Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Tower flux measurements in support of …

other tower-flux groups,
aircraft teams,
atmospheric chemists,
Earth observation scientists,
etc…

Elizabeth Pattey,
Ray Desjardins,
Brian Lamb, Hal Westberg,
John Miller

– How studying unmanaged forest and managed agroecosystems provide insight on atmospheric biogeosciences

How FIFE and BOREAS Changed the World. Oct 6 –7,
NASA Goddard Space Flight Center, Greenbelt, MD

Canada

BOREAS –SSA-OBS
TF7 – 20 m
TF9 – 27 m

BOREAL ECOSYSTEM - ATMOSPHERE STUDY

Water

Energy

Carbon

open-sky laboratories over 50 x100 km study areas

Setup of all the equipment

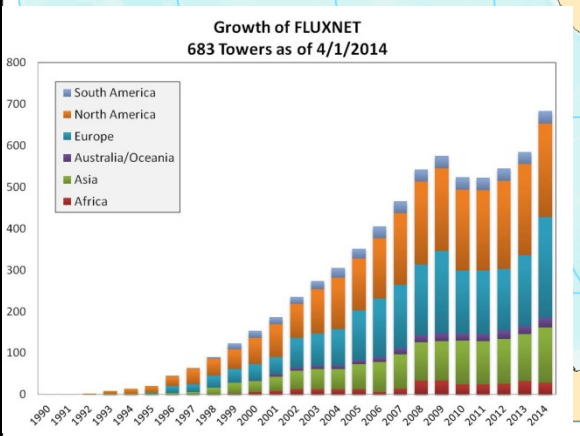
Lessons learned for EC flux measurements

- Turbulent flow in intake tubes of closed-path analyzers
- Heating or not heating the intake…
- Energy budget closure (impact measuring system configuration vs mesoscale circulation)
- Intermittent turbulence at night; u_* or σ_w screening
- Footprint expand at night (from 100s m daytime to 1000s m at night => impact on heterogeneous landscapes)
- Complex terrain surrounding flux towers
- Beware of the bears… no food on site, please!
- Beware of the bugs, wear nets…

FLUXNET

July 2015

723 Sites



Network

- Carboltaly (IT-FISR)
- TCOS Siberia (EU-FP5)
- AERONET
- Agroforestry Panama
- AmeriFlux
- AsiaFlux
- BERMS
- CNRM/GAME (METEO-FRANCE, CNRS)
- Canadian Carbon Program (CCP)
- CarboAfrica (EU-FP6)
- CarboEuroFlux (EU-FP5)
- CarboEurope
- CarboEurope-IP (EU-FP6)
- CarboExtreme (EU-FP7)
- Carbomont (EU-FP5)
- ChinaFlux
- EuroFlux (EU-FP4)
- European Unaffiliated
- GHG-Europe (EU-FP7)
- Greengrass (EU-FP5)
- IMECC (EU-FP6)
- JapanFlux
- KoFlux
- MIND (EU-FP5)
- Medeflu (EU-FP4)
- MexFlux
- OzFlux
- PhenoALP e-PHENO, ALCOTRA 07-13
- USCCC
- Unaffiliated
- Urban Fluxnet

Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC). 2013. FLUXNET Maps & Graphics Web Page. Available online [http://fluxnet.ornl.gov/maps-graphics] from ORNL DAAC, Oak Ridge, Tennessee, USA Accessed November 5, 2013

