APO Work shop, SIO, 18-20 Sep. 2015

Spatiotemporal variability in APO in the western Pacific region observed from the NIES's observing network

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Outline

- NIES O_2 observation network
- Climatological variations of APO in the western Pacific (WP) (Tohjima et al., 2012 (GBC) + updated data)
  - Seasonal amplitude
  - Seasonal phasing
  - Annual mean APO
- Inter-annual variation in the annual mean APO in WP (Tohjima et al., 2015 (Tellus) + updated data)

NIES flask O_2 measurement network

North America:
Pyxis, f: 2001/12~2007/8
Skaubryn, f: 2005/5~2010/7
Pyxis, f: 2012/5~2013/4
New Century-2, f: 2014/6~

COI:
f: 1998/12~
i: 2005/3~

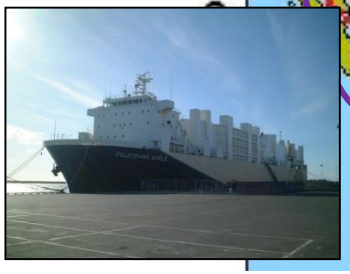
HAT:
f: 1997/7~
i: 2006/10~

SIO:
f: 2010/2~

MNM:
f: 2011/9~

（MLO
2010/5~）

f: flask; i: in-situ

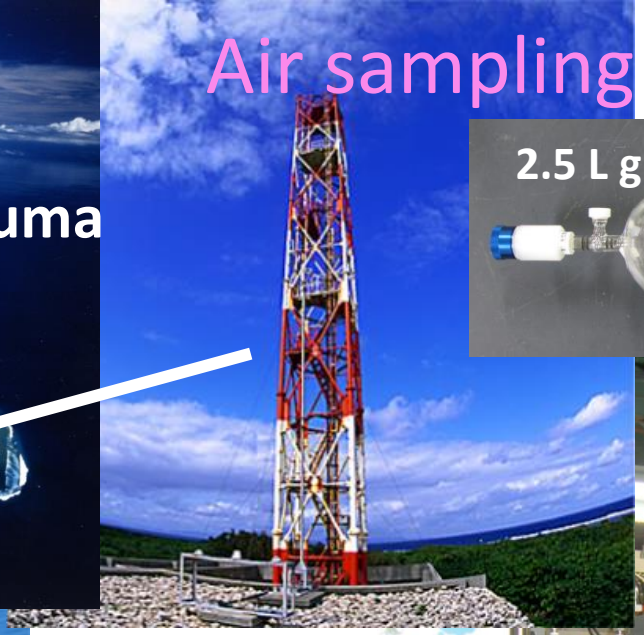


Australia/New Zealand:
MOL Golden Wattle, f: 2001/12~2002/5
MOL Glory, f: 2002/7~2003/2
Fujitrans World, f: 2003/2~2005/7
Trans Future-5, f: 2005/11~; i: 2007/9~

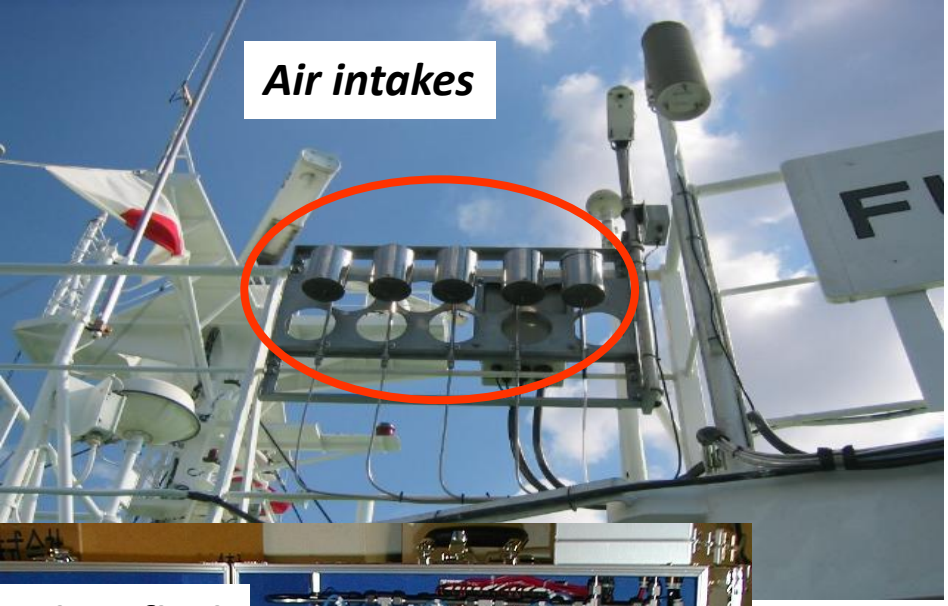
Southeast Asia:
Trans World, f: 2007/9~
Trans Future-1, f: 2010/11~2014/3

