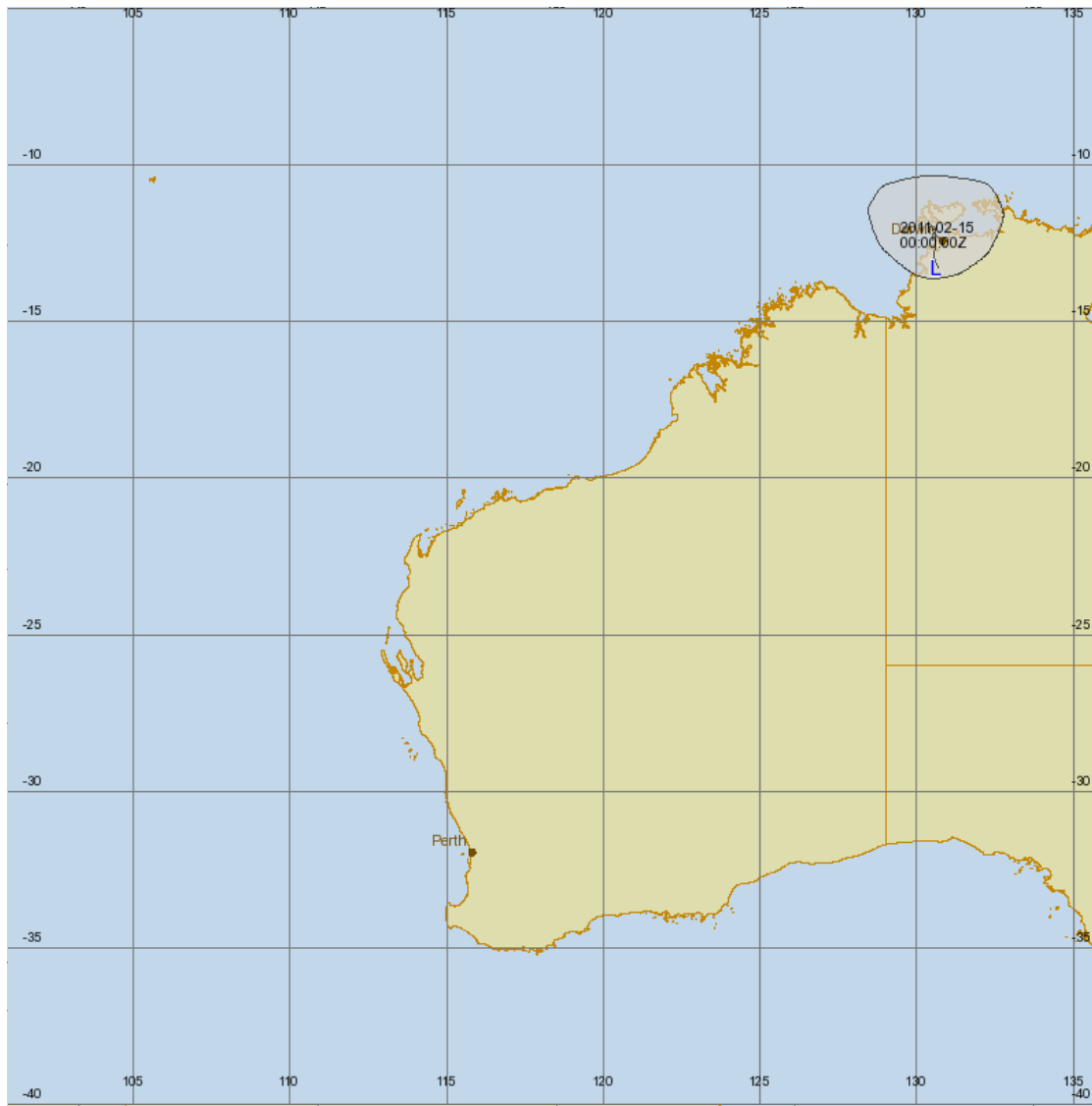
Severe Tropical Cyclone Alfred

[Tropical Cyclone Advice](#) Number 32 issued at 9:01 am WST Tuesday 14 March 2006



- ▶ Tropical Cyclones
- ▣ Current Cyclones
- Weather information
 - ▣ All weather warnings
 - ▣ Wind forecast maps
 - ▣ Radar
 - ▣ Rainfall and River Conditions
 - ▣ Satellite
- Sea surface temperature
 - ▣ North West Australia
 - ▣ Northern Territory
 - ▣ Queensland
- ⊕ Cyclone Outlooks
- ⊕ Previous Cyclones
- ⊕ Cyclone Climatology
- ▣ Cyclone XML Info
- ▶ National Weather Services
 - Weather & Warnings
 - Radar Viewer
 - Tsunami Warnings
 - Weather Maps
 - Satellite Images
 - Agriculture
 - Marine
 - UV Protection

