Development of a cloud-screening method for MAX-DOAS observations

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Goal:

qualify sky and cloud conditions from MAX-DOAS data in context of NORS data delivery

Sky conditions

Trace gas retrievals hindered by **clouds** and **aerosols**

→ introduce additional photon absorption
multiple scattering
strong temporal variation

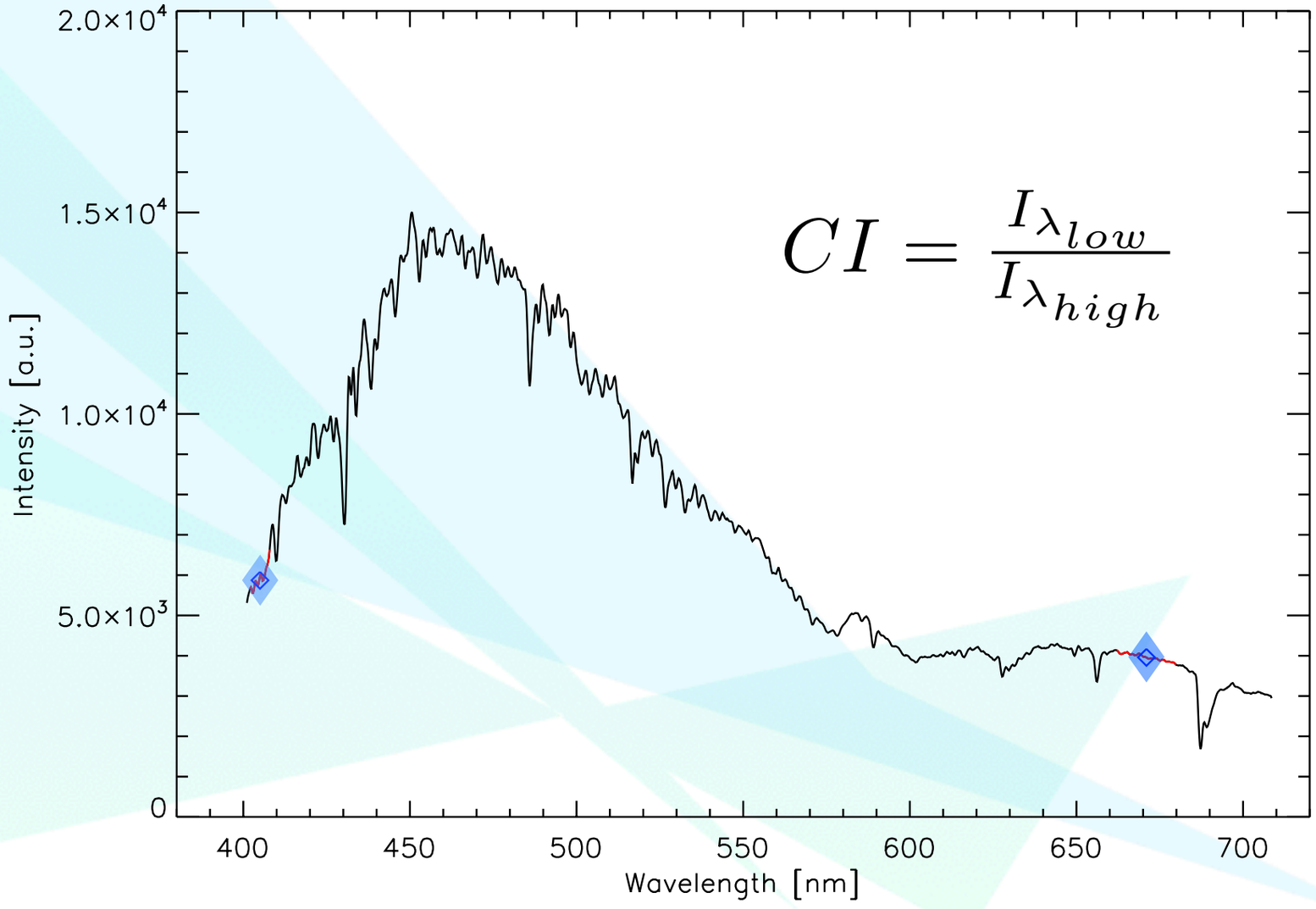
Degenerate problem: thin/thick clouds, fog, haze, high/low aerosol load, white clouds, grey clouds,....

→ difficult to distinguish

Tools: the colour index

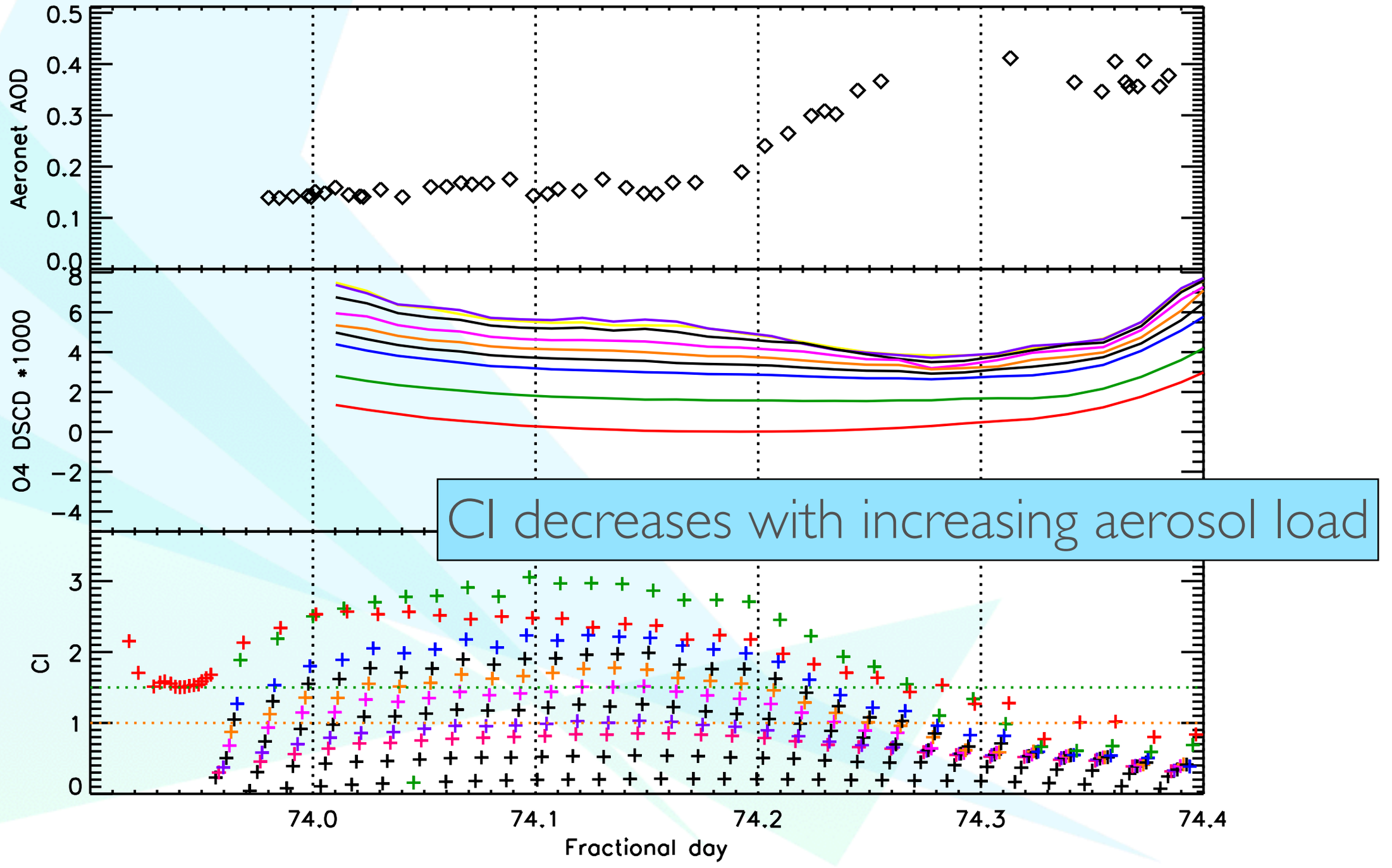
Use observed colour of the sky for characterization

