



FINNISH METEOROLOGICAL INSTITUTE

# Statistical Inversion Algorithm for MODIS AOD Retrieval

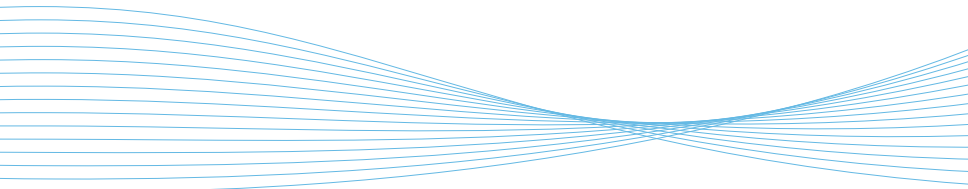
Antti Lipponen

`antti.lipponen@fmi.fi`

Finnish Meteorological Institute

Yoram Kaufman Memorial Symposium

June 21, 2016



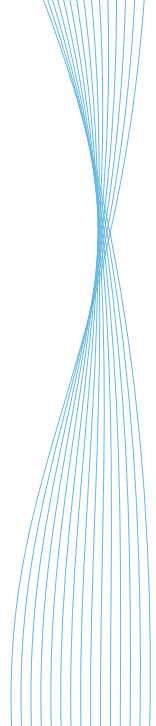
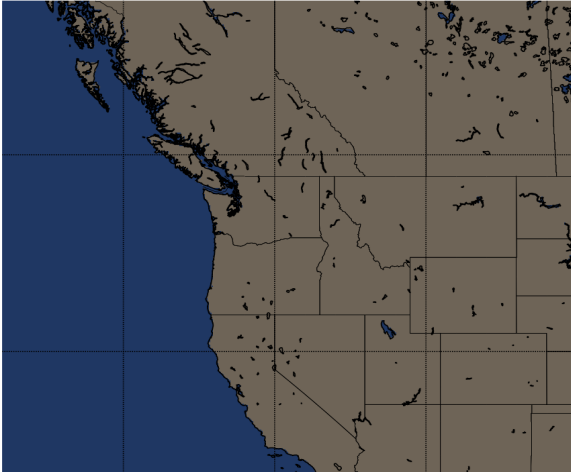


- Tero Mielonen (FMI)
- Mikko Pitkänen (FMI)
- Rob Levy (GSFC)
- Ville Kolehmainen (UEF)
- Sami Romakkaniemi (FMI)
- Antti Arola (FMI)



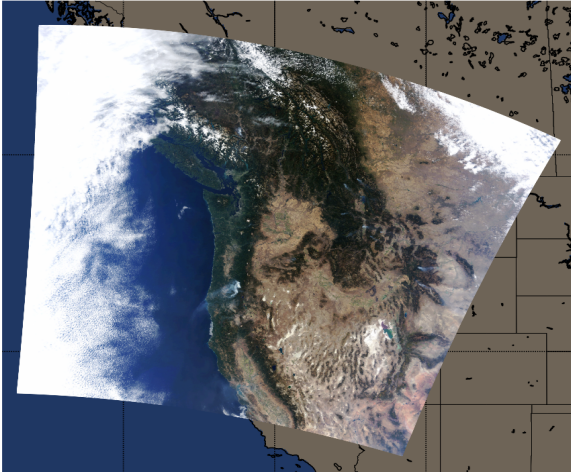


## Typical granule: 27 September 2009



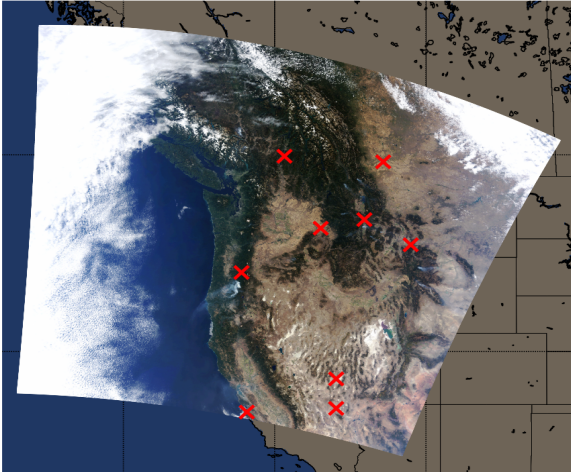


## Typical granule: 27 September 2009



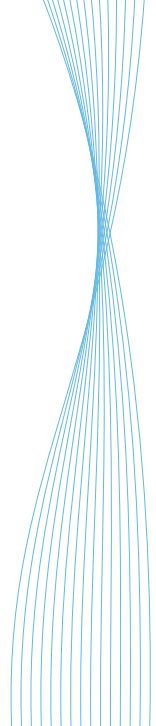
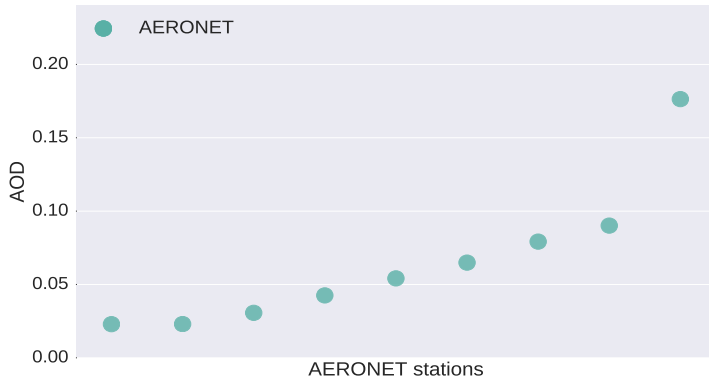


