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

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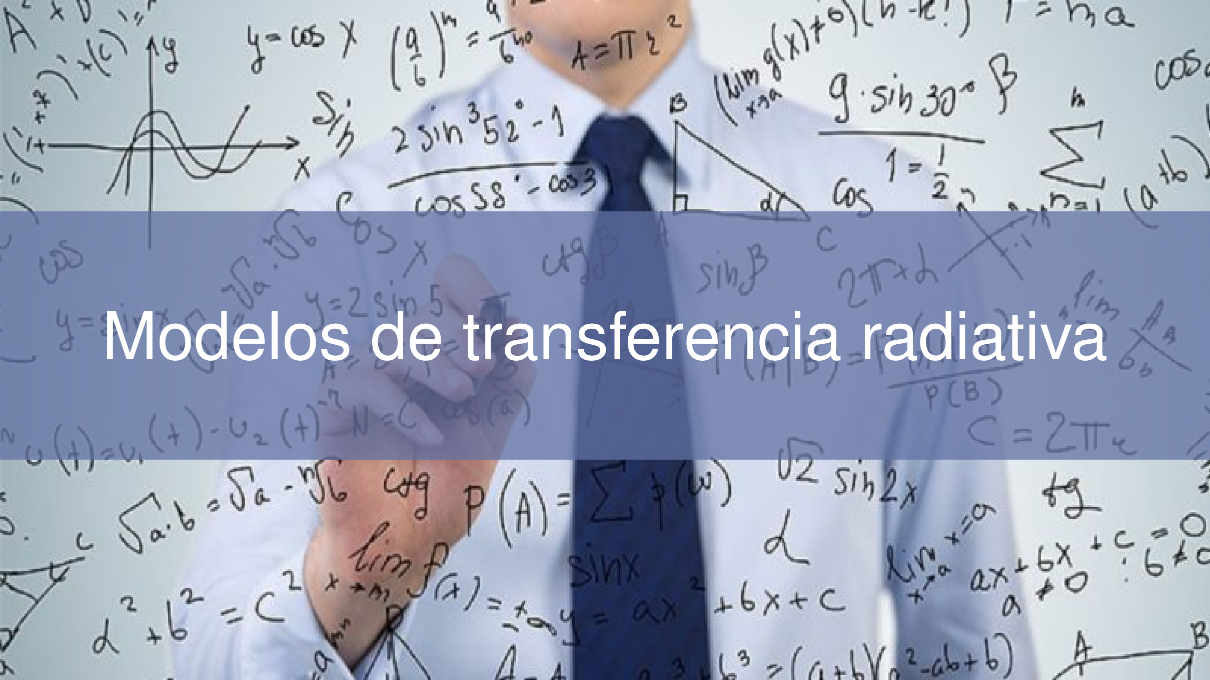
8 de julio de 2021

Modelos de transferencia radiativa



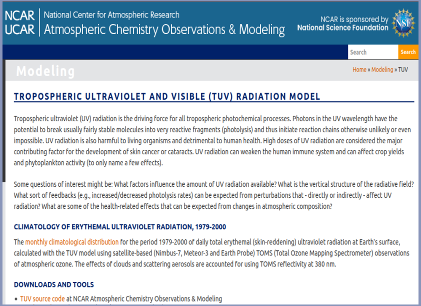


Figura 1: Tropospheric Ultraviolet and Visible (TUV) radiation model. [1]

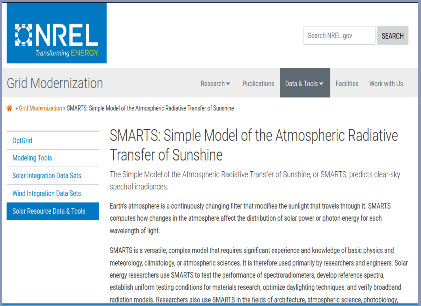


Figura 2: Simple Model of the Atmospheric Radiative Transfer of Sunshine. [2]

