Biomass burning, intensive agriculture, atmospheric emissions and carbon accumulation in the Colombian Orinoco River Basin

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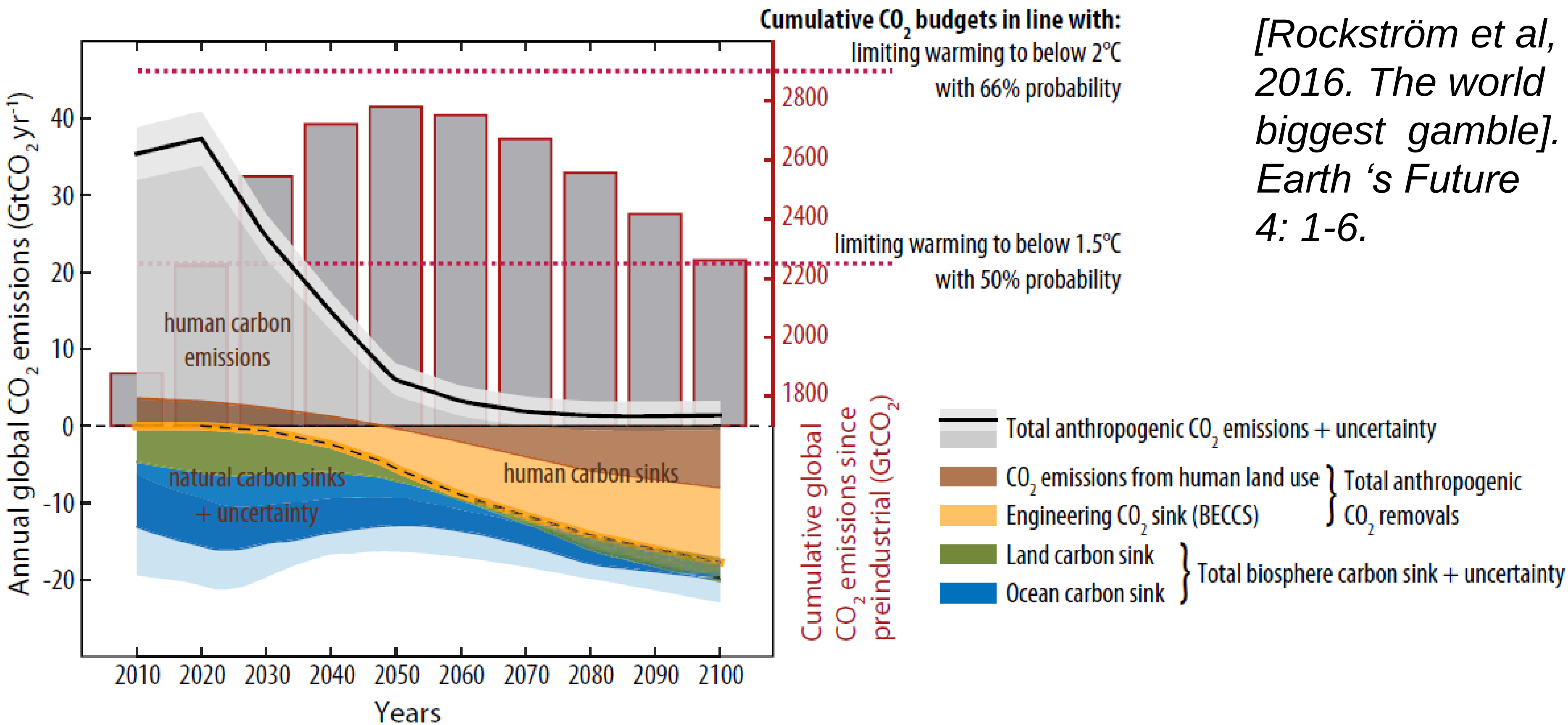
Symposium
Conceptual Design of an Ecological Observatory System for Colombia
Universidad Nacional de Colombia – Medellin, November 22, 2016

Outline

- The **need for a global zero-carbon (C) roadmap**
- Agriculture, forestry and other land use (AFOLU) **greenhouse gas (GHG) sources and sinks in Colombia**
- **Agriculture in the Orinoco River Basin High Plains**
- **GHG emissions and C accumulation due to intensive agriculture** (with conservation practices)
- Atmospheric impacts of **biomass burning**
- Conclusions and perspectives

Need for a zero-C roadmap



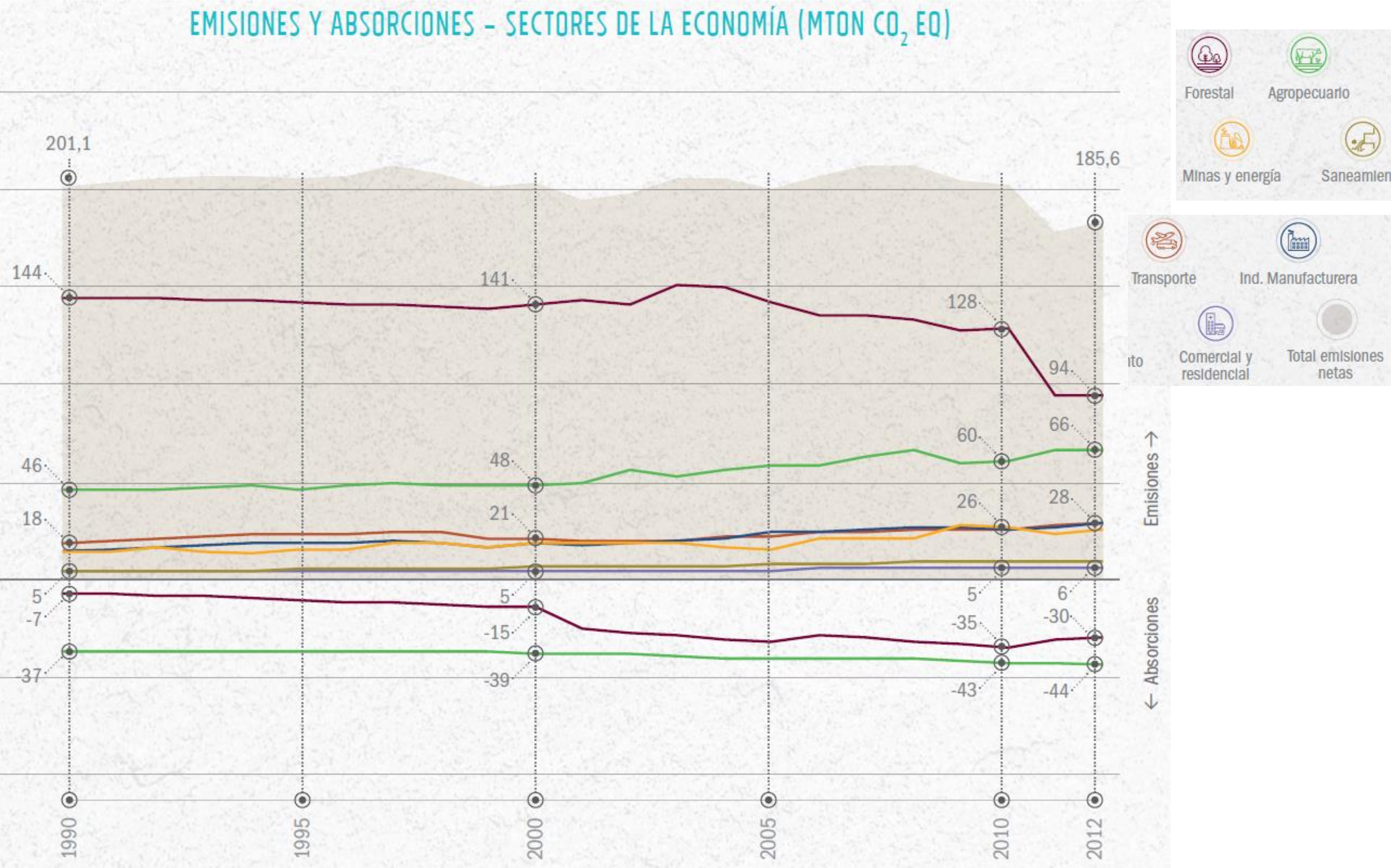
[Rockström et al, 2016. The world biggest gamble]. Earth 's Future 4: 1-6.

