Toward integrated understanding of spatial variability in Asian carbon fluxes using AsiaFlux network and AsiaMIP datasets

Masayuki Kondo,

Kazuhito Ichii,
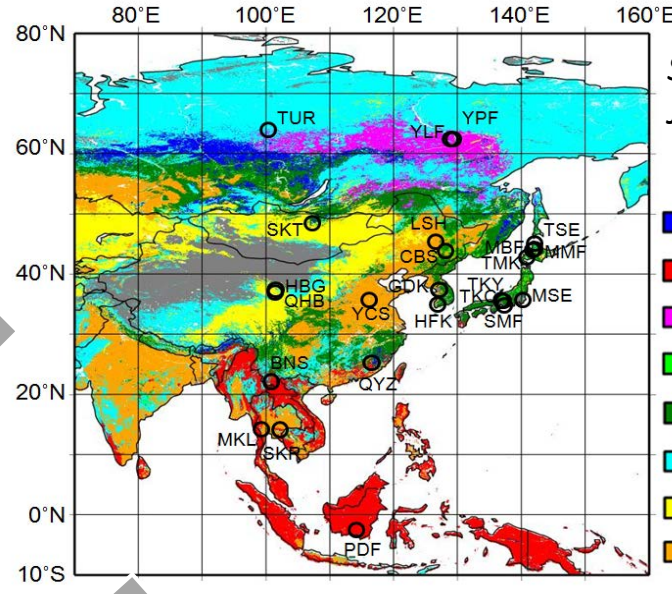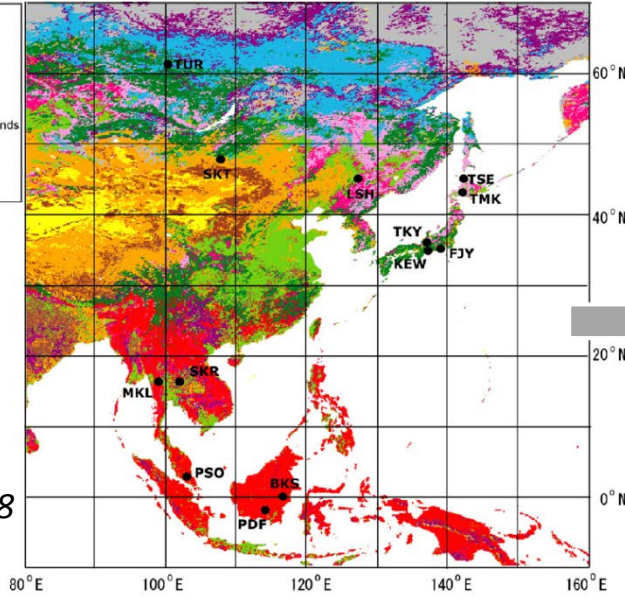
Taku M. Saitoh,

Masahito Ueyama,

and Nobuko Saigusa

Development of AsiaFlux network

Hirata et al. 2008 Agric For Met

Saigusa et al. 2013 J For Res

13 sites

27 sites

Currently 107 sites

Syntheses of carbon fluxes across Asia

2008
Temporal and spatial variations in the seasonal patterns of CO_2 flux in boreal, temperate, and tropical forests in East Asia

Nobuko Saigusa [a,*], Susumu Yamamoto [b], Ryuichi Hirata [c], Yoshikazu Ohtani [d], Reiko Ide [c], Jun Asanuma [e], Minoru Gamo [a], Takashi Hirano [f], Hiroaki Kondo [a], Yoshiko Kosugi [g], Sheng-Gong Li [e,h,j], Yuichiro Nakai [d], Kentaro Takagi [i], Makoto Tani [g], Huimin Wang [a,h]

2008
Spatial distribution of carbon balance in forest ecosystems across East Asia

Ryuichi Hirata [a,*], Nobuko Saigusa [b], Susumu Yamamoto [c], Yoshikazu Ohtani [d], Reiko Ide [a], Jun Asanuma [e], Minoru Gamo [b], Takashi Hirano [f], Hiroaki Kondo [b], Yoshiko Kosugi [g], Sheng-Gong Li [e,h,j], Yuichiro Nakai [d], Kentaro Takagi [i], Makoto Tani [g], Huimin Wang [b,j]

2008
Spatial variability and major controlling factors of CO_2 sink strength in Asian terrestrial ecosystems: evidence from eddy covariance data

TOMOMICHI KATO* and YANHONG TANG†

2010
Impact of meteorological anomalies in the 2003 summer on Gross Primary Productivity in East Asia

N. Saigusa[1], K. Ichii[2], H. Murakami[3], R. Hirata[4], J. Asanuma[5], H. Den[6], S.-J. Han[7], R. Ide[1], S.-G. Li[8], T. Ohta[9], T. Sasai[10], S.-Q. Wang[8], and G.-R. Yu[8]

2013
Dataset of CarboEastAsia and uncertainties in the CO_2 budget evaluation caused by different data processing

Nobuko Saigusa · Sheng-Gong Li · Hyojung Kwon · Kentaro Takagi · Lei-Ming Zhang · Reiko Ide · Masahito Ueyama · Jun Asanuma · Young-Jean Choi · Jung Hwa Chun · Shi-Jie Han · Takashi Hirano · Ryuichi Hirata · Minseok Kang · Tomomichi Kato · Joon Kim · Ying-Nian Li · Takahisa Maeda · Akira Miyata · Yasuko Mizoguchi · Shohei Murayama · Yuichiro Nakai · Takeshi Ohta · Taku M. Saitoh · Hui-Ming Wang · Gui-Rui Yu · Yi-Ping Zhang · Feng-Hua Zhao

2013
Spatial patterns and climate drivers of carbon fluxes in terrestrial ecosystems of China

GUI-RUI YU*, XIAN-JIN ZHU*†, YU-LING FU*, HONG-LIN HE*, QIU-FENG WANG*, XUE-FA WEN*, XUAN-RAN LI*†, LEI-MING ZHANG*, LI ZHANG*, WEN SU*, SHENG-GONG LI*, XIAO-MIN SUN*, YI-PING ZHANG‡, JUN-HUI ZHANG§, JUN-HUA YAN¶, HUI-MIN WANG*, GUANG-SHENG ZHOU∥, BING-RUI JIA∥, WEN-HUA XIANG**, YING-NIAN LI††, LIANG ZHAO††, YAN-FEN WANG†, PEI-LI SHI*, SHI-PING CHEN∥, XIAO-PING XIN‡‡, FENG-HUA ZHAO*, YU-YING WANG§§ and CHENG-LI TONG¶¶

2013
Temperature and precipitation control of the spatial variation of terrestrial ecosystem carbon exchange in the Asian region

Zhi Chen [a,b], Guirui Yu [a,*], Jianping Ge [c], Xiaomin Sun [a], Takashi Hirano [d], Nobuko Saigusa [e], Qiufeng Wang [a], Xianjin Zhu [a,b], Yiping Zhang [f], Junhui Zhang [g], Junhua Yan [h], Huimin Wang [a], Liang Zhao [i], Yanfen Wang [b], Peili Shi [a], Fenghua Zhao [a]

2014
High carbon dioxide uptake by subtropical forest ecosystems in the East Asian monsoon region

Guirui Yu [a,1], Zhi Chen [a,b,1], Shilong Piao [c,d], Changhui Peng [e,f], Philippe Ciais [g], Qiufeng Wang [a], Xuanran Li [a], and Xianjin Zhu [a]

2015
Covariation between gross primary production and ecosystem respiration across space and the underlying mechanisms: A global synthesis

Zhi Chen [a,b], Guirui Yu [a,*], Xianjin Zhu [a], Qiufeng Wang [a], Shuli Niu [a], Zhongmin Hu [a]

2016
Age and climate contribution to observed forest carbon sinks in East Asia

Shan Gao [1,2], Tao Zhou [1,2], Xiang Zhao [3], Donghai Wu [3], Zheng Li [1,2], Hao Wu [1,2], Ling Du [1,2,4] and Hui Luo [1,2]

