MODIS Atmosphere Team Webinar Series #5: Overview of the 3 km aerosol product in Collection 6

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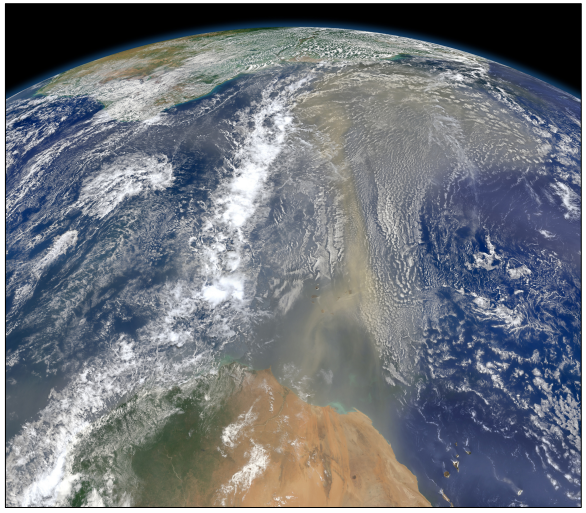
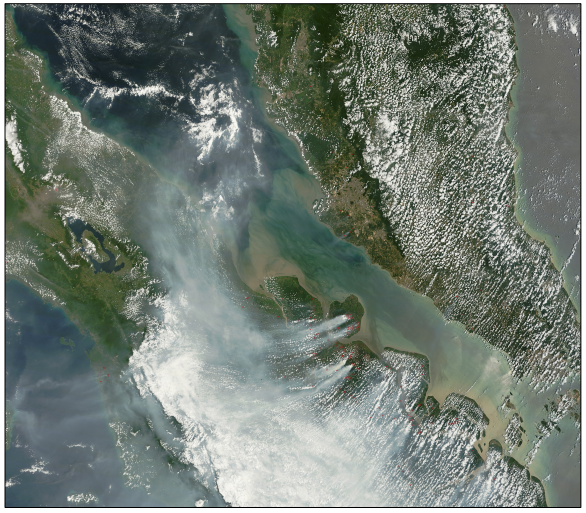
21 July 2014


Images from NASA Earth Observatory, http://earthobservatory.nasa.gov/

Atmosphere Team Webinar Schedule

http://aerocenter.gsfc.nasa.gov/ext/registration/

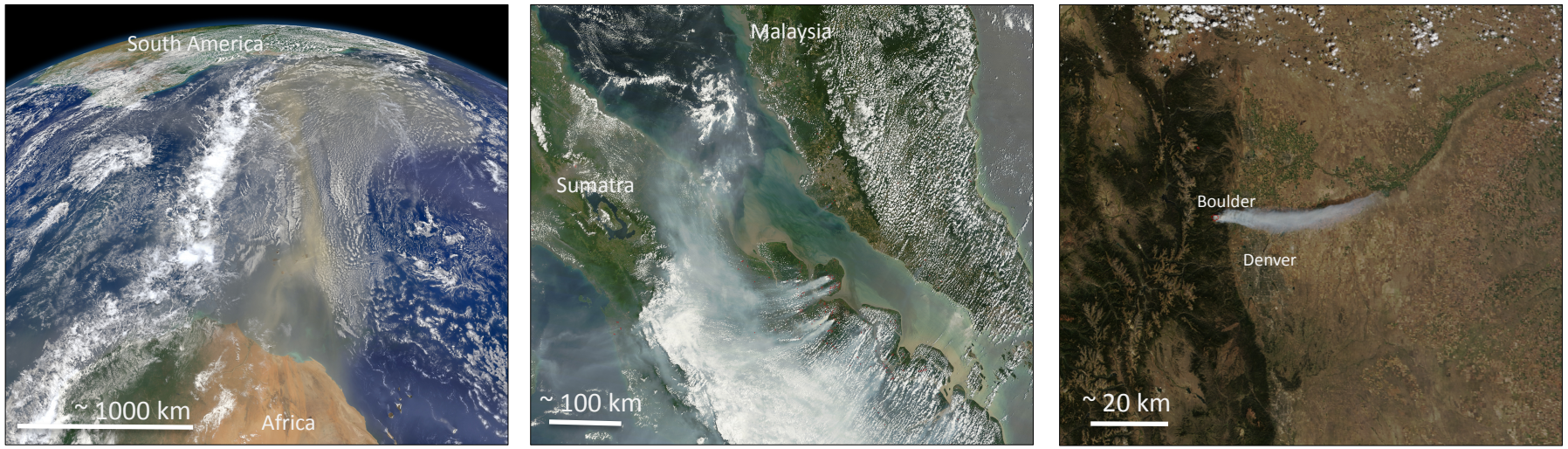
Topic	Presenter(s)	Date
Overview of Collect 6 update L1 Calibration Overview	Steve Platnick Jack Xiong	25-Jun-14
MODIS Dark Target Global 10 Km Product	Rob Levy	2-Jul-14
MODIS Aerosols Deep Blue	Andy Sayer	9-Jul-14
MODIS Aerosols Merged Dark Target: Deep Blue Product	Rob Levy / Andy Sayer	16-Jul-14
MODIS Dark Target 3 Km Product	Leigh Munchak	23-Jul-14
MOD035 Cloud Mask and Clear Sky Products atmosphere profile and clear sky radiance maps	Steve Ackerman	13-Aug-14
MOD06 Cloud Top Properties Product	Paul Menzel	20-Aug-14
MOD06 Cloud Optical Properties Product	Steve Platnick	27-Aug-14
MOD08 Level 3 Product	Steve Platnick / Bill Ridgway	3-Sep-14
Archives/Data Acquisition: LAADSWEB, MIRADOR, ECHO-Reverb	To Be Determined.	10-Sep-14
MODIS Atmosphere Educational Materials & Resources	Richard Kleidman	17-Sep-14
Giovanni - Aerosols Express	Jim Acker	24-Sep-14
MAIAC 1 Km Aerosol Product	Alexei Lyapustin	01-Oct-14

Outline

1. Motivation
2. Overview (where this new 3 km products fits in the MODIS structure)
3. Aerosol retrieval strategy and modifications for 3 km
4. Initial results and validation

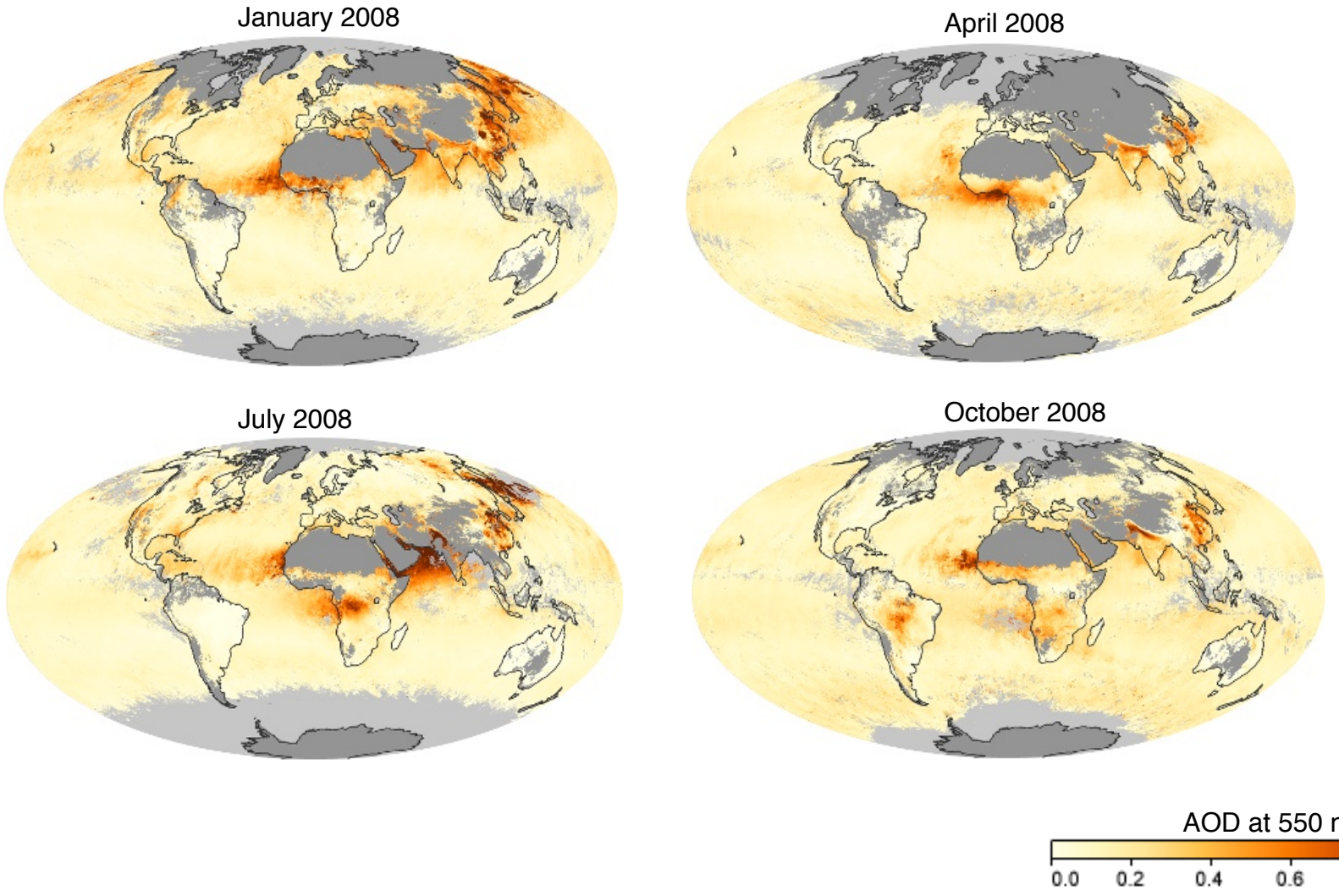
Motivation

Aerosols vary on global, regional, and local scales



It is difficult to pick one appropriate spatial scale for the variety of aerosol phenomena on Earth

The MODIS aerosol products were originally designed for climate applications. The 10 km spatial scale of the aerosol product reflected that application.

