SAM Constrain Case Study: A Fairly Detailed History of Results

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* = not yet finished, - final slide numbers not yet set

Poster Variables

On poster	Additional
CWP + IWP	Liquid Cloud Water (QCL)
Total Cloud Water	Cloud Ice (QCI)
SGS Cloud Fraction	Resolved TKE
Total LWSE Flux	SGS LWSE Flux
Precipitation Rate	CWP
Precipitation Flux	IWP
Inversion Height	
Total TKE	
SGS TKE	

Q Plot Variables

- QCFLUX - liquid water flux
- QIFLUX - ice flux
- QTFLUX - nonprecipitating water flux (total)
- QTFLUXS - nonprecipitating water flux (sgs)
- QPFLUX - precipitating-water turbulent flux (total)
- QPFLUXS - precipitating-water turbulent flux (sgs)
- QNFLUX - liquid water flux + ice flux
- QVFLUX - QTFLUX - QTFLUXS - QCFLUX - QIFLUX
- Temperature Flux - (TLFLUX - TLFLUXS) + QCFLUX - (QPFLUX - QPFLUXS) + QIFLUX

TKE Components

- SHEAR
- SHEARS
- BUOYA
- BUOYAS
- DISSIP
- DISSIPS

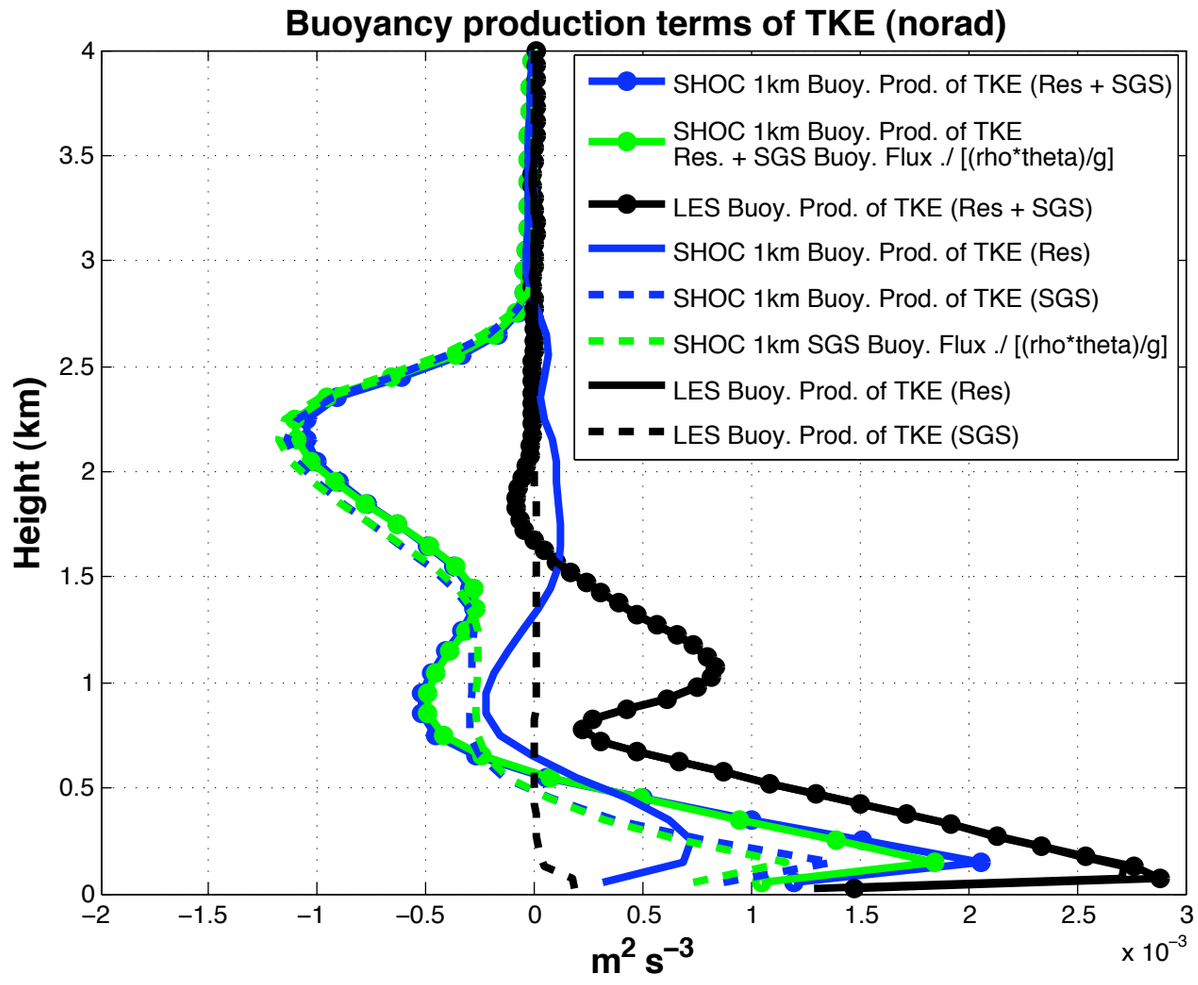
Transport Terms:
ADVTR
PRESSTR
ADVTRS

BUOYAS vs BUOY_SGS

plots: http://home.chpc.utah.edu/~u0652833/SAM_constrain/buoyancyplots/

- theta*pho/g conversion factor from W/m^2 to m^2/s^3

- BUOYAS and BUOY_SGS roughly equivalent.

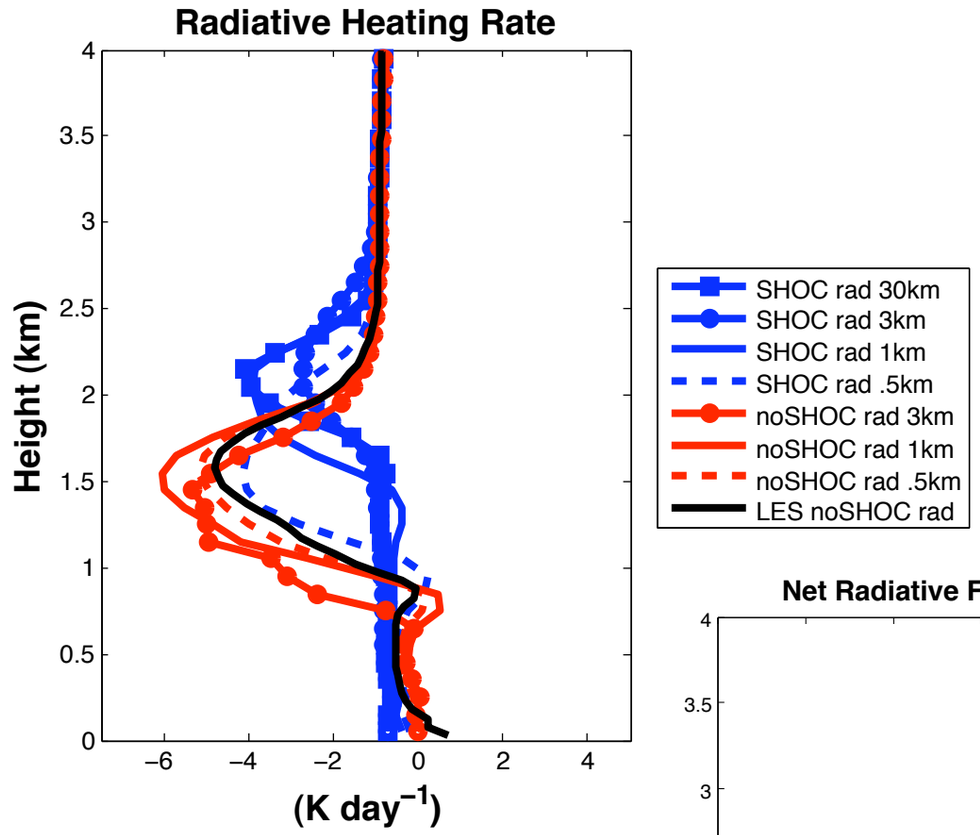


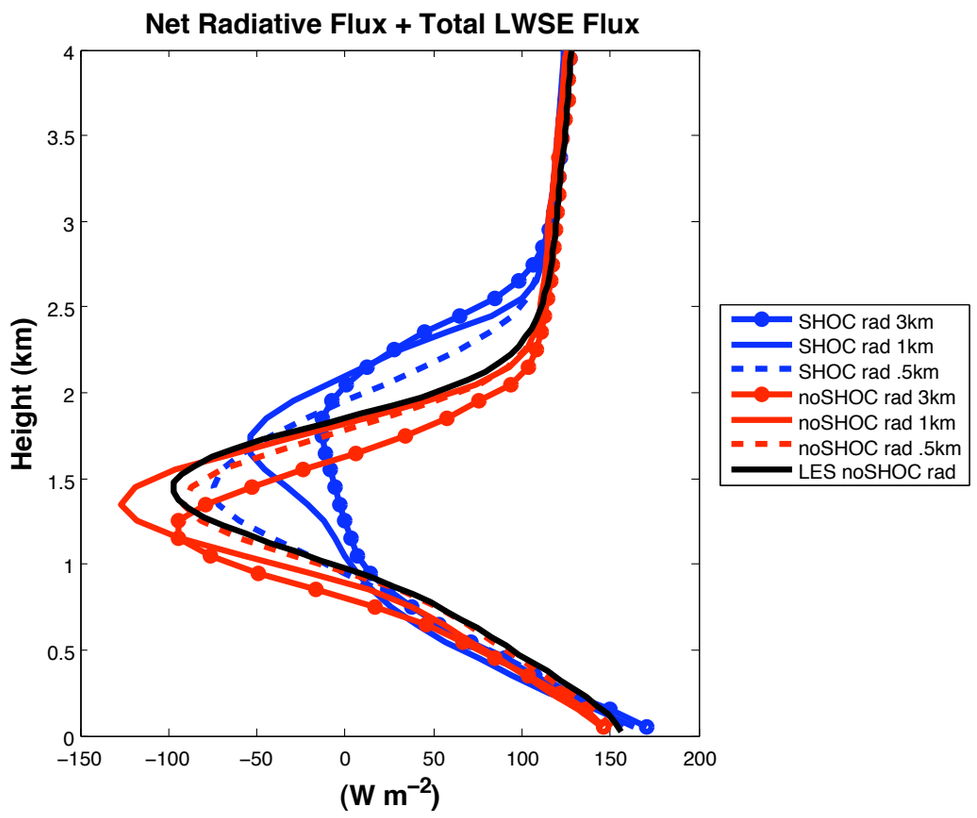
Radiative Heating Rates

plots: http://home.chpc.utah.edu/~u0652833/SAM_constrain/radiativefluxheat_plots/

- LES is closer to noSHOC and SHOC .5km for radiative heating.

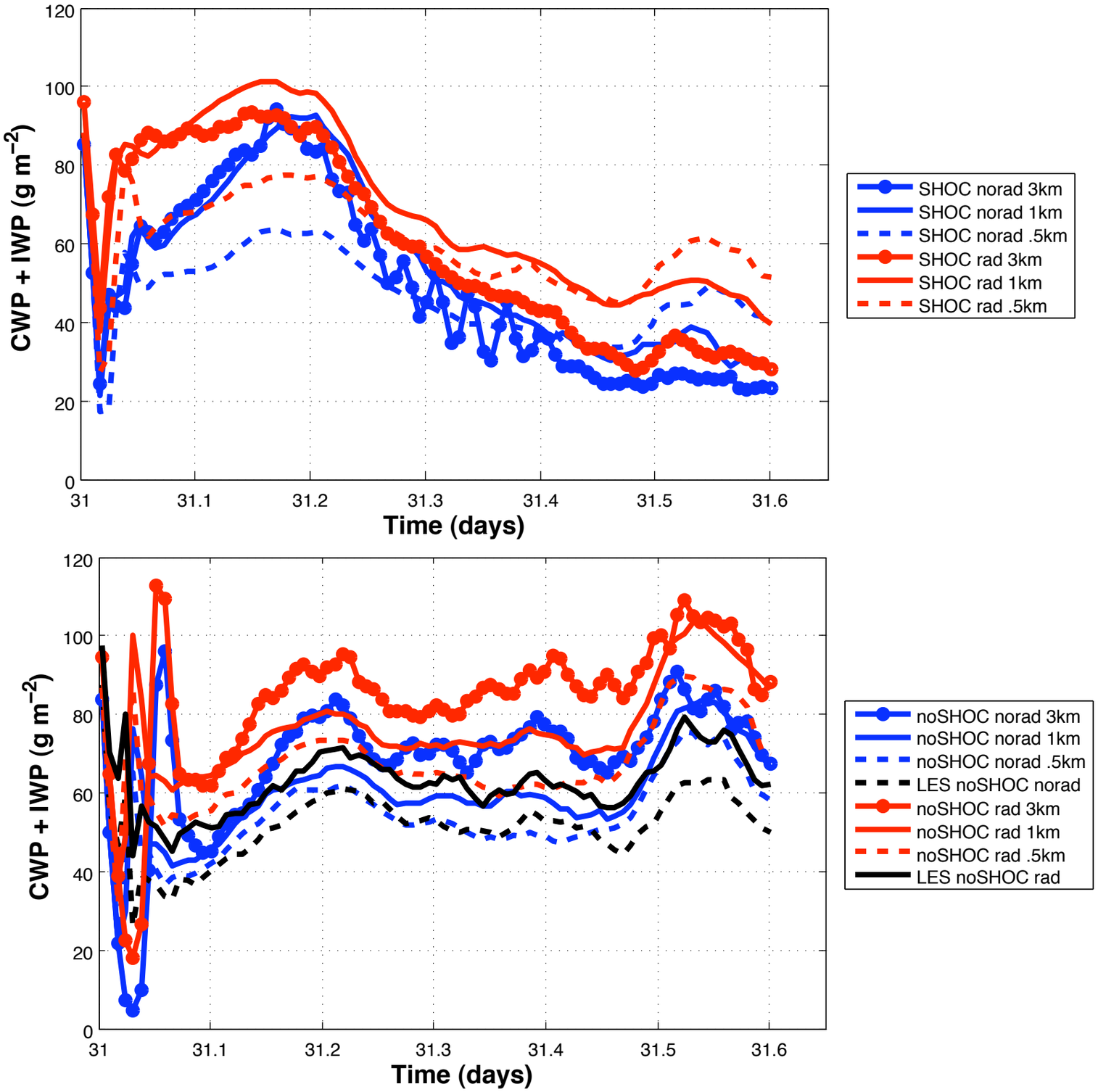
- SHOC runs have higher elevation peak in radiative heating (cooling) rate.





Poster Plots - CWP + IWP

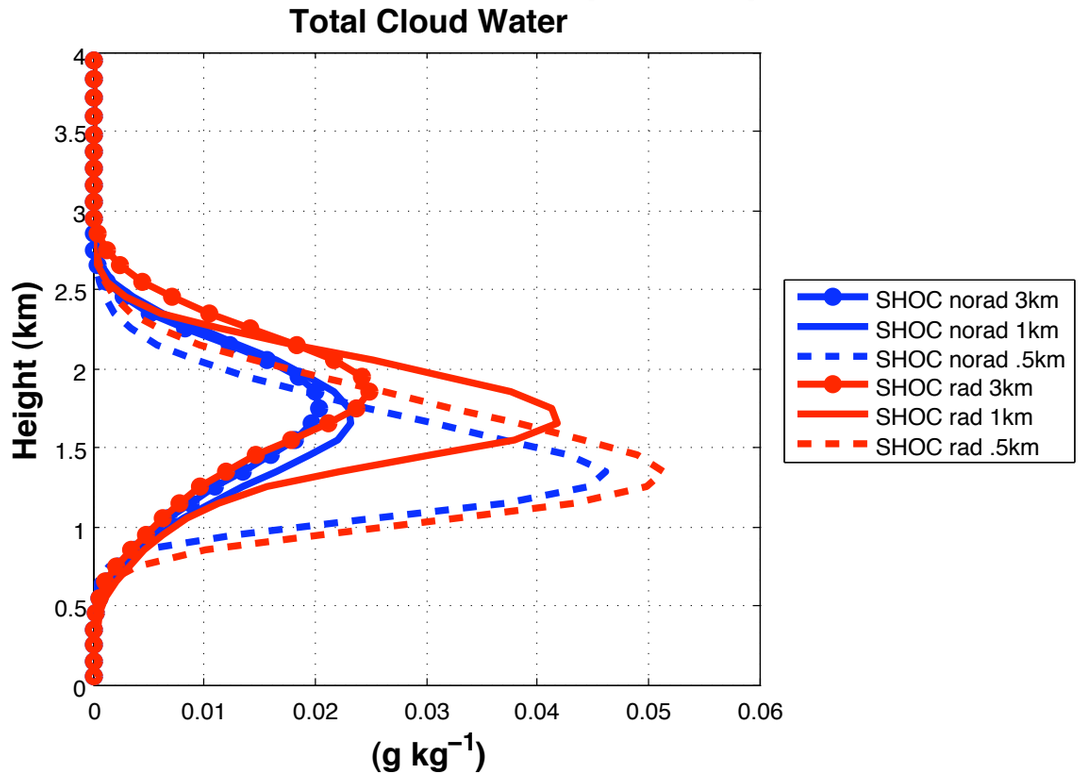
- Rad plots have higher CWP+IWP
- SHOC plots decrease over time.
- .5km SHOC and noSHOC closer together.

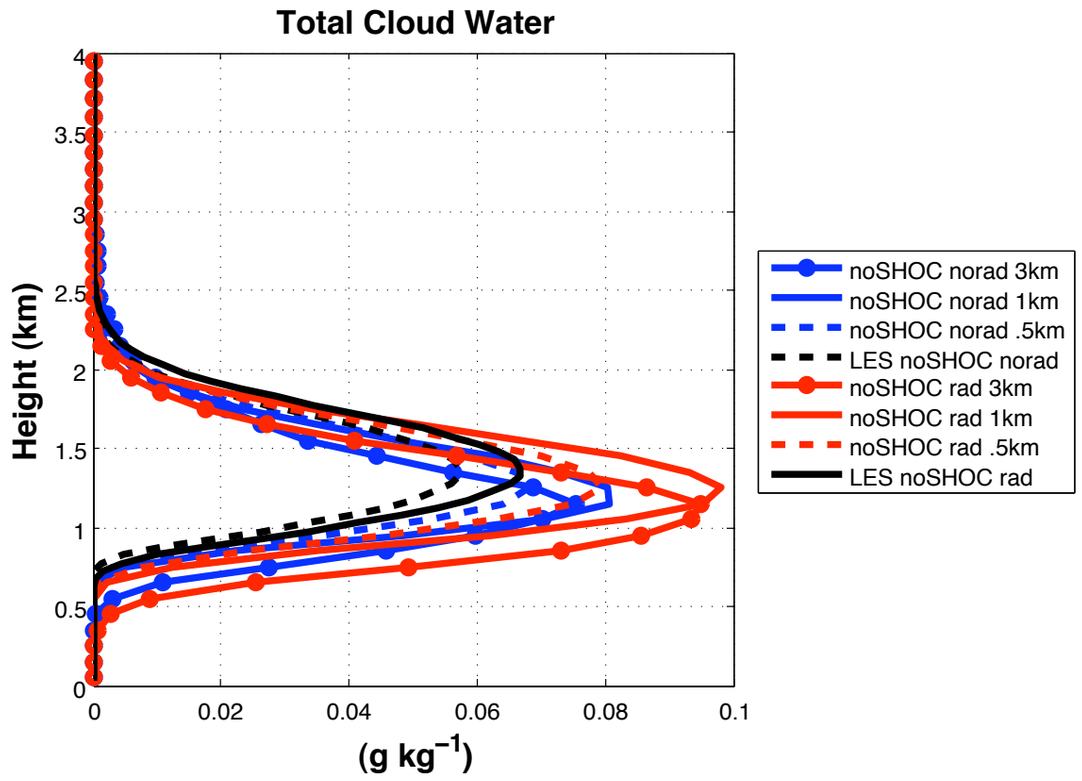


Poster Plots - Total Cloud Water

plots: http://home.chpc.utah.edu/~u0652833/SAM_constrain/posterplots/

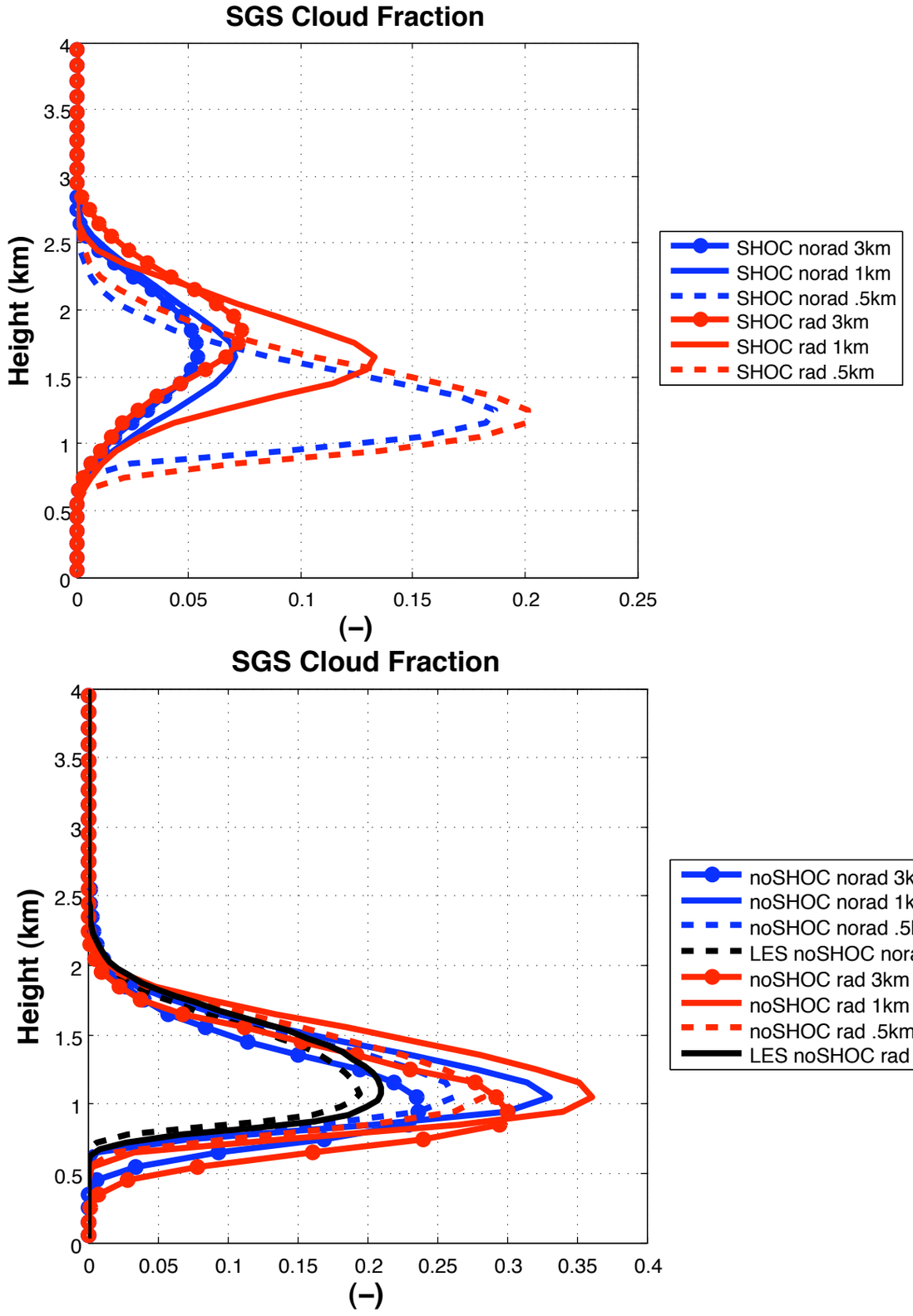
- Cloud water higher in .5km runs for SHOC but lower in .5km noSHOC.
- Cloud water higher in noSHOC runs.
- Rad higher than norad.





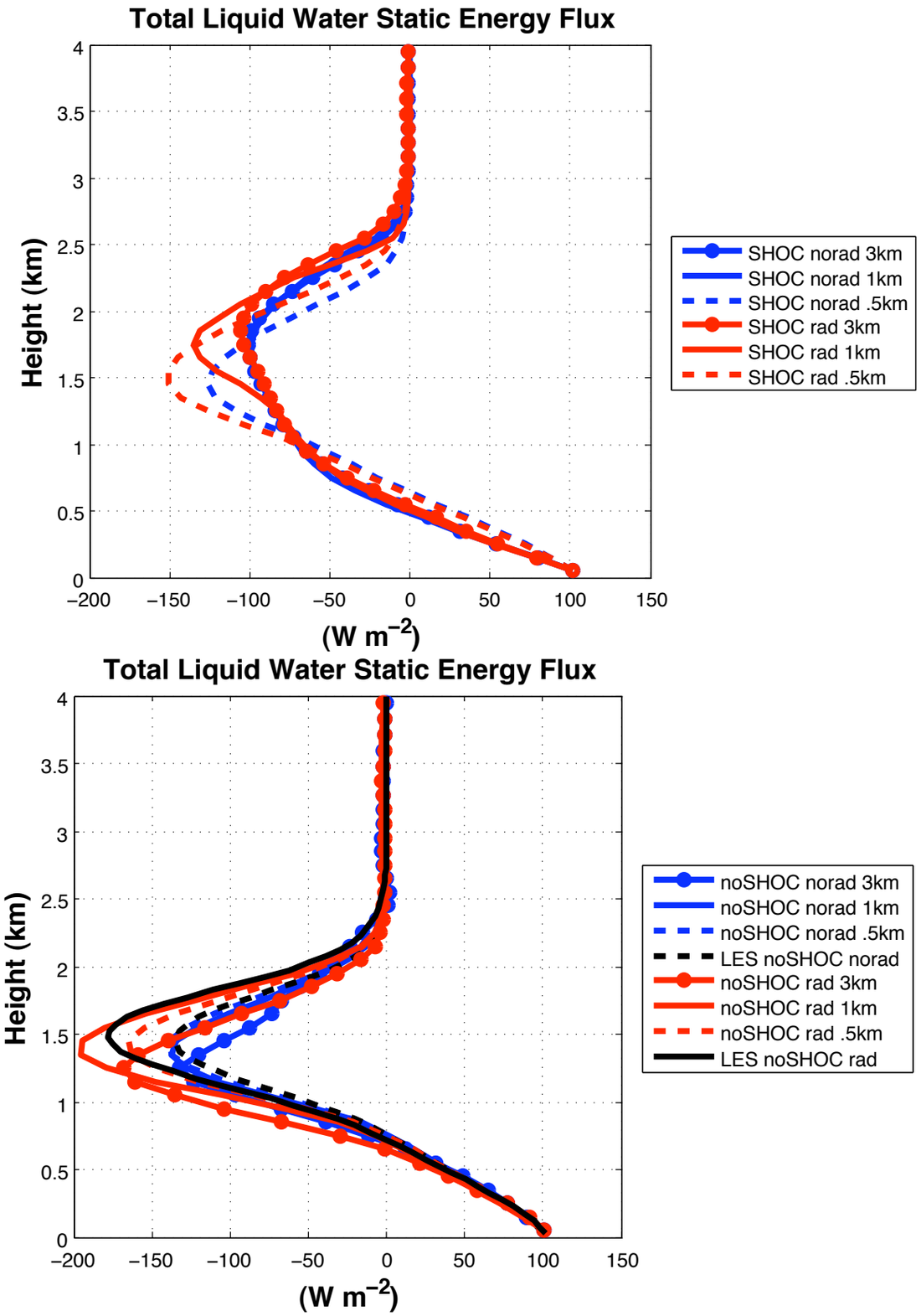
Poster Plots - Cloud Fraction

- .5km runs similar SHOC and noSHOC.
- noSHOC cloud fractions higher than SHOC runs.
- SHOC runs (1, 3km) have peak cloud fraction at higher altitude than noSHOC
- Rad higher than norad.



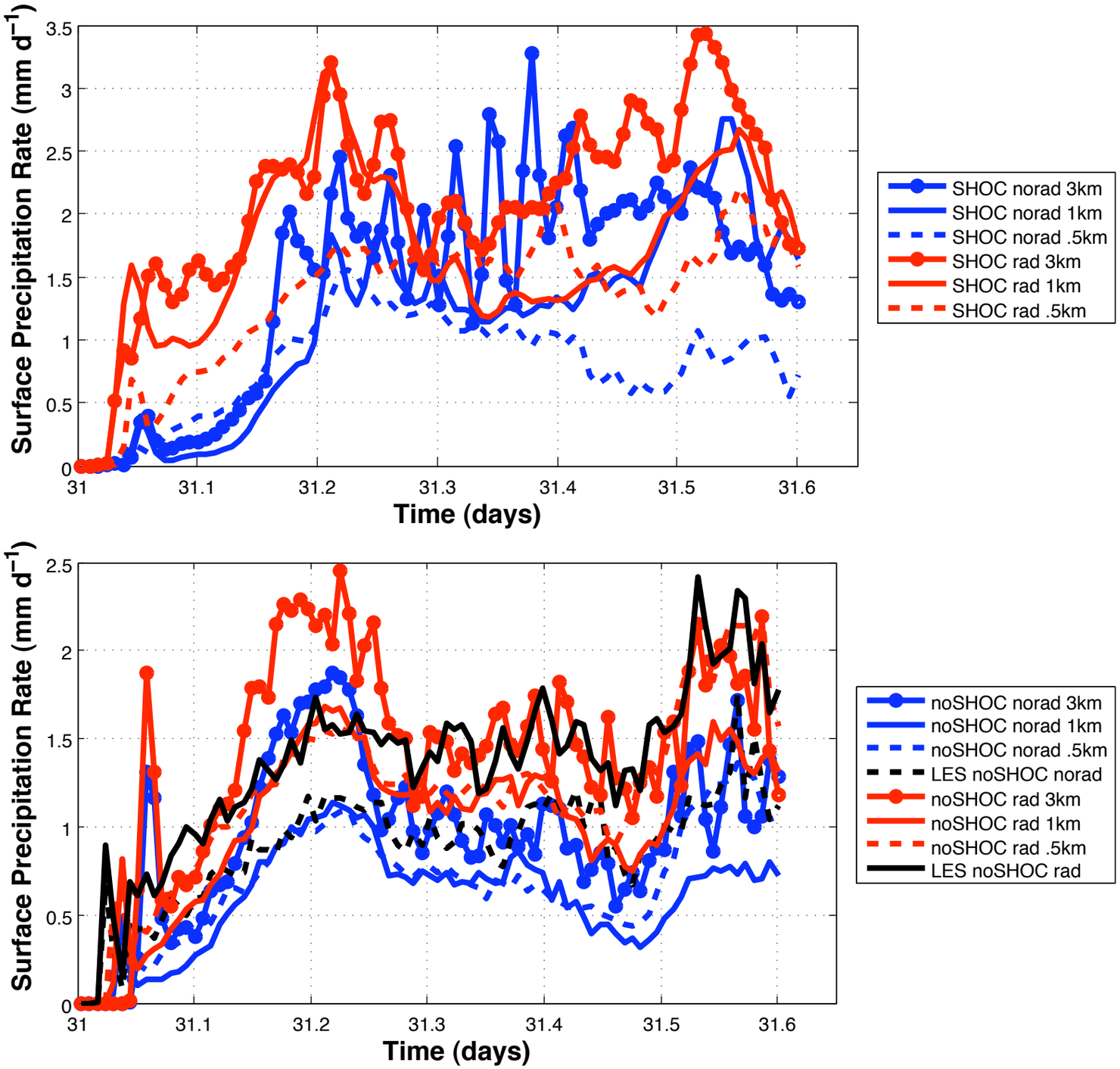
Poster Plots - LWSE Flux Total

- noSHOC has higher LWSE flux values.
- SHOC has higher altitude peak.
- .5km SHOC closer to LES and noSHOC.
- Rad higher than norad.



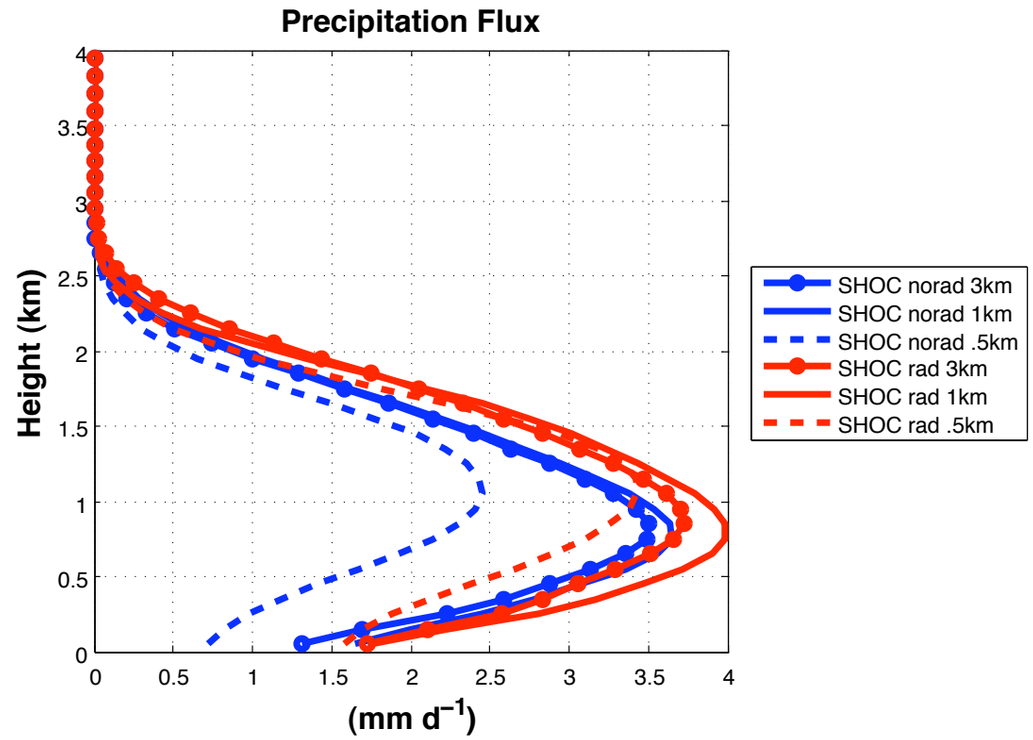
Poster Plots - Precip. Rate

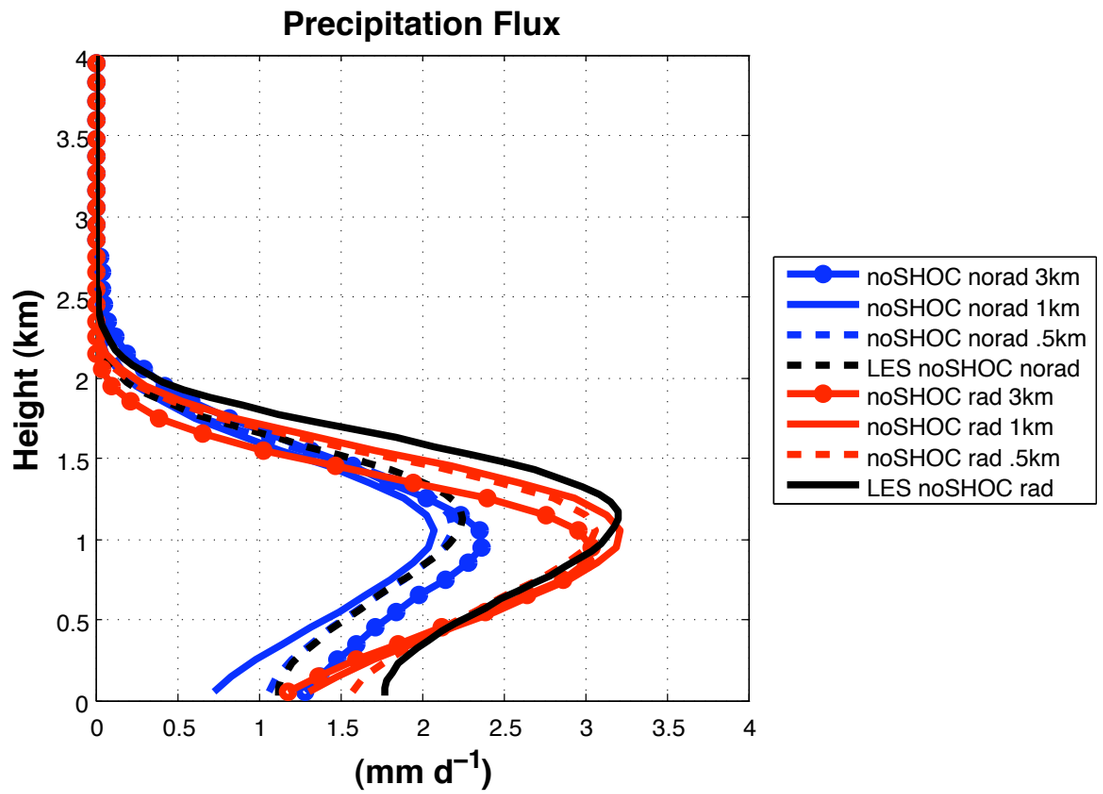
- Higher precip rates in rad than norad.
- Higher precip rates in 3km than .5km
- Higher precip rates in SHOC than noSHOC.



Poster Plots - Precip. Flux

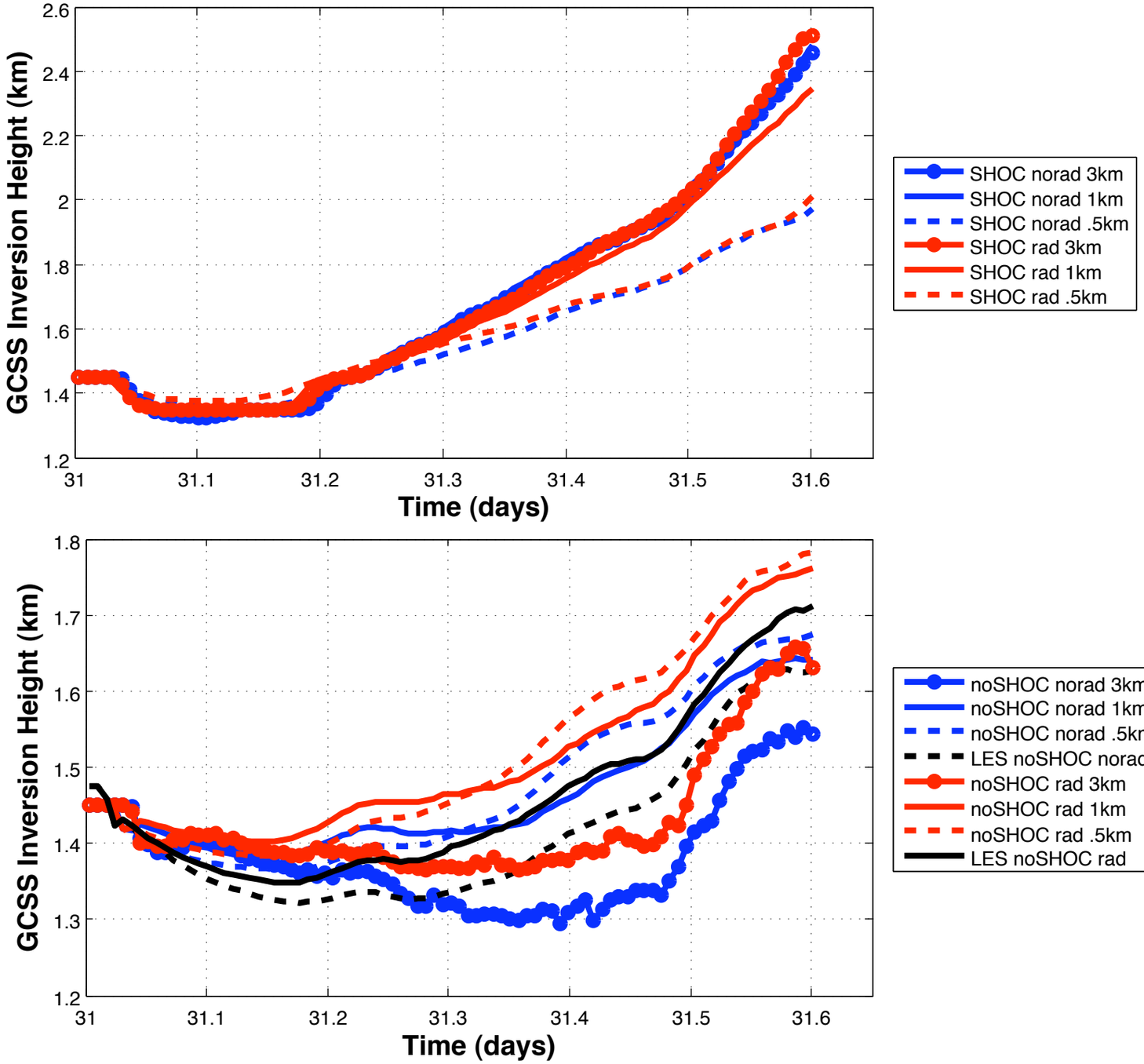
- Precip flux higher in: SHOC, rad, 3km.
- LES is near .5km for rad and norad.





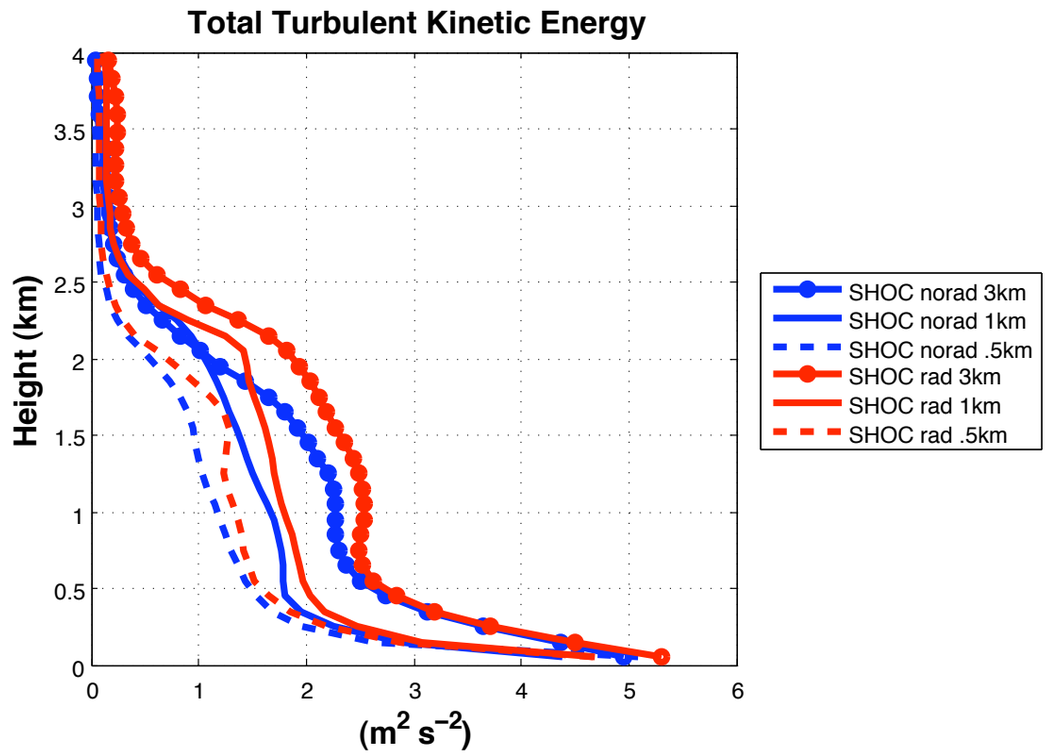
Poster Plots - ZINV

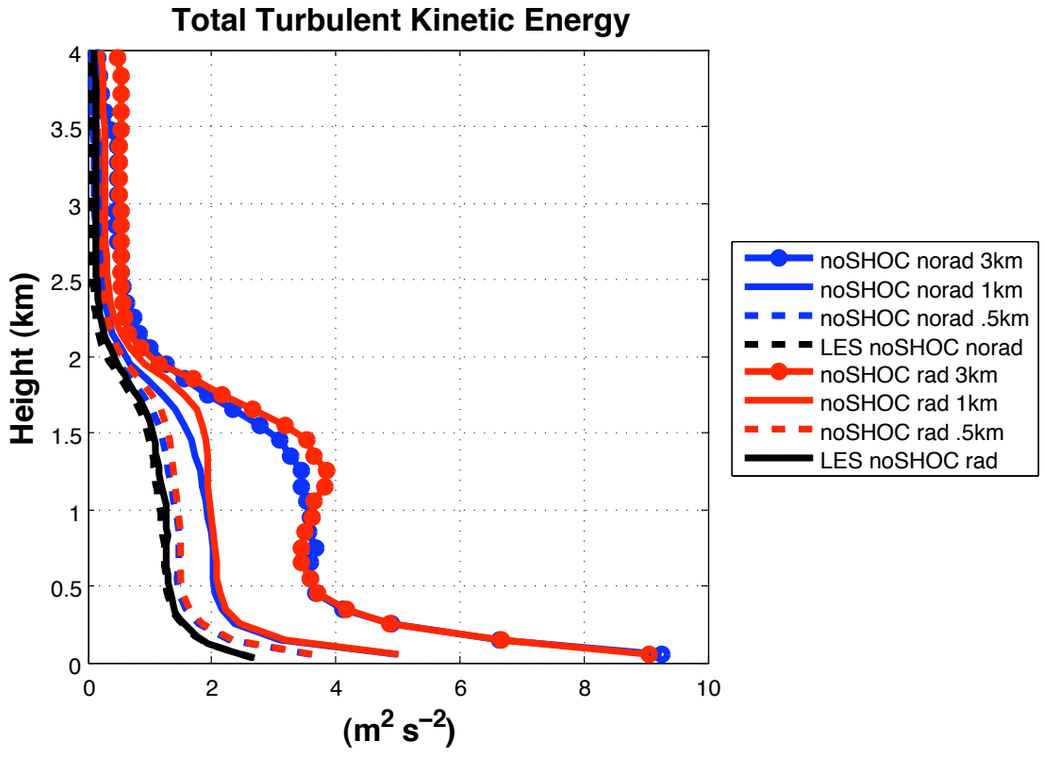
- ZINV higher for SHOC than noSHOC.
- .5km lines closer together.
- Higher for rad than norad in noSHOC/LES



Poster Plots - TKE Total

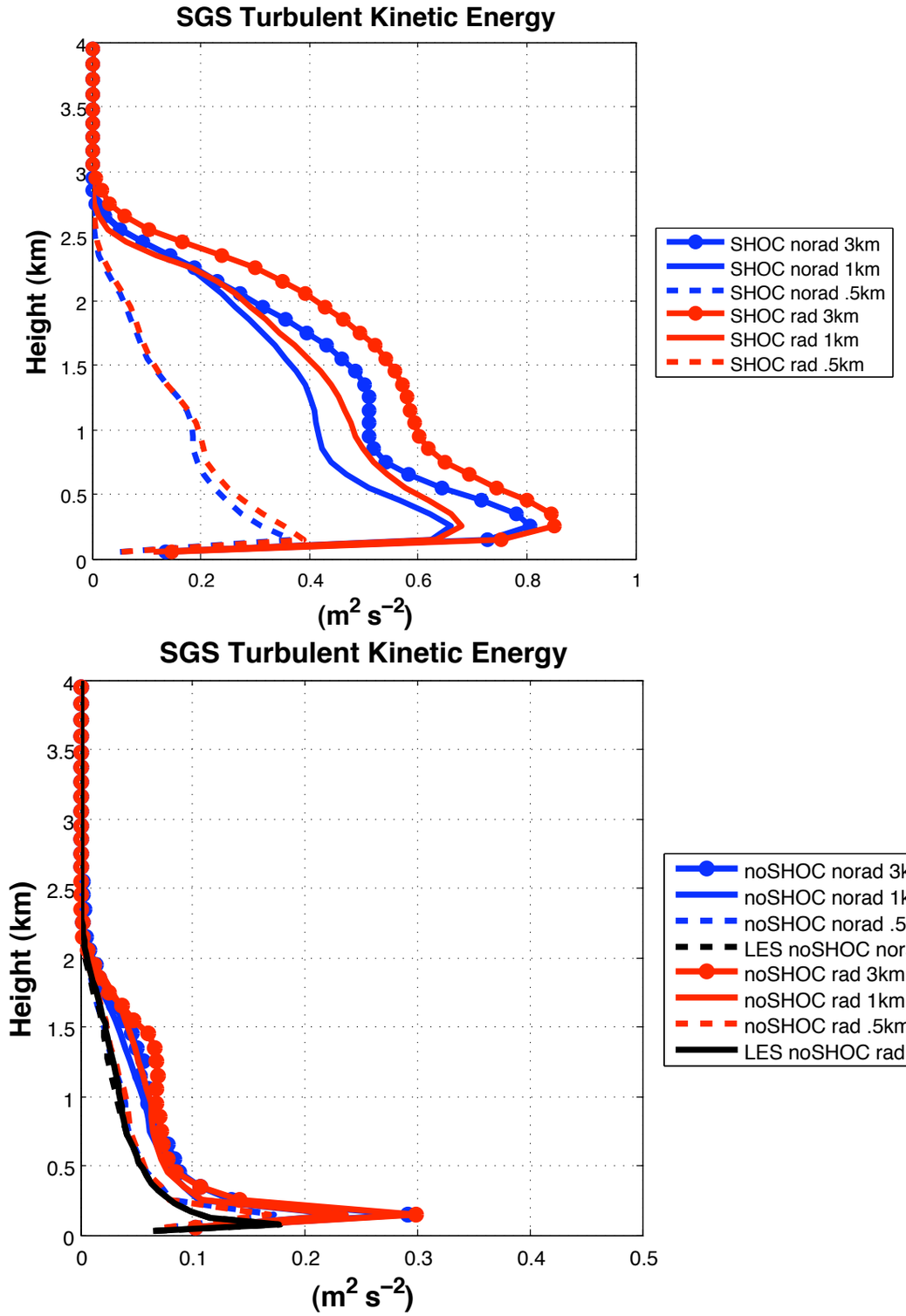
- Rad higher than norad.
- .5km lower than larger grids.
- SHOC and noSHOC similar for .5 and 1km.





Poster Plots - TKE SGS

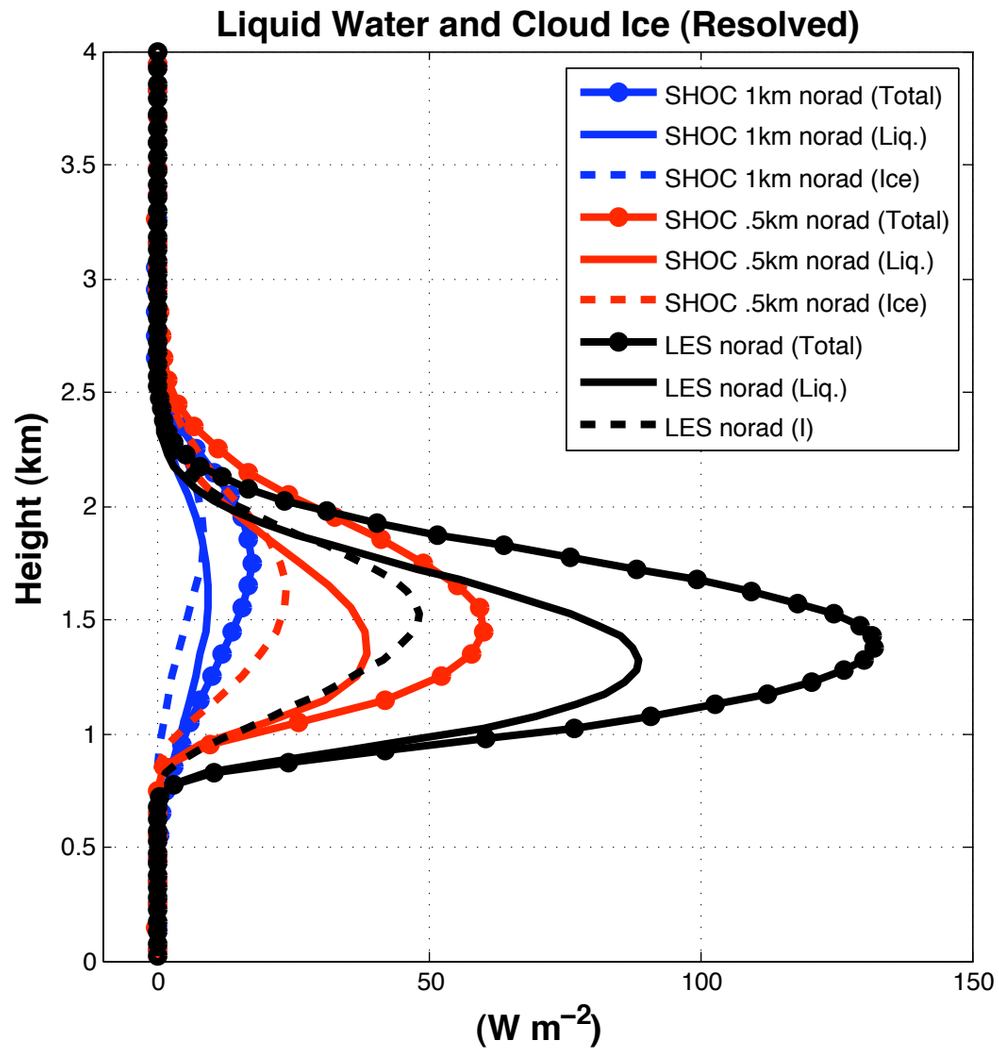
- SHOC much larger than noSHOC.
- Rad slightly higher than norad.
- Smaller grid spacing has lower SGS values.



QFlux Plots: QC QI QN

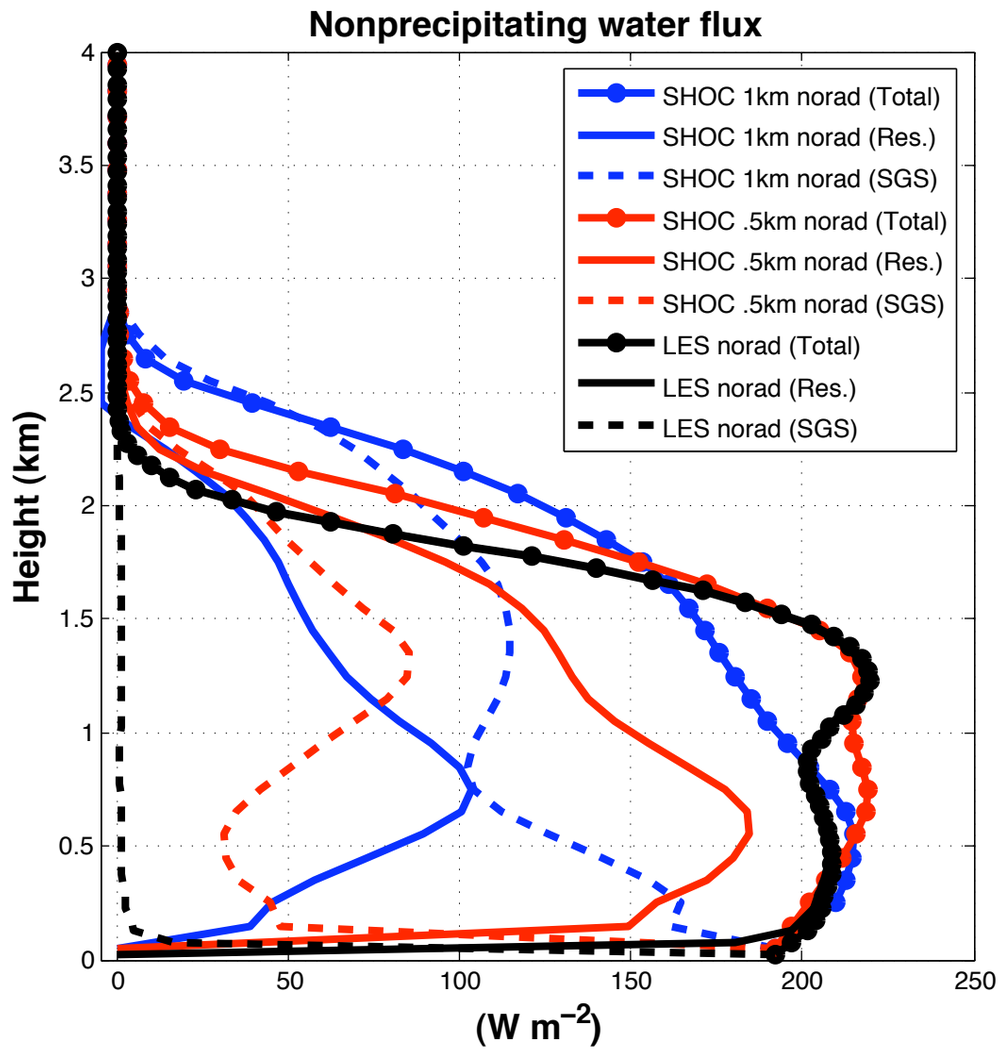
plots: http://home.chpc.utah.edu/~u0652833/SAM_constrain/q_plots/

- LES much higher than SHOC.
- .5km values much lower than larger grids.
- Liquid makes up most of the QN.



