An application of DNDC to assess greenhouse gas emissions from different rice cultivation systems in Taiwan

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Climate change

Climate would affect agriculture

Climate Change

Agriculture

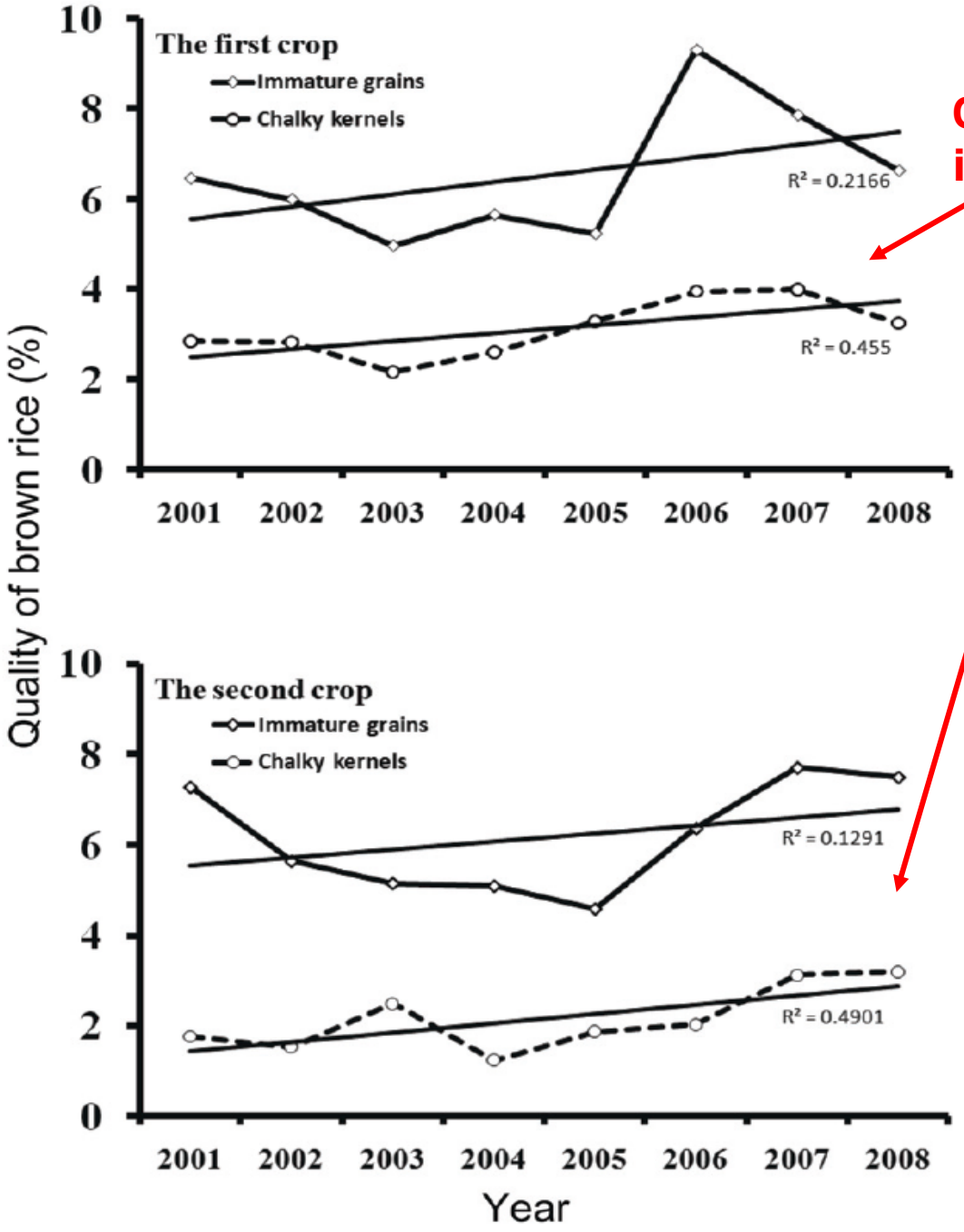
Damages of agriculture

Corn

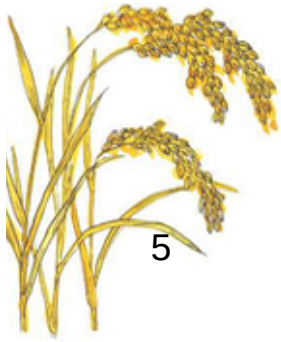
Wheat

Rice

Chalky grain



Chalkness is increasing

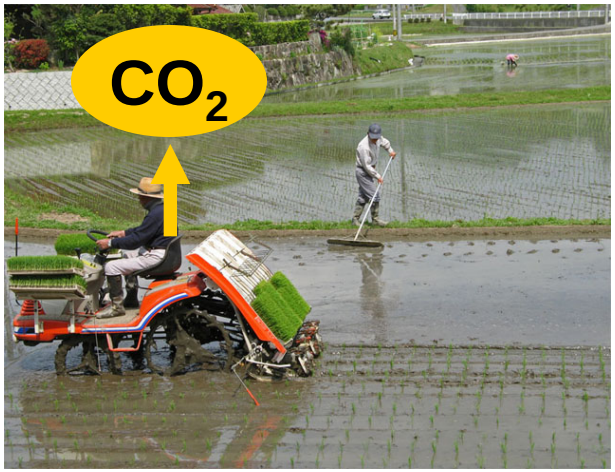


Agriculture would also aggravate climate change

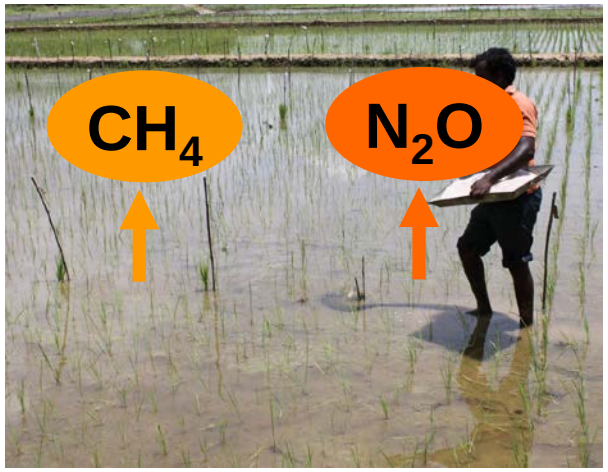
Climate Change

Agriculture

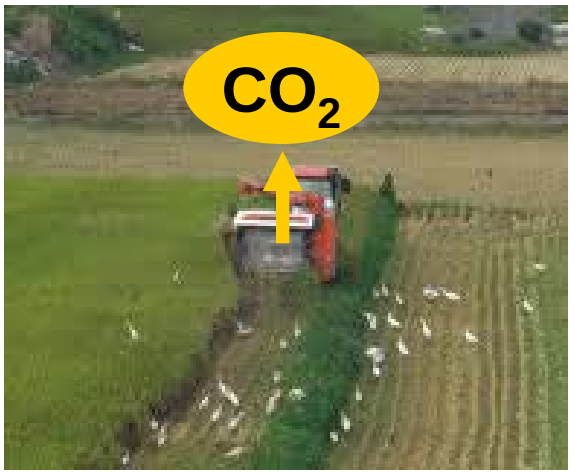
Greenhouse gas emissions from agriculture



