Update on STE of ozone

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Outline

- Review
- Data and method
- Tropopause height
- STE ozone flux
- On-going Work

Motivation and objectives

- What is the relative importance of tropospheric photochemical production and STE to the springtime ozone maximum in the low part of troposphere ?

- How does STE flux change with seasons and latitude?

Review of previous work

- Last time we discussed two difficult issues

1) Determination of tropopause height

2) Calculation of STE ozone flux

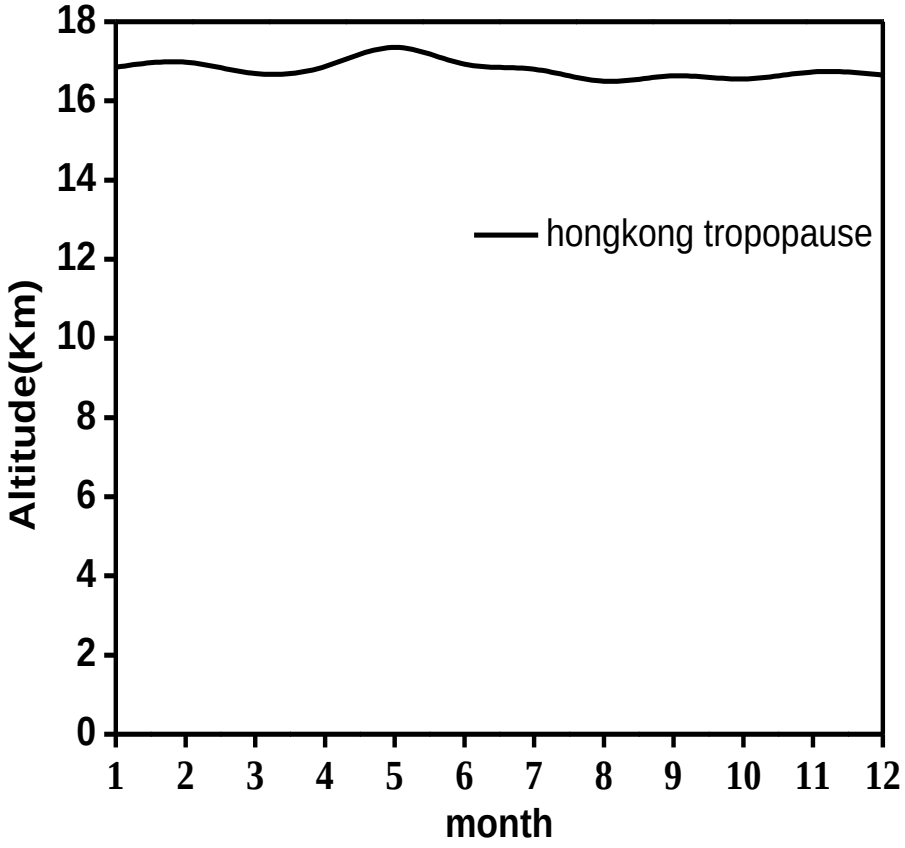
Data and method

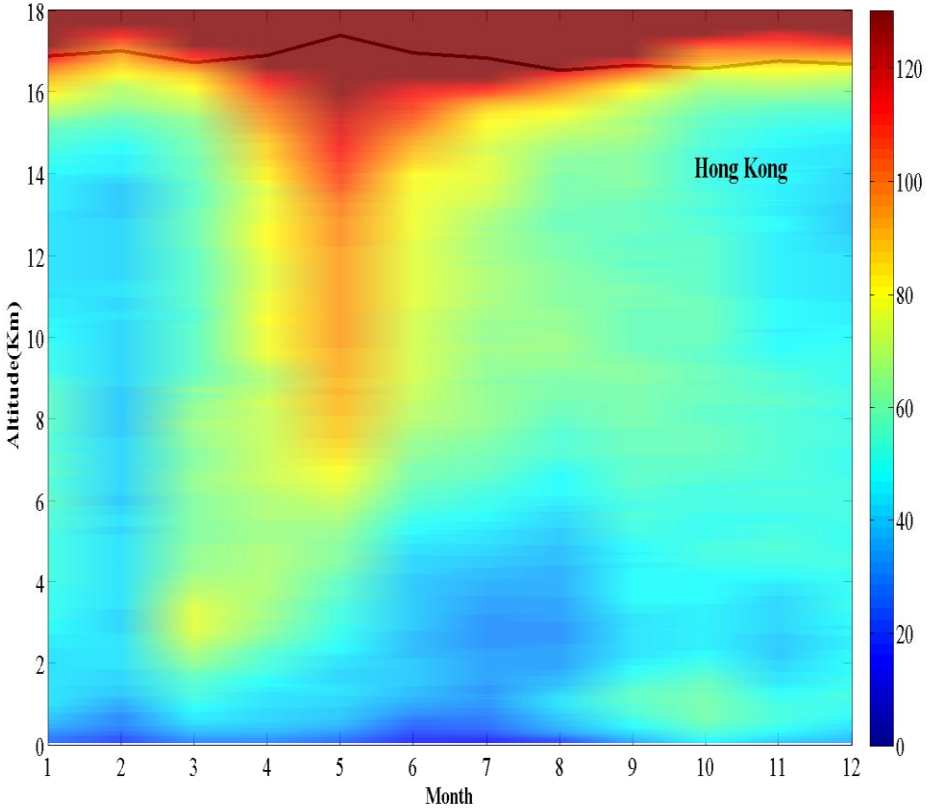
- Ozone sounding data from WOUDC http://www.woudc.org/index_e.html

- The 10 years Ncep(2.5° x2.5° ,level:26) data sets including: air,RH,u,v,p,ω。Use the pv.gs script from the net to calculate the tropopause ,and use the ozone sounding data to verify the results .

