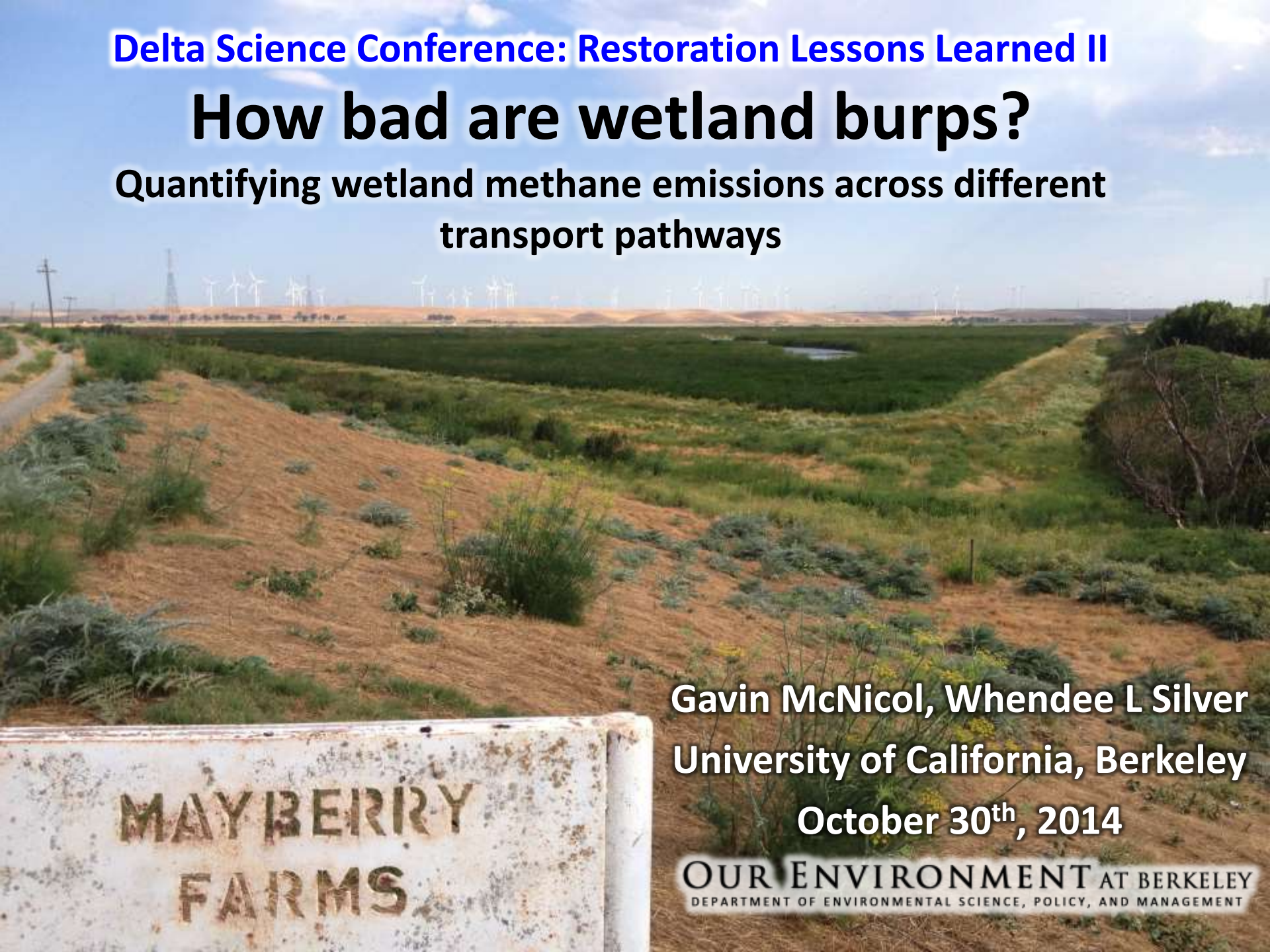
Delta Science Conference: Restoration Lessons Learned II

How bad are wetland burps?

Quantifying wetland methane emissions across different transport pathways



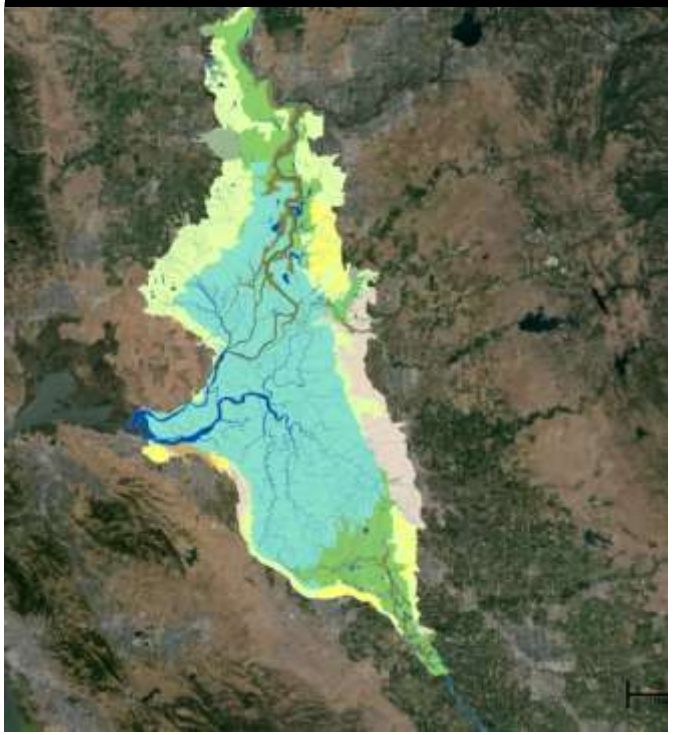
Gavin McNicol, Whendee L Silver
University of California, Berkeley

October 30th, 2014

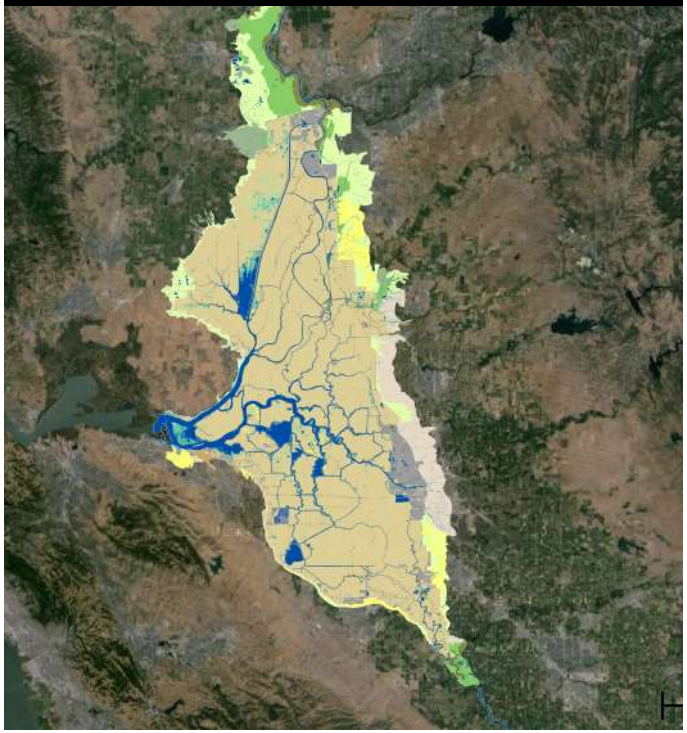
OUR ENVIRONMENT AT BERKELEY
DEPARTMENT OF ENVIRONMENTAL SCIENCE, POLICY, AND MANAGEMENT

History of Delta Land-use Change

Holocene-1850: 1,400 km^2 of Delta tidal wetlands



Early 2000s: > 90% wetlands reclaimed for agriculture



Source: *Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Patterns and Process*, by the San Francisco Estuary Institute - Aquatic Science Center

Extreme Subsidence

Sherman Island,
Sacramento Delta, CA

Extreme subsidence (8-12 m)

<u>Subsidence hazards:</u>

- Levee failure and flooding
- Salt intrusion
- Habitat
- **Carbon dioxide emissions**

Extreme Subsidence

Sherman Island,
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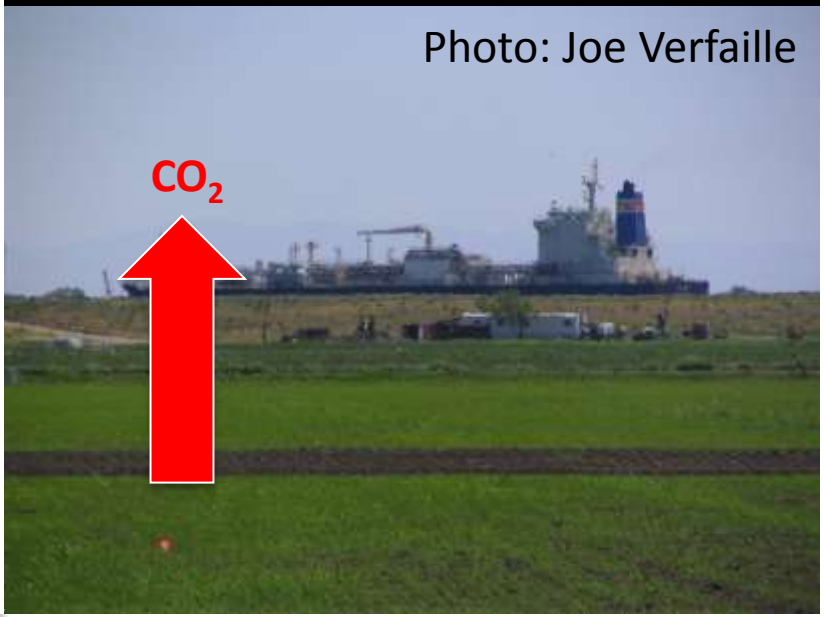
Extreme subsidence (8-12 m)



<u>Subsidence hazards:</u>

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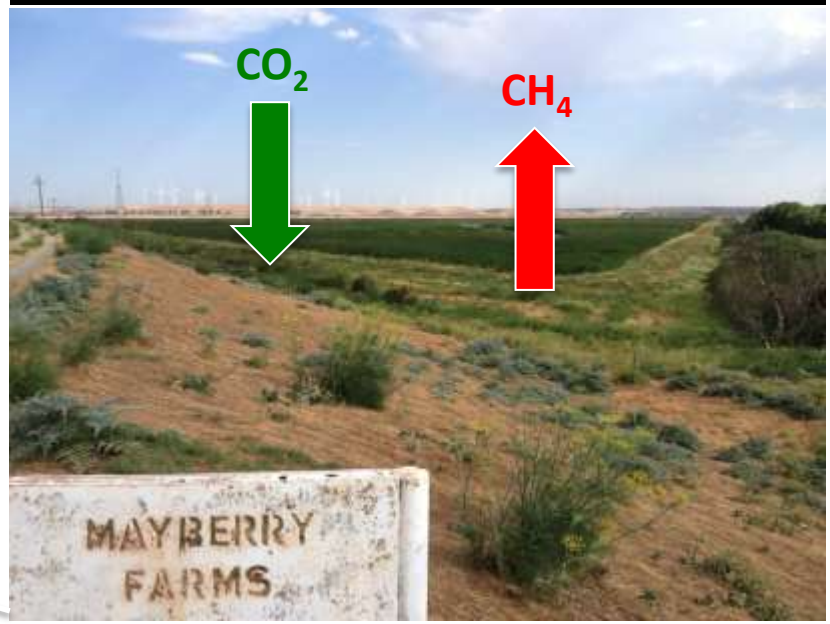
Delta Wetland Restoration

Sherman Island,
Sacramento Delta, CA

Mayberry Restored Wetland



Wetland Restoration Effects:

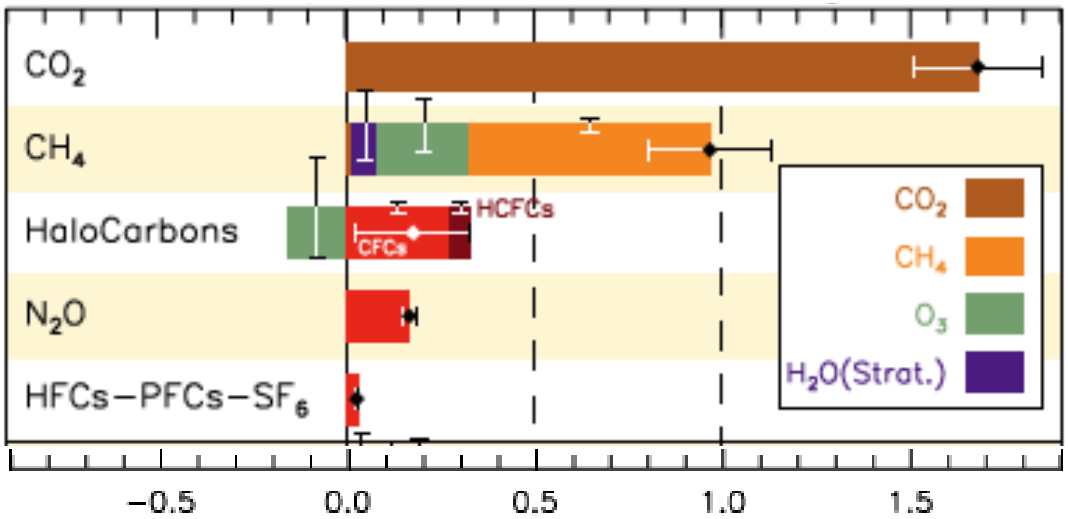
- Carbon sequestration
- Rebuild soils
- New habitat
- **Methane emissions**

Why do we care about methane?

- Methane (CH_4) is a potent greenhouse gas (GHG)
- Responsible for > 30% of post-Industrial climate forcing from GHGs
- Short lifetime in atmosphere (≈10 years)

Components of Radiative Forcing

Well Mixed GHGs

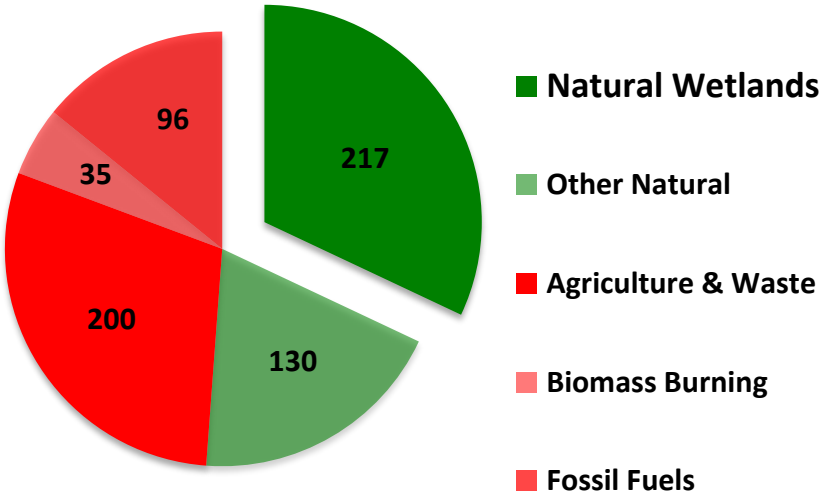


Forcing (W m^{-2})

Adapted from: IPCC 2013 – Chapter 8: Anthropogenic and Natural Radiative Forcing

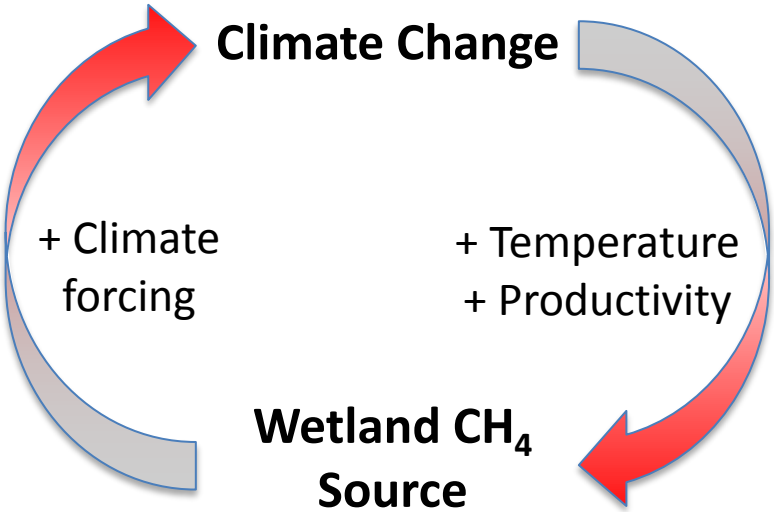
Why methane from wetlands?

