

# A Cloud Climatology for Western Australia

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# Issues

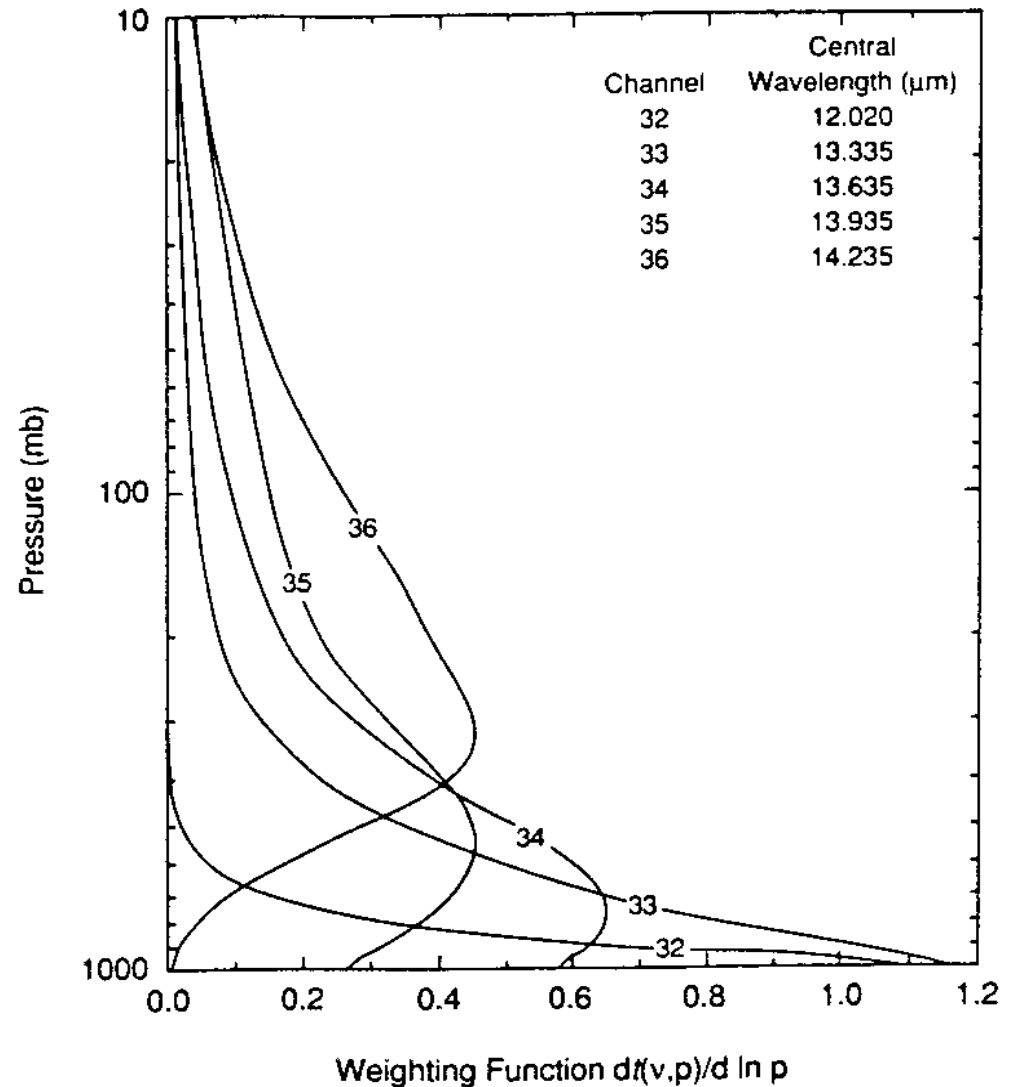
- What has happened over the last 20 years to cloud cover over WA and the globe?
- Do clouds and rainfall correlate over WA?
- Or do we have clouds but they just won't rain?

# High Resolution Infrared Radiometer Sounder (HIRS)

- Aboard NOAA polar orbiting satellites
- HIRS/2
- 23 year archive (1979 to 2001)
- CO<sub>2</sub> slicing method is used to retrieve cloud height and cloud amount (a.k.a. cloud effective emissivity)

# CO<sub>2</sub> slicing method

- Infra-red CO<sub>2</sub> channels between 13 μm and 15 μm detect radiation from different levels in the atmosphere.



# CO<sub>2</sub> slicing method

- The solution to a simplified radiative transfer equation using 2 spectrally close CO<sub>2</sub> channels and based on a single cloud layer assumption can determine cloud height.
  - High clouds (14.2μm/13.9μm)
  - Mid clouds (13.9μm/13.6μm)
  - Low clouds (13.6μm/13.3μm)
- Effective emissivity,  $N\varepsilon$ , can then be derived.  
( $\varepsilon$ , cloud emissivity;  $N$ , cloud fraction)
- Method is best suited for higher clouds < 700hPa. When cloud radiance signal < 5x instrument noise, 11μm channel used. Primarily low level clouds.

