The impact of feedback on cosmological gas accretion

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NO FEEDBACK vs. FEEDBACK

(Fiducial Illustris Model)

"simple physics"

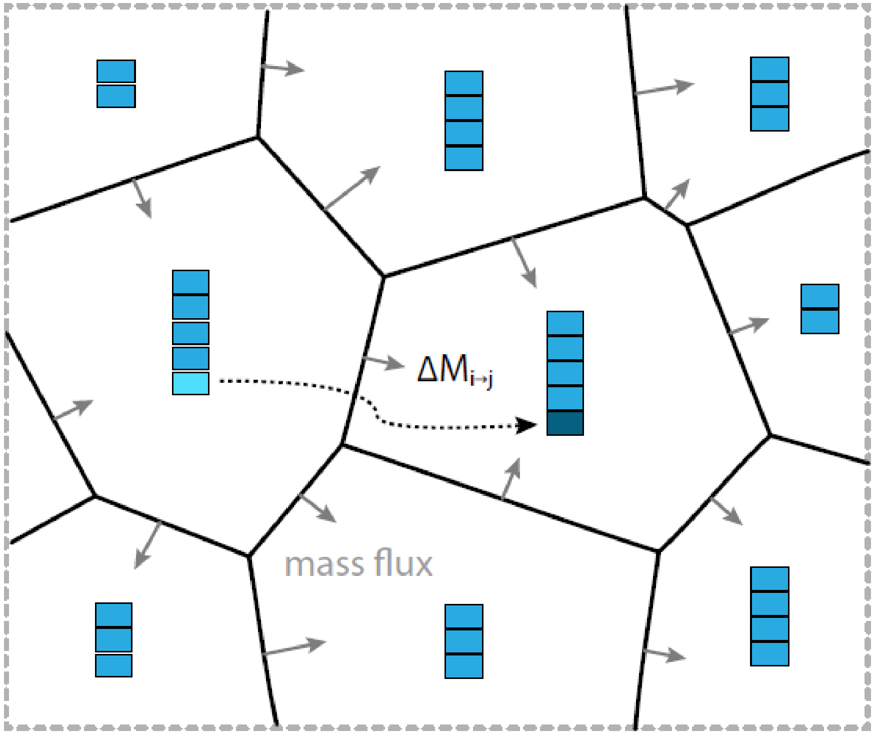
- 20/h Mpc box
- WMAP-7 cosmology
- Radiative cooling + UVB heating (primordial H,He)
- Subgrid K-S type star formation recipe
- No stellar/AGN feedback (no winds/outflows)

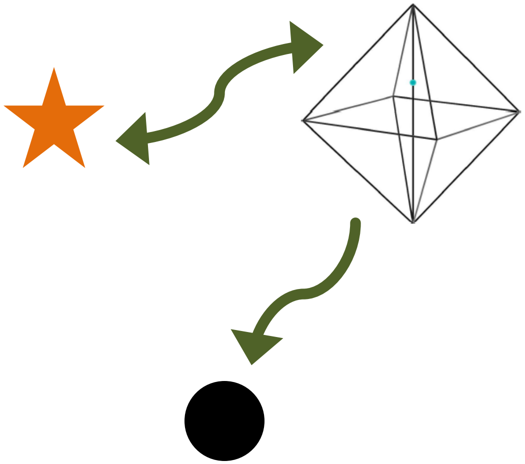
"minimally comprehensive, standard state of the art"

- Metal line cooling (CLOUDY)
- Stellar evolution: mass/metal return
- Stellar feedback: SNIa, SNII, AGB
- Chemical enrichment: H, He, C, N, O, Ne, Mg, Si, Fe
- Kinetic wind treatment -> galactic-scale outflows
- Black hole feedback (quasar/radio mode), nearby radiation effects

Gas Elements	DM Particles	Vel Tracers	MC Tracers	$m_{\rm target/SPH}$ $[h^{-1}M_\odot]$	$m_{\rm DM}$ $[h^{-1}M_\odot]$	ϵ $[h^{-1}$ kpc$]$
128^3	128^3	1 x 128^3	10 x 128^3	4.8 x 10^7	2.4 x 10^8	4.0
256^3	256^3	1 x 256^3	10 x 256^3	6.0 x 10^6	3.0 x 10^7	2.0
512^3	512^3	1 x 512^3	10 x 512^3	7.4 x 10^5	3.7 x 10^6	1.0

In order to trace the history of accreting gas in a grid-type code, we developed a "Monte Carlo tracer particle" scheme.





Tracks mass transfer between all baryonic components in the simulation.

