The role of organization in tropical large-scale, convective interactions

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Goal

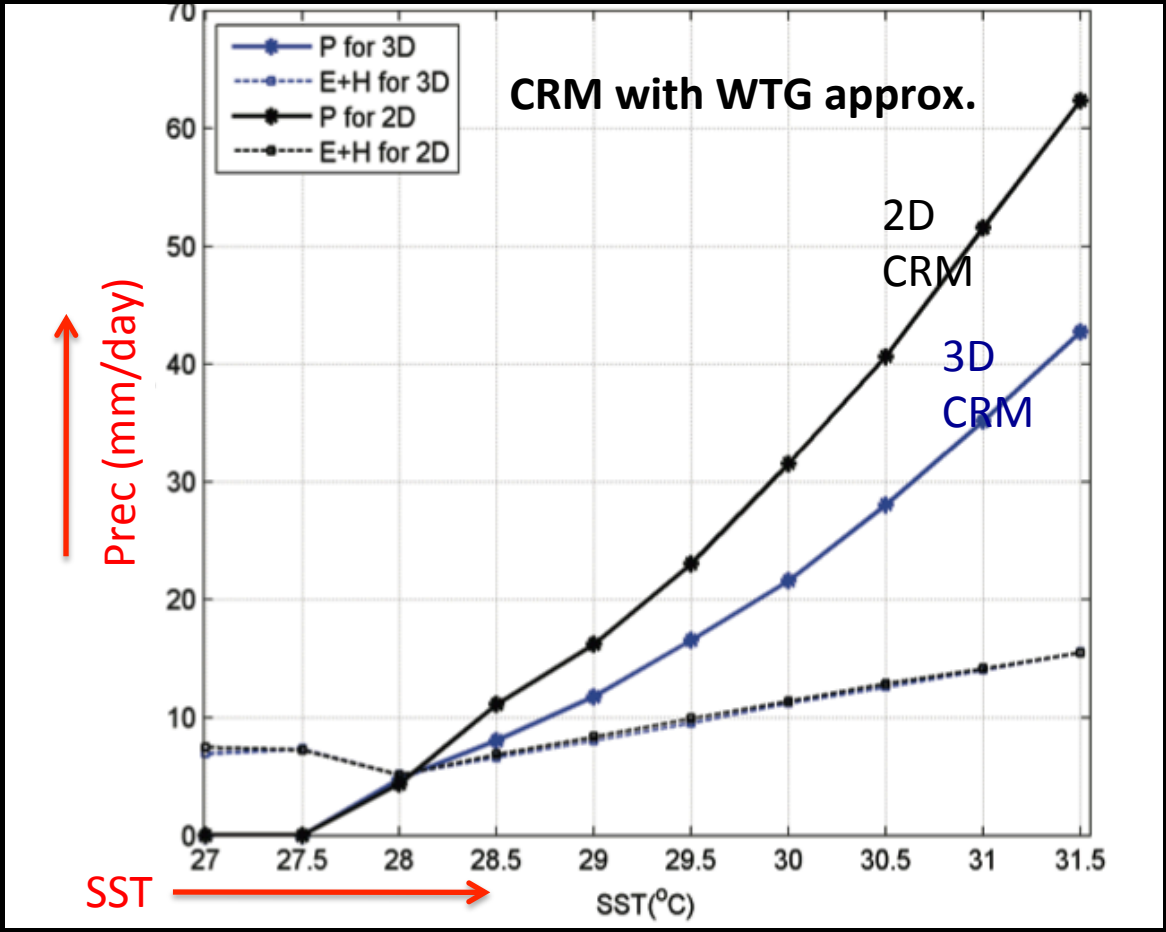
- To better understand the role convective organization plays in coupling convection and the larger-scale

Approach

- Use CSRM in a wave equation test harness to measure **convection + large-scale *interaction***
- Manipulate CSRM to **control "organization"**

Hypothesis

- For the coupled convective, large-scale system, organized convection is more responsive than scattered convection



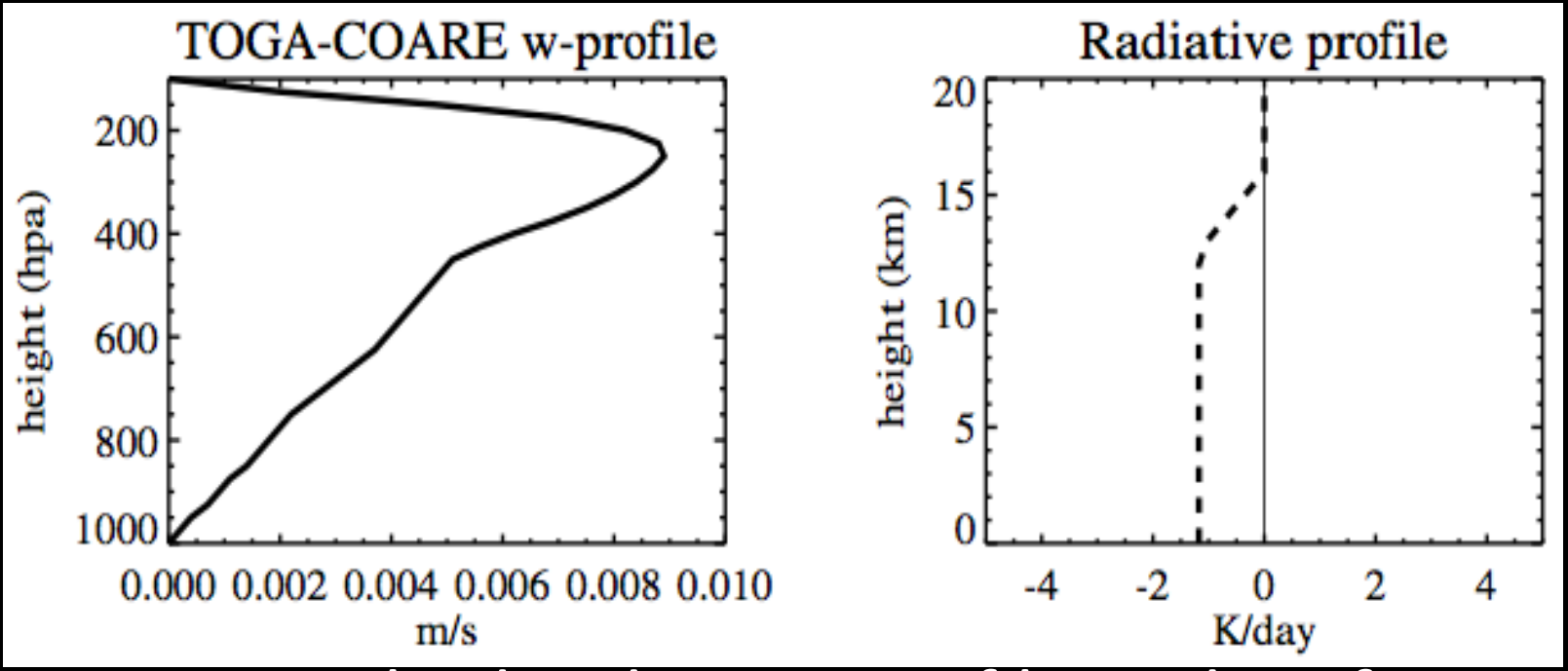
Wang and Sobel 2011

CSRM: System for Atmospheric Modeling (SAM)

- The nuts and bolts:
  - Anelastic equations of motion
  - Smagorinsky-type turbulence closure
  - Prognostic thermo. variables: liquid water static energy, total non-precip. water, & total precip. water
  - Bulk microphysics

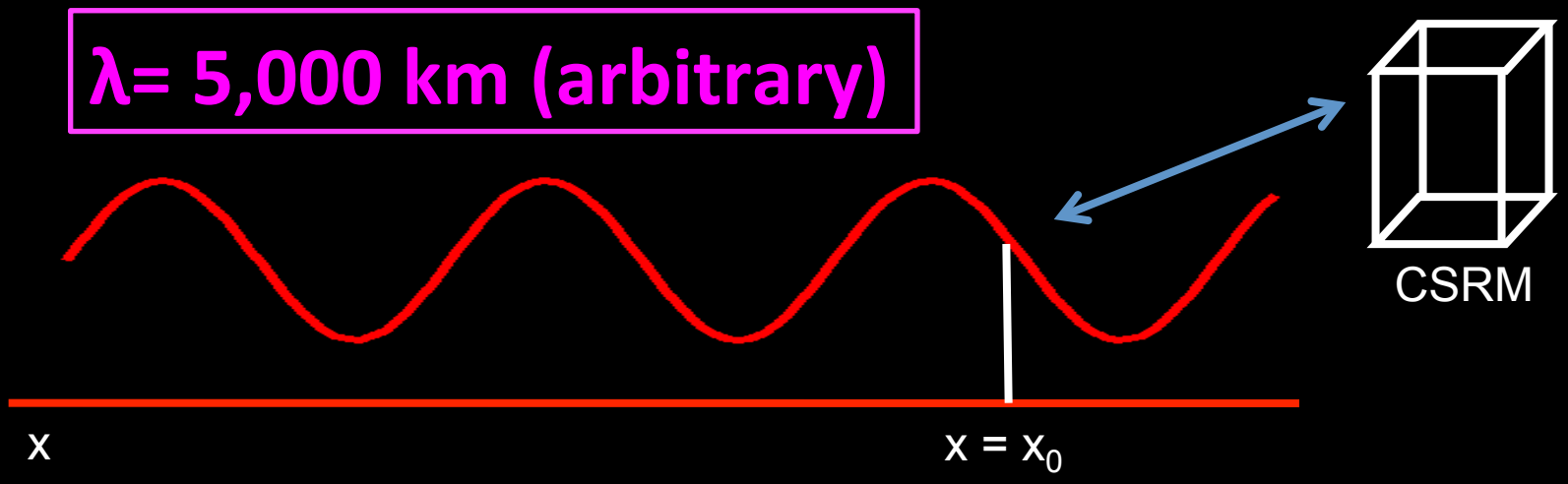
SAM provided by Marat Khairoutdinov

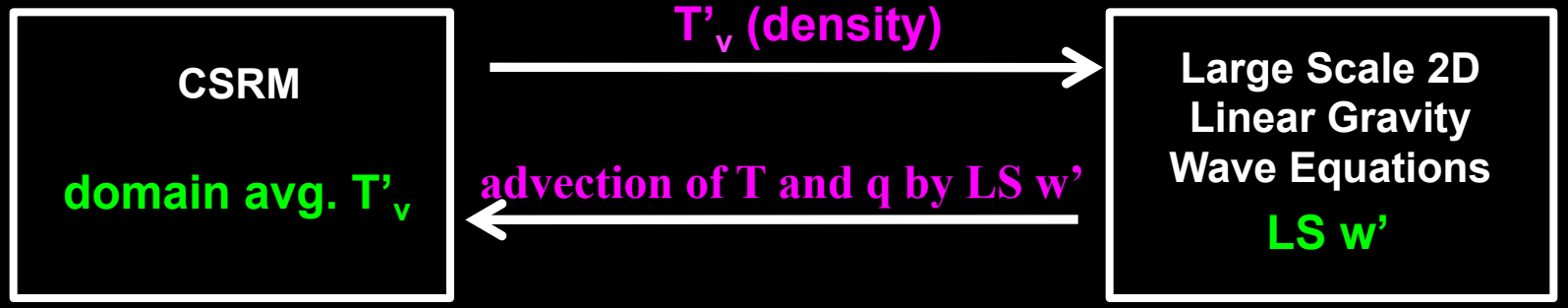
CSRM: System for Atmospheric Modeling (SAM)



- Prescribed radiation profile and surface wind speed in flux formula
- Background vertical velocity profile
  - acts only on background temperature and moisture profile, so constant forcing of the CSRM

