The VIS/NIR BRDF atlas for RTTOV : From MODIS C5 to C6

Jérôme Vidot[1], Eva Borbas[2], James Hocking[3] and Pascal Brunel[1]

[1]CMS, Météo-France

[2]CIMSS, Univ. Wisconsin, USA

[3]MetOffice, UK

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Outline

- Motivation
- Methodology
- From MODIS C5 to C6:

1. Impact on quality flag
2. Impact on SEVIRI TOA reflectance over land
3. Impact on snow spectral albedo

- Summary

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Motivation

- **RTTOV simulates clear-sky/single-layer cloud VIS/NIR TOA radiances (0.4 - 2.5 µm) since V11 (2013) and full scattering (RTTOV_DOM) since V12 (2017).**
  - GEO: SEVIRI/MSG, GOES, AHI/HIMAWARI, …
  - LEO: MODIS, VIIRS, AVHRR,…
  - Future: ABI/GOES-R, MetImage/EPS-SG, FCI/MTG,…

- **Need of a spectrally resolved land surface BRDF model:**
  - Snow-free conditions: RTTOV version 11.1 (Vidot and Borbas, 2013)
  - Snow-covered conditions: RTTOV version 11.3 (2015)
  - Global atlas of monthly mean values for 2007 at 0.1°

- **Examples of application:**
  - Regional O3 OSSE study for TEMPO (Lead by B. Pierce NOAA)
  - FCI/SEVIRI aerosol assimilation in MOCAGE CTM (CNRM PhD student M. Descheemaecker)

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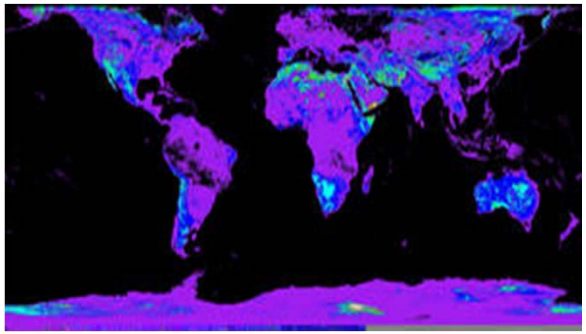
Methodology

- Adapted from IR land surface emissivity atlas (UWIREMIS model)

MODIS L3 product MCD43C1 16-days 0.05°
BRDF parameters at 7 VIS/NIR channels



3 linear parameters semi-empirical model of Ross-Li (Lucht et al., 2000)

$$BRDF(\lambda, \theta_S, \theta_V, \Delta\varphi) = f_{iso}(\lambda) + f_{vol}(\lambda) K_{vol}(\theta_S, \theta_V, \Delta\varphi) + f_{geo}(\lambda) K_{geo}(\theta_S, \theta_V, \Delta\varphi)$$

Isotropic scattering

Volumetric scattering

Geometric scattering

λ wavelength

θ_S Solar zenith angle

θ_V Viewing zenith angle

$\Delta\varphi$ Azimuth angles difference

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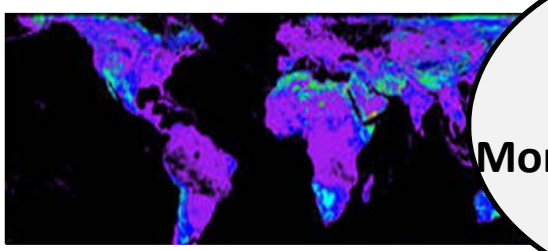
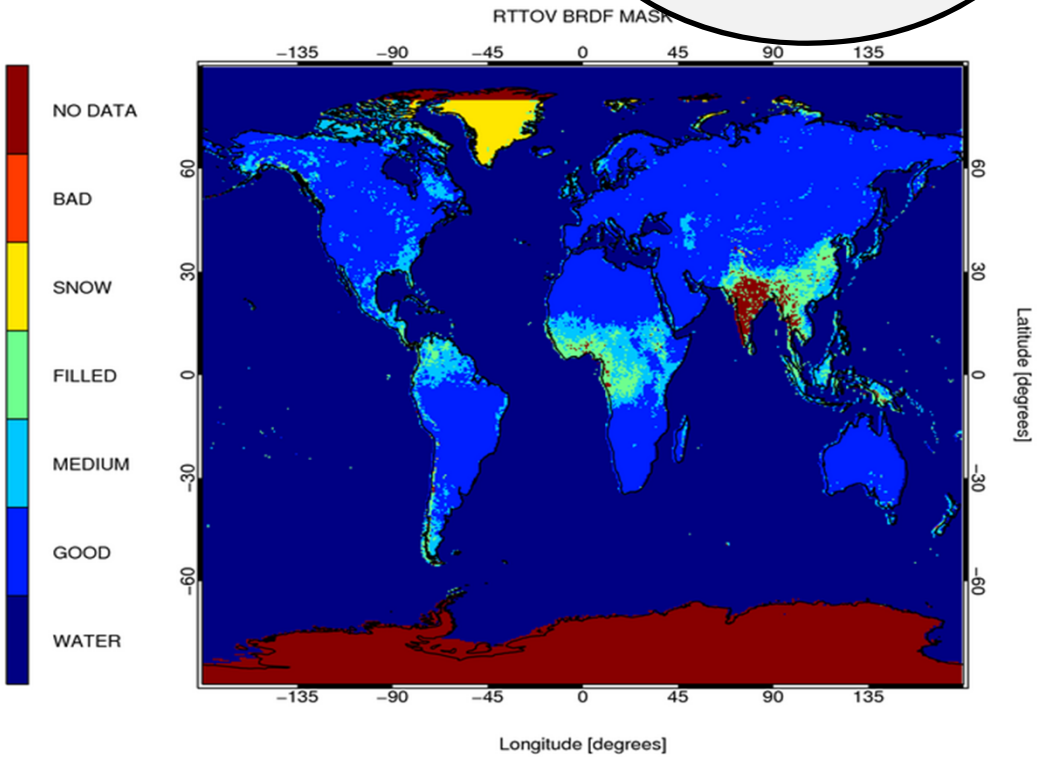


