Variability and trends in global cloud parameters from O_2 A-band measurements by GOME and SCIAMACHY

Piet Stammes, Nicolas Fournier, Ping Wang, Maarten Sneep, and Ronald van der A

KNMI, De Bilt (NL)

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Overview

- Clouds and Earth's albedo
- Contribution from GOME and SCIAMACHY: O_2 A-band
- FRESCO cloud algorithm
- Effective cloud fraction concept
- Results for cloud fraction and cloud pressure
- Comparison with OMI and ISCCP data
- Conclusions

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Clouds and Earth's albedo

The Earth's albedo is largely determined by clouds.

Some typical global averages:

- geometric cloud fraction $c_g \sim 0.7$ (from MODIS)
- cloud albedo $A_c \sim 0.4$ (for $\tau = 5$)
- clear sky (surface) albedo $A_s \sim 0.1$

Earth's albedo $A = c_g \times A_c + (1-c_g) \times A_s \sim 0.28 + 0.03 = 0.31$

Global average solar irradiance at TOA is 342 W/m^2.

A change of 0.01 in global cloud fraction leads to a change of 1 W/m^2 in radiative forcing (2 x CO_2 = 4 W/m^2)

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Earth's albedo trend 2000-2004

From CERES satellite and Earthshine (new Moon) measurements

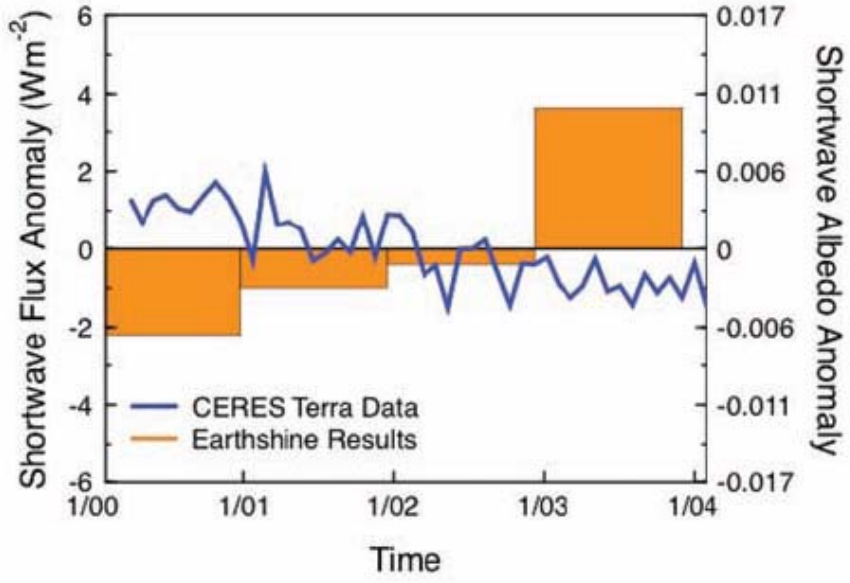

Fig. 1. Comparison of global satellite anomalies in reflected solar flux for 2000 through 2003. Earthshine results from (*4*) are shown in orange, and blue indicates the global satellite results from the CERES radiation budget instrument designed to measure global albedo from the NASA Terra spacecraft.

(Wielicki et al., 2005)

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Cloud detection with GOME and SCIAMACHY

- Clouds affect trace gas retrievals by shielding, by their albedo, and by in-cloud absorption
  (see NO_2 poster of Ping Wang).
- Therefore, there exist several cloud detection methods to correct for the presence of clouds.
- We use the **FRESCO method** applicable to GOME and SCIAMACHY.
- The cloud results from FRESCO are also interesting in themselves for global climate studies.

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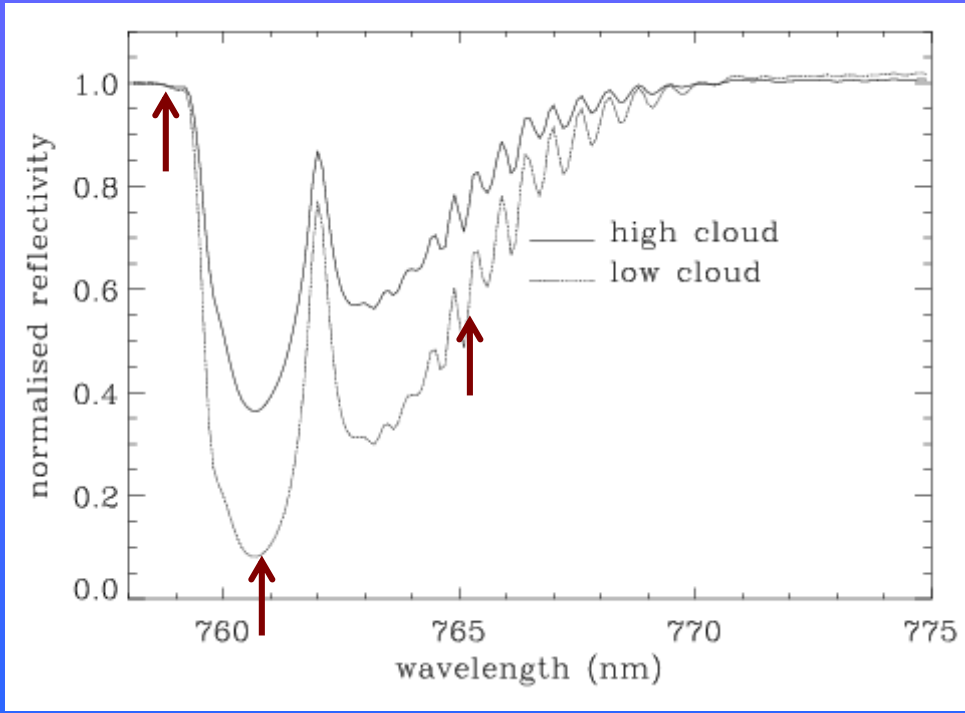
Principle of FRESCO algorithm



O_2 *A* band

FRESCO fits a modelled spectrum to the measured spectrum in three 1-nm windows of the O_2 *A*-band, and produces an effective cloud fraction *c* and cloud pressure *P*.

