# Scale-aware tests of the MYNN-EDMF PBL and shallow cumulus scheme in a multi-column framework

Wayne M. Angevine, Joe Olson, Jake Gristey, Ian Glenn, and Graham Feingold

*CIRES, University of Colorado, and NOAA ESRL*

Conclusions:

Grid spacing is not resolution!

At 600m spacing, reducing parameterized mixing degrades performance

M-CISCs are not an adequate substitute for parameterized mixing

The grey zone is a real problem, not so easily solved

# Scale awareness

Do the scale-aware aspects of MYNN-EDMF behave as expected?

What do we expect as grid spacing decreases?

- Resolved vertical motions should increase
- Parameterized (vertical) mixing should decrease
- Net result should be equal mean mixing on the aggregated cell

Some information provided by upscaled LES (e.g. Honnert et al.)

**BUT**

Resolved vertical motions on gray-zone grids are not the same as in the real atmosphere, but are governed by grid size and effective resolution [Ching et al. (2014) and Zhou et al. (2014)]

"Model Convectively Induced Secondary Circulations" (M-CISCs)

Effective resolution is larger than grid spacing (4-8*Δx)

[Beare 2014, many others]

What do we mean by "gray zone"?

Also known as "terrra incognita" (Wyngaard)

The range of grid spacing where important motions are neither fully resolved nor completely subgrid

For PBL and shallow cumulus, characteristic scales are

200-2000 m,

depending on BL depth and cloud layer depth

# Test method: Multi-column or Partially-convection-permitting model

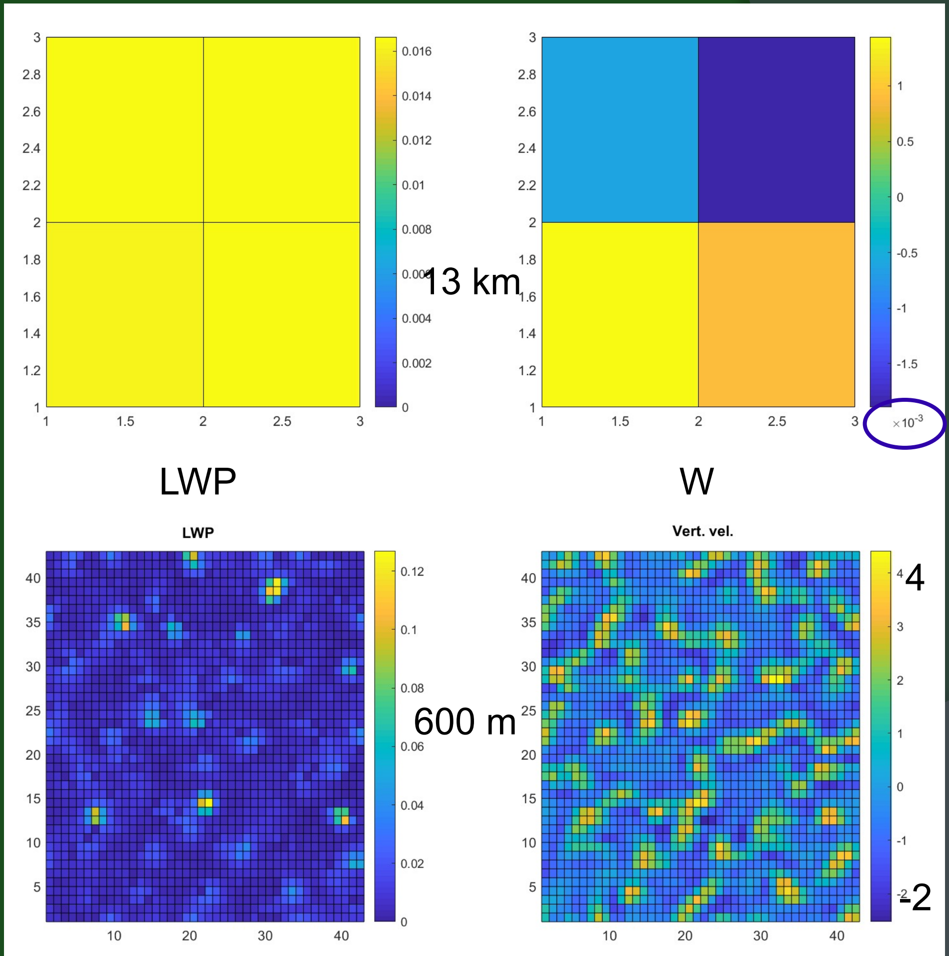
Usual WRF "single-column" setup is a 2x2 grid with doubly-periodic boundary conditions and strong horizontal diffusion

Here the grid spacing is decreased but the grid covers the same area, still doubly-periodic, no artificial diffusion

