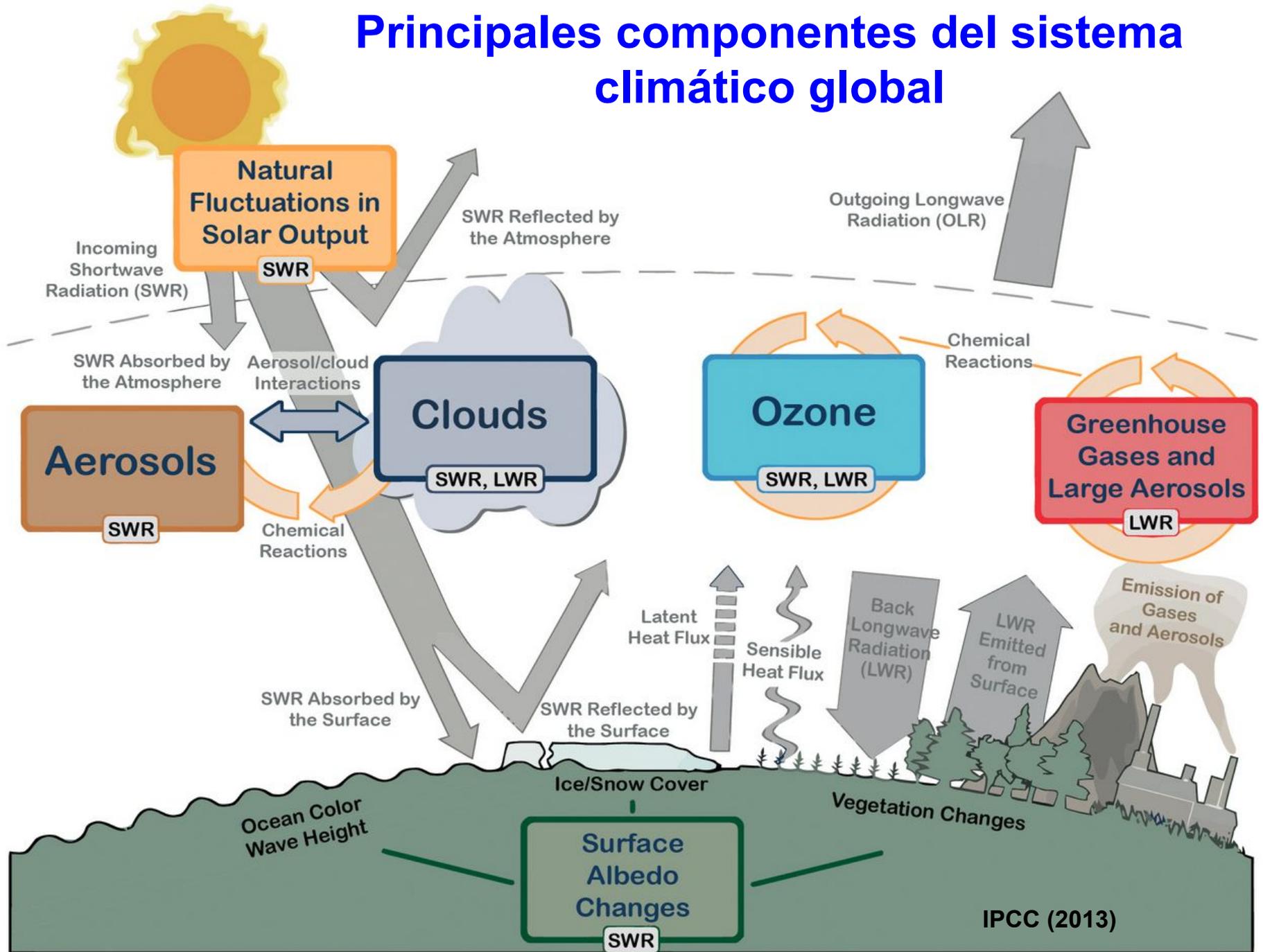




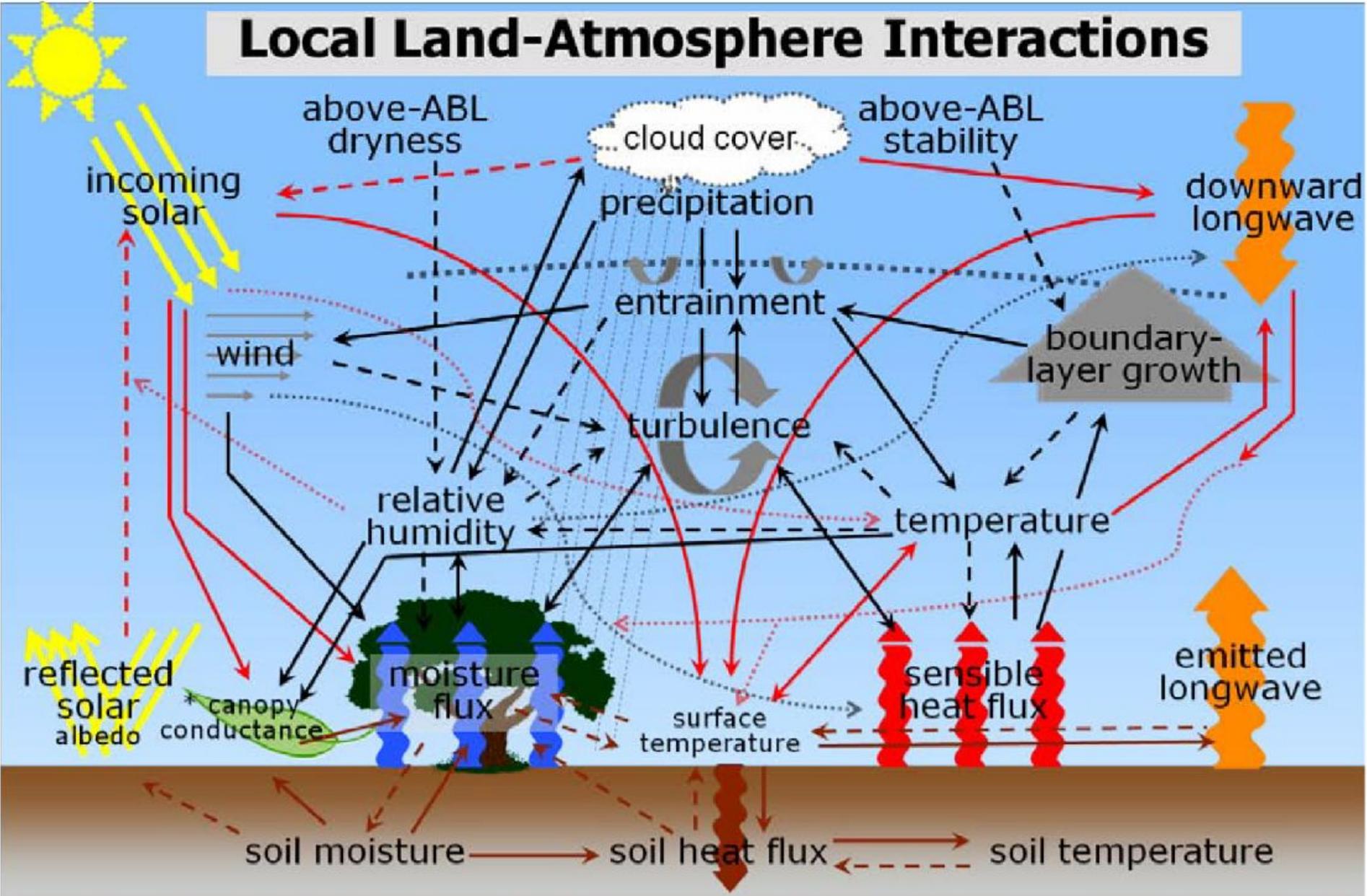
Radiación solar y balance de energía

Christian Torres
Instituto de Oceanografía
Universidade Federal do Rio Grande, Brasil
christian010194@gmail.com

Principales componentes del sistema climático global



Local Land-Atmosphere Interactions

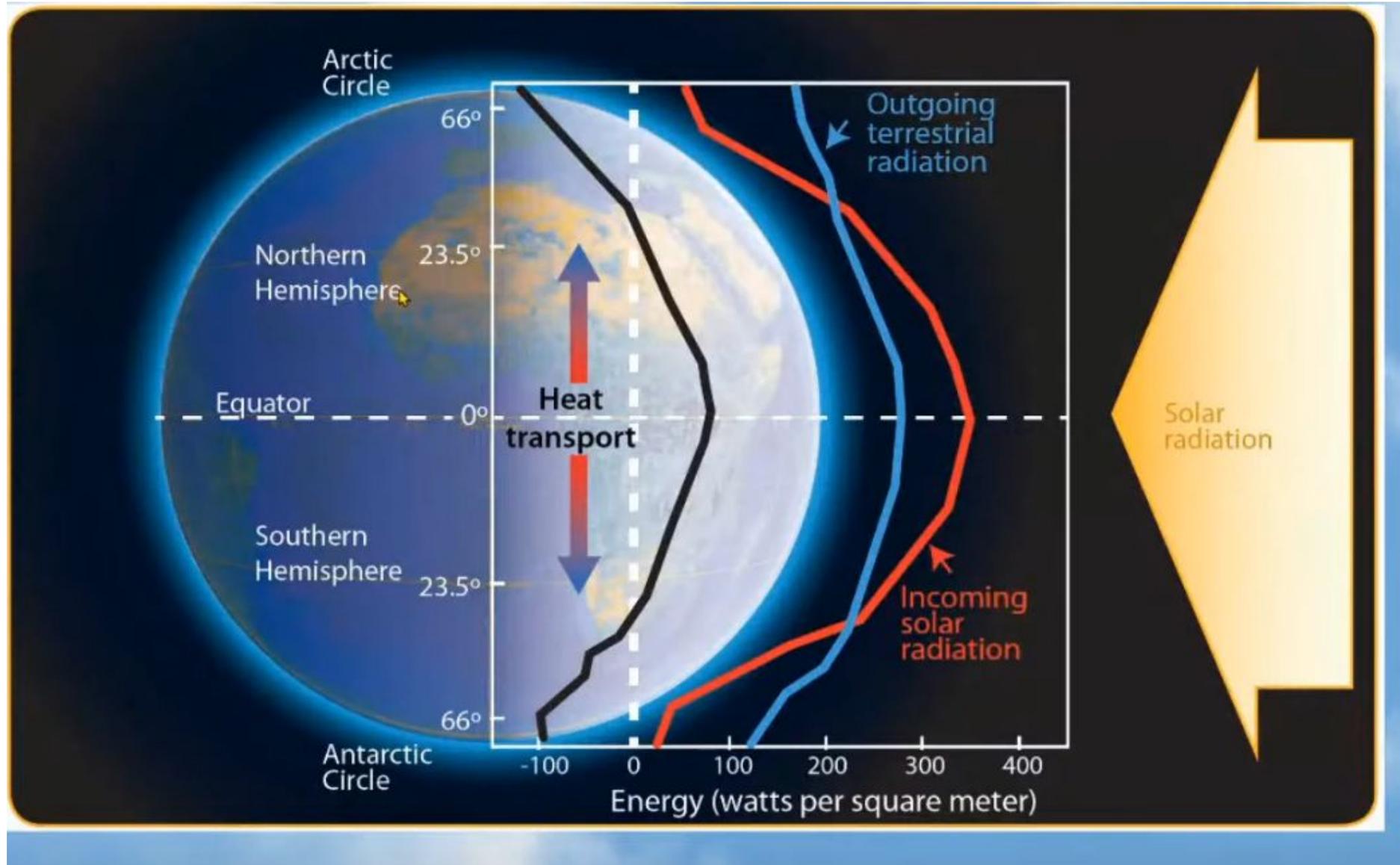


*positive feedback for C3 & C4 plants and negative feedback for CAM plants for incoming solar; negative feedback above optimal temperatures

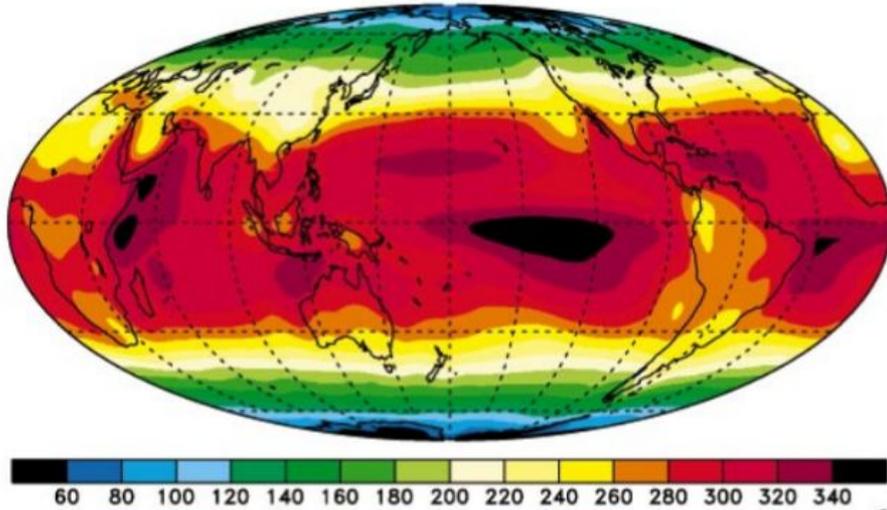
————> positive feedback
 - - - -> negative feedback

————> land-surface processes ———> surface layer & ABL ———> radiation

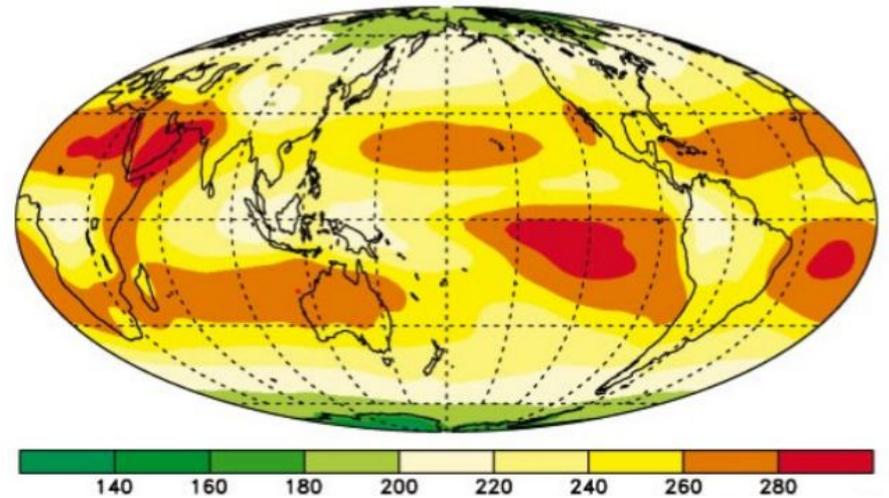
Balance de radiación solar



Distribución de la radiación en la Tierra (W/m^2)



Radiación de onda corta entrante promedio anual en el tope (W/m^2)