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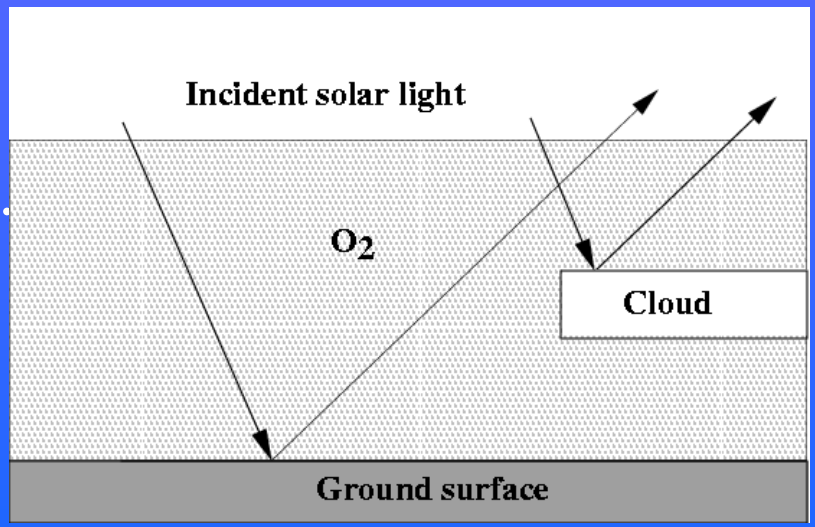
FRESCO atmospheric model

- Partly cloudy pixels are assumed to be covered by a bright Lambertian cloud (A_c=0.8) with an effective cloud fraction *c*.
- A fraction *1-c* is covered by the surface with albedo A_s, taken from the GOME albedo database (Koelemeijer et al., 2003).
- The only process in the atmosphere is absorption by O_2.



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Effective cloud fraction

- Geometric (real) cloud fraction and cloud albedo cannot be distinguished for the large pixels of GOME, SCIAMACHY and OMI.
- Effective cloud fraction =

  geometric cloud fraction x cloud albedo / 0.8.
- This approach allows consistency in both the cloud retrieval and the cloud correction part of trace gas retrieval algorithms.
- The assumption A_c=0.8 produces the smallest errors for O_3 and NO_2.

  (see NO_2 poster of Ping Wang).

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Use of effective cloud fraction for Earth's albedo studies

- The effective cloud fraction is independent of detailed cloud model assumptions, and is only a *radiative-equivalent* cloud parameter.
- Therefore, it is useful for trend studies of the contribution of clouds to the Earth's albedo.
- Essential: good radiometric calibration of satellite sensor.

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Results: mean global cloud parameters

Effective cloud fraction:

- GOME FRESCO v. 3/v.4: 0.32/0.30
- OMI O_2-O_2: 0.34
- ISCCP: ≈ 0.30

Cloud pressure:

- GOME FRESCO v. 3 (Hitran 1996): ≈ 650 hPa
- GOME FRESCO v. 4 (Hitran 2004): ≈ 700 hPa
- OMI O_2-O_2: ≈ 750 hPa
- ISCCP: ≈ 600 hPa
- Radiosondes: 665 hPa

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Variability in global cloud parameters

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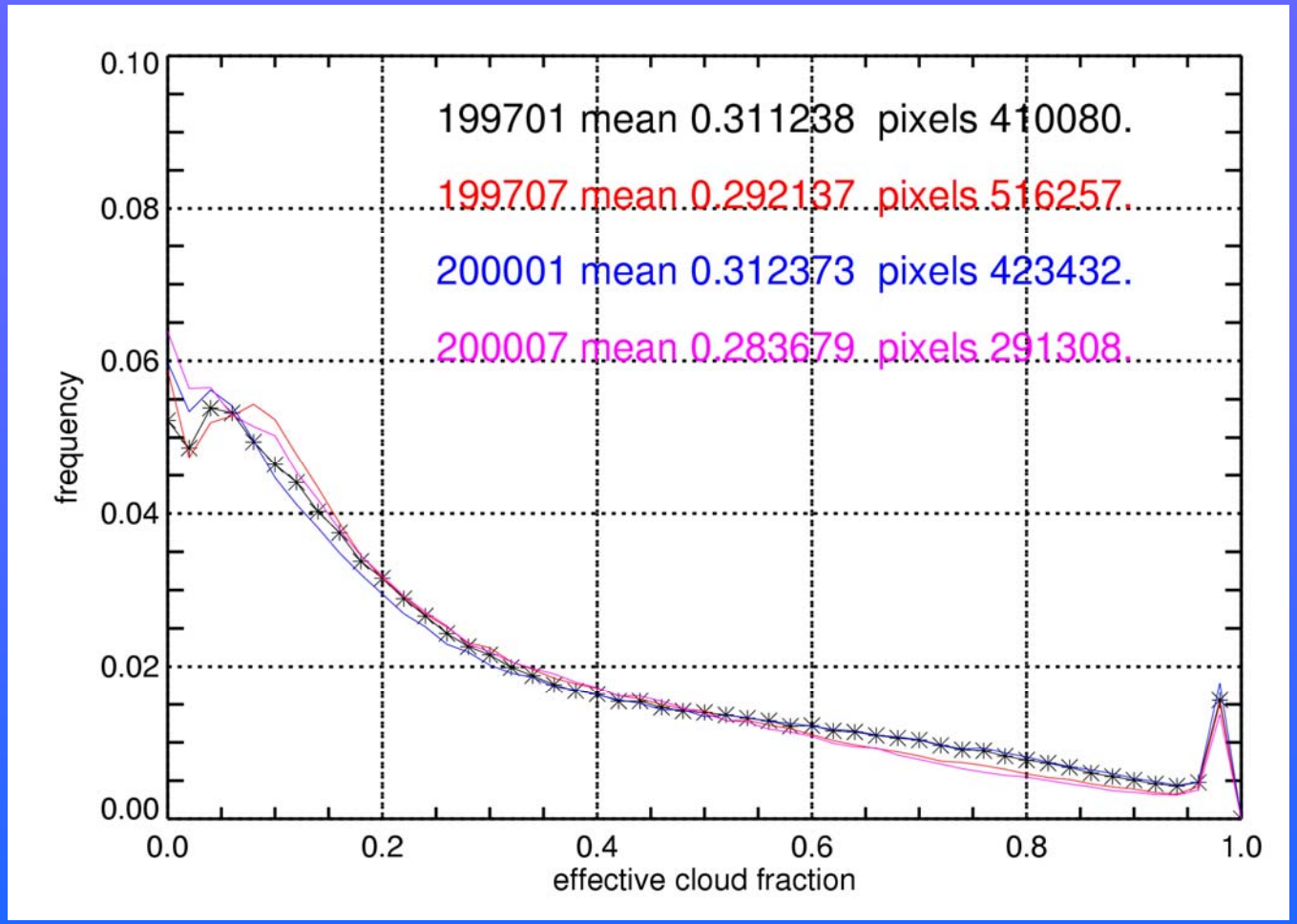
GOME effective cloud fraction distributions



