



CHARMS: consistent extinction/backscatter processing

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The Lidars

$3\beta+2\alpha$ aerosol retrievals

SGP Raman lidar (RL):

- Extinction (α) (355nm)
- Aerosol backscatter (β) (355nm)
 - 2 FOVs

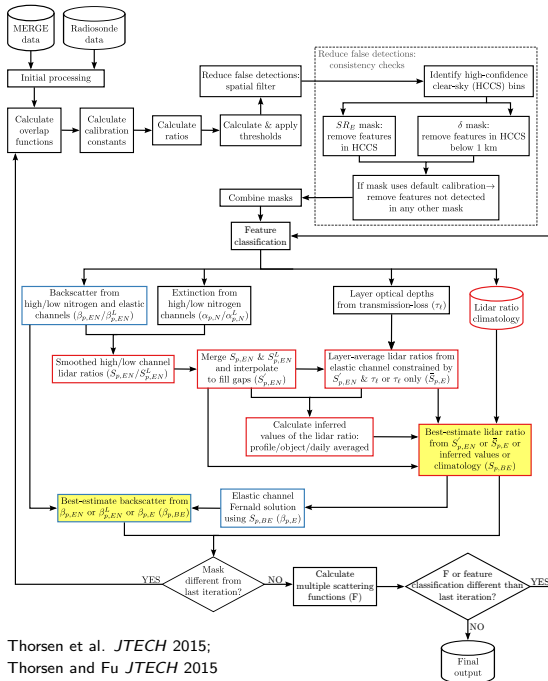
Univ. Wisconsin HSRL:

- Aerosol backscatter (β) (1064nm)
- Aerosol backscatter (β) (532nm)
- Extinction (α) (532nm)

The approach

- Need to combine the HSRL/RL data for input into the aerosol microphysical retrievals
- Want to sample the same volume of atmosphere
- 10 min and 60m averages
(microphysical retrievals want the noise below $\sim 20\%$)
- Raman is noisier \rightarrow match the HSRL to the Raman's processing

RL-FEX (Feature detection and EXtinction)



Main outputs:

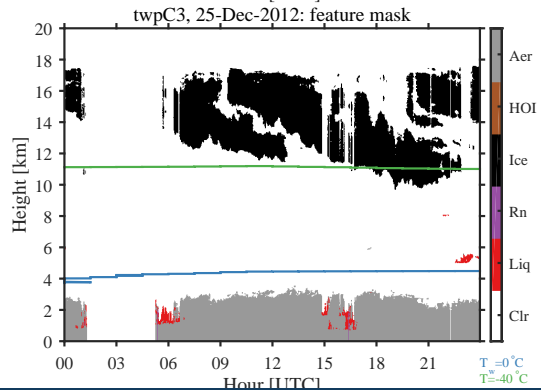
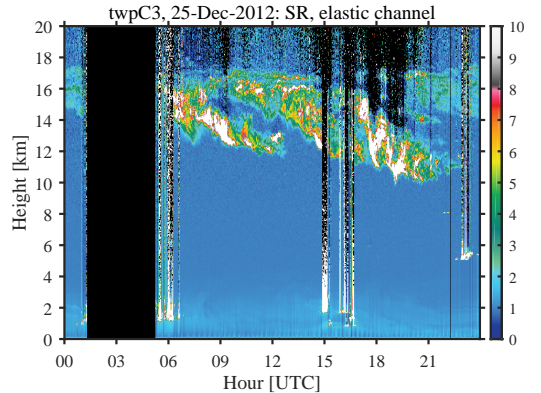
- Feature mask (aerosol/rain/liquid/ice/HOI)
- Cloud/aerosol extinction
- Cloud/aerosol back-scatter

RL-FEX: extinction

- Aerosol mask applied
 - Only smooth significant aerosol signals
 - Don't smooth cloud signal into aerosol
- Work towards a smoothed lidar ratio (even though extinction is the real noisy one)
 - Easier to smooth
 - Linear smoothing (straightforward error propagation)
- Extinction = Backscatter \times smoothed lidar ratio
(better preserve the extinction's spatial structure)

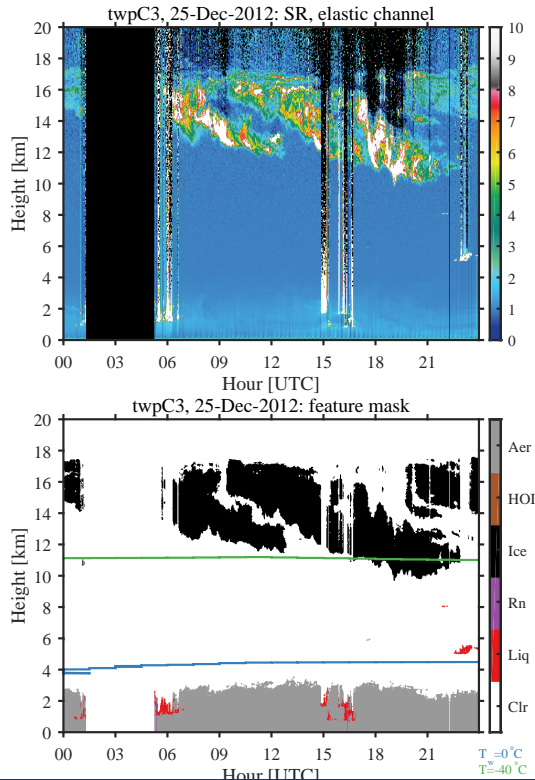
Lidar ratio: Raman method

- Obtain a smoothed lidar ratio ($= \frac{\text{extinction}}{\text{backscatter}}$)



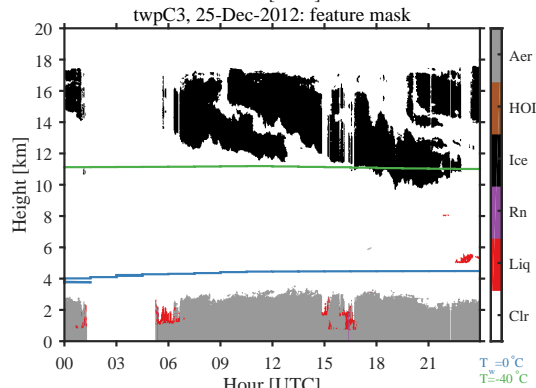
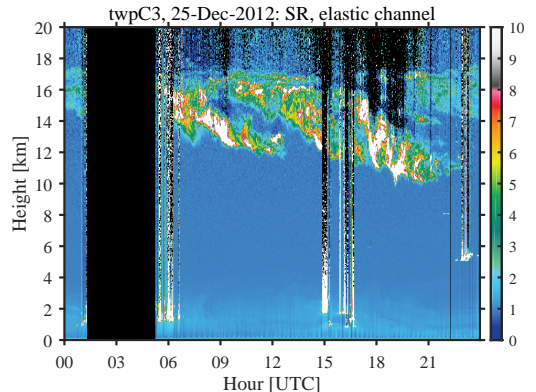
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- Lower height bins ignored (overlap)



