Some examples for piggybacking in WRF

1. *Piggybacking with different microphysics:*
    a. **WSM6 as DRIVER, and Thompson scheme as PIGGYBACKER**

Figure: Precipitation difference [mm] (Red: Driver larger than piggybacker, Blue: Piggybacker larger than driver).

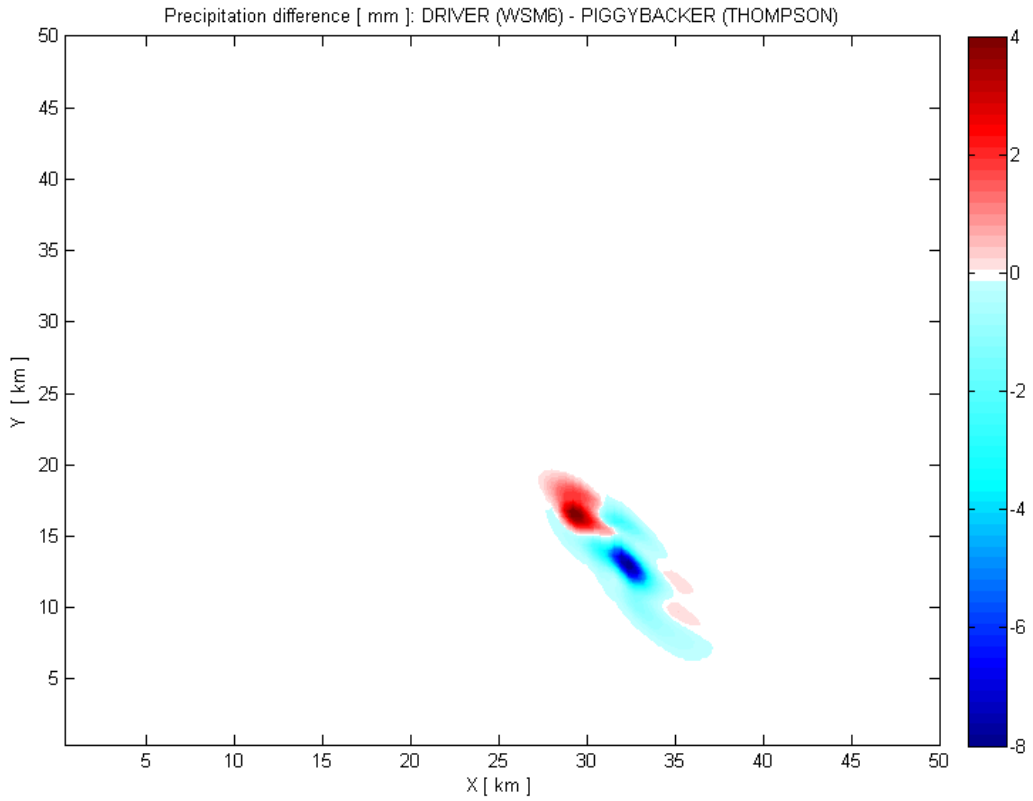


Figure: Mean difference fields (DRIVER – PIGGYBACKER): (a) Temperature, (b) Water vapor mixing ratio, (c) Cloud water mixing ratio, (d) Rain water mixing ratio, (e) Rain water number concentration, (f) Snow mixing ratio, (g) Pristine ice mixing ratio, (h) Pristine ice number concentration and (j) Graupel mixing ratio. (Red: Driver larger than piggybacker, Blue: Piggybacker larger than driver).

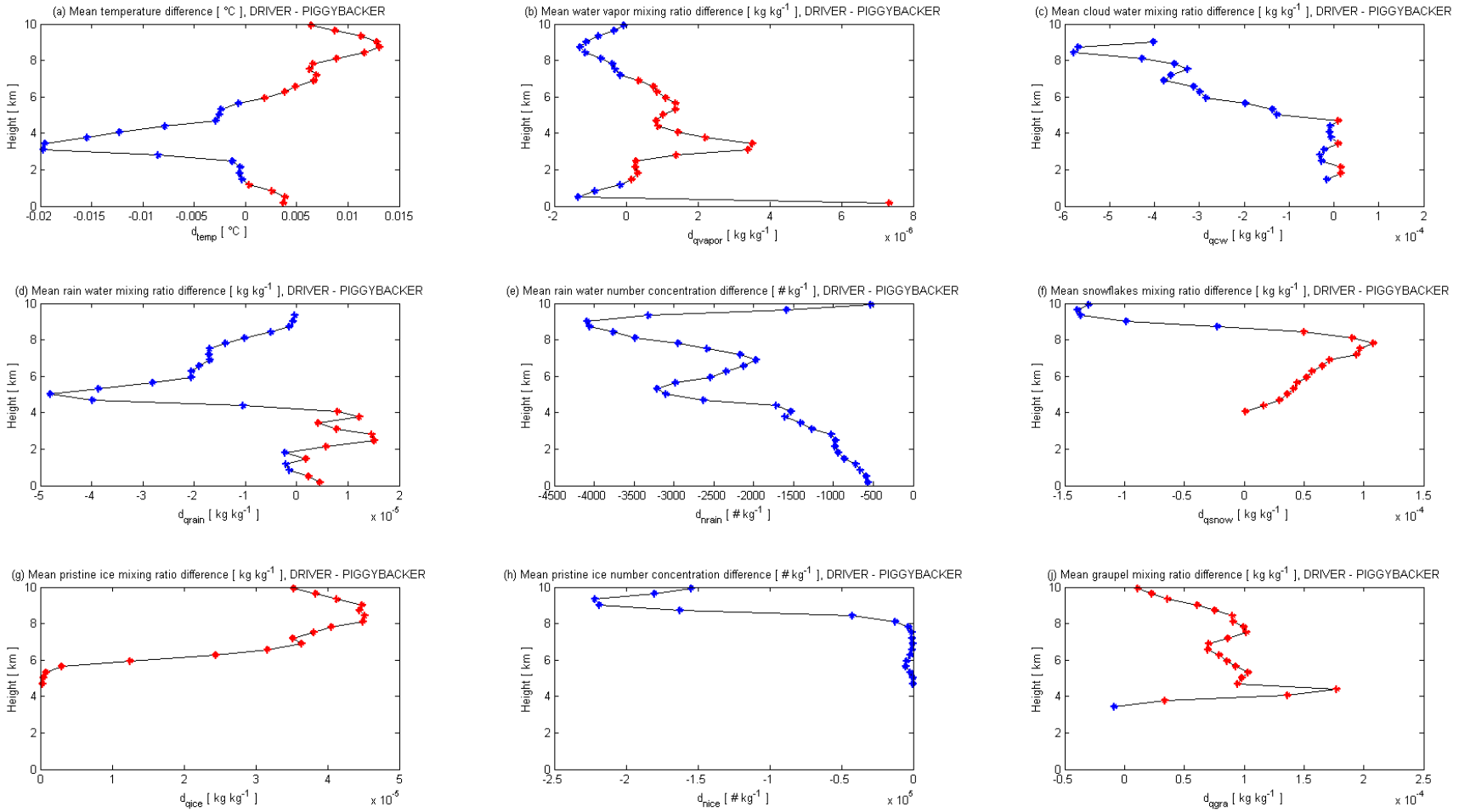
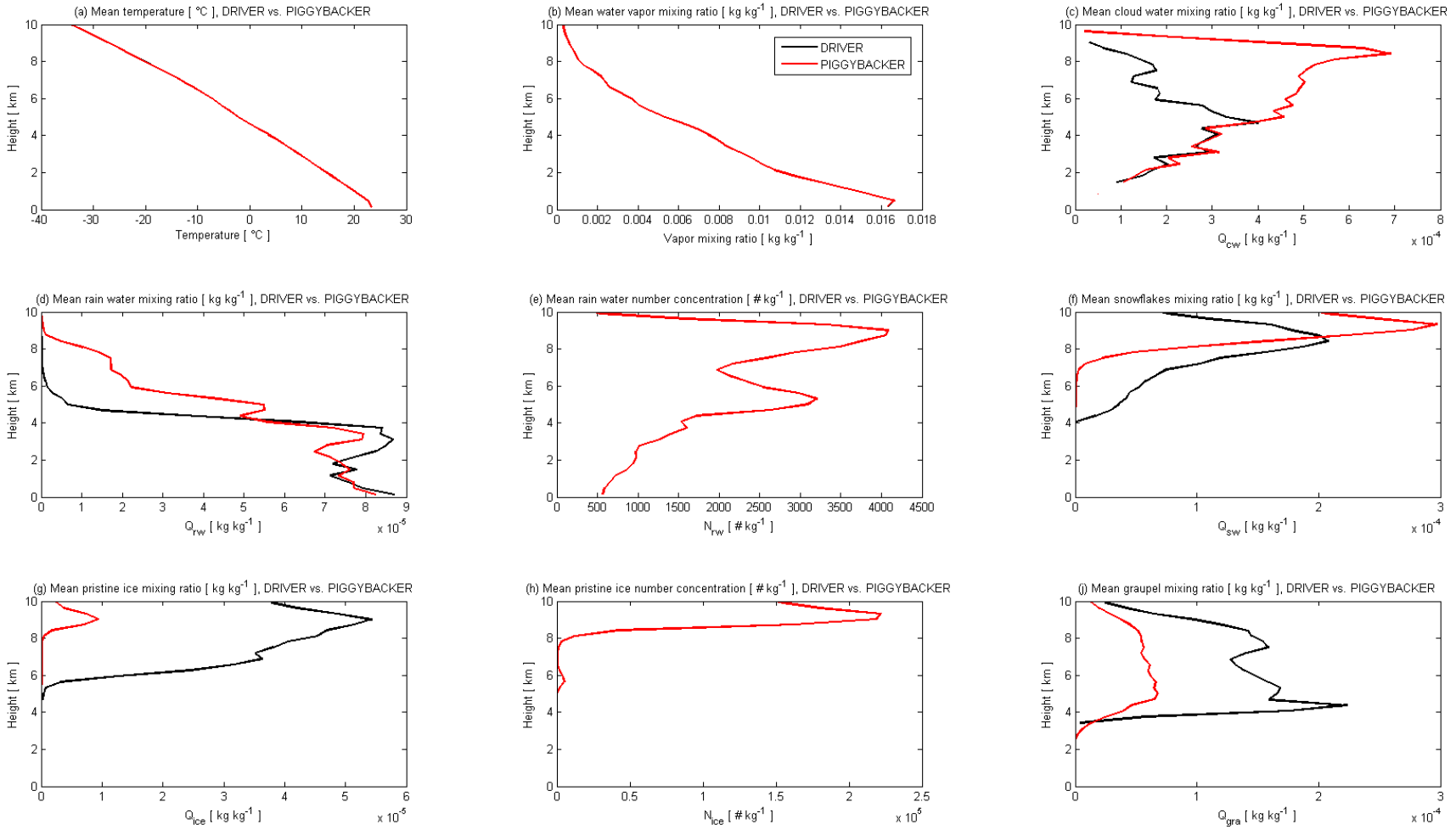


Figure: Mean fields: (a) Temperature, (b) Water vapor mixing ratio, (c) Cloud water mixing ratio, (d) Rain water mixing ratio, (e) Rain water number concentration, (f) Snow mixing ratio, (g) Pristine ice mixing ratio, (h) Pristine ice number concentration and (j) Graupel mixing ratio. (Black: Driver, Red: Piggybacker).



b. Thompson scheme as DRIVER and WSM6 as PIGGYBACKER

Figure: Precipitation difference [mm] (Red: Driver larger than piggybacker, Blue: Piggybacker larger than driver).

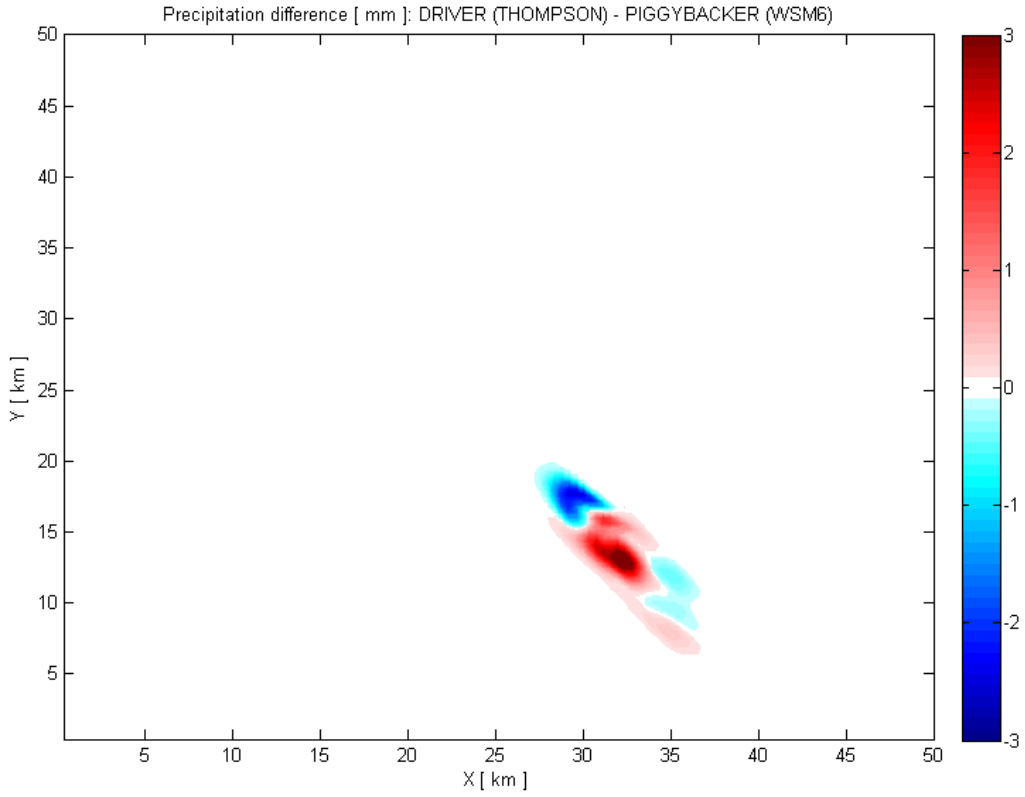


Figure: Mean difference fields (DRIVER – PIGGYBACKER): (a) Temperature, (b) Water vapor mixing ratio, (c) Cloud water mixing ratio, (d) Rain water mixing ratio, (e) Rain water number concentration, (f) Snow mixing ratio, (g) Pristine ice mixing ratio, (h) Pristine ice number concentration and (j) Graupel mixing ratio. (Red: Driver larger than piggybacker, Blue: Piggybacker larger than driver).

