Observational approaches for understanding land cover change impact on surface climate

David Fitzjarrald
Jungle Research Group
Atmospheric Sciences Research Center
University at Albany, SUNY

Land cover property changes

1. Natural (seasonal changes, vegetation phenology)

2. Changes in land use (agricultural, deforestation, reforestation--e.g., eucalyptus)

3. Transient (soil moisture following rainfall)

All influence

- surface energy partition,

- CBL thickness,

- cloud fraction in periods between the exciting weather

- precursor conditions to strong convection.

What do we need observations for anyway?

Over the years, a slow mutation from "ground truth" to "validation"

Remorse: what did you (will you) wish for later?

"Unfortunately we have no good observations and we must only present model results…."

OR (as spoken by a student at a meeting in 1973):

"Let us compare the results of our model with the data and see which is better."

How do you reconcile an intensive (short) field program with an effort to understand climate?

Weather <------------------------------> Climate

Popular solution: find 4-6 similar cases, make a composite, simply assert that this demonstrates the ‘influence’ that mechanism X has on climate?

We seek to deploy a surface sensor array for an intensive observation period in such a way that it can inform the existing network of operational measurements.

We seek to identify the biases that mesoscale & smaller features introduce into even the best point measurements. (example, the semi-mythical ‘vegetation breeze’)

Don’t form grid averages too early in the game.

Only after repeated and exhaustive testing, do we begin to believe some of the remote sensing products. (Using remote sensing ‘data’ should not be an exercise in labeling.
(e.g., soil moisture, soil moisture ‘memory’.)

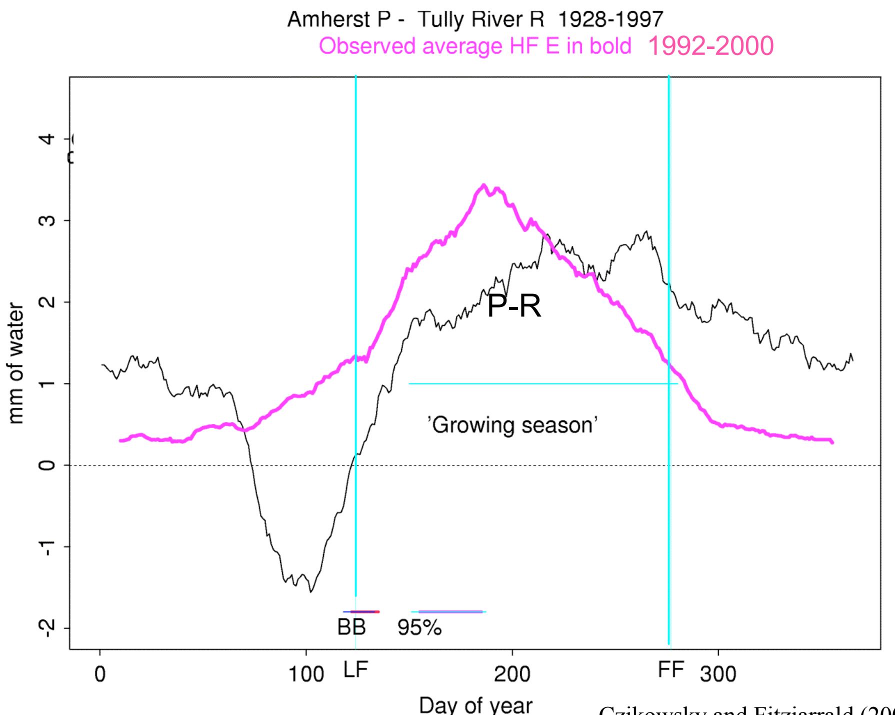
When all else fails to make sense, chuck the data and make your assertions using reanalysis ‘data’ or other model output.

Leaf emergence effects, NE US

Surface water balance:

$$ET = P - R - \Delta S$$

annually $\Delta S \approx 0$

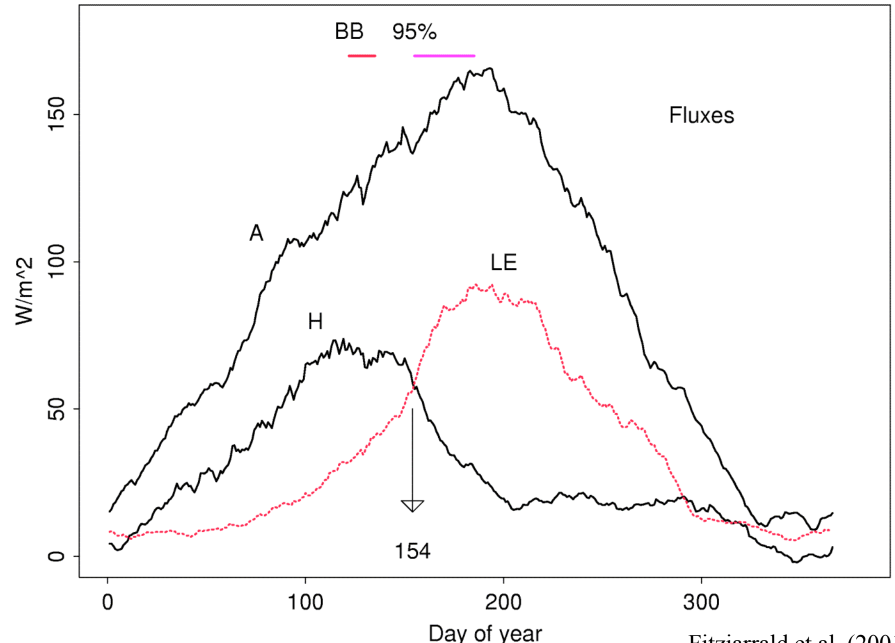


Czikowsky and Fitzjarrald (2004)

Energy balance:

$$A = -(Q^* - G) = H + LE + Adv$$

Upward fluxes are positive

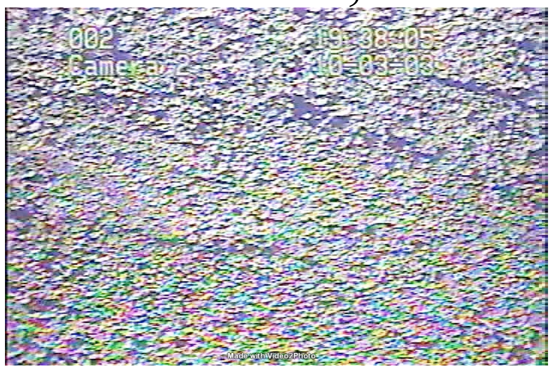


Fitzjarrald et al. (2001)

At HF, long-term annual measured ET (481 mm) is nearly equal to *P-R* estimated ET (483 mm)

So is fall …..

October 3, 2003



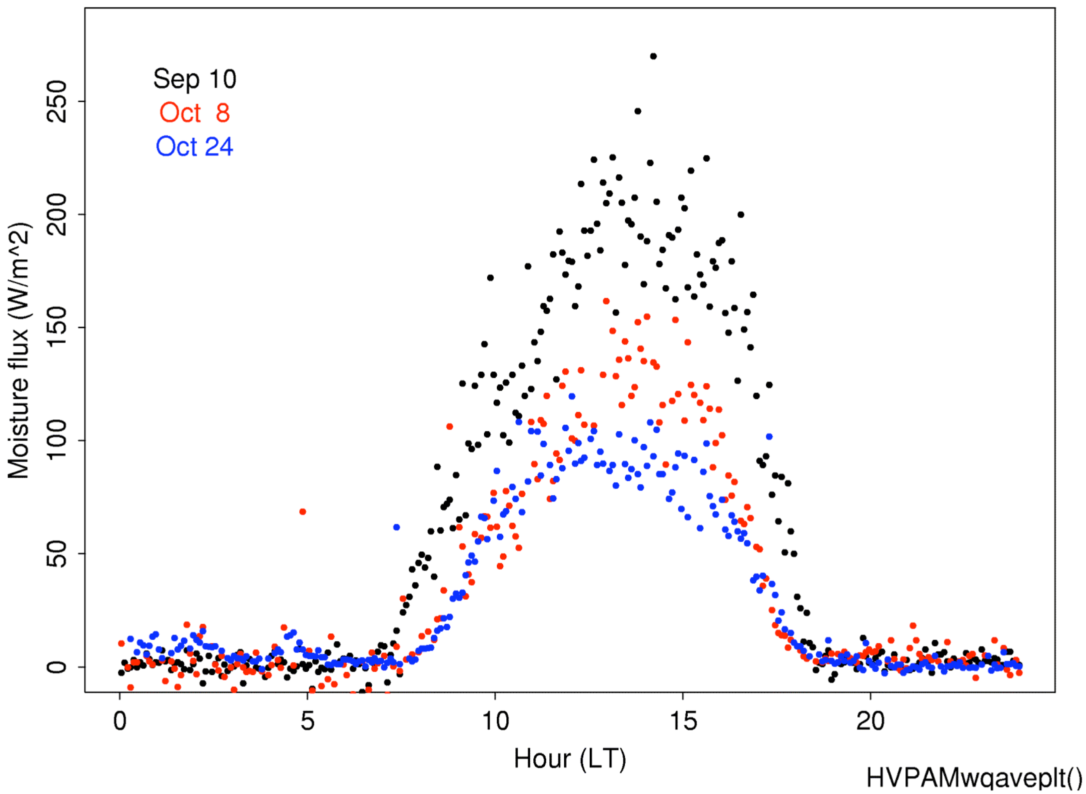
October 11, 2003

October 25, 2003

October 30, 2003

Land cover change (seasonal)

Seasonal changes are nicely 'captured' with the ISSF from NCAR *but are 4-6 weeks sufficient?*



Seasonal changes in H,LE lead to changes in:

* streamflow

(recession times & diurnal component)

*cloud base height ;

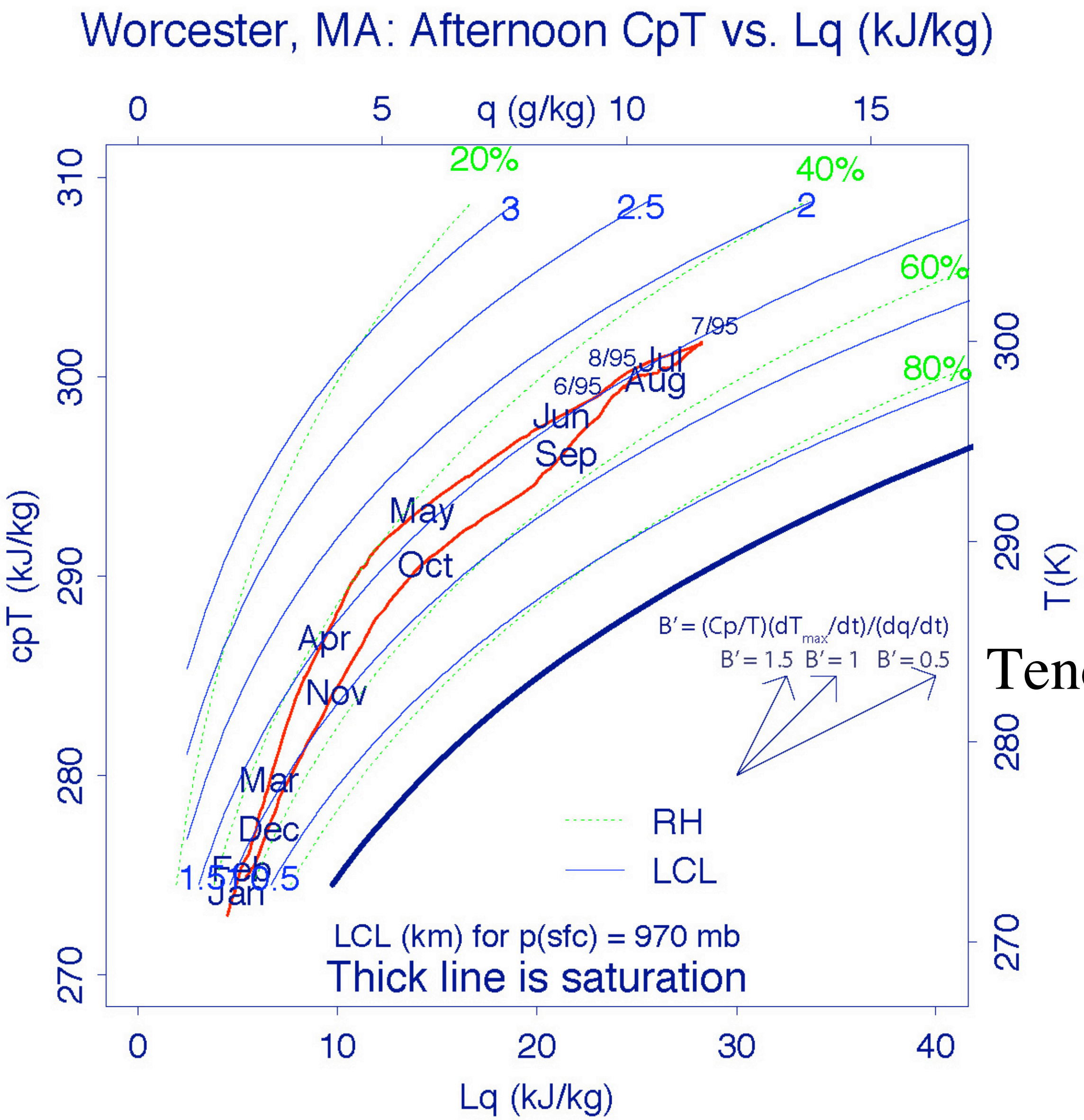
*BL *q*.

What else?

