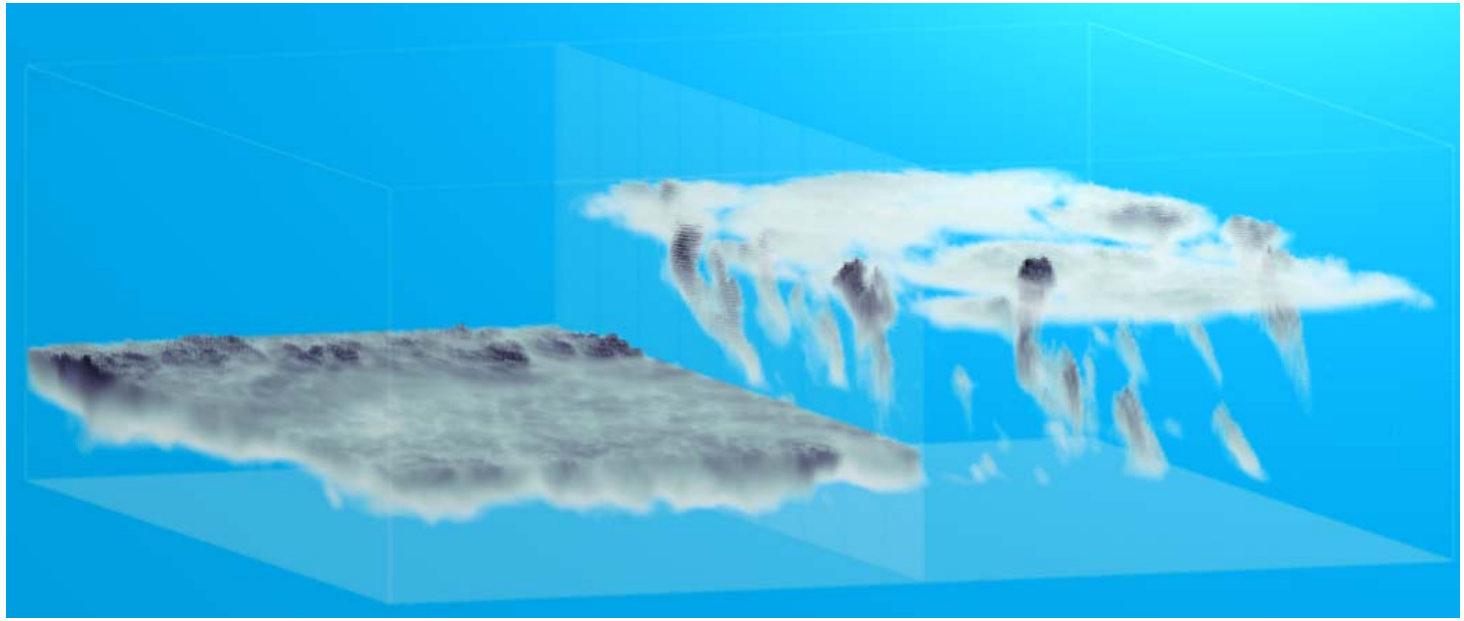
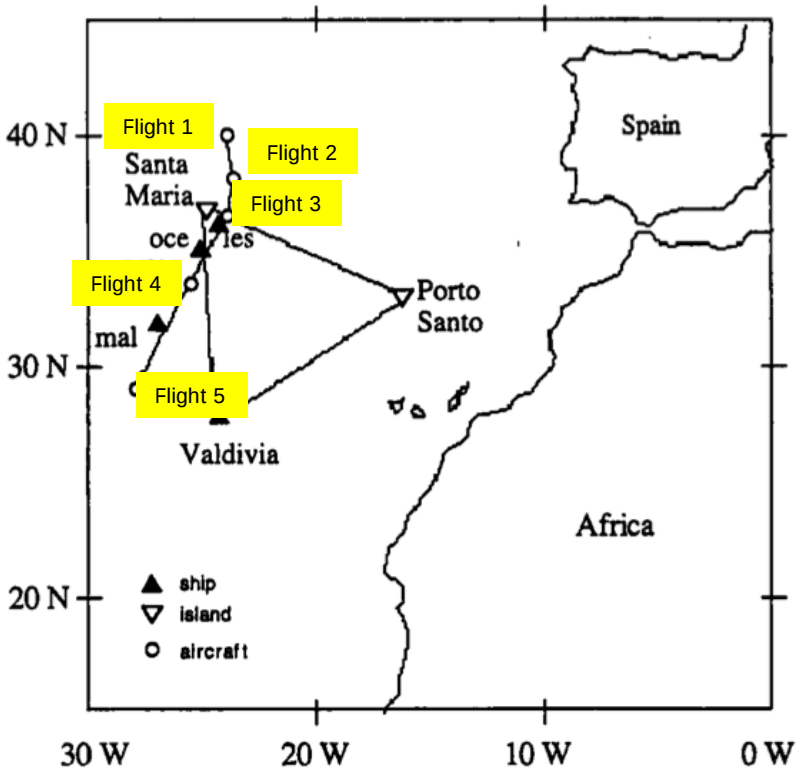
The ASTEX Lagrangian model intercomparison case



