X-ray mass proxies from hydrodynamic simulations of galaxy clusters (paper I) accepted by MNRAS

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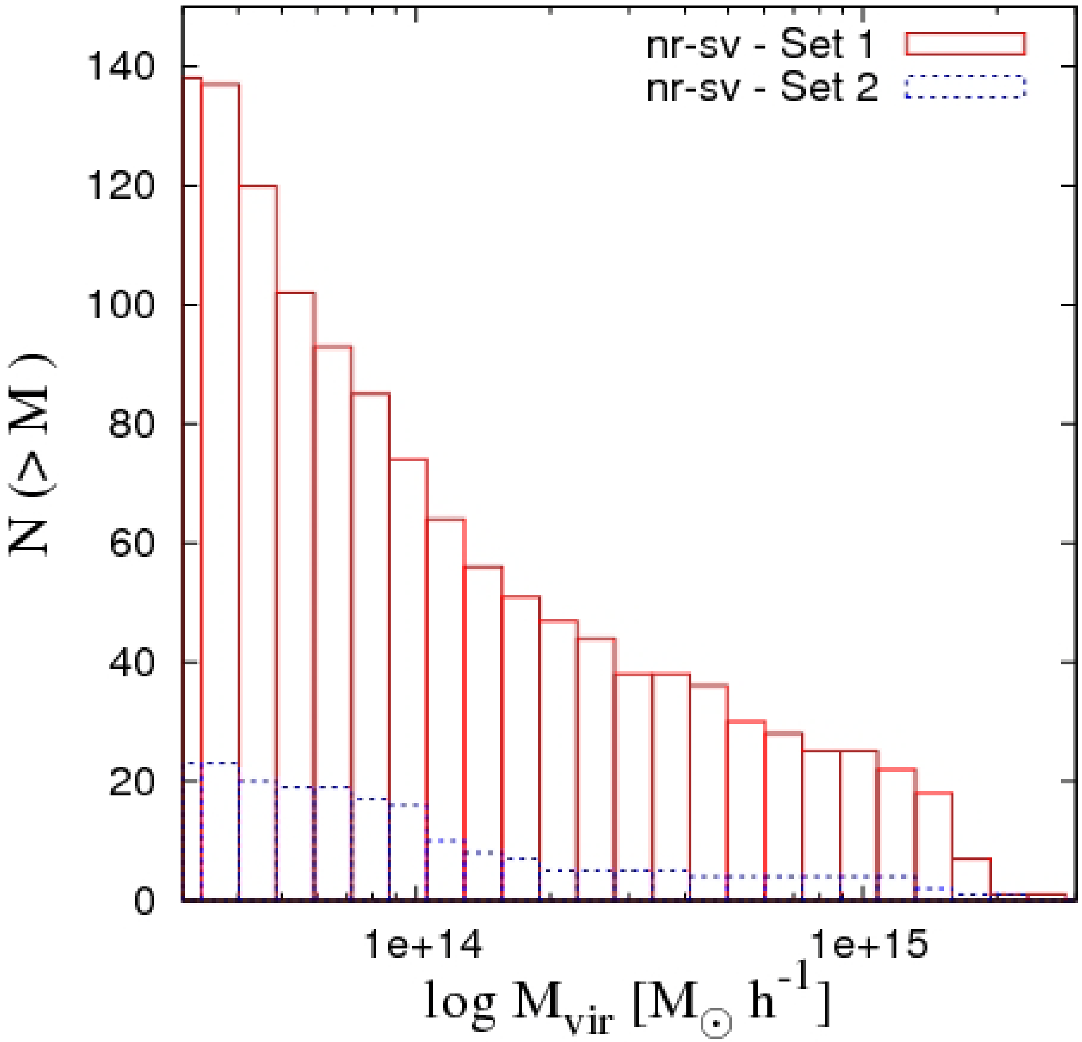
SAMPLE



- Set 1:
  - 140 with $M_{vir}>10^{15}$ M_{sun}/h
  - 30 with $M_{vir}>10^{15}$ M_{sun}/h

  two physics treatments:

  a. NR

  b. CSF-M-W
- Set 2:
  - 18 with $M_{500}>10^{15}$ M_{sun}/h
  - 4 with $M_{vir}>10^{15}$ M_{sun}/h
  - Seven physics treatment:

  a. NR-SV

  b. NR-RV

  c. CSF

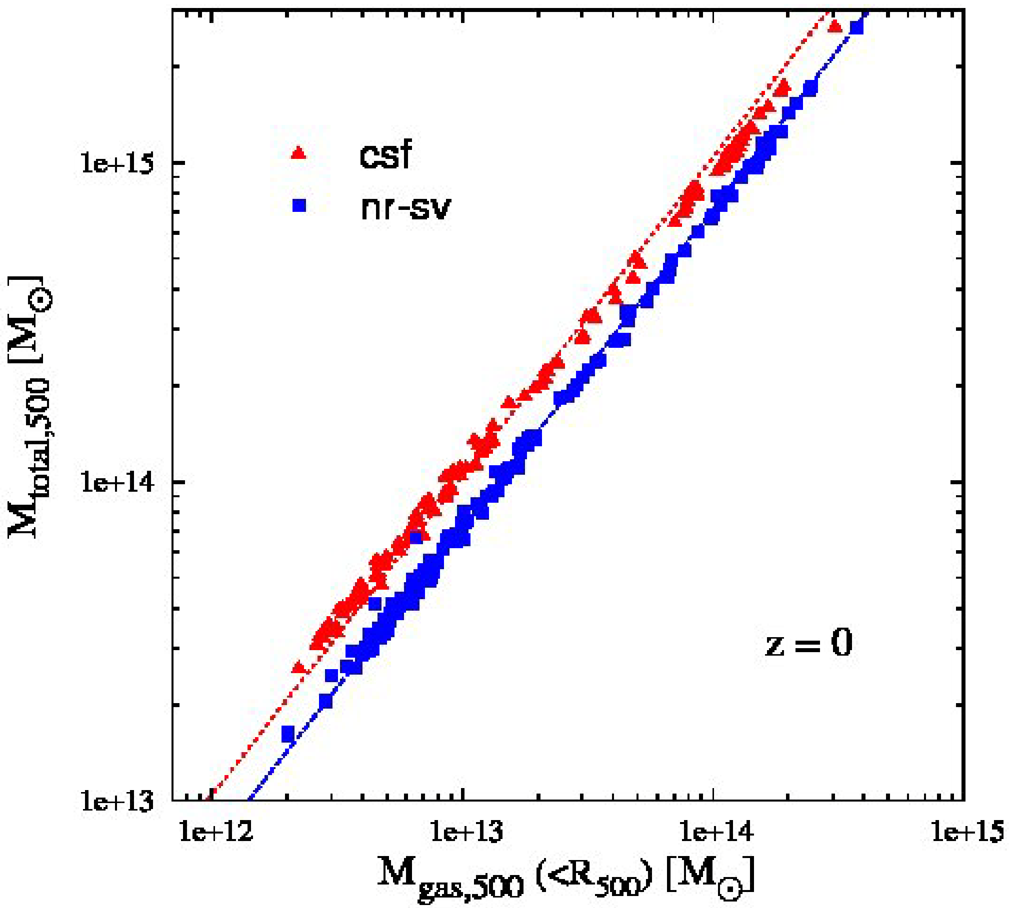
  d. CSF-C

  e. CSF-M-W

  f. CSF-M-NW

  g. CSF-M-AGN

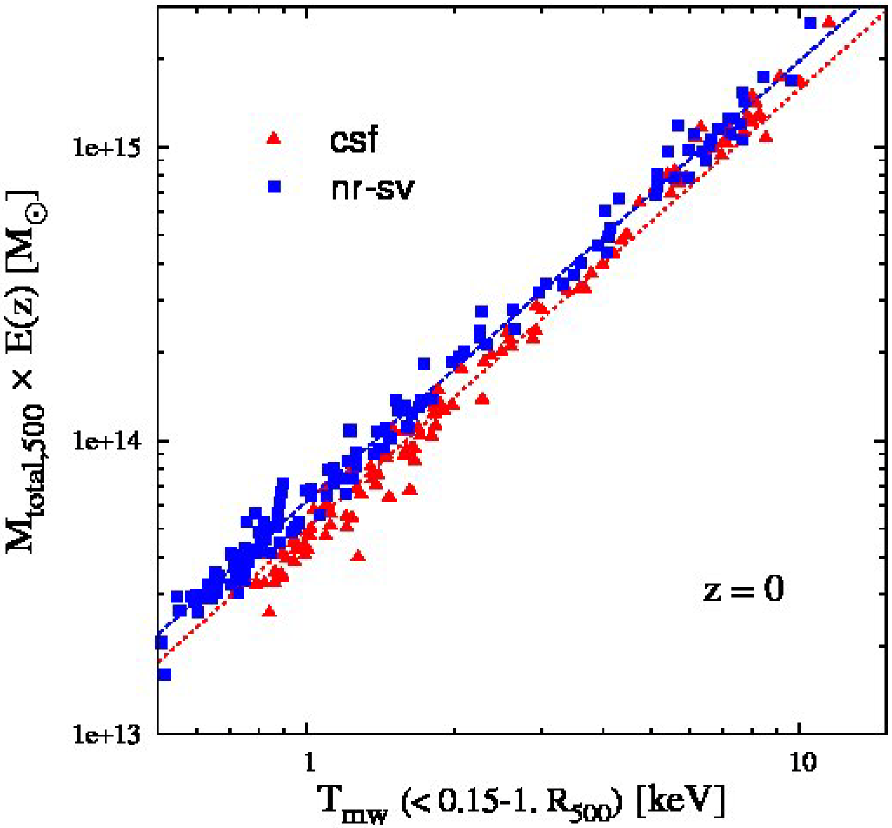
SCALING RELATIONS: M_{gas}



- Nv relation is close to SS (β =0.981 +-0.004)
- CSF relation is shallower (β =0.929 +-0.003)
- Values at z=0

In radiative simulations the conversion of baryons into stars is relatively more efficient in lower mass systems, thus corresponding to a lower mass fraction of gas left in the hot diffuse phase

SCALING RELATIONS:T

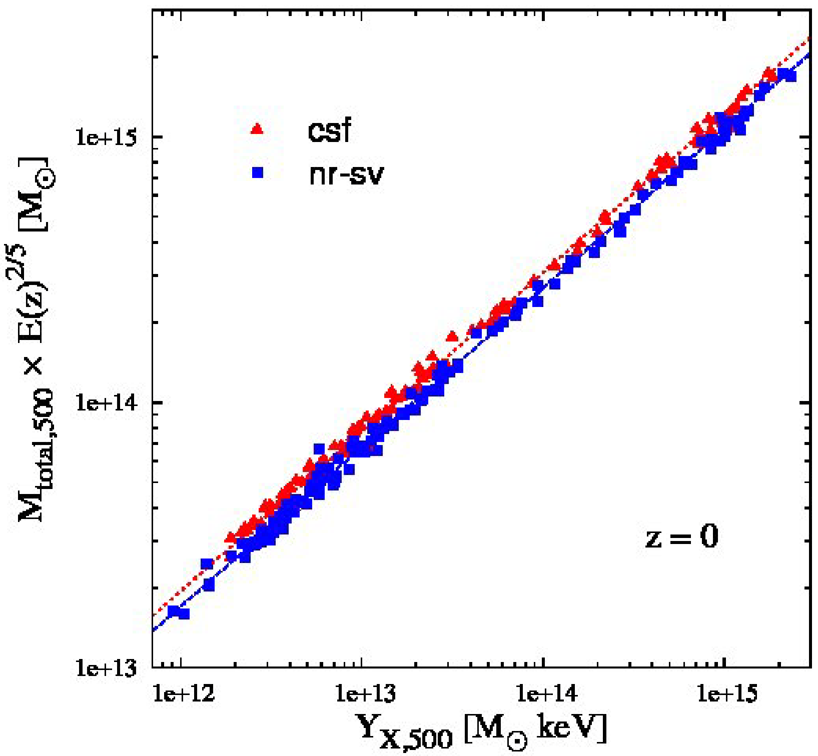


- Nv relation is close to SS (β =1.517 +-0.012)
- CSF relation is steeper (β =1.615 +- 0.016)
- Values at z=0