To generate a benefit for society



Daily weather observations → climate data

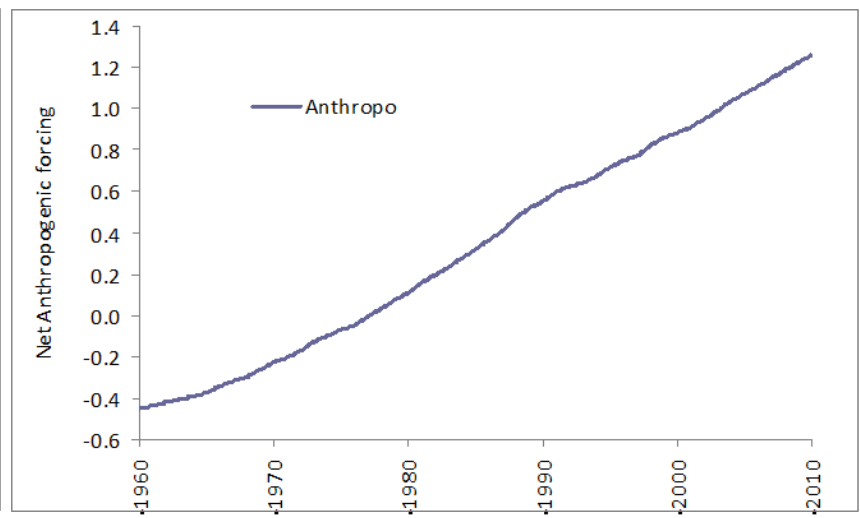
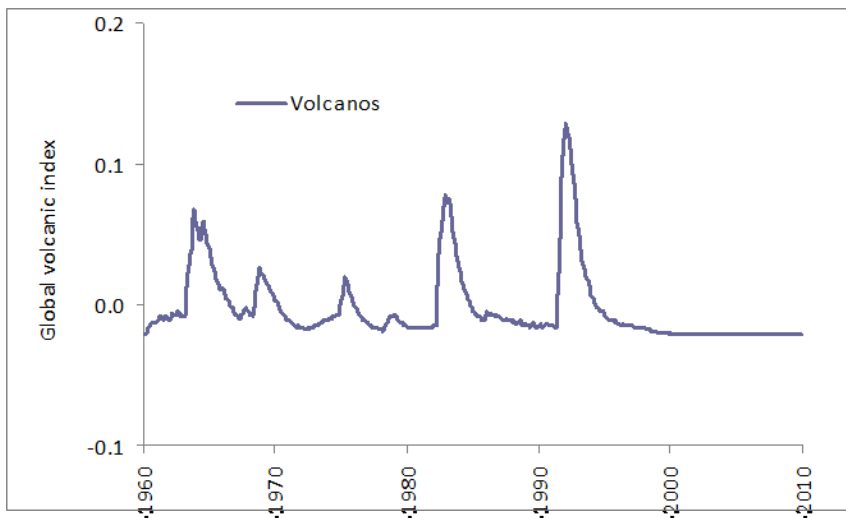
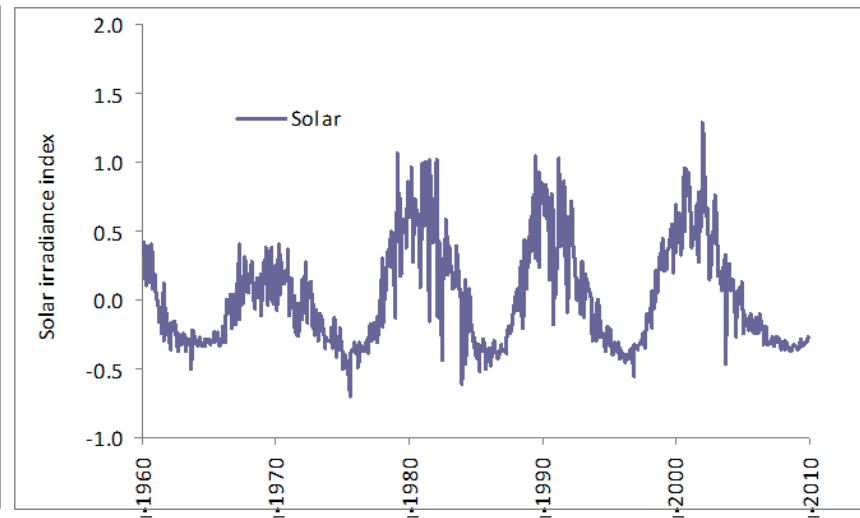
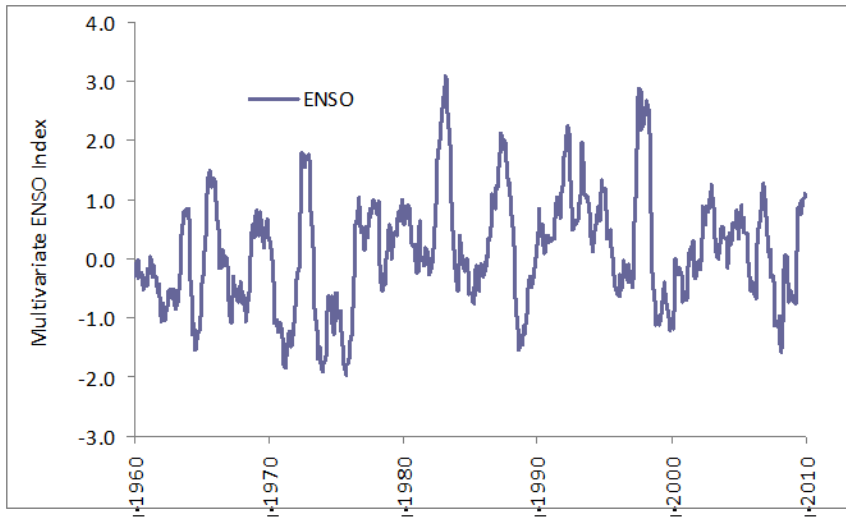
- WMO requires >30 years of data in a climate record
- Requires careful curation of data records to understand and account for non-climatic influences
- Cannot accumulate the plethora of available weather data in this way – so focus usually is on a climate reference network to yield a national climate database
- Analysis of such a record provides a basis for doing climate science in a variety of ways



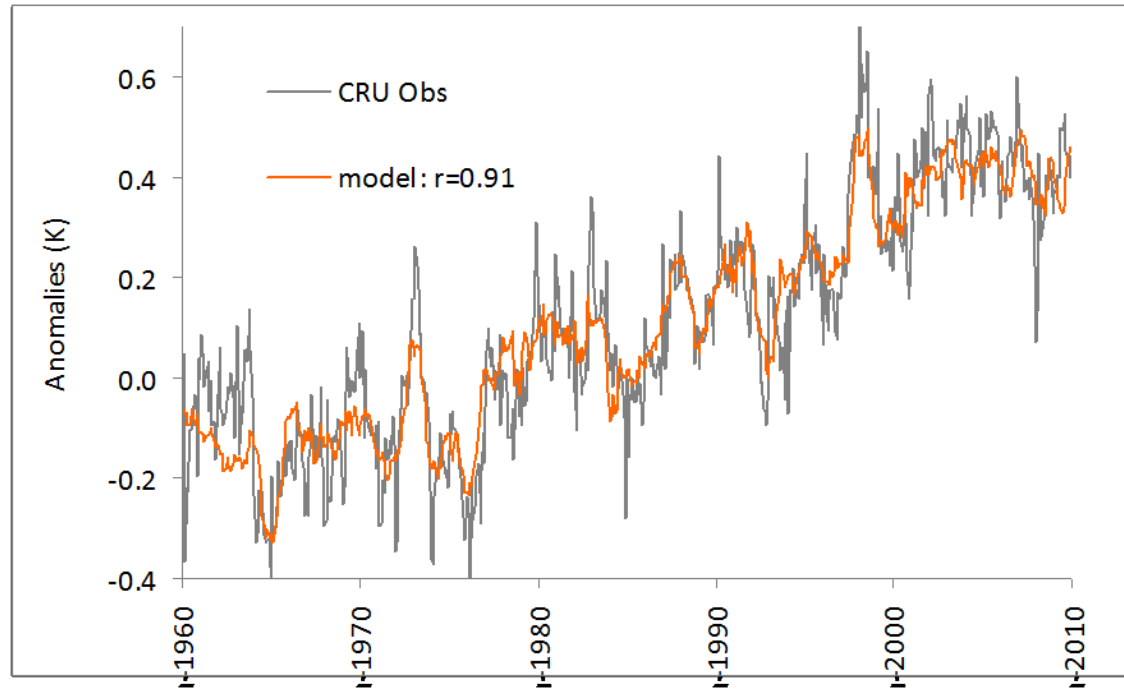
Example – analysis of global signals

- Here we consider just 4 indices created from observational data records (after Lean & Rind, 2009):
 - Multivariate ENSO index (Wolter and Timlin, 1988)
 - Volcanic aerosols (Sato et al., 1993)
 - Solar irradiance (Lean et al., 2005)
 - Nett anthropogenic (Hansen et al., 2007)
- Along with the global average temperature anomaly
 - HadCRUT3v available from the University of East Anglia Climatic Research Unit (Brohan et al., 2006)

→ Observationally based "indices"

