Modeling Methane Emission in Littoral Zone of Miyun Water Reservoir with DNDC

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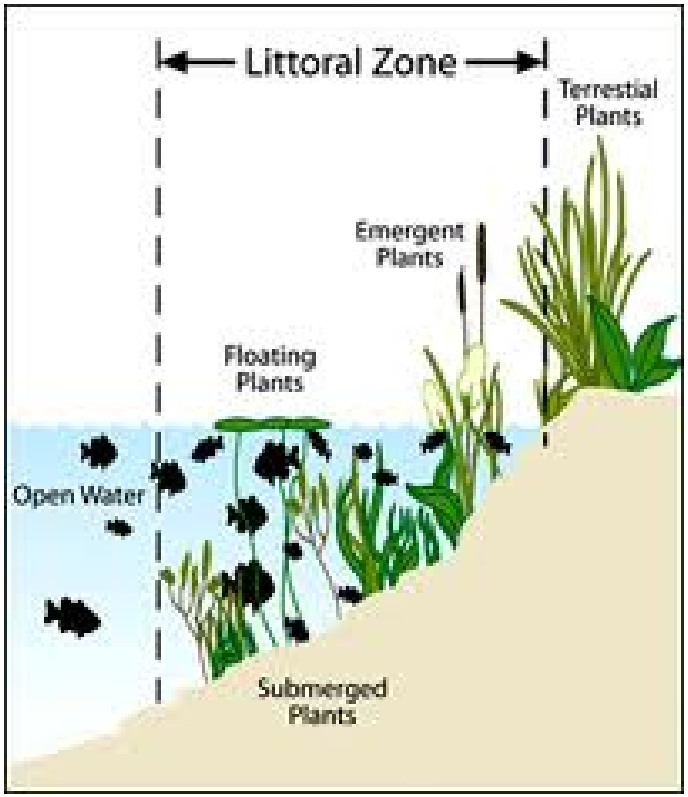
Background

Littoral zone as the hotspot of methane emission

Experienced seasonal dynamics of water table fluctuation and vegetation which are determining the conditions for production, oxidation and the net of CH_4 fluxes from wetland(Roulet et al.,1992; Moosavi and Crill, 1997).

93Tg $CH_4 yr^{-1}$ form open-freshwater aquatic system
10Tg $CH_4 yr^{-1}$ from plants in littoral zones.
(Bastviken, Tranvik et al. 2011)

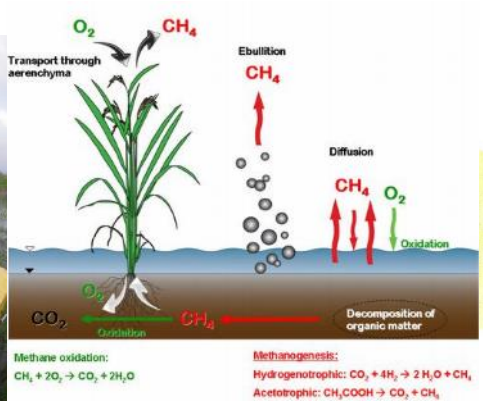
66–77% of the total CH_4 emission was released from the littoral zone where is accounting less than 25% of lake area.
(Juutinen, Alm et al. 2003)

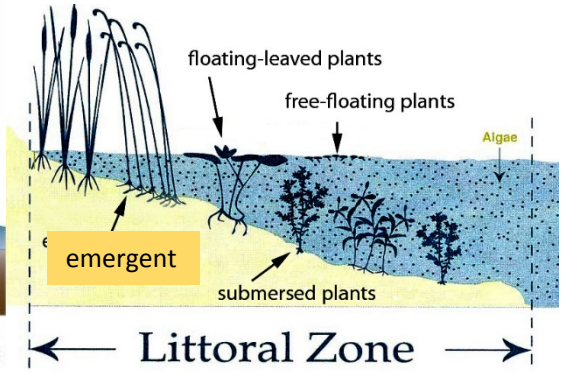


Background

Littoral zone as the hotspot of methane emission

- Increasing of filed monitoring and experiment validation for littoral zone or riparian zone
- **BUT**, hardly the model application has found for littoral zone of Water Reservoir or Lake
- **Increasing** number of water reservoirs result in **hotter** controversy on its clean(BP 2009, Gunkel 2009, Li and Lu 2012, Bridgham, Cadillo-Quiroz et al. 2013).





