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METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

# Information content analysis: Combination of satellite and ground-based observations enables more accurate aerosol SSA retrievals at low aerosol loadings

Antti Lipponen and Antti Arola

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# x: meeting was in Barcelona

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| | |
|---|---|
| Helsinki | 50% |
| Barcelona | 50% |

x: meeting was in Barcelona
y: it was afternoon

| | |
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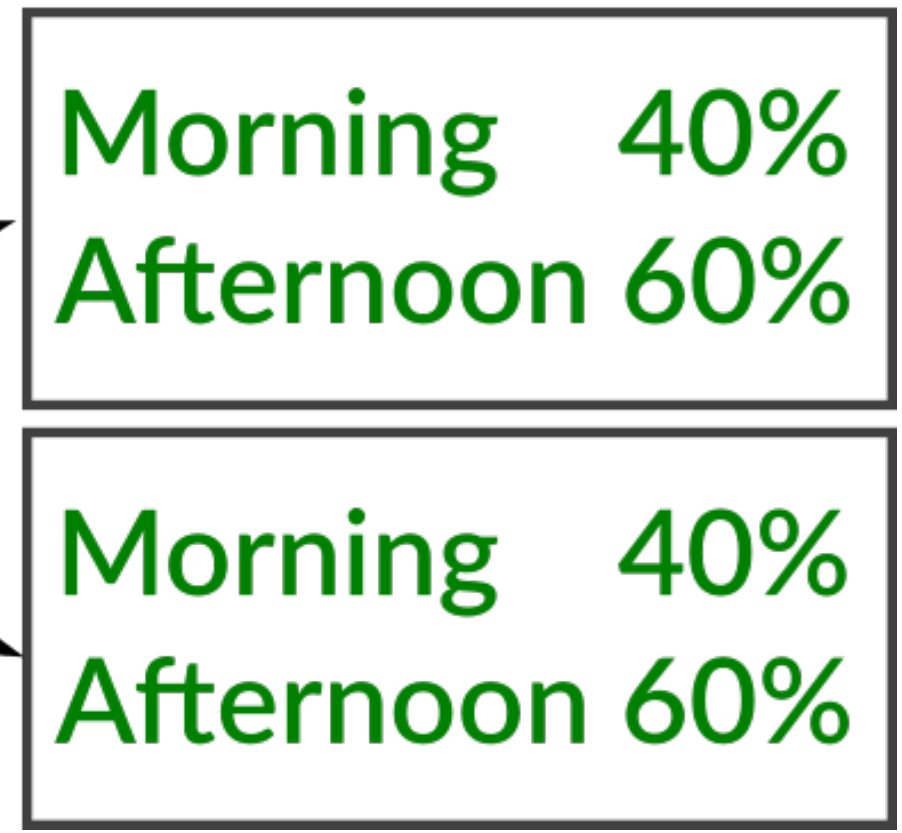
Helsinki 50%

Barcelona 50%



Bayes' theorem $p(x|y) = \frac{p(y|x)\,p(x)}{p(y)}$

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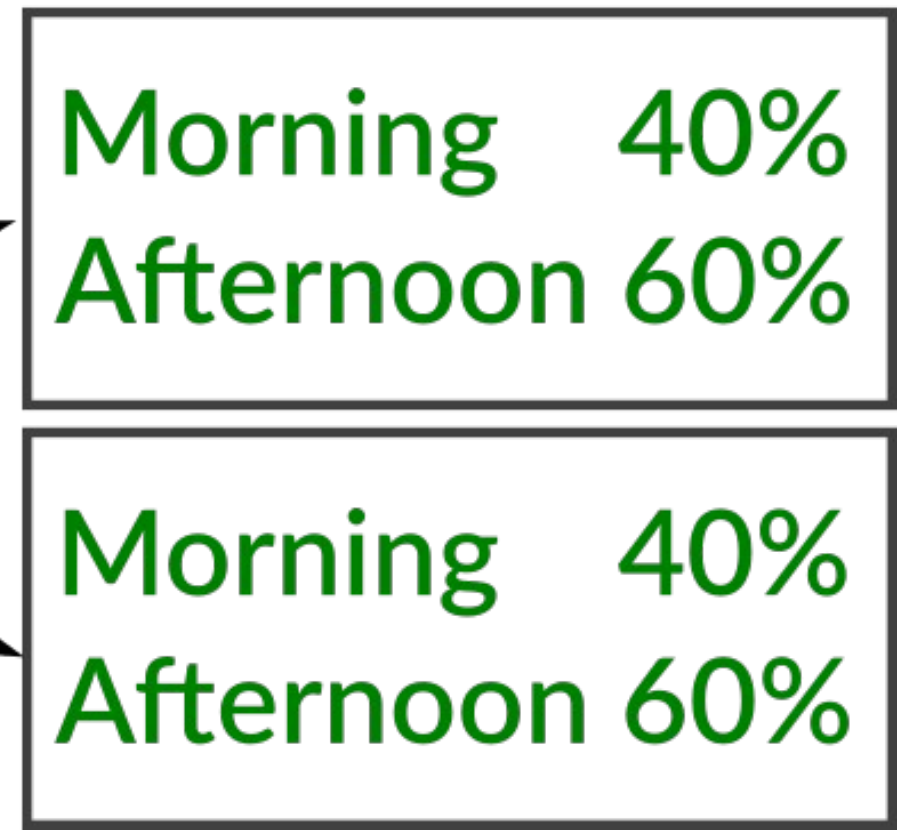
Helsinki 50%