ISSF Station Network Average Evaporation:

Sep 10, Oct 8, and Oct 24, 2003

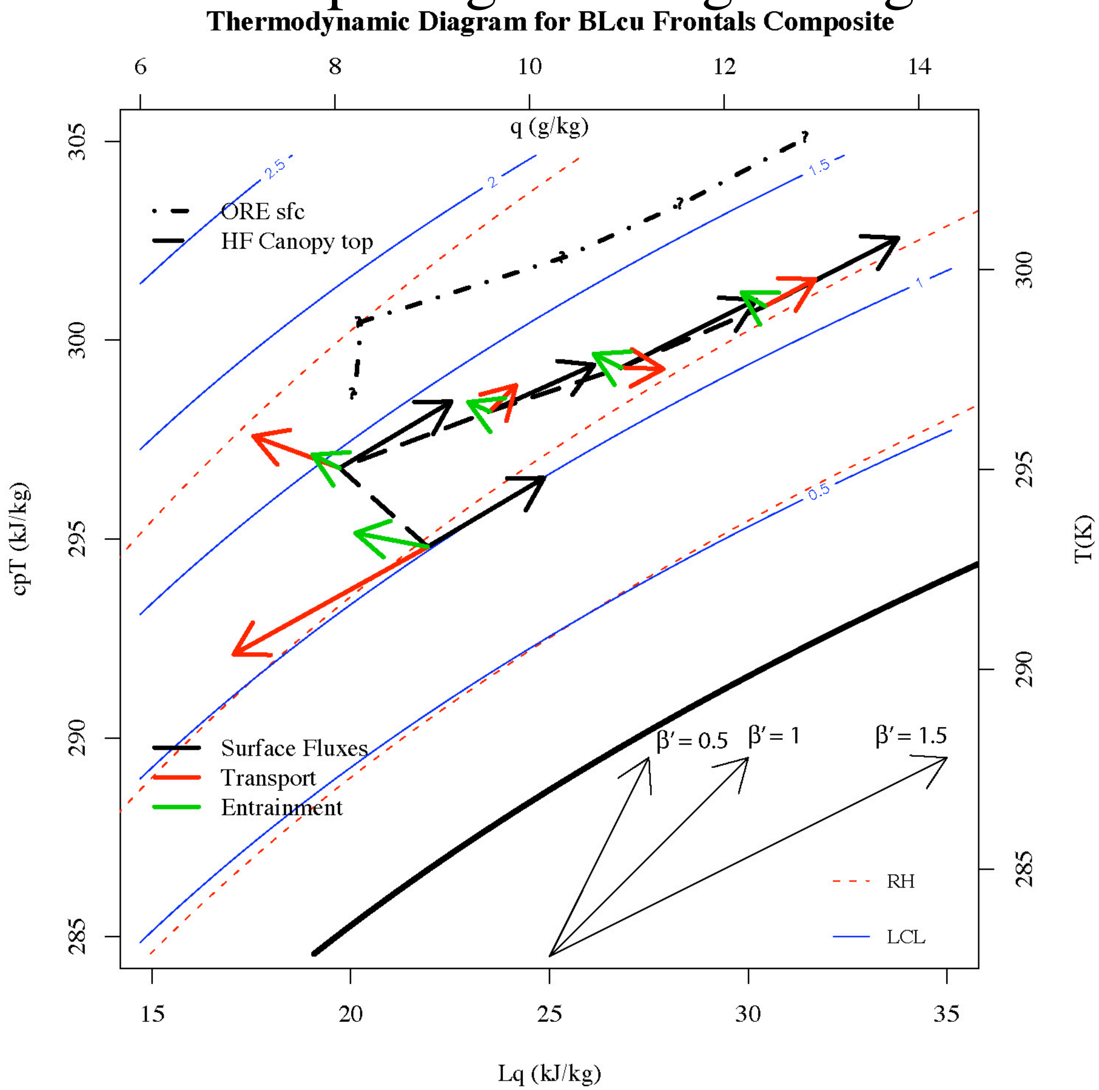
Average of 9 ISSF stations, Hudson valley USA (HVAMS)



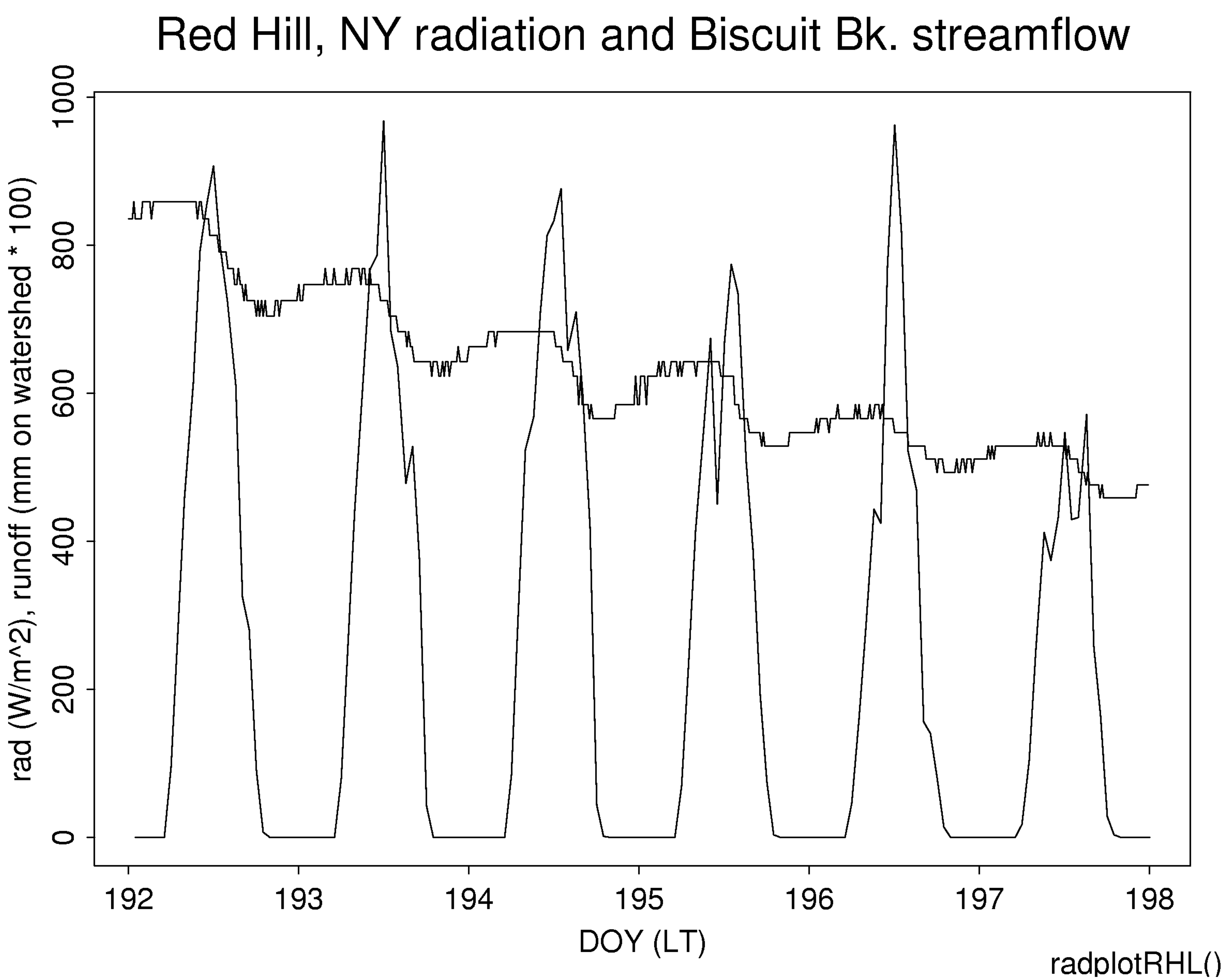
Tendency BR

CLIMATE: we need to link the short term record to what is believed (against all logic), the climate station record.

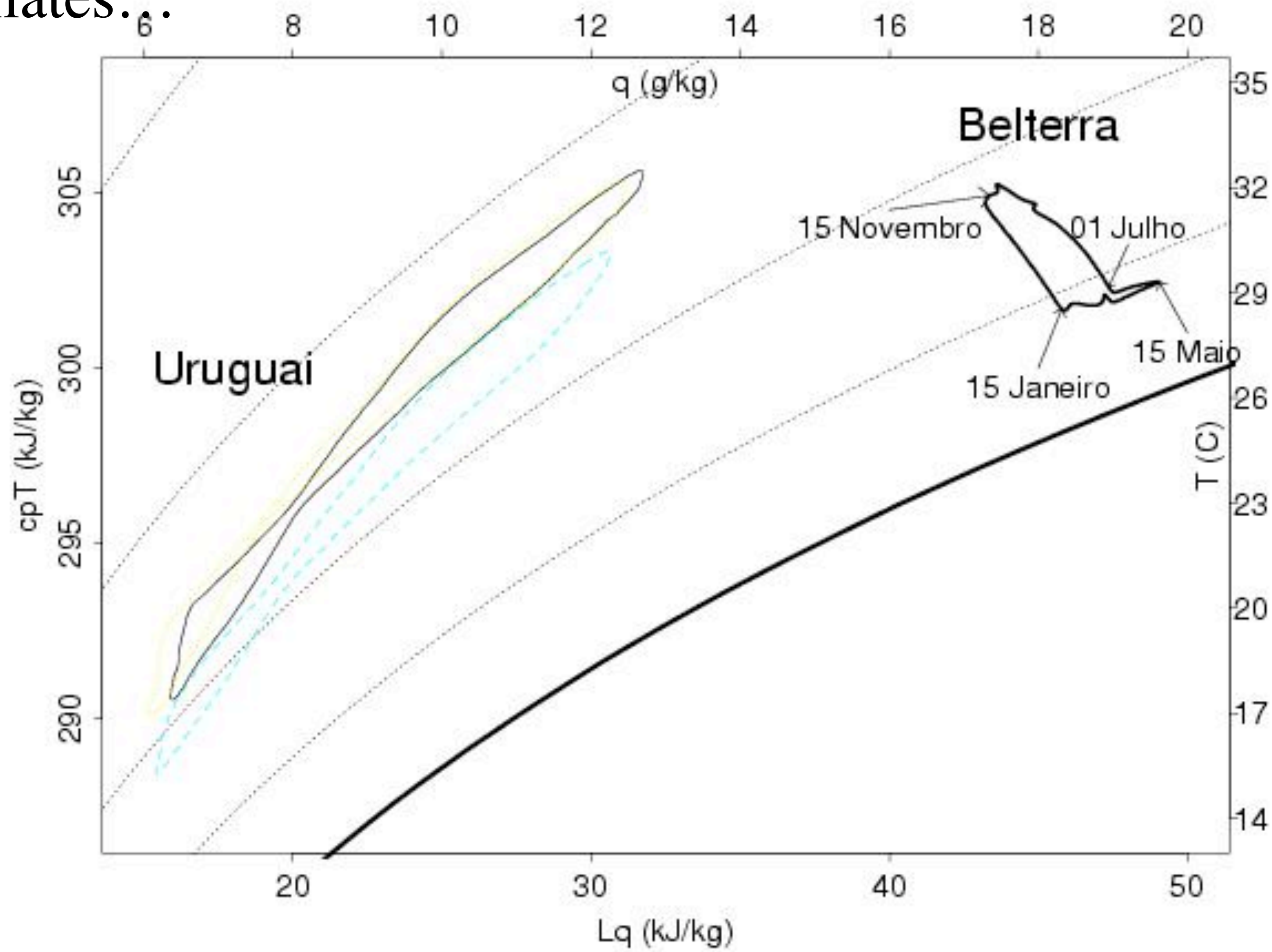
Days after cold frontal passage in the growing season, NE USA



WEATHER (you get part way there using 'synoptic composites')
Boundary layer clouds are defining a sequence of BL equilibria that combine to make 'summer'

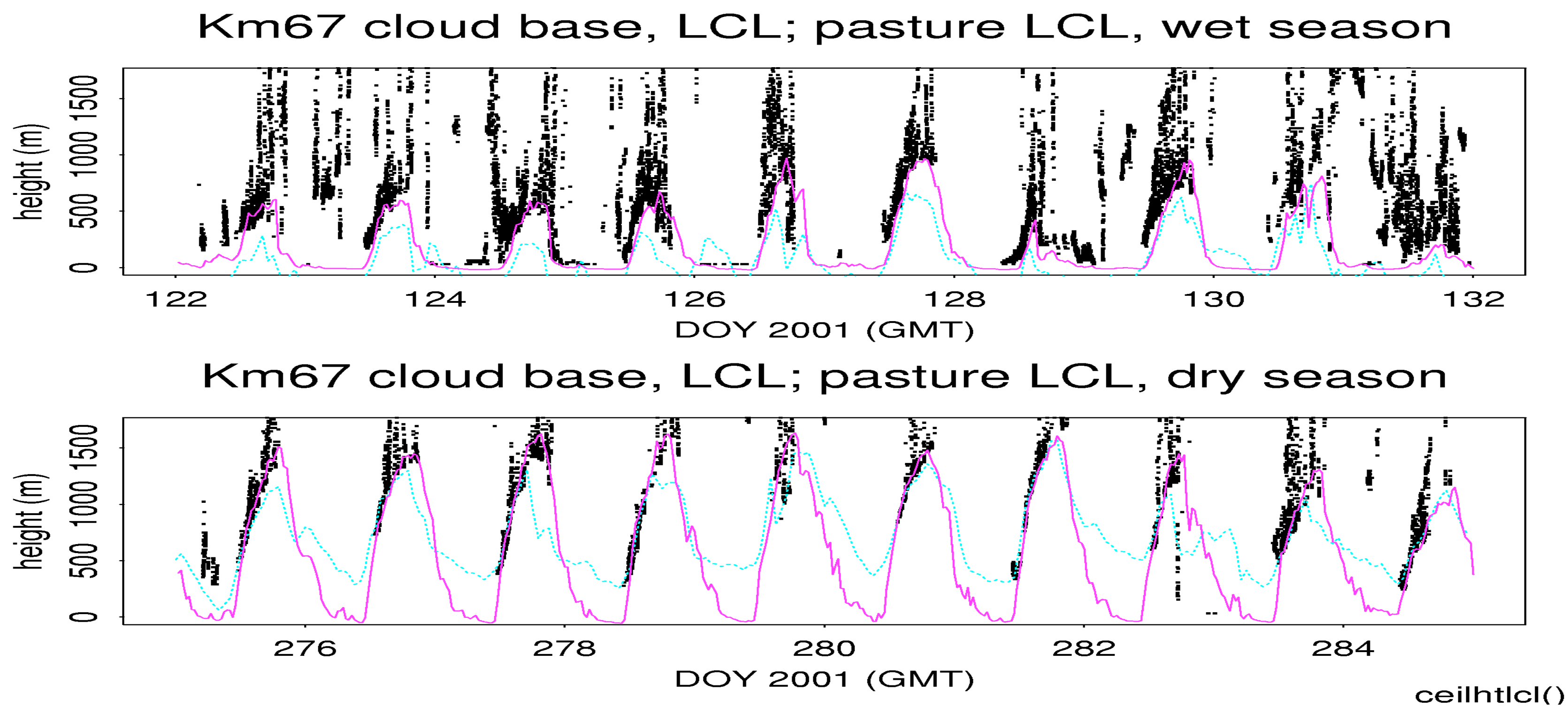

Red Hill, NY radiation and Biscuit Bk. streamflow
rad (W/m^2), runoff (mm on watershed * 100)
0
200
400
600
800
1000
192
193
194
195
196
197
198
DOY (LT)
radplotRHL()

The same signal should be seen in the La Plata basin without the leaf emergence 'kink'. In E. Amazon, you find a dry/wet season couple, and the LCL & cloud base oscillates…



Amazonas case--wet season vs. dry season, ceilometer cloud base.

