Optimización de la búsqueda de parámetros atmosféricos en modelos de transferencia radiativa

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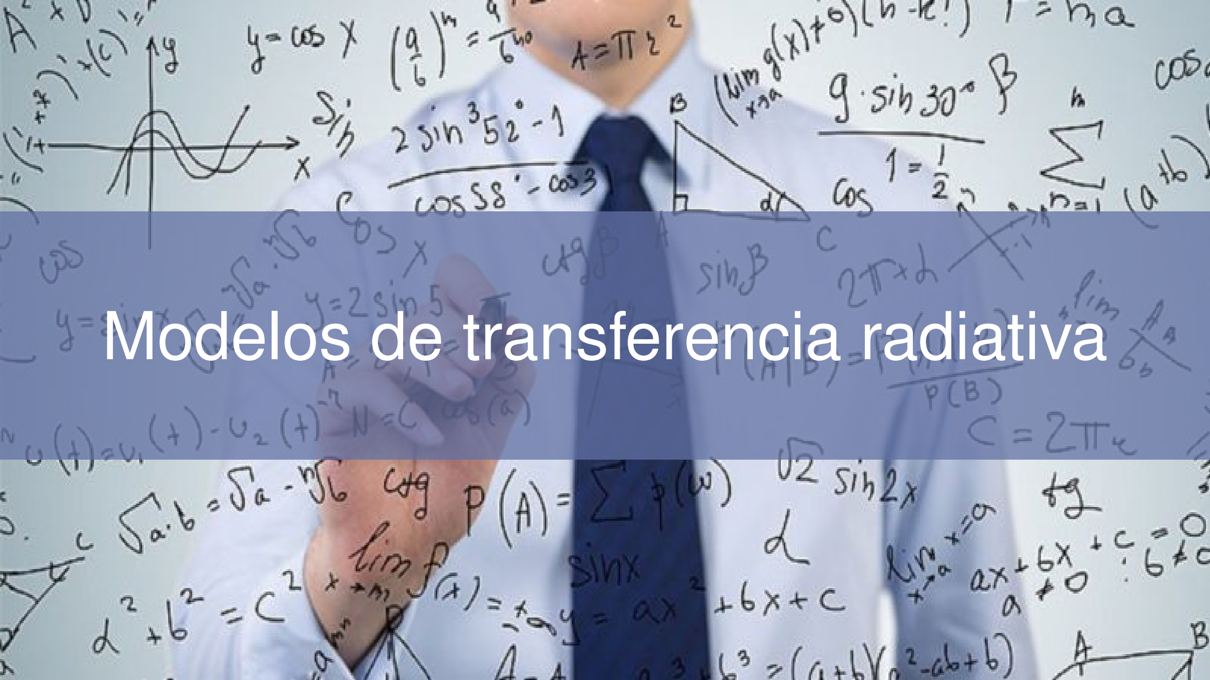
Modelos de transferencia radiativa



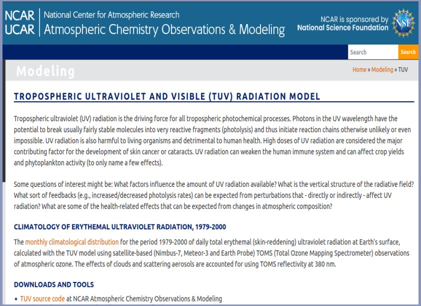


Figura 1: Tropospheric Ultraviolet and Visible (TUV) radiation model. [1]

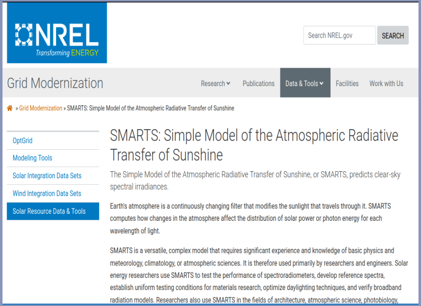


Figura 2: Simple Model of the Atmospheric Radiative Transfer of Sunshine. [2]

¿Qué hacen estos modelos?

$$\frac{dE}{dAdt} = I_\nu(\hat{k}, \vec{r}, t)\vec{k} \cdot \vec{n} d\Omega d\nu \qquad [3]$$

```
'AOD=0.041 '
2
25.750 0.476 0
1
'USSA'
1
0
1 0.2740
0
3
390
0
'S&F_URBAN'
5
0.041 2
18
1
51 37.0 180.0
285 2800 1 1366.1
2
285 2800 1
1
4
1
0 2.9 0
0
0
1
3
2015 1 11 8.2167 25.75 -100.255 -6
```

