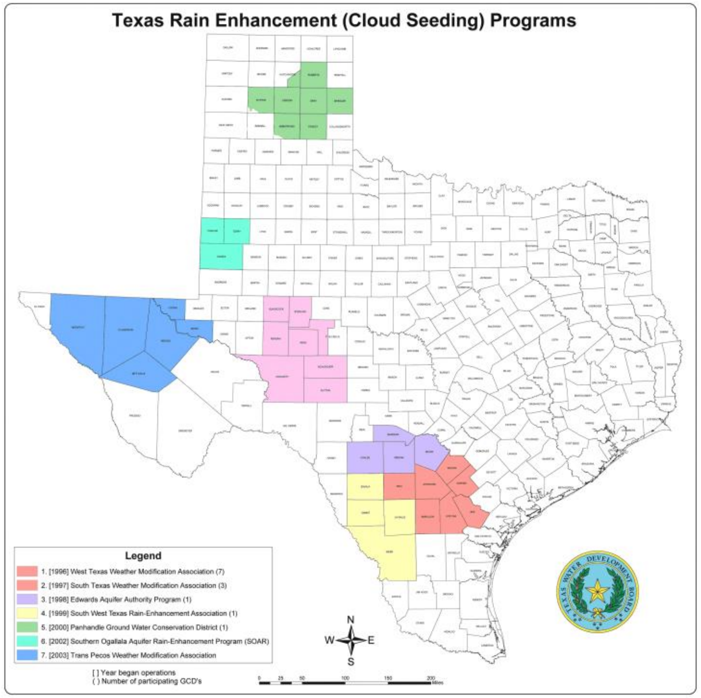
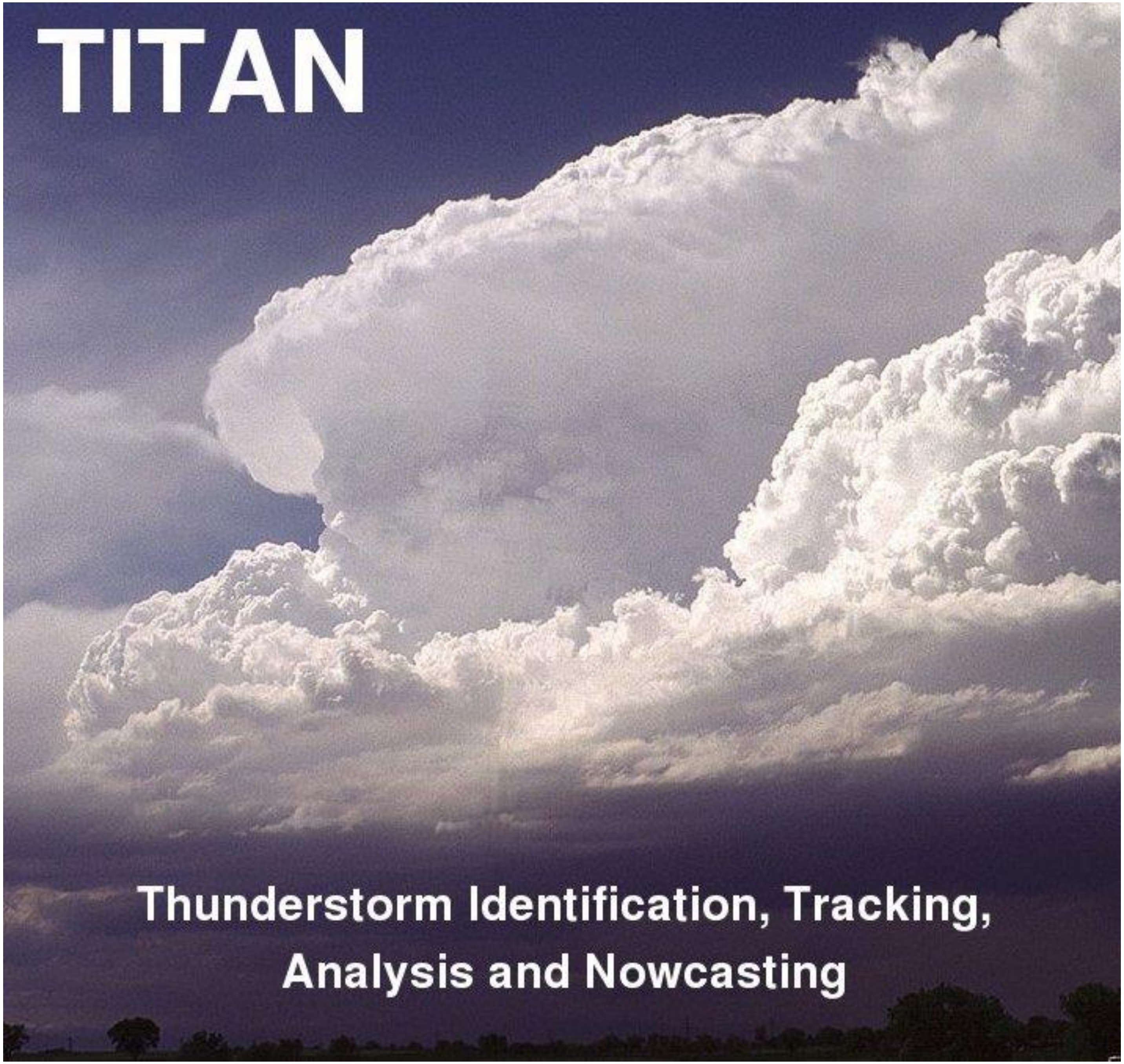
Morphological Analysis of Seeding Signals in Texas

