AEROSAT Perspectives
On Collaboration with Modelling

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AEROSAT Goals (1)

- **Work with modelers to make satellite aerosol data as useful as possible for climate modeling (e.g., AeroCom)**
- **Achieve open and active exchange of information**
  - Retrievals and their strengths and limitations
  - Match requirements of users to technical capabilities of the data
  - Share the latest technological advances
  - Work toward inter-operability (data formats, data standards)
- **Forum for satellite aerosol retrieval experts**
  - Learn from each other, collaborate as appropriate
  - Initiate new developments
  - Discuss harmonization

AEROSAT Goals (2)

- **Promote the use of satellite data**
  - As **complementary** to other sources of information
  - To better understand the role of aerosols in climate, climate change, air quality, and atmospheric processes
- **Forum includes satellite data users** (AEROCOM / CCMI models, ICAP forecasts) **and data providers** (AERONET reference, space agencies)
  - Listen to each others' needs and limitations
  - Discuss what is possible; Motivate new activities
  - Contribute to integration of satellite & suborbital observations
- AEROSAT is an unfunded network (like AEROCOM)

Challenges for Satellite Aerosol Remote Sensing

- Providing *Consistent, Global, 3-D Aerosol Amount and Type* products
- Providing *Quantitative, Credible Uncertainty Estimates*
- Producing *Long-term* satellite data records
- Applying satellite datasets to *Constrain* and/or *Validate Models*
- *Using Models* to supplement measured quantities
- Exploit satellite information content to constrain aerosol type
- Finding *CNN proxies*
- Using *Multiple Data Sources* to constrain models
- Providing *"Deliverables"* (results) on zero budget...

The Role of Satellite Retrievals

frequent, global *snapshots*; aerosol amount & aerosol type maps, plume & layer heights

Remote-sensing Analysis
- Retrieval Validation
- Assumption Refinement

Regional Context

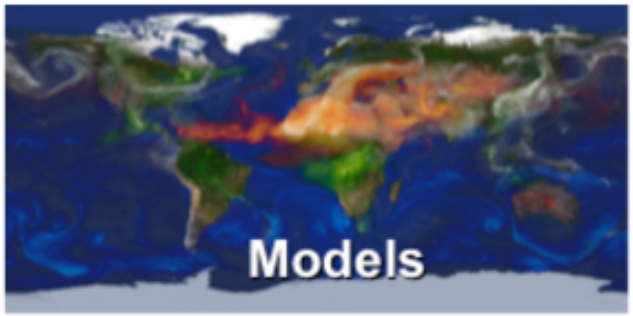
targeted chemical & microphysical detail

point-location time series

CURRENT STATE
- Initial Conditions
- Assimilation

Aerosol-type Predictions; Meteorology; Data integration

Model Validation
- Parameterizations
- Climate Sensitivity
- Underlying mechanisms



space-time interpolation,
Aerosol Direct & Indirect Effects
calculation and prediction

Must ***stratify*** the global satellite data to treat appropriately situations where **different physical mechanisms** apply

Adapted from: Kahn, Survy. Geophys. 2012

Perspectives on Collaboration with Modelers

- **Support model-satellite consistency**
  - Discuss + publish ***definition similarities & differences*** (Mod + Sat)
  - Provide ***aerosol typing information*** in a useful form
    -- Includes application of ***optical vs. compositional types***
  - Provide ***uncertainty characterization*** in a useful form

- **Guide the use of satellite datasets**
  - Provide a ***critical assessment*** of strengths and limitations
  - Provide harmonized ***quality statements***
  - Create ***data-record ensembles*** –> report the spread / confidence

