

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights
2006-2008

SO₂

Sarychev
2009/06/16
(g26,27)

Extra Slides

Dust/Volcanic Ash and SO₂ Products

Sergio DeSouza-Machado

Joint Center for Earth Systems Technology and
University of Maryland Baltimore County Physics Department

JPL

March 22, 2016

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights

2006-2008

SO2

Sarychev

2009/06/16

(g26,27)

Extra Slides

- Dust/Volcanic Ash Optical Depth and Height Retrievals
 - Detection : use dust flag as is
 - Height retrieval (default : GOCART climatology)
 - OD retrieval
 - $T(z)$, $WV(z)$, surface temp retrieval
- SO2 retrievals
 - Scott Hannon's "reset" code
 - OEM code, using initialization from Scott

Tasks

Dust/Ash

Dust Flag

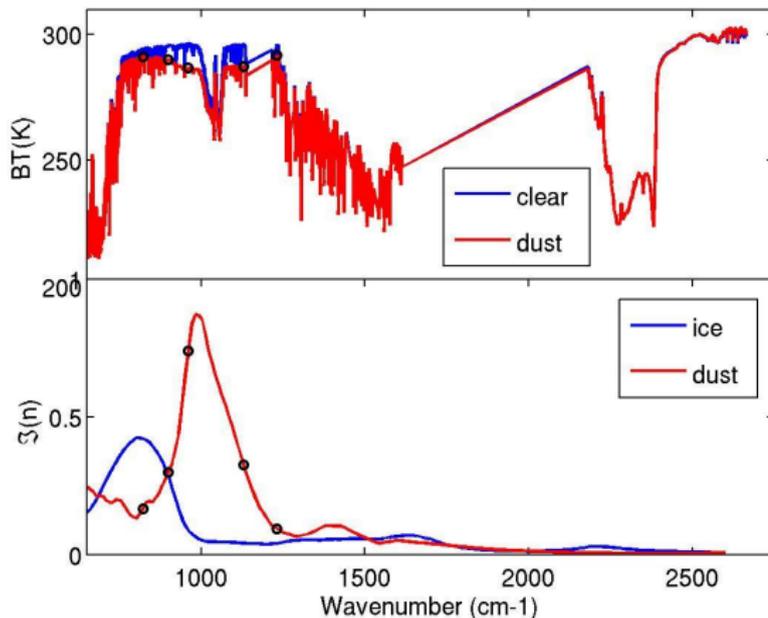
Retrieval

Example

Example Results

Dust heights
2006-2008SO₂Sarychev
2009/06/16
(g26,27)

Extra Slides



(a) 822.4 cm^{-1} (532) (b) 900.3 cm^{-1} (758) (c) 961.1 cm^{-1}
 (903) (d) 1129.0 cm^{-1} (1249) (e) 1231.3 cm^{-1}

Tasks

Dust/Ash

Dust Flag

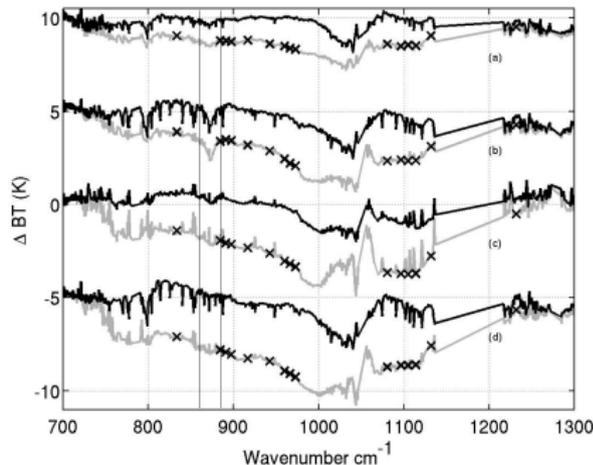
Retrieval

Example

Example Results

Dust heights
2006-2008SO₂Sarychev
2009/06/16
(g26,27)

Extra Slides



- AIRS has hundreds of low noise channels in thermal infrared window, where dust effects are important
- Vince has also pointed out AIRS data could be used to exploit this information

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights

2006-2008

SO2

Sarychev

2009/06/16

(g26,27)