→ Colour Index = ratio of intensities



Colour-index variation

Example day: Clear with rising aerosol load



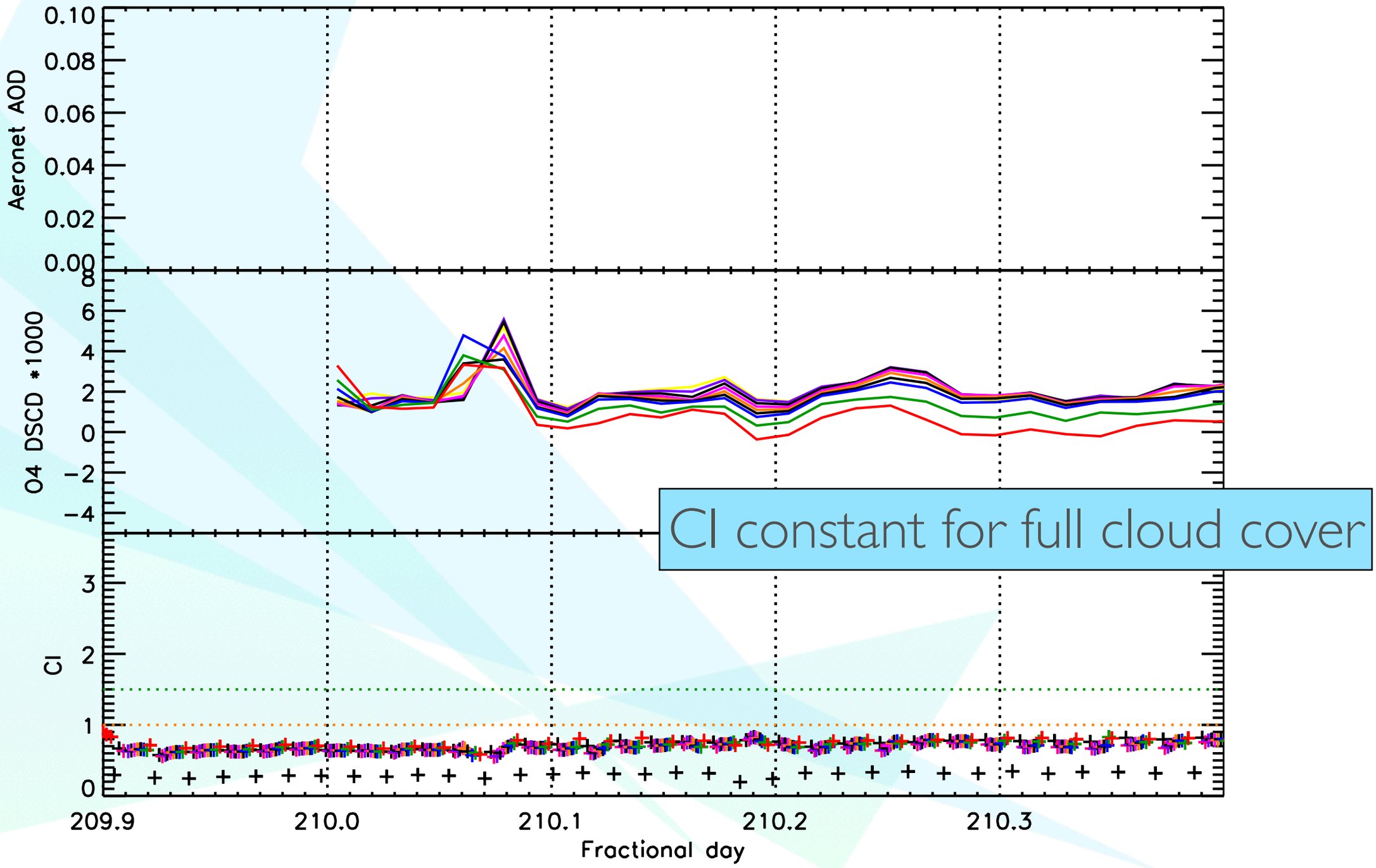
elev.

elev.

