Cloud Structure Anomalies Over Tropical Pacific During 97/98 El Nino

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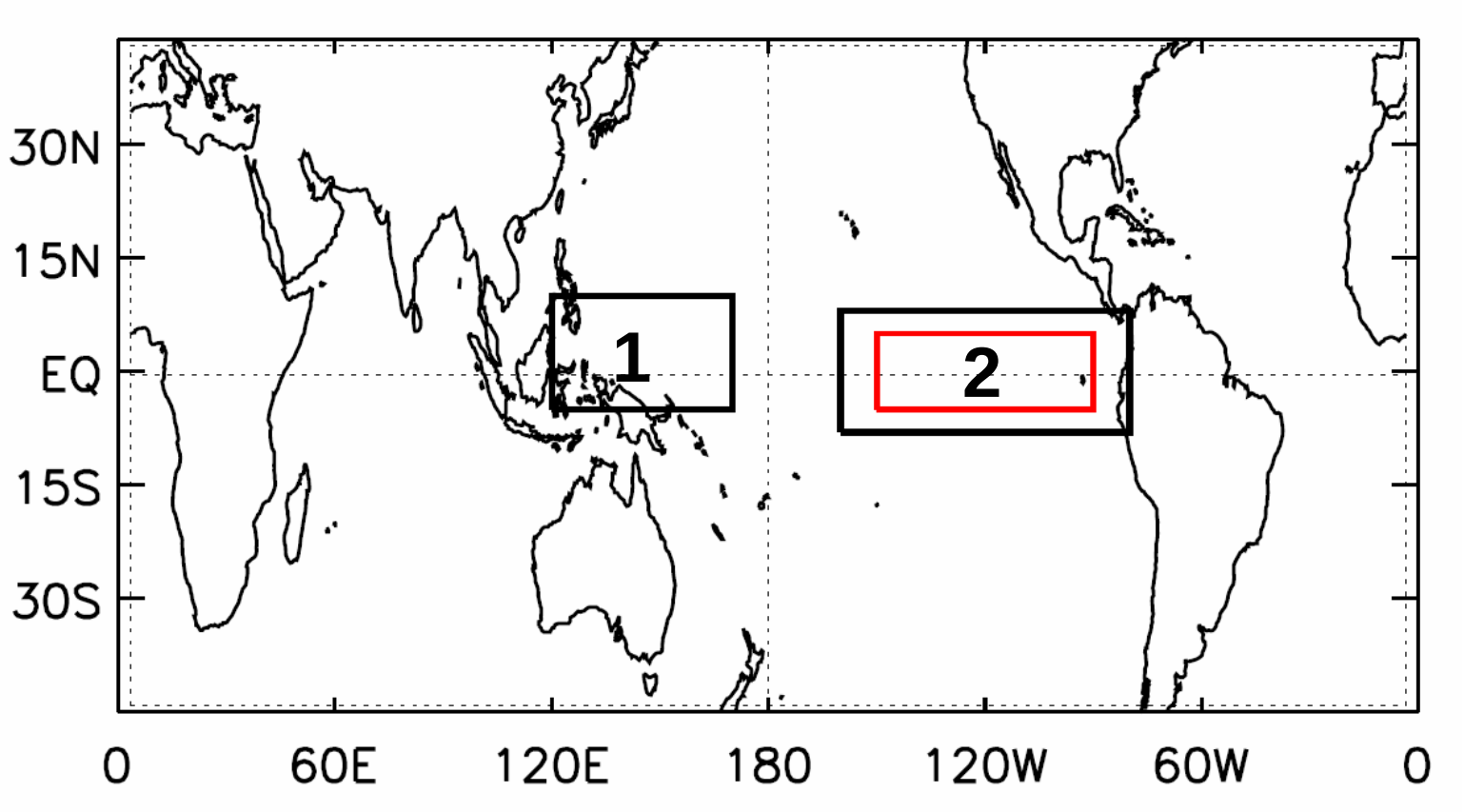
Motivation

- To show cloud structure changes from several highly correlated cloud variables over the equatorial Pacific during the 97/98 El Nino by using CERES data.

- To investigate the apparent negative correlation between OLR and SST under both all and clear sky over the eastern equatorial Pacific during the strong El Nino.