SAM with parameterized large-scale dynamics

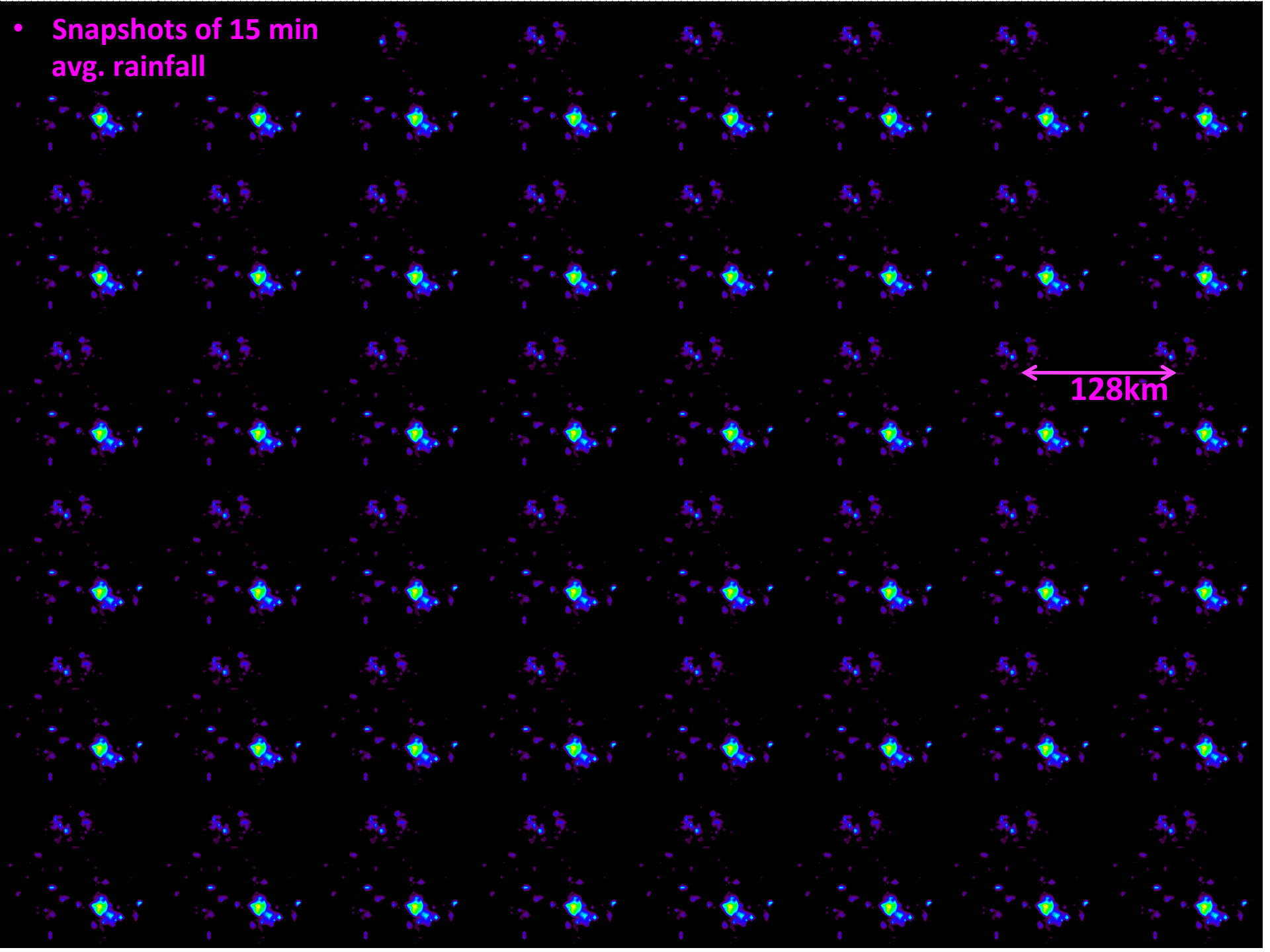


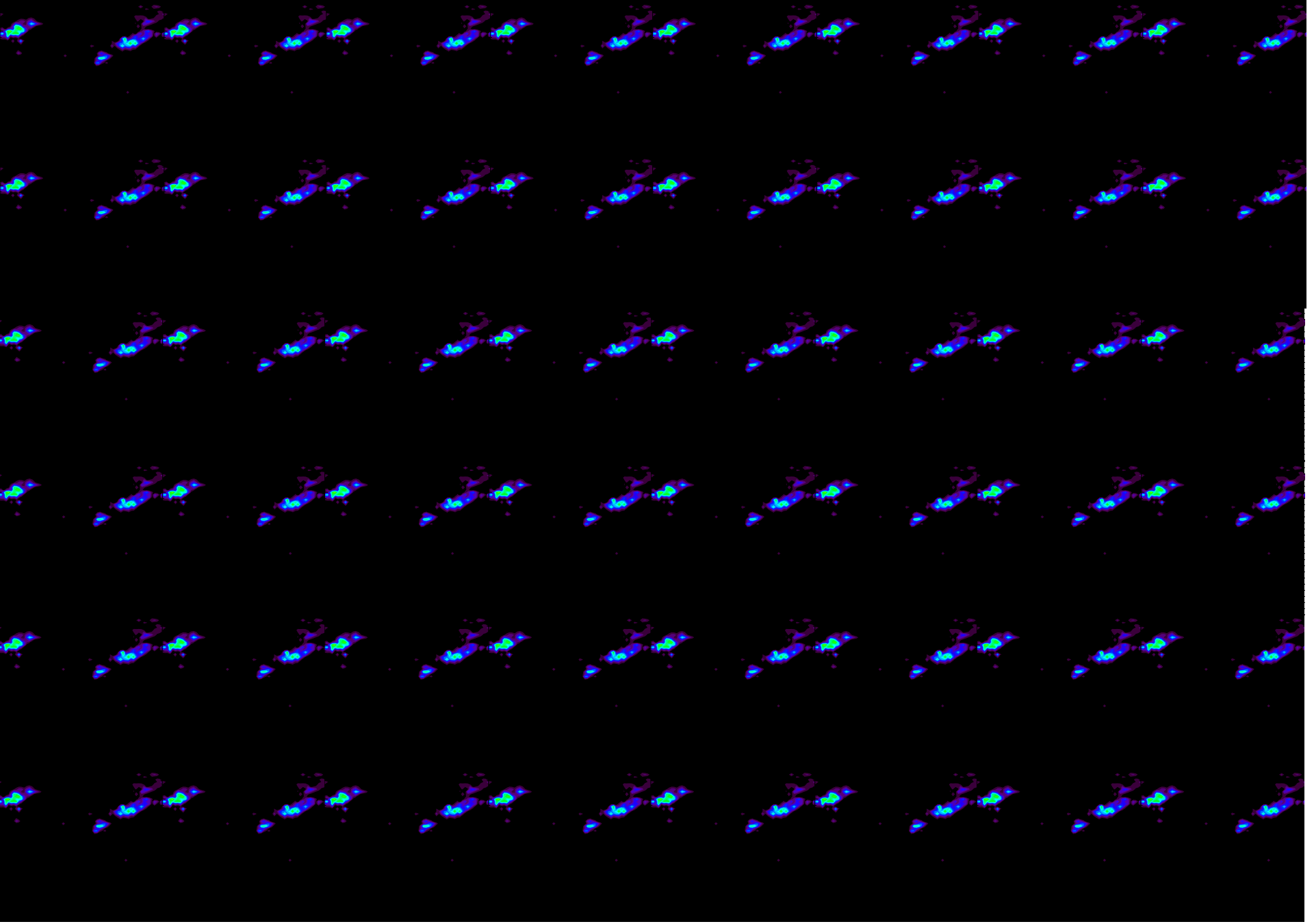


(Kuang 2008)

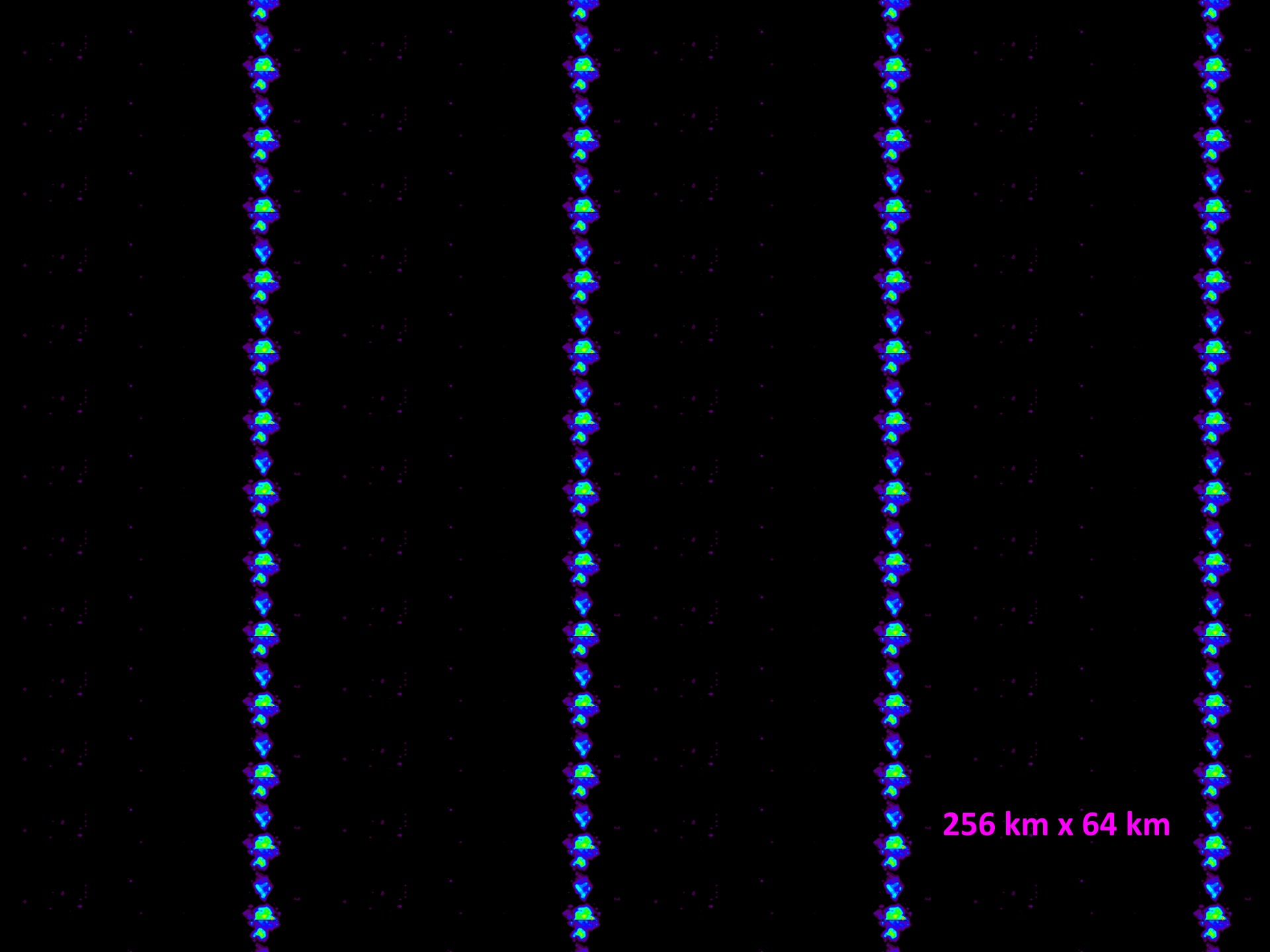
More or less *organized* convection via altering domain geometry, size, or adding shear

