

Visible Emission Management Community-Facility-Fire

The Digital Opacity Compliance System
Third Generation (DOCS3):

USEPA Alternative Method 082

Visible Emission Opacity,
Particulate and Volatiles

Shawn Dolan

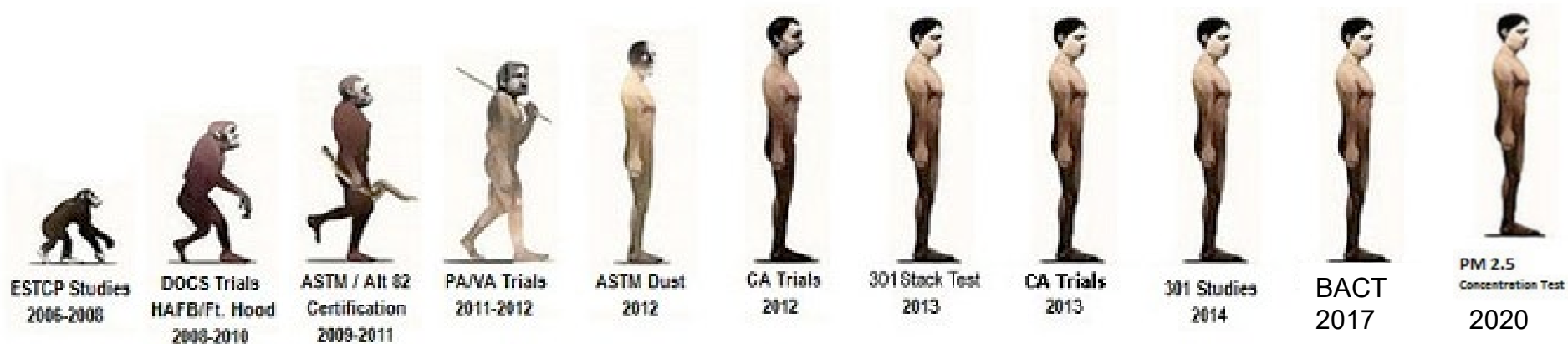
Virtual Technology LLC

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Evolution of DOCS II (2006-2020)

Evolution of DOCSII...The Road to SaaS



DOCS

DOCS II

DOCS II Web

DOCS II SaaS

DOCS III SaaS

OMG
COVID



Evolution of DOCS II

- 2000 to 2005 – Several research projects contracted by DOD & Universities
 - EPA TTN, ETC Publishes PRE-008 - Determination of Visible Emissions Opacity from Stationary Sources Using Computer-based Photographic Analysis Systems
- 2005 to 2009 – Research continued by DOD
 - 2007 - ASTM Workgroup formed due to EPA consensus standard direction
 - 2009 - ASTM D7520-09 approved and published
- 2012 October – ASTM D7520-13 Update Approved by ASTM
 - Allows use of any Digital Image Device: High-Definition Recorders (Digital Video), (Cell Phones), all Sony CCD based Cameras (98% of HDR, Surveillance market)
 - Allows certification of optical and digital zoom
- 2012 February – EPA Office of Air Quality Planning and Standards published US EPA Alternate Method 082 (ALT 082), **Broadly Applicable Standard:**
 - Digital Camera Opacity Techniques (DCOTs) can be used “in lieu of Method 9”, for all subparts of 40 CFR 60, 61 and 63
 - Federal Permit changes not required
 - Match ASTM D7520-09
 - Stationary, Mobile, Fugitive

***US EPA ALT 082 Broadly Applicable Standard
Prove in 2012-Most Credible Evidence Today***



Evolution of DOCS II Continued

- 2012 to Present – Fugitive Dust Applicability
 - Original research performed June 05’- June 11’
 - Full NIST Long Path Trans. certification completed January 2012
 - ASTM Research Report submitted to committee July 2012
 - Applicable to fugitives per 40 CFR 60 Subpart 000 October 2012
- 2013 – 301 Testing began to eliminate 7’ ASTM stack exit limit
 - EPA desired “comparison with current compliance method”
 - Results ALT 082 is the same as Method 9 observers on stack exits greater than 7’.
- 2015- EPA opinion “Any Creditable Evidence” rule of Clean Air Act, DCOT Most Credible
 - Applicable to all Source types “a picture says a thousand words”.
- 2015- FerroAlloy NESAP defines DCOT as BACT, and mandates for Process Fugitive Emis.
- 2016 – ASTM D7520-16 Approved no limits on Applicability. Stationary, Mobile, Fugitive
- 2017 – FerroAlloy NESHAP final reconsideration ruling DCOT is BACT for Opacity.
- 2018 – DOCS II Flare Watch Development begins expanded background, auto detect
- 2019 – DOCS II Heavy Diesel Inspection and Maintenance Full Speed Opacity Monitoring
- 2021 – Auto-Detect released to production clients (COVID Delayed 8Mo.)
- 2021 – Heavy Diesel Inspection and Maintenance Toll Integration (COVID Delayed 8Mo.)