Study Area



Western: 5S-10N, 120E-170E
Eastern: 7.5S-7.5N,80W-160W
El Nino Index 3: 5S-5N, 90W-150W

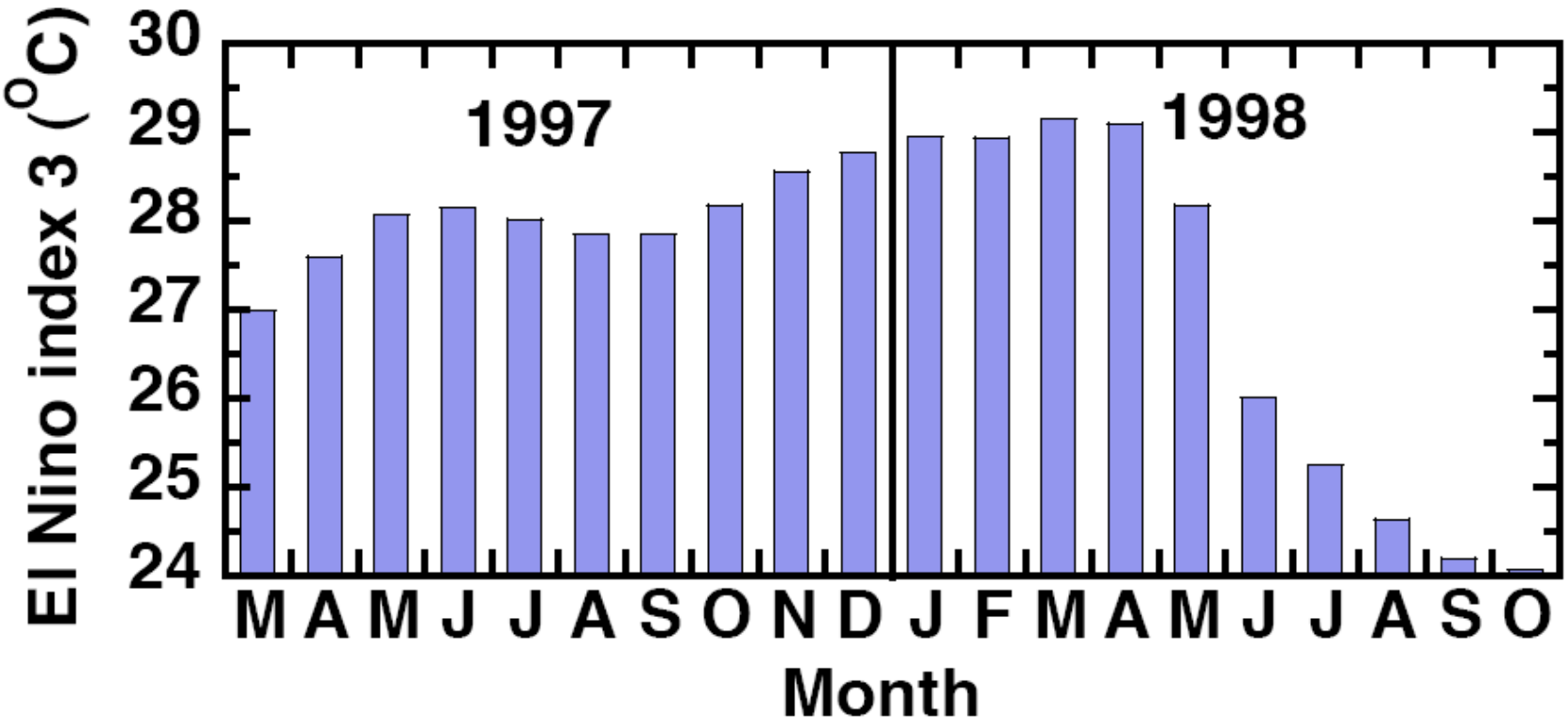
Data

- CERES SRBAVG2 data:

  cloud fraction, cloud altitude, cloud optical depth and OLR

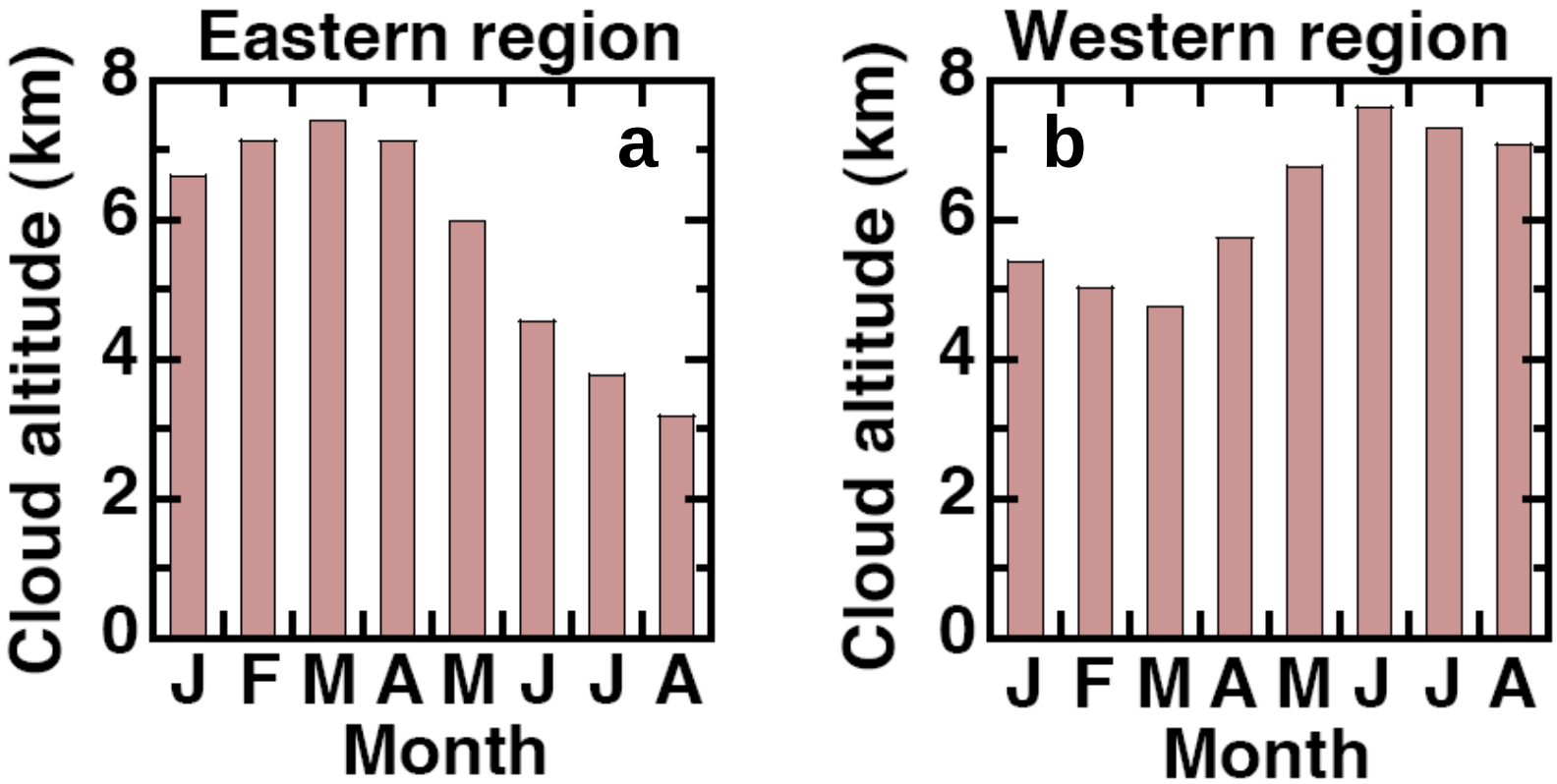
  Time: January -- August, 1998
- NOAA CDC: NINO3
- NOAA NCDC: SST
- ECMWF Reanalysis: P, T, SH (specific humidity)

1997/98 El Nino Index 3



Index 3: 5S-5N, 90W-150W

Cloud Altitude



Cloud Property Formula

$$\overline{A} = \frac{\sum_{j=1}^{n}\sum_{i=1}^{4} A_{ij} f_{ij}}{\sum_{j=1}^{n}\sum_{i=1}^{4} f_{ij}}$$

