Aerosol Assessement

an update

Jeff Reid … and partners

the first page

- A Critical Review of the Efficacy of Commonly Used Aerosol Optical Thickness Retrievals
  - literature assessment
  - report to the Radiation Committee of GEWEX
    - commissioned by NASA Radiation Sci. Prog.
  - draft: July 20, 2015
  - assessment Panel:
    - Jeffrey S. Reid (editor), Sundar A. Christopher, Richard A. Ferrare, Paul A. Ginoux, Stefan Kinne, Gregory G. Leptoukh, W. Stackhouse
  - oversight:
    - Hal B. Maring, Charles M. Ichoku

the reports content

- level 3 1x1 monthly gridded AOD products
  - averaged, without or without objective error
  - these data-sets are numerous and available
  - Nature of the Problem: Fundamentals of Satellite Based Aerosol Products / Applications
  - Overview of Assessed Satellite Products
  - Evaluation of Product Evaluation, Verification and Intercomparion Studies
  - Satellite and model relationships
  - Aerosol Optical Thickness Trends

the status

- the good news
  - a BIG report exists (+ 80 pages of references)
- the bad news
  - little has happened during the last year (the latest version still has a July 2015 date)
  - … as Jeff (assuming overall responsibility) wanted to include new items (on the SE Asia hot-spot, MODIS, MISR)… he was side-tracked
- the way out ?
  - support and encourage Jeff …

– still relevant? new things happened since !

new developments

- AeroSAT
  - internally ongoing assessments !

  – uncertainty
  – air quality ?
  – new satellites
  – retrieval model issues
  – longterm records
  – vs modeling
  – new challenges

AeroSAT …unfunded like AeroCom

- a forum on satellite retrievals of aerosols
  - integral part of AeroCom meeting (since 2013)
    - lead by R.Kahn (GSFC) and T.Popp (DLR)
- goals
  - open and active exchange of information
    - on retrievals: their strengths and limitations
    - match user requir. to technical capabilities
    - benefit from latest technological advances
    - harmonize data format standardization
  - forum for satellite aerosol retrieval experts
    - learn, initiate, harmonize, interact with users
  - promote the use of satellite data

AeroSAT topics … at Beijing 2016

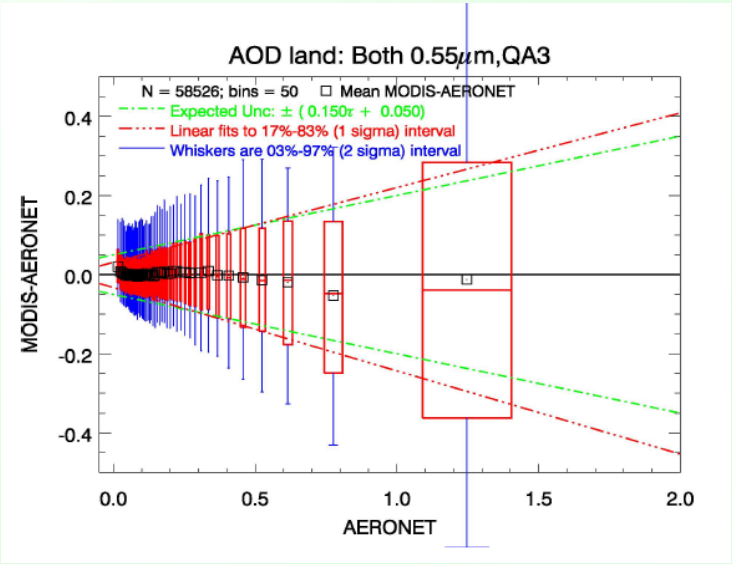
- characterizing retrieval uncertainty
  - pixel uncertainty required in assimilations
- challenges for contributions to air quality ass.
  - column properties vs near surface needs
- constraining aerosol type
  - since arbitrary … just for administrators ?
- long-term data record
  - are records accurate/long enough for trends?

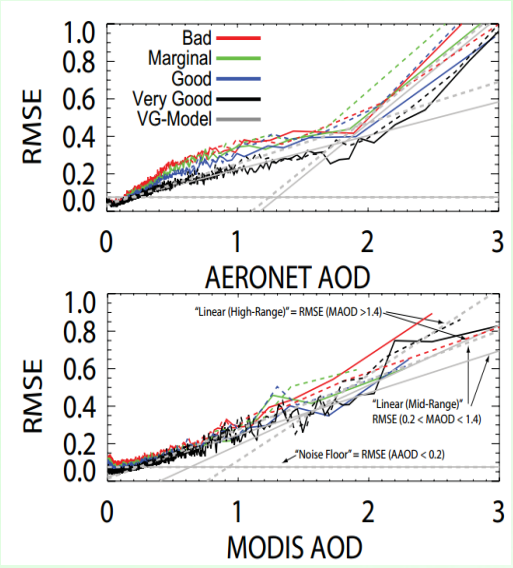
uncertainty – least square?