The radiative physics increases the temperature of ICM by a large amount in less massive systems. More efficient cooling -> strong adiabatic compression of gas in the center-> lack of pressure support -> increase of temperature in the center

See Kravtsov et al. 2006

SCALING RELATIONS:YX

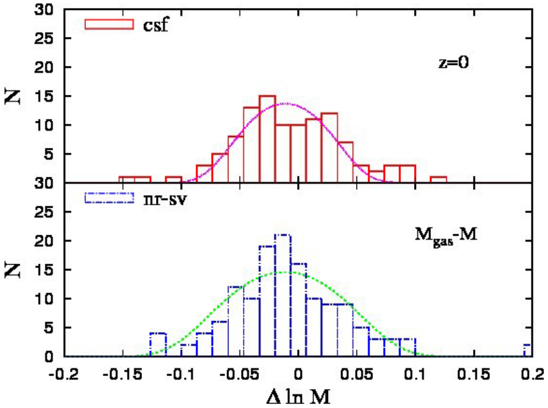


- NV and CSF are very close to SS (β =0.597 +-0.03 andβ =0.591 +- 0.003)
- The opposite deviations of M-Mg and M-T are compensated in M-YX

Effect of including cooling, star formation and SN feedback has a modest effect on M500-Yx

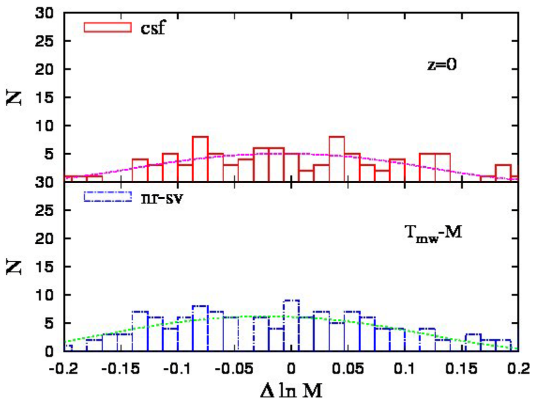
SCATTER: $\sigma_{\Delta \ln M}$

4%



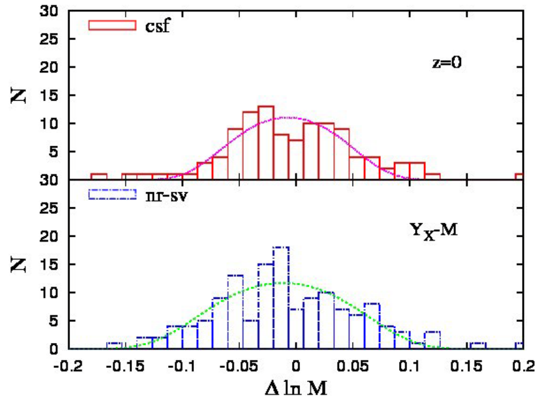
5.5%

11%



12%

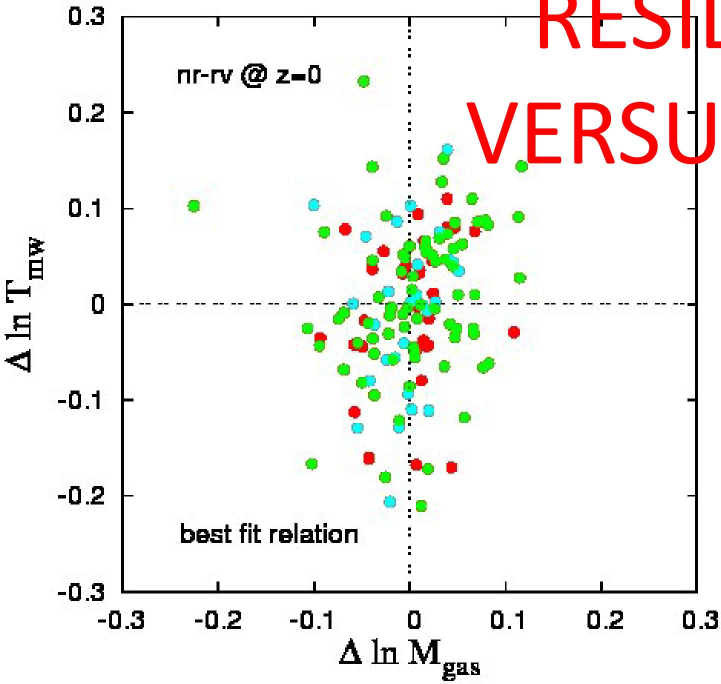
5%

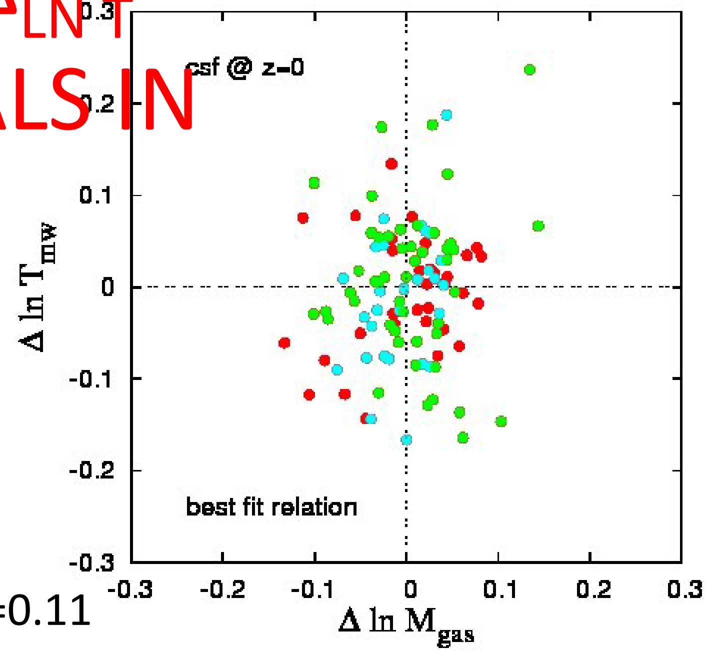


6.4%

- R.m.s. scatter in $M_{tot,500}$ around the fitting relations
- The distribution of the residuals is close to log-normal
- The M-Mg relation presents the lower scatter