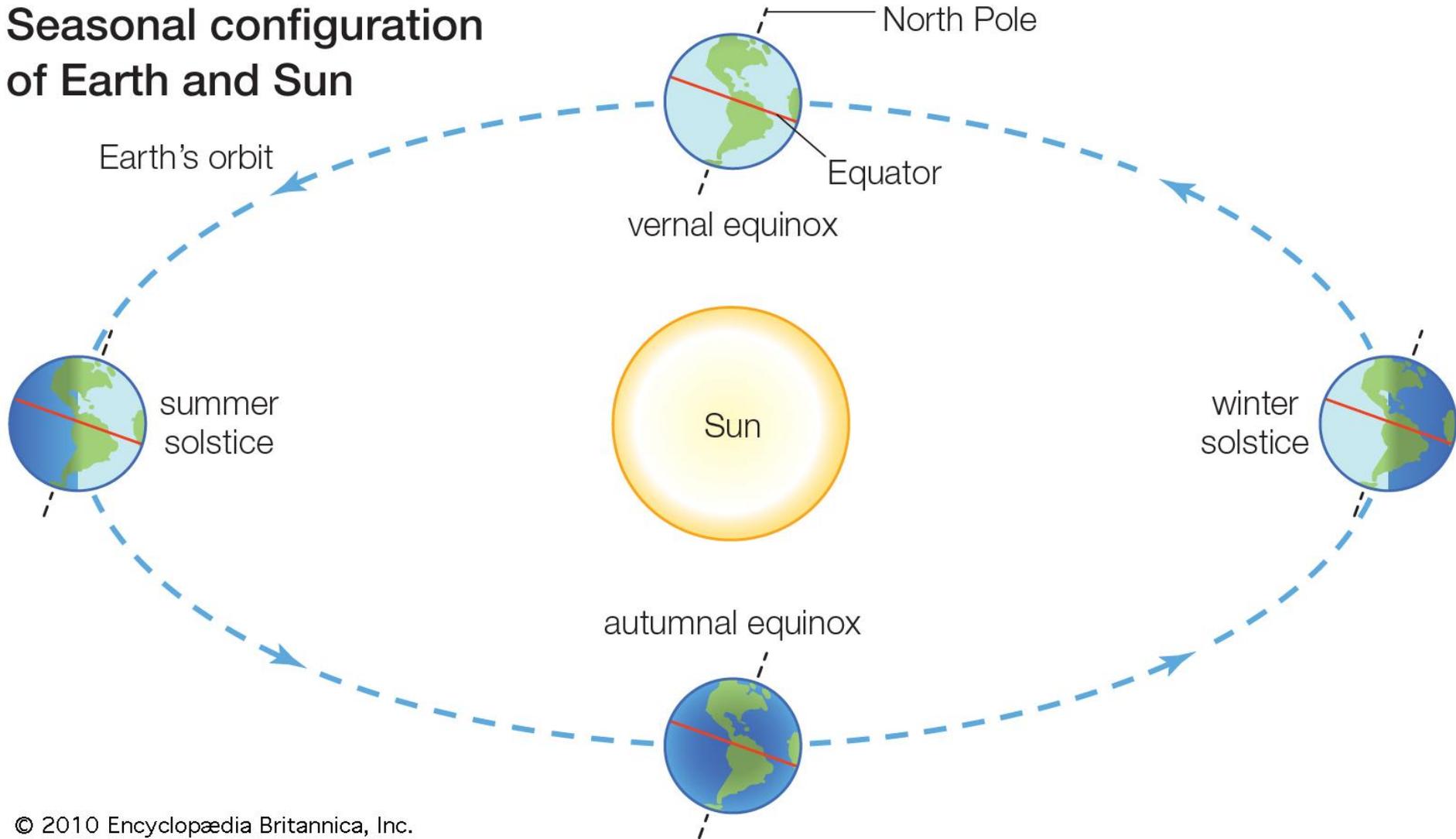


Radiación de onda larga saliente promedio anual en el tope (W/m^2)

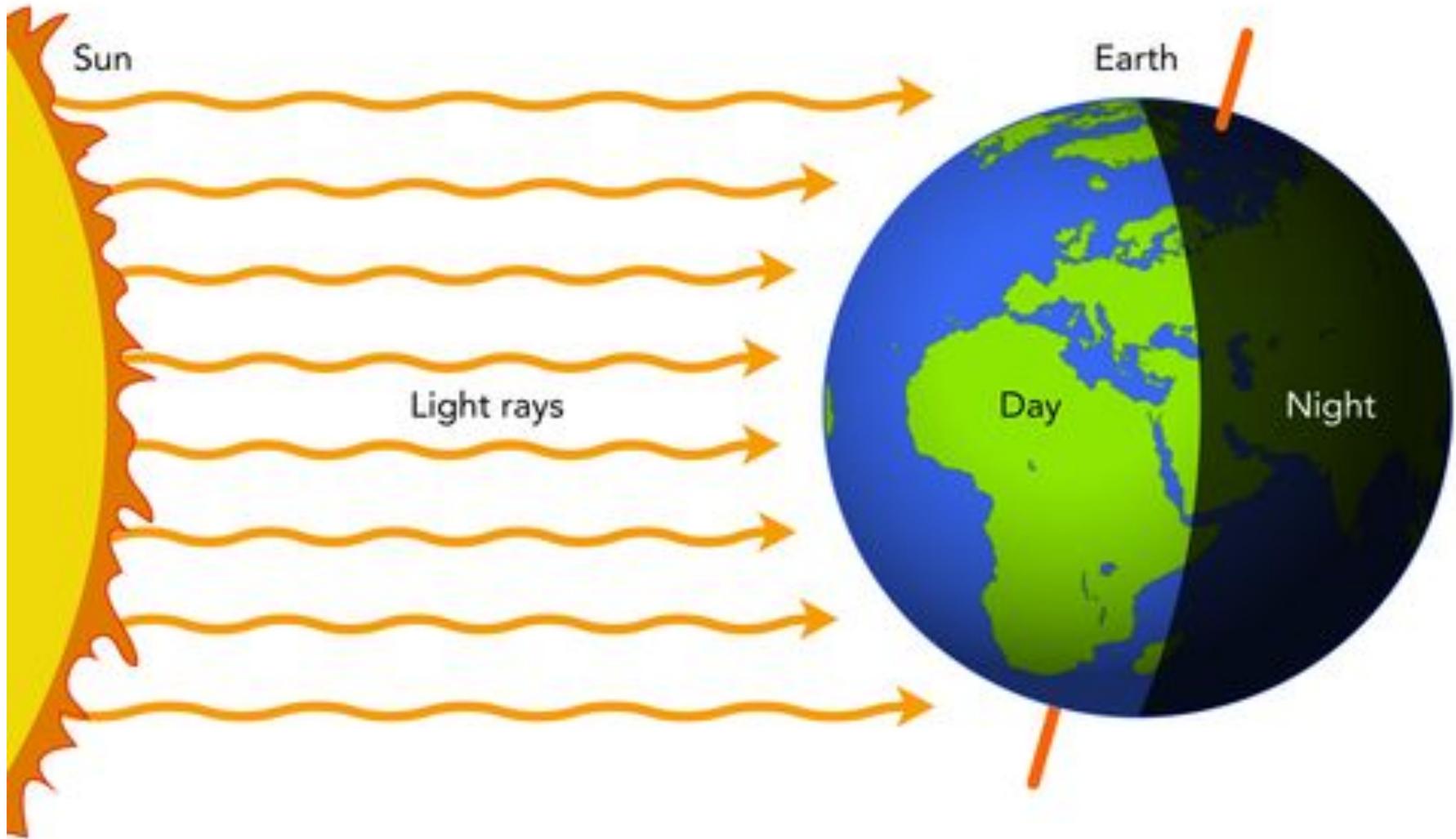
Trenberth y Stepaniak (2003, J. Clim.)

Variación estacional de la radiación solar

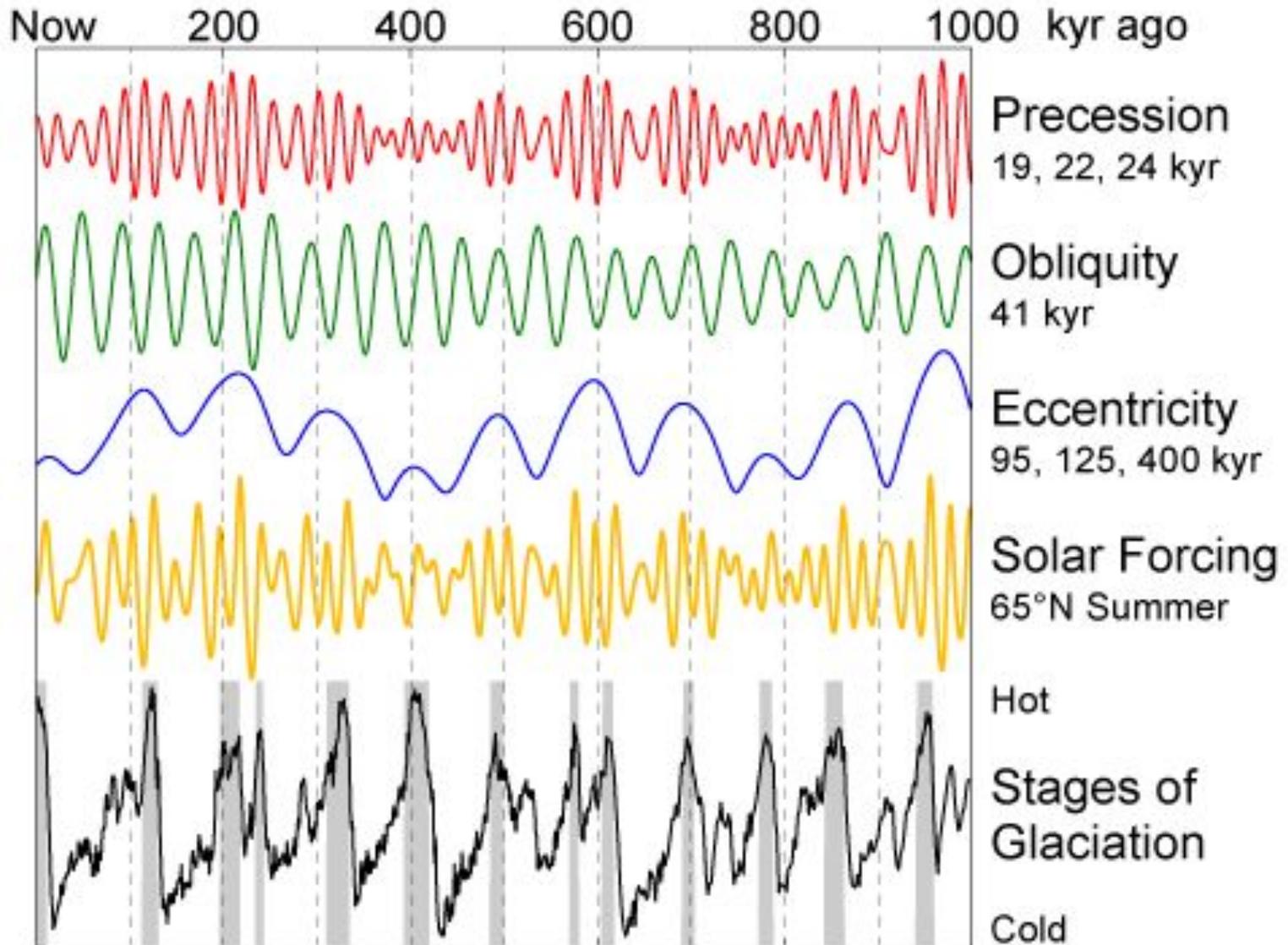
Seasonal configuration of Earth and Sun



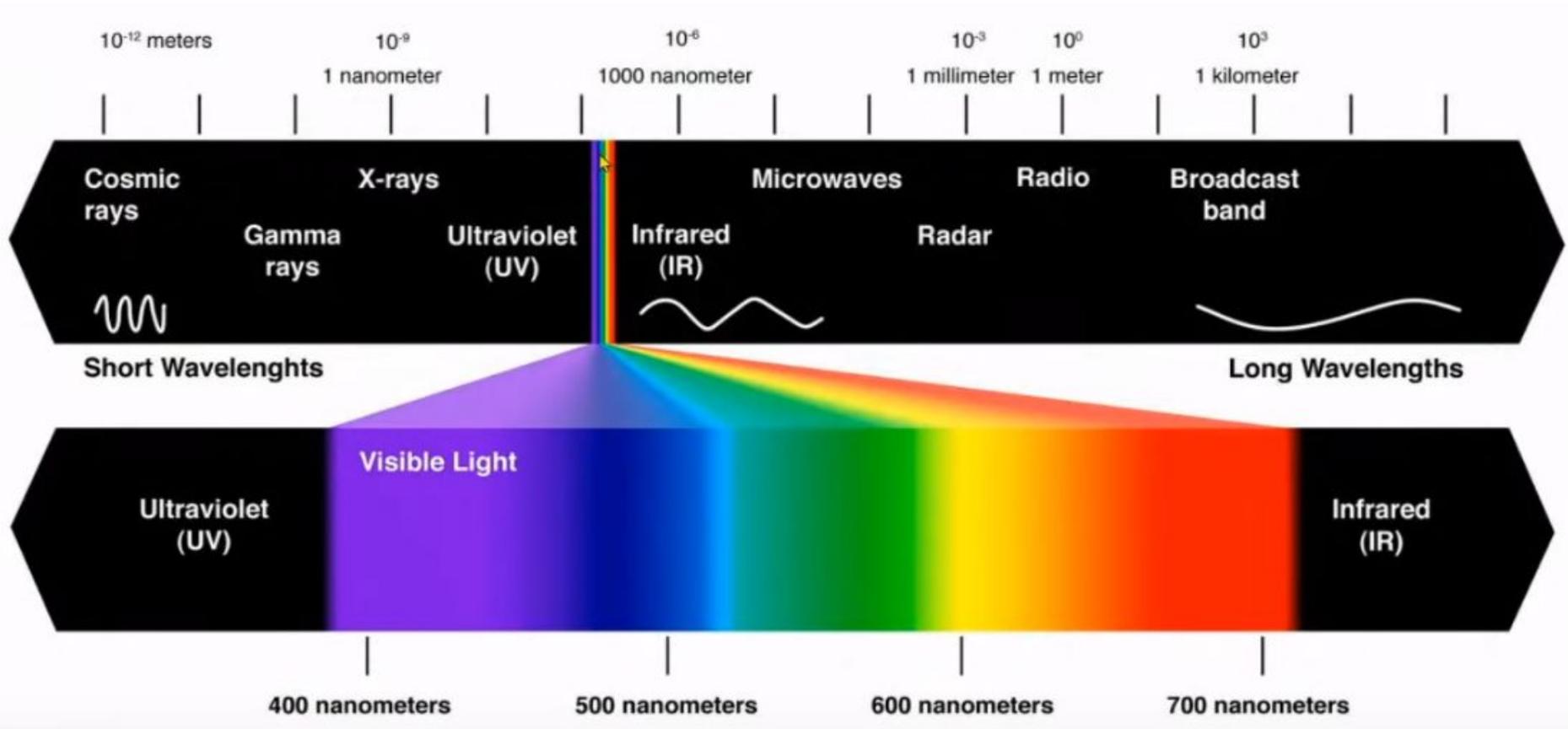
Variación de la radiación solar día y noche