Stephan de Roode and Johan van der Dussen

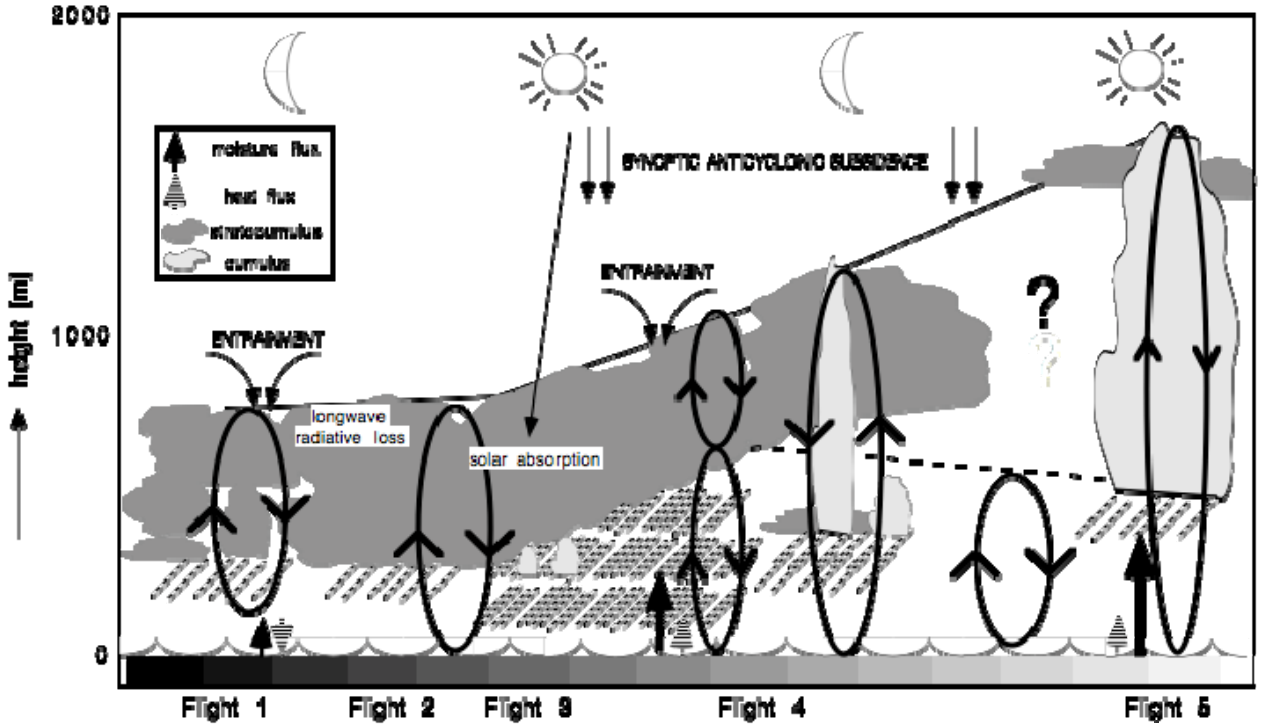
TU Delft, Netherlands

The ASTEX First Lagrangian (June 1992)



- Lagrangian evolution of cloudy boundary layer observed
- Five aircraft flights
- Duration: two days

ASTEX observed stratocumulus to cumulus transition



Bretherton and Pincus, 1995

Bretherton et al, 1995

Duynkerke et al, 1995

De Roode and Duynkerke, 1997

GCSS case, 1995

EUCREM/GCSS, Duynkerke et al, 1999

like GCSS ATEX case, Stevens et al, 2001

Study of ASTEX First Lagrangianwtih SCM and 2D models byBretherton et al, 1999*:*

"there are substantialquantitativedifferences in the cloud cover and liquid water pathbetween models."

Contents

- Motivation
- LES results
- SCM results
- Conclusions/outlook

ASTEX case: motivation

- stratocumulus to cumulus transitioncontroledby
  - SST, large-scaledivergence, inversionstability ->sensitivity tests
- Use ASTEX observations to validate LES & SCM results of a transition
- additionaldiagnosticsfrom LES to validate SCM parameterizations
  -eddydiffusivity, PDFs of heat and moisture, mass flux statistics, 3D fields

Model initialization

Model set up and large-scaleforcing

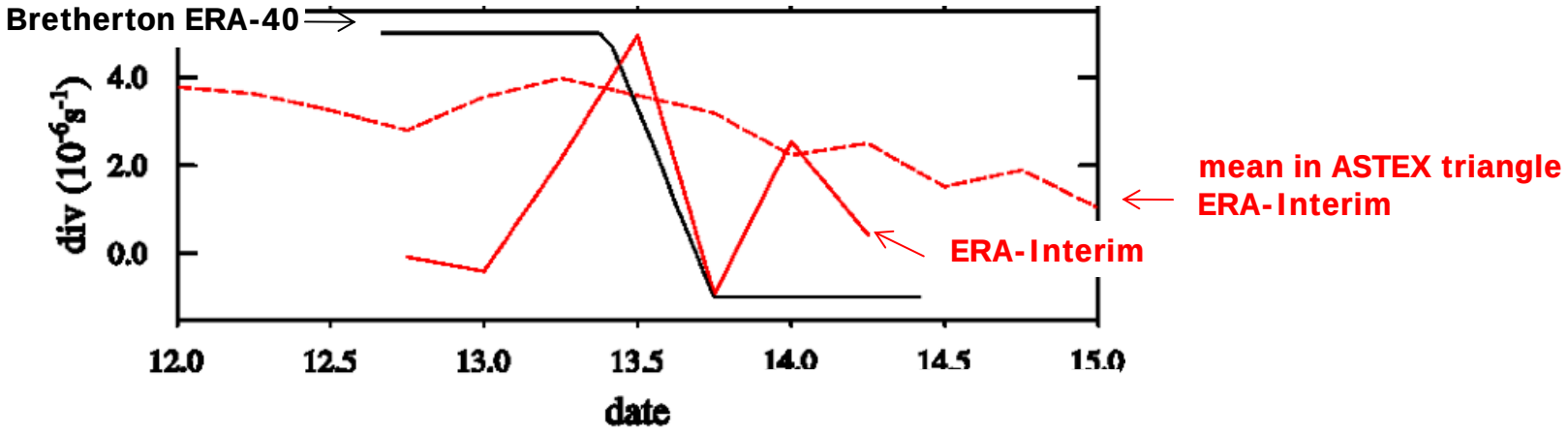
•Large-scaleforcing (SST &large-scalesubsidence) fromBretherton et al. (1995, 1999)

• Model initializationfromFlight 2 (A209)

