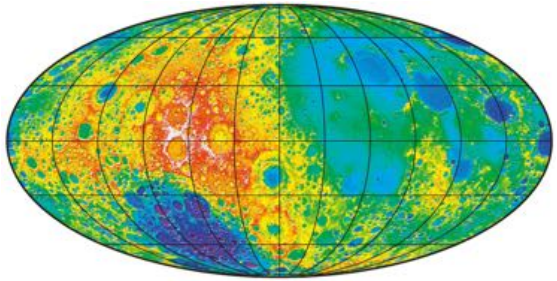
Crustal recycling and the history of magmatism in Venus

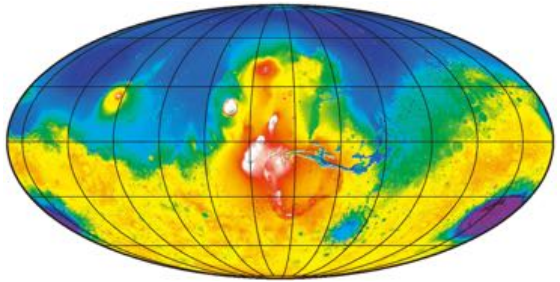
Masaki Ogawa

(University of Tokyo at Komaba)

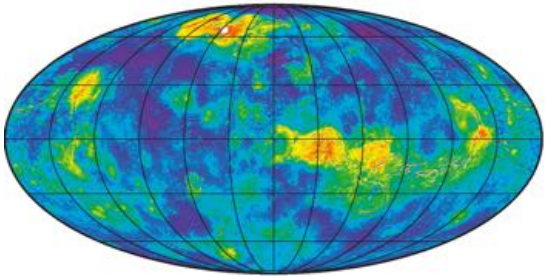
Moon; 1/100 M_{Earth}



Mars; 1/10 M_{Earth}



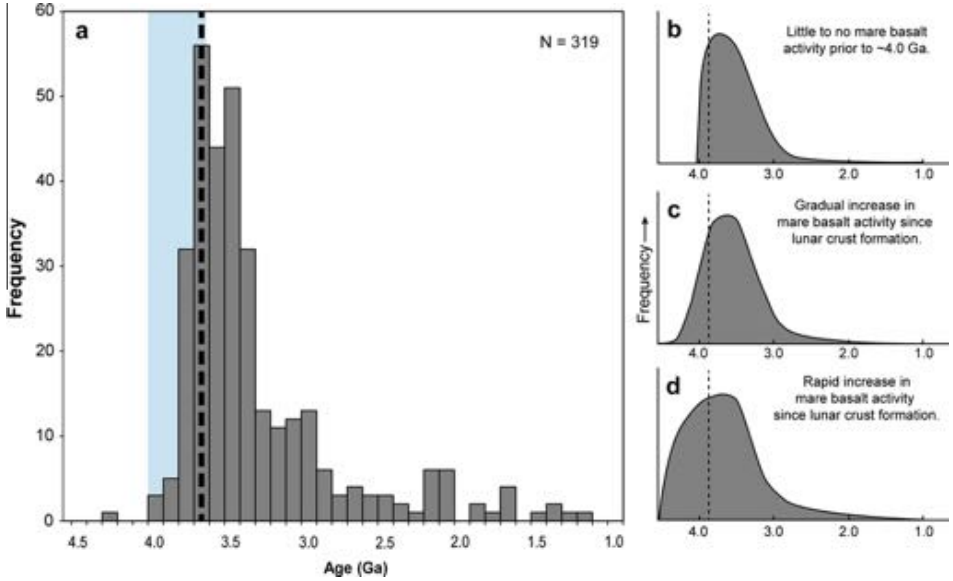
Venus; 0.8 M_{Earth}



(Wieczorek, 2015)

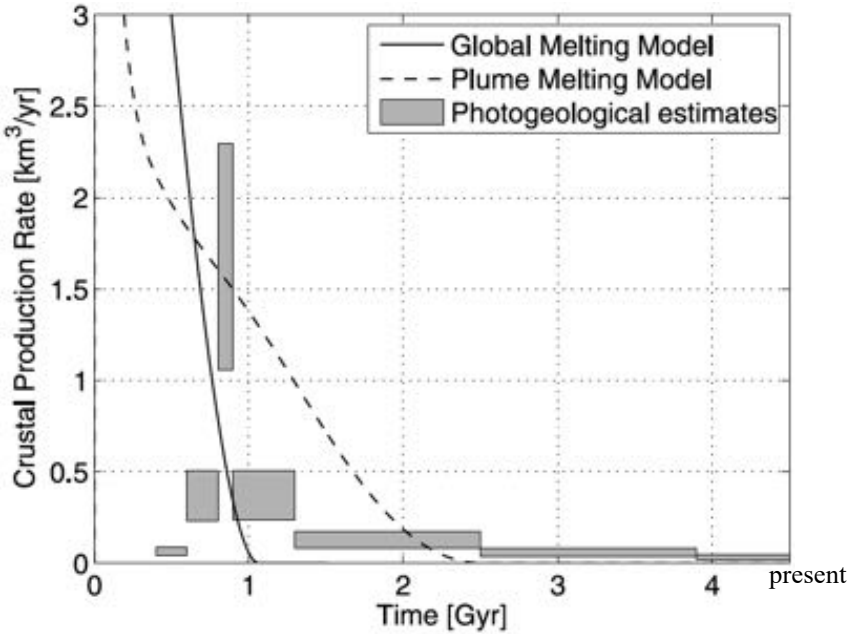
In small planets, magmatism declines early in their histories

Moon



(Whitten & Head., 2015)

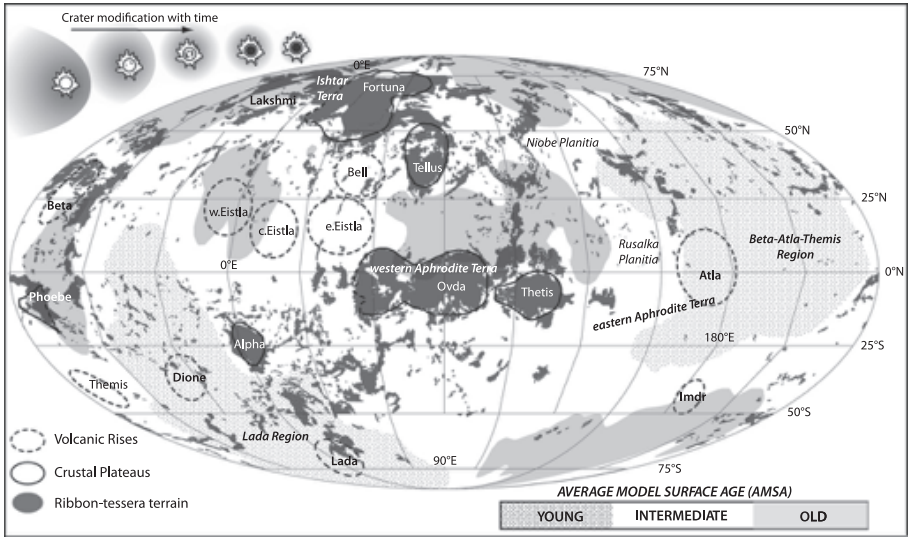
Mars



(Grott et al., 2013)

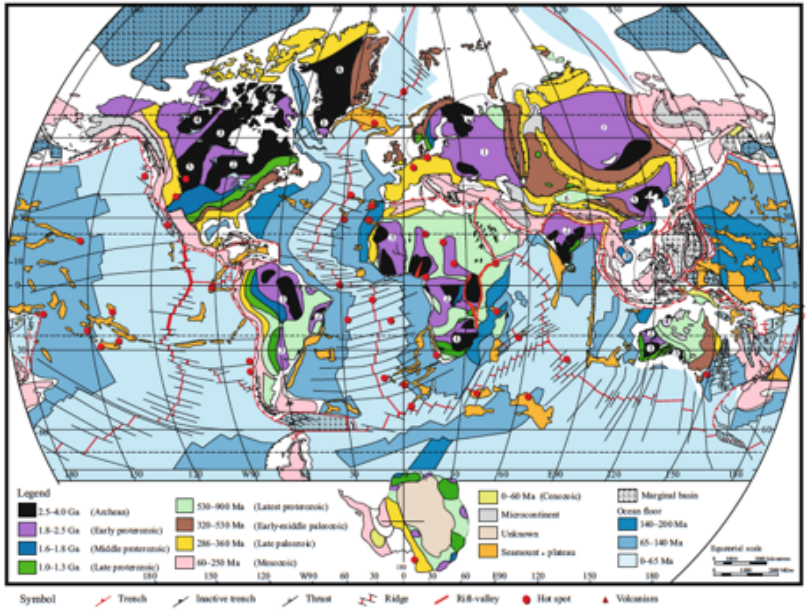
Magmatism is active even today in larger planets.

Venus



(Bjonnes et al., 2012)

Earth



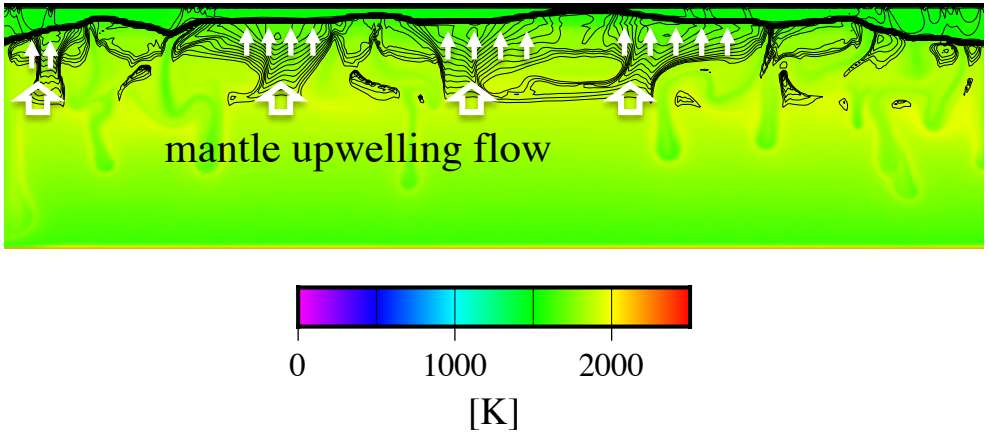
(Utsunomiya et al., 2007)

What is the reason for the long-lasting magmatism in large planets?

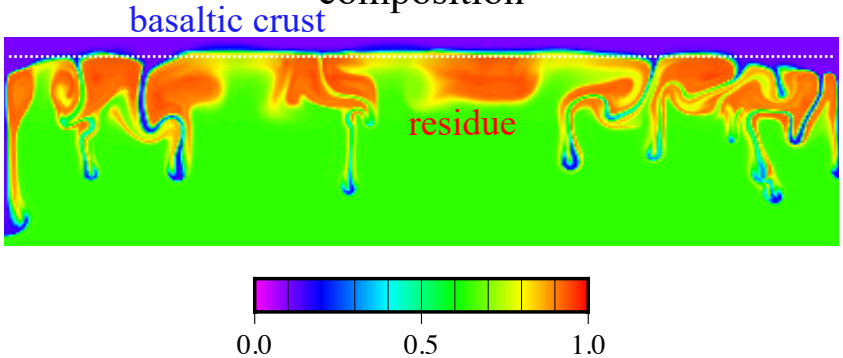
Is the large heat capacity of large planets the only reason?

a numerical model of magmatism & convection in Martian mantle

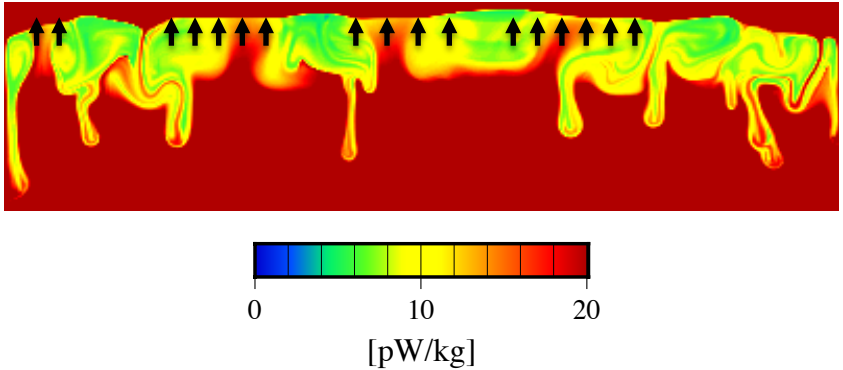
T & magma



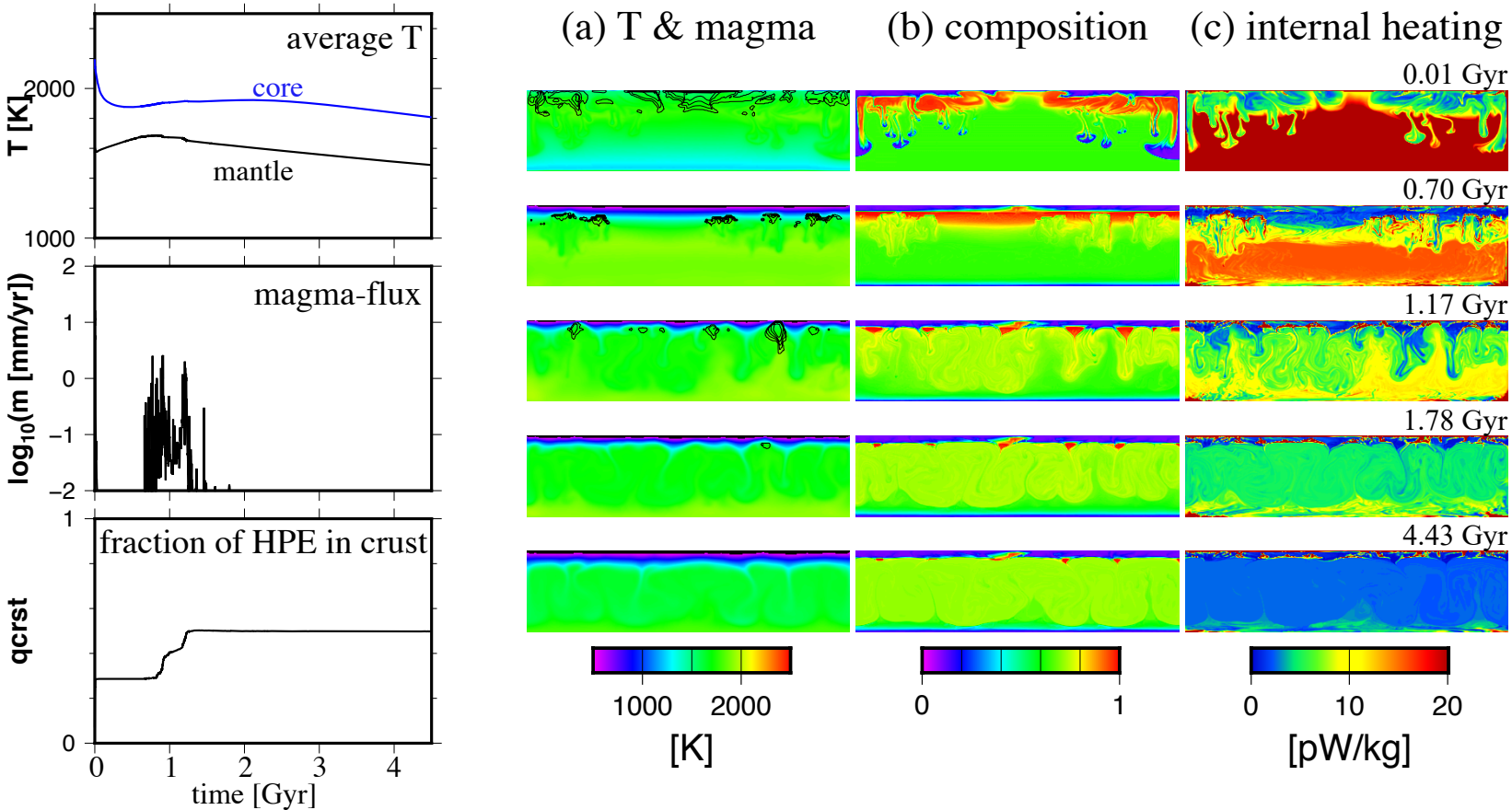
composition



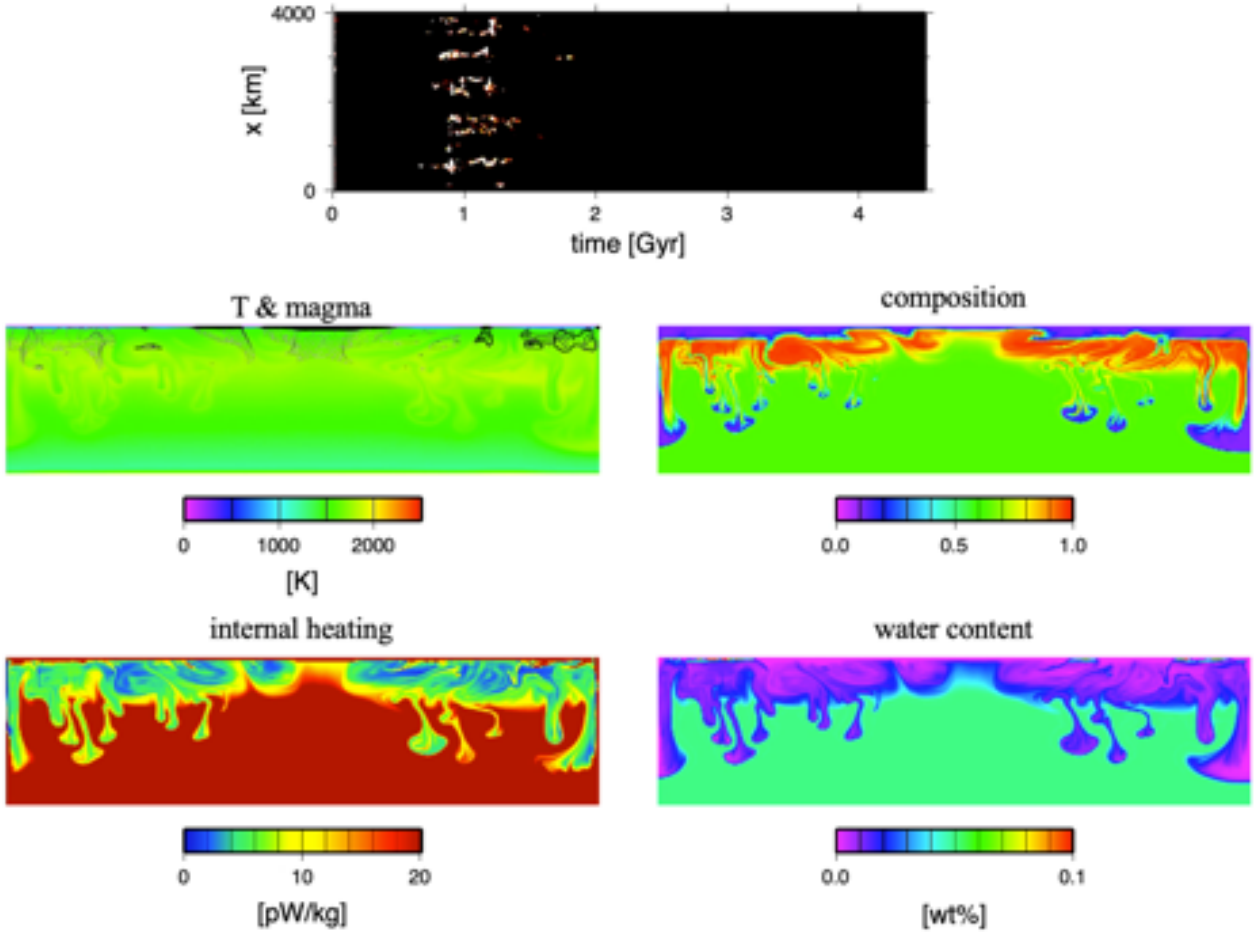
internal heating



Extraction of heat producing elements by magmatism is the reason.



A model of mantle evolution in Mars

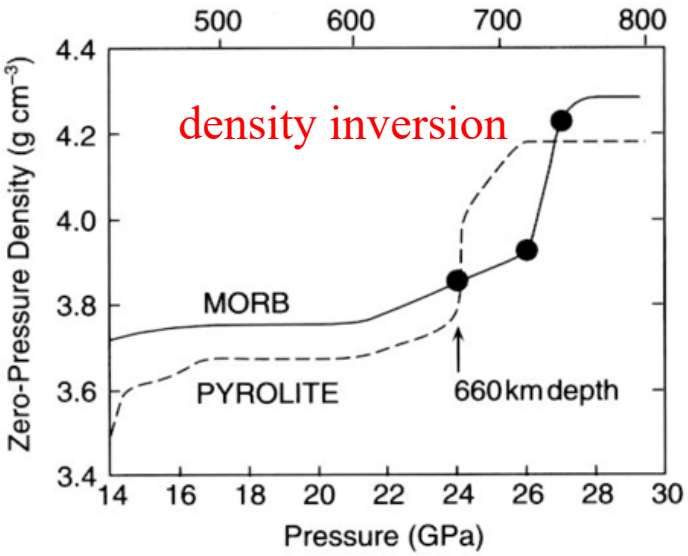


Crustal recycling is necessary for magmatism to continue long.

⇓

How did the crust recycle? In Earth by plate tectonics. In Venus?

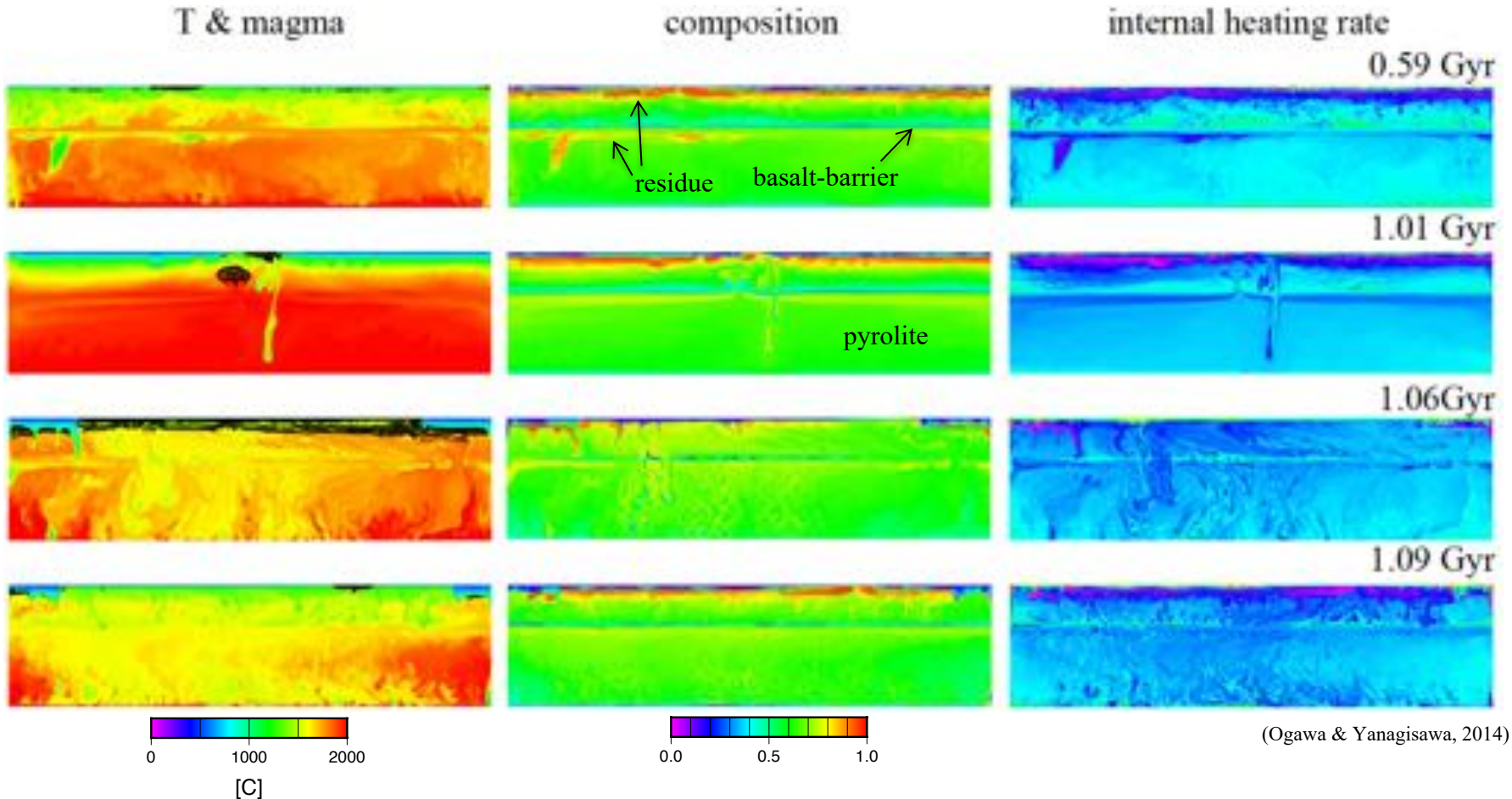
Venus = Mars + the lower mantle



(Hirose, 1999)

Pyrolite: average mantle materials
MORB: basalt

Mantle-burst caused by the density-inversion

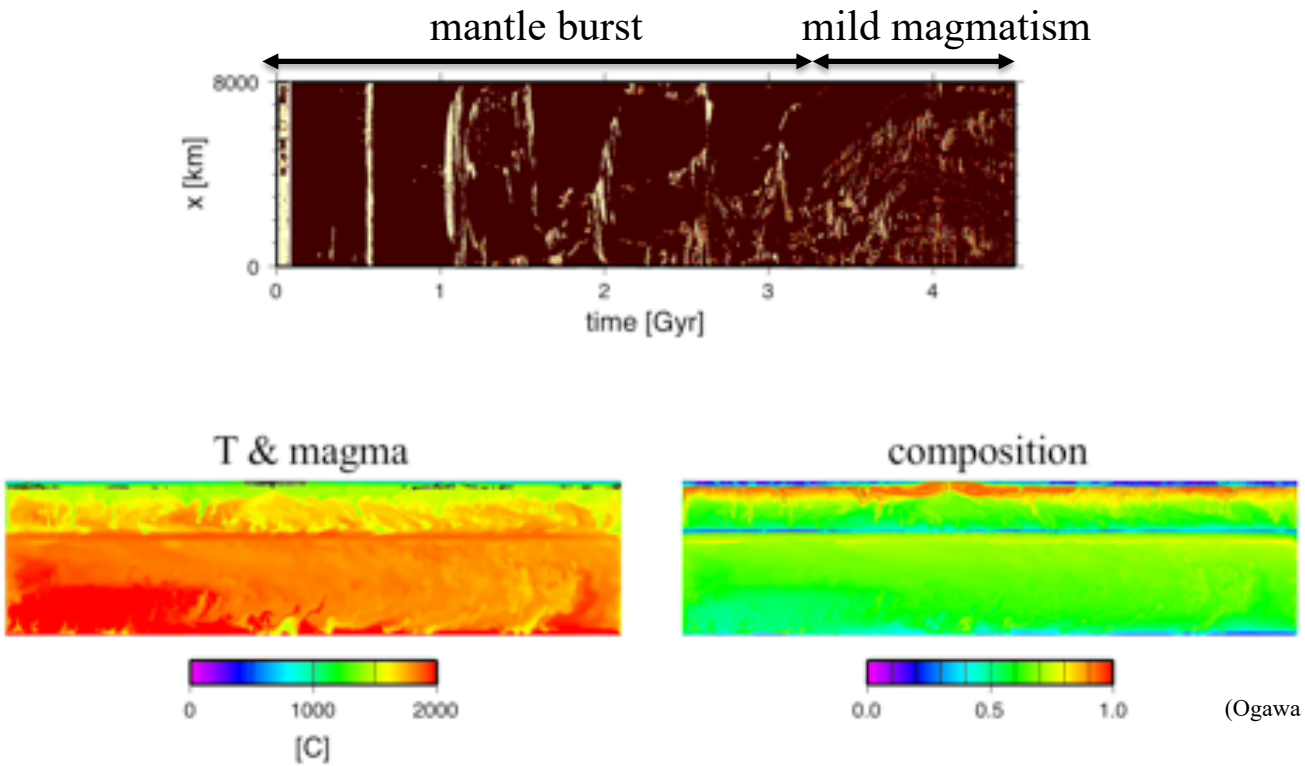


(Ogawa & Yanagisawa, 2014)

A two-stage evolution model of the Venus' mantle

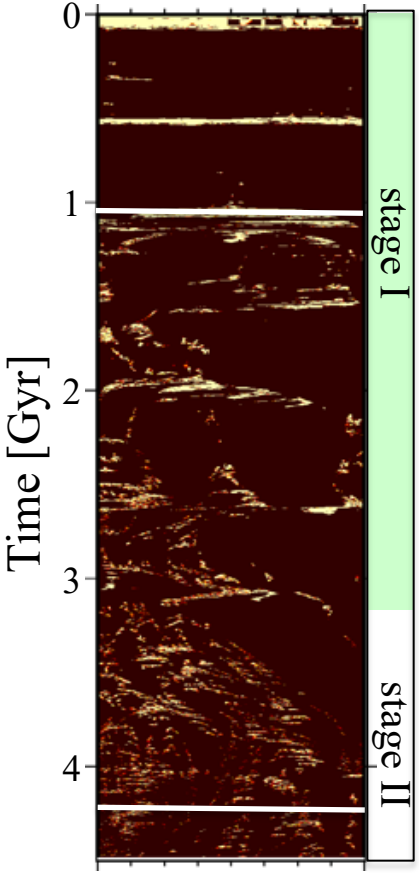
Stage 1: Mantle bursts repeatedly occur to cause a vigorous magmatism, and the crust recycles.

Stage 2: Mantle bursts subside due to decay of HPEs. The crust recycled on Stage 1 heats the mantle to cause a mild & continuous magmatism.

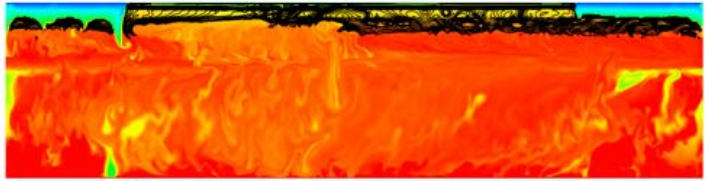


(Ogawa & Yanagisawa, 2014)

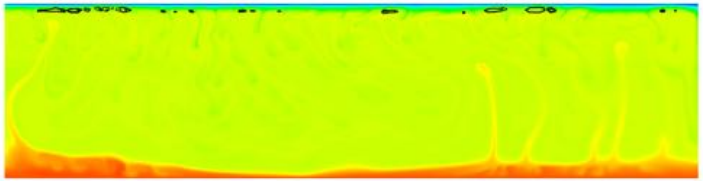
The early “mantle burst” stage may correspond to the era of tessera terrane, while the later “mild magmatism” stage may correspond to the era when volcanic plain was formed.

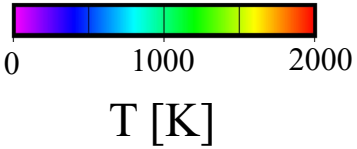


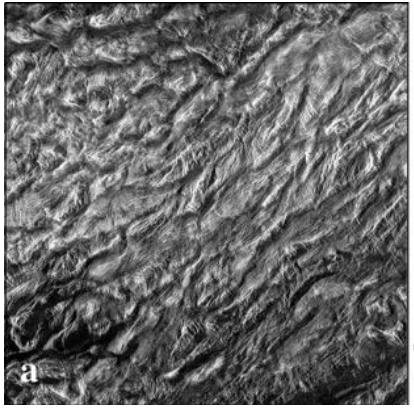
surface deformation by matnel bursts → tessera?

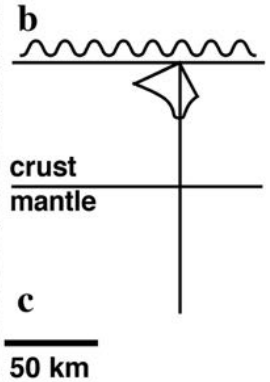


mild magmatism → resurfacing?

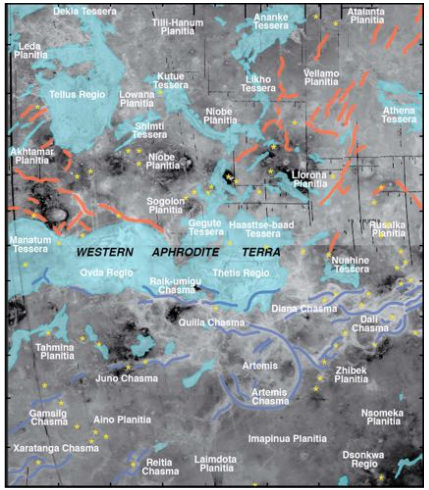


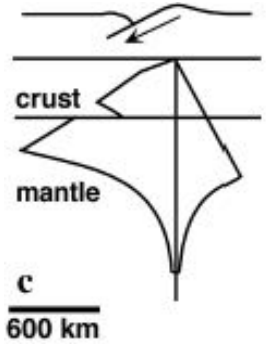






(Brown & Grimm, 1999)





(Hansen & Lopez., 2018)

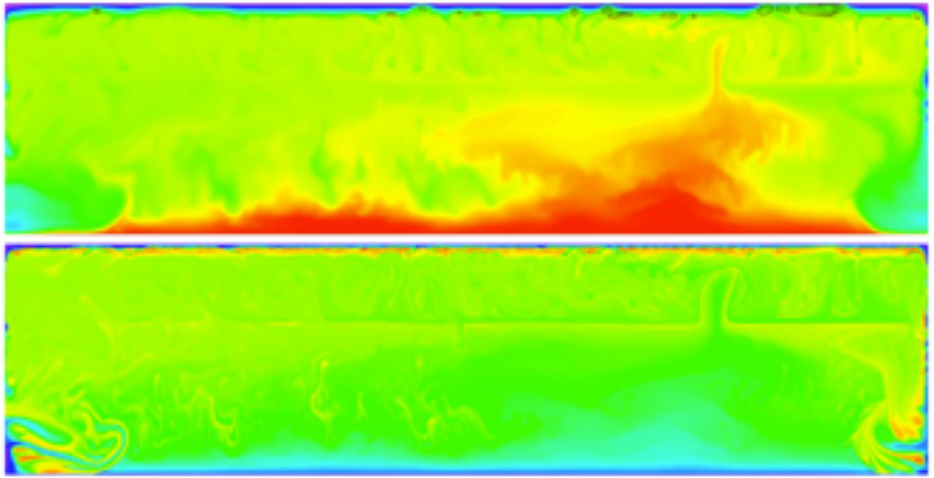
Conclusion

Crustal recycling by mantle bursts is probably the main reason for the long-lasting magmatism on Venus.

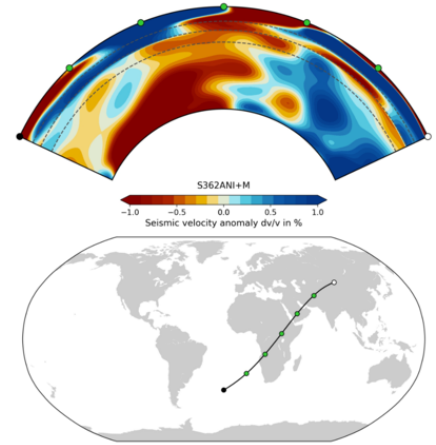
Mantle bursts can occur in the Earth, too. ⇒ Large Igneous Provinces?

temperature

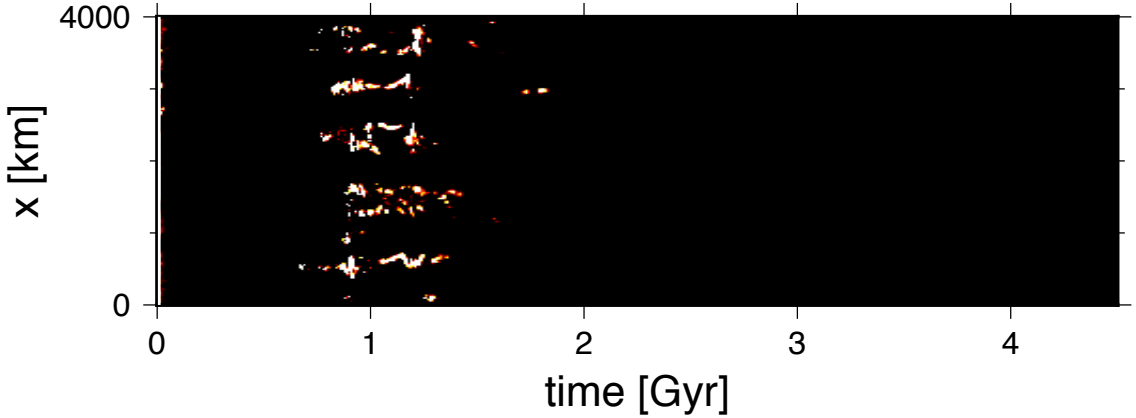
composition



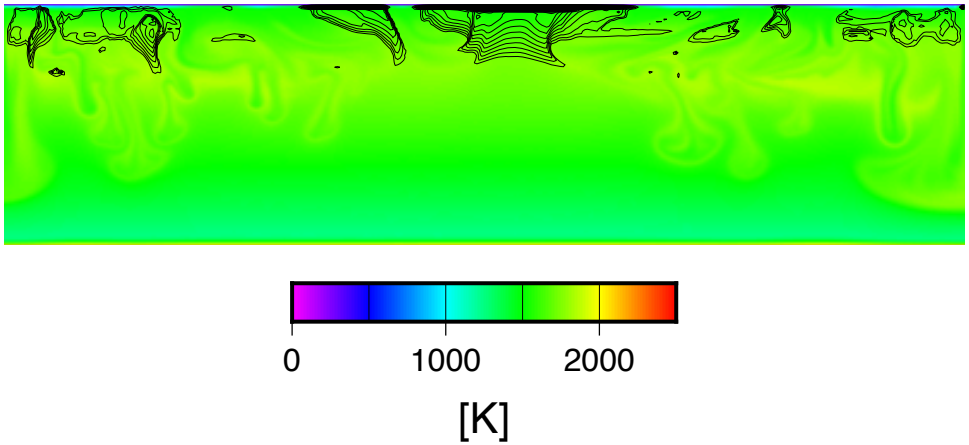
LLSVP in the Earth



S362ANI+M (submachine, oxford)



T & magma



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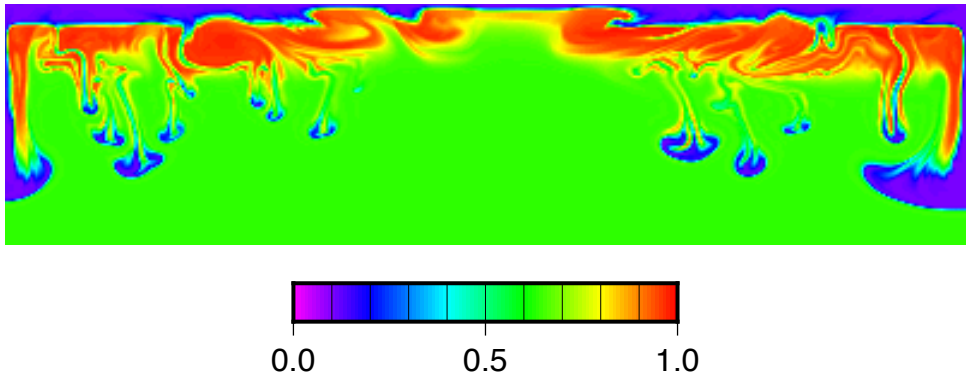
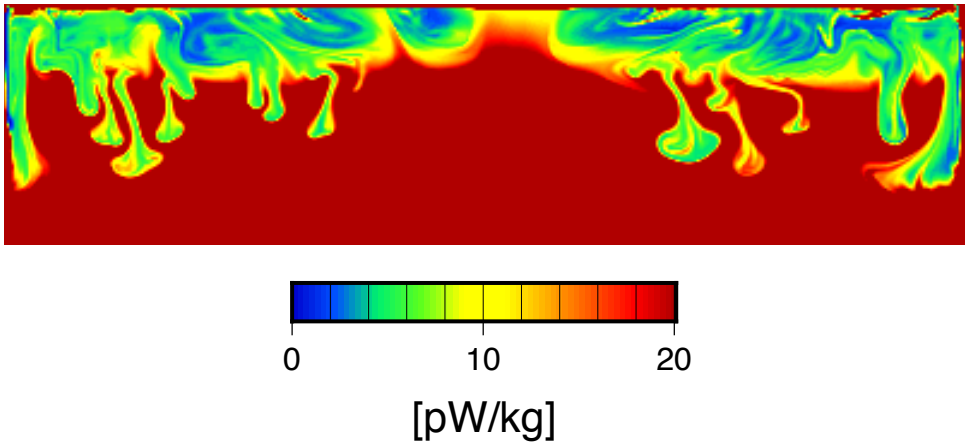
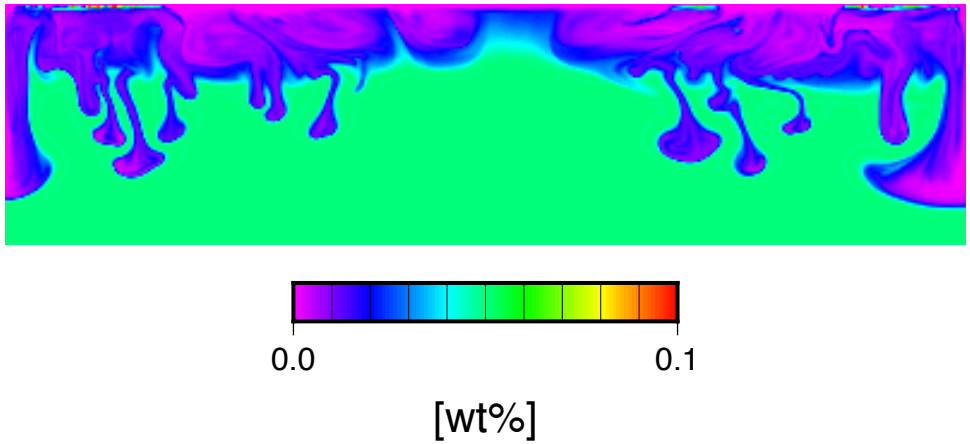
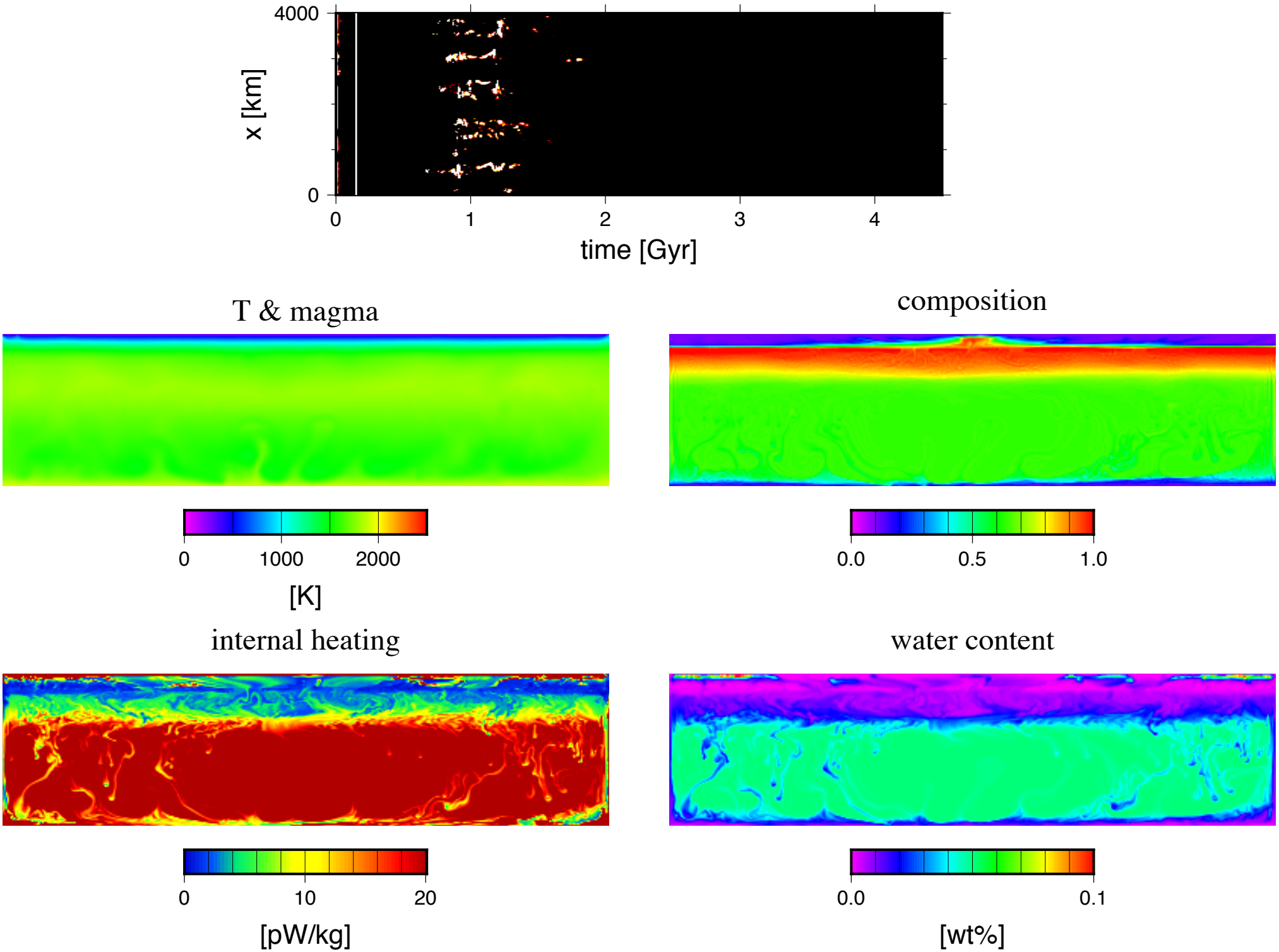


internal heating



water content

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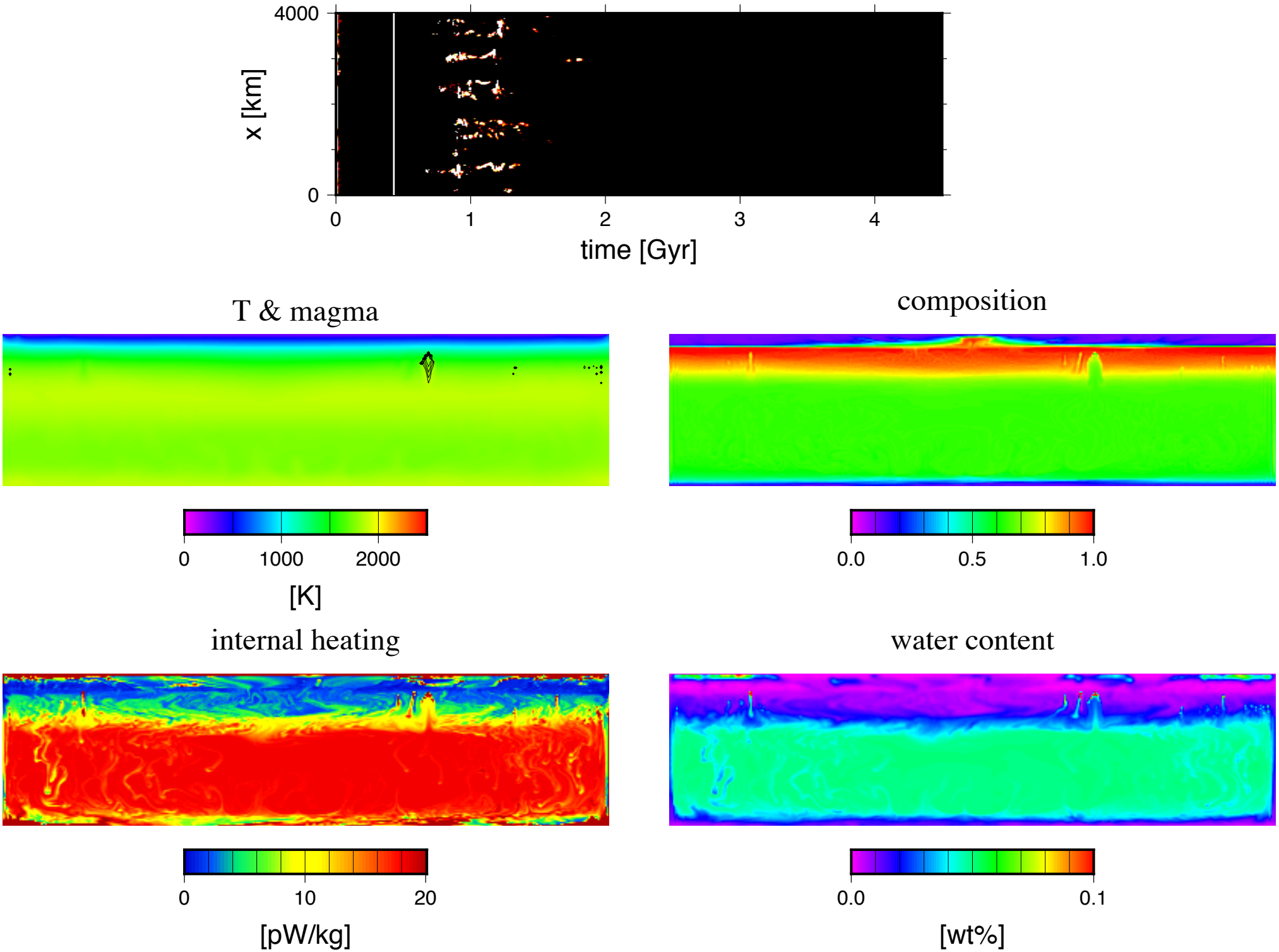
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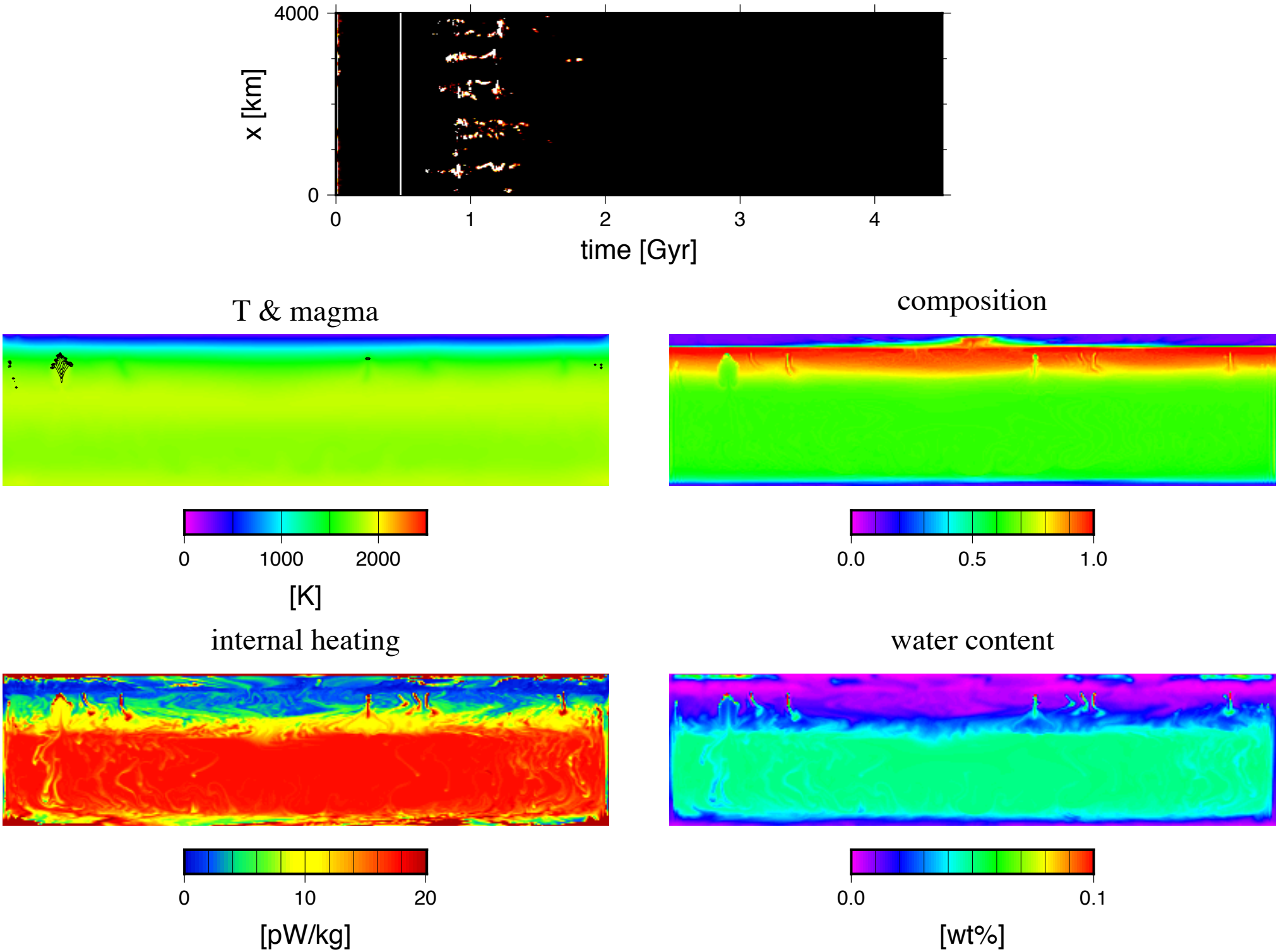
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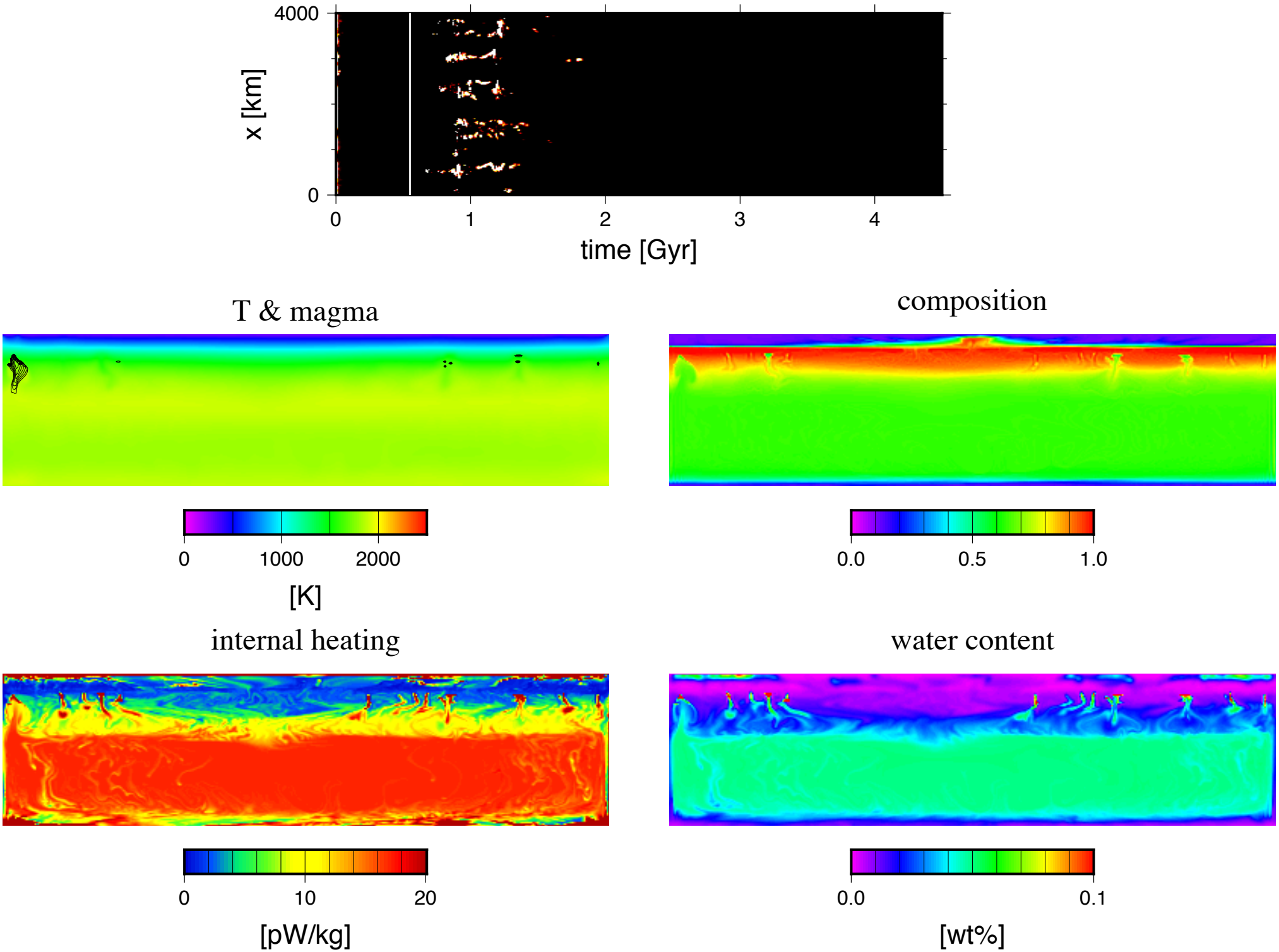
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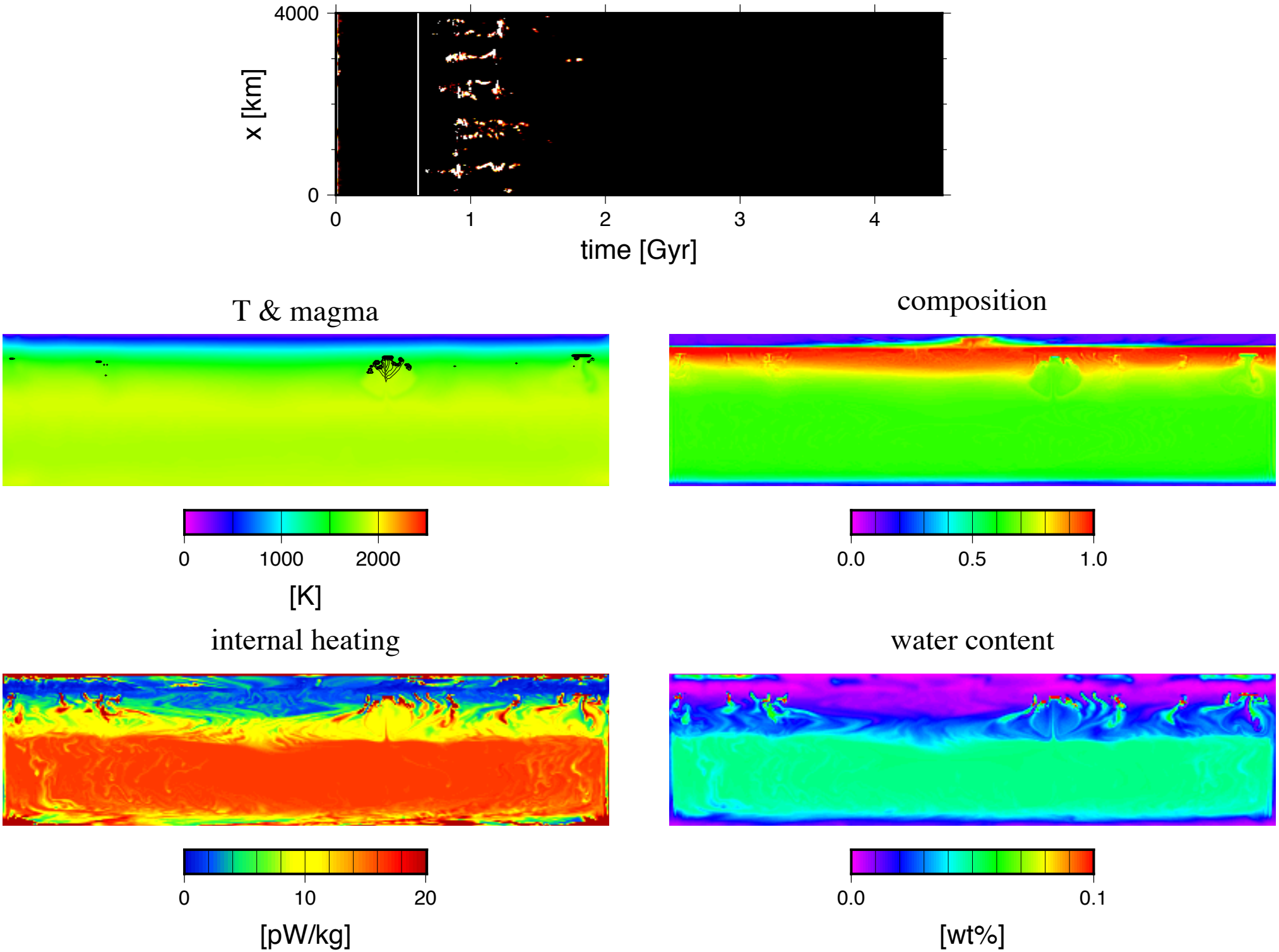
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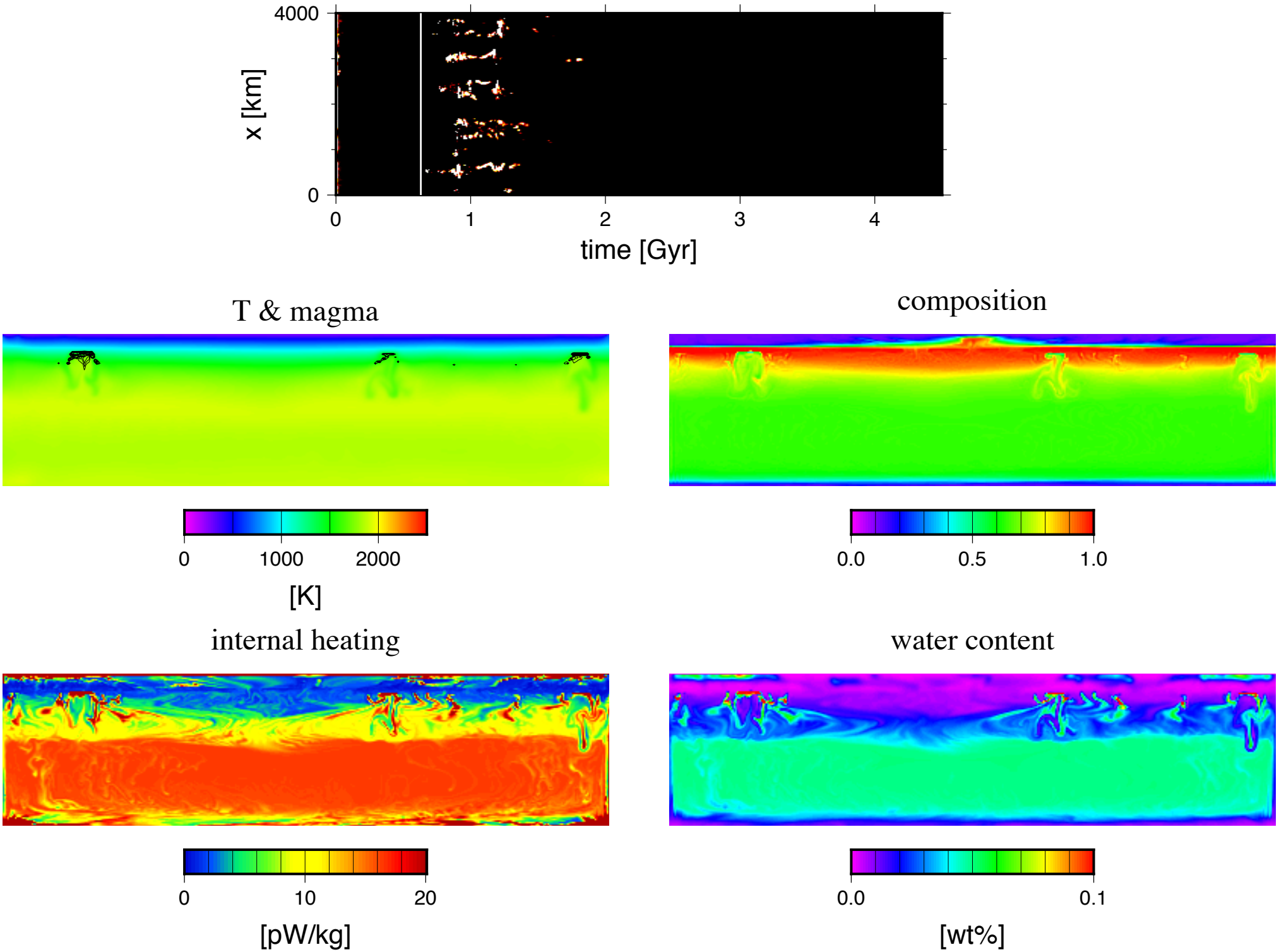
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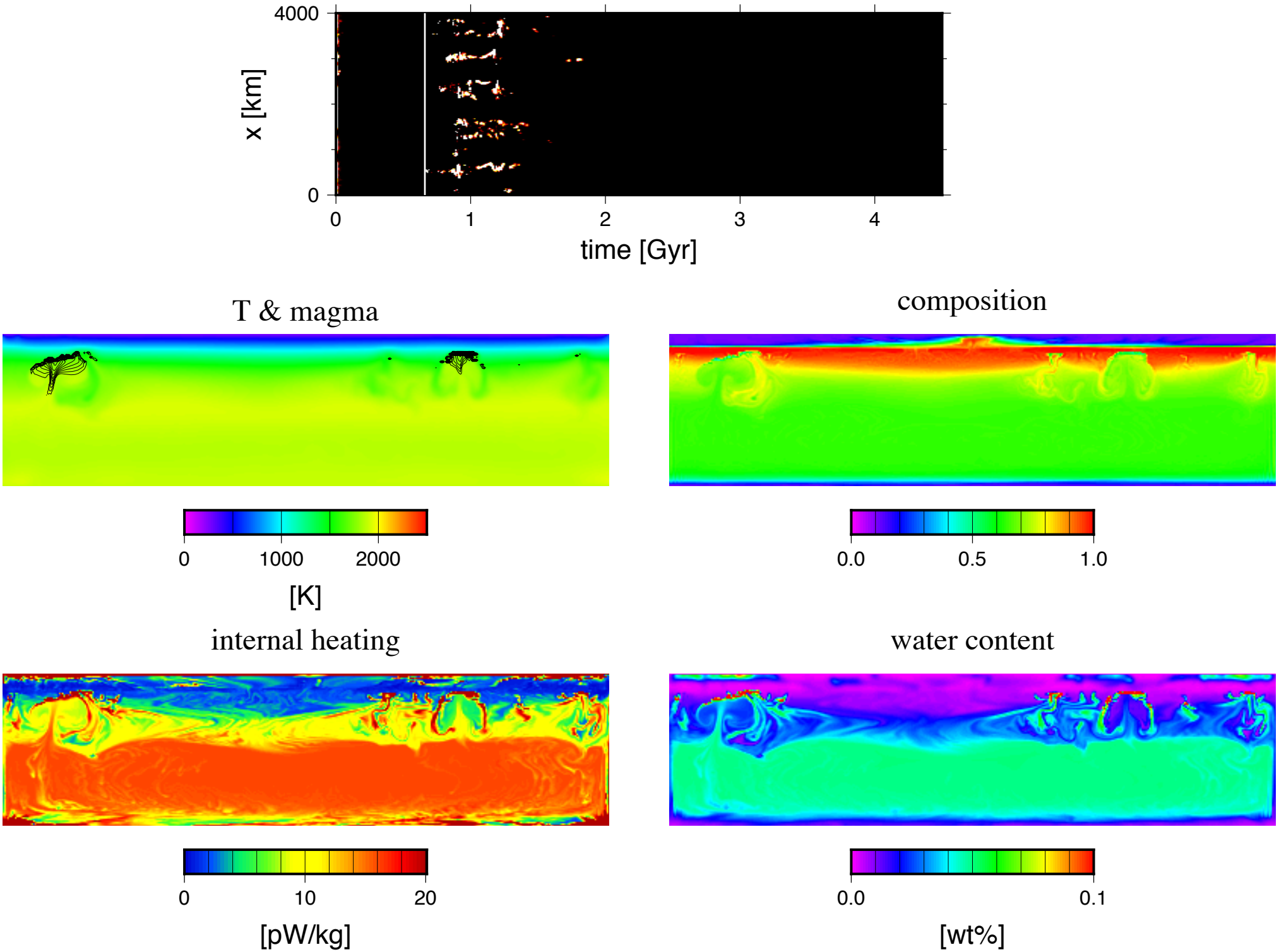
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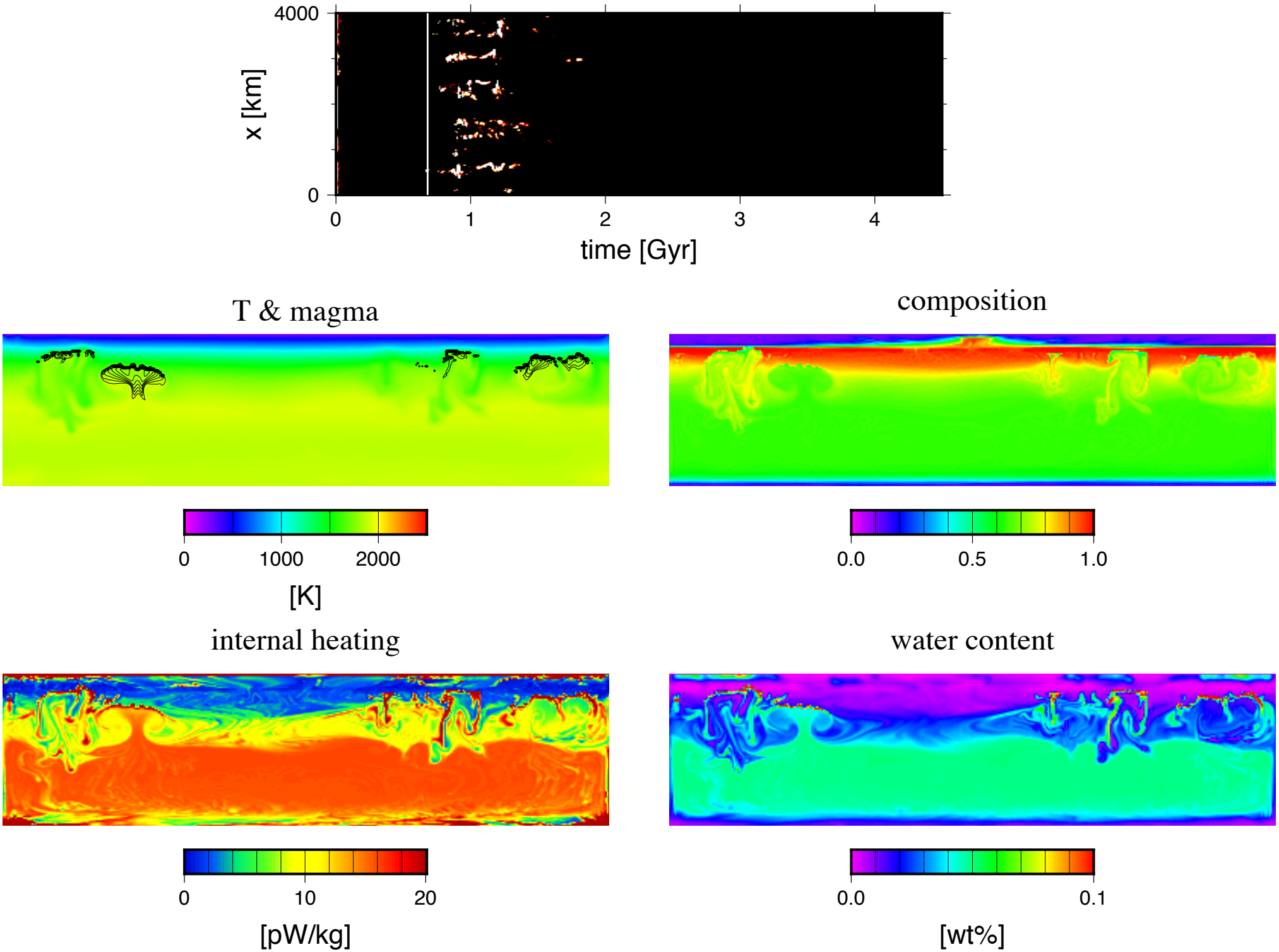
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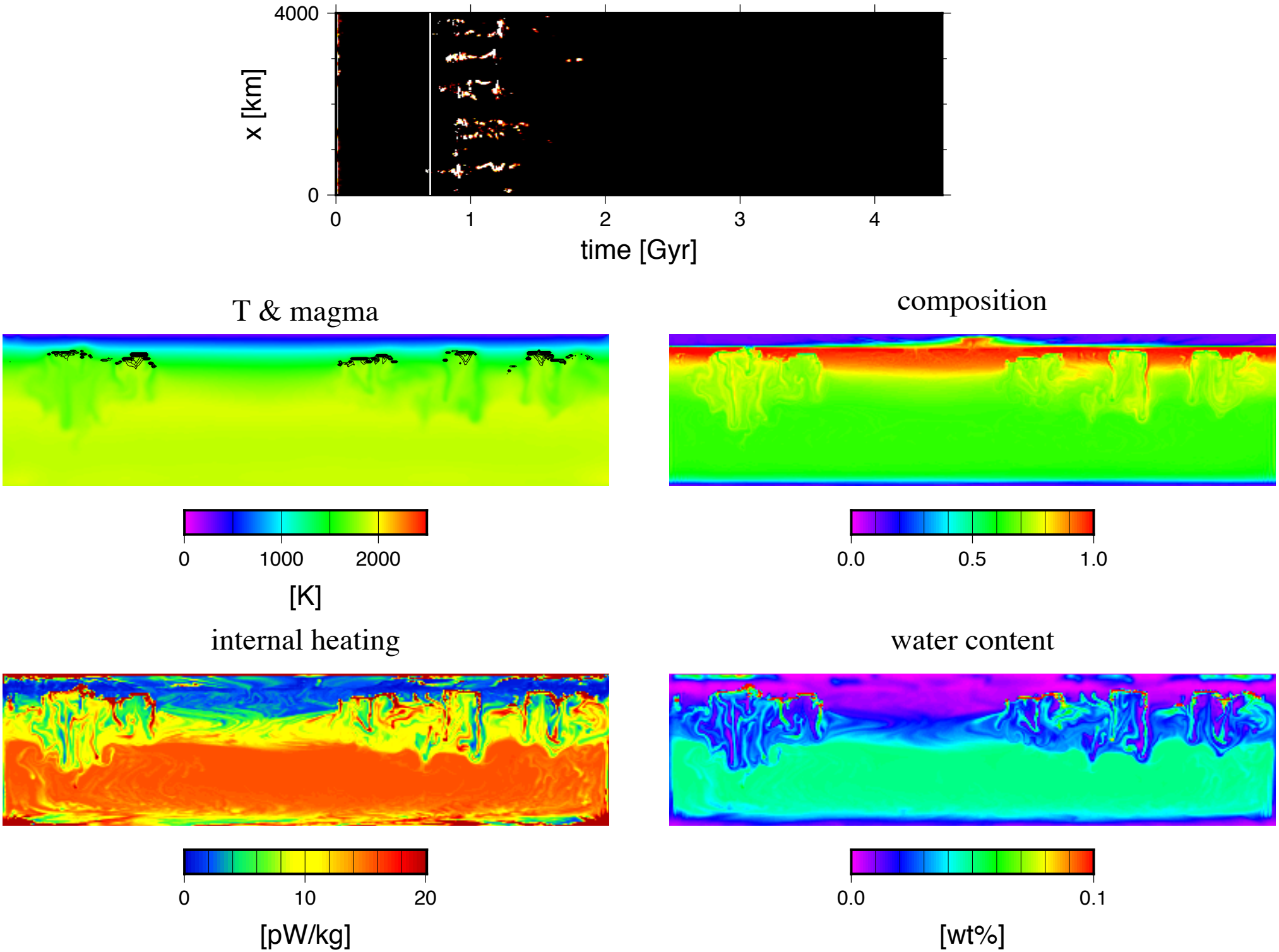
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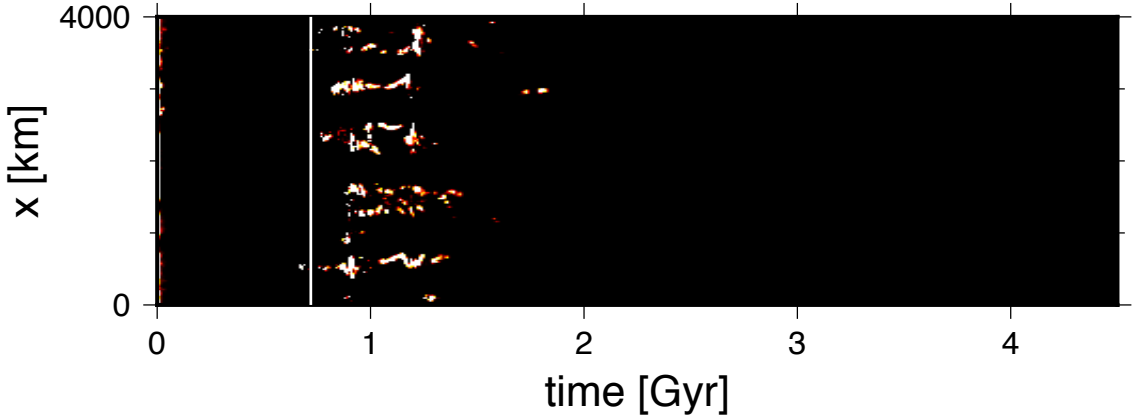