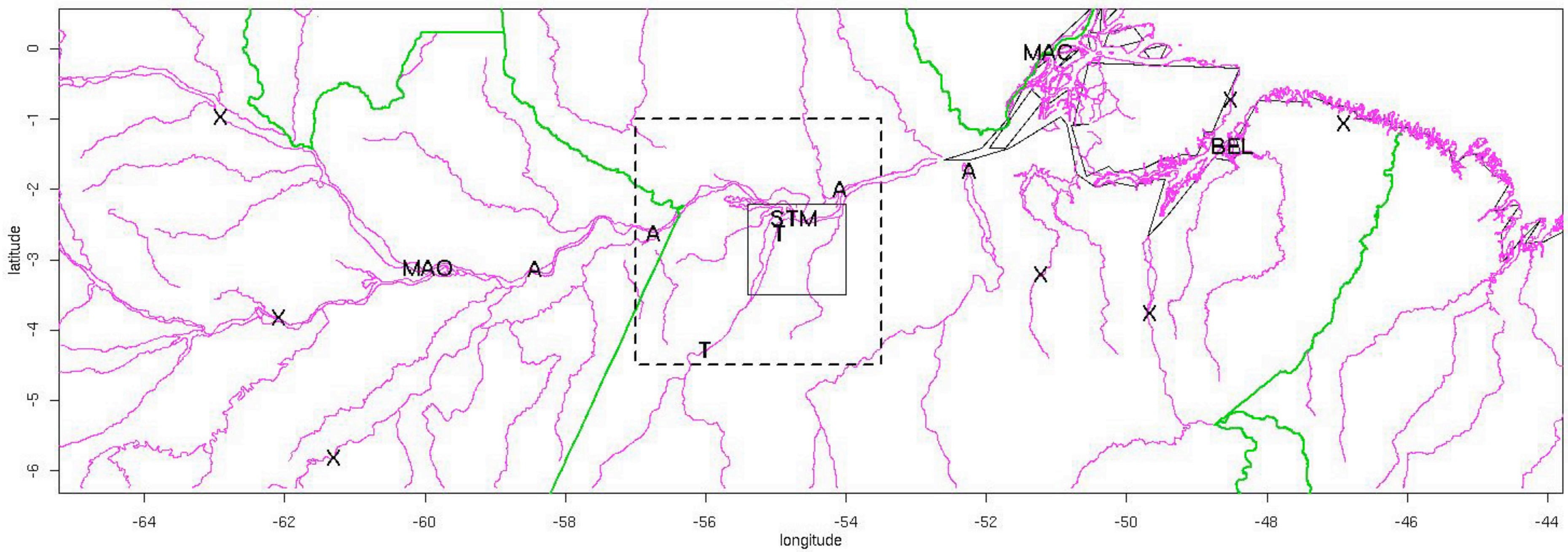
(The cloud base in the forest follows the LCL of the nearby cleared areas, not the local LCL.)



A request for instrumentation might include an discussion of a data analysis strategy, a plan for integrating and intercomparing the data from an IFC with long-term observations.

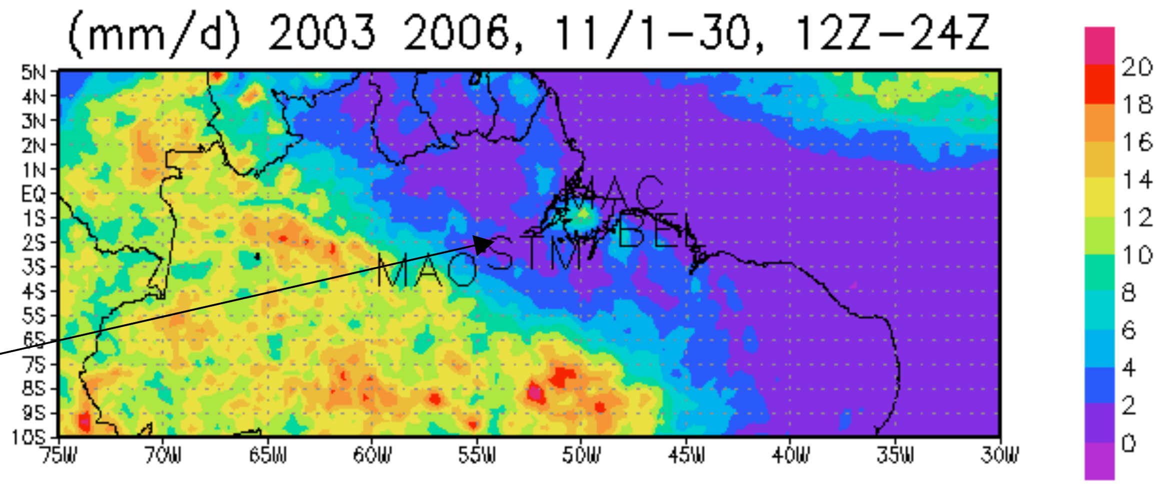
All this *before* or *during* the period of modeling, of ‘golden day’ foci.

Another example from LBA, mesoscale effects on rainfall



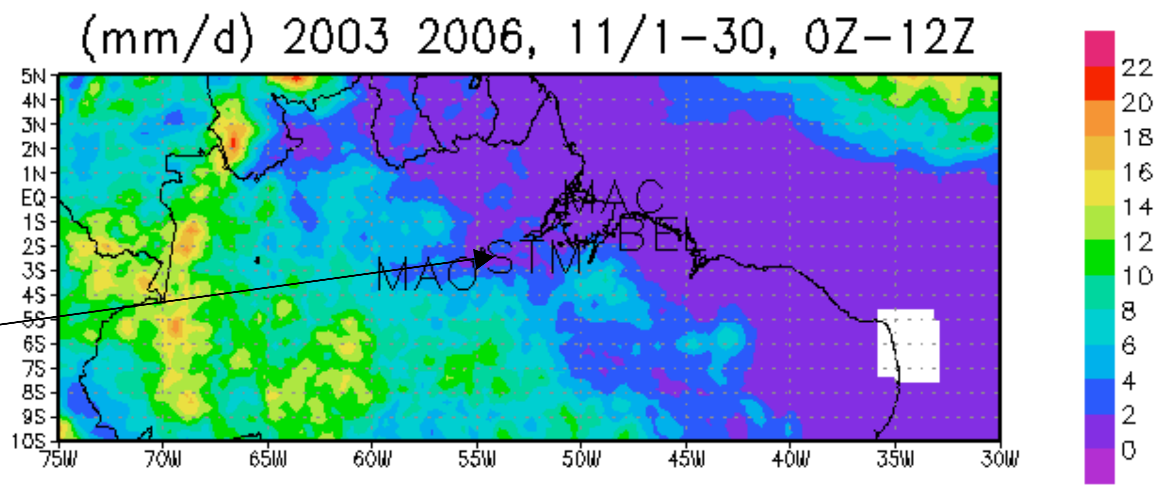
Special characteristics of rainfall at the Tapajós-Amazon confluence.
Close to a sharp large-scale rainfall gradient.

DRY SEASON!



STM

DAY



STM

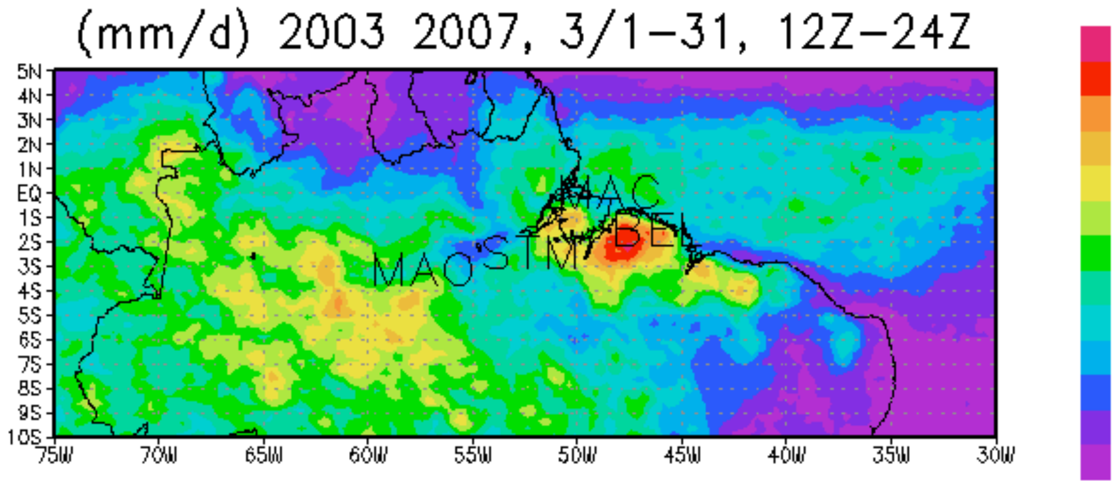
NIGHT

0.25° CMORPH November average 2003-2007

Remotely sensed signal (CMORPH), to understand larger scale pattern… CMORPH March average 2003-2007

WET SEASON!

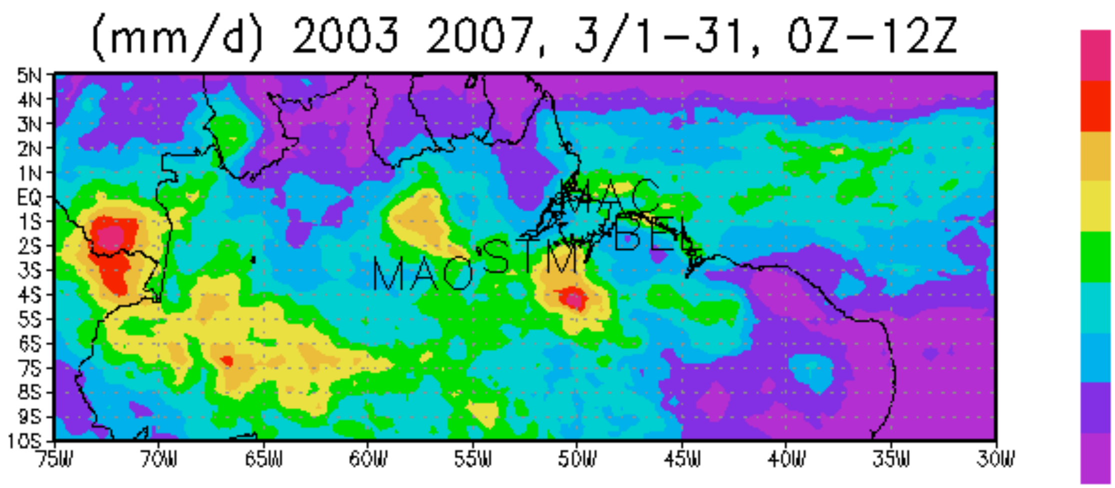
DAY



What would be comforting to believe:
Large squall lines come in from the coast.

These arrive at STM at night, and that explains why the region has a nocturnal rainfall peak. (This is nicely shown by Kousky's animations.)

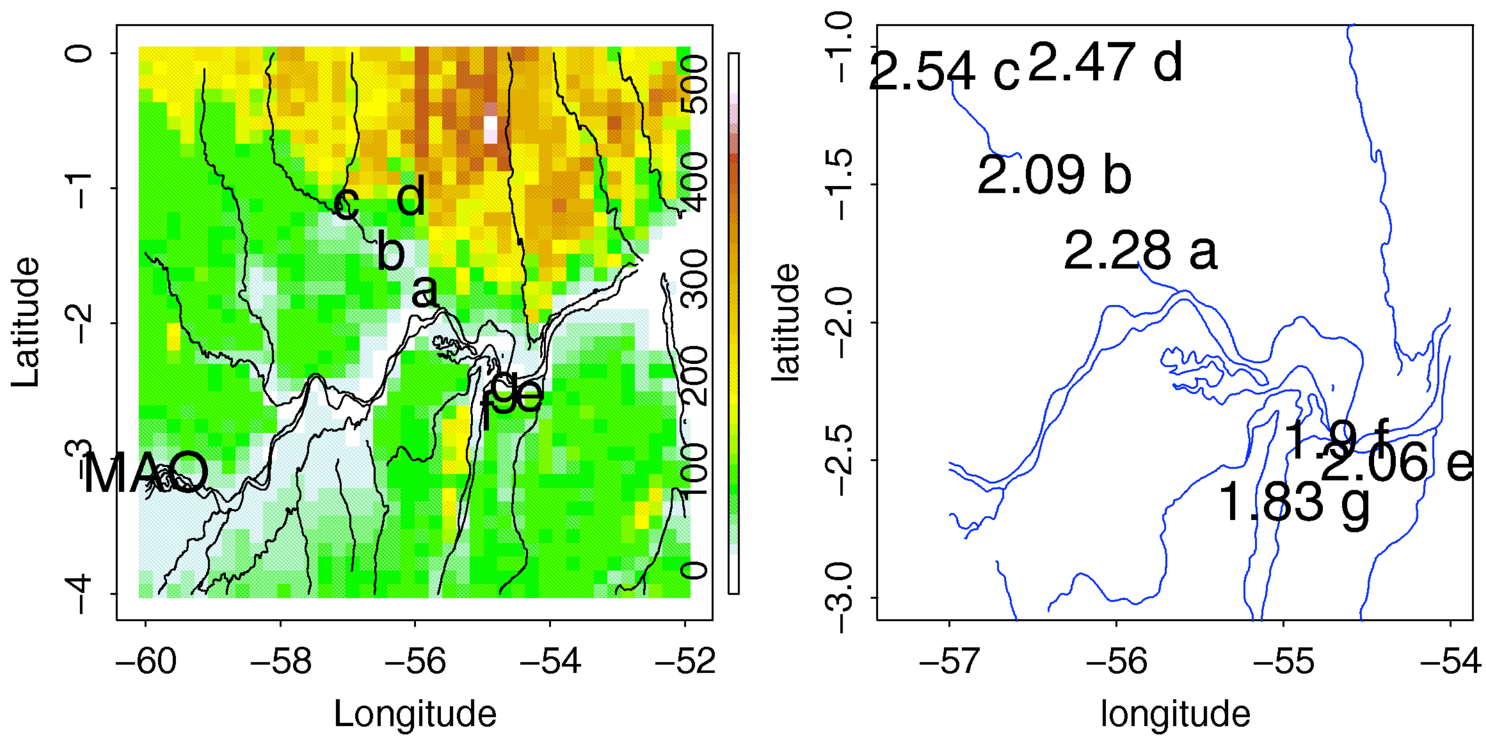
NB: large increase in nocturnal rainfall just NW of STM.