- assimilations require (pixel) error definitions
  - errors are often to general (GCOS, MODIS)
  - even given error-cones often do not apply
- why least square linear fits do NOT work ?
  - lack of linear relationship (e.g. reflect vs SSA)
  - no independence between data and errors
  - no constant variance of errors
  - no normality of errors
  - what would / could work ?

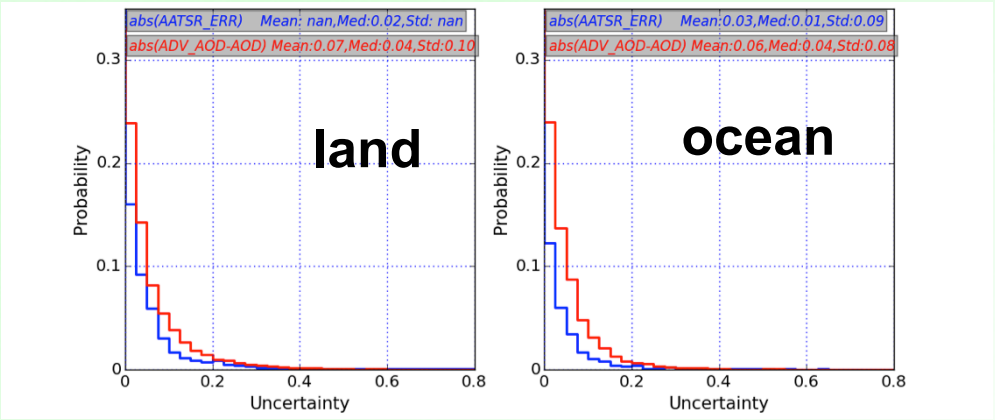
uncertainty – more useful metric

error statistics vs. AOD





compliance with uncertainty estimates



estimated error

actual error

ATSR ADV(FMI) retrieval deviations

error underestimate by a factor 2

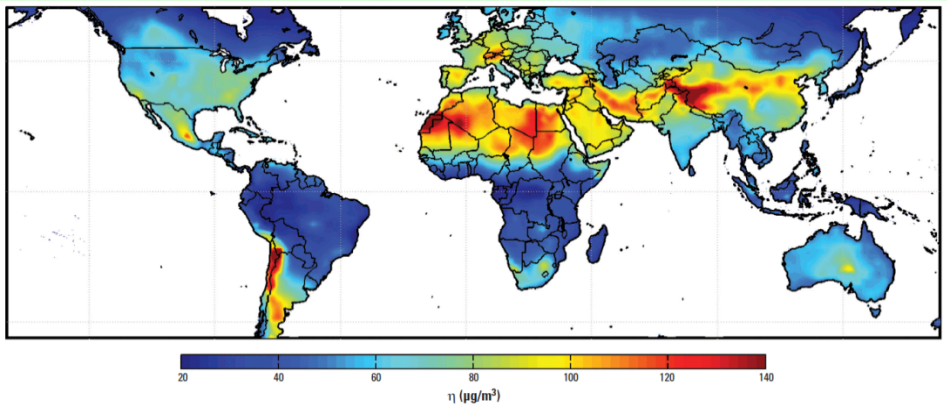
A.Sayer (GSFC)

air quality ?

- **difficult**
  - **over China: poll winter max, AOD summer max**
  - **easier with high resolution & high coverage**
- **with modeling ?**

$$AOD = PM_{2.5}\, H\, f(RH)\, \frac{3Q_{ext,dry}}{4\rho\, r_{eff}} = PM_{2.5}\, H\, S$$