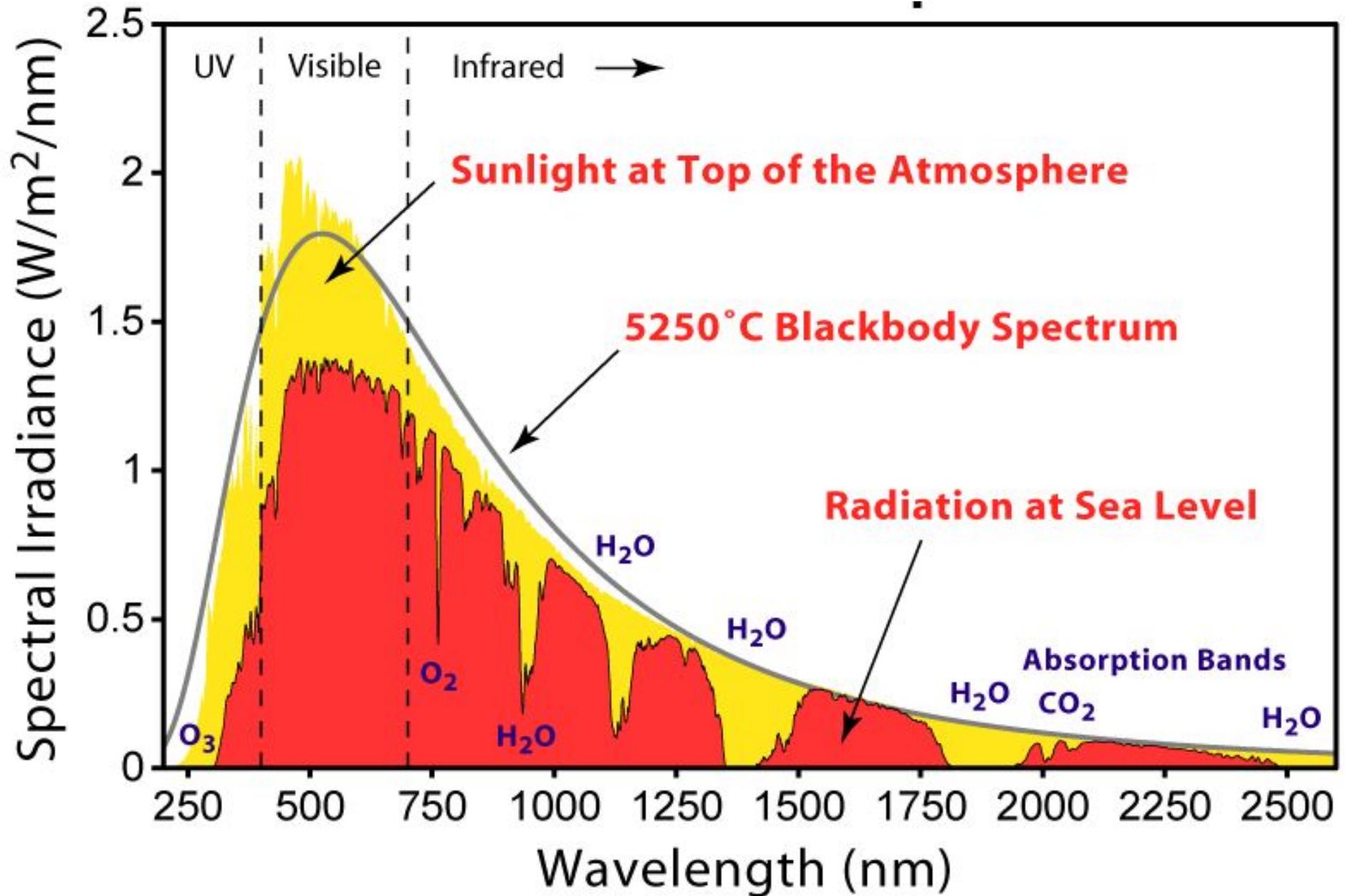
Cambios en el la órbita de la Tierra



Espectro electromagnético

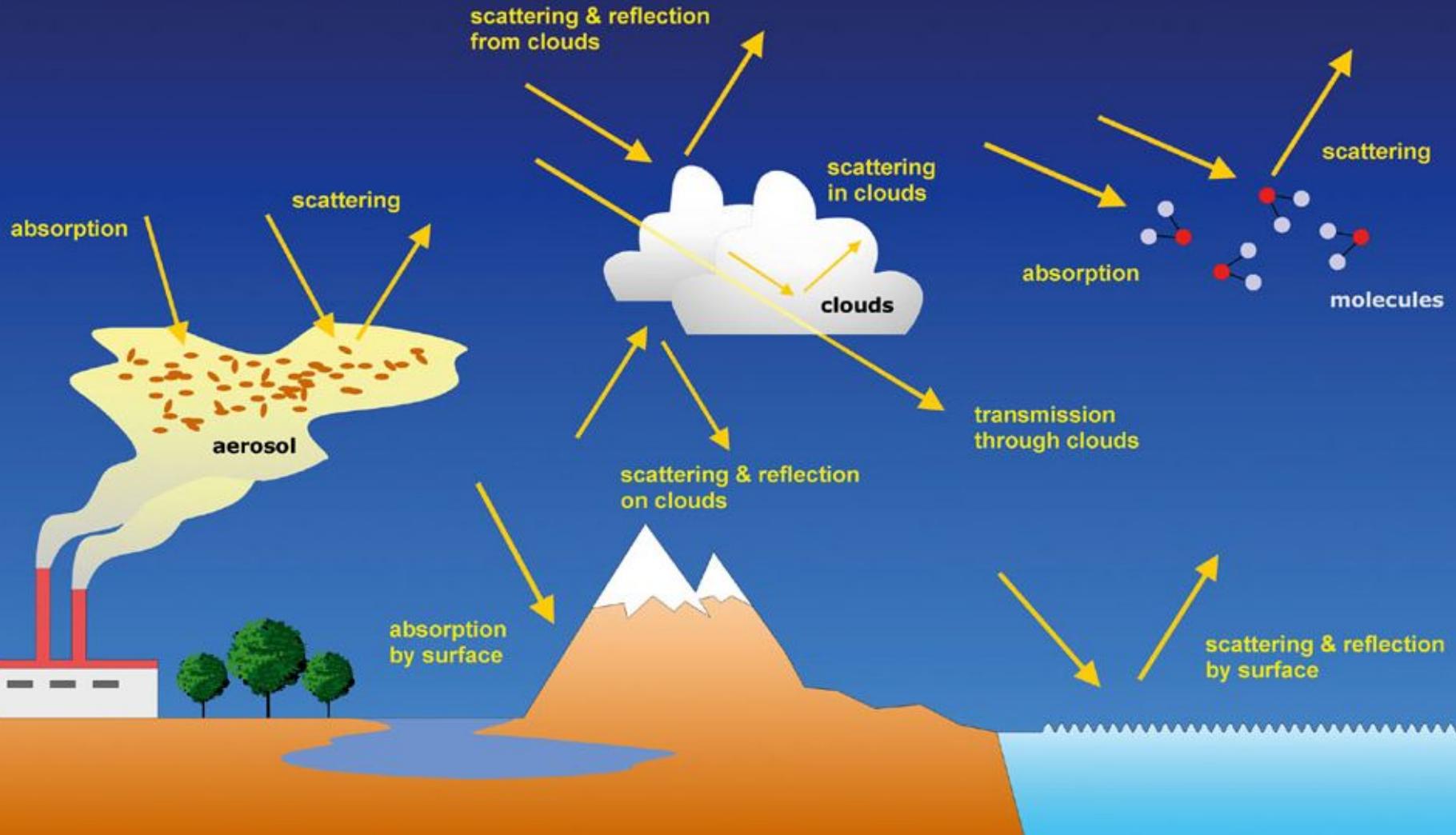


Espectro de la radiación solar



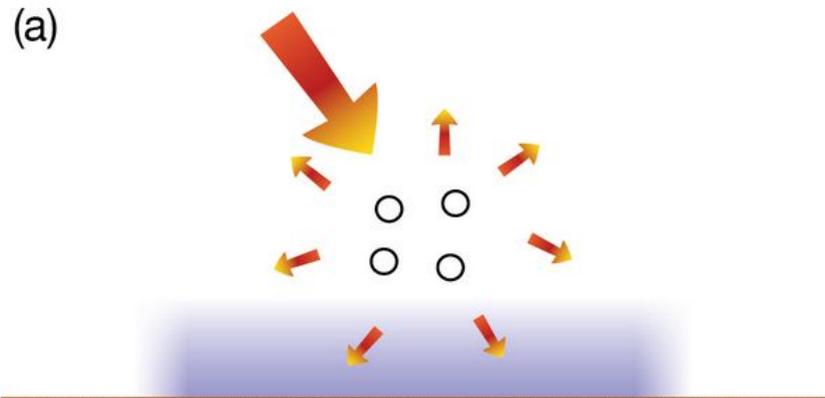
Interacción radiación-atmósfera

Atmospheric Propagation Effects

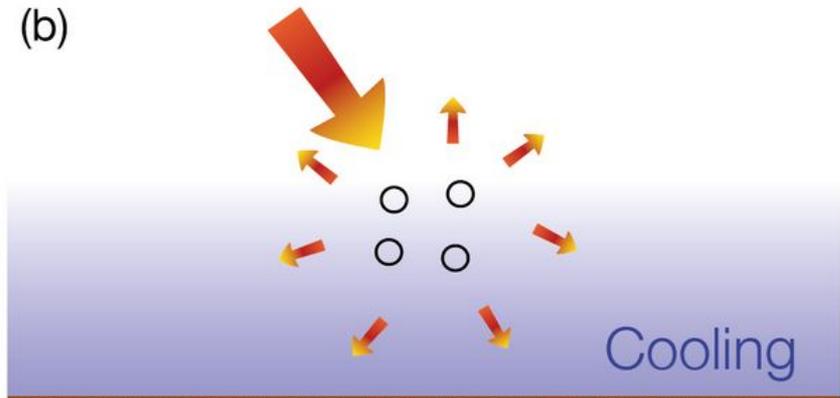


Interacciones Aerosol-Radiación

Scattering aerosols

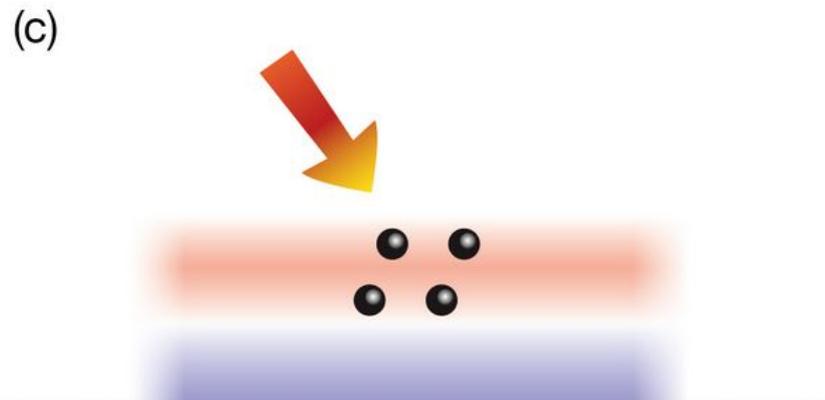


Aerosols scatter solar radiation. Less solar radiation reaches the surface, which leads to a localised cooling.

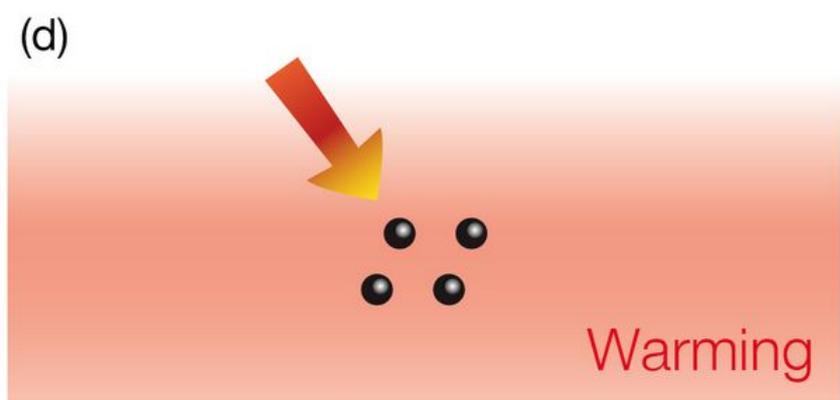


The atmospheric circulation and mixing processes spread the cooling regionally and in the vertical.

Absorbing aerosols



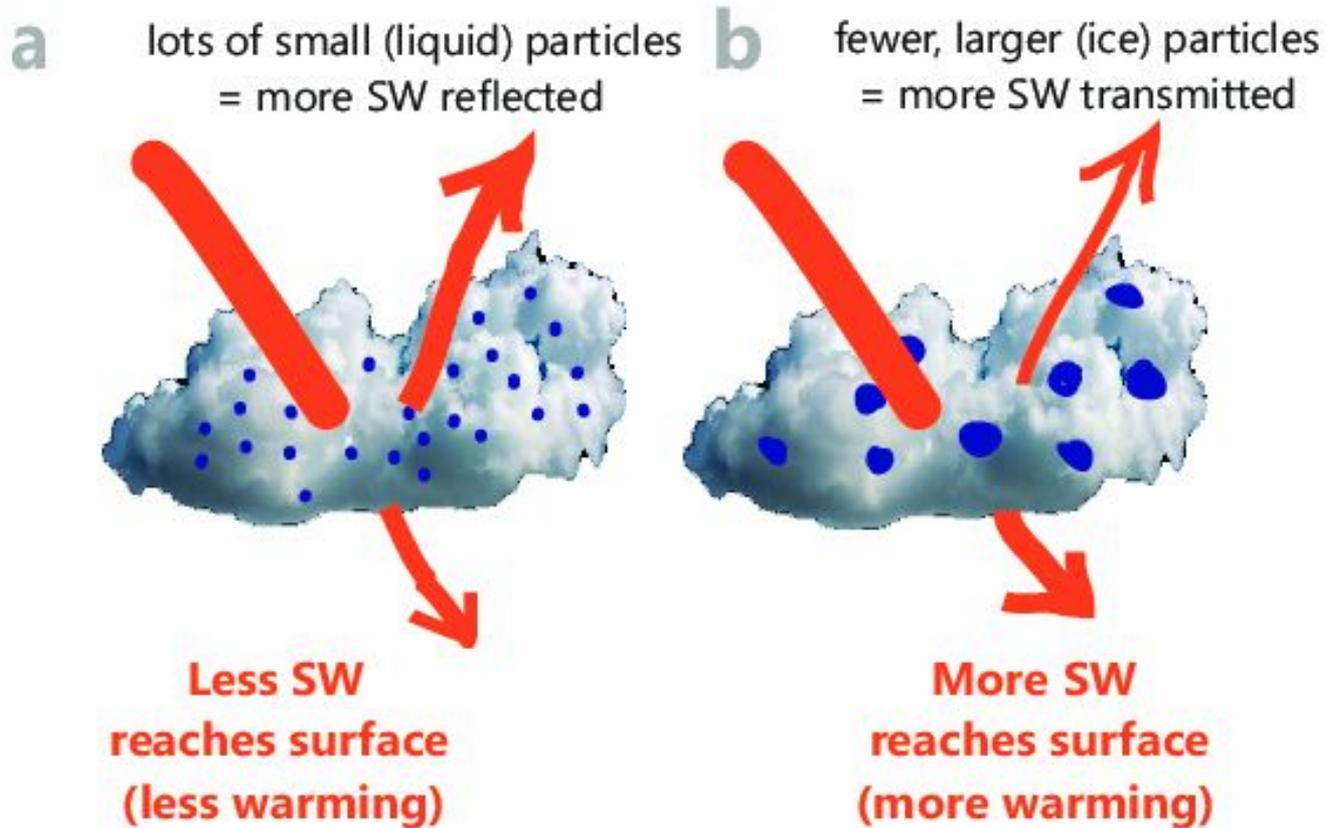
Aerosols absorb solar radiation. This heats the aerosol layer but the surface, which receives less solar radiation, can cool locally.