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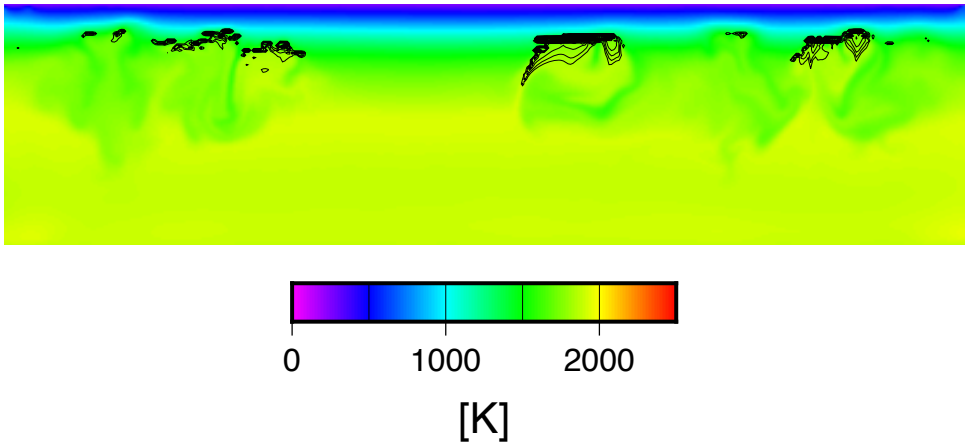

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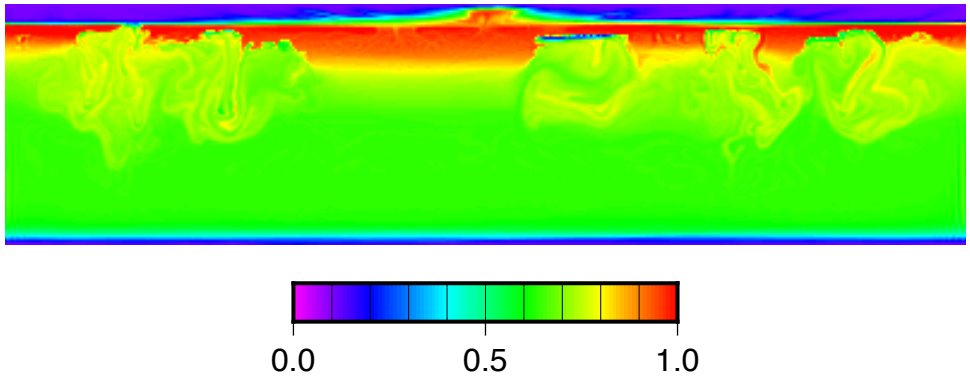
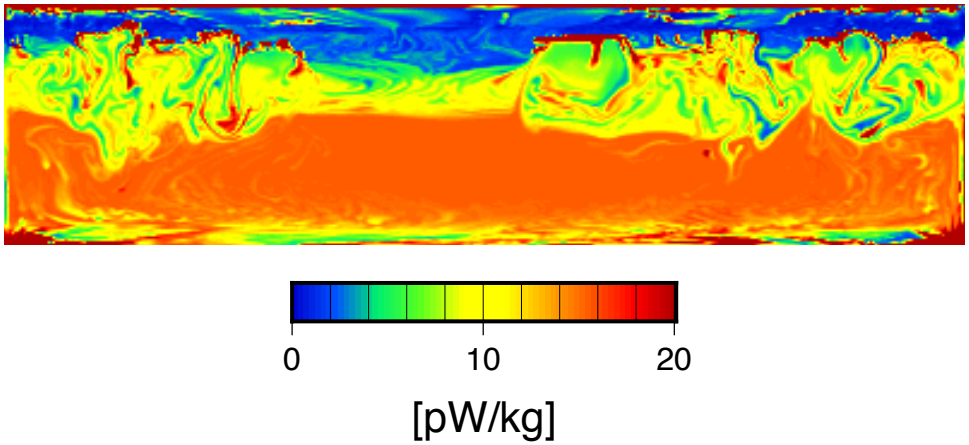


internal heating



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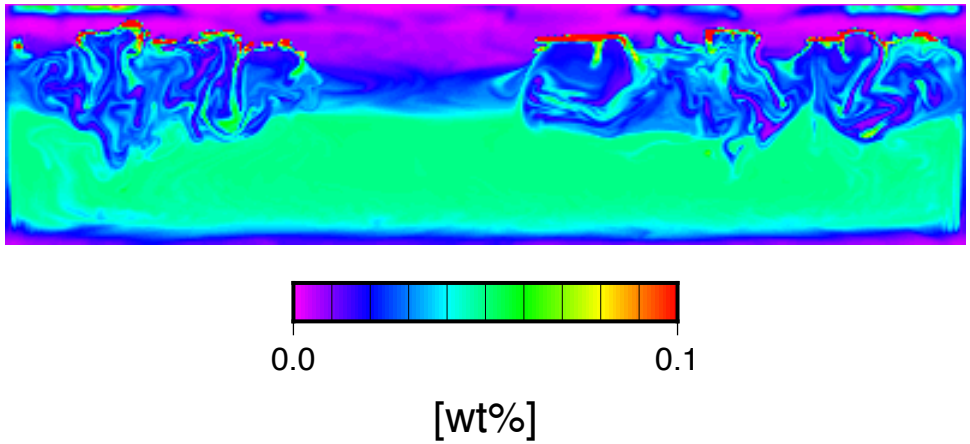

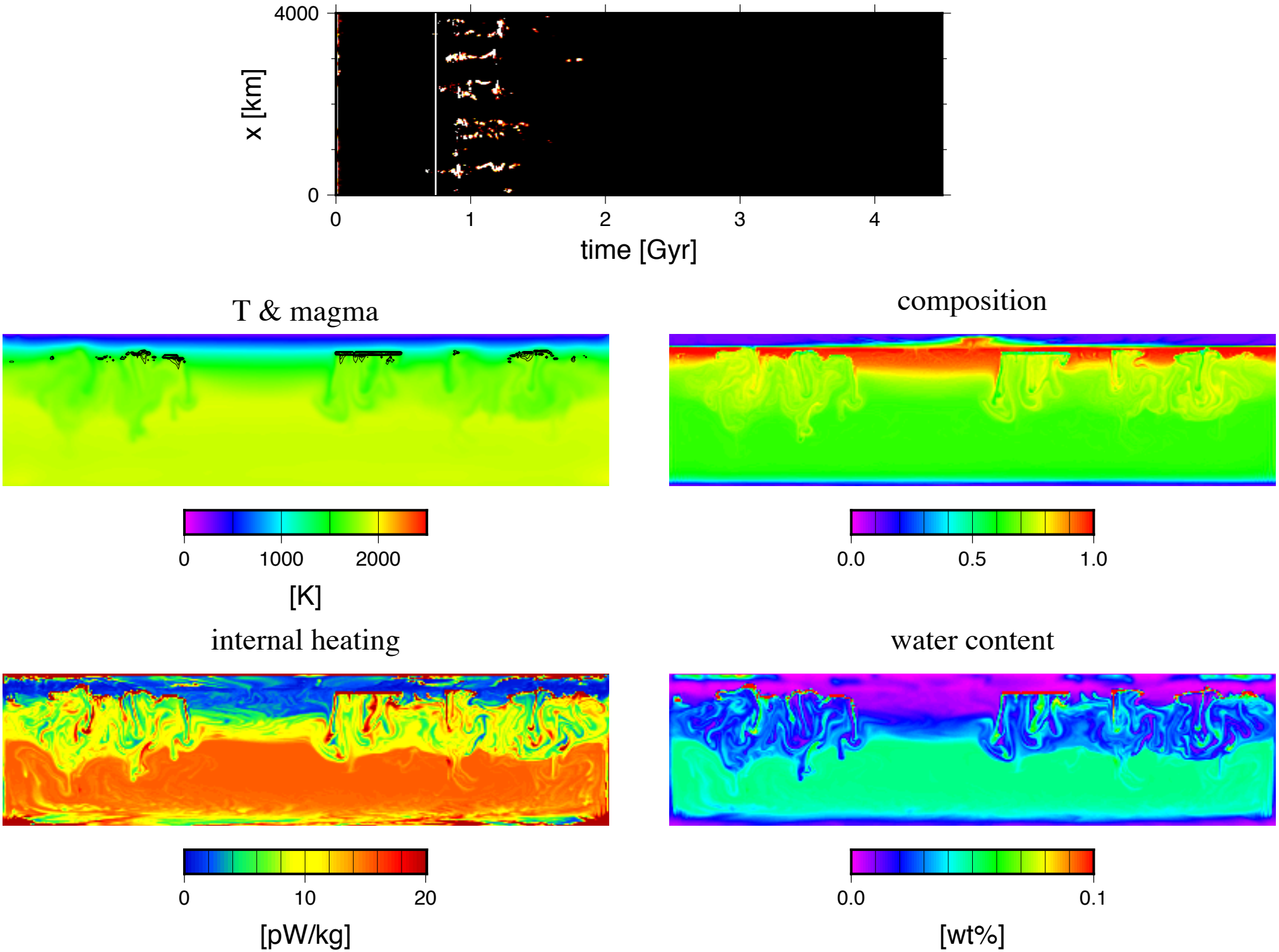
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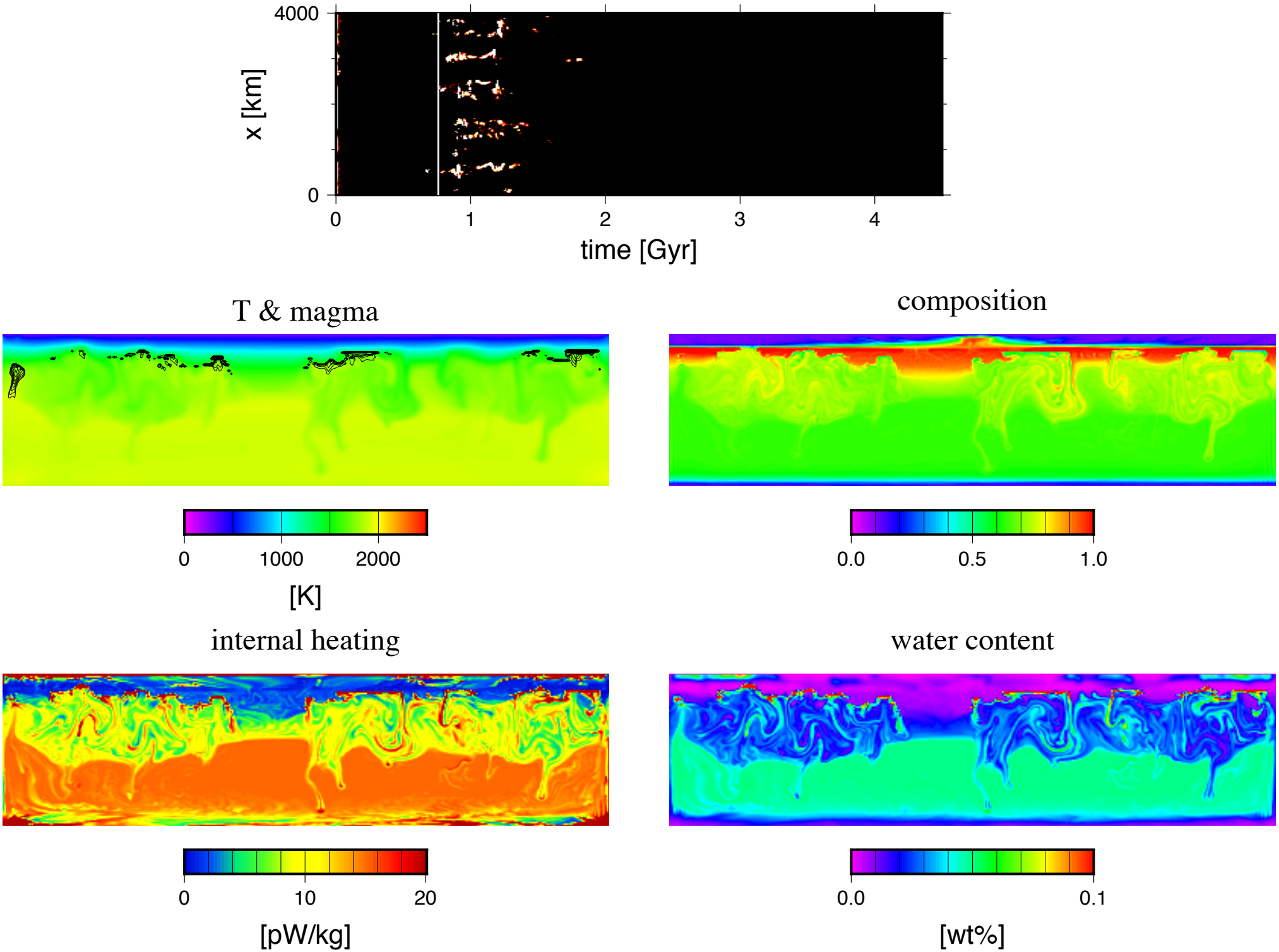
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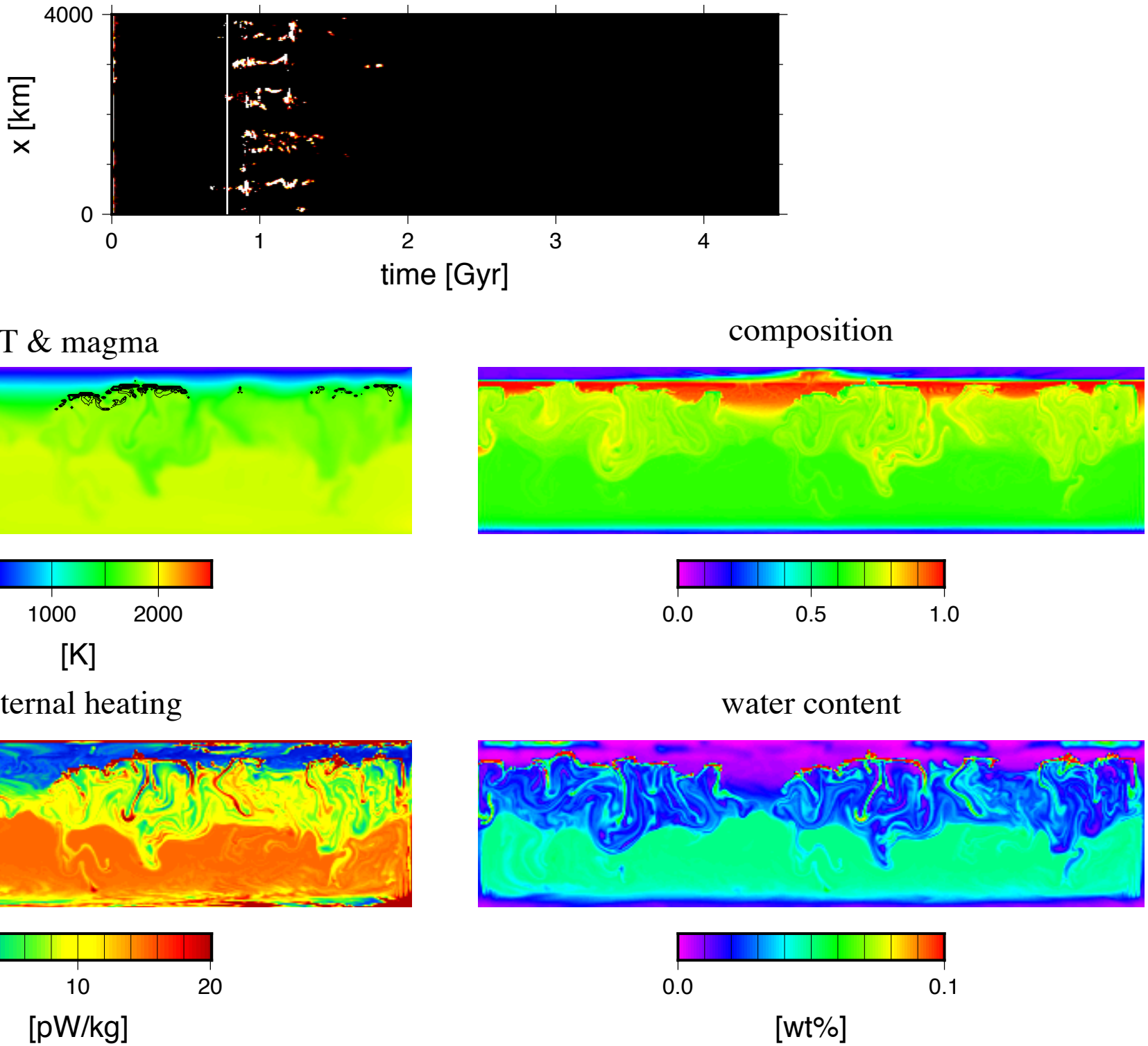
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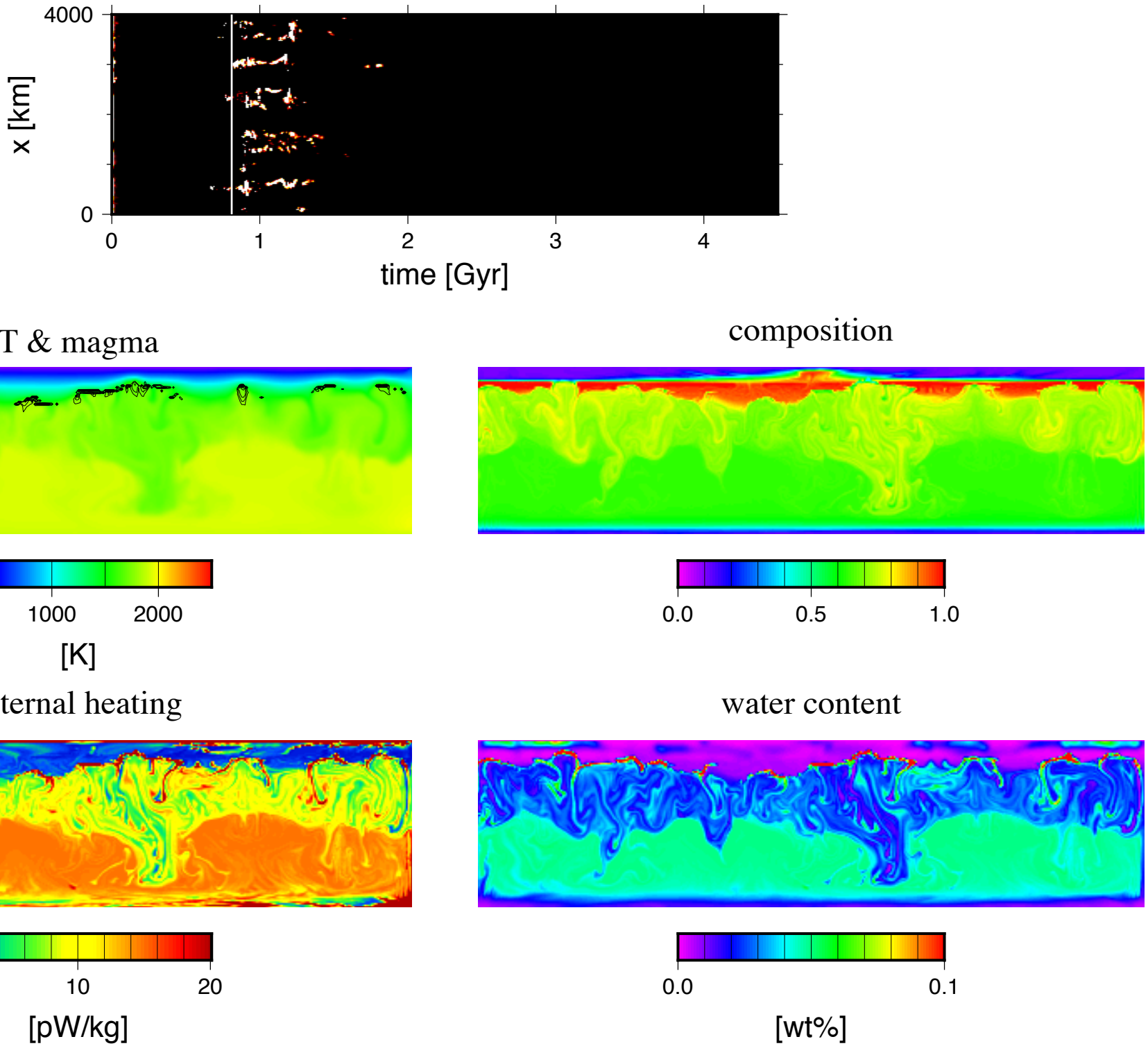
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time [Gyr]
T & magma
0
1000
2000
[K]
composition
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1.0
internal heating
0
10
20
[pW/kg]
water content
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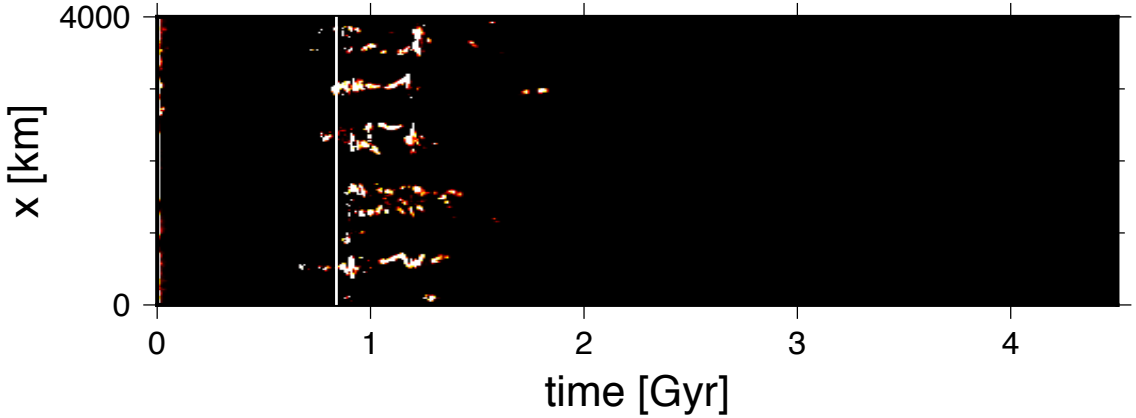
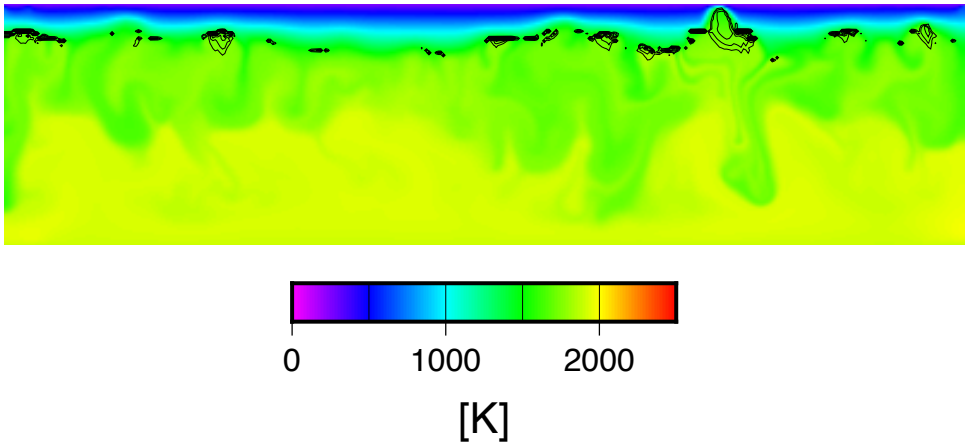
0.1
[wt%]



T & magma



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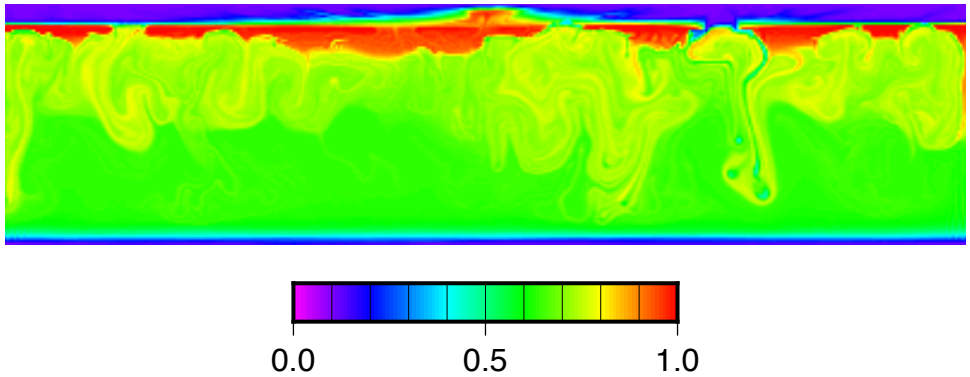
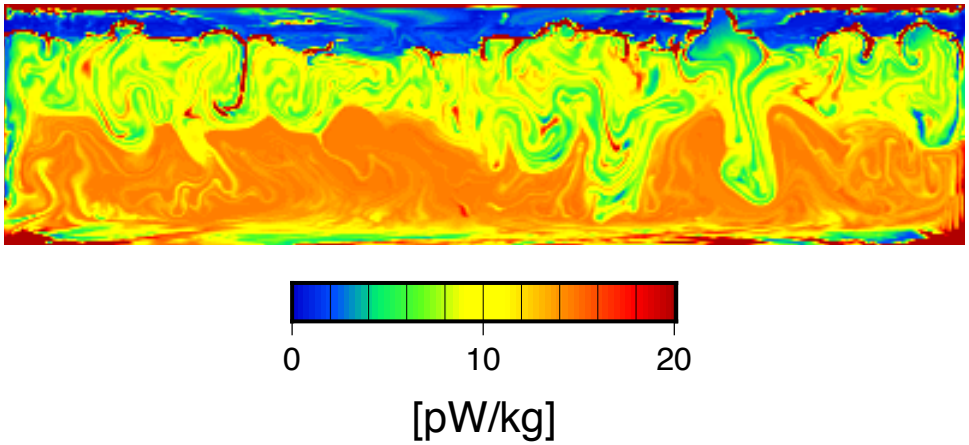


internal heating



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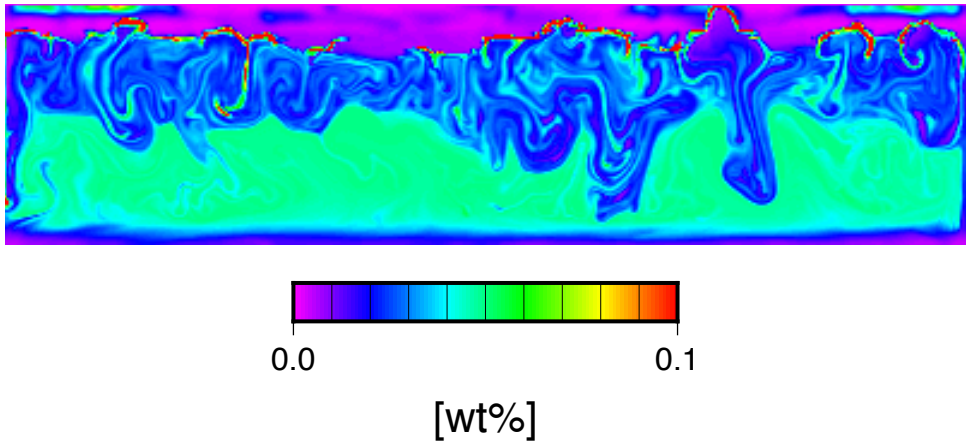

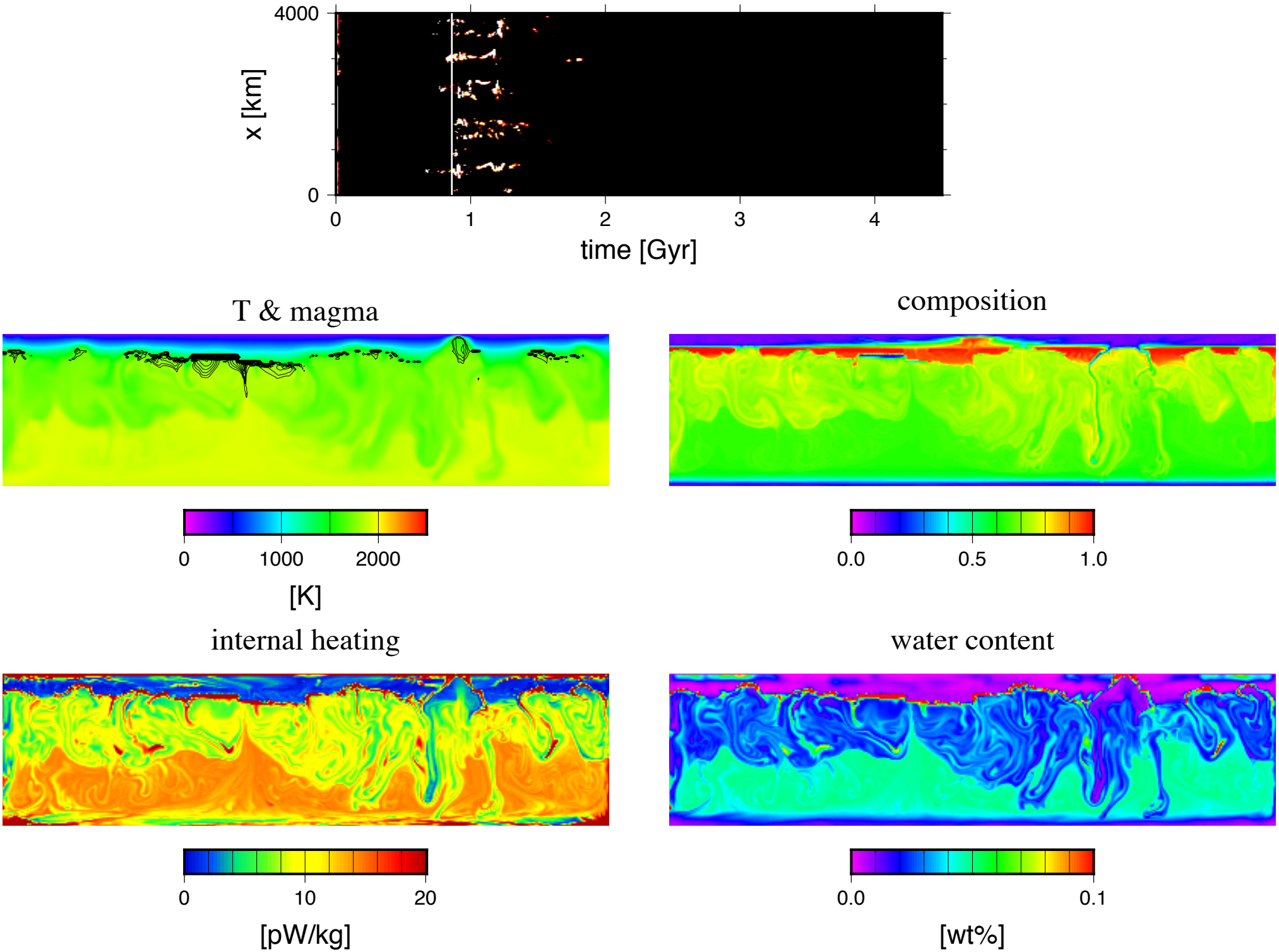
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composition
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internal heating
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[pW/kg]
water content
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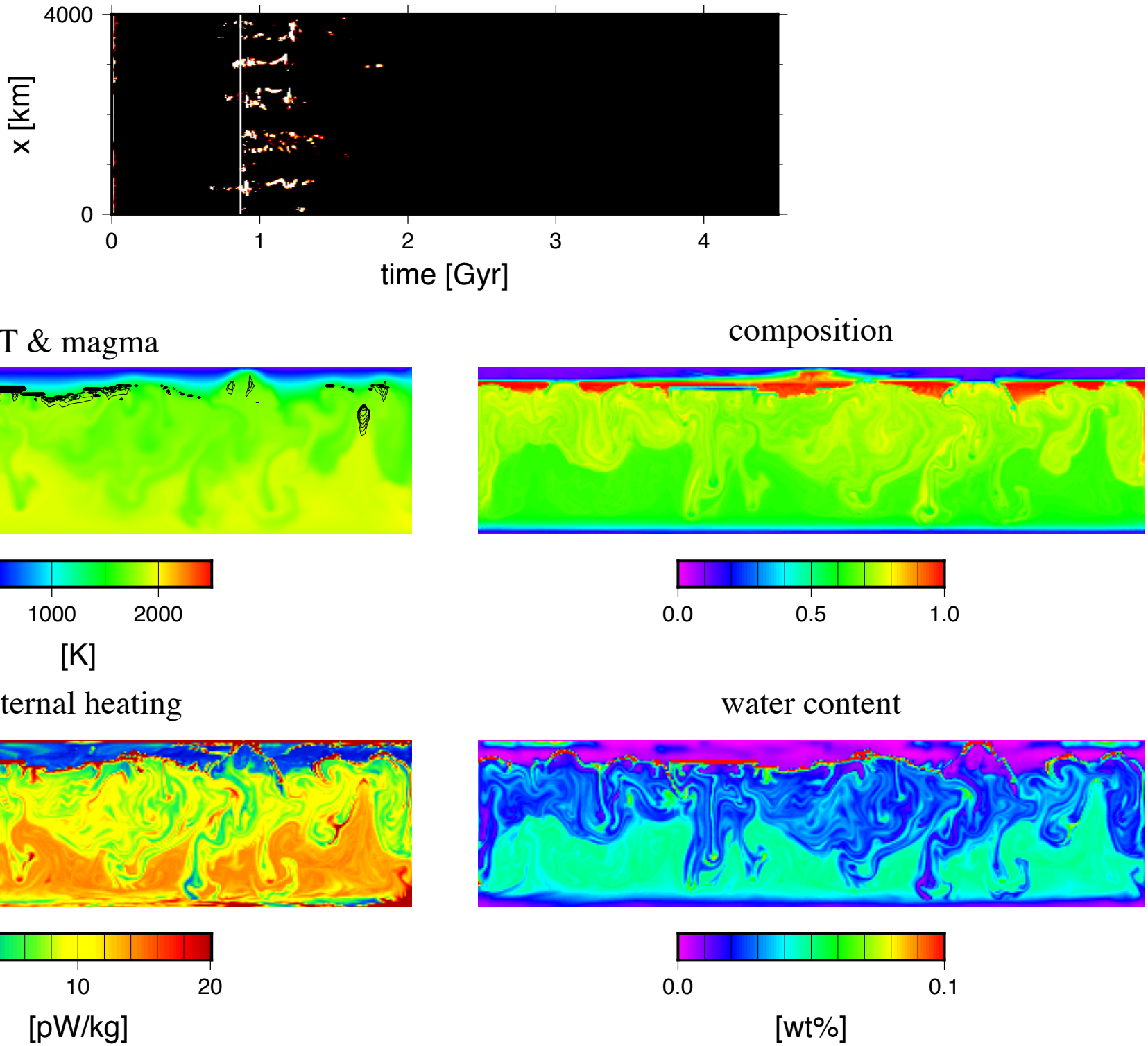
[wt%]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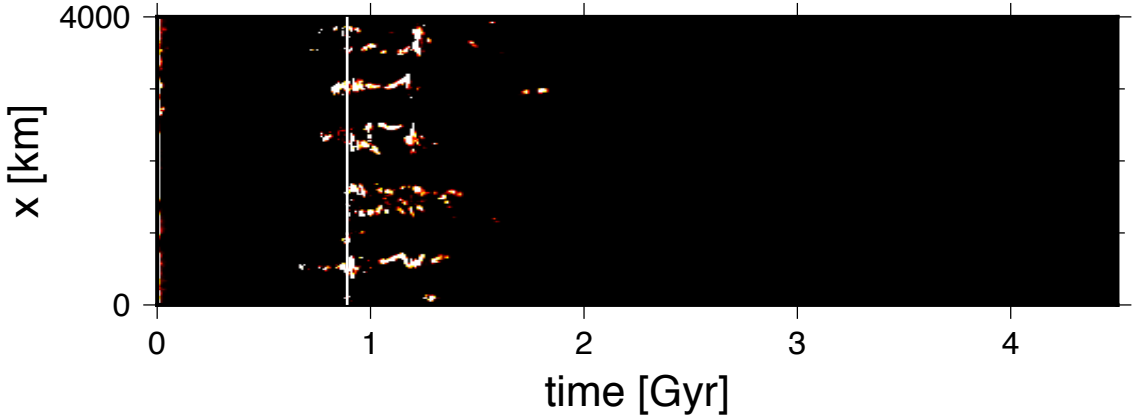

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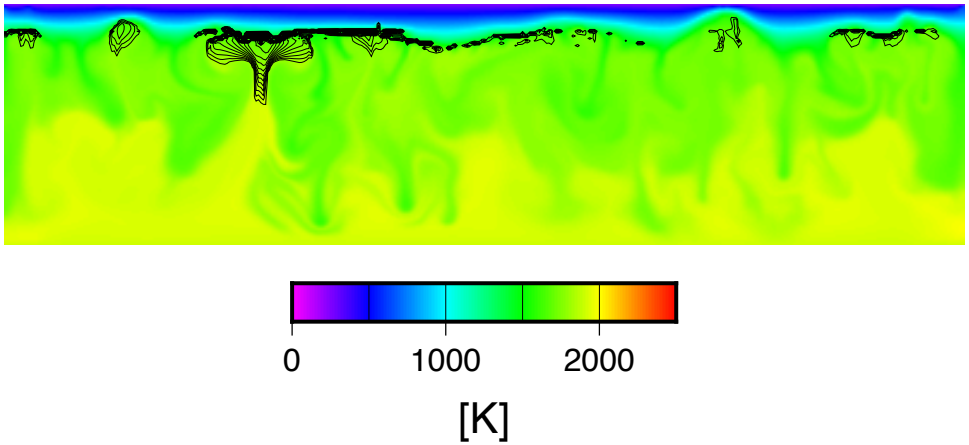

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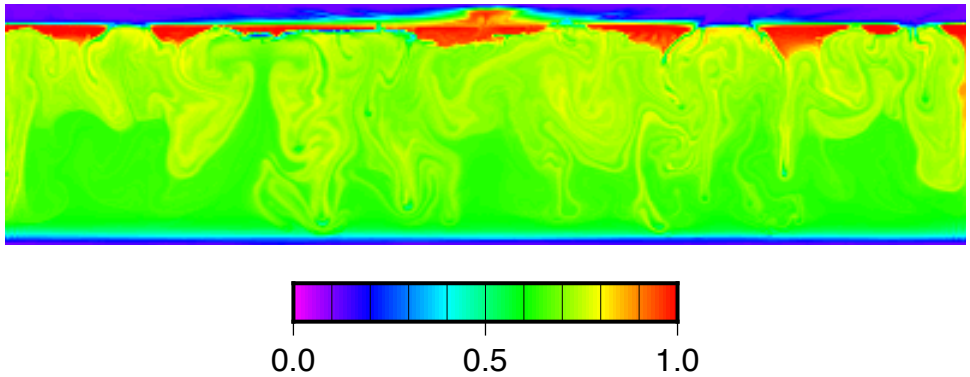

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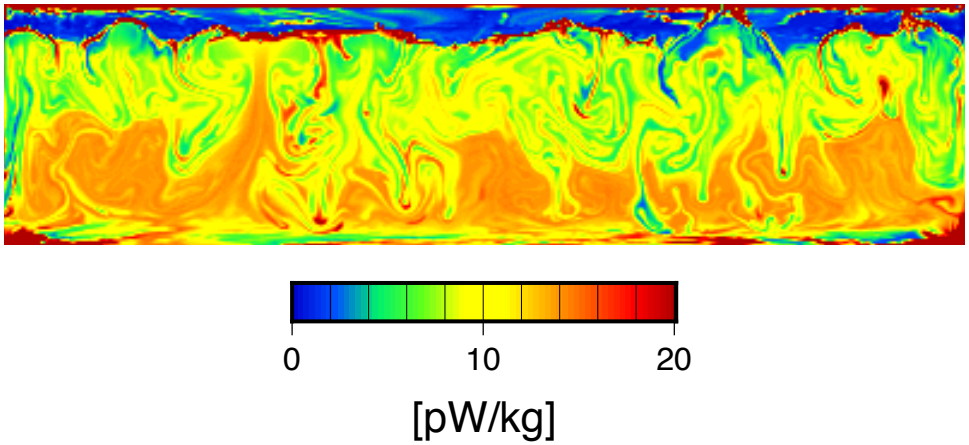

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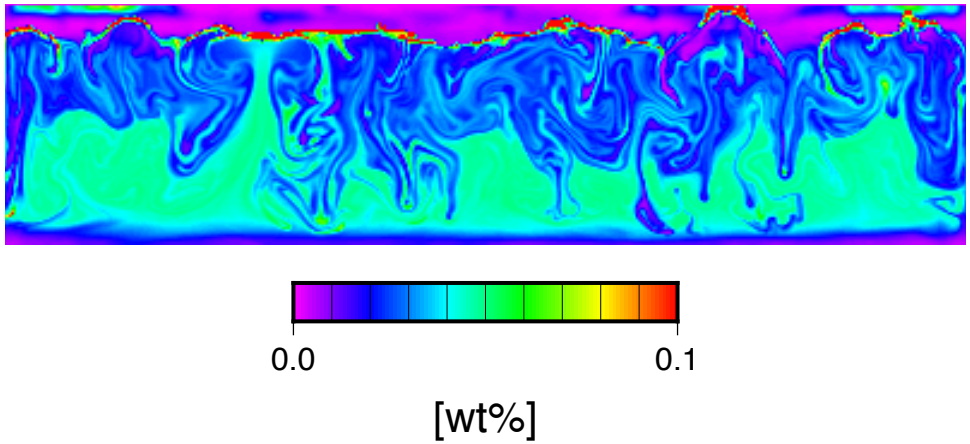

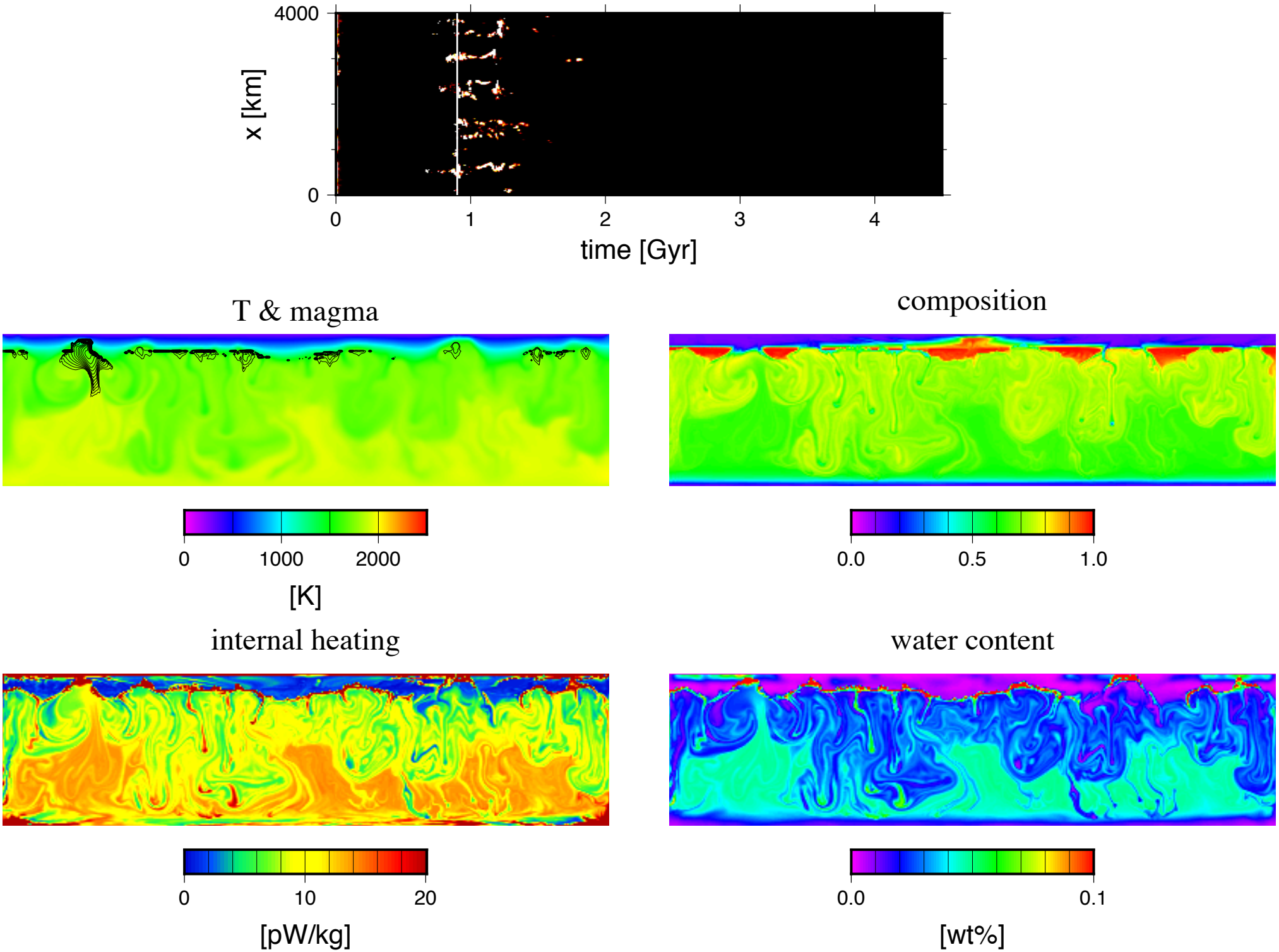
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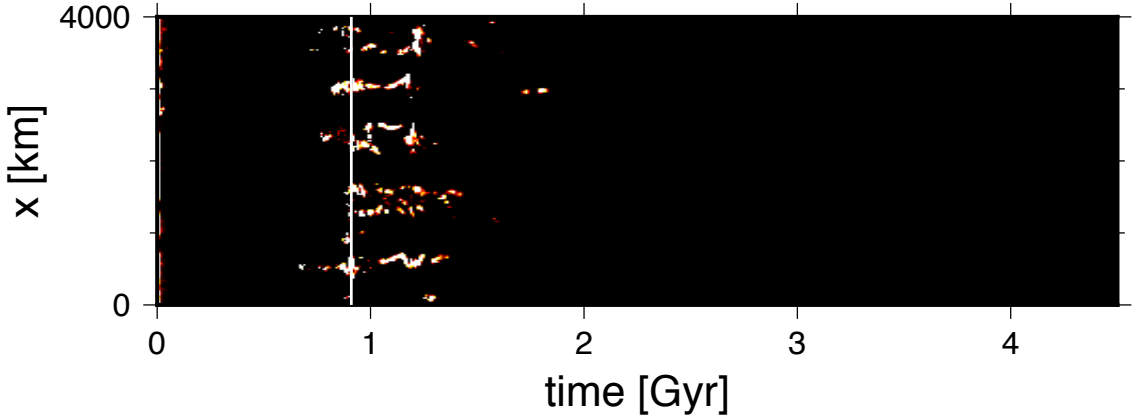

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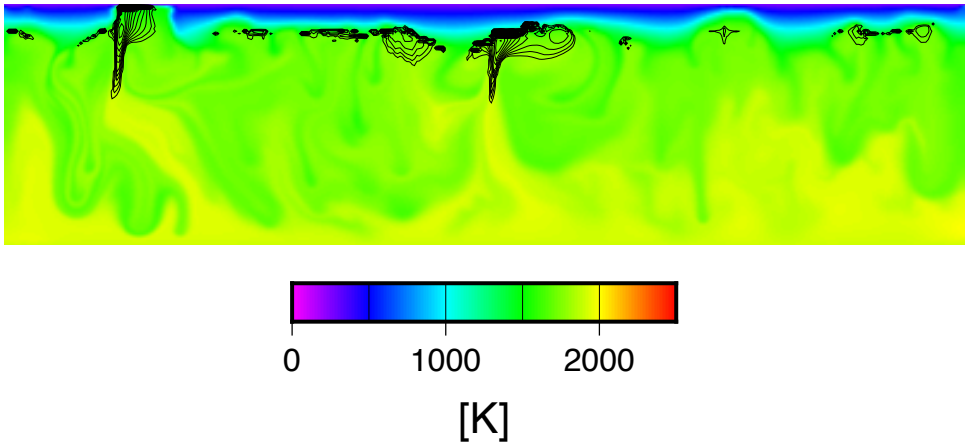

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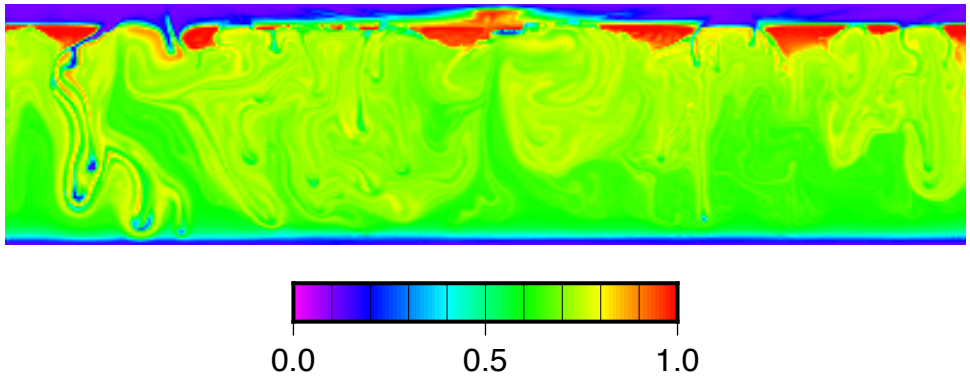
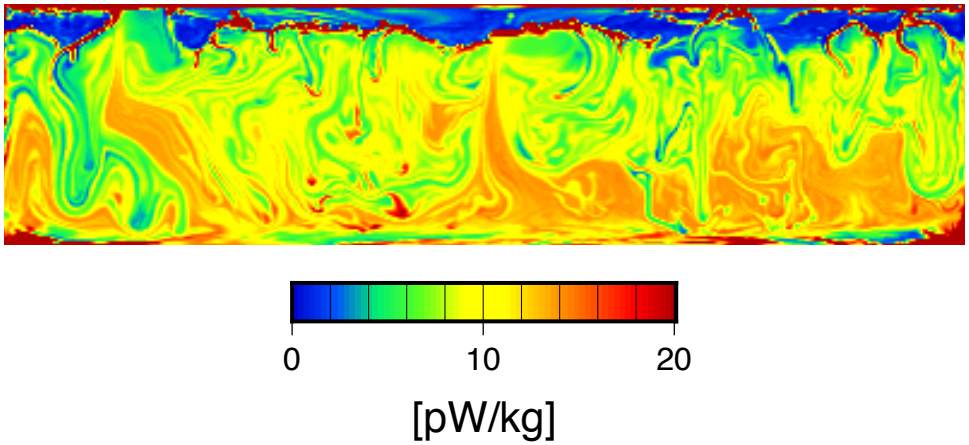


internal heating



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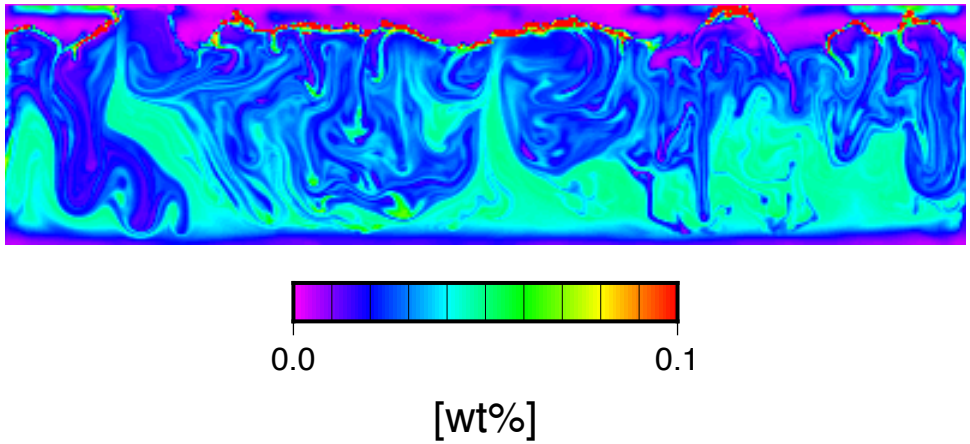
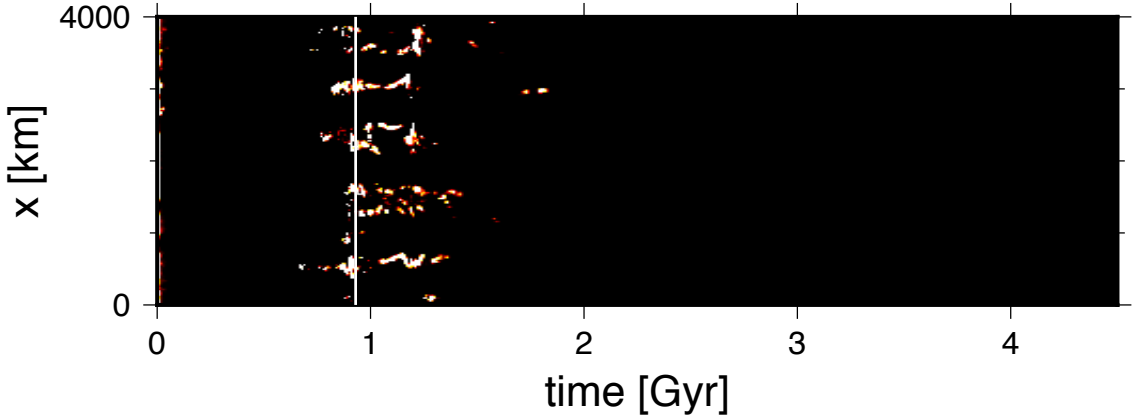
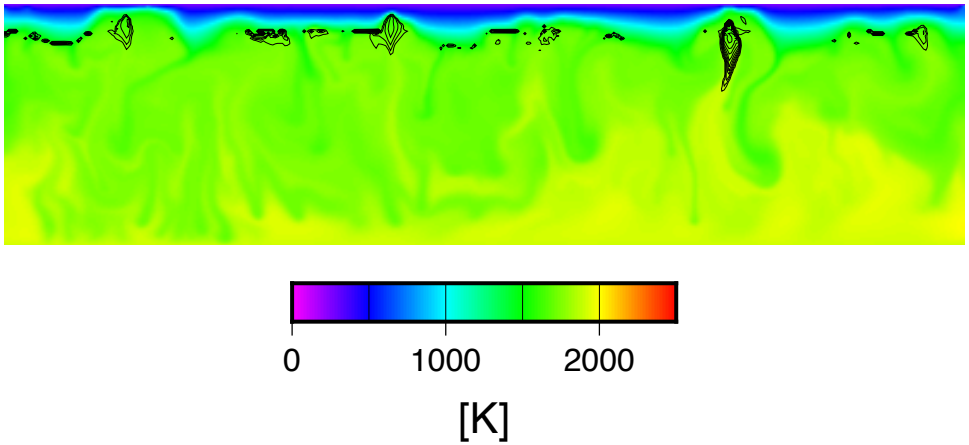