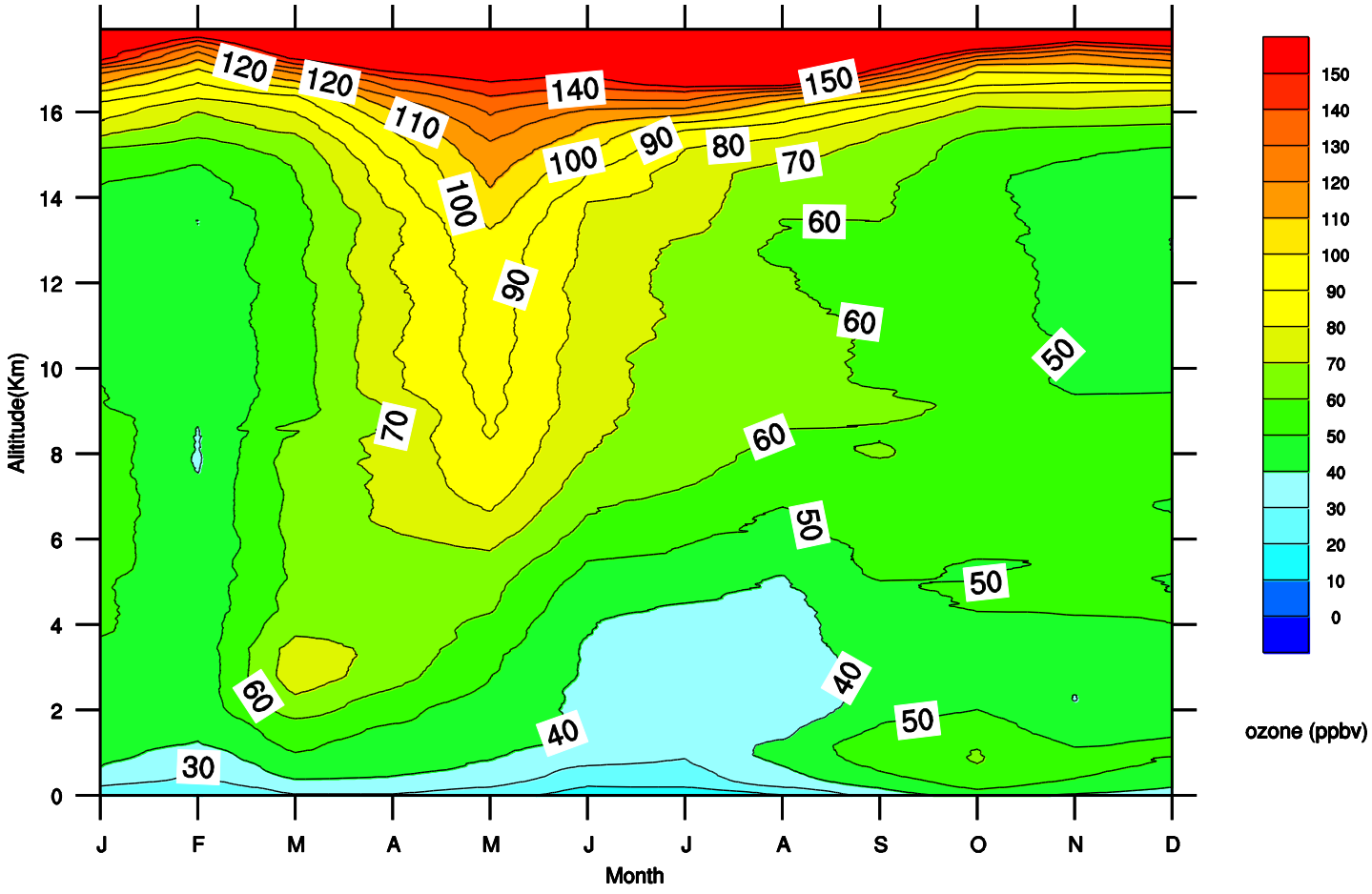
Define the tropopause

- Hong Kong(22.3° N，114.3° E):2PVU

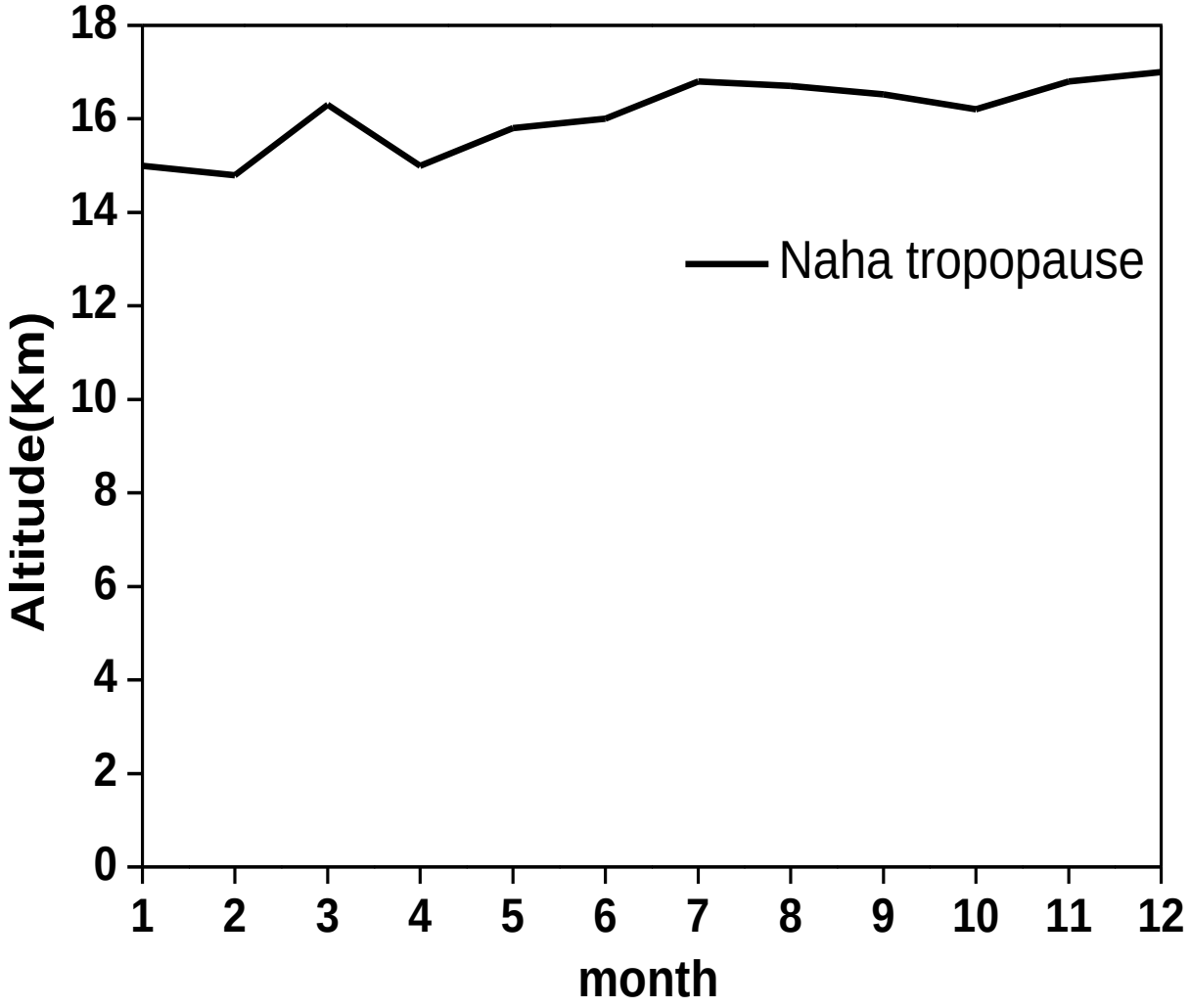




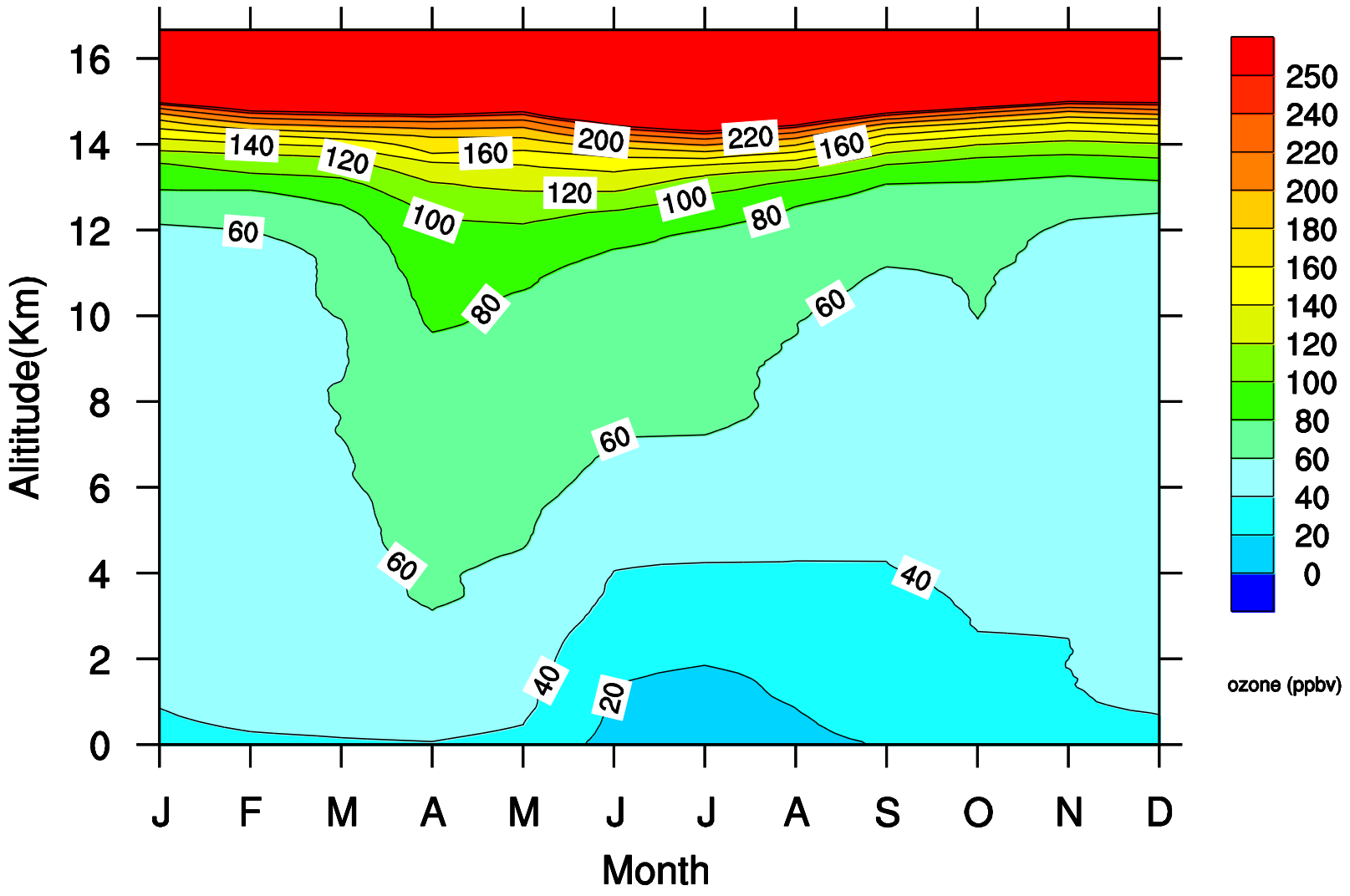
Hongkong


Alititude(Km)
0
2
4
6
8
10
12
14
16
J
F
M
A
M
J
J
A
S
O
N
D
Month
120
120
110
100
140
150
100
90
80
70
60
90
60
50
70
60
50
50
60
40
40
50
30
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ozone (ppbv)