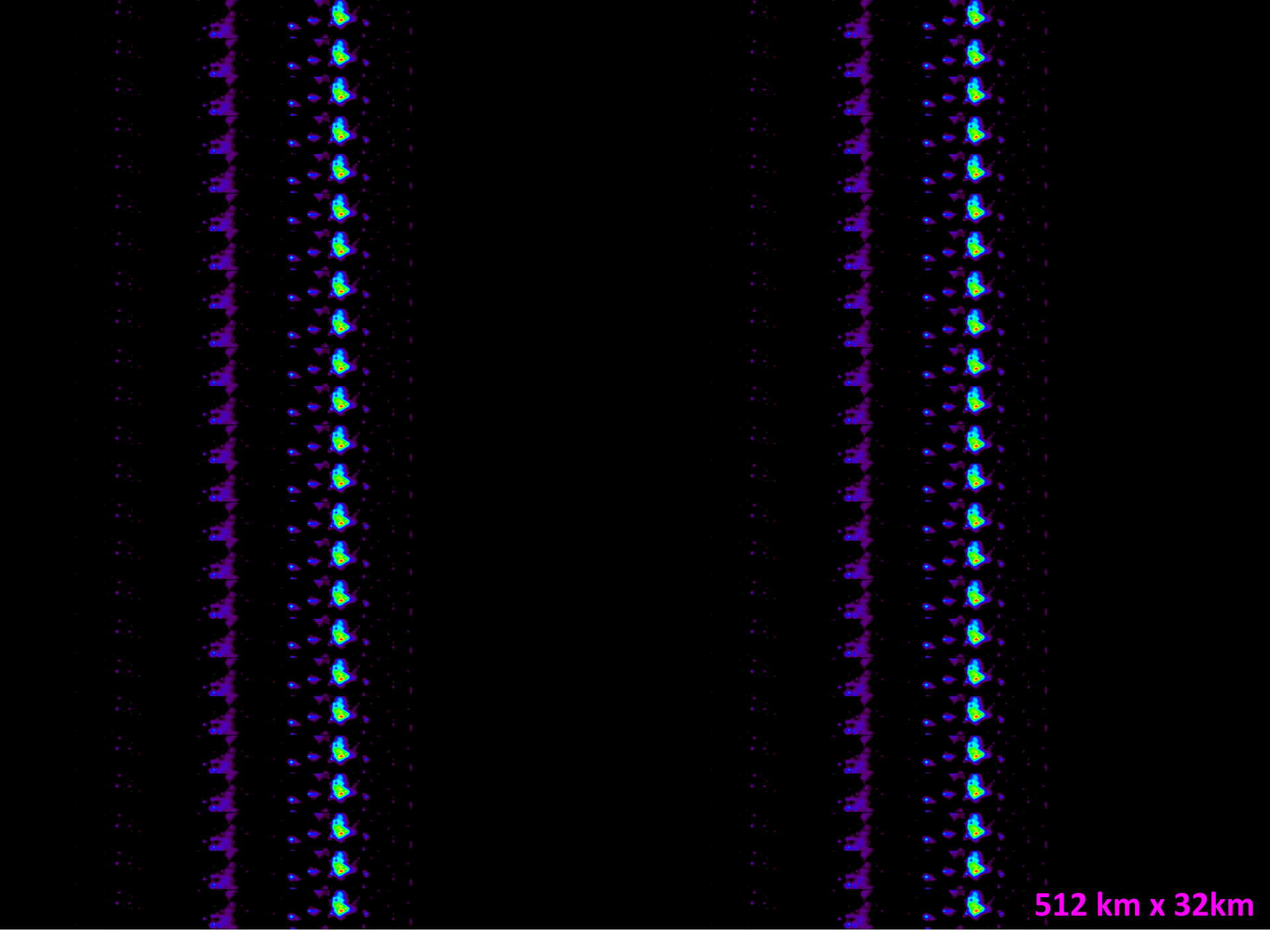
- Snapshots of 15 min avg. rainfall



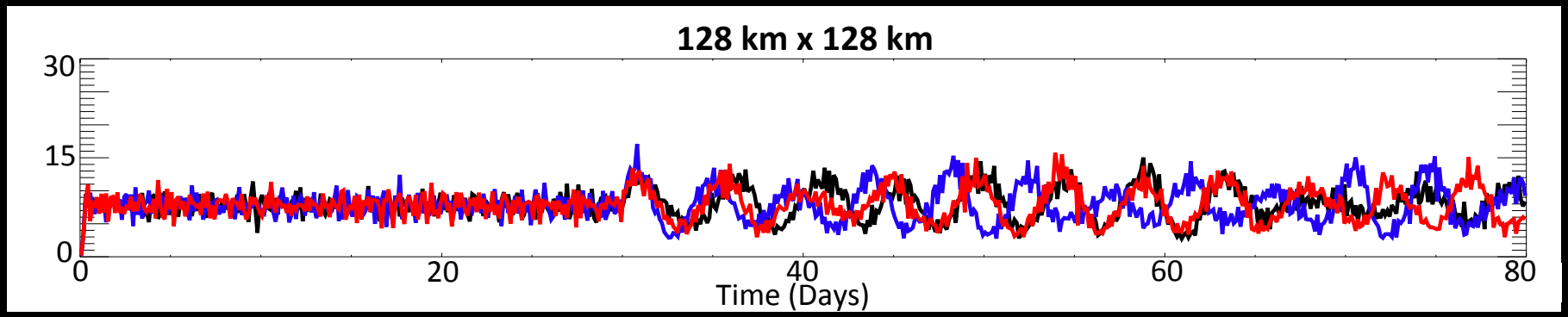


128 km x 128 km + shear

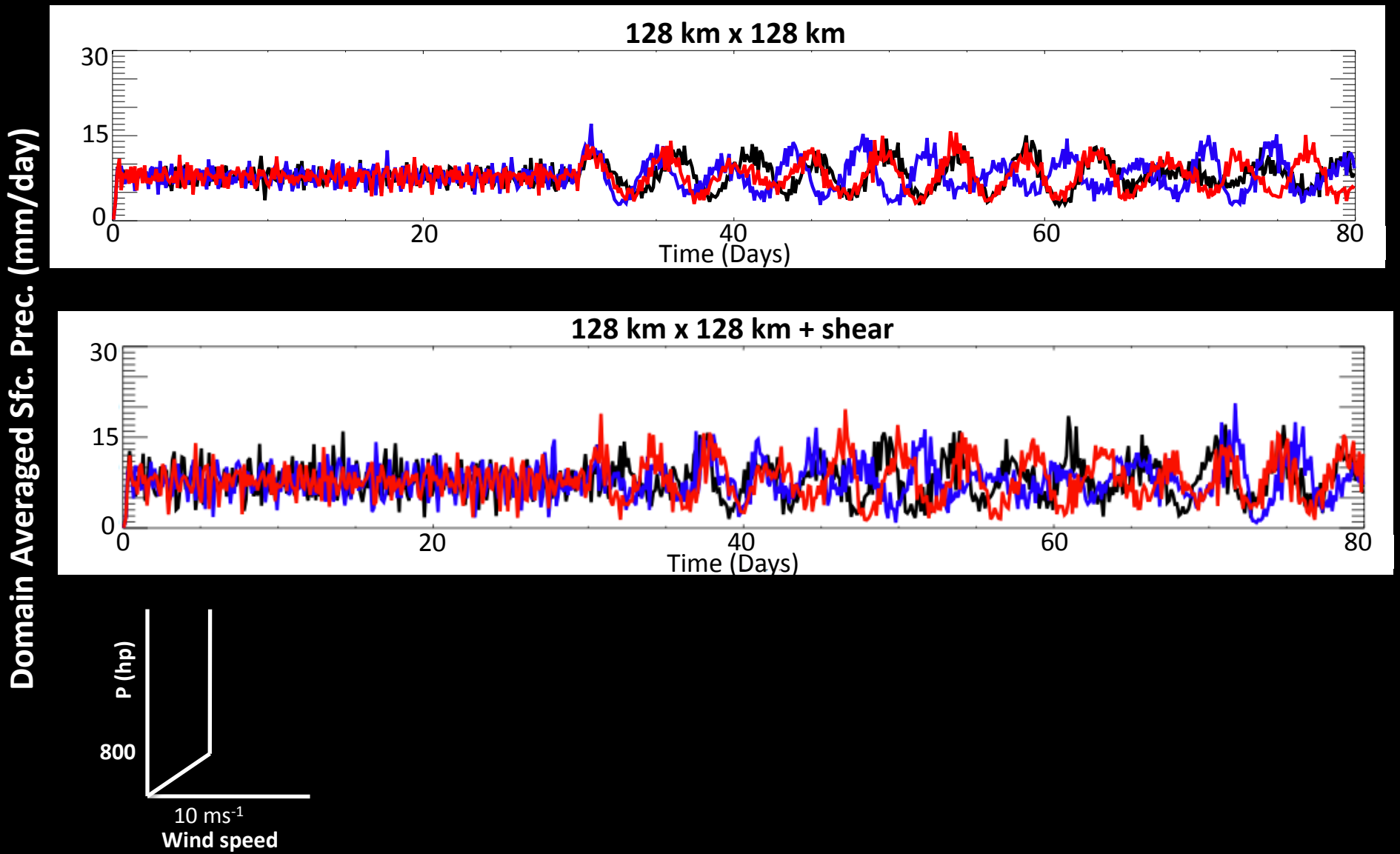

256 km x 64 km


512 km x 32km

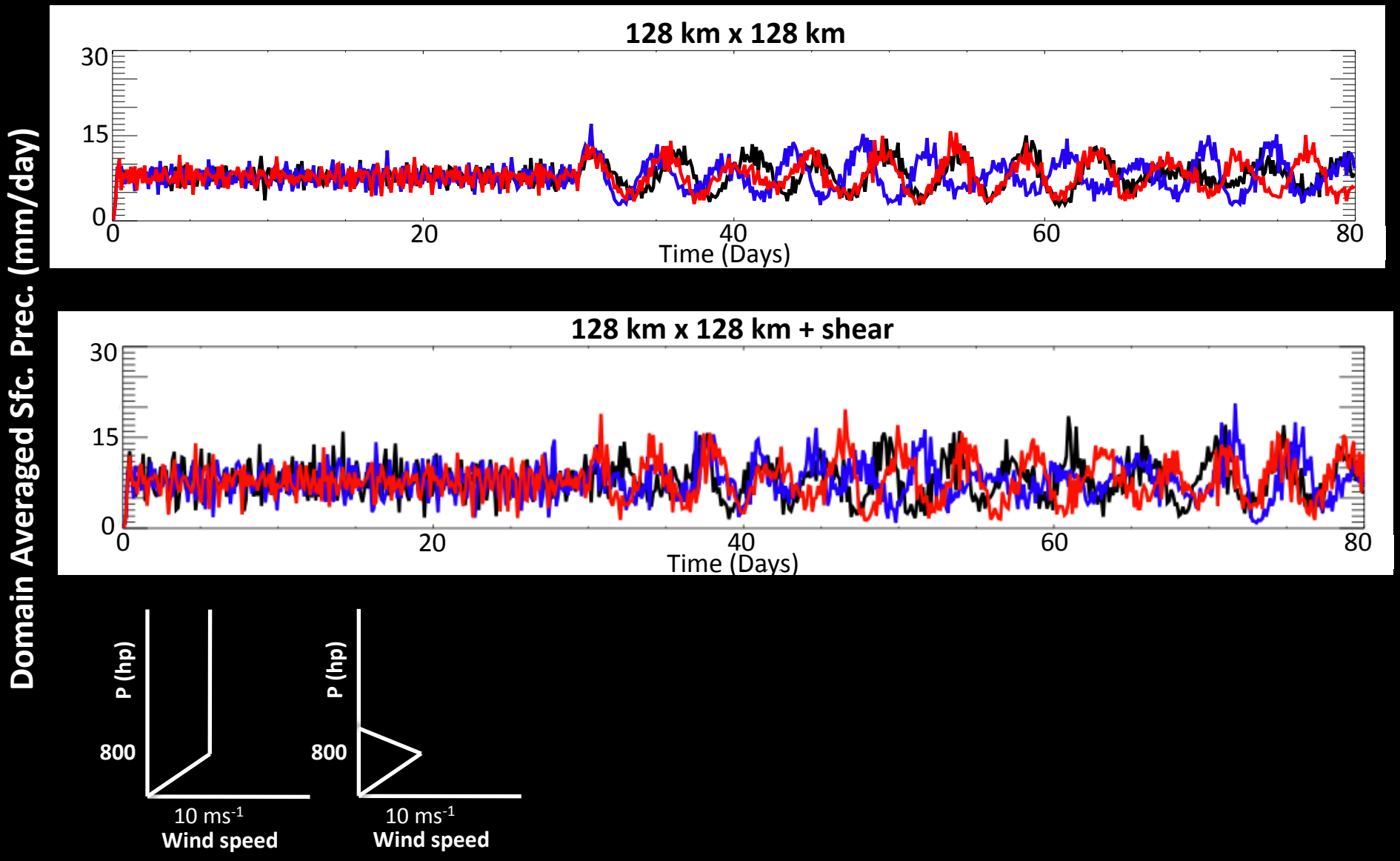
Altering organization with shear



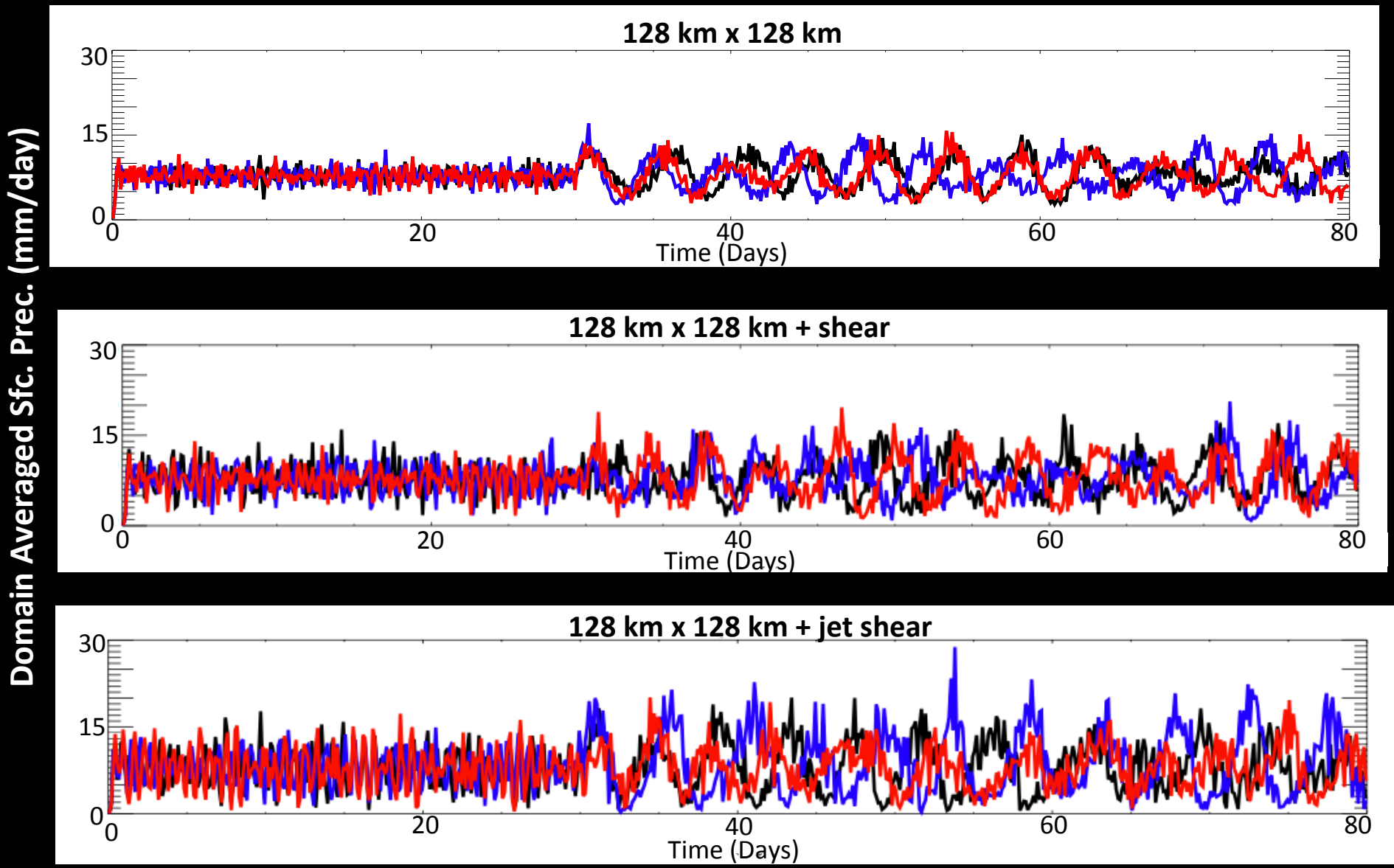
Altering organization with shear