- Identical to first GCSS ASTEX "A209" modelingintercomparison case

•Microphysics: drizzle and cloud droplet sedimentation

•Shortwave and longwaveradiation



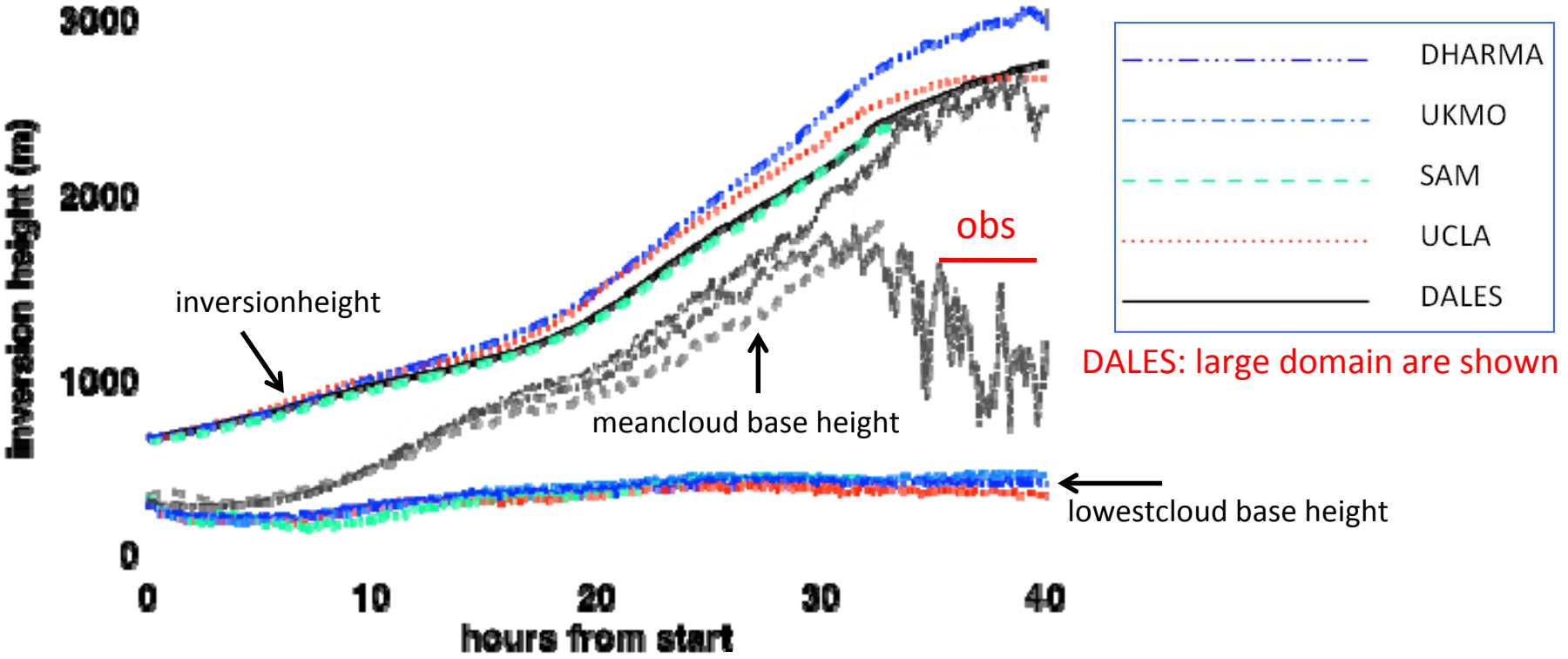
LES participants

LES model	Institution	Investigator
DALES	TU Delft	de Roode
UCLA/MPI	MPI	Sandu
UKMO	UKMO	Lock
SAM	Univ Washington	Blossey
DHARMA	NASA	Ackerman
Warschau	Warschau	Kurowski

Use SCM version that is identical to the operational GCM

SCM model	Institution	Investigator
RACMO	KNMI	dalGesso
EC-Earth	KNMI	dal Gesso
ECMWF	ECMWF	Sandu
ECMWF-MF	DWD	Koehler
JMA	Japan	Kawai
PDFbasedscheme	Wisconsin	Larson
LMD GCM	LMD	Bony
UKMO	UKMO	Lock
Arpege	Meteo France	Bazile/Beau
MPI	ECHAM	Suvarchal

Cloud boundaries: all LES models give cumulus under stratocumulus

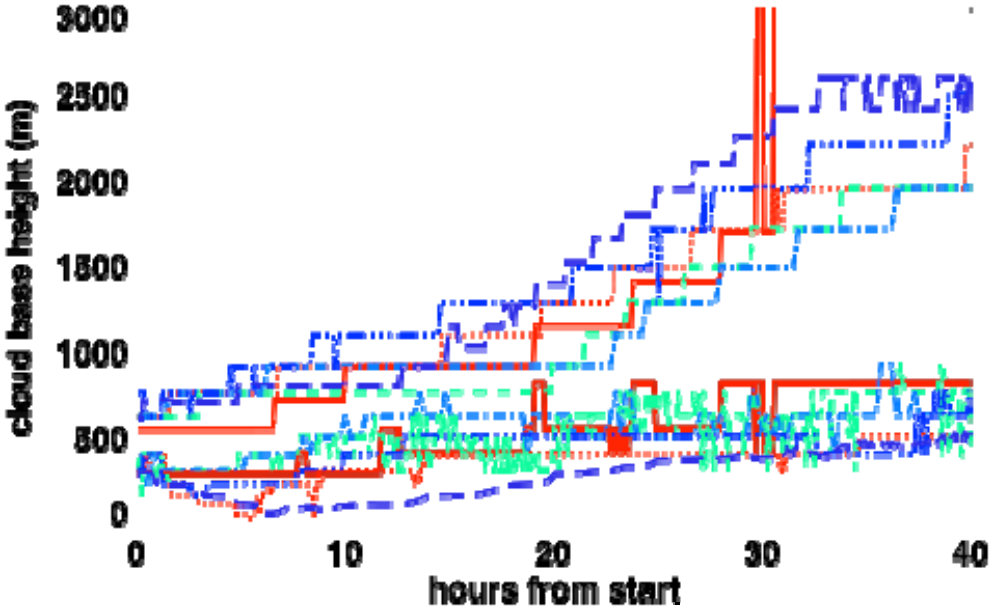


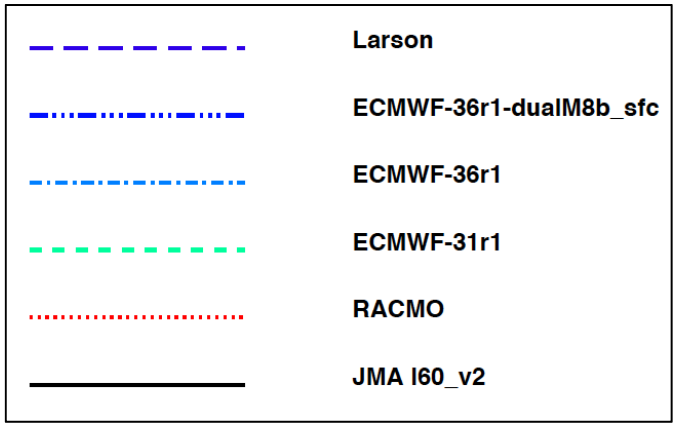
DALES: large domain are shown

Boundarylayertoodeepcompared to observations

Last 10 hours of simulations are lessreliable (spongelayer, coarserverticalresolution)

