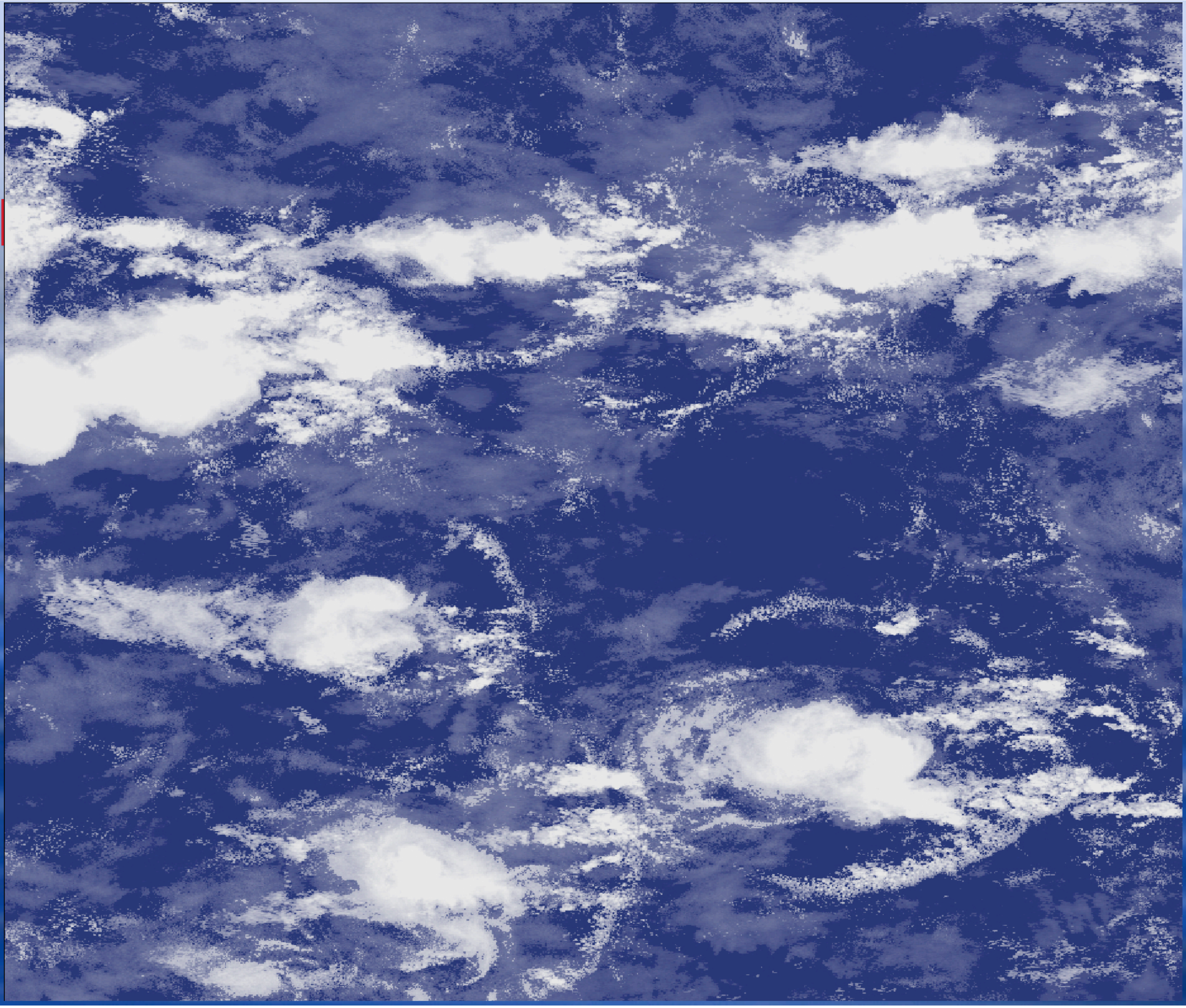
Developing SGS turbulence models for CRMs or MMFs