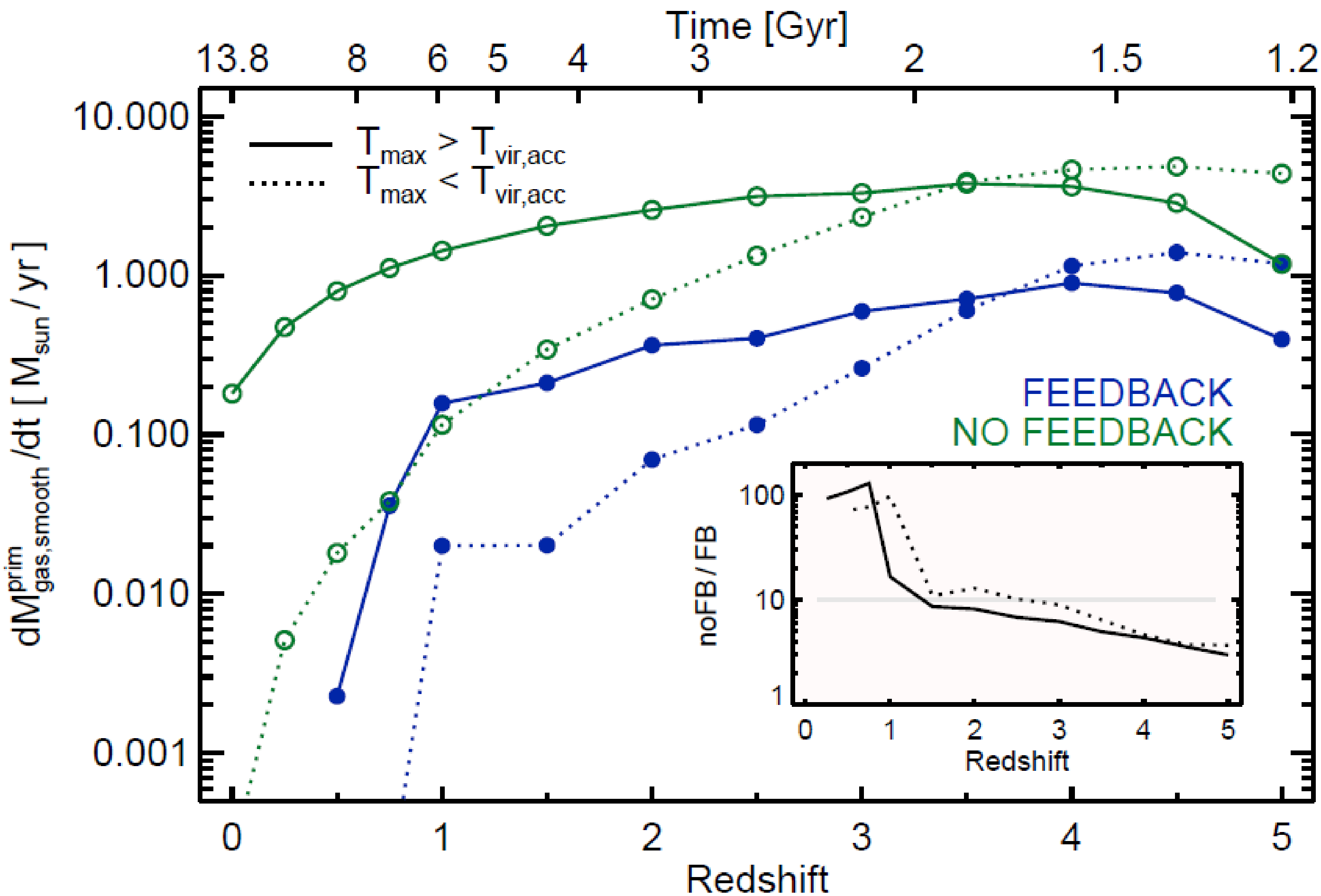
Genel, Vogelsberger, DN+ (2013)

Accretion rate of smooth, primordial gas suppressed by feedback for ~$10^{11.5}$ halos, regardless of T_{max} / T_{vir}.

Mode
Smooth
Stripped
Clumpy

Origin
Primordial
P+Recyc

Direction
In
Out
Net



Also considering the recycled contribution supports late time net accretion (and SFR) in the feedback run.