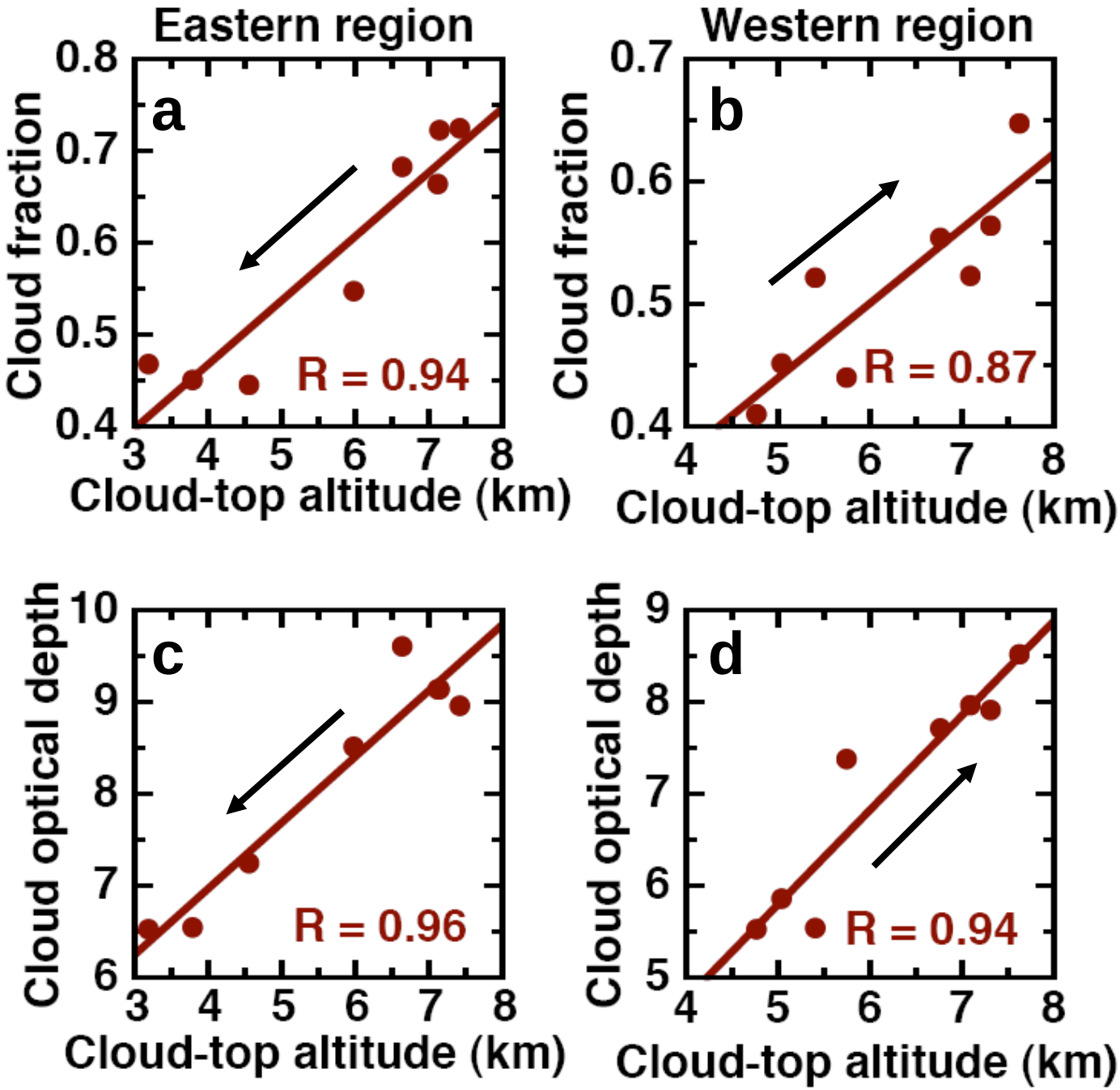
$\overline{A}$: is the regional monthly average