2017
Comprehensive synthesis of spatial variability in carbon flux across monsoon Asian forests

Masayuki Kondo [a,*], Taku M. Saitoh [b], Hisashi Sato [a], Kazuhito Ichii [a,c]

and more

2

What did we learn from syntheses of carbon fluxes across Asia
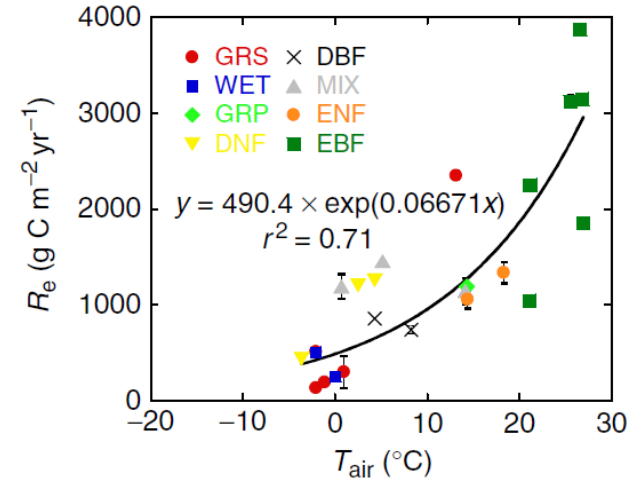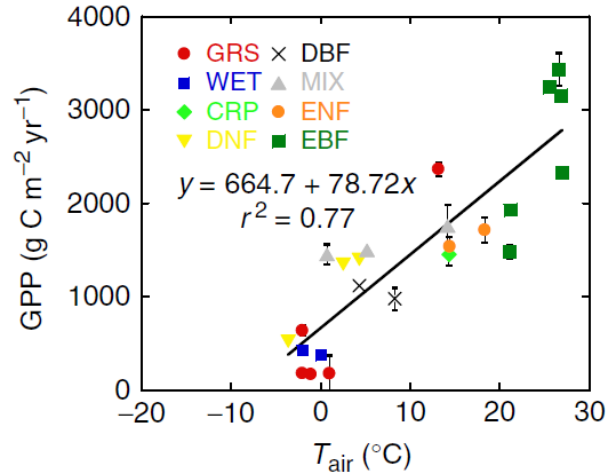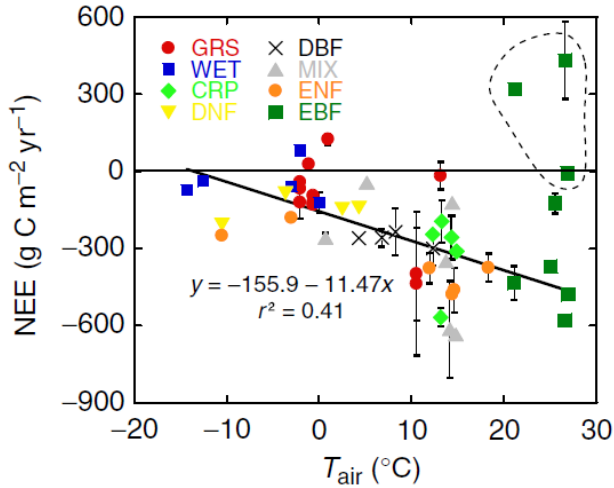
Two key findings

1. Temperature exerts the dominant control on spatial variability of GPP, RE, and NEP

e.g. Kato and Tang 2008 Global Change Biol; Hirata et al. 2008 Agric For Met; Kondo et al. 2017 Agric For Met
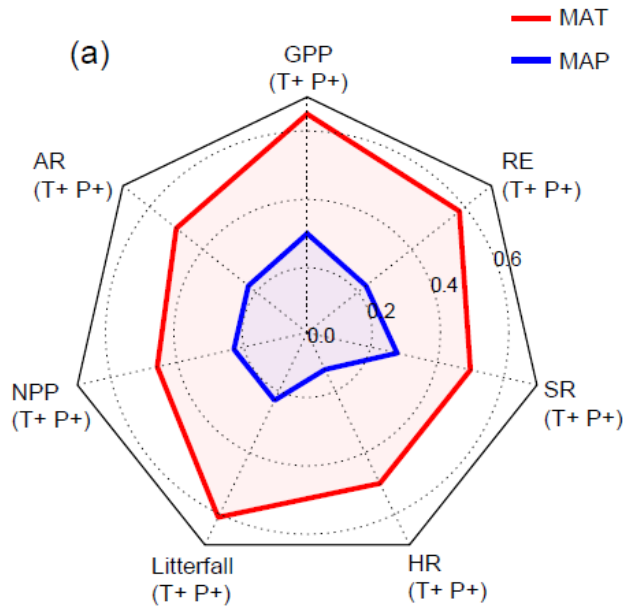
2. Forest age and nitrogen deposition are the key factors for large carbon uptake in subtropical forests

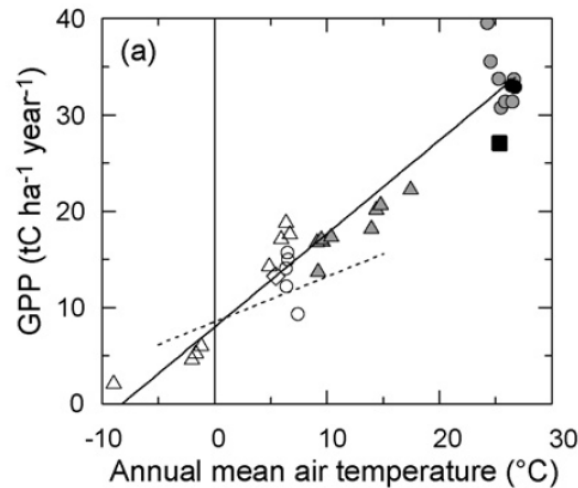*e.g. Yu et al. 2014 PNAS; Gao et al. 2016 Environ Res Lett; Kondo et al. 2017 Agric For Met*

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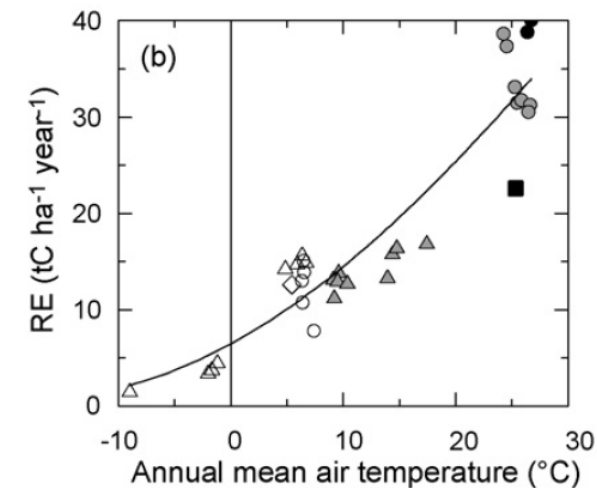# Temperature control on carbon fluxes in Asia

$y = -155.9 - 11.47x$
$r^2 = 0.41$

$y = 664.7 + 78.72x$
$r^2 = 0.77$

$y = 490.4 \times \exp(0.06671x)$
$r^2 = 0.71$

Kato and Tang 2008 Global Change Biol

Kondo et al. 2017 Agric For Met

Hirata et al. 2008 Agric For Met

4

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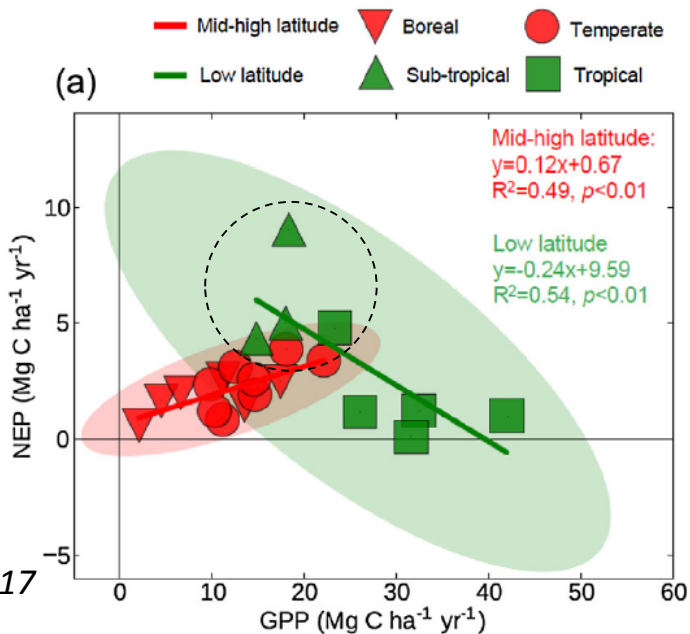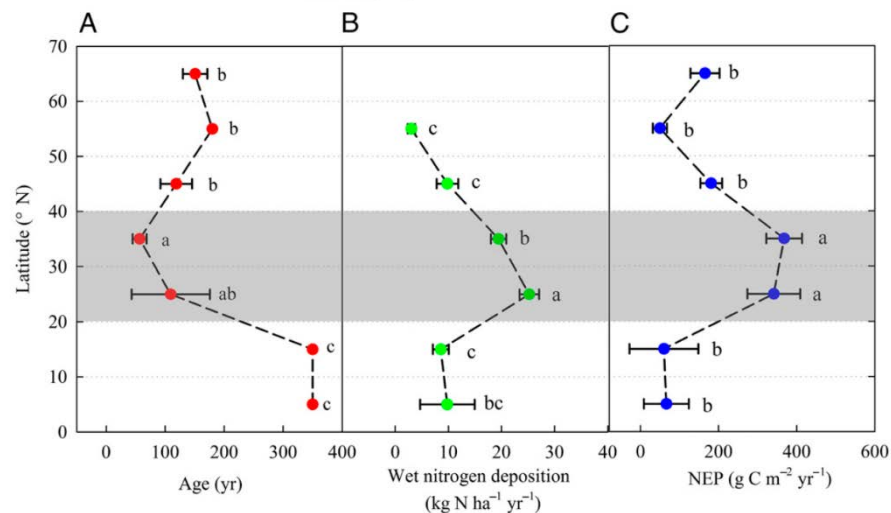
Large carbon uptake in subtropical forests
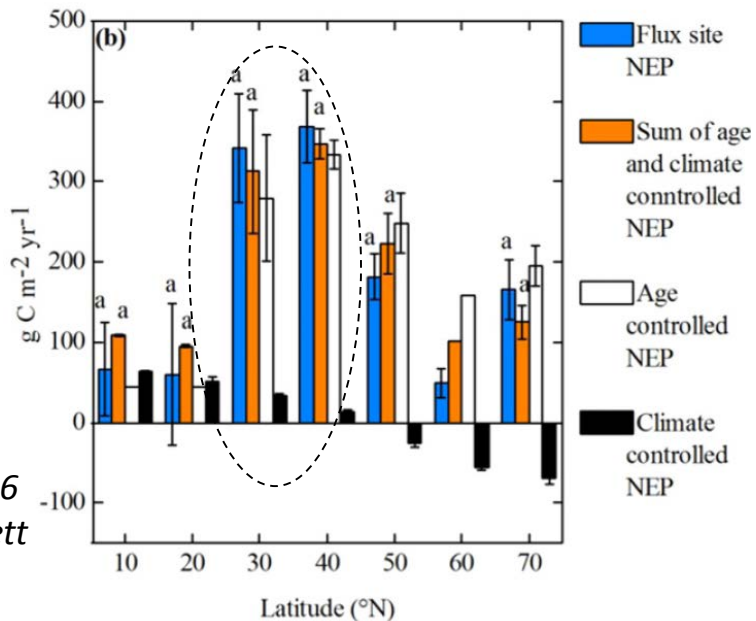
Gao et al. 2016 Environ Res Lett
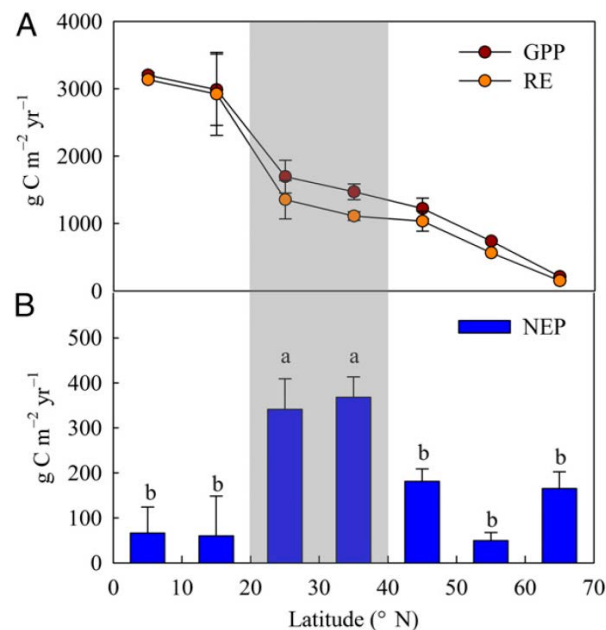
Yu et al. 2014 PNAS

