Shallow cumulus evaluated with the LASSO (ensemble LES) framework

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Outline:
What and why is LASSO?
The shallow cumulus challenge
Results
Areas for improvement

What and why LASSO?

Shallow cumulus present an ongoing challenge to WRF.

A variety of physics options intend to represent these clouds.

Finding a good configuration is complicated by the lack of good observations.

The DOE ARM project LASSO now provides several cases with shallow cumulus (alpha 1 used here) .

Cases are based on observations at the ARM Southern Great Plains site.

For each case, an ensemble of large eddy simulations were run using different initial conditions and advection terms.

A major advantage of LASSO is that we can distinguish between differences that are due to uncertainties in the case setup, versus those that are unambiguously caused by the WRF schemes themselves.

This presentation: WRF single-column tests using the LASSO framework

MYNN PBL with EDMF

TEMF PBL

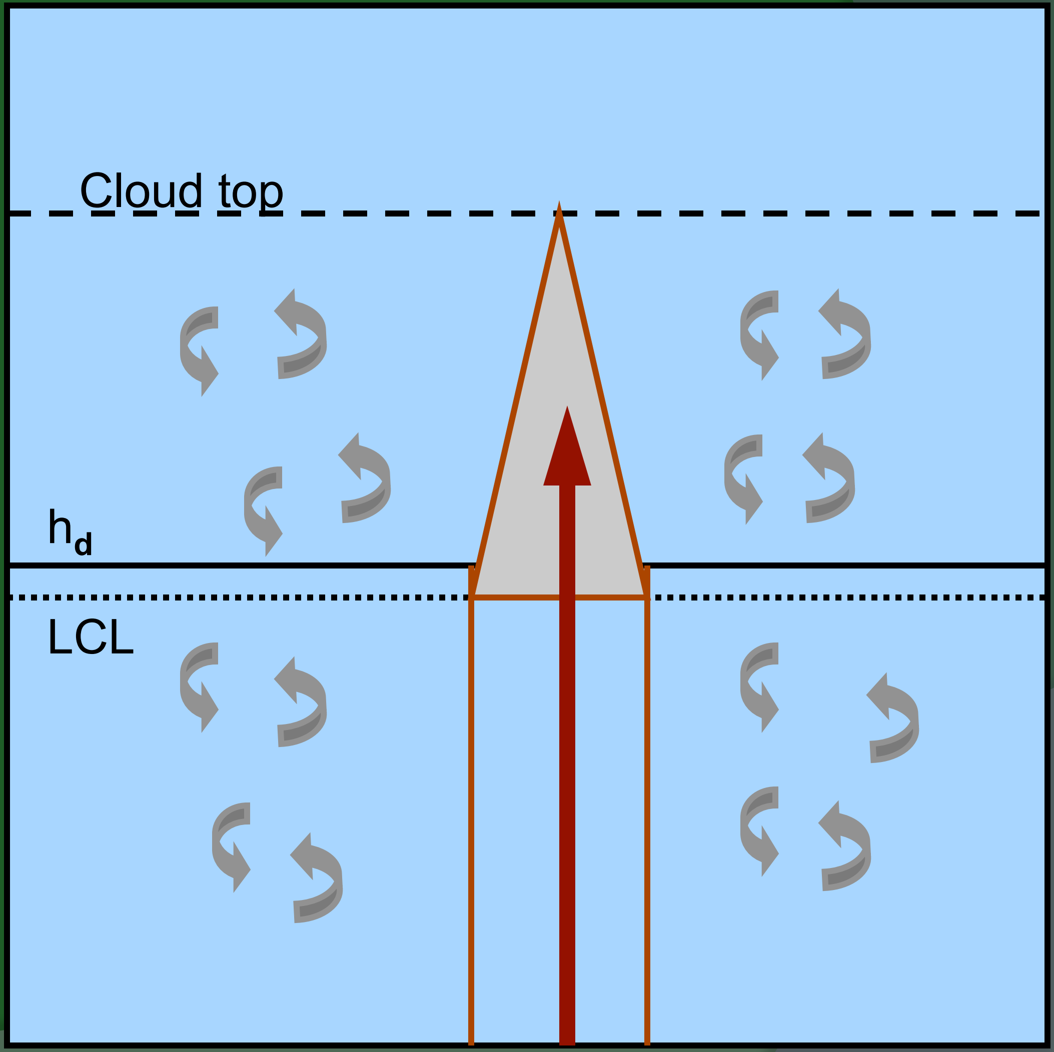
EDMF schemes for PBL and shallow Cu

Originated with Pier Siebesma and Joao Teixeira about year 2000

Eddy Diffusion and Mass Flux in both subcloud and cloud layers

Mass flux provides non-local transport in convective BL (with or without cloud) and natural representation of BL-rooted clouds

