Probability

Multi-dimensional probability distribution

$$P(\underbrace{X_1, X_2, X_3, ..., X_n}_{\text{Random variables}})$$

Example with two variables

Marginal probability

$$p(X_1) = \sum_{X_2} p(X_1, X_2)$$

Example with two variables

Conditional probability

$$p(X_1|X_2) = \frac{p(X_1, X_2)}{p(X_2)}$$

$$p(X_2|X_1) = \frac{p(X_1, X_2)}{p(X_1)}$$

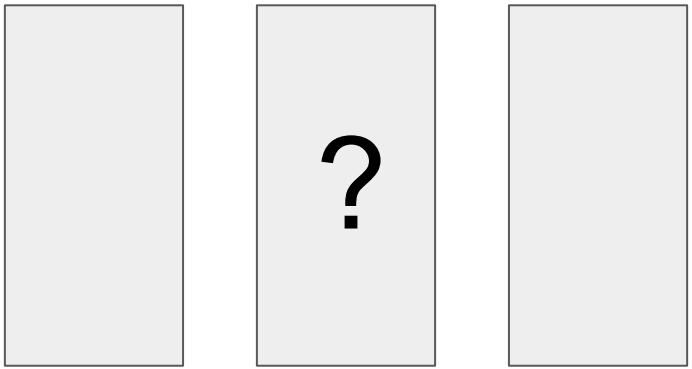
Example with two variables

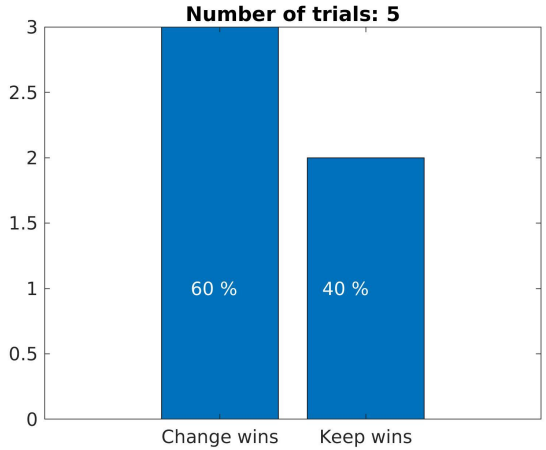
Monthy Hall problem

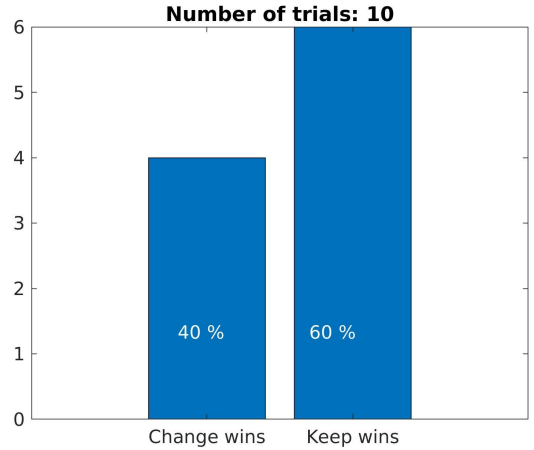
Description:

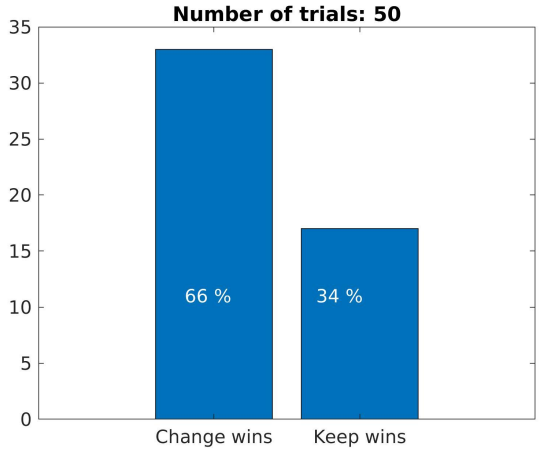
- 3 doors, one prize hidden behind one of them.
- STEP 1: You choose one door, kept closed.
- STEP 2: A person, who knows where is the prize, opens another door than yours. That door must be empty (can’t open the winning door).
- STEP 3: That person now asks you and if you want to change your first choice.

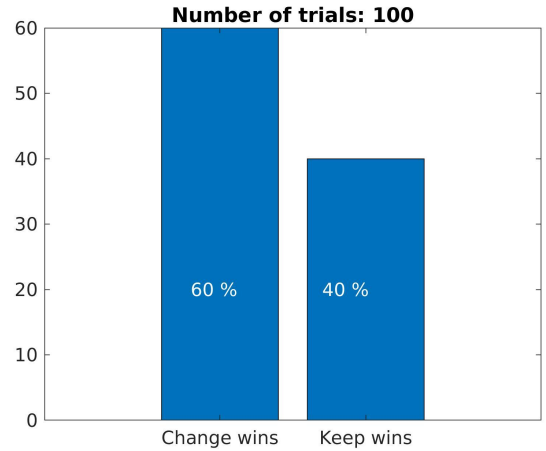
What should you do?

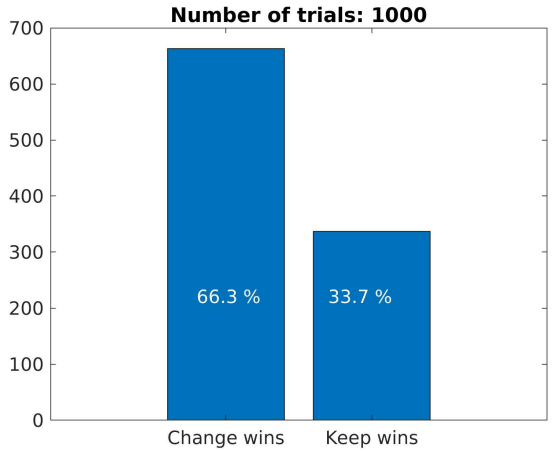


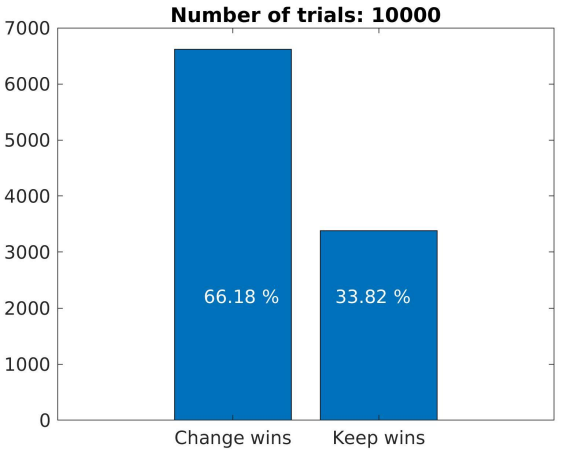

Number of trials: 5
3
2.5
2
1.5
1
0.5
0
60 %
40 %
Change wins
Keep wins


Number of trials: 10
6
5
4
3
2
1
0
40 %
60 %
Change wins
Keep wins


Number of trials: 50
35
30
25
20
15
10
5
0
66 %
34 %
Change wins
Keep wins


Number of trials: 100
60
50
40
30
20
10
0
60 %
40 %
Change wins
Keep wins


Number of trials: 1000
700
600
500
400
300
200
100
0
66.3 %
33.7 %
Change wins
Keep wins