Background

Littoral zone of Water Reservoir

- **Over 80,000** large and small reservoirs were build in China till 2008
- **Modelling is emergent** , different Dam Water Level Management Plan(DWLMP) could directly lead to the variance of methane emission.
- If succeed, provide **professional advices** in DWLMP to make truly clean operation.

Background

Beijing Miyun Reservoir (40° 29'N, 116° 50'E)

The maximum water area:188 km^2

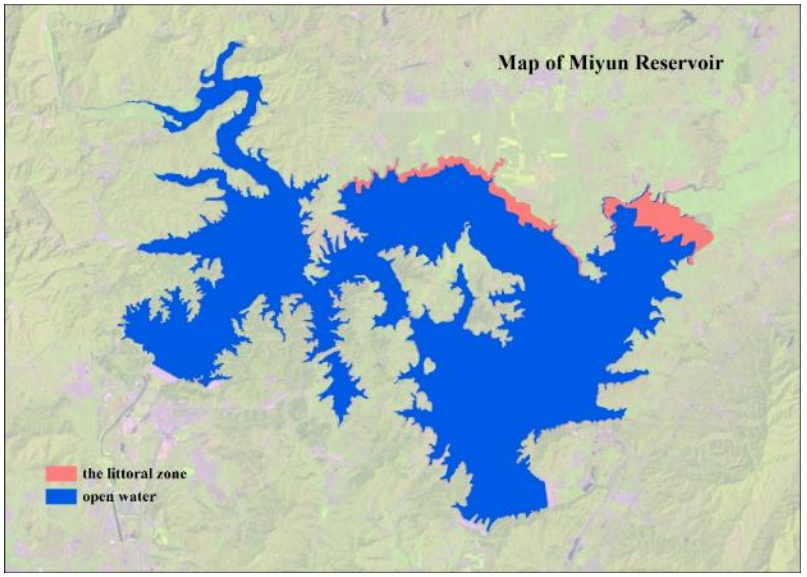
Average air temperature: 10.5° C

Ice-free Period: April to November

Annual average precipitation:600mm, 80% from Jul. to Aug.

Water level change: 1-5 meters

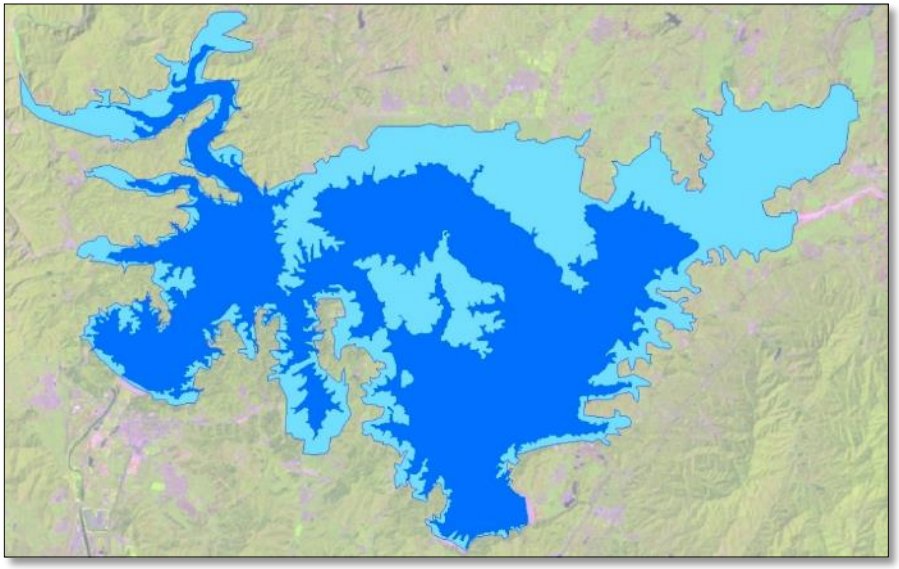
Age： 60Yrs



Background

Beijing Miyun Reservoir (40° 29'N, 116° 50'E)

- South-to-North Diversion Project in 2014
- **Water level rising of 10-15m**
- and **new** littoral zone and riparian wetland

