Solar radiative fluxes derived from VIIRS products with ABI algorithm

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Introduction

- Since the launch of the S-NPP satellite the VIIRS instrument has been providing an extensive and qualitative description of the atmosphere-earth system at high spatial resolution.
- This presentation demonstrates the feasibility of deriving surface and top of atmosphere solar radiation using the GOES-R/ABI radiation budget algorithms driven by products obtained from VIIRS on S-NPP.
- The fluxes derived this way are radiatively consistent with the VIIRS products used as inputs and can be used, for example, for verification of various models that utilize or predict solar radiation.

Methodology

- Radiative transfer calculation based on pre-calculated lookup tables (direct path of GOES-R ABI algorithm)
  - Atmopshere reflectivity (***R^0***), direct and diffuse transmissivity (***T^0_{dir}***, ***T^0_{dif}***), and spherical reflectivity and transmissivity (***$\check{R}$***, ***$\check{T}$***) for clear-sky, water cloud and ice cloud scene types are pre-calculated
  - Function of spectral bands; solar zenith angle; precipitable water; ozone; surface elevation; aerosol optical depth and single scattering albedo; cloud optical depth, radius and top height

- Combined with the input surface albedo (***α***), total reflectance (***R***) and transmittance (***T***) are calculated based on the adding equation of radiative transfer (Chandrasekhar, 1960):

$$R = R^0 + \gamma\tilde{T} \qquad T = T^0 + \gamma\tilde{R}$$

where $\gamma = \frac{\alpha T^0}{1 - \alpha\tilde{R}}$ and $T^0 = T^0_{dir} + T^0_{dif}$

And the downward shortwave radiation at surface (***DSR***) and reflected shortwave radiation at top-of-atmosphere (***RSR***) are calculated as:

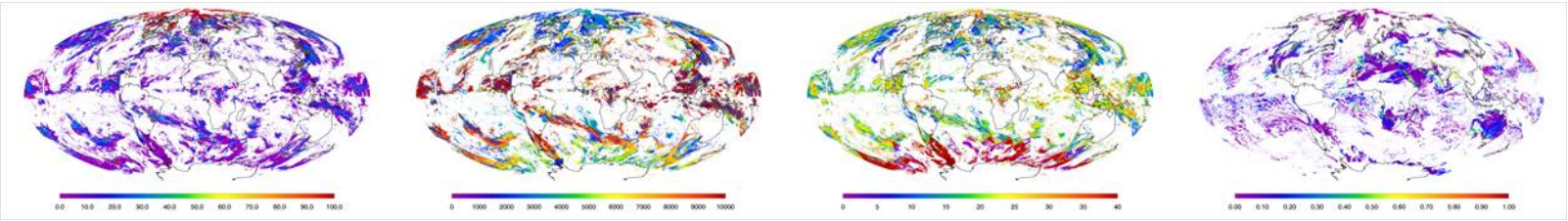
$$DSR = T * cos\theta_0 * \frac{S_0}{d^2}$$

$$RSR = R * cos\theta_0 * \frac{S_0}{d^2}$$

Where ***S_0*** is the solar constant
d is the actual sun-earth distance (in astronomical units)
θ_0 is solar zenith angle

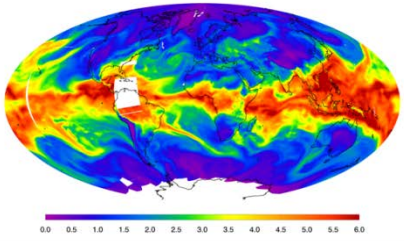
Inputs

- Geometry/location (from VIIRS)
  - Solar zenith angle, longitude, latitude, surface elevation
- Atmosphere (from VIIRS retrieval or ancillary model data)
  - Cloud optical depth, top height, phase, effective radius; Aerosol optical depth, single scattering albedo (type)

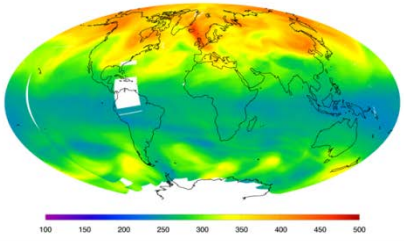


Cloud Optical Depth | Cloud Top Height [m] | Cloud Effective Radius [μm] | Aerosol Optical Depth