# HIRS data corrections

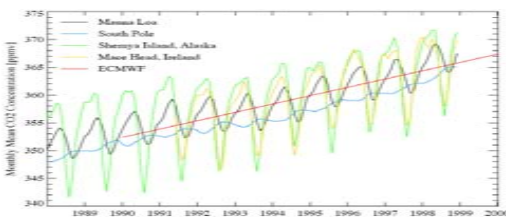
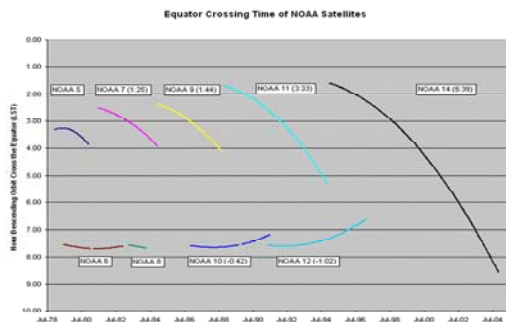
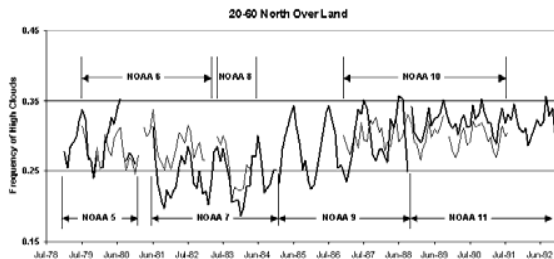


Figure 1. Time series of monthly mean surface CO<sub>2</sub> volume mixing ratios for 4 flask stations. The red line represents the values used by ECMWF.

- Anomalous satellite data or gaps and out of family instrument data
  - Only used HIRS/2, 2pm orbit data after 1985.
- Orbit drift
  - Corrected to 2pm equator crossing time
- CO<sub>2</sub> increase
  - Adjusted for increase from 345 ppmv in 1985 to 375 ppmv in 2001

# Global Results

# HIRS Global Summary\*

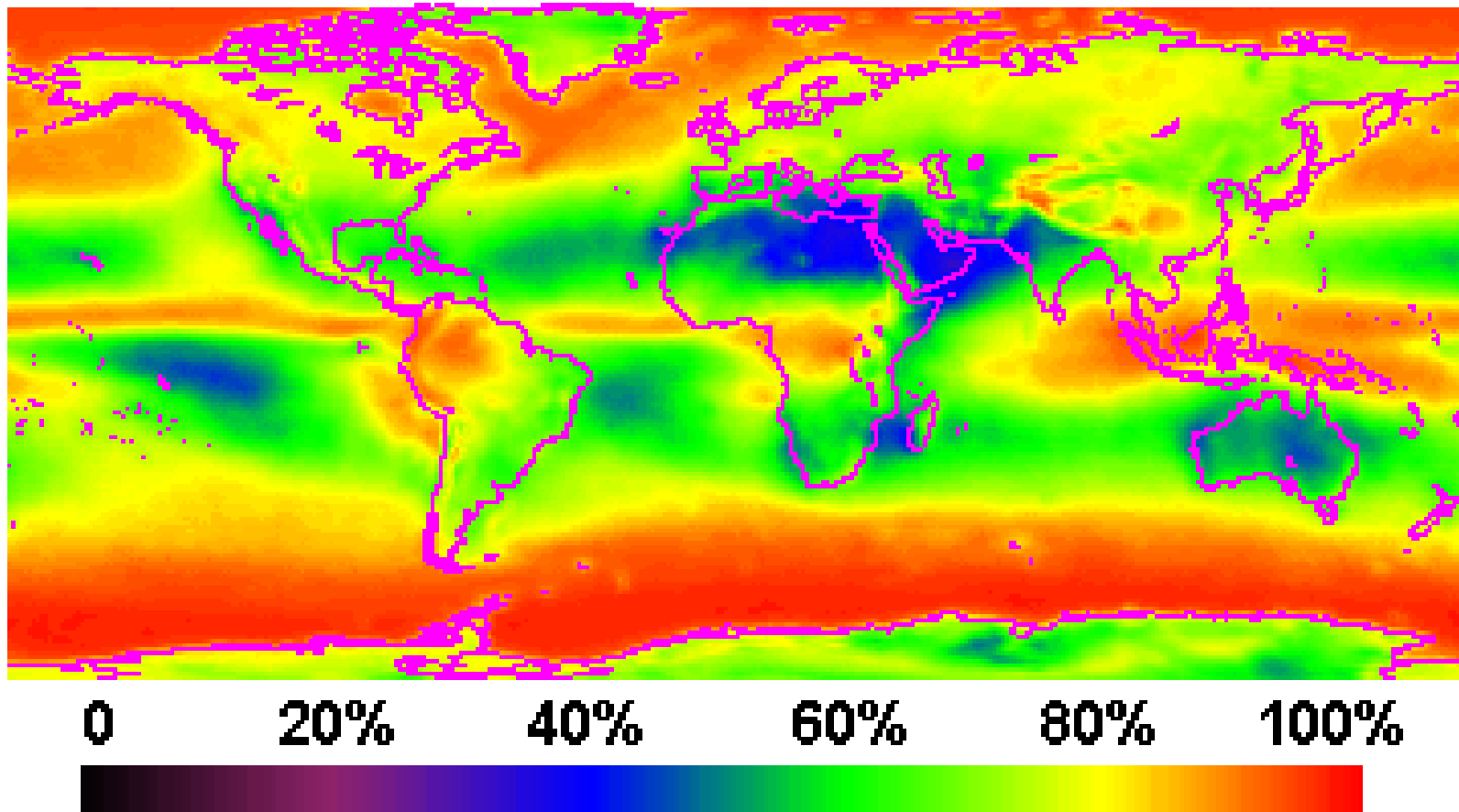
## (1979 to 2001)

	Thin ( $N_{\varepsilon} < 0.5$ )	Thick ( $0.5 < N_{\varepsilon} < 0.95$ )	Opaque ( $N_{\varepsilon} > 0.95$ )	All
High ( $< 440$ hPa)	15%	15%	3%	33%
Mid (440-700 hPa)	7%	10%	9%	26%
Low ( $> 700$ hPa)	-	2%	47%	49%
All	20%	23%	32%	75%