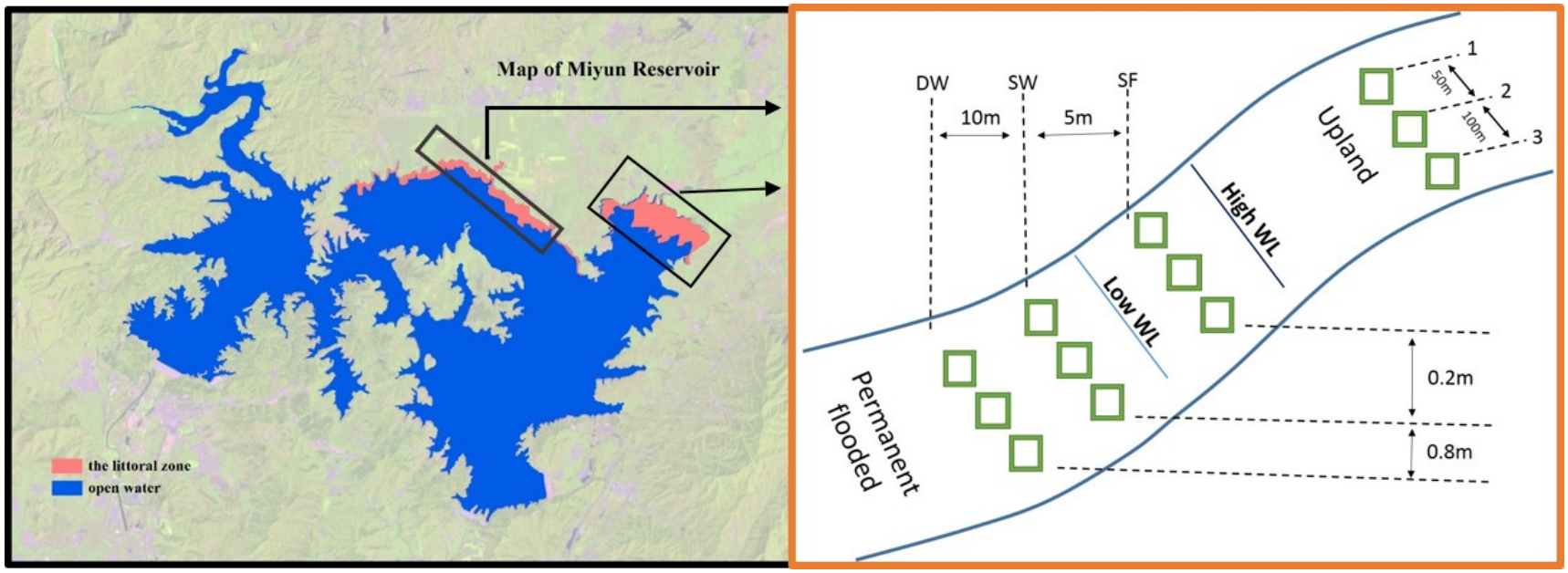


The deep water show the open-water area and the light blue indicate the open-water area after re-impound

Purpose

To figure out which parts or whether the whole littoral zone is suitable for methane emission modelling by Wetland-DNDC.

Sampling



•Sampling design. WL: water level. The sites are grouped at different elevations. DW: deep water site; SW: shallow water site; SF: seasonal flooded site. 1, 2 and 3 are different vegetation types.

Model

Model Parameter inputs

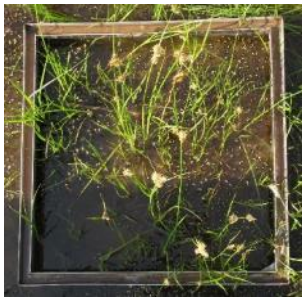
- Daily precipitation and average air temperature. (Weather Statio
- Daily water level (Website of National Hydrologic Information)
- Soil property and vegetation data (field data)
- Some data in reference values

site	soil floor	texture	pH	SOC kgC/kg	BD g/cm3	Porosity
A1	MF	Loamy sand	7.9	0.013	1.7	0.36
A2	MF	Clay	7.86	0.014	1.01	0.771
A3	MF	Sand	7.9	0.013	1.7	0.36
B1	MF	Silt loam	8.04	0.006	1.33	0.498
B2	MF	Sandy loam	8.11	0.009	1.31	0.497
B3	MF	Clay loam	8.05	0.007	1.19	0.549
C1	MF	Sandy loam	8.08	0.006	1.45	0.452
C2	MF	Sandy loam	7.96	0.007	1.43	0.462
C3	MF	Silt loam	8	0.007	1.36	0.488