Many EDMF schemes are in use for research and operations, mostly in Europe

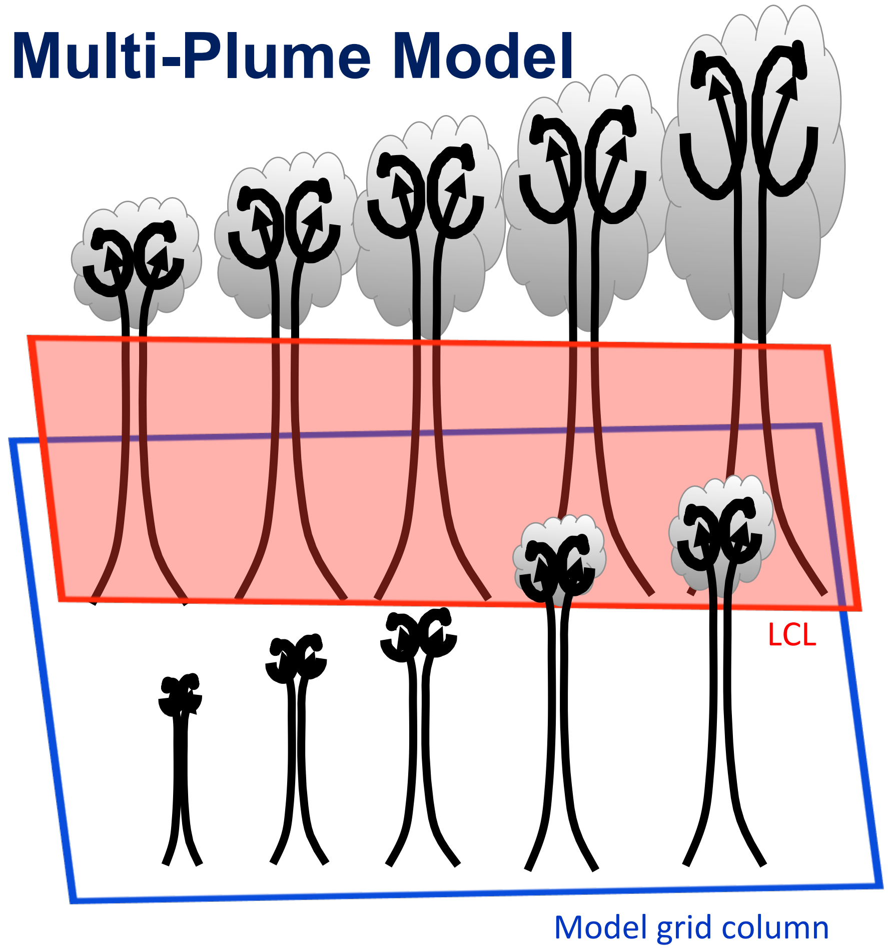


MYNN-EDMF: Dynamic Multi-Plume Model

An attempt to explicitly model plumes of various sizes that are likely to exist in a given atmospheric state, following **Neggers (2015, JAMES)** and **Suselj et al. (2013, JAS)**.

- Total maximum number of plumes possible in a single column: 10.
- Diameters (ℓ): 100, 200, 300, 400, 500, 600, 700, 800, 900, and 1000 m.
- Lateral entrainment varies for each plume $\propto (w\ell)^{-1}$.
- Plumes condense only if they surpass the lifting condensation level (LCL).

The scheme also includes "subgrid stratus" from a statistical diagnosis, quasi-independent from the MF clouds



6 June case
Cloud characteristics

Each day has 30+ LES simulations with different model, intial, and boundary conditions

All simulations are “good”, using well-developed analyses based on observations

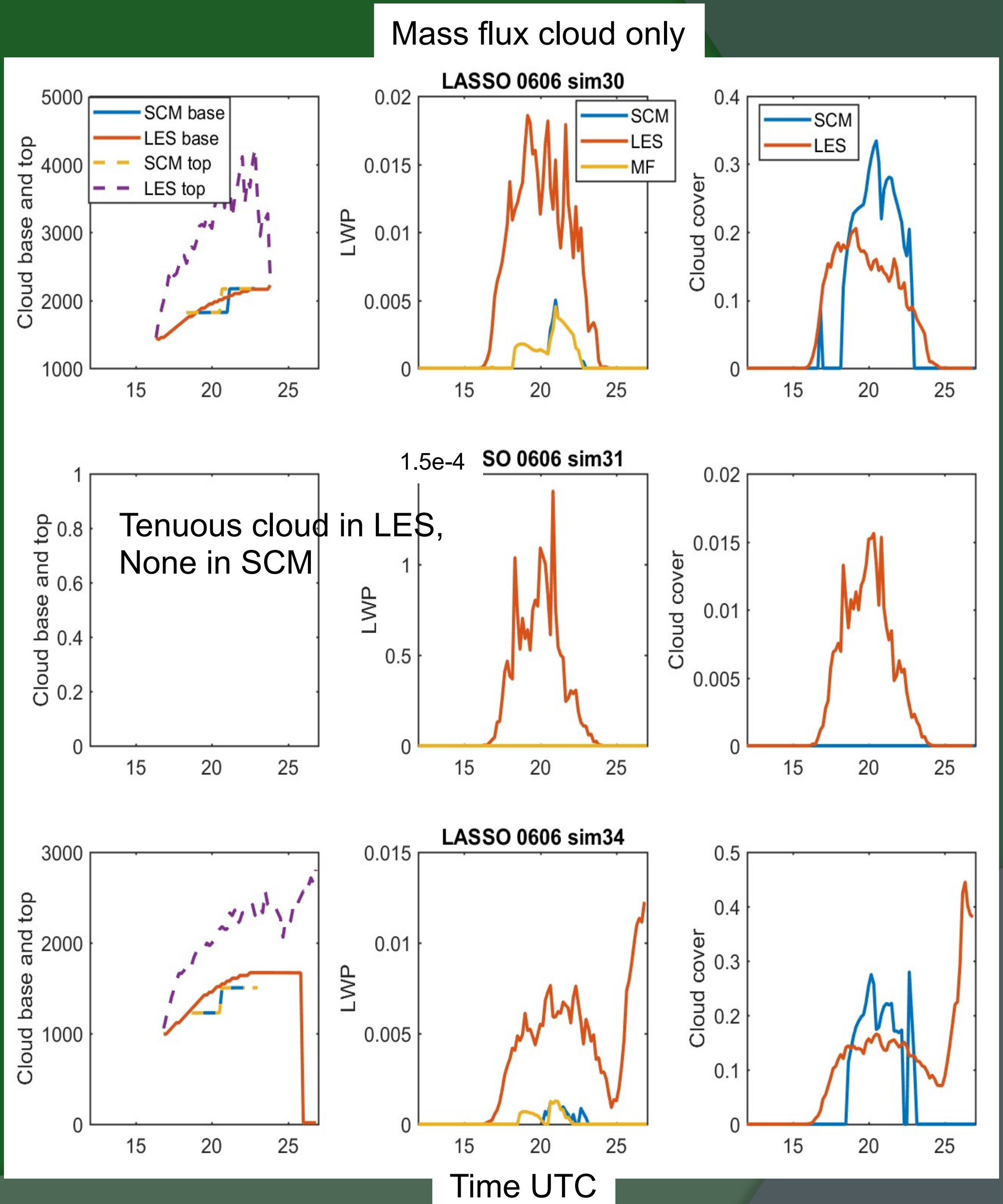
I chose three simulations for each day, all with WRF LES. Initial, boundary conditions and forcing all the same source:

sim30 VARANAL

sim31 MSDA

sim34 ECMWF

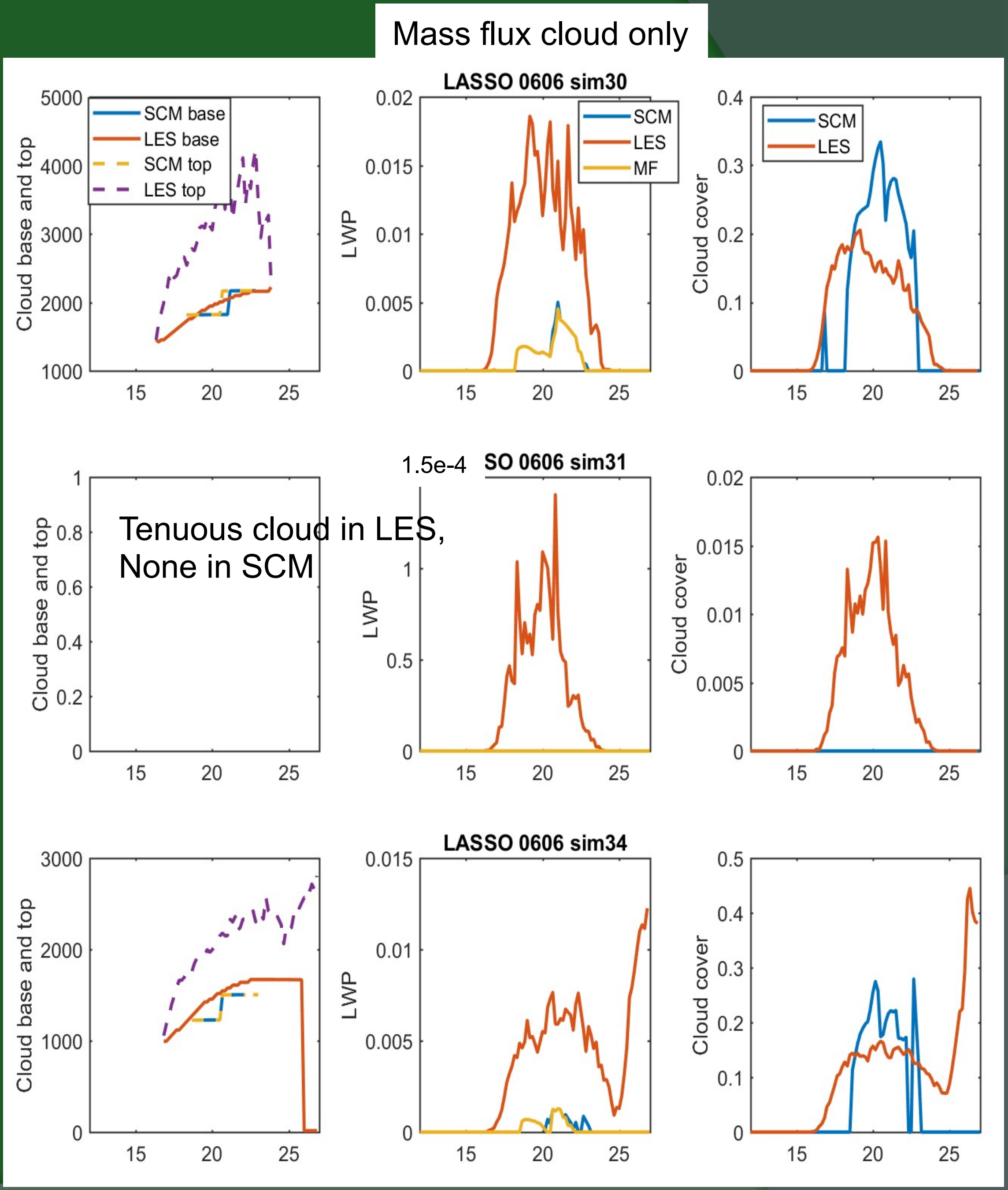
Note varying vertical scales!



6 June case
Cloud characteristics

Different simulations are very different in cloud cover and LWP

Features to note:
SCM cloud base low
Top also low
Onset late
LWP underestimated
Cloud cover good

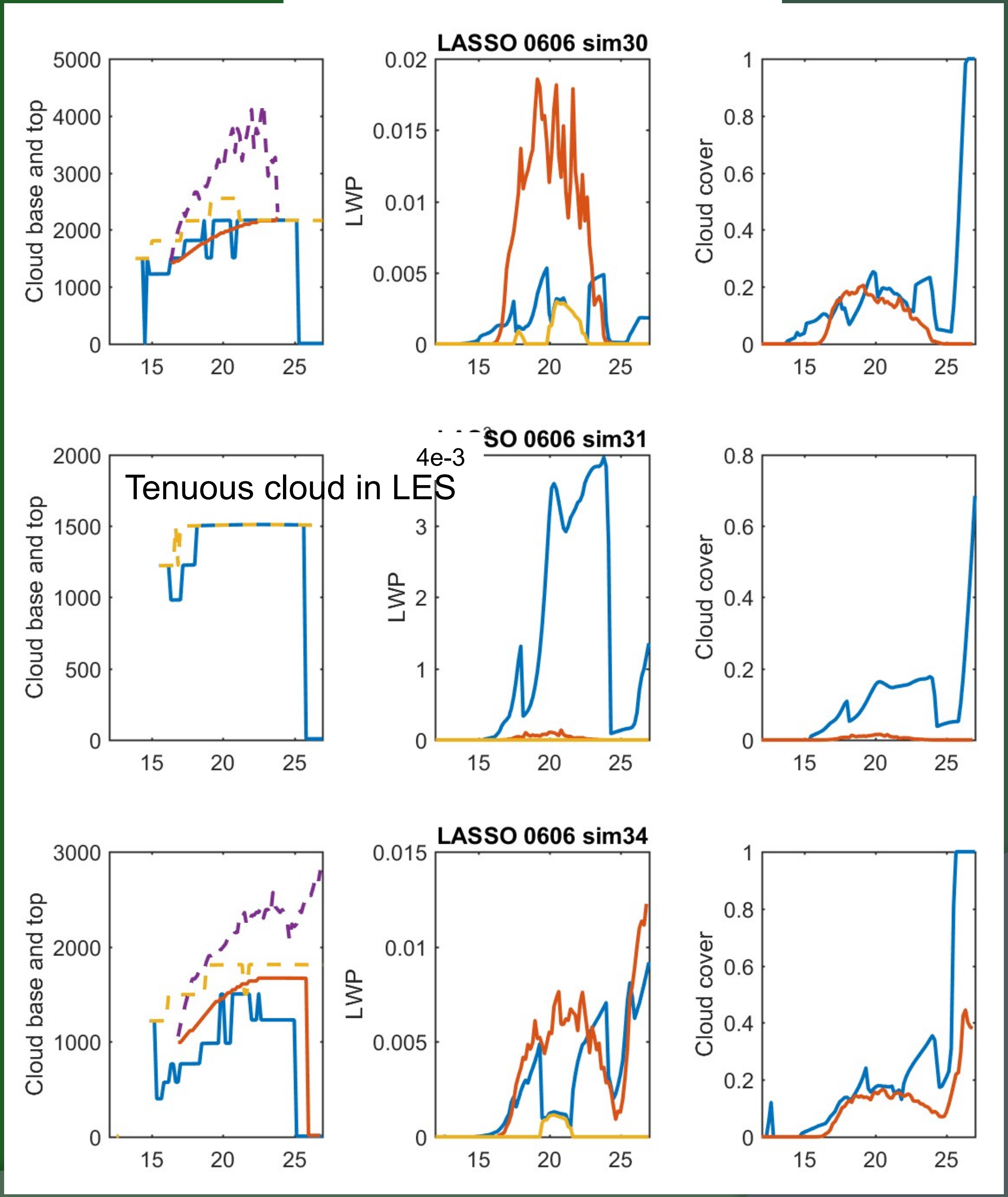


6 June case
Cloud characteristics

Adding subgrid stratus within MYNN-EDMF

Onset time much improved
Tenuous cloud in sim31 now present, but too much
SCM cloud base and top still low
LWP improved
Cloud cover good
Fog forms late in run