NIGHT

"It is a capital mistake to theorize before you have all the evidence. It biases the judgment." . -- Sherlock Holmes

A very few stations with a long-term (>20 years) record.



One way to improve rain gauge statistics (at least at 1 point).

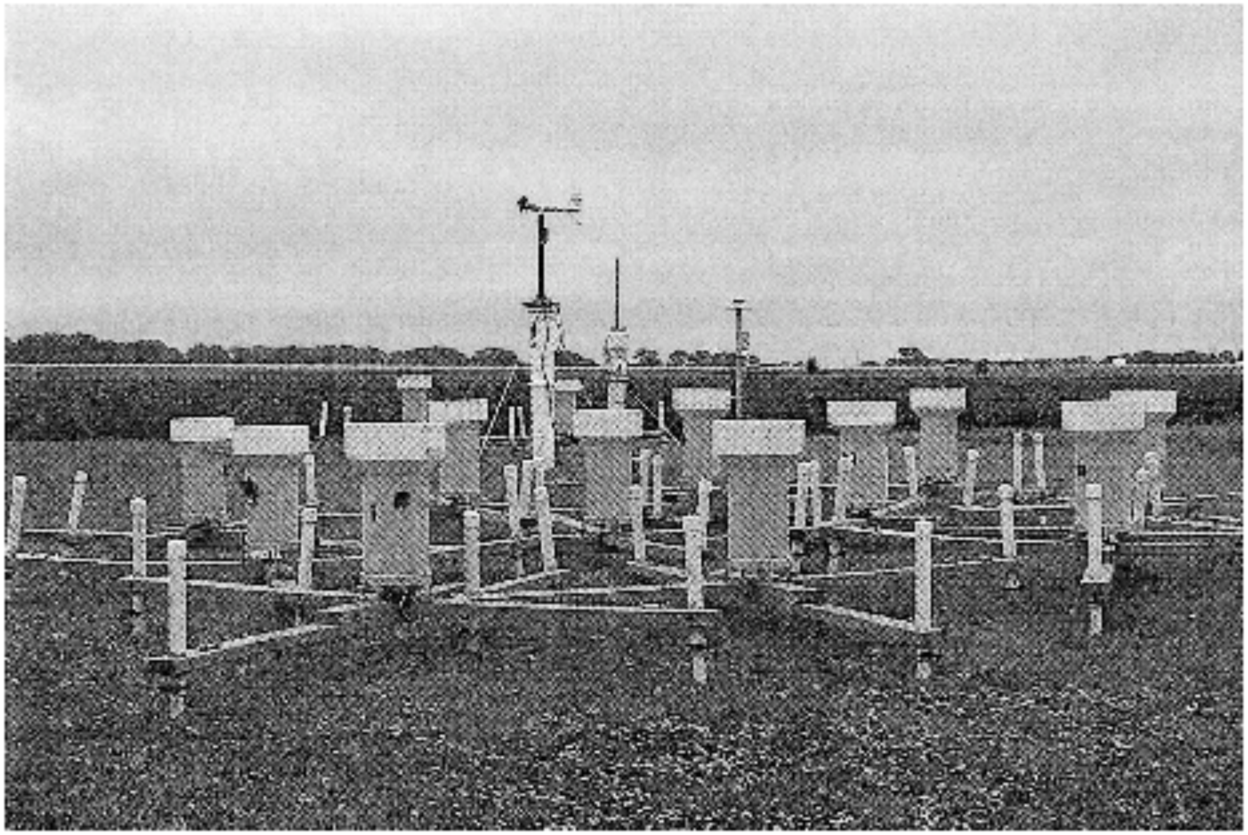
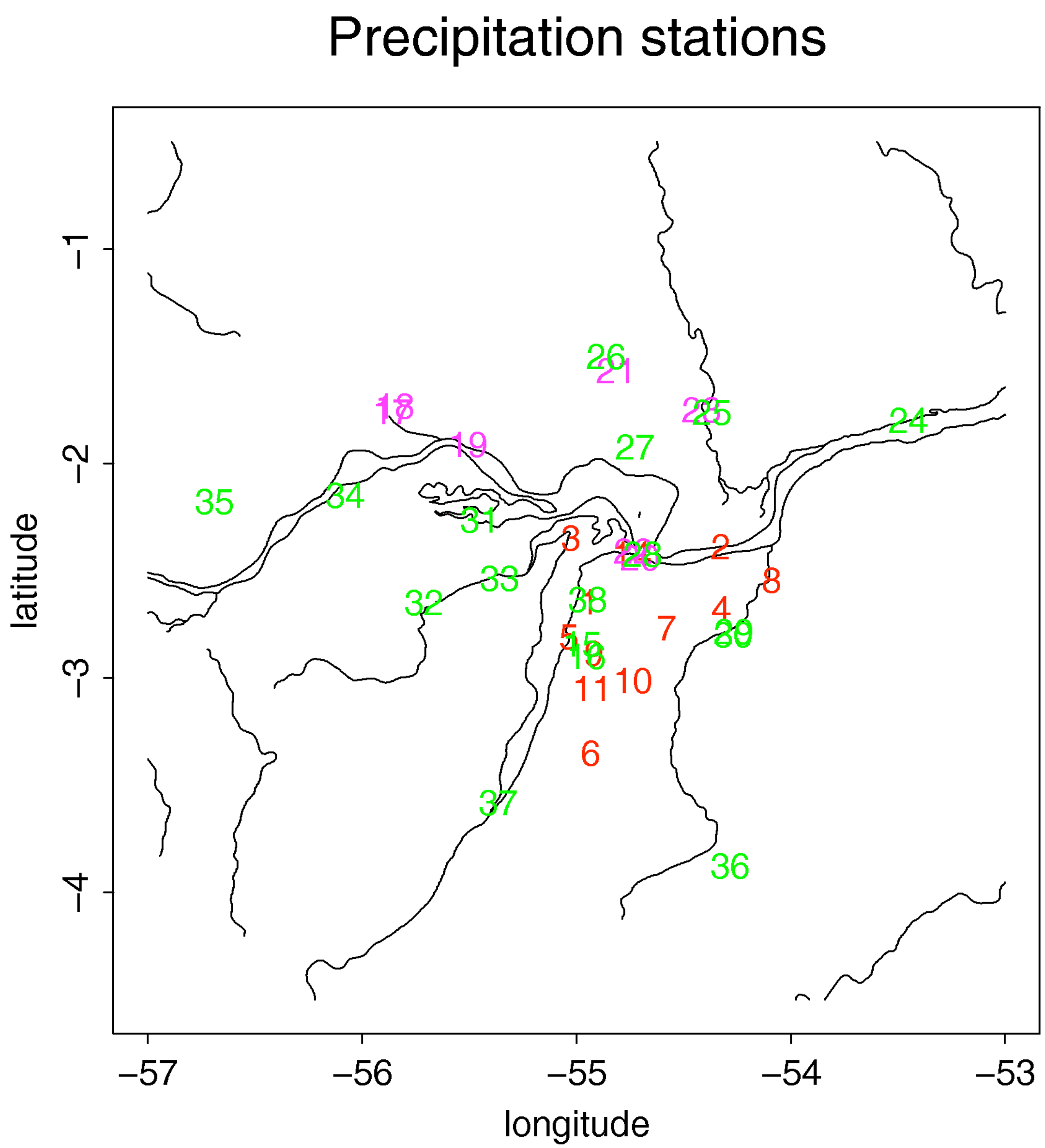


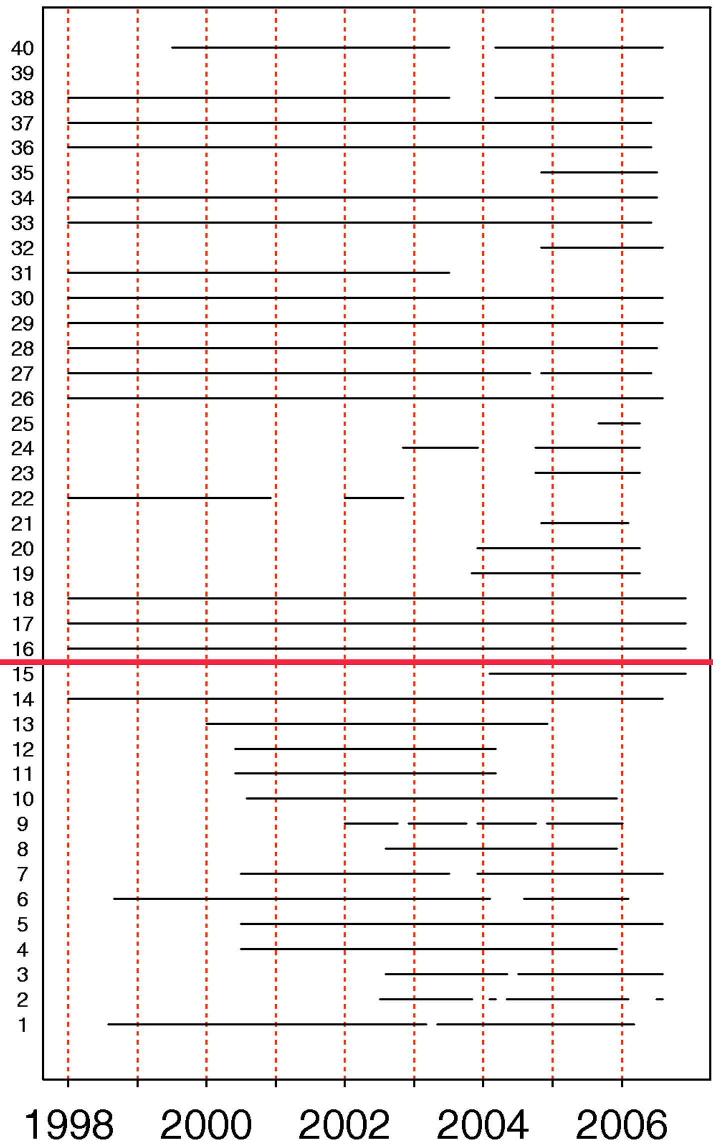
FIG. 1. A view of the cluster of 15 collocated PicoNet rain gauges that was deployed in the autumn of 1999. The gauges are mounted on wooden frames and have HOBO dataloggers attached to their sides. Visible in the center is a NOAA/PMEL automatic TAO weather station that was evaluated using the PicoNet measurements.



Precipitation stations
latitude
longitude
−57
−56
−55
−54
−53
−1
−2
−3
−4

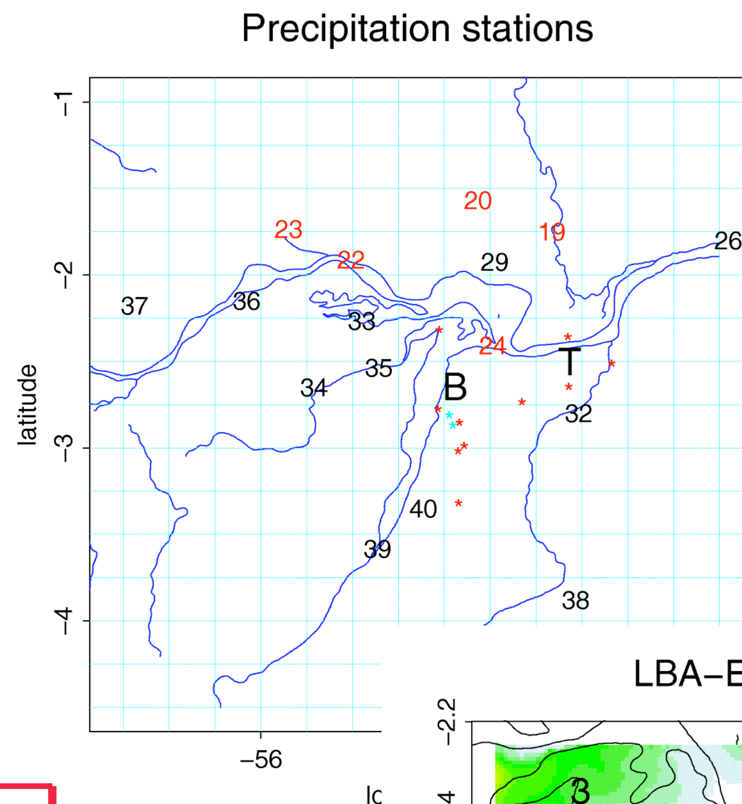
Rainfall stations examined.