¿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

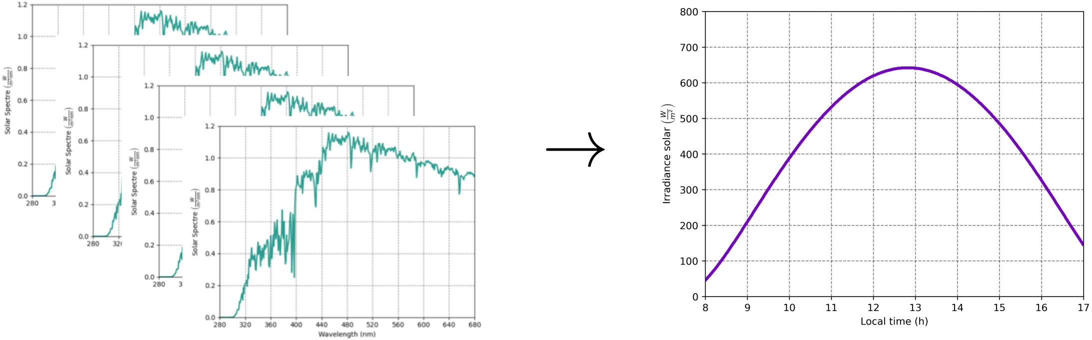
```
TUV inputs:
==================================================================
inpfil =        CDMX  outfil =        cdmx  nstr =            -2
lat =         19.420  lon =        -99.145  tmzone =        -6.0
iyear =         2016  imonth =           1  iday =             9
zstart =       2.245  zstop =       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

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

```
# 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
Wavelength (nm)
280 320 360 400 440 480 520 560 600 640 680
0.0 0.2 0.4 0.6 0.8 1.0 1.2
Irradiance solar
Local time (h)
8 9 10 11 12 13 14 15 16 17
0 100 200 300 400 500 600 700 800

Recolección de datos

Mediciones satelitales

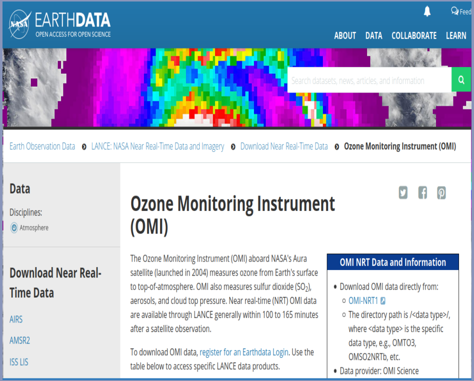


Figura 6: Página web del proyecto OMI. [4]

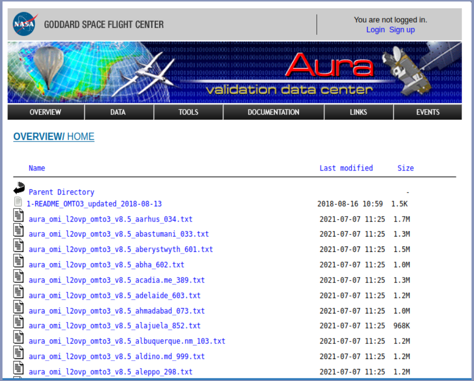


Figura 7: Página web de los datos OMI. [5]

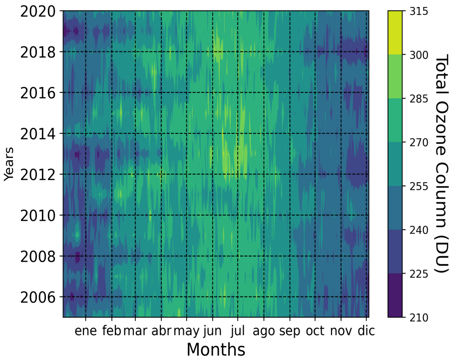


Figura 8: Datos de columnas de Ozono en CDMX.