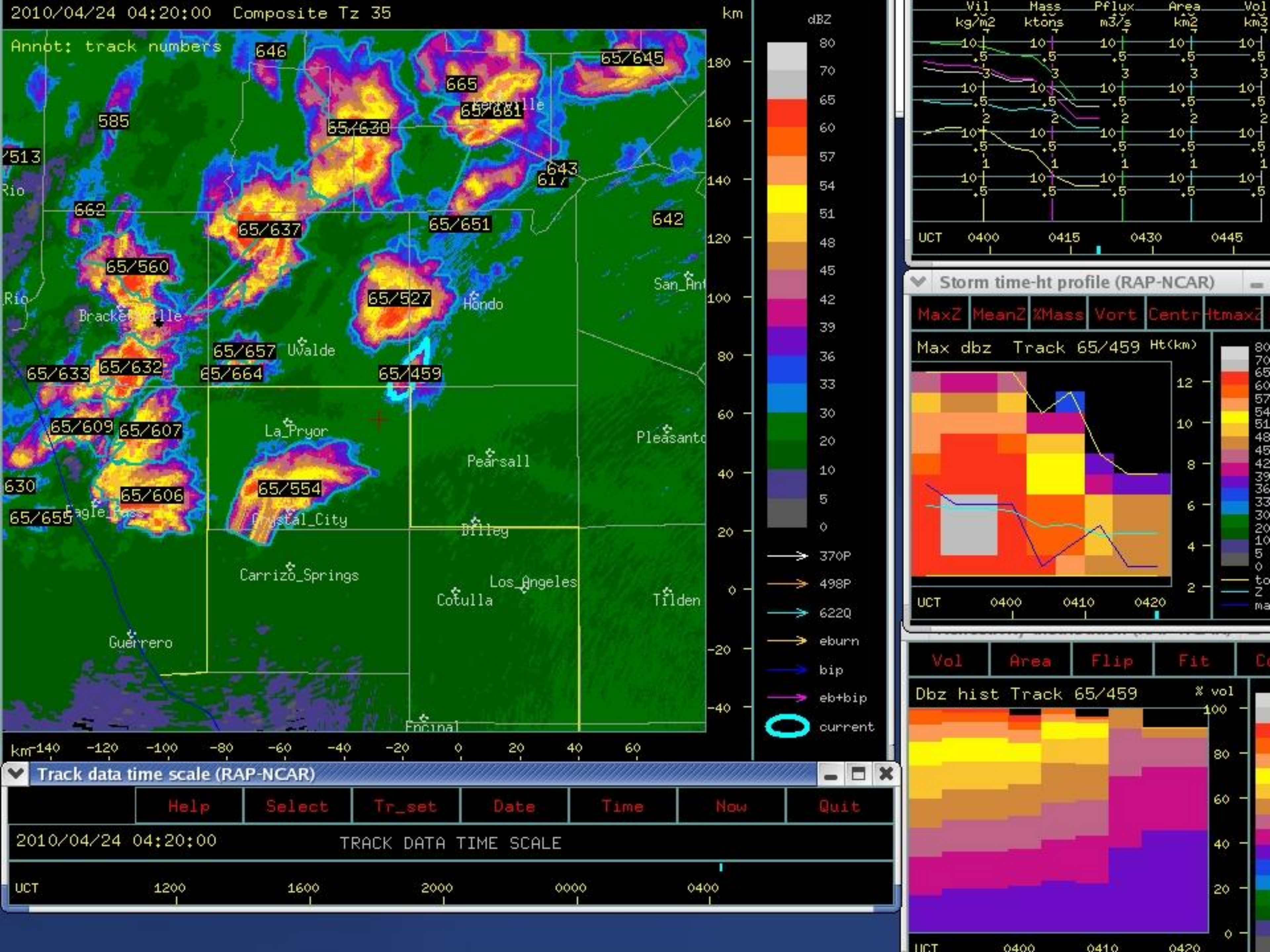
2004-2012



2013 WMA annual meeting
San Antonio April 11th

Arquimedes Ruiz-Columbie
Todd Flanagan
Jonathan Jennings
Stephanie Beall
Jennifer Puryear
Craig Funke


TITAN
Thunderstorm Identification, Tracking,
Analysis and Nowcasting



2010/04/24 04:20:00 Composite Tz 35
Annot: track numbers
646
65/645
665
65/661
585
65/638
/513
643
617
662
65/651
642
65/637
65/560
San_Ant
65/527
Hondo
Brackettville
65/657
Uvalde
65/633
65/632
65/664
65/459
65/609
65/607
La_Pryor
Pleasanton
Pearsall
630
65/554
65/606
65/655
Eagle_Pass
Crystal_City
Dilley
Carrizo_Springs
Los_Angeles
Cotulla
Tilden
Guerrero
Encinal
km
dBZ
370P
498P
622Q
eburn
bip
eb+bip
current
Vil kg/m2
Mass ktons
Pflux m3/s
Area km2
Vol km3
UCT 0400 0415 0430 0445
Storm time-ht profile (RAP-NCAR)
MaxZ
MeanZ
%Mass
Vort
Centr
Htmax
Max dbz Track 65/459
Ht(km)
UCT 0400 0410 0420
Vol
Area
Flip
Fit
Dbz hist Track 65/459
% vol
Track data time scale (RAP-NCAR)
Help
Select
Tr_set
Date
Time
Now
Quit
2010/04/24 04:20:00
TRACK DATA TIME SCALE
UCT 1200 1600 2000 0000 0400

TITAN (Thunderstorm Identification Tracking Analysis and Nowcasting)

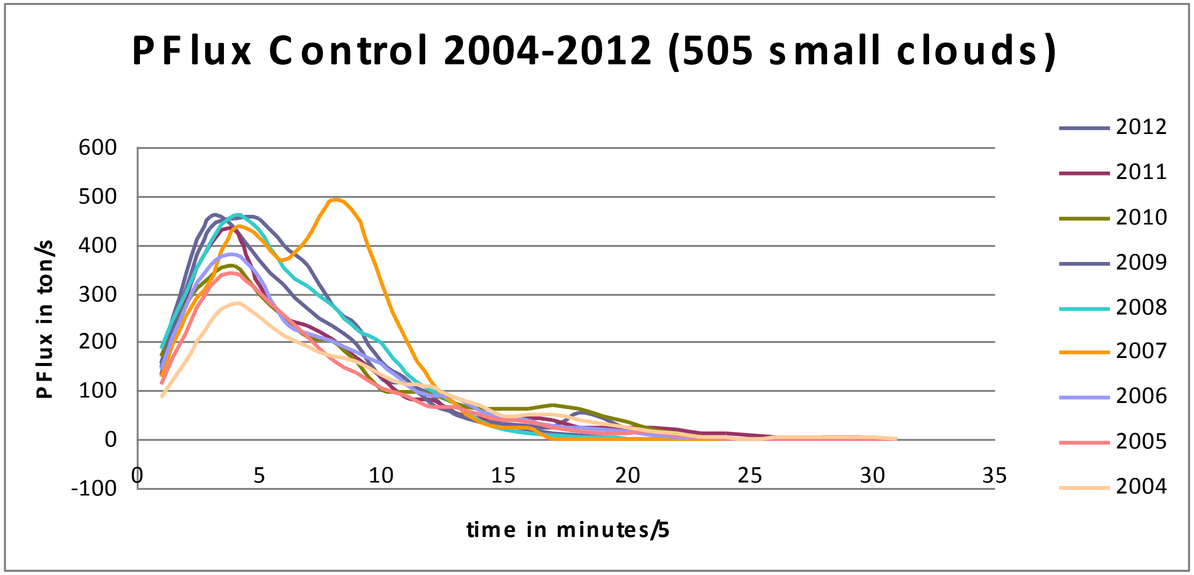
- Created in South Africa 1993
- Used there for the first time in Weather Modification in 1995
- Has a software for evaluation purposes:

1) The **TrackMatch Utility** allows to match seeded clouds with similar unseeded ones;

2) The **PartialProps Utility** creates the cases' files (seeded and unseeded);

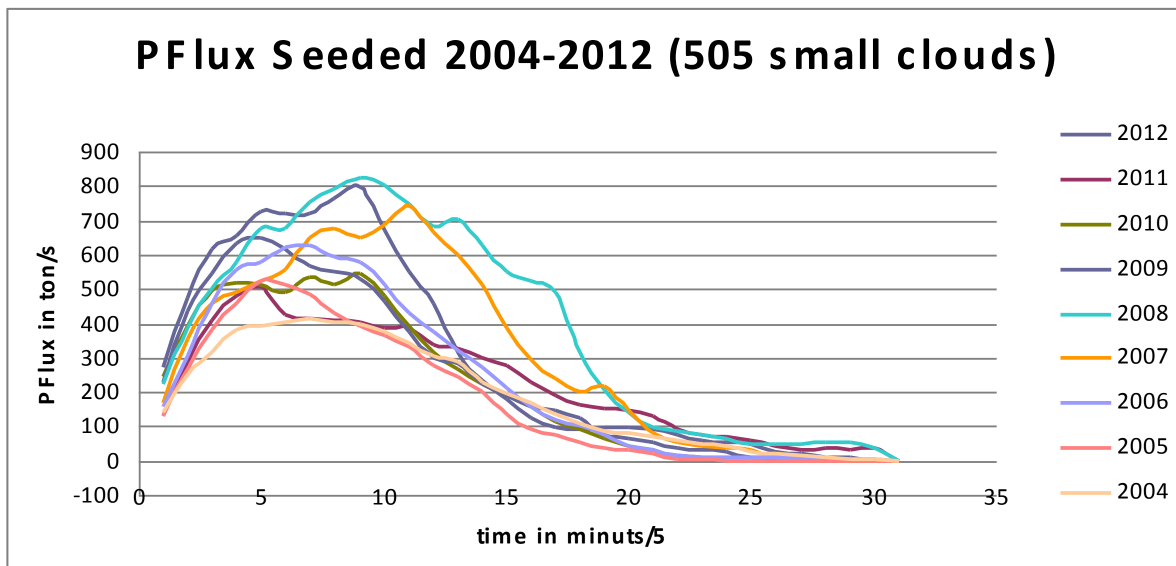
3) The **CaseStats Utility** permits the comparison between seeded and unseeded cases.

