The TEMF Boundary Layer Scheme: Implementation And Tests Of Shallow Cumulus Cases

Wayne M. Angevine

CIRES, University of Colorado, and NOAA ESRL

Thorsten Mauritsen

Max Planck Institute for Meteorology, Hamburg

Hongli Jiang

CIRA, Colorado State University, and NOAA ESRL

Why a new scheme?

- Existing schemes in WRF have known deficiencies in stable conditions
  - too little mixing or too much
- Fair-weather cumulus “fall in the crack” between BL schemes and cumulus schemes
- Non-local component of convective BL transport is still an issue
- Many groups are moving toward a convective BL scheme incorporating eddy diffusion and mass flux -- “EDMF”

The stable side (Mauritsen et al. 2007 JAS)

- Use of total turbulent energy in stable stratification (potential + kinetic energy)
  - therefore no implicit critical Ri
- Use of local gradient Ri stability functions
  - does not assume a single surface-based BL
  - “sharp tails”
- A length-scale incorporating z, f and N
- Avoids self-correlation in selection of empirical coefficients
- Tested in almost 100 LES cases

The convective side (Angevine 2004 JAM)

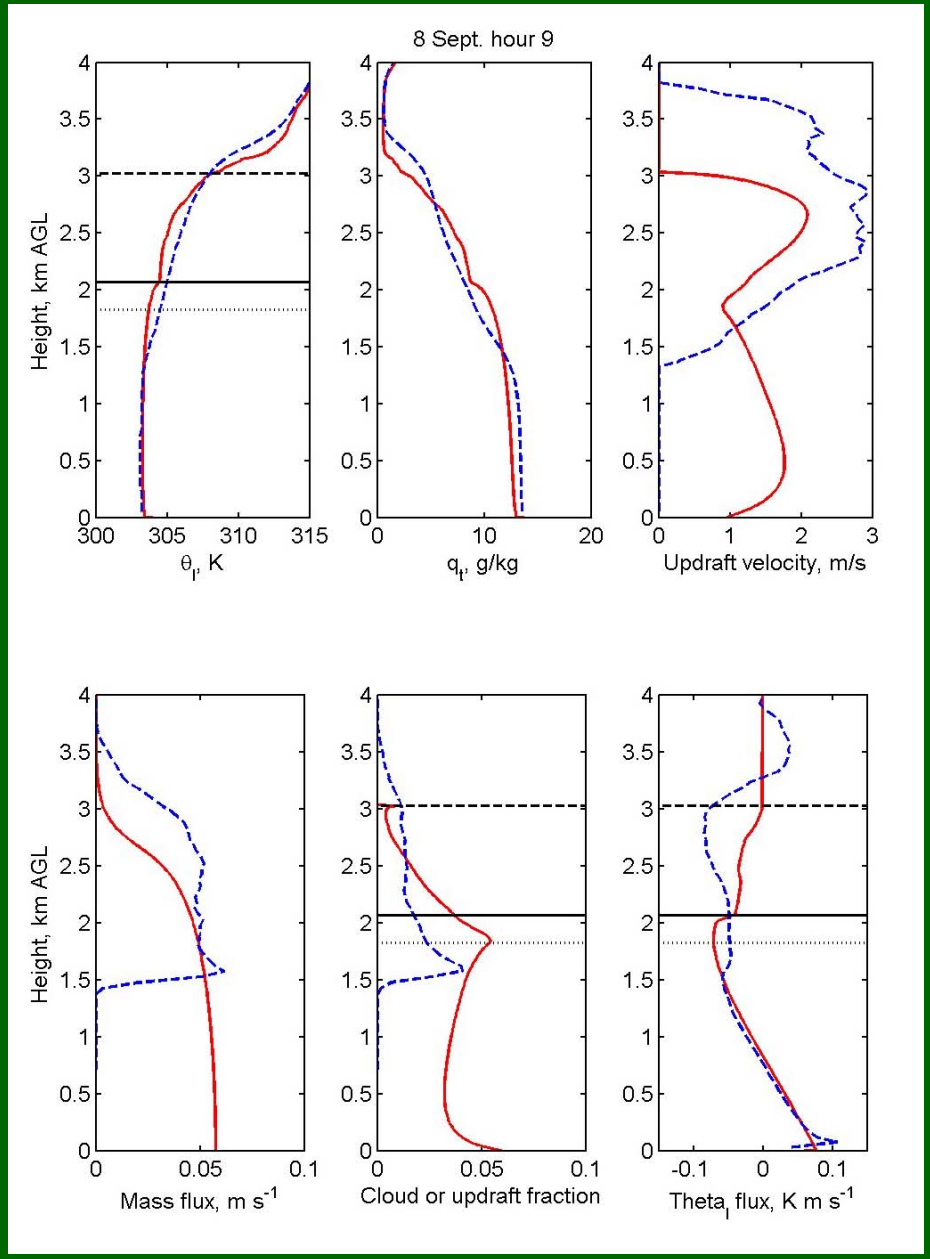
- Eddy diffusion – Mass flux (EDMF) scheme
- Patterned after work by Siebesma, Teixeira, and others
- Diffusion coeffs. based on total energy (TE)
- Mass flux transports all quantities, including TE, U, V
- Length scale based on distance from surface and inversion

