Carbon Cycle Implied by a 2-D Atmospheric Transport Model and CO_2 Concentration Data (10/28/2003)

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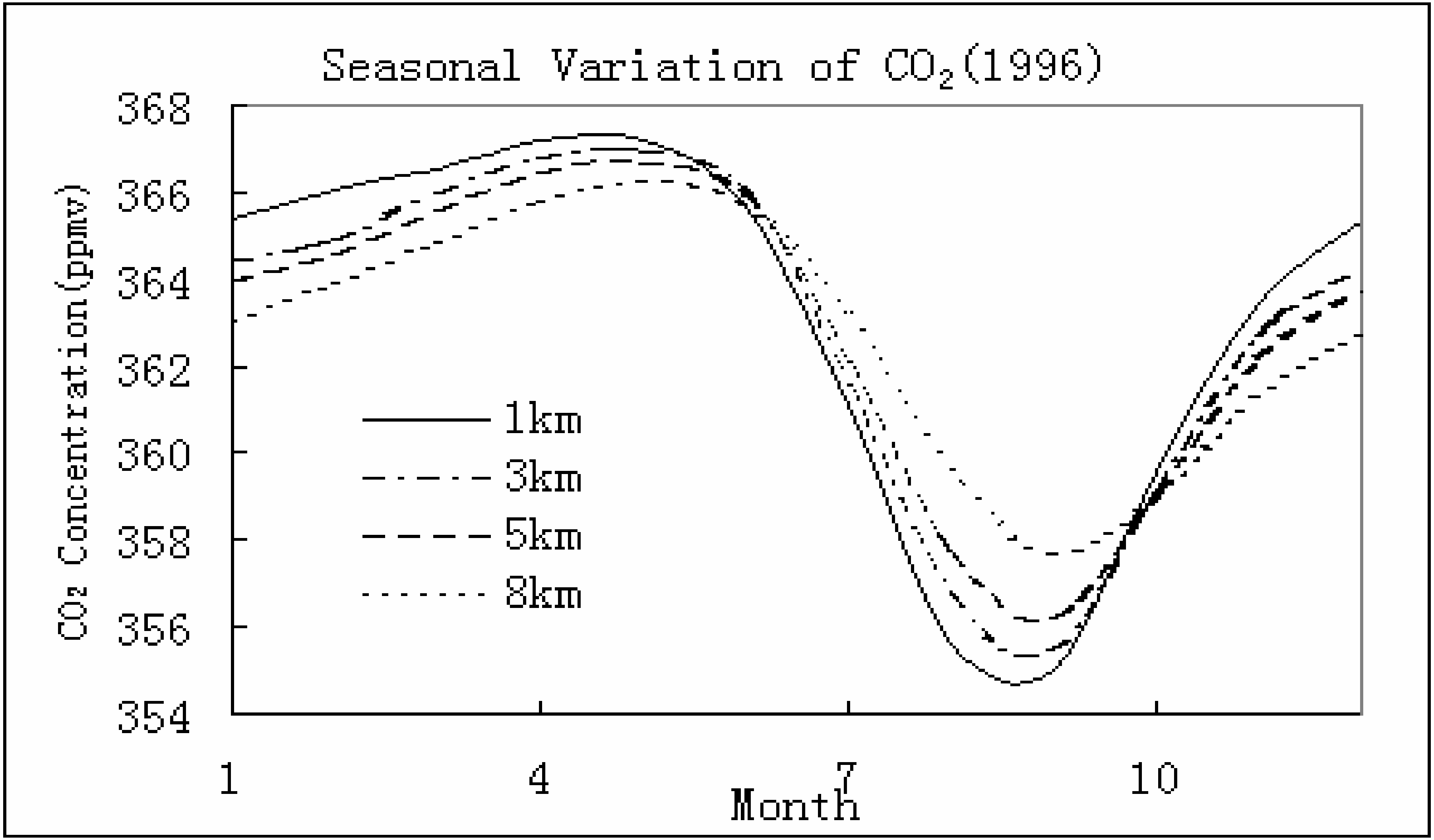
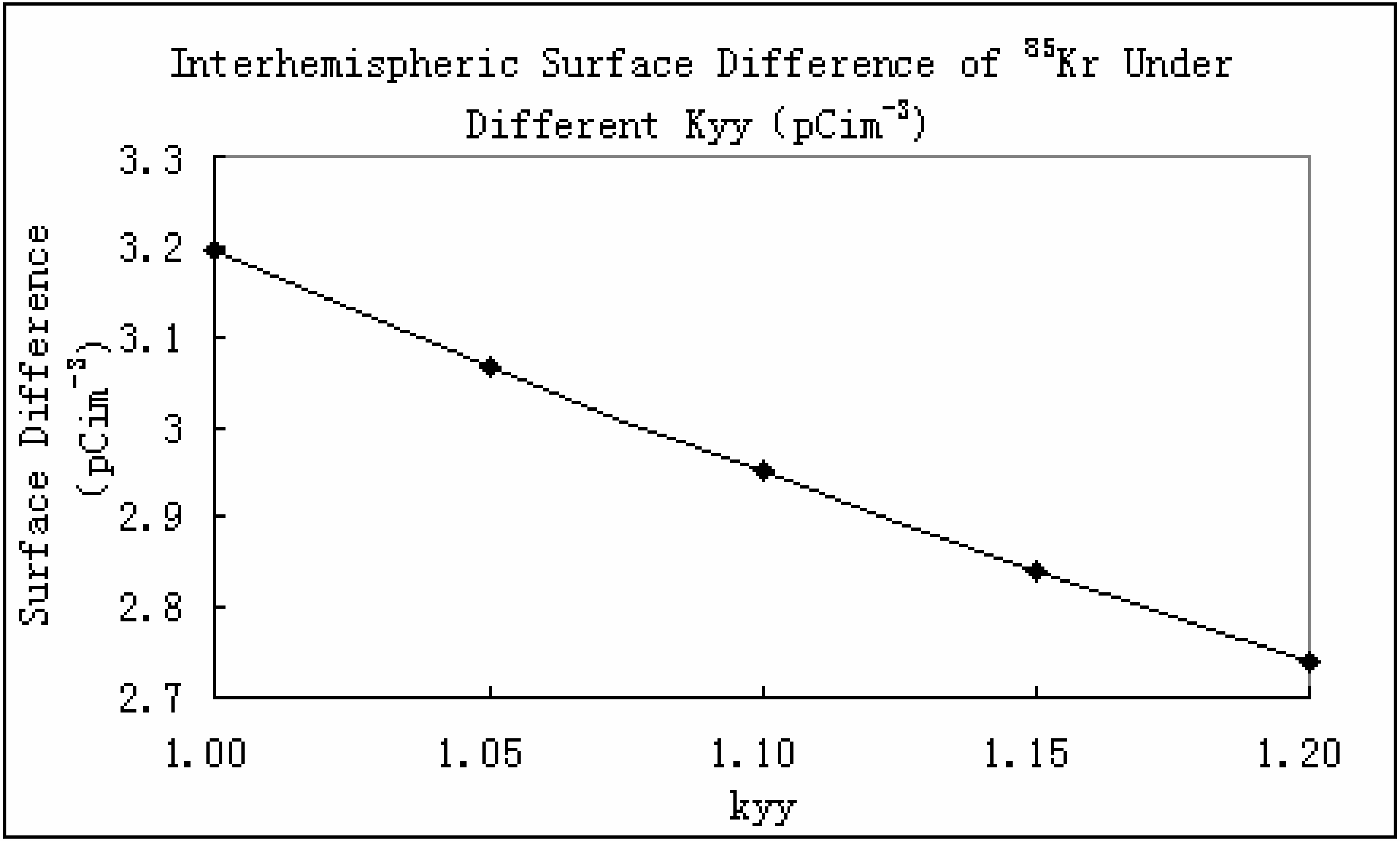
I. 2-D Atmospheric Transport Model