- Limiting warming to 2 °C requires **emission peak @ 2020 + full decarbonization @ 2050 + negative emissions > 2050**

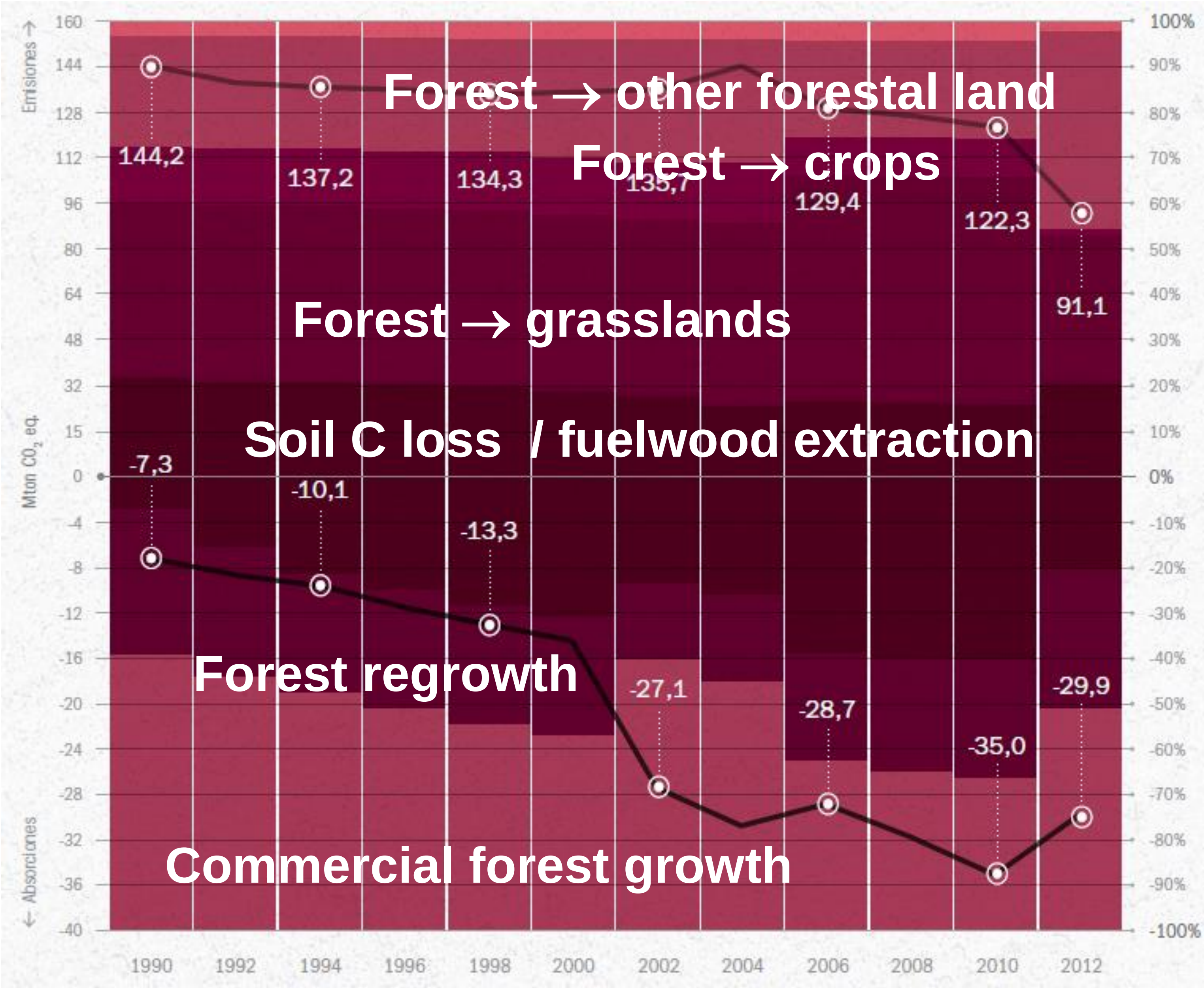
Need for a zero-C roadmap

- Nations will bust remaining C budget (~400 GtCO2 for $\Delta T \cong 1.5$ ℃) $\rightarrow$ **~10 more y @ current ~40 GtCO2 !**
- Current contributions $\rightarrow \Delta T = 2.9 - 3.4$ ℃ (1σ) by 2100
- **Resilience of natural C sinks probably deteriorating** $\rightarrow$ some may cross tipping points
- Require reduction of CO2 (long term) and SLCF (CH4, HFC, aerosols – BC, NO3)
- Negative emission technologies (NET): **biosphere C uptake $\leftarrow$ land management practices**, C capture and storage (CCS), **bioenergy with CCS** (BECCS comparable to ocean sink!)
- **Ecosystem restoration / resilience must be on top of agenda $\rightarrow$ ensure ecosystem services** (includes reforestation, afforestation C farming)

GHG sources and sinks in Colombia

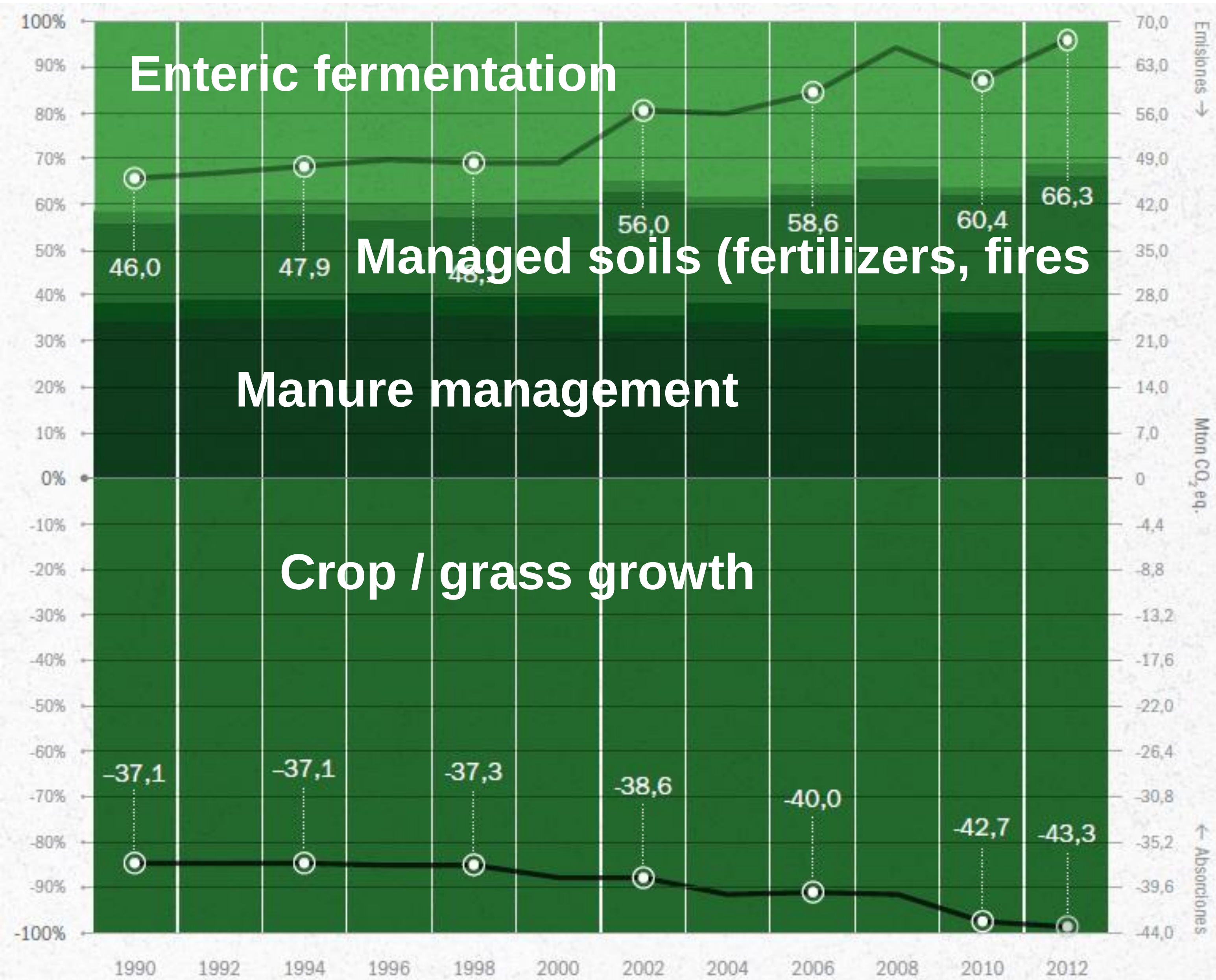


GHG sources and sinks – Forest sector



[Pulido et al, 2016. Inventario nacional y departamental de gases de efecto invernadero]

