SIB4 COS & CO2 fluxes, and a preliminary comparison to ORCHIDEE

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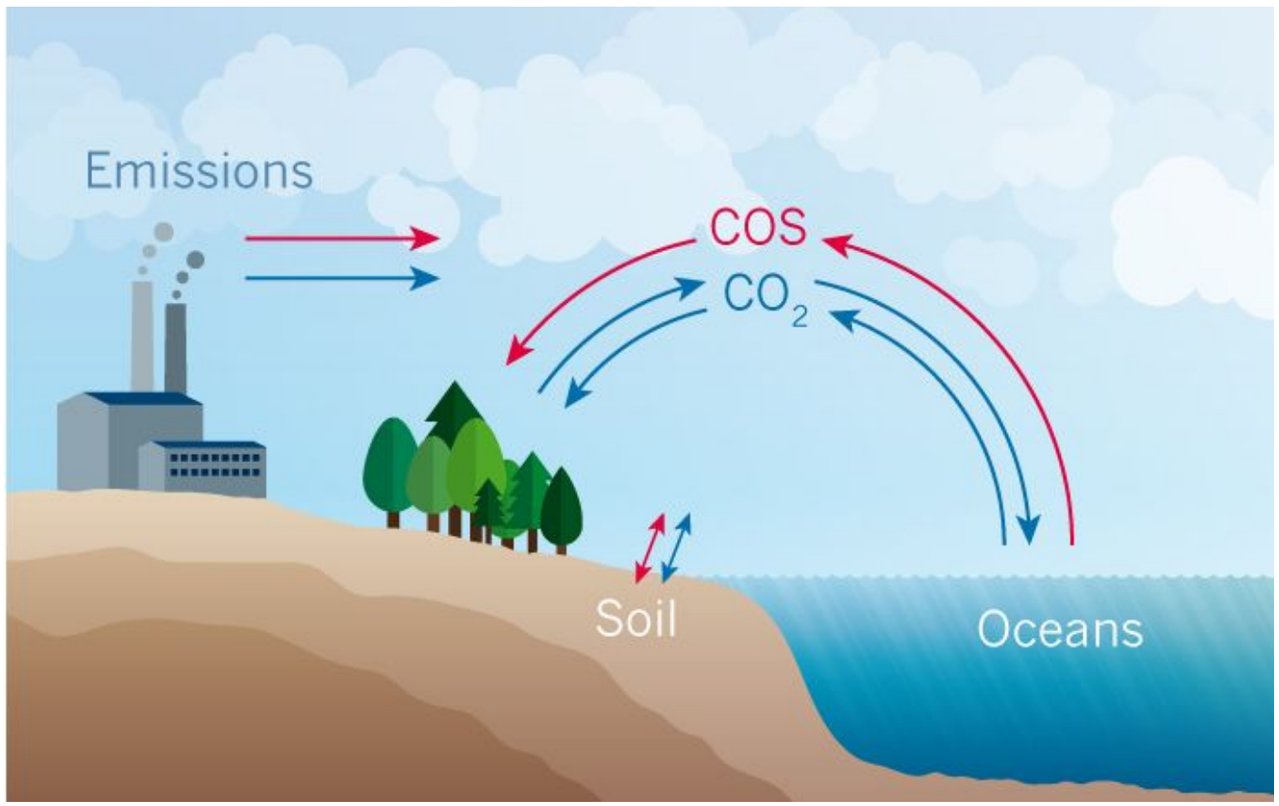
I. Introduction

- **Photosynthesis** by land plants accounts for the **largest uptake of CO2**, but **this flux cannot be measured directly.**
- **Carbonyl sulphide (COS)** is suggested as **powerful tracer** of **Gross Primary Productivity (GPP)** (Campbell *et al.*)
- Quantitative aspects of the **coupling of COS & CO2 exchange** by plants are still **uncertain**.
- The aim of this presentation is to determine the **characteristic of COS & CO2** in the ecosystem according to the **various temporal and spatial scales**.
- Here, we present implementation result of **Simple Biosphere Model4 (SiB4)** to find a **relationship between COS and CO2 exchange** in biosphere.
  To **evaluate** the **COS calculation** in SiB4, comparison with another **biosphere model (ORCHIDEE)** was performed.

I.I. CO2 & COS Budget

- **CO2** exchange reflects **several opposing fluxes** of **uptake** and **release** => **Difficult to quantify photosynthetic** uptake by plants
- **COS** is predominantly **produced in the ocean** surface and **consumed by land plants** accompanying photosynthesis
- **The ratio** of **COS to CO2 uptake** by land plants during photosynthesis is **predictable**
- CO2 & COS are also produced in large quantities by **human activities**, and be exchanged between the **atmosphere and the soil**



Den Yakir, 2017

II. Data and Methods

- Models : SiB4 and ORCHIDEE
- Targets
  - Materials: COS and CO2
  - Period: 5years (2011 ~ 2015) for monthly, a year (2011) for hourly
  - Area : Global and sub-regions
    - Big difference & interesting areas (urban or tropical forest)