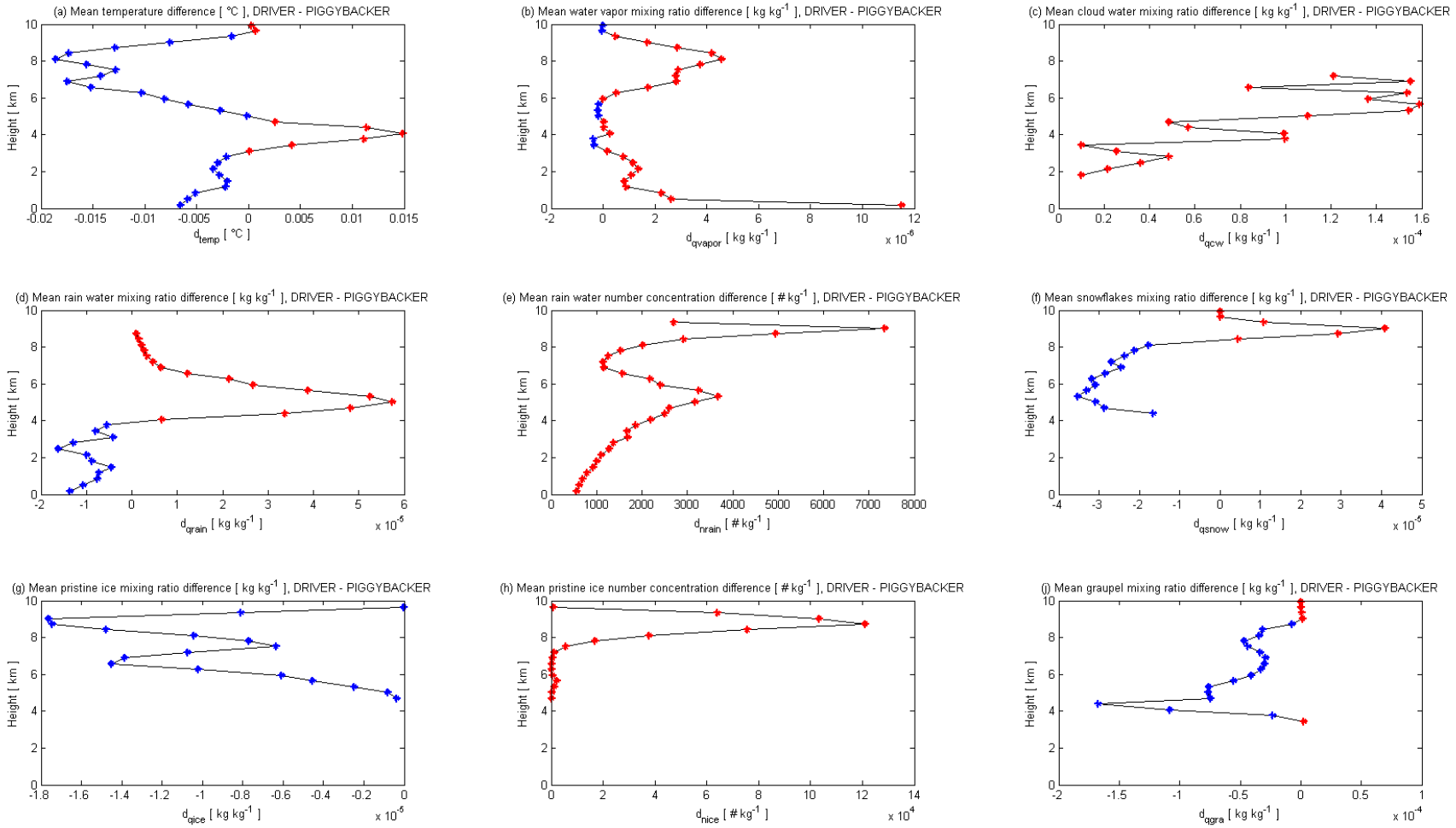


Figure: Mean fields: (a) Temperature, (b) Water vapor mixing ratio, (c) Cloud water mixing ratio, (d) Rain water mixing ratio, (e) Rain water number concentration, (f) Snow mixing ratio, (g) Pristine ice mixing ratio, (h) Pristine ice number concentration and (j) Graupel mixing ratio. (Black: Driver, Red: Piggybacker).

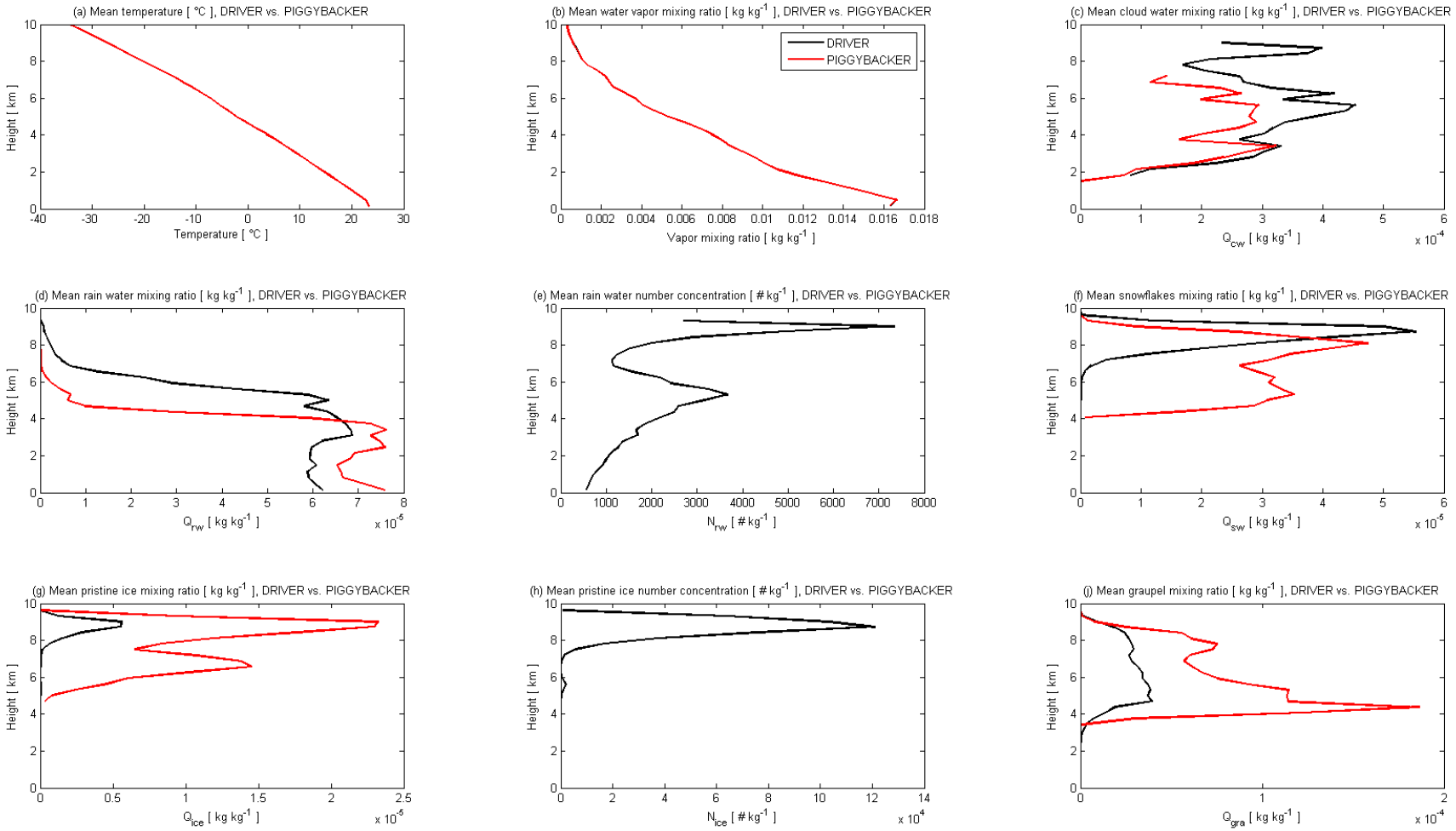


Figure: WSM6 as DRIVER and Thompson as PIGGYBACKER vs. Thompson as DRIVER and WSM6 as PIGGYBACKER mean variables: (a) Temperature, (b) Water vapor mixing ratio, (c) Cloud water mixing ratio, (d) Rain water mixing ratio, (e) Rain water number concentration, (f) Snow mixing ratio, (g) Pristine ice mixing ratio, (h) Pristine ice number concentration and (j) Graupel mixing ratio. (Black: Thompson is the DRIVER and WSM6 is the PIGGYBACKER, Red: WSM6 is the DRIVER and Thompson is the PIGGYBACKER).