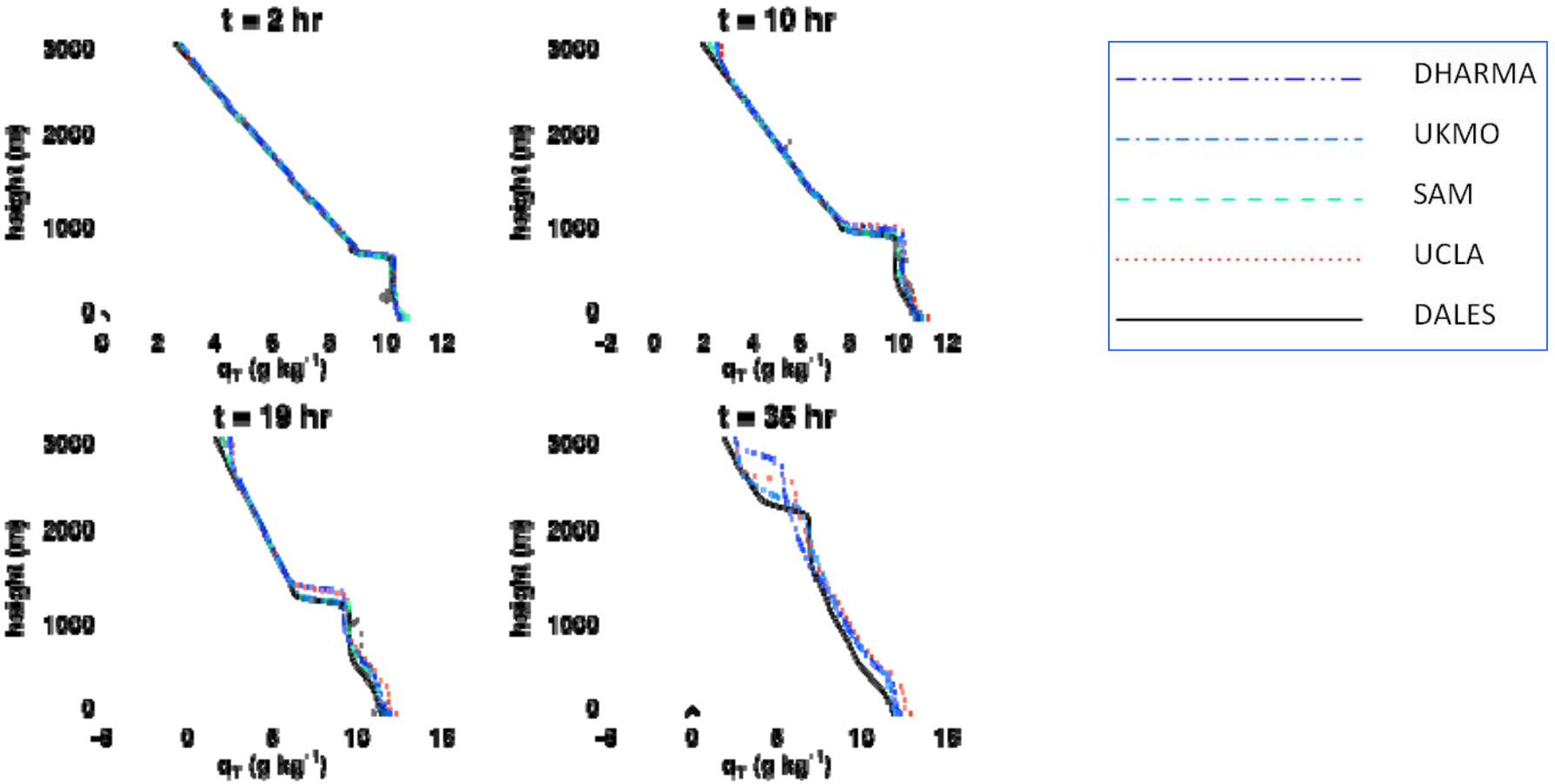
SCM cloud boundaries



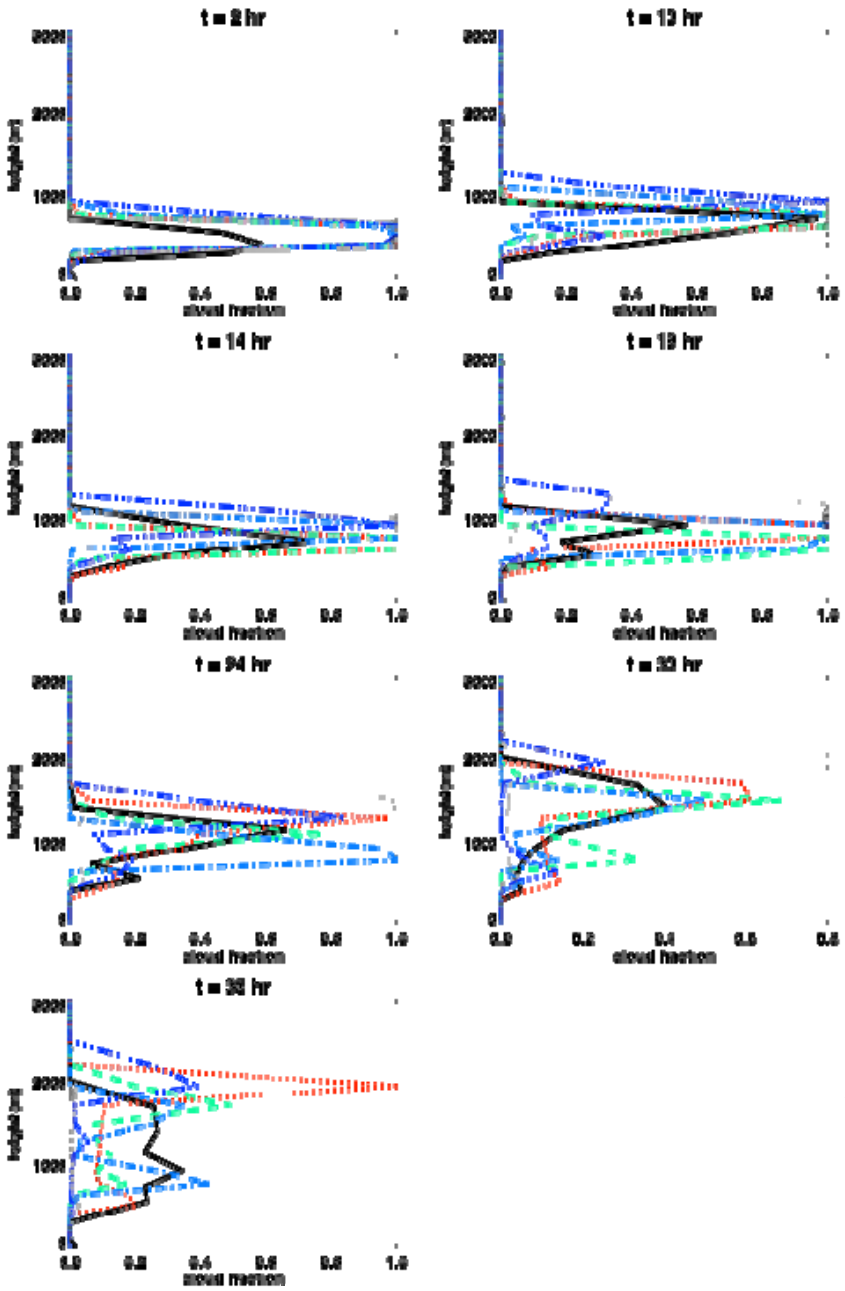


Deepening of boundarylayer is wellrepresented

LES: Total water content



Mean state duringfirst part of ASTEX Lagrangian is wellrepresented

