

# FEDERAL LAND MANAGERS CLASS I VISIBILITY ISSUES



# TOPICS

- CALPUFF
- POSTUTIL
- CALPOST
- Visibility Calculations
- EPA's New Tang Curve
- Ammonia Limiting
- New Calpost methods

# CALPUFF / FLAG A VISIBILITY PHASE 1 TECHNIQUE

- FLAG procedures provide a visibility Phase 1 technique
- If a source passes FLAG visibility analysis “AS IS” FLMs feel fairly comfortable that the source is unlikely to trigger an adverse impact concern.
- If source fails screen it warrants further scrutiny : NOT TWEAKS to the system to bias the results
- Types of Tweaks: adjustments to natural background conditions
- Sea salts; time of day; night time cloud cover; smoke from wildfires; weather events

# 40CFR 51.301

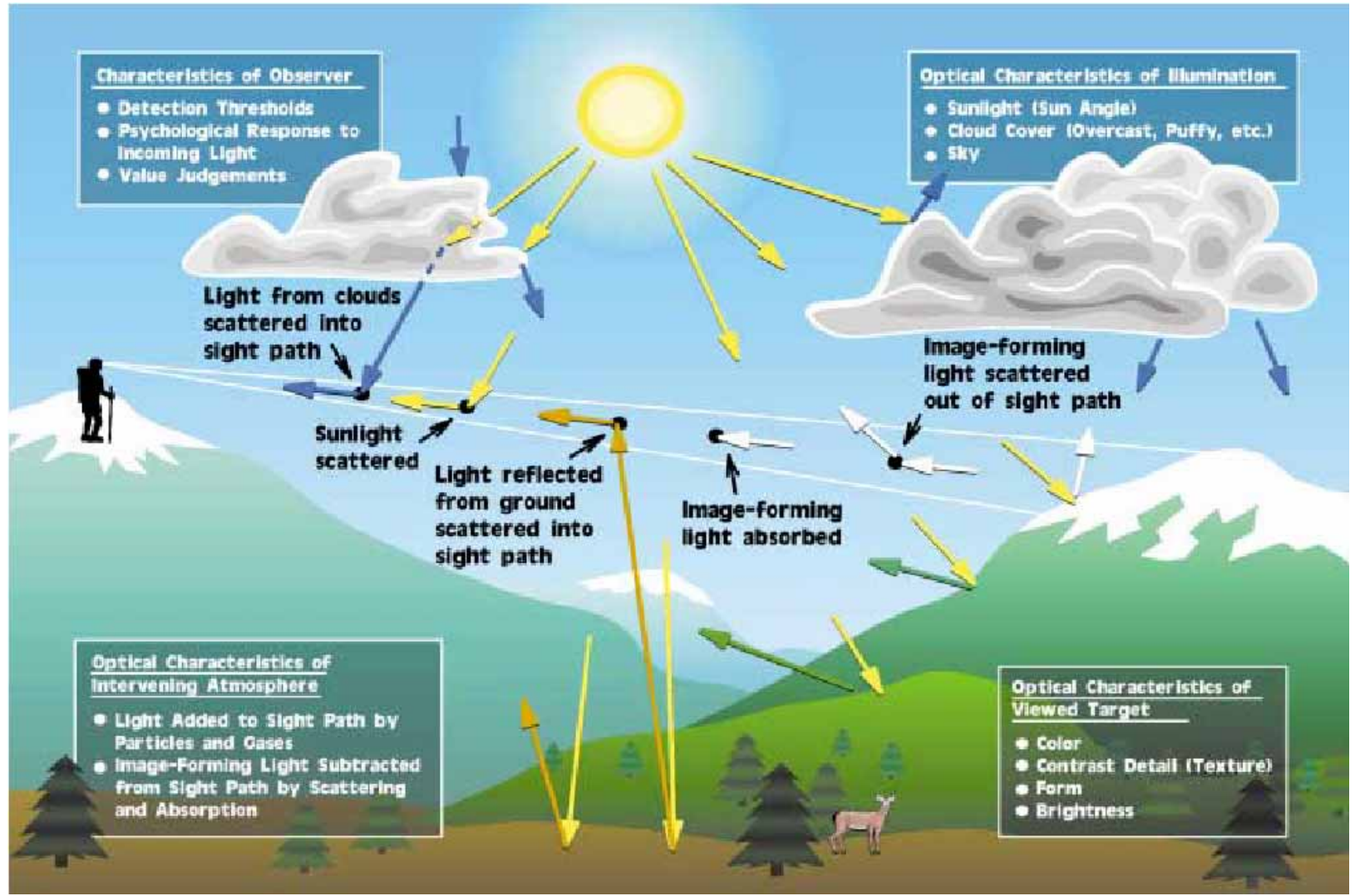
- Adverse impact on visibility means:
  - (2) The frequency and timing of natural conditions that reduce visibility. This term does not include effects on integral vistas.