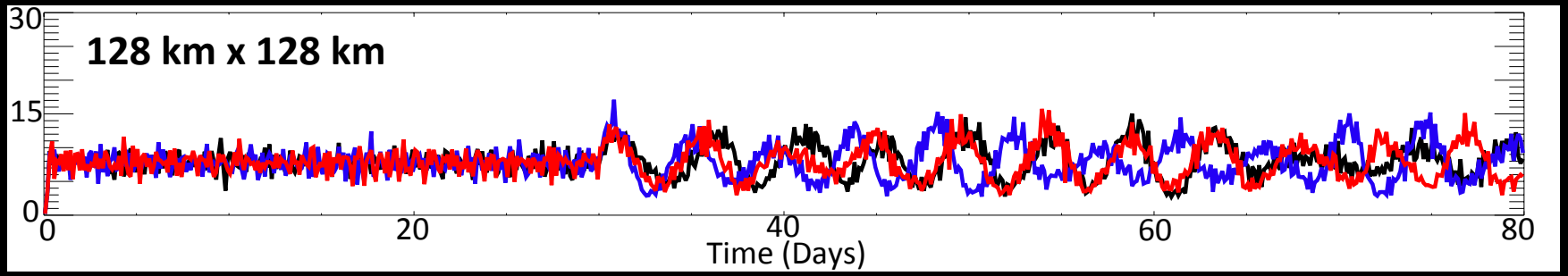
Altering organization with shear



Altering organization with shear

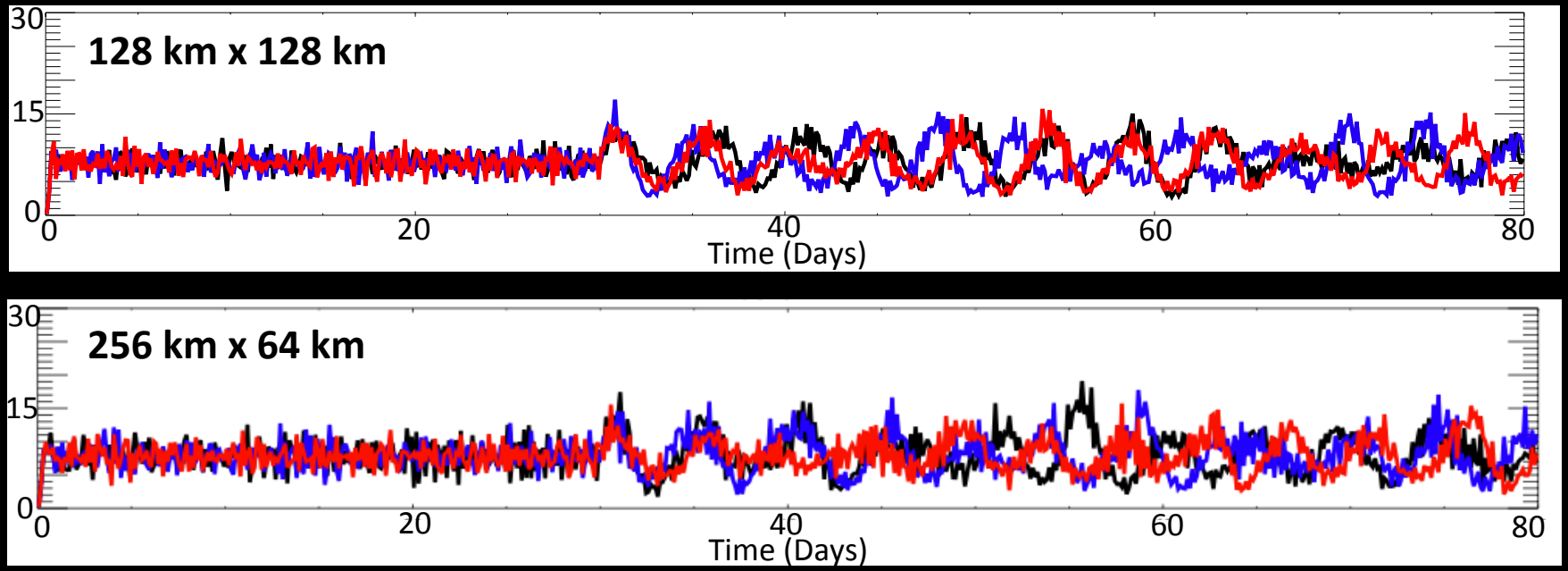


Altering organization by changing domain shape

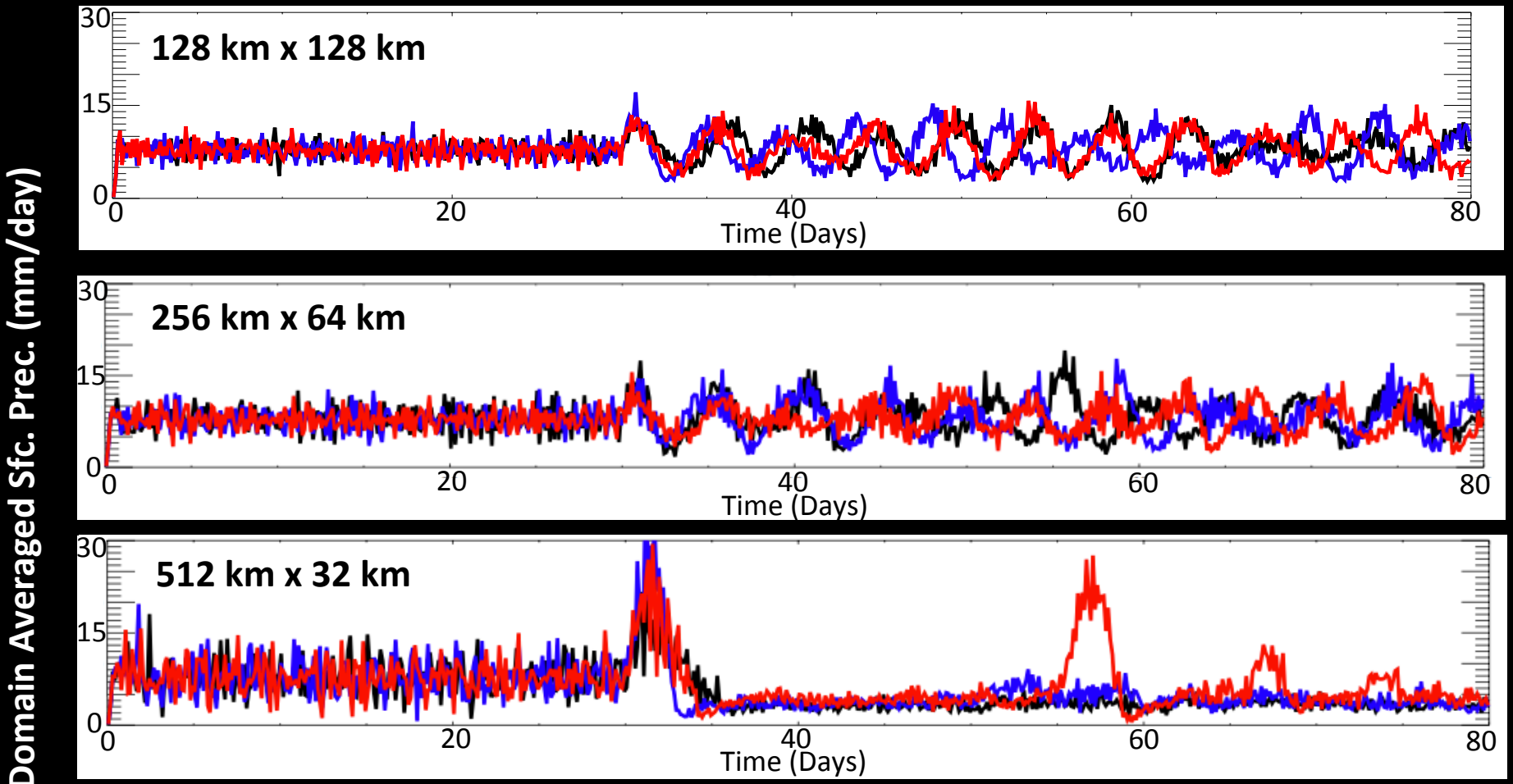


Domain Averaged Sfc. Prec. (mm/day)

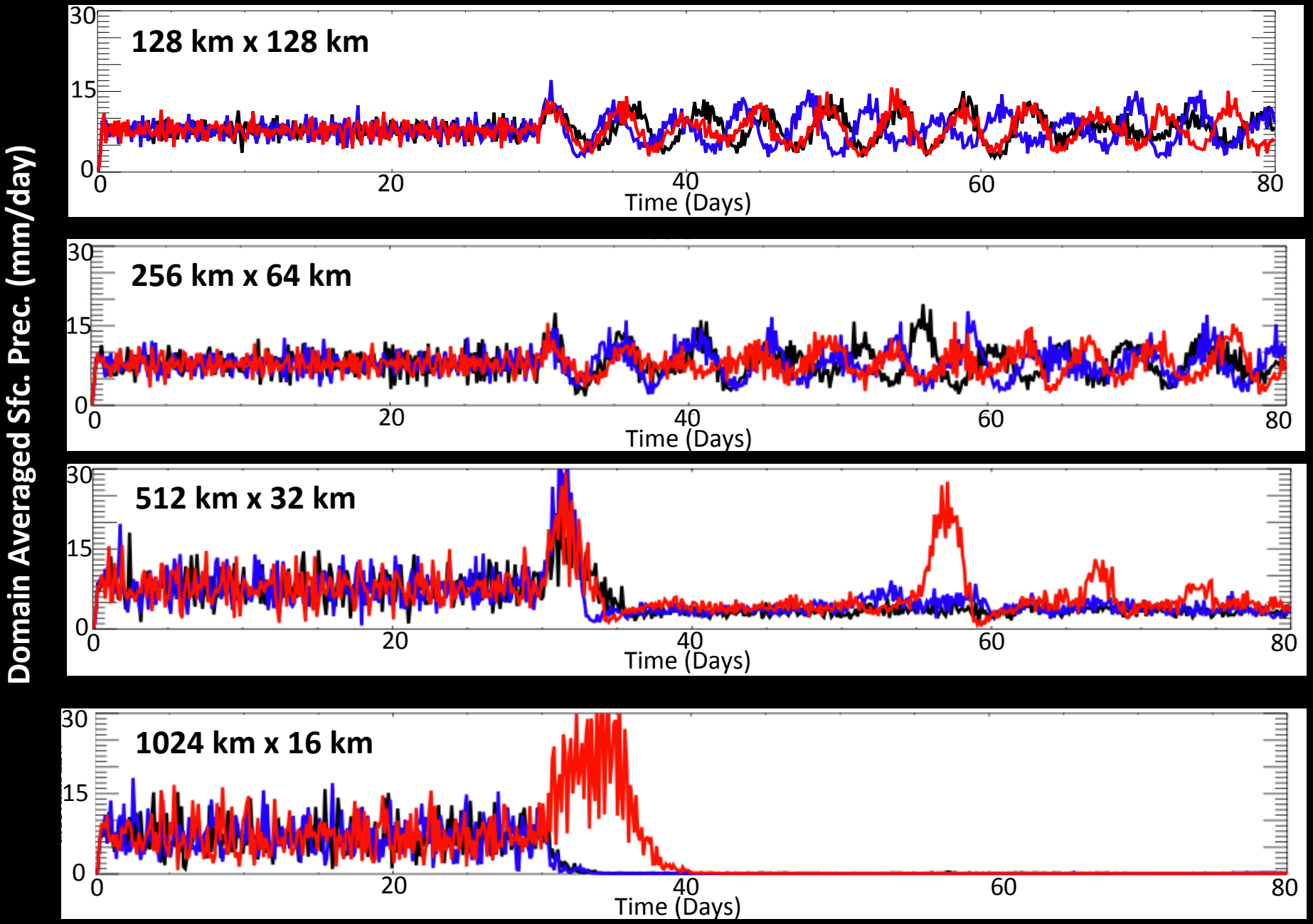
Altering organization by changing domain shape