- **Wetlands are the largest natural source of atmospheric CH_4**



Total Sources: 347 Tg CH_4 yr^{-1}

- **Methane-climate change feedback**



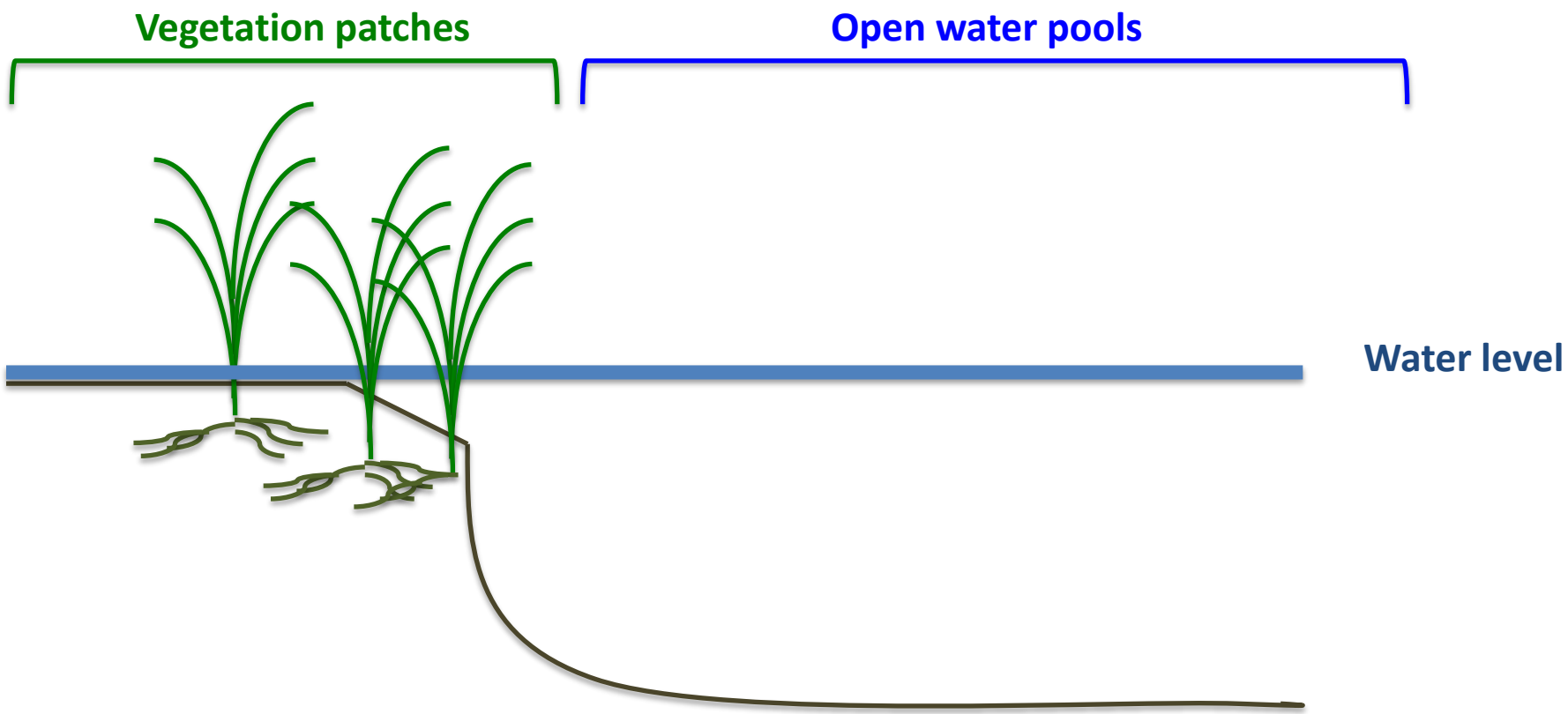
Data and text: IPCC 2013 – Chapter 6: Carbon and Other Biogeochemical Cycles

Wetland Structure Affects CH_4 Dynamics

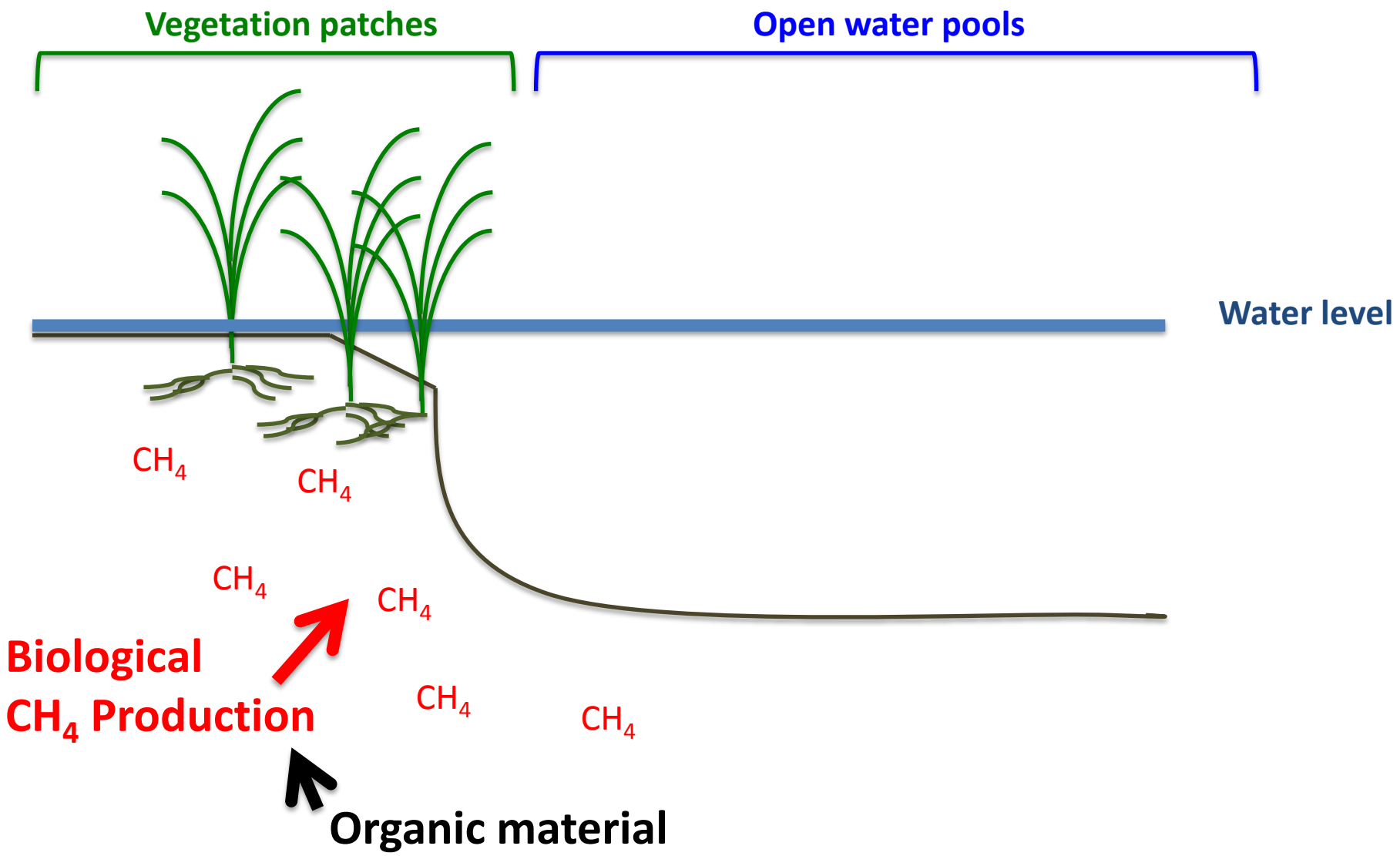
Mosaic of open water pools and vegetation patches

Image Source: Google Maps

Wetland Structure Affects CH_4 Dynamics



Wetland Structure Affects CH_4 Dynamics



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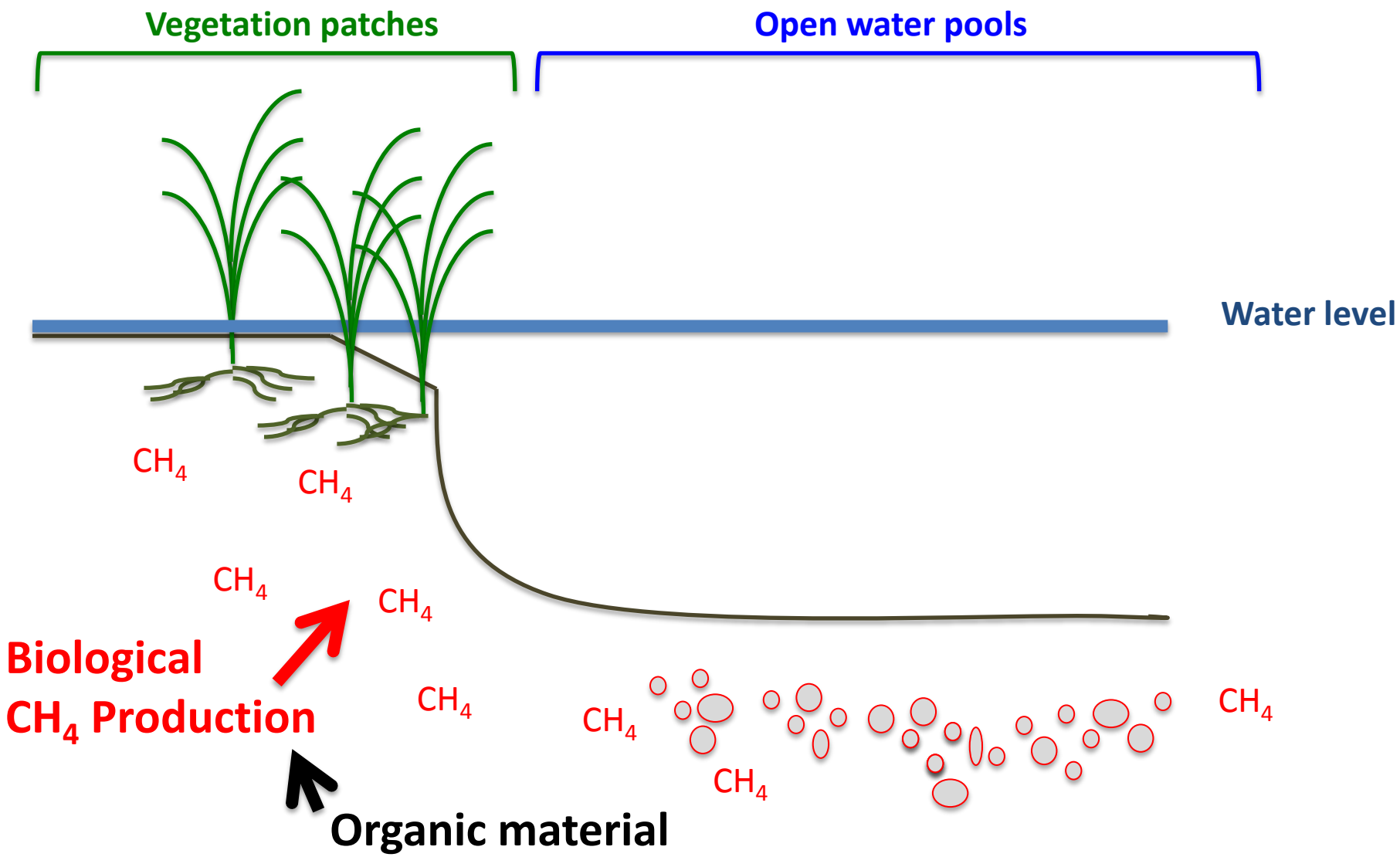
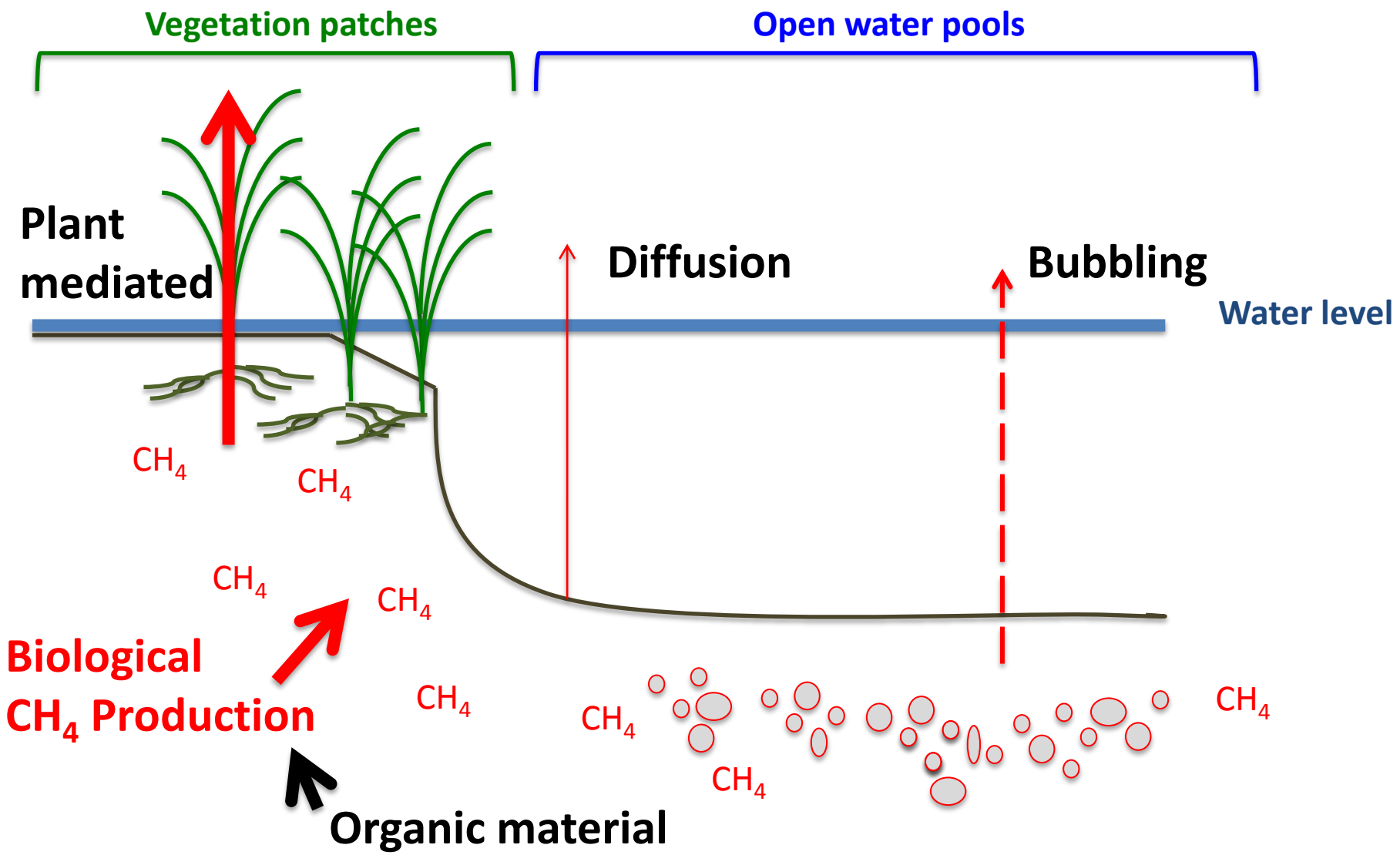