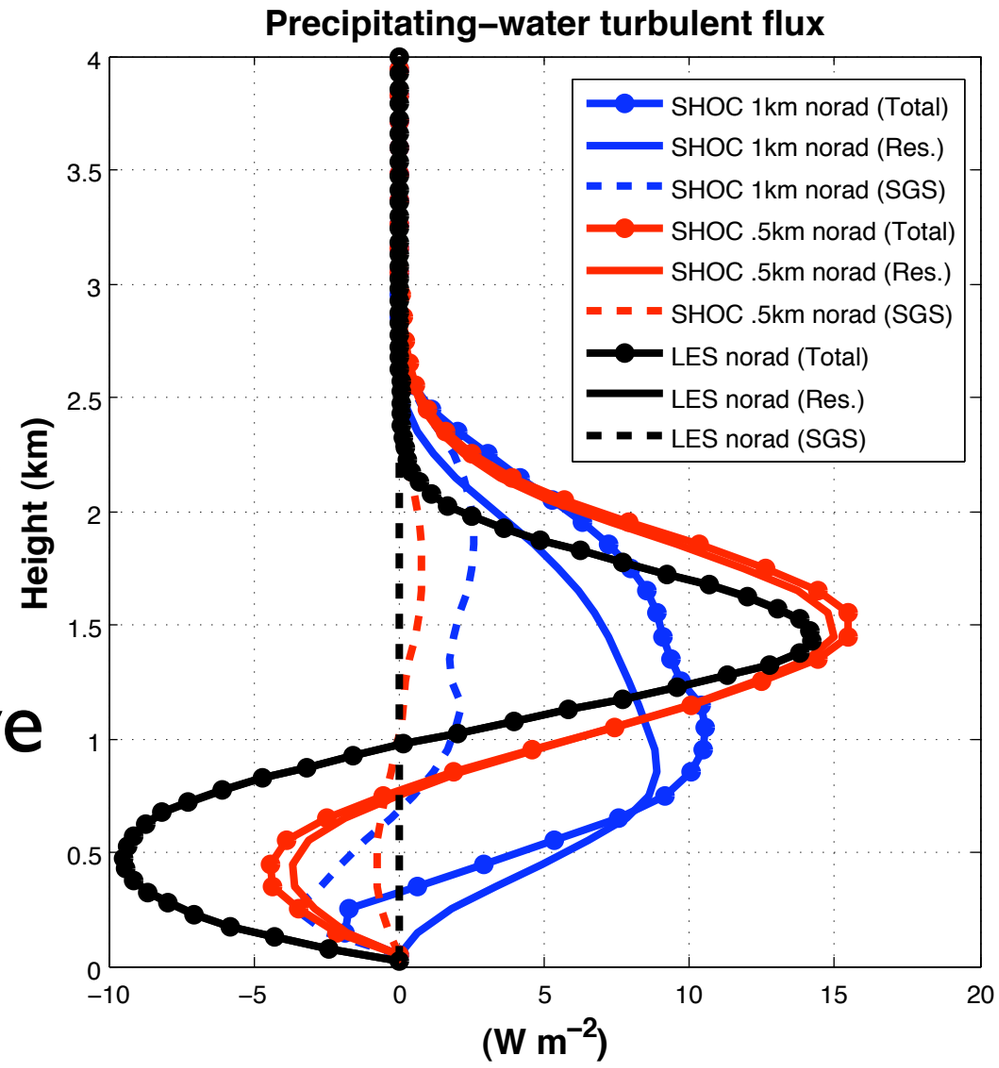
QFlux Plots: QT

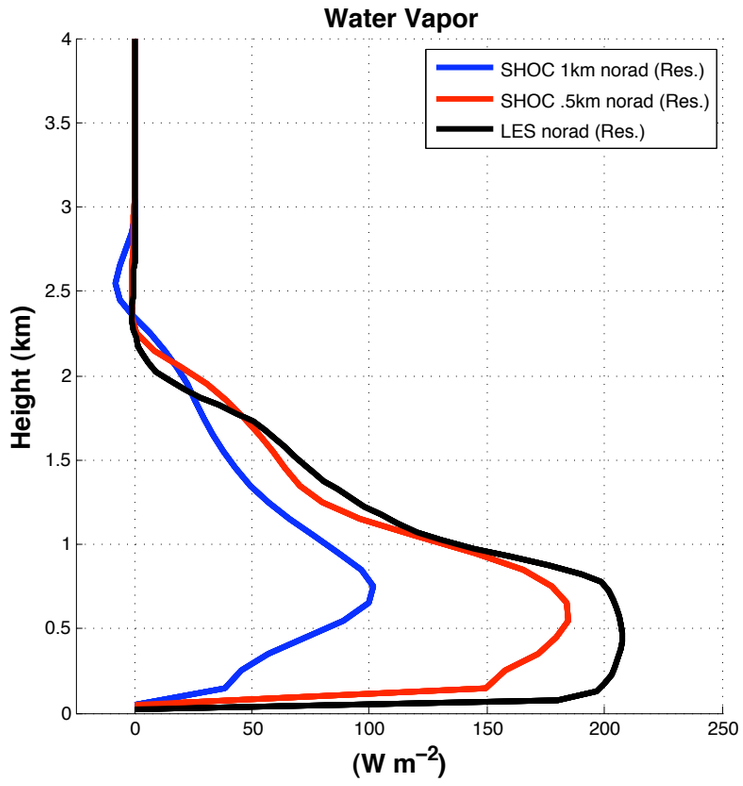
- Mostly resolved other than for 1km SHOC.
- Similar up to 1.75km then drops towards 0.
- .5km SHOC and LES close.



QFlux Plots: QP & QV

- QP mostly resolved
- .5km SHOC closer to LES
- Negative <1km, positive 1-2km.

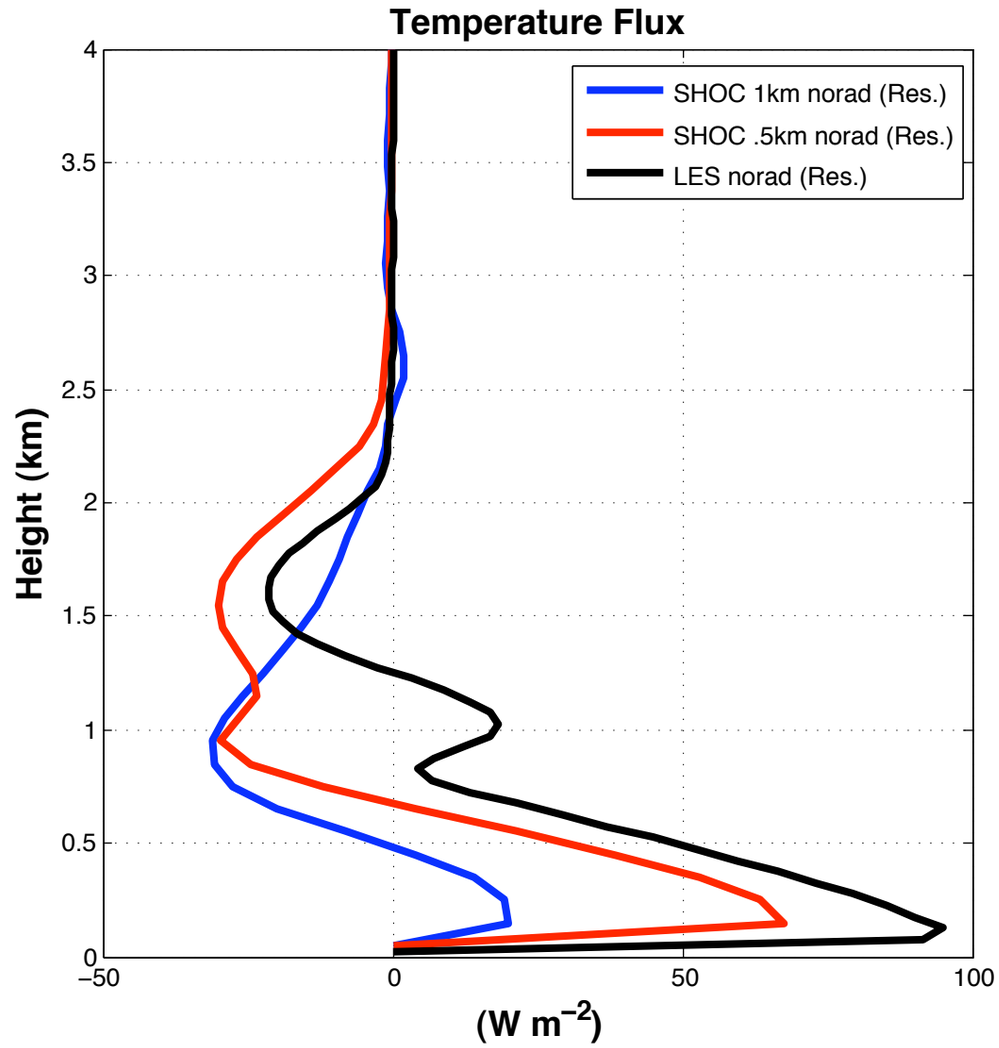




LES and SHOC .5km close. Peak QV around .5-1km.

QFlux Plots: Temp. Flux

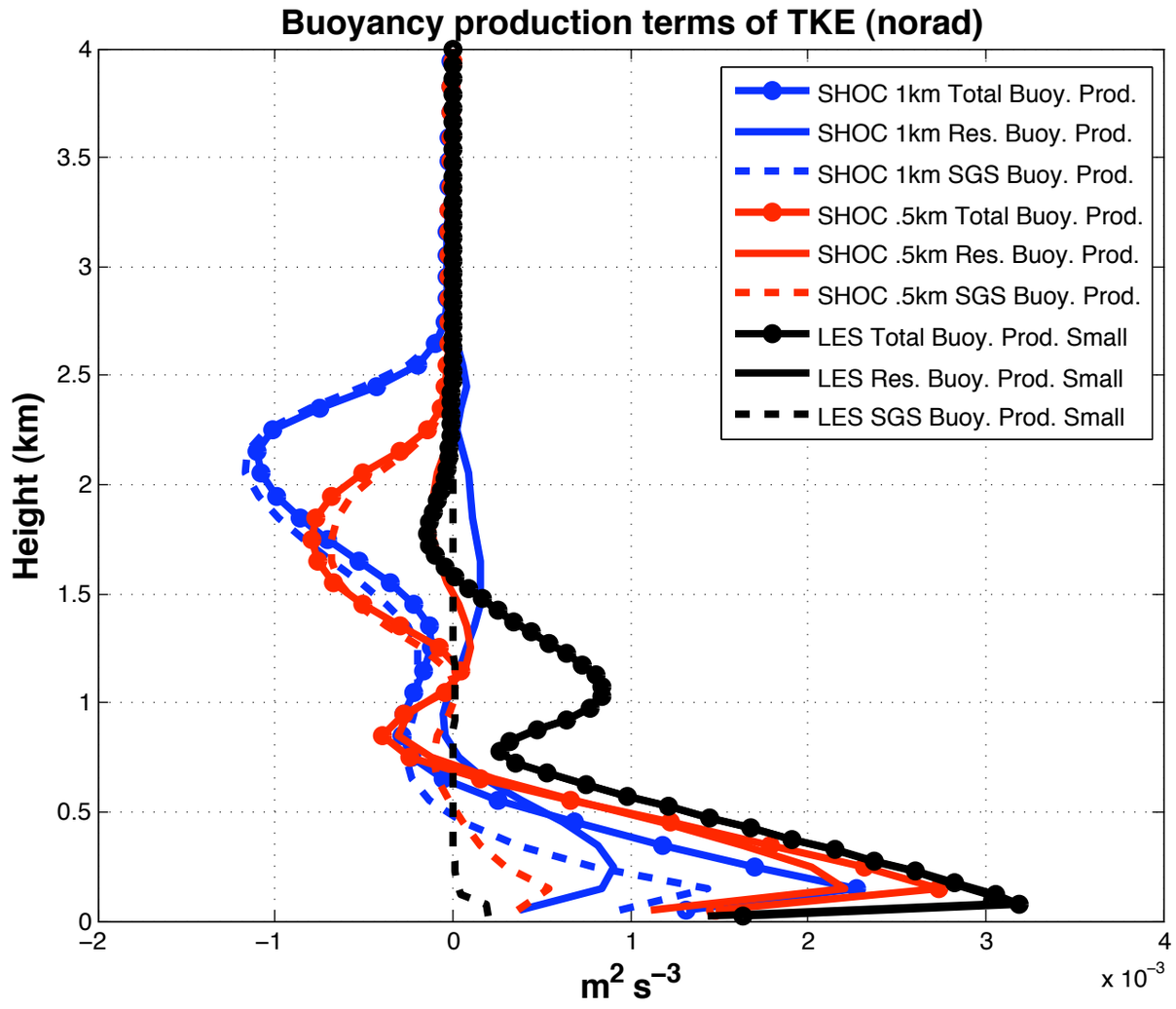
- LES more positive than SHOC.
- Peak around .2km.
- Negative from 1.5-2km.
- (TLFLUX - TLFLUXS) + QCFLUX - (QPFLUX - QPFLUXS) + QIFLUX



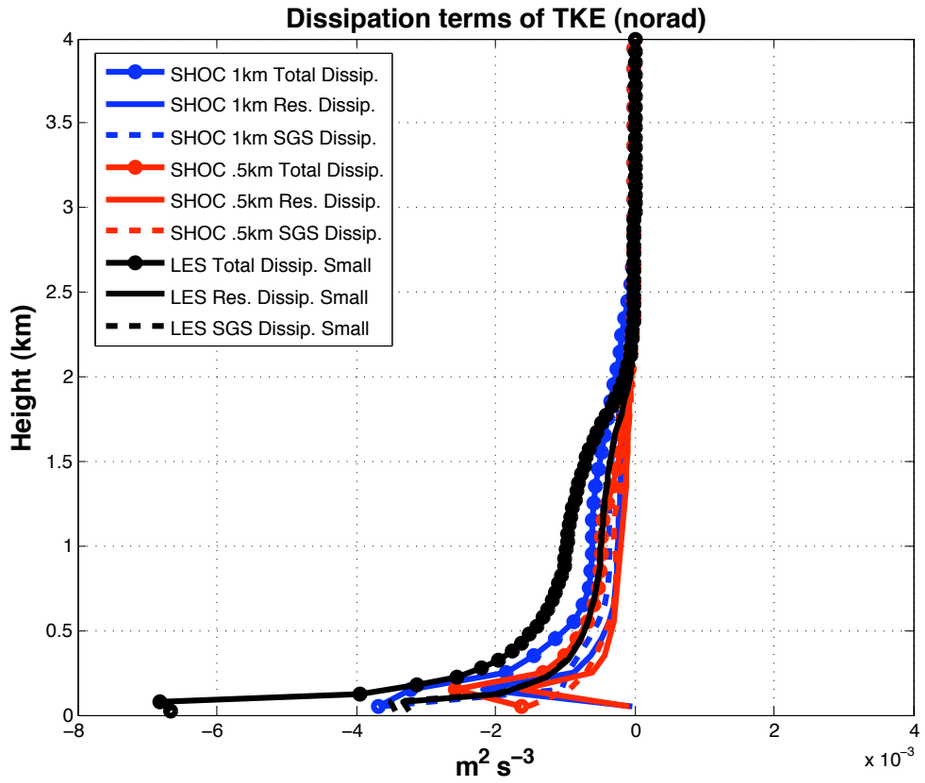
TKE Term Plots - Buoyancy

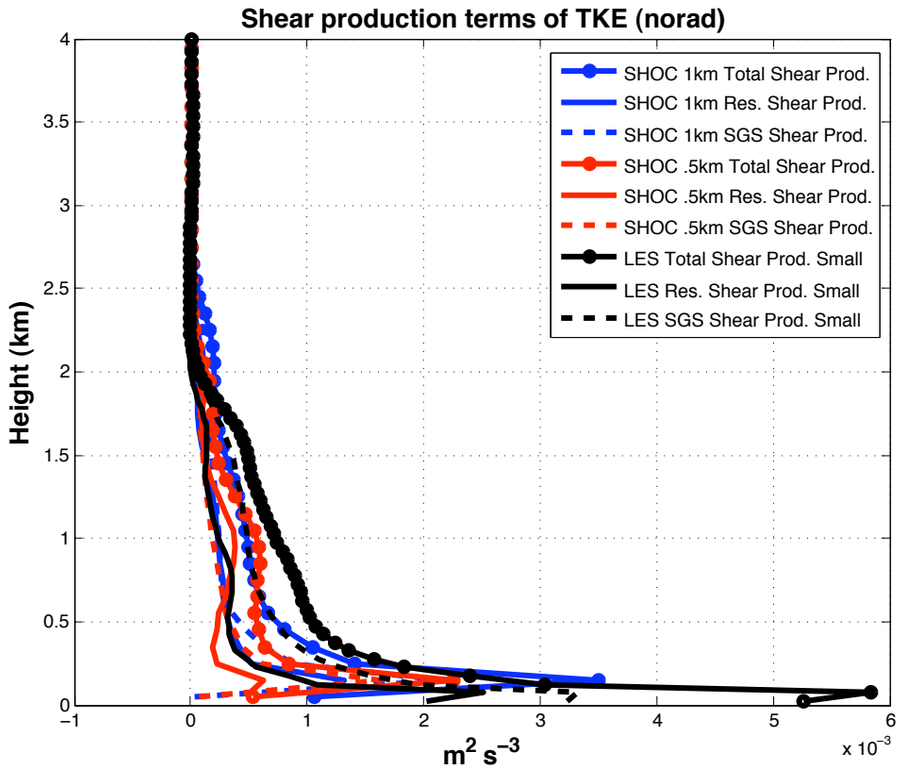
plots: http://home.chpc.utah.edu/~u0652833/SAM_constrain/TKEterm_plots/

- LES higher than SHOC, more positive.
- Resolved is primary component for .5km and LES.
- Peak at low elevation.



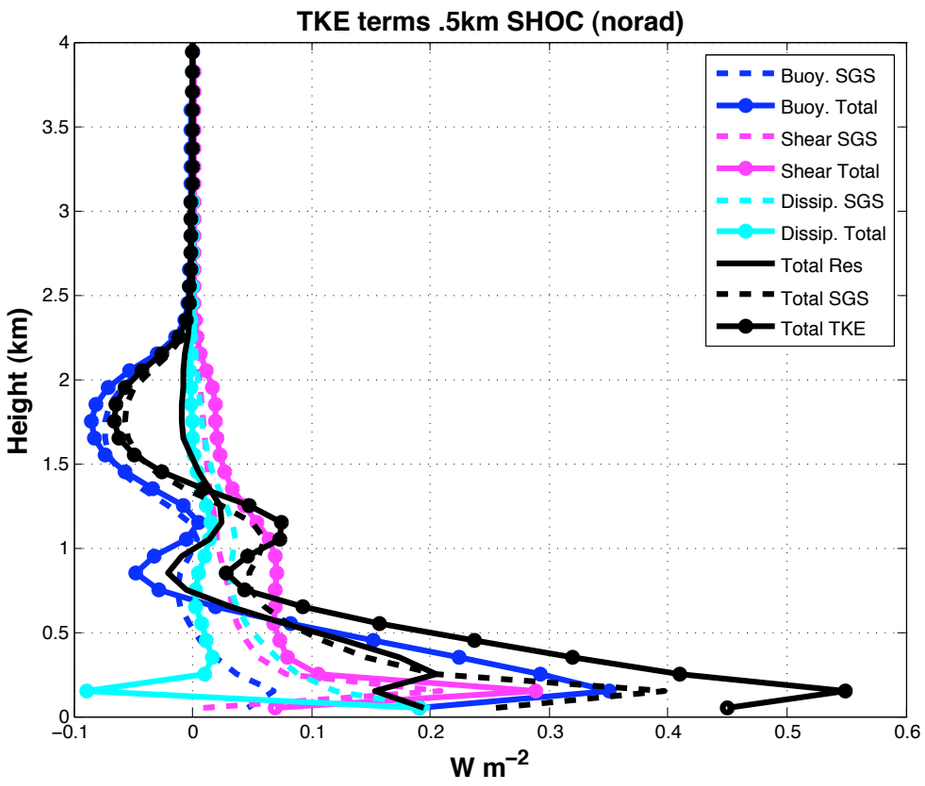
TKE Term Plots - Shear & Dissipation

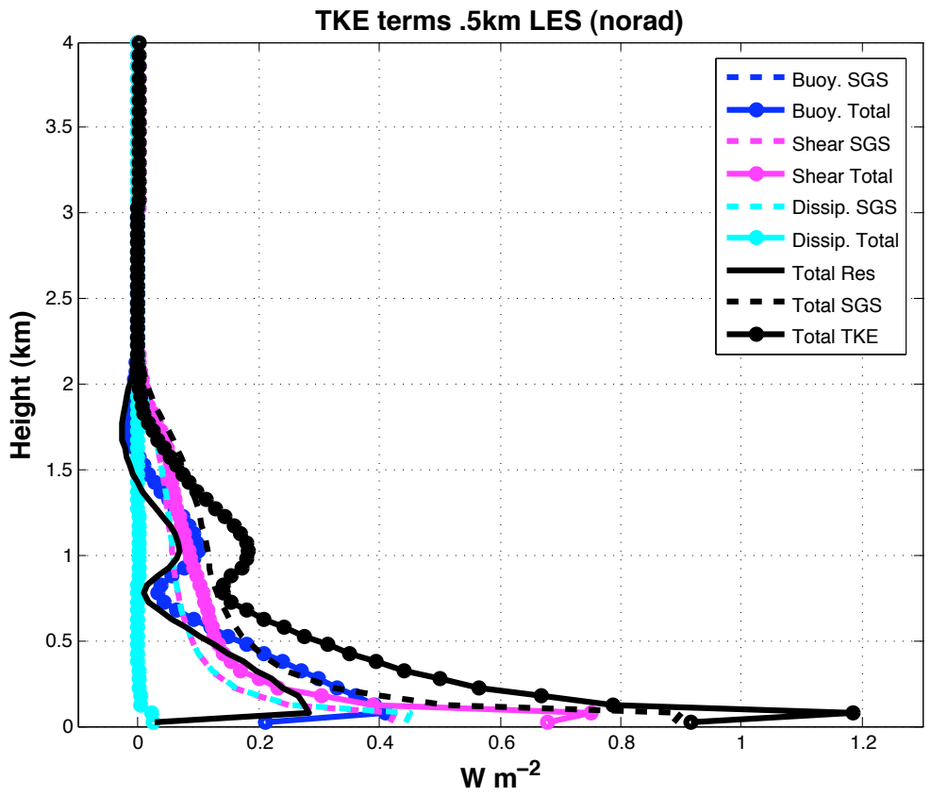




- Shear and dissip terms opposite sign.
- Shear slightly larger.
- LES terms larger.

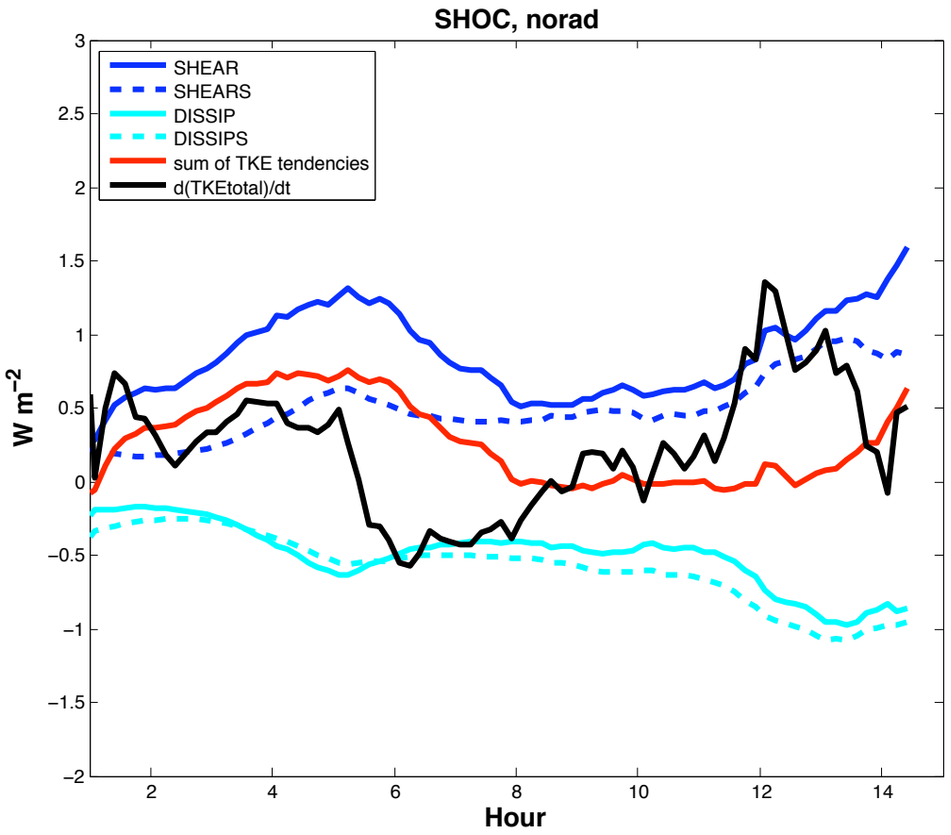
TKE Term Plots - Total

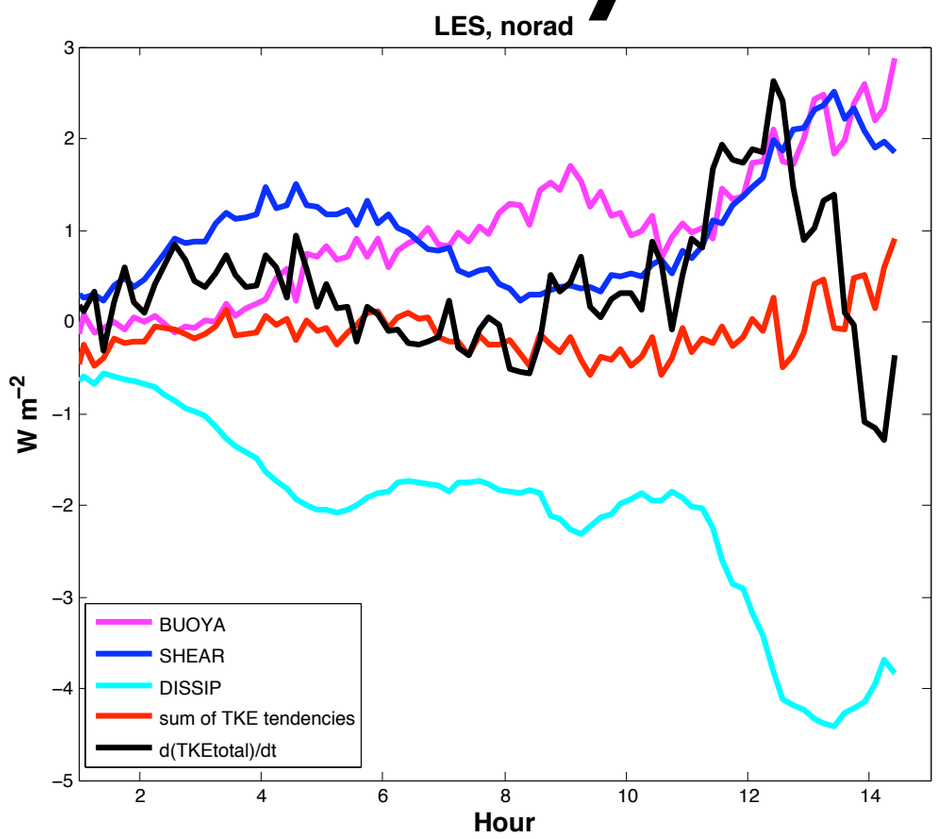




- NOTE: I need to flip the dissip term on these plots.

TKE Term Plots - dTKE/dt vs TKEtendency





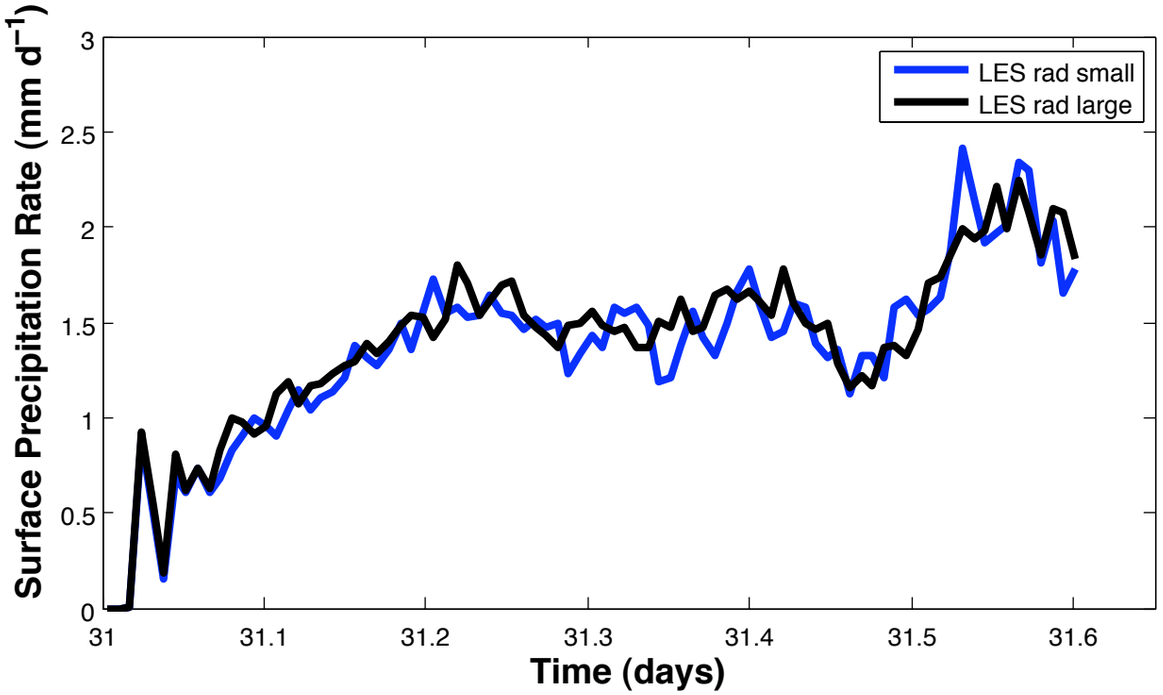
- SHOC closer to 0
- vertically integrated total (dTKEtotal/dt)
- sum of vert. int. shear, dissip, buoyancy.

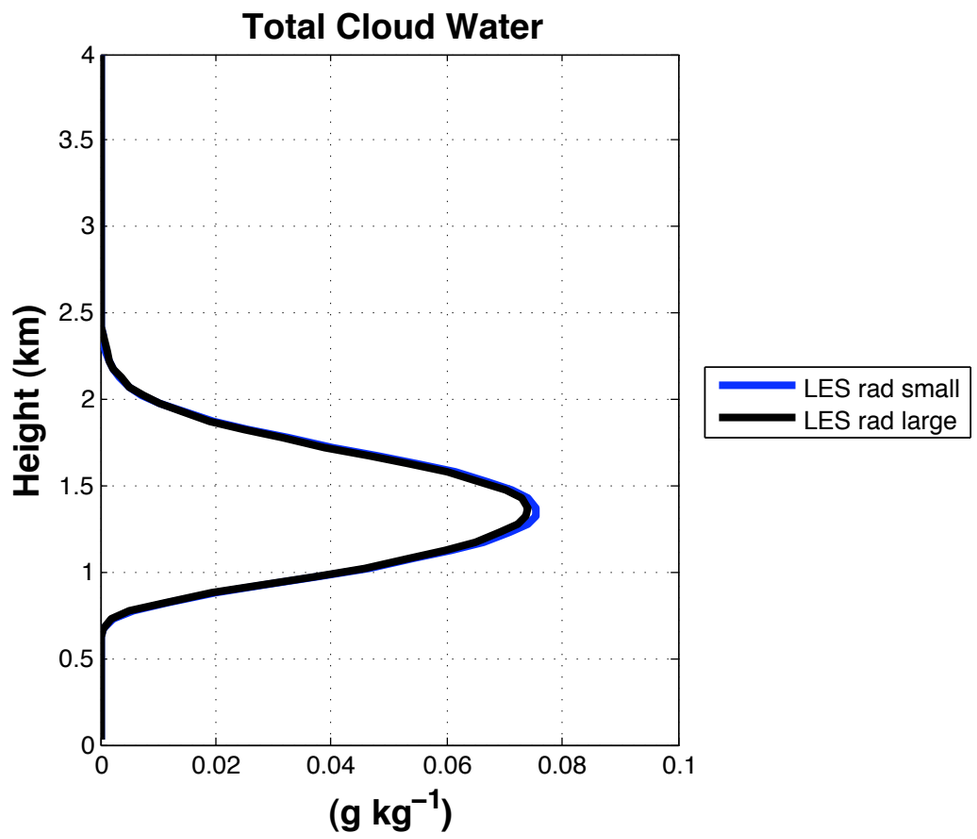
Varied Grid Size Plots

http://home.chpc.utah.edu/~u0652833/SAM_constrain/LESgridcompareplots_805v805b/

- This looks at 805 vs 805b.
- LES 100m noSHOC runs with radiation.
- Only difference is one grid (805b) is twice as large.

Varied Grid Size Plots





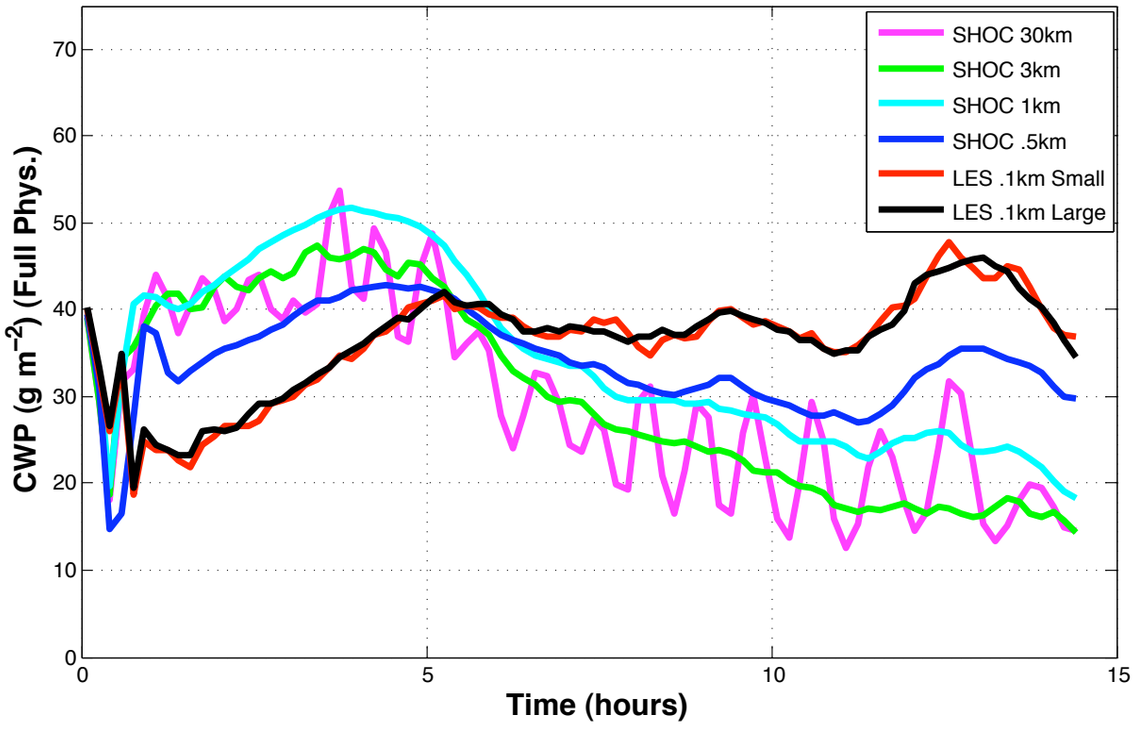
- Hourly averages smooth everything out. The only signals come from variables that aren't hourly averaged (like surface precip rate).

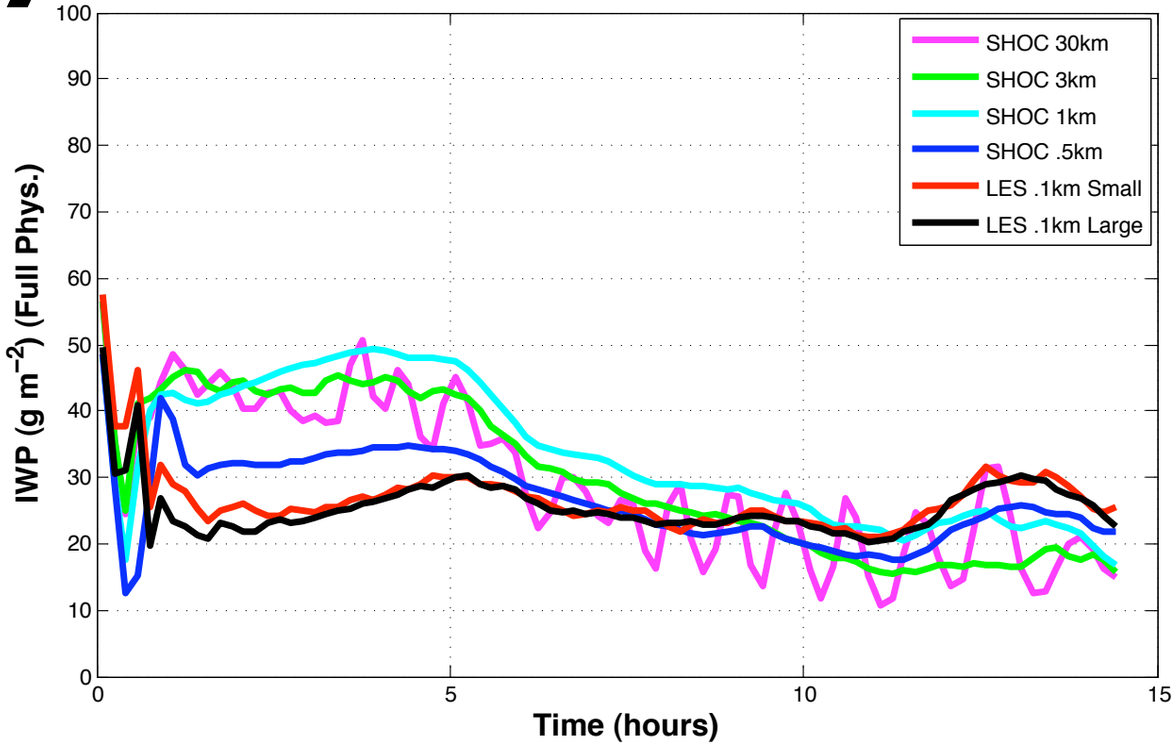
Full Physics Plots

http://home.chpc.utah.edu/~u0652833/SAM_constrain/full_physics_series/

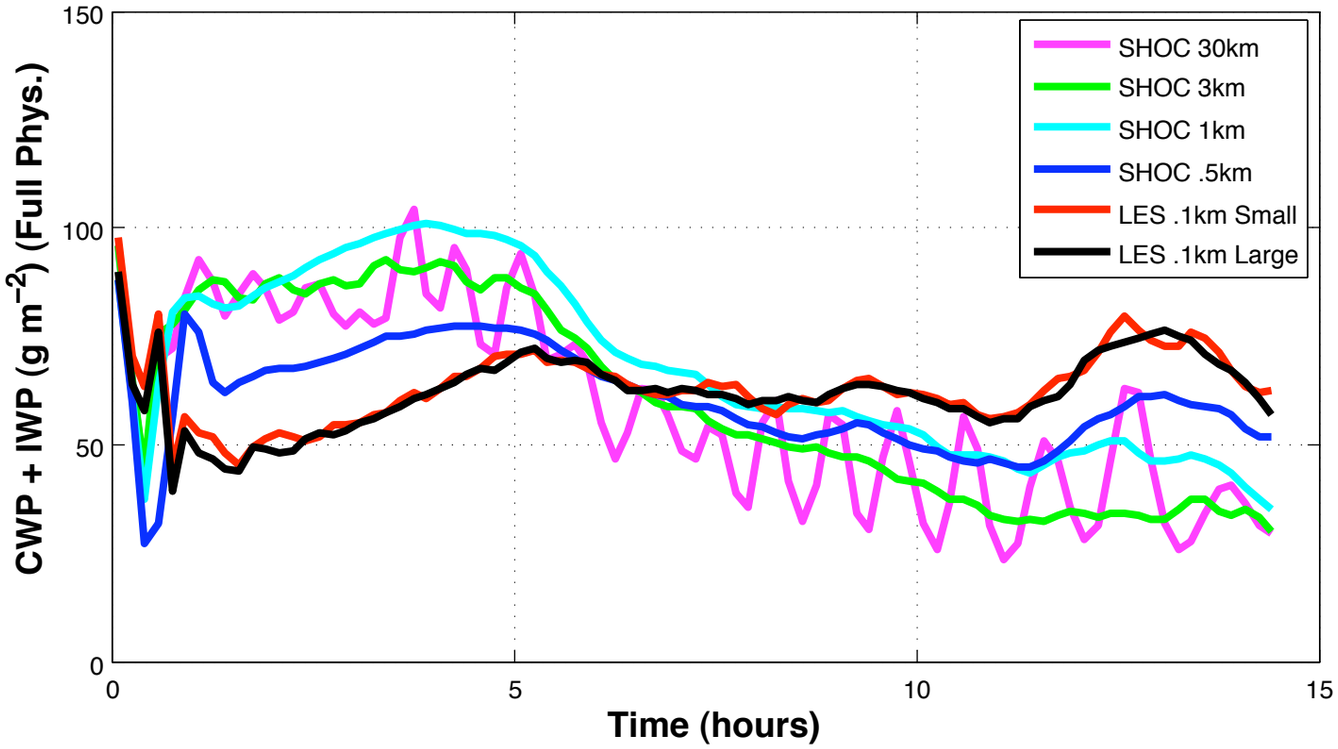
- These are basically a different format of organizing the poster plots results.
- All later datasets are compared relative to this set, with only the significant differences highlighted.
- Runs are 601 602 603a 604 805 805b

Full Physics

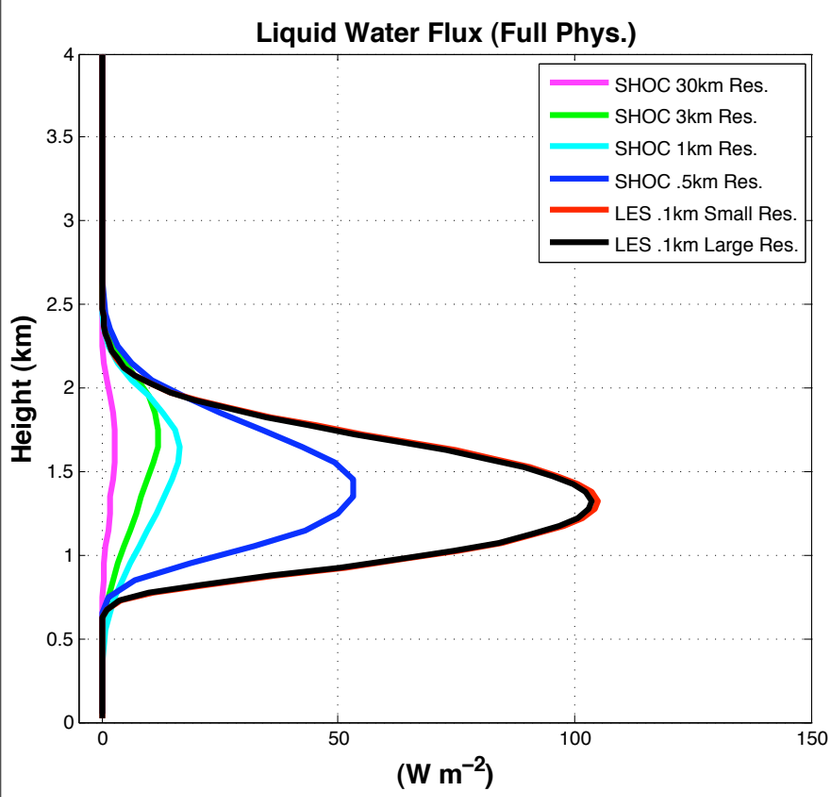


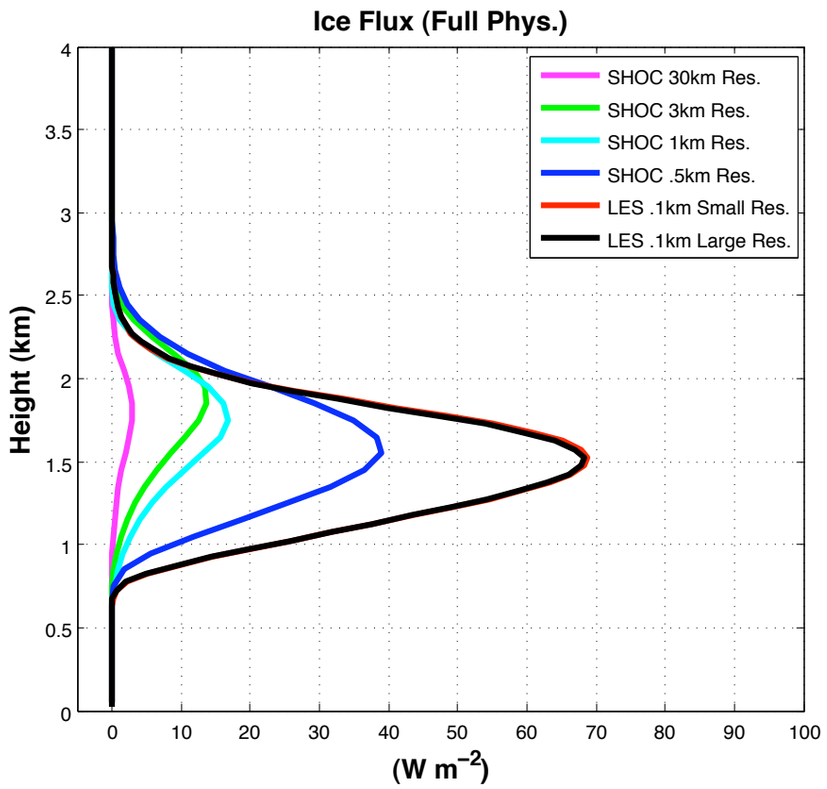


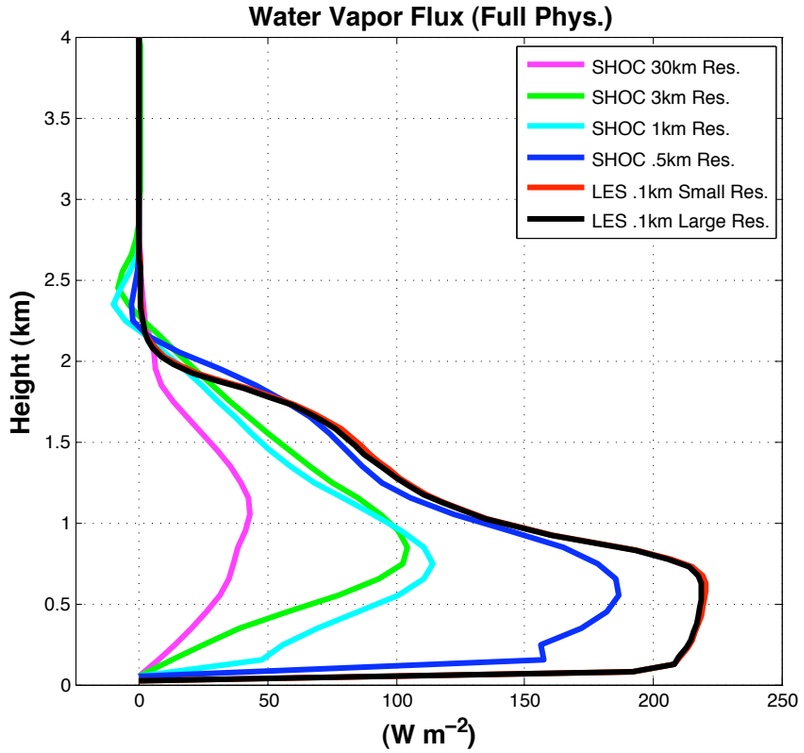
- LES starts lower, ends higher than SHOC.
- SHOC IWP and CWP decreases over time though steady-ish for .5km



Full Physics

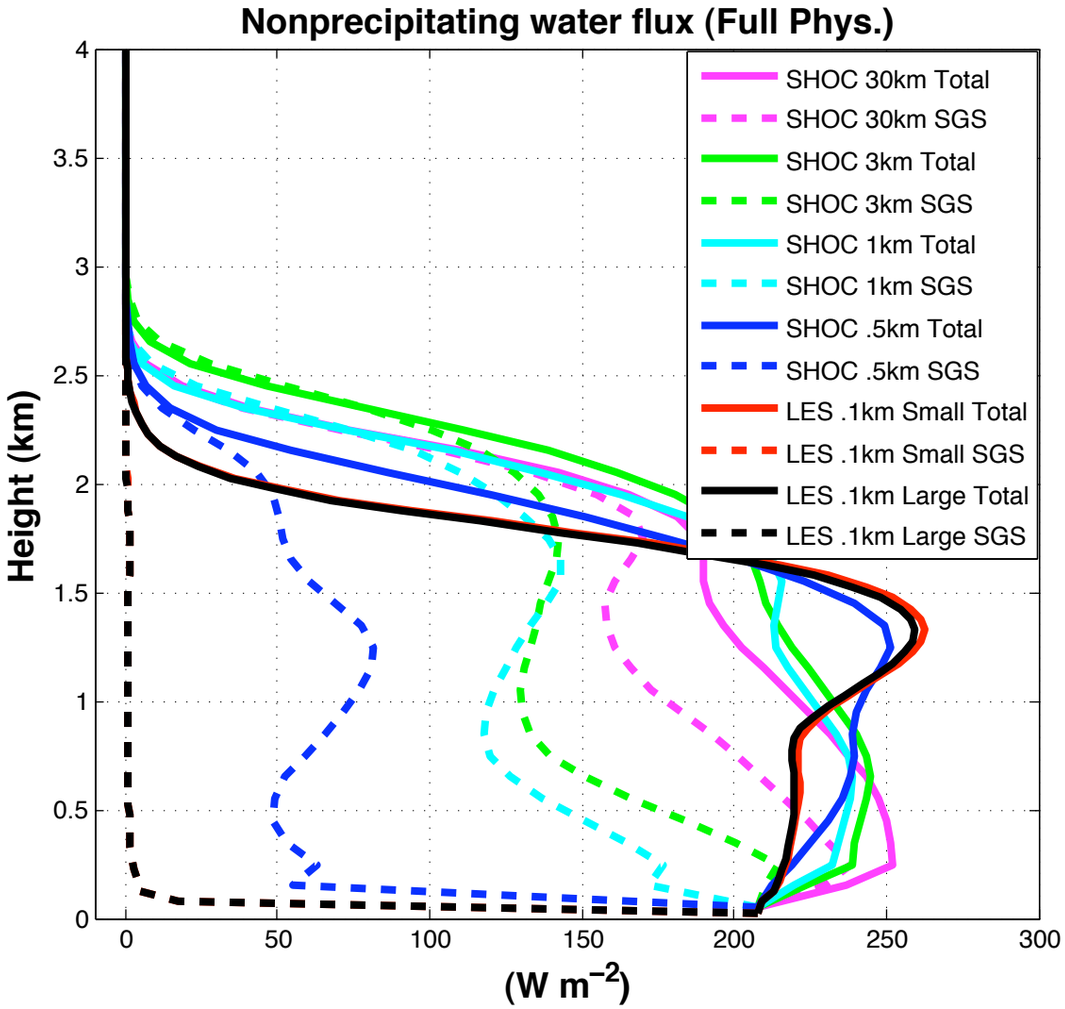


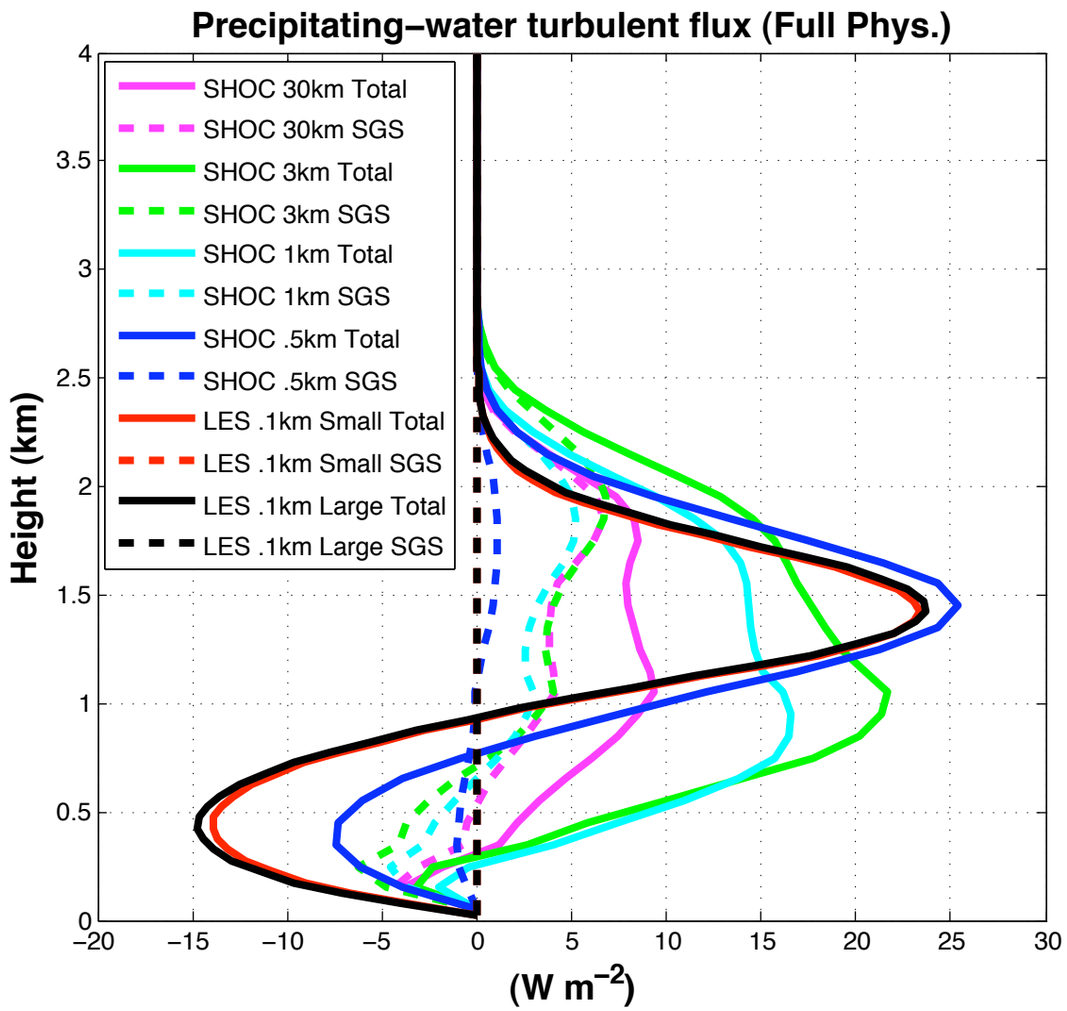




- High res. SHOC closer to LES but still underestimates QCL and QI.
- Altitude of low-res SHOC runs higher than LES.
- Water vapor maximum lower in altitude.

