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A potential Feature Mask algorithm for the EarthCARE lidar

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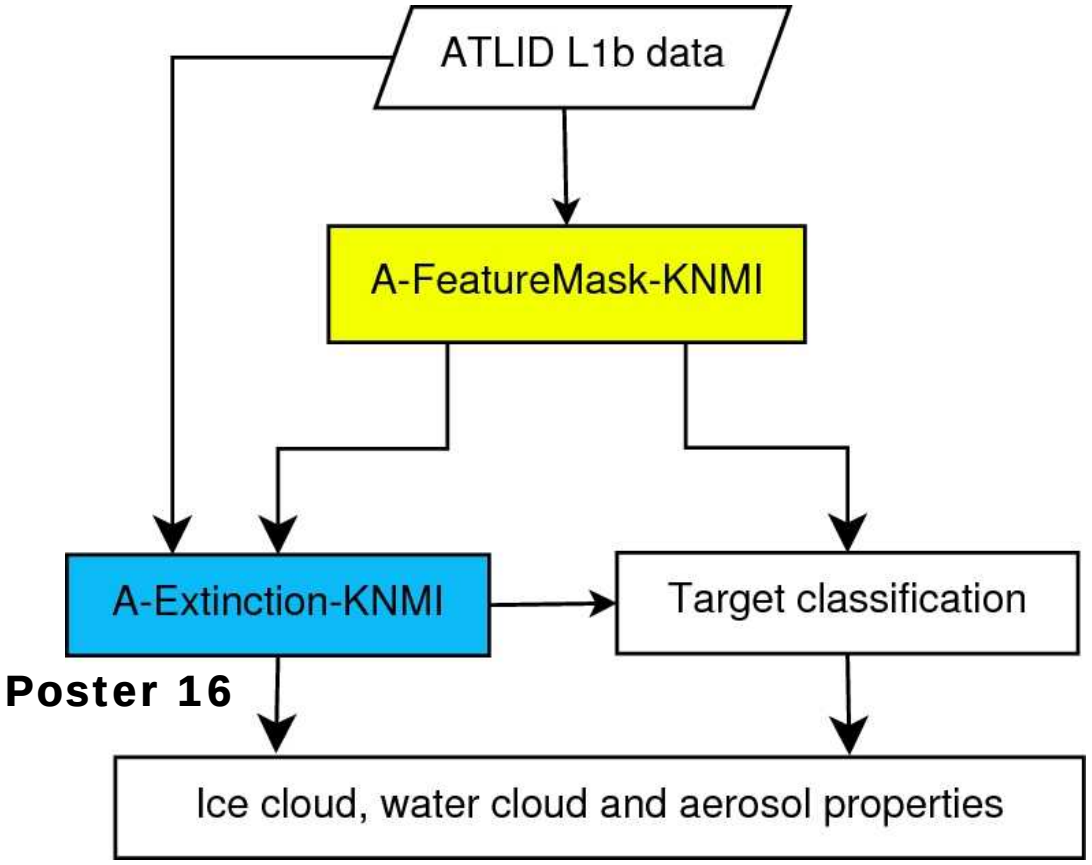
Outline

1. ATLID algorithm overview
2. Feature Mask goals
3. ATLID signals
4. A-FeatureMask description
5. ECSIM & Calipso Examples
6. Conclusions

ATLID only Algorithms



The FeatureMask is an important first step in the retrieval of higher order products (extinction and target classification)

Feature-Mask Goals

1. Retrieving a mask which finds both aerosols and clouds
2. Retrieve information on high resolution, preferably a single shot mask.
3. As few a-priori S/N settings as possible (flexibility)

What information do we have

1. Mie channels detect only particles (contaminations due to noise, not molecular returns).
2. Rayleigh channel always detects molecular returns except below high optical thick features
3. SNR will be too low to retrieve aerosols and thin cirrus on a single shot resolution directly