Extra Slides

- Effects of dust/ash on AIRS radiances are combination of amount and dust layer height (and size, species)
- **Can fit data assuming dust at any height : (low z, large OD) vs (high z, small OD)**
- Our RT code assumes scattering effects are small (single scattering albedo $\omega \ll 1$); works best in Thermal Infrared (not reliable in SWIR)
- Climatological aerosol heights will always yield an OD estimate, but most likely incorrect (current databases do not distinguish between smoke or dust)
- Using χ_{min}^2 can work, but need accurate scattering models/ scattering parameters else the individual pixel results are "noisy" (χ^2 computed over handful of channels in TIR)
- **When dust layer heights are correct (eg validated by Calipso) we find MODIS 550 nm OD / AIRS 900 cm^{-1} OD ~ 4**

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

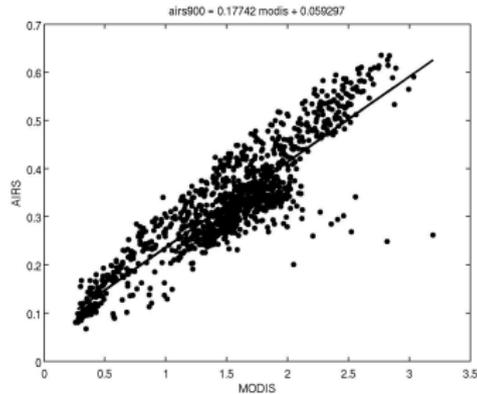
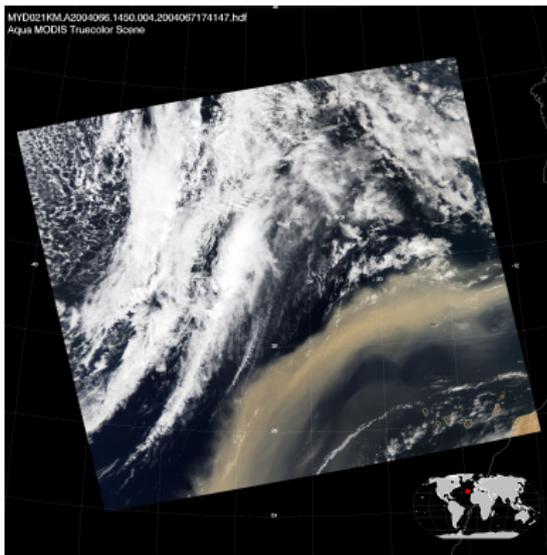
Example Results

Dust heights
2006-2008

SO2

Sarychev
2009/06/16
(g26,27)

Extra Slides



Placed AIRS dust at 600 mb; **AIRS : MODIS \simeq 5**

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights
2006-2008

SO2

Sarychev
2009/06/16
(g26,27)

Extra Slides

- Use this constraint in daytime MODIS/AIRS synergy to retrieve height **by looping over 1:0.5:6.0 km and doing retrievals at each height, then comparing to MODIS**
- Once height is obtained, can retrieve accurate OD
- Use those with scattering code to retrieve geophysical $T(z)$, $WV(z)$, $O_3(z)$, surface temp
- Sun glint regions : fill in 550 nm OD using 2d interpolation
- Night time : use χ_{min}^2 from selected TIR channels

Doing all these steps takes about 20 mins for very dusty granule (~ 3000 fovs)

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights
2006-2008

SO2

Sarychev
2009/06/16
(g26,27)

Extra Slides

- **Climatological Height, and OD retrieval** - very reliable, not accurate
- **χ^2 Height, and OD retrieval** - "needs work", better than climatology
- **MODIS/AIRS Height, and OD retrieval** - optimal (daytime)

Having determined the above, fix dust height/amount, surface emissivity and solve for **geophysical state**
T(z), WV(z), O3(z), stemp using OE

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights
2006-2008

SO2

Sarychev
2009/06/16
(g26,27)

Extra Slides

- Have June 2006 - Dec 2008 Calipso aerosol centroid heights
- Ran above retrieval, gathered results for various geographical regions
- Compared AIRS/MODIS synergy, AIRS χ^2 , GOCART climatology vs Calipso
- Works quite well over water, problems(?) over land
- Climatology not so good over Pacific/land, phase shift over Atlantic

