Multi-year global aerosol distributions from MODIS (and MISR) and GOCART

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Introduction

- MODIS has now provided almost 7 years of global aerosol products
- MODIS has simulated aerosol research exponentially, especially has helped advance global aerosol chemistry transport models, including GOCART

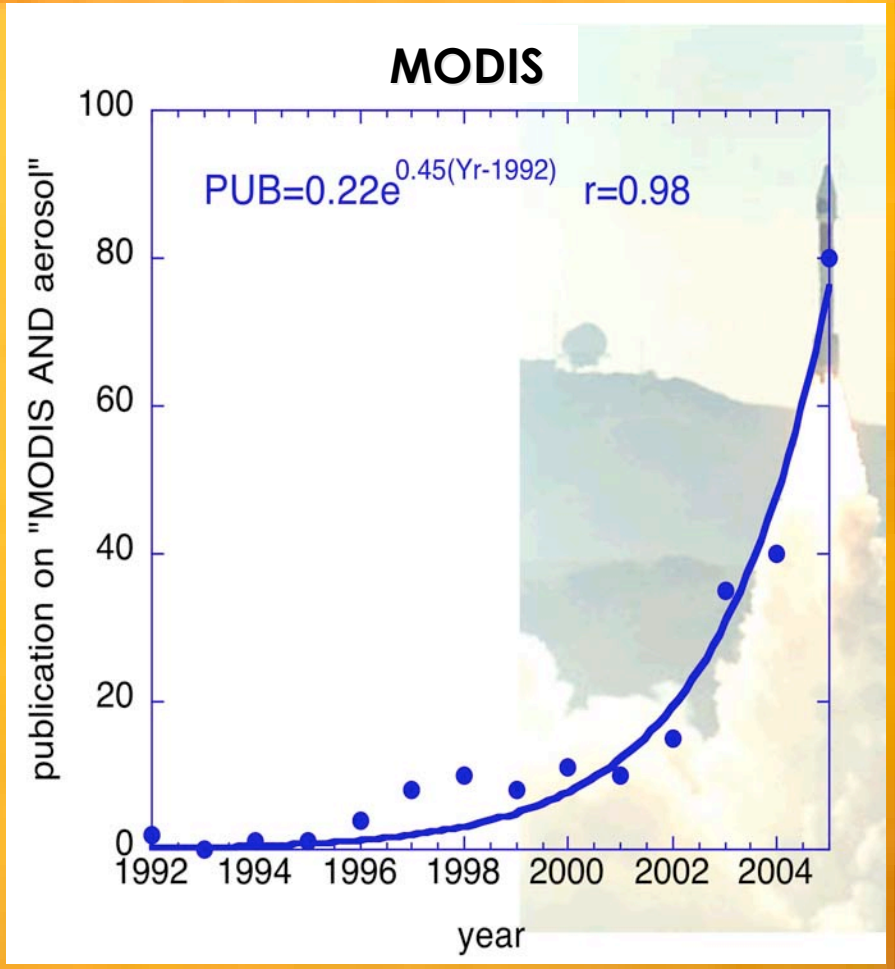


Figure from Yoram Kaufman

Global aerosol distributions

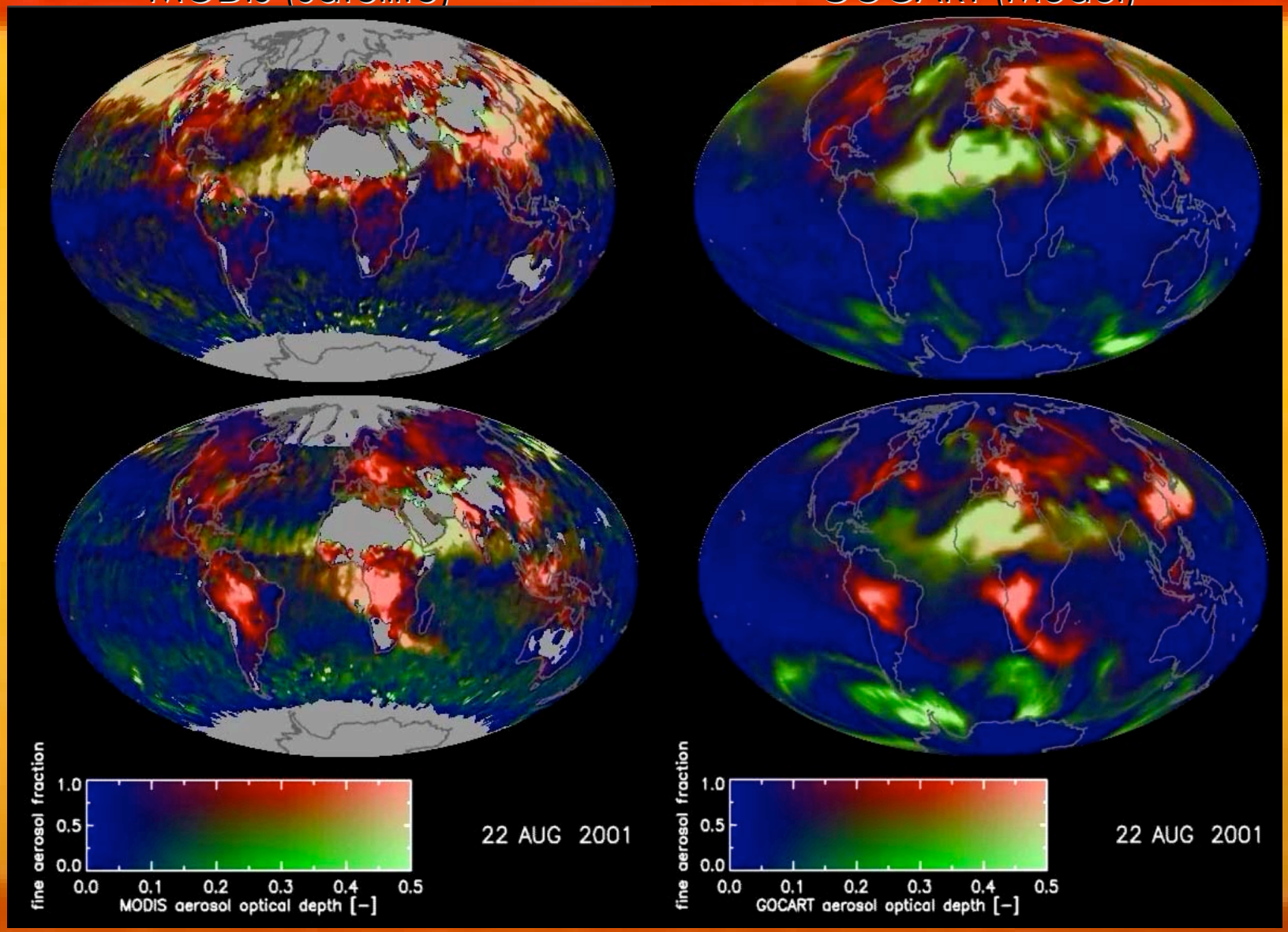
MODIS (Satellite)

GOCART (Model)

4/13/2001

8/22/2001

Aerosol optical thickness (AOT)

