A Cirrus Detection Technique for SCIAMACHY on board ENVISAT

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Cirrus Detection

- Starting point: Use of the reflected sunlight

➢ *Knap et al.* [2002] take into account a normalized *two point* spectral slope *S* around 1.6 μm (also,e.g. Pilewskie & Twomey, 1987)

➢ *S* increases with τ^{ICE} & crystal size; presents a small sensitivity with the geometry (μ_o, μ, ϕ); ground effects are unimportant over surfaces like the ocean, green vegetation or liquid clouds

➢ Ambiguity for mixed phase $(\tau^{WATER} + \tau_1^{ICE}) = \tau_2^{ICE}$

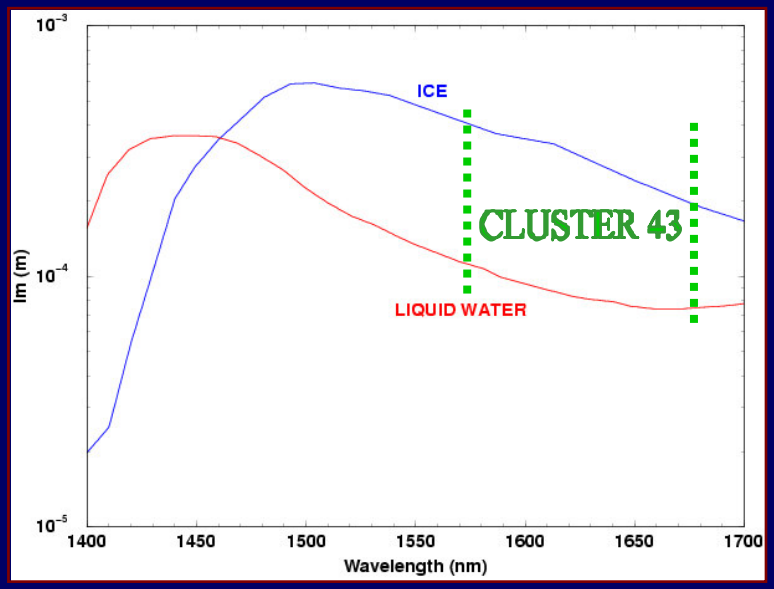
- SCIAMACHY: We use a linear *fit* to the spectral slope around 1.6 μm. The normalized slope defines our Cloud Phase Index

Why does the method work ?

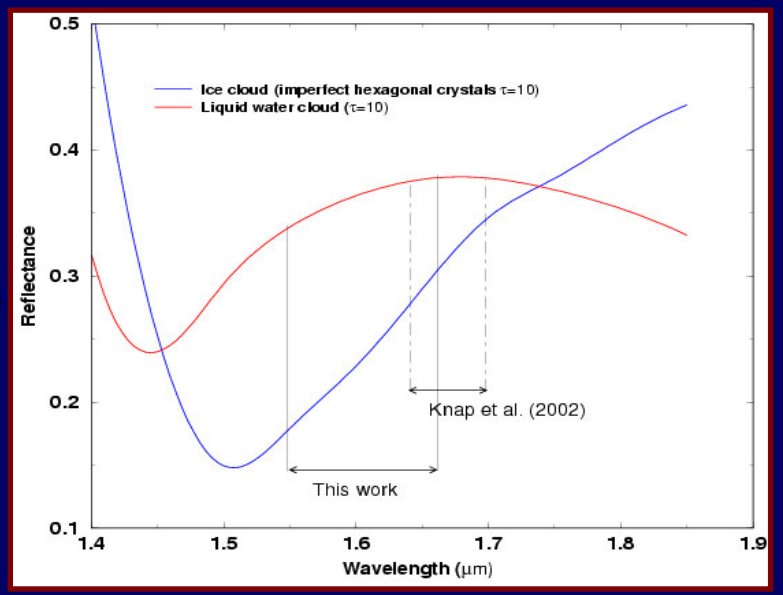
- The Im part of the refractive index for liquid water / ice is different around 1.6 μm
- No atmospheric contribution, except residual CO_2

➢ *Cloud Phase Index* = $(dR/d\lambda)_{\lambda=1.67} / R(1.63)$

Im [refractive index]