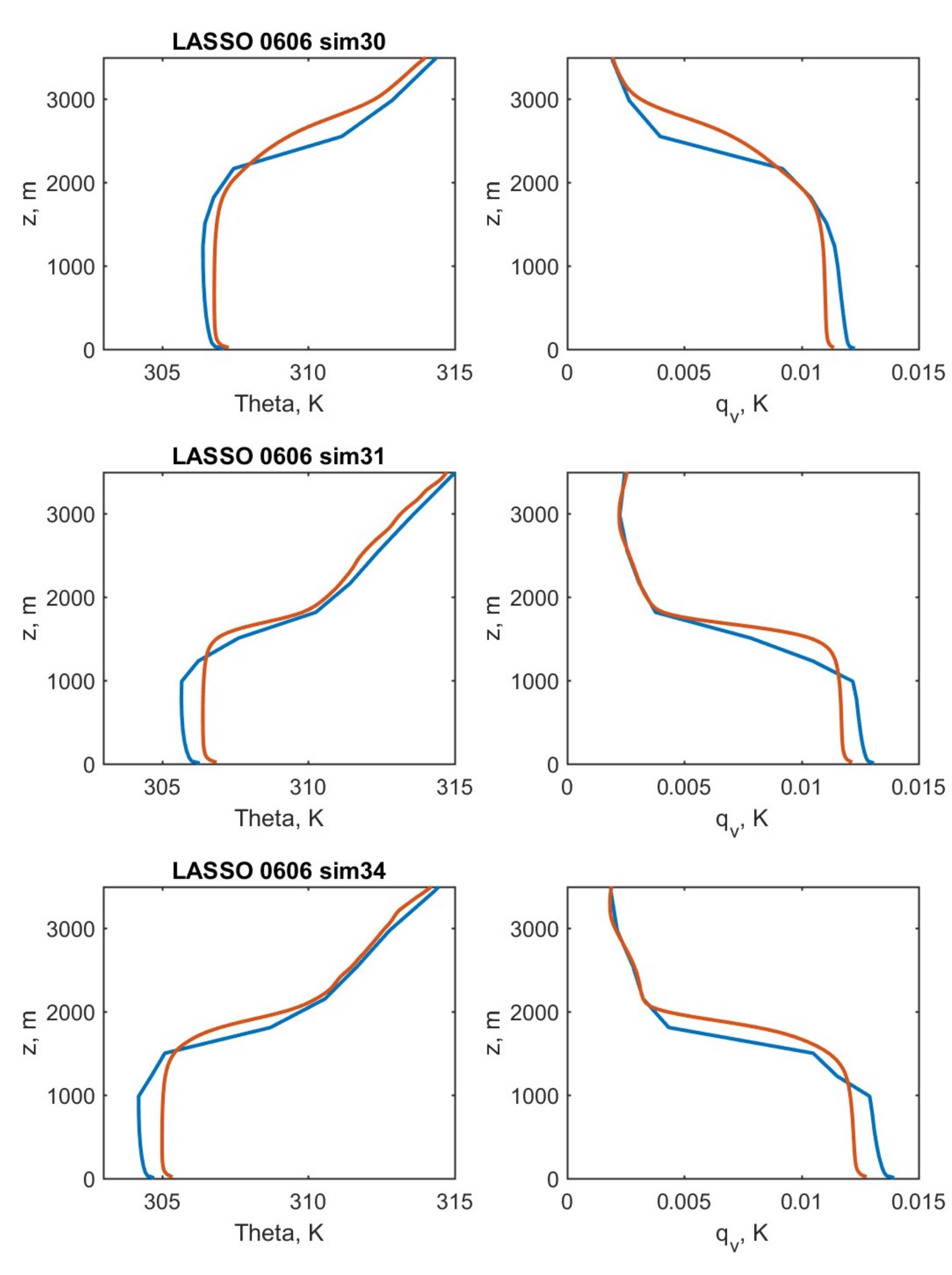
Subgrid stratus cloud included



6 June case Profiles

Different simulations have very different boundary layer heights and surface temperatures

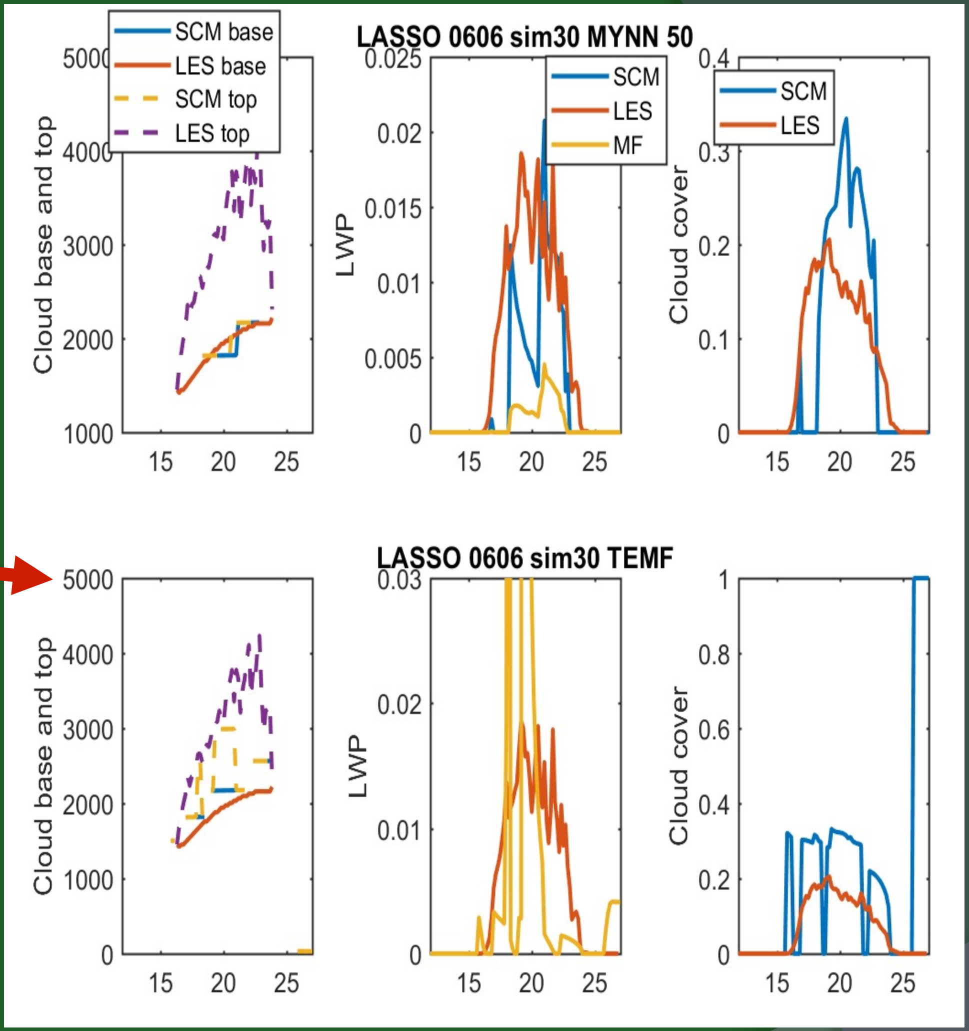
SCM generally:
Too cool
Too moist
Too shallow
Not smooth (vertical resolution)