  - Precipitable water and ozone amount



Total Precipitable Water [cm]

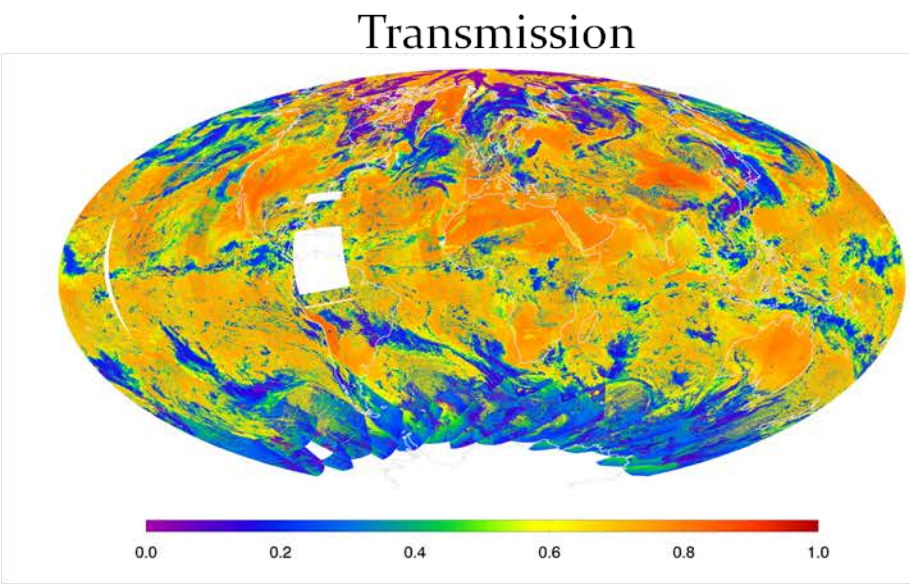


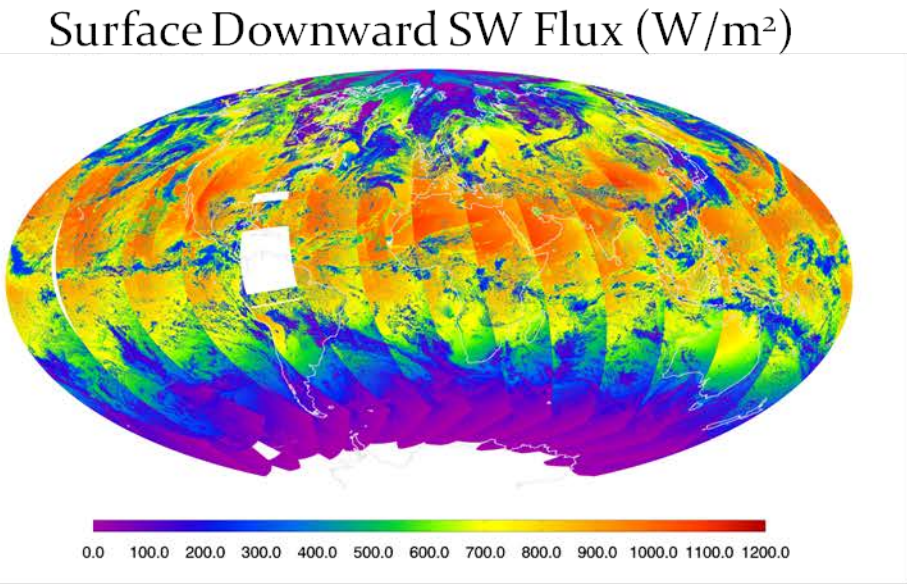
Ozone [Dobson]

- Surface albedo (from VIIRS retrieval)
  - Set to zero for now

Results (1)