# EXAMPLES OF BALANCING WITHIN THE VISIBILITY ANALYSIS

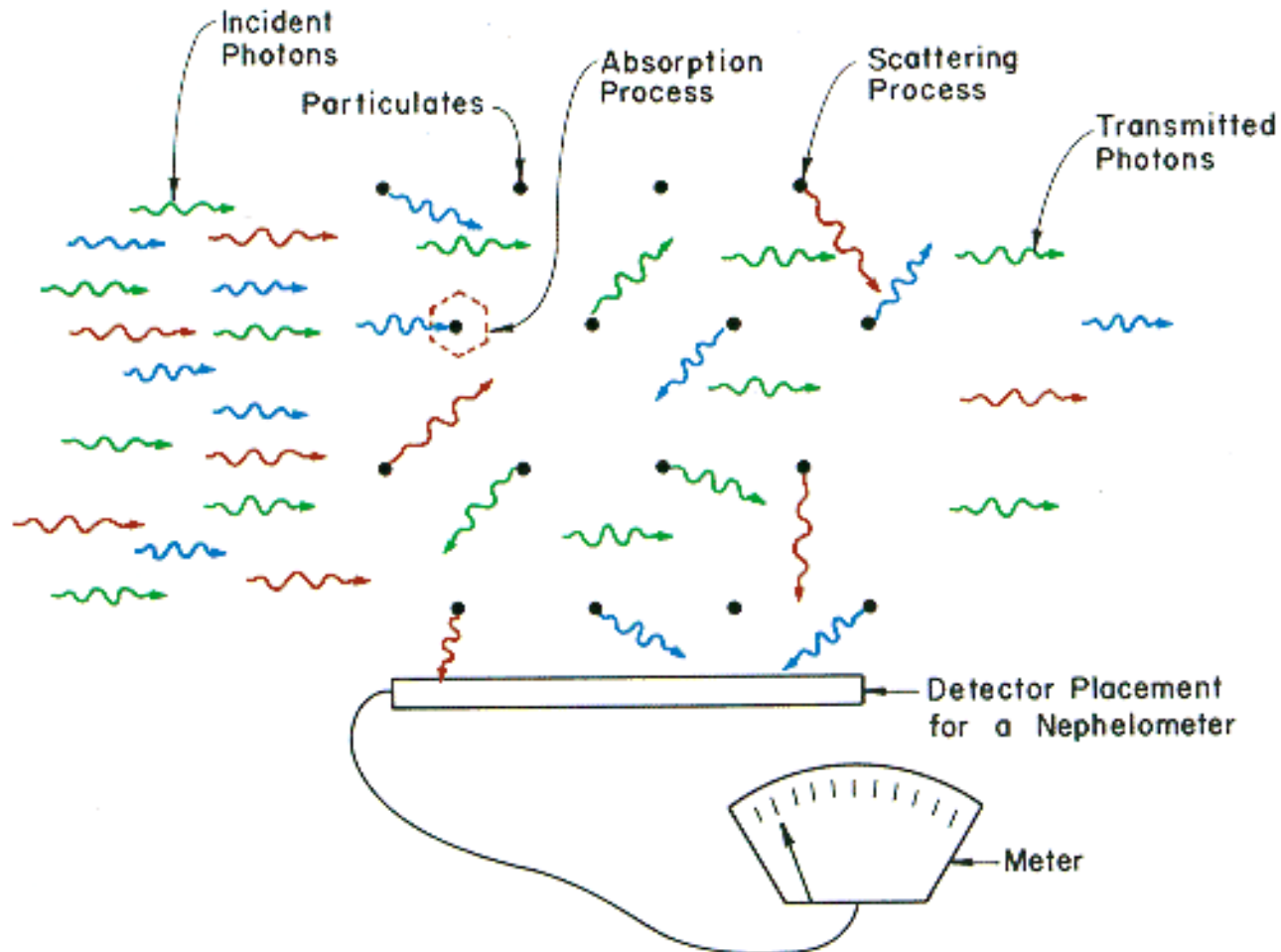
- Reduces impacts < Lack of Aqueous phase chemistry
- Reduced impacts < 24-Hour Value accounts for model uncertainty
- Reduces impacts < simple first order chemistry
- Increases impacts > Single Receptor instead of sight path integration and Monte Carlo radiative transfer
- Increases impacts > No explicit WX obscuration
- Reduces impacts < RH MAX=95% accounts for some WX in the west
- Reduces impacts < 80\*80 km & 36\*36 km MM5 is not refined, does not depict terrain
- Reduces impacts < 3-5 years of met data does not represent all weather conditions for the lifetime (30-50 years of the plant)