RESIDUALS IN $\Delta_{\mathrm{LN\ T}}$ VERSUS RESIDUALS IN $\Delta_{\mathrm{LNM\ GAS}}$

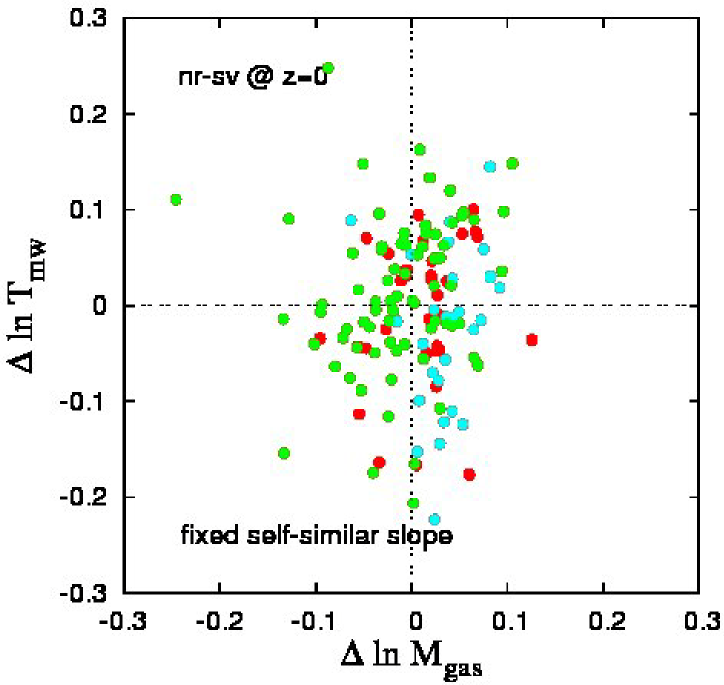


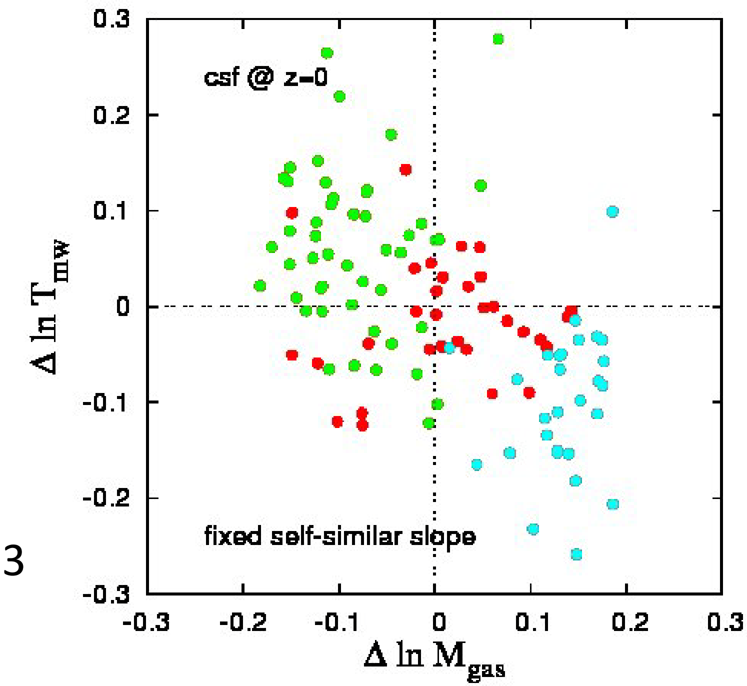


Respect best-fit relation

R=0.24

R=0.11



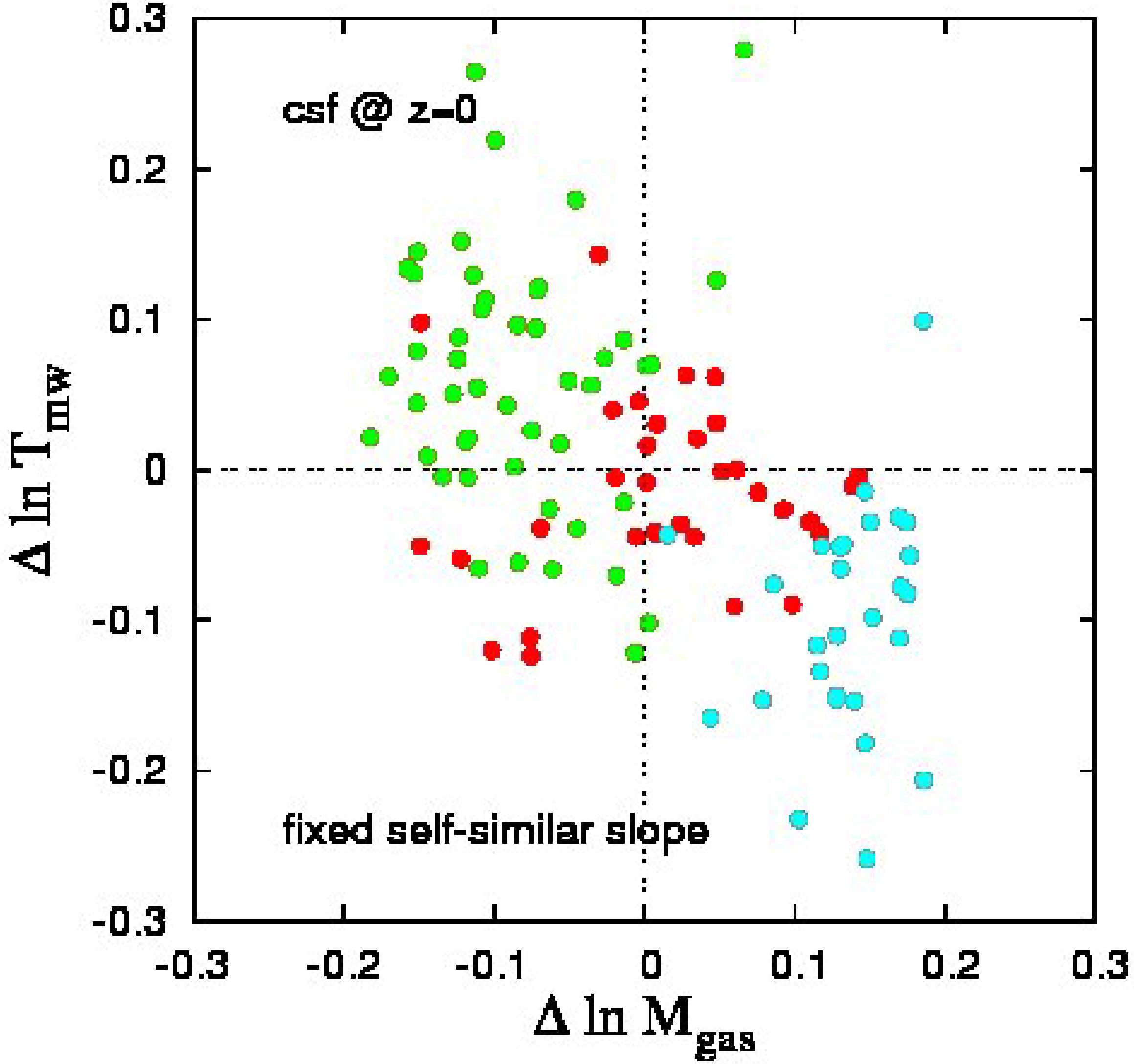


Respect SS relation

R=0.14

R=-0.53

ANTI-CORRELATIONS FOR CSF-M-W CLUSTERS is actually a direct result