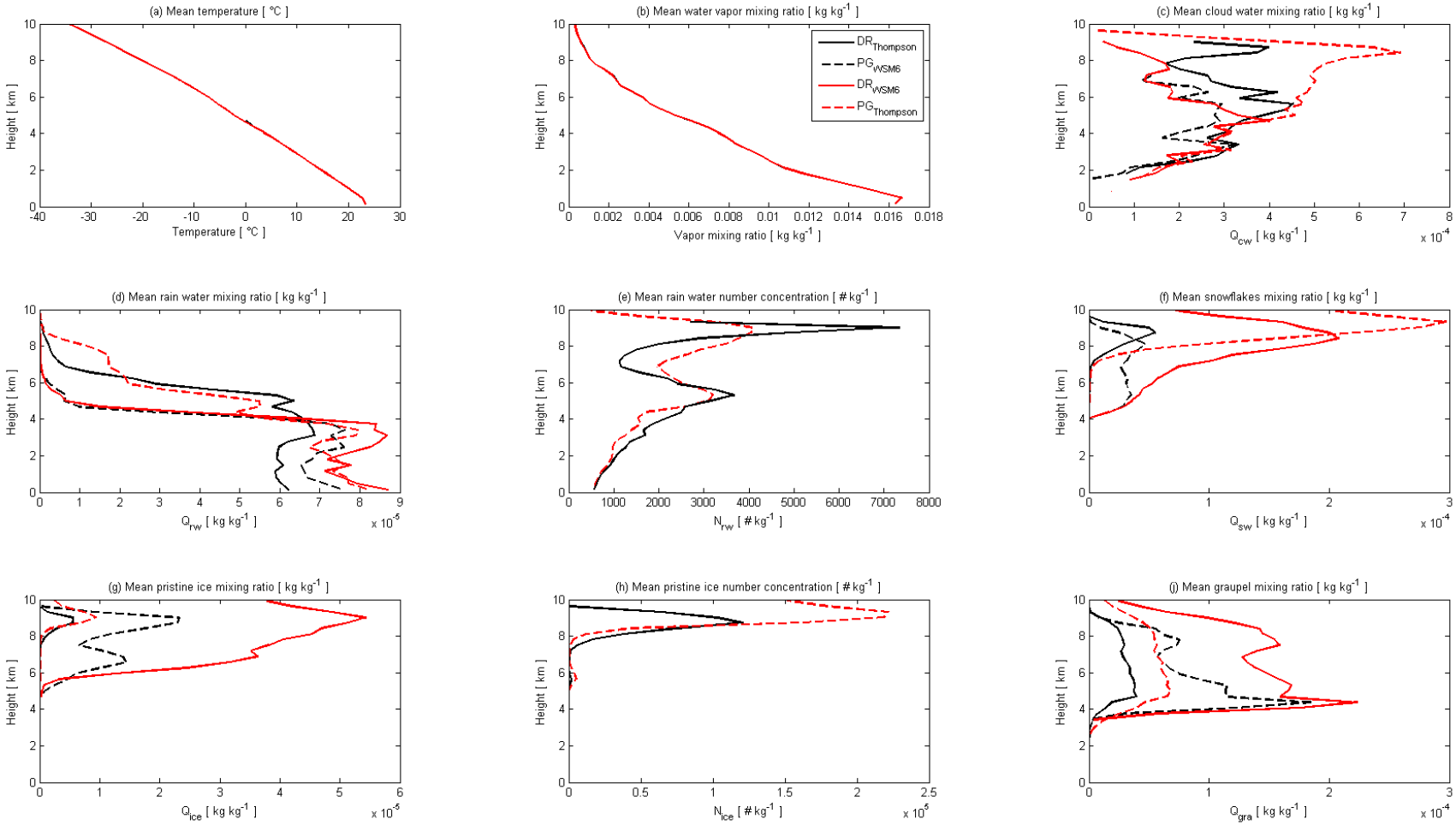
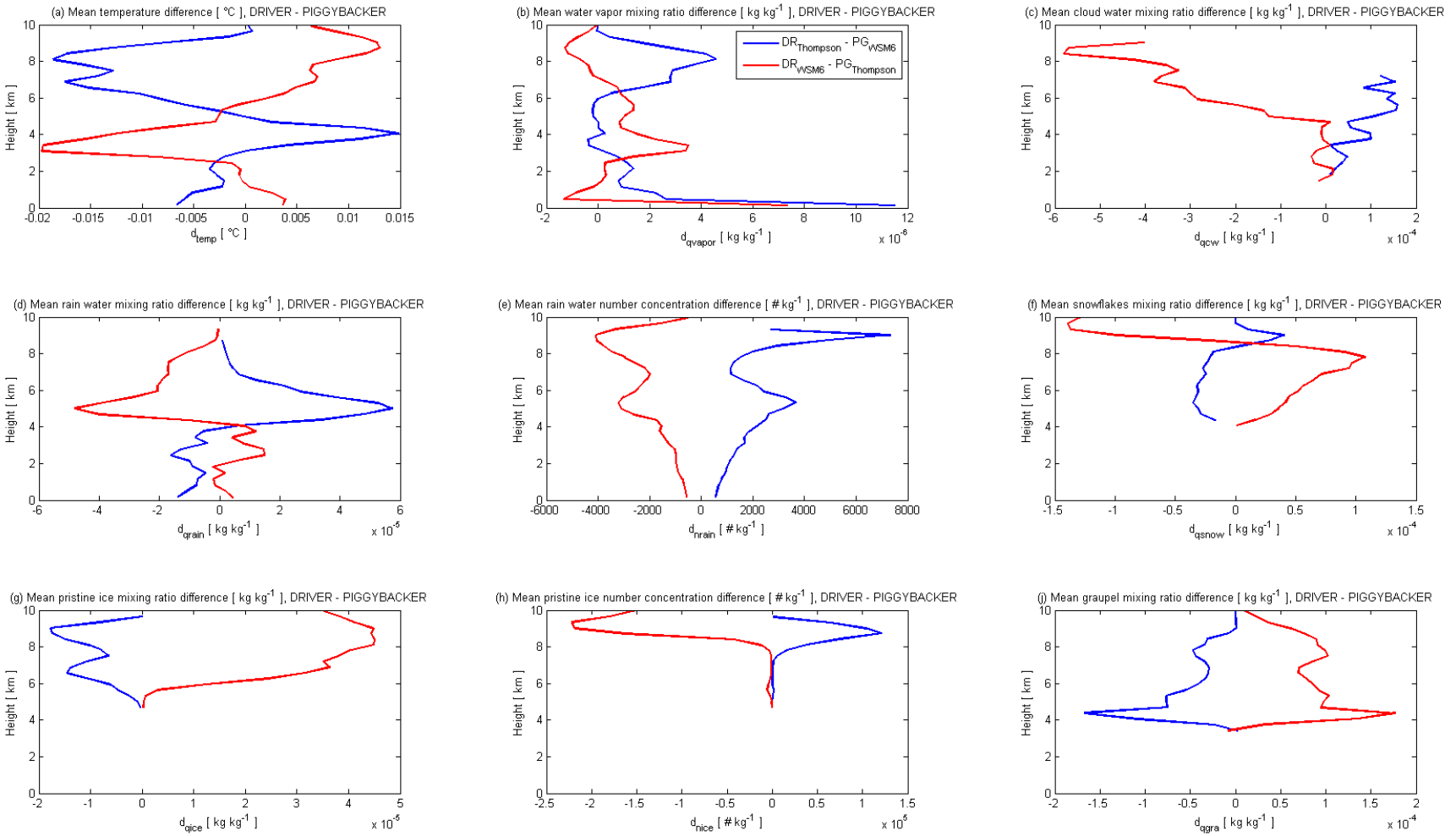


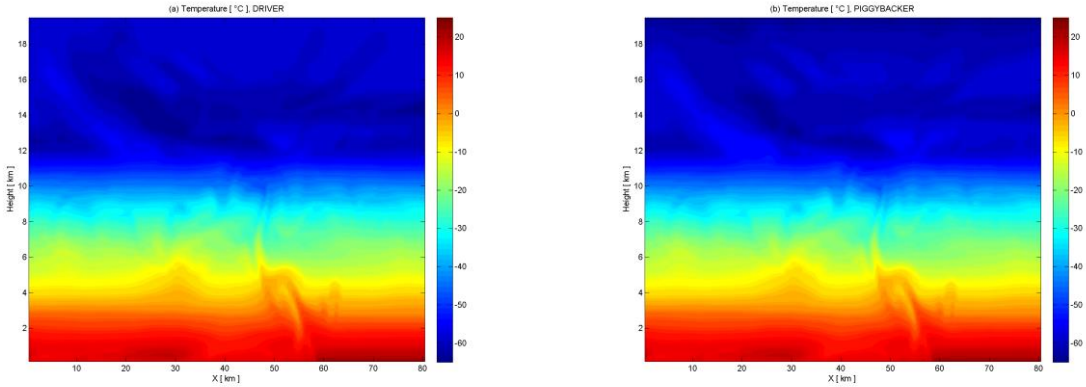
Figure: WSM6 as DRIVER and Thompson as PIGGYBACKER (red) vs. Thompson as DRIVER and WSM6 as PIGGYBACKER (blue) mean difference: (a) Temperature, (b) Water vapor mixing ratio, (c) Cloud water mixing ratio, (d) Rain water mixing ratio, (e) Rain water number concentration, (f) Snow mixing ratio, (g) Pristine ice mixing ratio, (h) Pristine ice number concentration and (j) Graupel mixing ratio.



2. *Piggybacking with different initial conditions (2D idealized squall line):*

   a. **Deep convection as DRIVER, little difference in initial temperature as PIGGYBACKER**

Figure 1: Temperature field, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



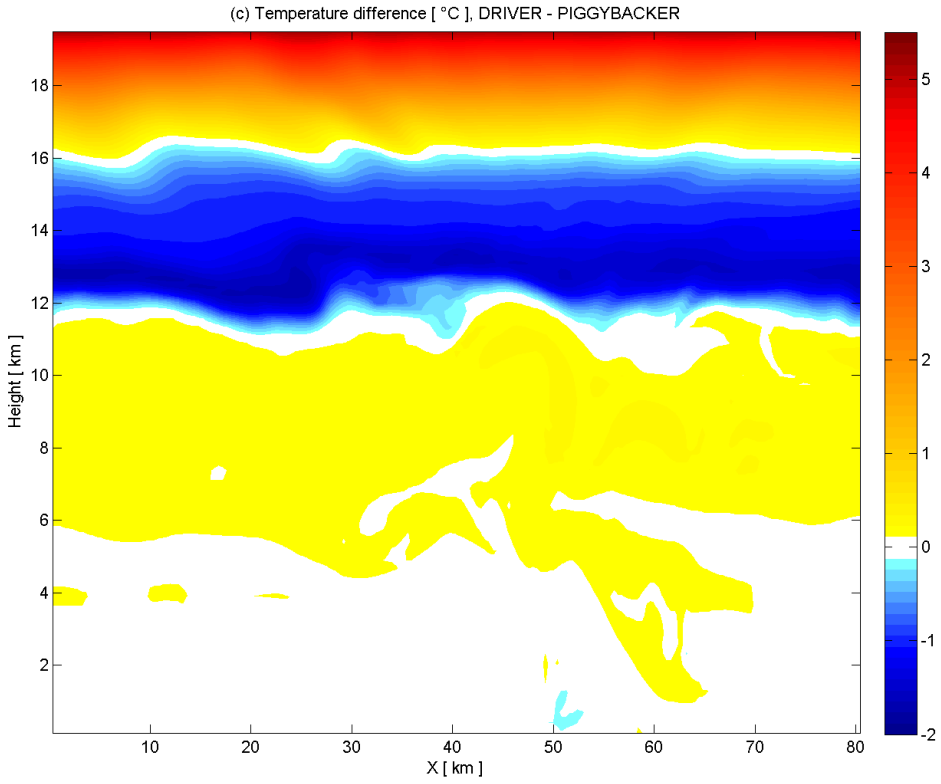
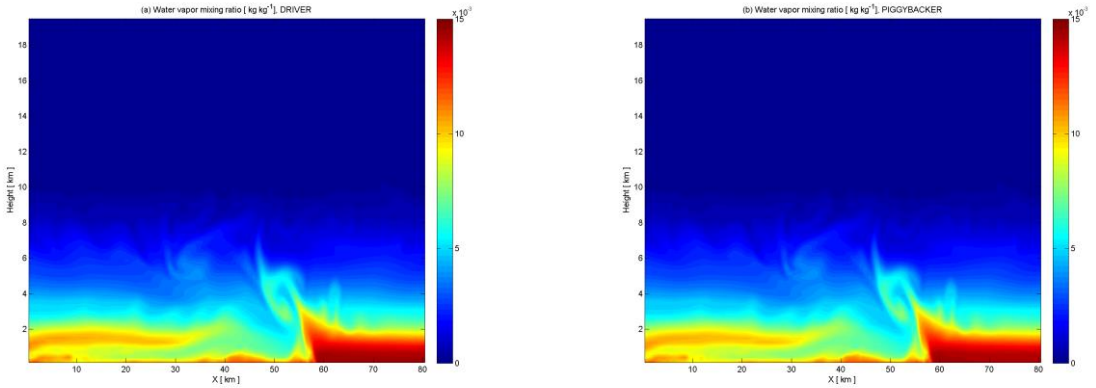


Figure 2: Water vapor mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



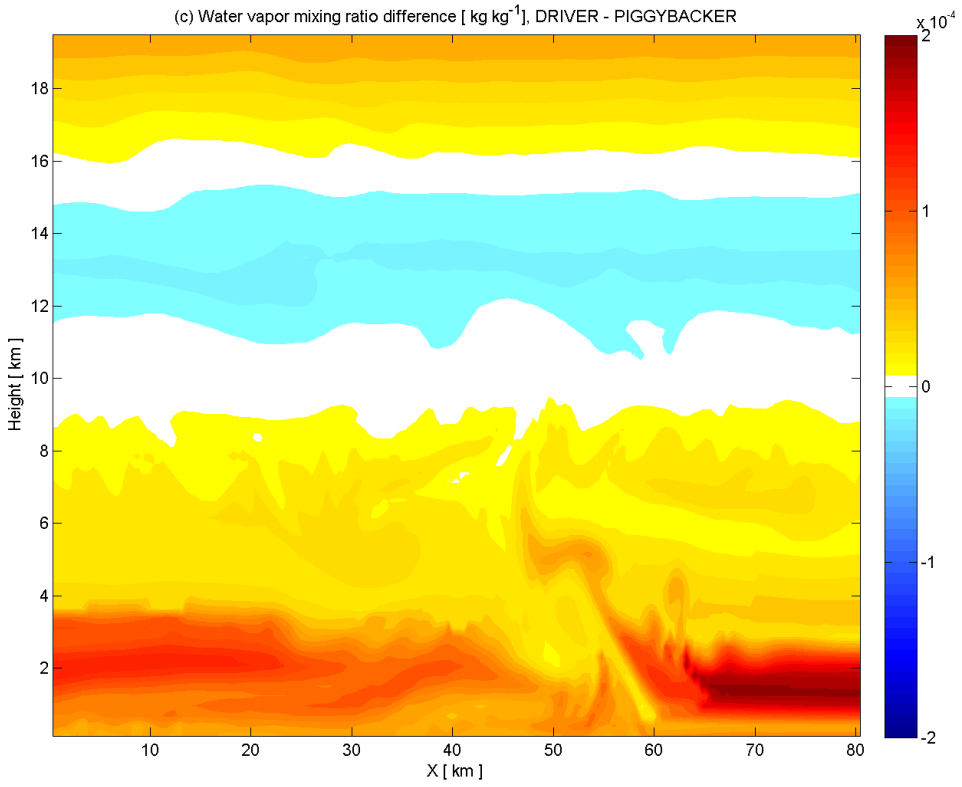


Figure 3: Rain water mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)