60N
40N
20N
90E
120E
150E
180
150W
120W
90W

Air sampling at ground sites

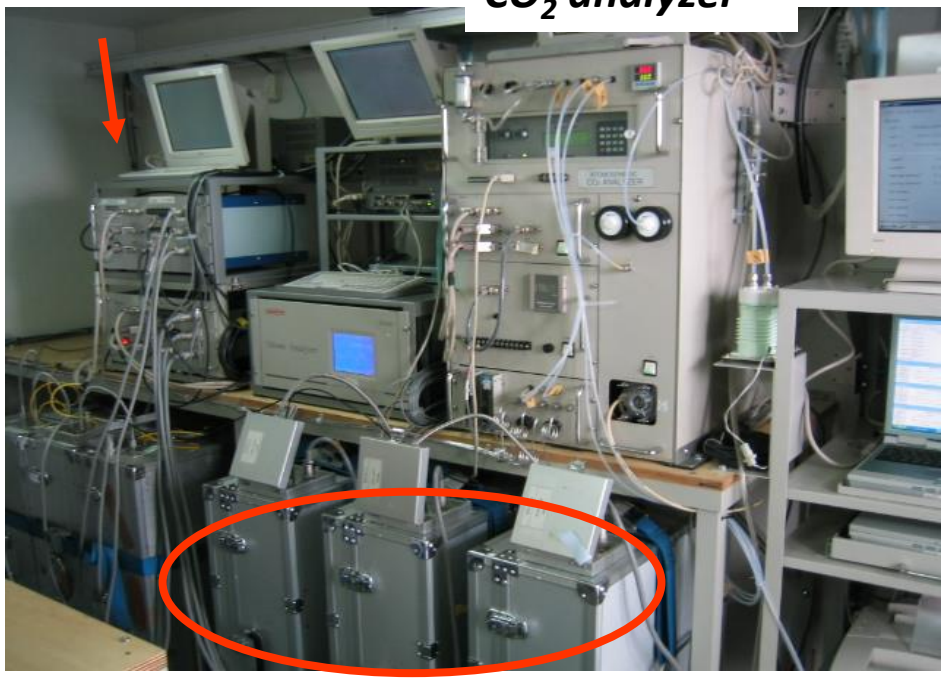


Automated flask sampling system

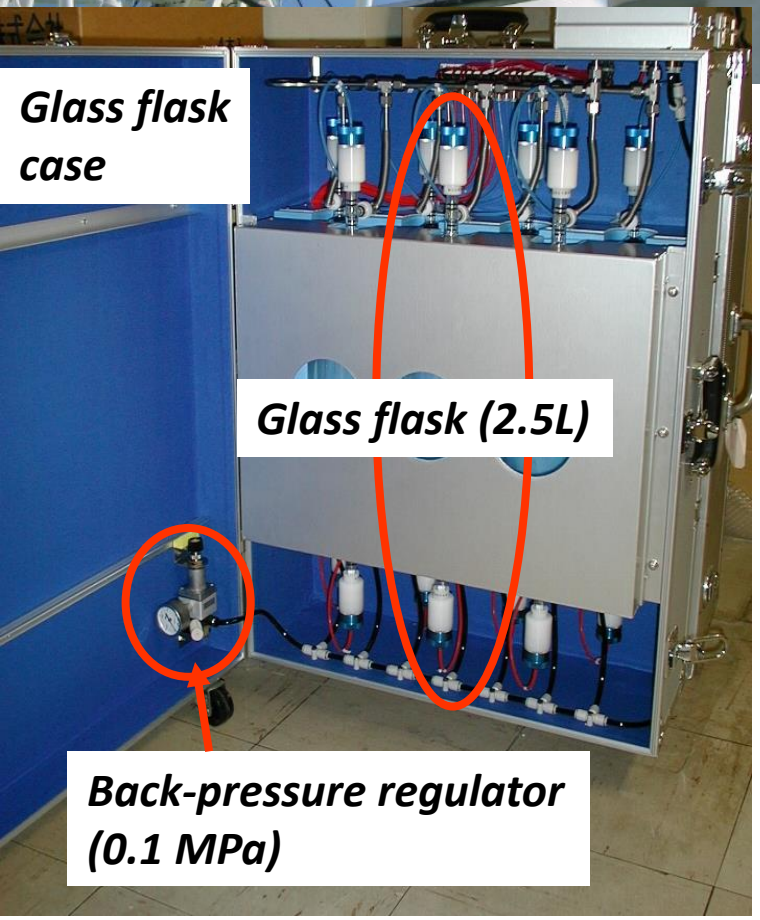


Sampling controller

CO_2 analyzer

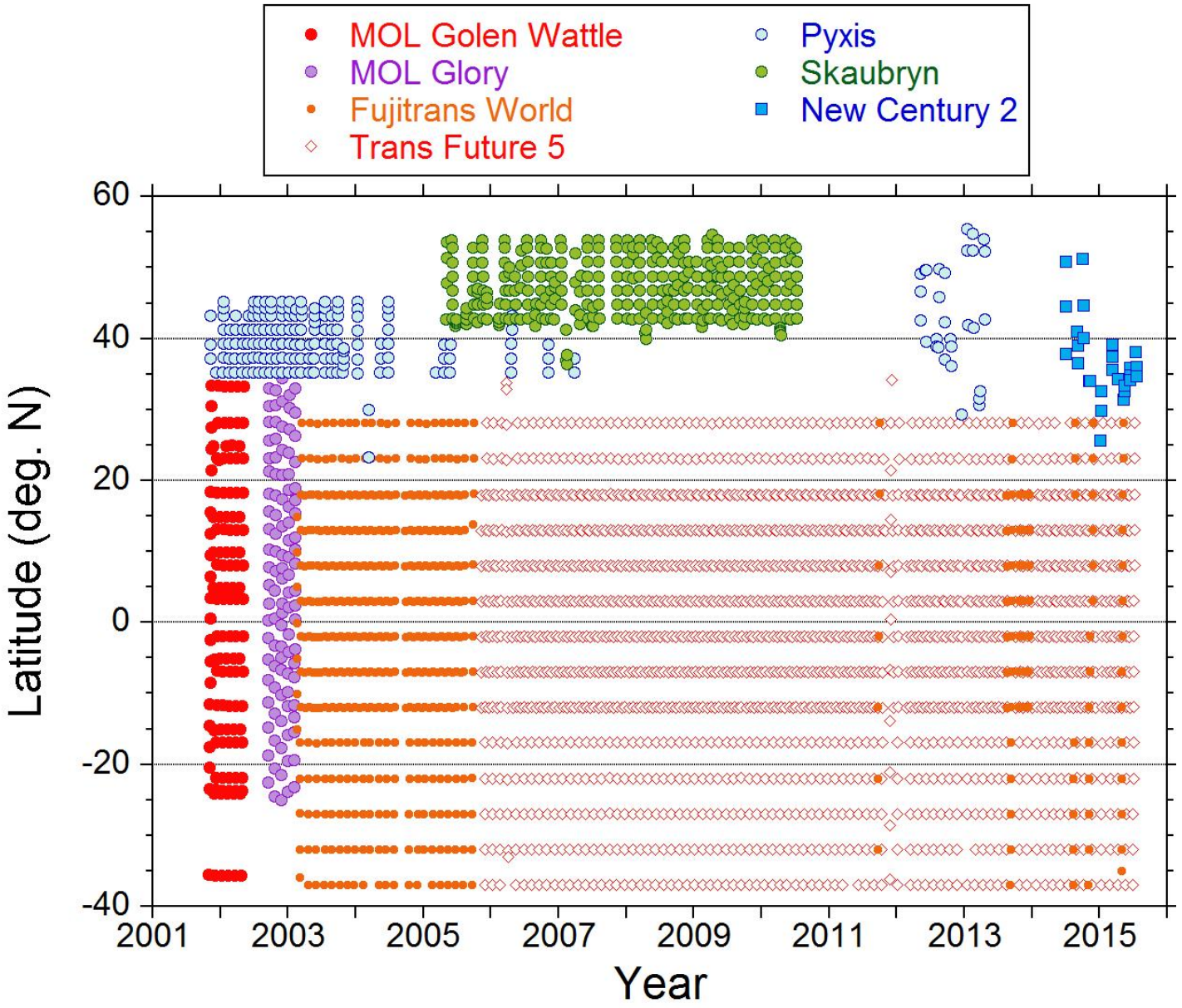


Glass flask case

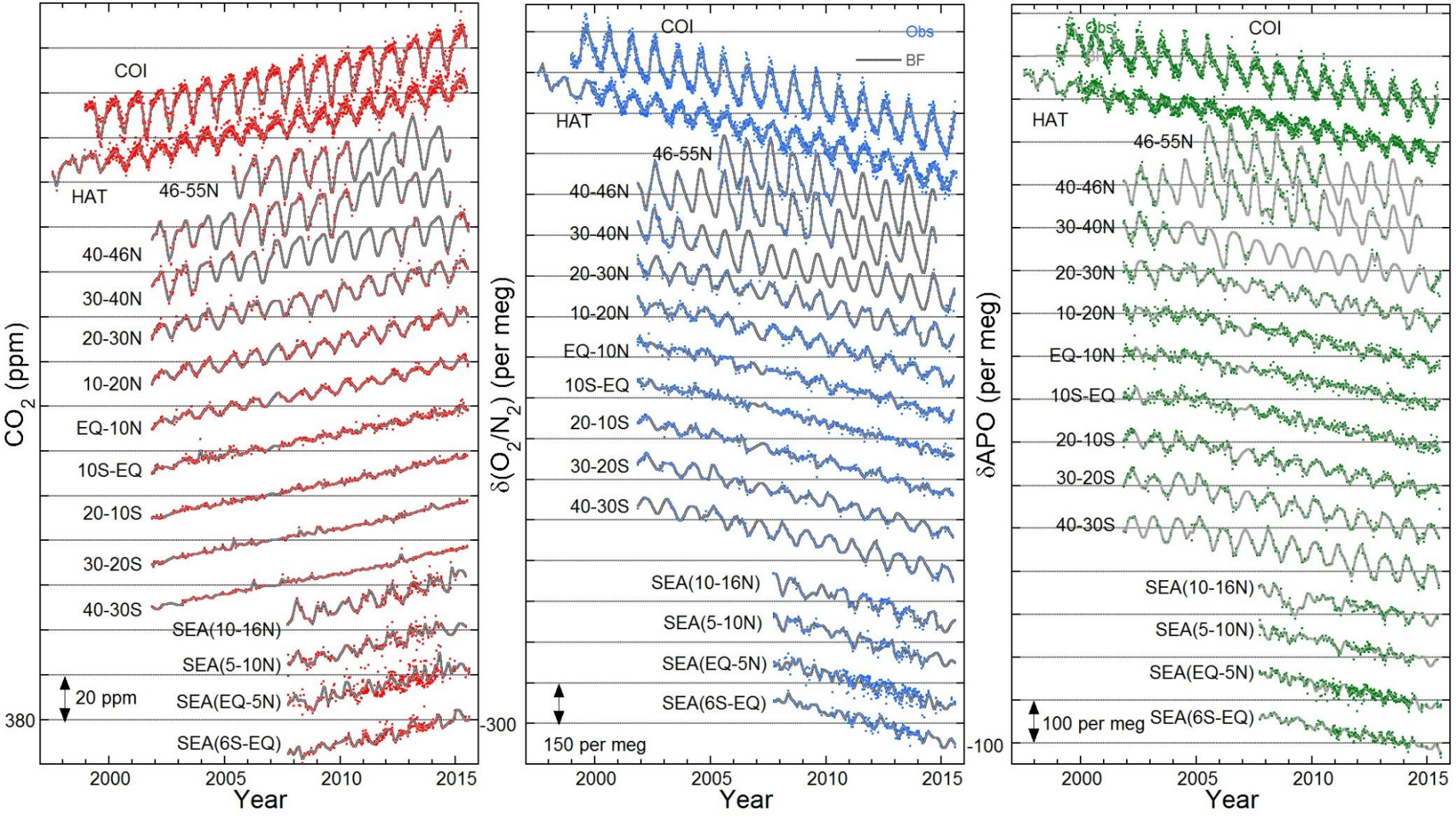


Cold traps (-40C)