Chin-Hoh Moeng
National Center for Atmospheric Research

CMMAP team meeting (Jan. 2010)



Our approach:

Benchmark simulation that resolves
a wide range of scales

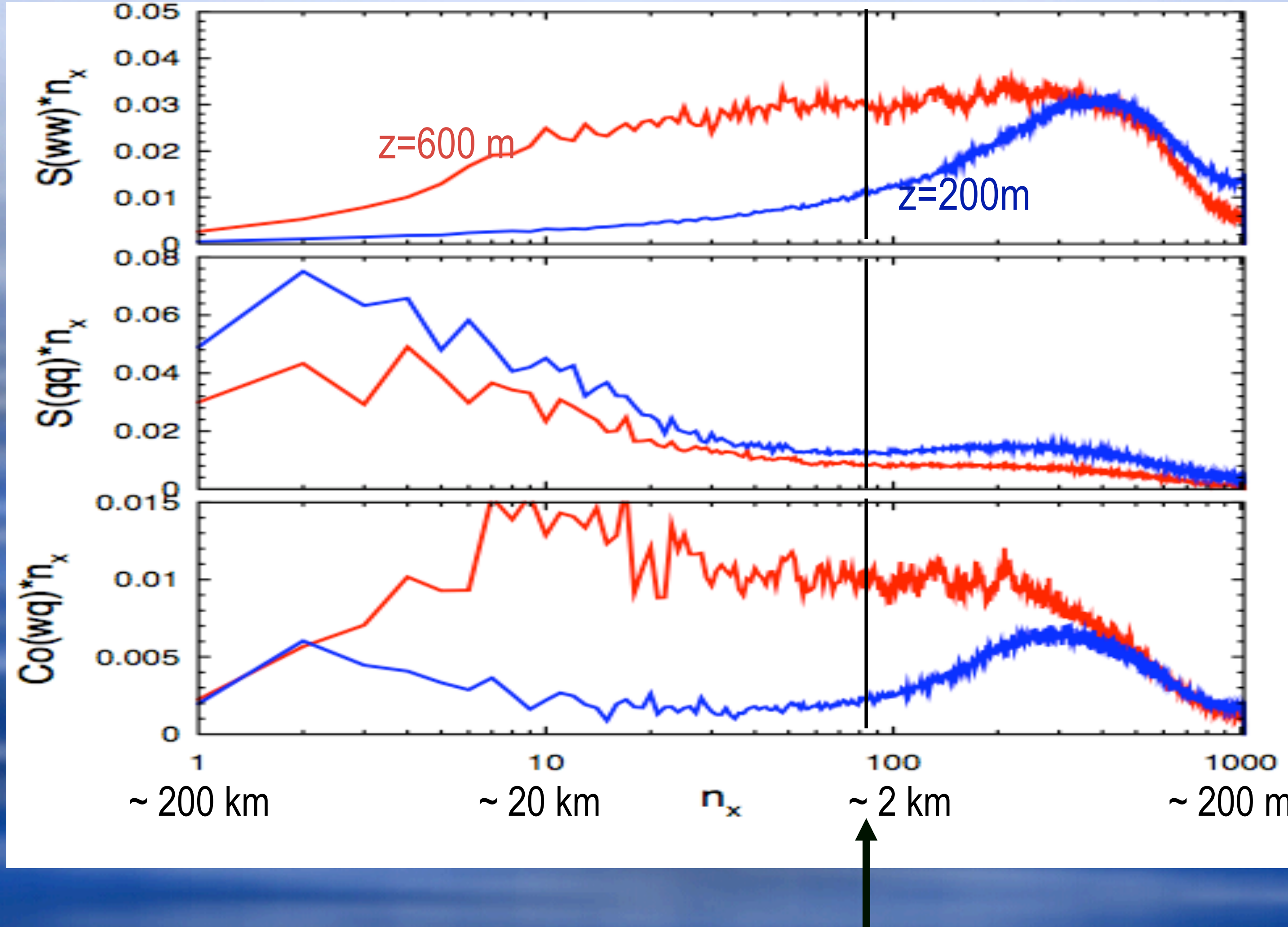
deep/middle/shallow clouds and turbulence…