FLUXNET

July 2015

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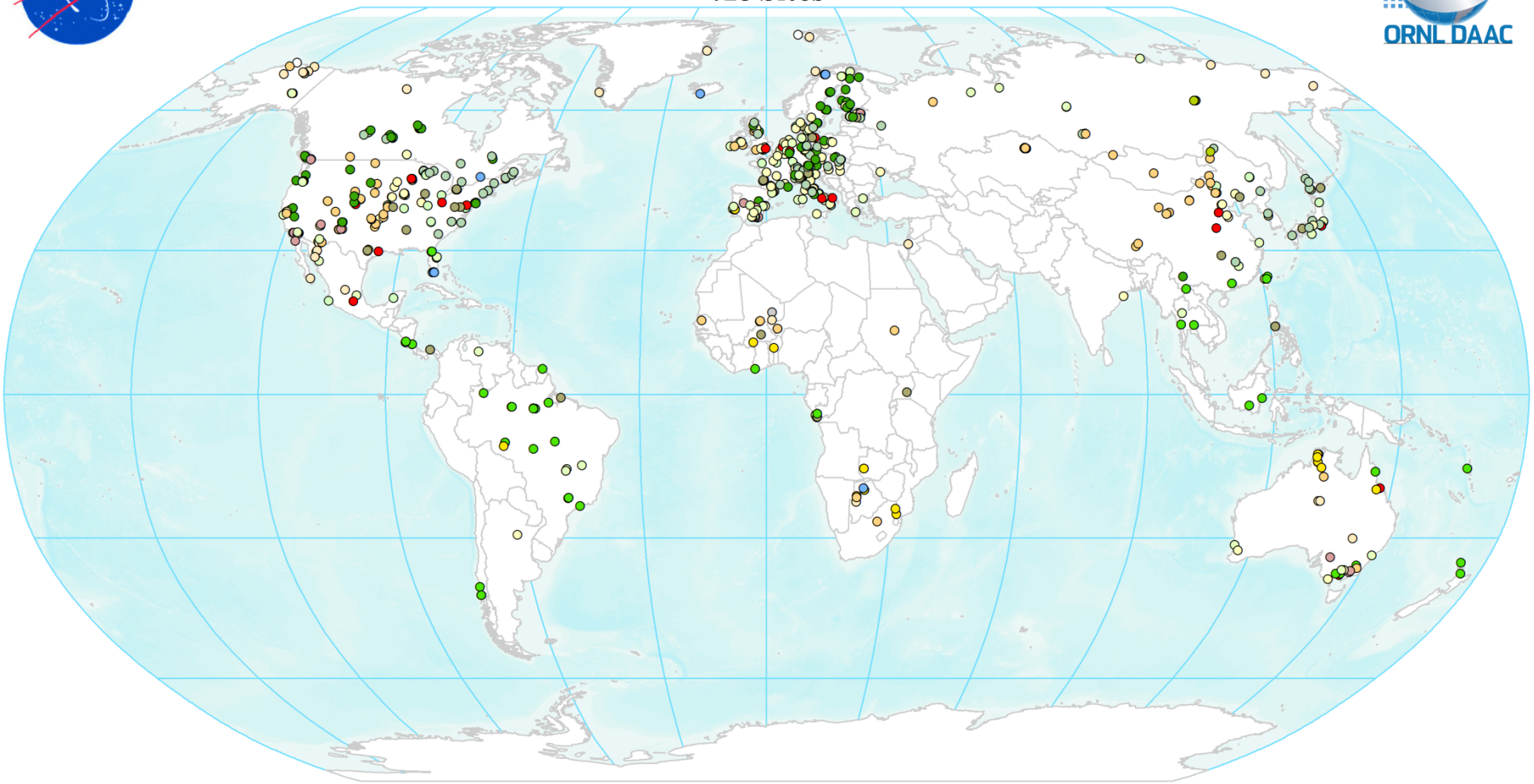
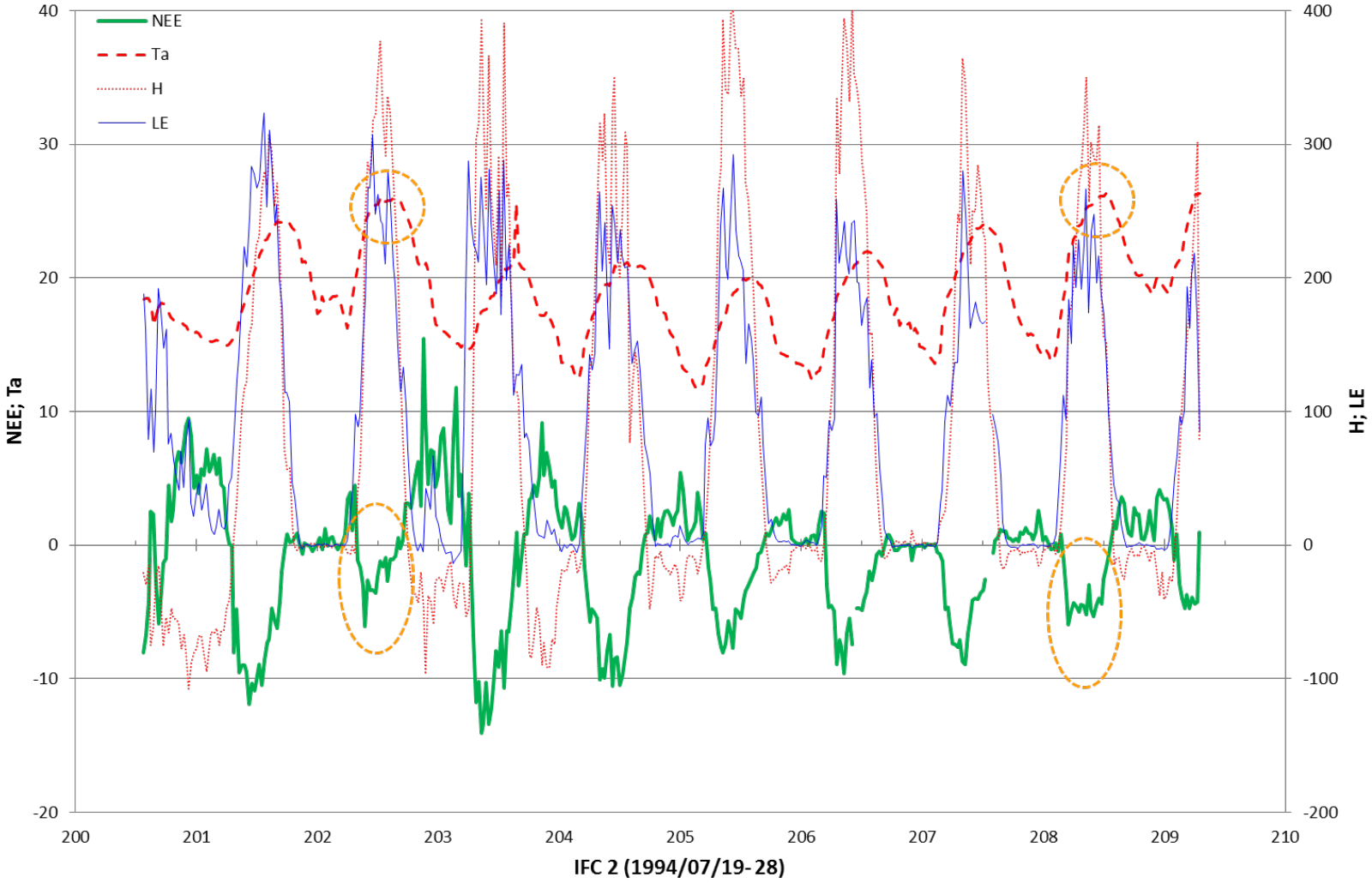


Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC). 2013. FLUXNET Maps & Graphics Web Page. Available online [http://fluxnet.ornl.gov/maps-graphics] from ORNL DAAC, Oak Ridge, Tennessee, USA Accessed November 5, 2013

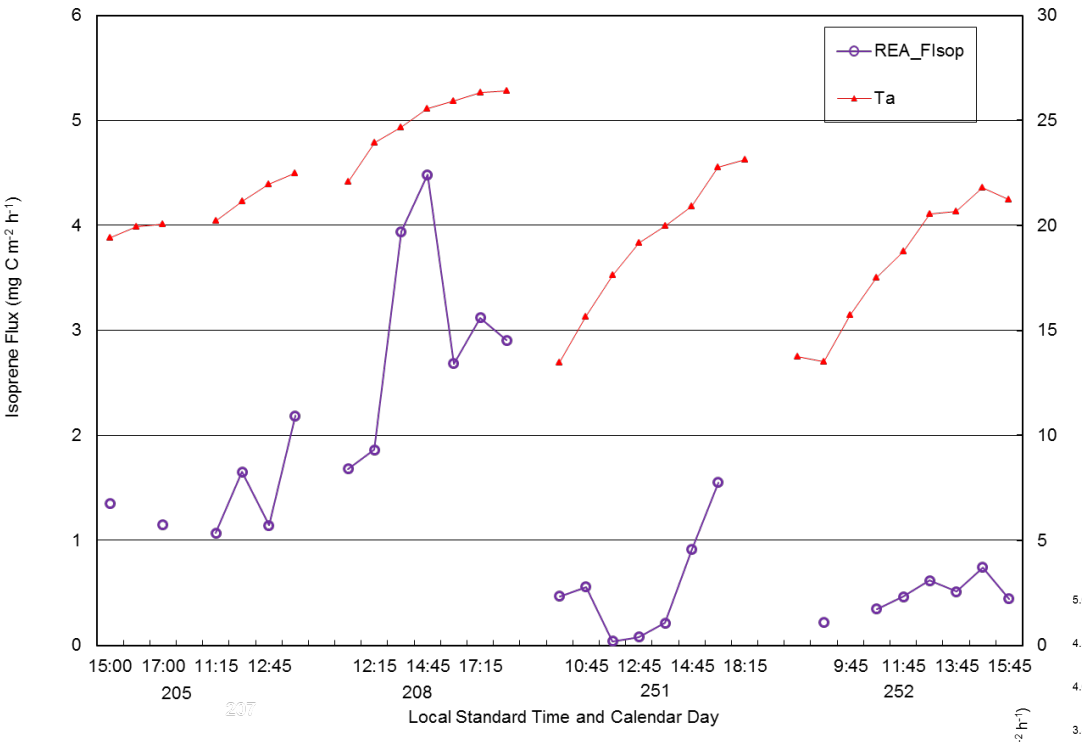
EC Fluxes in SSA-OBS

- Boreal forest and old black spruce in particular behave like arid ecosystems, very conservative in ressource management
  - the evaporative fraction was relatively constant,
  - As well as max NEE over the growing season, which did not closely follow LAI pattern,
  - LAI was highest during IFC2 (while more respiration during dayttime occurred compared to the other IFCs)