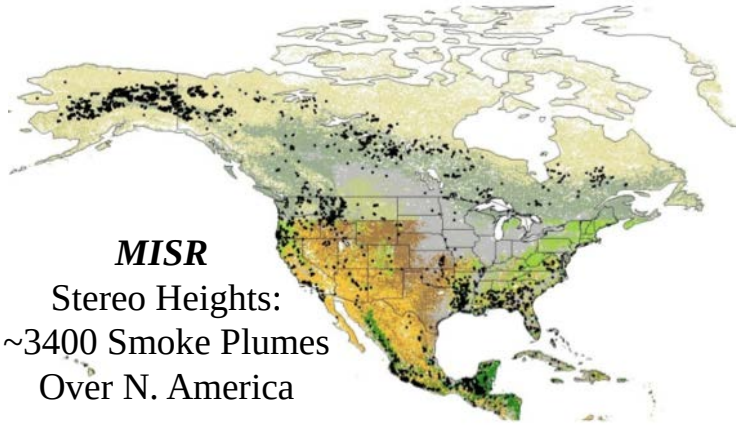
- **Experiments**
  - Involve modelling to tie evaluations to critical variables
  - Develop smart ways to integrate complementary information content

AeroSat in the First Four Years

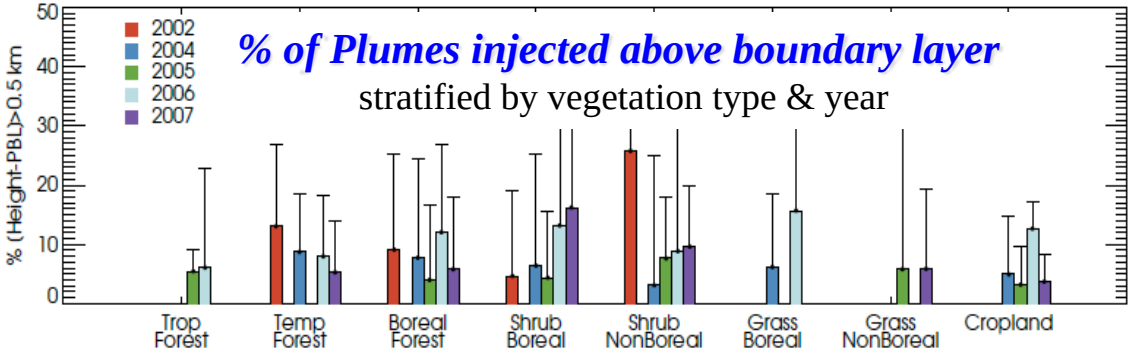
- **Joint Sessions with AeroCom**
  - Needs of modelers ←→ Possibilities & limitations of data producers
  - Common understanding of definitions
- **Internal Retrieval Expert Discussions**
  - Principles, *consistent definitions*, strengths / limitations
  - Constraining *aerosol type* with satellite data
  - Deriving *pixel-level uncertainties*
  - Producing *long-term* satellite data records
  - Satellite capabilities / limitations for *air quality applications*
- **Summary (draft) outcomes**
  - Intensified dialogue (among retrieval experts & with modelers)
  - List of long-term datasets
  - List of inter-comparison studies
  - Inventory of aerosol-type products & definitions
  - Review of validation metrics (linear regression; confidence intervals, etc.)
  - Major advances in assigning *pixel-level uncertainties*
  - Satellite constraints on *biomass burning injection height & source strength*

Wildfire Smoke *Injection Heights* & *Source Strengths*

[These are *the two key parameters* representing aerosol sources in climate models]