The GOMACCS cases

- Gulf of Mexico Atmospheric Composition and Climate Study
- September 2006
- LES simulations with RAMS/LES
- Shallow cumulus over land
- TEMF 1D / SCM in Matlab
- Boundary conditions from LES

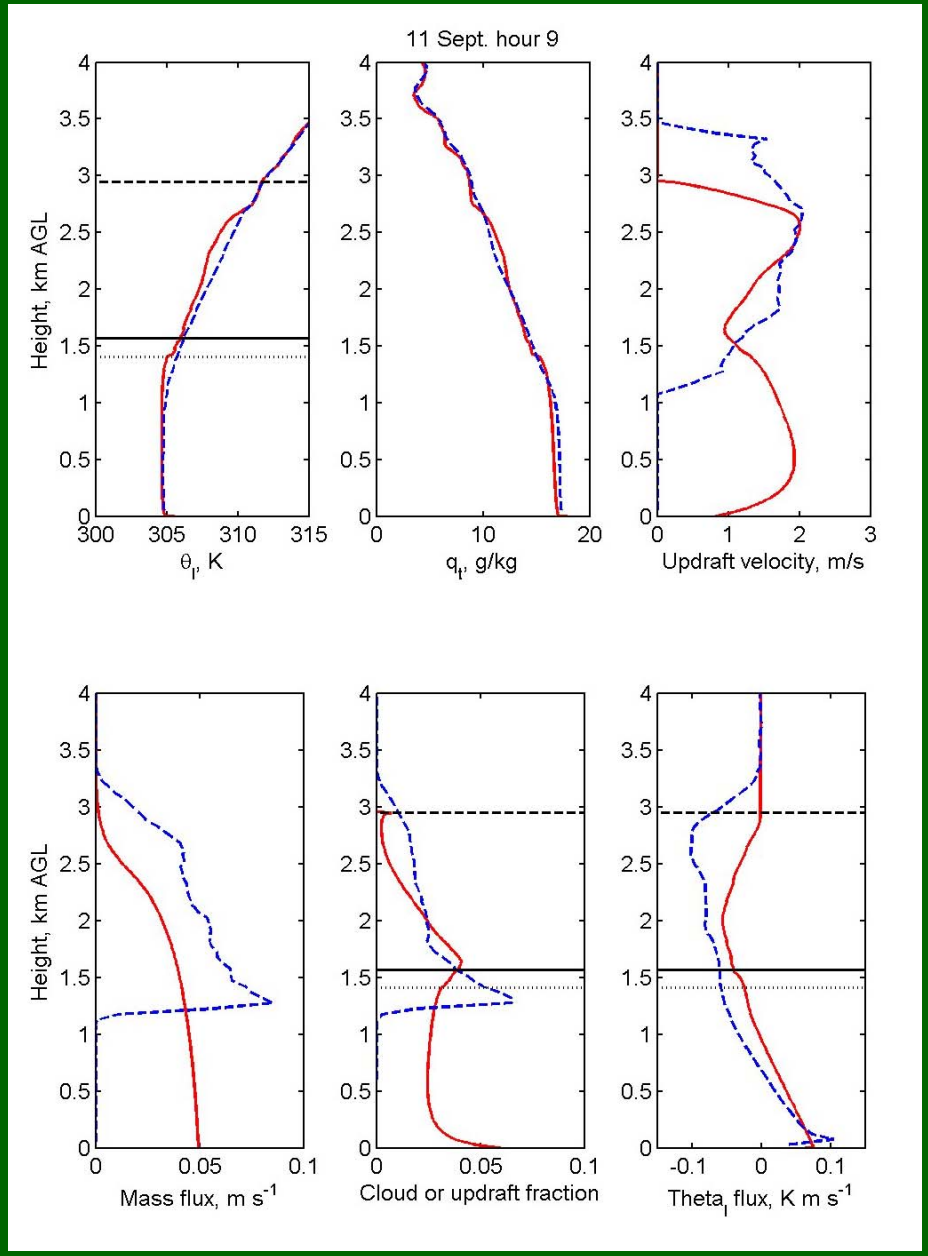
TEMF vs. LES 8 September

- Profiles at 1500 LST as labeled
- Red = TEMF, blue = LES
- Good correspondence in theta and q
- Reasonable correspondence in cloud parameters (note these are snapshots)