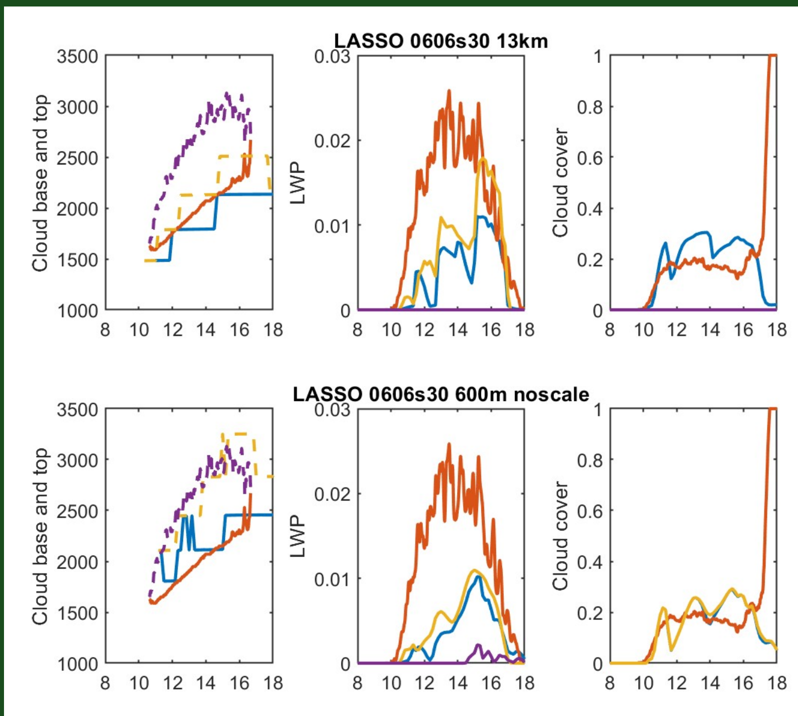
Grid spacing controls scale-aware aspects of the PBL / shallow Cu scheme

Initialization:

- Uniform vertical sounding
- Coupled land surface
- Perturbed soil moisture to break symmetry (0.1% perturbation)



# What happens in the multi-column simulation (without scale awareness)?



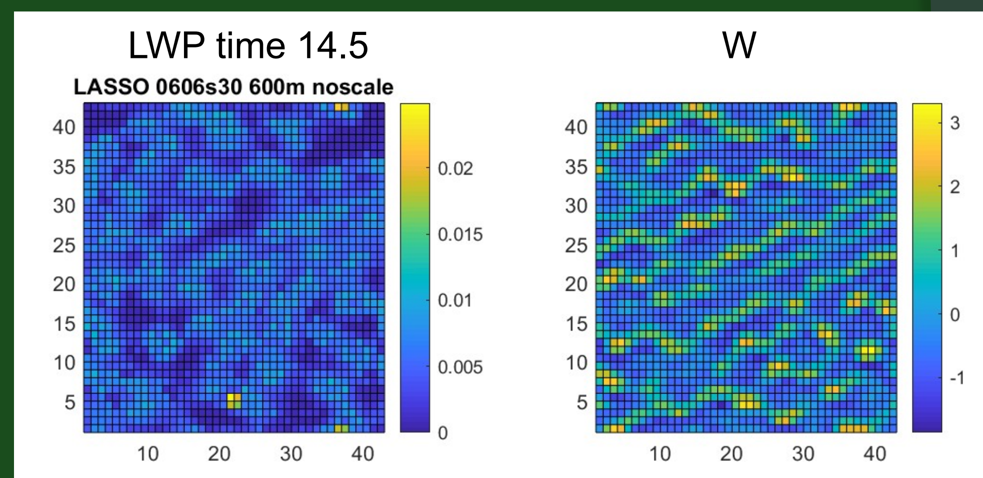

Fine grid has higher cloud base and top, similar cloud cover

LWP proportion between mass flux, non-convective subgrid, and grid scale cloud changes

Vertical velocity pattern varies in time

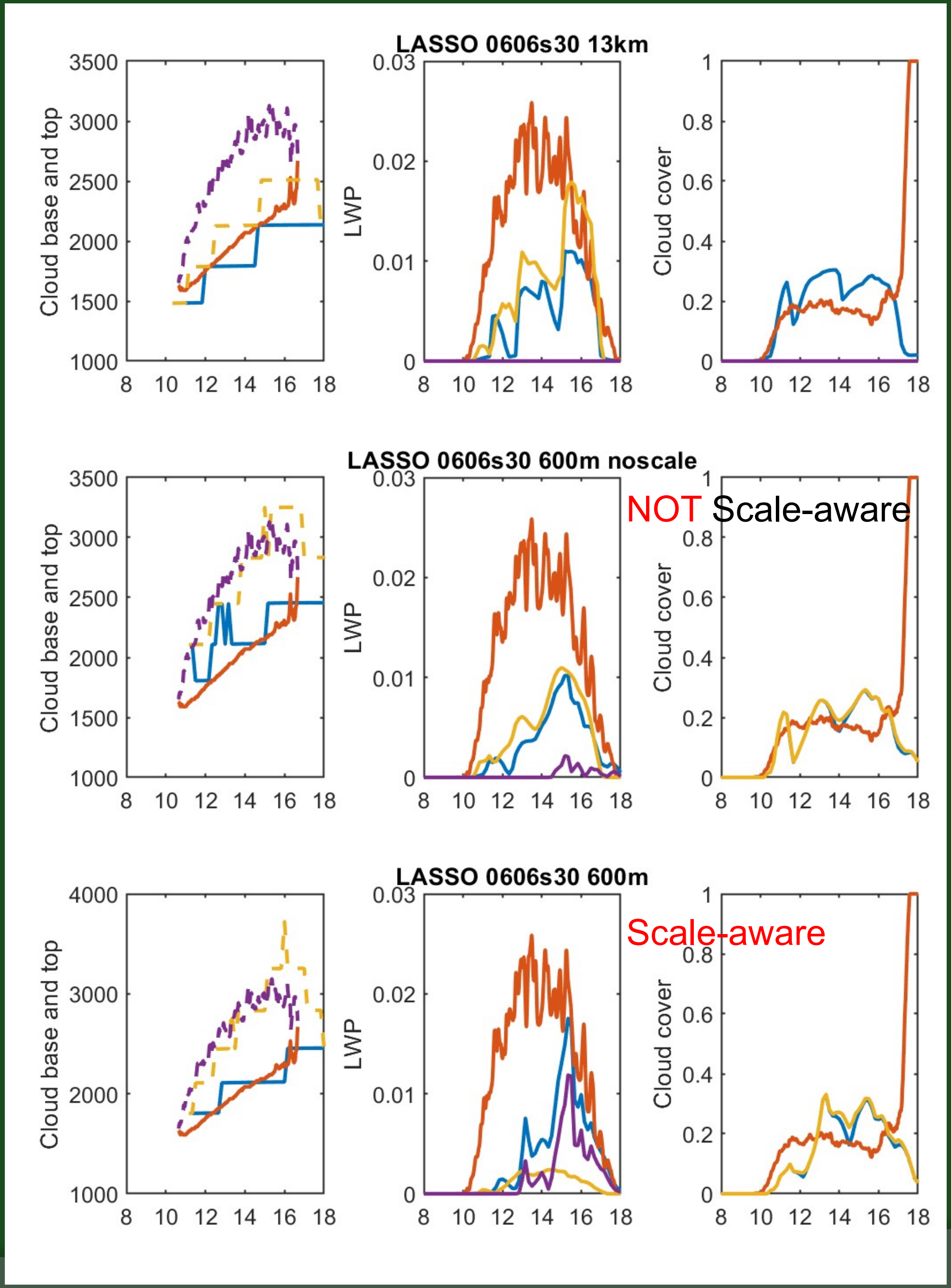
(linear to cellular)