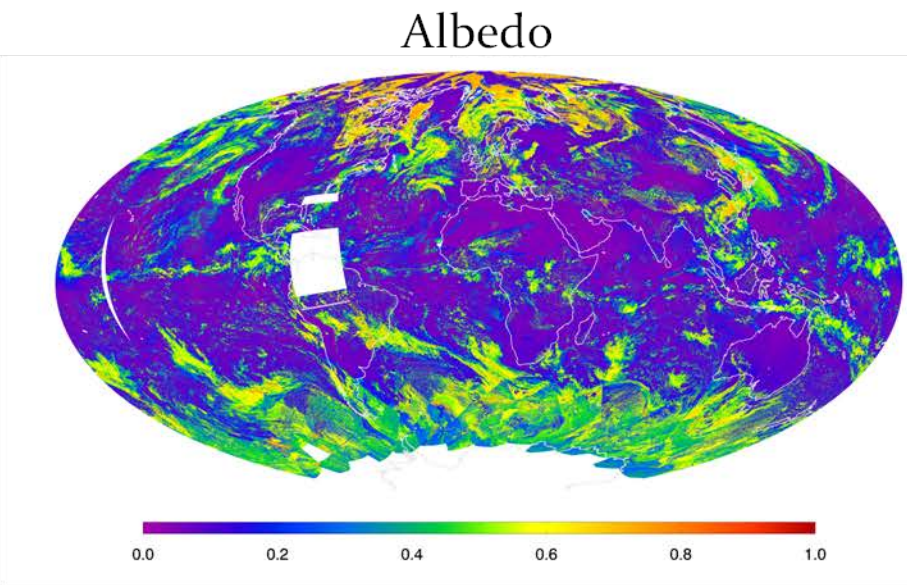
- Calculated atmospheric transmission (left) and surface downward SW flux (right) for day 05/15/2012.

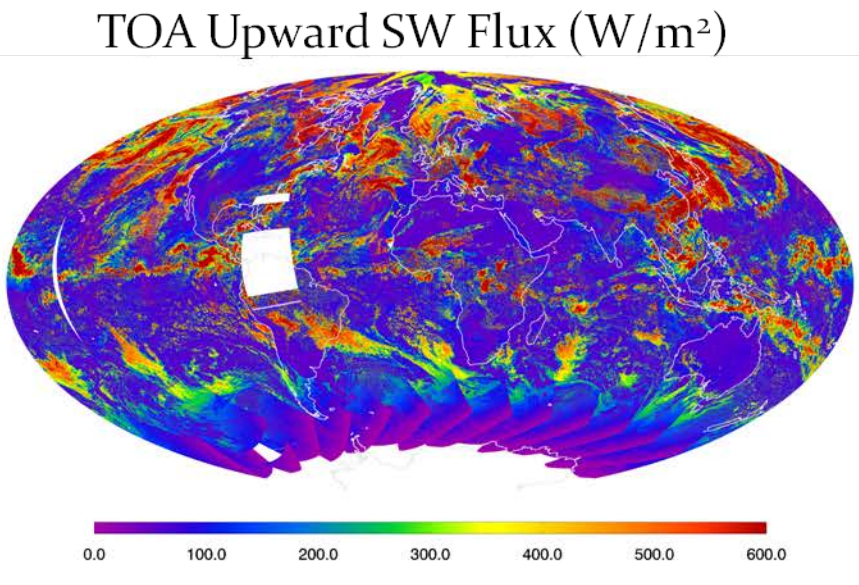




Results (2)

- Calculated TOA albedo (left) and upward SW flux (right) for day 05/15/2012.





Recommendation

- Shortwave radiation calculation from VIIRS data/products can be preformed at the bottom of the VIIRS processing chain to assemble the individual retrievals for a comprehensive characterization of the atmosphere-earth system.
- Lookup table approach is computationally efficient without extra heavy demand on the present processing environment.

Future Plans

- Evaluate the calculated shortwave radiation with TOA and surface measurements as an aggregated validation of the individual VIIRS retrievals
- Using S-NPP CERES broadband shortwave radiance measurements to tune the calculated radiation.
- Derive empirical narrow to broadband conversion relationship from the VIIRS and CERES shortwave radiance measurements.
- Apply the inversion scheme (indirect path of GOES-R ABI algorithm) to the cases where key component retrievals are not available.

References

Chandrasekhar, S., 1960: *Radiative Transfer,* New York, Dover, 393 p.