FRESCO v. 4

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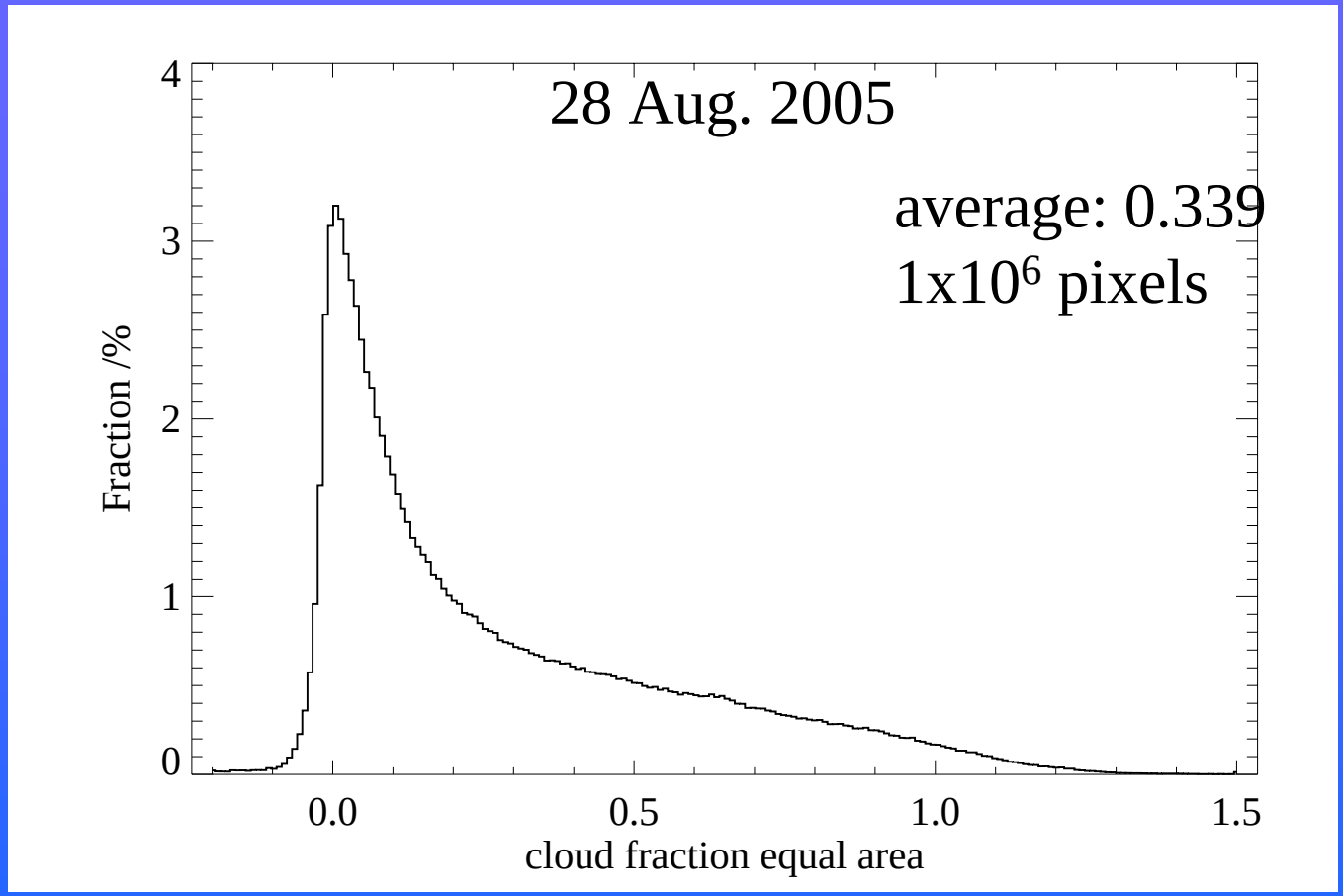
OMI O_2-O_2 eff. cloud fraction distribution



(See poster of Maarten Sneep)

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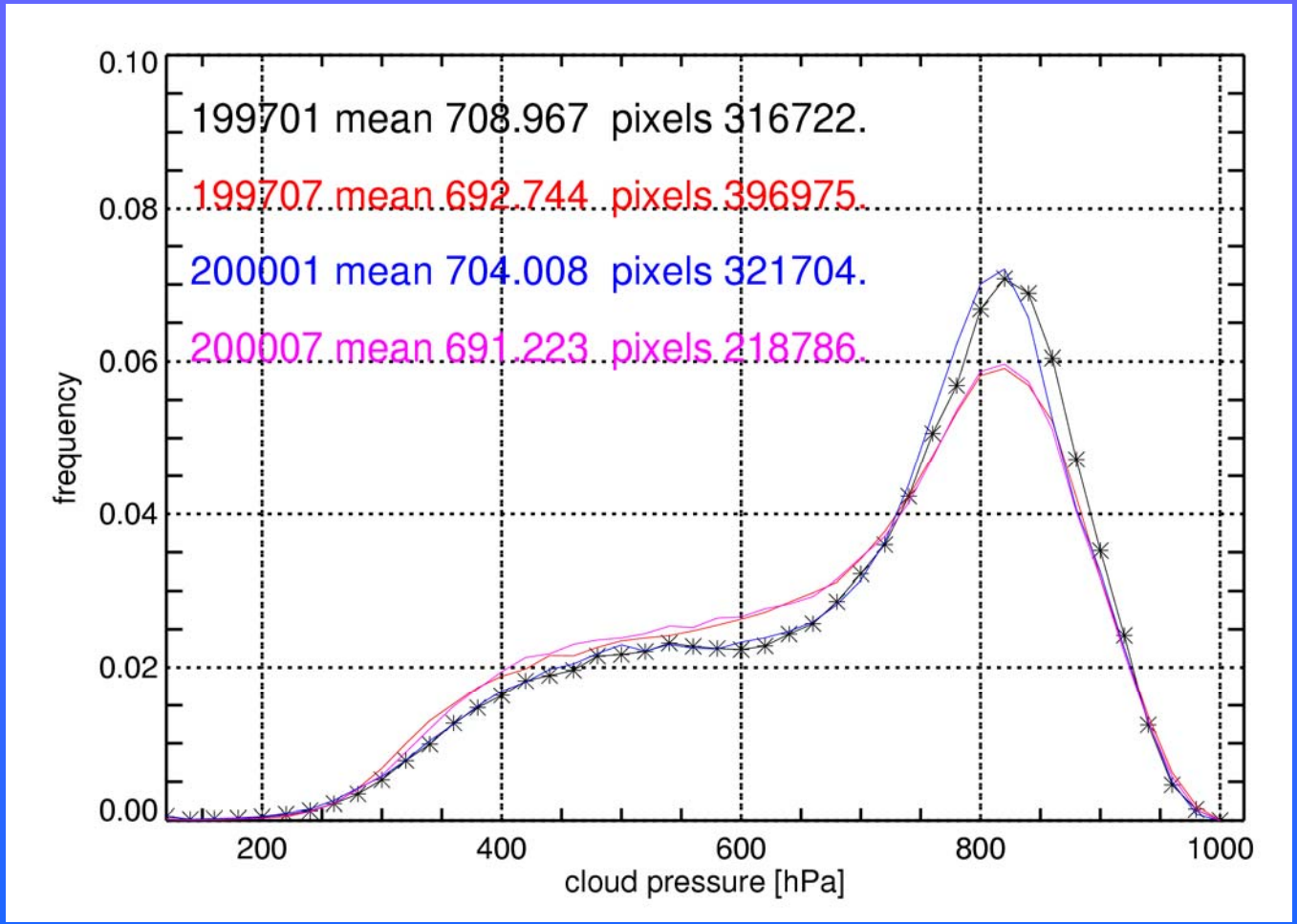
GOME cloud pressure distributions