Profiles smoother at 600m (not shown)




In LWP plots:
Red: LES
Yellow: MF cloud
Blue: Total cloud
Purple: Grid cloud

# Is scale awareness beneficial?




6 June 2015

Scale-aware cloud is late(r) and has less LWP, but its cloud base is better

Profiles are nearly indistinguishable

In LWP plots:
Red: LES
Yellow: MF cloud
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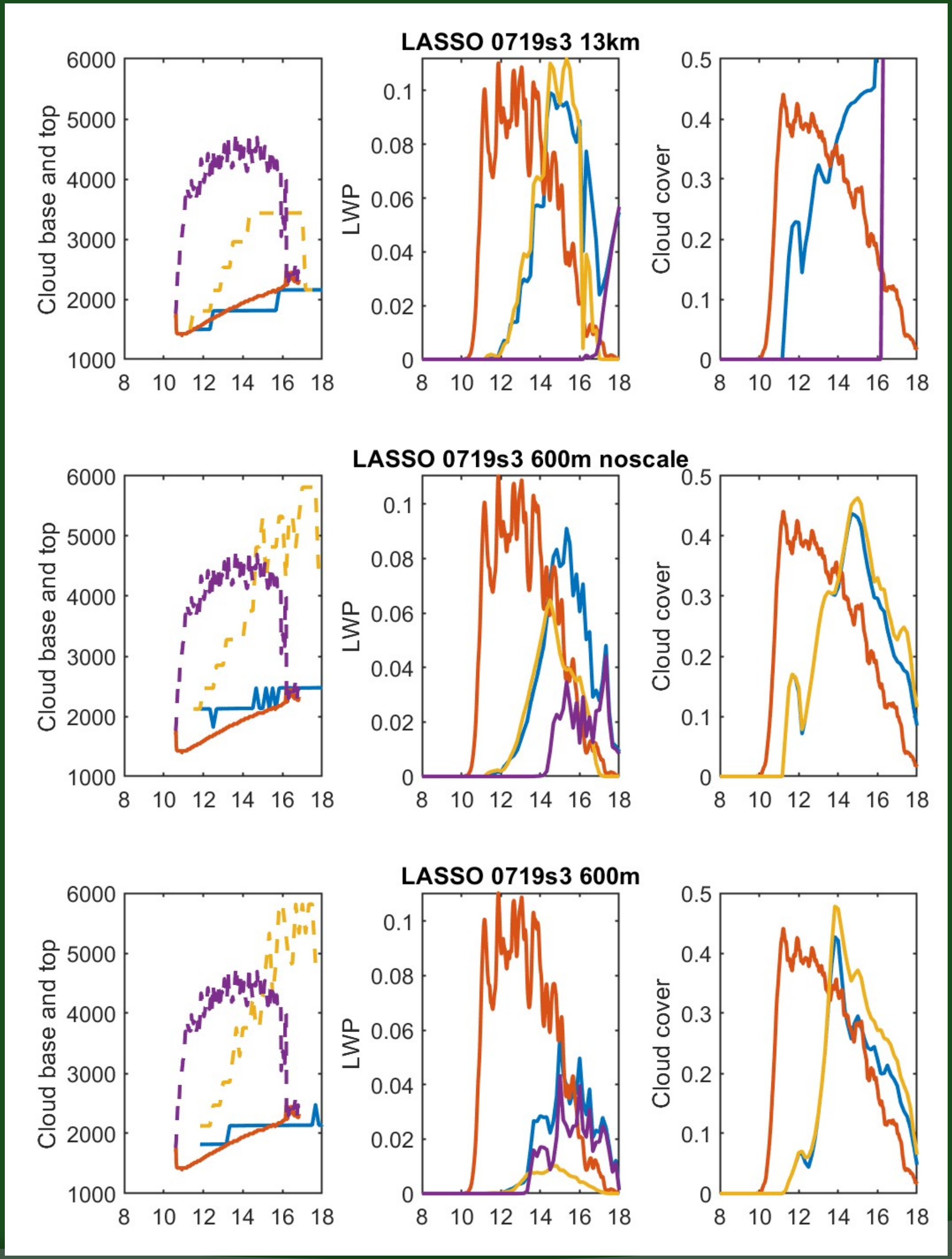