Resampling

Monthly means at 0.1°
Quality Flags



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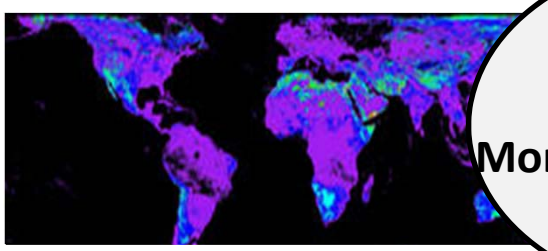
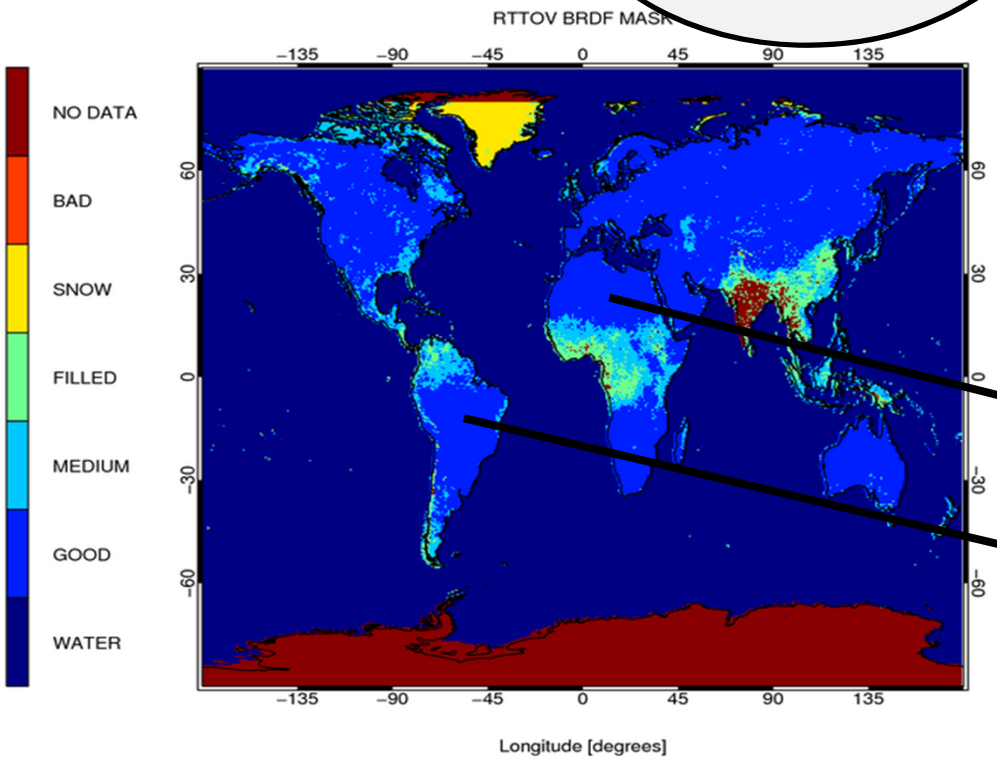
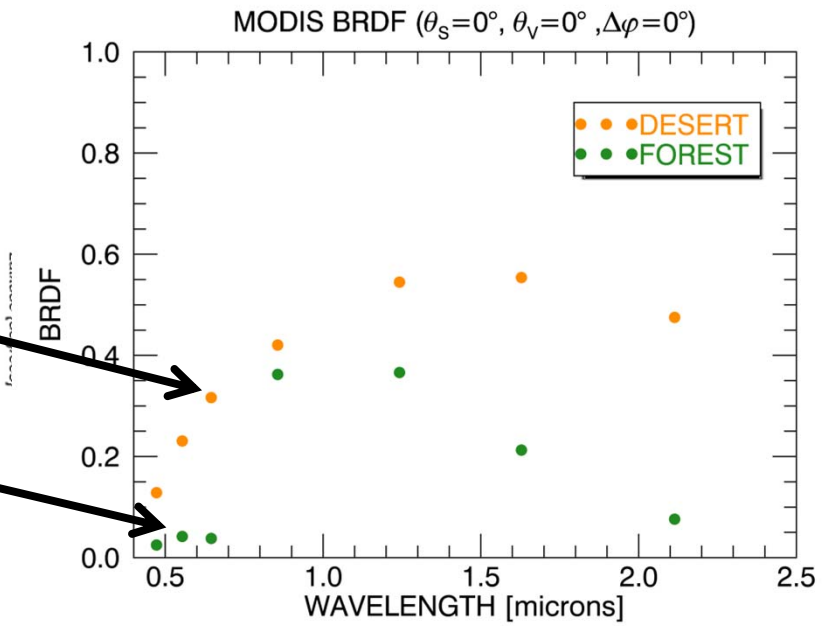


Resampling

Monthly means at 0.1°
Quality Flags

Inputs:
date, lat, lon,
geometry





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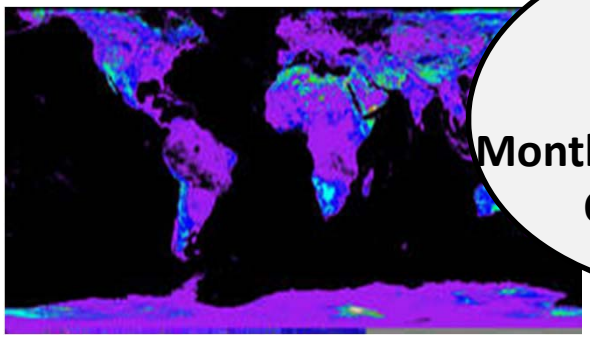

Resampling

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Inputs:
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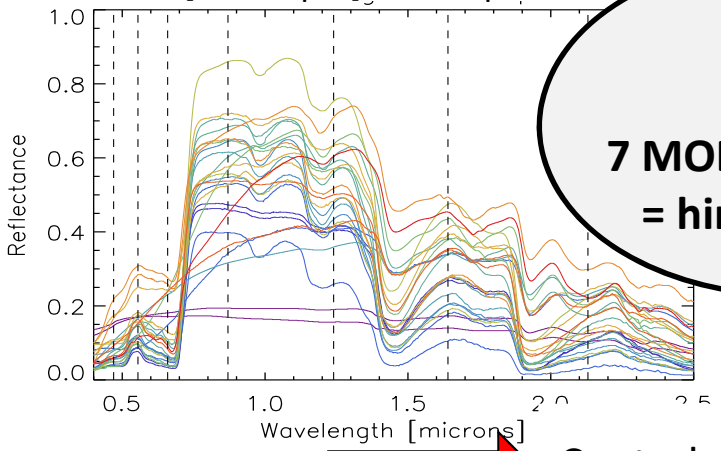
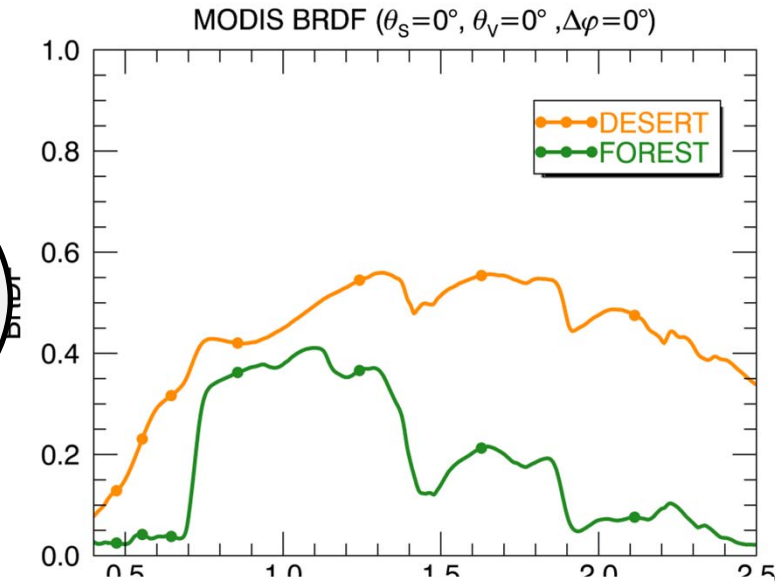
geometry