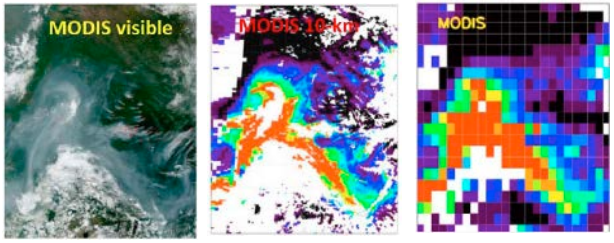


MISR
Stereo Heights:
~3400 Smoke Plumes
Over N. America

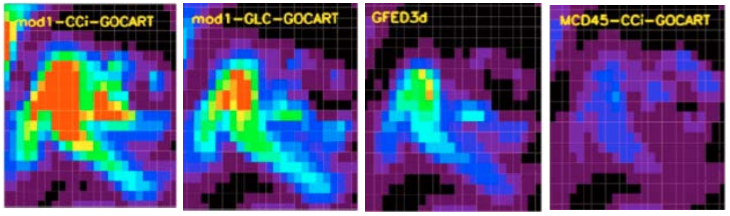


% of Plumes injected above boundary layer
stratified by vegetation type & year

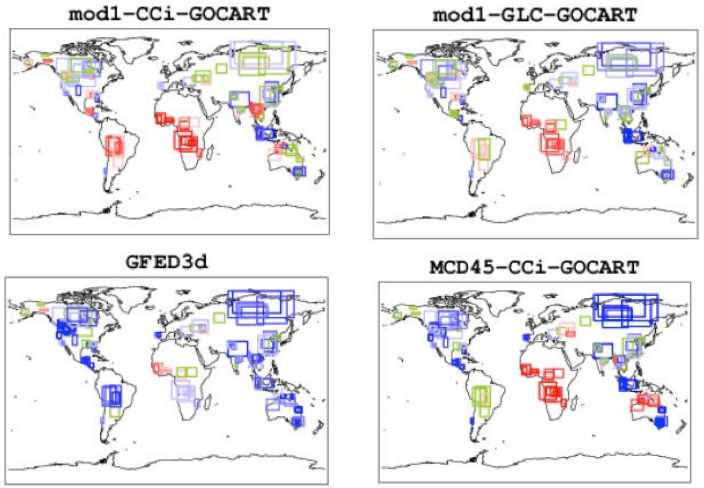
Val Martin et al. ACP 2010, 2012, 2018



MODIS Smoke Plume Image & Aerosol Amount Snapshots



GoCART Model-Simulated Aerosol Amount Snapshots
for *Different Assumed Source Strengths*

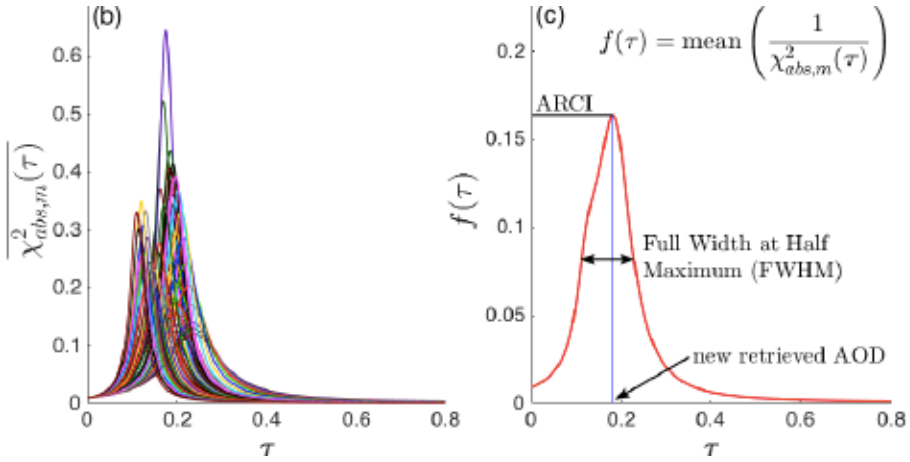


Different Techniques for *Assuming Model Source Strength*
Overestimate or ***Underestimate*** Observation
Systematically in Different Regions