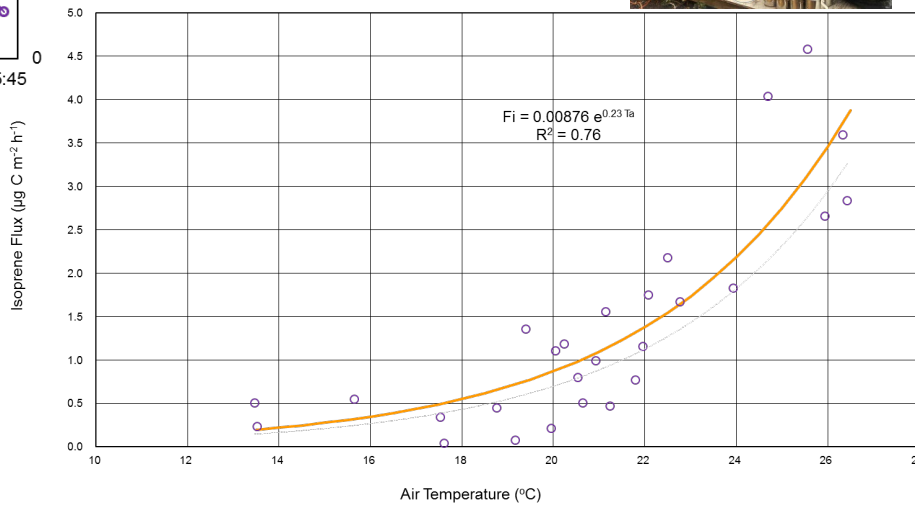
Turbulent Fluxes during IFC 2



Isoprene Fluxes (IFC 2-3)



- Thermoprotection mechanism
- Standard isoprene emission factor (30°C, 1000 PAR) of the boreal black spruce revisited
- 6 μg C g^{-1} h^{-1} rather than 18 μg C g^{-1} h^{-1}



870 JOURNAL OF APPLIED METEOROLOGY VOLUME 38

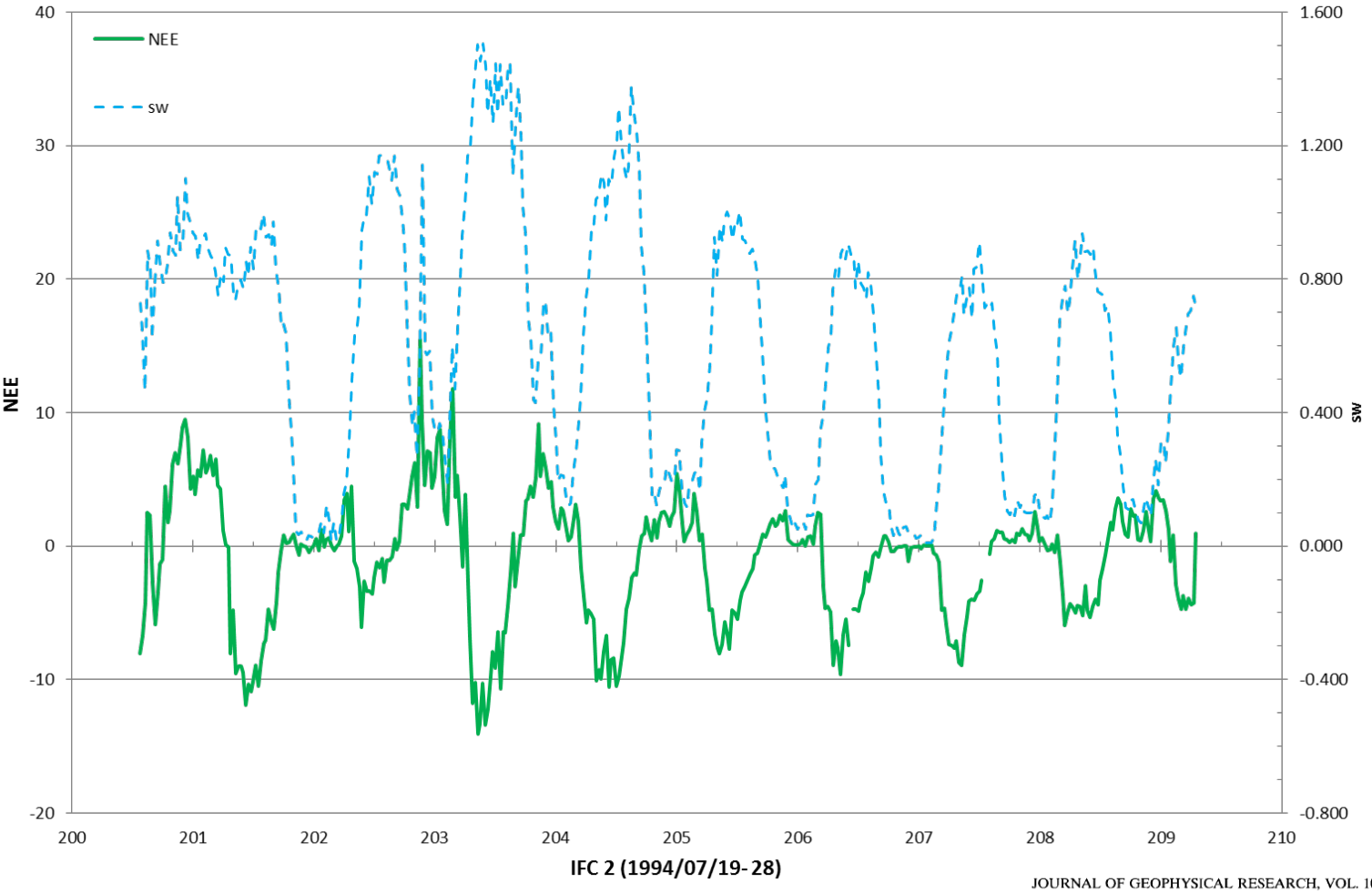
Measurement of Isoprene Emissions over a Black Spruce Stand Using a Tower-Based Relaxed Eddy-Accumulation System*