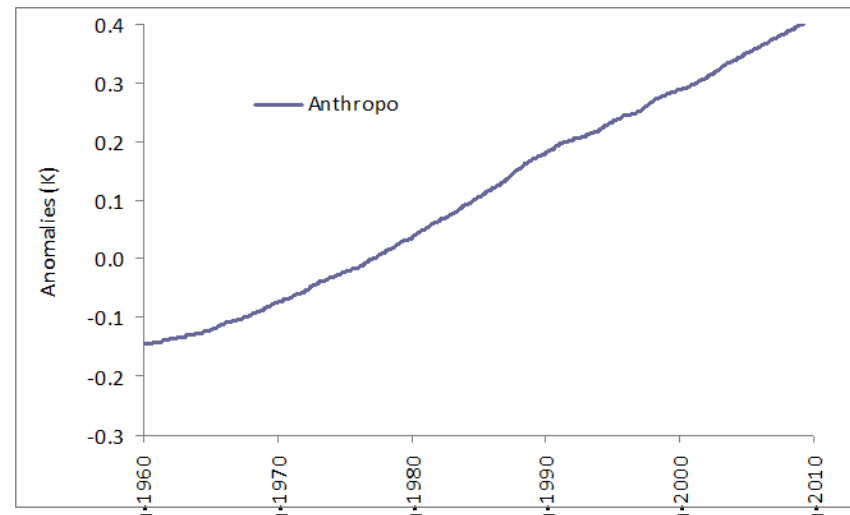
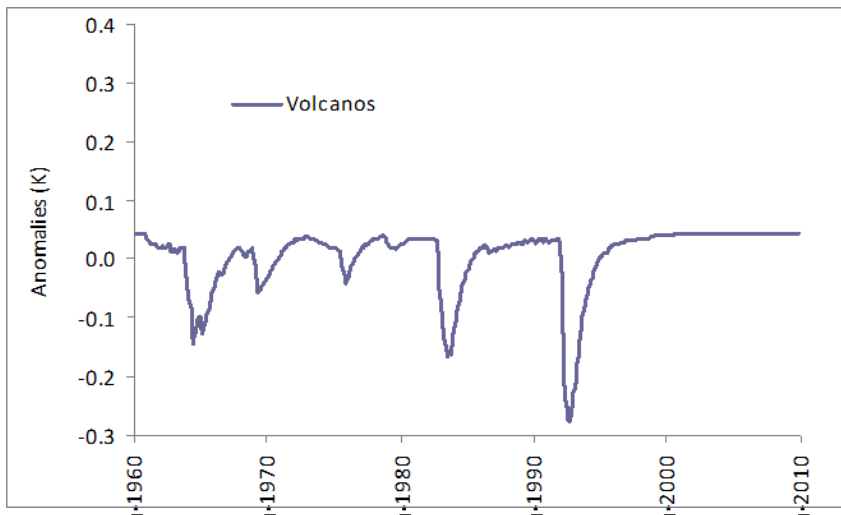
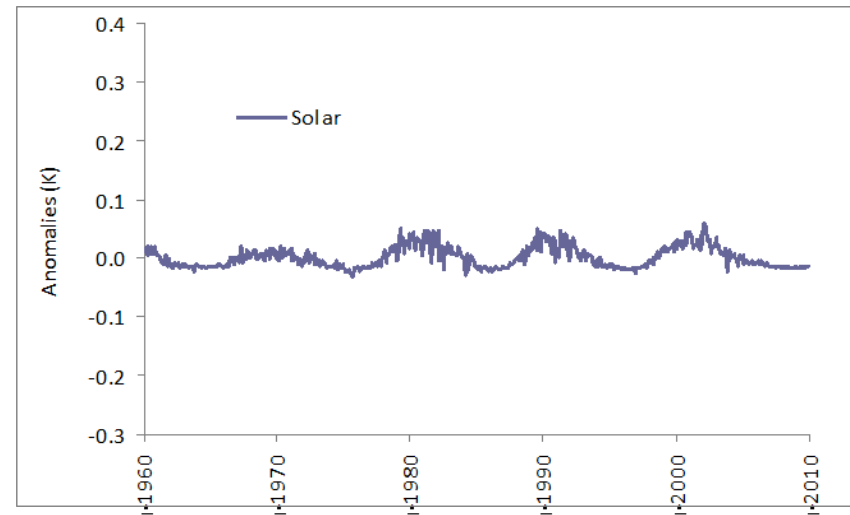
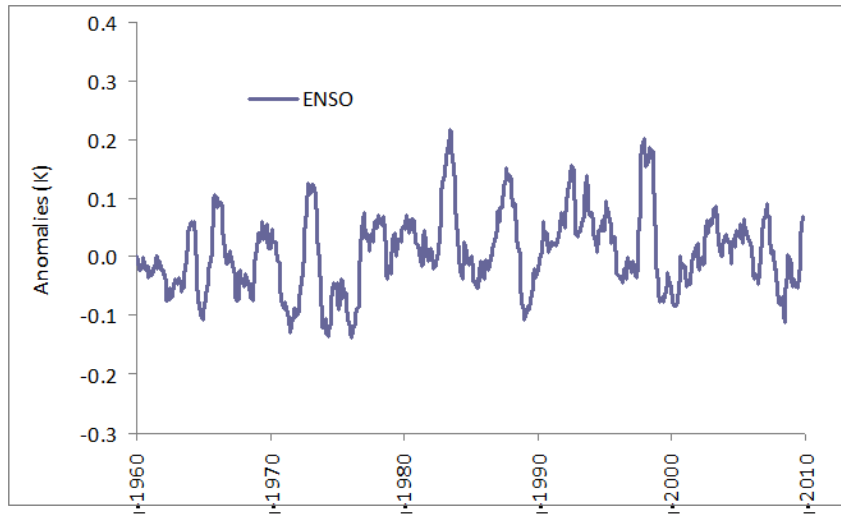


Global average T anomaly (monthly)



- $\Delta T = a + b_1.E + b_2.V + b_3.S + b_4.A$
(Lean & Rind, 2009)
- What happens if we analyse the global T anomaly in terms of the 4 'indices' (3 are forcings - volcanos, solar, anthropo - while ENSO is about internal climate system variability) using multiple regression