Model

A1-Trapa bicornis

A2-Typha angustifolia



B1-Scirpus planiculmis

B3-Polygonum orientale

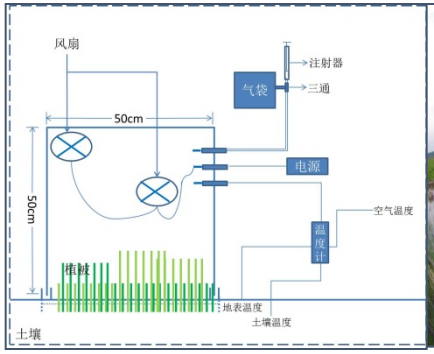
C1-Cirsium setosum

Condition	Water depth Fluctuation	Vegetation Type	Species	No.
DW	80-180cm	Hydrophytes	*Trapa bicornis + Myriophyllum verticillatum*	A1
			Typha angustifolia	A2
			(blank)	A3
SW	0-120cm	Hygrophytes	*Scirpus planiculmis*	B1
			Bidens pilosa	B2
			Polygonum lapathifolium	B3
SF	-40-60cm	Mesophytes	*Cirsium setosum*	C1
			Hemarthria altissima	C2
			Polygonum lapathifolium	C3

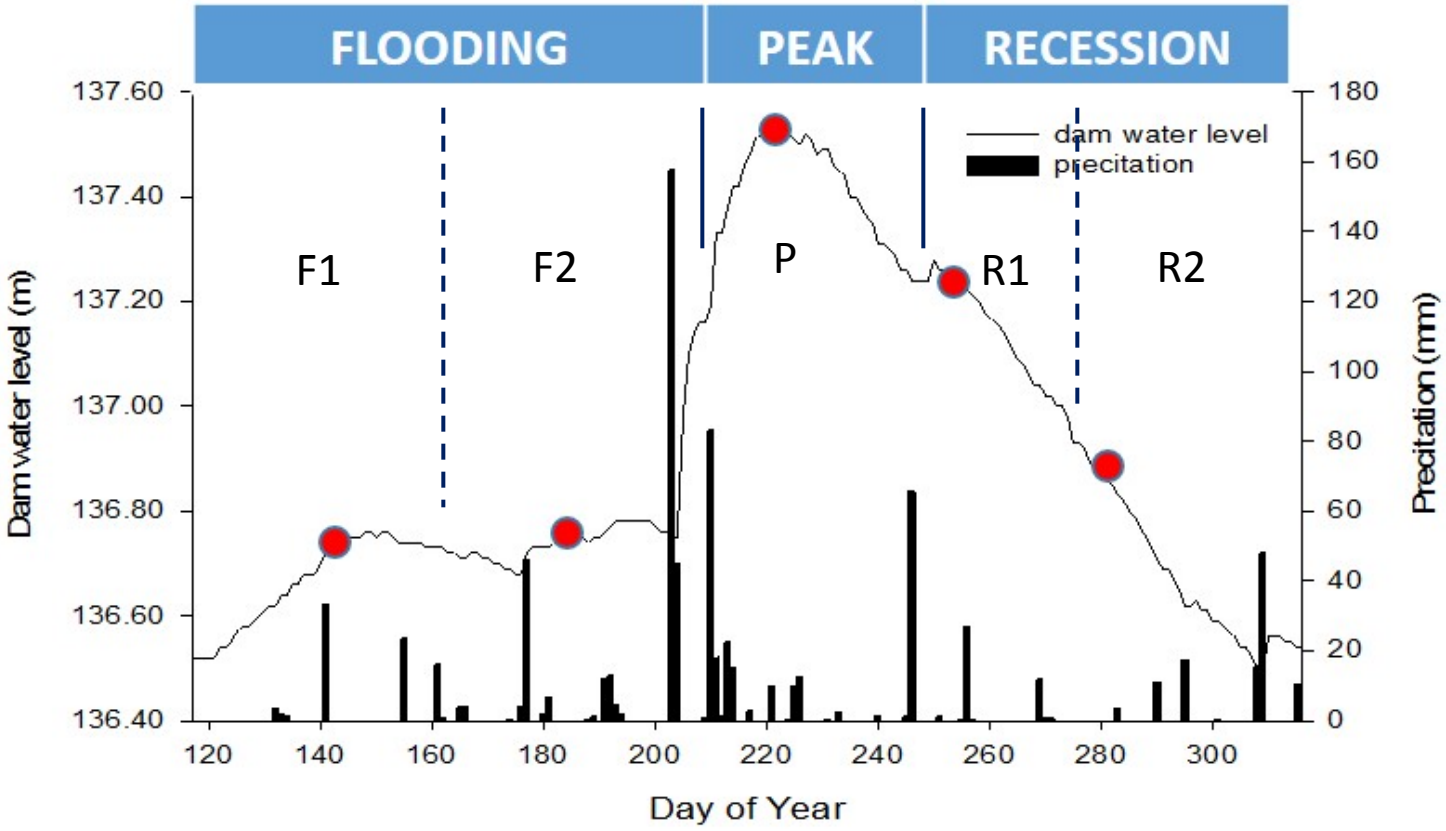
Field

Field data

- Chamber Technique Standard
- Taken on May26-28th, June 30th–July2nd, August5-10th, September 5-9th, Octorber10-12th in 2012. The observation in July was interrupted by the rainstorm and delayed to August.

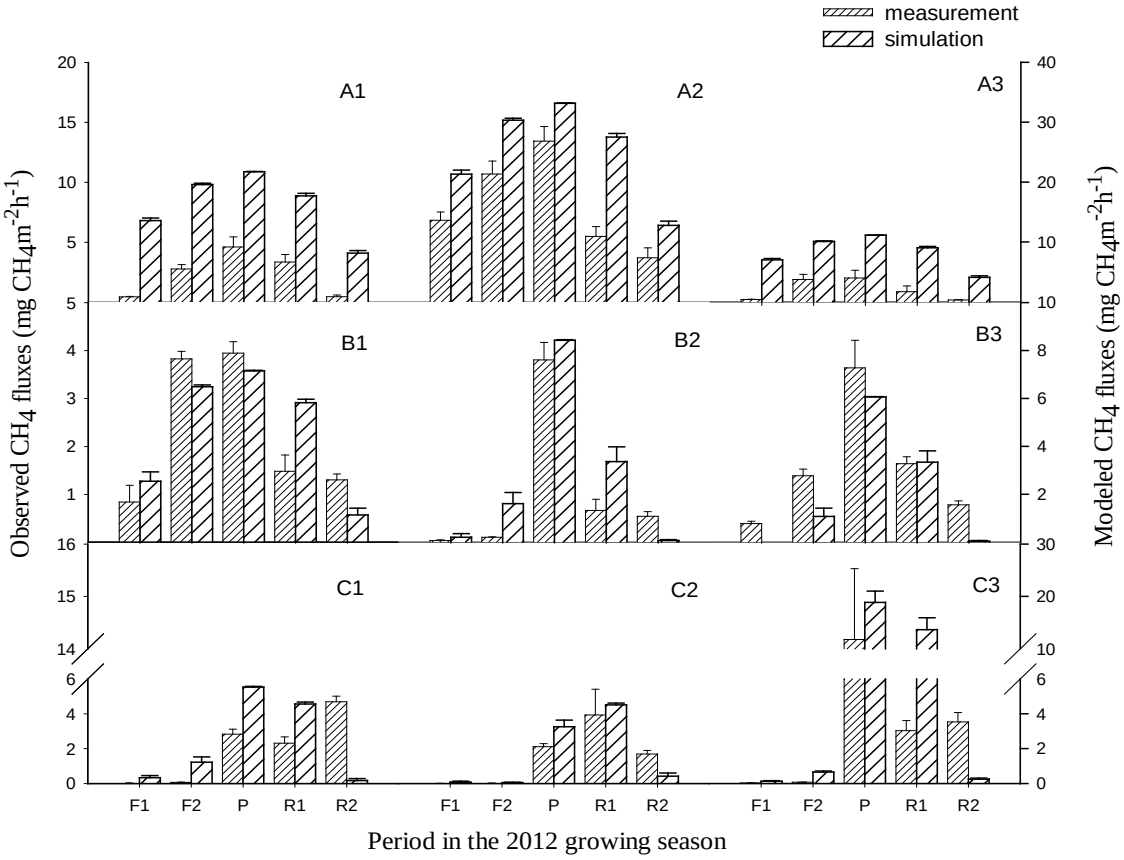


Method



Five periods were set according to the hydrological pattern as Flooding period, Peak time and Recession period.