Number of trials: 10000
7000
6000
5000
4000
3000
2000
1000
0
66.18 %
33.82 %
Change wins
Keep wins

Bayes theorem

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

Independent variables

$$p(X_1, X_2, X_3, X_4) = p(X_1)p(X_2)p(X_3)p(X_4)$$

Pairwise dependent (Markov chain)

$$p(X_1, X_2, X_3, X_4) = p(X_1)p(X_2|X1)p(X_3|X_2)p(X_4|X_3)$$

A hint!

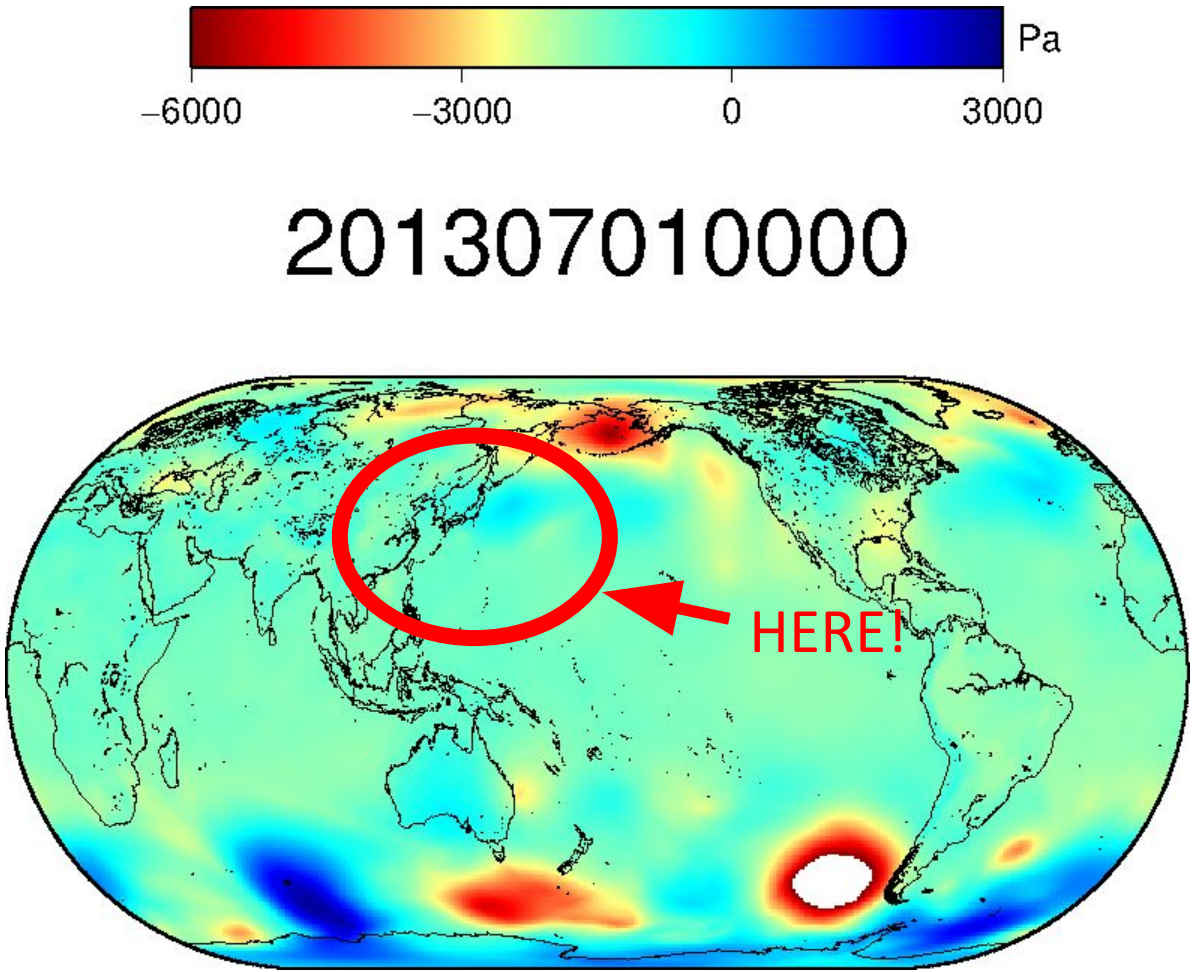
Always think and work in terms of entire tables! (this is not always honoured in courses in mathematical statistics, but it is good advice)

If all you need is a particular value in some table, think first how to calculate the entire table, and only thereafter pick the value you need.

This is because there is usually no shortcut directly to the value you need, and formulas become simpler.

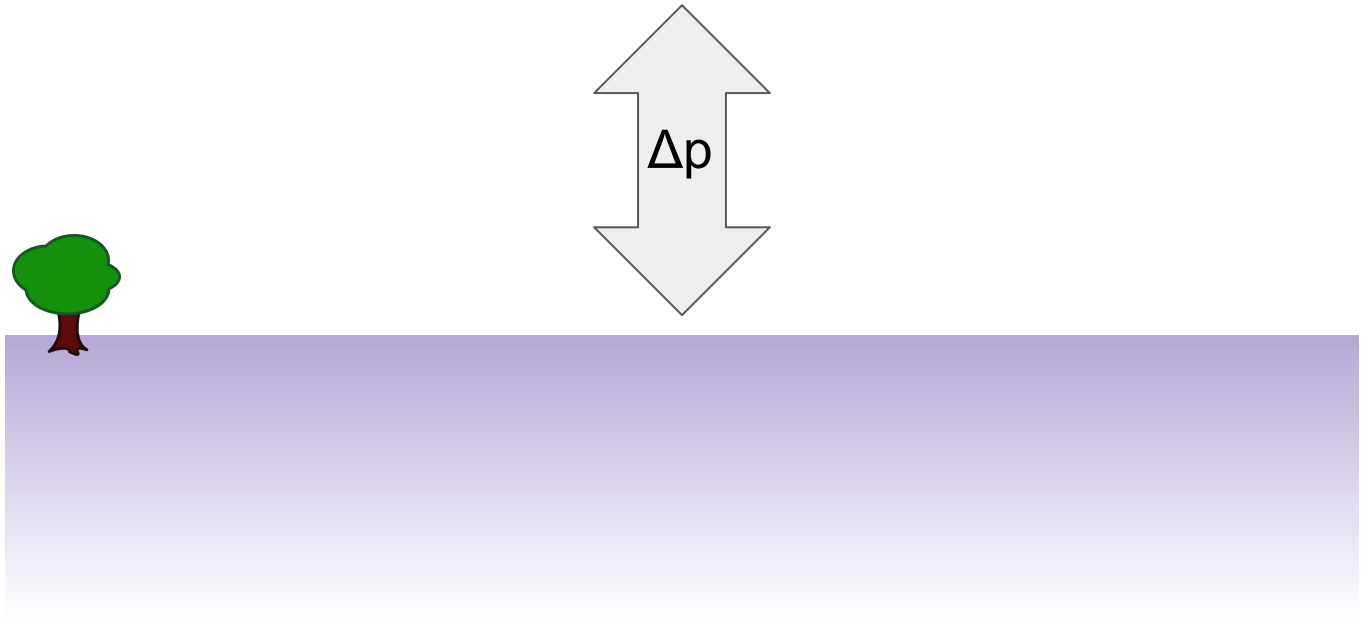
Can typhoons trigger earthquakes ?