Wetland Structure Affects CH_4 Dynamics



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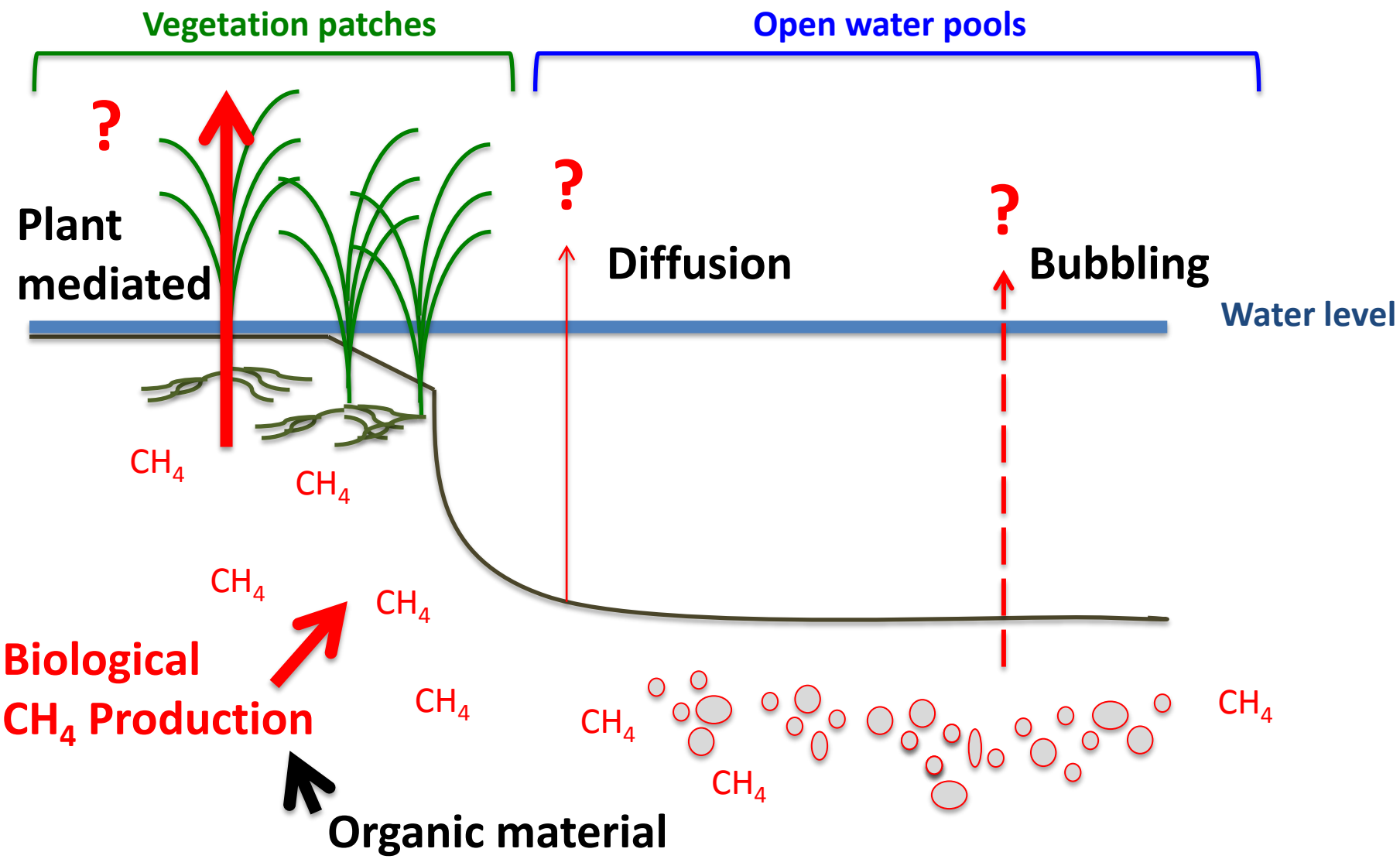

Motivating Question

1. How do open-water pools compare to vegetation patches as sources of wetland CH_4?

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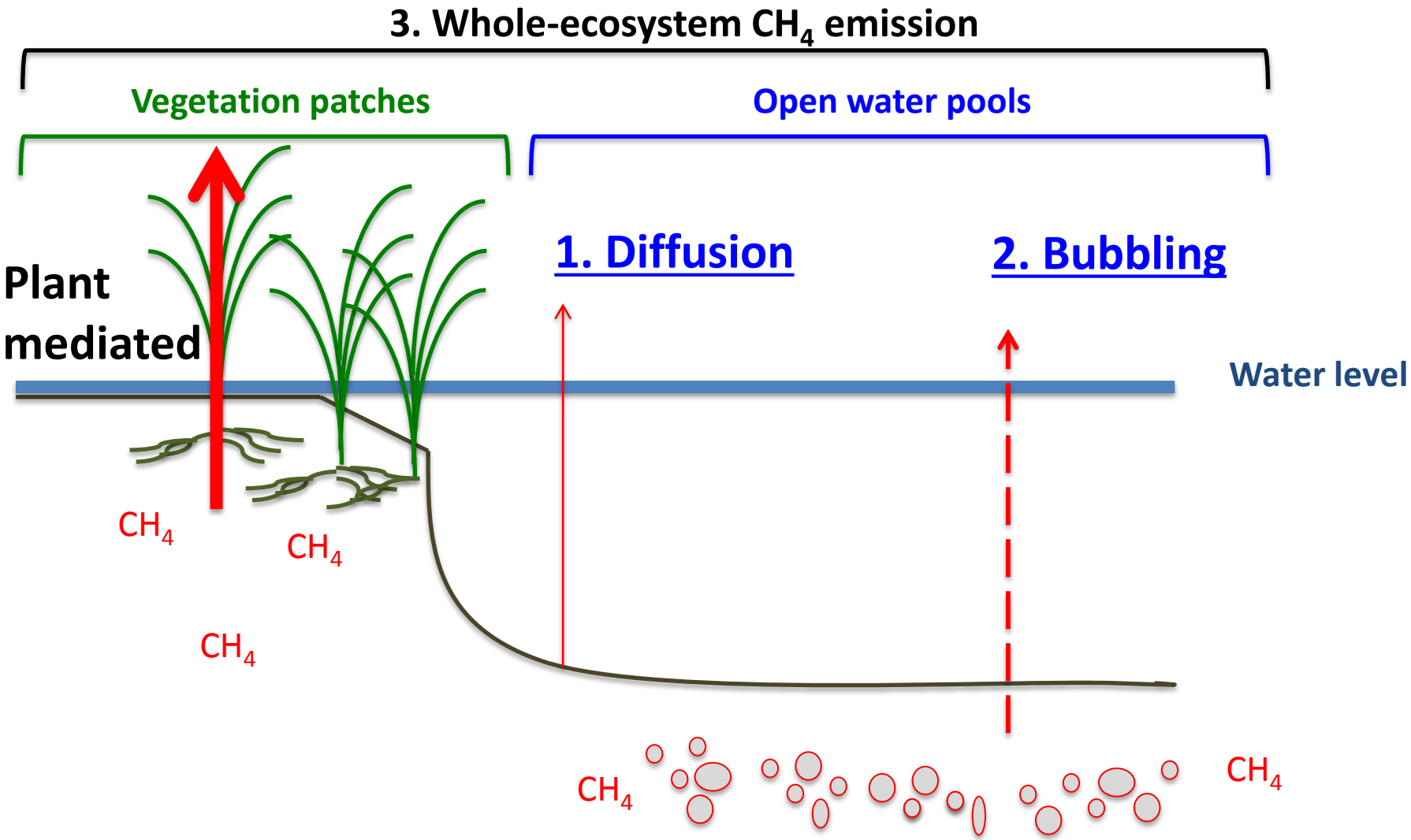


Approach

1. **Diffusive Emissions of CH_4**

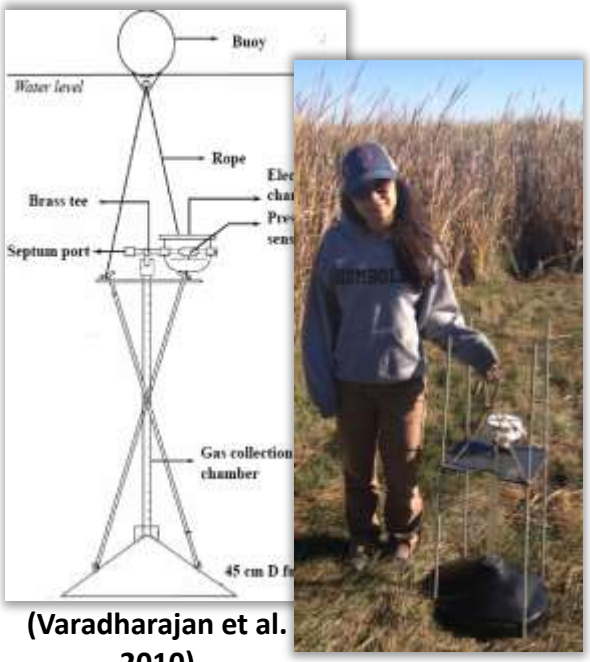
$$Flux = k([CH_4]_{aq} - [CH_4]_{eq})$$

MacIntyre et al. 1995

1. **Bubbling Emissions of CH_4**

12 bubble collection chambers

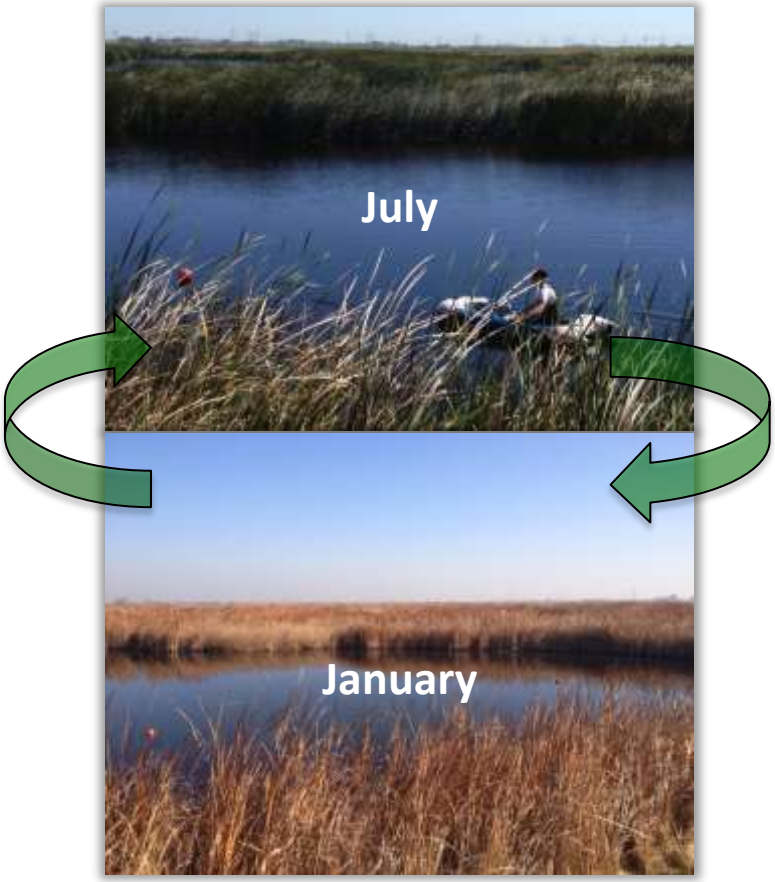
Bubble volume, CH_4 content



(Varadharajan et al. 2010)