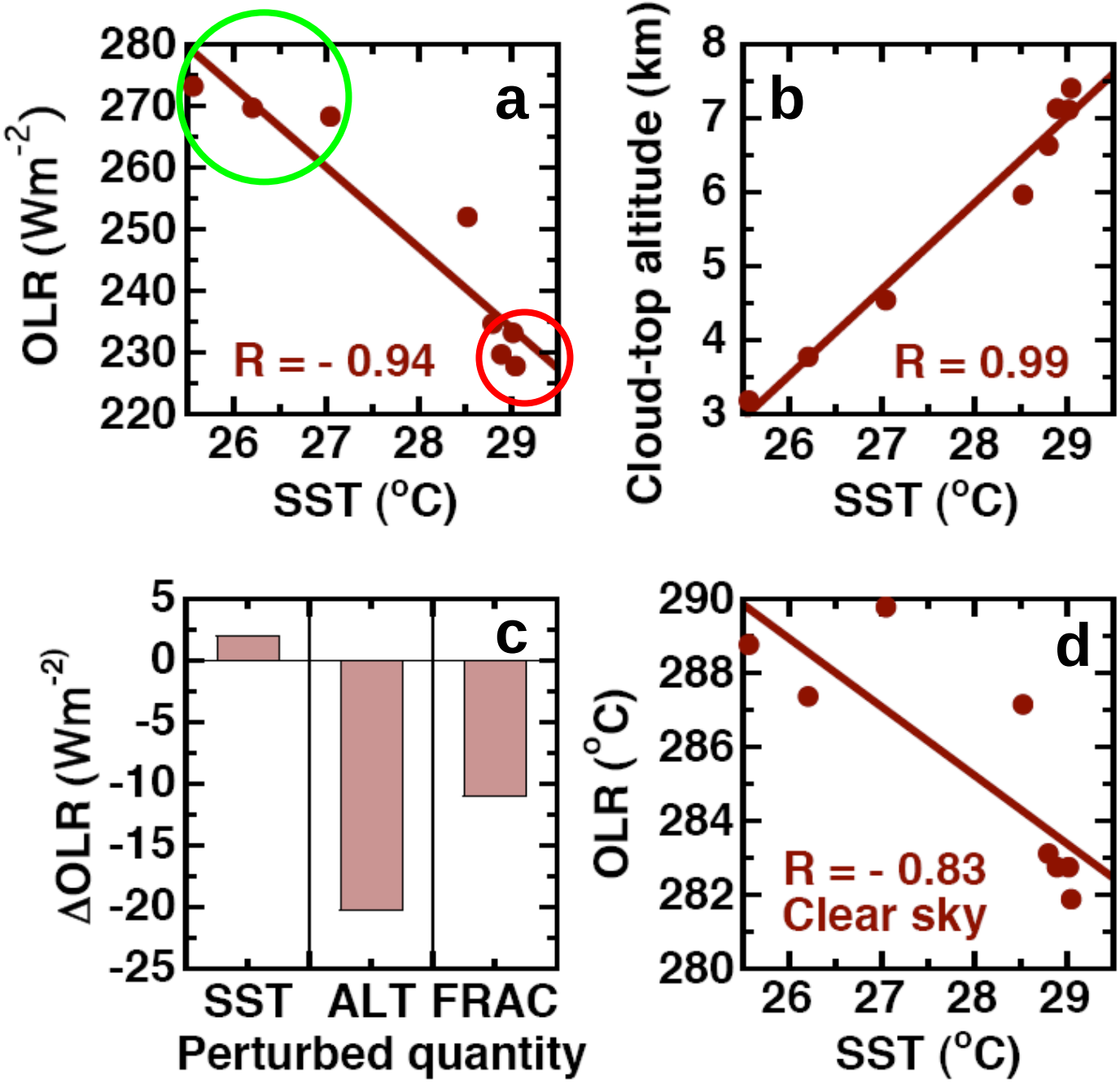
A_{ij} : specific variable for each grid