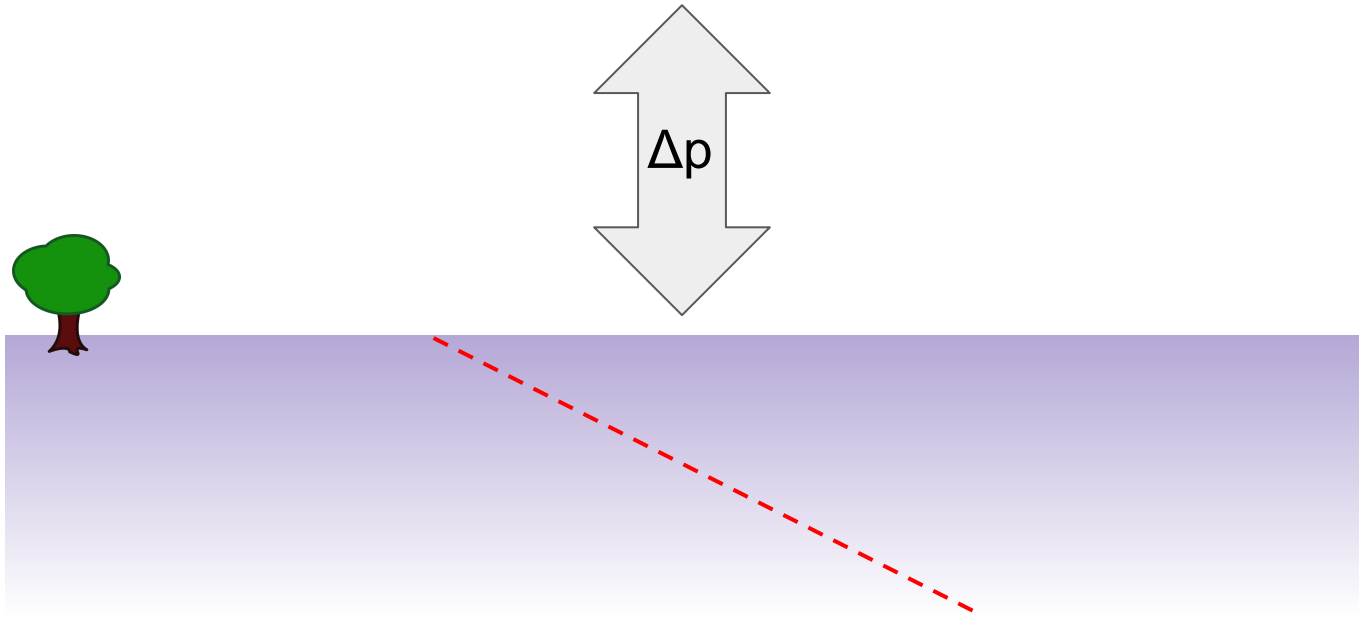
A personal perspective (-- *not* probability --)

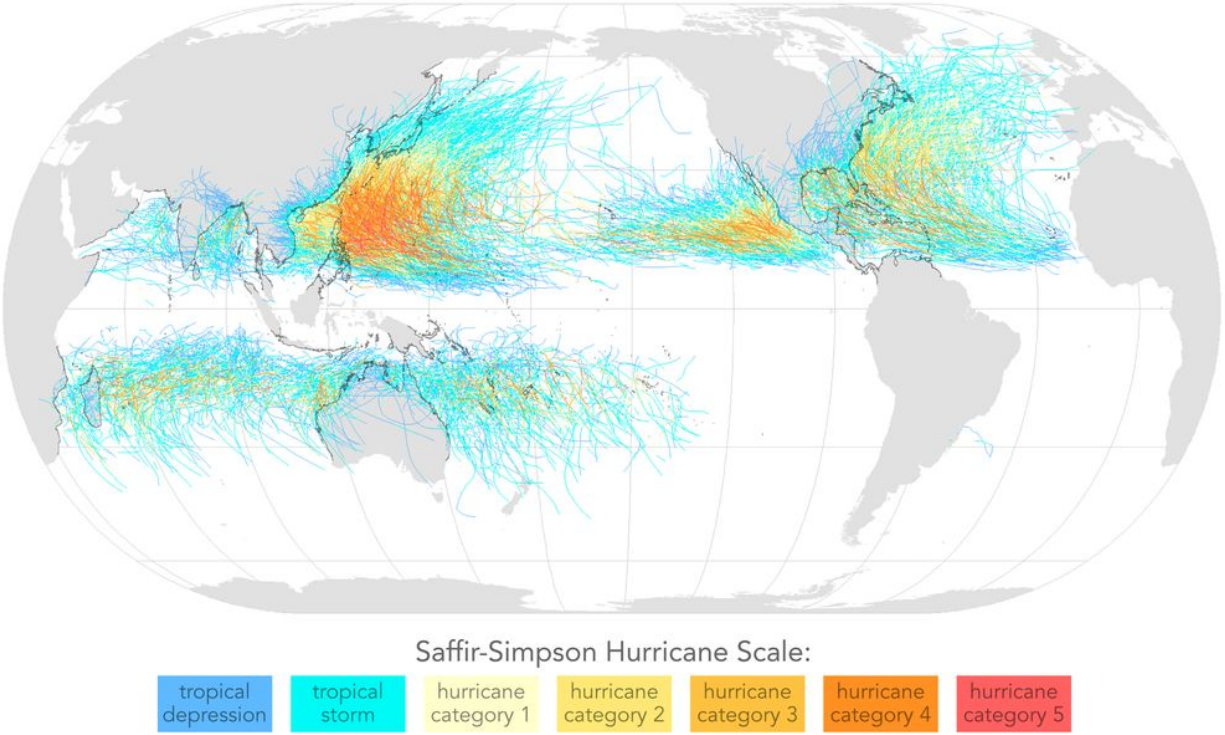


Surface air pressure variations

What is air pressure ?