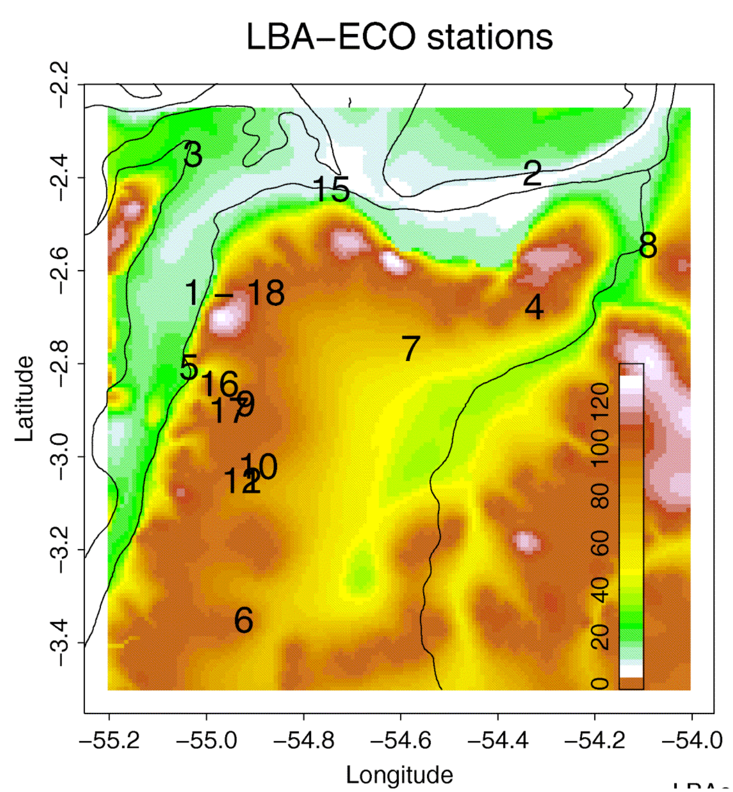
“Hidro stations”



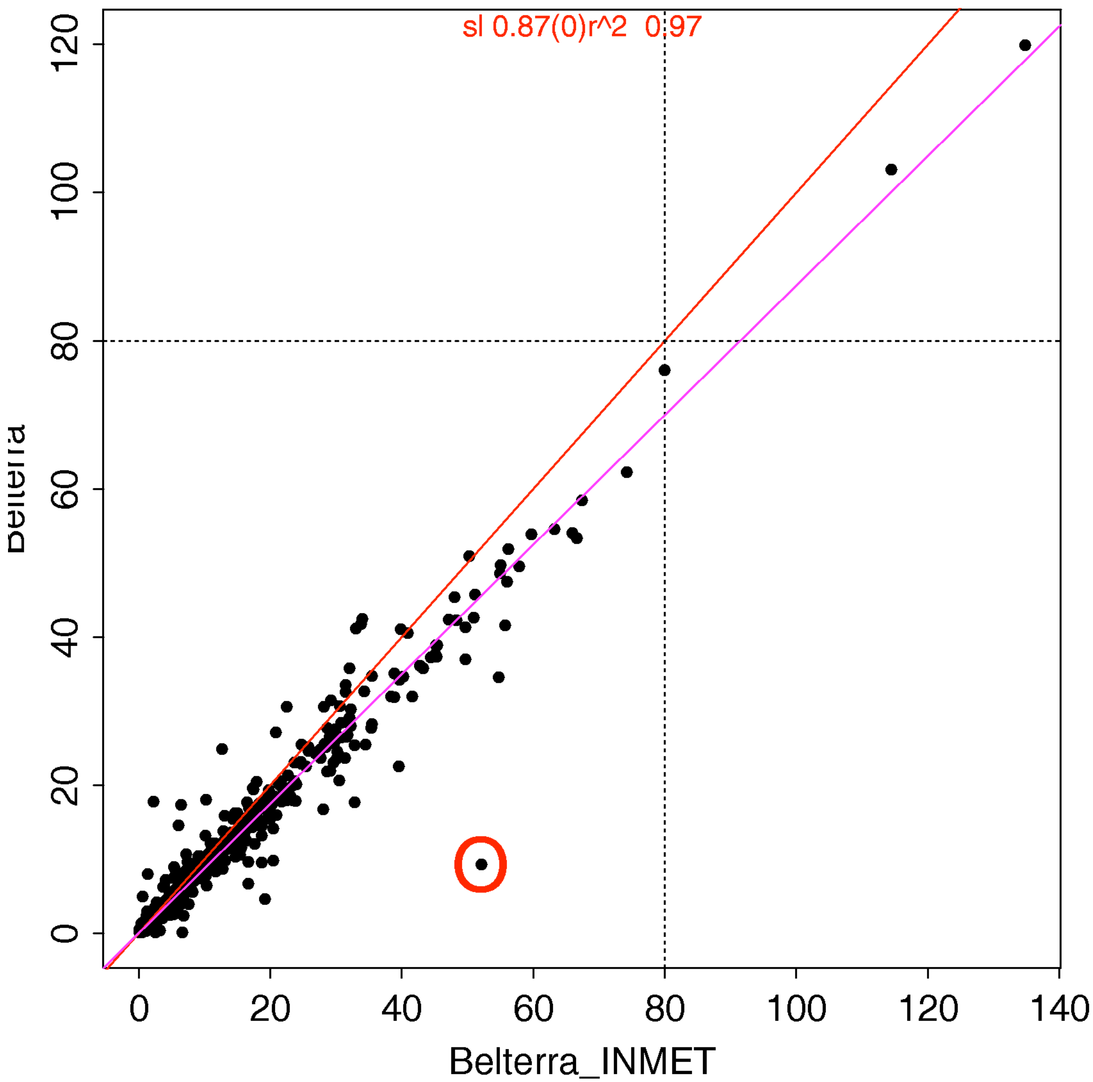
Data availability

LBA-ECO stations

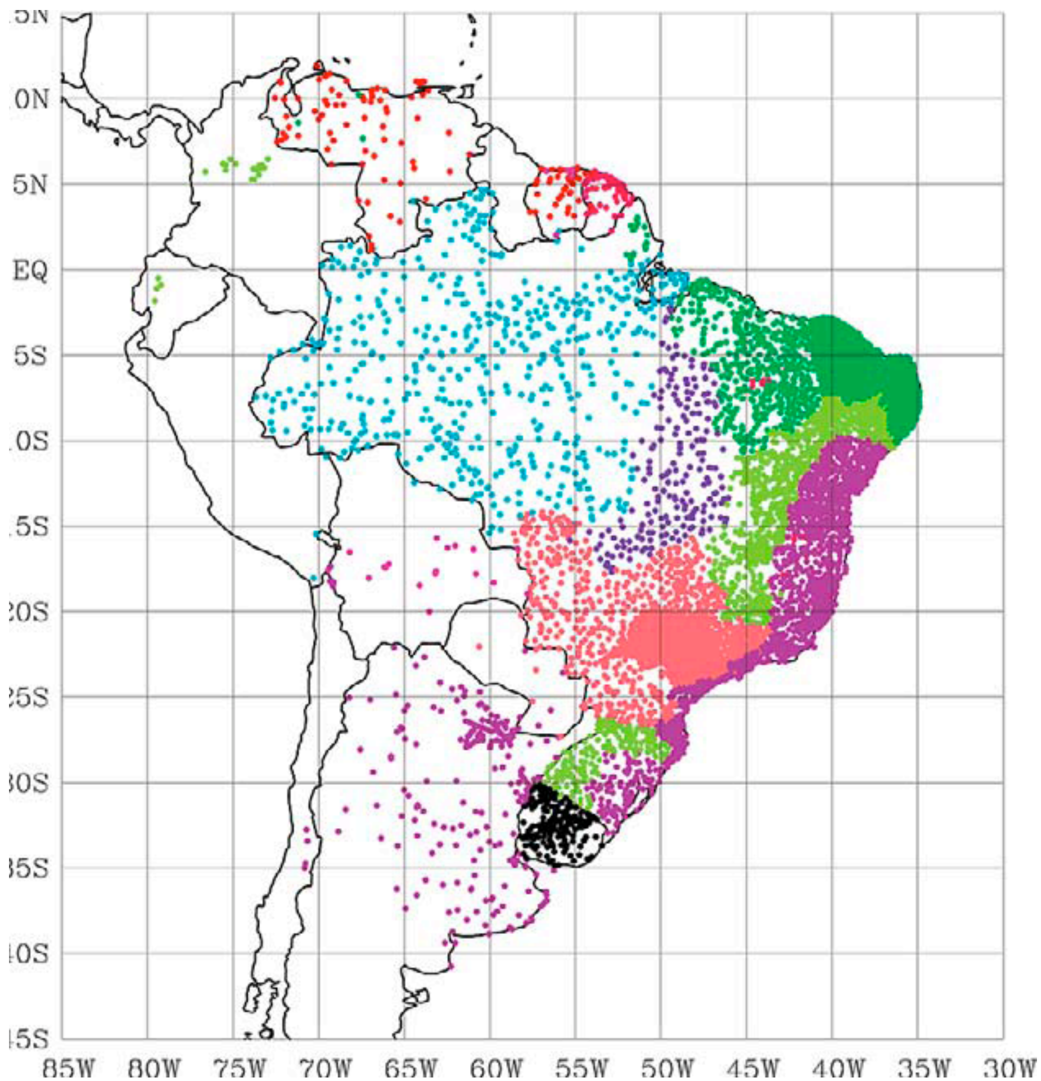




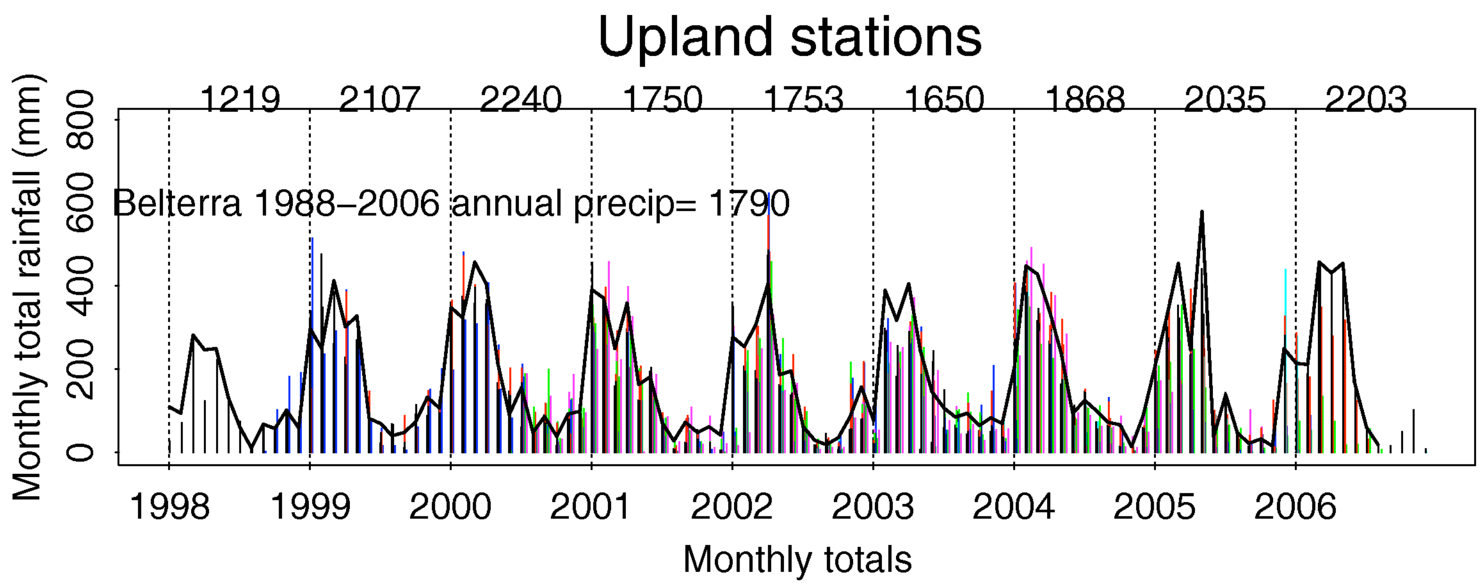
Reconciling the long-term record from simple raingauges with tipping bucket data.

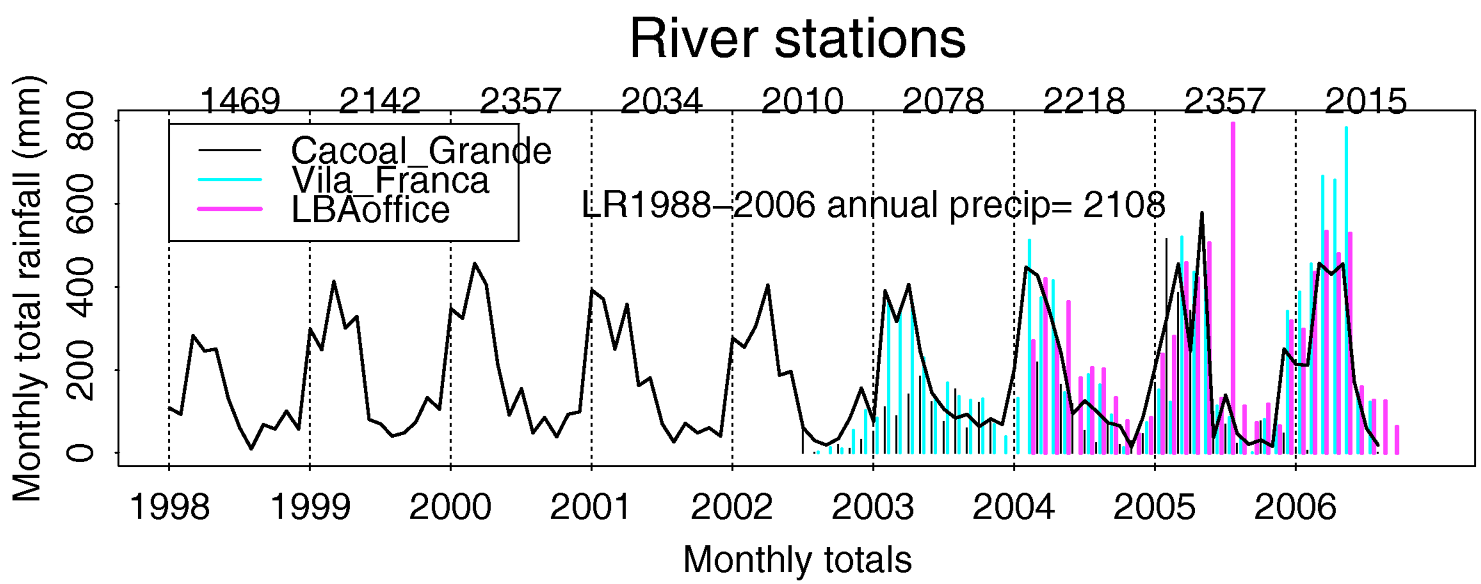


Leibman and Allured, stations (BAMS 2005) …
Daily gridded data



Does the gridded data tell you want you want to know?





We need a specific plan to deal with

•Intercomparison of field project sensors with the opertional record.   (don't necessarily believe the calibrations.)

• Surface array designed to observe the relevant spatial climatic gradients (land cover, topography effects) and a deployment long enough to observe parts or all of the seasonal cycle, characteristic synoptic events.

•If you going seeking a particular storm, MCC, gryphon, or whatever, have a 'fair weather' science plan as a complement.