T & magma



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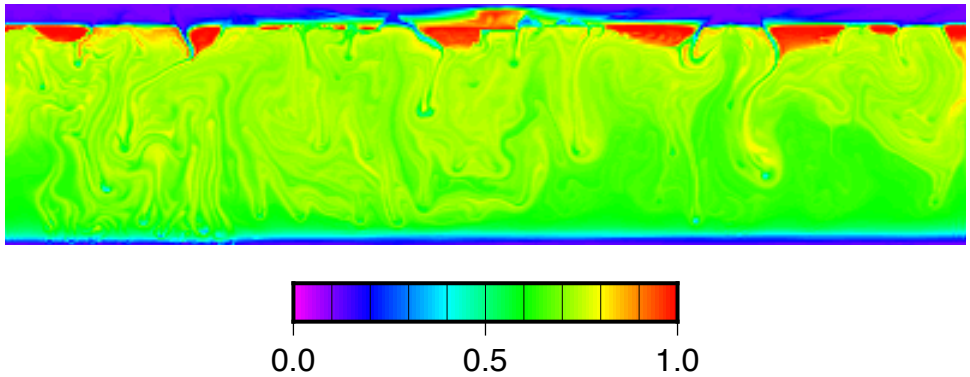
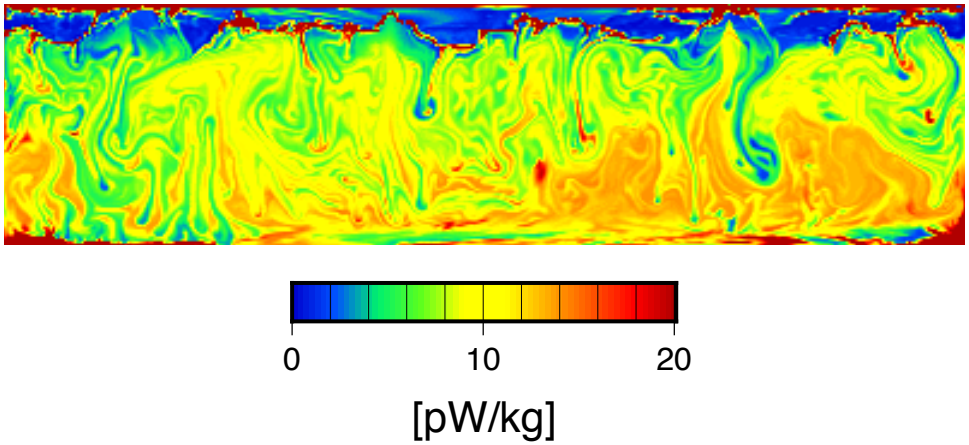
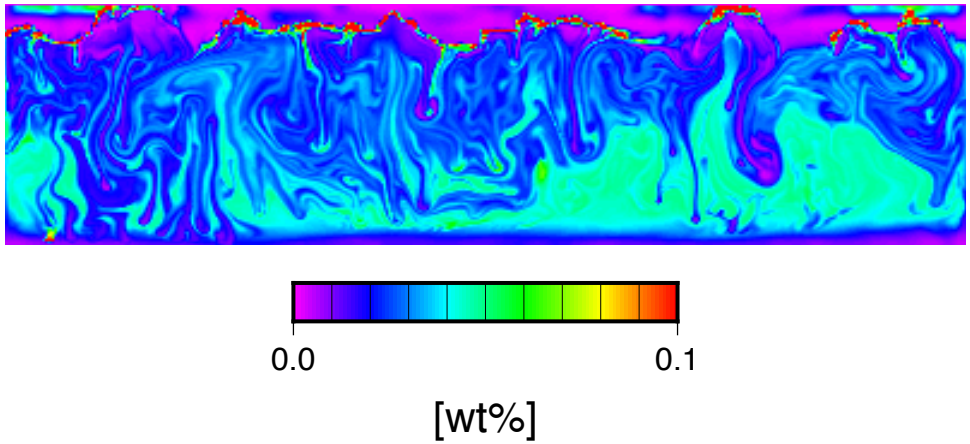
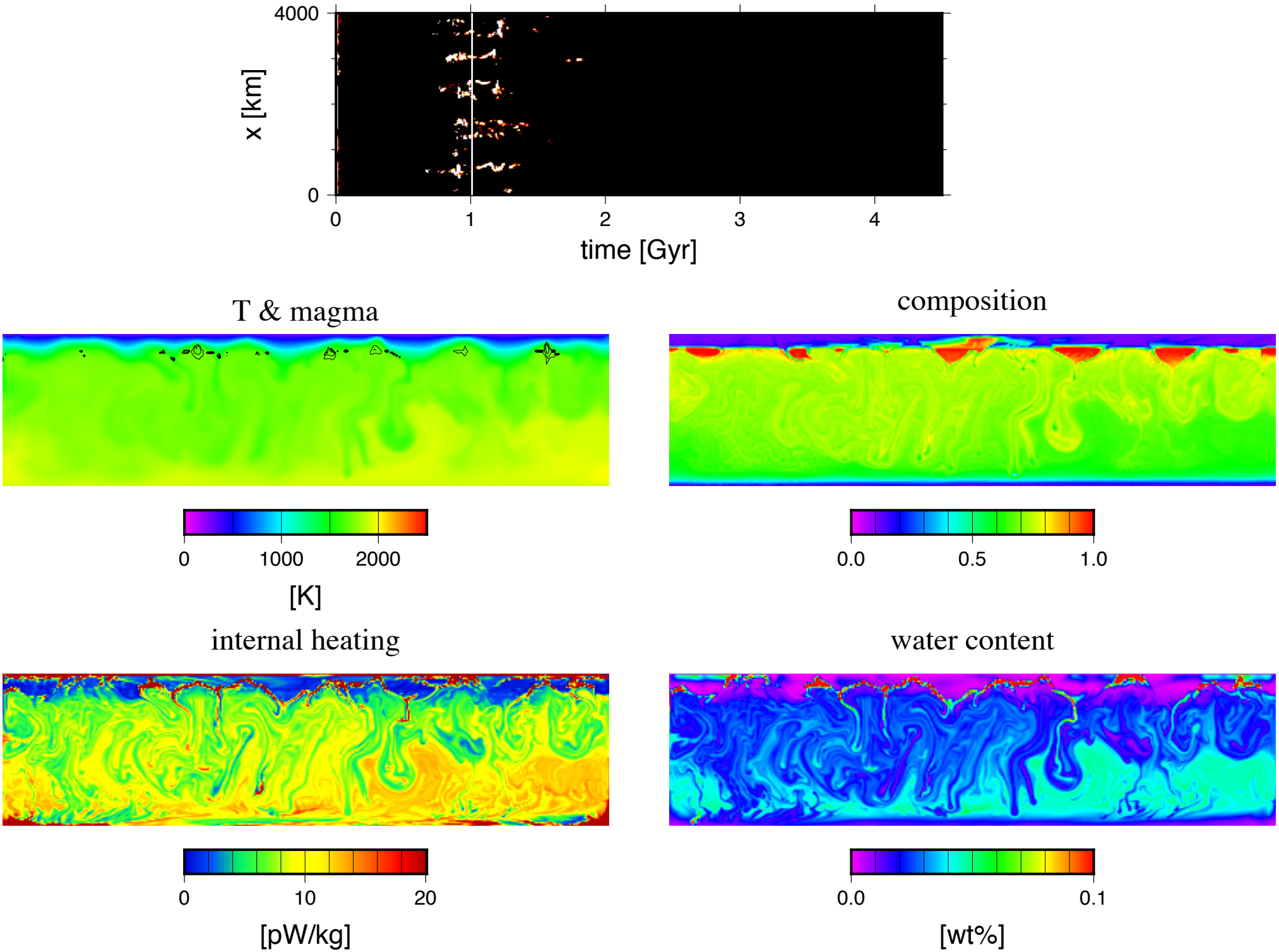


internal heating



water content

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composition
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internal heating
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[pW/kg]
water content
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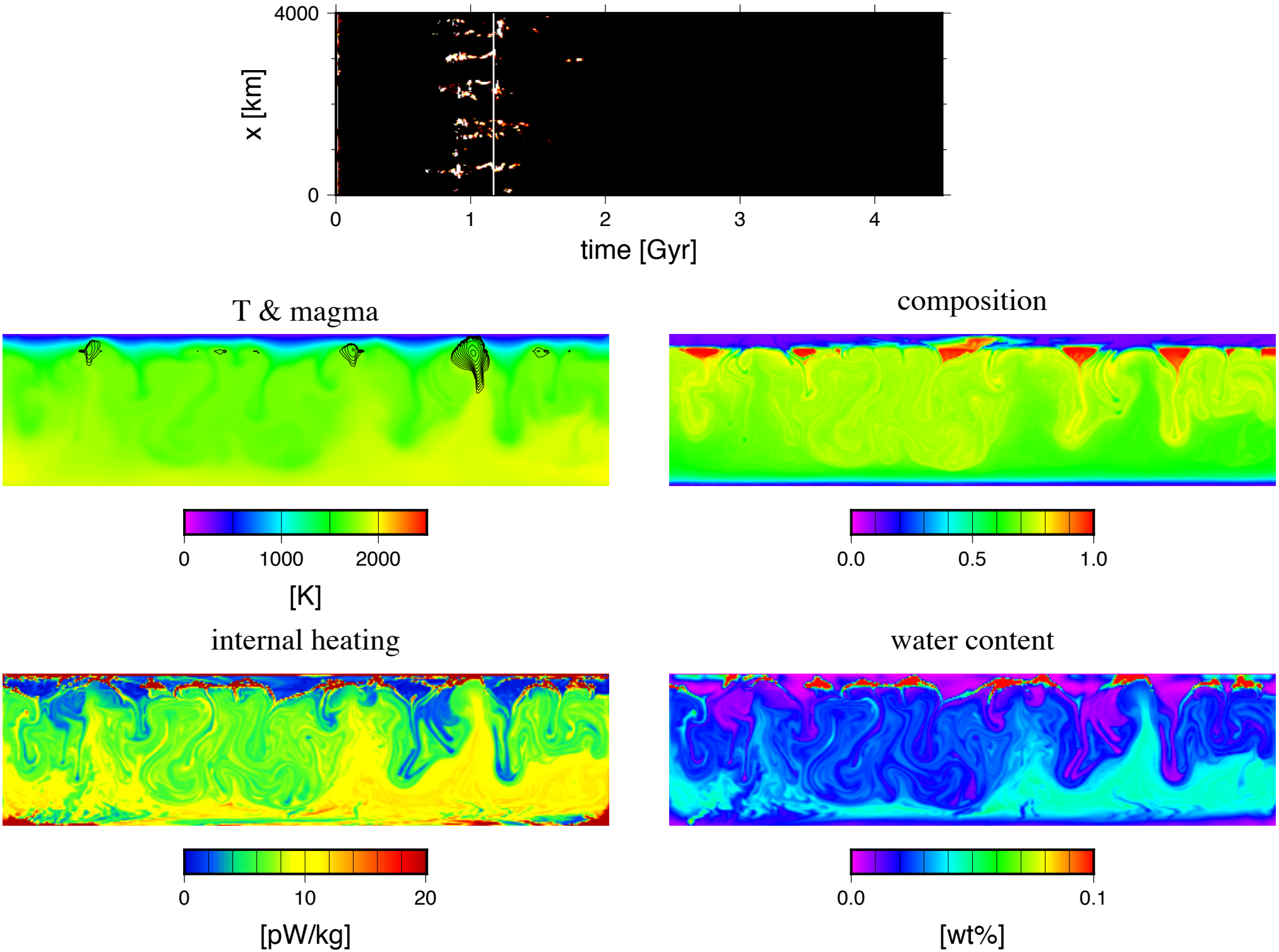
[wt%]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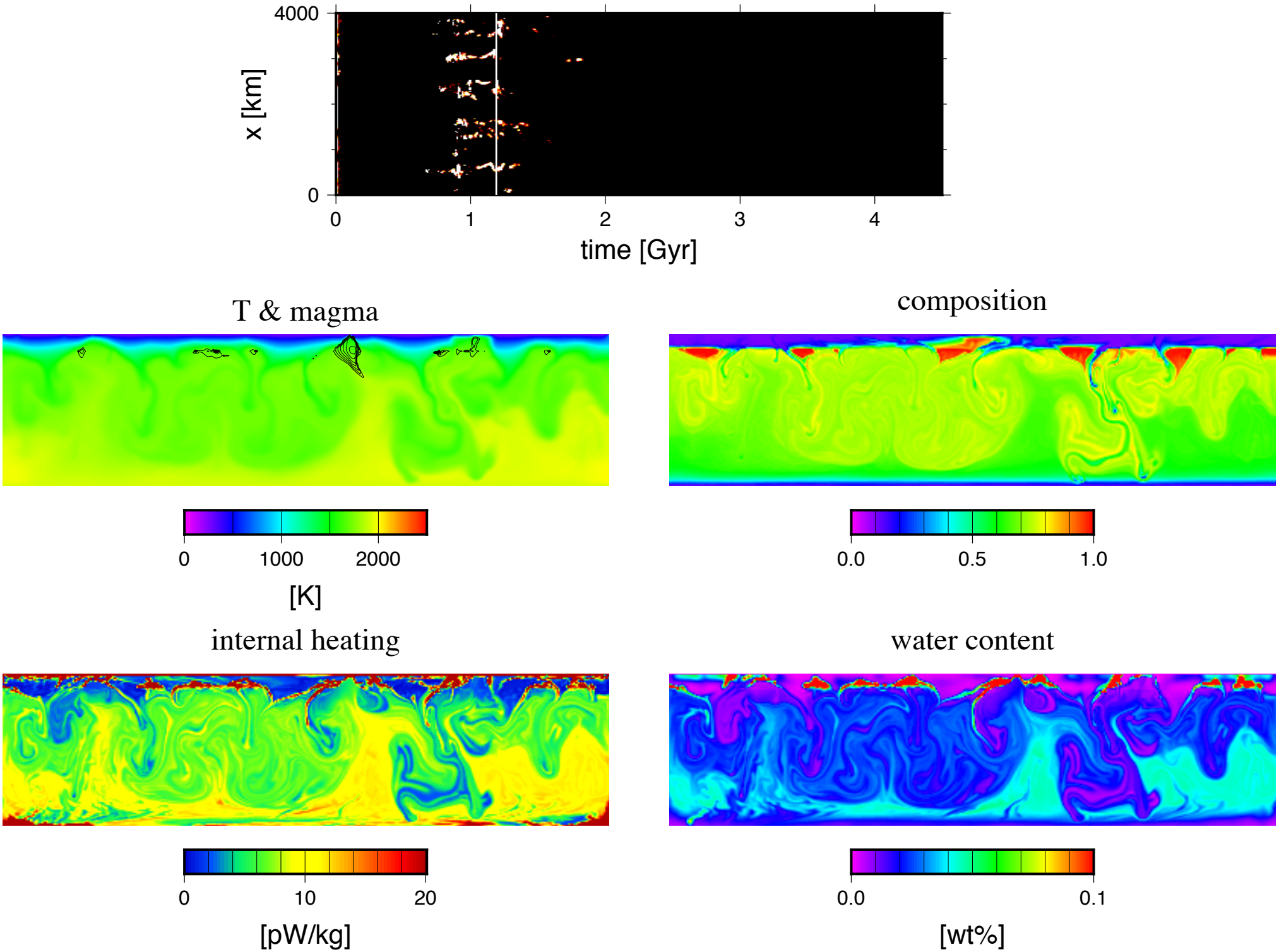
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internal heating
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water content
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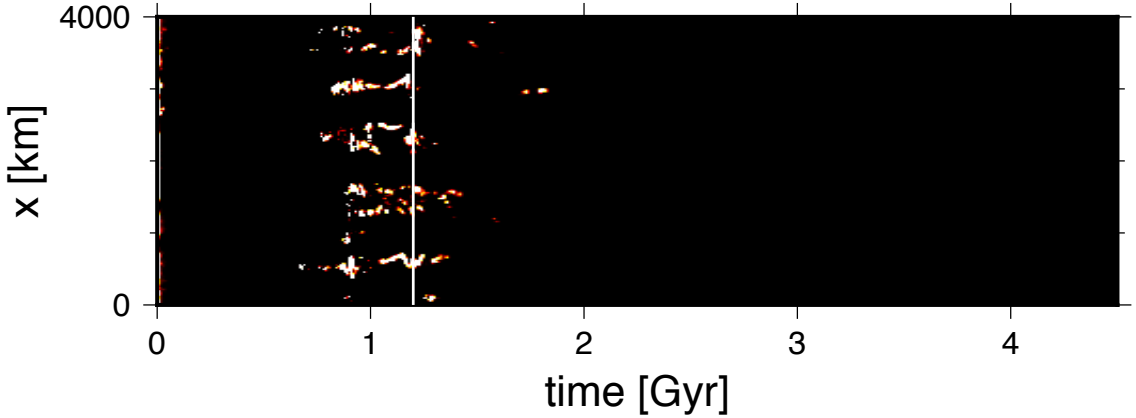

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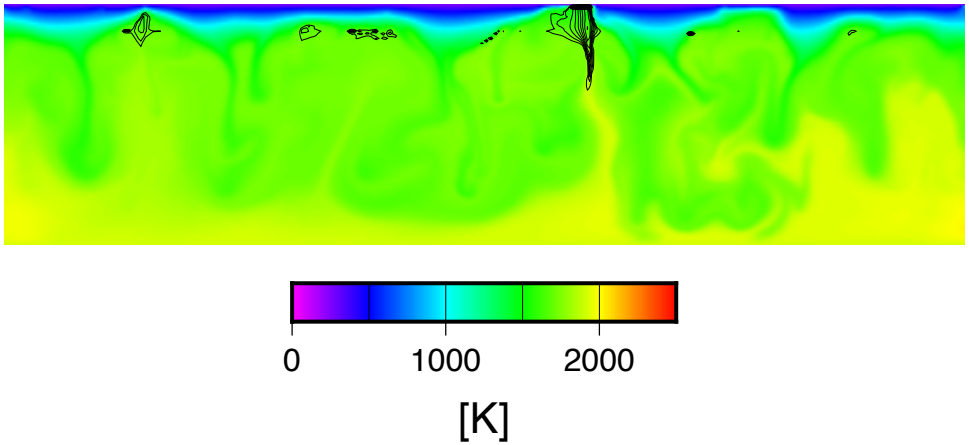

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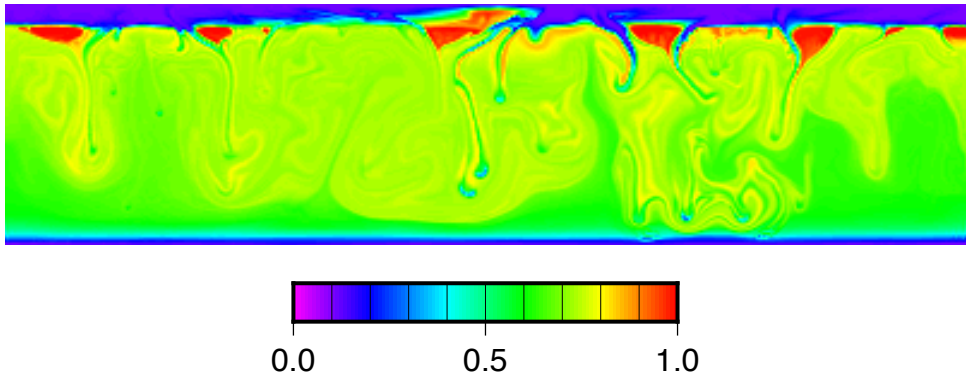
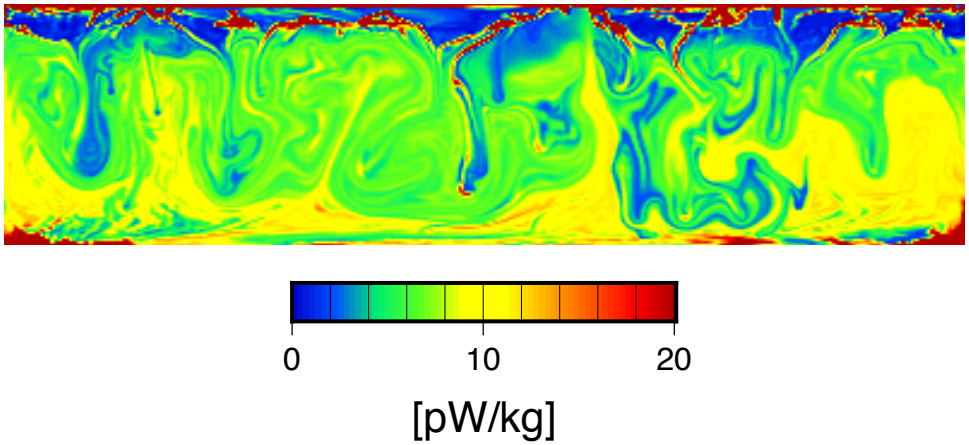
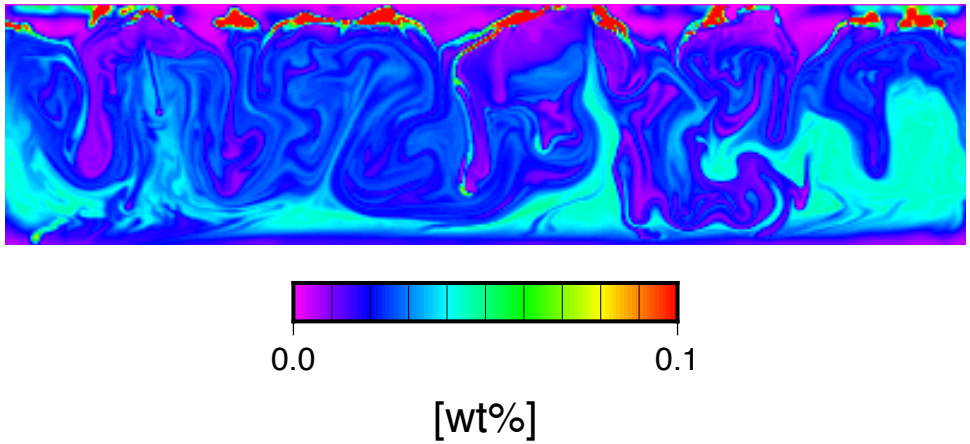
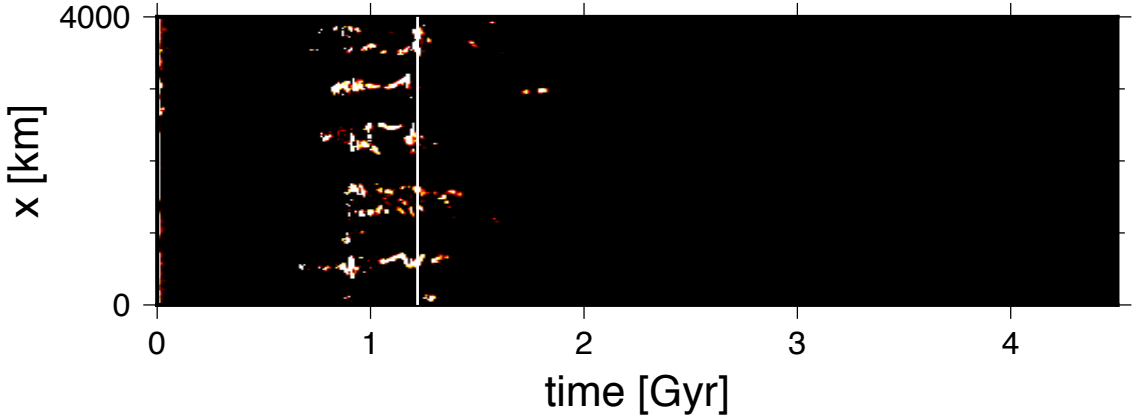


internal heating



water content





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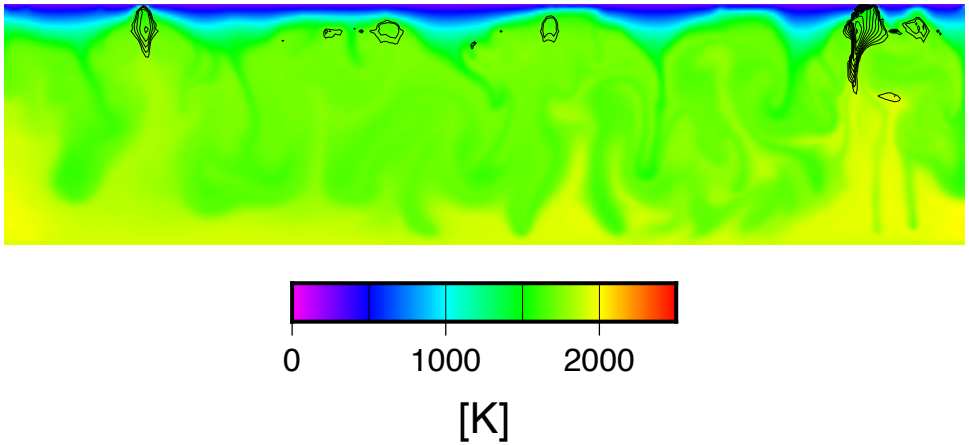

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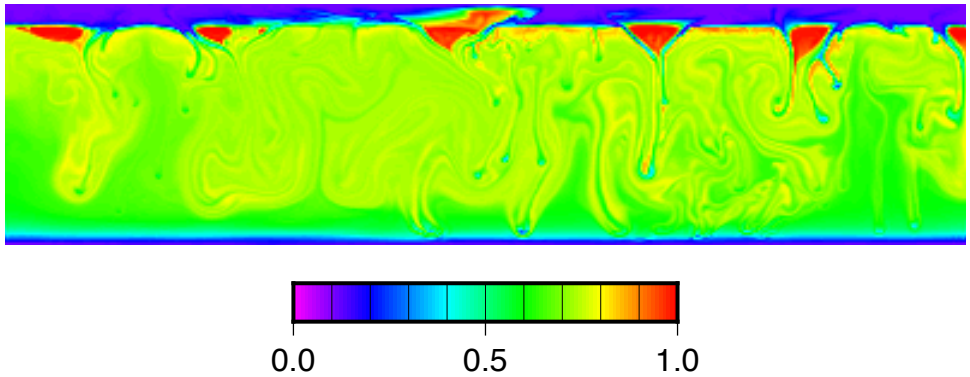
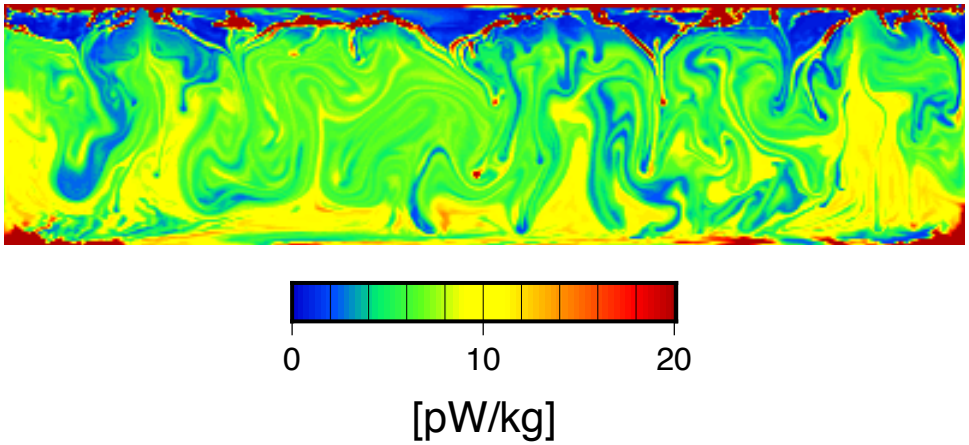


internal heating



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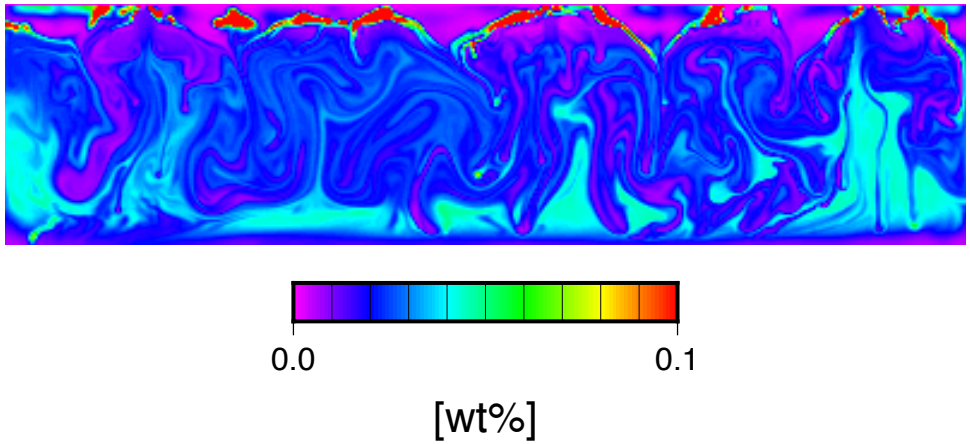
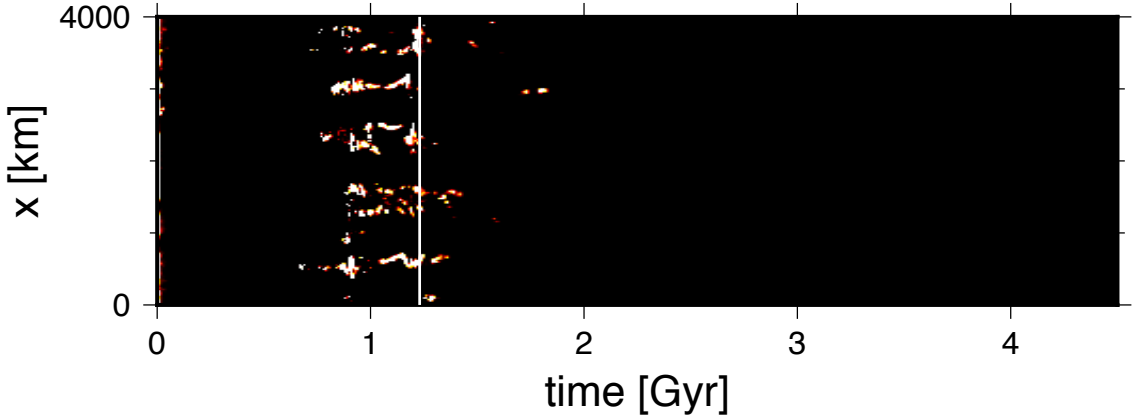
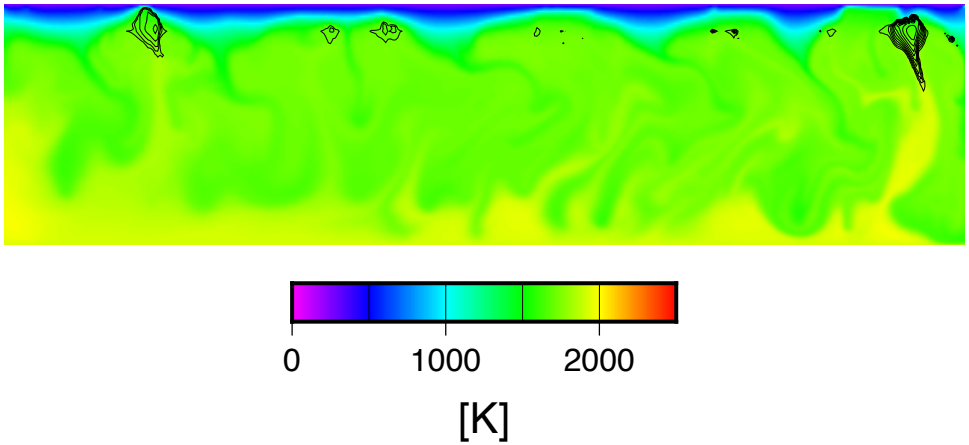




T & magma



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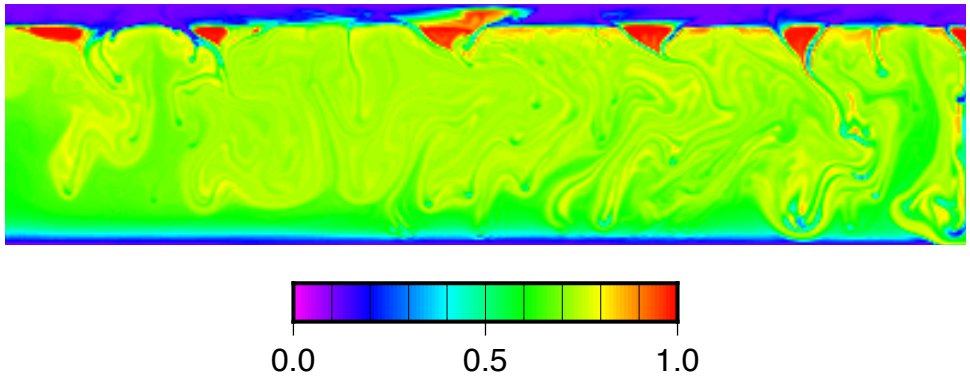
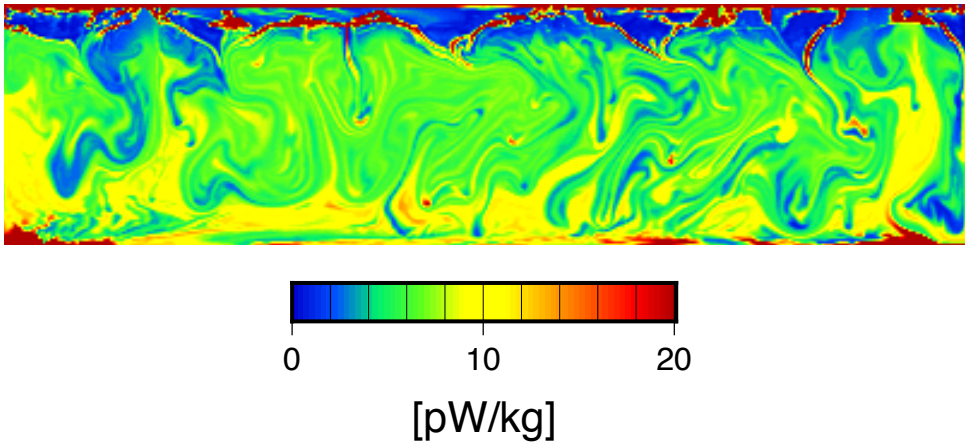


internal heating



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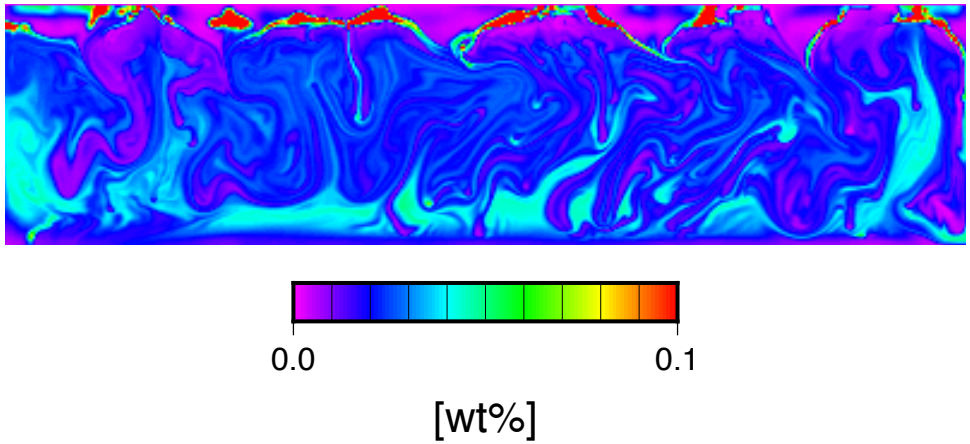

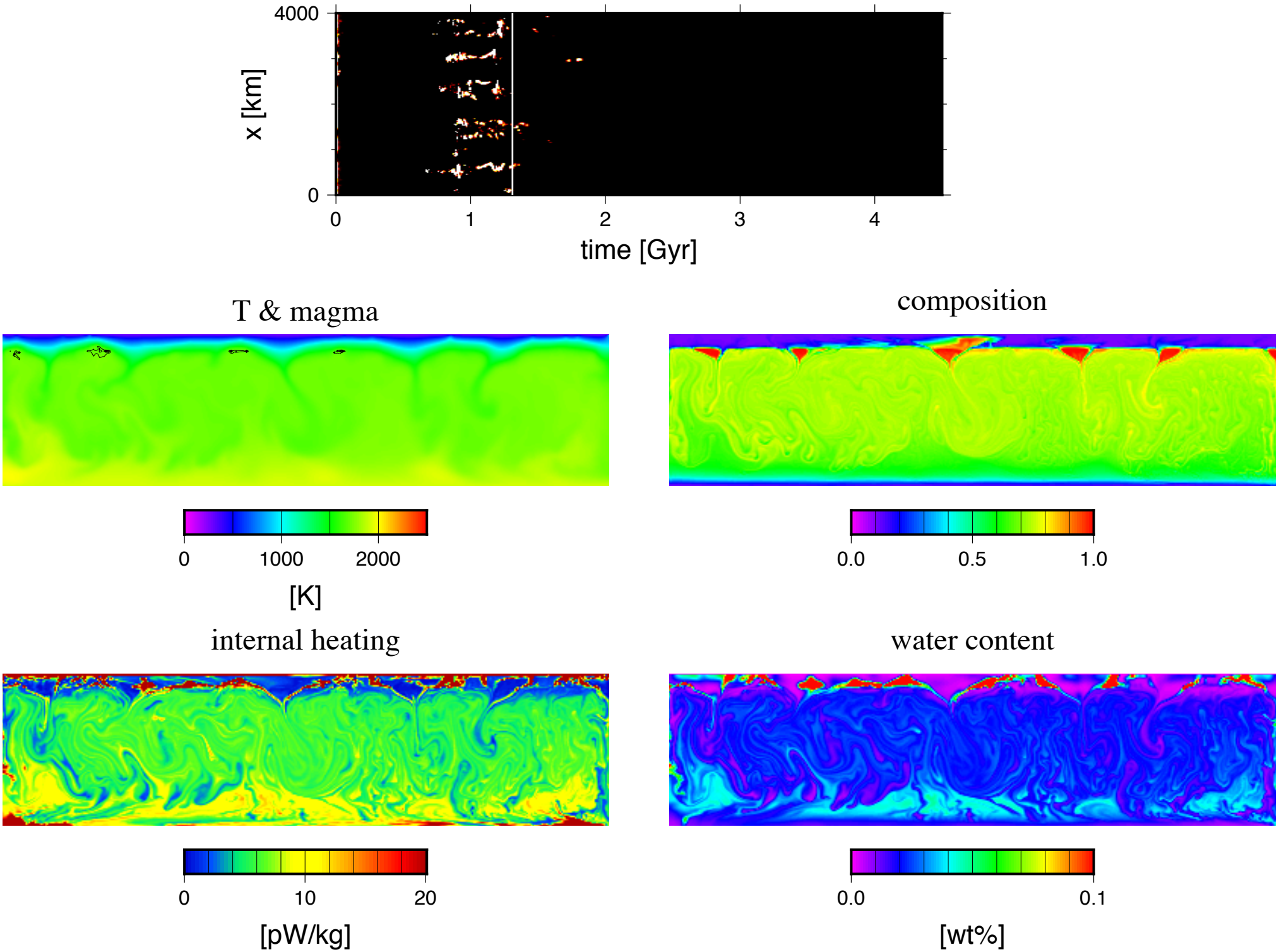
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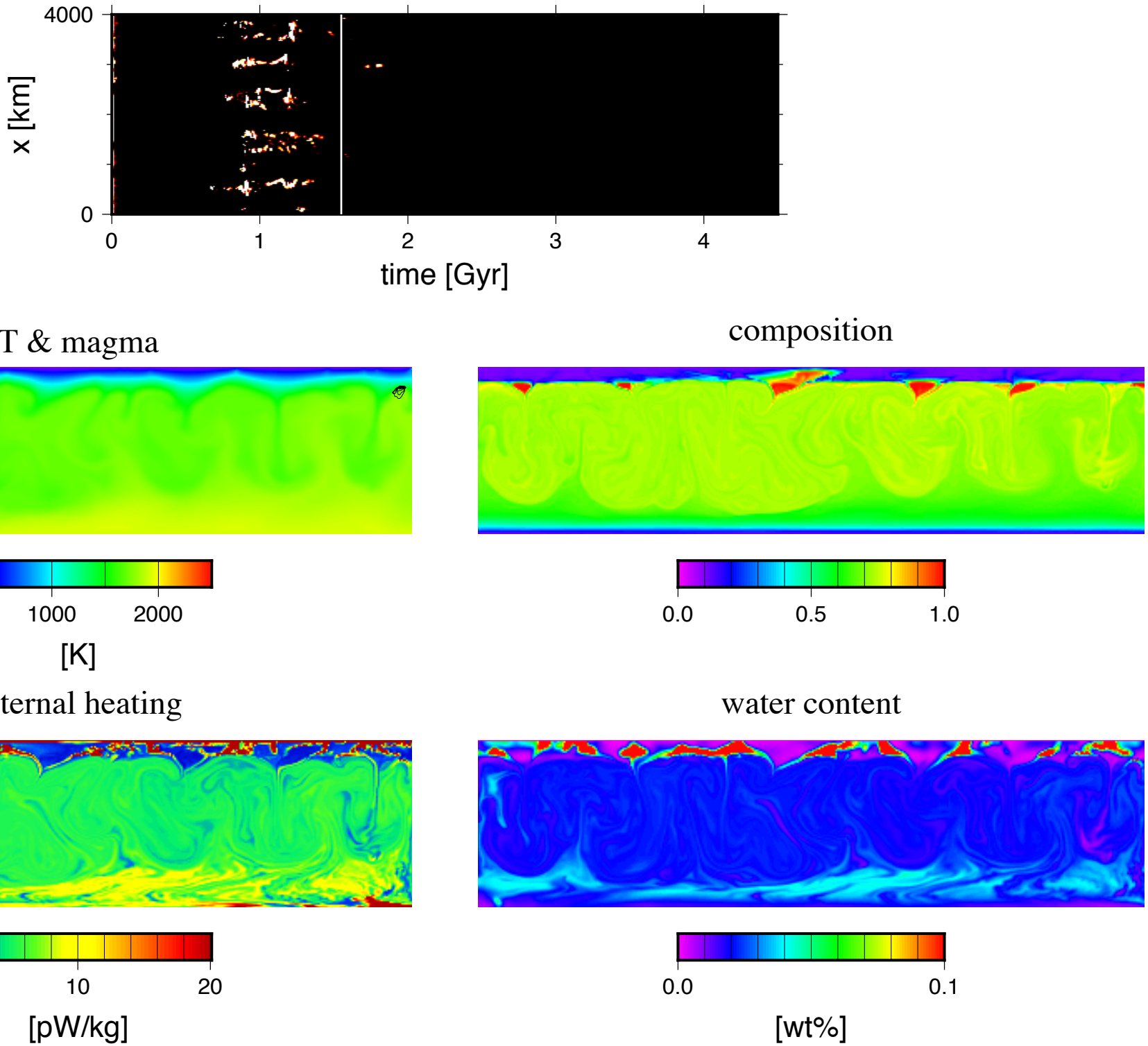
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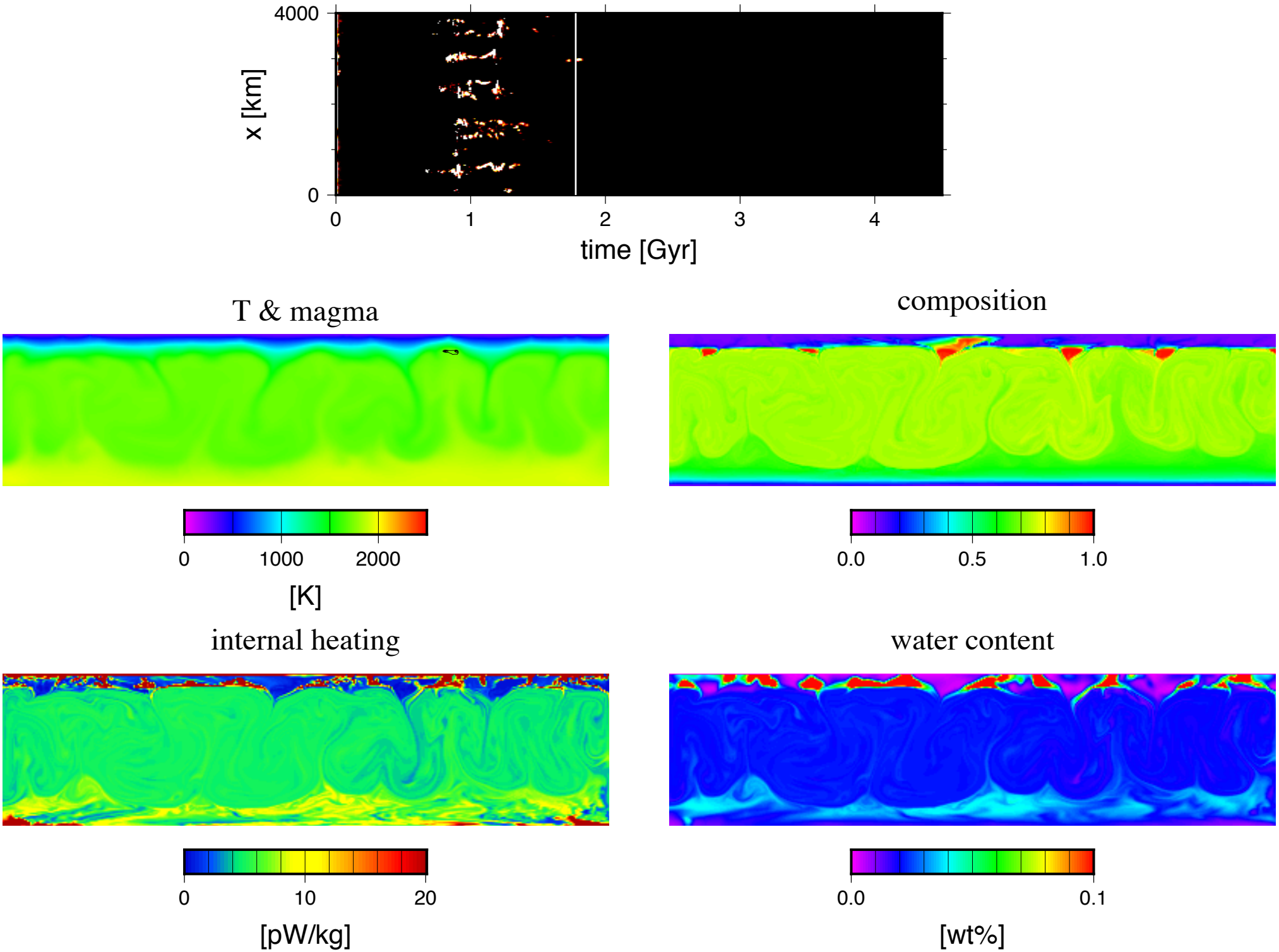
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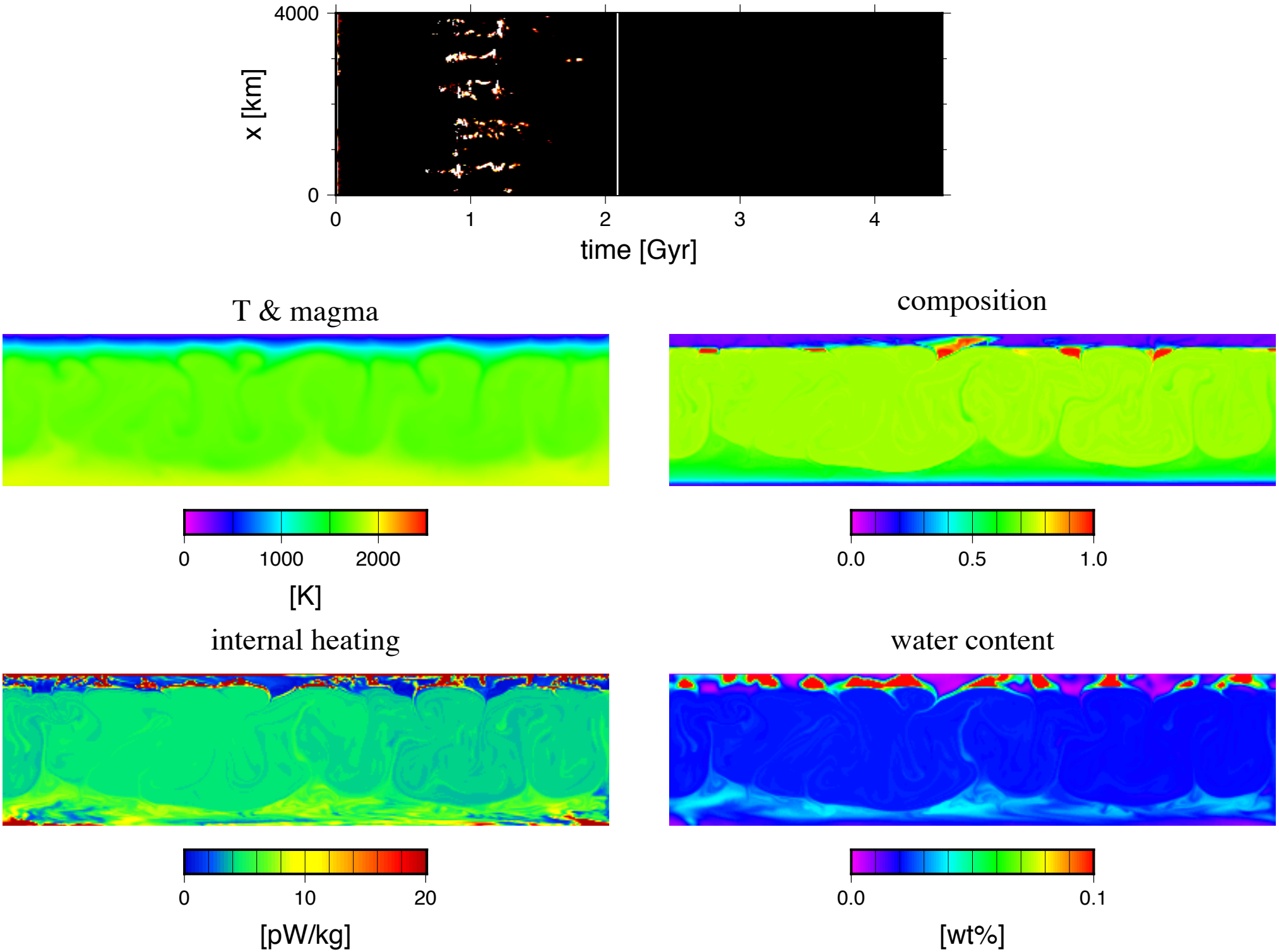
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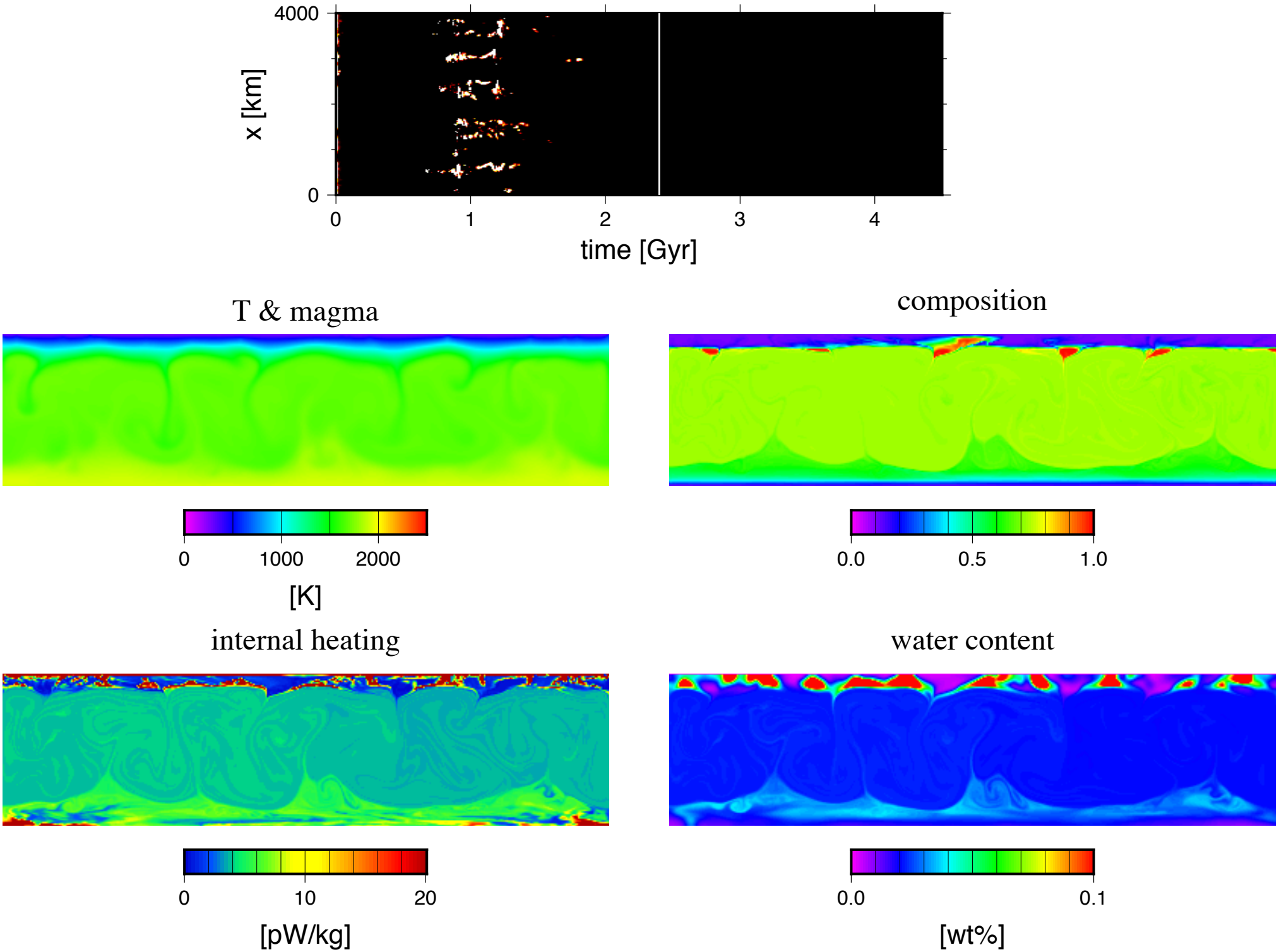
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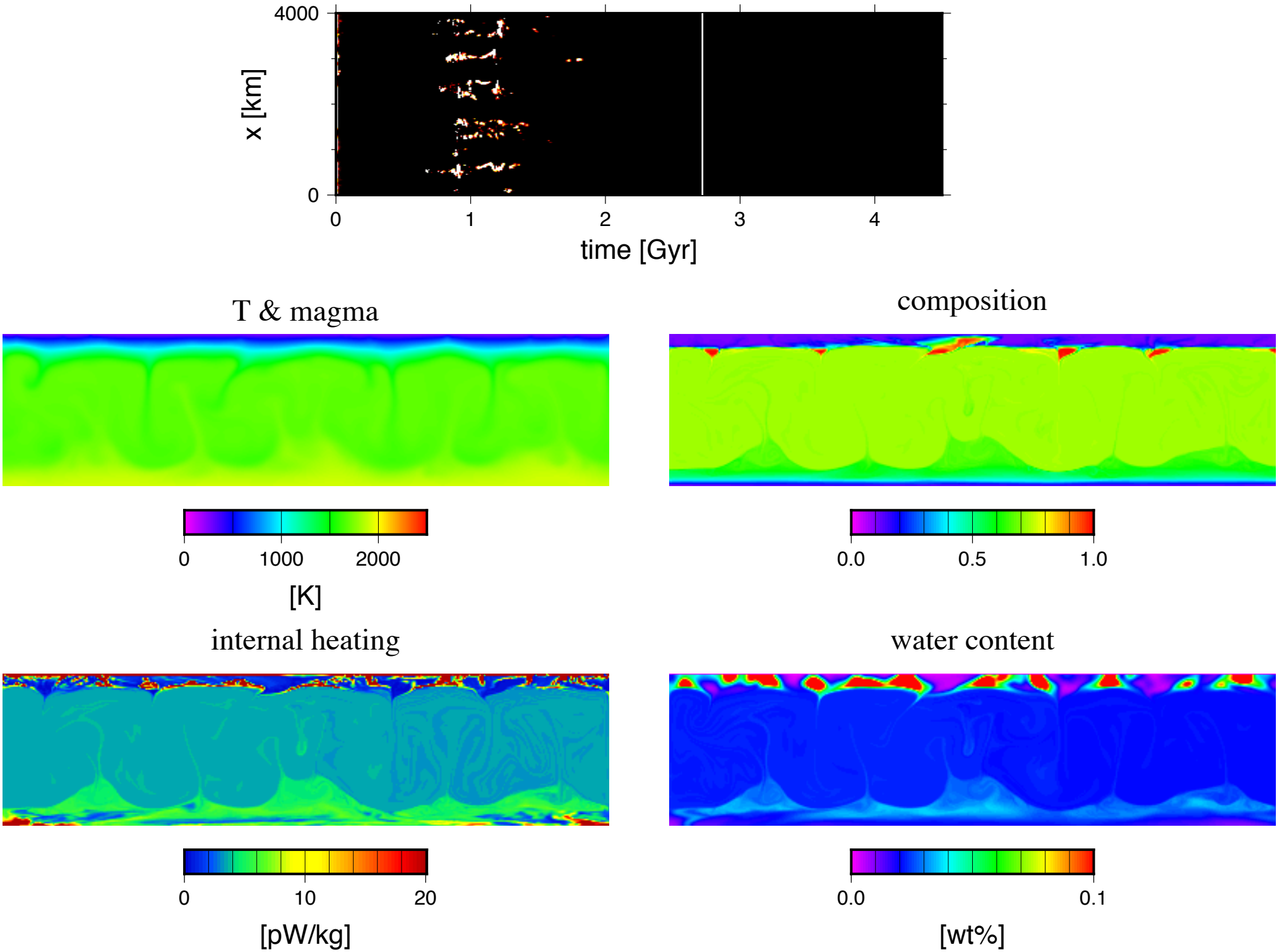
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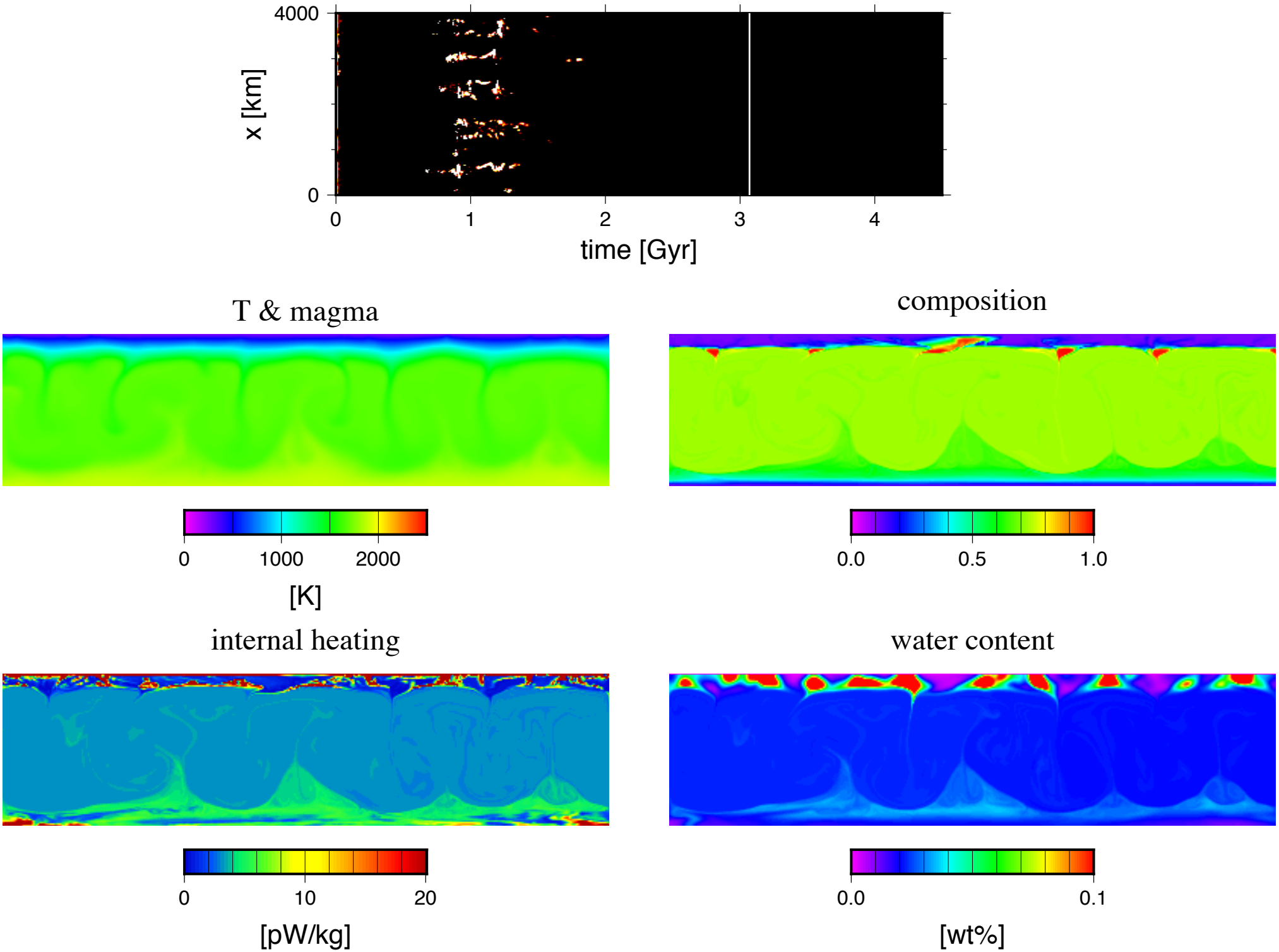
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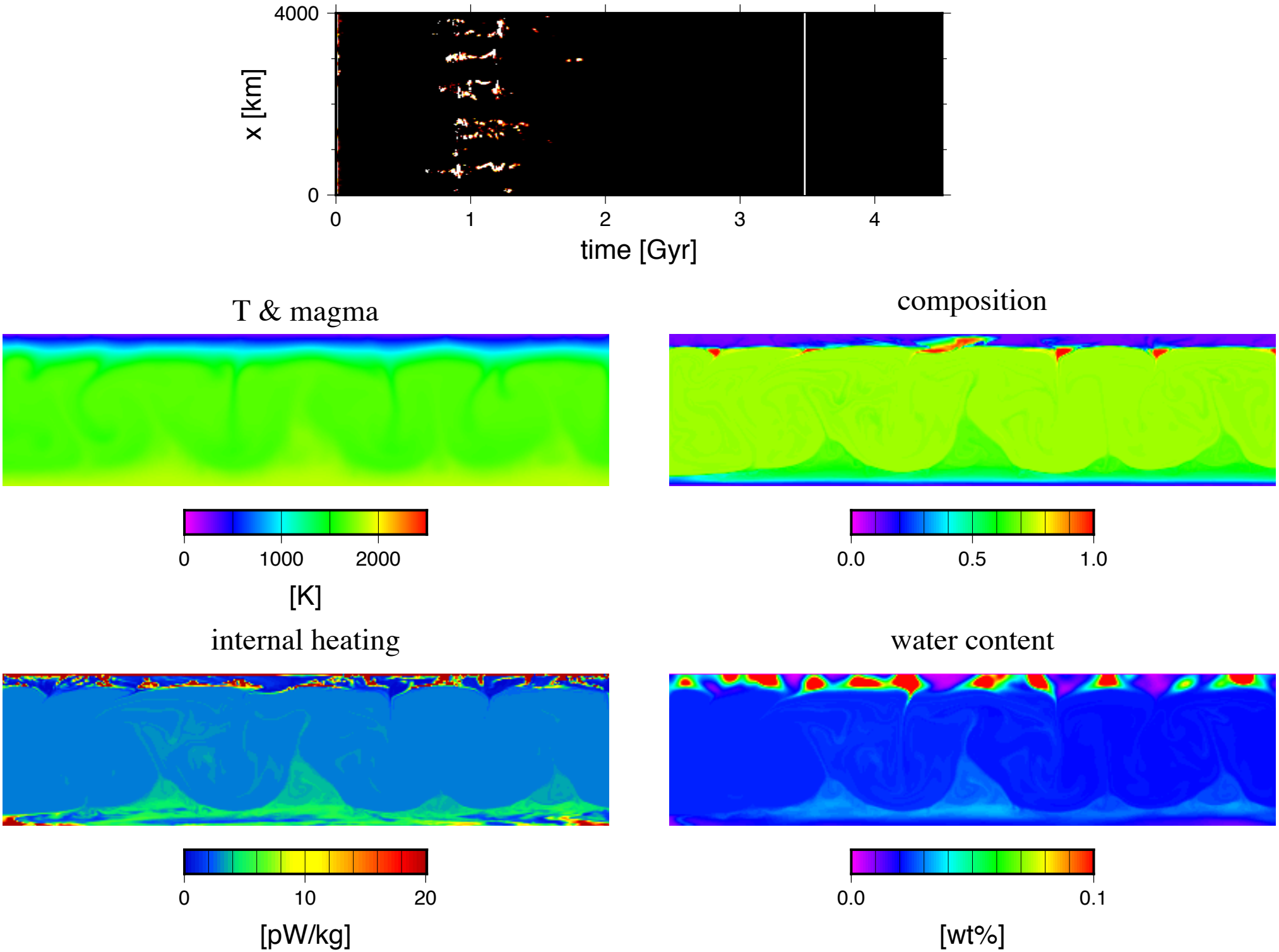
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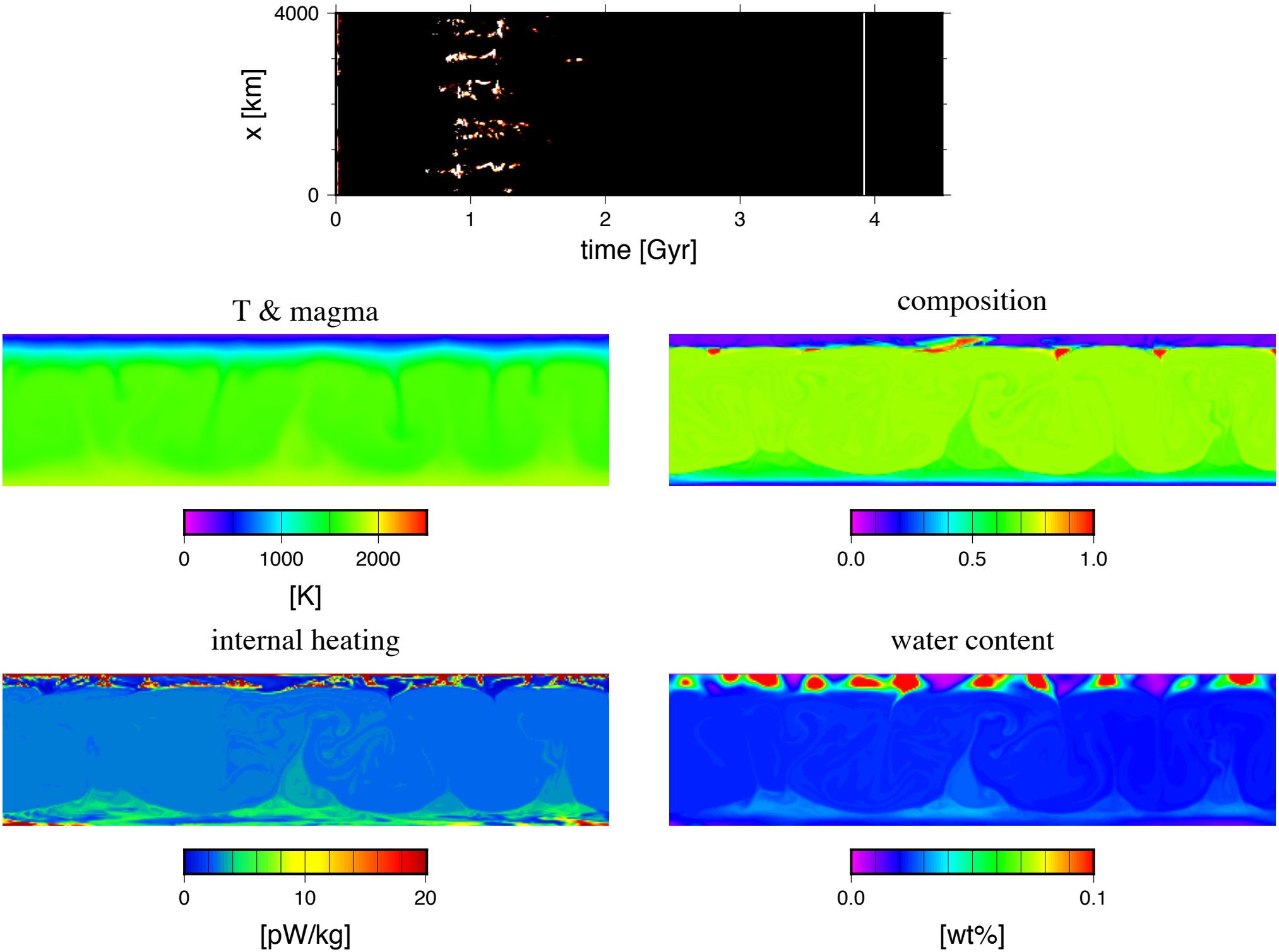
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time [Gyr]
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1000
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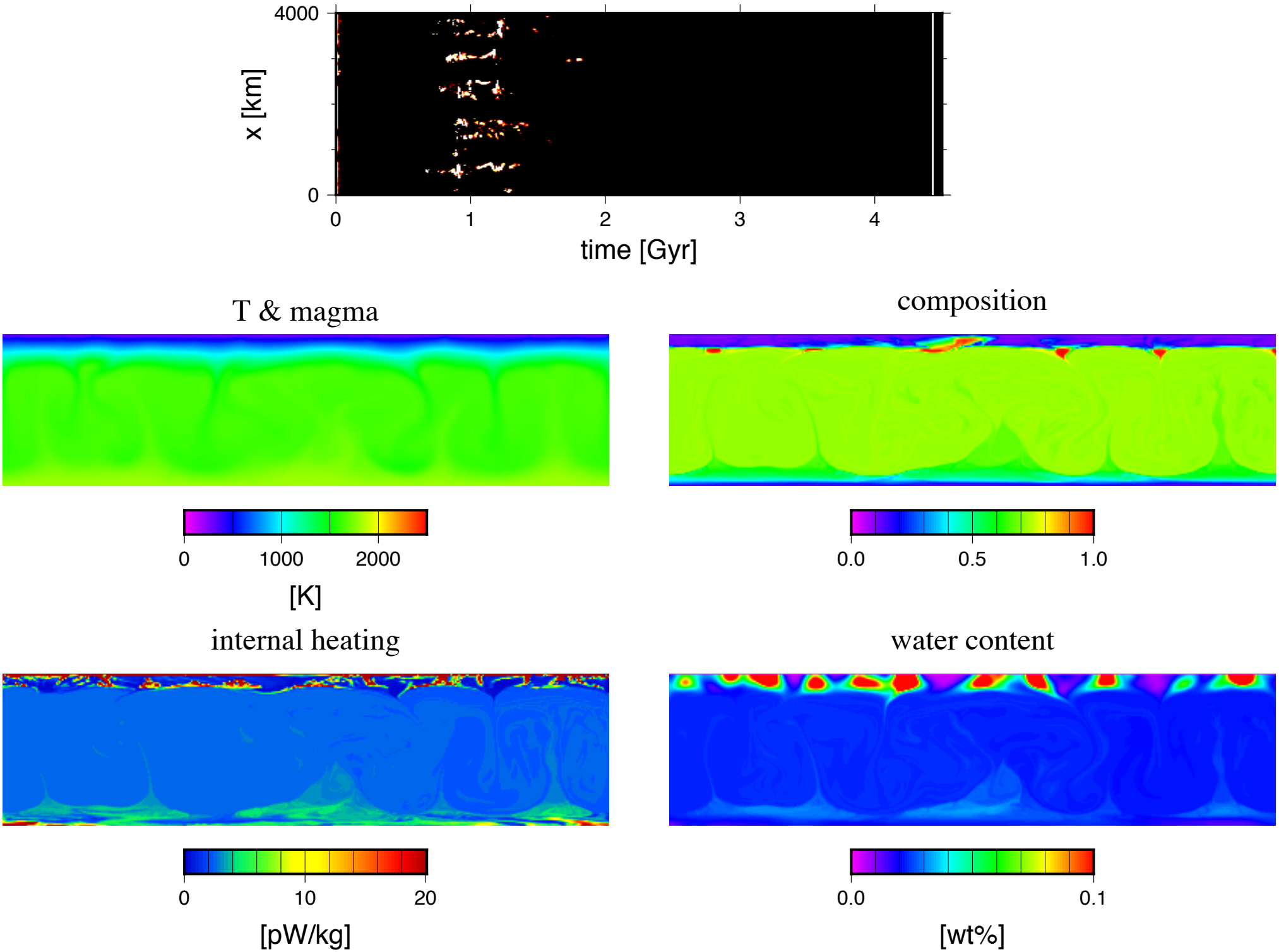
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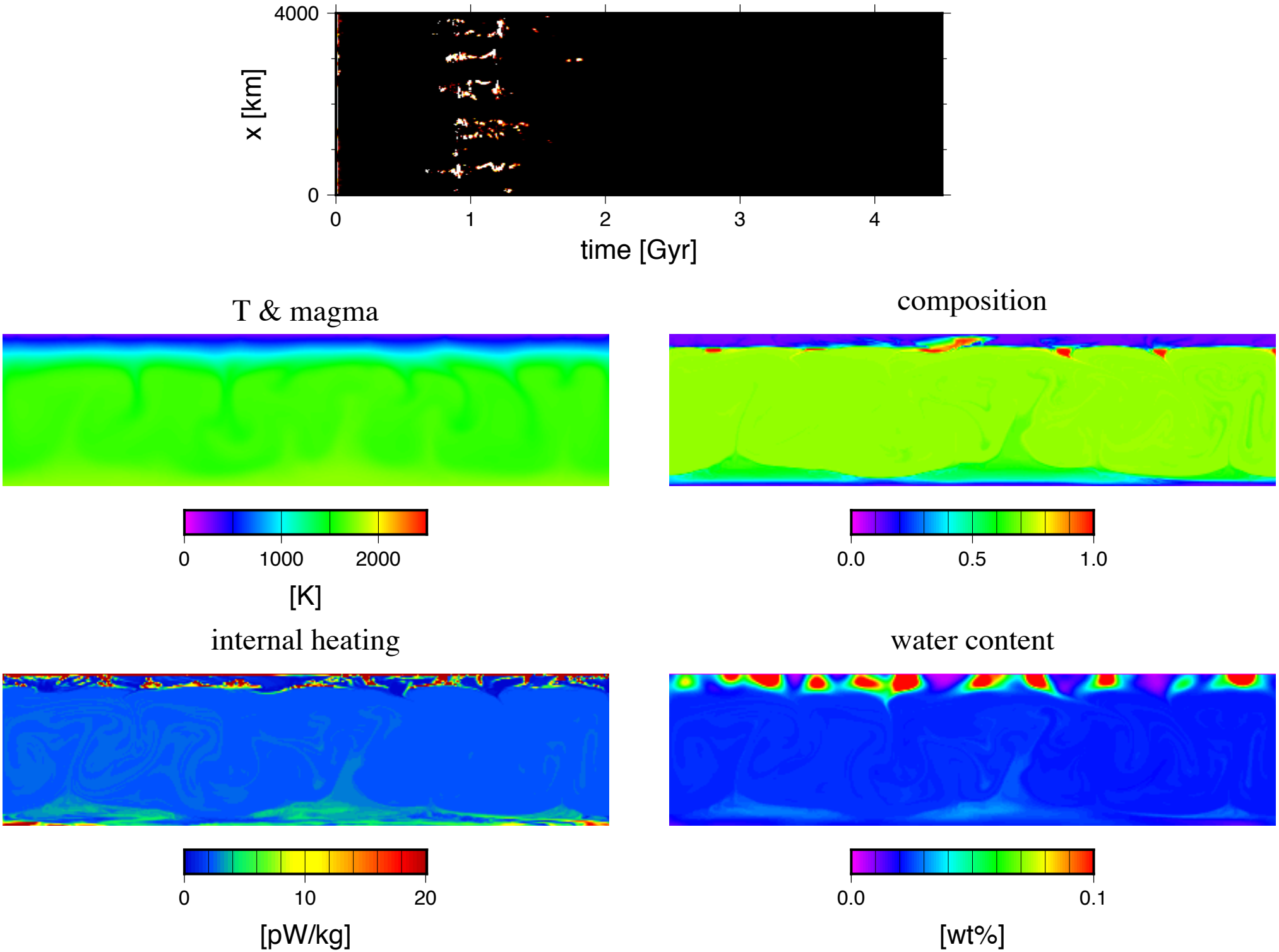
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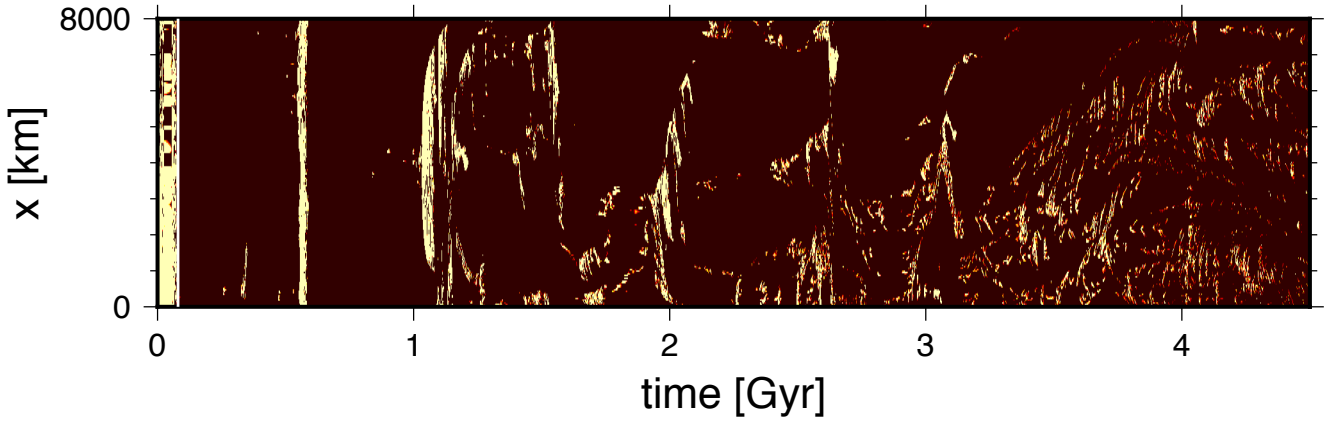