Figura 3: Archivo de inputs del modelo SMARTS

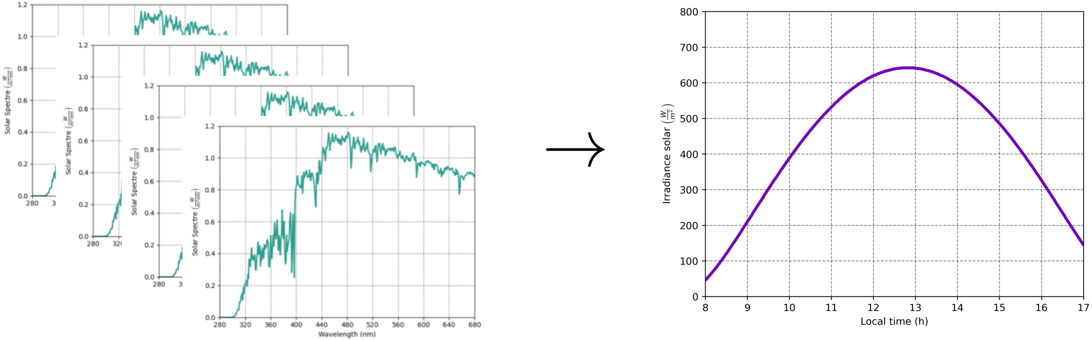
```
TUV inputs:
==================================================================
inpfil =        CDMX  outfil =         cdmx  nstr =            -2
lat =         19.420  lon =         -99.145  tmzone =        -6.0
iyear =         2016  imonth =            1  iday =             9
zstart =       2.245  zstop =        80.000  nz =              81
wstart =     280.000  wstop =       400.000  nwint =          120
tstart =      10.000  tstop =        15.000  nt =              61
lzenit =           F  alsurf =        0.080  psurf =       -999.0
o3col =      228.380  so2col =        0.000  no2col =       0.100
taucld =       0.000  zbase =         4.000  ztop =         5.000
tauaer =       0.061  ssaaer =        0.800  alpha =        1.000
dirsun =       1.000  difdn =         1.000  difup =        0.000
zout =         2.245  zaird =    -9.990E+02  ztemp =     -999.000
lirrad =           T  laflux =            F  lmmech =           F
lrates =           T  isfix =             0  nms =              2
ljvals =           F  ijfix =             0  nmj =              0
iwfix =            0  itfix =             0  izfix =            0
==================================================================
```

Figura 4: Archivo de inputs del modelo TUV

$$I(t) = \int_{\lambda_0}^{\lambda_i} E(\lambda, t) d\lambda \quad (1)$$

```
# Calculo de la irradiancia solar a partir de los resultados del modelo SMARTS
size = np.size(irradiance)
integral = irradiance[0]
for i in range(1, size):
    integral += irradiance[i]*(wavelength[i]-wavelength[i-1])
```

Figura 5: Implementación de la ecuación 1.


Solar Spectre $\left(\frac{W}{m^2 \cdot nm}\right)$
Wavelength (nm)
Irradiance solar $\left(\frac{W}{m^2}\right)$
Local time (h)

Recolección de datos

Mediciones satelitales

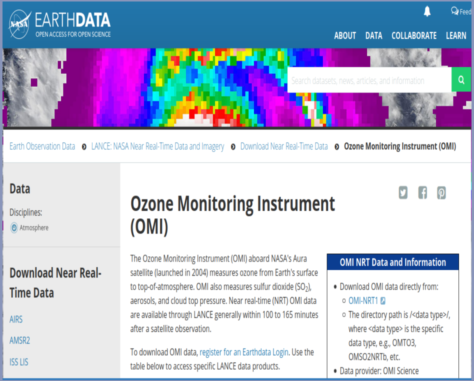


Figura 6: Página web del proyecto OMI. [4]

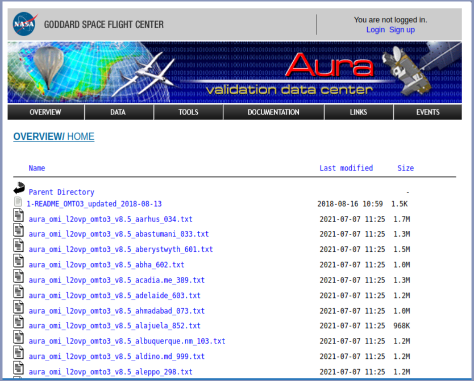


Figura 7: Página web de los datos OMI. [5]

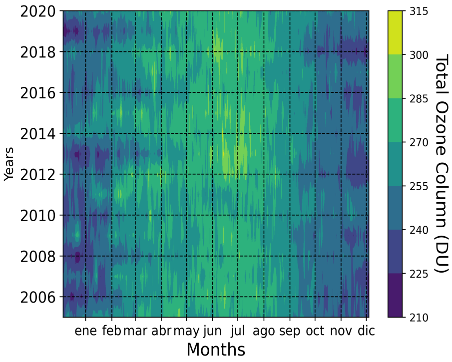


Figura 8: Datos de columnas de Ozono en CDMX.

