

INDICATION OF SOLAR SIGNAL IN INDIAN OCEAN DIPOLE (IOD) PHENOMENA OVER INDONESIA



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BACKGROUND

The geographic position of Indonesian archipelago is at equator and also between two continents and two oceans.

There are some (ocean-atmosphere) phenomena that contribute to affect this region, such as:

- El Nino Southern Oscillation (ENSO) in Pacific Ocean
- Indian Ocean Dipole (IOD) Mode in Indian Ocean

that can cause severe flood and drought in some Indonesian region

ENSO phenomena makes dry season in Indonesia longer (especially in eastern Indonesia) than usual that cause severe drought.

Meanwhile IOD, the interaction of ocean-atmosphere in tropical Indian Ocean is believed to cause some severe drought in western Indonesia.

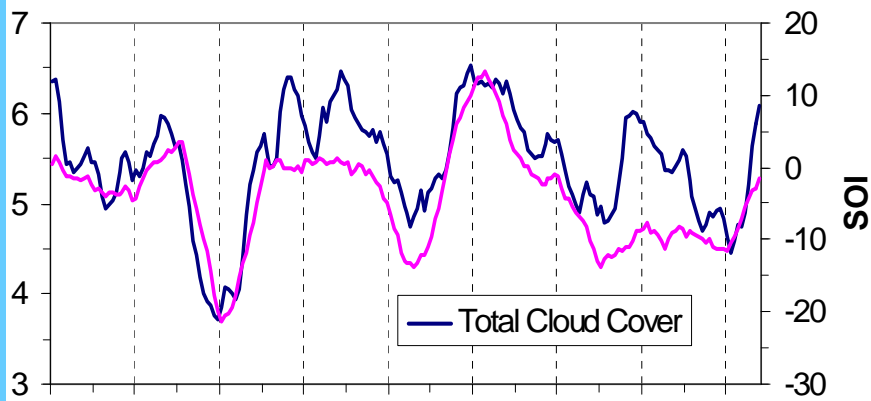
The climate characteristic in any region in Indonesia is not the same.
Three climate patterns that usually used in climate analysis:

- Monsoon pattern,
- Equatorial pattern, and
- Local pattern

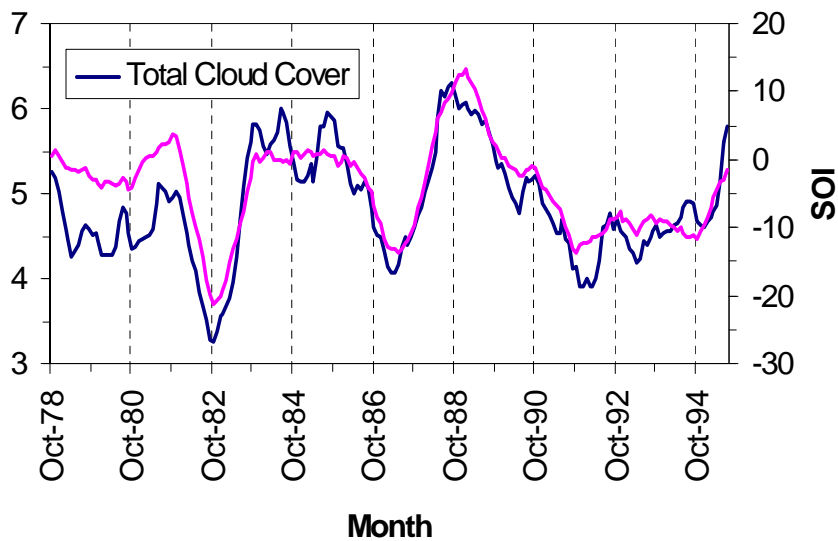
According to Saji et. al, ENSO (as a regional factor), explains about 30% of the total variation of anomalous Indian Ocean SSTs, while the dipole mode 12%

This is suggest that there should be another factor that takes part in influencing climate's variability.