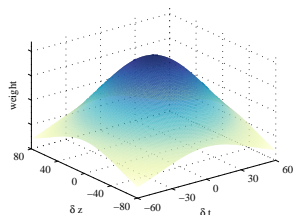
Lidar ratio: Raman method

- Obtain a smoothed lidar ratio ($= \frac{\text{extinction}}{\text{backscatter}}$)
- Lower height bins ignored (overlap)
- Retrieved at multiple effective resolutions
 - Obtain the lidar ratio with a random error $< 30\%$ at the least amount of smoothing possible
 - Maximize amount/accuracy of retrievals at the expense of an unpredictable variable resolution

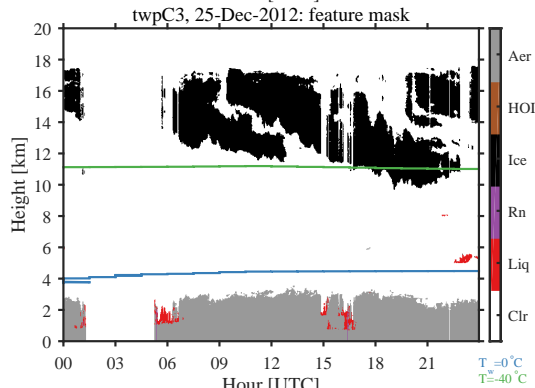
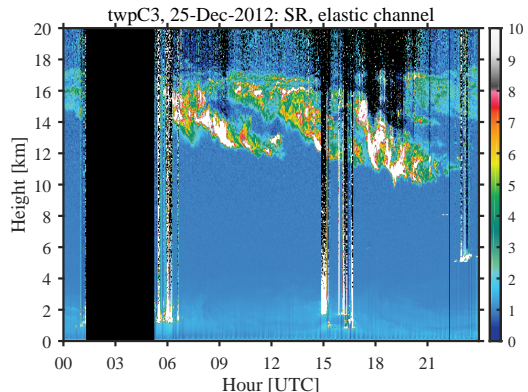


Lidar ratio: Raman method

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- Smoothing: 2D Gaussian

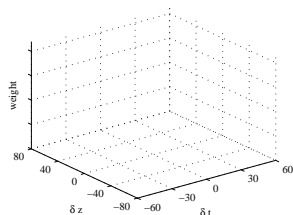


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Level 2	10×5
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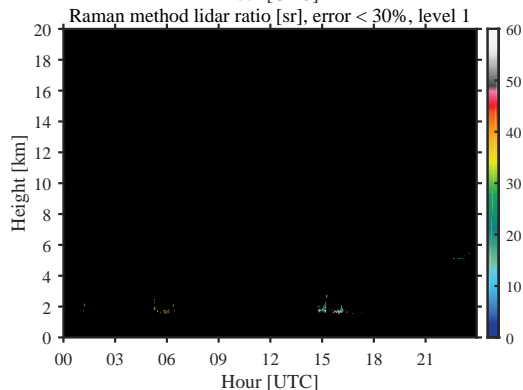
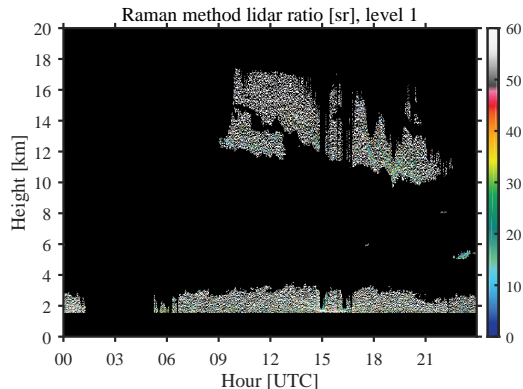


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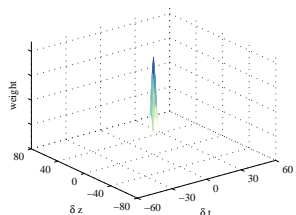


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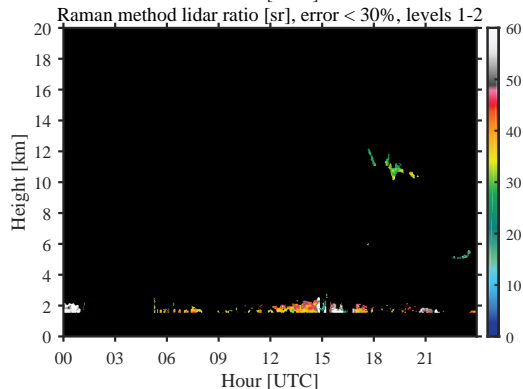
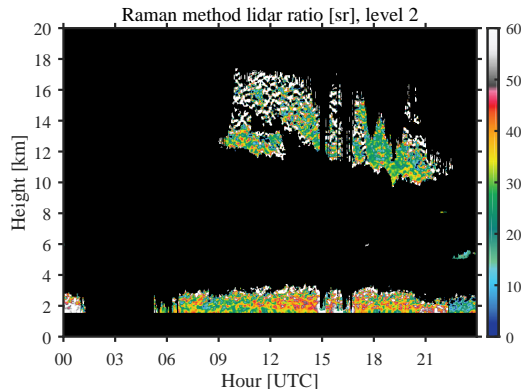


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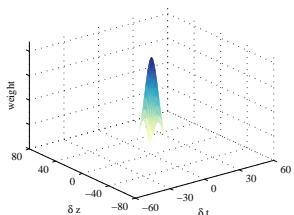


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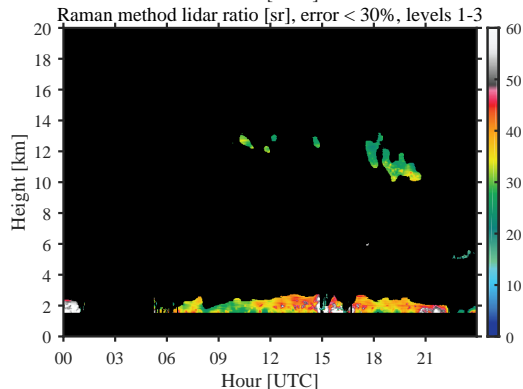
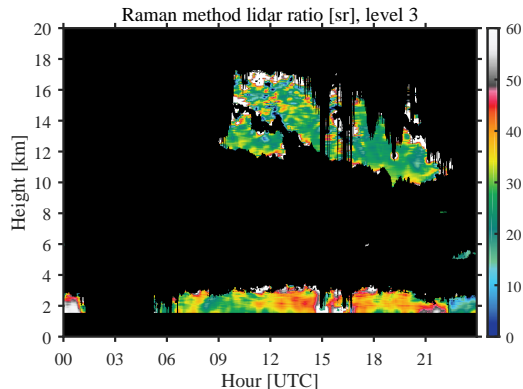