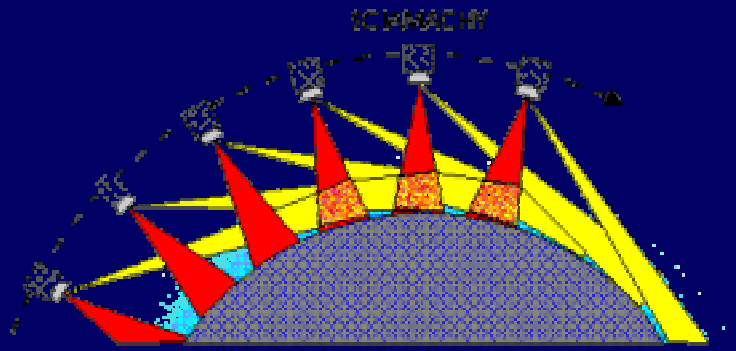


Simulations

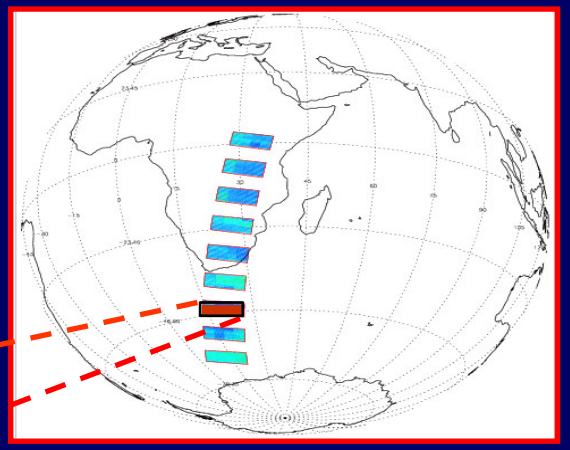


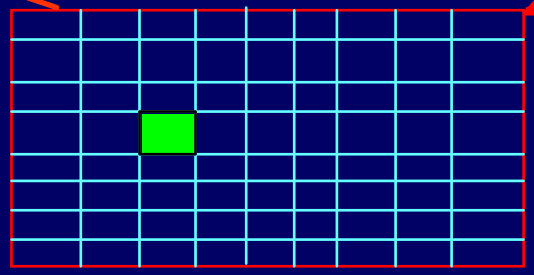
SCIAMACHY: A spectrometer (0.24-2.38 µm) on board ENVISAT