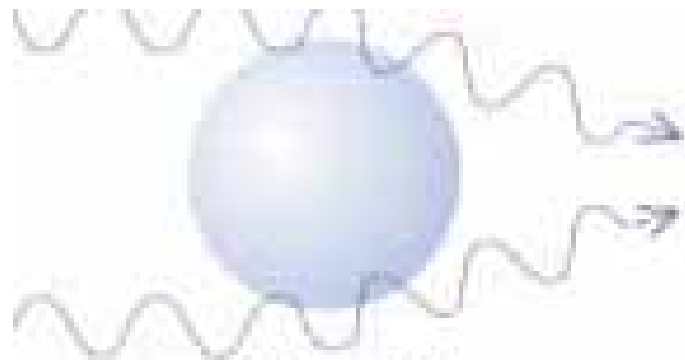
# Legitimate Refinements

- Higher resolution MM data/wind fields with verification
  - 4\*4 km grid; winds; precipitation; clouds; 3-5 years of met data
- Chemistry
  - CAMX like chemistry with plume in grid
  - Aqueous phase chemistry;  $\text{NH}_3$  fields; realistic oxidant field ( $\text{O}_3$ ) ( $\text{H}_2\text{O}_2$ )
- Radiative transfer model
  - Analyze Uniform haze
  - Analyze Layered haze

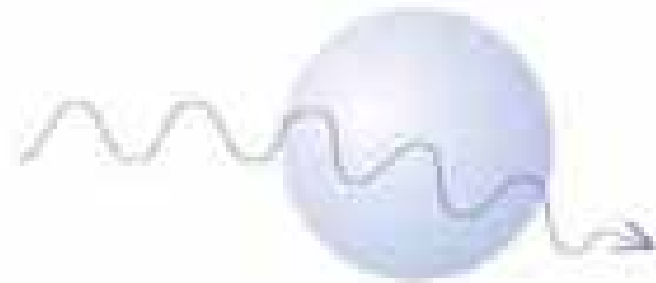


# Measuring Light Scattering Nephelometer





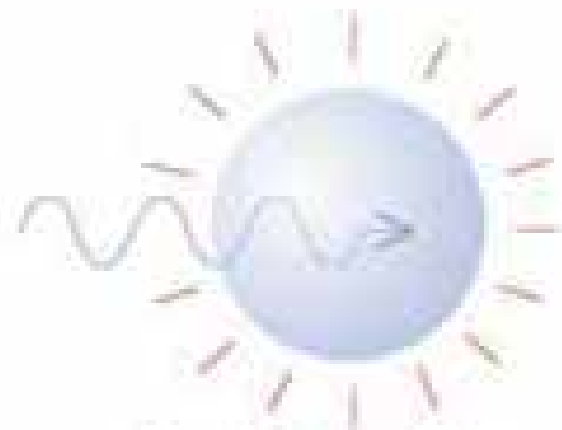
**a. Diffraction**



**b. Refraction**



**c. Phase Shift**



**d. Absorption**



*Fig. 3.9 Smoke trapped by an inversion layer in the Grand Canyon. During the winter months inversions are quite common in almost all parts of the United States.*