GHG sources and sinks – Agriculture



[Pulido et al, 2016. Inventario nacional y departamental de gases de efecto invernadero]

Drivers, project motivation

- Drivers: population increase, per capita income increase → increasing demand for food and feedstocks →
- Land use changes @ 2050: **136 Mha will be incorporated to agriculture in Latin America** and Africa; 64 Mha will be abandoned in developed countries → net 72 Mha
- Motivation question: **How would GHG fluxes and air quality change in the Orinoco River High Plains are "fully" transformed into intensive agriculture** (e.g. as happened in the Cauca River Valley?)
- Colciencias funded project *"Atmos. emissions and impact on air quality associated to land use change and intensive agriculture in the Colombian Orinoquia"*
- 2 Fulbright grants, 1 USDA grant, 2 USAID grants

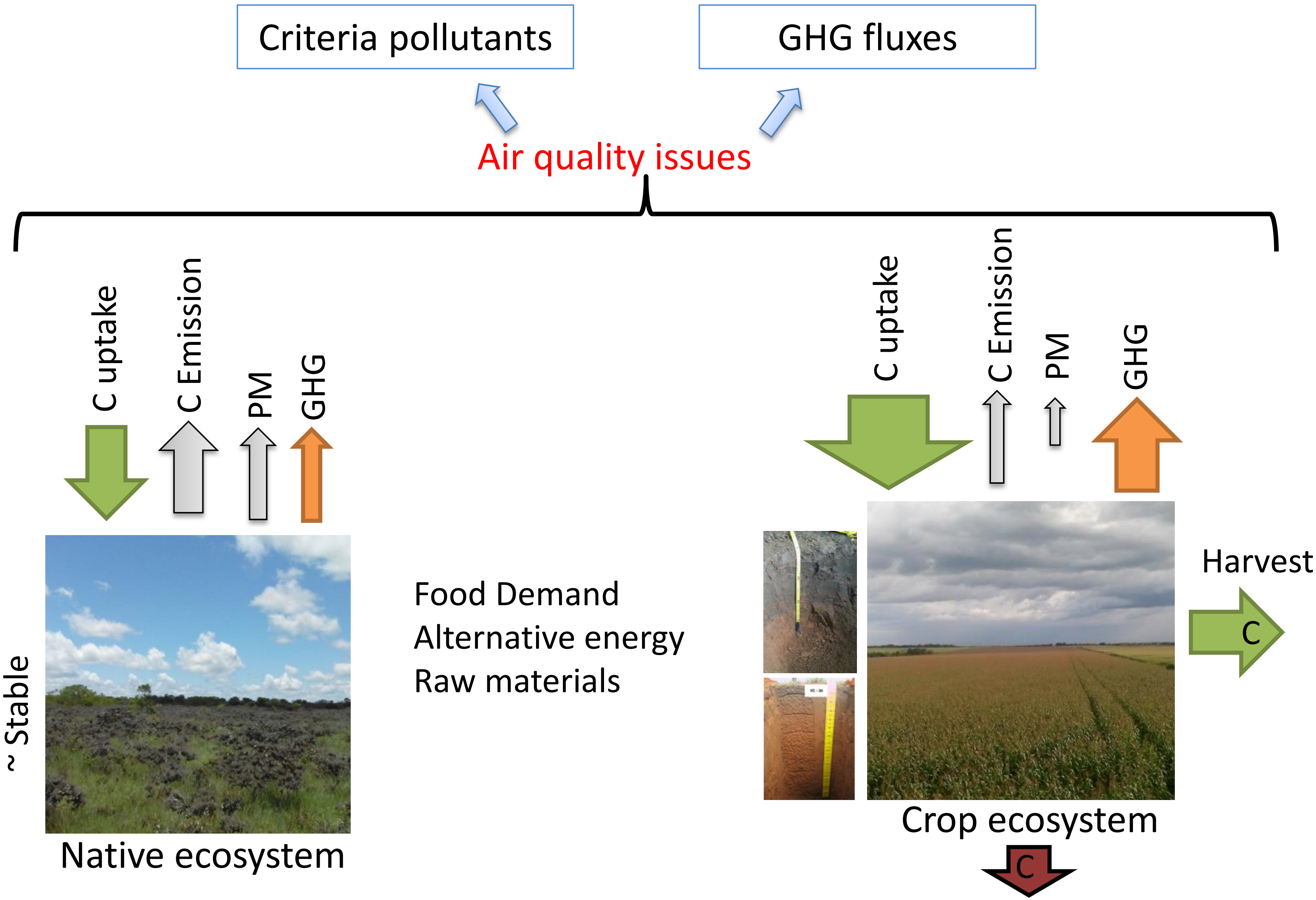
Orinoco River Basin

High Plains ~9.8 Mha (40%)
Agribusiness Area ~2.8 Mha
Agricultural Area ~1.2 Mha
Current Agr. Area ~ 0.4 Mha
Colombian agricultural area is 7 Mha.

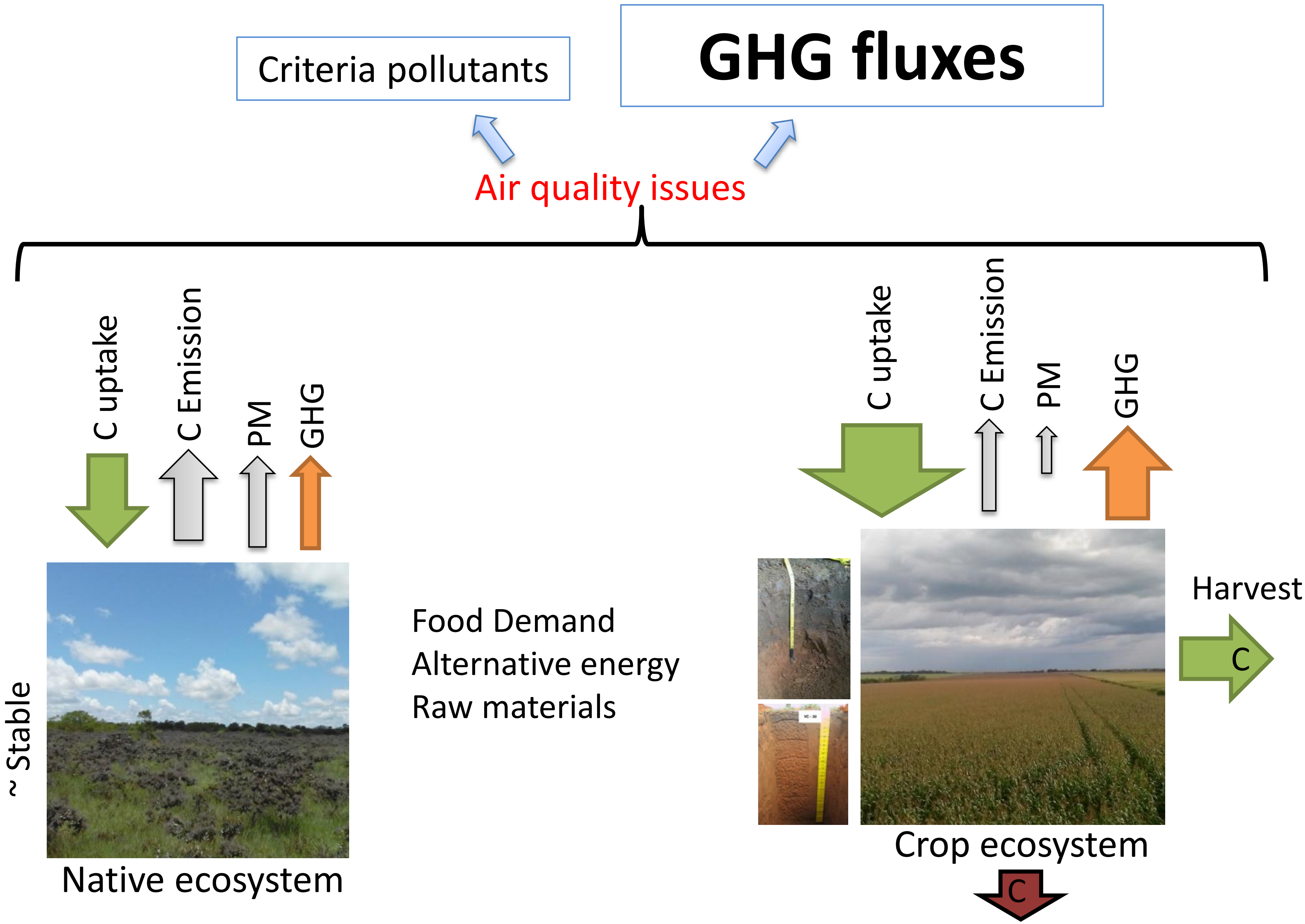
COLOMBIAN ORINOCO REGION: ~35

Cattle grazing	• ~**9.7 M ha** (Viloria, 2009)
Agriculture	• **~450.000 ha** (Ministerio de Agricultura y Desarrollo Rural, 2013)
Oil production	• **73% of national production** (Agencia Nacional de Hidrocarburos, 2014)

