

Stochastic Parameterization



PHILOSOPHICAL TRANSACTIONS

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THE ROYAL
SOCIETY



MATHEMATICAL, PHYSICAL
& ENGINEERING SCIENCES

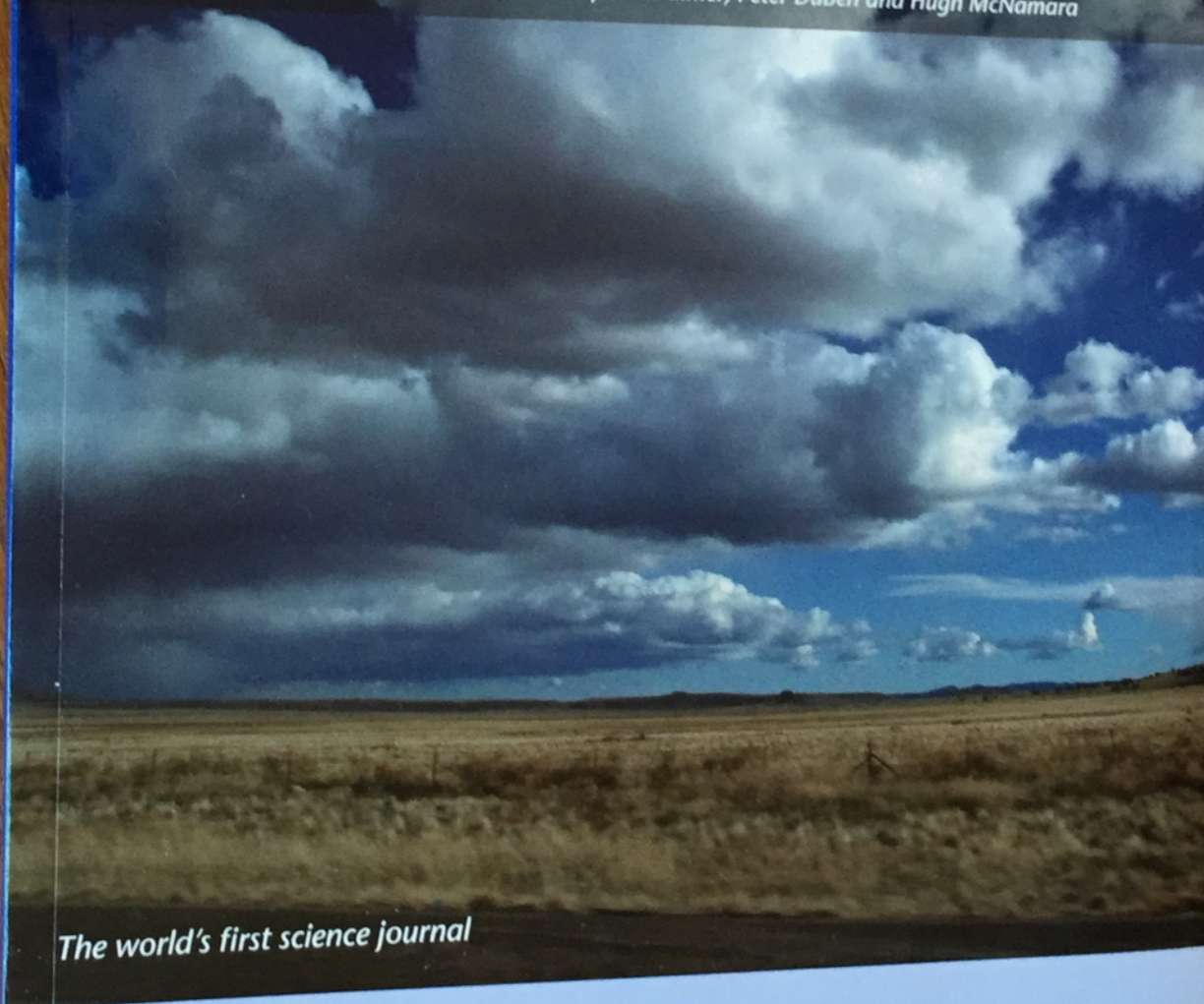
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Stochastic modelling and energy-efficient computing for weather and climate prediction