# PM SPECIATION for VISIBILITY IMPACTS

PM-coarse

PM-fine

Elemental Carbon

Secondary Organic Aerosols

Sulfuric Acid Mist

Pulverized Coal boilers

Circulating Fluidized Bed boilers

Natural Gas Turbines

Oil Fired Turbines

[http://www2.nature.nps.gov/air/Permits/emissions\\_ControlTech.htm](http://www2.nature.nps.gov/air/Permits/emissions_ControlTech.htm)

# Effects on Visibility

CALPOST-----INPUT GROUP: 2

Extinction Efficiency (1/Mm per ug/m\*\*3)

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MODELED particulate species:

PM COARSE (EPPMC) -- Default: 0.6 ! EPPMC = 0.6 !

PM FINE (EPPMF) -- Default: 1.0 ! EPPMF = 1.0 !

BACKGROUND particulate species:

PM COARSE (EPPMCBK) -- Default: 0.6 ! EPPMCBK = 0.6 !

Other species:

AMMONIUM SULFATE (EESO4) -- Default: 3.0 ! EESO4 = 3.0 !

AMMONIUM NITRATE (EENO3) -- Default: 3.0 ! EENO3 = 3.0 !

ORGANIC CARBON (EEOC) -- Default: 4.0 ! EEOC = 4.0

SOIL (EESOIL)-- Default: 1.0 ! EESOIL = 1.0 !

ELEMENTAL CARBON (EEEC) -- Default: 10. ! EEEC = 10.0 !

# “Ammonia Limiting”

- $\text{NH}_3$  affects  $\text{NO}_3$  concentrations
- $\text{SO}_4$  affects  $\text{NH}_3$  concentrations
  - i.e.  $\text{NH}_3$  preferentially reacts with  $\text{SO}_4$
- $\text{NH}_3$  DOES NOT affect  $\text{SO}_4$  concentrations
- $\text{SO}_4$  assumed to be  $(\text{NH}_4)_2\text{SO}_4$ 
  - Could be  $\text{NH}_4\text{HSO}_4$ ,  $\text{H}_2\text{SO}_4$ , or  $(\text{NH}_4)_3\text{H}(\text{SO}_4)_2$
- $\text{NH}_3 + \text{HNO}_3 \leftrightarrow \text{NH}_4\text{NO}_3$ 
  - $\text{NH}_4\text{NO}_3 \rightarrow f(\text{RH}, \text{T})$

# POSTUTIL

- CALPUFF may overestimate the amount of  $\text{NH}_4(\text{NO}_3)$  formed due to overlapping puffs
- Recommended to run to properly apportion the available background ammonia to the number of puffs in each grid cell. This post processing was also done so as not overestimate the amount of ammonium nitrate particles formed. The adjusted binary concentration output files are then applied in the CALPOST model to derive the visibility impacts.
- Set `MNITRATE = 1`

## Background Extinction Computation

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Method used for background light extinction

(MVISBK) -- Default: 6 !MVISBK = 2 !