Transplanting



Cultivation & Fertilization

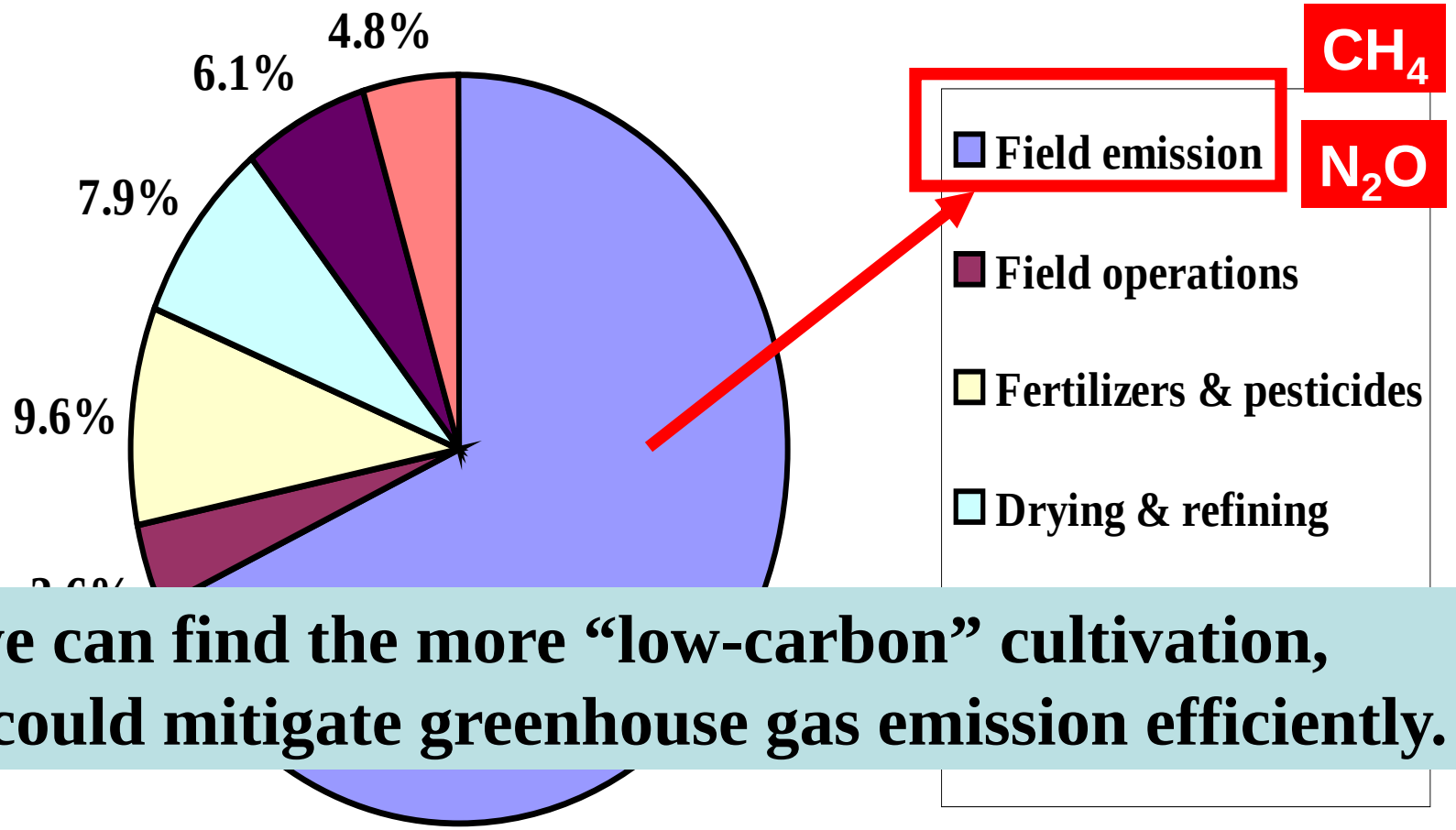


Harvest

Drying and Polishing

Transportation

Global Warming Potential (GWP) of rice production in Italy



If we can find the more "low-carbon" cultivation, we could mitigate greenhouse gas emission efficiently.

(Blengini and Busto, 2009)

A practice of
Climate Smart Agriculture
is needed

Climate Smart Agriculture (CSA)

- **Sustainably increasing agricultural productivity and incomes**
- **Adapting and building resilience to climate change**

Adaptation

- **Reducing and/or removing greenhouse gases emissions, where possible**

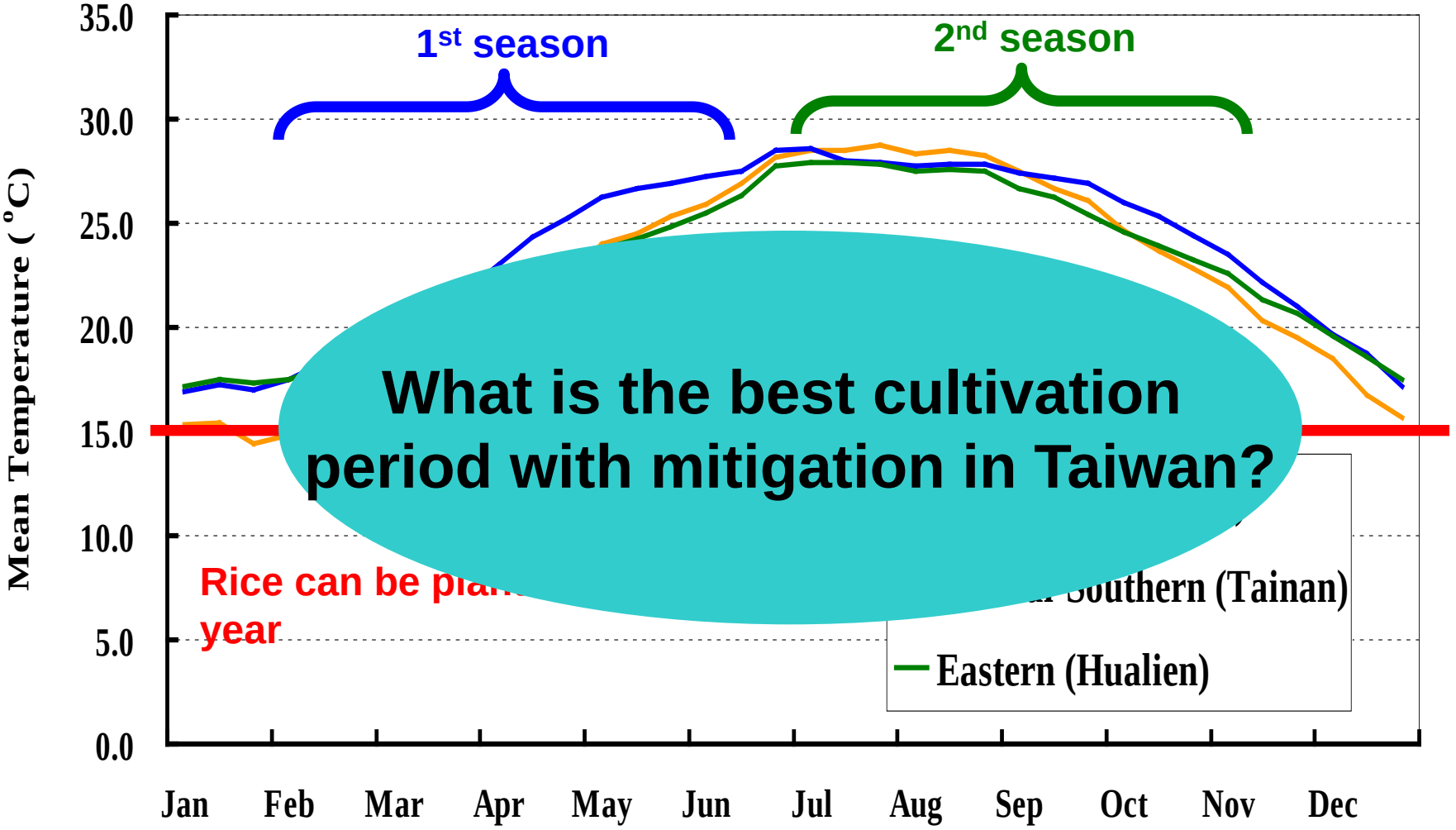
Mitigation

(FAO, 2013)

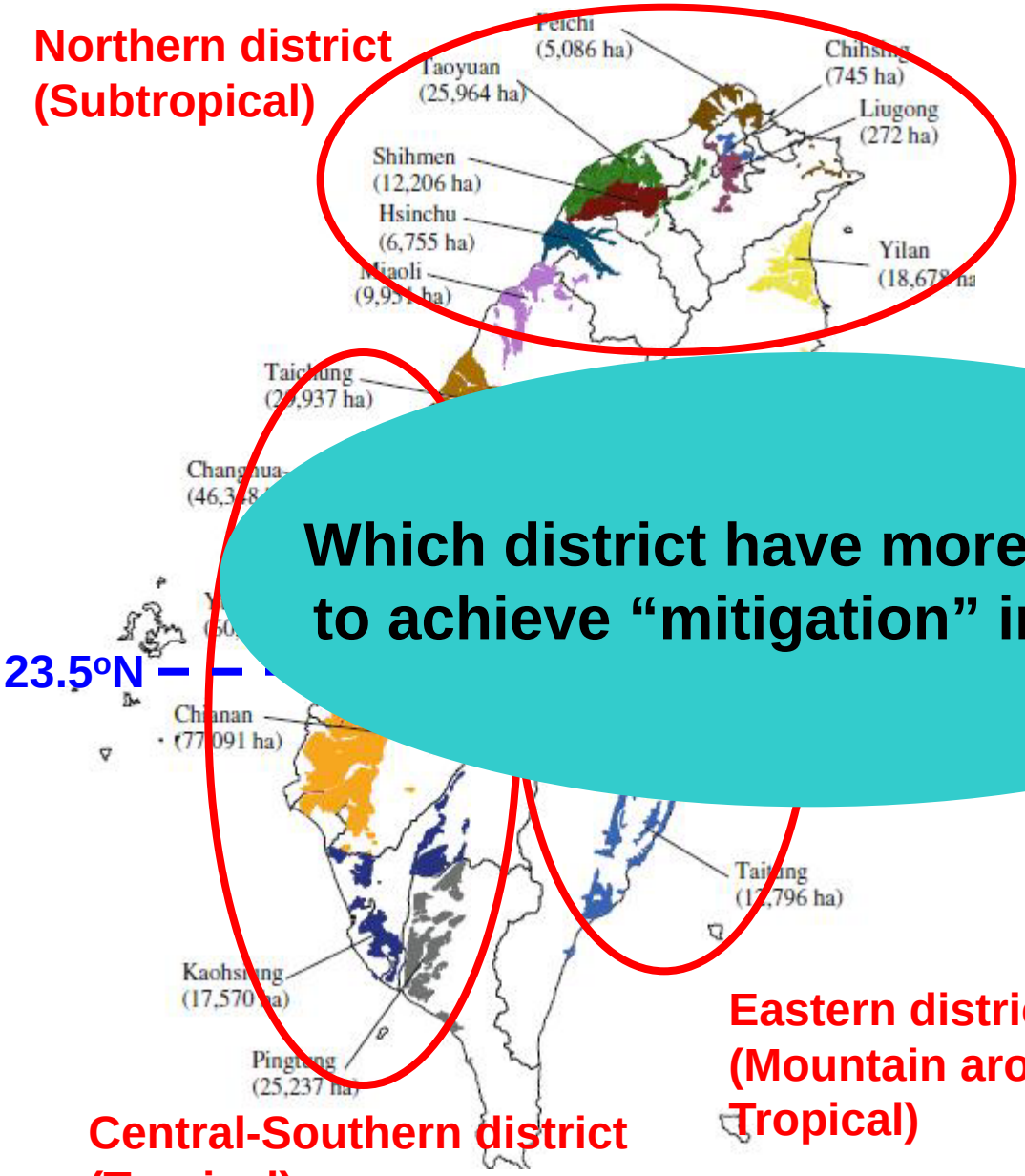
Strategies of Adaptation and Mitigation

- **Adaptation**
  - **Appropriate cultivation period**
  - **Water managements**
  - **Heat resistant cultivars**
- **Mitigation**
  - **Appropriate cultivation period**
  - **Fertilization managements**
  - **Choose the appropriate site for cultivation**

