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presentation:

The Future Role of LES in Parameterization of Turbulence and Clouds in the PBL

- 1. Investigating ‘superparameterization’ of convective turbulence and clouds in the PBL**
- 2. Studying PBLs over complex terrain and heterogeneous land use**

Investigating ‘superparameterization’ of the convective PBL



- What are the physical aspects of its “resolved” 2D plumes?
- What controls the behavior of those hypothetical 2D plumes?
- How does the 2D solution depend on the orientation of the 2D model?



Models and Regimes



■ The Models

- The 3D model: NCAR LES code, as baseline calculations
- The 2D model: same as LES but set all



■ The 3D Convection Regimes

- free convective PBL (no mean wind)
- shear-convective PBL (with mean wind)



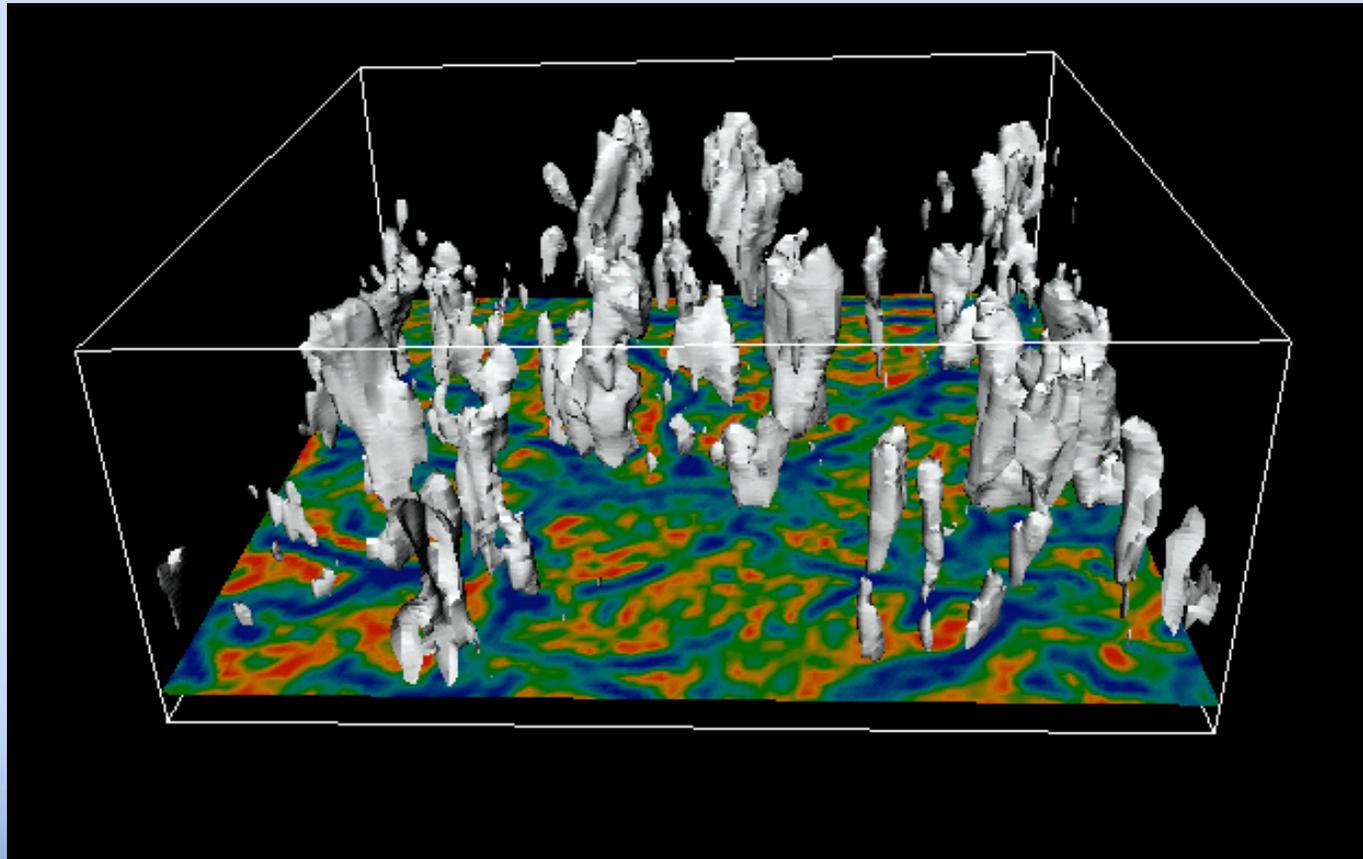
The Free Convective PBL



- Simplest convective system in the atmosphere
- Statistically homogeneous in the horizontal directions; no realizable 2D motion
- Analogous to tropical deep convection:
 - Forced by surface heating
 - Random in space and time
 - Capped by a strong inversion
 - Inherently 3D (in most situations)



Convective updrafts

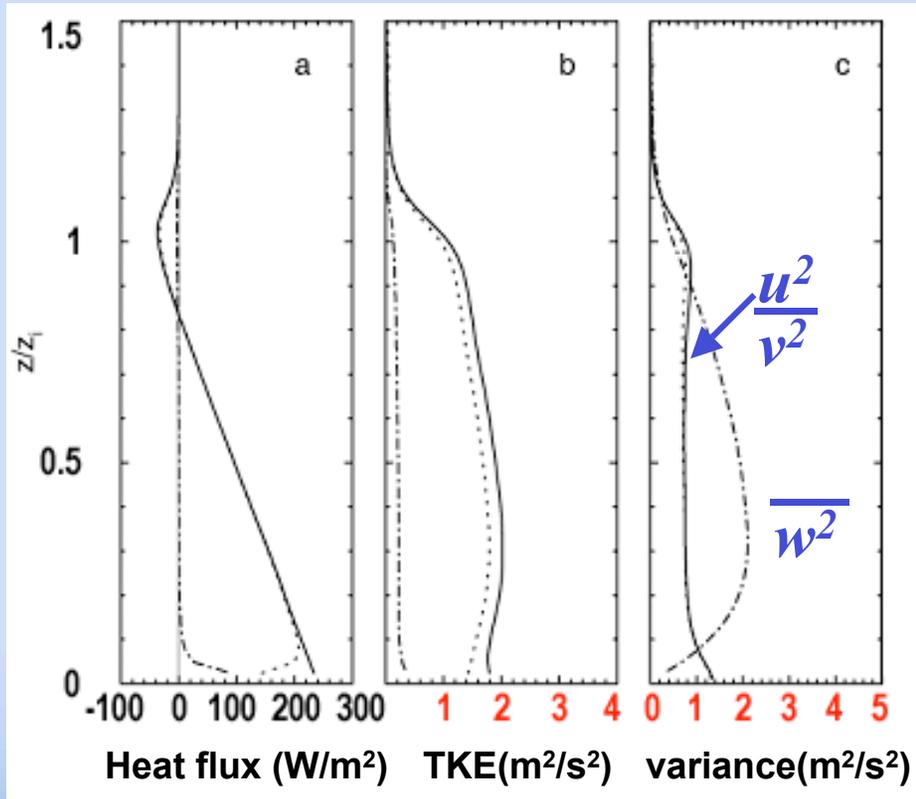


The Free Convective PBL (Results)