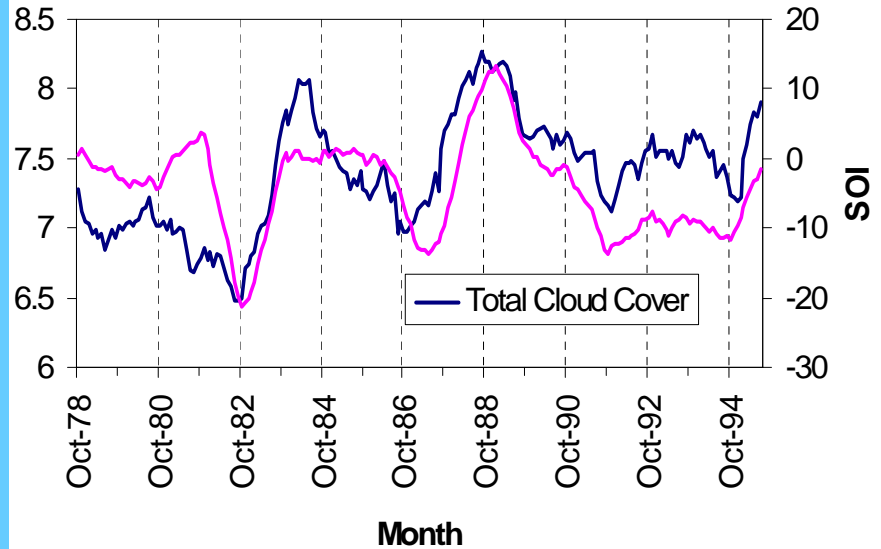
Pola Monsun R=0.8



Pola Lokal R=0.85

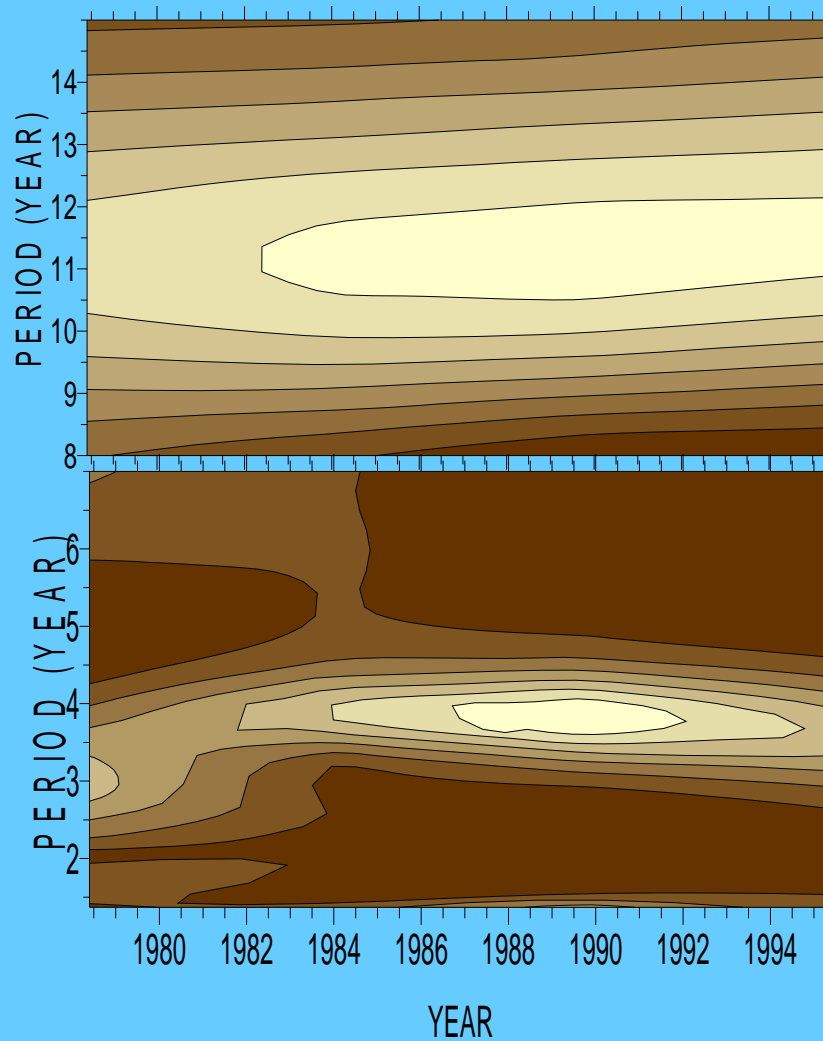


Pola Ekuator R=0.49



Correlation total cloud cover over Indonesia based on their climatic pattern and Southern Oscillation Index (SOI) as ENSO indicator for monsoon, equatorial and local pattern