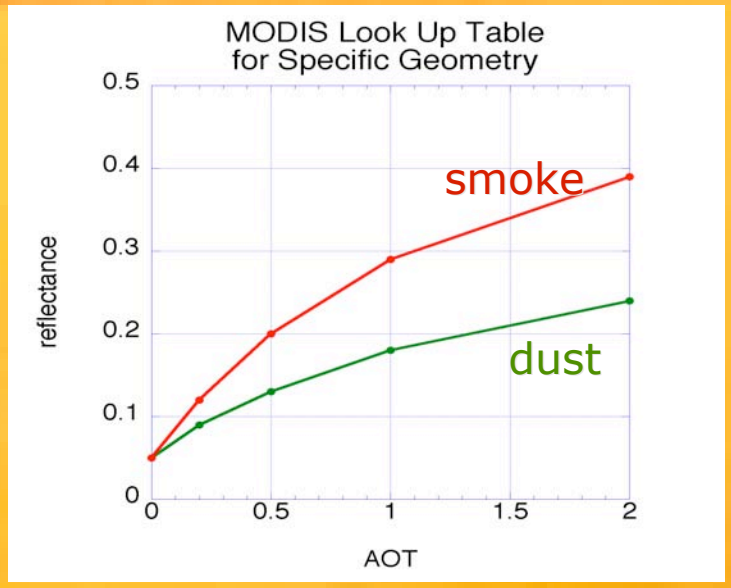


Comparisons between MODIS and GOCART

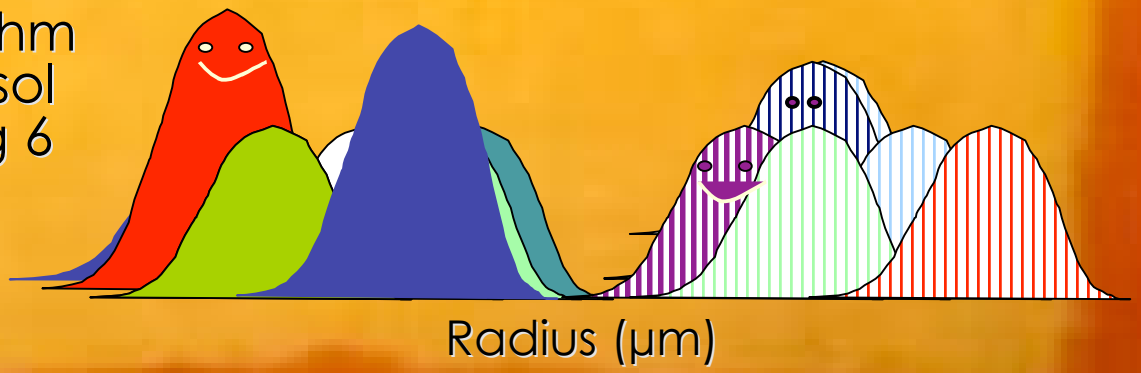
MODIS	GOCART
First launched on Terra in 1999	First version developed in 1999
Remotely sensing aerosol from space	Theoretically (or ideally) calculating aerosol from computer
Taking measurements 2 times/day (Terra & Aqua) for clear skies	Saving model output every 3 hours for all skies
Seeing aerosol "top down": measuring "radiance" from space	Simulating aerosol "bottom up": starting with surface emissions
Converting "radiance" to "aerosol optical thickness"	Converting "mass concentrations" to "aerosol optical thickness"

How does MODIS get AOT?