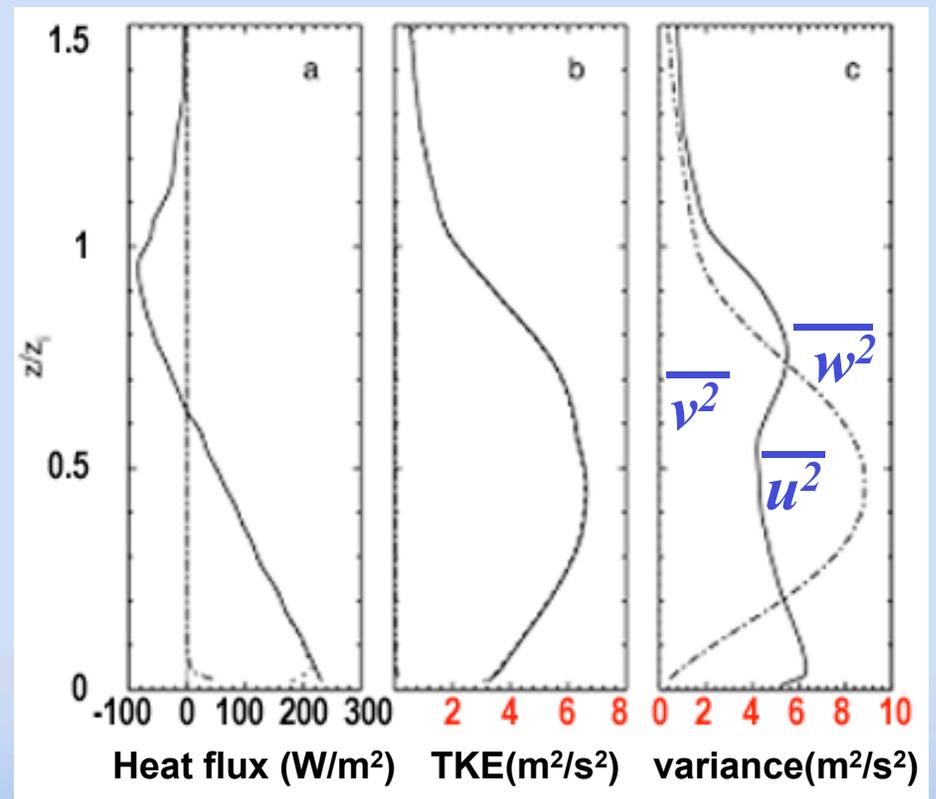


- To show the sensitivity of statistics to the SGS KM and KH in the 2D model
 - F-3D (LES) vs. F-2D-A (smaller SGS KM and KH)
 - F-3D (LES) vs. F-2D-B (larger SGS KM and KH)