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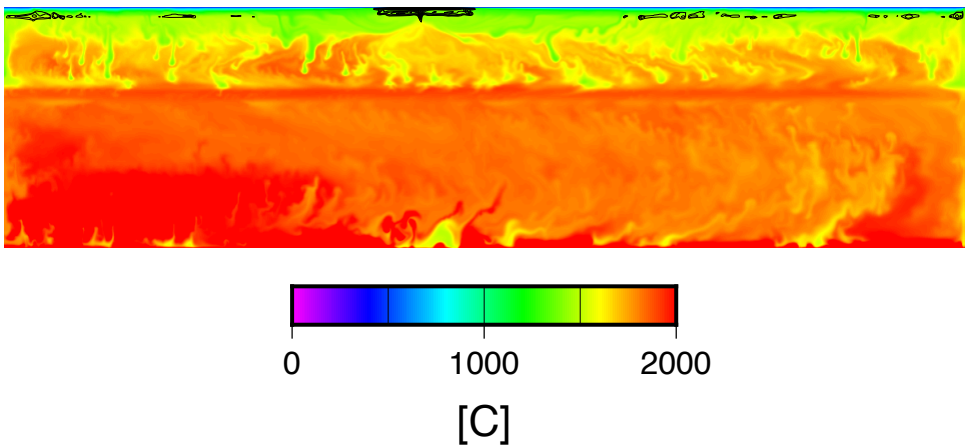

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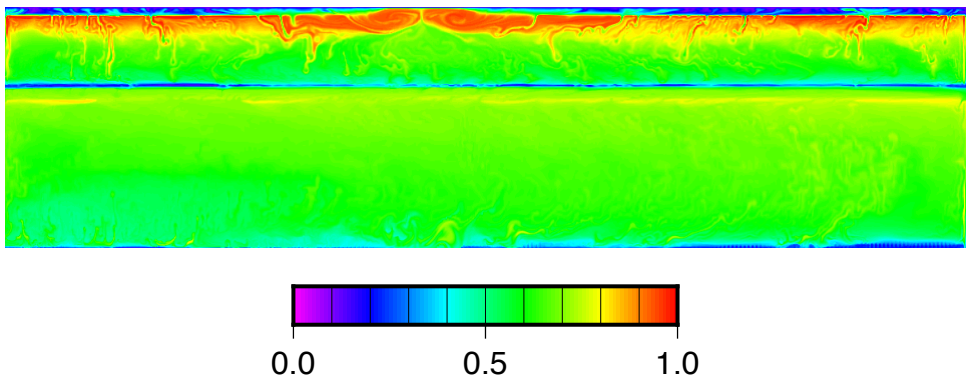

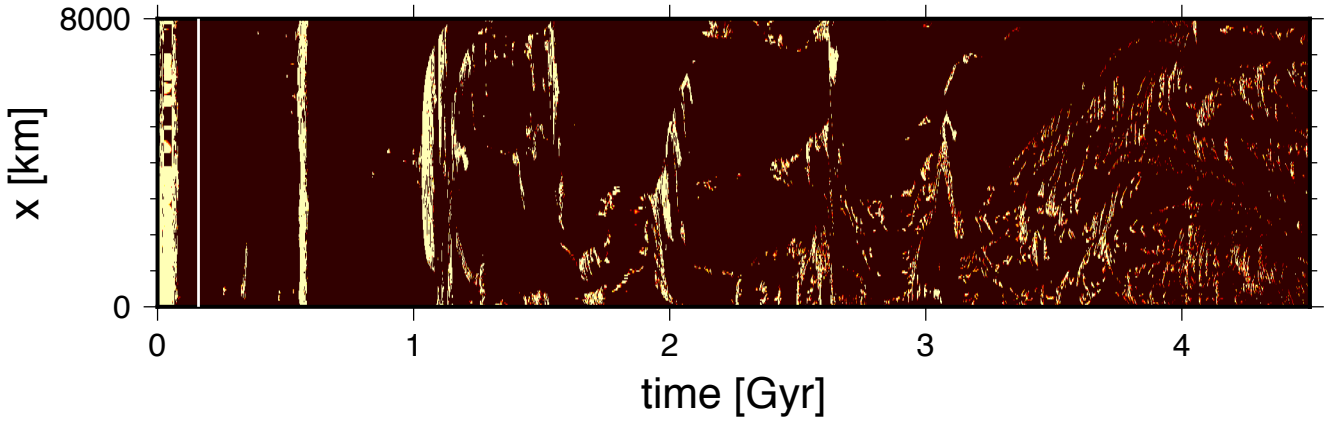

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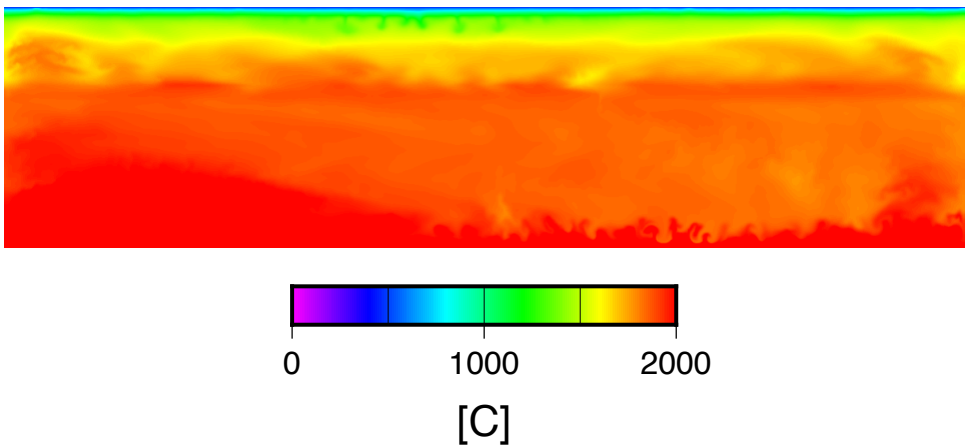

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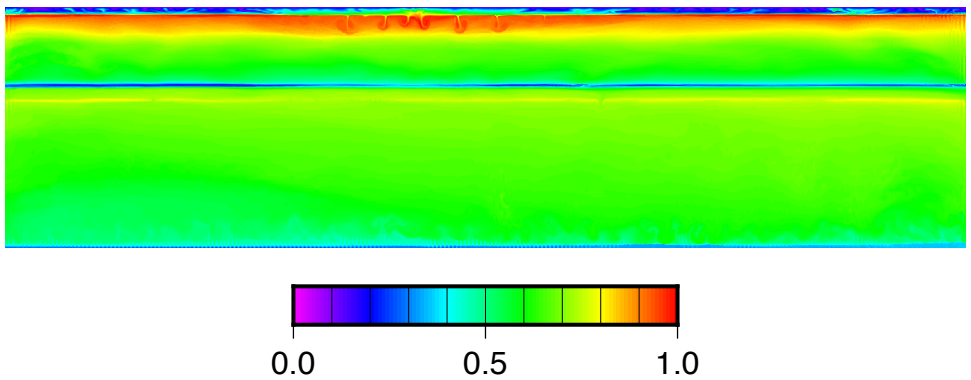

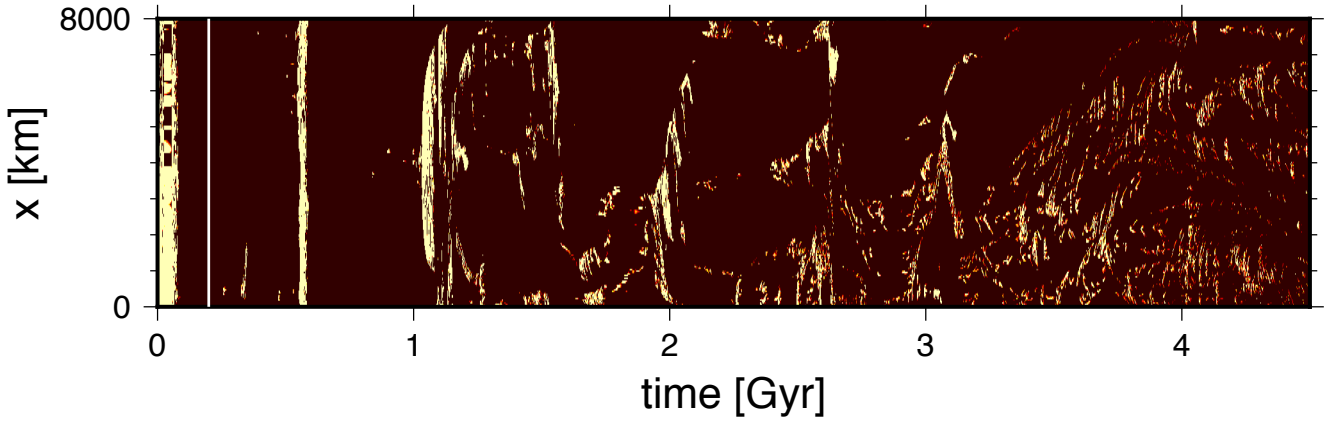

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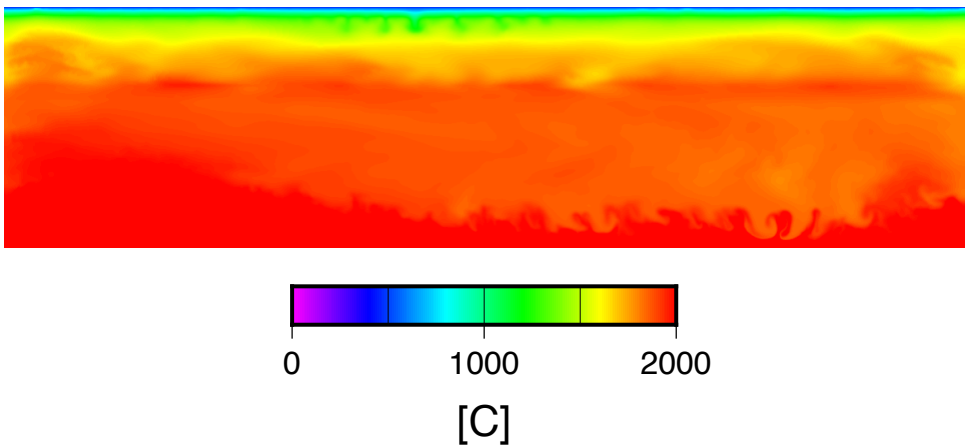

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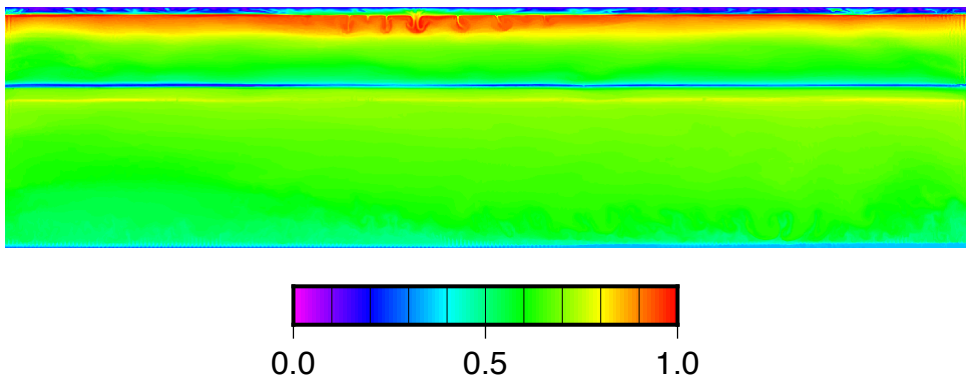

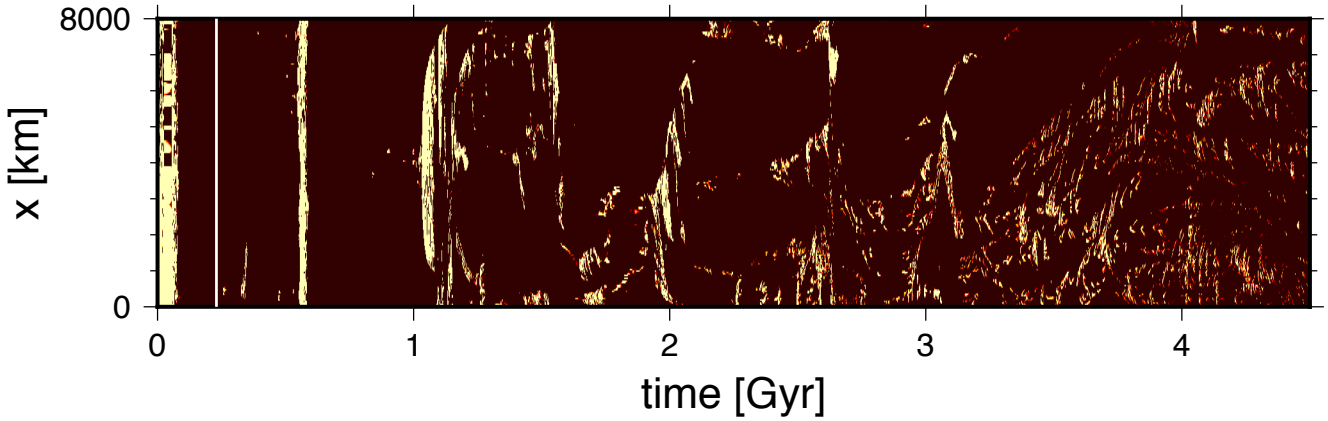

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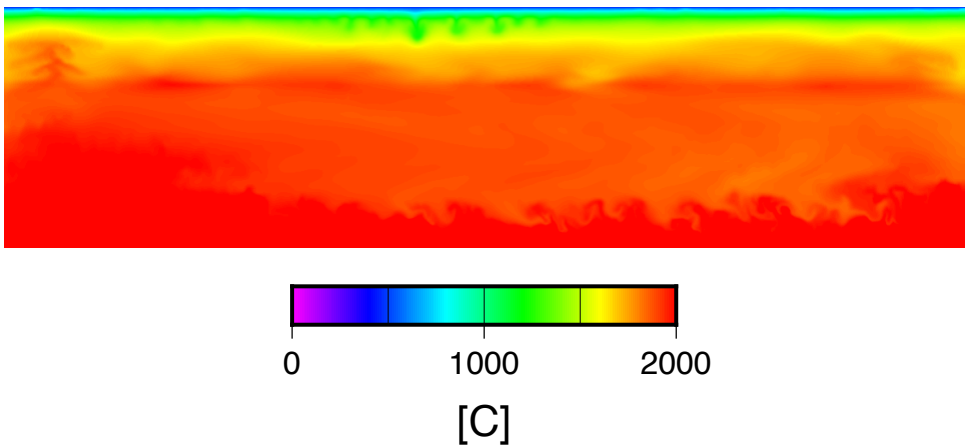

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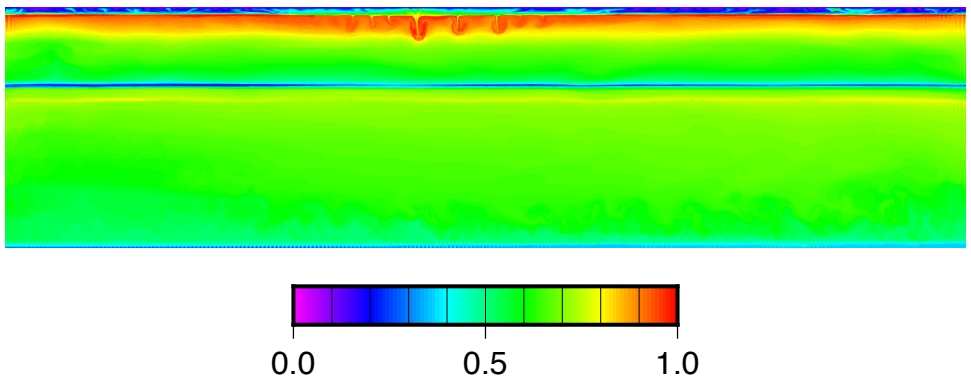

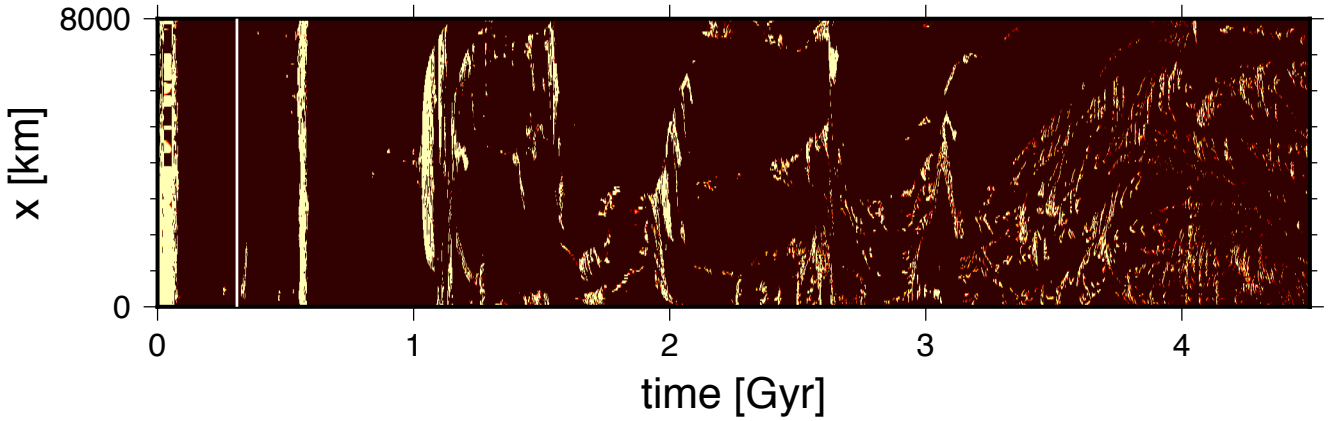

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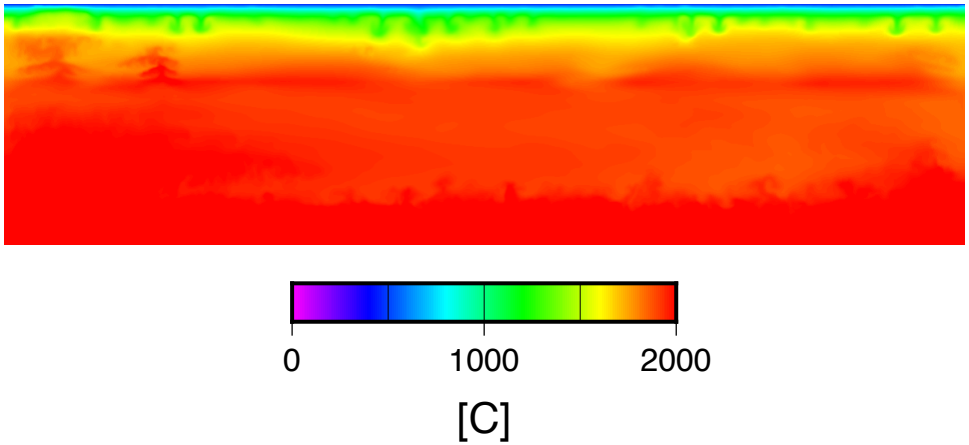

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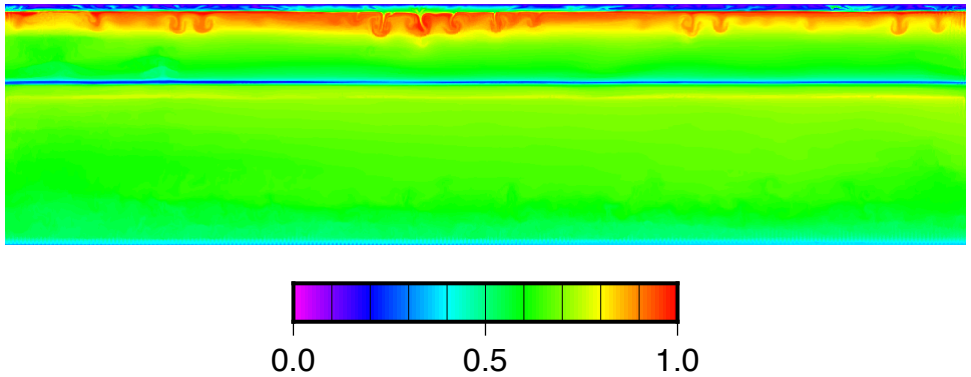

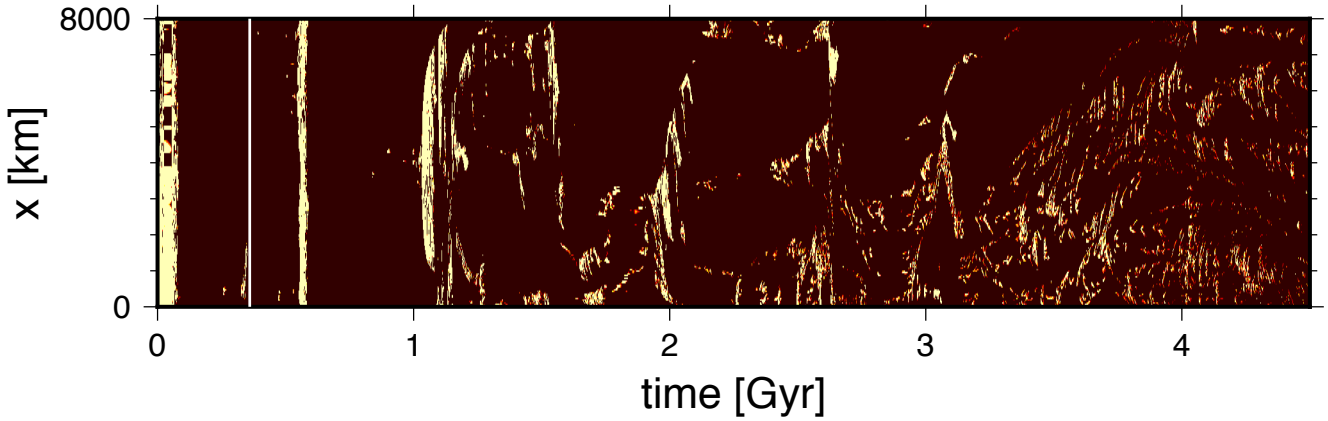

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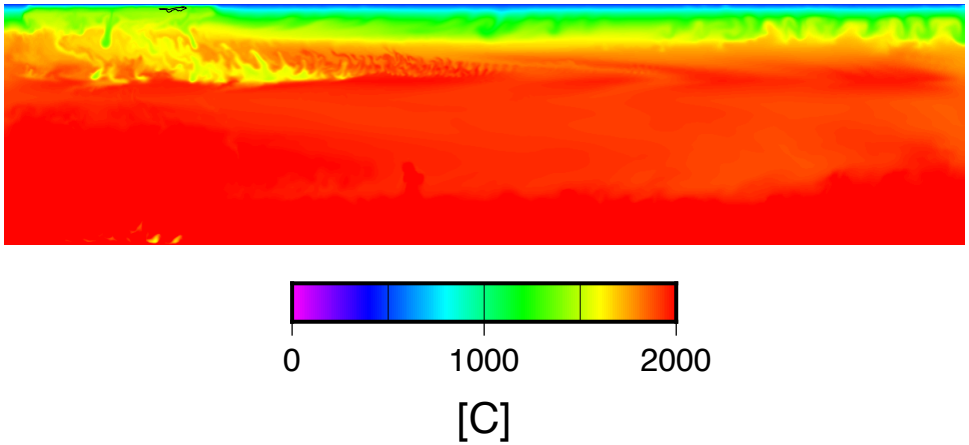

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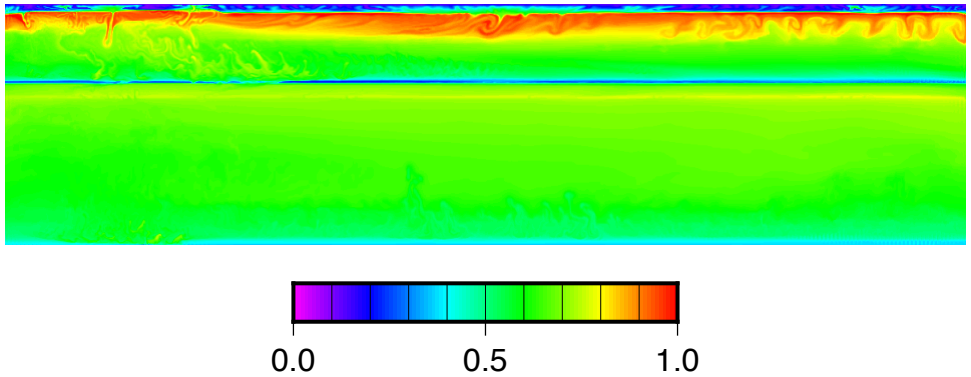

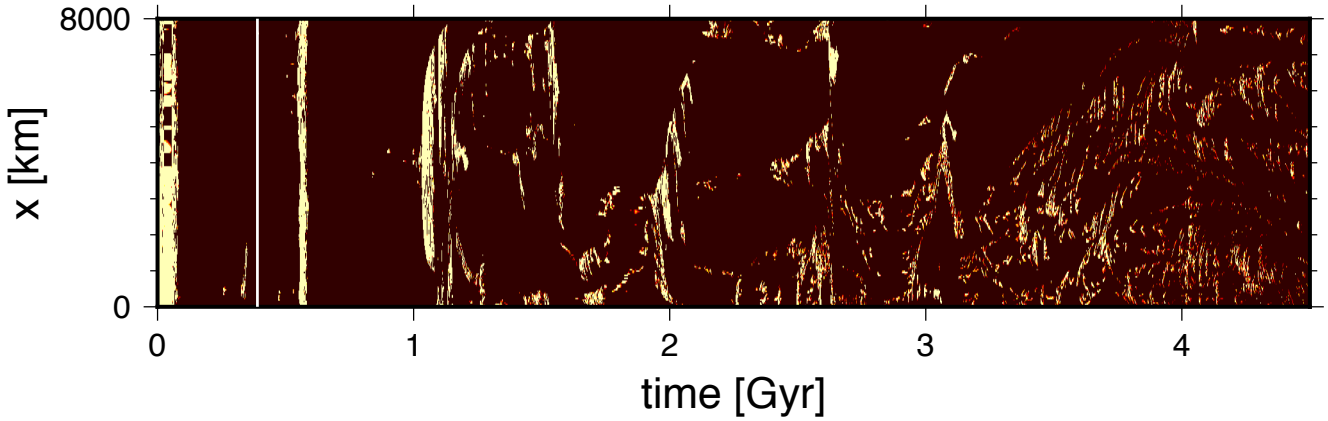

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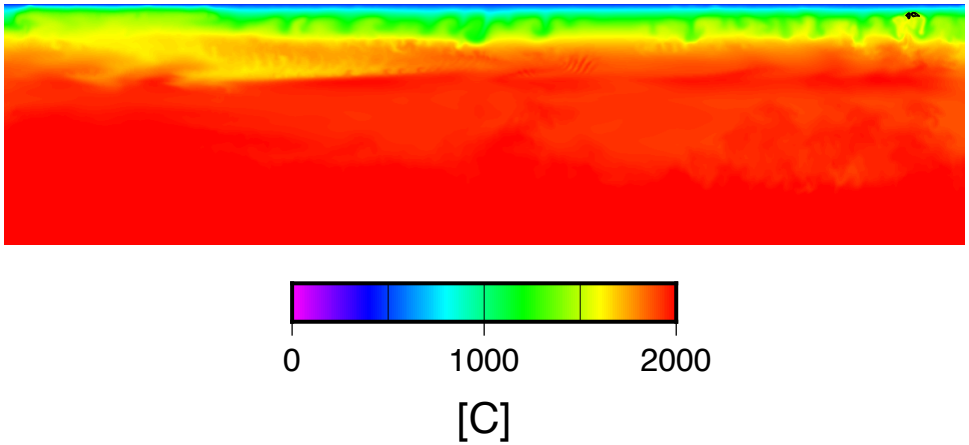

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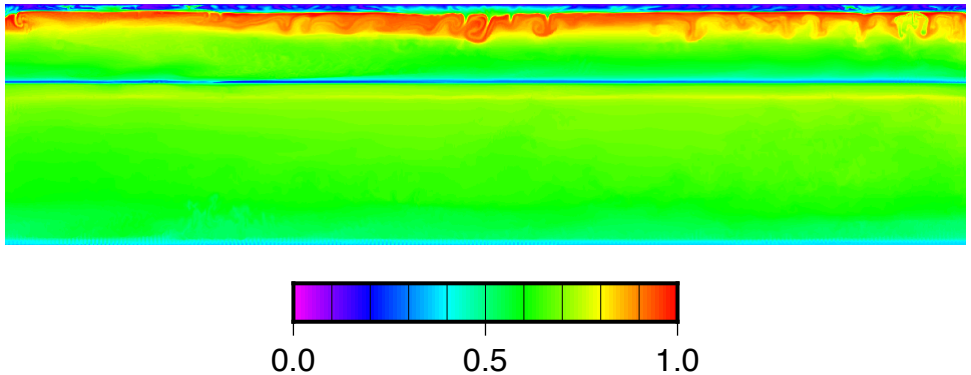

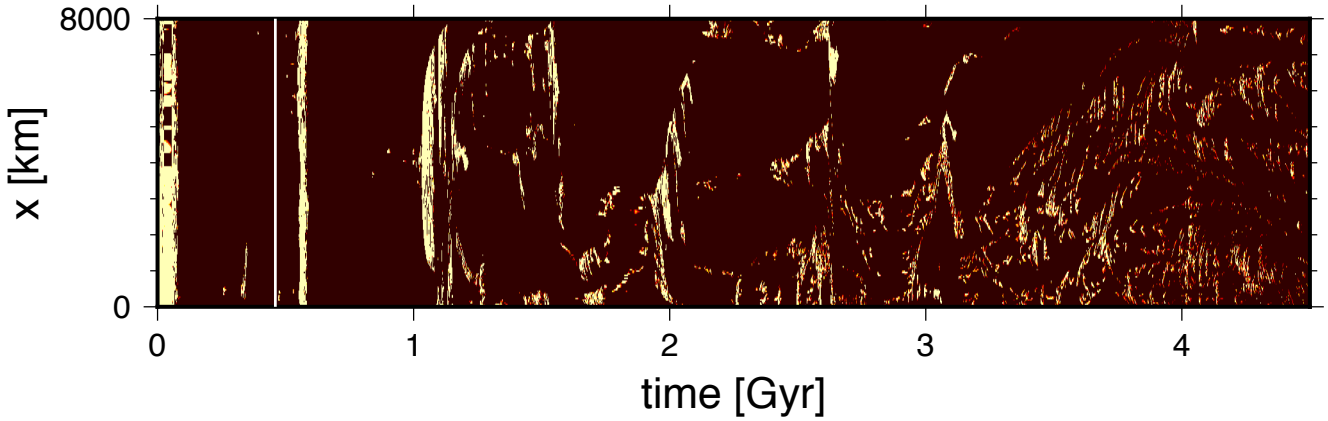

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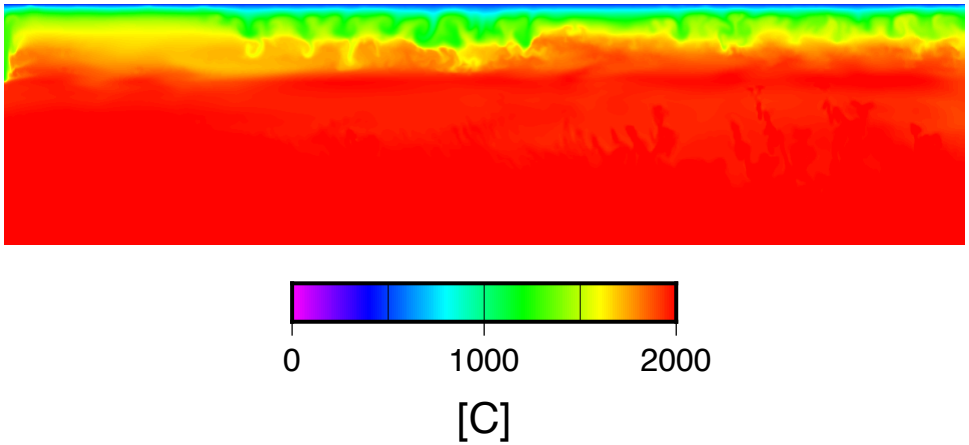

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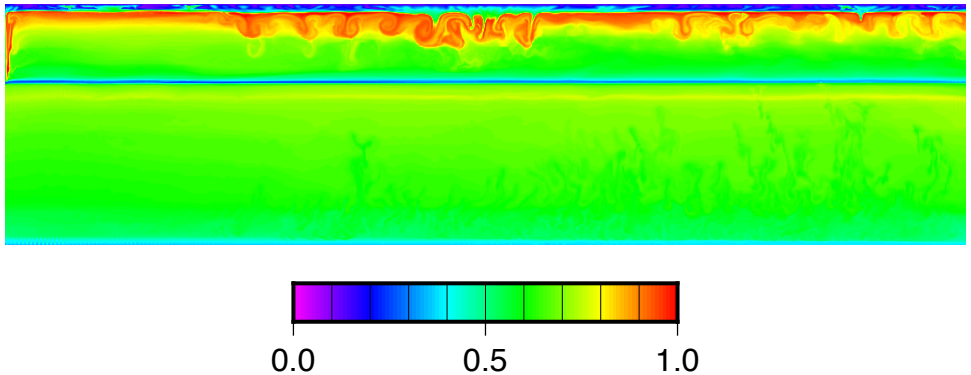

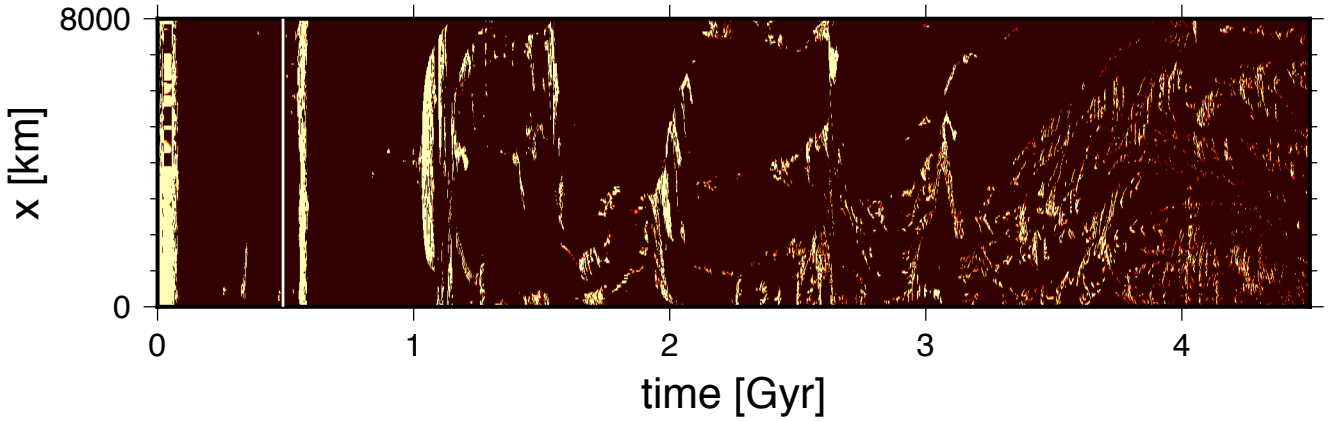

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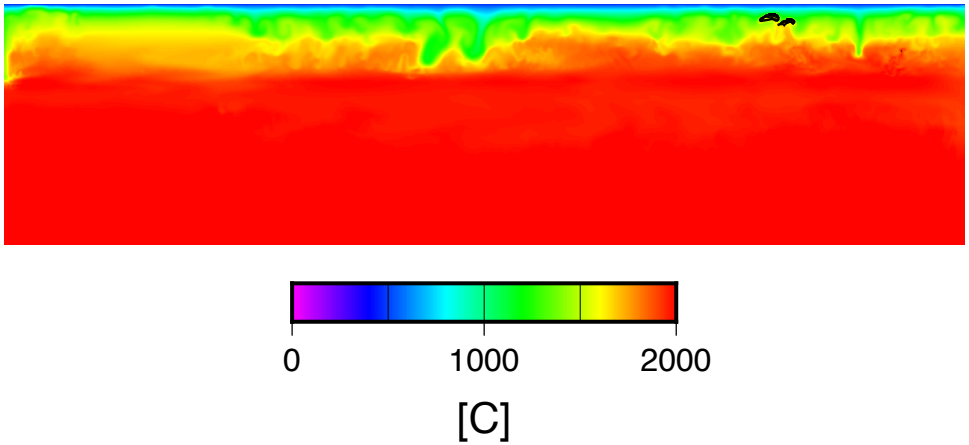

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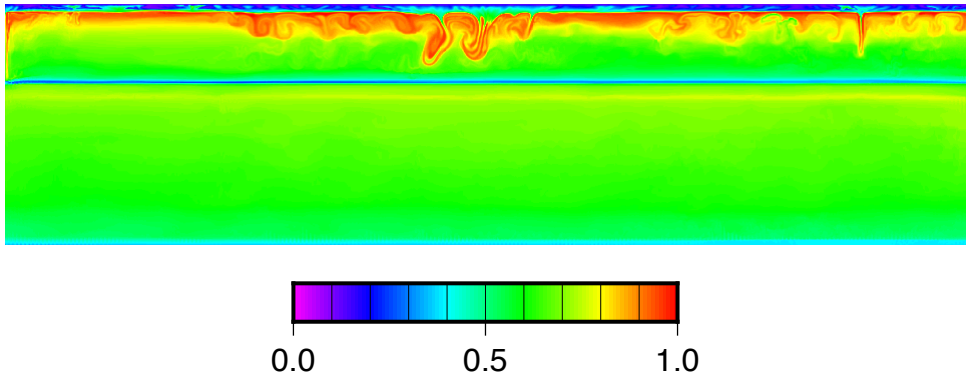

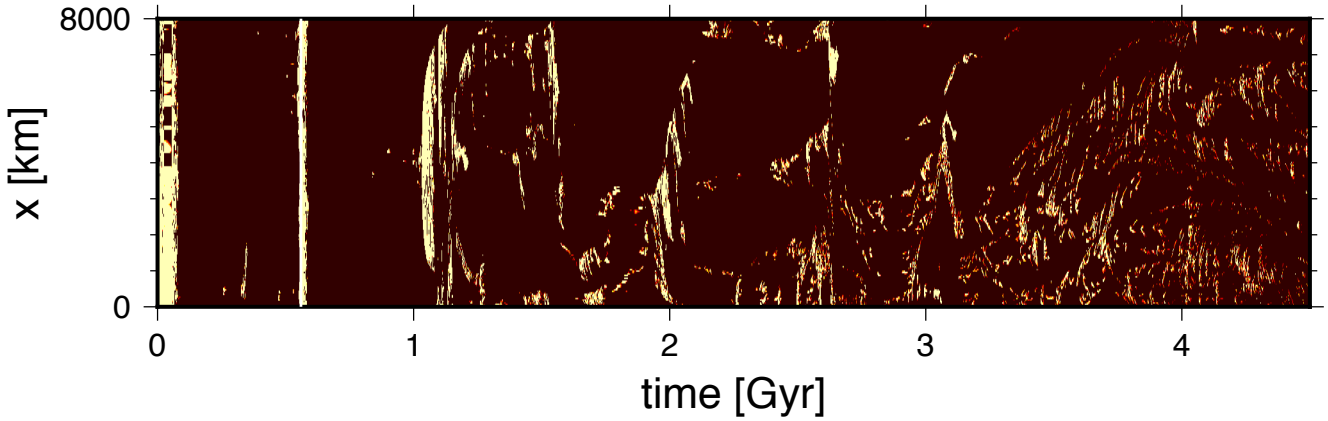

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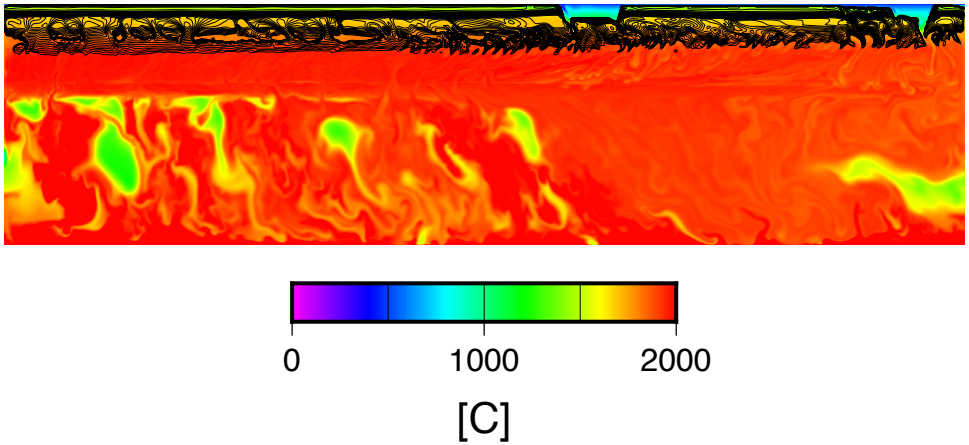

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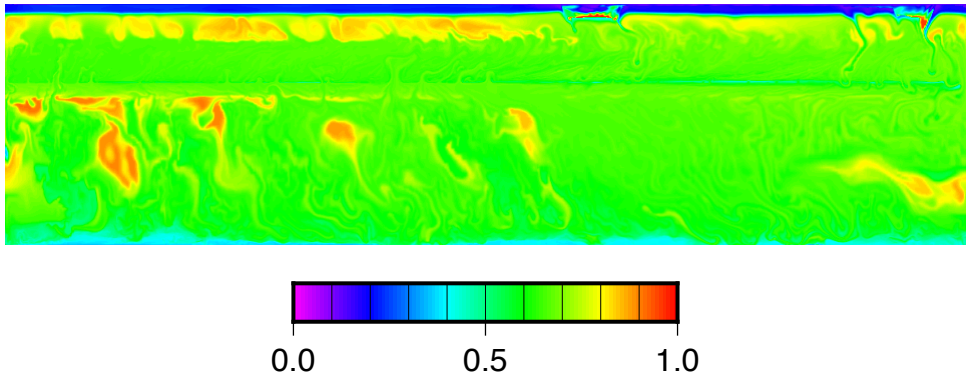

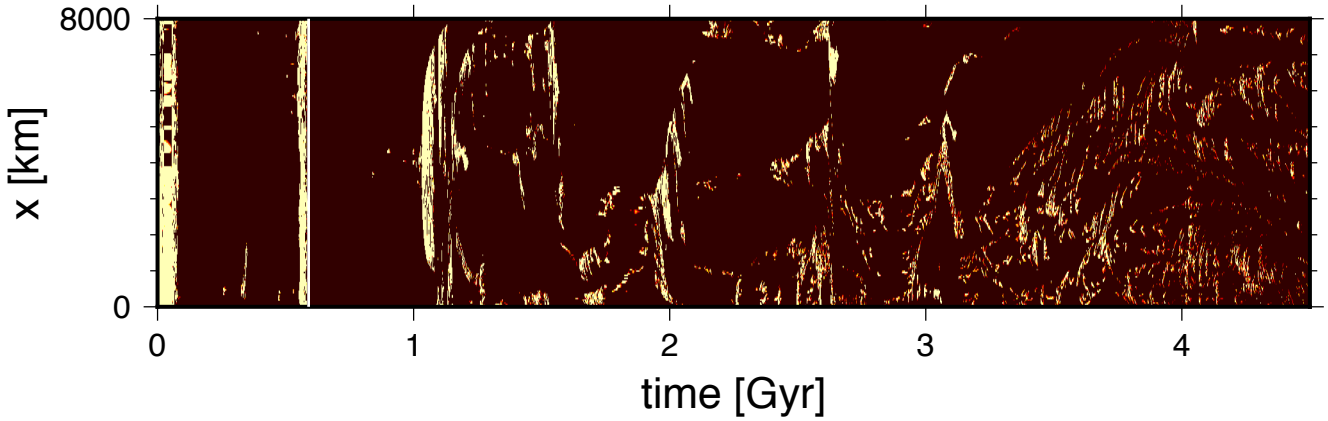

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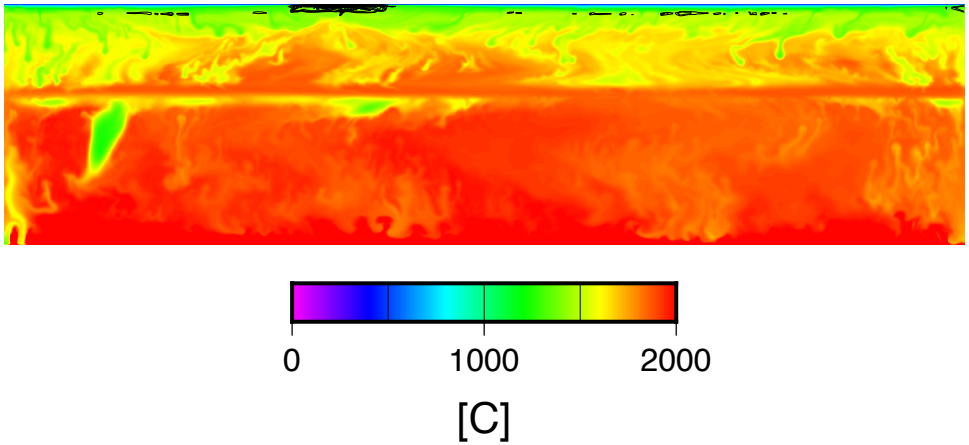

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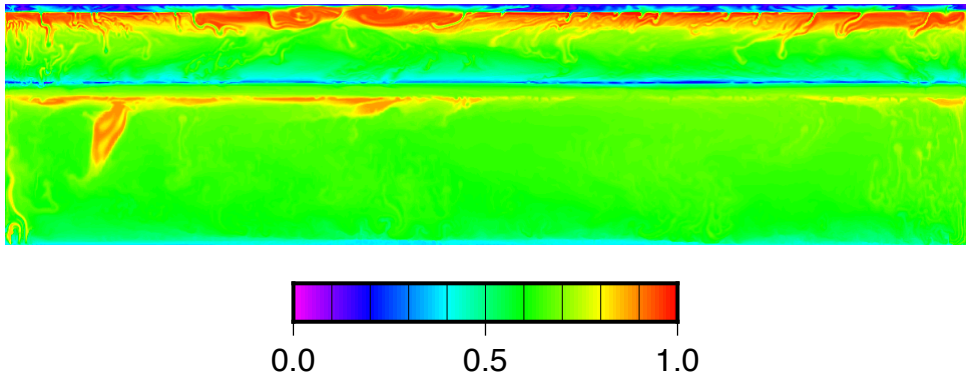

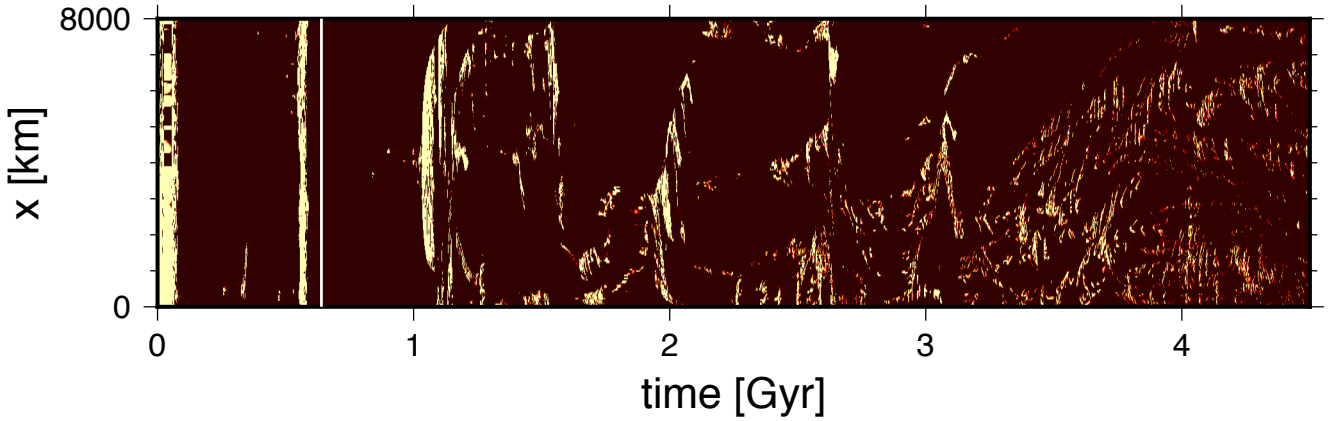

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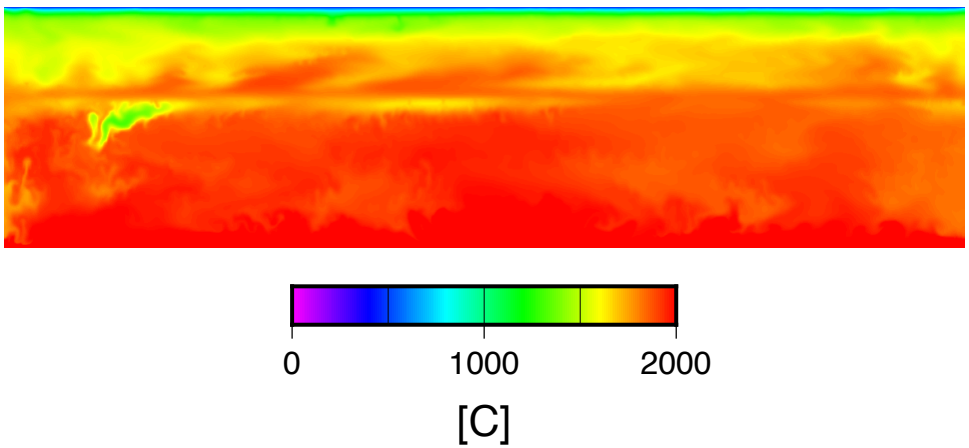

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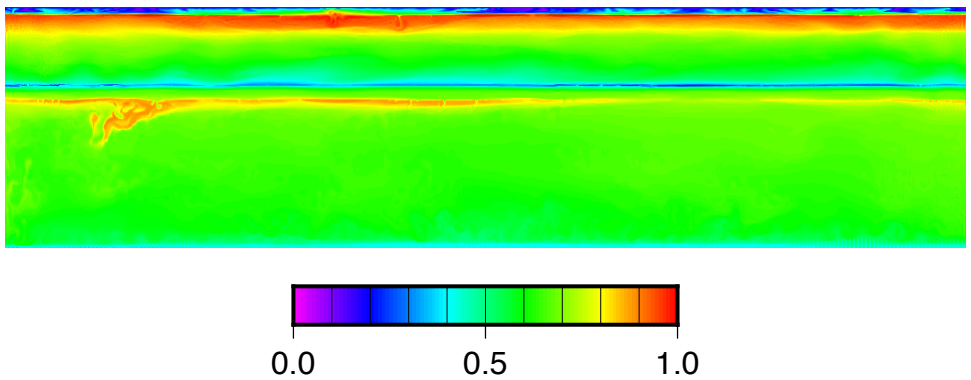

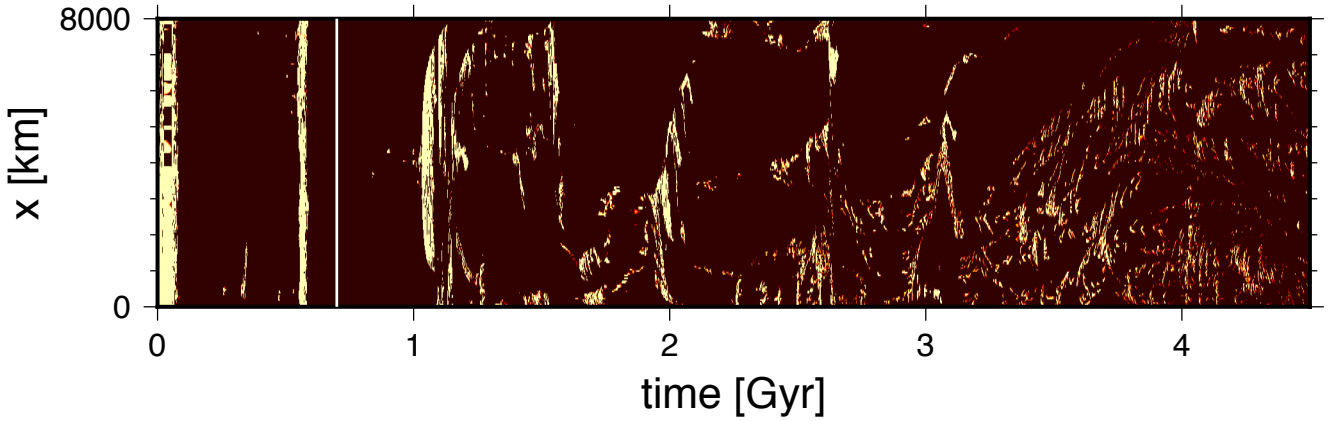

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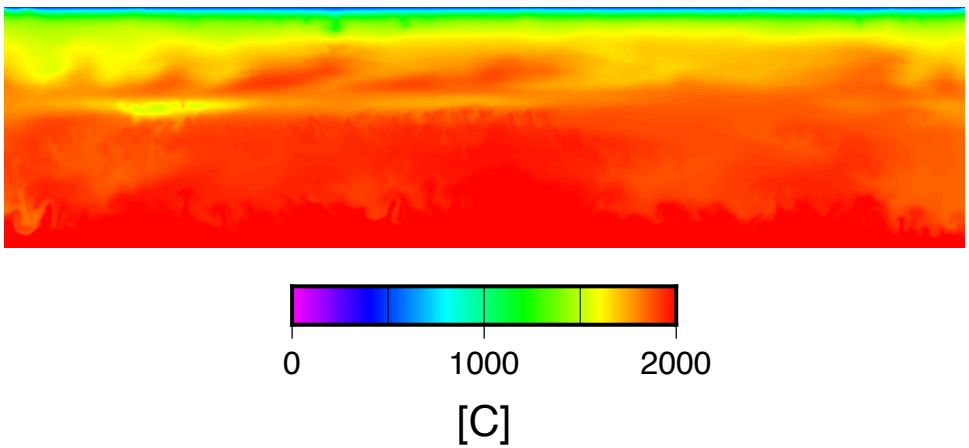

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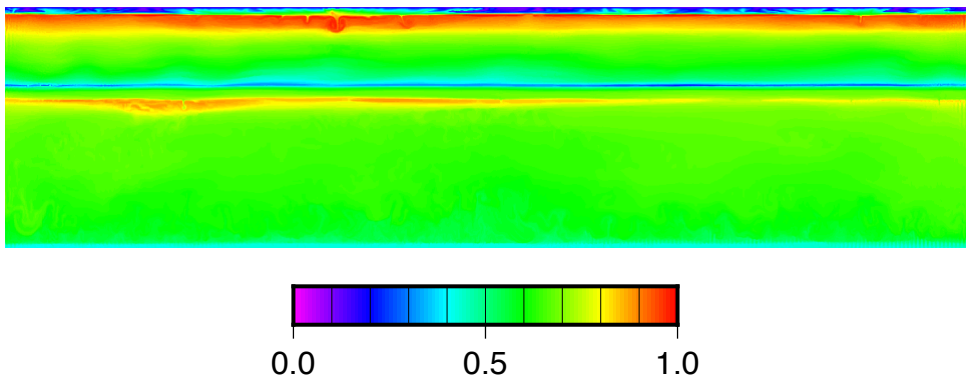

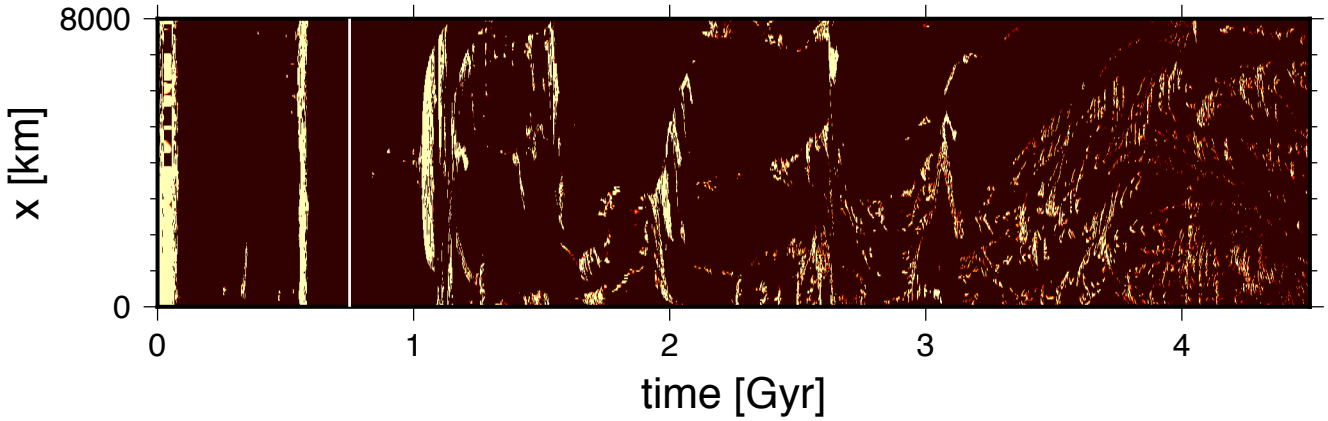

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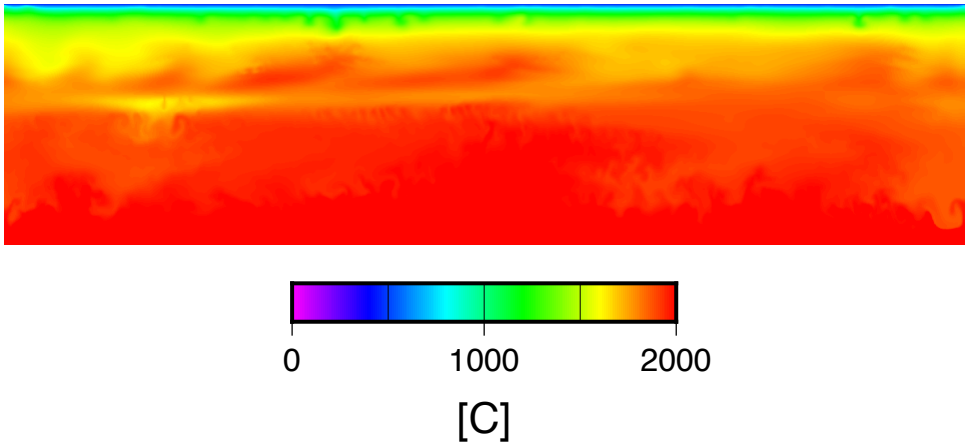

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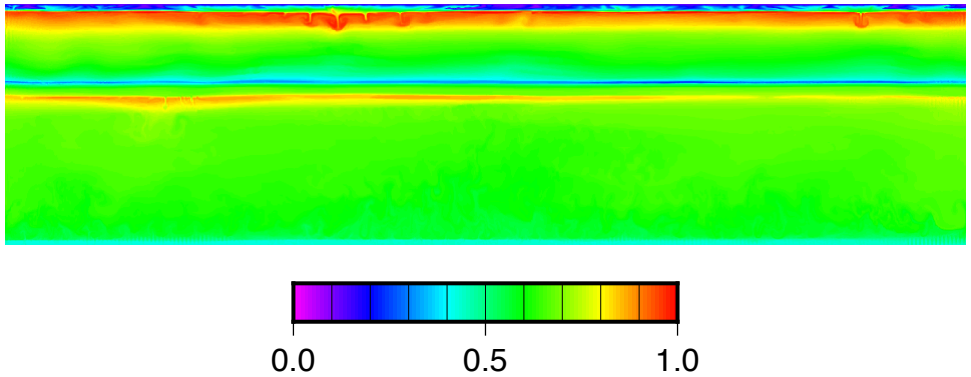

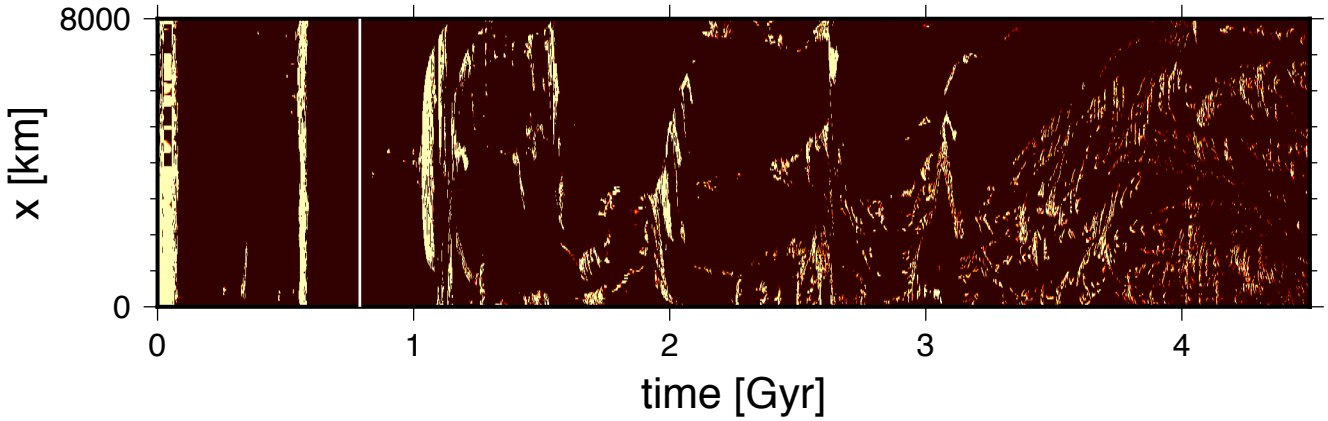

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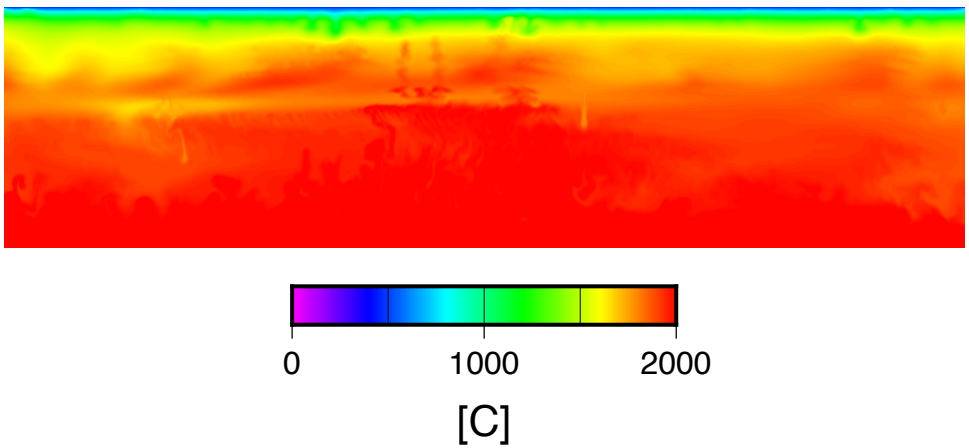

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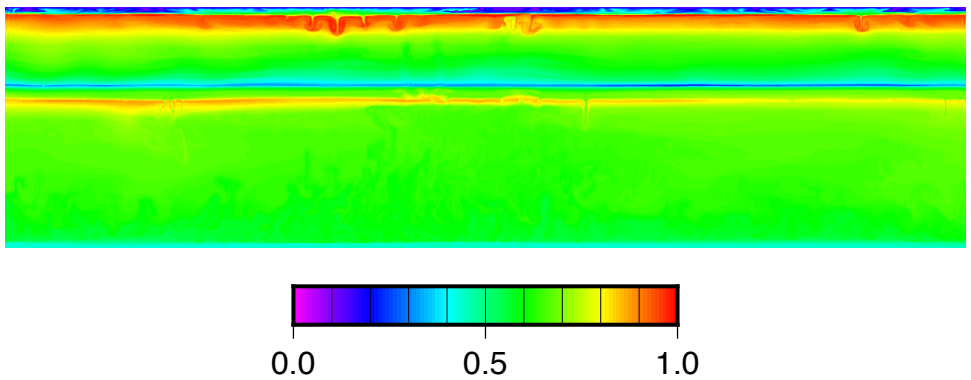

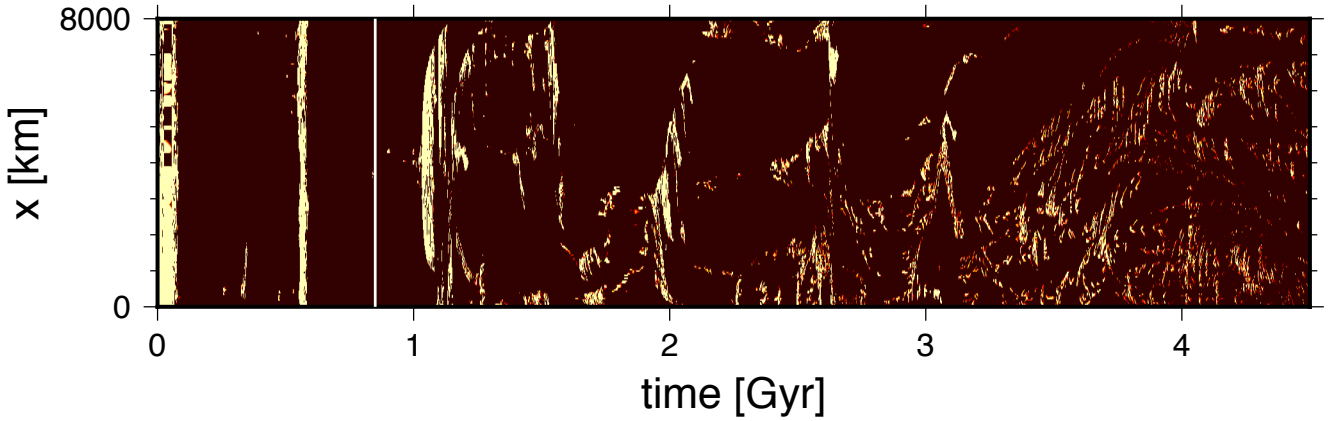

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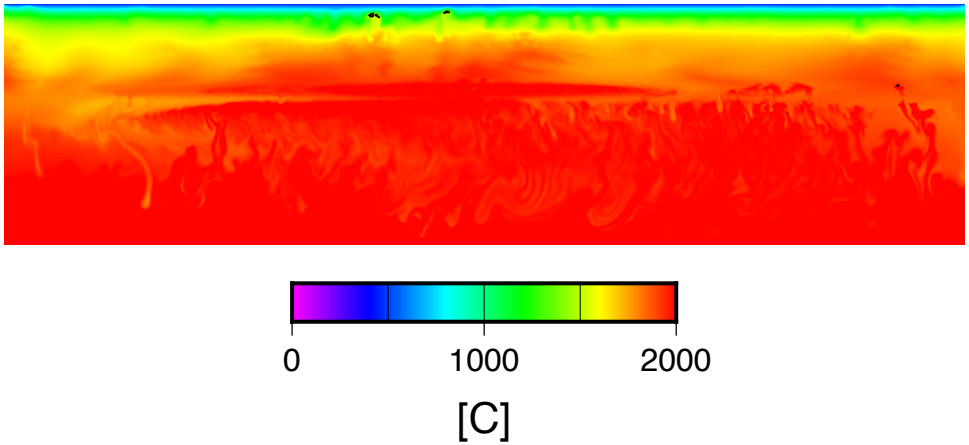

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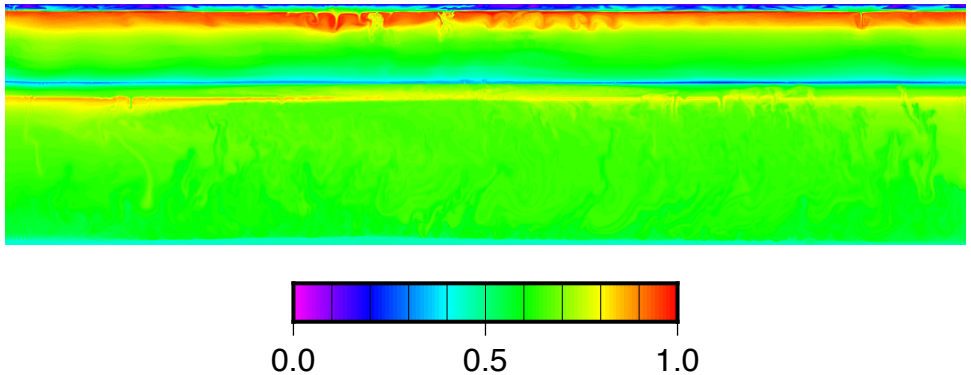