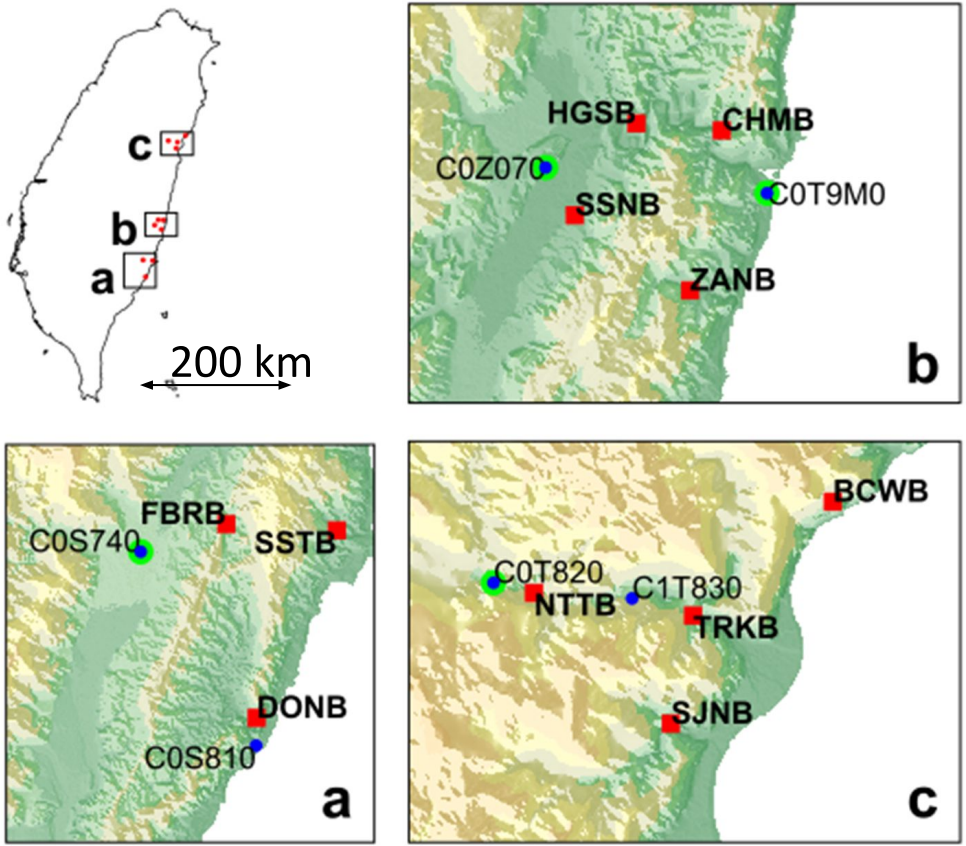

Δp


Δp



Tropical Cyclones, 1945–2006. Data from the Joint Typhoon Warning Center and the U.S. National Oceanographic and Atmospheric Administration