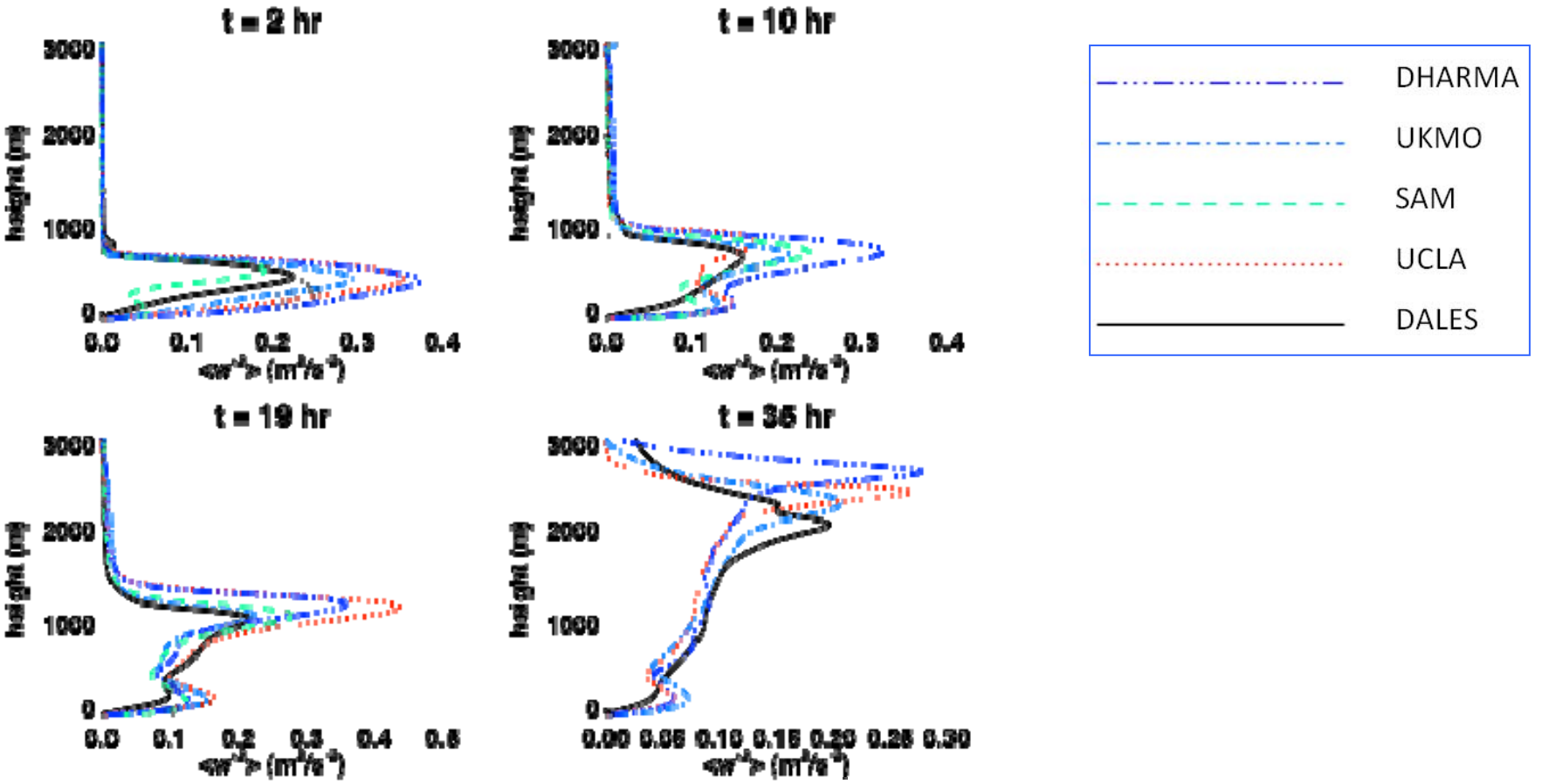


Cloud fraction

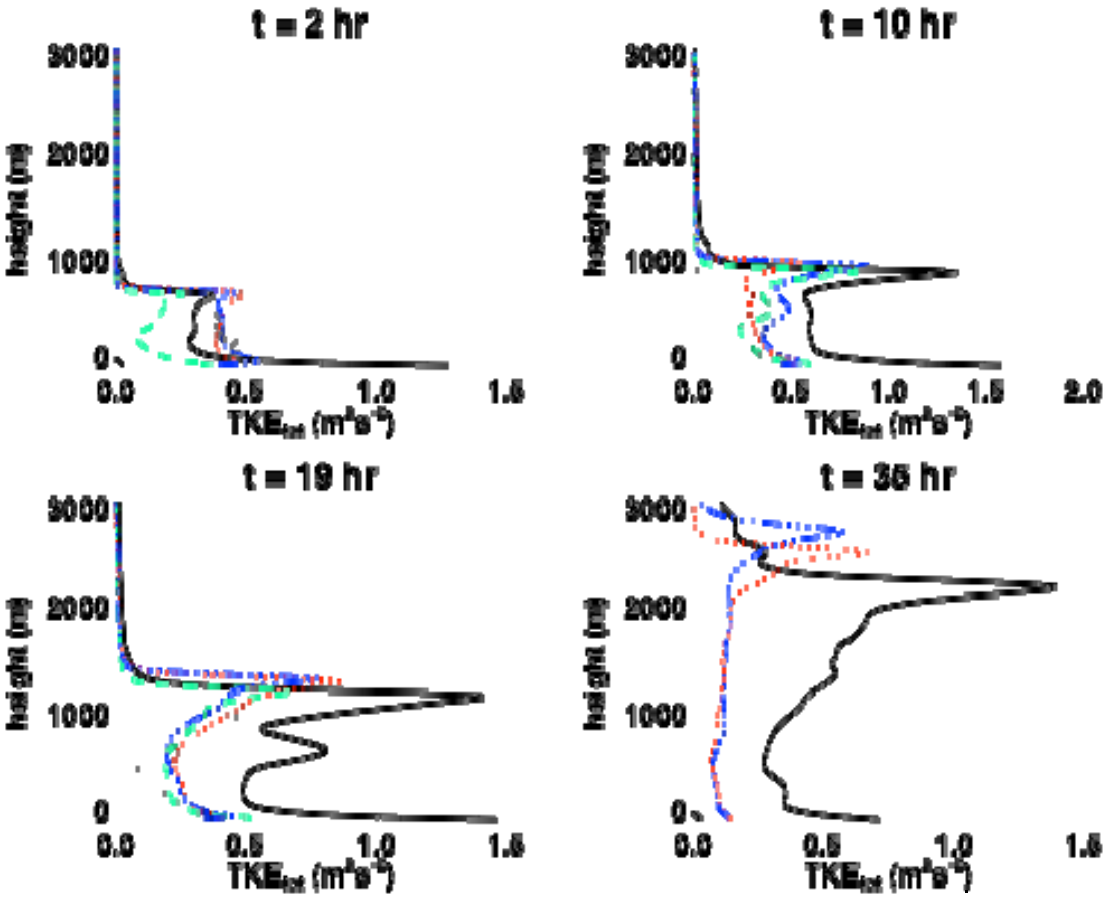
Larson	
ECMWF-36r1-dualM8b_sfc	
ECMWF-36r1	
ECMWF-31r1	
RACMO	
JMA I60_v2	

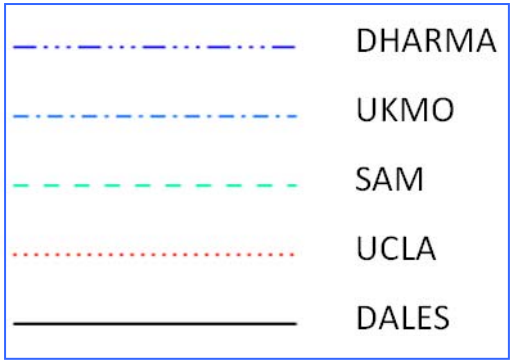
SomeSCMsexhibitcloudfraction maxima nearcloud base and top