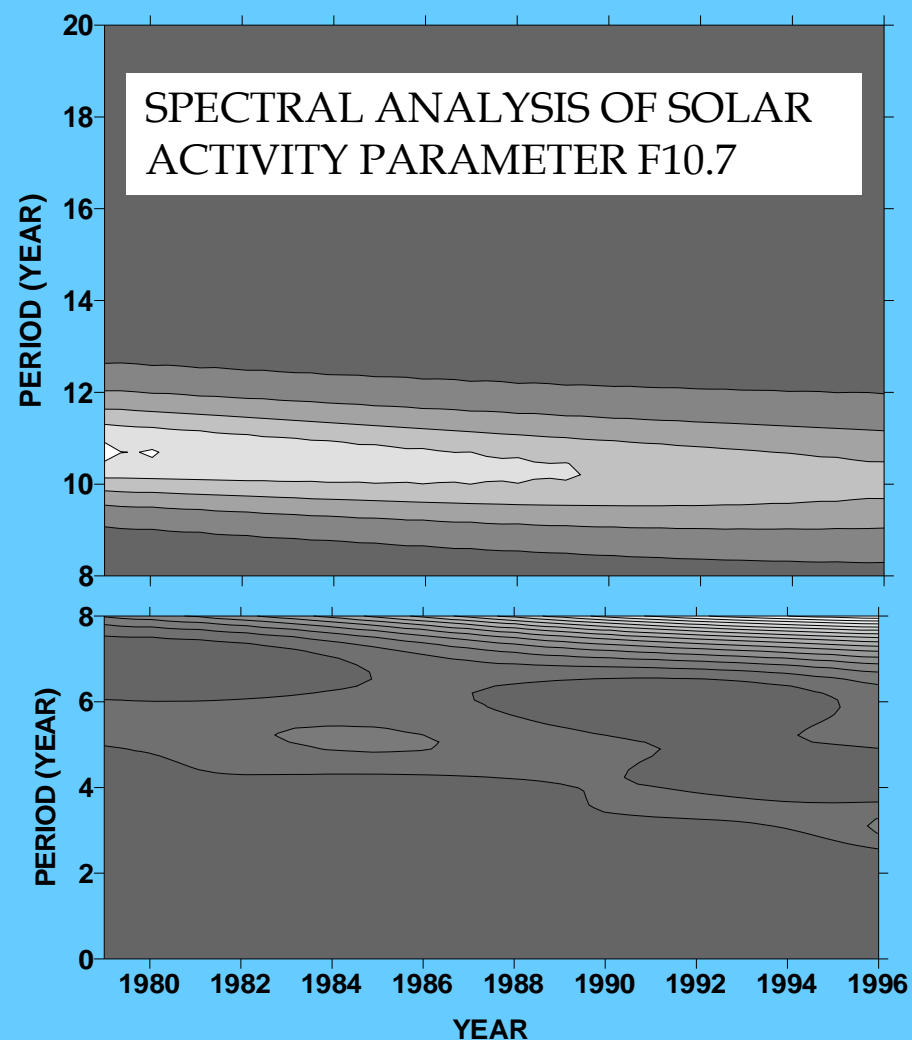
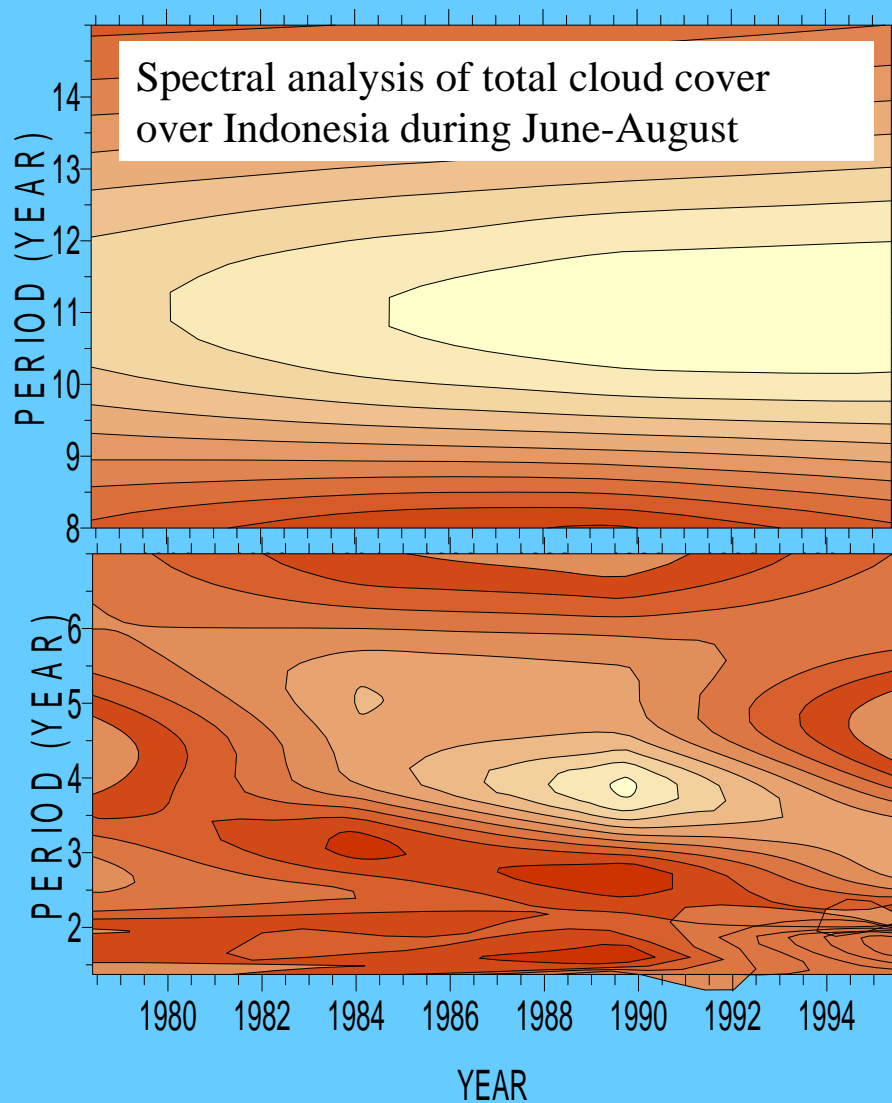
Previous Study