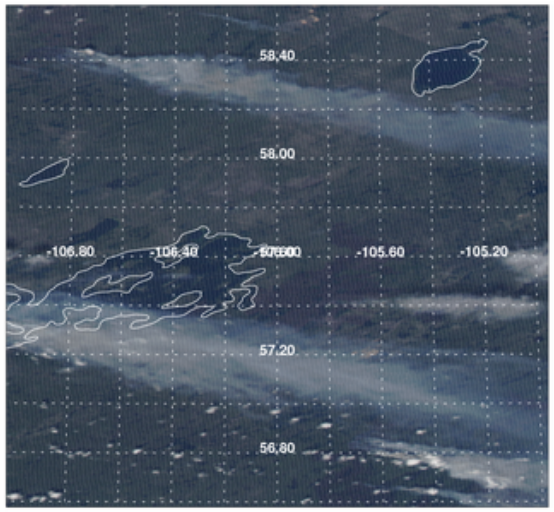


The problem : Fine scale features are not always adequately resolved by the 10 km spatial scale.

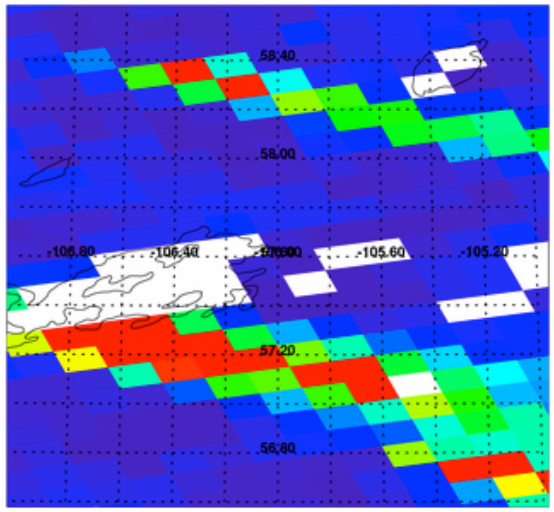
But, 10 km scale sometimes required to ‘beat down noise’

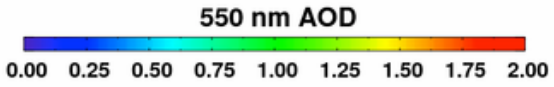
Solution? Introduce a new product at 3 km, while maintaining the original 10 km product as well.

MODIS RGB

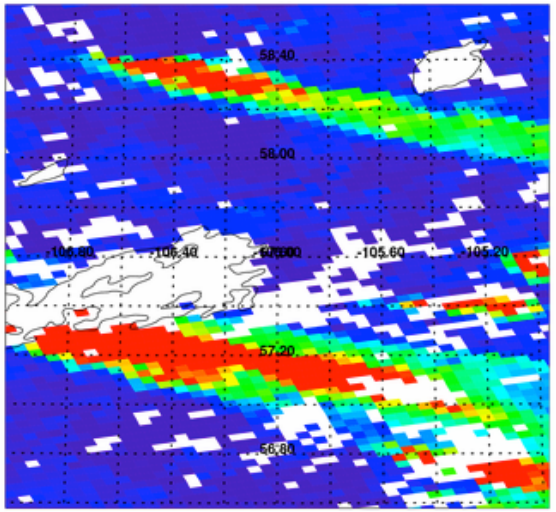


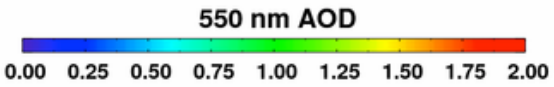
MODIS 10 km AOD





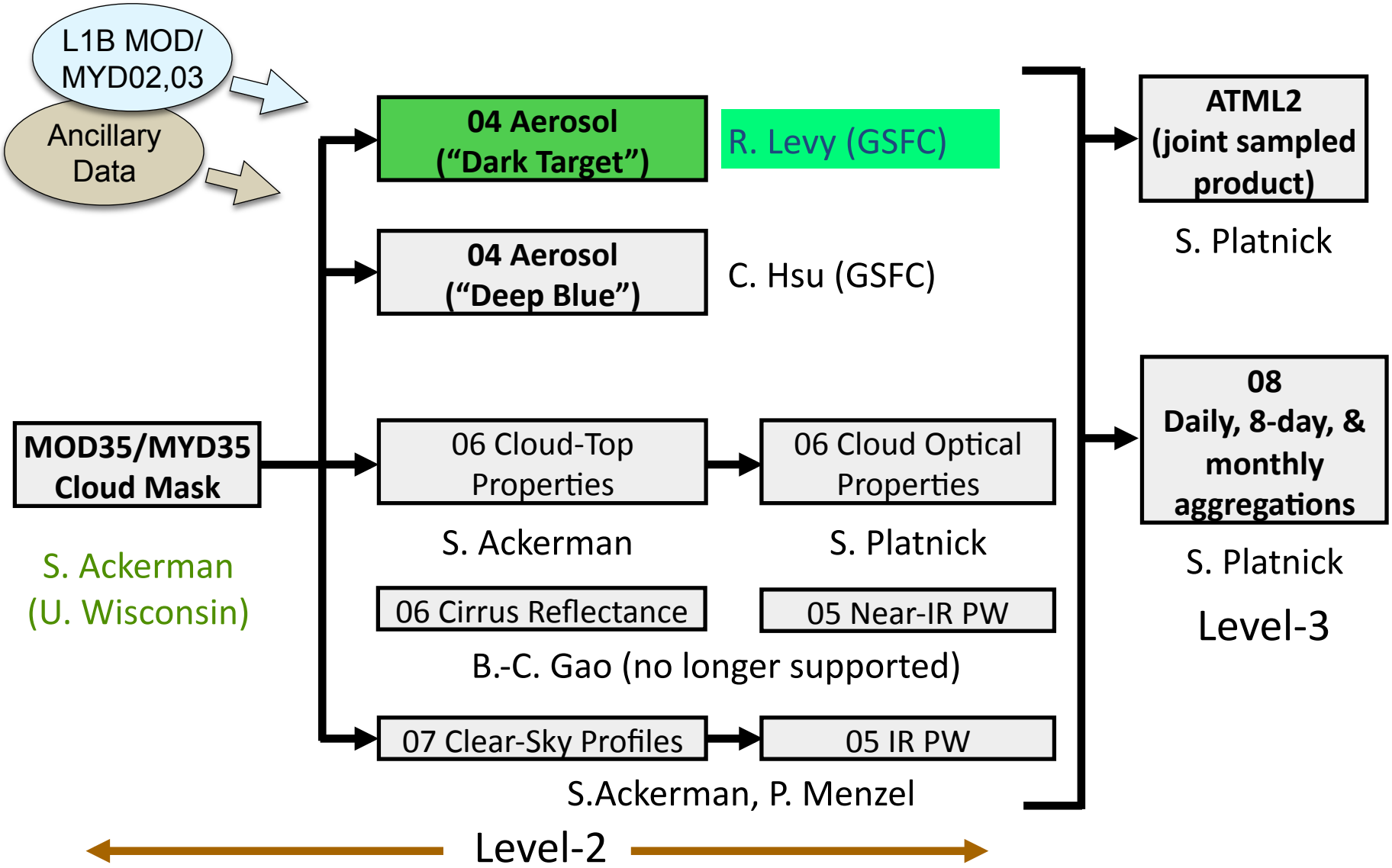
MODIS 3 km AOD





3 km product in the MODIS Architecture

MODIS Atmosphere Team Product Organization and People



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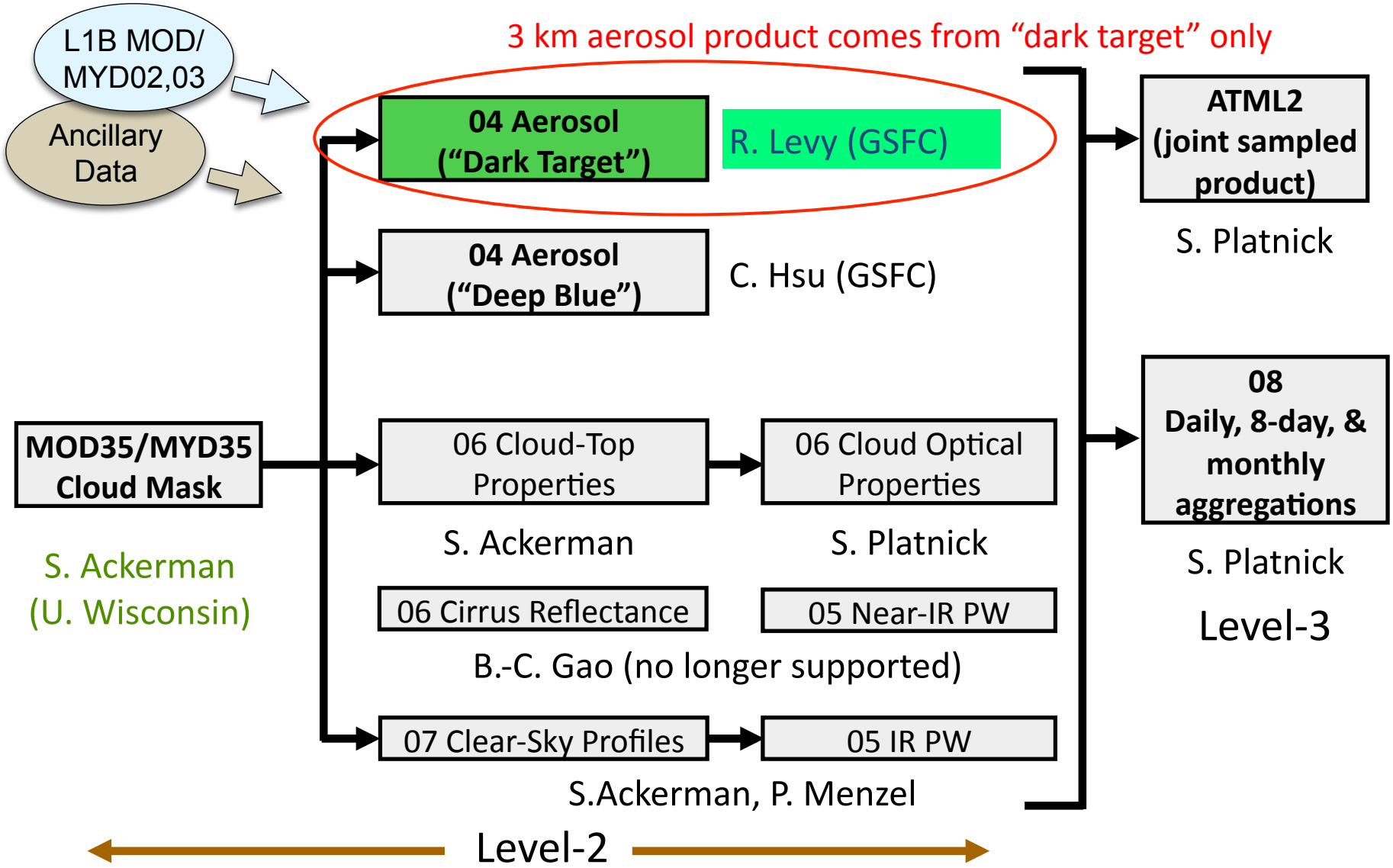