## Typical granule: 27 September 2009



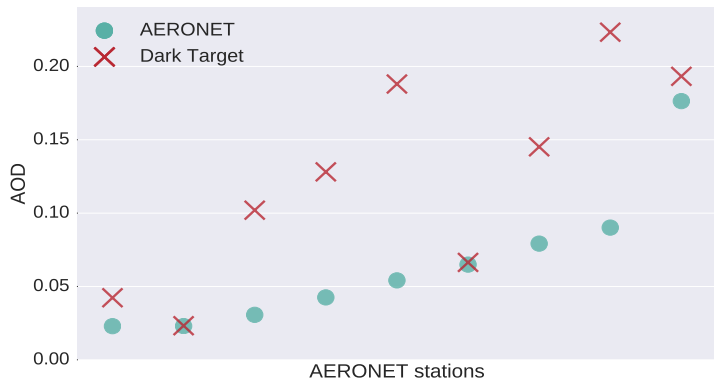


## Typical granule: 27 September 2009



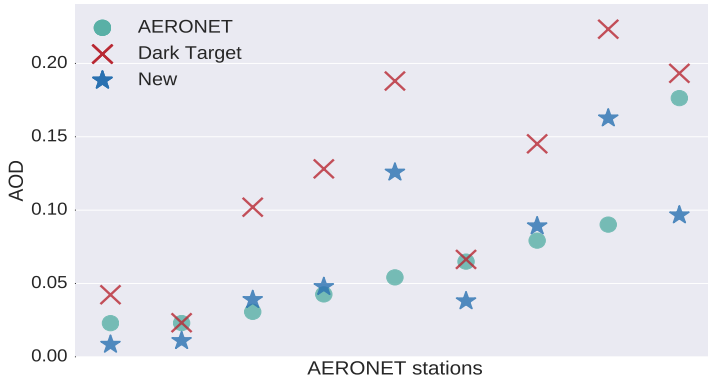


## Typical granule: 27 September 2009





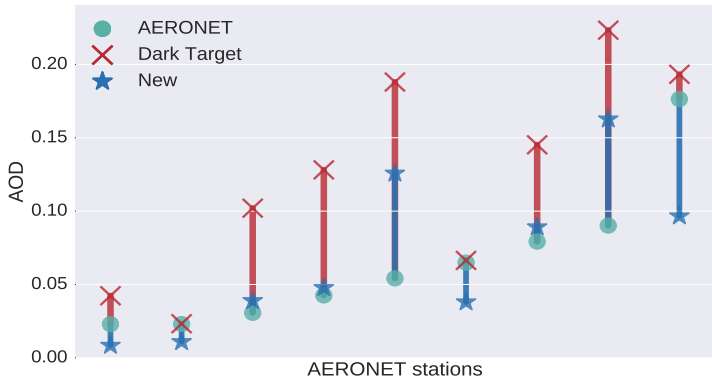
## Typical granule: 27 September 2009





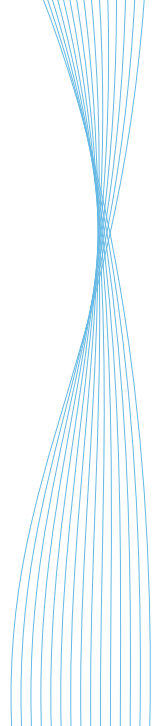
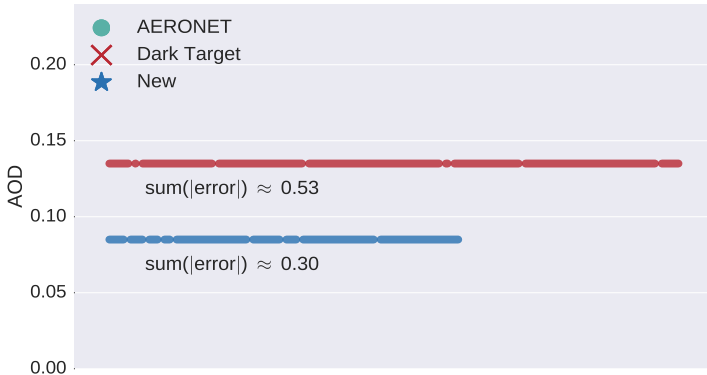


## Typical granule: 27 September 2009





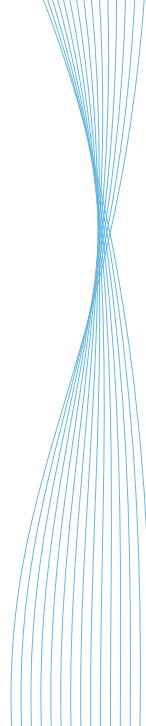
## Typical granule: 27 September 2009





FINNISH METEOROLOGICAL INSTITUTE

# New retrieval algorithm





# New retrieval algorithm

## 1. Statistical (Bayesian) inversion



## New retrieval algorithm

1. Statistical (Bayesian) inversion
2. Modified surface reflectance relationship



## New retrieval algorithm

1. Statistical (Bayesian) inversion
2. Modified surface reflectance relationship
3. Quantities retrieved
  - AOD
  - fine mode fraction
  - surface reflectances at 466 and 644 nm



## New retrieval algorithm

1. Statistical (Bayesian) inversion
2. Modified surface reflectance relationship
3. Quantities retrieved
  - AOD
  - fine mode fraction
  - surface reflectances at 466 and 644 nm