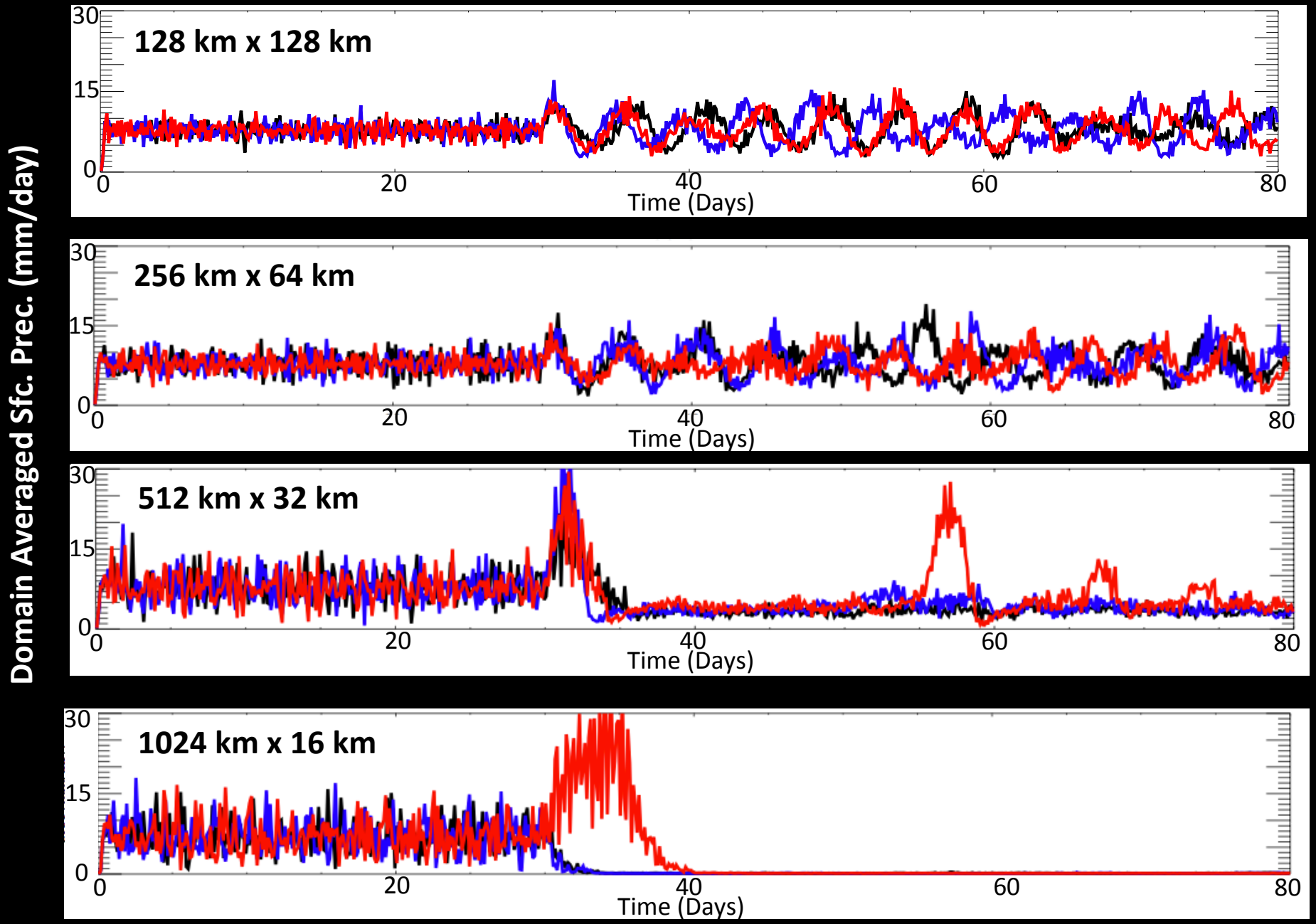


Altering organization by changing domain shape

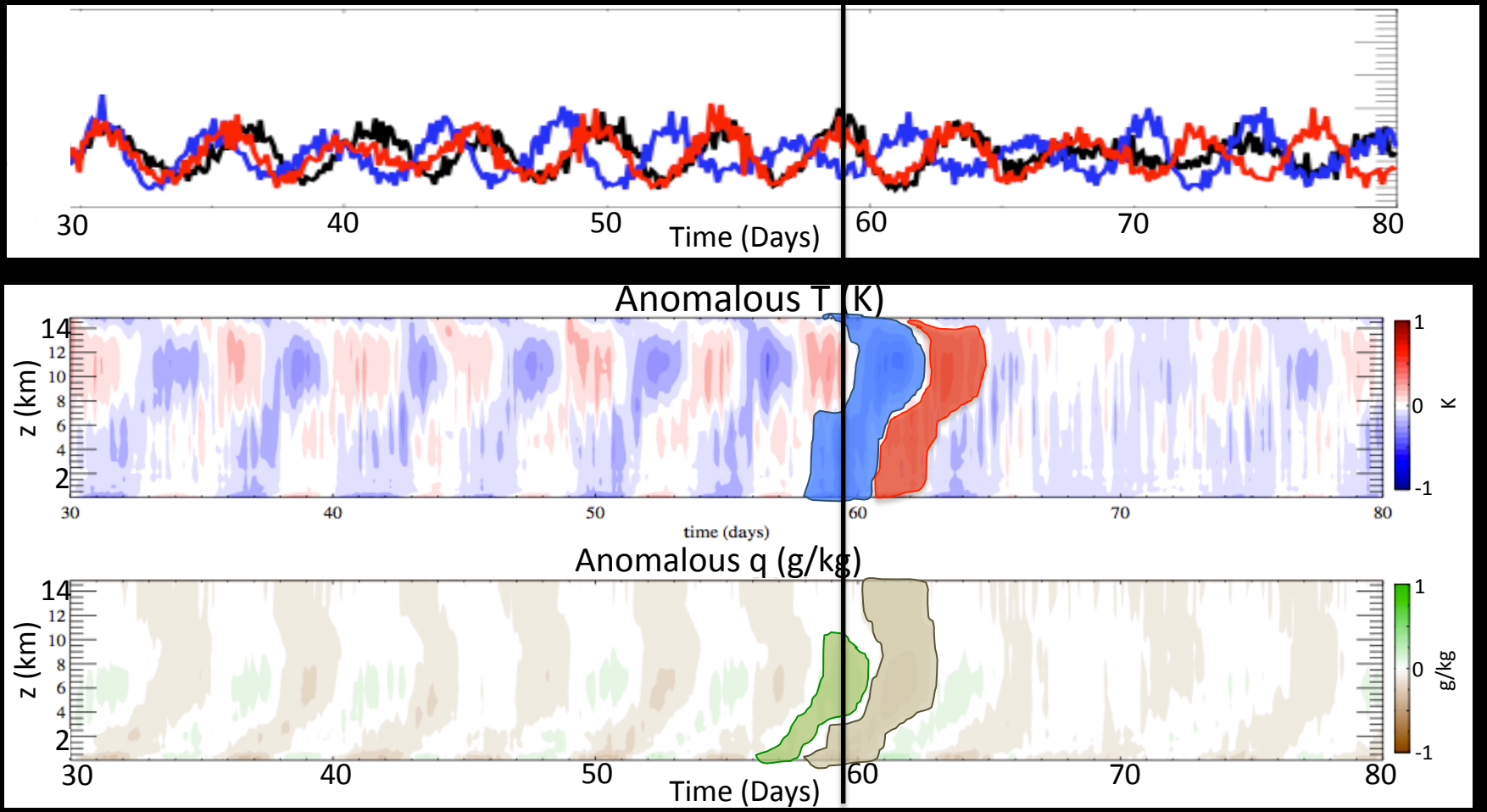


Altering organization by changing domain shape

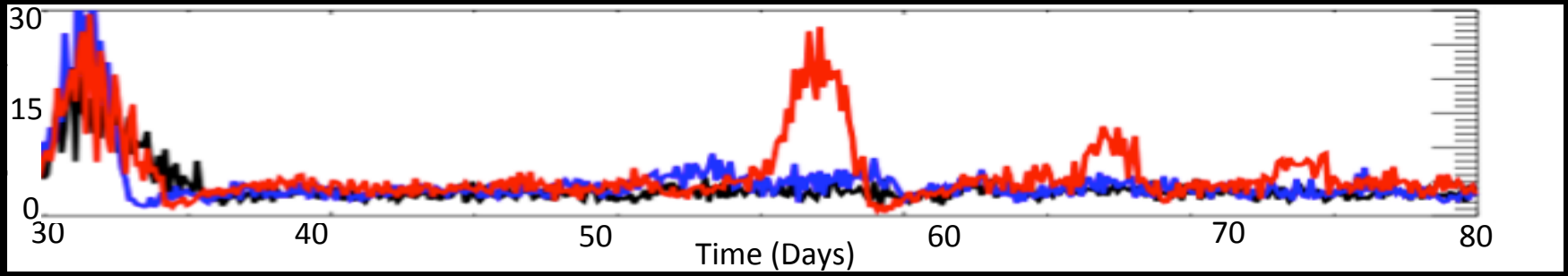


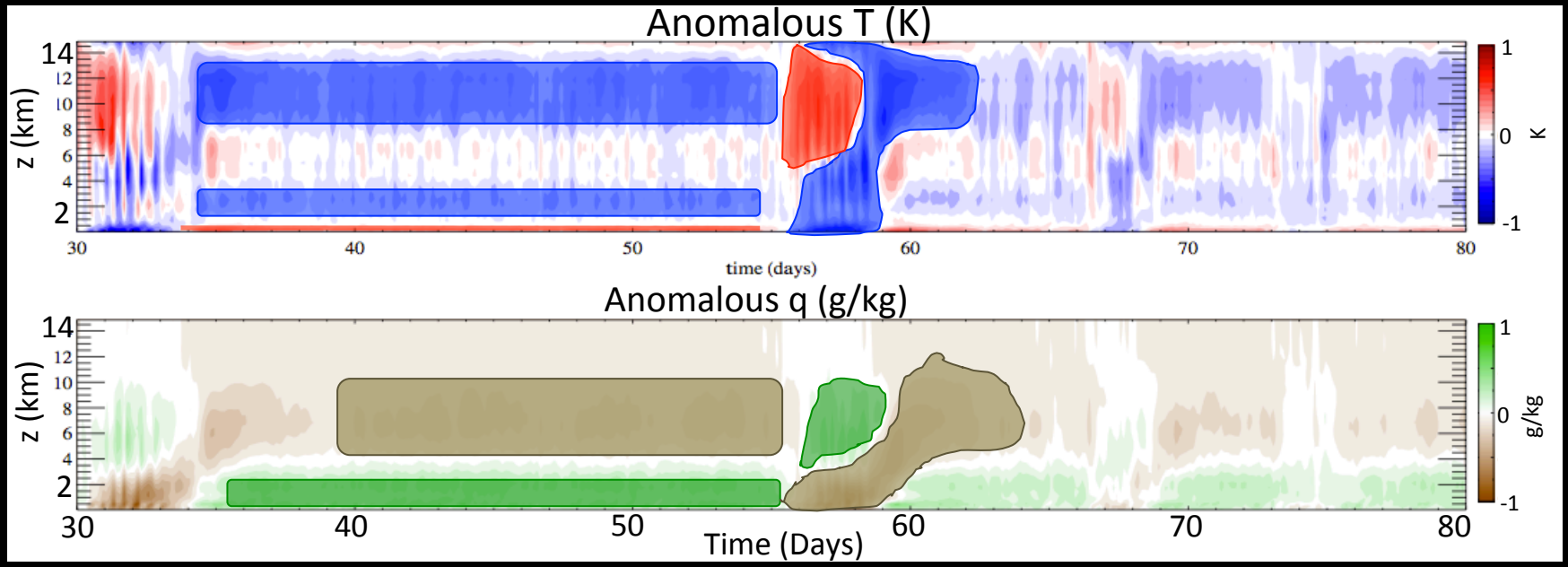

Domain Averaged Sfc. Prec. (mm/day)
128 km x 128 km
256 km x 64 km
512 km x 32 km
1024 km x 16 km
30
15
0
0
20
40
60
80
Time (Days)

Vertical Structure: 128 km x 128 km



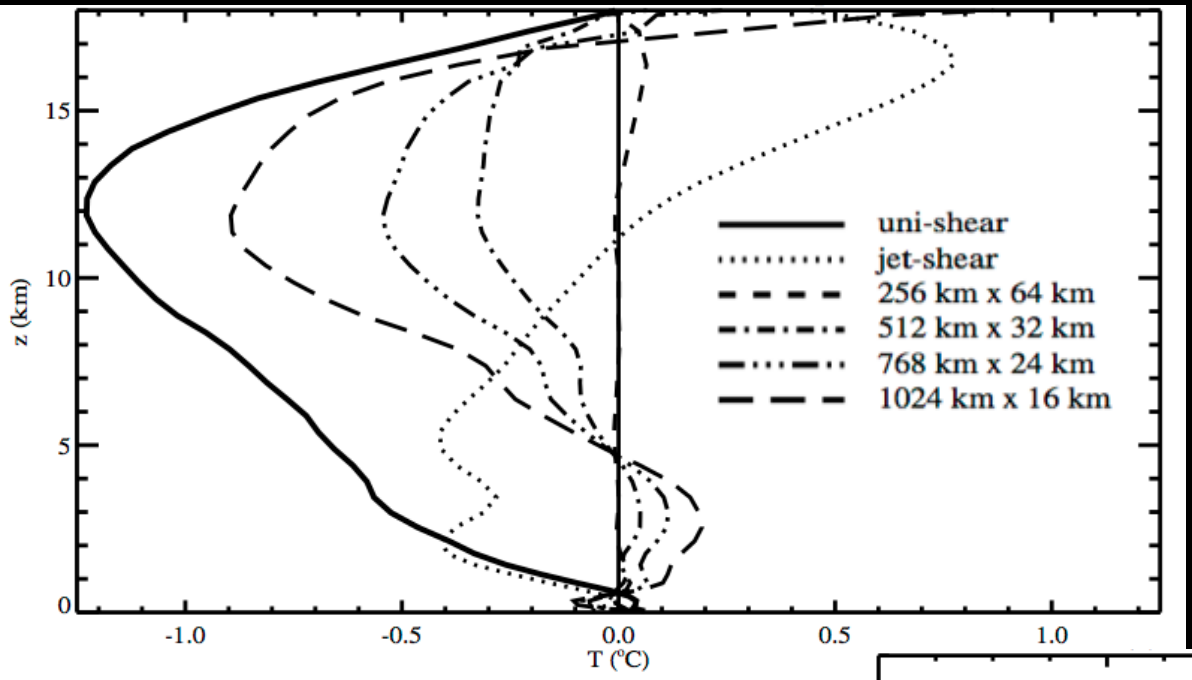
Vertical Structure: 512 km x 16 km





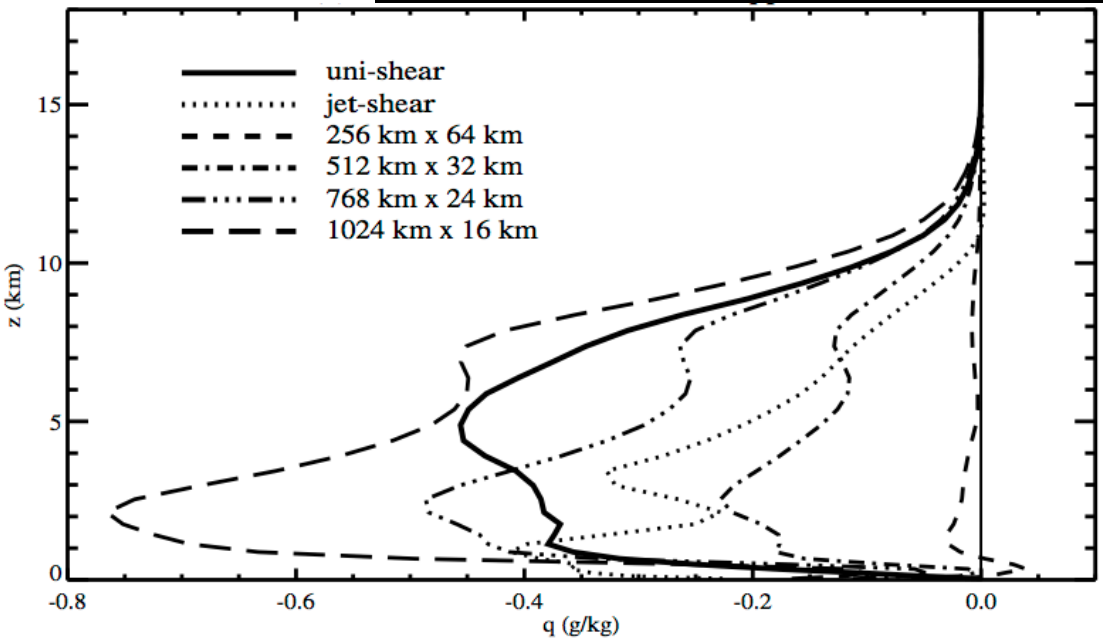
Can we understand this behavior?

Differences in Domain Soundings:

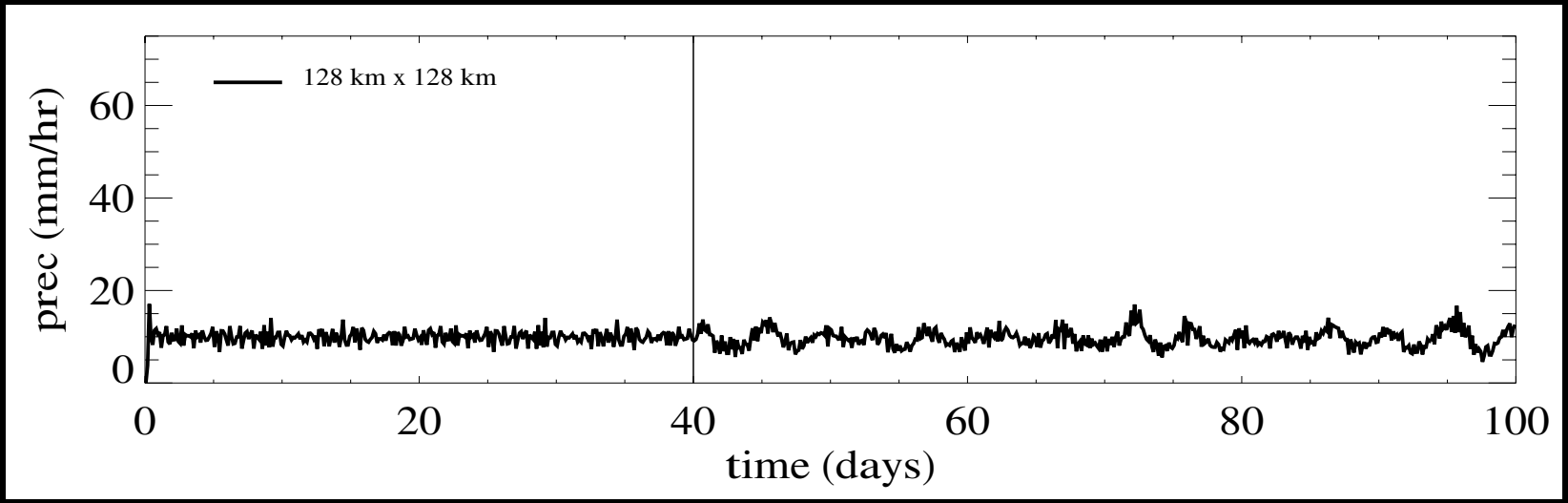


- Comparing the average over the last 50 days of a 100 day *no coupled* run in indicated domain set-up to 128 km x 128 km no coupled average.

