



**28th Clouds and the Earth's Radiant Energy System (CERES)
Science Team Meeting
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Aerosols Over Oceans from NOAA-KLM/AVHRR3 and EOS/MODIS: Building Consistency

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Contributions:

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NASA/GSFC: Lorraine Remer

**NASA/LaRC: Bruce Wielicki, Pat Minnis & Team,
Norman Loeb, Walt Miller,
Erika Geier, Kathleen Morris**



NOAA-KLM/AVHRR3

- 1) NOAA-16 (L) (SEP 2000, 02:00 PM)
- 2) NOAA-17 (M) (JUN 2002, 10:00 AM)

- AEROBS Operational (PATMOS Plans)
- $\tau_1(0.63)$, $\tau_2(0.83)$, $\tau_3(1.61 \mu\text{m})$ /Single-Channel

| | |
|---------------------------|---------------------------|
| NOAA16: 12-20 Feb 2003 | NOAA17: 12-20 Feb 2003 |
|---------------------------|---------------------------|

EOS/MODIS

- 3) TERRA (DEC 1999, 10:30 AM)
 - 4) AQUA (MAY 2002, 01:30 PM)
- CERES SSF (FM1/2 & FM3/4)
 - $\tau_1(0.63)$, $\tau_2(1.61 \mu\text{m})$ /AVHRR-like & MODIS-like

| | |
|--|----------------------------------|
| TERRA: 15-21 Dec 2000 TERRA: 1-7 Jun 2001 | AQUA: 1-7 Sep 2002 (FM4 only) |
|--|----------------------------------|



Cloud Screening



MODIS-like (Ref?):

Done by MODIS Team

AVHRR-like (Minnis et al): Consistent w/ TRMM/VIRS

Glint Screening

MODIS-like:

Beyond 40° glint

AVHRR-like:

Beyond 40° glint & Anti-solar side of Orbit

Aerosol Algorithm

MODIS-like (Tanre et al. 1997)

- Spectral: 6 bands from 0.55-2.13 μm
- Aerosol: Var Bi-LogNormal (Mode Location/Ratio)
- Surface: Fresnel ($V=7$ m/s) + Black (except 0.55 μm)
- RT Model: Ahmad-Fraser (JAS 1981)

AVHRR-like (Ignatov Stowe 2002; Ignatov et al. 2003)

- Spectral: Single-Channel: 0.659 & 1.640 μm
- Aerosol: Prescribed (Fixed) Mono-LogNormal
- Surface: Fresnel ($V=1$ m/s) + Small Diff.Ref.
- RT Model: Vermote et al. 6S (IEEE/TGARS 1997)

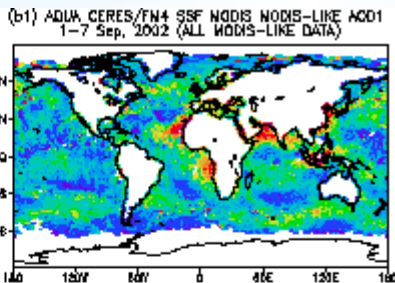
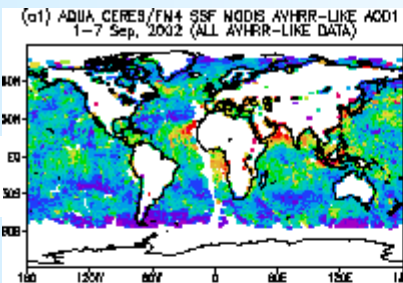


Aqua τ_T @ 0.659 μm : 1-7 Sep 2002

AVHRR-like

MODIS-like

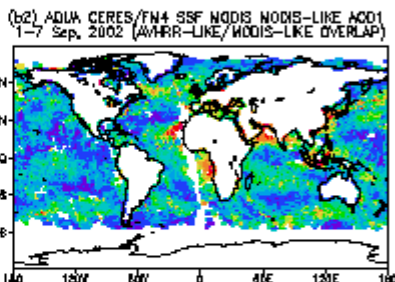
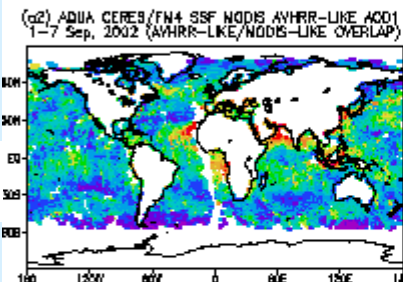
- Data good
- Patterns similar
- τ coherent with cloud, A_T



$A_T \sim 43\%$

$A_T \sim 53\%$

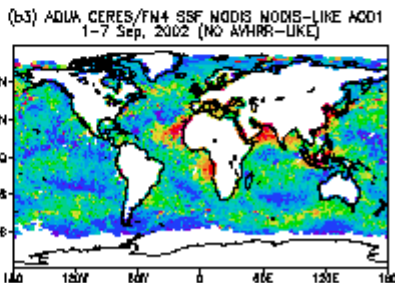
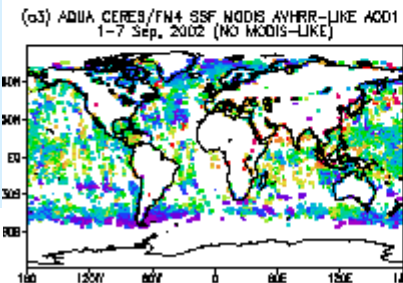
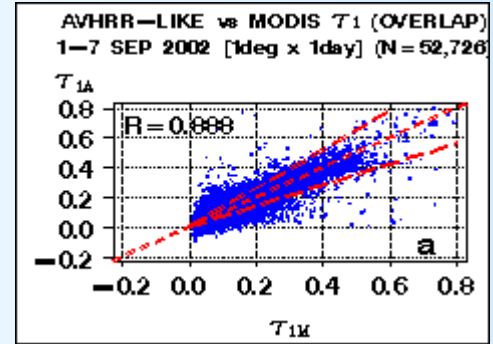
ALL DATA