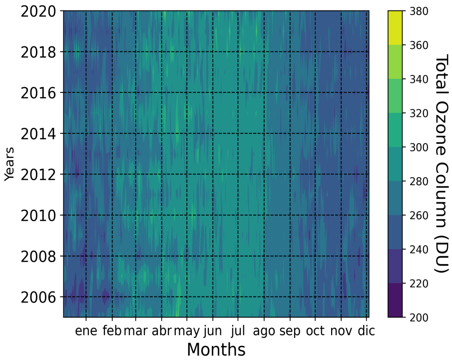


Figura 9: Datos de columnas de Ozono en Monterrey.

Mediciones in situ

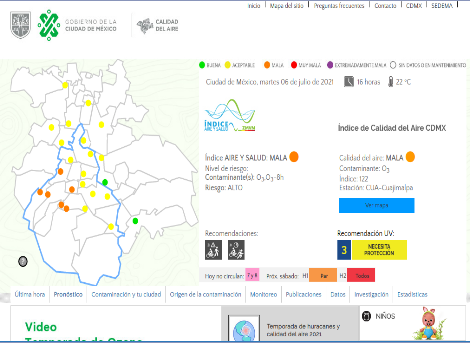


Figura 10: Página web de la SEDEMA. [6]

Figura 11: Página web del SIMA. [7]

$$
\begin{aligned}
\text{UVB} &\rightarrow [280nm, 320nm] \\
\text{UVA} &\rightarrow [320nm, 400nm] \\
\text{UVB+UVA} &\rightarrow [280nm, 400nm]
\end{aligned}
$$

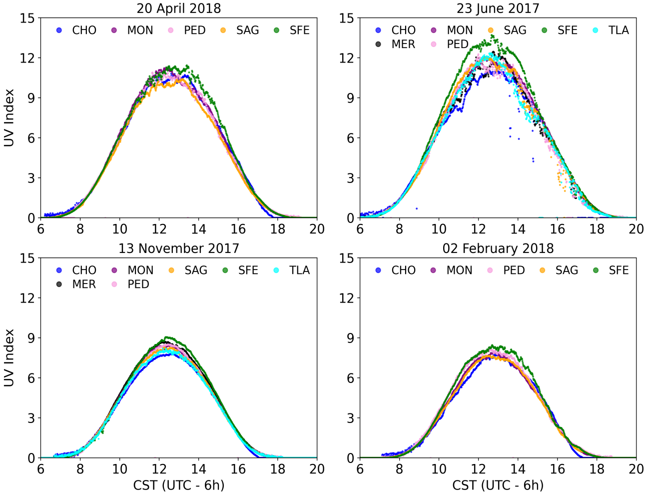


Figura 12: Mediciones de indice UV en las diferentes estaciones de monitoreo de la SEDEMA. [6]

Primera aproximación a la solución: Búsqueda de los parámetros por diferenciales

$$RD = \left(\frac{Model - measurement}{measurement}\right) * 100$$

```python
while 9 <= RD <= 11:
    execute_model(parameters)
    model_result = read_model_results()
    RD = obtain_RD(model_result,
                   measurement)
    if not(9 <= RD <= 11):
        aod = aod+delta_aod
```