STWMA (Pleasanton: 2004-2012)

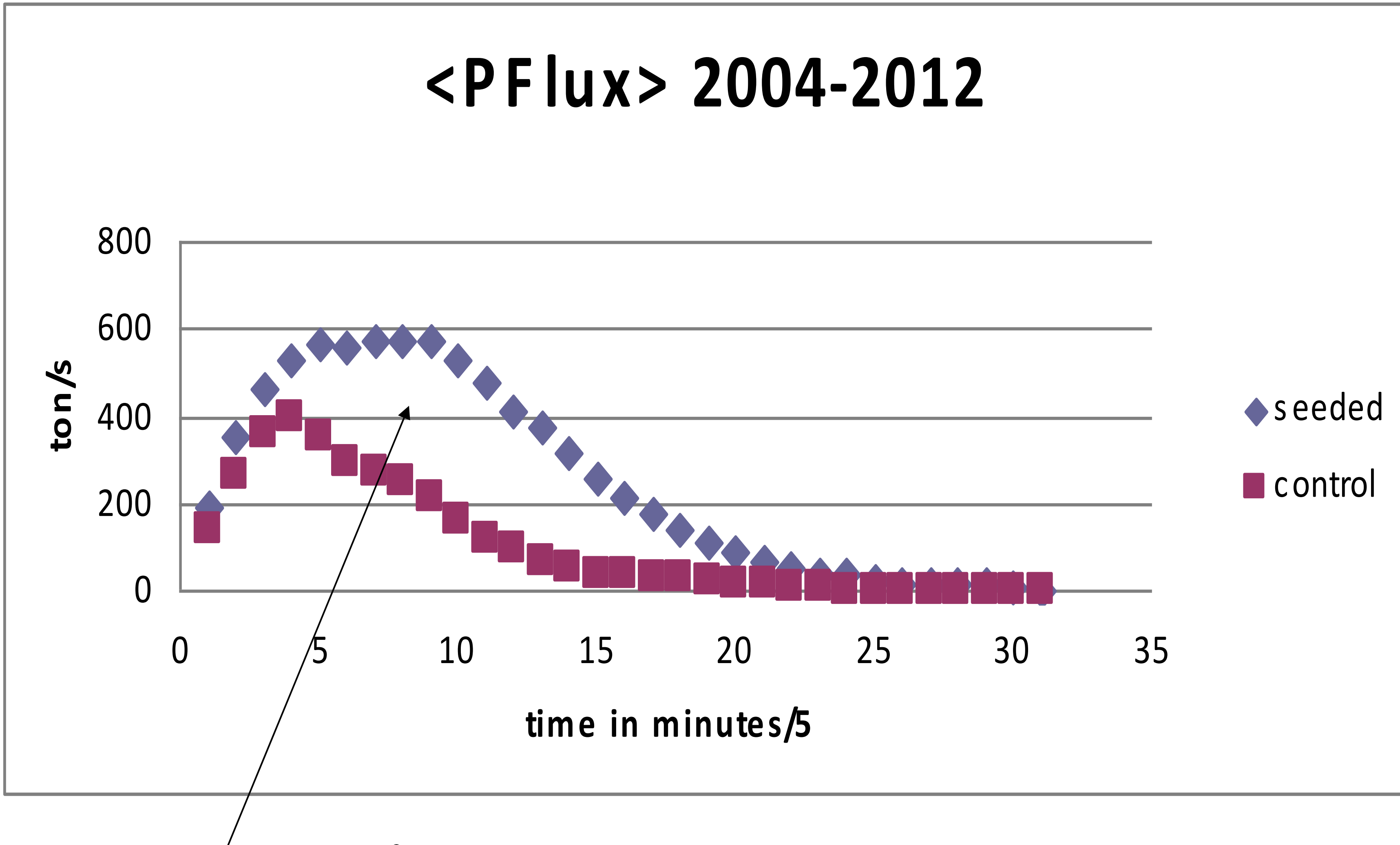


Check the vertical scales

Seeded cases have wider, higher, and longer PFlux signals

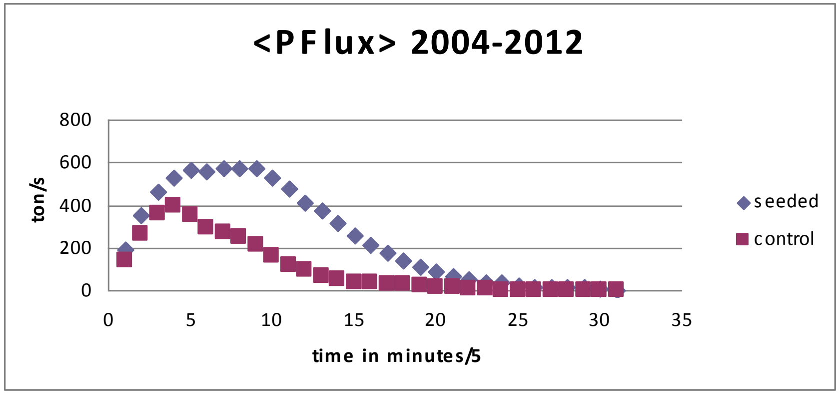


PFlux average (STWMA 2004-2012)



$$\Delta_{\mathrm{Pr}ecMass} = \int_{\tau} [PFlux\_seeded - PFlux\_control]dt$$

Fitting (included data linearization)