↓

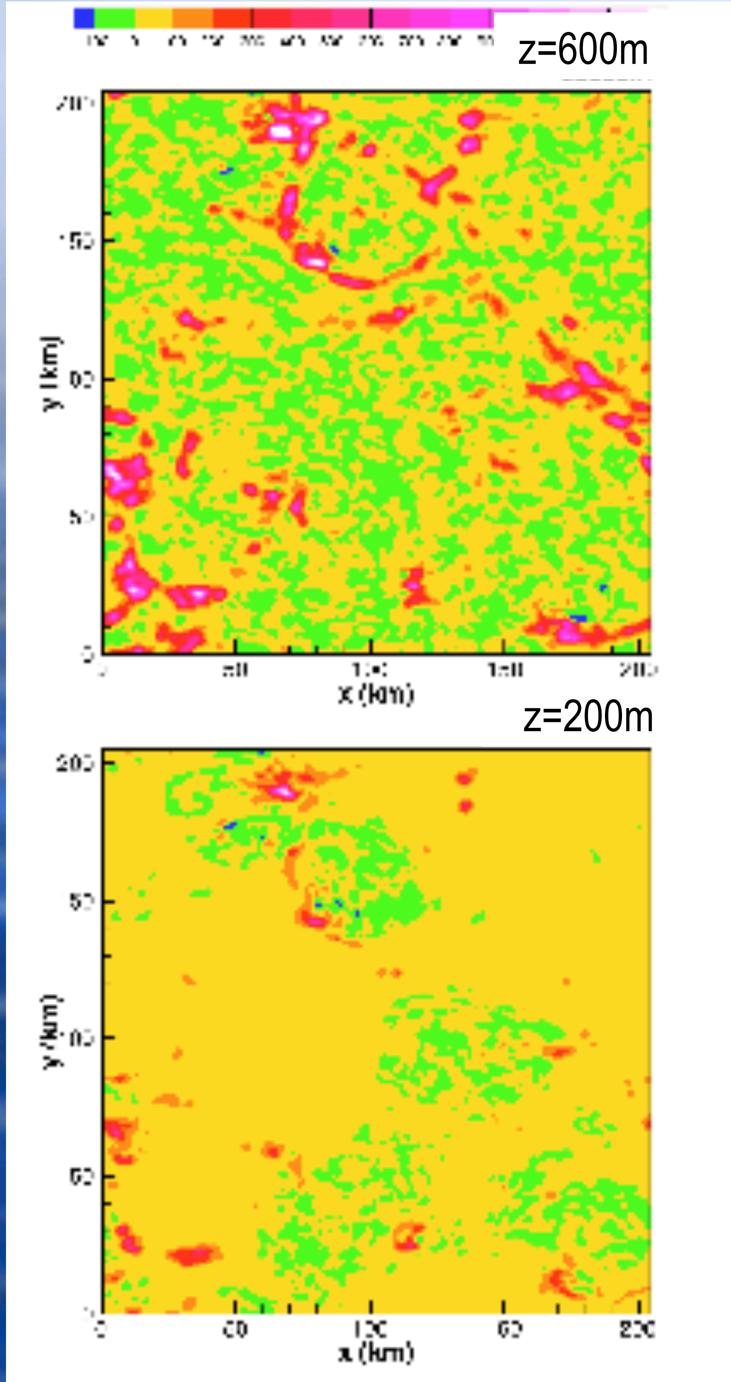
Separate scales to:
CRM "resolvable" and "SGS" components

$$w = \tilde{w} + w'$$

Spectra from the benchmark run



Split into "resolvable" and "SGS" components according to a typical CRM resolution.