E. PATTEY AND R. L. DESJARDINS
Eastern Cereal and Oilseed Research Centre, Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada

H. WESTBERG AND B. LAMB
Laboratory for Atmospheric Research, Washington State University, Pullman, Washington

T. ZHU
Eastern Cereal and Oilseed Research Centre, Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada

CO_2 Fluxes during IFC2



JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 102, NO. D24, PAGES 28,967–28,975, DECEMBER 26, 1997

Mass and energy exchanges over a black spruce forest during key periods of BOREAS 1994

E. Pattey, R. L. Desjardins, and G. St-Amour

NBL technique to measure Ecosystem Respiration in 1996

ELSEVIER

Agricultural and Forest Meteorology 113 (2002) 145–158

AGRICULTURAL AND FOREST METEOROLOGY

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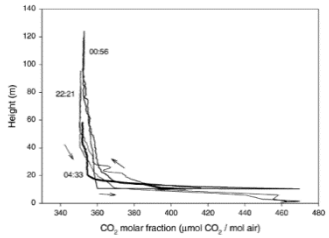
$$F_C = \int_0^Z \frac{\partial C}{\partial t} dz + A_C$$

Measuring nighttime CO_2 flux over terrestrial ecosystems using eddy covariance and nocturnal boundary layer methods

E. Pattey [a,*], I.B. Strachan [b], R.L. Desjardins [c], J. Massheder [d]

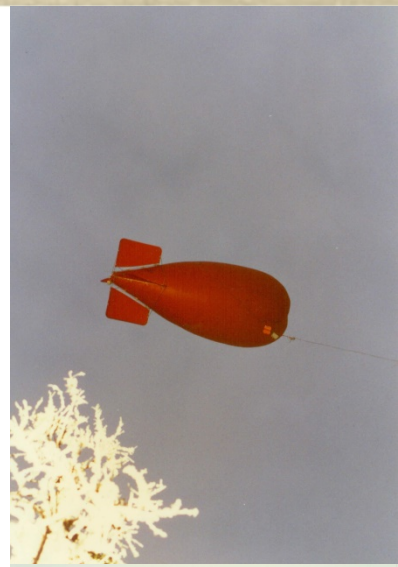
[a] *Eastern Cereal and Oilseed Research Centre, Research Branch, Agriculture and Agri-Food Canada, Ottawa, Ont., Canada*
[b] *Department of Natural Resource Sciences and Department of Geography, McGill University, Montreal, Que., Canada*
[c] *Research Branch Headquarters, Agriculture and Agri-Food Canada, Ottawa, Ont., Canada*
[d] *Institute of Ecology and Resource Management, Edinburgh University, Edinburgh, UK*



Comparison between CO_2 flux for boreal forest in 1996 using eddy covariance (EC) and using the NBL budget technique[a]

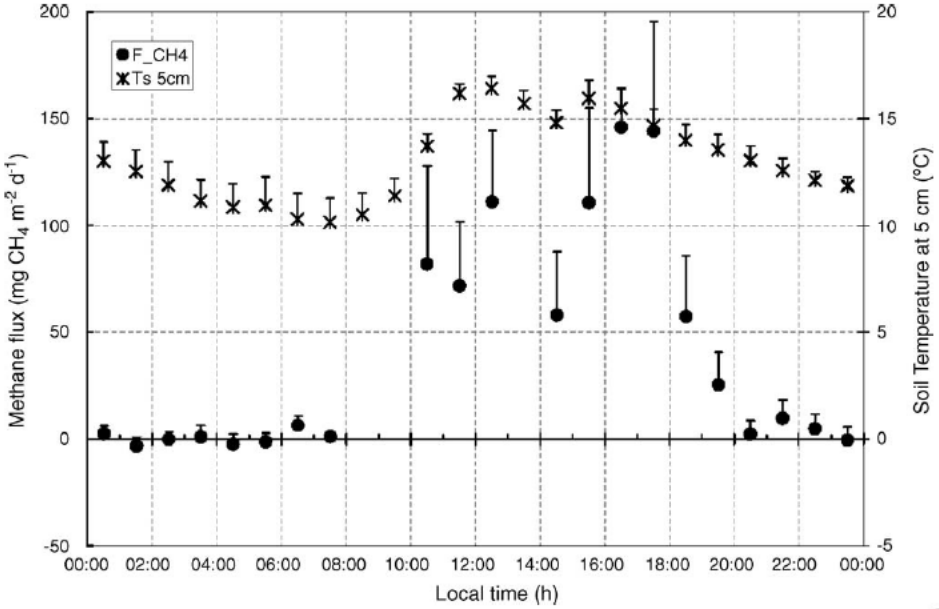
Day	σ_w (m s^{-1})	T_a (°C)	CO_2 EC (mg m^{-2} s^{-1})	NBL budget (mg m^{-2} s^{-1})	
				LI-6262	CIRAS
193	0.28	19.4	0.07		
194	0.25	17.3	0.04		
195	0.14	16.0	0.02		
196	0.16	14.8	0.09		
197	0.06	16.8	0.01		
198	0.21	17.8	0.09	0.17	
199	0.73	15.8	0.19		
200	0.79	16.5	0.18		
201	0.18	15.1	0.04	0.12	0.11
202	0.19	13.7	0.10		
203	0.53	12.7	0.14	0.10	0.10
204	0.54	14.6	0.18		
205	0.09	15.2	0.02		0.11

[a] The NBL budget used two systems to measure CO_2 flux (LI-6262 and CIRAS). Also shown are the mean nighttime standard deviation of vertical wind speed (σ_w) and air temperature (T_a).