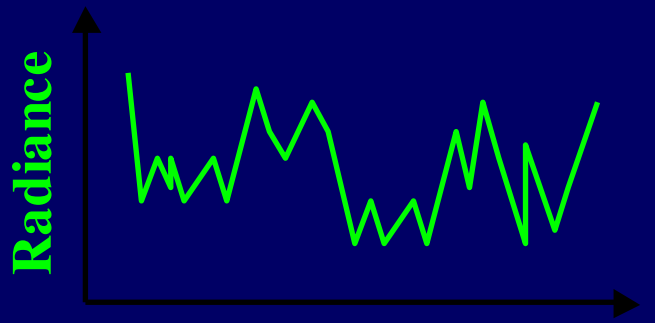
NADIR & LIMB



Nadir states





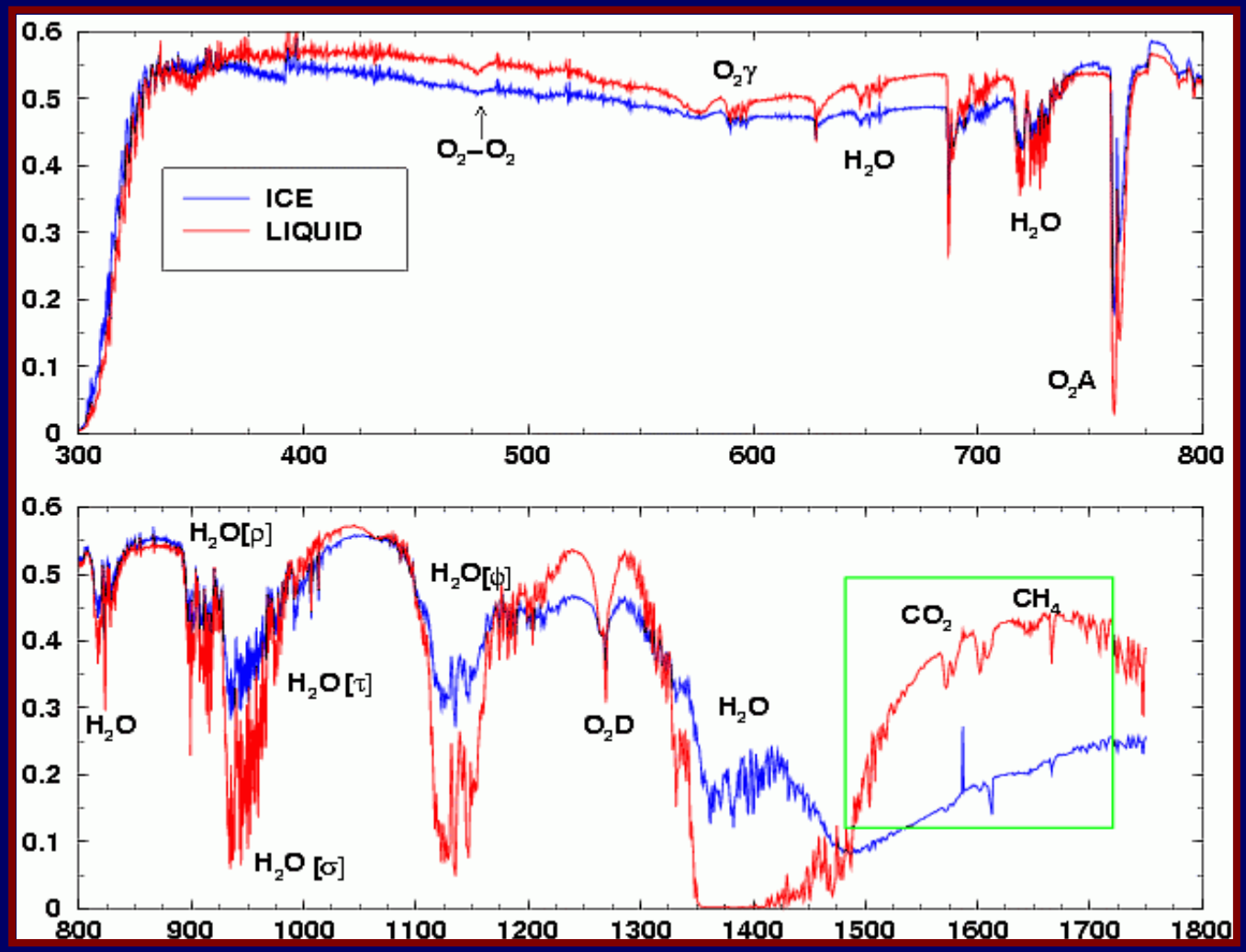


1 state ≈ 50-200 pixels

along x across track ≈ 60x(30-240) km²

$\lambda_1 \ldots \lambda_n$ (= cluster)