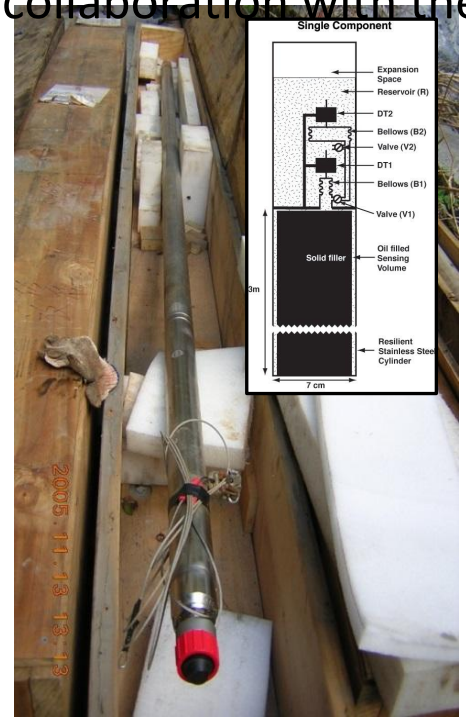
Dense borehole strainmeters network

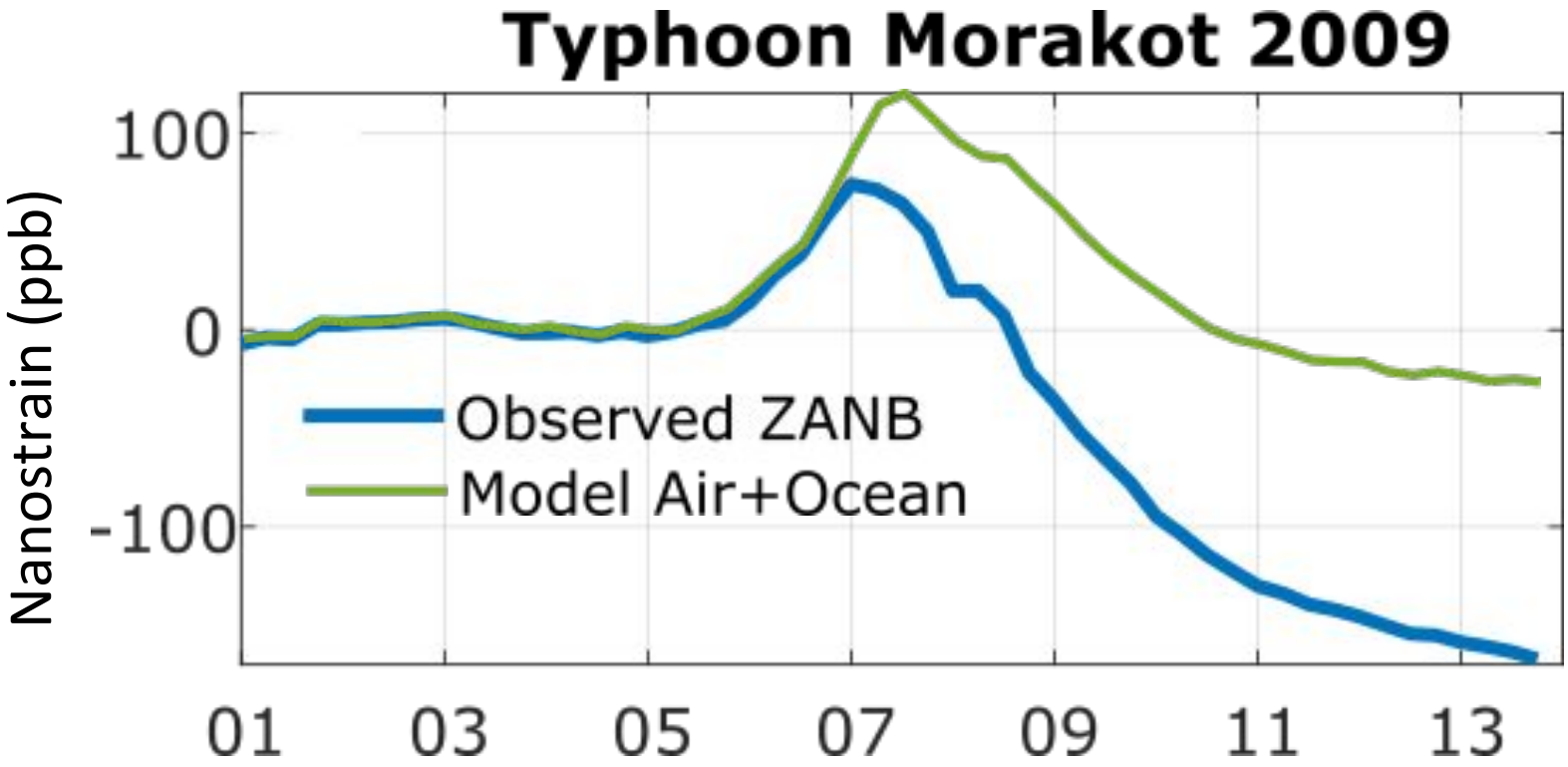


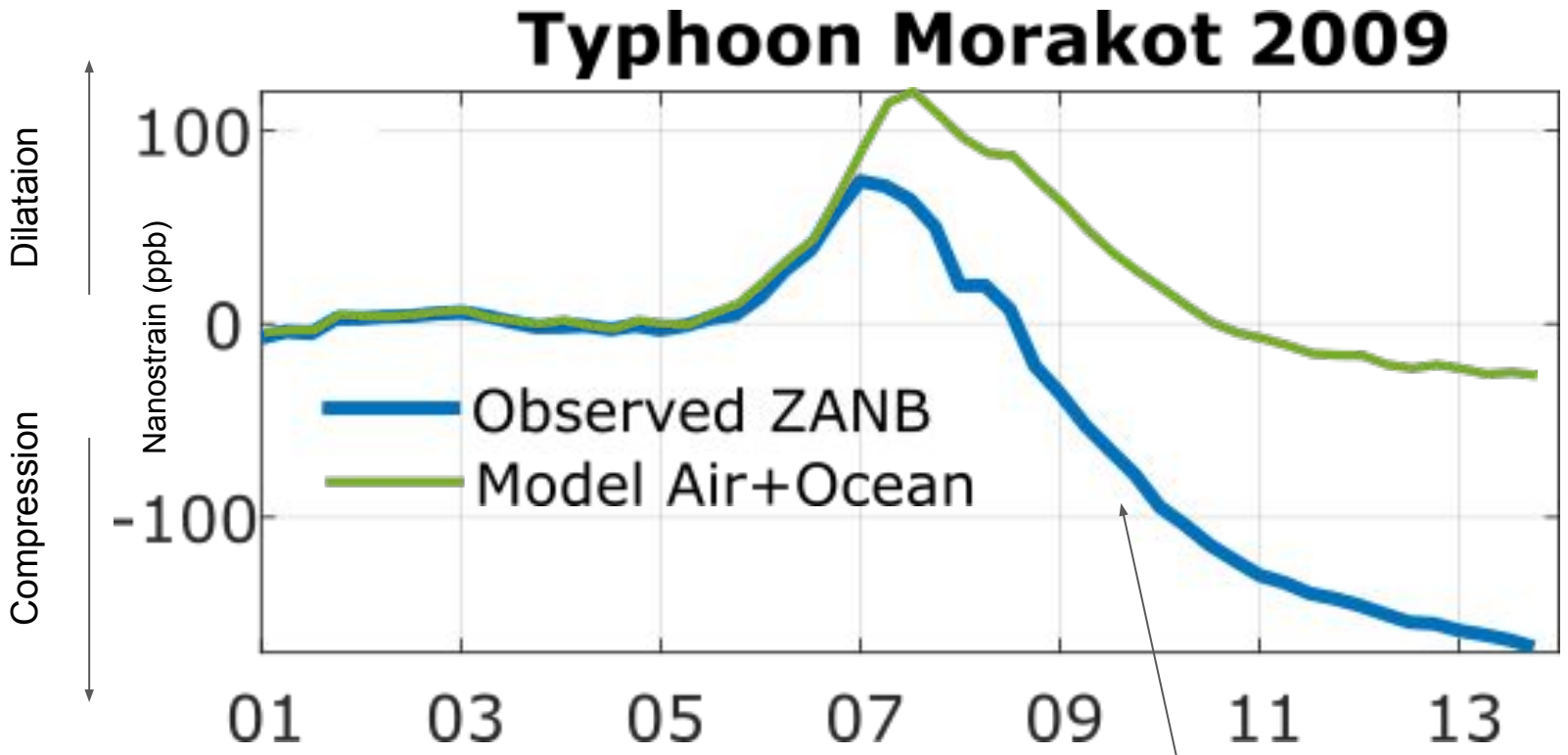
Strainmeters set at 200 m depth on average

Sacks-Evertson borehole strainmeter

in collaboration with the DTM, Carnegie institution of Washington




Typhoon Morakot 2009
Nanostrain (ppb)
100
0
-100
Observed ZANB
Model Air+Ocean
01
03
05
07
09
11
13



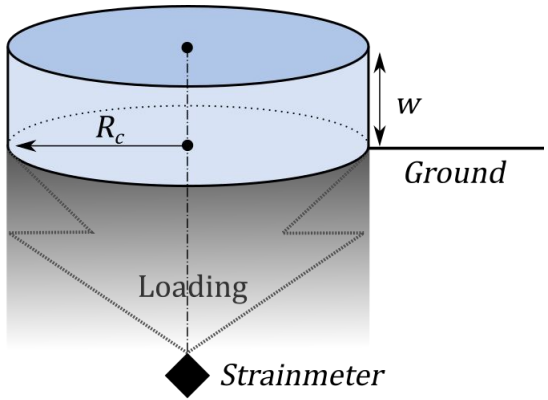
Dilatation ~OK, but miss the compression