Land use and land use change impacts



Land use and land use change impacts



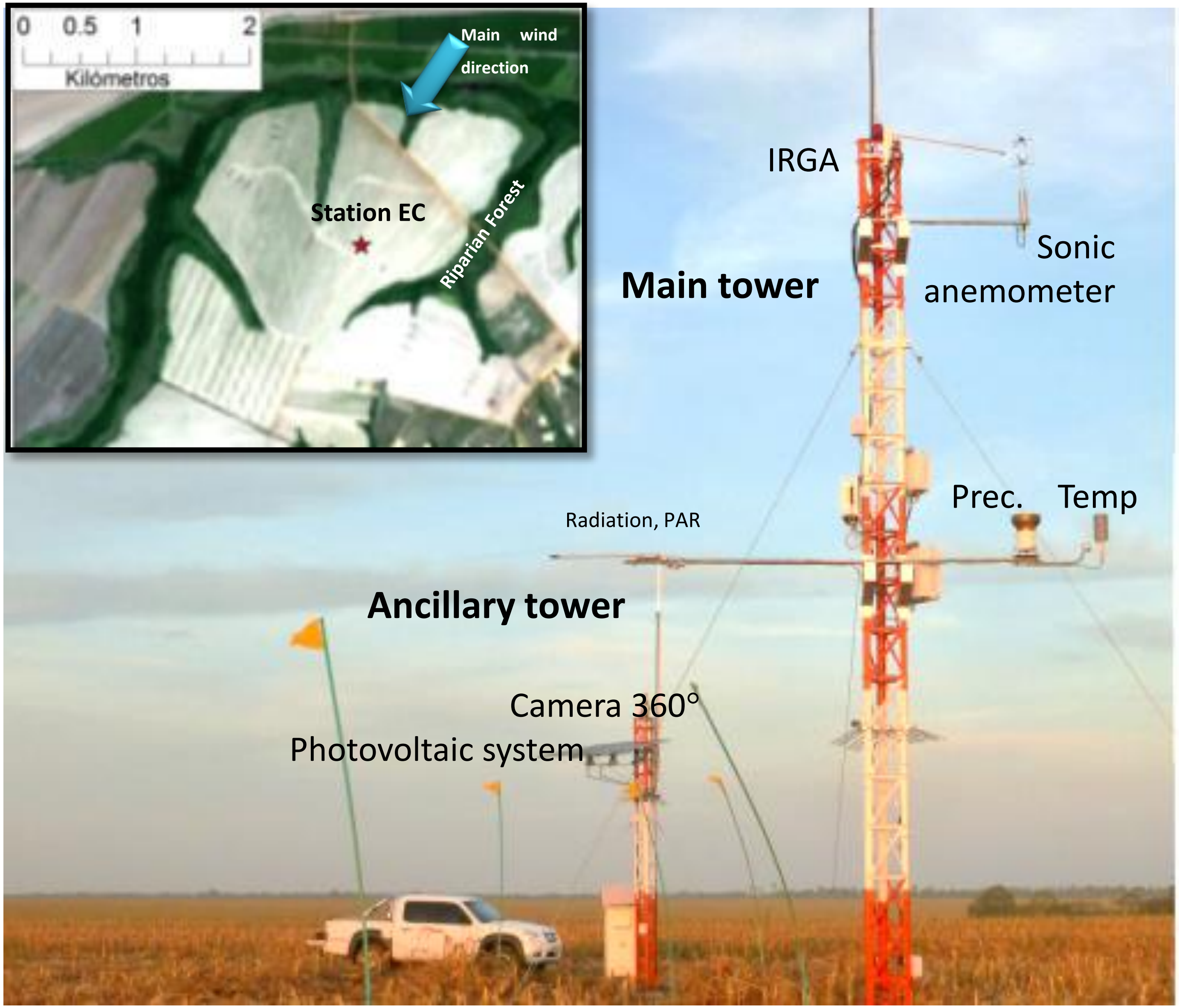
Work hypothesis

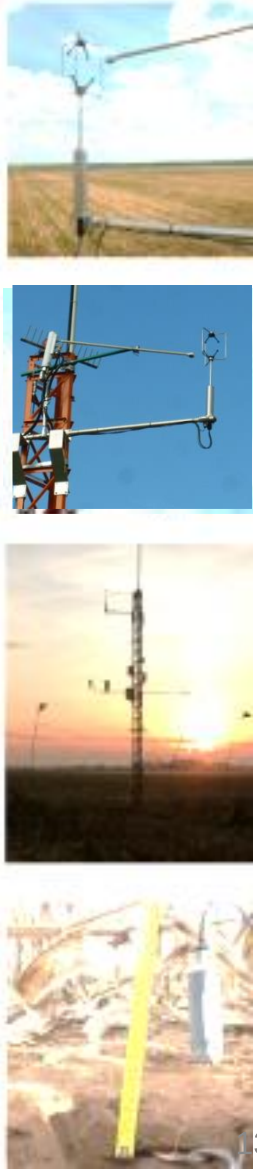
Due to the relative low above ground biomass in the savanna ecosystem and the high efficiency of tropical crops, the land use change in this type of savanna could convert it from a small C sink to a important C sink if conservation agricultural practices are applied, and the burned area will decrease due to the management soil

Native Savanna
experimental station – Taluma, Meta.

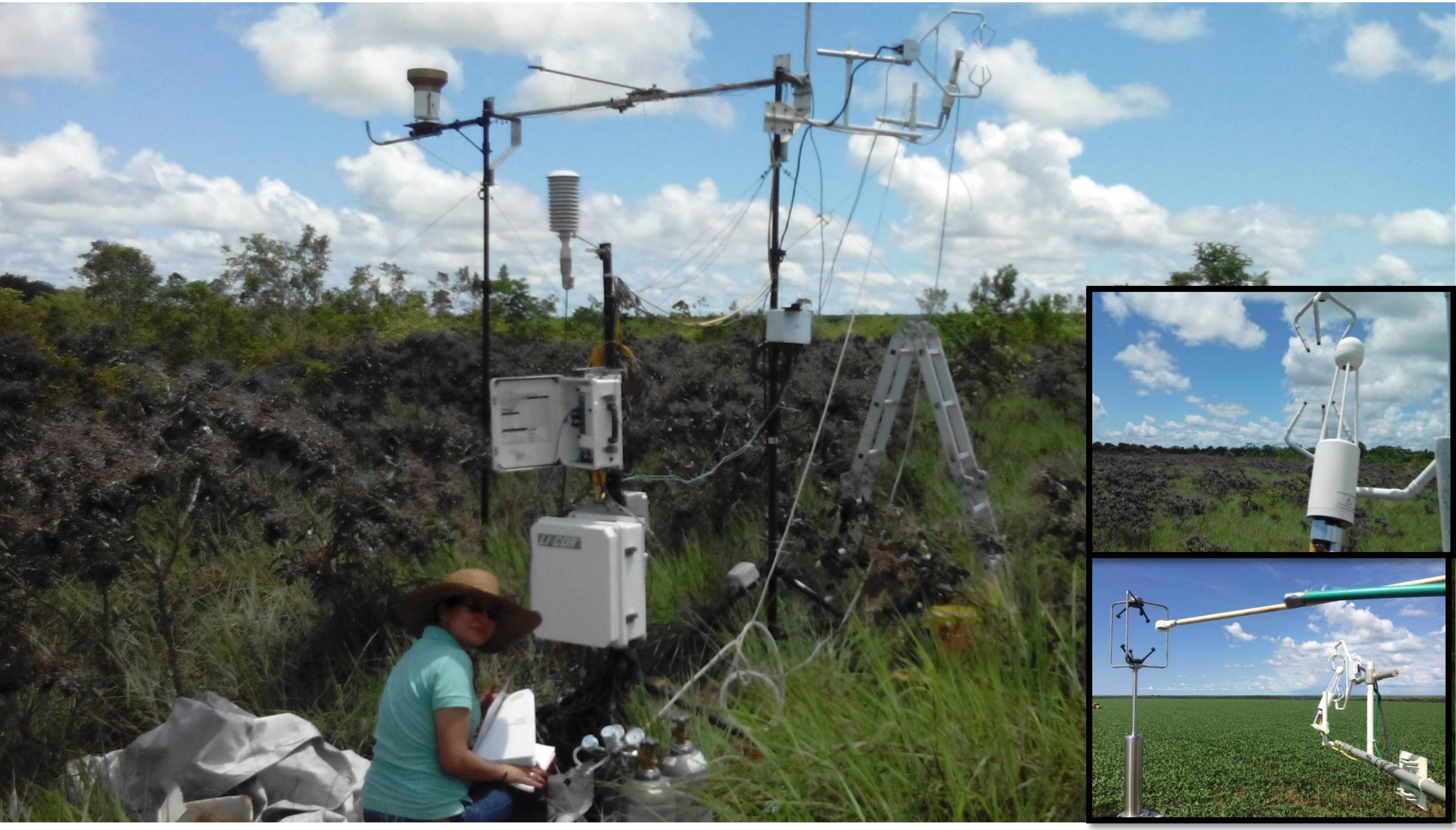
Agriculture plot with different practices – Puerto Lopez, Meta.