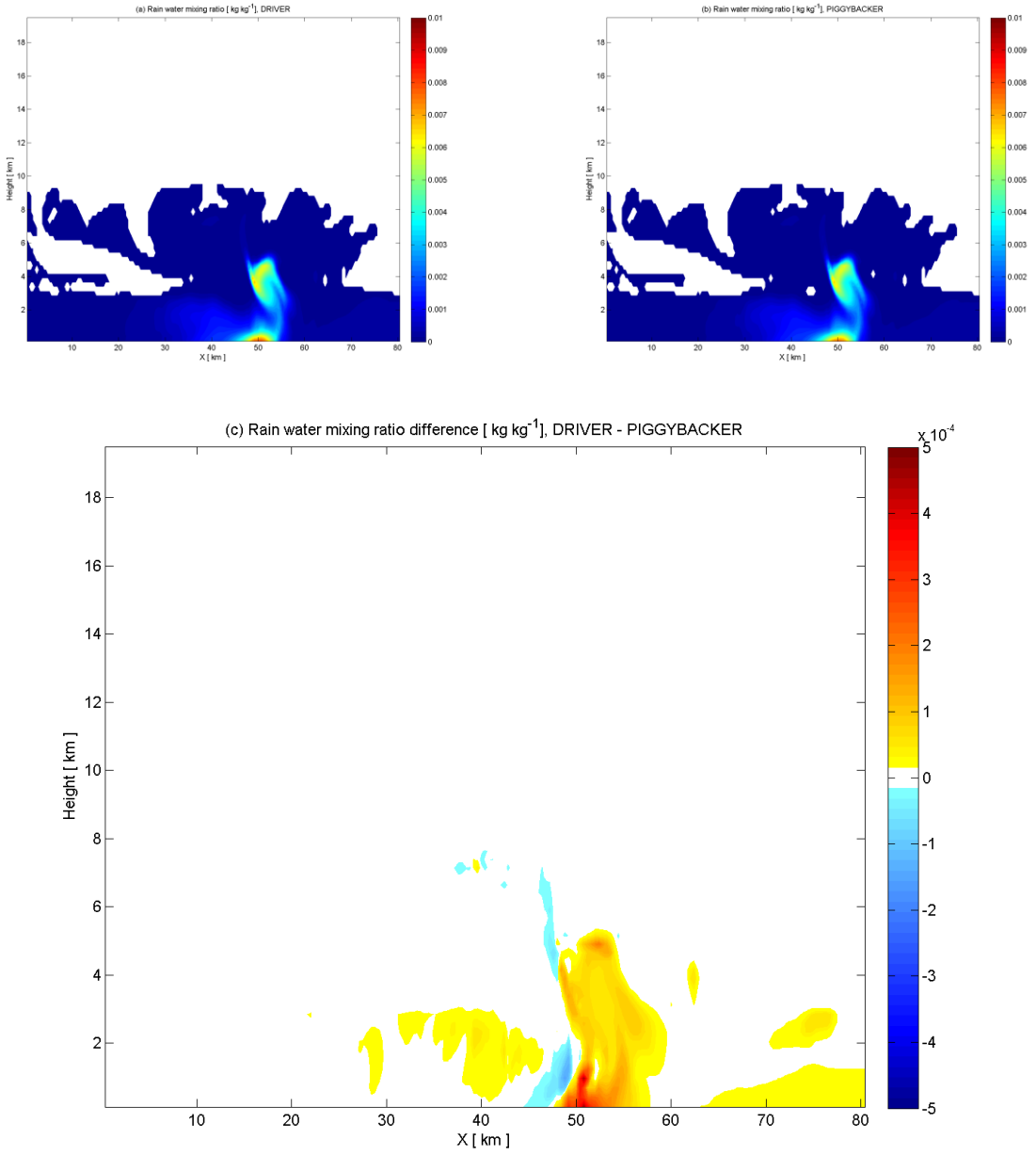
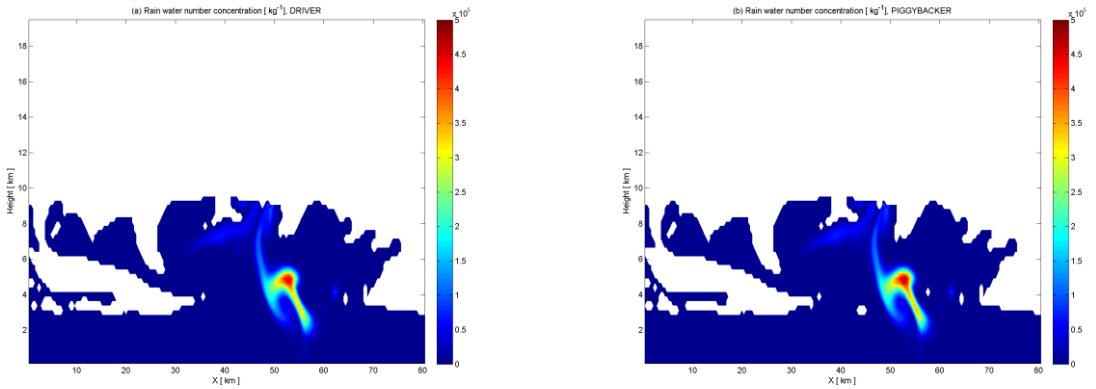


Figure 4: Rain water number concentration, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



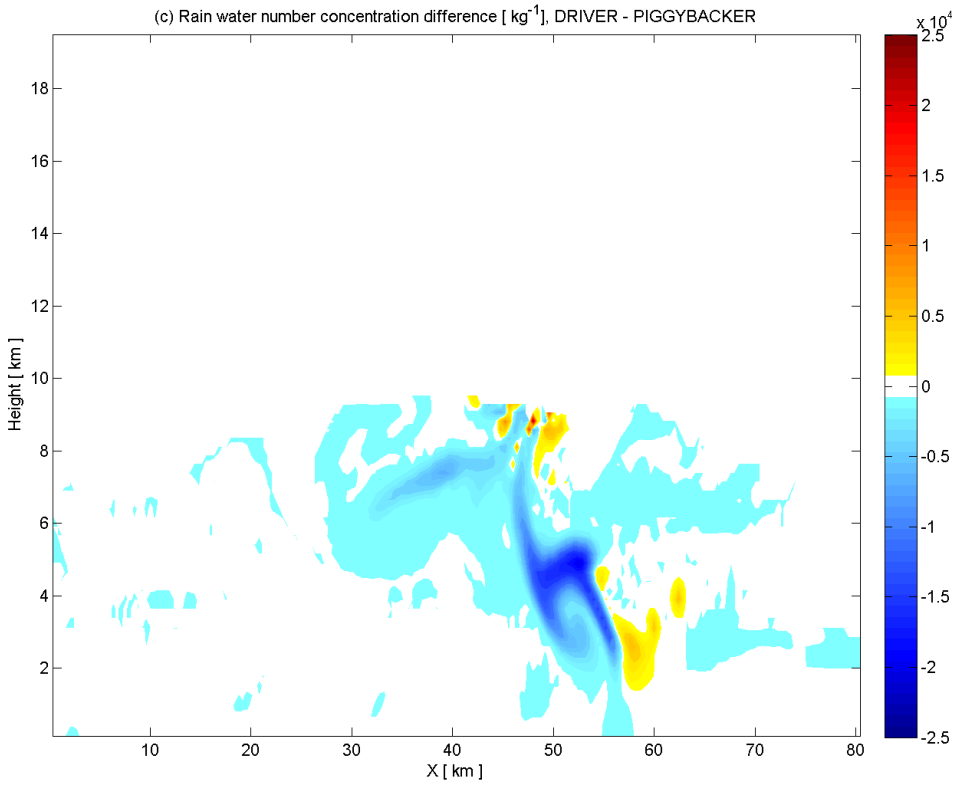
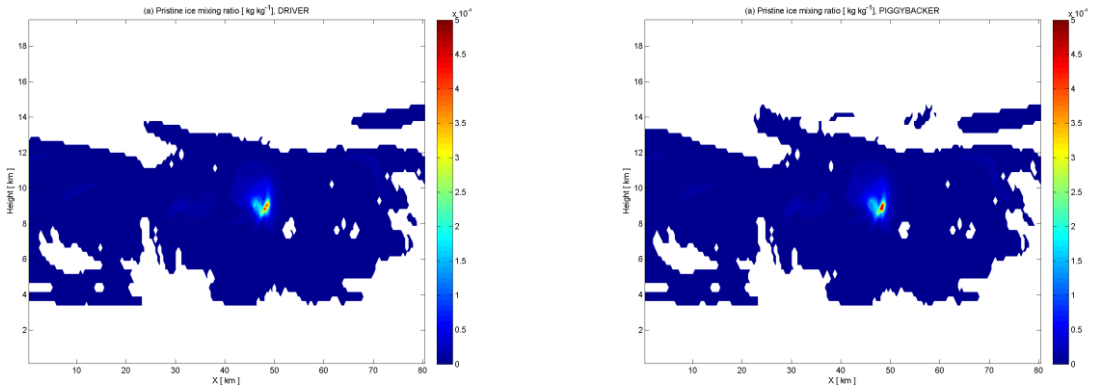


Figure 5: Pristine ice mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



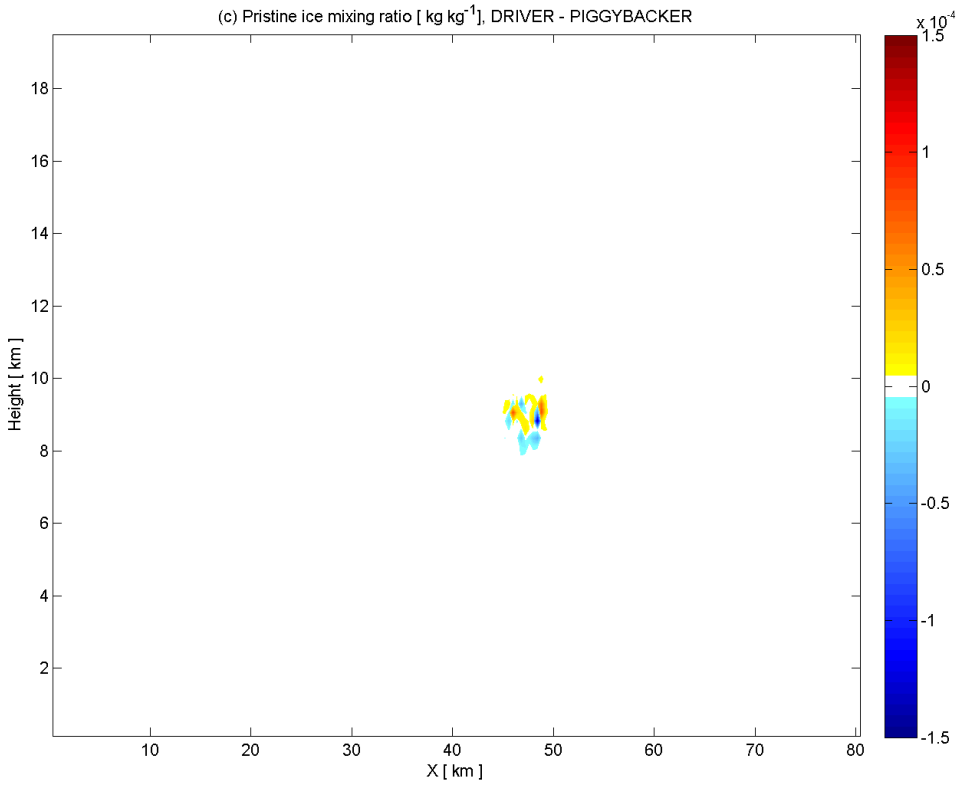
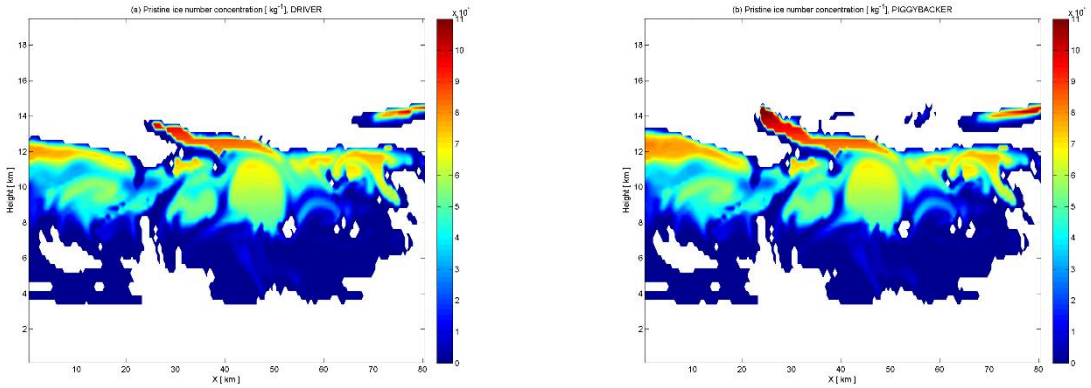


Figure 6: Pristine ice number concentration, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