USGS 126 soil and vegetation spectra
[0.4-2.5µm] at 0.01 µm



PCA

7 MODIS channels
= hinge points

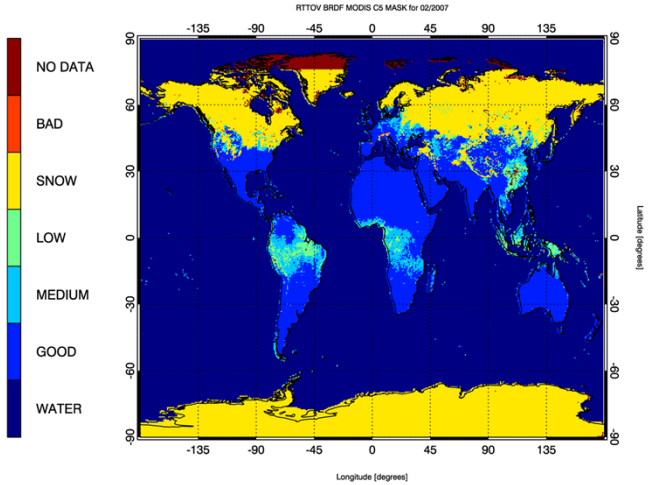


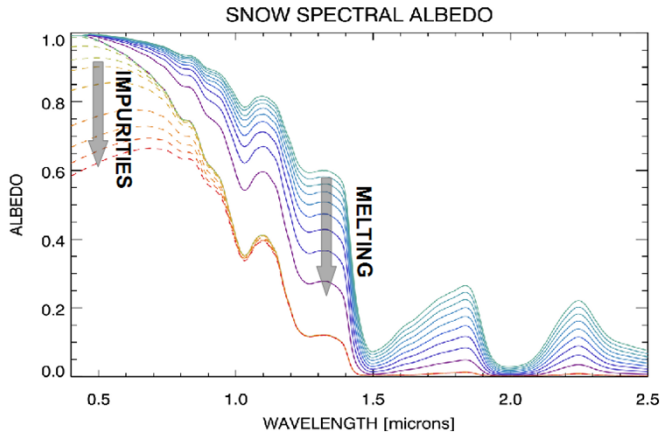
Central wavelength of any ISRF is finally interpolated

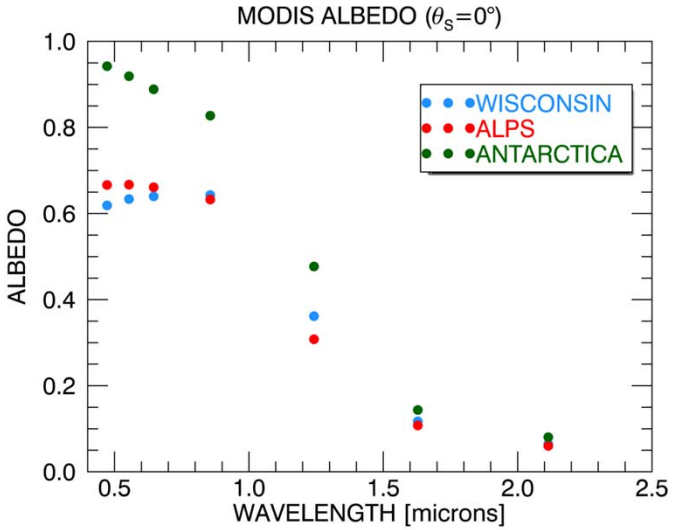
Methodology for snow

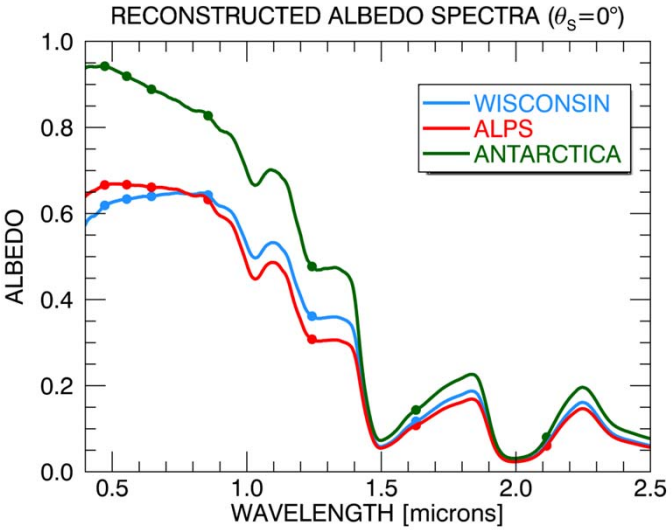
- Based on MODIS BRDF and albedo model (Schaaf et al., 2002)

$$a(\lambda, \theta_S) = f_{iso}(\lambda) + f_{vol}(\lambda)[\alpha_1 + \alpha_2\theta_S^2 + \alpha_3\theta_S^3] + f_{geo}(\lambda)[\alpha_4 + \alpha_5\theta_S^2 + \alpha_6\theta_S^3]$$