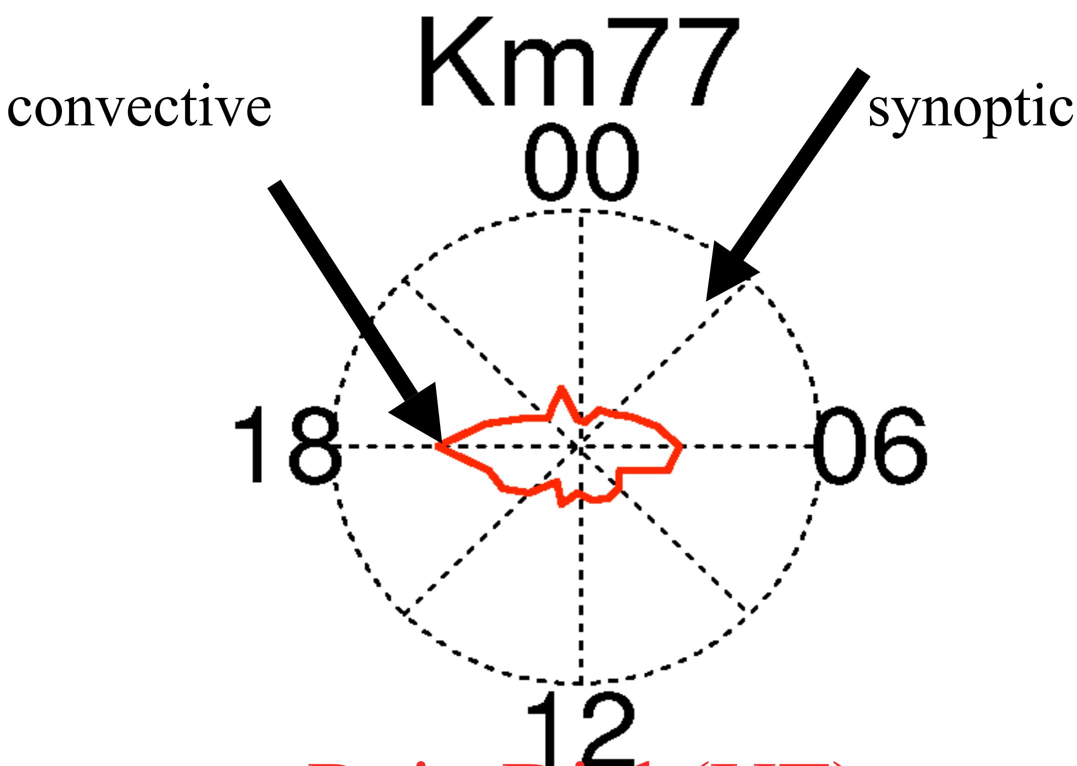
Mesoscale bias, LBA rainfall example.

Naïve scientist sees no clouds over the rivers, all climate stations along the rivers, concludes that there is a systematic bias in rainfall measurements in the Amazon.

Finds that the partition of rainfall into locally convective and larger scale systems conforms to the hypothesis (diurnal).

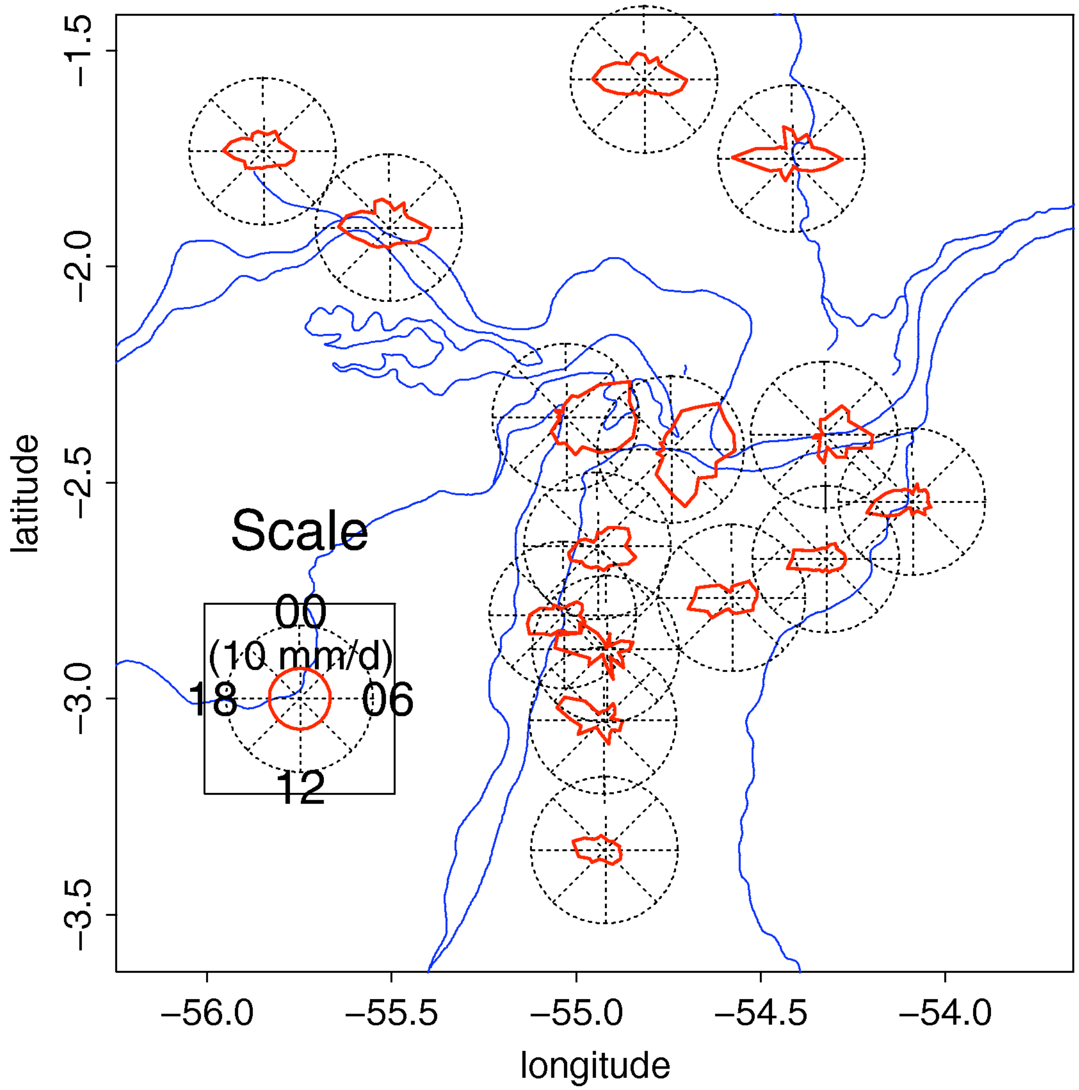
But more rain overall near the river--the opposite bias from the ‘back of the envelope’ estimate.

Santarém region, eastern Amazon basin.
Afternoon precipitation from local convective activity
Nocturnal from instability lines that roll over at 3-6 am.

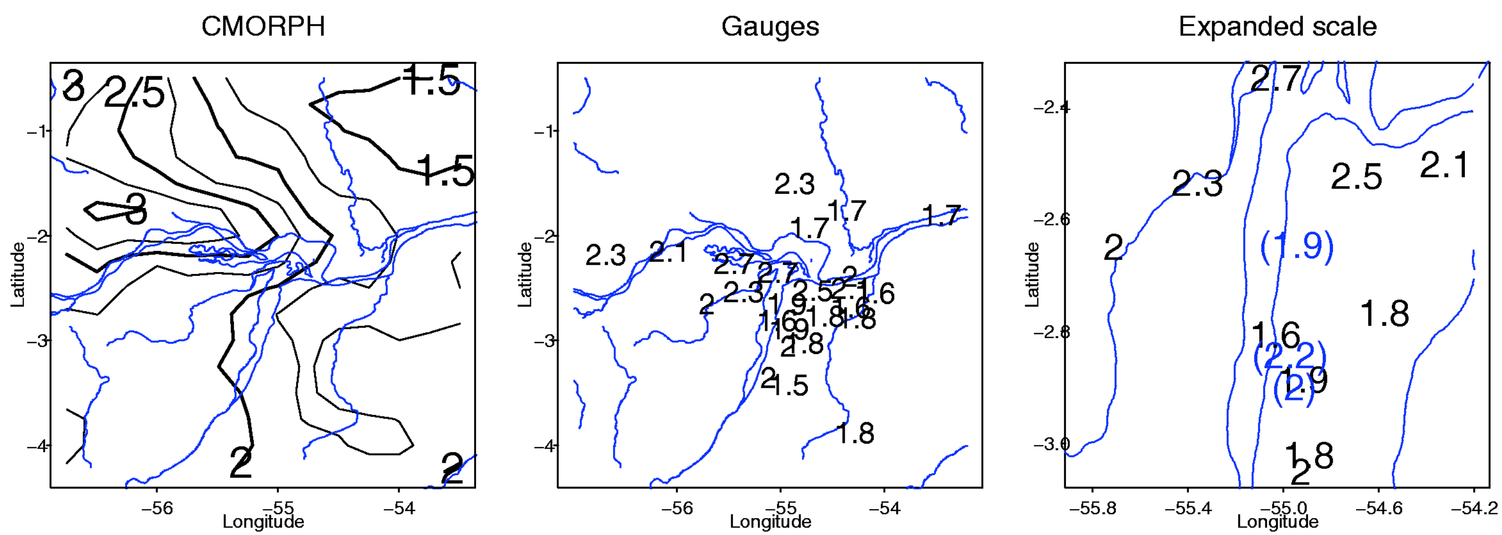


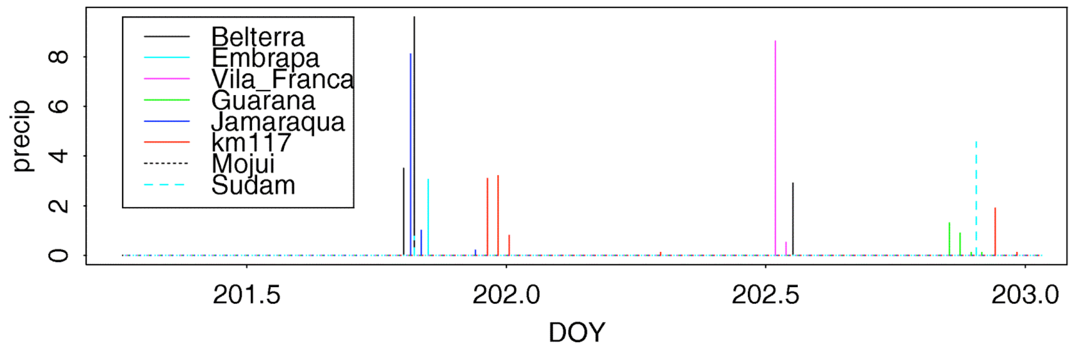
Rain Dial (UT)

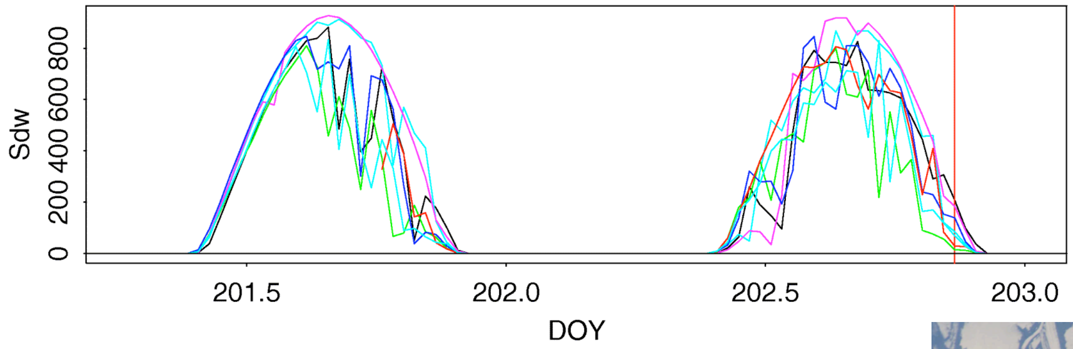
Wet Season



−1.5
−2.0
−2.5
−3.0
−3.5
latitude
−56.0
−55.5
−55.0
−54.5
−54.0
longitude
Scale
00
(10 mm/d)
18
06
12

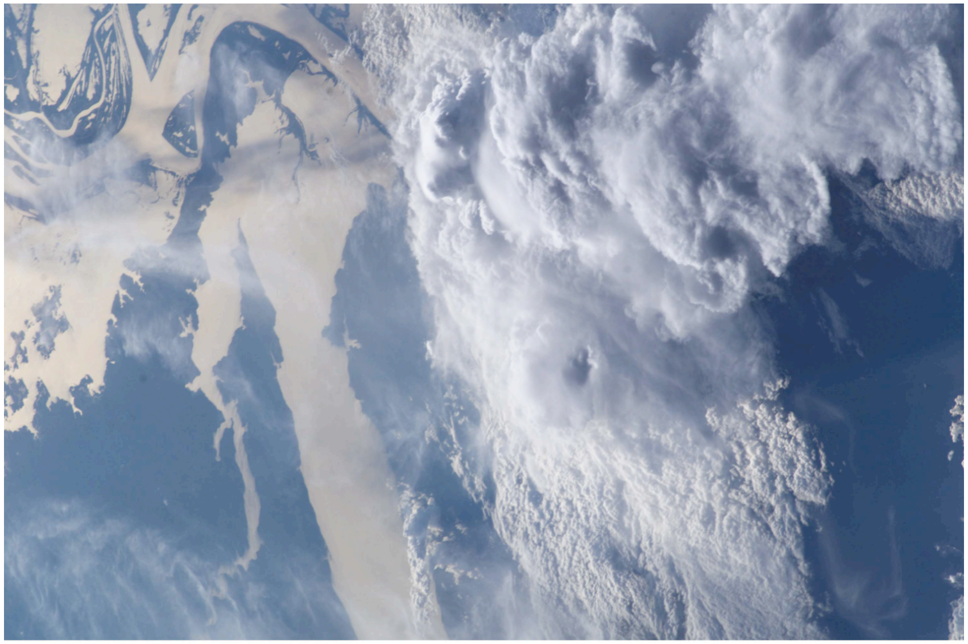

CMORPH
Gauges
Expanded scale
Latitude
Longitude
−56
−55
−54
−1
−2
−3
−4
−55.8
−55.4
−55.0
−54.6
−54.2
−2.4
−2.6
−2.8
−3.0