The appearance of solar signal and regional signal (ENSO) on cloud cover over Indonesia with monsoon pattern during dry season (June-August) by using spectral analysis method

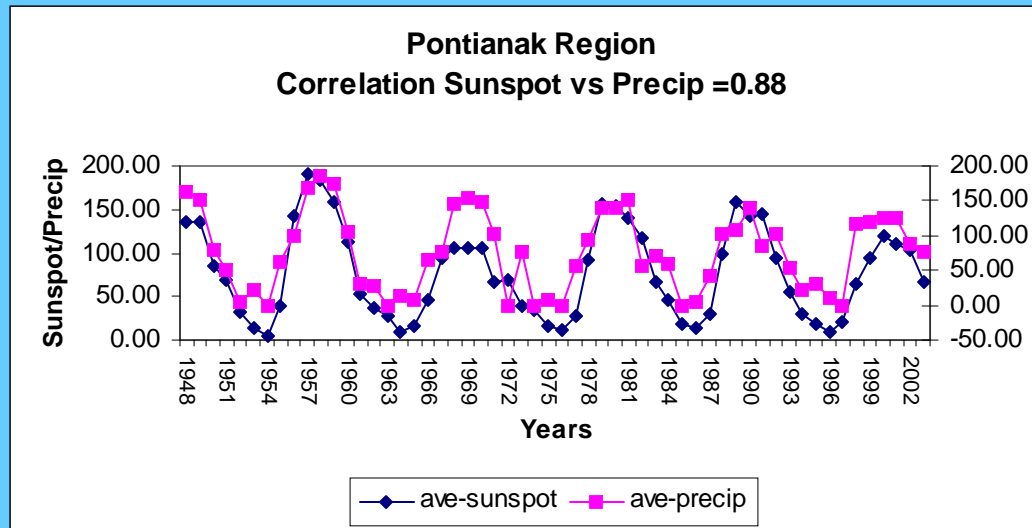
Periodicity about 11 year indicated as solar signal.