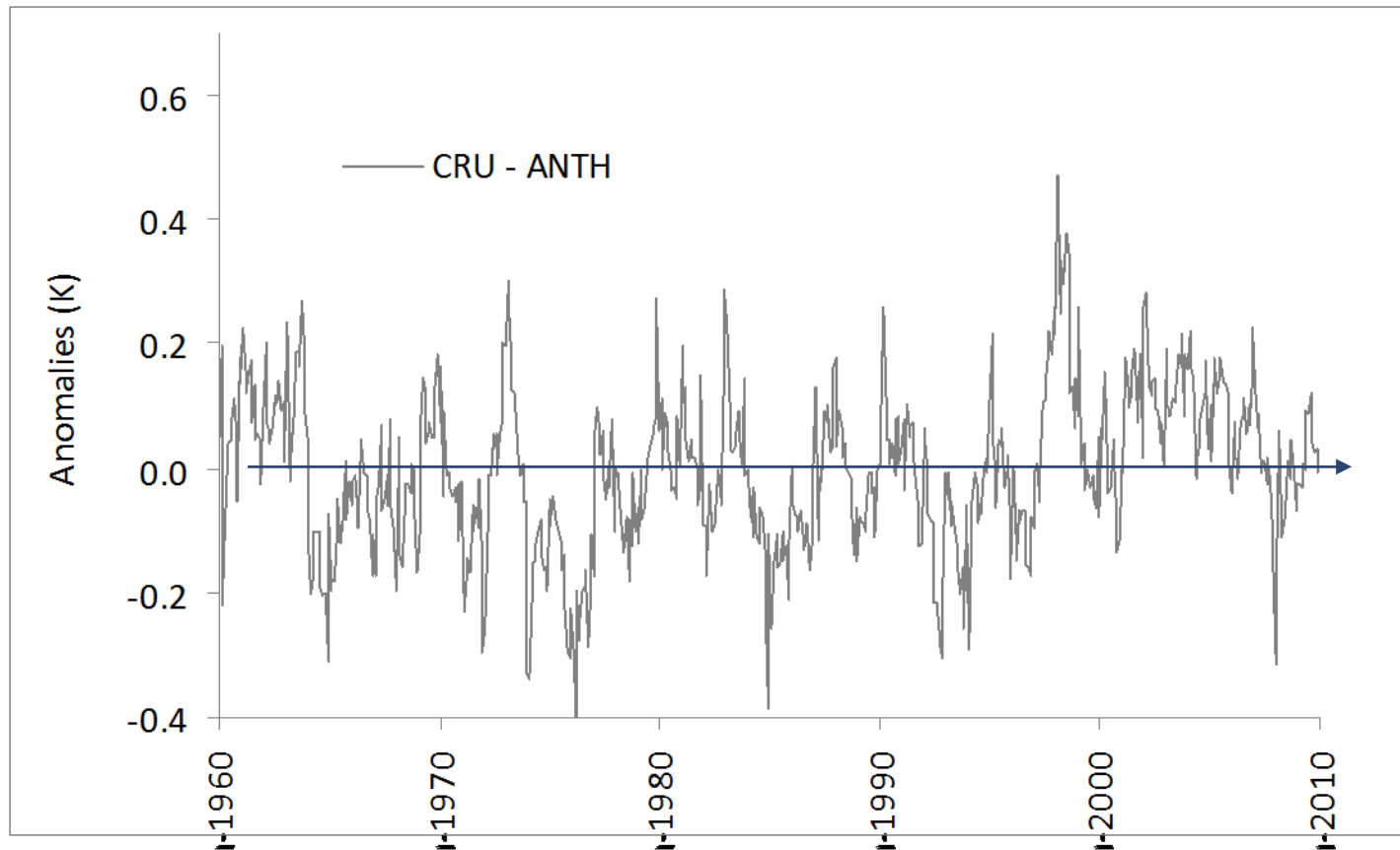
ΔT components – 83% of variance explained



- $\Delta T = a + b1.E + b2.V + b3.S + b4.A$
(Lean & Rind, 2009)



Now subtract ANTHR effect from observed global T



Conclusions

- **Climate observations** synthesised into global indices confirm that:
 - Variability and trend in global T anomalies can be very largely explained empirically by variations in indices representing three drivers of climate – GHGs, volcanos and solar irradiance – plus one measure of internal climate variability at global scale – ENSO
 - The only one of the four observationally-derived indices that explains the observed global temperature trend is nett anthropogenic (greenhouse gas) forcing

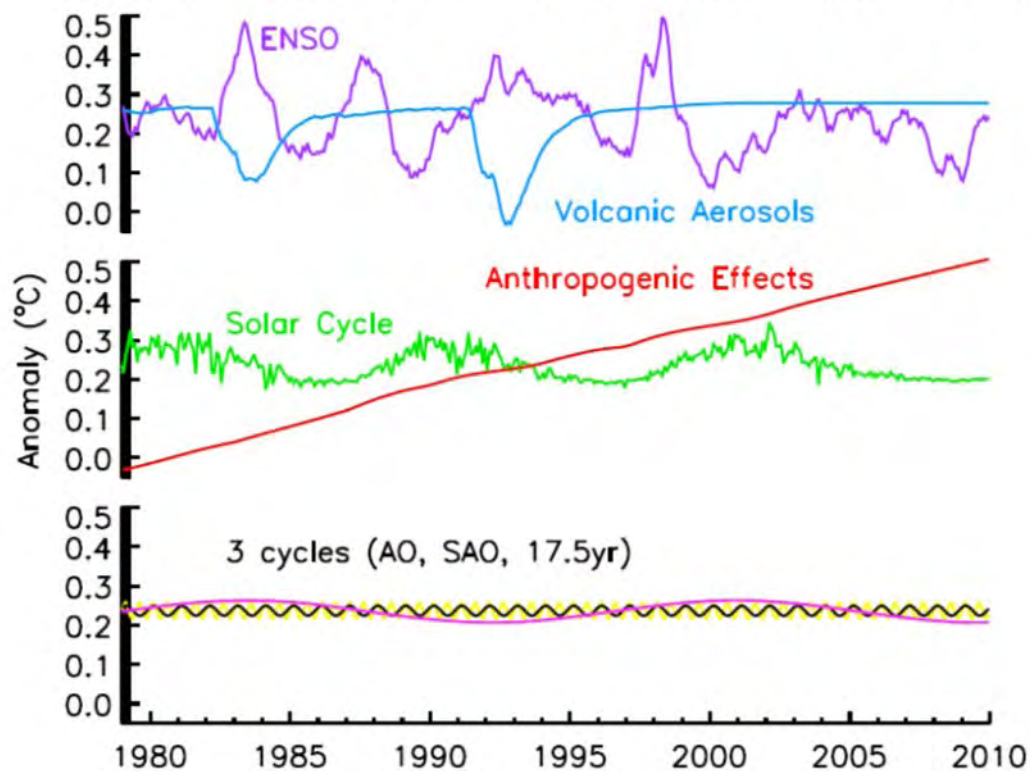
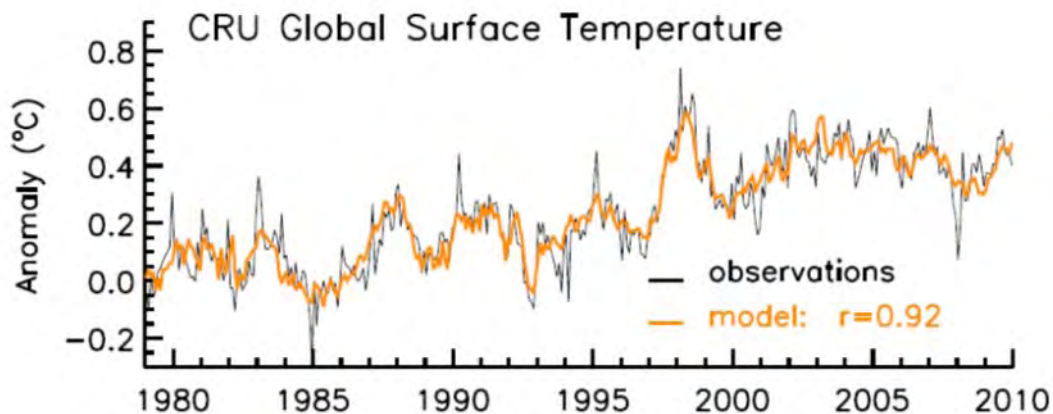


Can this approach be extended?