- Naha（26.1° N，127.4° E）：2PVU



Naha


Alititude(Km)
16
14
12
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J F M A M J J A S O N D
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60
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40
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20
250
240
220
200
180
160
140
120
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80
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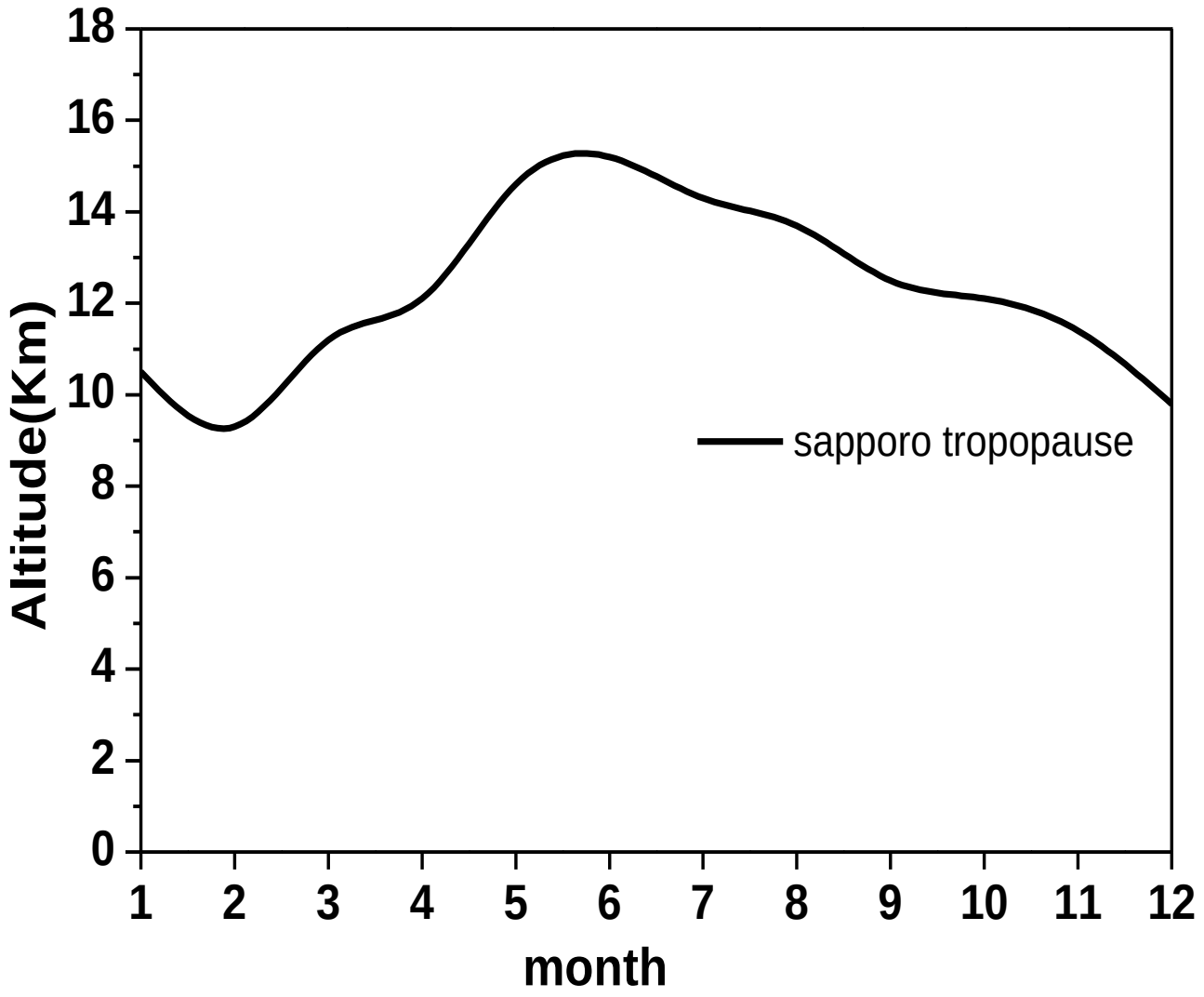
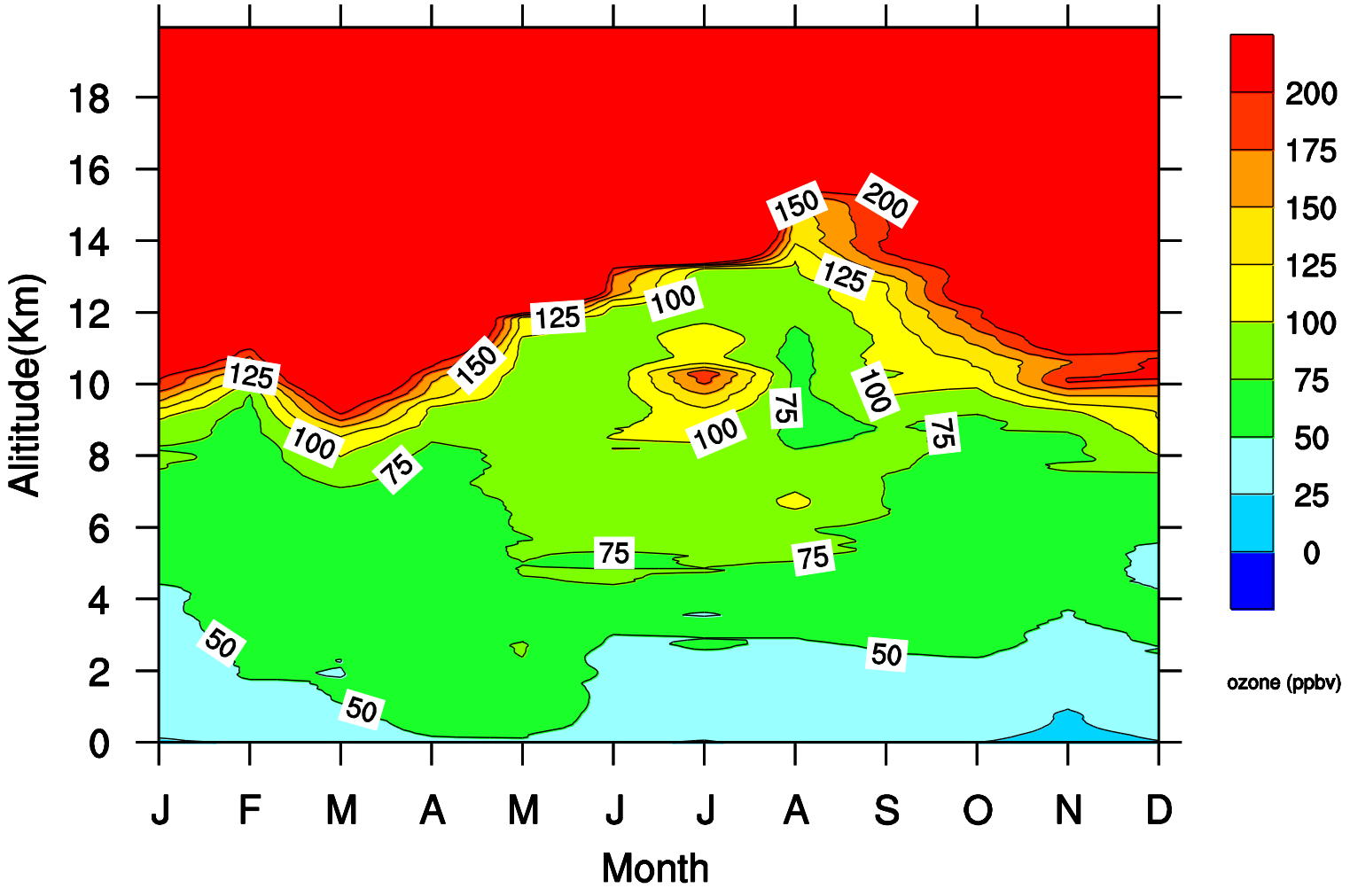
20
0
ozone (ppbv)