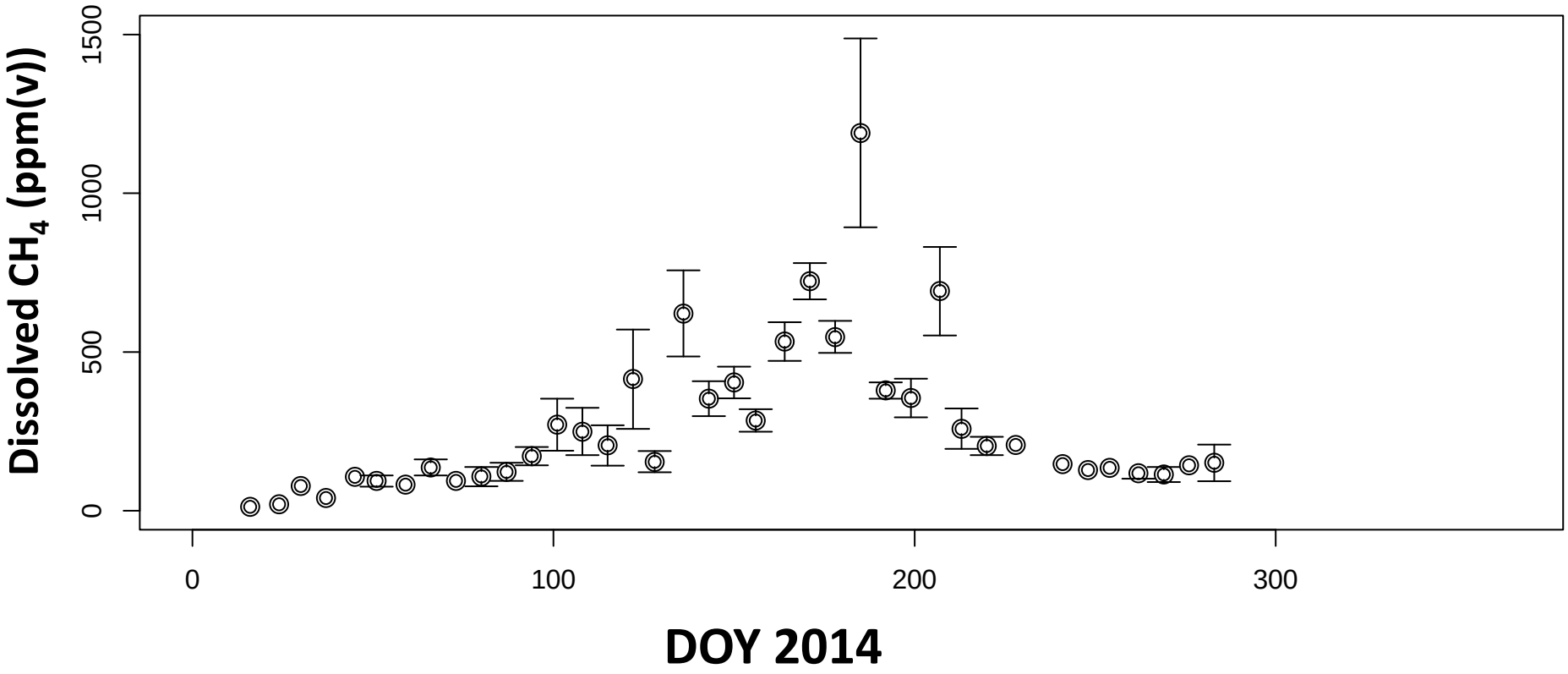
Adapted design

1-year of observations

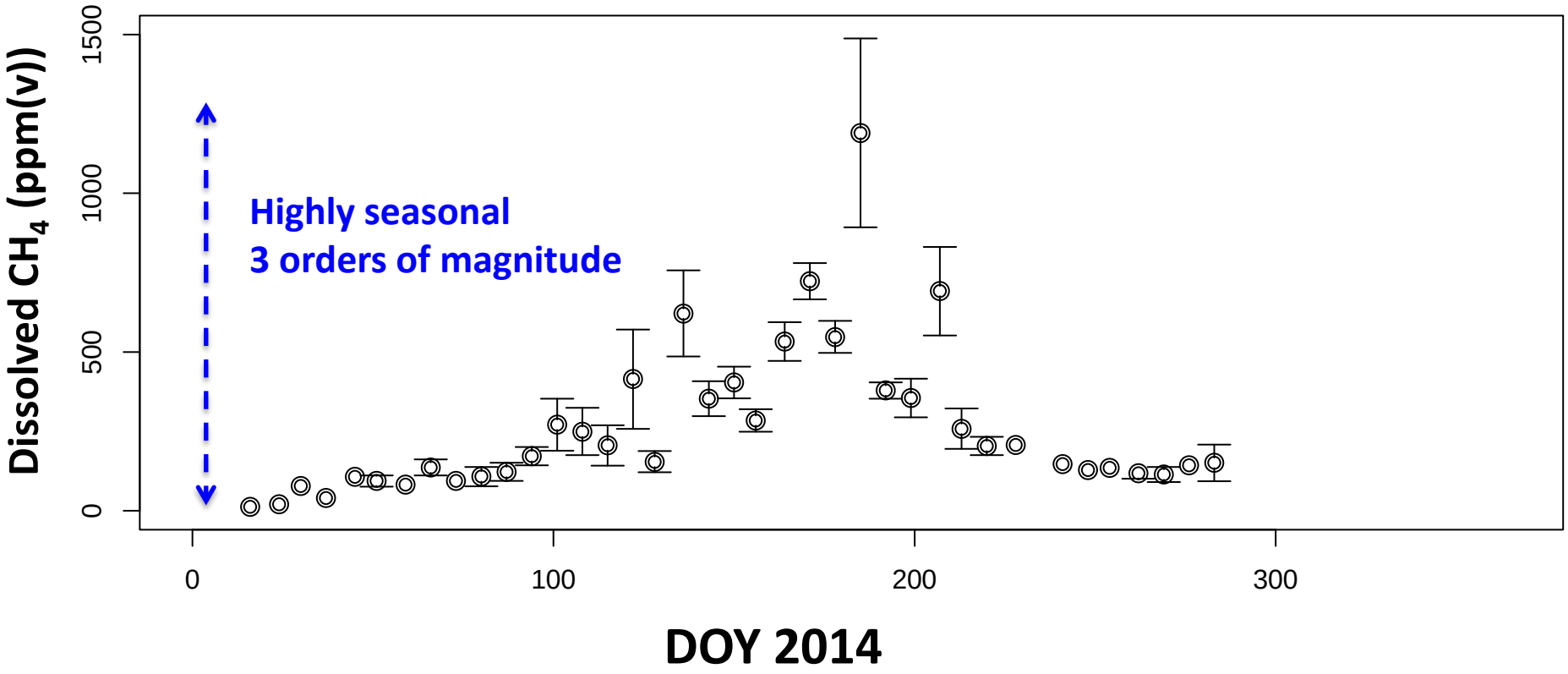


Capture annual cycle

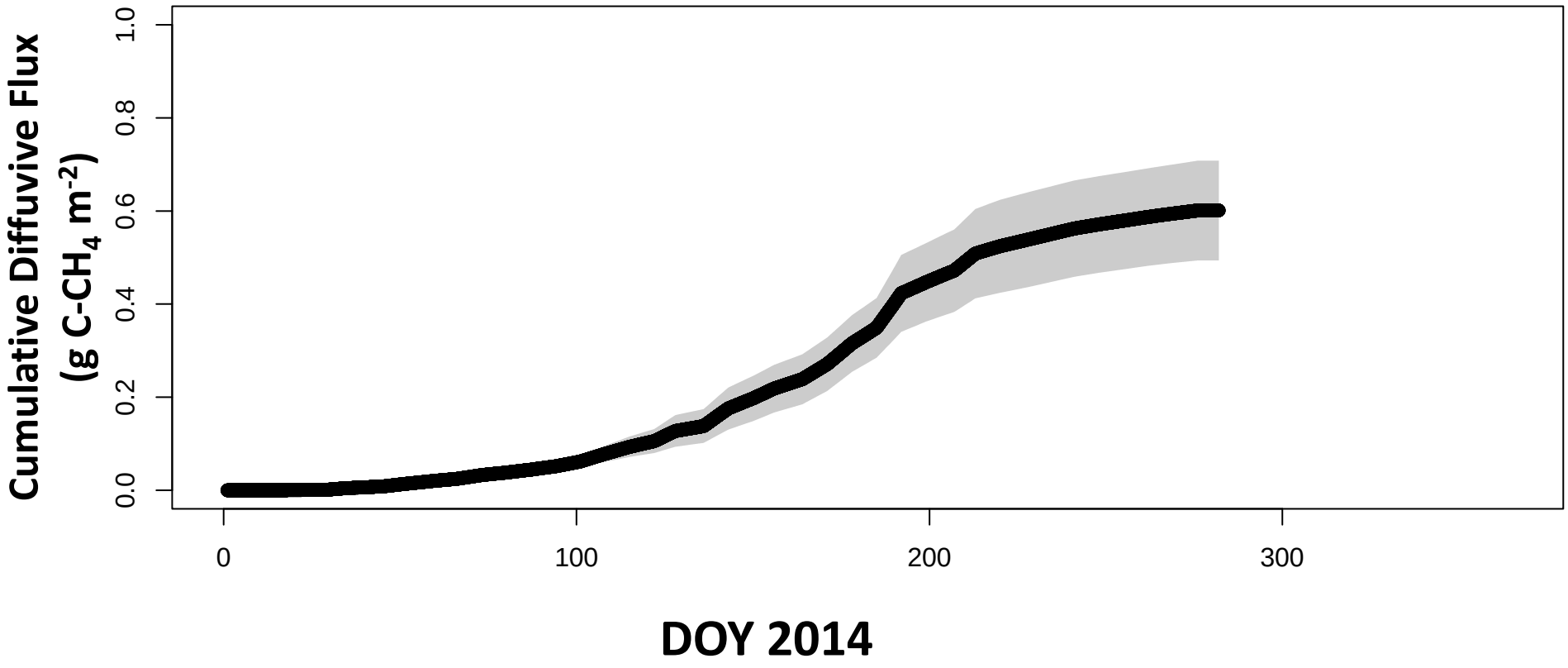
Open-Water Dissolved CH_4



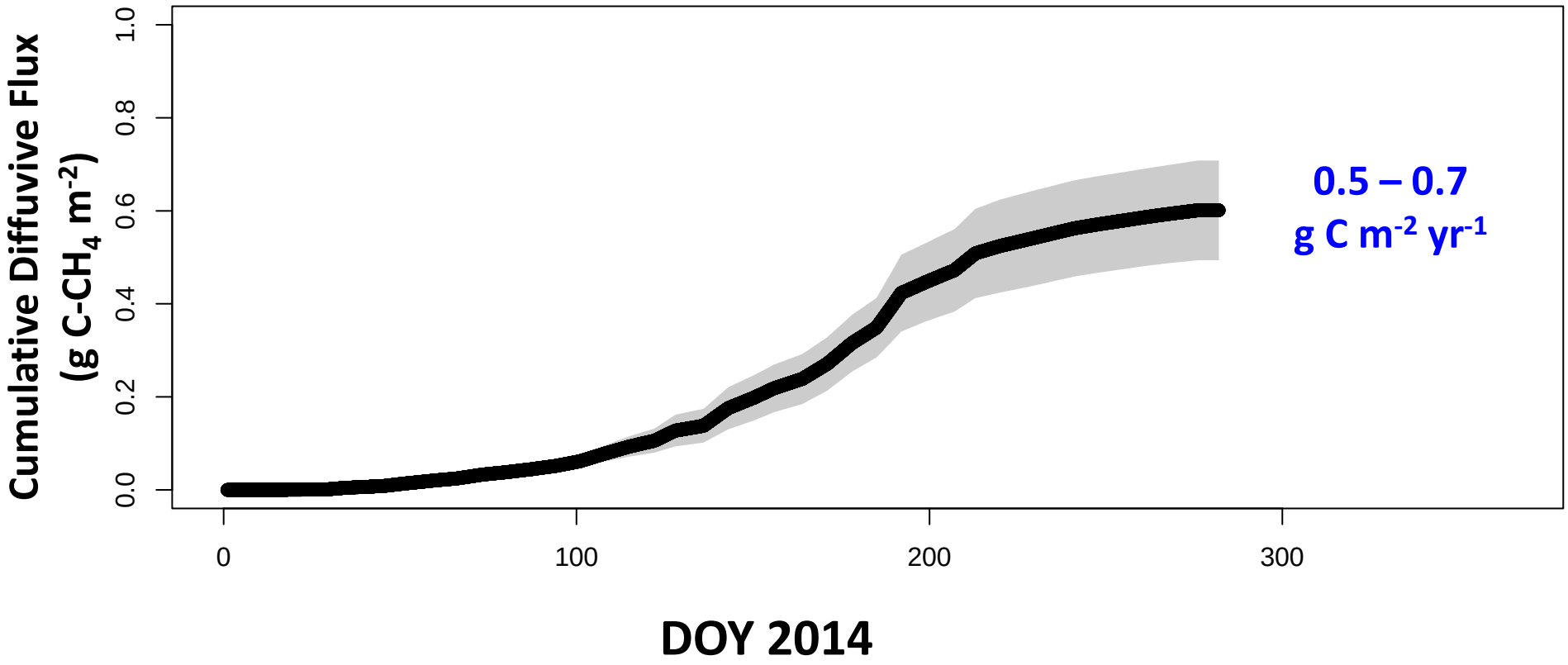
Open-Water Dissolved CH_4



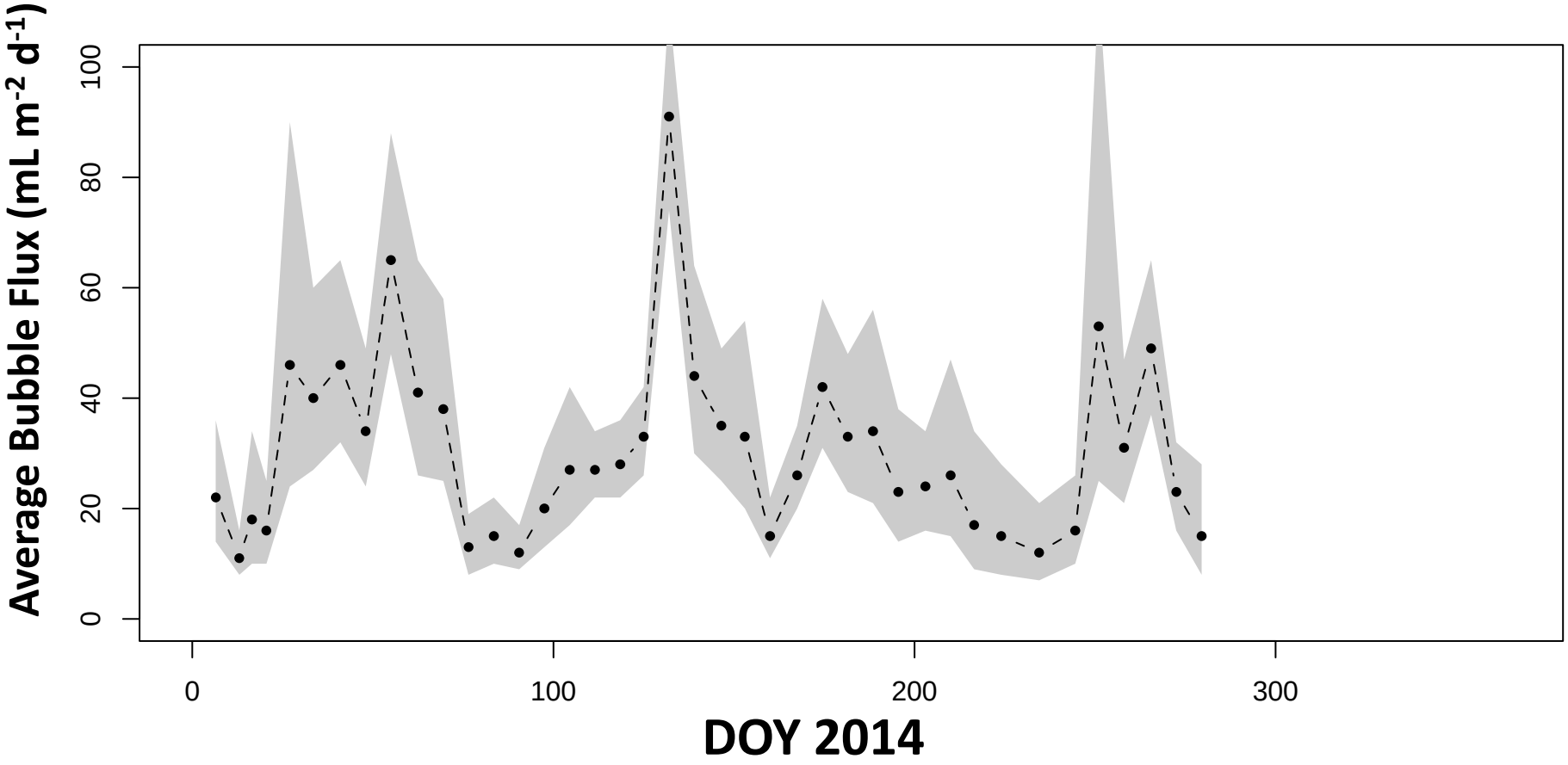
Diffusive Release of CH_4



Diffusive Release of CH_4