Eddy covariance C fluxes at the crop site

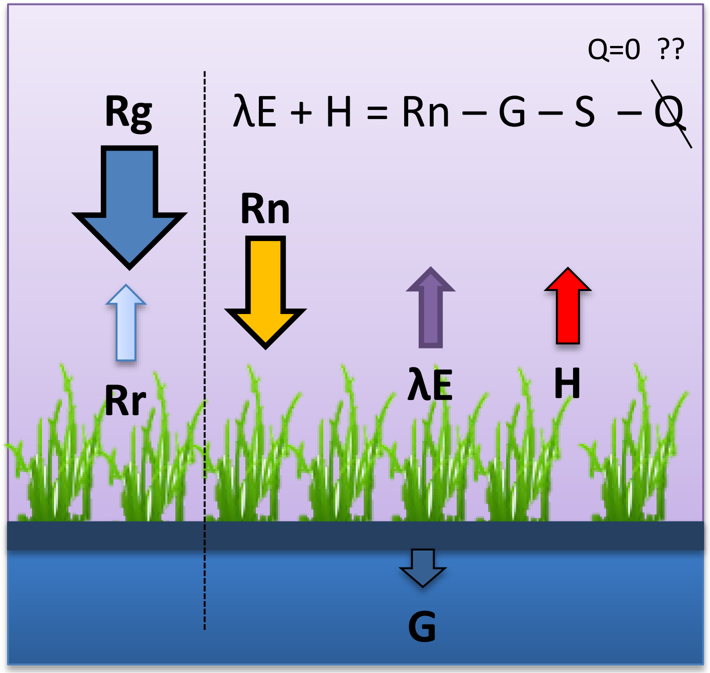




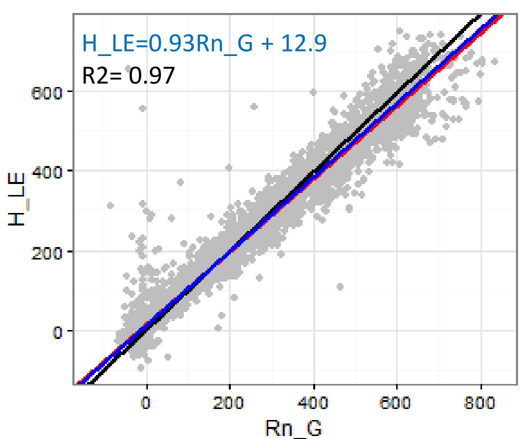
Eddy covariance C fluxes at the native savanna site



EC measurements QA/QC → intercomparison / energy balance



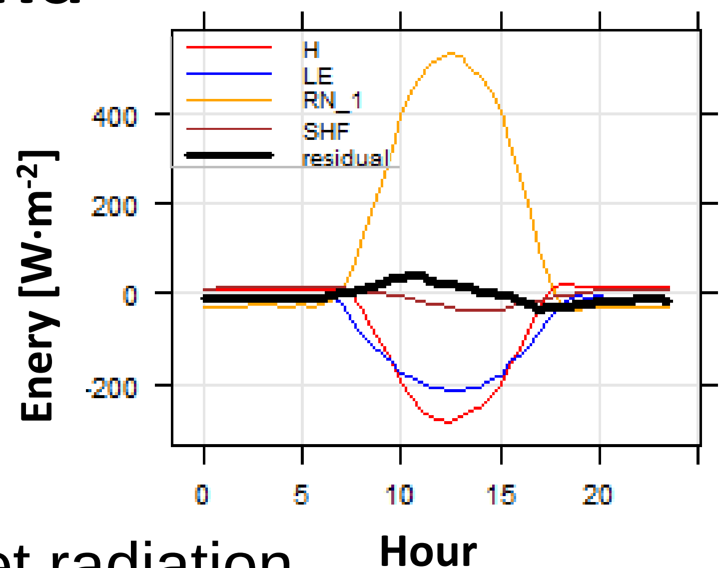
(Wilson et al., 2002)



$$Res = R_n - H - \lambda E - G$$

(T. Foken et al., 2006)

Savanna



Rn: Net radiation

H: Sensible heat flux

λE: Latent heat flux

G: Soil heat flux

S: Photosyntesis energy

Q: Stored energy

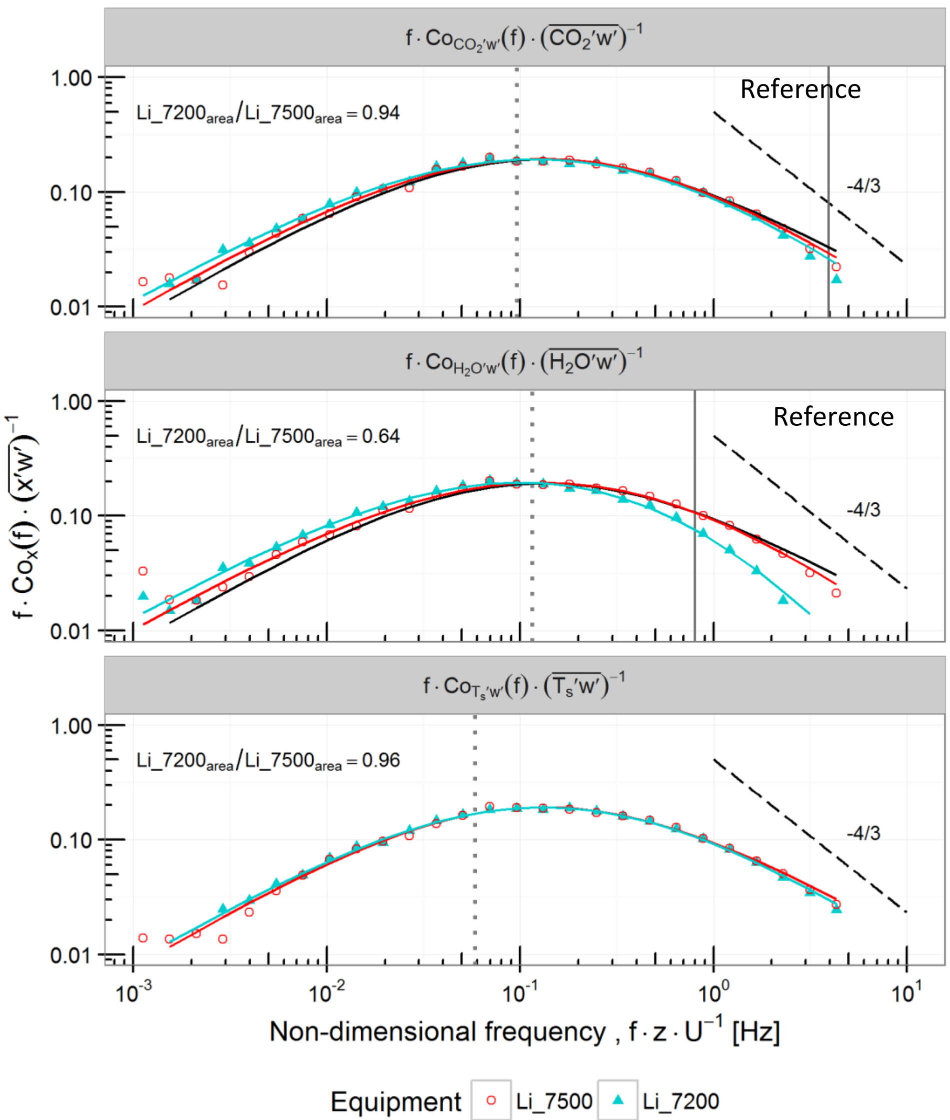
Intercomparison → cross validation

Data analysis period:

2015-08-09 / 2015-10-18

We compared both systems at crop site before starting measurement over the savanna site

Intercomparison → cross validation



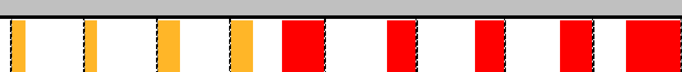
- Corrected w' are highly comparable (open path – enclosed path)
- Upon correction, resulting CO2 fluxes are highly comparable
- **The enclosed path system has a strong attenuation for water vapor fluxes despite the short intake tube (tube length and cap play role)**
- However using an appropriate correction, the under estimation was only ~4%.