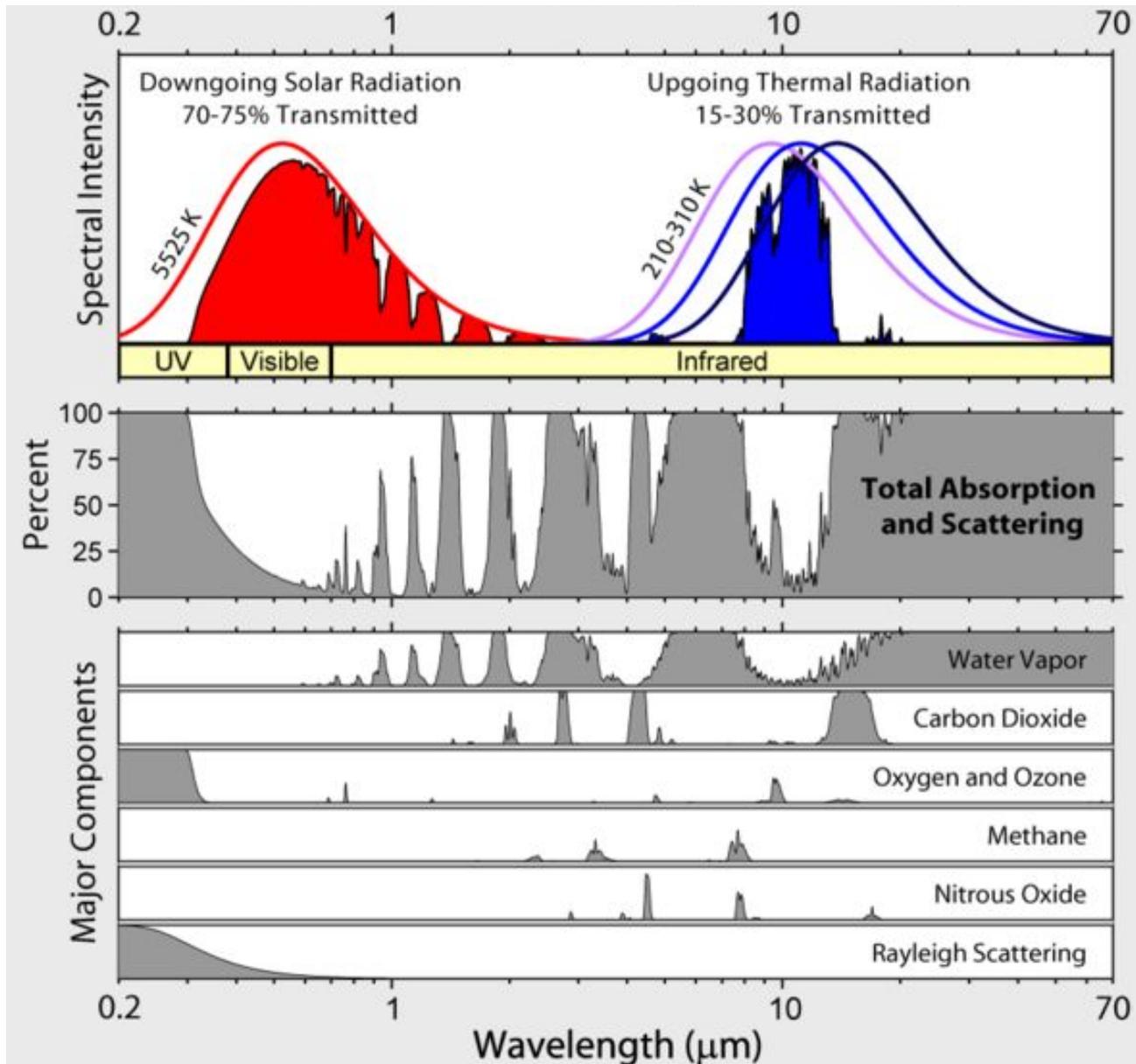
At the larger scale there is a net warming of the surface and atmosphere because the atmospheric circulation and mixing processes redistribute the thermal energy.

Interacciones Aerosol-Nubes

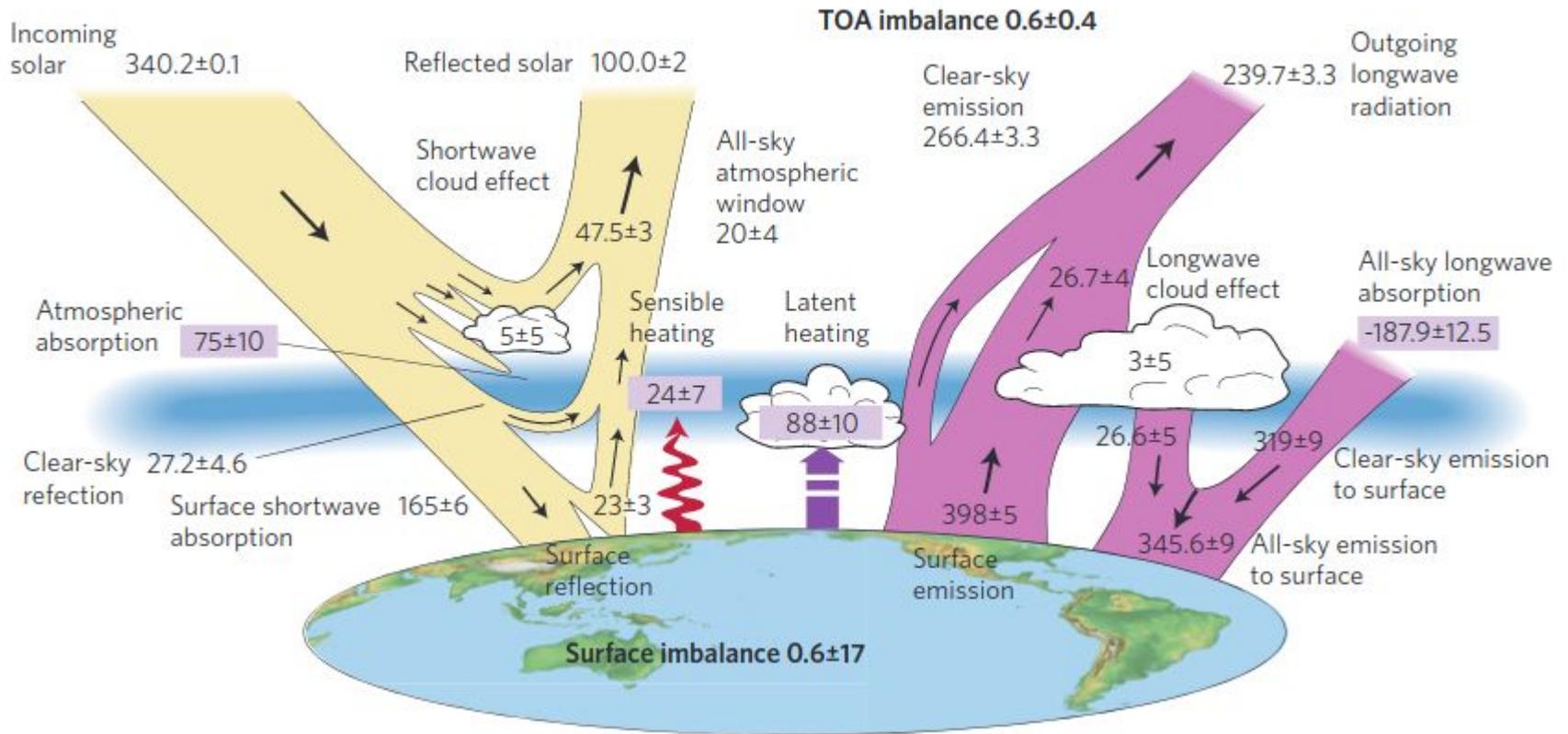
Incoming solar shortwave (SW)



Radiación transmitida por la atmósfera



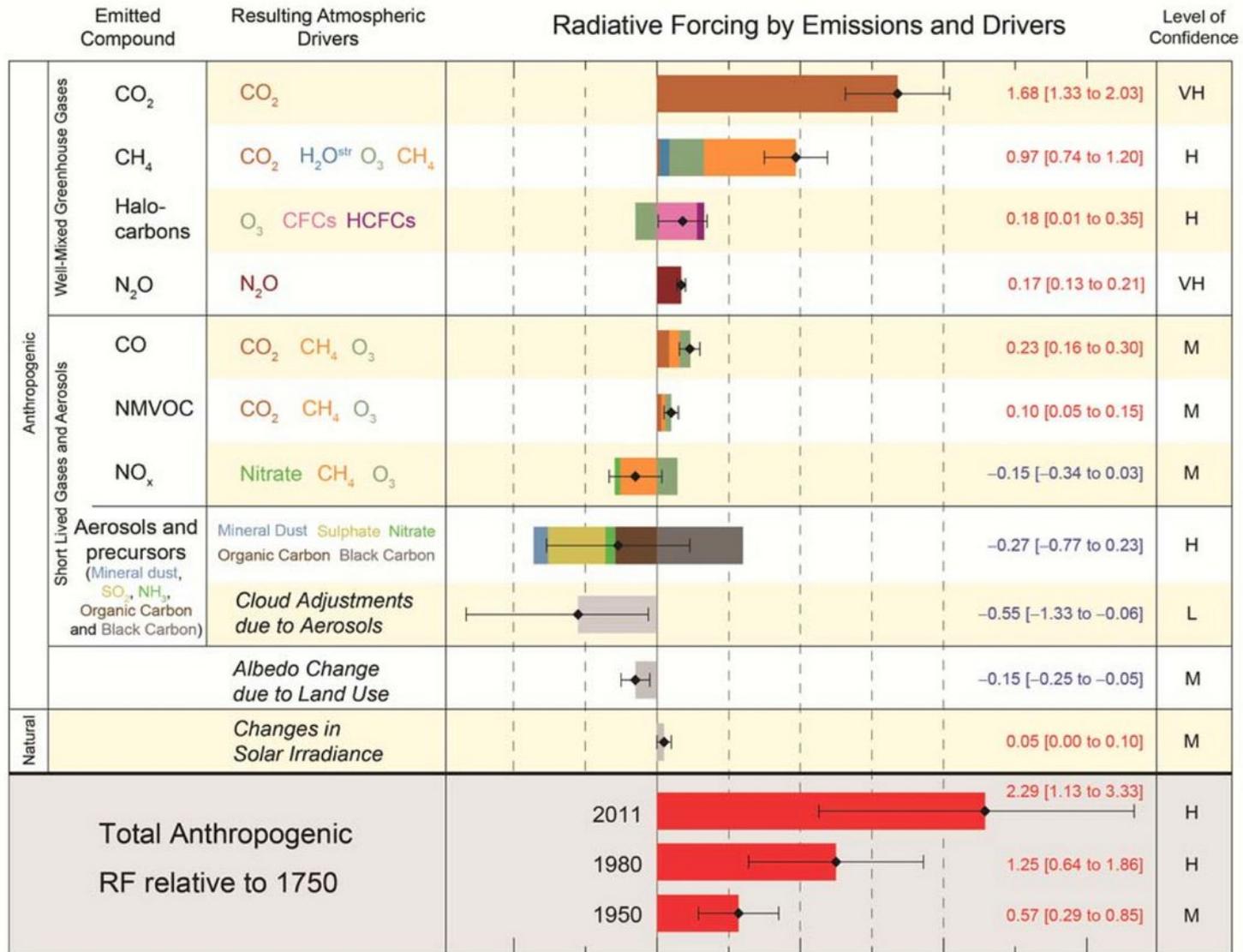
Balance de energía del sistema terrestre (W/m^2)



Stephens et al., (2012, Nature)

El balance de energía promedio anual global de la Tierra para aproximadamente el periodo de 2000-2010. Todos los flujos de energía están en W/m^2 . Los lujos solar están en amarillo y los flujos infrarrojos en rosado.

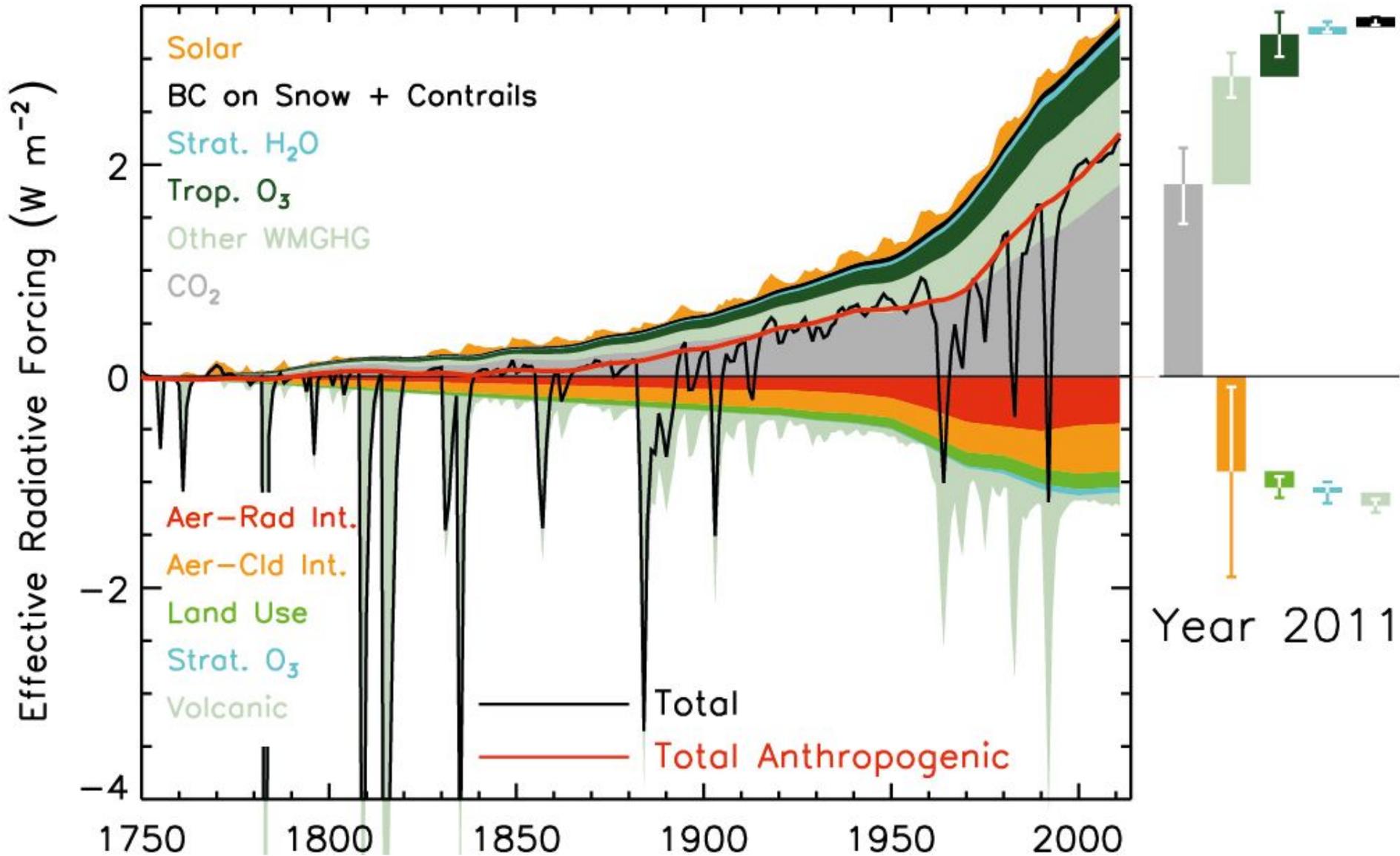
Forzamiento radiativo del sistema global climático (IPCC 2013)

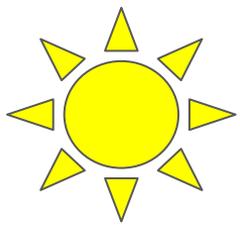


IPCC (2013)