Bubble Release Rate



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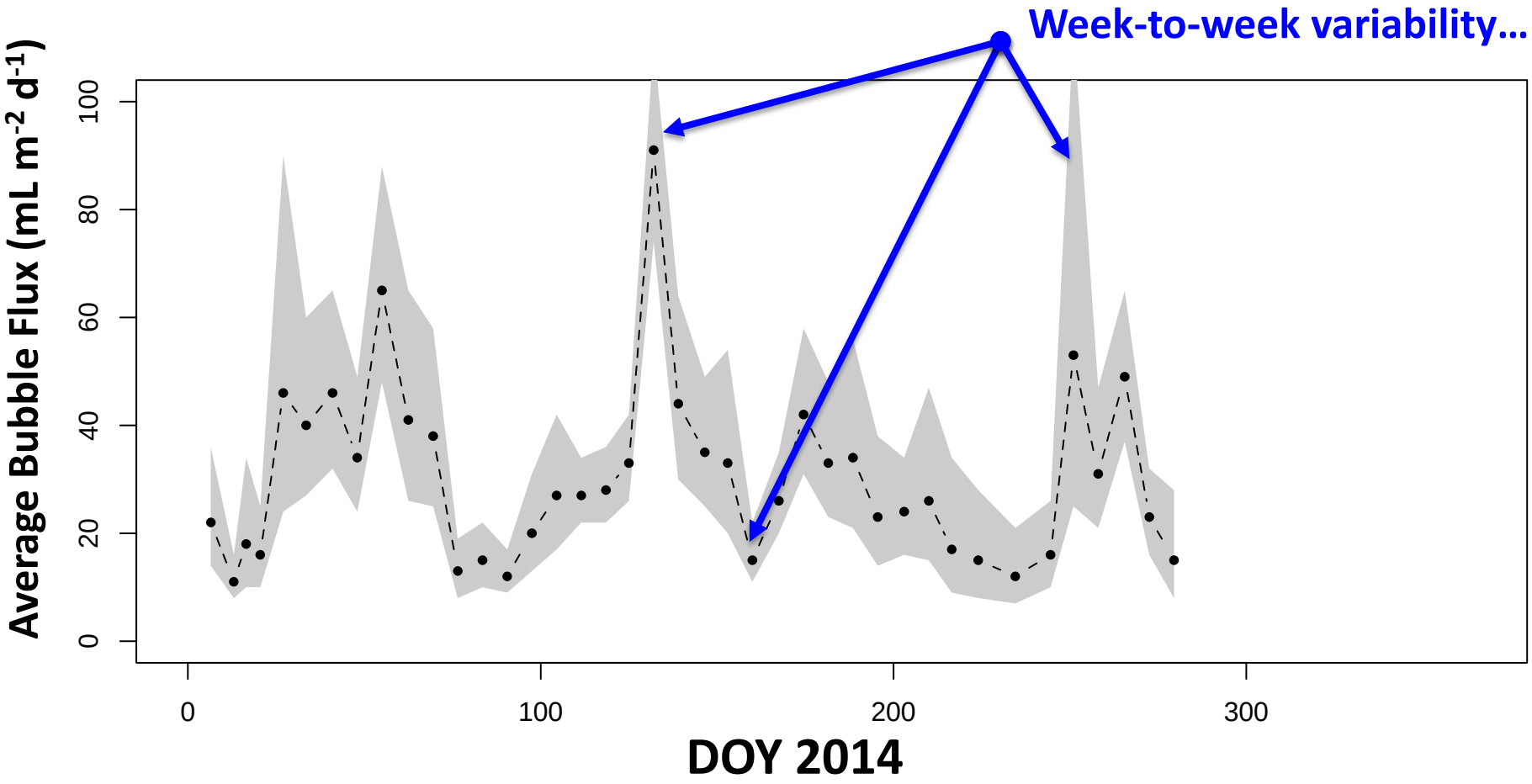

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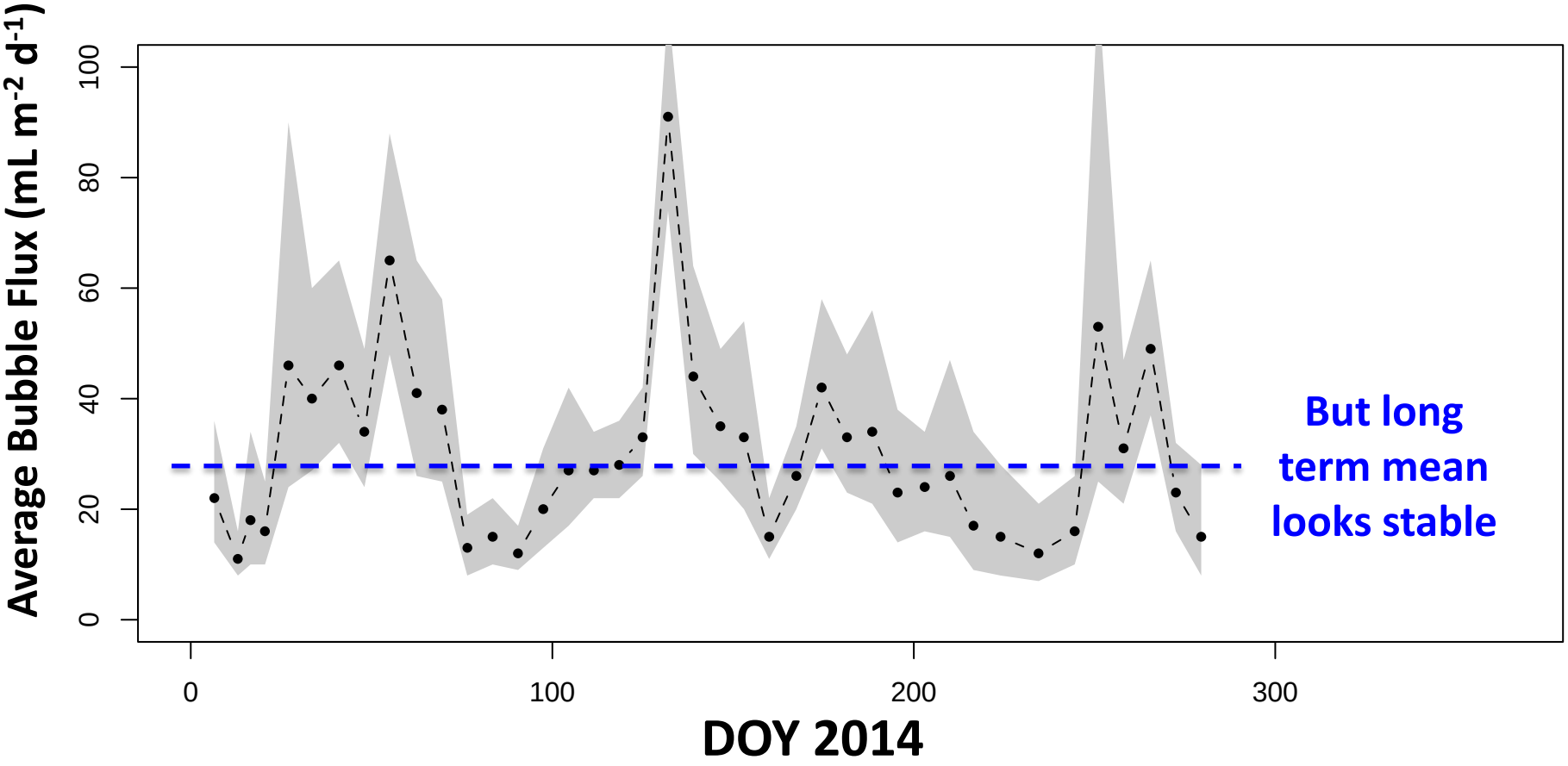

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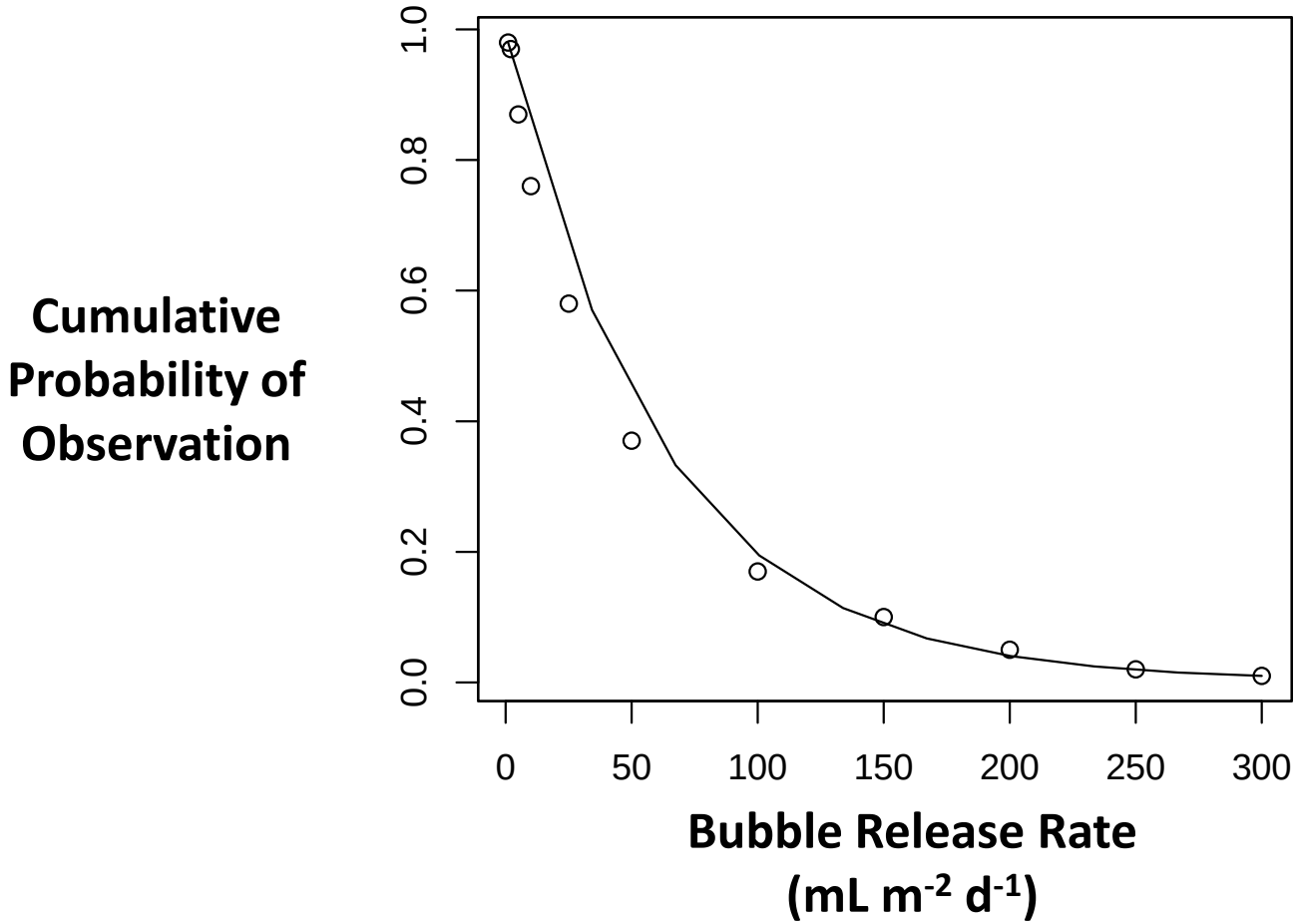

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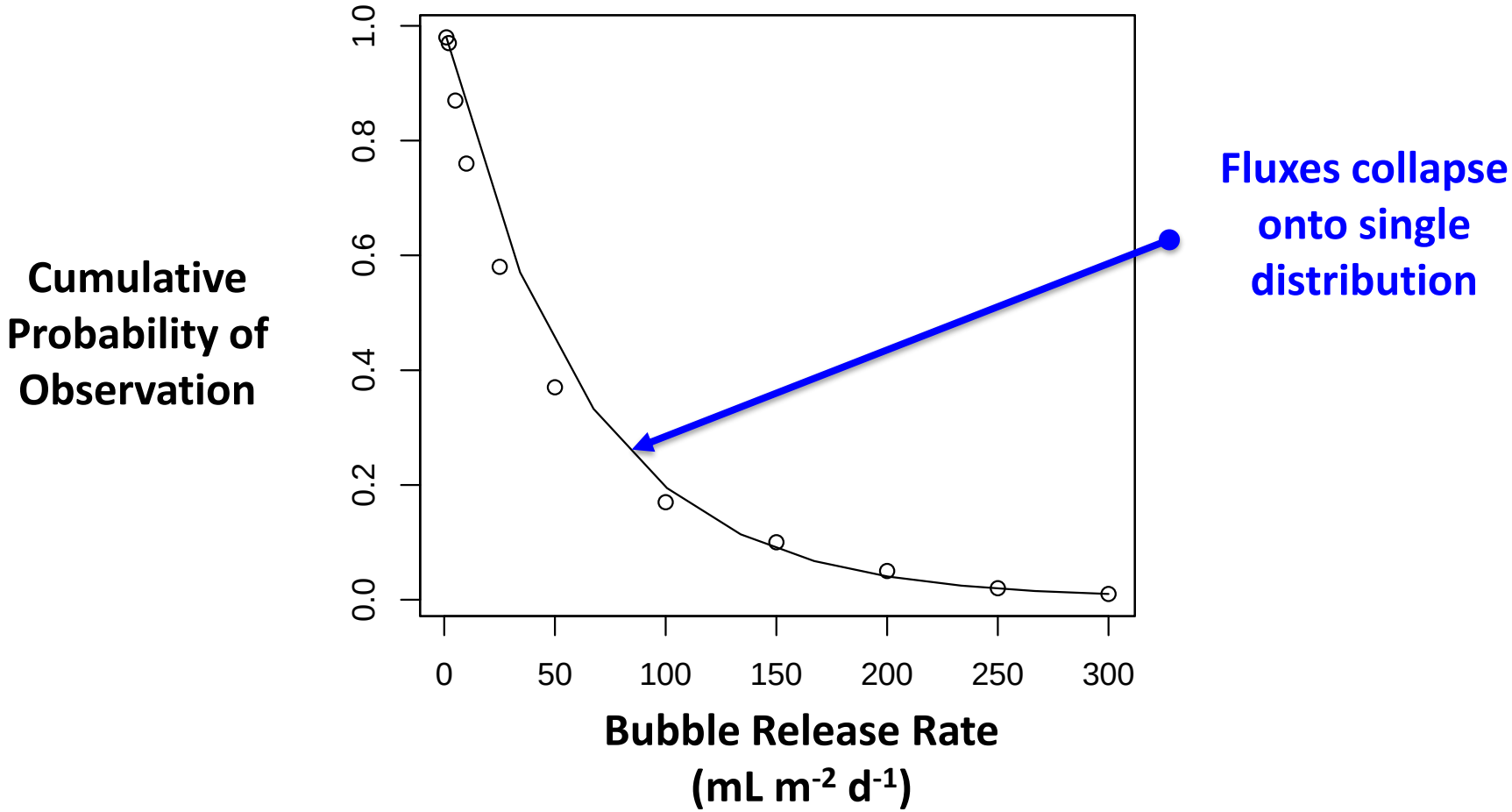