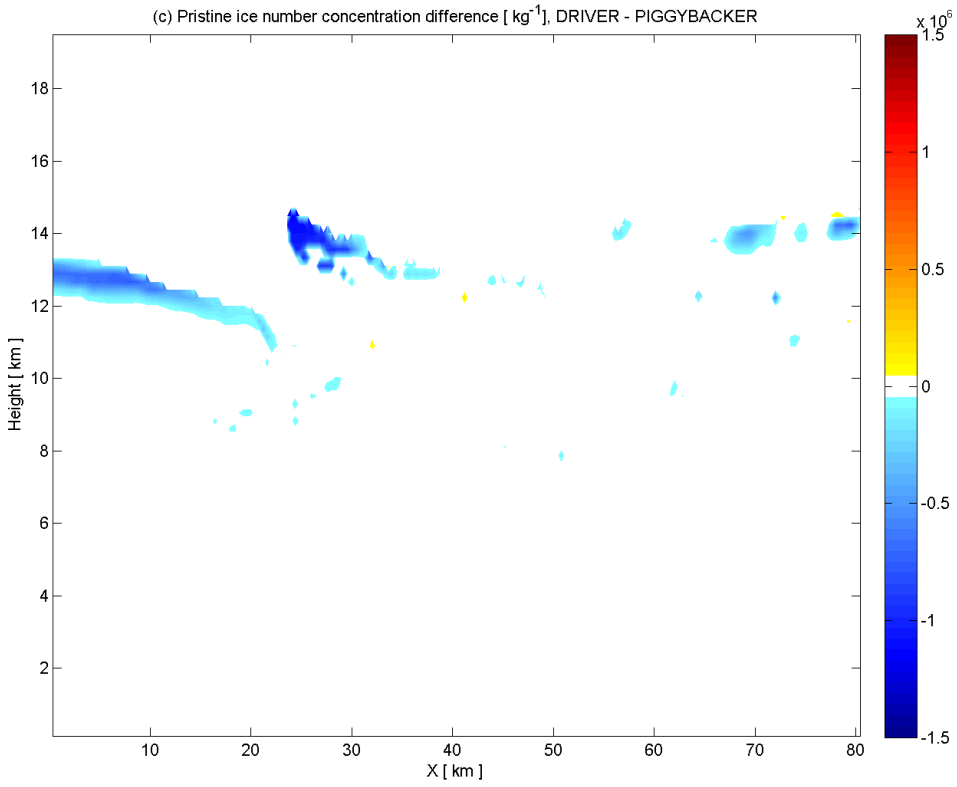
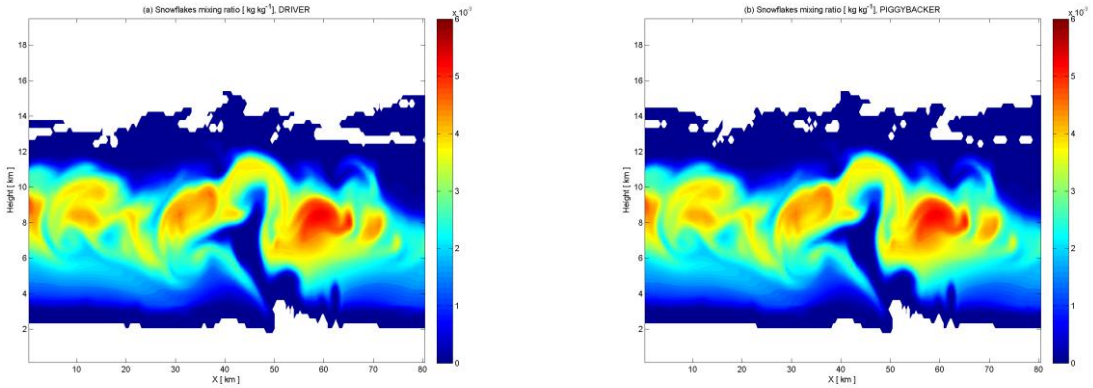


Figure 7: Snowflakes mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



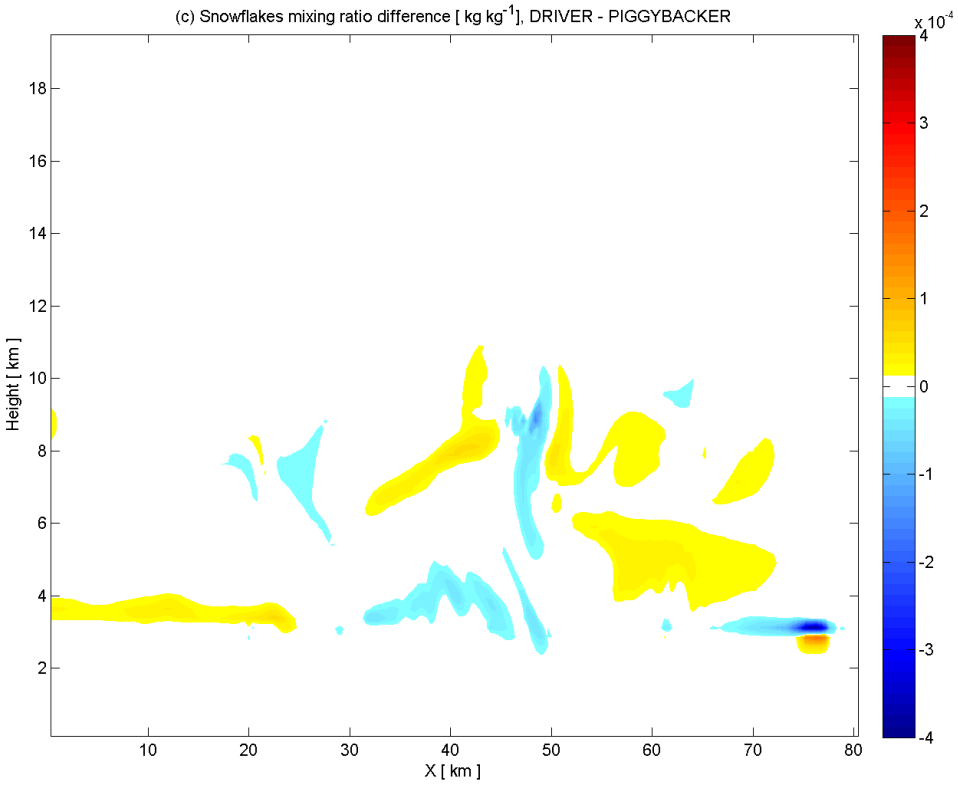
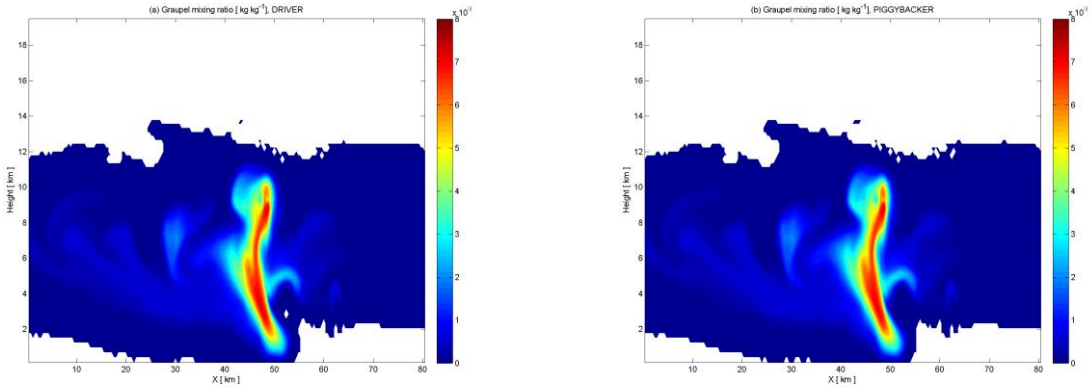


Figure 8: Graupel particle mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



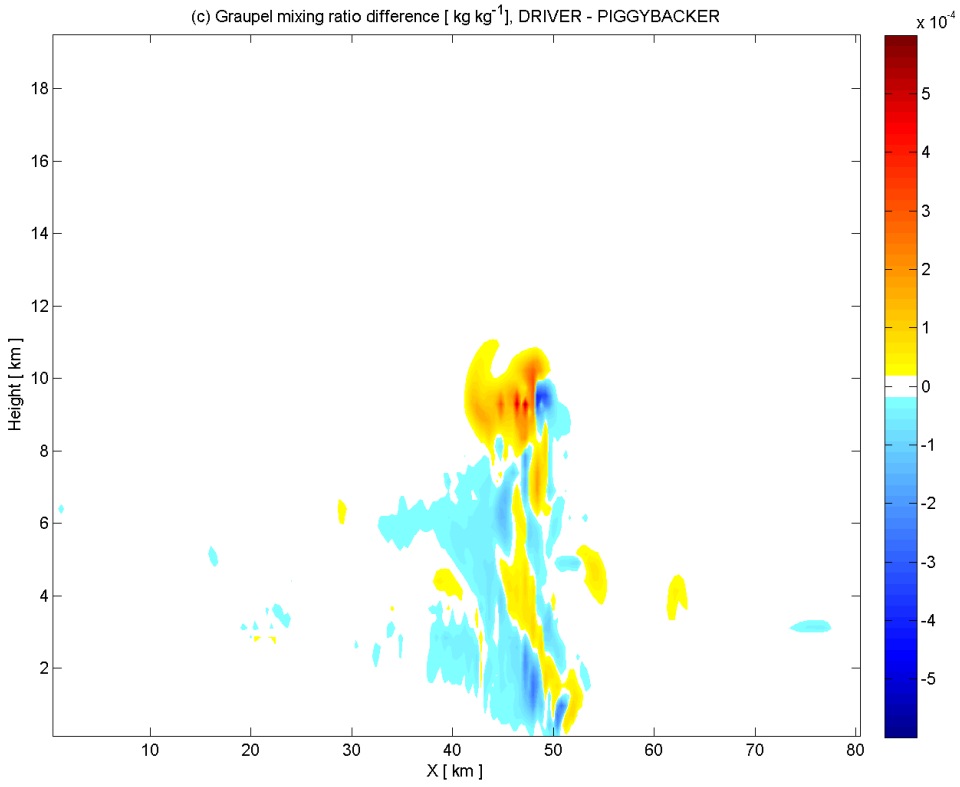
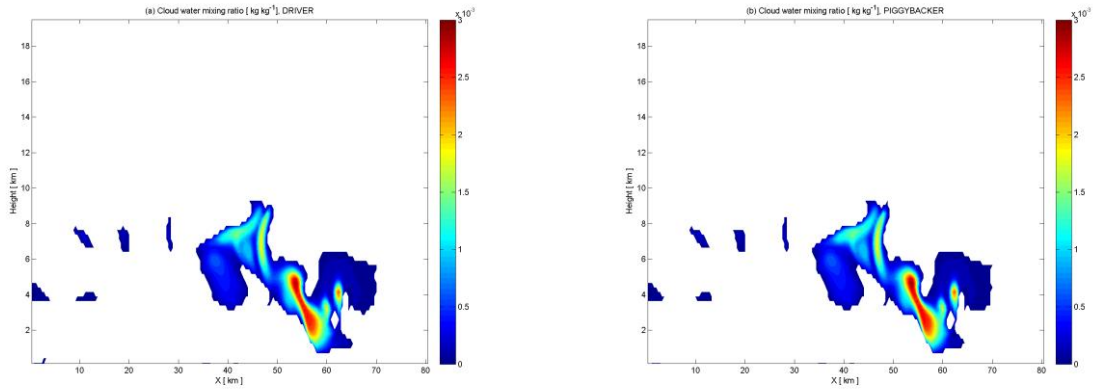