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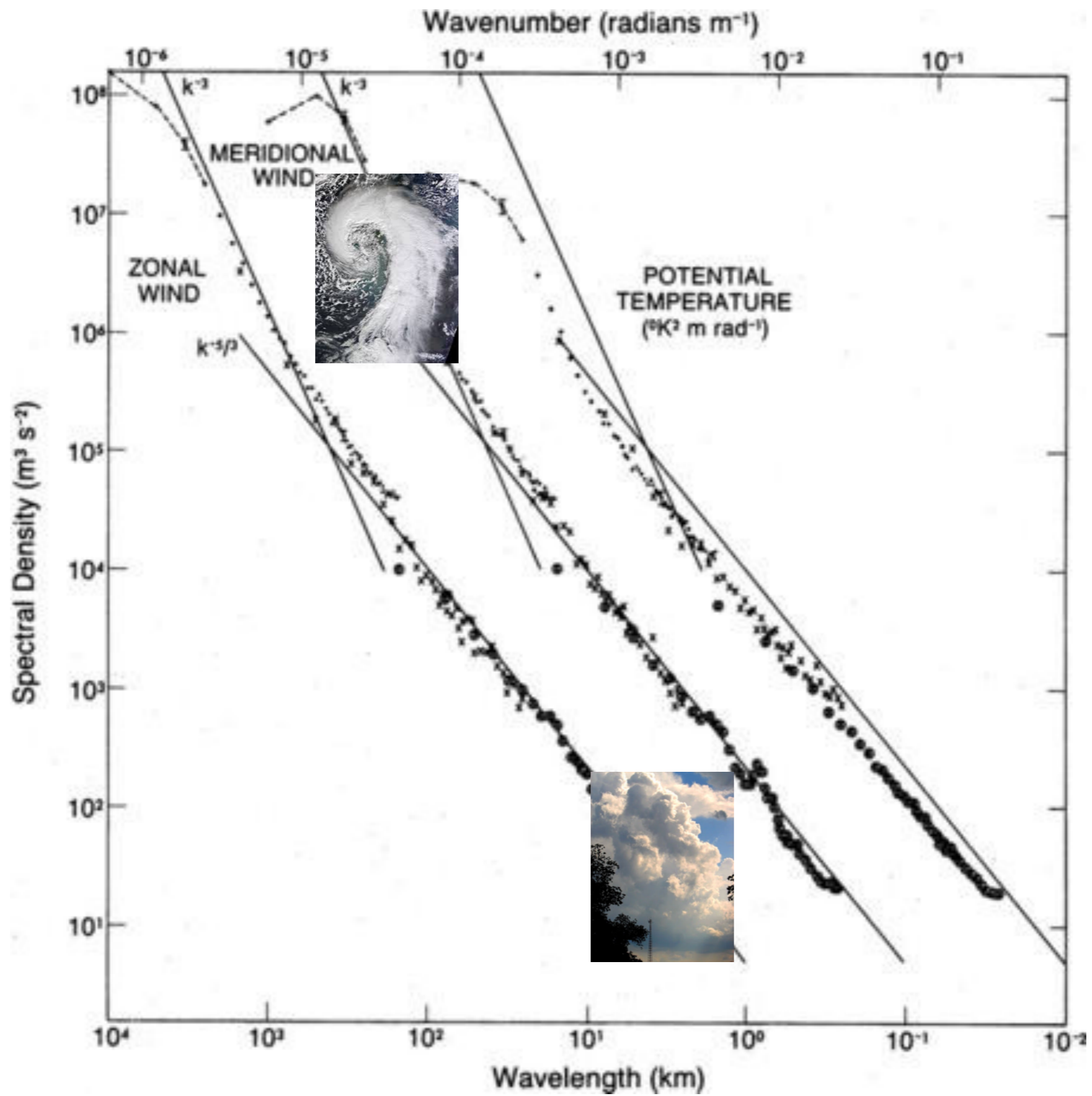


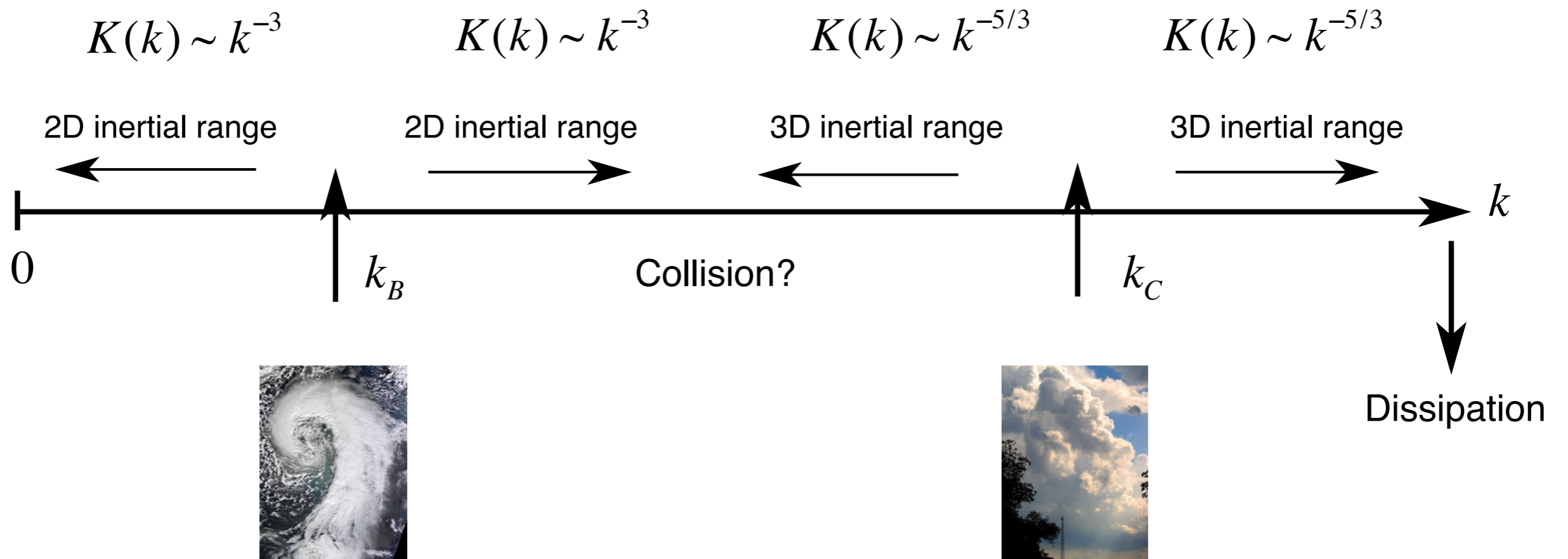
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Cascades