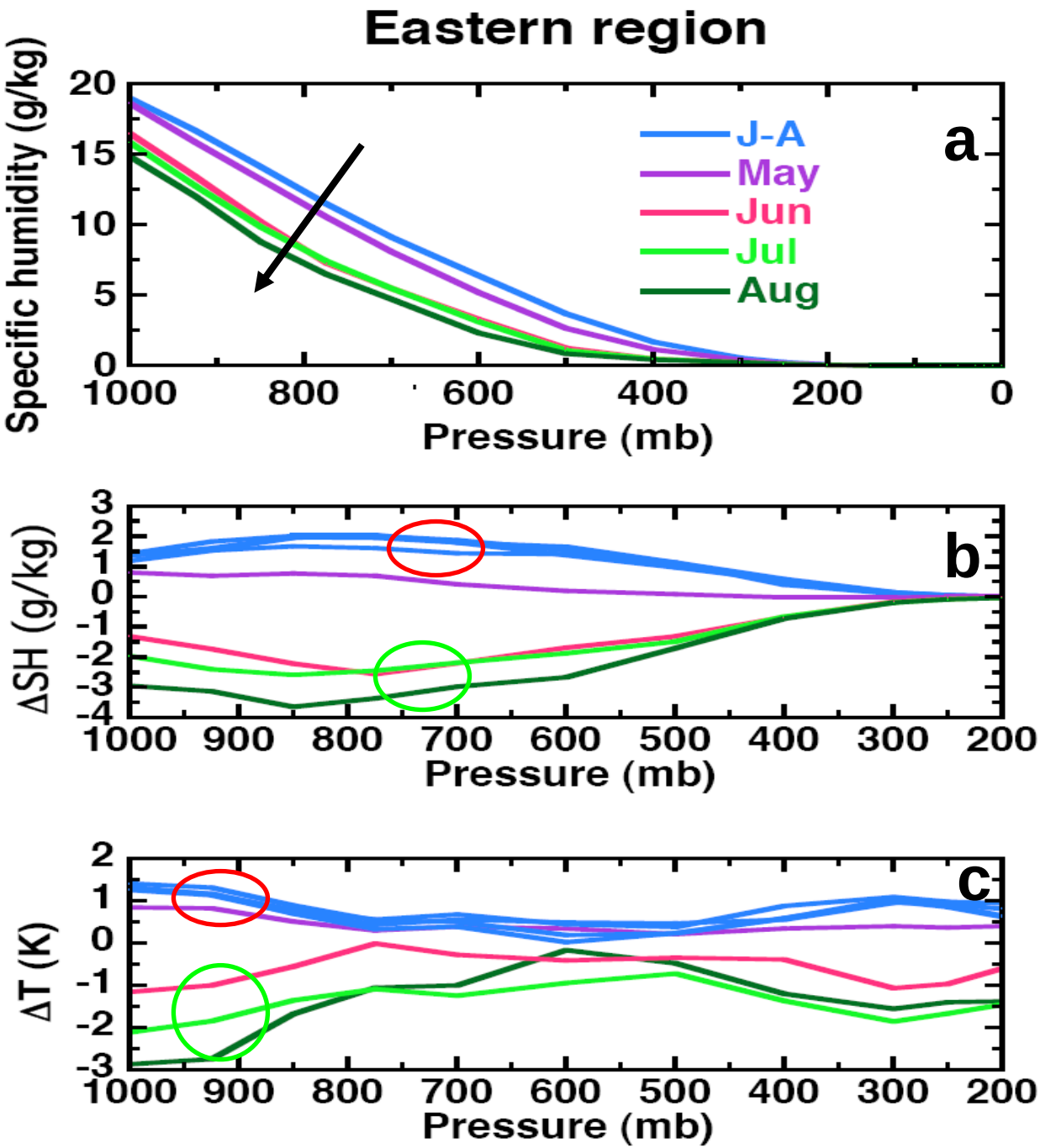
f_{ij} : cloud fraction

n : is the total number of 1×1 grids within the region

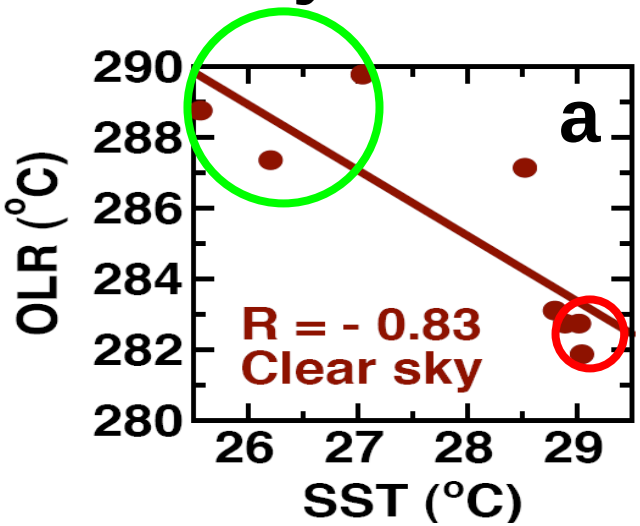
4 : four non-overlapping layers.