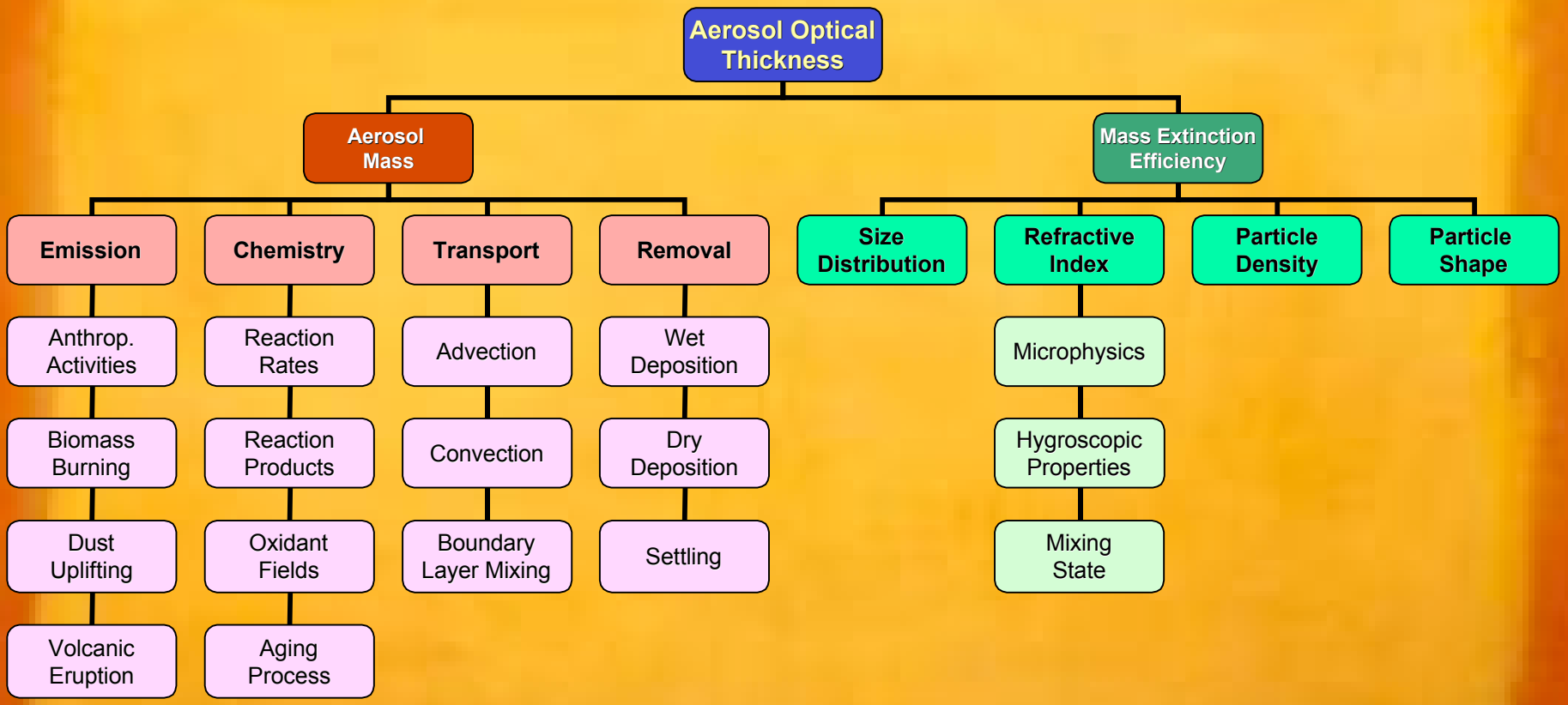
- Over land:
  - Finding a cloud-free scene
  - Knowing/guessing surface reflectance
  - Knowing/guessing aerosol type
  - Choosing an AOT number from the LUT



- Over ocean:
  - Allowing the algorithm to find its own aerosol model by matching 6 MODIS reflectance with LUT values
  - Better constrained



How does GOCART get AOT?



- Obviously MODIS and GOCART have very different ways to get the AOT – are we "seeing" the same thing?
  - What we have learned from the comparisons among MODIS, MISR, AERONET, and GOCART (2000 – 2005)
  - Thoughts and questions regarding using data and model

GOCART, MODIS, MISR time series

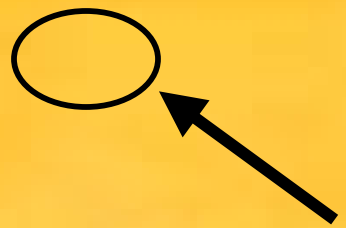
MODIS: Terra, C004, 1x1 MISR: Vx(?), 1x1 GOCART: v4.0, 2.5x2

MODIS and MISR data downloaded from Giovanni website

Looking closer and using AERONET as "ground truth"

- AERONET measures AOT directly
- Data have been widely used for satellite validation and model evaluation
- Limitations:
  - Sites mainly over land
  - "point" measurements
  - Even "truth" has different versions – we are now using the new version, 2