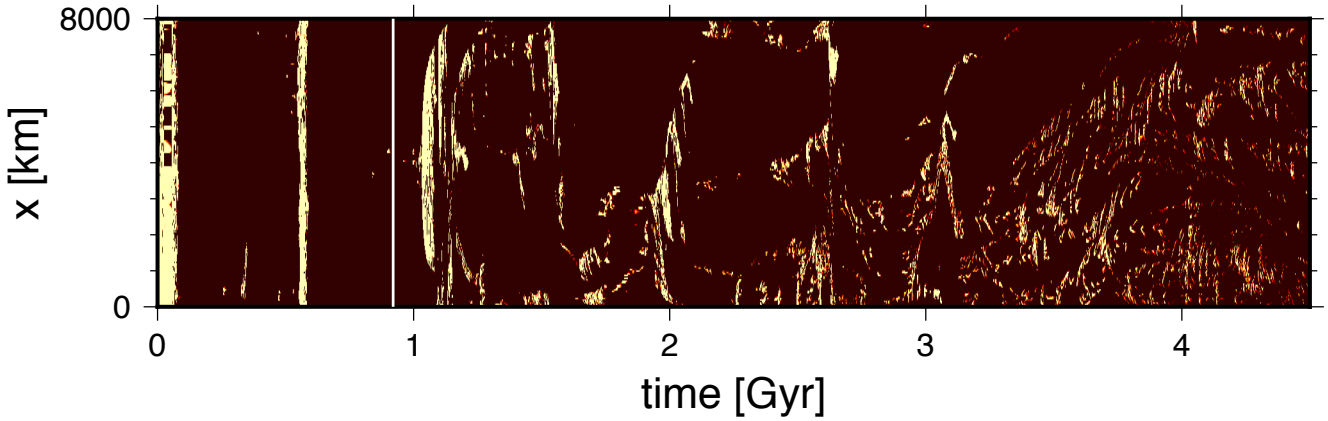

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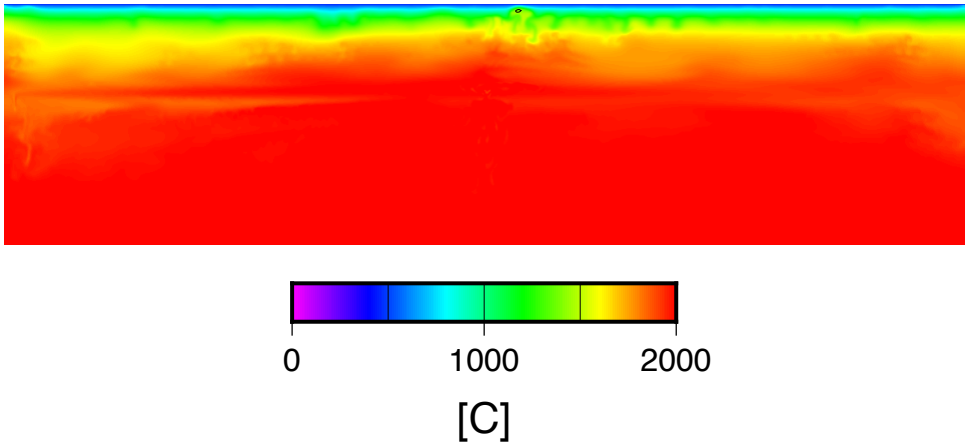

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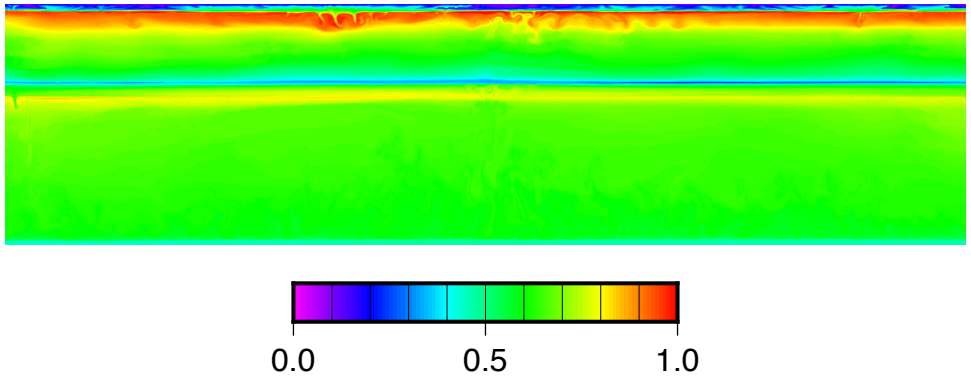

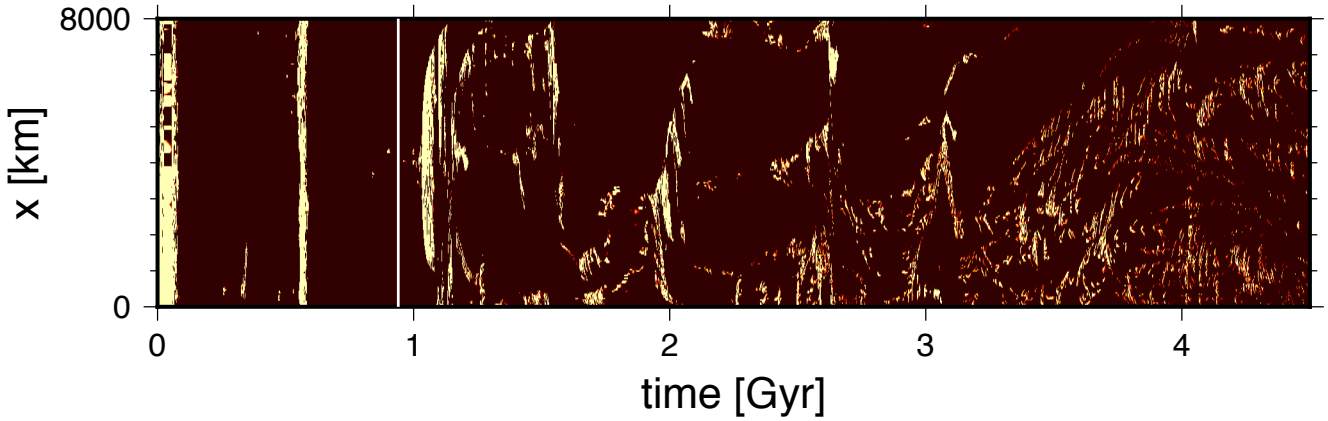

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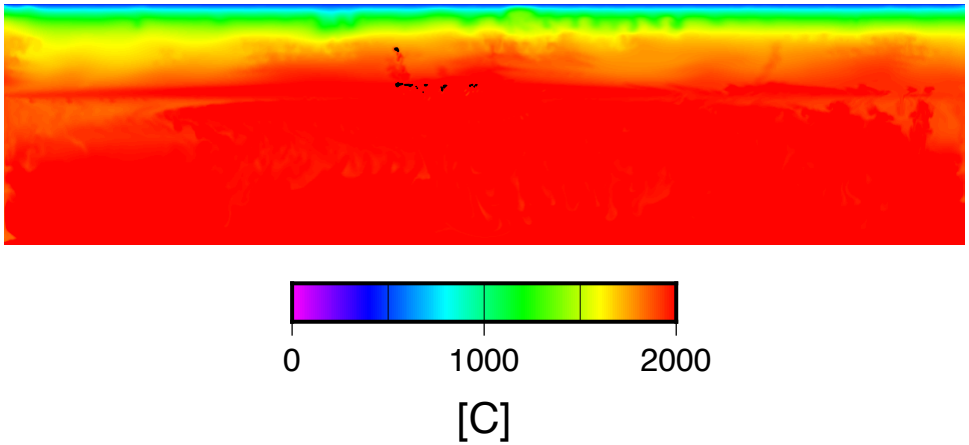

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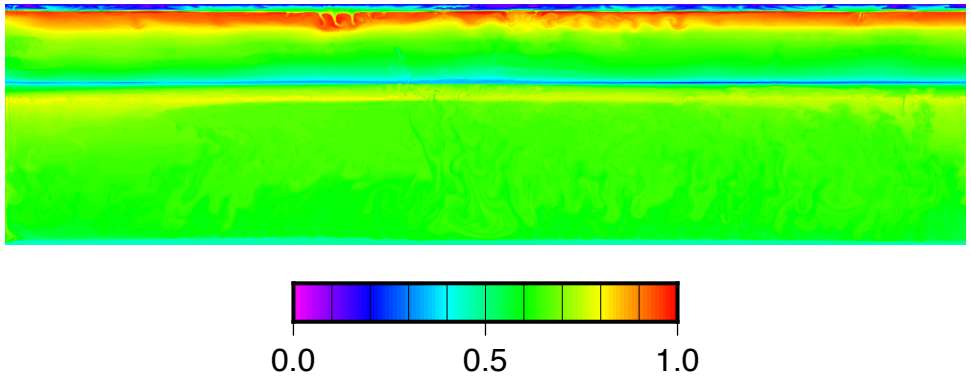

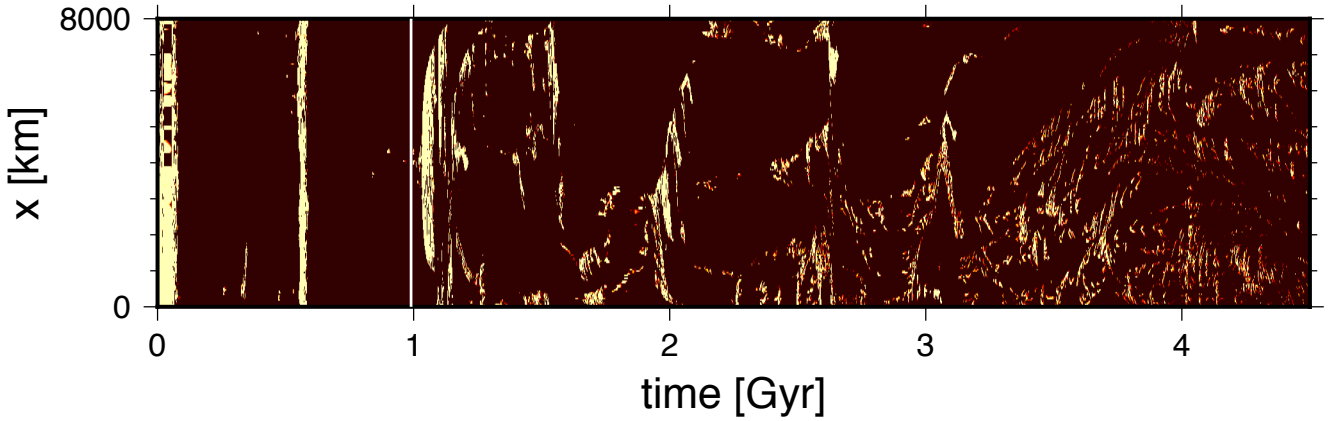

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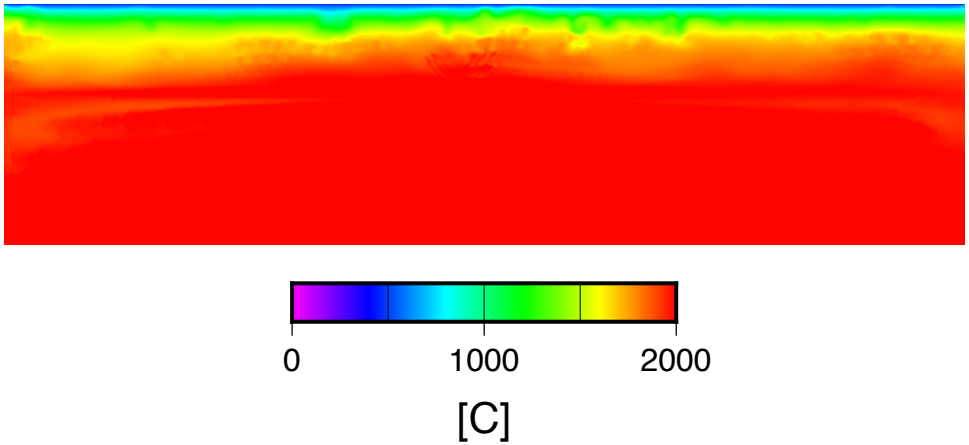

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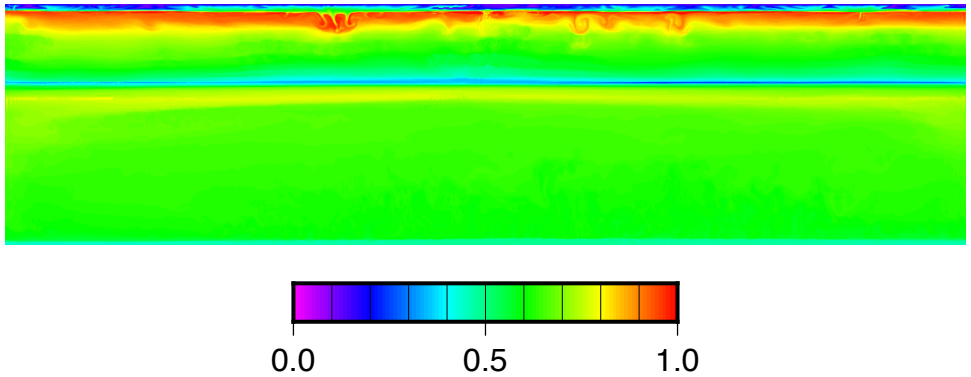

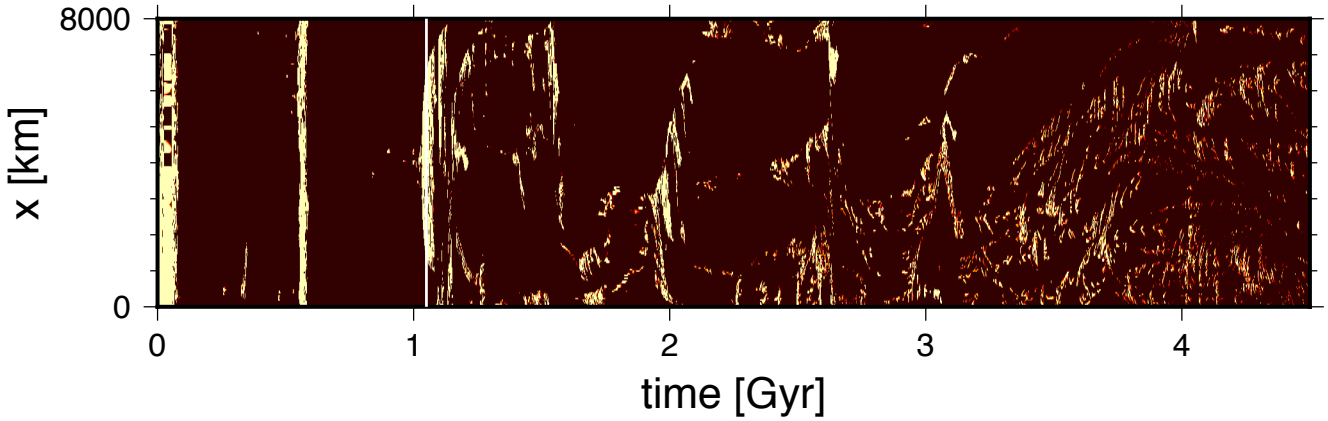

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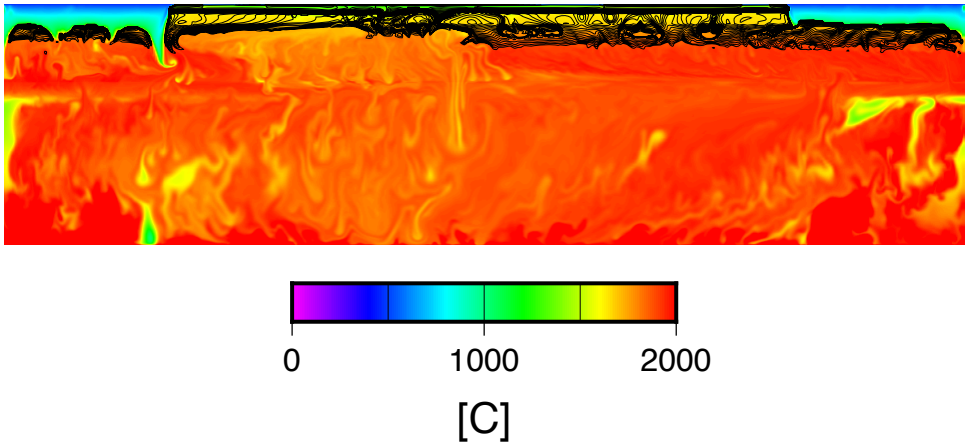

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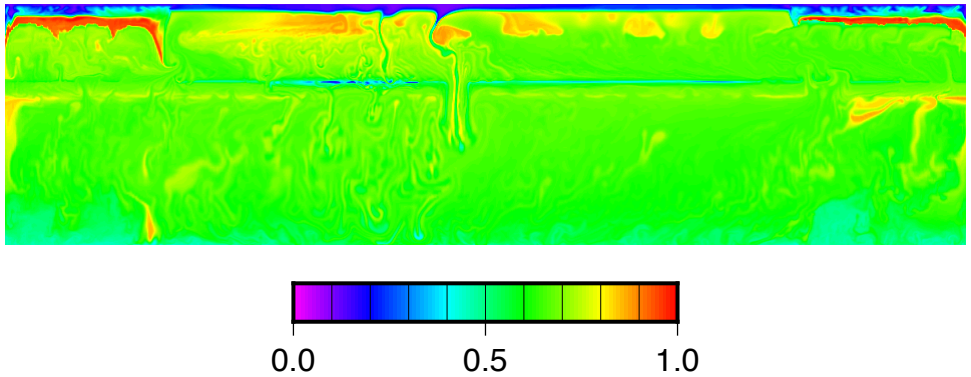

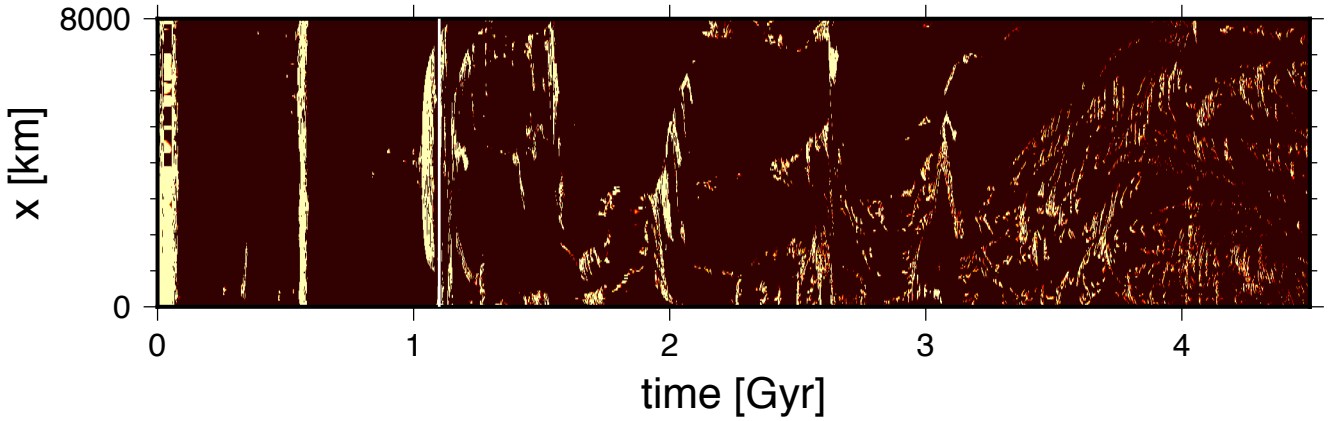

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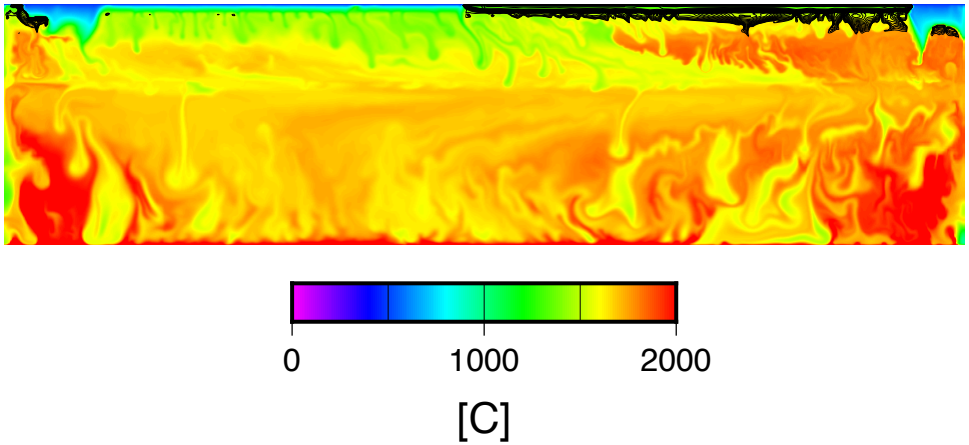

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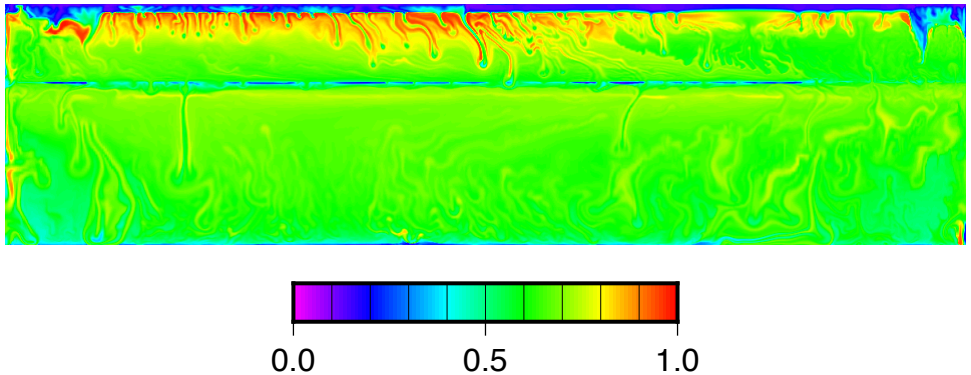

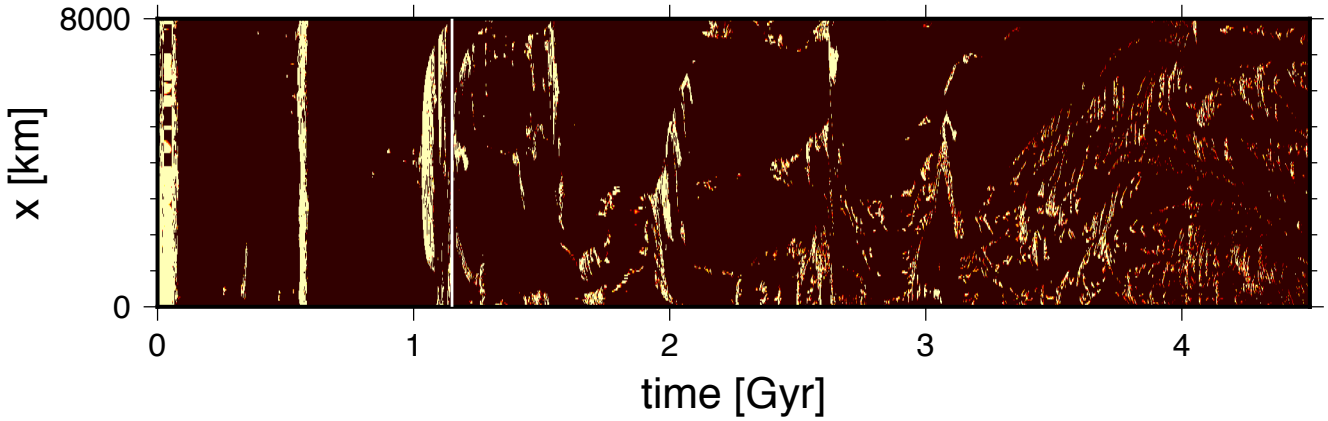

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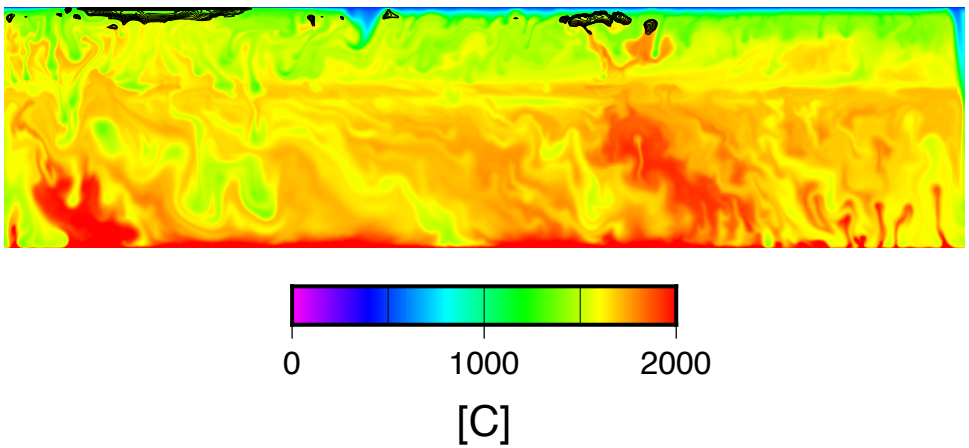

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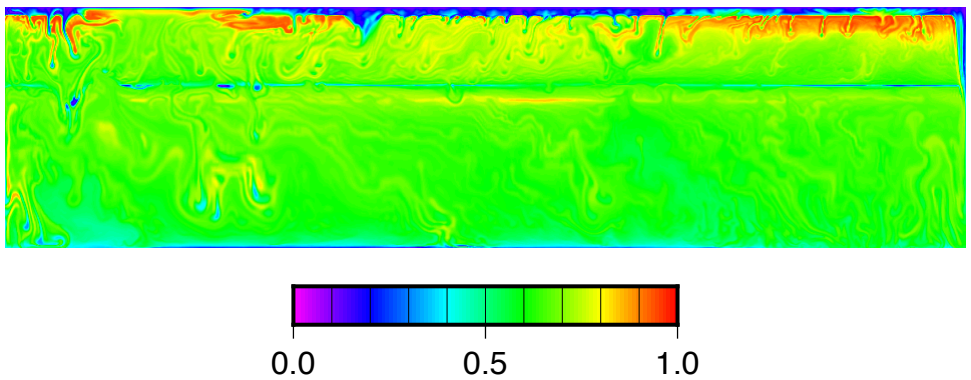

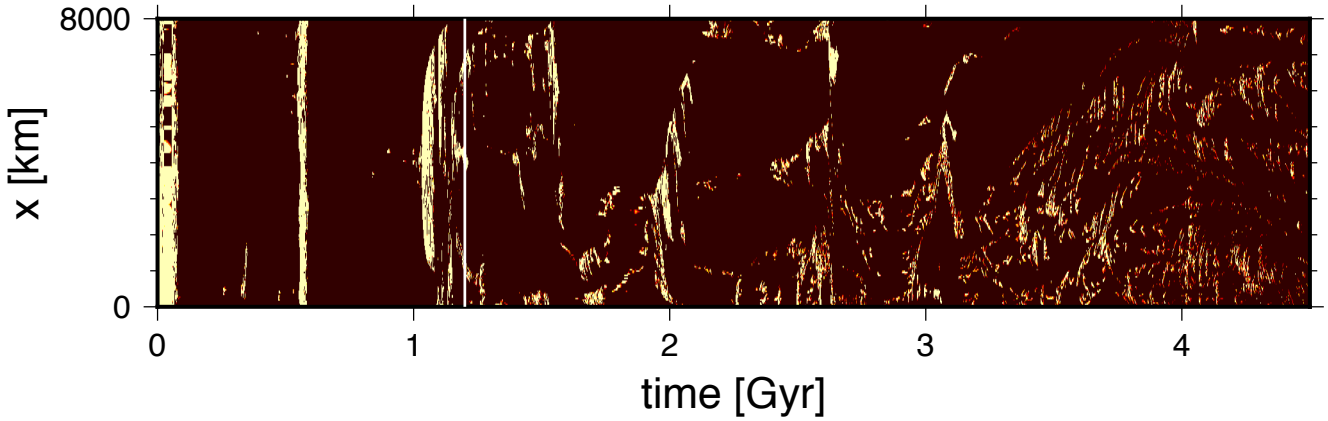

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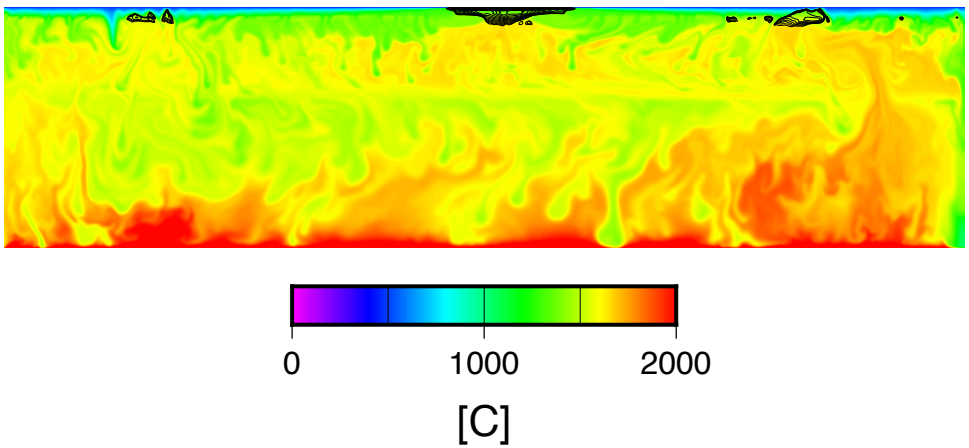

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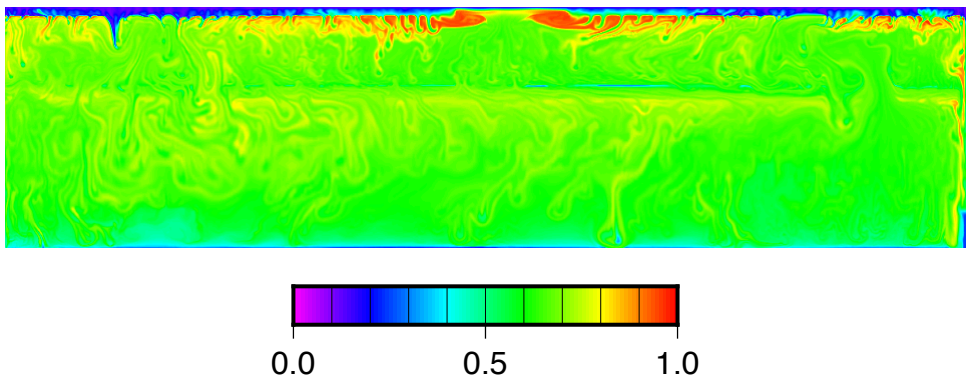

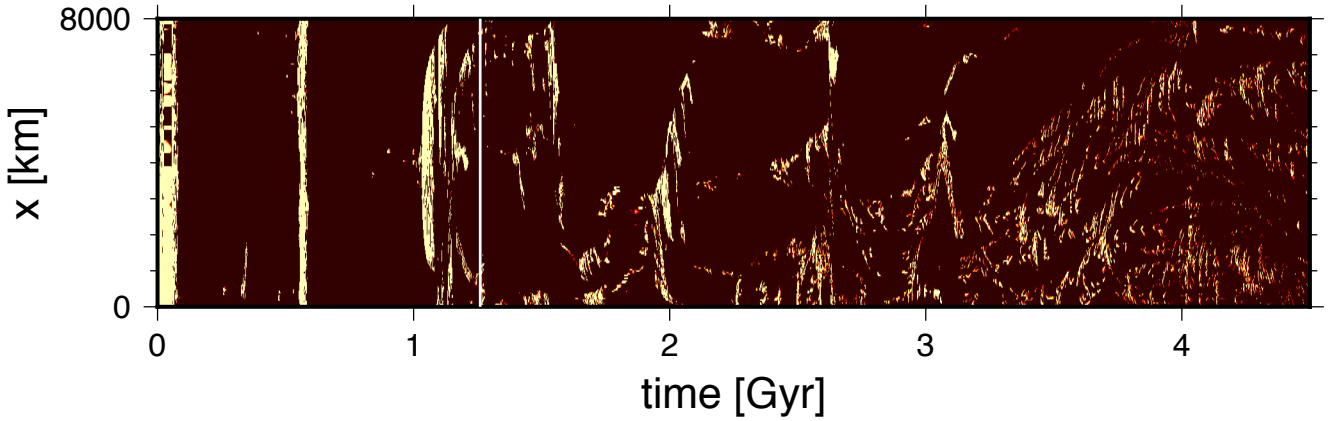

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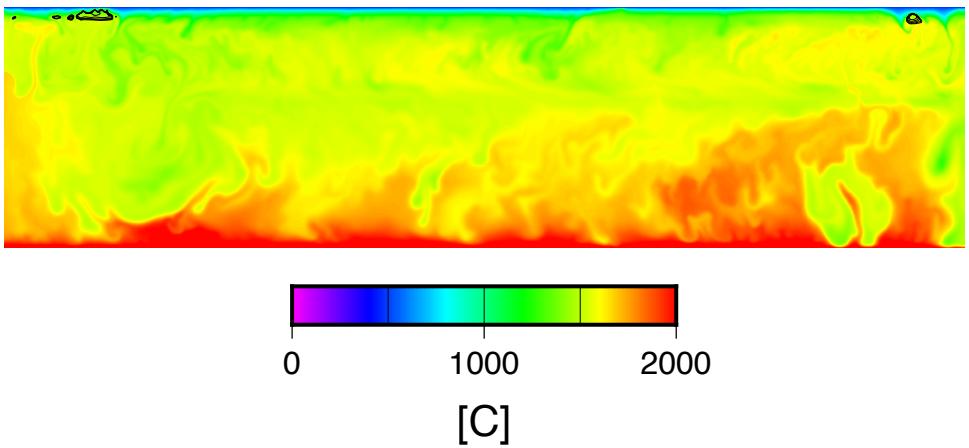

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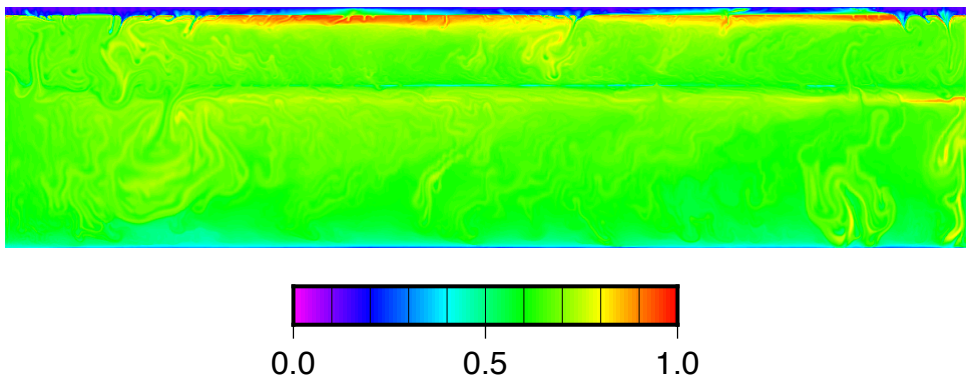

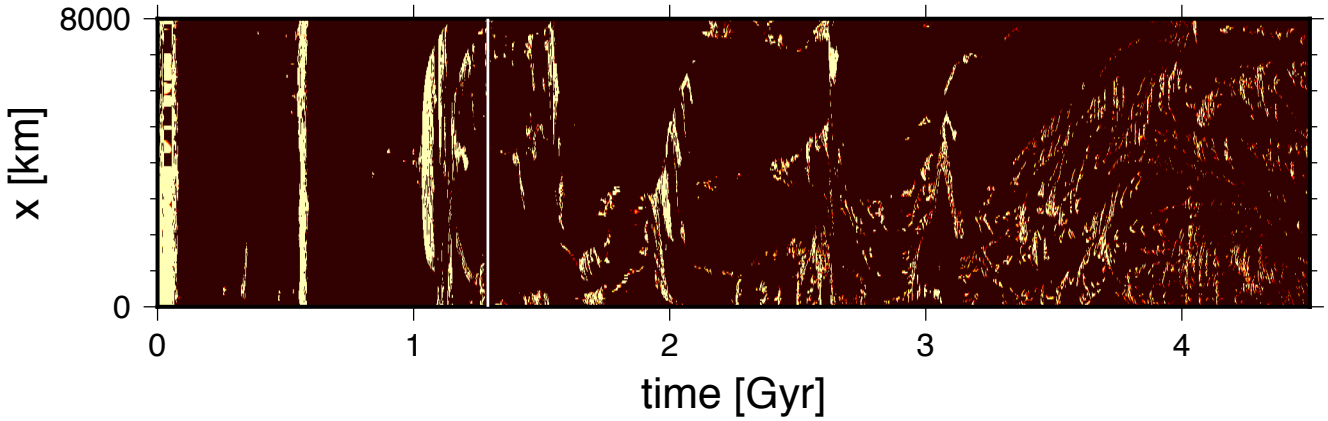

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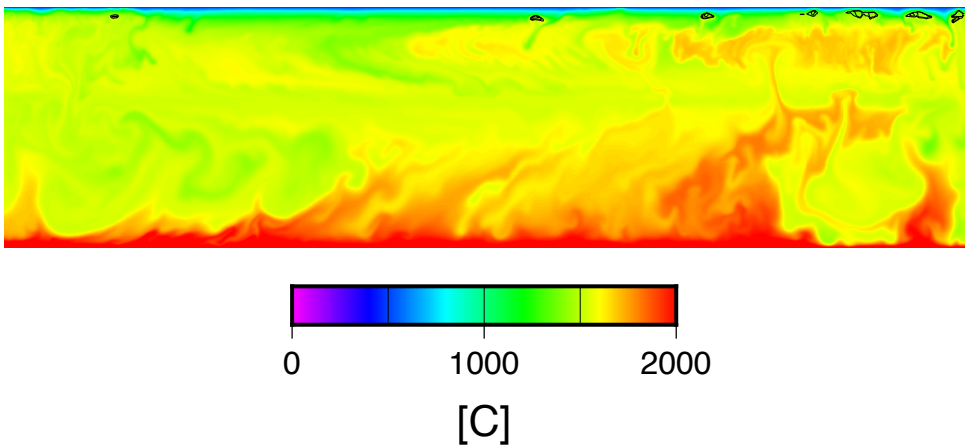

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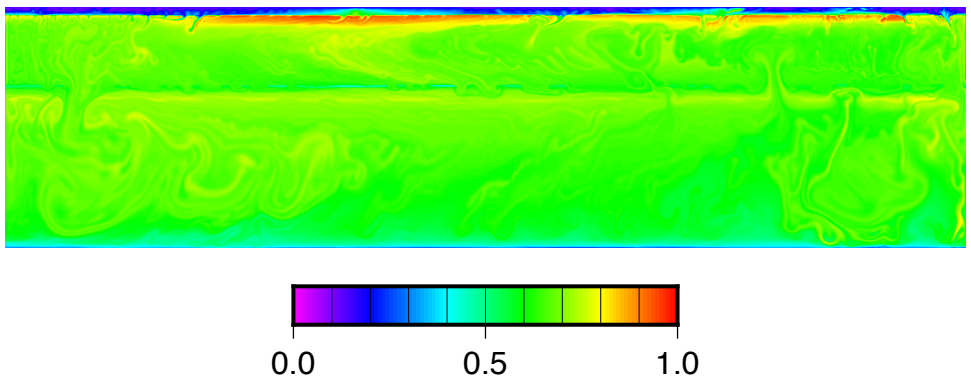

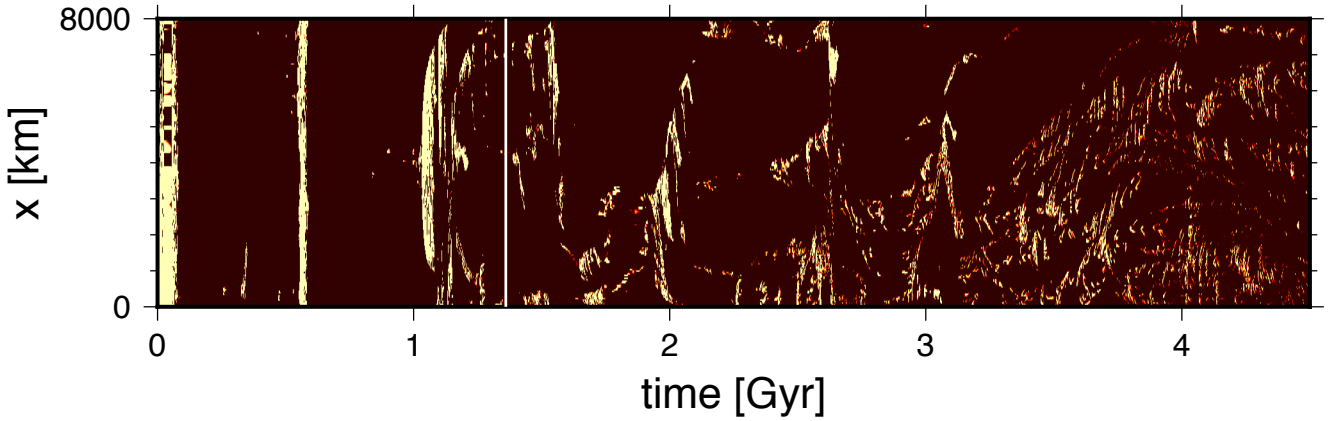

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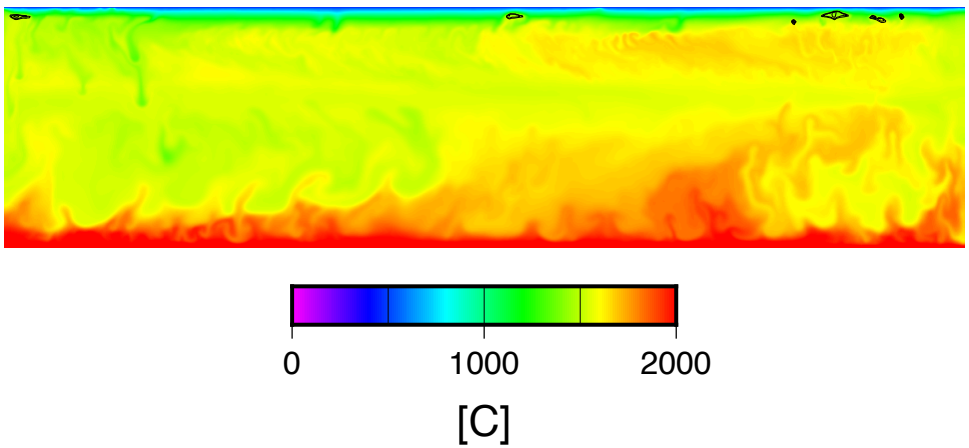

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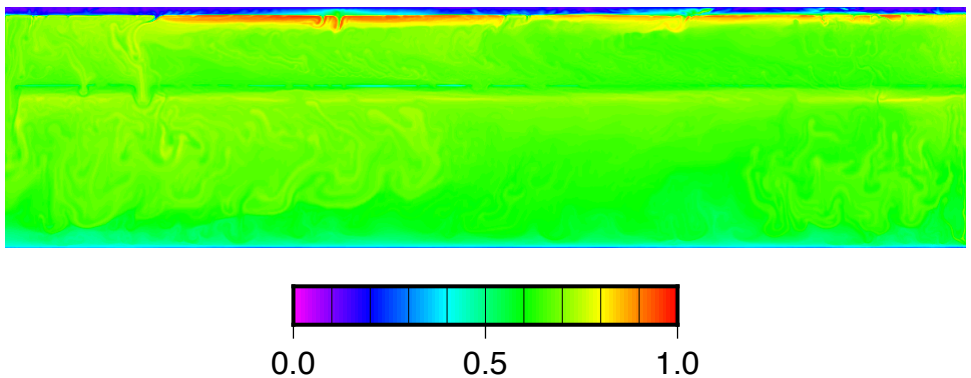

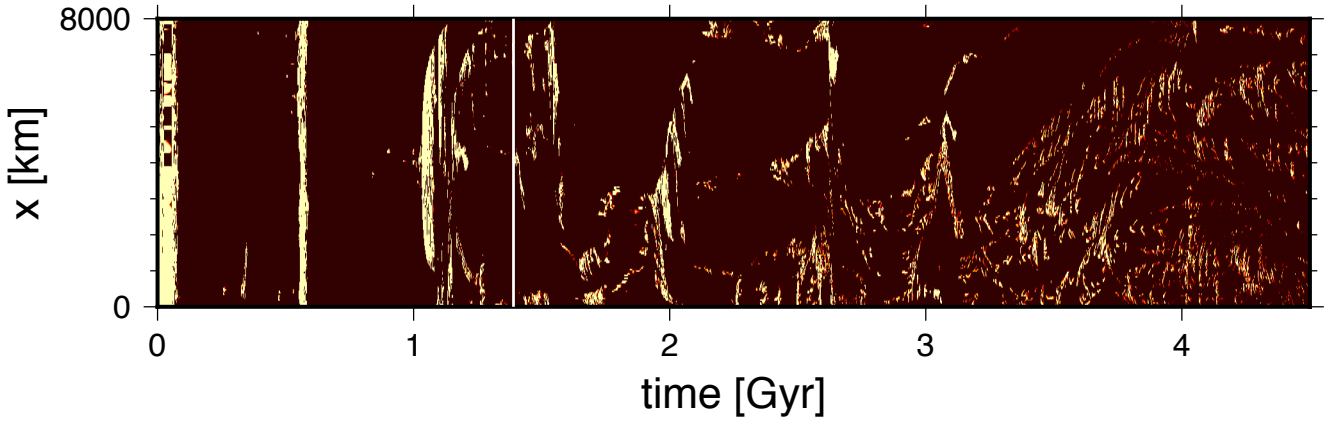

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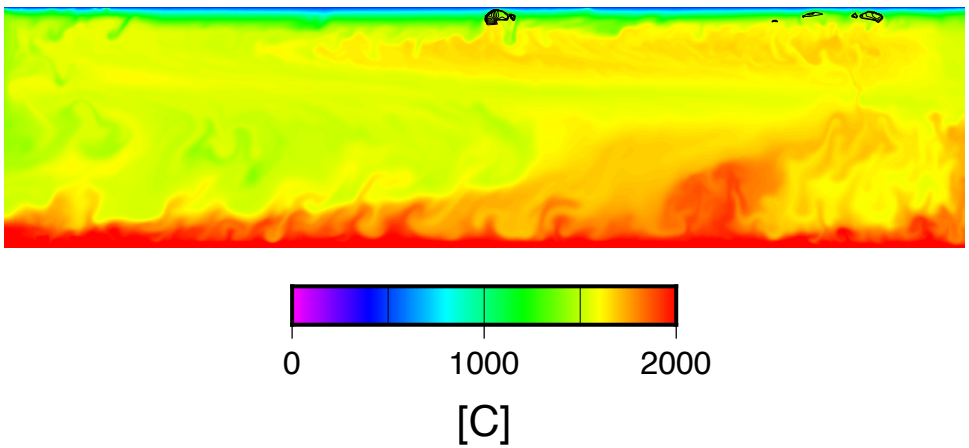

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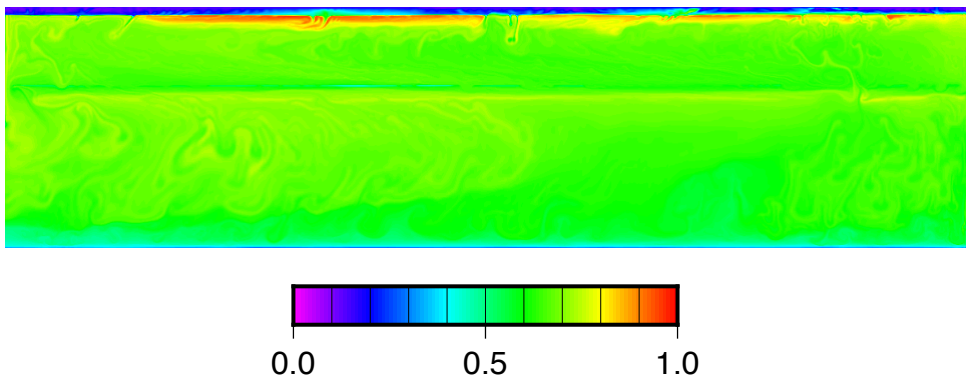

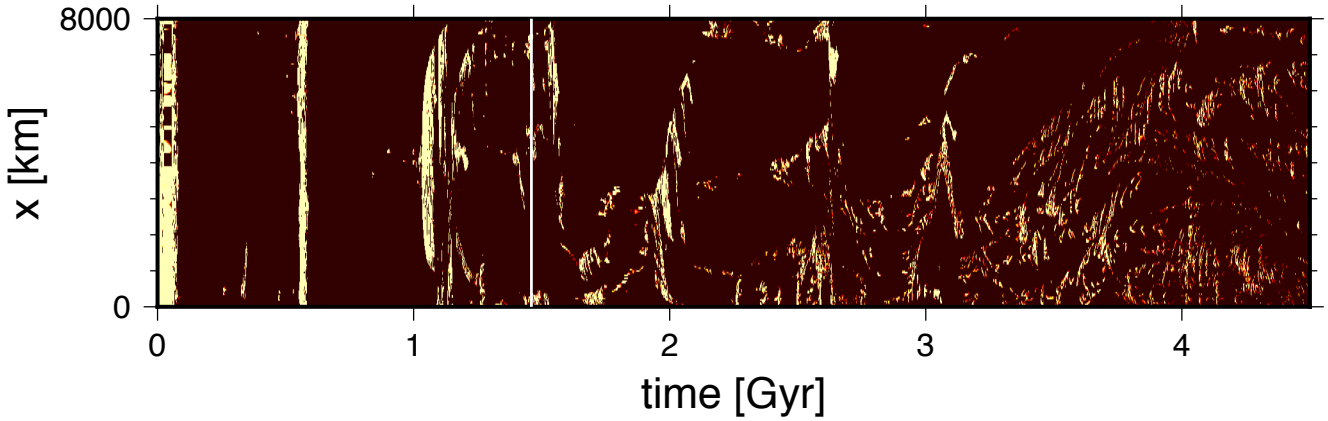

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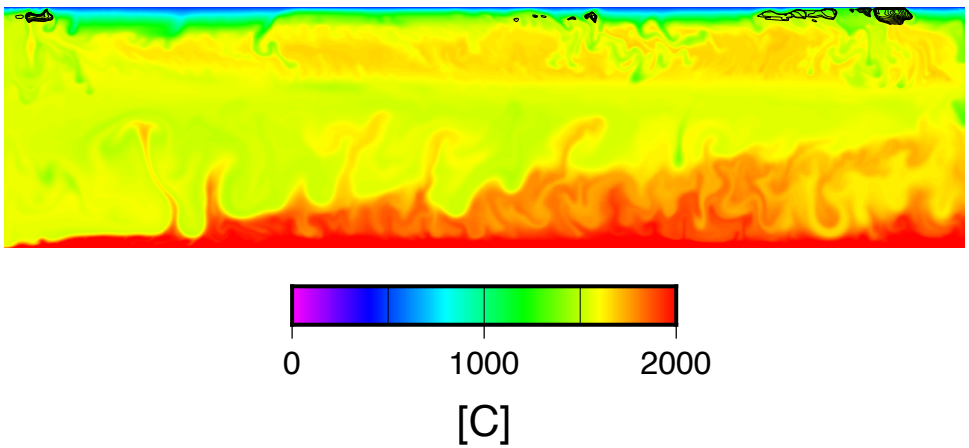

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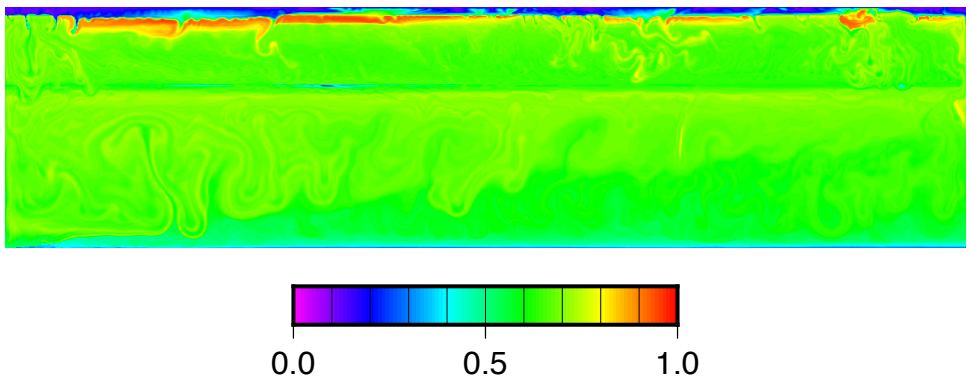

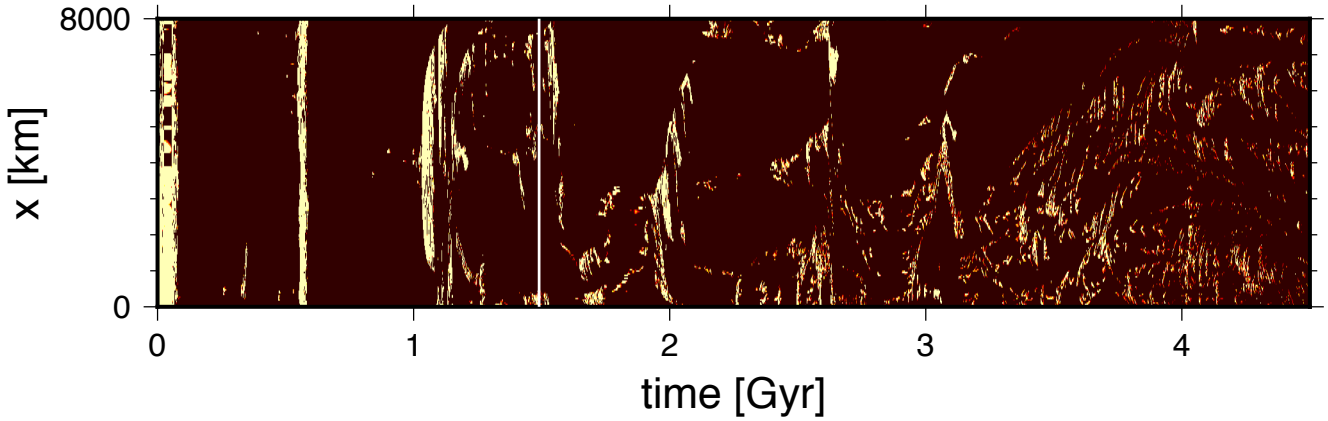

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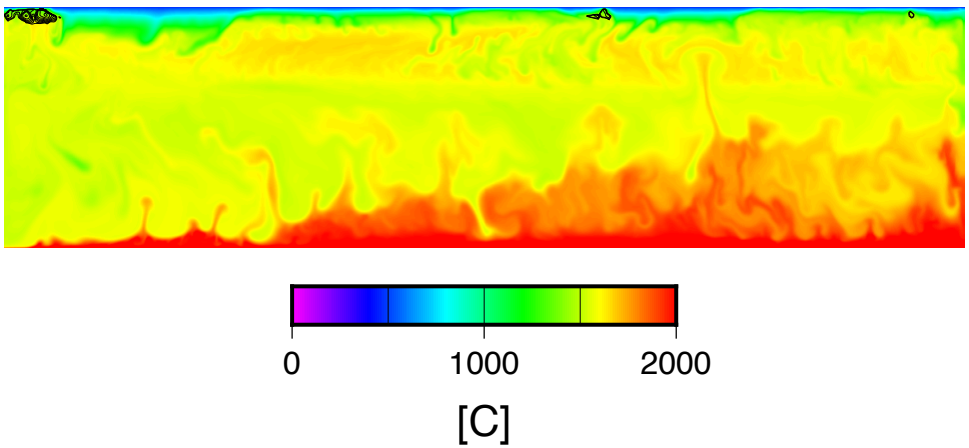

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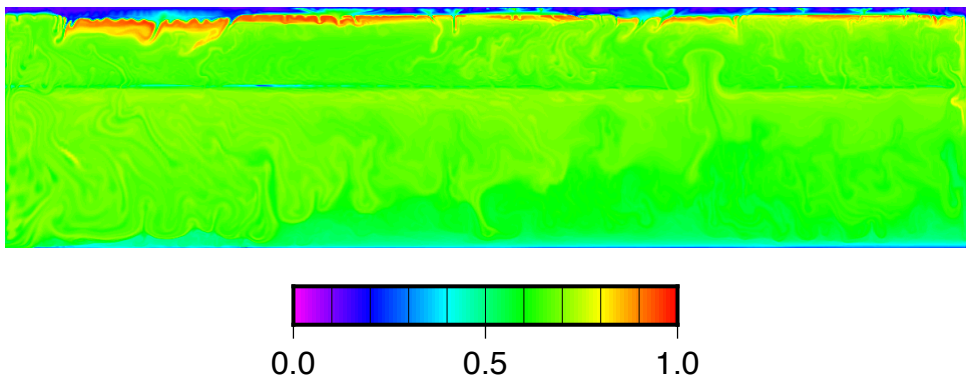

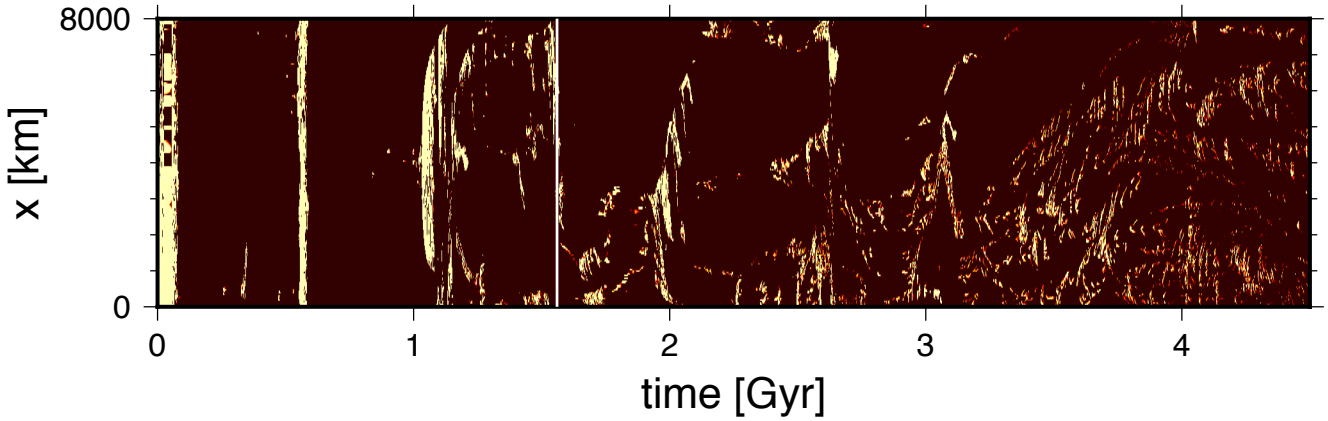

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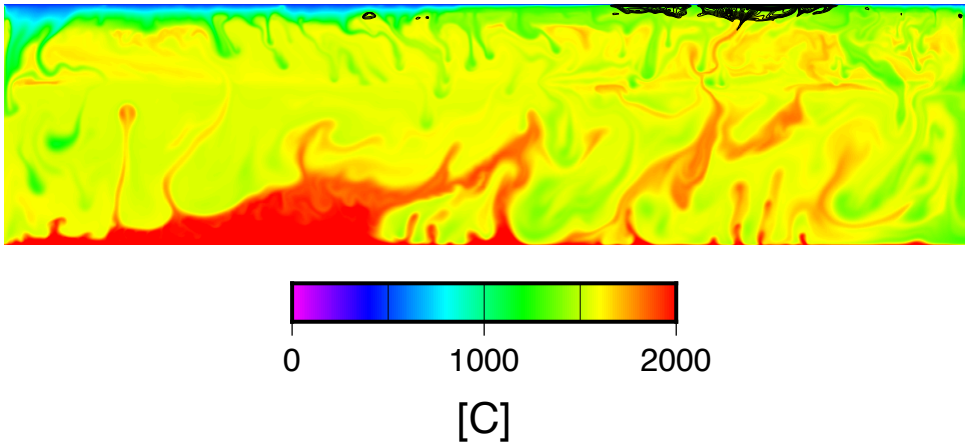

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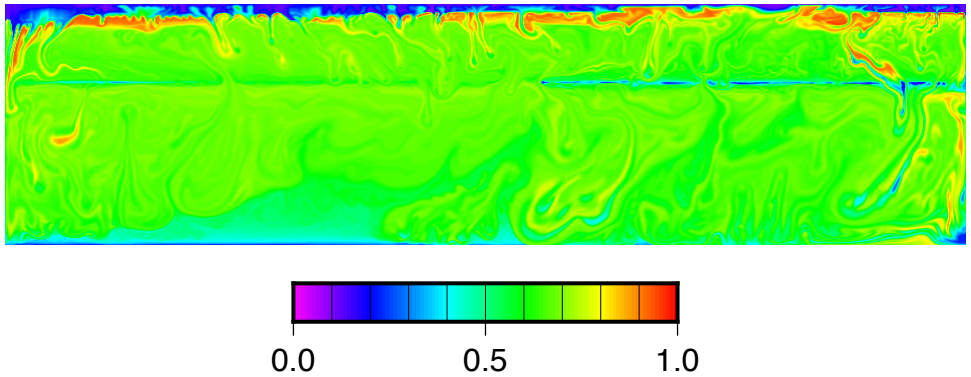

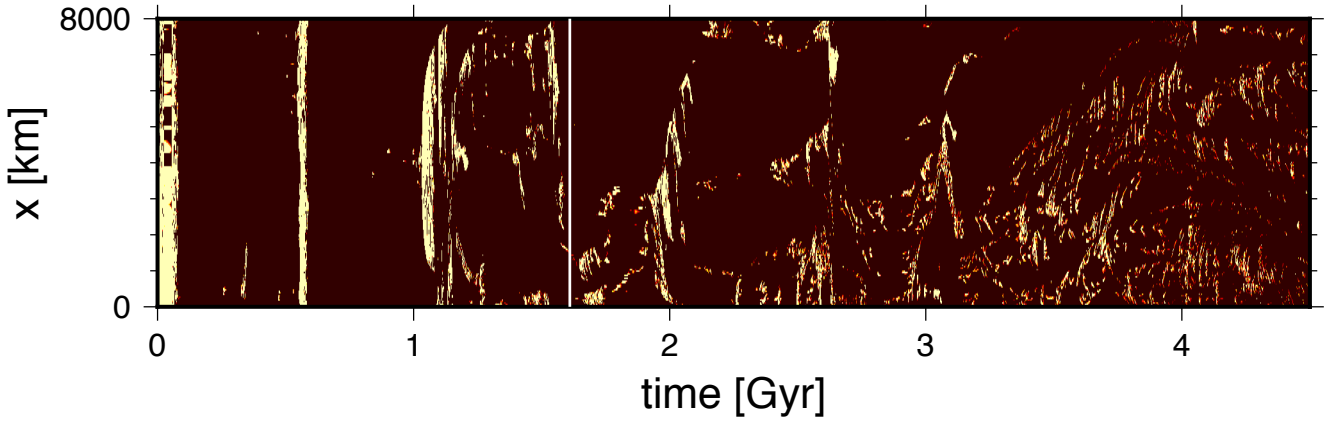

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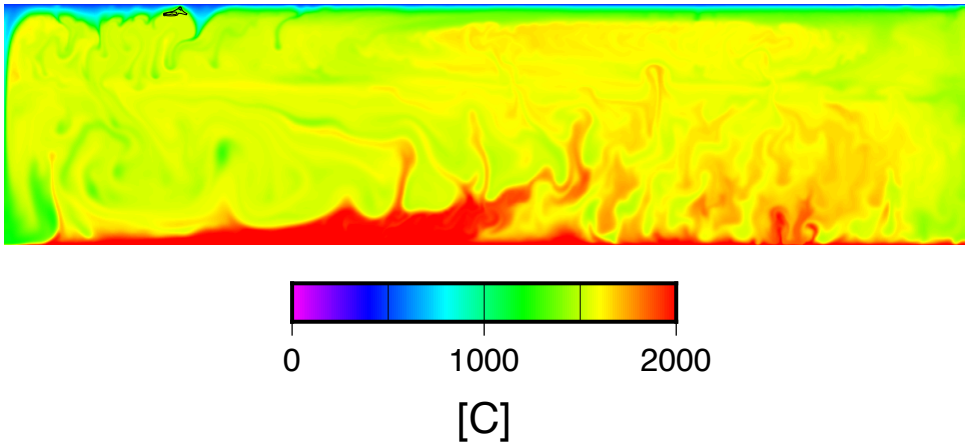

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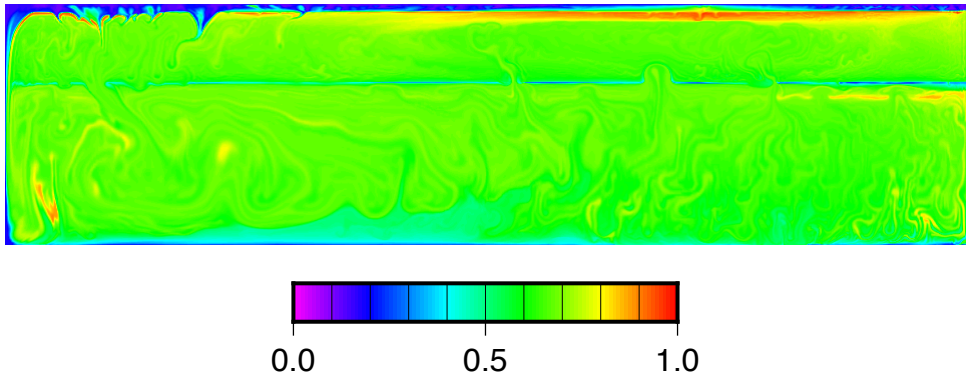

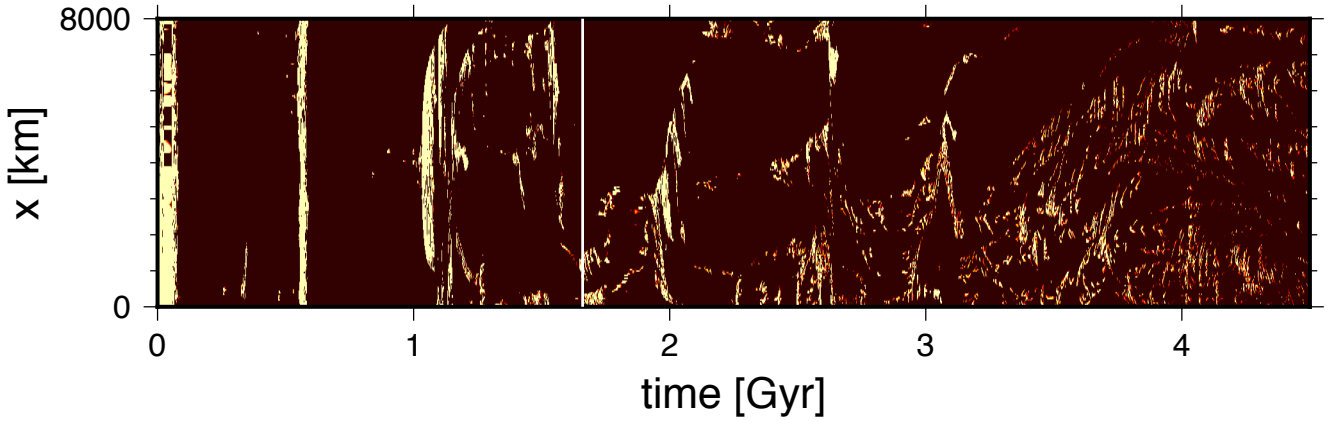

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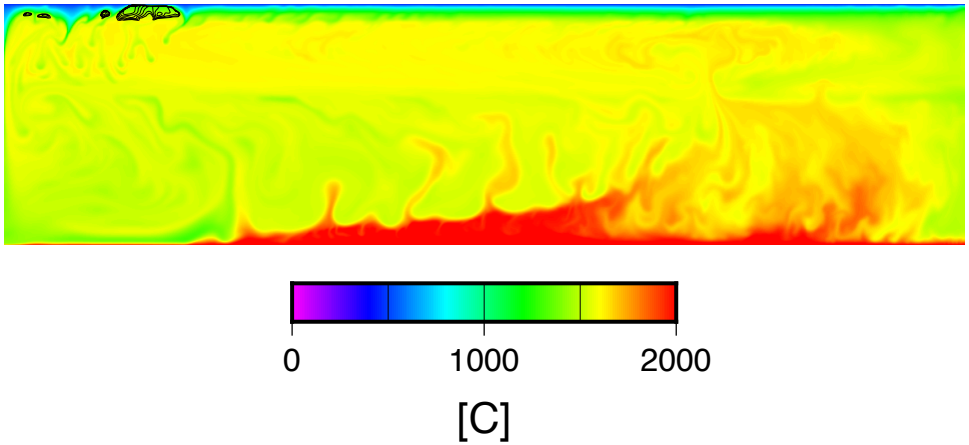

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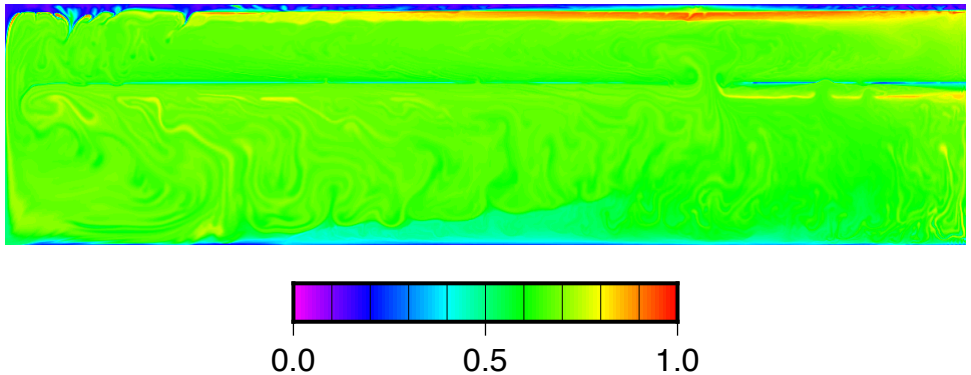