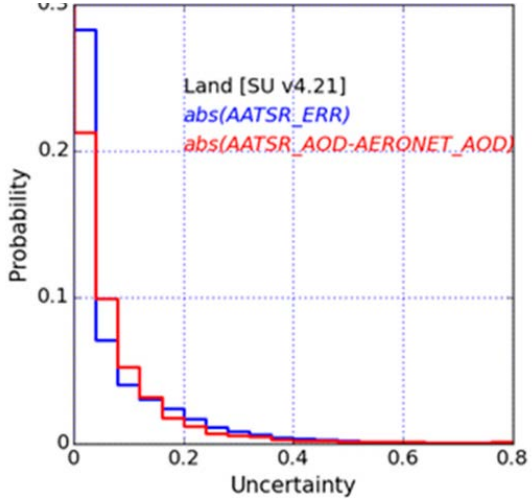
Petrenko et al., JGR 2012, 2017, 2018

Useful validation metrics

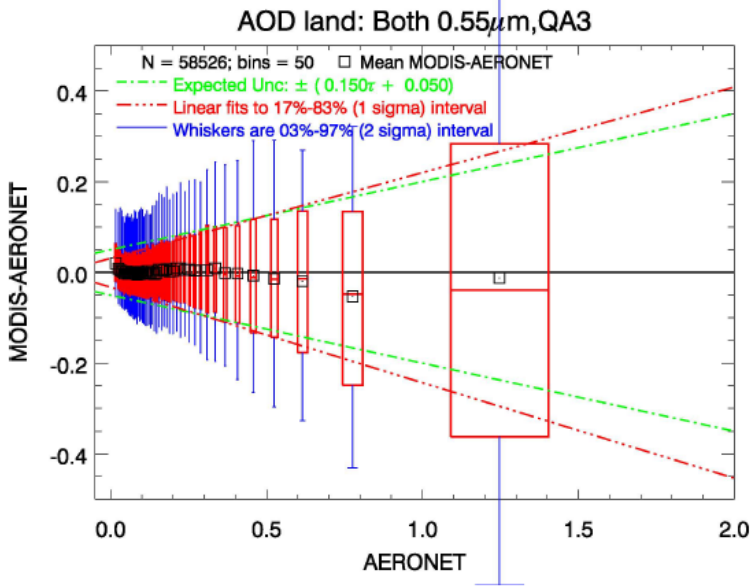
Inverse goodness-of-fit metric



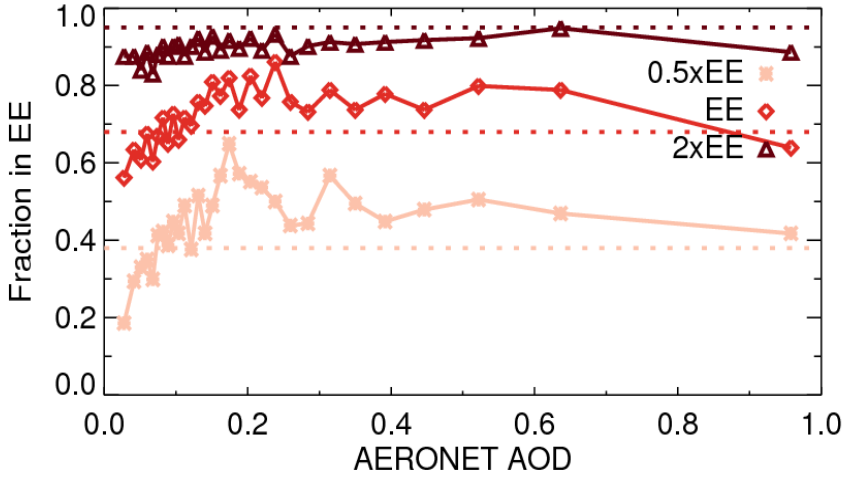
Compliance with uncertainty estimates



Error statistics as function of AOD



Fraction of pixels within error envelope



Modified from: Andrew Sayer, AEROSAT 2016 Beijing

New AeroSat (and AeroCom) Experiment Task groups (2017)

- ***Aerosol Retrieval Comparison*** [***Kinne, Schuttgens***]

- ***Characterizing retrieval uncertainties*** [***Sayer, Povey, Govaerts, Levy, Patadia, Witek, Kahn, Dubovik, Mei, Rozanov, Thomas, Kolmonen, Stebel, Limbacher, Lyapustin, Popp***]

- ***Joint Remote-Sensing AOD and Type*** [***Kinne, others***]

- Connecting ***model – satellite aerosol type*** [***Mona, Kahn, Tsigaridis***]

- Constraining ***Aerosol Vertical Distribution*** [***Winker, Kahn, Nowotnick, Colarco***]

- ***Consistent multi-sensor trends*** [***Sogachewa, Schulz, Popp***]

- ***CCN new approach*** [***Rosenfeld, Christensen, Bauer, Shanzuka, Stier***]

AeroSat 2018

- **Continue *Discussion* of Strengths & Limitations**
  - Help guide users dealing with larger / multiple datasets
    - Re-activate GEWEX assessment
    - Experiments to compare
    - How to judge / improve consistency?
  - Aerosol type
    - Progress on translation between satellite and modelling worlds

- **AeroSat Experiments**
  - Assess first set of experiments
  - Critical review of what is possible (unfunded)
  - Learn from AEROCOM

- **Possibilities for contributing to aerosol-cloud interaction studies**

- **GCOS statement of guidance / requirements**