

Characteristics of precipitation in the Santarém study region

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You know my method. It is founded upon the observation of trifles. -- Sherlock Holmes

Do river breezes or other mesoscale circulations introduce a bias in the regional rainfall climate record?

“Chance has put in our way a most singular and whimsical problem, and its solution is its own reward.” Sherlock Holmes

- Most climate stations are along the rivers.
- Rivers are clearer than inland.

Therefore, there is more rain inland.

There is nothing more deceptive than an obvious fact . -- Sherlock Holmes



INMET stations in NE Brazil



Astronauts take pictures!

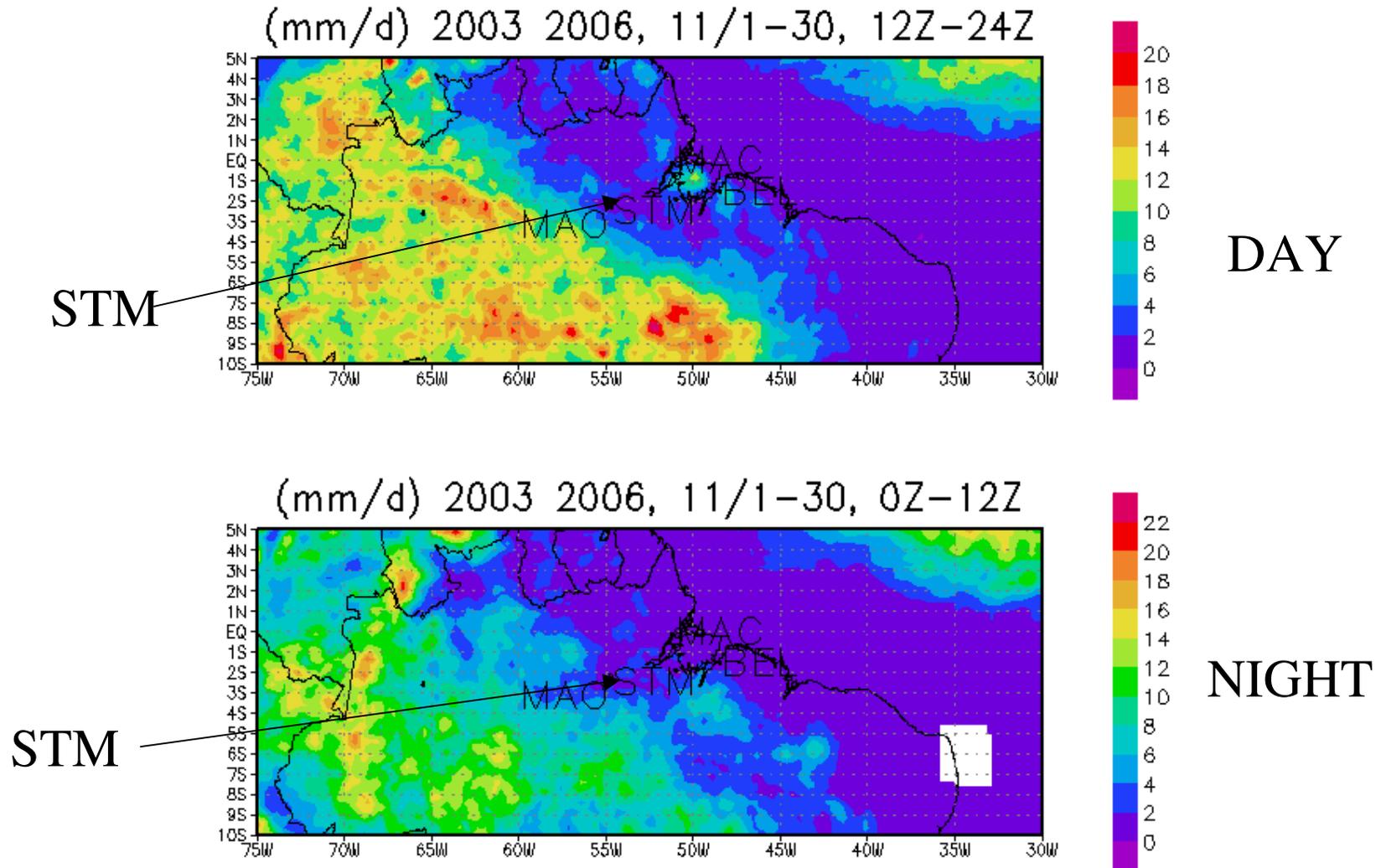
<-- Clearing commonly seen over rivers. (Amazon just W of Santarém).

But, a significant fraction of rain occurs during large storm events, some of which are large instability lines coming in from the coast. -->
(Tapajós-Amazon confluence.)



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



What would be comforting to believe:

Large squall lines come in from the coast.

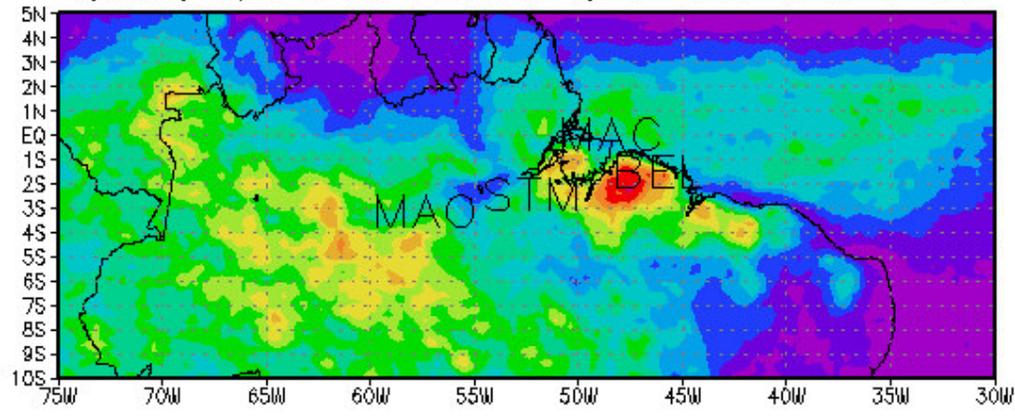
These arrive at STM at night, and that explains why the region has a nocturnal rainfall peak. (This is nicely shown by Kousky's animations.)

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

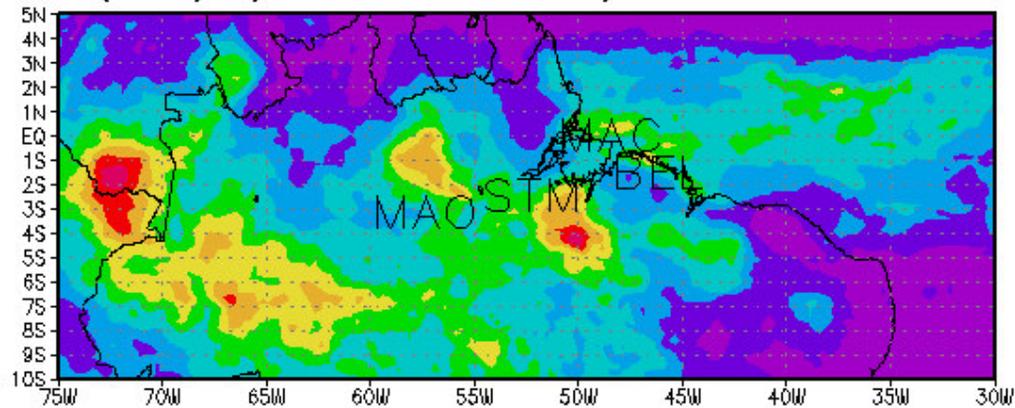
CMORPH March average 2003-2007

DAY

(mm/d) 2003 2007, 3/1-31, 12Z-24Z



(mm/d) 2003 2007, 3/1-31, 0Z-12Z



NIGHT

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

Confusions to our simple analyses:

River breeze affects daytime rainfall only, possibly up to 20%.
(*Molion and Dallarosa, 1991*)

Observations (e.g., *Nechet 1993; Angelis, et al., 2004*) indicate that nocturnal rainfall is the norm at Santarém.

Clearly there is large-scale *convergence* just to the west.