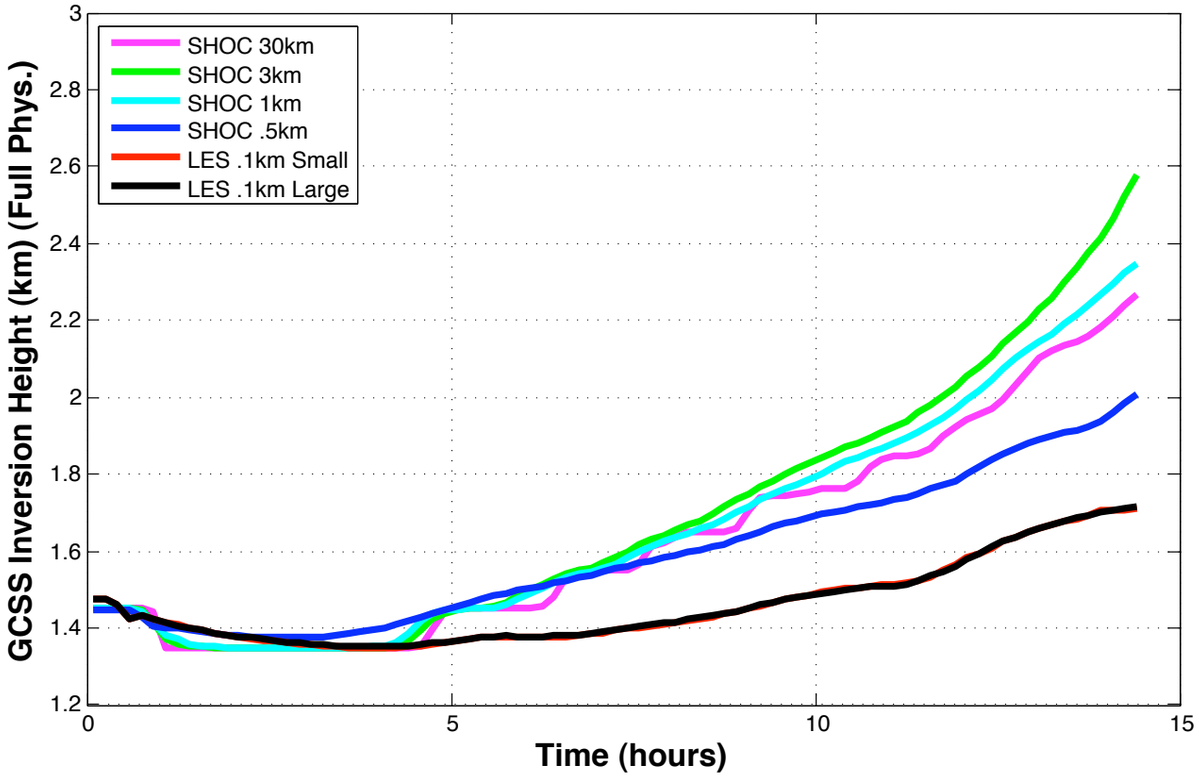
Full Physics

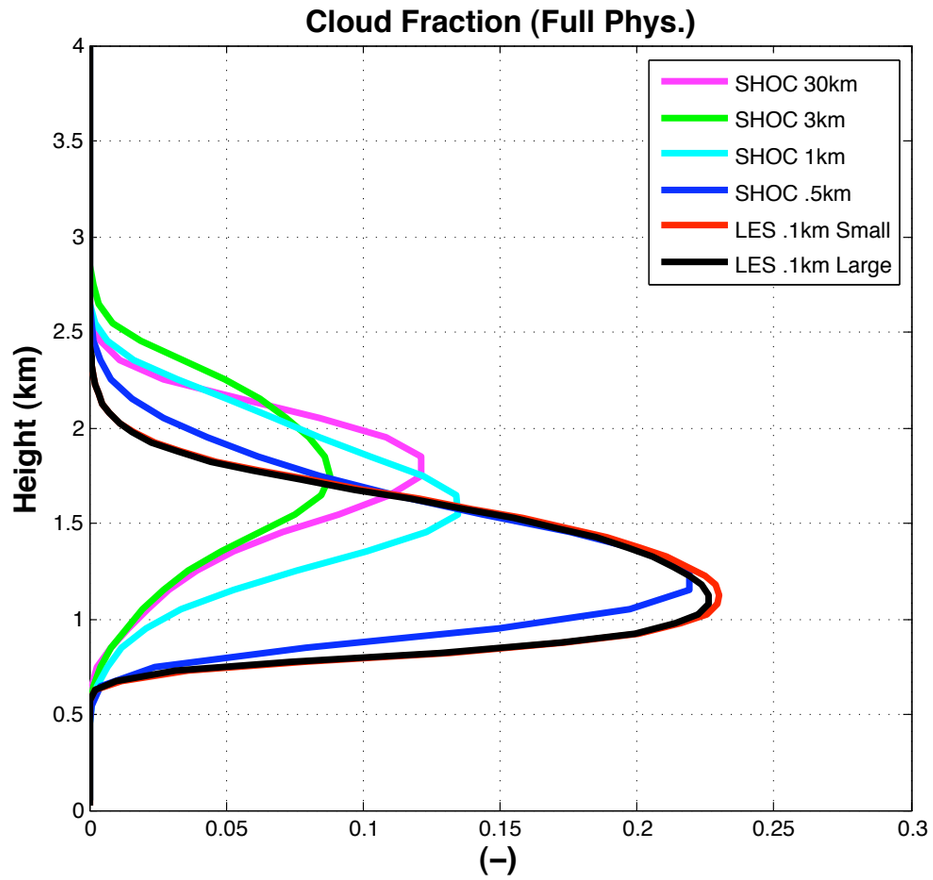


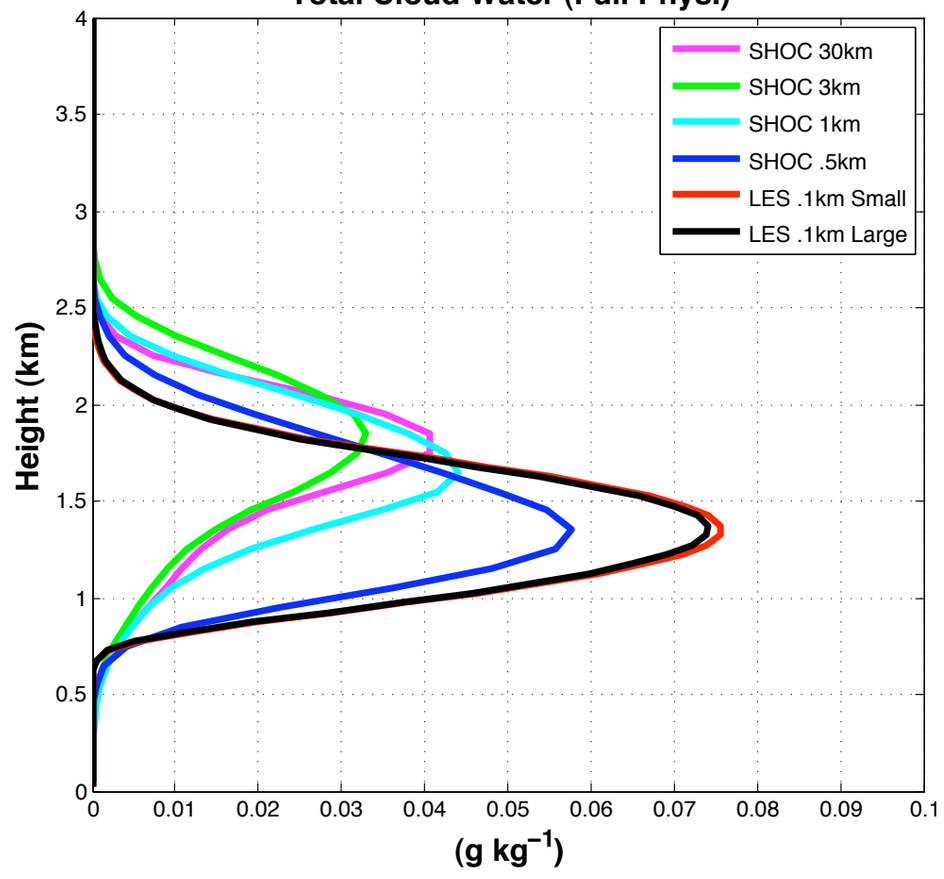


- QT is high up through cloud layer, decreases towards 0 above.
- QP negative near surface, positive above. LES a smoother double curve.

Full Physics

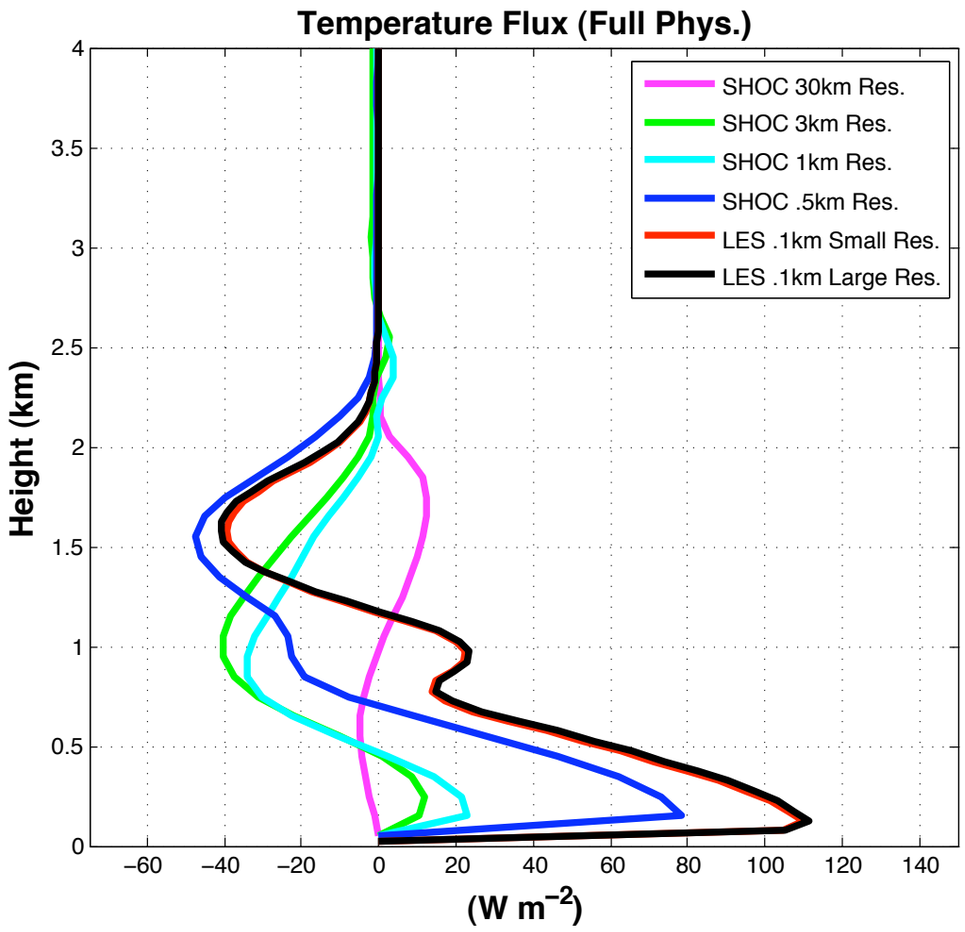


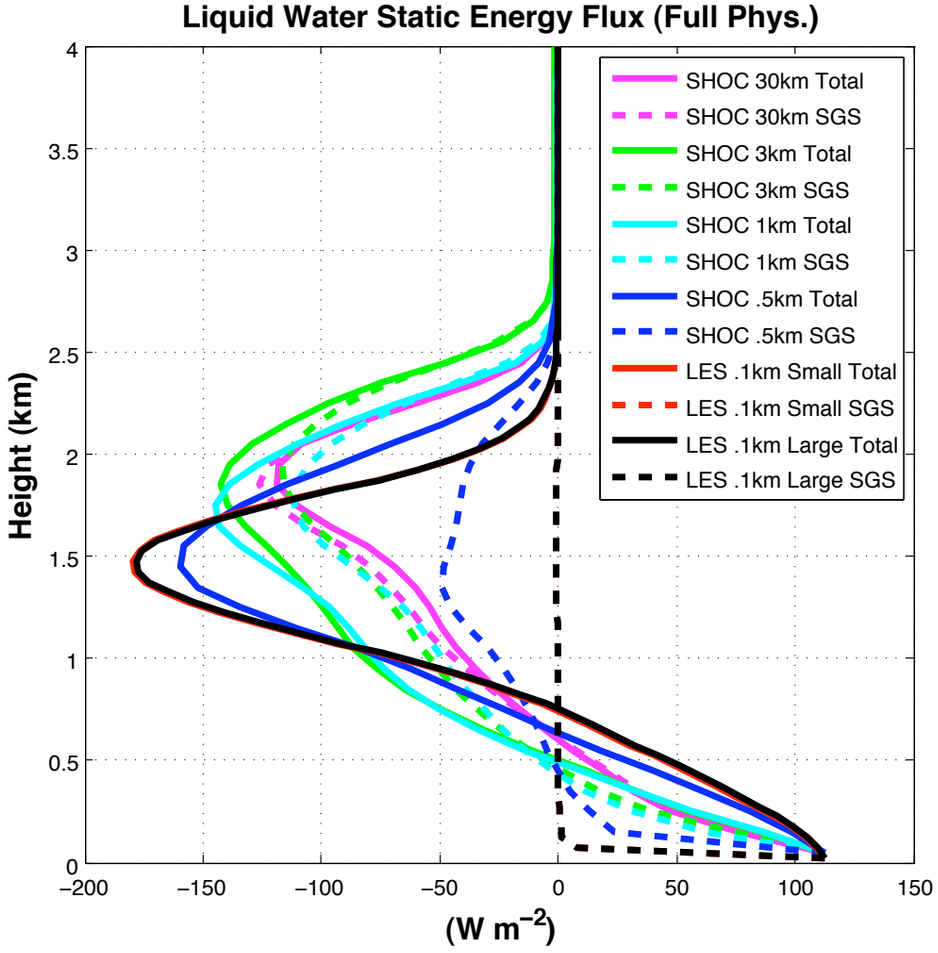




- Inversion height higher for low-res SHOC, lowest for LES.
- Cloud fraction and total cloud water are in sync.
- LES is lower in altitude and larger in magnitude than SHOC (except .5km).

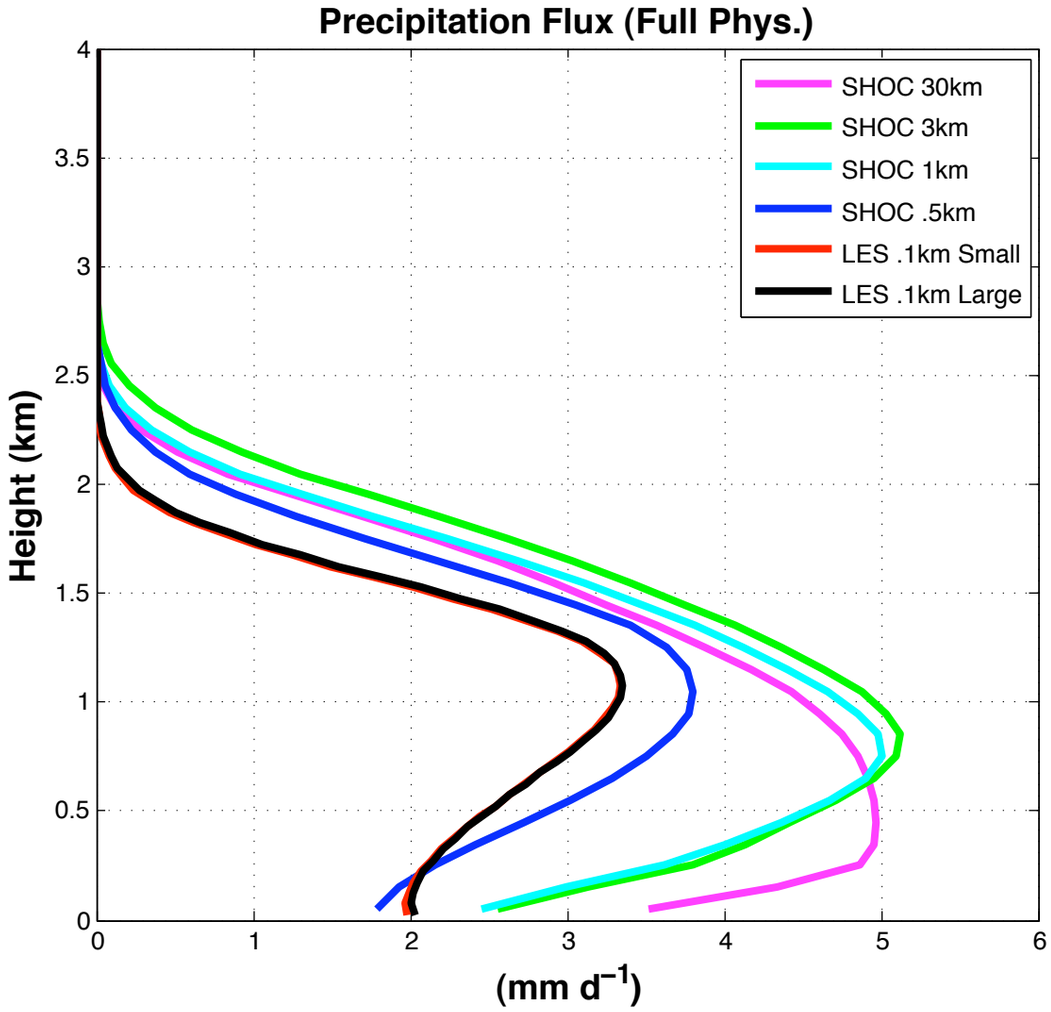
Full Physics

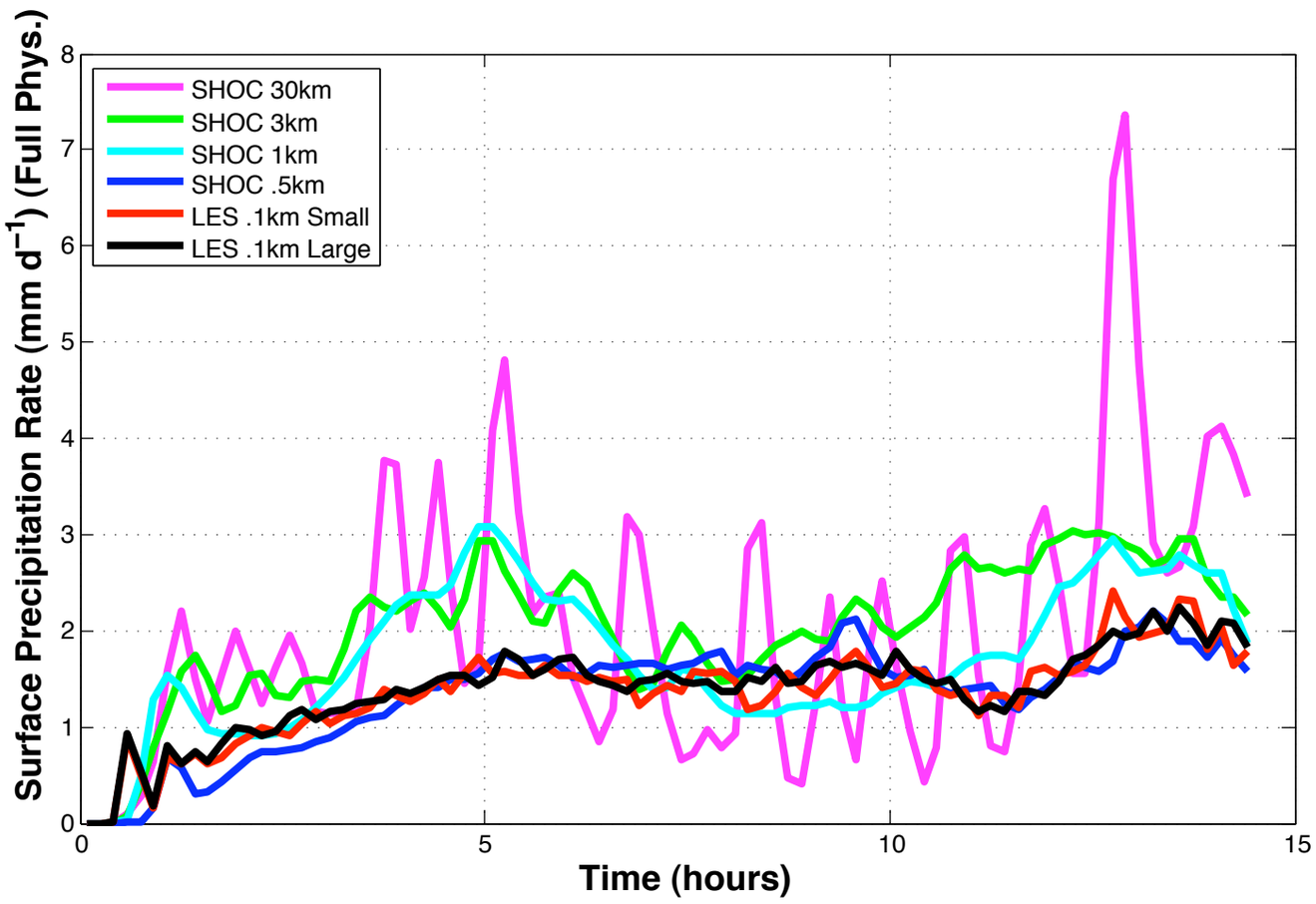




- Temp flux similar in shape to buoyancy except LES goes negative around 1.5km.
- LWSE flux lower in altitude and larger in magnitude for LES, similar to clouds.

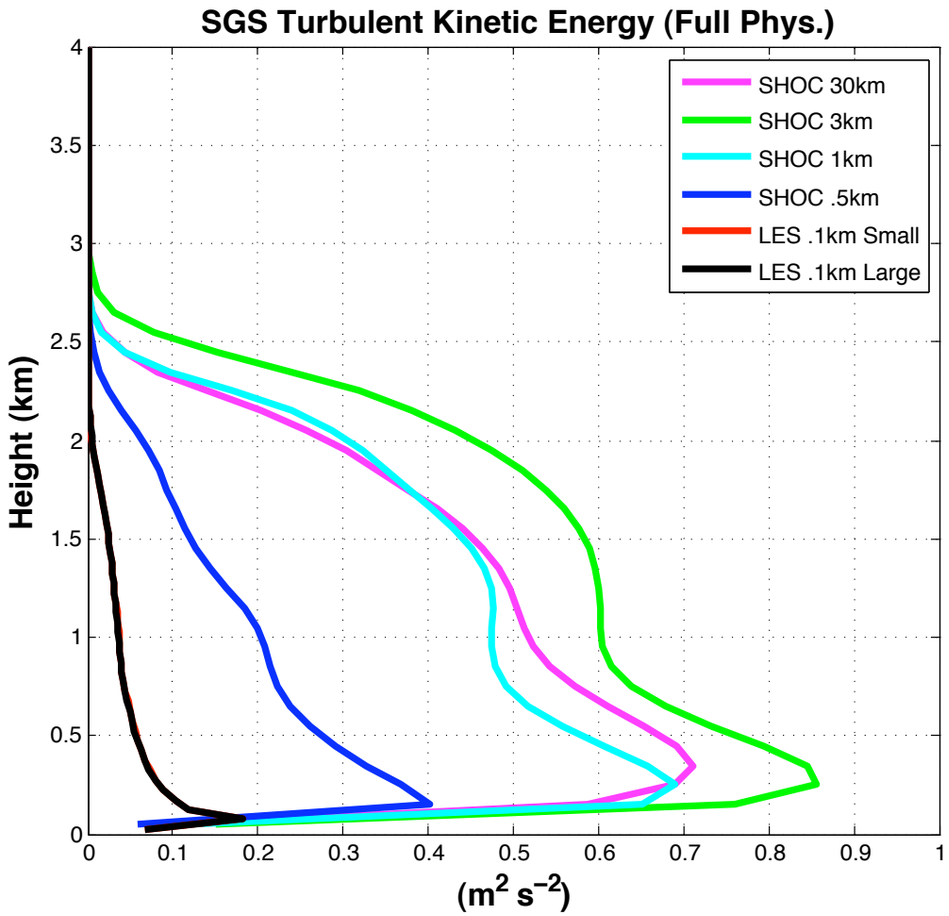
Full Physics

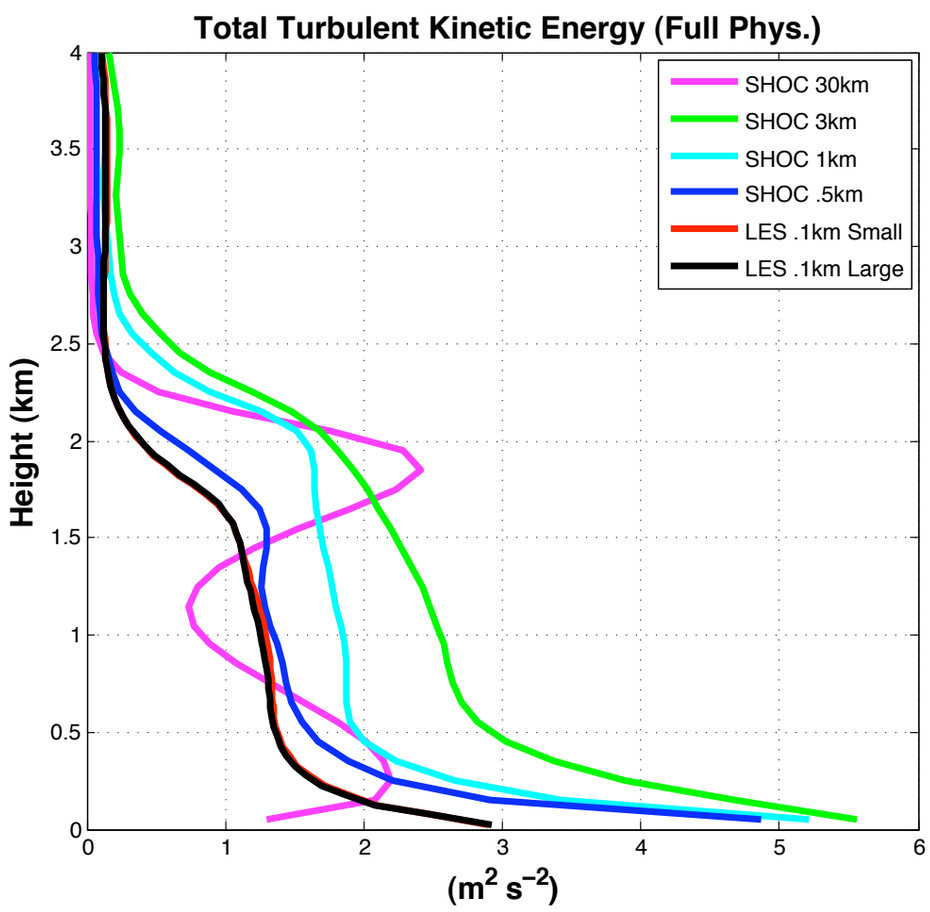




- LES has higher altitude and lower magnitude precip flux.
- The precip rate is similar for .5km SHOC and LES.
- Decreasing resolution increases the volatility.

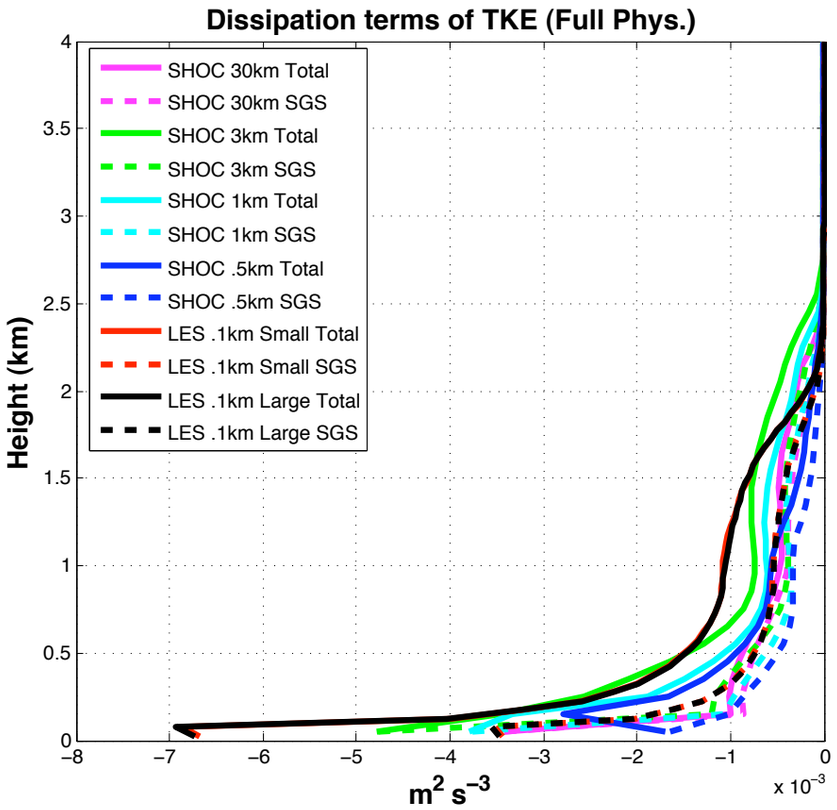
Full Physics

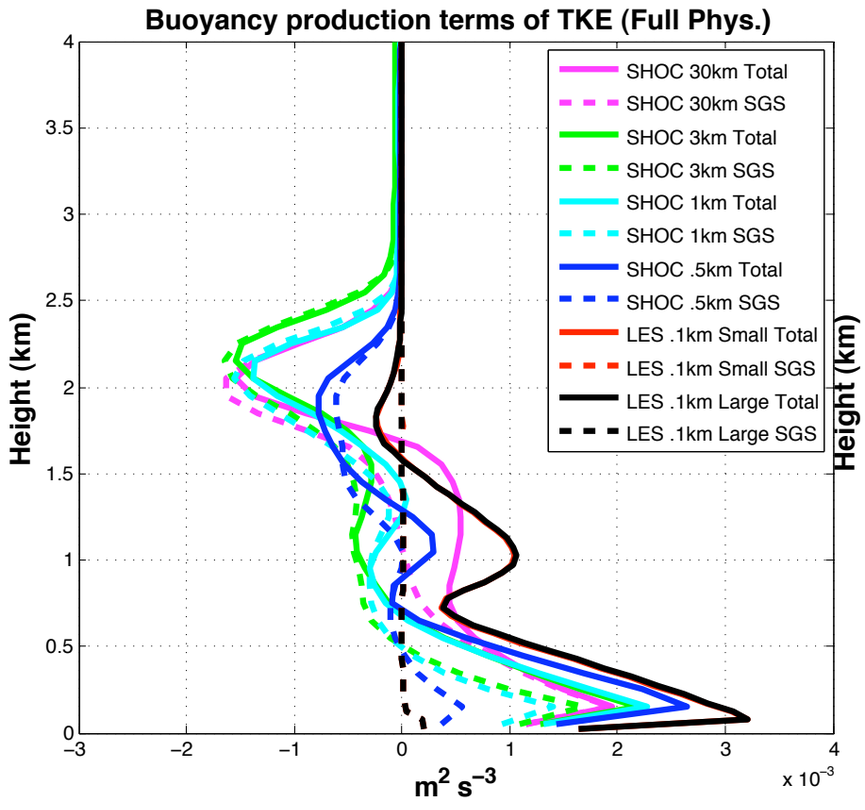


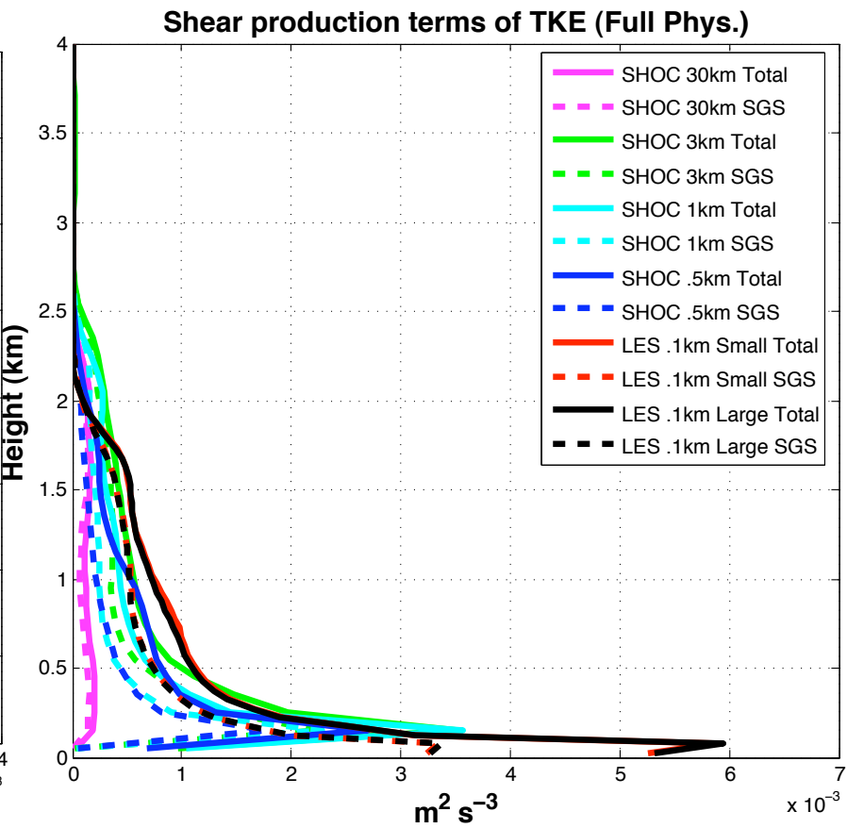


- SGS TKE much larger for SHOC than LES.
- Peak SGS TKE ~.2-.4km
- Total TKE close for high-res SHOC and LES. Low-res SHOC has higher total TKE.

Full Physics







- Shear and dissipation ~ mirrored, LES values larger than SHOC.
- Buoyancy has a positive bump near cloud level. LES more positive than SHOC.

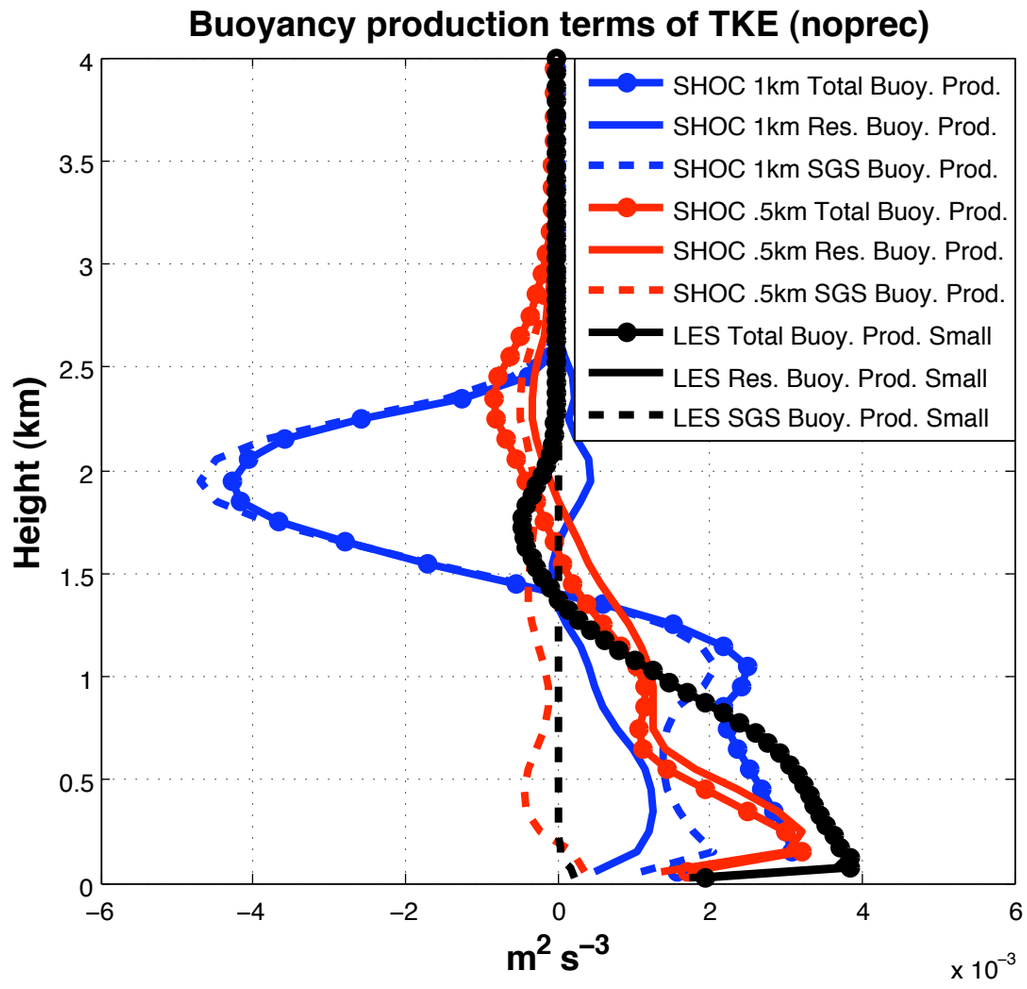
No Precip Plots

http://home.chpc.utah.edu/~u0652833/SAM_constrain/noprecip_series/

- Runs 603, 602b, 805a.
- 602b is SHOC 1km rad nopcp.
- 603 is .5km SHOC rad nopcp.
- 805a is LES 100m rad nopcp.
- Notable differences on following slides.

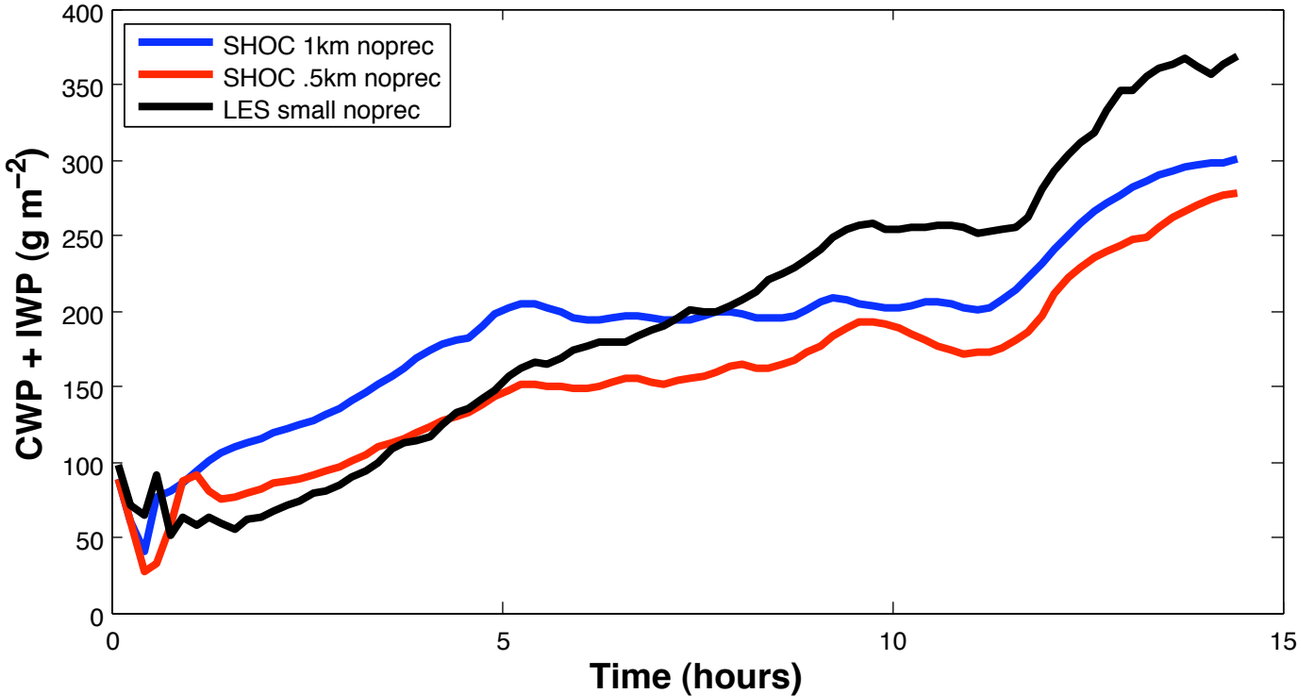
No-precip Plots

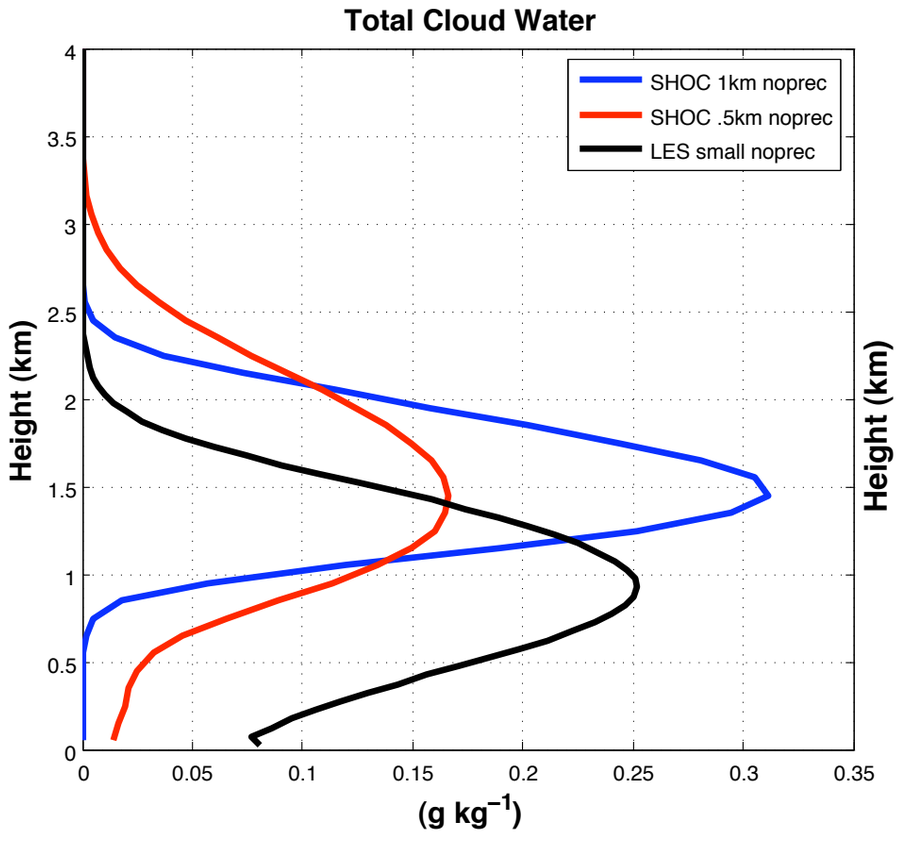
- Positive bump around cloud deck, 1.25km for SHOC, but .5km for LES.
- More negative values at 2km in HSOC 1km.

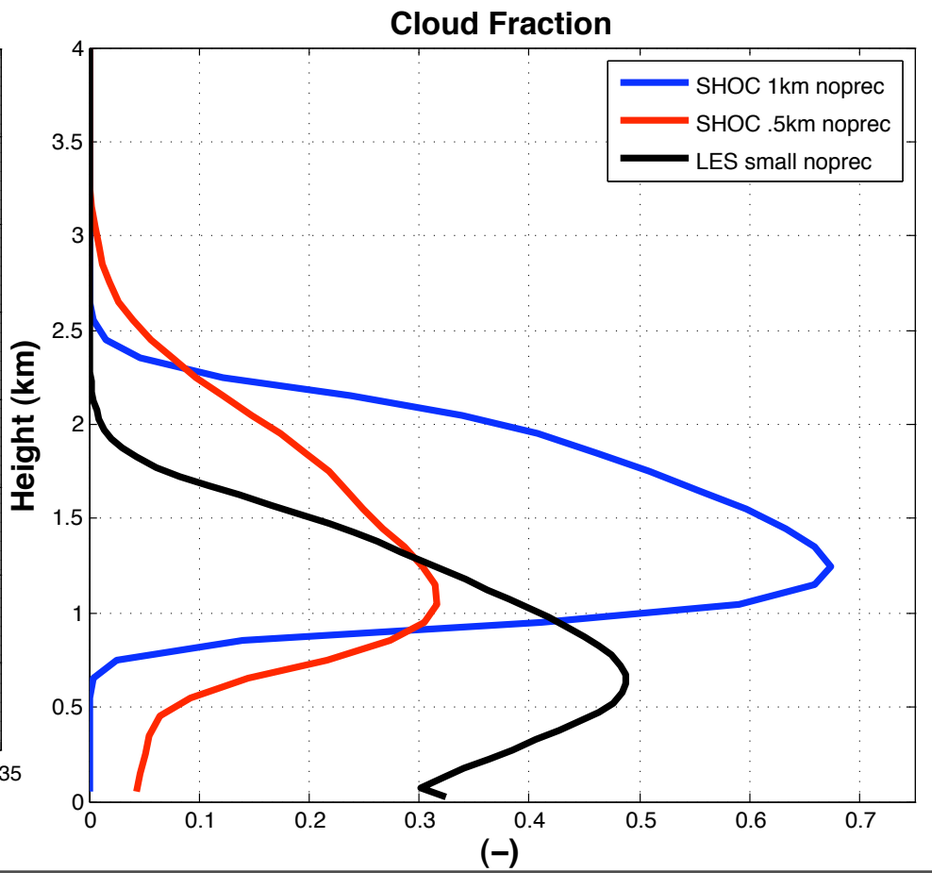


No-precip Plots

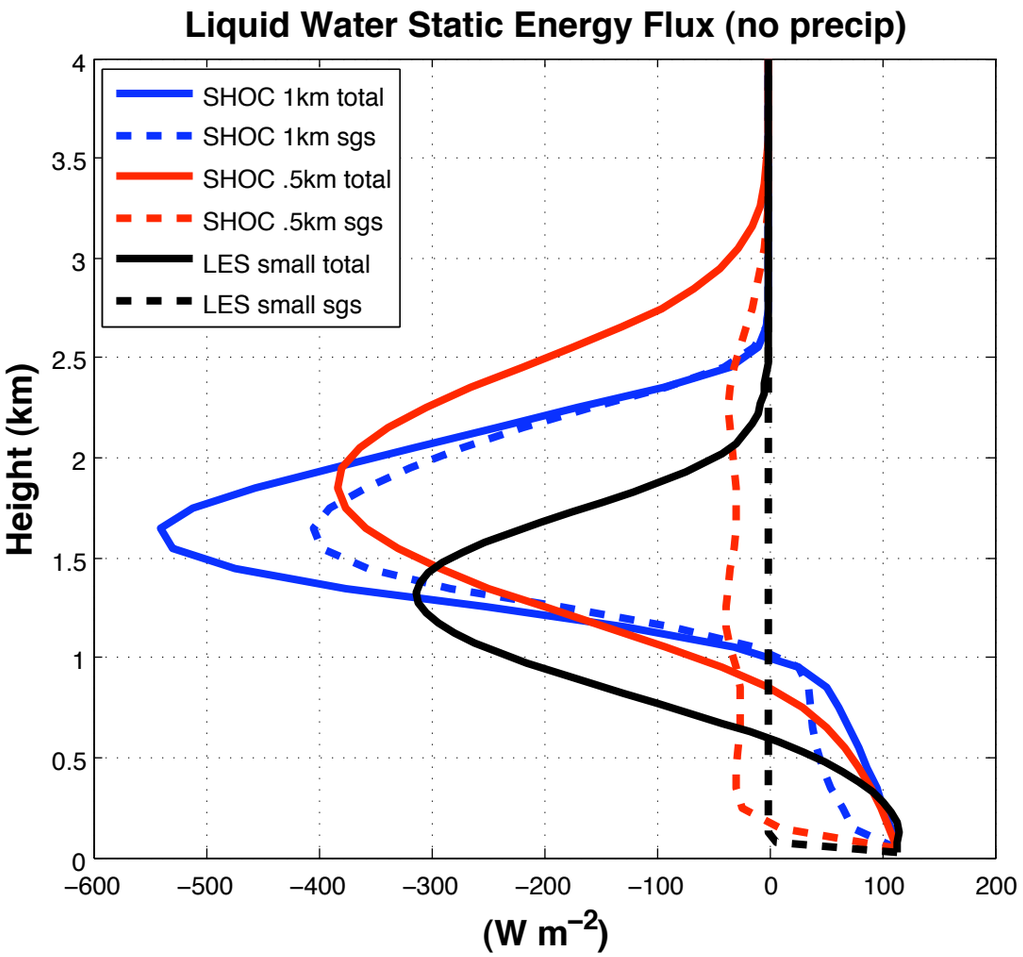
- Much higher total cloud water as CWP + IWP increases.
- Cloud deck is around 1.25km in SHOC but .75km in LES.
- There's around 2x the cloud in no-precip than full physics.

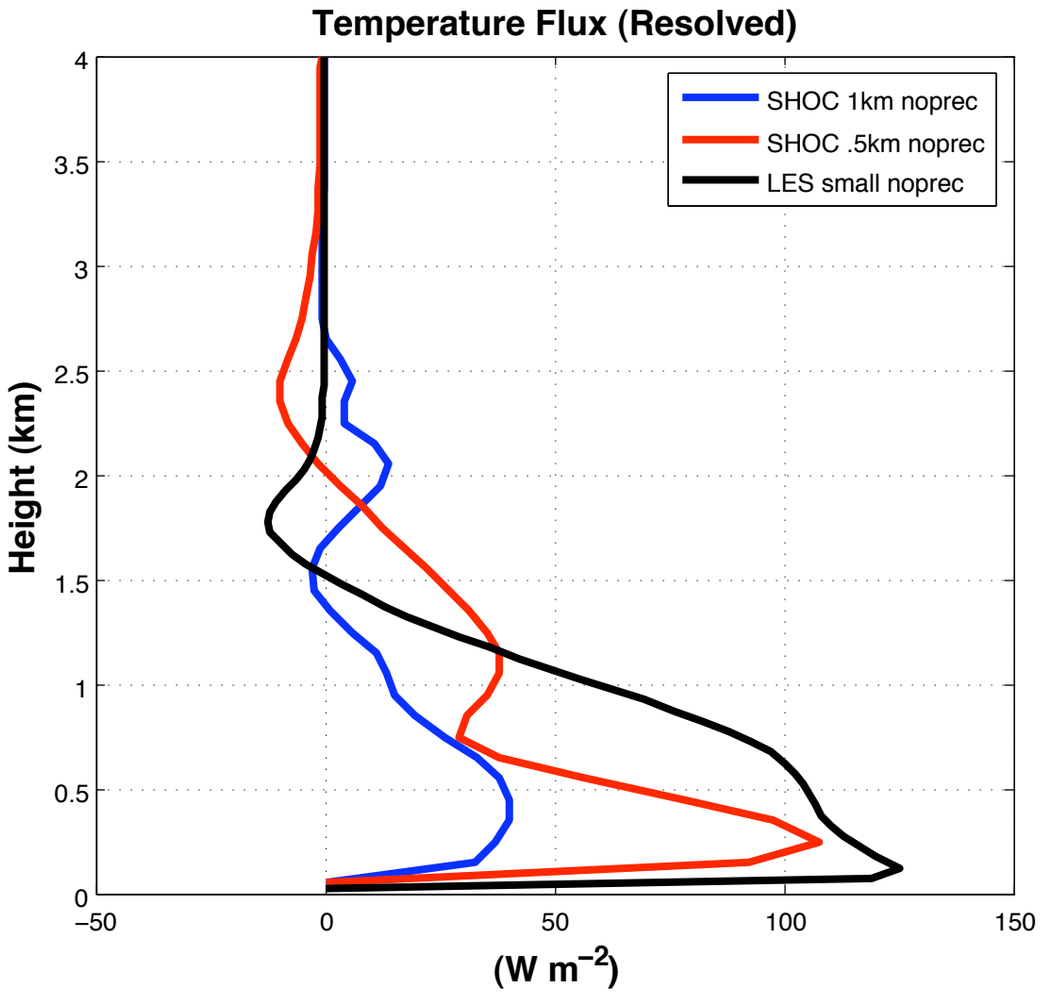






No-precip Plots

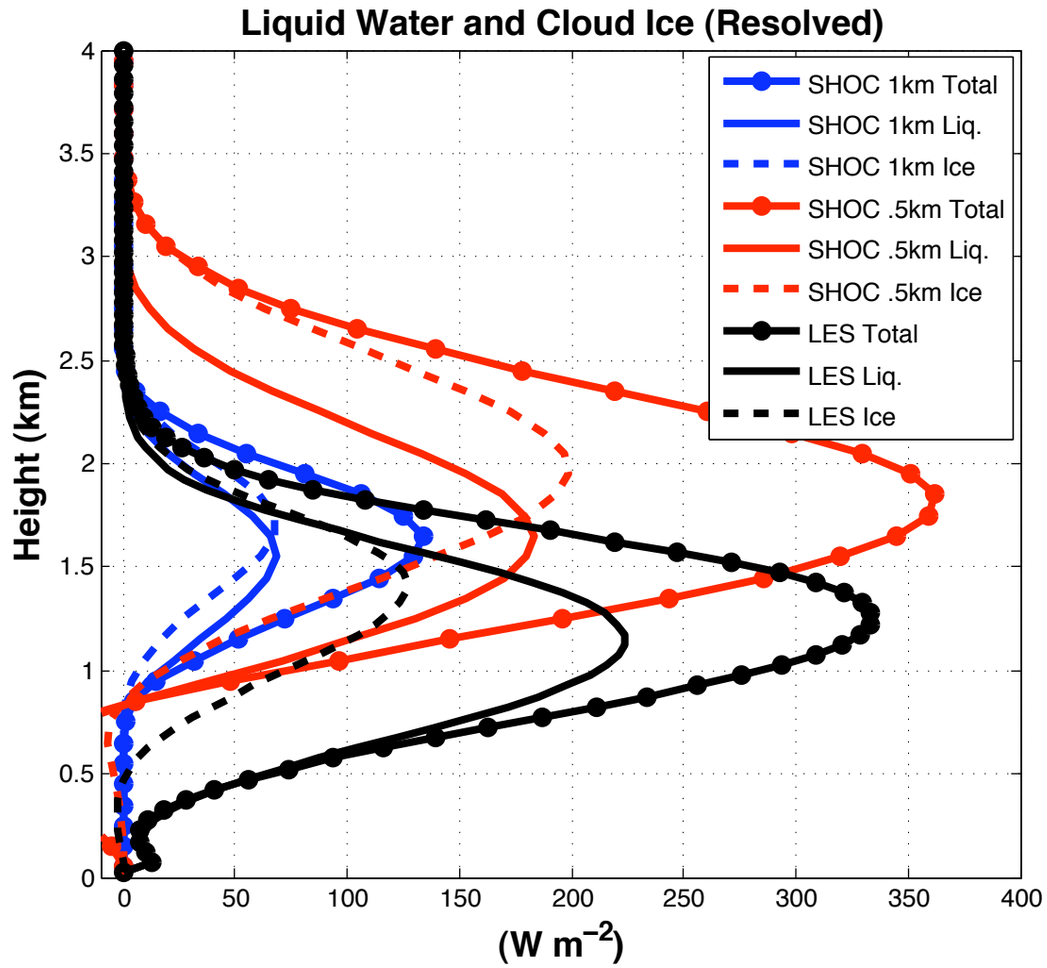


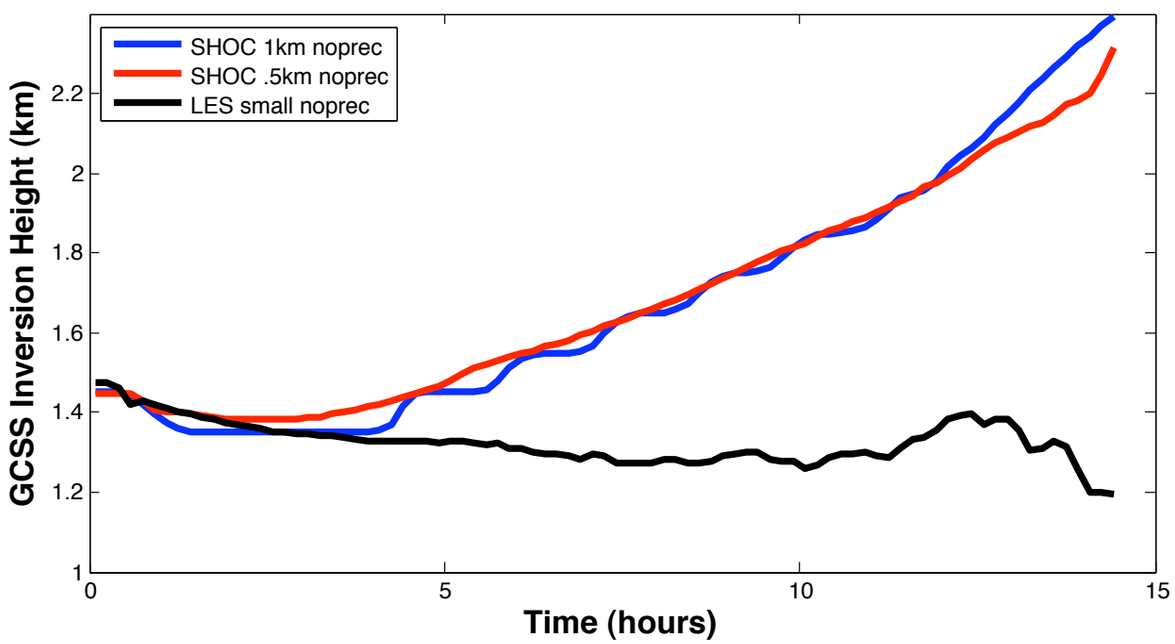


- Much larger SHOC values for LWSE
- Temp flux is much more positive than in full physics (no negative 1km SHOC values.)