$A_T \sim 42\%$

$A_T \sim 42\%$

OVERLAP



$A_T \sim 48\%$

$A_T \sim 59\%$

COMPLEMENT



- τ_M & τ_A : Correlated
- Scatter at low τ : Aerosol model unlikely

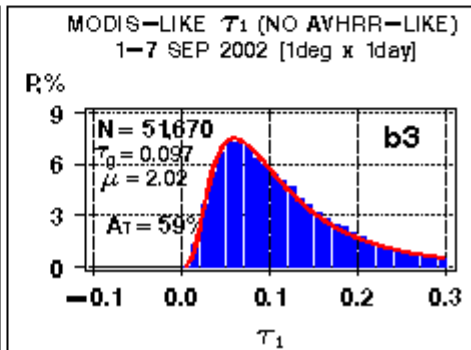
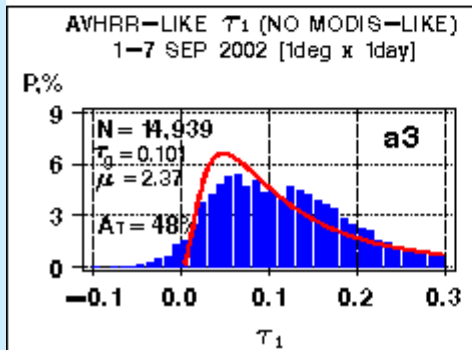
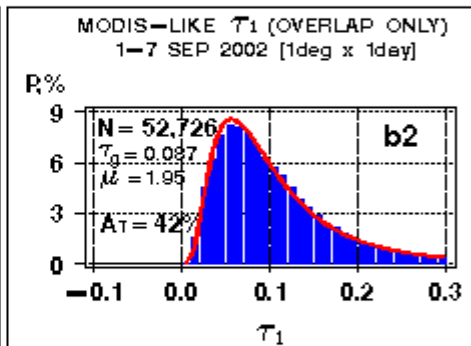
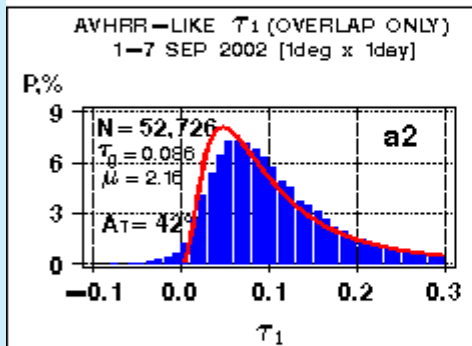
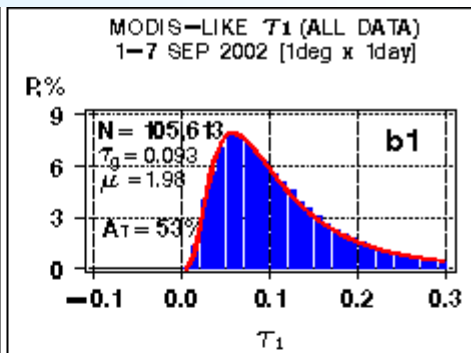
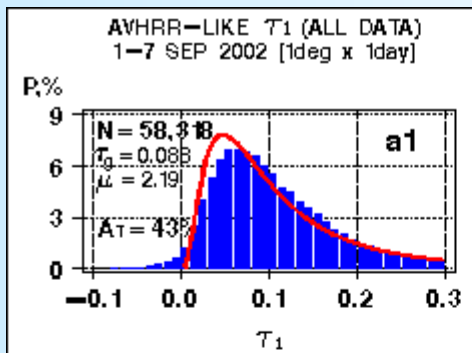


Aqua τ_1 @ 0.659 μm : 1-7 Sep 2002



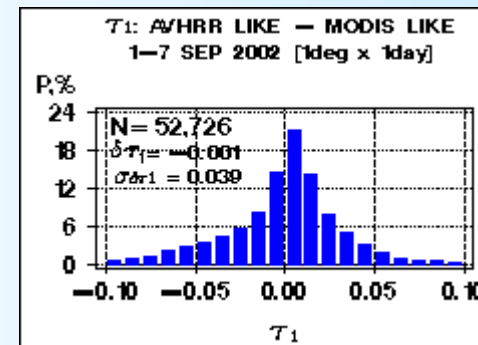
AVHRR-like

MODIS-like



- τ_M closer to LN than τ_A
- $\sigma_{\tau M} < \sigma_{\tau A}$
- No data with $\tau_M < 0$
- ~2% of data: $\tau_A < 0$

ALL DATA



OVERLAP

- $\tau_A - \tau_M$: bias $\sim -10^{-3}$; $\sigma_{\tau} \sim 0.04$

COMPLEMENT

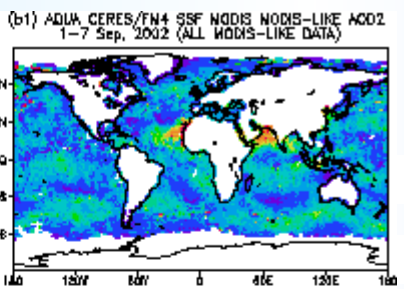
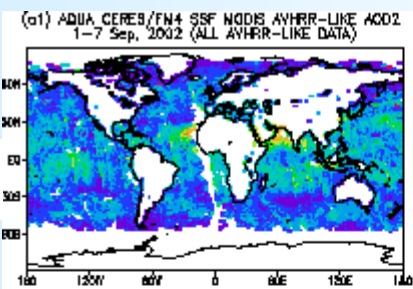


Aqua $\tau_2@1.640 \mu m$: 1-7 Sep 2002

AVHRR-like

MODIS-like

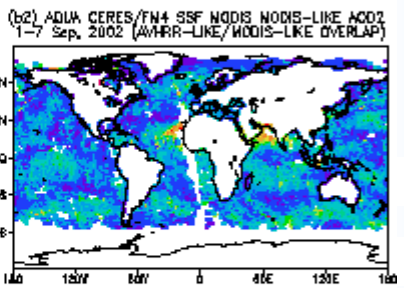
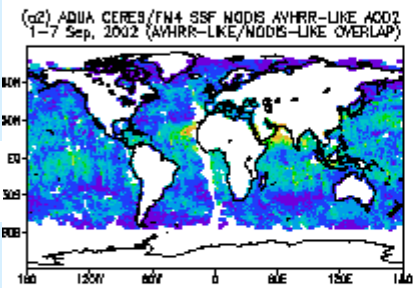
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- τ coherent with cloud, A_T



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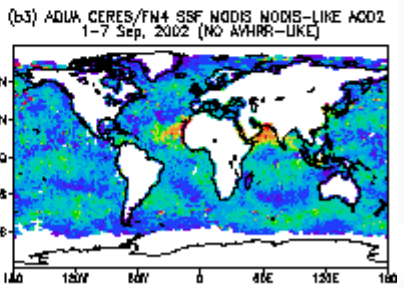
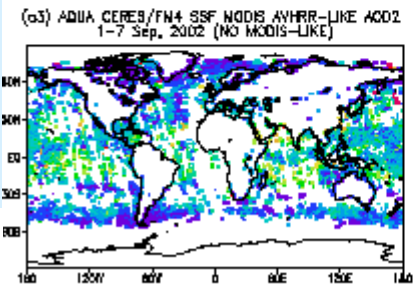
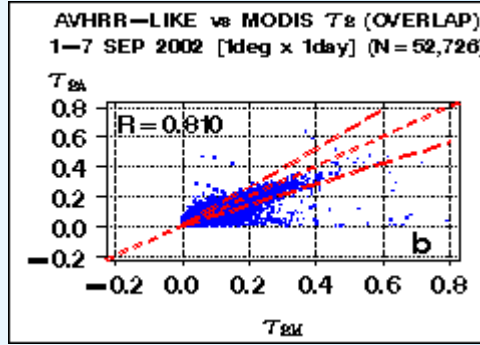
ALL DATA



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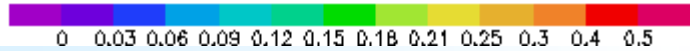
OVERLAP



$A_T \sim 48\%$

$A_T \sim 59\%$

COMPLEMENT



- τ_M & τ_A : Correlated
- Scatter at low τ :
Aerosol model unlikely
- Negative Rad truncated