CI decreases with increasing aerosol load

Colour-index variation

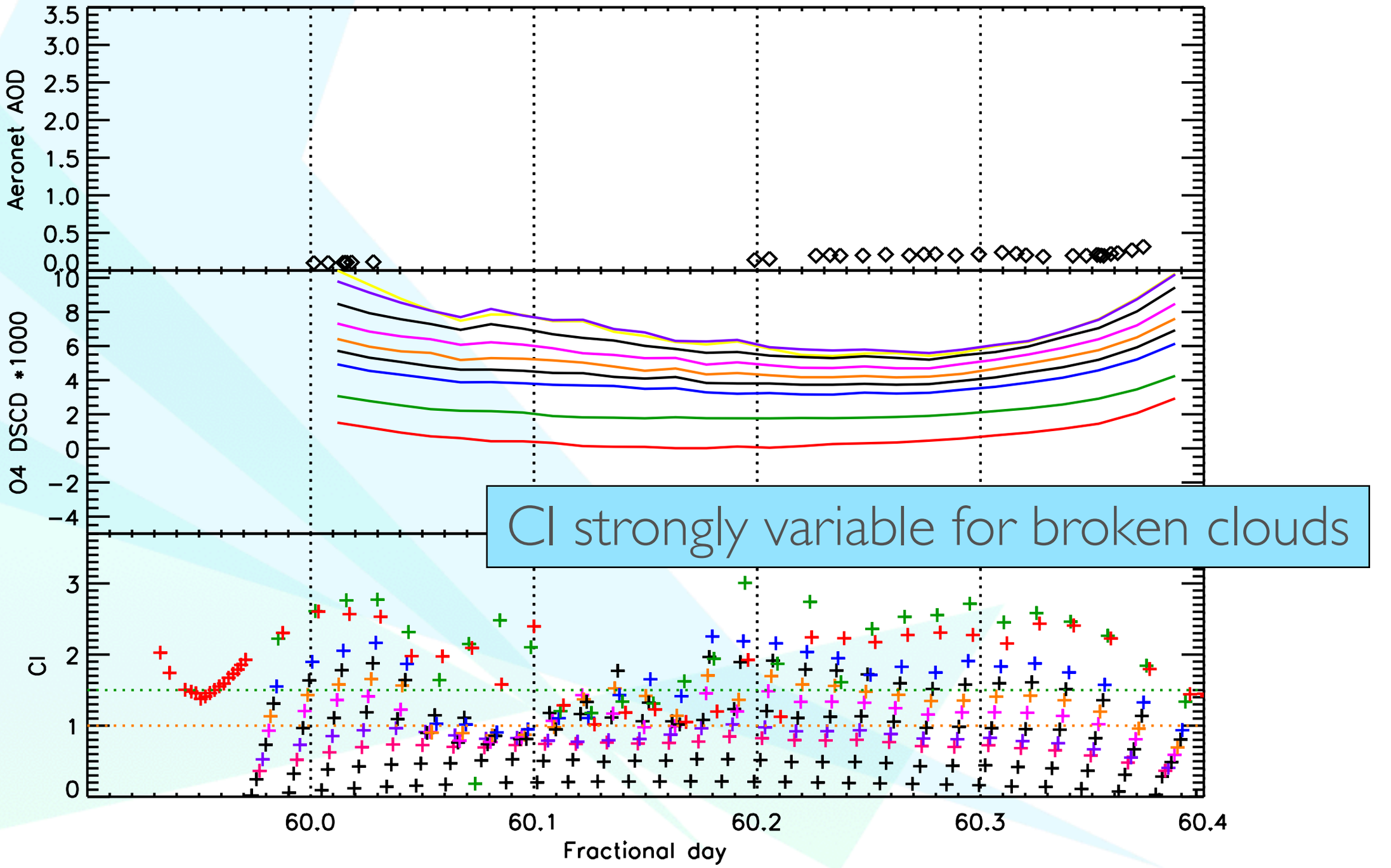
Example day: Full cloud cover



CI constant for full cloud cover

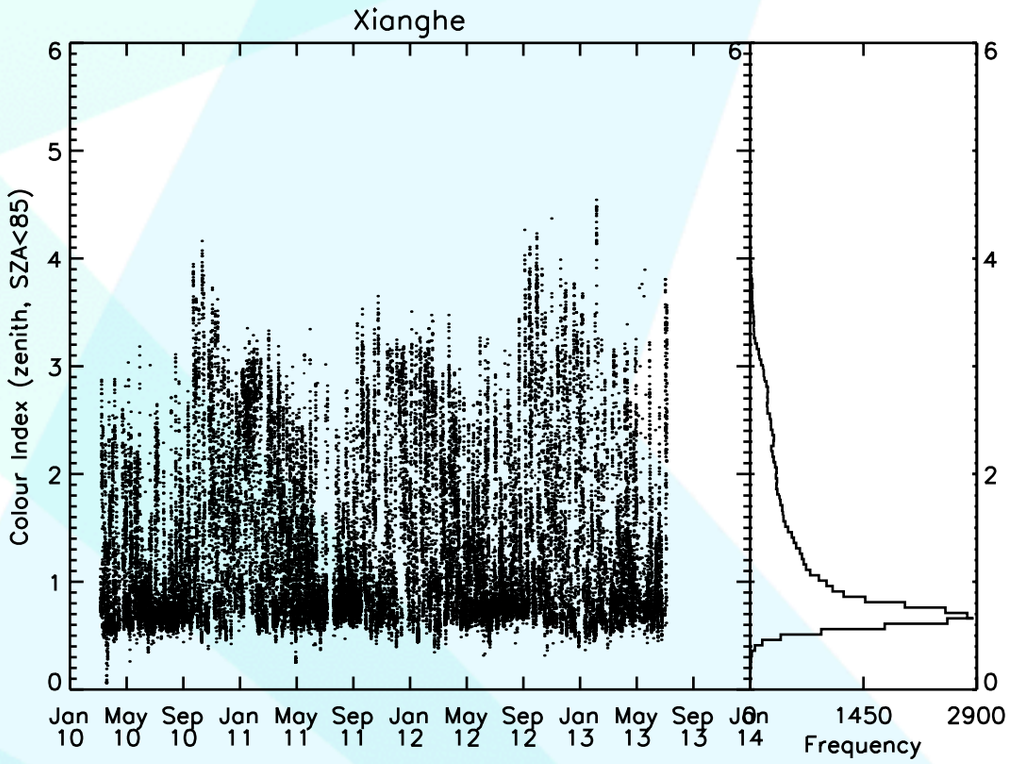
Colour-index variation

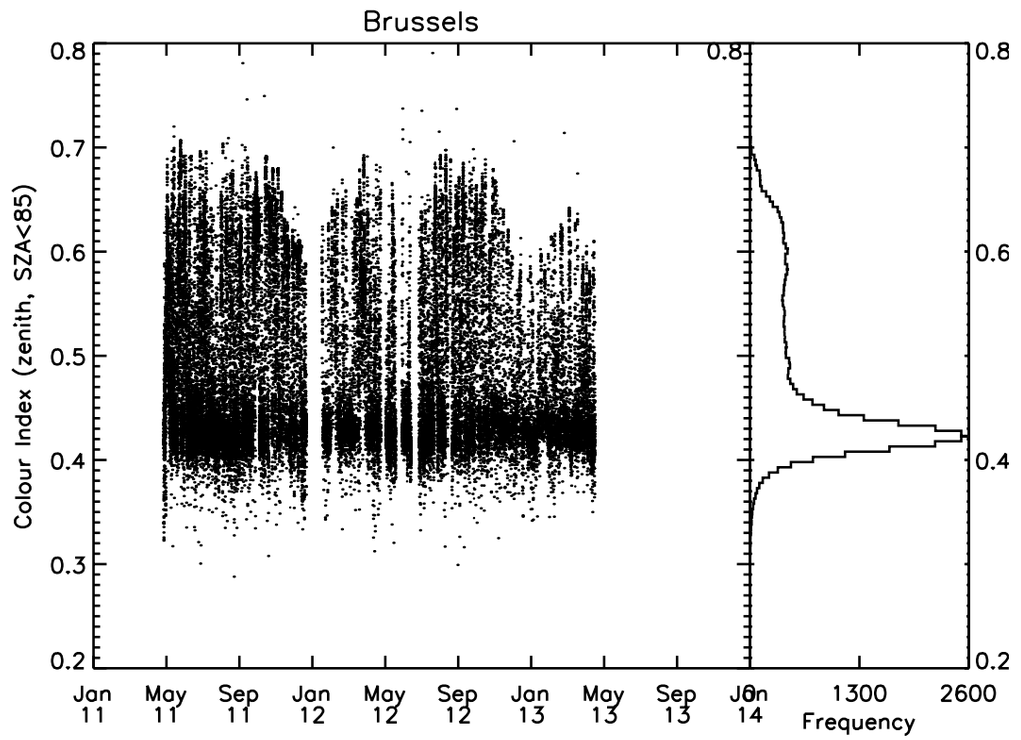
Example day: Clear with broken clouds

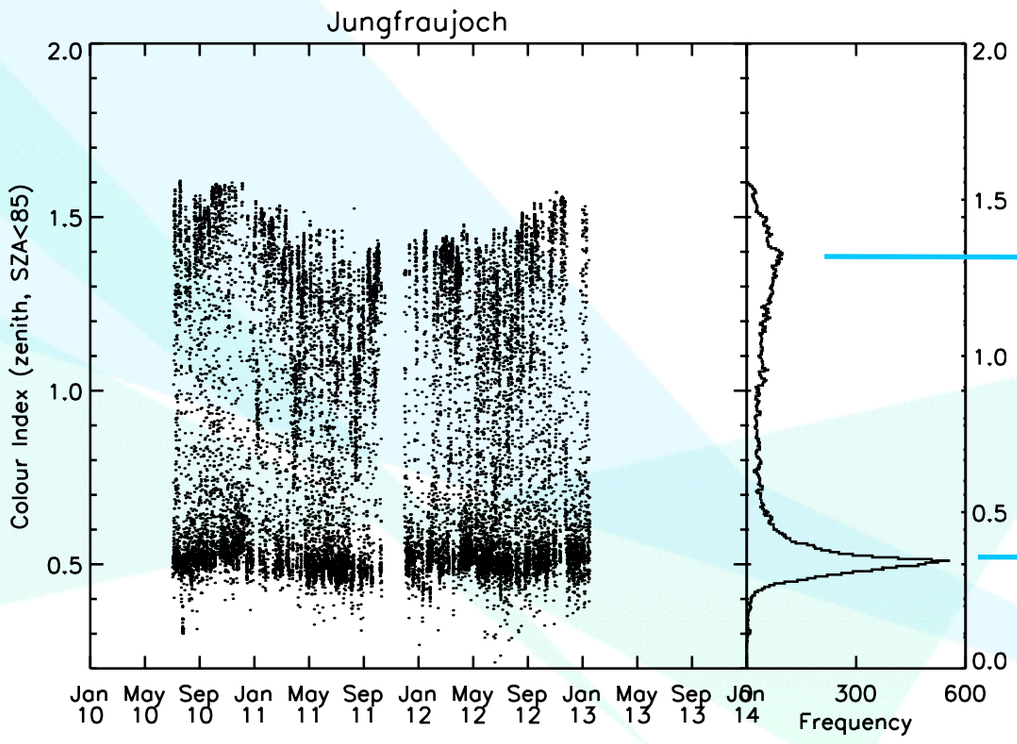


CI strongly variable for broken clouds

Colour-index trends







Our data sets clearly dominated by unclear skies

clear skies

cloudy skies

Cloud-screening flags

Using the colour index we define two flags:

- a flag to describe the general sky condition (clear/polluted/full-cloud cover)

→ ***Colour-Index flag***

- a flag to note the presence of scattered clouds

→ ***Broken-Cloud flag***

Colour-Index-flag determination

Link observed colour-index regions with sky conditions:

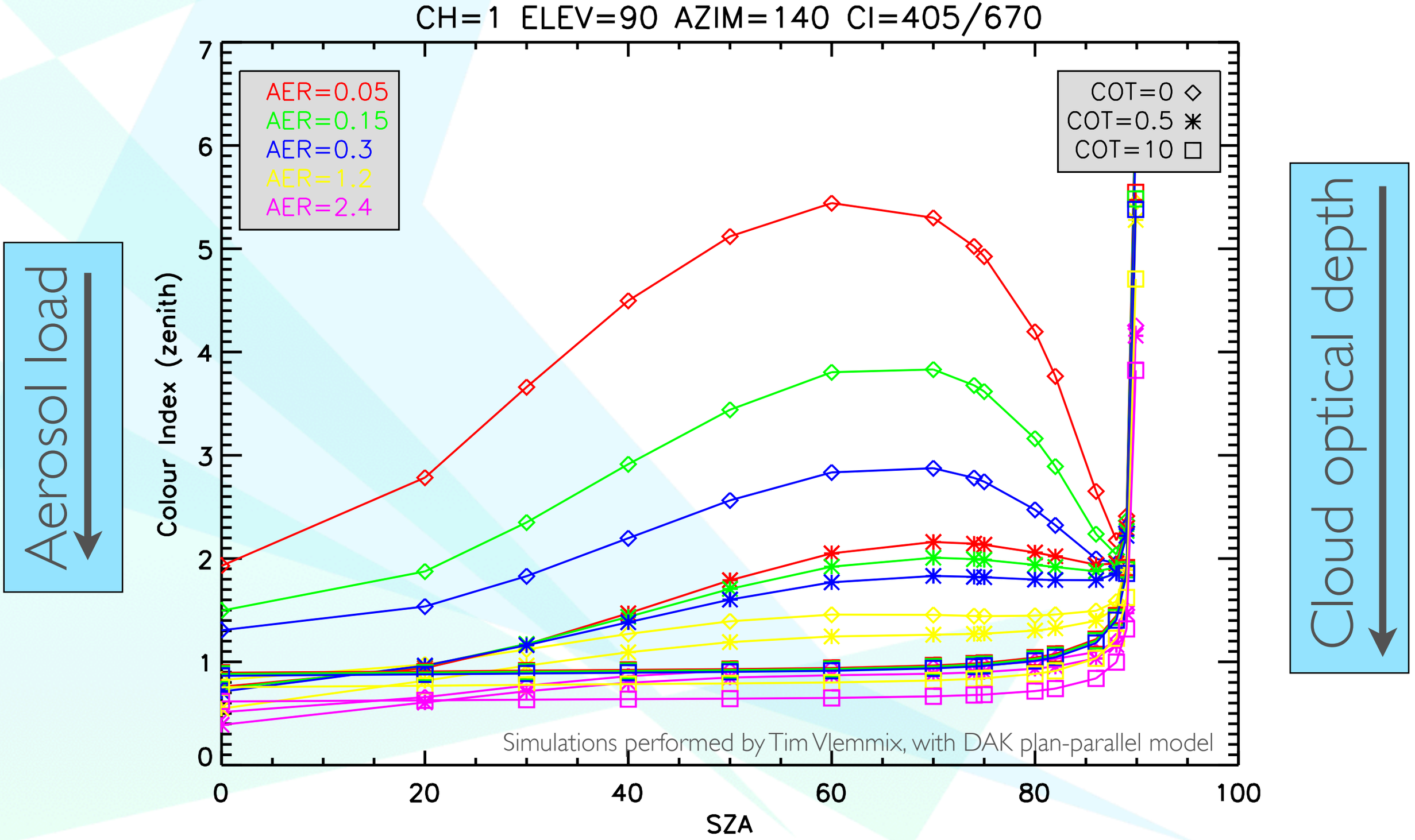
→ depends on: instrument, site, wavelengths

→ additional tools: - AERONET data
- simulations
- well-defined reference days
- user experience

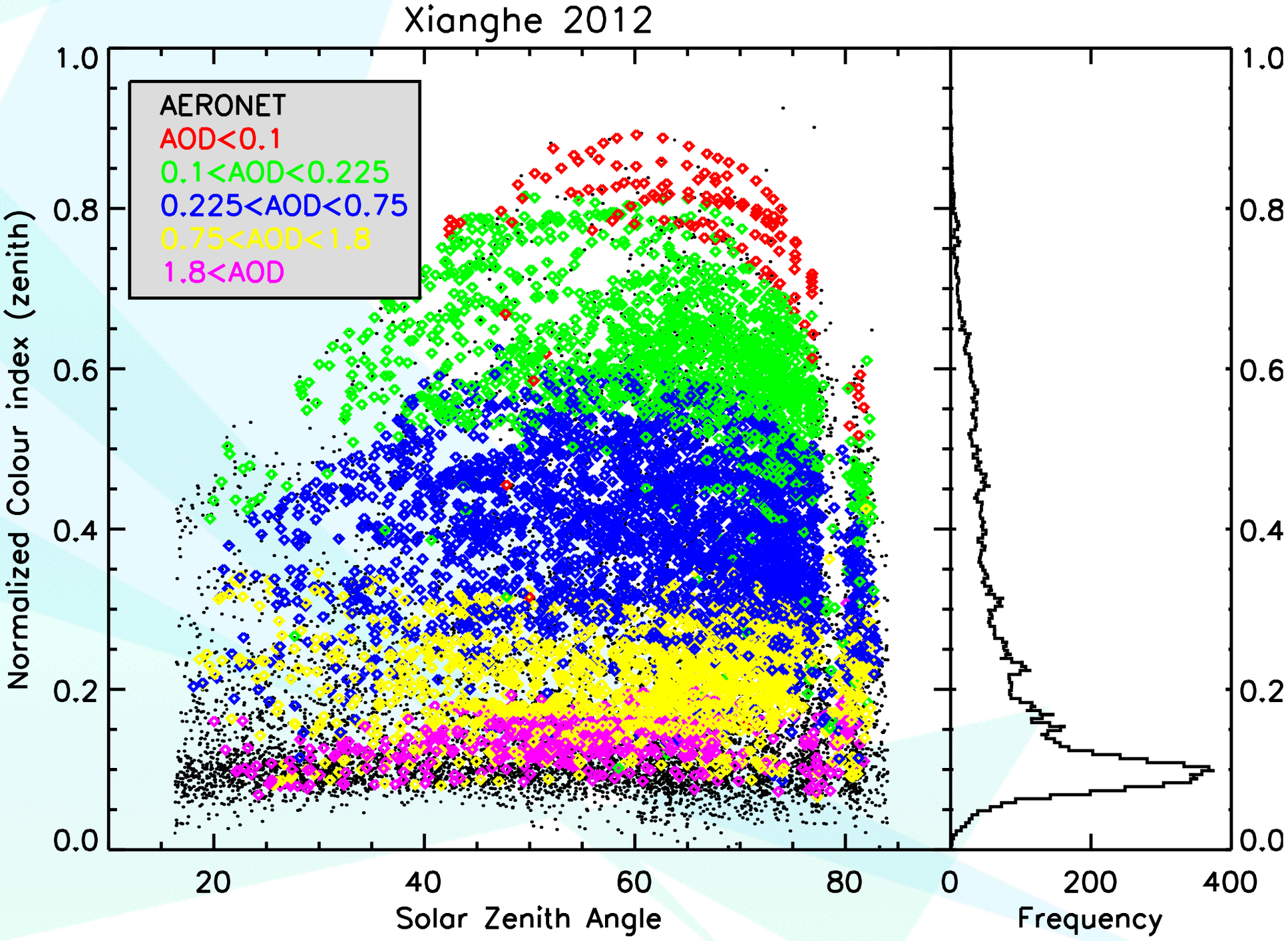
→ output: CI-flag with values

GOOD: little/no aerosols (AOD<0.2), no clouds
MEDIOCRE: little/strong aerosols (AOD<1.5), thin clouds
BAD: extreme aerosols (AOD>1.5), thick clouds