19 July 2016

Scale-aware cloud is late(r) and has less LWP, but its cloud base is better

Early cloud in LES not in any SCM/MCM simulation, timing generally not good

In LWP plots:
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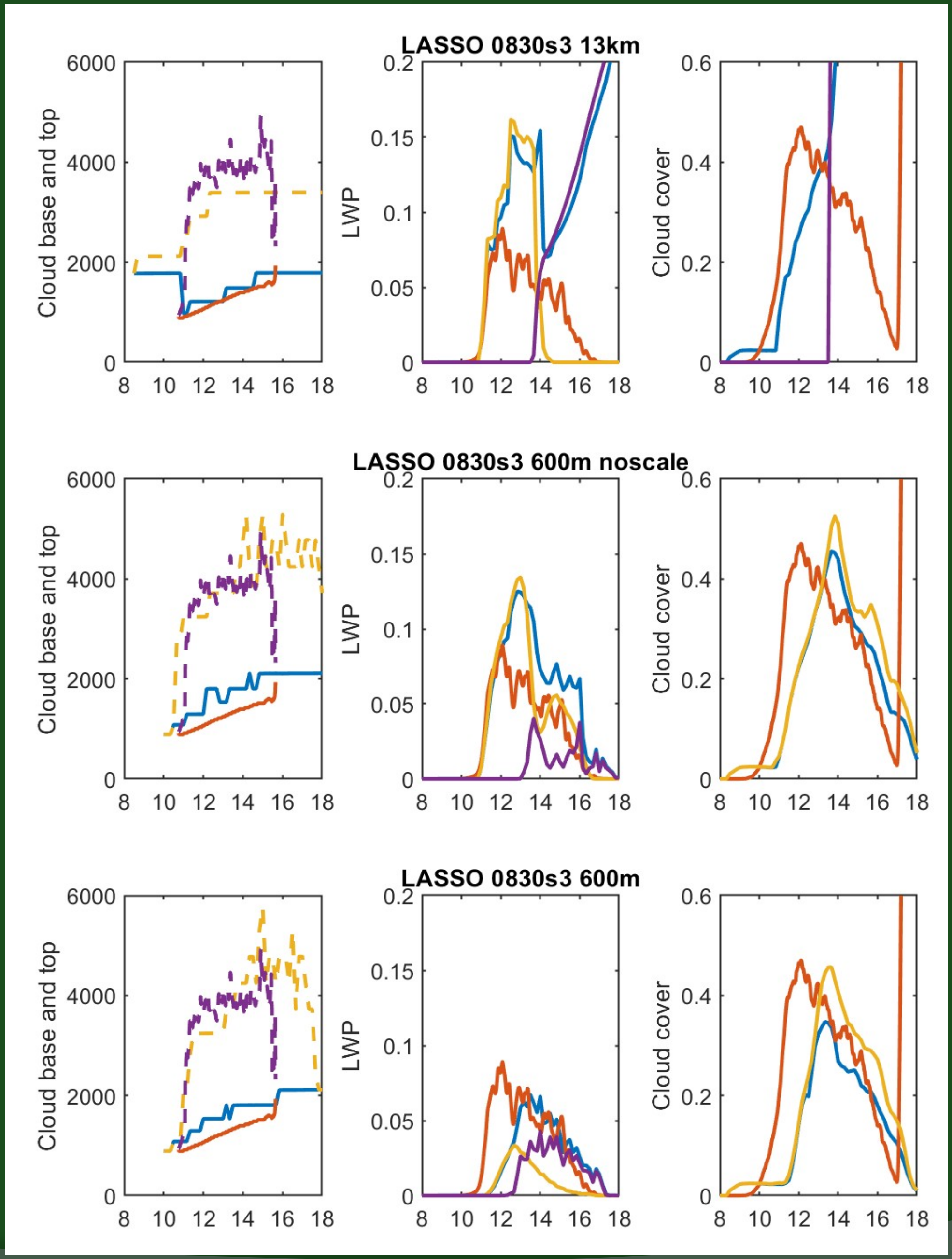


30 August 2016

Scale-aware cloud is late and has less LWP

Non-scale-aware (and 13km) have too much LWP early

Non-scale-aware timing of cloud onset nearly perfect

In LWP plots:
Red: LES
Yellow: MF cloud
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# Profiles