# New retrieval algorithm

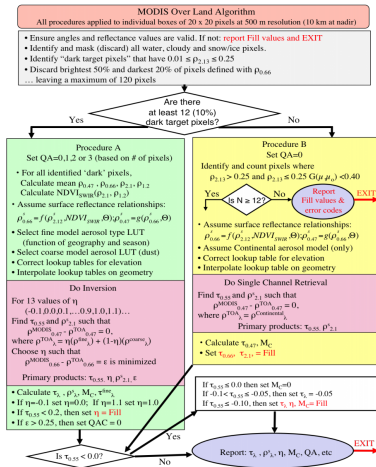


Figure from <http://darktarget.gsfc.nasa.gov/algorithm/land>





# New retrieval algorithm

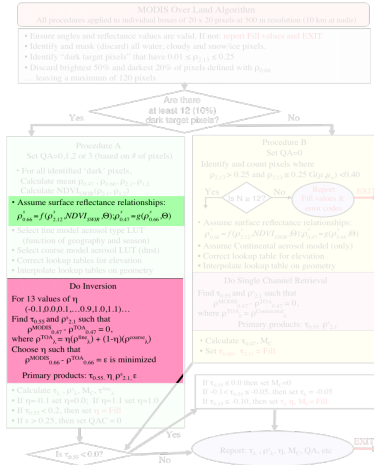
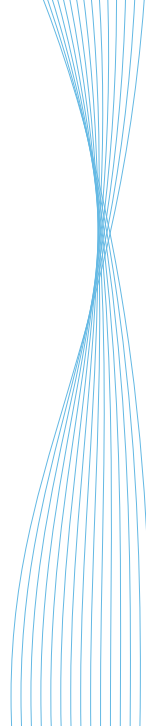
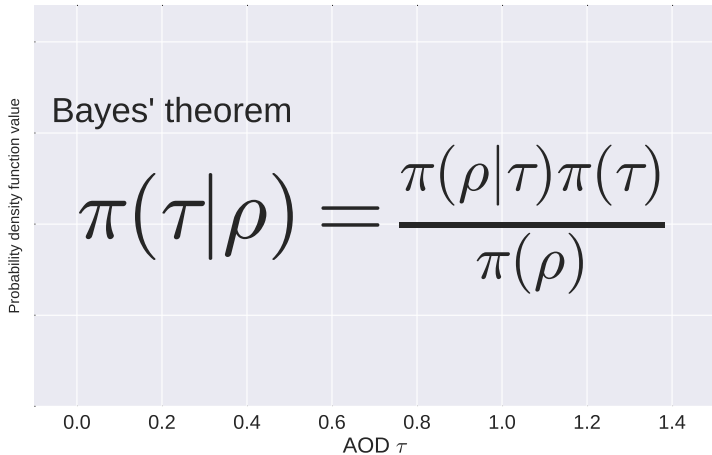


Figure from <http://darktarget.gsfc.nasa.gov/algorithm/land>

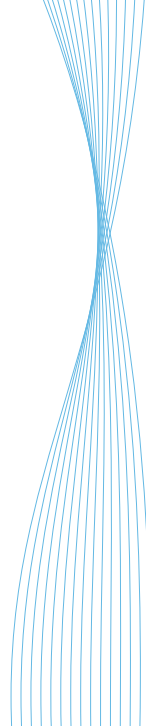
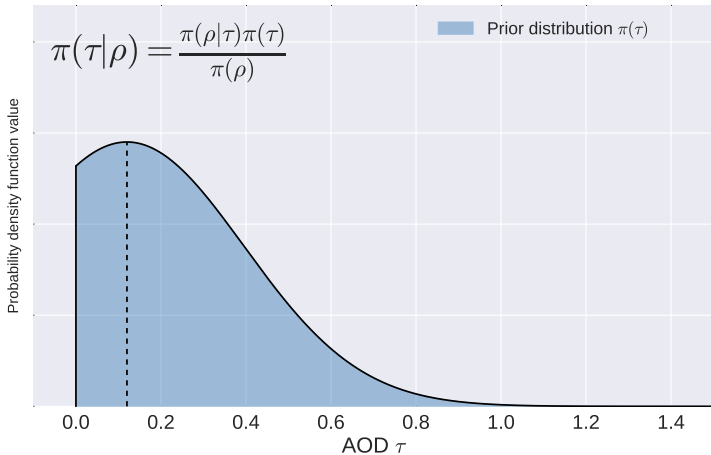


# 1. Statistical inversion



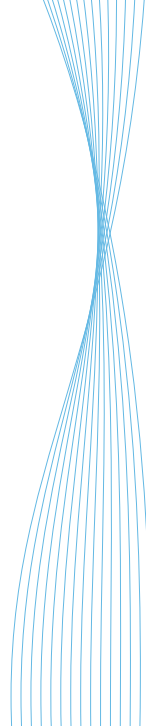
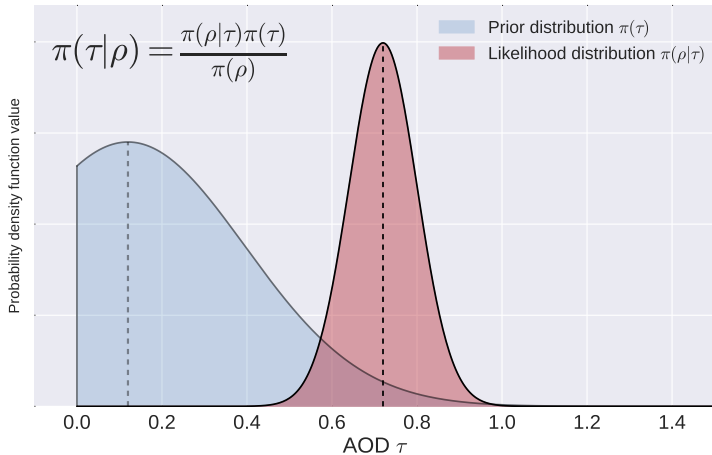


# 1. Statistical inversion



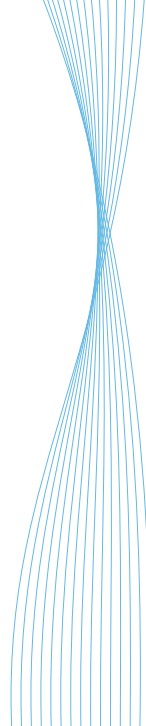
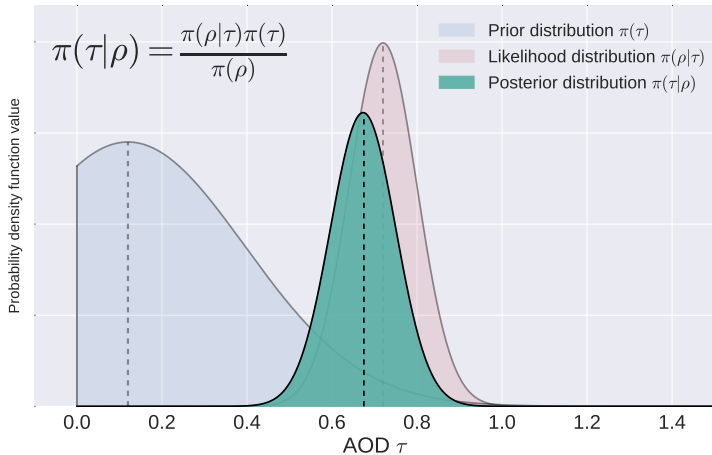