Tasks

Dust/Ash

Dust Flag

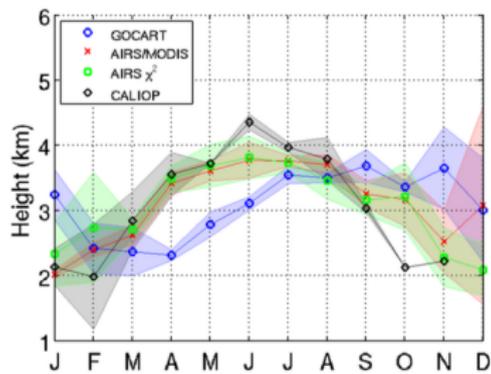
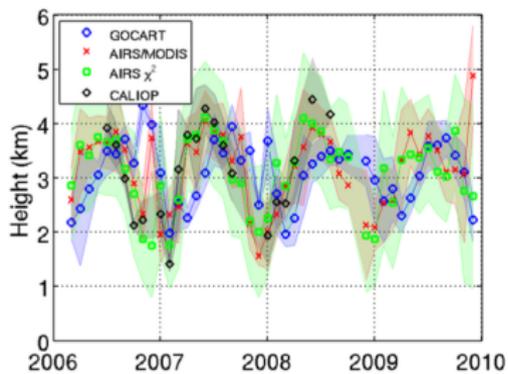
Retrieval

Example

Example Results

Dust heights
2006-2008SO₂Sarychev
2009/06/16
(g26,27)

Extra Slides



Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights
2006-2008

SO2

Sarychev
2009/06/16
(g26,27)

Extra Slides

- Have placed generic match-up code to run model ECM/ERA calcs with AIRS L1b data
- Have put code to match AIRS L1b data to ascending vs descending AIRS L3 climatology (very fast, less than 15 secs)
- SO2 retrievals using Scott Hannon's code and algorithm - linear interpolation
- Have also implemented OEM retrievals where col WV is adjusted (1400 cm⁻¹ channels), then SO2 retrievals done assuming WV is "corrected"
- Assumes SO2 plume is in upper troposphere, above WV (though can adjust height)
- V. Realmuto provided many other instrument retrievals to compare against

Tasks

Dust/Ash

Dust Flag

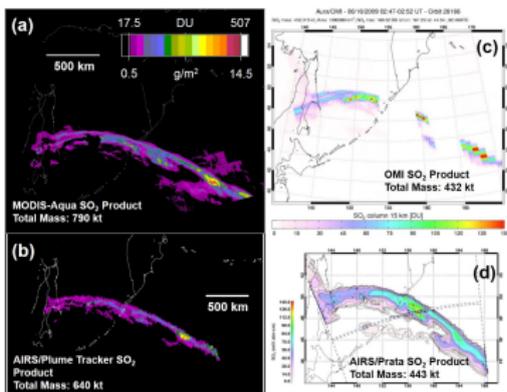
Retrieval

Example

Example Results

Dust heights
2006-2008SO₂Sarychev
2009/06/16
(g26,27)

Extra Slides



Emission (kilotons) using ECM			
UMBC OEM	AIRS	220.8	
UMBC RESET	AIRS	212.9	

Plume Tracker	MODIS	790
Plume Tracker	AIRS	640
Prata-Bernando	AIRS	440
Yang	OMI	430

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights
2006-2008

SO2

Sarychev
2009/06/16
(g26,27)

Extra Slides

DUST

- DUST/ASH : code to retrieve heights using MODIS synergy is "complicated" and "slow"
- AIRS L2 suggestion : use AIRS L3 matchup and **GOCART height climatology for single footprint ODs**
 - Already have this code running (eg 70 secs to do 2007/02/24 g111 with 1800 dust FOVS)

SO2

- SO2 : "reset" and "oem" code is **already running at JPL**
- AIRS L2 suggestion : can implement this (but specify at what height SO2 plume was placed at)

Placeholders for future products eg

- MODIS/AIRS height dust/ash retrievals
- dust and ash species identification

Thanks to Vince Realmuto, Scott Hannon and Larrabee Strow!

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights

2006-2008

SO2

Sarychev

2009/06/16

(g26,27)

Extra Slides

- Wrapper Code subsets dust flagged FOVS in a granule (rtp file, ECMWF geophysical fields)
- Needs to loop over heights 1.5 km : 0.5 km : 6 km
 - For all subset-ed dust FOVS, push out each height retrieval to a processor
 - For each H_n we get Newton-Raphson based $OD(z)$ estimate for all dust FOVS (as well as $\chi^2(z)$)
 - UMBC has 8 cpus/node
- Gathers together $OD(lat, lon, z)$ for each dust FOV
- **If daytime**
 - Loads in MODIS L2 data, interpolates across sun glint regions
 - Looks for height which gives closest $OD_{MODIS}/OD_{AIRS} = 4$
- **For both day and night**
 - Find height based on minimum $\chi^2(z)$
 - Use GOCART climatological height (varies with month, lat, lon)