Kondo et al. 2017 Agric For Met

From point to regional scales

✔ From site syntheses, we learned

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2. Forest age and nitrogen deposition are the key factors for large carbon uptake in subtropical forests

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✔ Regional scale syntheses are needed to estimate (1) continuous spatial variability and (2) carbon budget

Two major techniques to estimate regional carbon fluxes
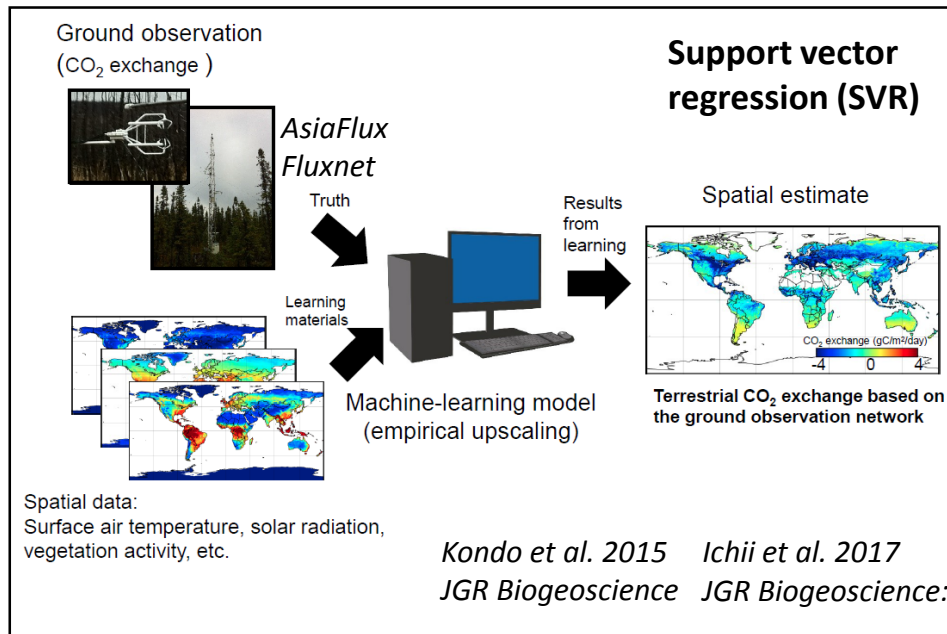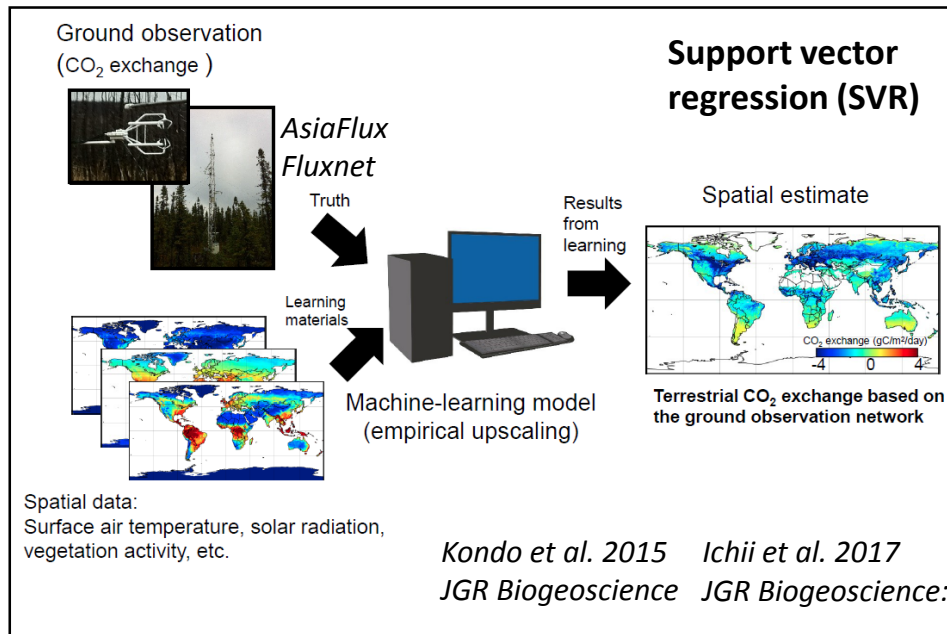
From point to regional scales

✔ From site syntheses, we learned

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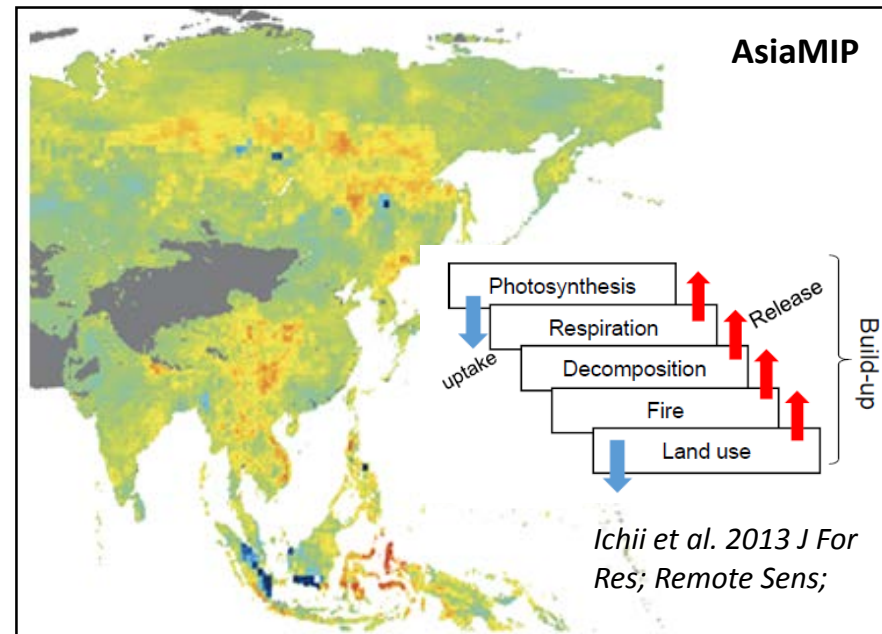2. Forest age and nitrogen deposition are the key factors for large carbon uptake in subtropical forests

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Two major techniques to estimate regional carbon fluxes

Empirical Upscaling of Eddy flux

Ground observation
(CO_2 exchange)

*AsiaFlux
Fluxnet*

Truth

**Support vector
regression (SVR)**

Learning
materials

Results
from
learning

Spatial estimate

Machine-learning model
(empirical upscaling)

CO_2 exchange (gC/m²/day)
-4   0   4

**Terrestrial CO_2 exchange based on
the ground observation network**

Spatial data:
Surface air temperature, solar radiation,
vegetation activity, etc.