DOCS II is the only ASTM D7520-16 & ALT 082 certified DCOT



Leading Organizations in Conservation, Compliance, Sustainability, Training
 Regulatory Policy and Enforcement, Local and International, all Agree
Digital Image Based Monitoring is the Way to GO

FAMILIES FOR CLEAN AIR



Digital Image Based Analysis, The "Best" Solution ⁵

Comparison of Compliance Methods

EPA Method 9

- (1) set of (25) White and (25) Black (50) readings
 - EPA Required Content Training
 - 50 plume certification
 - $\pm 7.5\%$ overall and $\leq 15\%$ within each set of 25.
- Cert. duration 6 months
- Operational conditions
 - Unlimited backgrounds
 - Unlimited weather conditions
- Paper Non-Validated Record

EPA ALT 08 “Electronic Method 9”; allows separation of data “Capture” from “Analysis”

EPA ALT 082

System Certification Performed by Vendor

- (6) sets of (25) White and (25) Black against various backgrounds (300 images)
 - 4 independent Analyst use System to derive Opacity of each image (1200 results)
 - All (4) Analyst must pass all (6) sets, $\pm 7.5\%$ overall and $\leq 15\%$ within each set of 25
- Cert. duration 3 ½ years
 - **Camera Operator Certification of Field user**
 - EPA Required Content Training
 - DCOT-specific training
 - Training for life (must submit 1 acceptable image for analysis quarterly; VTLLC company rule)
- Operational conditions
 - Unlimited backgrounds
 - Unlimited weather conditions
- Digital Validated Record



Problems & Solutions

Top 3 problems defending Method 9 Observations

1. VEE record not technically correct, missing data, sun angle, point of view.....
2. VEE not performed by Certified Observer
3. Smoke School Quality Assurance Protocol not meeting the requirements set forth by USEPA for VE certification programs

DOCS II solves top 3 problems

1. VEE record completely validated upon save
2. Certified Analyst always available to perform analysis
3. Certified Analyst history of opacity determination across hundreds of readings eliminating personnel bias

***DOCS II SaaS,
Complete & Validated, Certified, Reproducible
Most Samples are sent to Labs
Why not Opacity samples?***



DOCS II Compared to Humans

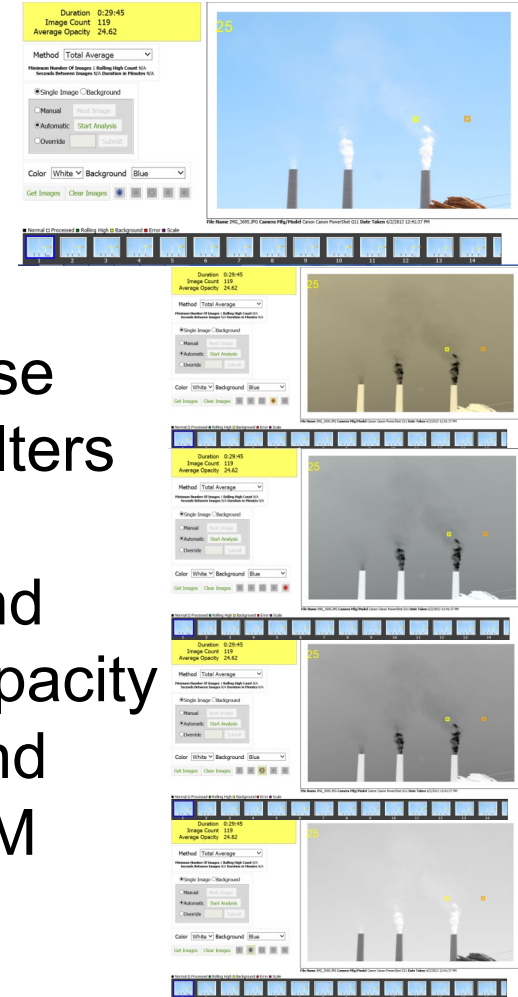
- Less variation than Method 9 against NIST traceable transmissometer
 - Average deviation count for students at CARB certification is 23
 - Typical deviation count for DOCS II on same certification run is 15
 - Over 95% of DOCS II readings were zero or 1 deviation count
- Average deviation under ideal conditions (high contrast)
 - DOCS II $\pm 5\%$
 - Method 9 $\pm 10\%$
- Average deviation under difficult conditions (low contrast)
 - DOCS II $\pm 10\%$
 - Method 9 $\pm 15\%$
- Flexible applicability
 - Clouds, Rain, Snow, Trees, & Buildings
 - Day or Night
 - Close & Far (Limited only by camera zoom)