SCIAMACHY: Ice cloud vs. liquid water cloud



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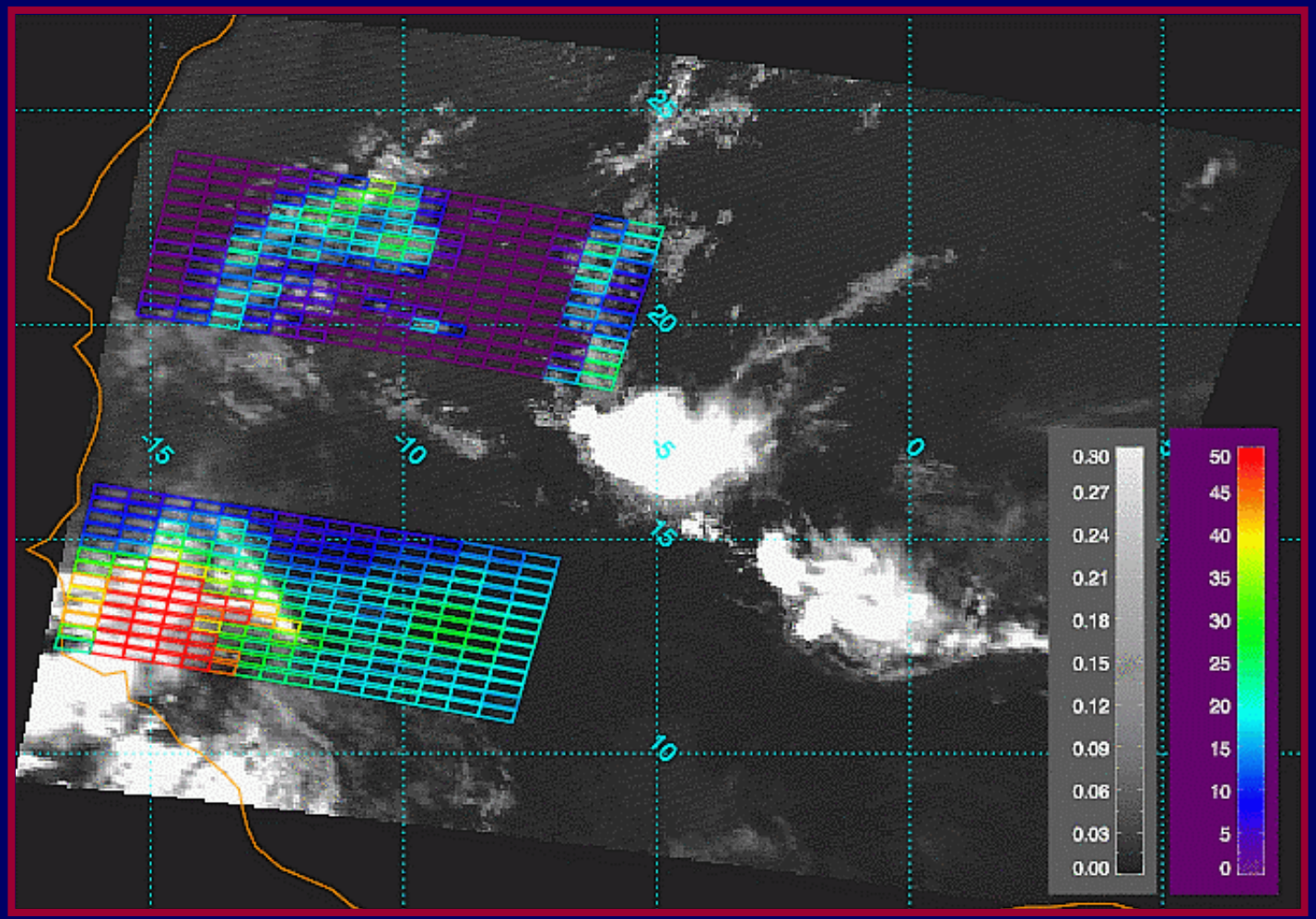