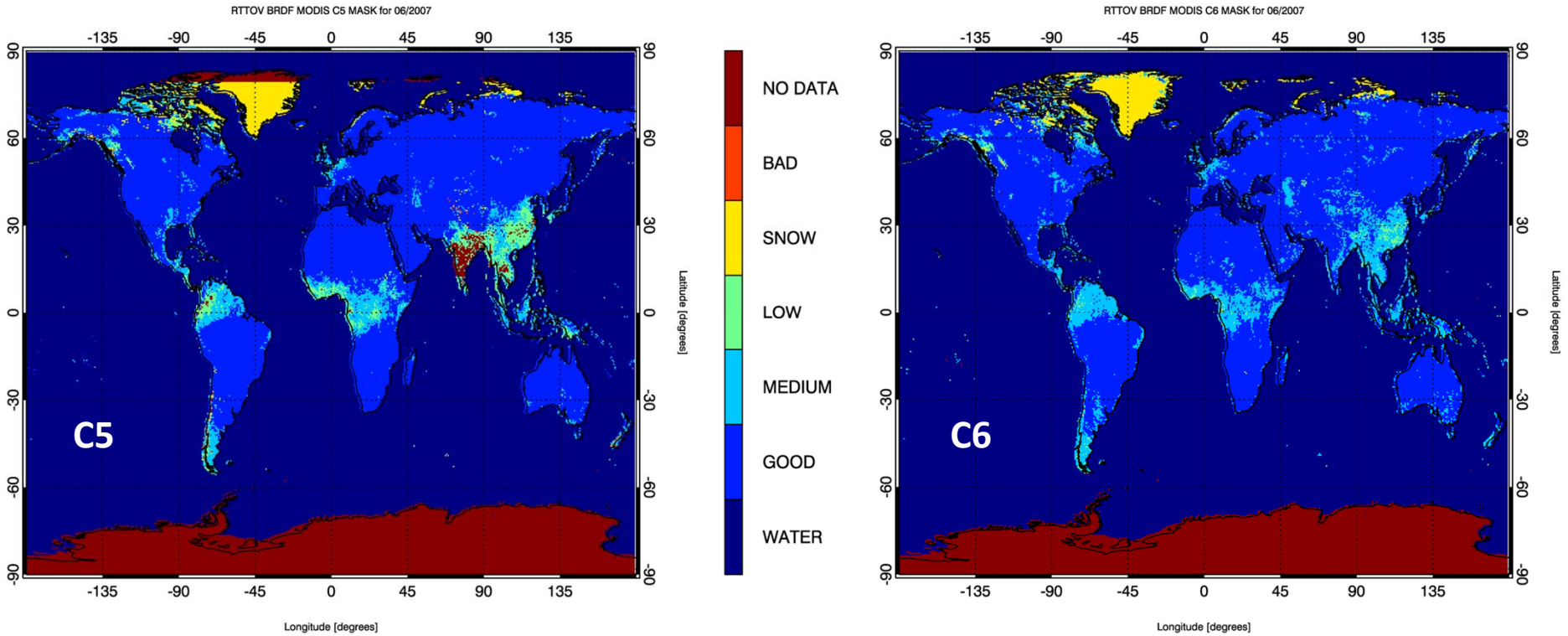






From C5 to C6: Impact on BRDF quality

- Example for June 2007



- More pixels as snow in high latitudes
- Remove all “no data” pixels in cloudy/aerosols area
- Less low quality pixels

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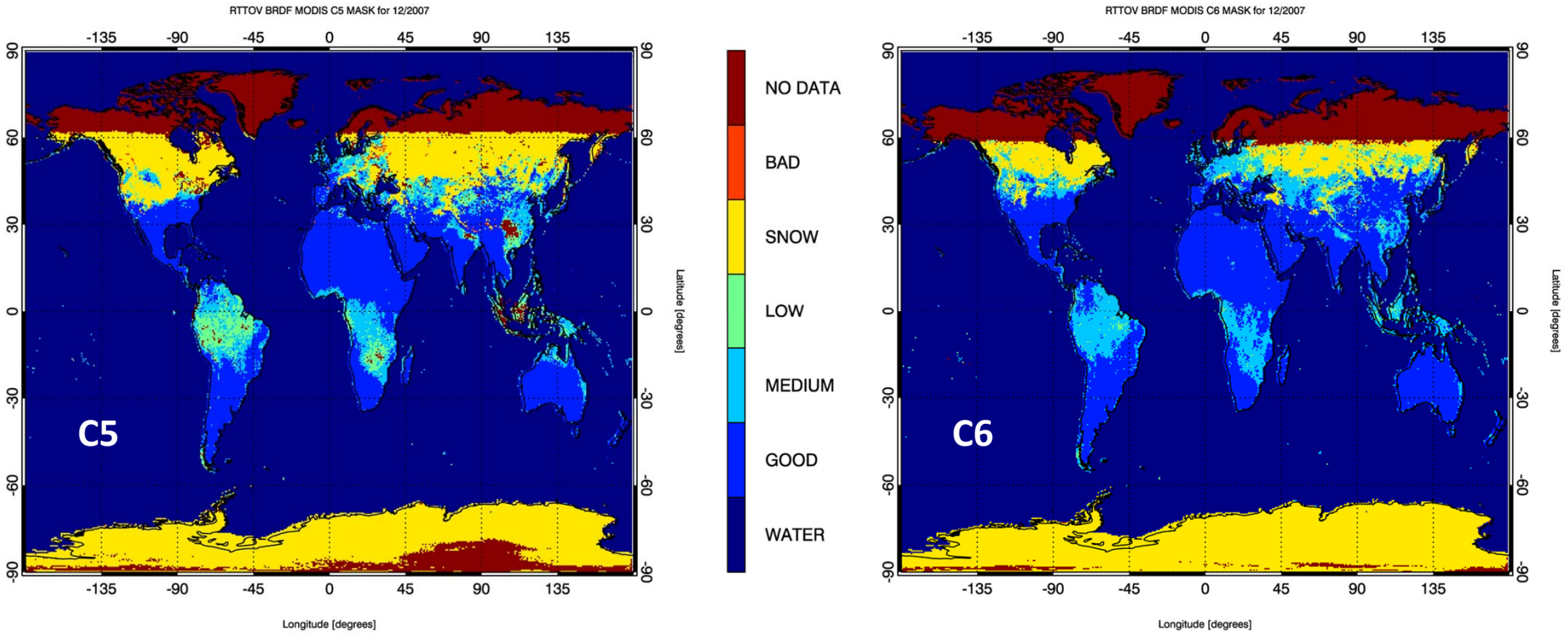
From C5 to C6: Impact on BRDF quality

- Example for December 2007



- Less pixels as snow in mid-latitudes areas
- Remove all “no data” pixels in cloudy/aerosols area
- Less low quality pixels