Simple, Fast, Reliable, Repeatable

How DOCS II Works

- An image or images of the emission source are captured by a certified Camera Operator using a certified camera
- The images are uploaded to the “Cloud” where they are acquired by a Certified Analyst who identifies the Regions of Interest (marked according to explicit rules and training)
- DOCS II then applies algorithms to the Regions of Interest and calculates the opacity of each image and the average, based on the selected rule, e.g. 6 min. avg., 3 min. avg.
- DOCS II generates a draft VEE report
- Source owner accepts and/or rejects the draft VEE report
- DOCS II generates final VEE report and archive record

Use
Filters
to
find
Opacity
and
PM



Simple, Fast, Reliable, Repeatable



Products Available

Regulatory Compliance, Community Conservation



Observation Analysis



Software As a Service

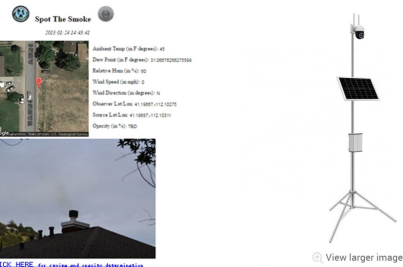
Observation Analysis



MPG/JPG
VEE Process

MPG/JPG
VEE Manage

Obs. Event Trans for Analysis



c Complaints

FUGITIVE OR SMOKE EMISSION INSPECTION

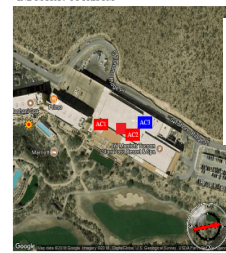
OUTDOOR LOCATION

COMPANY: SENSORY
LOCATION: STARR PASS CONVENTION
COMPANY REP: SDD
SKY CONDITION: CLEAR
TEMPERATURE: 63
REL HUMIDITY: 21
INDUSTRY: TOURISM

OBSERVER: LINDA RAWSON
AFFILIATION: SENSORY
DATE: 3/27/2018
PRECIPITATION:
WIND SPEED/DIR: 5 W
WET BULB TEMP: 22
PROCESS: NA

EVENT TIME LIMIT 3

SOURCE ID	SECONDS	IMAGE
AC1	65	
AC2	32	
AC3	0	



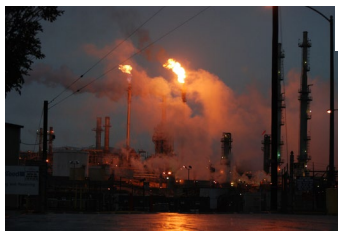
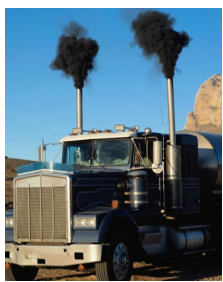
LONGITUDE: 111.02.51

Image	Quantity	Coordinates	Camera and Weather Information
	10	33.071250, -111.025000	Camera: MPT2000-Center PowerShot 011 Weather: 01 - Wind Speed 0 Mark: Marking 10
	10	33.071250, -111.025000	Camera: MPT2000-Center PowerShot 011 Weather: 01 - Wind Speed 0 Mark: Marking 10
	10	33.071250, -111.025000	Camera: MPT2000-Center PowerShot 011 Weather: 01 - Wind Speed 0 Mark: Marking 10
	10	33.071250, -111.025000	Camera: MPT2000-Center PowerShot 011 Weather: 01 - Wind Speed 0 Mark: Marking 10
	10	33.071250, -111.025000	Camera: MPT2000-Center PowerShot 011 Weather: 01 - Wind Speed 0 Mark: Marking 10
	10	33.071250, -111.025000	Camera: MPT2000-Center PowerShot 011 Weather: 01 - Wind Speed 0 Mark: Marking 10
	10	33.071250, -111.025000	Camera: MPT2000-Center PowerShot 011 Weather: 01 - Wind Speed 0 Mark: Marking 10
	10	33.071250, -111.025000	Camera: MPT2000-Center PowerShot 011 Weather: 01 - Wind Speed 0 Mark: Marking 10
	10	33.071250, -111.025000	Camera: MPT2000-Center PowerShot 011 Weather: 01 - Wind Speed 0 Mark: Marking 10
	10	33.071250, -111.025000	Camera: MPT2000-Center PowerShot 011 Weather: 01 - Wind Speed 0 Mark: Marking 10