  - **assume a well-mixed boundary layer height H**

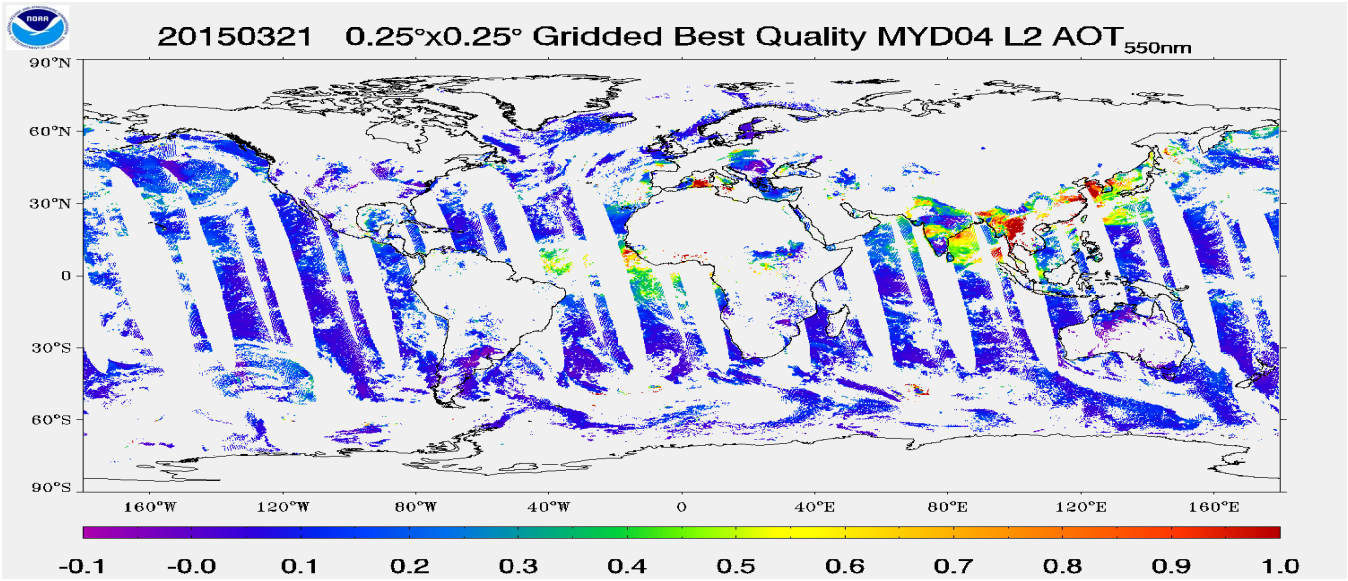


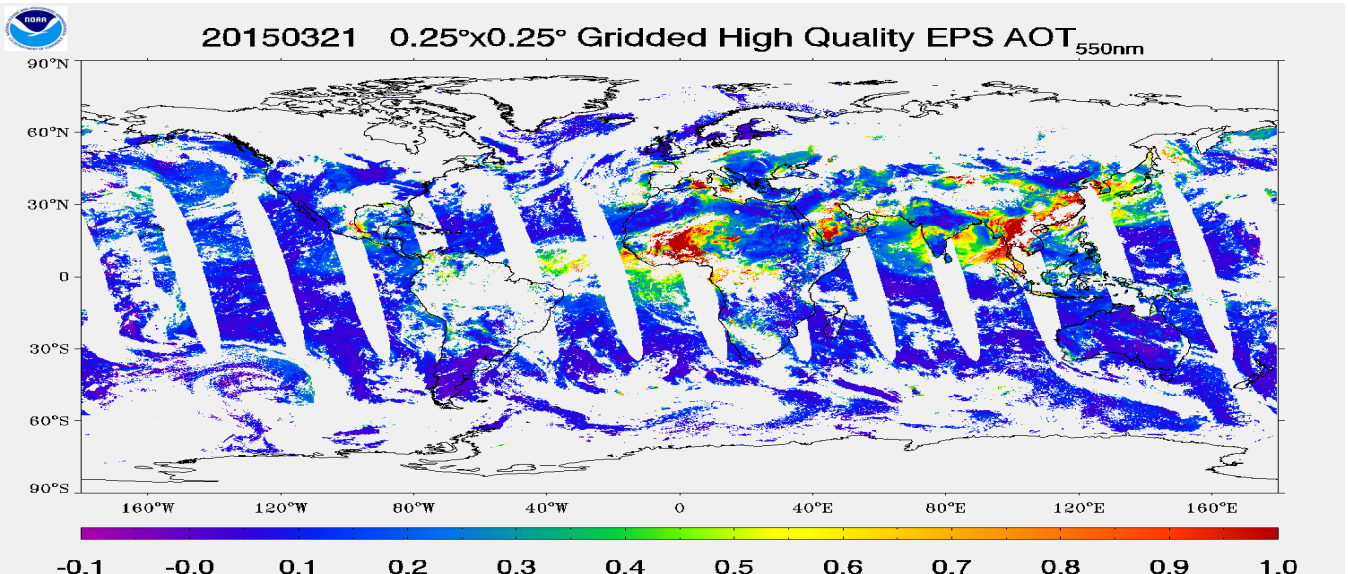
H*S
2001- 2006

new aerosol dedicated satellites

- many new satellites with aerosol retrieval capabilities
- VIIRS ← MODIS heritage US
- SLSTR ← ATSR heritage Europe
- GOCI, MI (geo) Korea
- HIMAWARI Japan
- …
  - usually different retrievals are tried or older (and somewhat) successful retrievals adapted