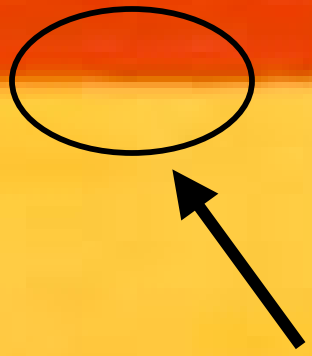
MODIS, MISR, GOCART, AERONET: 200009



Feature: SH biomass burning

- GOCART: biomass burning emissions seem too low
- MODIS: too high over North America, gap over bright surfaces
- MISR: covering desert, but gap over tropical land surfaces
- GOCART: AOT lower than satellite data over SH ocean

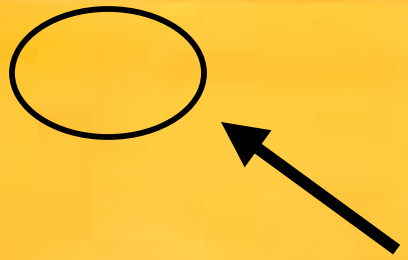
MODIS, MISR, GOCART, AERONET: 200104



Feature: Asian dust transport

- MISR: AOT over Asia seem too low, gap over tropical land surfaces
- MODIS: too high over North America, gap over bright surfaces
- GOCART: AOT lower than satellite data over SH ocean, much higher than MISR over Sahara

MODIS, MISR, GOCART, AERONET: 200403



Feature: African dust storm

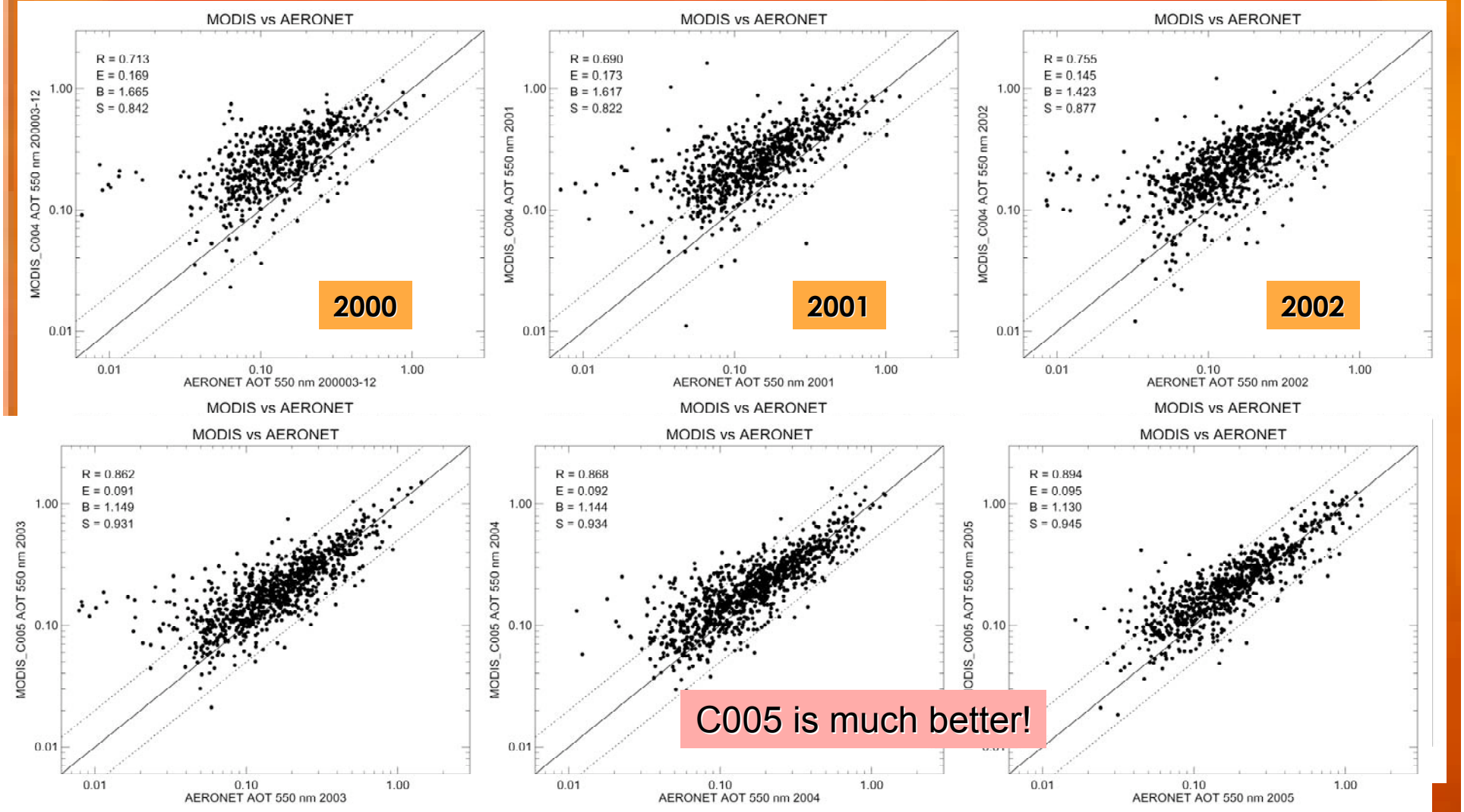
- MISR: AOT over Asia seem too low, gap over tropical land surfaces
- MODIS: too high over SH land (South America and Australia, gap over bright surfaces
- GOCART: SE Asia biomass burning too low