Onsite Observation Switch
Archive Storage

Multi Point
Method 22 Surveys

Electronic VEE Reports

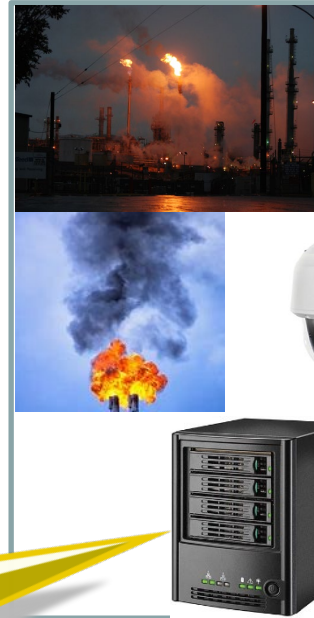
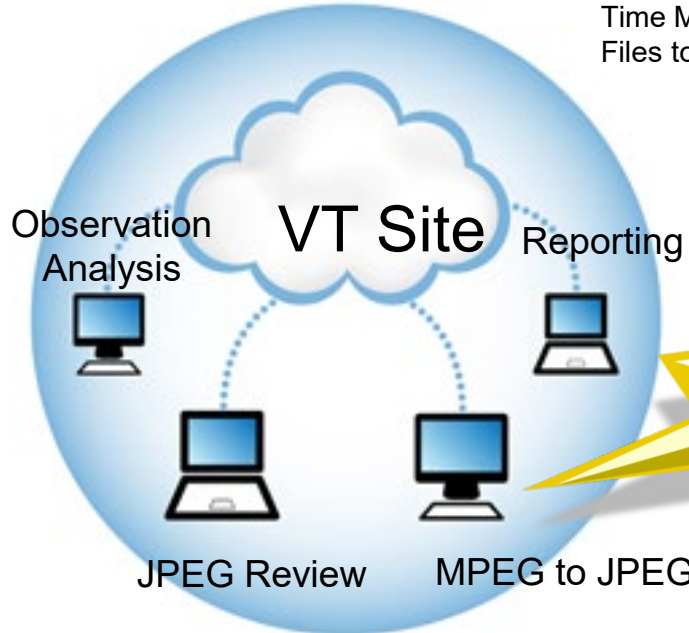




Flare Monitoring System with Opacity Event Reporting

Convert to JPEG every 15 seconds
During marked event times
and display for observation cut down

Time Marked
Files to Cloud



Flare Site

Local Mounted
Intrinsic all weather
Internet Protocol Cam

Local copy of MP4 "video files" mirrored
high-capacity drives, Archived monthly
Time marked by "Control Operators log"
for events or detections against known
backgrounds

Remote copy of MP4 "video files"
Control Operators log, Mark Event times.
Cuts MP4 into (1) JPG/15 seconds
Extracts JPG sets (Observations)
Runs screening on Observations
Marks observations JPG w opacity.
Generates Monthly and Semi Annual report.

The screenshot shows a web browser window with the URL https://virtualc.com/Docs_SaaS/Analysis.aspx?osida:18113. The page title is "Virtual Technology LLC - Lead...". The main content area has a green header with "DOCS II SaaS" and "Company Virtual Technology". Below the header are navigation tabs: Home, Properties, Source, Plume, Location, Analyze, Reports, Administration. The "Analyze" tab is active. The interface shows a "Method" dropdown set to "Total Average". Below this are instructions for selecting images and creating observation sets. A grid of four images shows a flare at different stages. At the bottom, there is a section for "Observations" and a Windows taskbar with the search bar.



Gas & Oil OOOOa Fugitive Emission Survey Opacity Event Reporting



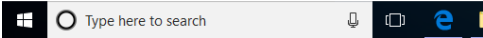
FUGITIVE OR SMOKE EMISSION INSPECTION

OUTDOOR LOCATION

COMPANY: SENSORY OBSERVER: LINDA RAWSON
 LOCATION: STARR PASS CONVENTION AFFILIATION SENSORY
 COMPANY REP: SDD DATE: 3/27/2018
 SKY CONDITION: CLEAR PRECIPITATION:
 TEMPERATURE: 63 WIND SPEED/DIR: 5 W
 REL HUMIDITY: 21 WET BULB TEMP: 22
 INDUSTRY: TOURISUM PROCESS: N/A