Figure 9: Cloud water mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



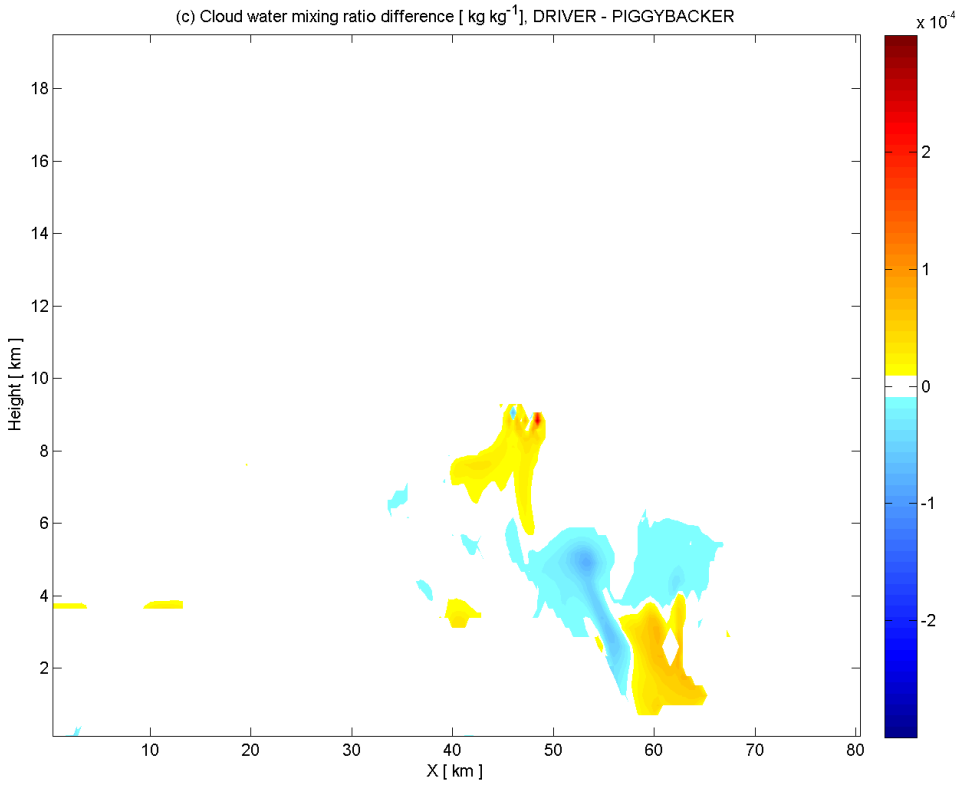
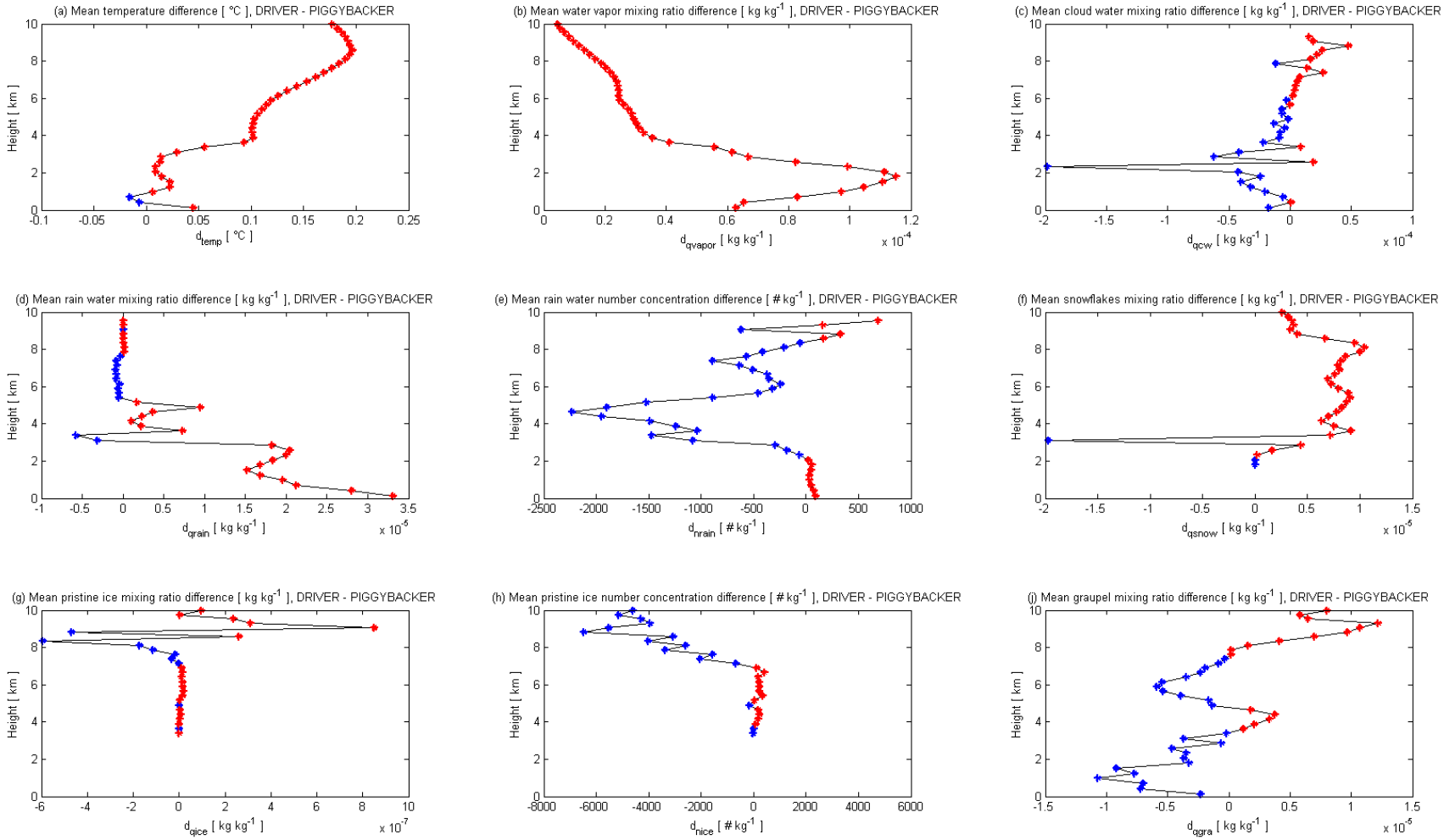


Figure 10: Mean difference fields (DRIVER – PIGGYBACKER): (a) Temperature, (b) Water vapor mixing ratio, (c) Cloud water mixing ratio, (d) Rain water mixing ratio, (e) Rain water number concentration, (f) Snow mixing ratio, (g) Pristine ice mixing ratio, (h) Pristine ice number concentration and (j) Graupel mixing ratio. (Red: Driver larger than piggybacker, Blue: Piggybacker larger than driver).



b. Deep convection as DRIVER, shallow convection as PIGGYBACKER

Figure 1: Temperature field, DRIVER (top left), PIGGYBACK (top right), difference (bottom)

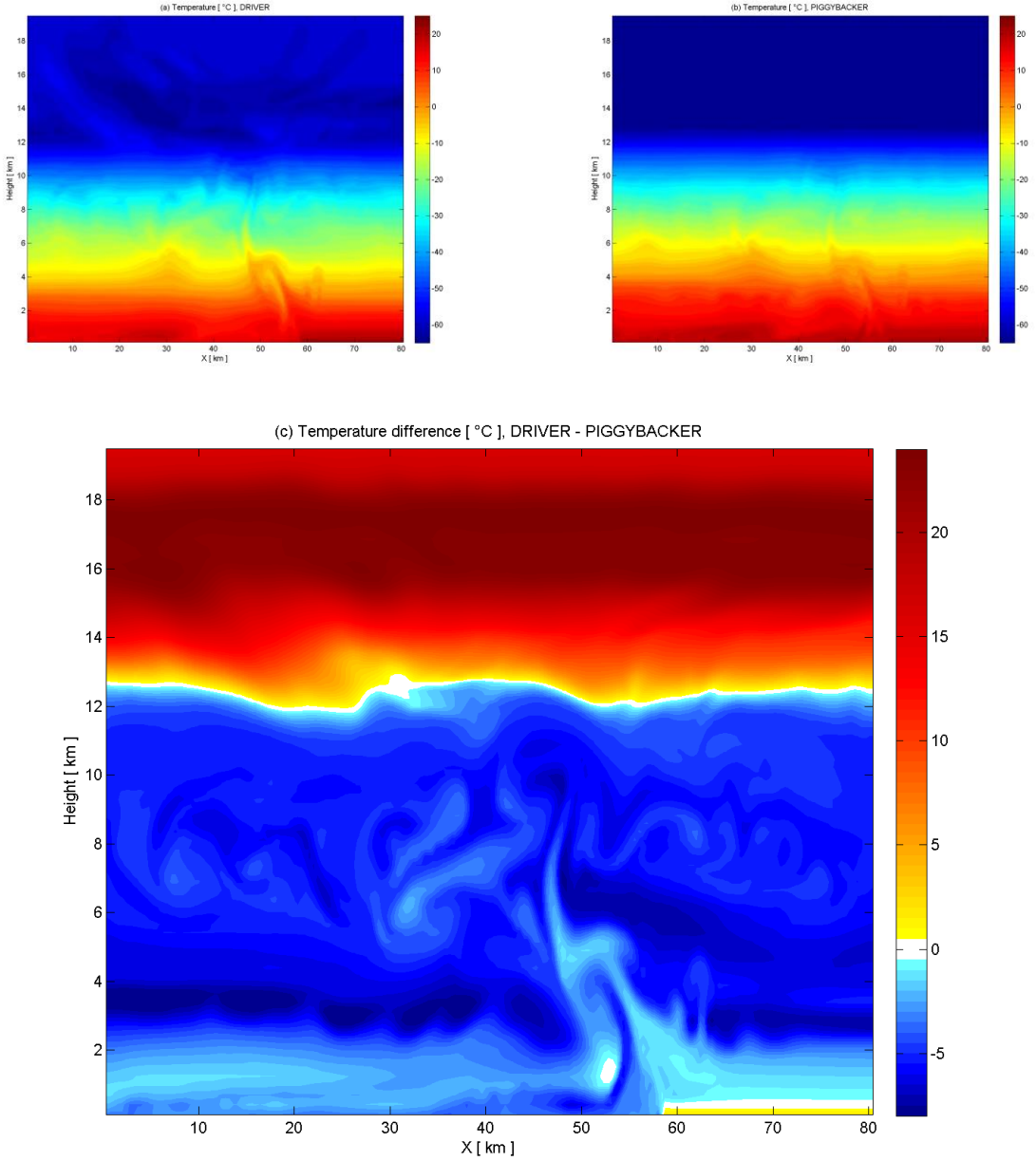
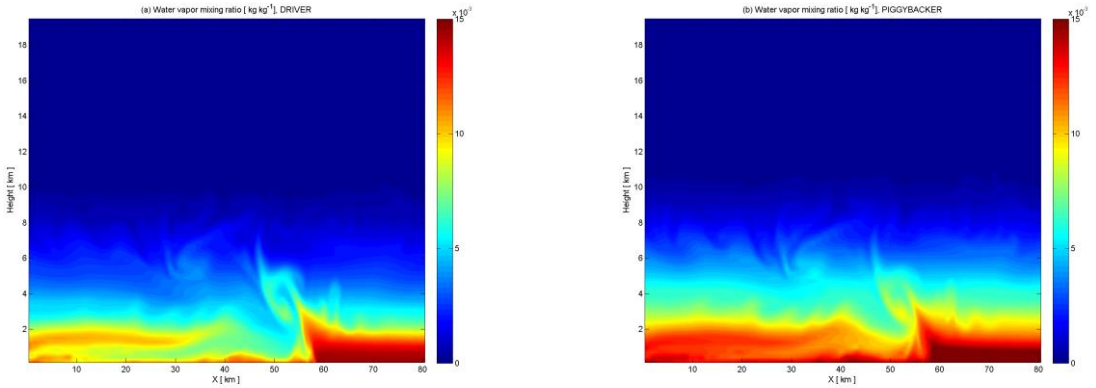


Figure 2: Water vapor mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



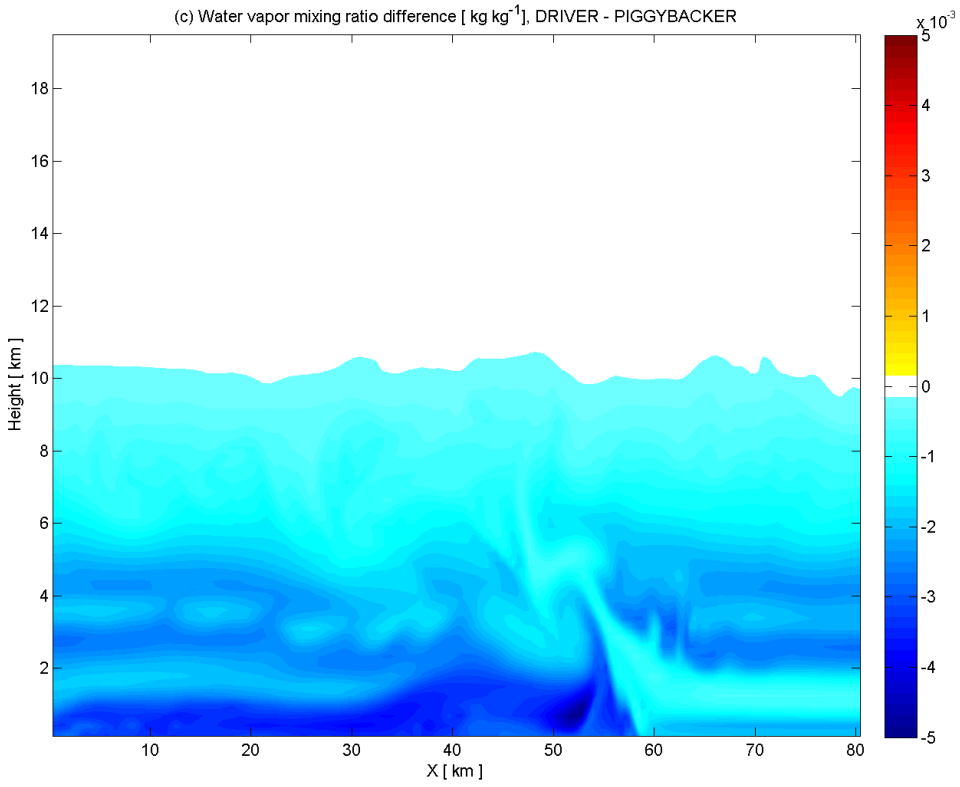
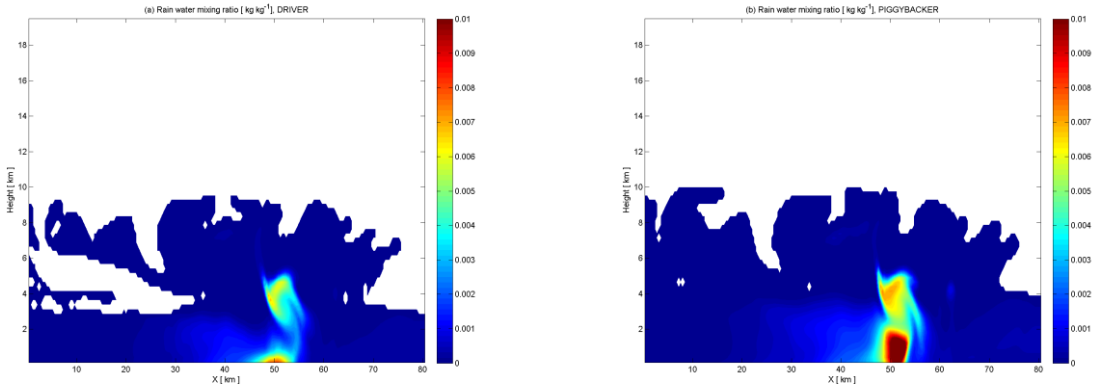