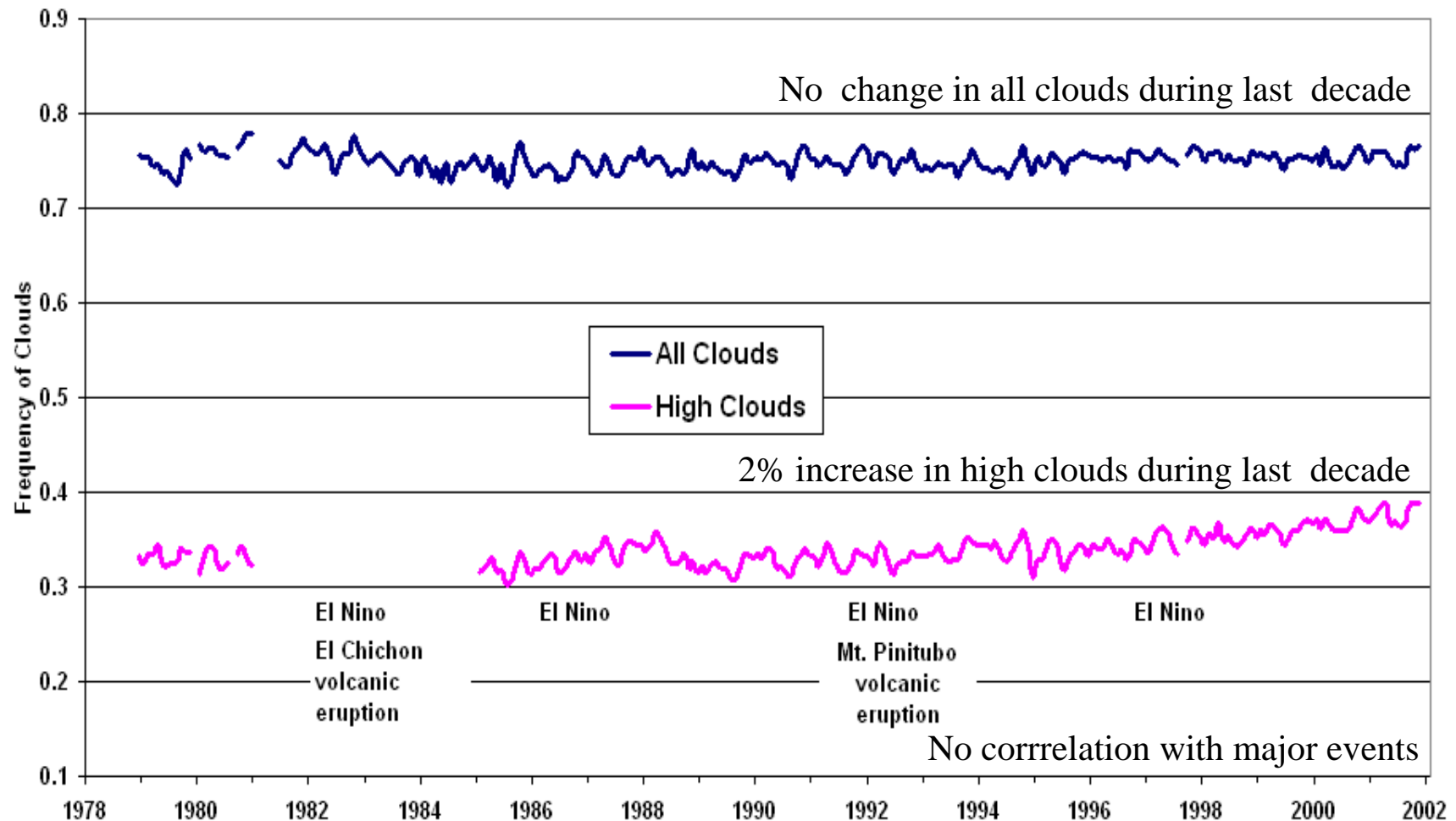
\* Using random overlap assumption

(Wylie et al, 2005)

Average frequency of all clouds found in HIRS data 1979-2001.