MODIS, MISR, GOCART, AERONET: 200407

Feature: North America Boreal fire

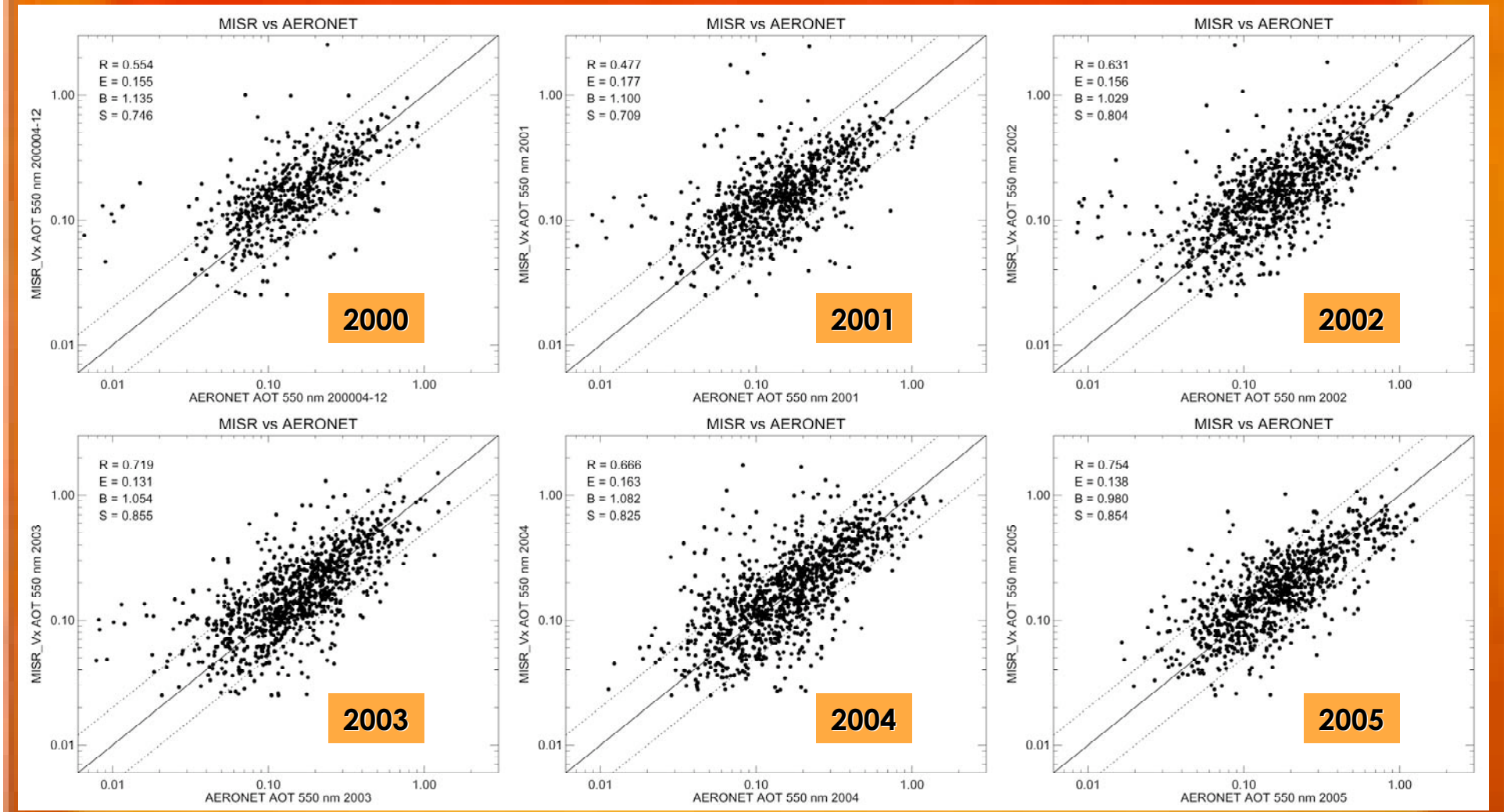
- GOCART: Boreal fire emission (or injection height) maybe too low so fire did not go far enough
- MISR: Excessive AOT over Greenland
- MODIS: AOT too high over North America boreal