new satellites VIIRS





single day coverage

MODIS
more mature

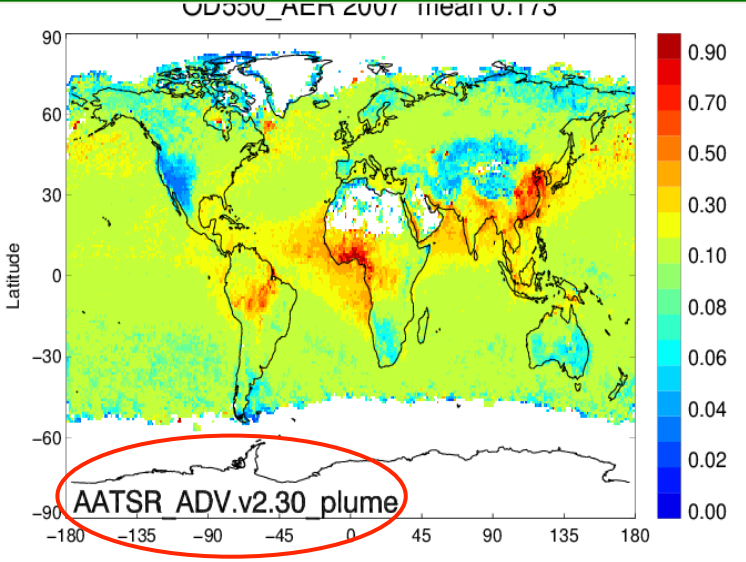
full yr 2015 now exists for VIIRS

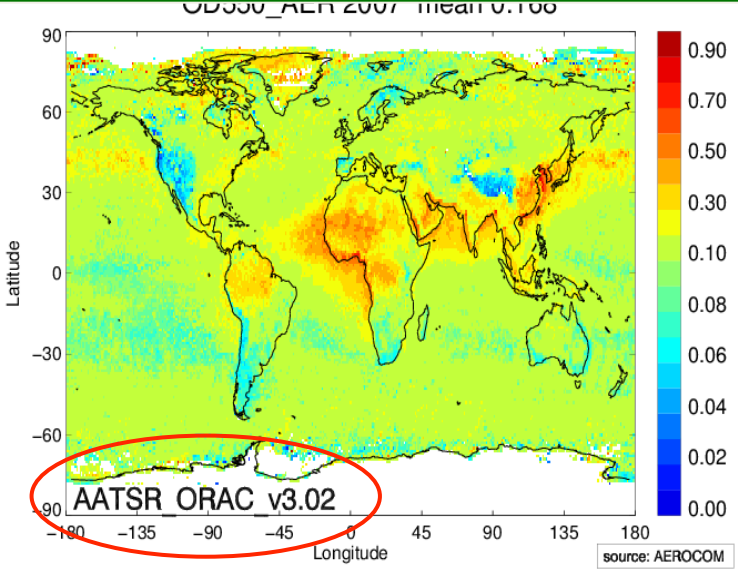
VIIRS
better coverage
migher resolution

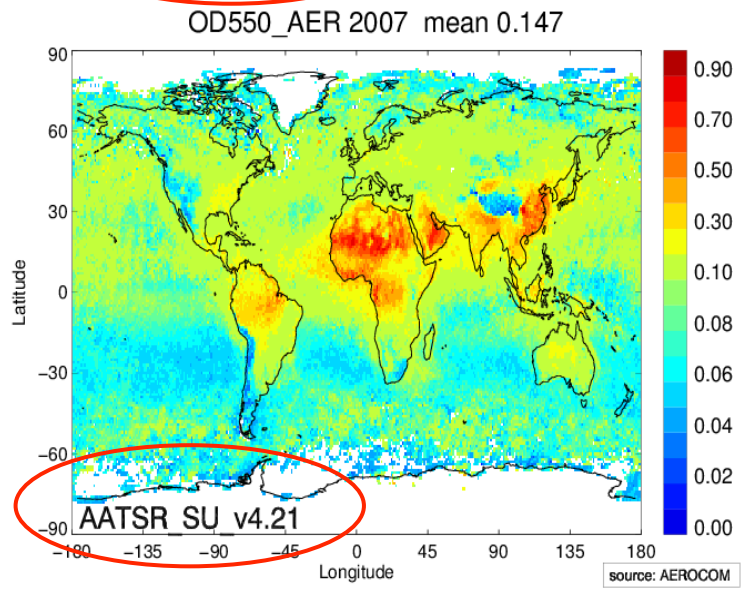
L.Remer (NOAA)