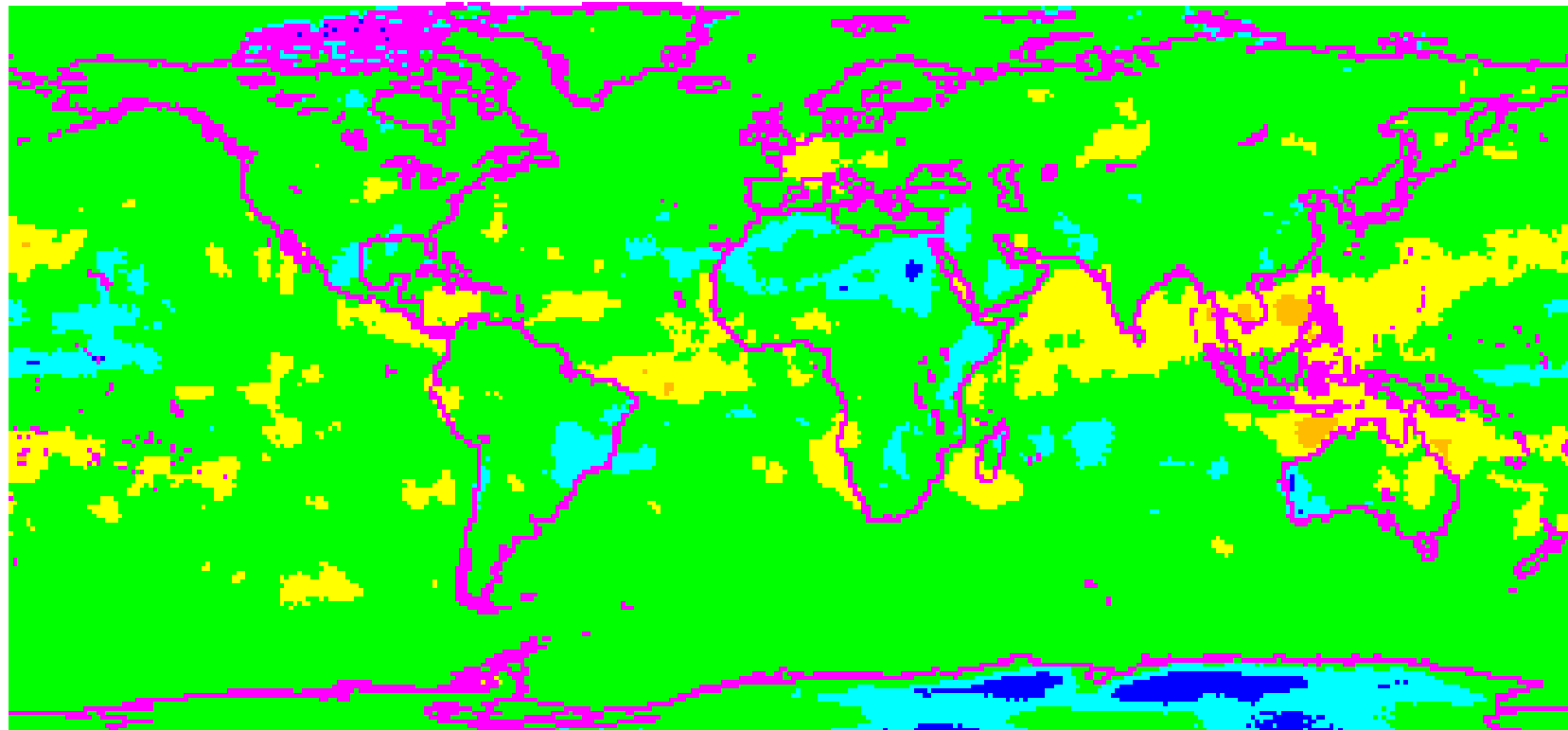


# HIRS near nadir (<25 deg) Cloud Observations since 1979



The monthly average frequency of clouds and high clouds (above 6 km) from 70 south to 70 north latitude from 1979 to 2002; Wylie et al (2005).

# Change in cloud frequency from the 1980s to the 1990s.



-10%   -5   -2   2   5   10%



# Western Australian Results

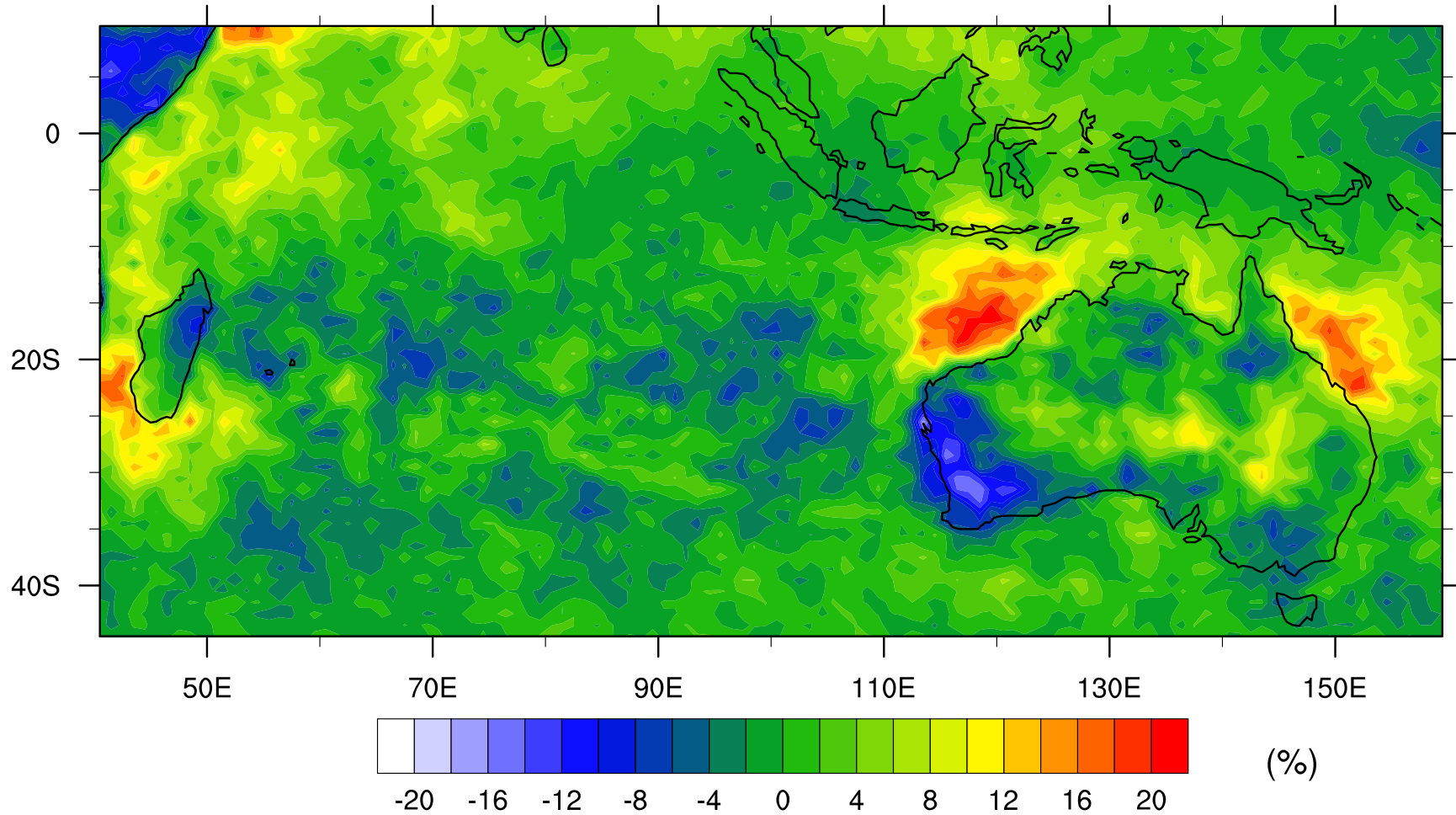
# HIRS WA Summary\* over land (1985 to 2001)