→IMAGE RECONSTRUCTION ALGORITHM

INPUT / OUTPUTS

INPUT

HSRL Mie Co-Polar
HSRL Mie cross-Polar
HSRL Rayleigh channel

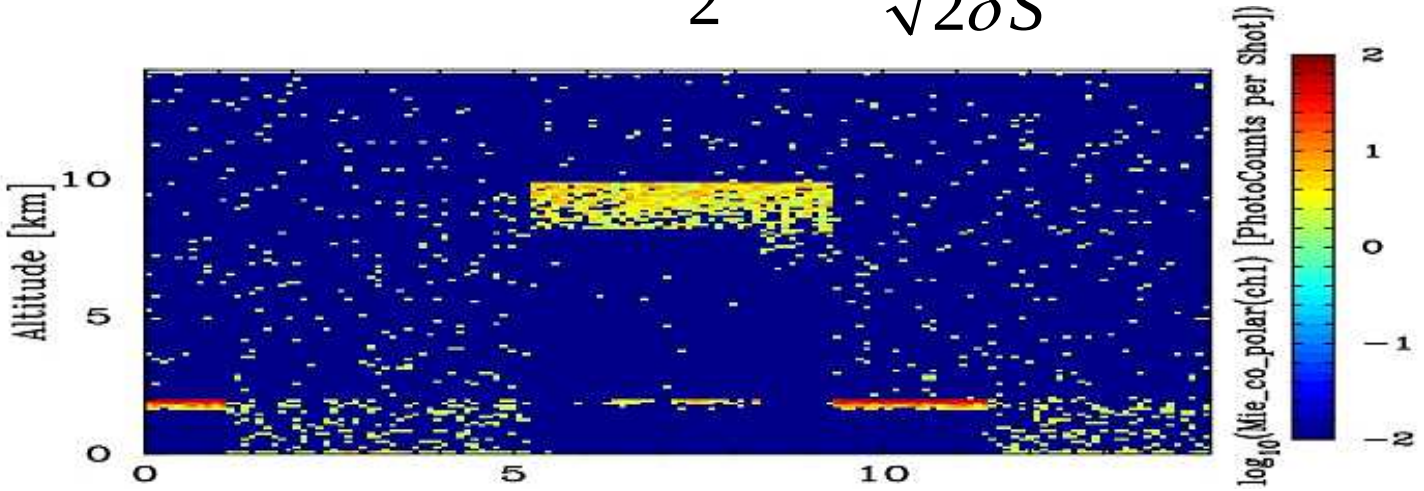
OUTPUT

A-FeatureMask

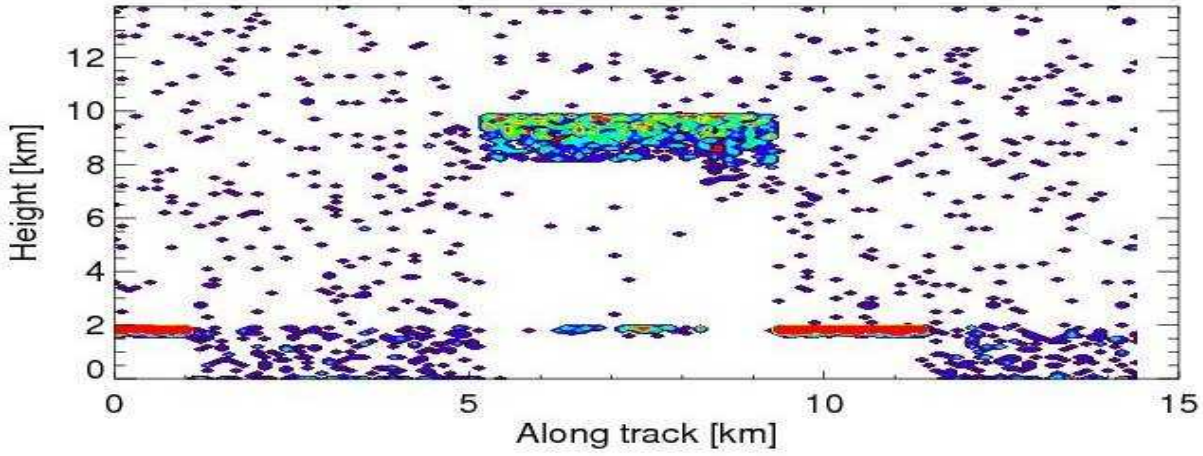
- **0 (very likely molecular)**
- **10 (very likely particles)**
- **-1 (no data)**
- **-2 (below surface)**

Probability Calculation

$$P(x,z) = 1 - \frac{1}{2} erfc\left(\frac{S - \delta S}{\sqrt{2}\delta S}\right)$$



Mie signal



Mie probability (0 -100 %)

FeatureMask calculation

To Calculate the FeatureMask 4 steps are performed

I. Calculate signal probability based on signal and noise

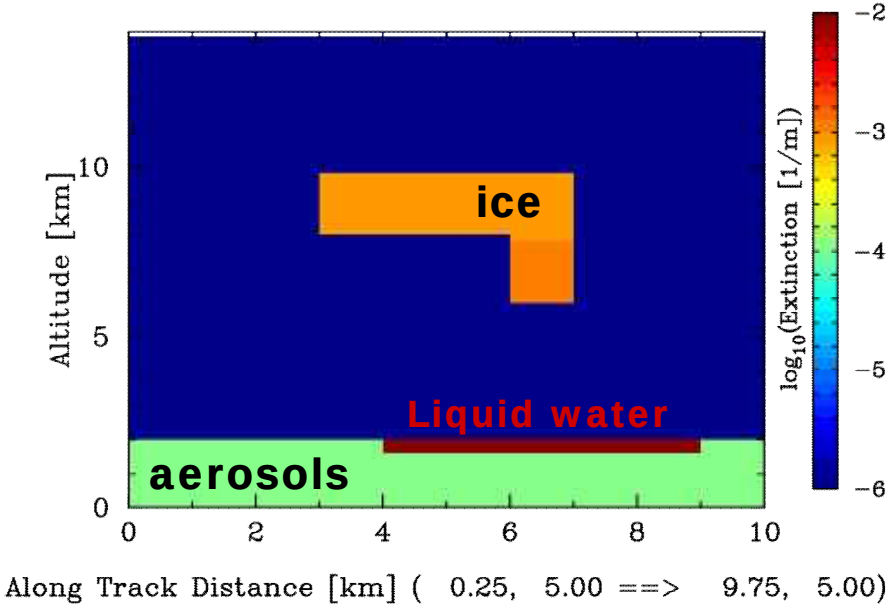
II. Median Hybrid calculation to find coherent structures within the image

III. Maximum entropy algorithm to derive the optimally smoothed image to find low SNR features

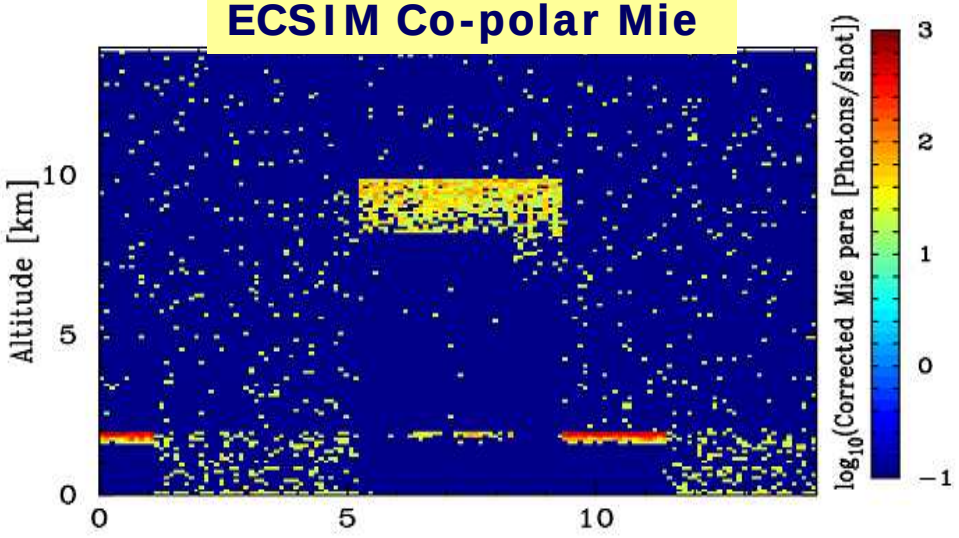
IV. Gaussian fit of the derived image histogram to distinguish signal from noise