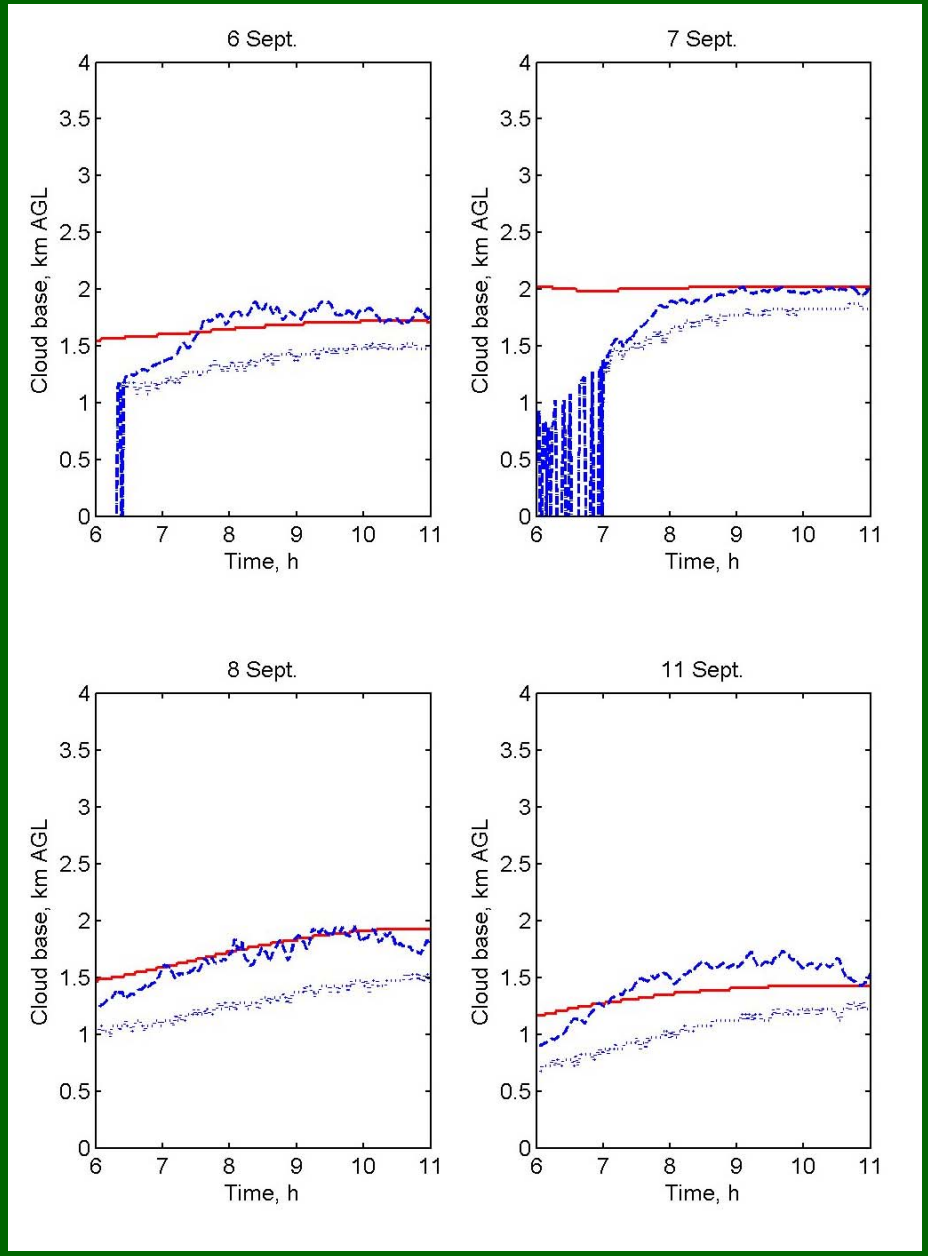
TEMF vs. LES 11 September

- Profiles at 1500 LST as labeled
- Red = TEMF, blue = LES
- Good correspondence in theta and q
- Reasonable correspondence in cloud parameters (note these are snapshots)