6 June 2015

600m profiles with and without scale awareness are nearly indistinguishable

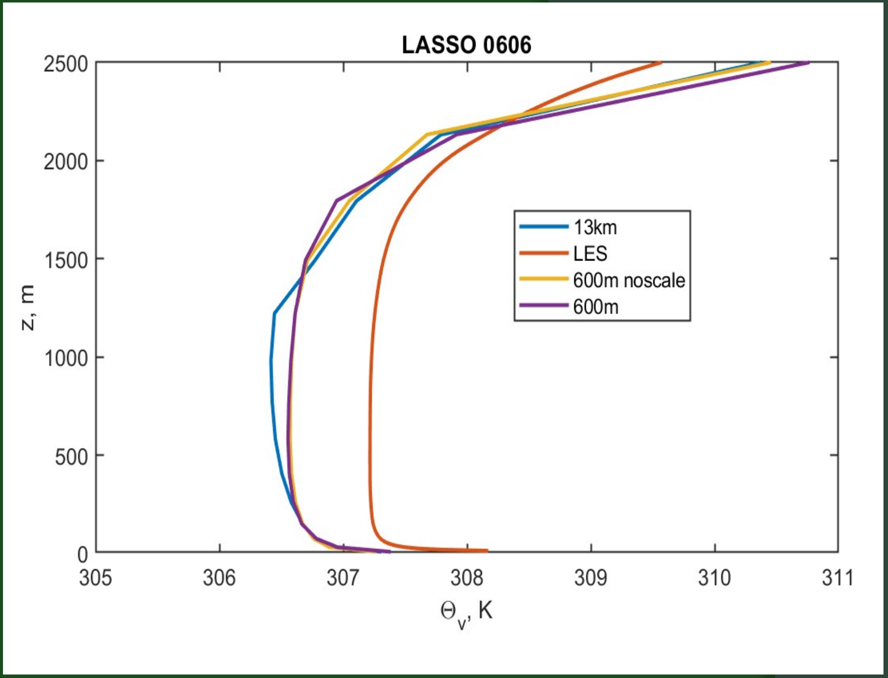
Slope of 600m profiles matches LES well

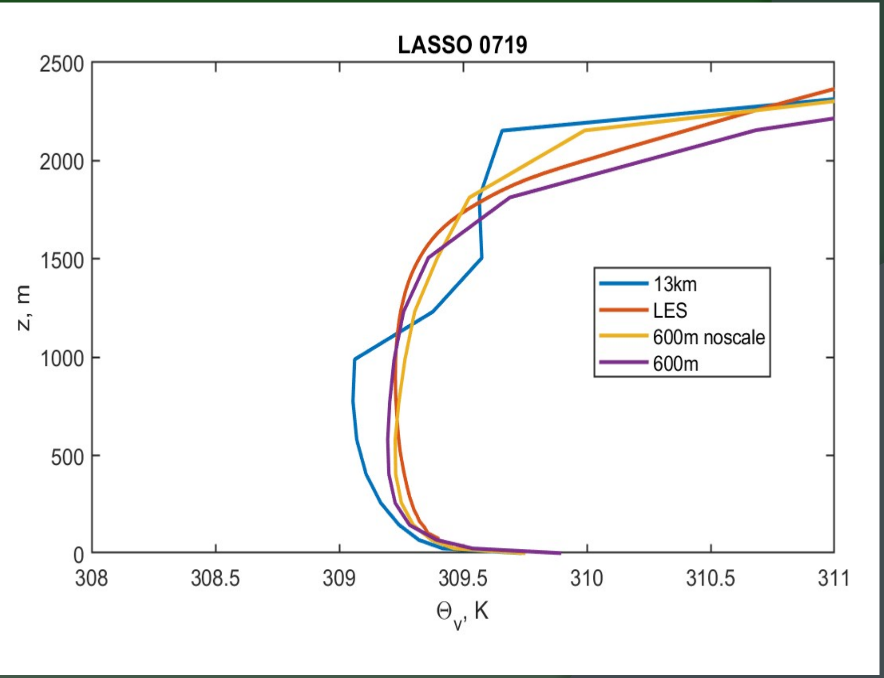
13km profile is too unstable below cloudbase, indicating too little mixing

19 July 2016

600m both too stable, non-scale-aware more so, indicating too much non-local mixing

13km profile is too unstable below cloudbase



# Mean LWP and instability

No scale awareness is superior in three cases (but 13km is better yet)

Middle case is ambiguous

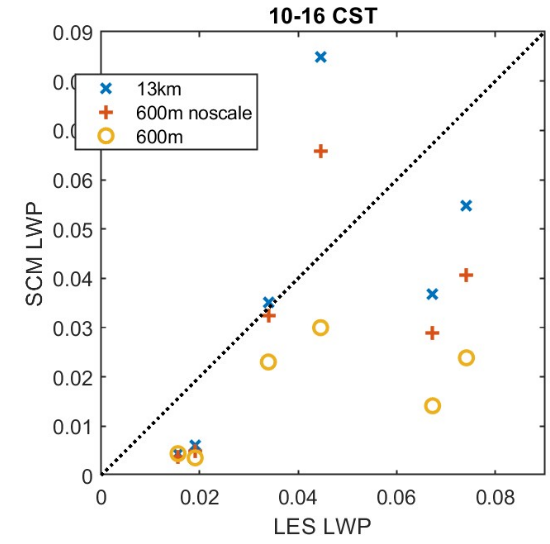
Cases with small LWP are not distinguishable (all underestimated)

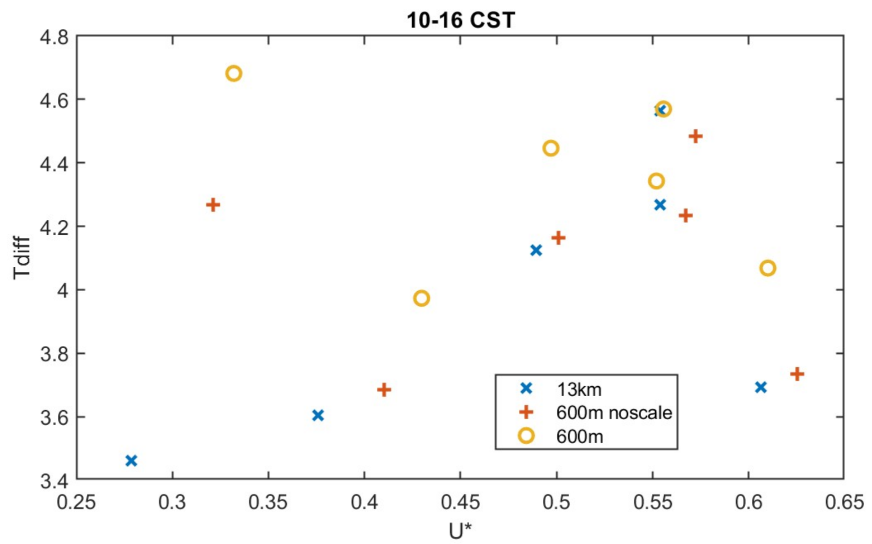
Surface temperature difference (instability):

Scale-aware version always has the largest difference

At small u* (light winds), 3 versions spread widely

Stability h/L is in the range -10 to -20 (rolls) except for 0830 (-50 to -70, cells) and 0609 (-20 to -40, ambiguous) – is there a pattern dependence of LWP over/under estimation?