Figure 3: Rain water mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



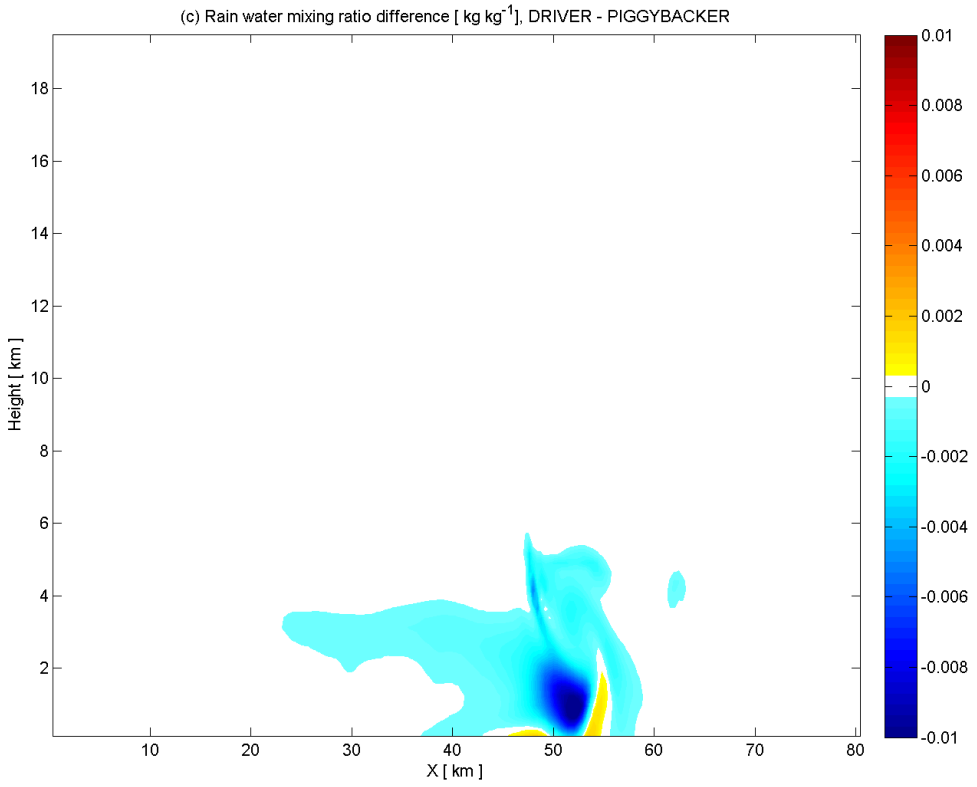
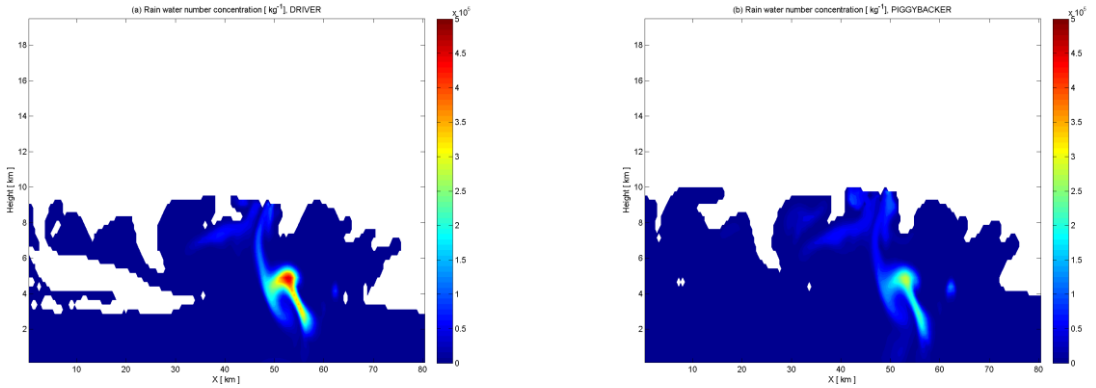


Figure 4: Rain water number concentration, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



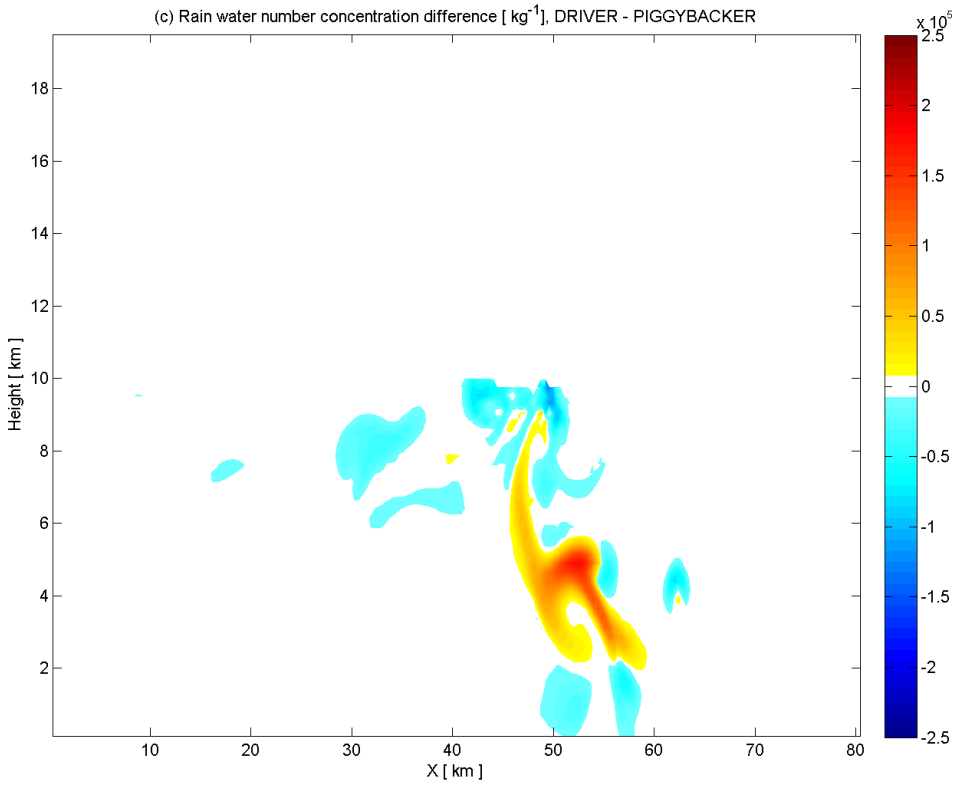
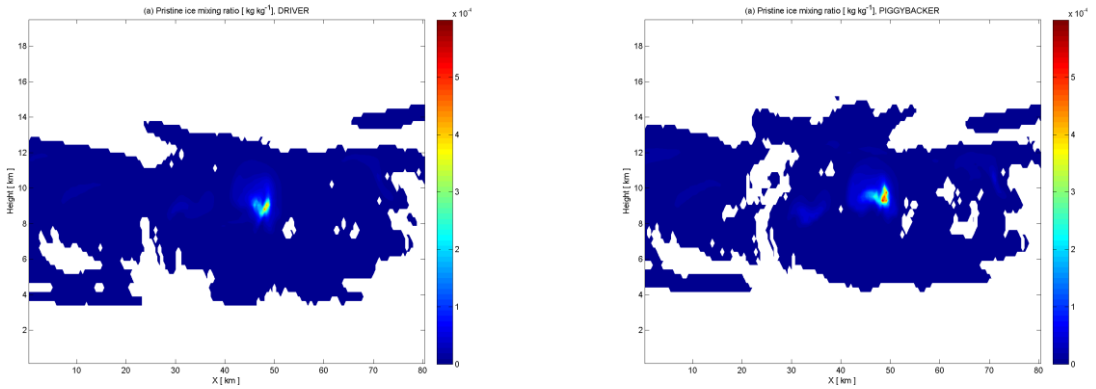


Figure 5: Pristine ice mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



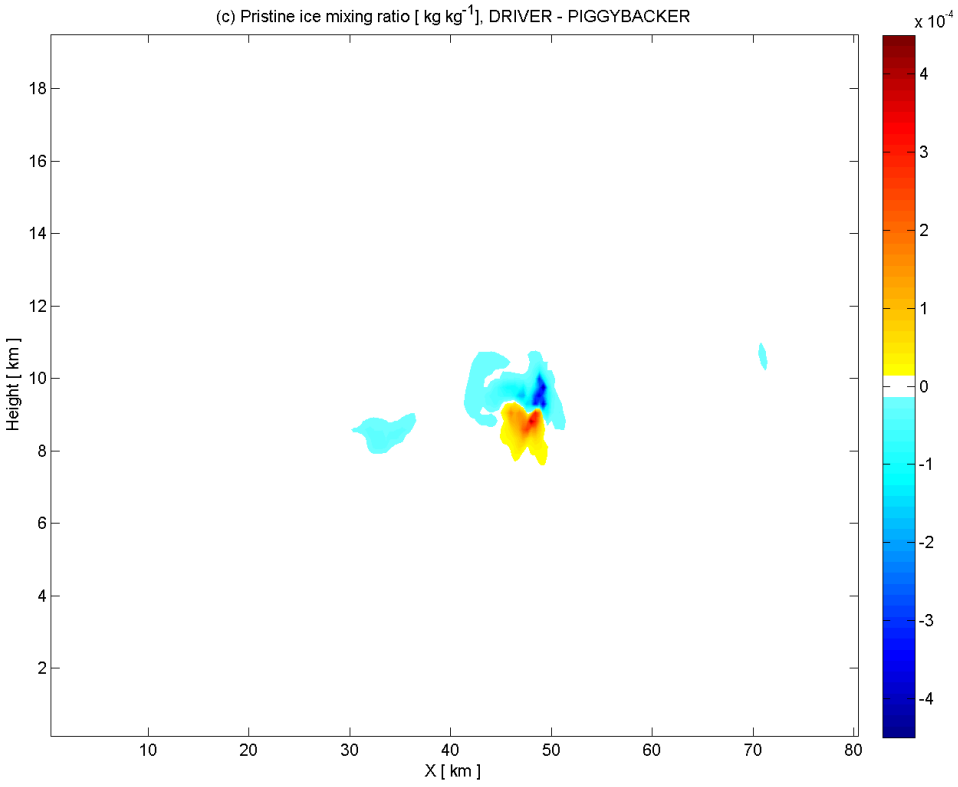
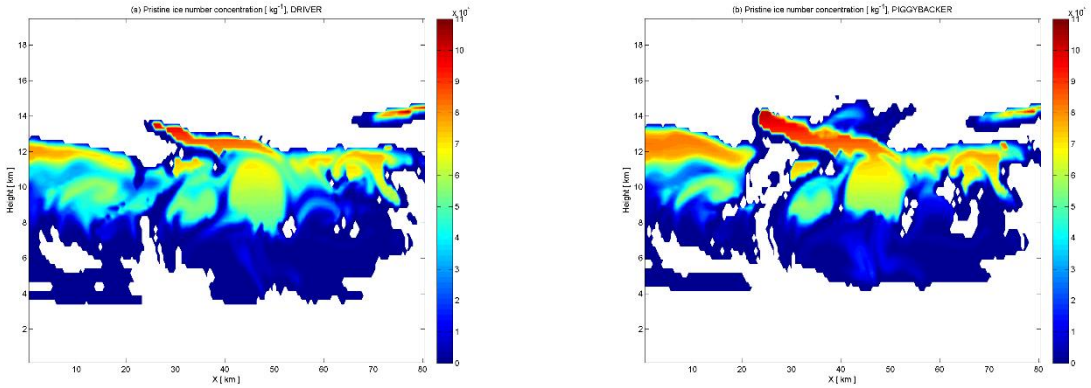


Figure 6: Pristine ice number concentration, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