Mode
Smooth
Stripped
Clumpy

Origin
Primordial
P+Recyc

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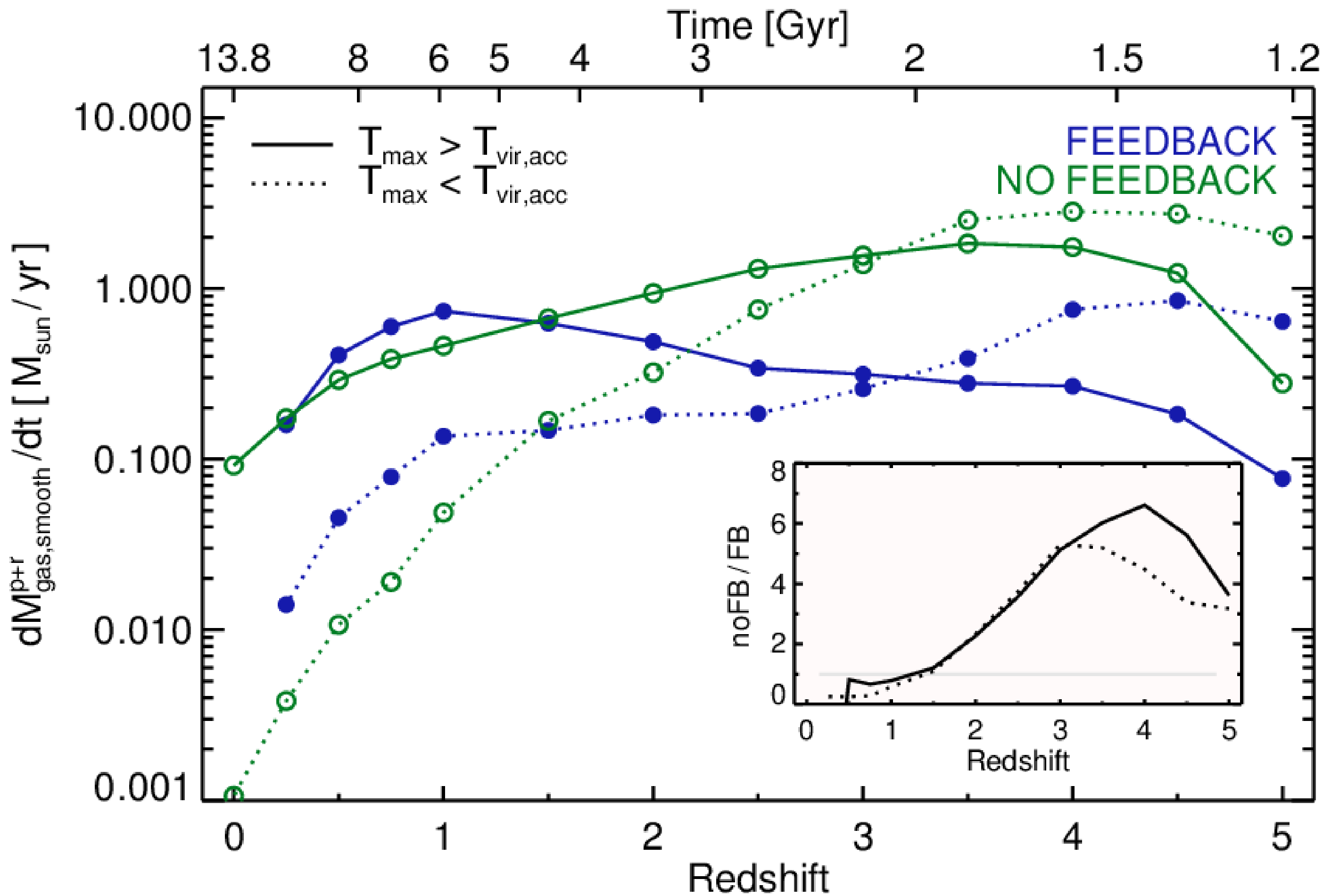
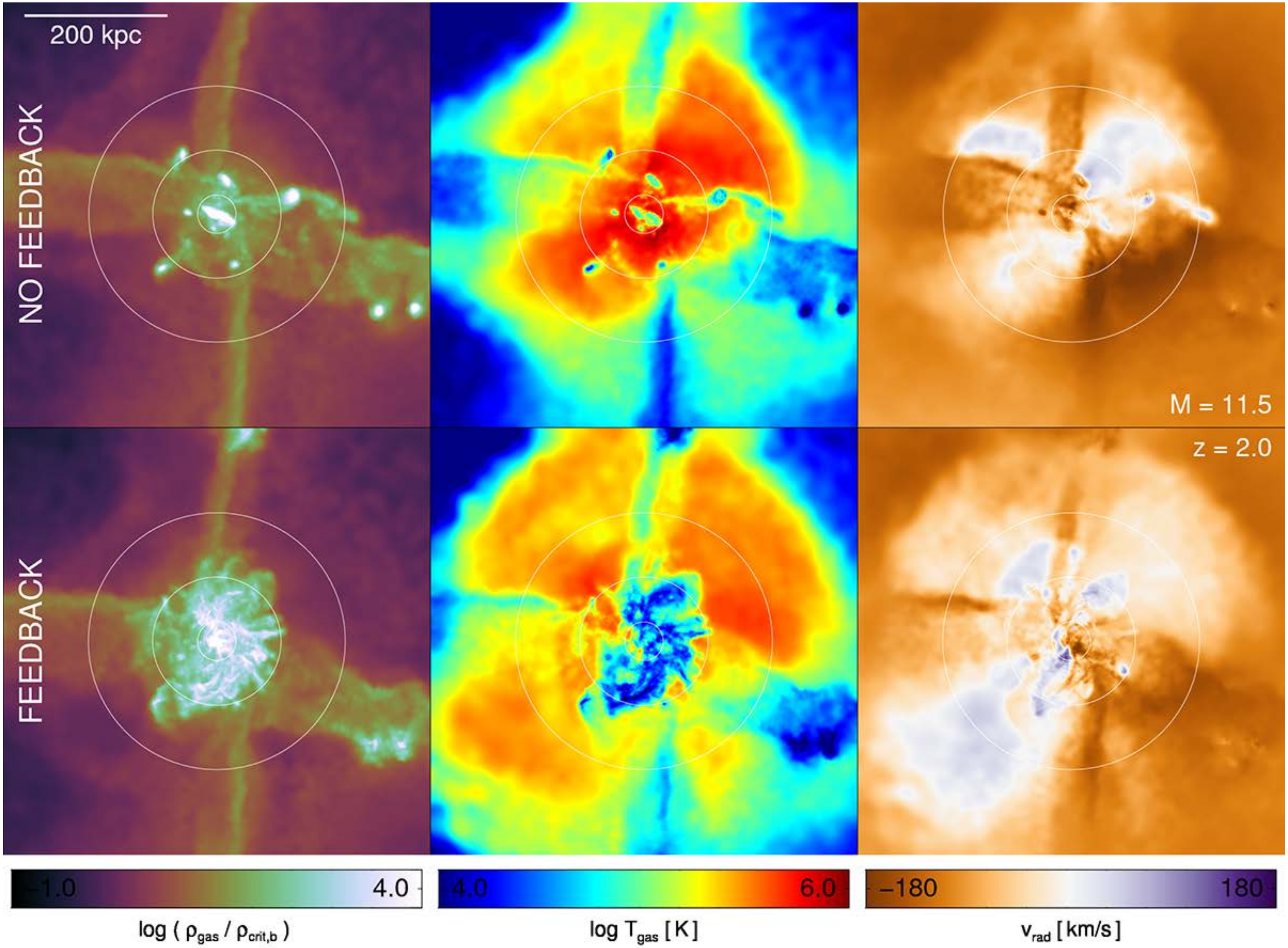
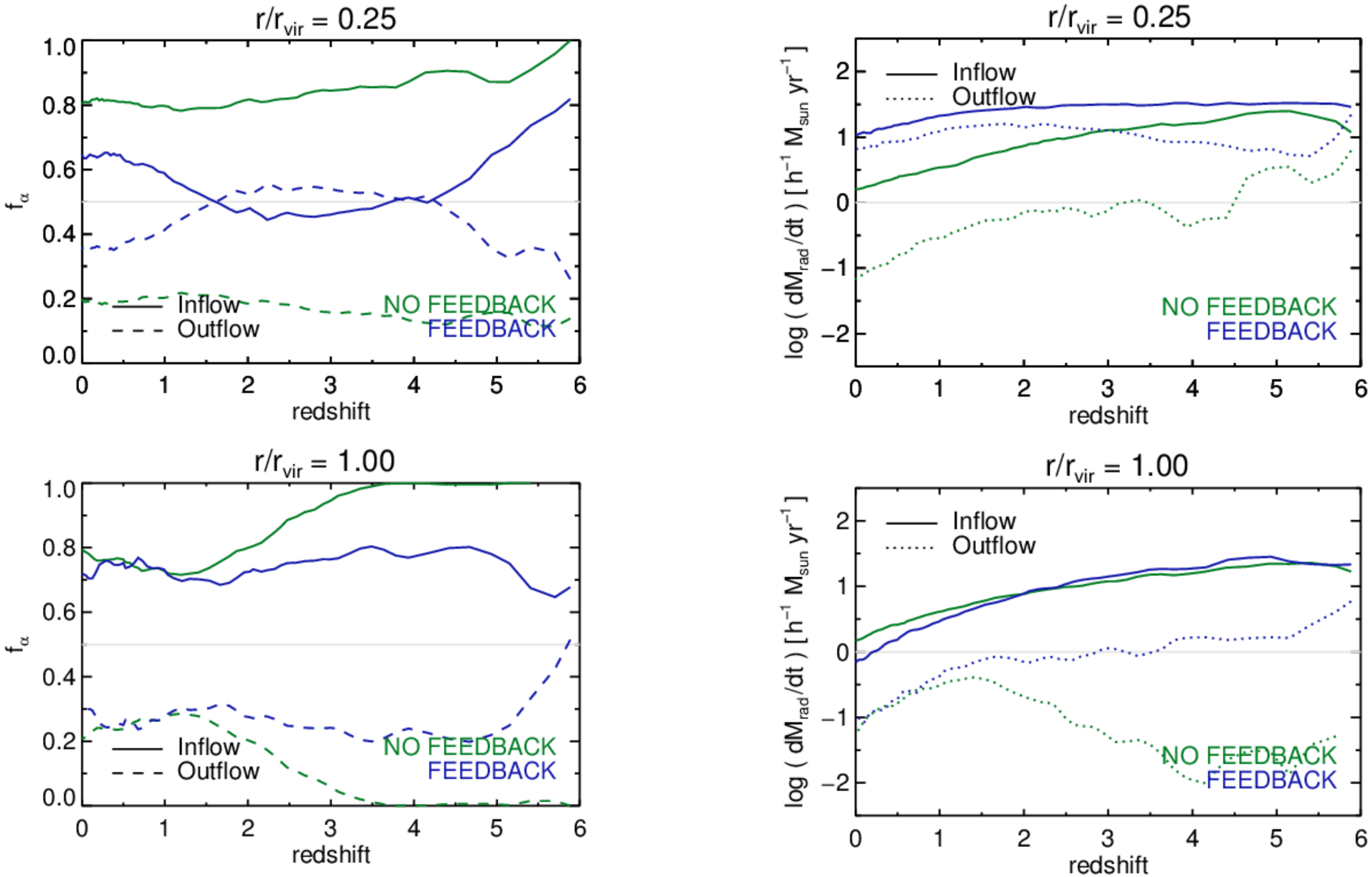
In
Out
Net