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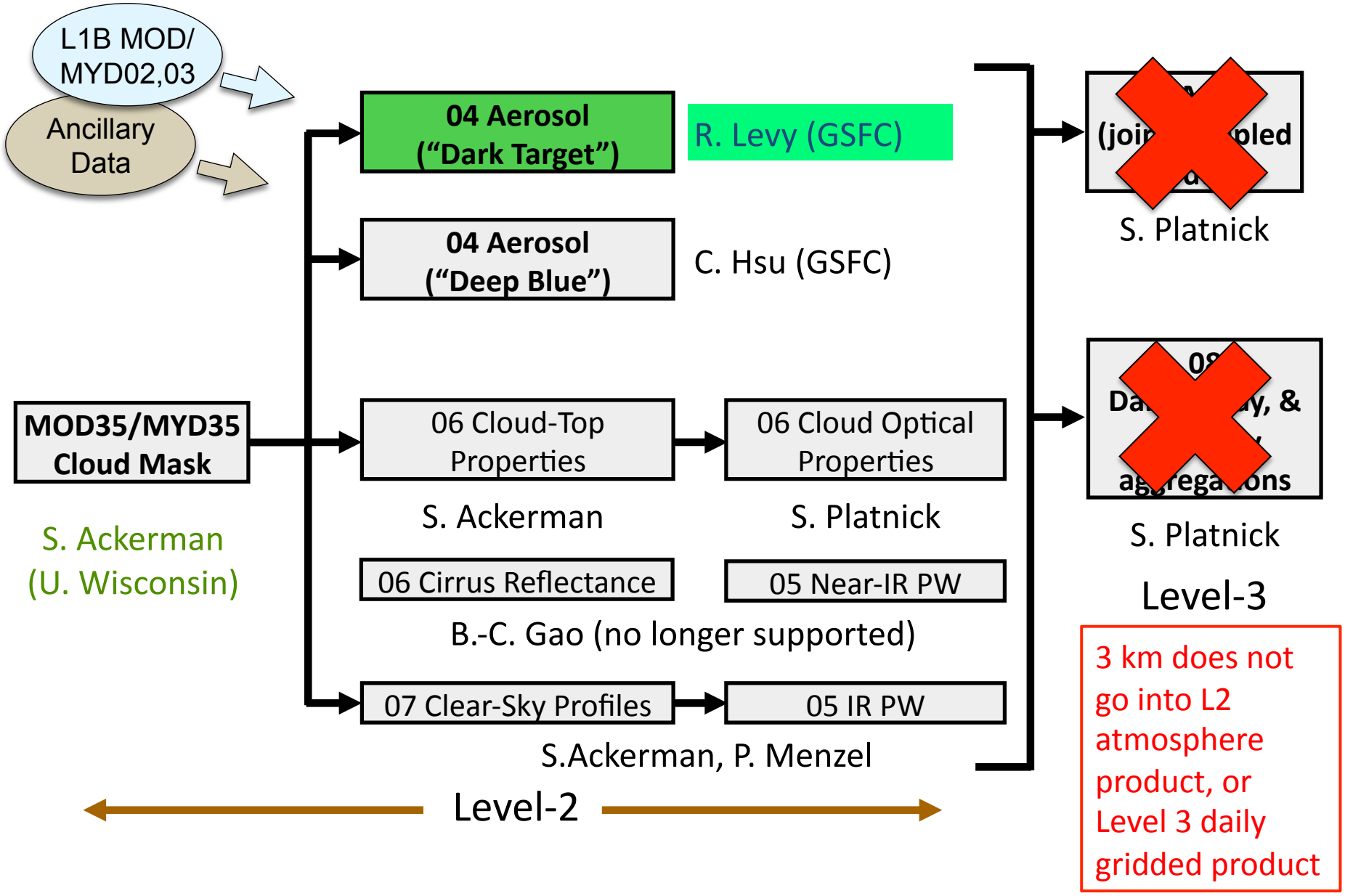

MODIS Standardized Filenaming Convention

NASA Earth Science Data filenames for MODIS

10 km aerosol product:
MxD04_L2.AYYYYDDD.HHMM.CCC.YYYYDDDHHMMSS.hdf

3 km aerosol product:
MxD04_3K.AYYYYDDD.HHMM.CCC.YYYYDDDHHMMSS.hdf

Definition of highlighted text:

MxD04 = Earth Science Data Type name (this is code for the "aerosol" product)

x = "O" for Terra or "Y" for Aqua

L2 = Denotes a Level-2 product (or L3 for Level-3, etc.). Changed to 3K for 3 km product.

A = indicates following date/time information is for the acquisition (observation)
YYYYDDD = acquisition year and day-of-year
HHMM = acquisition hour and minute start time
CCC = collection (e.g., '006' for Collection 6)
YYYYDDDHHMMSS = production data and time
hdf = denotes HDF file format

Status of MODIS C6 Production

- L1B exists for both Terra and Aqua (MxD02 and MxD03)
- Cloud Mask (MxD35) and Atmospheric Profile (MxD07) exist for both Terra and Aqua
- Processing of MYD04_3K products from Aqua MODIS started on 12-06-2013 and has completed.
  - Aqua L3 expected to begin soon
  - Terra reprocessing to start after completion of Aqua L3
- Both C6 and C5 processing streams will continue in parallel for about a year before being exclusively C6.
- Aerosol algorithm has been ported to work on Near Real Time (NRT from LANCE). 3 km product will be produced in NRT. I don't know the schedule for production

Aerosol algorithm and modifications for 3 km

Aerosol Algorithm Overview

Our aerosol remote sensing retrieval algorithm has multiple phases:

1. Organizing Level 1B radiance data into 10 km boxes for each 5 minute granule.
2. Removing distortion (gas absorption, angular effects) from the satellite signal
3. Deciding whether over “land” or “ocean”
4. Separating signal (aerosol) from noise (clouds, surface inhomogeneities, instrument issues, etc), includes “cloud masking”
5. Correctly interpreting the signal to AOD and aerosol size. “the retrieval”
6. Assigning quality assurance, reporting retrieved, derived, and diagnostic products. “the post-process”