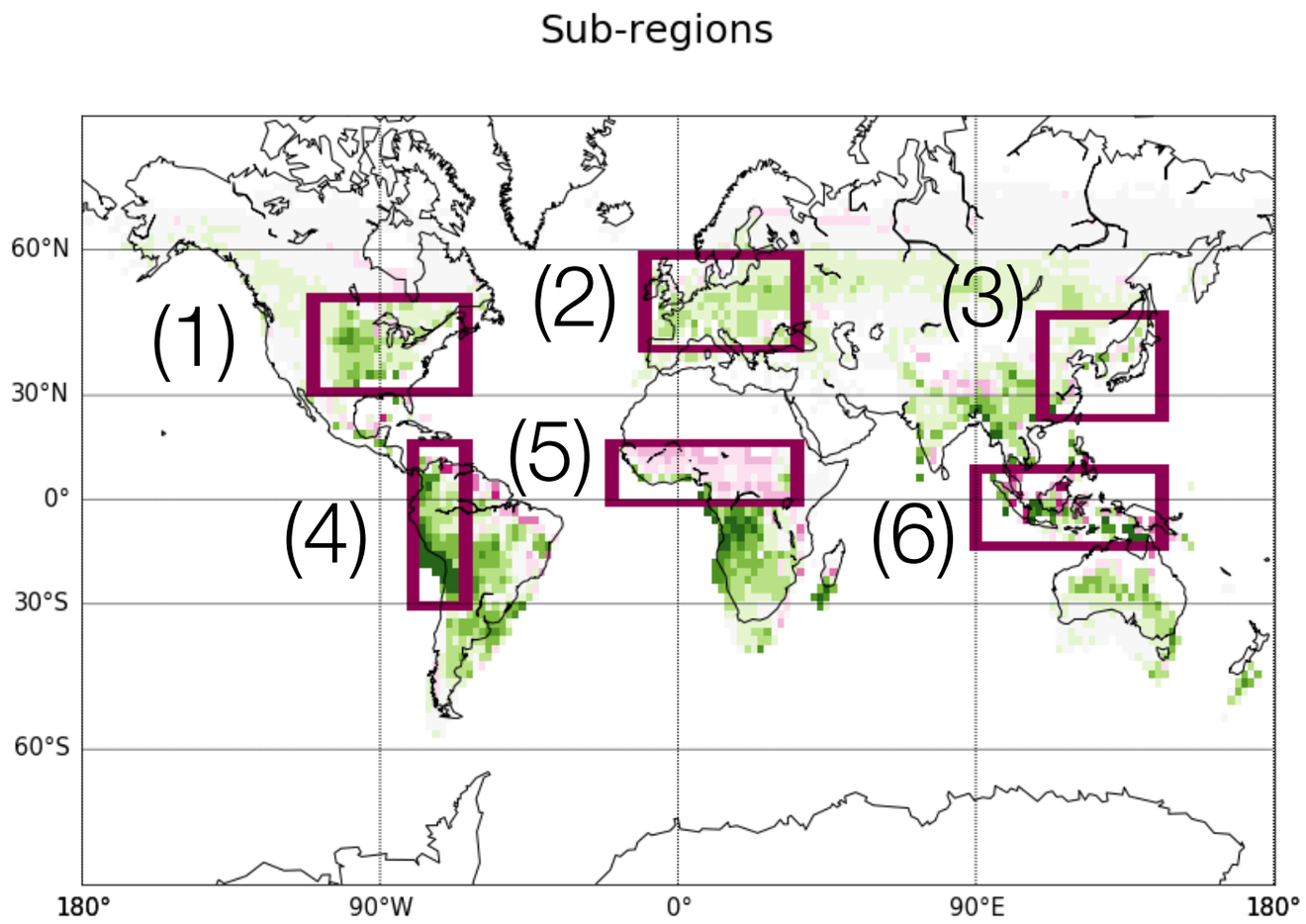


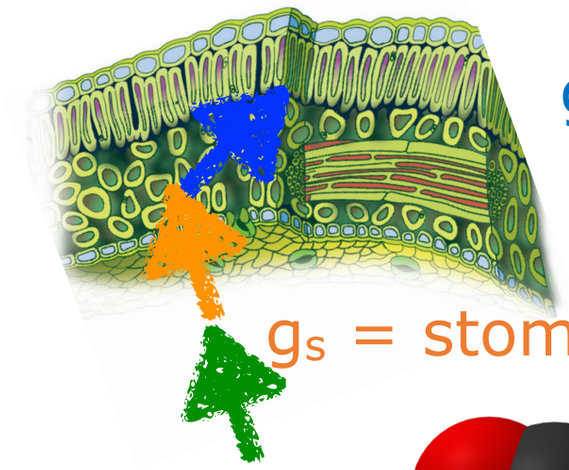
Figure. Difference of simulated COS flux between SiB4 and ORCHIDEE (SiB4-ORCHIDEE) and 6 sub-regions

II.I. COS flux calculation in SIB4

(Berry et al., 2013)

COS flux in SiB4 = COS (Plant & Soil)

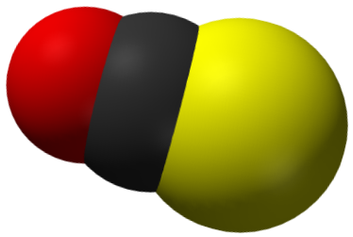
COS flux in ORCHIDEE = COS (Plant)

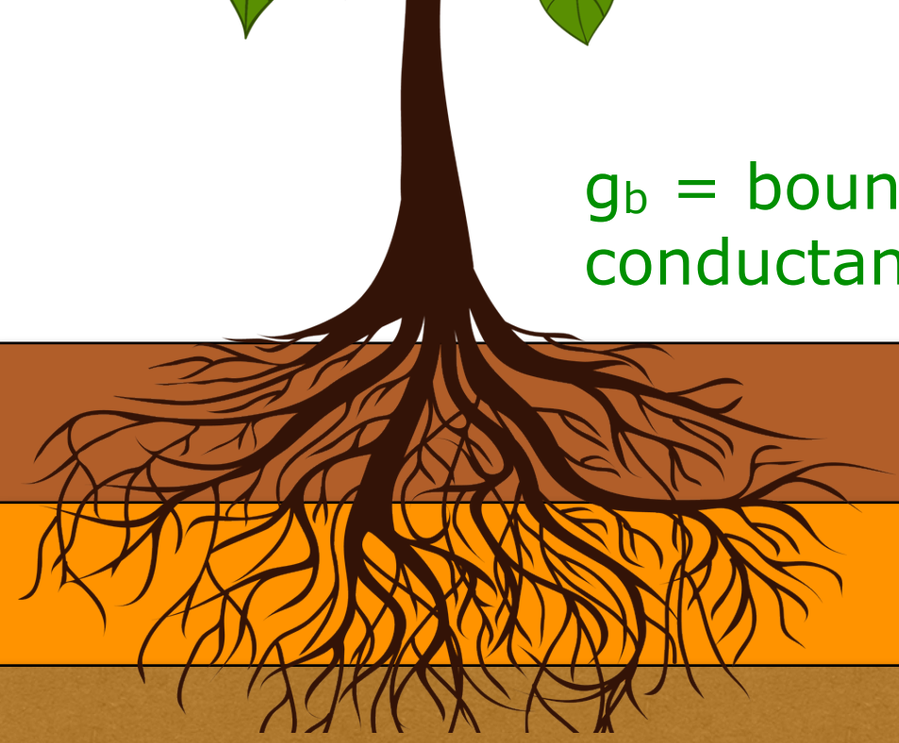


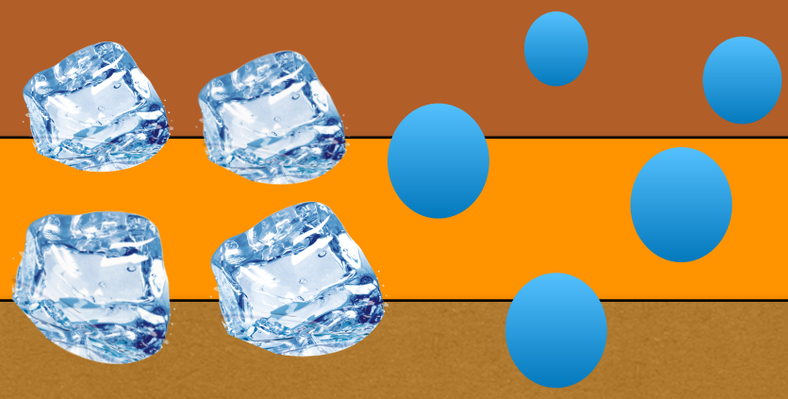
g_i = mesophyll diffusion + biochemical activity

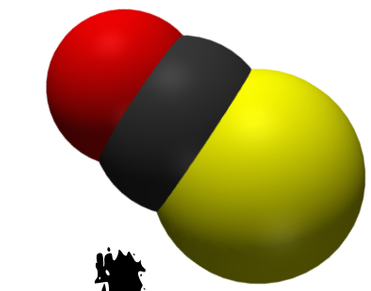
g_s = stomatal conductance

g_b = boundary layer conductance









Soil L1

Soil L2

Soil L3

Resp.(L1~3)/Resp.(1+2+3) x Resp.tot(all_layers)
x COS soil parameter x Frost x Moisture x Soil temperature