	Thin ( $N_{\varepsilon} < 0.5$ )	Thick ( $0.5 < N_{\varepsilon} < 0.95$ )	Pot. Rain ( $N_{\varepsilon} > 0.75$ )	All
High ( $< 440\text{hPa}$ )	10%	13%	8%	24%
Mid ( $440\text{-}700\text{hPa}$ )	4%	5%	5%	13%
Low ( $> 700\text{hPa}$ )	-	2%	35%	36%
All				<b>58%</b>

\* Using random overlap assumption

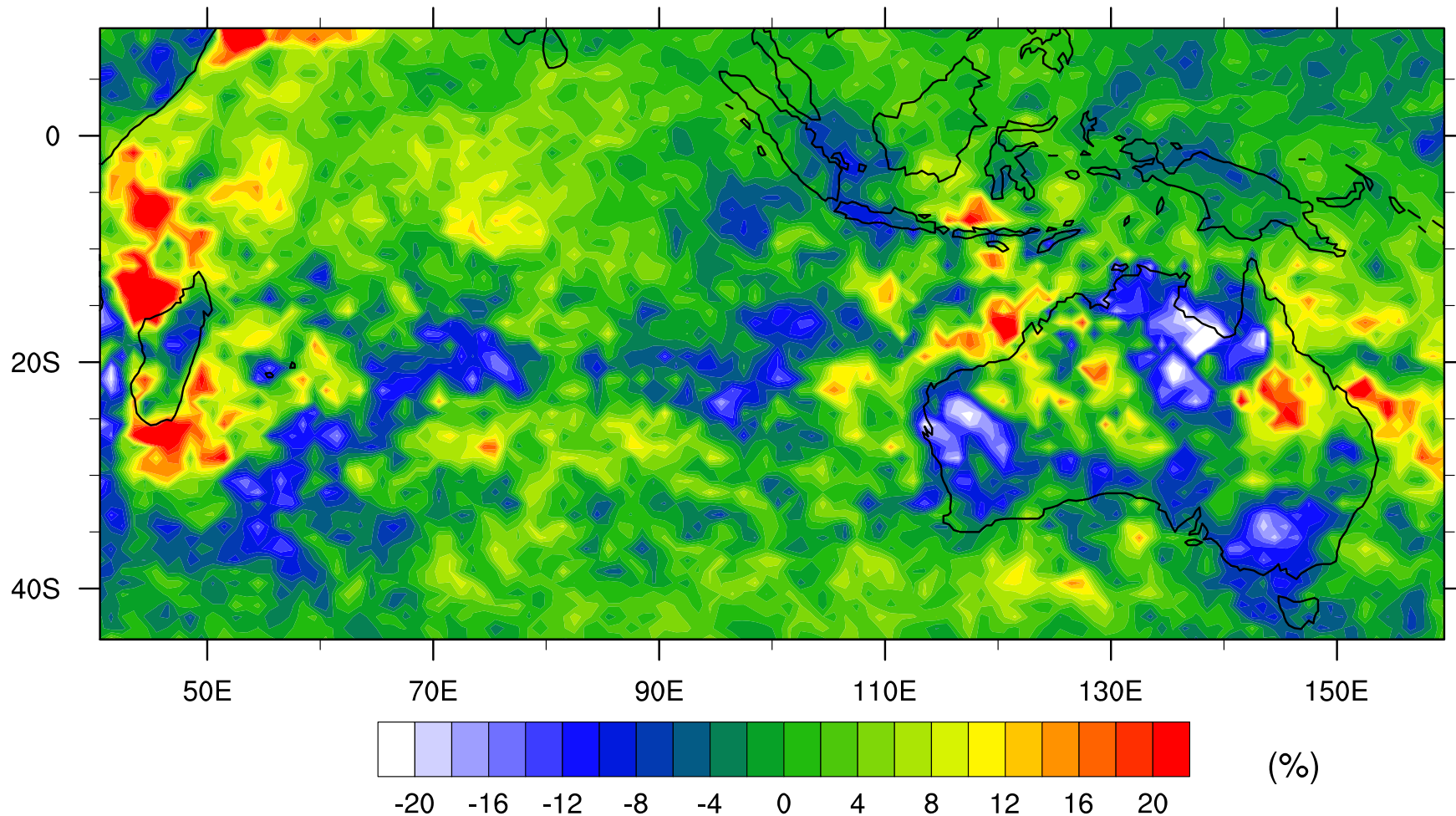
# Percentage change (1994 to 2001) – (1985 to 1992)