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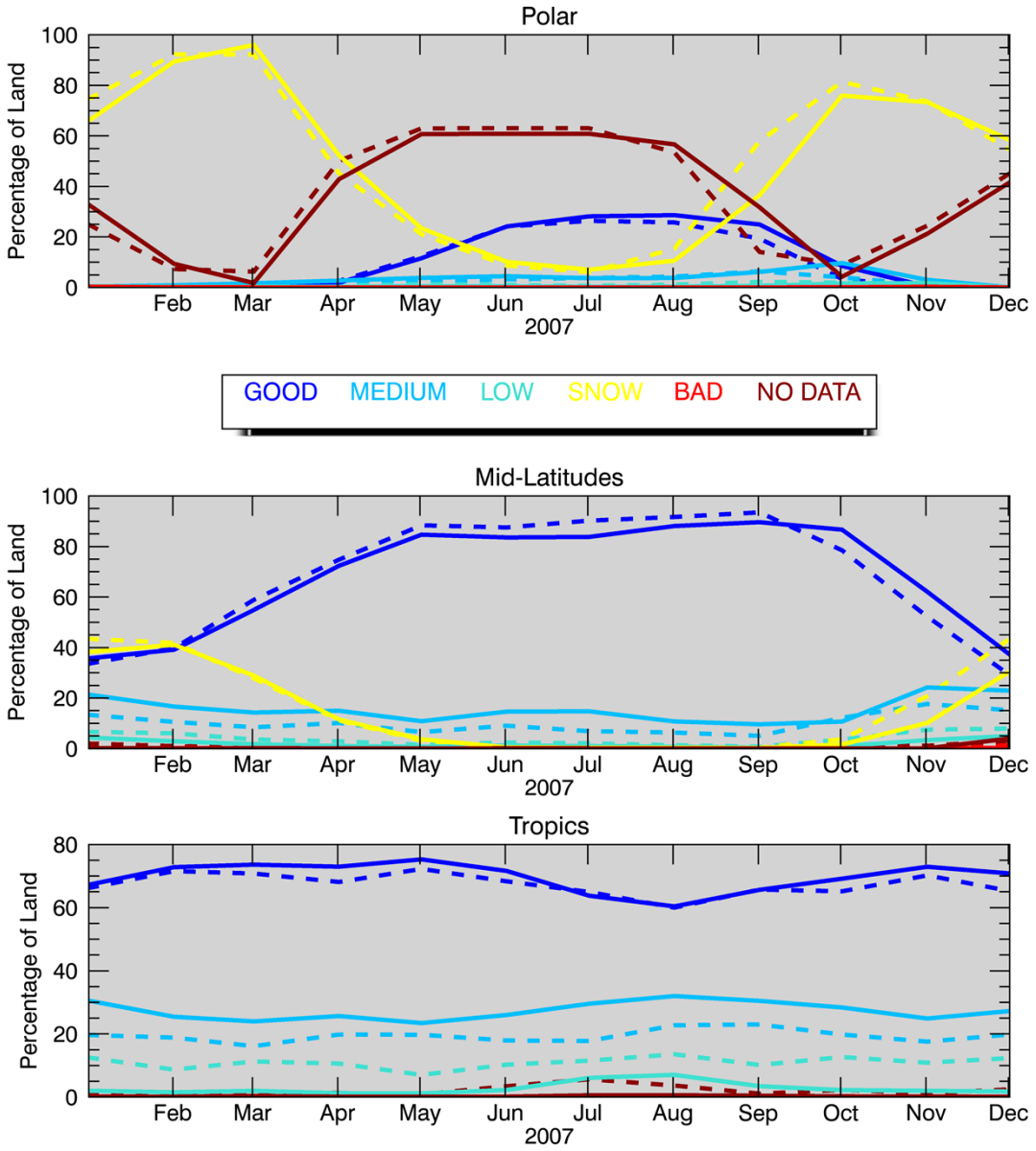
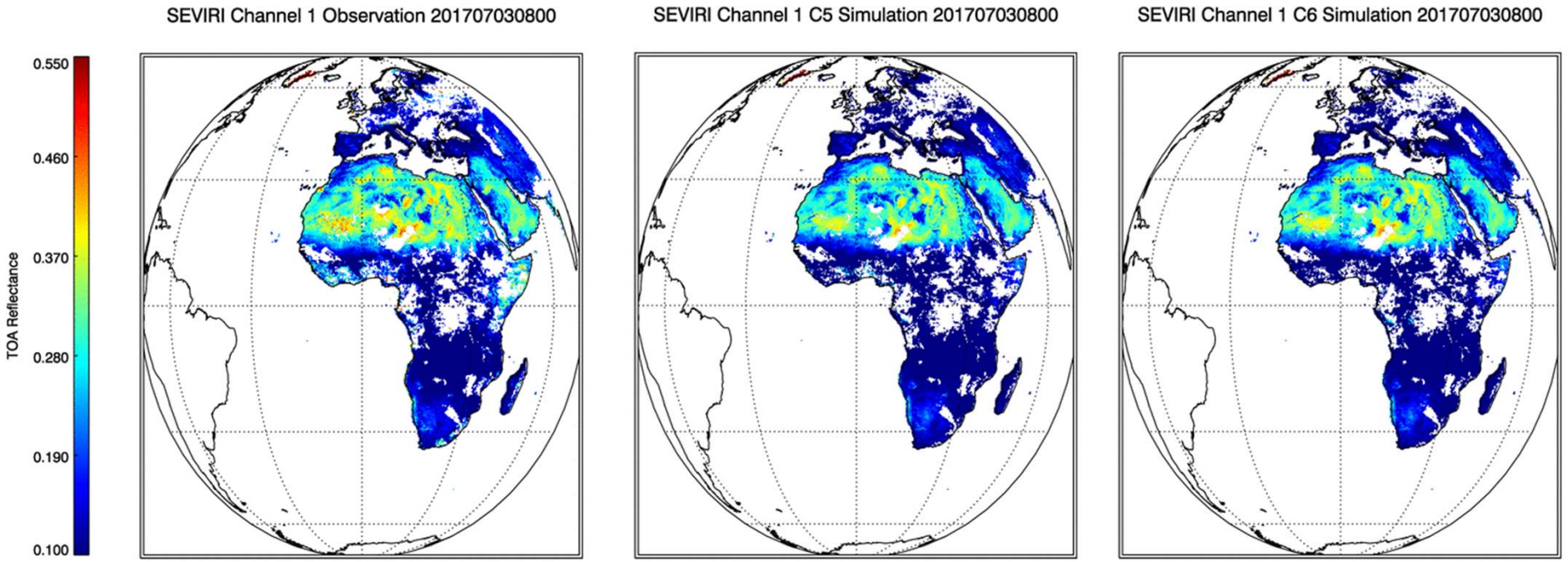
From C5 to C6: Impact on BRDF quality