FRESCO v. 4

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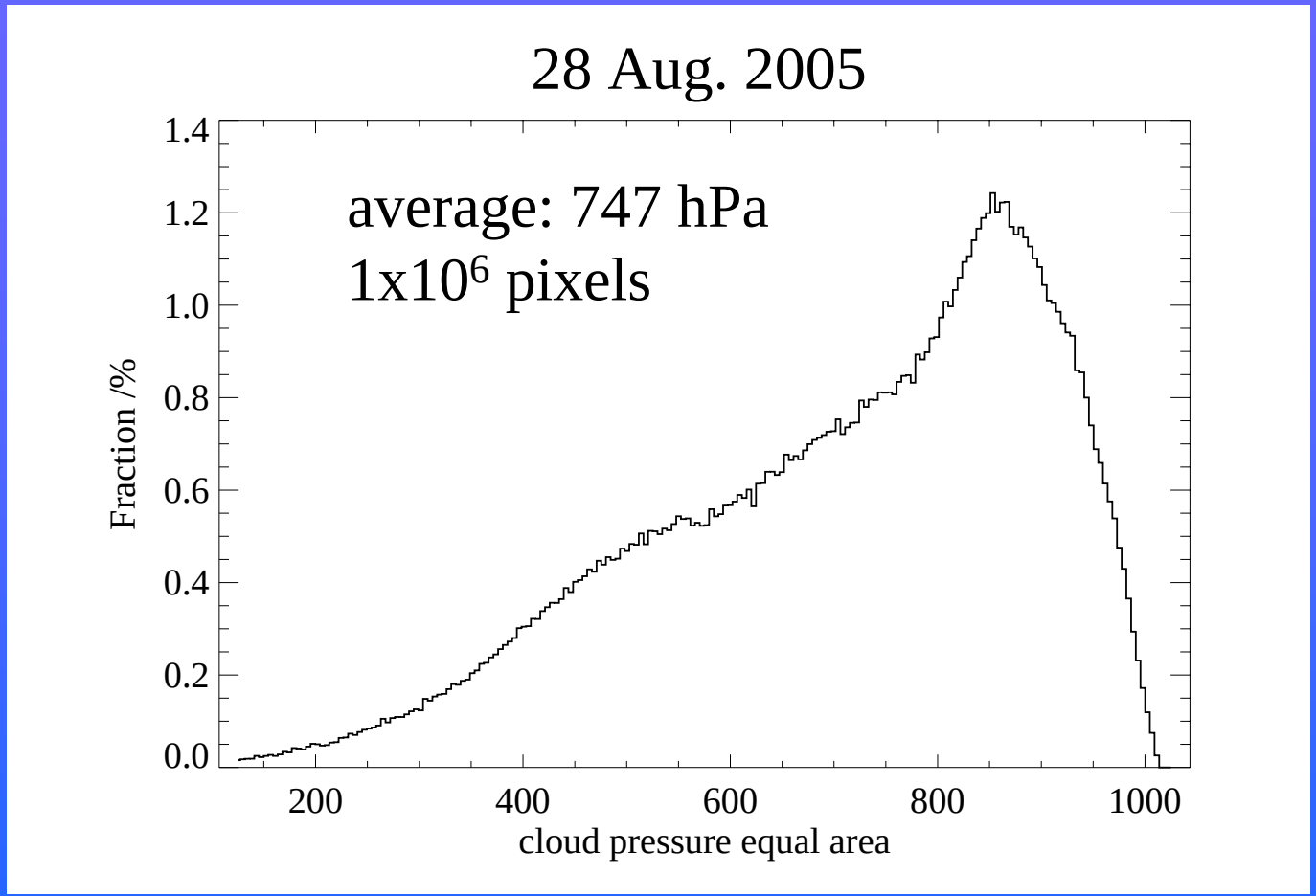
OMI O_2-O_2 cloud pressure distribution



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Trends in global cloud parameters