Vertical wind velocity variance



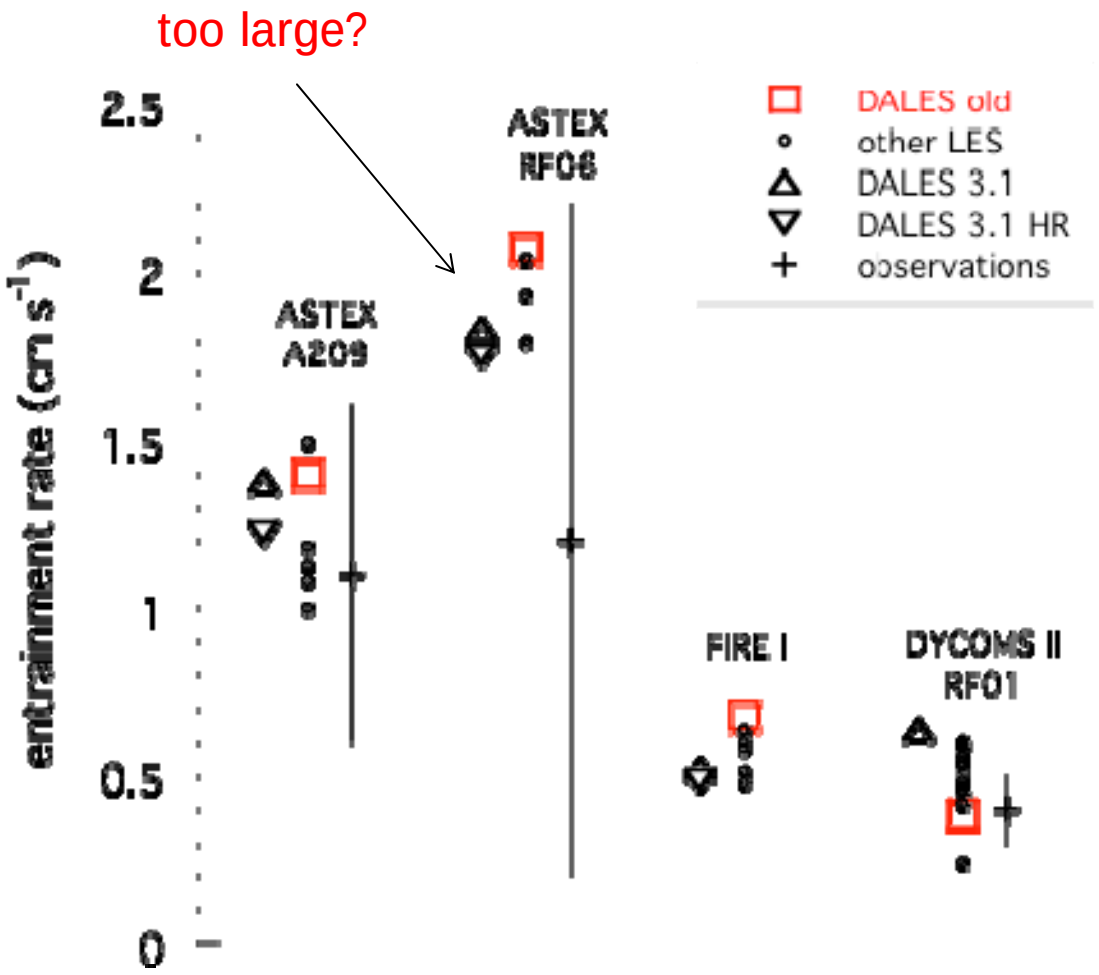
Turbulent kinetic energy





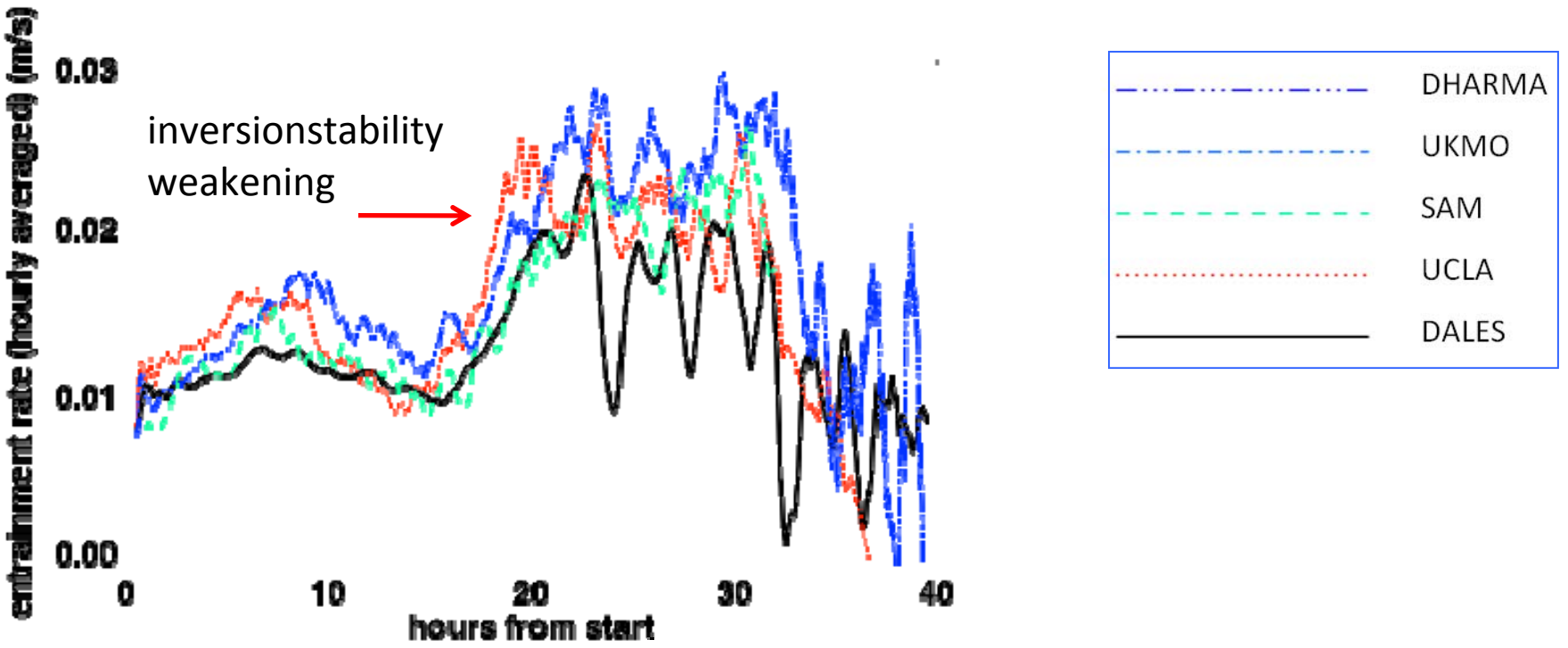
Observations: fluctuations at scales> 3 km are filtered out
(LES domain = 4 km, DALES large domain = 25.6 km)

Entrainment rates in previous LES intercomparison runs



Heus et al. (2010)