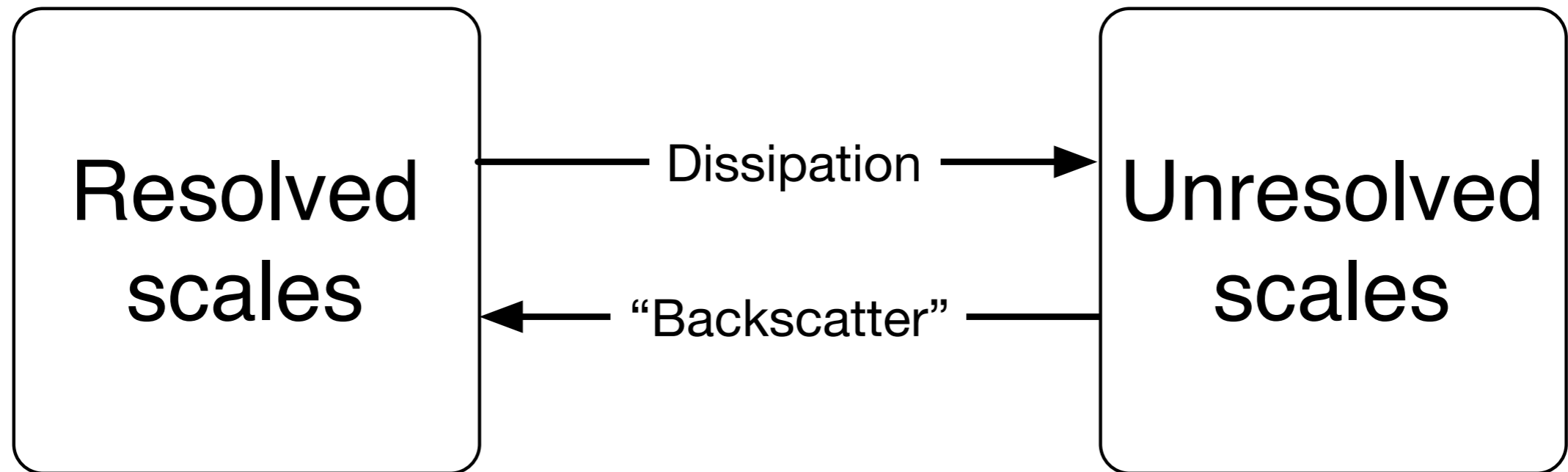


Cascades



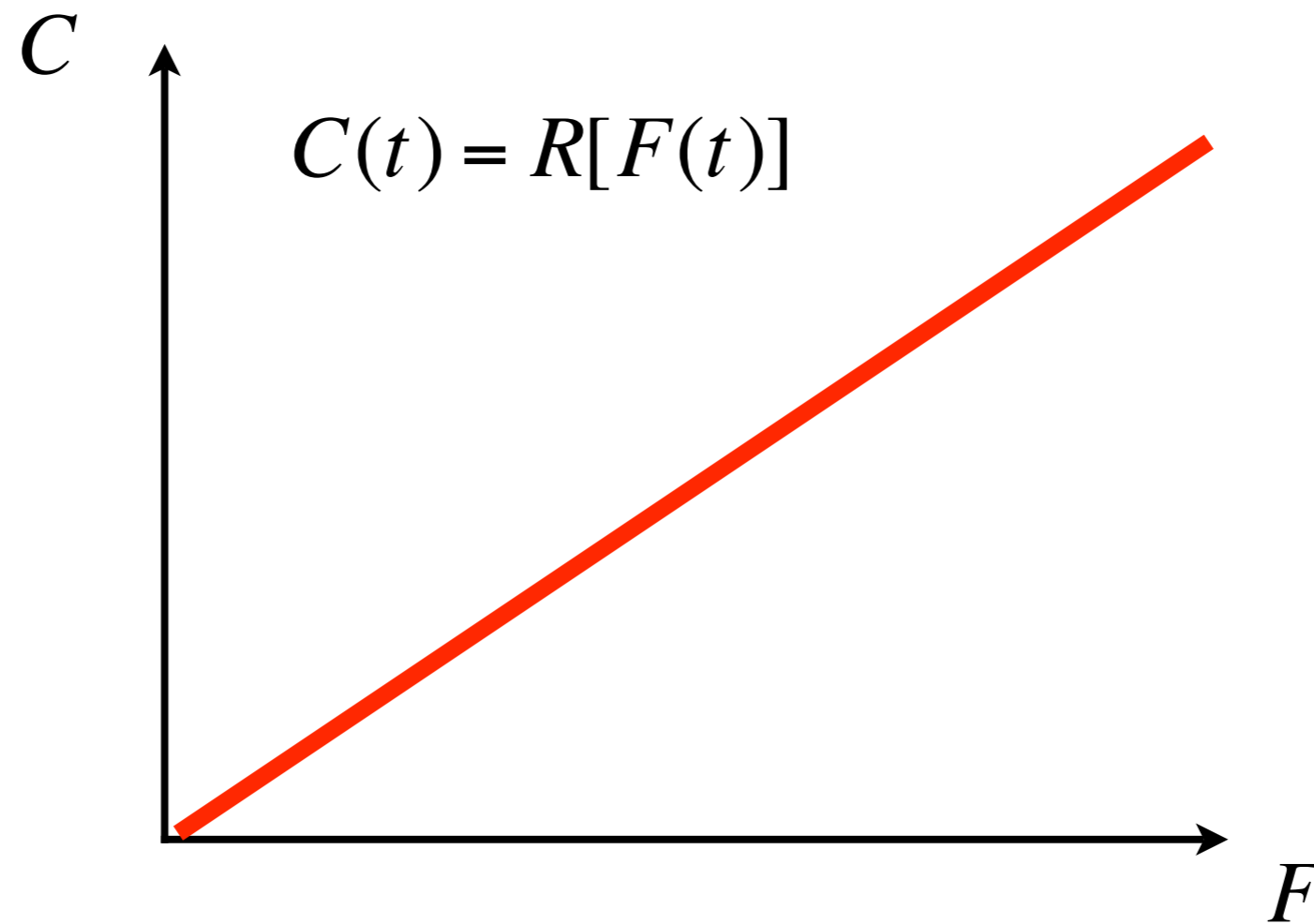
Anti-Cascades

A long-exposure photograph of a waterfall, showing the water as a series of vertical, blurred streams. The water is white and