- Yes – in four ways
 - Improved fit using additional lagged time series of the same 4 indices (Judith Lean)
 - Application to other global T anomaly records, such as mid-troposphere and upper atmosphere (Judith lean)
 - Application to regional T anomaly records, such as for the Australian region
 - Application to global climate model output



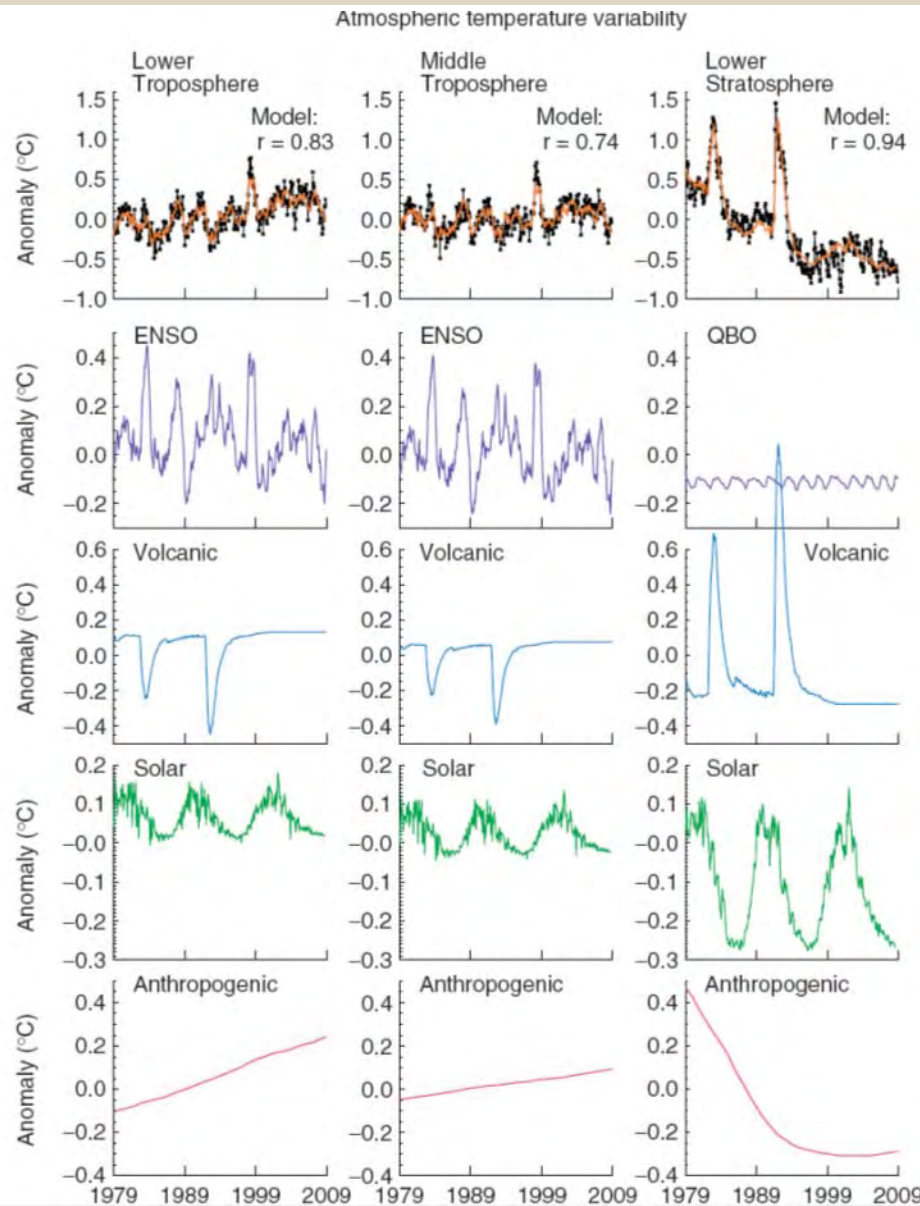
1. Improved fit



Kopp, G., and J. L. Lean (2011)
A new, lower value of total solar irradiance: Evidence and climate significance
Geophys. Res. Lett., 38, L01706,
doi:10.1029/2010GL045777.