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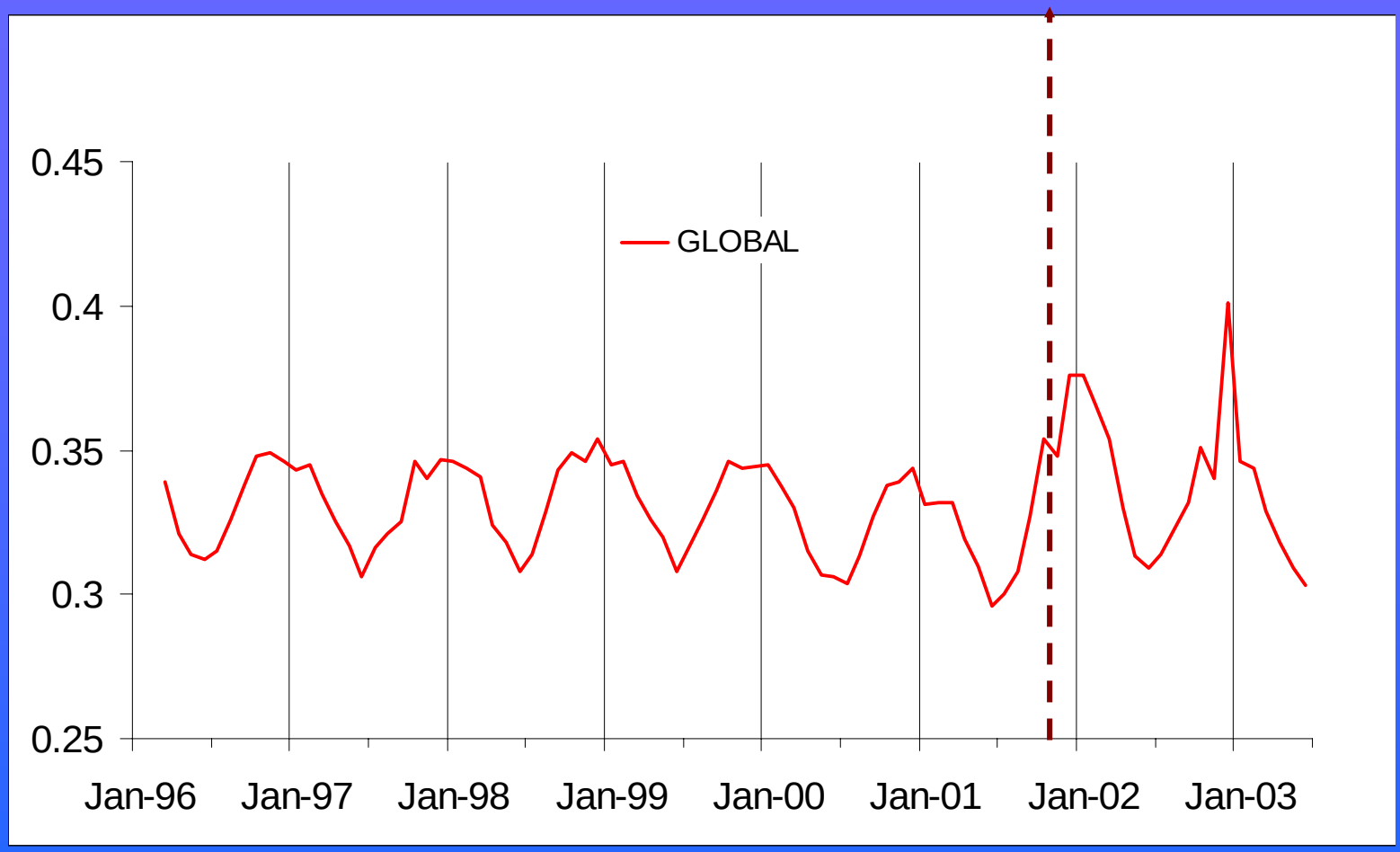
Global effective cloud fraction from GOME



FRESCO v. 3

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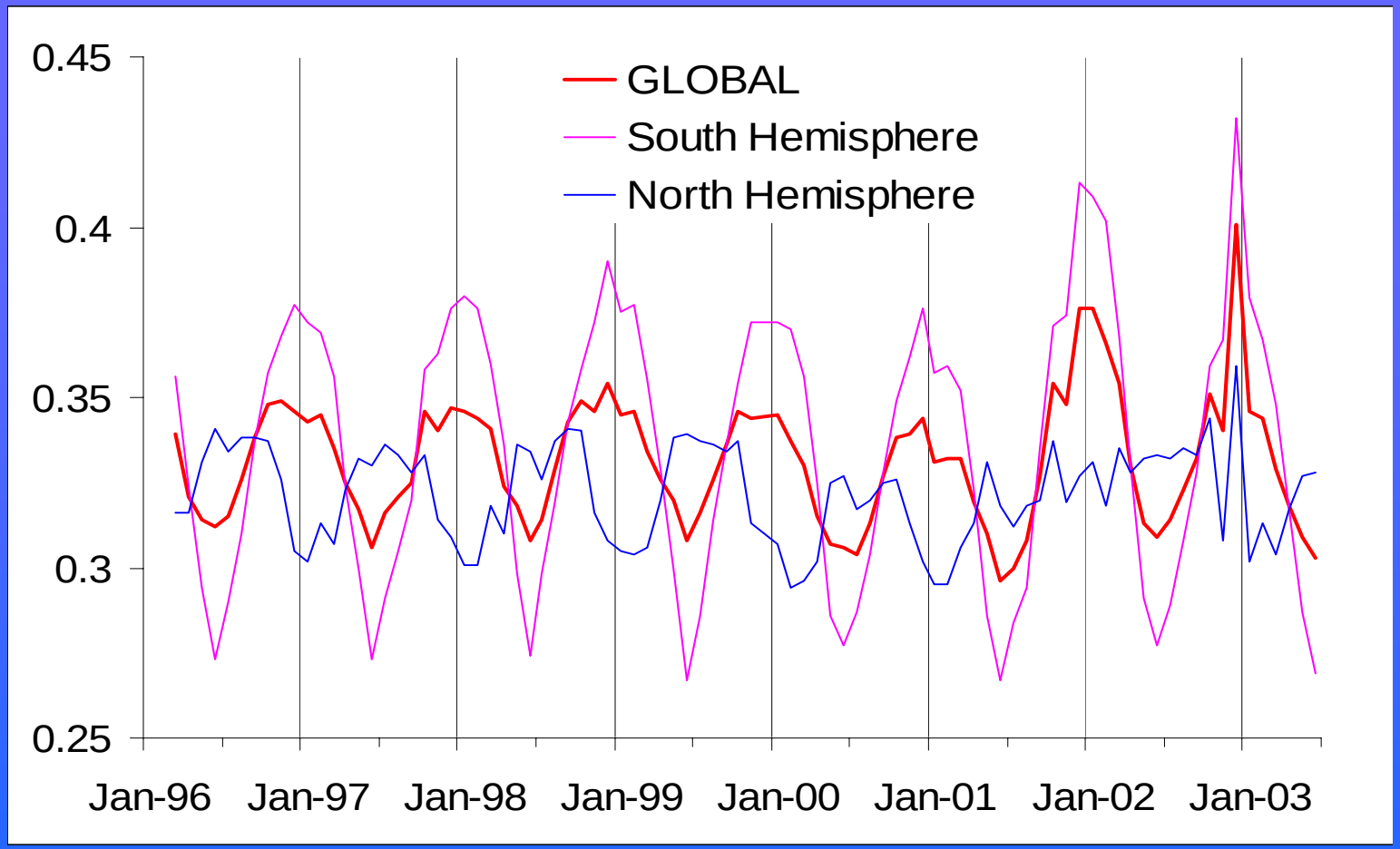
SH / NH differences in effective cloud fraction