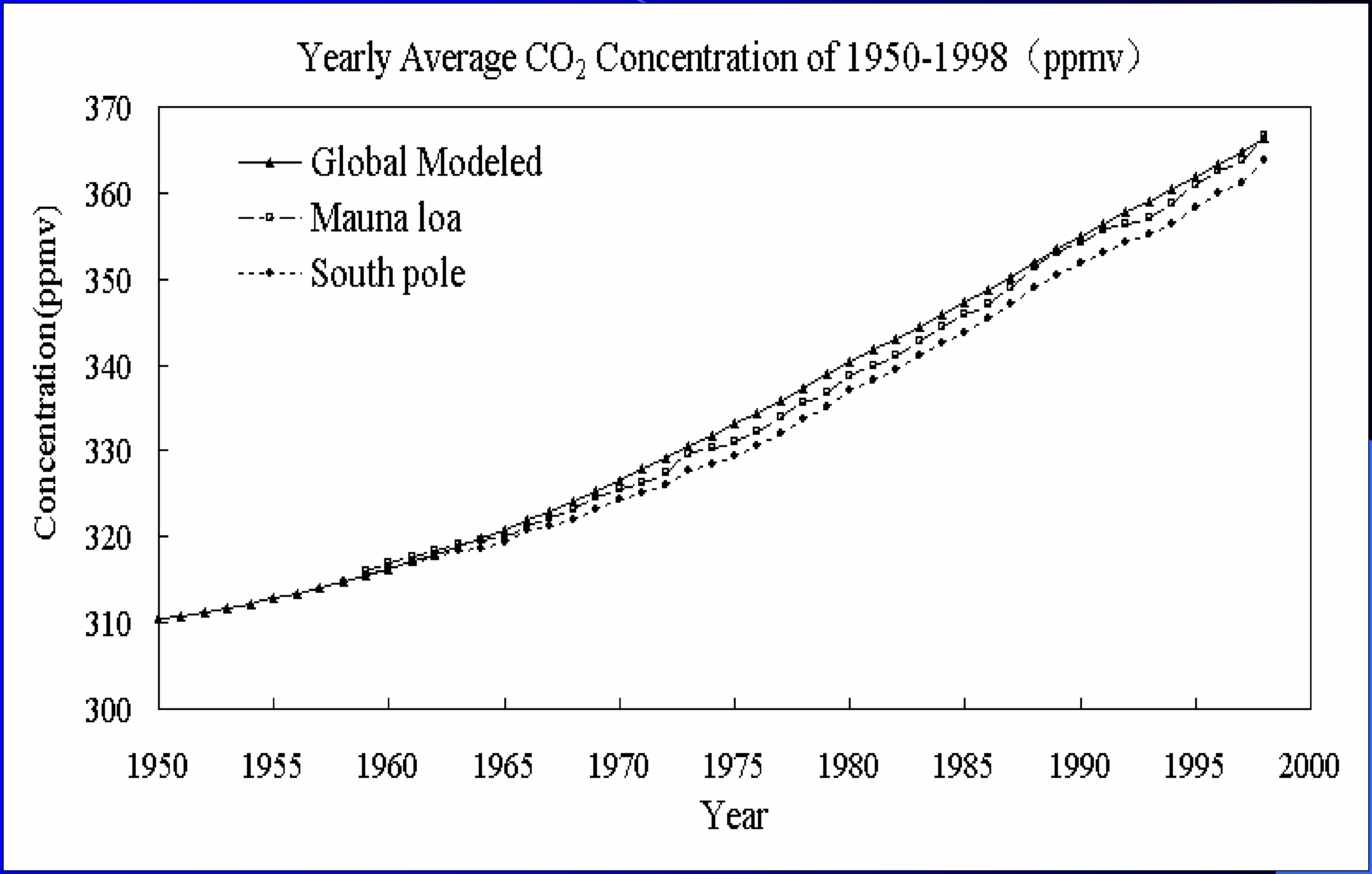
An original 2-D atmospheric chemistry transport model was developed by Dr. Zhang (Zhang, 1997, Zhang et al. 2001). Through altering the diffuse coefficients of the original model, an atmospheric CO_2 transport model was established by Mr. Li. Horizontally, the model includes the domain from 90° N to 90° S, with a resolution of 5° . Vertically, the model includes 21 levels from the ground to 20 km, with a resolution of 1 km.