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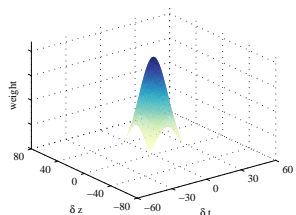


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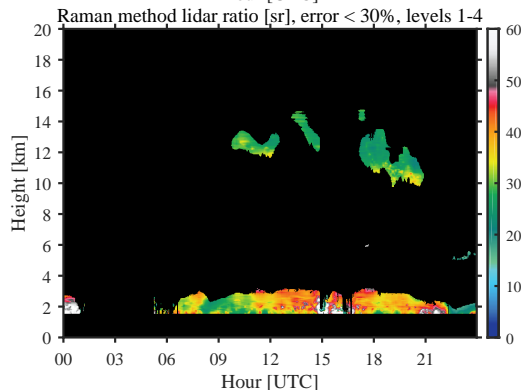
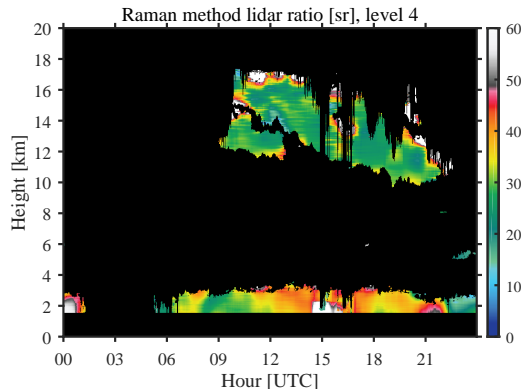


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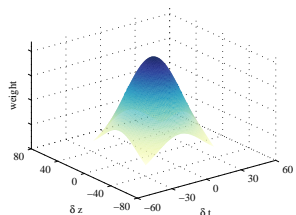


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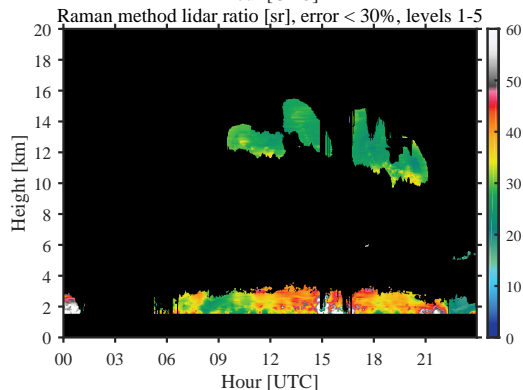
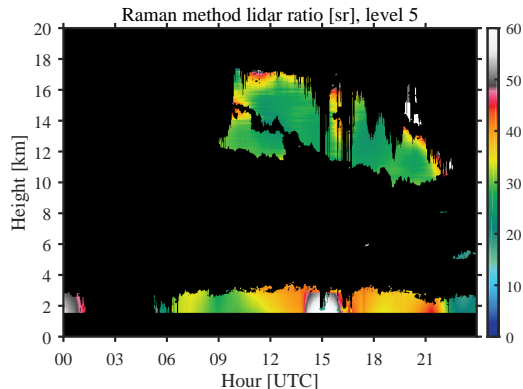


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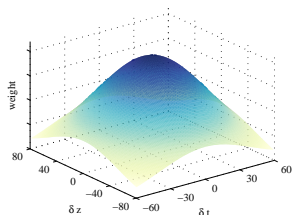


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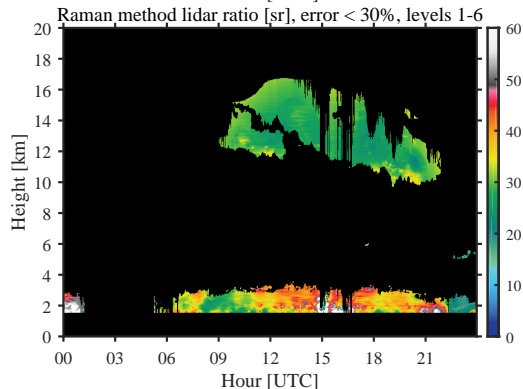
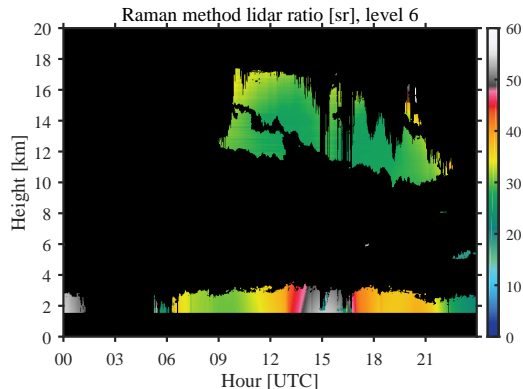


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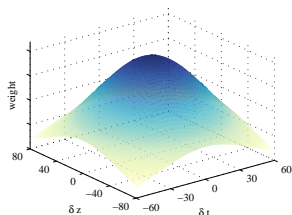


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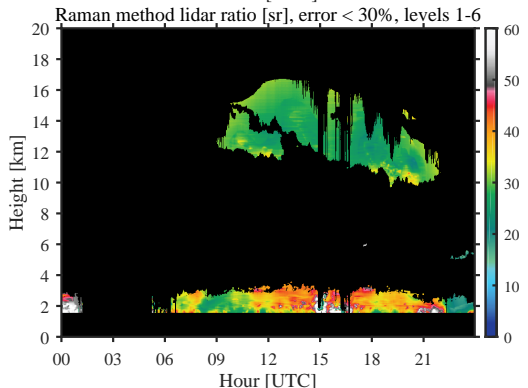
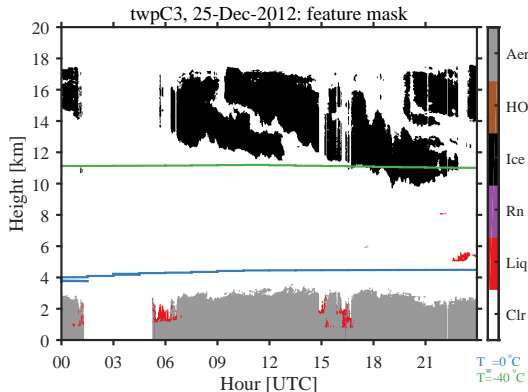