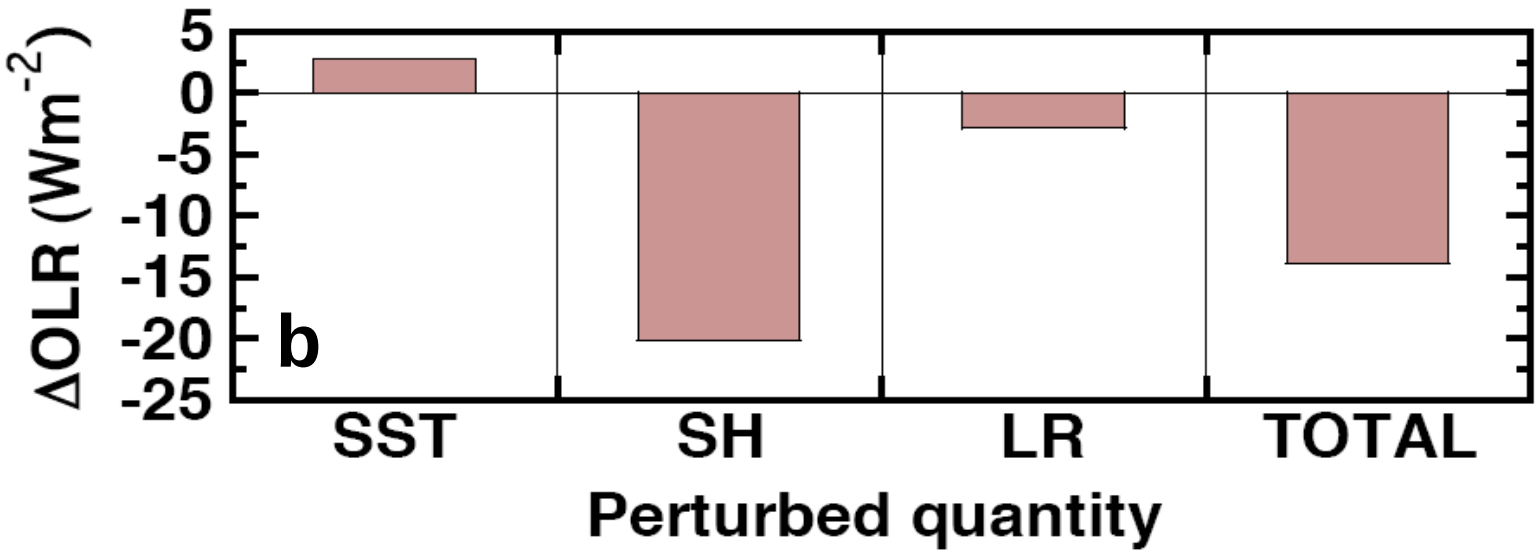

Eastern region
a
Cloud fraction
0.8
0.7
0.6
0.5
0.4
R = 0.94
3
4
5
6
7
8
Cloud-top altitude (km)
Western region
b
Cloud fraction
0.7
0.6
0.5
0.4
R = 0.87
4
5
6
7
8
Cloud-top altitude (km)
c
Cloud optical depth
10
9
8
7
6
R = 0.96
3
4
5
6
7
8
Cloud-top altitude (km)
d
Cloud optical depth
9
8
7
6
5
R = 0.94
4
5
6
7
8
Cloud-top altitude (km)


a
OLR (Wm^{-2})
280
270
260
250
240
230
220
26
27
28
29
SST (°C)
R = - 0.94
b
Cloud-top altitude (km)
8
7
6
5
4
3
26
27
28
29
SST (°C)
R = 0.99
c
ΔOLR (Wm^{-2})
5
0
-5
-10
-15
-20
-25
SST
ALT
FRAC
Perturbed quantity
d
OLR (°C)
290
288
286
284
282
280
26
27
28
29
SST (°C)
R = - 0.83
Clear sky


Eastern region
Specific humidity (g/kg)
20
15
10
5
0
1000
800
600
400
200
0
Pressure (mb)
J-A
May
Jun
Jul
Aug
a
ΔSH (g/kg)
3
2
1
0
-1
-2
-3
-4
1000
900
800
700
600
500
400
300
200
Pressure (mb)
b
ΔT (K)
2
1
0
-1
-2
-3
1000
900
800
700
600
500
400
300
200
Pressure (mb)
c

Clear Sky Sensitivity





Summary

- The changes of major cloud parameters are highly correlated over both western and eastern equatorial Pacific during 97/98 El Nino. Eastern region clouds become thicker and more wide spread due to stronger convection while western region shows just the opposite.
- The all sky OLR change over Eastern region is not directly driven by SST but mainly by cloud altitude and cloud fraction.
- The clear sky OLR change is mainly due to moisture change. The SST and lapse rate play minor and compensating roles for OLR change. All these factors play roles in all sky OLR change with relative smaller effects than that of cloud properties.