Cloud Frequency Percentage Difference, All Cloud



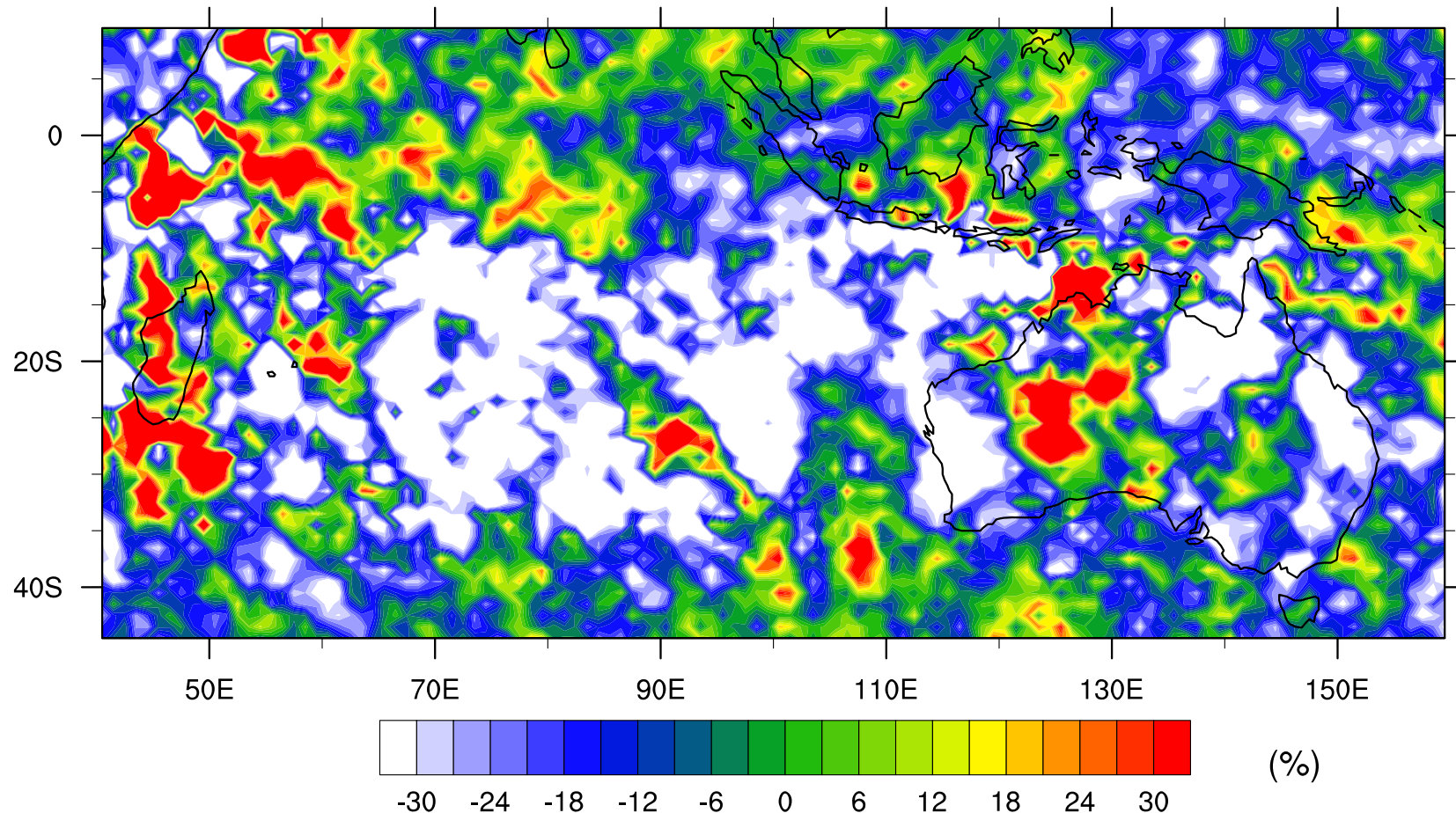
# Percentage change for Winter (1994 to 2001) – (1985 to 1992)

Winter Cloud Frequency Percentage Difference, All Cloud



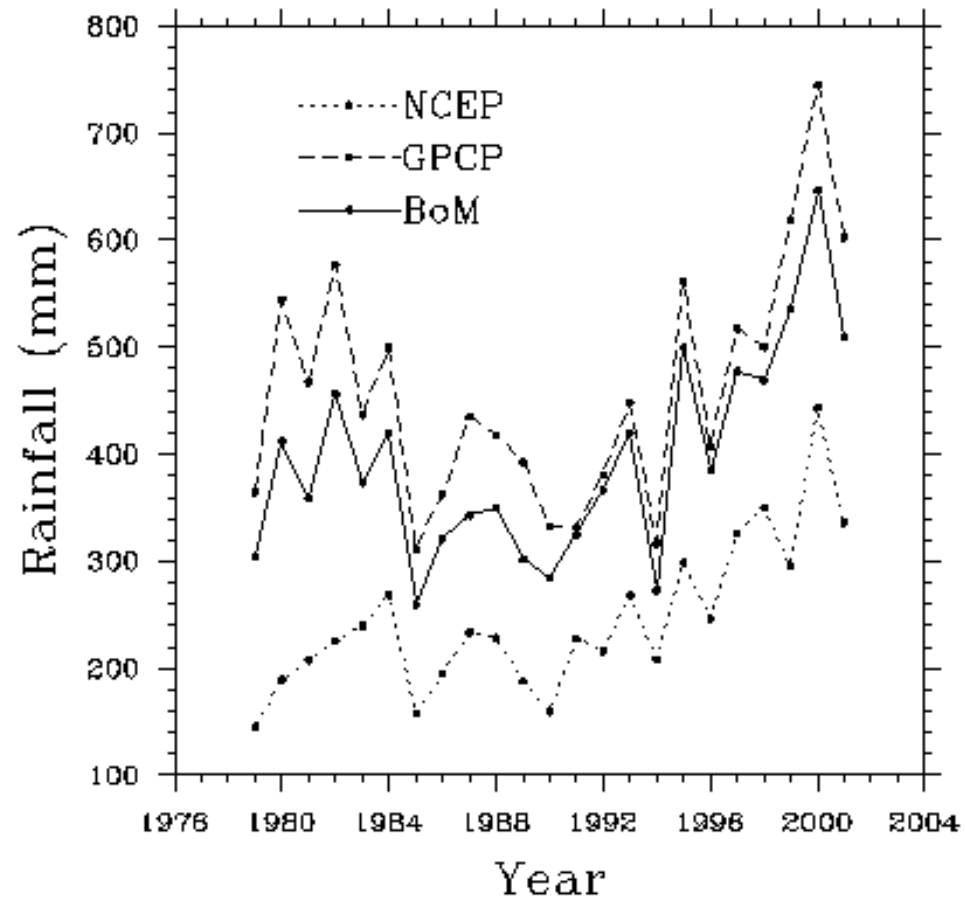
# Percentage change for Winter (1994 to 2001) – (1985 to 1992) (CTP < 700hPa, $\varepsilon > 0.75$ )