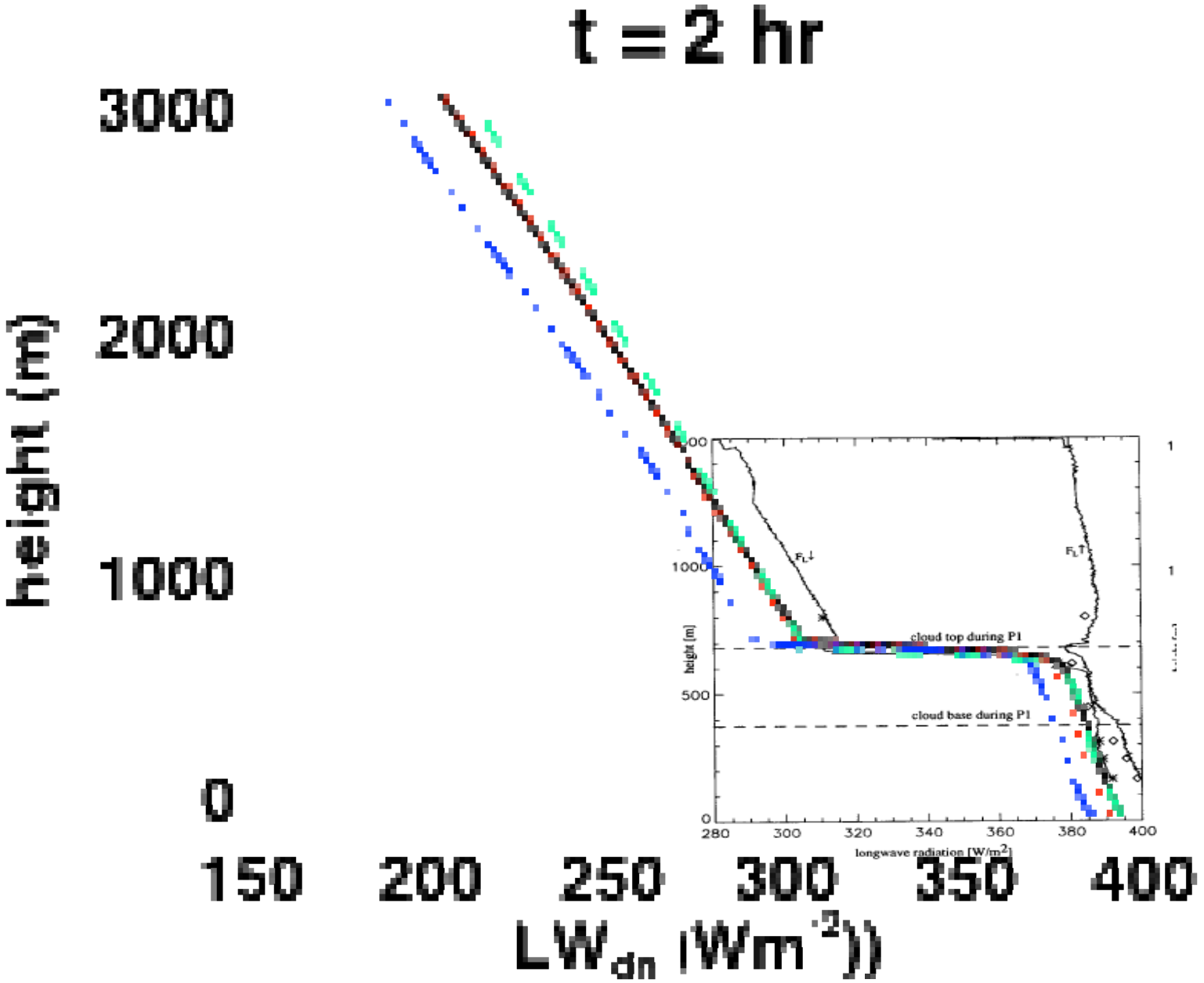
Entrainment



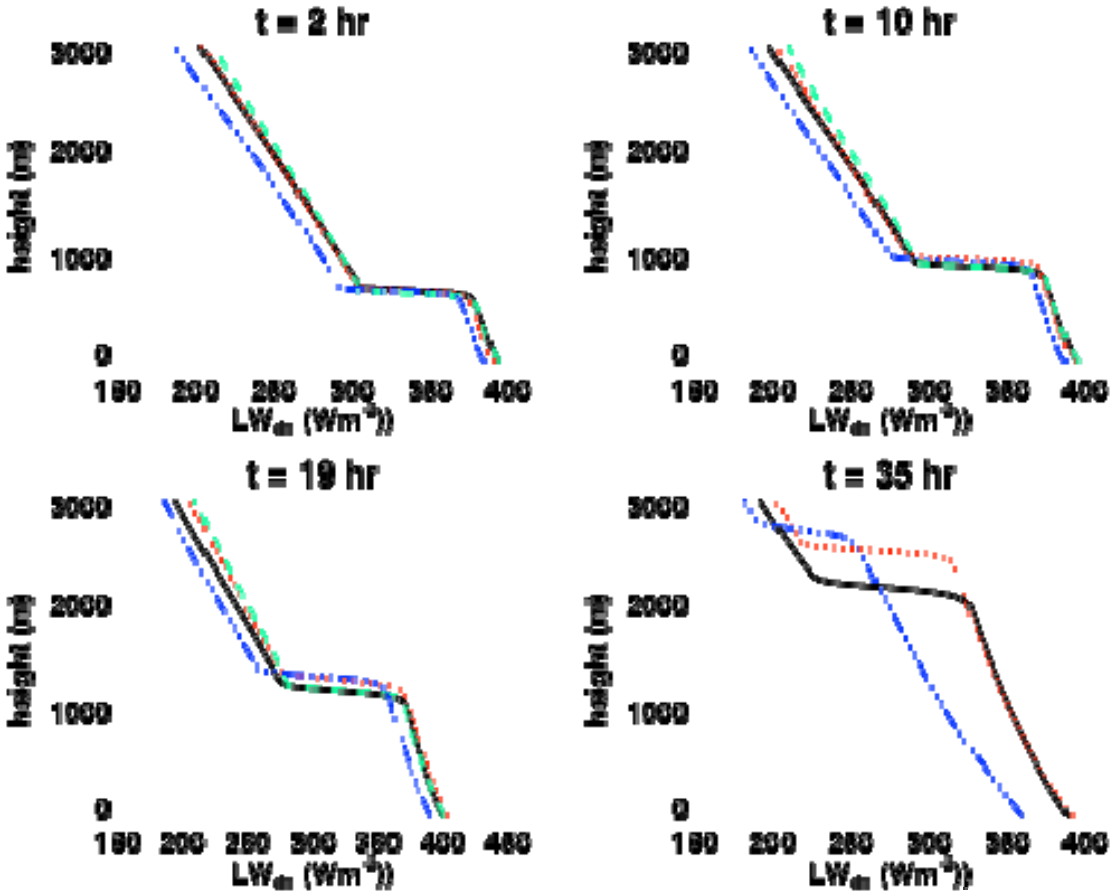
Entrainmentratedoublesduring the secondnight

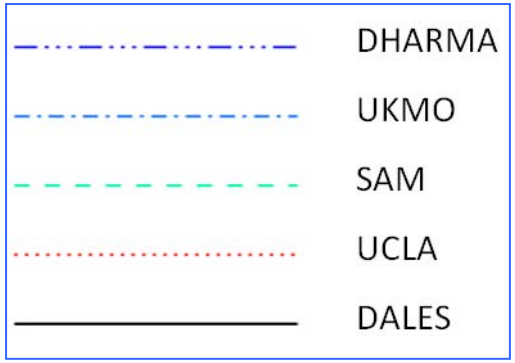
Entrainmentrate smaller thanduringprevious ASTEX intercomparison case. According to Ackerman and Brethertonthis is due to cloud droplet sedimentationleading to a reduction of evaporativecooling at cloud top.