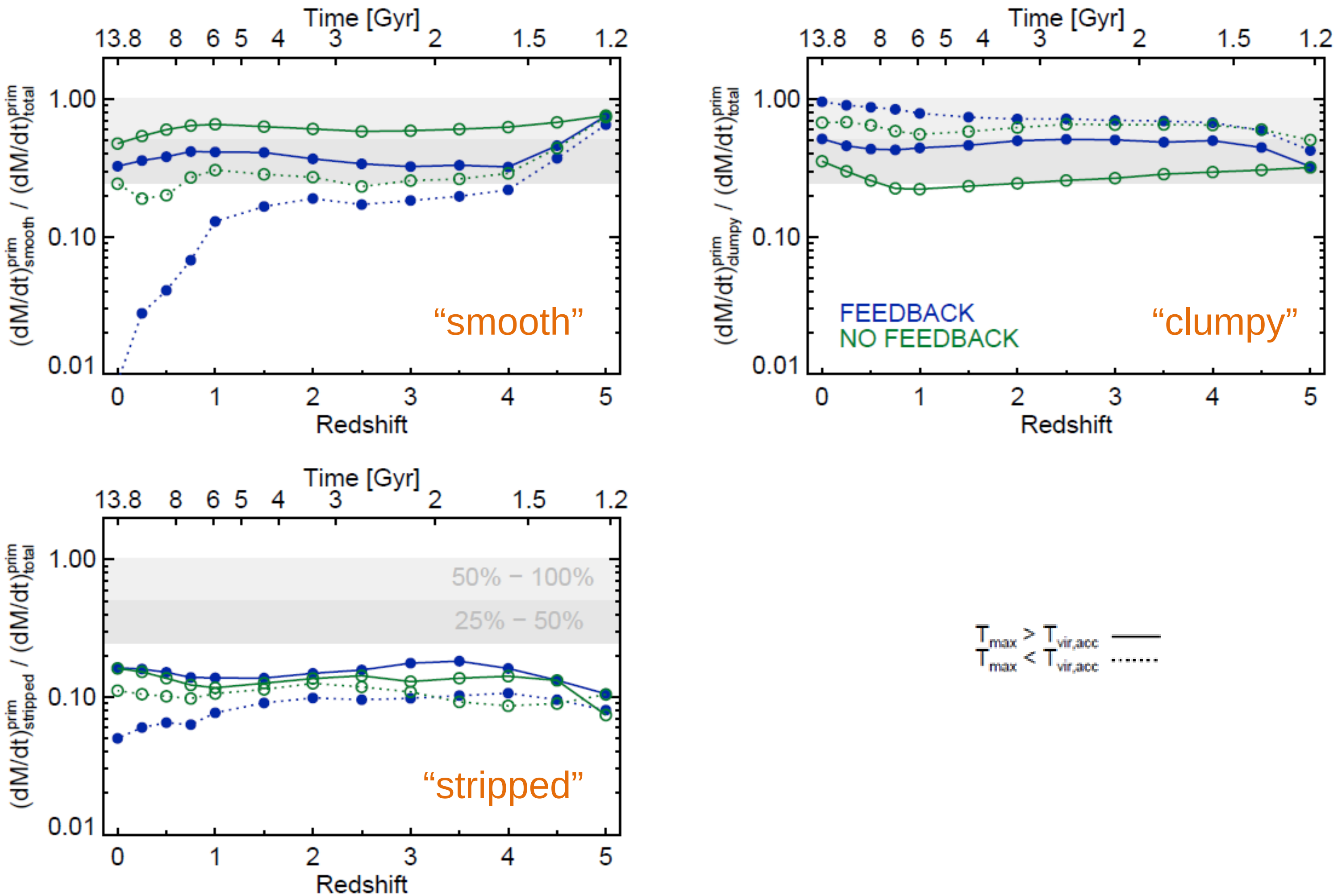
Nelson+ (in prep)