- Zonal statistics for Polar, Mid-latitudes and Tropics areas
- Dotted lines are C5
- Full lines are C6
- Less snow and more good pixels in Aug. to Oct. in polar areas. Same in Oct. to Dec. in Mid-Latitudes.
- Better improvement in Tropics (more good and medium pixels)



From C5 to C6: Impact on TOA reflectance

- Simulated SEVIRI images for July 3rd 2017 from 8 to 18 UTC (dt=1h) with UK MetOffice NWP fields



- C5 and C6 provides very good BRDF model for SEVIRI

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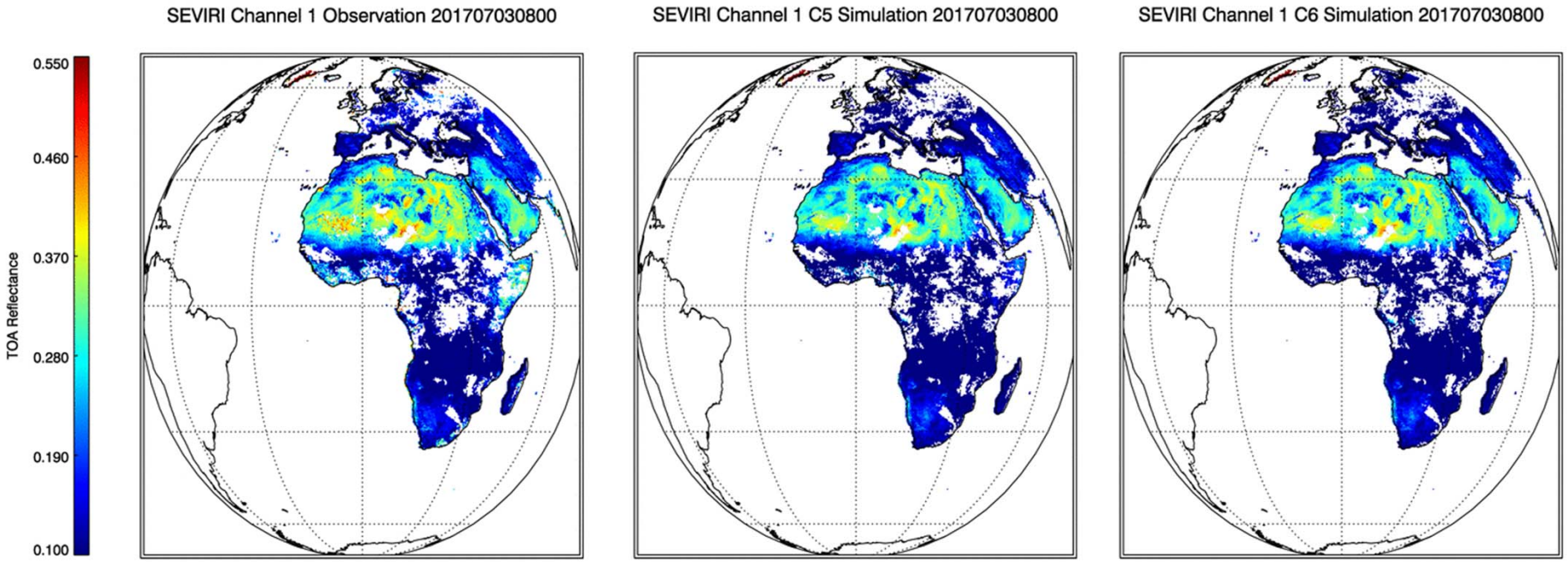

- C5 and C6 provides very good BRDF model for SEVIRI
- More differences at the edge of the SEVIRI disk, at sunset or sunrise

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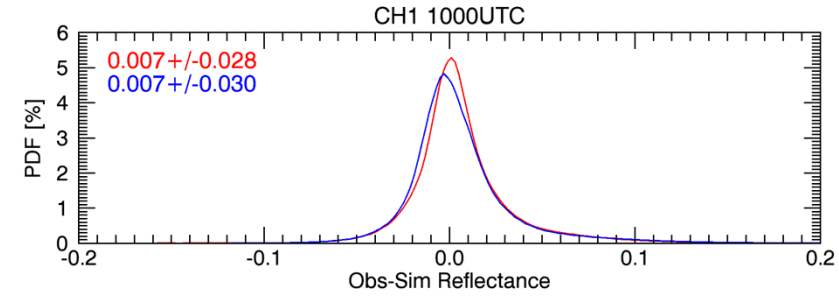
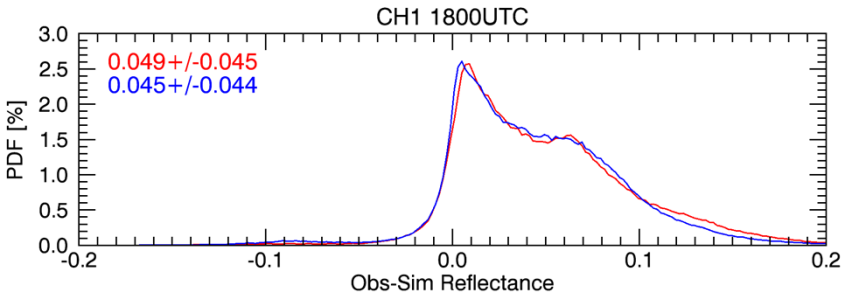
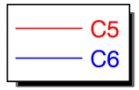
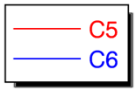
From C5 to C6: Impact on TOA reflectance

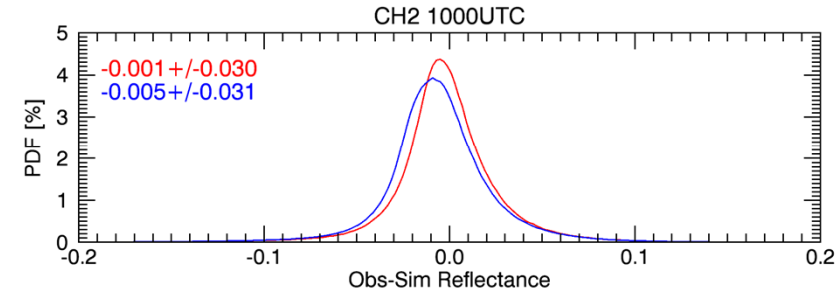
- Observation – Simulation histograms at 10 and 18 UTC