6 June case
Cloud characteristics

Comparing MYNN-EDMF with TEMF

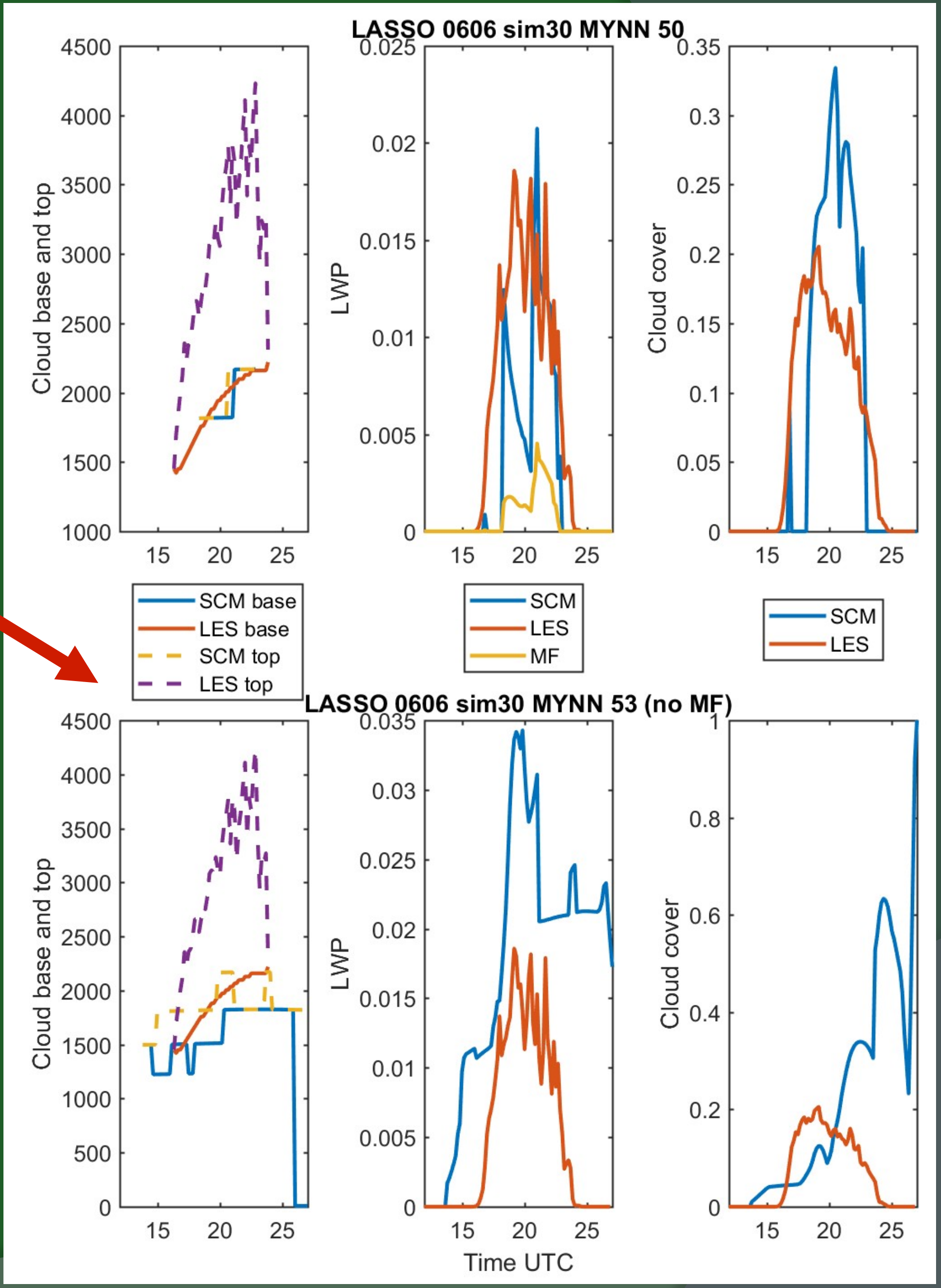
TEMF:
Onset time better
Cloud base a bit high
Cloud top better
Spikes of LWP up to 1
PBL very warm (not shown) – forcing issue?



6 June case
Cloud characteristics

What happens if mass flux is turned off completely?