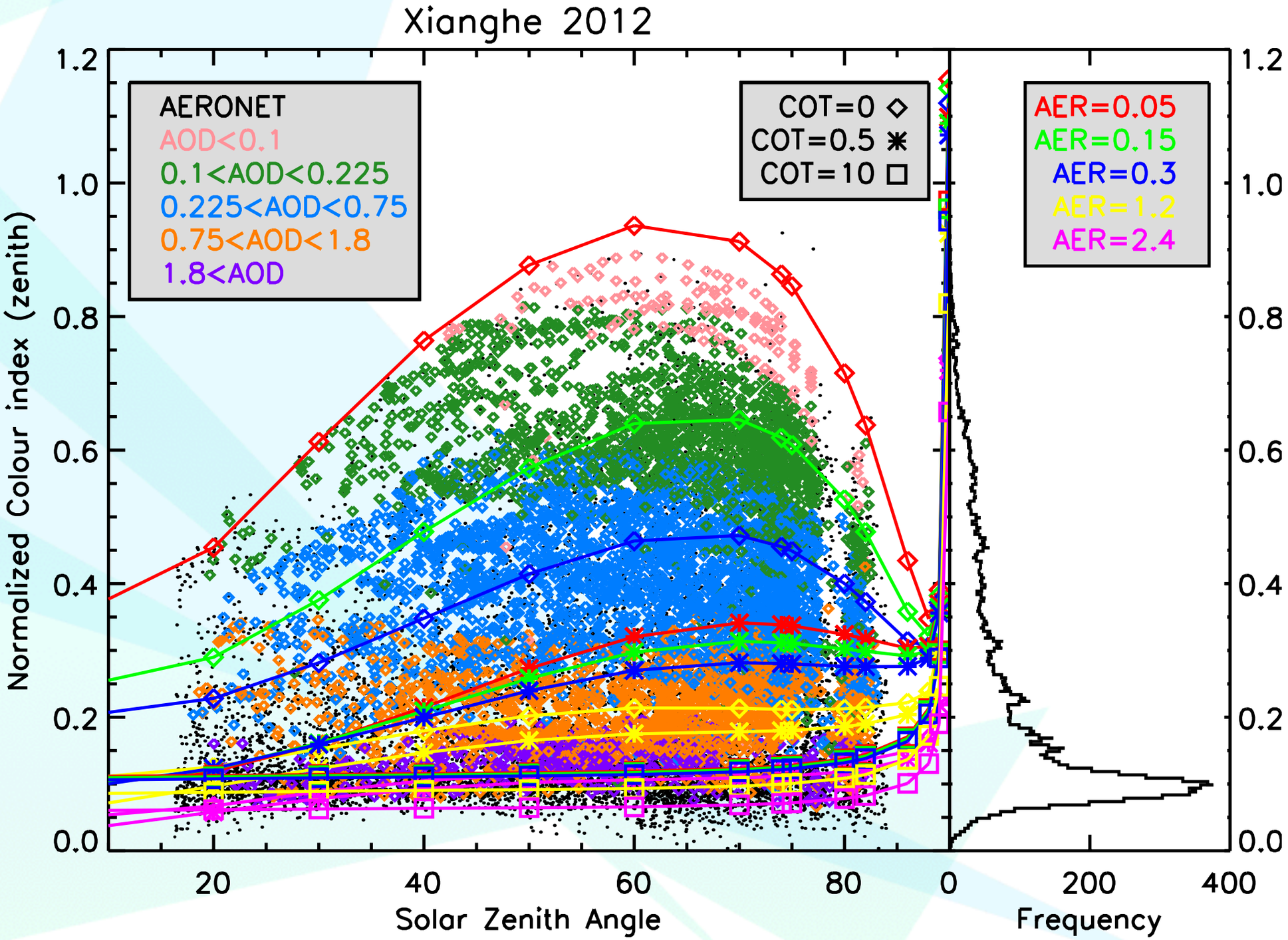
Colour-Index simulations



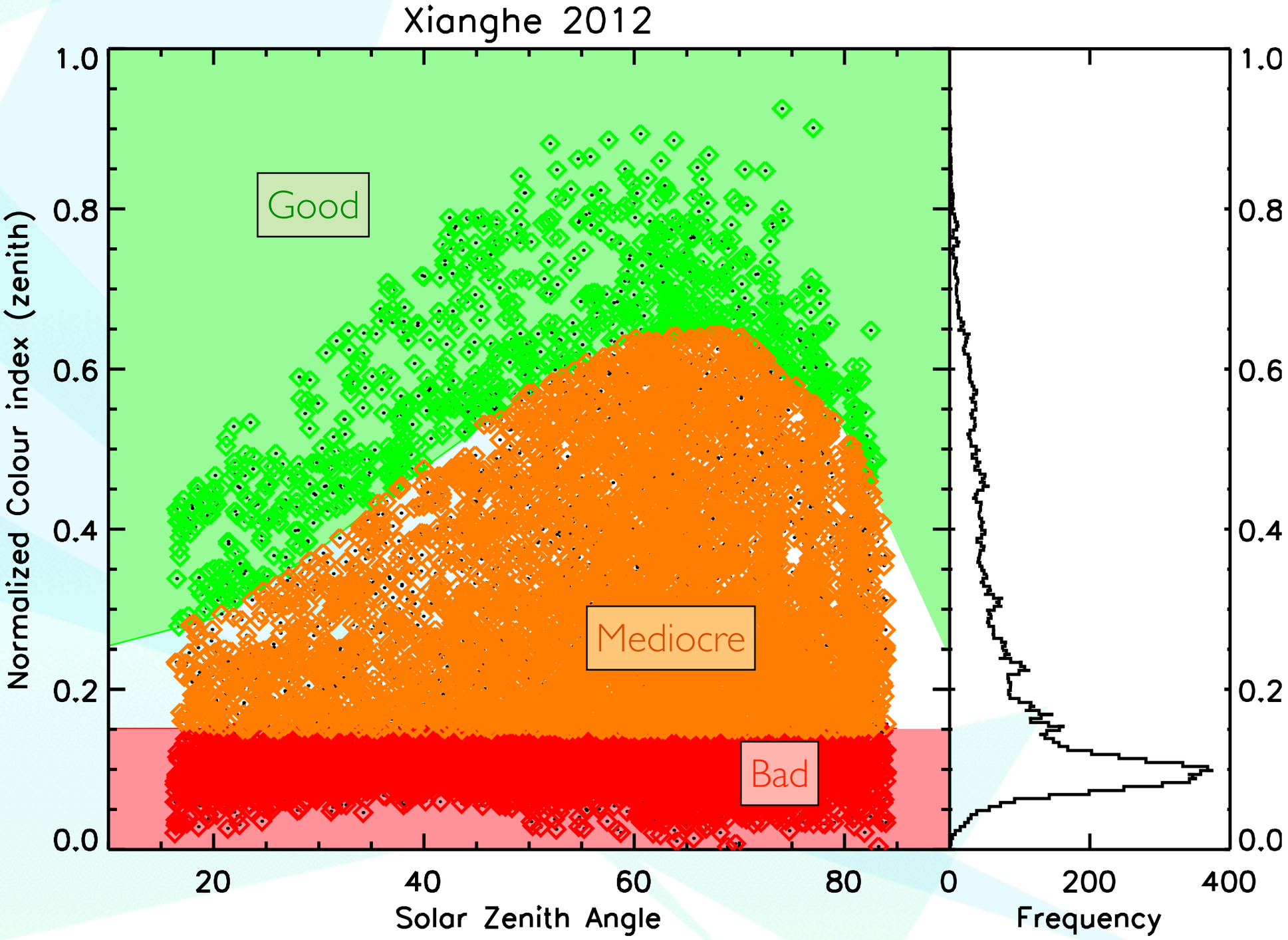
Colour-Index flag and AERONET AOD



CI-Flag determination



Colour-Index Flag

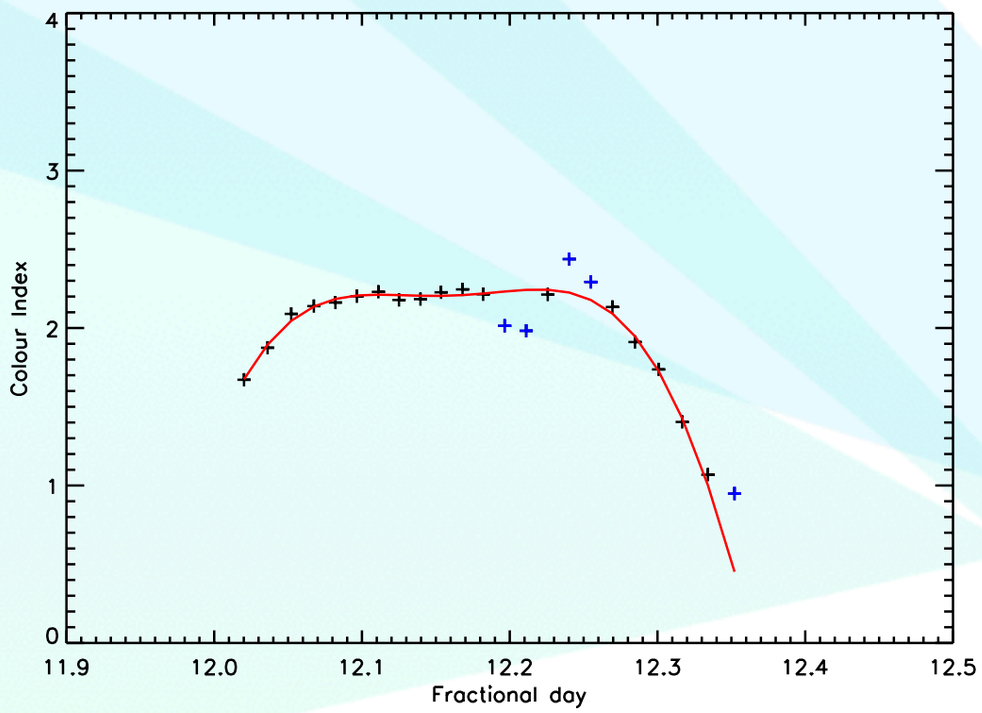


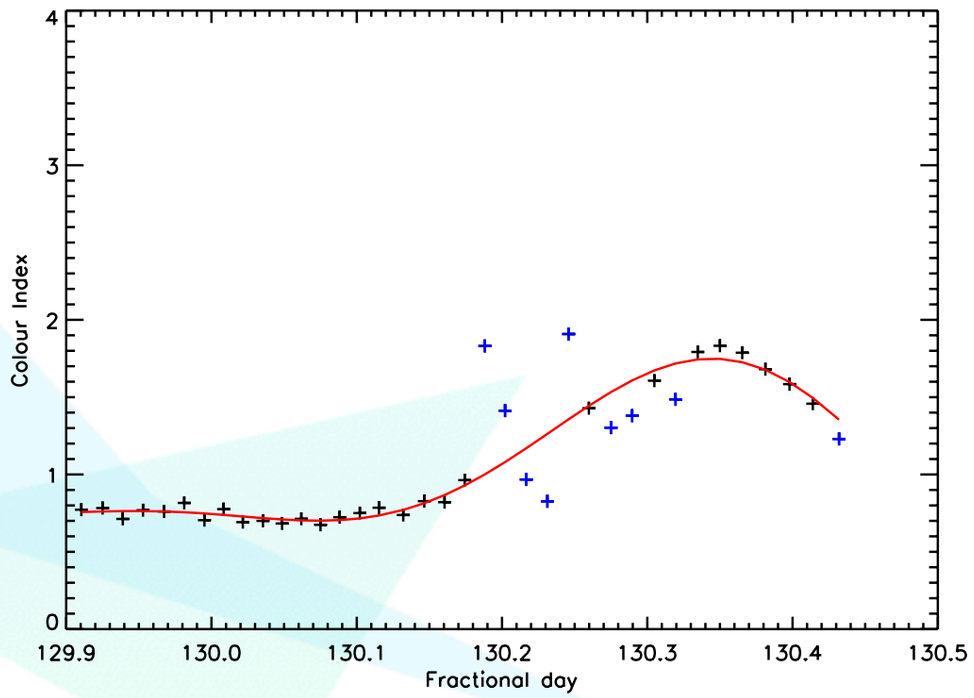
Broken-cloud flag

Temporal variation to determine presence of scattered clouds

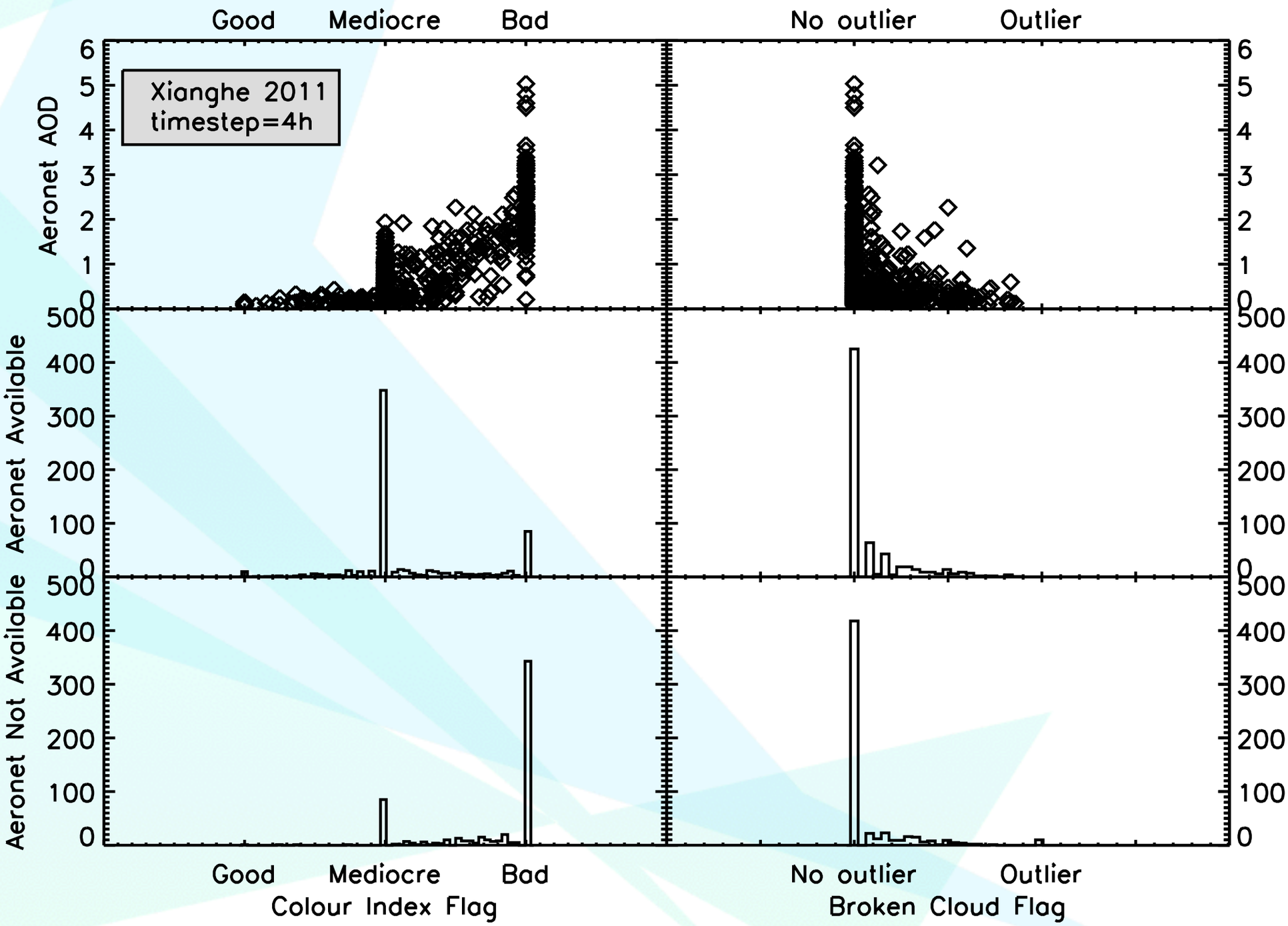