# 1. Statistical inversion



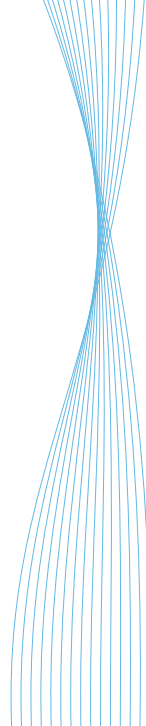


# 1. Statistical inversion



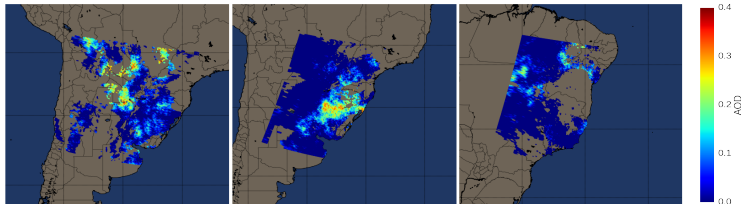


# 1. Statistical inversion - prior distributions

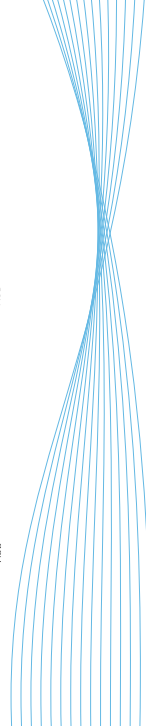
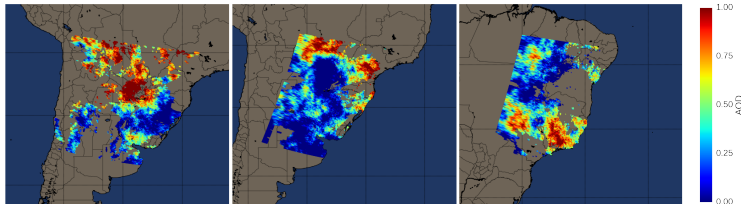


# 1. Statistical inversion - prior distributions

February

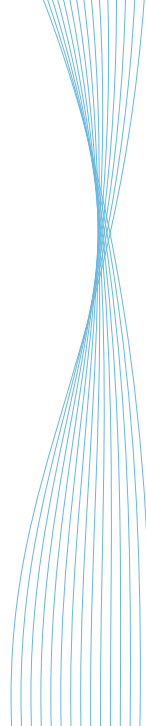


September





# 1. Statistical inversion - likelihood distributions







# 1. Statistical inversion - likelihood distributions

$$\rho = f(\tau, \eta, \rho_{0.466}^s, \rho_{0.644}^s) + e$$

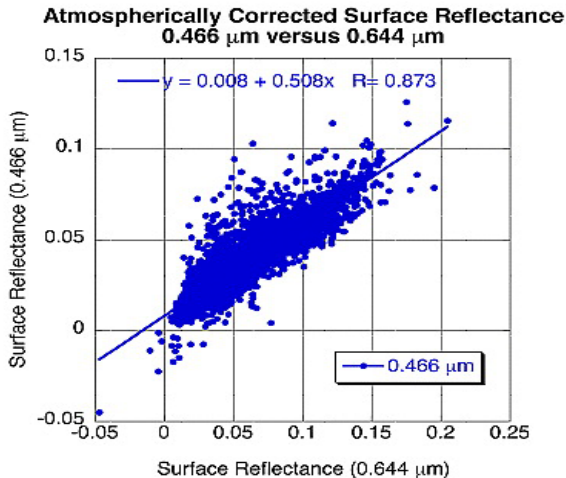
- Radiative transfer model
  - Lookup tables from Dark Target
- Gaussian noise model for  $e$
- Results in Gaussian likelihood distribution



## 2. Modified surface reflectance relationship



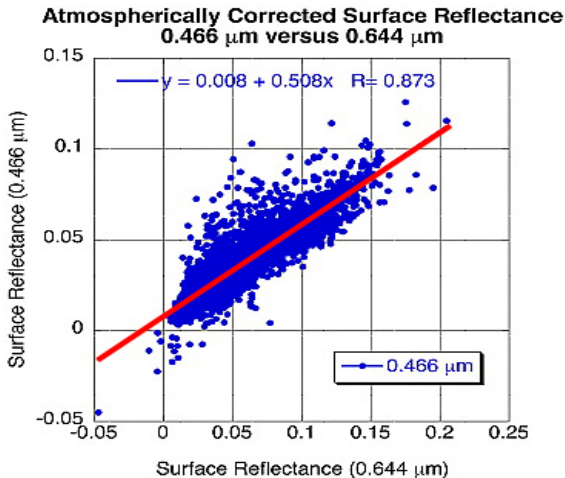
## 2. Modified surface reflectance relationship



Original figure from Levy, Remer, Mattoo, Vermote and Kaufman, JGR, 2007.