# Are these M-CISCs?

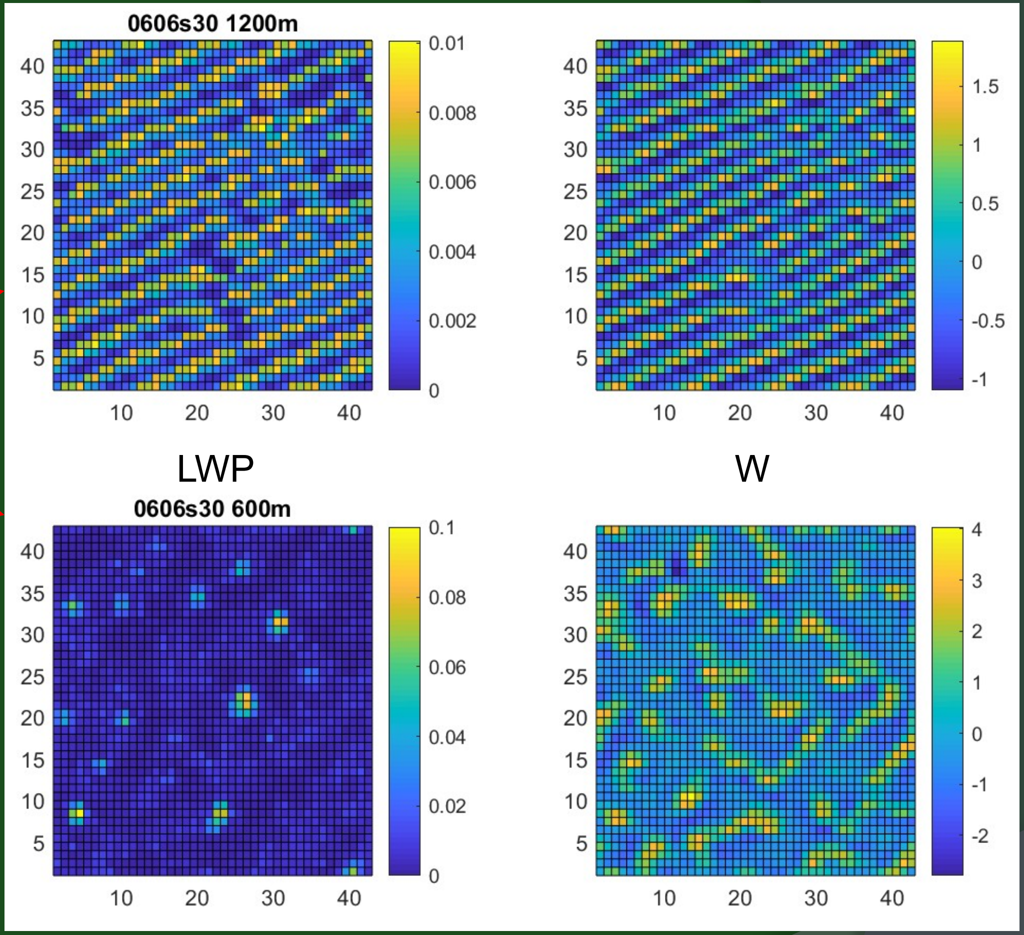
- ✓ Grid-dependent magnitude and pattern
- ✓ Delayed onset