Barcelona 50%



Bayes' theorem $p(x|y) = \frac{p(y|x)\,p(x)}{p(\text{HEL} \,\&\, \text{afternoon}) + p(\text{BCN} \,\&\, \text{afternoon})}$

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| | |
|---|---|
| Morning | 40% |
| Afternoon | 60% |

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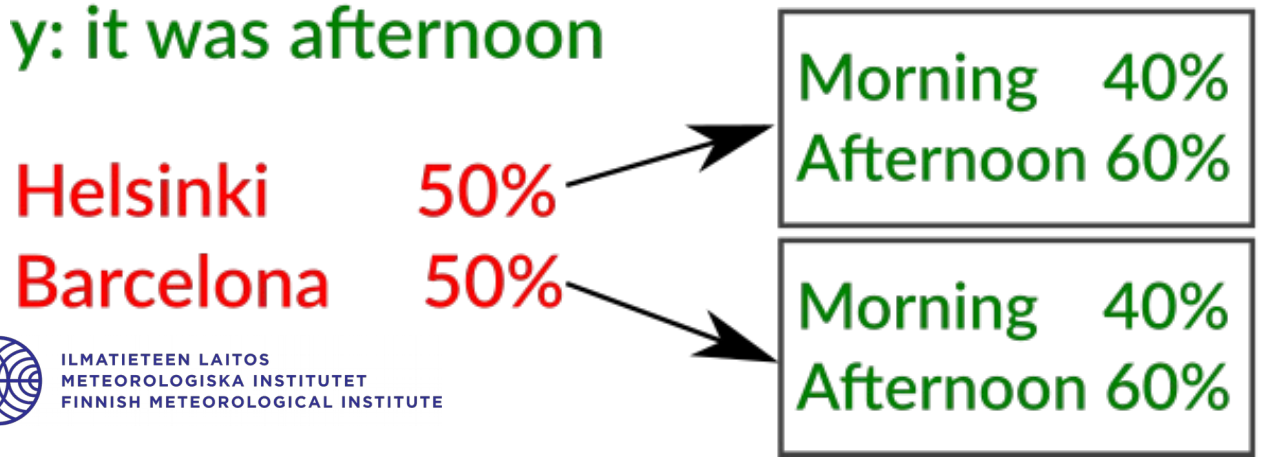

$$\text{Bayes' theorem} \quad p(x|y) = \frac{p(y|x)\,p(x)}{p(\text{HEL} \,\&\, \text{afternoon}) + p(\text{BCN} \,\&\, \text{afternoon})}$$

$$= \frac{p(y|x)\quad p(x)}{p(\text{HEL} \,\&\, \text{afternoon}) + p(\text{BCN} \,\&\, \text{afternoon})}$$

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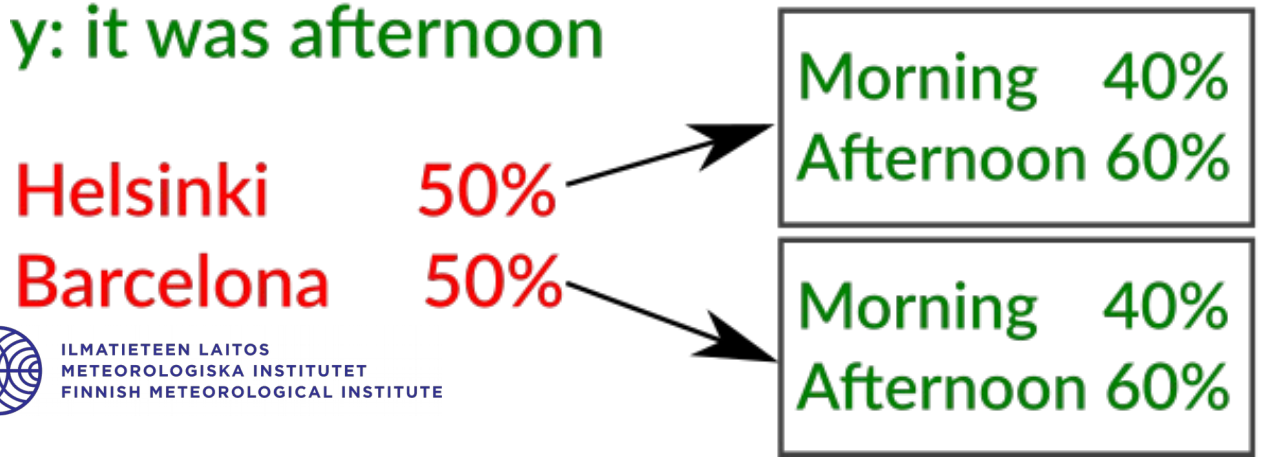