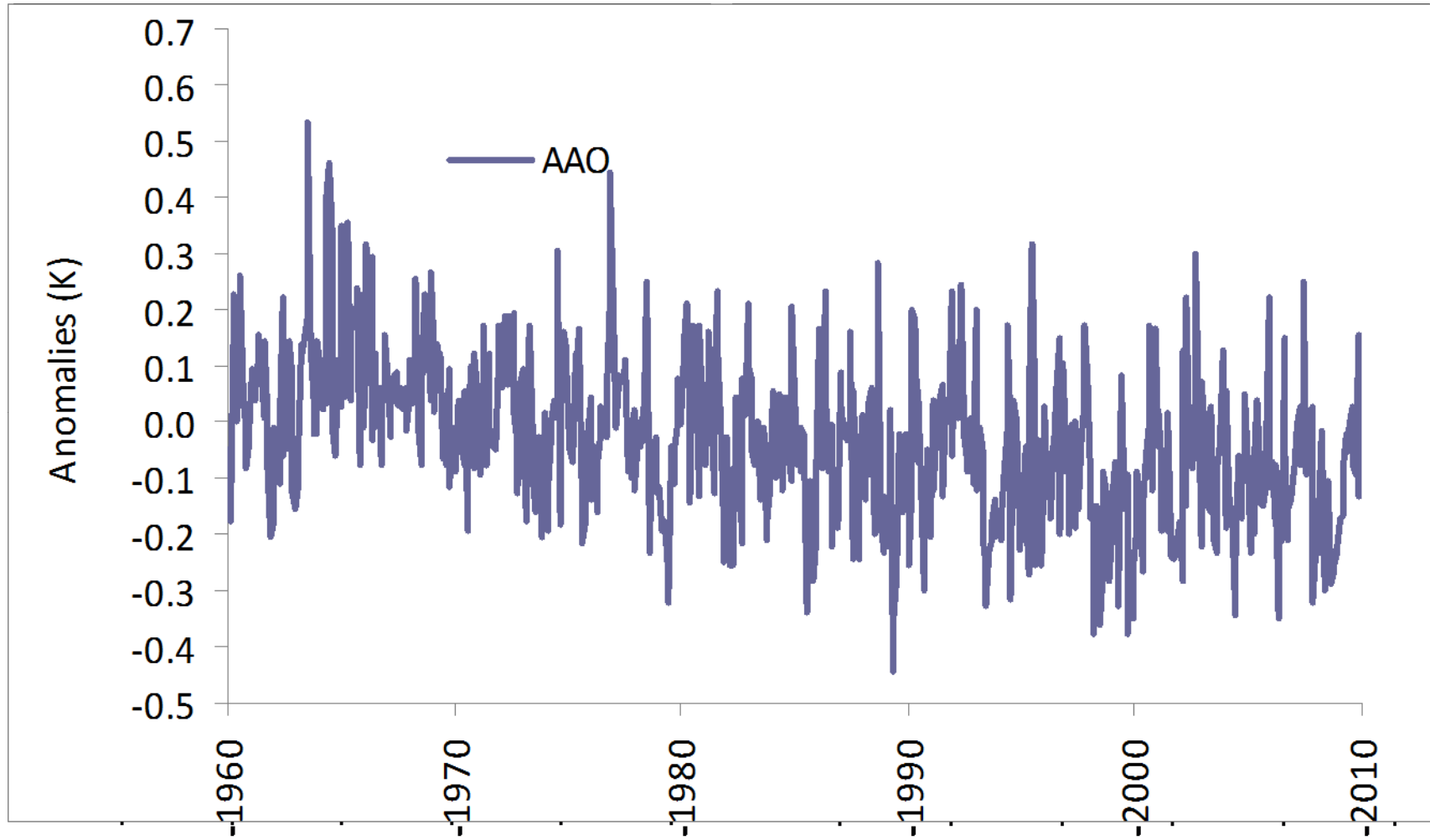
2. Application to other T records



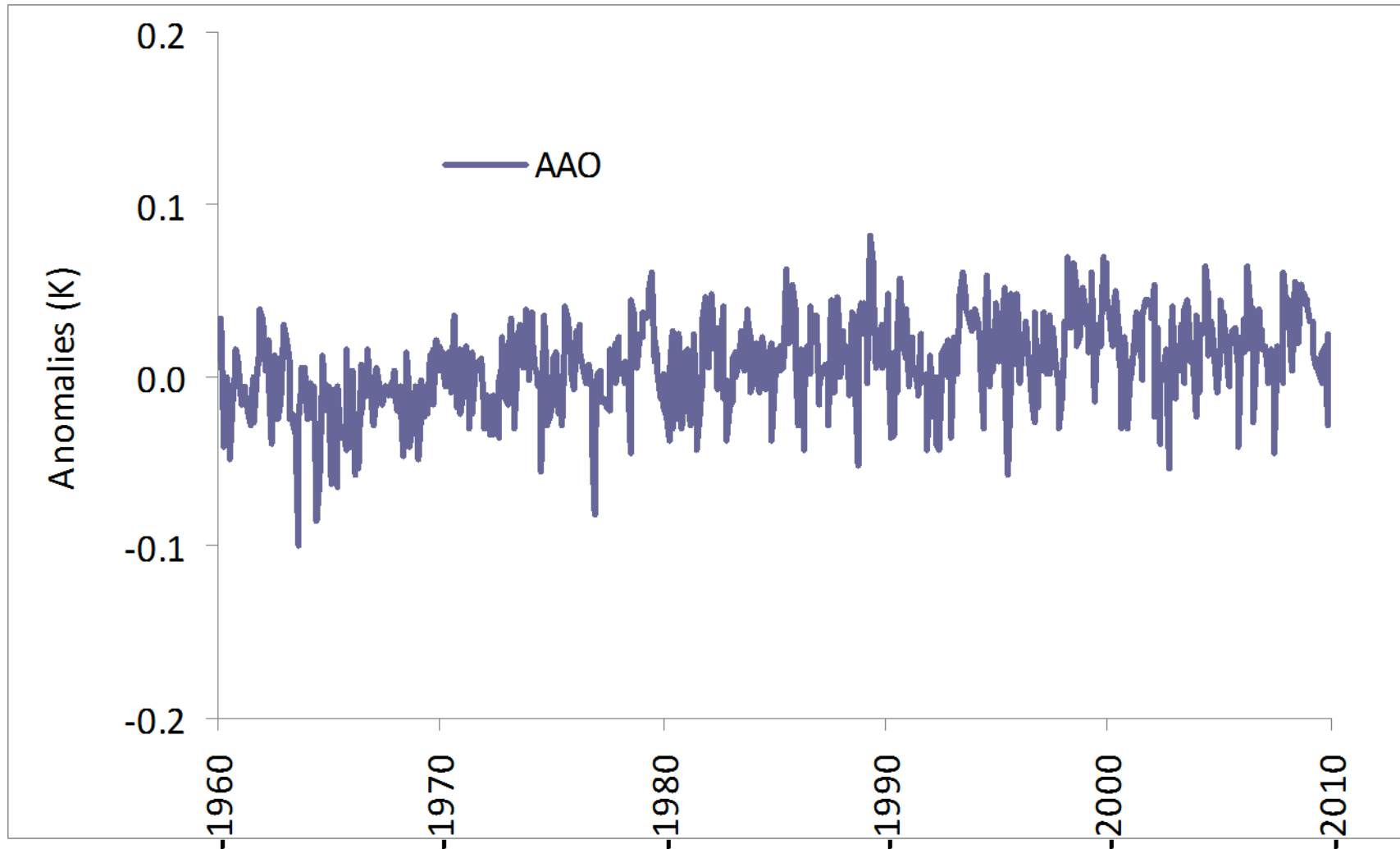
Judith L. Lean (2010)
Cycles and trends in solar irradiance and climate
Wiley Interdisciplinary Reviews: Climate Change
Volume 1, Issue 1, pages 111–122.