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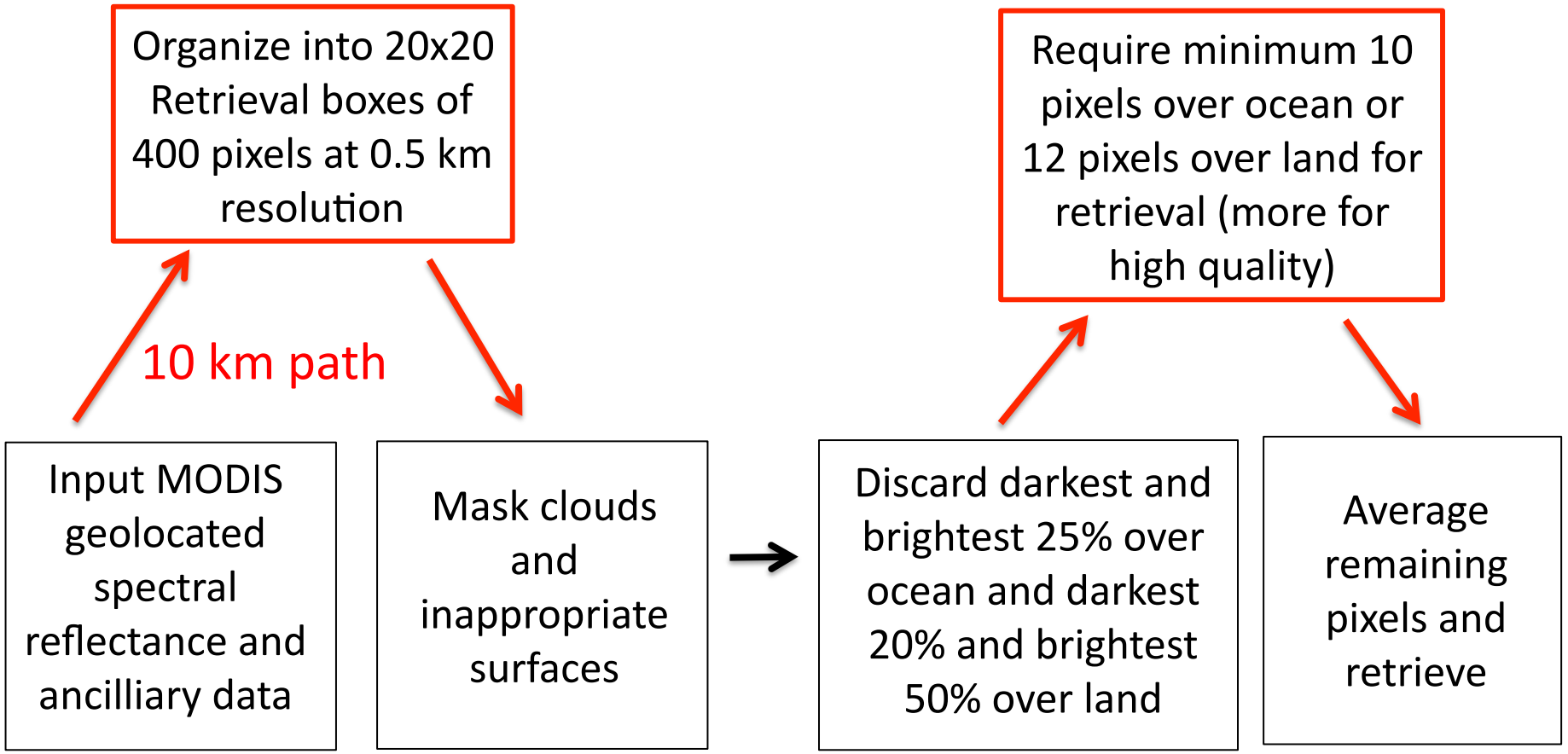
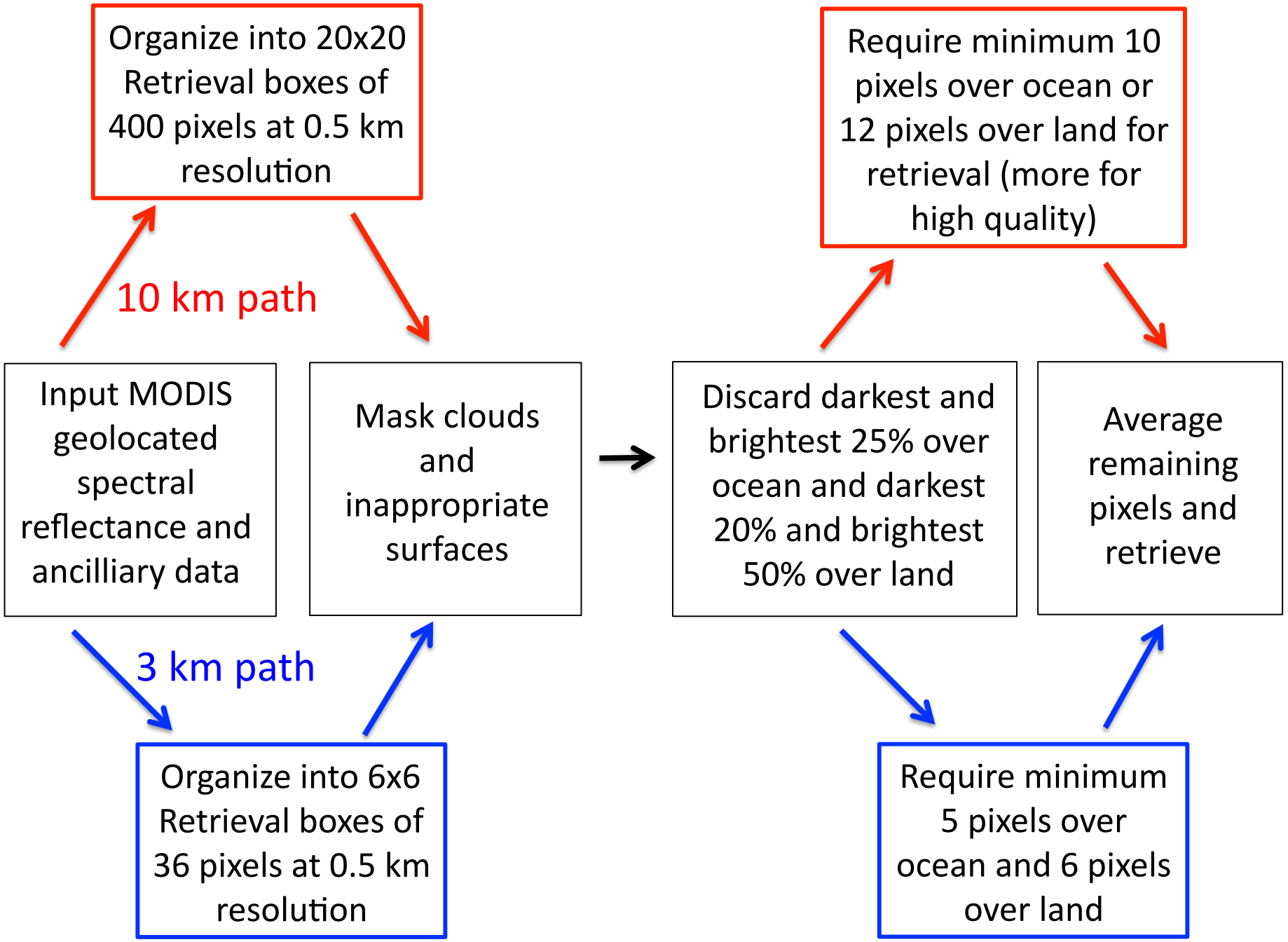
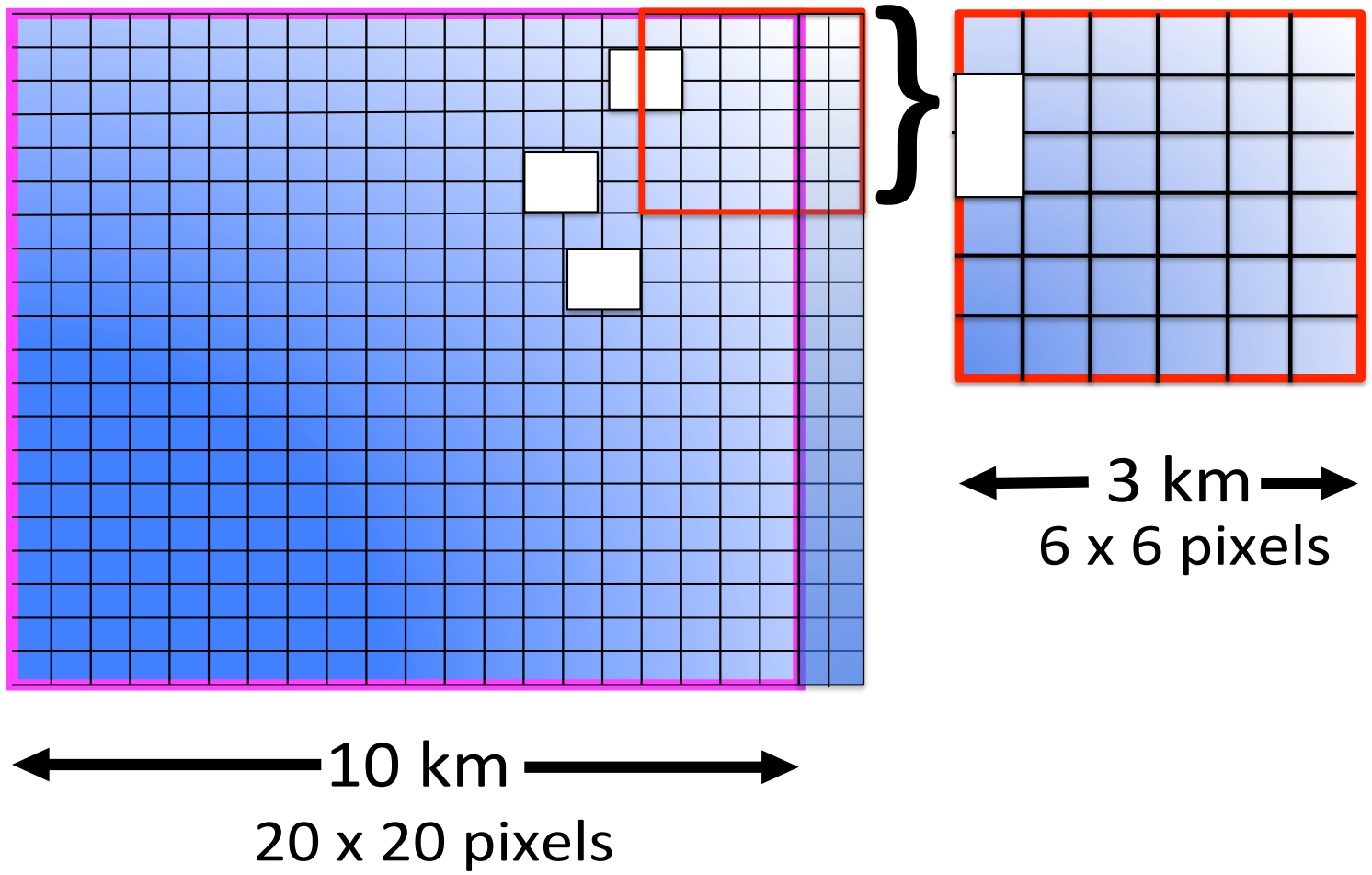
Only changes in the 3 km algorithm



This is a simplification. See Robert Levy's dark target aerosol product webinar for the nitty gritty details (http://modis-atmos.gsfc.nasa.gov/Webinar2014/MODISAtmWebinar2LevyDT.pdf)