Periodicity about 6 down to 3 year indicated as climatic signal



ENSO signals with the period of about 6 years down to 3 similar with the period evolution of solar activity parameter F10.7. (It seems the ENSO also is affected by solar activity) (Djamaluddin, 2003)

The region which represent middle Indonesian Maritime Continent, the average of monthly precipitation is seemingly affected by sunspot cycles.



Average monthly precipitations in a year vs. sunspot numbers in Pontianak, West Kalimantan Indonesia region (equatorial pattern). The sunspot numbers cycle is similar to precipitation cycle (The H. L, 2006).

The clustering method shows that the west Indonesian regions are mainly influenced by IOD cycle, the east Indonesian regions are mainly influenced by ENSO cycle and the middle regions are mainly influenced by sunspot numbers cycle

(The H.L, 2006)

Although there are some empirical evidence about solar effect on climate, actually the physical mechanism has not well known yet.

The cosmic rays interact in the upper atmosphere and produce secondary particles. When the neutrons or the muons interact with the air molecules or water molecules, they become charged and act as condensation nuclei for the formation of clouds.

During the sunspot minimum, the intensity of the cosmic ray becomes maximum which in turn increase the coverage of clouds. This implies that solar radiation reaching the earth will be minimized.

Conversely, during sunspot maximum, the intensity of cosmic ray reaching lower levels of the atmosphere reduces, the cloud cover decreases, furthermore extra energy received from flares during prominence eruptions, maximizes the amount of solar energy received on earth.

Therefore, Indonesia through the equator crosses, a number of large clouds will form and it can influence the heat source distribution.

This solar signal does not appear on all regions with different climate pattern or seasonal time ranges. The stronger solar signal appears when local or regional effects is least

Now we are reporting the correlation between cloud cover over Indonesia based on their climate pattern and IOD phenomena and also indication of solar signal in IOD

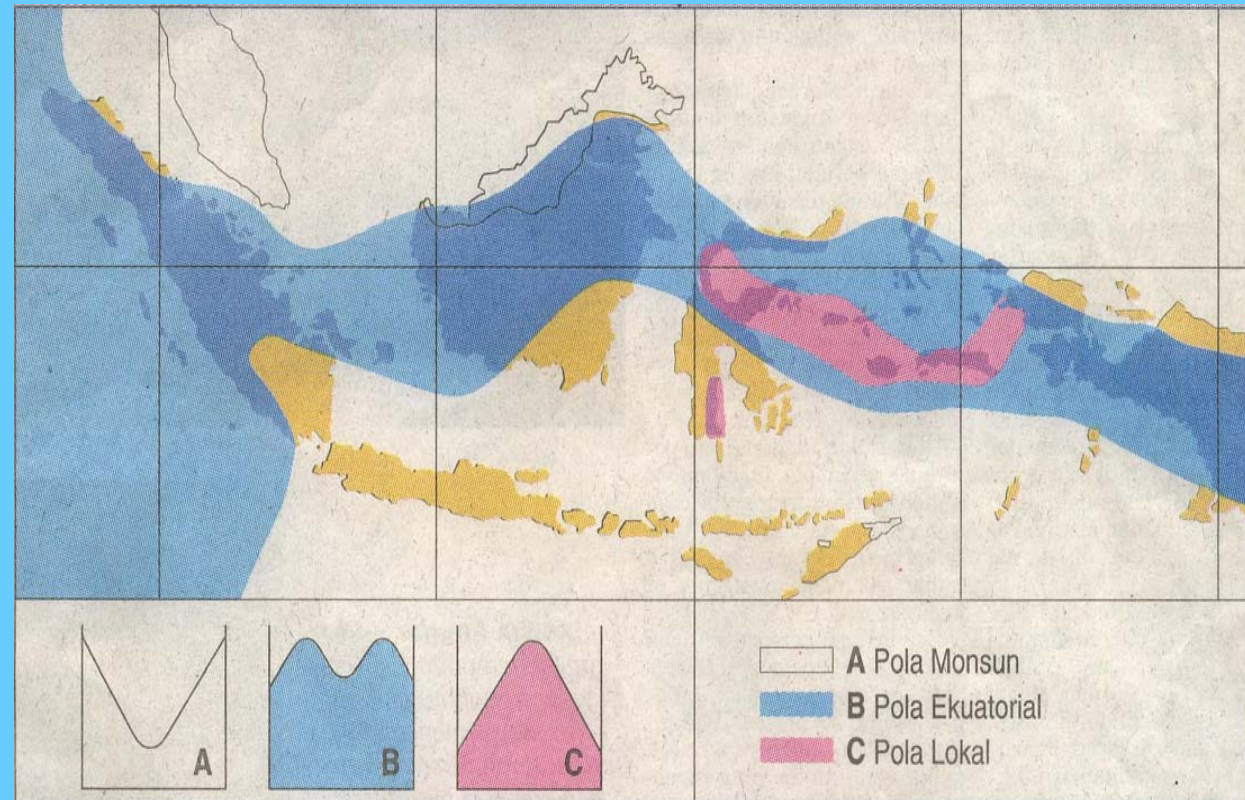
The spectral analysis was done by using computer program Weighted Wavelet Z-transform developed by the American Association of Variable Star Observers