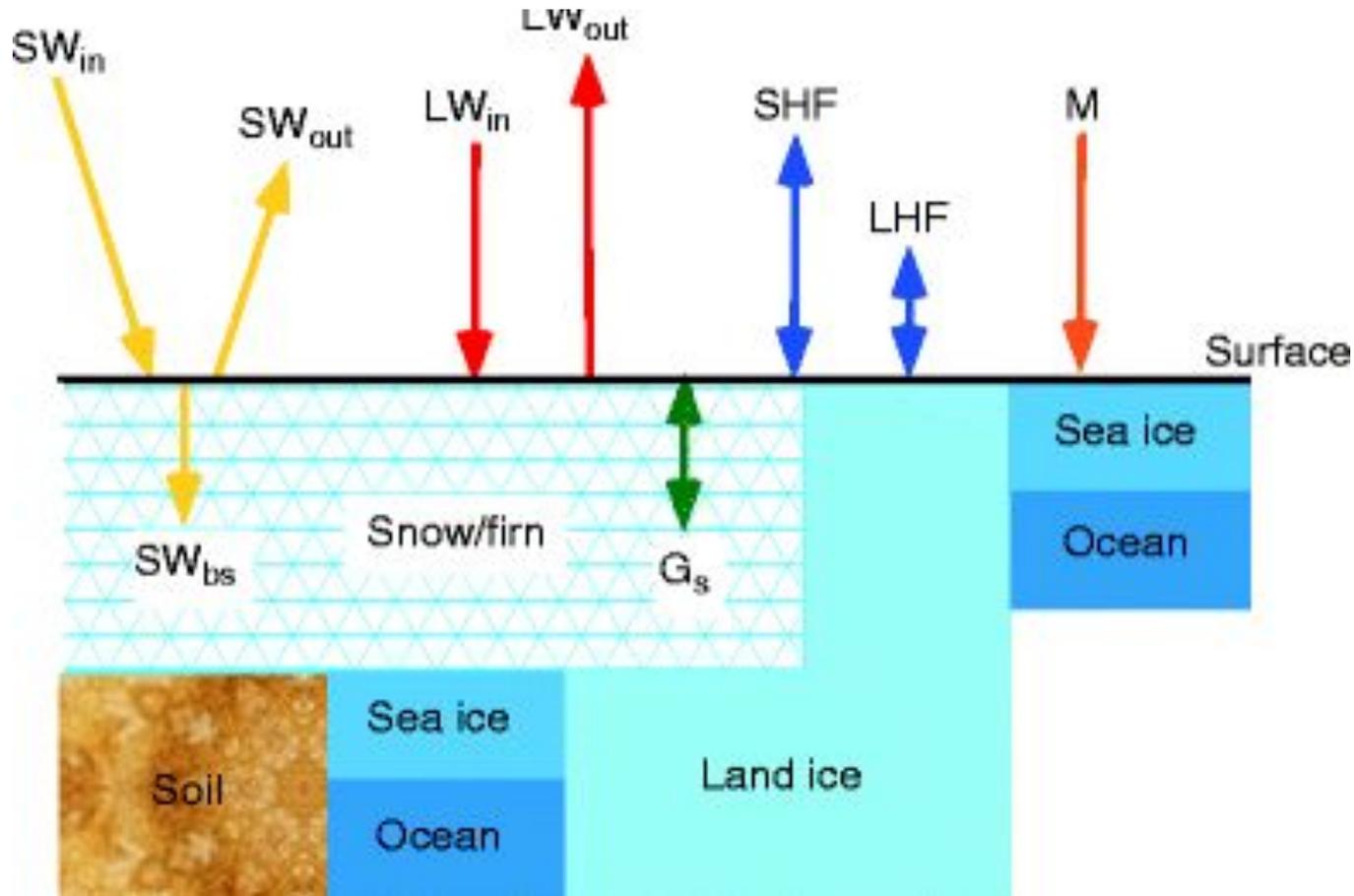
-1 0 1 2 3
Radiative Forcing relative to 1750 (W m⁻²)

Evolución temporal del forzamiento radiativo por componentes





Balance de energía superficial

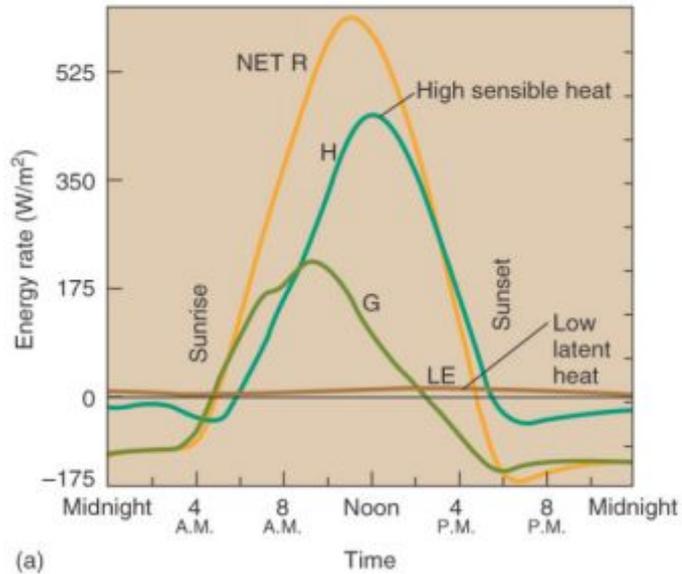


Ecuación del balance de energía superficial

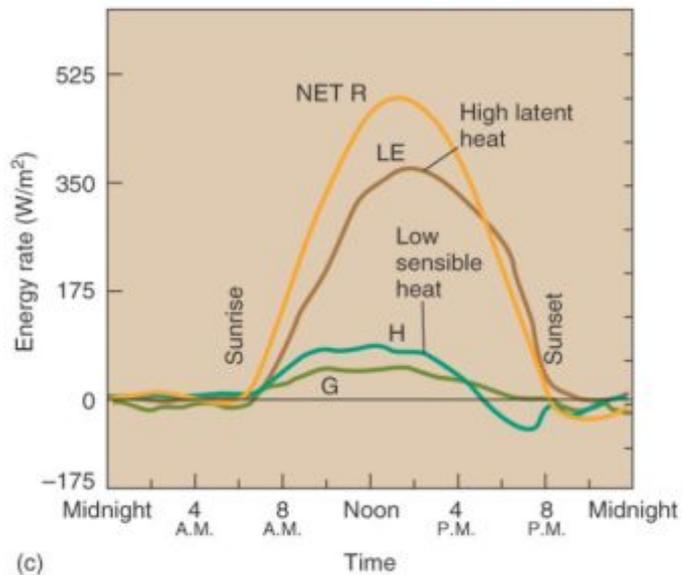
$$SEB = SW_{in} + SW_{out} + LW_{in} + LW_{out} + SHF + LHF + G_S + G_{rain}$$

Balance de energía superficial en ambientes no urbanos

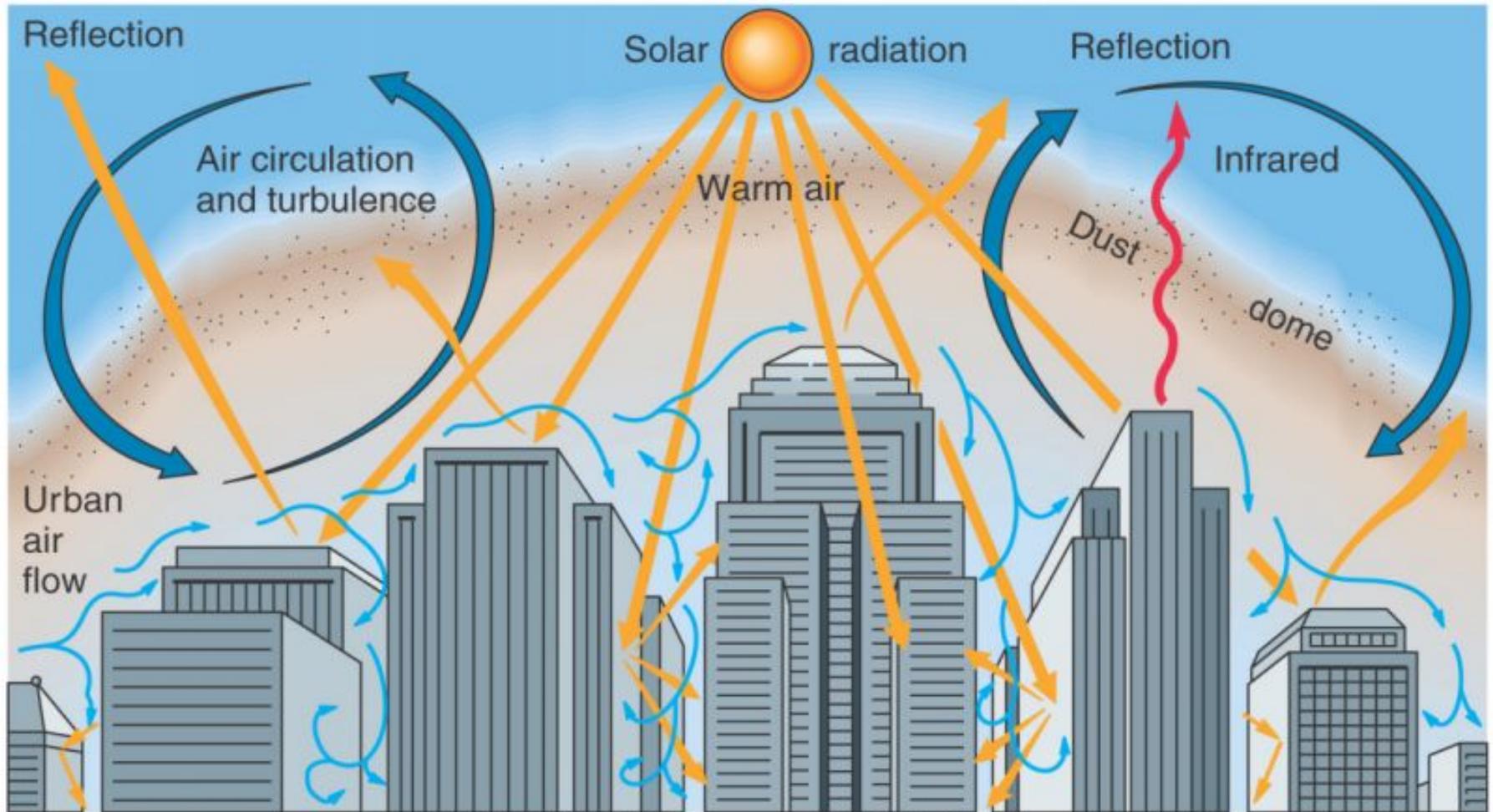
Desierto



Cultivo

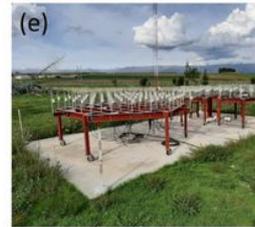
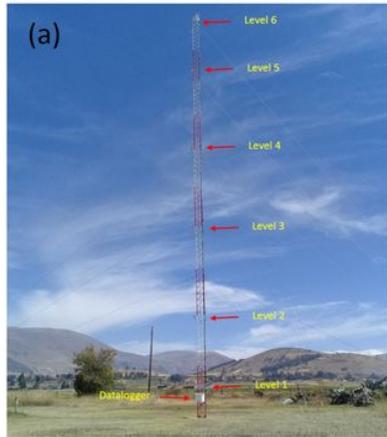


Balance de energía superficial en ambientes urbanos



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Laboratorio de Microfísica Atmósfera y Radiación (LAMAR)



- 1) Estación meteorologica automatica.
- 2) Estación meteorológica convencional.
- 3) Durómetros.
- 4 y 8) Torre de flujos.
- 5 y 7) Radares de precipitación y nubes.
- 6) Fotómetro solar.
- 9) Estación de radiación BSRN.

Flores et al., (2021, Atmosphere)

Medición de aerosoles en el OHY

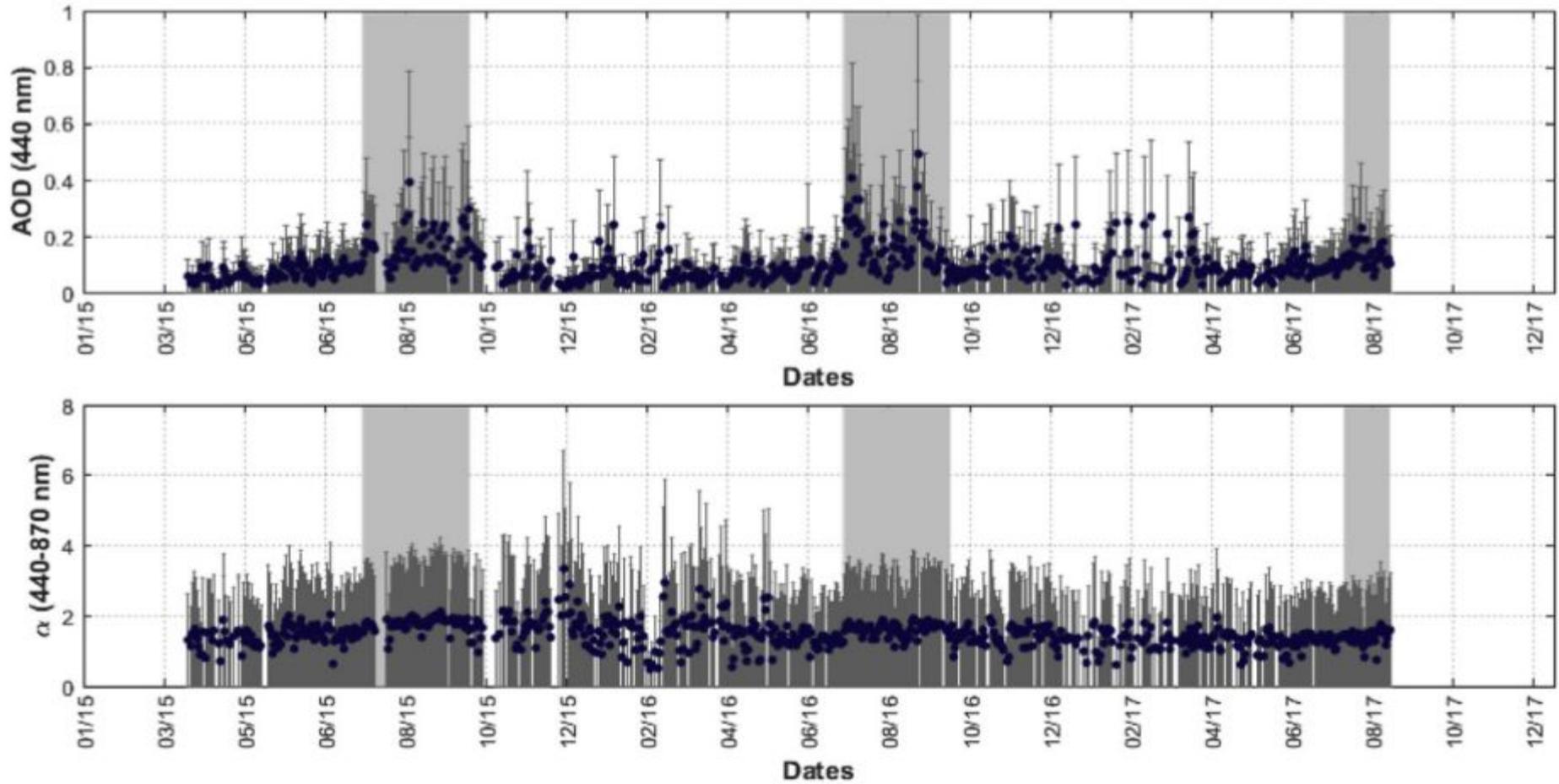


AERONERT NASA



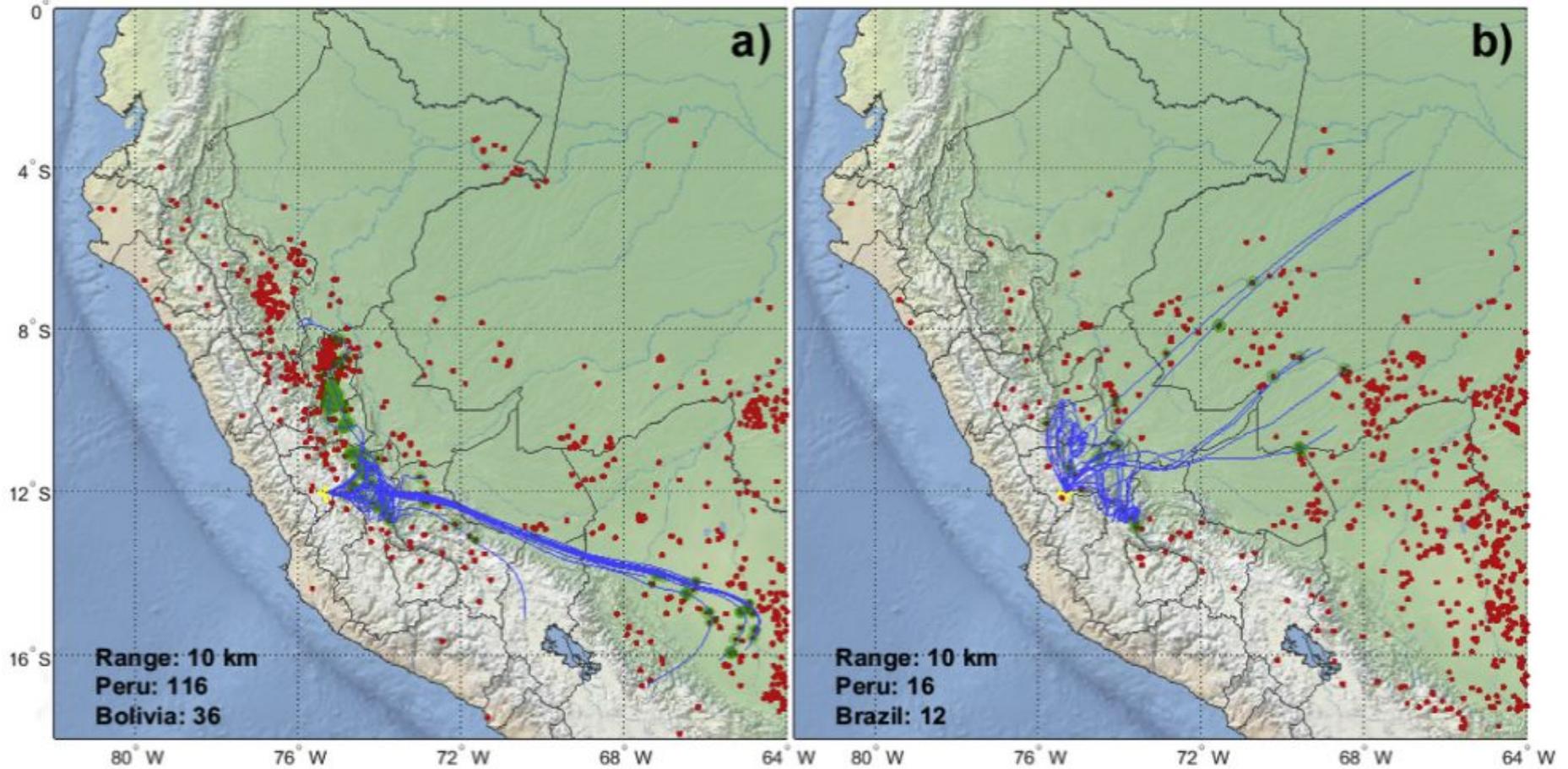
NASA (2021)