Organize into 20x20 Retrieval boxes of 400 pixels at 0.5 km resolution
10 km path
Input MODIS geolocated spectral reflectance and ancilliary data
Mask clouds and inappropriate surfaces
3 km path
Organize into 6x6 Retrieval boxes of 36 pixels at 0.5 km resolution
Discard darkest and brightest 25% over ocean and darkest 20% and brightest 50% over land
Require minimum 10 pixels over ocean or 12 pixels over land for retrieval (more for high quality)
Average remaining pixels and retrieve
Require minimum 5 pixels over ocean and 6 pixels over land

Pixel selection strategy



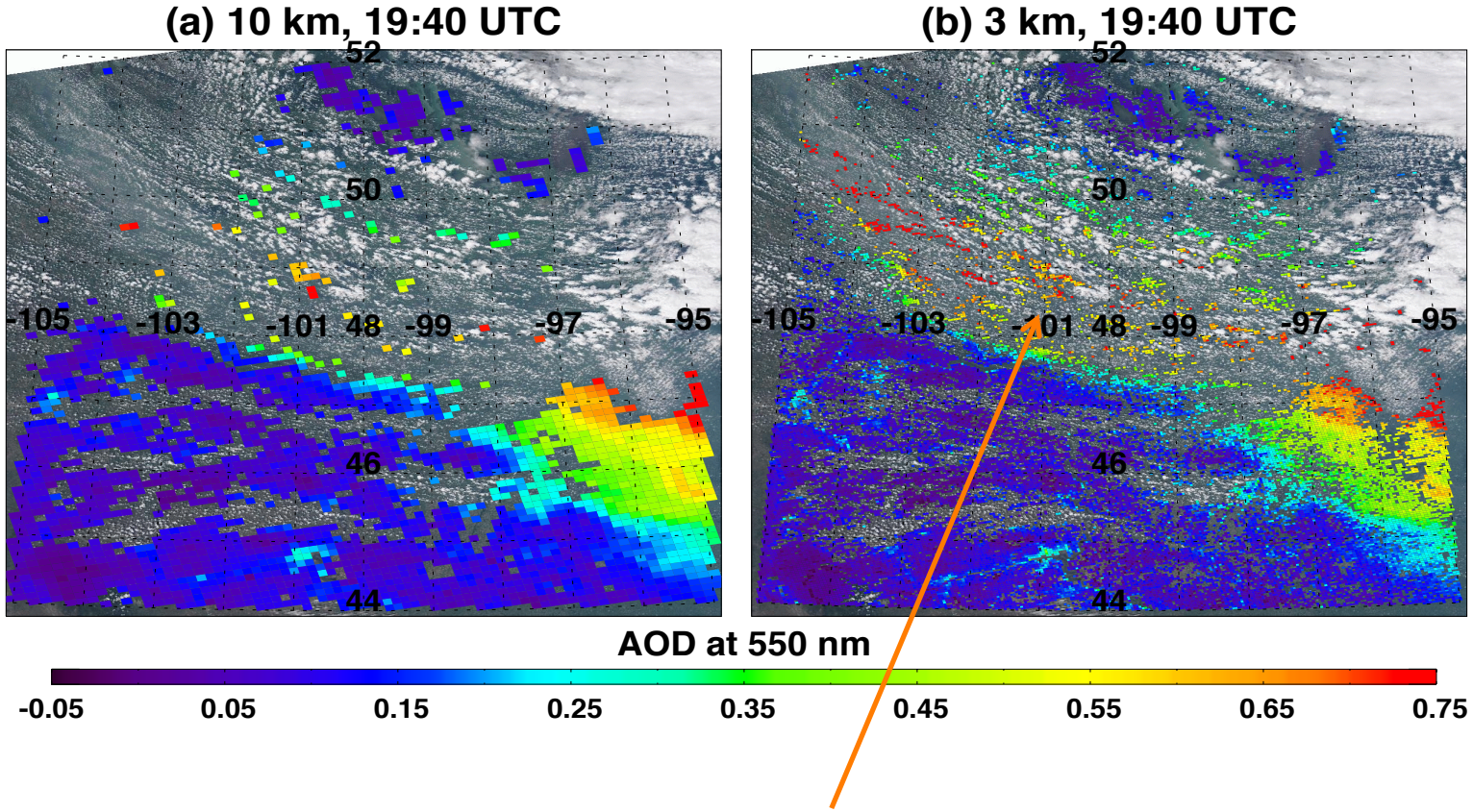
The only differences between the two algorithms are:

1) The size of the pixel-arrays defining each retrieval box
2) The minimum percentage of “good” pixels required for a retrieval.
3) 10 km algorithm will attempt a “poor quality” retrieval, 3 km algorithm will not

Everything else is the same!