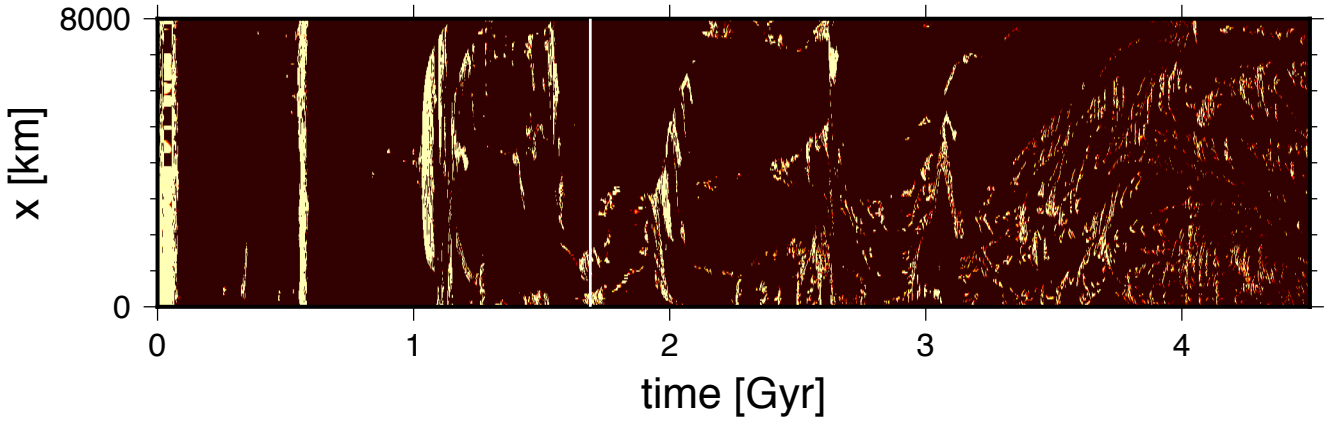

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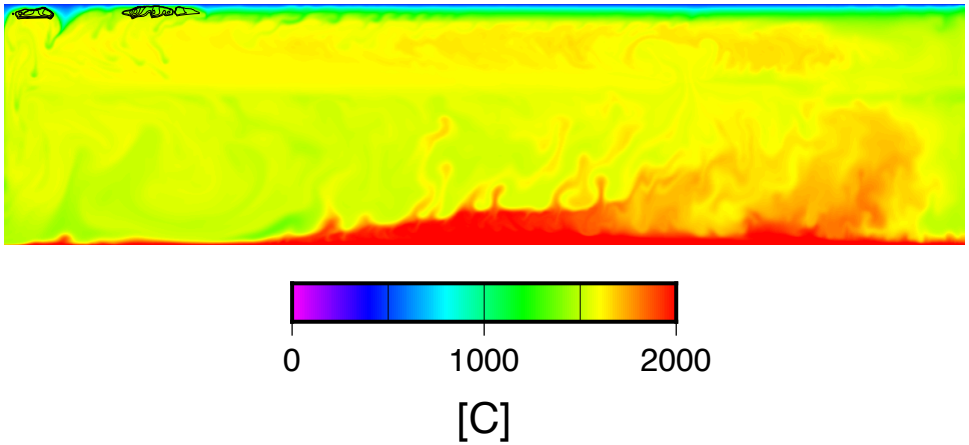

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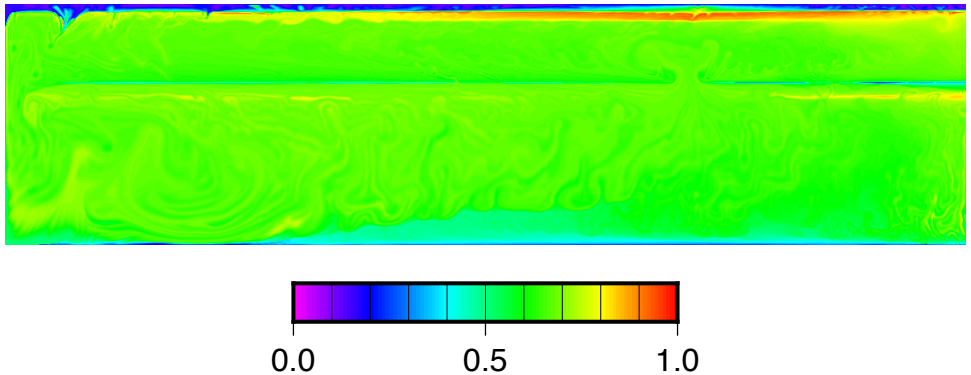

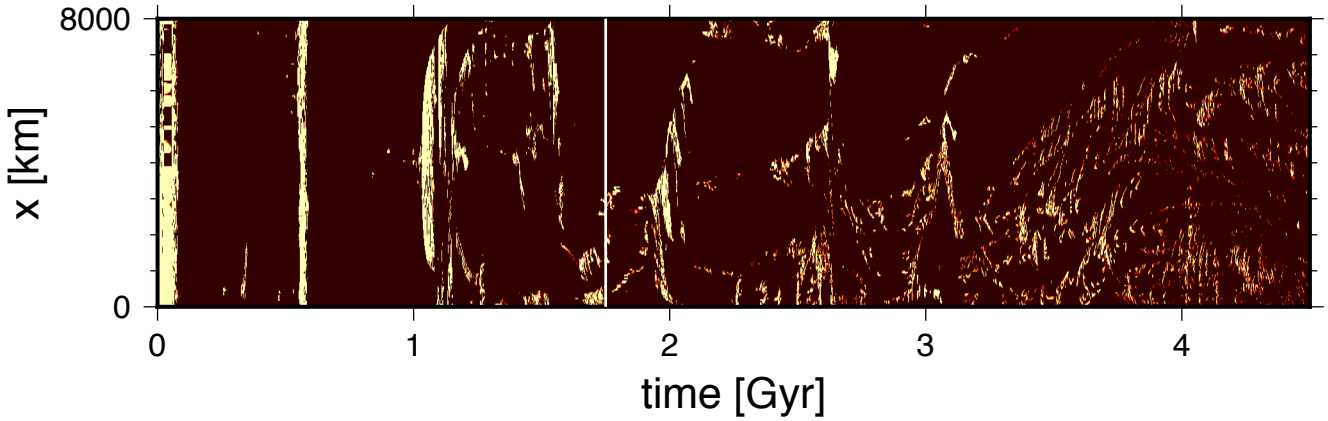

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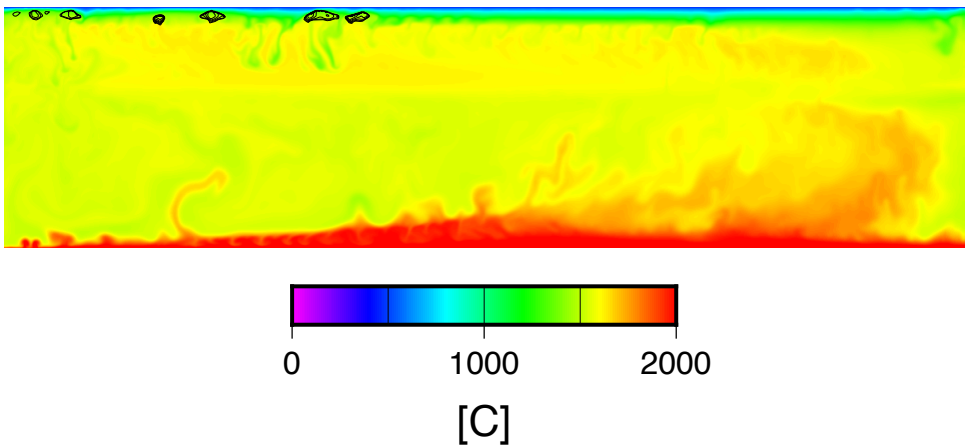

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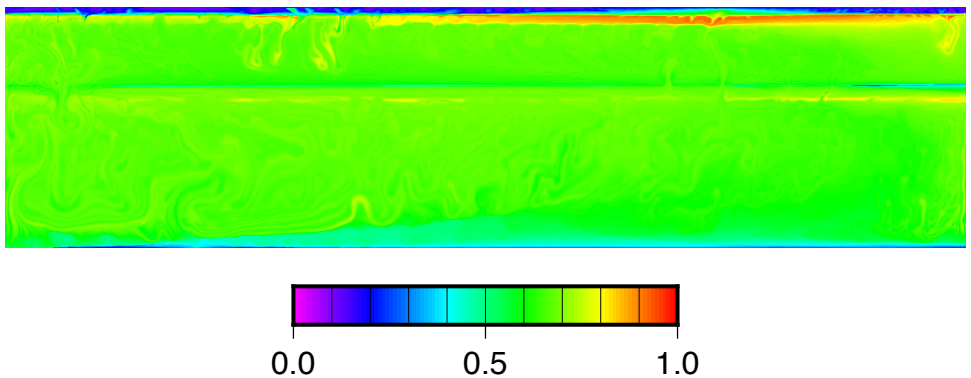

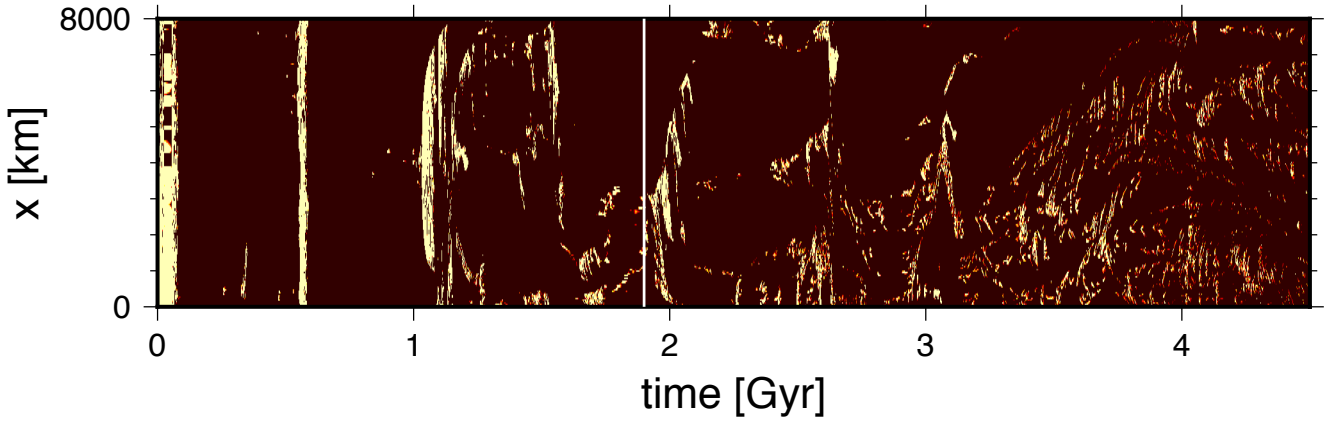

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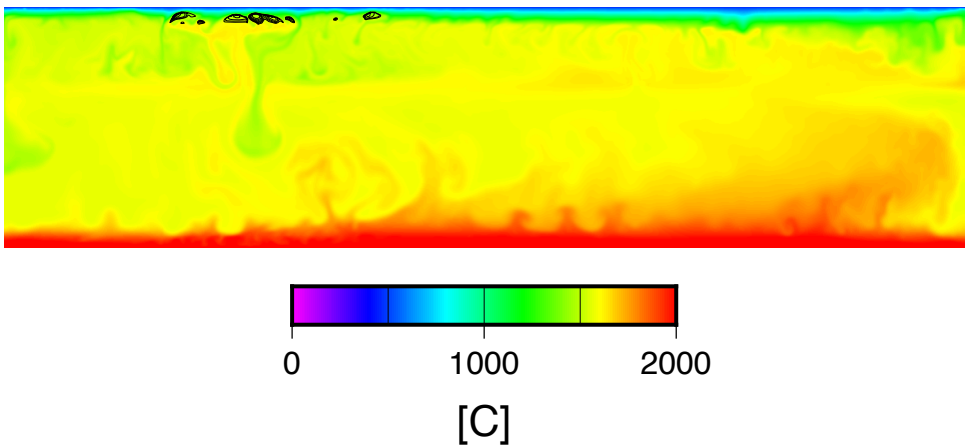

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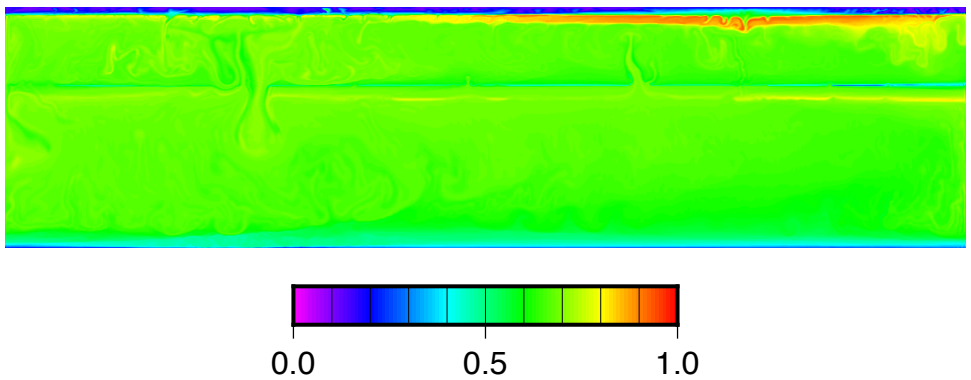

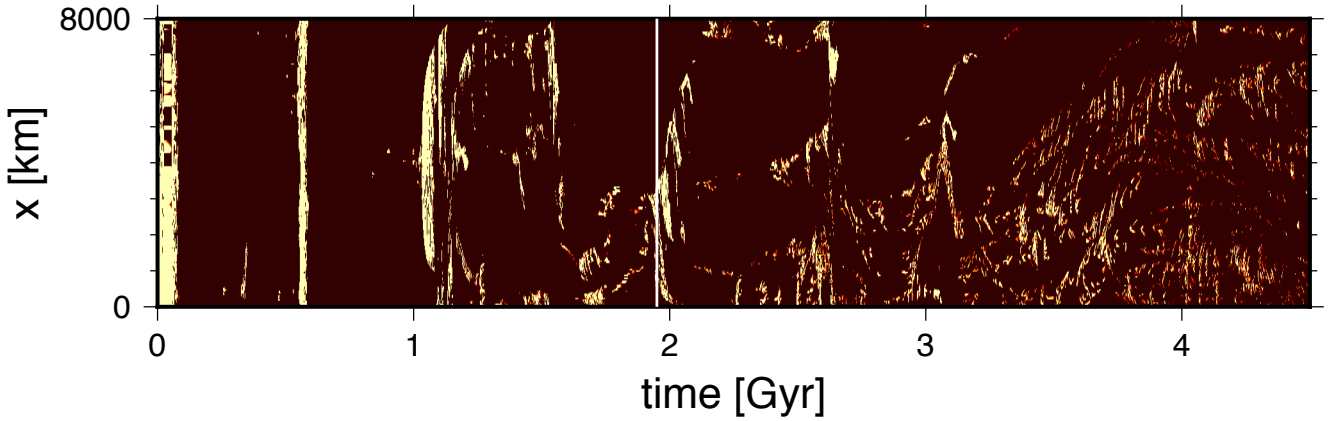

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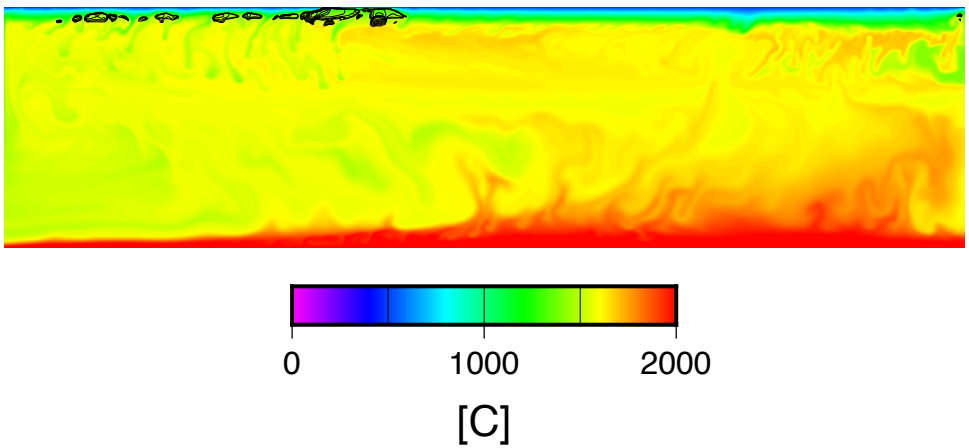

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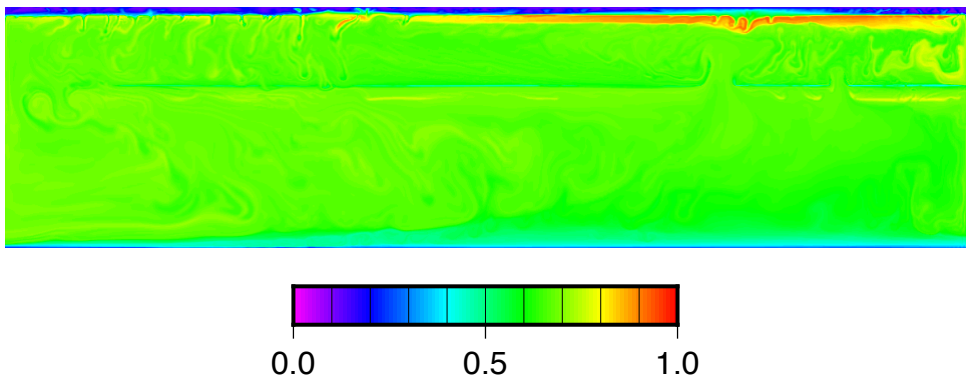

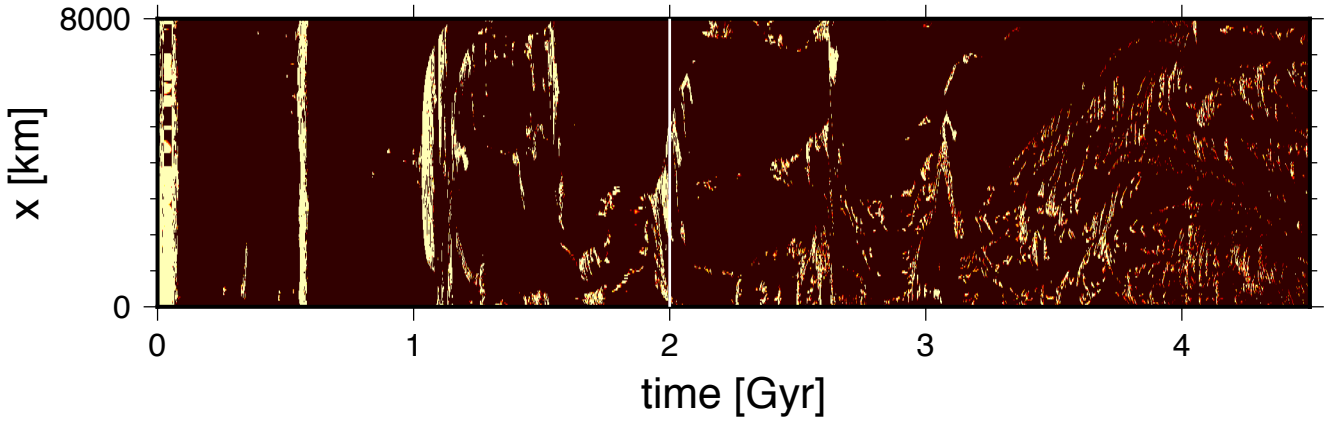

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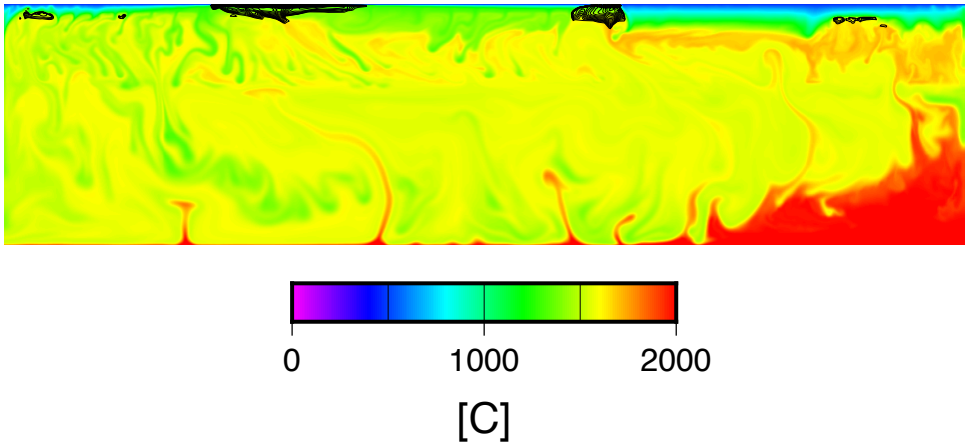

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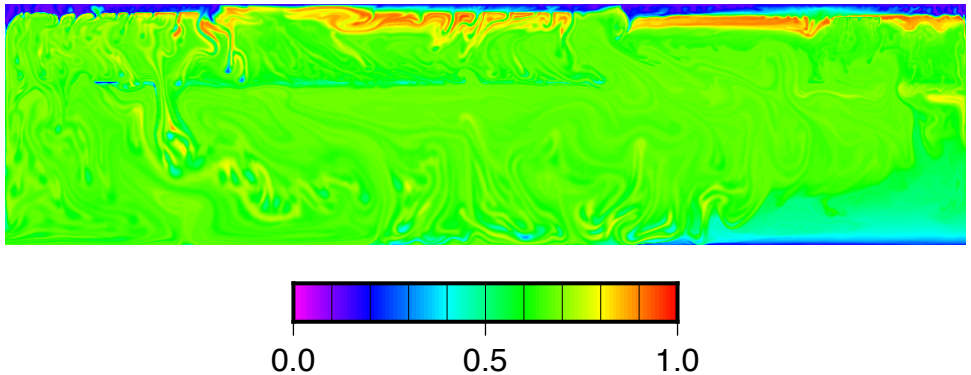

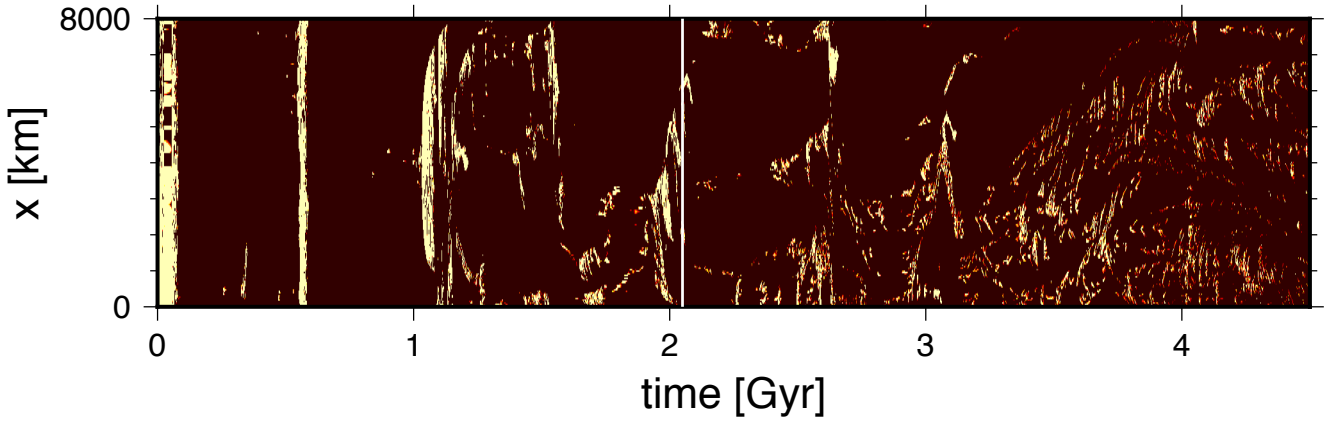

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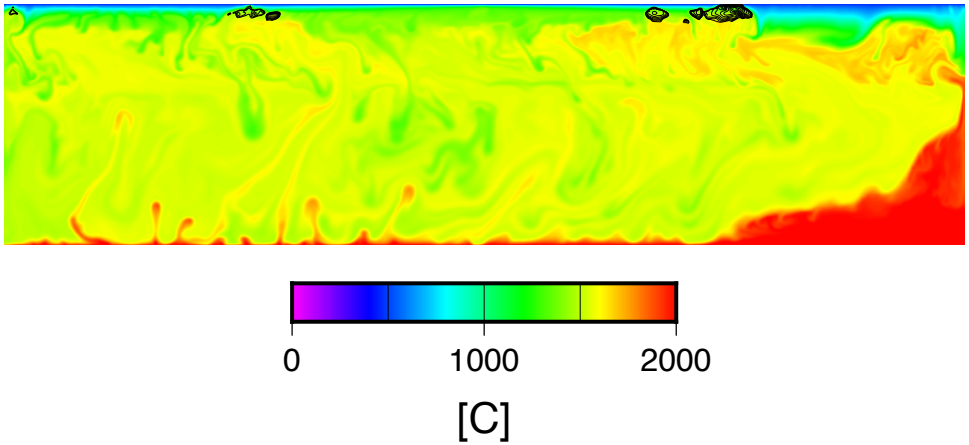

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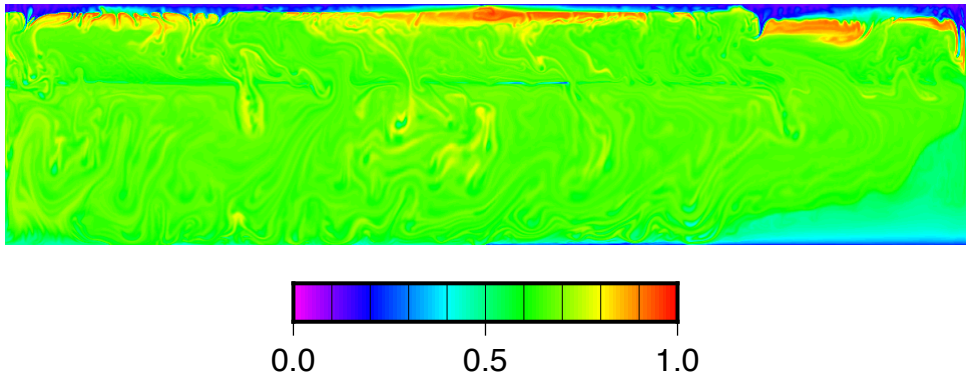

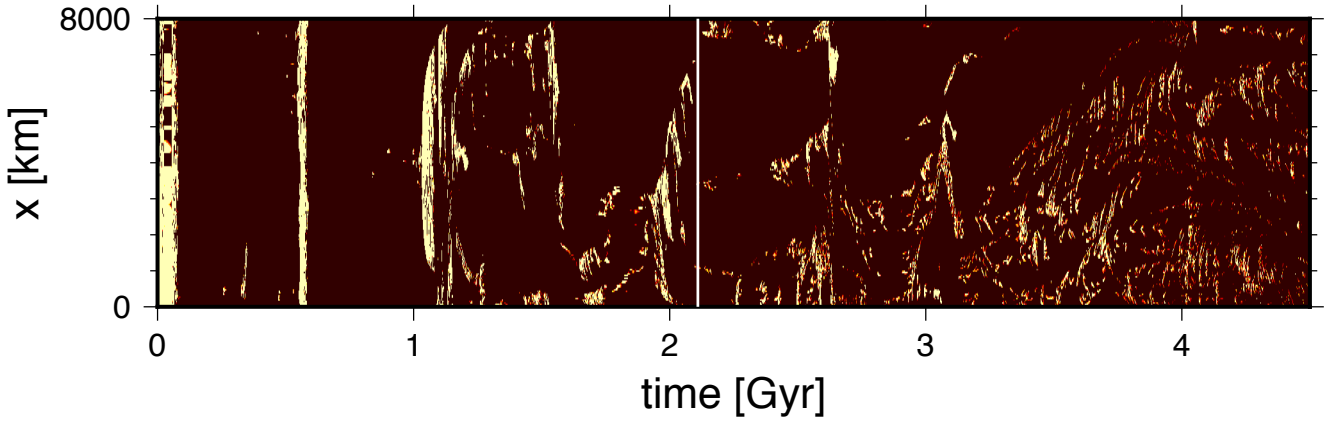

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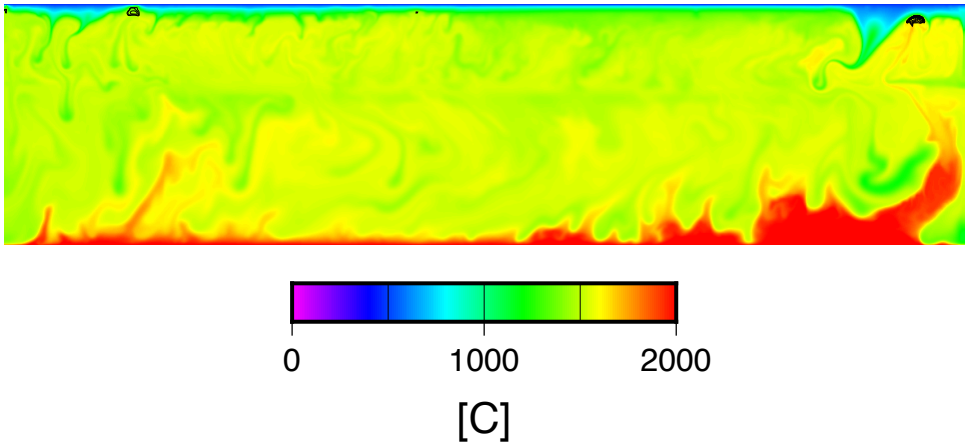

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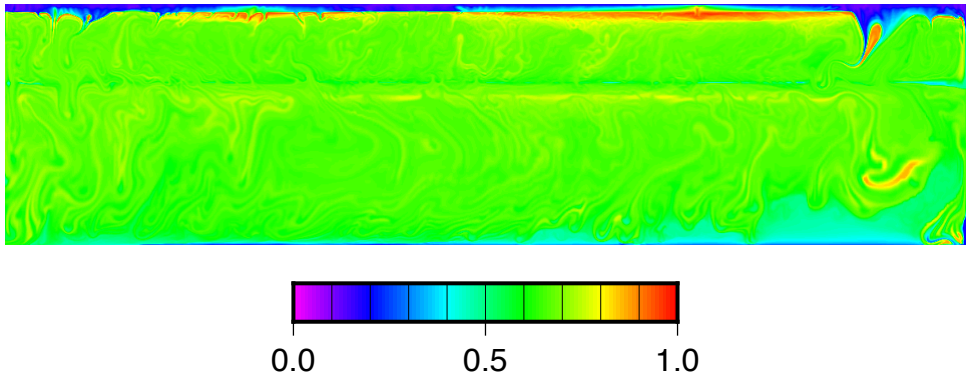

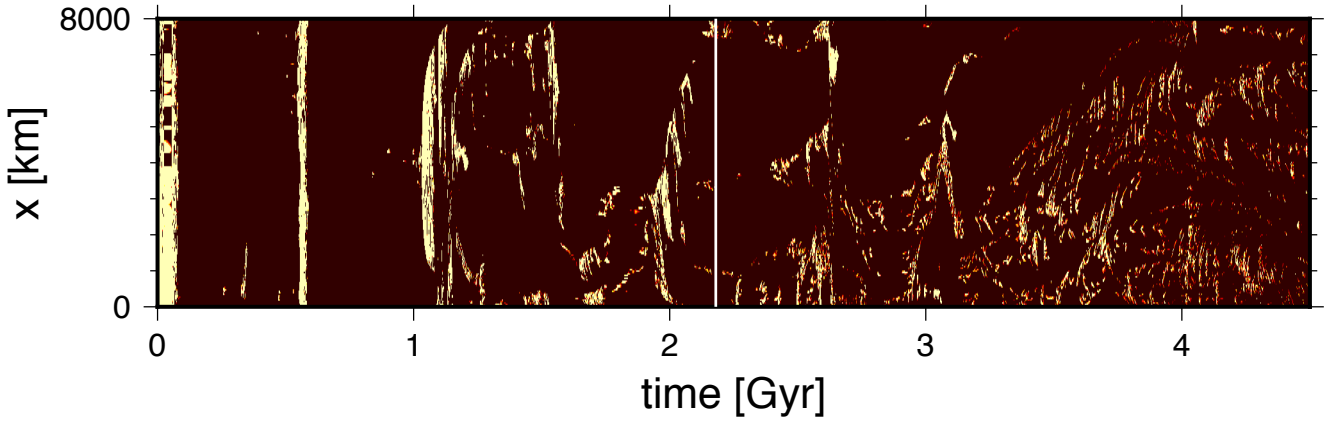

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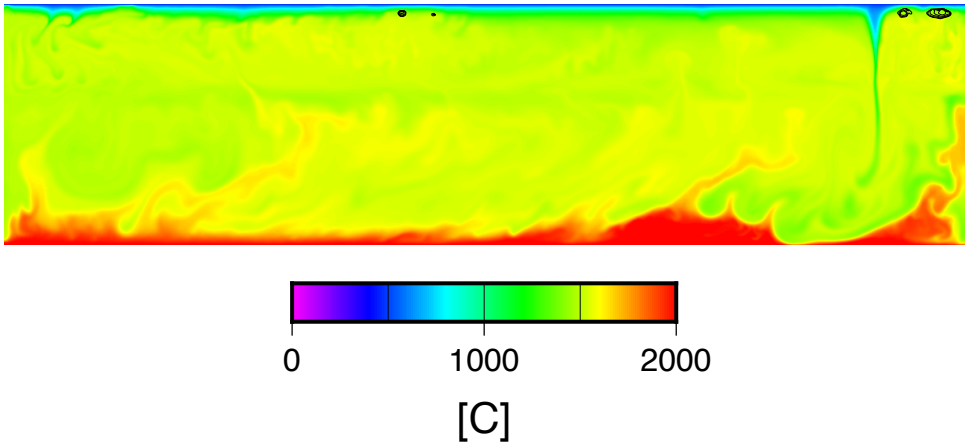

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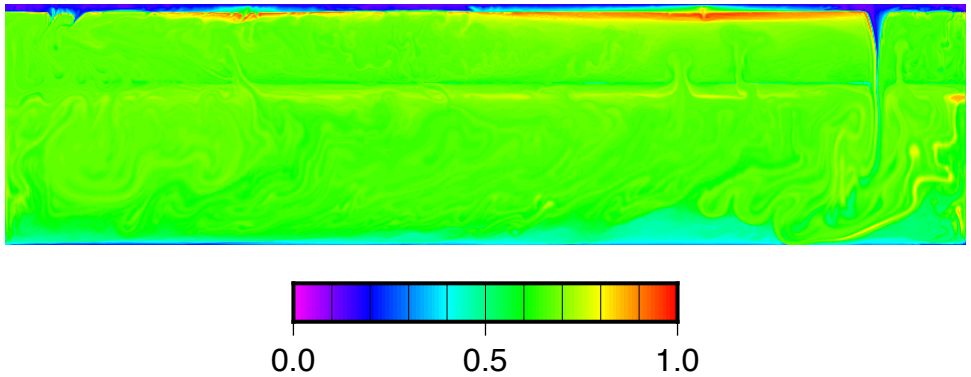

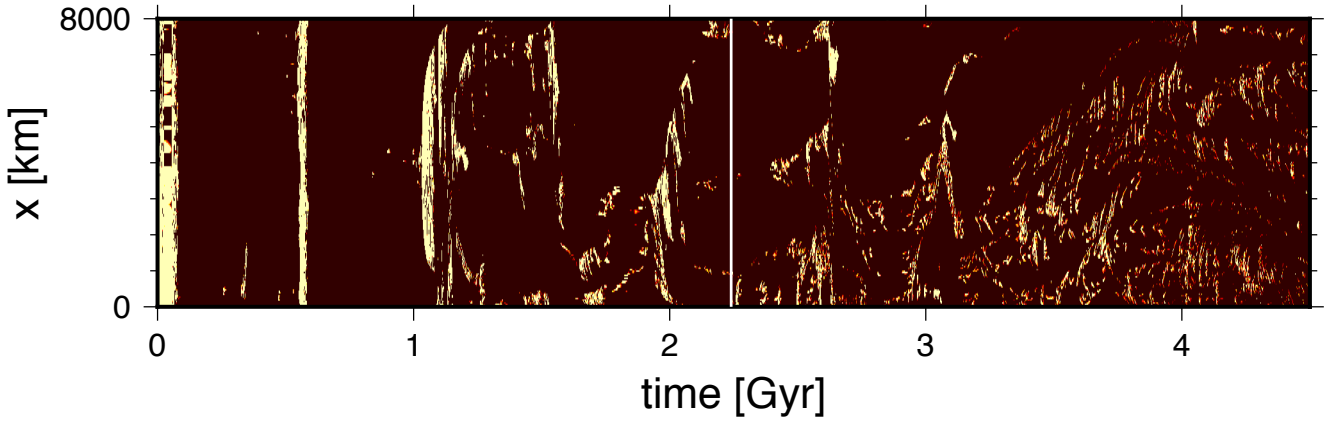

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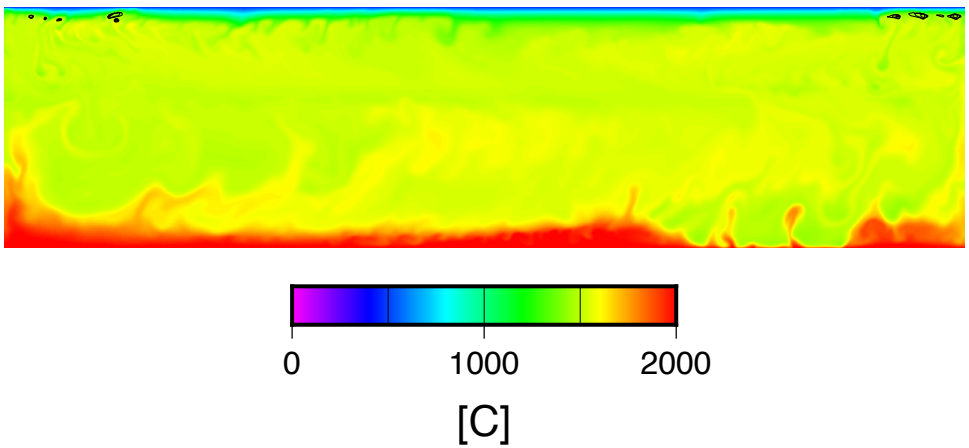

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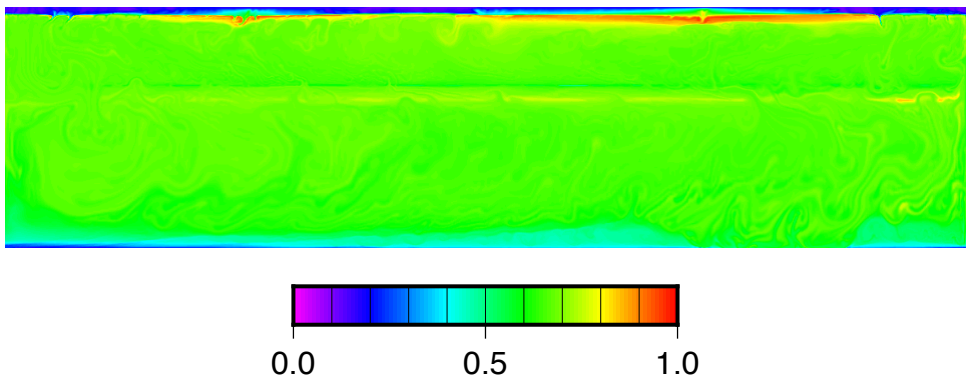

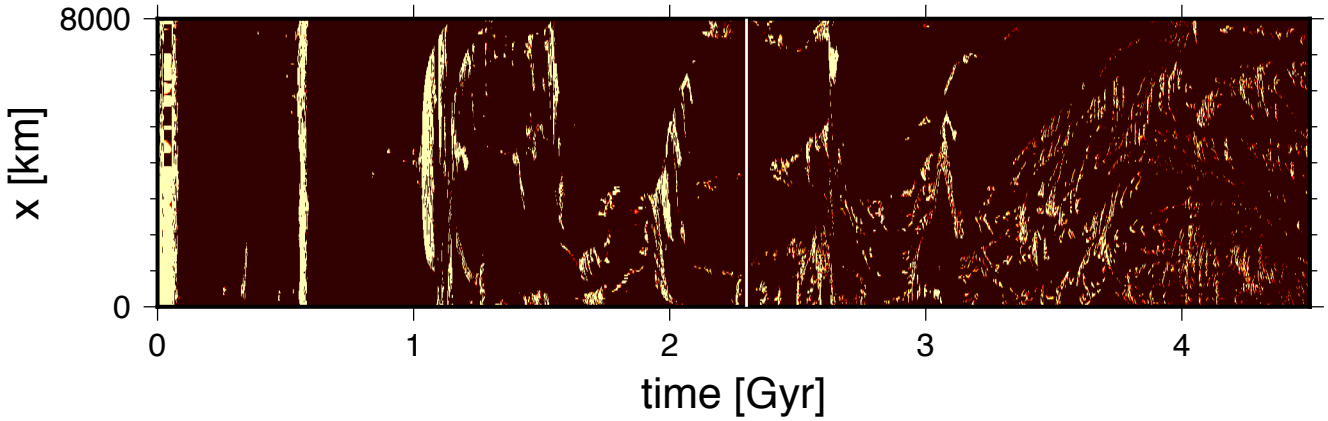

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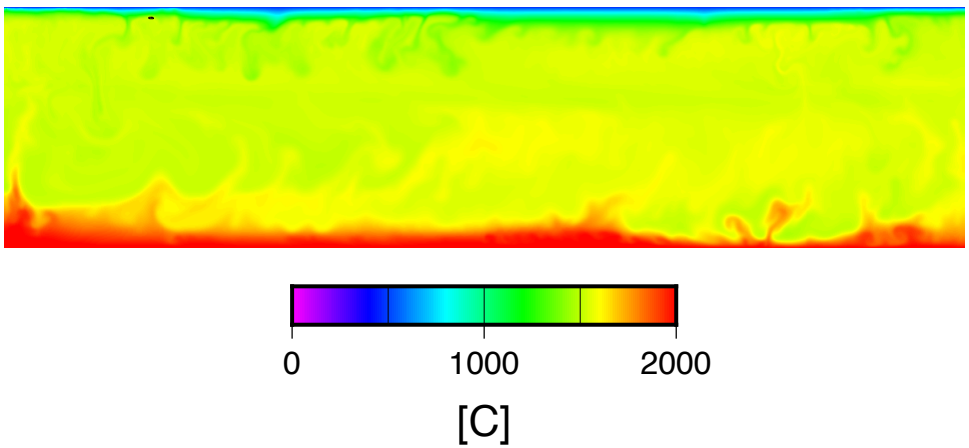

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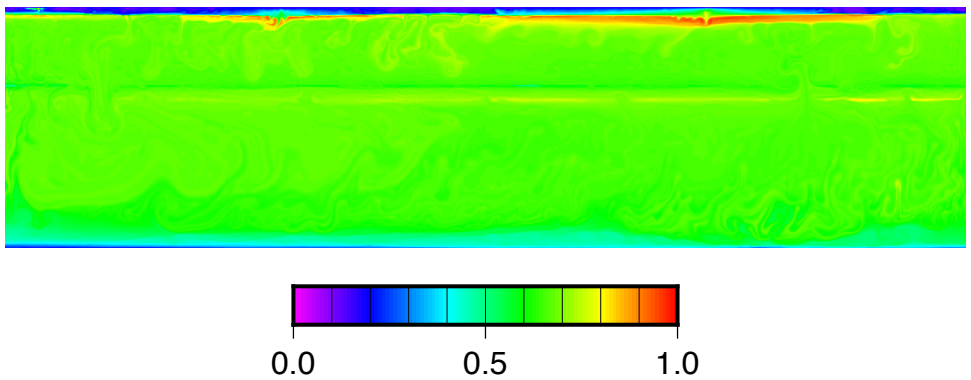

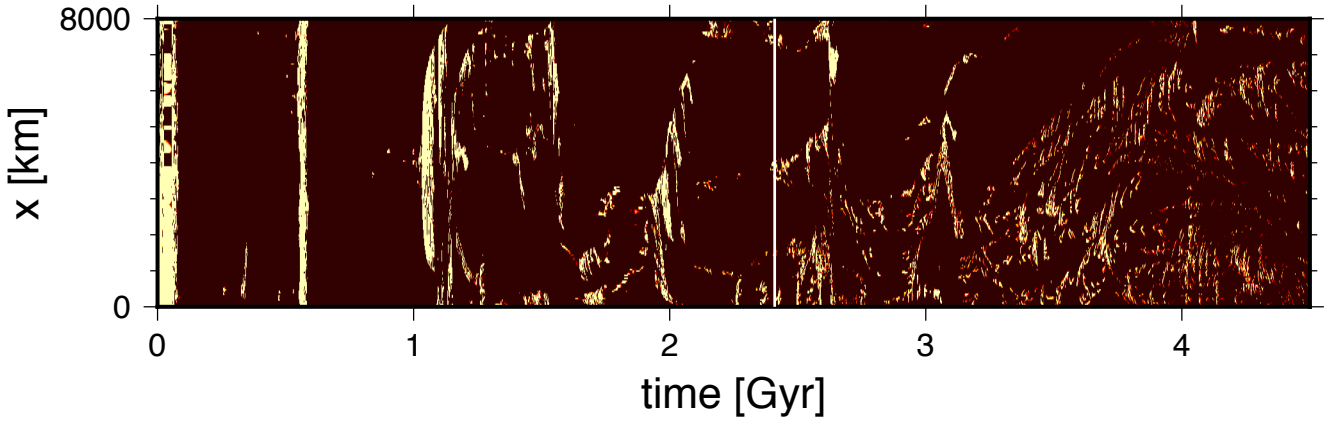

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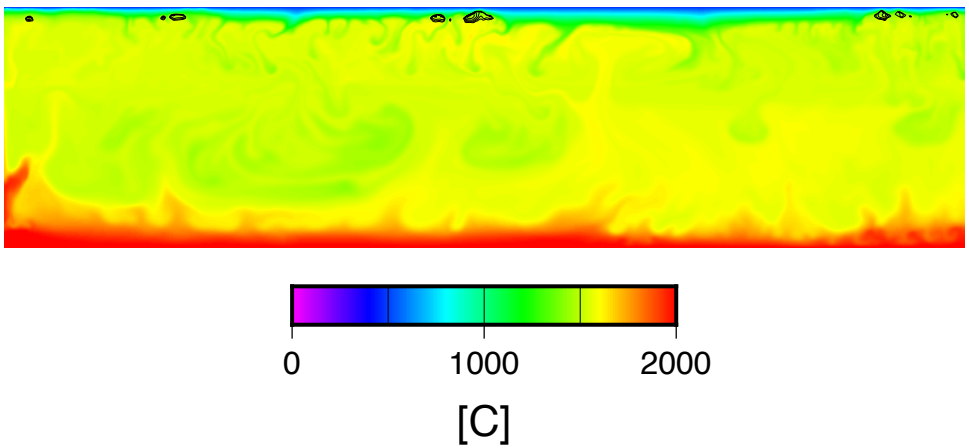

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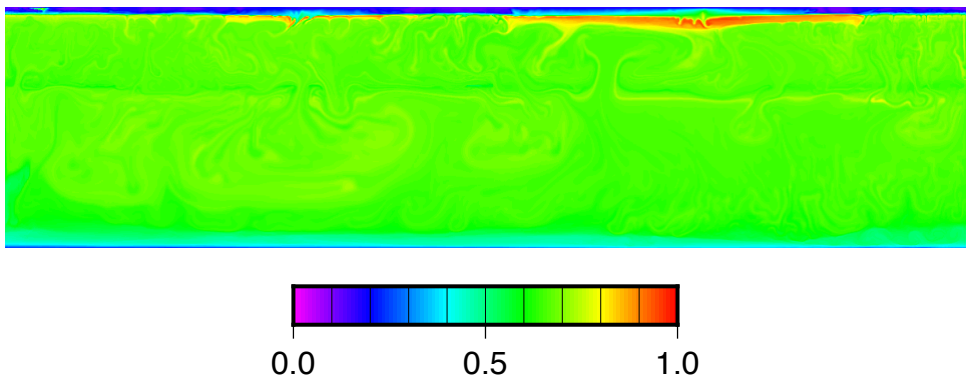

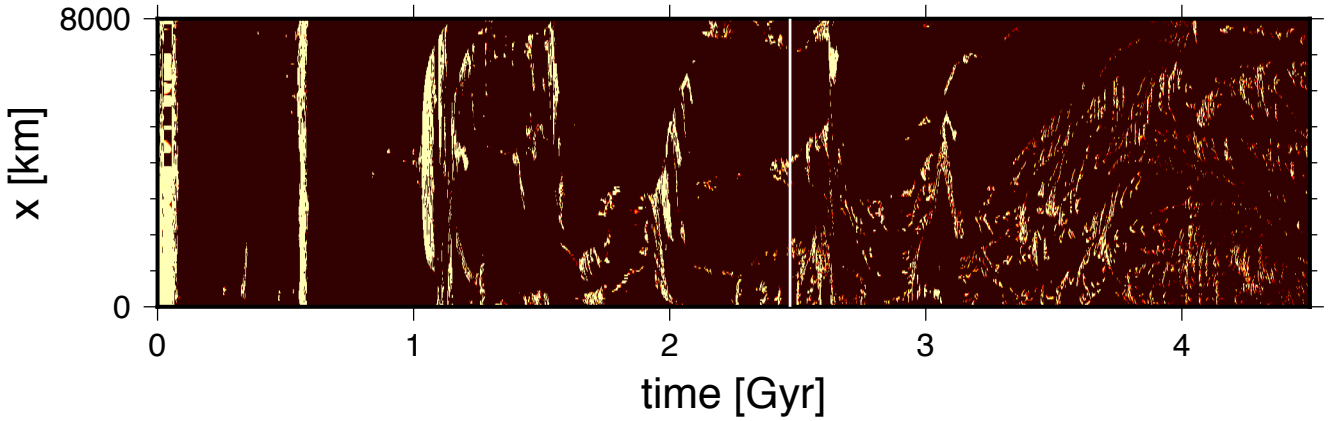

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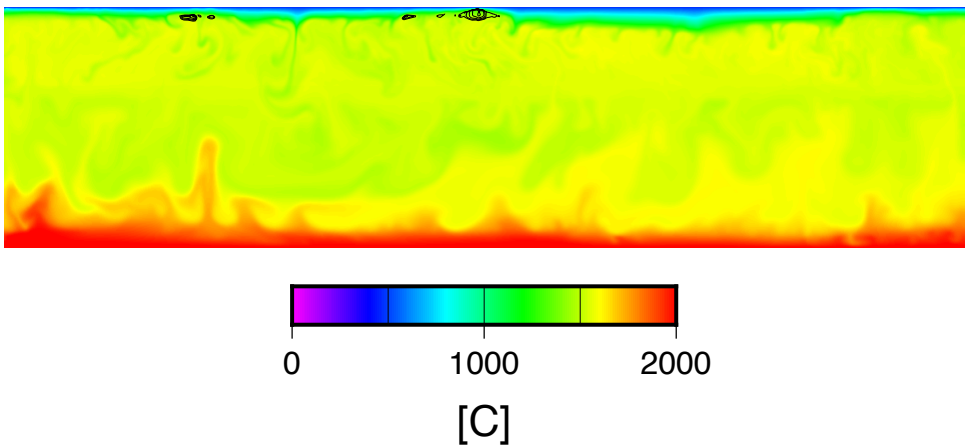

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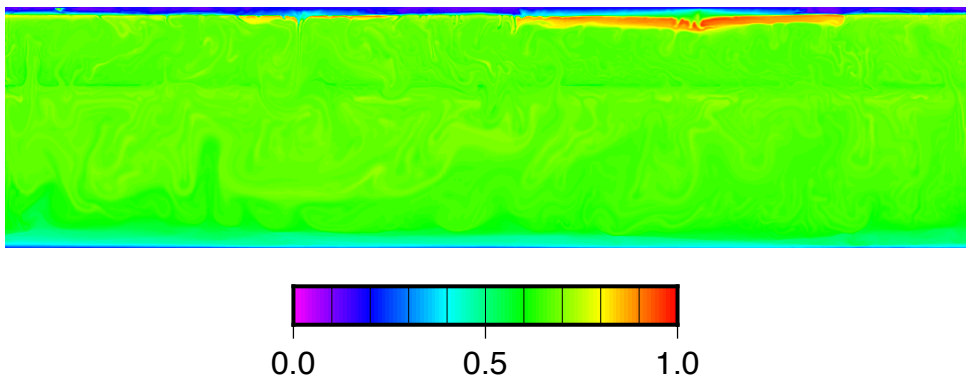

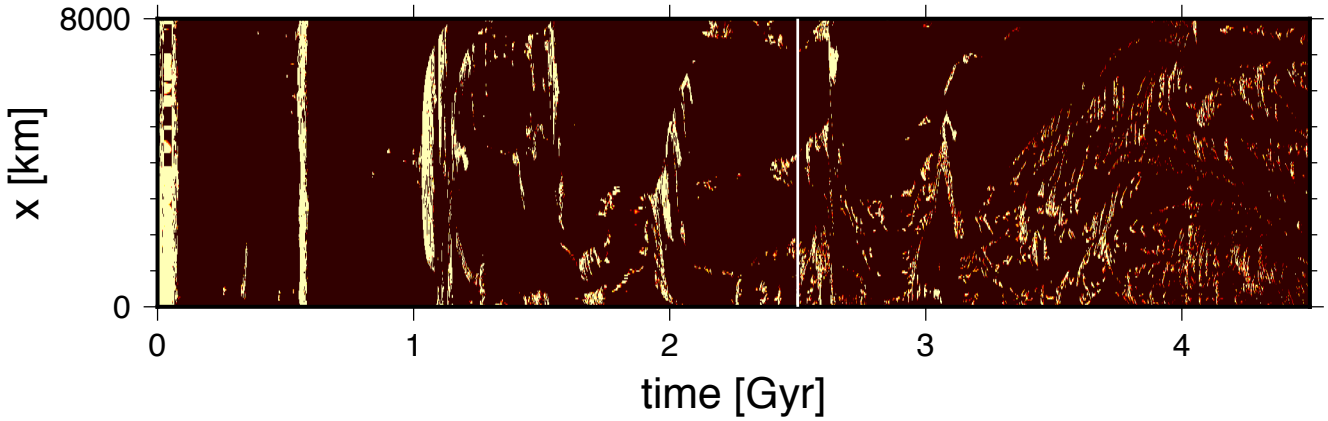

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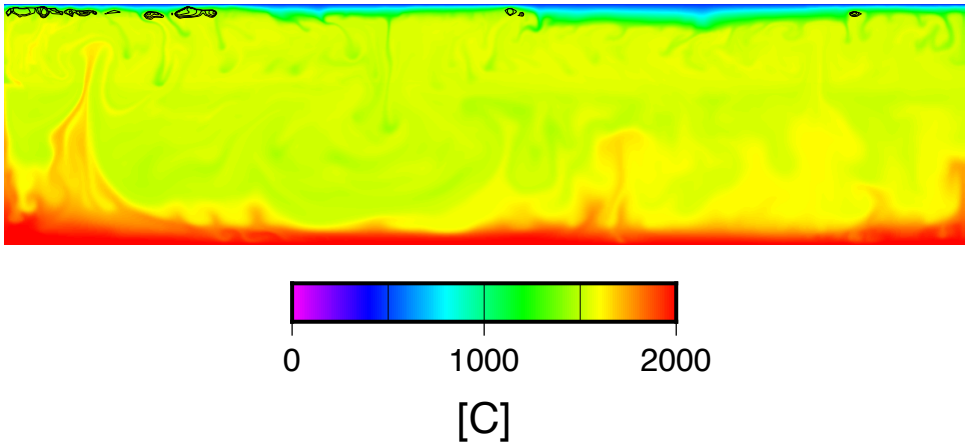

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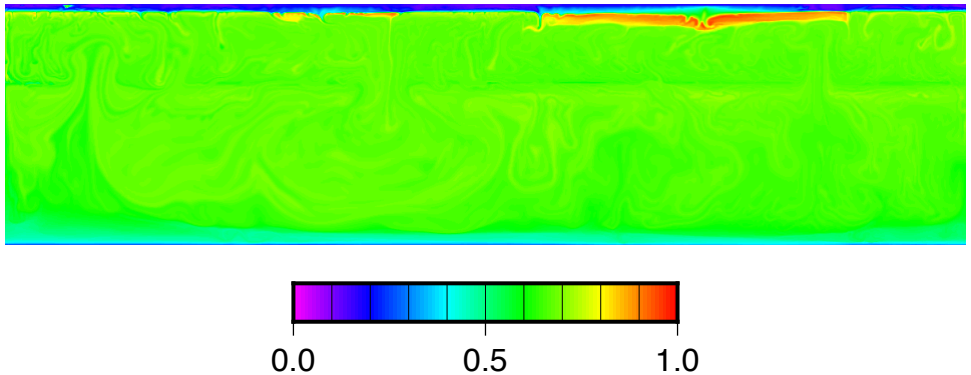

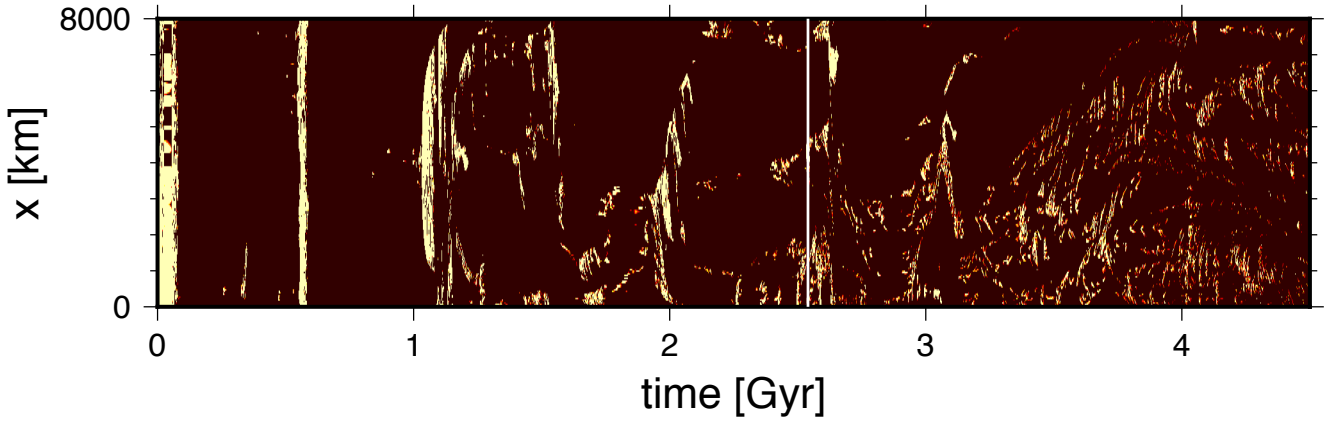

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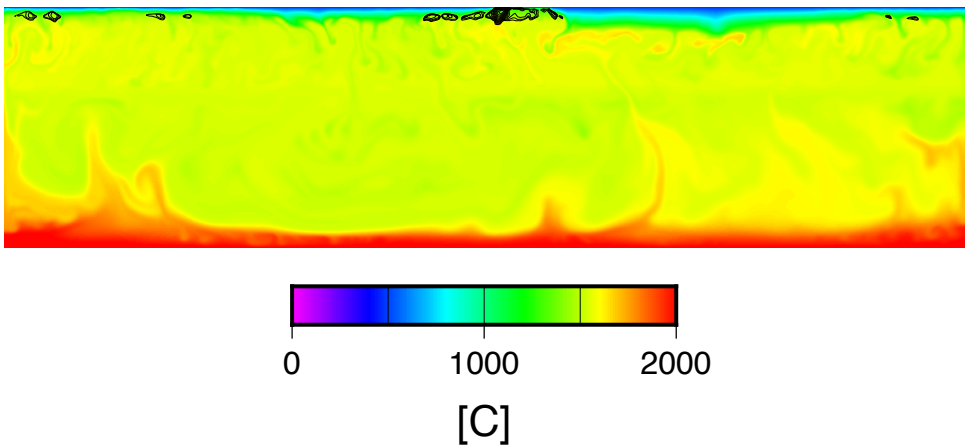

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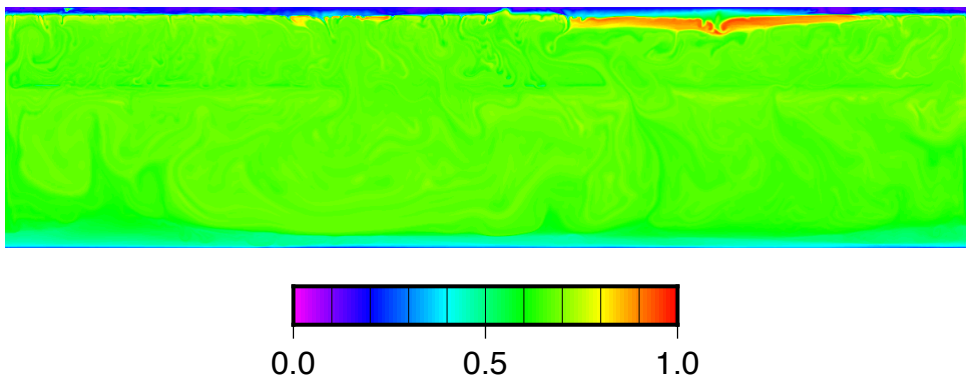

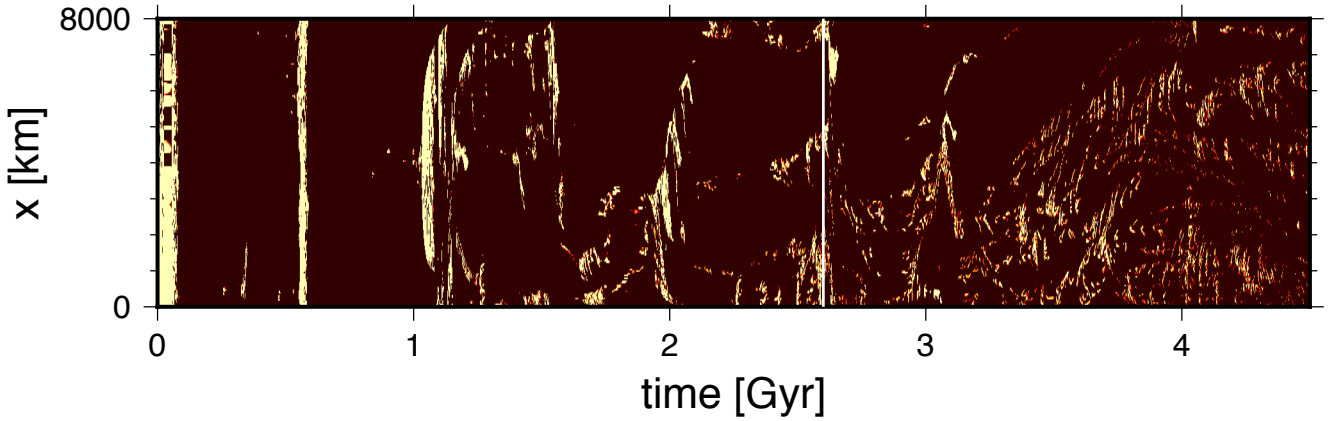

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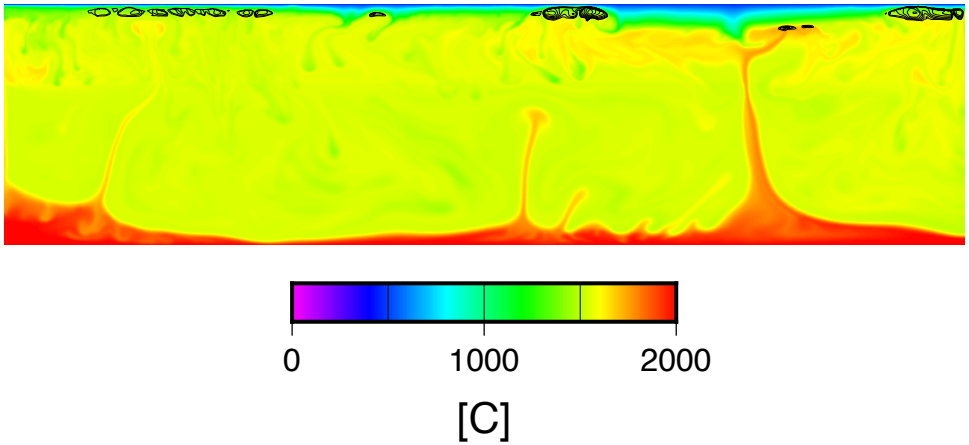

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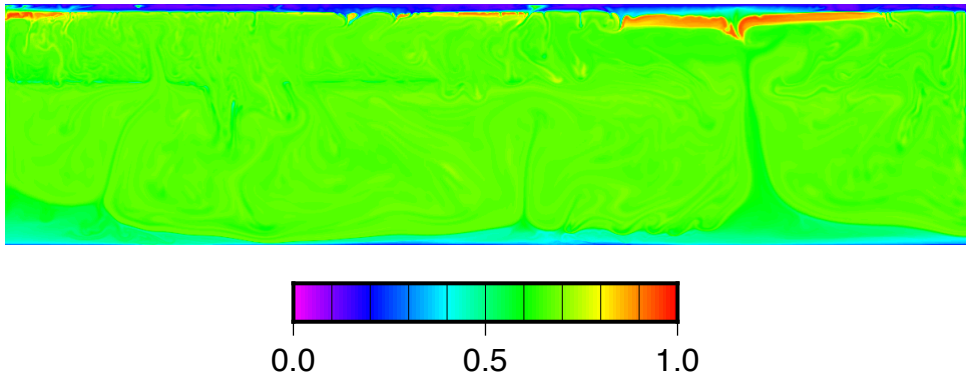

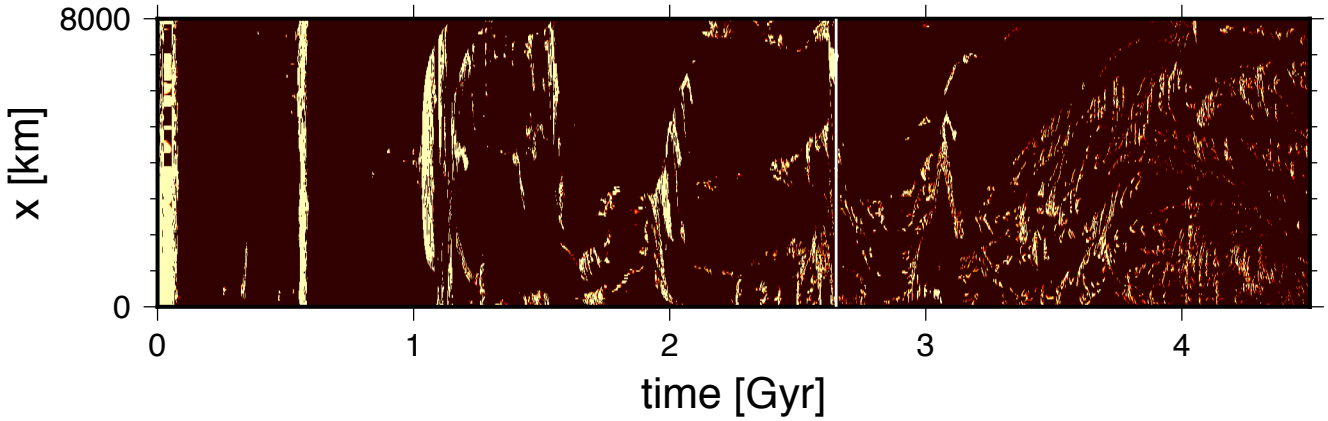

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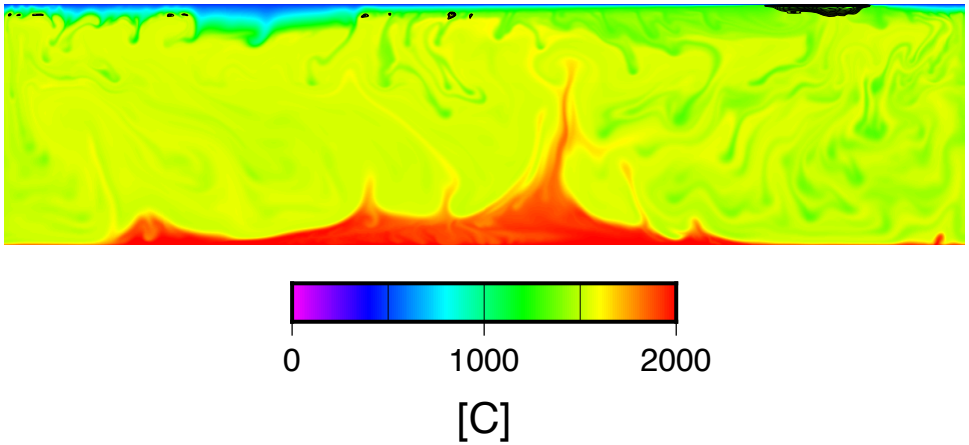

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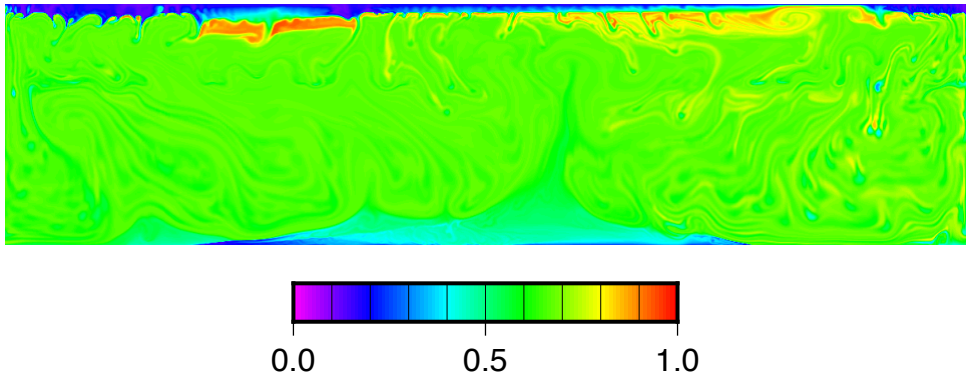