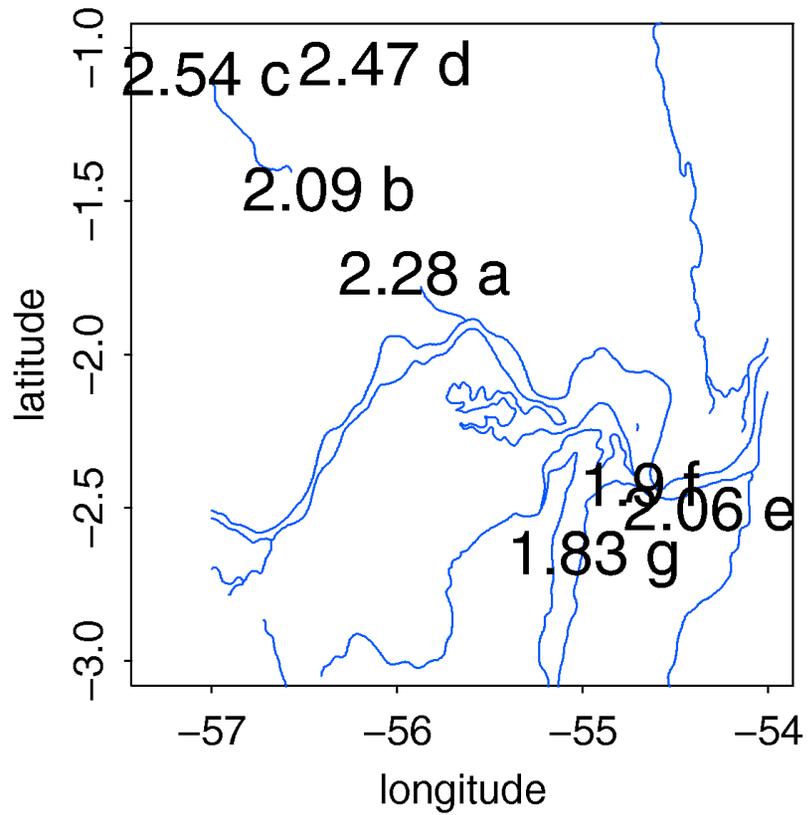
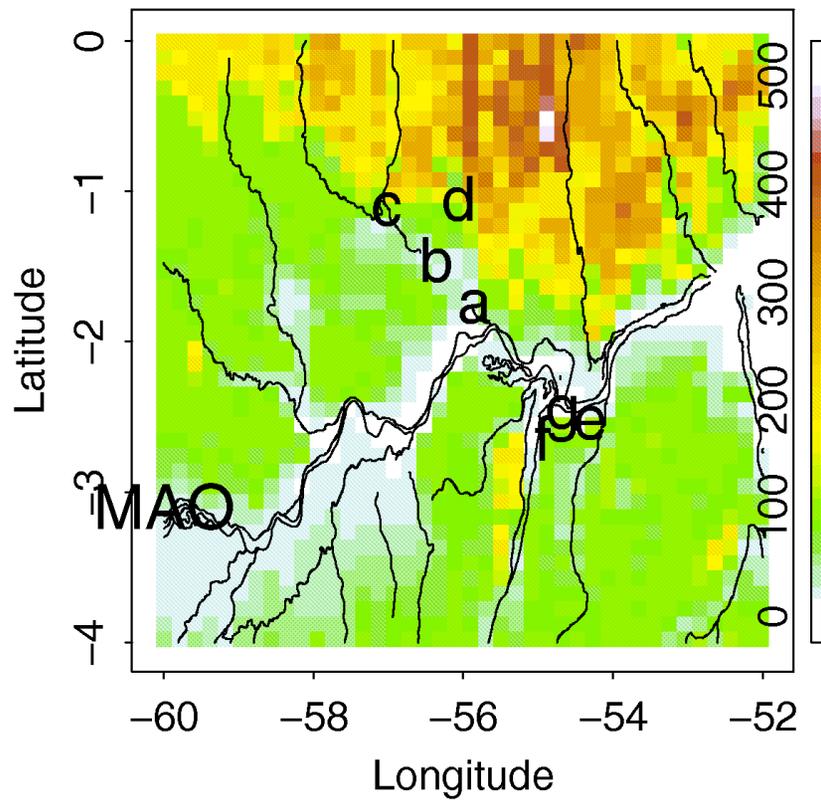
The role of *topography* has largely been ignored.

What is the rainfall pattern at the Tapajos-Amazon confluence?

Does a careful analysis bring lessons that can be applied across the Basin?

Molion & Dallarosa, 1993 cases
a, b, c, d.

f: Belterra
g: STM airport
h: Taperinha



- Is the larger precipitation to the NW of the confluence *really* because of the Amazon river breeze?

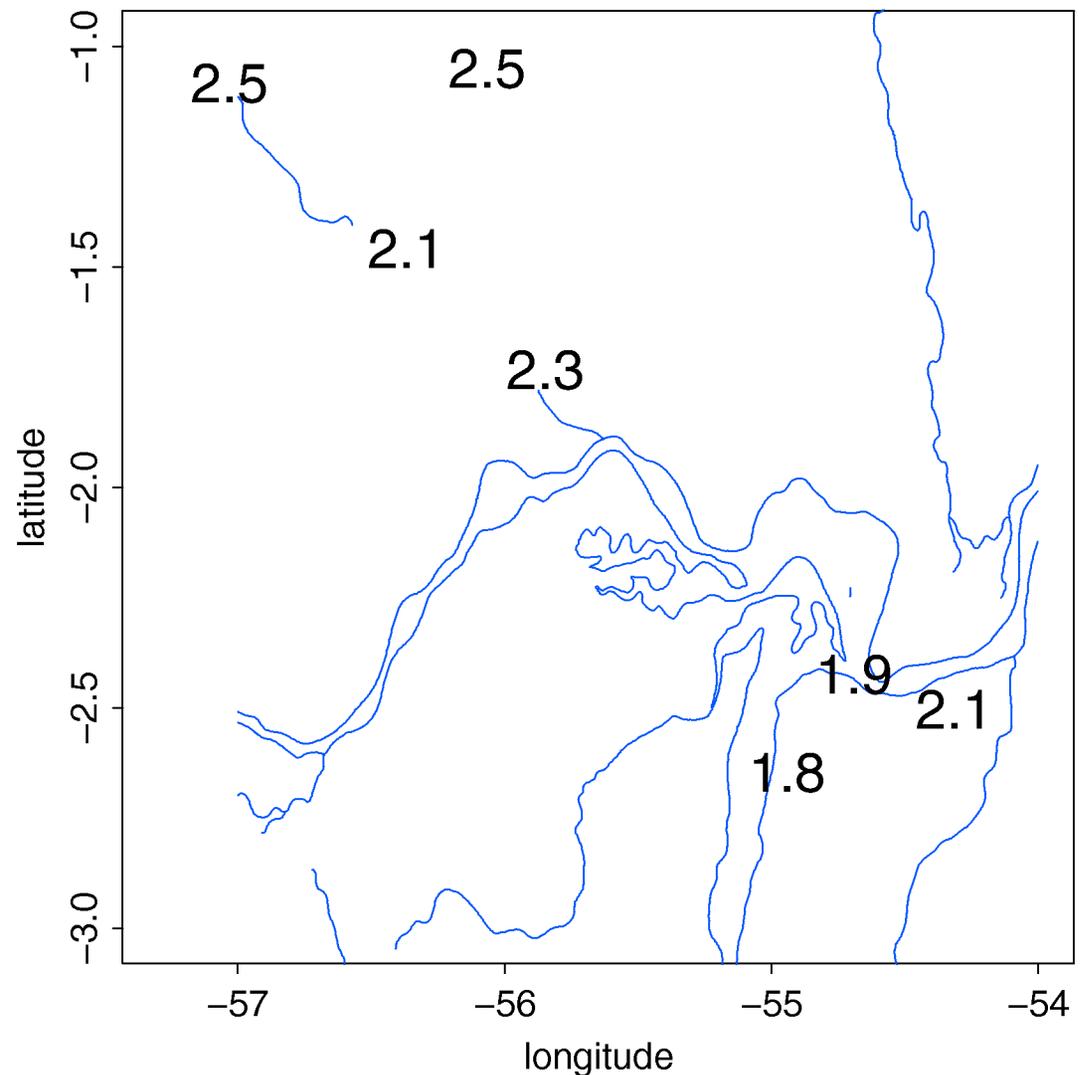
- There is a hint that rainfall decreases going south from the city of Santarém.