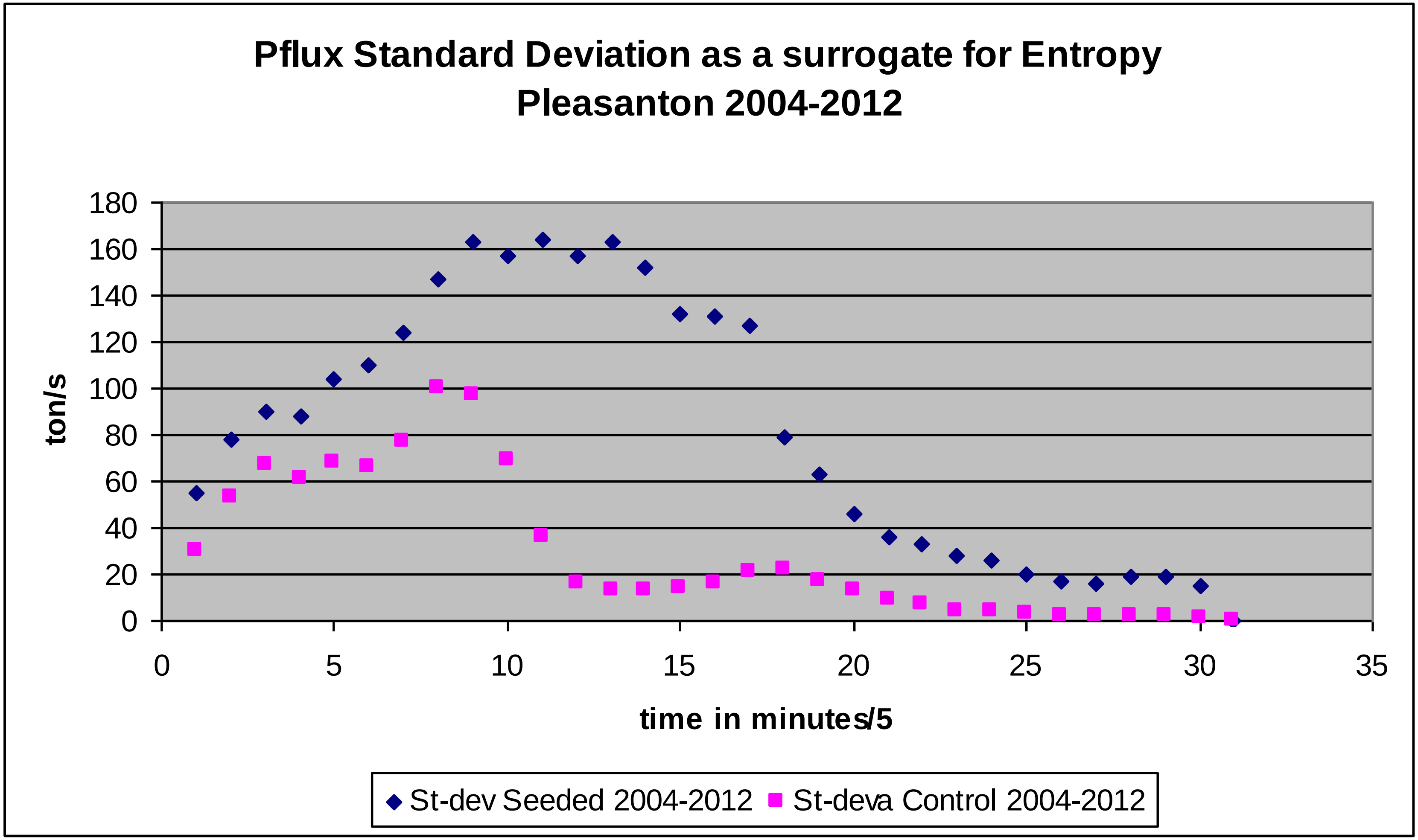


$$PFlux\_Control = 36.6e^{-0.07t}(t+1)^{1.251}$$

$$r_{control} = 0.994$$

$$PFlux\_Seeded = 25.2e^{-0.06t}(t+1)^{1.467}$$

$$r_{seeded} = 0.996$$



Two time scales: 1) growing variability (youth)

2) decaying variability (maturity and senescence)

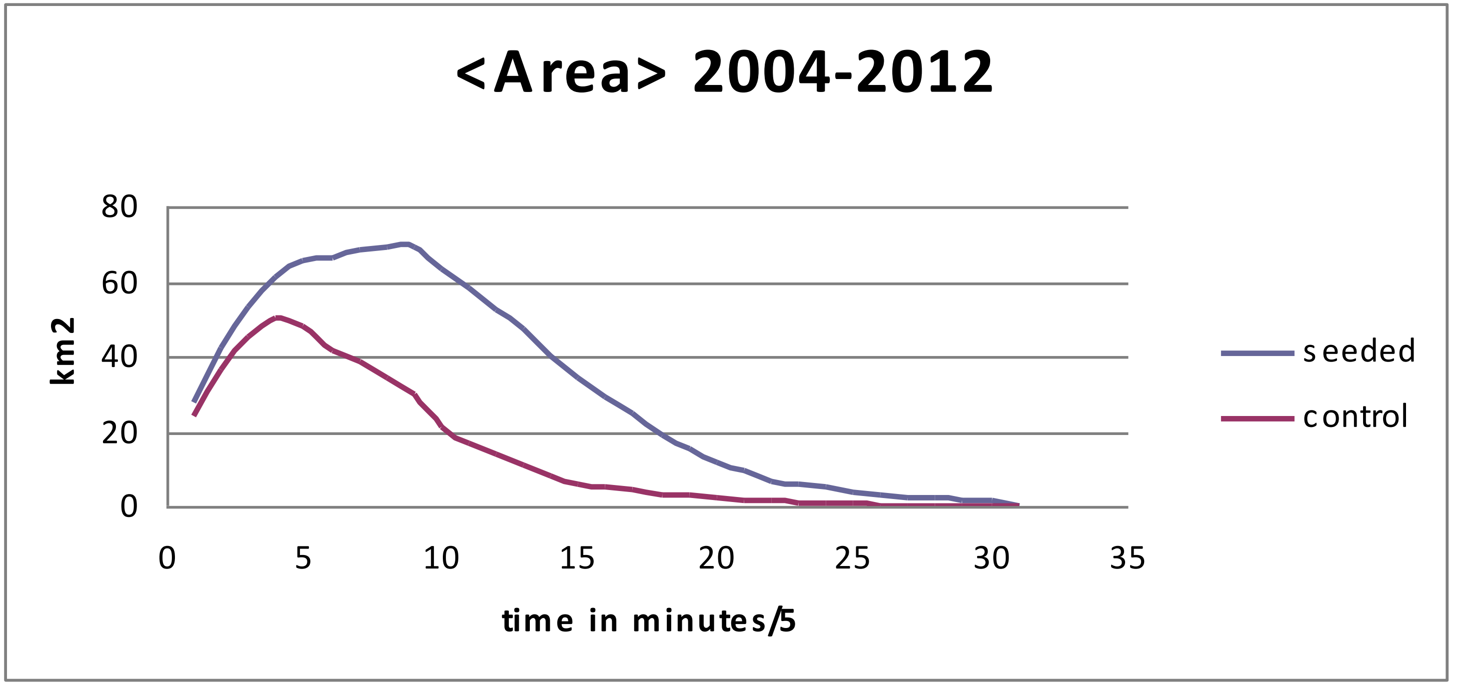
Storms are “far from equilibrium” dissipative systems, capable of self-organization because of the exchange of energy and matter with the surroundings, and the consistent export of entropy ; the entropy exchange rate depends on the storm age; one can think of two phases: **Youth**, with a growth of entropy production, and **Maturity** in which the rate decreases. The seeded cases seemed to extend a little longer the youth phase, maybe due to a more prolific generation of daughter cells.

$$\Delta S^{*} = \Delta S + \Delta S^{'}$$

Complications for a given storm when calculating the actual entropy:

- 1) heat transfer
- 2) mixing of substances (diffusion and dissipation)
- 3) phase transitions and possible chemical reactions.

STWMA (2004-2012)



Similar results were found for the variable **Area**.

$$A\_Control = 8.1e^{-0.06t}(t+1)^{0.9998}$$

$$r_{control} = 0.998$$

$$A\_Seeded = 2.9e^{-0.06t}(t+1)^{1.4654}$$

$$r_{seeded} = 0.994$$

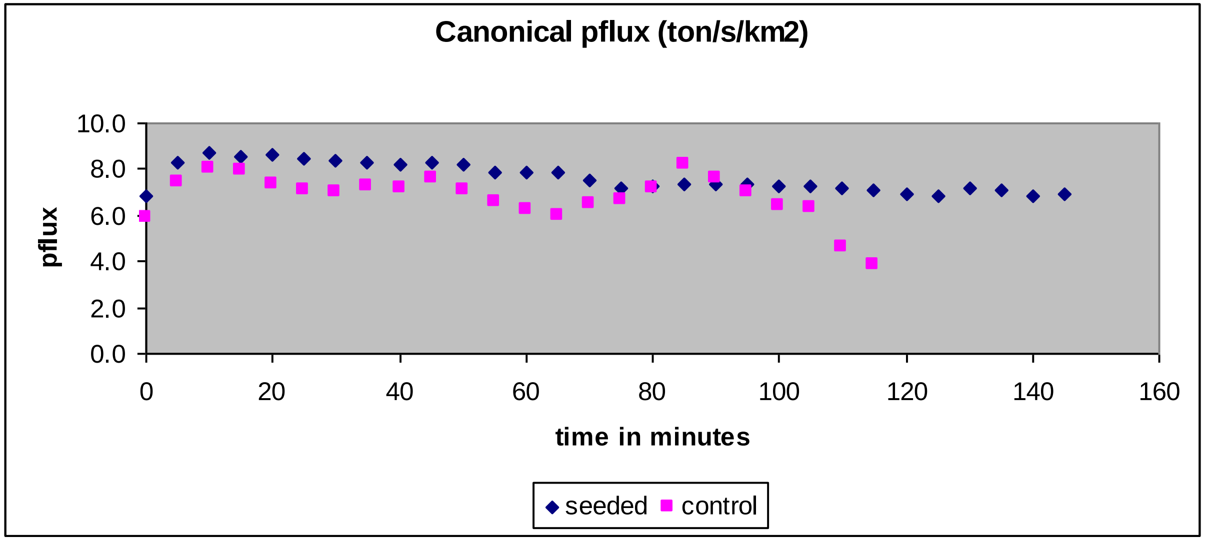
Now, what about the normalized PFlux?