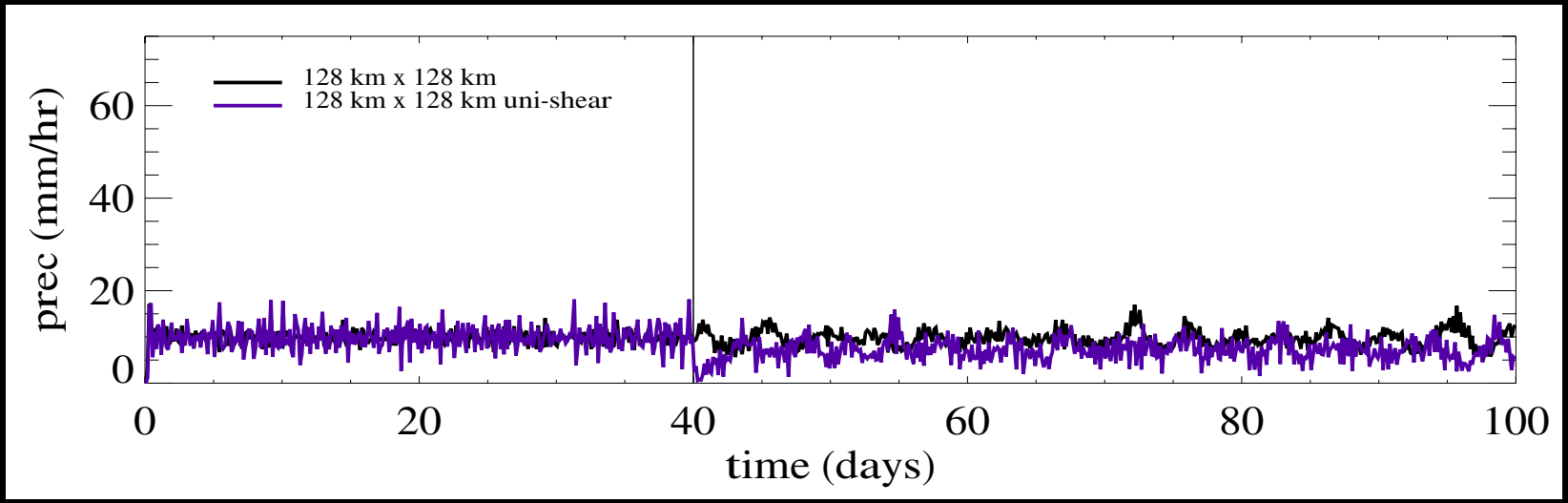
- Longer, narrower domains – drier, yet more unstable (in vertically averaged sense)
- Jet shear – drier, more stable
- **So what happens if you feed different domain set-ups the same T, q reference profile?**



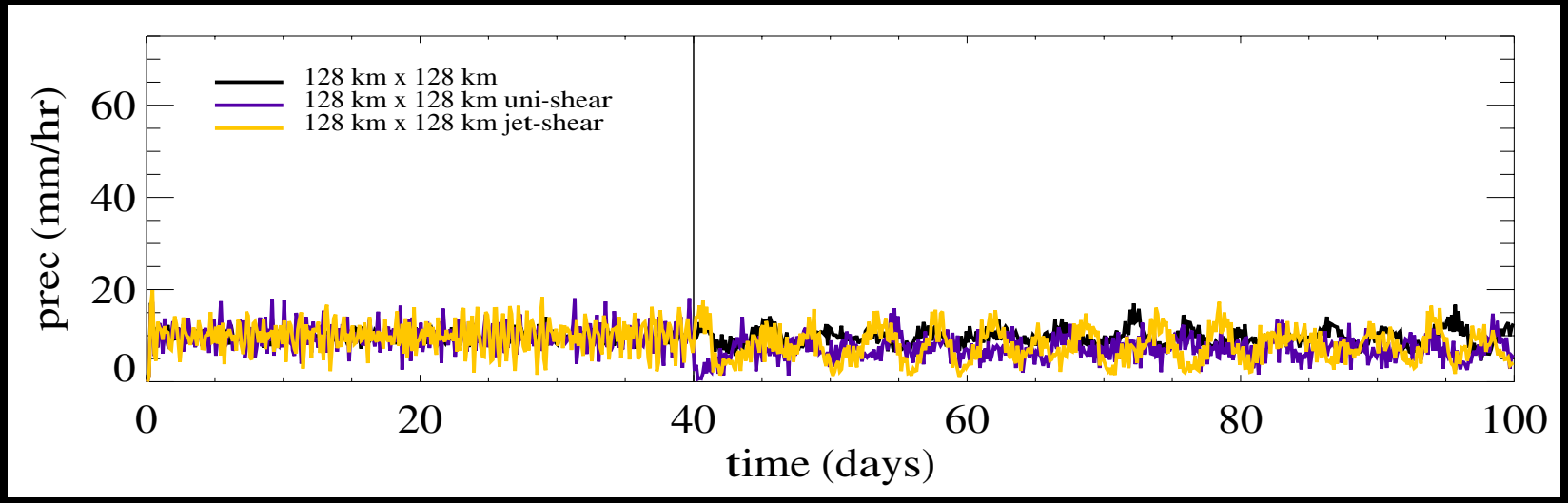
128 km x 128 km T, q-profile as T_{ref}, q_{ref}

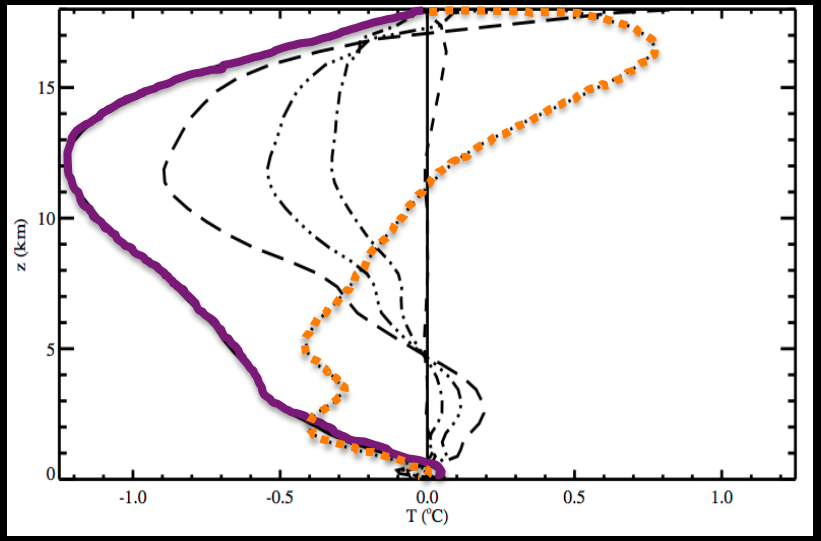


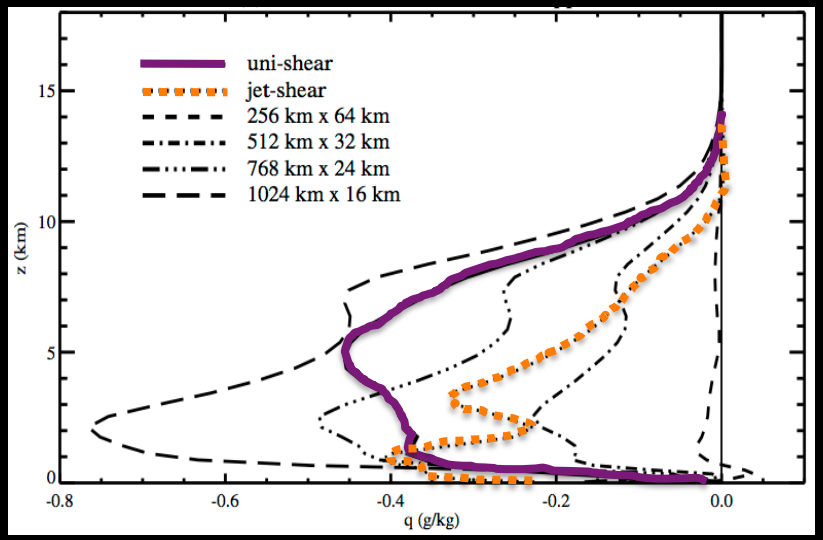
128 km x 128 km T, q-profile as T_{ref}, q_{ref}



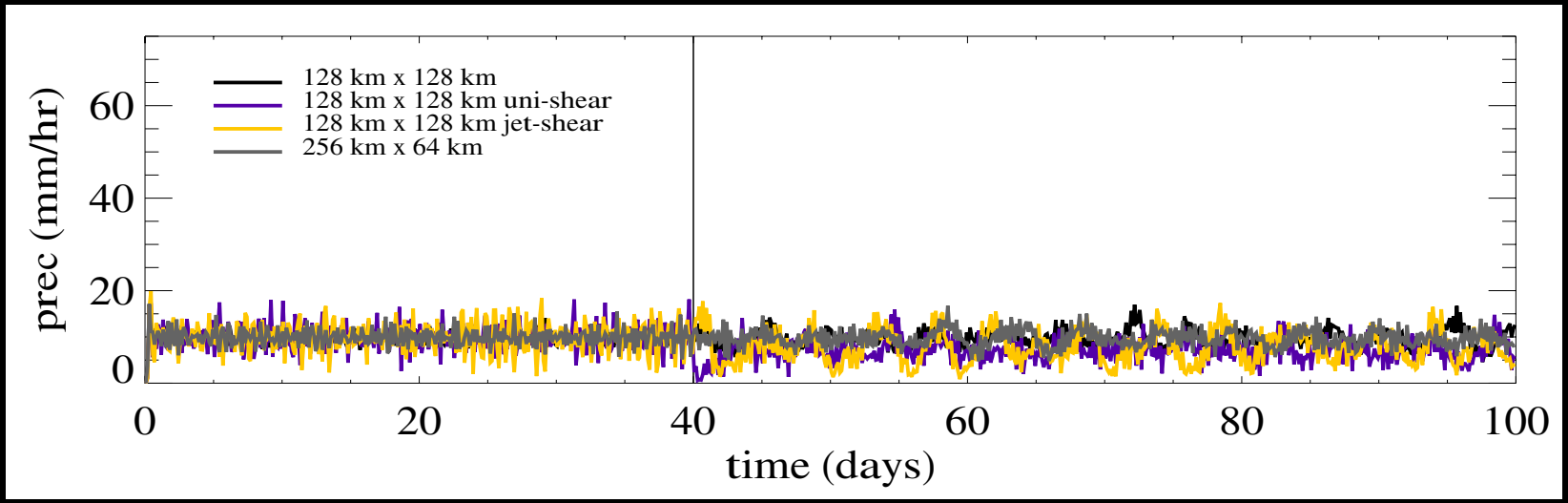
128 km x 128 km T, q-profile as T_{ref}, q_{ref}



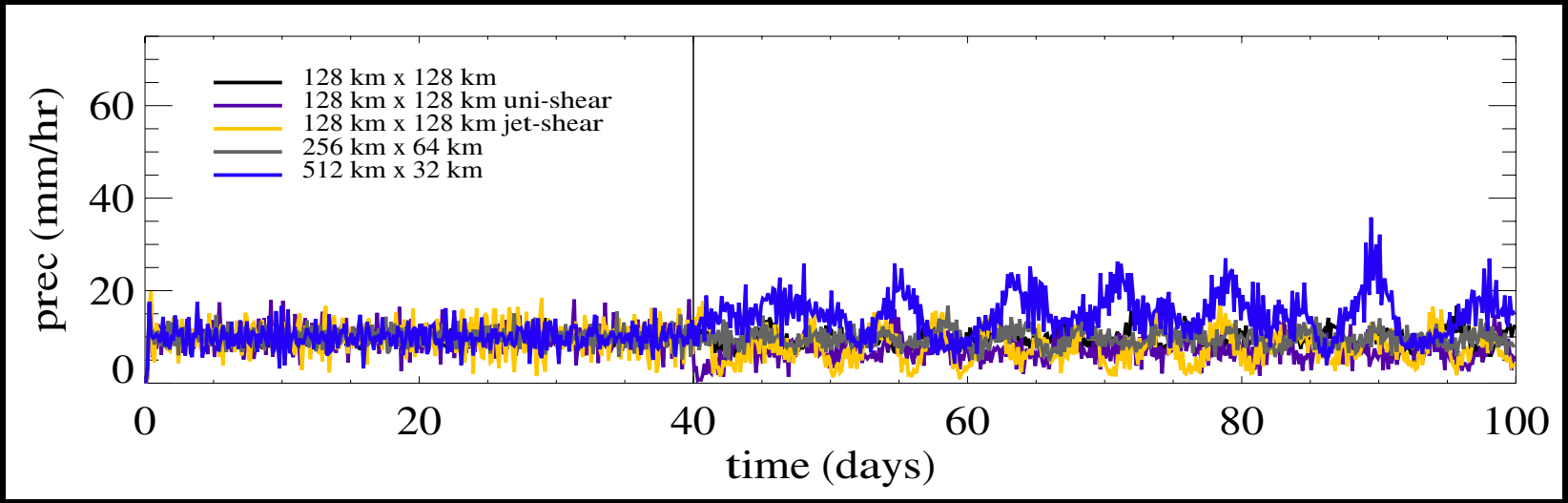




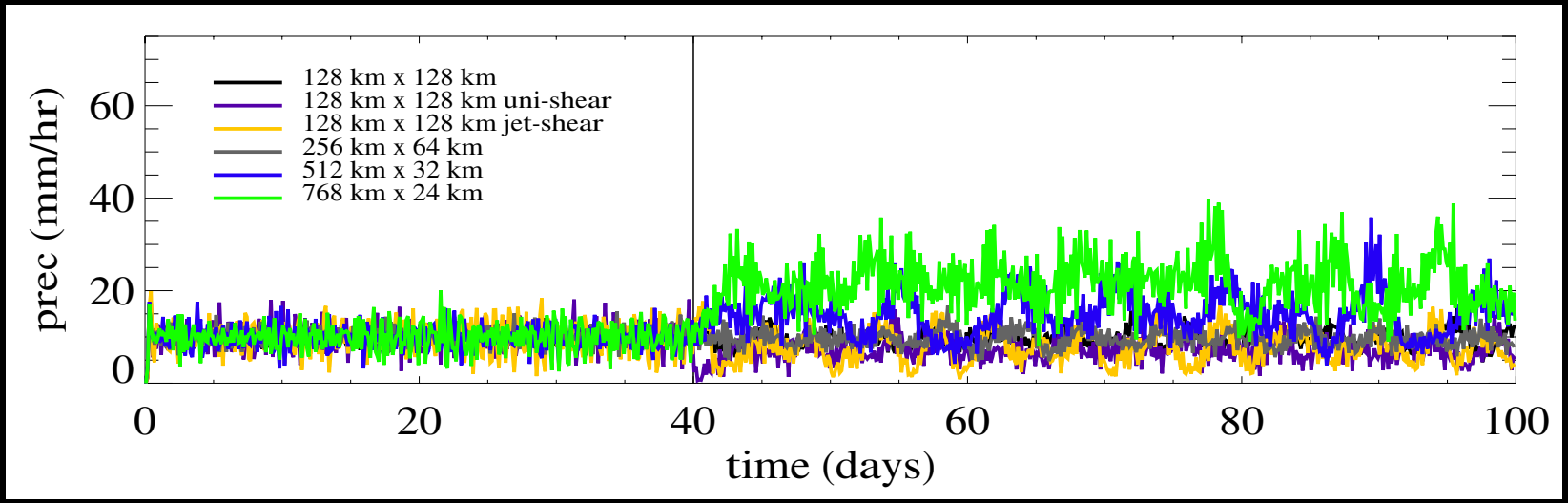
128 km x 128 km T, q-profile as T_{ref}, q_{ref}