MODIS (Cirrus Reflectance) SCIAMACHY (CPI)



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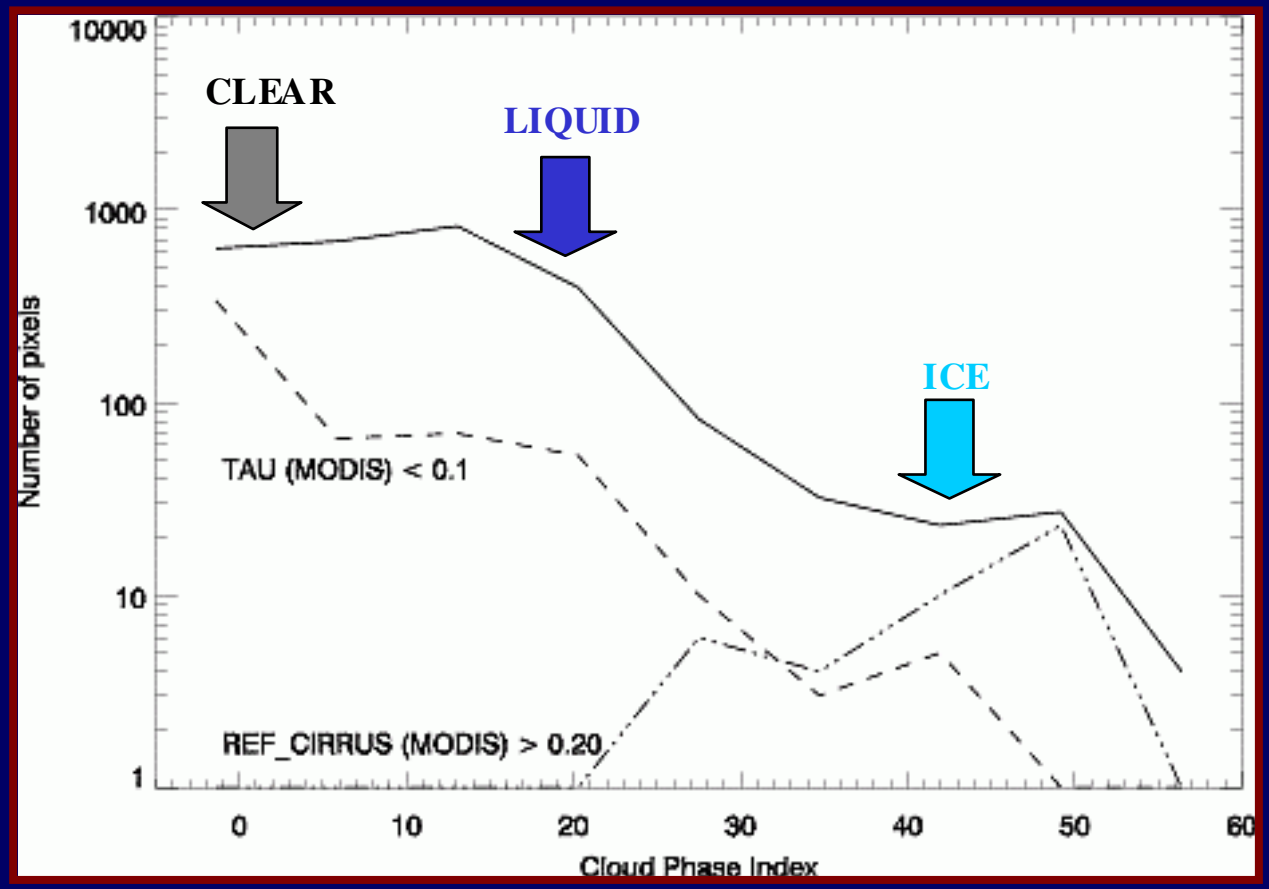
Intercomparison with MODIS