FRESCO v. 3

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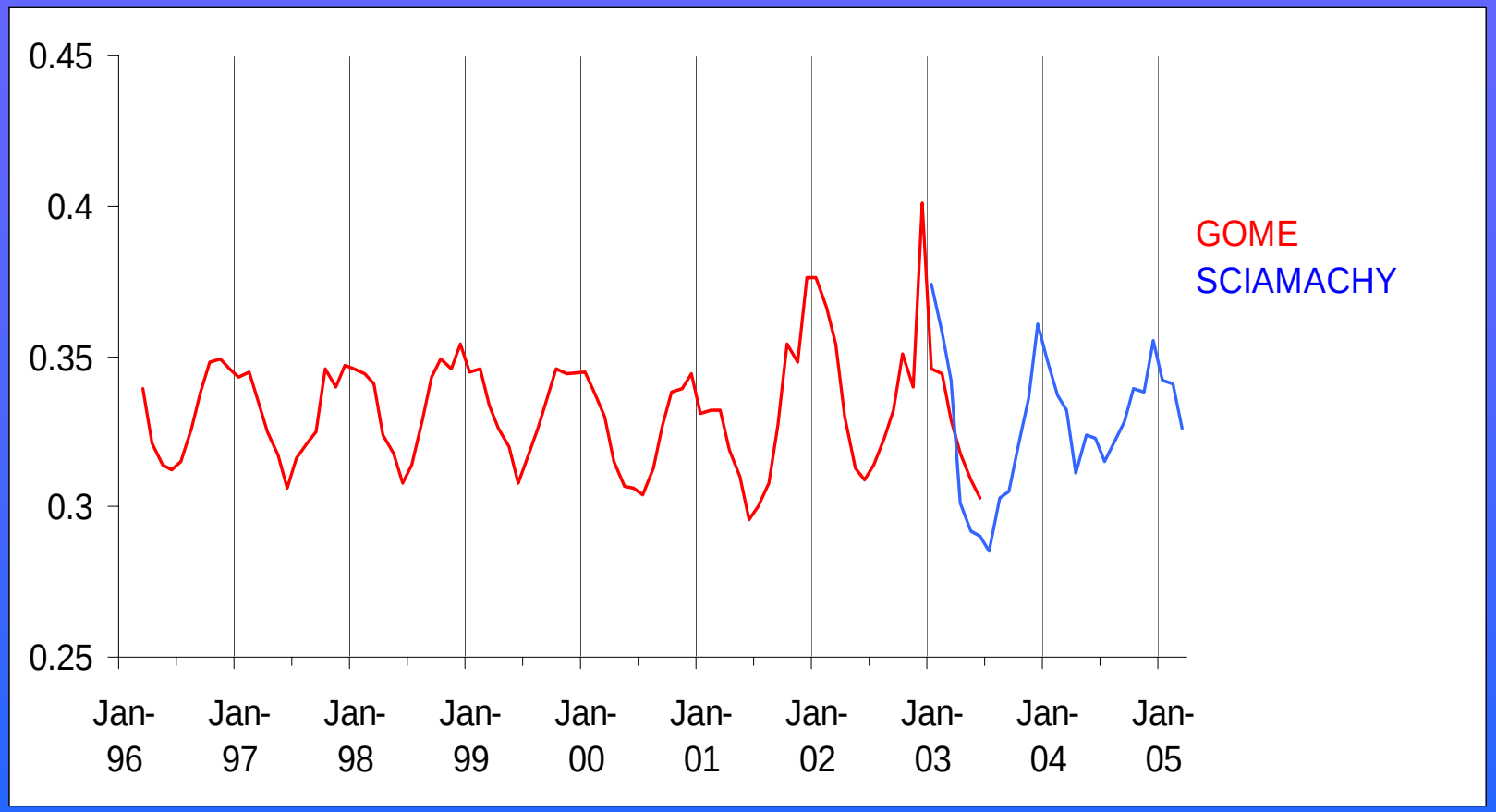
Comparison of effective cloud fractions from GOME and SCIAMACHY



FRESCO v. 3

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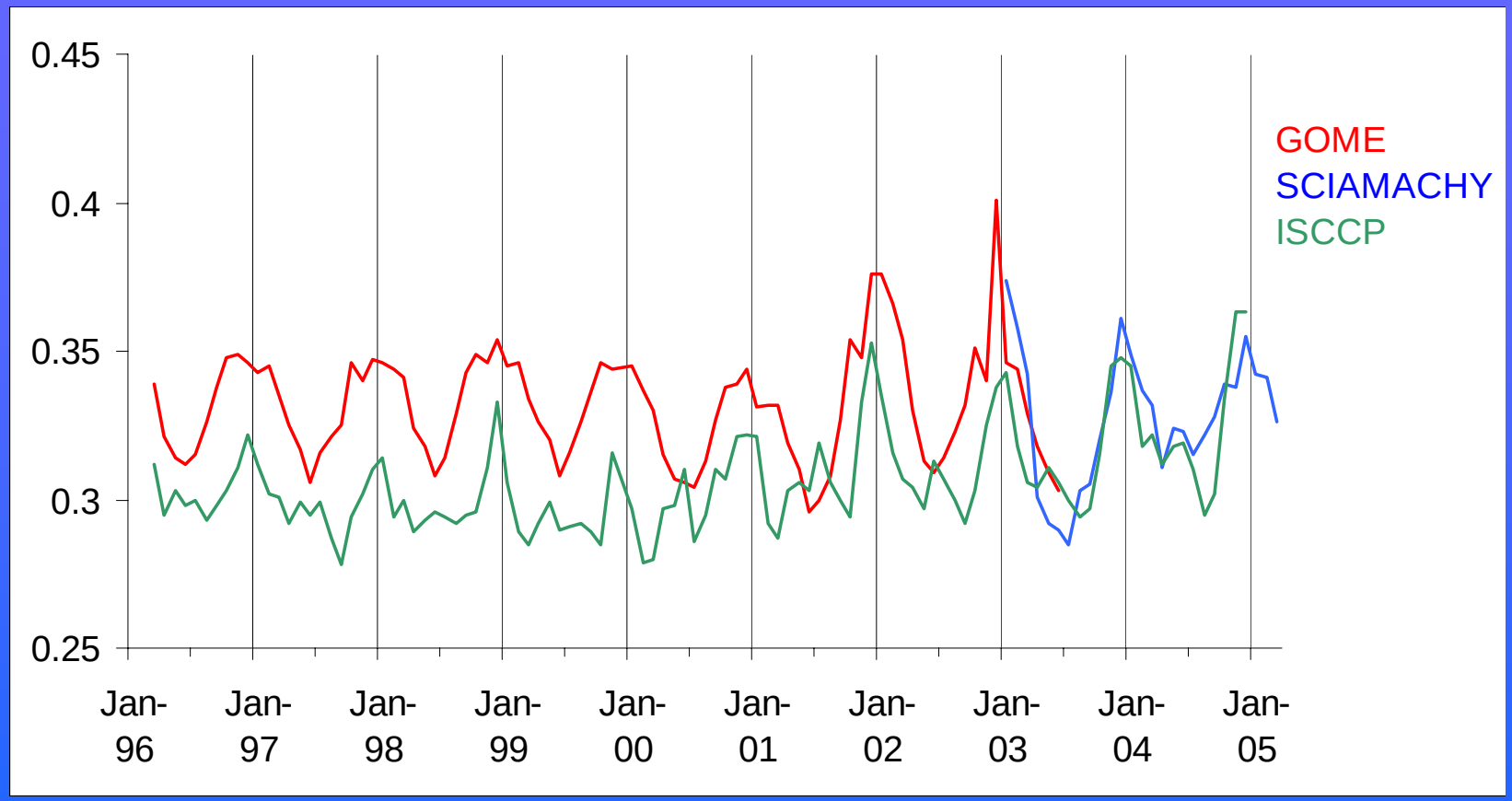
Comparison of effective cloud fractions with ISCCP