No-precip Plots

- ZINV doesn't increase for LES run in no-precip.
- Higher altitude of the maximum values of QCL, QI, QN.



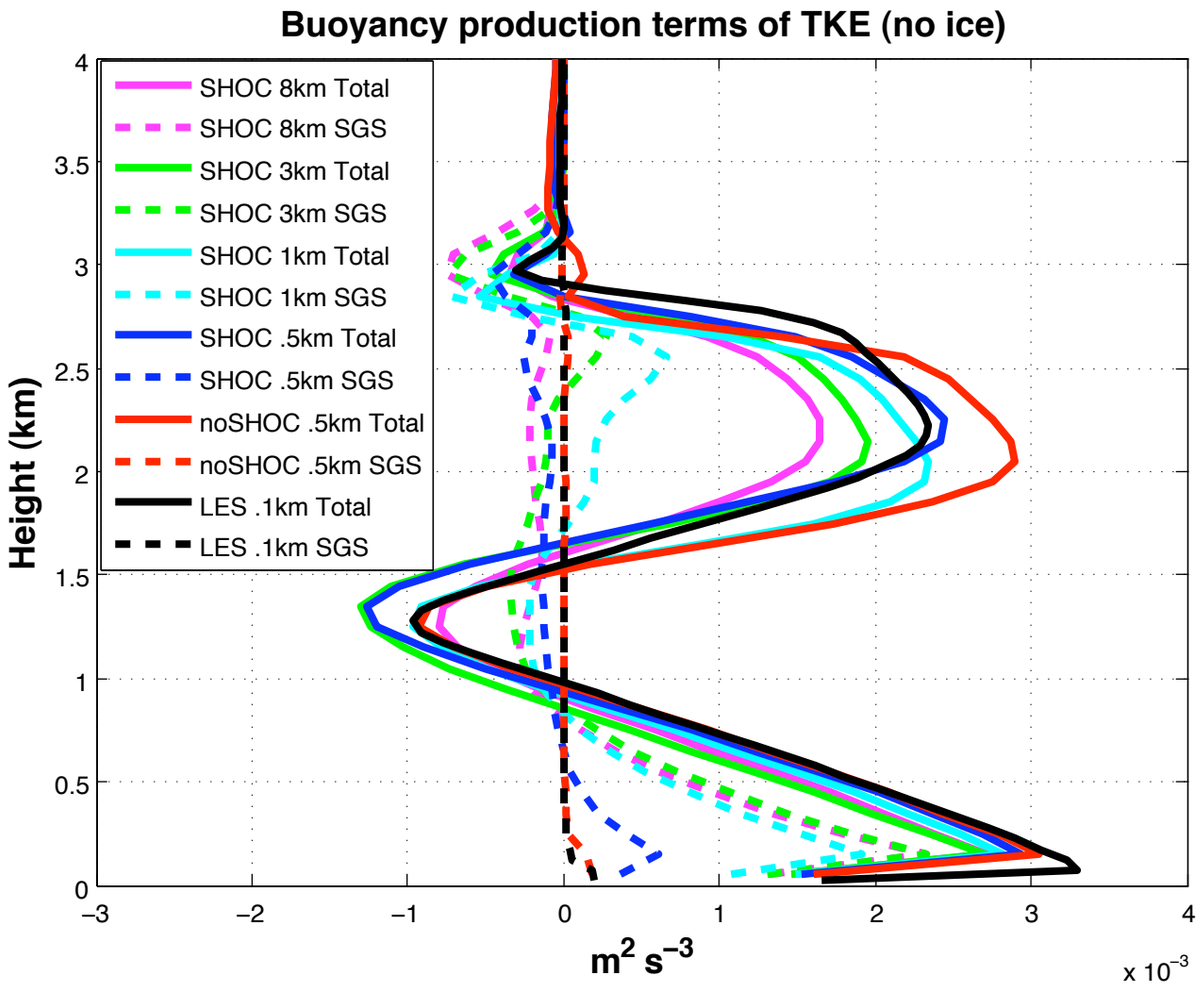


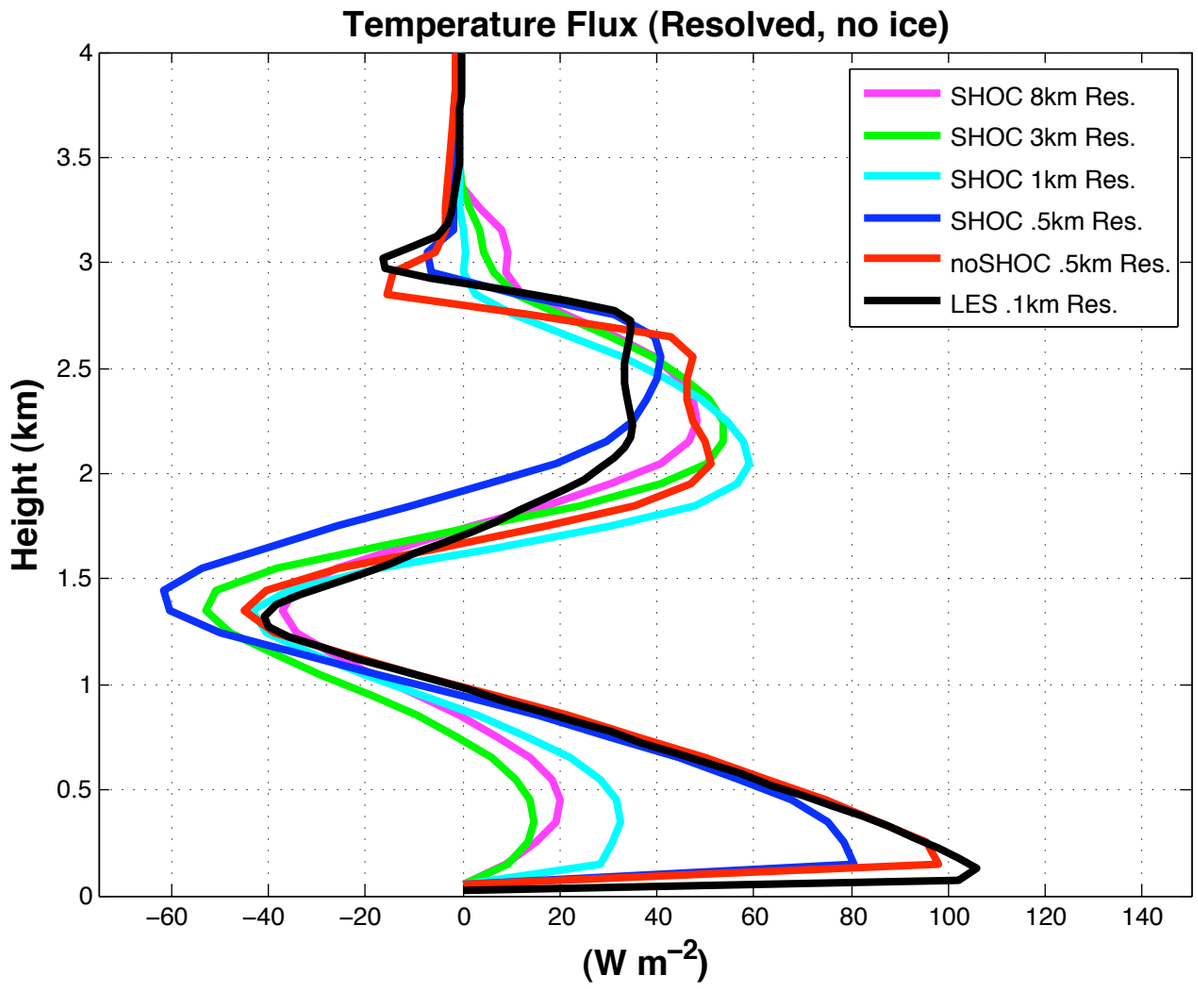
No Ice Plots

http://home.chpc.utah.edu/~u0652833/SAM_constrain/c_series_NoIce_plots/

- Runs 601c 602c 603c 604c SHOC
- Noshoc run 803c
- LES run 805c
- Comparatively these have shown some promise, suggesting that the primary issue is related to ice.

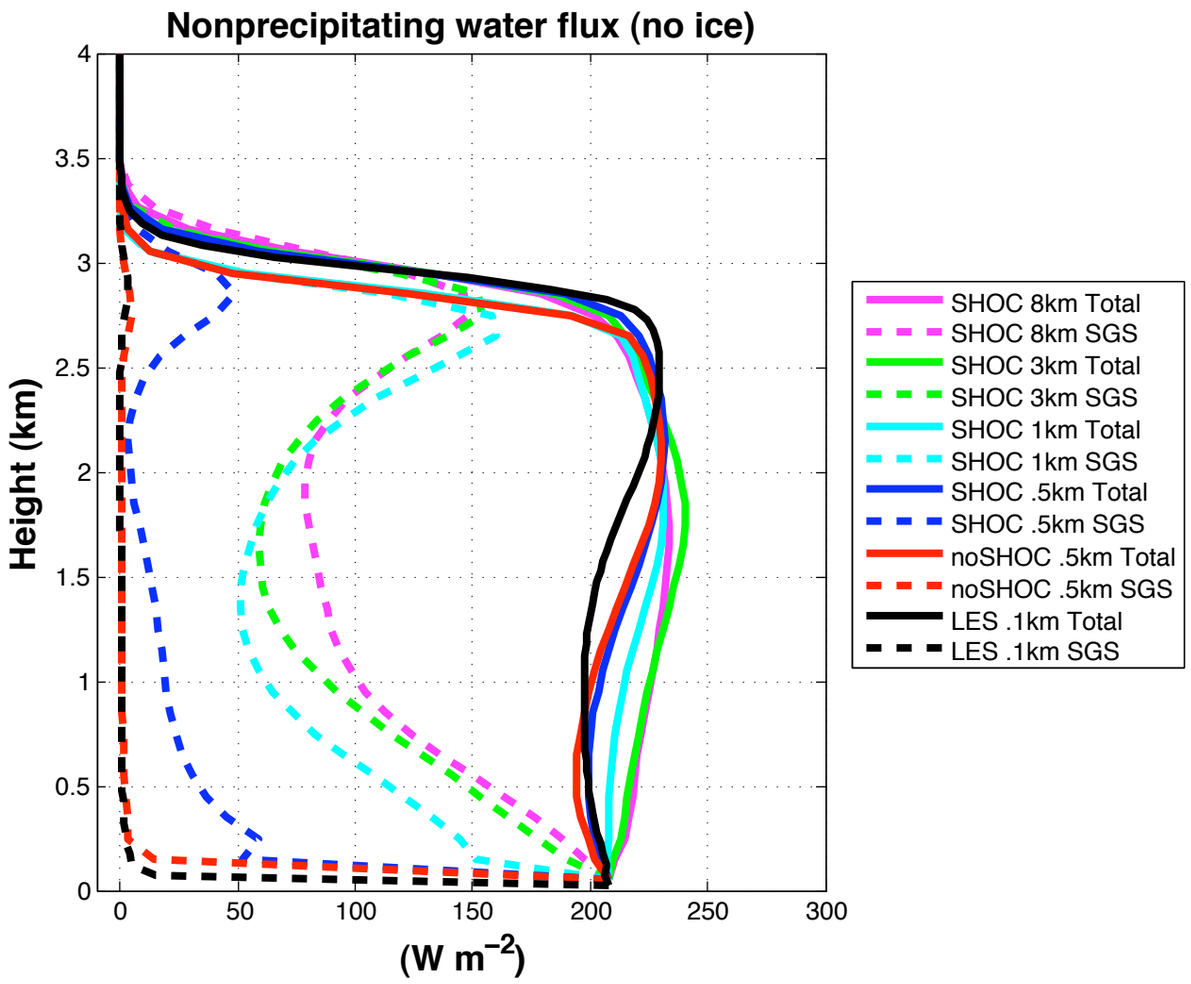
No Ice Plots

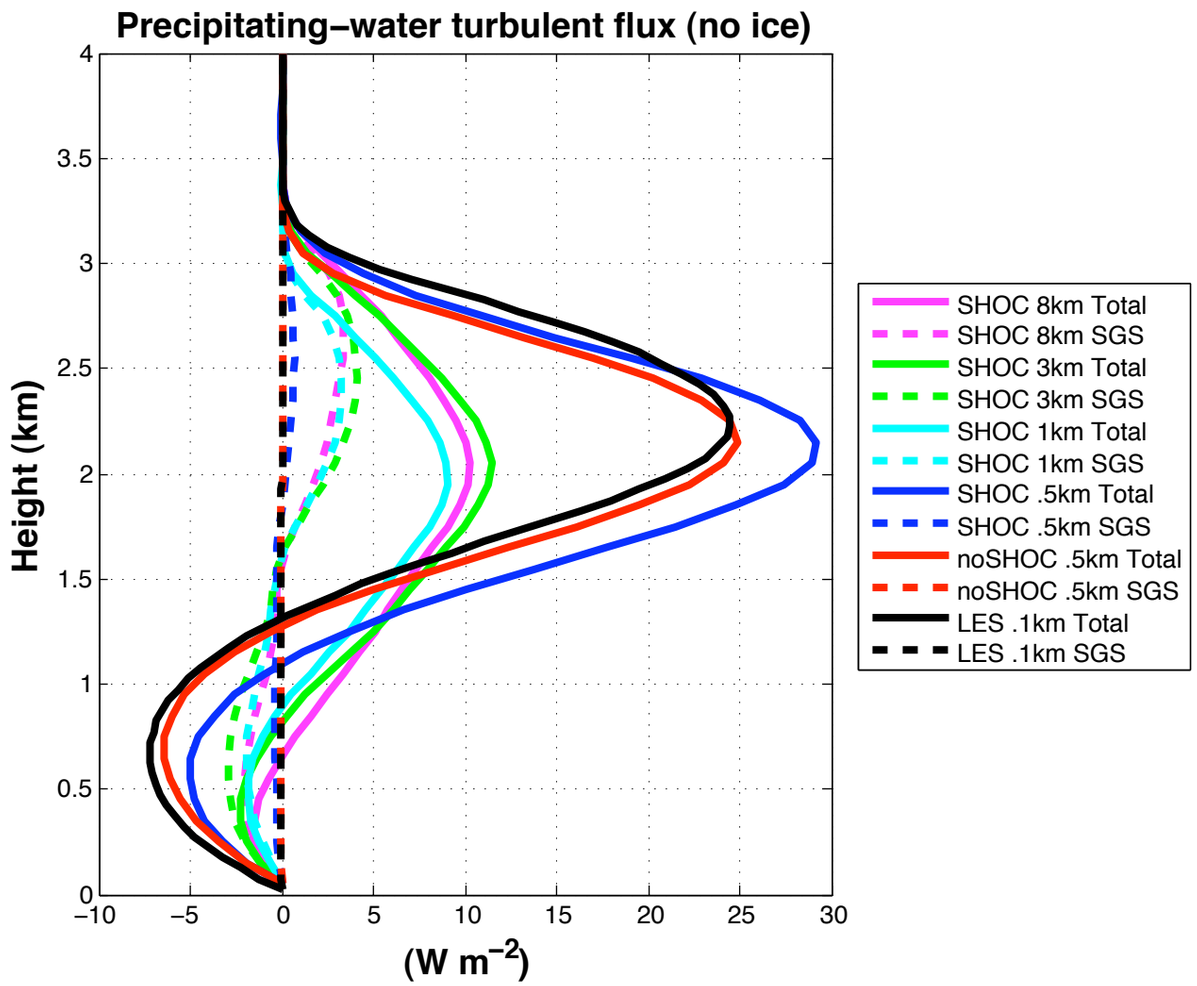




- Negative around 1.25km, positive around 2.25km. Sharper turns and larger magnitude at these two levels.

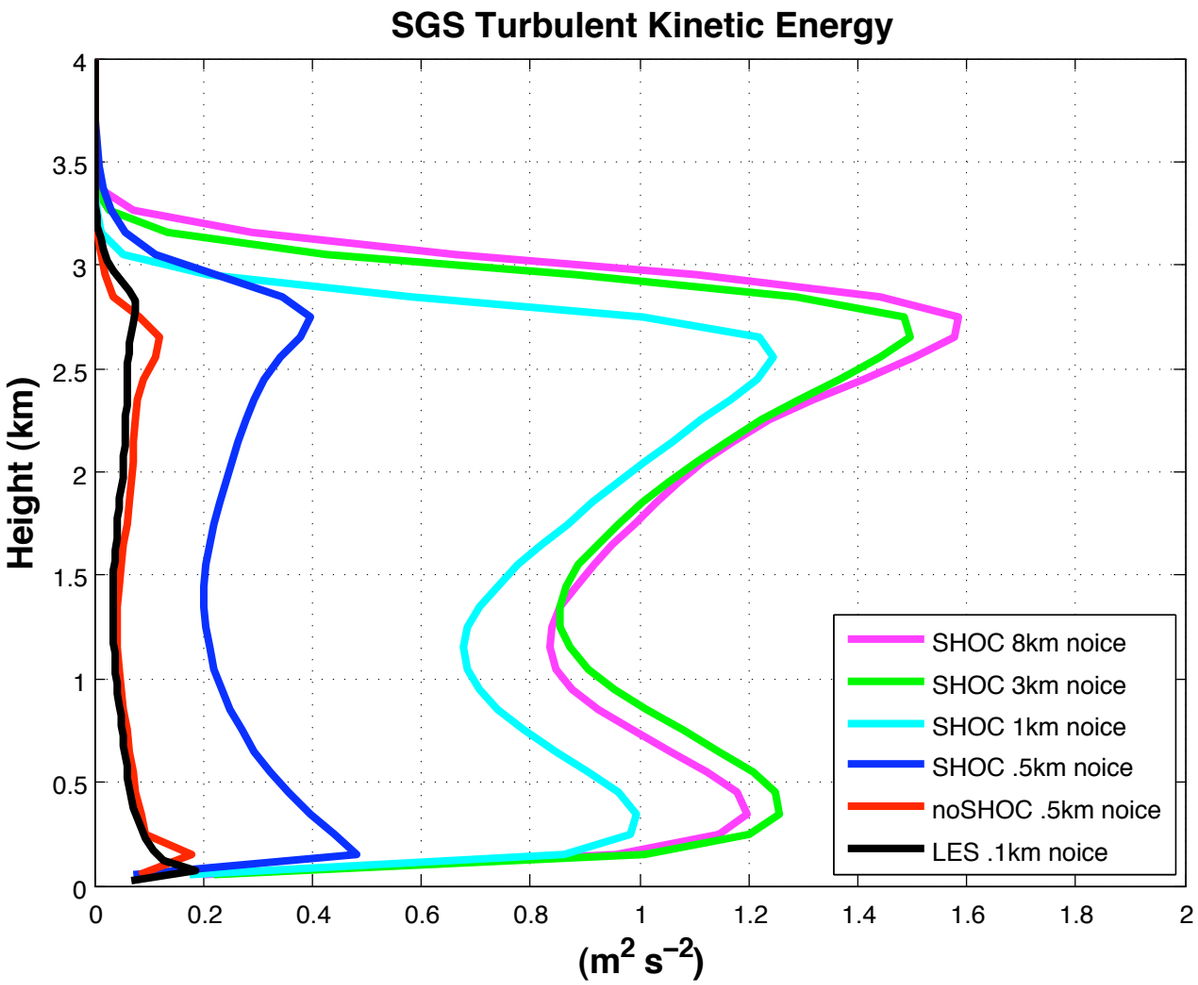
No Ice Runs

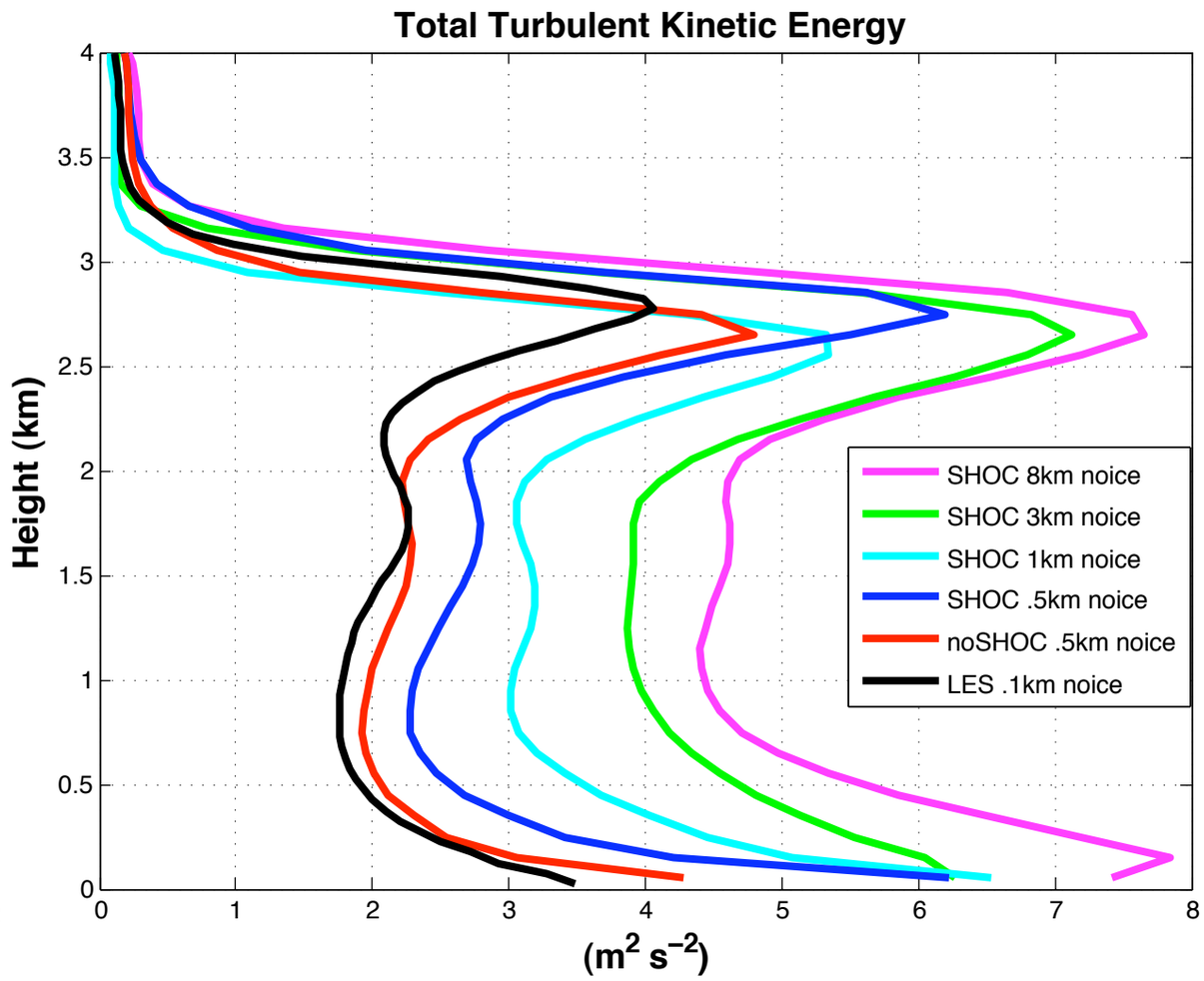




- Higher altitude of maximum values.
- QPFLUX more spread out, lower max magnitude.

No Ice Runs

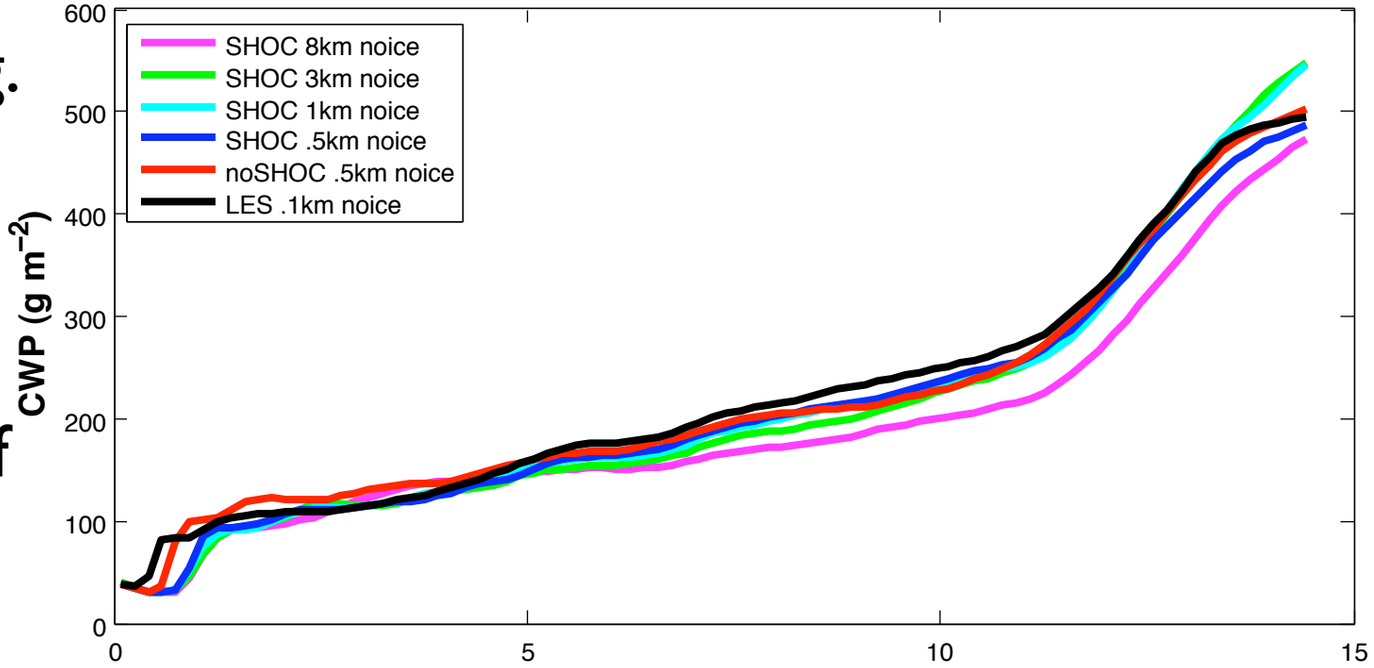


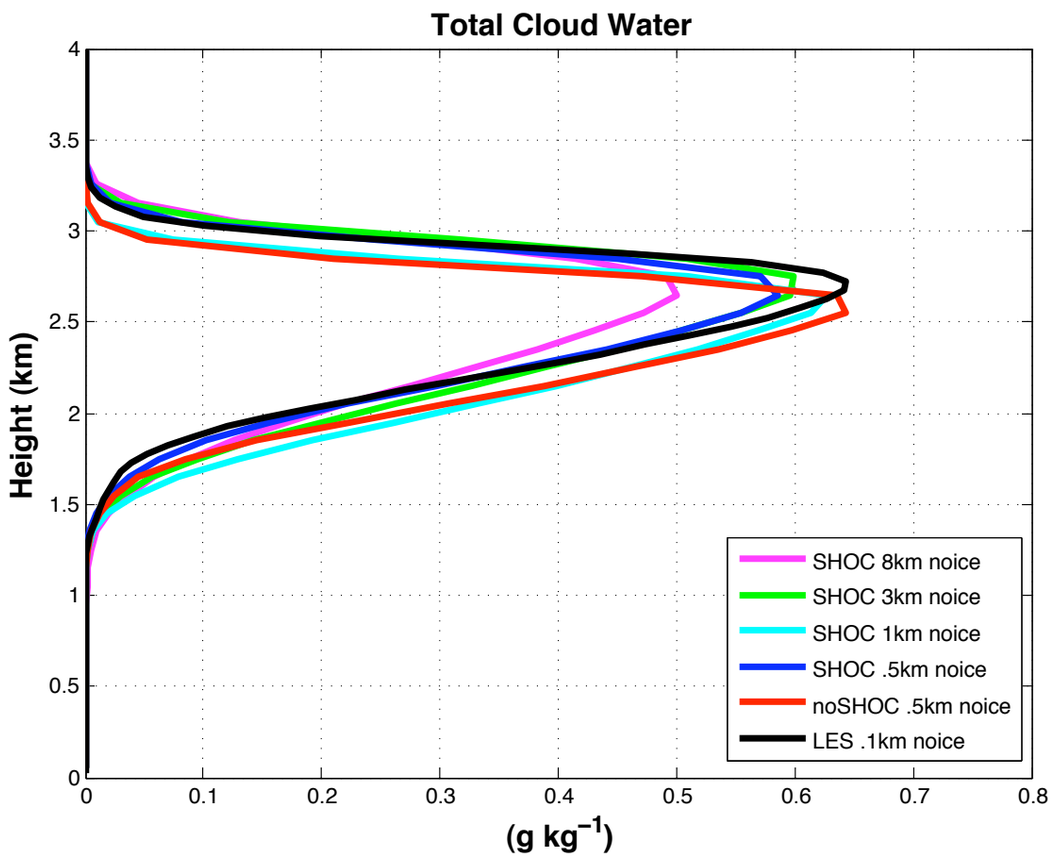


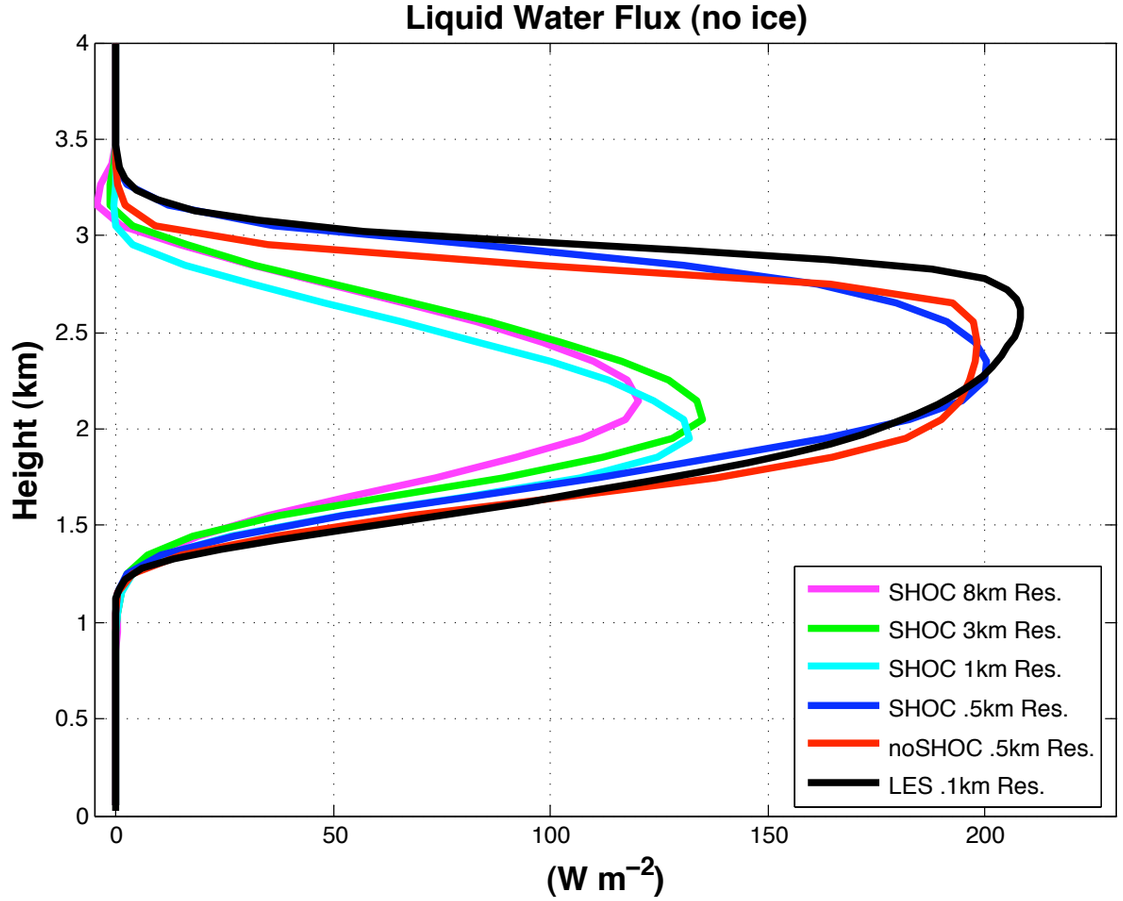
- Larger magnitudes of TKE throughout boundary layer.
- Peak in TKE at 2.75km.

No Ice Runs

- CWP is constantly increasing.
- CWP LES and SHOC values similar.
- Total cloud water 10x that of full phys, close together.
- QC much higher.

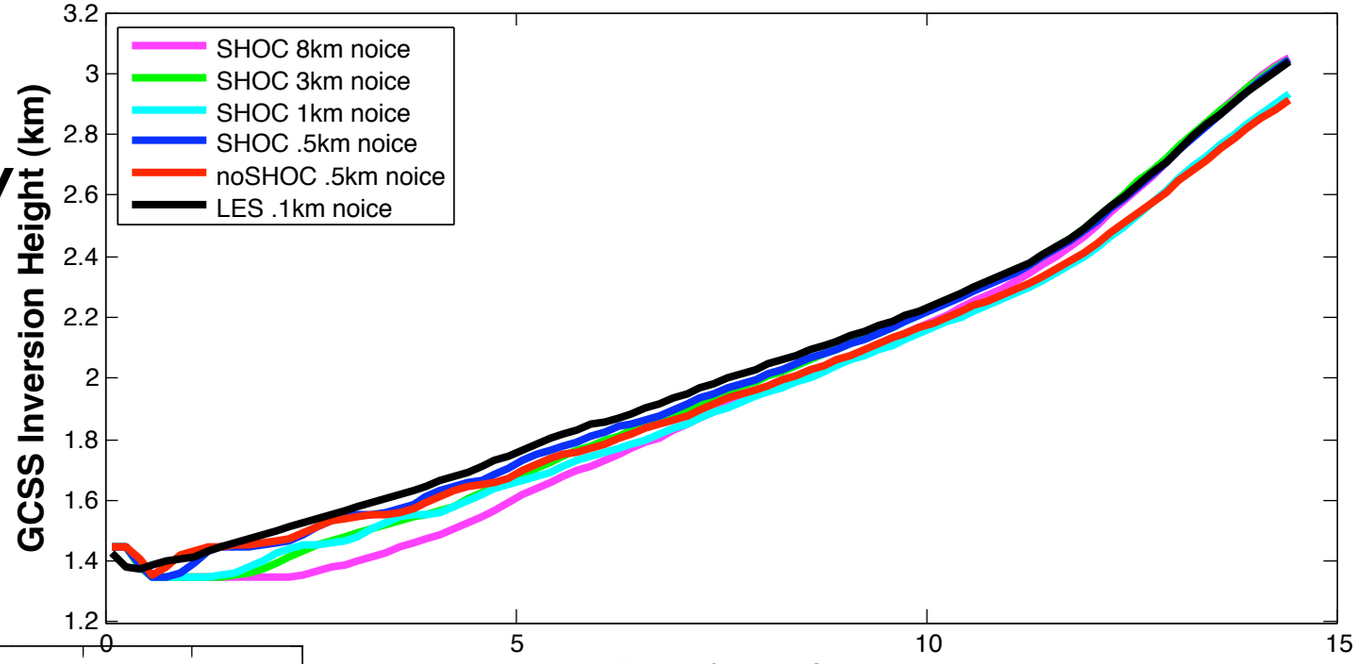


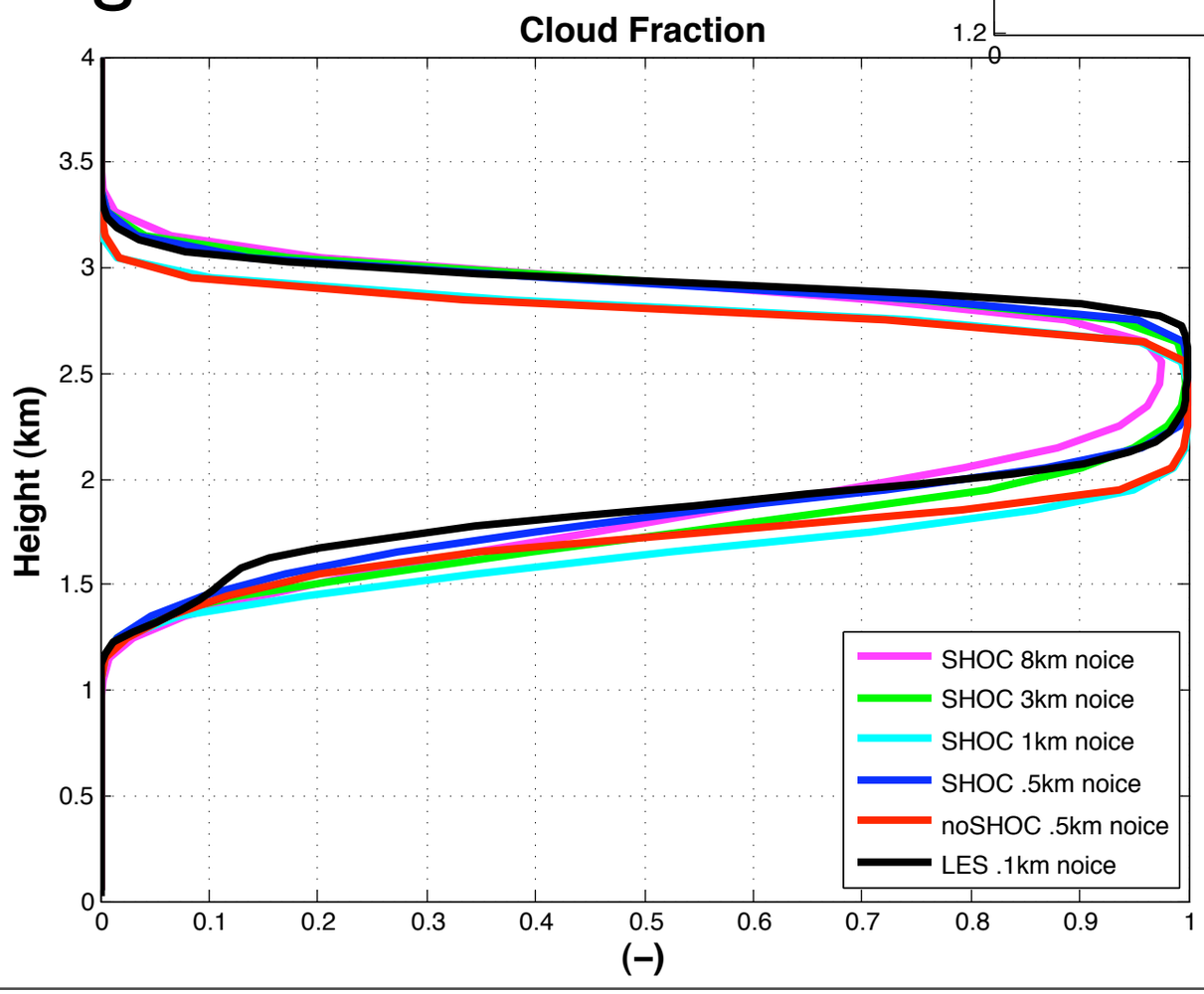


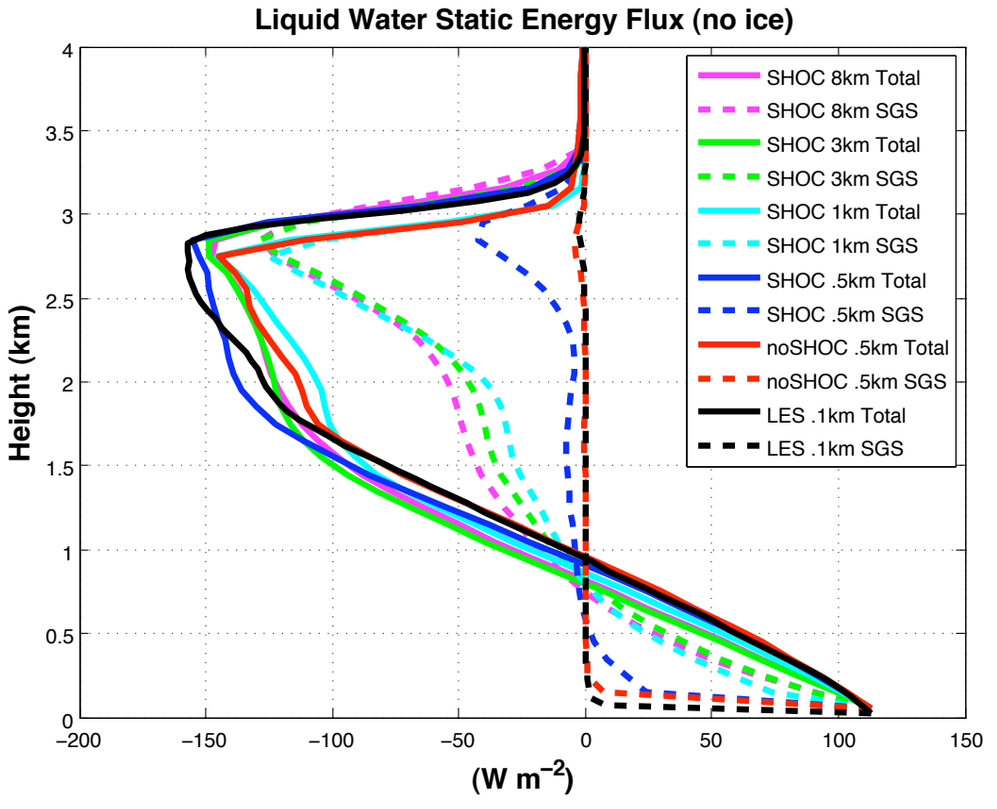


No Ice Runs

- Total cloud coverage.
- Inversion height steadily rises, LES with SHOC.
- LWSE altitude of max higher.

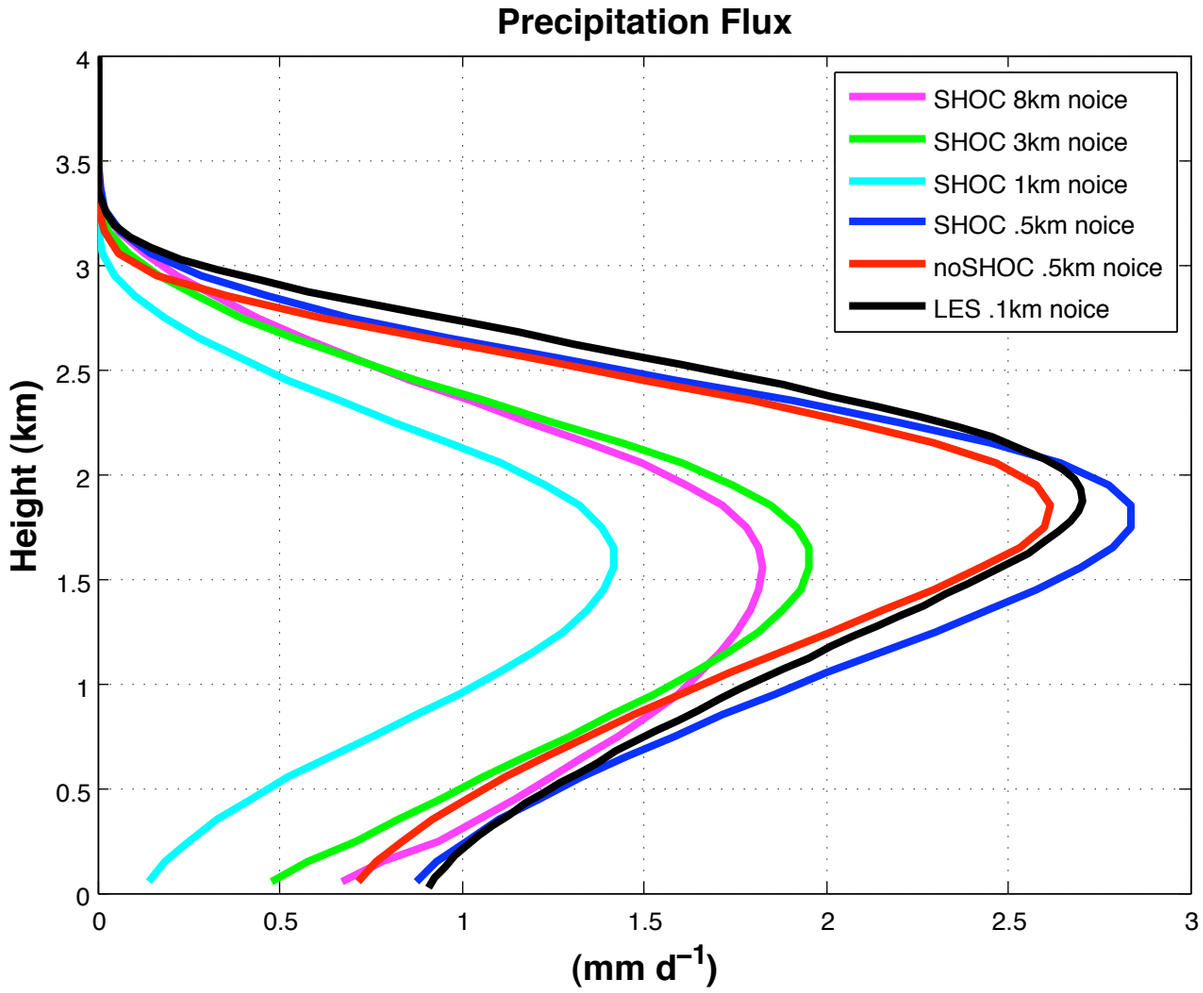




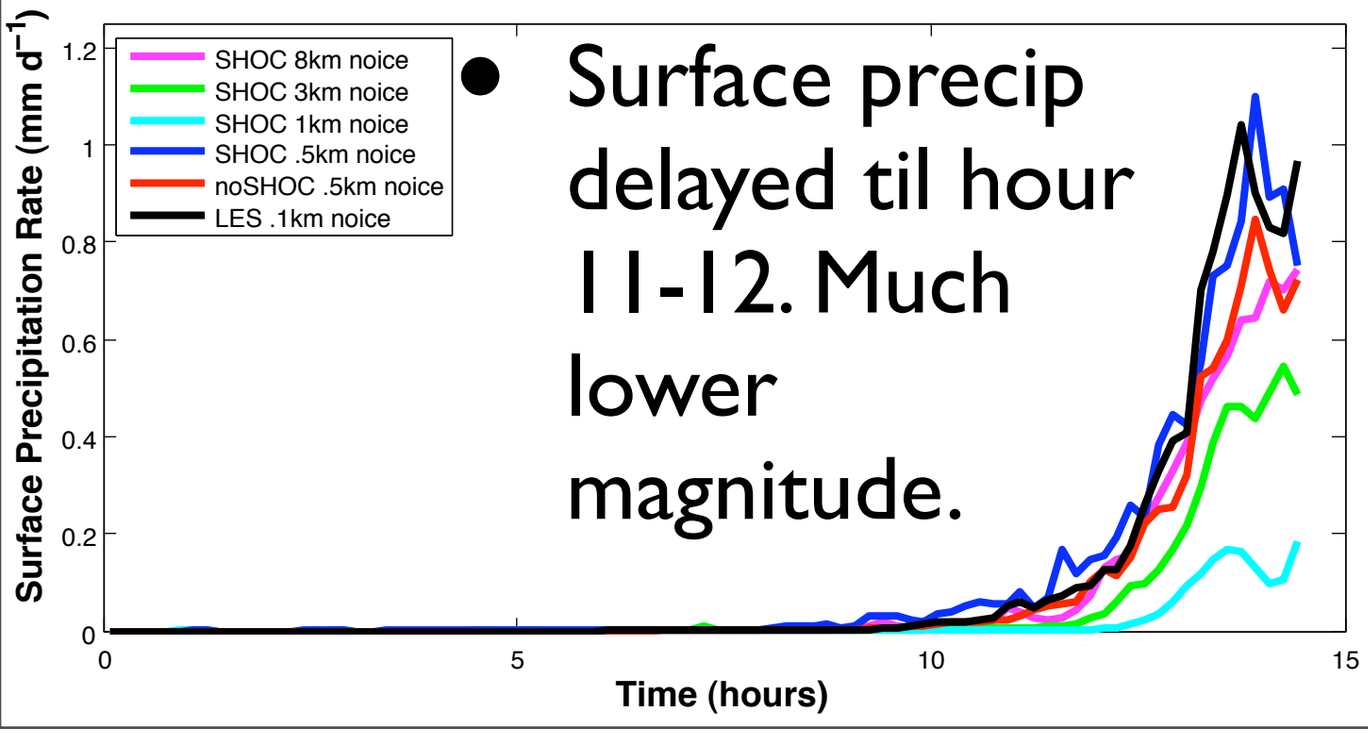


No Ice Runs

- Higher altitude of precip flux, lower magnitude.



- Surface precip delayed til hour 11-12. Much lower magnitude.

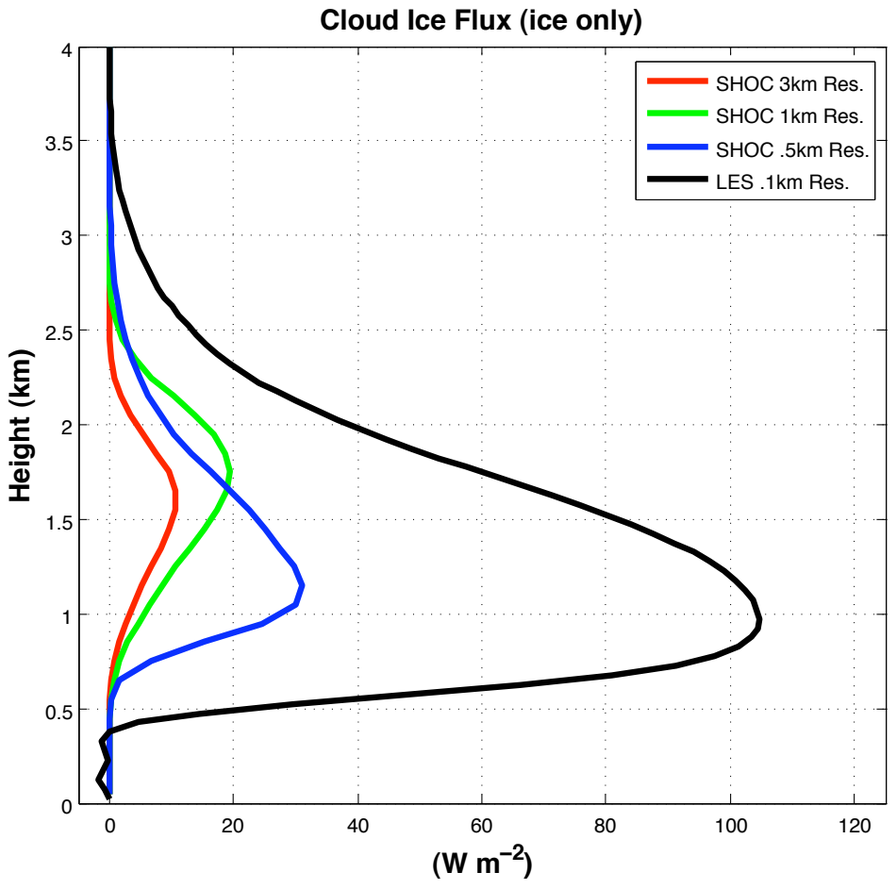


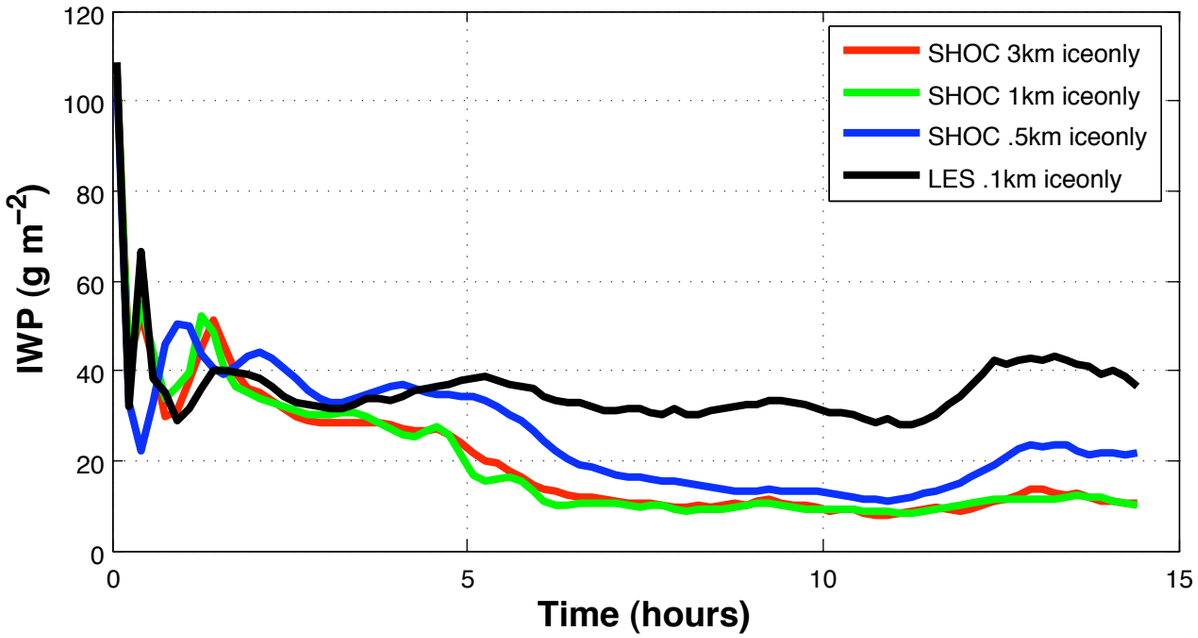
Ice Only Plots

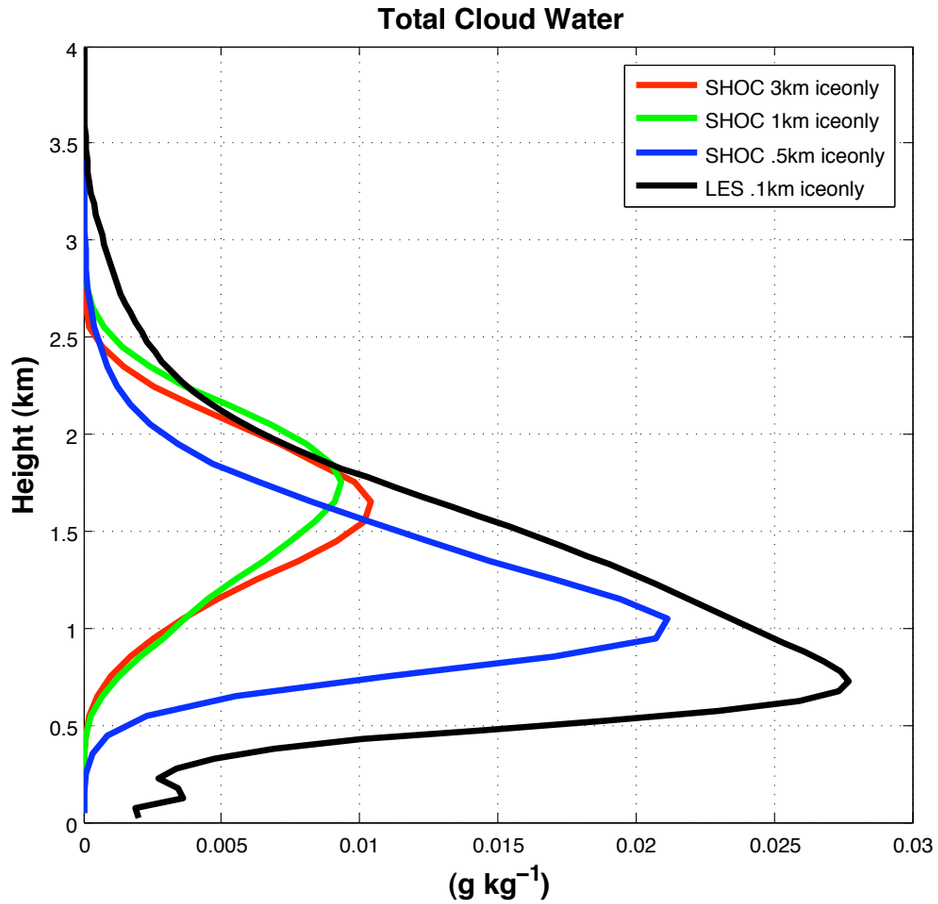
http://home.chpc.utah.edu/~u0652833/SAM_constrain/d_series_iceonly_plots/

- SHOC runs 601d 602d 603d
- LES run 805d
- These runs don't appear to show much improvement overall relative to the full physics plots.