Terra $\tau_1 @ 0.659 \mu m$

15-21 Dec 2000

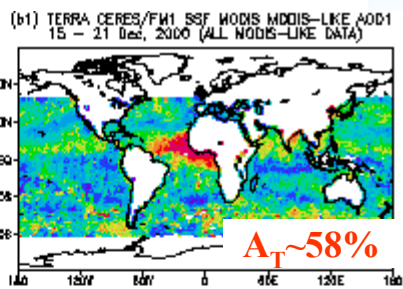
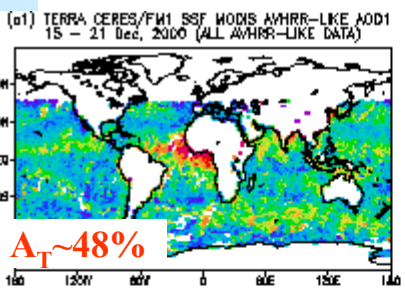
1-7 Jun 2001

AVHRR-like

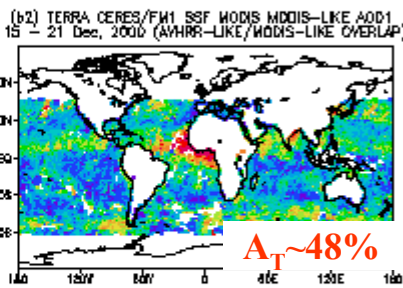
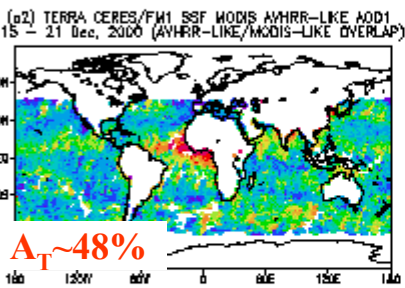
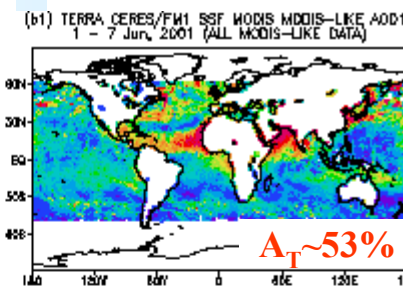
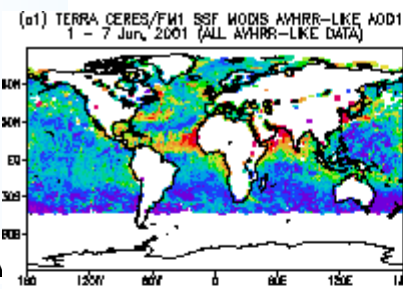
MODIS-like

AVHRR-like

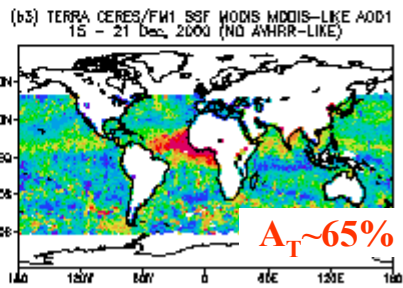
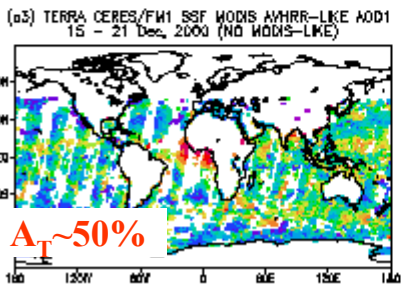
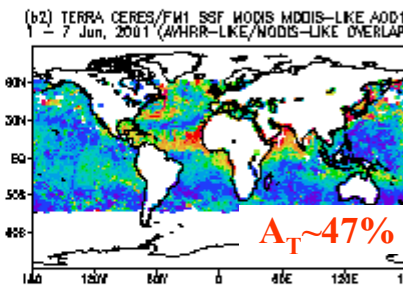
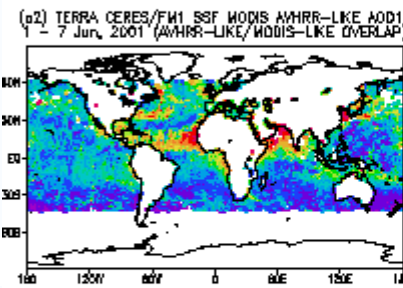
MODIS-like



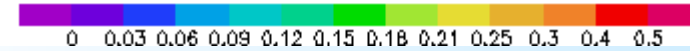
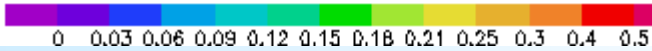
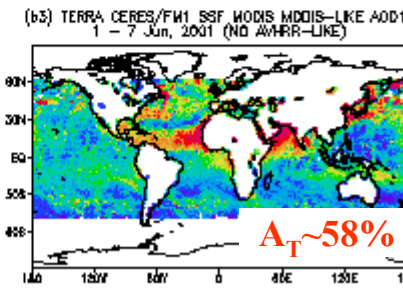
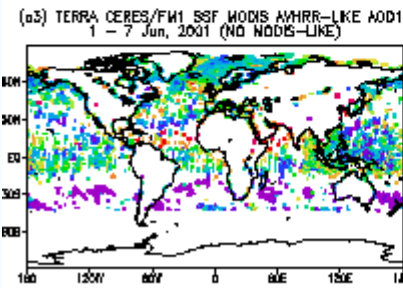
ALL DATA