of the offset of scaling relations in T and gas M with respect to the expected self-similar ones



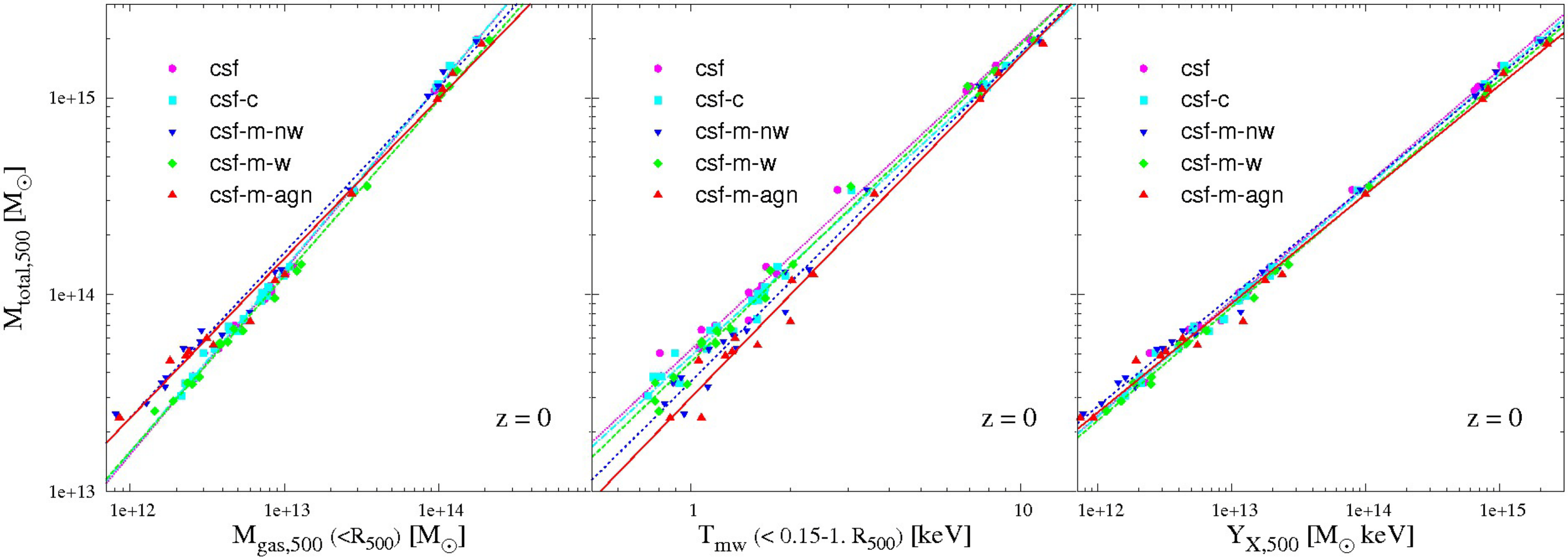
For low mass clusters, the amount of gas is lower and temperatures are higher than expected

The presence of anti-correlation is a spurious effect of imposing the self-similar slopes to the best fitting scaling relations