Variación temporal de los aerosoles en el OHY



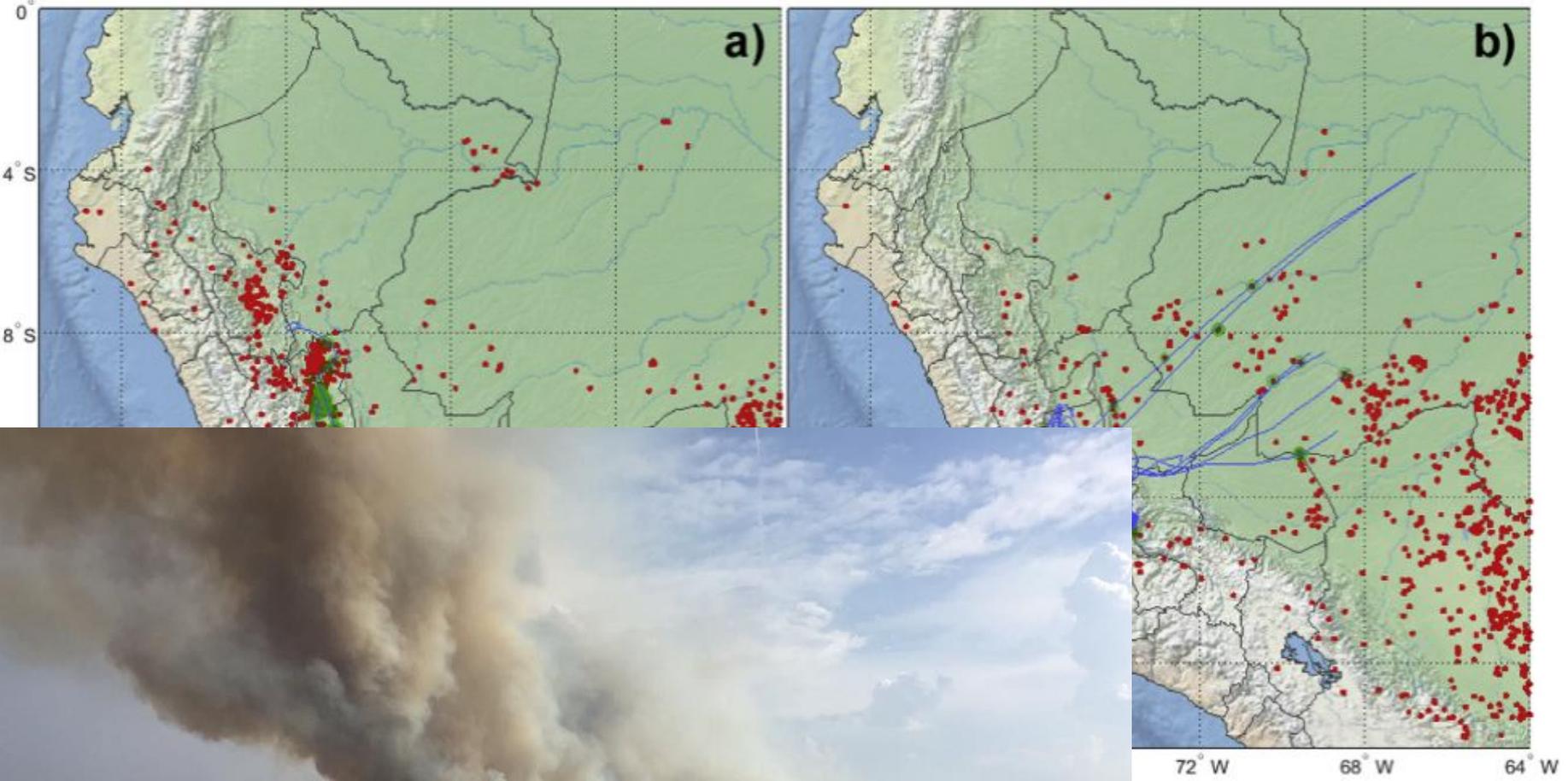
Espesor óptico de aerosoles y coeficiente de armstrong.

Efectos de las quemas de biomasa en el OHY



Estevan et al., (2019, Atmosphere)

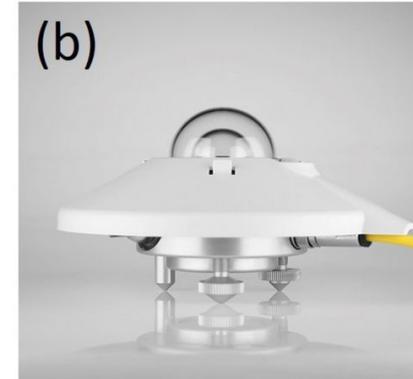
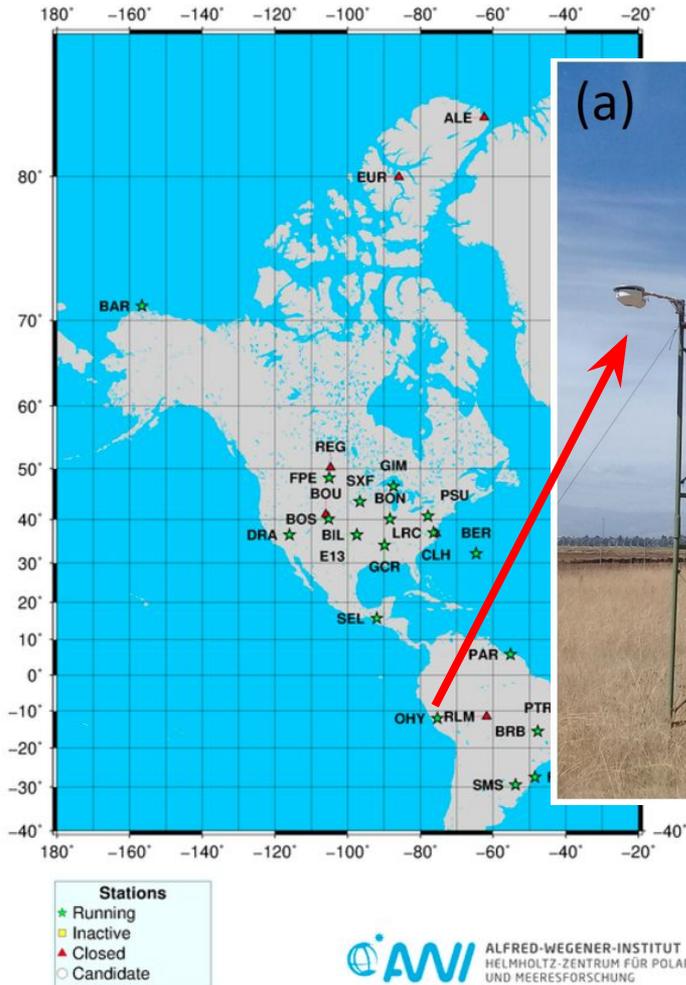
Efectos de las quemas de biomasa en el OHY



an et al., (2019, Atmosphere)

Medición de radiación solar en el OHY

Running, inactive, planned and closed BSRN Stations, March 2021

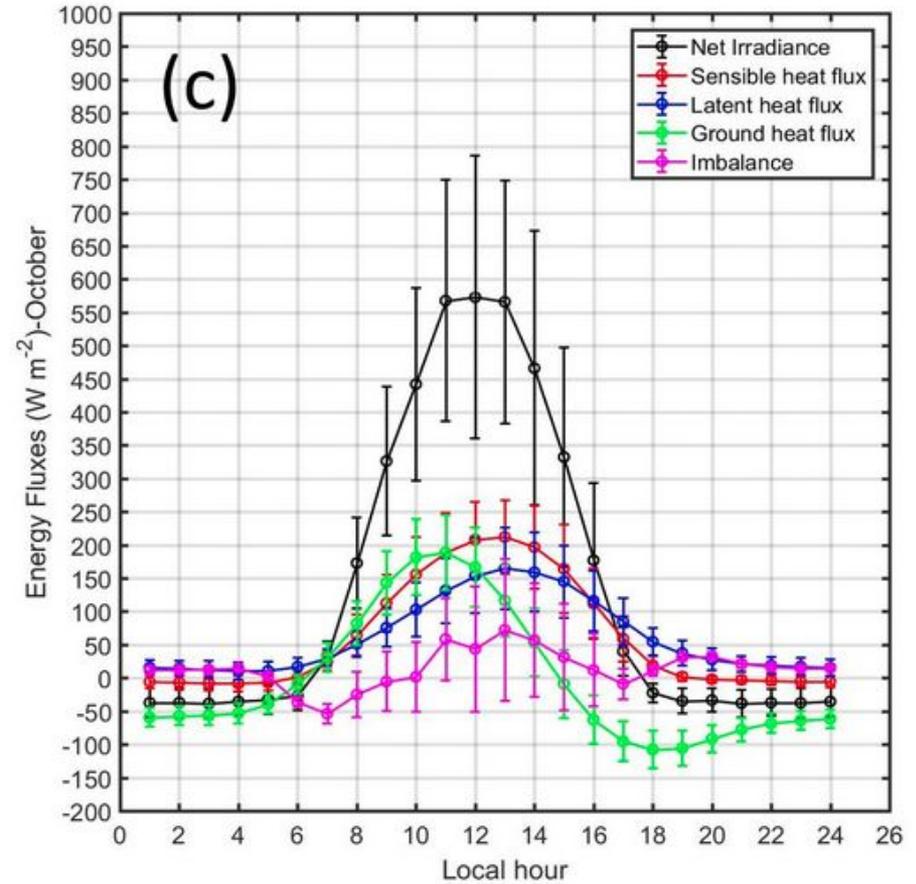
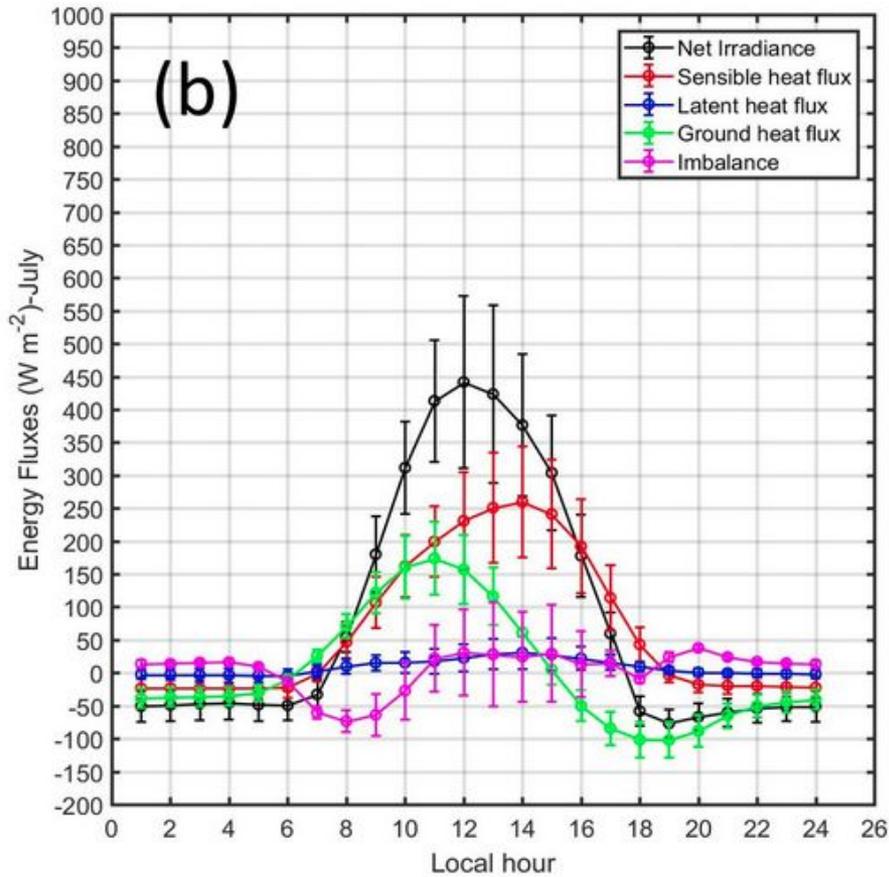


Flores et al., (2019, Atmosphere)

<https://dataportals.pangaea.de/bsrn/>

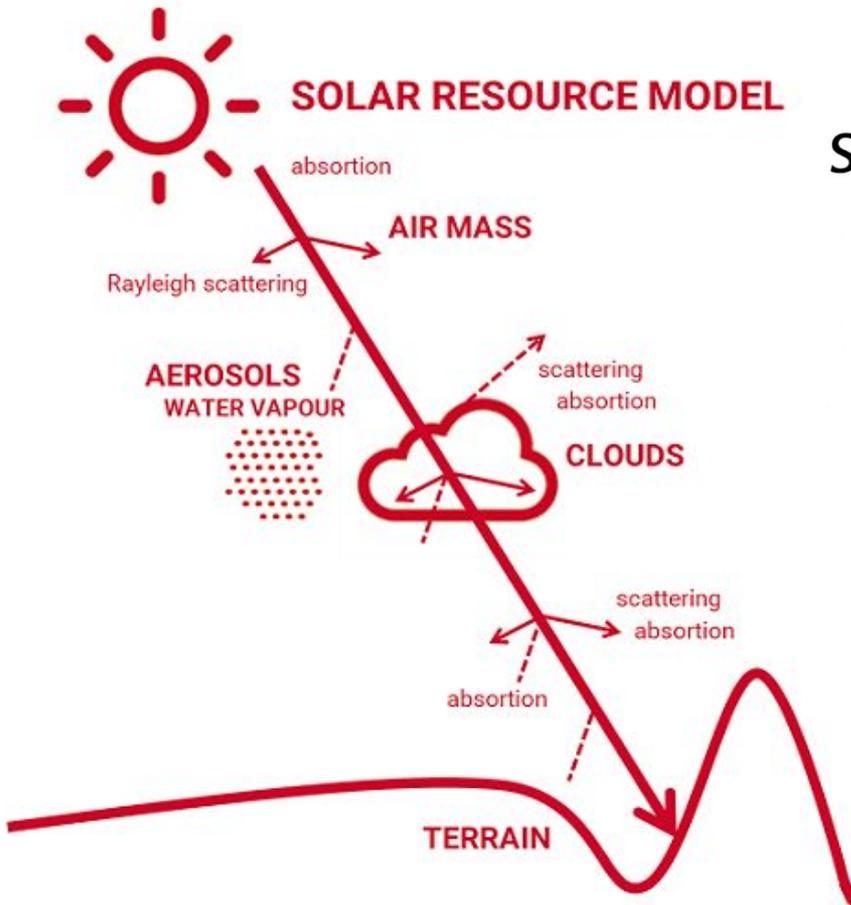
Baseline Surface Radiation Network (BSRN)

Ciclo diario del balance de energía superficial en el OHY

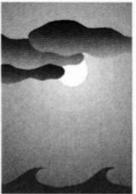


Componentes del balance de energía superficial en el OHY.