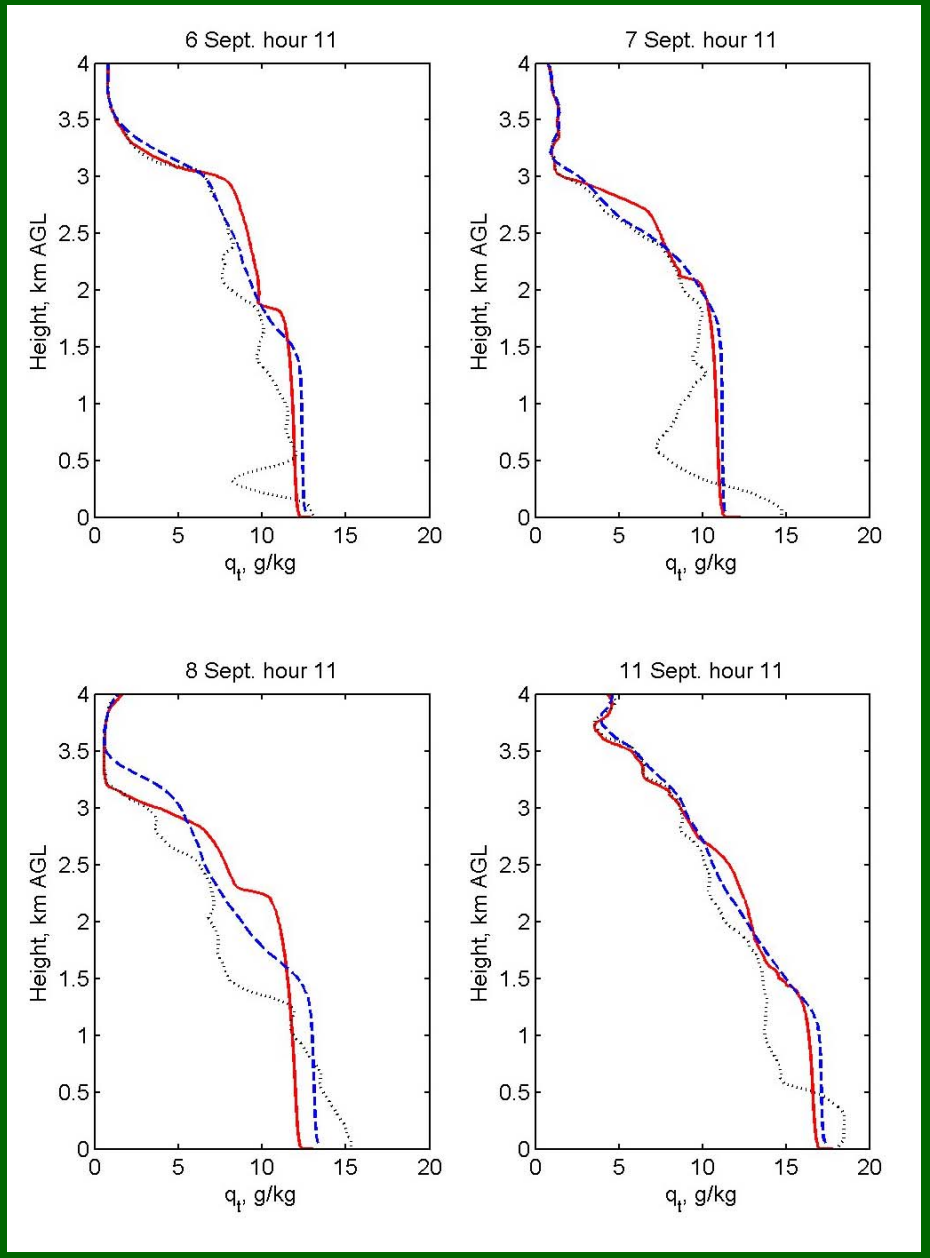
TEMF vs. LES

- Cloud base time series
- Red = TEMF, blue = LES
- TEMF predicts higher cloud base early
  - top entrainment
  - immediate response to surface forcing vs. LES spinup time