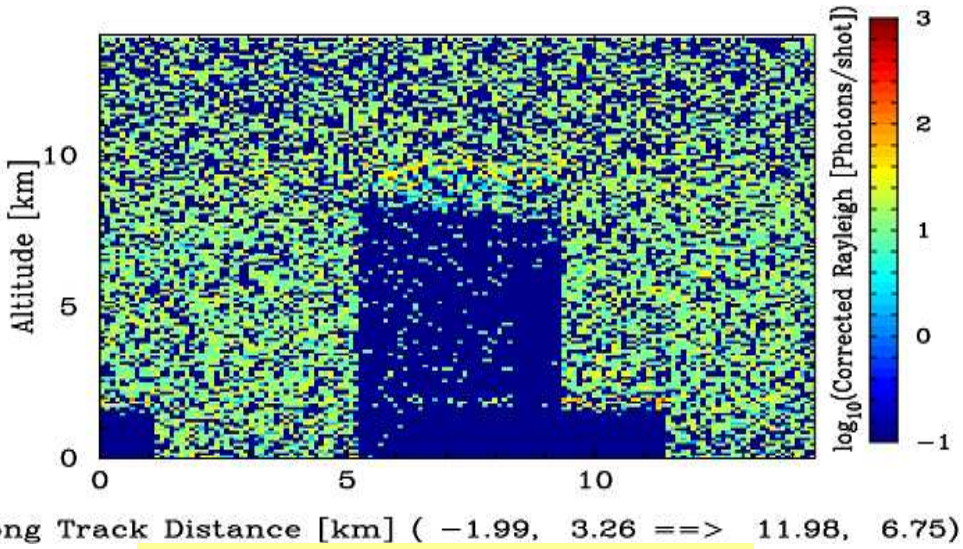
ATLID Input signals

Model input extinction



ECSIM Co-polar Mie





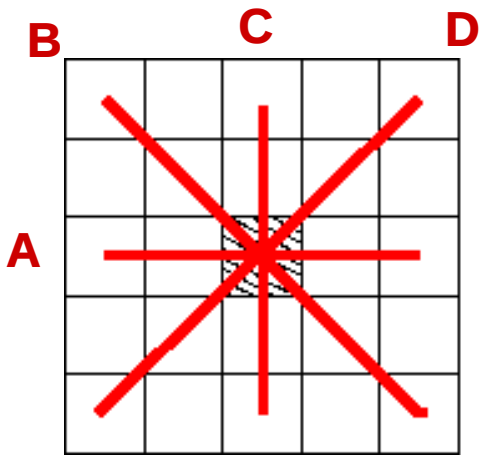
ECSIM Rayleigh signal

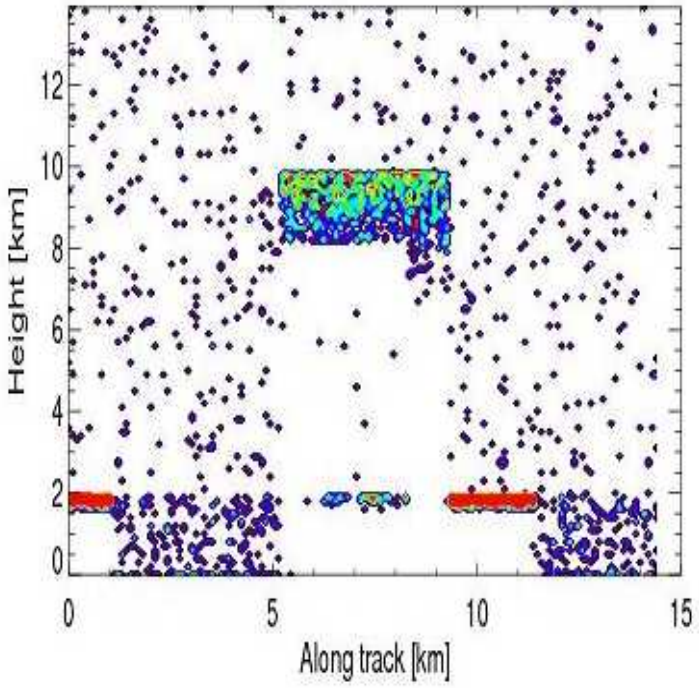
Median-Hybrid

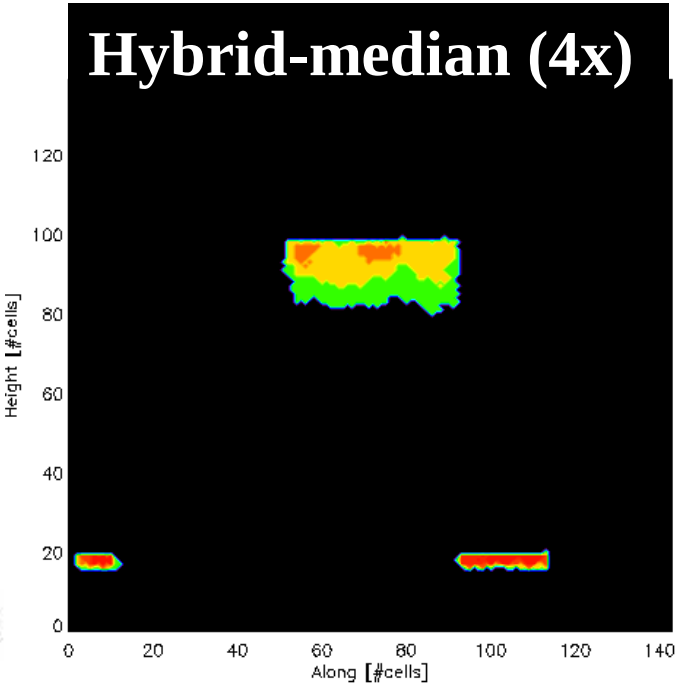
Use median hybrid method (edge preserving image reconstruction tool).

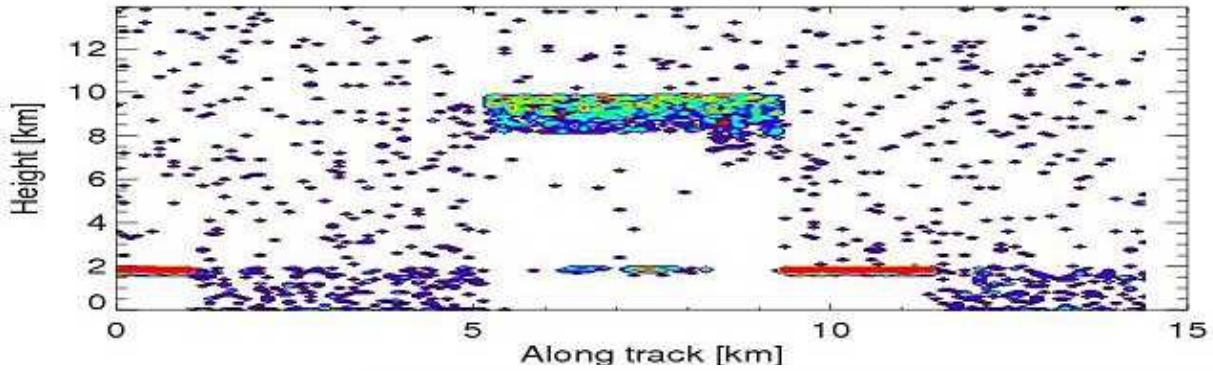
- **Scan over grid**
- **For each point use the following procedure:**