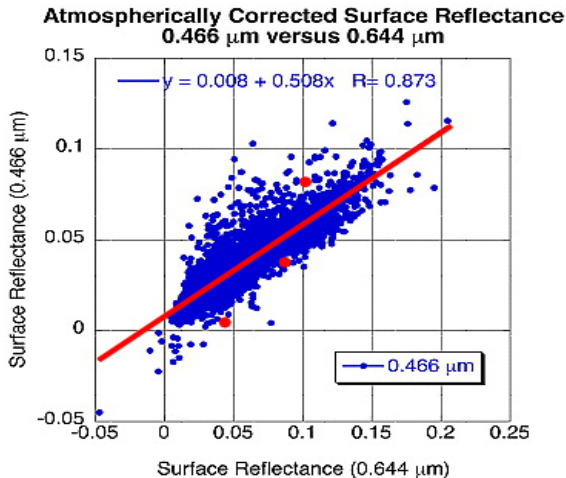
## 2. Modified surface reflectance relationship



Original figure from Levy, Remer, Mattoo, Vermote and Kaufman, JGR, 2007.



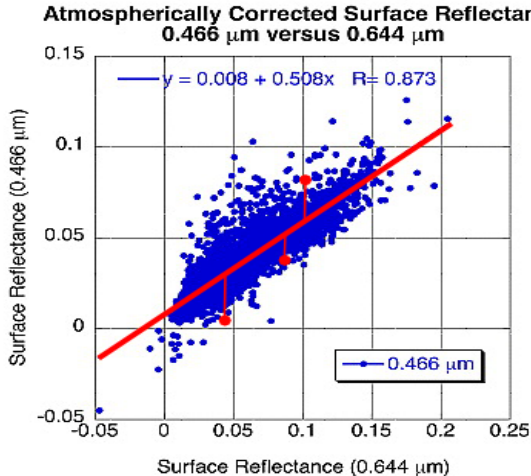
## 2. Modified surface reflectance relationship



Original figure from Levy, Remer, Mattoo, Vermote and Kaufman, JGR, 2007.



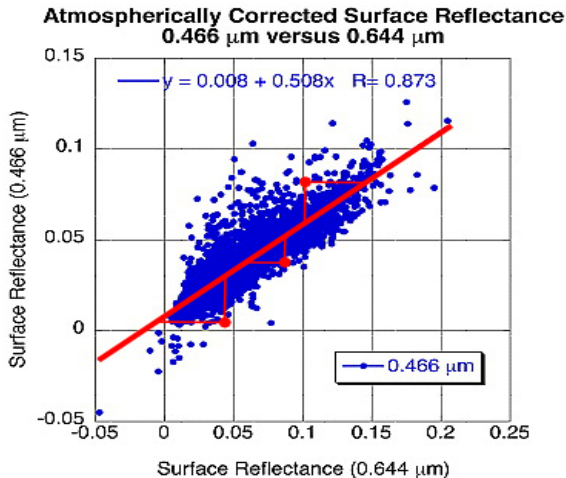
## 2. Modified surface reflectance relationship



Original figure from Levy, Remer, Mattoo, Vermote and Kaufman, JGR, 2007.



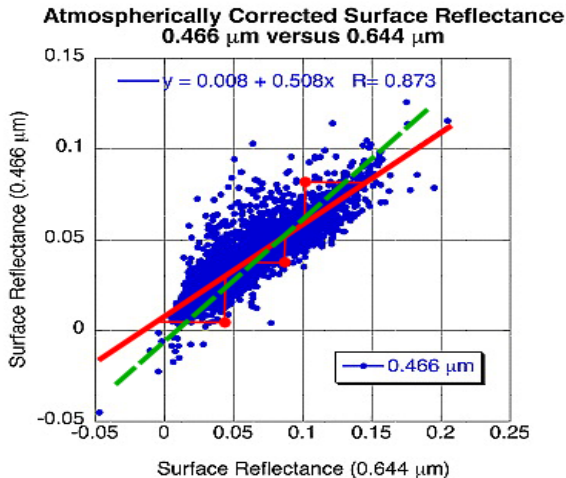
## 2. Modified surface reflectance relationship



Original figure from Levy, Remer, Mattoo, Vermote and Kaufman, JGR, 2007.



## 2. Modified surface reflectance relationship

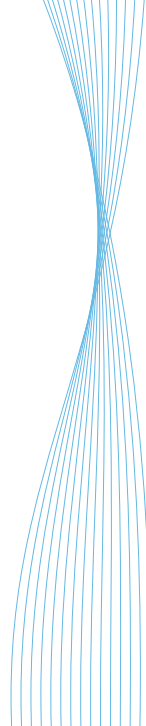
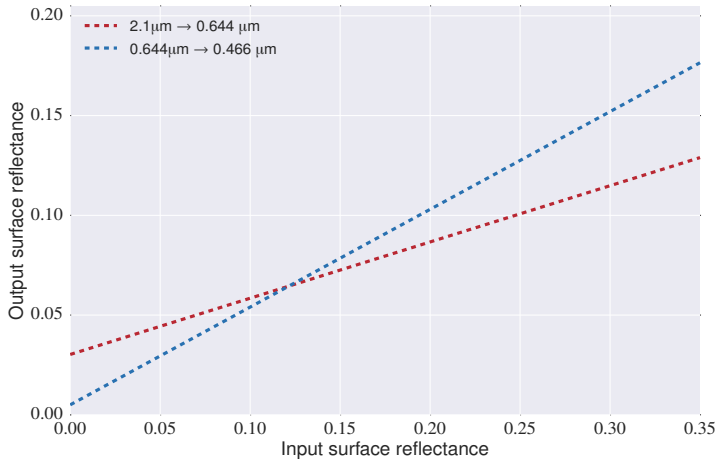


Original figure from Levy, Remer, Mattoo, Vermote and Kaufman, JGR, 2007.