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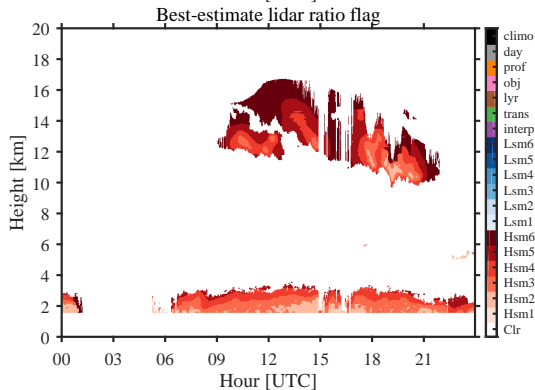
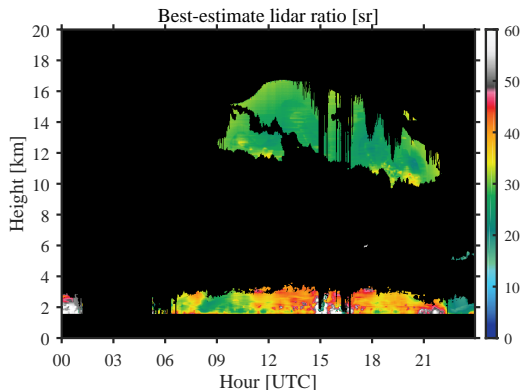
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Lidar ratio: Best-estimate

Directly-retrieved:

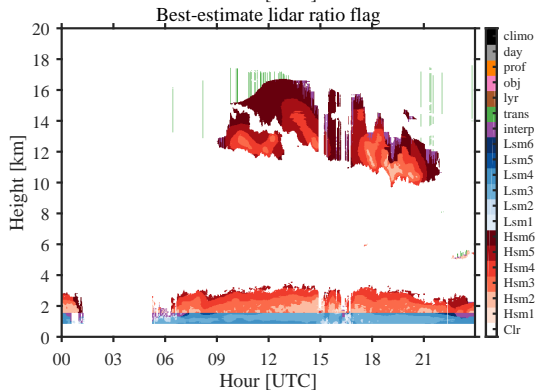
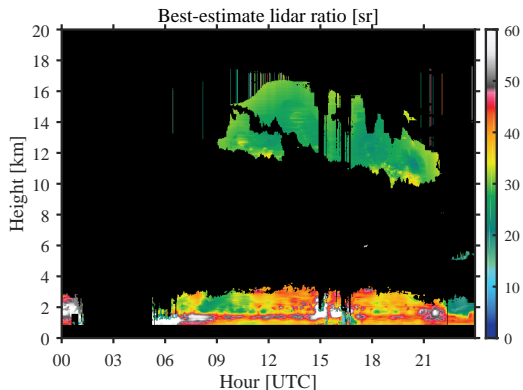
① High channel Raman method



Lidar ratio: Best-estimate

Directly-retrieved:

- ① High channel Raman method
- ② Low channel Raman method
- ③ Interpolation
- ④ Layer-averaged constrained by transmission-loss and ① – ③



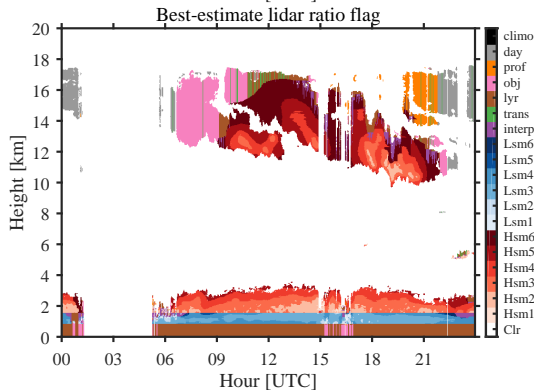
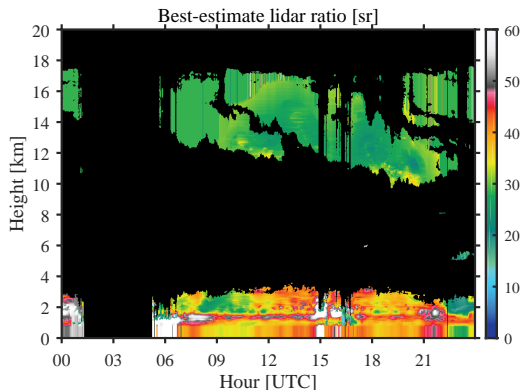
Lidar ratio: Best-estimate

Directly-retrieved:

- ① High channel Raman method
- ② Low channel Raman method
- ③ Interpolation
- ④ Layer-averaged constrained by transmission-loss and ① – ③

Inferred: averages of the above values

- ⑤ Layer-averaged: ① – ④
- ⑥ Object-averaged: ① – ④
- ⑦ Profile-averaged: ① – ④
- ⑧ Daily-averaged: ① – ④



RL-FEX: updates

- Stricter uncertainty requirement for high channel ($<15\%$); low channel still $<30\%$.
- Raised minimum trustworthy height to attempt a lidar ratio retrieval using the high channels to 2km (from 1.5km)
- Improved combining of FOVs for backscatter (low channel only used below 0.8 km)

HSRL-FEX

Apply the same processing to the HSRL

- Match RL height/times (10min/60m)
- Apply RL-FEX aerosol mask

HSRL-FEX

Apply the same processing to the HSRL

- Match RL height/times (10min/60m)
- Apply RL-FEX aerosol mask
- UW-processed 532nm/1064nm backscatter → output

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Apply the same processing to the HSRL

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- 532nm molecular signal → extinction (finite difference)

HSRL-FEX

Apply the same processing to the HSRL

- Match RL height/times (10min/60m)
- Apply RL-FEX aerosol mask
- UW-processed 532nm/1064nm backscatter → output
- 532nm molecular signal → extinction (finite difference)
- Smooth 532nm backscatter/extinction to get the lidar ratio
 - ① Same smoothing as used for the RL high channels
 - ② Same smoothing as used for the RL low channels