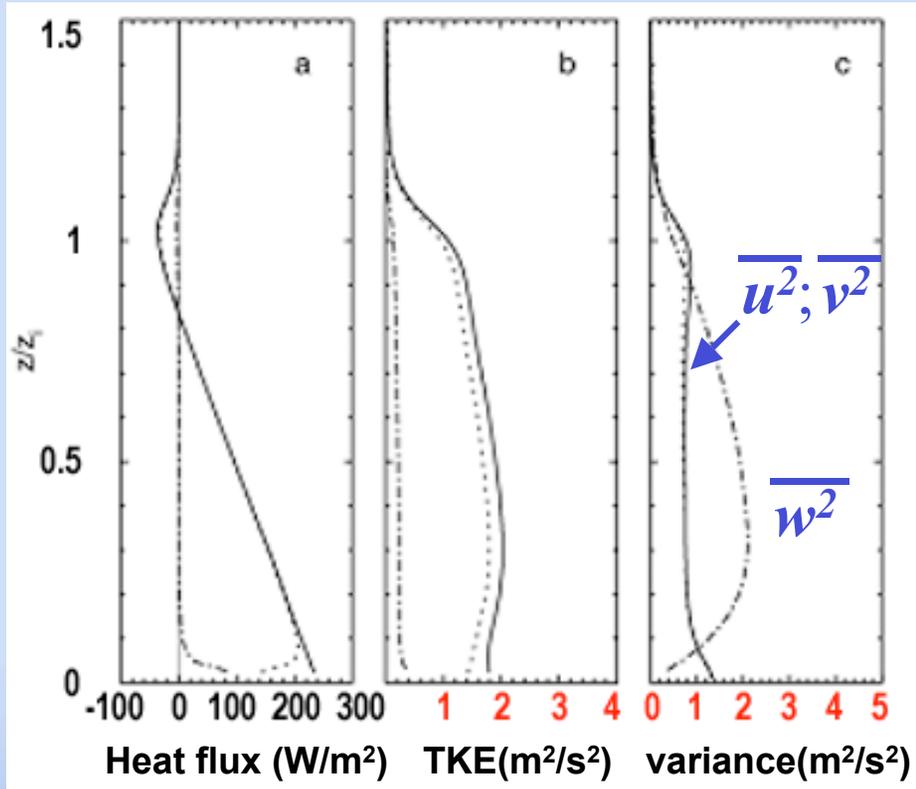


F-3D

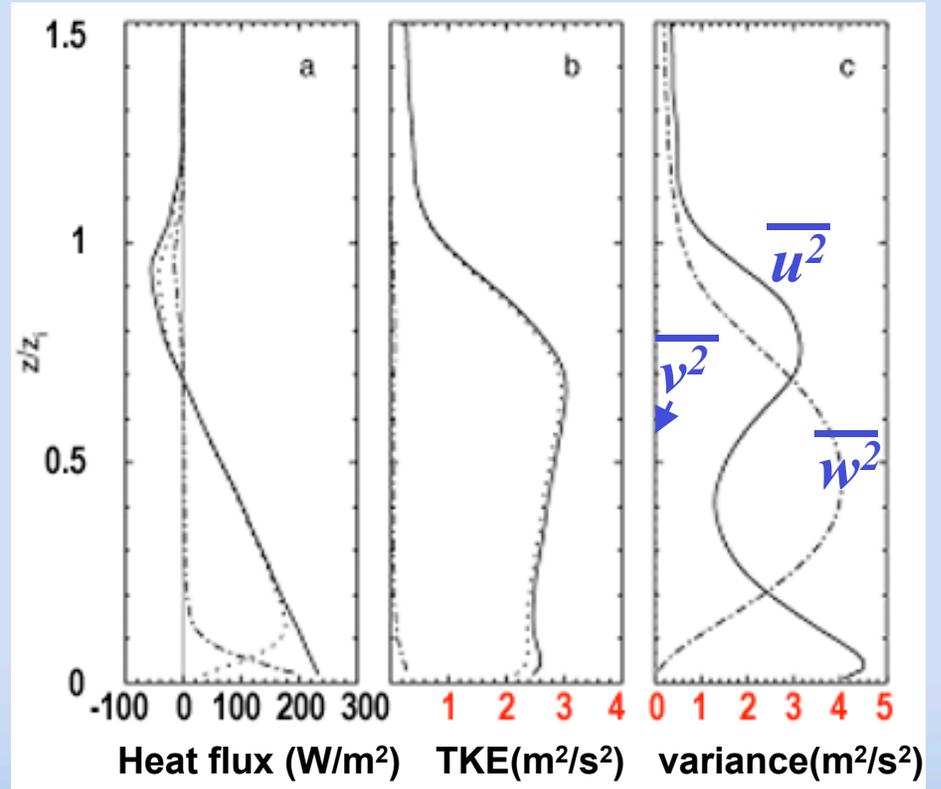


F-2D-A





F-3D



F-2D-B



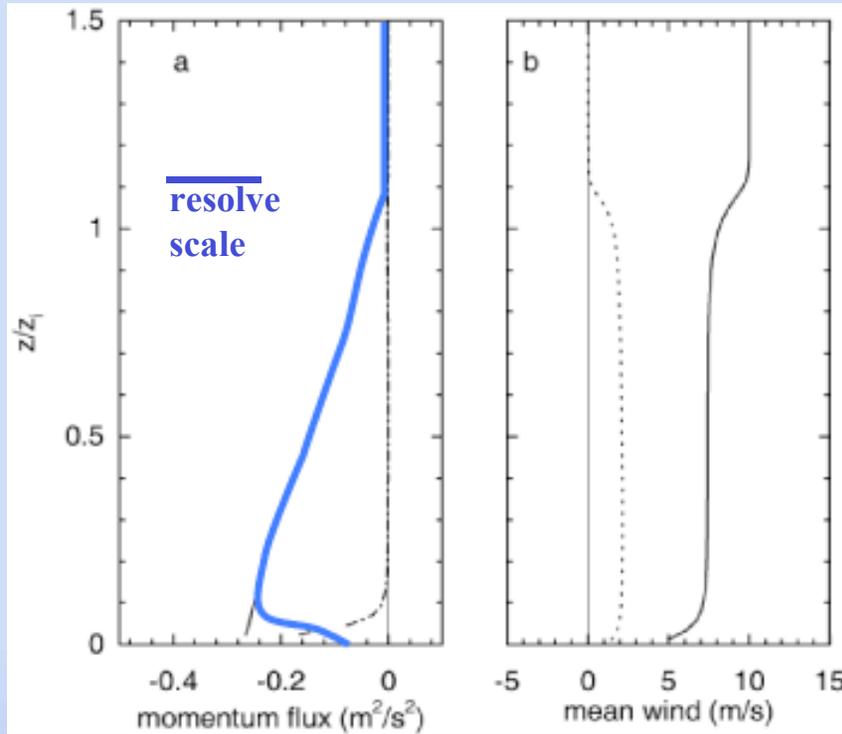
The Shear-Convective PBL



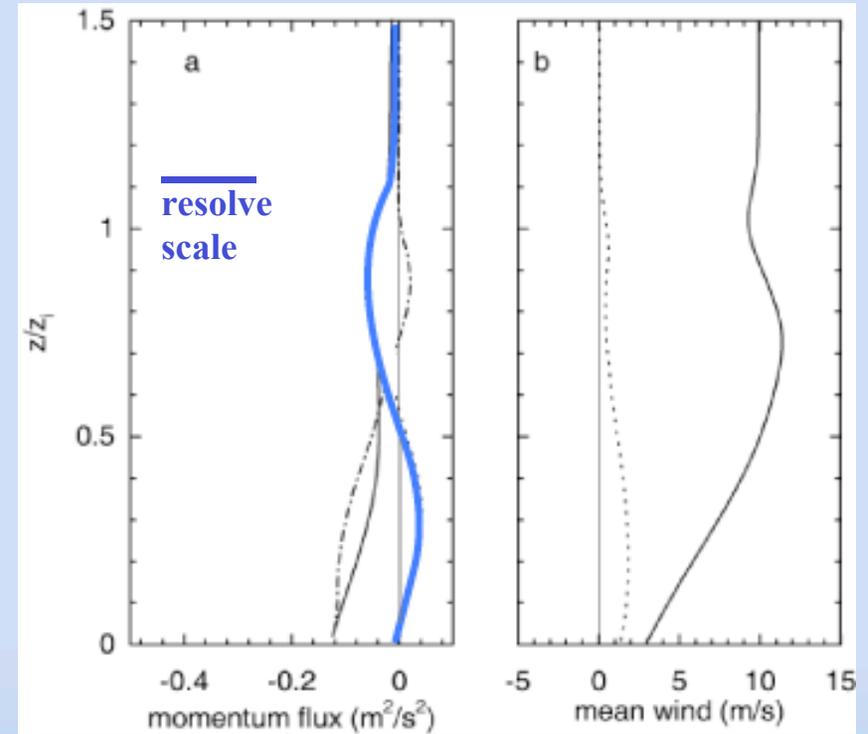
- A case to show the sensitivity of the 2DT solution to the orientation of the model domain
- S-3D (LES) vs. S-2D-U (2D domain \parallel geostrophic wind)
- S-3D (LES) vs. S-2D-V (2D domain \times geostrophic wind)