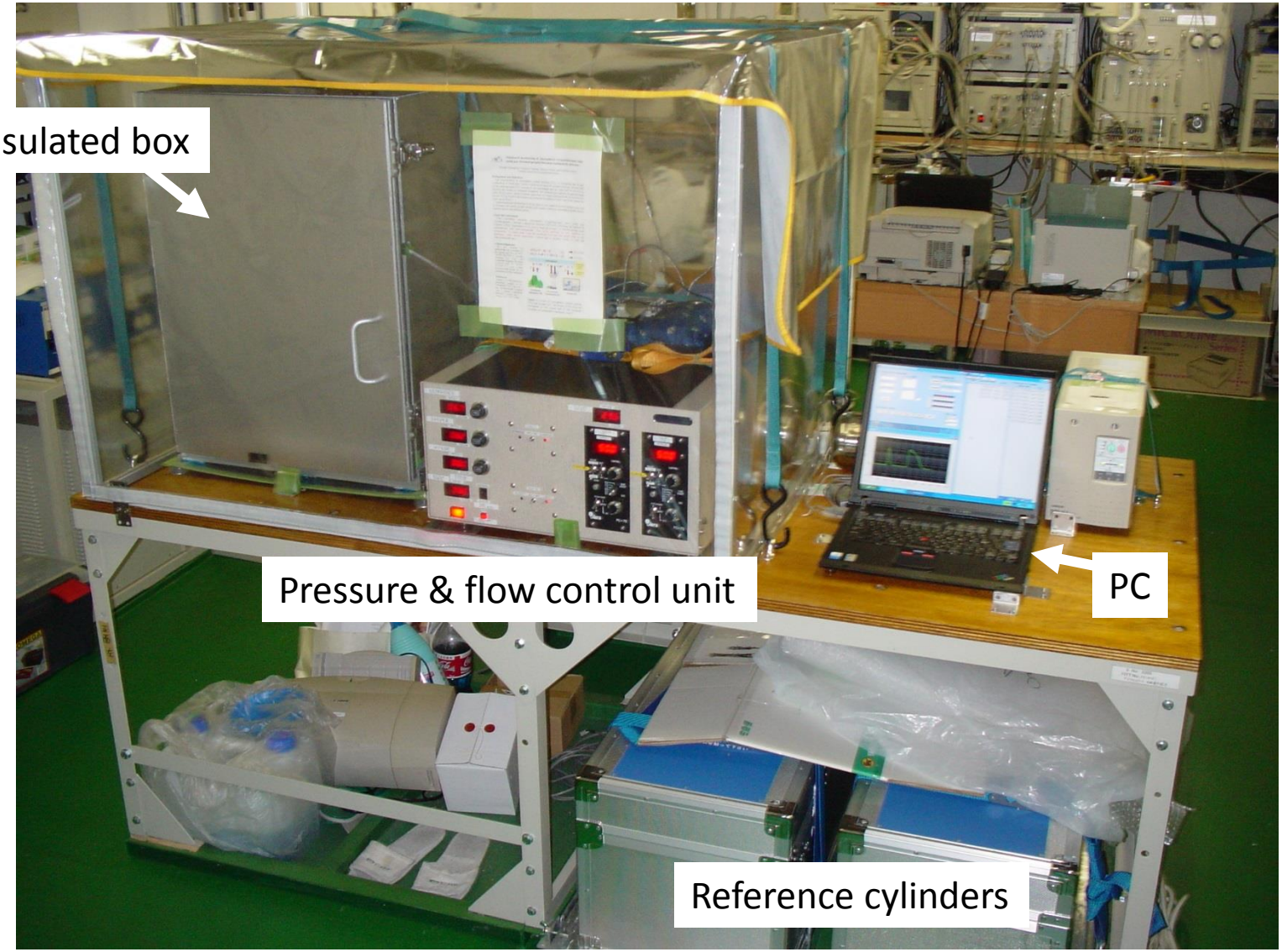
Distribution of shipboard sampling sites in the western Pacific