HSRL-FEX

Apply the same processing to the HSRL

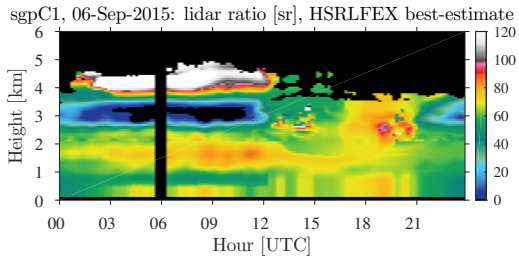
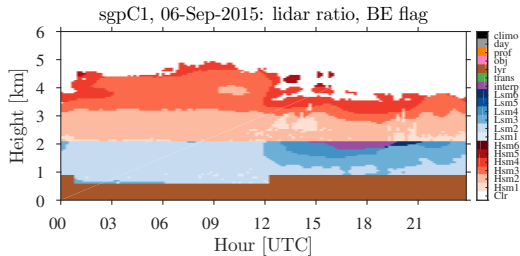
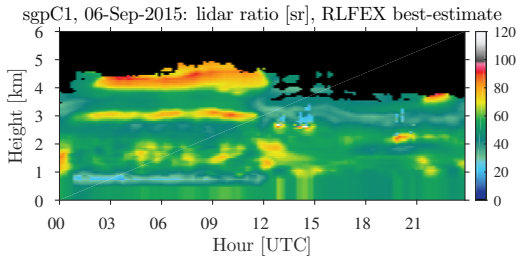
- Match RL height/times (10min/60m)
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- UW-processed 532nm/1064nm backscatter → output
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- Smooth 532nm backscatter/extinction to get the lidar ratio
 - ① Same smoothing as used for the RL high channels
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- Mimic the RL-FEX best estimate: combine the high/low “channels”, use layer-averages to fill in near the surface

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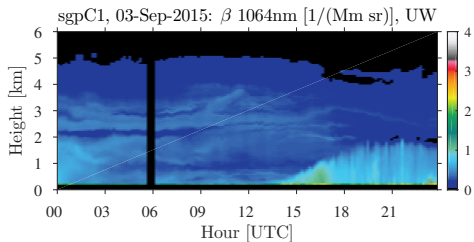
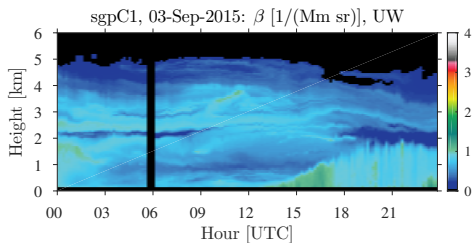
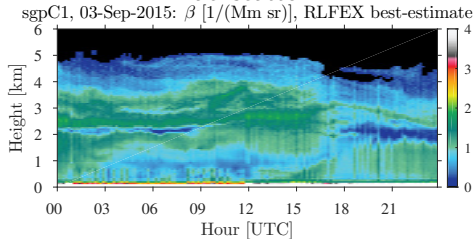
Apply the same processing to the HSRL

- Match RL height/times (10min/60m)
- Apply RL-FEX aerosol mask
- UW-processed 532nm/1064nm backscatter → output
- 532nm molecular signal → extinction (finite difference)
- Smooth 532nm backscatter/extinction to get the lidar ratio
 - ① Same smoothing as used for the RL high channels
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- Mimic the RL-FEX best estimate: combine the high/low “channels”, use layer-averages to fill in near the surface
- 532nm extinction = backscatter × smoothed lidar ratio

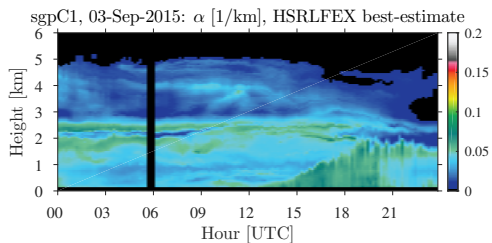
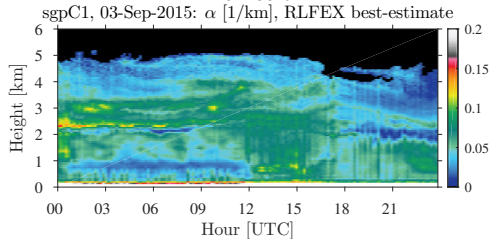
Lidar ratio



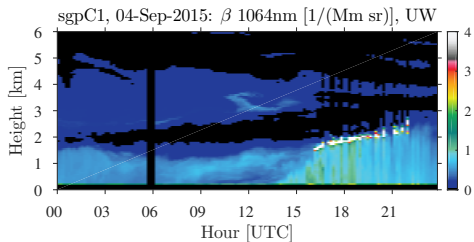
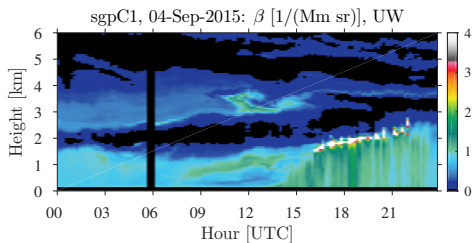
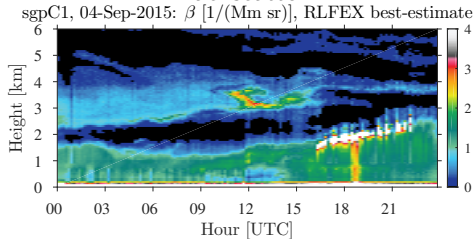
Backscatter



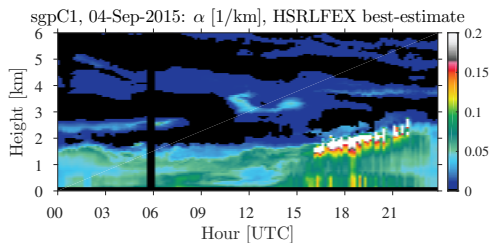
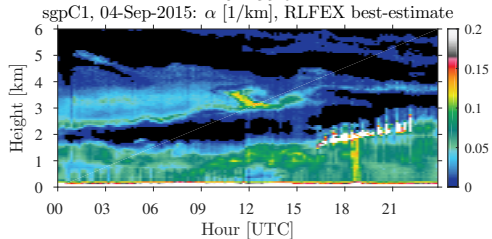
Extinction