MD: 1978-1988

Belterra: 1988-2006

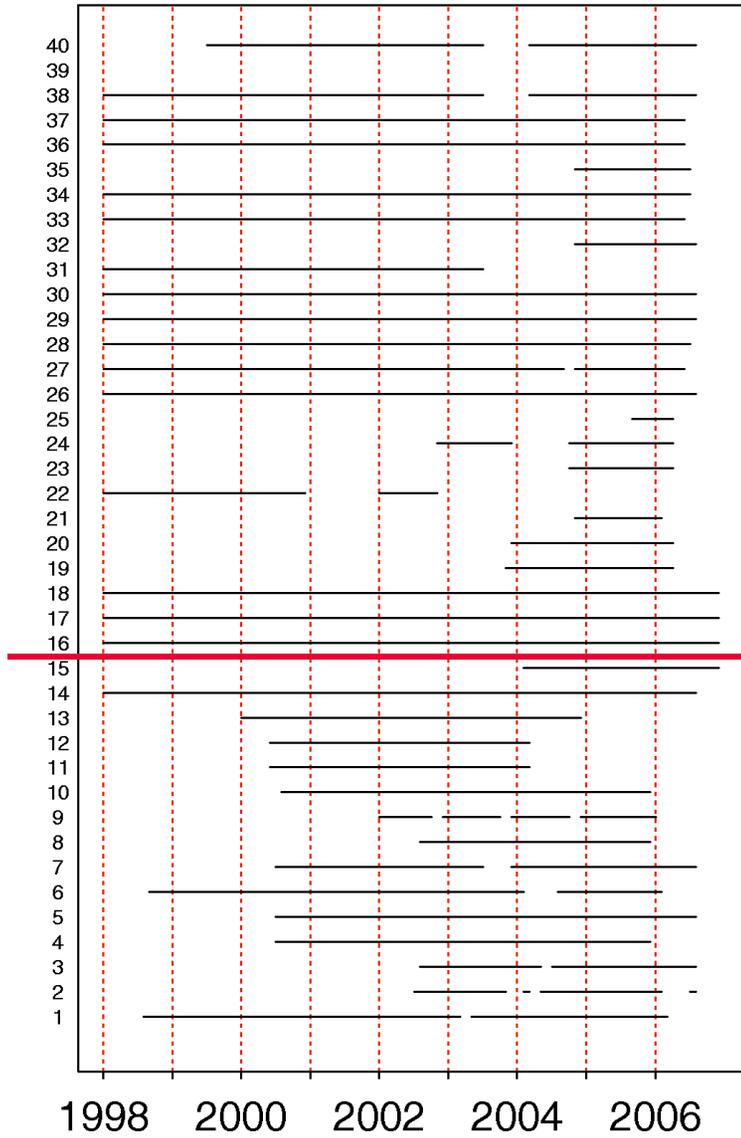
Taperinha: 1917-1983

Historical annual rainfall totals (m)



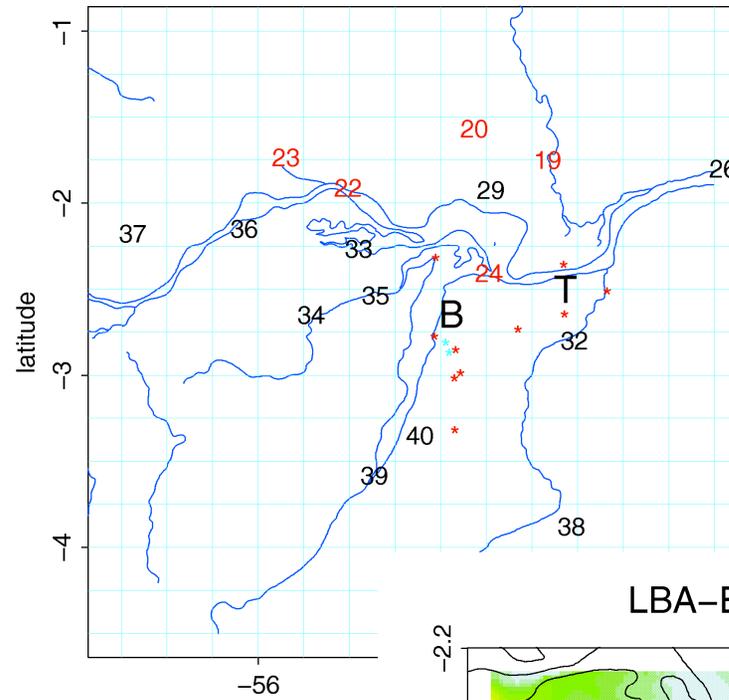
Rainfall stations examined.

“Hydro stations”

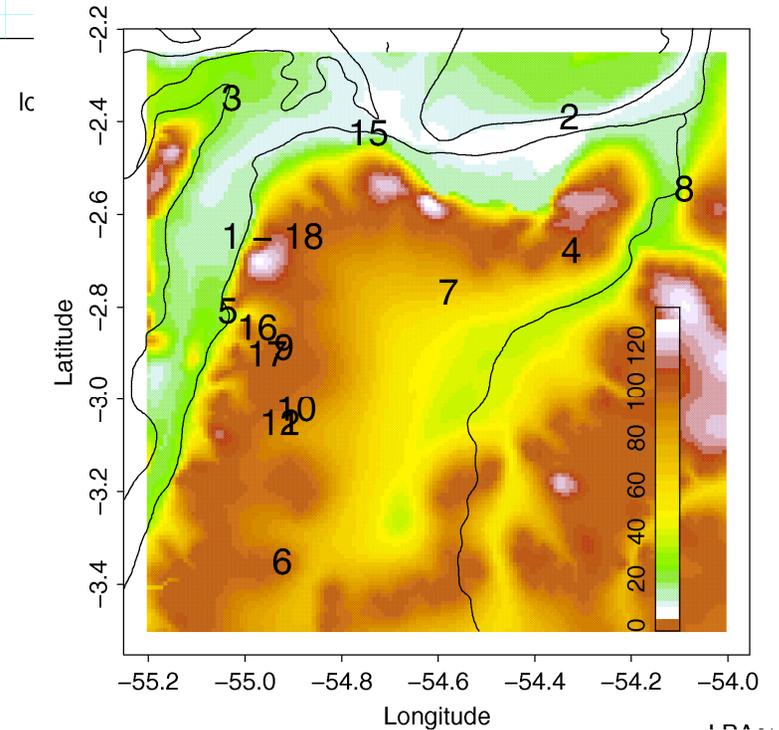


Data availability

Precipitation stations

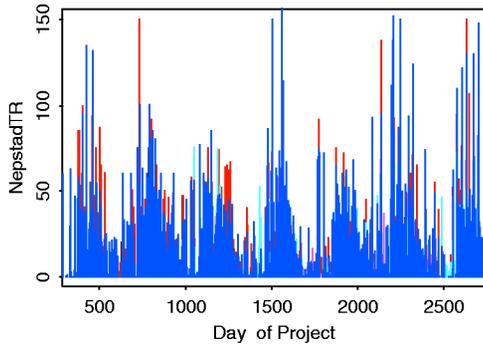


LBA-ECO stations

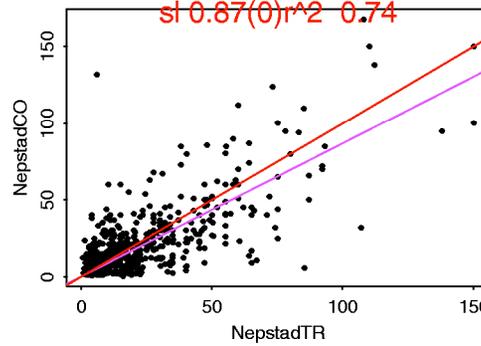


Consistency among rain gauges, daily rainfall totals:

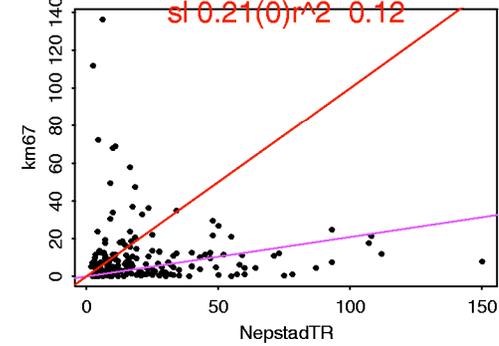
Day selection on: Sunday ; off: Saturda



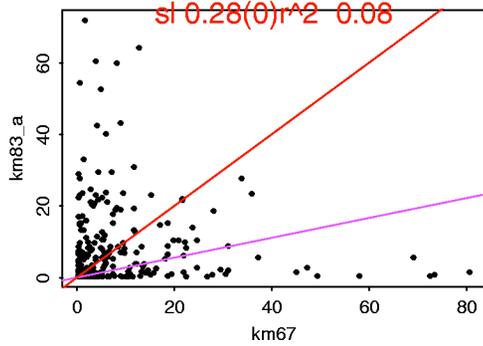
NepstadTR – NepstadCO



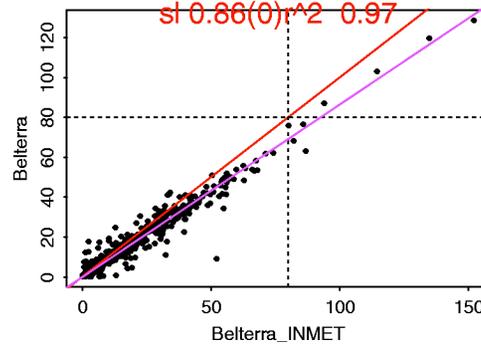
NepstadTR – km67



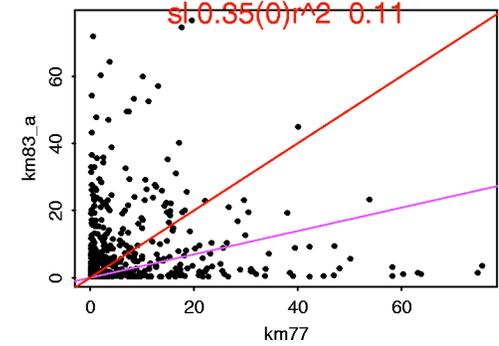
km67 – km83_a



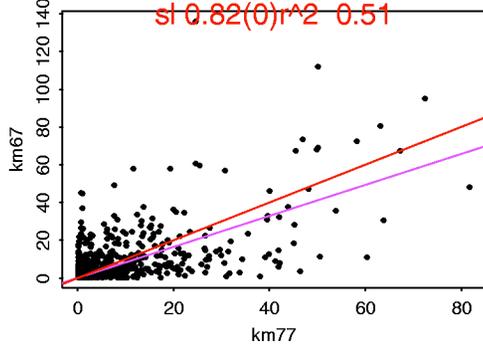
Belterra_INMET – Belterra comp



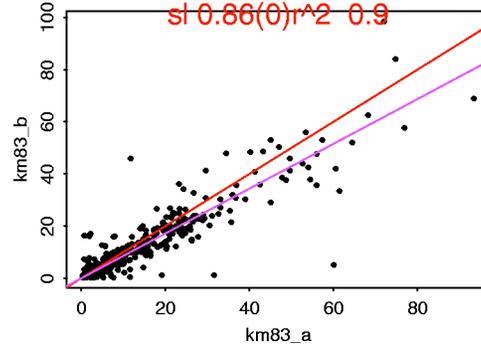
km83_a – km77



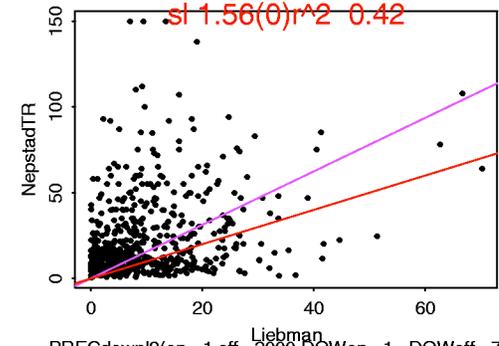
km77 – km67



km83_a – km83_b



Liebman – NepstadTR

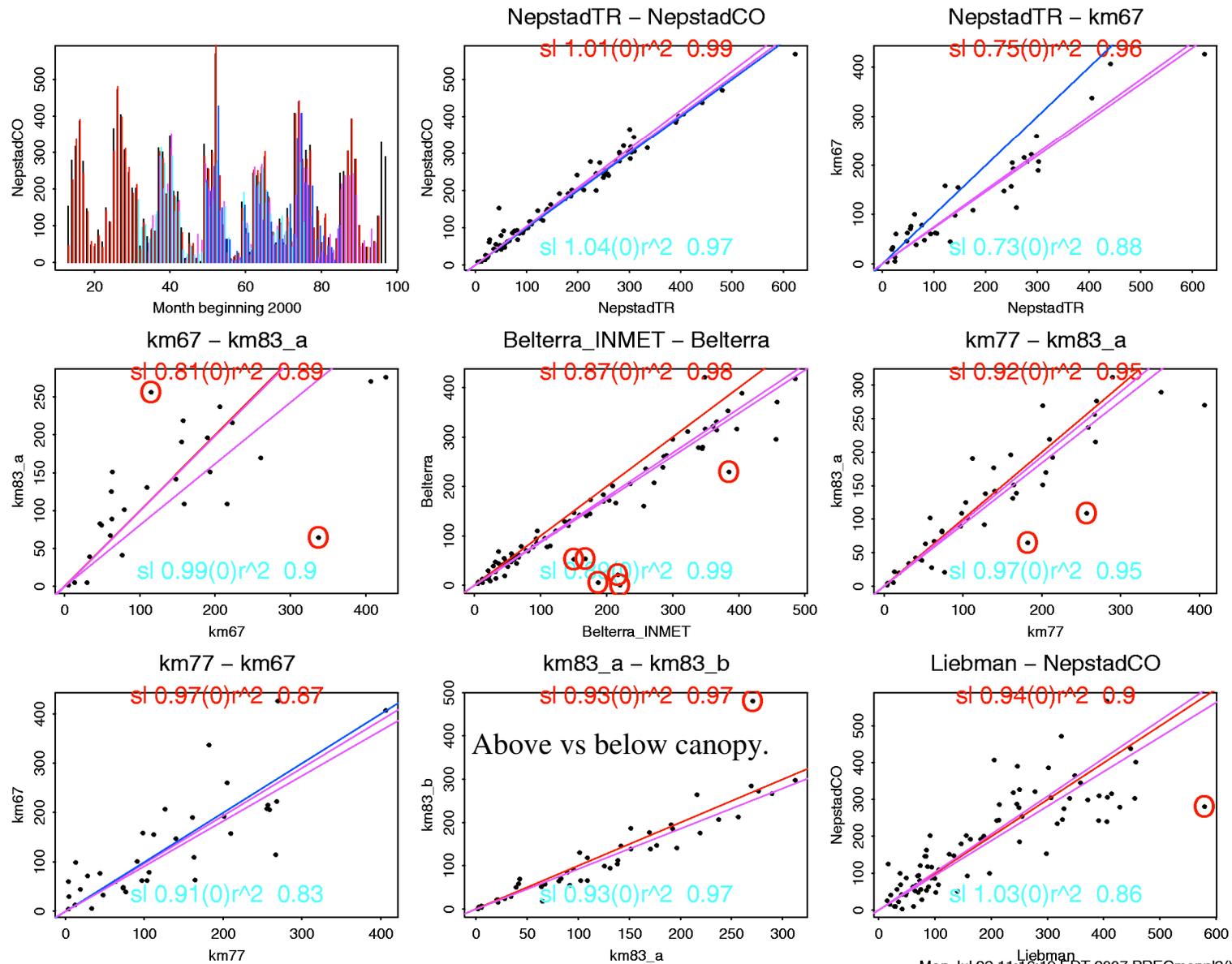


PRECdowpl2(on= 1 off= 3000 DOWon= 1 , DOWoff= 7)

What a mess....