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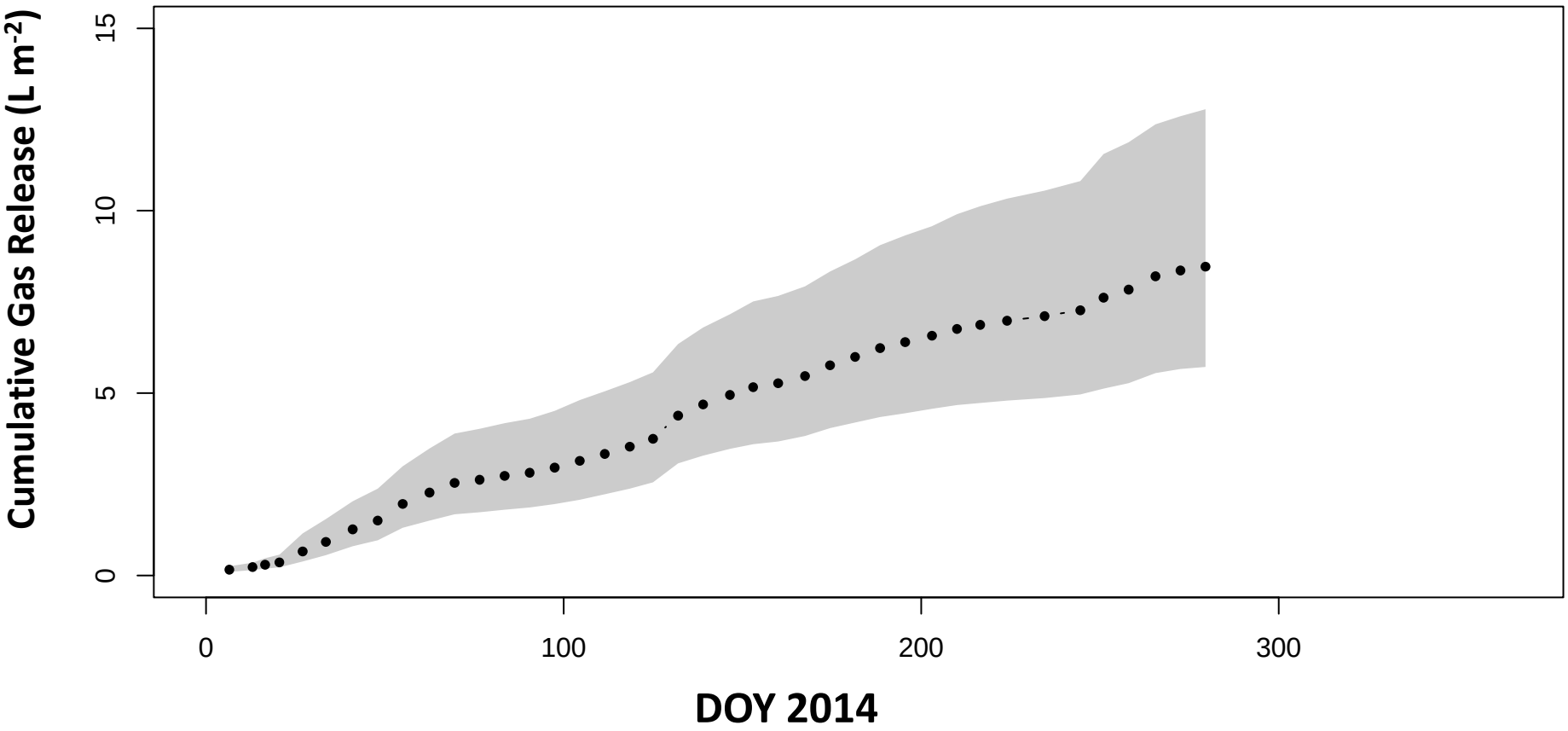

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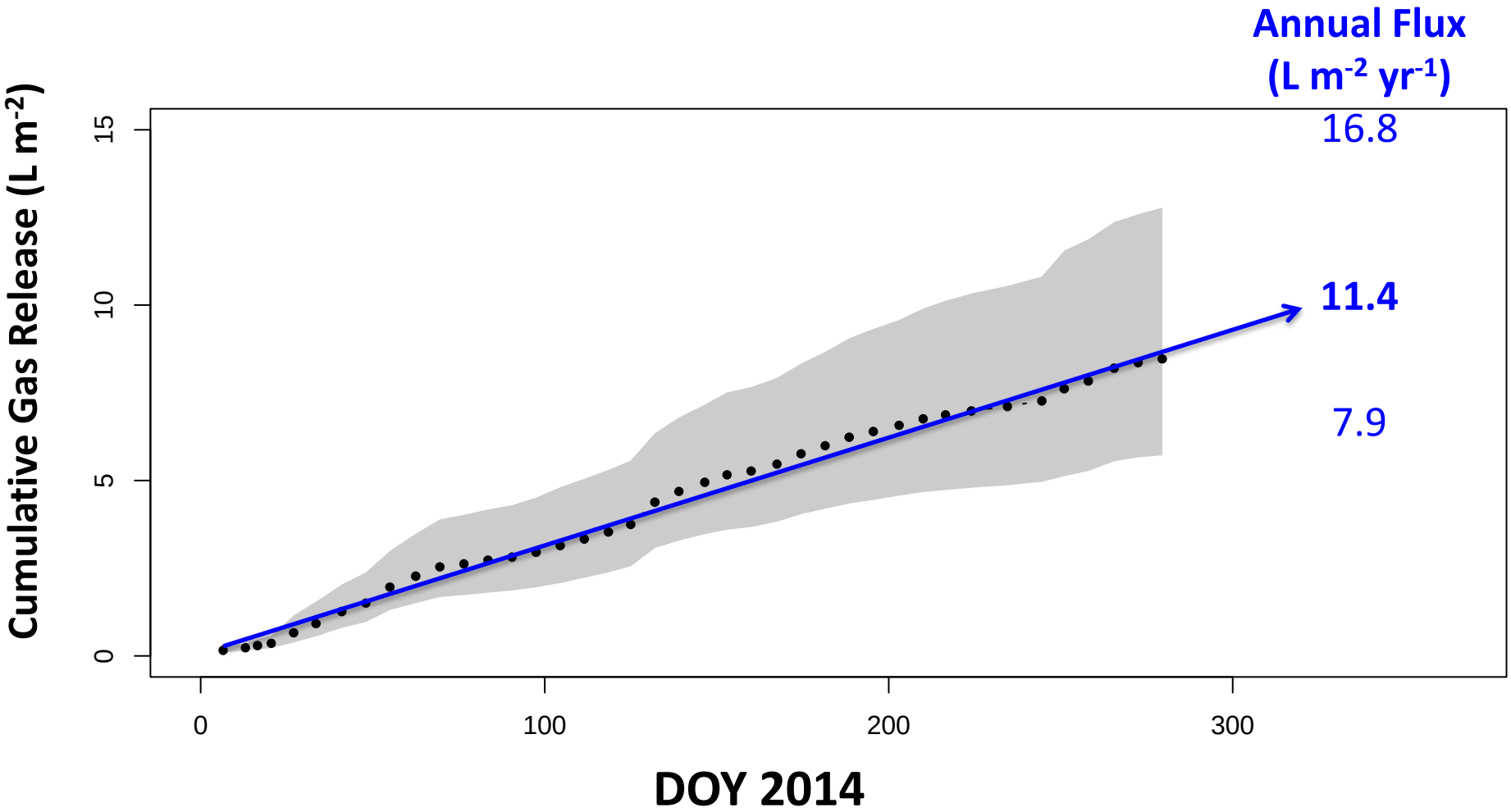
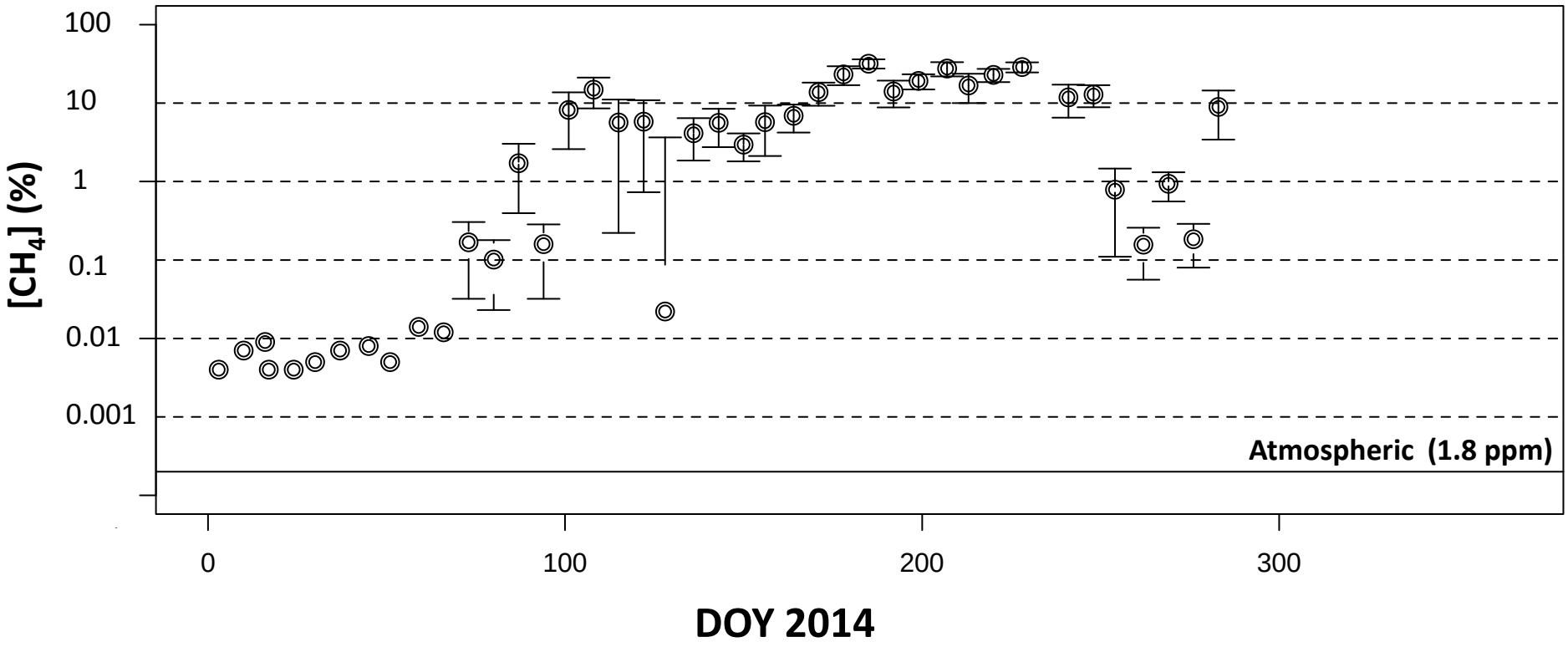


Bubble CH_4 Content



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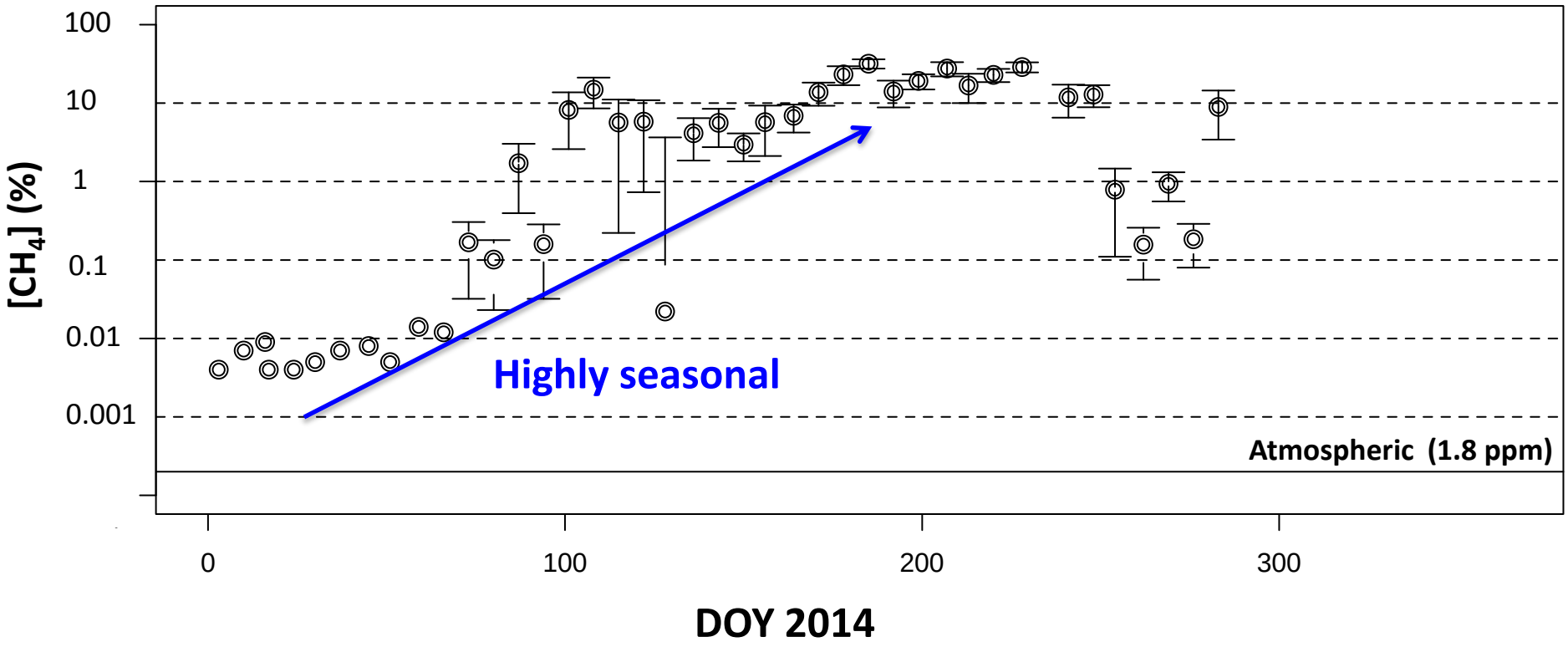