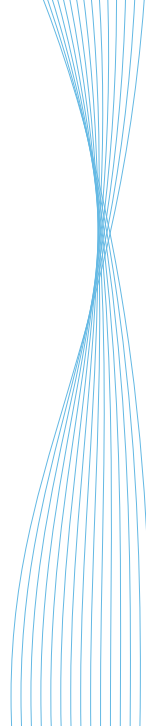
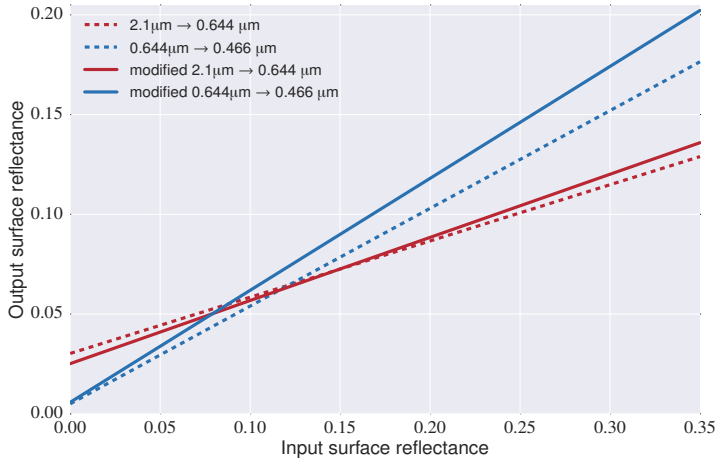


## 2. Modified surface reflectance relationship





## 2. Modified surface reflectance relationship

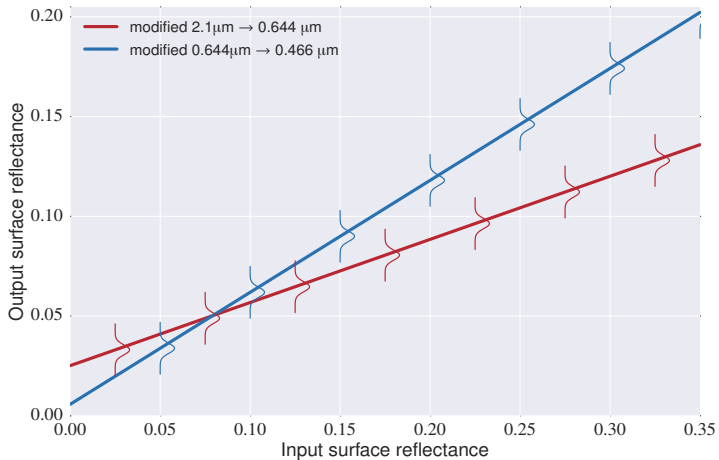




### 3. Quantities retrieved - AOD, FMF, $\rho^s \times 2$



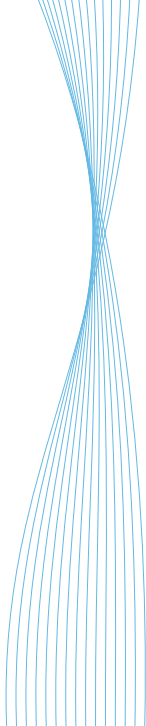
### 3. Quantities retrieved - AOD, FMF, $\rho^s \times 2$





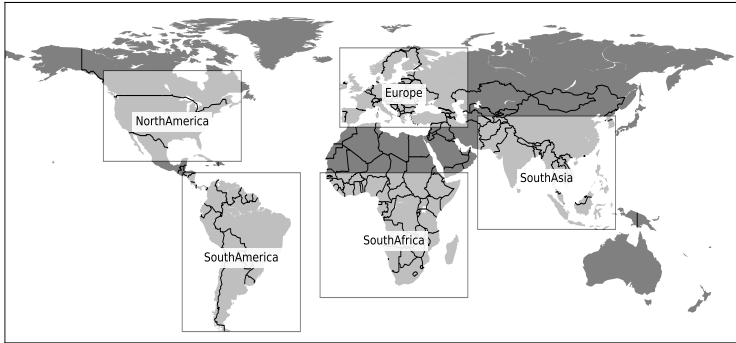
FINNISH METEOROLOGICAL INSTITUTE

# Results



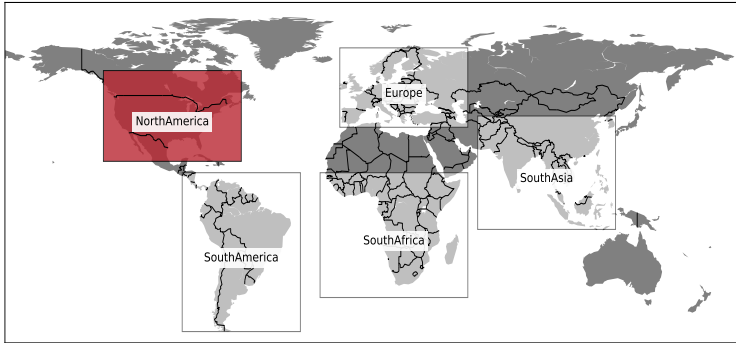


## Results





## Results





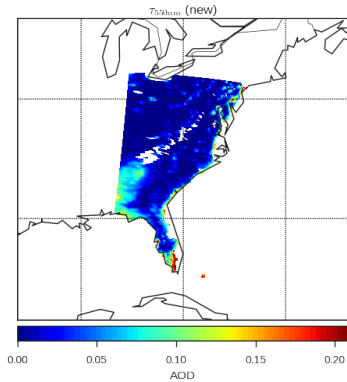
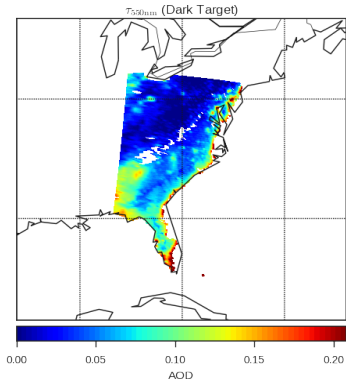
## Results - North America