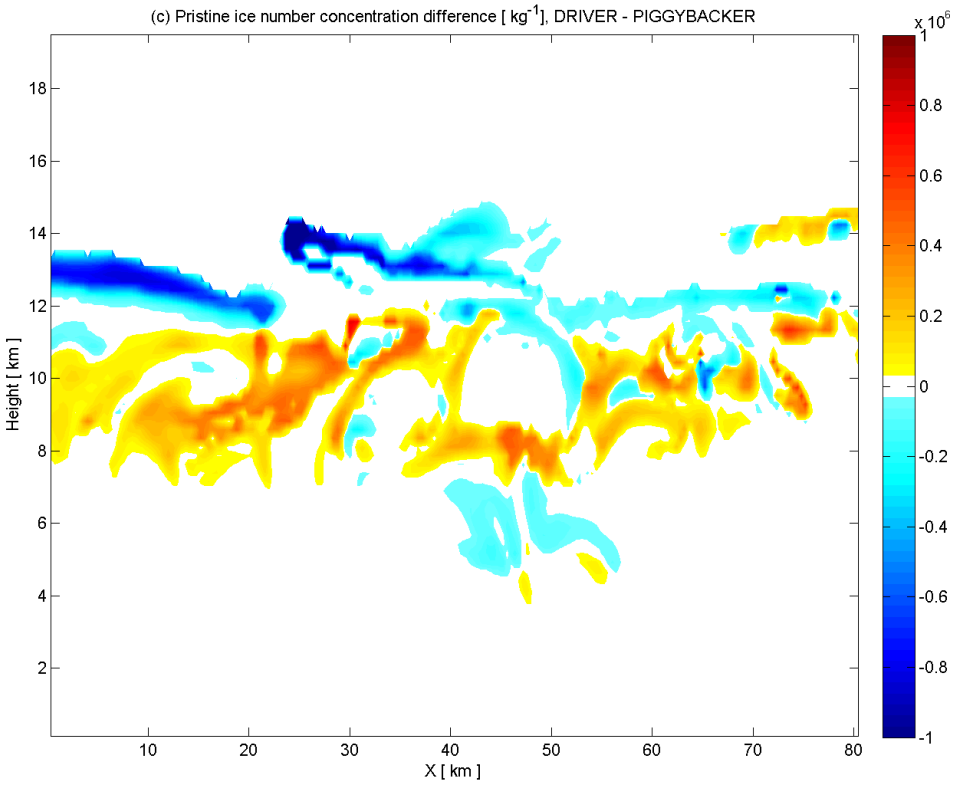
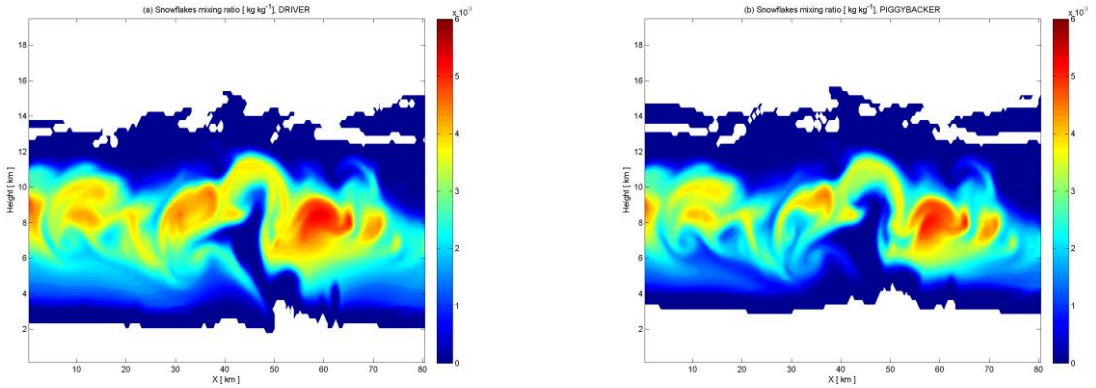


Figure 7: Snowflakes mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



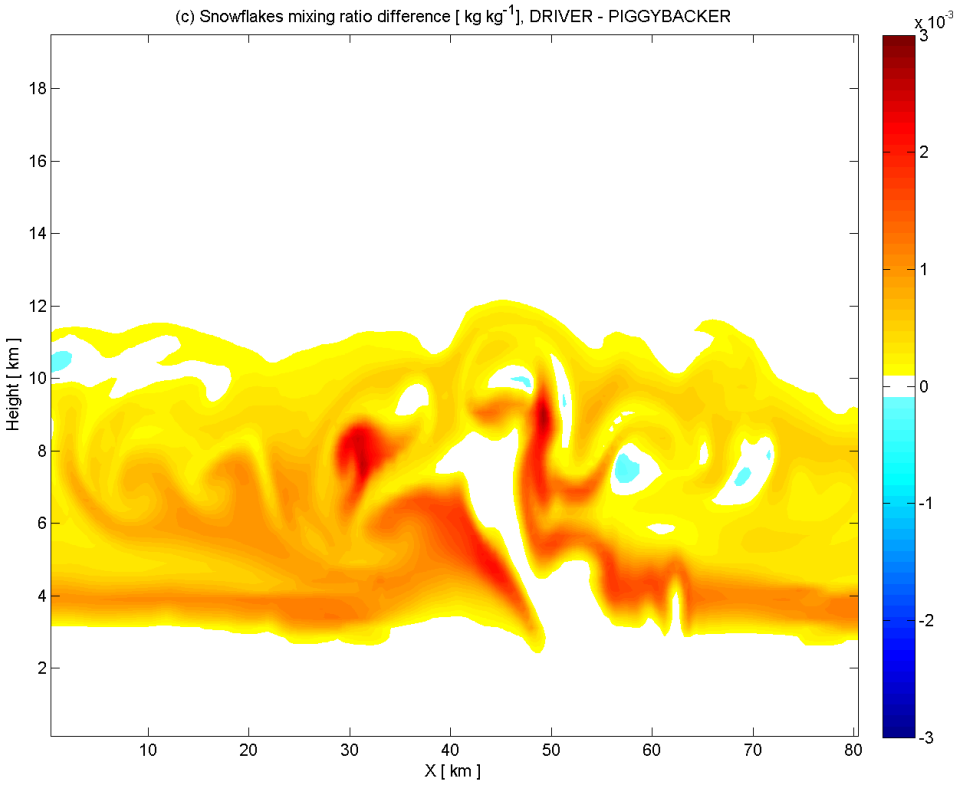
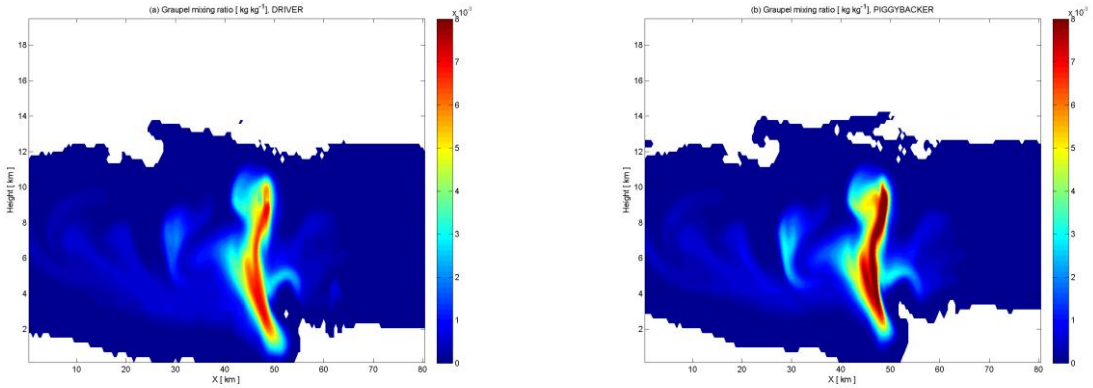


Figure 8: Graupel particle mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



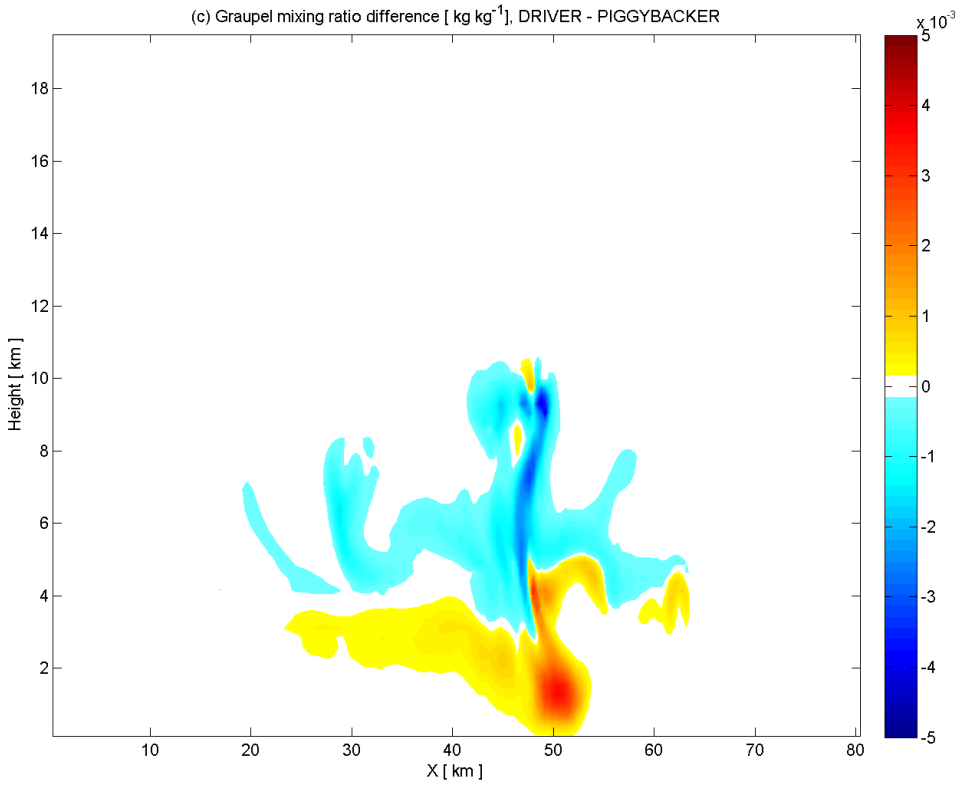
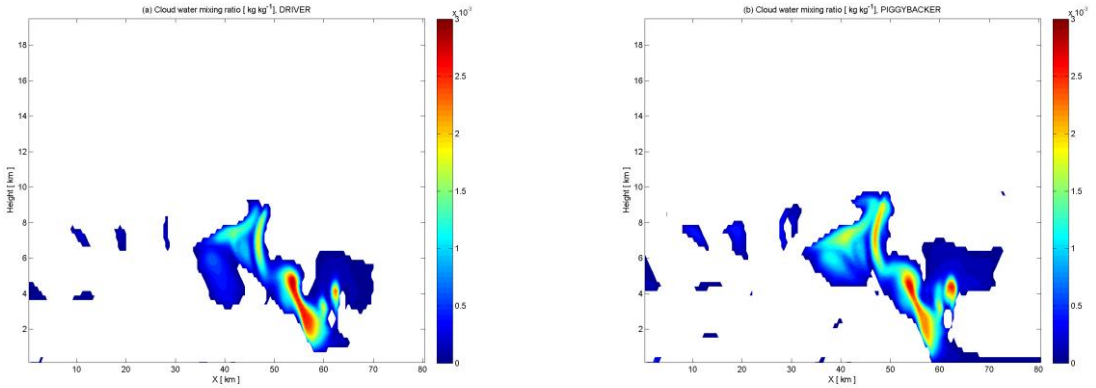


Figure 9: Cloud water mixing ratio, DRIVER (top left), PIGGYBACK (top right), difference (bottom)



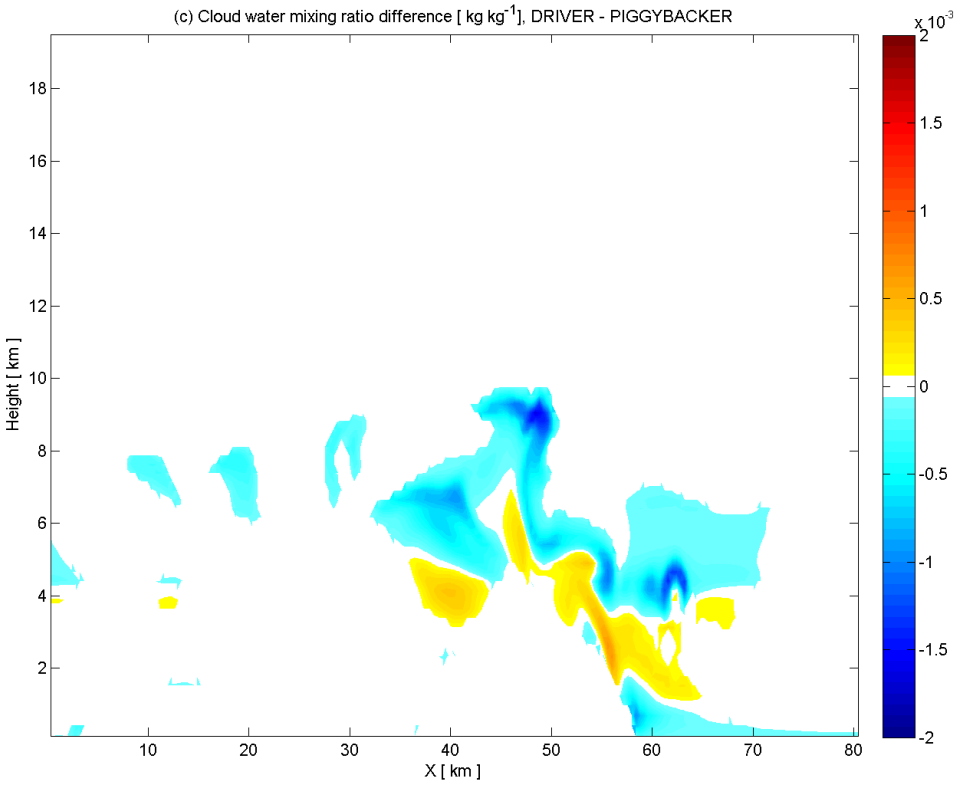


Figure 10: Mean difference fields (DRIVER – PIGGYBACKER): (a) Temperature, (b) Water vapor mixing ratio, (c) Cloud water mixing ratio, (d) Rain water mixing ratio, (e) Rain water number concentration, (f) Snow mixing ratio, (g) Pristine ice mixing ratio, (h) Pristine ice number concentration and (j) Graupel mixing ratio. (Red: Driver larger than piggybacker, Blue: Piggybacker larger than driver).