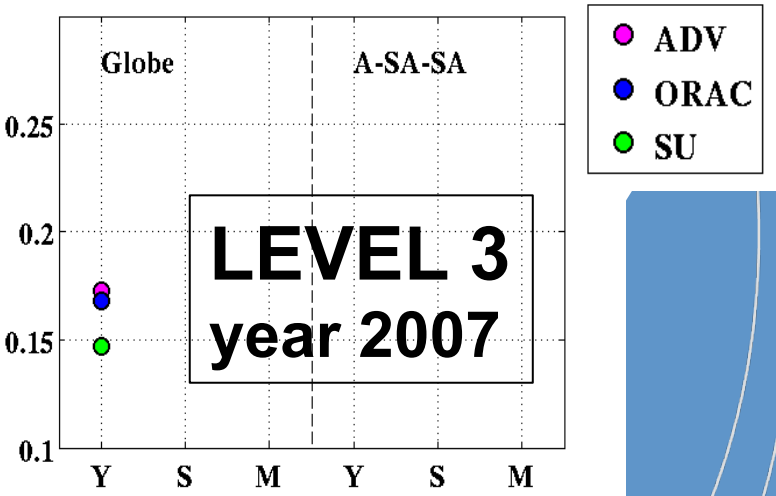
retrieval model differences matter

3diff ATSR retrievals applied to same sensor data





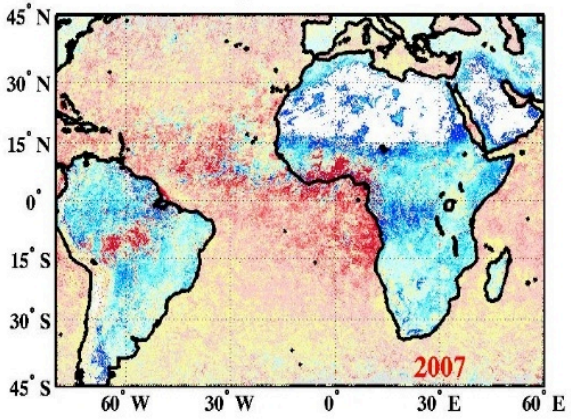




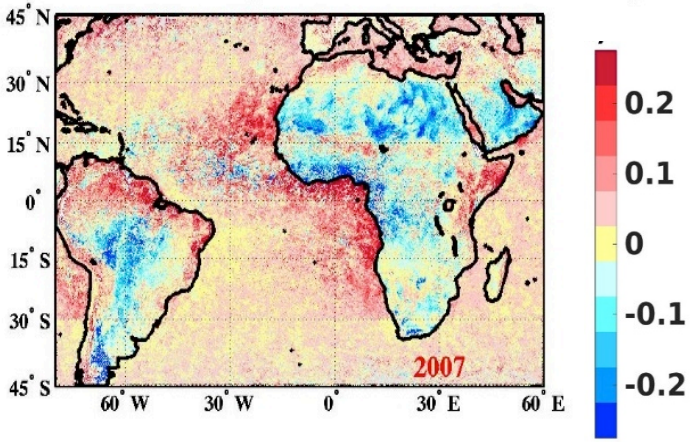
L.Sogocheva (FMI) AeroSAT 2016

… even L2 differences ! (2007)

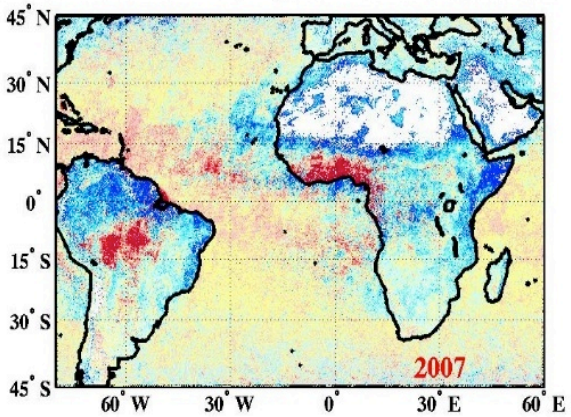
ADV-SU AOD (mean difference 0.001)



ORAC-SU AOD (mean difference 0.023)



ADV-ORAC AOD (mean difference -0.03)



detailed investigations are underway to investigate differences → eventually retrievals will get better

if reliable ref data exist for

- **lower rad. boundary**
- **best aerosol model**

from L.Sogocheva (FMI) AeroSAT 2016 presentation

long-term data records

- mainly for AOD, pieced together, assumptions
  - major consistency issues — MODIS Terra drift
    - subsequent instruments — MODIS Aqua vs Terra
    - similar but diff instruments — VIIRS vs MODIS Aqua
    - different retrieval assumptions — MISR vs MODIS