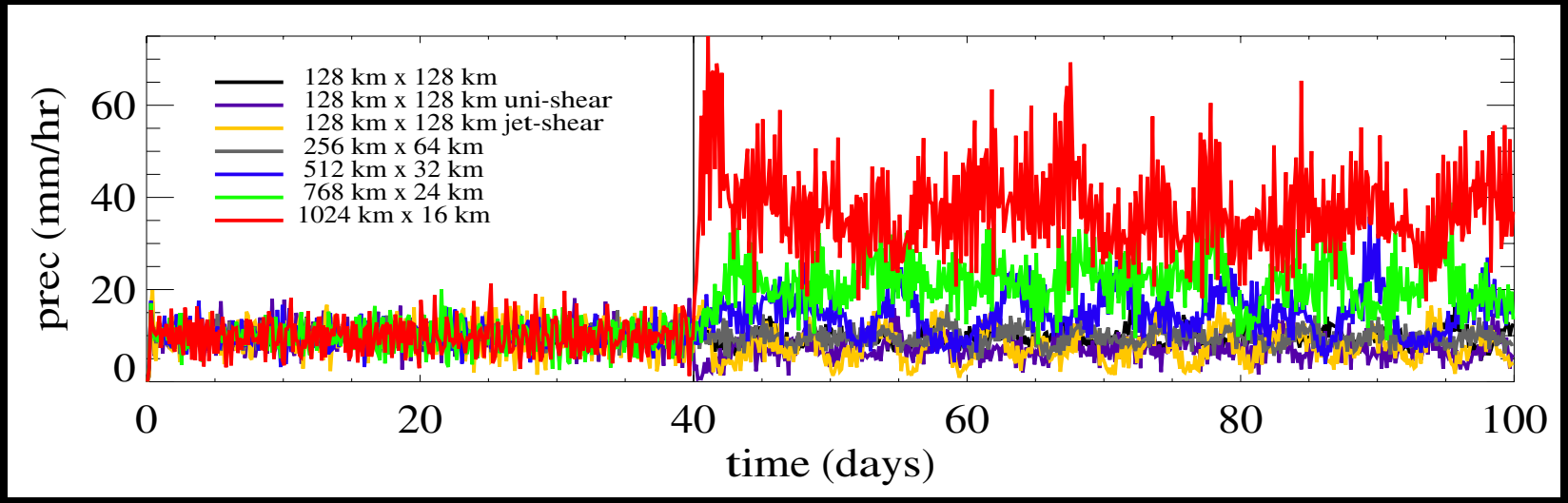
128 km x 128 km T, q-profile as T_{ref}, q_{ref}

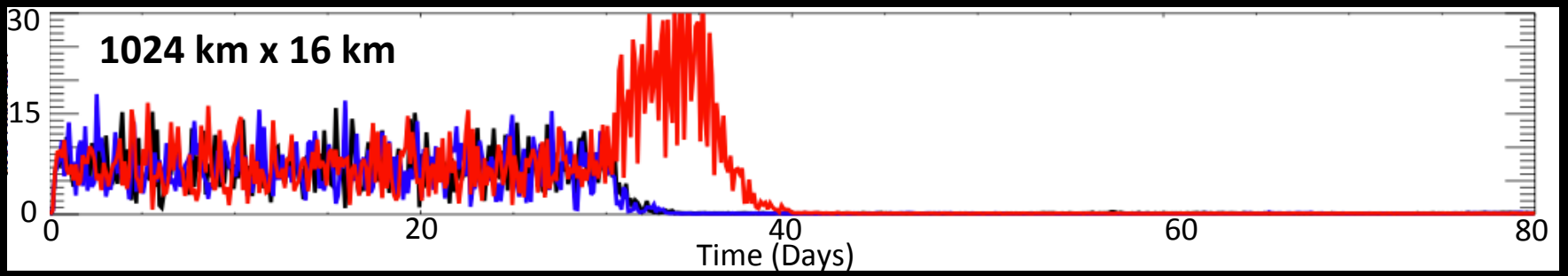


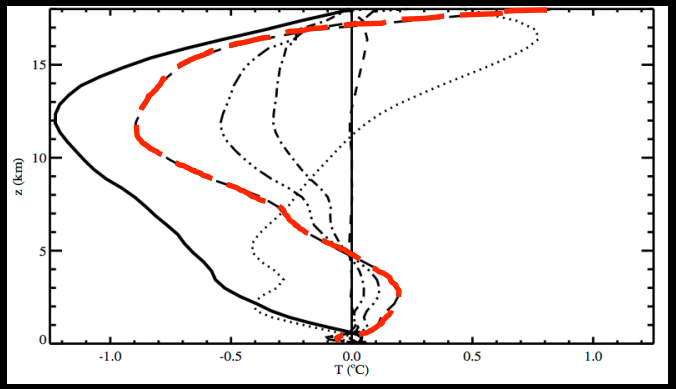
128 km x 128 km T, q-profile as T_{ref}, q_{ref}

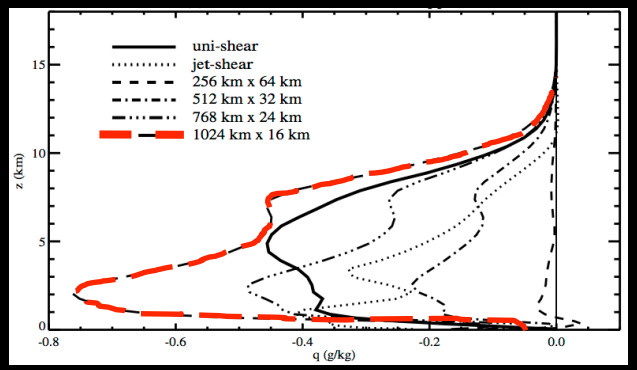


128 km x 128 km T, q-profile as T_{ref}, q_{ref}





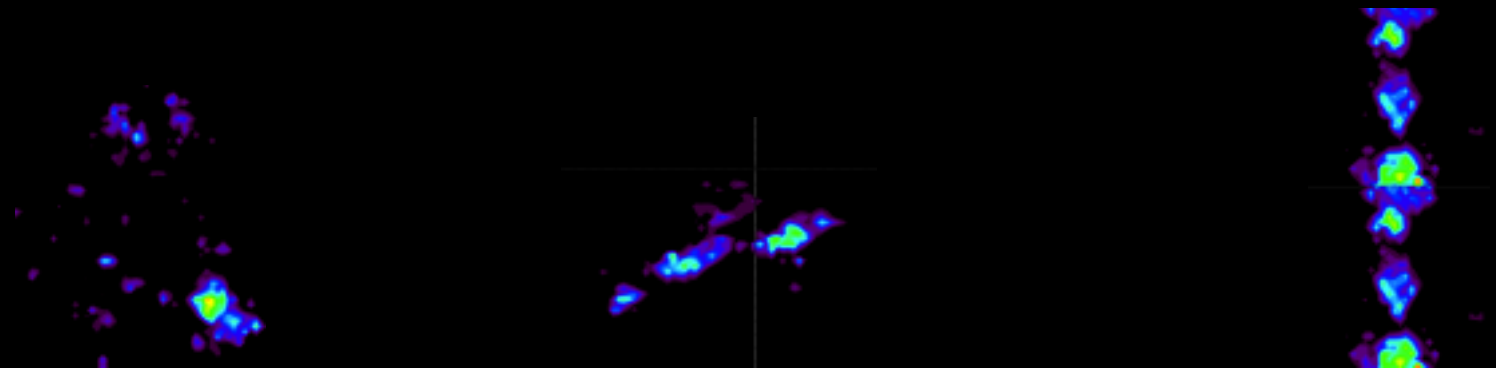




Question: Why don't shear cases behave same way?

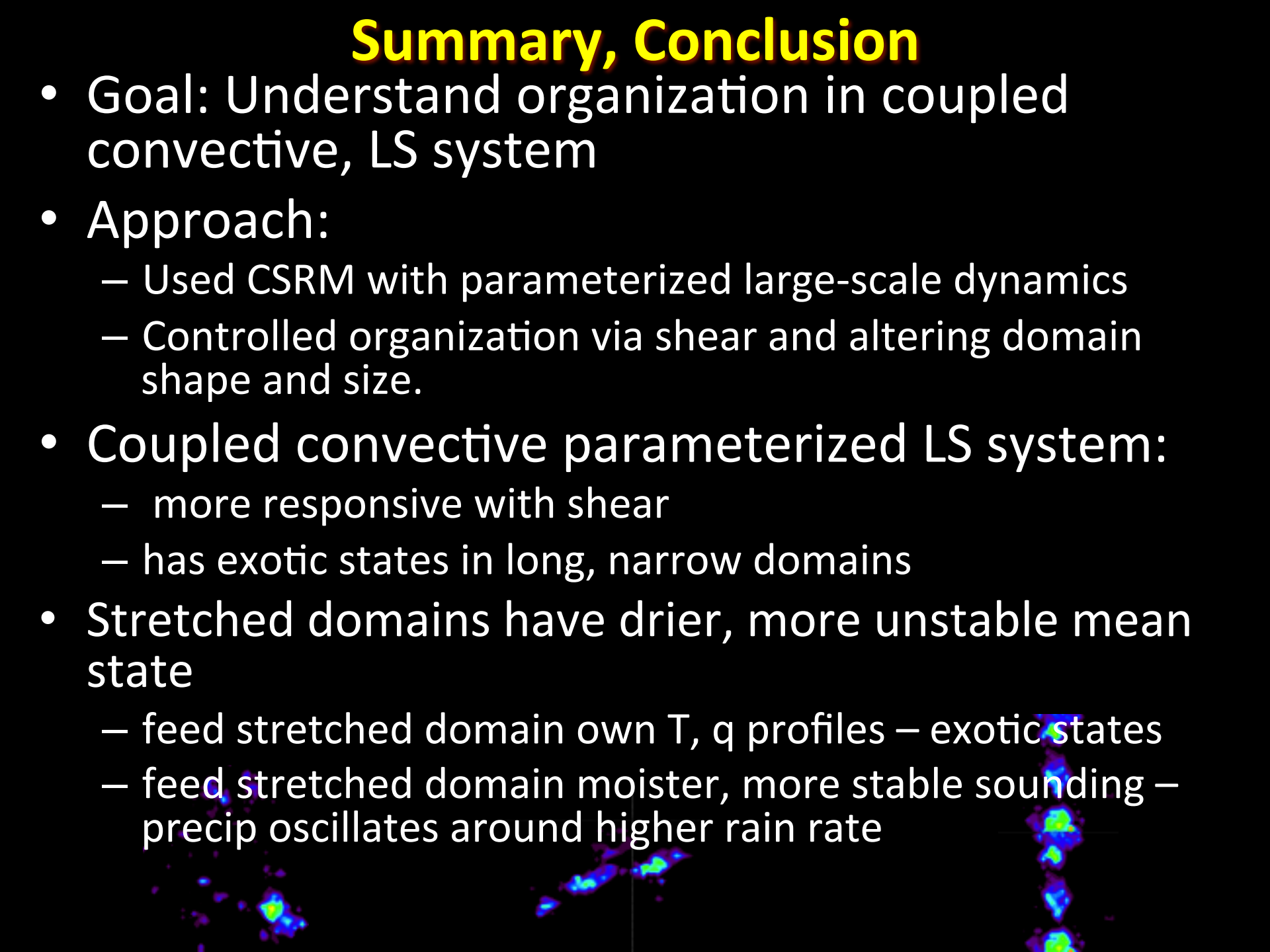
Future work

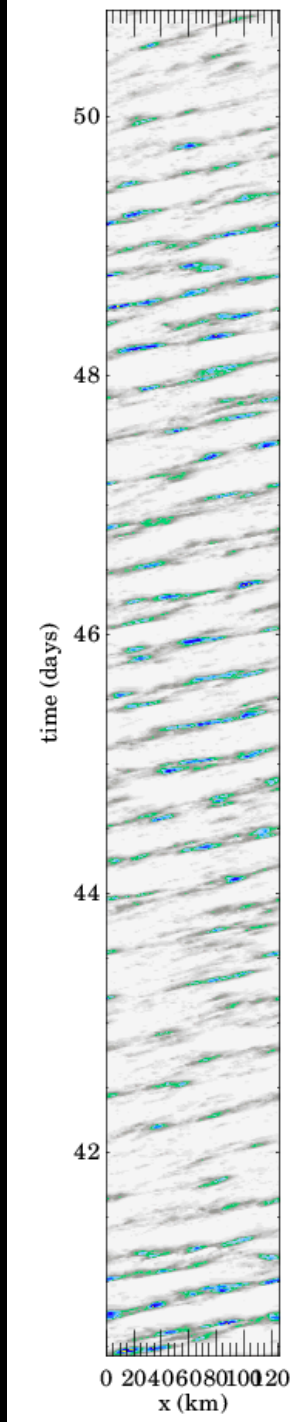
- Specify temperature and moisture profiles separately in different domain set-ups
- Test domain set-ups in super-param set up