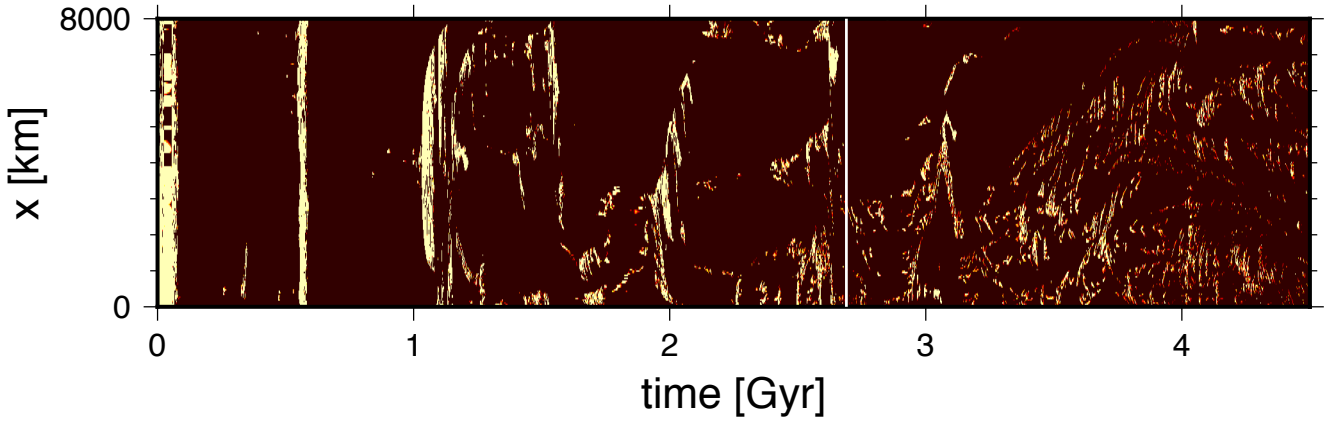

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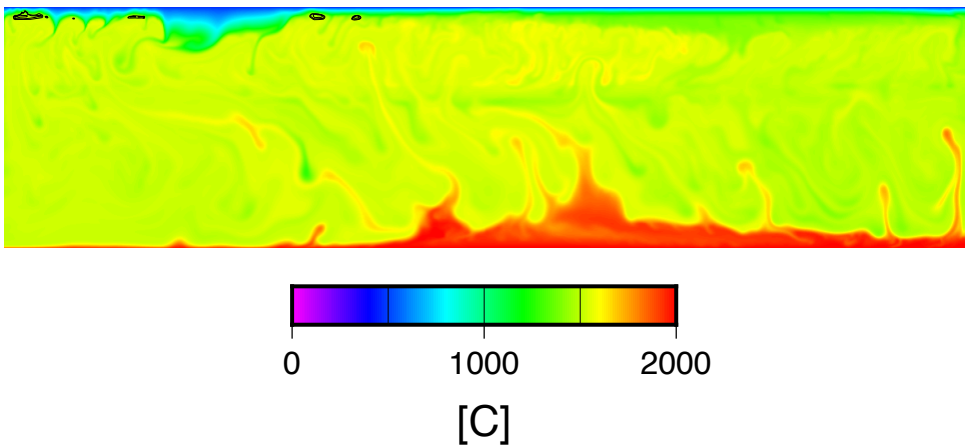

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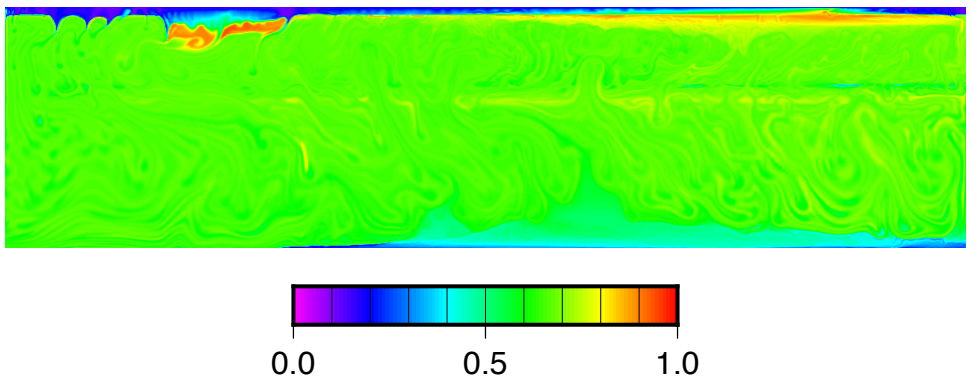

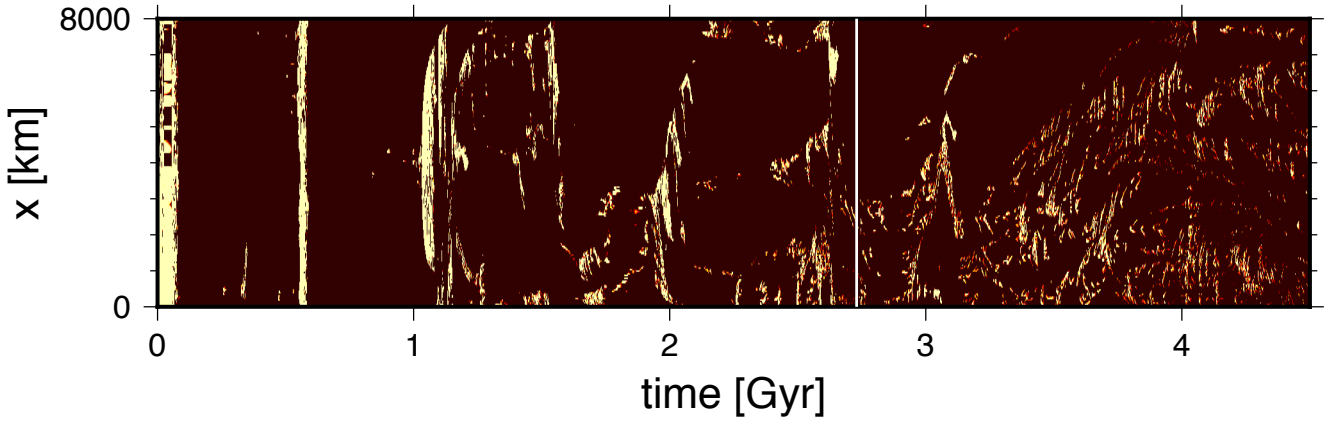

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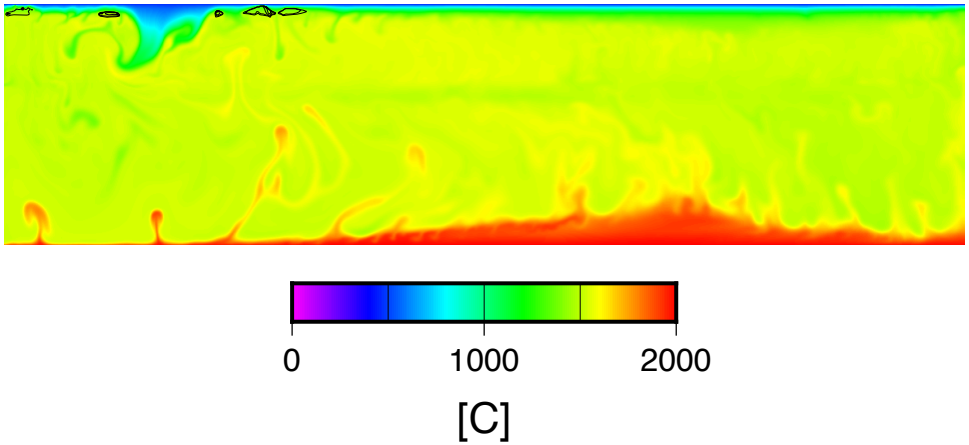

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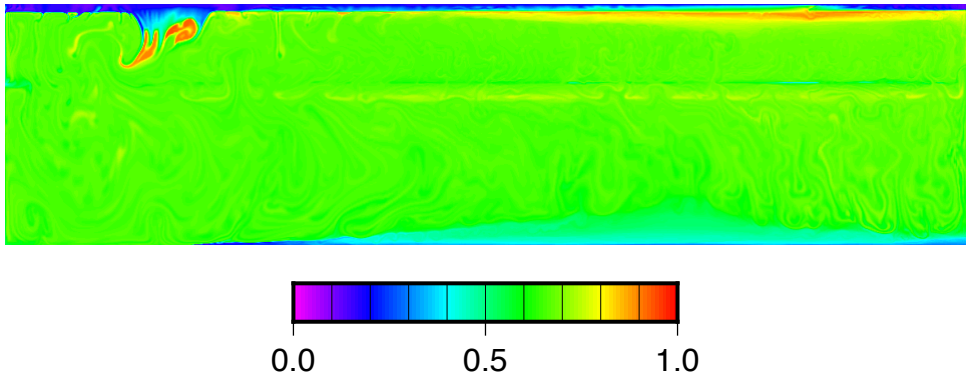

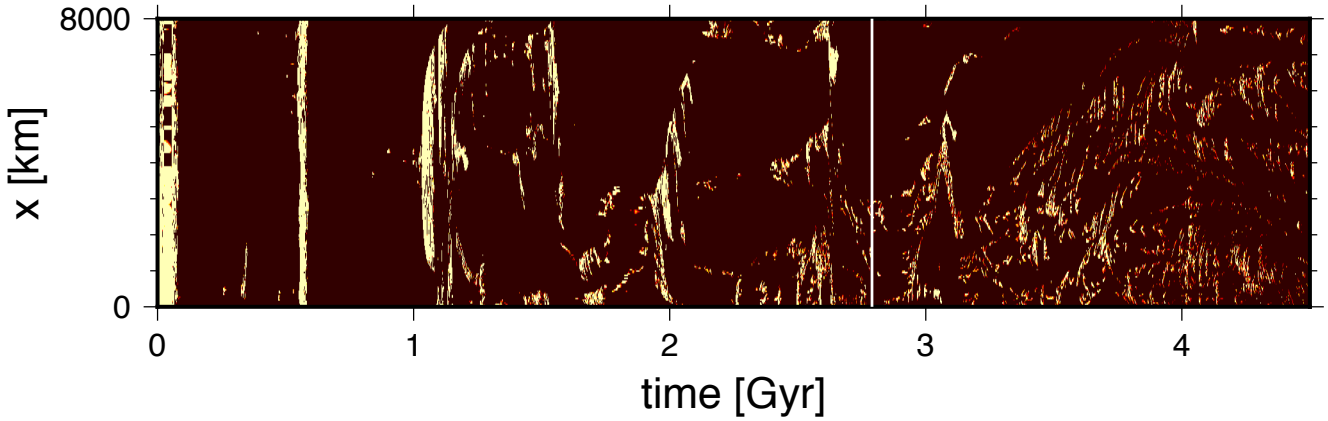

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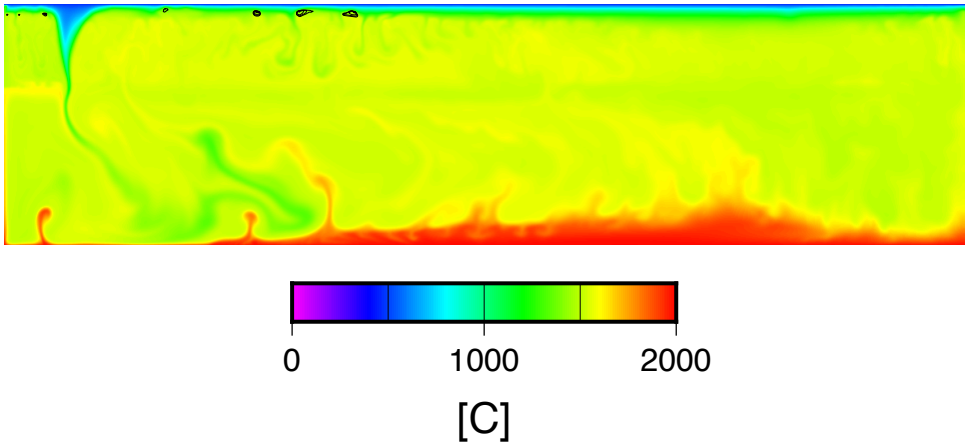

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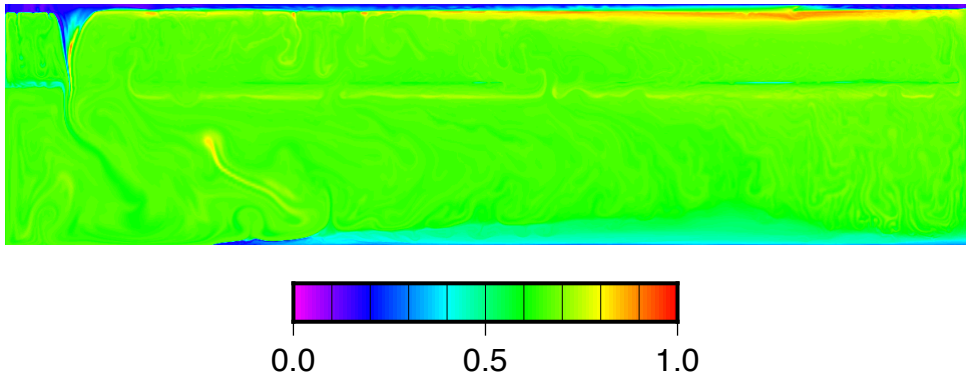

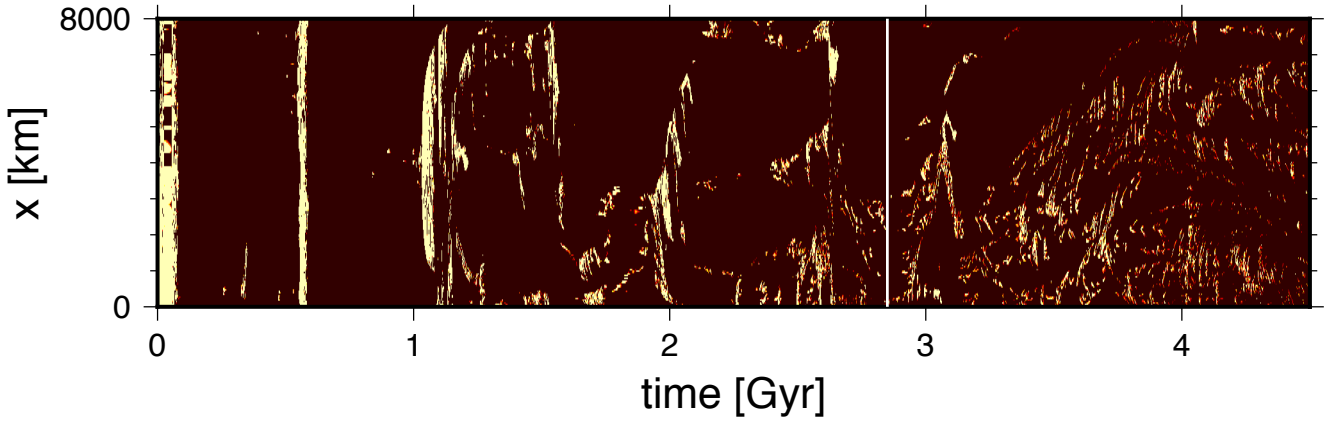

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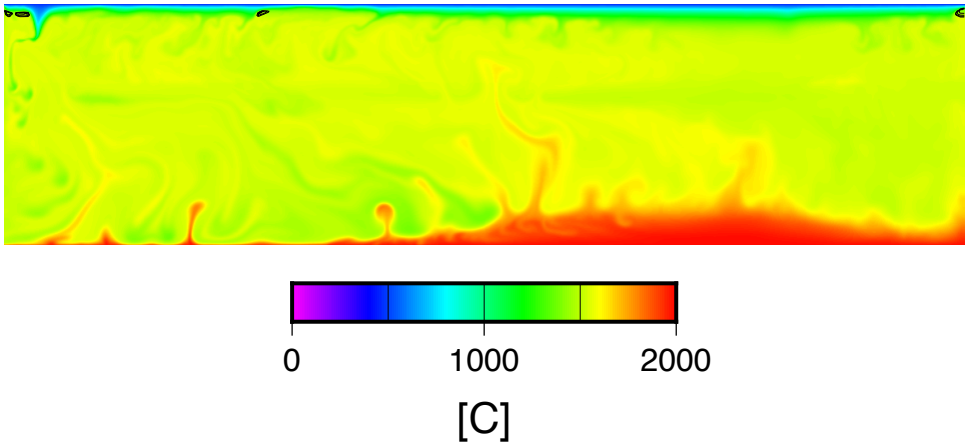

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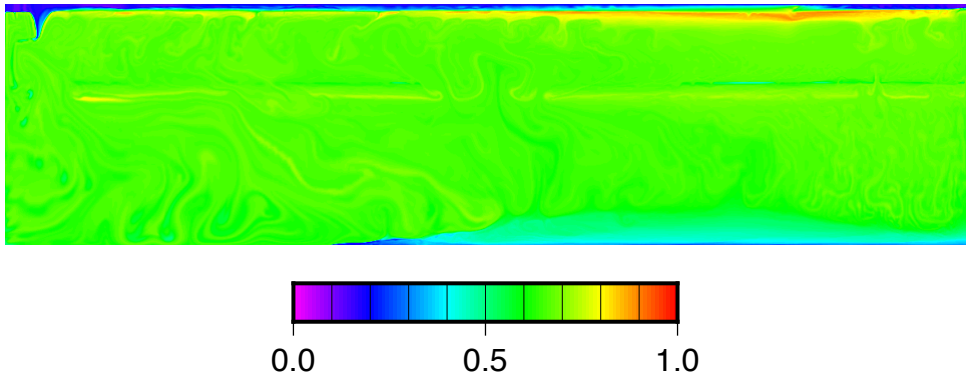

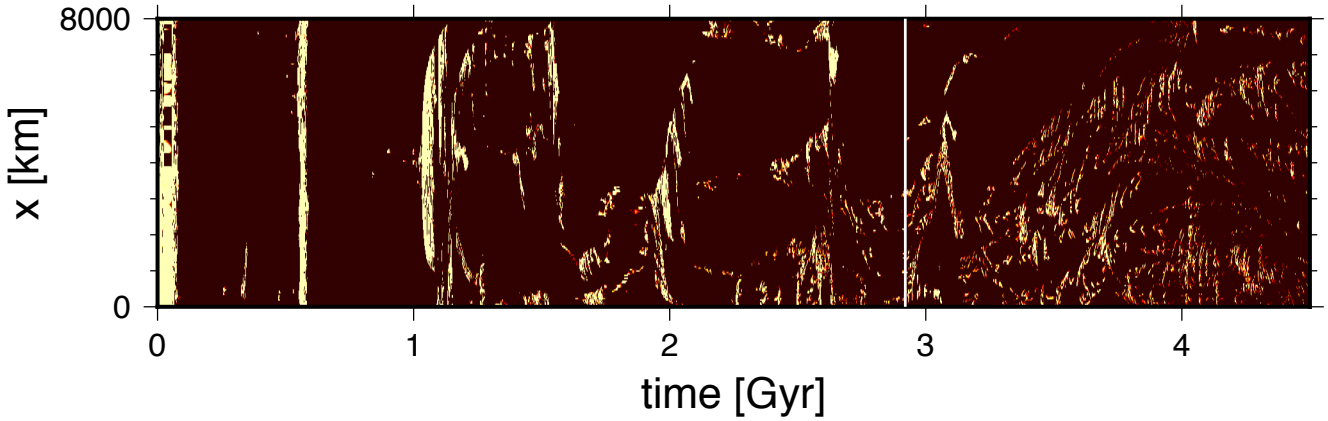

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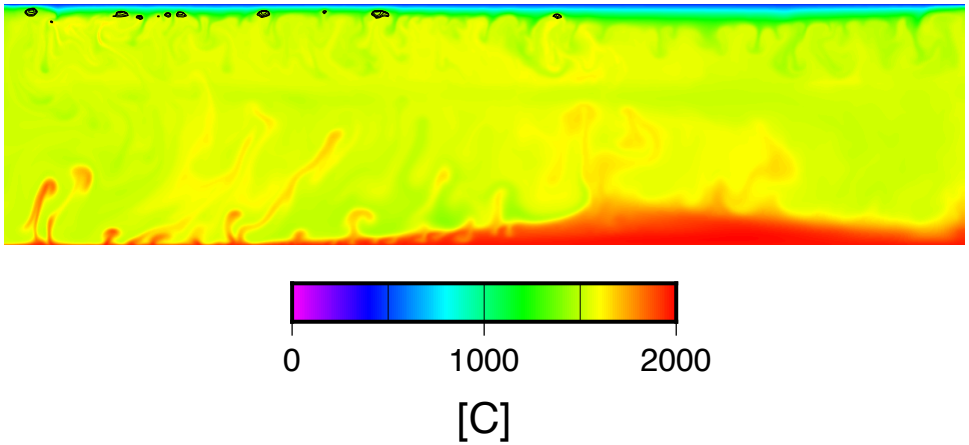

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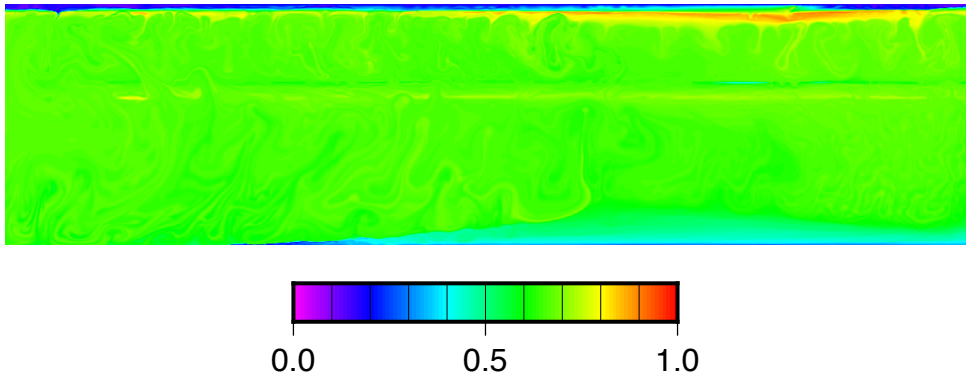

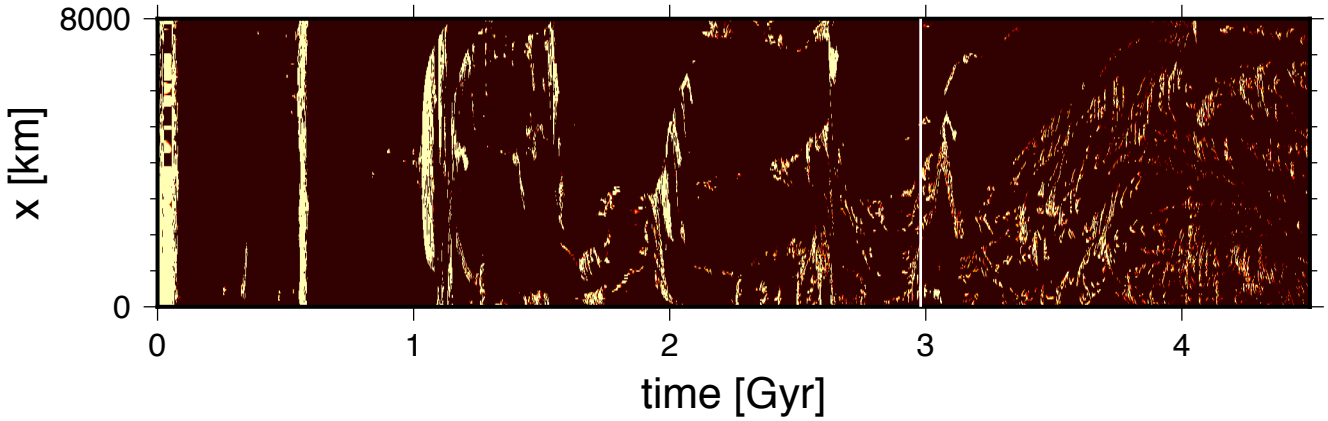

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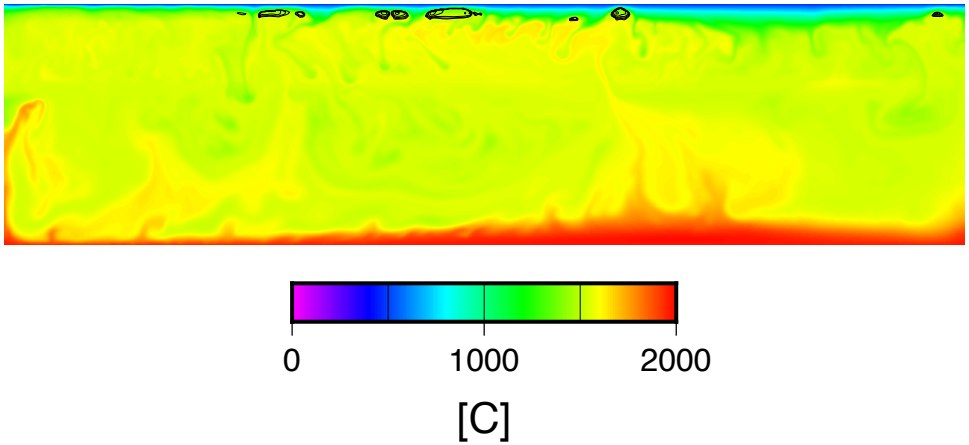

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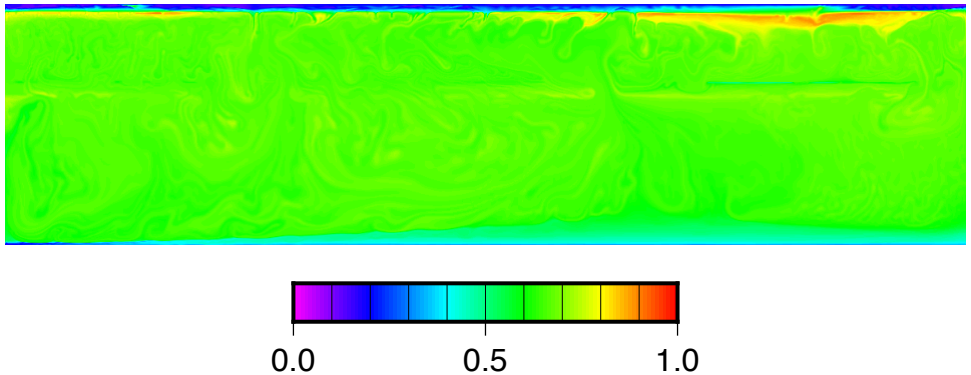

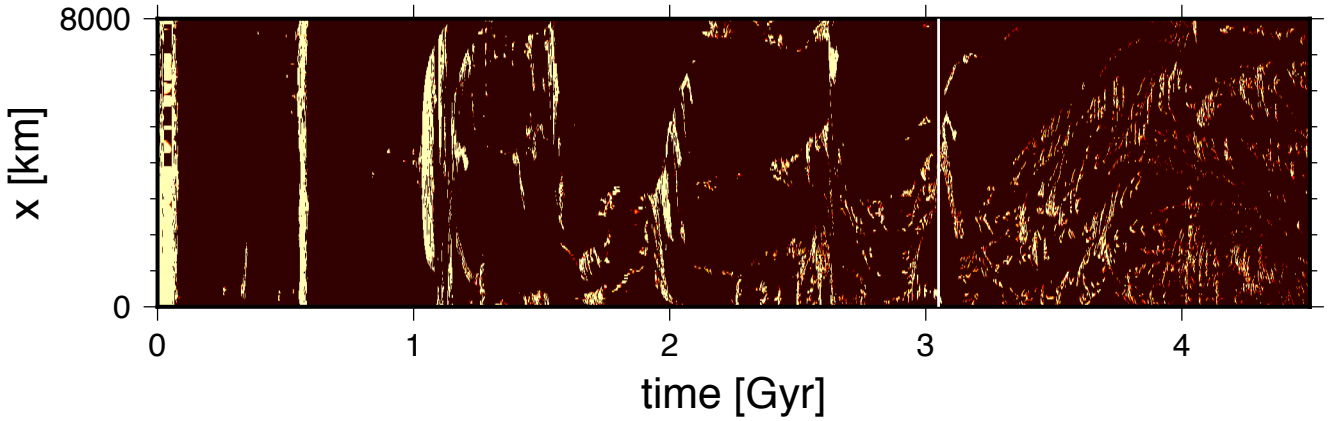

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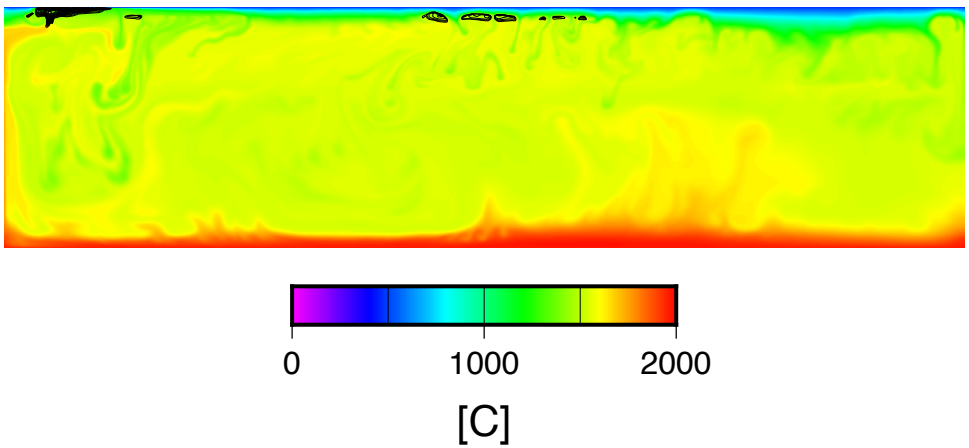

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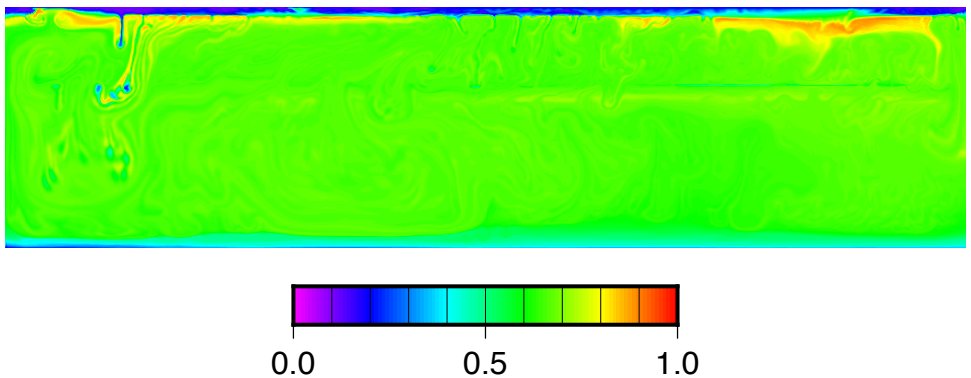

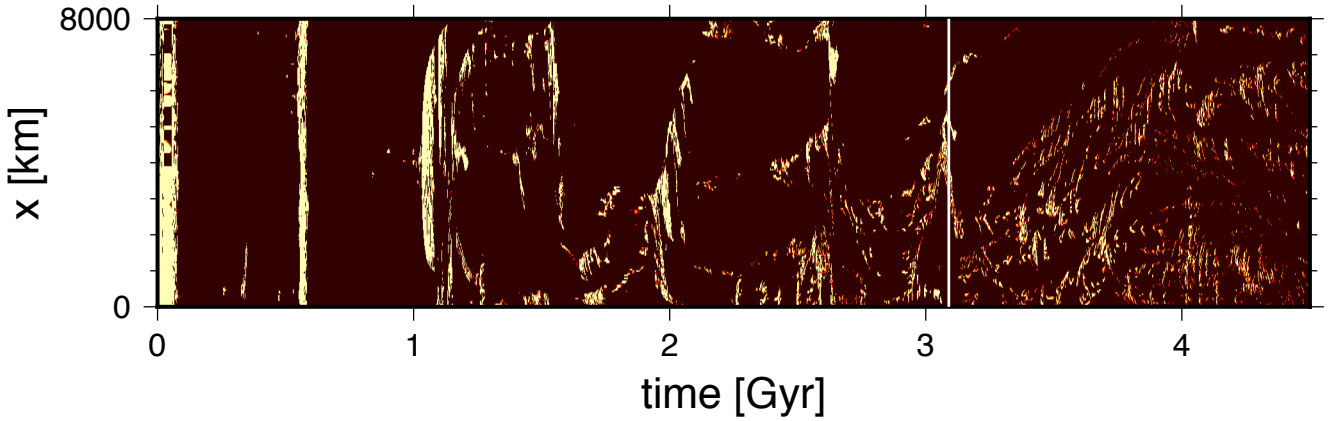

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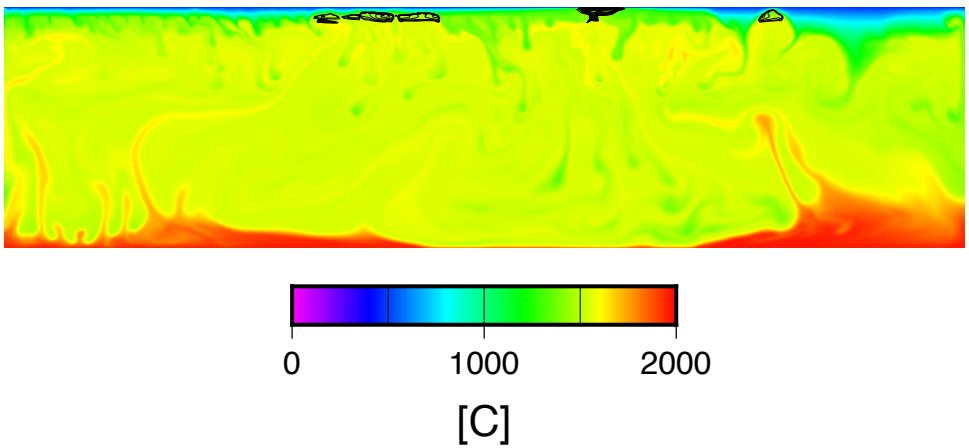

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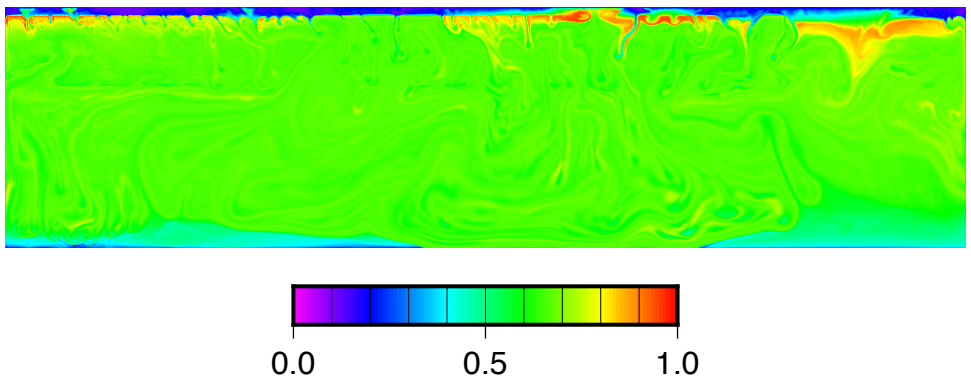

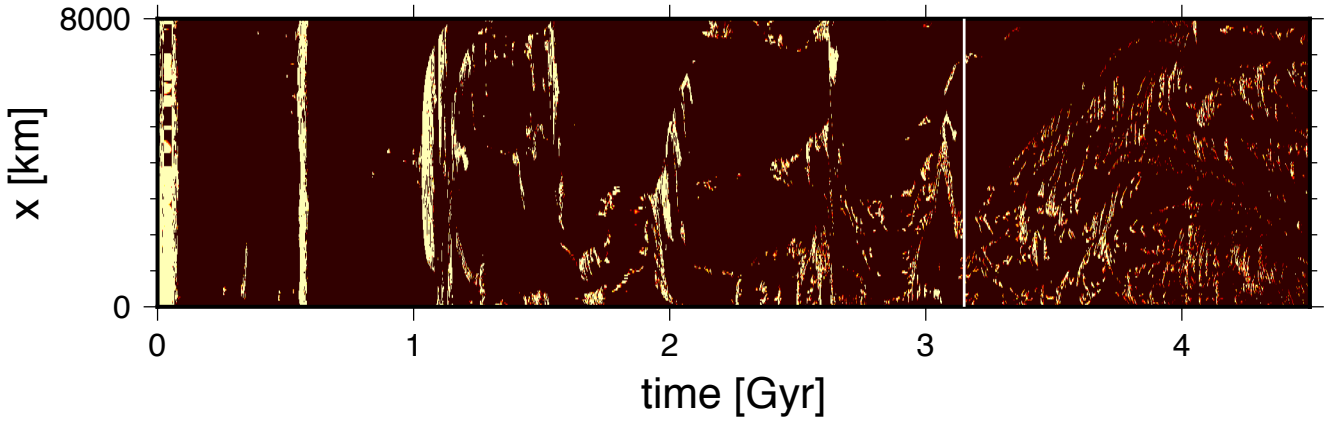

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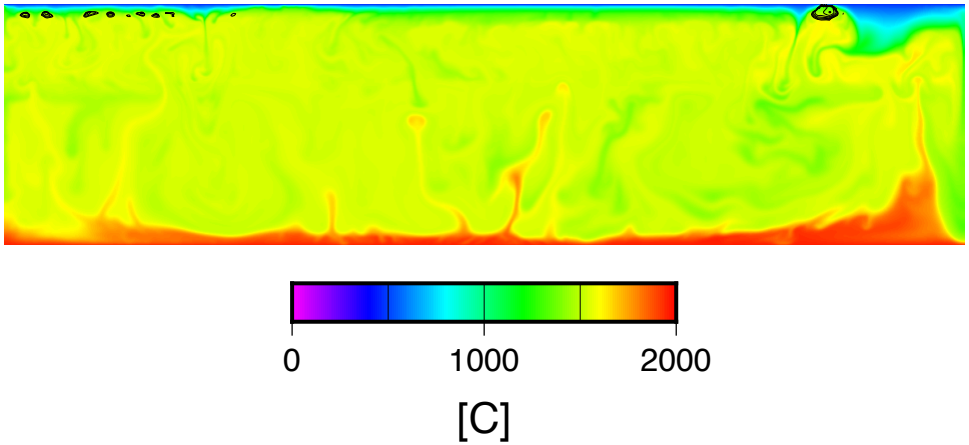

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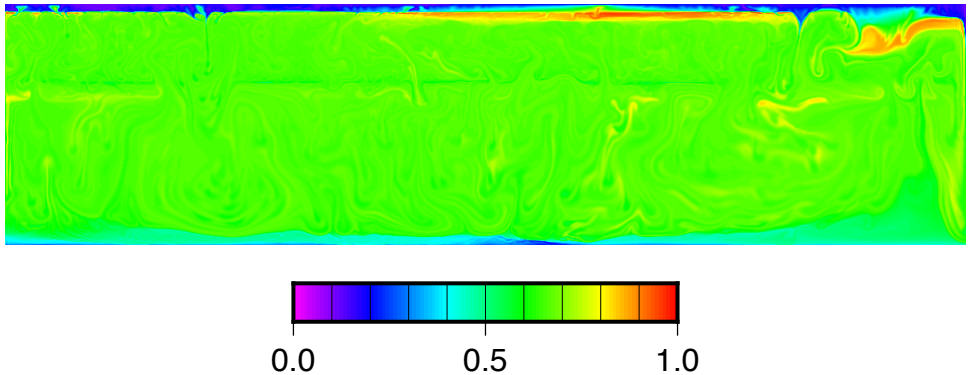

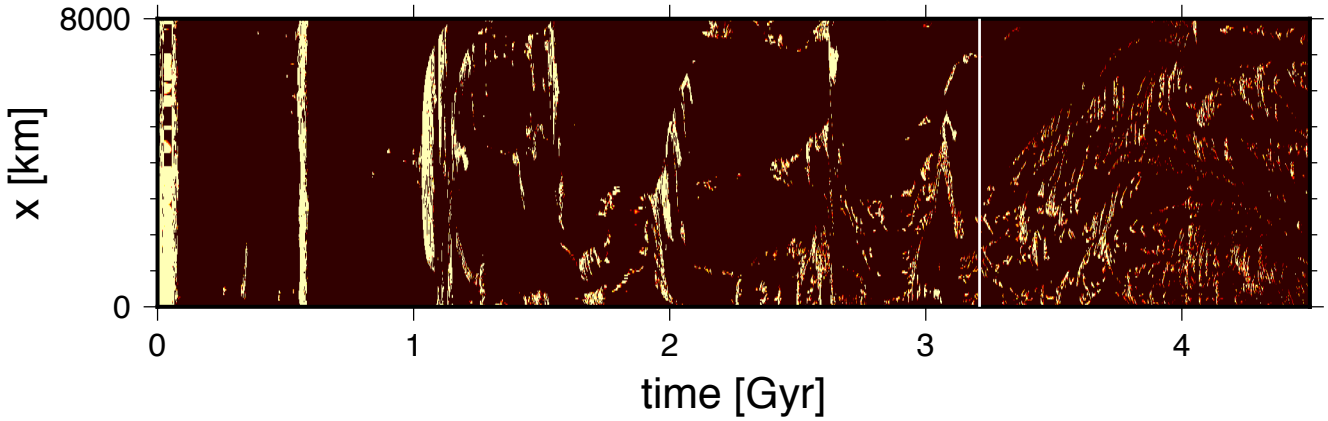

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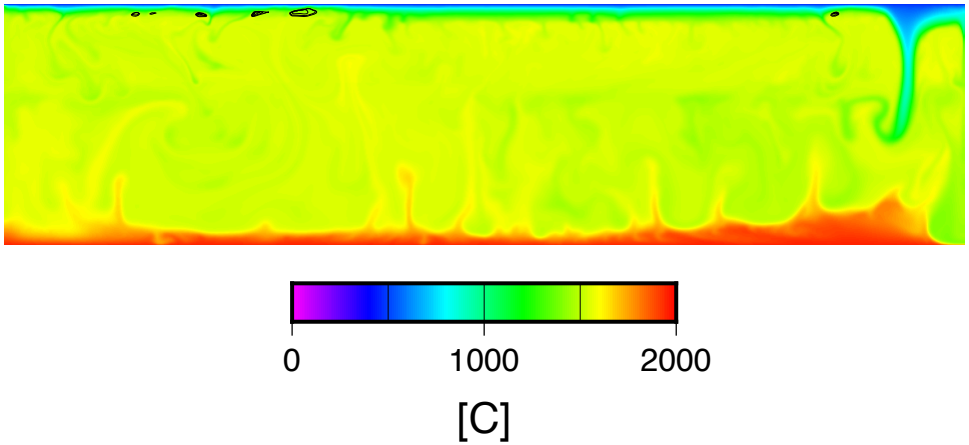

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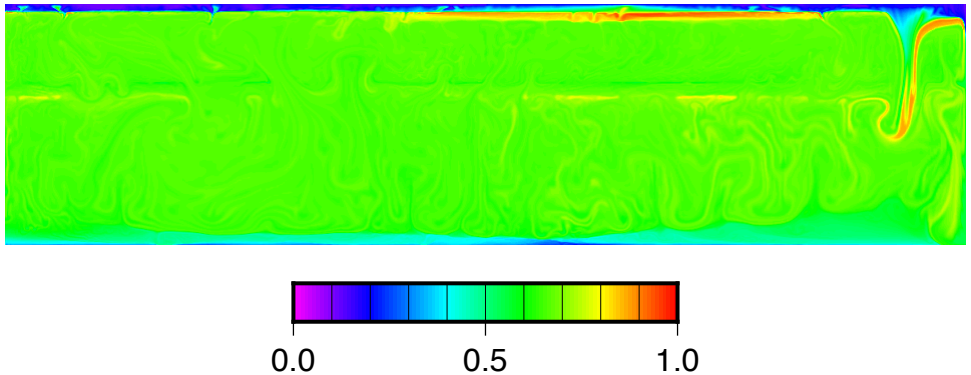

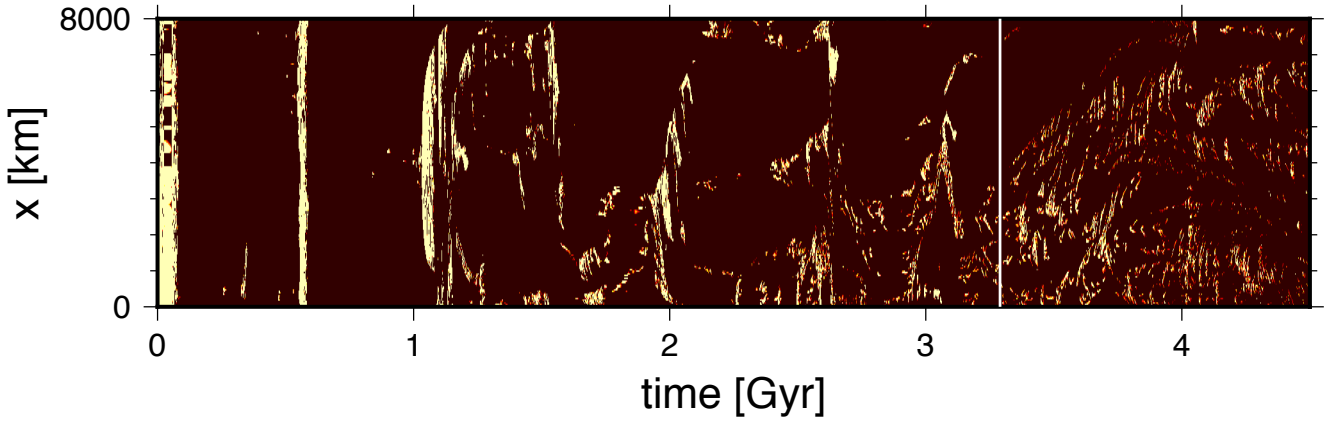

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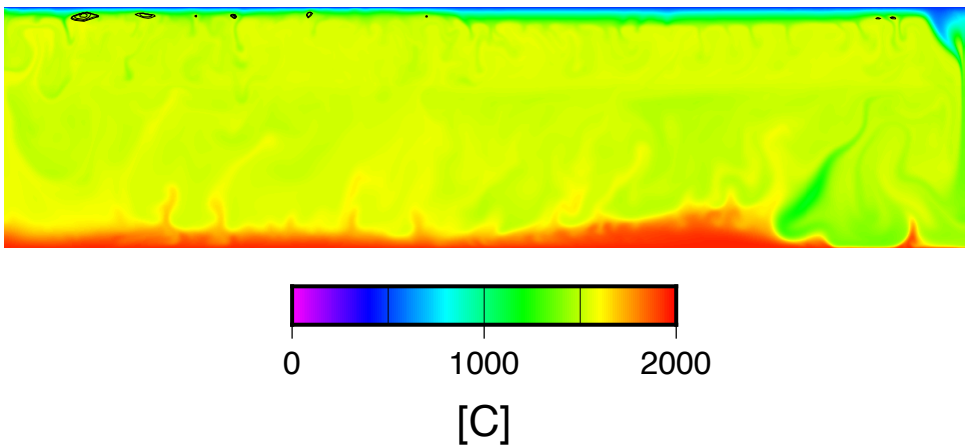

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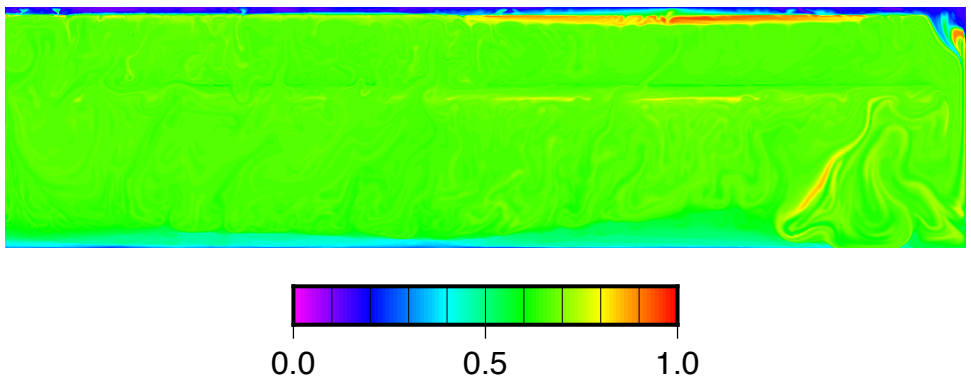

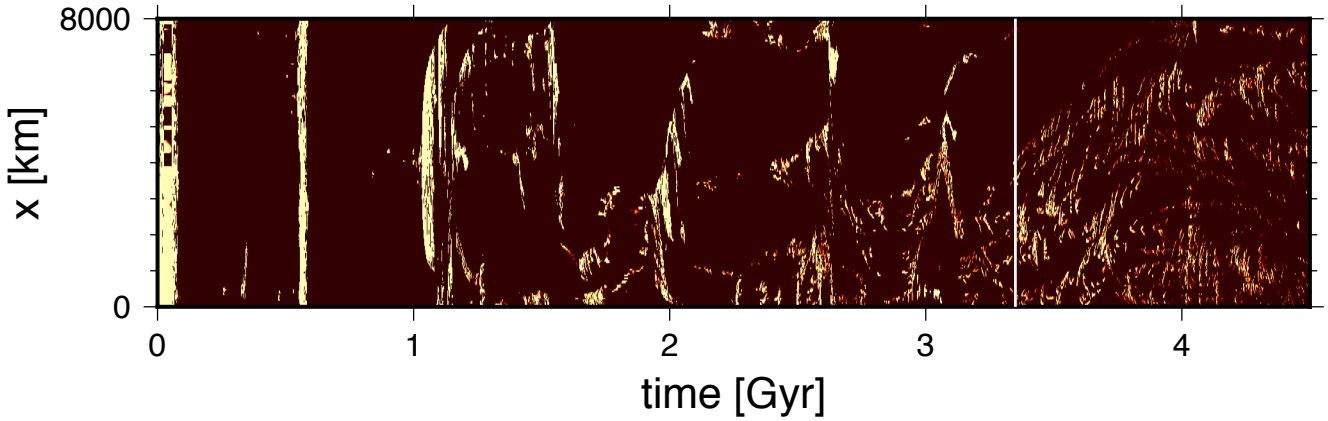

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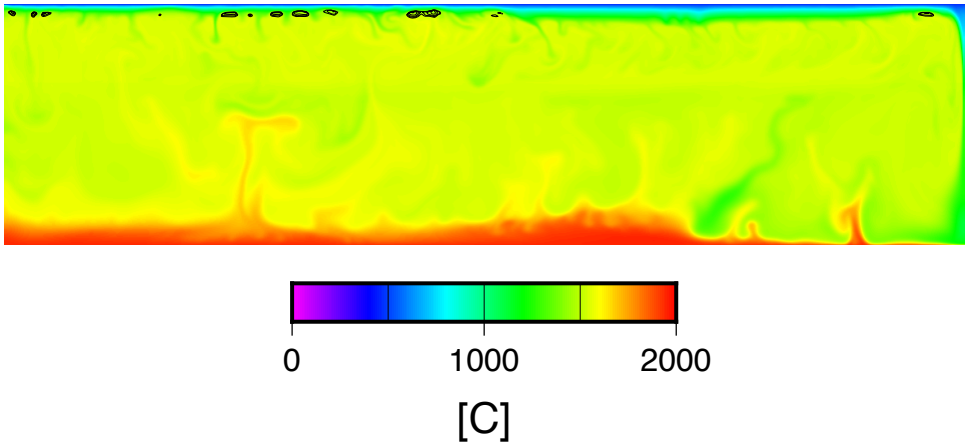

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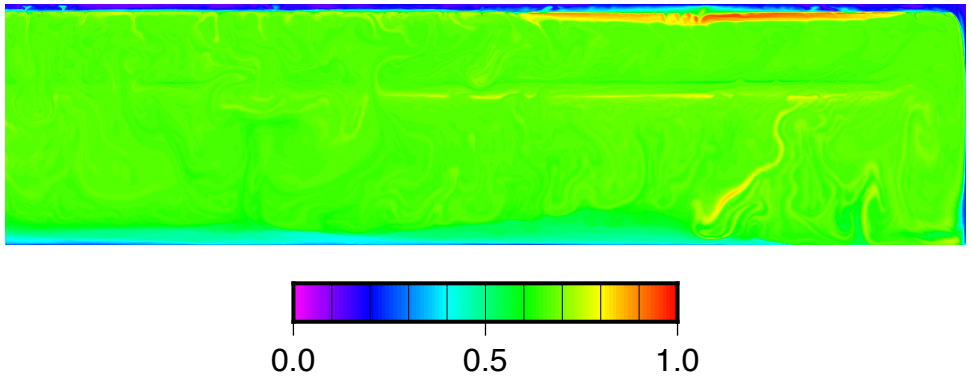

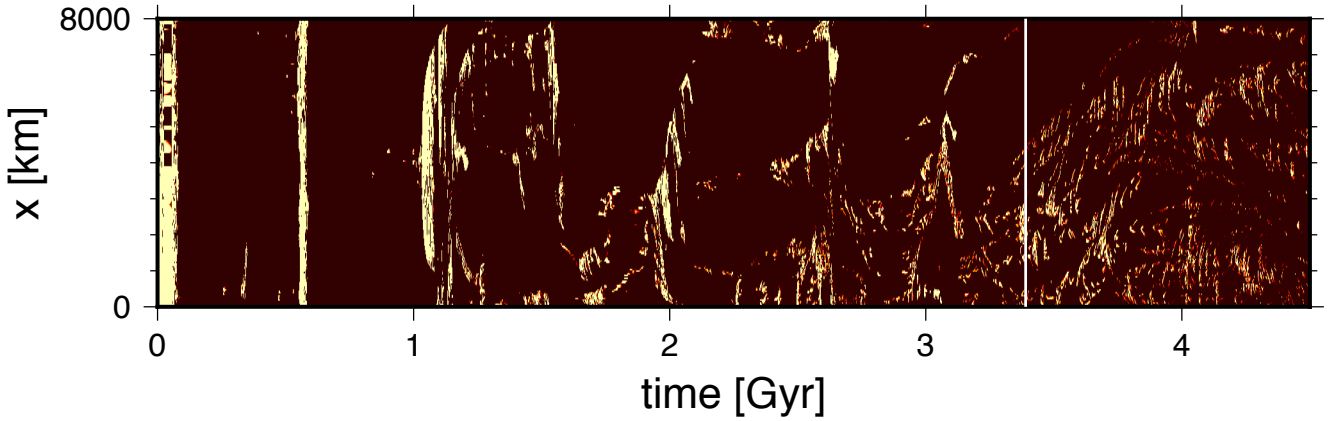

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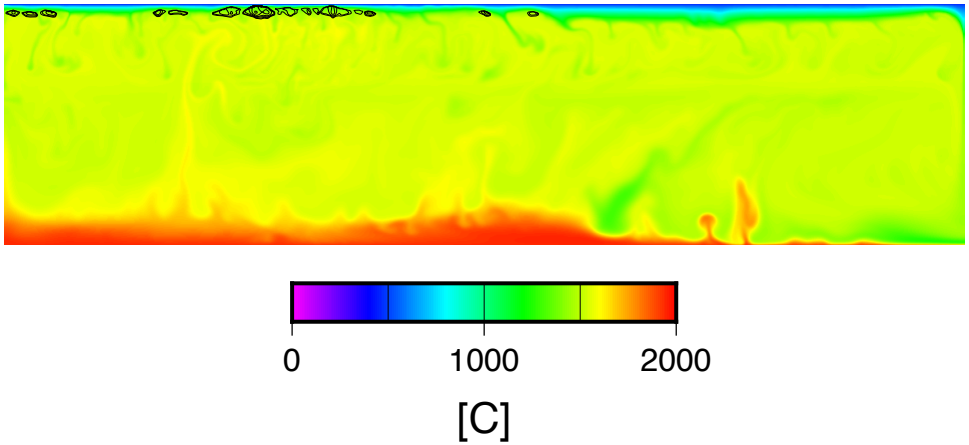

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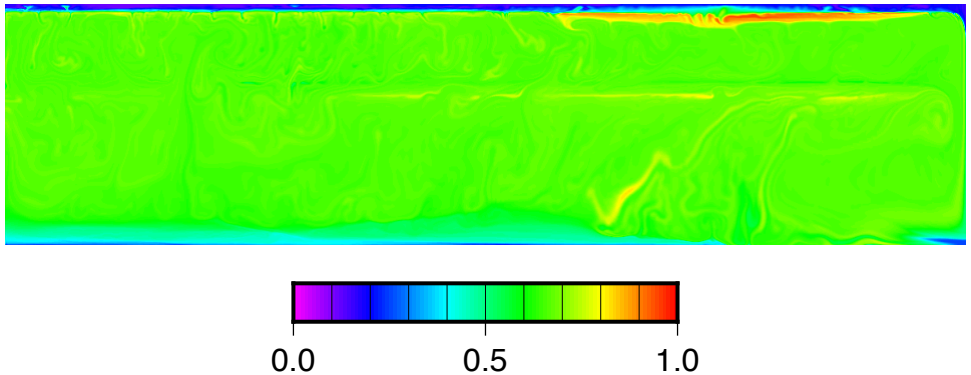

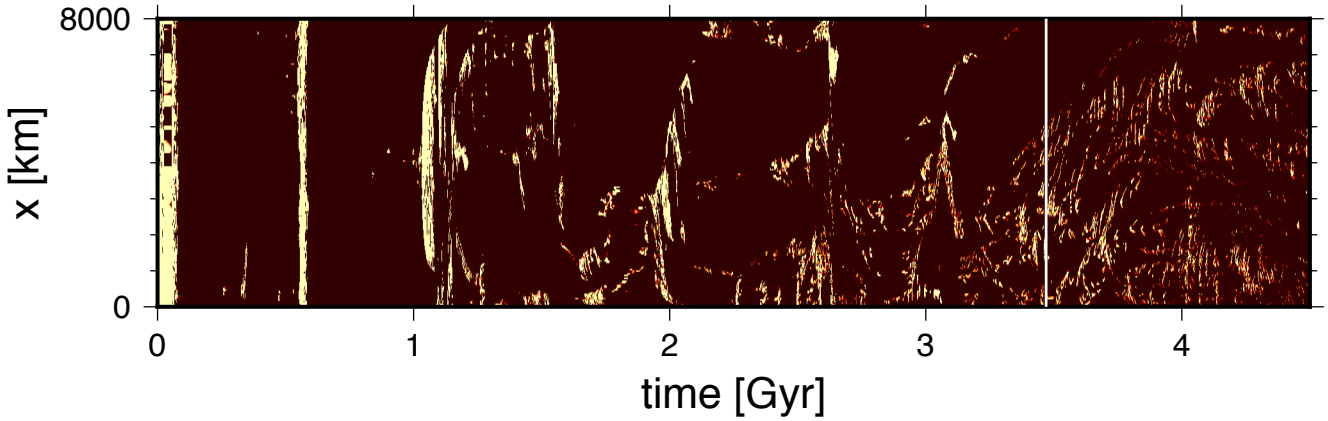

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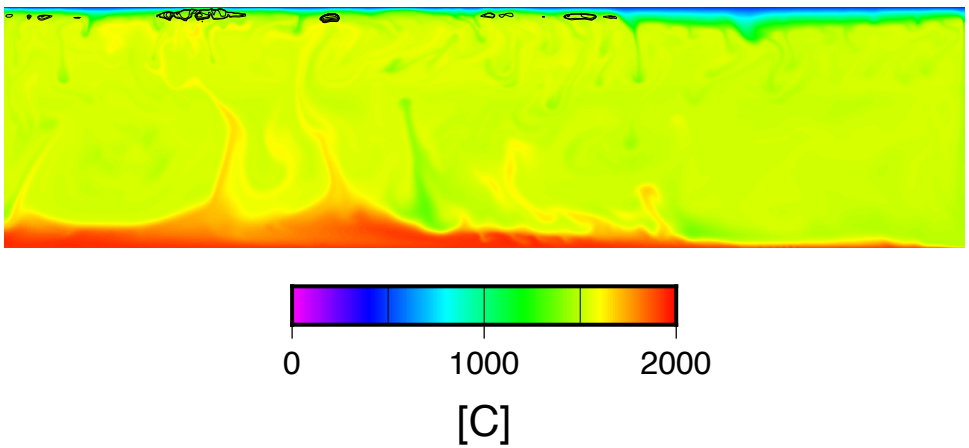

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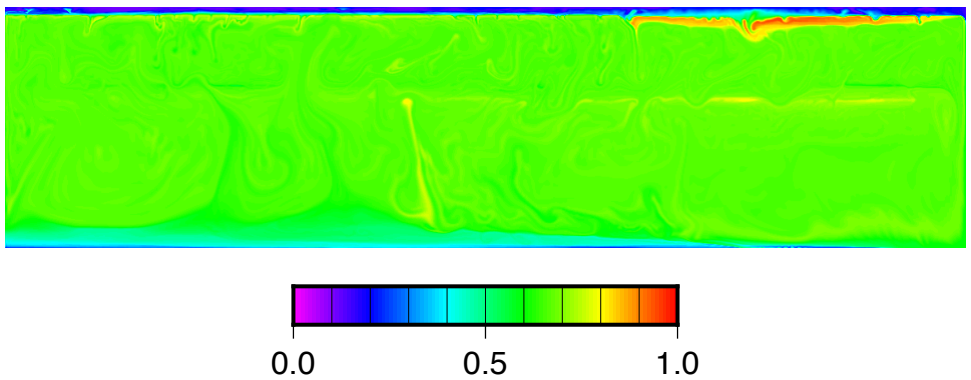

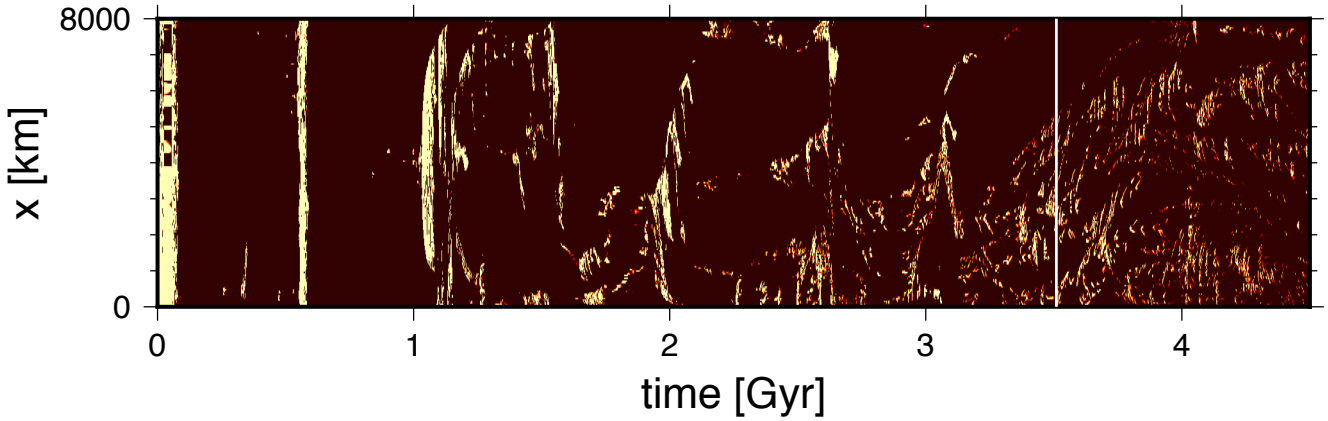

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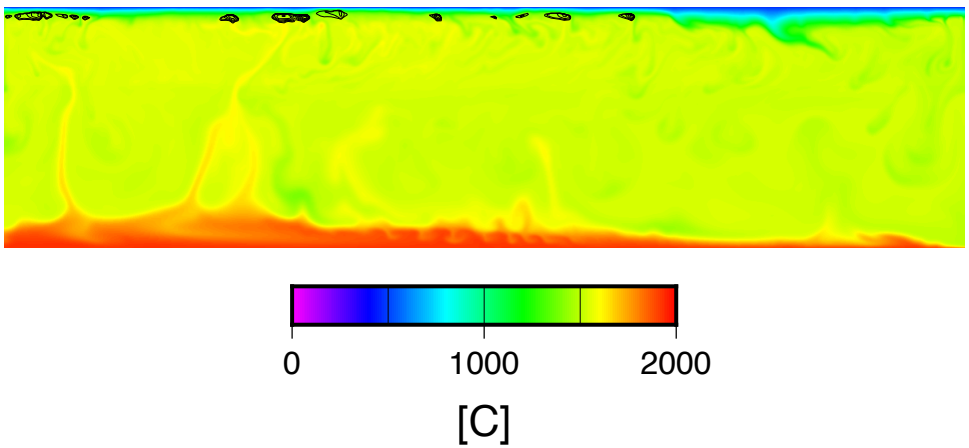

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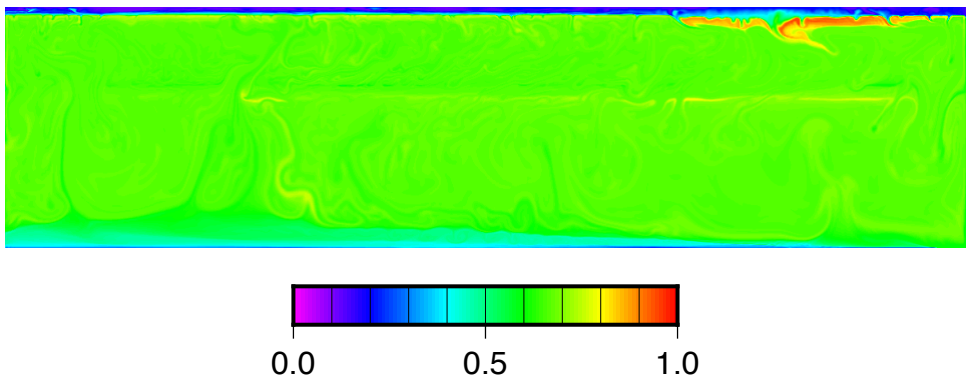

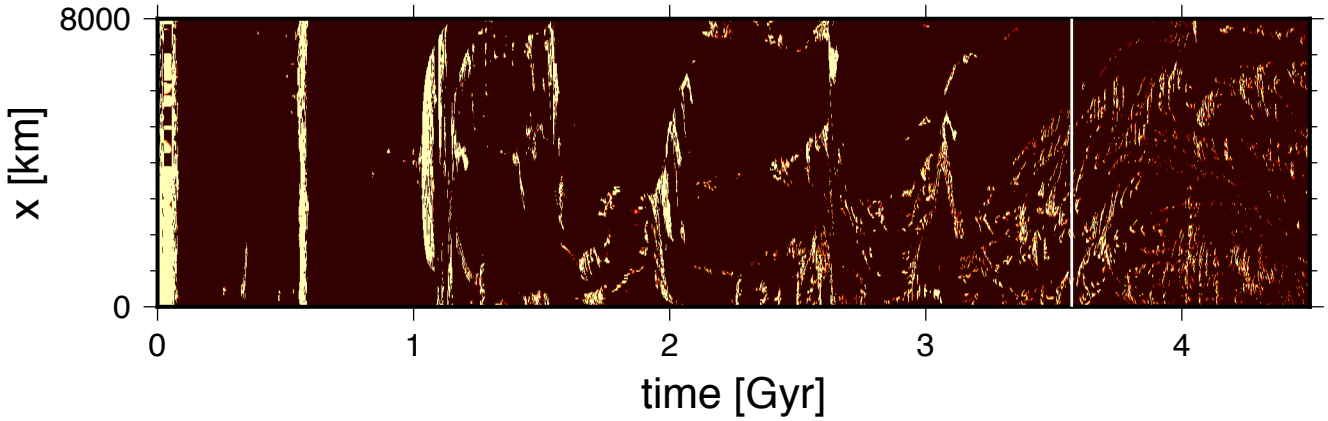

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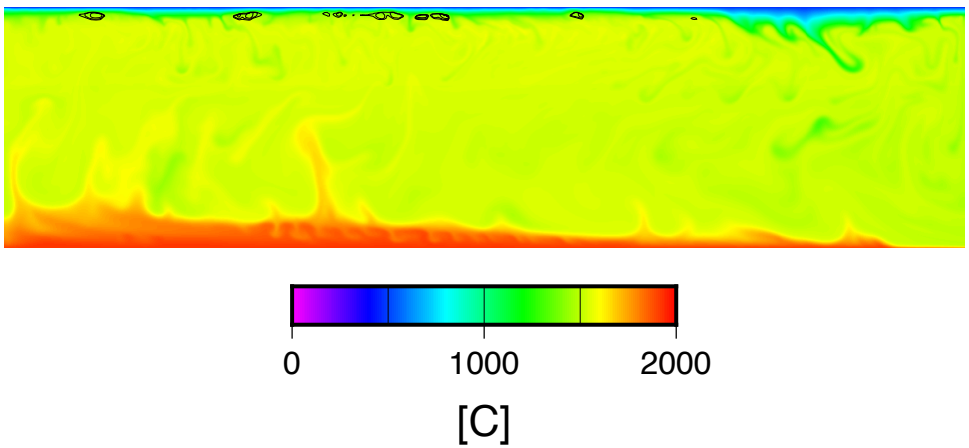

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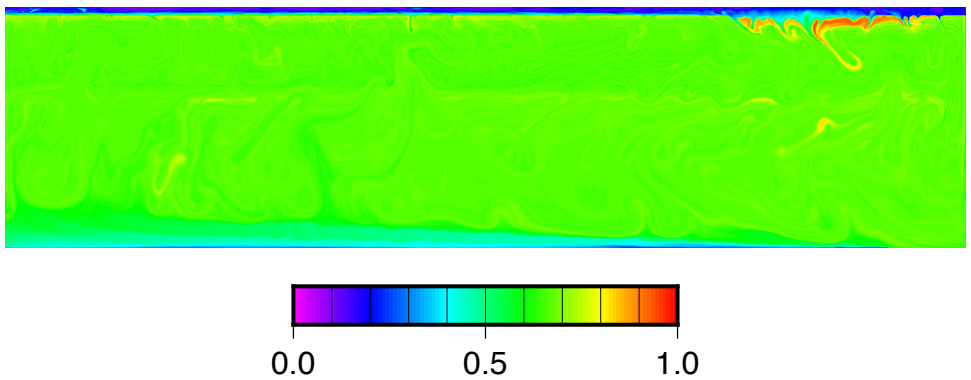