Ice Only Plots

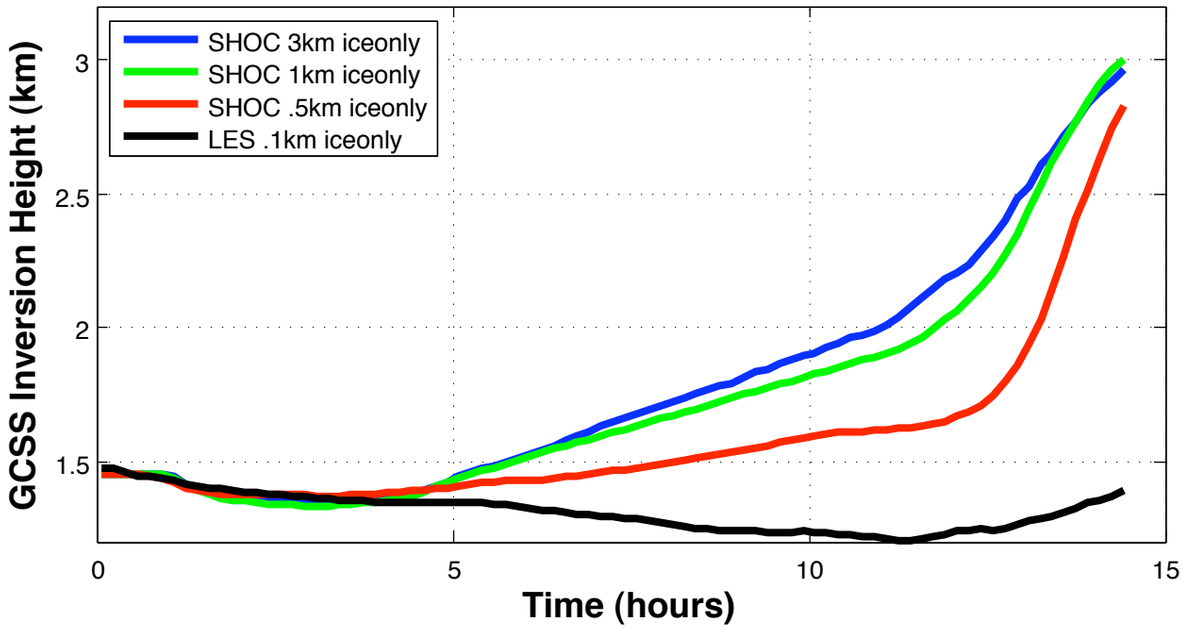


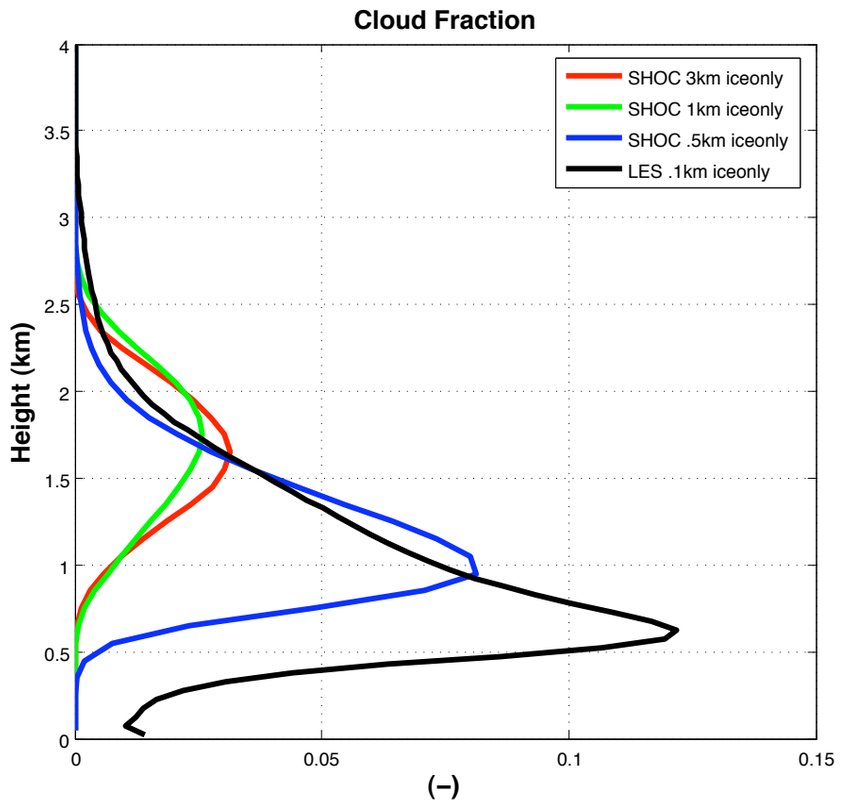




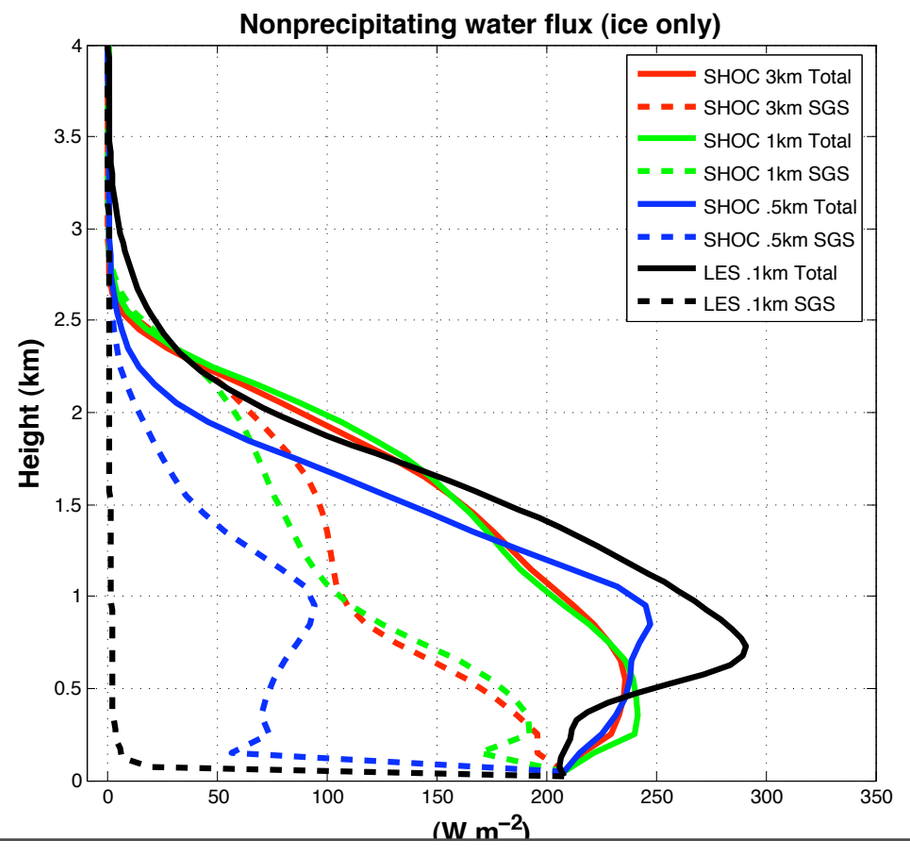
- QI is much more underestimated in SHOC than in fullphys.
- IWP is higher in the LES than SHOC (vice versa for fullphys)
- Total cloud water has lower altitude/ magnitude.

Ice Only Plots

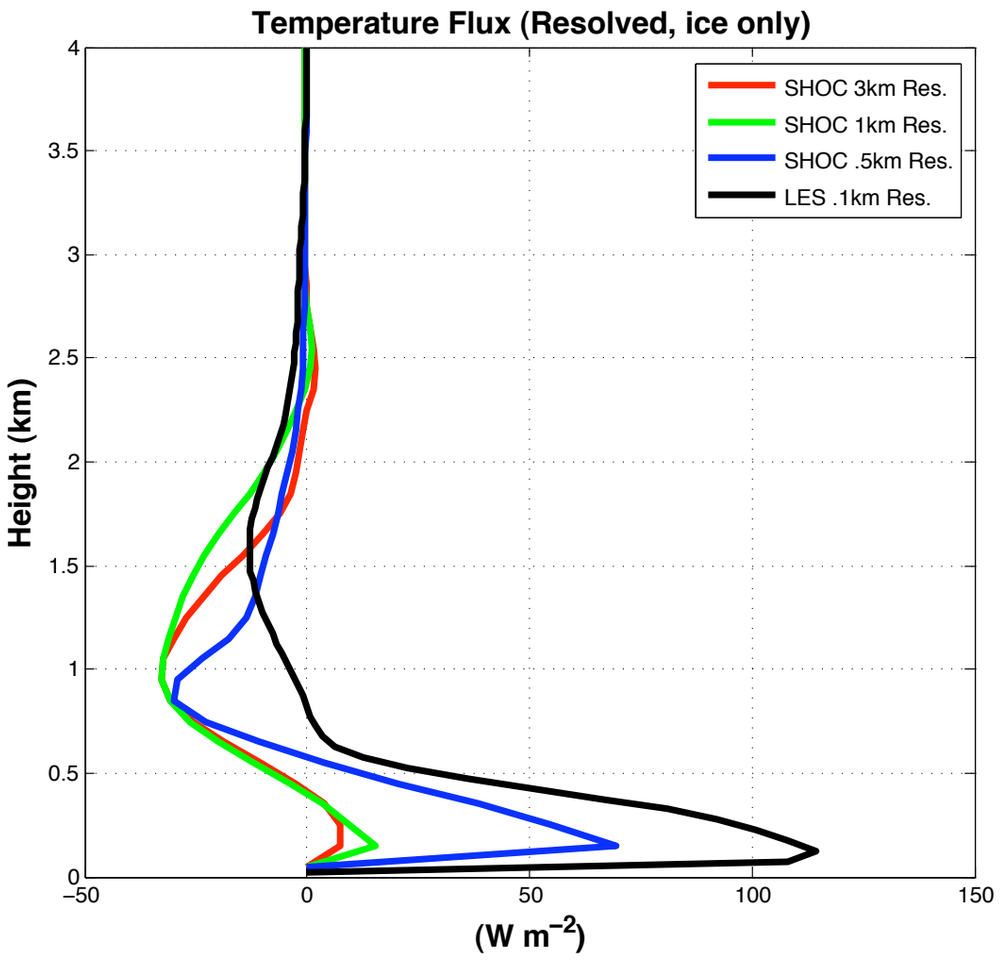


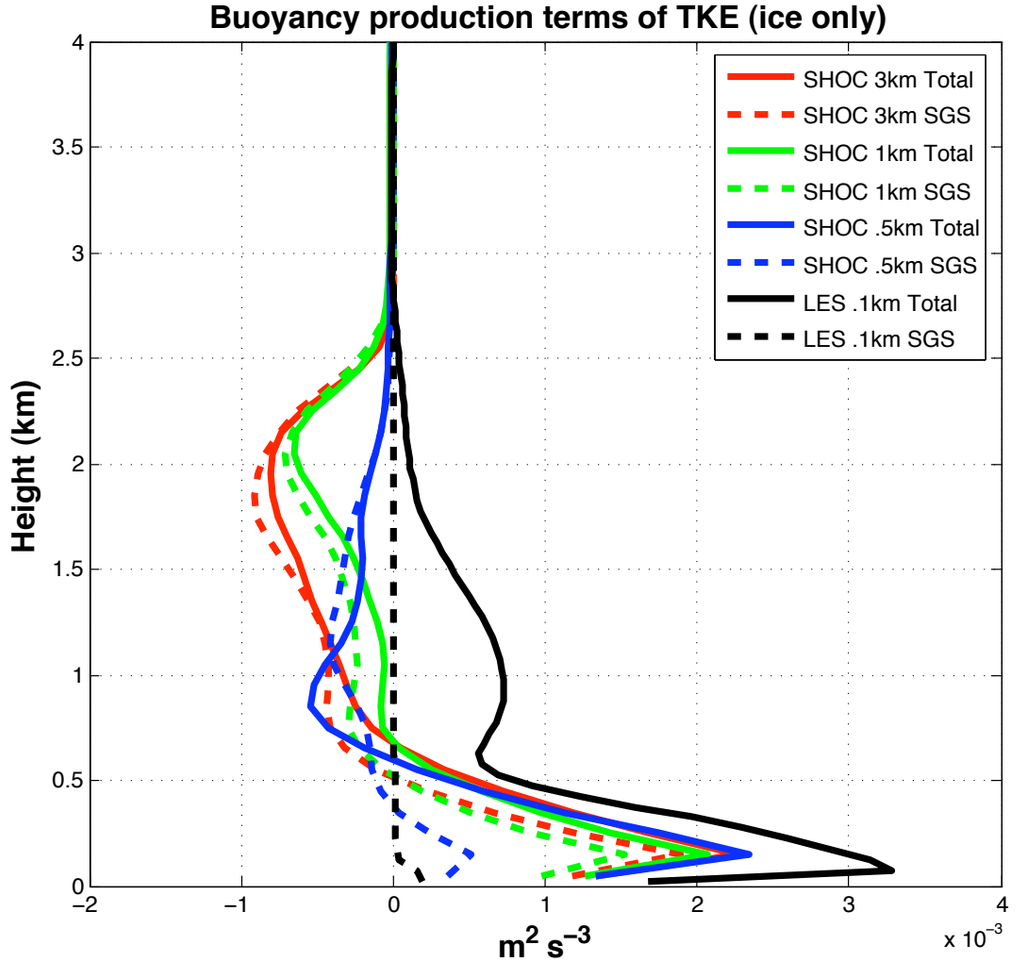


- ZINV declines in LES, larger separation.
- Cloud fraction lower magnitude/ altitude than fullphys.
- QT lower in altitude, more graudalal decline.



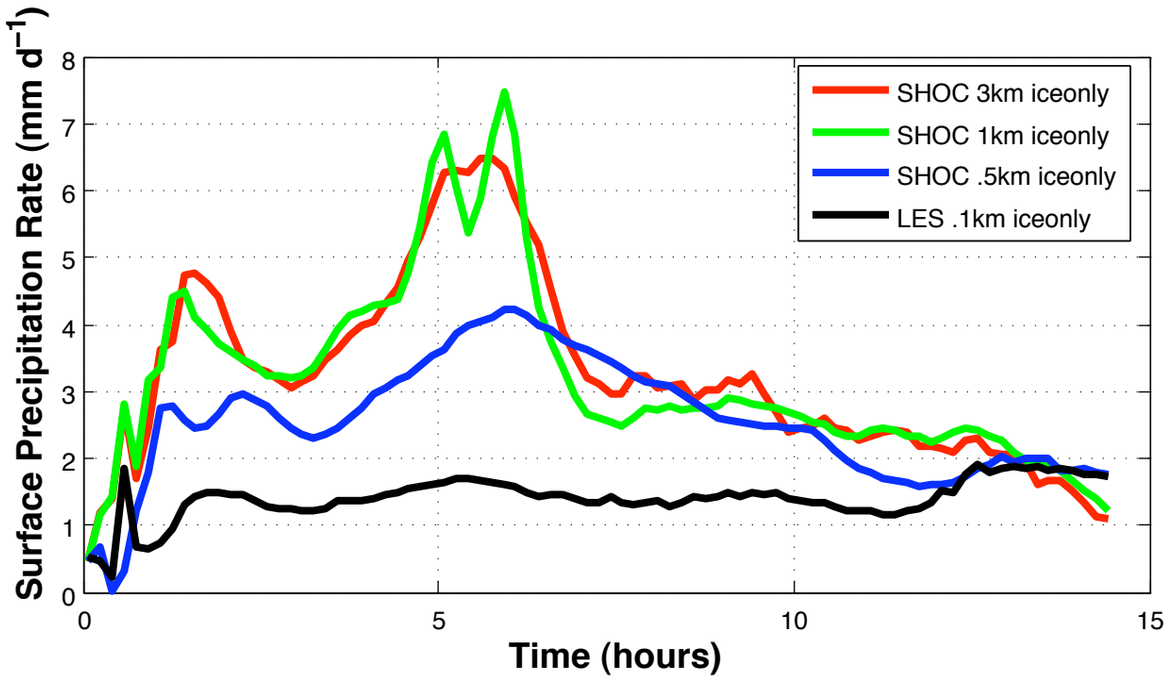
Ice Only Plots

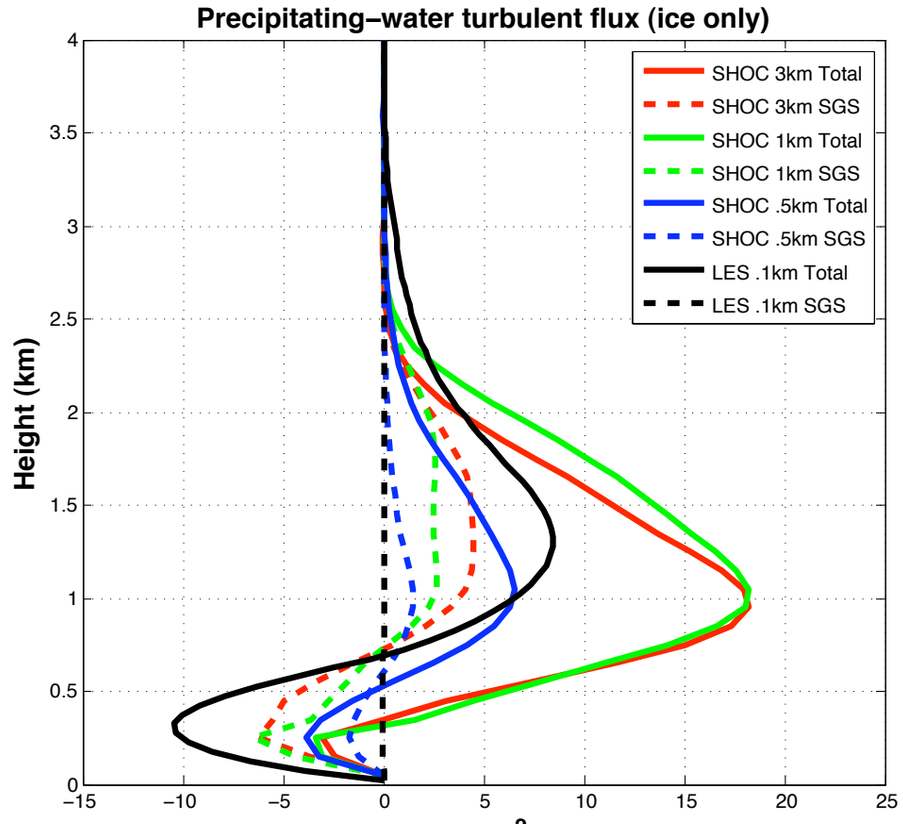


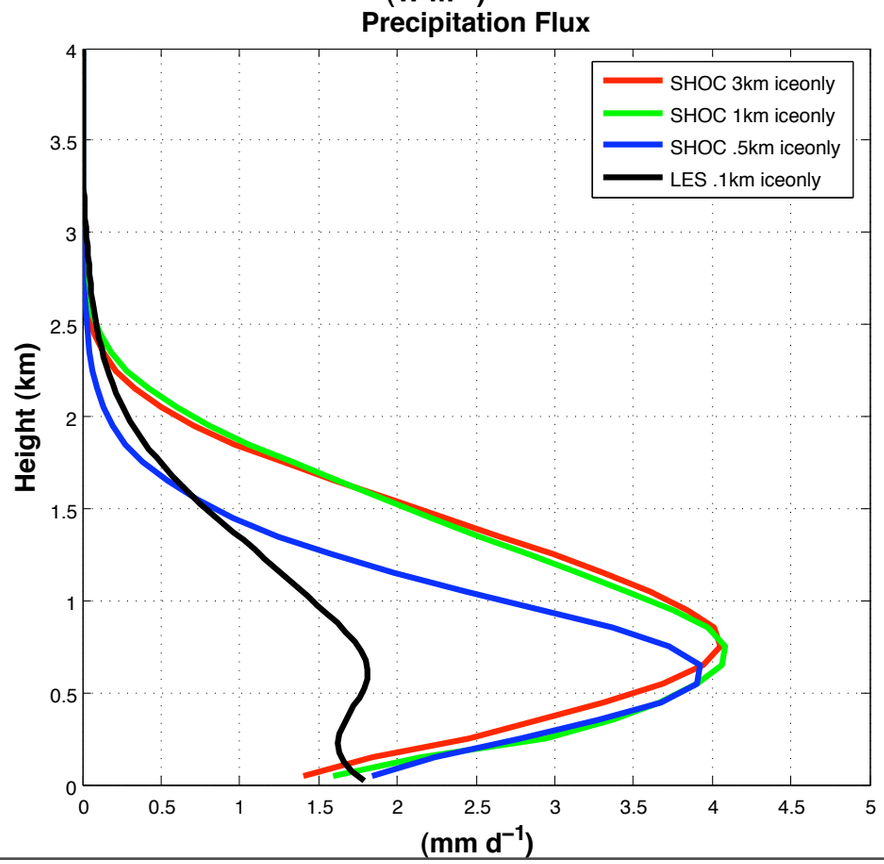


- Temp flux - .5km SHOC much farther from LES.
- Buoyancy - LES still never negative, far from SHOC runs.

Ice Only Plots







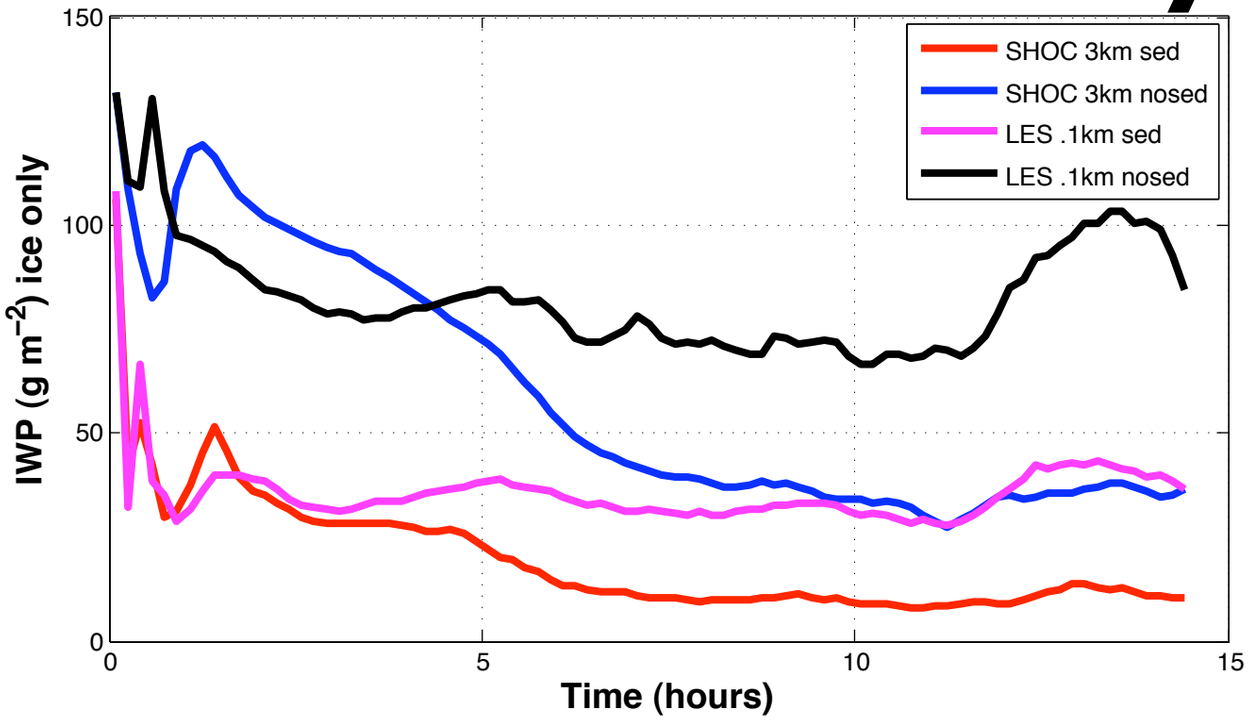
- Surface precip much higher in SHOC than LES or fullphys until end of period.
- QP is lower in magnitude for LES . 5km SHOC , larger for low res SHOC.
- Precip flux is 2x LES in SHOC at cloud height.

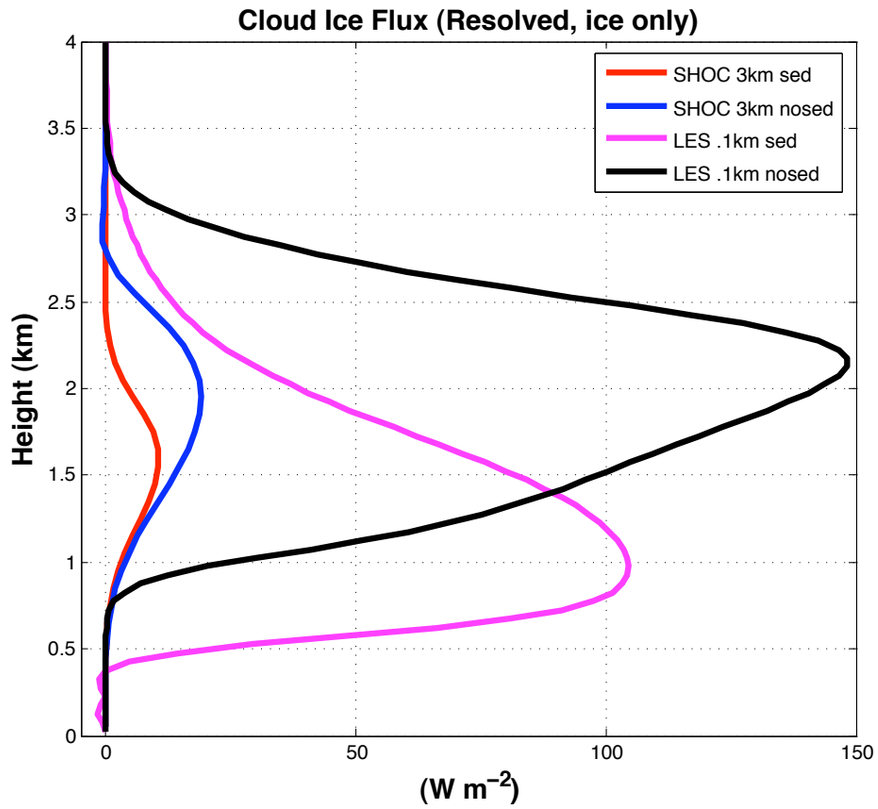
Ice Only No Sed Plots

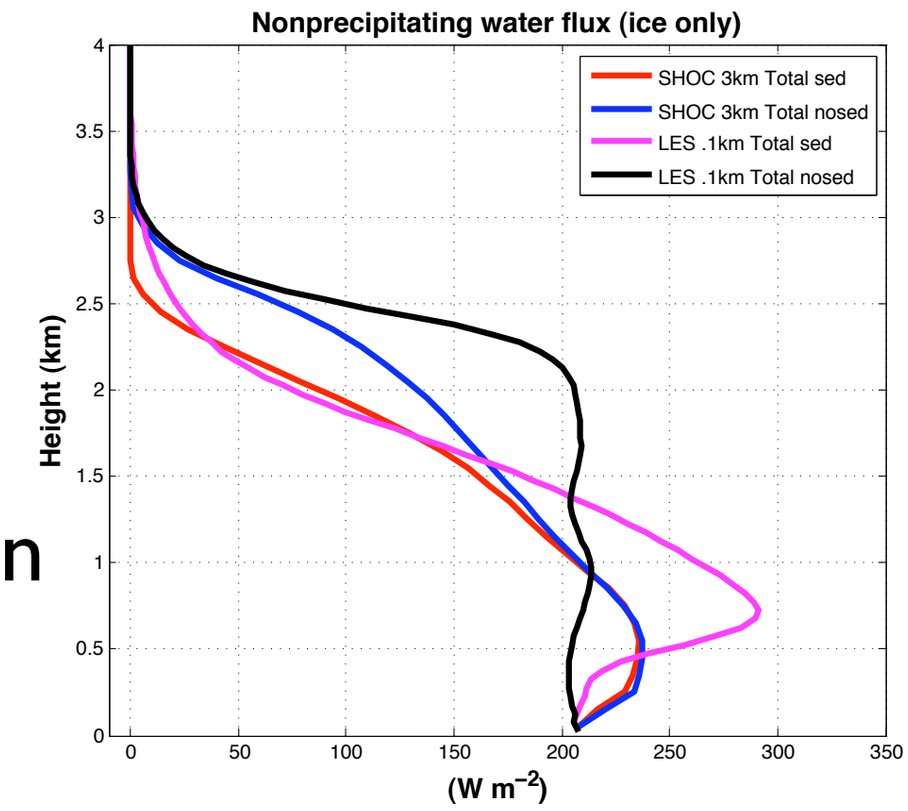
http://home.chpc.utah.edu/~u0652833/SAM_constrain/e_series_IceonlyNoSediment_plots/

- The e-series plots are ice-only like the d-series and have no ice sedimentation like the f-series.
- These plots have two e-series runs and two d-series runs.
- Runs 601d and 805d from no-ice.
- Runs 601e and 805e from no-sedice.
- These plots are going to be compared to ice with only significant differences noted.

Ice Only No Sed

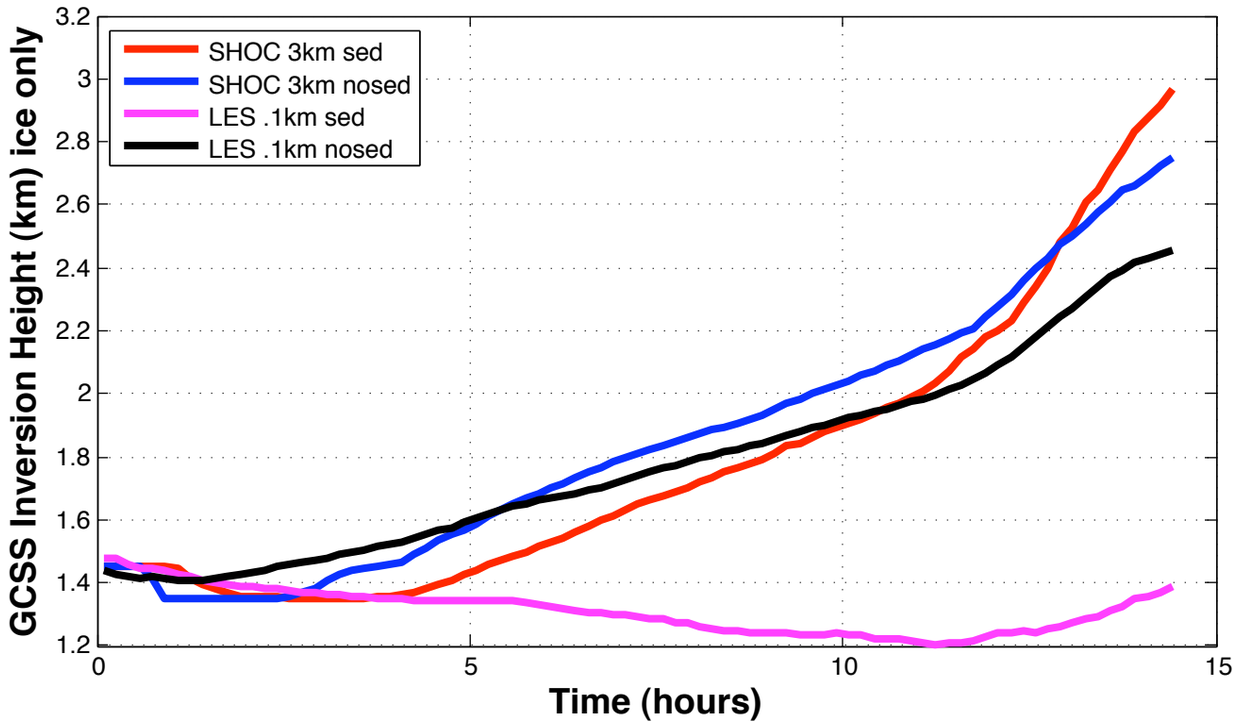


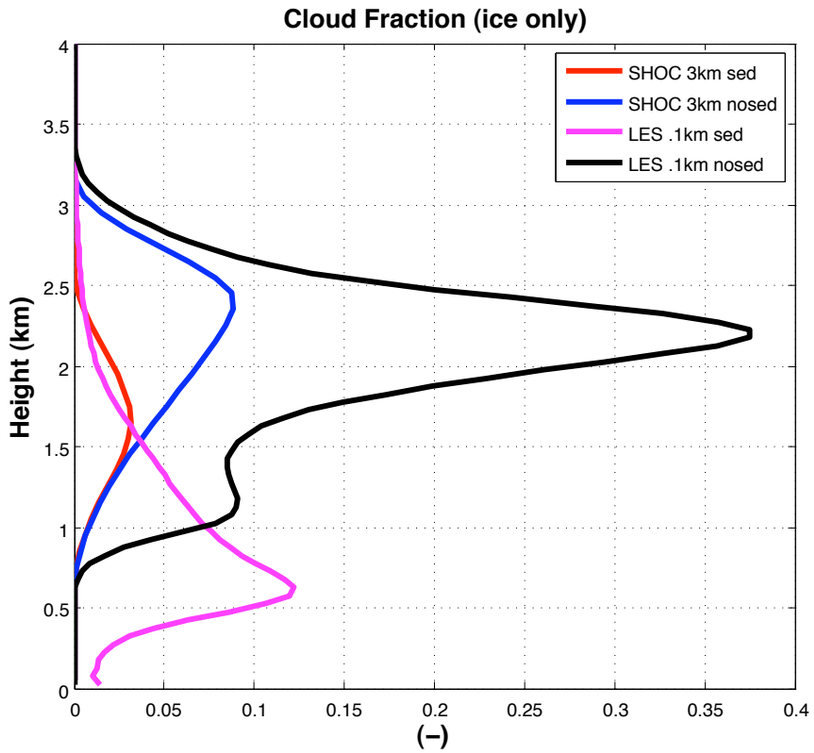


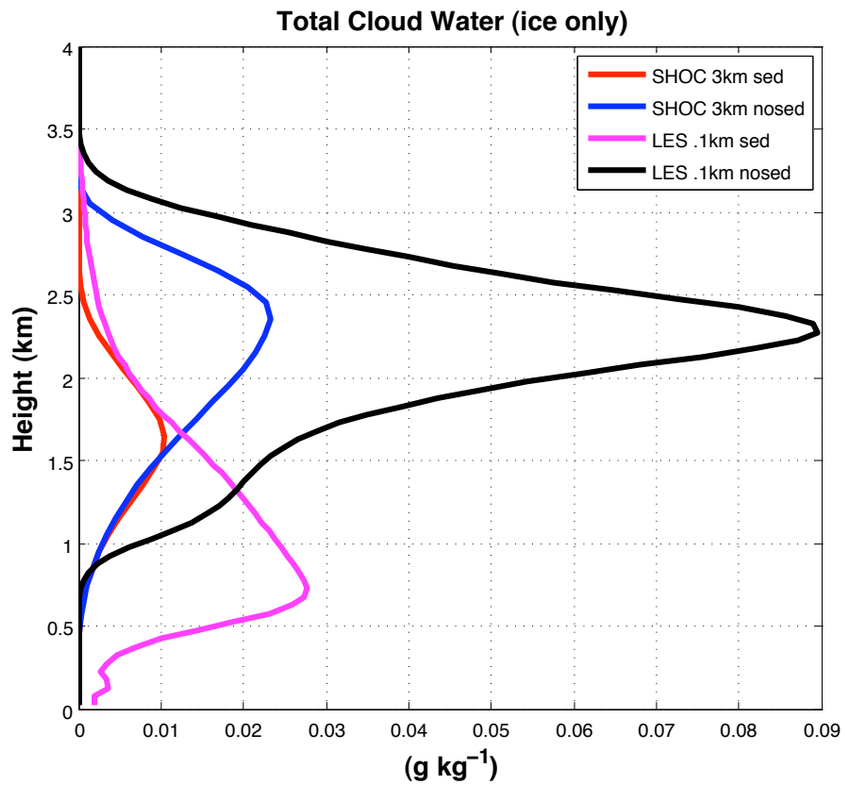


- No-sed runs have higher IWP.
- Nosed runs have higher altitude/magnitude.
- QT is higher altitude reaching in LES.

Ice Only No Sed

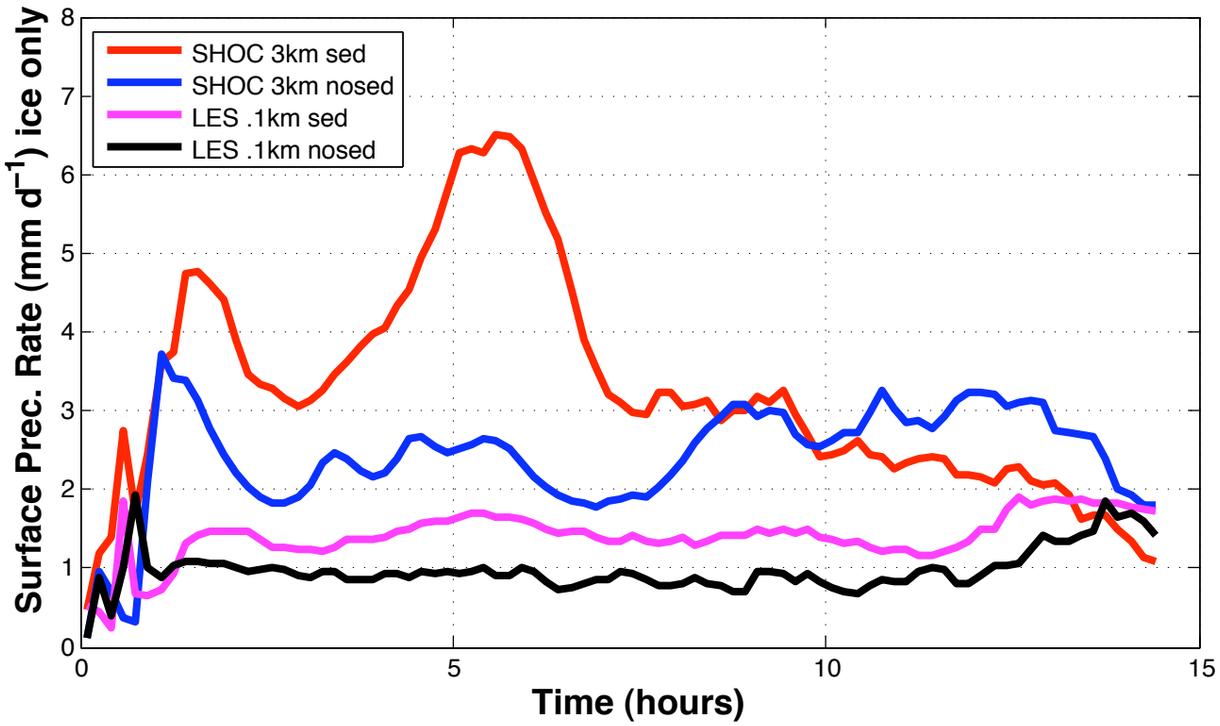


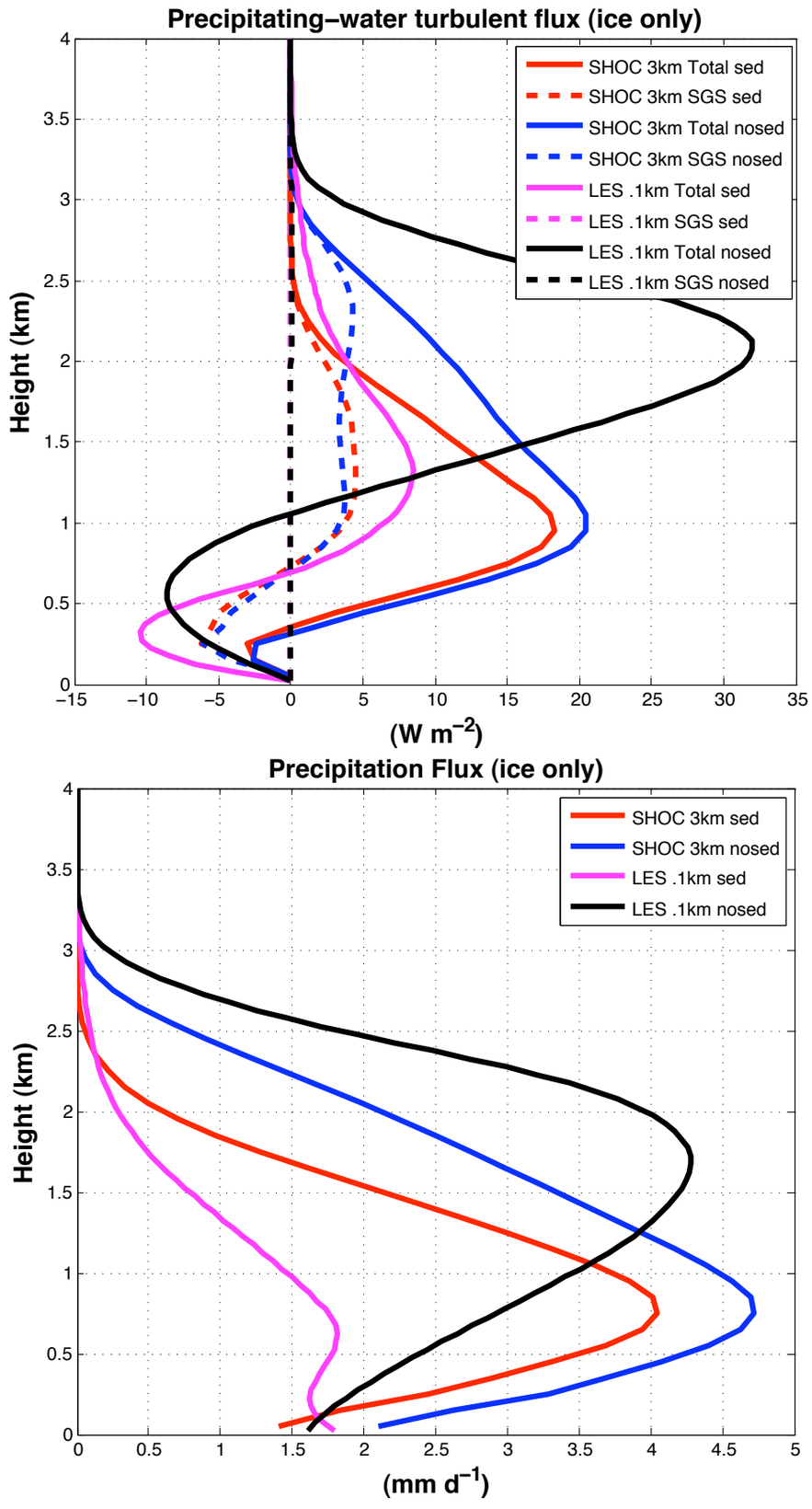




- ZINV is comparable in LES nosed to SHOC.
- Cloud fraction and total cloud water is higher in altitude/ magnitude in no-sed.

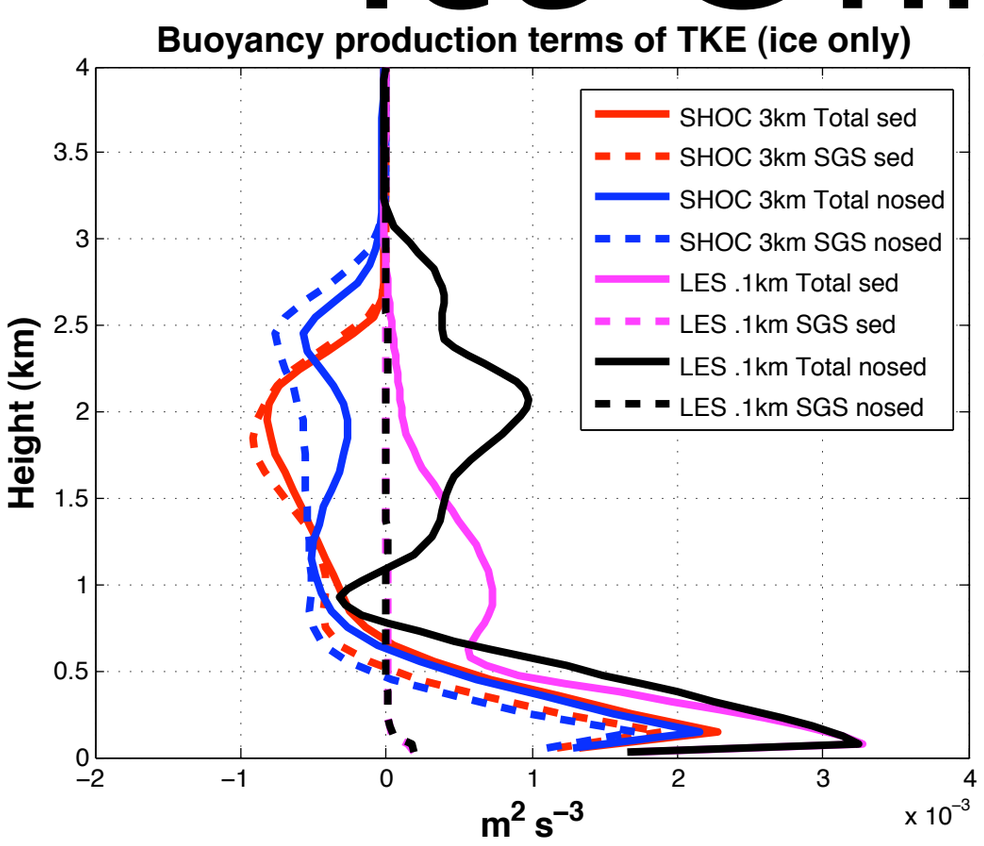
Ice Only No Sed

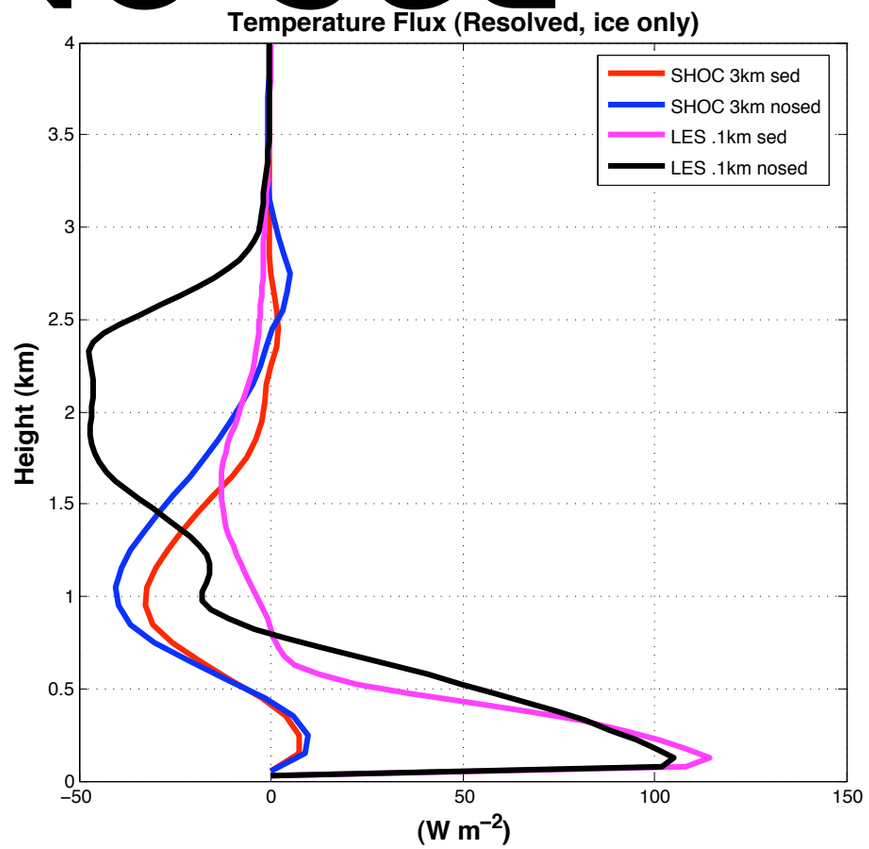




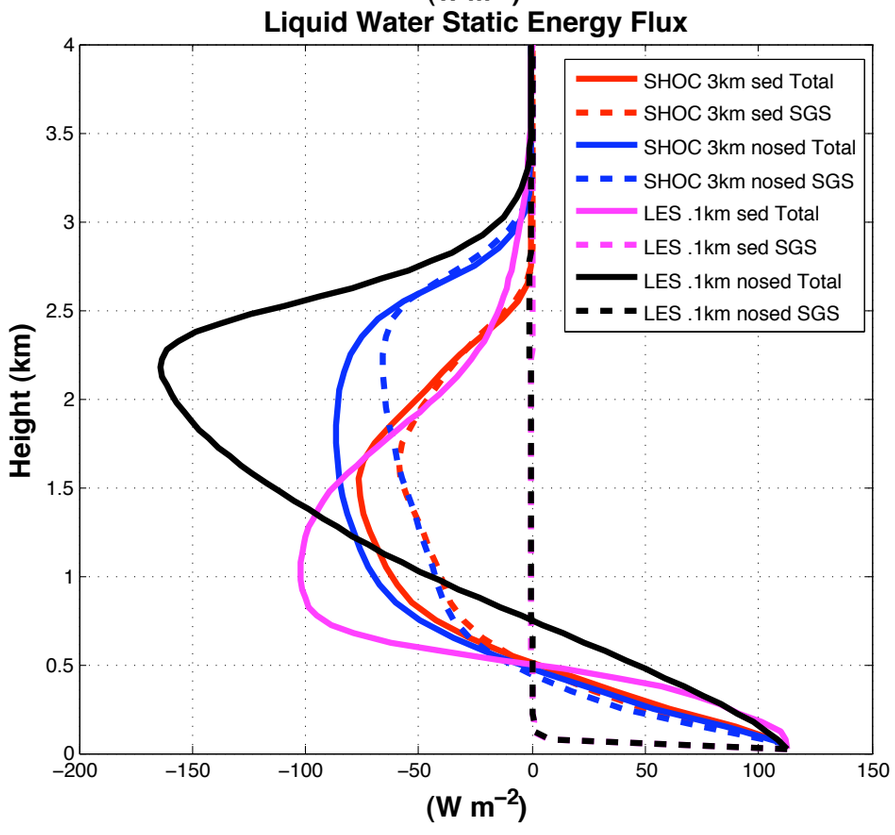
- No-sed starts lower, ends higher for surf. prec.
- QP and prec. flux is much higher in altitude/magnitude in no-sed.

