How can we couple "traditional/true/classical/baroque/bulk" and "super" parameterizations?

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Continuing roles for traditional parameterizations

When resources are constrained:

    Long integrations (e.g. paleoclimate)

    In models with other expensive processes (e.g. chemistry)

    Ensembles

As "theories": compact representations of our understanding

Almost all climate simulations in the next … years will be made with traditional parameterizations

What might parameterizations look like in ten years?

Superparameterization (SP)

    Adequate resolution(s), sample size

    2D vs. 3D issues

    Generalized (other embedded models, grids?)

    Extended vs. contained coupling

Traditional parameterizations (TP)

    Explicit treatment of sub-gridscale variability

    Correct-ish coupling between processes (more unified)

    Consistent assumptions across processes

    Perhaps some stochastic components

What's the best we can hope for?

What can a traditional parameterizations conceivably do?

    Representations of sub-grid variability, and so reduced tuning

    Variability about mean relationships

    (More) Unified physics

    Memory and organization (crudely)

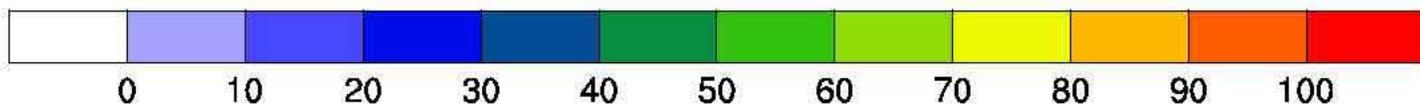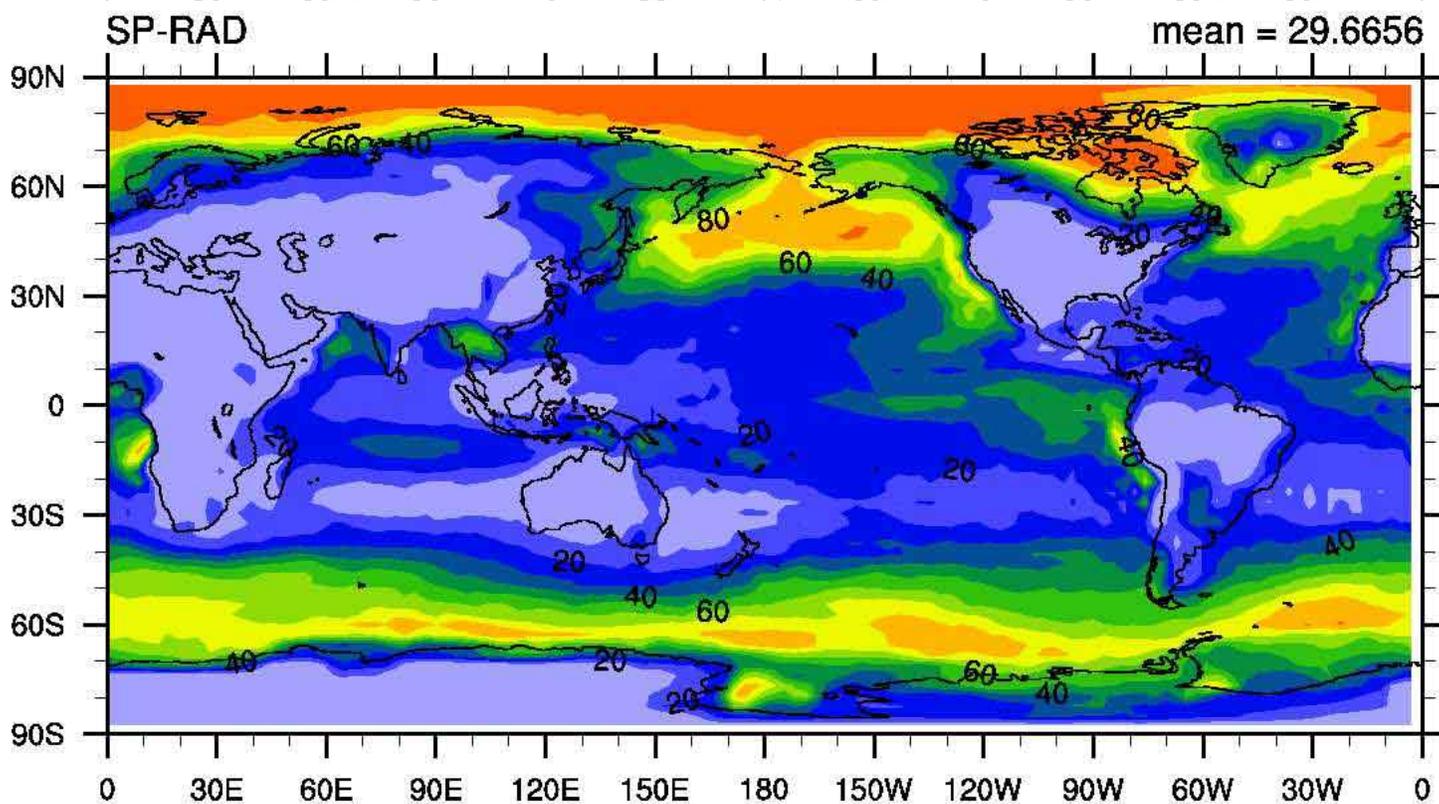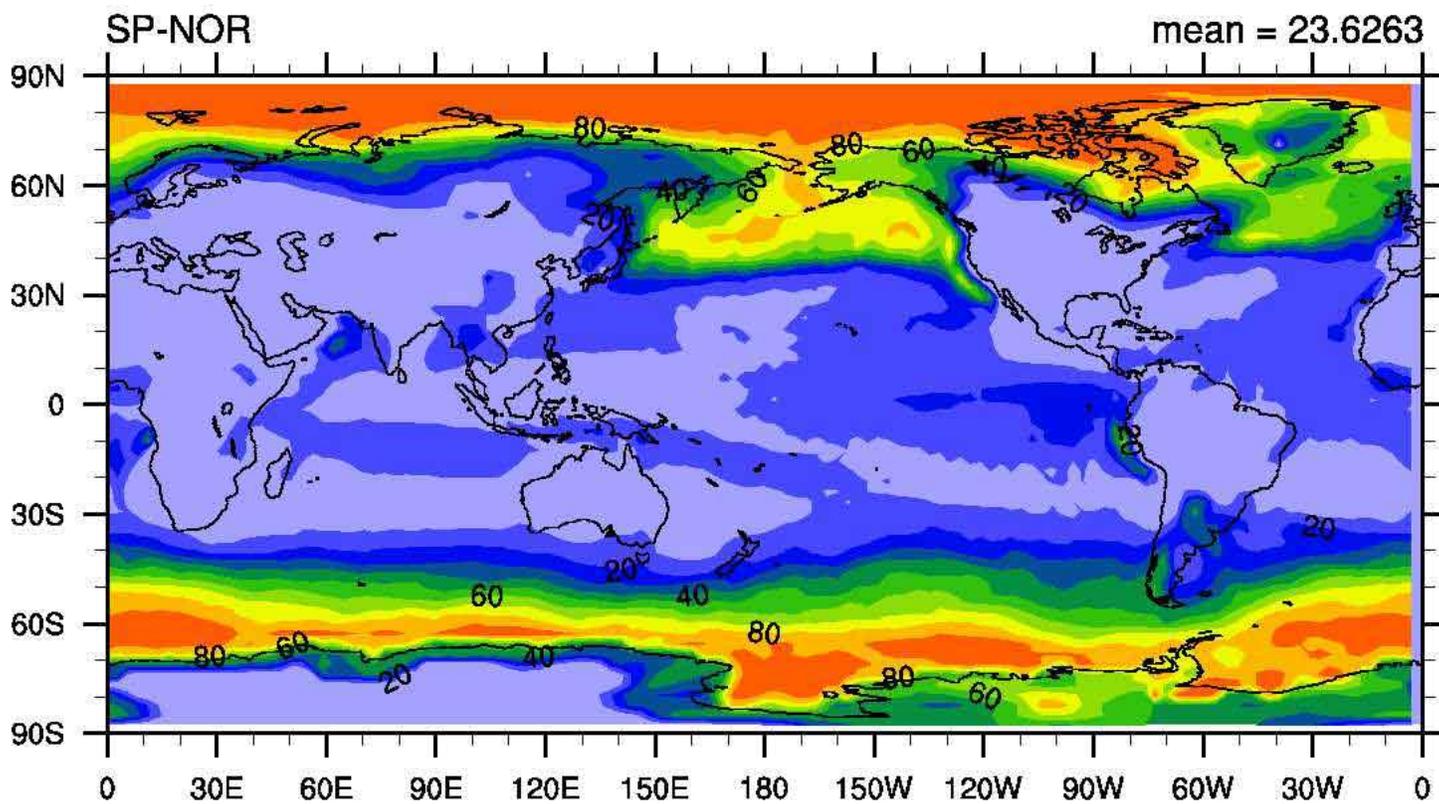What can't a traditional parameterization possibly do?