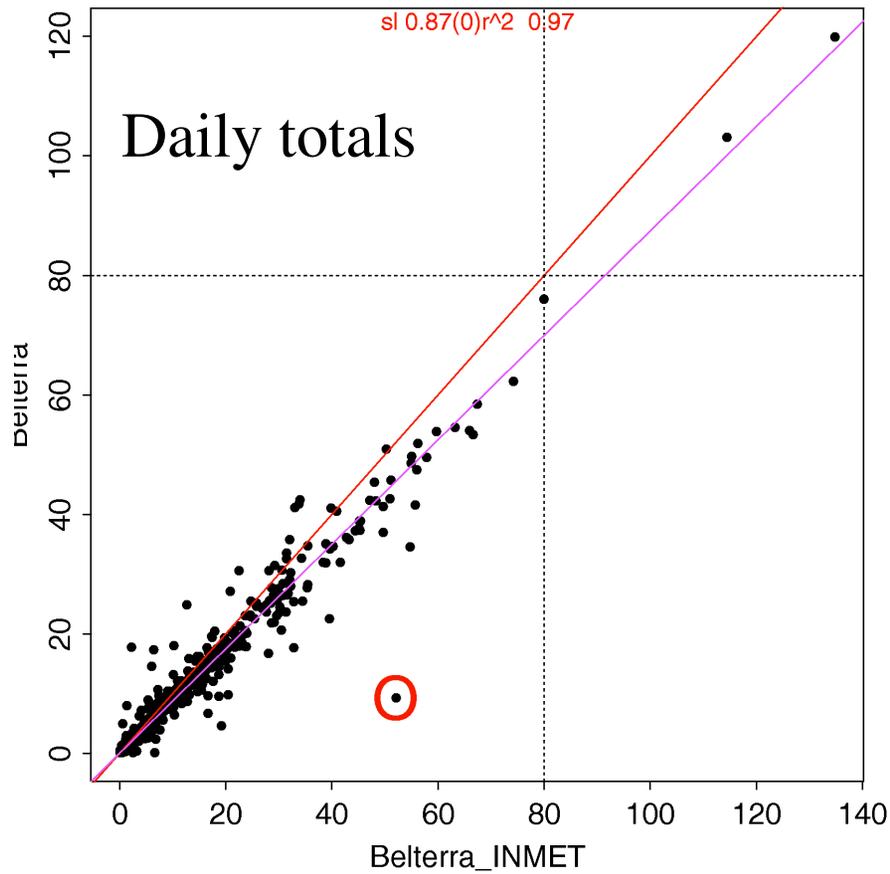
Monthly rainfall totals:

How come the Terra Rica and Casa da Onça results are *so* close?

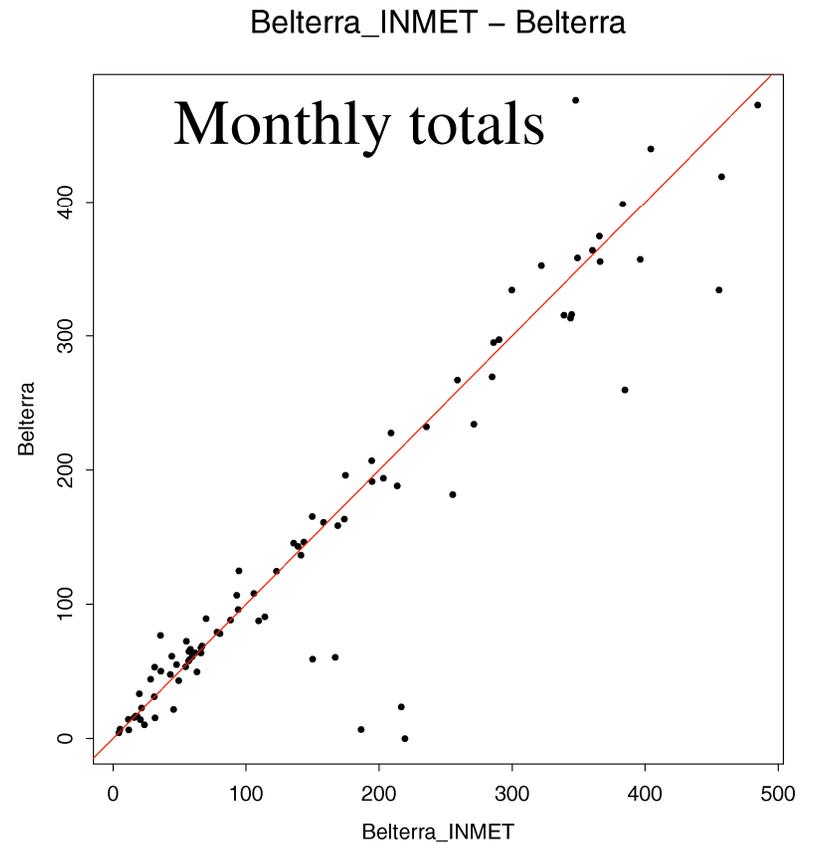


Liebman
Mon Jul 23 11:16:19 EDT 2007 PRECmonpl3()

We must look for consistency. Where there is want of it we must suspect deception.

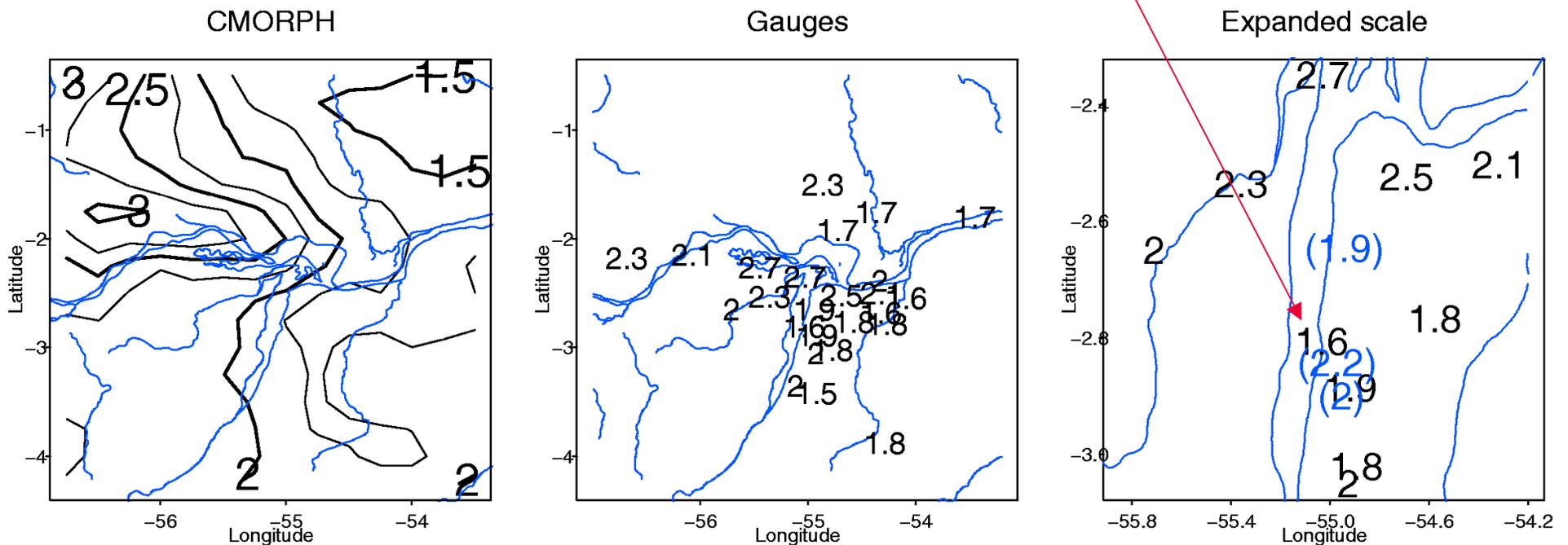


Consistency between Belterra tipping bucket and Belterra INMET totals between daily and monthly used to coordinate comparisons: TB is 13% lower than conventional totals, in the best of situations. This correction is applied in subsequent plots.



Patchy time series: estimate annual total by getting the daily average for each month of the year, then scaling back to annual sum.