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$$= \frac{0.6 * 0.5}{0.5 * 0.6 + 0.5 * 0.6} =$$

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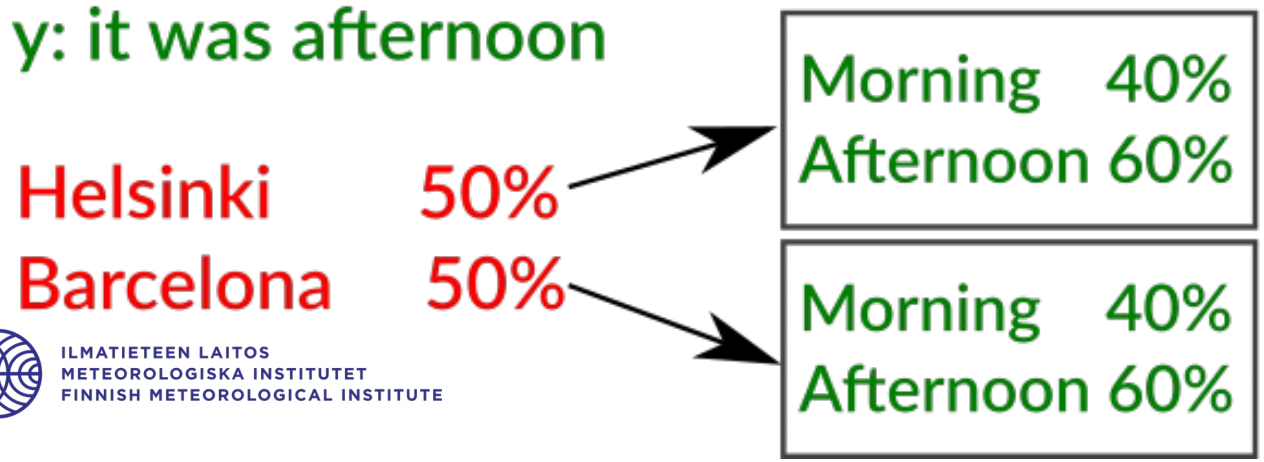

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$$= \frac{0.6 * 0.5}{0.5 * 0.6 + 0.5 * 0.6} = 0.5$$

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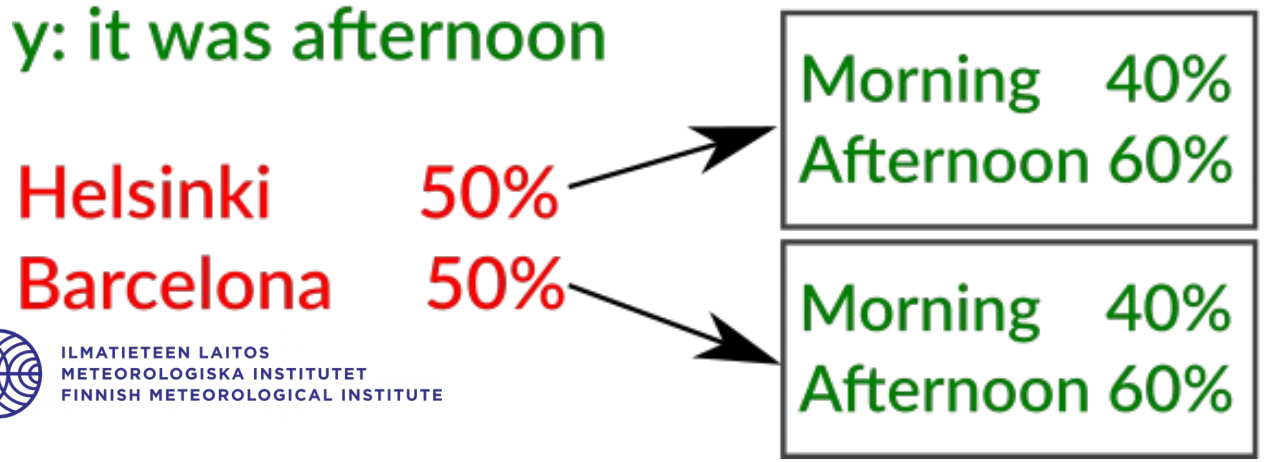