Methane Fluxes @ SSA-OBS

IFC2 - 1994



Methane fluxes (instantaneous values, midday average ± standard error) measured in the area of old black spruce and along a transect over Candle Lake (SK) from several passes of the NRC Twin Otter using the relaxed eddy accumulation technique

Date, CD	Flight track	Altitude (m agl)	Mean ΔCH_4 (nmol mol^{-1} dry air)	S.E. (ΔCH_4) (nmol mol^{-1} dry air)	$\sigma' w'$ (m s^{-1})	CH_4 flux (mg m^{-2} d^{-1})
20 April 2002, 110	CL Spruce	34	0.81	0.64	0.91	24
	OBS	33	−0.47	1.17	0.99	−15
	OBS	32	0.97	0.79	0.97	31
	OBS	33	0.60	1.88	0.99	19
	OBS	32	0.48	1.20	1.00	16
	CL Spruce	43	0.95	1.34	0.92	29
	Average					17 ± 7
21 April 2002, 111	CL Spruce	46	0.44	1.22	1.23	17
	OBS	43	−0.23	1.62	1.19	−9
	OBS	43	−0.76	1.51	1.25	−30
	OBS	43	1.99	1.59	1.15	73
	OBS	42	3.07	1.24	1.20	117
	CL Spruce	46	1.73	1.43	1.14	63
	Average					39 ± 23

IFC1 - 1994

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Agricultural and Forest Meteorology 136 (2006) 222–236

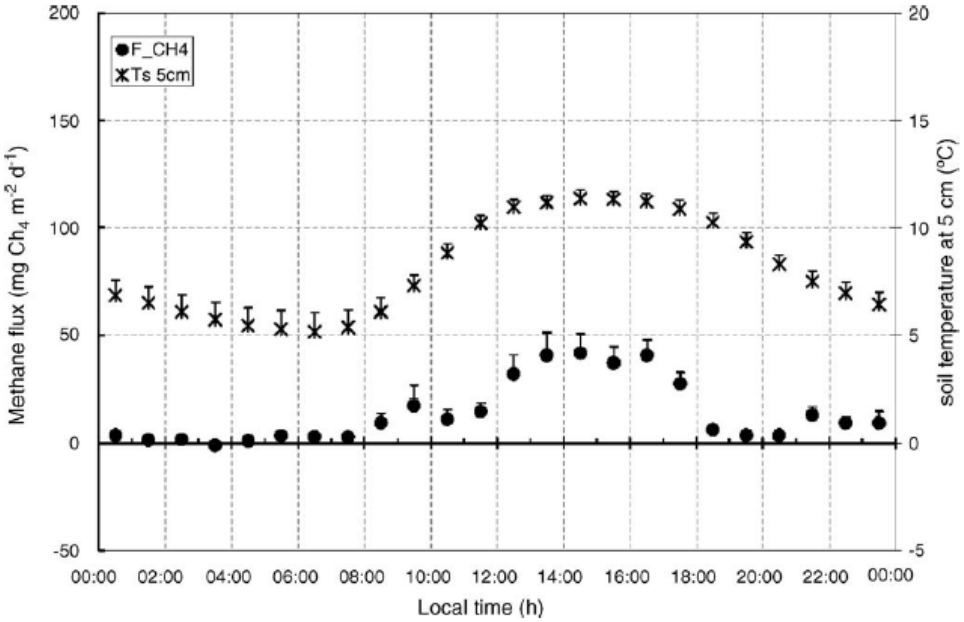
AGRICULTURAL AND FOREST METEOROLOGY

www.elsevier.com/locate/agrformet

Application of a tunable diode laser to the measurement of CH_4 and N_2O fluxes from field to landscape scale using several micrometeorological techniques