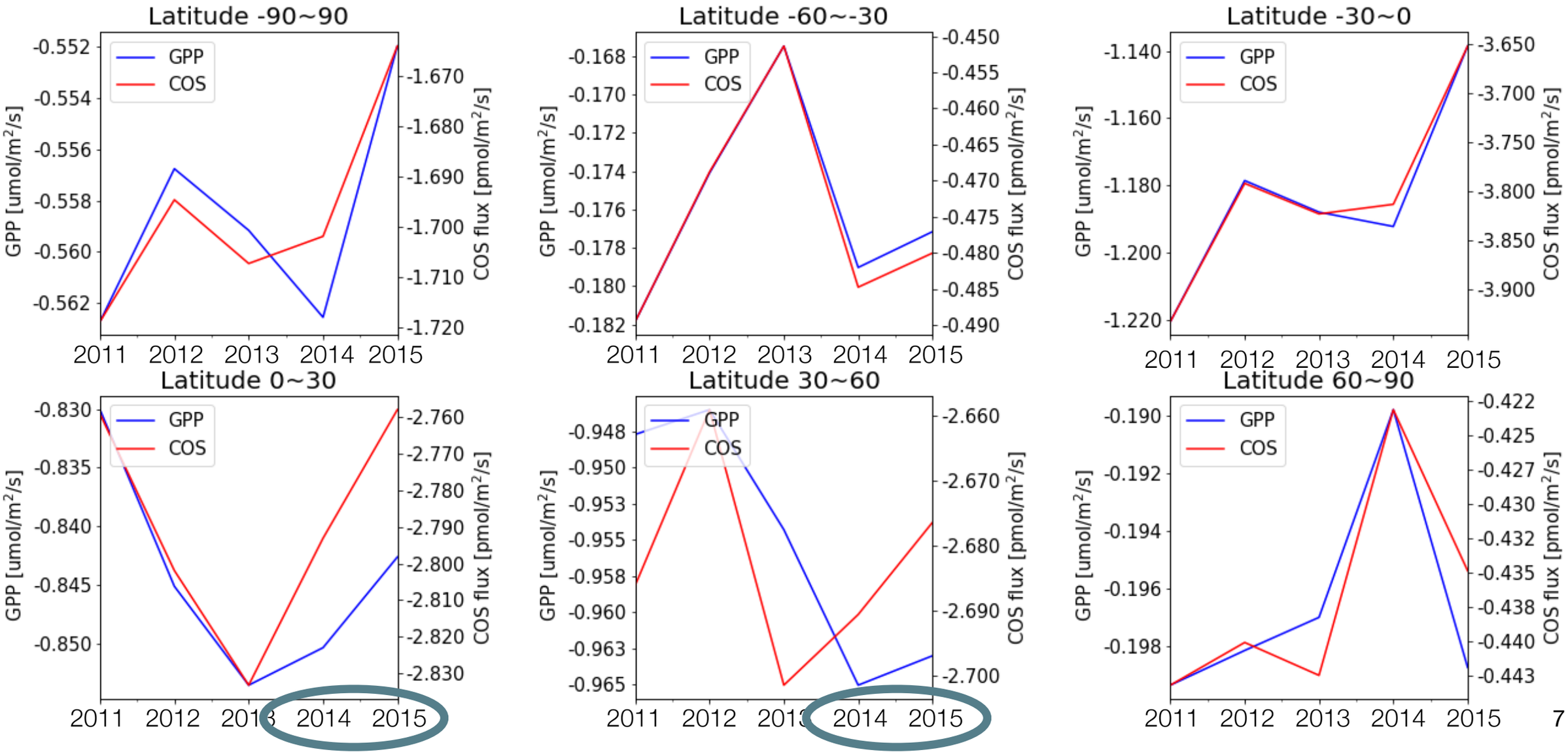
III. Results

III.I COS and CO2 in SiB4

III.I.I. Inter-annual variation

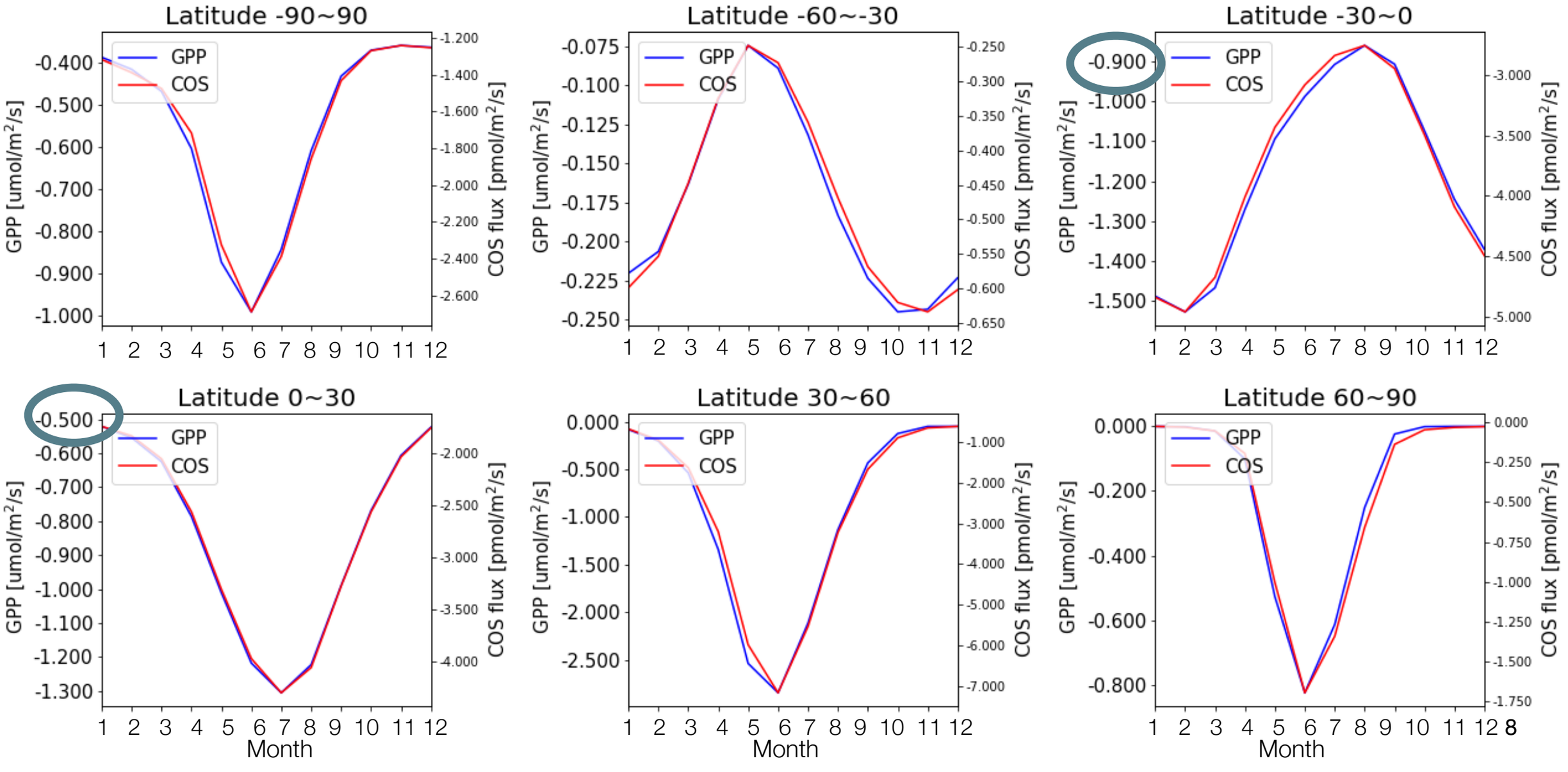
- GPP & COS uptake **have slightly weakened** for 5 years in global (same pattern: 0~30S)
- Different patterns in 0~60N from 2014 to 2015 year.

Inter-annual variation : GPP v.s. COS



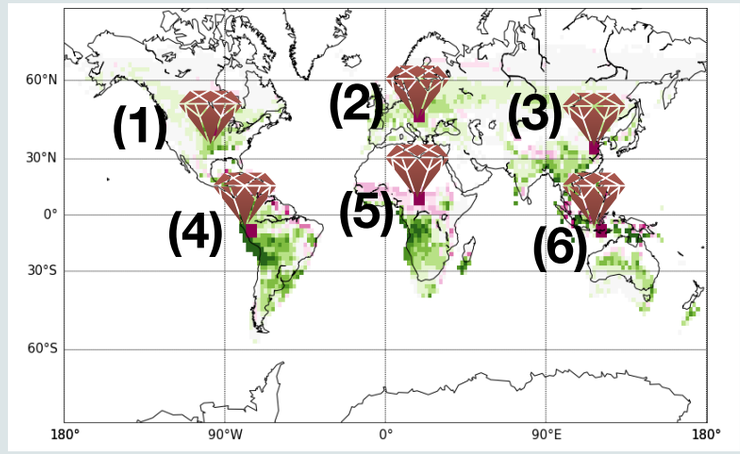
III.I.II. Monthly variation

- Globally, **strong peak** in **summer**
- Although differences in scale, COS &CO2 have **similar patterns**
- (30S~30N) Still has uptake values in winter-> dense tropical forest