Ice Only No Sed

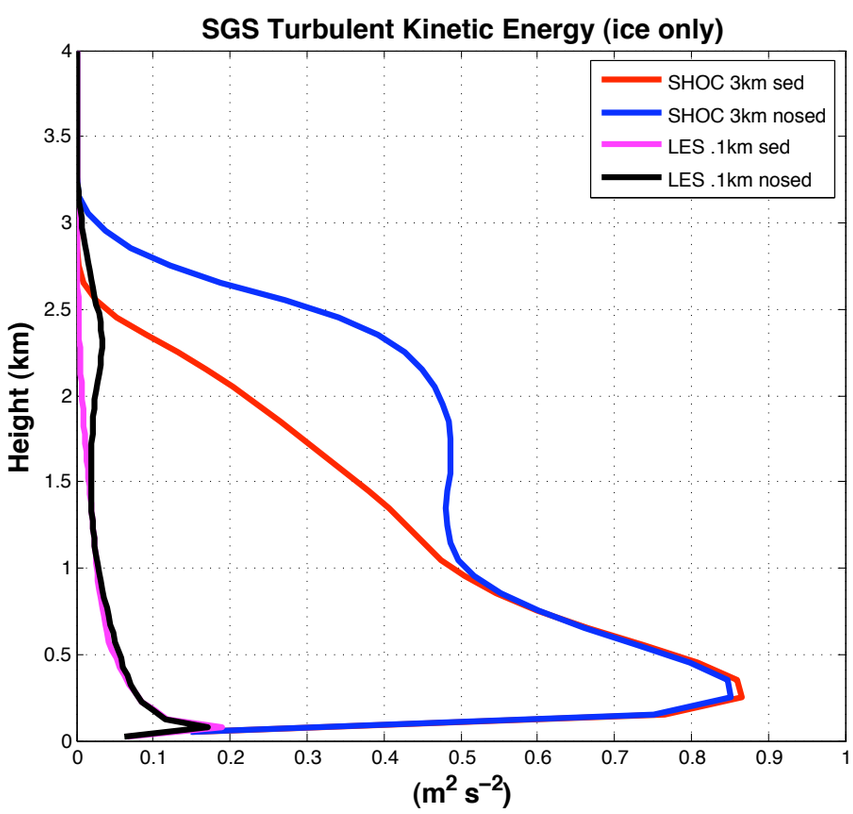


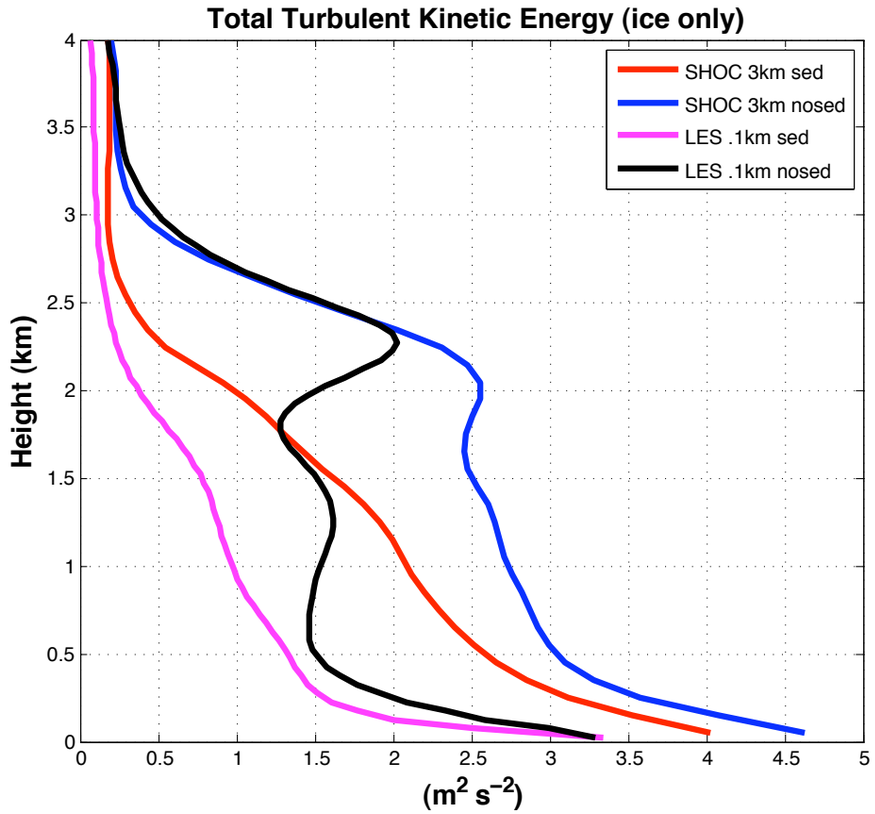


- Buoyancy goes negative in midlevels.
- Temp flux and LWSE more negative in LES.



Ice Only No Sed





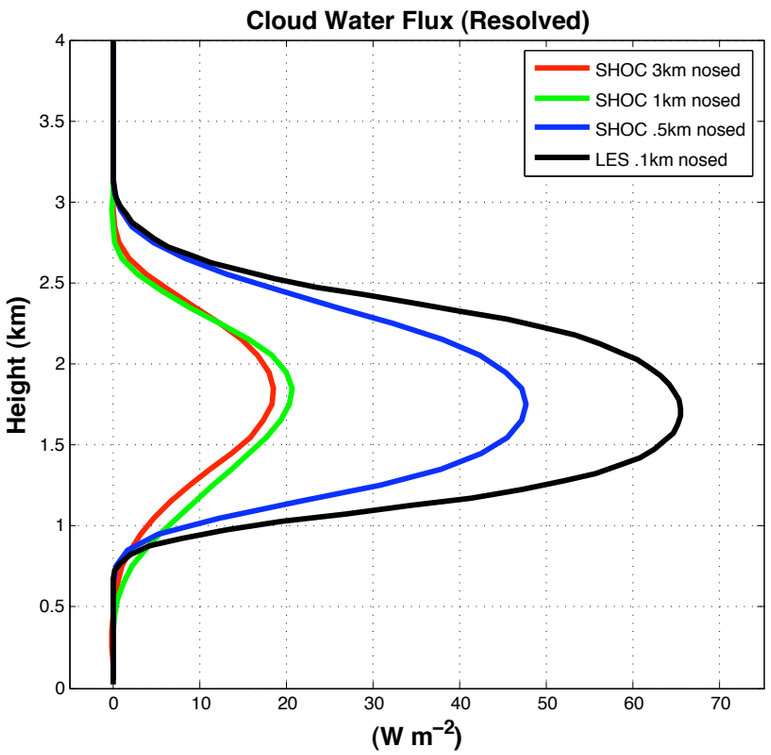
- SGS - higher SHOC magnitude in no-sed.
- Total - Higher magnitude no-sed runs.

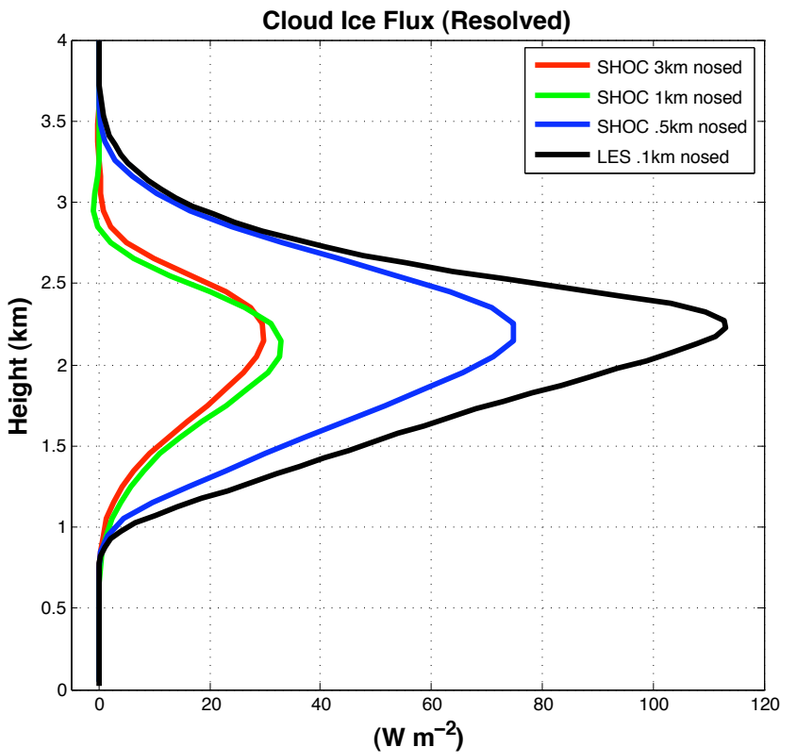
No Sed Plots

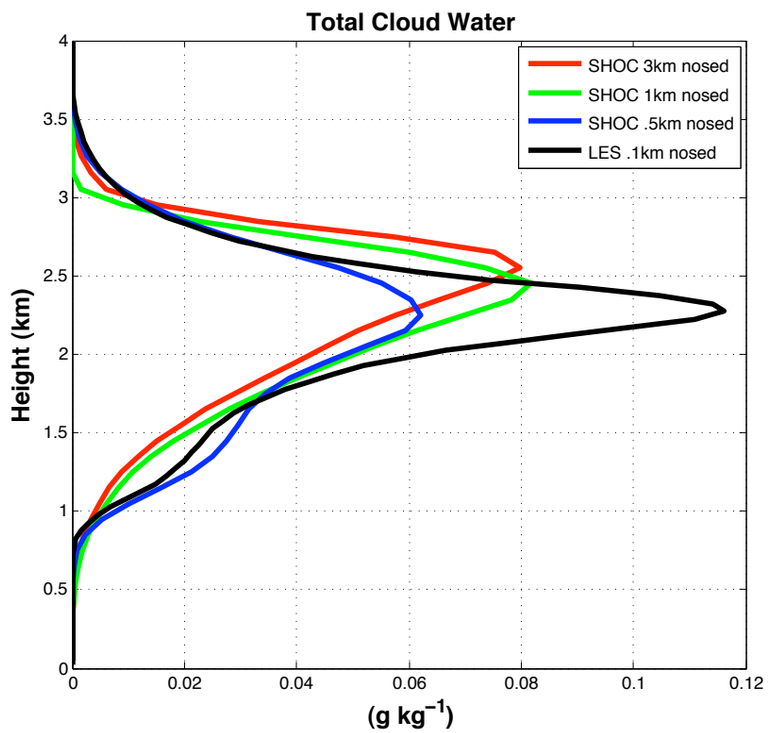
http://home.chpc.utah.edu/~u0652833/SAM_constrain/f_series_NoSed_plots/

- Includes SHOC runs 601f 602f 603f.
- LES run 805f.
- Comparisons are to full physics.

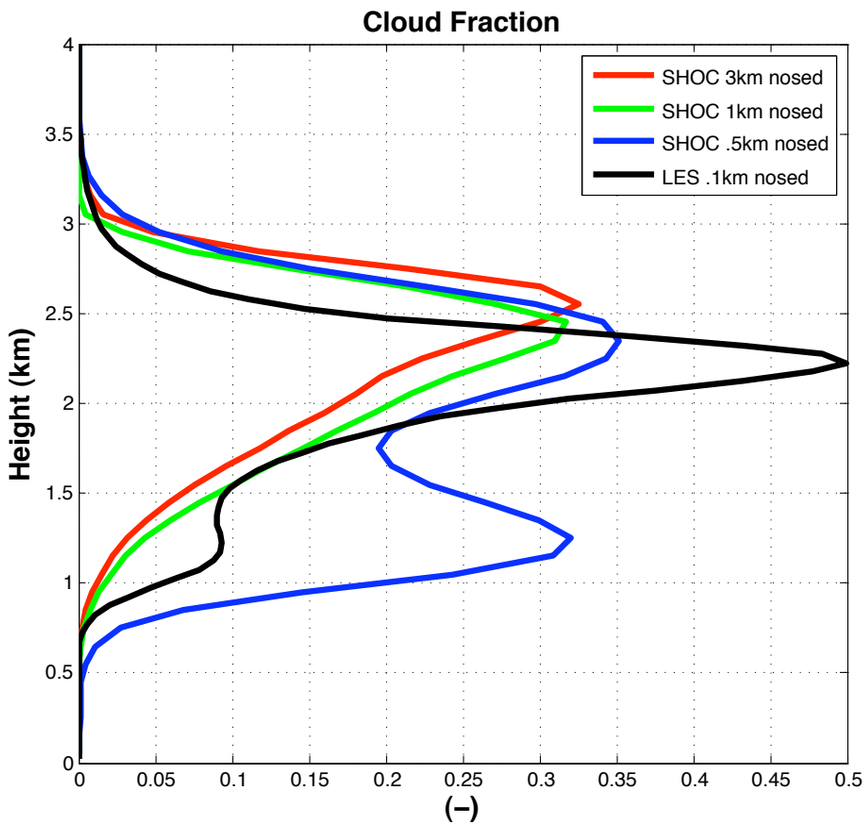
No Sed Plots



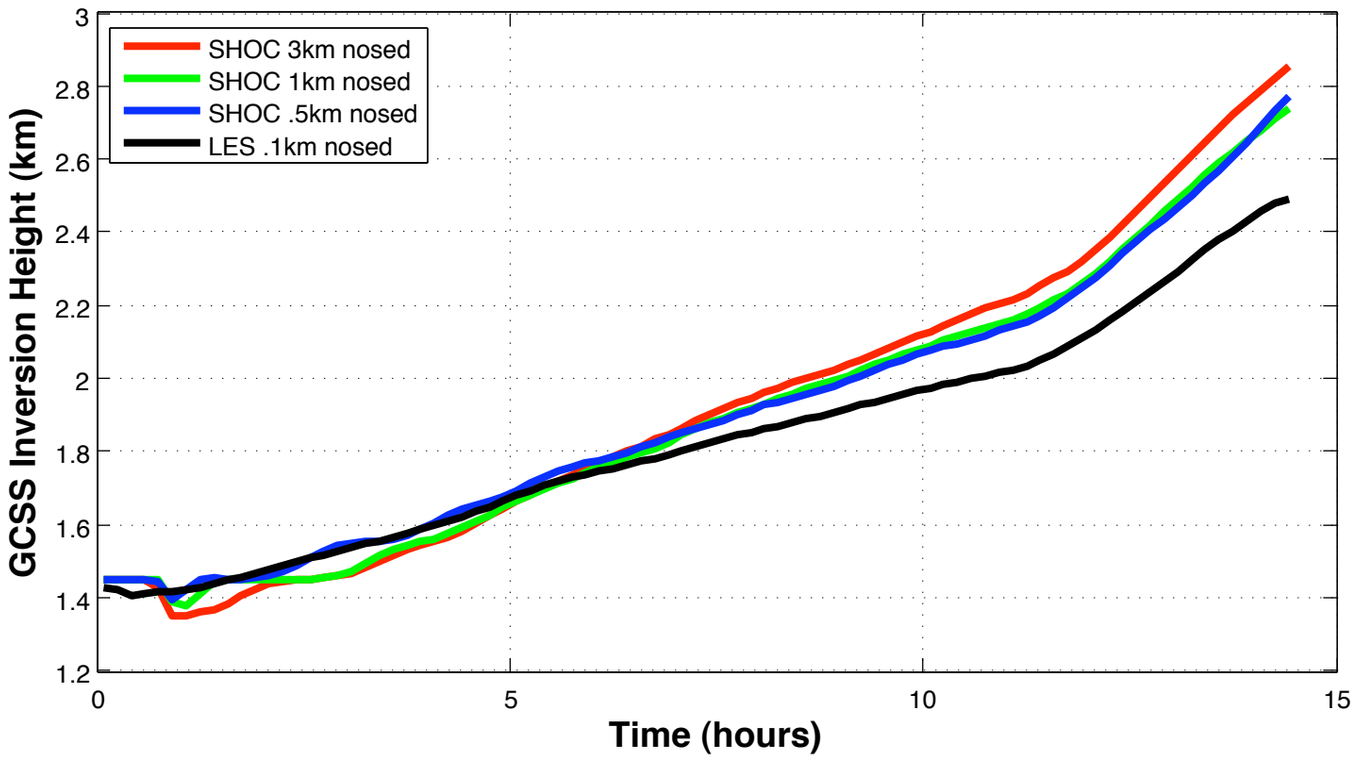


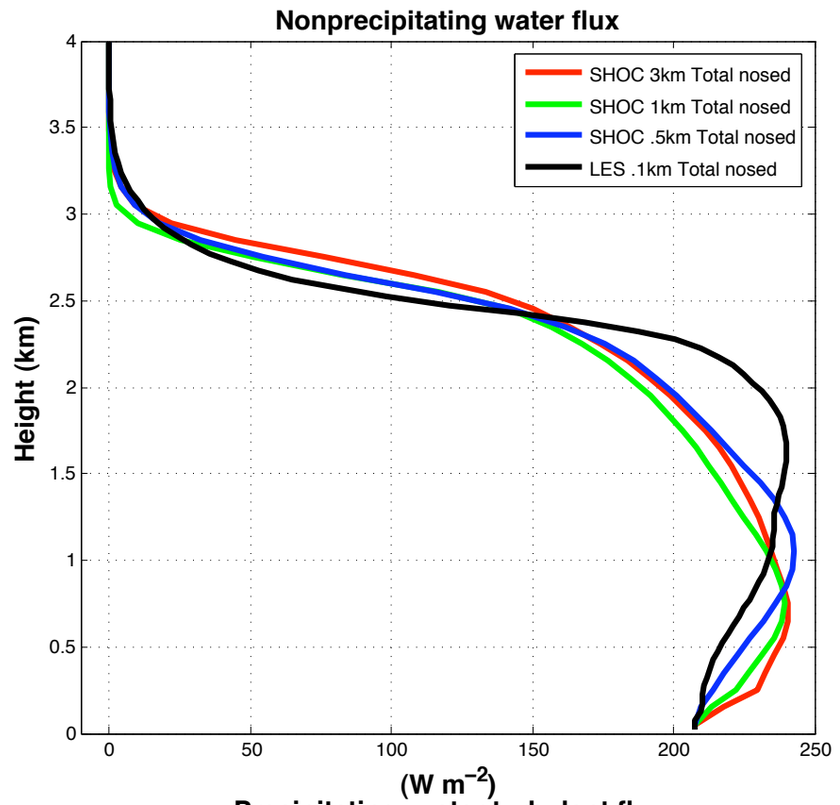


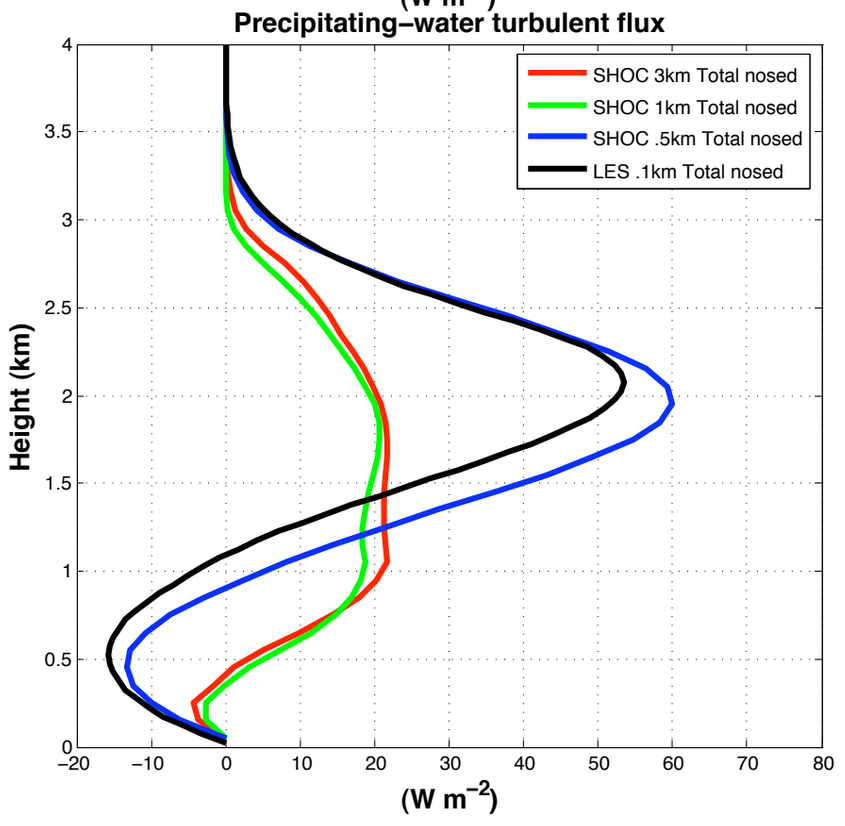
- QC - LES smaller, aligned altitude.
- QI - Larger in no-sed, aligned altitude.
- Total cloud water: larger mag, aligned alt.
- Cloud Frac. - double mag. , altitude aligned, .5km SHOC two peaks.



No Sed Plots

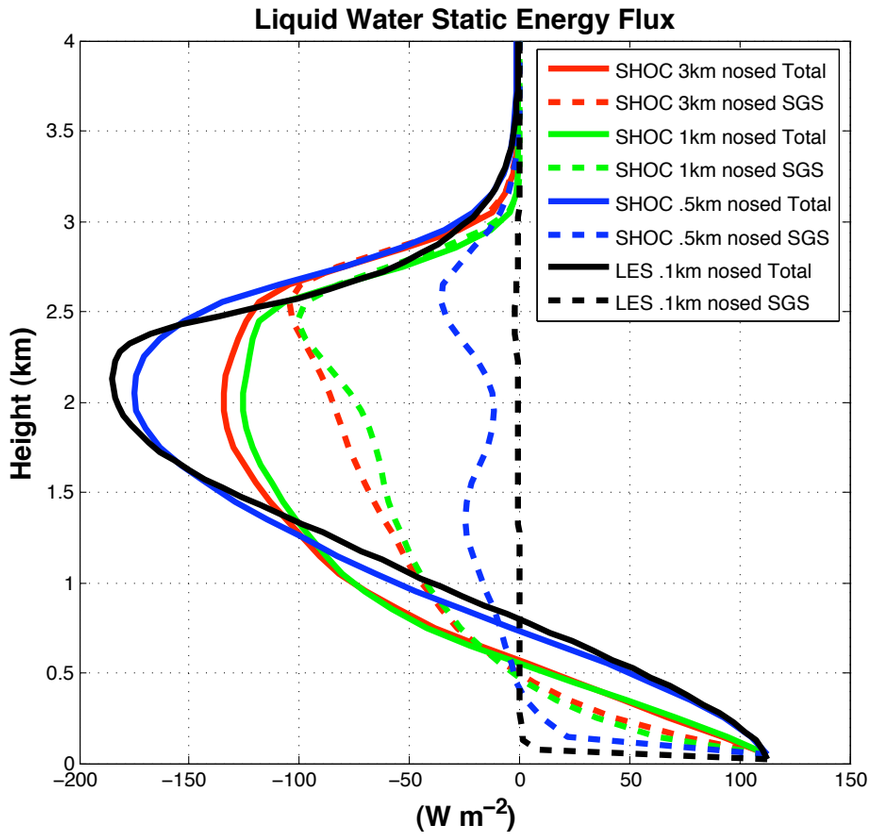


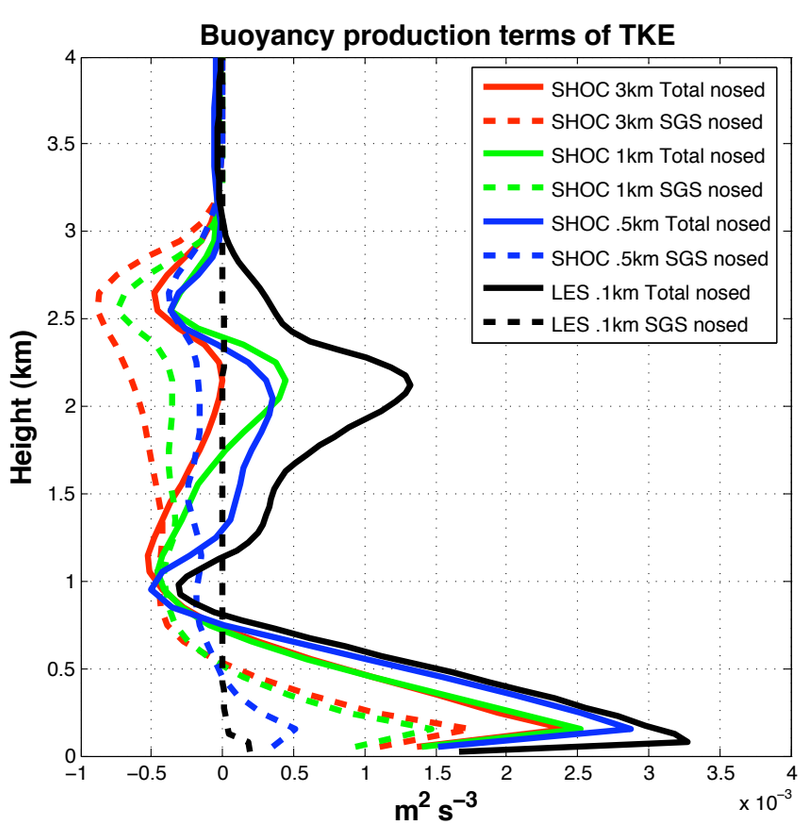




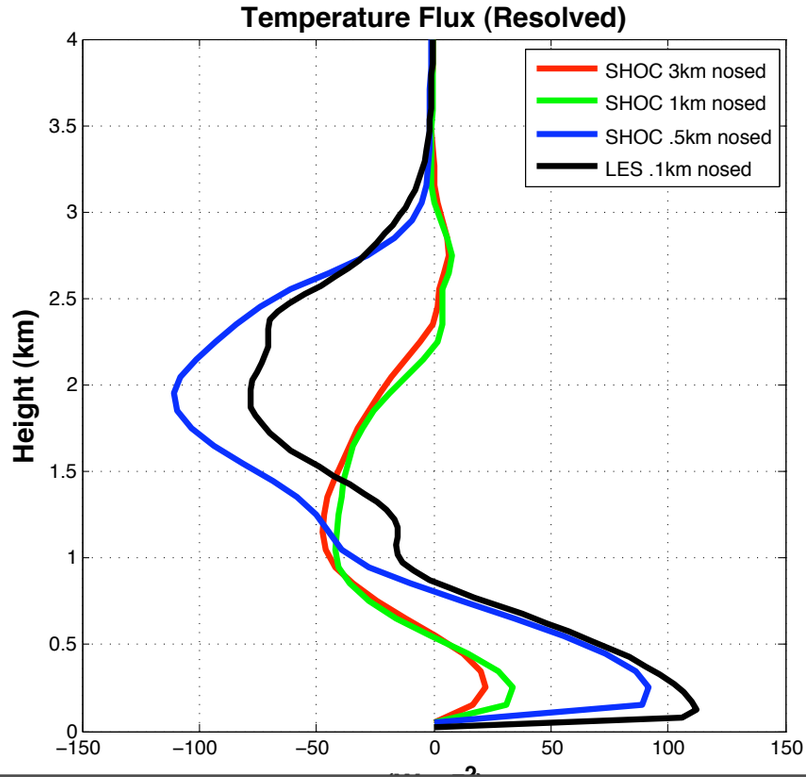
- ZINV - LES and SHOC close together.
- QT - higher altitude reaching
- QP - much larger LES and .5km SHOC magnitude

No Sed Plots

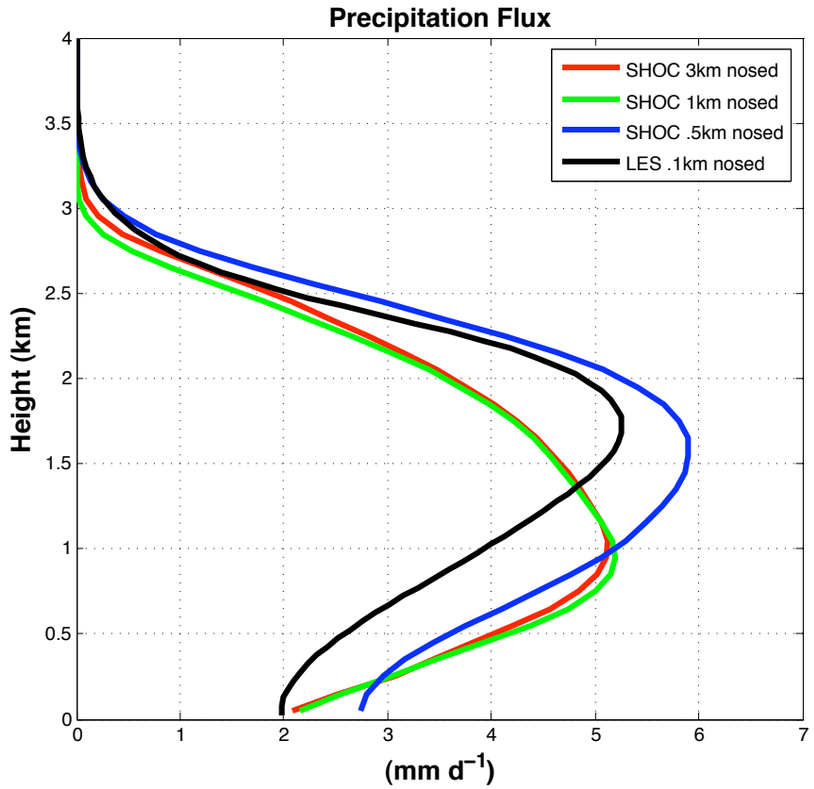


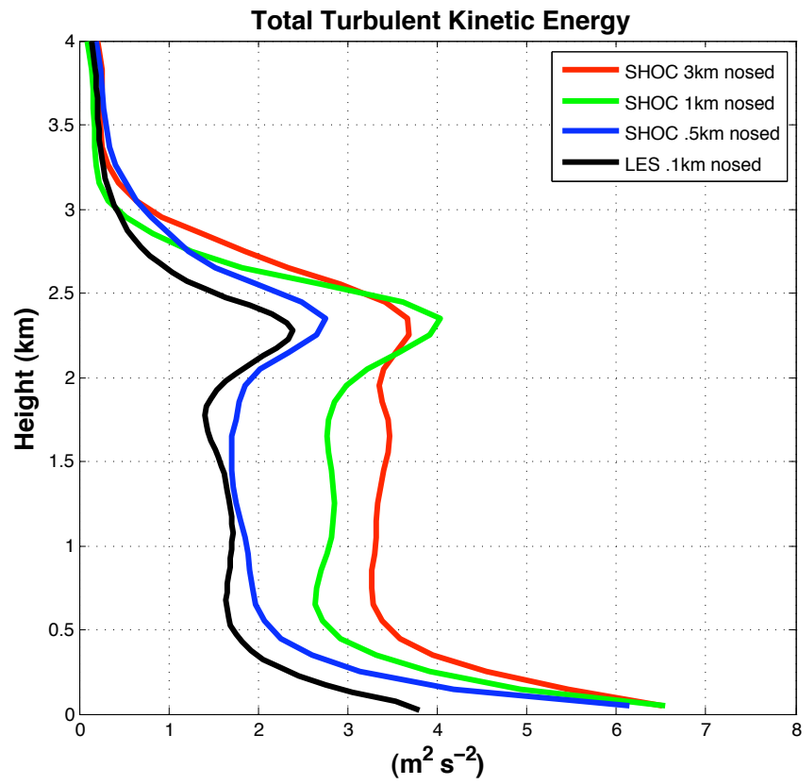


- LWSE more aligned in altitude.
- Buoyancy - LES positive at 2km rather than negative in full physics.
- Temp flux much more negative at 2km than full phys.



No Sed Plots





- Precip curves are closer, larger magnitude for .5km and LES.
- Total TKE has a bump around 2km cloud max.

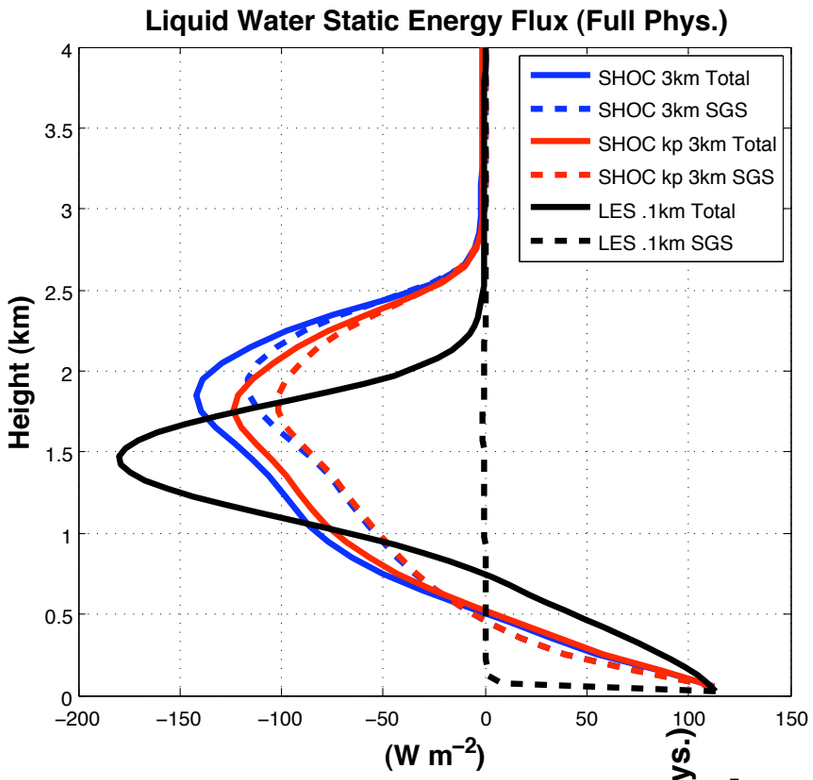
Kp series

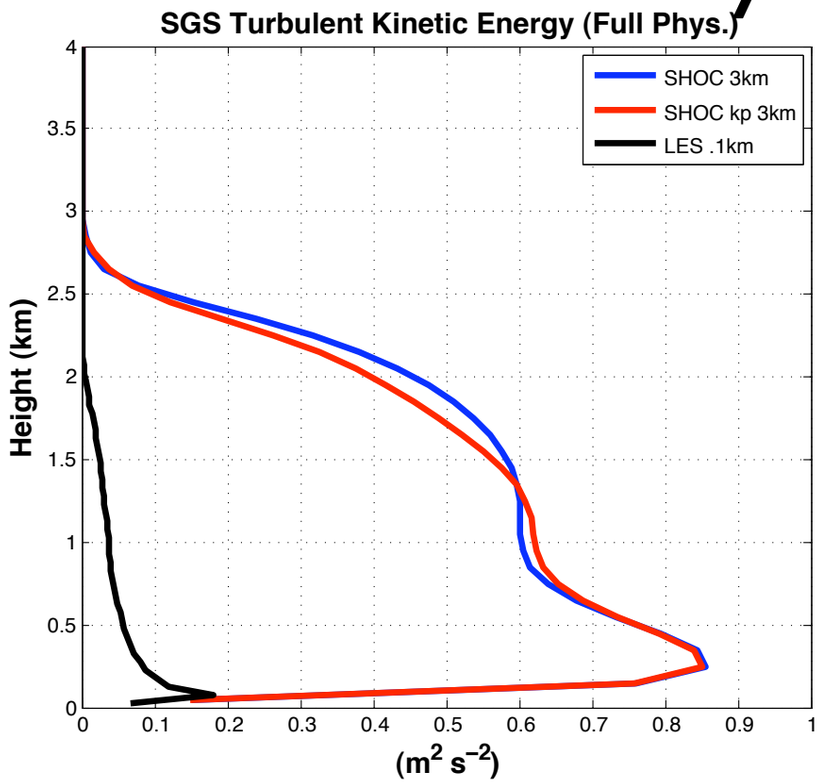
http://home.chpc.utah.edu/~u0652833/SAM_constrain/full_physics_series_kp/

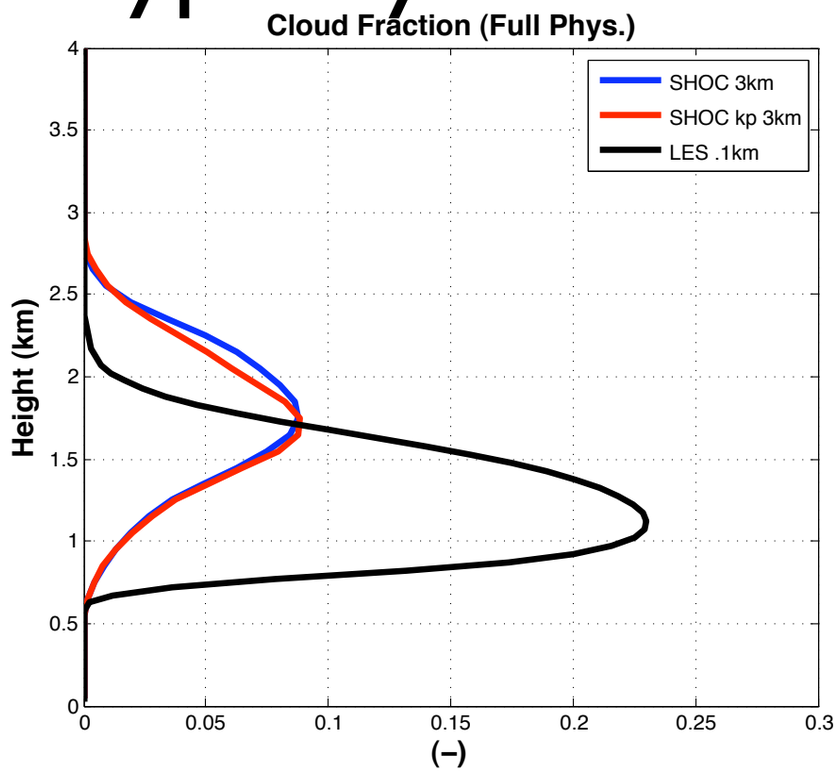
- This test is to see if running a SAM run on kingspeak vs updraft makes a difference.
- While there might be some difference in how the systems run the program, this is mostly just looking at what the randomness of the initial conditions can lead to...

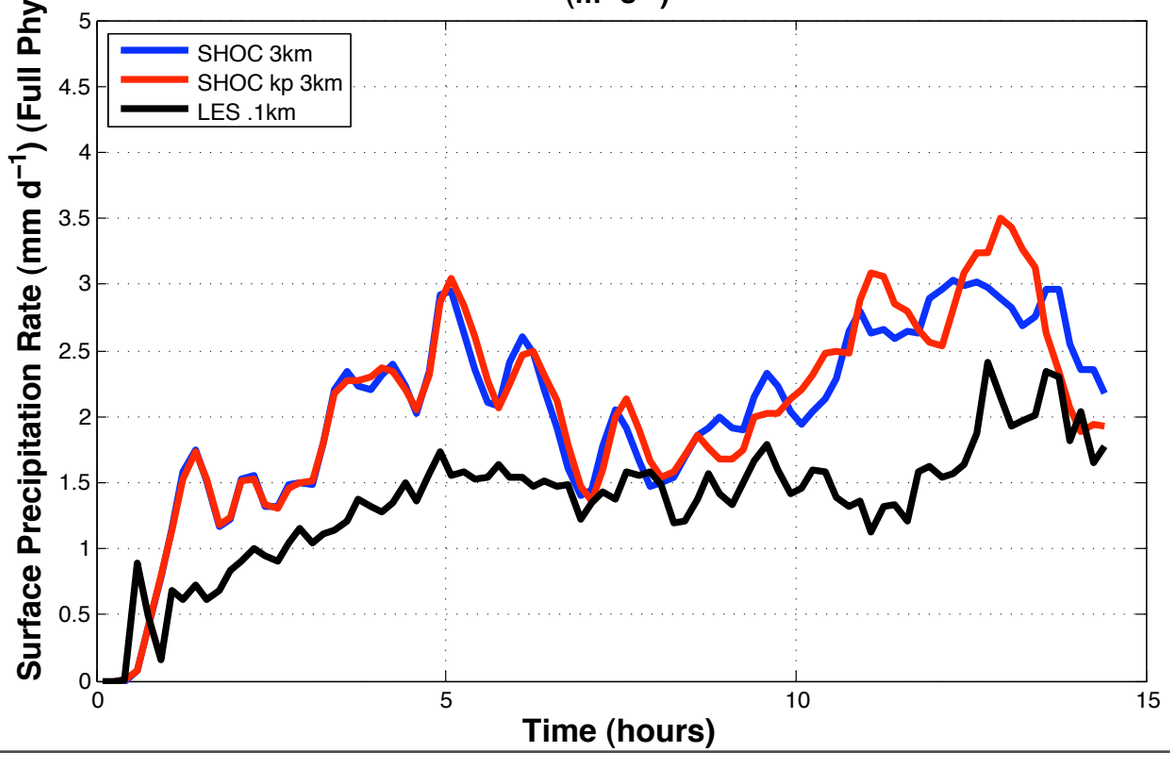
Kp Series

... and while differences exist they're typically small.









Kp-fix Plots

http://home.chpc.utah.edu/~u0652833/SAM_constrain/full_physics_series/kp_fix_plots/

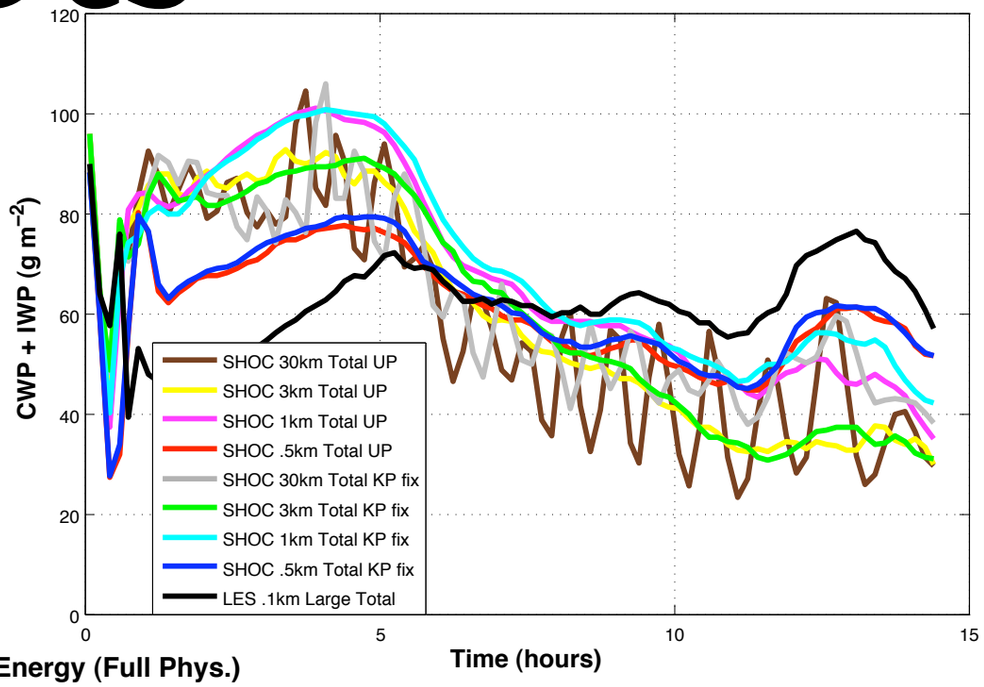
http://home.chpc.utah.edu/~u0652833/SAM_constrain/c_series_NoIce_plots/kpfix_plots/

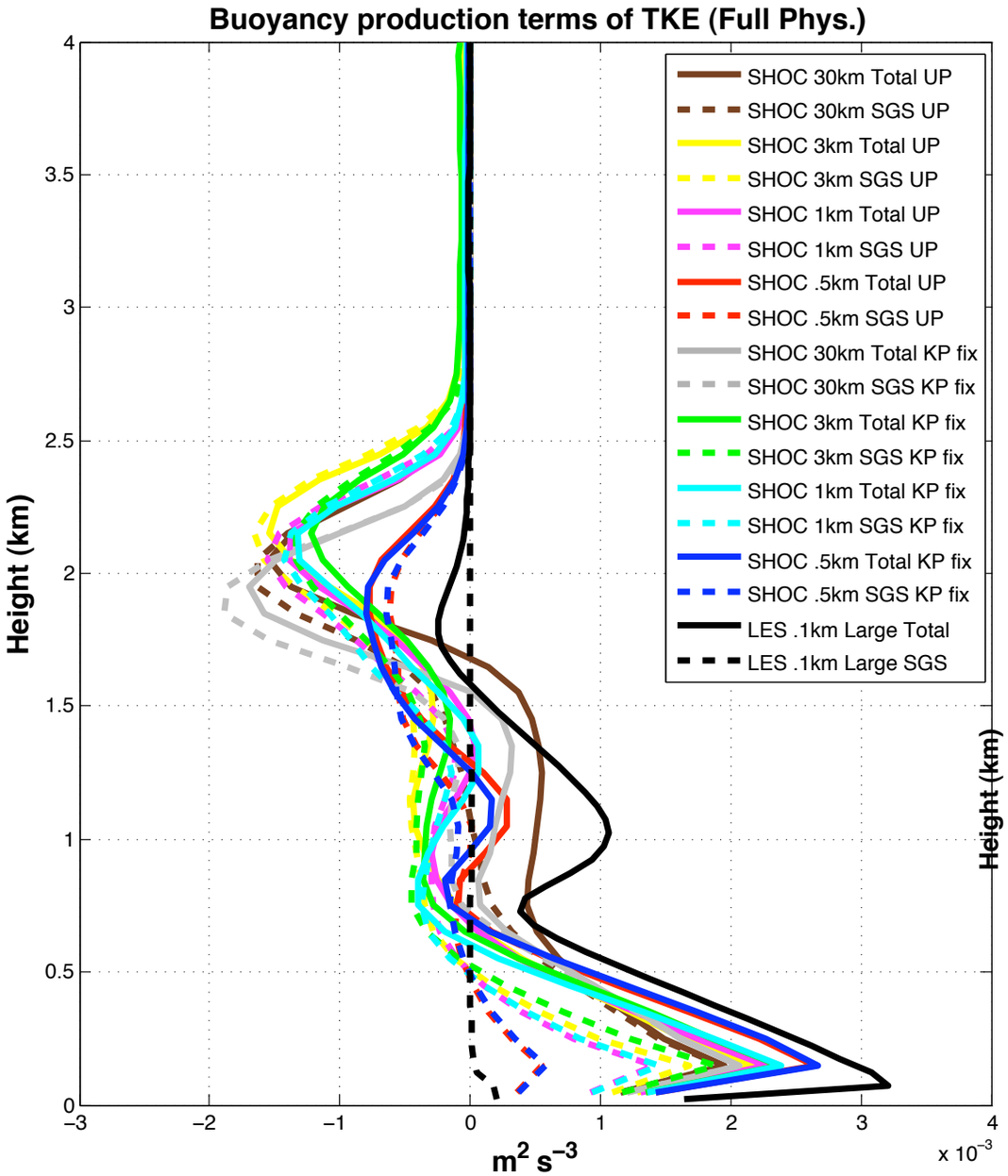
http://home.chpc.utah.edu/~u0652833/SAM_constrain/d_series_iceonly_plots/kpfix_plots/

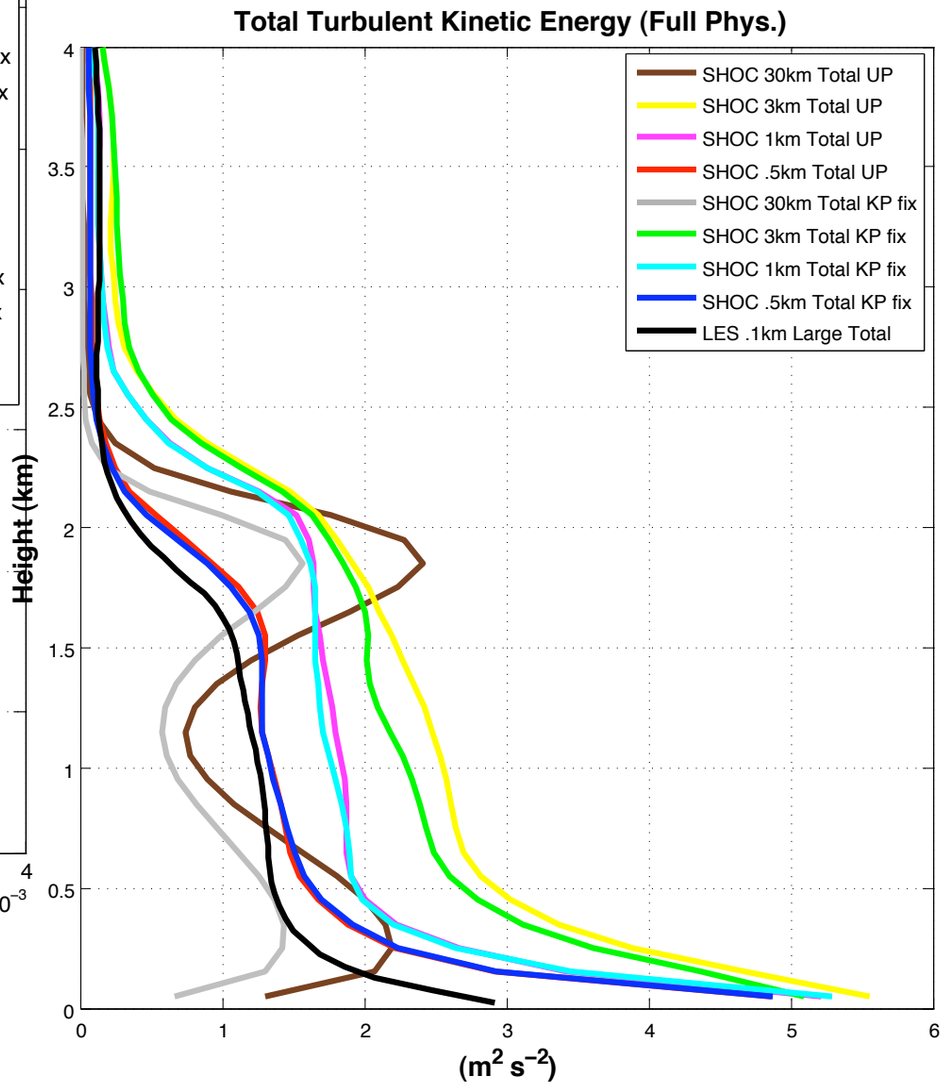
- These are from runs that have the corrected code for W3.
- Since the correction is to a coefficient of one part of W3 it was uncertain what the effect would be.

Kp-fix plots

It ended up also being trivial.
For full physics...

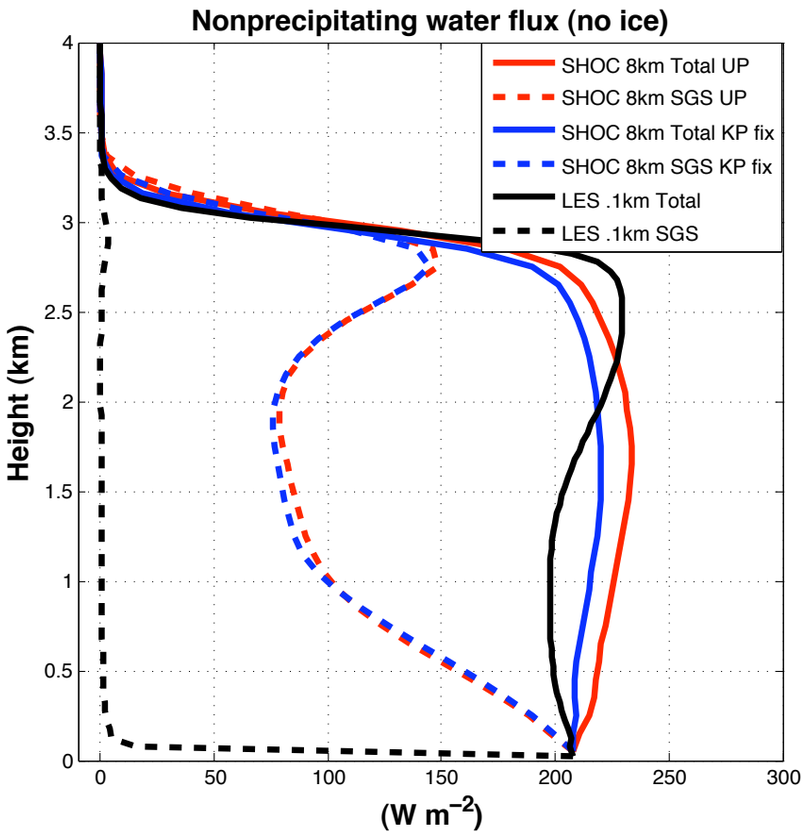


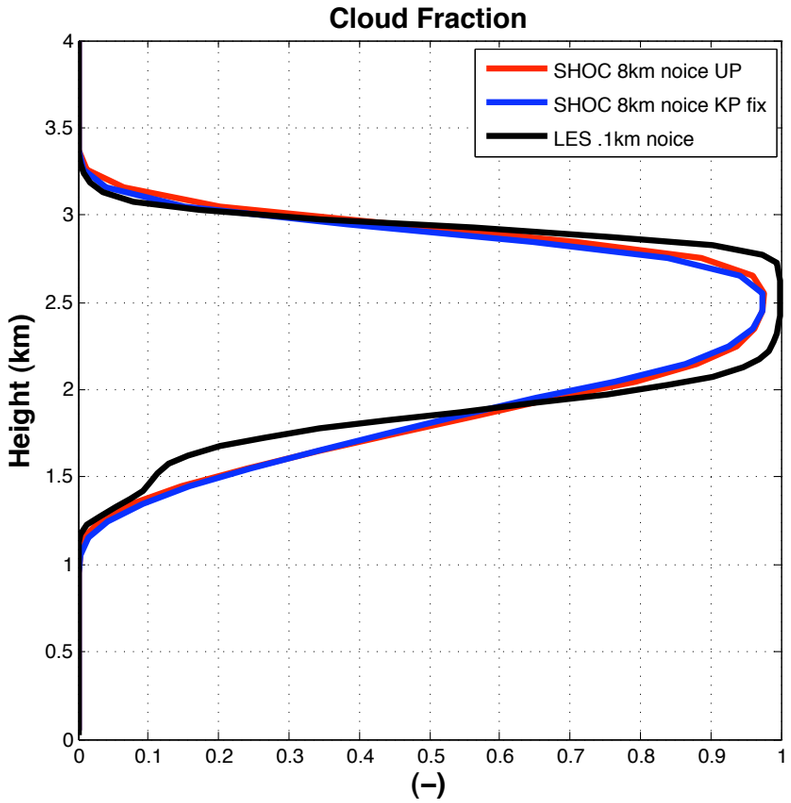


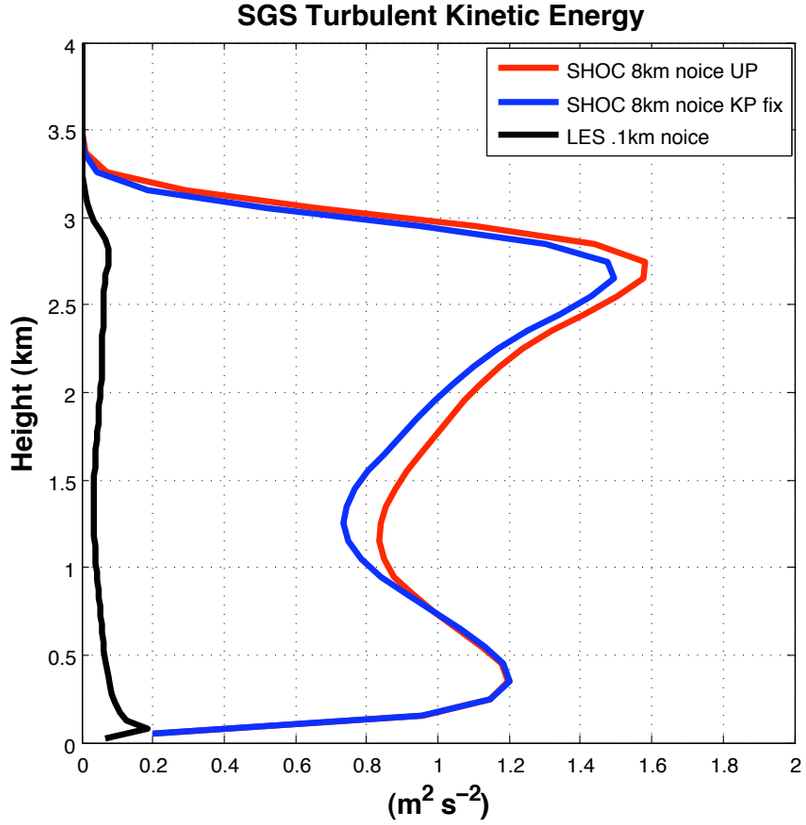


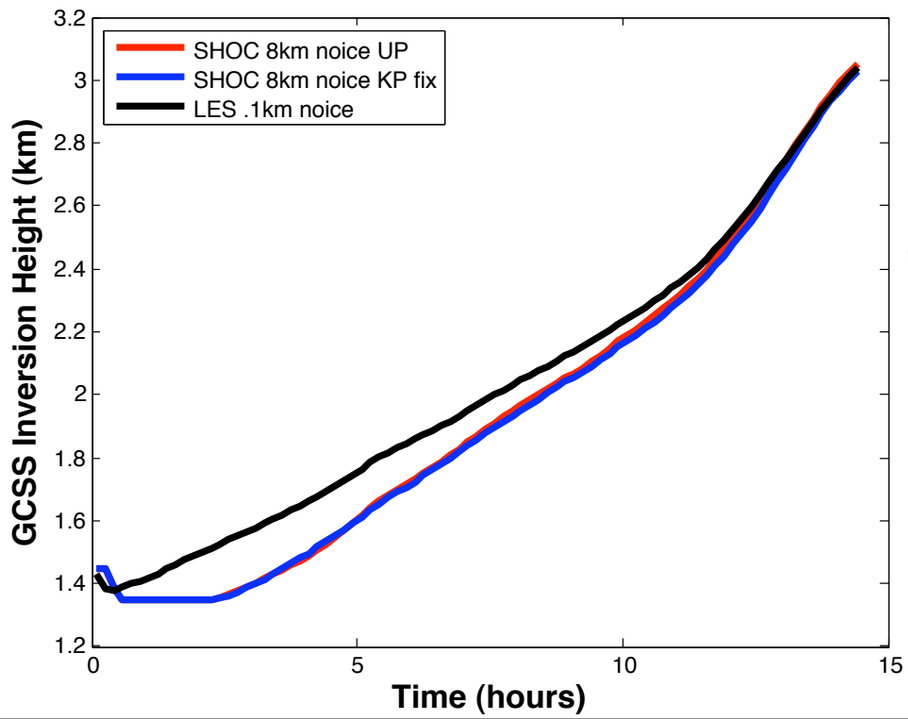
Kp-fix plots

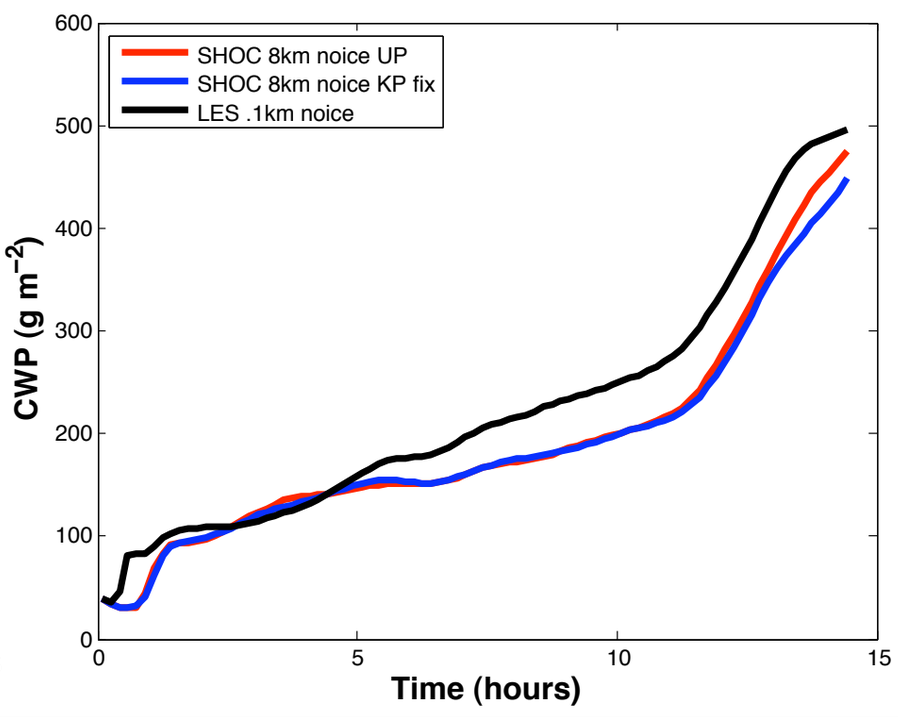
...or no ice...