$$P = Median[\bar{A}, \bar{B}, \bar{C}, \bar{D}]$$

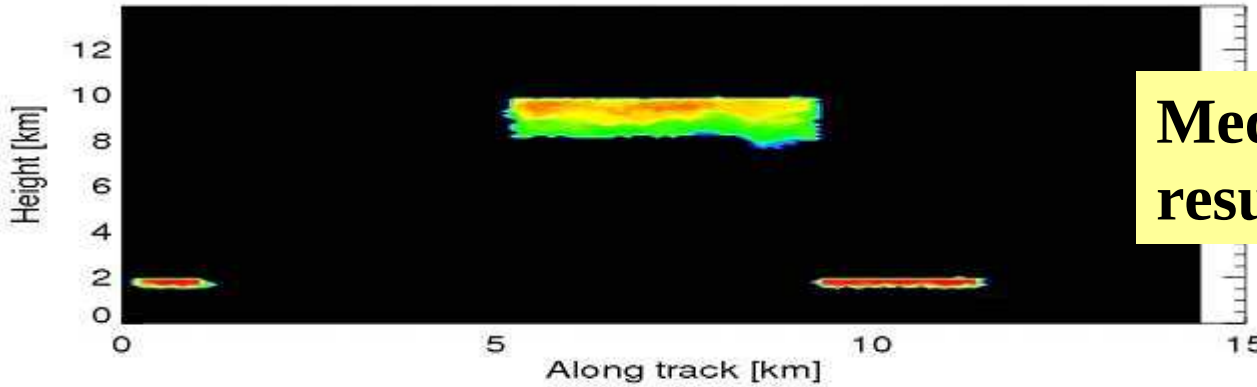






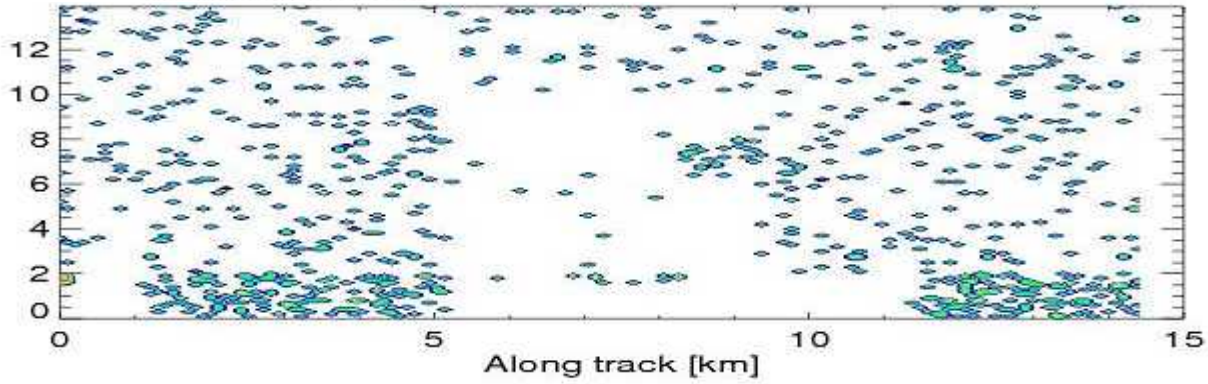


Mie probability (0 -100 %)



Median Hybrid result

Signal without coherent structures → Input to the max entropy routine



Max_entropy

- Scheme will use an iterative convolution of a simple 2-d ‘gauss’ over the entire image. This image will use the original probability without the found median-hybrid features