→ model observations with double-sine function
and detect outliers (10% from fit)
→ assign each scan with flag: ***No Outlier*** or ***Outlier***

→ no information on presence of full-cloud cover!

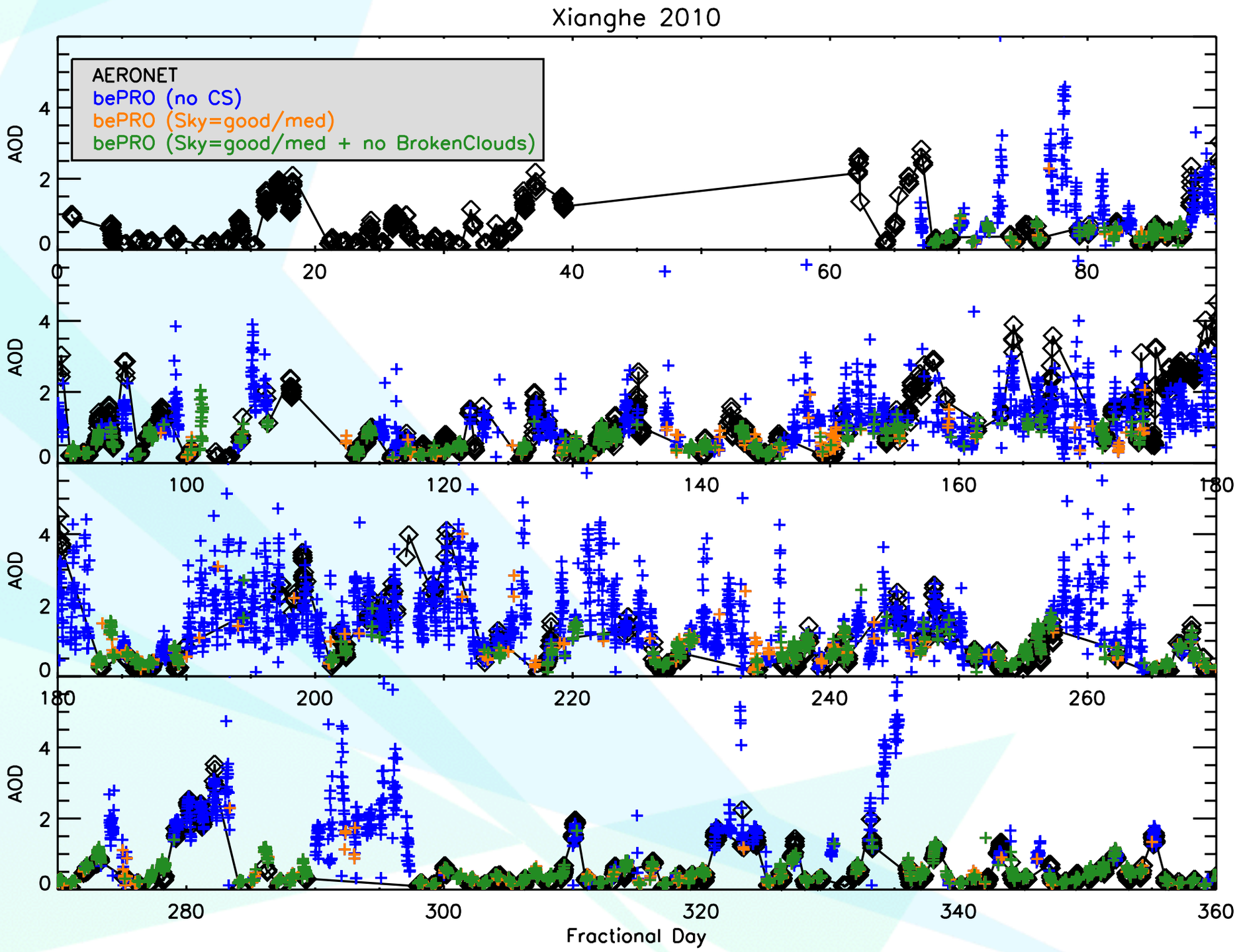




Cloud-screening flags versus AERONET



Influence on aerosol retrievals



simulations made with bePRO radiative transfer model (Clémer et al. AMT,3,863, 2010)