Temperature in Taiwan



Taiwan



- Rice can be
  - wth in almost
  - lain
  - ed into 3 main rice districts
    - Northern
    - Central-Southern
    - Eastern

Materials and Methods

- **We conducted 2 parts in this research**
  - **Comparison among different cultivation periods (17 periods in 2 years were included)**
  - **Comparison among 3 main districts (Northern, Central-Southern, Eastern)**

    and 4 cultivation practices (Conventional, Organic, Integrated, Natural)
- **Items of analysis**
  - **Grain yield**
  - **Global warming potential per hectare**
  - **Global warming potential per kg polished rice**

How to analyze greenhouse gas emissions

- DNDC model
  - Denitrification-Decomposition model
- A biogeochemical model
- Data input
  - Climate: temperature, precipitation, radiation
  - Soil: texture, pH, bulk density, soil organic carbon
  - Management: planting period, fertilization, irrigation
- Data output
  - Field emission of CO_2, CH_4, N_2O (per hectare)
- Certification of using DNDC in Taiwan

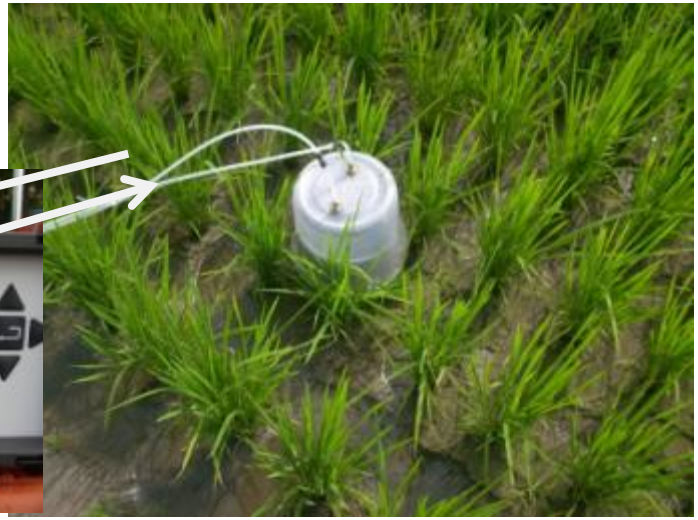
Instruments of GHGs measurement

	CO_2	CH_4	N_2O
Chamber	O	O	O
EC	O	O	X

Open system CH_4 analyzer

Eddy Covariance

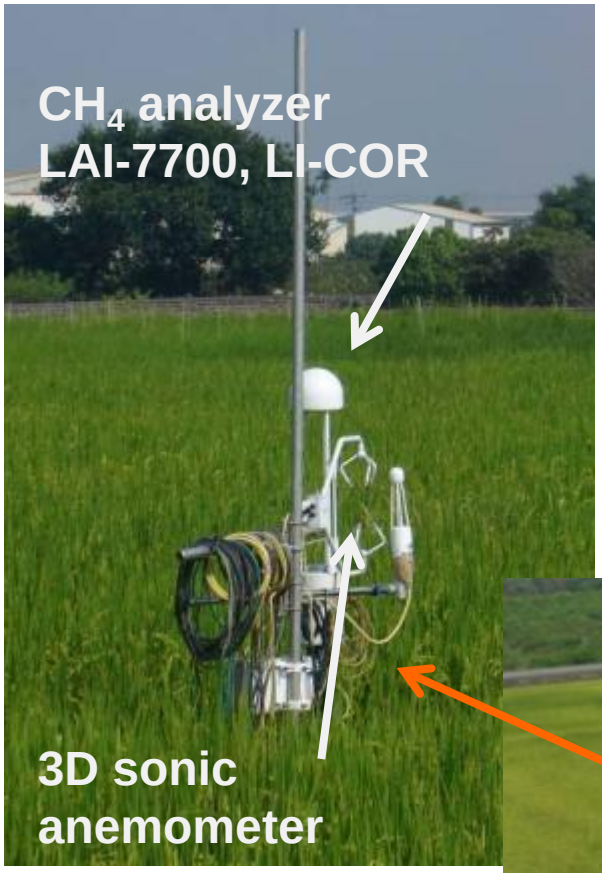
Gas analyzer

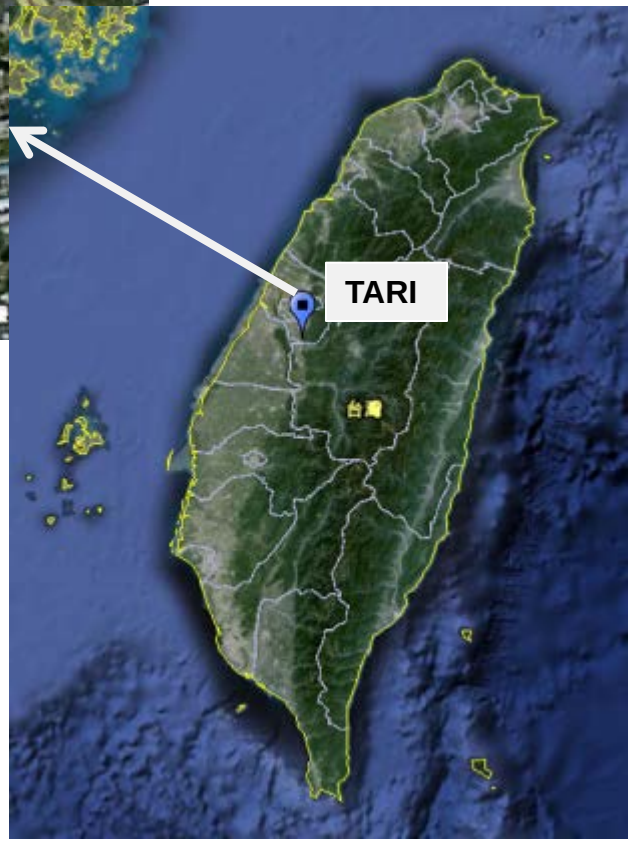


Chamber method

(Chen *et al.*, 2013)

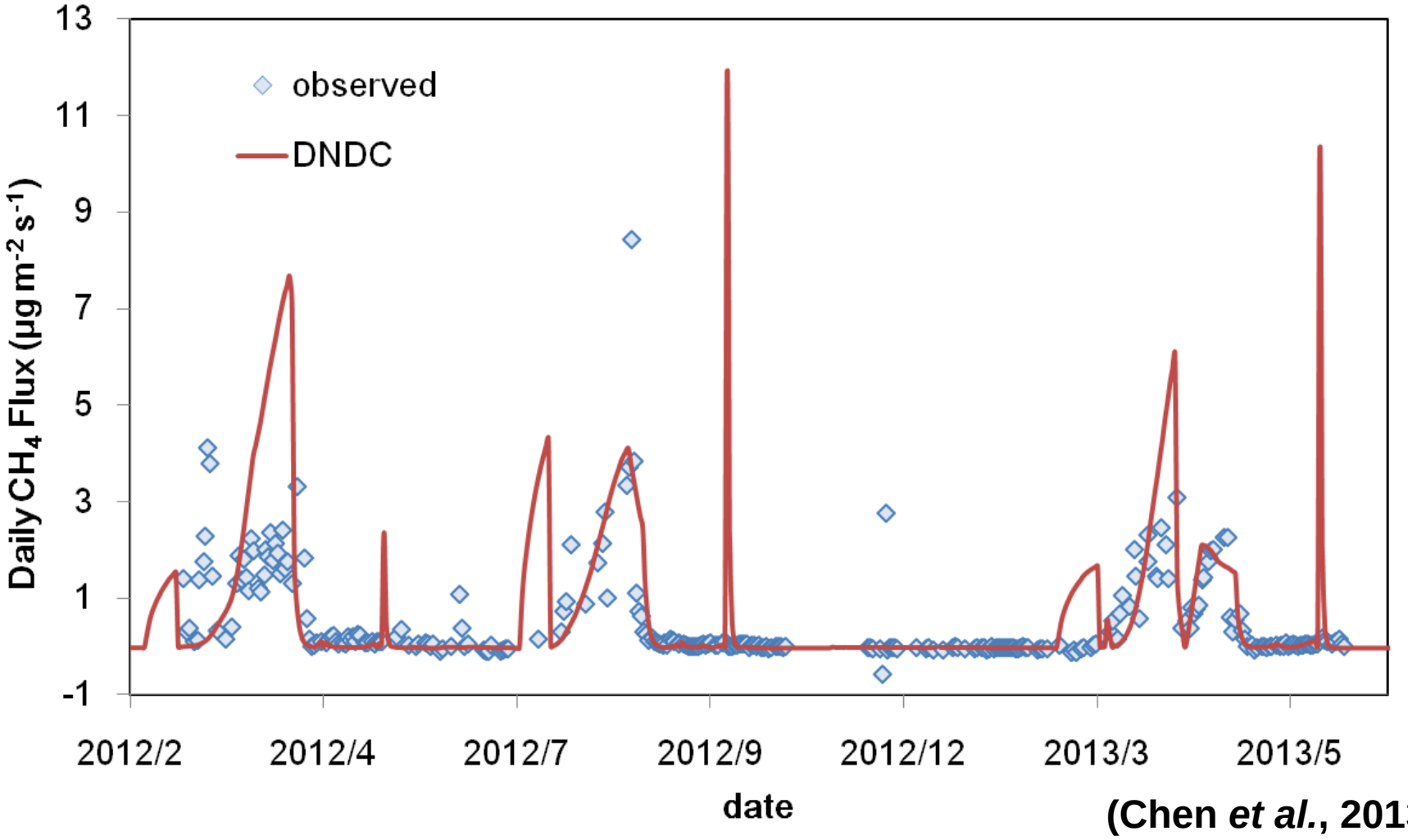
Methane emission from paddy measured by Eddy Covariance Method