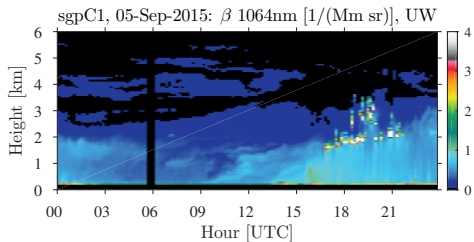
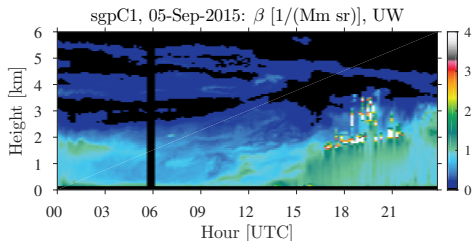
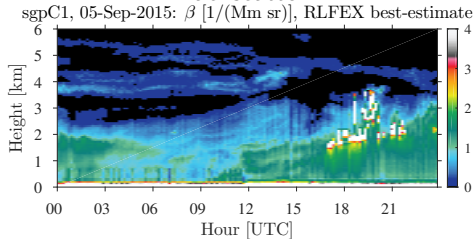
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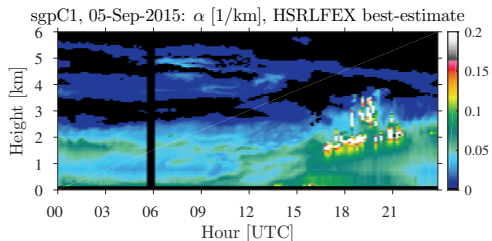
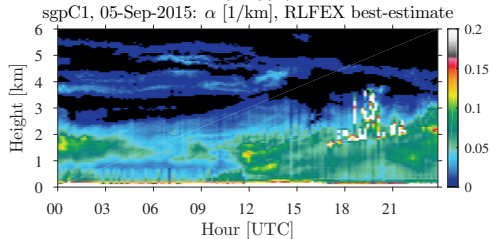
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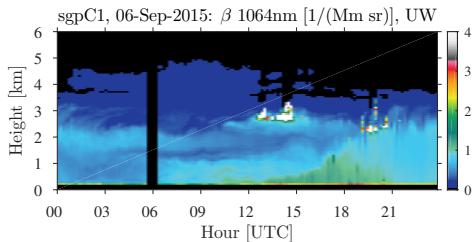
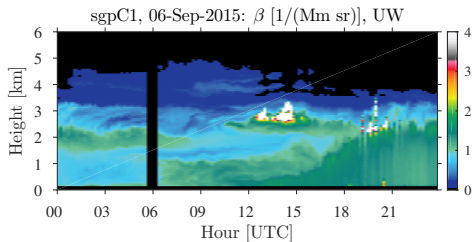
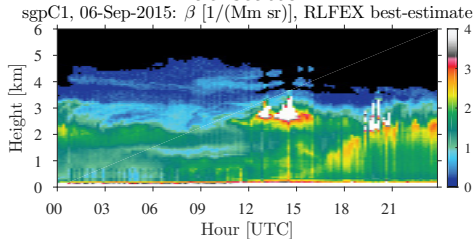
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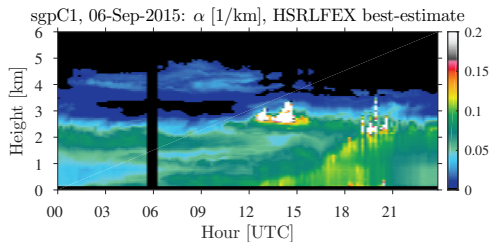
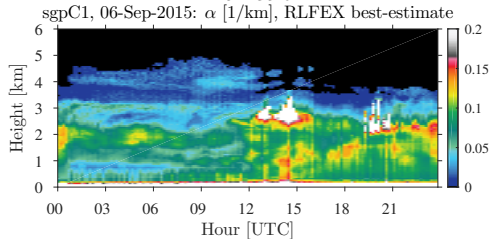
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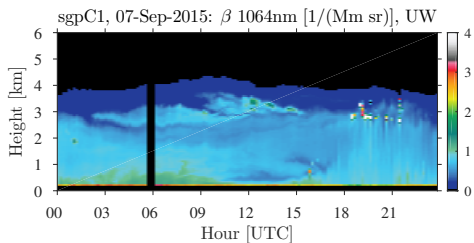
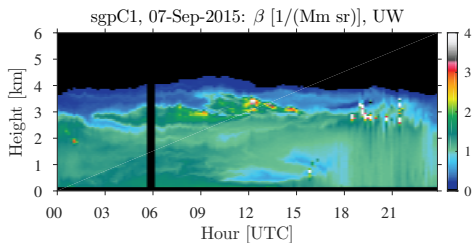
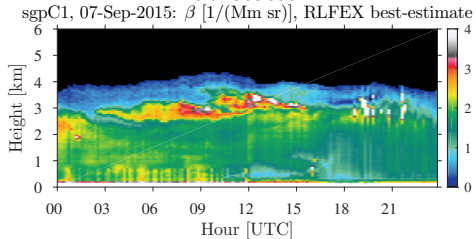
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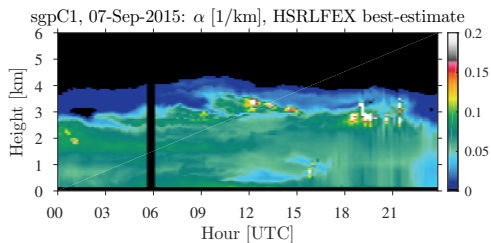
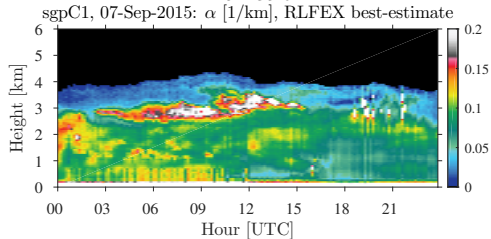
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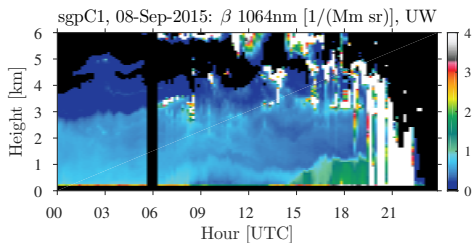
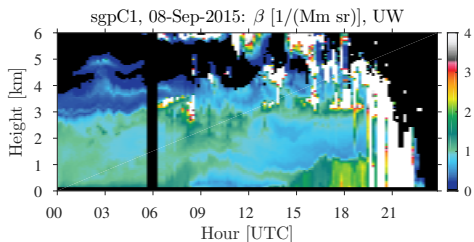
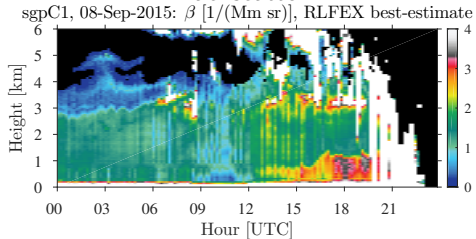
Backscatter