Also retrieve local SGS fluxes from the benchmark run: τ_{wq}

e.g., filter width = 4 km

used as a reference
(“truth”)

Three simple models

Model 0: $\tau_{wq} = -K_h \partial\tilde{q} / \partial z$; where $K_h \propto \ell\sqrt{e}$

Model 1: Same as Model 0 but the SGS length scale depends on filter width, wall scale, and local stability.

Model 2: Add a "mass-flux" M-term to Model 1;

$$M - term \propto \tilde{w}(\tilde{q} - < q >)$$

The proportionality empirically obtained; depends on z ds.

Spatial distributions

retrieved and modeled SGS q-fluxes

filter width = 4 km

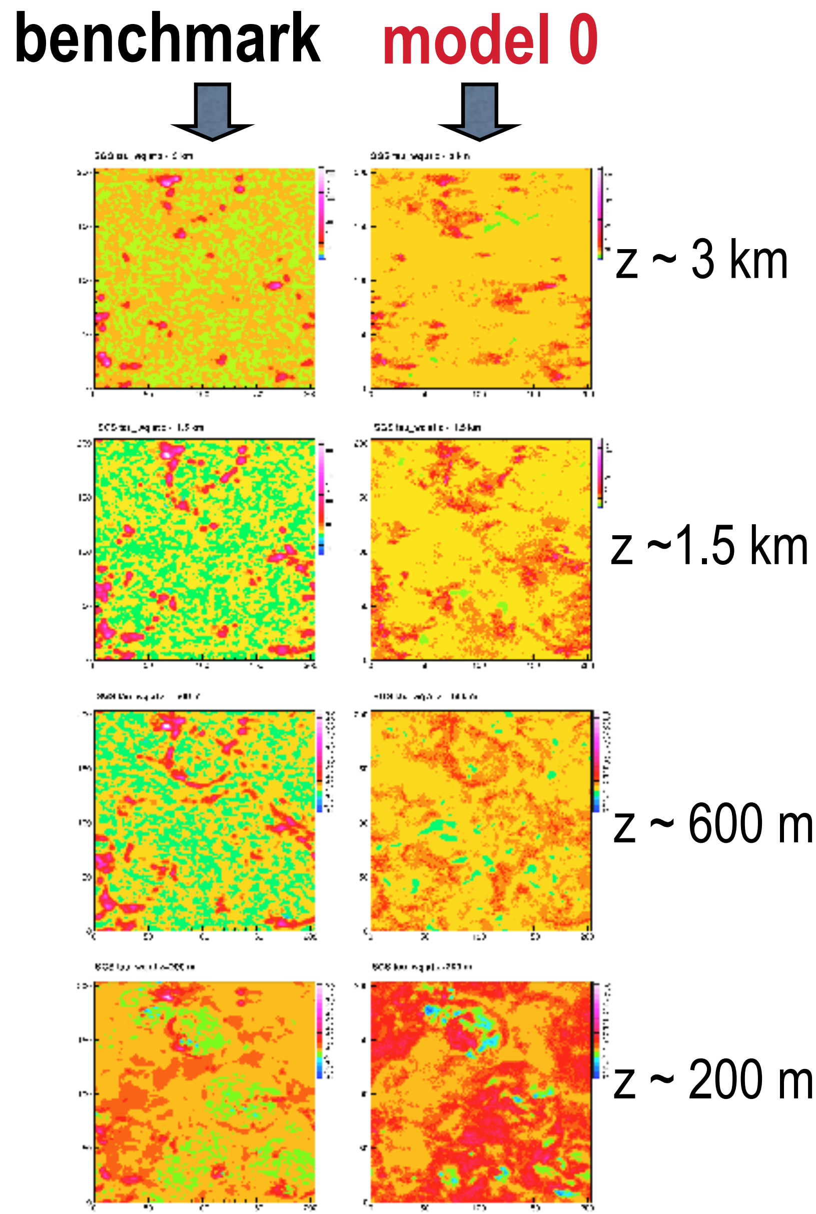


Figure 1: Model 0: with just the K term.