OVERLAP

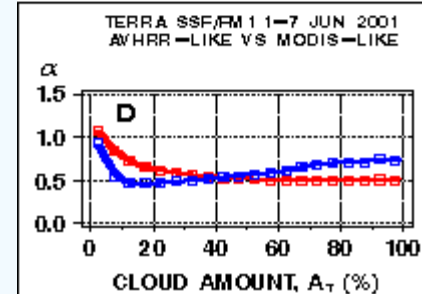
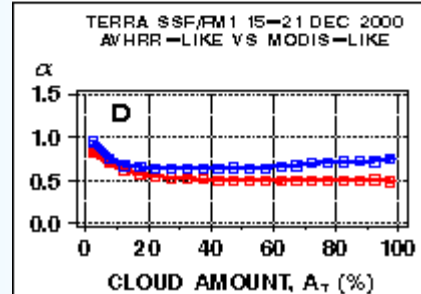
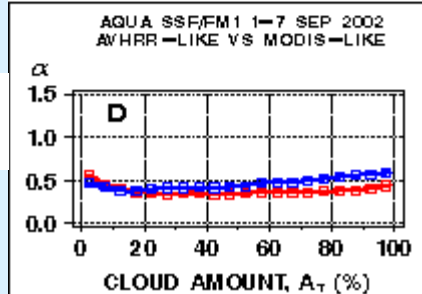
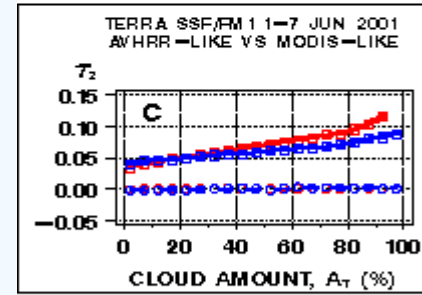
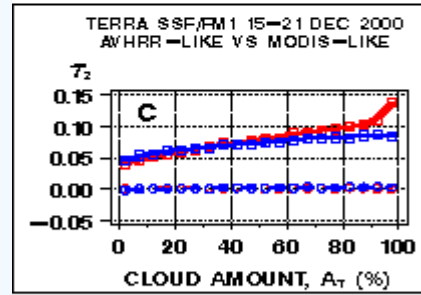
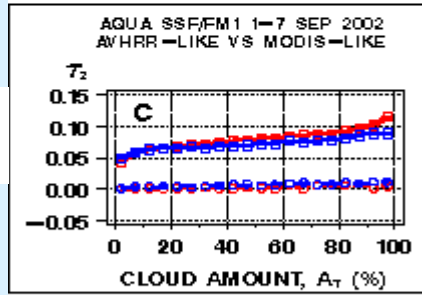
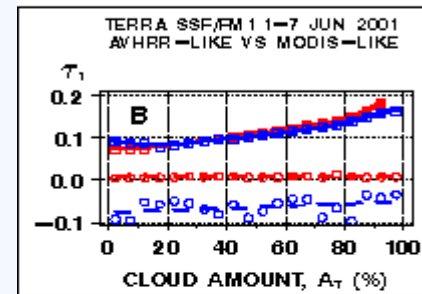
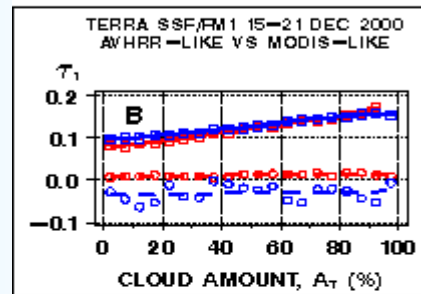
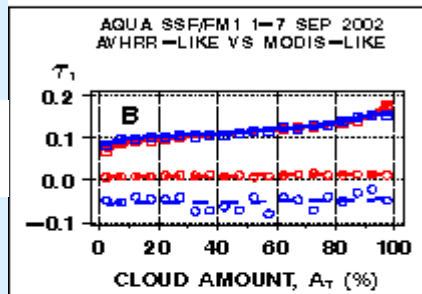
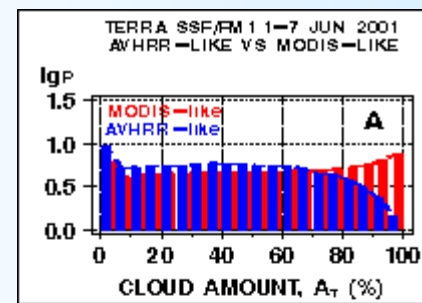
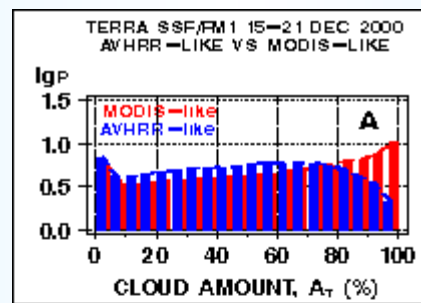
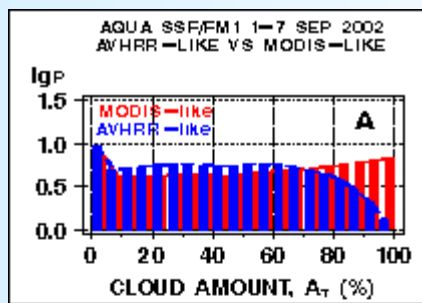


COMPLEME





MODIS Aerosol/Cloud Correlation



Aqua Sep 2002

Terra Dec 2000

Terra Jun 2001

τ_1 (0.659 μm)

τ_2 (1.640 μm)

α



CONCLUSION TO MODIS

τ/α -Retrievals:

- **MODIS-like: better quality (τ , α)**
- **AVHRR-like: Insight into channel's performance**
- **AVHRR-like and MODIS-like: Much similarity**
- **Correlation: τ_1 (R~0.8-0.9), τ_2 (R~0.6-0.8), α (R~0.4-0.7)**
- **Sampling: As/More important as aerosol algorithm**
- **Ambient cloud amount: Key parameter**

ISSUES

- 1) **Aerosol/Cloud**
- 2) **Truncation of negative radiances @ 1.640 μm**
- 3) **Terra differences: Dec 2000 vs. Jun 2001**



8-month average AOD@0.55 μm : Nov 1996 - Jun 1997

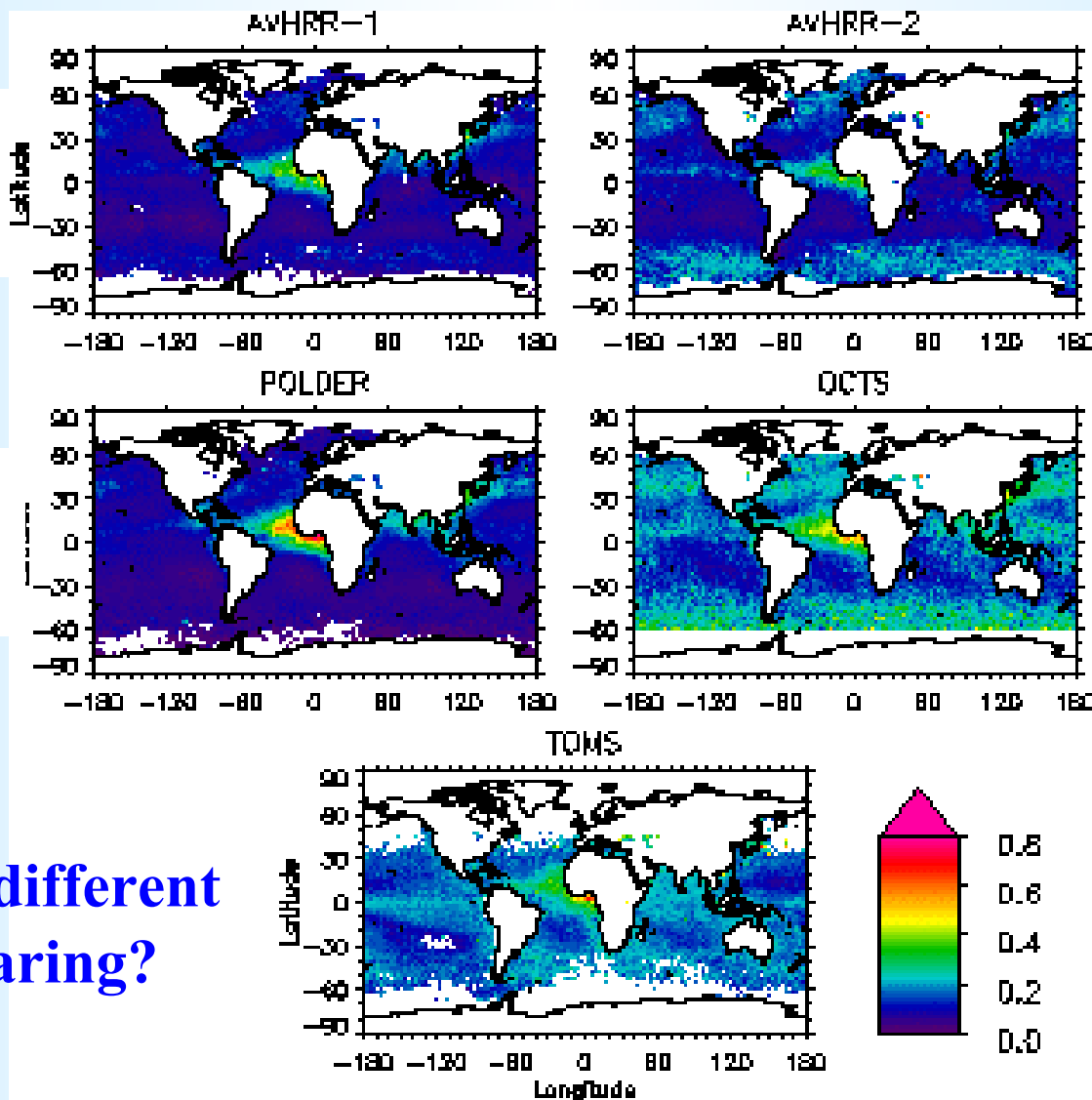
NOAA14/AVHRR
PATMOS
(Stowe et al. 1997)

ADEOS/POLDER
(Goloub et al. 1999,
Deuze et al. 2000)

NOAA14/AVHRR
ISCCP/GACP
(Mishchenko et al.
1999)

ADEOS/OCTS
(Higurashi and
Nakajima 1999)

??/TOMS
(Torres et al. 2002)



- Products different
- Cloud clearing?