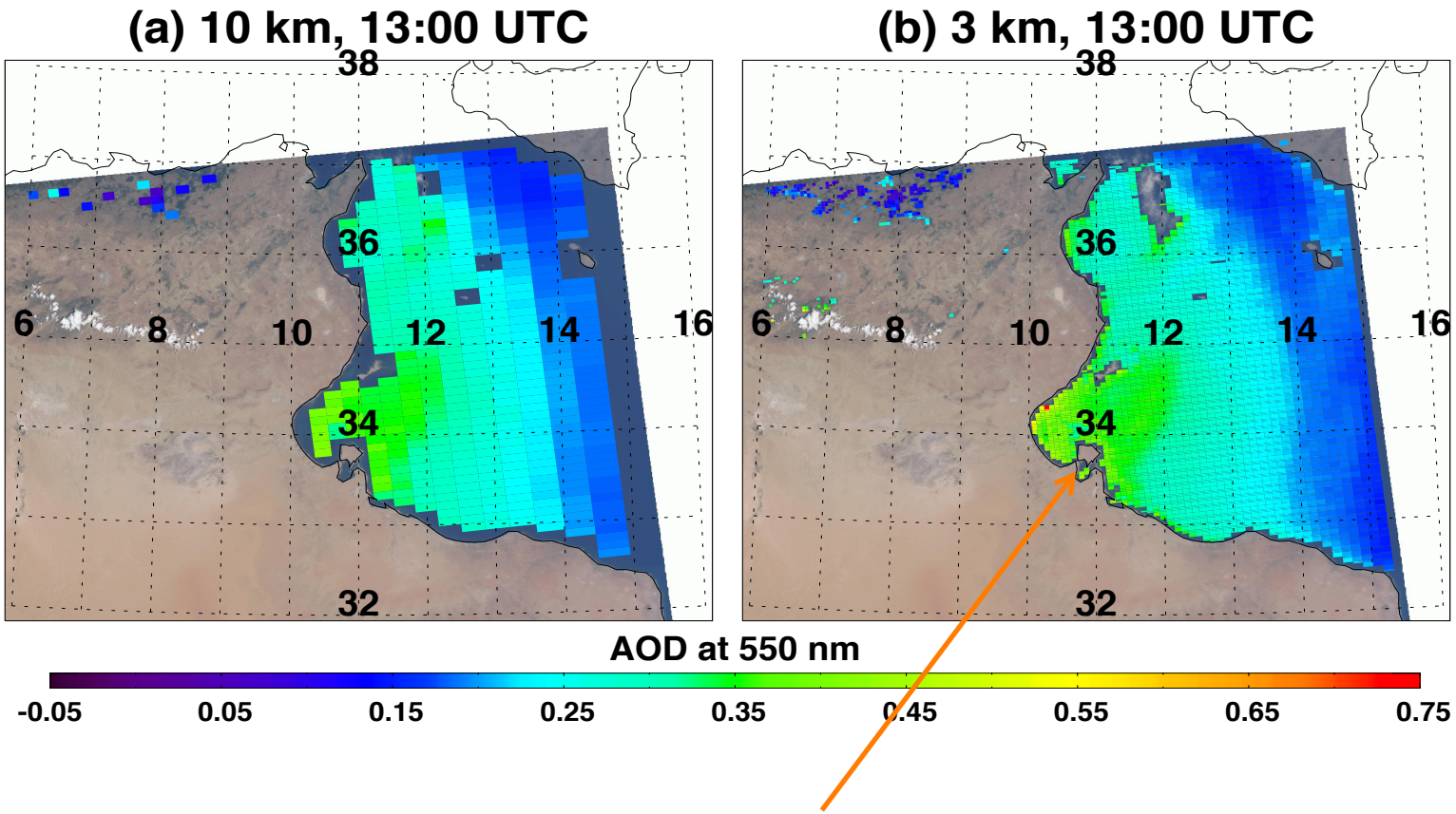
Initial results and validation

Example granules



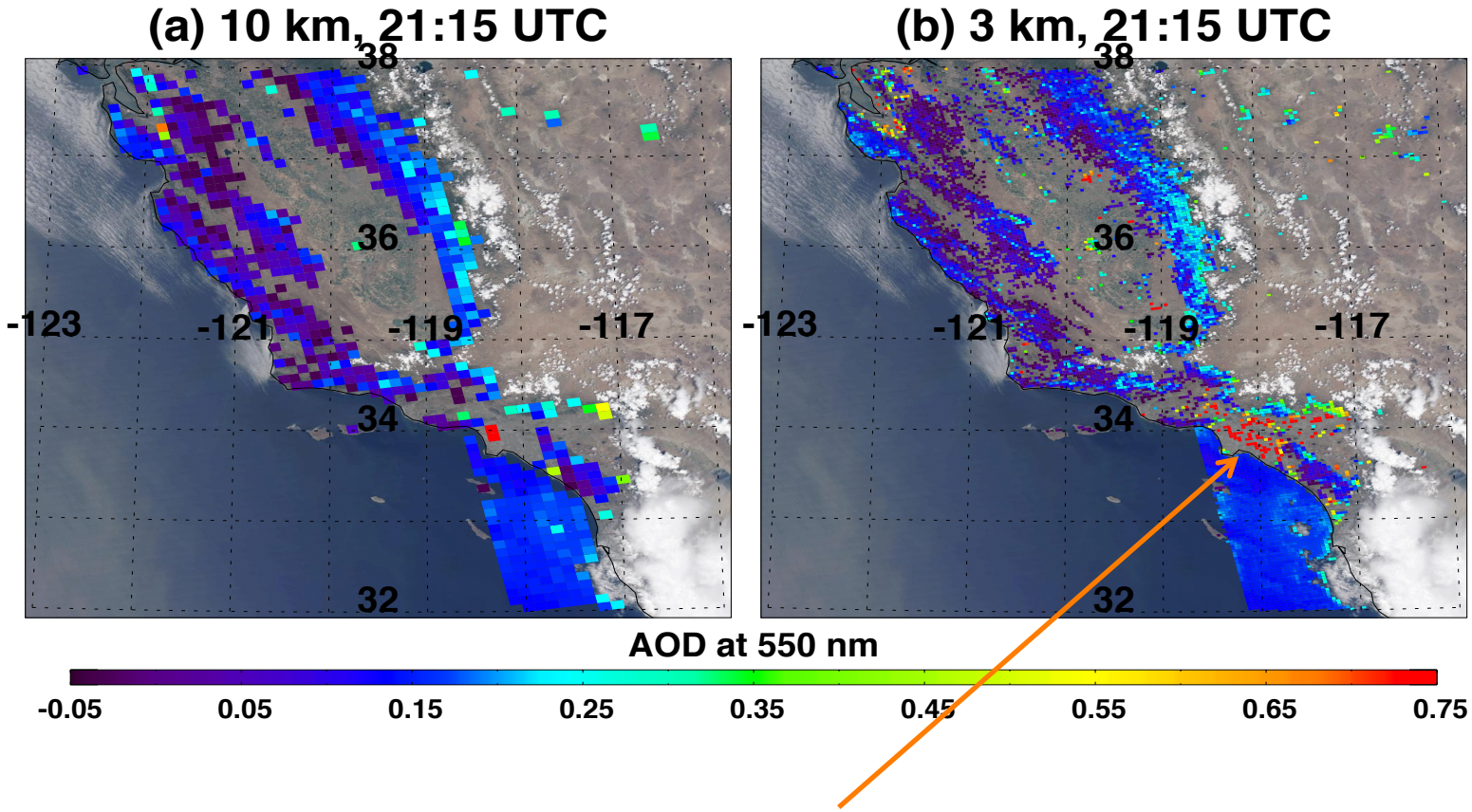
3 km product better resolves smoke plume through broken clouds

Example granules



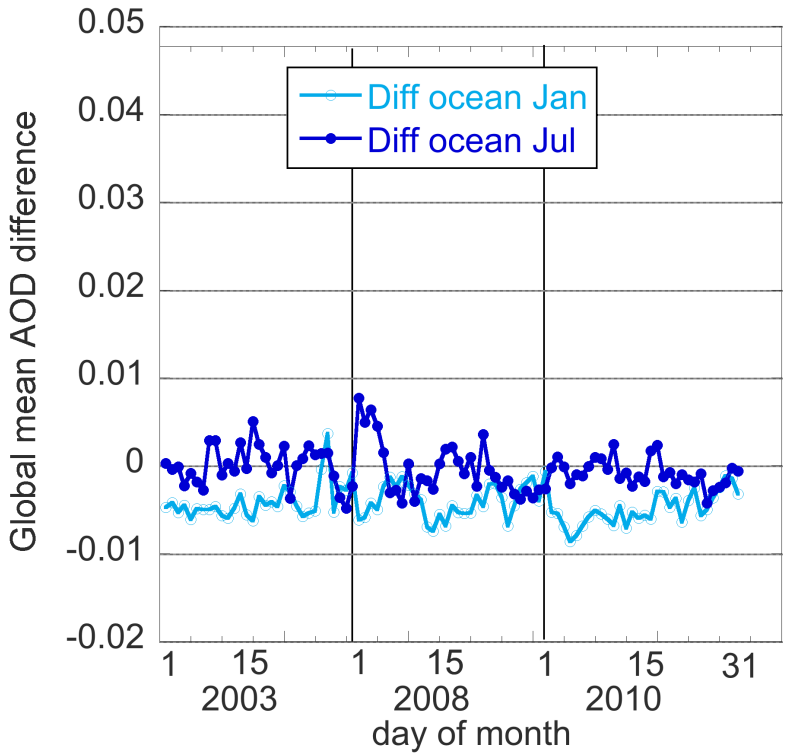
3 km product retrieves closer to islands and coastlines