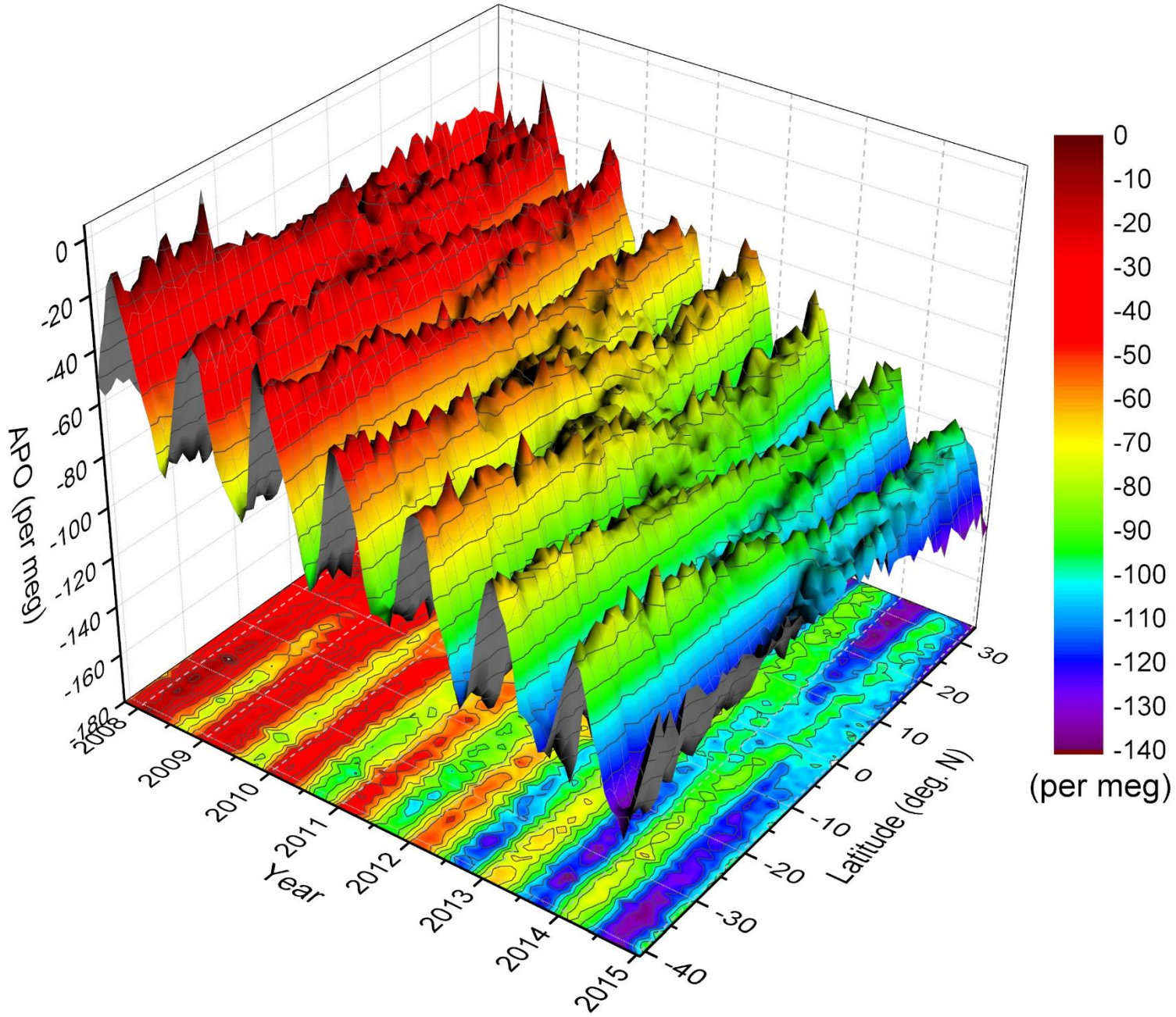
Observation from NIES Flask Network



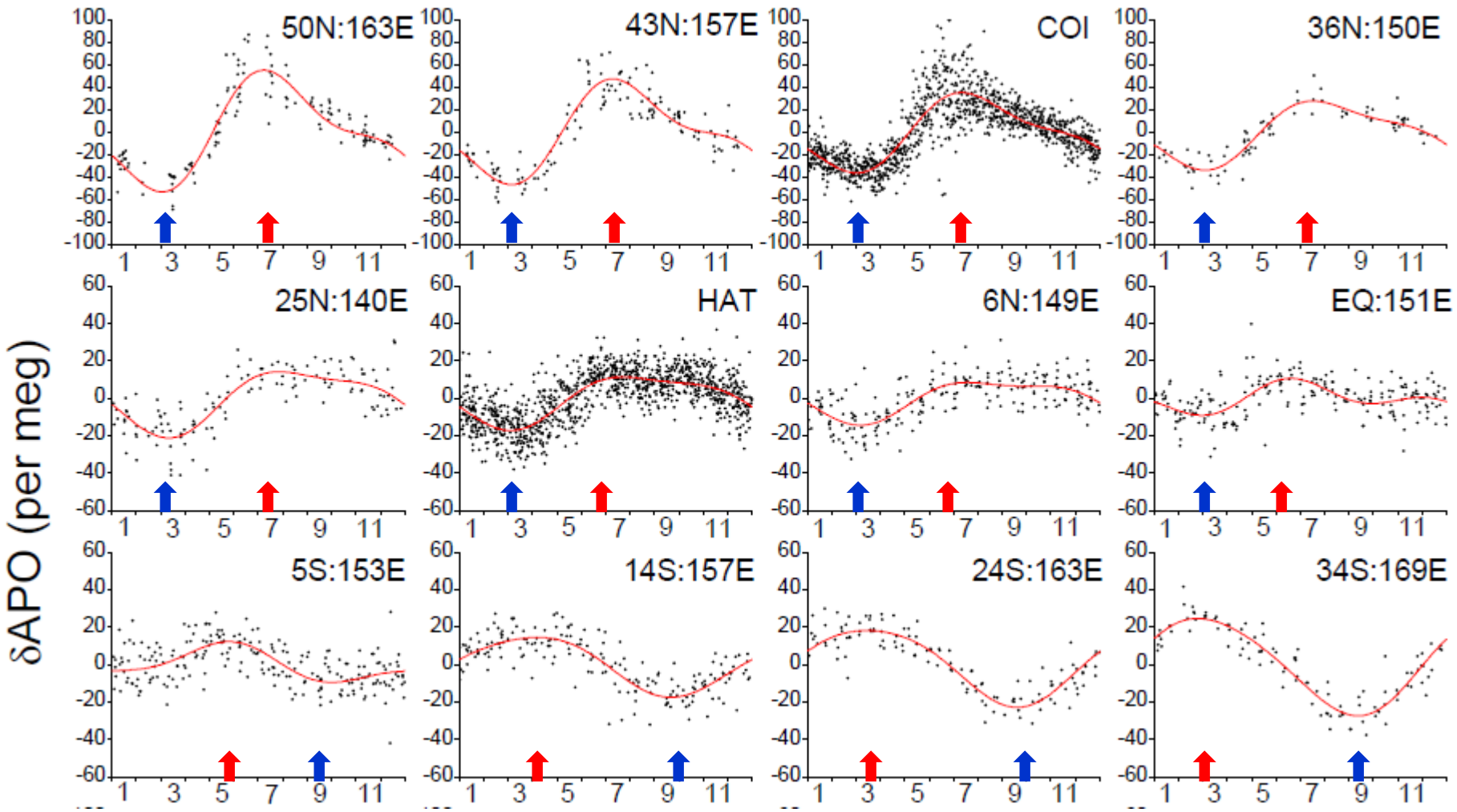
Onboard measurements of O_2/N_2 by GC/TCD (Yamagishi et al. 2012, JGRa)



Time-latitude surface of monthly APO based on in-situ measurements



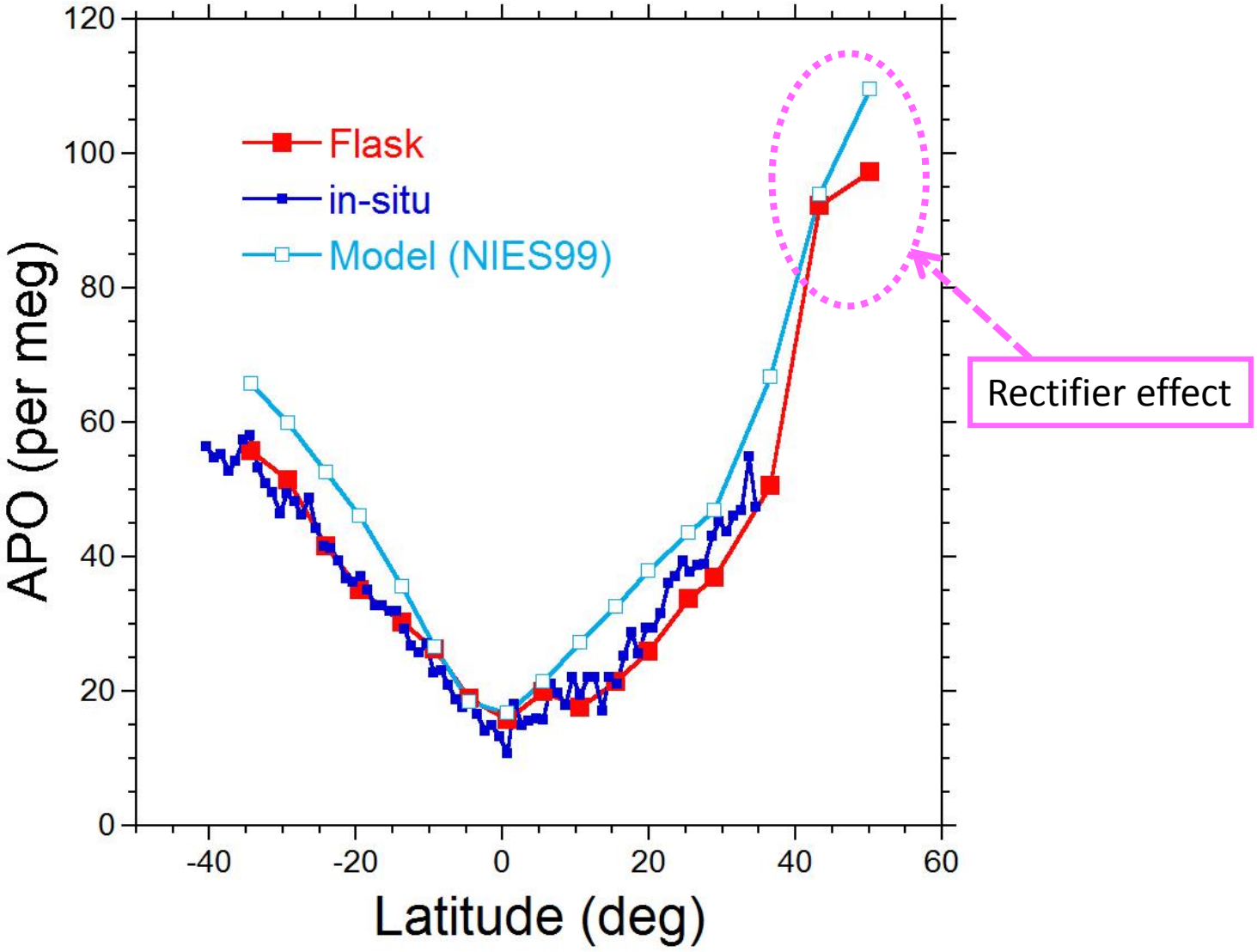
Seasonal cycle of APO in the western Pacific region



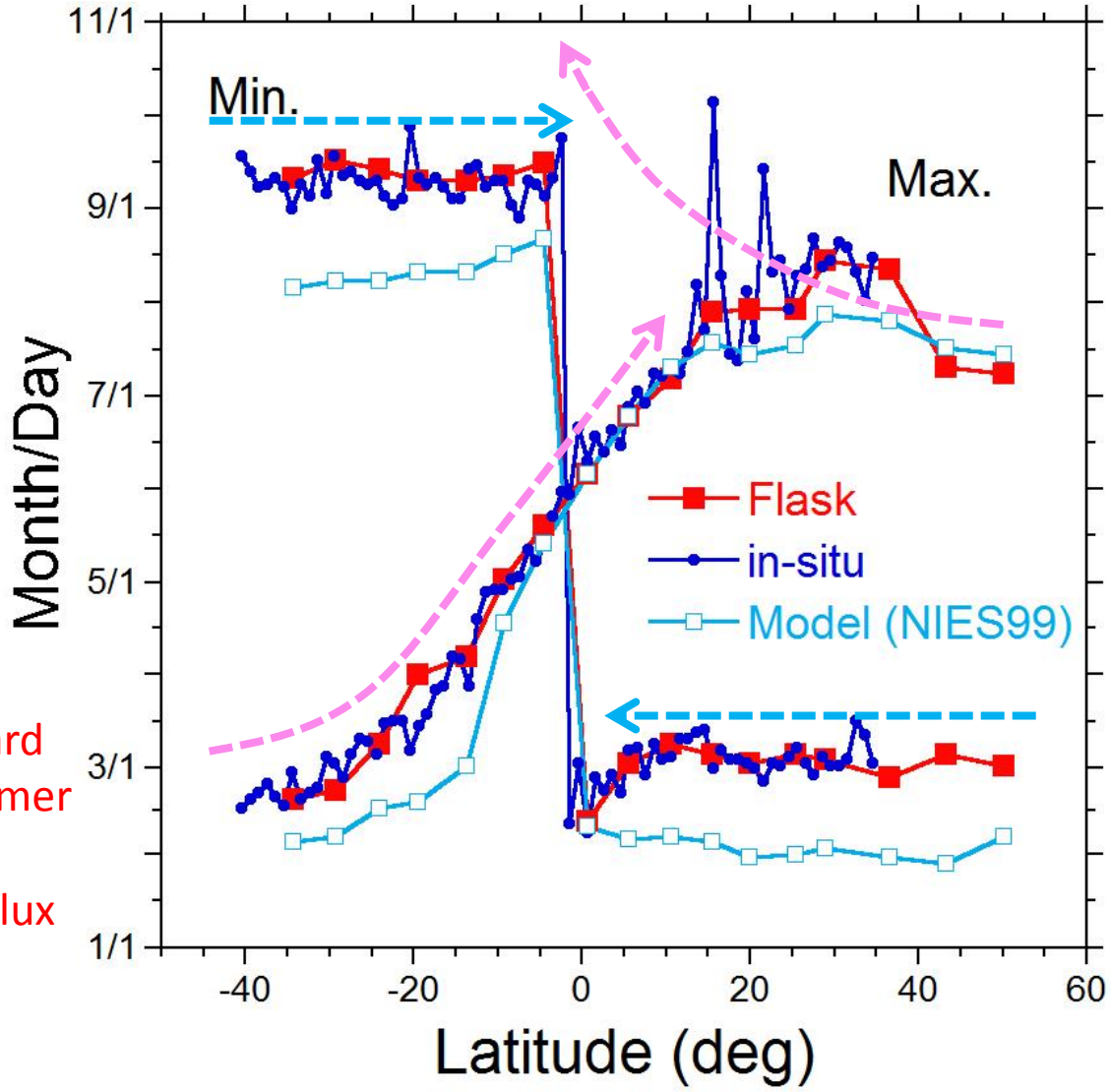
Atmospheric transport model, meteorological data and fluxes used for the APO simulation