    Explicit structure (vertical, mesoscale)

    Processes coupling on cloud scale

    Memory (exactly)

We don't know how much SP buys *in principle*

JJA Low-level Cloud Fraction

SP-NOR   mean = 23.6263

SP-RAD   mean = 29.6656

Biases associated with proper overlap of homogeneous clouds

BIAS IN RADIATIVE HEATING (0.01 K/day)

SW HEATING

LW HEATING
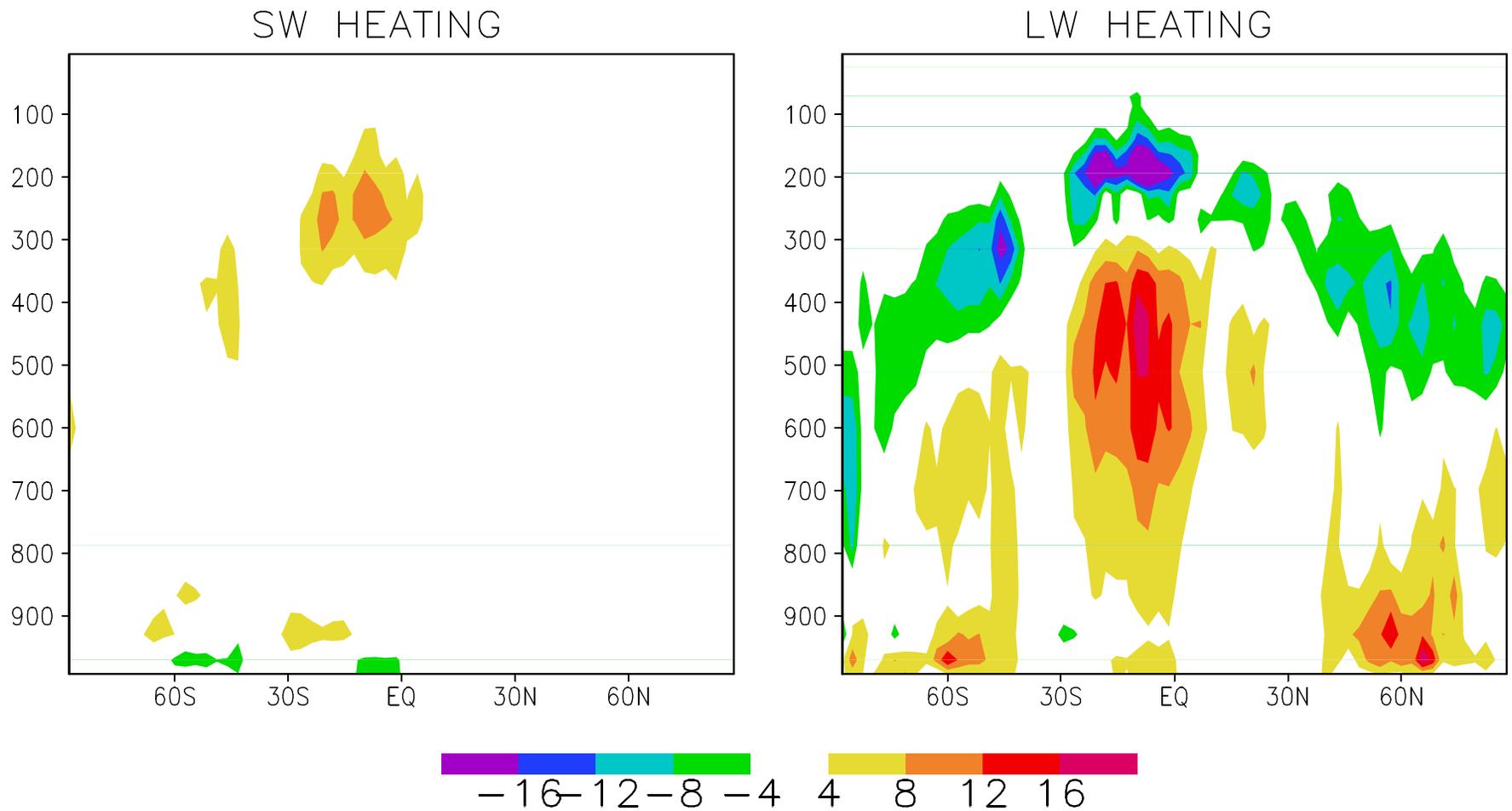
Using SP data sets to learn about sub-grid scale variability