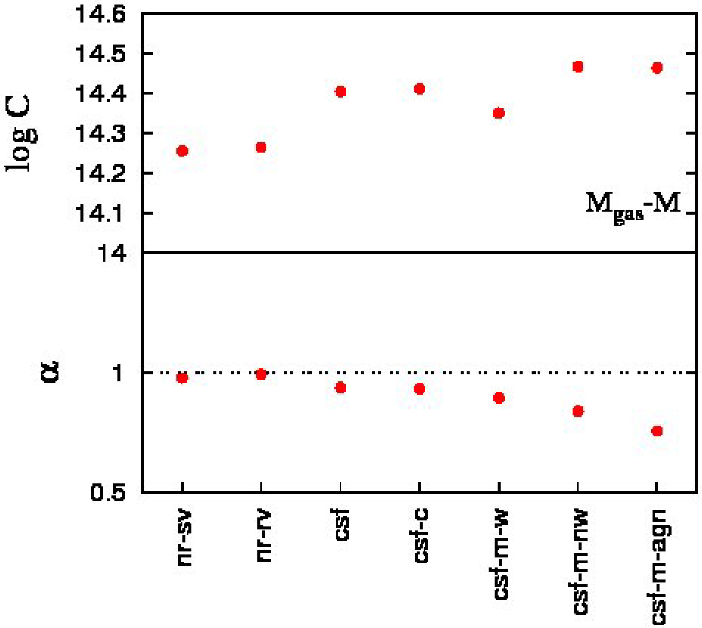
R=-0.53

See Borgani&Kravtsov 2009

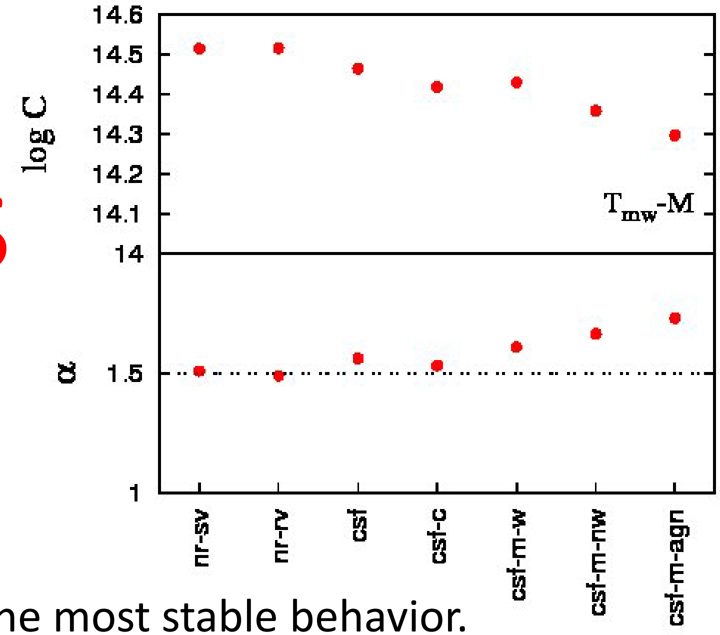
PHYSICS



•LOW MASS SYSTEMS:
•Effect of thermal conduction is quite small
•AGN remove a significant amount of gas from the central regions and heat up the systems
•Simulations without feedback transform a big quantity of hot gas into stars (gas mass is lower and temperature higher)



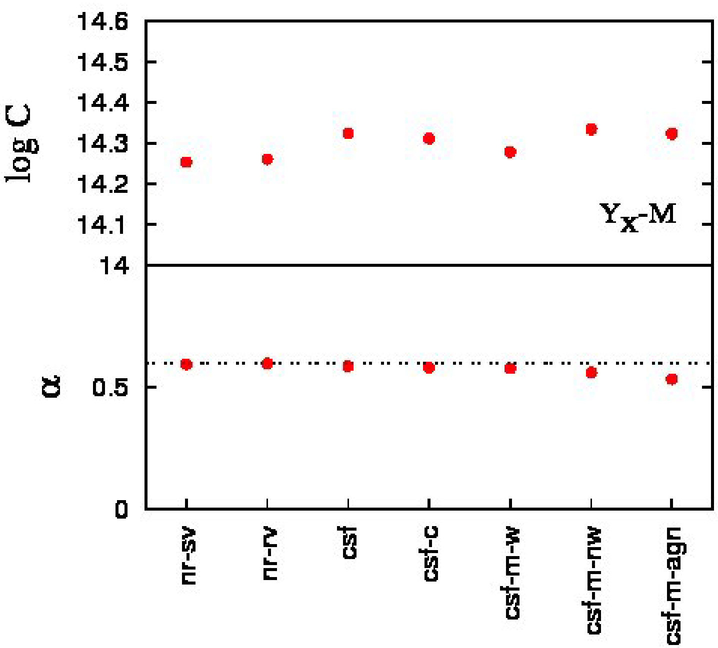
PHYSICS



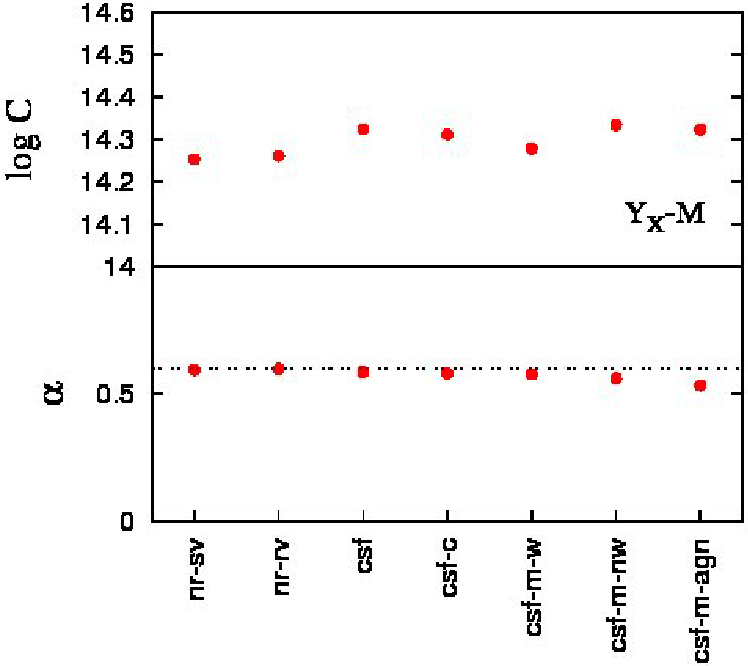
The Yx proxy has the most stable behavior.