- 15 granules / month (180 granules)
- Total of 656 AERONET comparisons



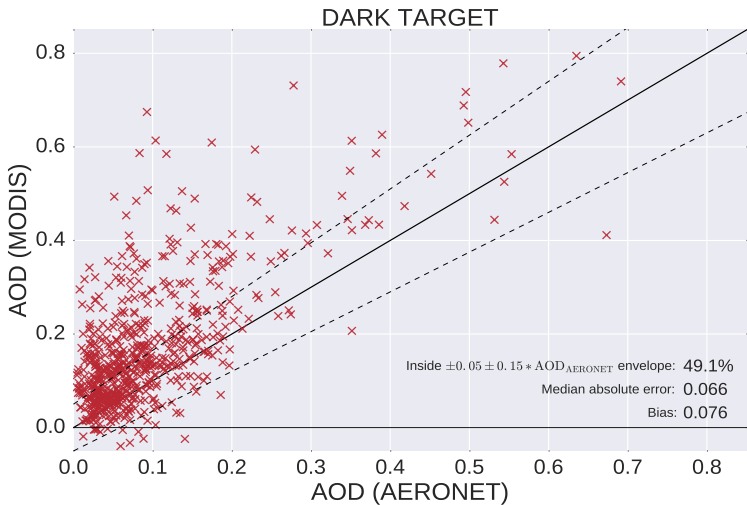


## Results - North America



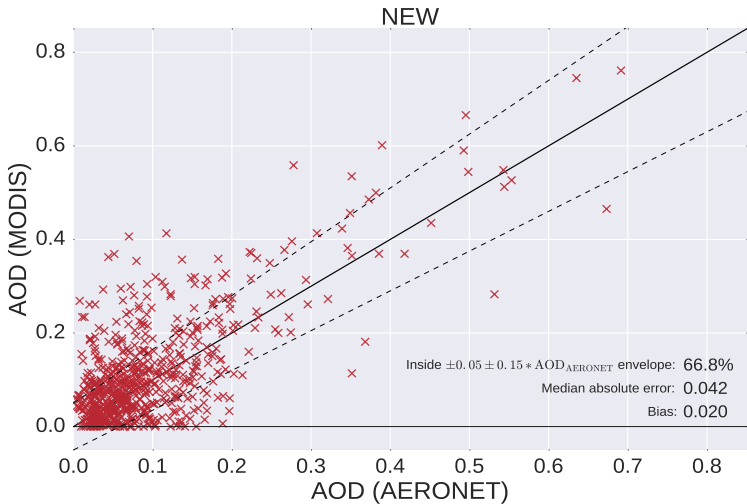


## Results - North America



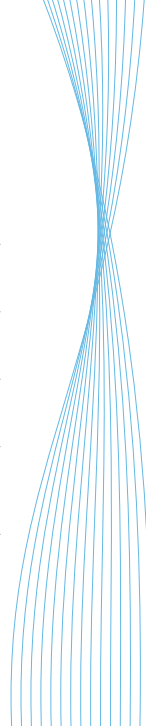
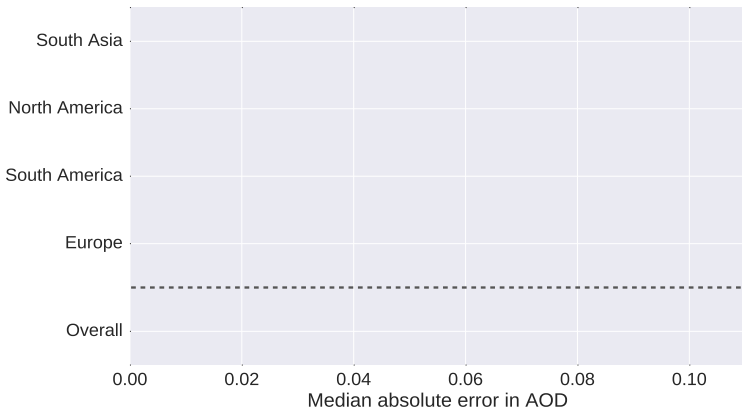