Remotely sensible data

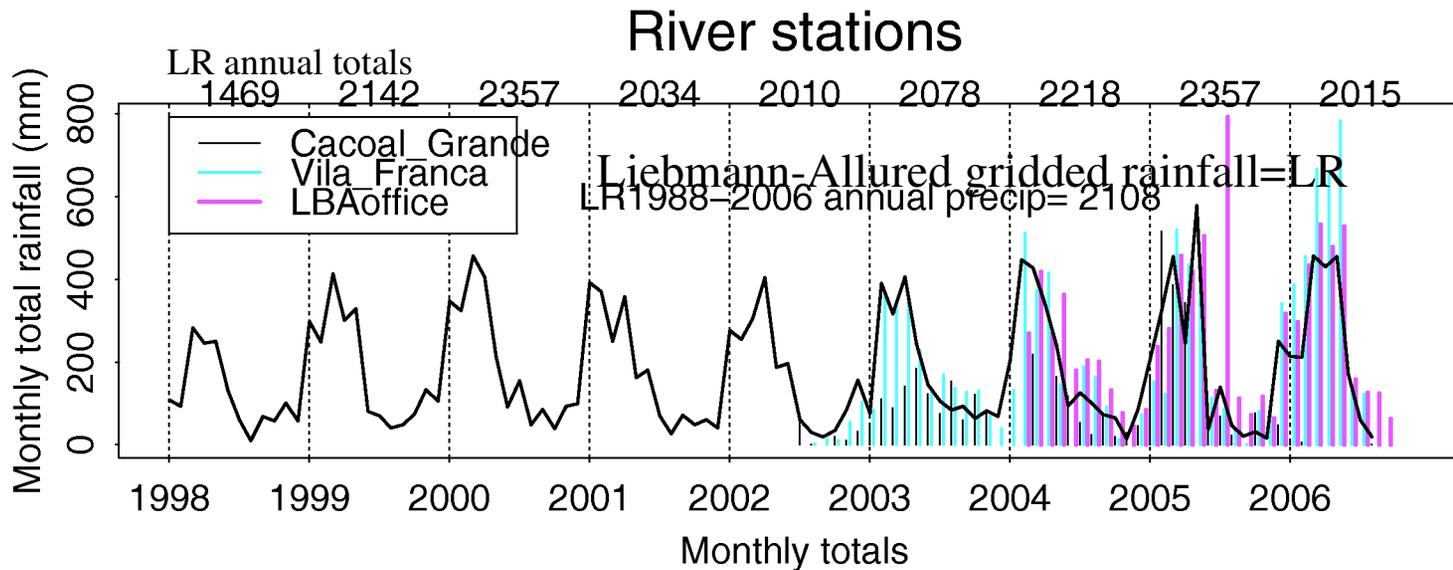
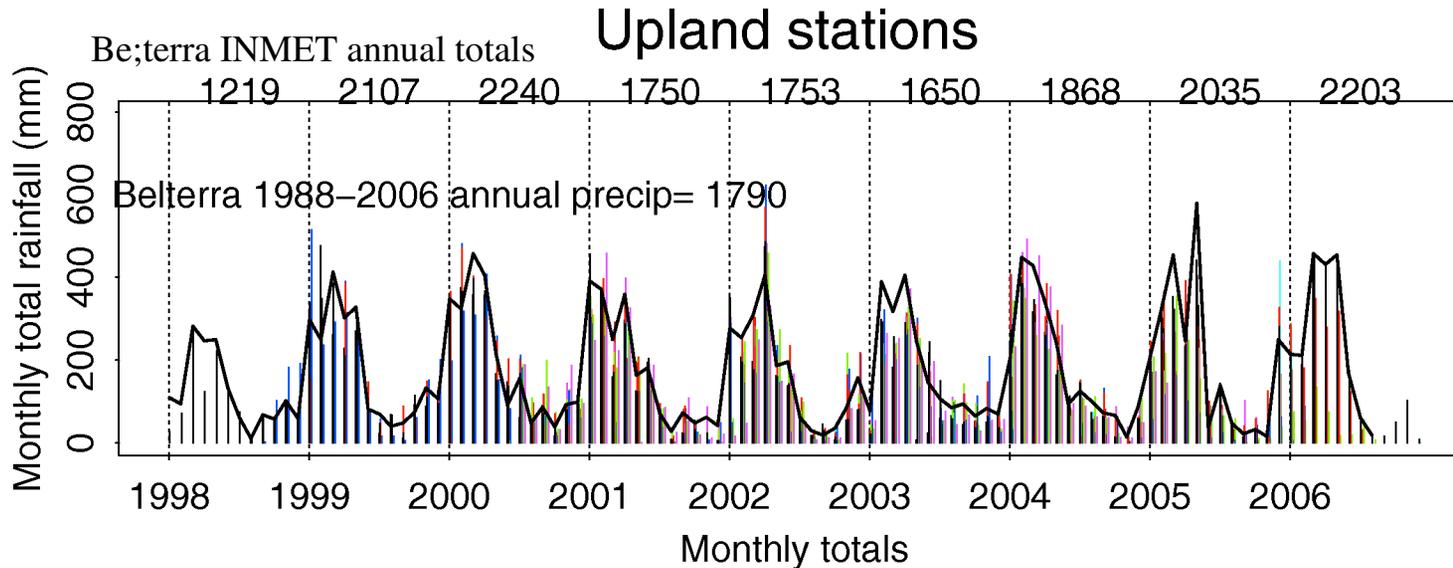


Direct rain gauge results. *Seca Floresta, INMET gauges in ()*

A pattern of strong regional rainfall gradients emerges in CMORPH, and appear in the direct data too.

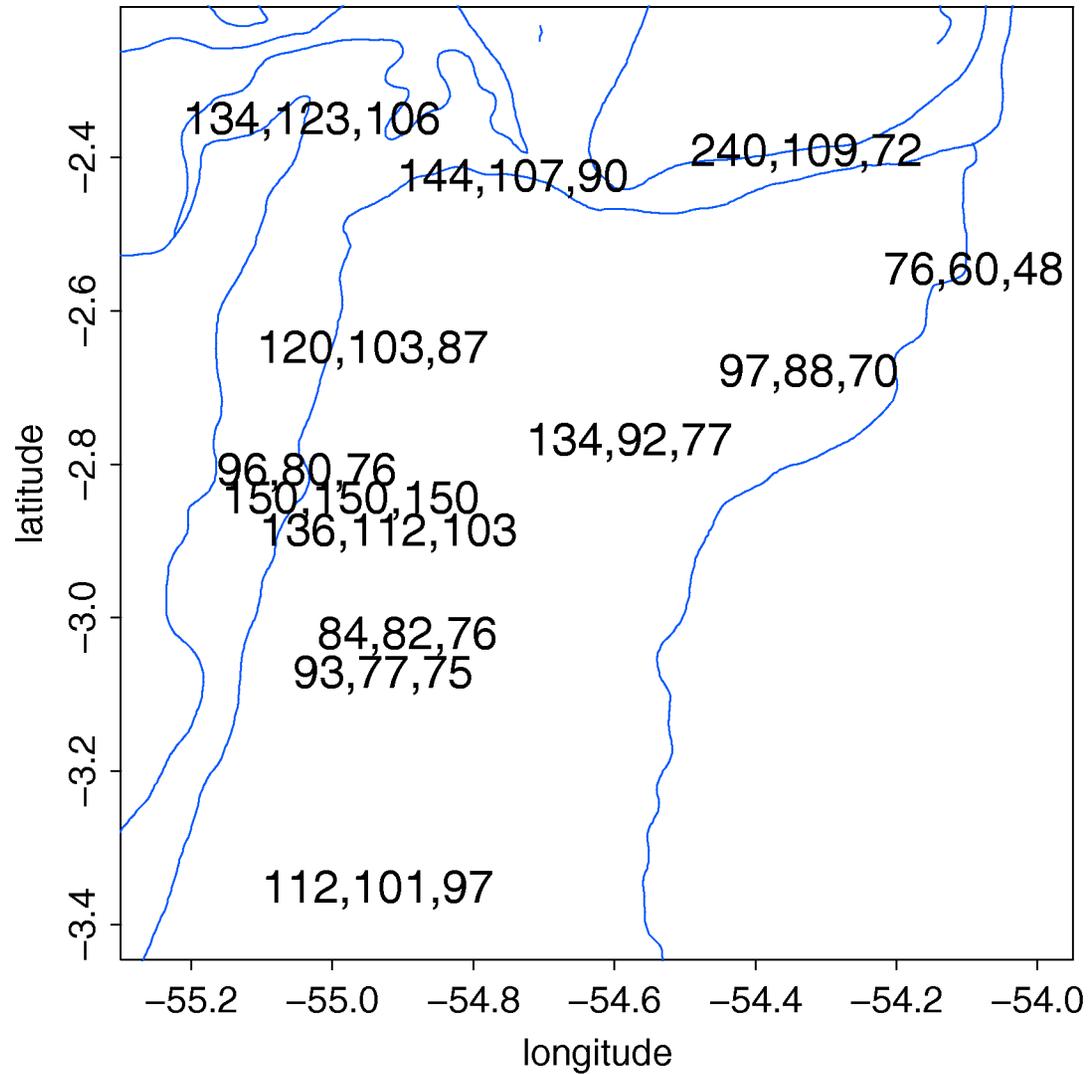
All LBA-ECO years are not identical; should our claims of general results occasionally be tempered?

Popular gridded rainfall data follows the higher values for stations close to the Amazon channel.