LONGITUDE: 111.02.51.970 W
 LATITUDE: 32.12.57.458 N



FUGITIVE OR SMOKE EMISSION INSPECTION

OUTDOOR LOCATION

COMPANY: SENSORY OBSERVER: LINDA RAWSON
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LONGITUDE: 111.02.51.970 W

EMISSION POINTS EVENT TIME LIMIT 3

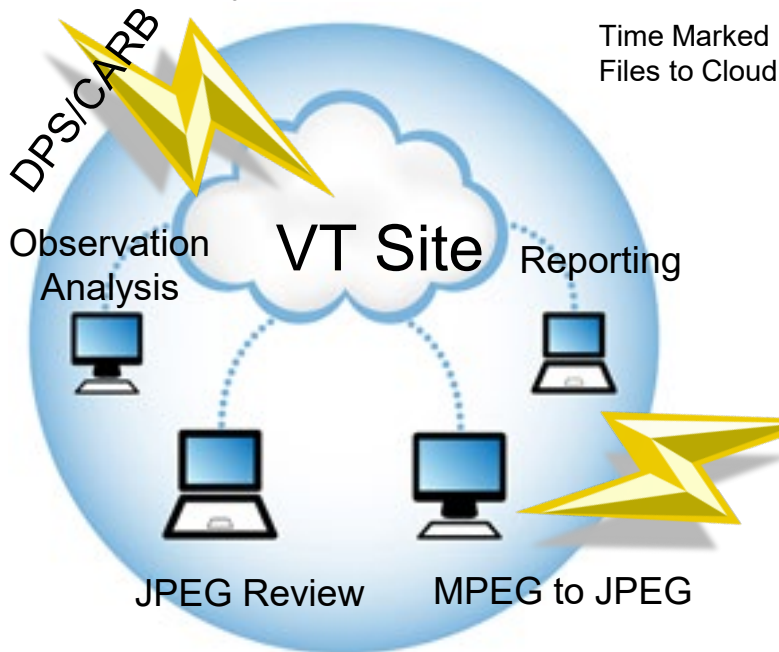
SOURCE ID	SECONDS	IMAGE
AC1	65	
AC2	32	
AC3	0	

- User drags the emission points from facility onto map.
- Emission Points all start Blue
- User touches each Emission point as they see emissions
- Emission points toggle color Green on Red off
- Clock displays survey time and remaining time
- End of Survey sum totals all on/off events by source and compares to limit
- Generates Survey report listing emission units, visible emission time
- User prompted to record picture of exceeding emission units.



Heavy Duty Vehicle Emissions Enforcement

Convert to JPEG every 15 seconds
During marked event times
and display for observation cut down



Enforcement Site

Local Mounted all Weather IP Cam



Local copy of MP4 "video files" mirrored high capacity drives, Archived monthly
Time marked by "Control Operators log" for events.



Remote copy of MPEG "video files"
Plate/Transponder number tag to images.
MP4 into JPG at set interval (reduce storage)
Opacity Analysis on high image (smoke > 5%)
Creates Violation Record (Image, Opacity, Plate/Trans)
Transmits Violation record to ??? For enforcement
Automated Enforcement Close out
Generates monthly follow up report



Complaint Management

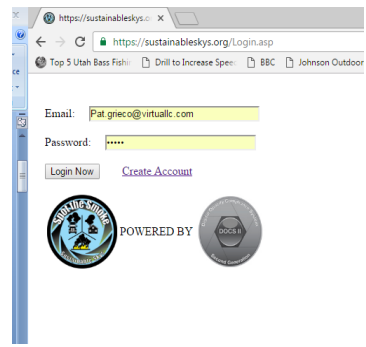
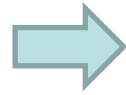
People Complaint About What They

See with their Eyes, Smell with their Nose, Hear with their Ears

Navigate to SustainableSkys.Org

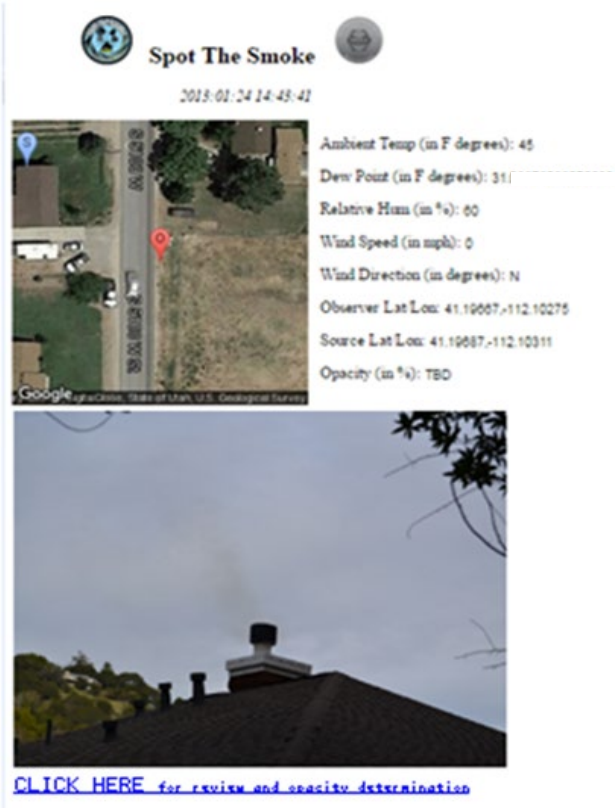
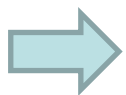
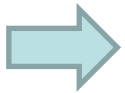
Log In or Create an Account