We might use SP datasets to evaluate aspects of parameterizations

      Distributions (one-point statistics)

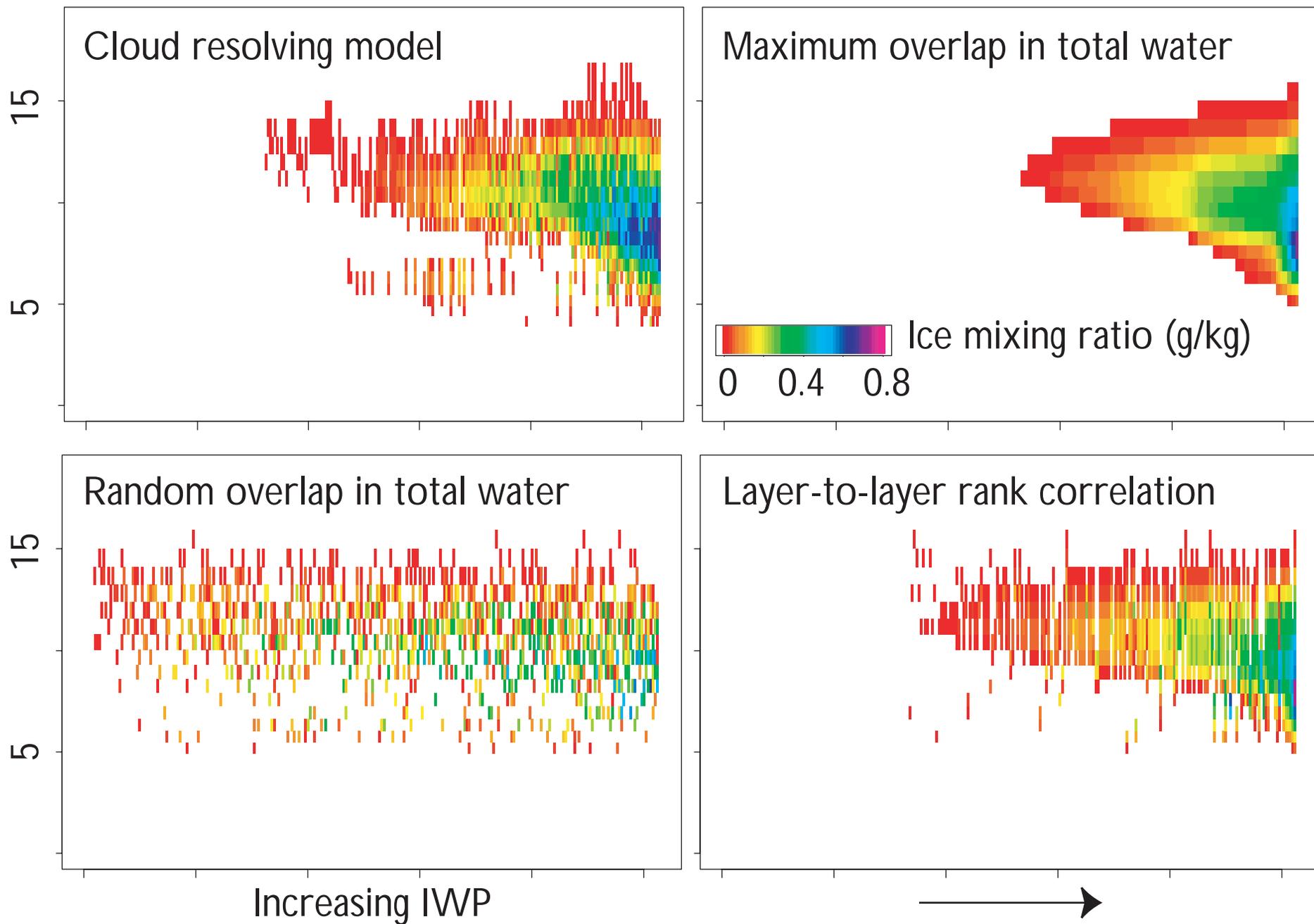   Arrangements/organization (correlations, i.e. overlap)