frothy, contrasting with the dark green foliage in the background. The text "Anti-Cascades" is overlaid in the center in a bold, white, sans-serif font.

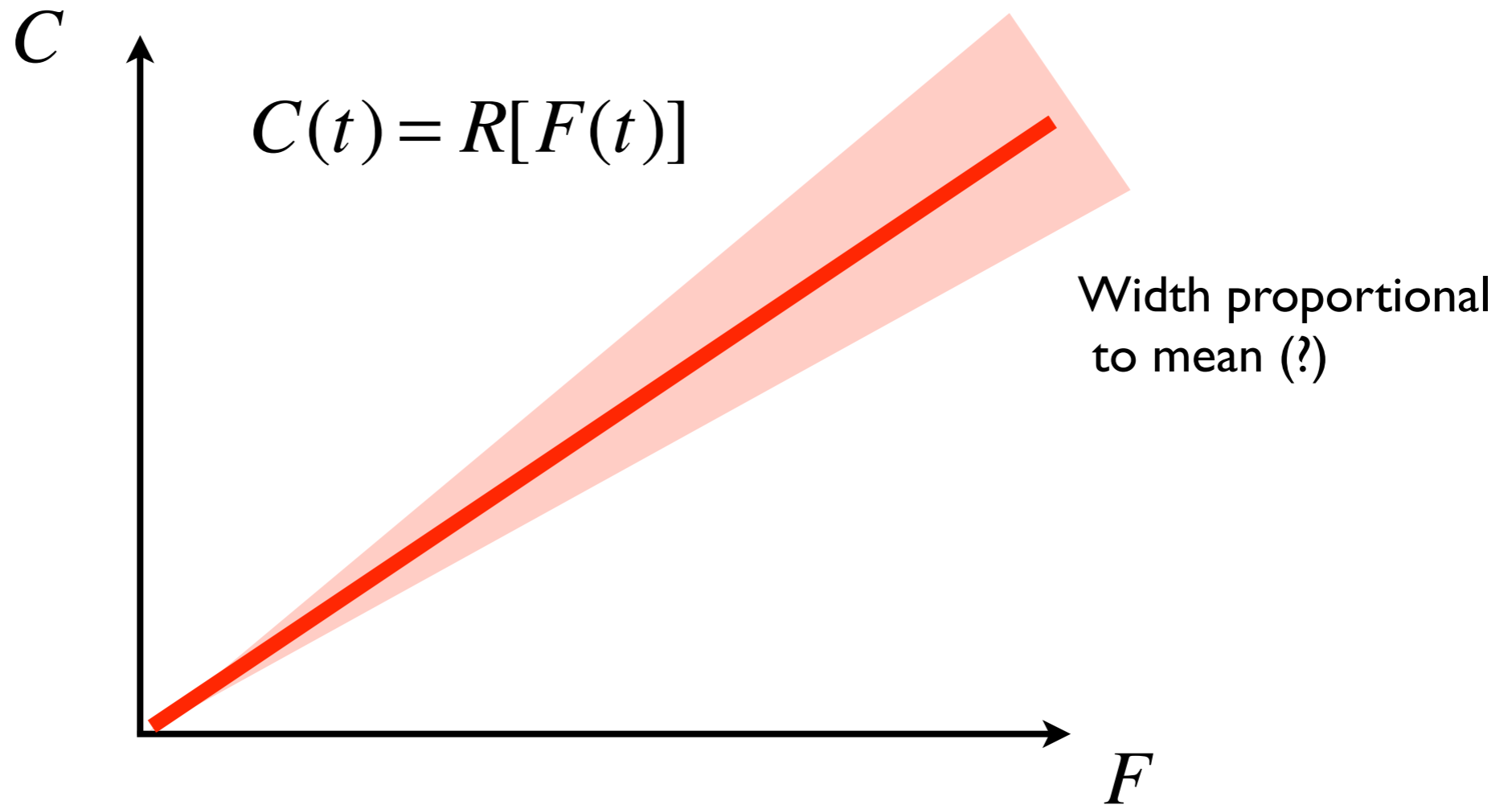


But there are instabilities
on these scales.