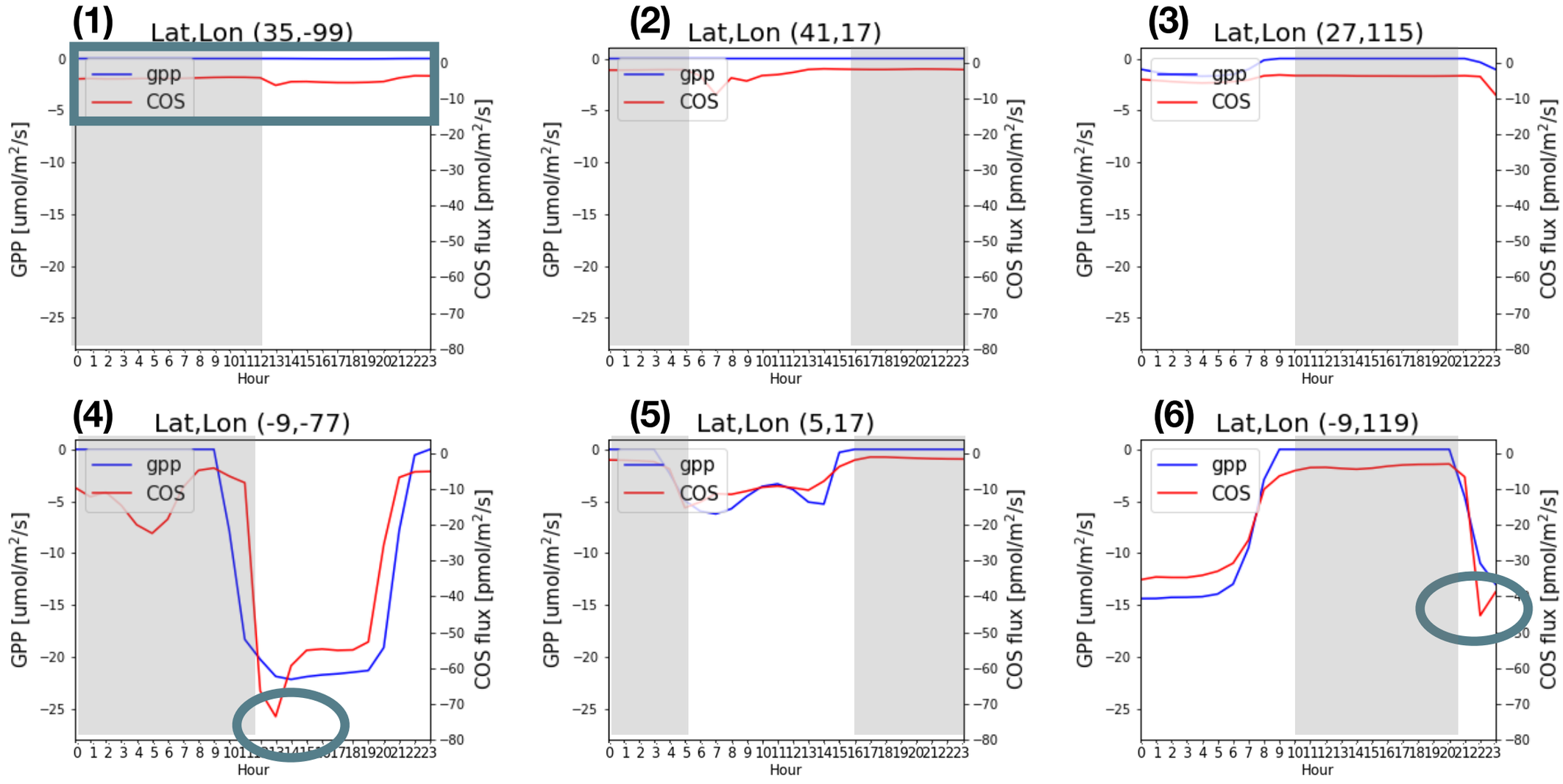


III.I.II. Diurnal variation (January)

- [R1,2,3: no plant] COS diffuses into soil
- [R4,6] Peak of **COS flux** in **early morning,** uptake in **nighttime** **-> incomplete closure of stomata** & the **light independence** of the enzyme carbonic anhydrase

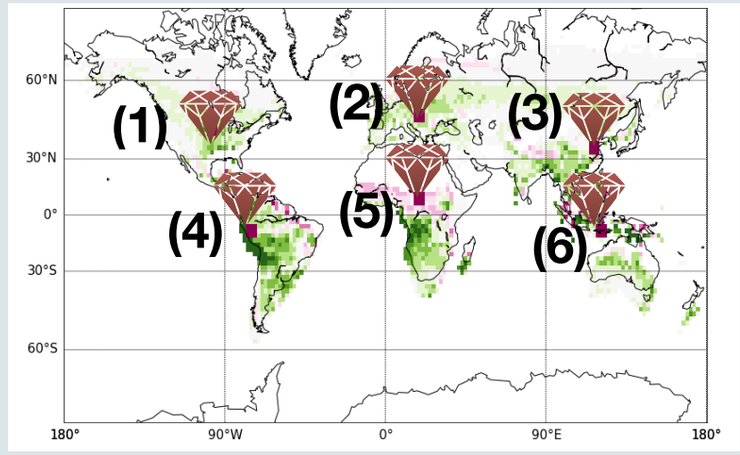


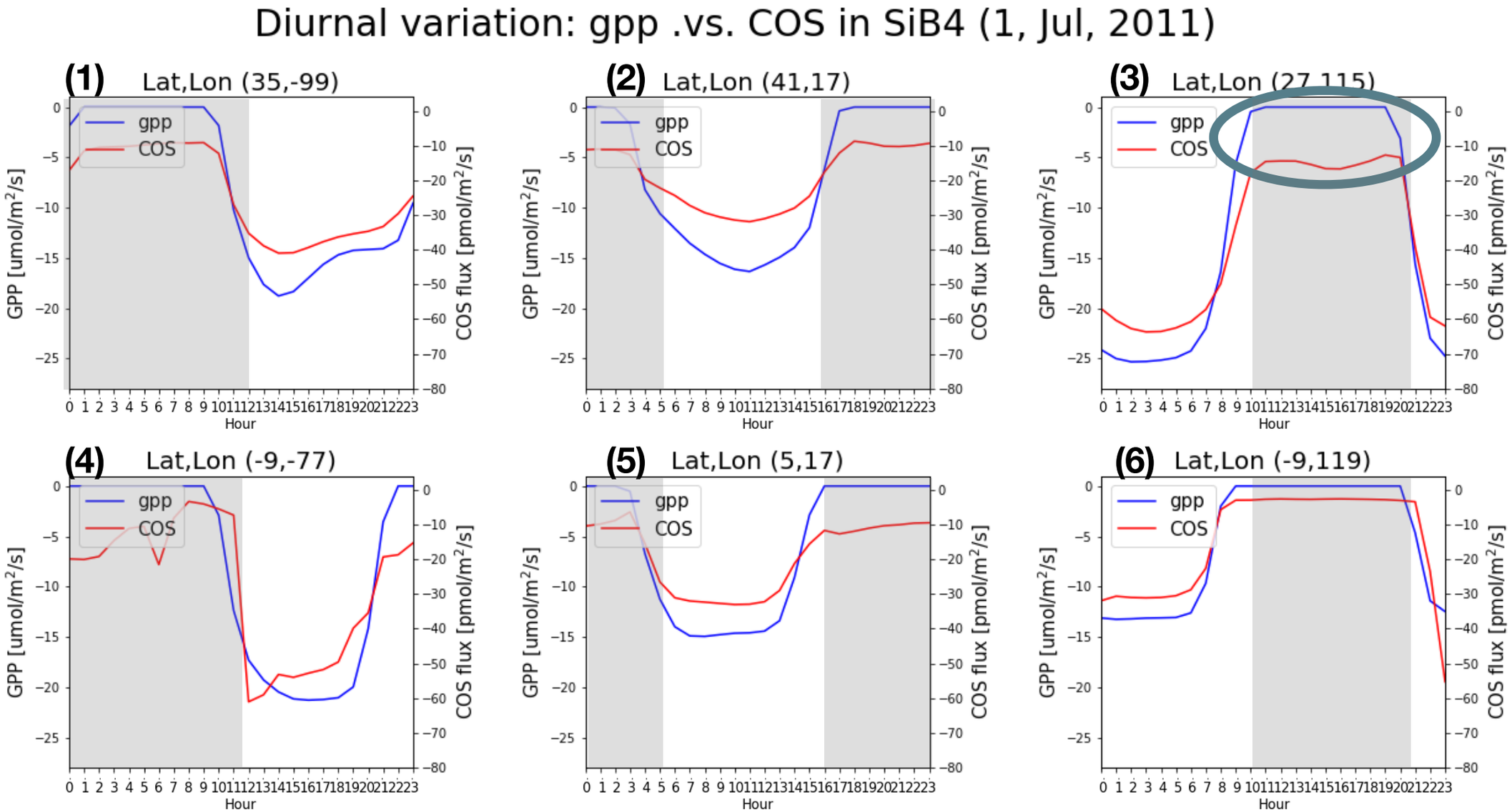
- Diurnal variation: gpp .vs. COS in SiB4 (1, Jan, 2011)



III.I.II. Diurnal variation (July)

- **Similar pattern** between COS & GPP (Plants active), COS uptake in **nighttime**
- As **region4**, some **challenges** exist to use COS flux as a tracer of GPP