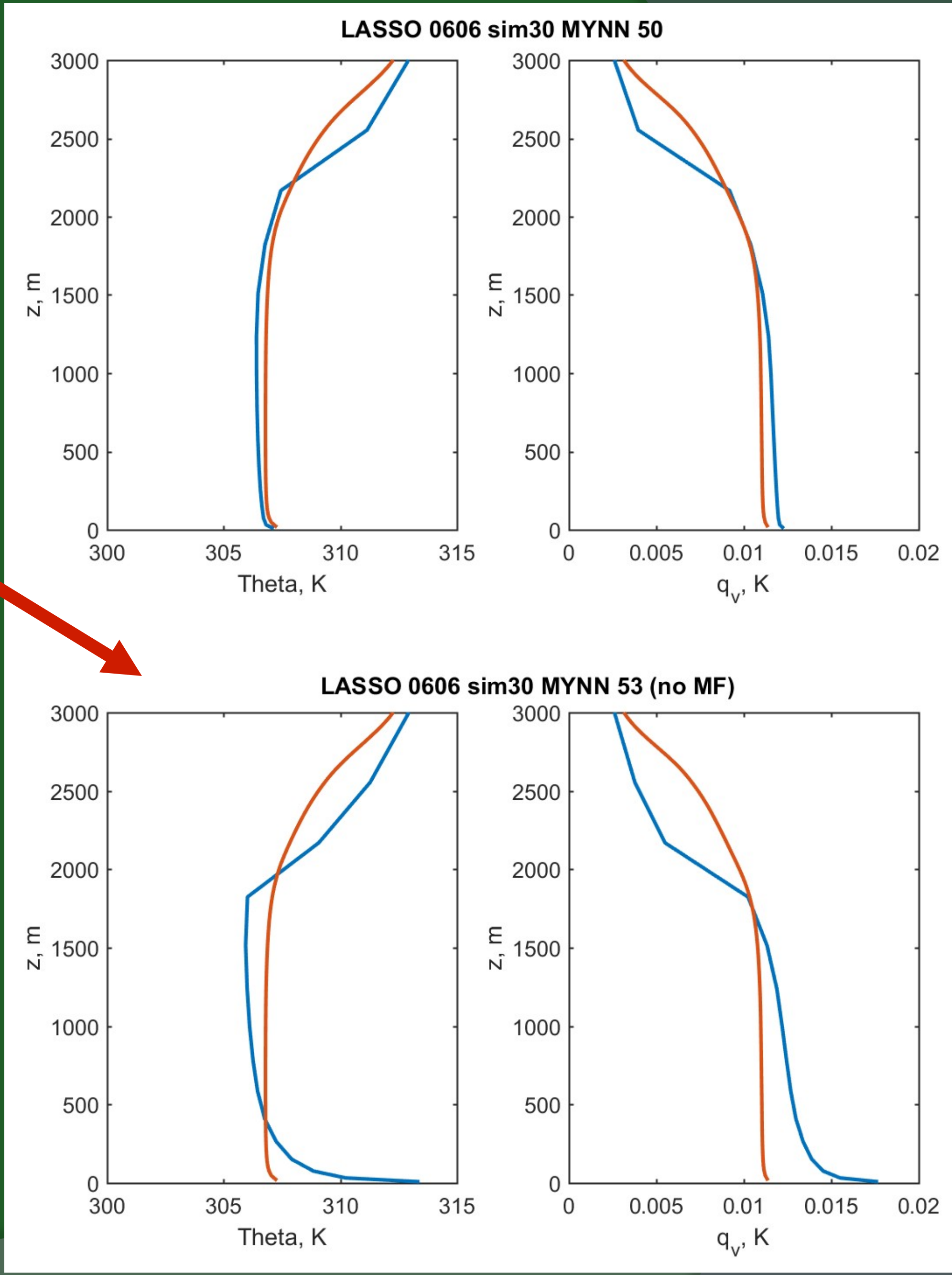
Onset time too early
Cloud base too low
Cloud top too low
LWP and cloud cover too large



6 June case profiles (no MF)

What happens if mass flux is turned off completely?

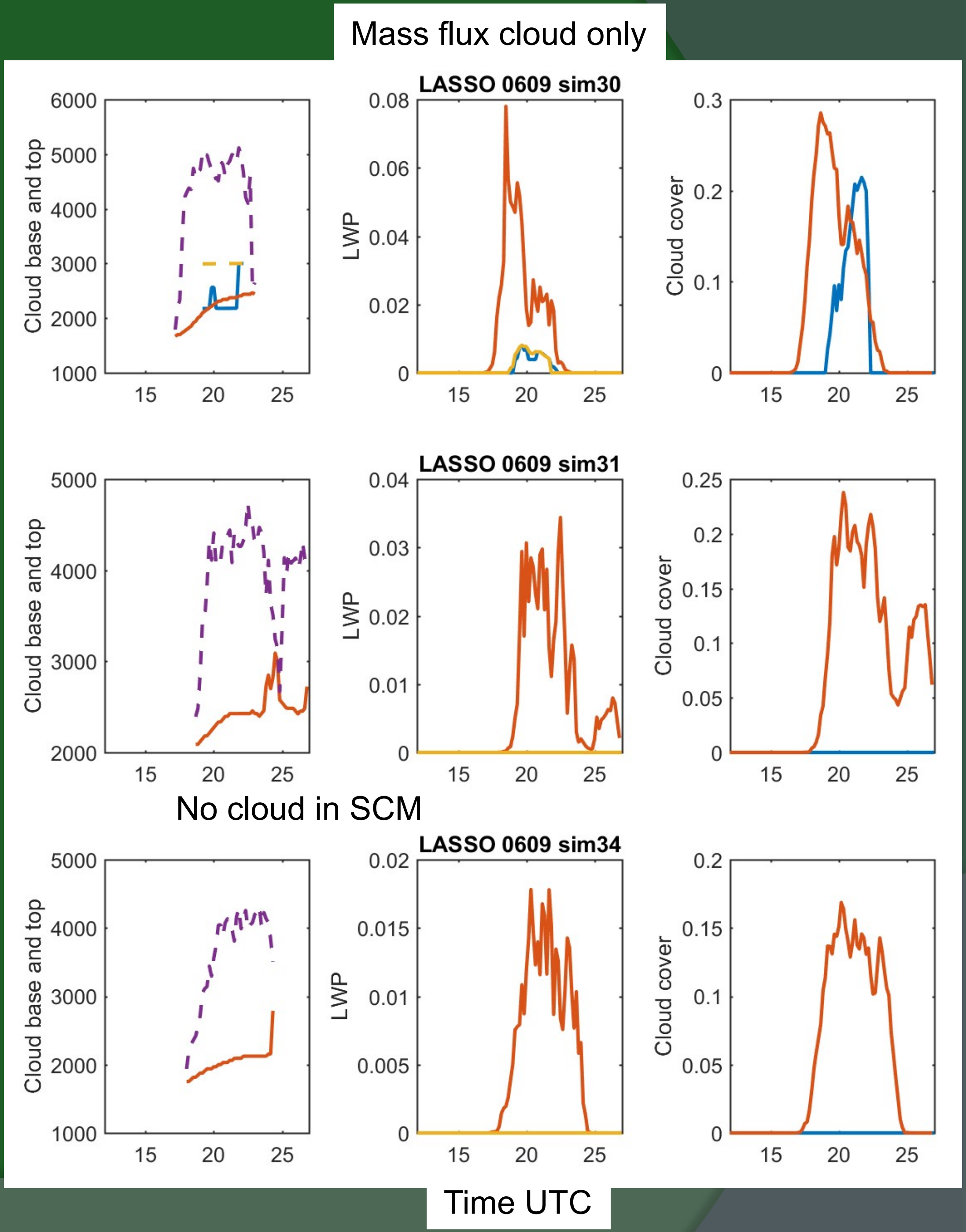
Typical profiles for a purely local PBL scheme:
Too warm and moist near surface
PBL top too low, inversion too sharp