Deterministic parameterization



~~Stochastic~~ Non-Deterministic Convection

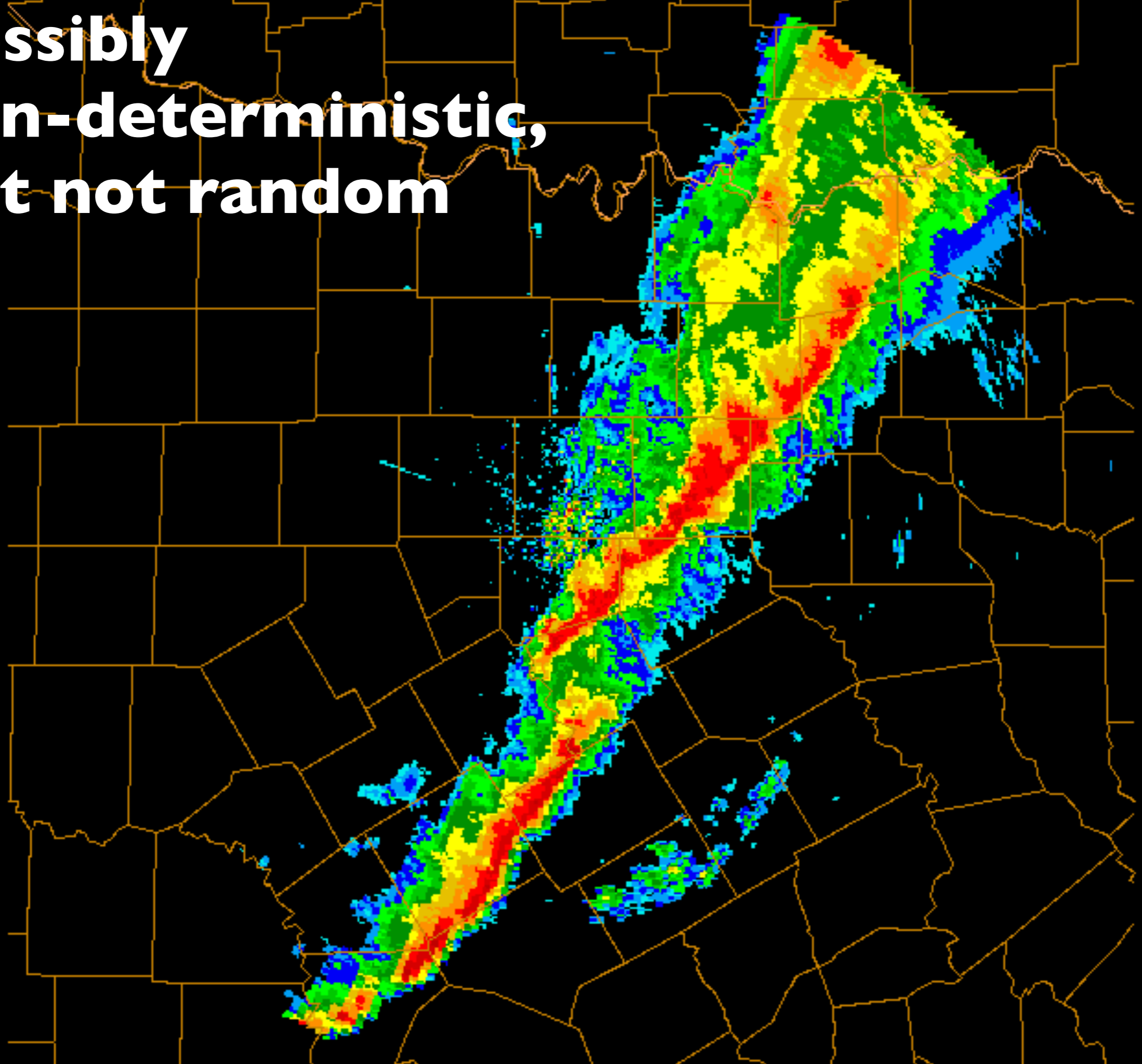


Non-deterministic convection is
convection that not fully controlled by the large-scale.
It might be “random,” or it might not.

What is the nature of the non-deterministic effects?

- ◆ Noise from the cheap seats?
- ◆ Self-organized mesoscale weather systems?
- ◆ Energy supplied by dissipation of the larger scales?
- ◆ Instabilities that generate energy directly on the smaller scales?
 - ▲ Cumulus convection
 - ▲ Mesoscale organization