Submit to create a Draft Report
Submit Draft for Opacity Analysis
Receive Final Report



Touch the Screen to Indicate
Where you are looking

Take or Attach an Exiting
Picture



Where are the Complaints? To Build Community Air Monitoring Infrastructure

Spot the Smoke

30,000 Downloaded on Android

- Spot the Smoke Released in March 2014 (7 Step)
 - Buggy and did not operate well on iPhone (Safari) platform
 - Revision 2, in June 2015 still has browser compatibility (5 Step)
 - works plug and play 70% of the time.
 - Revision 4, Released January 2017, (3 Step)
 - Revision 5, Released January 2020, (2 Step w/Autofill)
- Stationary Sources
 - Requiring Permits, require other compliance monitoring
 - Category people pay to expedite
- Mobile Sources
 - Smaller mobile sources, cars, trucks
 - Requiring frequent licensing
 - Larger mobile sources, planes, trains, ships
 - Reduced licensing frequency
- Fugitive Area Sources
 - Larger sources farms and agriculture
 - Fugitive emissions, largest category of undocumented air pollution
 - Includes Wood Smoke also category people pay to expedite
- Natural Area Sources (spikes during event)
 - Great Dust Storm and Forest Fire Pictures
 - Not predictable

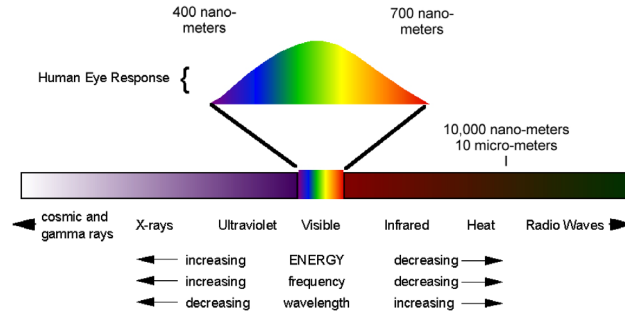
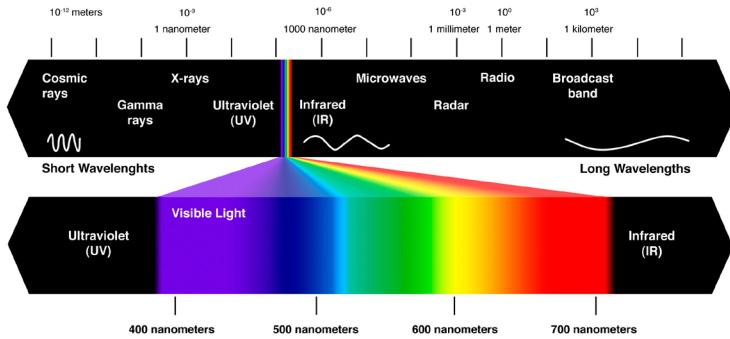


Future Now: PM Speciation

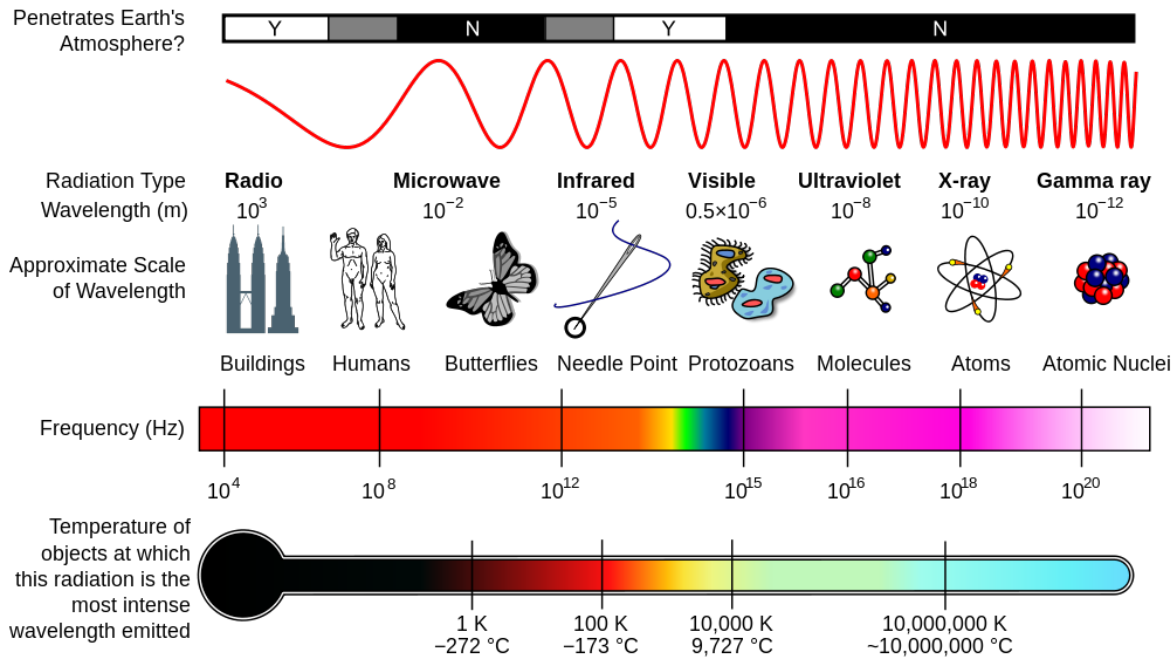
- Measuring PM Concentration via: Light Scatter, Energy Emittance (Oscillation) , Temperature variation,