      Relationships between processes
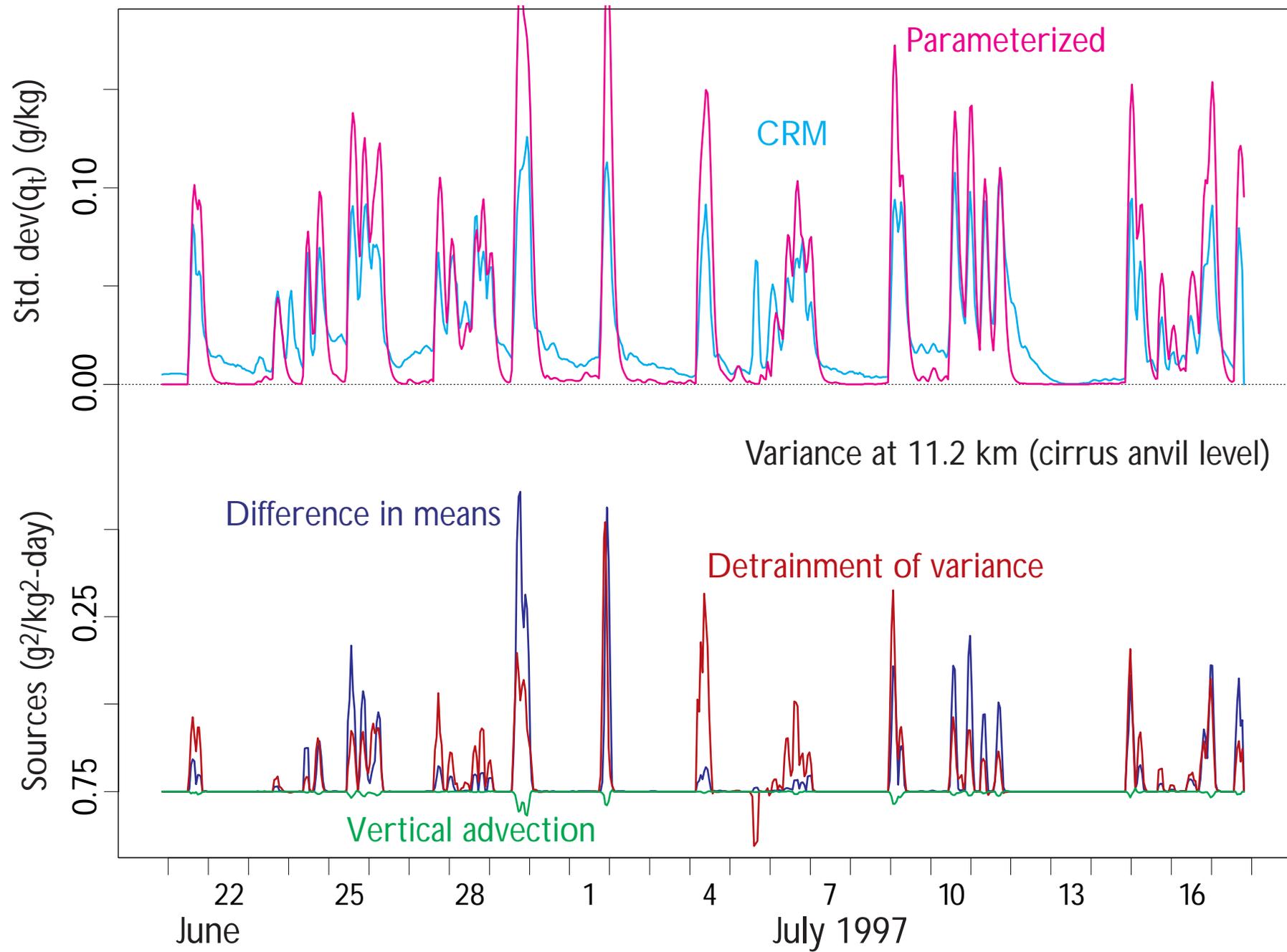
Superparameterization datasets vs. cases studies

      Large sample, wide range of conditions

      Consistent with large-scale dynamics (?)

      Caveat: CRM clouds have undergone limited evaluation

Cloud resolving model

Maximum overlap in total water

Random overlap in total water

Layer-to-layer rank correlation

Ice mixing ratio (g/kg)

0   0.4   0.8

Increasing IWP

SP guidance on non-unique solutions

Large-scale information may not uniquely determine process rates

Parameterizations could include random elements deliberately

    Non-linearities can bite!