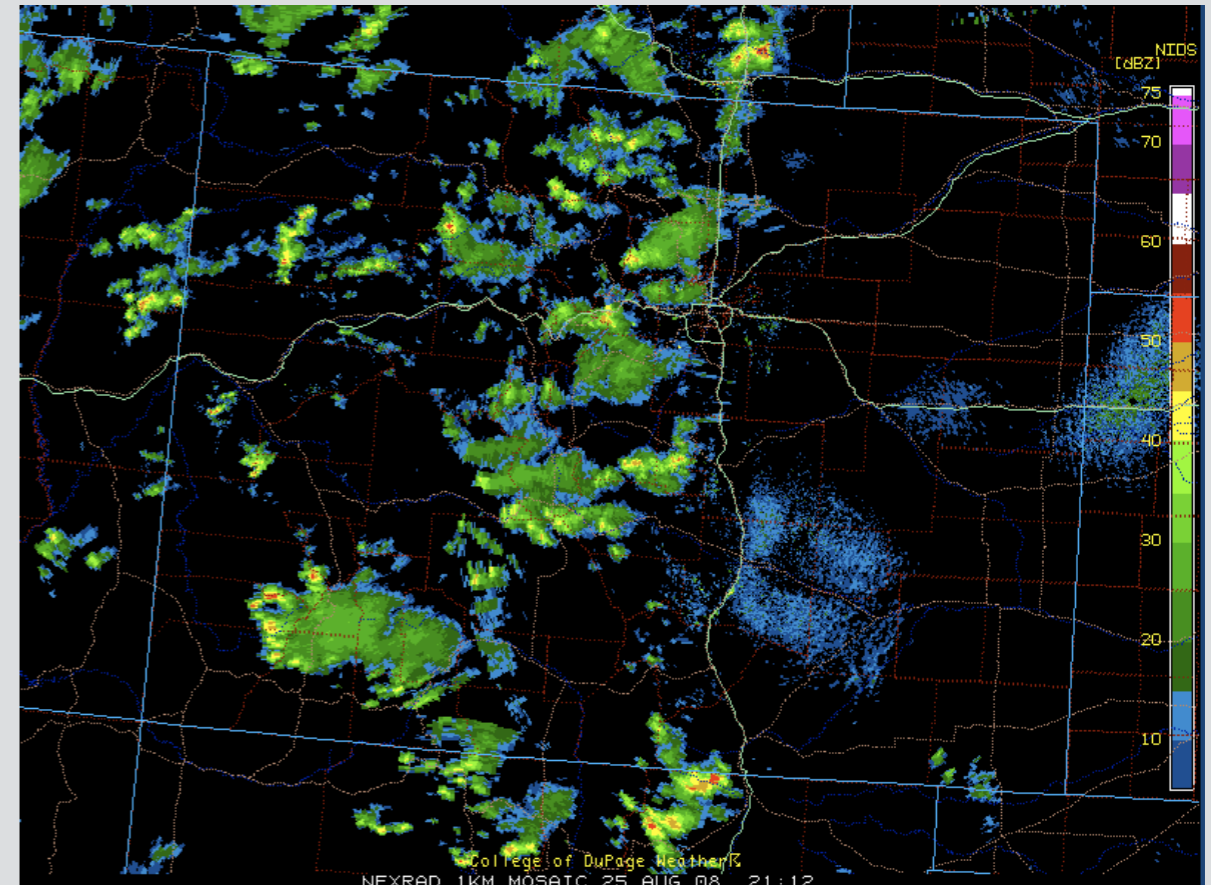
**Possibly
non-deterministic,
but not random**