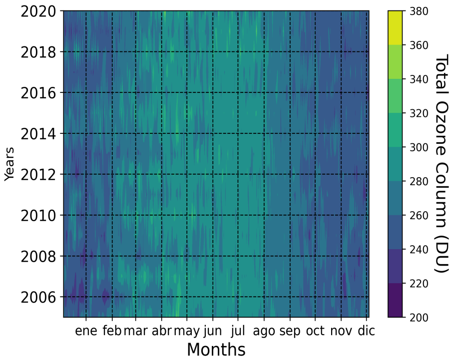


Figura 9: Datos de columnas de Ozono en Monterrey.

Mediciones in situ

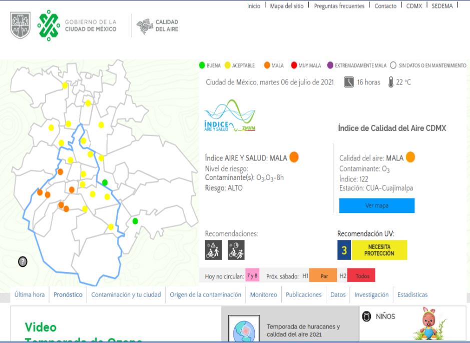


Figura 10: Página web de la SEDEMA. [6]

Figura 11: Página web del SIMA. [7]

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

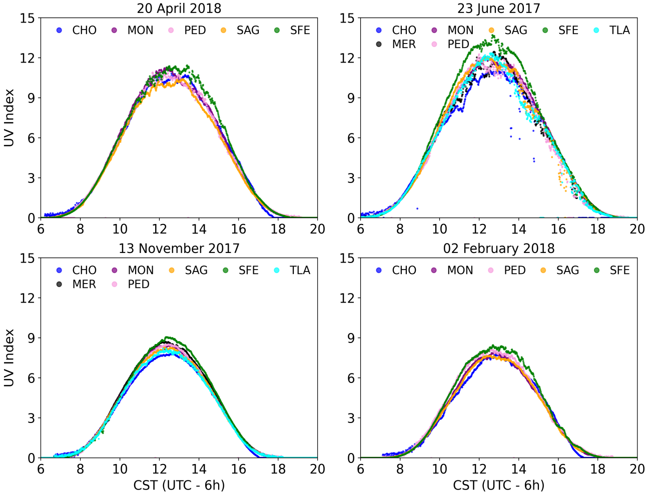


Figura 12: Mediciones de indice UV en las diferentes estaciones de monitoreo de la SEDEMA. [6]

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

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

```
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
```

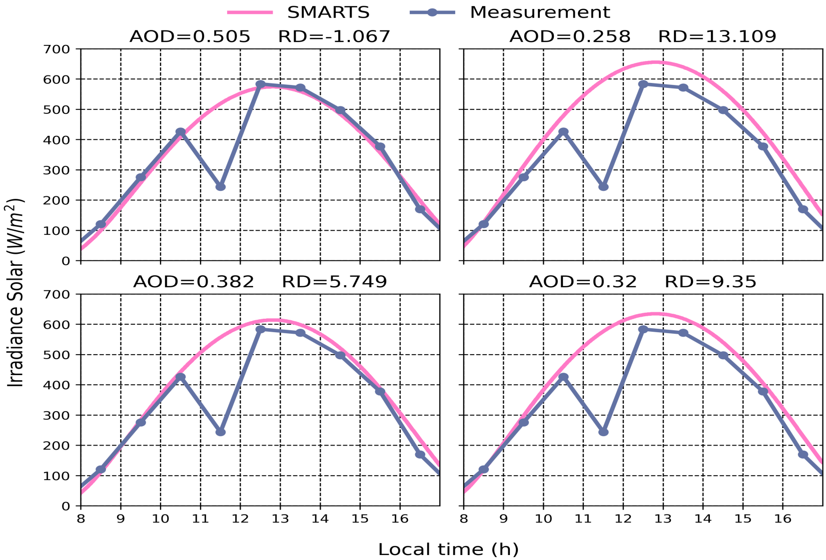


Figura 13: Resultados del Modelo SMARTS haciendo uso de la búsqueda binaria.


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/.