Result



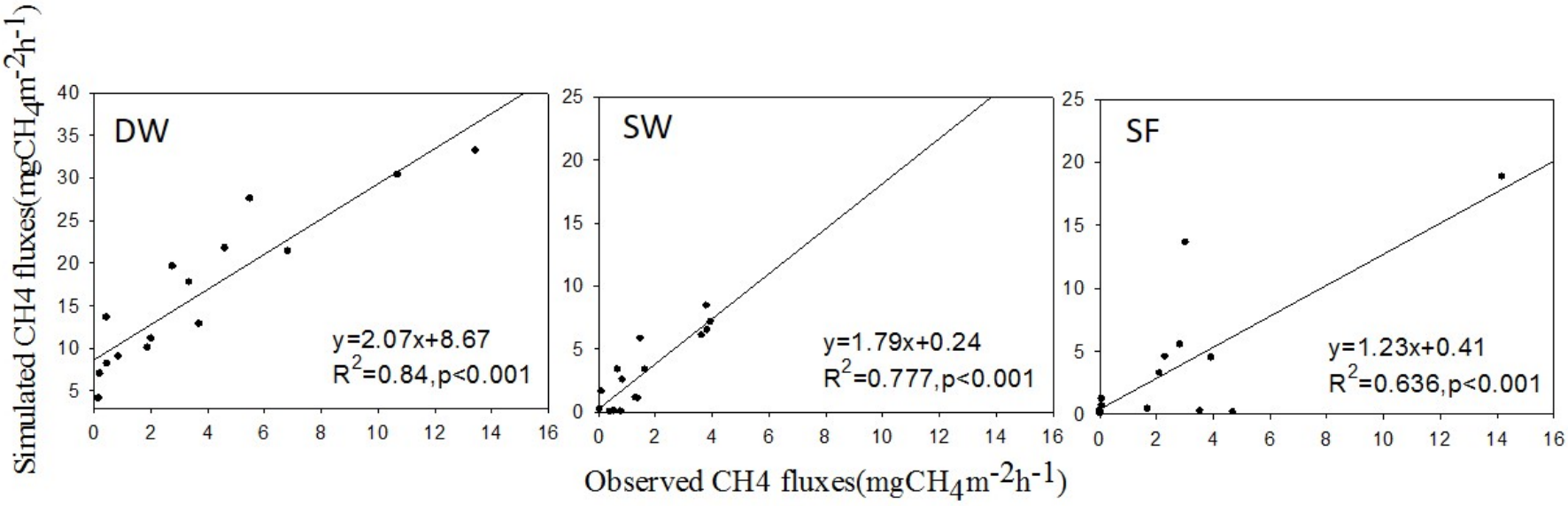
- **the modeled and observed CH4 fluxes consistent in temporal pattern**