1. CPI is calculated with SCIAMACHY data
2. A histogram with the SCIAMACHY CPI values is made
3. Clear / cloudy pixels are found using the MODIS *Cloud Optical Thickness* product. A threshold of $\tau \approx 0.1$ represents the boundary clear/cloudy
4. Ground pixels with cirrus are found with the MODIS *Cirrus Reflectance* product. A threshold of ≈ 0.2 is equivalent to $\tau^{ICE} \approx 3$
5. The combination of both thresholds determines the CPI values for liquid water clouds

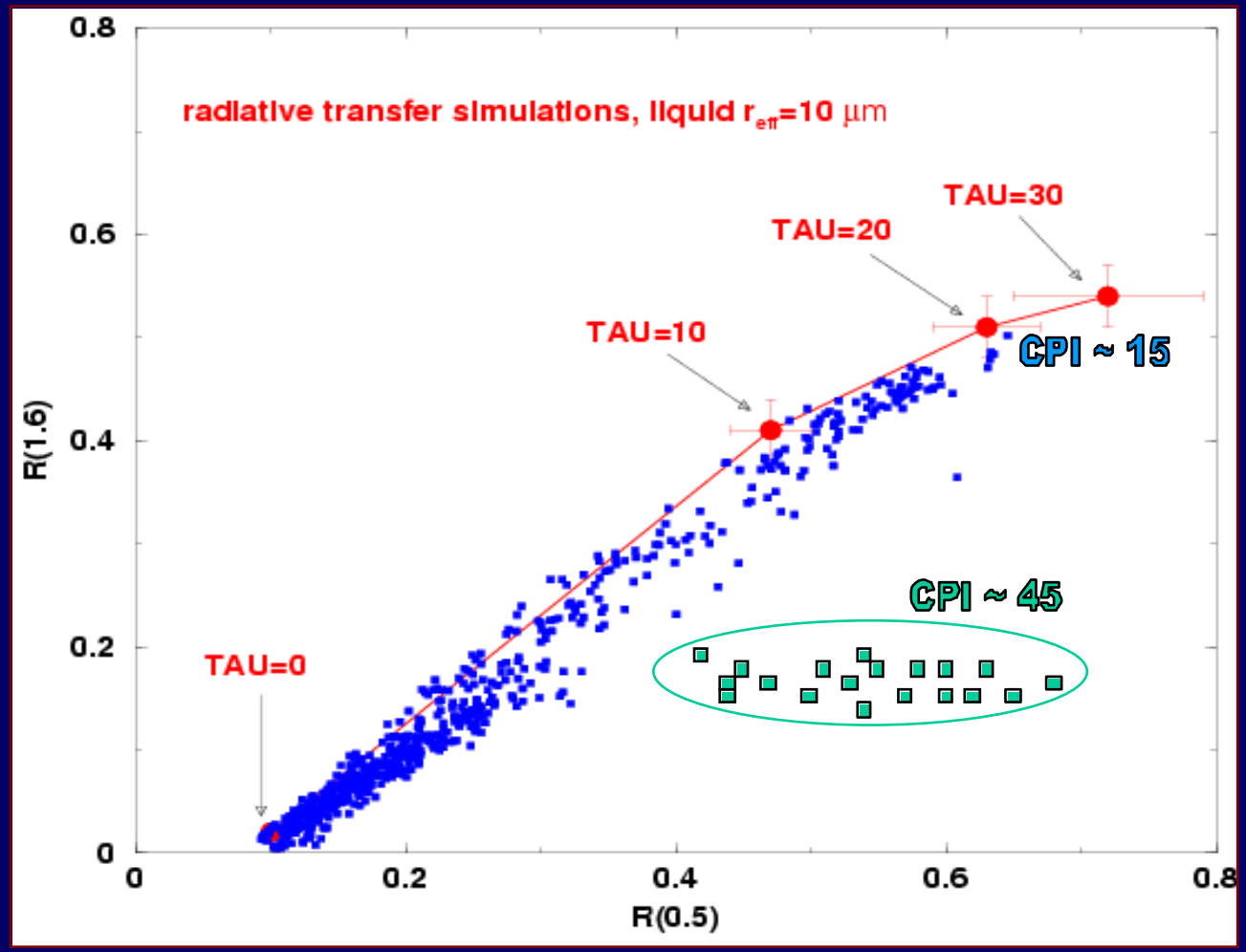
Histogram of SCIAMACHY data including MODIS products

Cloud Optical Thickness and *Cirrus Reflectance*

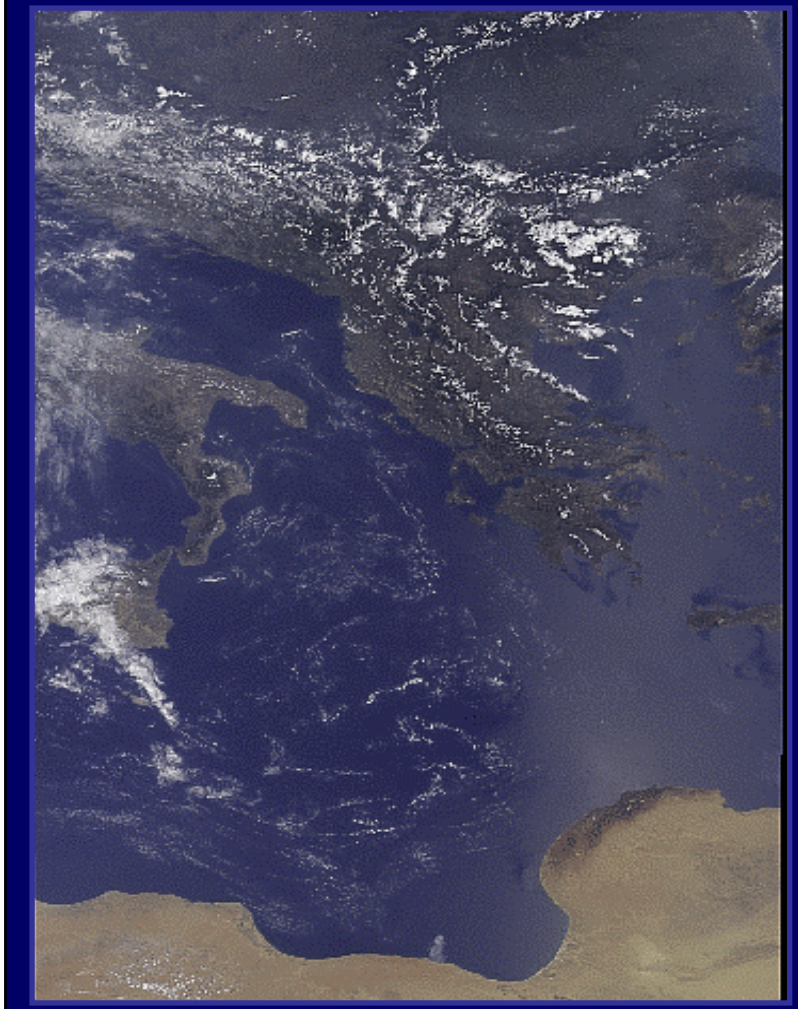
log scale !!