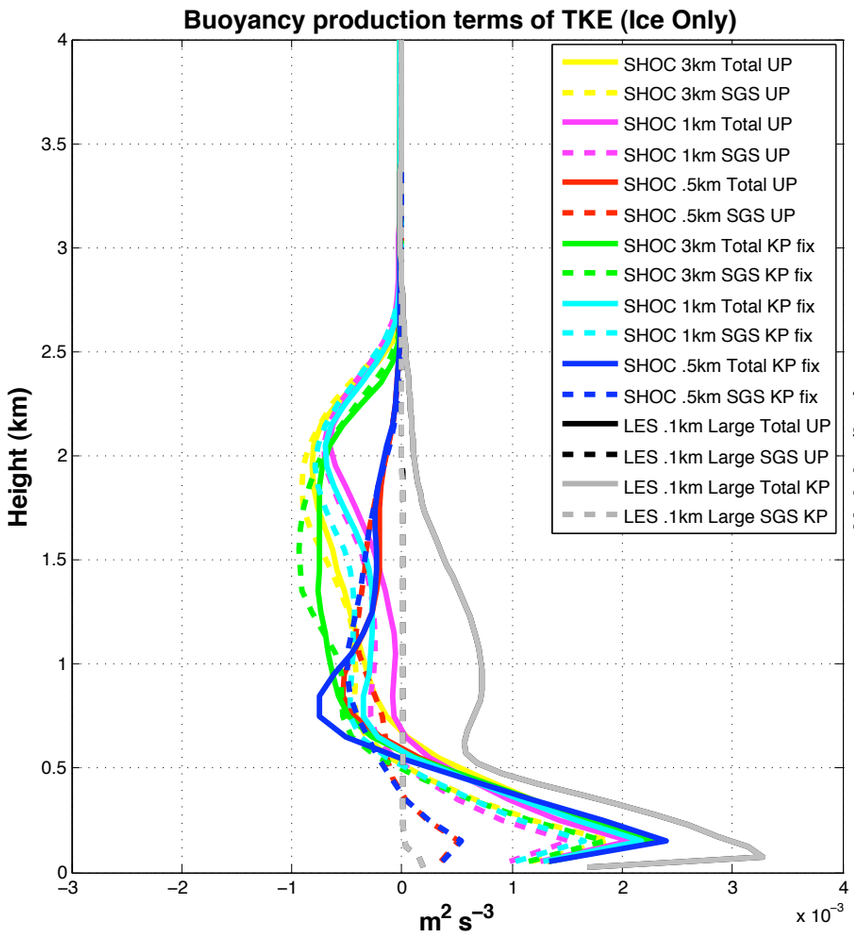


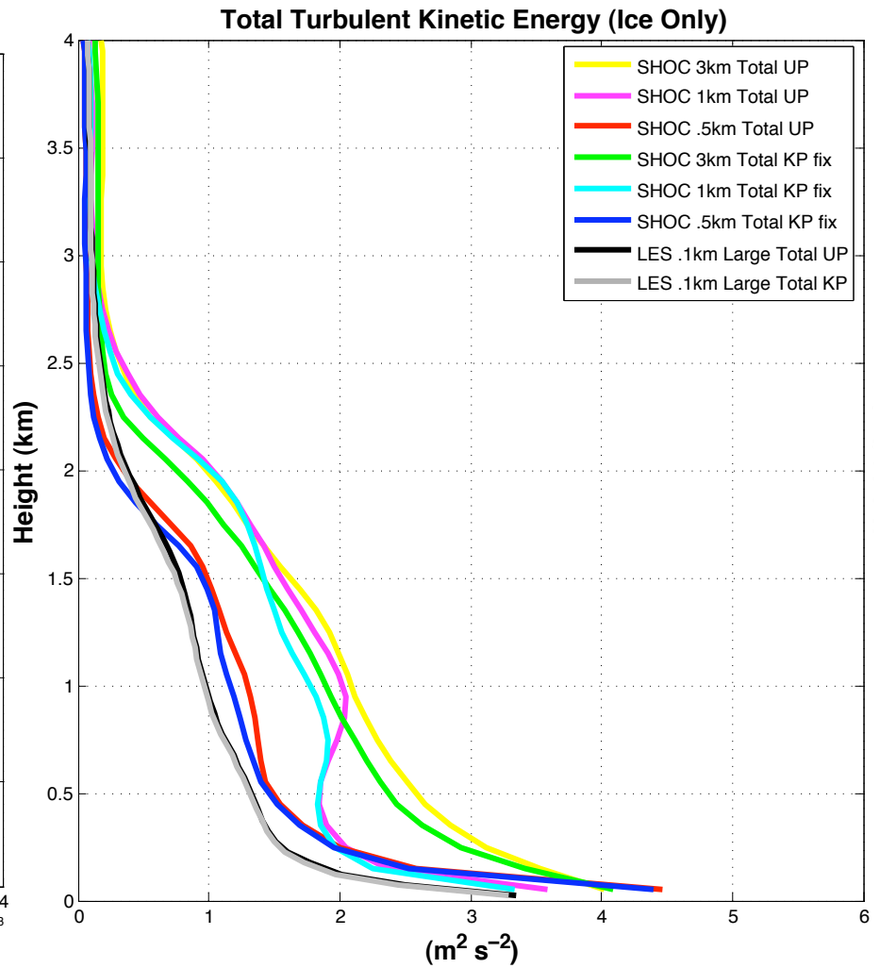


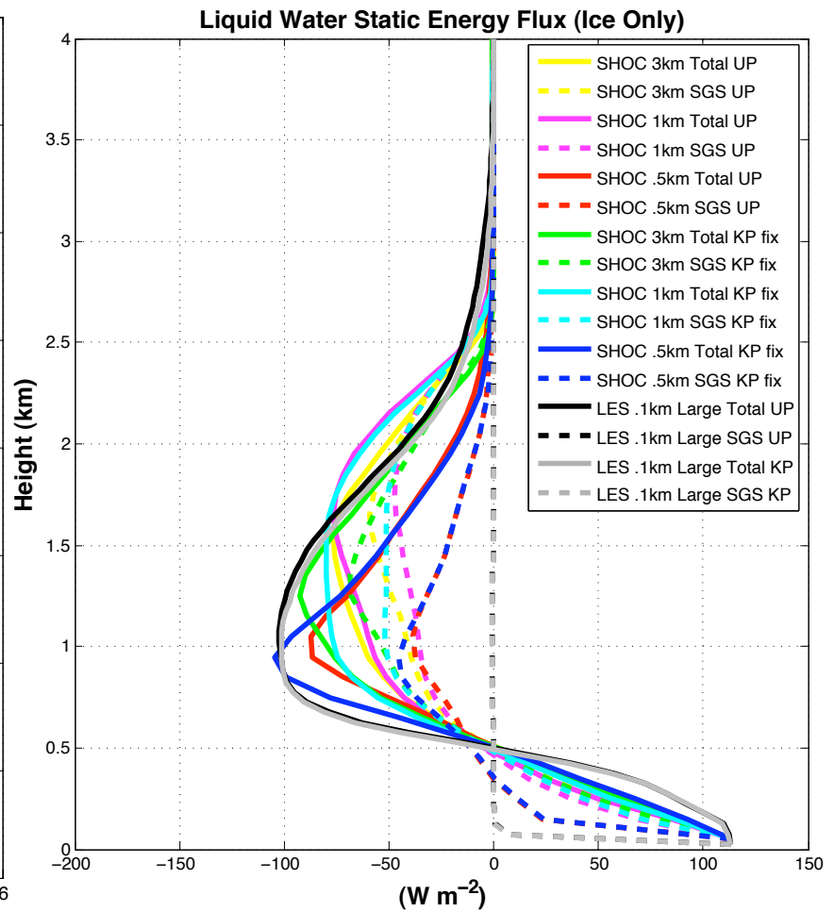


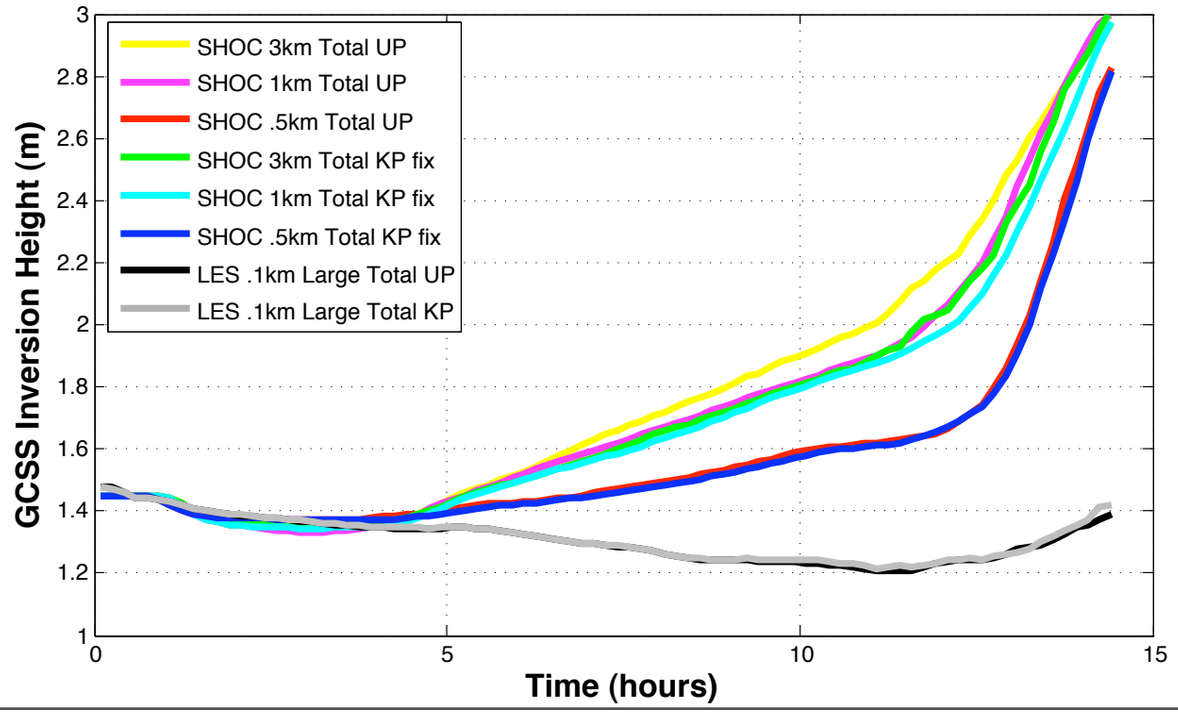


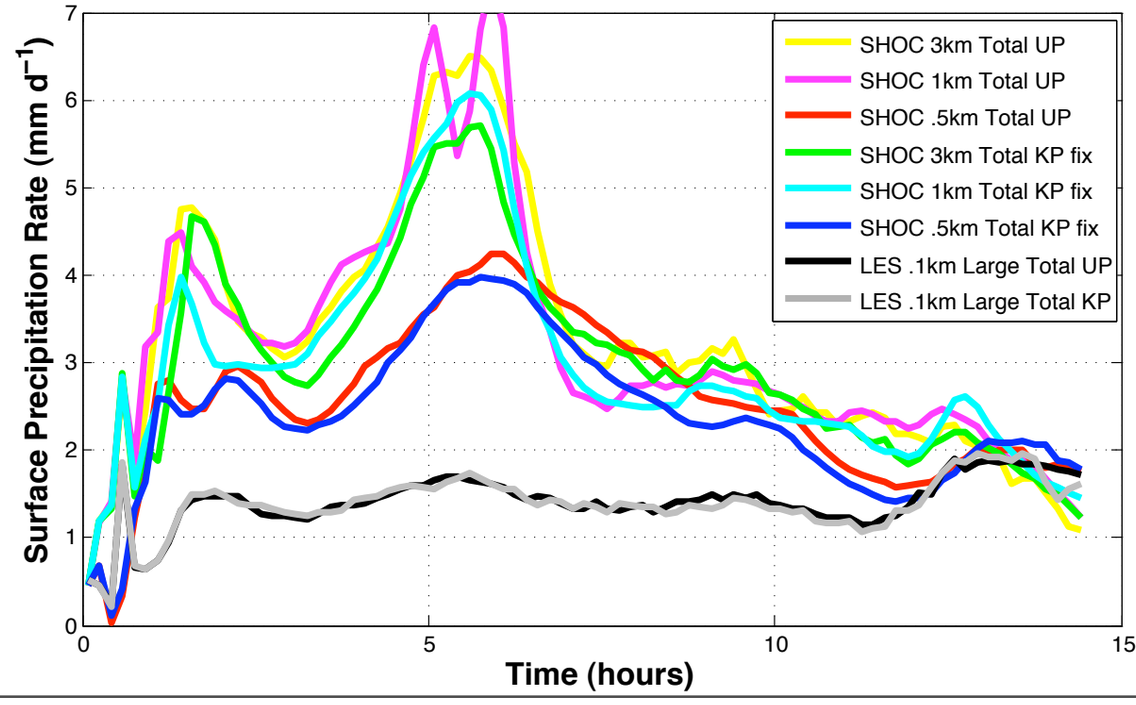
Kp-fix plots


Buoyancy production terms of TKE (Ice Only)
Height (km)
m² s⁻³
x 10⁻³
SHOC 3km Total UP
SHOC 3km SGS UP
SHOC 1km Total UP
SHOC 1km SGS UP
SHOC .5km Total UP
SHOC .5km SGS UP
SHOC 3km Total KP fix
SHOC 3km SGS KP fix
SHOC 1km Total KP fix
SHOC 1km SGS KP fix
SHOC .5km Total KP fix
SHOC .5km SGS KP fix
LES .1km Large Total UP
LES .1km Large SGS UP
LES .1km Large Total KP
LES .1km Large SGS KP


Total Turbulent Kinetic Energy (Ice Only)
Height (km)
(m² s⁻²)
SHOC 3km Total UP
SHOC 1km Total UP
SHOC .5km Total UP
SHOC 3km Total KP fix
SHOC 1km Total KP fix
SHOC .5km Total KP fix
LES .1km Large Total UP
LES .1km Large Total KP


Liquid Water Static Energy Flux (Ice Only)
Height (km)
(W m⁻²)
SHOC 3km Total UP
SHOC 3km SGS UP
SHOC 1km Total UP
SHOC 1km SGS UP
SHOC .5km Total UP
SHOC .5km SGS UP
SHOC 3km Total KP fix
SHOC 3km SGS KP fix
SHOC 1km Total KP fix
SHOC 1km SGS KP fix
SHOC .5km Total KP fix
SHOC .5km SGS KP fix
LES .1km Large Total UP
LES .1km Large SGS UP
LES .1km Large Total KP
LES .1km Large SGS KP

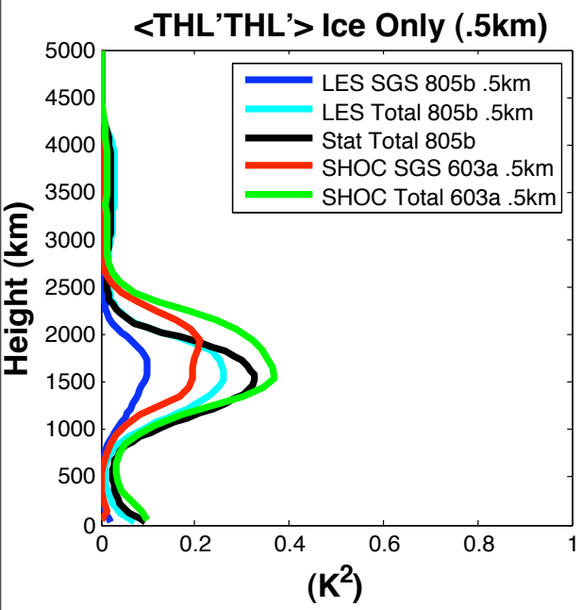

GCSS Inversion Height (m)
Time (hours)
SHOC 3km Total UP
SHOC 1km Total UP
SHOC .5km Total UP
SHOC 3km Total KP fix
SHOC 1km Total KP fix
SHOC .5km Total KP fix
LES .1km Large Total UP
LES .1km Large Total KP

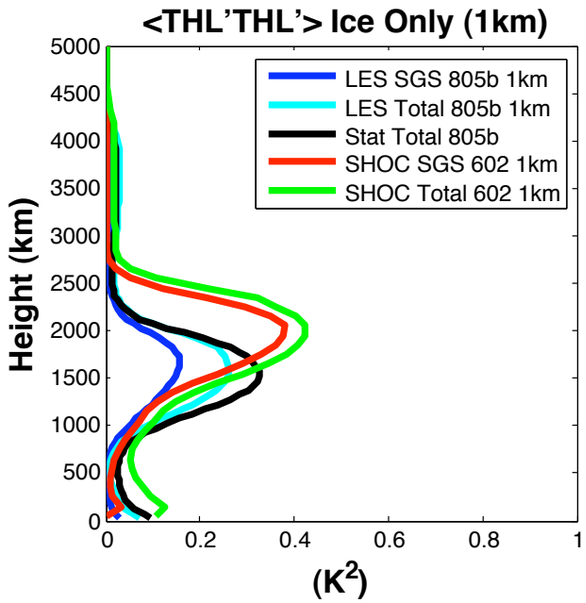

Surface Precipitation Rate (mm d⁻¹)
Time (hours)
SHOC 3km Total UP
SHOC 1km Total UP
SHOC .5km Total UP
SHOC 3km Total KP fix
SHOC 1km Total KP fix
SHOC .5km Total KP fix
LES .1km Large Total UP
LES .1km Large Total KP

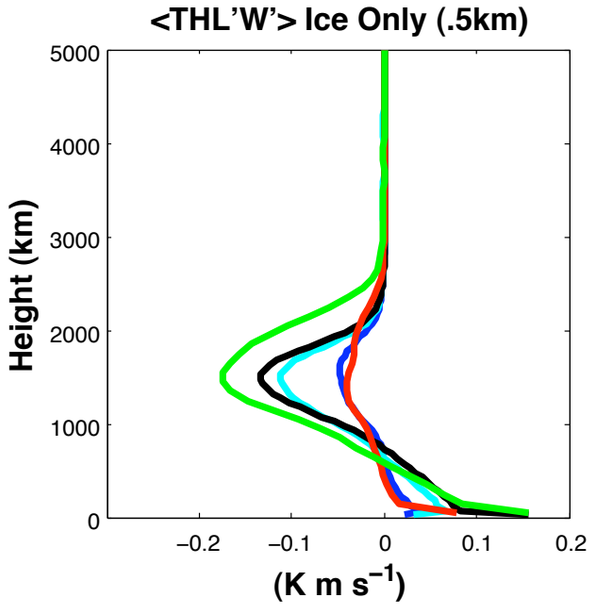
Moment Plots

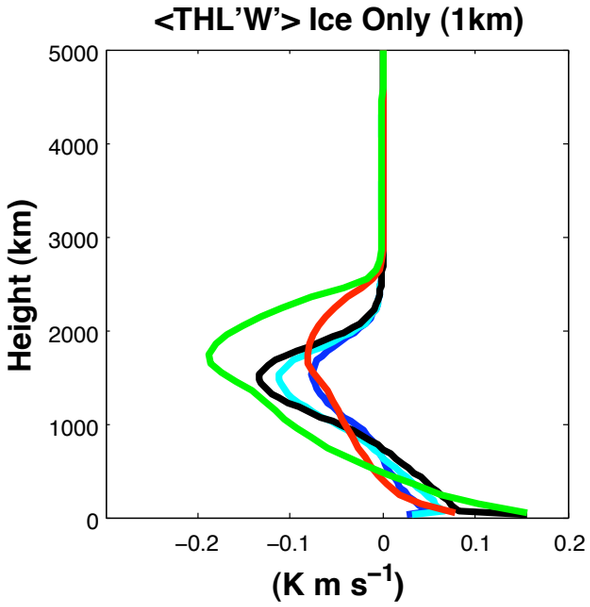
- These plots involve QT, W, and THL variables from the stats and moments files.
- This section will start with full physics and highlight relevant differences in ice only and no ice.

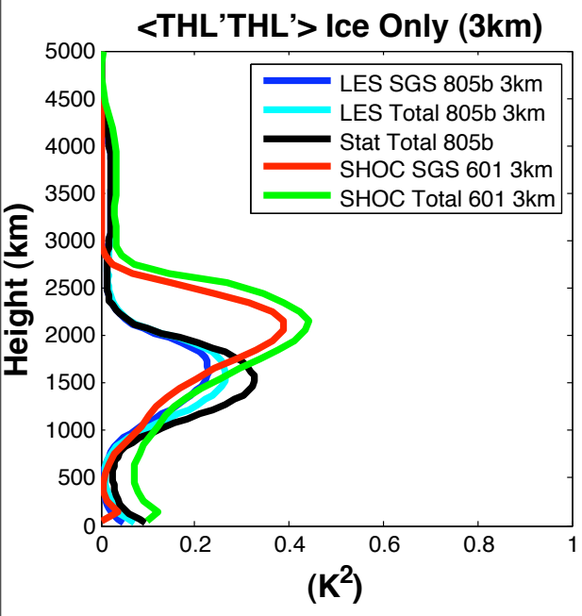
Moment Plots - Full Physics



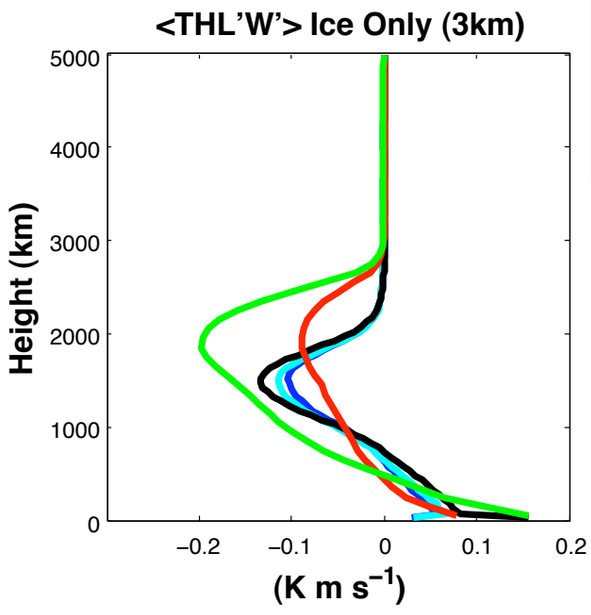


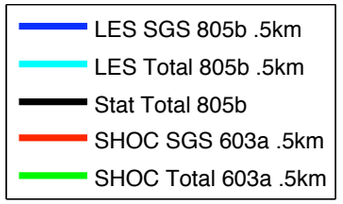


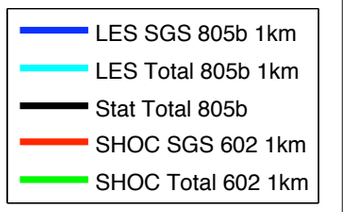


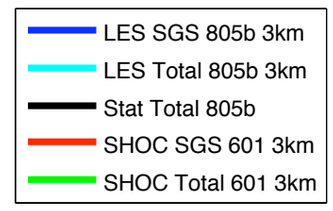


- THL'THL' - SHOC overestimates SGS and total. Overestimates altitude in 1km and 3km.
- THL'W' - SHOC too high on SGS for lower resolution. SHOC overestimates total.

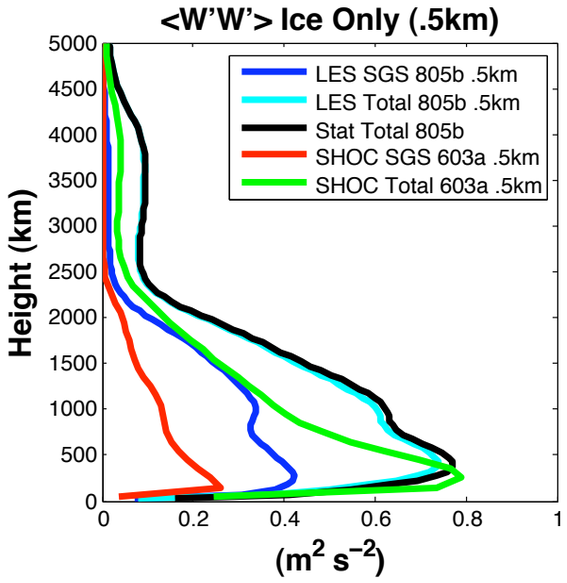


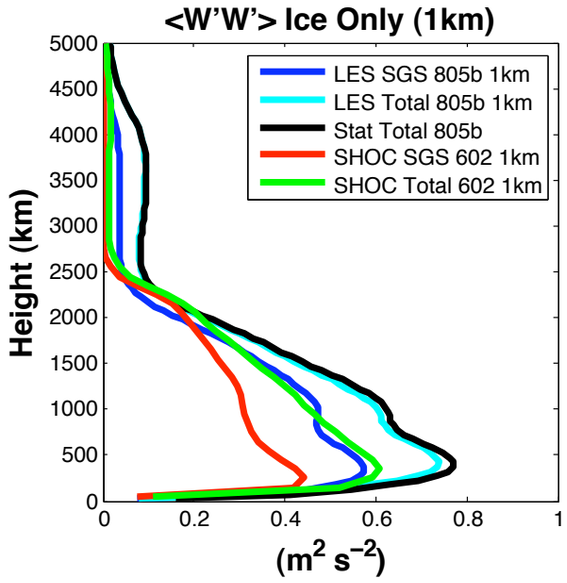


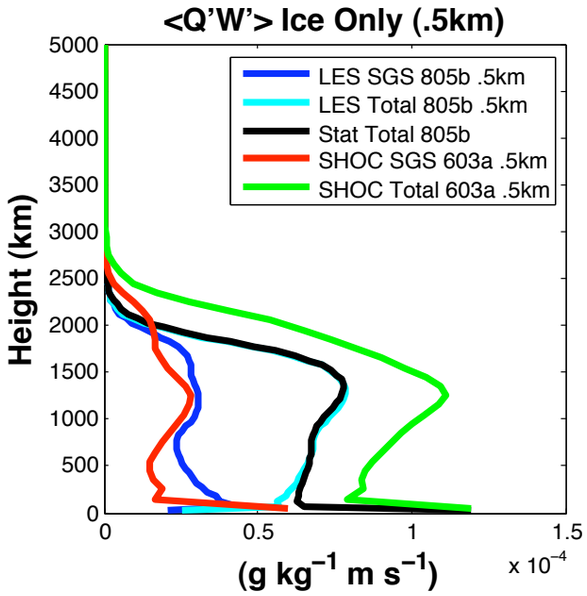


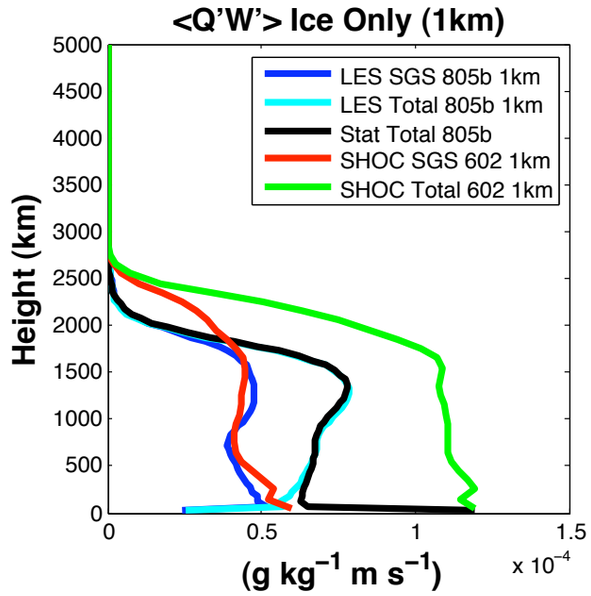


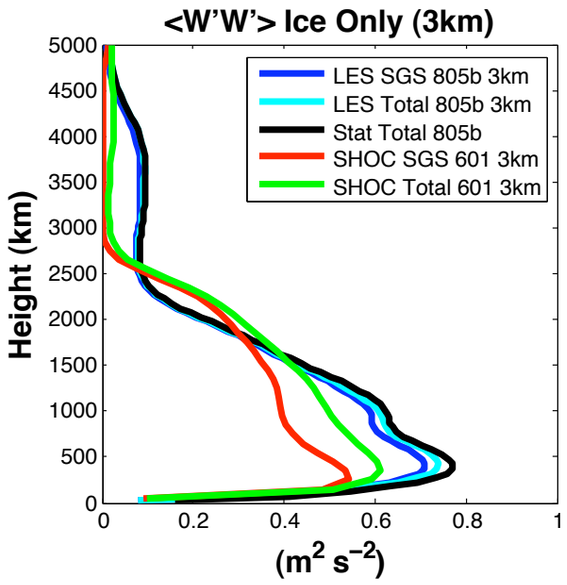
Moment Plots - Full Physics



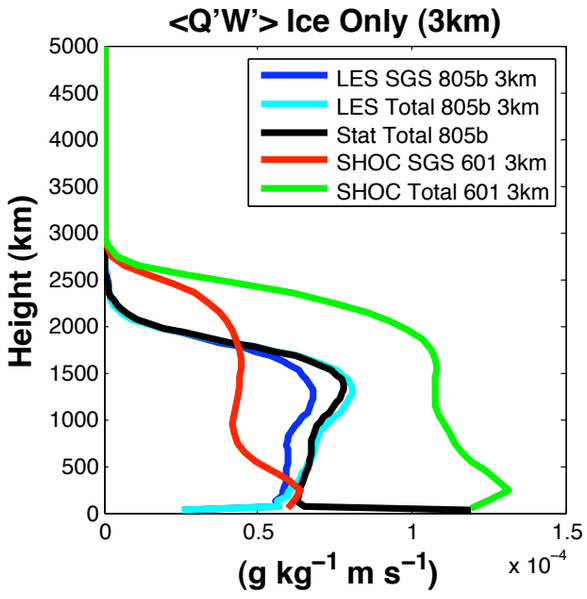








- W'W' - SHOC underestimates SGS and total.

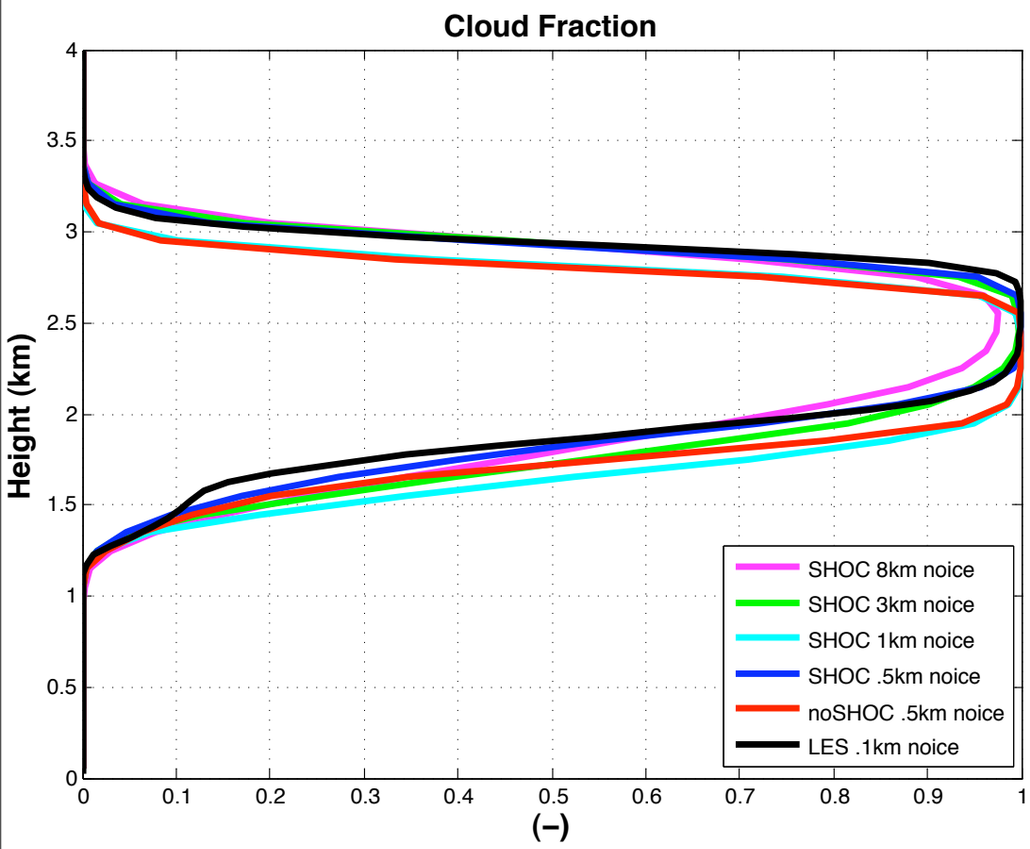


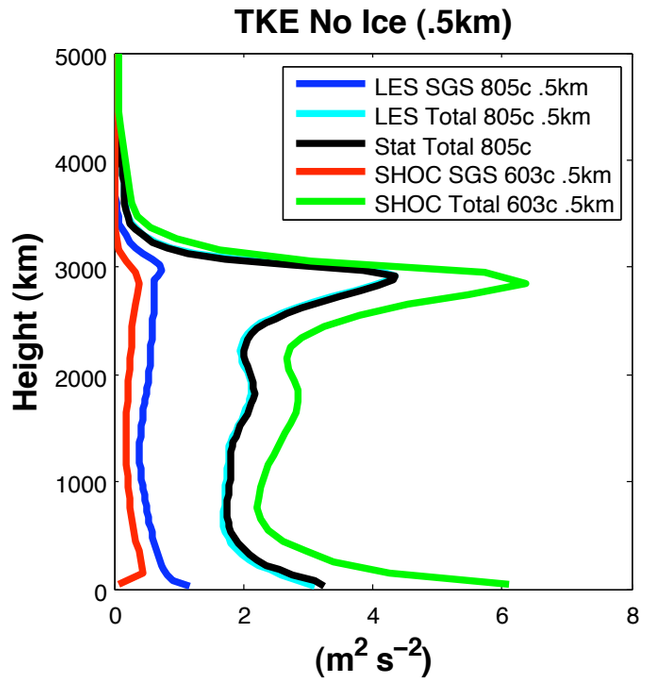
Mixing Length Plots

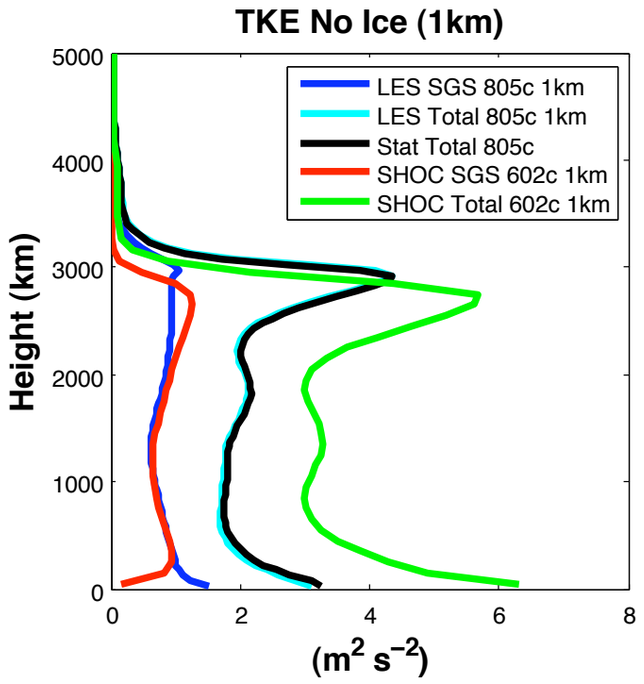
http://home.chpc.utah.edu/~u0652833/SAM_constrain/mixlength_plots/

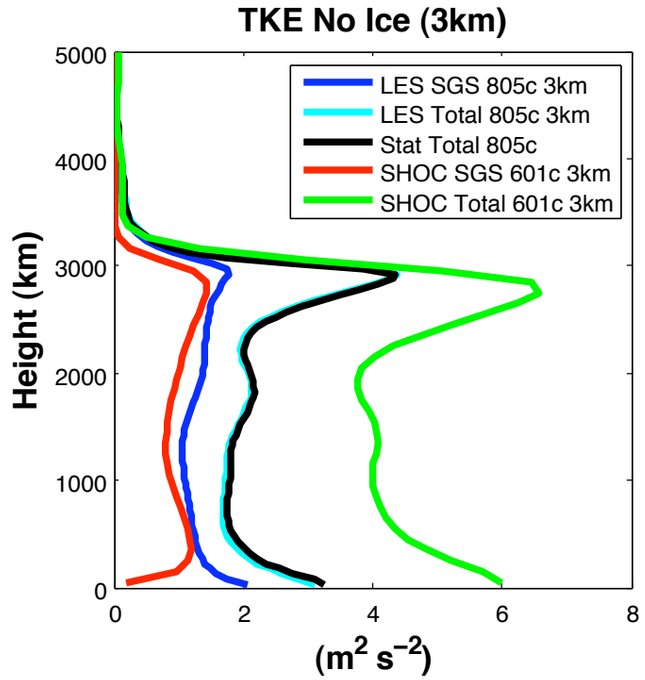
- This includes mixing length, w*^3 and cloud fraction. Also includes LES length scale and Cee plots.
- Runs performed are full physics, no ice (c-series), and ice only (d-series).

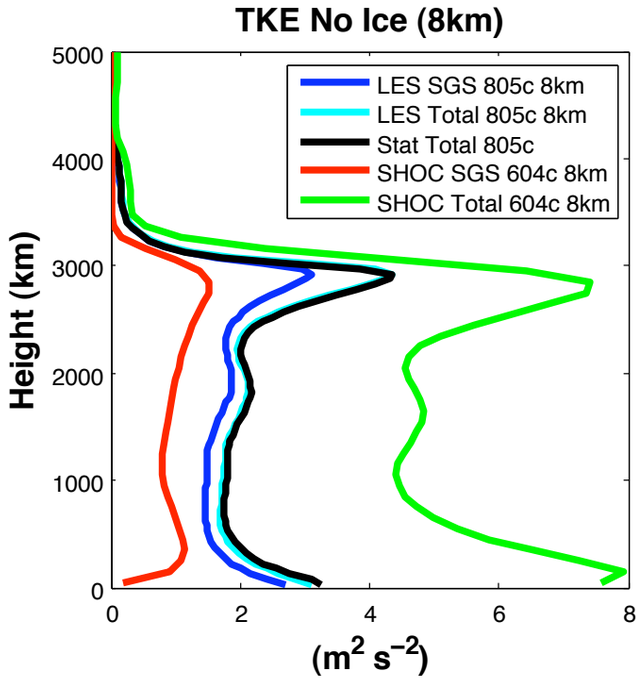
CFrac & TKE - No Ice





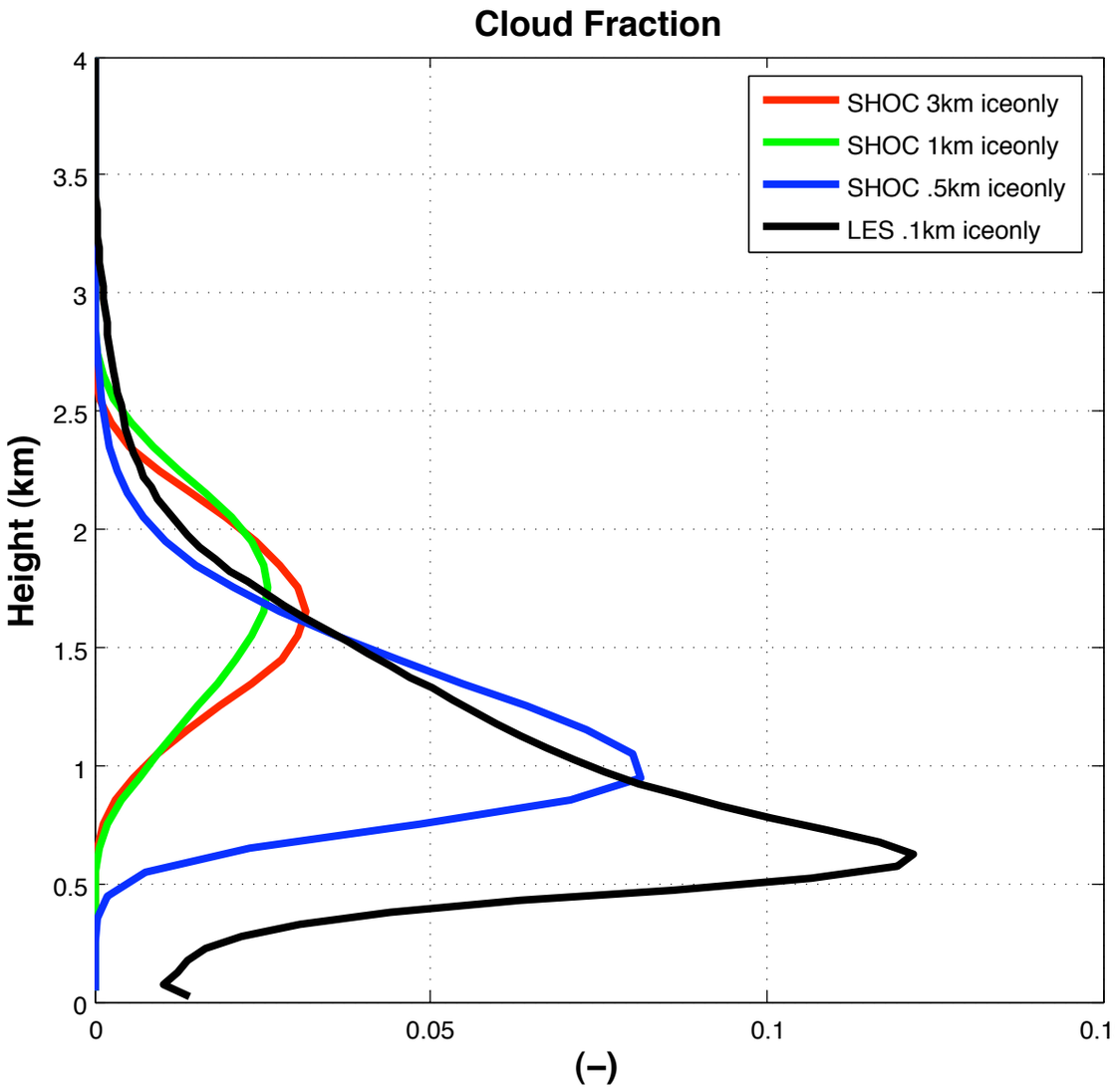


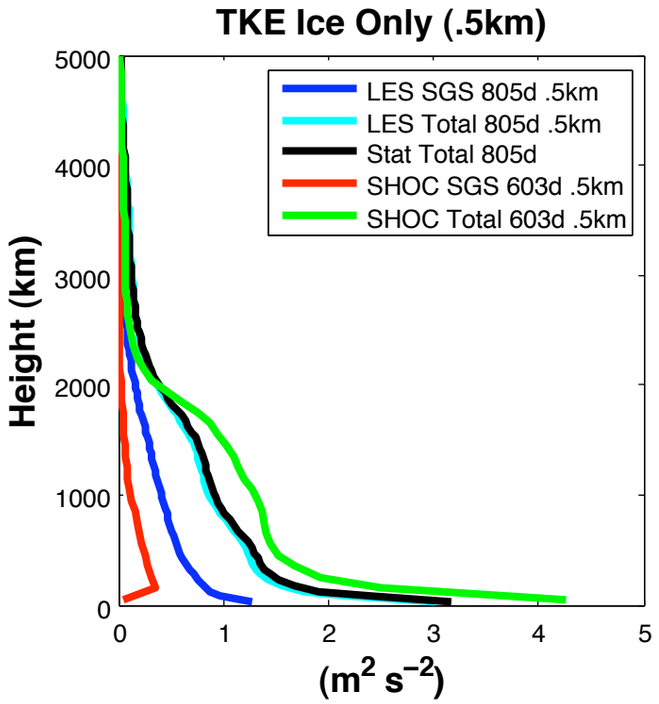


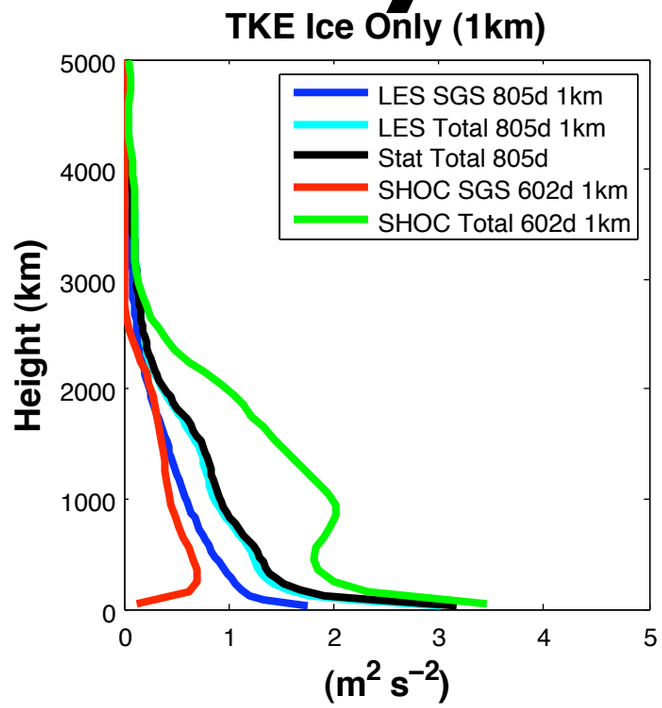


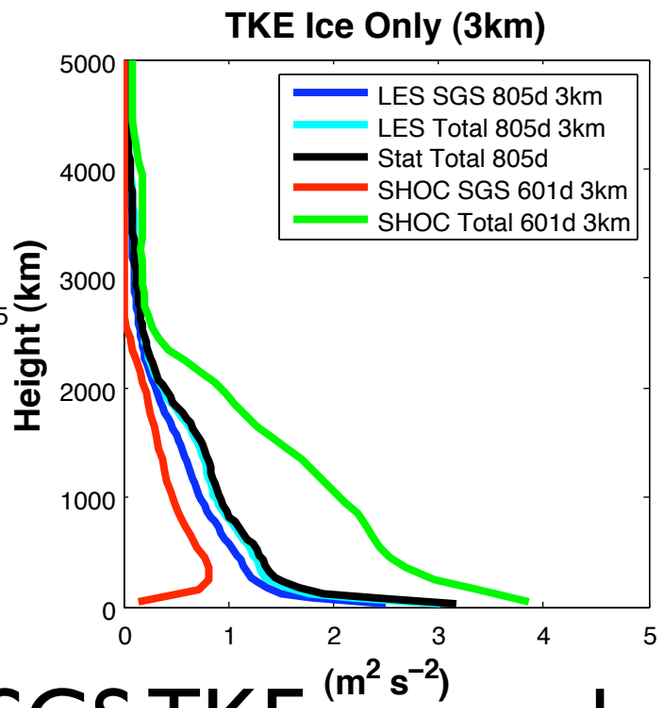
Other than with 1km, SHOC underestimates SGS TKE, even below cloud base in no ice runs.

CFrac & TKE - Ice Only



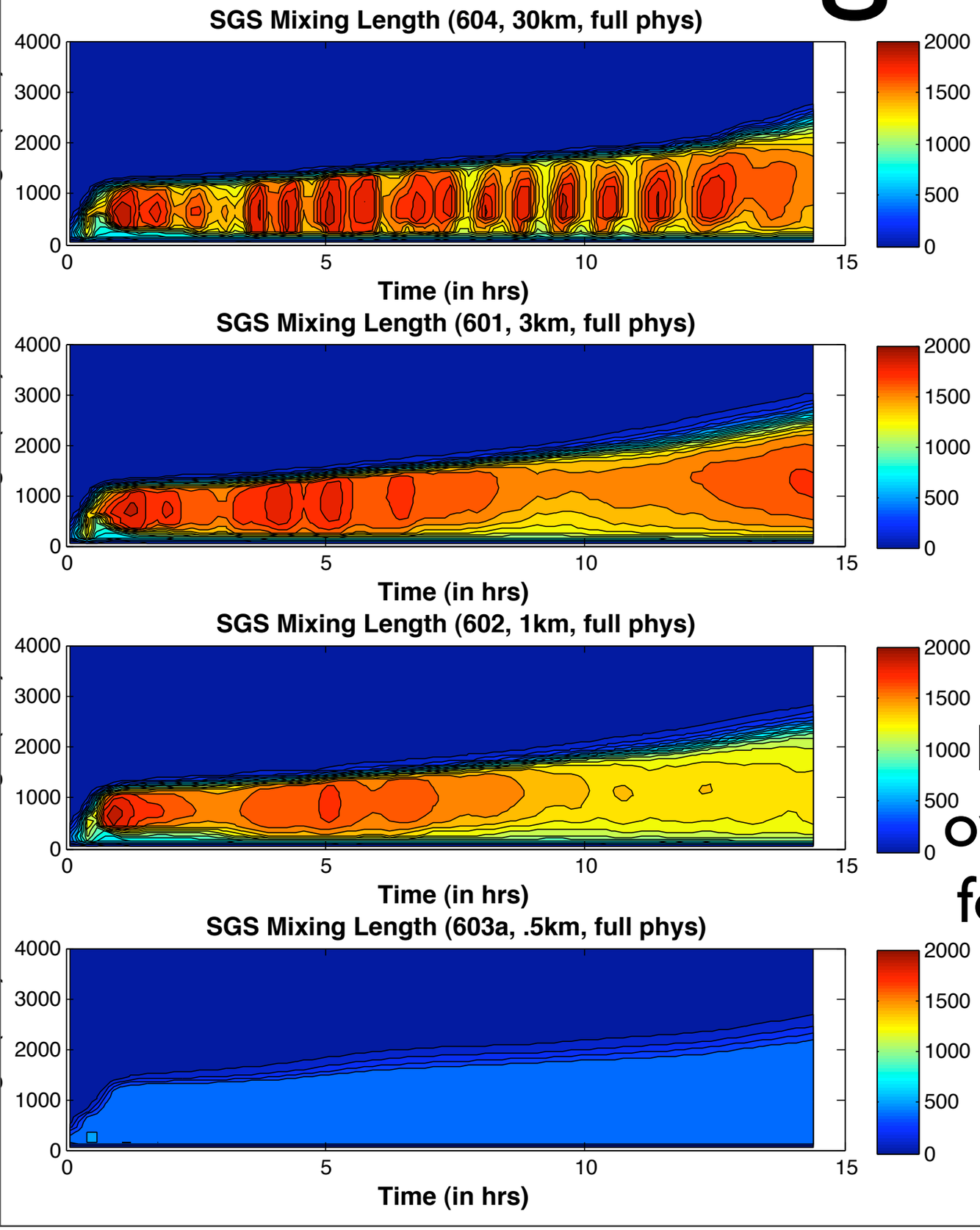


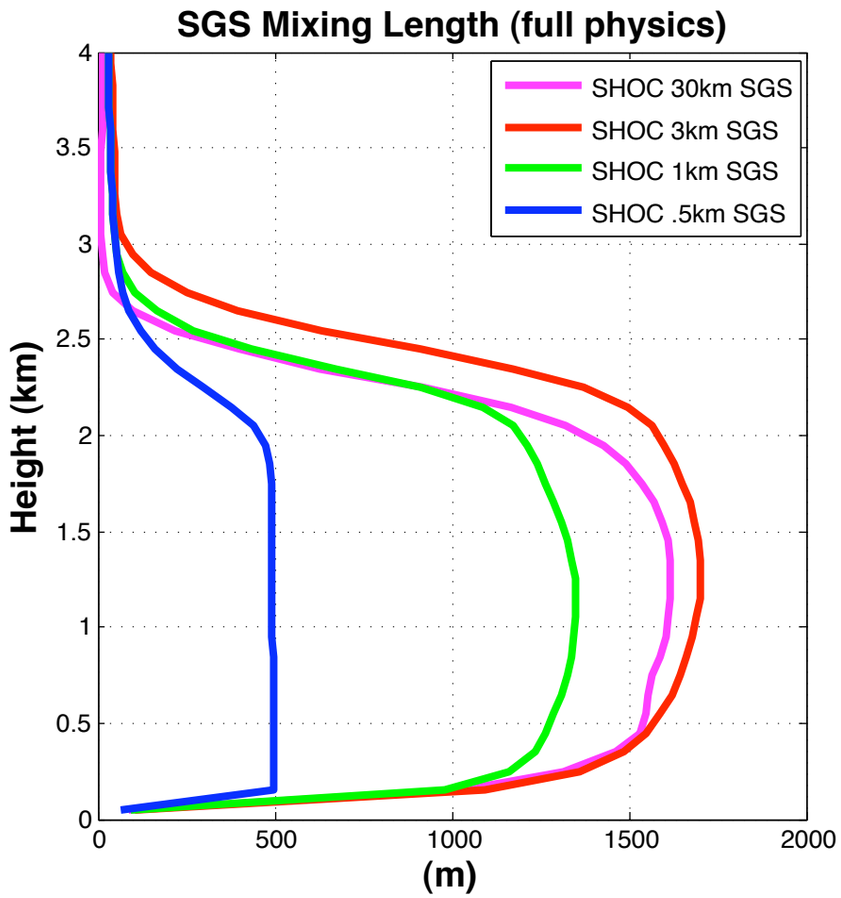




Again, SHOC underestimates SGS TKE even when below cloud base (for the most part, 1-2% cloud isn't much).