✓ Atmospheric transport	NIES99 TM Maksyutov and Inoue (2000) (with 2.5x2.5 horizontal resolution with 15 sigma levels)
✓ Meteorological data	JCDAS25 reanalysis data
✓ Ocean fluxes	
– O_2 annual mean	Gruber et al. (2001)
– N_2 annual mean	Gloor et al. (2001)
– O_2 seasonal anomaly	Garcia & Keeling (2001)
– N_2 seasonal anomaly	Blaine (2005)
– CO_2 monthly mean	Takahashi et al. (2002) and (2009)
✓ Fossil fuel O_2 and CO_2 fluxes	CDIAC(2006) (Andres, et al., 2009) Keeling (1988)

Latitudinal distribution of seasonal amplitude in the western Pacific



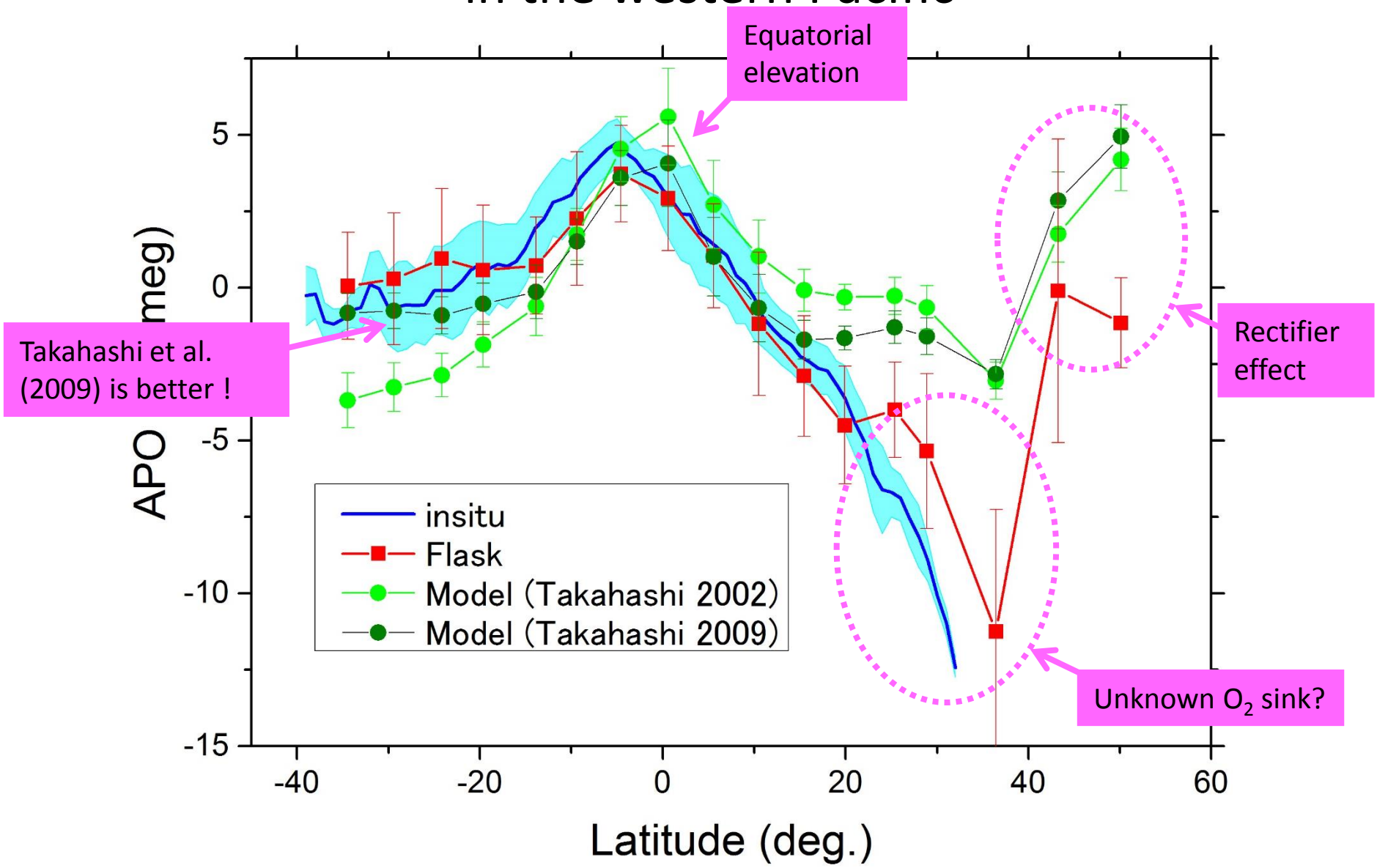
Latitudinal distribution of seasonal max. and min. in the western Pacific



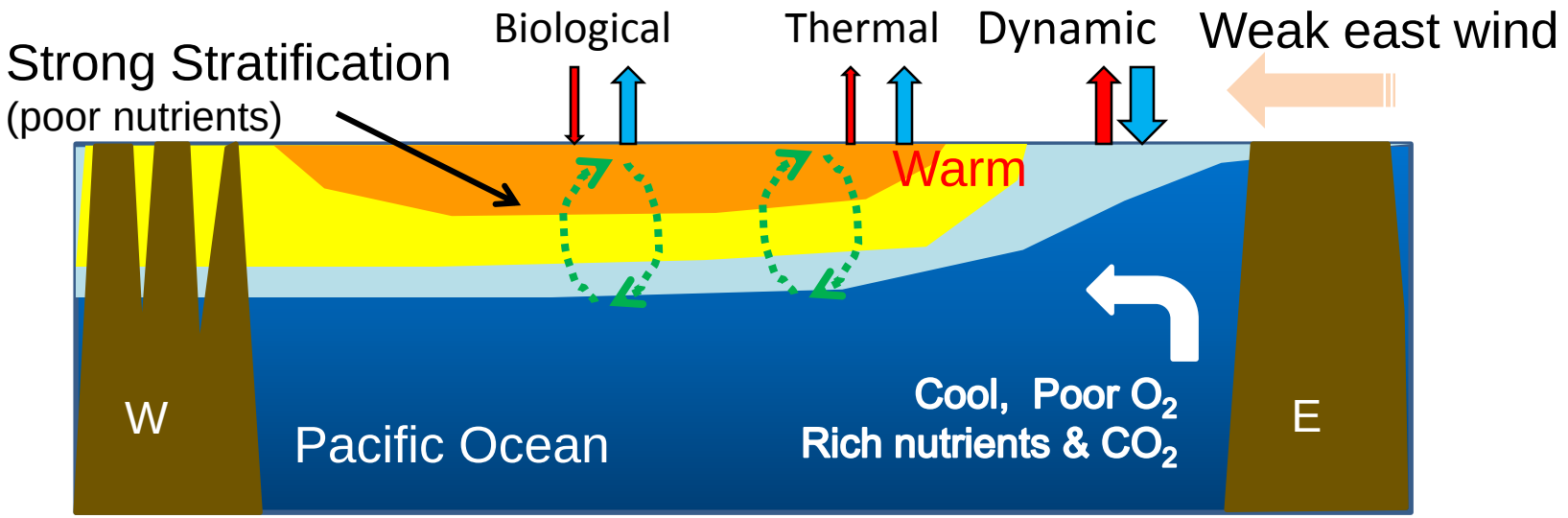
Weak equatorward transport in summer
+
Larger seasonal flux in SH