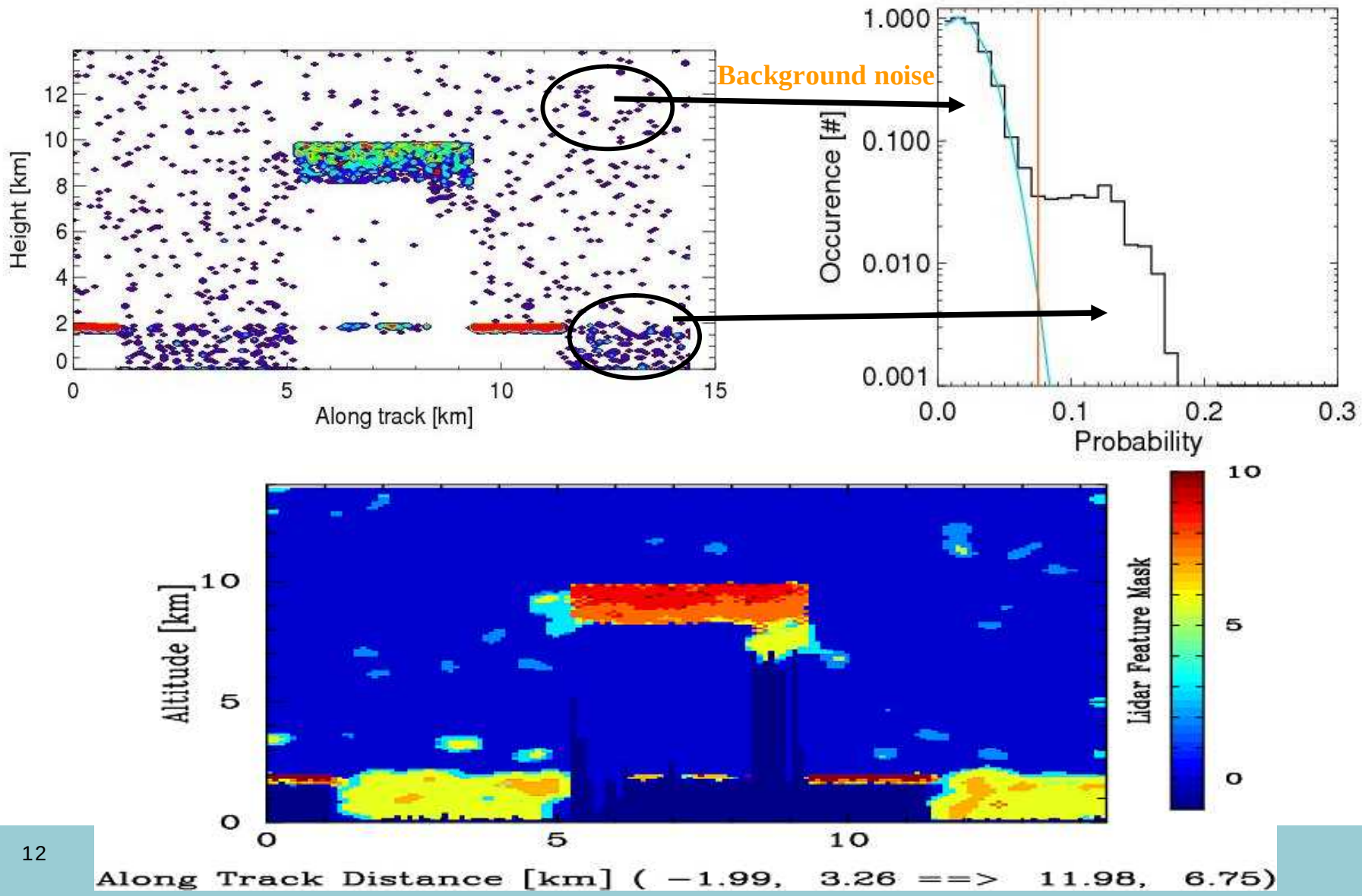
111
181
111

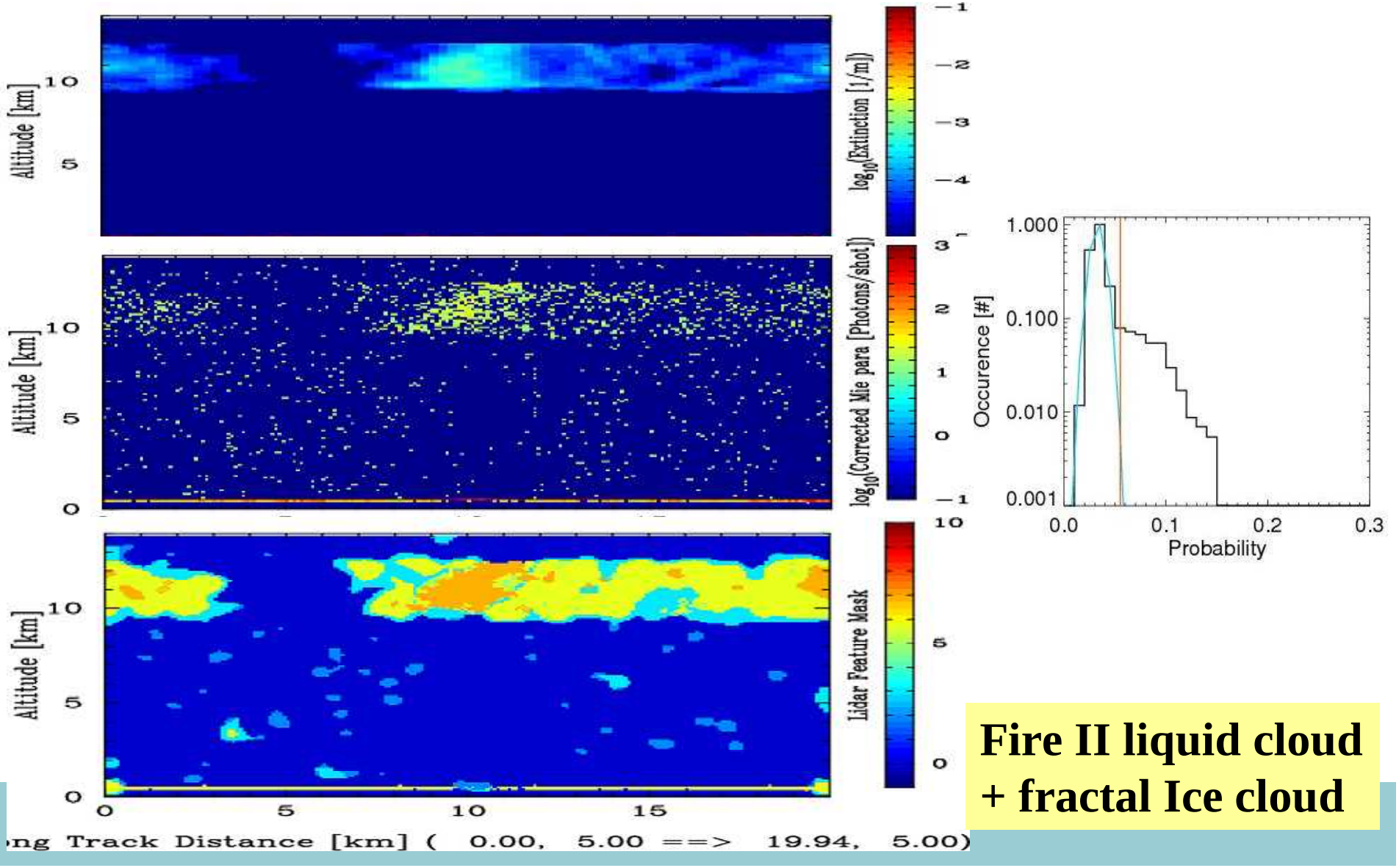
- Calculate the Max Entropy and Chi^2-difference for each iteration

$$[-\sum_i P_i \log(P_i)] - \lambda g \sum_i (P_i - Ps_i)^2 / \delta Ps_i^{\,2}$$

- Find the ‘best combination’ of the relationship to find the image which shows the best smoothing but still reflects the original data (this includes a calculation of the lambda factor).
- Check the ‘derived’ image on its properties (step IV)