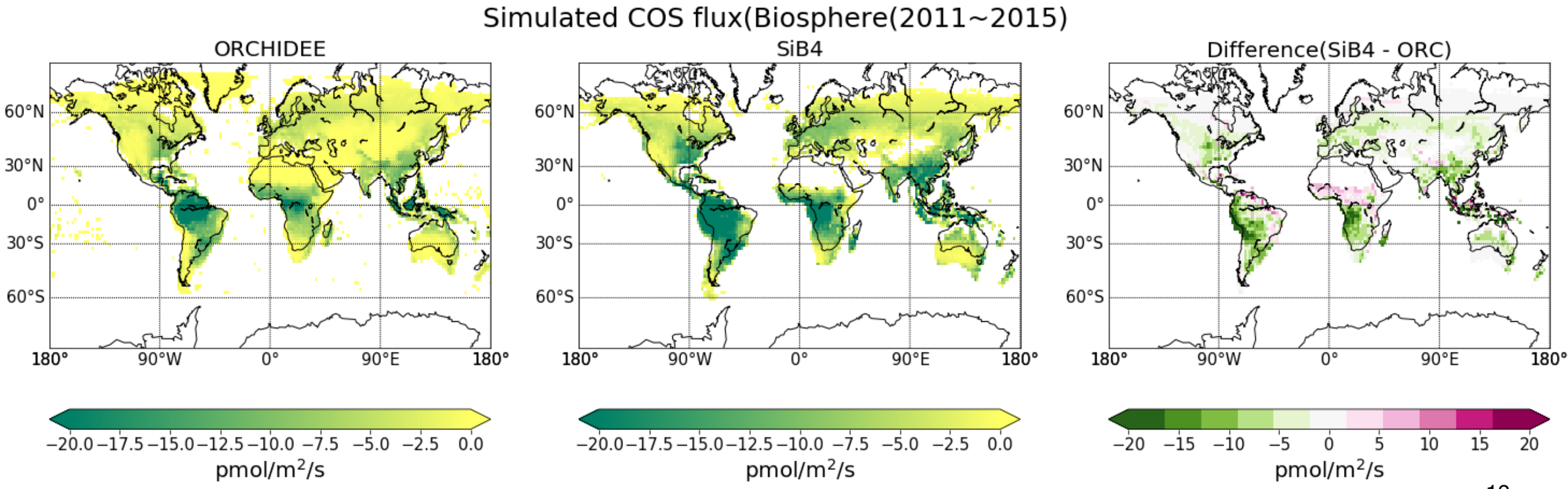




Results II. COS comparison (ORCHIDEE v.s. SiB4)

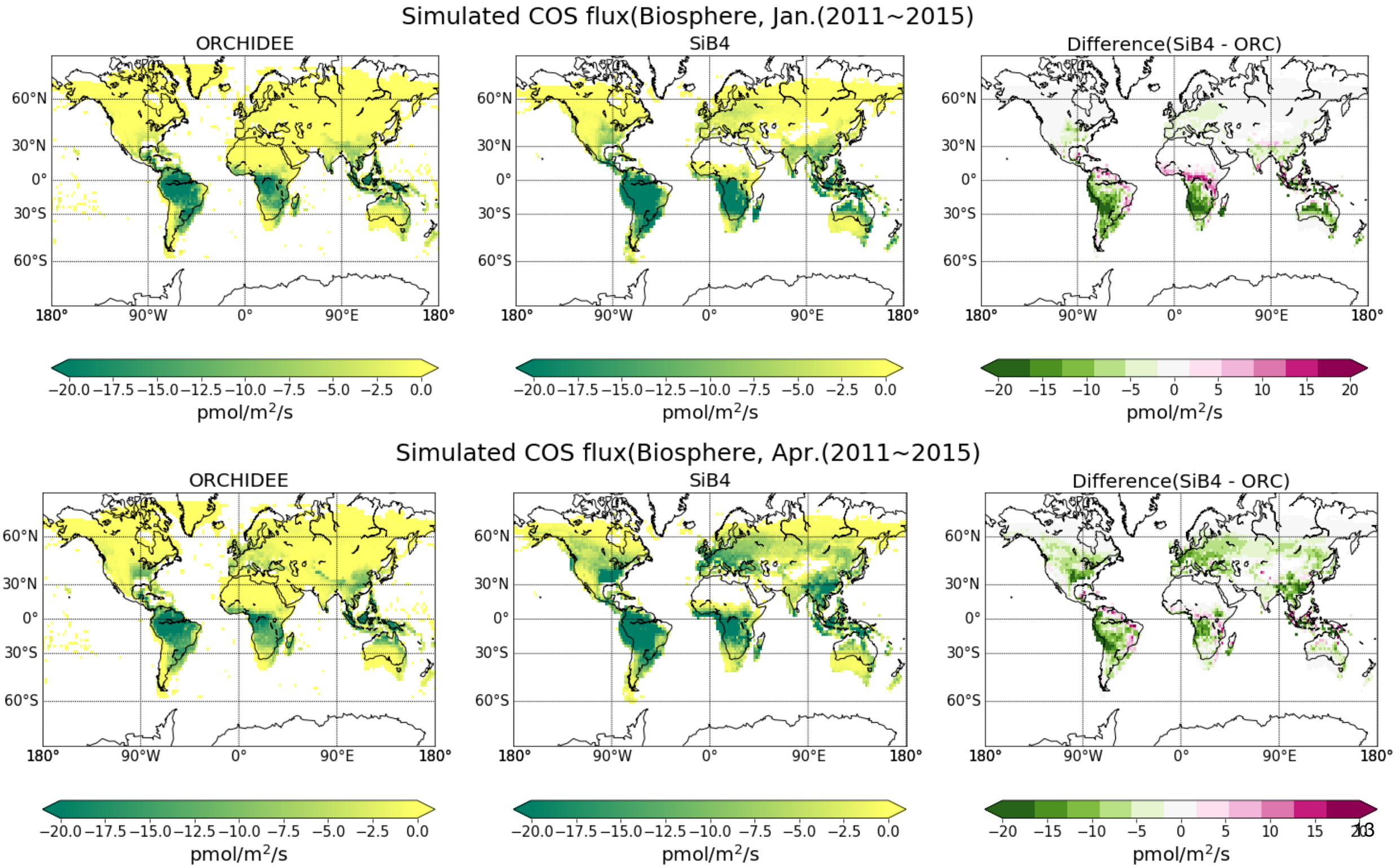
III.II.I. COS Spatial Distribution

- **[Averaged COS flux for 5 years]**
- **Stronger uptake** in areas, well-known as **forest or croplands** than barren area, especially that simulated from SiB4
- In summer and winter, difference distributes in northern and southern hemisphere, respectively
  -> discrepancy in COS uptake in **densely vegetated area**