Momentum fluxes and the mean wind



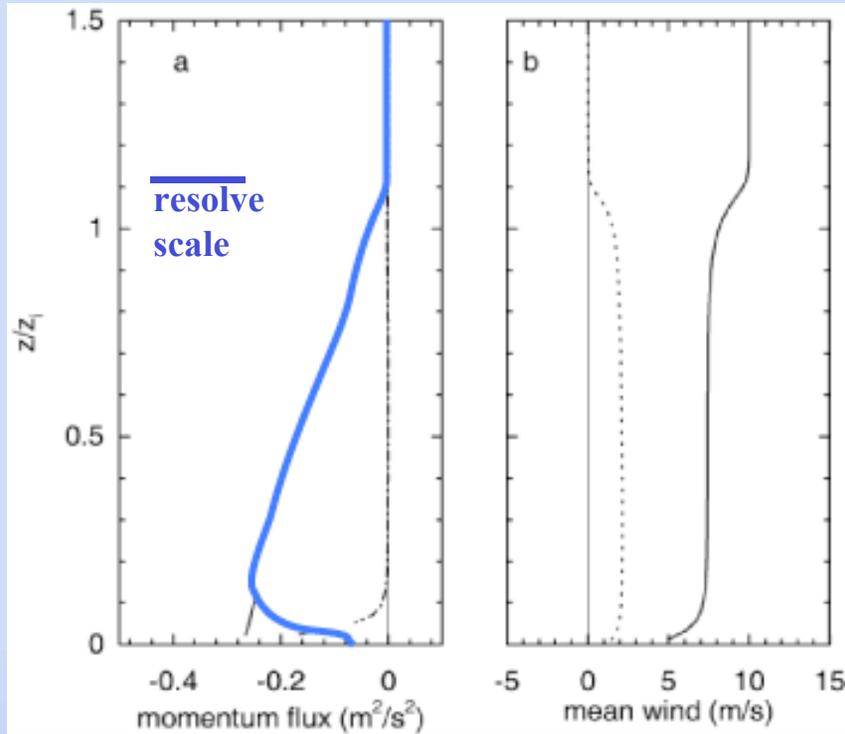
S-3D



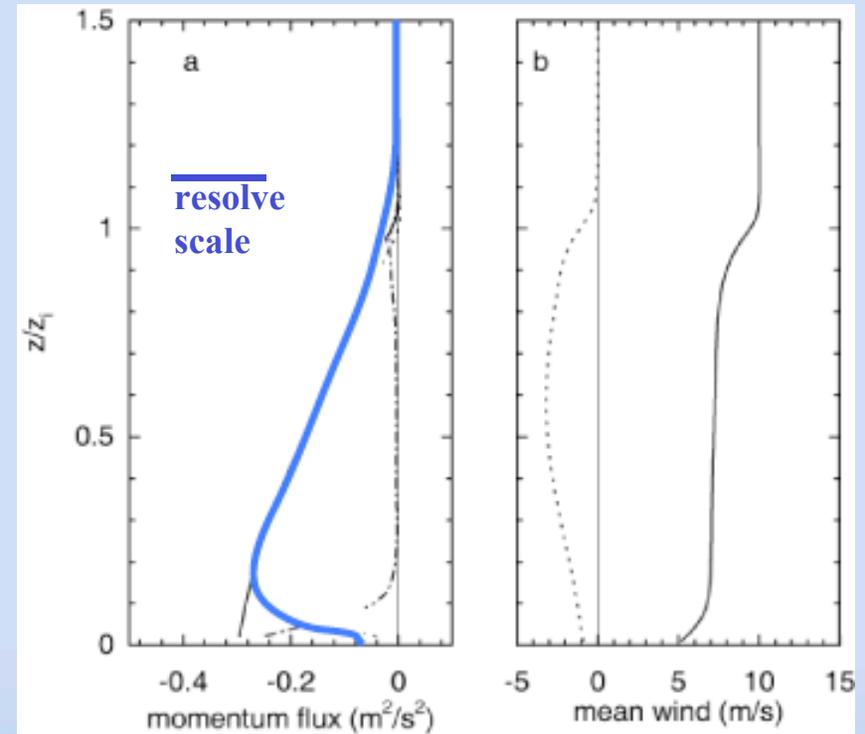
S-2D-U



Momentum fluxes and the mean wind



S-3D



S-2D-V



Summary



- A 2DT model is a parameterization (not a simulation) for 3D convection
- With proper SGS eddy viscosity and orientation of the domain, the hypothetical 2D plumes can behave somewhat like their 3D counterparts – statistically
- FUTURE STUDY → ‘Superparameterization’ of PBL clouds?