Analytically:

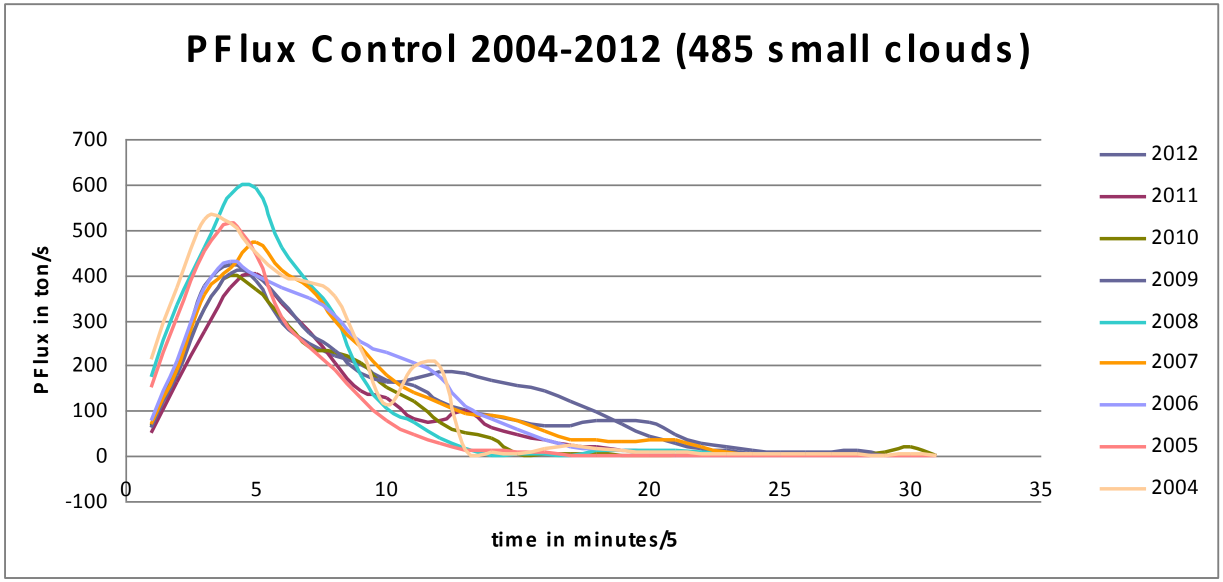
$$pflux-Control=\frac{PFlux\_Control}{Area\_Control}=\frac{36.6e^{-0.07t}(t+1)^{1.251}}{8.1e^{-0.06t}(t+1)^{0.998}}\approx 4.5e^{-0.01t}(t+1)^{0.25}$$

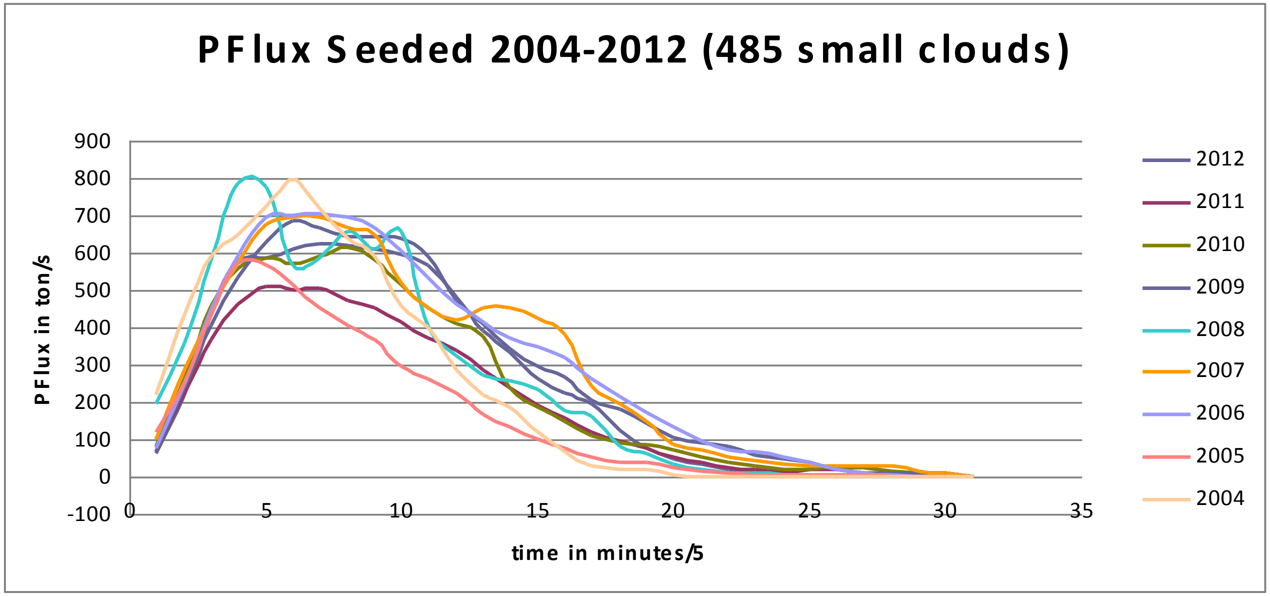
$$pflux\_Seeded=\frac{PFlux\_Seeded}{Area\_Seeded}=\frac{25.2e^{-0.06t}(t+1)^{1.467}}{22.9e^{-0.06t}(t+1)^{1.465}}\approx 1.1(t+1)^{0.001}$$

By numbers from the dataset:

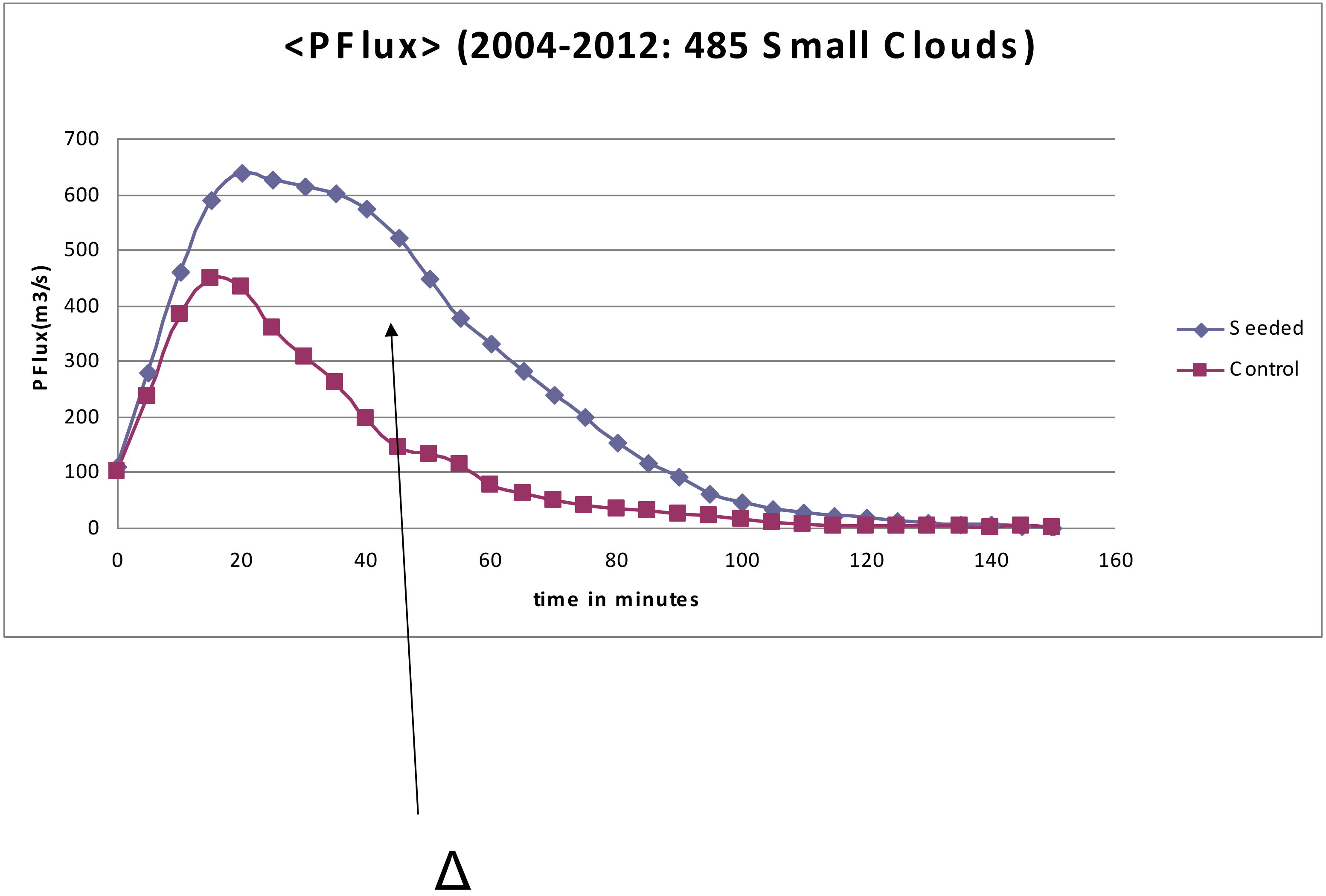


WTWMA (San Angelo 2004-2012)

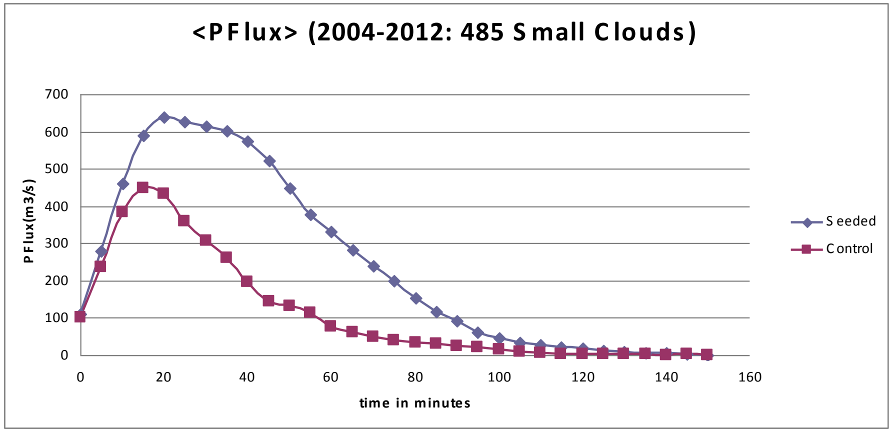




PFlux average (WTWMA 2004-2012)



Fitting



Same for both!

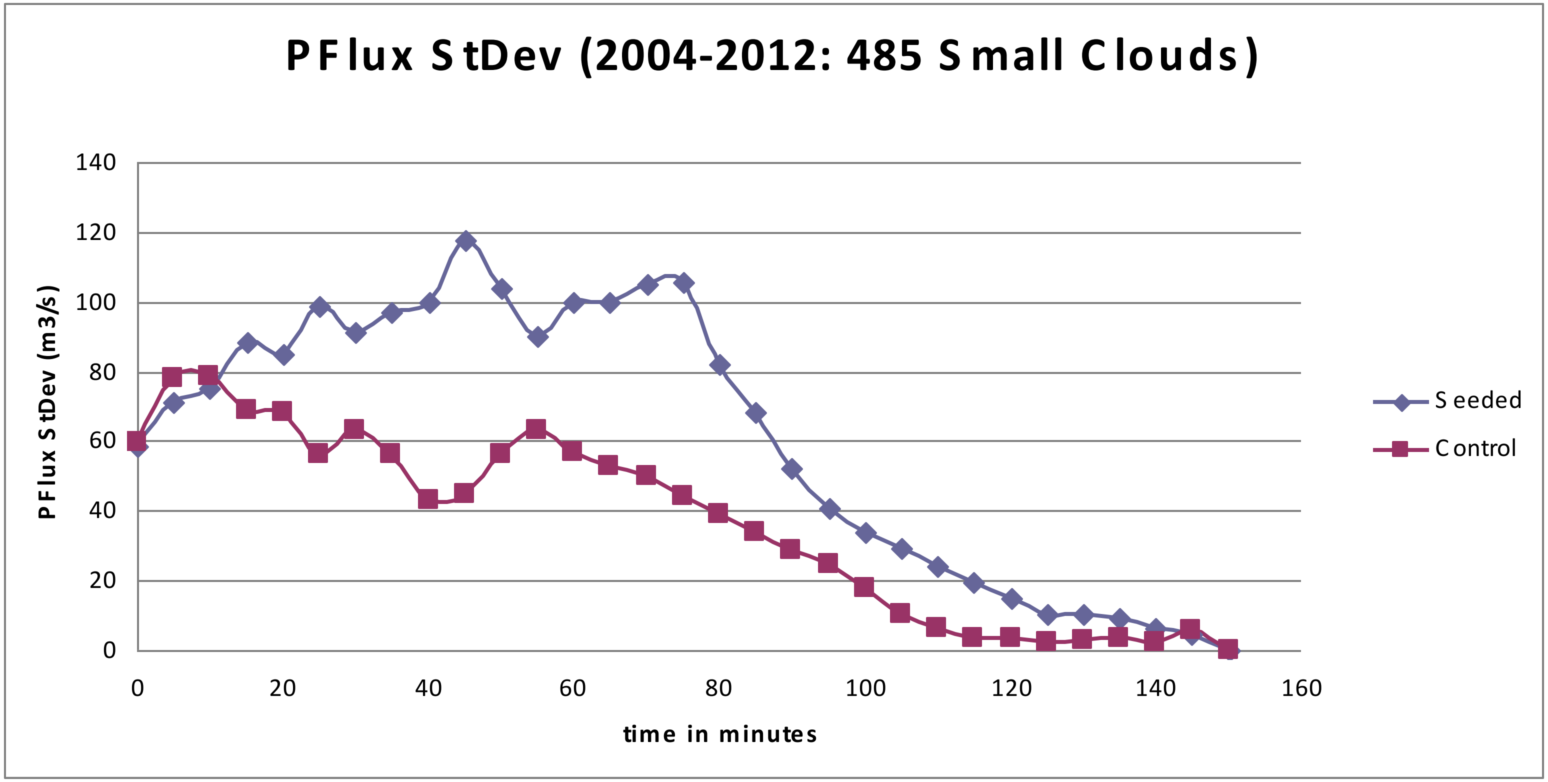
$$PFlux\_Control = 95.6e^{-0.06t}(t+1)^{0.843}$$