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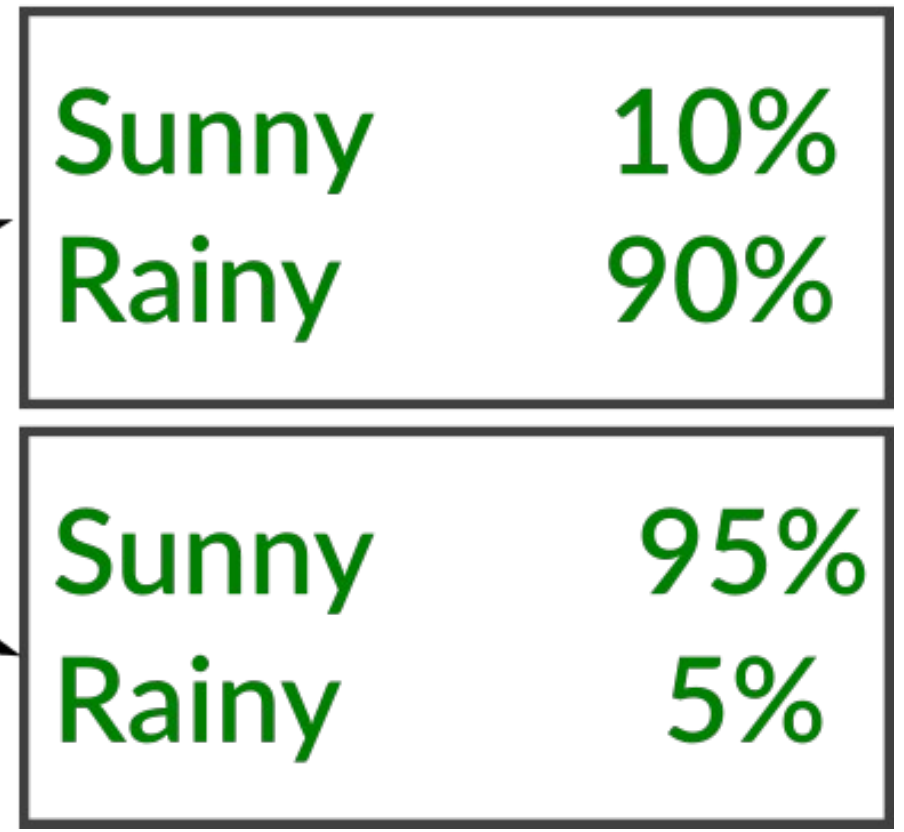

# Bayes' theorem $p(x|y) = \frac{p(y|x)\,p(x)}{p(\text{HEL} \,\&\, \text{sunny}) + p(\text{BCN} \,\&\, \text{sunny})}$

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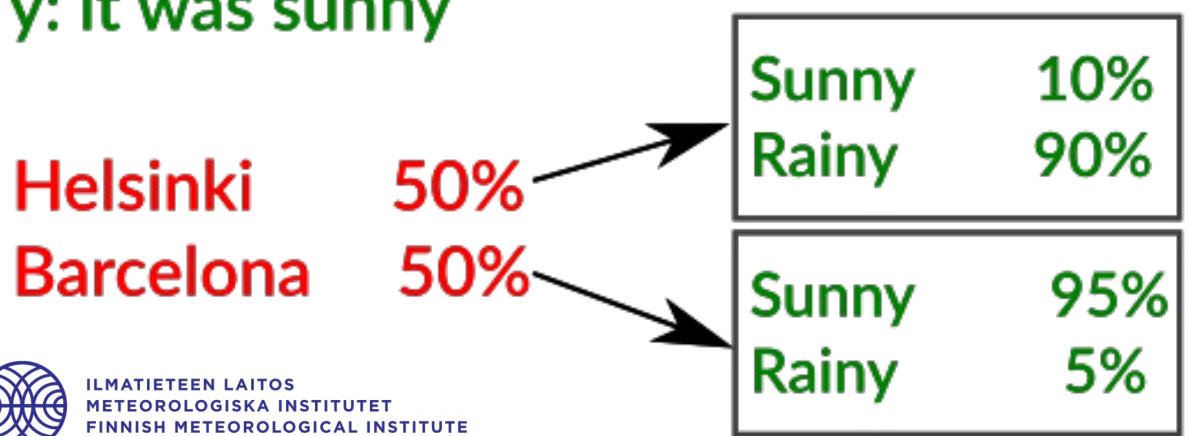