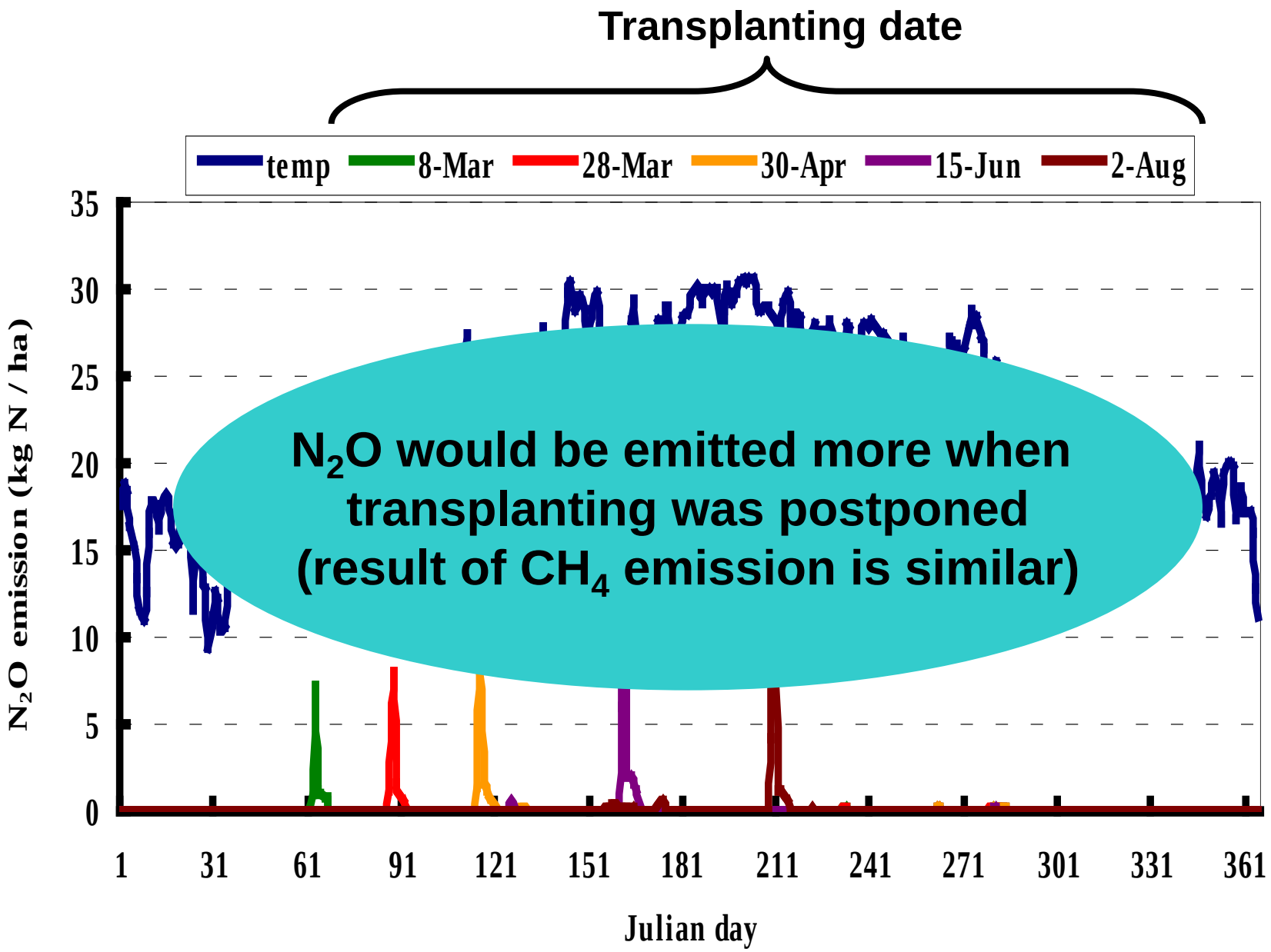
(Chen *et al.*, 2013)

Comparison on simulated by DNDC model and measured CH_4 flux from paddy in Taiwan

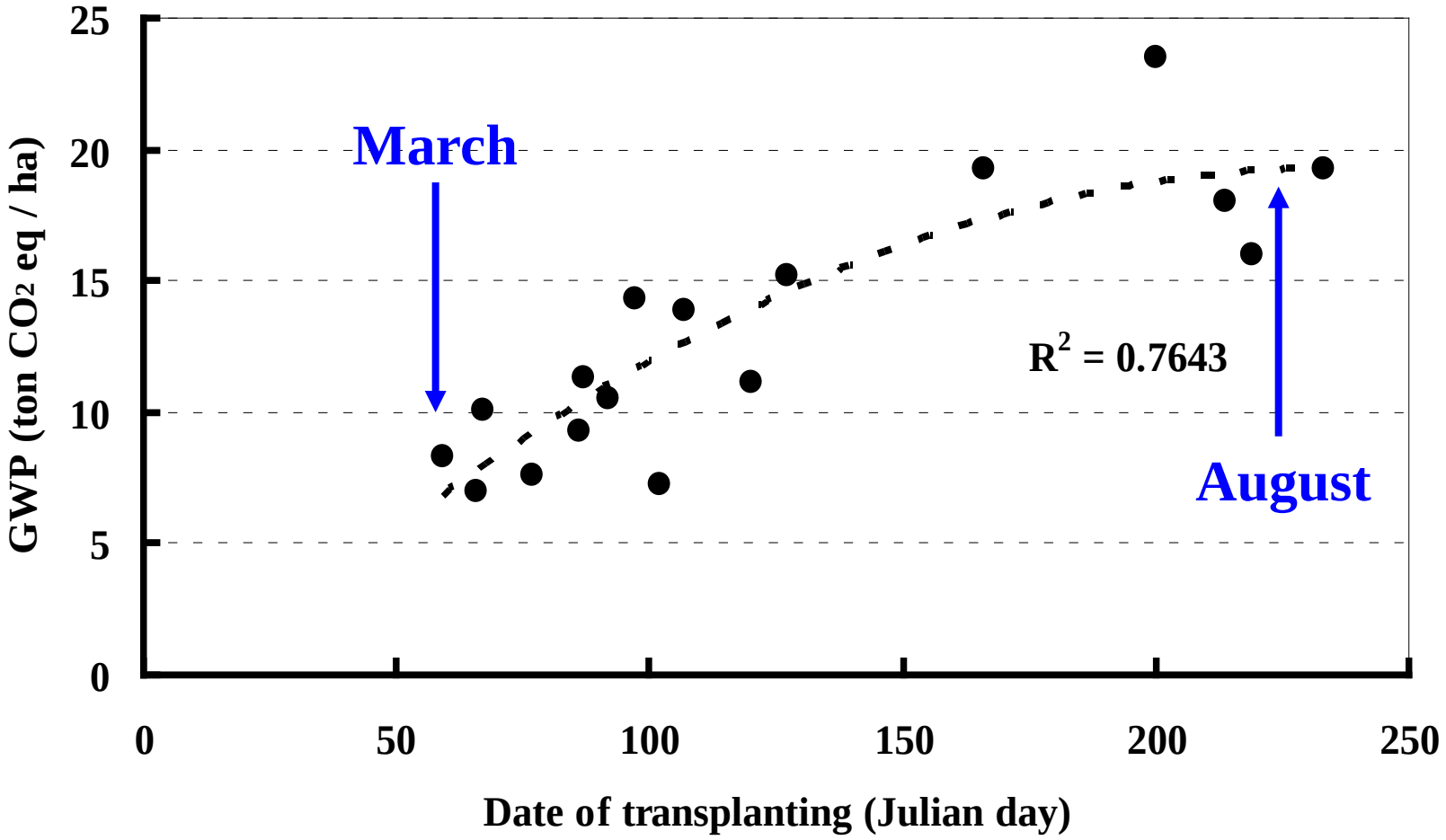


(Chen *et al.*, 2013)

Comparison among different dates of transplanting


Transplanting date
temp
8-Mar
28-Mar
30-Apr
15-Jun
2-Aug
N2O emission (kg N / ha)
35
30
25
20
15
10
5
0
1
31
61
91
121
151
181
211
241
271
301
331
361
Julian day
N2O would be emitted more when transplanting was postponed (result of CH4 emission is similar)