$$r_{control} = 0.9877$$

$$PFlux\_Seeded = 64.3e^{-0.06t}(t+1)^{1.223}$$

$$r_{seeded} = 0.9904$$

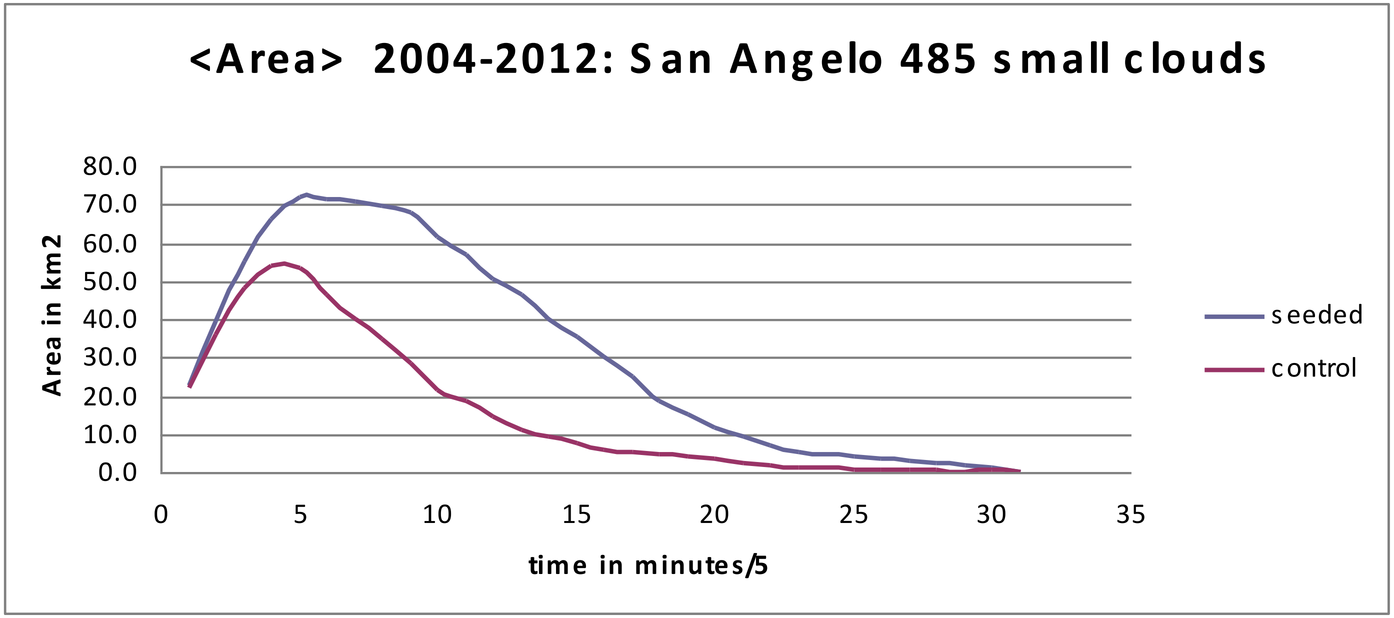
PFlux standard deviation as a surrogate for entropy



Two time scales: 1) growing variability (youth)

2) decaying variability (maturity and senescence)

WTWMA 2004-2012



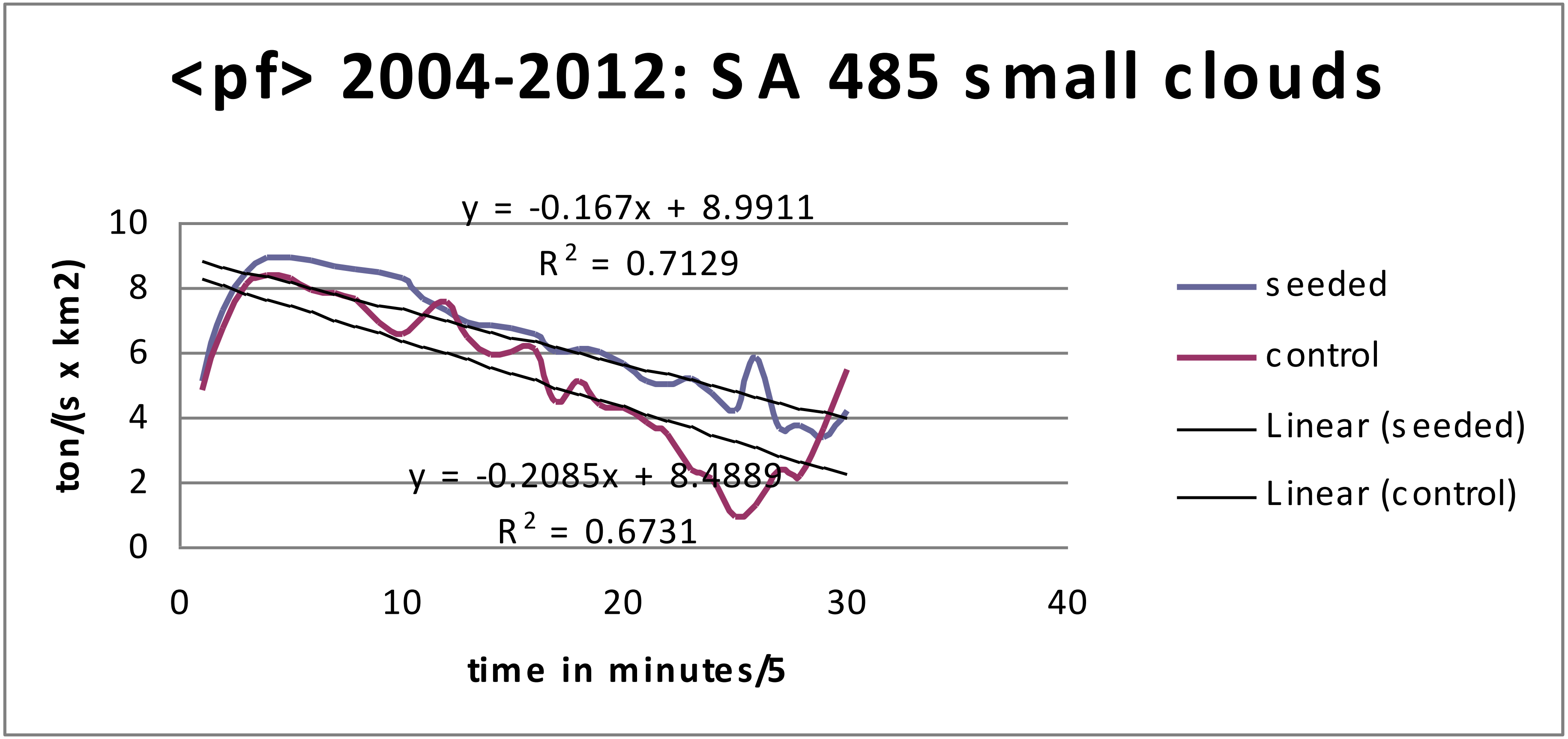
$$A\_Control = 11.7e^{-0.06t}(t+1)^{0.830}$$

$$r_{control} = 0.995$$

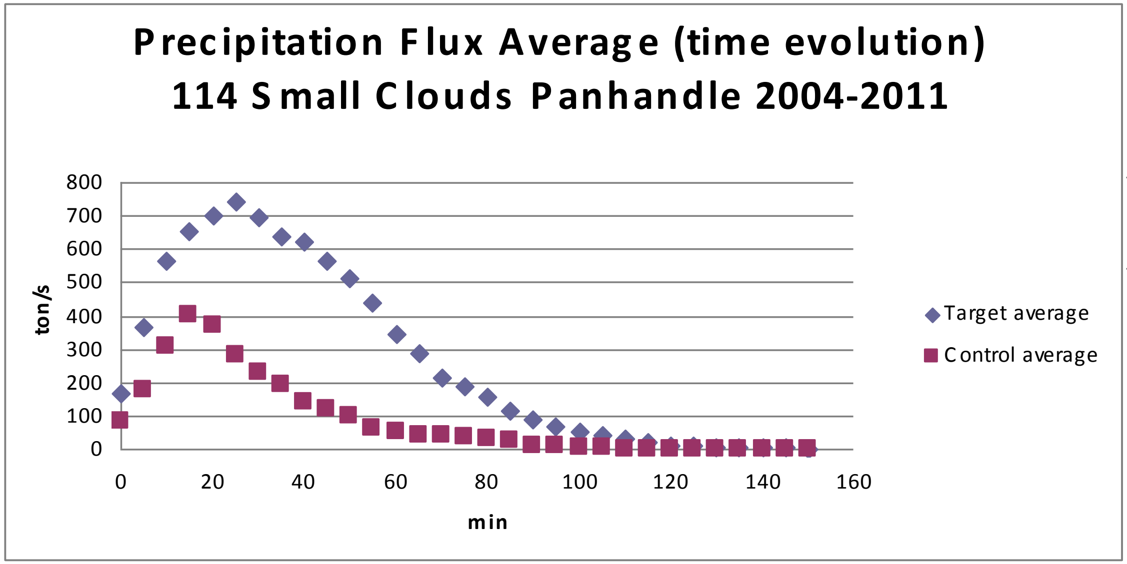
$$A\_Seeded = 2.9e^{-0.06t}(t+1)^{1.471}$$

$$r_{seeded} = 0.996$$

Canonical pflux (ton/s/km^2)