FRESCO v. 3

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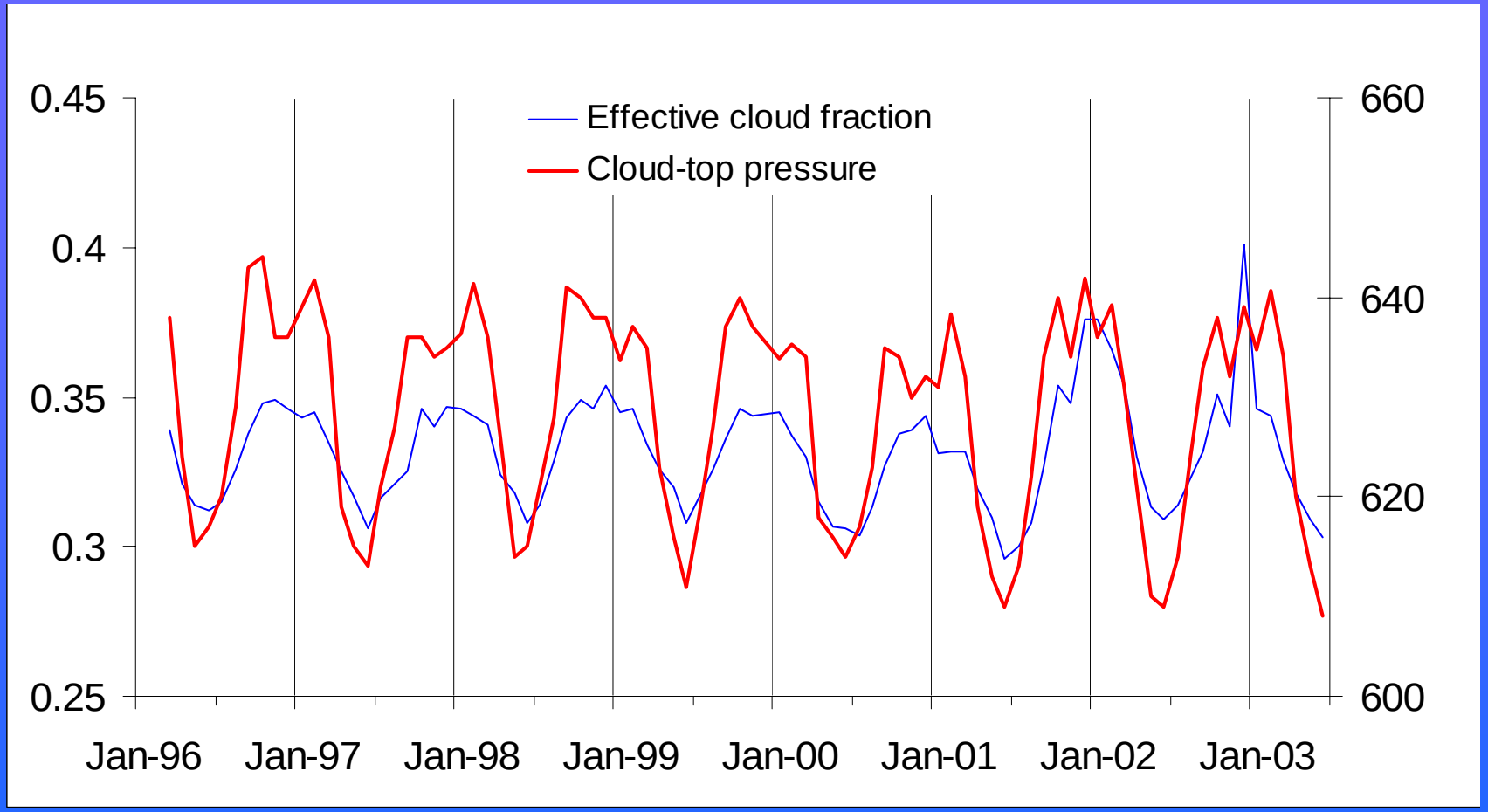
Global cloud pressure from GOME



FRESCO v. 3

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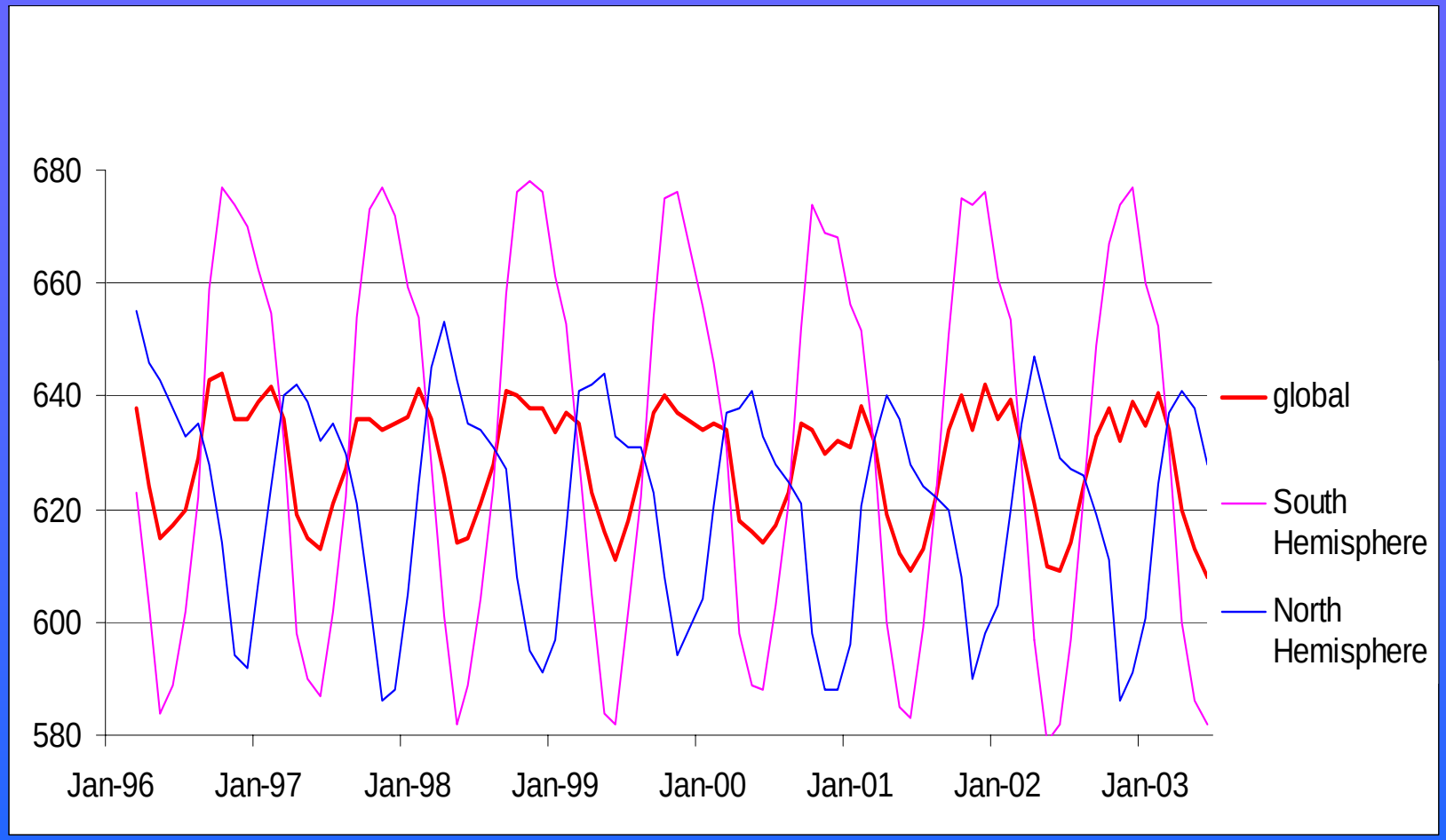
SH / NH differences in cloud pressure