Check for Signal & Noise





Fire II liquid cloud + fractal Ice cloud

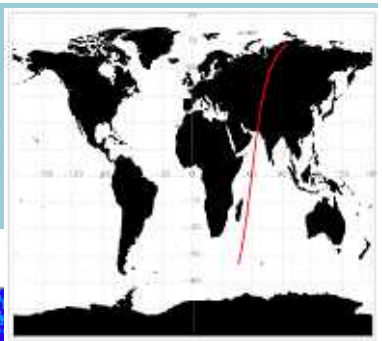
Testing with Calipso data

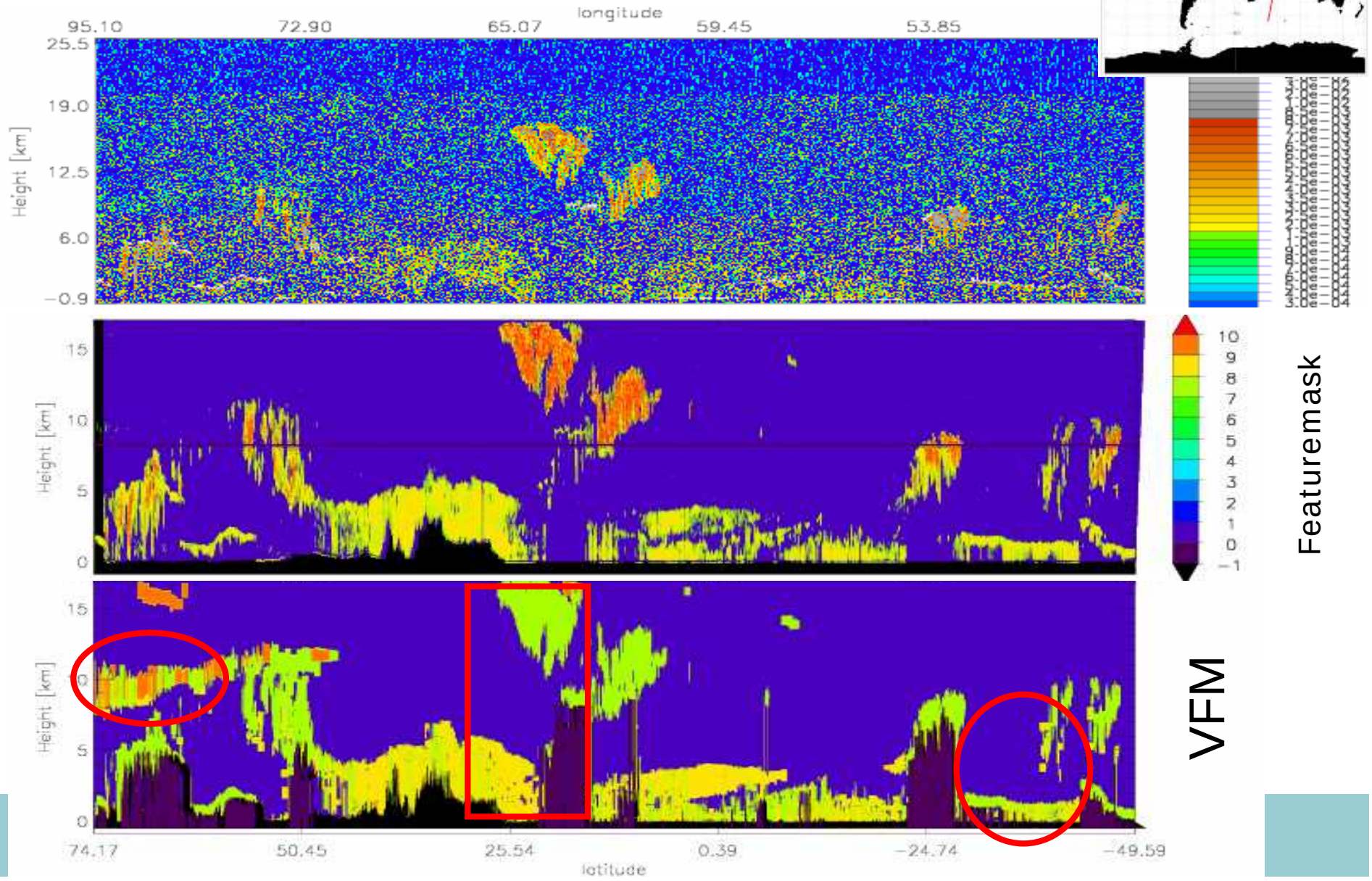
As there is no HSRL lidar in space we improvise!

Calipso has 2 channels 532nm and 1064 nm, EarthCARE channels are at 355nm

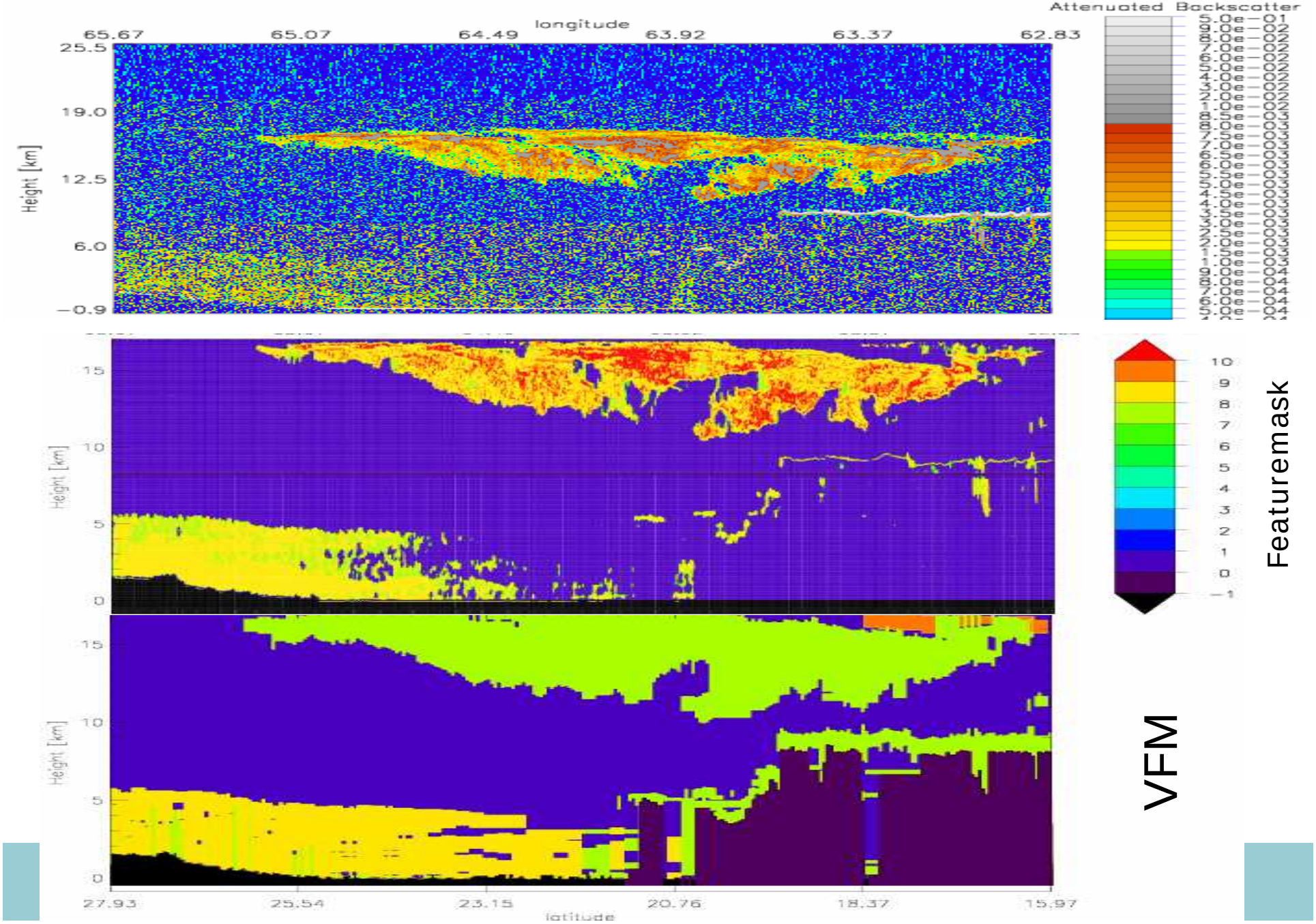
- 532 nm has a lot of molecular backscatter
- 1064 nm only minor molecular backscatter but also reduced aerosol backscatter.
- We will use the 1064nm signal for testing of the featuremask algorithm
- At this point only median hybrid algorithm and use the 20th convolved image for the signal/noise determination (no determination of the maximum entropy optimum)