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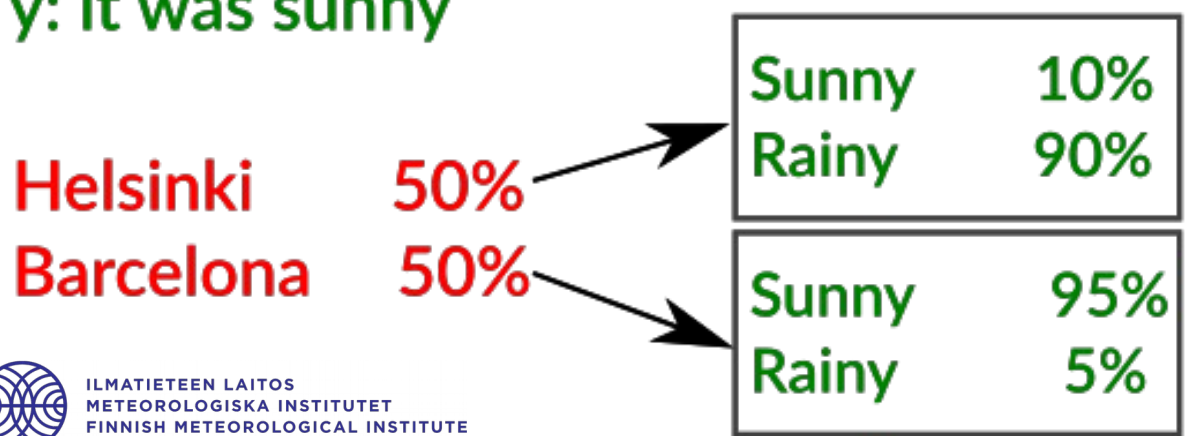

$$\text{Bayes' theorem} \quad p(x|y) = \frac{p(y|x)\,p(x)}{p(\text{HEL} \,\&\, \text{sunny}) + p(\text{BCN} \,\&\, \text{sunny})}$$

$$= \frac{0.95 * 0.5}{0.5 * 0.1 + 0.5 * 0.95}$$

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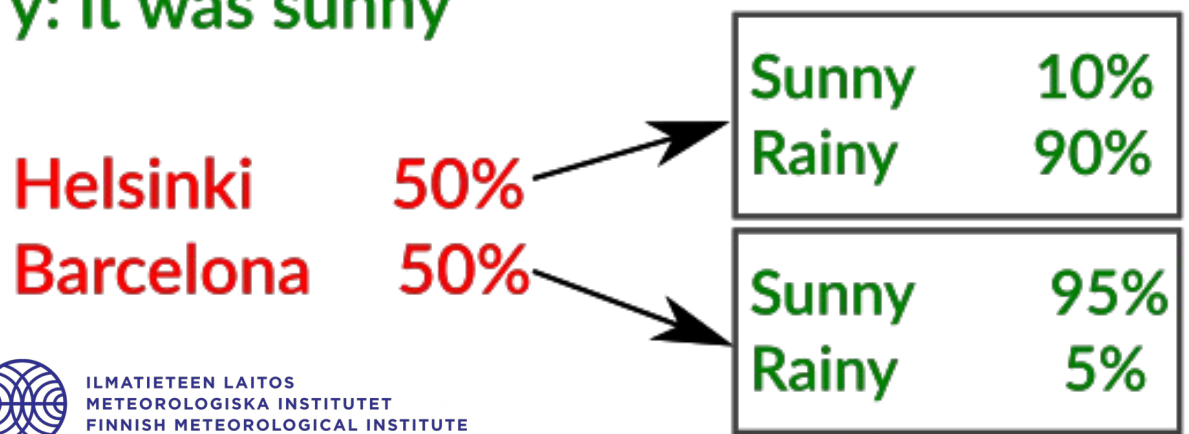

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$$= \frac{0.95 * 0.5}{0.5 * 0.1 + 0.5 * 0.95} \approx 0.90$$

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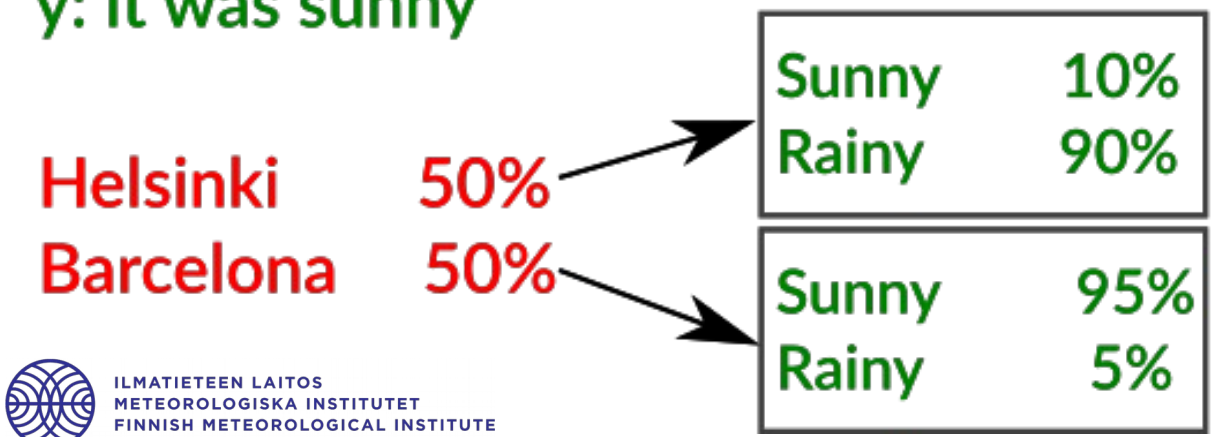

# INFORMATION CONTENT ANALYSIS

- Bayes' theorem
- Multivariate Gaussian distributions + additive obs. noise
- Combine AERONET inversion & MODIS observations

→ Can we improve SSA retrievals at low AOD?