NOAA-KLM/AVHRR3

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 - 2) NOAA-17 (M) (JUN 2002, 10:00 AM)
- AEROBS Operational (PATMOS Plans)
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| NOAA16: 12-20 Feb 2003 | NOAA17: 12-20 Feb 2003 |
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EOS/MODIS

- 3) TERRA (DEC 1999, 10:30 AM)
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|---|----------------------------------|



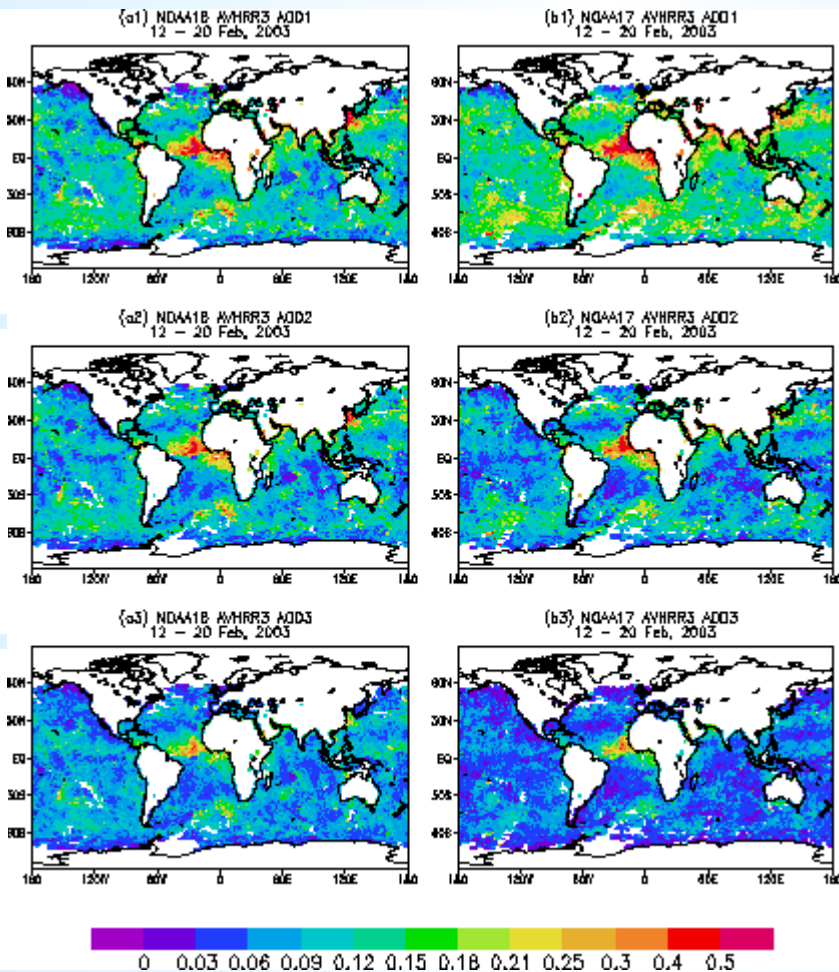
NOAA-KLM AVHRR/3 Aerosols

12-20 February 2003

τ_1 (0.63 μm)
 $R_1=0.82$
 $\delta\tau_1\sim+0.03$
 $\sigma_{\tau_1}\sim0.05$

τ_2 (0.83 μm)
 $R_2=0.80$
 $\delta\tau_2\sim-0.01$
 $\sigma_{\tau_2}\sim0.04$

τ_3 (1.61 μm)
 $R_3=0.74$
 $\delta\tau_3\sim-0.02$
 $\sigma_{\tau_3}\sim0.03$



- Patterns similar
- Correlation R high
- R decreases with λ
- Biases opposite in channels (calibration)
- σ_{τ} decreases with λ

NOAA-16 (2 PM)

NOAA-17 (10 AM)



CONCLUSION TO AVHRR

τ -Retrievals:

- NOAA-KLM/AVHRR3 aerosol up & running
 - Good to monitor aerosol/AVHRR performance
- <http://www.osdpd.noaa.gov/PSB/EPS/Aerosol/Aerosol.html>
- <http://www.saa.noaa.gov/>
- AVHRR calibration major issue
 - Care advised in quantitative use

PLANS

- 1) PATMOS processing/Cal adjusted
- 2) Self- and Inter-consistency of NOAA-16 & -17
- 3) Merge with Terra/Aqua MODIS for cross-checks



OUTSTANDING ISSUES

Cloud/Aerosol Correlation

- understand physics (residual cloud in the FOV vs. cloud/aerosol interaction)
- new strategies of cloud clearing: continuum aerosol-cloud

Data Quality

(Sampling/Cal/Truncation)

- important for aerosol product
- more science in decision making
- unification/standardization



Aqua $\tau_2@1.640 \mu m$: 1-7 Sep 2002

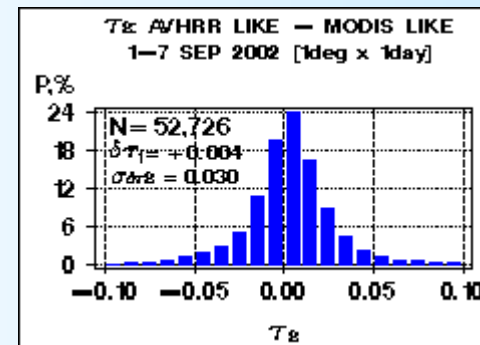
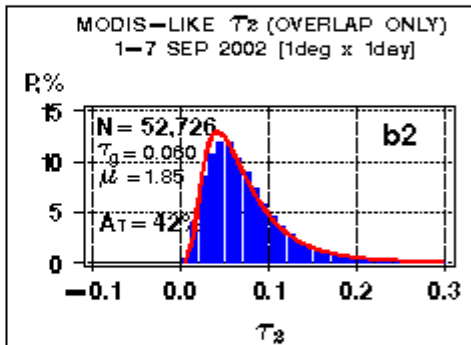
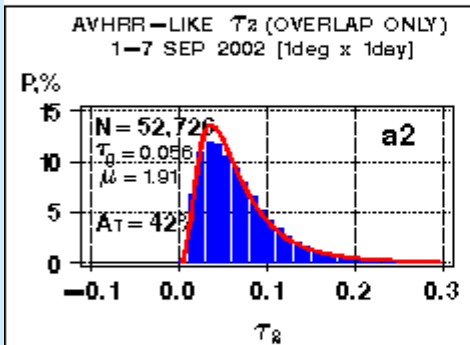
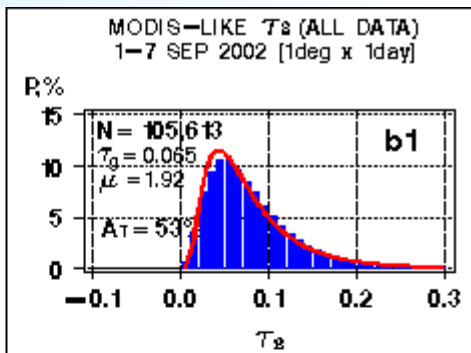
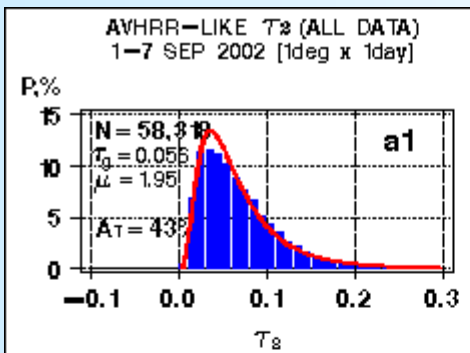