Segunda aproximación a la solución:
Búsqueda de los parámetros por medio del algoritmo de búsqueda binaria

```python
while 9 <= RD <= 11:
    execute_model(parameters)
    model_result = read_model_results()
    RD = obtain_RD(model_result,
                   measurement)
    if not(9 <= RD <= 11):
        aod = aod_binary_search(RD,
                                aod)
```

```python
def aod_binary_search(self, aod, RD):
    """
    Función que calcula el AOD que se introducira en el modelo SMARTS
    este emplea una busqueda binaria para que sea más eficiente
    """
    if self.RD_search(RD):
        self.aod_i = aod
    elif RD > self.parameters["RD limite"]+self.parameters["RD delta"]:
        self.aod_i = aod
    else:
        self.aod_lim = aod
    aod = self.obtain_aod(self.aod_lim,
                          self.aod_i)
    return aod

def obtain_aod(self, aod_i, aod_f):
    return round((aod_i+aod_f)/2, 3)

def RD_search(self, RD):
    lim_i = self.parameters["RD limite"]-self.parameters["RD delta"]
    lim_f = self.parameters["RD limite"]+self.parameters["RD delta"]
    return lim_i < RD < lim_f
```

```
Calculando el dia 2015-01-11
AOD_i   AOD     AOD_f   RD
0.01    0.505   1       7.812
0.01    0.258   0.505   17.906
0.258   0.382   0.505   12.764
0.382   0.444   0.505   10.369

Calculando el dia 2015-01-12
AOD_i   AOD     AOD_f   RD
0.01    0.505   1       17.57
0.505   0.752   1       7.194
0.505   0.629   0.752   12.38
0.629   0.691   0.752   9.793

Calculando el dia 2015-01-17
AOD_i   AOD     AOD_f   RD
0.01    0.505   1       16.497
0.505   0.752   1       6.262
0.505   0.629   0.752   11.286
0.629   0.691   0.752   8.764
0.629   0.66    0.691   10.028
```

```
Calculando el dia 2015-01-11
AOD_i   AOD     AOD_f   RD
0.01    0.505   1       -1.067
0.01    0.258   0.505   13.109
0.258   0.382   0.505   5.749
0.258   0.32    0.382   9.35

Calculando el dia 2015-01-12
AOD_i   AOD     AOD_f   RD
0.01    0.505   1       7.938
0.01    0.258   0.505   23.347
0.258   0.382   0.505   15.525
0.382   0.444   0.505   11.646
0.444   0.475   0.505   9.806

Calculando el dia 2015-01-17
AOD_i   AOD     AOD_f   RD
0.01    0.505   1       6.977
0.01    0.258   0.505   21.899
0.258   0.382   0.505   14.338
0.382   0.444   0.505   10.58
```

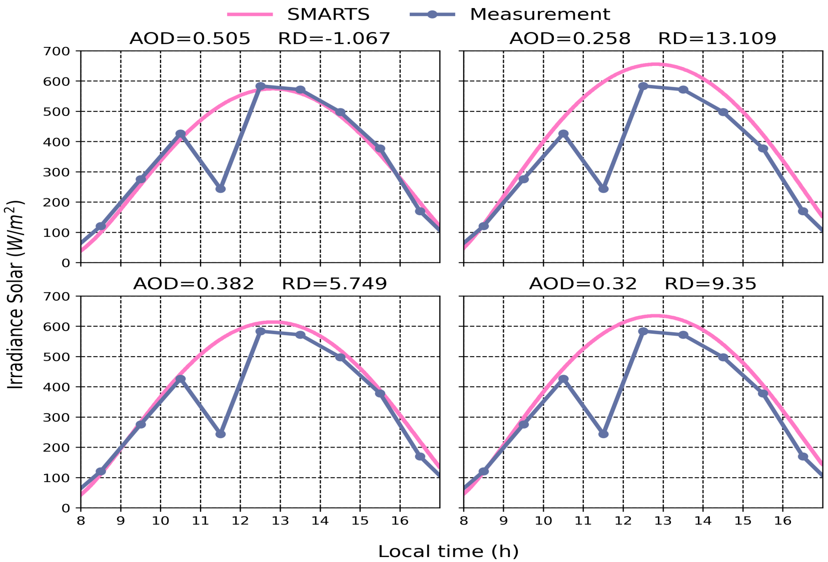


Figura 13: Resultados del Modelo SMARTS haciendo uso de la búsqueda binaria.


THANK YOU

[1] NCAR, "Atmospheric chemistry observations & modeling." https://www2.acom.ucar.edu/modeling/tropospheric-ultraviolet-and-visible-tuv-radiation-model, 7 2021.

[2] NREL, "Smarts: Simple model of the atmospheric radiative transfer of sunshine." https://www.nrel.gov/grid/solar-resource/smarts.html, 7 2021.

[3] A. Carramiñana, *Transferencia radiativa*, ch. 2, pp. 1–24. INAOE, 8 2020. https://www.inaoep.mx/~alberto/cursos/radiacion/cap2.pdf.

[4] EarthData, "Ozone Monitoring Instrument (OMI)." https://earthdata.nasa.gov/earth-observation-data/near-real-time/download-nrt-data/omi-nrt.

[5] Goddard Space Flight Center, "Aura Validation Data Center." https://avdc.gstfc.nasa.gov/pub/data/satellite/Aura/OMI/V03/L2OVP/OMTO3/.

[6] SEDEMA, "Sistema de Monitoreo Atmosférico,Ciudad de México." http://www.aire.cdmx.gob.mx/default.php?opc=%27aKBhnmI=%27&opcion=bQ==.

[7] SIMA, "Sistema integral de monitoreo ambiental." http://aire.nl.gob.mx/.