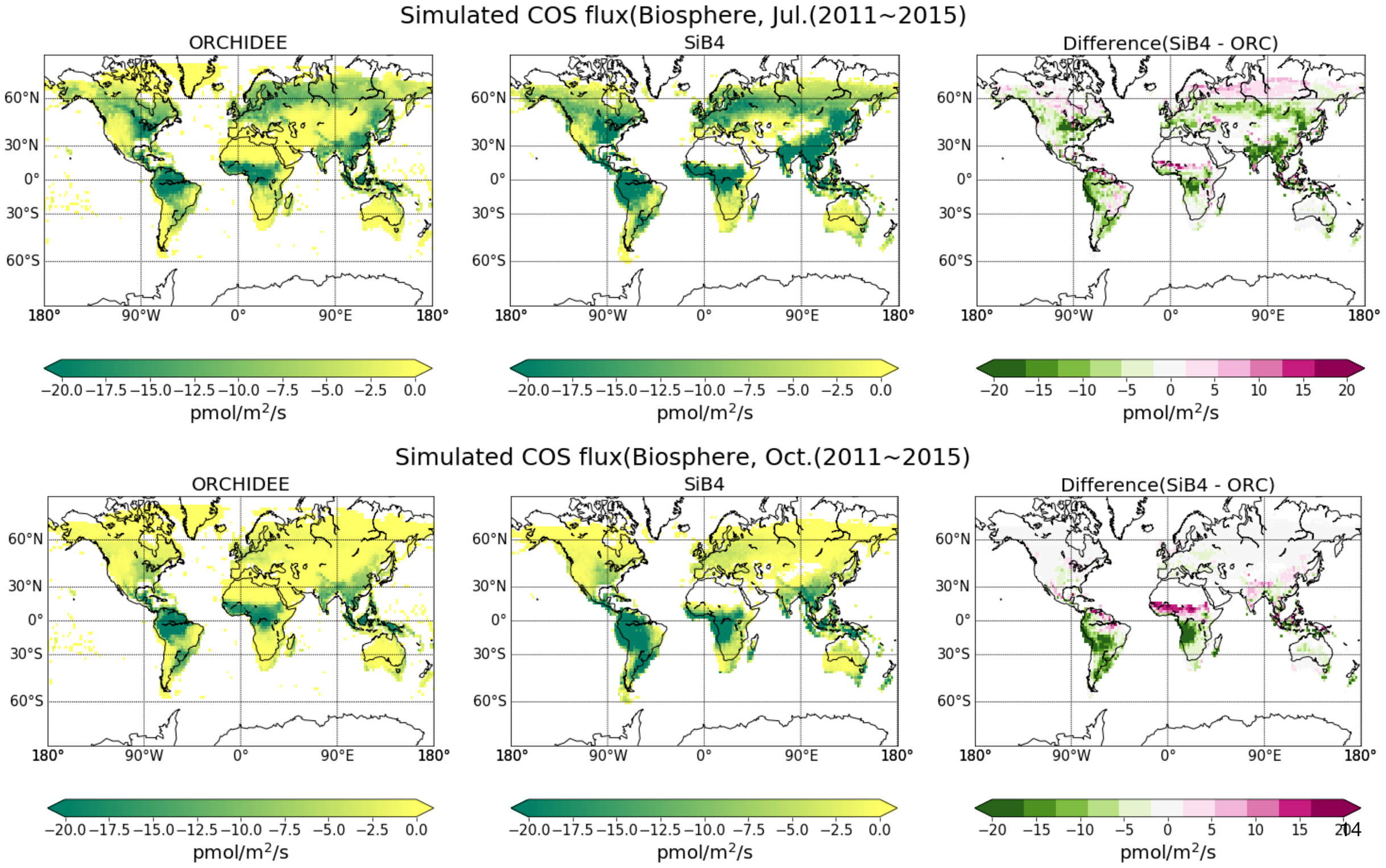
III.II.I. COS Spatial Distribution

- **Monthly averaged COS flux (January, April)**



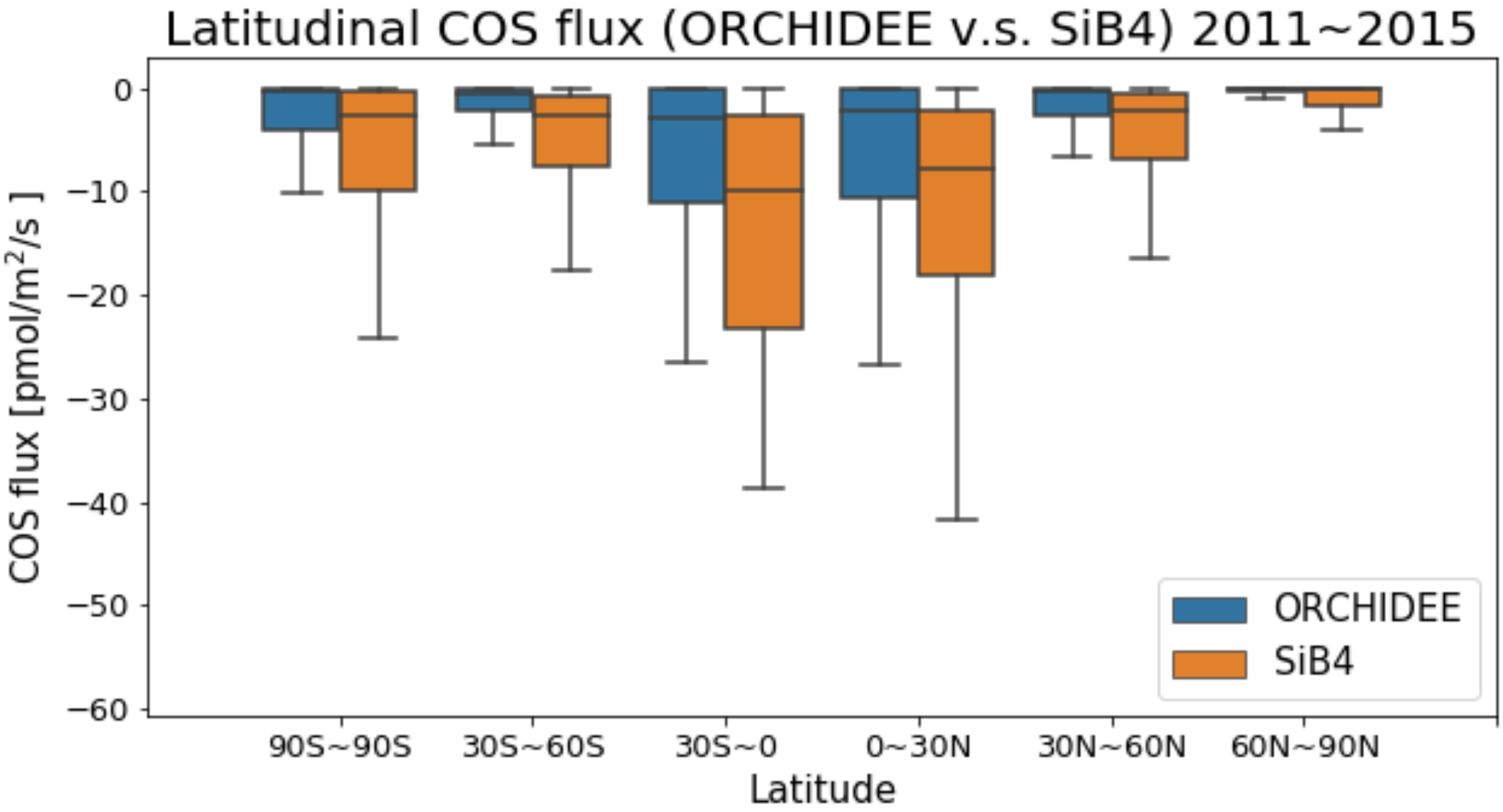
III.II.I. COS Spatial Distribution

- **Monthly averaged COS flux (July, October)**



III.II.II. COS Latitudinal Variation

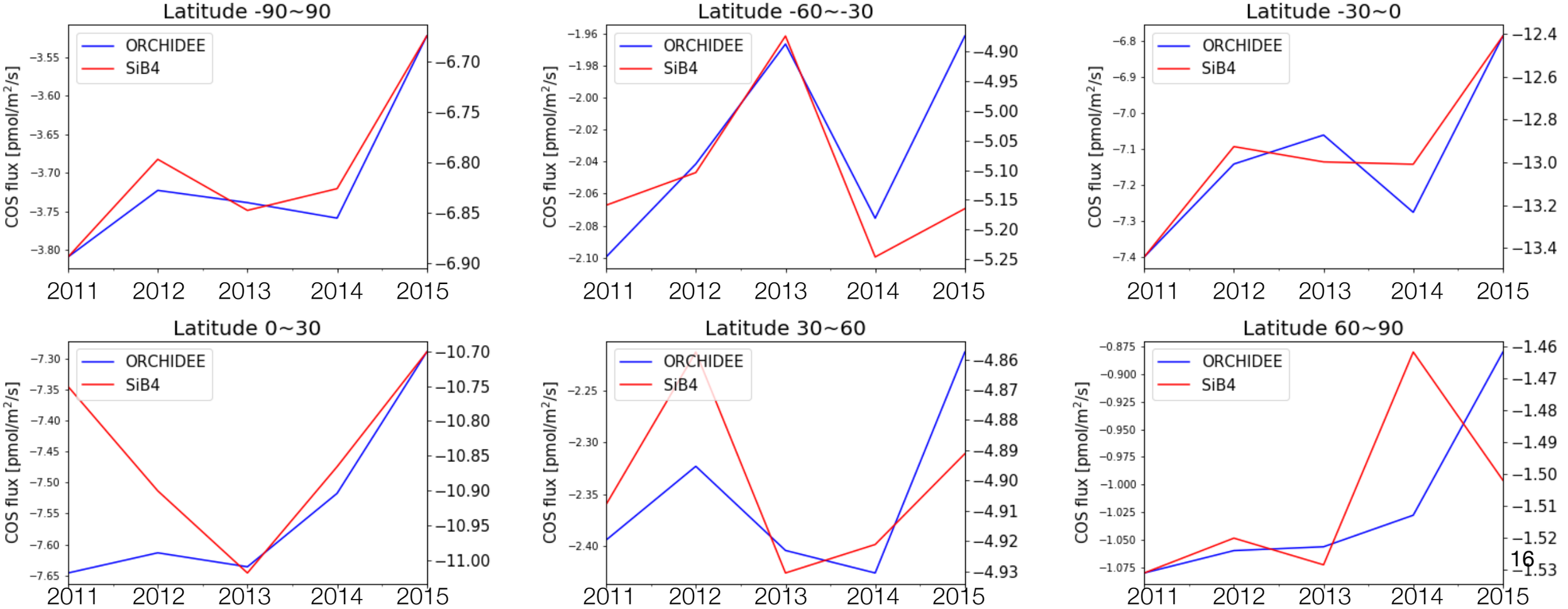
- **SiB4** simulates **more COS uptake** than ORCHIDEE for global
- **Tropical region** (30N ~ 30S), **uptake is stronger** and more **variable in SiB4** than ORCHIDEE