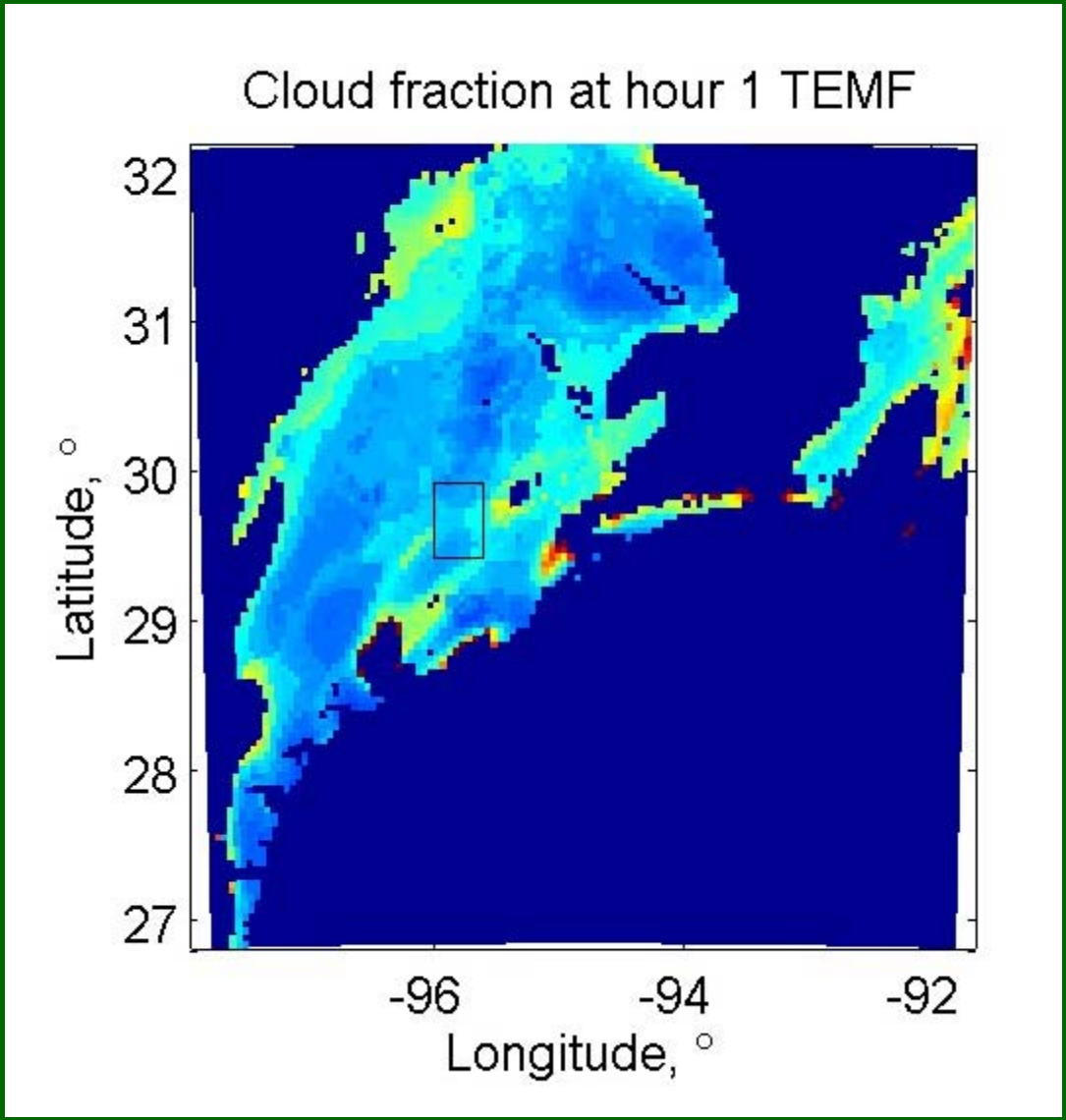
TEMF vs. LES

- Final q profiles at 1700 LST
- q (moisture) is a proxy for surface-emitted pollutants
- Red = TEMF, blue = LES
- Cloud base in TEMF is higher early
- Cloud top is never as high as in LES
- Small tendency to move too much moisture from lower to upper layer
- Much better than any scheme lacking cloud