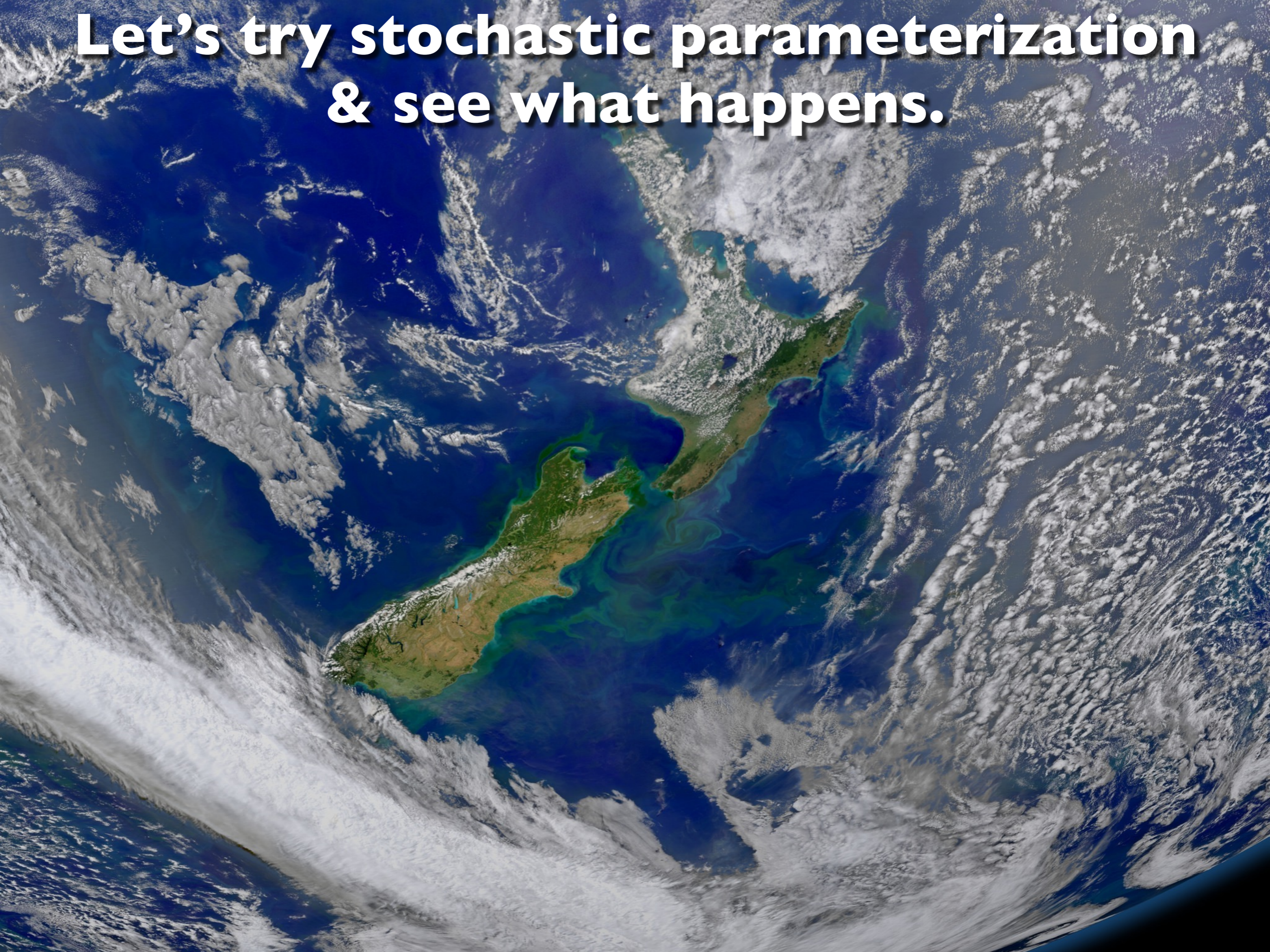
Stochastic Physics & The Grey Zone

With a grid spacing of 20 km or less, we definitely do not have a statistically meaningful sample of large clouds in each grid column.

Even with a grid spacing of 200 km, the number of large clouds in a grid column is worryingly small.



**Let's try stochastic parameterization
& see what happens.**



What we all do

- ◆ Identify a model deficiency (our cup runneth over)
- ◆ Introduce a change to the model physics (a stochastic parameterization, for instance)
- ◆ Demonstrate that the change leads to an improvement in the model results
- ◆ Conclude that the change to the physics brings it closer to the true physics

I'm sorry, this just isn't very convincing.

What would be more convincing is a mechanistic analysis.

Example: Ensemble spread is too small

Need stochastic physics?

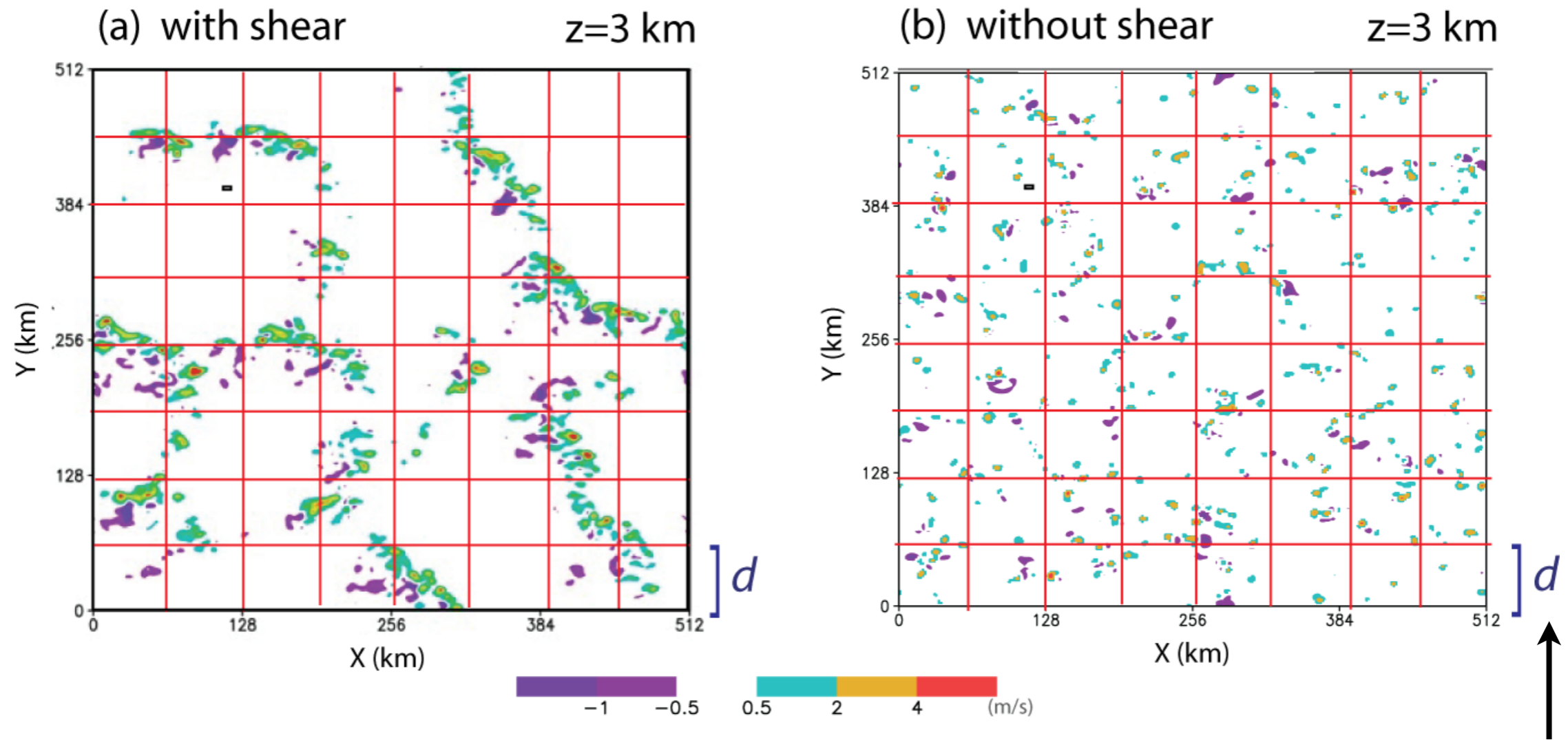
OR

Model is overdamped?