## Results - North America



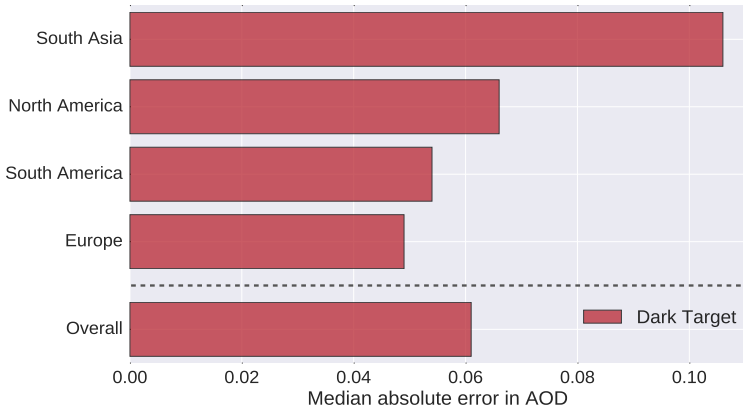


## Results - Median absolute error in AOD



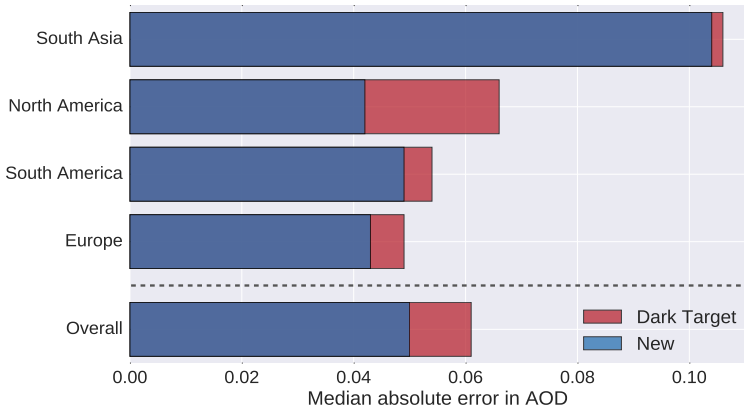


## Results - Median absolute error in AOD



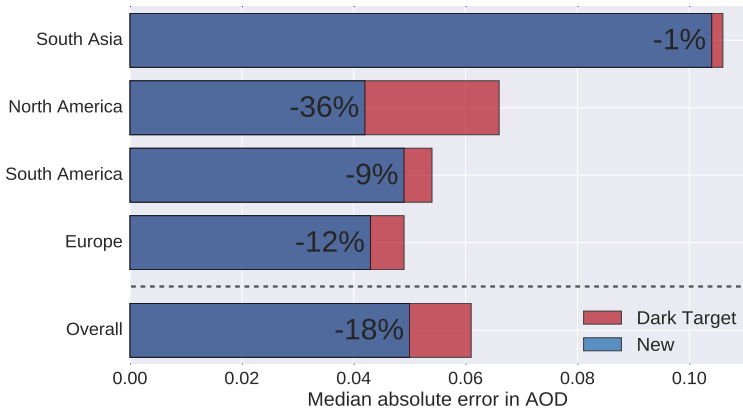


## Results - Median absolute error in AOD



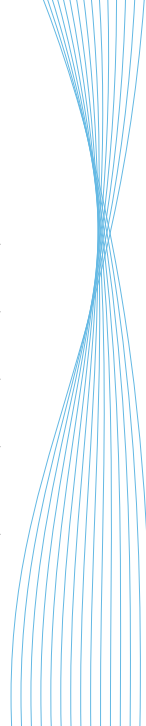
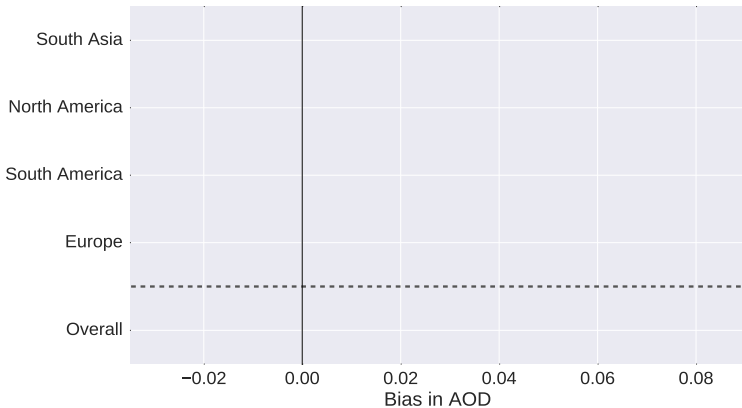


## Results - Median absolute error in AOD





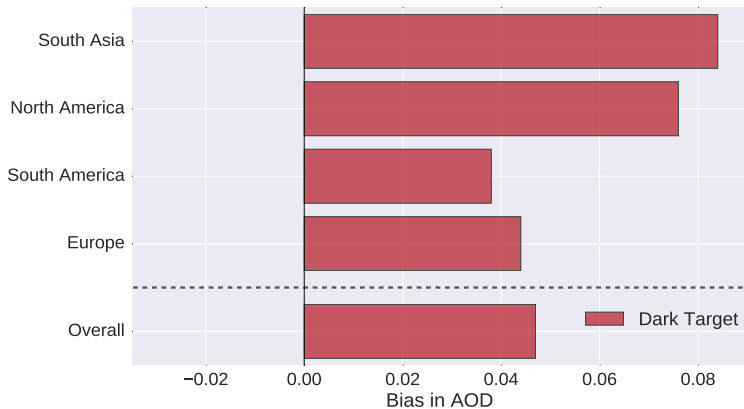
## Results - Bias in AOD





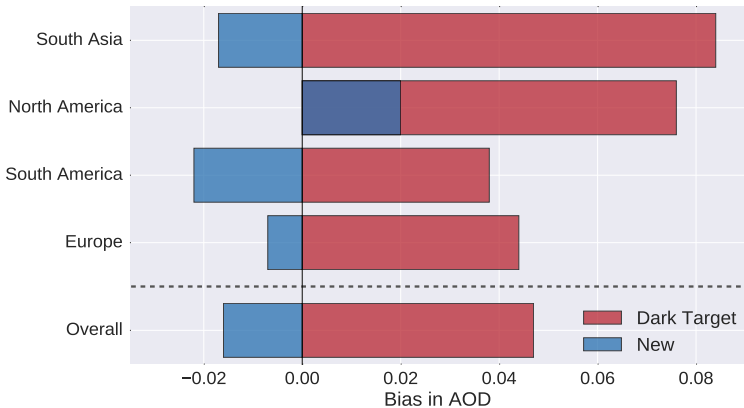


## Results - Bias in AOD



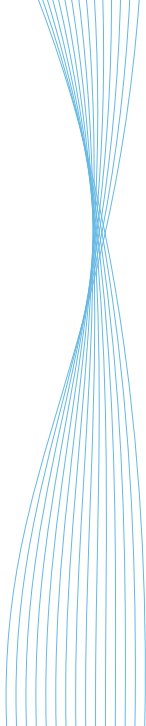


## Results - Bias in AOD





# Conclusions





## Conclusions

- A statistical inversion based inversion algorithm for MODIS AOD retrieval was developed



## Conclusions

- A statistical inversion based inversion algorithm for MODIS AOD retrieval was developed
- Significantly improves the accuracy of retrieved AOD in most of test areas
  1. Spatial correlation models
  2. Modified surface reflectance relationship
  3. Surface reflectance is estimated in addition to AOD and FMF



## Conclusions

- Manuscript under preparation, will be submitted soon
- Code package (Python) will be released with the paper
  - Want early access to the codes? Please ask [antti.lipponen@fmi.fi](mailto:antti.lipponen@fmi.fi)



## Conclusions

- Manuscript under preparation, will be submitted soon
- Code package (Python) will be released with the paper
  - Want early access to the codes? Please ask [antti.lipponen@fmi.fi](mailto:antti.lipponen@fmi.fi)
- Want to try the algorithm e.g. with different instrument or in retrieval of other quantities?
- Have ideas to further develop the inversion algorithm?
- All comments, ideas, etc. are very welcome

Thank you for your attention!

`antti.lipponen@fmi.fi`



ILMATIETEEN LAITOS  
METEOROLOGISKA INSTITUTET  
FINNISH METEOROLOGICAL INSTITUTE