According to Tans et al. (1989), when testing the model, the seasonal cycle of atmospheric CO_2 at different altitude was used as the gauge for vertical transport, while the inter-hemisphere difference of surface ^{85}Kr was used as the criterion for horizontal transport.


Seasonal Variation of CO2(1996)
368
366
364
362
360
358
356
354
CO2 Concentration(ppmv)
1km
3km
5km
8km
1
4
7
10
Month


Interhemispheric Surface Difference of 85Kr Under Different Kyy (pCim-3)
Surface Difference (pCim-3)
3.3
3.2
3.1
3
2.9
2.8
2.7
1.00
1.05
1.10
1.15
1.20
kyy

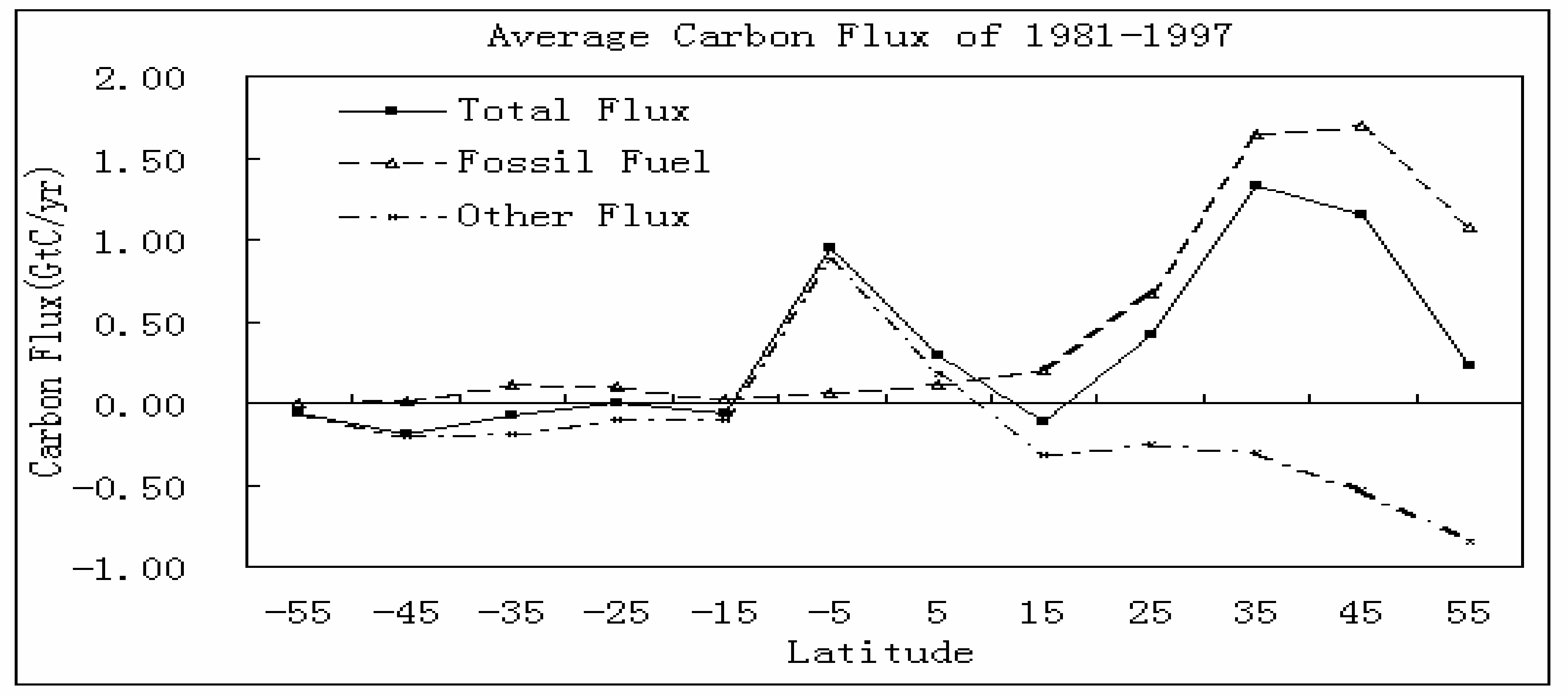
To test the steadiness of the model, we simulated the trend of global CO_2 during the interval from 1950 to 1998, and found good agreement between the modeled trend and the observation data in Mauna Loa and South Pole stations.