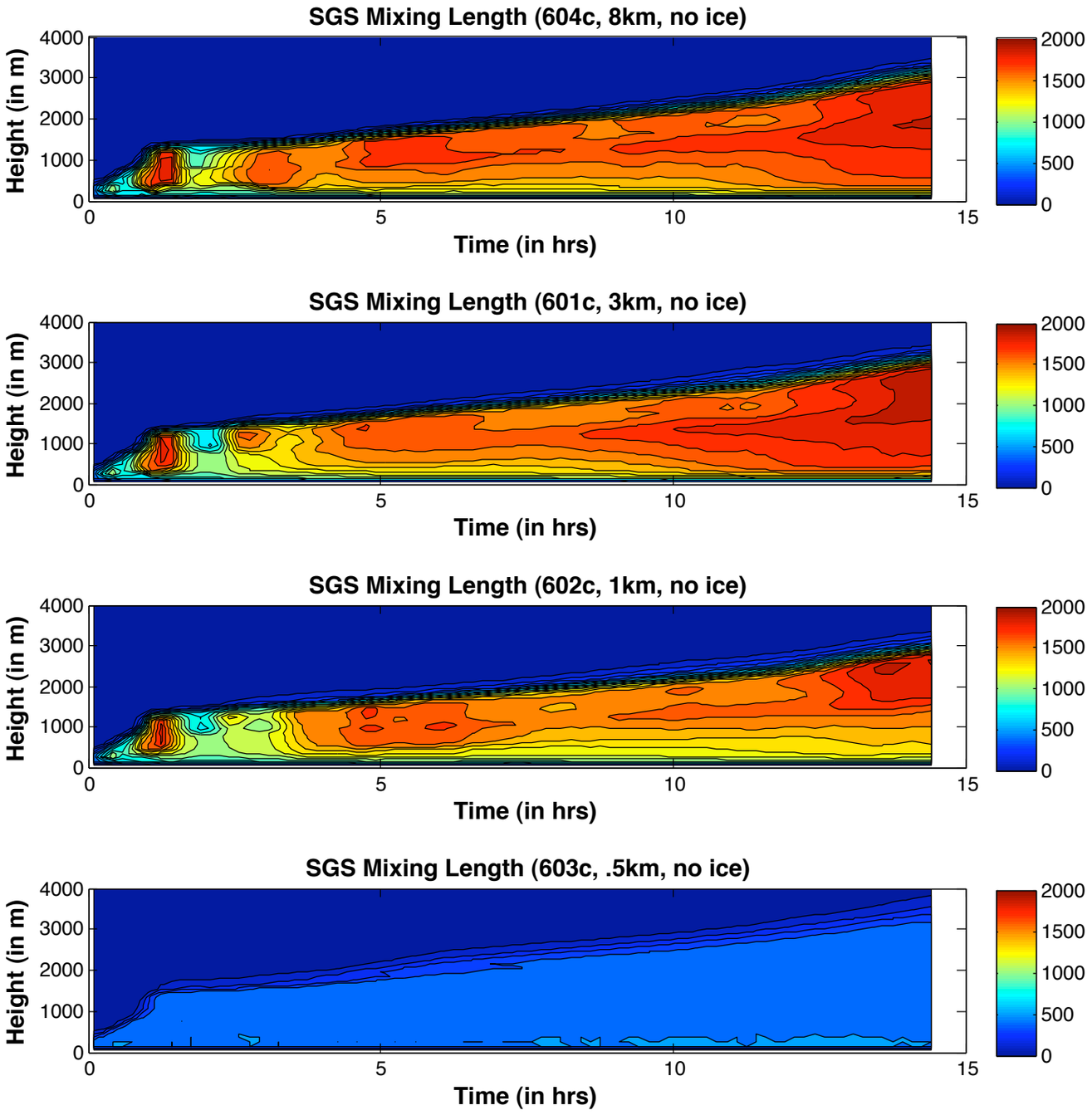
Mixing Lengths

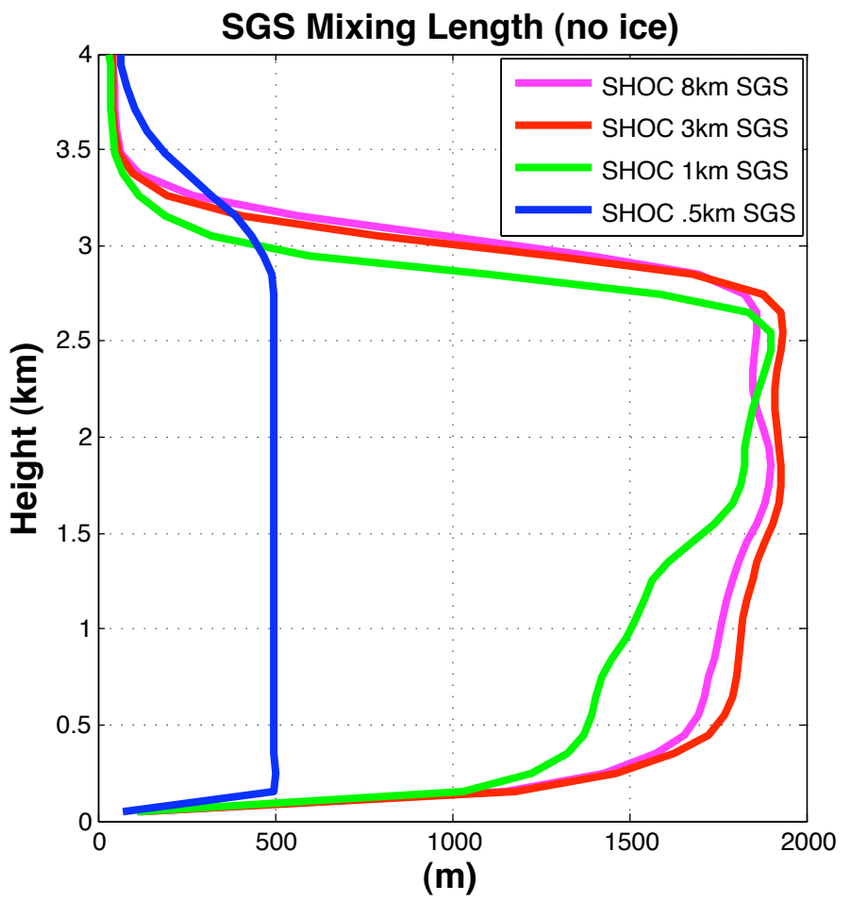




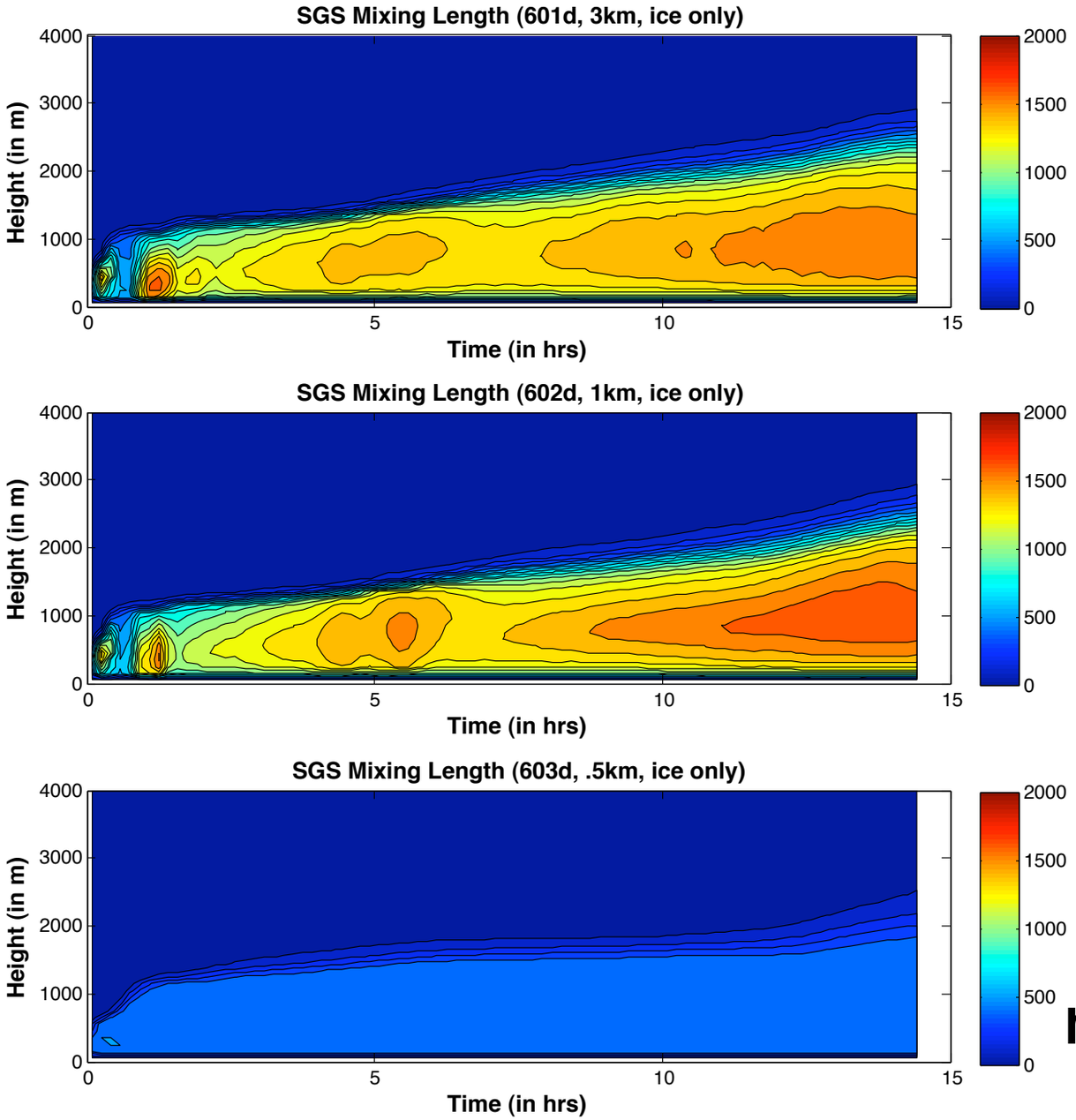
Mixing length starts to decrease over time at 1km resolution, while for no ice and ice only magnitude still increasing.

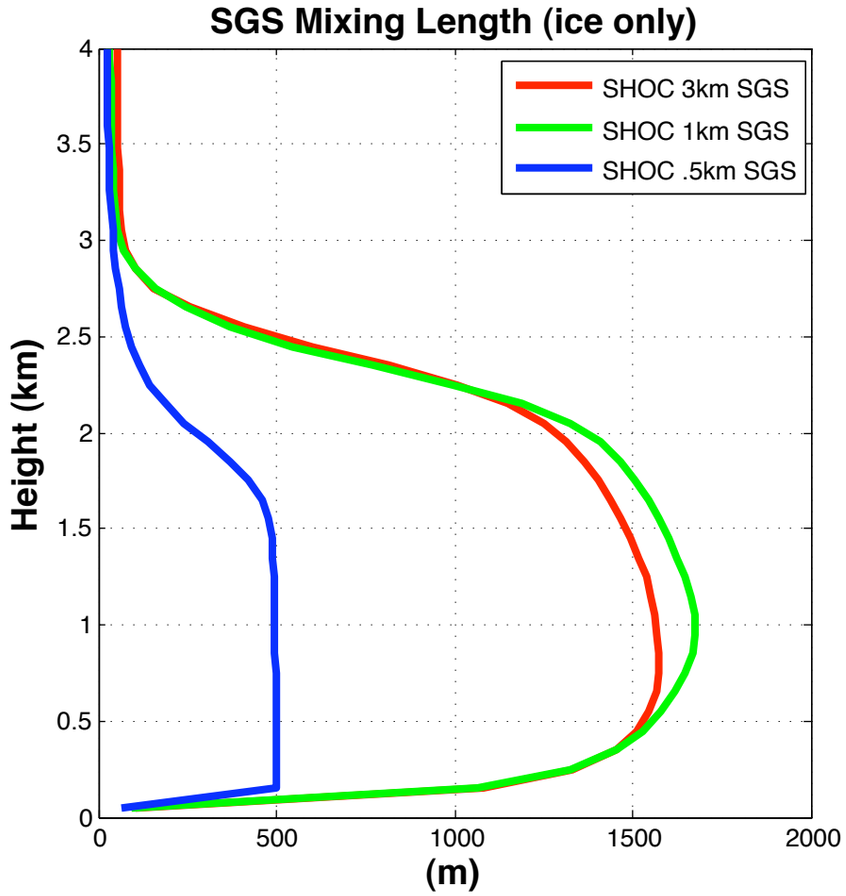
Mixing Lengths





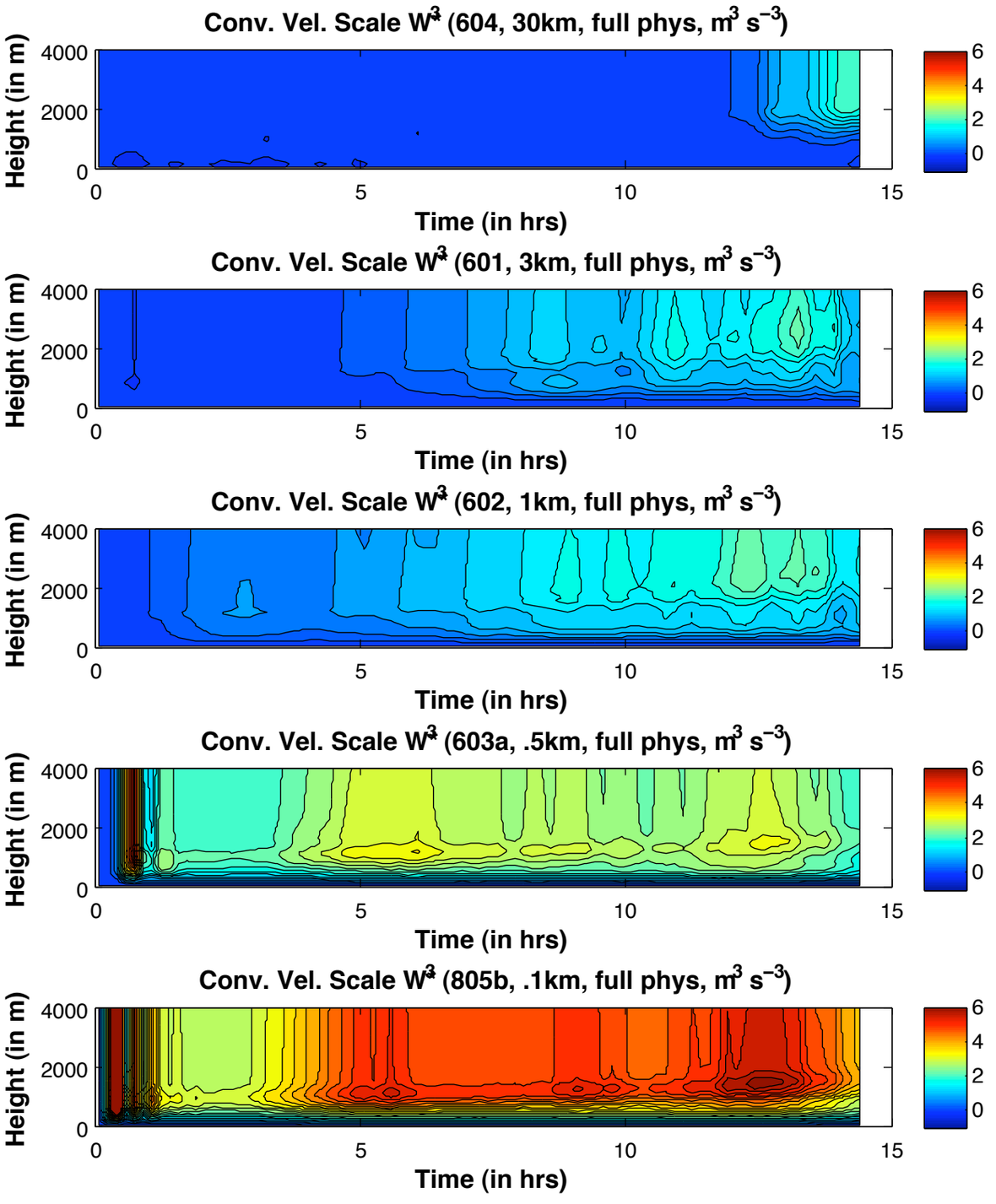
Mixing Lengths

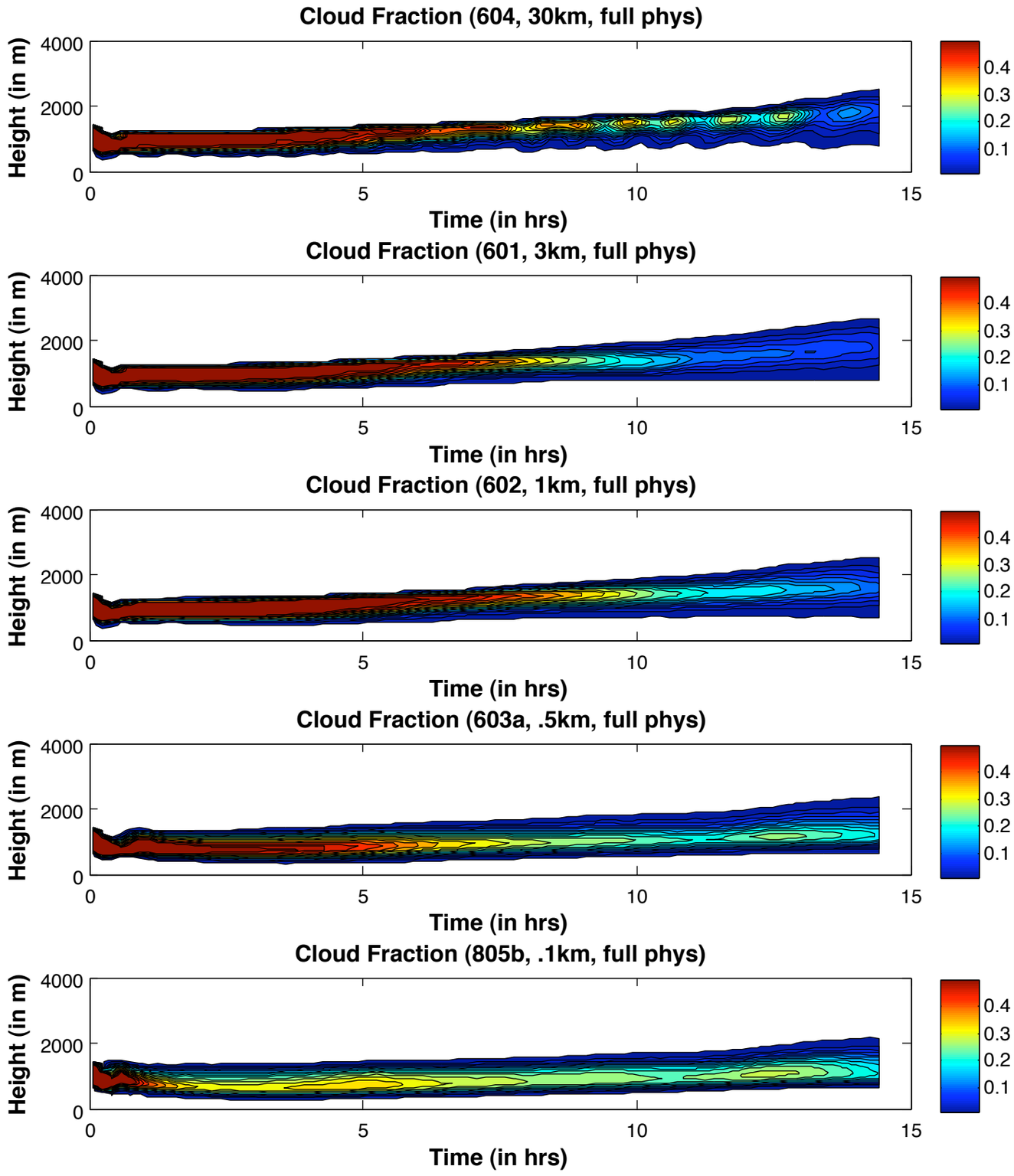




Unlike full physics (and to lesser extent no-ice), ice only seems to reach max mixing length ~1km grid.

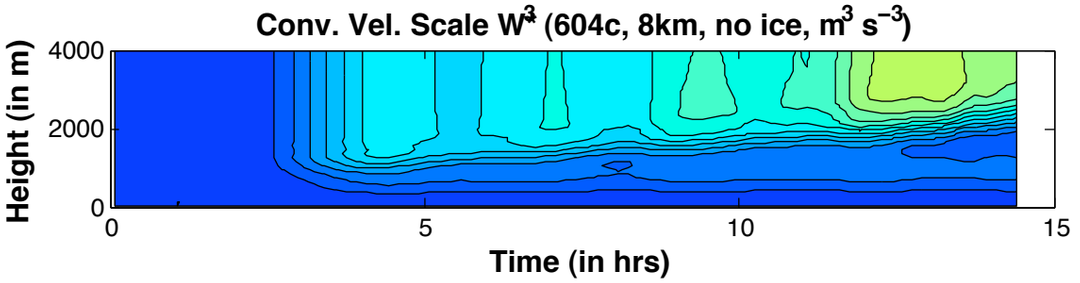
W*^3 & CloudFraction

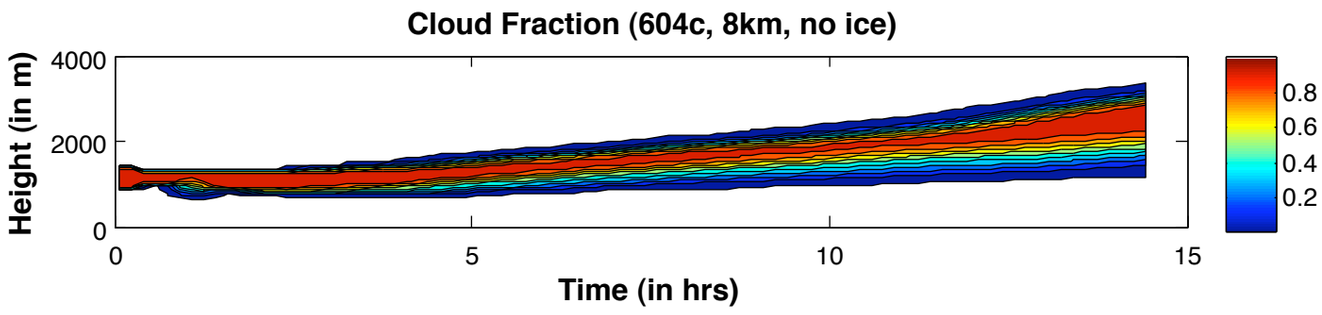


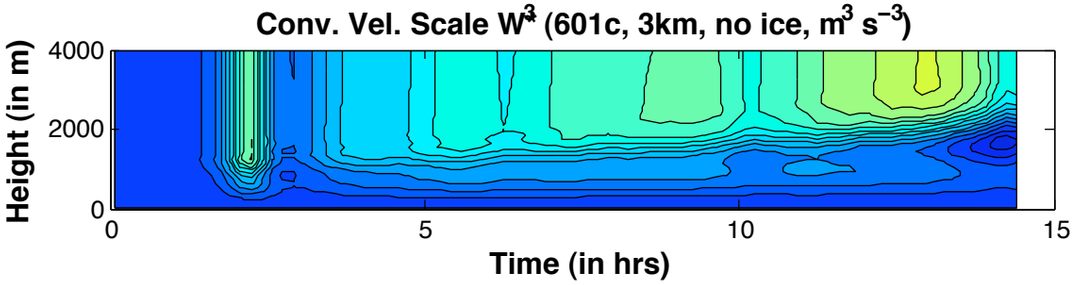


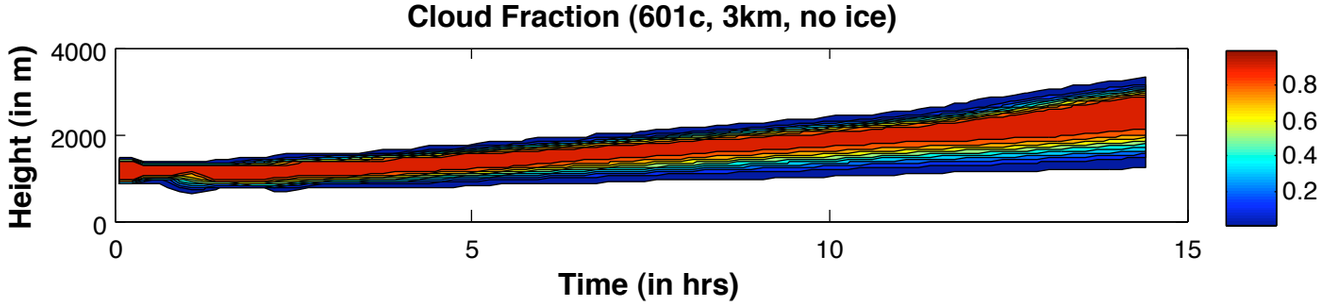
For all 3 run types (full phys, ice only, no ice) W*3 increases over time.

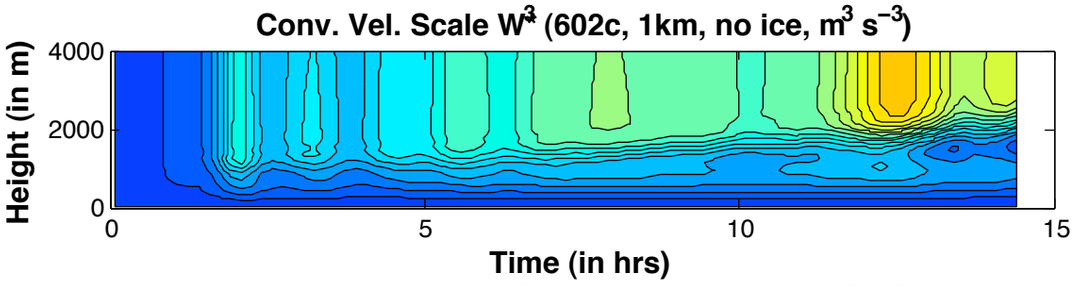
W*^3 & CloudFraction

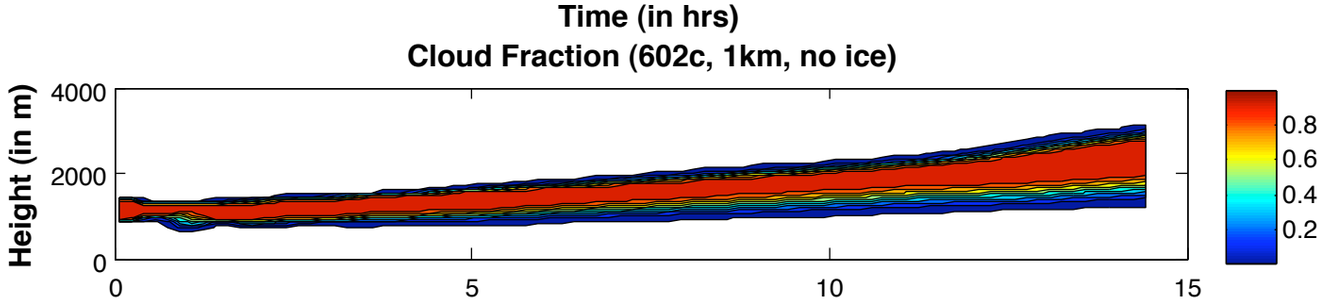


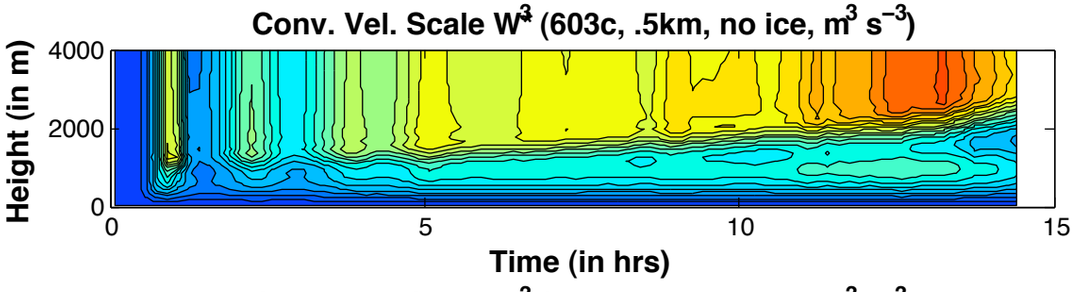


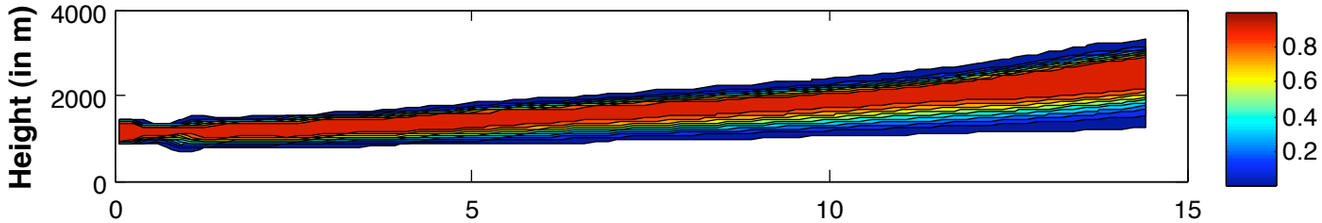


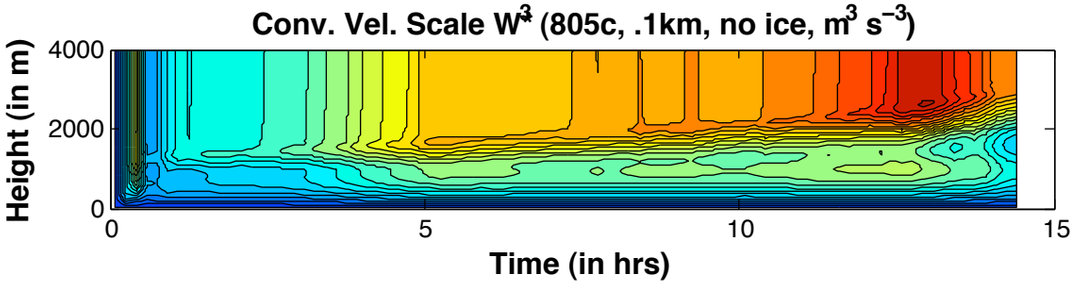


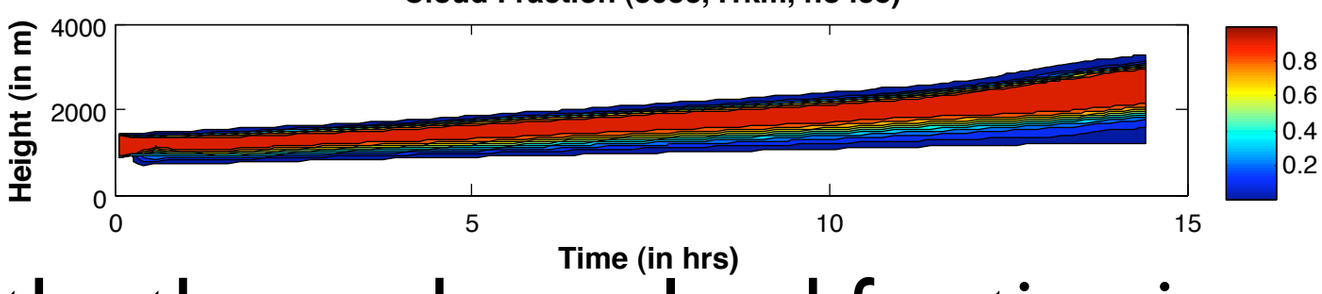






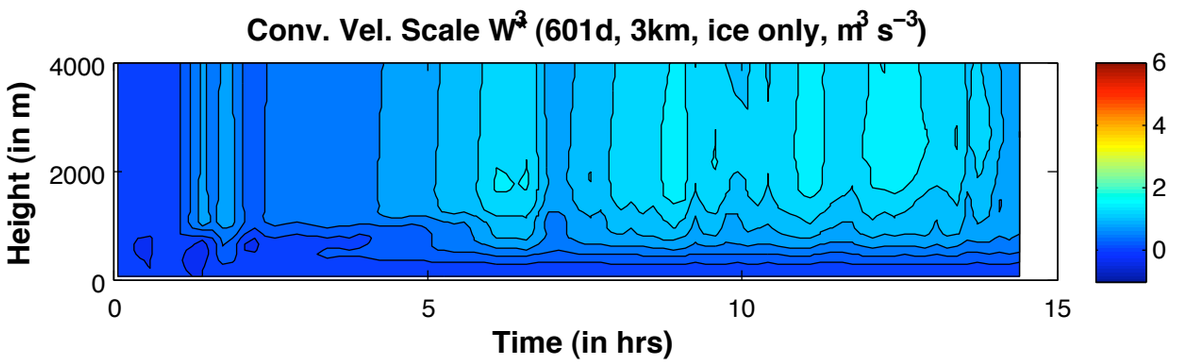


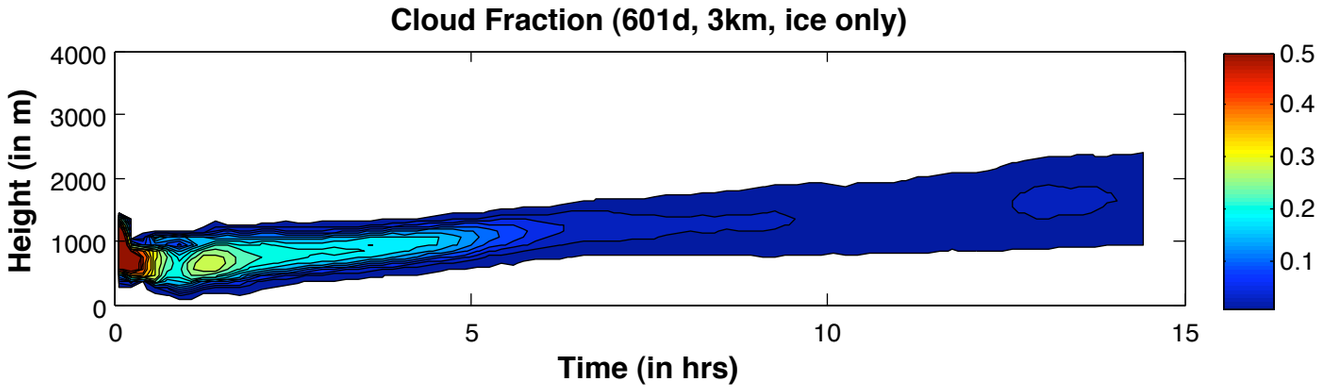


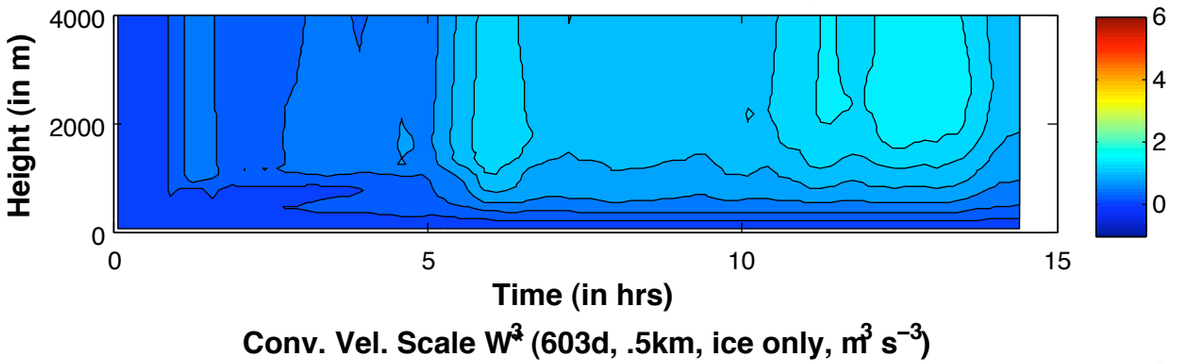


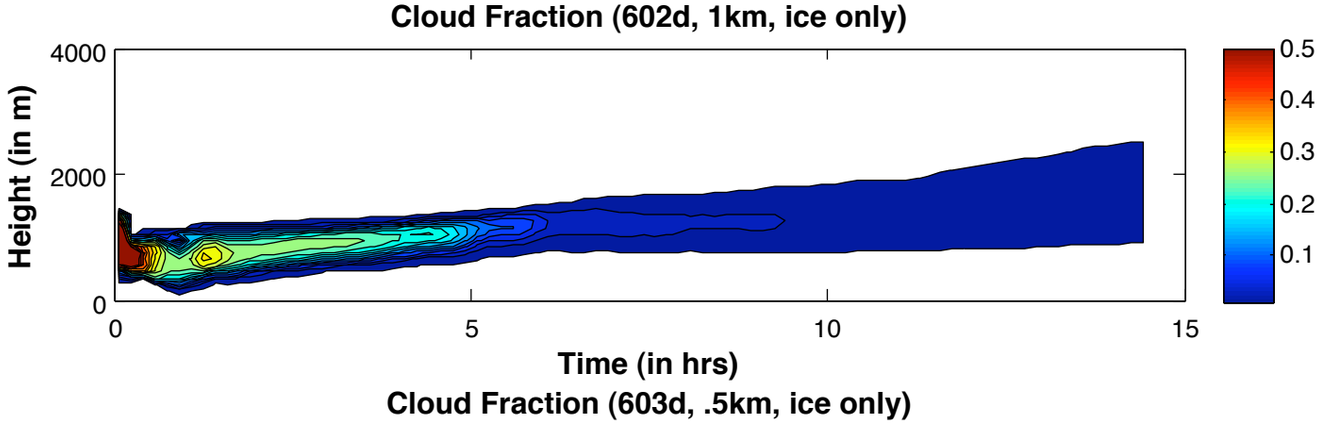
This is the only run type of the three where cloud fraction is sustained throughout.

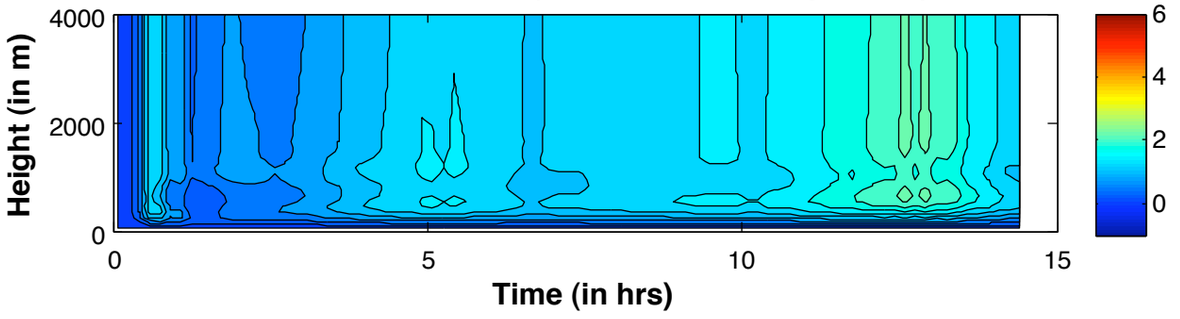
W*^3 & CloudFraction

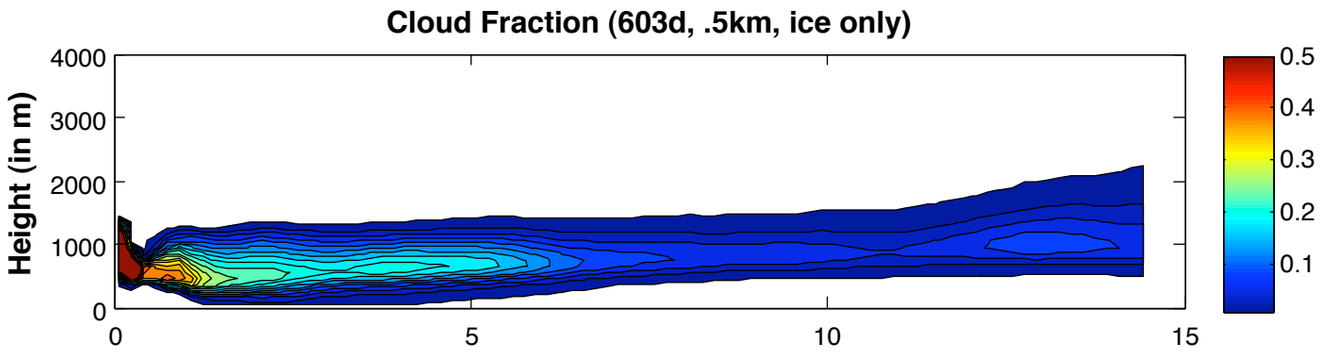


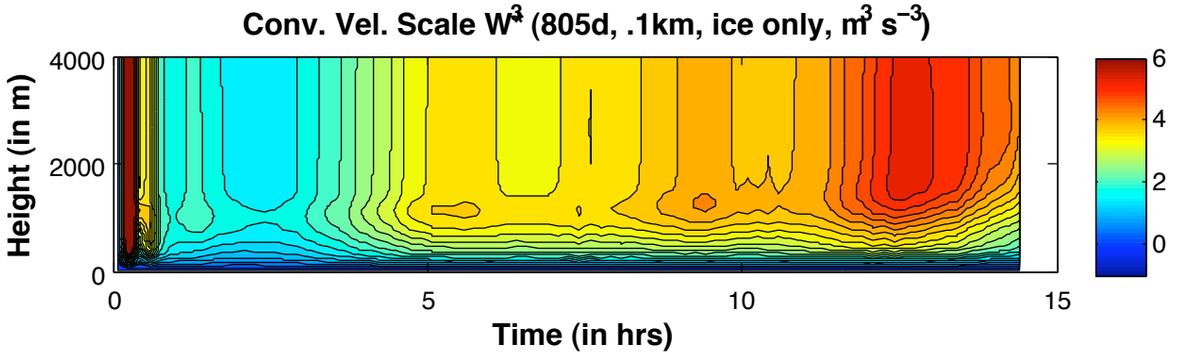


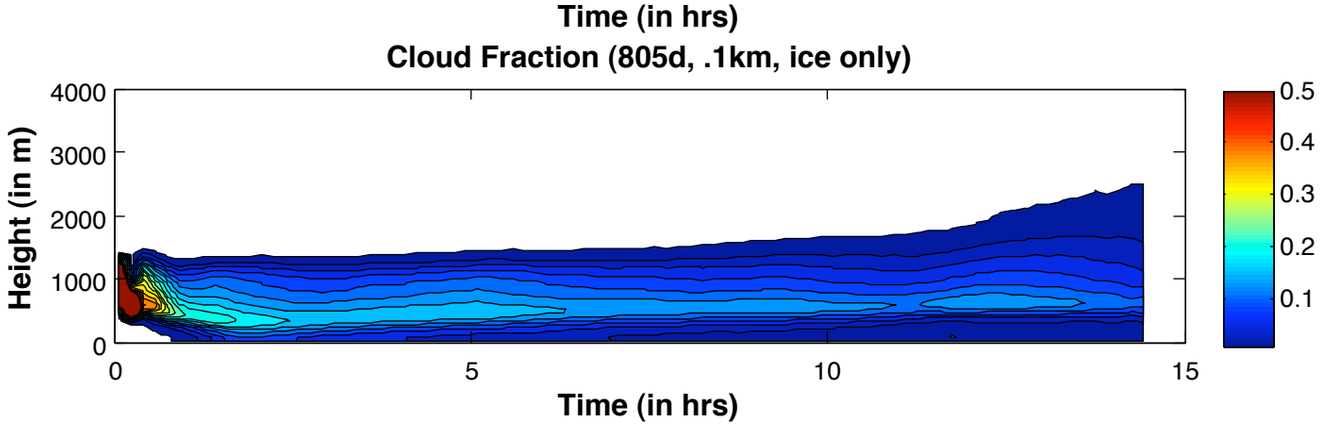








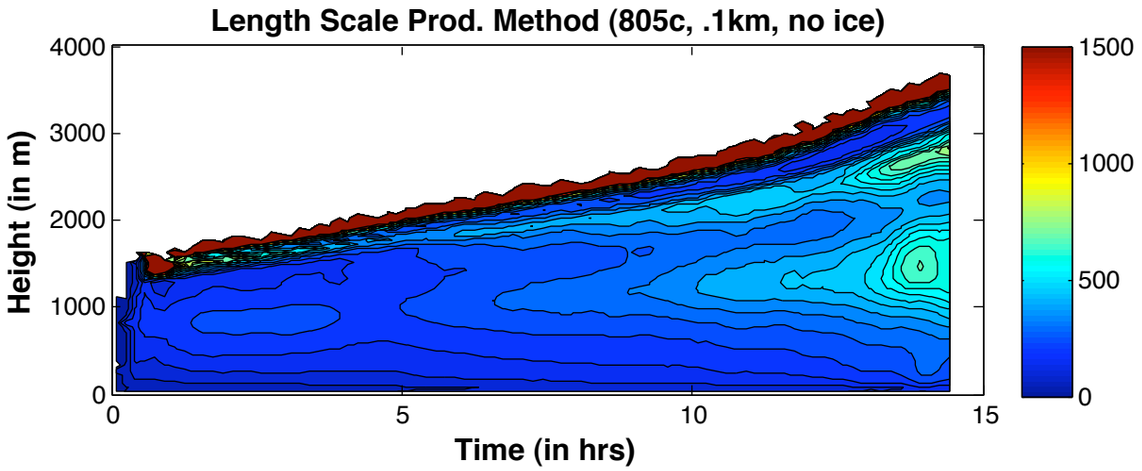


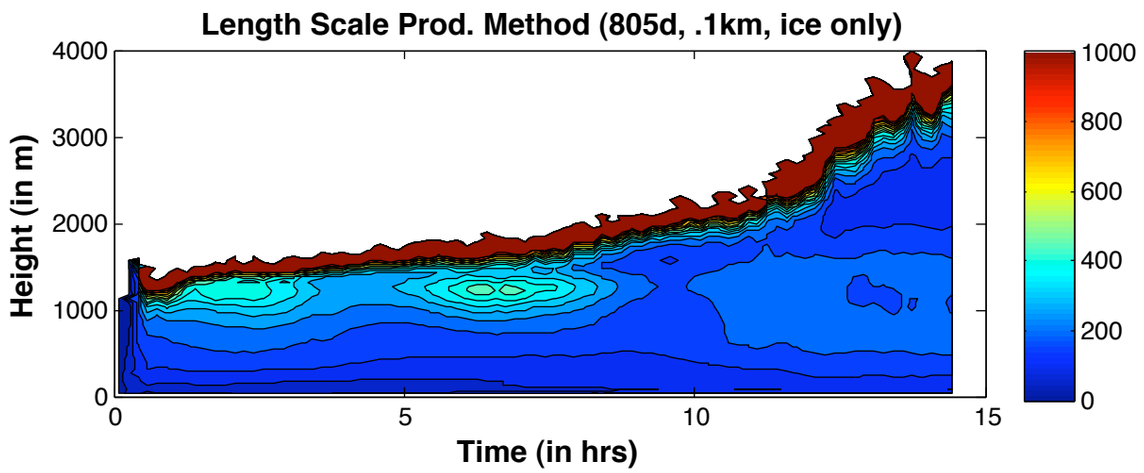


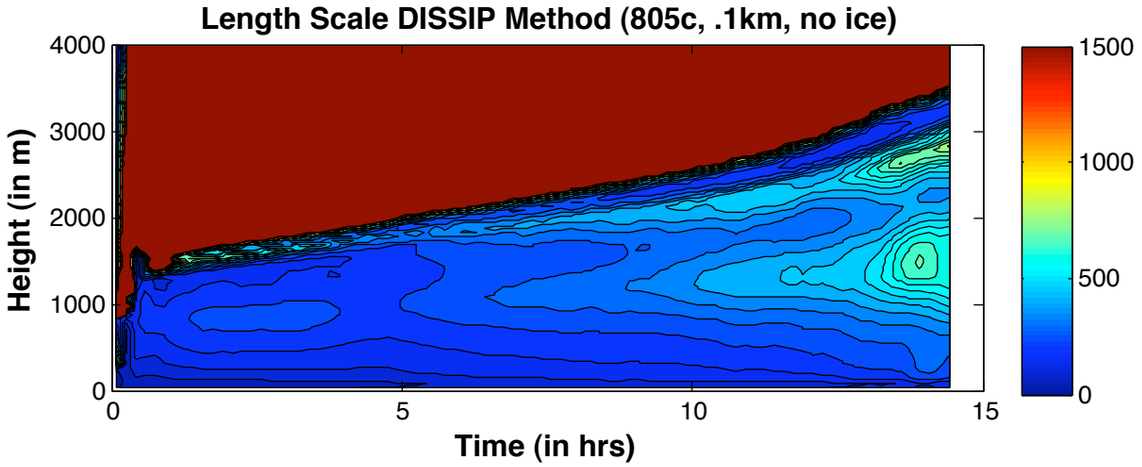
LES Length Scale

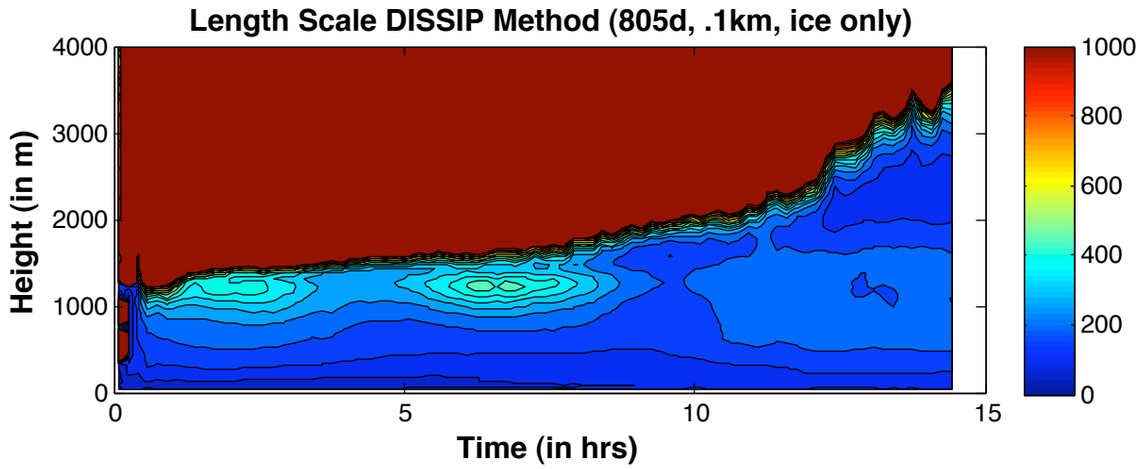
- Calculated using the stats files several ways
- prod method = (TKE + TKES)^(3/2) ./ (SHEARS + BUOYAS)
- dissip method = (TKE + TKES)^(3/2) ./ DISSIP
- dissips method = (TKE + TKES)^(3/2) ./ DISSIPS
- methods similar in boundary layer, dissip shoots off above

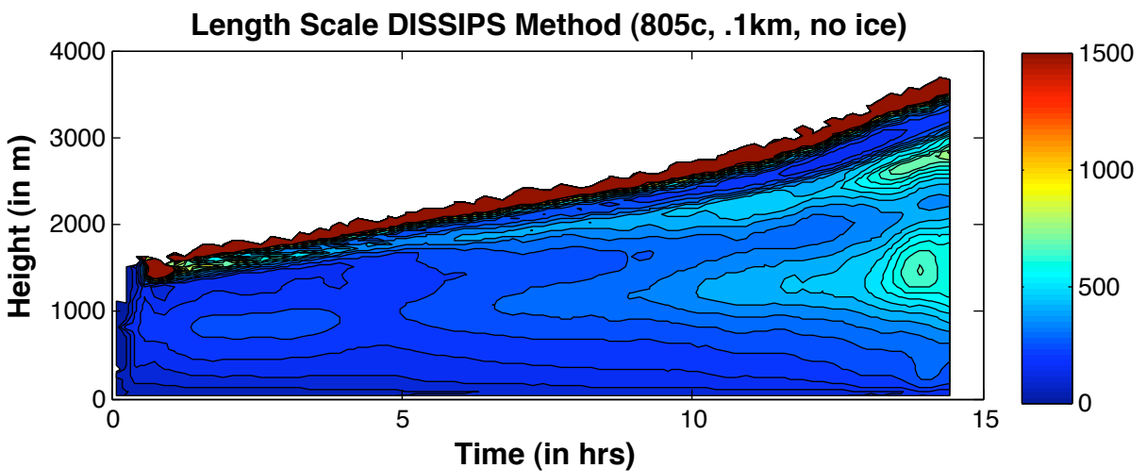
LES Length scale

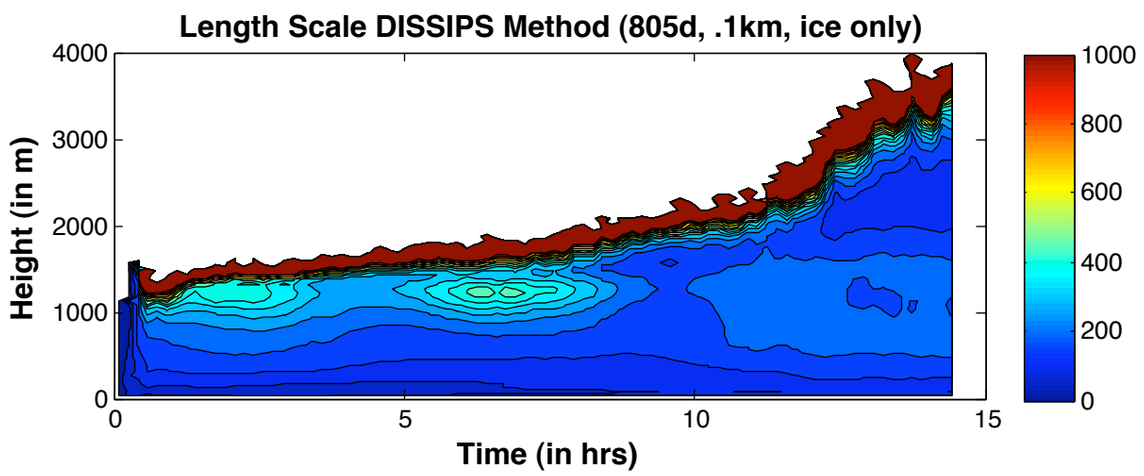












Cee - Run 604

- Cee is a constant in the equations for mixing length, generally between 1 and 2.
- Cee = mix_sgs .* dissip ./ (TKES ^ (3/2))