Winter Cloud Frequency Percentage Difference, CTP < 700hPa,  $\varepsilon > 0.75$

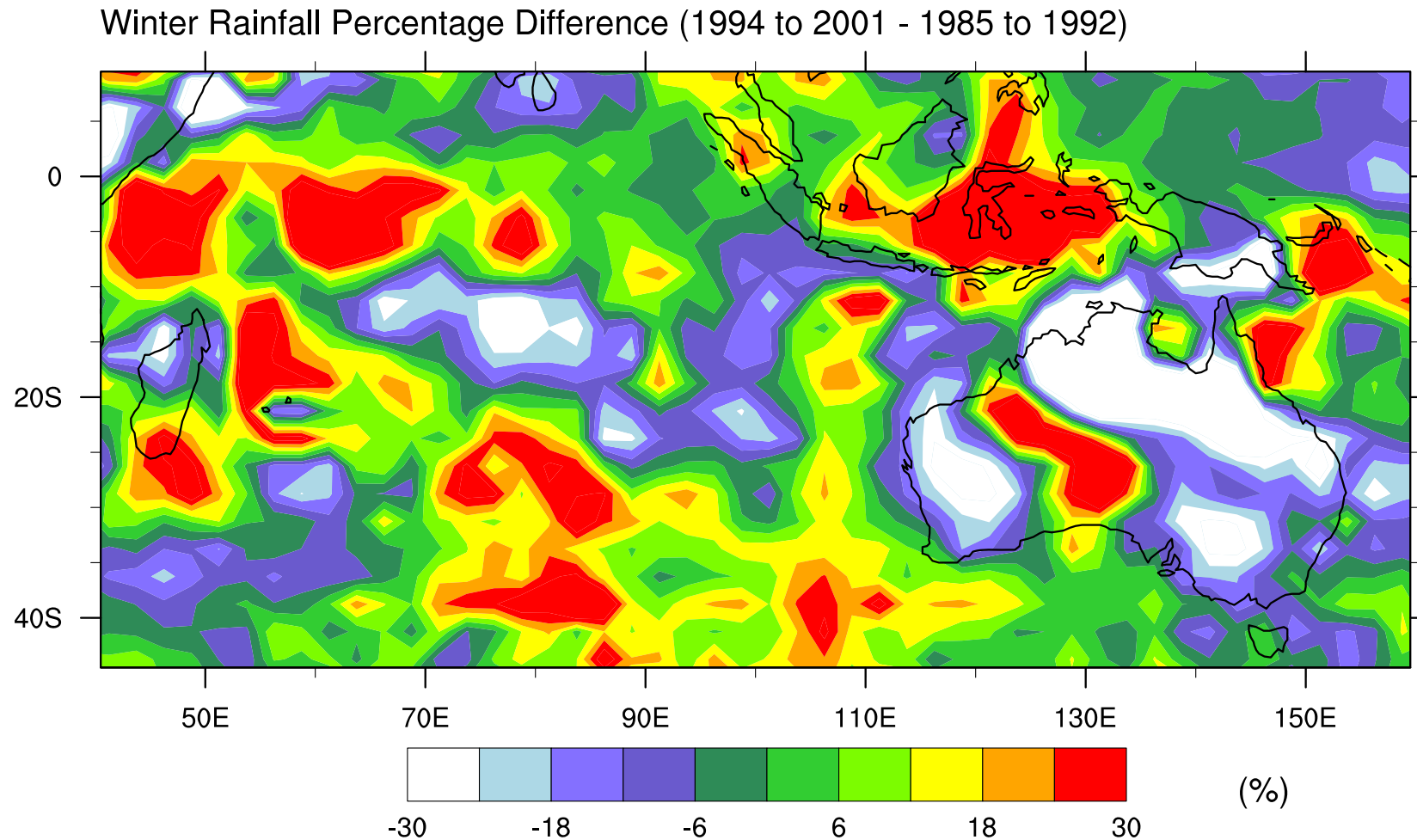


# Rainfall comparison

WESTERN AUSTRALIAN ANNUAL RAINFALL

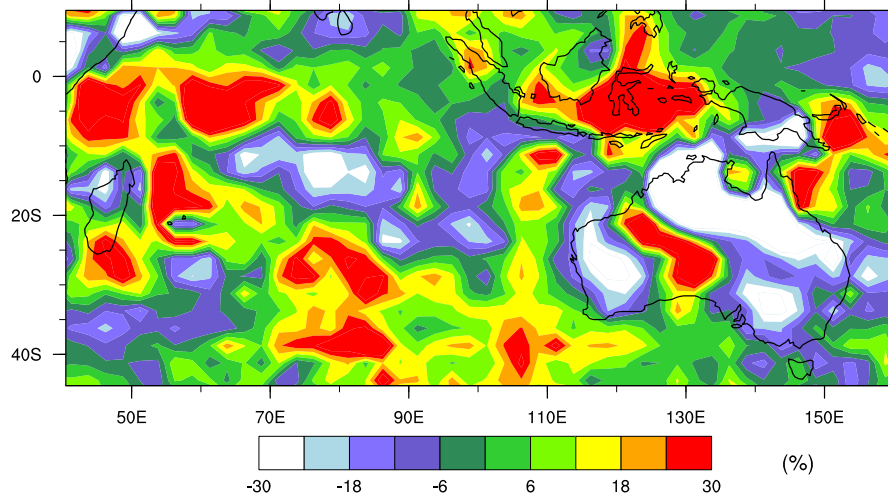


# Percentage change of GPCP Winter rainfall (1994 to 2001) – (1985 to 1992)

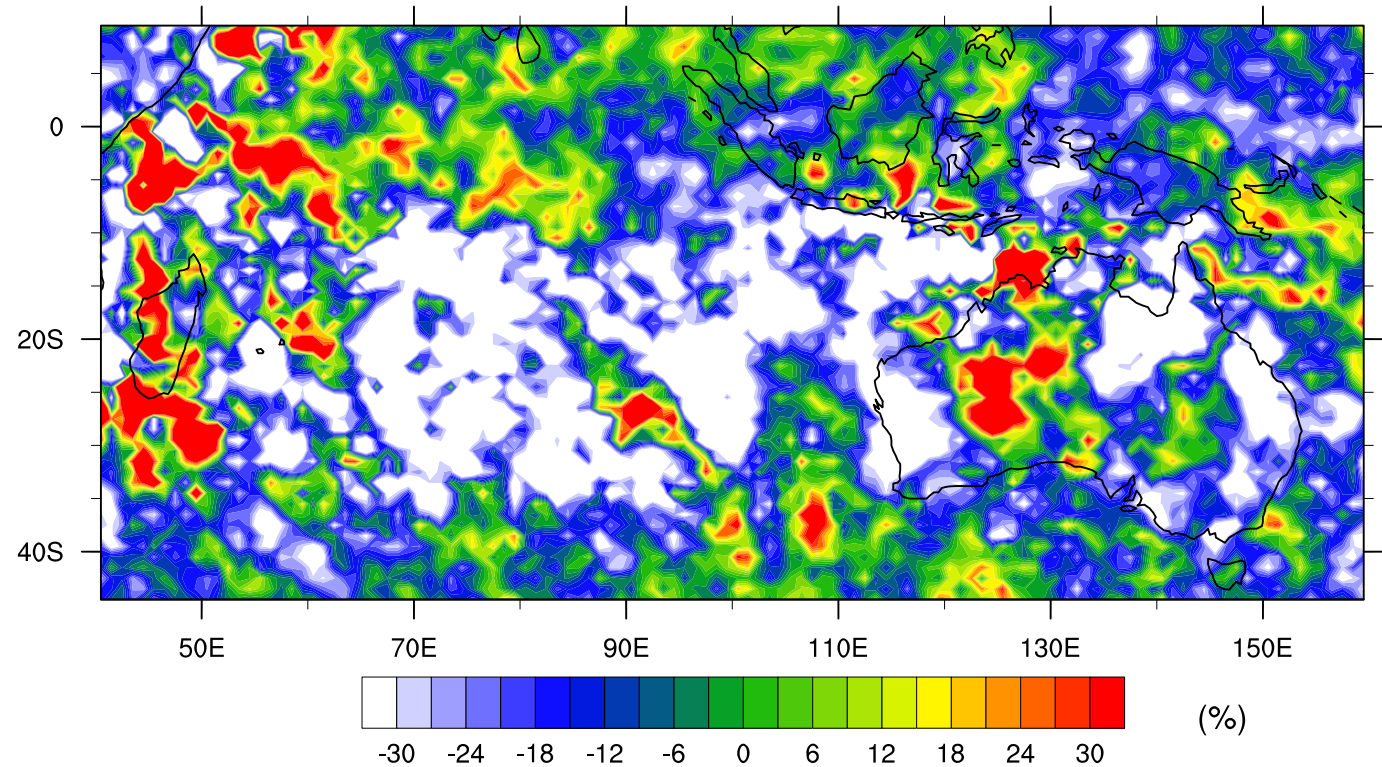


# Comparison between Winter clouds and rainfall

Winter Rainfall Percentage Difference (1994 to 2001 - 1985 to 1992)



Winter Cloud Frequency Percentage Difference, CTP < 700hPa,  $\epsilon > 0.75$



# Future Work

- HIRS has provided an initial testing ground for developing a relationship between cloud properties over WA and rainfall.
- Scientific advancement with the MODIS instrument has allowed for new cloud products (i.e. Cloud Effective Radius, Cloud Optical Depth, Cloud Phase)
- Using both L2 and L3 MODIS products, further investigation is planned of precipitating cloud systems passing over WA.