Yearly Average CO2 Concentration of 1950-1998（ppmv）
Global Modeled
Mauna loa
South pole
Concentration(ppmv)
370
360
350
340
330
320
310
300
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Year

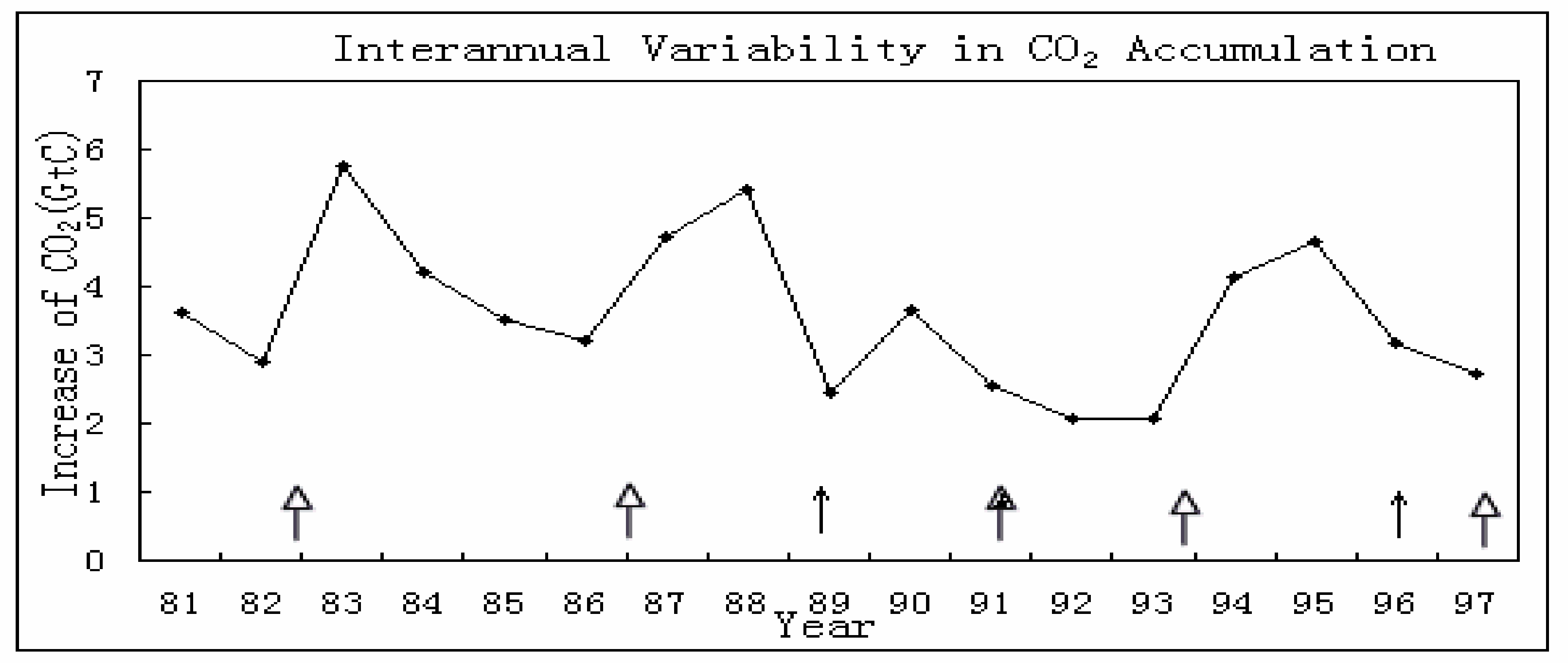
II. Results

1 Carbon flux distribution (CO_2 source: fossil fuel 15-60° N, ocean and land cover change 15S-15° N, and sink: land ecosystem from 30 ° N)



2. Interannual variability in carbon cycle

ENSO events maybe had contributed to this variability (arrows are ENSO events, arrow in 1991 is Pinatubo)