What do I mean by “A Mechanistic Analysis?”

- ◆ Show where the non-deterministic effects come from.
 - ▲ “Backscatter?”
 - ▲ Convection?
 - ▲ Mesoscale?
- ◆ Show how the non-deterministic effects alter the larger scales.
- ◆ Use a large-domain CRM.

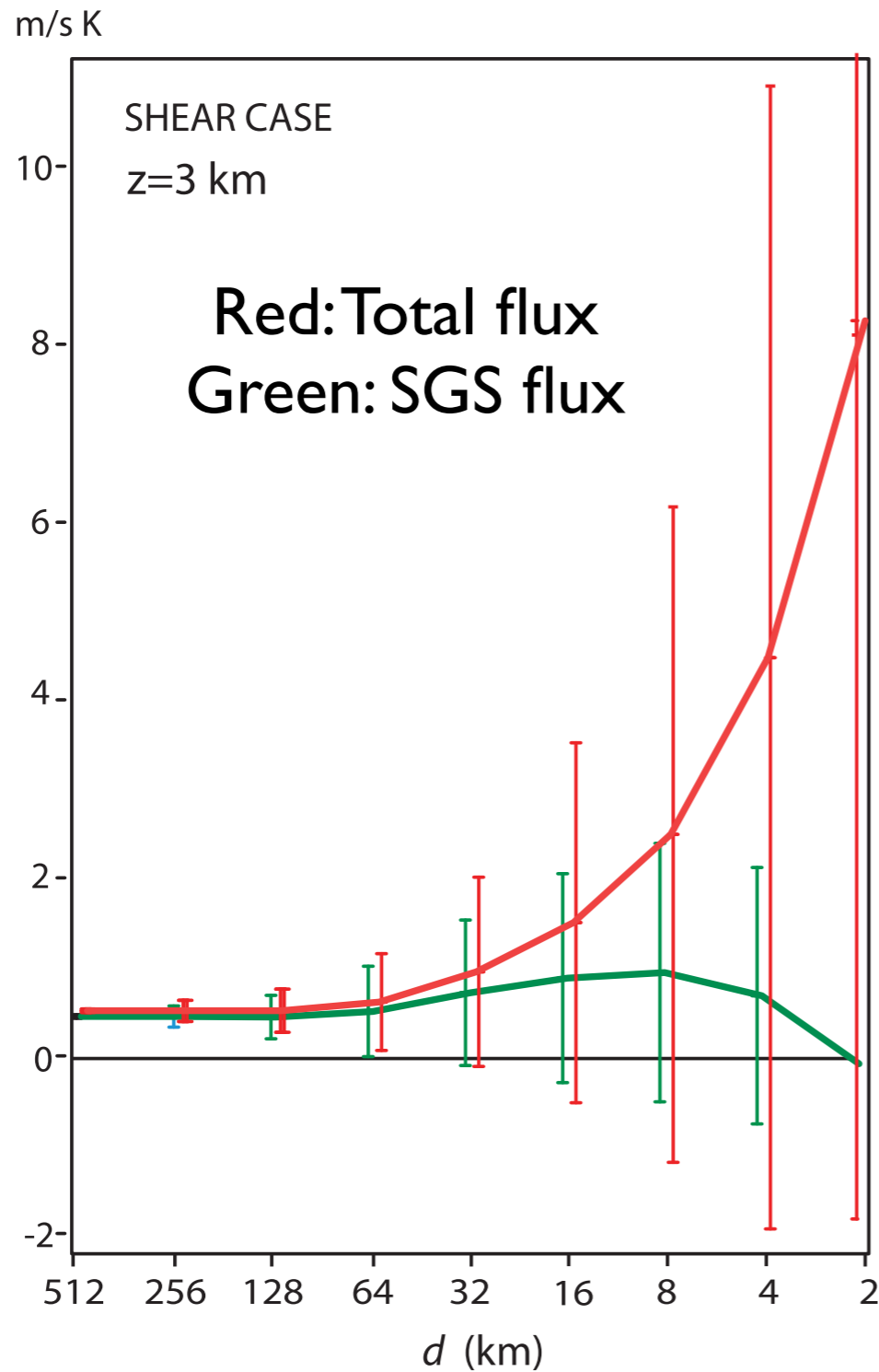
Use a CRM to test ideas.



Vertical velocity 3 km above the surface

Subdomain size,
used to analyze
dependence on
grid spacing

Fluxes where convection is active



Standard deviation of total flux

Standard deviation of SGS flux

The SGS flux becomes more stochastic, but so does the resolved flux.

On the other hand...

The SGS flux becomes smaller, but the resolved flux becomes bigger.

So how important is the SGS stochasticity?

Convince me.

- ◆ Show where the non-deterministic effects come from.
 - ▲ “Backscatter?”
 - ▲ Convection?
 - ▲ Mesoscale?
- ◆ Show how the non-deterministic effects alter the larger scales.
- ◆ Use a large-domain CRM.