Digital Images Contain The Building Blocks



Light Scatter is a well known Measurement Principle, As Particle size = Wave length = known Scatter (LiDAR)



Temperature change measurement is the baseline for all FTIR based Optical Gas Imaging

Each Pixel holds the values to measure scatter, temp change

Basic Research Reused from APTI 325

Mass Emissions/Opacity Relationship

background appears under both conditions and not focus only on the appearance of the background through the emissions. The observer should remember that the goal in determining opacity values is to judge how much the unobserved background is changed by the emissions.

Notes

Mass Emissions/Opacity Relationship

Generally, denser plumes have more particles and, consequently, higher mass emissions. When Method 9 was promulgated, the relationship between opacity and mass emissions was not well developed. Today, opacity can be predicted if sufficient information about the emissions is available. Factors that affect the mass emissions/opacity relationship include:

- The number of particles
- The particle size distribution
- The pathlength through the plume
- The density of the particles
- The spectral characteristics of the light
- The index of refraction of the particle
- The opacity of the plume in terms of transmission

The relationship can be described by the following equation:

$$C = \frac{K R \ln(T)}{P}$$

in which: C = mass concentration
 K = particle size distribution
 R = particle density
 T = equivalent transmittance
 P = pathlength through the plume

As the pathlength through the plume increases, the opacity increases because the number of particles between the source of light and the detector or observer has increased.

The natural log, ln, of the equivalent transmittance, which is referred to as optical density, is also directly proportional to particle concentration. All other factors being equal, opacity is a function of the number of particles in a specified size distribution per unit volume of gas. Particle density is used to convert particle concentration to mass concentration.