3a. Application to Australian land T records

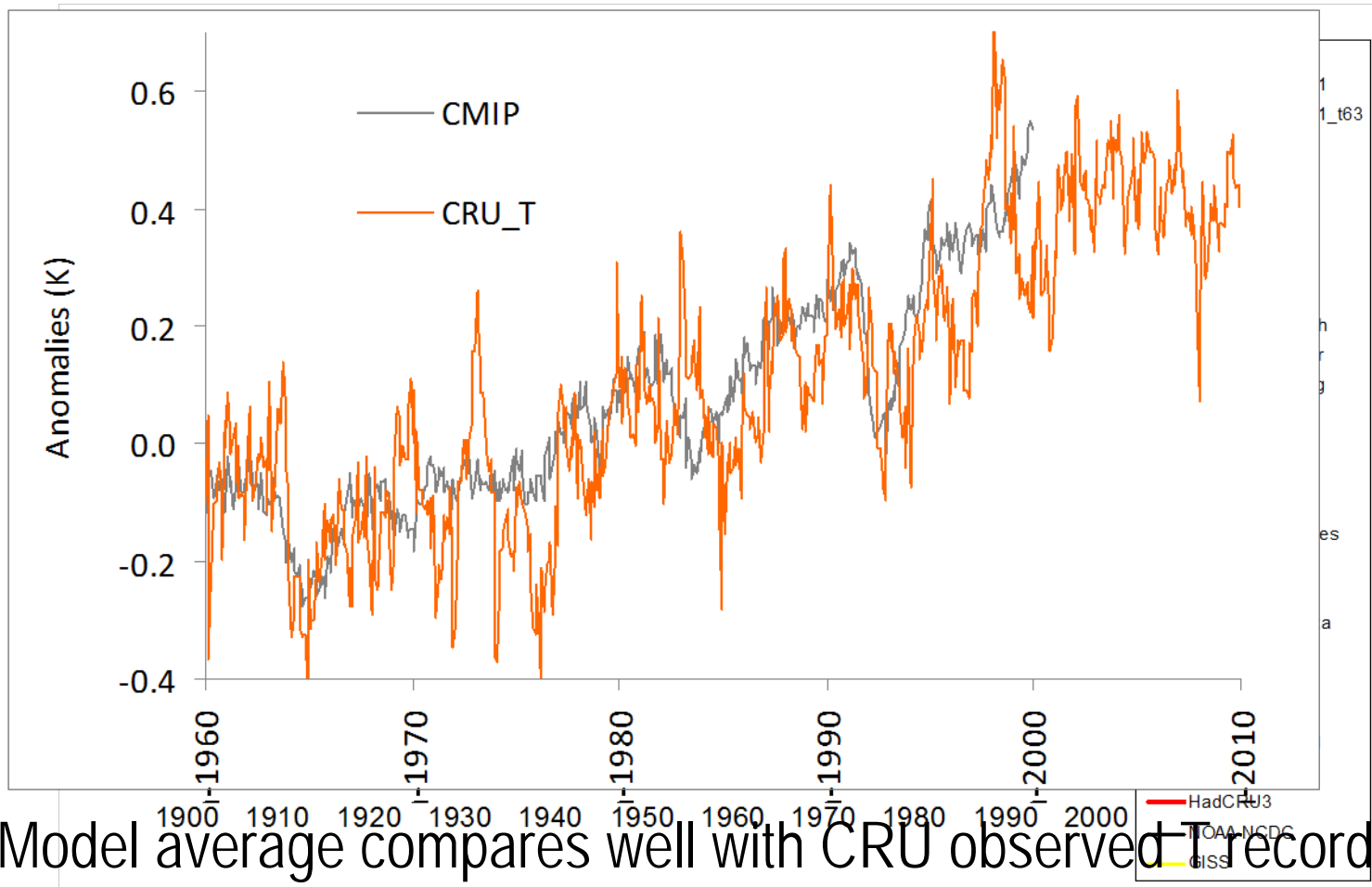


3b. Application to Australian SSTs

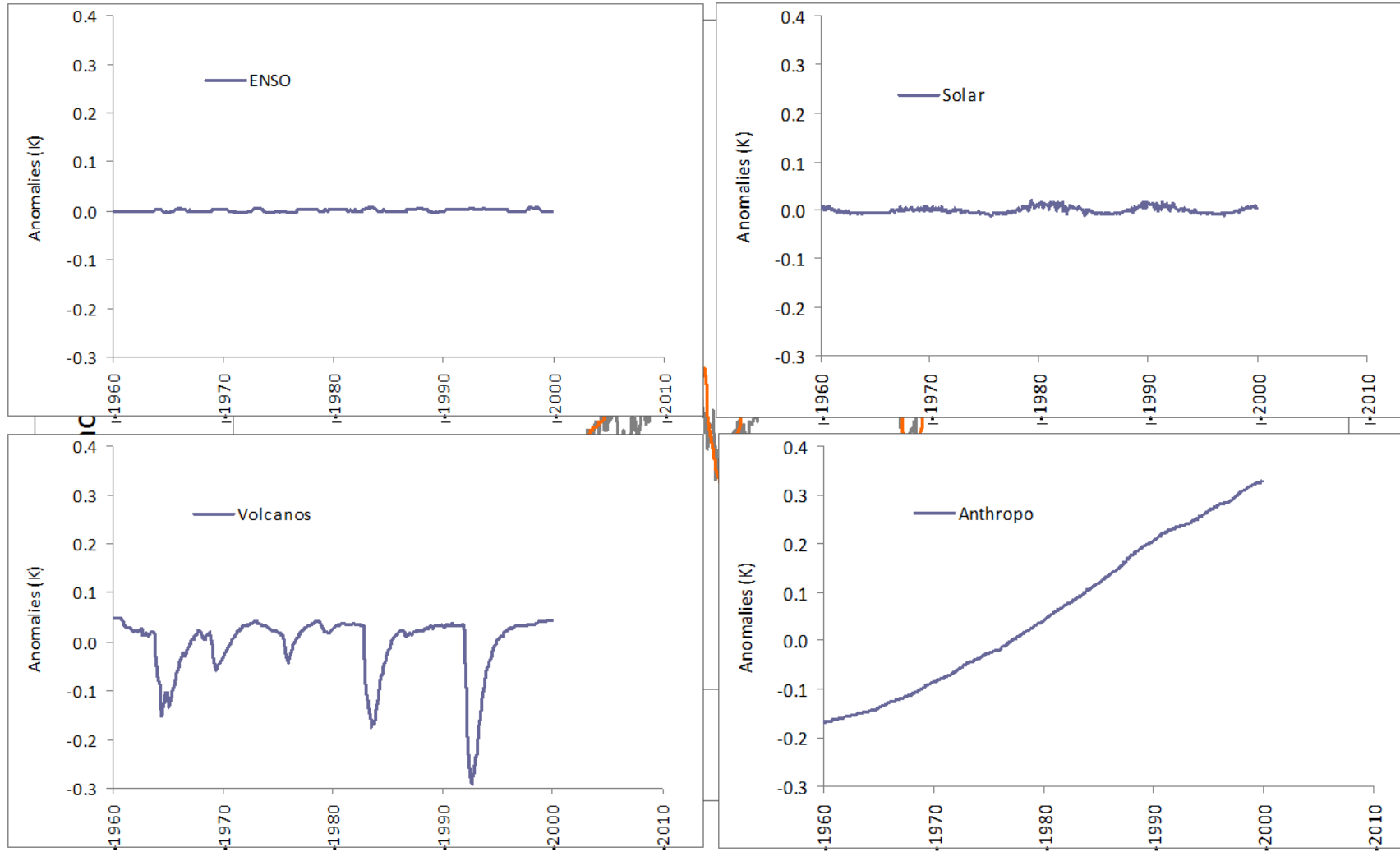


4. Application to climate model output

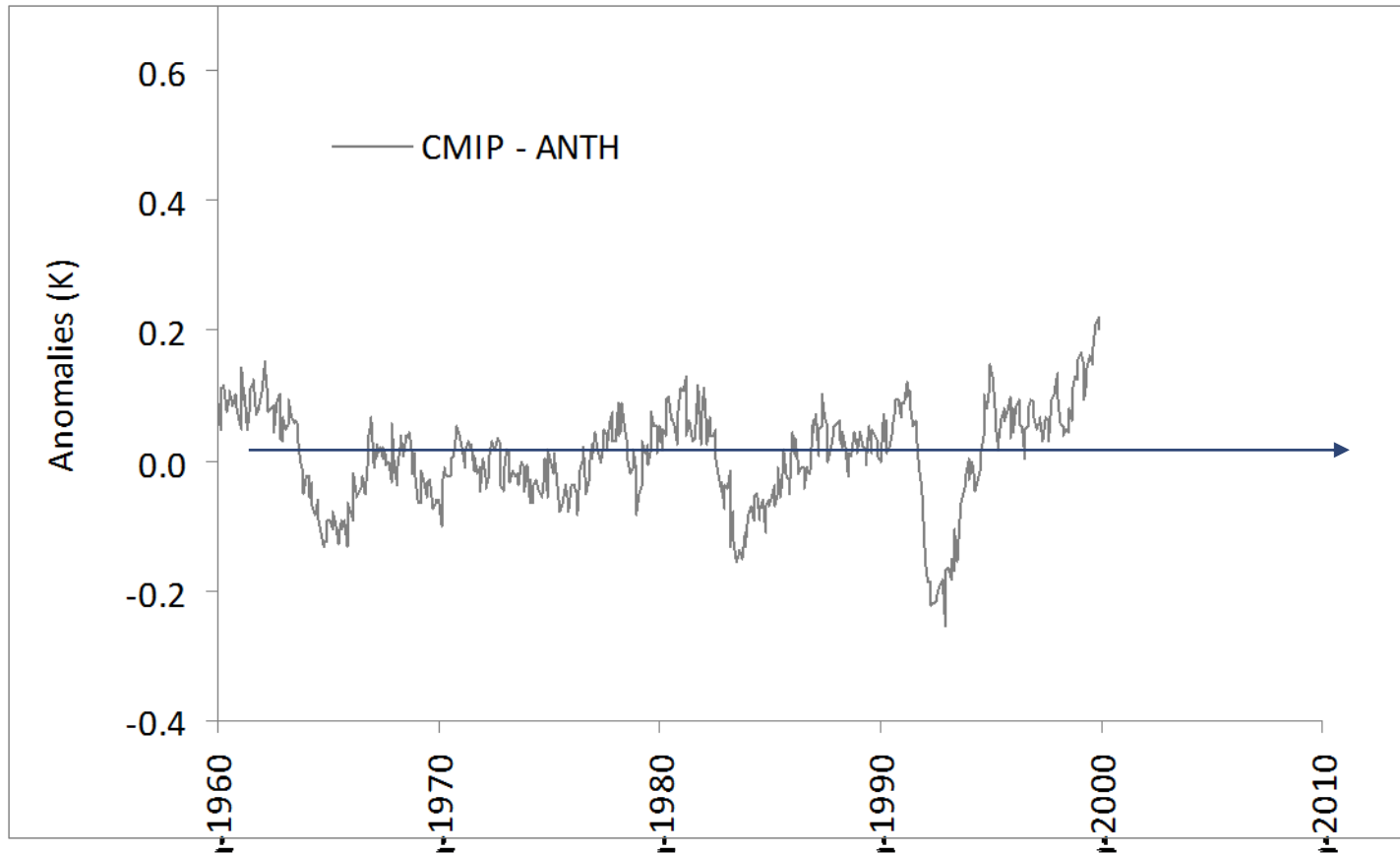
- CMIP3 20th century runs – runs started ~1860