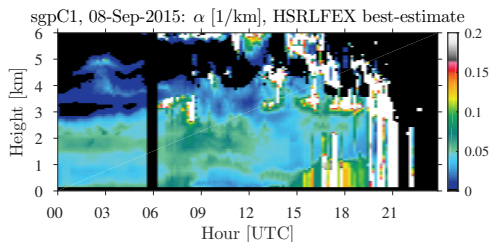
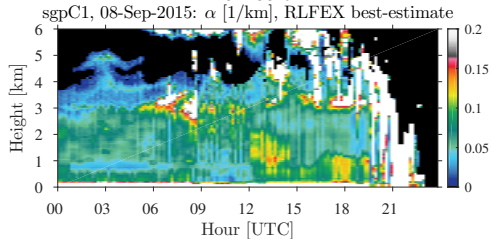
Extinction



Backscatter



Extinction



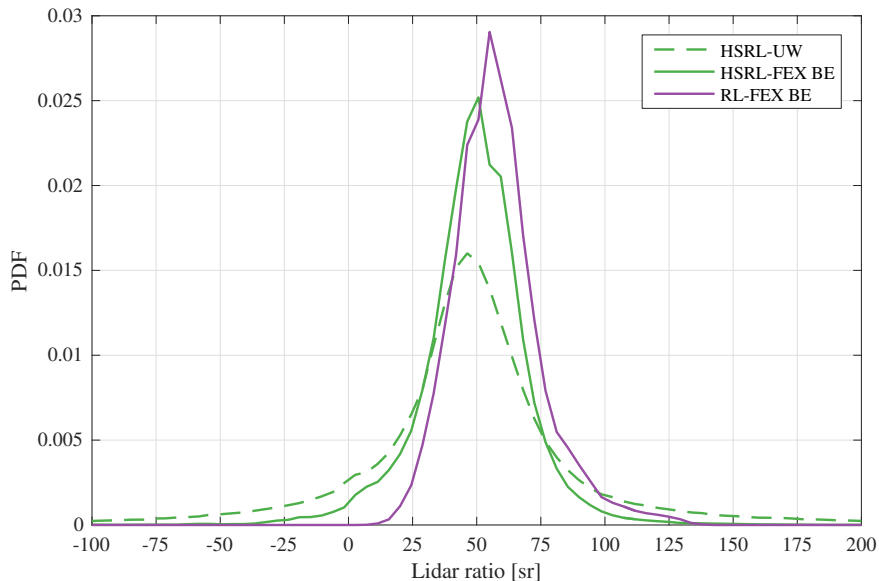
http://www.tylerhorsen.com/bagohsrlfex_charms/

Raman issues

- SGP calibration/overlap is tough (FEX tries hard to “calibrate it away”) (data from Darwin is great)
- Unsure how accurate the RL depolarization is

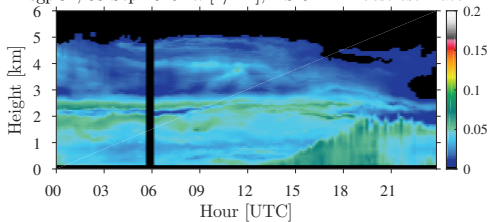
HSRL issues

- 1064nm backscatter
- Negative extinction (and therefore lidar ratio)