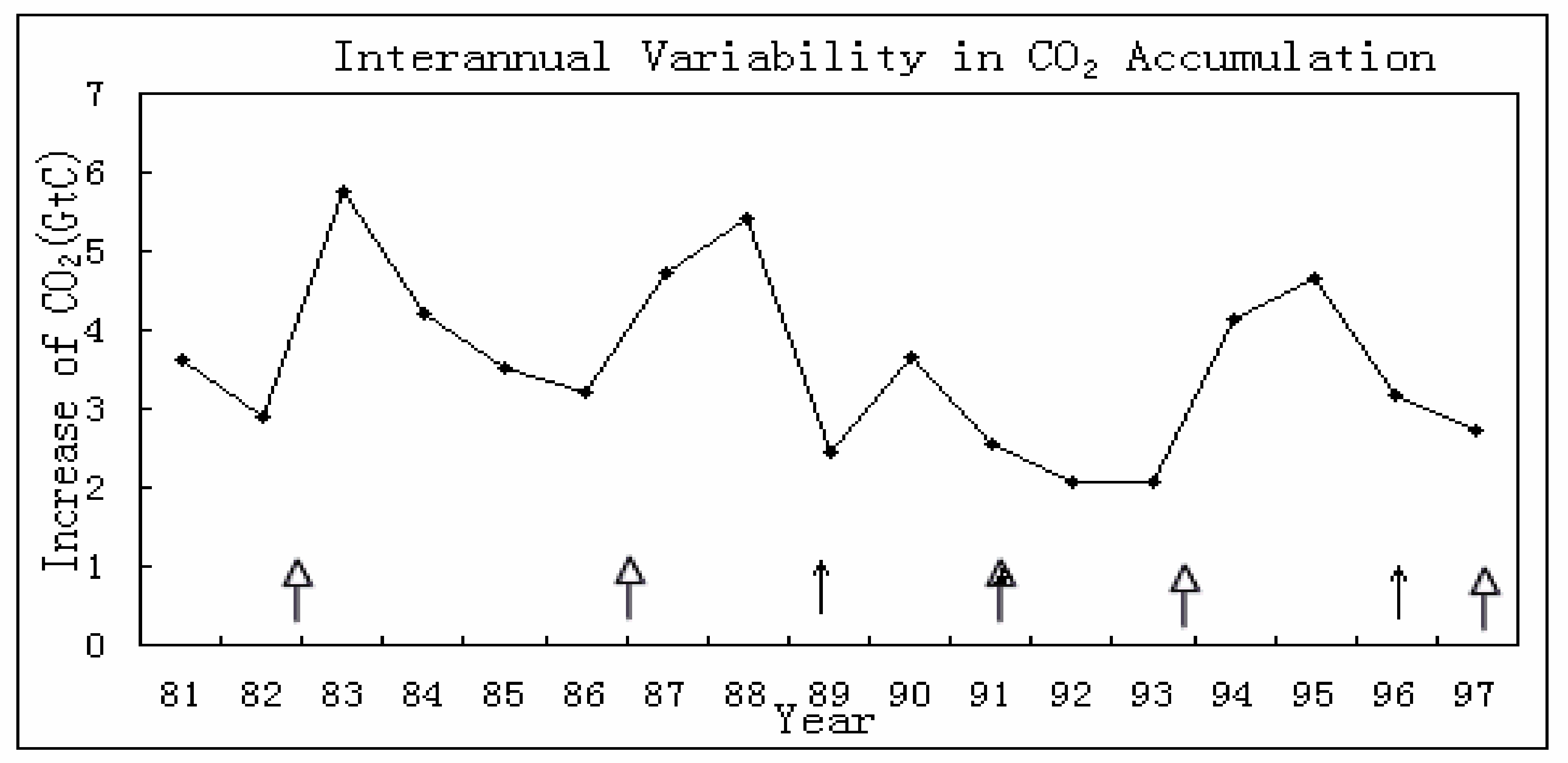
There are strong fluctuations in the rate of atmospheric CO_2 increase during ENSO episodes.

Feely et al. (1987) reported that CO_2 emission from equatorial Pacific Ocean largely stopped in 1982.

3 Effect of Pinatubo volcano eruption

Generally, decline in surface temperature due to aerosols emitted by the volcanic eruption, is believed to be a major reason for this drop of carbon flux. Lucht et al. (2002) simulated the cooling effect of the Pinatubo eruption. Their results demonstrated a net primary production decrease of 21.5 gC/m^2 as well as a higher R_h (heterotrophic respiration) reduction of 32.2 gC/m^2.