MODIS vs AERONET, 2000 – 2005



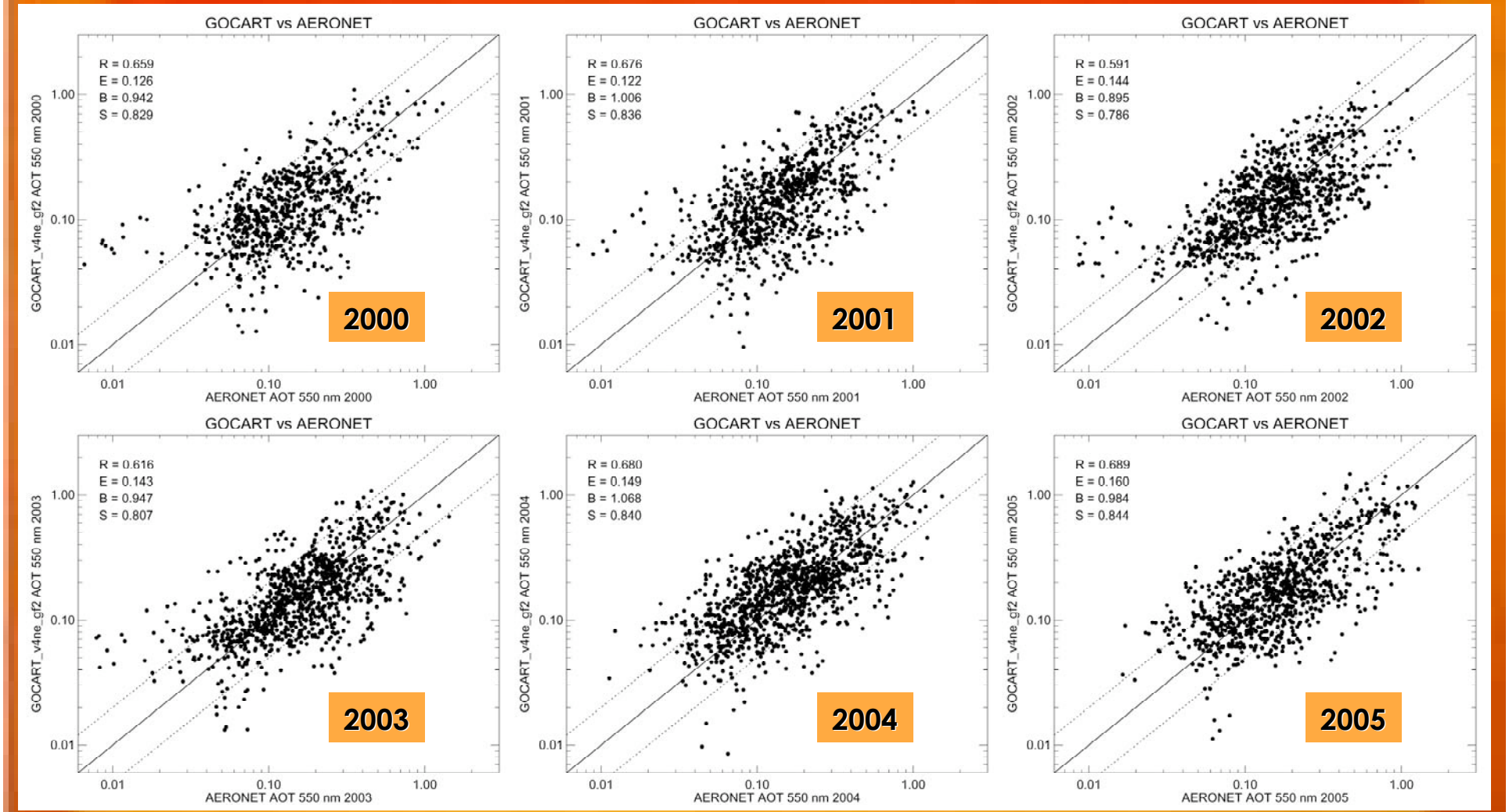
Relatively higher correlations, but overall biased high (~30 – 67%)