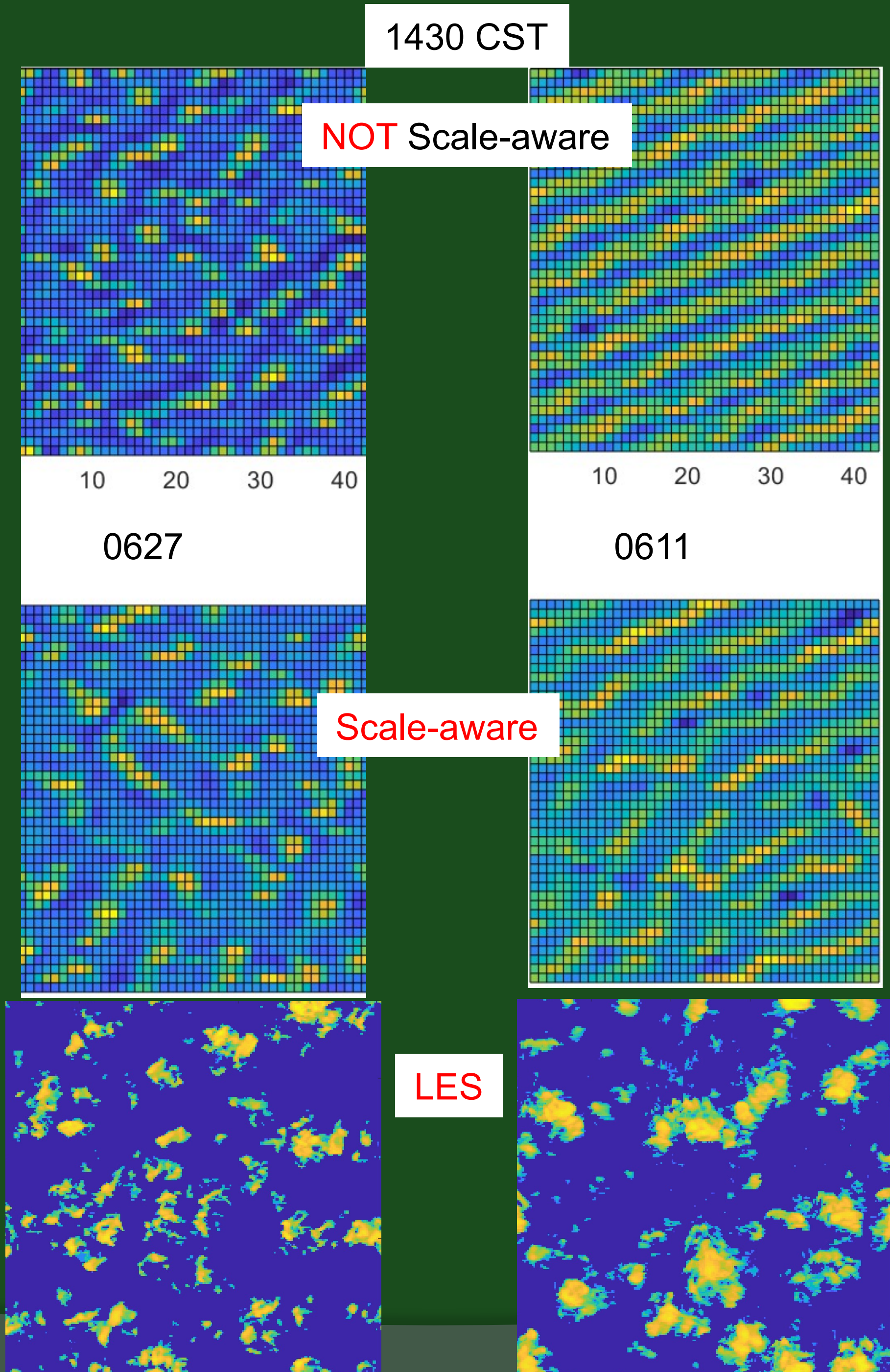
Now showing 1200m vs. 600m grid

Parameterized and grid scale motions trade off in managing instability in the surface layer

Note that M-CISCs are present even though this is a non-local scheme

Additional diffusion damps M-CISCs (not shown)






# Are M-CISCs good?

Patterns vary in a realistic way
Realistic not necessarily real

0627 has moderate instability
0611 has the least instability and the largest difference between scale-aware and non-scale-aware
Both have similar u*

LES cellular in both cases
LES structures larger than MCM on 0611, contrary to expectation

# Summary

Multi-column framework is effective for testing scaling behavior and scale awareness

Scale awareness in MYNN-EDMF works as designed, but more thought is needed
In these cases, scale awareness is detrimental to performance

- Timing
- LWP

Why?

- Grid size is not resolution
- Upscaled LES represents more scales of motion

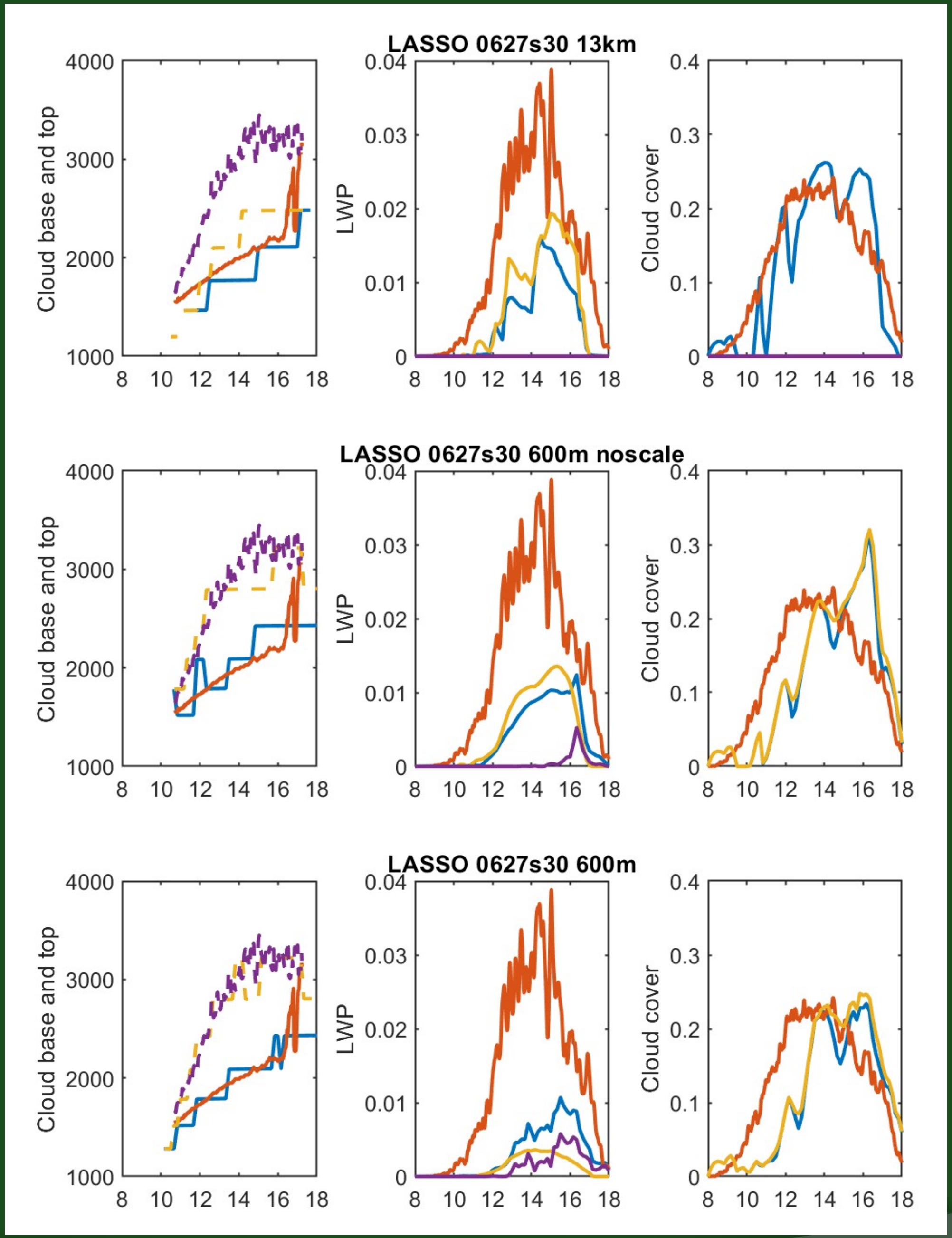
Would conclusions be different if parameterized mixing were stronger at 13km?