Pinatubo

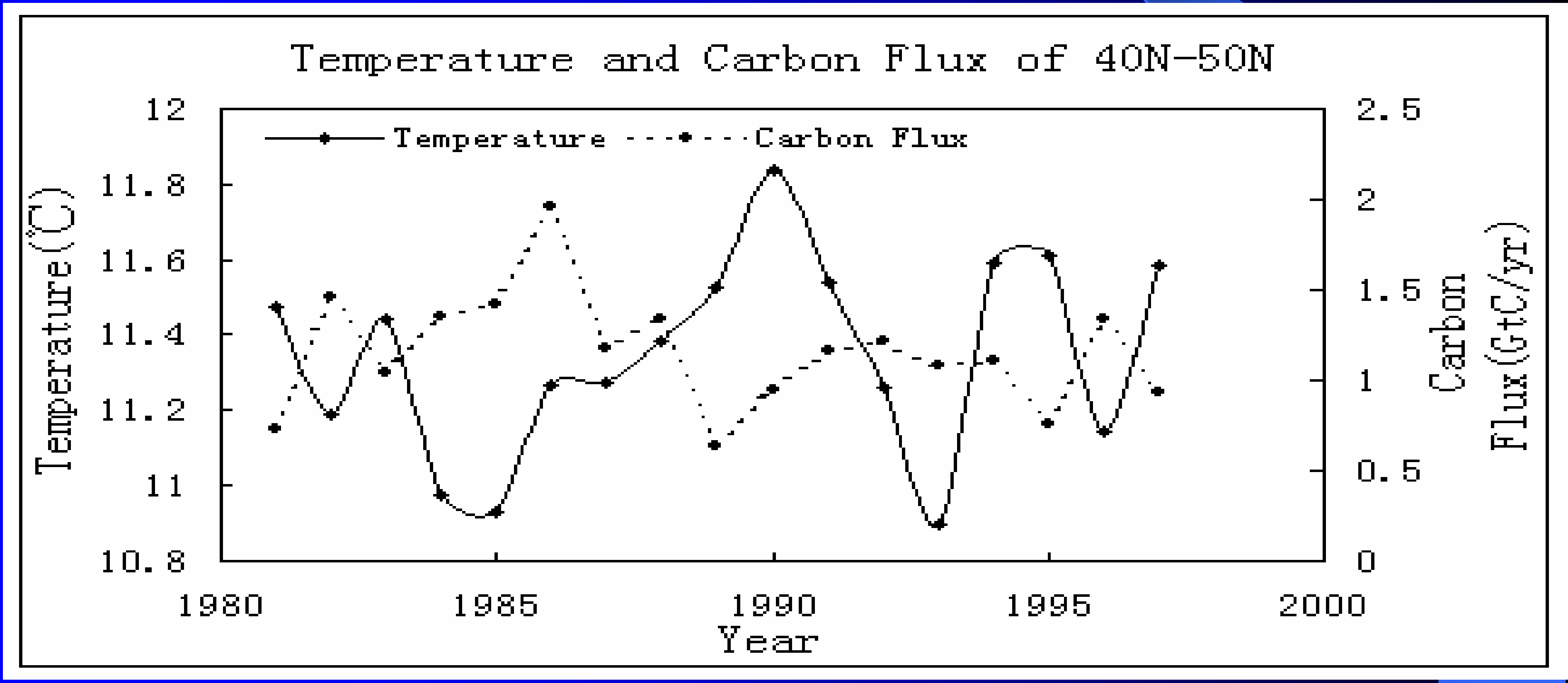


Interannual Variability in CO_2 Accumulation
Increase of CO_2 (GtC)
7
6
5
4
3
2
1
0
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
Year