Correlation between GWP and date of transplanting



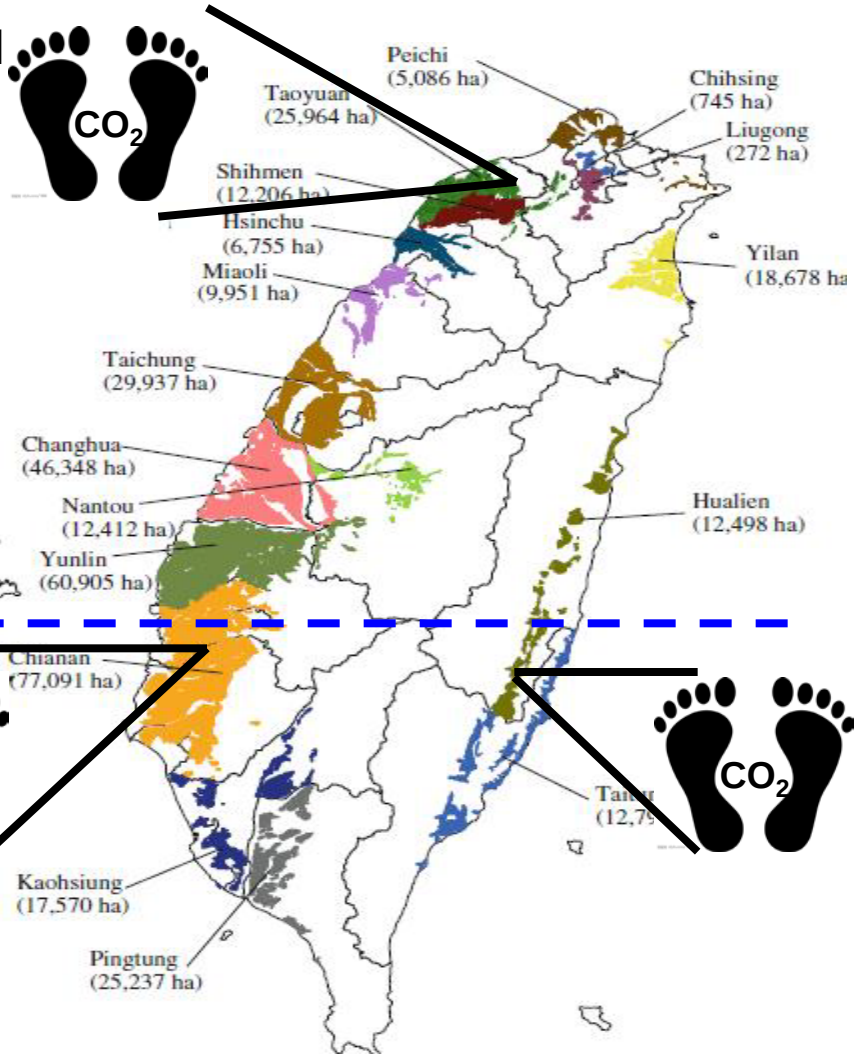
Brief Summary

- **There would be larger amount of greenhouse gas emission if we postpone the date of transplanting more.**

- **Best date of transplanting is about it of the conventional 1st cropping season (transplanting at February or March).**

Comparison among different districts and practices

1. Conventional
2. Organic
3. Integrated

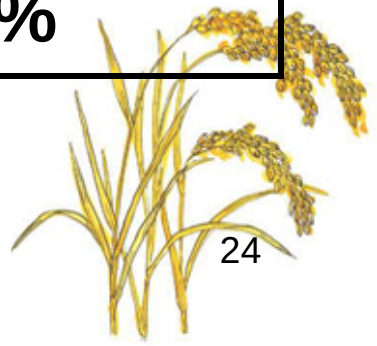


1. Conventional
2. Organic
3. Natural

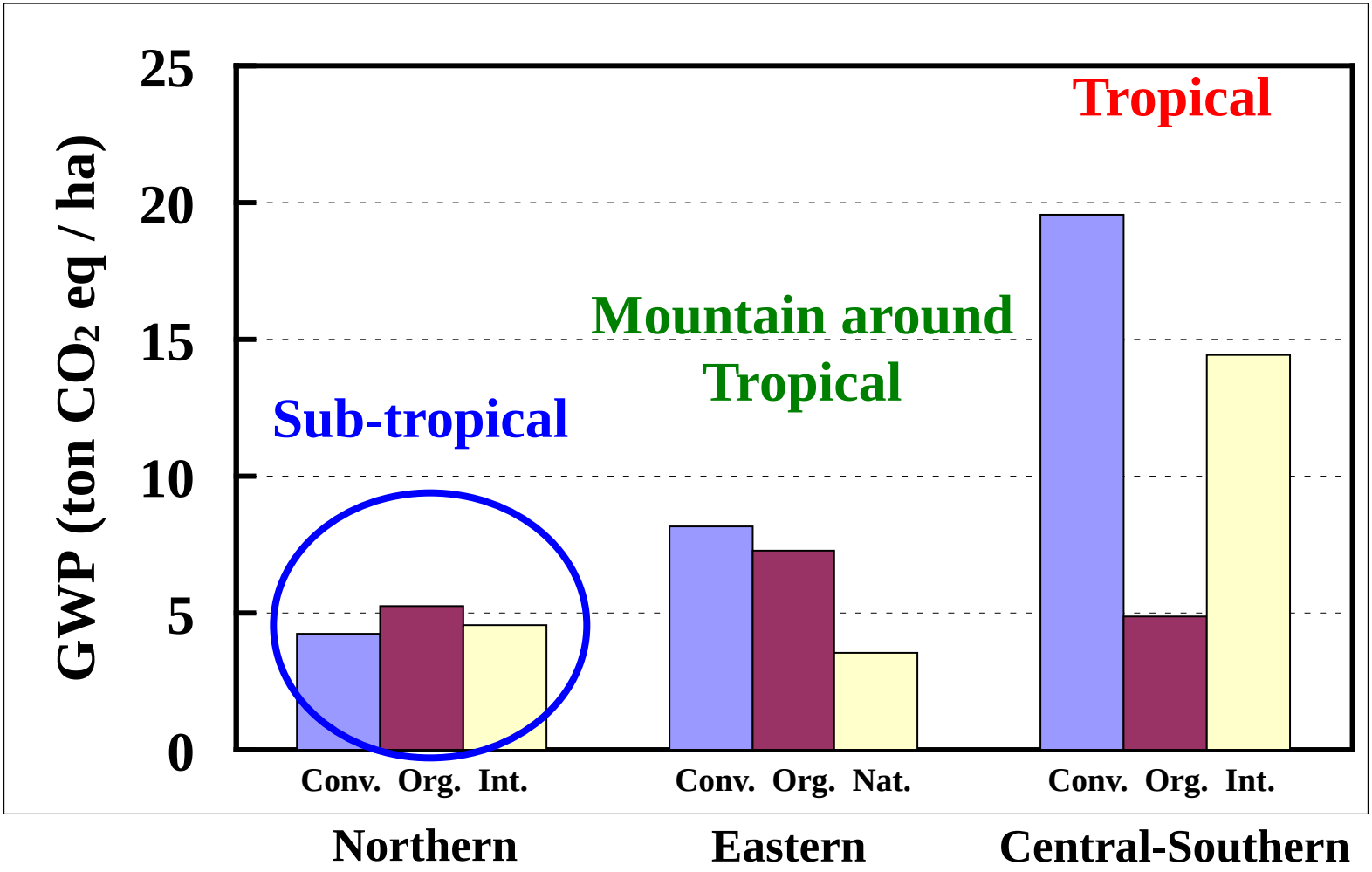
1. Conventional
2. Organic
3. Integrated

Cultivation practices

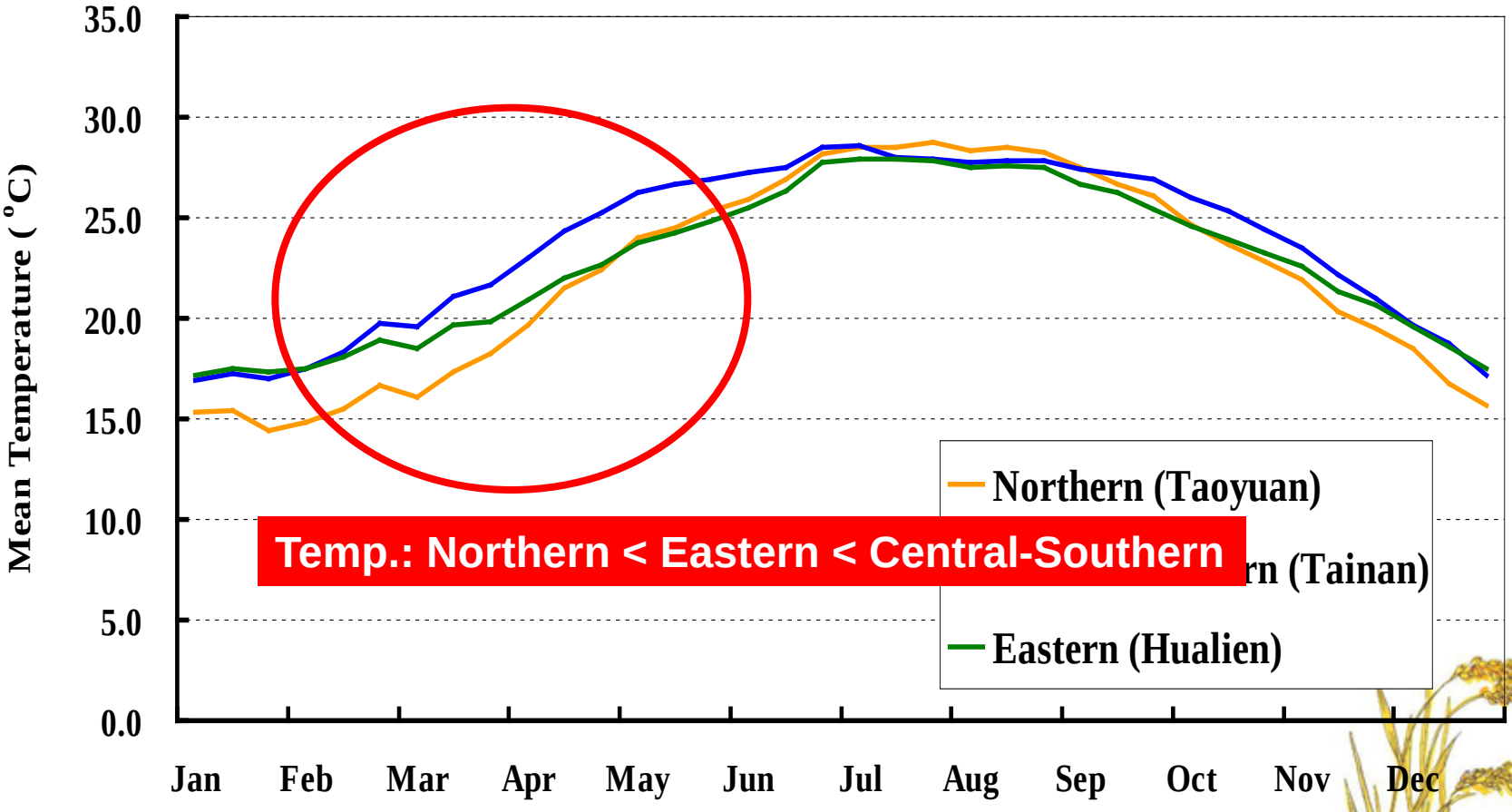
Cultivation practices	Mineral fertilizer	Organic fertilizer
Conventional	100 %	0 %
Organic	0 %	100 %
Integrated	50 %	50 %
Natural	0 %	0 %