    - consistency of reference data-sets — AERONET
  - possible solutions
    - assess overlaping periods
    - tie to reference dataset (also over a gap)
    - pixel-level uncertainties; need harmonization
    - tie through geo data (with diurnal cycle)
    - good documentation/ std. naming & format
- do not get tempted by request for global trends

Some 10+ year passive satellite-based aerosol records in US

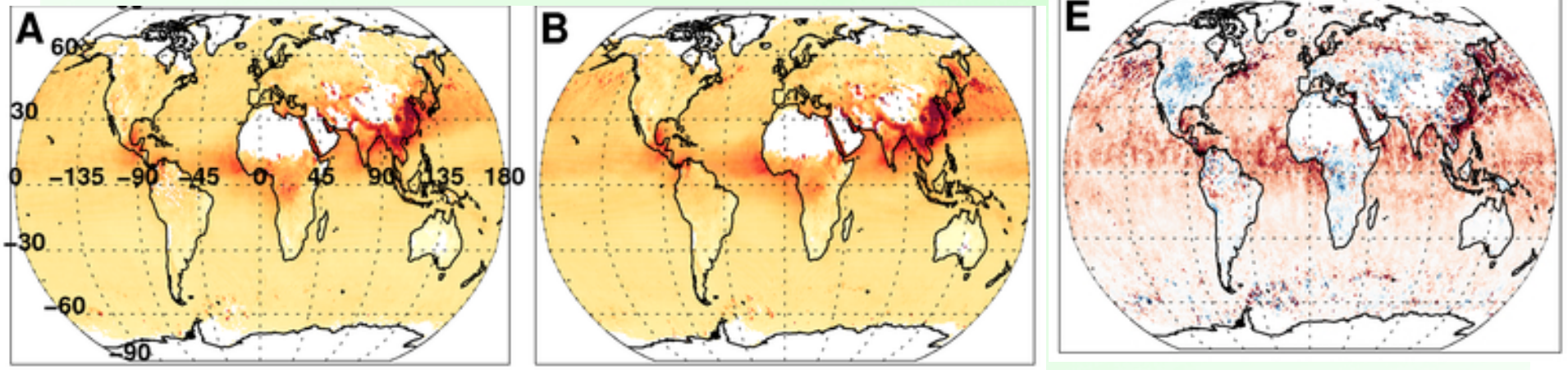
Variable(s)	Satellite	Time-Period	Who?
AOD (Dark-target) Ocean + land (dark)	MODIS → VIIRS	2000-?	GSFC
AOD (Deep-Blue) Land (all) + ocean	SeaWIFs/MODIS →VIIRS	1997-?	GSFC
AOD (DT +new) Ocean + Land (dark)	VIIRS --> JPSS	2012-?	NOAA-STAR
AOD (AVHRR)	AVHRR	1980s -	Various (NOAA)
UV-A **INDEX**	TOMS → OMI	1980s -	GSFC
SSA/AAOD (need z))	OMI	2005-	GSFC
AOD	MISR	2000-present	JPL/GSFC
Aerosol "**type**" ?	MISR	2000-present	GSFC
AOD AAOD size-dis	AERONET (ground!)	1990s-?	GSFC