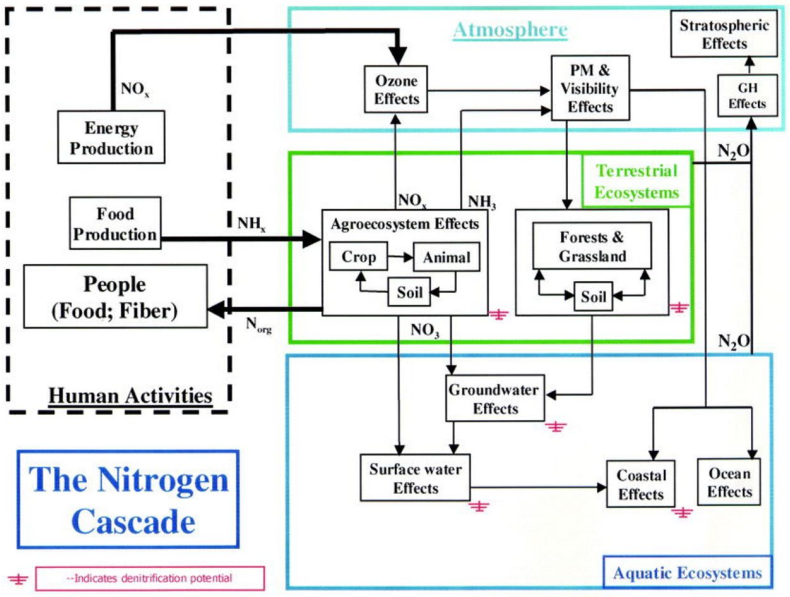
E. Pattey [a,*], I.B. Strachan [b], R.L. Desjardins [a], G.C. Edwards [a], D. Dow [a], J.I. MacPherson [c]

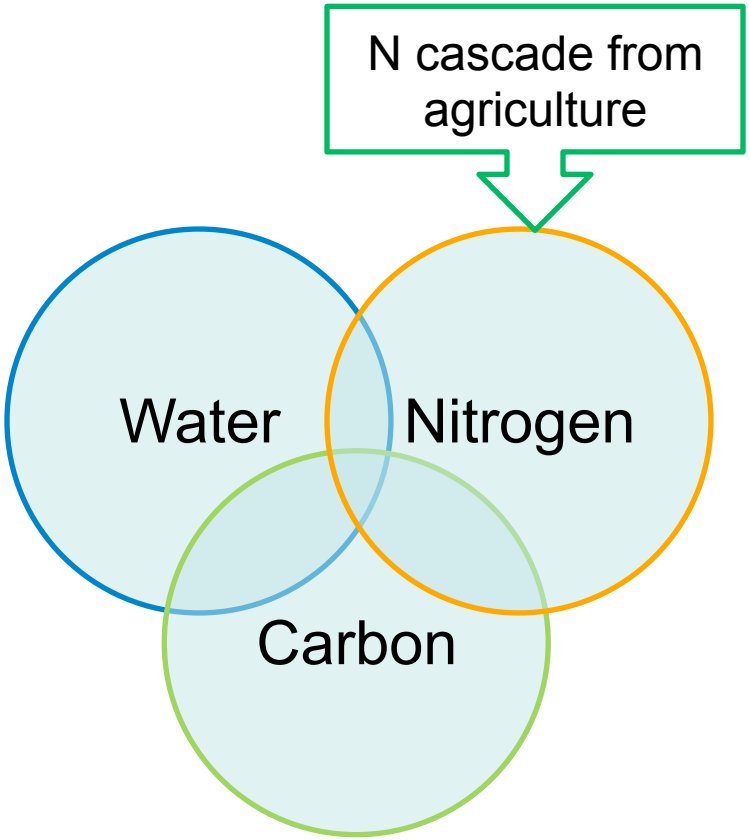
IFC3 - 1994



Leading the path to more trace gas flux measurements using REA and other micromet. tech.

- More CH_4 fluxes
- N_2O fluxes in agricultural fields (Twr) and regions (A/C)
- NH_3 fluxes & PM emissions





N Cascade: sequential effects of a N atom on various reservoirs after its conversion to Nr
Galloway, (2003)

EO – Fluxes
EO – Crop Productivity

- Understory Reflectance to account for its contribution to CO_2 fluxes (Miller et al., 1997)
- Improved biophysical descriptors using HR (Crop Chl, Green LAI, crop fraction) (Haboudane et al.,2002, 2004; Liu et al. 2008)
- f_{APAR} in Monteith's RUE model for estimating corn biomass, yield and crop stress (Liu et al., 2010)
- Assimilation of EO derived descriptors in verified crop models for regional crop predictions (Jégo, 2012)
- Impact of 1) resolution and quality of soil database as input to crop model for regional crop modelling using EO (Jégo et al., 2015)
- Impact of 2) spatial precipitation (grid<2.5 km for Eastern Canada) on crop yield prediction using EO (Jégo et al, 2015)
  - Link with Global Precipitation Mission
- Using verified crop models and long climate data series to derive NUEopt, Nopt, and provide decision-support information towards N recommendations.

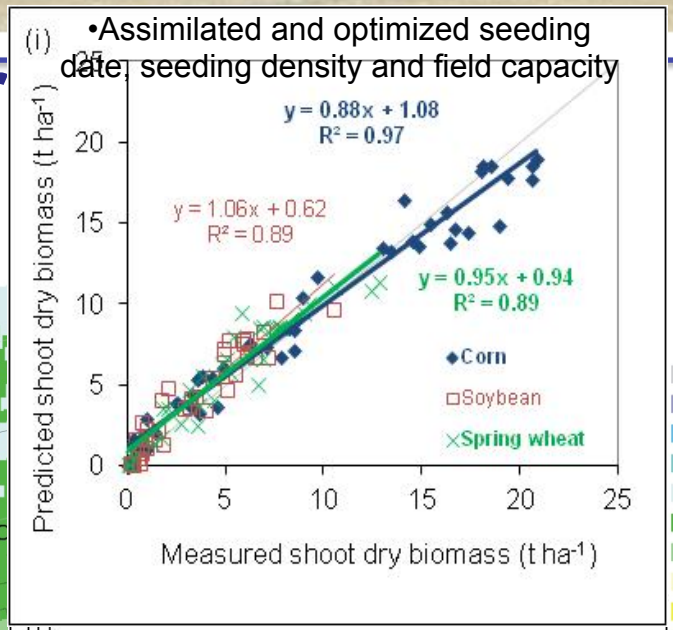
LAI assimilation in STICS crop model for yield predictions of field crops