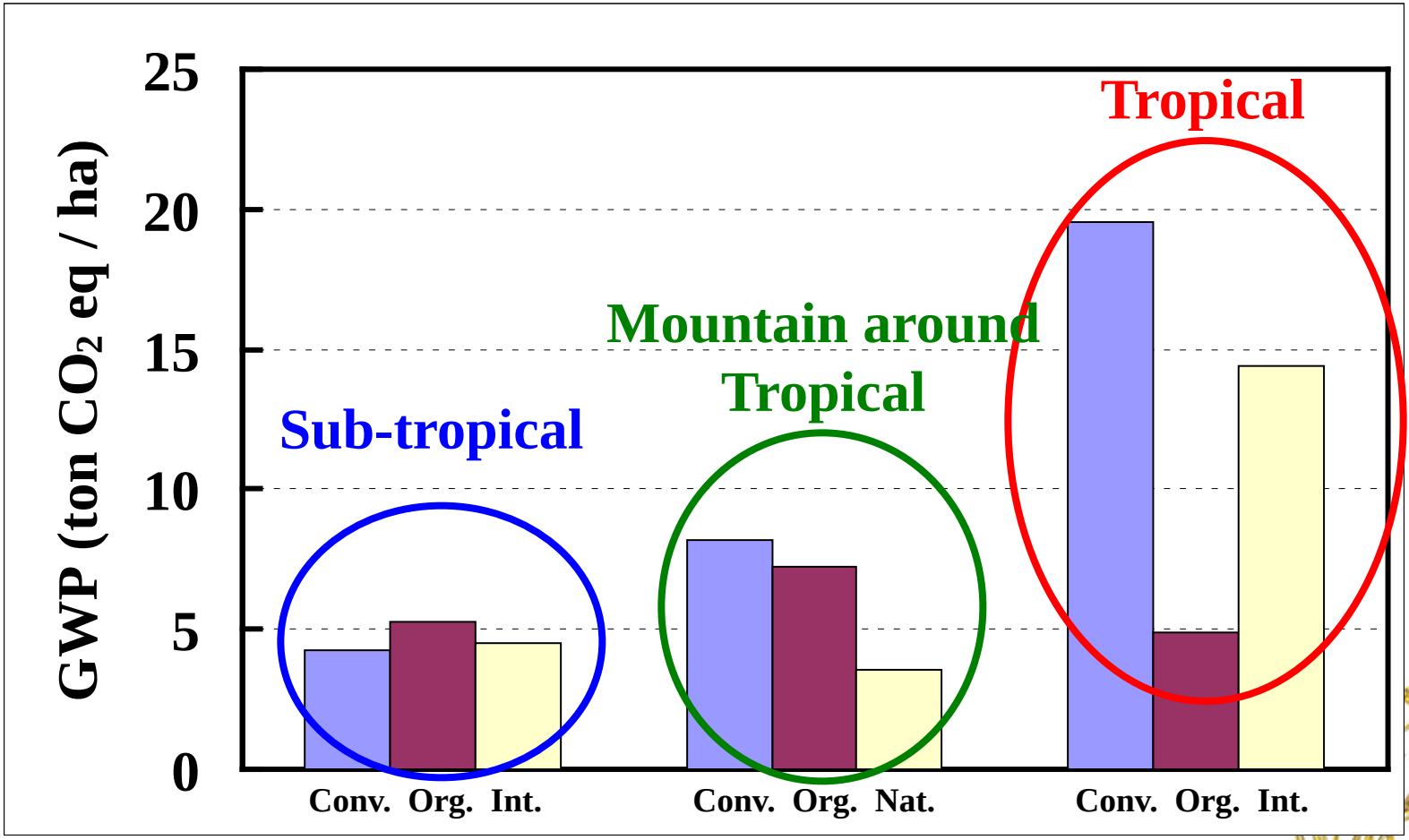
GWP per hectare



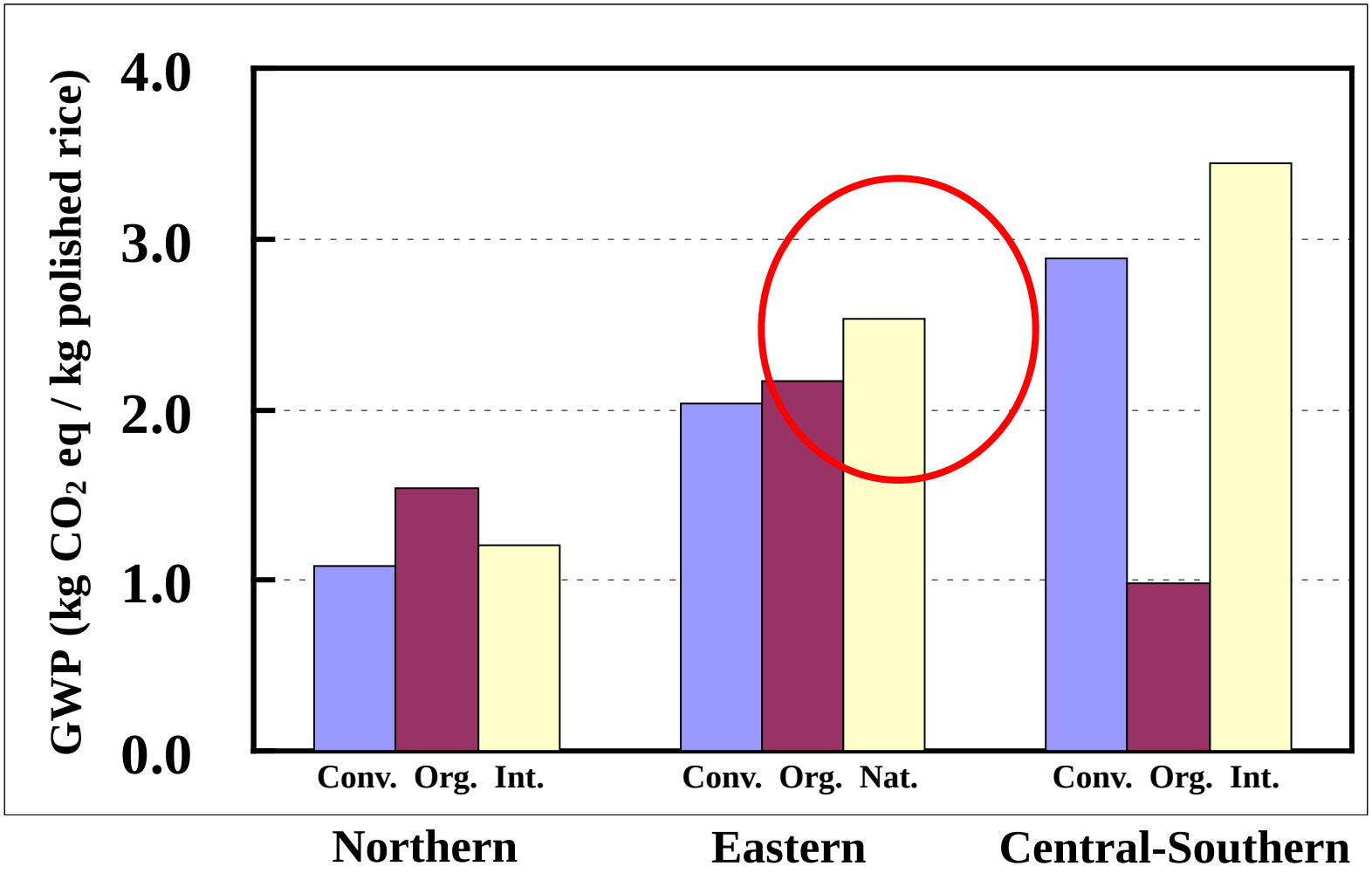
Temperature of 3 districts



GWP per hectare



GWP per kg polished rice



Brief Summary – Northern (Subtropical)