200 kpc
NO FEEDBACK
FEEDBACK
M = 11.5
z = 2.0
-1.0
4.0
log (ρgas / ρcrit,b)
4.0
6.0
log Tgas [K]
−180
180
vrad [km/s]

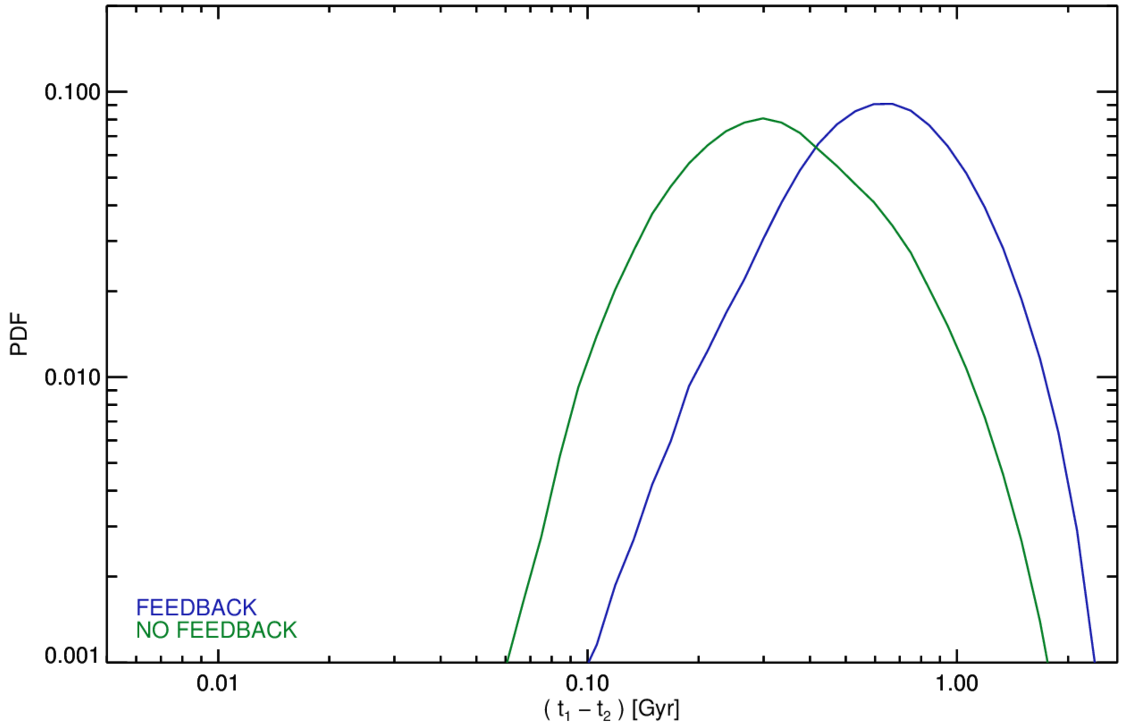
Feedback boosts spherical covering fractions of outflow as well as outflow rates, strongly at 0.25 r_{vir}, somewhat at 1.0 r_{vir}.



The fractional contribution of smooth accretion is suppressed across all redshifts, and particularly so for T_{max} / T_{vir} material at z < 1.



The presence of feedback increases the time taken by gas to transit from the virial radius to the galaxy.