*Kondo et al. 2015
JGR Biogeoscience*

*Ichii et al. 2017
JGR Biogeoscience:*

From point to regional scales

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Two major techniques to estimate regional carbon fluxes

Empirical Upscaling of Eddy flux

Biosphere Model

Ground observation
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Surface air temperature, solar radiation, vegetation activity, etc.

Kondo et al. 2015 JGR Biogeoscience   *Ichii et al. 2017 JGR Biogeoscience:*

AsiaMIP

Photosynthesis
Respiration
Decomposition
Fire
Land use

uptake   Release   Build-up

Ichii et al. 2013 J For Res; Remote Sens;

Issues remaining in regional carbon flux estimates

Syntheses of regional carbon fluxes are needed…
but there are issues in regional carbon flux estimations.

Issues remaining in regional carbon flux estimates

There are issues in regional carbon flux estimations...
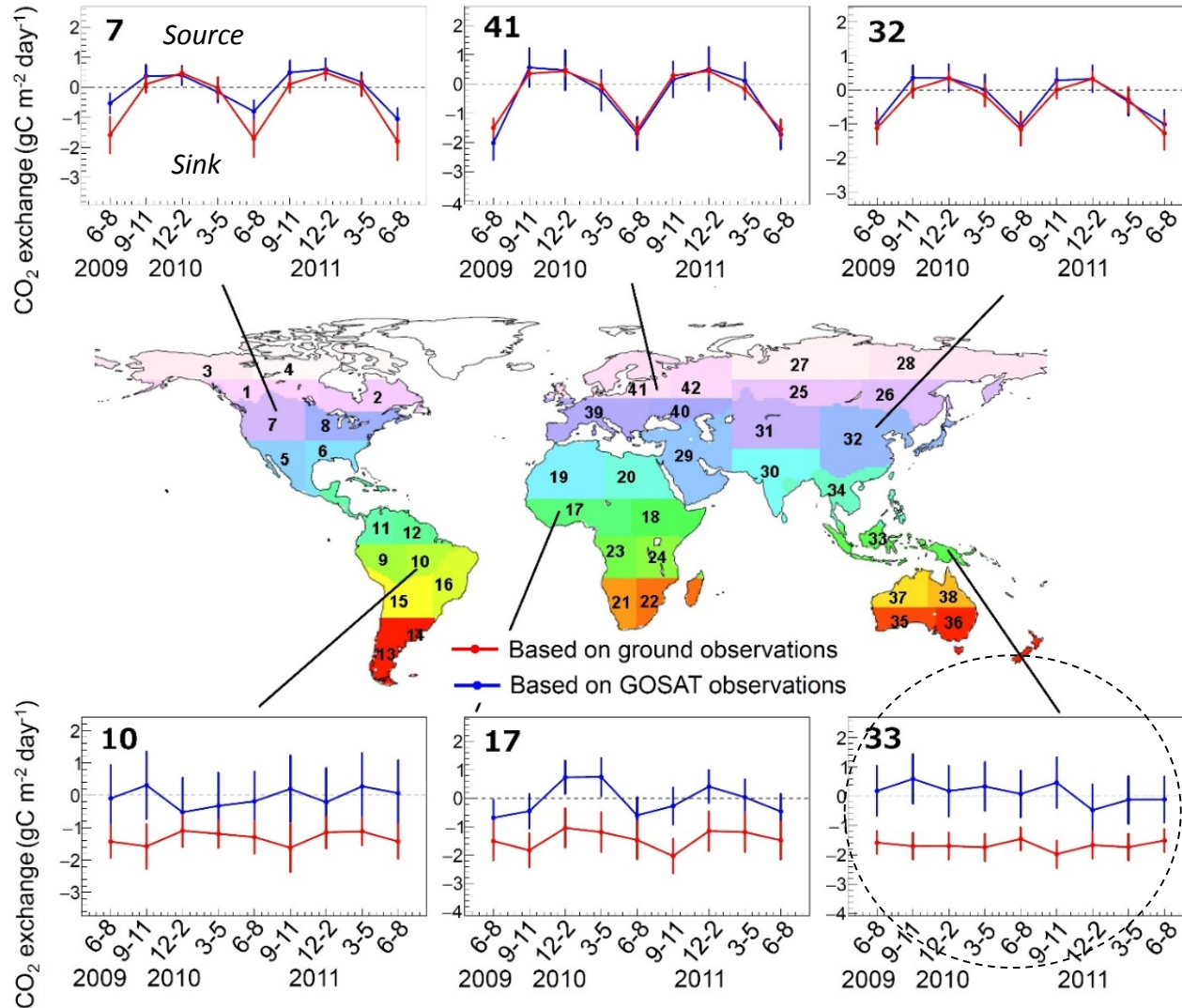(1) a case of *empirical upscaling*
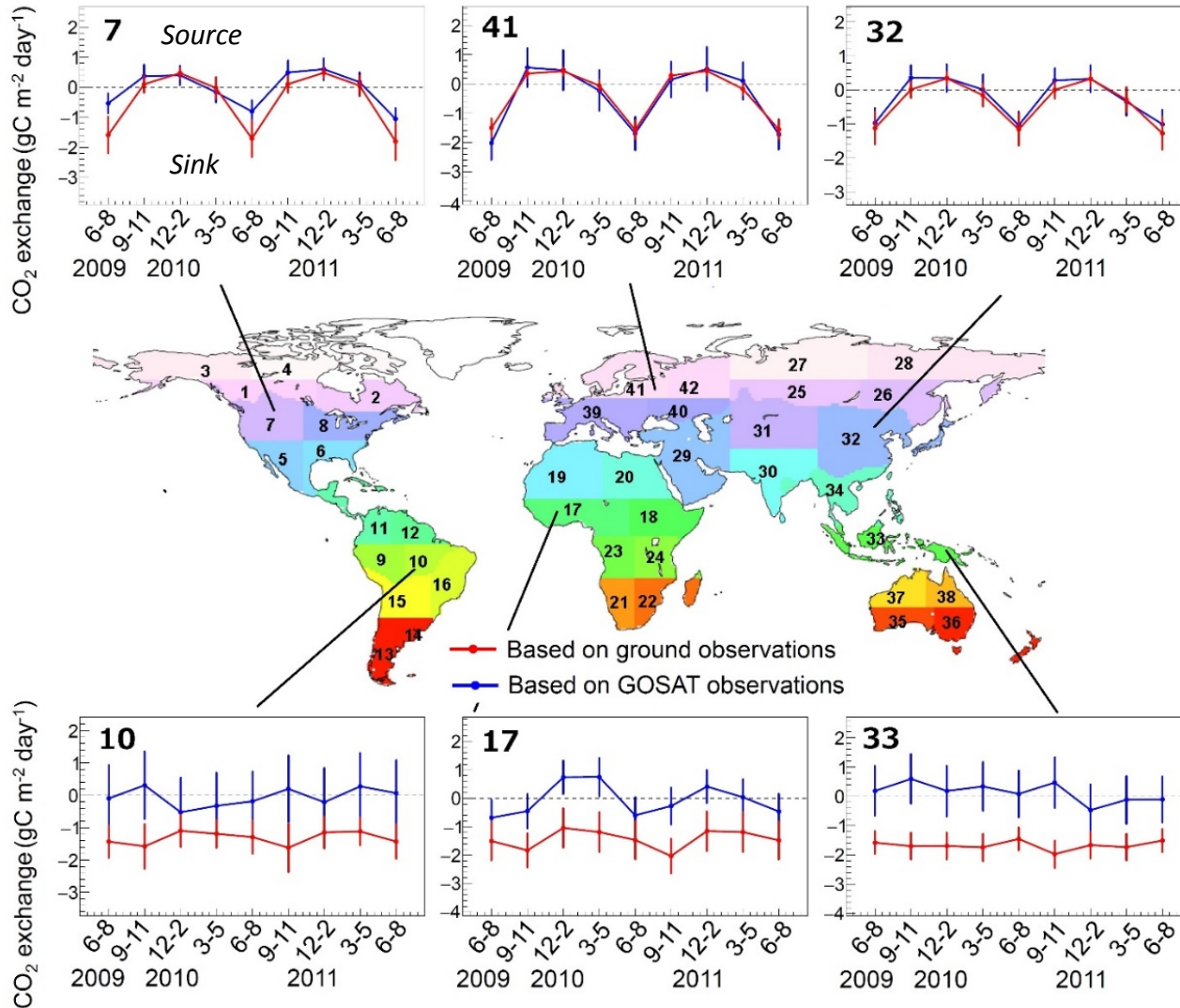
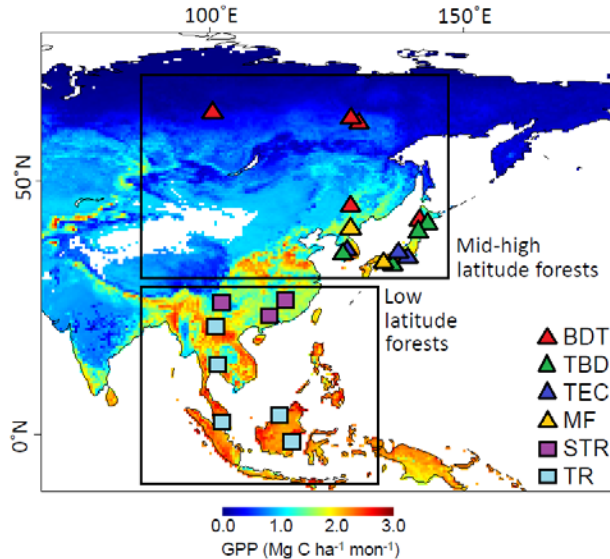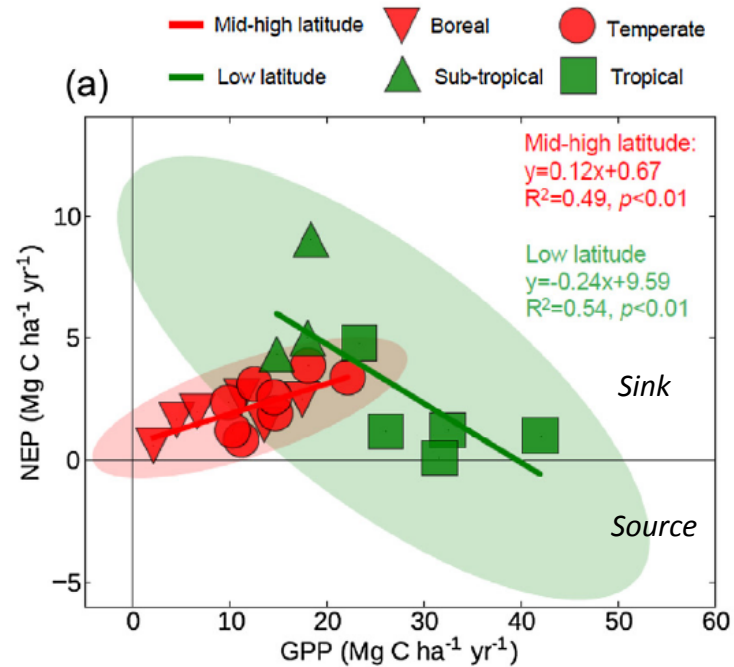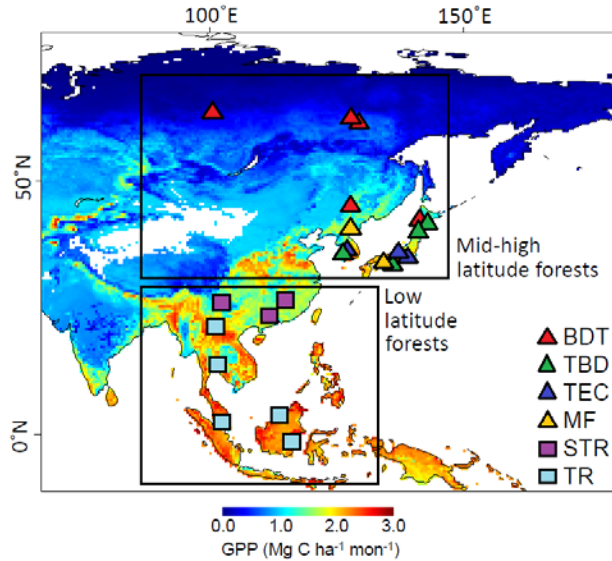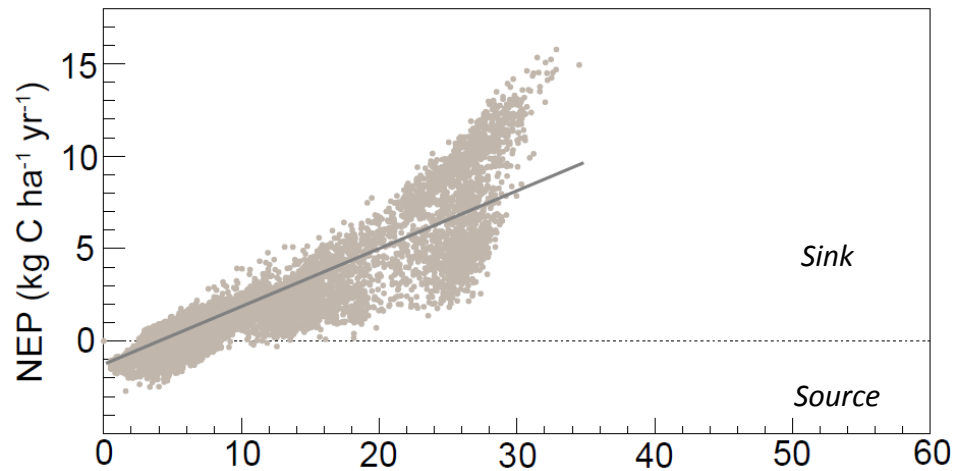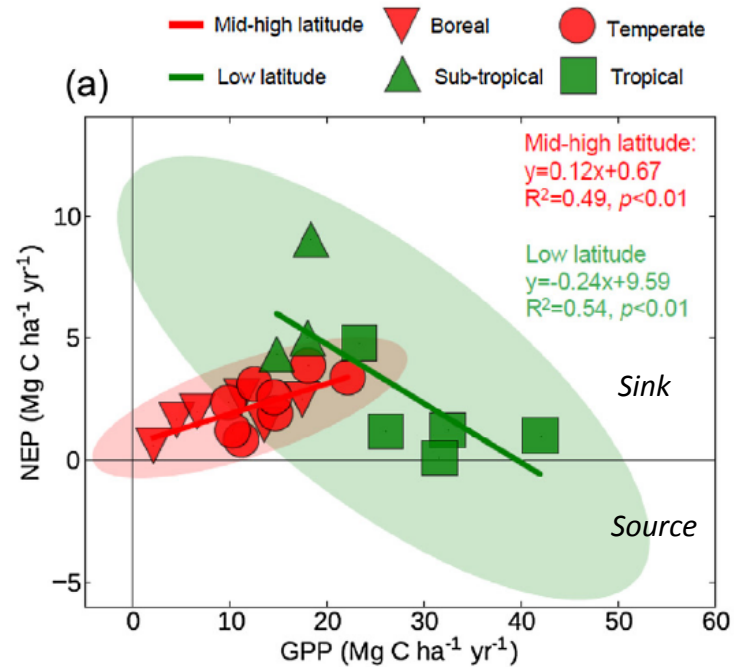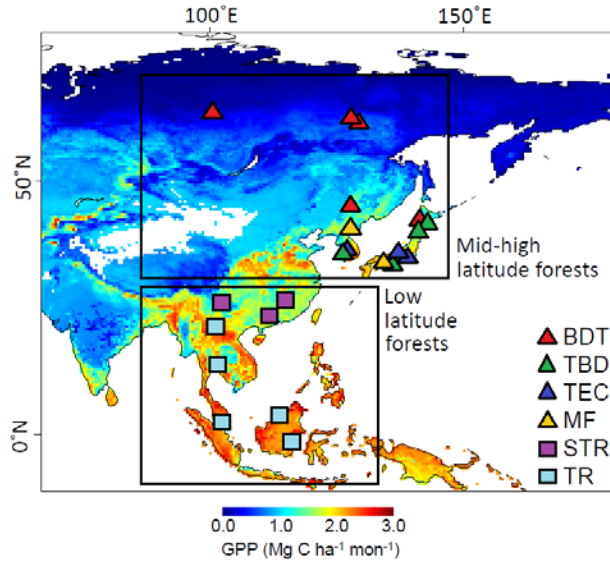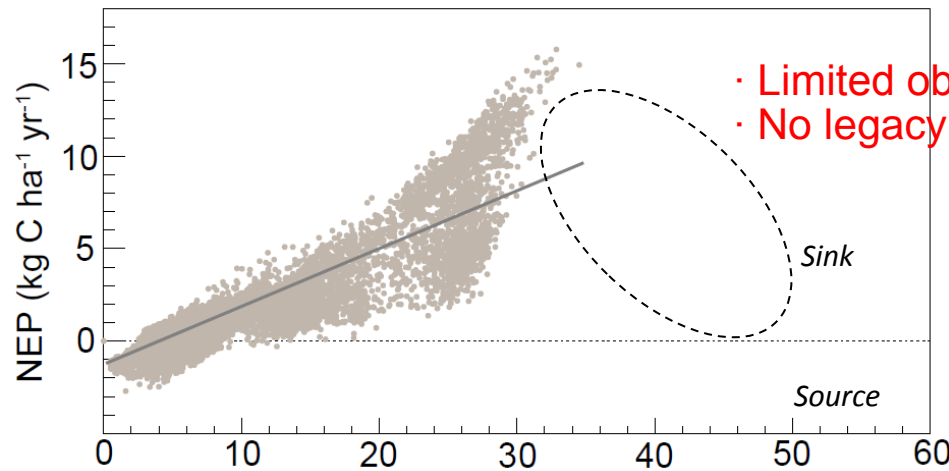
Based on Kondo et al., 2015 JGR