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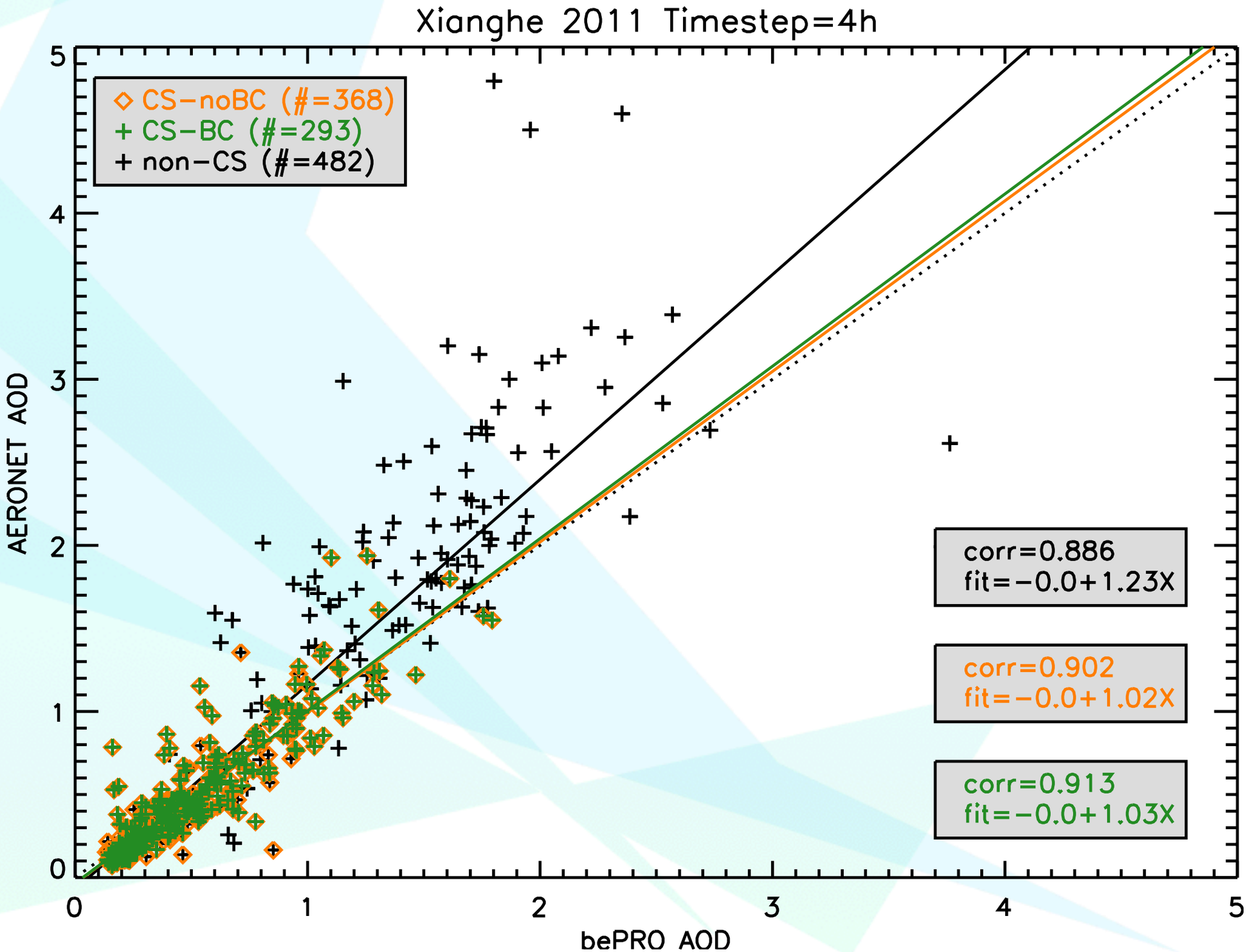

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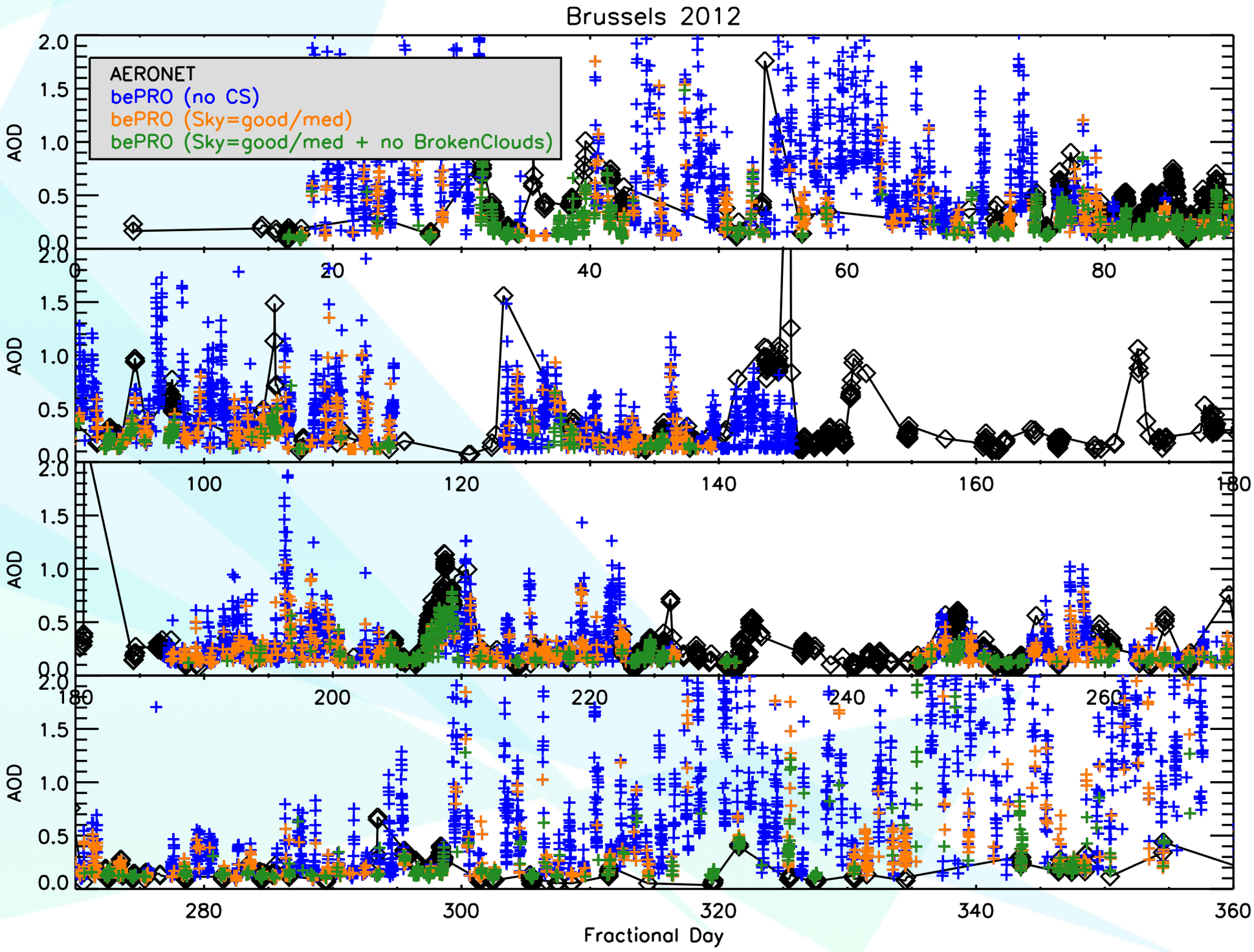