III.II.III. COS Inter-annual Variation

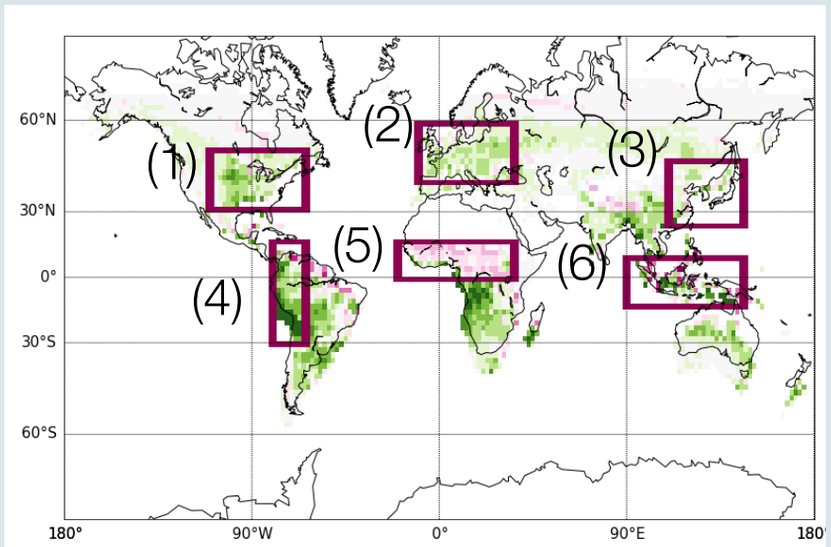
- Globally, COS flux was **weakened for 5 years** slightly
- **Smaller** COS uptake in **ORCHIDEE** due to **absence of soil flux**
- [0~30S] Remarkable agreed **declined uptake**, but **large bias**
- Some **different patterns** for 5 years in other latitude regions

Interaual variation: ORCHIDEE v.s. SiB4 (diff. scale)

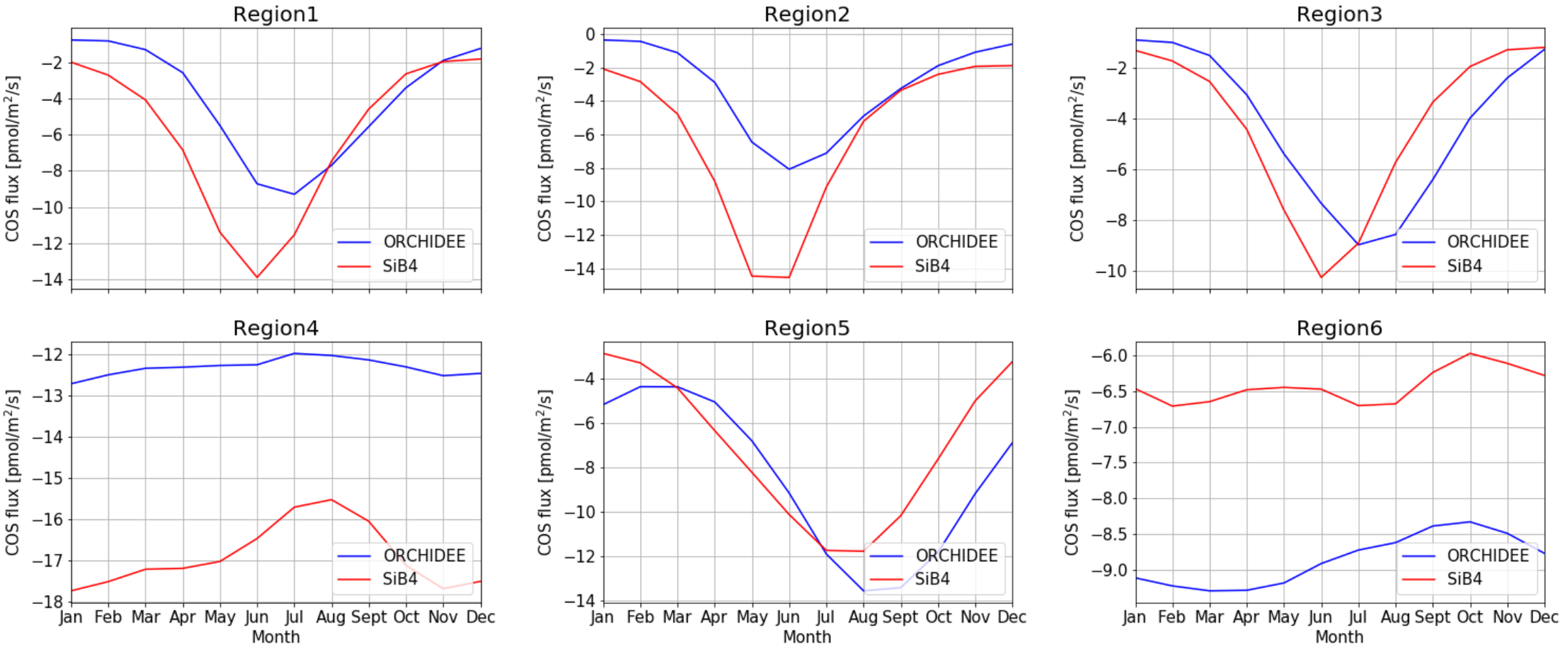


III.II.IV. COS Sub-regional S.V.

- **Similar pattern** in all regions
- [R1,2,4] **stronger COS uptake in SiB4** than ORCHIDEE, especially in **summer**
- **Time lag** for a month between two models
- [R4,6] Big differences of value for **all seasons** -> Soil uptake + another reason

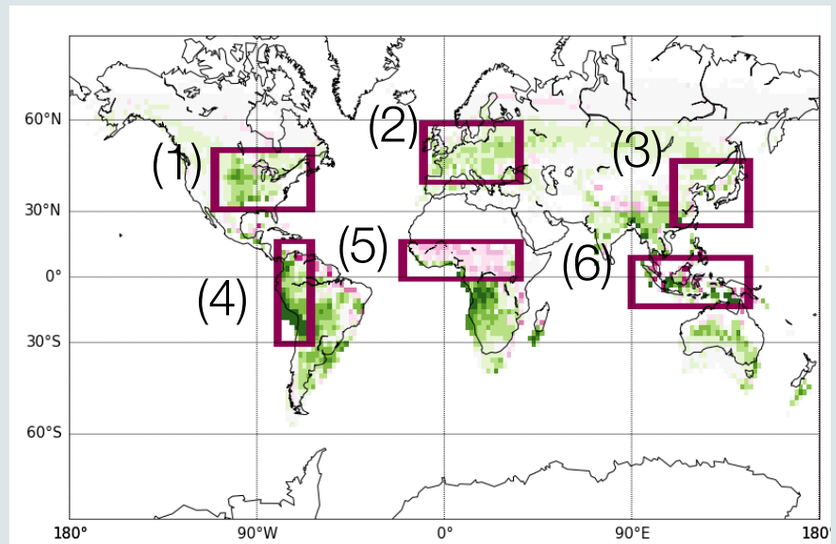


Monthly variation: ORCHIDEE v.s. SiB4 (2011~2015)