C fluxes at the crop site (preliminary)

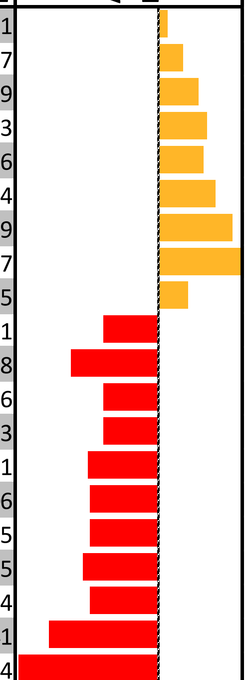
Daily average fluxes [kg C-CO_2·ha^{-1}·day^{-1}], monthly [kg C-CO_2·ha^{-1}·$month^{-1}$] and total [kg C-CO_2·ha^{-1}] of carbon, La Fazenda station.

Mes	Residuos de maíz	Maleza	Preparación suelo	Maleza 2	Maíz	Residuos de maíz2	Siembra	Brachiaria	Soya*	Dias del mes	total mensual	Acumulado del periodo
14-dic	23.44									14	328	328.21
15-ene	20.28									31	629	956.77
15-feb	20.36									28	570	1526.9
15-mar	9.809	13.27								15/16	359	1886.3
15-abr		-3.69								30	-111	1775.6
15-may		-49	29.37							6/26	470	2245.4
15-jun			41.59	13.27						10/21	694	2939.9
15-jul				-3.69	13.47805					3/29	380	3319.7
15-ago					-69.6185					31	-2158	1161.5
15-sep					-110.426					30	-3313	-2151
15-oct					-52.1519	14.86				26/6	-1267	-3418
15-nov						37.416	34.967	39.222		9/4/18	1222	-2196
15-dic								0.1018		31	3	-2193
16-ene								-18.321		31	-568	-2761
16-feb								1.8977		29	55	-2706
16-mar								0.3681		31	11	-2695
16-abr								-23.703	48.635	25/6	-301	-2995
16-may									10.03	31	311	-2684
16-jun									-55.202	30	-1656	-4341
16-jul									-54.699	22	-1203	-5544
subtotal cobertura	21	-11	20	1.5	-61	15	10	0	-14	591		
Acumulado por cobertura	1674	-192	1180	267.5	-6436.03	425.9	139.87	-345.72	-2256.7			
Acumulado del periodo	1674	1482	2661	2929	-3507.23	-3081	-2941.5	-3287.2	-5543.9			

Acumulado del periodo



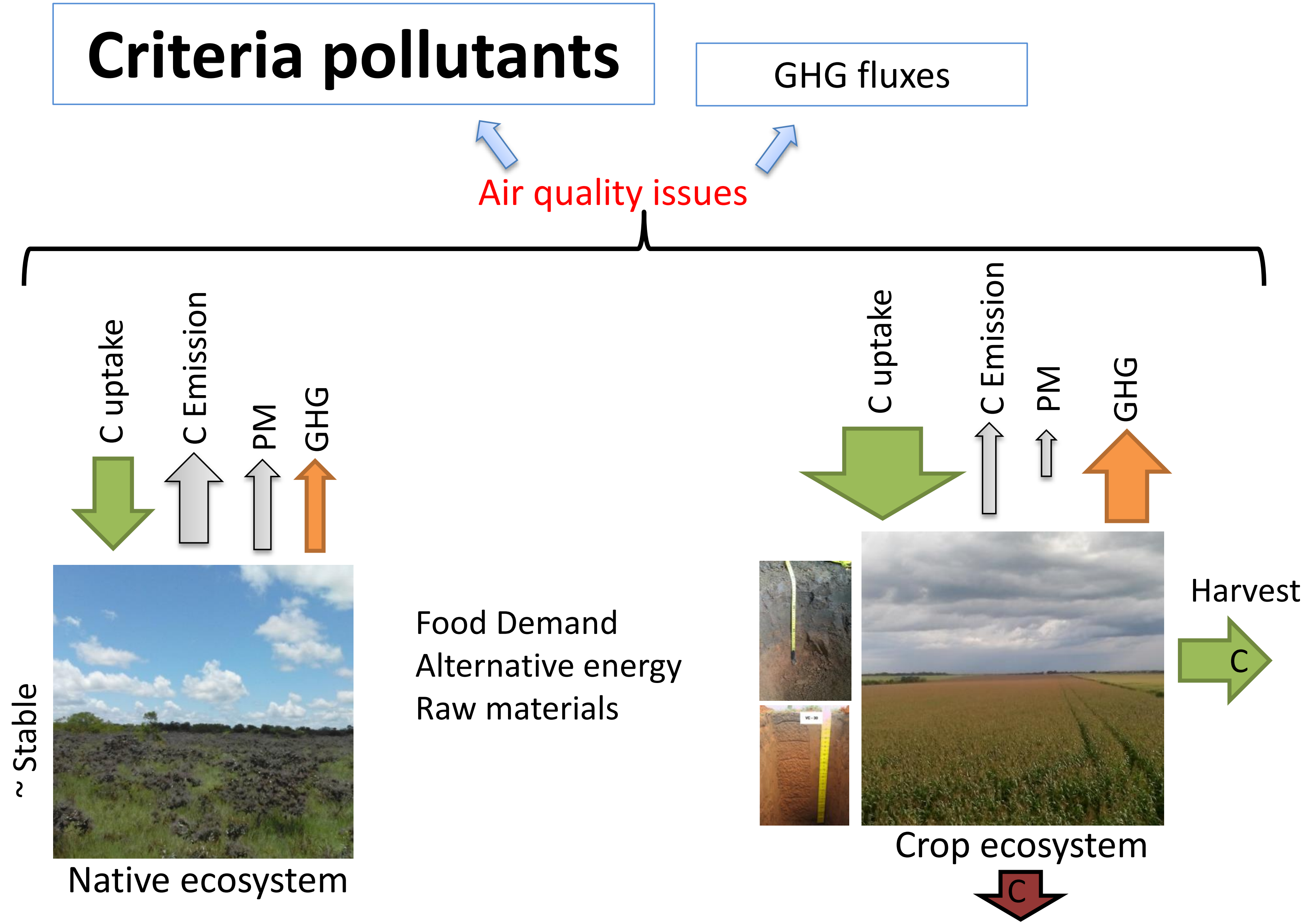
Acumulado del periodo



During this period **~ 5.5 ton C /ha were sequestered**.

The use of *Brachiaria* as a cover crop avoid lossing carbon.