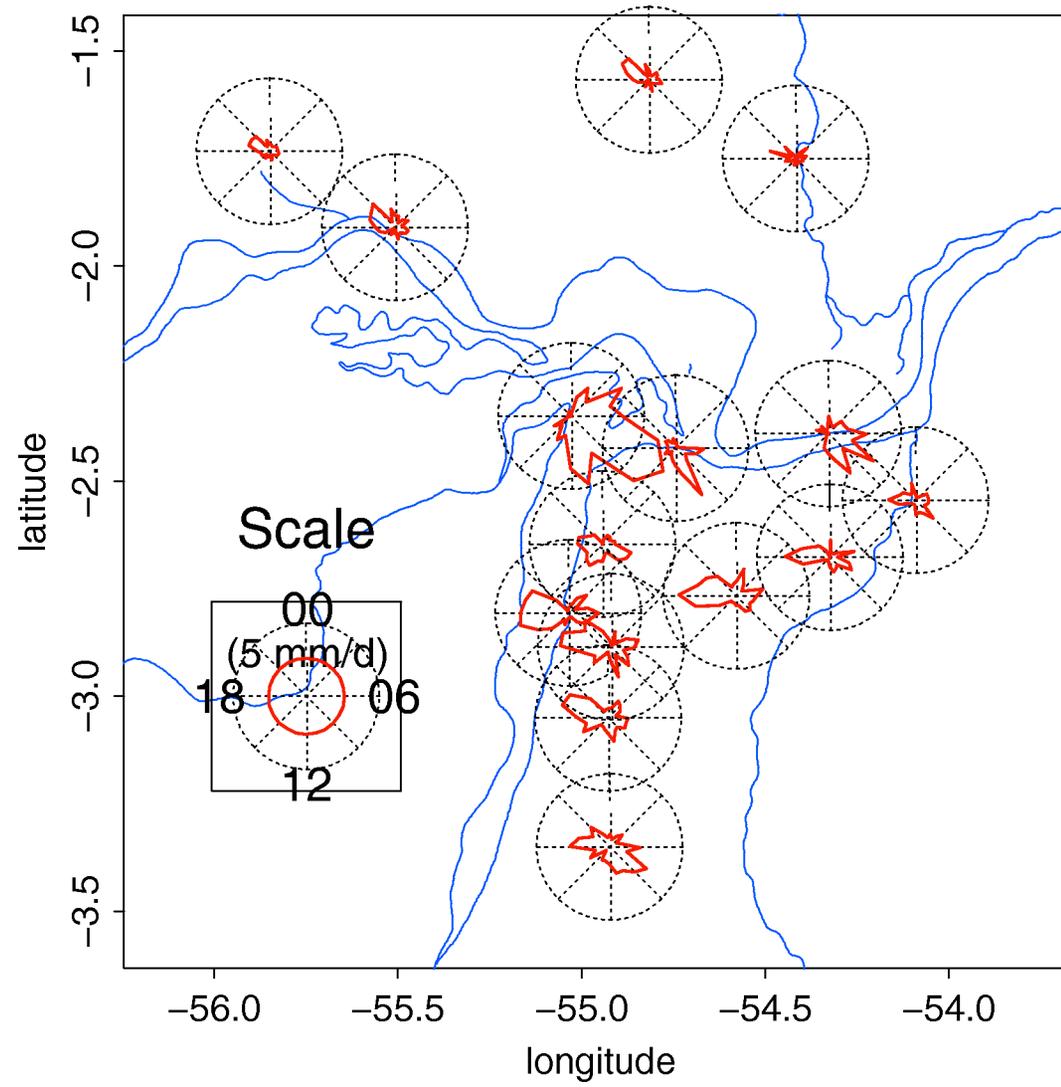
Some preference for extreme rainfall along the Amazon channel.

Extreme daily precipitation (mm)