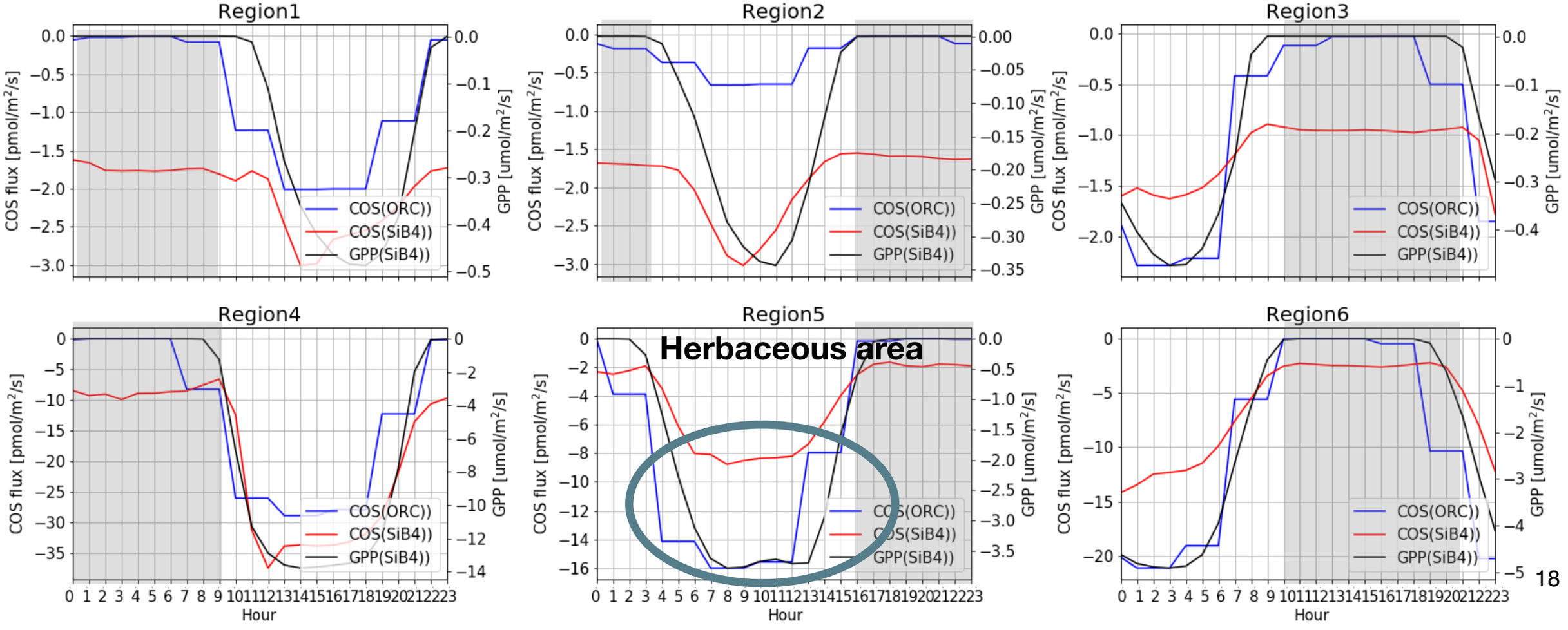


III.II.V. COS Sub-regional D.V. (January)

- Two models have **different diurnal variation** according to the regions
- **[Night]** uptake in **SiB4 COS**, due to hydrolized COS in soil
- **[Day] large difference** in both COSs -> soil uptake + **another regional reason**

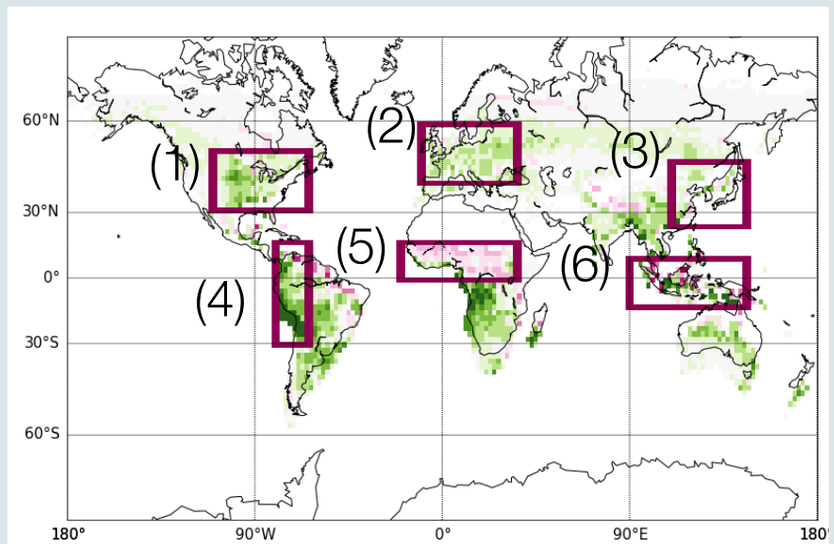


Diurnal variation: ORCHIDEE v.s. SiB4 (1, Jan, 2011)

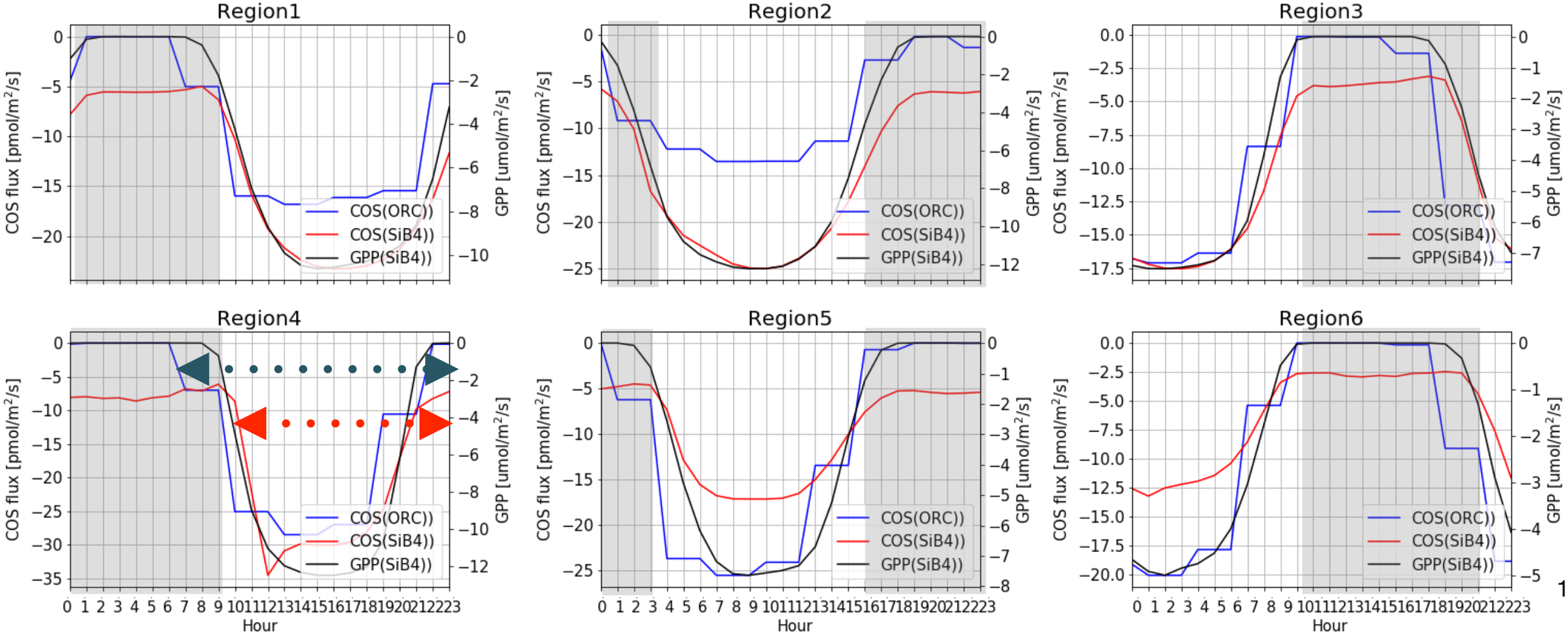


III.II.V. COS Sub-regional D.V. (July)

- **Strong uptake** during **daytime** in both, **small uptake** in **nighttime in SiB4**
- **Uptake-hour** of SiB4 GPP is similar SiB COS
  - But, **ORCHIDEE COS starts to uptake earlier** in R1,4,5,6



Diurnal variation: ORCHIDEE v.s. SiB4 (1, Jul, 2011)



IV. Summary

- We explored **relationship** between **COS and CO2** exchange in biosphere using **comparison** of **two land surface models** SiB4 and ORCHIDEE in global and sub-regions for 5 years (2011~2015)
- COS flux from SiB4 is calculated with uptake from **plants** and **soil organisms** (enzyme carbonic anhydrase). ORCHIDEE does not include soil parameterisation.
- COS & CO2 uptake **had weaken for 5 years** and two have similar pattern in monthly variation. As for diurnal, **big differences** were shown at **nighttime** and **some peaks in the morning** in COS flux.
  -> due to the **light independence** of the enzyme carbonic anhydrase
- COS flux from **SiB4** has **stronger uptake** than that from ORCHIDEE, and has **different magnitude** in seasonal & diurnal variation, especially in 30S~0N region (tropical forest -> a lot of uncertainties)
- COS flux from **SiB4 has uptake in nighttime**, but that from ORCHIDEE has almost 0 value -> enzyme effect in soil in nighttime, and other reasons
- We can make the coupling system between COS & CO2 with acquired characteristics, and they will reflected in COS inversion system.

Thank you for your attention