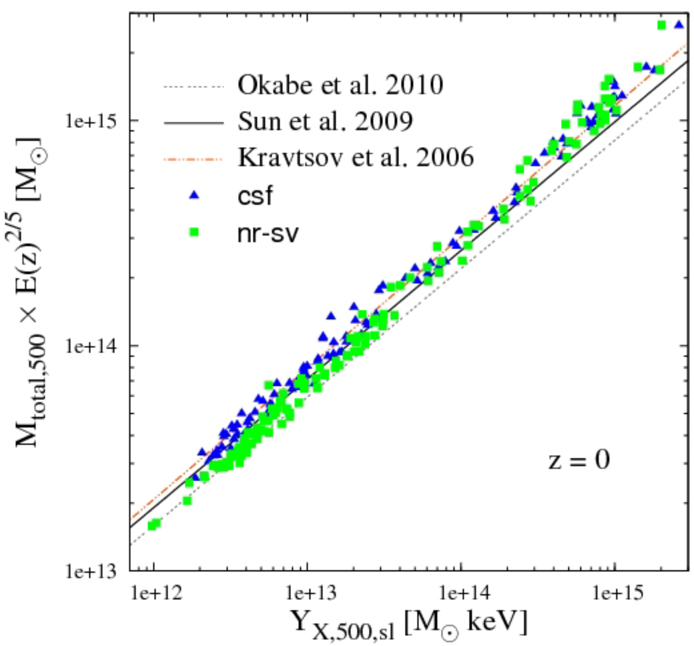
Non-radiative runs show a consistent agreement with self-similar slopes

AGN have the effect of removing gas from the center and heat up the ICM

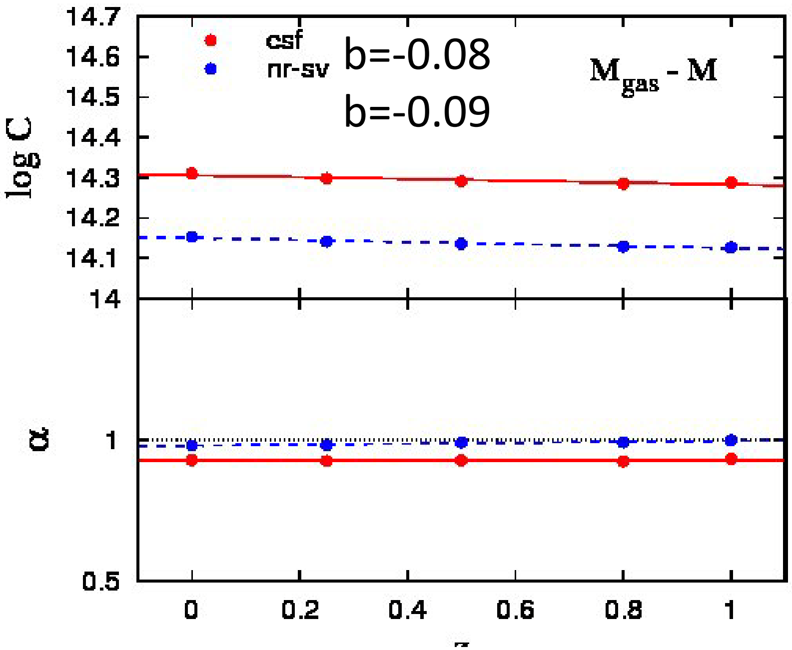


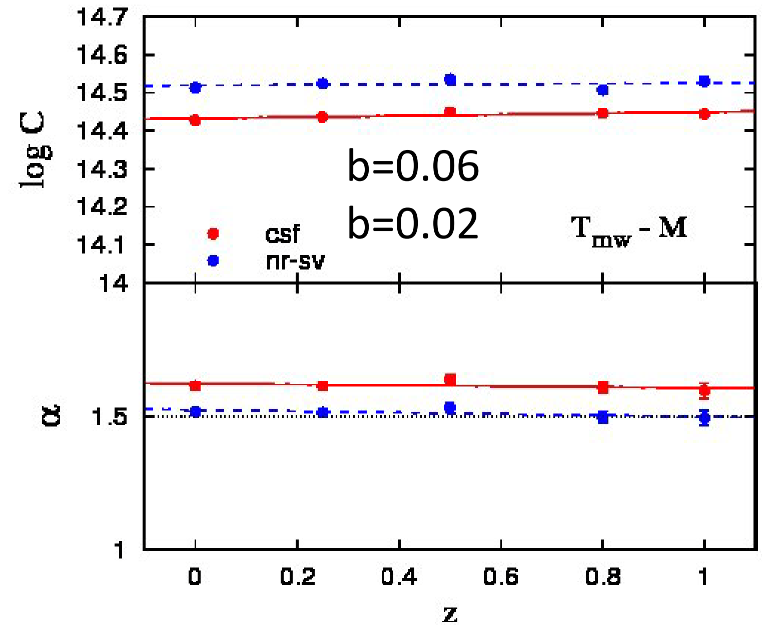
M-YX comparison with data



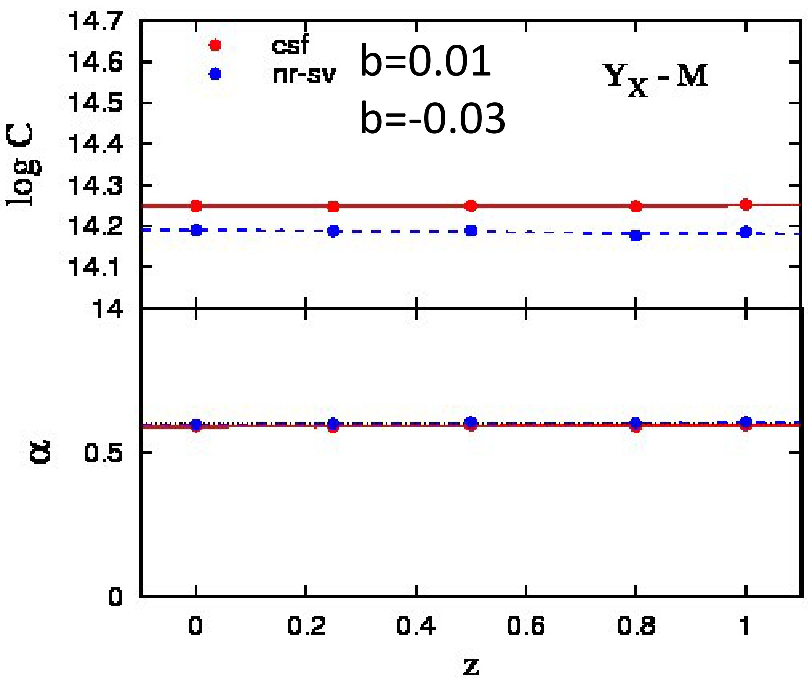


- Simulation intrinsic relation is steeper than data
- T_X spectroscopic may increase the difference
- Need of AGN feedback