4. (cont.) Multiple regression using indices

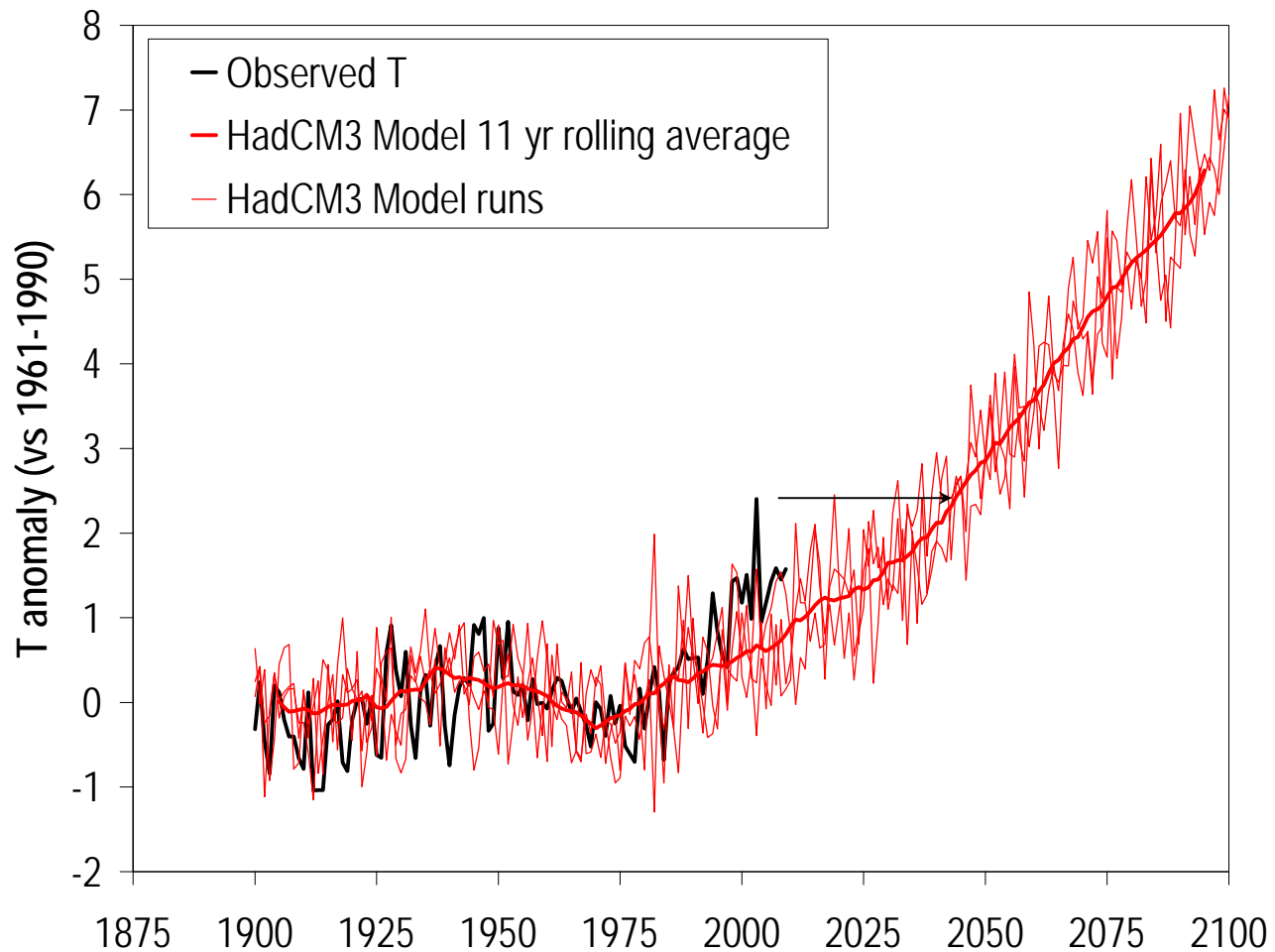


Now subtract ANTHR effect from CMIP global T



We do this to generate a benefit for society

Consider the European heatwave of 2003

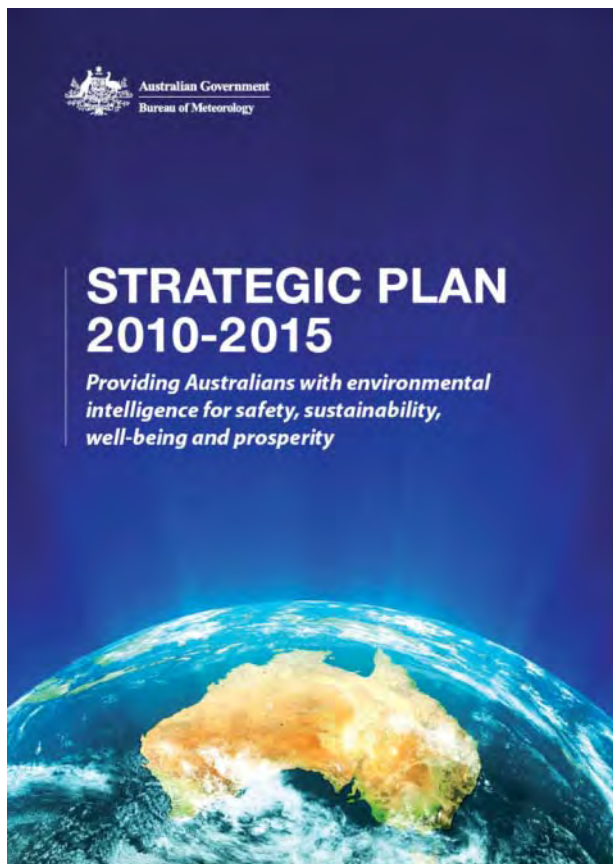


Source: UK Met Office



Conclusion: the foundation for climate science is to be found in climate observations

- observations
 - + climate systems science
 - + computer models
 - = societal benefit
- (environmental intelligence!)



- Example 1 – cyclone Yasi track forecasts
- Example 2 – observed 20th C global T anomalies
- Example 3 – observed upper air T anomalies
- Example 4 – Australian 20th C air and SST anomalies
- Example 5 – modelled 20th C global T anomalies
- Example 6 – European heatwave extremes