AVHRR-like

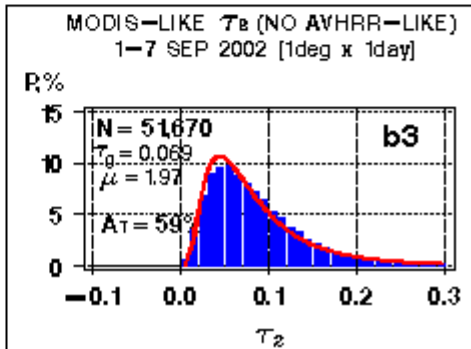
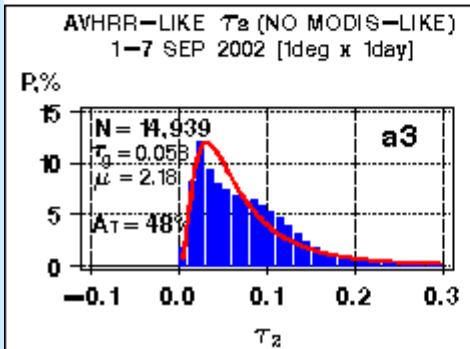
MODIS-like

- τ_M & τ_A : deviate from LN
- $\sigma_{\tau_M} < \sigma_{\tau_A}$
- No data with $\tau_M < 0$
- No data with $\tau_A < 0$
(Negative Rad truncated)

ALL DATA



OVERLAP



- $\tau_A - \tau_M$: bias $\sim +4 \times 10^{-3}$; $\sigma_{\tau} \sim 0.03$

COMPLEMENT

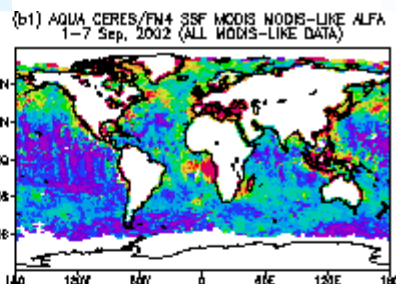
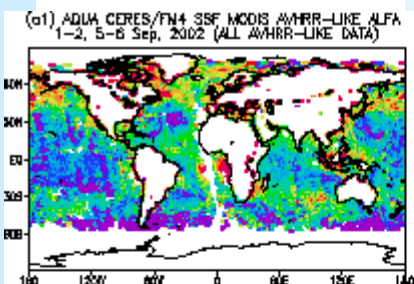


Aqua α (0.659/1.640 μm): 1-7 Sep 2002

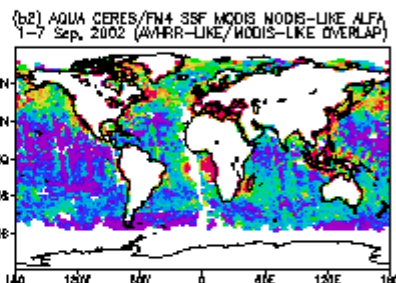
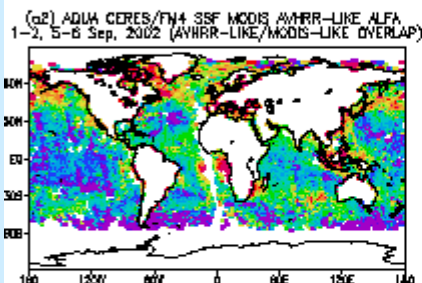
AVHRR-like

MODIS-like

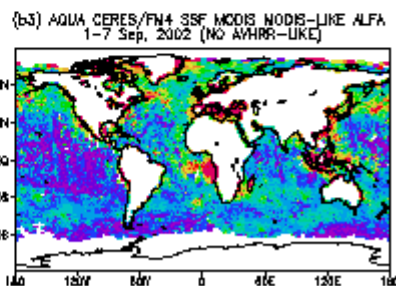
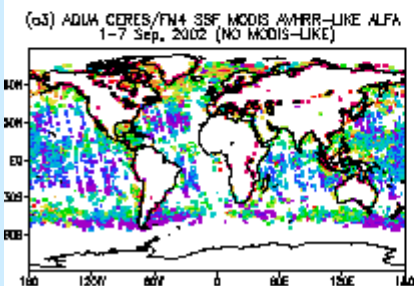
- Data noisy/stripy
- Some similarity in patterns
- α -coherence with cloud low



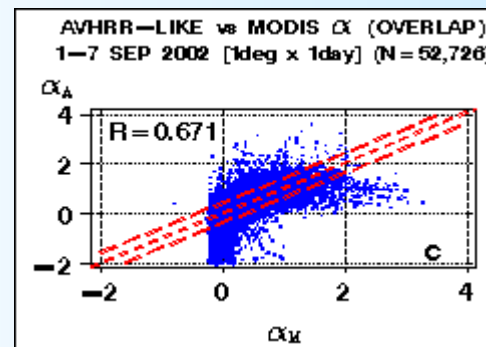
ALL DATA



OVERLAP



COMPLEMENT



- α_M & α_A : Correlated
- Scatter: mostly at low τ (Indeterminacy 0/0)
- α_M truncated