Jump in downward longwaverad smaller in observations

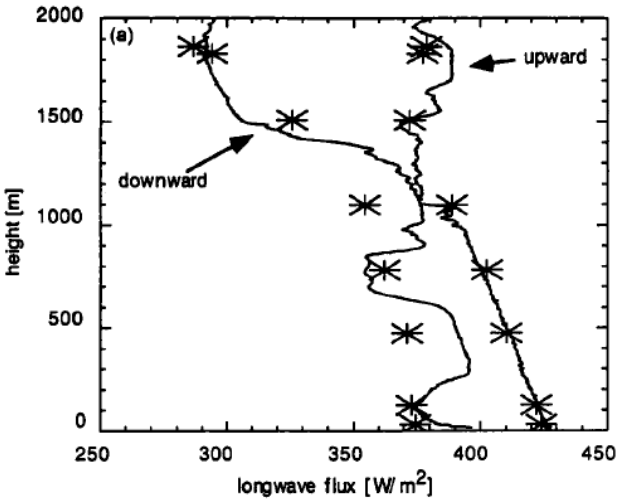


Longwave down





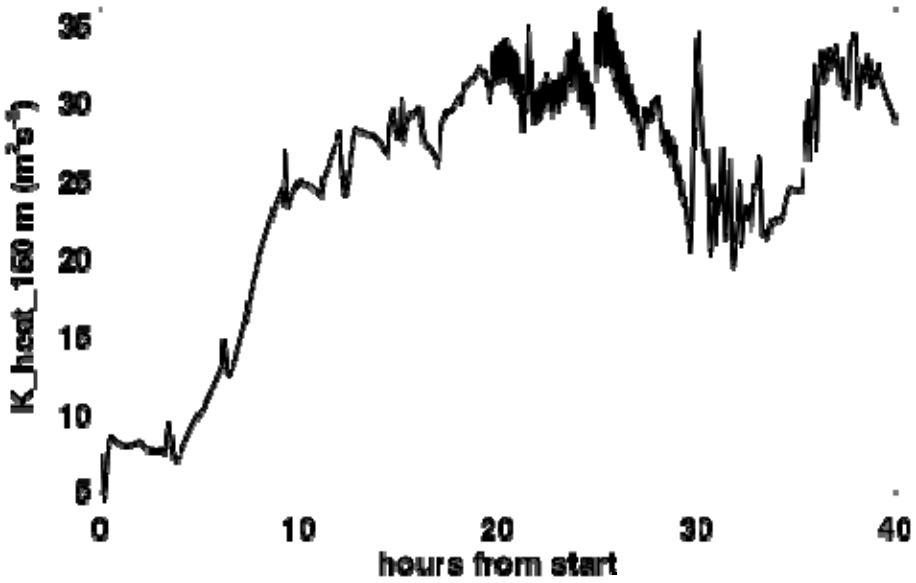
Obst=36h

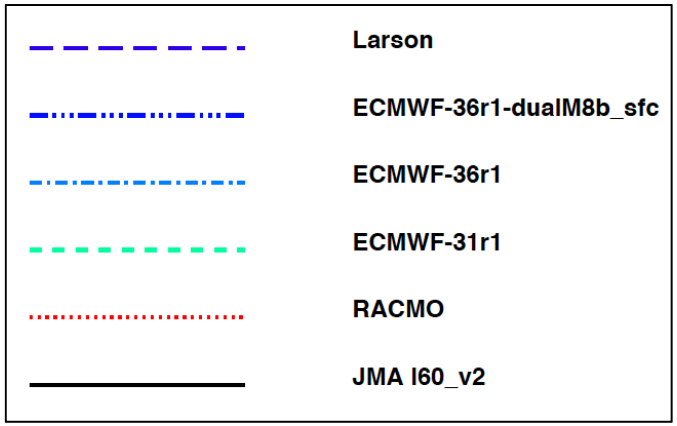


Presence of high cloudsduringlatter part of transition.

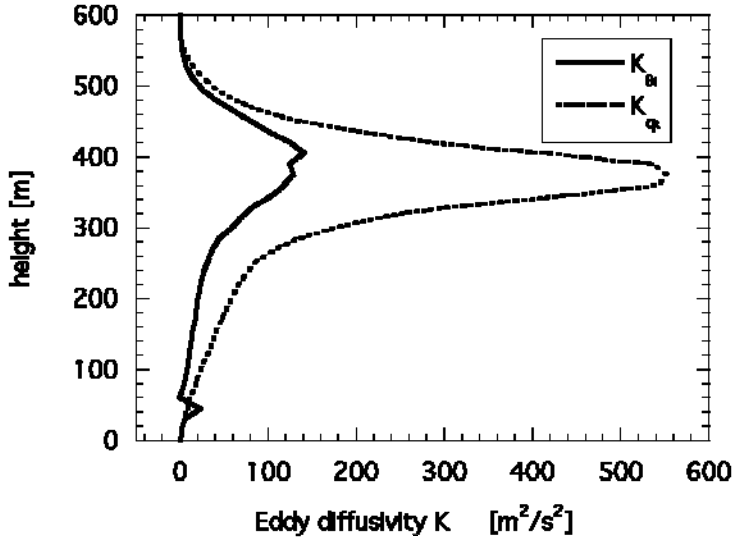
A largerlongwaveradiativecoolingratewillcause a largerentrainmentrate and deeperboundarylayers

LES diagnostics:Eddy diffusivity





LES results EUROCS FIRE stratocumulus: diagnosededdydiffusivity



Do SCMsusesimilardiffusivitiesformoisture and heat?

What did we learn

LES models canreproduce bulk features of the observedcloudtransition

- mean state and turbulencestructure

Entrainmentrate smaller than in previous ASTEX intercomparison cases

Negativedivergencehalfway the transitioncausesdeepercloudlayers

Outlook/suggestions

Refine case specificationsforSCMs and LES models:
- Large-scaledivergence
- All models need to usesameinitial profiles
- Strongerdecrease of geostrophicforcingwith time?

model output
- 3D fieldsfordetailedstatistics important for SCM parameterizations (a few Tb for data storageavailable)
- newsimulationsbefore 1 December

Sensitivity test
- increasedownwardlongwaveradiationwith time (cirrus effect)

Radiationschemes
- Calculateradiativefluxesfor a few "standard" atmospheric profiles (maybeincludeit as standard output?)