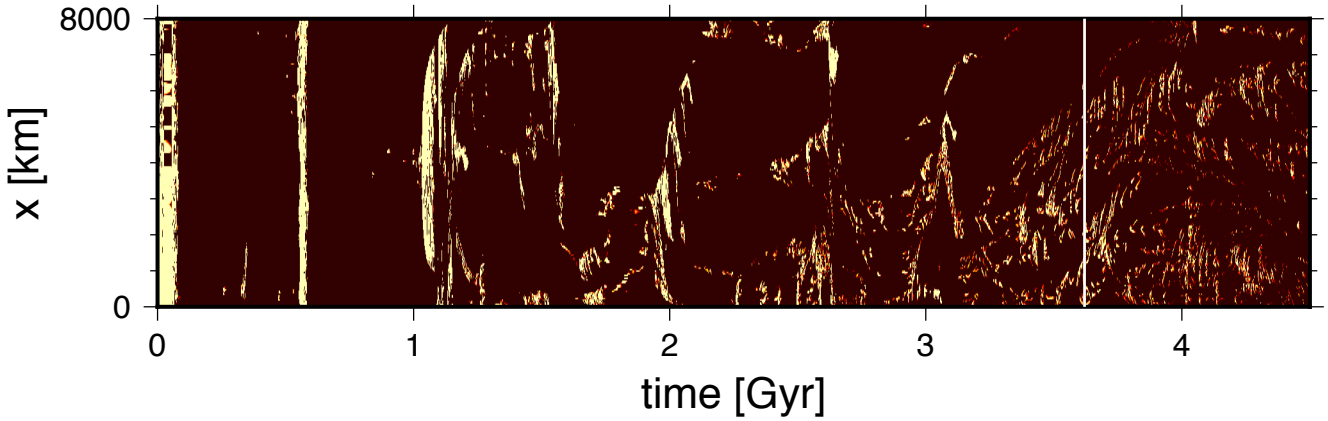

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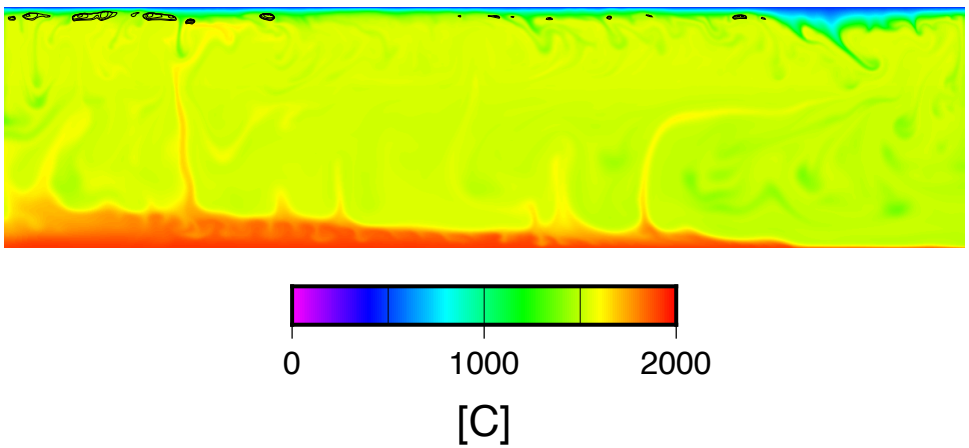

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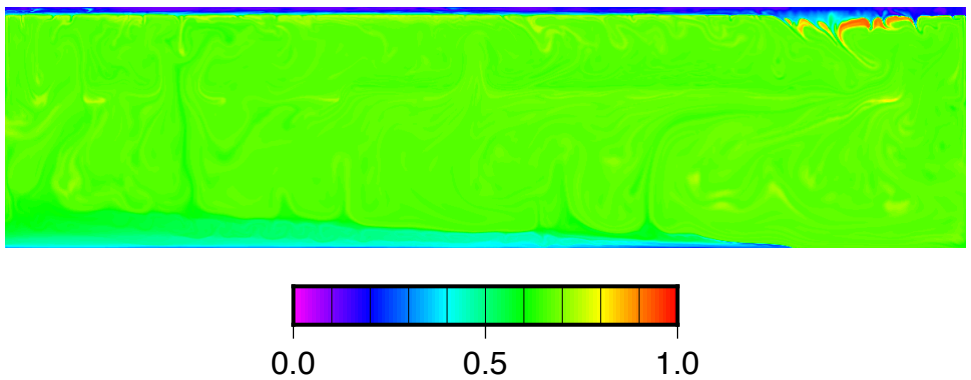

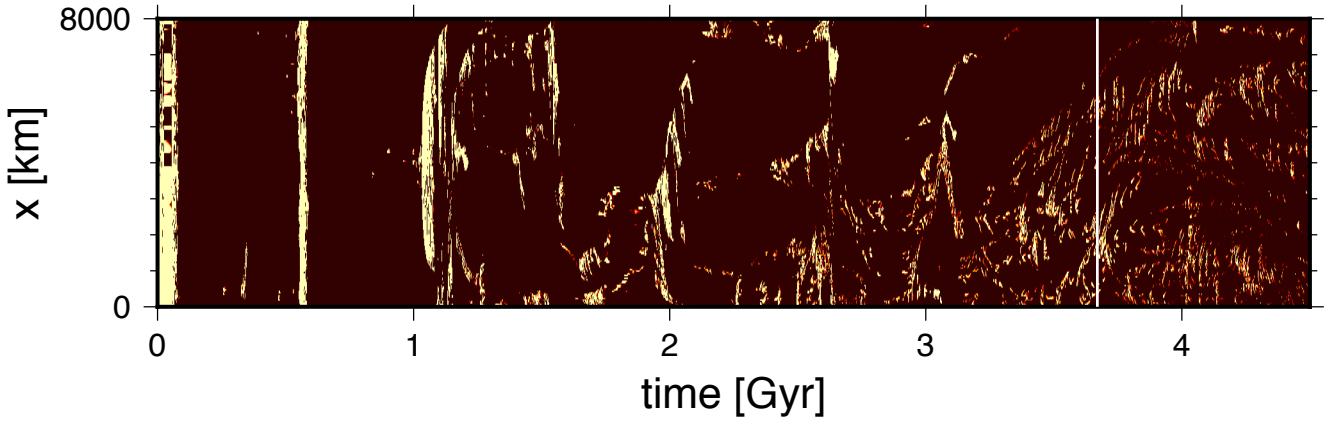

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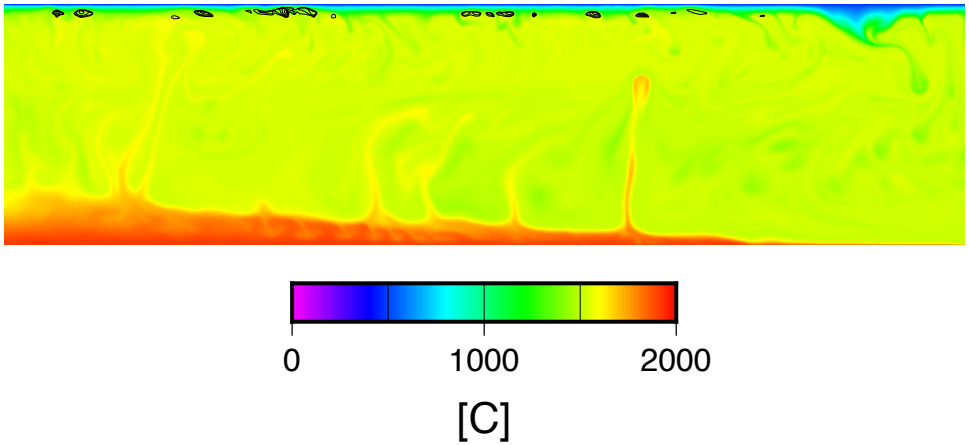

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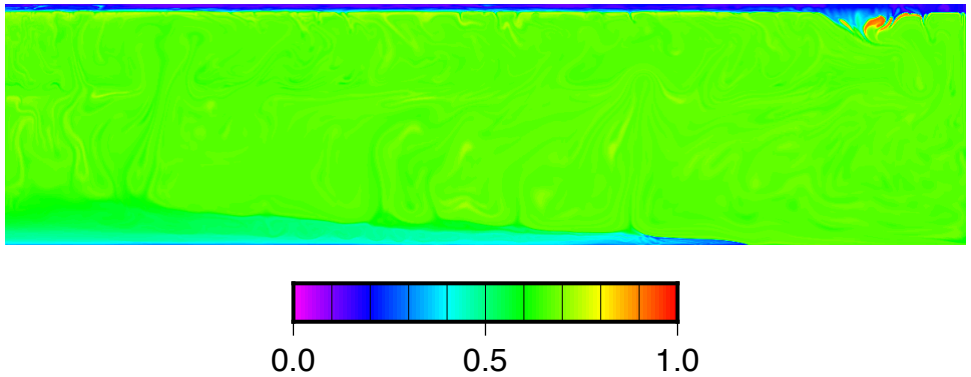

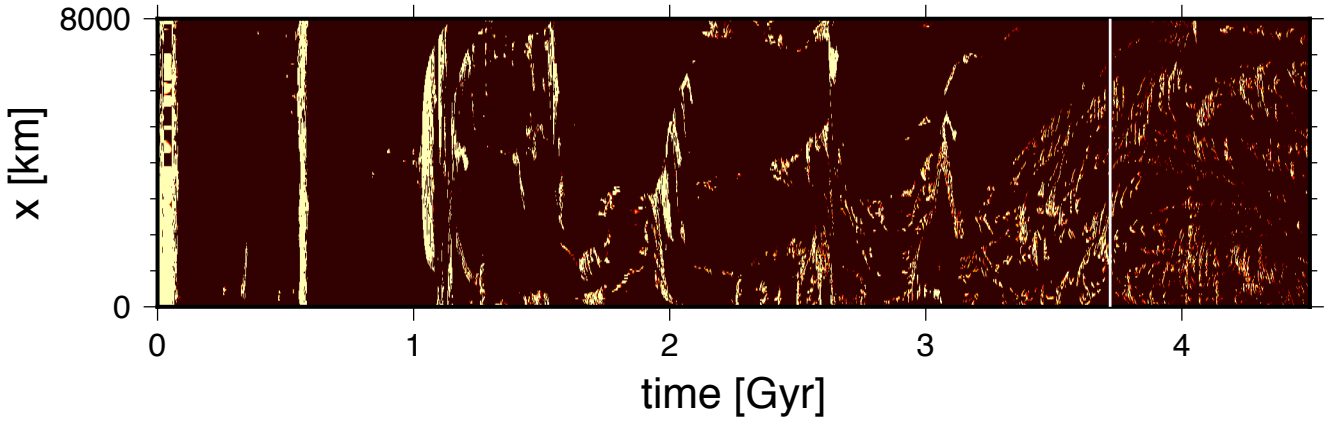

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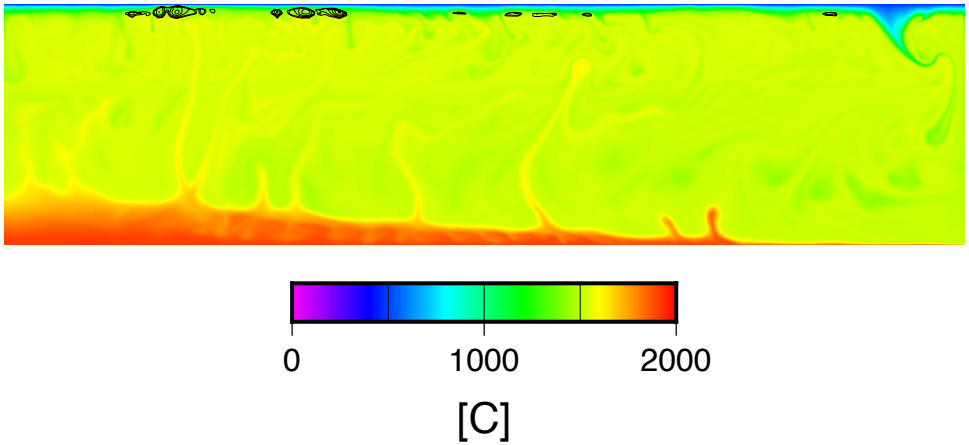

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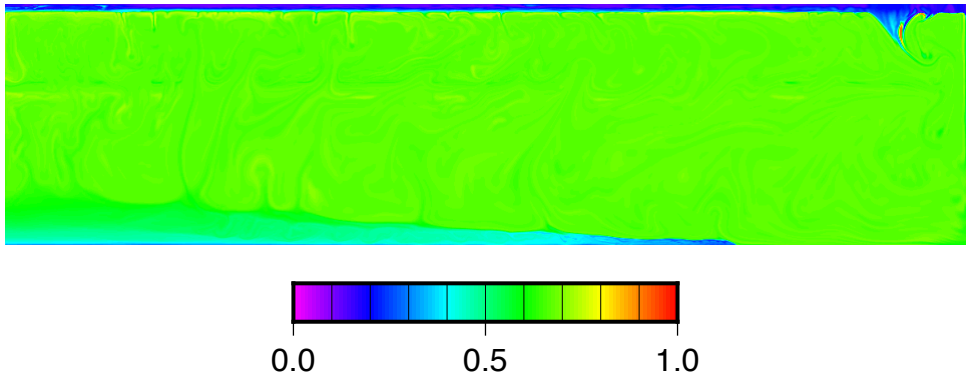

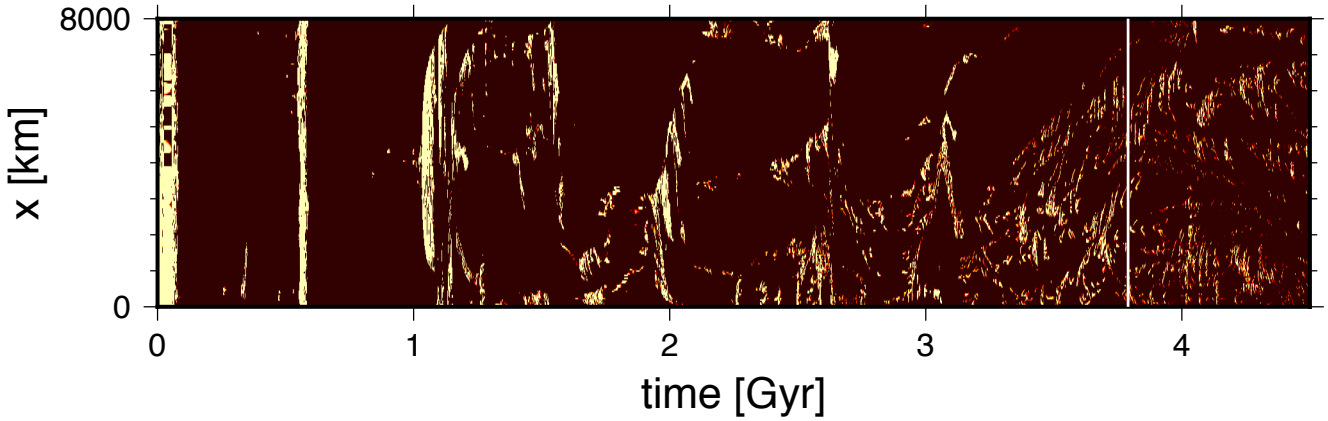

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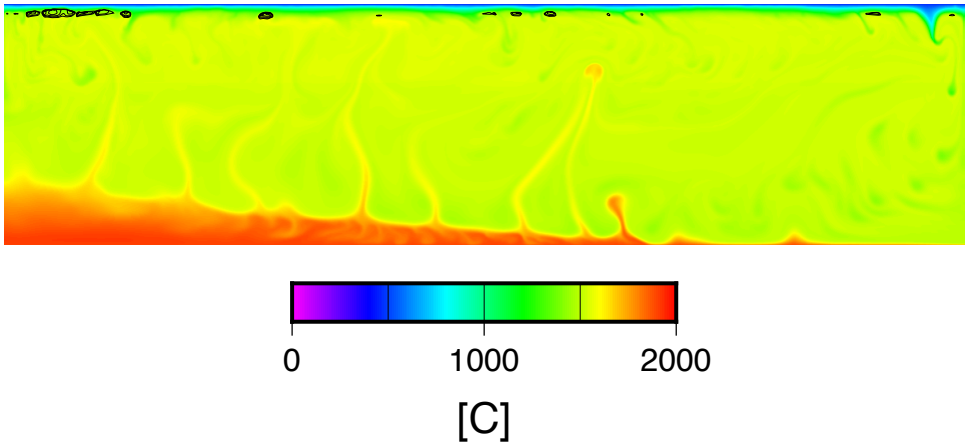

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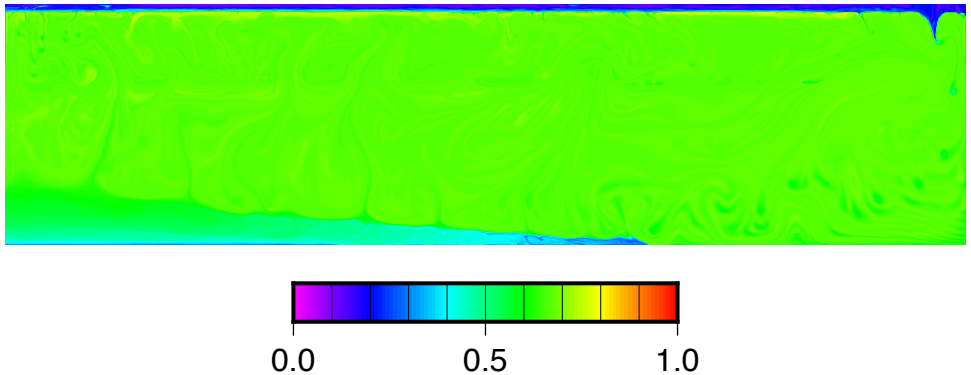

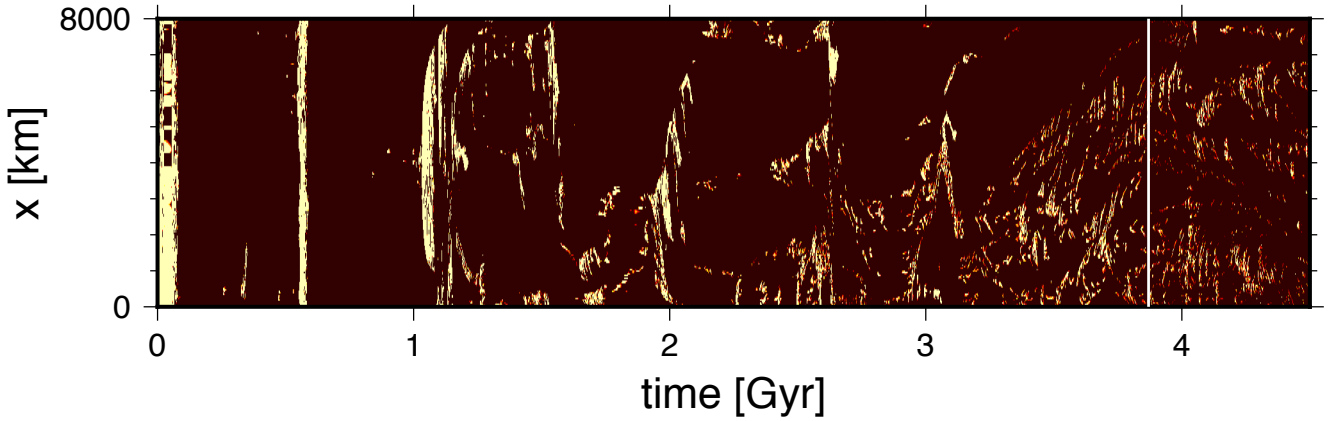

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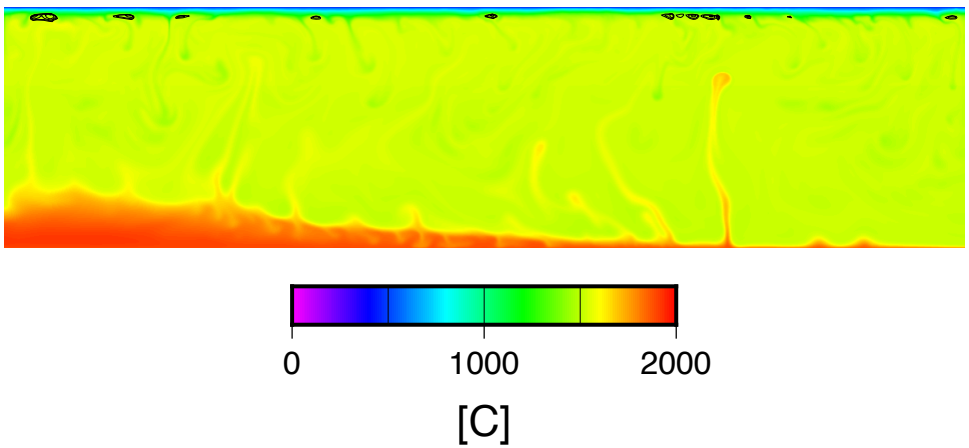

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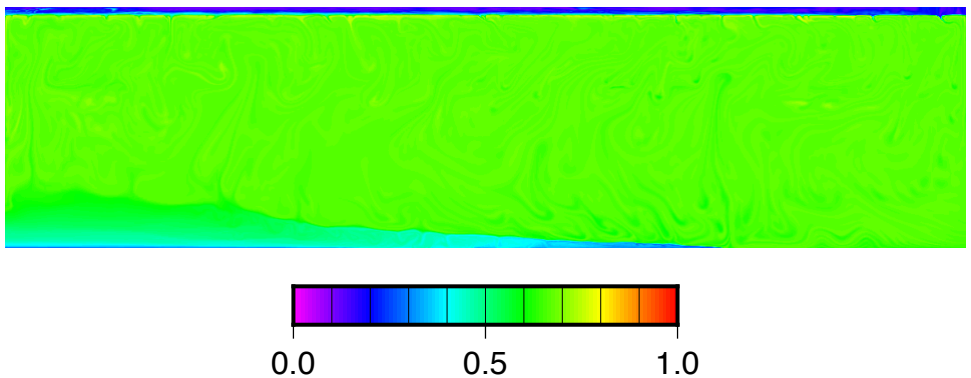

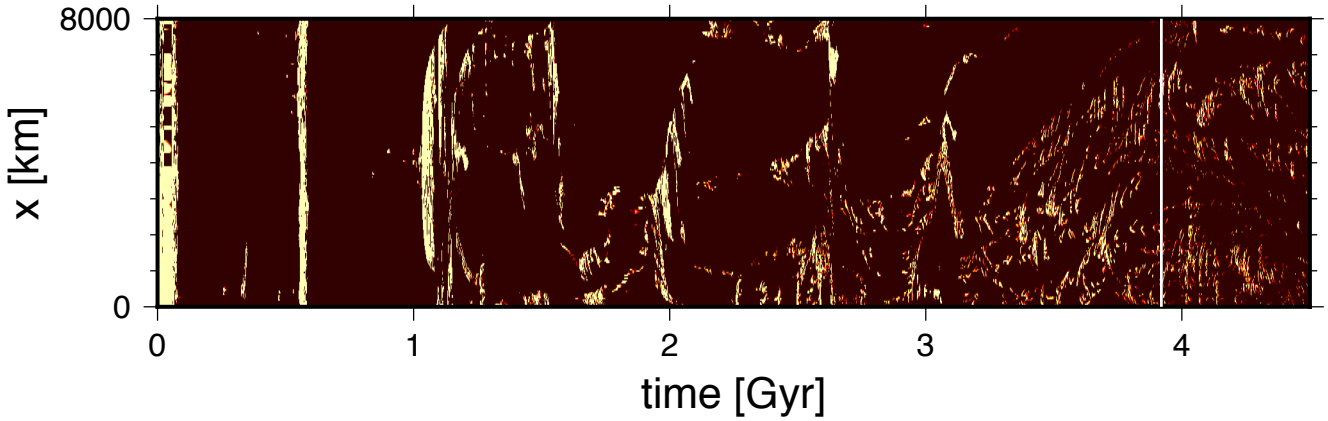

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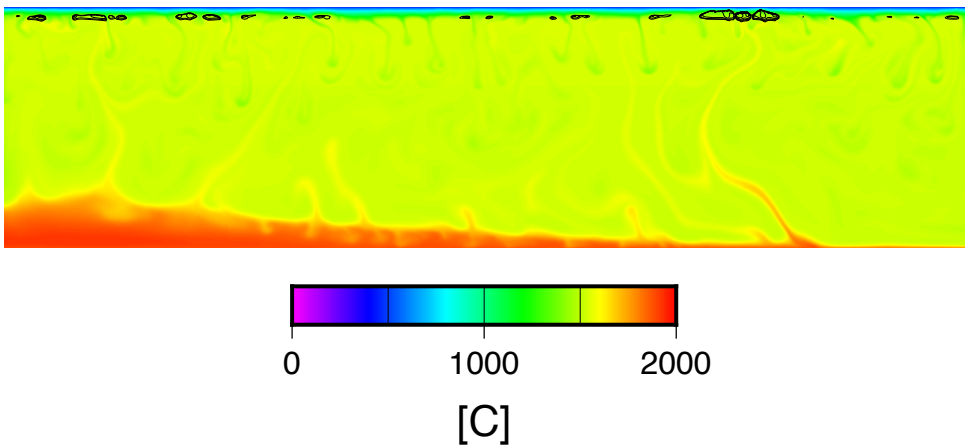

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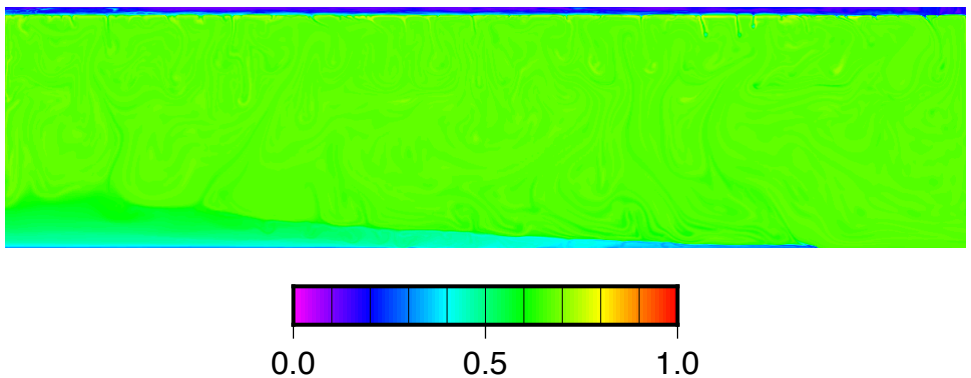

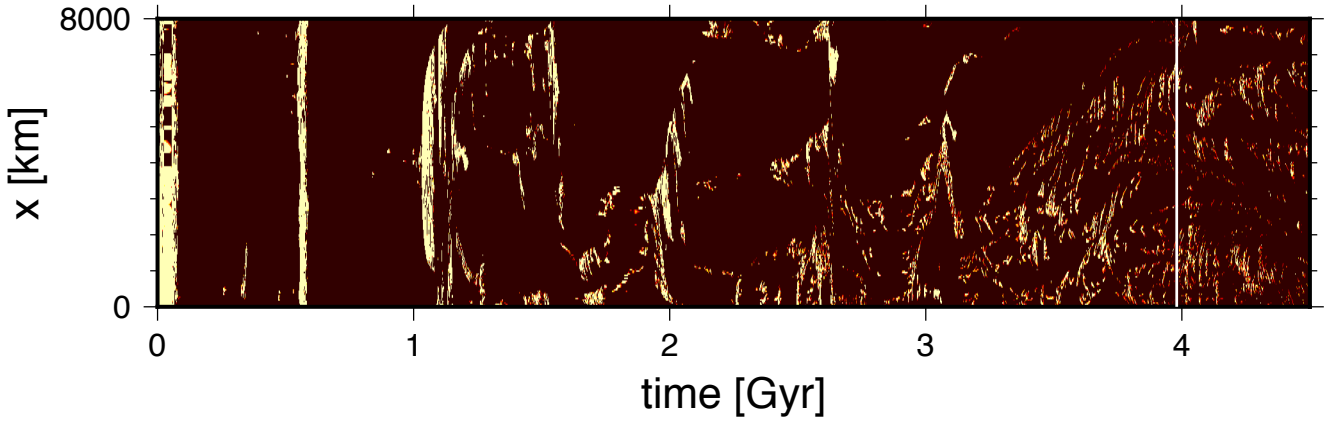

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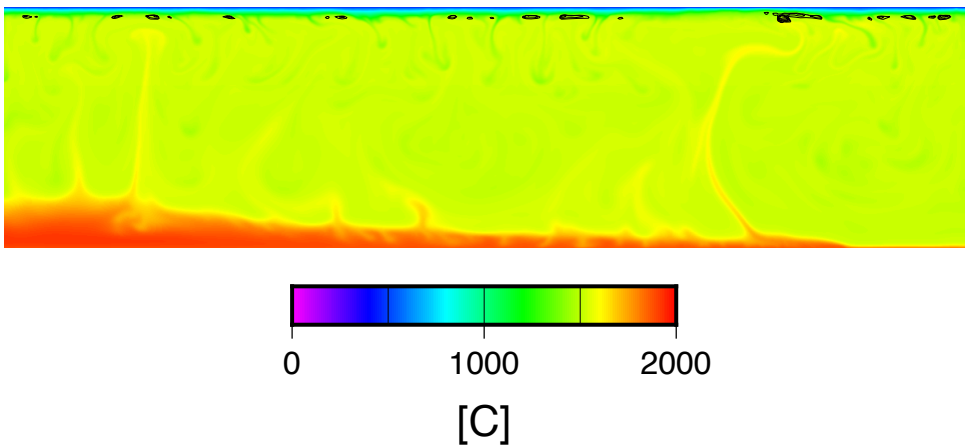

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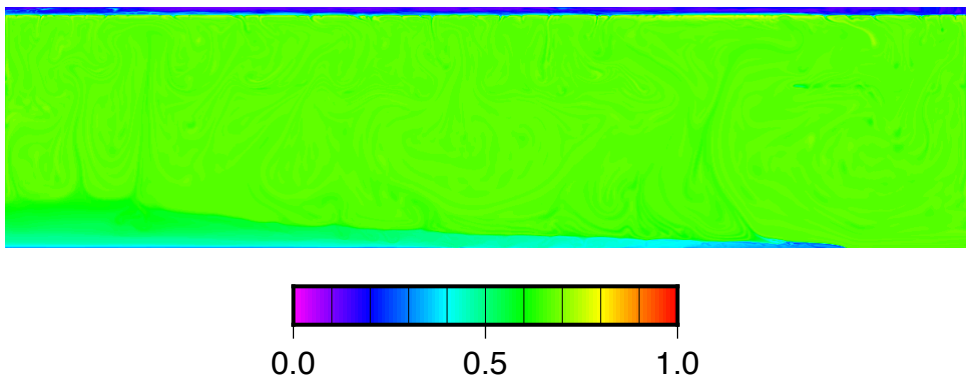

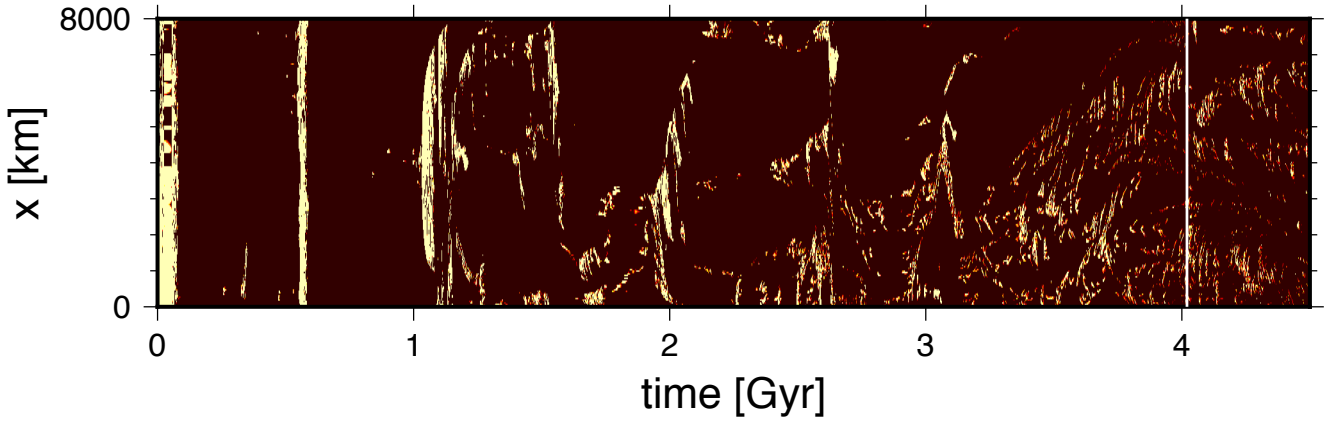

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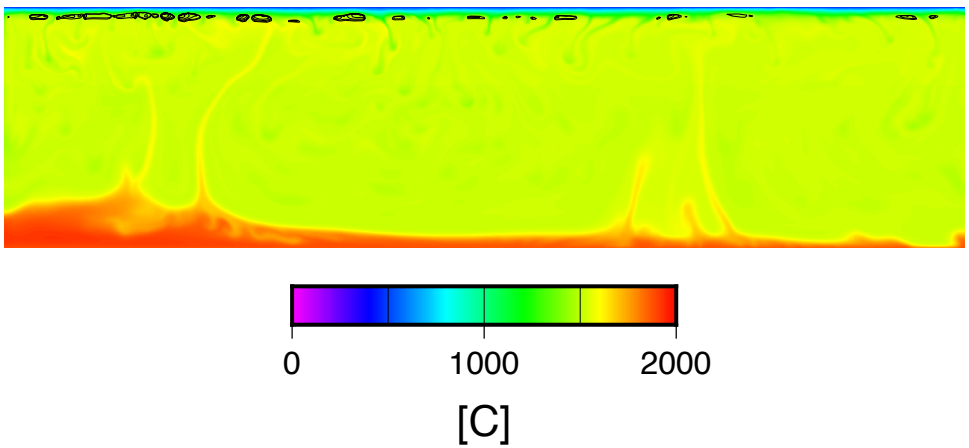

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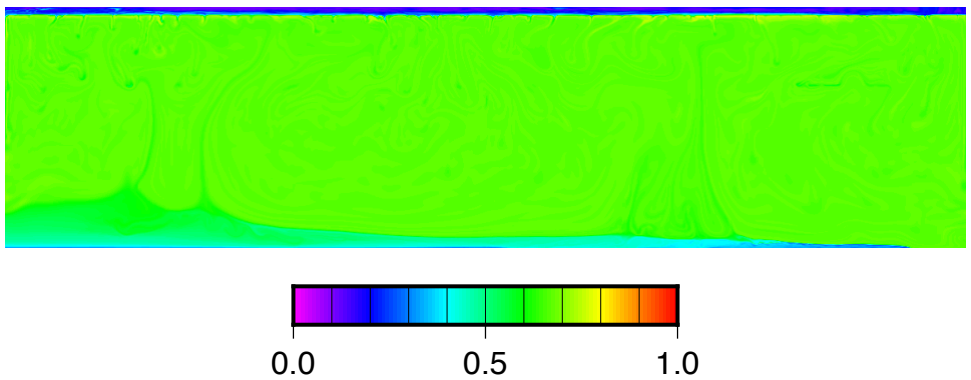

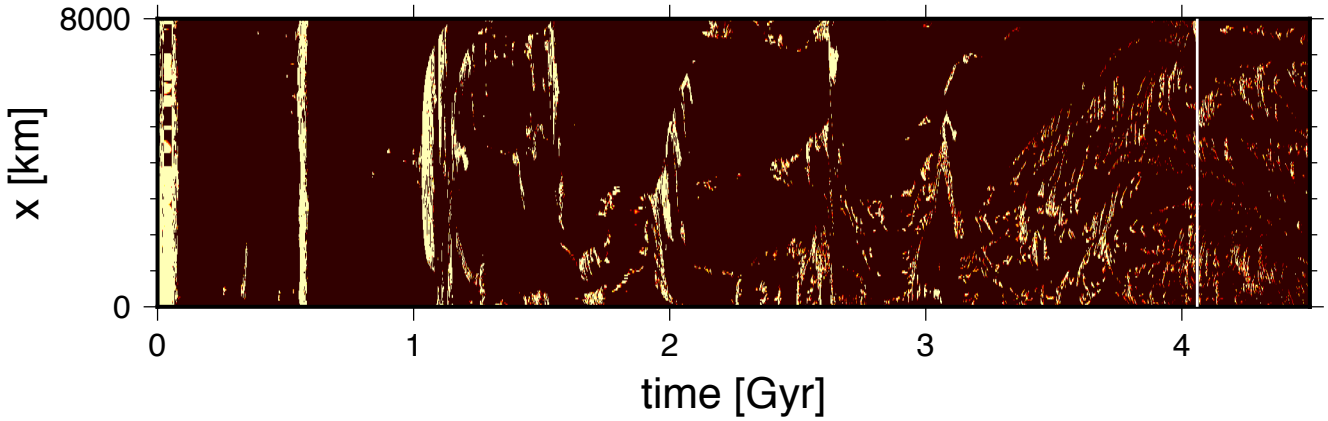

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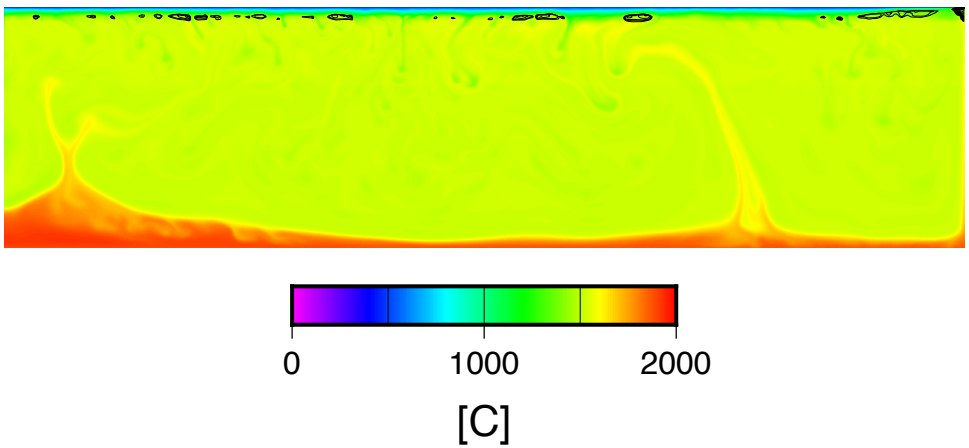

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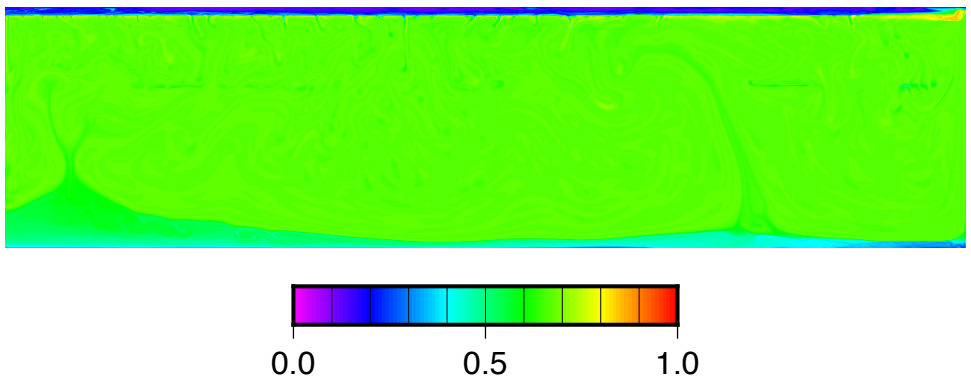

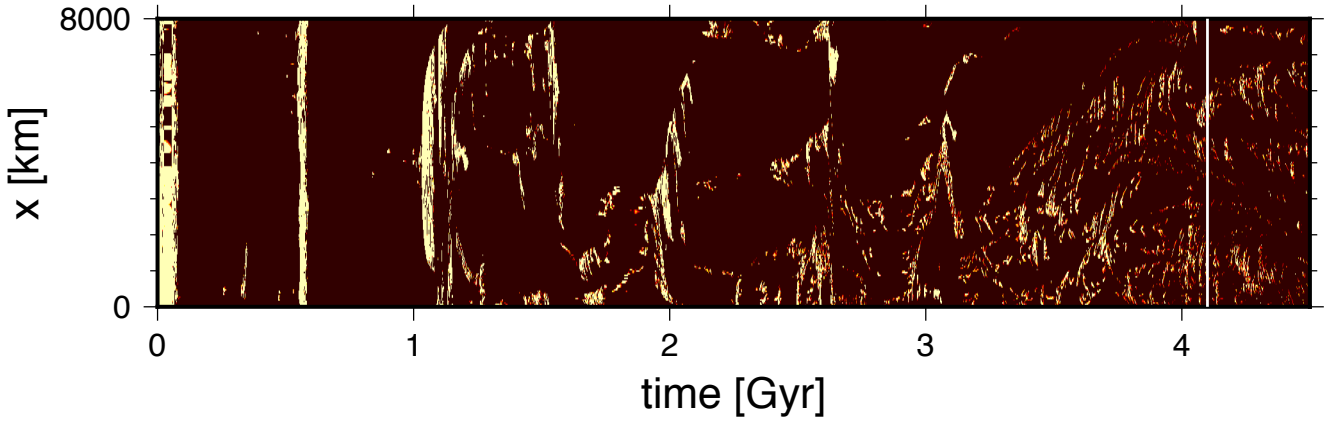

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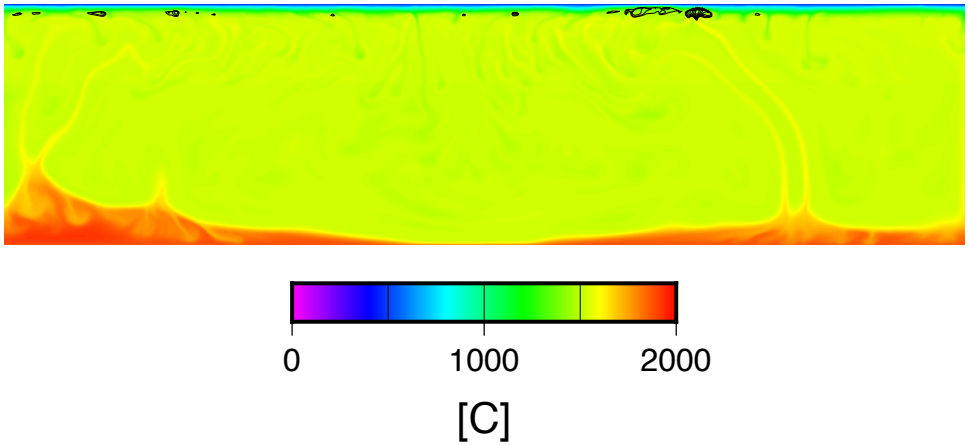

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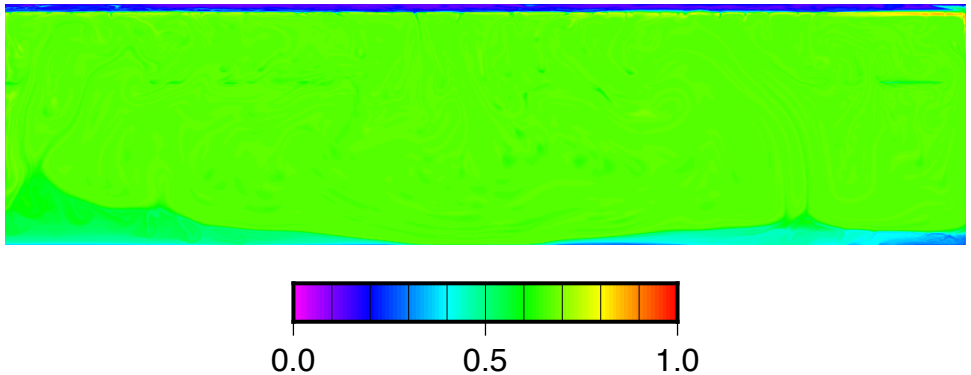

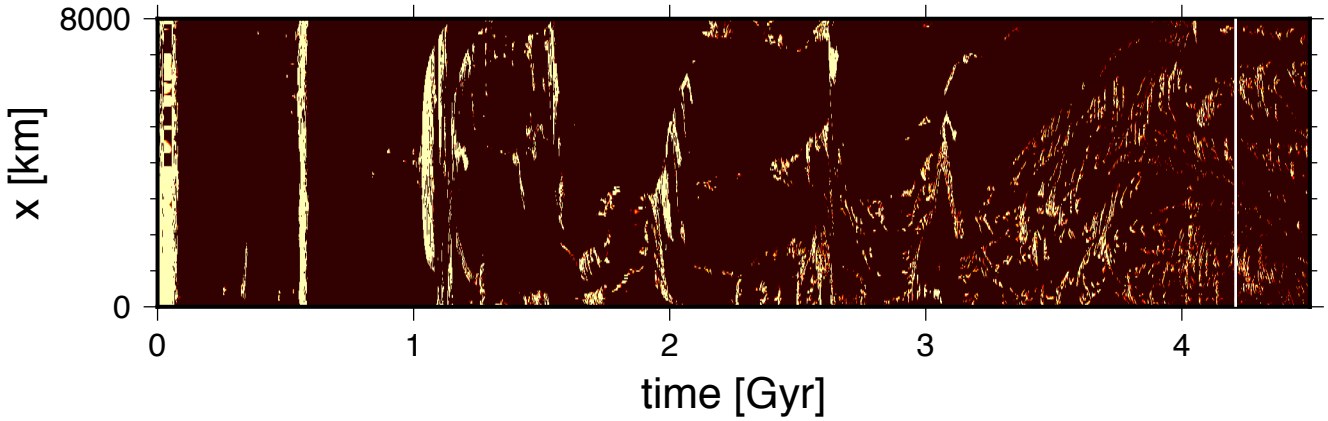

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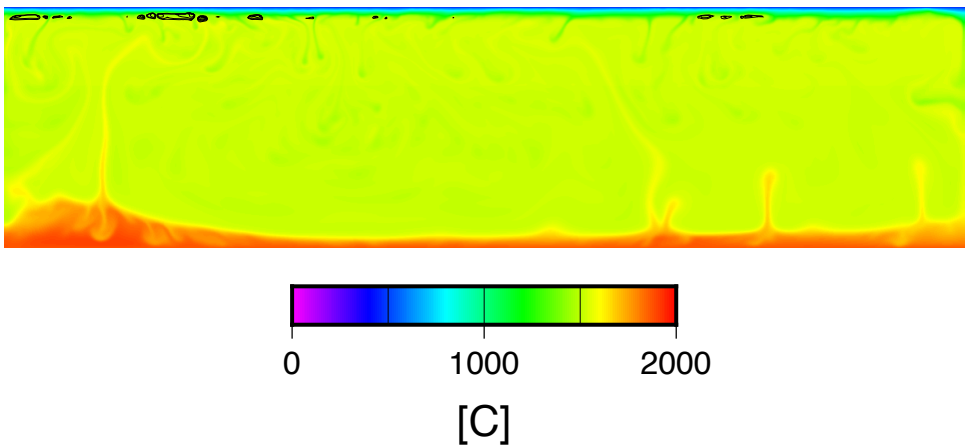

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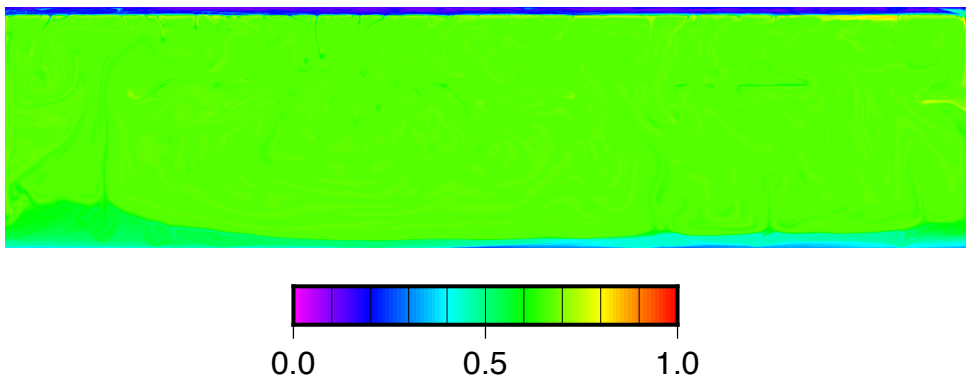

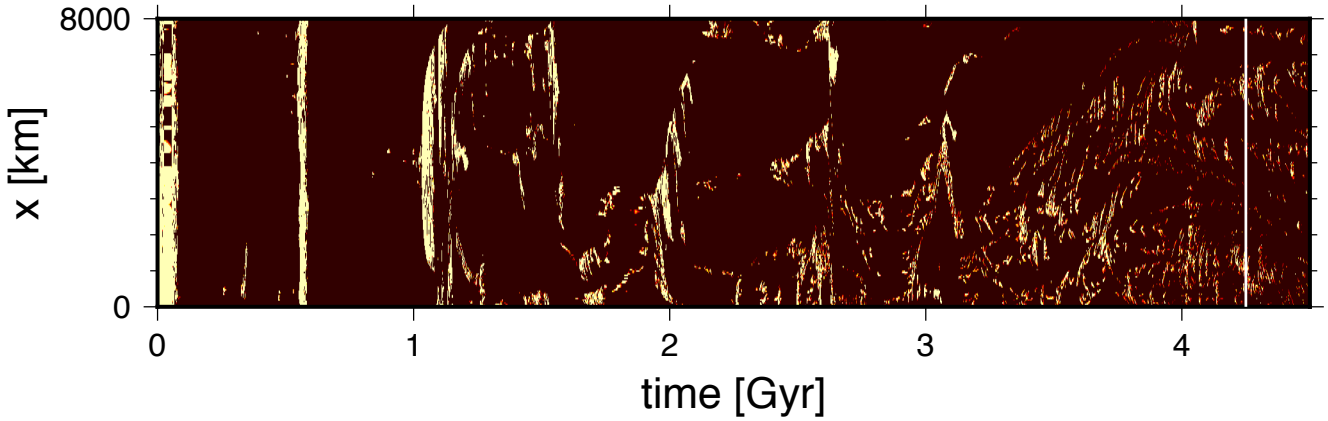

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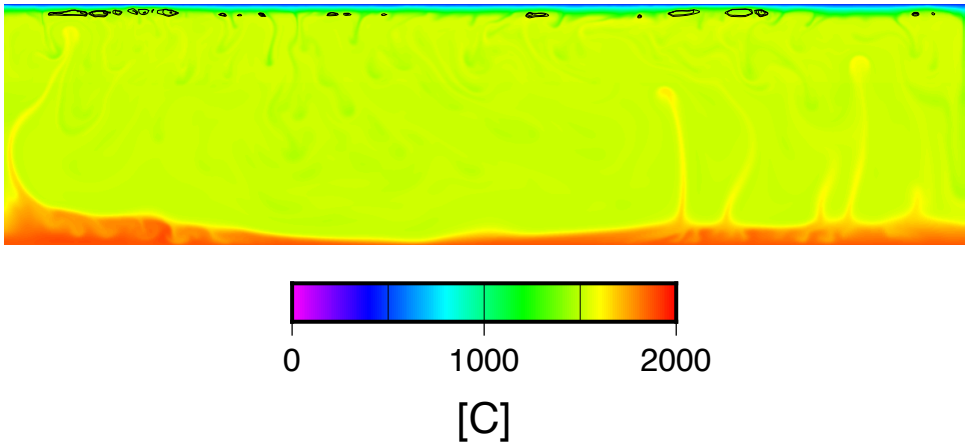

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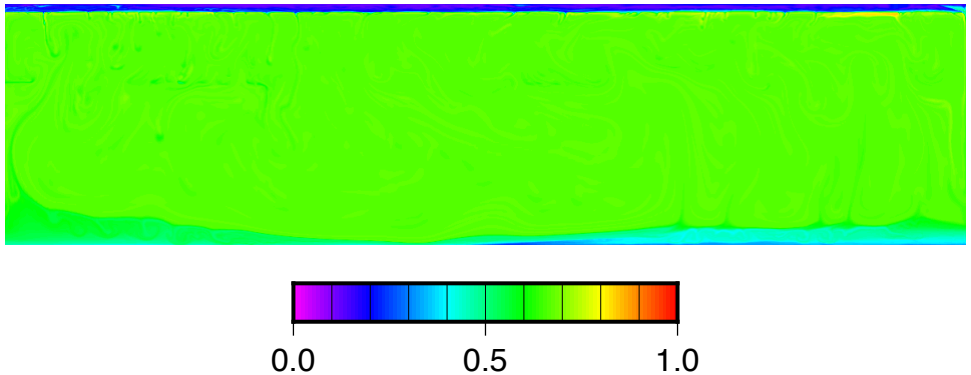

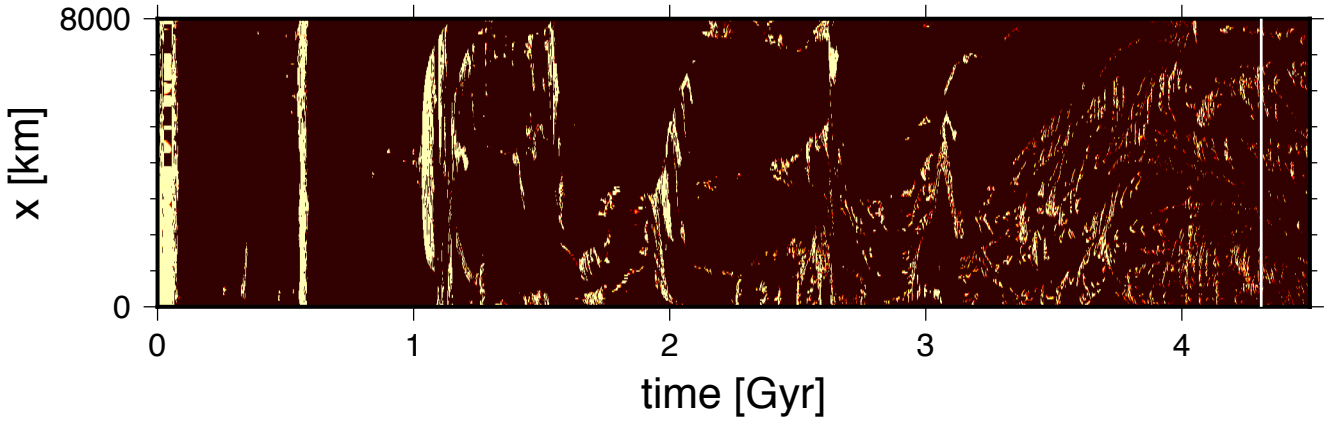

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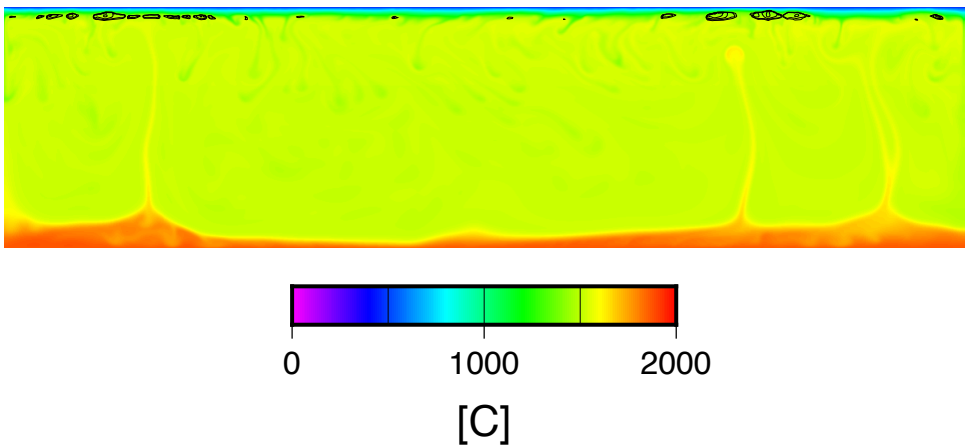

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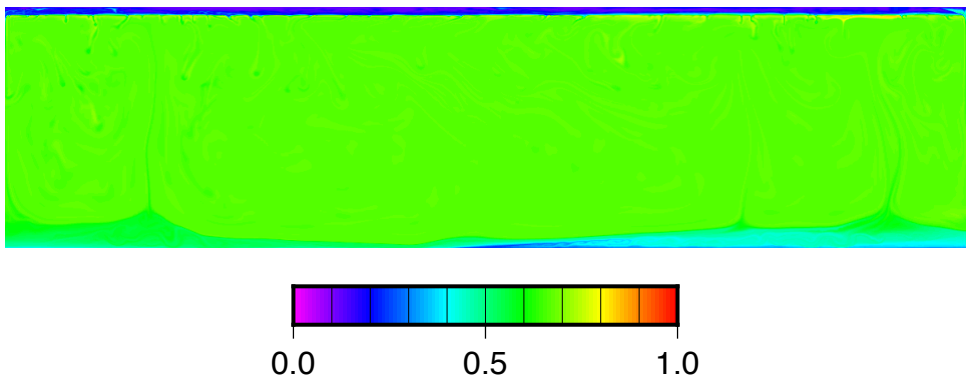

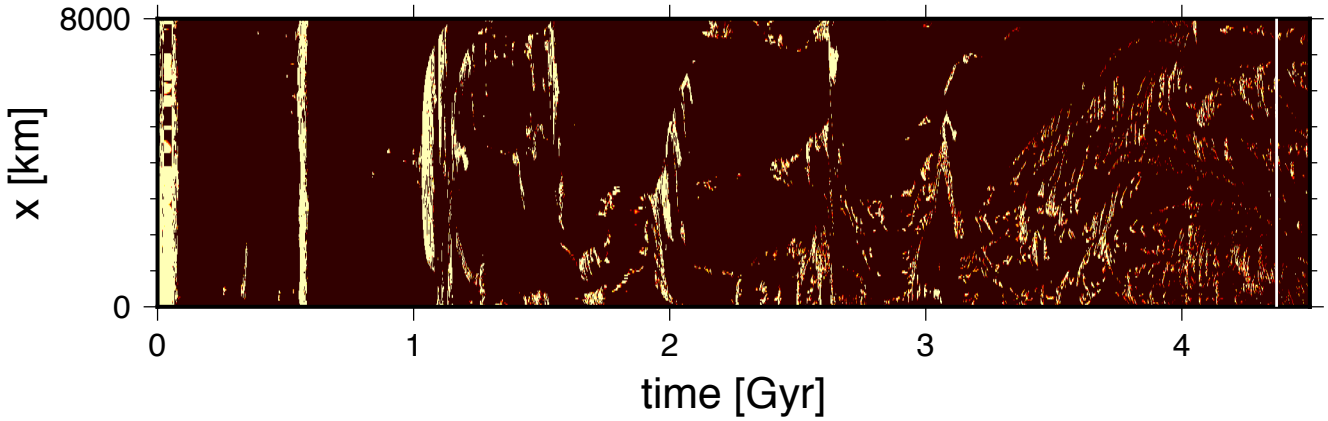

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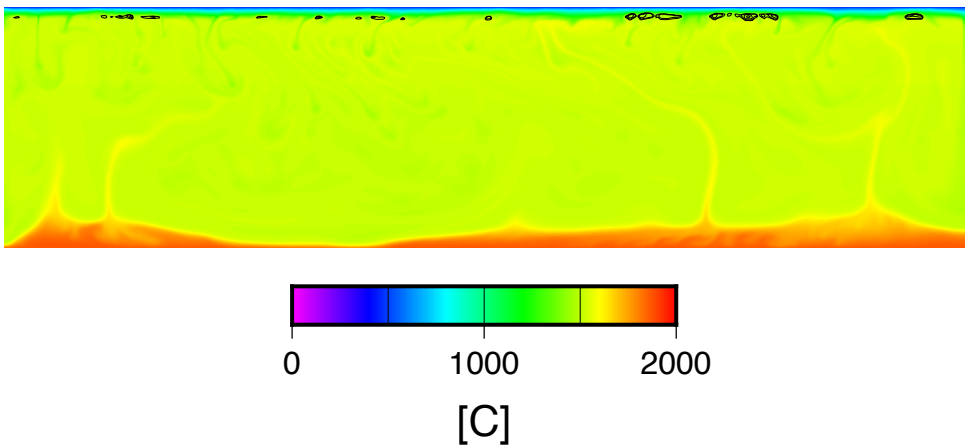

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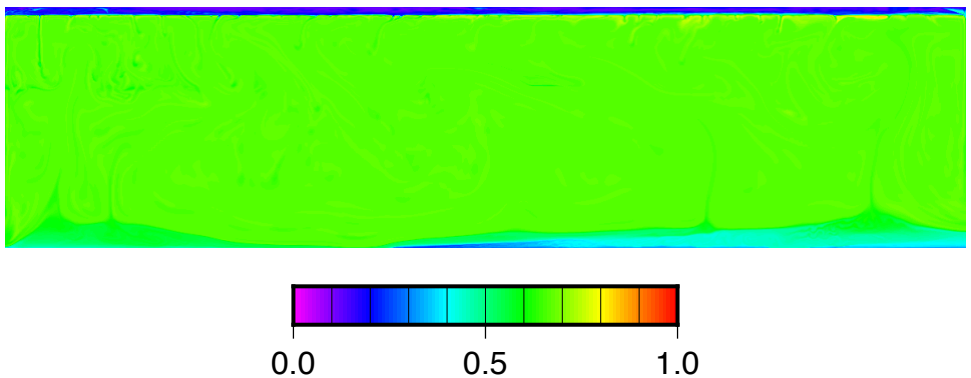

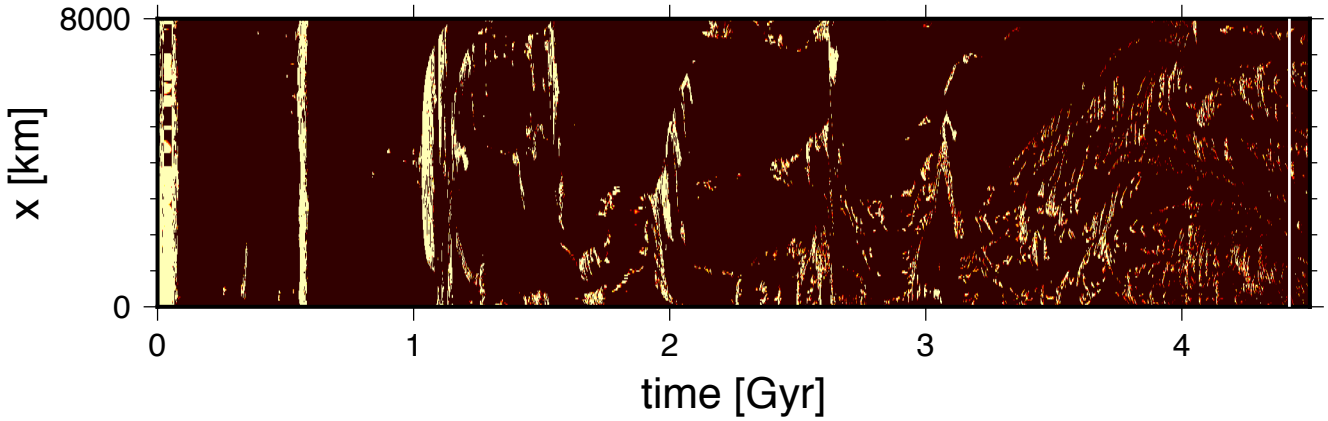

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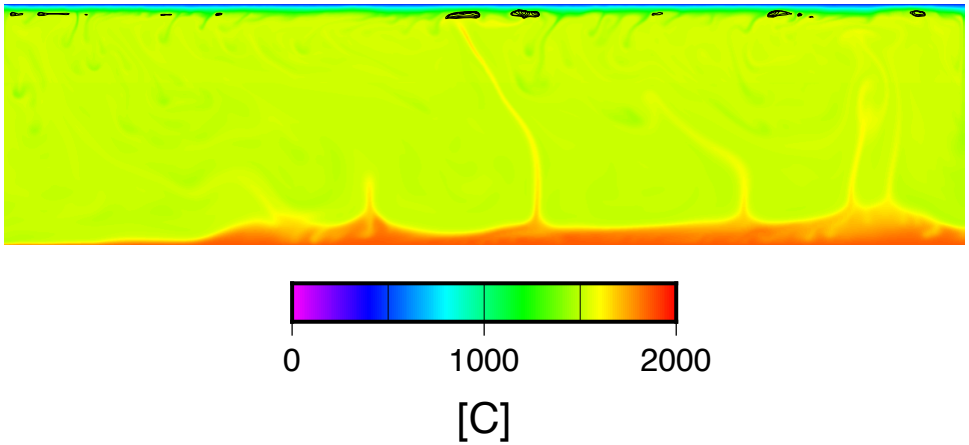

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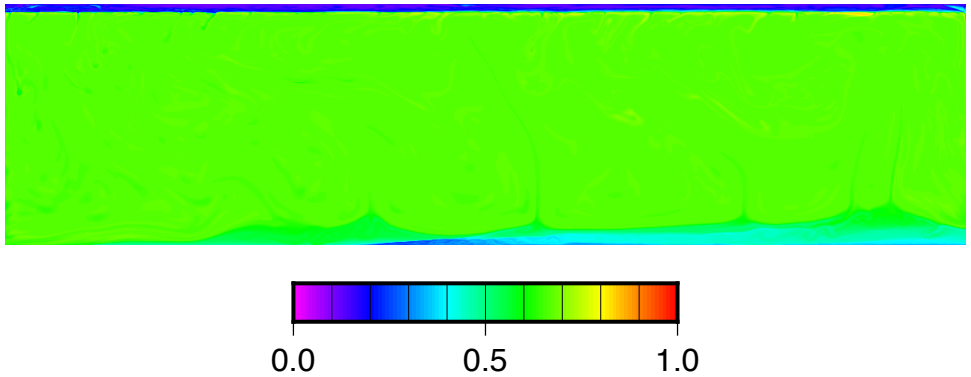

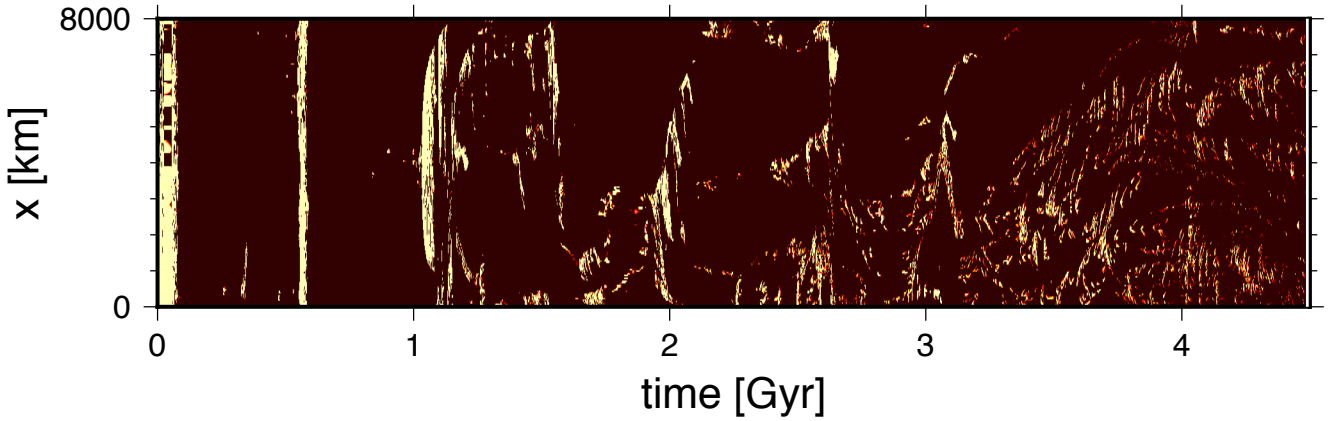

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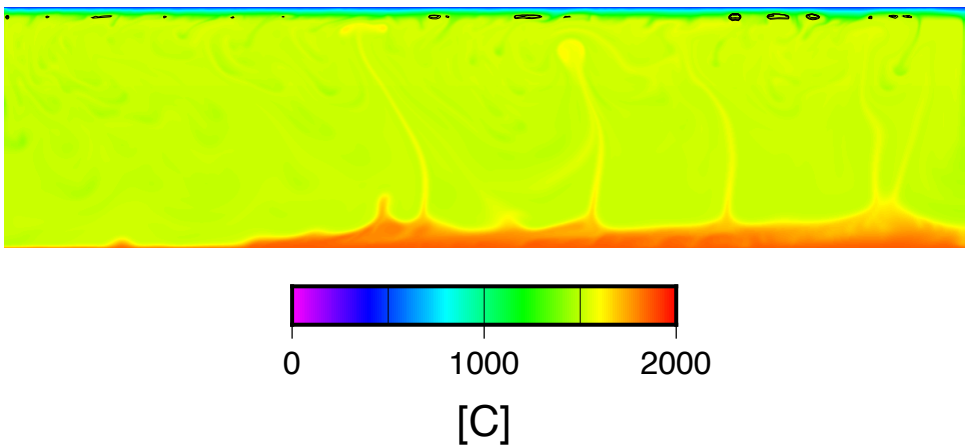
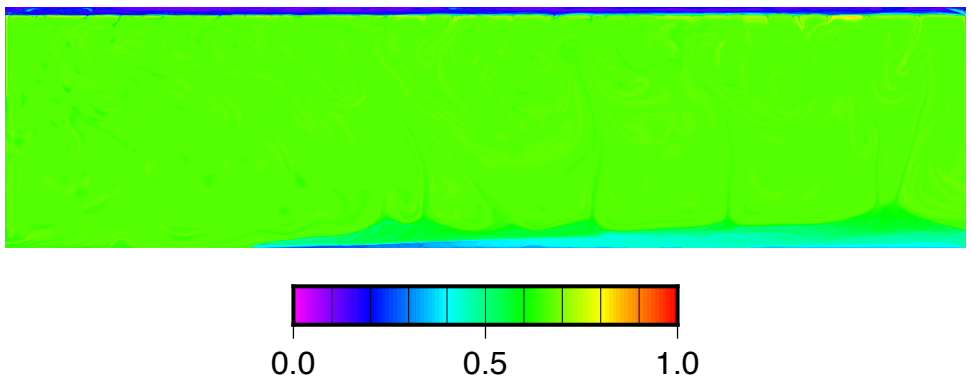
composition