(Jégo et al., 2015)

All-LAI

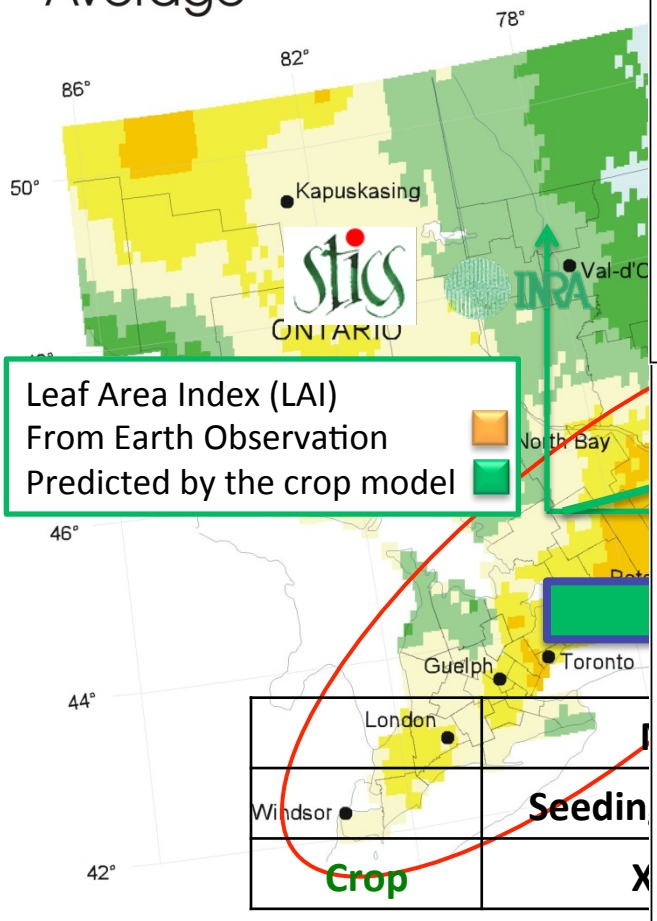
Earth Observation data:
vegetation index MTVI2 (EVI2)

•Assimilated and optimized seeding date, seeding density and field capacity



growing time

Average



Legend for:
Average, Median and 90th Percentile

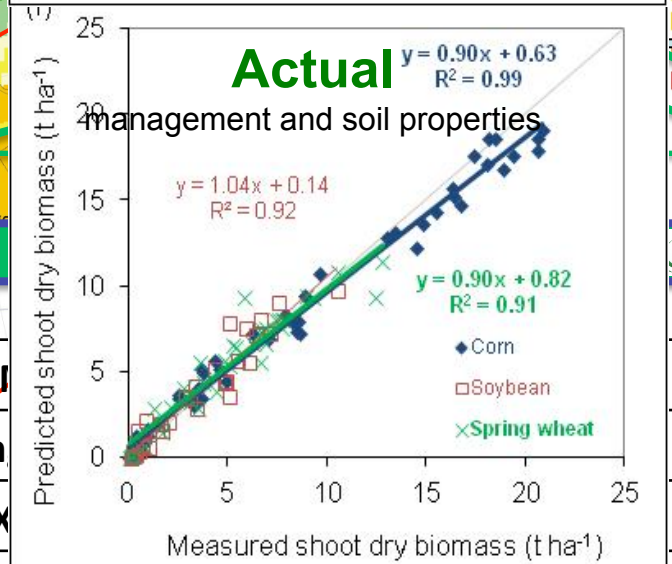
(mm)

- < −200
- −200 to −150
- −150 to −100
- −100 to −50
- −50 to 0
- 0 to 50
- 50 to 100
- 100 to 150
- 150 to 200
- 200 to 250
- > 300

Leaf Area Index (LAI)
From Earth Observation
Predicted by the crop model

Actual

management and soil properties



Minimization

Re-initialization

Crop	Seedin
	X

Soil properties
moisture at field capacity
X

BOREAS take home message

- This is not only about scientific achievements
- This about human synergy

Sorry, I did not ask permission for using pics ☺

BOREAS and the human factor still connected

Still no permission asked for using this pic… ☺

...the ones we keep in our heart

I cannot ask permission any more... ☹

Gerry St-Amour

Paul Jarvis

and my SO, William, who passed away between IFC 1 & 2 in 1994

Thank you !

For information: Elizabeth.Pattey@agr.gc.ca