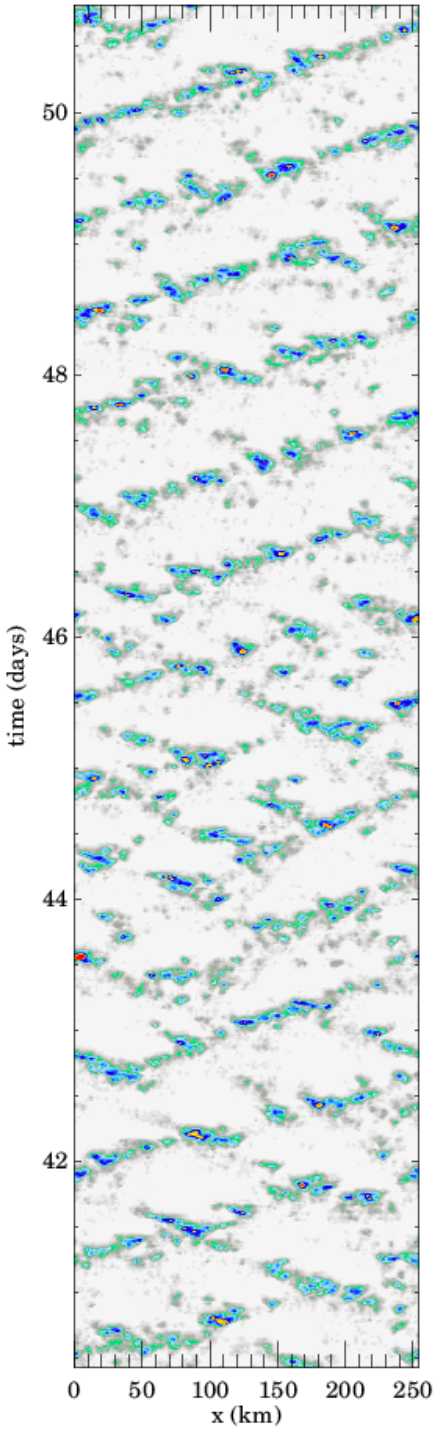


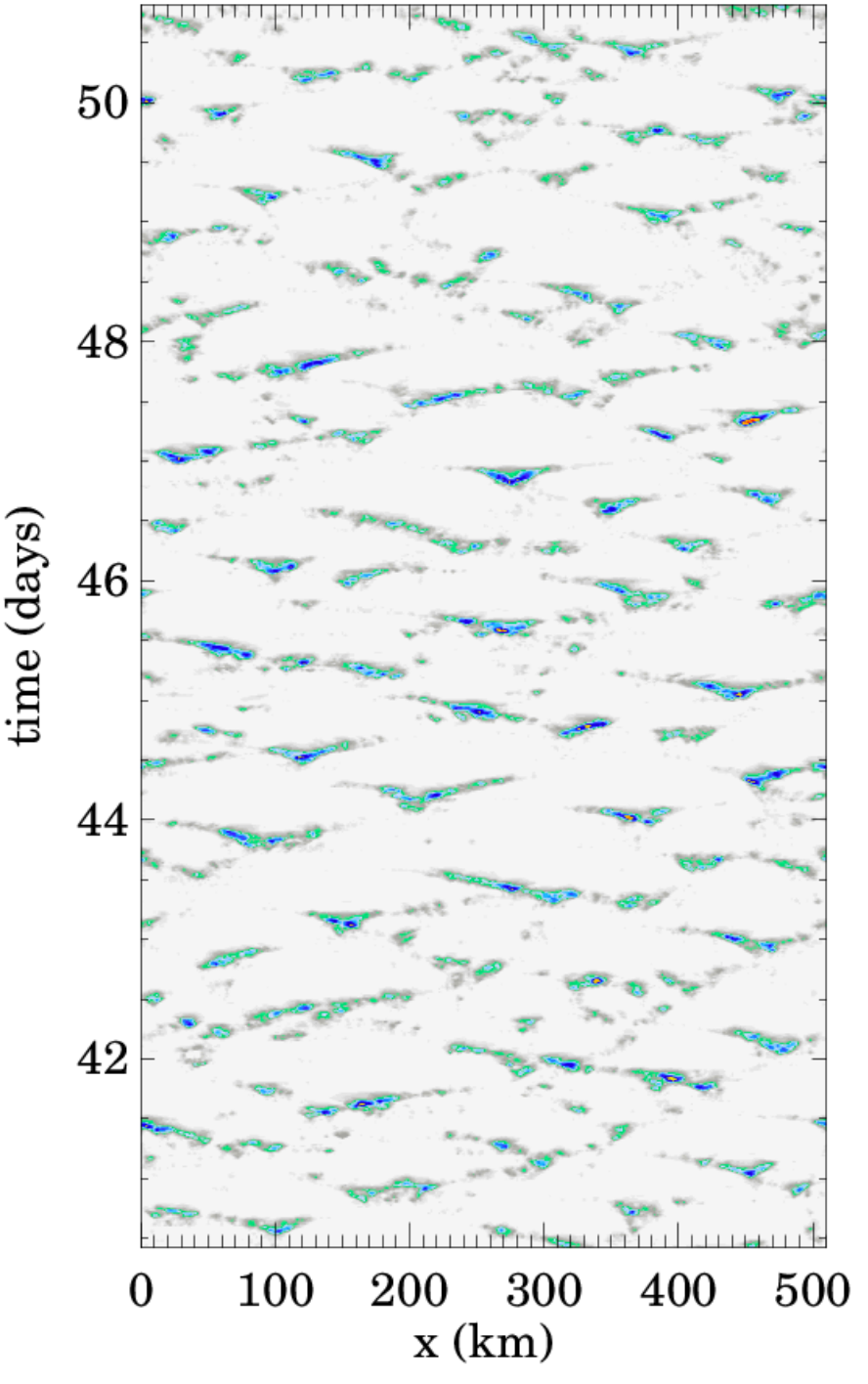
Summary, Conclusion

- Goal: Understand organization in coupled convective, LS system
- Approach:
  - Used CSRM with parameterized large-scale dynamics
  - Controlled organization via shear and altering domain shape and size.
- Coupled convective parameterized LS system:
  - more responsive with shear
  - has exotic states in long, narrow domains
- Stretched domains have drier, more unstable mean state
  - feed stretched domain own T, q profiles – exotic states
  - feed stretched domain moister, more stable sounding – precip oscillates around higher rain rate




50
48
46
44
42
time (days)
0 20 40 60 80 100 120
x (km)


50
48
46
44
42
time (days)
0 50 100 150 200 250
x (km)


50
48
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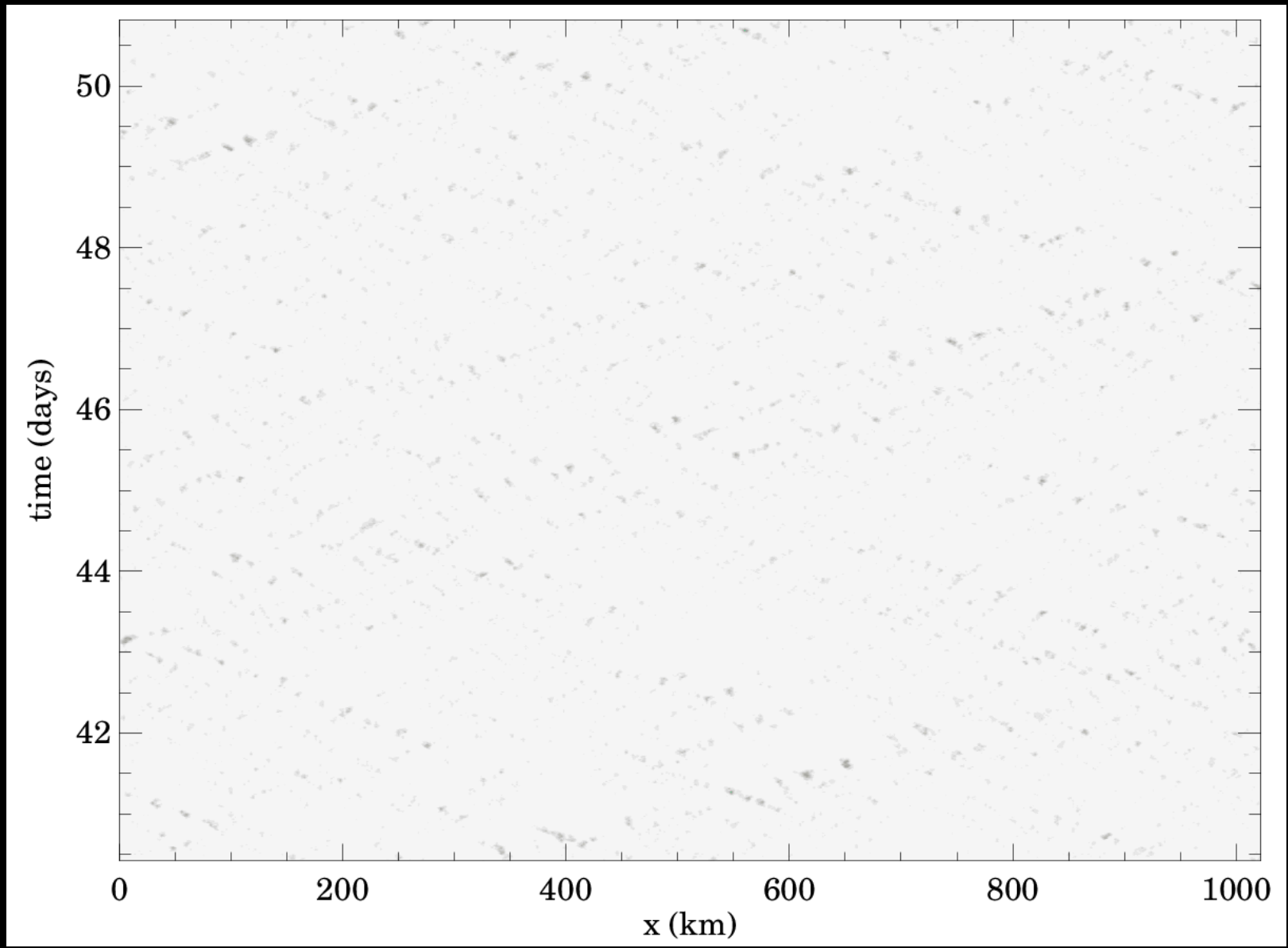
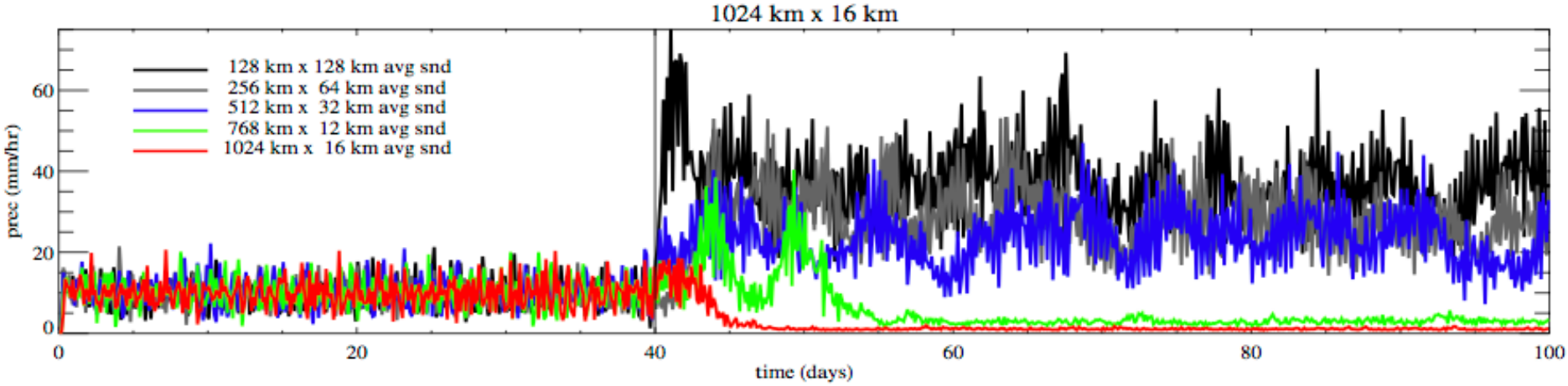
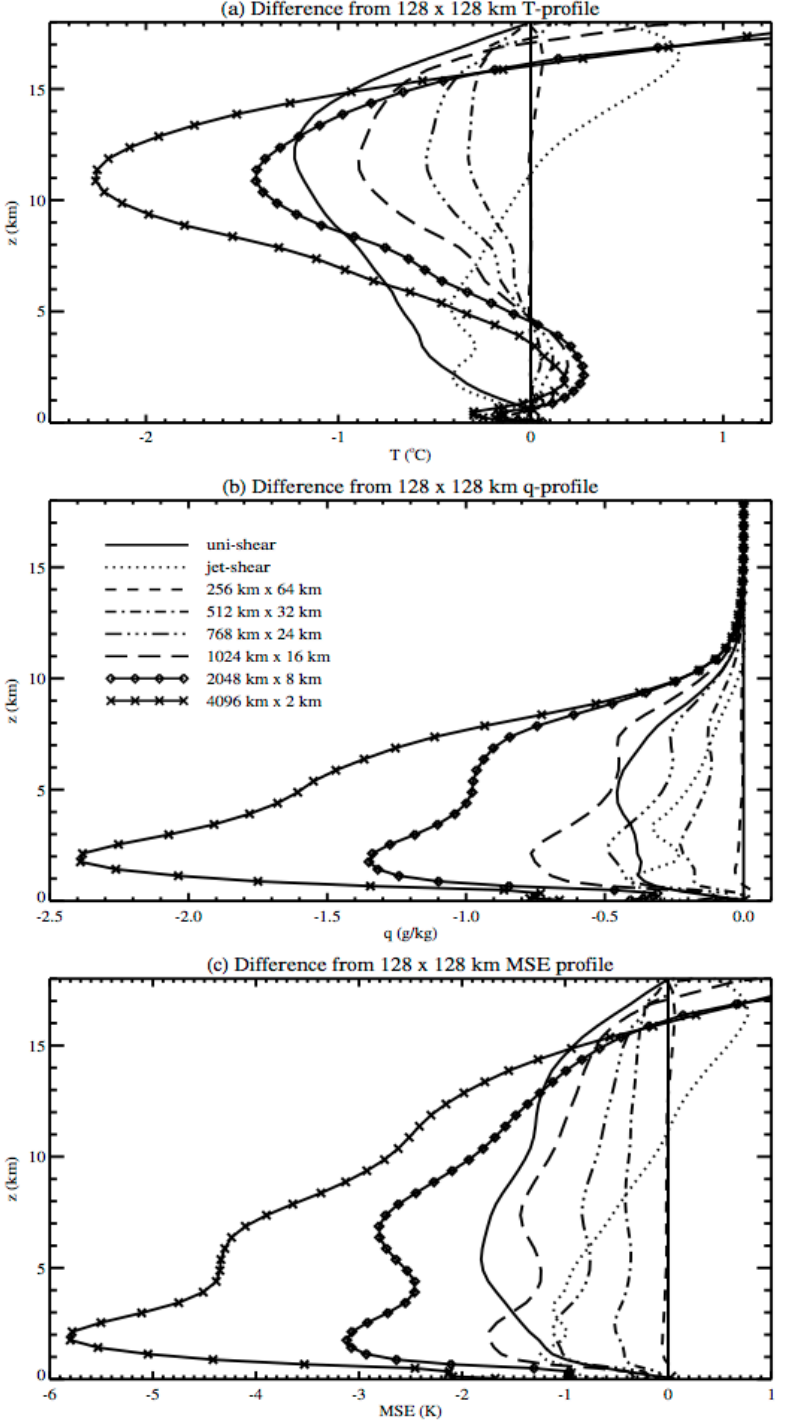
44
42
time (days)
0 100 200 300 400 500
x (km)


50
48
46
44
42
time (days)
0
200
400
600
800
1000
x (km)


1024 km x 16 km
128 km x 128 km avg snd
256 km x 64 km avg snd
512 km x 32 km avg snd
768 km x 12 km avg snd
1024 km x 16 km avg snd
prec (mm/hr)
time (days)
0
20
40
60
80
100


(a) Difference from 128 x 128 km T-profile
z (km)
T (°C)
(b) Difference from 128 x 128 km q-profile
uni-shear
jet-shear
256 km x 64 km
512 km x 32 km
768 km x 24 km
1024 km x 16 km
2048 km x 8 km
4096 km x 2 km
q (g/kg)
(c) Difference from 128 x 128 km MSE profile
MSE (K)