- Height from MODIS : have worked out an estimate of δh given retrieved h and MODIS/AIRS ratio of 4 (and assuming MODIS OD is "perfect")
- Geophysical : comes from OEM

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights

2006-2008

SO2

Sarychev

2009/06/16

(g26,27)

Extra Slides

Column Jacobians (with SO₂ x 10,100) (Tropical profile)

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

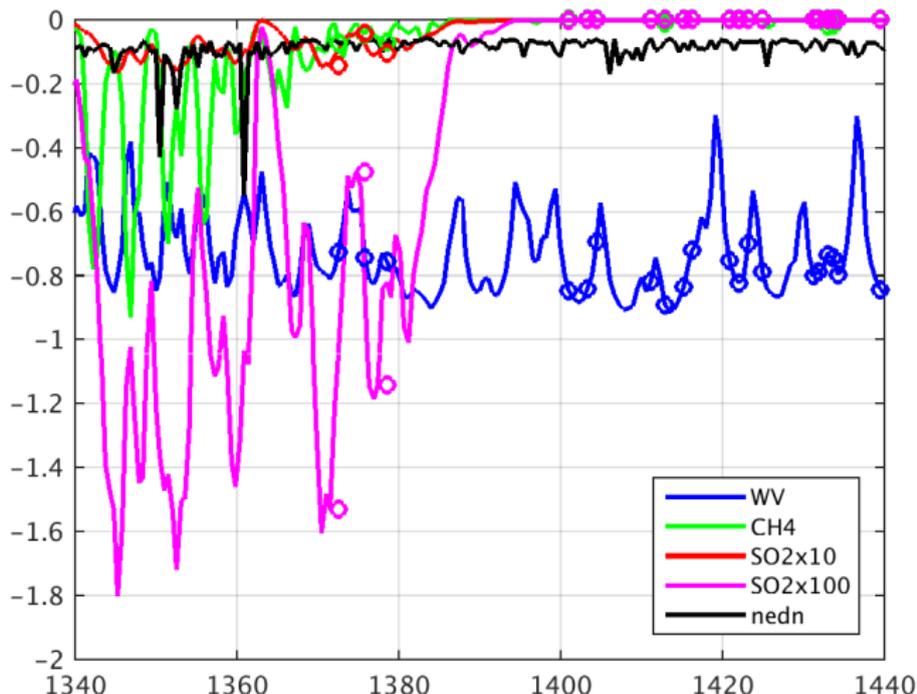
Example Results

Dust heights
2006-2008

SO₂

Sarychev
2009/06/16
(g26,27)

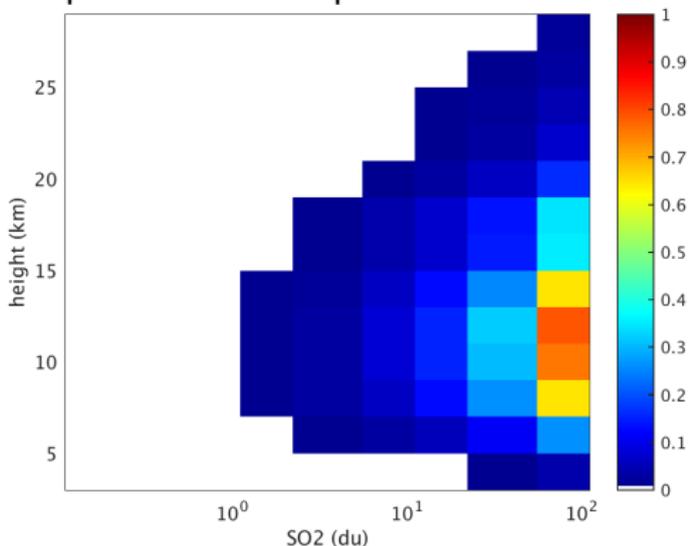
Extra Slides



Begin to see the signal pop out beyond noise at x10 (1 du) levels

AIRS NeDN in strong SO₂ channels ~ 0.07 K

See how AIRS observed BT in strong SO₂ channel(s) change as we put in slab SO₂ perturbation in 2 km thick layer



Optimal SO₂ height detection is in UT or higher

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights
2006-2008

SO₂

Sarychev
2009/06/16
(g26,27)

Extra Slides

Tasks

Dust/Ash

Dust Flag

Retrieval

Example

Example Results

Dust heights

2006-2008

SO₂

Sarychev

2009/06/16

(g26,27)

Extra Slides