Increase during the flooding period

Then, raised to peak

And a decline at the recession time

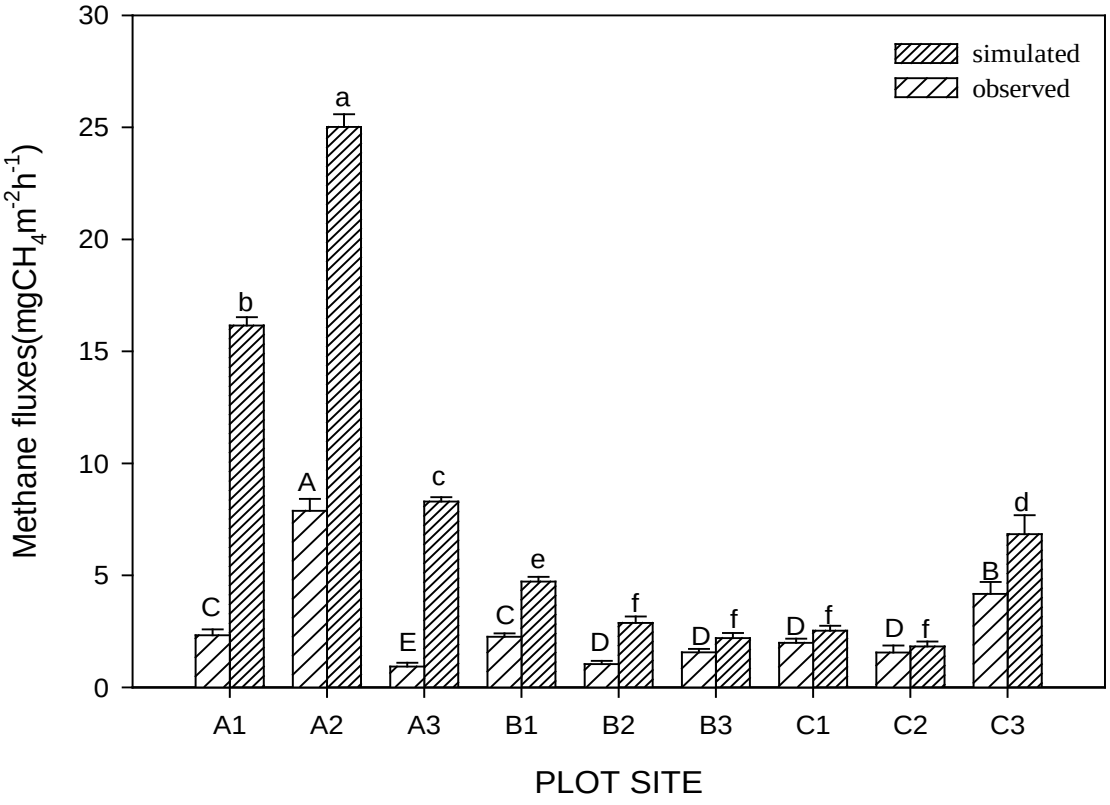
Result



The value of R^2 ranged from 0.63-0.84 with significant correlation at three conditions.

However, the overestimation appears, especially at deep water site where needed improvements in Wetland-DNDC model (Zhang, Li et al.2002, Zhang, Sachs et al.2012)

Result

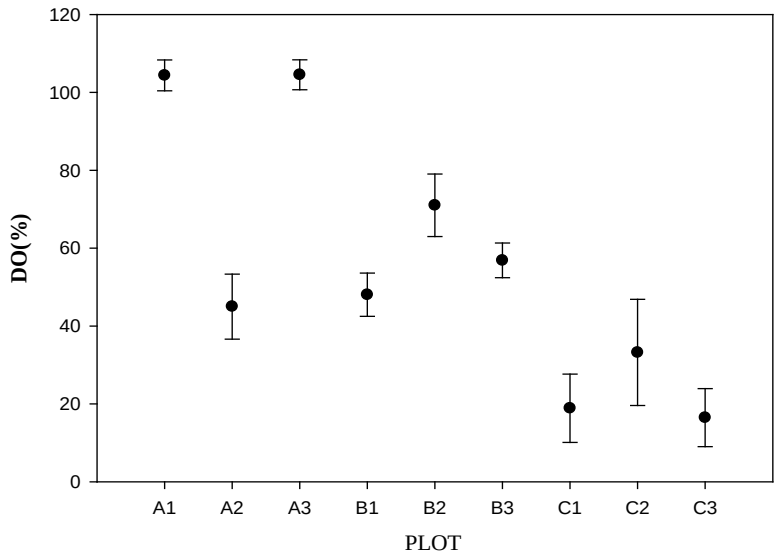


- **Agreement in plant-specific plots**

As the modeled and observed CH4 fluxes

- Superior in emergent aquatic plant(A2) and other studies have showed the same results(Hirota, Tang et al.2004, Duan, Wang et al.2005, Bergström, Mäkelä et al.2007).
- No difference among other emergent plants(B2,B3,C1,C2), possibly because of the close contribution of photosynthesis to the methanogenesis(Dorodnikov, Knorr et al. 2011)

Discussion



The observed results showed the significant negative relationship between DO and CH_4 flux(DW: n=72, $p<0.01$; SW: n=72, $p<0.01$; SF: n=24, $p<0.01$)