MISR vs AERONET, 2000 – 2005



Little systematic bias globally, but less tight correlations

GOCART vs AERONET, 2000 – 2005



Little systematic bias globally, but less tight correlations

These comparisons have revealed:

- MODIS (collection 4):
  - In general biased high over land
  - No coverage over deserts and snow/ice
  - **Collection 5** will have less bias and include over desert retrieval (deep blue)
- MISR (version x):
  - No systematic bias over land
  - Data coverage limited over regions where clouds often in presence due to its sparse spatial coverage
  - Over Asia the AOT seem too low – "hit or miss" problem

These comparisons have revealed:

- GOCART (version 4.0):
  - Biomass burning emissions seem too low in most cases (GFED v2) – currently several different methods being investigated
  - Dust is higher than MISR in the source regions
  - Maritime AOT lower than MODIS and MISR, but difficult to verify since no AERONET data
  - No systematic bias compared with AERONET

Questions from me

- Data fusion: is "MODIS over ocean + MISR over land" the best combination to represent the global aerosol picture?
- Data assimilation: What to assimilate? How to maintain the consistency between optical measurements with aerosol composition and mass concentrations?
- Inversion: If satellite data are biased and model processes are uncertain, how can we get the source right through inversion?

Last but not least: AOT is only a part of the problem…

- While satellite data (from passive sensors) have "forced" models to improve their simulations of AOT, their provide little constraints on 3 major quantities that diversify the modeling community (e.g. AEROCOM results):
  - Vertical distributions
  - Aerosol composition
  - Aerosol hygroscopic property (water up take)

Looking forward to next year –

- Vertical data from CALIPSO
- Absorbing AOT from OMI
- Improved version(s) from MODIS and MISR
- Field measurement data
  - Chemical composition
  - RH effects
  - Wet removal (very little data!!!)
- Model improvements (as always)
  - Emission, emission, emission (biomass burning, sea-salt, dust)
  - Higher resolution simulations (1.25° x 1°)
  - Hemispheric Transport of Atmospheric Pollutants (HTAP) experiments – Aerosol + CO