Strong equatorward transport in winter

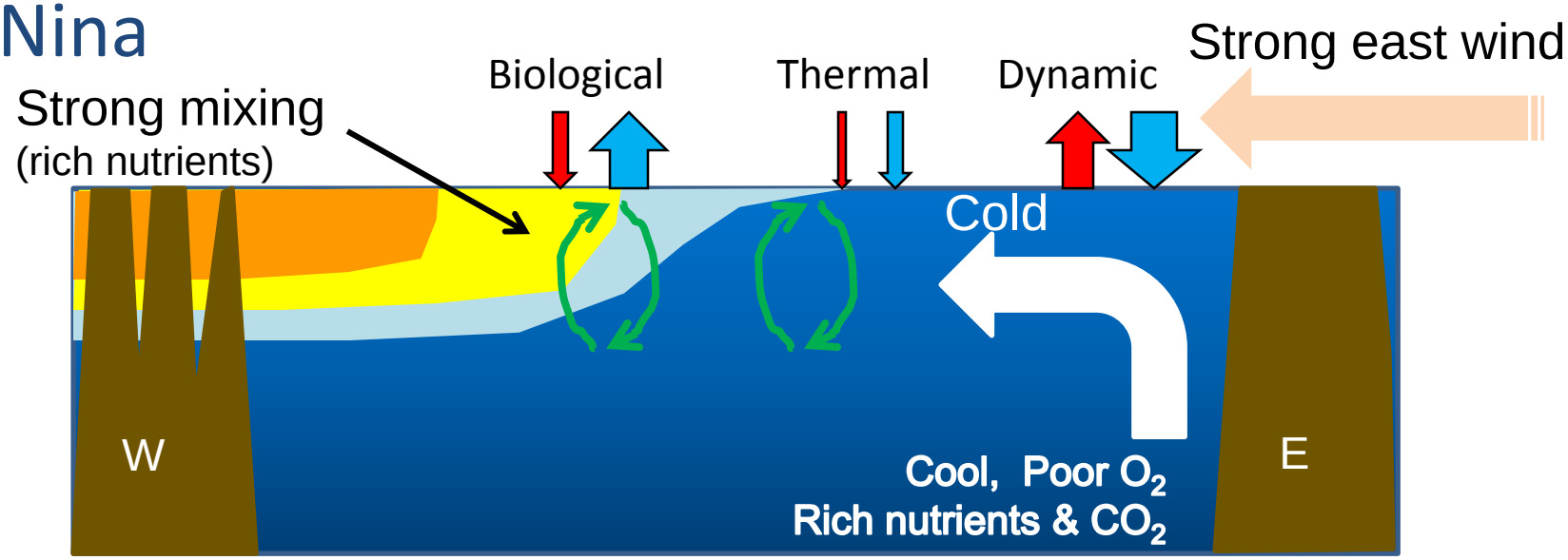
Latitudinal distribution of annual mean APO in the western Pacific



El Nino



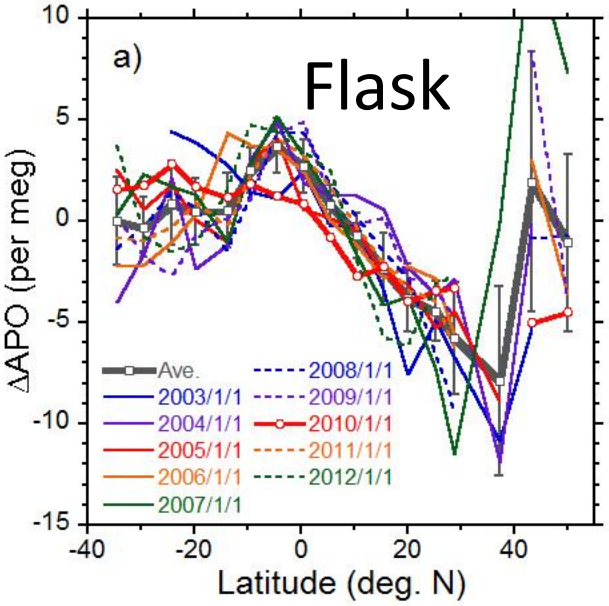
La Nina

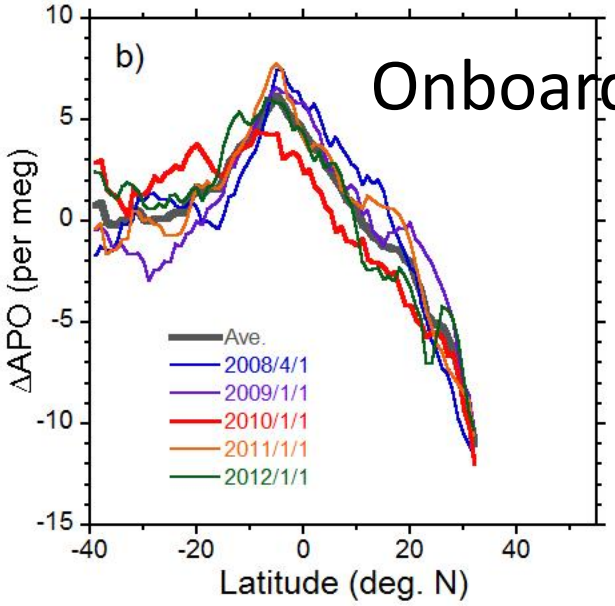


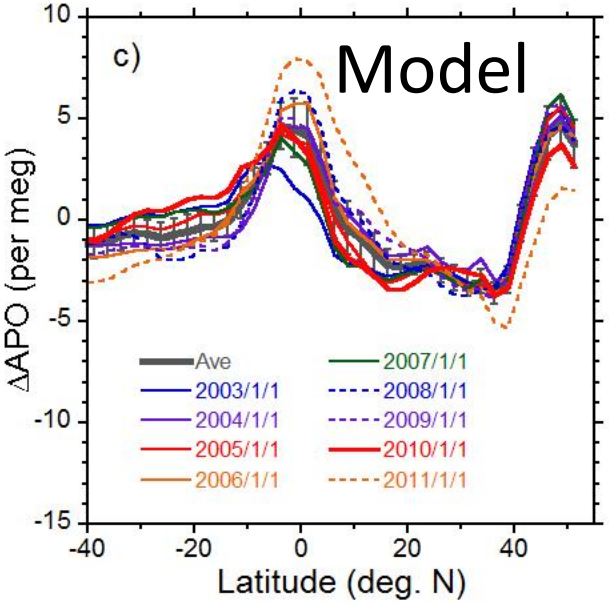
Question

- Does ENSO cycle influence the magnitude of the equatorial APO bulge?
  - Does El Nino event enhance or suppress the APO emissions from the tropical Pacific ocean? How about La Nina?

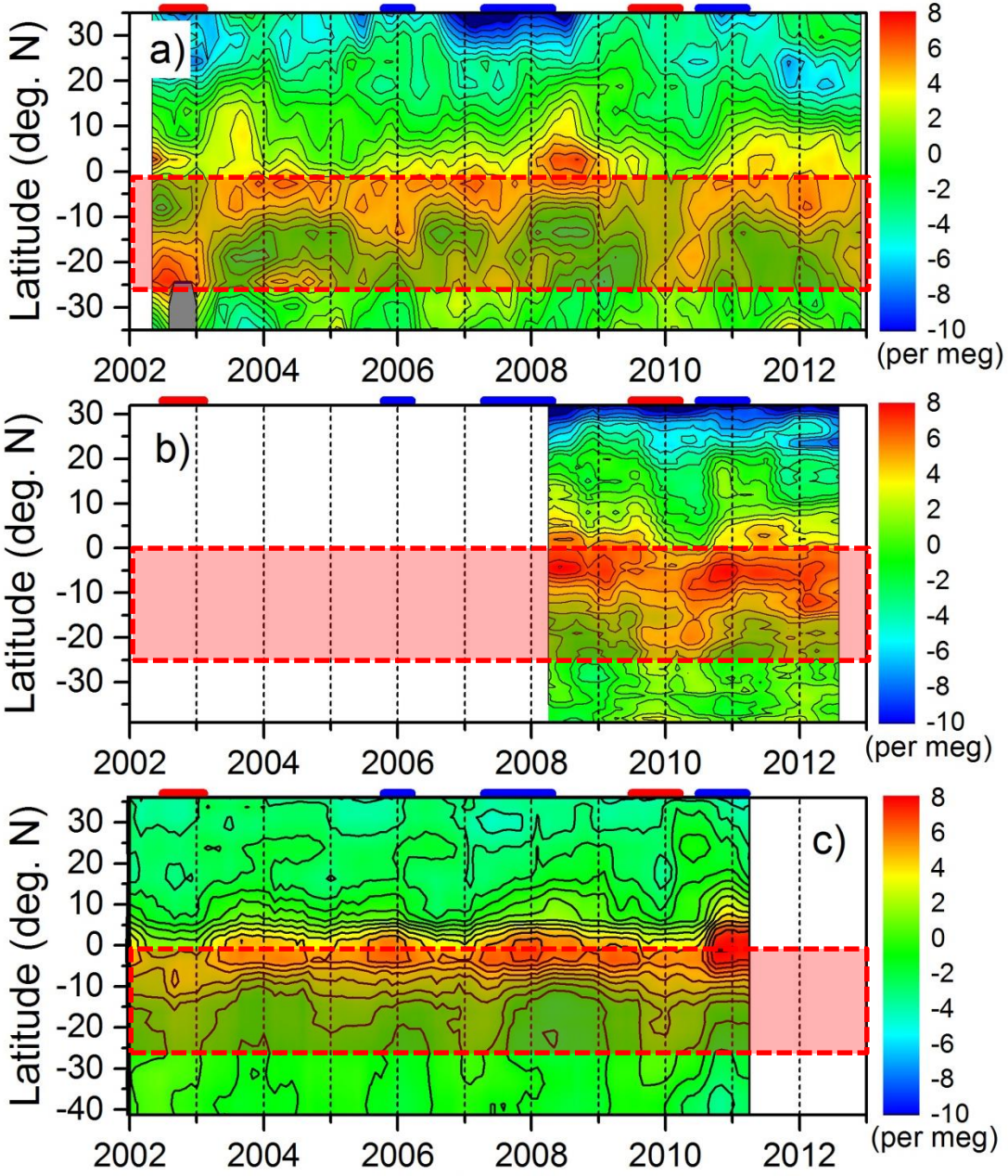
Latitudinal distribution of annual mean APO