- **Low temp. and low GWP**
- **Water management**
  - **Performing intermittent irrigation to reduce CH_4 emissions**

Brief Summary – Central-Southern (Tropical)

- **High temp. and high GWP**
- **Rationale fertilization**
  - **Reducing amount**
- **Water management**
  - **Immediately flooding after fertilization**
  - **Preventing N_2O emissions**

Brief Summary – Eastern (Mountain around Tropical)

- **High GWP of Org.**
  - **More CH_4**
    - **Long growth period**
- **Water management**
  - **Performing intermittent irrigation to reduce CH_4 emissions**
- **Low yield and low GWP of Nat.**

Conclusion

- **Climate Smart Agriculture should consider both adaptation and mitigation**

- **We could change transplanting time, cultivation location or practice to improve the yield and GWP**

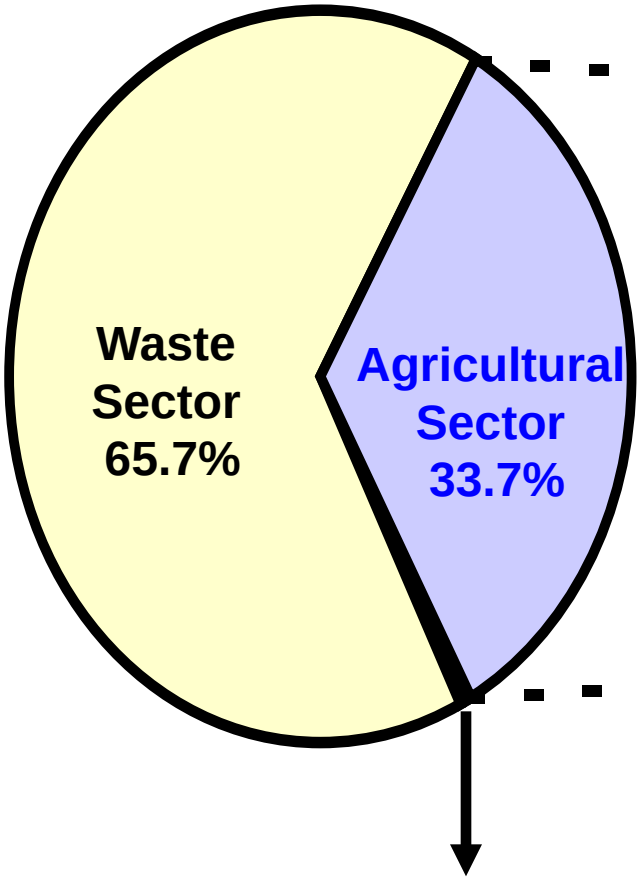
Conclusion

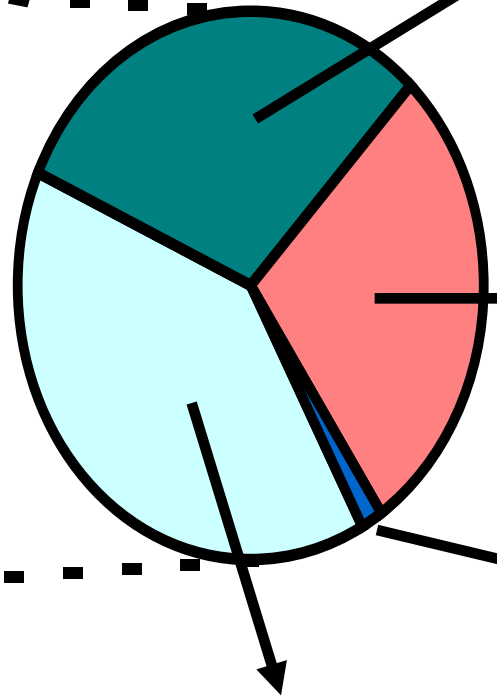
- **To reduce GWP, in Taiwan,**
  - **Transplanting time should be as possible as early ;**
  - **Northern district is better ;**
  - **Integrated farming might be a direction**

THANK YOU

We Need Your Advices

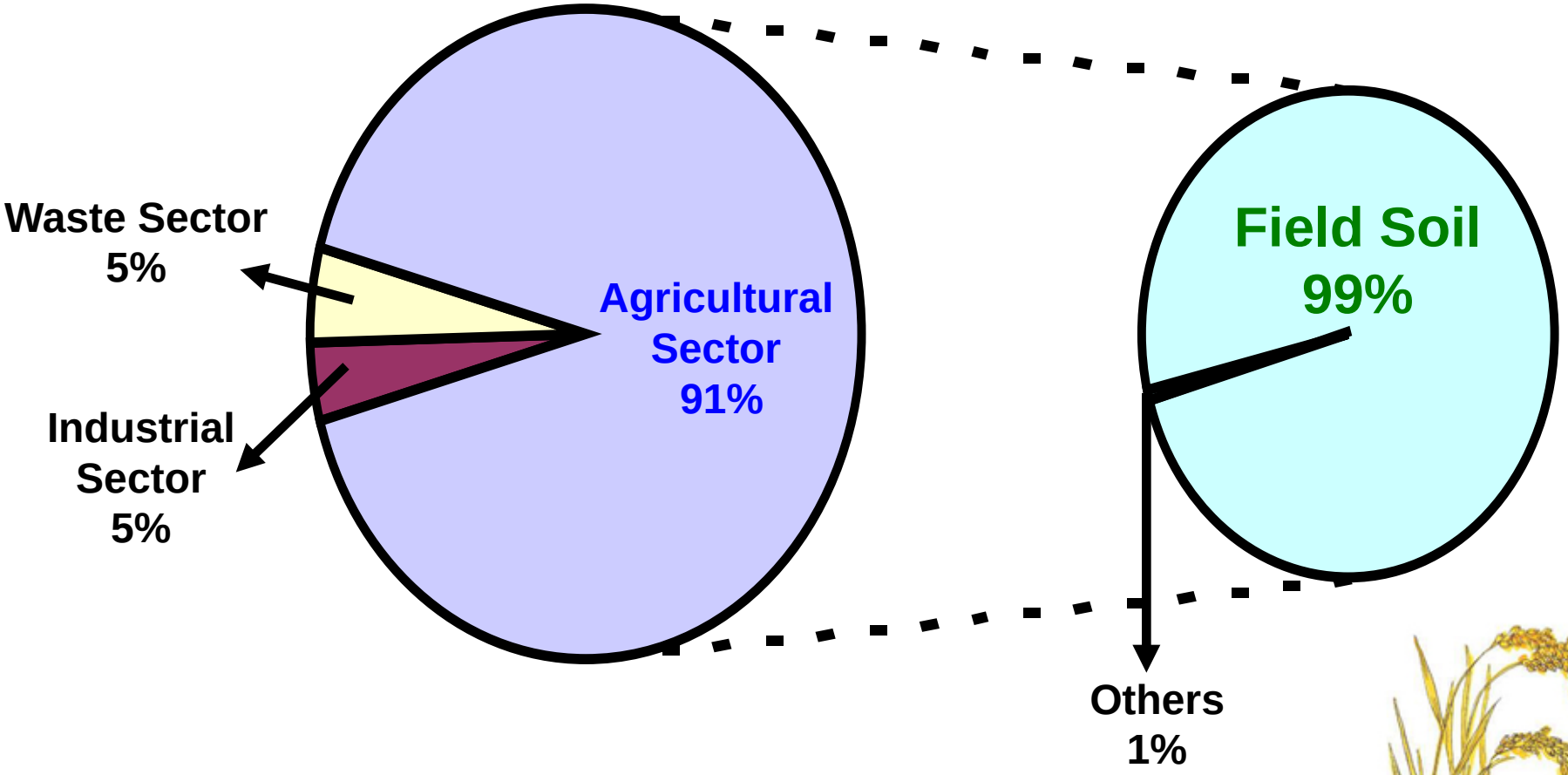
CH_4 emission of every sector in Taiwan





(Executive Yuan of Taiwan, 2012)

N_2O emission of every sector in Taiwan



(Executive Yuan of Taiwan, 2012)