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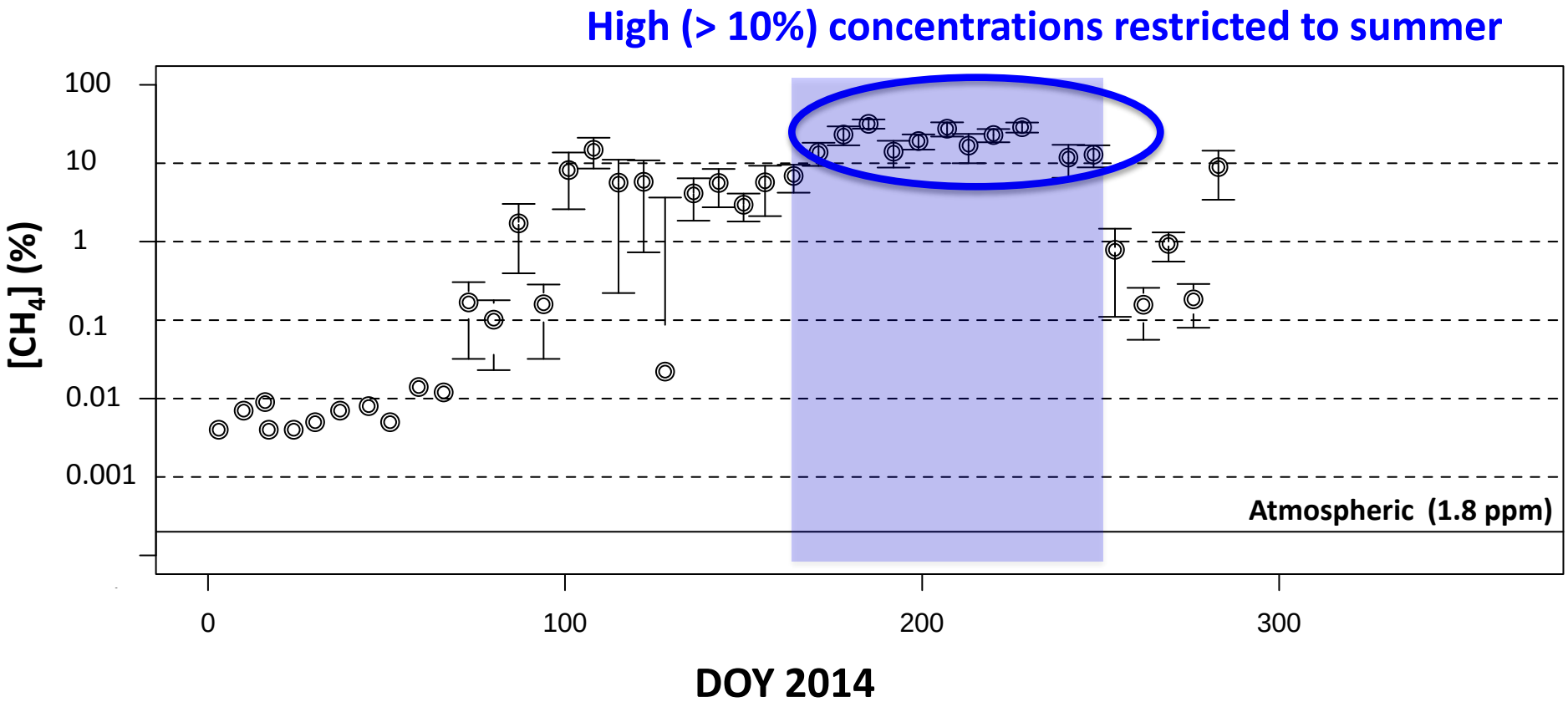
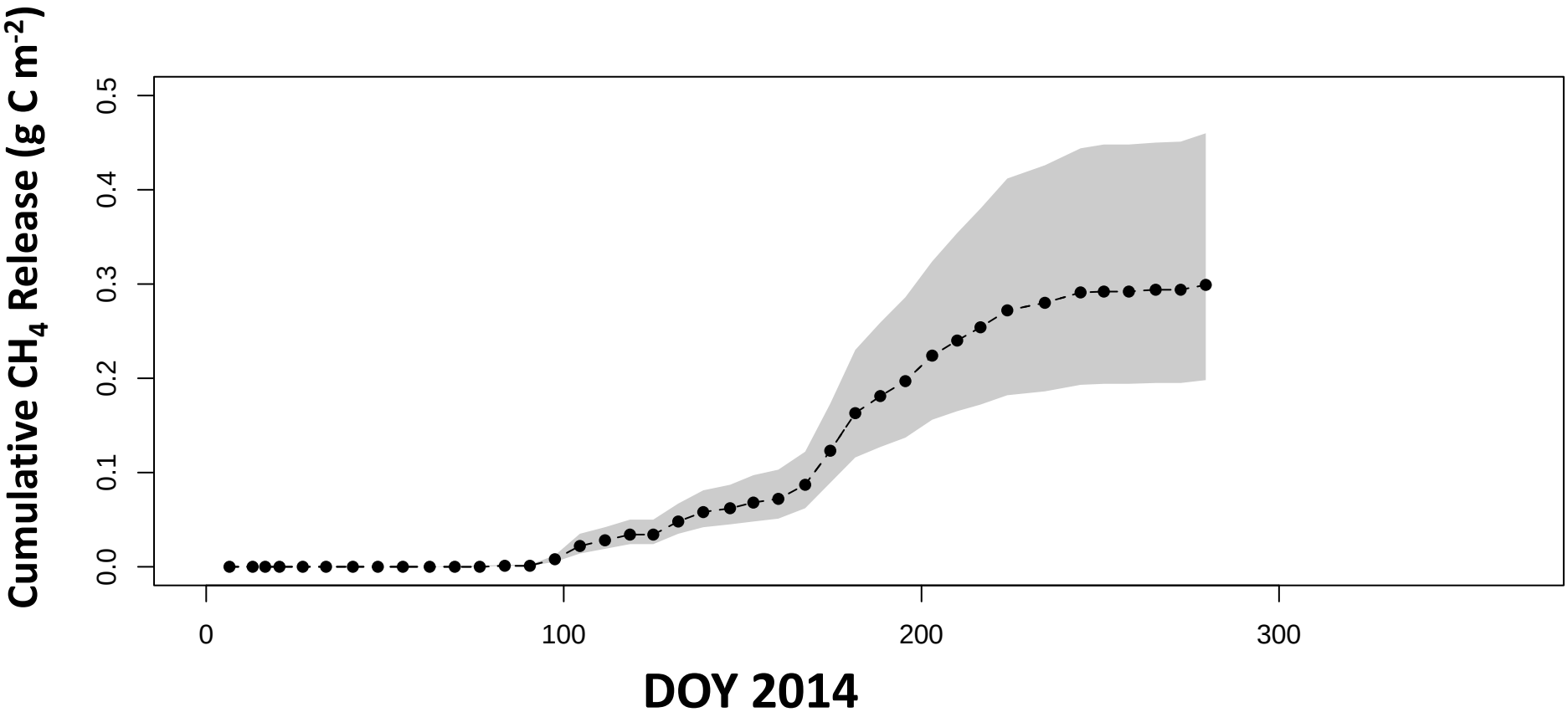
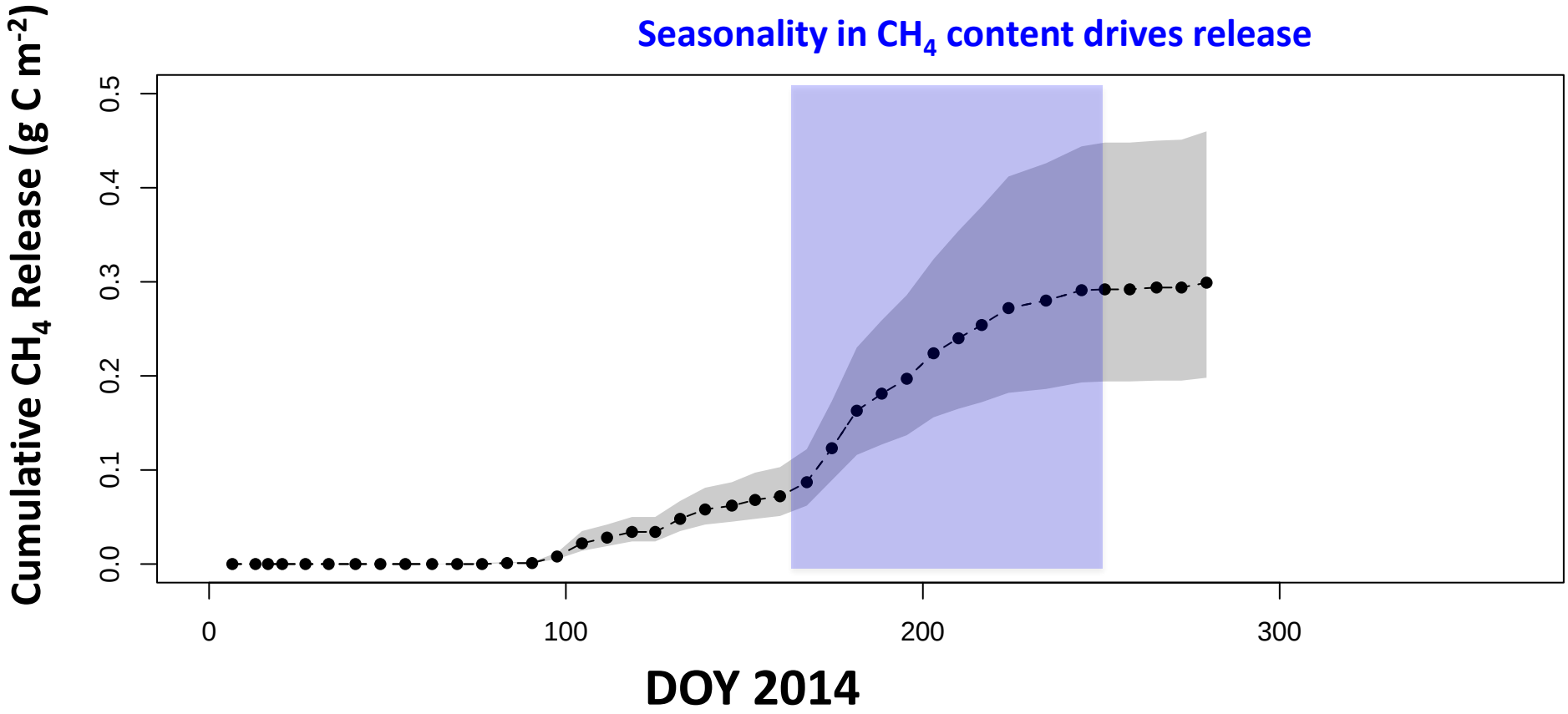


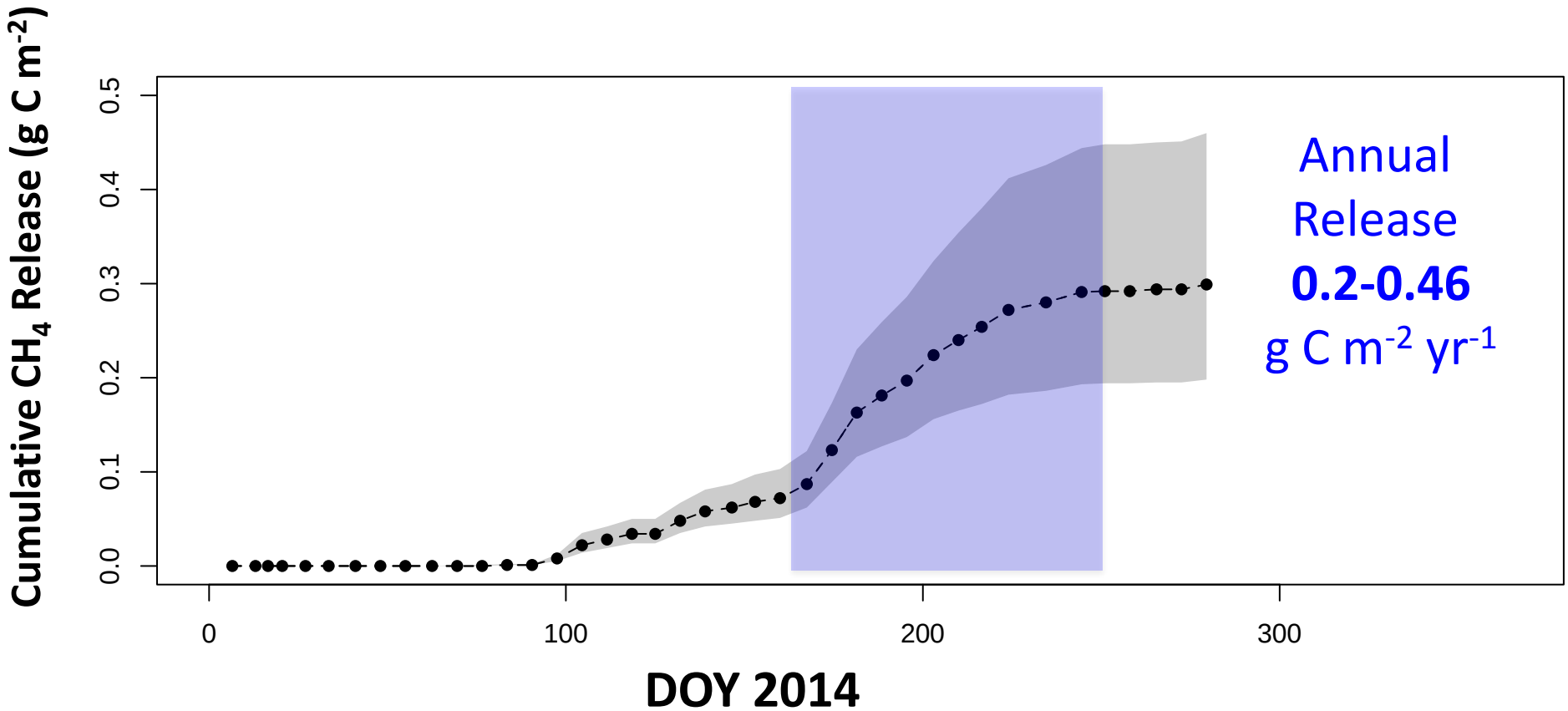
Annual Bubble CH_4 Release



Annual Bubble CH_4 Release



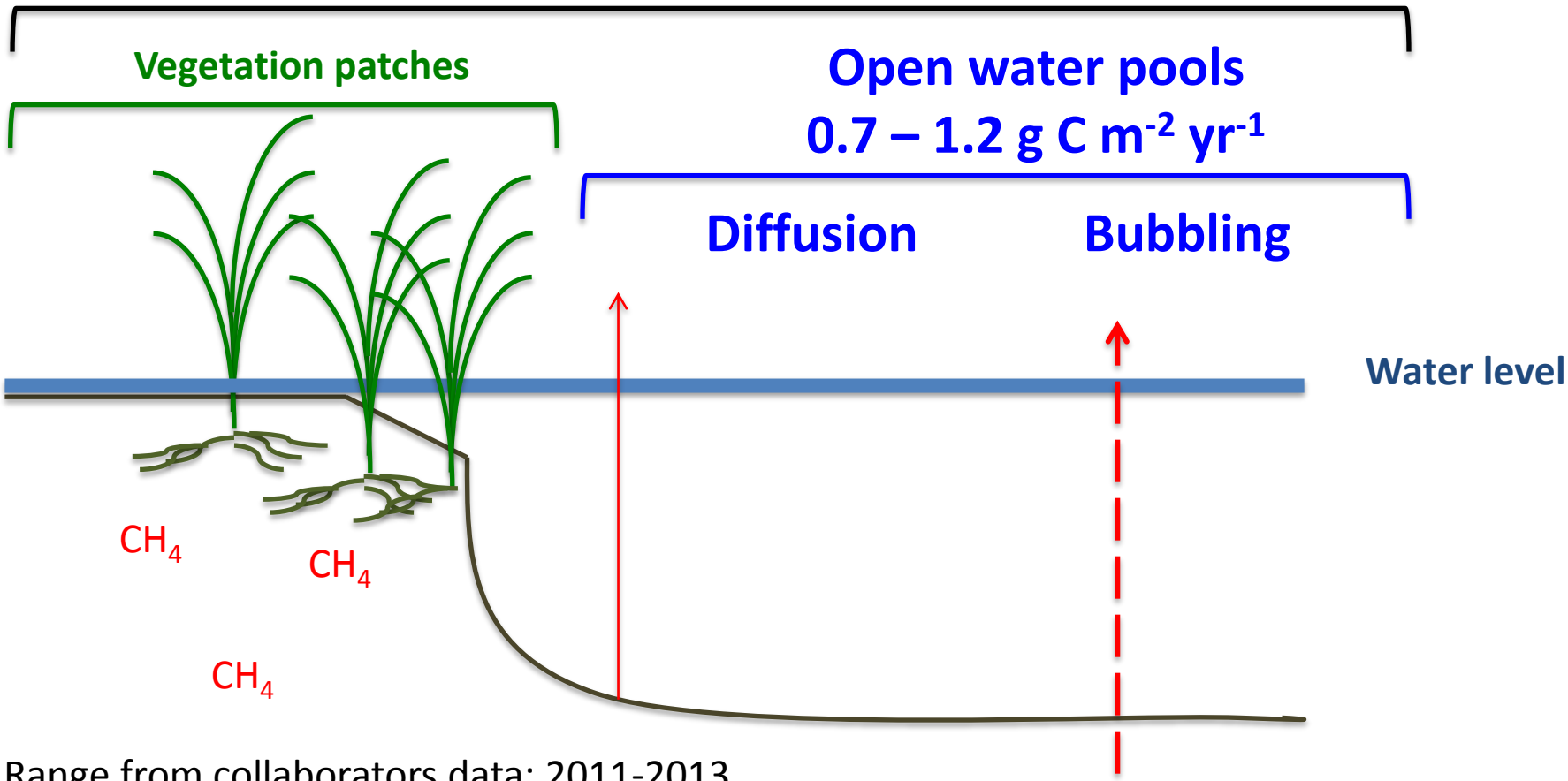
Annual Bubble CH_4 Release



Putting Fluxes in Context

Whole-ecosystem CH_4 emission*

On order of: ≈10 g C-CH_4 m^{-2} yr^{-1}



* Range from collaborators data: 2011-2013

Summary

- **We found:**
  - Aseasonal bubble production (11.4 L m^{-2} yr^{-1})
  - Seasonal bubble CH_4 content
  - Open water fluxes 1-10% of whole ecosystem
  - ➢ Ecosystem structure controls patterns of CH_4 release

Future Work

- Complete flux measurements
- Understand seasonality in bubble CH_4 content
  - Is it site-specific?