from R.Levy's (GSFC) AeroSAT 2016 presentation

VIIRS vs MODIS

- **VIIRS is supposed to extend MODIS data**
  - **same DT retrieval applied after spectral adjust**

MODIS **VIIRS** **diff**

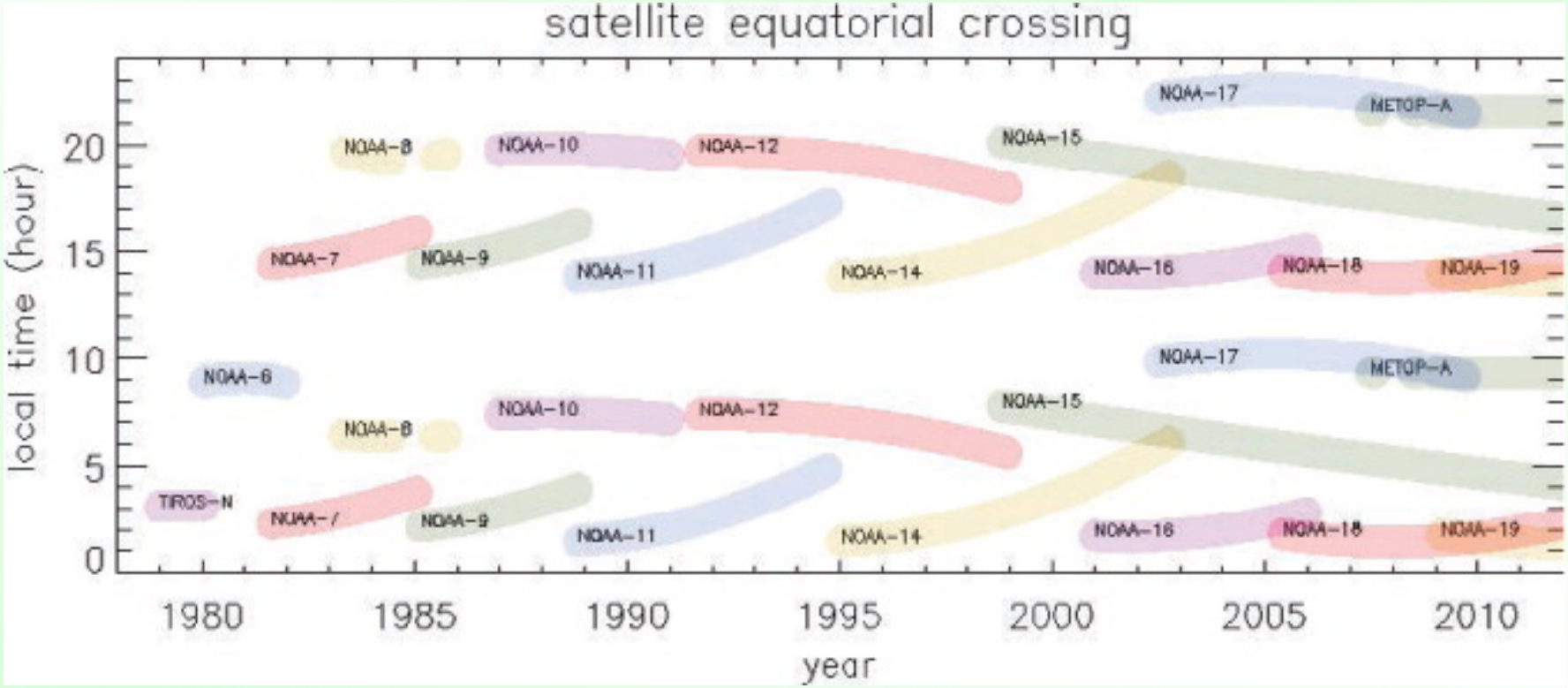


  - unfortunately … **a systematic bias over ocean**
    - **VIIRS higher by 20%**

from R.Levy's (GSFC) AeroSAT 2016 presentation

how to go back in time

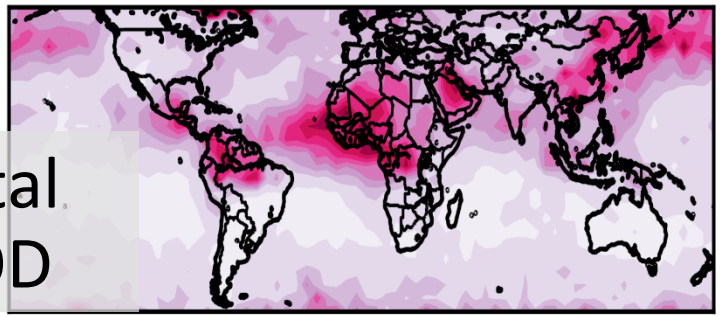
- **even more complicated**
  - **less capable sensors, poor calibration, drifts**



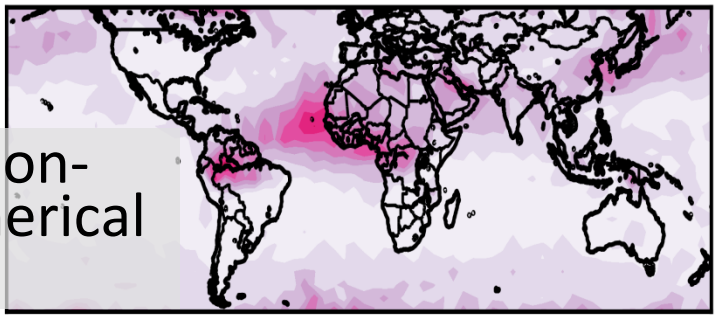
NOAA sensor drifts during lifetime (A,Heidinger 2014)

AOD interann. variability for spring

application: variability-yes, trends-no

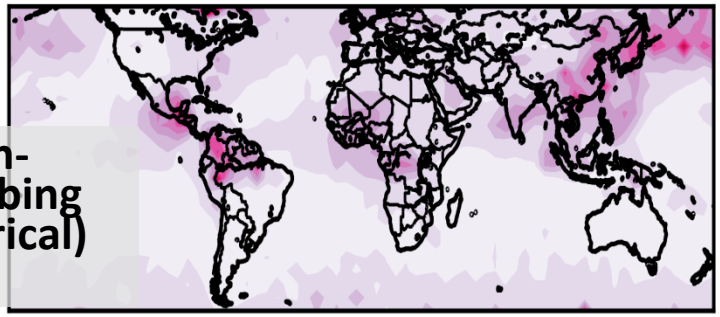


Total AOD

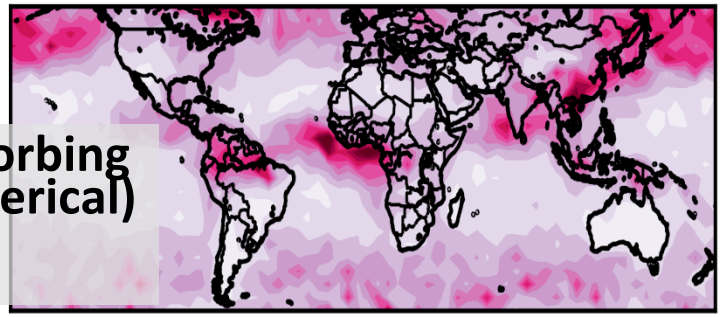


non-spherical

dust: off Africa



non-absorbing (spherical)



absorbing (spherical)