Modelado de la radiación solar en el OHY usando SBDART



SBDART: A Research and Teaching Software Tool for Plane-Parallel Radiative Transfer in the Earth's Atmosphere



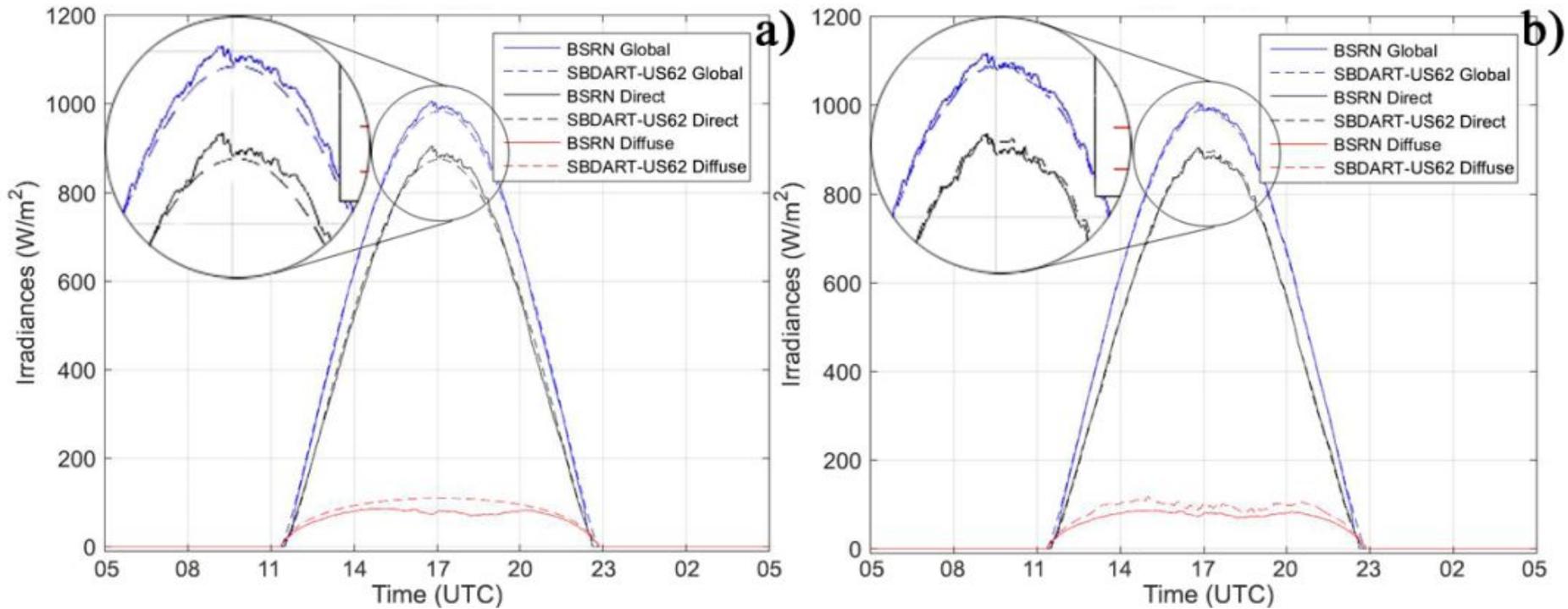
Paul Ricchiuzzi,* Shiren Yang,* Catherine Gautier,*+ and David Sowle#

Ricchiuzzi et al., (1998, BAMS)

MODIS
AERONERT NASA
ERAINTERIM
BSRN

<https://github.com/paulricchiuzzi/SBDART>

Modelado de la radiación solar en el OHY



Radiación solar para 7 de agosto de 2017.

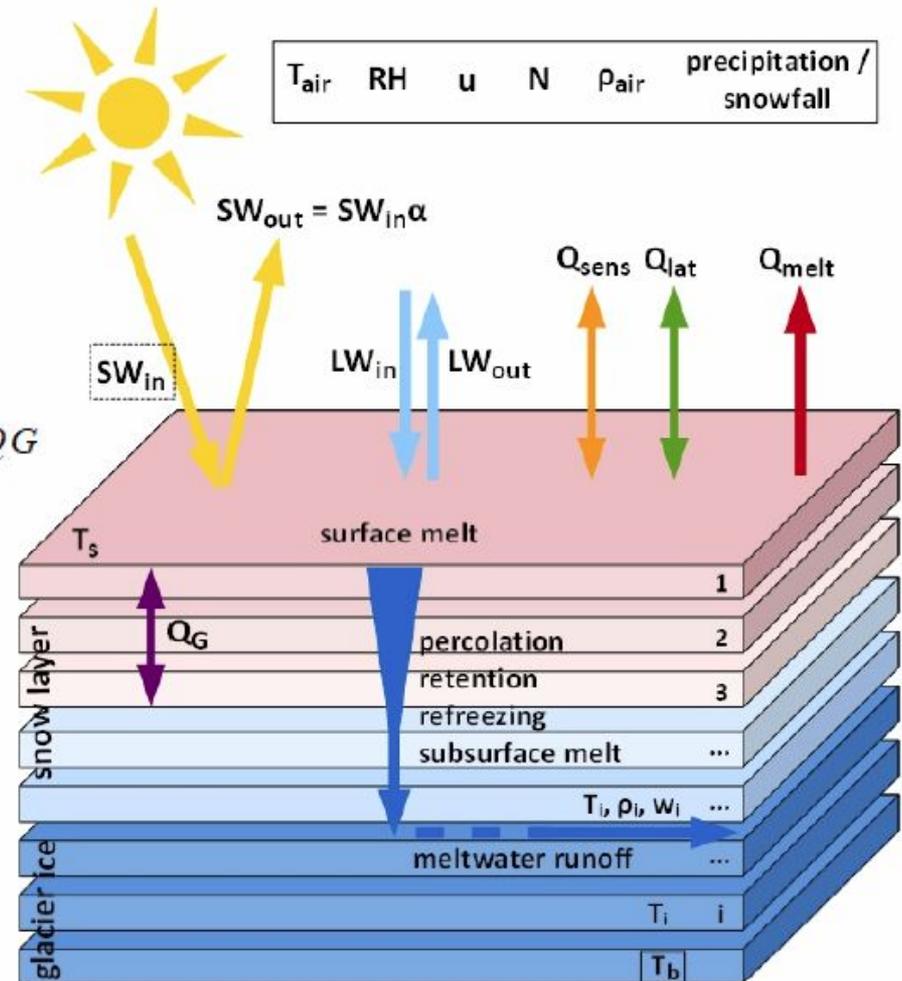
Balance de energía superficial en un glaciar

Balance de energía superficial

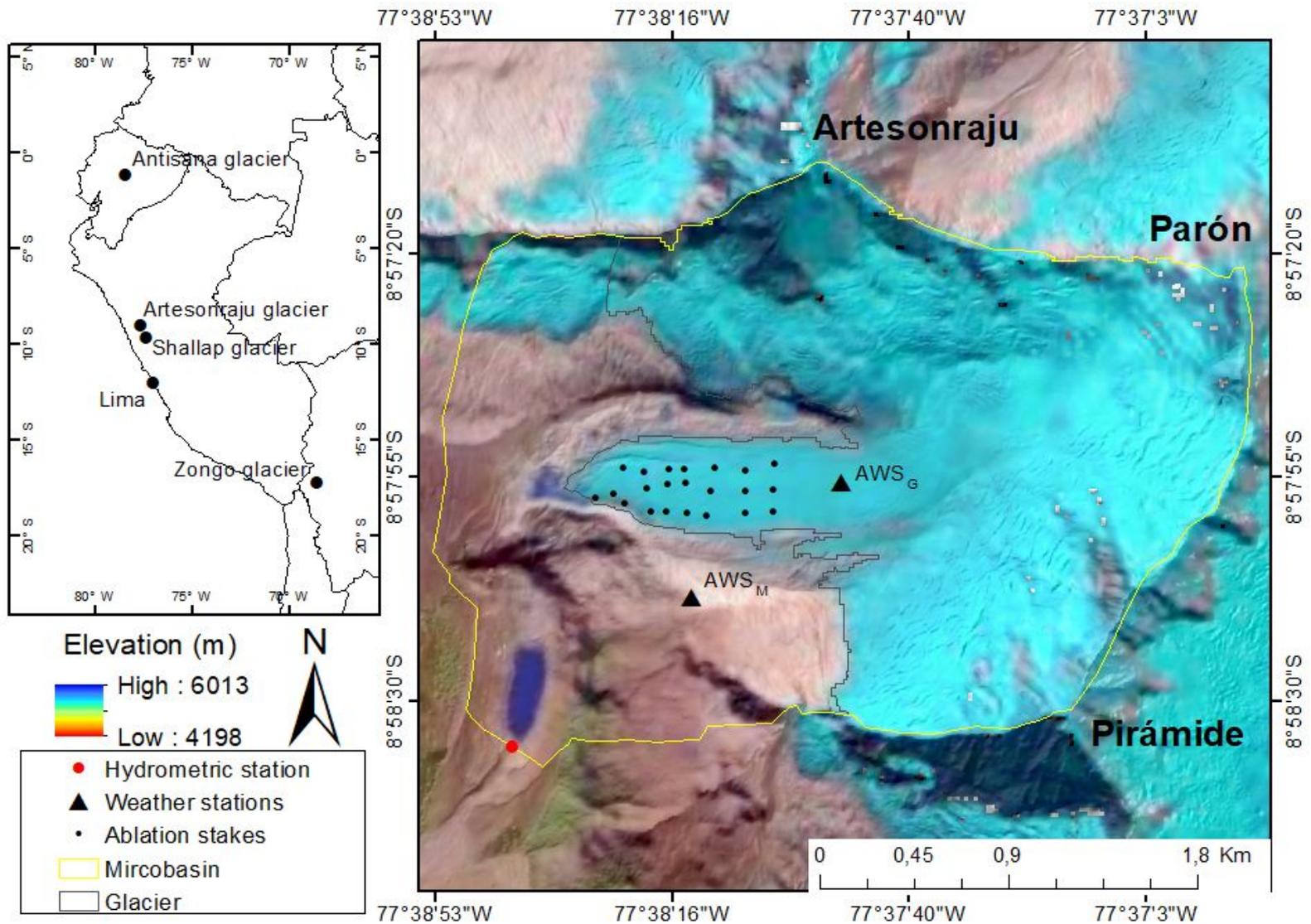
$$F = SW_{in} (1 - \alpha) + LW_{in} + LW_{out} + Q_{sens} + Q_{lat} + Q_G$$

Balance de masa superficial

$$MB_T = Sn + Melt_{sur} + Sub + Dep + Eva + Ref + Melt_{sub}$$

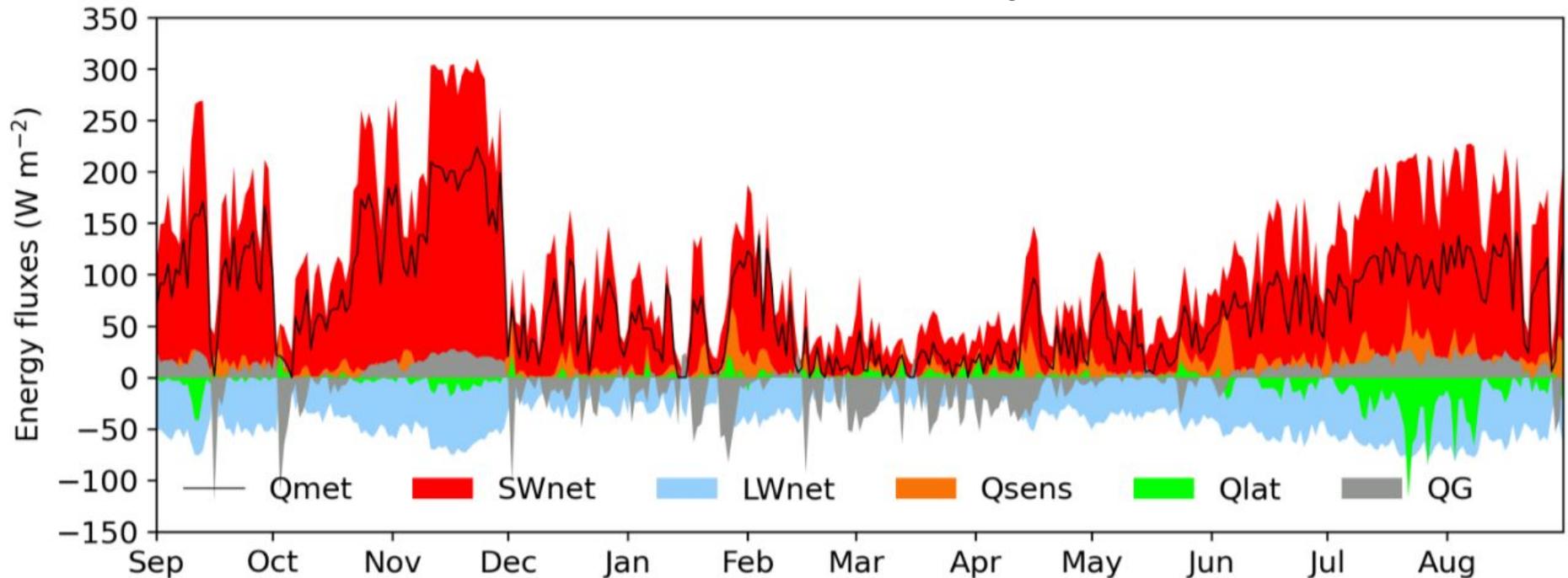


Balance de energía superficial para un glaciar en la Cordillera Blanca, Perú



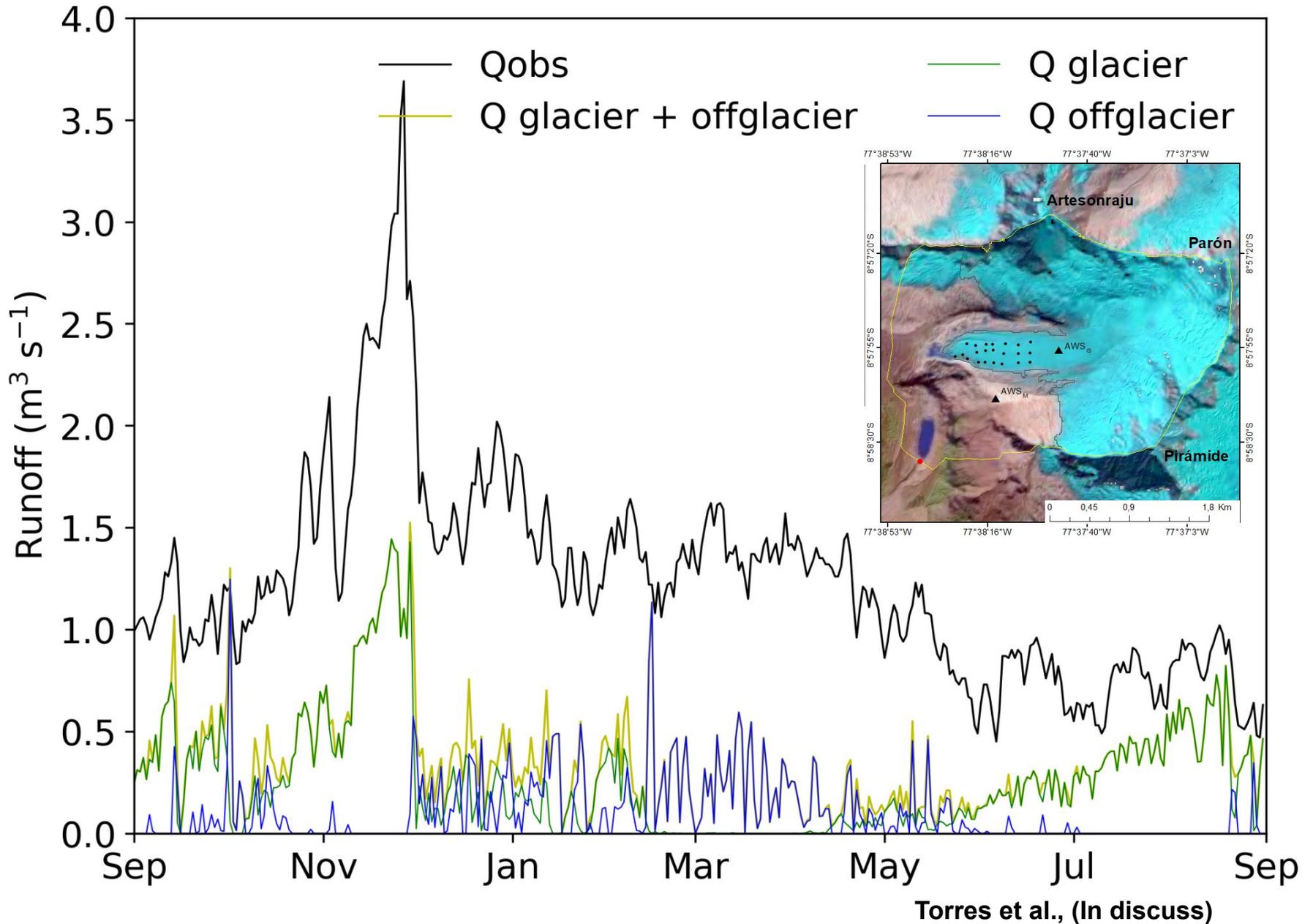
Balance de energía superficial para un glaciar en la Cordillera Blanca, Perú