Next case : 9 June
Cloud characteristics

Different simulations are very different in cloud cover and LWP

Features to note:
No mass-flux cloud in SCM in two simulations with weaker cloud in LES – is there a threshold?
Cloud base low
Top also low
Onset late
LWP underestimated
Cloud cover OK

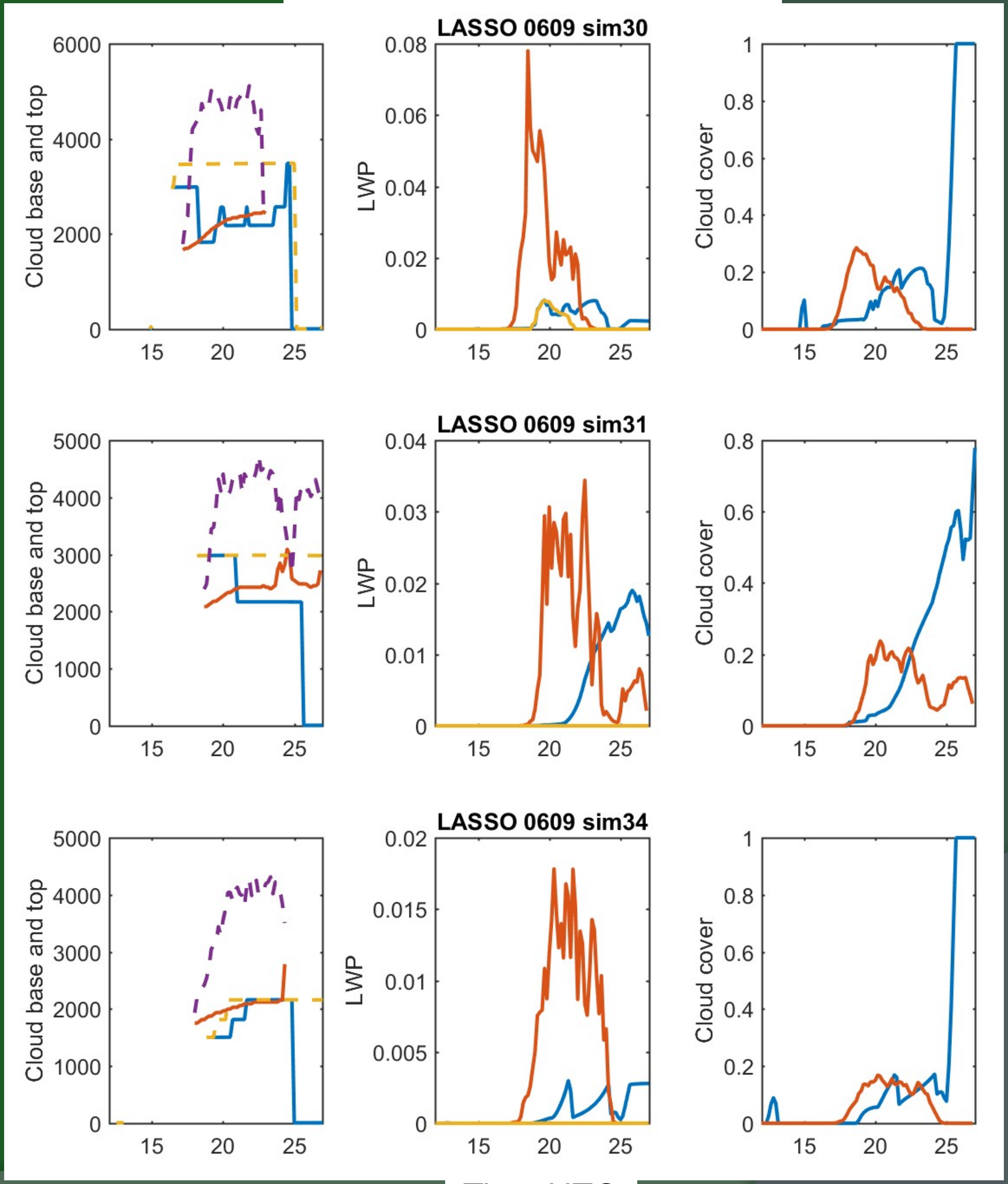


Next case : 9 June
Cloud characteristics

With subgrid stratus included

Cloud base low
Top also low
Onset still late
LWP underestimated
Cloud cover magnitude reasonable, but timing off (too much cloud cover late)