- Sapporo（43.1° N，141.3° E）:1.5PVU



Sapporo


Alititude(Km)
0
2
4
6
8
10
12
14
16
18
J
F
M
A
M
J
J
A
S
O
N
D
Month
200
175
150
125
100
75
50
25
0
ozone (ppbv)

Calculation of STE ozone fluxes

- Thanks for the STE calculation procedure provide by J. Barr´e ：

Wei’ s formula to calculate STE flux of ozone:

$$F(\rho) = -g^{-1}\left(\frac{DP}{Dt} - \frac{\partial P_{tp}}{\partial t} - V \cdot \nabla P_{tp}\right) = \left(\frac{1}{g}(V \cdot \nabla P)_{tp} - \frac{\omega}{g}\right) + \frac{1}{g}\frac{\partial P_{tp}}{\partial t}$$

ω=DP / Dt vertical velocity

P_{tp}:pressure of the tropopause

Calculation of STE ozone fluxes(ext.)

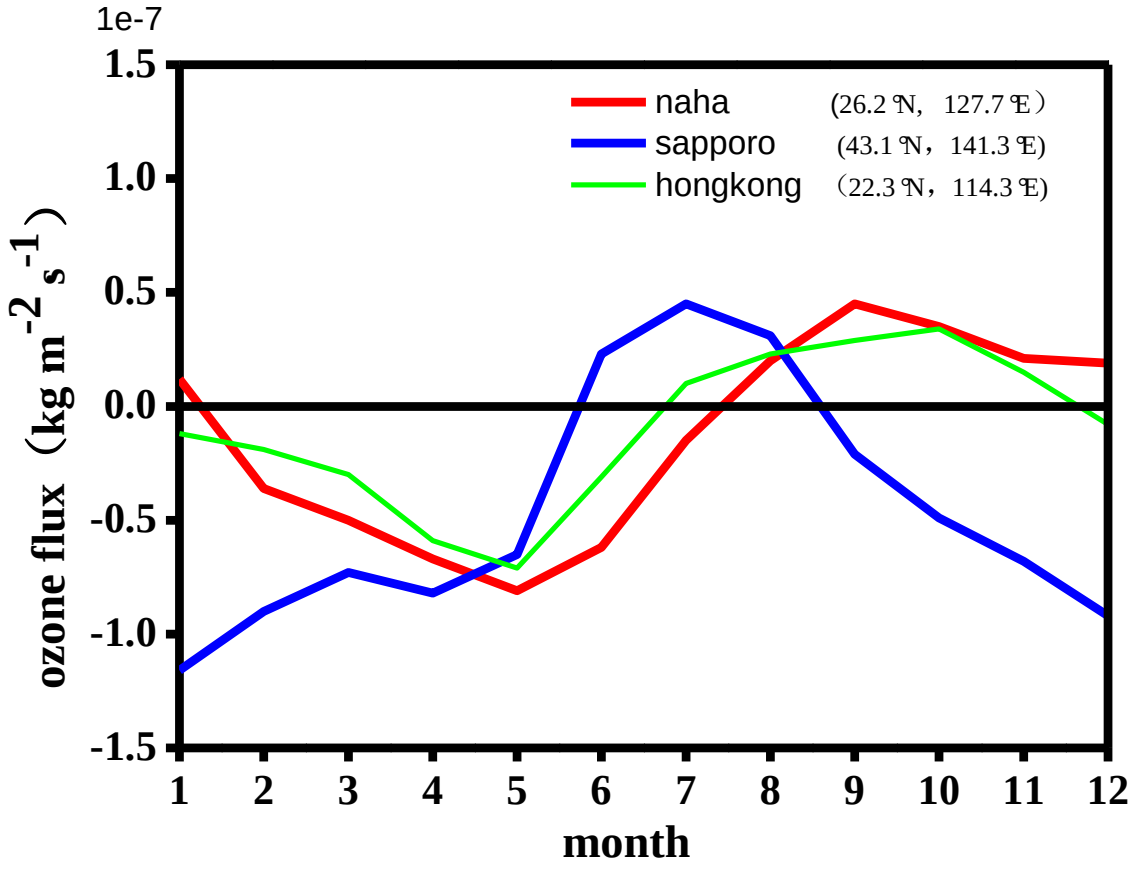
$$F(\rho) = -g^{-1}\left(\frac{DP}{Dt} - \frac{\partial P_{tp}}{\partial t} - V \cdot \nabla P_{tp}\right) = \left(\frac{1}{g}(V \cdot \nabla P)_{tp} - \frac{\omega}{g}\right) + \frac{1}{g}\frac{\partial P_{tp}}{\partial t}$$