    Might introduce temporal/spatial correlation (proxy for memory)

Parameterizations might also include random elements

    "accidentally", by using approximate solutions

Noise generally affects large-scale only when correlated

    SP can help us learn about time/space correlation scales

Data underlying a "stochastic" microphysics parameterization
McFarquhar et. al, 2003
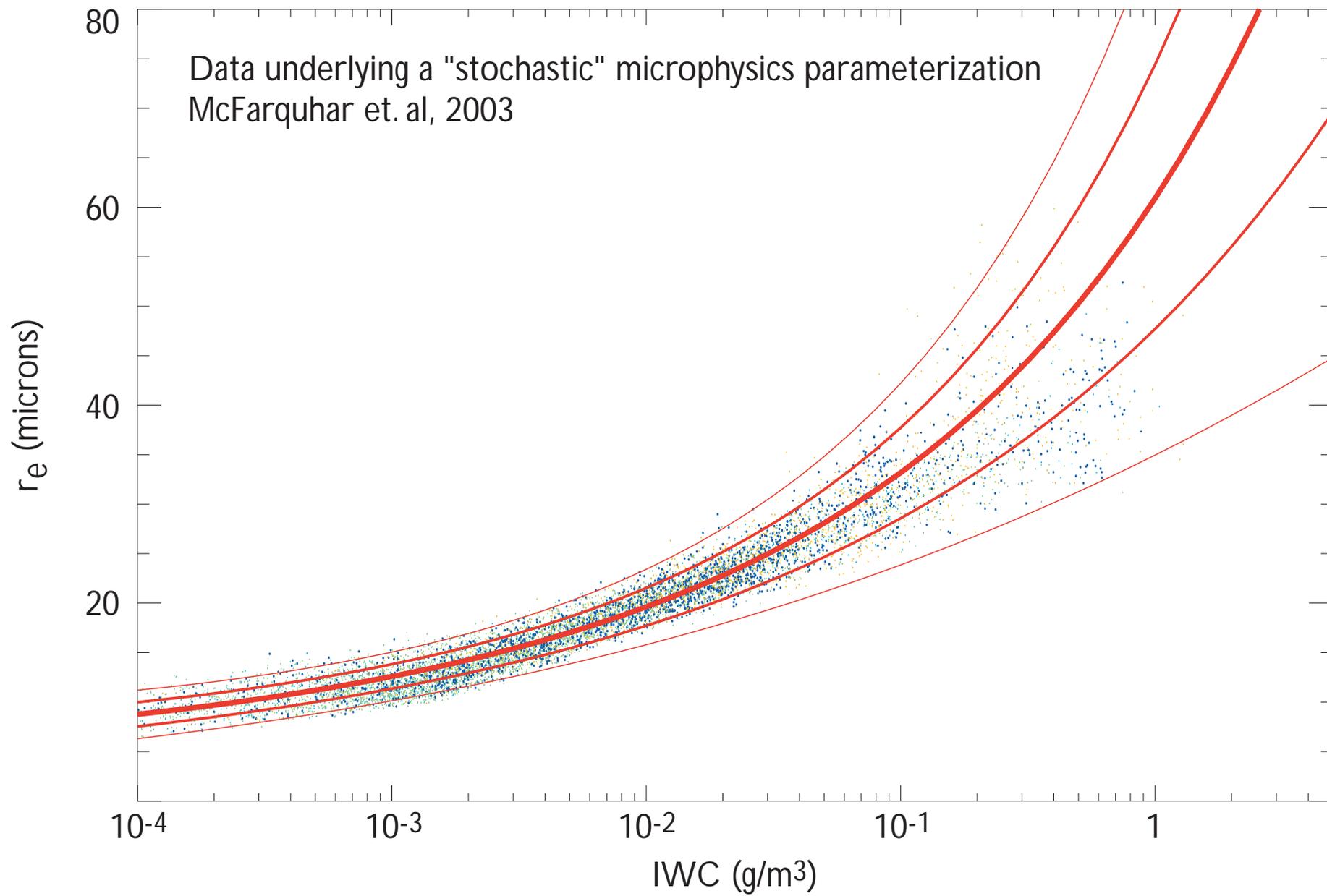
Maybe failure is where we learn the most

What if SP works but TP doesn't?

> Cloud-scale interactions among processes?
>
> Poor representations of variability or organization in TP?
>
> Persistence/memory?

What if TP works but SP doesn't?

> CRM clouds have undergone limited evaluation; may have
> different sensitivities than TP

What if neither works?

> Some processes (microphysics, turbulence) are parameterized in
> both contexts; perhaps these are crucial