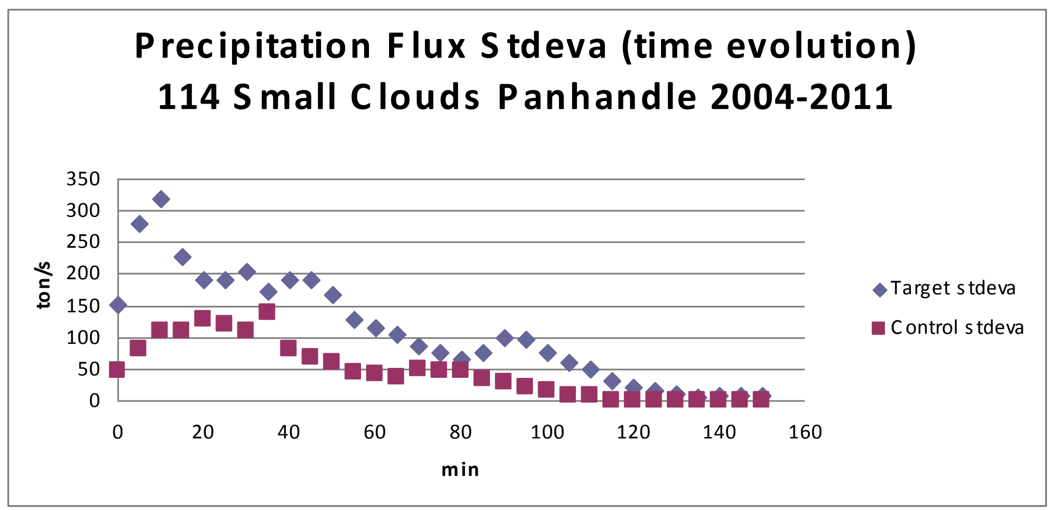
PGCD 2004-2011 (114 small clouds)



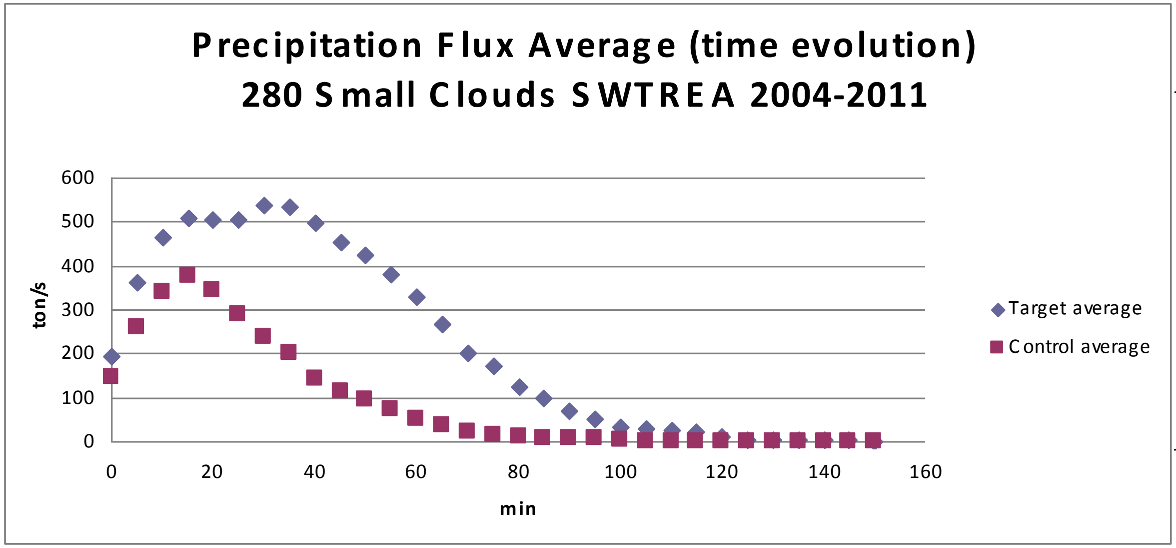
$$PFlux\_T = 11.82e^{-0.076t}(t+1)^{1.92}$$

$$PFlux\_C = 19.49e^{-0.081t}(t+1)^{1.47}$$

$$r_{seeded} = 0.994 \qquad r_{control} = 0.979$$



SWTREA 2004-2011 (280 small clouds)

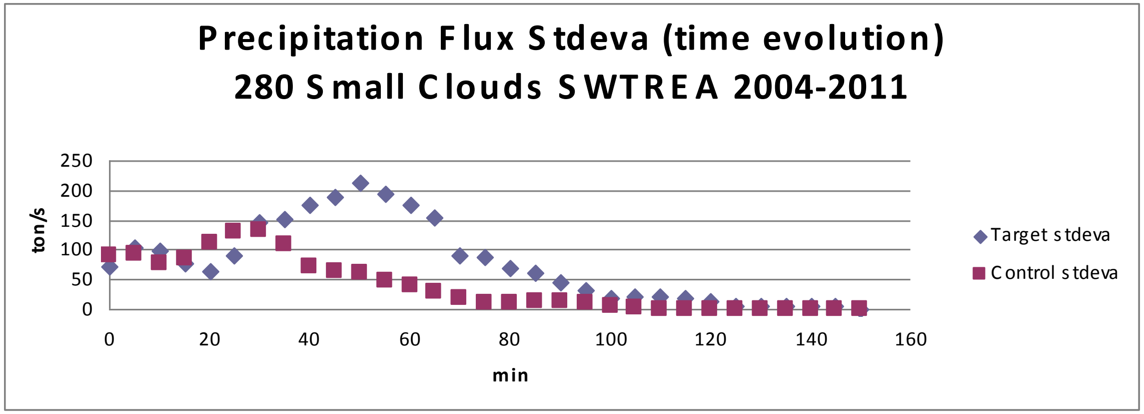


$$PFlux\_T = 8.00e^{-0.079t}(t+1)^{2.02}$$

$$r_{seeded} = 0.987$$

$$PFlux\_C = 33.45e^{-0.086t}(t+1)^{1.34}$$

$$r_{control} = 0.991$$



A dessert!

$$y = Ce^{-\alpha t}(t+1)^{\beta}$$

$$\frac{dy}{dt} = C(-\alpha)e^{-\alpha t}(t+1)^{\beta} + Ce^{-\alpha t}\beta(t+1)^{\beta-1}$$

$$\frac{dy}{dt} = -\alpha y + \frac{\beta}{t+1}y$$

$$\frac{dy}{dt} = (-\alpha + \frac{\beta}{t+1})y$$

$$\frac{dy}{y} = -\alpha dt + \frac{\beta}{t+1}dt$$

Summary

- The large TITAN archive has allowed us to do some data mining and to find different signals of modification in small seeded clouds.
- Some analytical expressions seem to indicate regularities which depend upon the specific target areas (a physical geographic variety).
- **Can we find them in randomized double blind seeded cases?**