Issues remaining in regional carbon flux estimates

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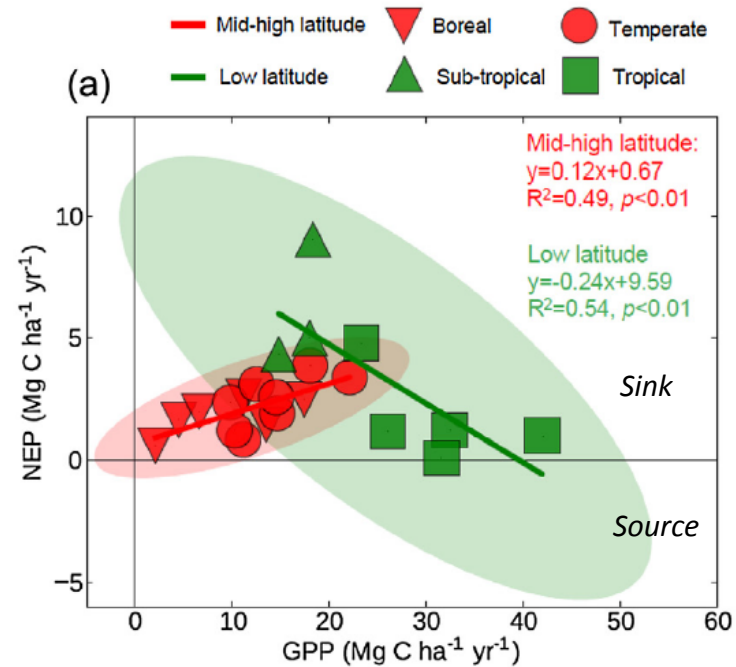

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Kondo et al. 2017 Agric For Met

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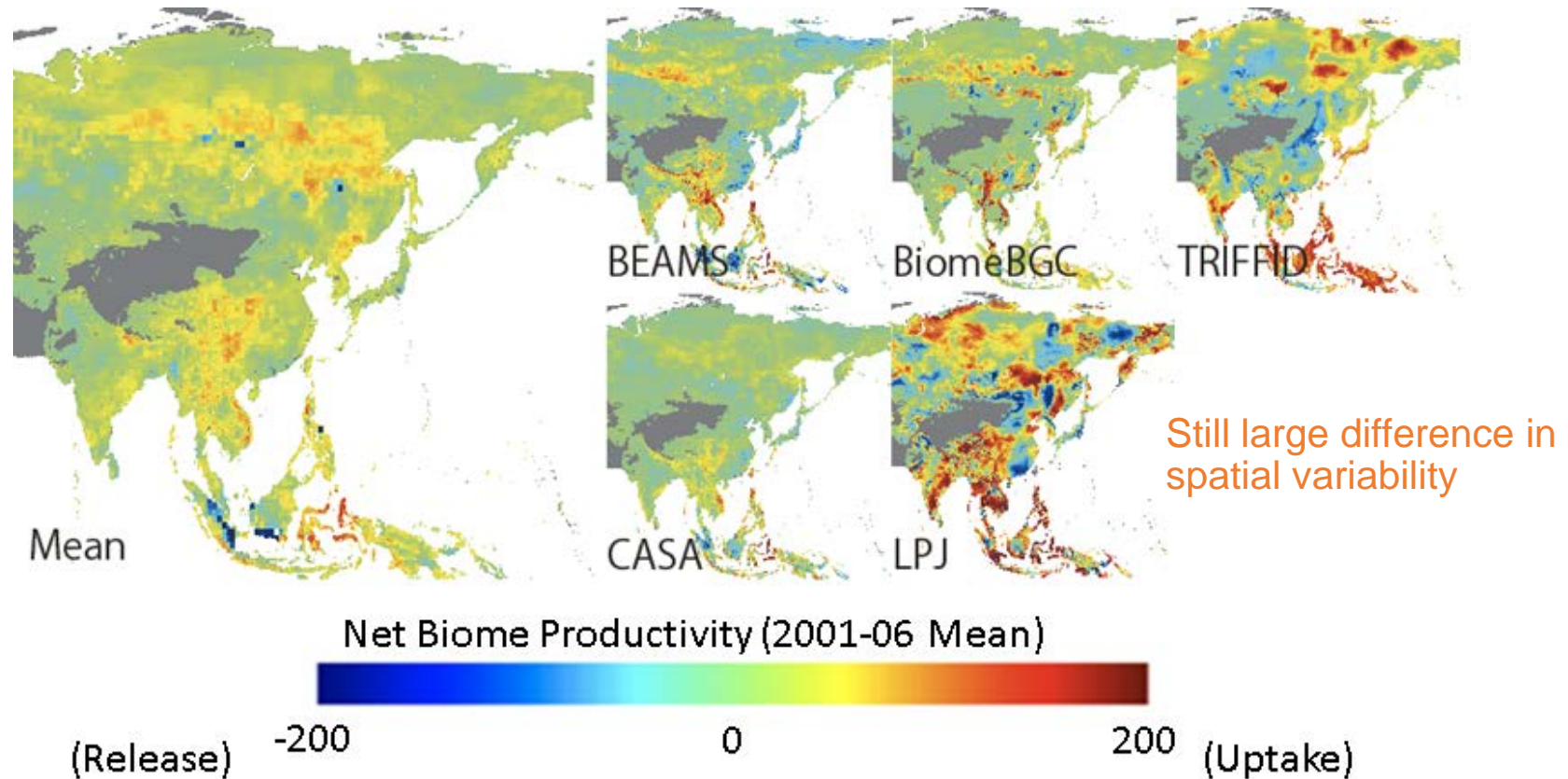
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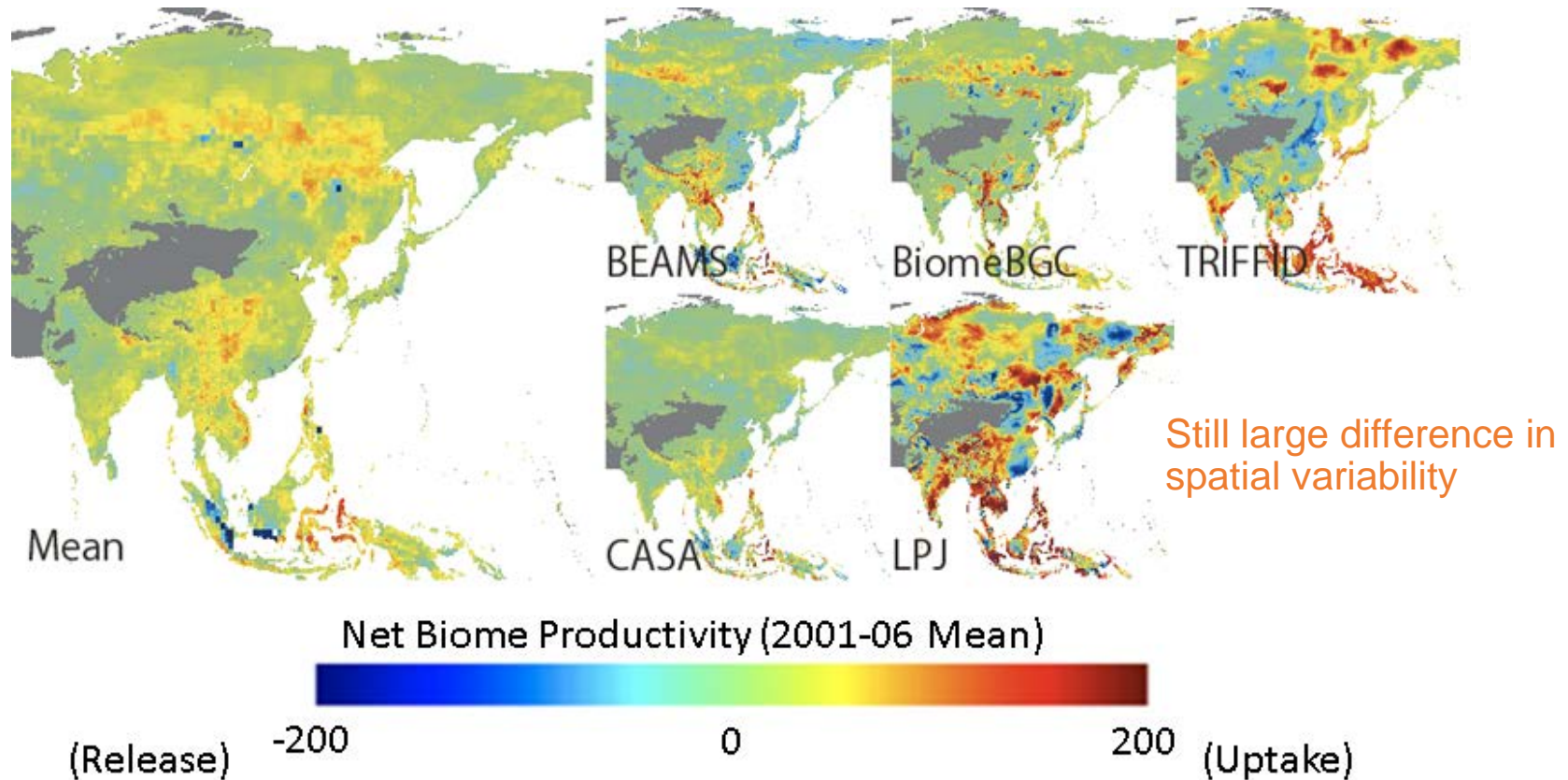
There are issues in regional carbon flux estimations...
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Kondo et al. 2017 Agric For Met