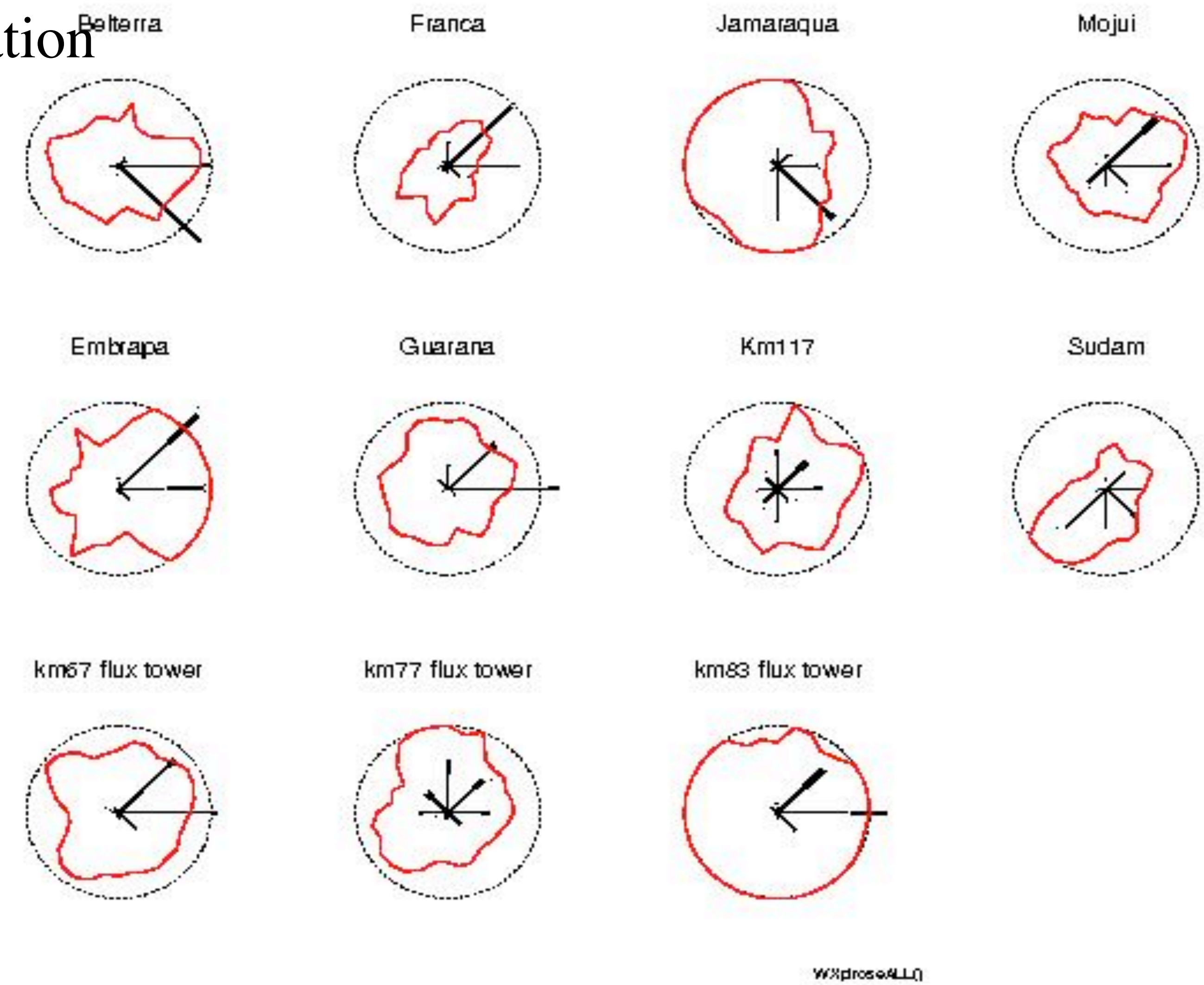
An dramatic case, but how can the surface data be interpreted?

"How do we know when we win?"

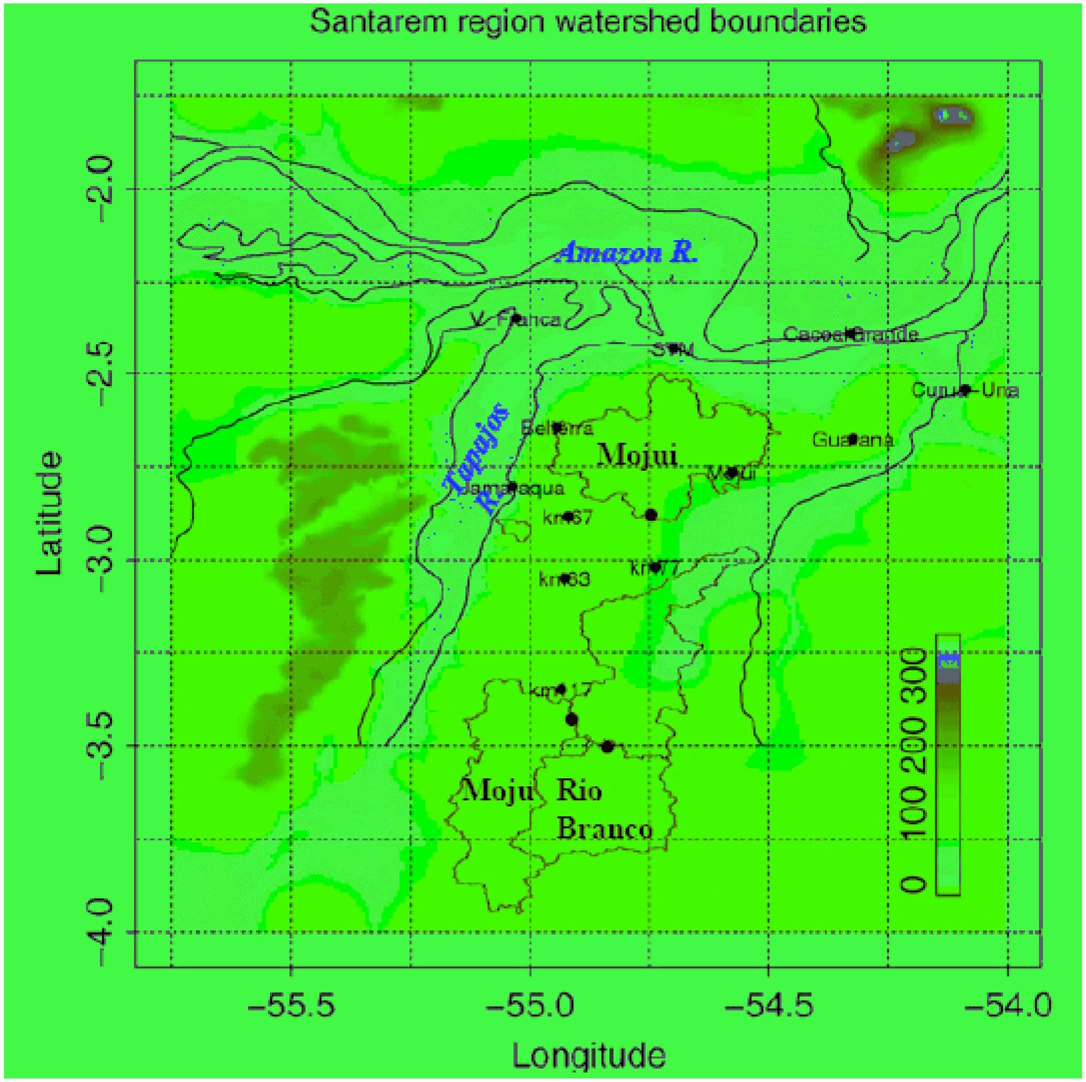


Wind representation

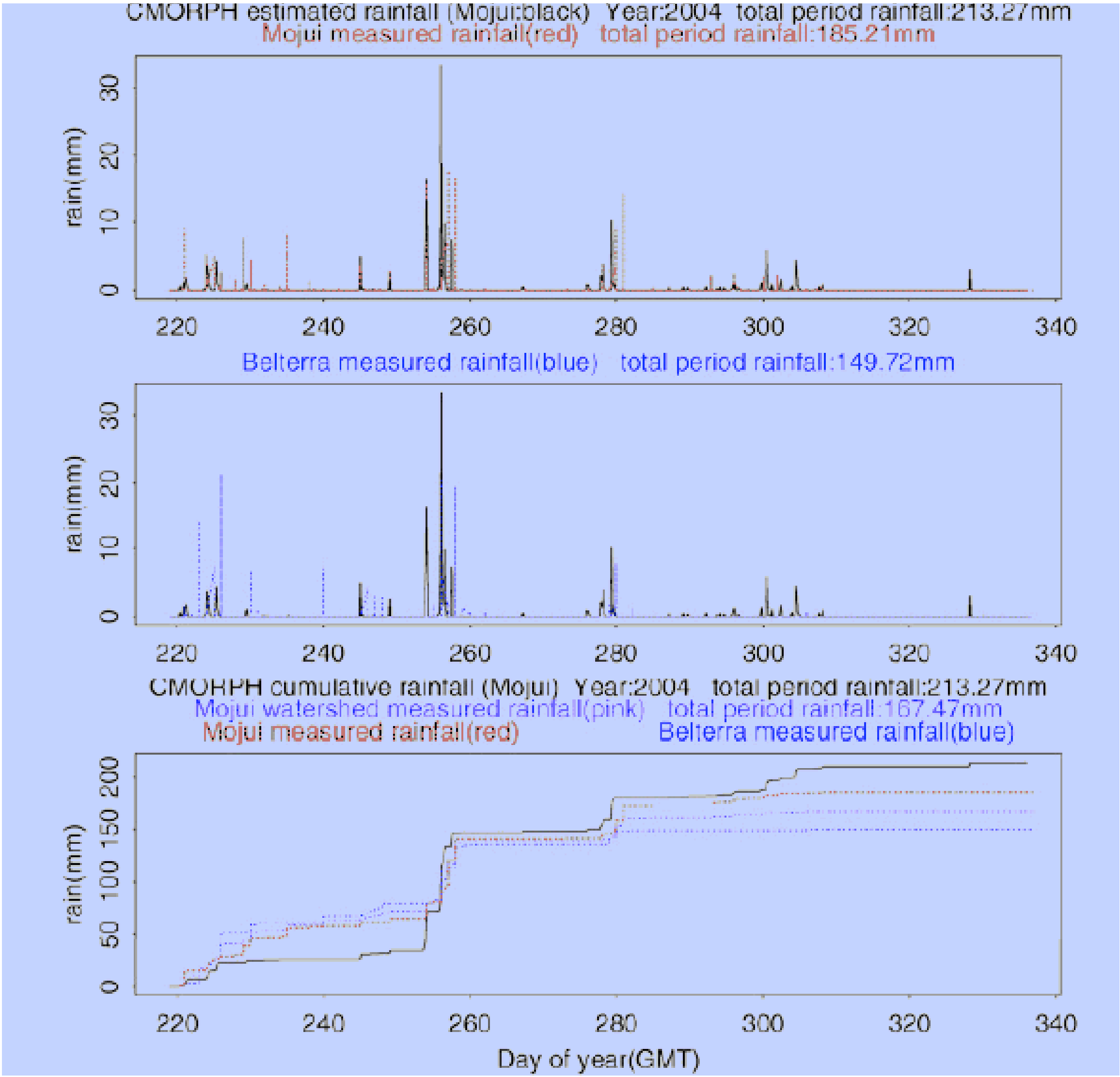
Fujita's
transmission
factors;
wind roses

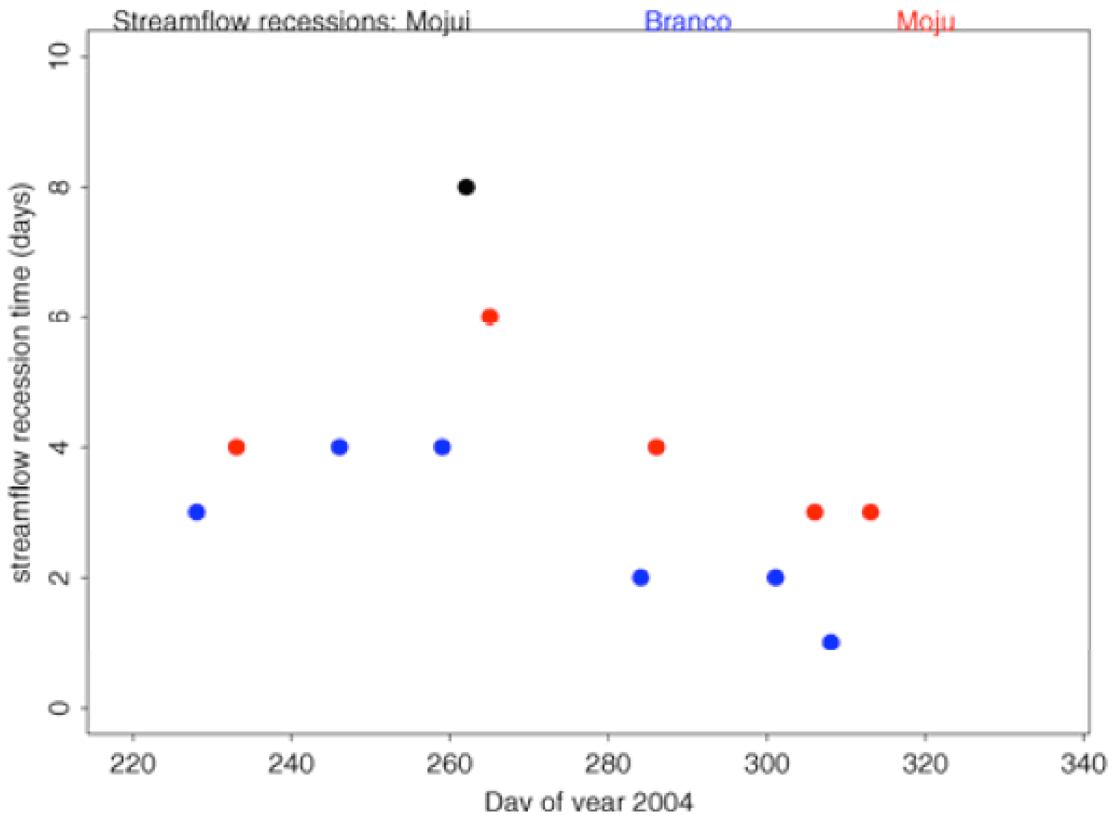


Assessing CMORPH in small watersheds…….