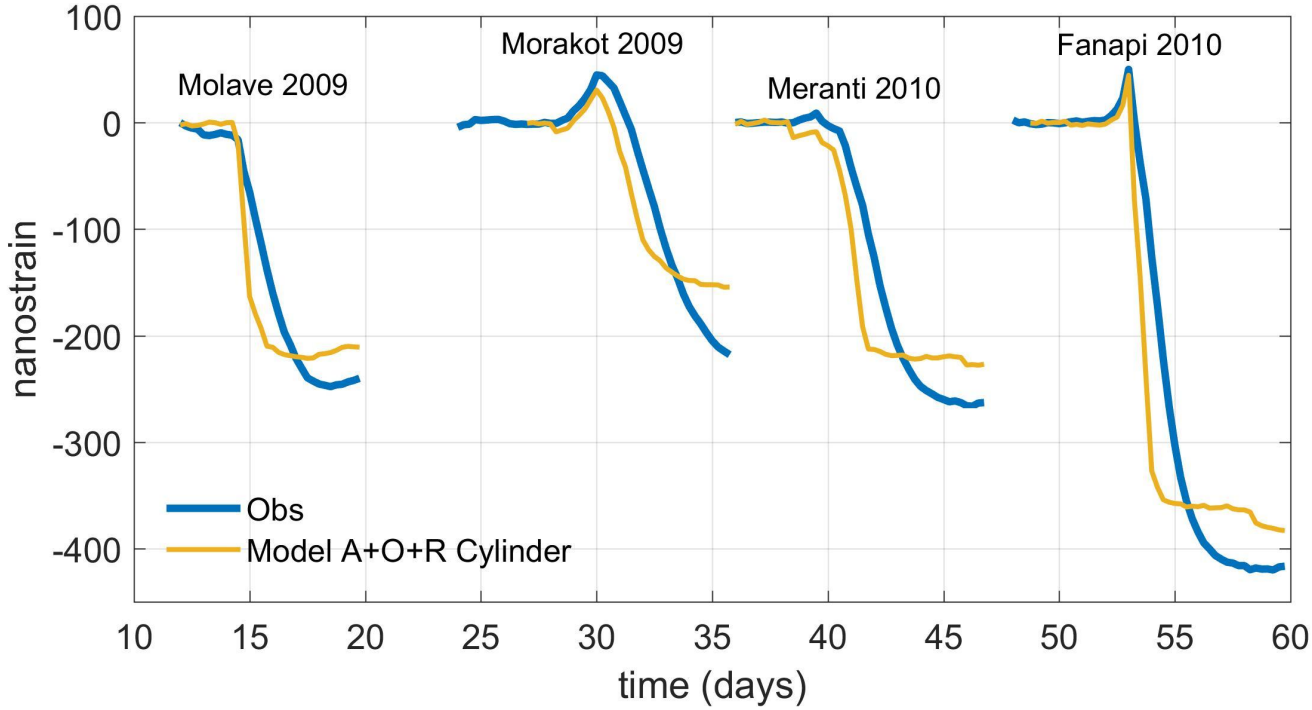
Why ??

Rainwater loading

Use the **closest rainfall gauges** to each studied borehole strainmeter.