- 1 = Supply single light extinction and hygroscopic fraction - IWAQM (1993) RH adjustment applied to hygroscopic background and modeled sulfate and nitrate
- 2 = Compute extinction from speciated PM measurements (A)
  - Hourly RH adjustment applied to observed and modeled sulfate and nitrate
  - RH factor is capped at RHMAX
- 3 = Compute extinction from speciated PM measurements (B) - Hourly RH adjustment applied to observed and modeled sulfate and nitrate - Receptor-hour excluded if  $RH > RHMAX$ 
  - Receptor-day excluded if fewer than 6 valid receptor-hours
- 4 = Read hourly transmissometer background extinction measurements - Hourly RH adjustment applied to modeled sulfate and nitrate - Hour excluded if measurement invalid (missing, interference, or large RH) - Receptor-hour excluded if  $RH > RHMAX$ 
  - Receptor-day excluded if fewer than 6 valid receptor-hours
- 5 = Read hourly nephelometer background extinction measurements - Rayleigh extinction value (BEXTRAY) added to measurement - Hourly RH adjustment applied to modeled sulfate and nitrate
  - Hour excluded if measurement invalid (missing, interference, or large RH)
  - Receptor-hour excluded if  $RH > RHMAX$  - Receptor-day excluded if fewer than 6 valid receptor-hours
- 6 = Compute extinction from speciated PM measurements
  - FLAG RH adjustment factor applied to observed and modeled sulfate and nitrate
- 7 = Compute extinction from speciated PM measurements as in [2]
  - for 'unobstructed' conditions; replace with extinction from observed visual range for fog/precipitation conditions - Hourly RH adjustment applied to observed and modeled sulfate and nitrate - RH factor is capped at RHMAX - When fog/precip is observed, replace computed Bext with:  $Bext(1/Mm) = 3912/VR(km)$

# Possible New Method

- Earth Tech proposes refined regional haze analysis in addition to FLAG analysis
  - use Method 7' to account for meteorological interferences
  - use Ammonia Limiting Method with background effects on ammonia consumption and the nitrate equilibrium accounted for
  - use EPA's  $f(\text{RH})$  curves

# Aspects of Method 7'

- Method 7 accounts for change to natural background visibility due to precipitation and fog events
- Method 7' is a variation that responds to FLM concerns that a single weather event hour can substantially change the daily calculation results for Method 7, as FLAG computes the ratio
- Instead, Method 7' takes *hourly* ratios, so the effect of one hour is isolated to  $1/24$  of the total daily average extinction change

# Aspects of Method 7', cont.

- The precipitation and fog effects are obtained from the liquid water content data and precipitation data in the 3D.DAT file
- Method 7' natural extinction for affected hours is calculated using precipitation rate and/or hydrometeor mixing ratios
- Methods 2' and 7' are equivalent when there is no weather, they differ only for those hours with meteorological interferences