Land use and land use change impacts



Air quality measurement campaign
December 2014 -February 2015

La Libertad

Harvard impactor - PM10 (Cuarzo)

Harvard impactor - PM10 (Teflón)

- Hi-Vol PM10 (Cuarzo)
- Harvard impactor PM10 (Teflón)
- Cascade impactor

Taluma

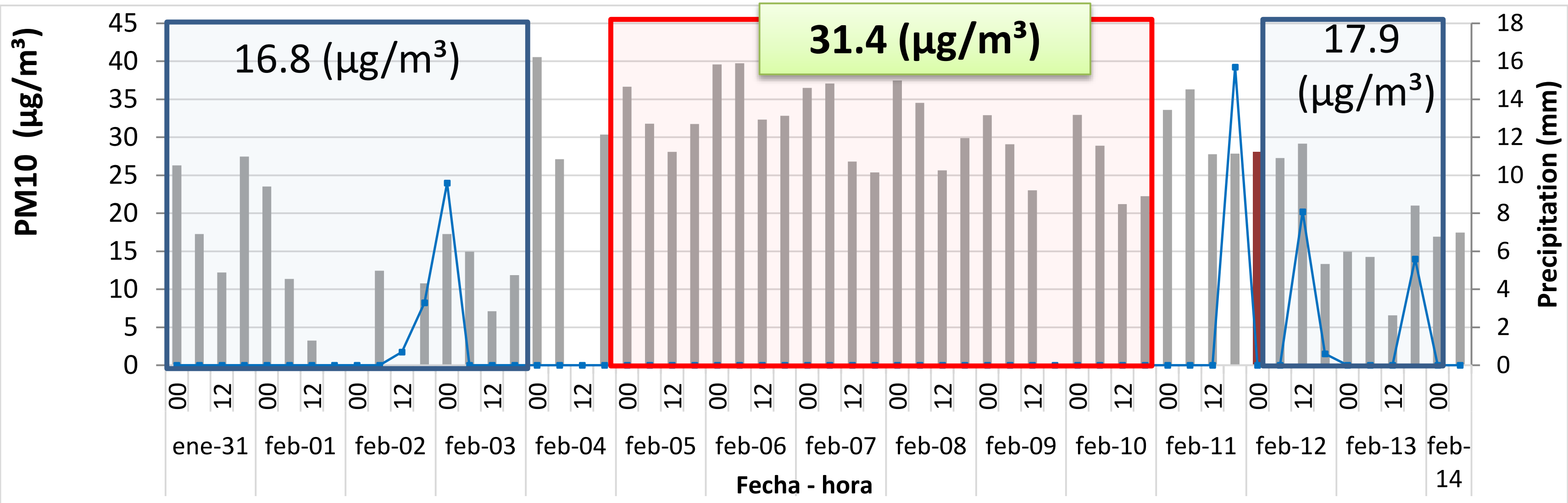
- Weather station
- Automatic sampler PM10

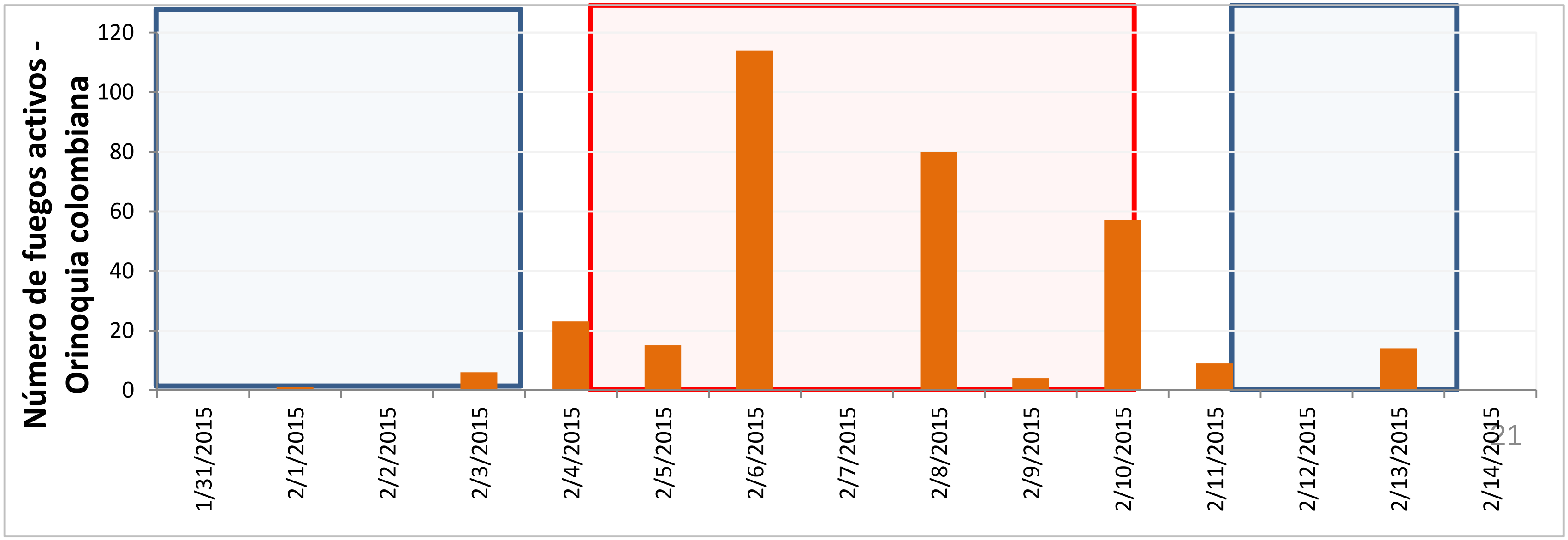
UNAL Arauca

Harvard impactor -PM10 (Cuarzo)

Harvard impactor - PM10 (Teflón)

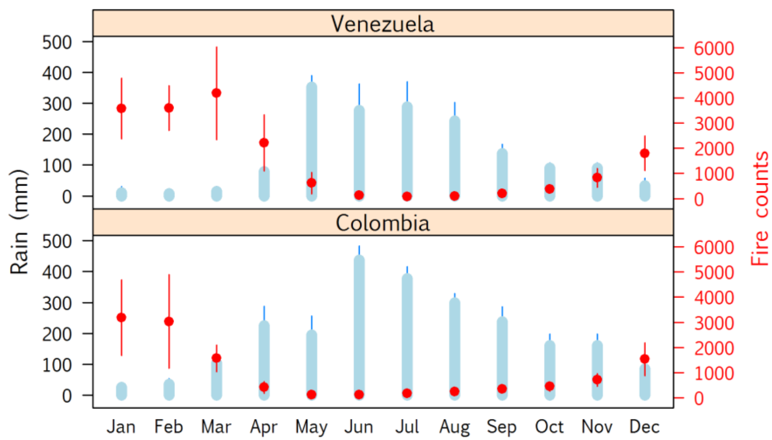
Taluma – February 2014

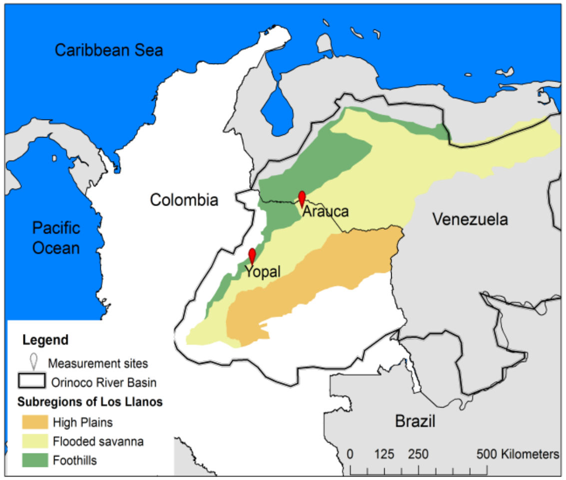




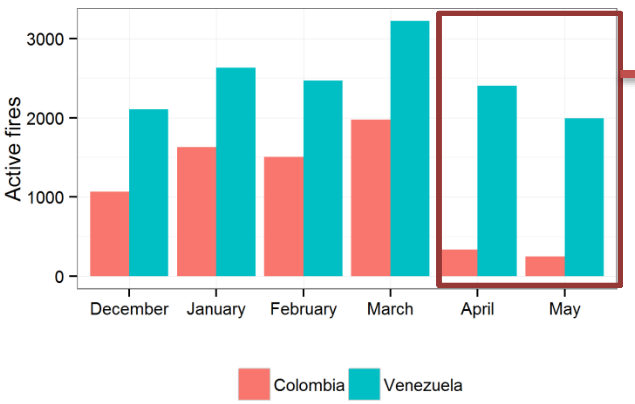
Corporinoquia measurement campaign: Yopal and Arauca April-May 2015