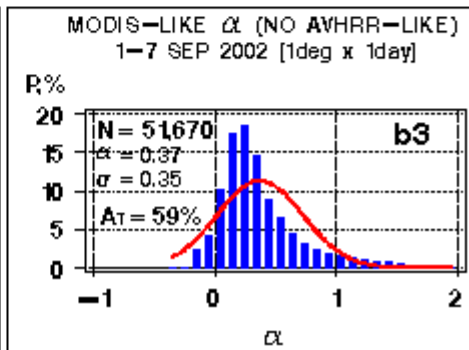
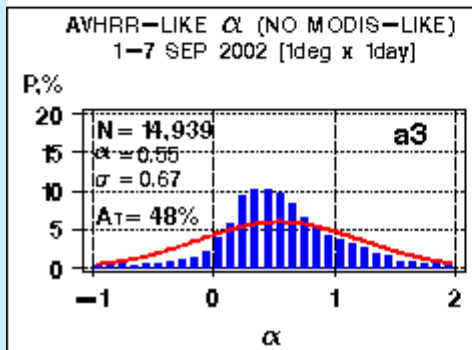
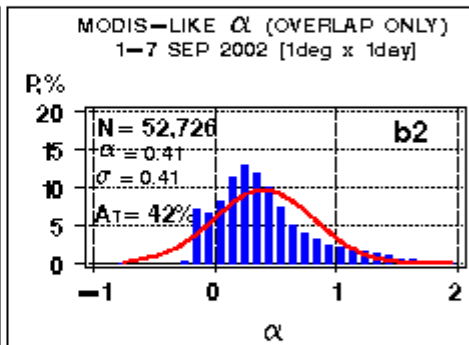
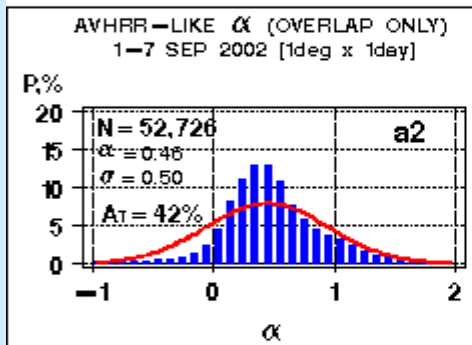
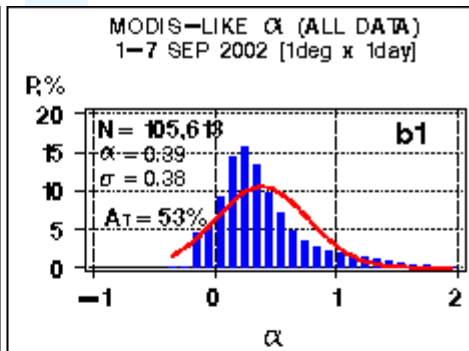
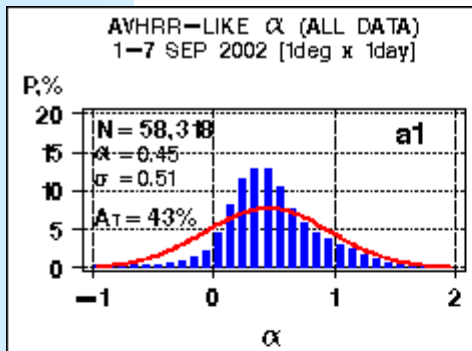




Aqua α (0.659/1.640 μm): 1-7 Sep 2002

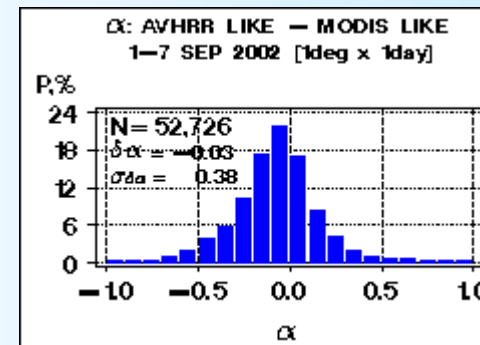
AVHRR-like

MODIS-like



- α_M & α_A : deviate from N
- $\sigma_{\alpha M} < \sigma_{\alpha A}$
- No data with $\alpha_M < -0.2$

ALL DATA



OVERLAP

- $\alpha_A - \alpha_M$: bias $\sim -3 \times 10^{-2}$; $\sigma_{\alpha} \sim 0.4$

COMPLEMENT



Terra $\tau_2@1.640 \mu\text{m}$

15-21 Dec 2000

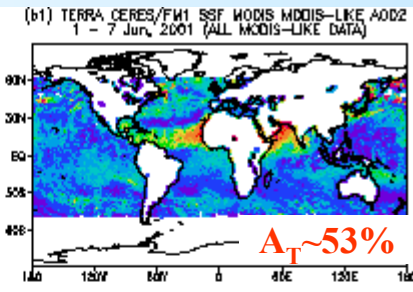
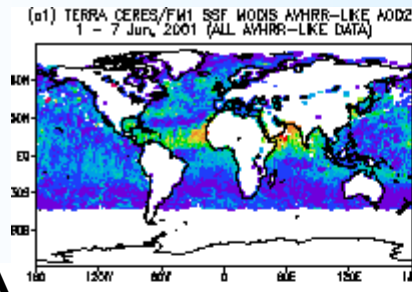
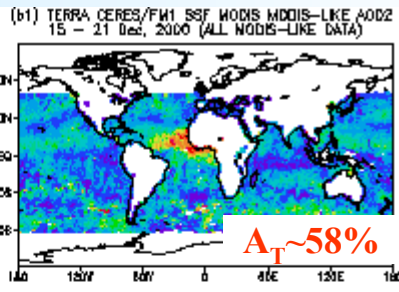
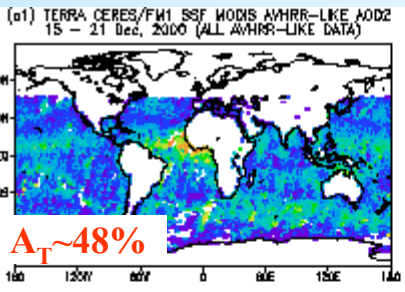
1-7 Jun 2001

AVHRR-like

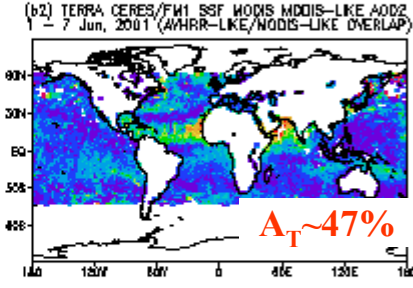
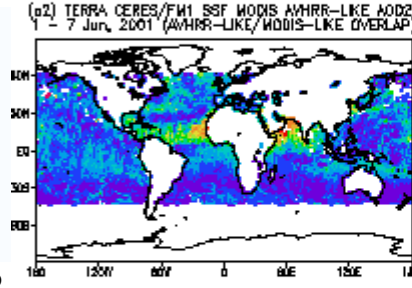
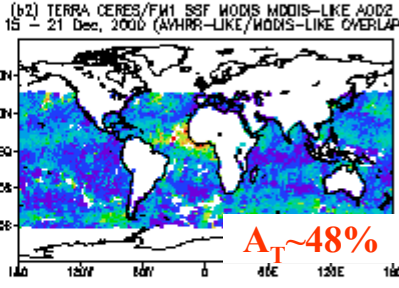
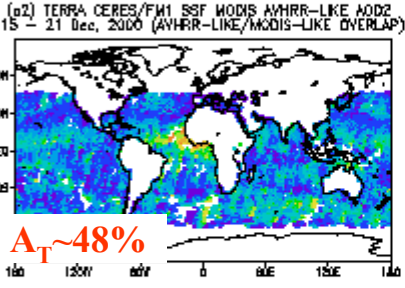
MODIS-like