Spatial distributions

retrieved and modeled SGS q-fluxes

filter width = 4 km

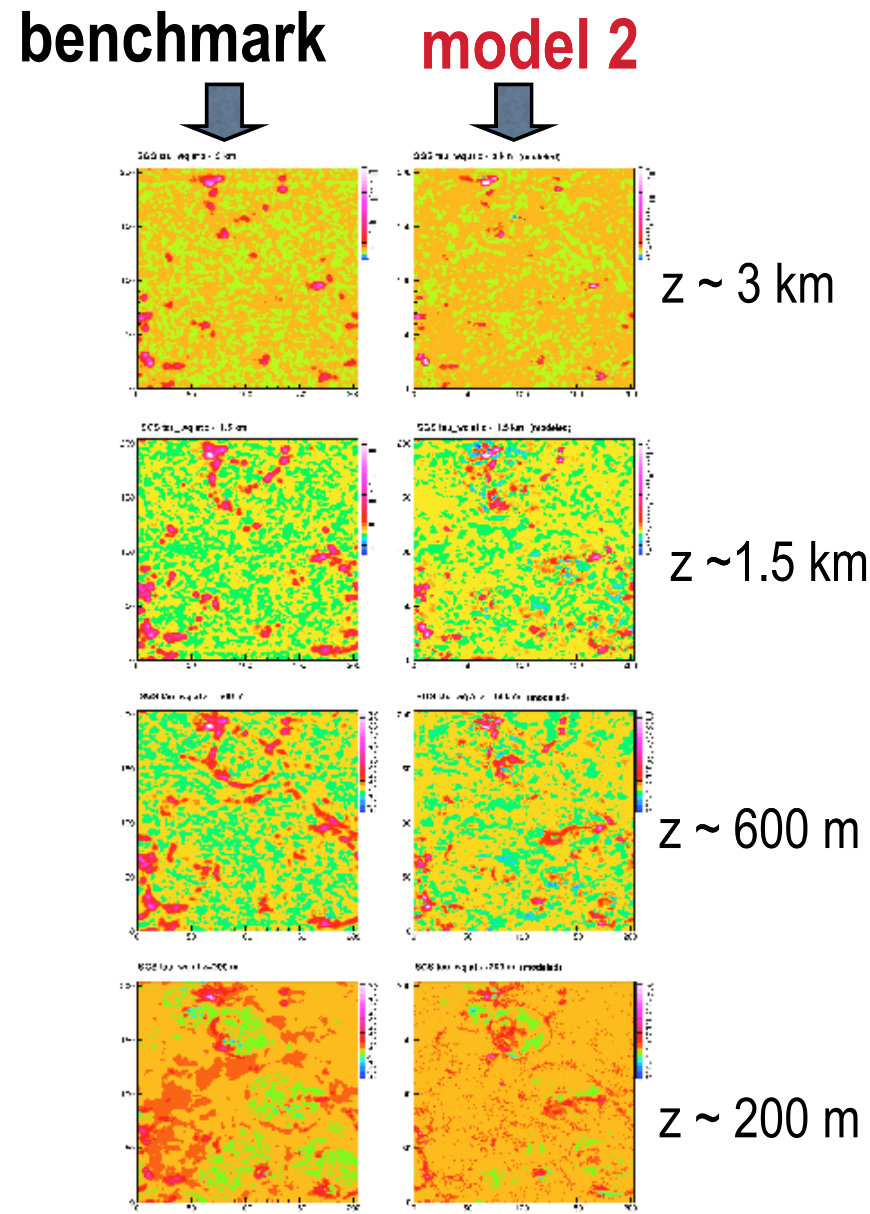
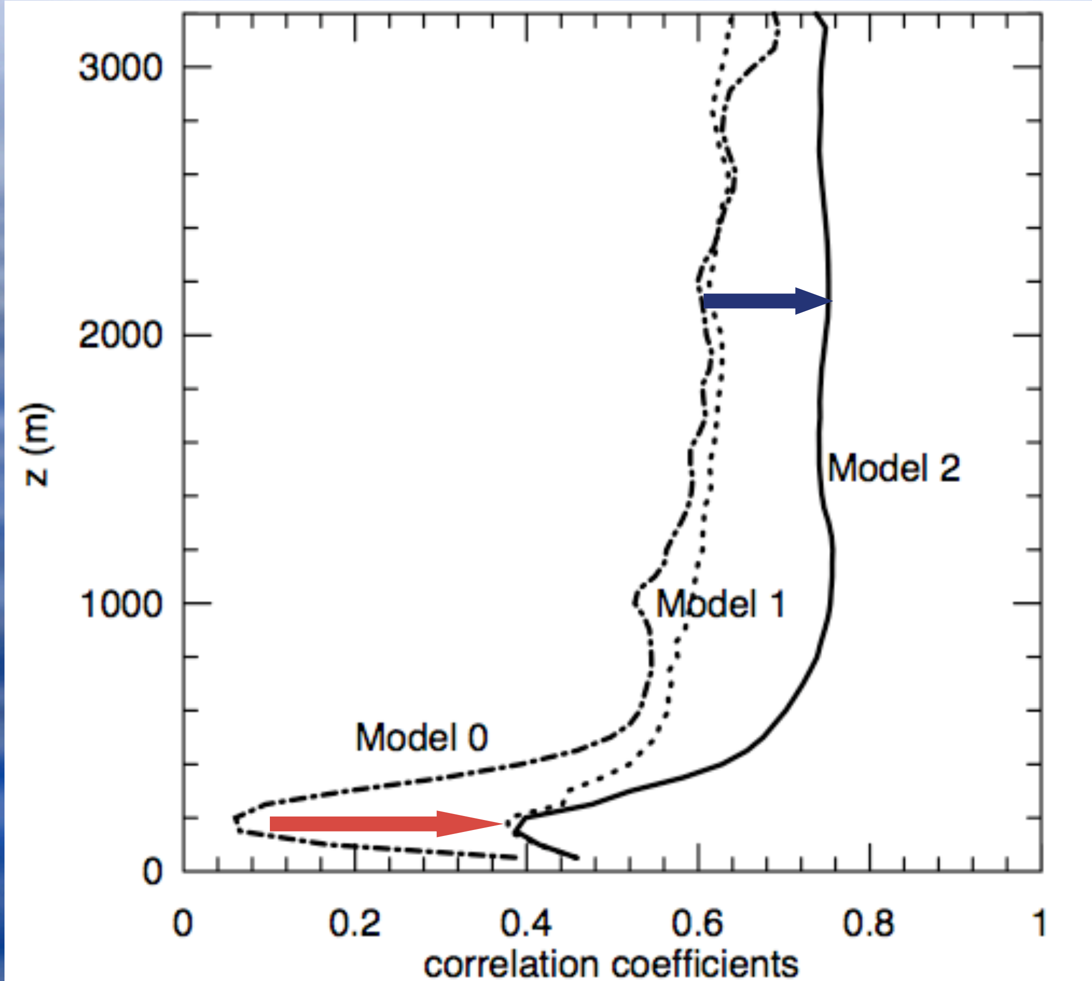