A. The rainwater falling nearby the strainmeter immediately loads the ground





Underestimate the amplitude of the compression

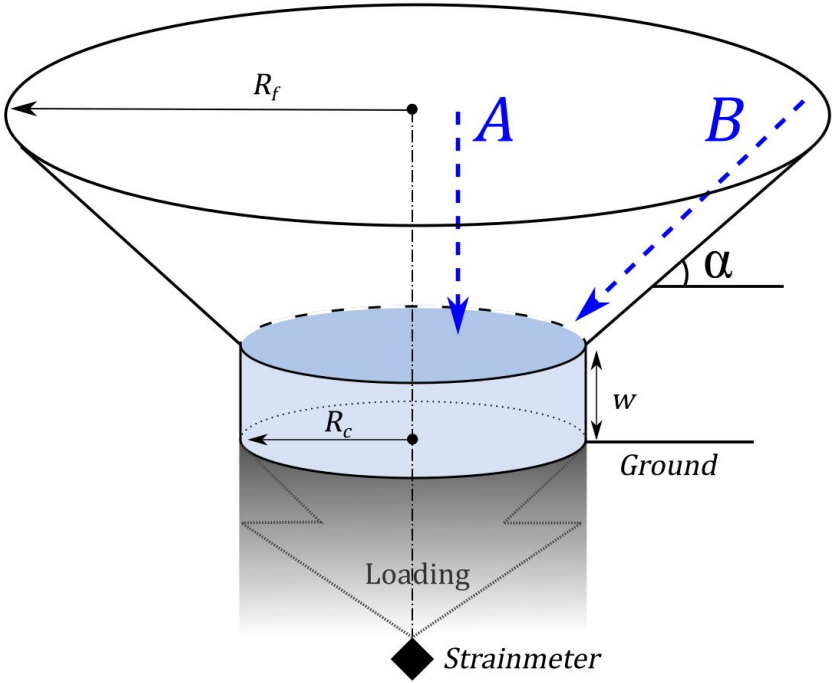
Computed compression too fast

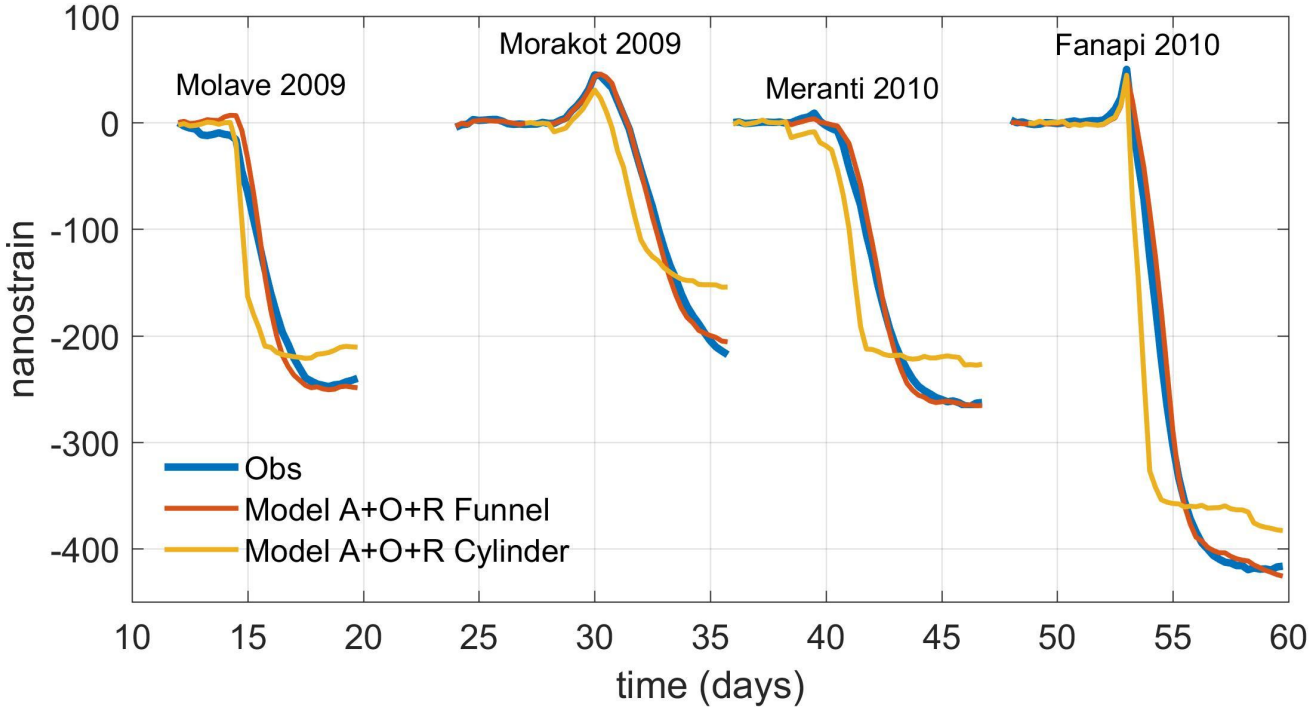
Rainwater loading

Use the **closest rainfall gauges** to each studied borehole strainmeter.

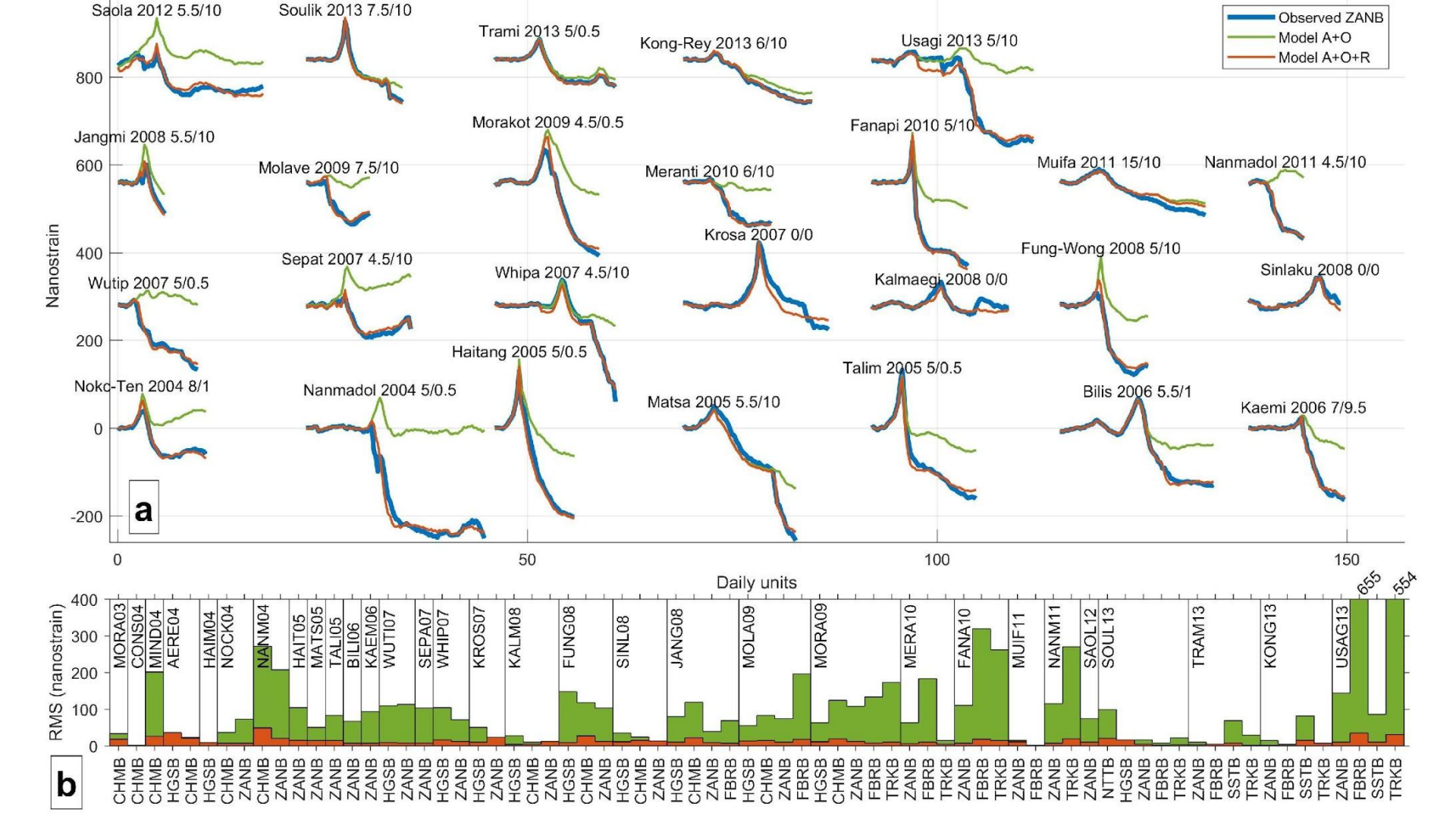
A. The rainwater falling nearby the strainmeter immediately loads the ground

B. The local topography drains the rainwater, which can eventually concentrate toward the strainmeter □ amplified rainwater loading delayed by the draining time