AVHRR-like

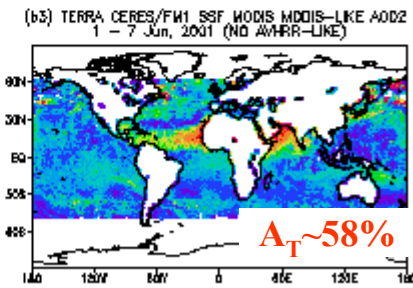
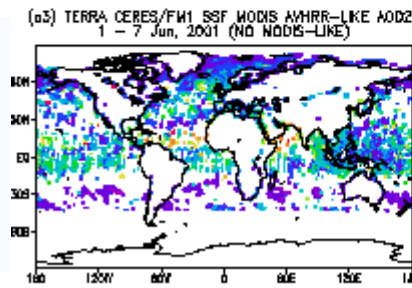
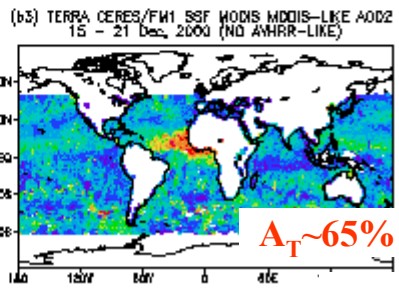
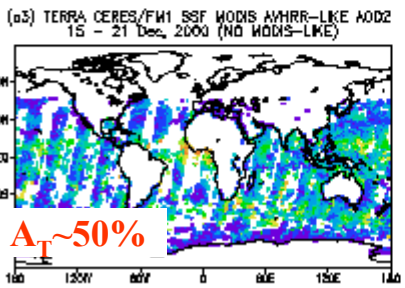
MODIS-like



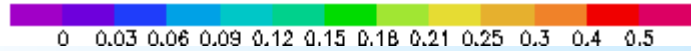
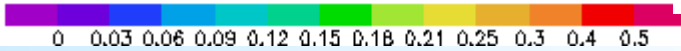
ALL DATA



OVERLAP



COMPLEMEN





Terra α (0.659/1.640 μm)

15-21 Dec 2000

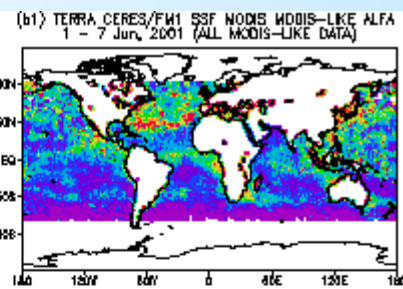
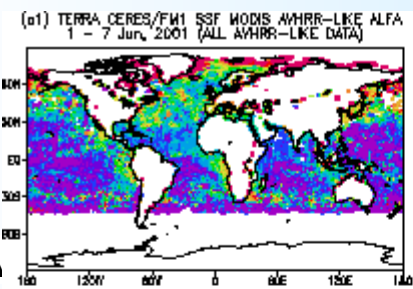
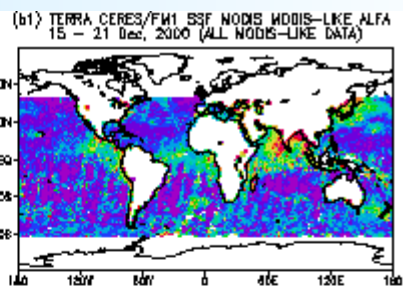
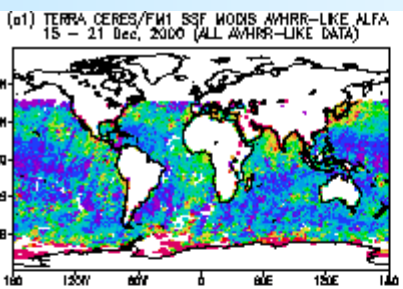
1-7 Jun 2001

AVHRR-like

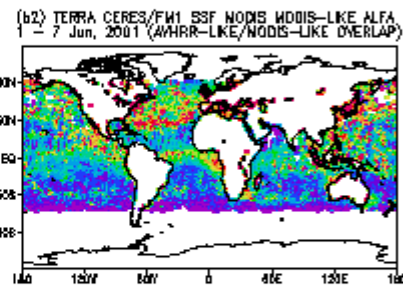
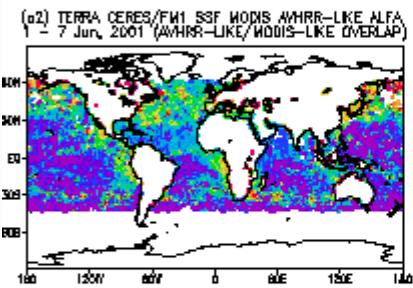
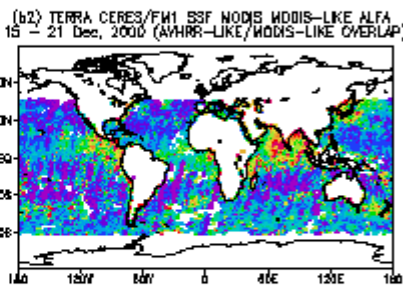
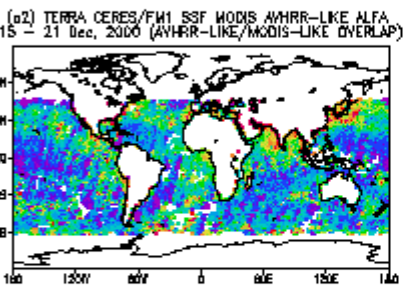
MODIS-like

AVHRR-like

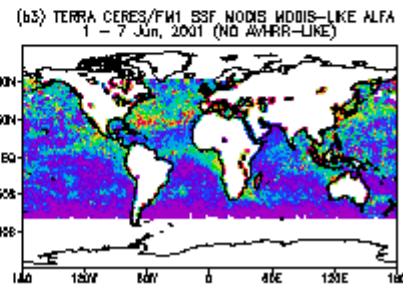
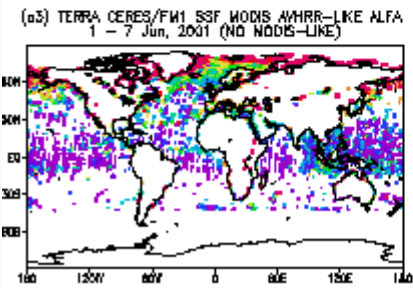
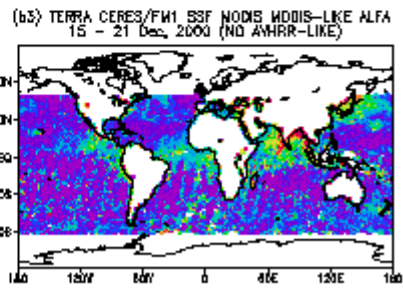
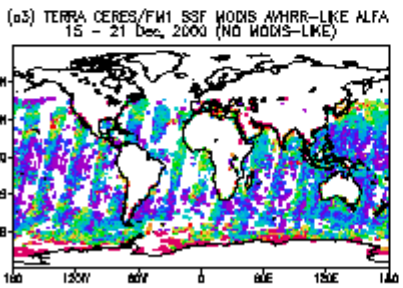
MODIS-like



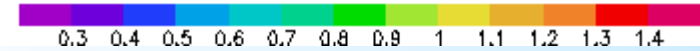
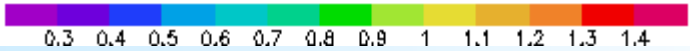
ALL DATA



OVERLAP



COMPLEME





BIASES AND NOISE

- Calibration
- Temporal Variability
- Cloud Cover
- Spatial Variability
- Algorithm