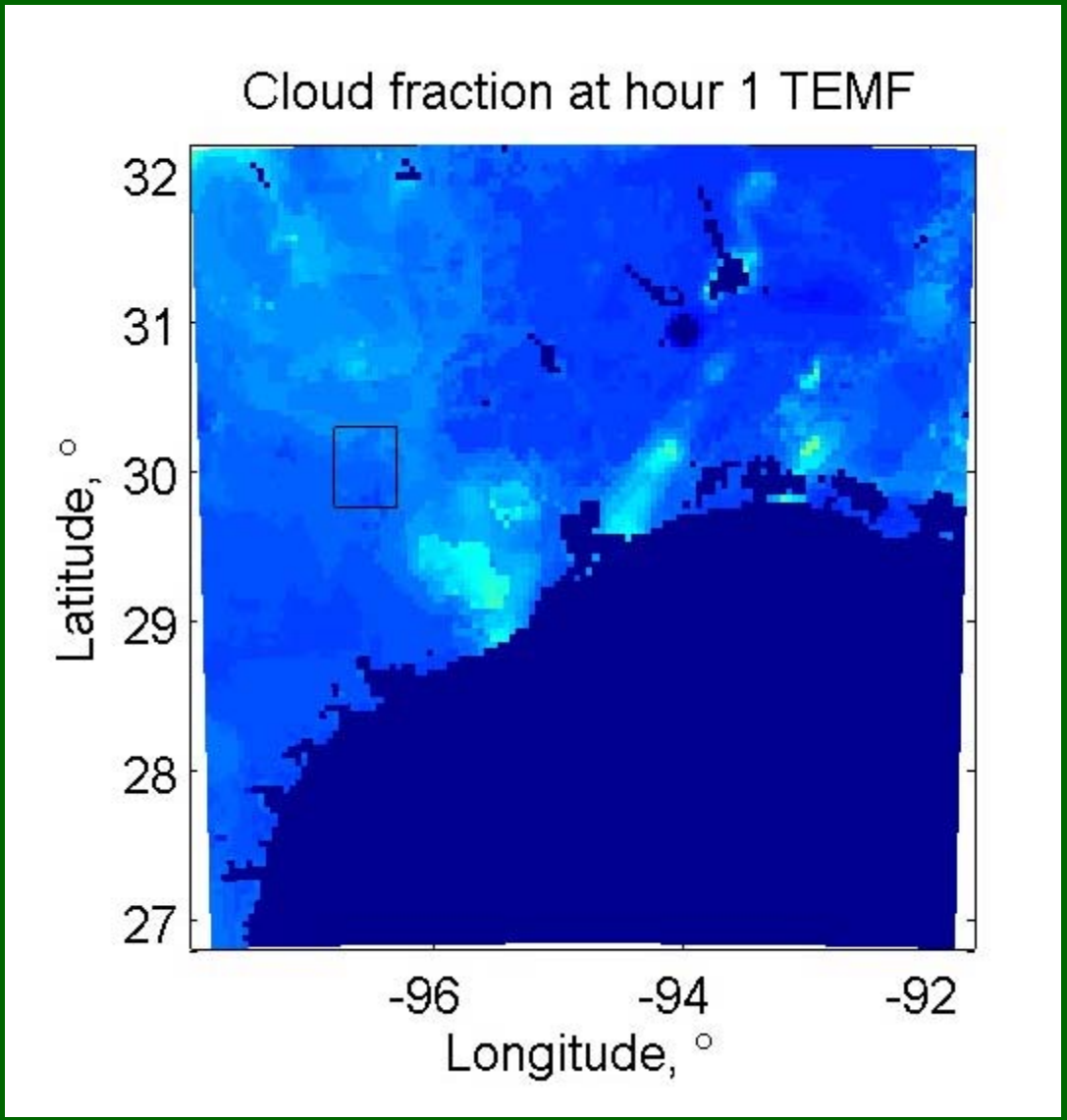
3D runs in WRF

- 8 September
- Shallow cumulus simulated over much of Texas
- Roughly corresponds to satellite picture
- Black box shows flight area
- Cloud fraction at cloud base 3-7%



3D runs in WRF

- 11 September
- Shallow cumulus simulated over much of Texas
- Roughly corresponds to satellite picture
- Black box shows flight area
- Cloud fraction at cloud base 2-5%



Status and plans

- TEMF implemented in Matlab, 1D
- Implemented in WRF (not released)
- Available to collaborators now
  - Please see one of us to talk about collaboration!
- Need to test and evaluate:
  - converging parameters with other EDMF schemes
  - effect on various applications (offsetting errors)
  - more shallow cumulus cases
  - what happens with more cloud or even stratocumulus?
  - interface to cumulus scheme(s)

Stability functions

- Dashed lines show empirical fits used in the scheme
- (Normalized) momentum transport continues at high Ri
- “Sharp tails”