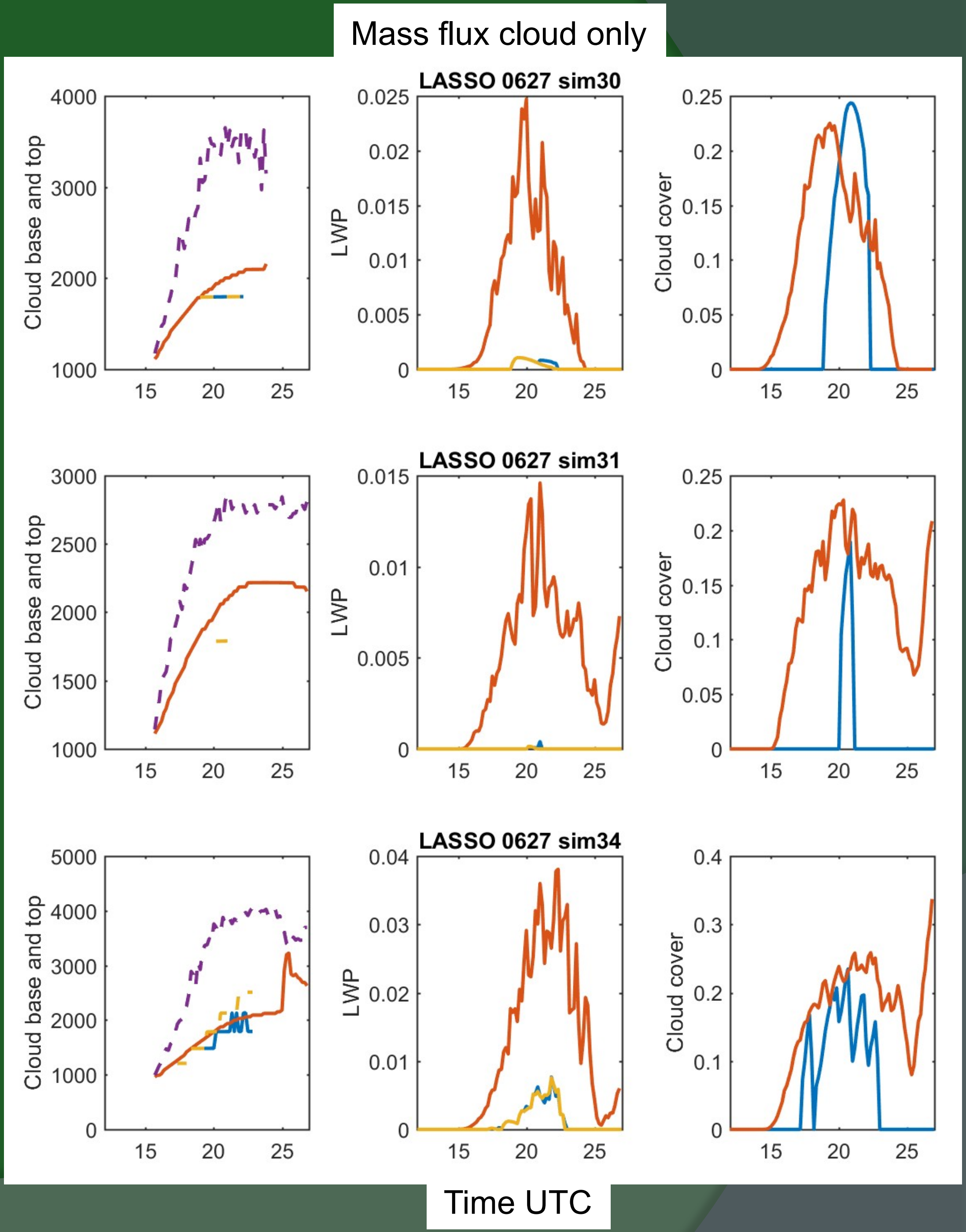
Subgrid stratus cloud included



Time UTC

Third case : 27 June
Cloud characteristics

No mass-flux cloud in SCM in sim31 with weak cloud in
Cloud base low
Top also low
Onset late
LWP underestimated
Cloud cover OK

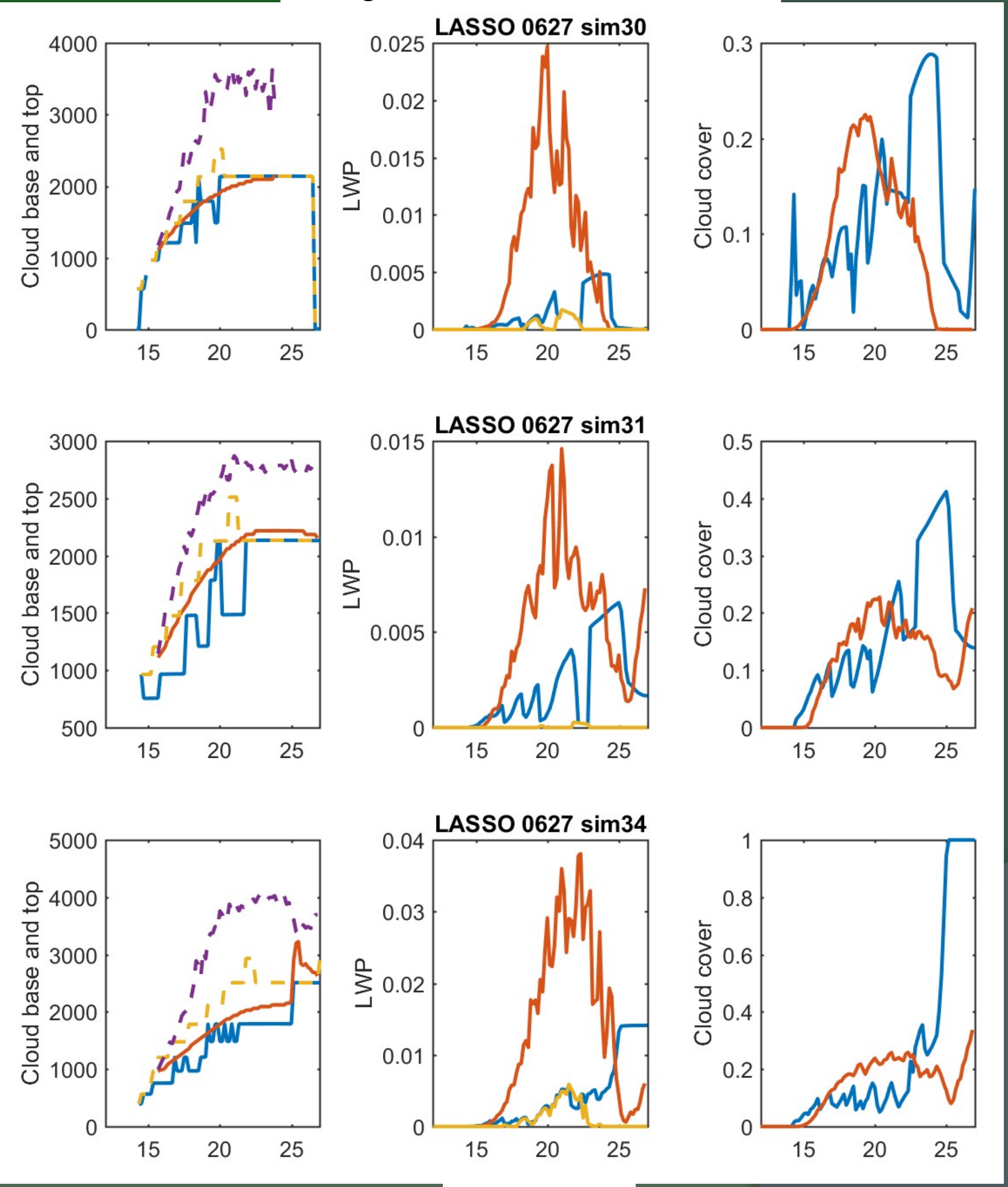


Third case : 27 June
Cloud characteristics

With subgrid stratus included

Cloud base low
Top also low
Onset OK
LWP underestimated
Cloud cover magnitude reasonable, but timing off (too much cloud cover late)

Subgrid stratus cloud included



Time UTC

Summary

MYNN-EDMF is doing a reasonable job with these challenging cases, and much better than any PBL scheme unaware of clouds

LASSO provides us with process information that will allow for targeted action

Major differences between simulations based on different “good” analyses

We have only looked at a few of the many degrees of freedom in setup

General weaknesses of MYNN-EDMF with mass flux cloud only:

No mass-flux cloud in SCM in simulations with weaker cloud in LES – is there a threshold?

Cloud base low

Top also low

Onset late

LWP underestimated

PBL too cool, moist, and shallow

Profiles not smooth (vertical resolution?)

With subgrid stratus included:

Onset timing often improved

LWP underestimation reduced, but timing off (too much cloud cover late)

Need to improve consistency between MF cloud and subgrid stratus