Figure 1: Horizontal distributions of the LES-retrieved SFS fluxes with a filter width of 4 km (left panels) and the modeled SGS fluxes (right panels) of water vapor at z = 3000 m, 1500 m, 600 m, and 200 m (from top to bottom).

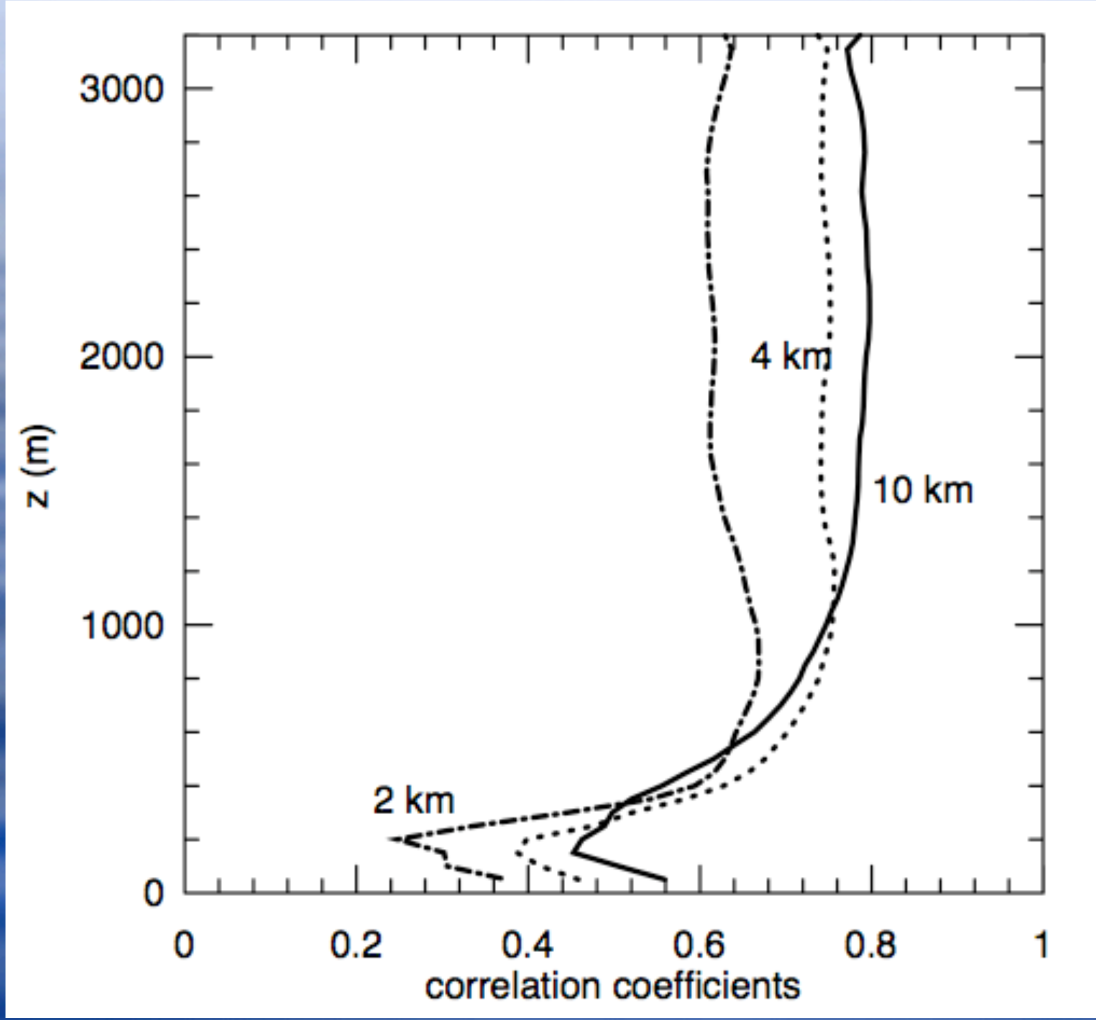
1. Length-scale corrections improve the presentation in the PBL

2. Mass-flux term improves the presentation above



Spatial correlation with the benchmark fluxes

Model-2 performance with various filter widths



- Δf = 4 km corresponds to a CRM grid mesh~1km.

Future studies

1. Test model-2 in SAM and in prototype MMF (both 2D&3D CRMs).
2. Create benchmark simulations for various cloud types.

Investigate all cloud types

Create a database of benchmark simulations of all cloud regimes: tropical cloud systems, midlatitude storms, squall lines...