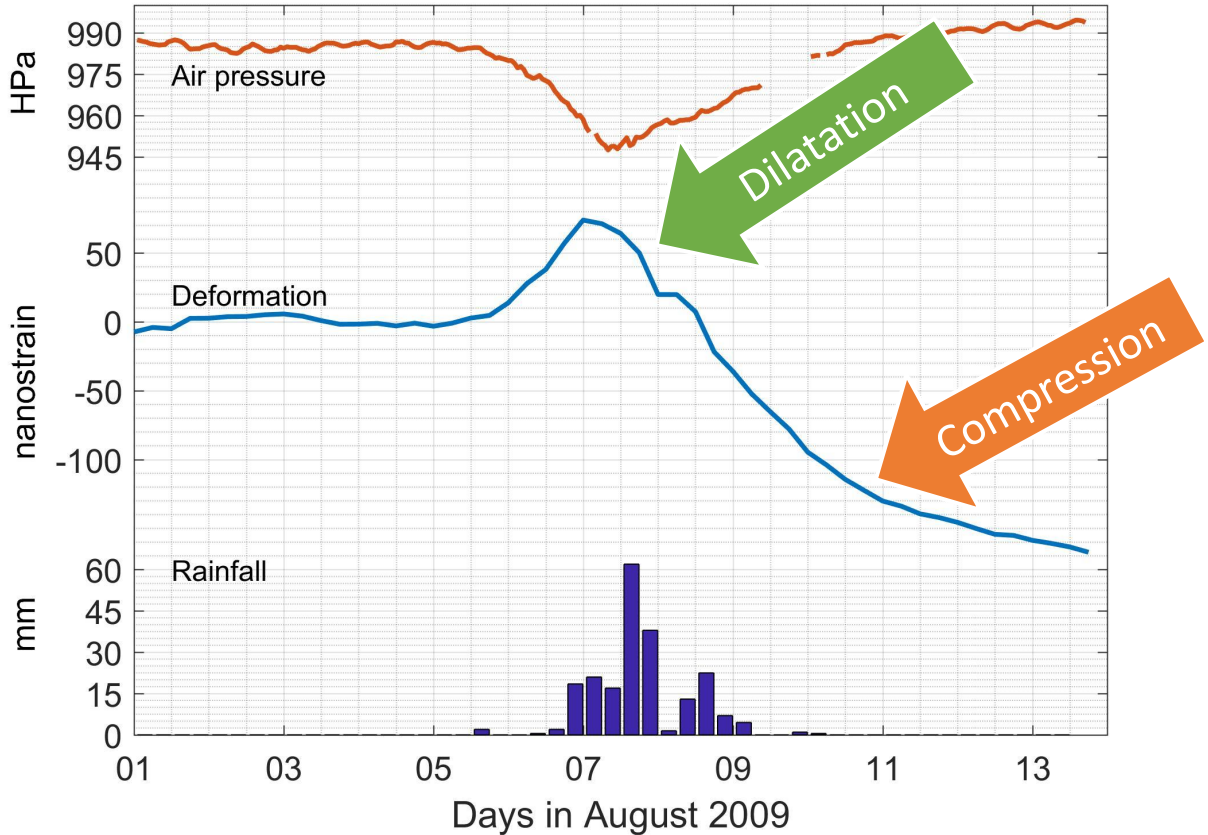




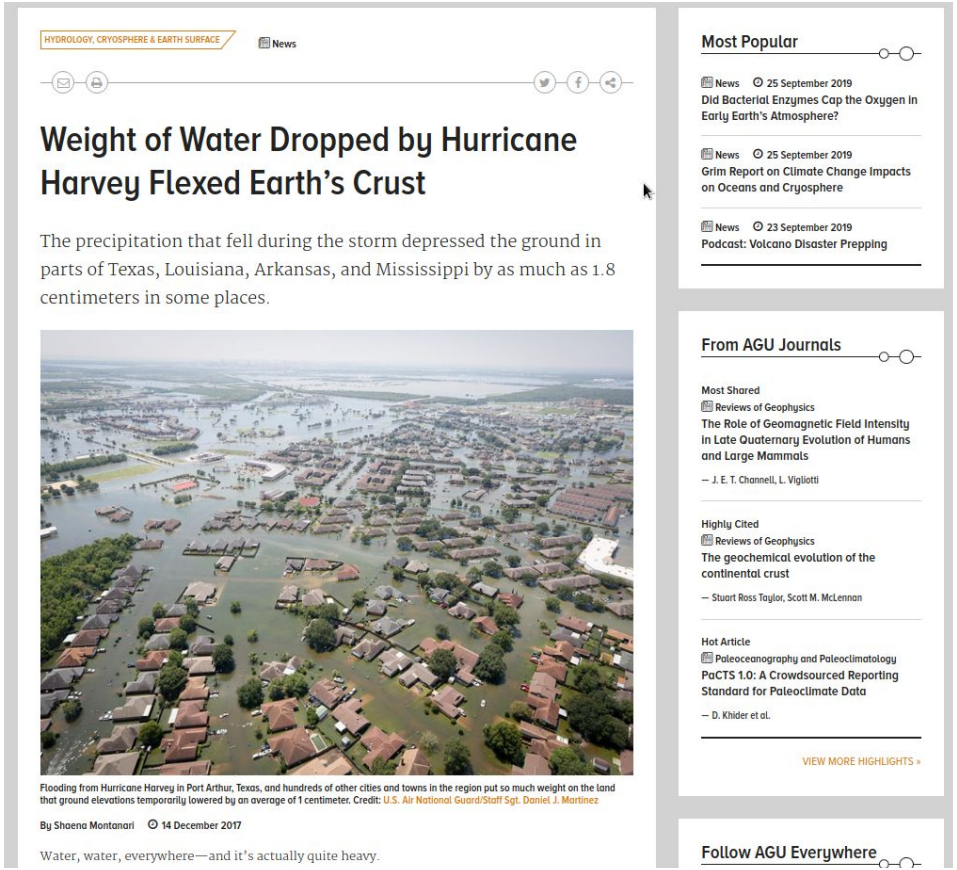
Importance of the draining area
Exhibits the runoff's dynamics


Observed ZANB
Model A+O
Model A+O+R
Saola 2012 5.5/10
Soulik 2013 7.5/10
Trami 2013 5/0.5
Kong-Rey 2013 6/10
Usagi 2013 5/10
Jangmi 2008 5.5/10
Molave 2009 7.5/10
Morakot 2009 4.5/0.5
Meranti 2010 6/10
Fanapi 2010 5/10
Muifa 2011 15/10
Nanmadol 2011 4.5/10
Krosa 2007 0/0
Wutip 2007 5/0.5
Sepat 2007 4.5/10
Whipa 2007 4.5/10
Kalmaegi 2008 0/0
Fung-Wong 2008 5/10
Sinlaku 2008 0/0
Haitang 2005 5/0.5
Talim 2005 5/0.5
Nokc-Ten 2004 8/1
Nanmadol 2004 5/0.5
Matsa 2005 5.5/10
Bilis 2006 5.5/1
Kaemi 2006 7/9.5
Nanostrain
a
Daily units
RMS (nanostrain)
655
554
MORA03
CONS04
MIND04
AERE04
HAIM04
NOCK04
NANM04
HAIT05
MATS05
TALI05
BILI06
KAEM06
WUTI07
SEPA07
WHIP07
KROS07
KALM08
FUNG08
SINL08
JANG08
MOLA09
MORA09
MERA10
FANA10
MUIF11
NANM11
SAOL12
SOUL13
TRAM13
KONG13
USAG13
b

Typhoon's strain signature



https://eos.org/



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Weight of Water Dropped by Hurricane Harvey Flexed Earth's Crust

The precipitation that fell during the storm depressed the ground in parts of Texas, Louisiana, Arkansas, and Mississippi by as much as 1.8 centimeters in some places.

Flooding from Hurricane Harvey in Port Arthur, Texas, and hundreds of other cities and towns in the region put so much weight on the land that ground elevations temporarily lowered by an average of 1 centimeter. Credit: U.S. Air National Guard/Staff Sgt. Daniel J. Martinez

By Shaena Montanari | 14 December 2017

Water, water, everywhere—and it's actually quite heavy.

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Data is the reality, always try to compare models and data

But wrong models can fit data. When you don’t know, try first the simple models and then elaborate.

When models and data still don’t fit, then you may have something new to uncover! (but re-check your computations first)