· Limited observations in tropics
· No legacy and nitrogen effects

Based on Kondo et al., 2015 JGR

Issues remaining in regional carbon flux estimates

There are issues in regional carbon flux estimations...
(2) a case of *biosphere models (AsiaMIP)*

Still large difference in spatial variability

Issues remaining in regional carbon flux estimates

There are issues in regional carbon flux estimations...
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Still large difference in spatial variability

Net Biome Productivity (2001-06 Mean)

(Release) -200   0   200 (Uptake)

Forcing:
· Atmospheric CO_2 →
· Climate variables →
· Legacy (age)
· Nitrogen deposition

Biosphere model

Output:
→ Carbon flux without legacy and nitrogen fertilization effects

Issues remaining in regional carbon flux estimates

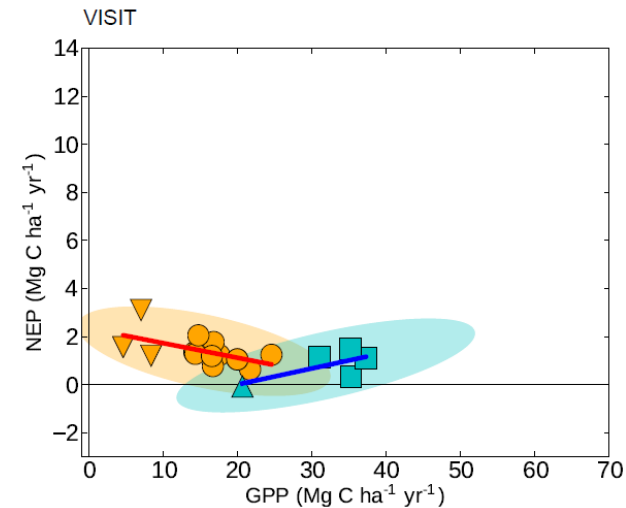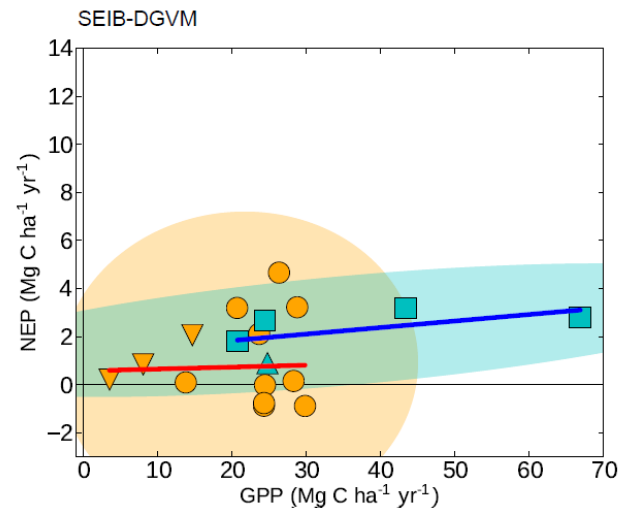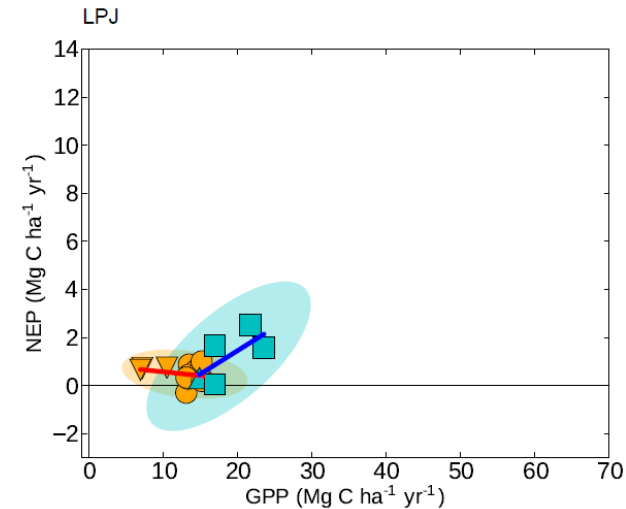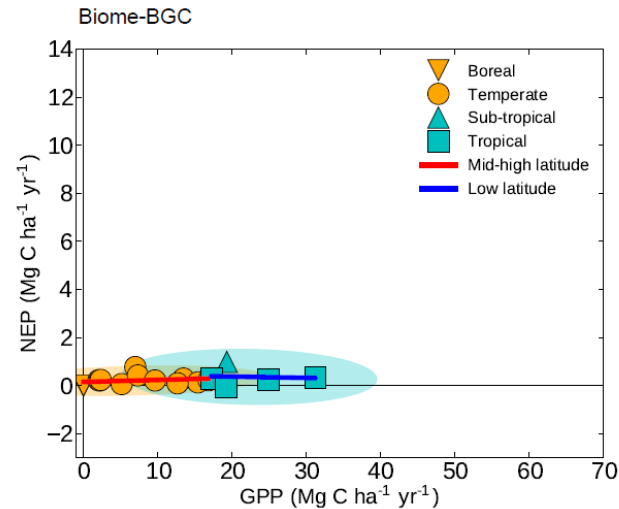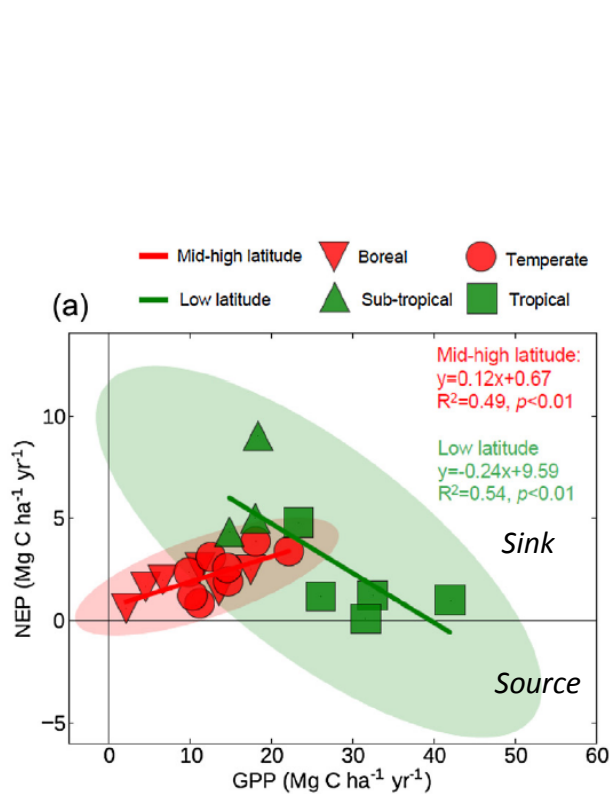There are issues in regional carbon flux estimations...
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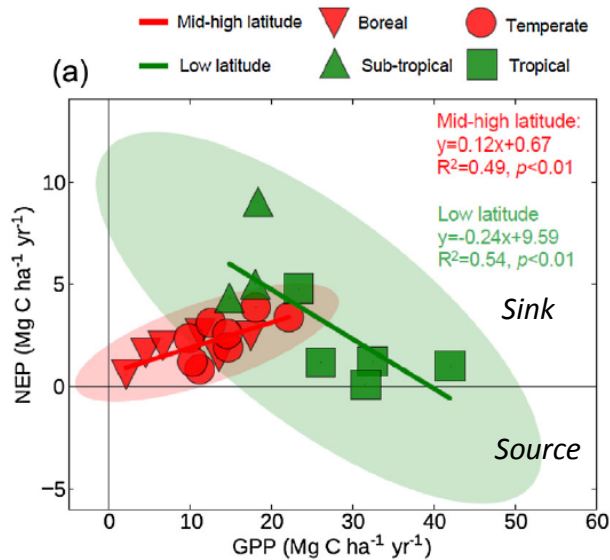
Issues remaining in regional carbon flux estimates

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Conclusion

The current state of regional carbon flux estimations in Asia…

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Empirical upscaling (SVR):

1. Too much of carbon sink in tropics

2. Limitations in tropical observations

3. Do not consider legacy and nitrogen deposition effects

AsiaMIP:

1. Large model-by-model variability

2. Variation in climate sensitivity

3. Do not consider legacy and nitrogen deposition effects

We need spatial information of legacy and nitrogen deposition

Conclusion

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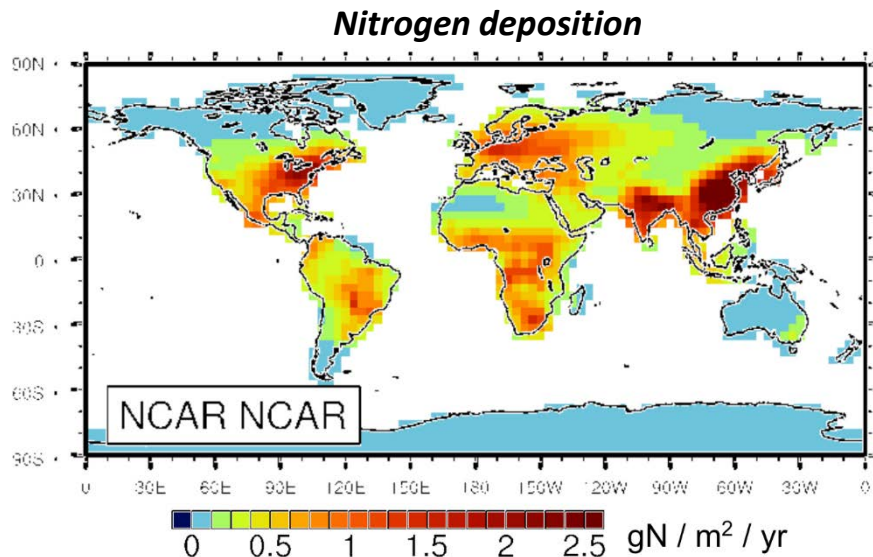✔ Issues remaining in regional estimates,

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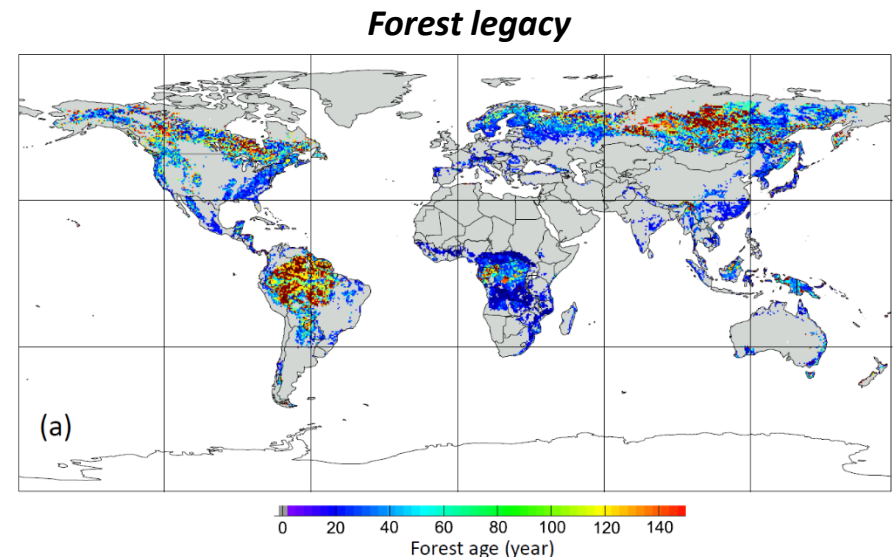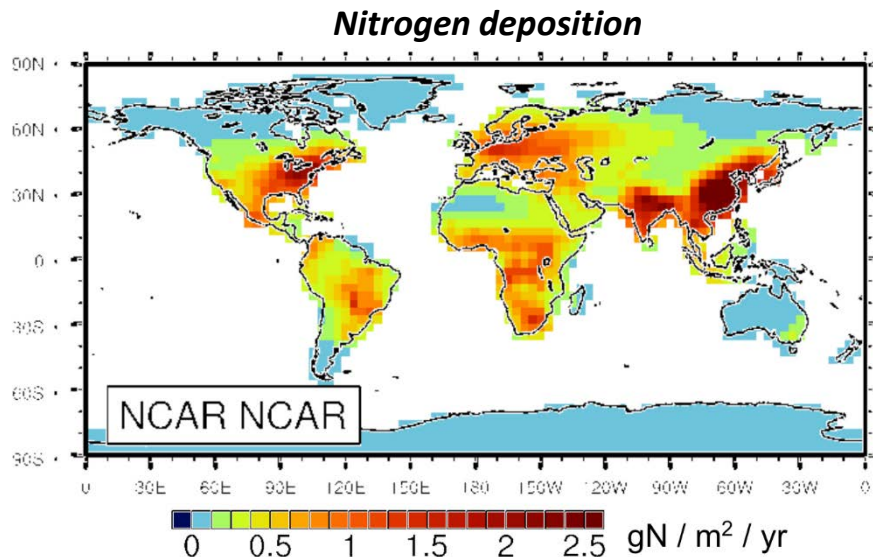✔ Issues remaining in regional estimates,

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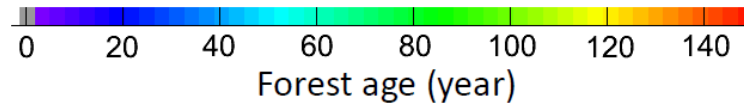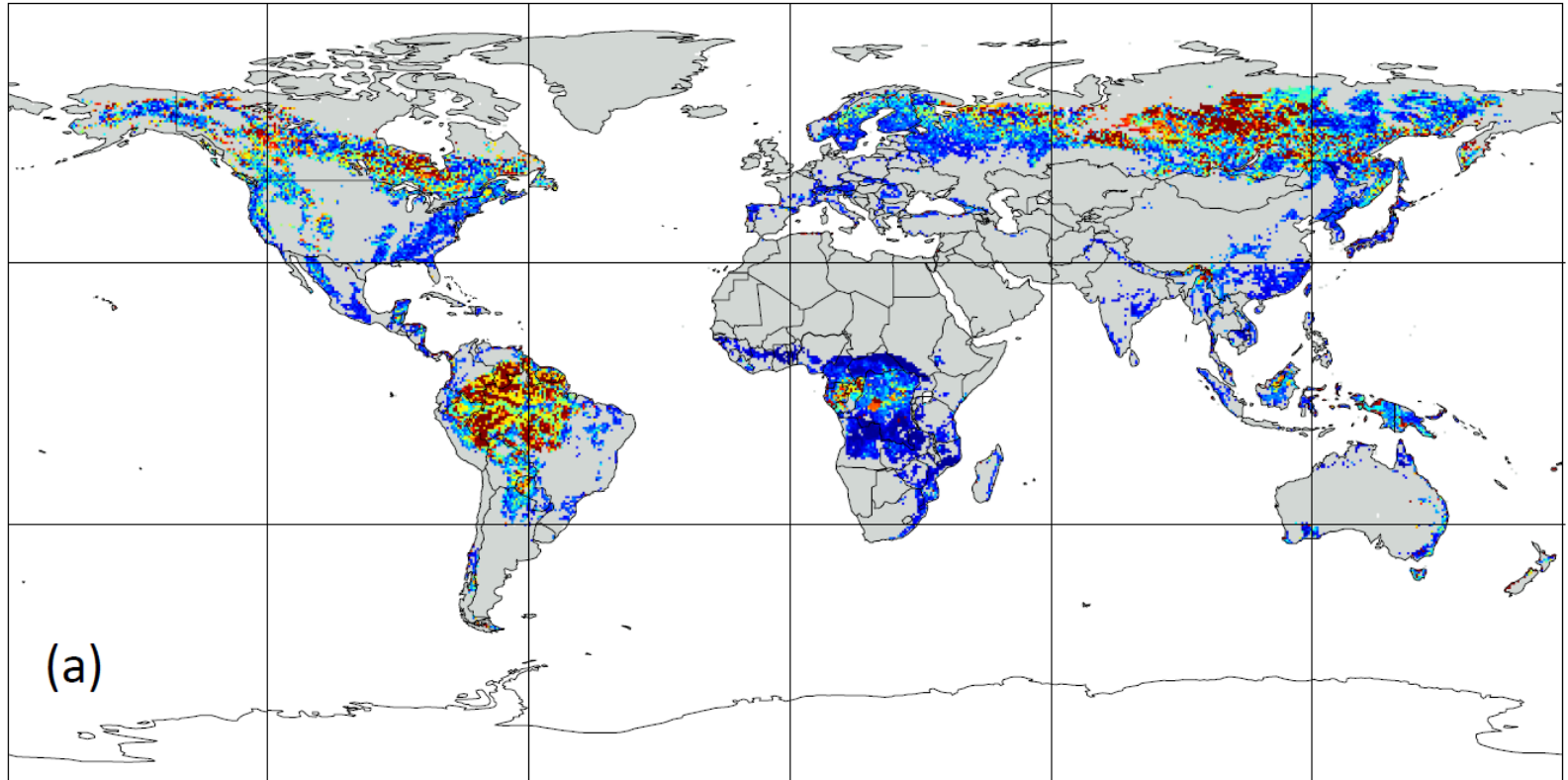3. Do not consider legacy and nitrogen deposition effects

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Nitrogen deposition

Forest legacy

Kondo M, Poulter B, Calle L, Liu YY, van Dijk AIJM in prep

What is missing in regional estimates

(a)

Forest age (year)

Kondo M, Poulter B, Calle L, Liu YY, van Dijk AIjM in prep