Time-latitude distribution of annual mean APO



Flask

In-situ

Model

Temporal variations in annual mean APO gradients and Nino 4 index

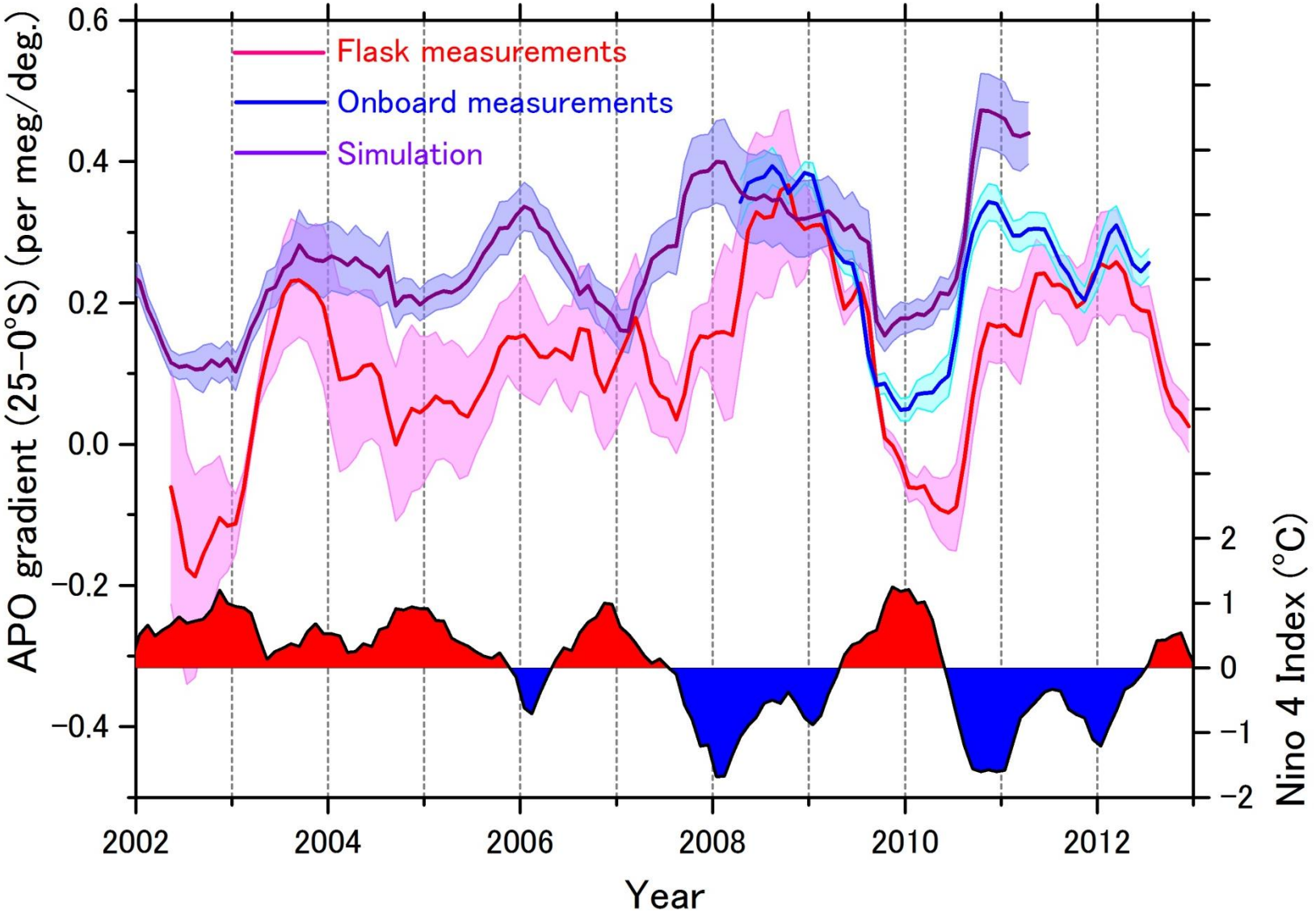
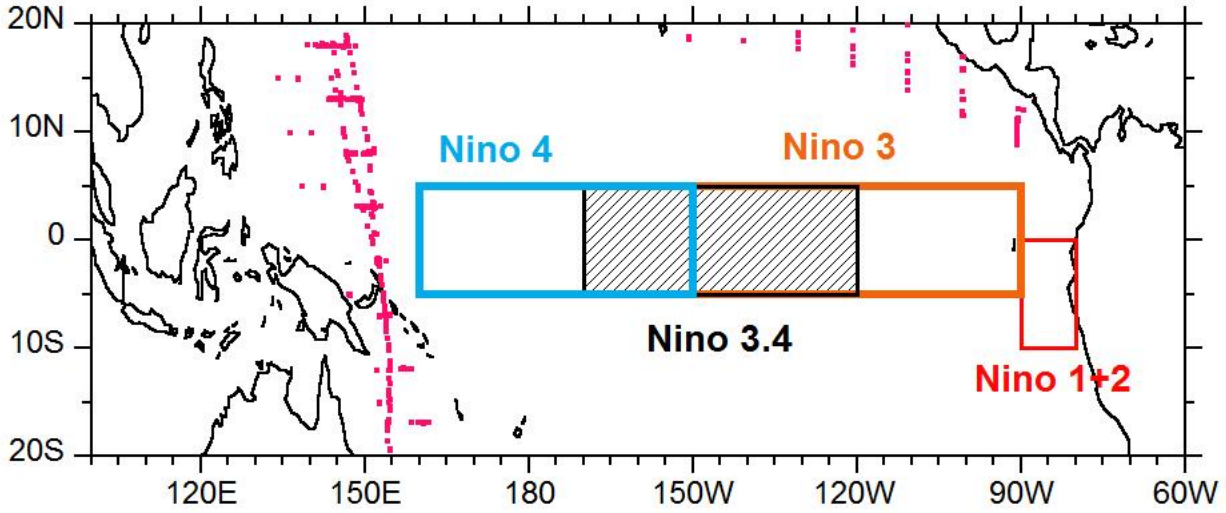


Table 2. Correlation coefficients between the APO gradients and ENSO indices

ENSO index	Flask		Shipboard		NIES-TM	
or NIES-TM	Zero-lag[a]	Lagged[b]	Zero-lag[a]	Lagged[b]	Zero-lag[a]	Lagged[b]
Nino 1+2	0.17(0.06)	-0.34(+10)	-0.03(0.86)	-0.38(+7)	-0.26(0.01)	-0.51(+3)
Nino 3	-0.28(0.00)	-0.50(+5)	-0.46(0.00)	-0.68(+3)	-0.70(0.00)	-0.78(+2)
Nino 3, 4	-0.49(0.00)	-0.65(+4)	-0.65(0.00)	-0.80(+3)	-0.84(0.00)	-0.87(+1)
Nino 4	-0.55(0.00)	-0.69(+4)	-0.76(0.00)	-0.84(+2)	-0.88(0.00)	-0.90(+1)

[a]Values in parentheses are p-values.