Contributions of DNDC

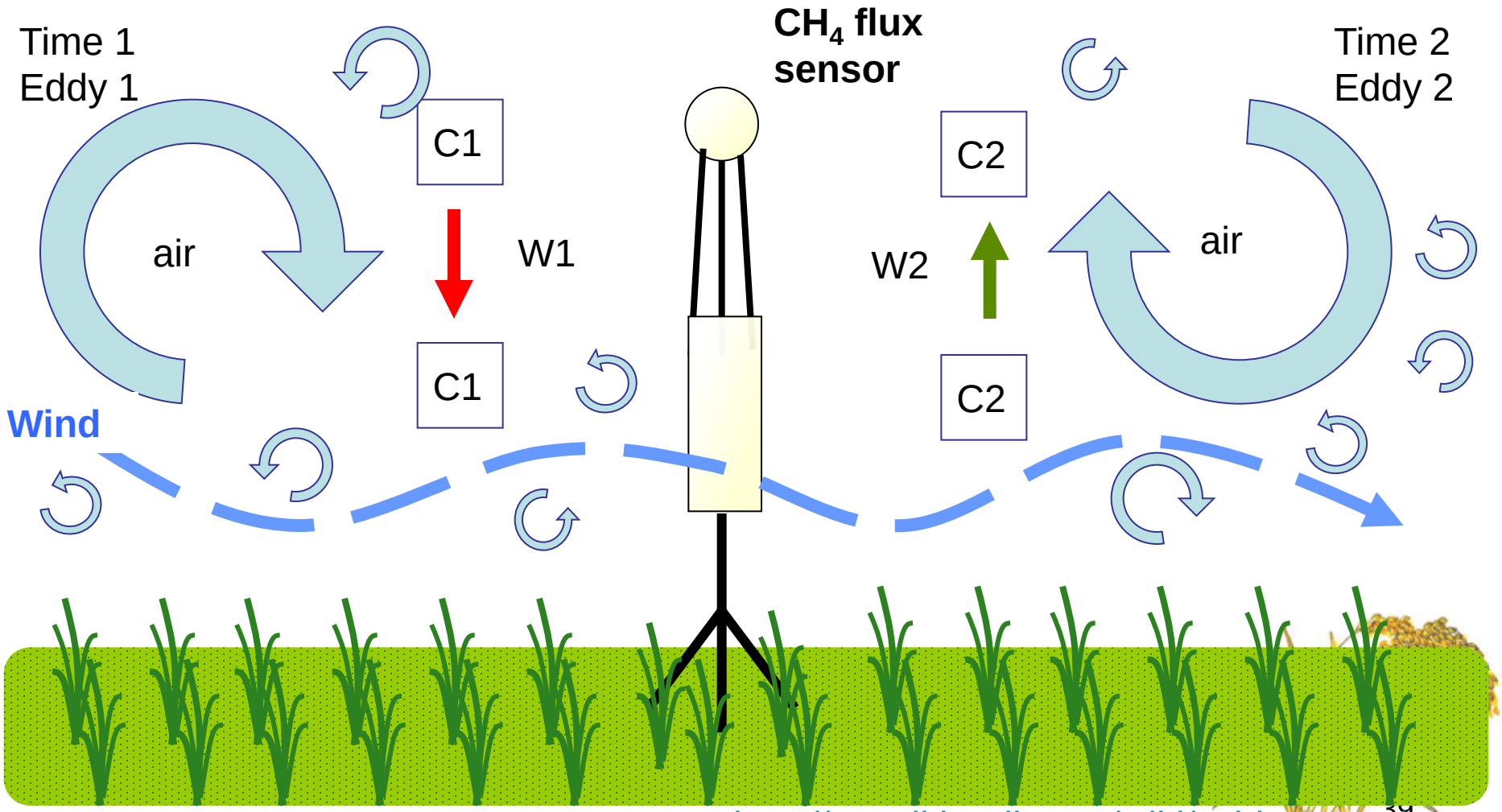
- **Rapid and precise**
- **Field emissions of GHG**
  - **For assessment of GWP in one field**
- **Daily emission**
  - **finding hotspots and making strategies**

Data needed of DNDC

- **Climate**
  - **From Central Weather Bureau**
- **Soil**
  - **Collections of soil samples before planting**
  - **Measurements of soil physical and chemical traits**
- **Manag**

Traceable system is needed

Eddy Covariance, EC



http://en.wikipedia.org/wiki/Eddy_covariance

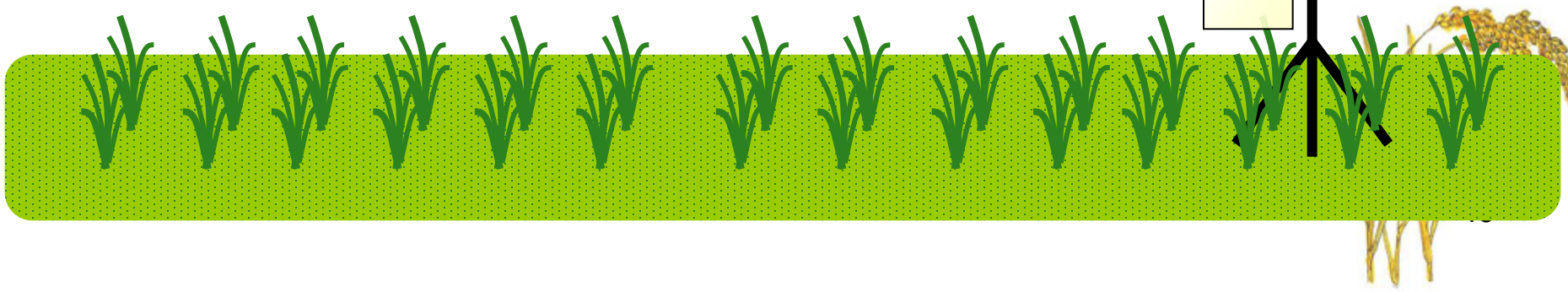
Eddy Covariance, EC

$$F_c = \overline{(\bar{c} + c')} \times (\bar{w} + w')$$

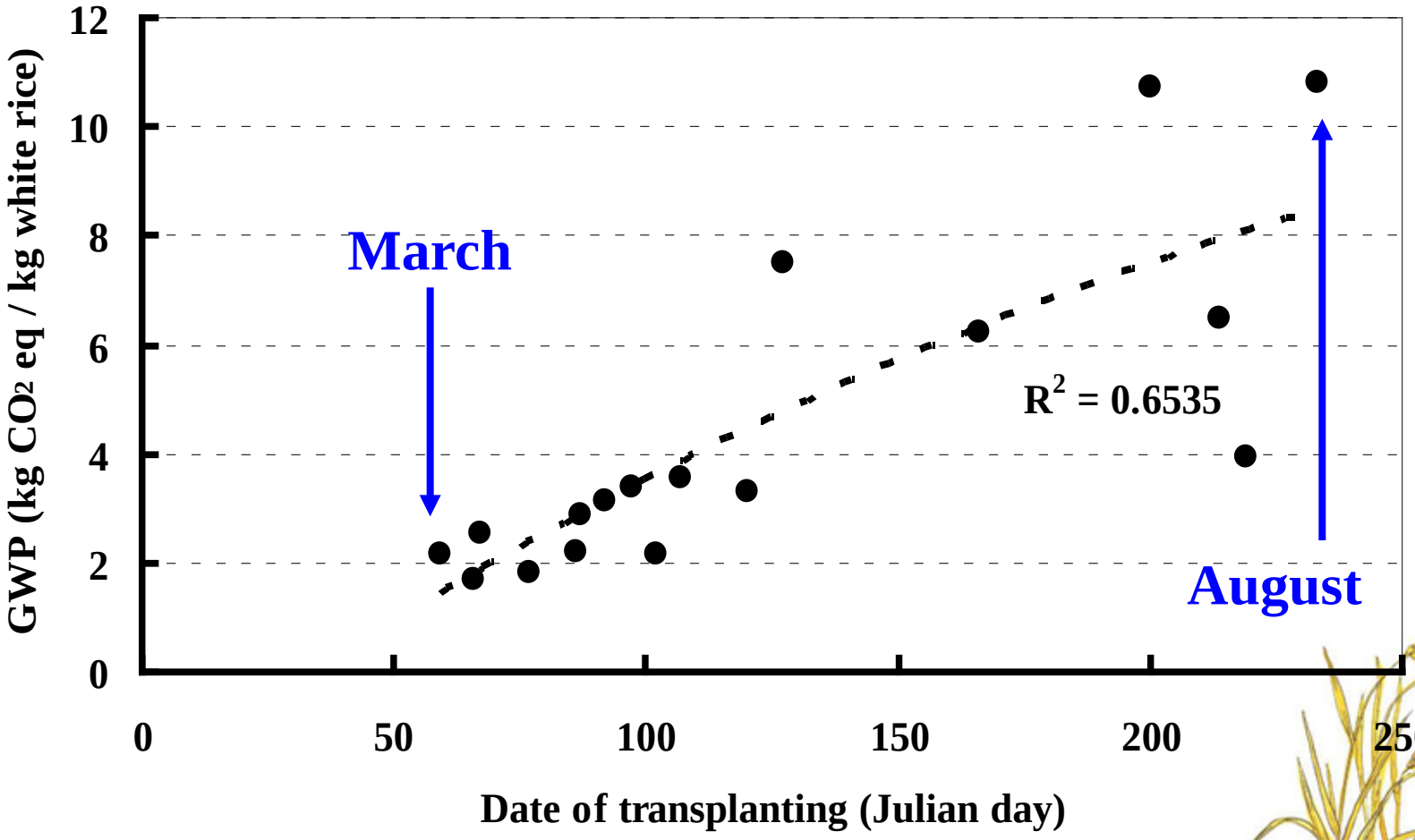
$$\Rightarrow \quad F_c = \overline{c'w'}$$

F_c : eddy flux
c' : gas concentration
w' : wind speed

stull, 1988



Correlation between GWP and date of transplanting



Taiwan Agriculture and Food Traceability System

Traceable system

Traceable Agricultural Product

Certification

Record sheet

作業日期	作業種類	
2013/02/04	整地	整地
2013/02/05	插秧	插秧
2013/02/08	除草	除草
2013/02/11	施用肥料	施用肥料 使用肥料： 農友牌尿素 - 80公斤
2013/02/27	施用肥料	施用肥料 使用肥料： 宜農中性複合肥含鎂5號 - 320公斤
2013/03/18	施用肥料	施用肥料 使用肥料： 宜農中性複合肥含鎂5號 - 200公斤
2013/04/04	施用防治資材	施用防治資材 防治對象： 水稻稻熱病及紋枯病
2013/04/15	施用肥料	施用肥料 使用肥料： 宜農中性複合肥含鎂5號 - 80公斤
2013/04/22	施用防治資材	施用防治資材 防治對象： 稻熱病
2013/06/14	收割	收割

Tillage

Transplanting

Type of fertilizer

amount

Fertilization

Date

Management

Contents of management