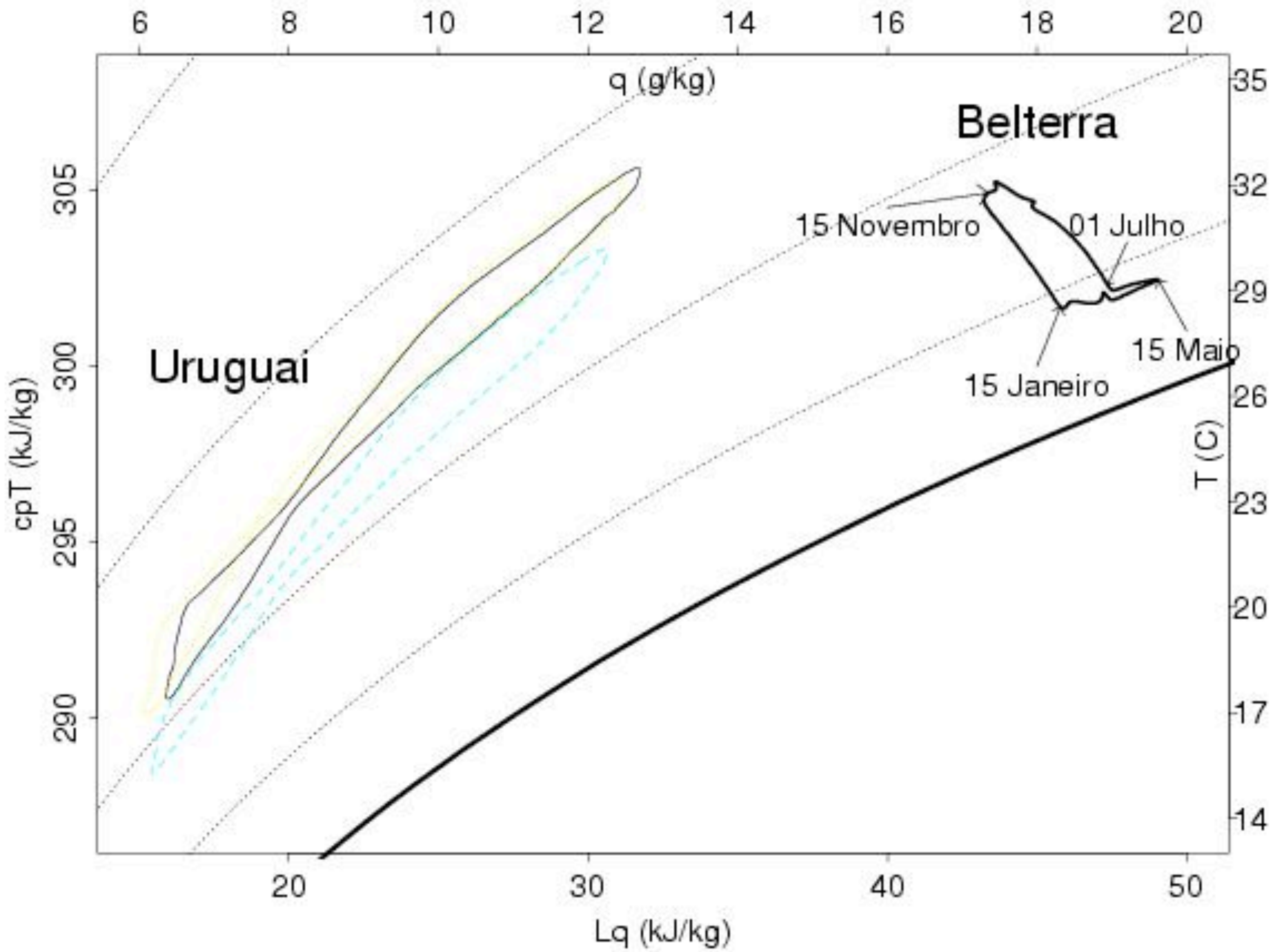


Not so bad in LBA ….



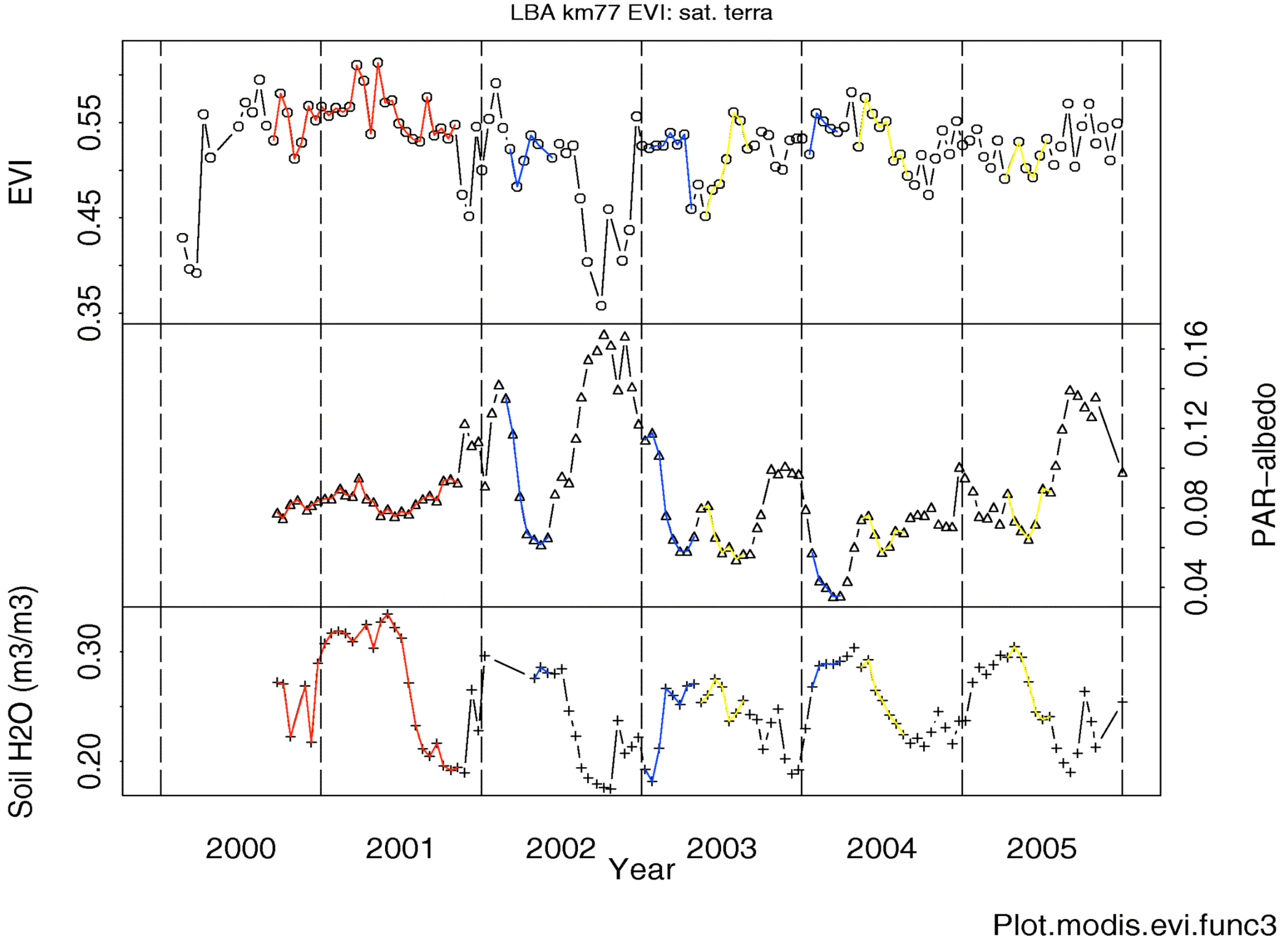


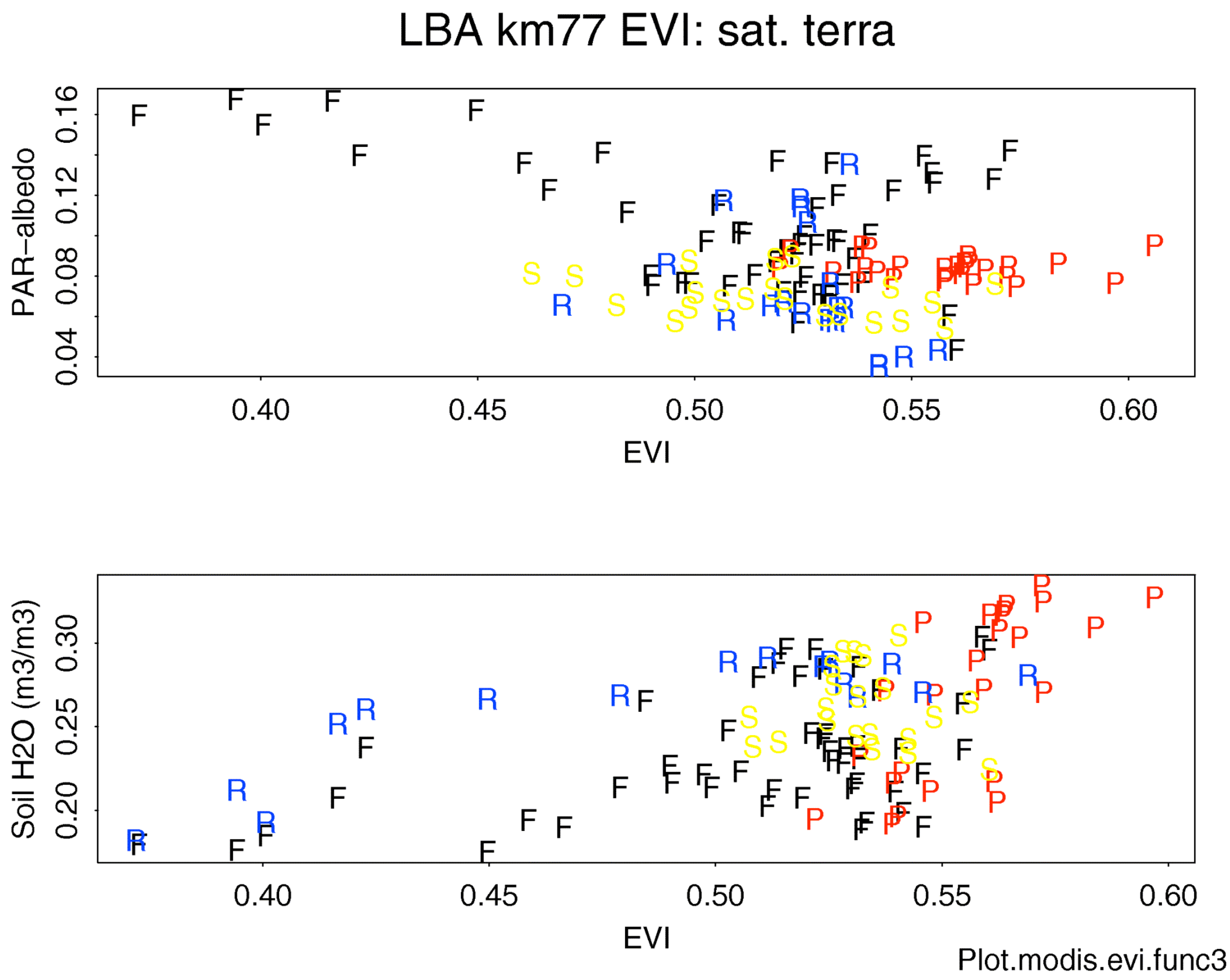
Streamflow recessions: Mojui
Branco
Moju
streamflow recession time (days)
Dav of vear 2004



q (g/kg)
6
8
10
12
14
16
18
20
Belterra
15 Novembro
01 Julho
15 Maio
15 Janeiro
Uruguai
cpT (kJ/kg)
305
300
295
290
T (C)
35
32
29
26
23
20
17
14
Lq (kJ/kg)
20
30
40
50

Agricultural land cover change associated with crops
Changing while you stay at one place--but tricky to detect
With satellite based indices (crop phenology)

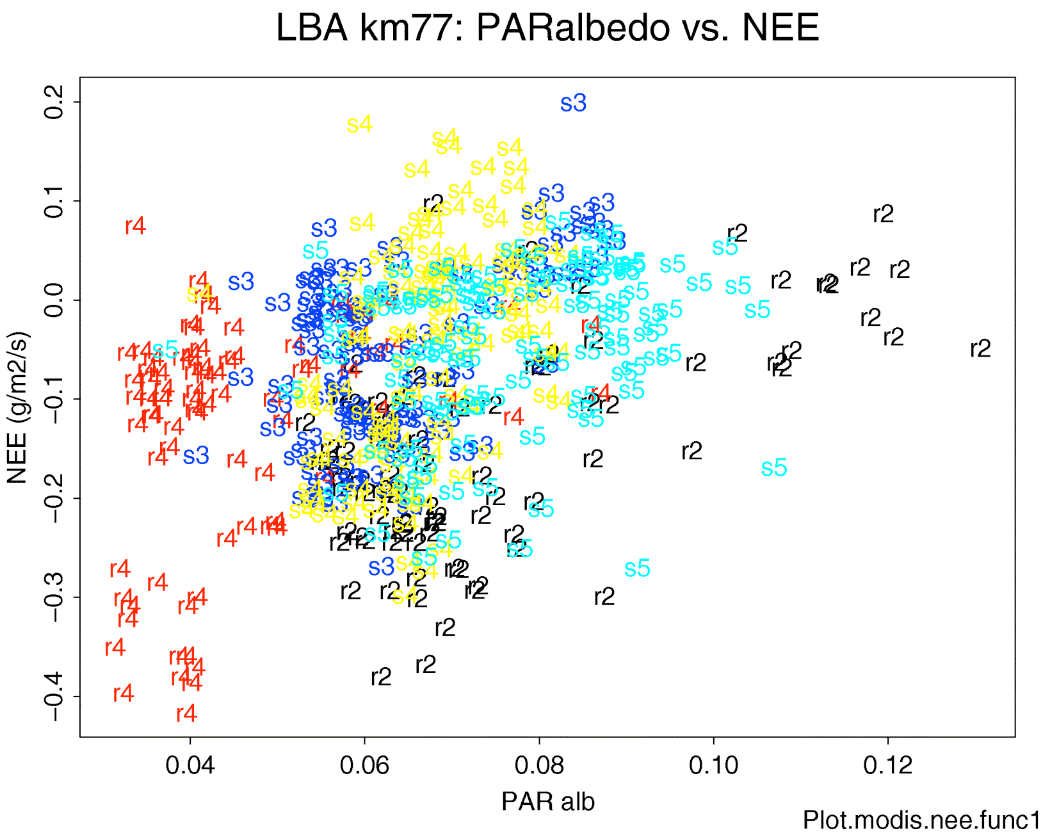




Fallow

Rice

Pasture


LBA km77: PARalbedo vs. NEE
NEE (g/m2/s)
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
0.04
0.06
0.08
0.10
0.12
PAR alb
Plot.modis.nee.func1

Make a plan for your experiment & your ‘anti-experiment”.
(“We were ready but no good case occurred, so we stayed in the hotel in Acapulco…”)

The plan should include a way to intercompare sensors in an IFC with those that make up the long-term record.

Make sure that all signals are being recorded fast enough to allow for innovative use later.
(e.g., 15 minute streamflow both for storm surge *and* the diurnal ET signal.)