Calipso 1064 nm data
2008-09-13 (T13T21-27-32ZN)

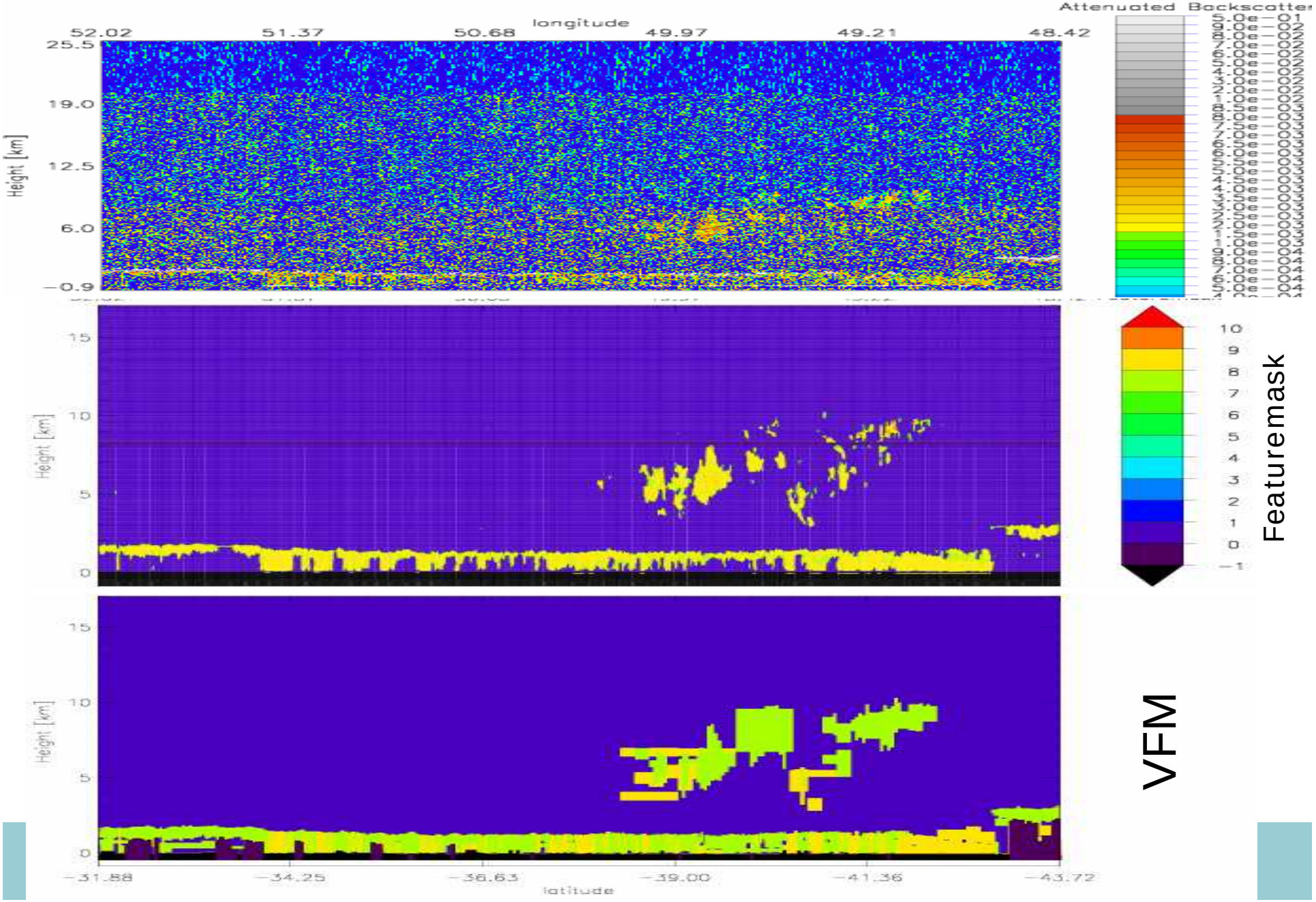




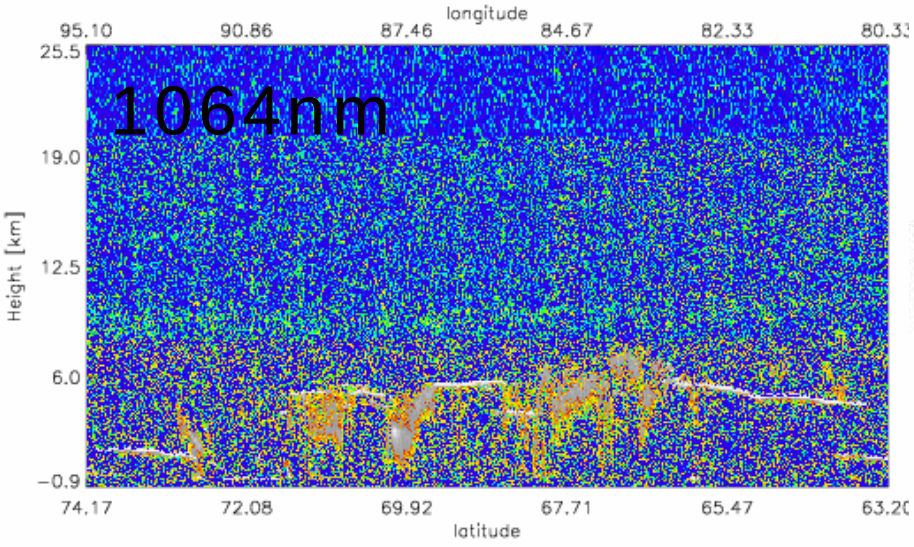
Ice, liquid and aerosols

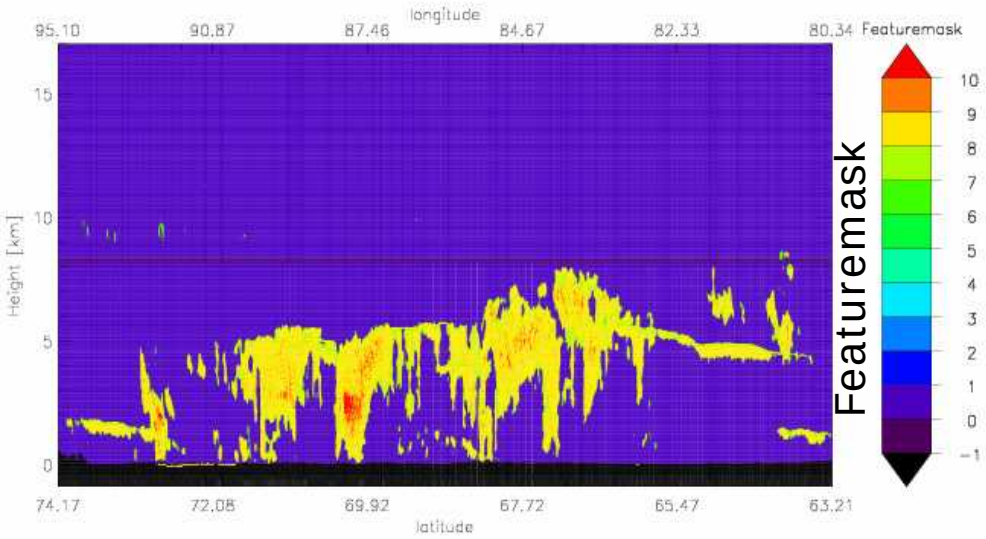


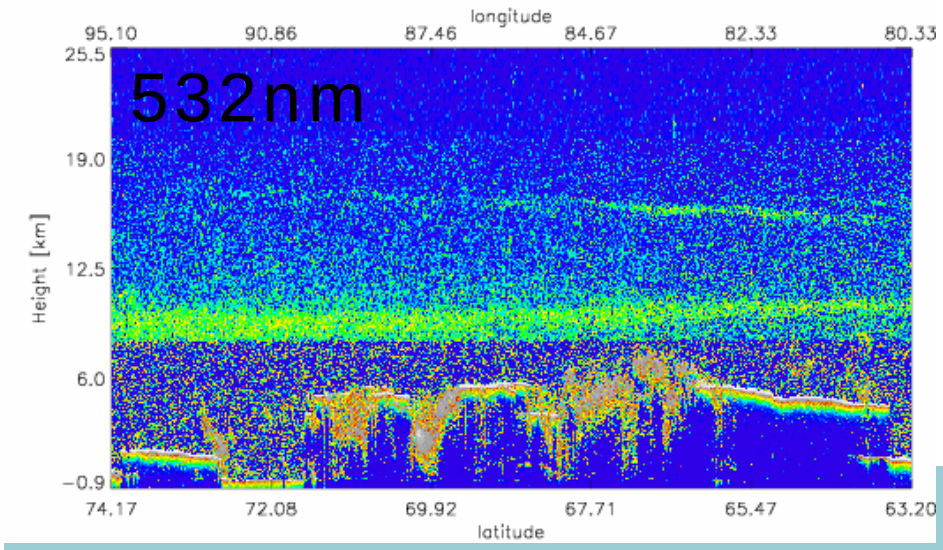
Broken cloud layer with aerosols & high level clouds

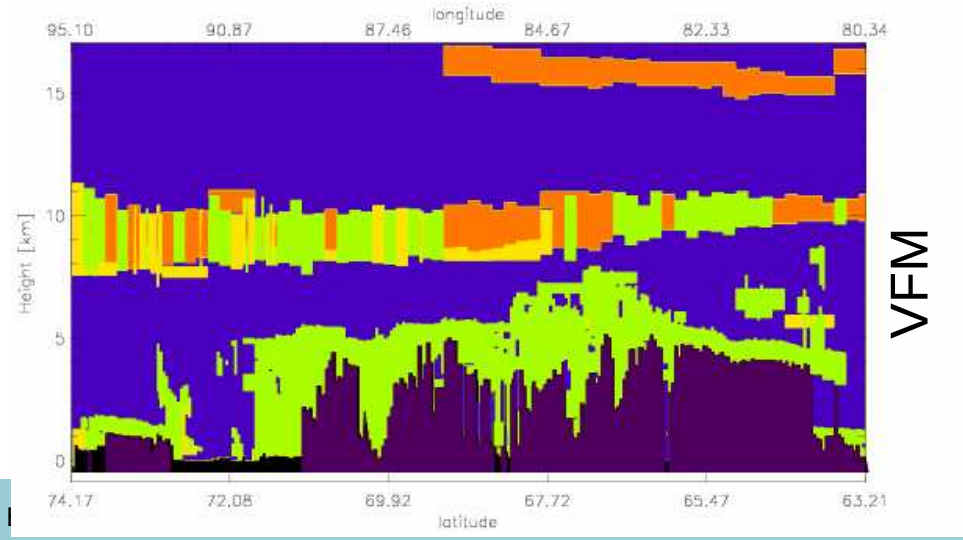


Calipso Missing layer scene
Very low 1064 signals









Conclusions

- A new FeatureMask algorithm has been constructed using image reconstruction techniques.
- Both the mask and signals can be downscaled to lower resolutions in order to calculate higher order products (added product: Feature fraction).
- The algorithm has been tested using ECSIM data.
- A start has been made using the 1064nm Calipso data, giving very good comparison with vfm and eye-fitting.
- Future tests can include ground based and/or aircraft HSRL data and ADM data (when available).

We are looking for a Postdoc (two years) to work on EarthCARE lidar algorithm development starting this summer.

Please let us know if you are or know the perfect candidate.