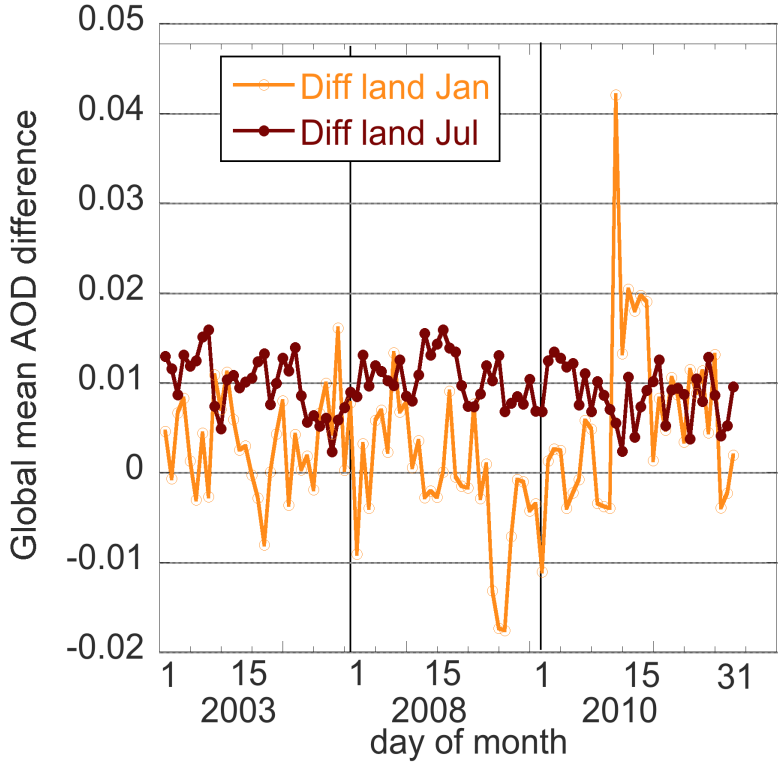
Example granules



3 km product tends to be noisier than 10 km

Comparison of global mean AOD from 10 and 3 km

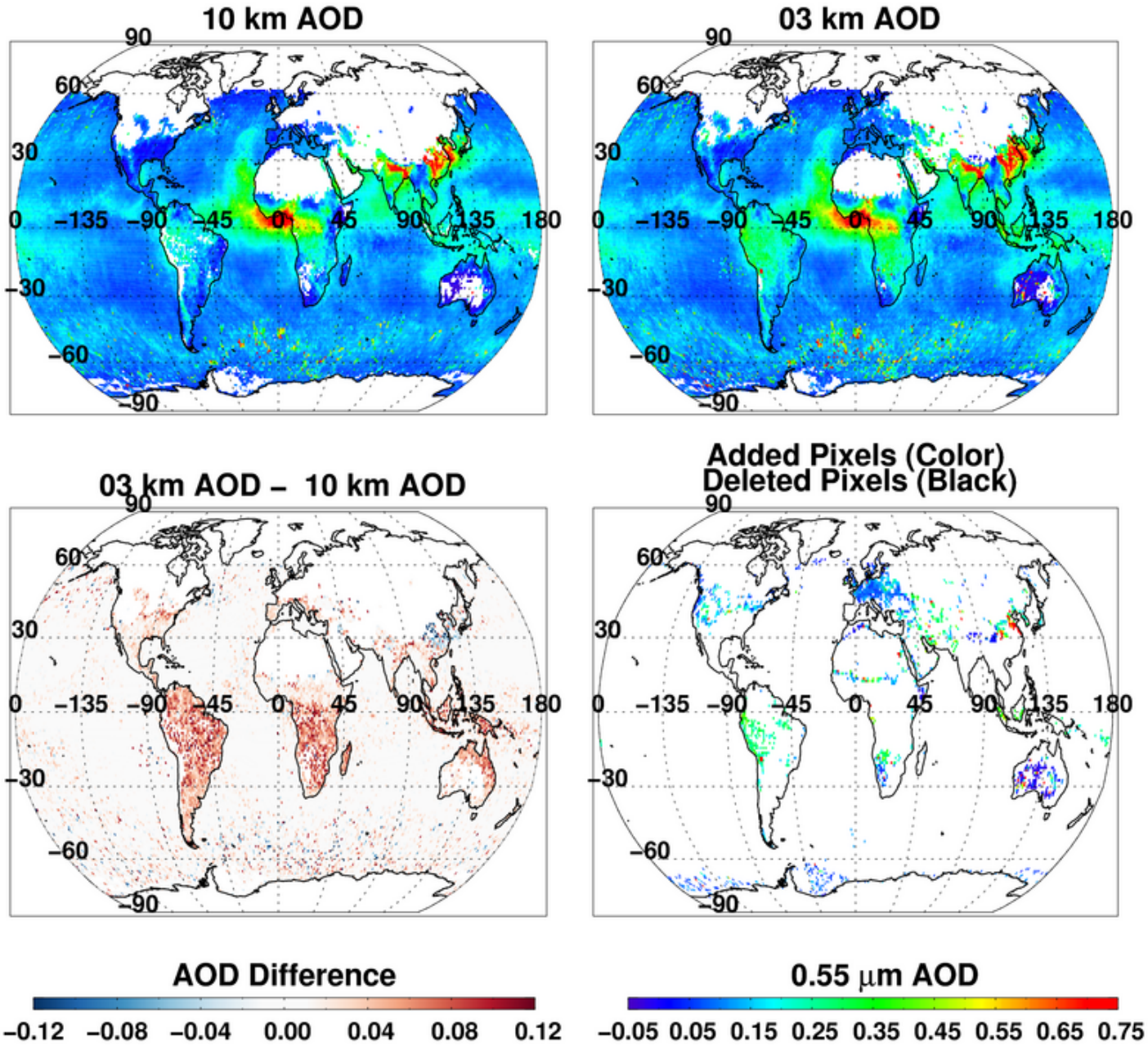




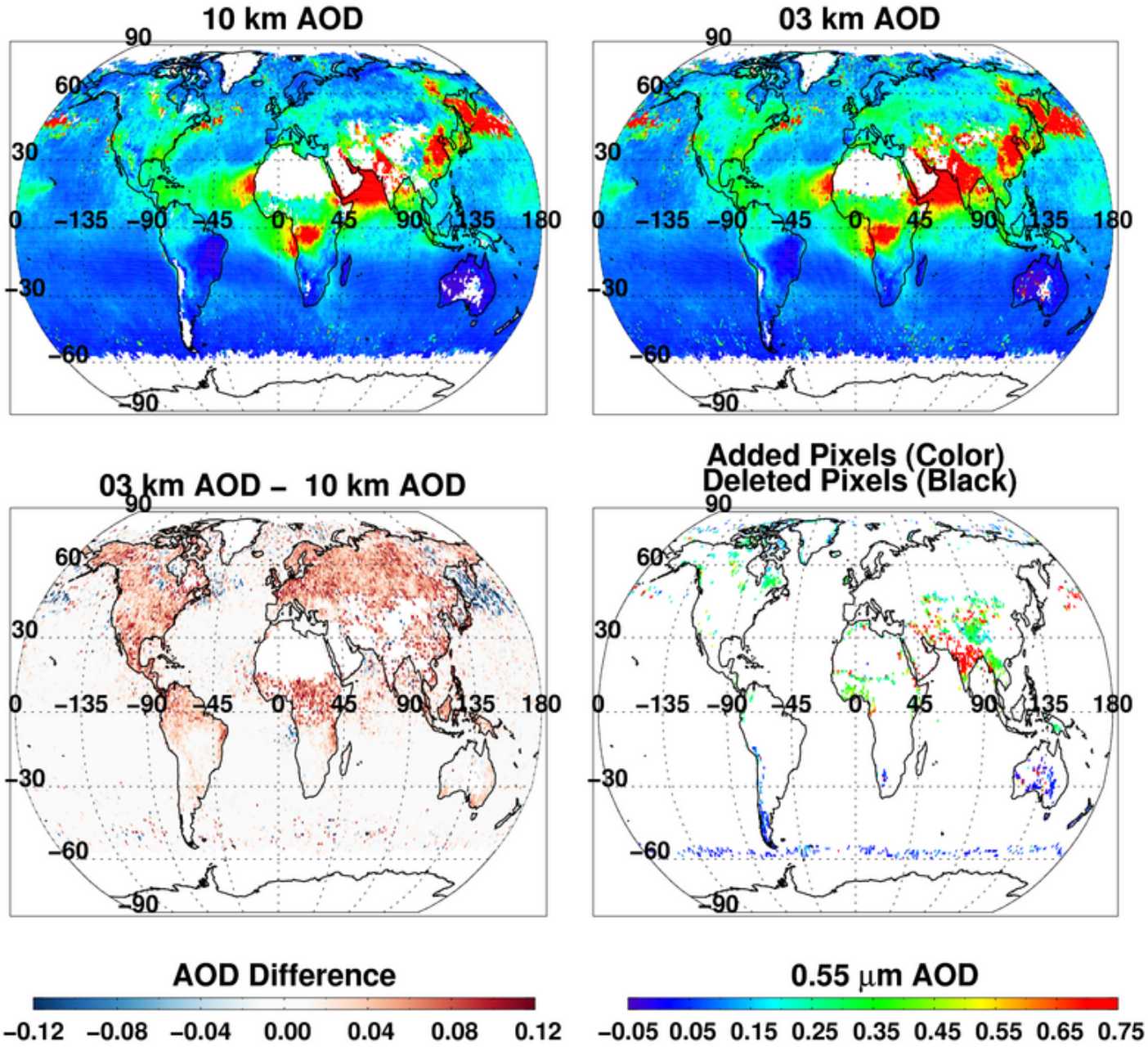
Globally, 3 km AOD is 0.01 to 0.02 higher than 10 km AOD over land.

Proportionally greater number of very low AOD retrievals in 3 km product over ocean

January 2008

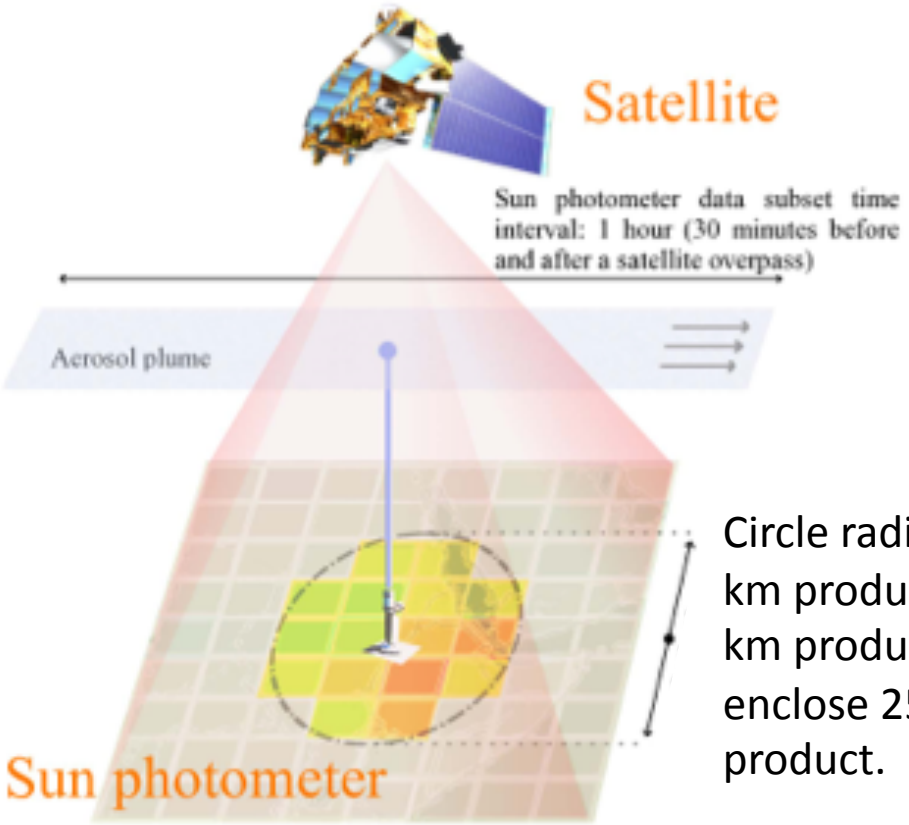


July 2008


10 km AOD
03 km AOD
03 km AOD – 10 km AOD
Added Pixels (Color)
Deleted Pixels (Black)
90
60
30
0
−30
−60
−90
−135
−90
−45
0
45
90
135
180
AOD Difference
−0.12 −0.08 −0.04 0.00 0.04 0.08 0.12
0.55 μm AOD
−0.05 0.05 0.15 0.25 0.35 0.45 0.55 0.65 0.75

Validation strategy

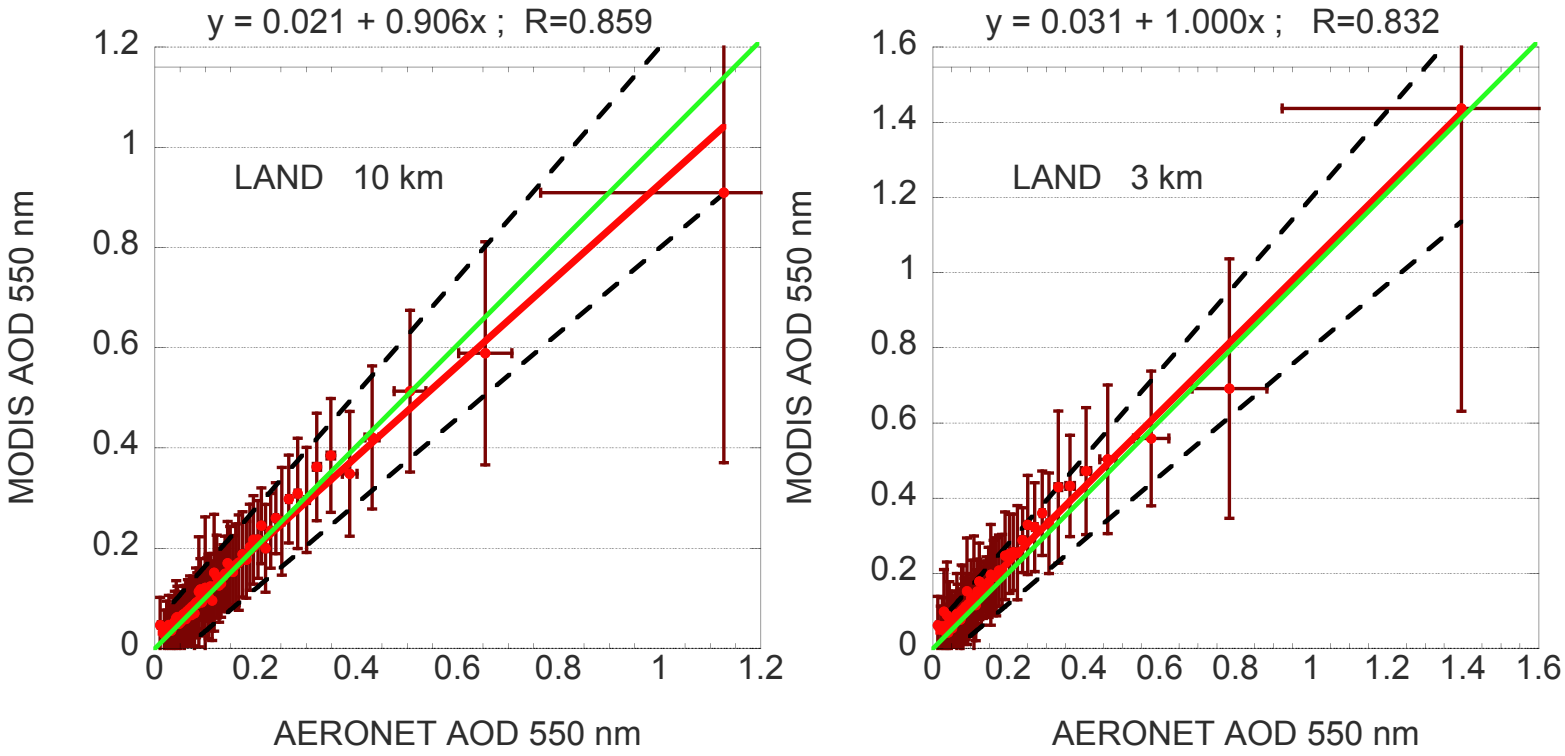
Satellite measures AOD in an area around the sun photometer, while the sun photometer measures AOD at a point throughout time. Spatio-temporal averaging is employed to compare the two measurements.