# 8 hours with weather – CALPOST Visibility Method

| YEAR | DAY | TIME | RECEPTOR     | SRC     | BCKG+SRC<br>Method 2 | BCKG<br>Method 2 | BCKG+SRC<br>Method 7 | BCKG<br>Method 7 | WEATHER | %CHNG<br>Method 2 | %CHNG<br>Method 7 |
|------|-----|------|--------------|---------|----------------------|------------------|----------------------|------------------|---------|-------------------|-------------------|
| 1996 | 13  | 100  | 732          | 0       | 22.423               | 22.423           | 7807                 | 7807             | fog     | 0                 | 0                 |
| 1996 | 13  | 200  | 732          | 0.002   | 22.425               | 22.423           | 7814.511             | 7814.51          | fog     | 0.007             | 0                 |
| 1996 | 13  | 300  | 732          | 0.054   | 21.581               | 21.527           | 7817.244             | 7817.19          | fog     | 0.251             | 0.001             |
| 1996 | 13  | 400  | 732          | 0.26    | 22.683               | 22.423           | 7817.45              | 7817.19          | fog     | 1.159             | 0.003             |
| 1996 | 13  | 500  | 732          | 0.218   | 22.641               | 22.423           | 10069.467            | 10069.25         | fog     | 0.968             | 0.002             |
| 1996 | 13  | 600  | 732          | 0.878   | 23.301               | 22.423           | 12255.048            | 12254.17         | fog     | 3.914             | 0.007             |
| 1996 | 13  | 700  | 732          | 2.591   | 24.118               | 21.527           | 5470.131             | 5467.54          | fog     | 12.035            | 0.047             |
| 1996 | 13  | 800  | 732          | 3.735   | 26.158               | 22.423           | 2970.625             | 2966.89          | fog     | 16.657            | 0.126             |
| 1996 | 13  | 900  | 732          | 4.808   | 26.335               | 21.527           | 26.335               | 21.527           |         | 22.335            | 22.335            |
| 1996 | 13  | 1000 | 732          | 5.016   | 26.179               | 21.163           | 26.179               | 21.163           |         | 23.698            | 23.698            |
| 1996 | 13  | 1100 | 732          | 5.449   | 26.976               | 21.527           | 26.976               | 21.527           |         | 25.309            | 25.309            |
| 1996 | 13  | 1200 | 732          | 5.518   | 26.681               | 21.163           | 26.681               | 21.163           |         | 26.073            | 26.073            |
| 1996 | 13  | 1300 | 732          | 2.105   | 22.946               | 20.841           | 22.946               | 20.841           |         | 10.099            | 10.099            |
| 1996 | 13  | 1400 | 732          | 2.52    | 23.361               | 20.841           | 23.361               | 20.841           |         | 12.093            | 12.093            |
| 1996 | 13  | 1500 | 732          | 3.668   | 24.509               | 20.841           | 24.509               | 20.841           |         | 17.602            | 17.602            |
| 1996 | 13  | 1600 | 732          | 3.093   | 23.934               | 20.841           | 23.934               | 20.841           |         | 14.843            | 14.843            |
| 1996 | 13  | 1700 | 732          | 3.232   | 24.073               | 20.841           | 24.073               | 20.841           |         | 15.507            | 15.507            |
| 1996 | 13  | 1800 | 732          | 5.337   | 26.864               | 21.527           | 26.864               | 21.527           |         | 24.791            | 24.791            |
| 1996 | 13  | 1900 | 732          | 7.01    | 30.857               | 23.847           | 30.857               | 23.847           |         | 29.396            | 29.396            |
| 1996 | 13  | 2000 | 732          | 8.215   | 32.062               | 23.847           | 32.062               | 23.847           |         | 34.448            | 34.448            |
| 1996 | 13  | 2100 | 732          | 12.173  | 36.02                | 23.847           | 36.02                | 23.847           |         | 51.047            | 51.047            |
| 1996 | 13  | 2200 | 732          | 12.86   | 42.546               | 29.686           | 42.546               | 29.686           |         | 43.322            | 43.322            |
| 1996 | 13  | 2300 | 732          | 0.147   | 23.994               | 23.847           | 23.994               | 23.847           |         | 0.617             | 0.617             |
| 1996 | 14  | 0    | 732          | 0.505   | 30.191               | 29.686           | 30.191               | 29.686           |         | 1.7               | 1.7               |
|      |     |      |              |         |                      |                  |                      |                  |         |                   |                   |
|      |     |      | 24h-Average: | 3.72475 | 26.36908333          | 22.64433333      | 2602.875167          | 2599.151         |         | 16.16129167       | 14.71108333       |

Method 2=(3.724/22.6)\*100= 16.44892762  
 Method 7=(3.724/2599.15)\*100= **0.143306438**  
 Method2p= 16.16129167  
 Method7p= **14.71108333**