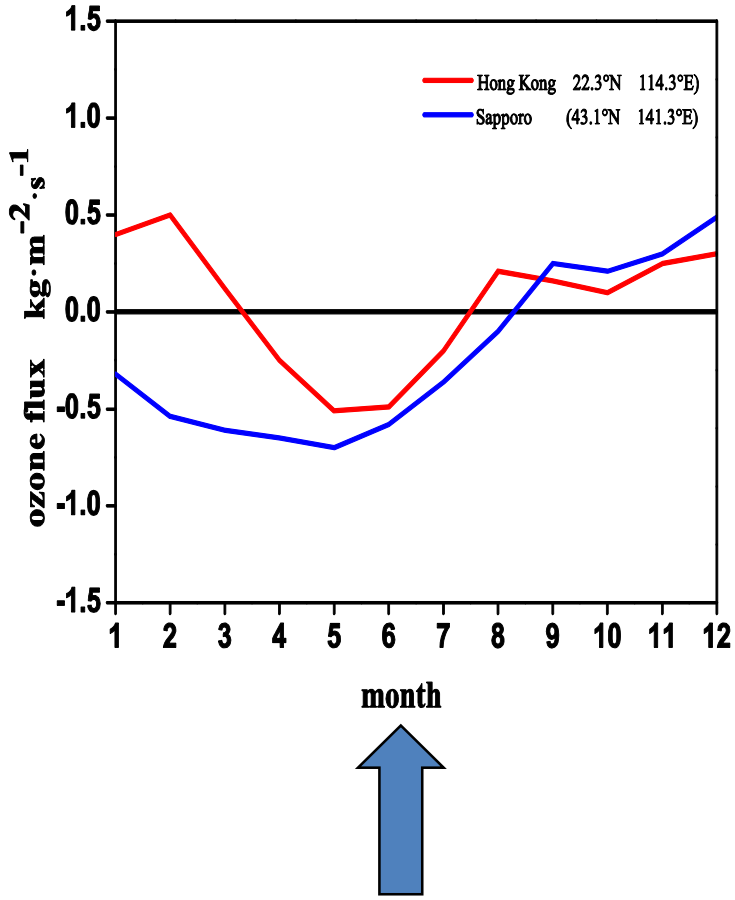
$$= F_{AM} + F_{TM},$$

F_{AM} represents the change caused by air motion, F_{Tm} represents the change of topopause lead to flux change. The former is critical.

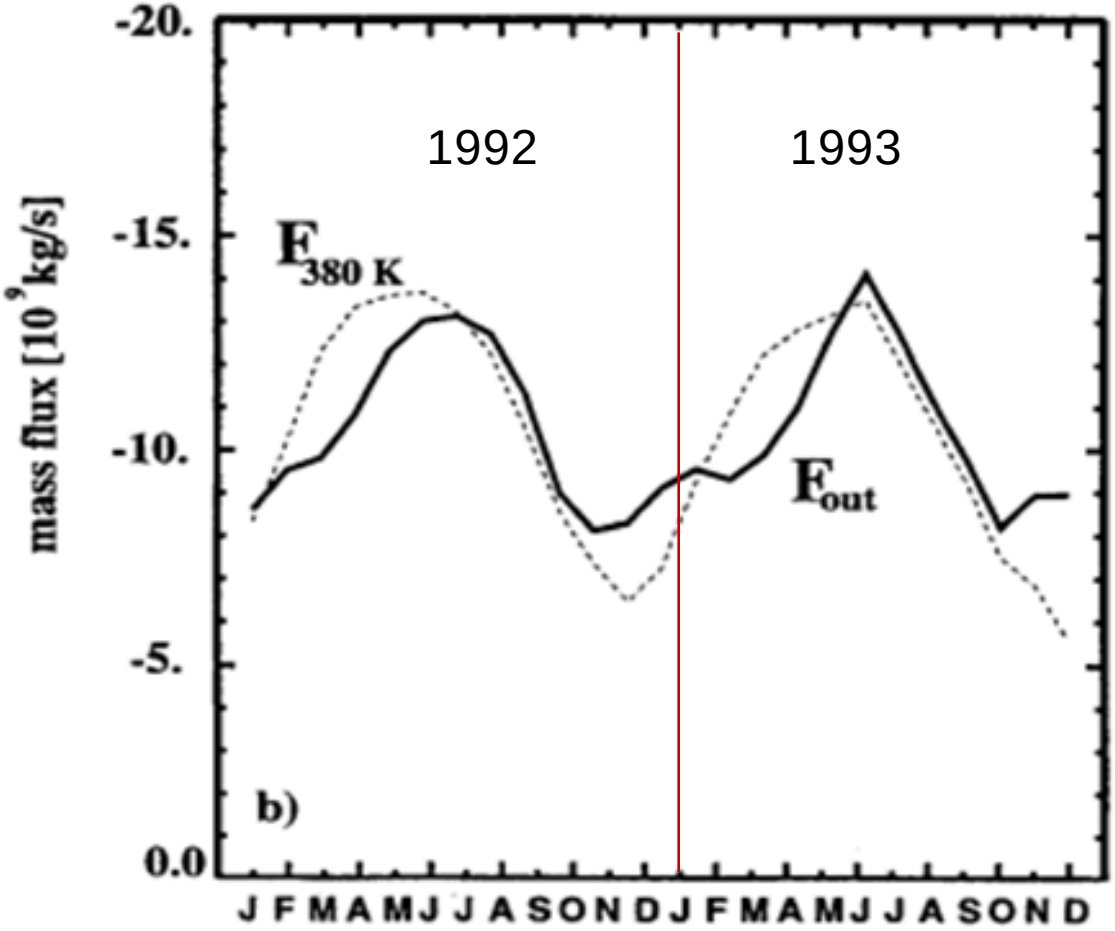
F_{AM}= → + ↑ (majority)