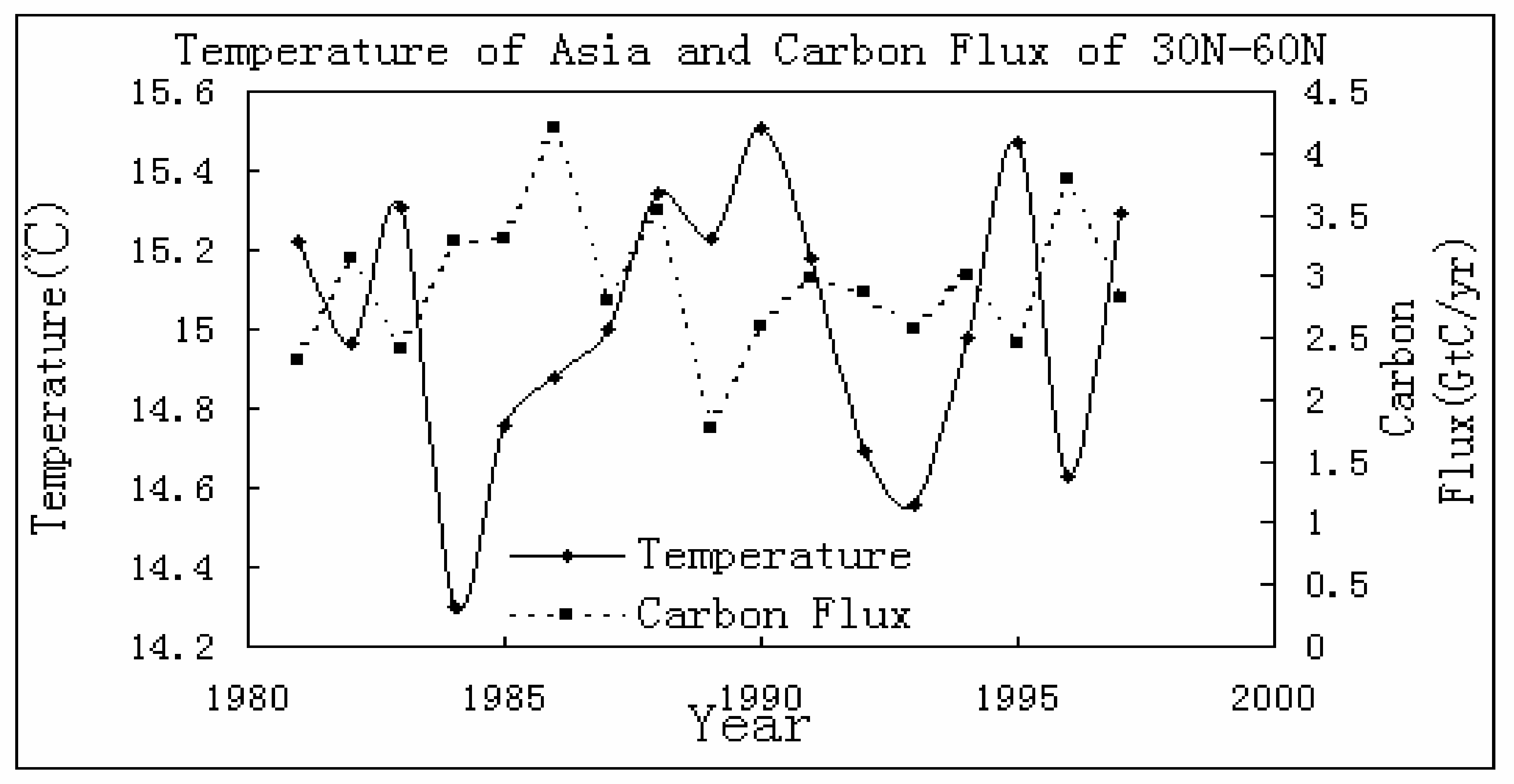
4 Correlation analysis

No much obvious correlation was found between carbon flux, and temperature, precipitation , due to the limitation of 2-dimension data and the complexity of carbon cycle. But carbon flux in the area of 40-60 °N, which included relative large land area, showed negative correlation with temperature.

C flux in the area between 40° and 50° N, showed negative correlation with temperature



Correlation between the carbon flux of 30° -60° N and the average surface temperature of Asia (25° - 60° N and 40° -120° E)



This implied that, the activity of terrestrial ecosystems in this area, responses to climatic factors and contributes to oscillation in carbon flux.

Demonstrated above, implies that terrestrial carbon cycle process in mid-high latitude area of north hemisphere, could probably dominate the carbon flux fluctuation in this area. Specially, the data for Asia could provide some clues about the longitudinal location of so-called “missing carbon sink”, which is now still under investigation (3-D)

III. Conclusions

- Carbon flux distribution between 60° S and 60° N for the period of 1981-1998 was studied with our 2–D transport modal.
- The pattern of carbon flux distribution, coupled with known fluxes from fossil fuel combustion and ocean, strongly indicated the possible terrestrial carbon sink located in Northern Hemisphere (north of 30° N).

- There is considerable interannual variability in both of the total amount and the spatial distribution of carbon fluxes, especially in years with ENSO events.
- Possible explanation for such variation is that fluctuations in temperature, precipitation and other factors, caused by ENSO and other episodes, have influenced the terrestrial and oceanic carbon cycle processes.

Thanks