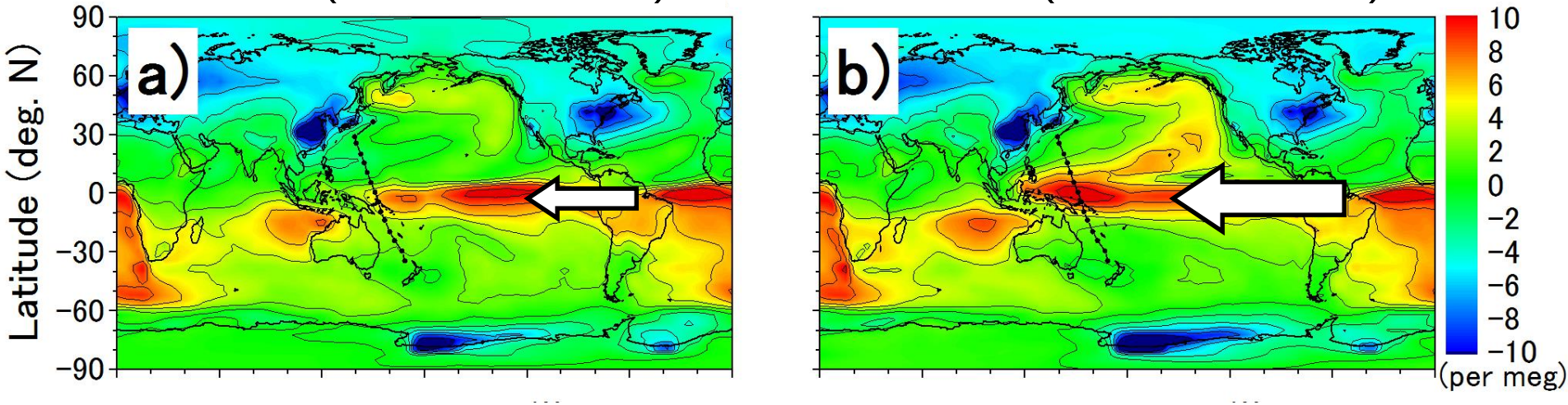
[b]Values in parentheses are lag times which give the best correlation coefficients.



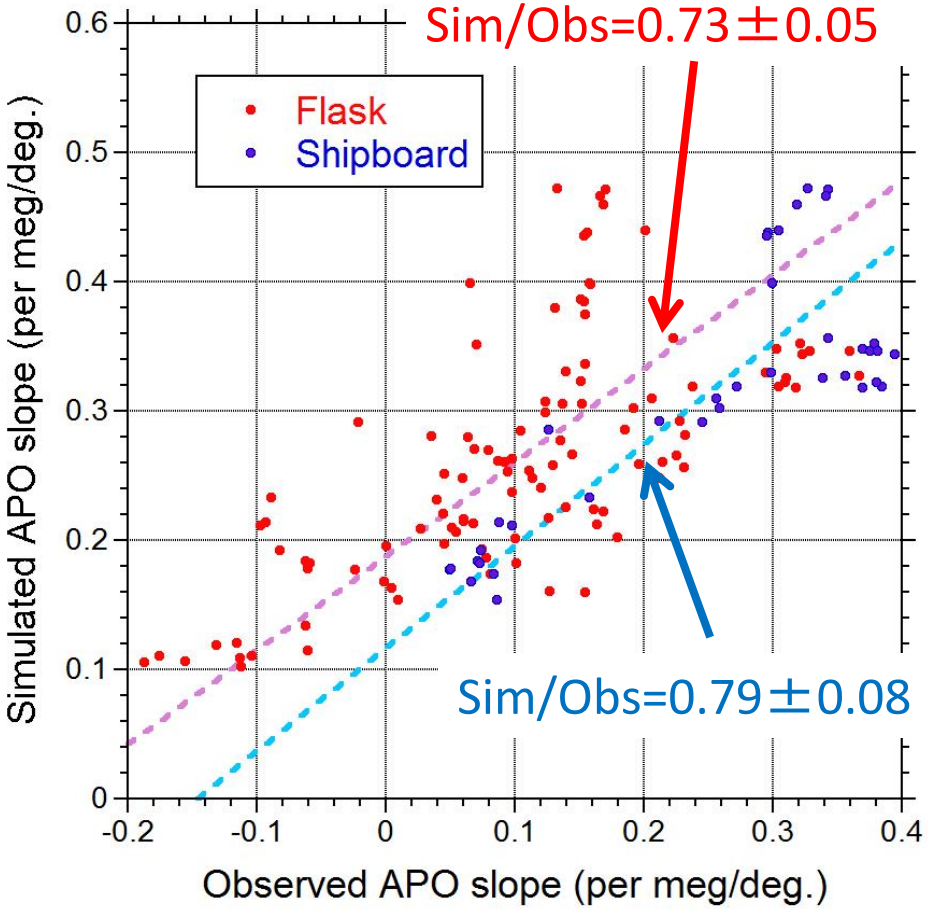
Influence of the atmospheric transport on the equatorial APO bulge

El Niño
2010/1 (2009/7 – 2010/6)

La Niña
2011/1 (2010/7 – 2011/6)



Relationship between simulation and observation



Model results underestimate by 20~30%

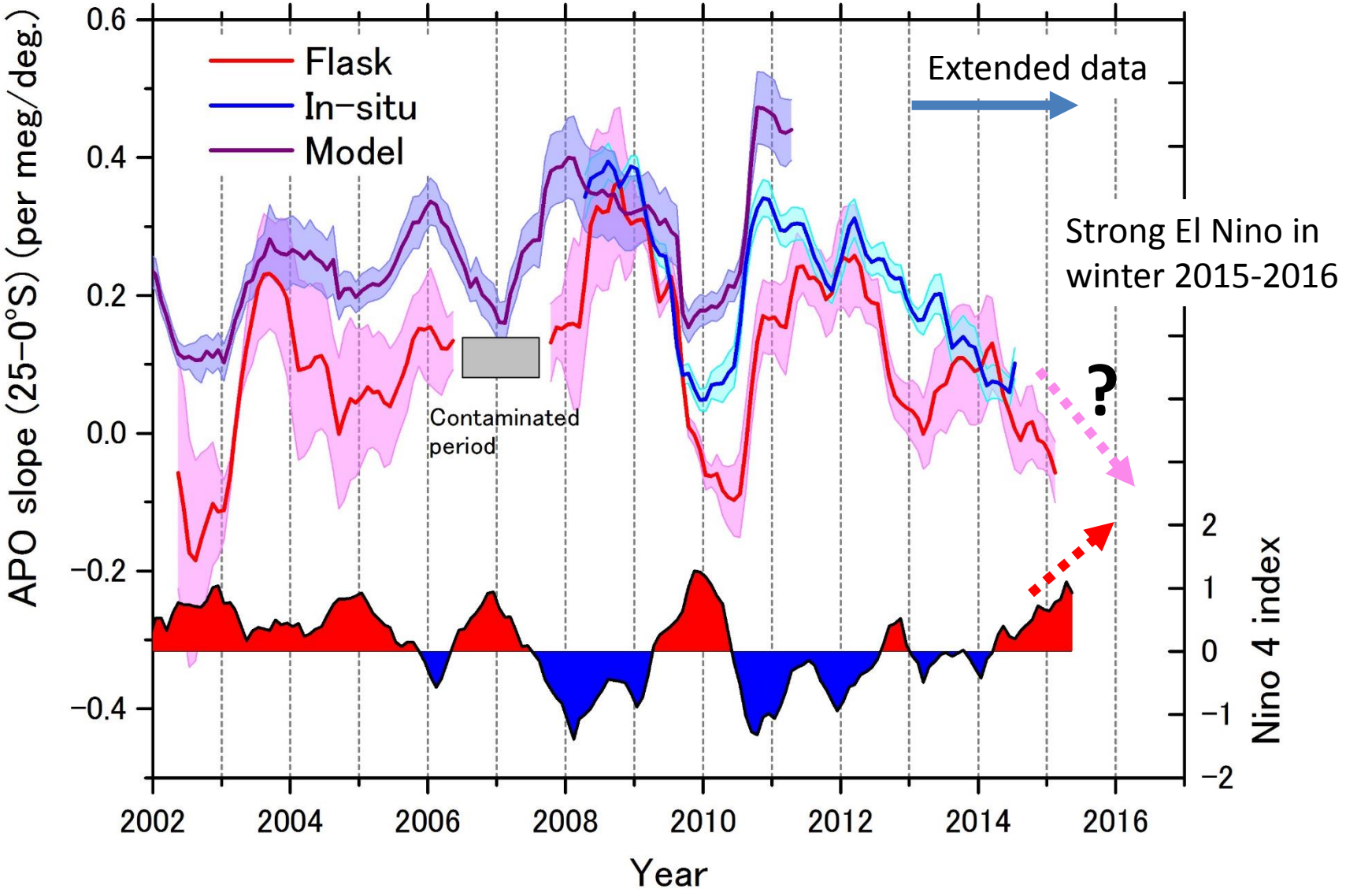
⇩

Variations of ~±0.03 per meg/deg. might be attributed to the flux variations

⇩

Based on the sensitivity experiments, the estimated APO fluxes from the tropical Pacific region are ±10 Tmol O_2/yr or ±23 Tmol CO_2/yr

Updated change in the APO slope



Summary

- Our observation is useful to study the spatio-temporal variability in the APO in the western Pacific region.
- Since atmospheric transports considerably affect the spatio-temporal variability of surface APO, sophisticated transport models are required to study the air-sea gas exchange in depth.

Thank you for your attention.
ご清聴ありがとうございました。