wildfires: boreal west Africa

16 years of MISR data

from H.Lee (JPL) AeroSAT 2016 presentation

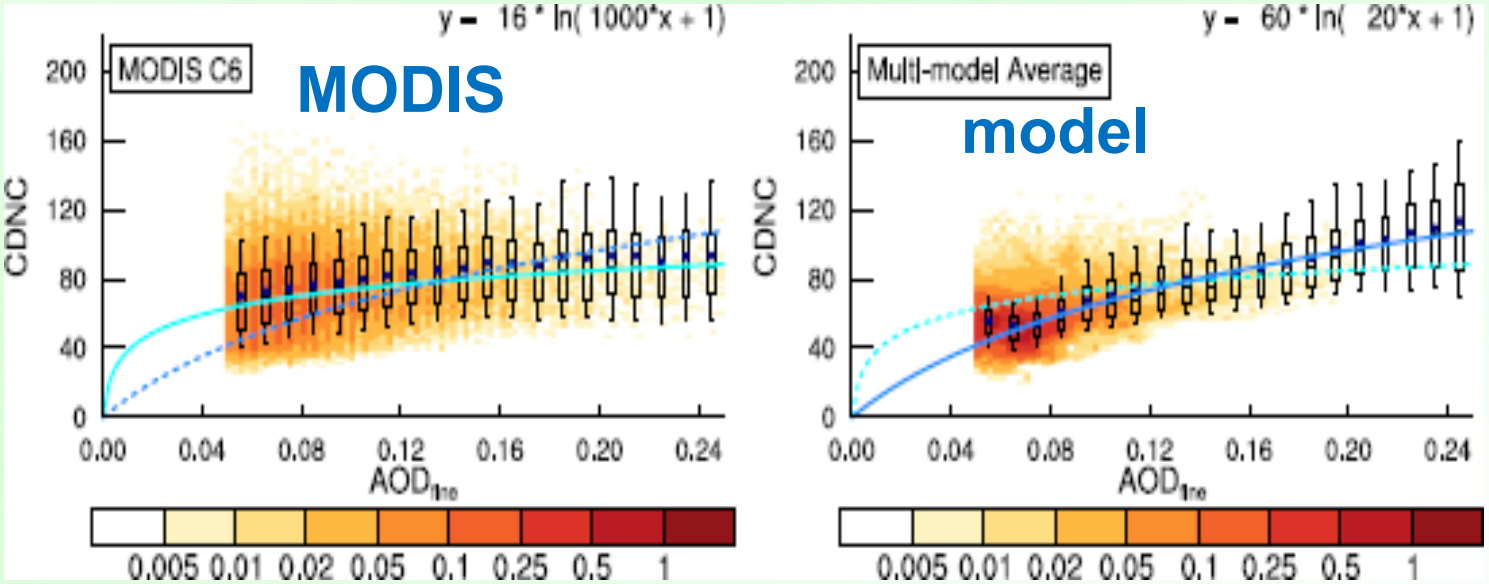
vs modeling

- larger AOD differences over
  - Sahara (notoriously diff over bright surfaces)
  - Australia (very low AOD retrievals
  - polar region: no data (except CALIPSO)
- need to document /reveal retrieval assumptions
  - aerosol model (absorption and size)
  - surface reflectance

simply make assumptions a retrieval output !

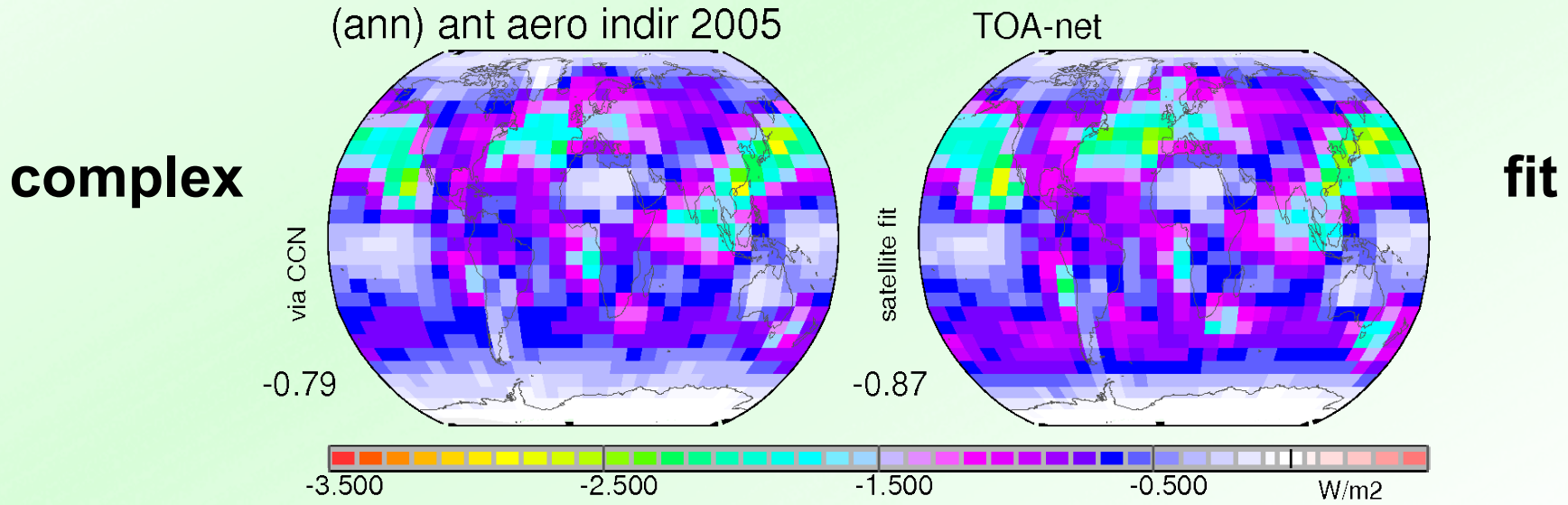
new challenges

- link aerosol retrievals to retrievals of other environmental properties to constrain models via relationships of joint histograms
- example: AOD fine (aero#) vs CDNC (drop#)



aerosol indirect (Tomey) effect

- application of observation based ‘median fit’
- d(CDNC) = ln(.001*AODf,today)/ln(.001*AODf,PI)
  - yield aerosol indirect forcing results compare well (pattern, strength) to complex pathways:
    - crit.radius, CCN, supersat, CCN vs CDNC



final slide

- the GEWEX report is a great resources
  - but mainly for older, circulated data-sets
  - but too large for quick answers to users
- the aerosol retrieval community now meets regularly to share ideas / interact with users
  - but multi-sensor capabilities are avoided
- for climate records
  - applying the same successful retrievals (e.g. dark target, tanre ocean) to different sensors