Are M-CISCs desirable or not?

Maybe, if users are educated about what they're seeing
Timing and pattern are wrong

Simply reducing activity of parameterized mixing is not a full solution to the grey zone problem of sub-3-km grids for convective PBL and shallow Cu
Perfect performance in SCM/MCM may not be what we want in 3D

For details of 2015 cases see Angevine et al. (2018) Monthly Weather Review




# Is scale awareness beneficial?

27 June 2015

Scale-aware cloud is late(r) and has less LWP, but its cloud base is better

Profiles are nearly indistinguishable

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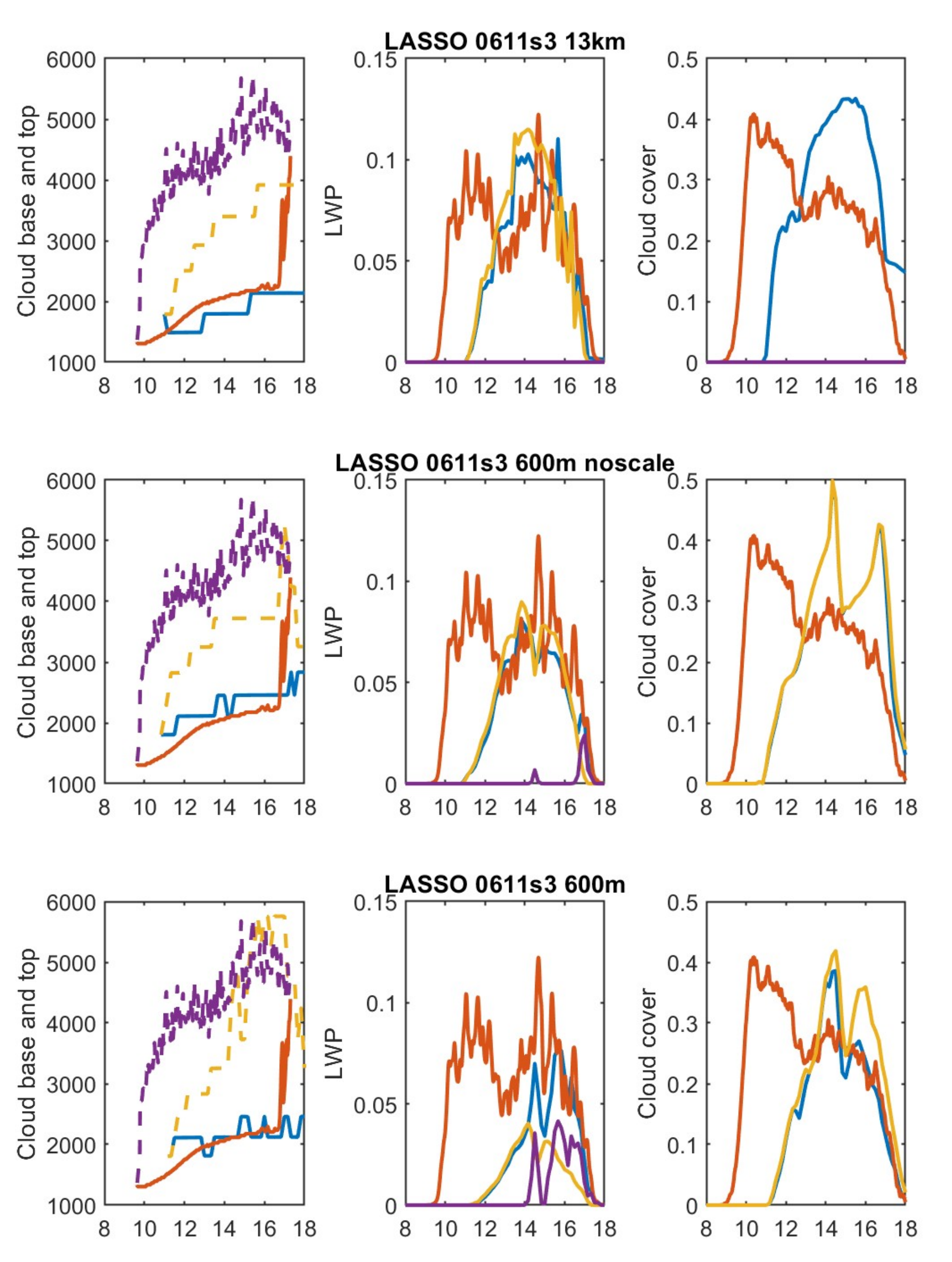


# Is scale awareness beneficial?

11 June 2016

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Early cloud in LES not in any SCM/MCM simulation

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