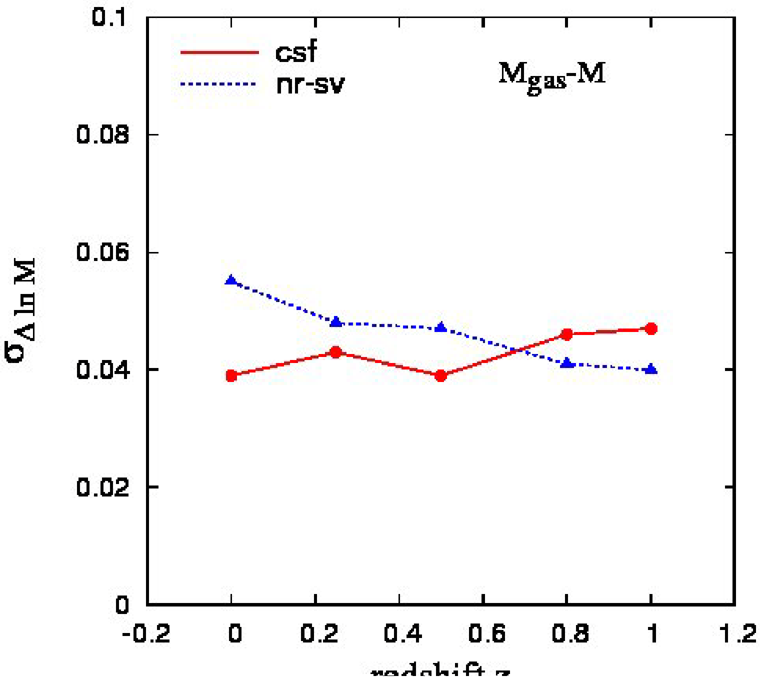


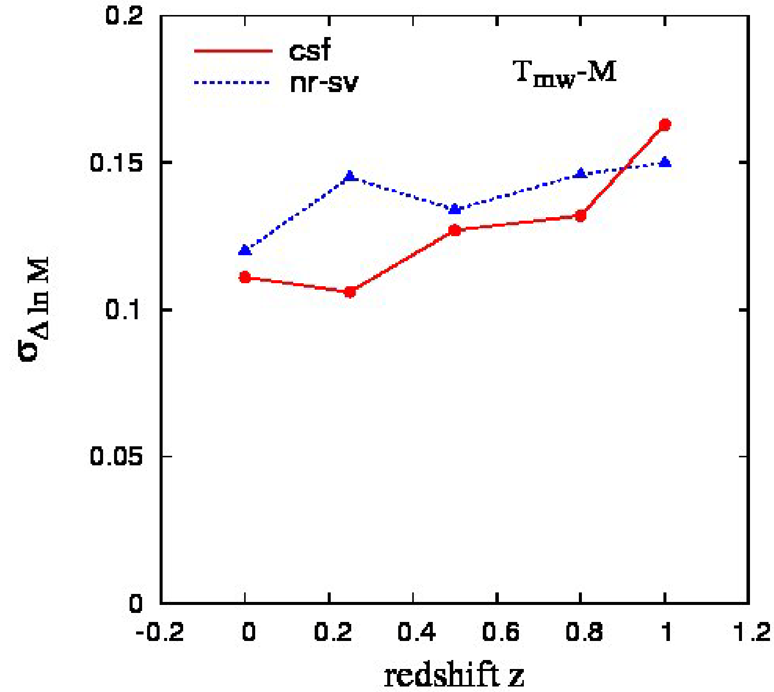
EVOLUTION Normalization and slope

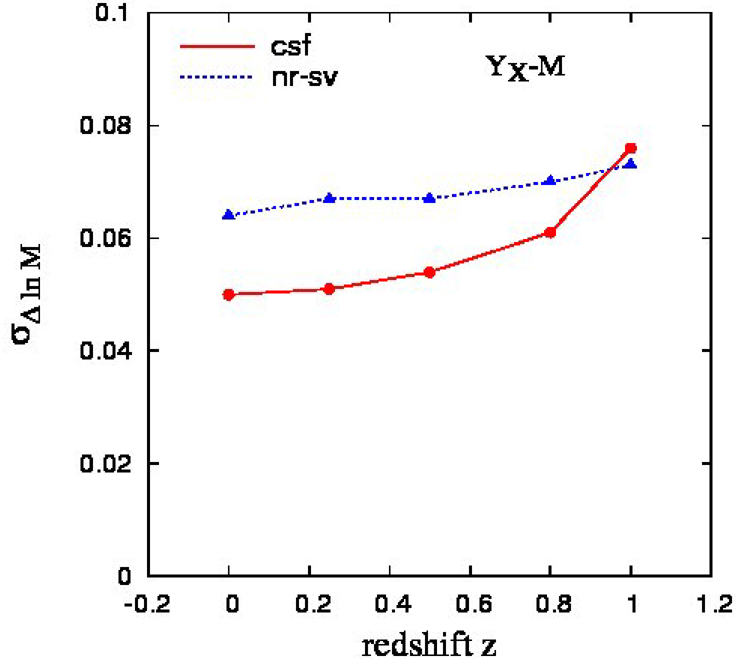


$\log(C(z)) = \log(C_0) + b\,(1+z)$

Slopes overlap for M-Y







EVOLUTION
Scatter

Temperature is sensitive to substructures and dynamical state of clusters -> High redshift objects are not relaxed

CONCLUSION

- NR simulations are closer to self-similar behavior
- M-T is steeper than SS, opposite for M-M_{gas}
- Y_X is close to SS
- M-M_{gas} presents the smallest scatter
- PHYSICS: slope more distant from SS for AGN, NW,W
- EVOLUTION: almost none in normalization, very small in M_{gas} and T (none in Y_X)
- EVOLUTION: scatter increases with z for T and Y_X