Acknowledgements

Collaborators:
Dennis Baldocchi,
Sara Knox,
Cove Sturtevant
(Baldocchi Lab, UCB)

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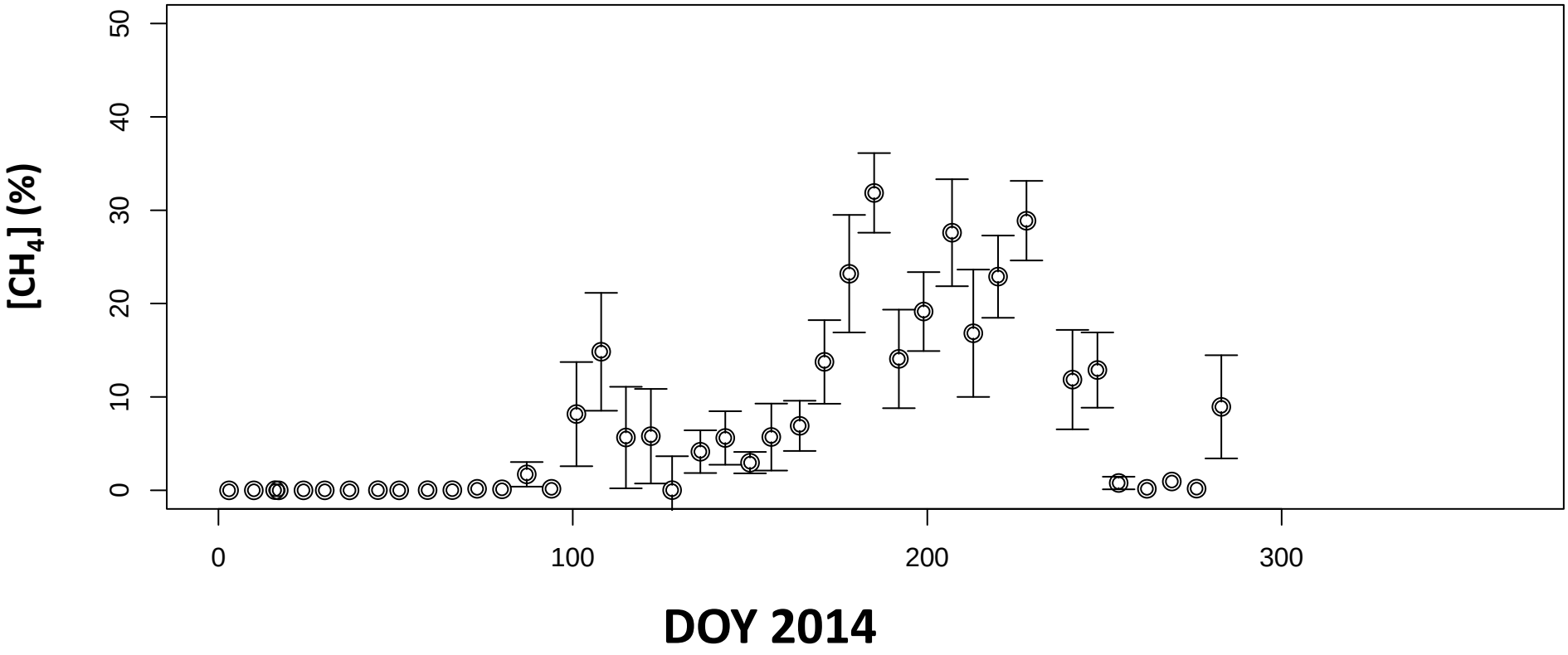
Ryan Salladay,
Laura Southworth

Delta Community Mentors
Belinda Morris (American Carbon Registry, CA Director)
Bryan Brock (CA-DWR, Site Manager)
Campbell Ingram (Delta Conservancy, Director)

Funding:
Delta Science Fellowship 2012-2014 - Delta Science Program
Doctoral Dissertation Improvement Grant 2014-2015 – National Science Foundation

2. Bubble CH_4 content



Thesis Questions

1. **How much gas is released via open-water ebullition?**
2. **How do open-water pools compare to vegetation patches as sources of wetland CH_4?**
3. **Do carbon source of wetland CH_4 vary between pools and patches?**

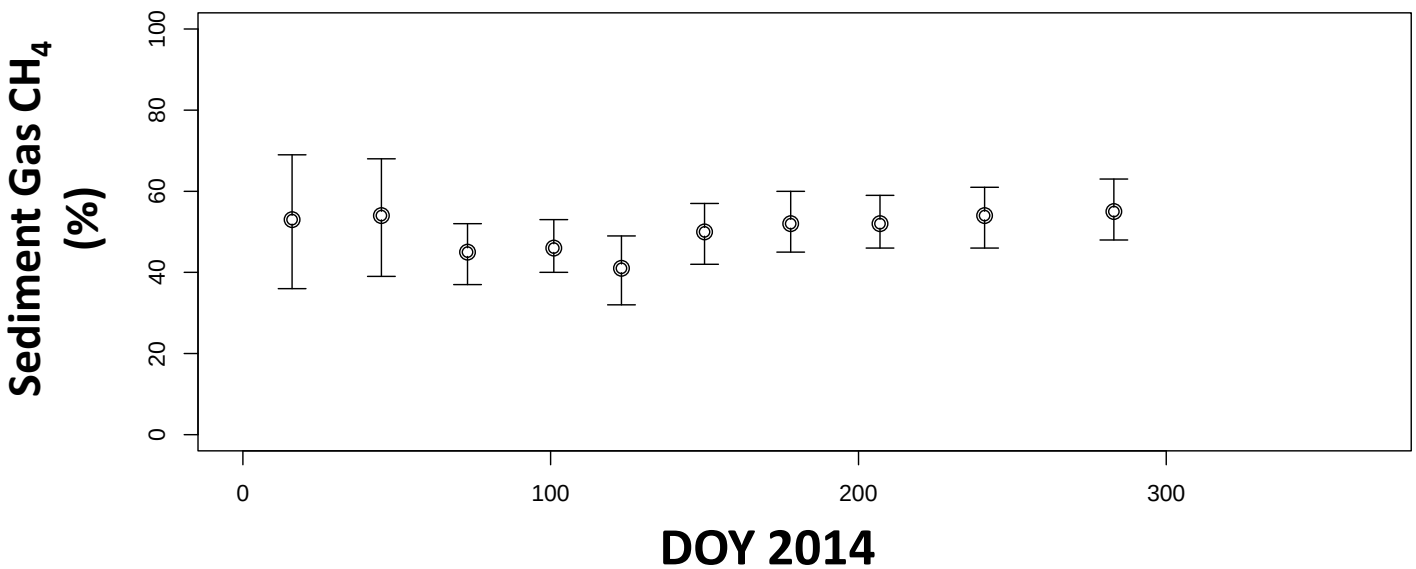
	Bubble Flux Rate	
	Daily ($ml\ m^{-2}\ d^{-1}$)	Annual ($L\ m^{-2}\ yr^{-1}$)
Upper (95%)	46	16.8
Mean	**31**	**11.4**
Lower (95%)	22	7.9

- Error constrained to better than ± 50 % of mean
- High rates compared to other systems (refs)

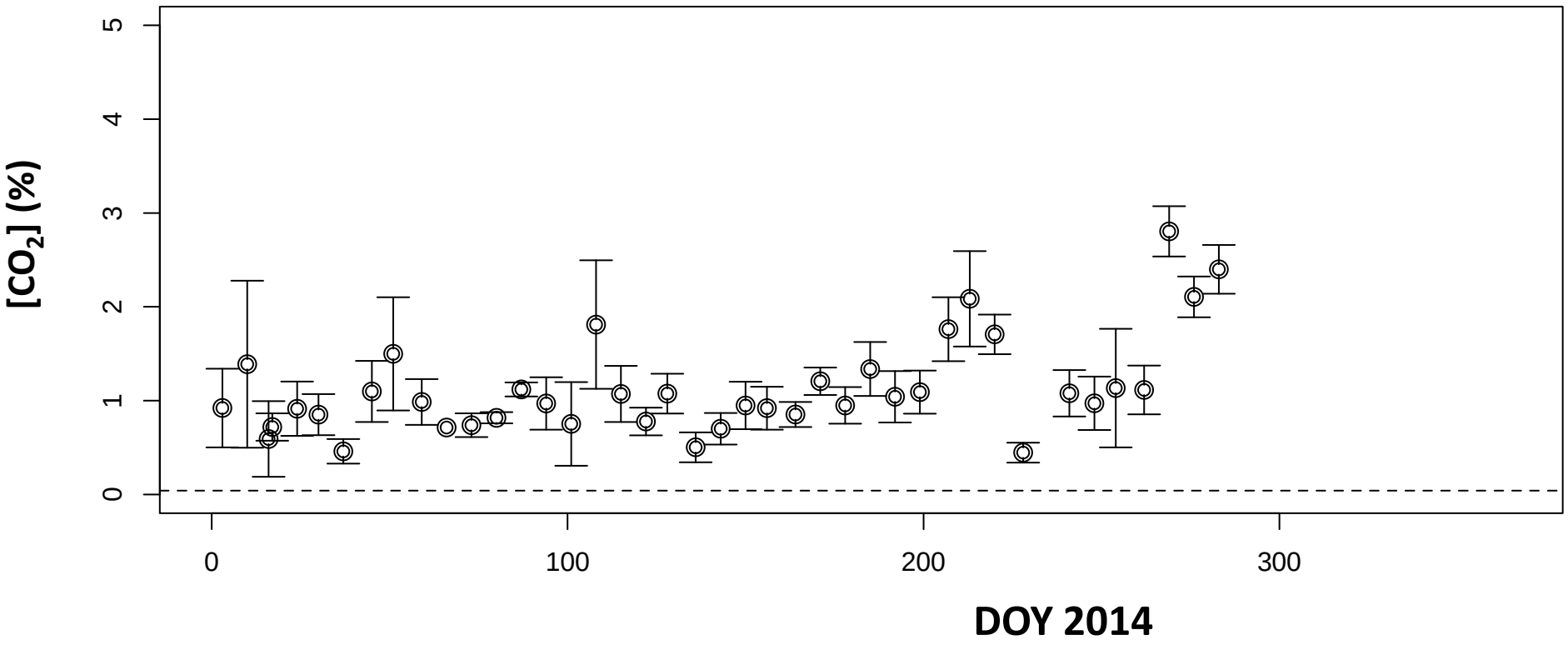
Seasonality in CH_4 Concentrations Drives Low Releases

	Annual Ebullition ($g\ C\text{-}CH_4\ m^{-2}\ yr^{-1}$)	Annual Ecosystem ($g\ C\text{-}CH4_4\ m^{-2}\ yr^{-1}$)	Potential Ebullition ($g\ C\text{-}CH_4\ m^{-2}\ yr^{-1}$)
Upper (95%)	0.46	-	4.5
Mean	**0.30**	**53 ± 0.78**	**3.1**
Lower (95%)	0.20	-	2.1

* Knox et al. (2014)

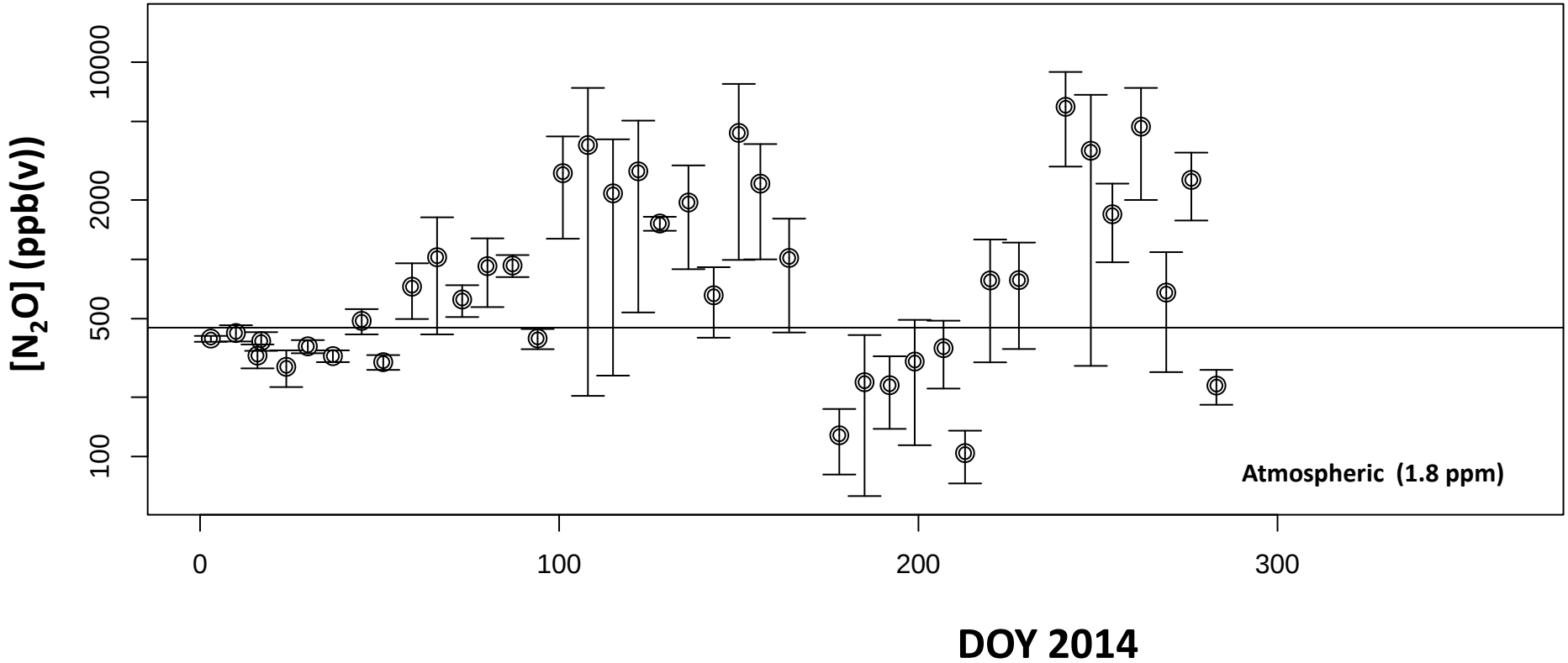


Results:
CO_2 bubble content



CO_2 concentrations were fairly constant:
1.16 ± 0.62 %

Results:
N_2O bubble content



N_2O concentrations were close to equilibrium

Growing-season saw occasional sinks and sources