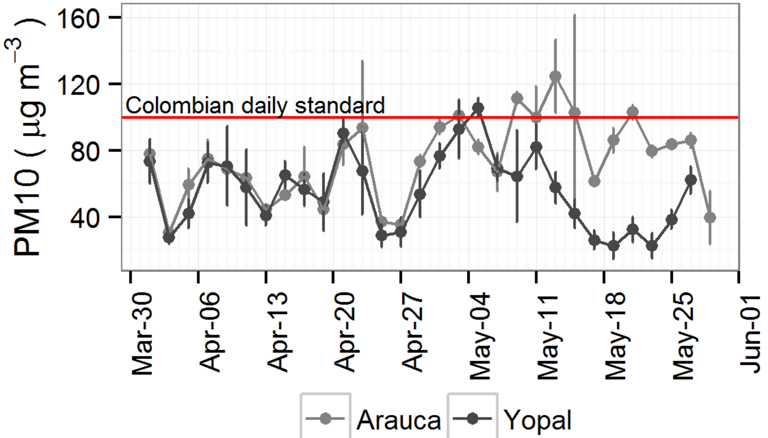
Monthly average rain (CRU data) and average active fires (MCD14 product) from 2001 to 2014



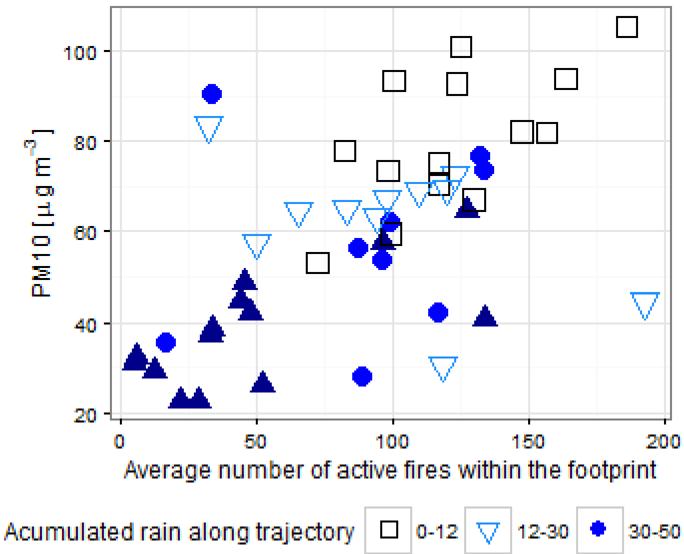


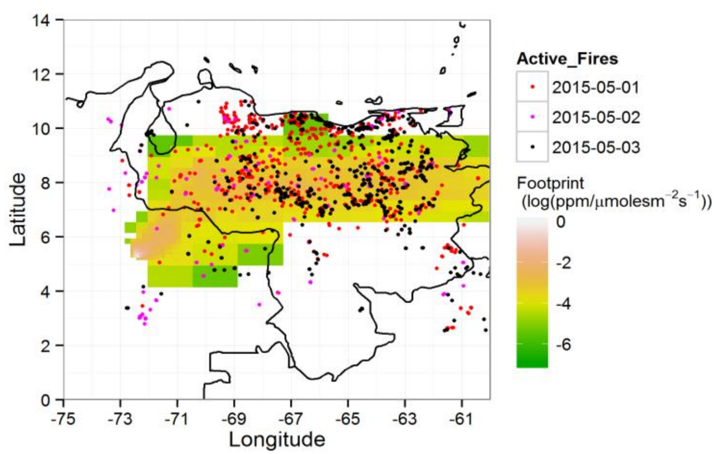
Active fires in Colombian and Venezuelan Llanos during the dry season 2014-2015

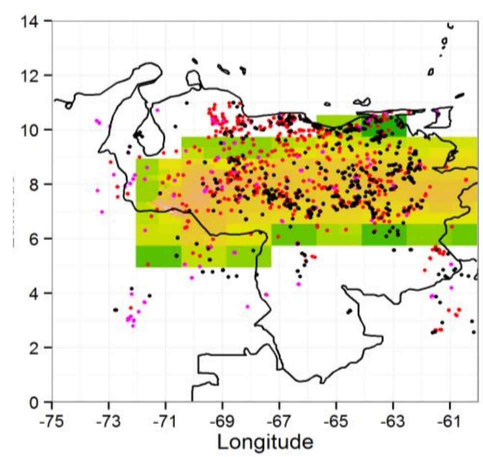




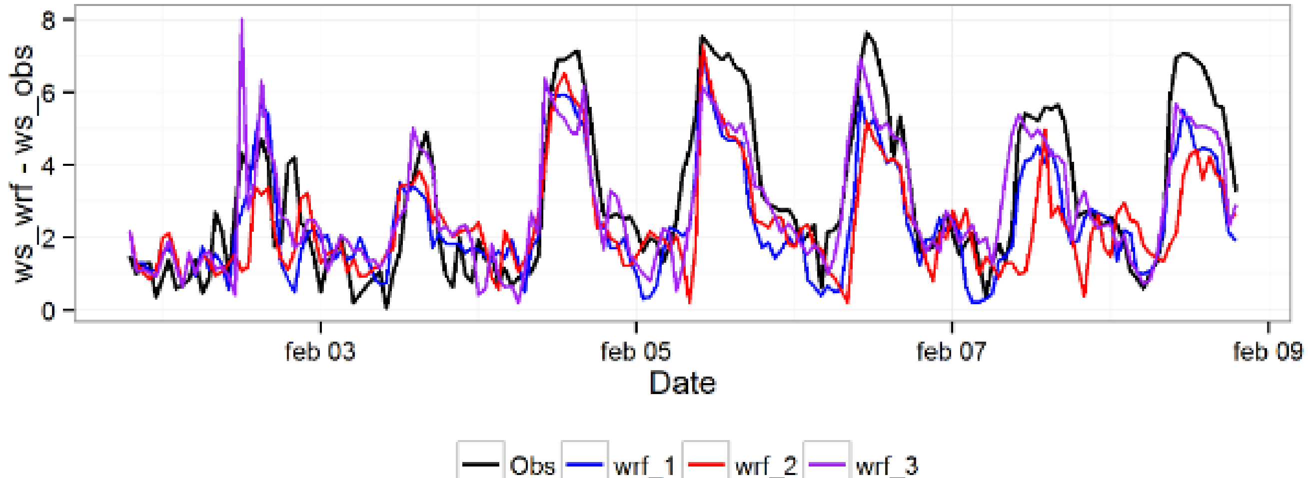
Effects of active fires on PM10 concentrations

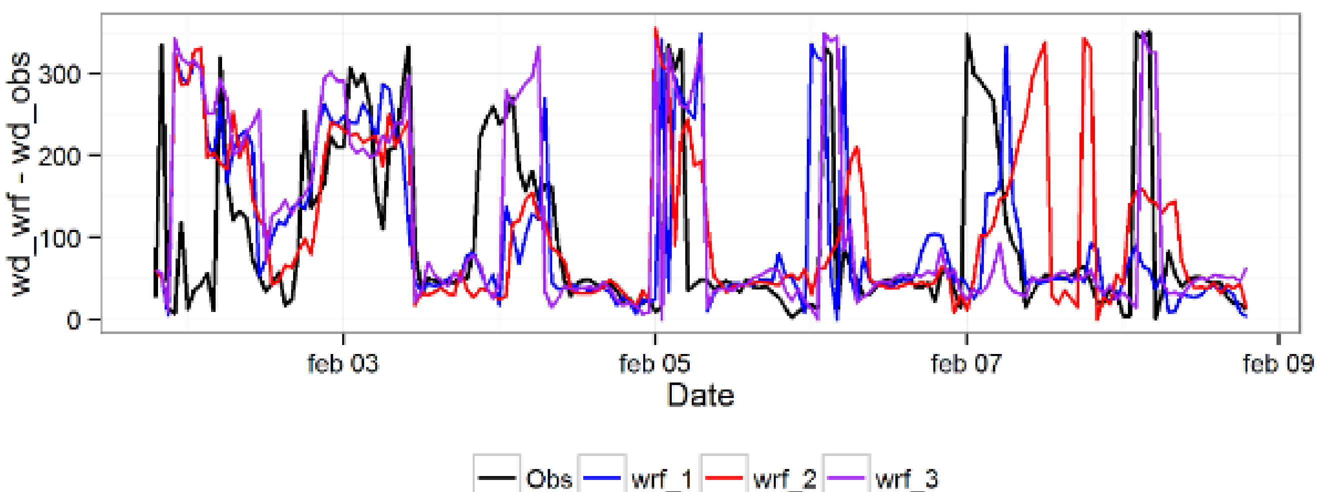






Upcoming: high resolution simulation of aerosol emission, transport and transformation





Short course – Workshop & Colloquium

Advanced methods for estimation and mesurement of GHG fluxes in agricultural and natural ecosystems

Junio 17-23, 2016
Stephen Ogle → Training on DayCent (ecological biogeochemical model)


Thank you!
Questions?