FRESCO v. 3

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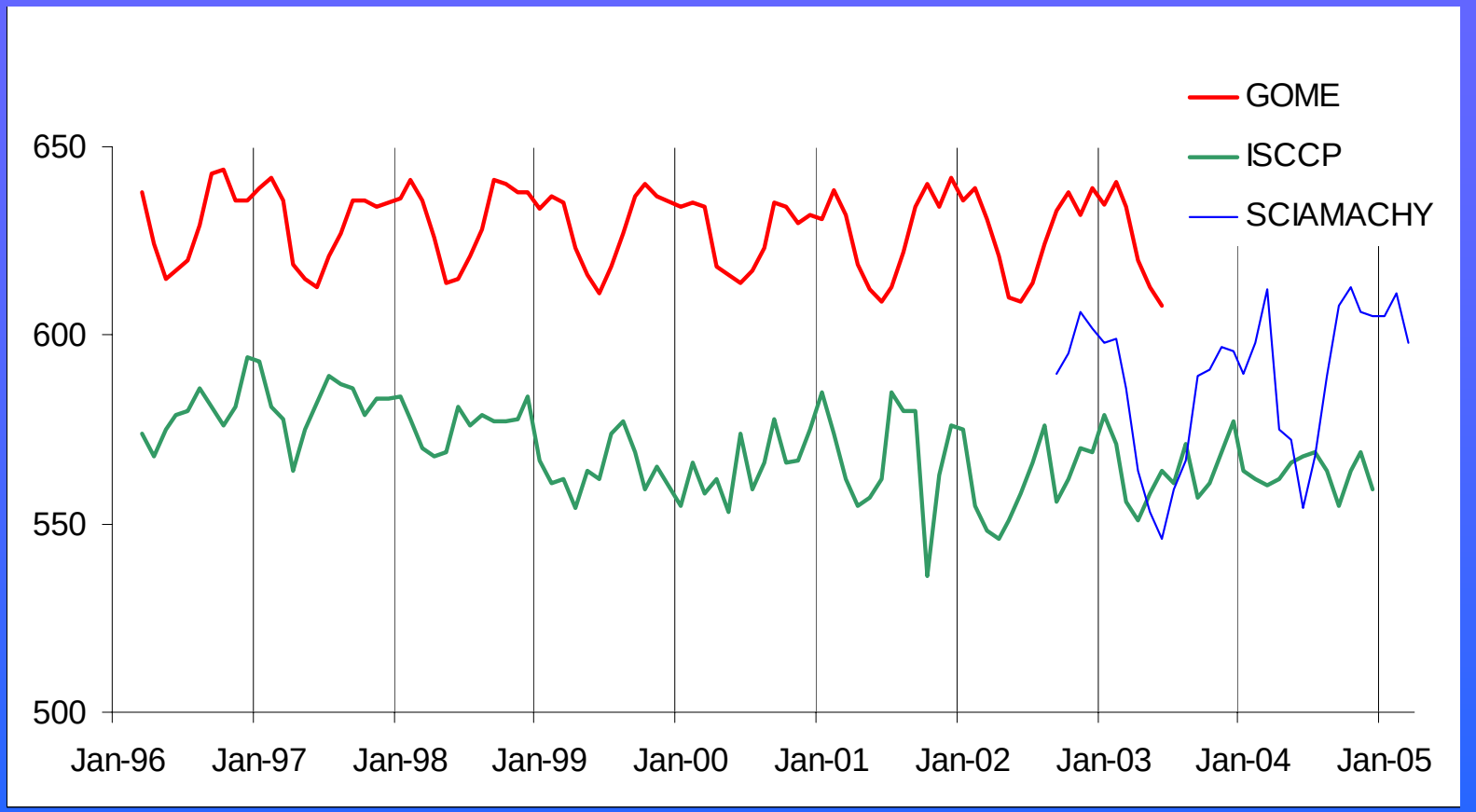
Comparison of cloud pressures with ISCCP



FRESCO v. 3

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Conclusions

- For the first time the global variability and trends in cloud parameters from GOME and SCIAMACHY O_2 A-band data have been presented.
- The significant increase in effective cloud fraction since 2001 agrees with the similar increase in Earthshine observed by Pallé et al. (2004) - but GOME L1 data suffer from a solar calibration problem since October 2001.
- We find very similar cloud parameter distributions for different years, but a variation with the season.
- We find similar cloud parameter distributions for GOME (O_2 A-band at 760 nm) and OMI (O_2-O_2 band at 477 nm).
- We find a bimodal cloud pressure distribution, unlike ISCCP.
- The seasonal variation of effective cloud fraction and cloud pressure is much clearer in GOME data than in ISCCP data.

FRESCO data are available on the TEMIS website:
www.temis.nl/fresco

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