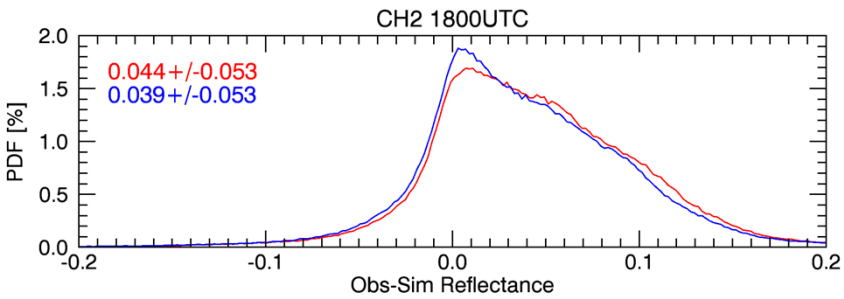


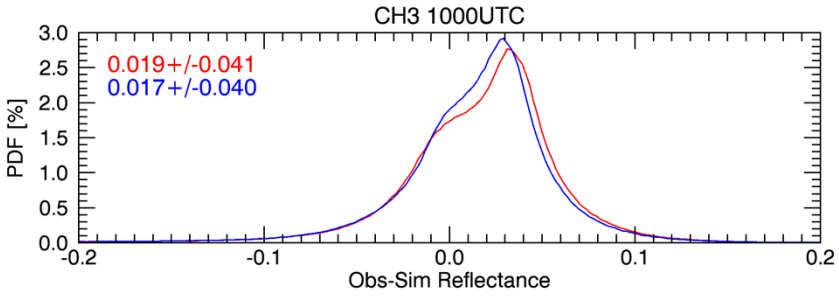


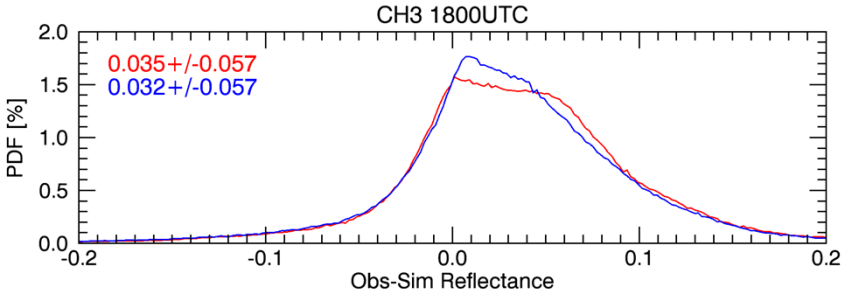






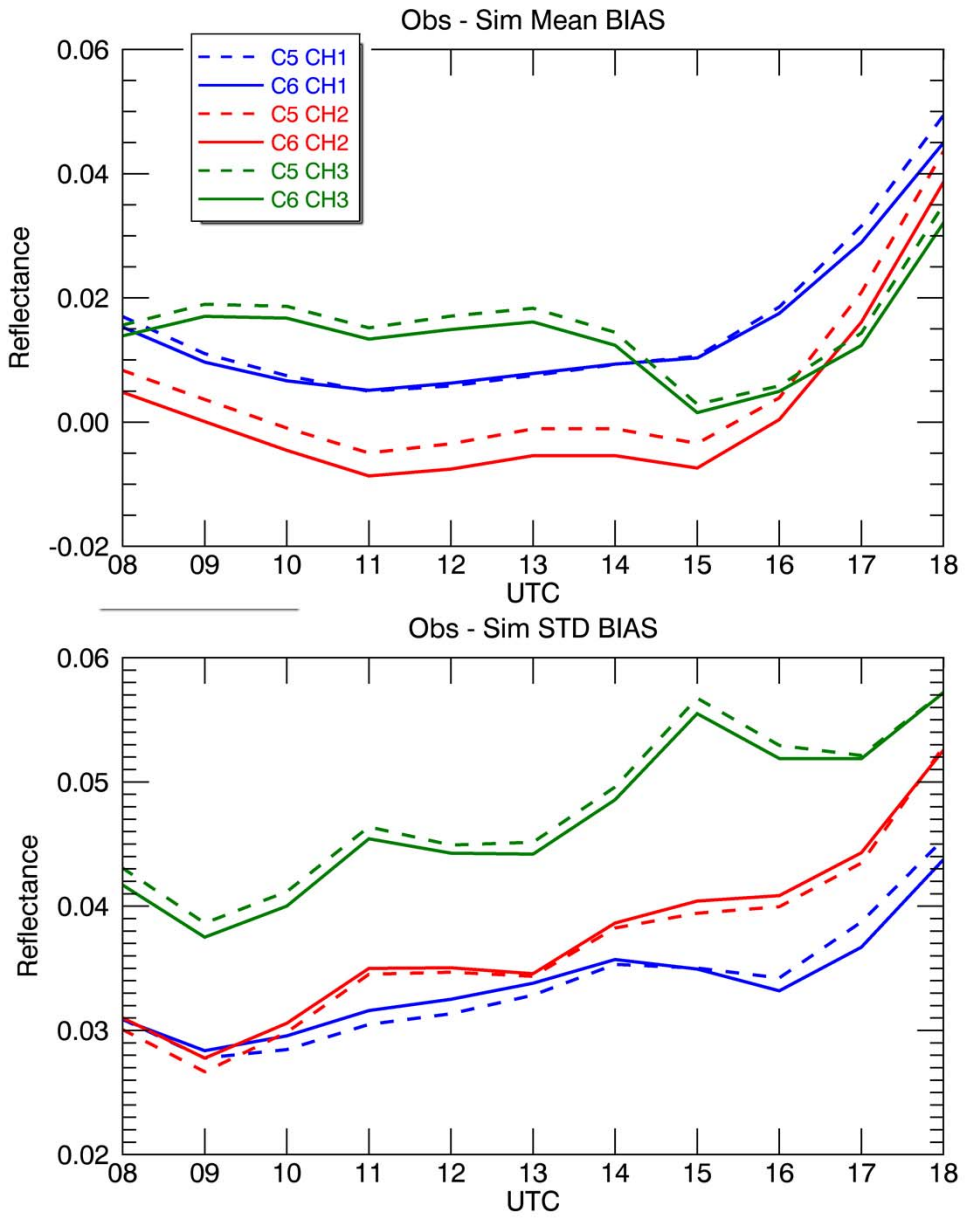






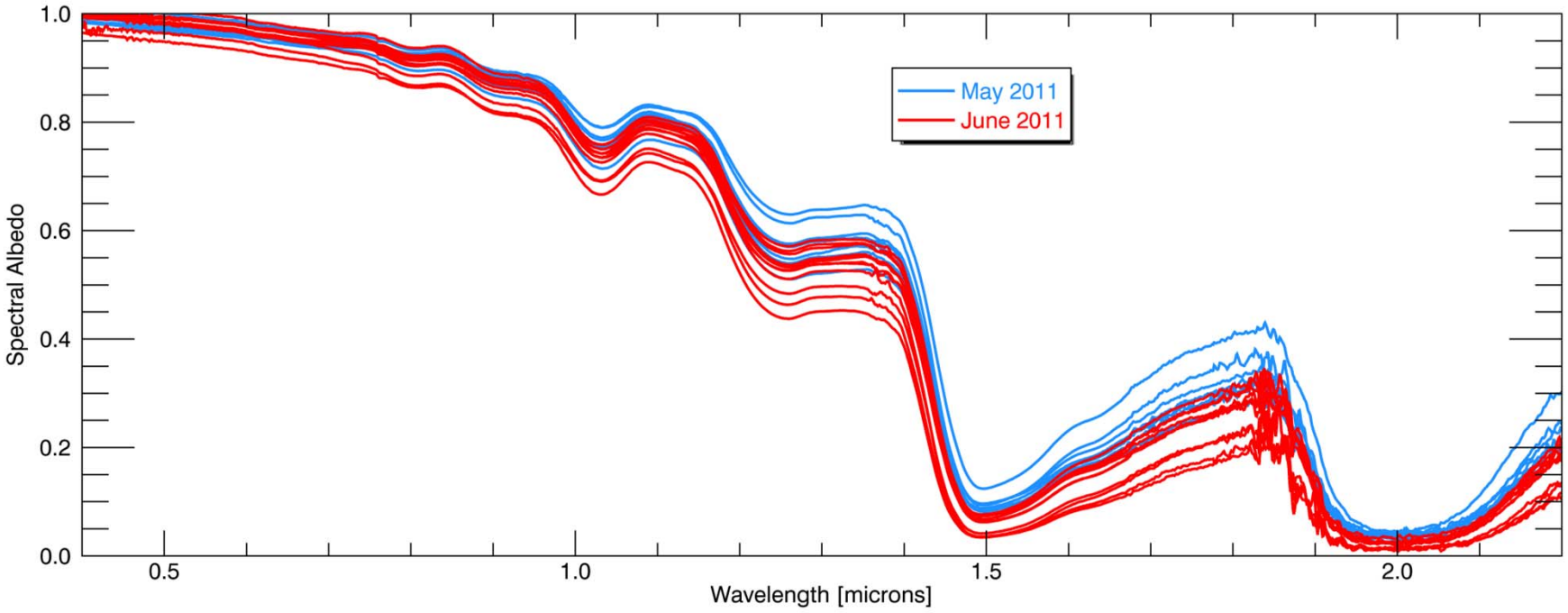
From C5 to C6: Impact on TOA reflectance

- Temporal statistics
- The simulation of SEVIRI channel 3 (1.6 microns) is improved all the day
- The simulation of SEVIRI channel 1 (0.6 microns) is not always improved
- The simulation of SEVIRI channel 2 (0.8 microns) is degraded almost all the time