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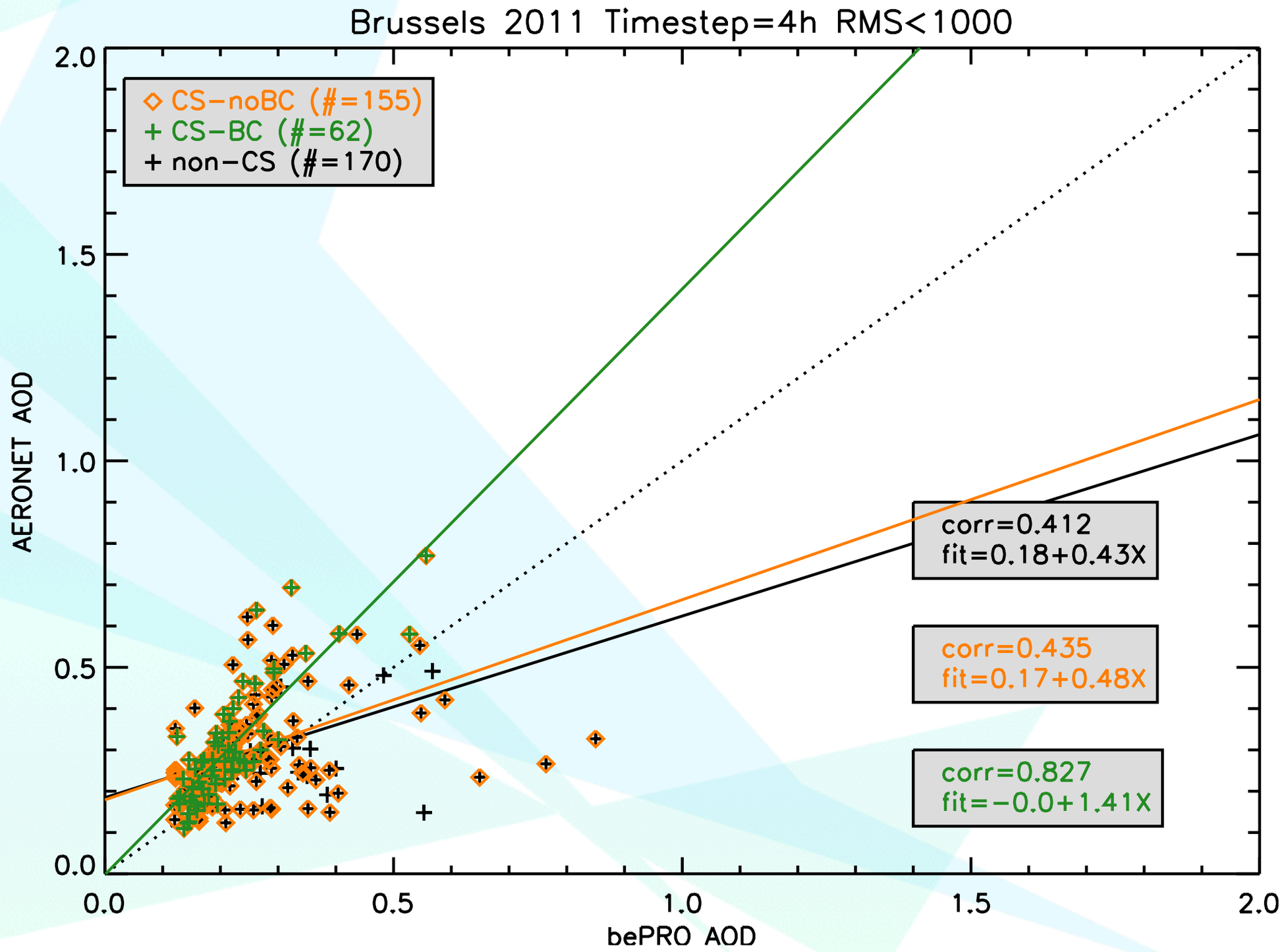
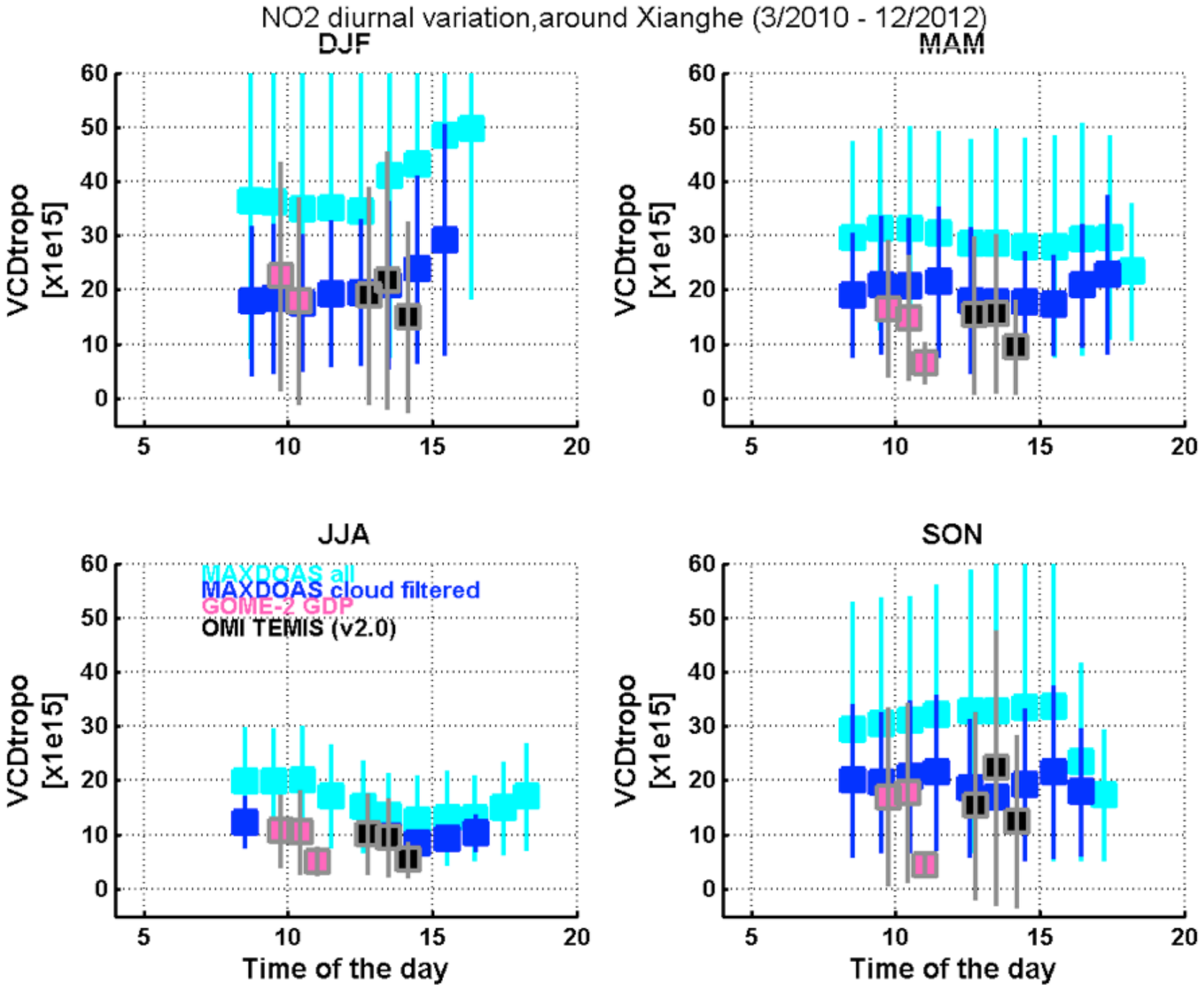


Influence on NO_2 retrievals



No CS
CS
GOME
OMI

Summary

The method:

- cloud-screening procedure produces 2 flags: sky condition (good/med/bad)
  broken clouds (yes/no)
- uses only zenith data and colour index

Positives:

- quick and easy once CI limits are defined
- short timesteps: information for each scan
- filtering shows good correlation with aeronet data
- improves retrievals

Negatives:

- not standalone, relies on user experience and additional information for setup
- difficult to determine limits for small data sets
- no distinction between aerosol/clouds
- improvement by using all elevations + O4 (see thomas' talk)

Conclusions

Our method shows promising results in characterizing the sky and cloud conditions of MAX-DOAS observations, without the need for other external cloud-detection systems.

Moreover, the method can be used to clean the dataset of observations made during adverse sky conditions.

Colour-index trends