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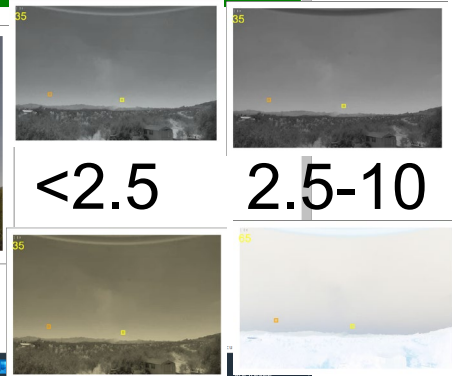
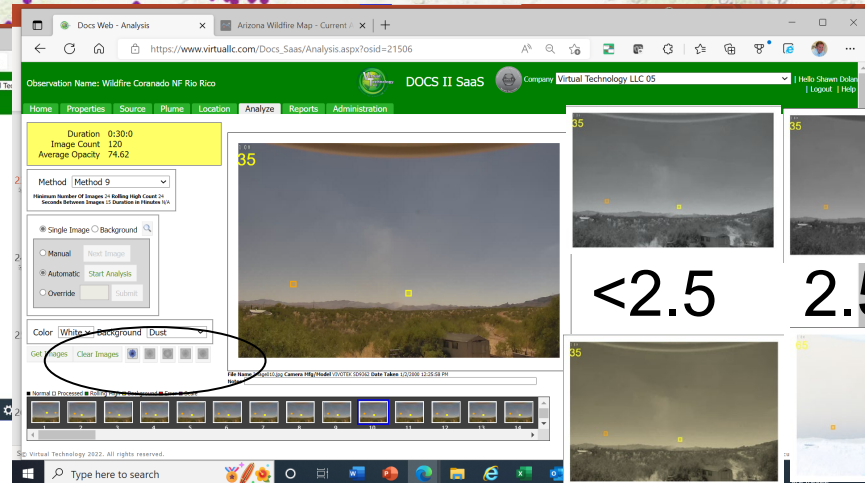
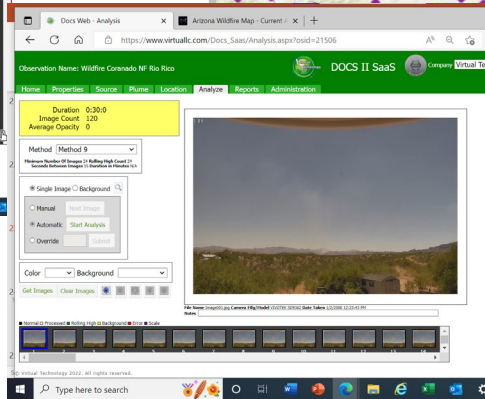
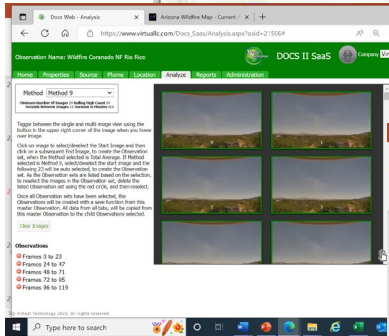
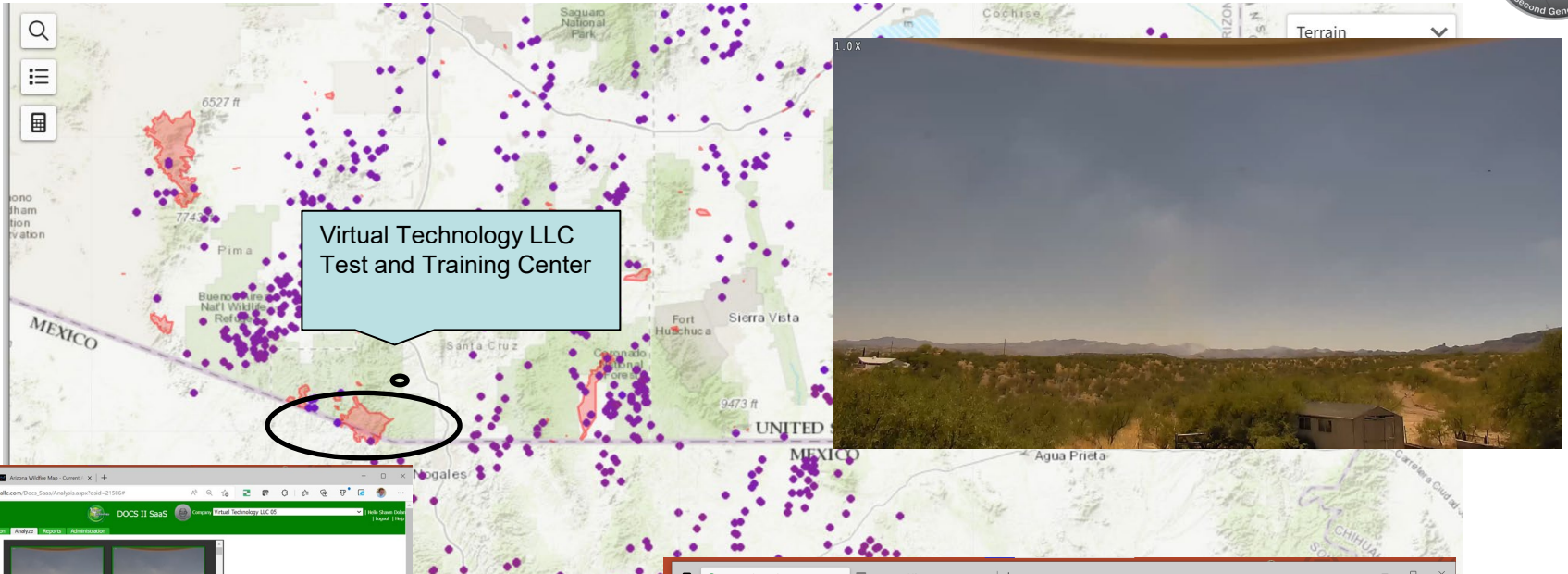
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Applied to Wildfires Southern Arizona 2022



<2.5 2.5-10

>10 VOC



Virtual Technology LLC

Automated Electronic Visible Emissions Observations

Visible Emission Surveys (Method 22)

Opacity Observations (Method 9)

Stack/Flare Watch (custom)

Heavy Duty Vehicle Emissions (custom)

Opacity to Speciated Particulate Concentration

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