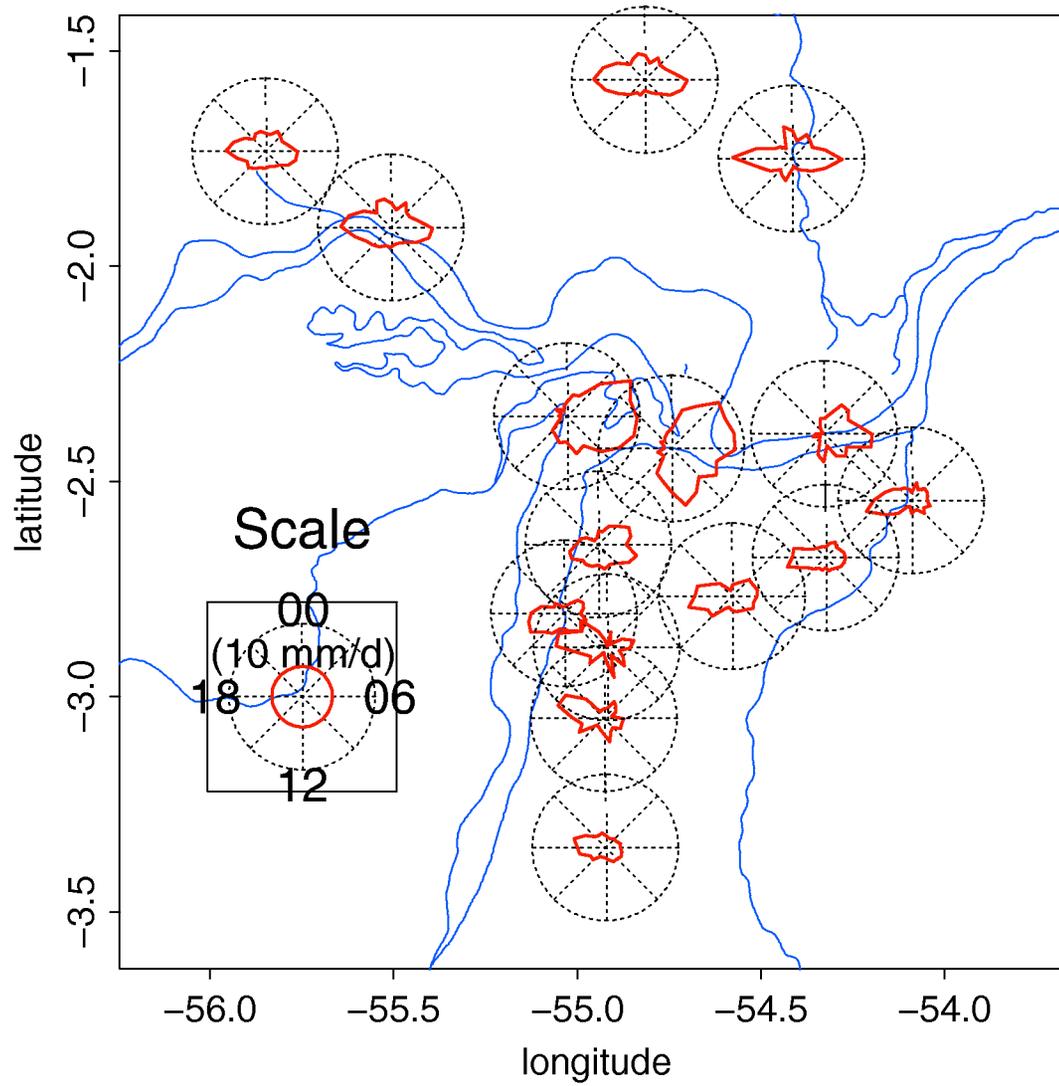


Dry season, days 196-348

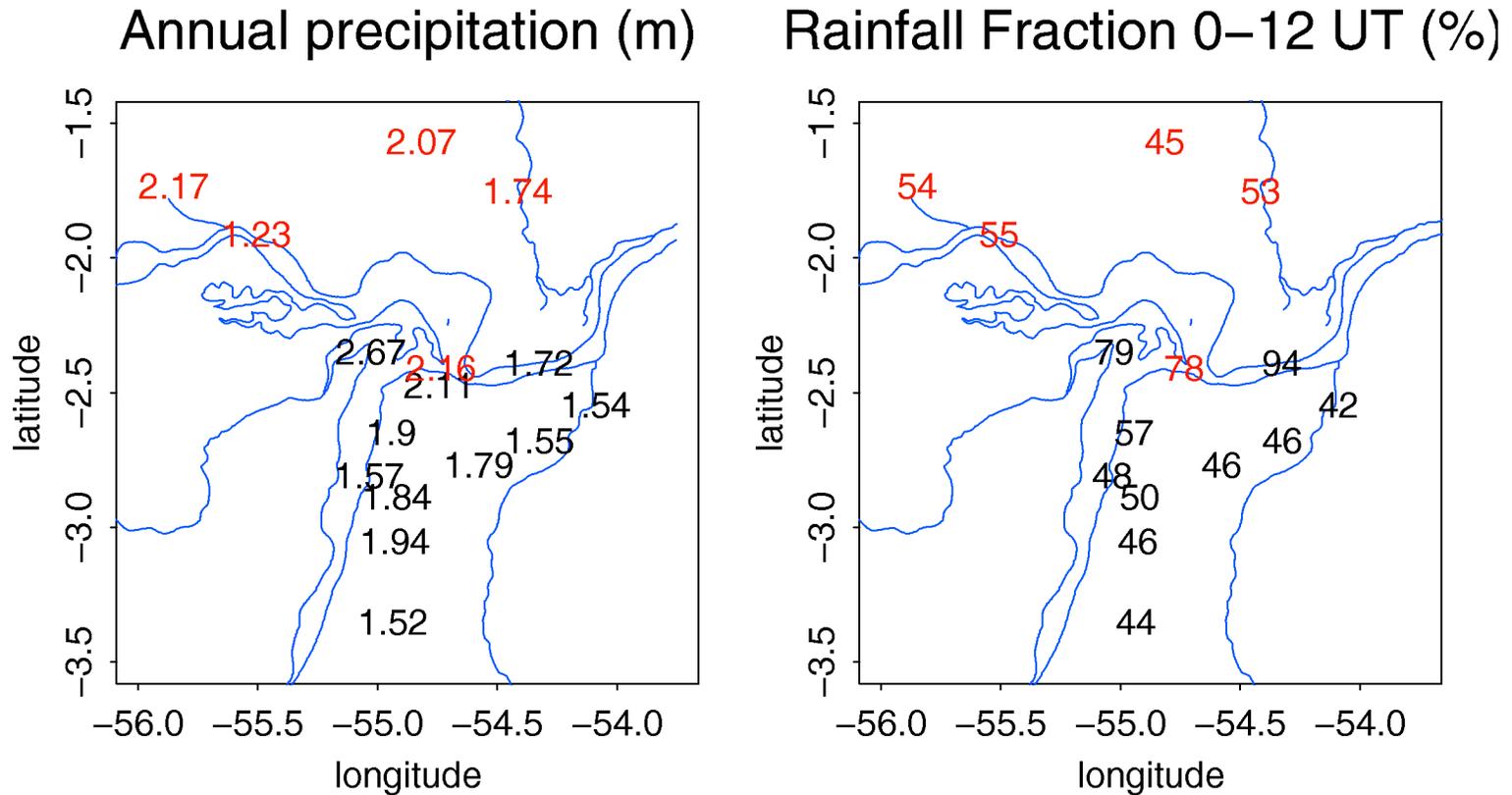
Dry Season



Wet Season



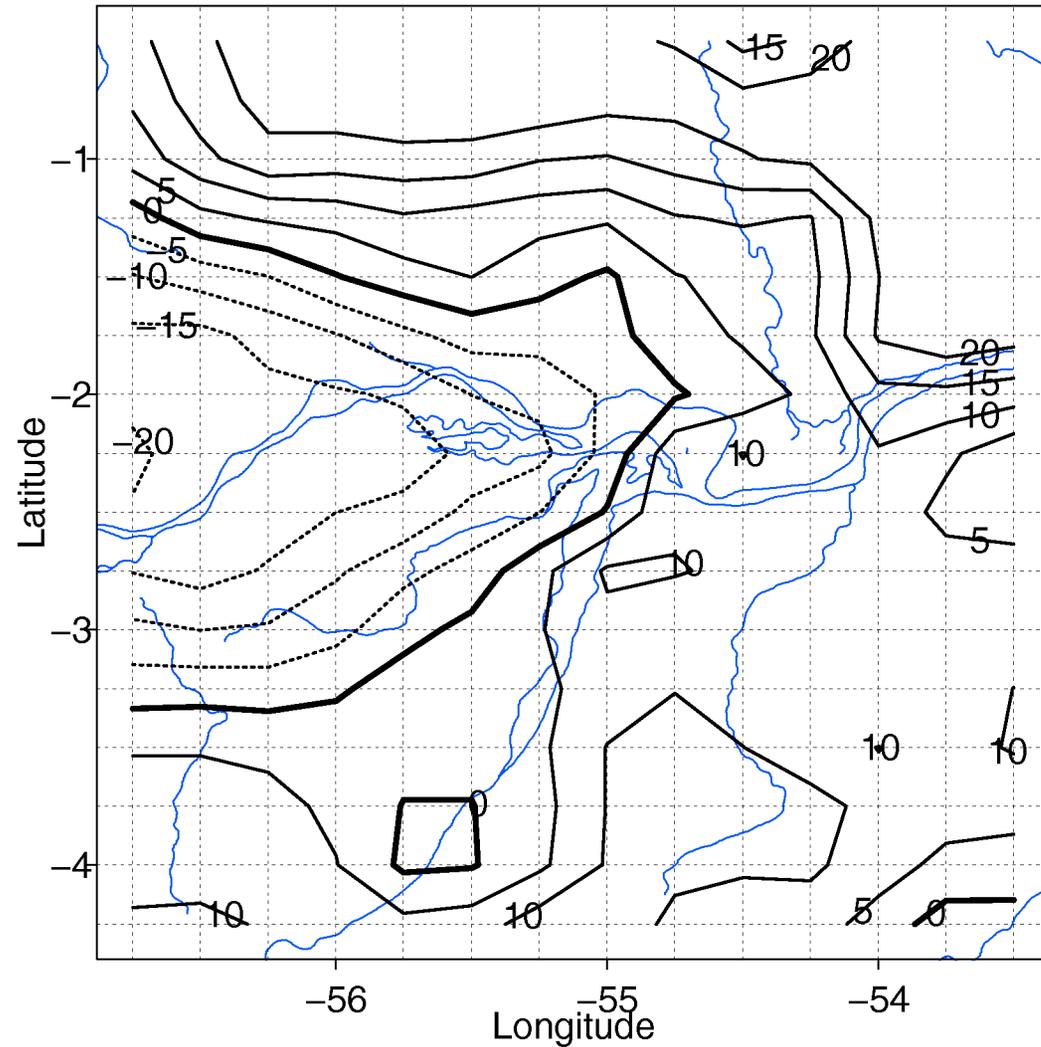
Summarizing the preference for nocturnal rainfall regionally.



The world is full of obvious things which nobody by any chance ever observes.

CMORPH results...

12UT–24UT precipitation fraction (%)



Preference for daytime
rainfall:

$$100 * (P_{\text{day}} - P_{\text{night}}) / P_{\text{total}}$$

Conclusions:

Rainfall is largest near the Amazon channel, where it is predominantly nocturnal. Amazon River breezes affects rainfall more than does the Tapajós breeze (normal to the predominant wind).

Speculation

The presence of the large 'lake' of open water at the rivers' confluence leads to processes that intensify nocturnal precipitation. As squall lines approach this region, enhanced moist inflow is possible, perhaps augmented by southerly channeling up the Tapajós channel as the storm approaches.

Larger rainfall totals further west could plausibly result from convergence promoted by the narrowing channel.

Future plans:

Address the channeling, breeze issue using mesoscale modeling case studies of well-documented individual squall line passages. (Júlia Cohen visiting Albany this year.)

Analyze CMORPH rainfall data at higher resolution. (It's really pretty good!).

Circumstantial evidence is a very tricky thing. It may seem to point very straight to one thing, but if you shift your own point of view a little, you may find it pointing in an equally uncompromising manner to something entirely different.

We balance probabilities and choose the most likely. It is the scientific use of the imagination. - *Sherlock Holmes*

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Michael Keller got the network started by facilitating the transfer of the original two weather stations to the region.

Initial installations at Belterra and km117 was guided by expert technician **Jorge de Melo** of CPTEC before the rest of the LBA-ECO Project began in earnest.

Carlos F. Angelis of CPTEC provided data from the *Hidro* network.

We are grateful for help in the field by **Kathleen Moore, Dwayne Spiess, Ralf Staebler, Alex Tsoyref, Eleazar Brait, Valdelírio Miranda**, and the rest of the staff of the LBA-ECO office in Santarém for logistics and other support, especially **Bethany Reed**.

Crucial daily total rainfall data for the Belterra INMET station was provided through the kind offices of **Alaor Moacyr Dall'Antonia Junior** and Director **Divino Moura** of INMET.

We are very pleased by the work of the CPC CMORPH team at the U.S. National Weather Service who have made those data available to the community.



That's all, from beginning...

I miss all of you. ---Dave

to end...