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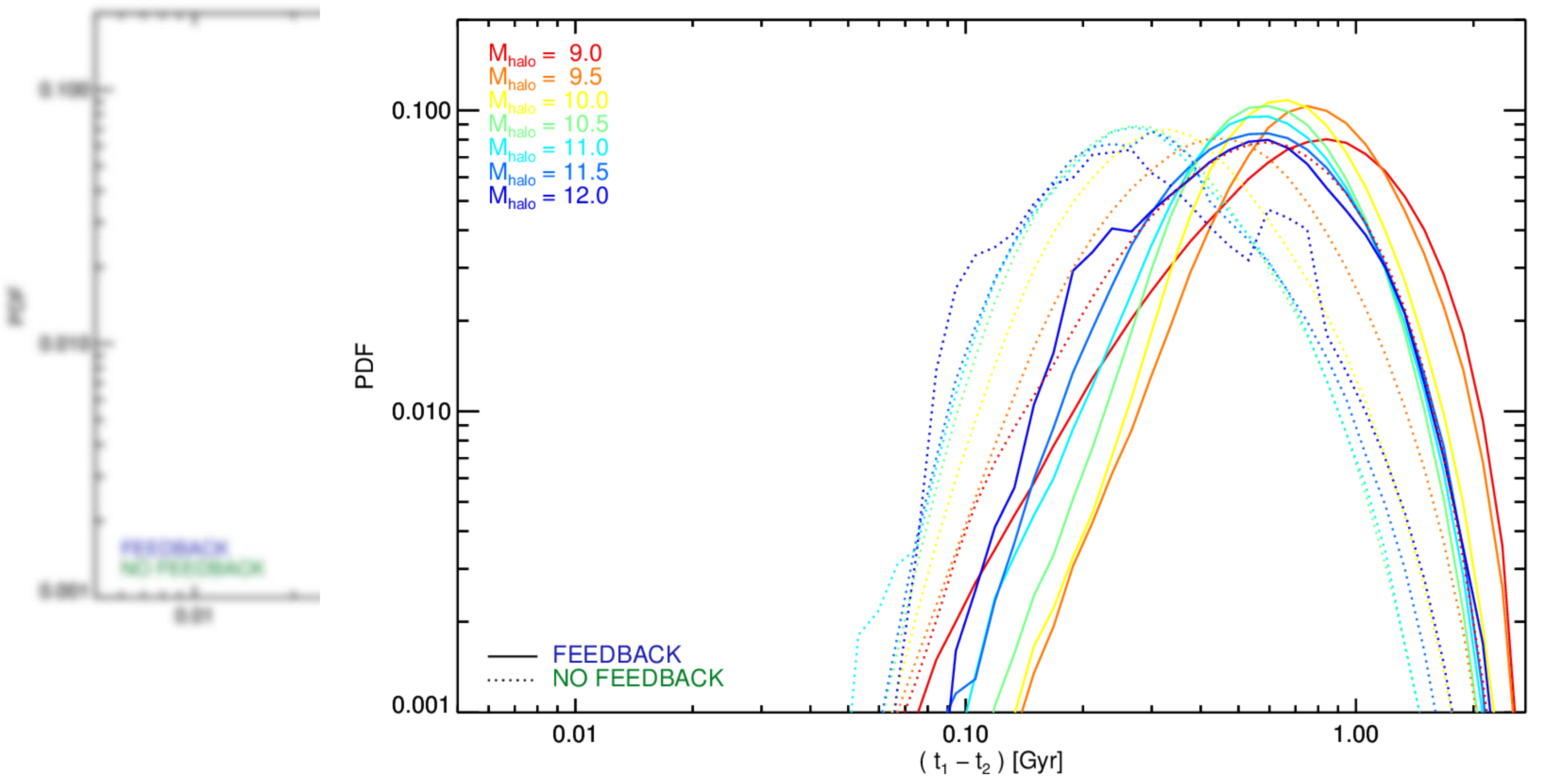
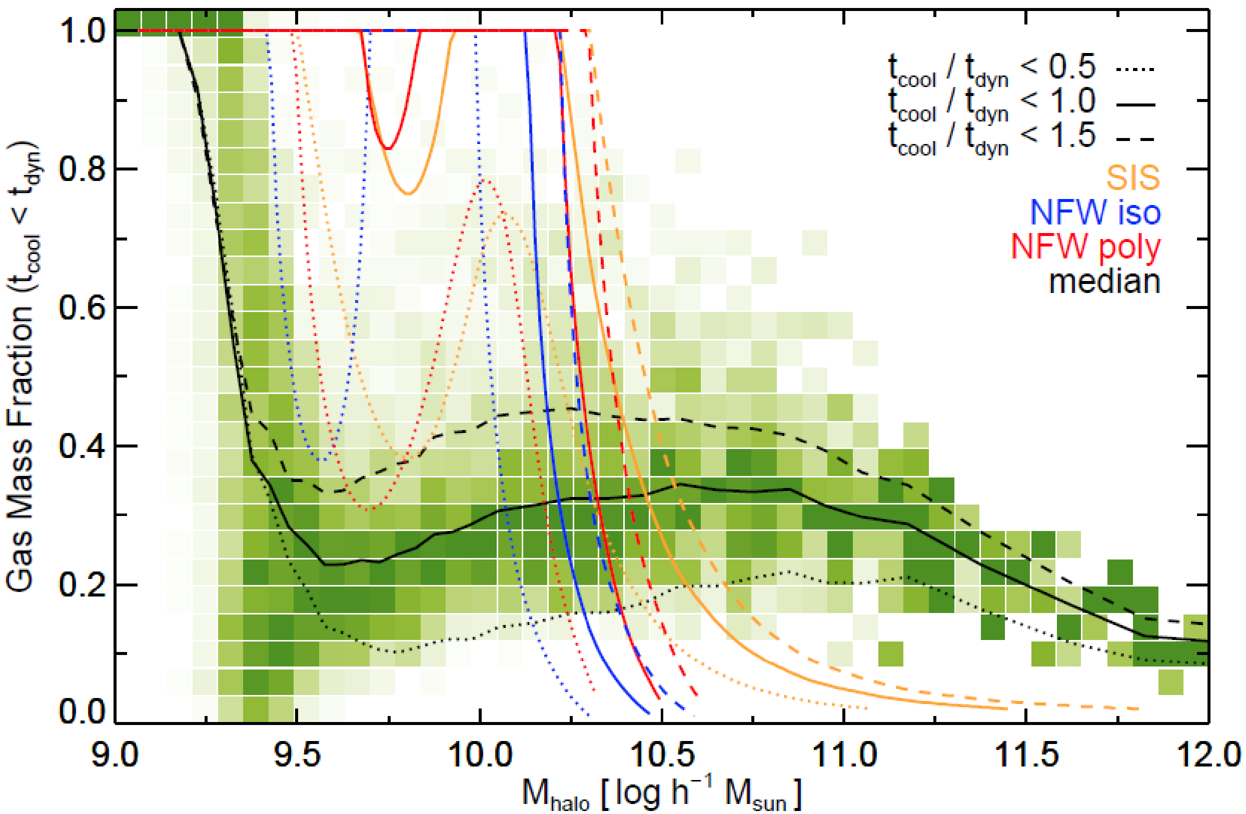
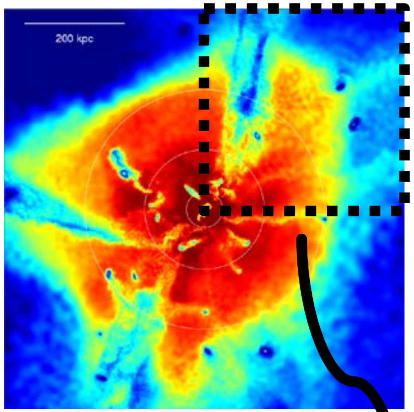