Glaciar Artesonraju

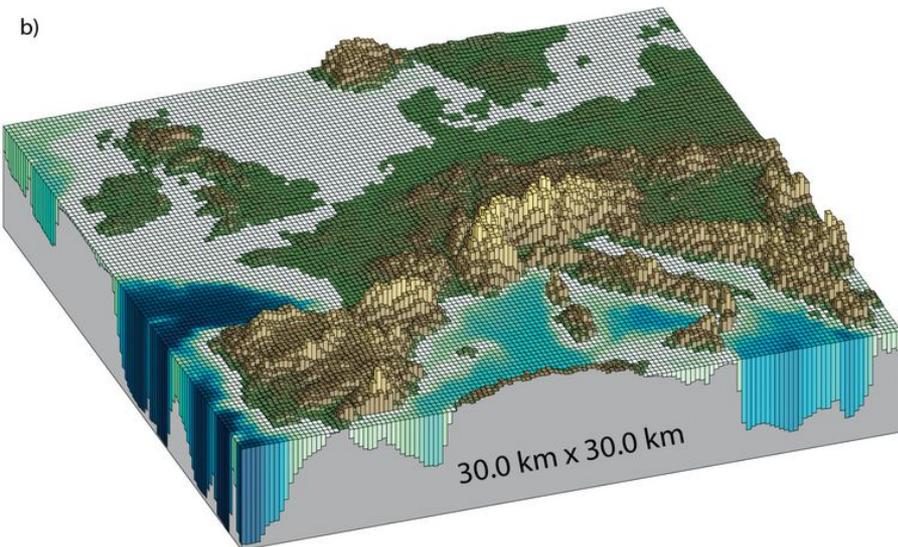
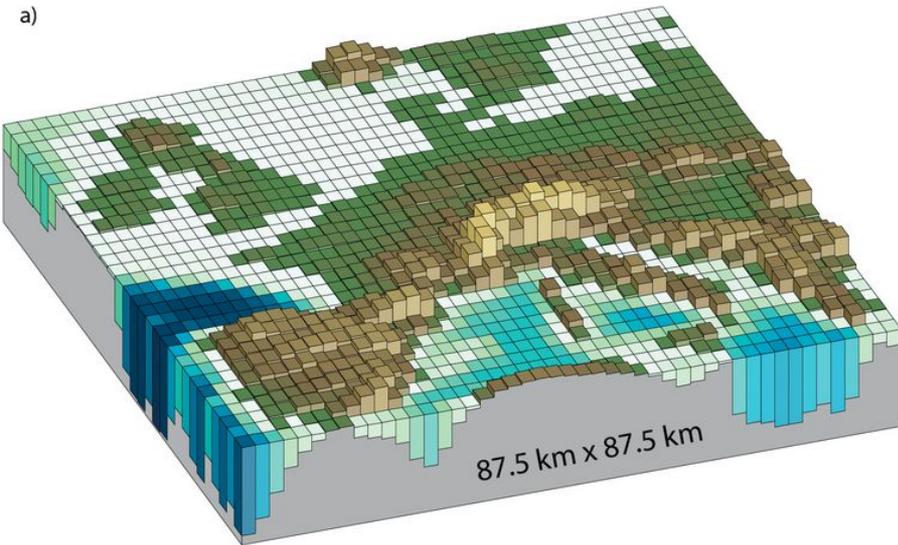


Componentes del balance de energía superficial para 2016/2017.

Escorrentía de un glaciar en Perú



Modelo Numérico Global

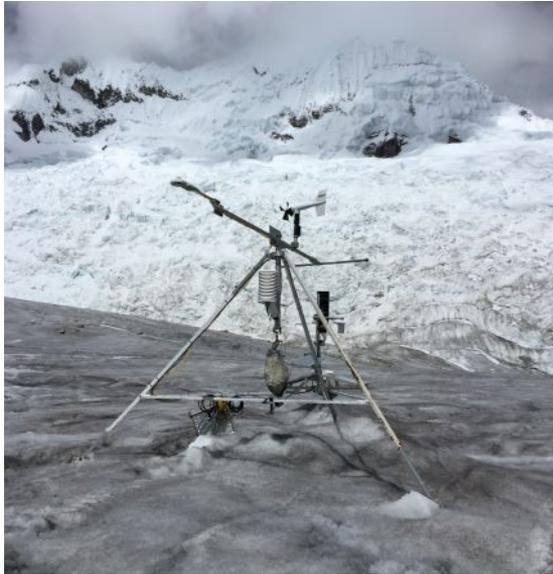


Centro Europeo de Previsiones Meteorológicas a Medio Plazo (ECMWF)

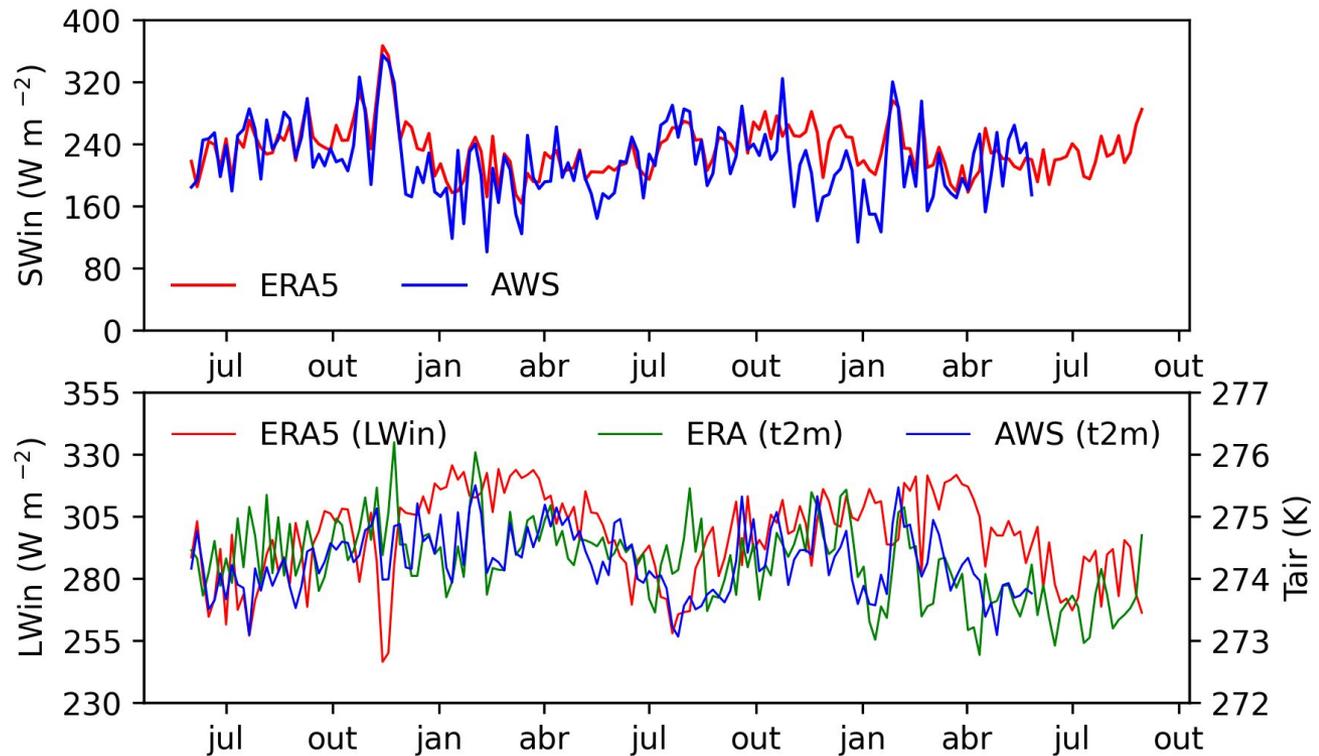
- Conjunto de datos de reanálisis ERA5.
- Sistema de Pronóstico Integrado (IFS) CY41R2 (Hersbach et al. 2020).
- Modelo Atmosférico
 - Resolución horizontal $0.25 \times 0.25^\circ$ (~30 km).
 - Resolución vertical 137 niveles desde la superficie hasta 80 Km de altura.
- Datos disponibles desde 1979 hasta el presente.
- Además, tienen una versión preliminar de datos desde 1950 hasta 1979.
- Almacén de Datos Climáticos (CDS).

<https://cds.climate.copernicus.eu/cdsapp#!/search?type=dataset>

Componentes del balance de energía desde ERA5



Cordillera Blanca, Perú



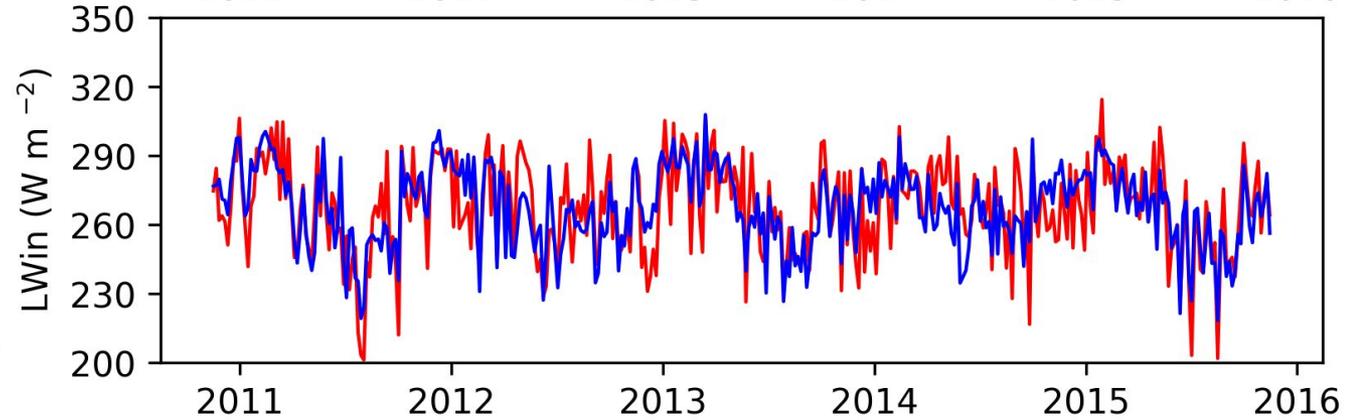
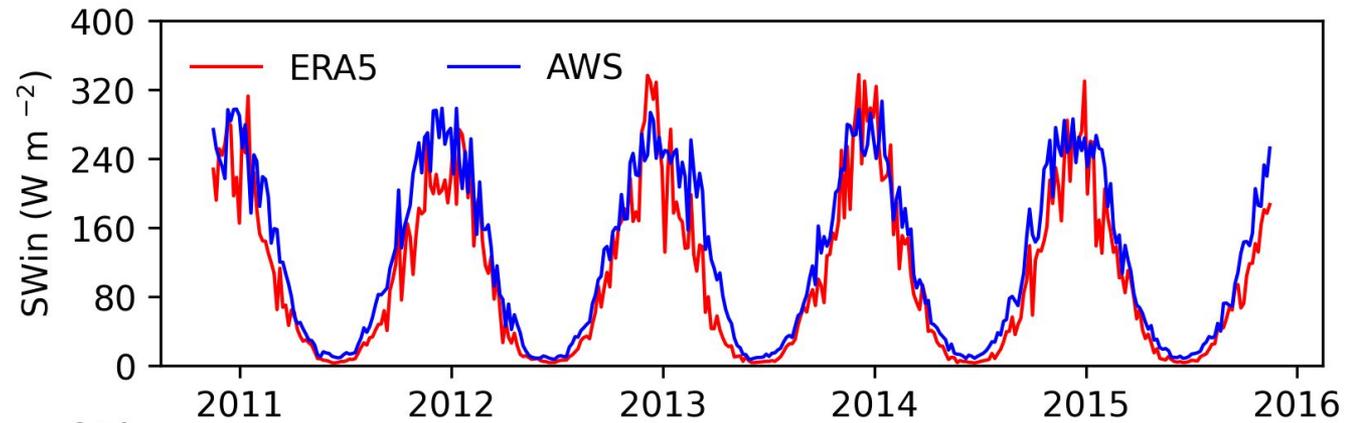
Periodo desde junio 2016 hasta agosto 2018

Torres, (In process, Theses)

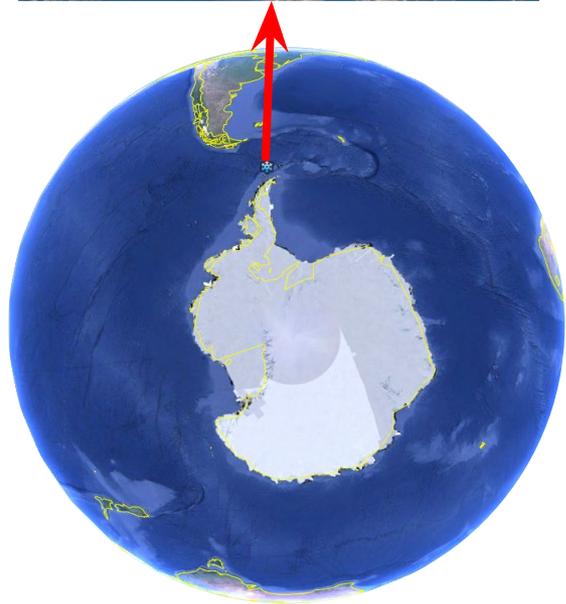
Componentes del balance de energía desde ERA5

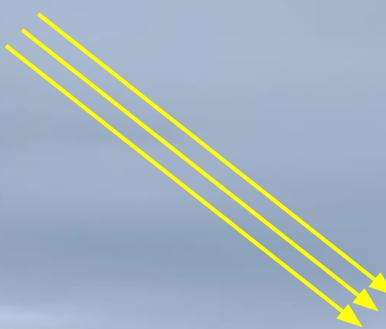
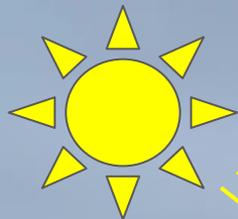


Península Antártica



Torres, (In process, Theses)





Muchas gracias