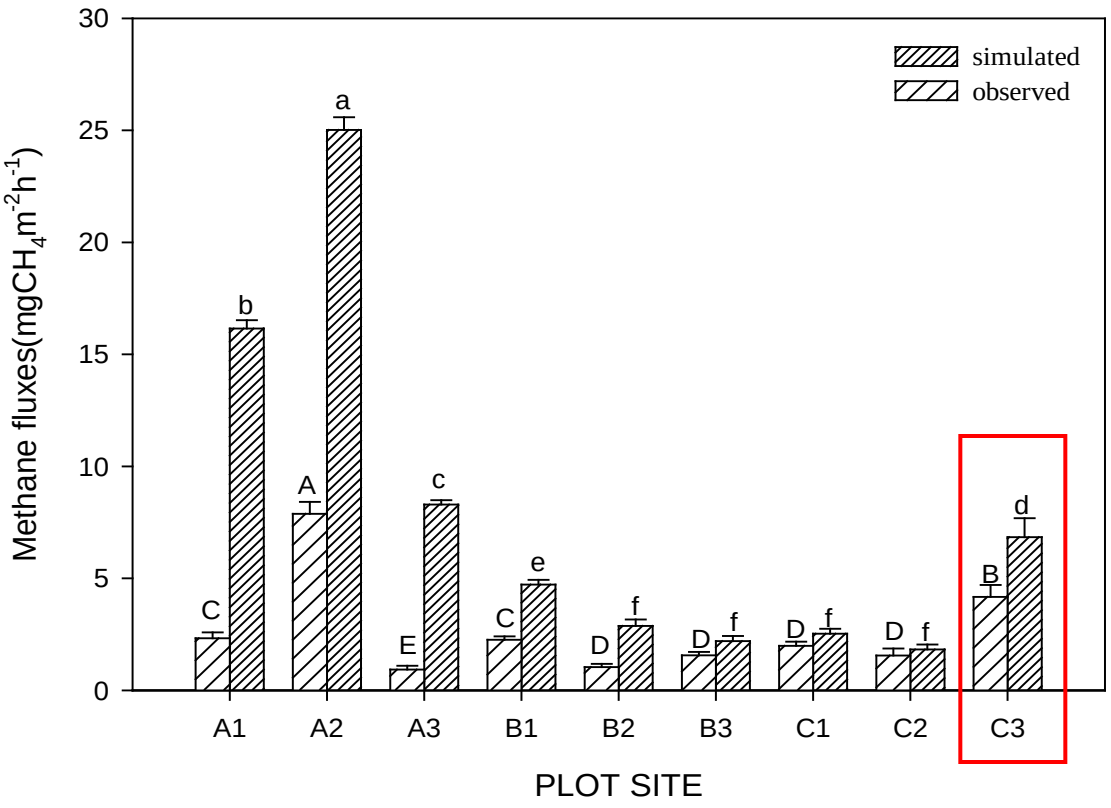
Higher DO in sites, lower observed results but now higher overestimated results in the model.

Considering CH_4 oxidation in water layer in Wetland-DNDC

Reeburgh(2007) has pointed out that the anaerobic oxidation is a major consuming way of CH_4 in marine. However, DO allowance may vary with habitat change (Knittel and Boetius 2009, Chowdhury and Dick 2013) .

The DO% in SF only measured in the peak time

Discussion



Whereas, the discrepancy between observed and simulated value for C3.

The model failed to simulate the increase of CH4 emission where the plant decaying after flooding.

The observation showed that the high emission in growing season is not only caused by high biomass but influenced by high metabolic rate of vegetation and agreed with other studies (Duan, Wang et al. 2006, Enrica, Rossano et al. 2010).

Conclusion

- Wetland-DNDC model is confident in simulating methane emission with the agreement of spatial and temporal pattern at the littoral zone of water reservoir.

- Water level change and vegetation are important parameters in Wetland-DNDC. Besides, they are also challenges for modelling as they played the mutual effects on methane production, transportation and oxidation.

- To the extent of whole reservoir, further study should pay more attention on modeling CH_4 emission from open-water area to estimate the total emission under different DWLMP conditions.

Acknowledgement

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Thanks for your Listening!

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Group Photo During GHG Field Work in Miyun Reservoir