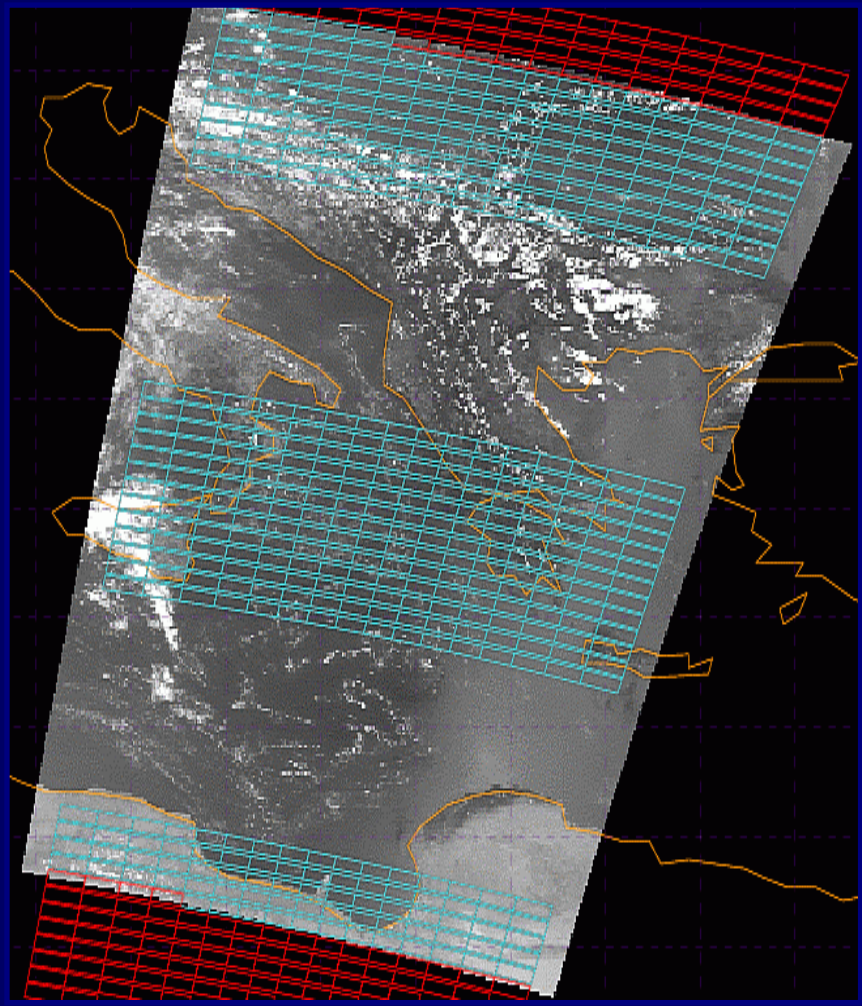


RT Comparison



Outlook: Cloud mask is better characterized by MERIS (there are no temporal offsets)





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Conclusions & Future Work

➔ Although limited, the set of SCIAMACHY data shows that the method works. More data are needed to compare the Cloud Phase Index with radiative transfer calculations that deal with ice crystals

📖 The VIS analysis can be improved with MERIS

📖 Addition of SCIAMACHY measurements such as 0.48 μm (O_2-O_2 band), 0.76 μm (O_2-A band) or 1.38 μm (H_2O band) is a work in progress

Acknowledgements

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- SCIAMACHY data are property of ESA
- MODIS data, obtained from EOS-Data Gateway, are property of NASA
- Cirrus (1st slide) from www.weatherpictures.nl/pictures by Bernard Hulshof (2002)
- Limb / nadir image from envisat.esa.int /instruments/sciamachy/descr/operations.html#measurement (©IFE/BREMEN)
- Snow crystal from Electron Microscopy Unit, Beltsville Agricultural Research Center (BARC), Maryland, USA. www.anri.barc.usda.gov/emusnow/

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