The fraction of hot halo gas "eligible" to cool onto the galaxy also remains relatively flat from 10^{10} to 10^{12}.

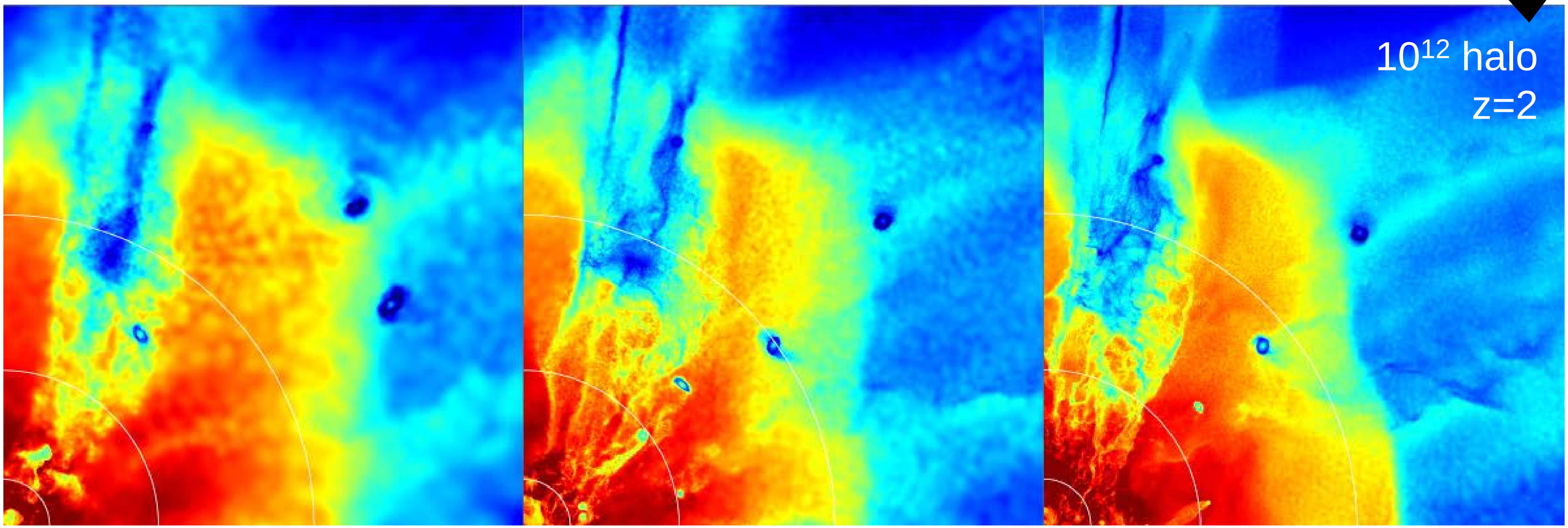


(NO FEEDBACK)

Although zooms of increasing resolution have good convergence of gas accretion properties, the stream-halo interactions/morphology becomes increasingly complex.



~ Illustris/Eagle x8 mass resolution x64 mass resolution



(gas mass resolution 5e5 -> 7e3) (“CGM res” 2.6 kpc -> 0.8 kpc)

Some Conclusions

1. Rate of smooth, primordial gas accretion suppressed by feedback for $\sim 10^{11.5}$ halos (by ~10 at z=2, increasing towards z=0).

2. Spherical covering factor of inflowing gas at 0.25 r_{vir} decreases, while the rates of both inflow and outflow increase.

3. The fractional contribution of smooth accretion is lower across all redshifts, and particularly so for T_{max} / T_{vir} material at z < 1.

4. The "halo transit time" of smooth accretion increases, but neither it (nor the fraction of gas with $t_{cool} < t_{dyn}$) vary strongly with halo mass.