**Analysis of fine-mode aerosol retrieval capabilities by different passive remote sensing instrument designs**

Kirk Knobelspiesse,[1,2,*] Brian Cairns,[1] Michael Mishchenko,[1] Jacek Chowdhary,[3,1] Kostas Tsigaridis,[3,1] Bastiaan van Diedenhoven,[3,1] William Martin,[3,1] Matteo Ottaviani,[1,4] and Mikhail Alexandrov[3,1]

[1]*NASA Goddard Institute for Space Studies, 2880 Broadway, New York, New York 10025, USA*
[2]*NASA Postdoctoral Program fellow, USA*
[3]*Columbia University, 2880 Broadway, New York, New York 10025, USA*
[4]*Stevens Institute of Technology, Hoboken, New Jersey, USA*

*kirk.knobelspiesse@nasa.gov*

# INFORMATION CONTENT ANALYSIS

$$\hat{\mathbf{S}}^{-1} = \mathbf{K}^T \mathbf{S}_\varepsilon^{-1} \mathbf{K} + \mathbf{S}_a^{-1}$$

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**Analysis of fine-mode aerosol retrieval capabilities by different passive remote sensing instrument designs**


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**kirk.knobelspiesse@nasa.gov*

# AERONET SSA

- Available in the inversion product
- Level-2
  - AOD (at 440 nm) > 0.4

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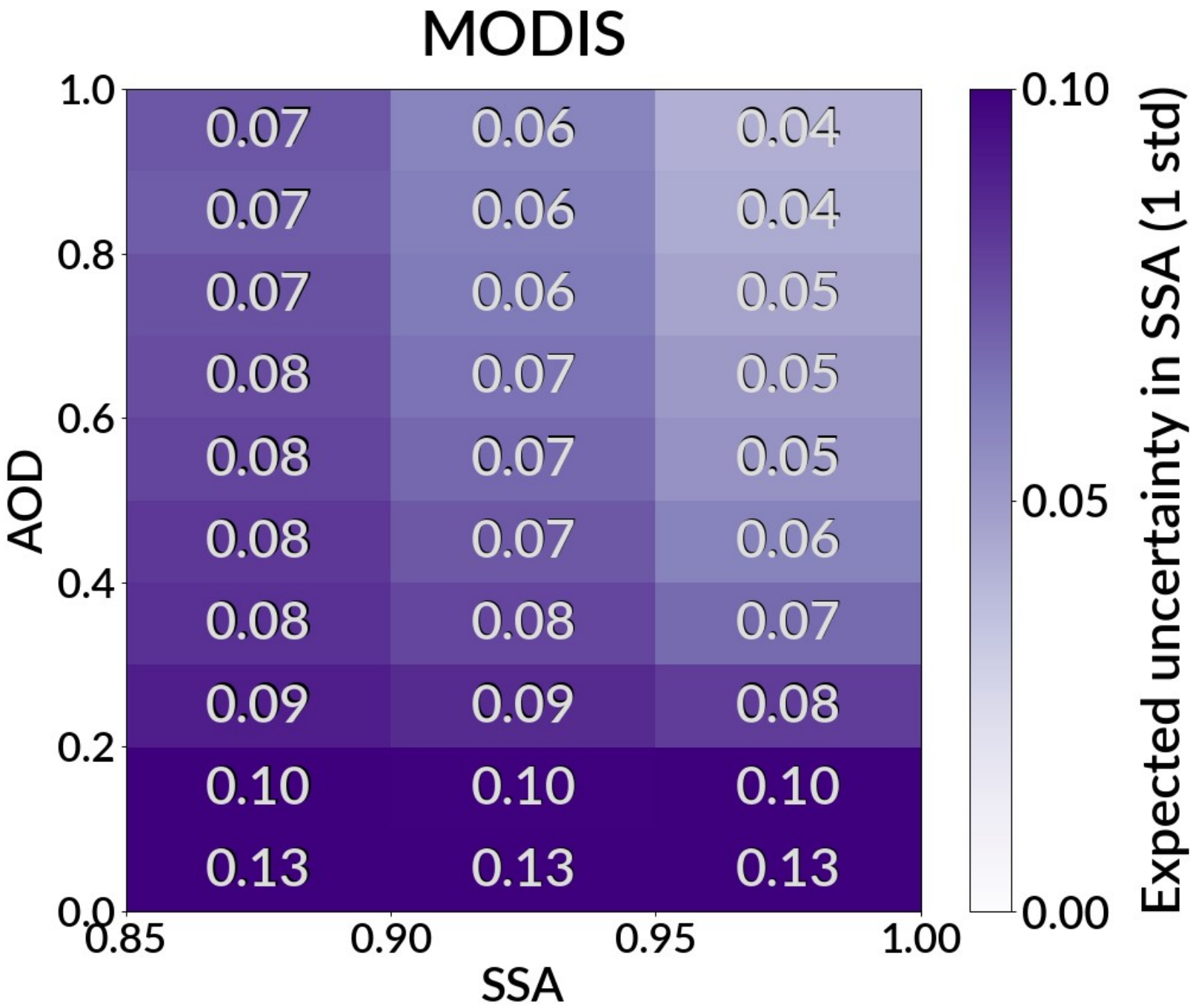
Technical details:

- Analysis based on radiative transfer (libRadtran) simulations
- MODIS bands 1-8 used, SZA=65°
- AERONET almucantar radiances at 440, 675, 870, 1020 nm, SZA=65°
- 2.5% uncertainty in MODIS reflectance, 5% AERONET almucantar radiances
- Parameters to be estimated

  AOD, SSA, ozone, aerosol layer height, Angstrom exponent (AE), absorbing AE, asymmetry parameter, surface pressure

# SSA




SSA Prior Std 0.15

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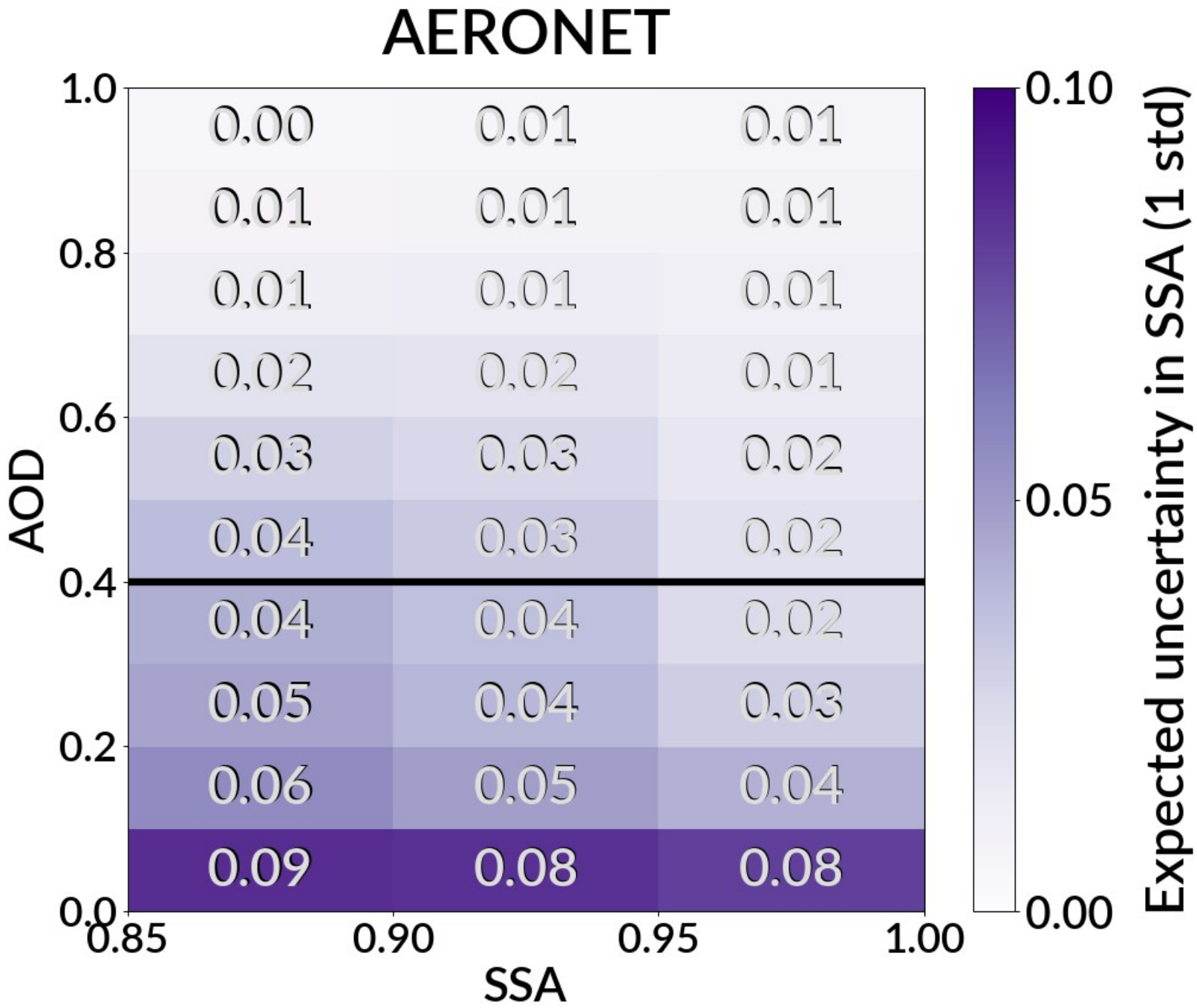
# SSA