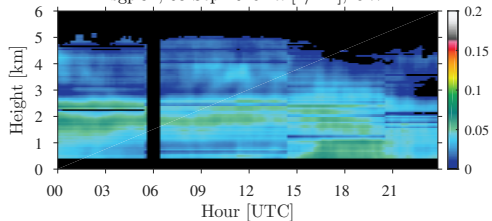
HSRL-FEX

sgpC1, 03-Sep-2015: α [1/km], HSRLFEX best-estimate

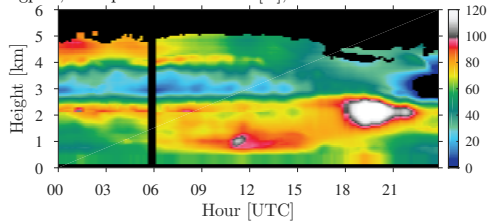


UW-processed

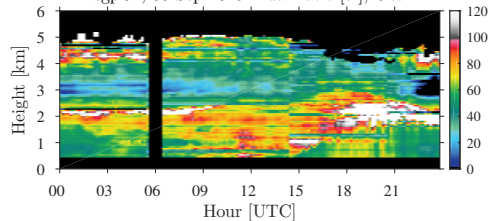
sgpC1, 03-Sep-2015: α [1/km], UW



sgpC1, 03-Sep-2015: lidar ratio [sr], HSRLFEX best-estimate

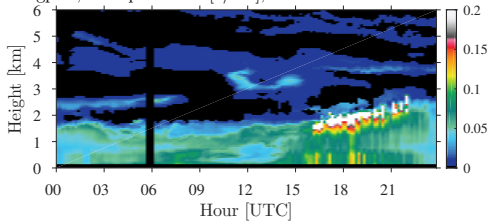


sgpC1, 03-Sep-2015: lidar ratio [sr], UW



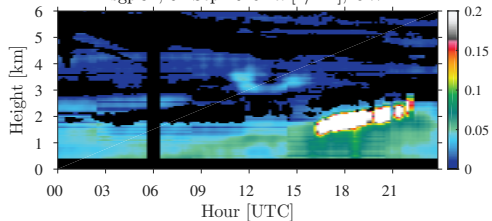
HSRL-FEX

sgpC1, 04-Sep-2015: α [1/km], HSRLFEX best-estimate

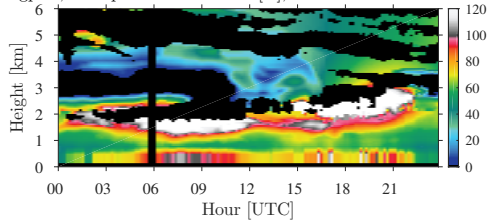


UW-processed

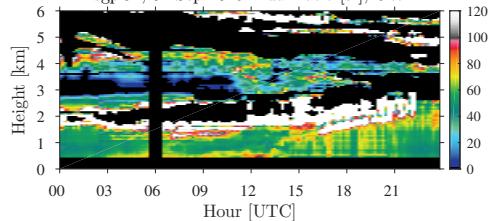
sgpC1, 04-Sep-2015: α [1/km], UW



sgpC1, 04-Sep-2015: lidar ratio [sr], HSRLFEX best-estimate

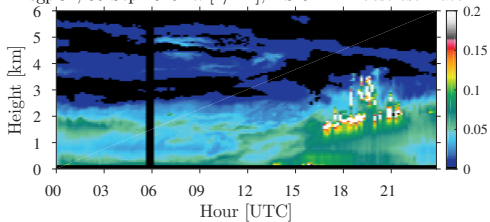


sgpC1, 04-Sep-2015: lidar ratio [sr], UW



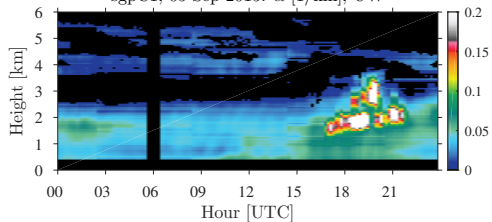
HSRL-FEX

sgpC1, 05-Sep-2015: α [1/km], HSRLFEX best-estimate

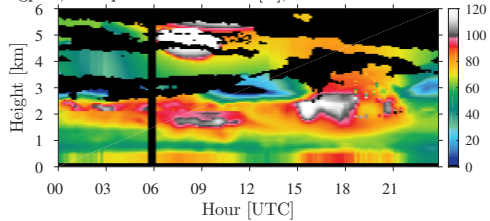


UW-processed

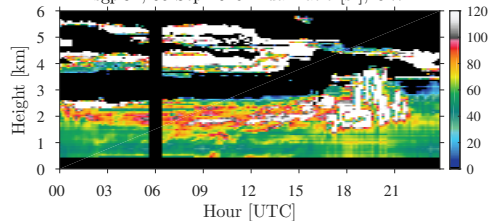
sgpC1, 05-Sep-2015: α [1/km], UW



sgpC1, 05-Sep-2015: lidar ratio [sr], HSRLFEX best-estimate

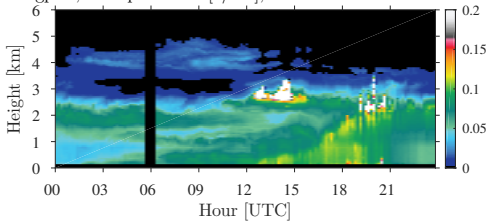


sgpC1, 05-Sep-2015: lidar ratio [sr], UW



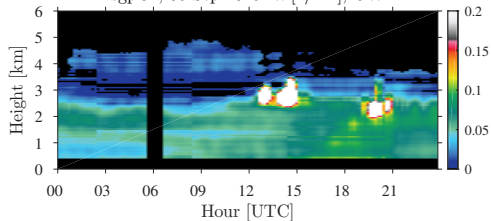
HSRL-FEX

sgpC1, 06-Sep-2015: α [1/km], HSRLFEX best-estimate

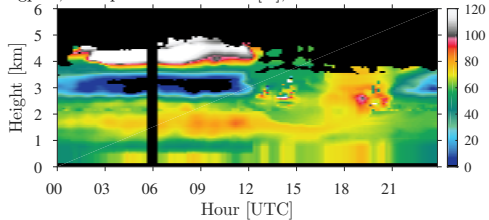


UW-processed

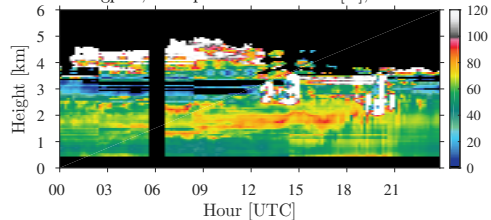
sgpC1, 06-Sep-2015: α [1/km], UW



sgpC1, 06-Sep-2015: lidar ratio [sr], HSRLFEX best-estimate

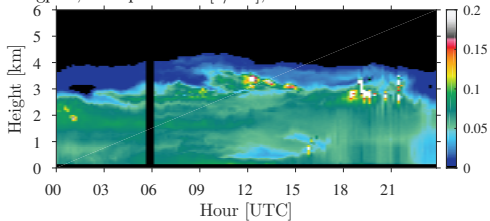


sgpC1, 06-Sep-2015: lidar ratio [sr], UW



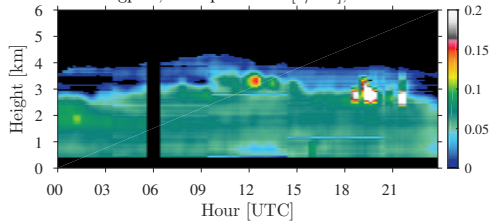
HSRL-FEX

sgpC1, 07-Sep-2015: α [1/km], HSRLFEX best-estimate

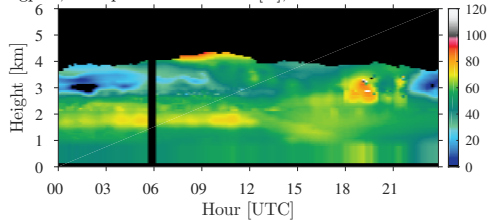


UW-processed

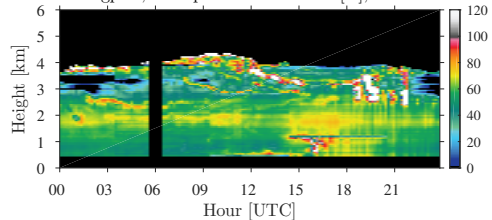
sgpC1, 07-Sep-2015: α [1/km], UW



sgpC1, 07-Sep-2015: lidar ratio [sr], HSRLFEX best-estimate

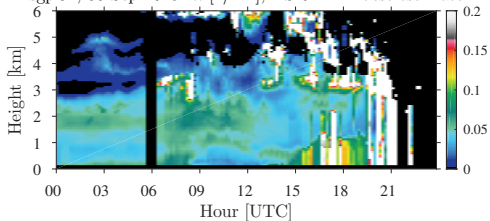


sgpC1, 07-Sep-2015: lidar ratio [sr], UW



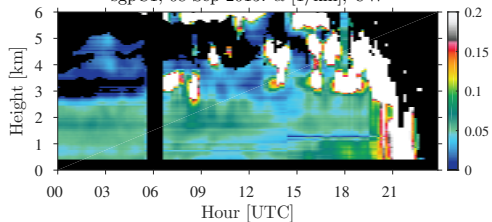
HSRL-FEX

sgpC1, 08-Sep-2015: α [1/km], HSRLFEX best-estimate

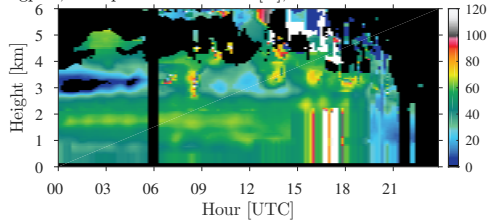


UW-processed

sgpC1, 08-Sep-2015: α [1/km], UW



sgpC1, 08-Sep-2015: lidar ratio [sr], HSRLFEX best-estimate



sgpC1, 08-Sep-2015: lidar ratio [sr], UW