# 24 hours with weather – CALPOST Visibility Methods

| YEAR | DAY | TIME | RECEPTOR     | SRC     | BCKG+SRC<br>Method 2 | BCKG<br>Method 2 | BCKG+SRC<br>Method 7 | BCKG<br>Method 7 | WEATHER | %CHNG<br>Method 2 | %CHNG<br>Method 7 |
|------|-----|------|--------------|---------|----------------------|------------------|----------------------|------------------|---------|-------------------|-------------------|
| 1996 | 12  | 100  | 627          | 0       | 29.686               | 29.686           | 1871.72              | 1871.72          | rain    | 0                 | 0                 |
| 1996 | 12  | 200  | 627          | 0       | 21.527               | 21.527           | 1496.52              | 1496.52          | rain    | 0                 | 0                 |
| 1996 | 12  | 300  | 627          | 0       | 29.686               | 29.686           | 1091.79              | 1091.79          | rain    | 0                 | 0                 |
| 1996 | 12  | 400  | 627          | 0       | 23.847               | 23.847           | 636.86               | 636.86           | rain    | 0                 | 0                 |
| 1996 | 12  | 500  | 627          | 0       | 23.847               | 23.847           | 10510.68             | 10510.68         | rain    | 0                 | 0                 |
| 1996 | 12  | 600  | 627          | 0       | 23.847               | 23.847           | 14740.56             | 14740.56         | rain    | 0                 | 0                 |
| 1996 | 12  | 700  | 627          | 0       | 29.686               | 29.686           | 16796.02             | 16796.02         | rain    | 0                 | 0                 |
| 1996 | 12  | 800  | 627          | 0       | 22.423               | 22.423           | 16807.49             | 16807.49         | rain    | 0                 | 0                 |
| 1996 | 12  | 900  | 627          | 0       | 21.527               | 21.527           | 6004.65              | 6004.65          | rain    | 0                 | 0                 |
| 1996 | 12  | 1000 | 627          | 0       | 22.423               | 22.423           | 636.9                | 636.9            | rain    | 0                 | 0                 |
| 1996 | 12  | 1100 | 627          | 0       | 21.527               | 21.527           | 636.92               | 636.92           | rain    | 0                 | 0                 |
| 1996 | 12  | 1200 | 627          | 0.129   | 21.292               | 21.163           | 637.069              | 636.94           | rain    | 0.61              | 0.02              |
| 1996 | 12  | 1300 | 627          | 0.803   | 21.644               | 20.841           | 637.763              | 636.96           | rain    | 3.851             | 0.126             |
| 1996 | 12  | 1400 | 627          | 2.451   | 23.614               | 21.163           | 639.43               | 636.98           | rain    | 11.578            | 0.385             |
| 1996 | 12  | 1500 | 627          | 4.153   | 25.316               | 21.163           | 641.152              | 637              | rain    | 19.621            | 0.652             |
| 1996 | 12  | 1600 | 627          | 4.521   | 25.362               | 20.841           | 641.531              | 637.01           | rain    | 21.691            | 0.71              |
| 1996 | 12  | 1700 | 627          | 5.766   | 26.929               | 21.163           | 642.776              | 637.01           | rain    | 27.245            | 0.905             |
| 1996 | 12  | 1800 | 627          | 4.624   | 26.151               | 21.527           | 641.643              | 637.02           | rain    | 21.477            | 0.726             |
| 1996 | 12  | 1900 | 627          | 3.94    | 25.467               | 21.527           | 6054.6               | 6050.66          | rain    | 18.303            | 0.065             |
| 1996 | 12  | 2000 | 627          | 2.733   | 24.26                | 21.527           | 8080.322             | 8077.59          | fog     | 12.693            | 0.034             |
| 1996 | 12  | 2100 | 627          | 1.116   | 22.643               | 21.527           | 8087.306             | 8086.19          | fog     | 5.183             | 0.014             |
| 1996 | 12  | 2200 | 627          | 1.62    | 24.043               | 22.423           | 10339.08             | 10337.46         | fog     | 7.223             | 0.016             |
| 1996 | 12  | 2300 | 627          | 8.576   | 32.423               | 23.847           | 10020.557            | 10011.98         | fog     | 35.964            | 0.086             |
| 1996 | 13  | 0    | 627          | 16.226  | 40.073               | 23.847           | 12209.065            | 12192.84         | fog     | 68.041            | 0.133             |
|      |     |      | 24h-Average: | 2.36075 | 25.385125            | 23.024375        | 5437.600167          | 5435.2396        |         | 10.56166667       | 0.161333333       |

Method 2=(3.724/22.6)\*100= 10.2532642  
 Method 7=(3.724/2599.15)\*100= 0.043434148  
 Method2p= 10.56166667  
 Method7p= 0.161333333

# Geikie Glacier 1899-2003

**2003**



**1899**



# MUIR 1941



# MUIR 2004



## FLM INFORMATION AVAILABLE AT:

- <http://www.nature.nps.gov/ard/>
- <http://www.nature.nps.gov/ard/fws/fwsaqb.html>
- <http://www.aqd.nps.gov/ard/flagfree/>
- <http://www.epa.gov/ttn/nsr/techinfo.html>
- [http://www2.nature.nps.gov/air/Permits/emissions\\_ControlTech.htm](http://www2.nature.nps.gov/air/Permits/emissions_ControlTech.htm)
- <http://www2.nature.nps.gov/air/maps/Receptors/index.htm>
- <http://www.epa.gov/scram001/t29.html>