Circle radius is 25 km for 10 km product and 7.5 km for 3 km product. Each circle will enclose 25 pixels of each product.

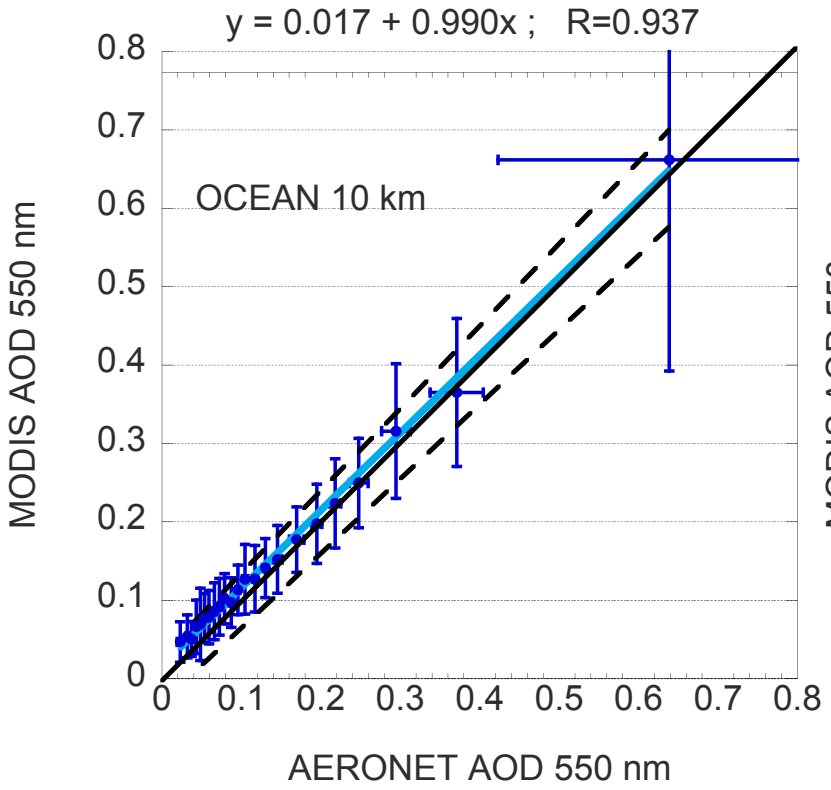
Petrenko et al., 2012

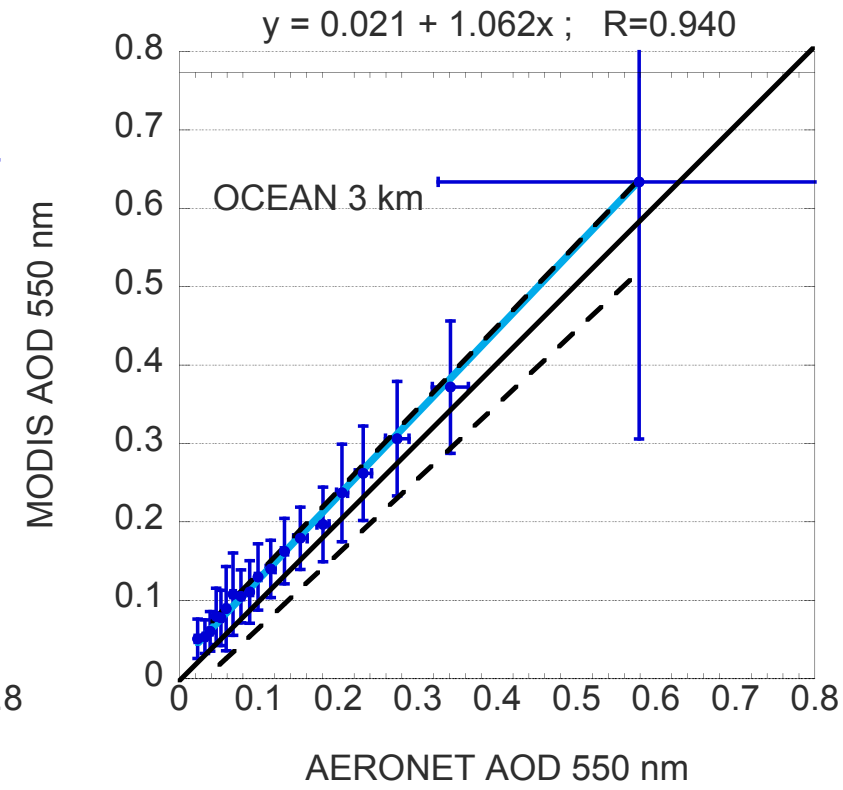
Validation with AERONET - land



- **Both 10 km and 3 km products are well correlated with AERONET**
- **3 km shows slight high bias and a bit more uncertainty**
- **Revised expected error for 3 km land product: ±0.05 + 0.2*AOD**

Validation with AERONET - ocean





Revised expected error for 3 km ocean product: ±0.04 + 0.05*AOD

Impact of averaging circle size on 3 km validation

Land or Ocean	Averaging Circle	AERONET Mean	MODIS Mean	Bias	R	Slope	Intercept	N	% within EE
Land	7.5	0.152	0.201	0.049	0.84	1.046	0.04	3280	62
Land	25	0.149	0.175	0.026	0.86	0.96	0.03	4513	70
Ocean	7.5	0.136	0.149	0.013	0.93	0.959	0.02	626	70
Ocean	25	0.152	0.179	0.027	0.93	1.086	0	1915	67

All MODIS data is from the 3 km product

Different spatial averaging circle sizes affects the ability to directly compare 10 and 3 km validation.

Summary and Recommendations

Summary

- 3 km aerosol product is NOT a new algorithm, it is an existing algorithm applied at a new resolution.

- 3 km aerosol product will not aggregate up to Level 3, or be included in the joint atmosphere Level 2 product

- 3 km retrieves slightly different global AOD than the 10 km product

- 3 km validates with AERONET slightly less well than the 10 km product, accordingly, new expected error bounds are defined.

Recommendations

- Global studies should continue to make use of the more robust and well-studied 10 km product. The 3 km product's use should be restricted to obvious situations that require finer resolution.

- Only the AOD at 550 nm has been studied in depth at this point. Difference in AOD at wavelengths, and differences in the size parameters over ocean are possible. More validation will be forthcoming.

- Aerosol-cloud studies with the 3 km product should proceed cautiously. At this time, we do not specifically know how the 3 km product is affected in the proximity of clouds.

- While the air quality community will be eager to apply the 3 km product across an urban landscape, this must proceed cautiously because of known artifacts in the product over urban surfaces.

The power of the 3 km product is on local, not global, scales.

Relevant Literature

MODIS Collection 6 algorithm and update:

Levy, R. C., Mattoo, S., Munchak, L. A., Remer, L. A., Sayer, A. M., Patadia, F., & Hsu, N. C. (2013). The Collection 6 MODIS aerosol products over land and ocean. *Atmospheric Measurement Techniques*, 6, 2989–3034. doi:10.5194/amt-6-2989-2013

MODIS 3 km algorithm and global validation:

Remer, L. A., Mattoo, S., Levy, R. C., & Munchak, L. A.. (2013). MODIS 3 km aerosol product: algorithm and global perspective. Atmospheric Measurement Techniques, 6, 1829–1844. doi:10.5194/amt-6-1829-2013

Application of 3 km product during a DISCOVER-AQ in Washington/Baltimore:

Munchak, L. A., Levy, R. C., Mattoo, S., Remer, L. A., Holben, B. N., Schafer, J. S., et al.. (2013). MODIS 3 km aerosol product: applications over land in an urban/suburban region. Atmospheric Measurement Techniques, 6, 1747–1759. doi:10.5194/amt-6-1747-2013

Application of 3 km product during ARCTAS :

Livingston, J. M., et al. (2014), Comparison of MODIS 3 km and 10 km resolution aerosol optical depth retrievals over land with airborne sunphotometer measurements during ARCTAS summer 2008, Atmos. Chem. Phys., 14, 2015-2038, doi:10.5194/acp-14-2015-2014**.**