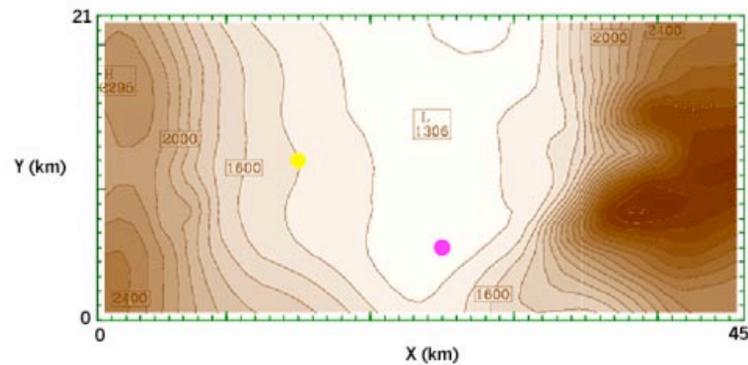
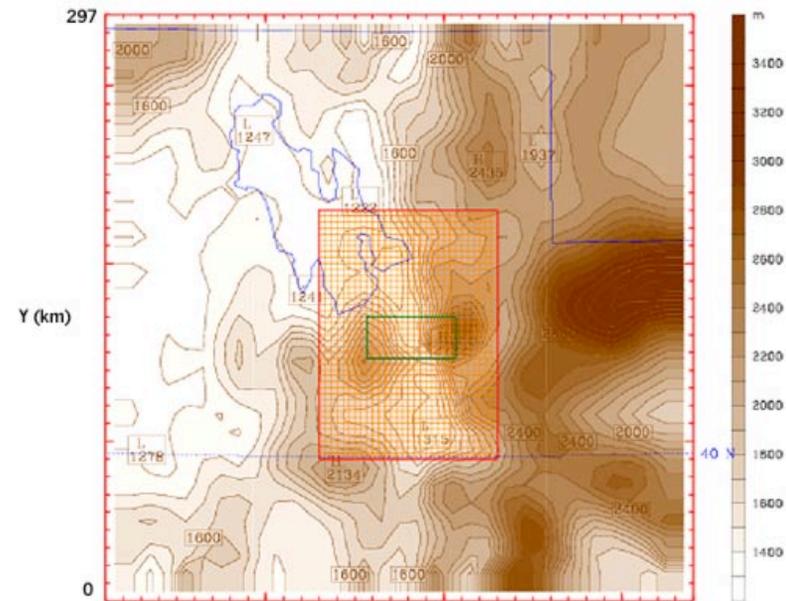


PBLs over complex terrain and heterogeneous surface



- Extend the LES technique to incorporate complex surface geometry and land use
- Examine turbulent transport process under time-evolving terrain-induced mesoscale forcing
- Improve PBL parameterizations of heterogeneous PBLs in weather or climate forecast models

Imbedding an LES domain inside the WRF model



Technical issues



- Inflow boundary condition for turbulent flow
- Subgrid-scale representation near irregular surfaces
- Analysis: proper scaling and representations of ensemble-mean statistics in horizontally-inhomogeneous PBLs



Scientific Issues



1. How do the terrain and mesoscale variations affect the turbulent transport?
2. Are the statistics highly dependent of local geography and land use?
3. How to improve parameterizations of PBL turbulence over irregular terrain or land-use regions?
4. How do chemical transport and reaction rate differ over complex environment, and how to represent these subgrid-scale effects in climate models?