We identified dipole mode by a simple index time series which describes the difference in SST anomaly between the tropical western Indian Ocean (50E-70E, 10S-10N) and the tropical south eastern Indian Ocean (90E-110E, 10S- Equator) (Saji et al, 1999)

Climate Patterns in Indonesia:

- A. Monsoon
- B. Equatorial
- C. Local

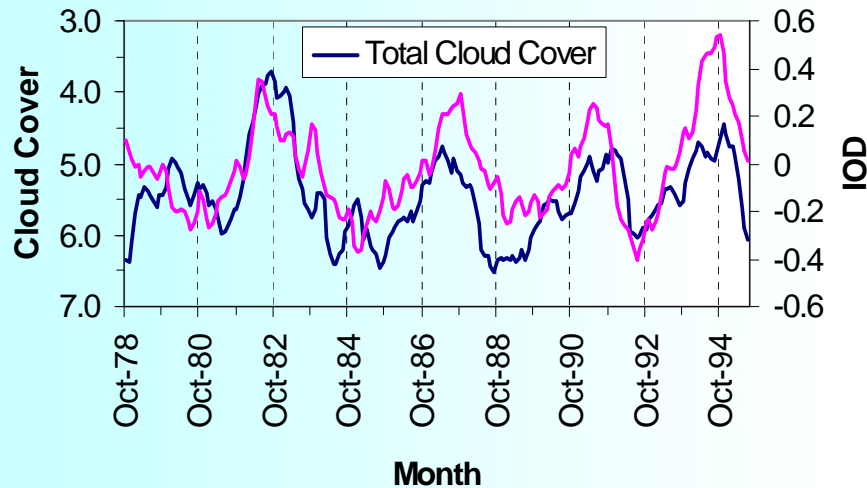
(Source: BMG)



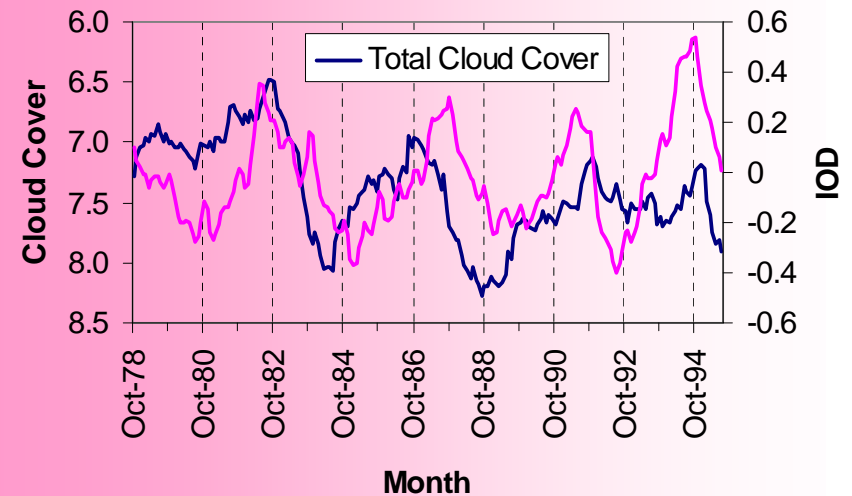
The division of analysed areas:

- ❖ Monsoon Pattern
($5^{\circ} - 11^{\circ} \text{ S}$, $101^{\circ} - 117^{\circ} \text{ E}$)
- ❖ Equator Pattern
($5^{\circ} \text{ N} - 3^{\circ} \text{ S}$, $91 - 99^{\circ} \text{ E}$) + ($5^{\circ} \text{ N} - 3^{\circ} \text{ S}$, $109^{\circ} - 117^{\circ} \text{ E}$)
- ❖ Local Pattern
($1^{\circ} - 7^{\circ} \text{ S}$, $121^{\circ} - 133^{\circ} \text{ E}$)

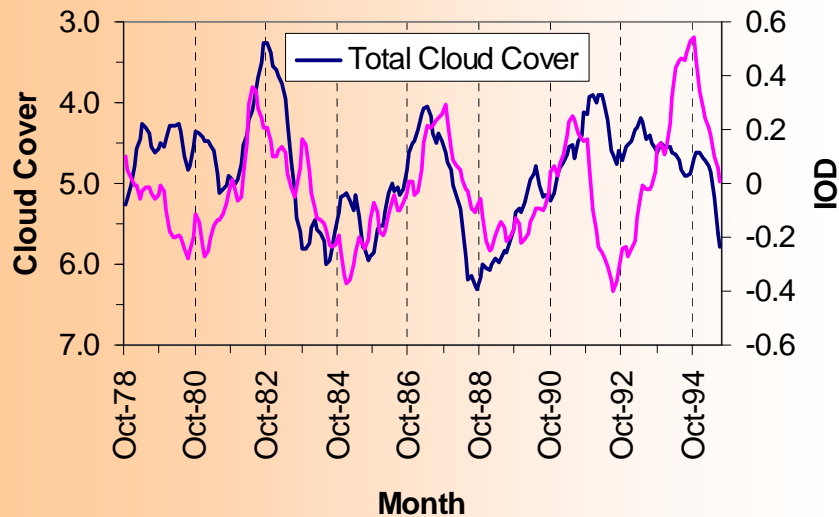
Monsoon Pattern (R=0.64)



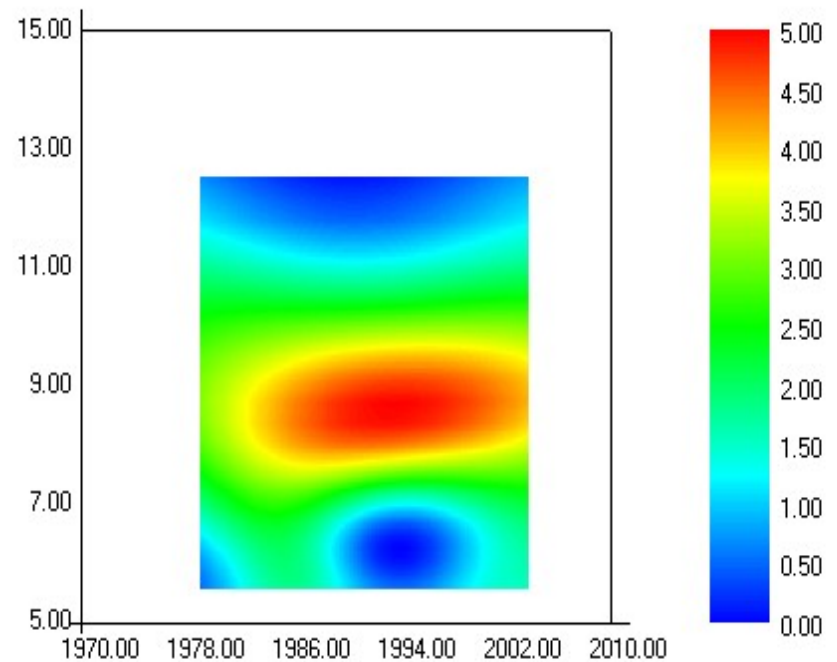
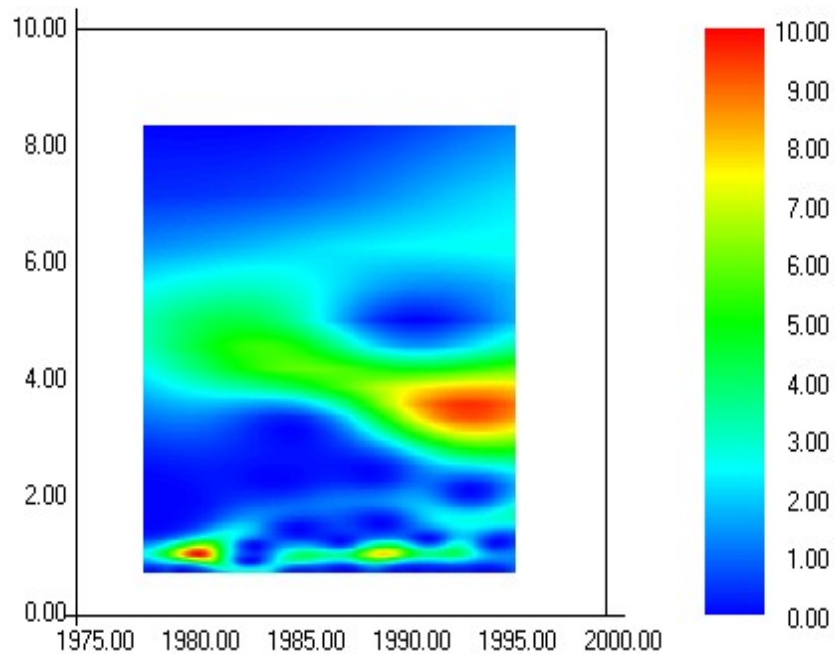
Equatorial Pattern (R=0.18)