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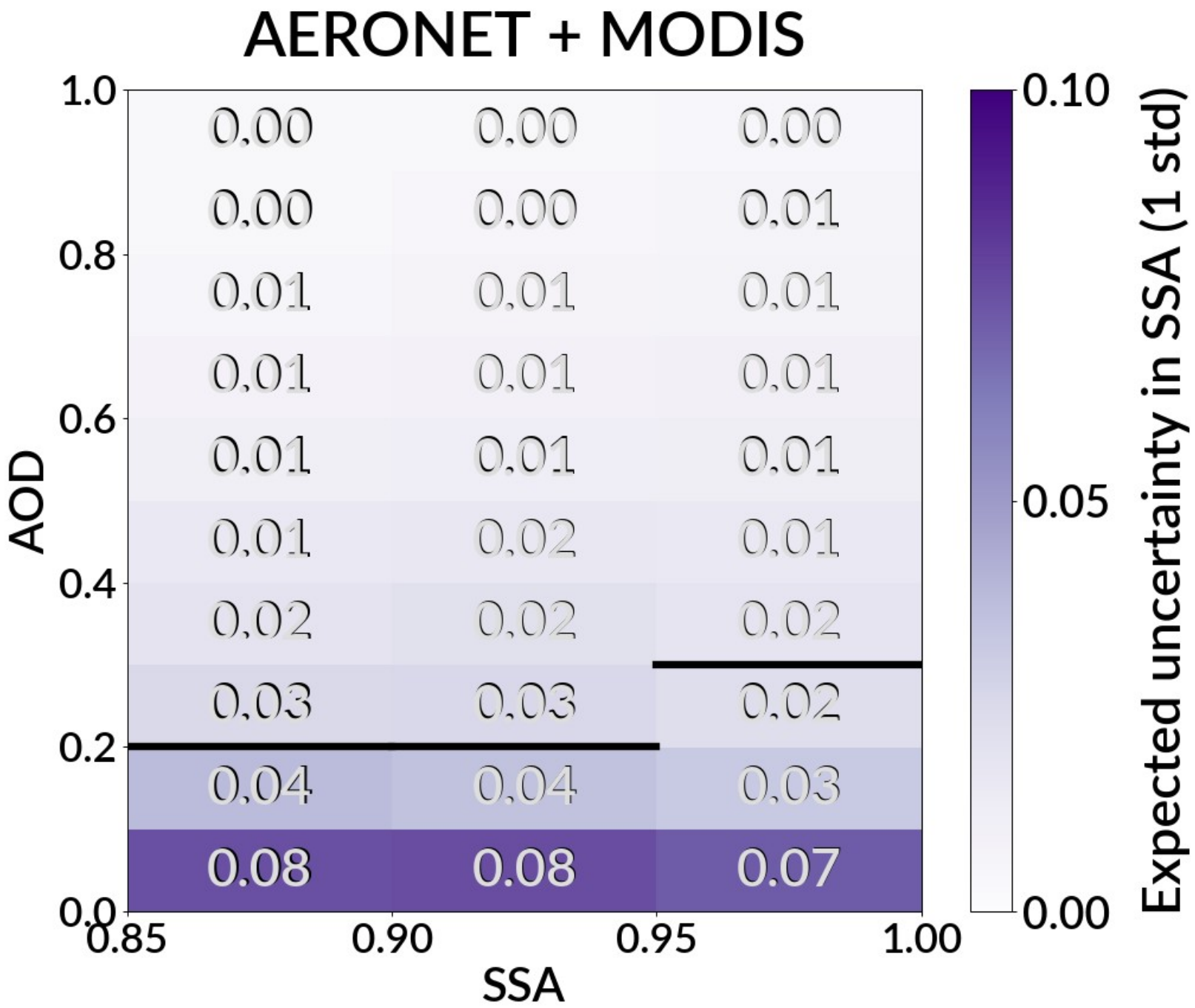
# SSA




SSA Prior Std 0.15

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- Bayes theorem' is a useful tool for info content analysis
- Combining bottom-of-the-atmosphere (BOA) and top-of-the-atmosphere (TOA) observations may improve the SSA retrievals
- Improved retrievals of SSA (and possibly other aerosol parameters) may help aerosol typing

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**Bayes' theorem is useful in info content analysis**

**Sometimes 1 + 1 > 2**

**Improved SSA retrievals may help aerosol typing**

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