Ozone flux monthly mean



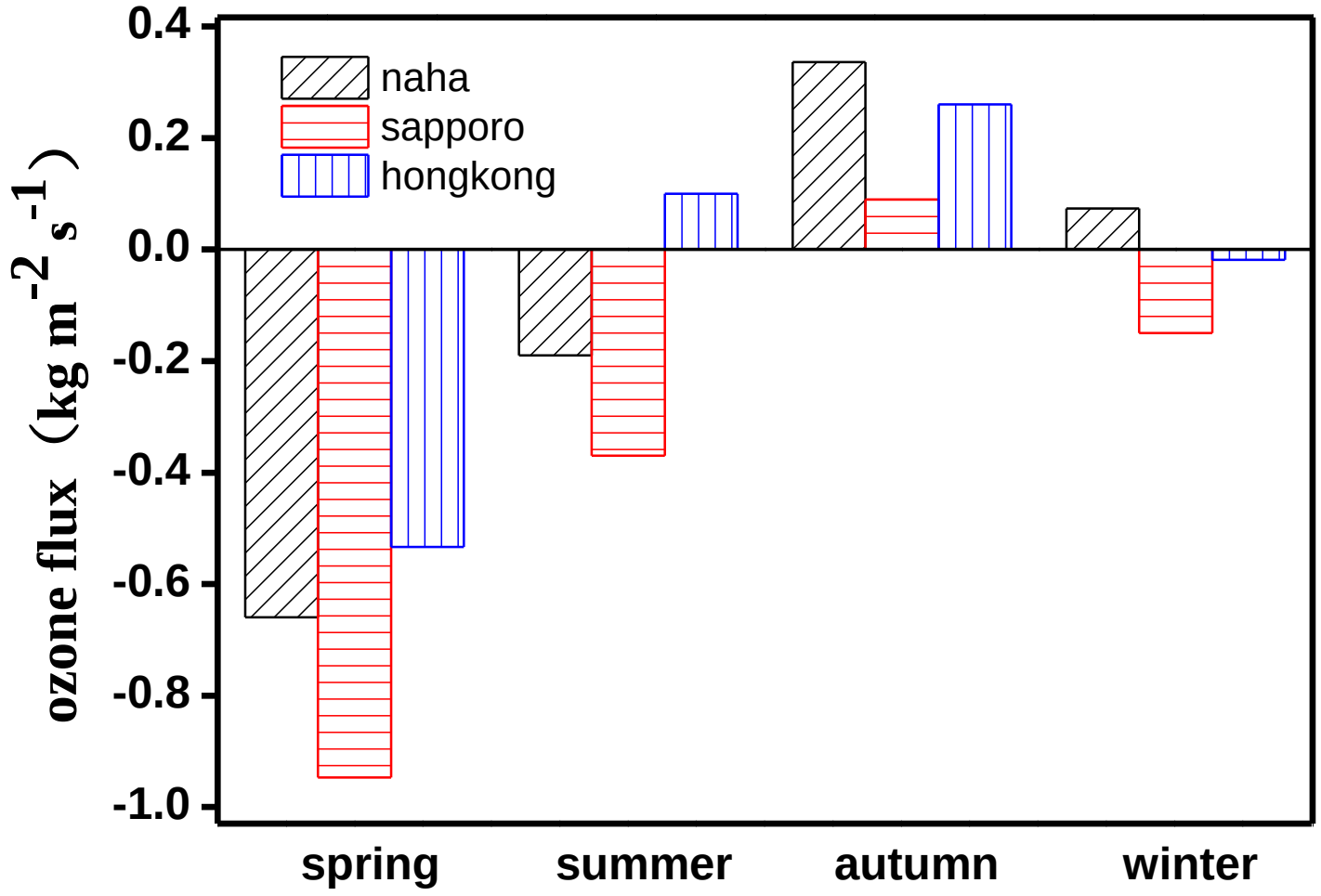


prior research

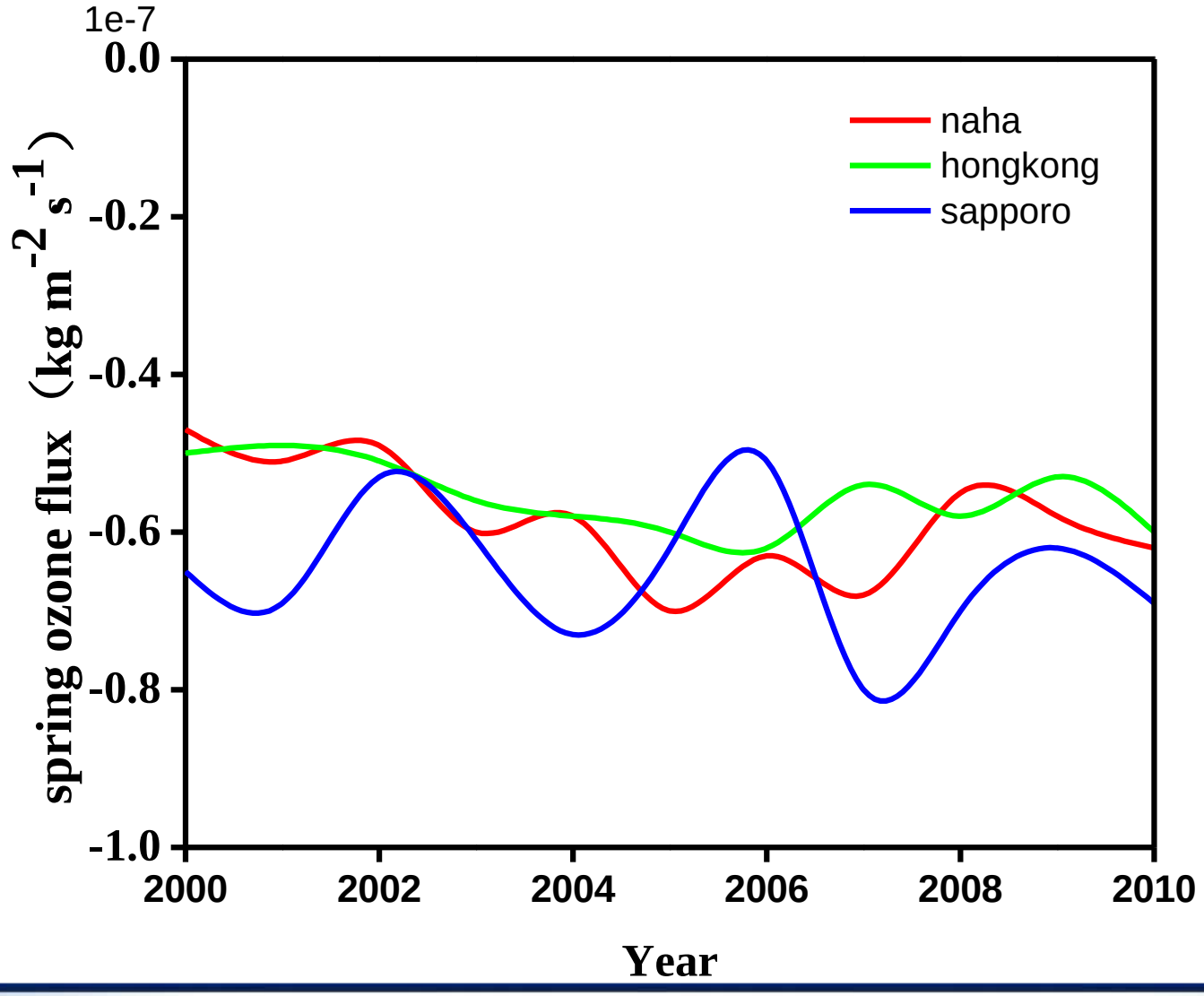


- Annual variation of the net downward mass transport across the extratropical tropopause (Fout, thick plain curve), the 380 K isentropic surface (F380, thin dashed curve), negative values denote downward mass flux. Taken from Appenzeller et al.[1996b]

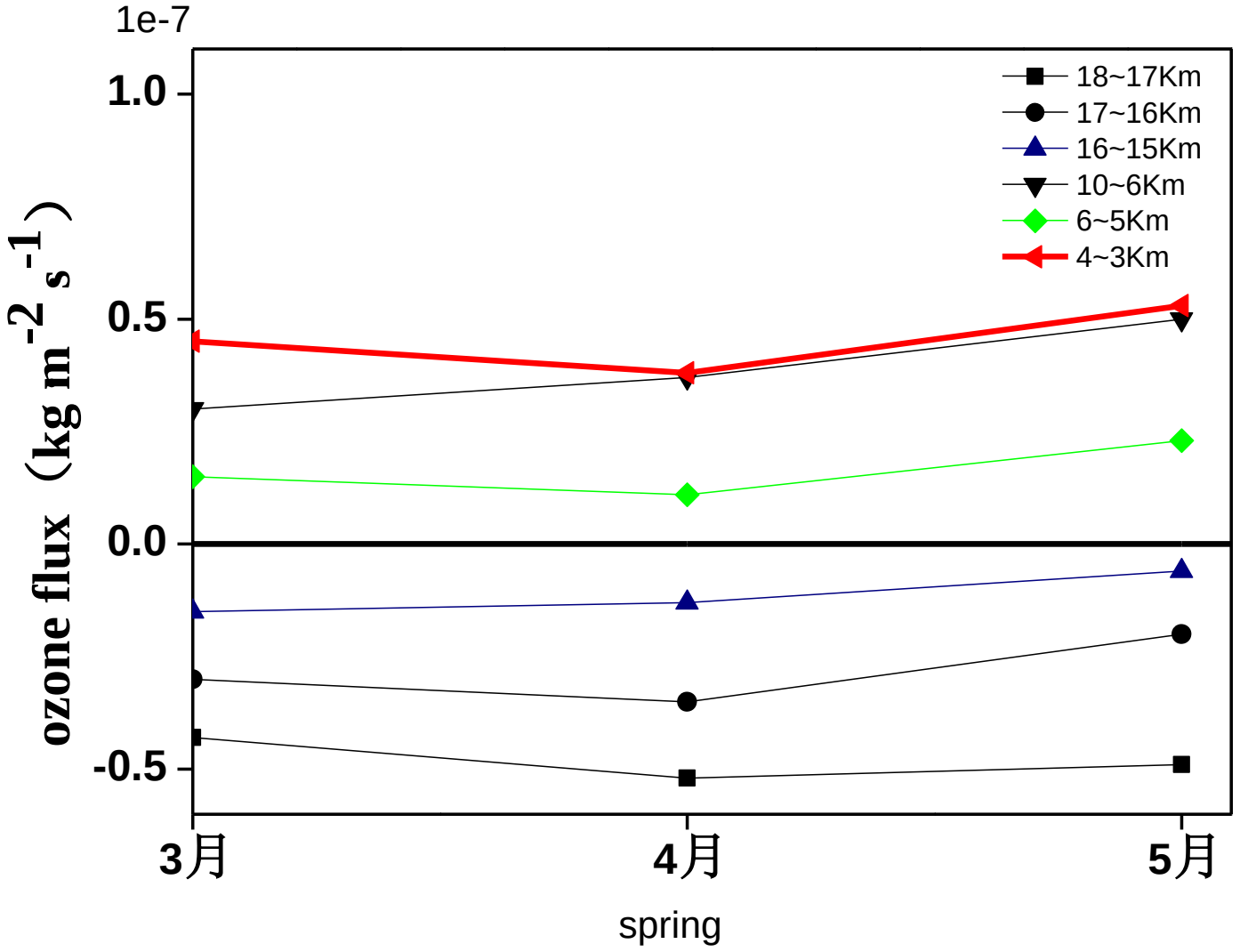
Seasonal variation



Annual variation



Vertical variation



Summary

- STE fluxes of ozone display different monthly mean variation along latitude. Hong Kong and Naha show similar behavior with most negative STE in Spring and largest positive STE in autumn. However, Sapporo shows totally different pattern with max in winter(S→T) and min in summer (T→S).
- Annual variation shows that stratosphere-to-troposphere ozone flux increases between 2000 and 2010.

Summary (cont.)

- In Spring, a strong downward STE flux is observed around the tropopause, decreased with decreasing height, then inversed around the middle part of troposphere (i.e., 5 km height).

On going work

- Tallied the results, try to explain what we have.

- Reading more references to help me better understanding the study and catch up with the recent development of research.

Thank you !