Local Pattern (R=0.33)



Correlation between total cloud cover over Indonesia and IOD for monsoon, equatorial and local pattern. We obtain the correlation coefficient are 0.64, 0.18 and 0.33 respectively. Running average 13 month to eliminate seasonal factor is applied to these data



Spectral analysis of IOD monthly data. There are periodicity about 6 down to 3 years and annual signal (left).

The periodicity about 9 years indicating the solar signal (right) appear for wet season in monsoon pattern (right).

This result implies that IOD mainly affected to western Indonesia region. When IOD is moving to positive value hence the total cloud cover, (including the convective cloud) is decreased and the sky is bright so no precipitation will be occurred. If IOD value relatively high, in long term, it can cause severe drought at some region. It should be noted that the correlation between total cloud cover for equatorial pattern is also weak when compared to Southern Oscillation Index (SOI) as ENSO indicator. It is suggested that the position at equator makes this region is affected by the Sun intensively, hence the global effects of ENSO and IOD become weaker.

SUMMARY

IOD phenomena influence on Indonesian climate, mainly over western Indonesia with monsoon climatic pattern, evaluated from the correlation with cloud cover as a climatic parameter. Using spectral analysis it also appears the periodicity about 11 years indicating the solar effects on IOD during wet season in Indonesian monsoon climate pattern.

It is found that solar signal does not appear on all regions with different climate pattern or seasonal time ranges. Generally, the stronger solar signal appears when local effects is less. Solar signal on cloud cover spectral with the period of about 11 years appear strongly during dry seasons (June - August), especially over the area with monsoon climate pattern. The ENSO signal with the period of about 3 - 6 years seems to be related with solar activity



REFERENCES

Saji, N. H. et al. Nature 401, 360-363 (1999)

Djamaluddin, T. Proc. ISCS 2003 Symposium. Slovakia, 355-357 (2003)

Sinambela, W. et al. Warta LAPAN 7, 116-127 (2005)

www.hadobs.org

MSC (Meteorological Satellite Center) 1978 – 1996. Cloud Amount in Monthly Report of Meteorological Center. Tokyo

Foster. Astron. J. 112 (4), 1709-1729 (1996)

Nugroho, J. T and Djamaluddin, T. Proc. of the 9th Asian-Pacific Regional IAU Meeting, 52-53 (2005)

The How Liong et. al, Prediction of Extreme Weather and Climate in Indonesian Maritime Continent Based on Sunspot Number, Seminar Antariksa III, LAPAN, 2006

ENSO: global climatology phenomena, increased of sea surface temperature in Pacific ocean, as the result of shifted convection (warm water pool) to central Pacific

Indicated by Sea Surface Temperature anomalous (+) at eastern Pacific and Soutern Oscillation Index (-) between Darwin and Tahiti

El Nino year:

77-78, 82-83, 86-87, 91-92, 93-94

La Nina year:

88-89