- Overall the mean biases are still below 2% during day and goes up to 5% at sunrise



From C5 to C6: Impact on snow albedo

- Comparison with in situ measurements
- Measurements at Summit Camp (72.6° N, 38.42° W)
- 19 spectra (8 in May 2011 and 11 in June 2011)
- ASD spectroradiometer (0.35 – 2.2 μm)
- Low Sun: Solar zenith angles = 50 – 60°



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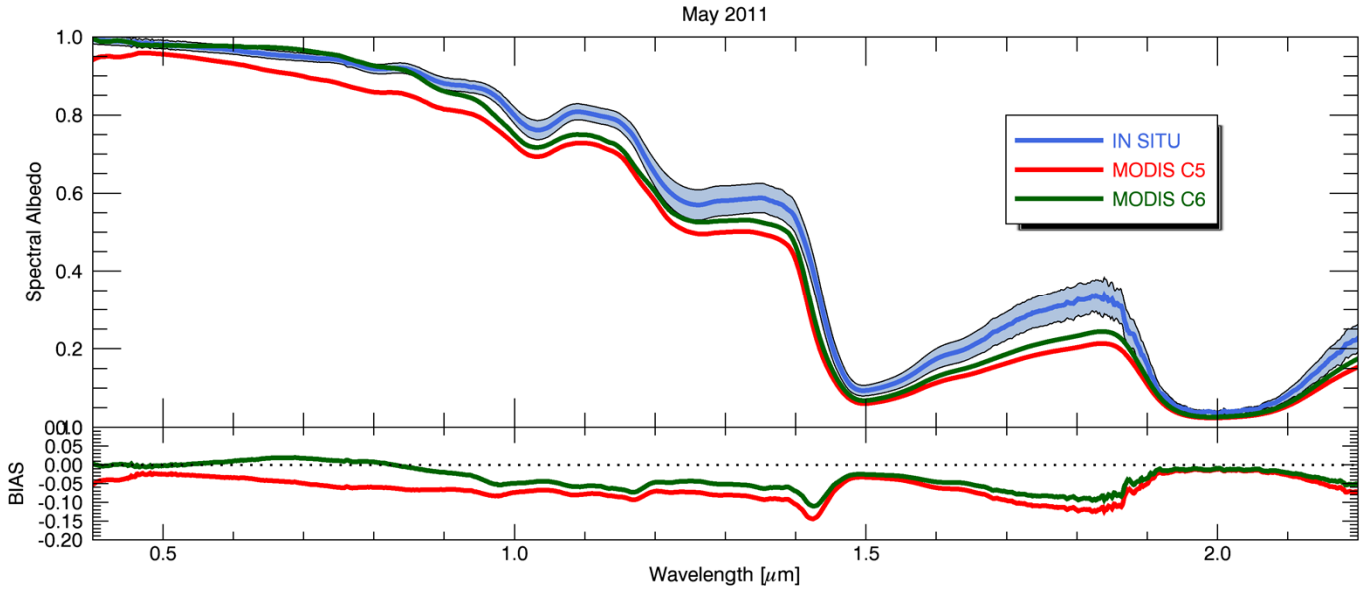
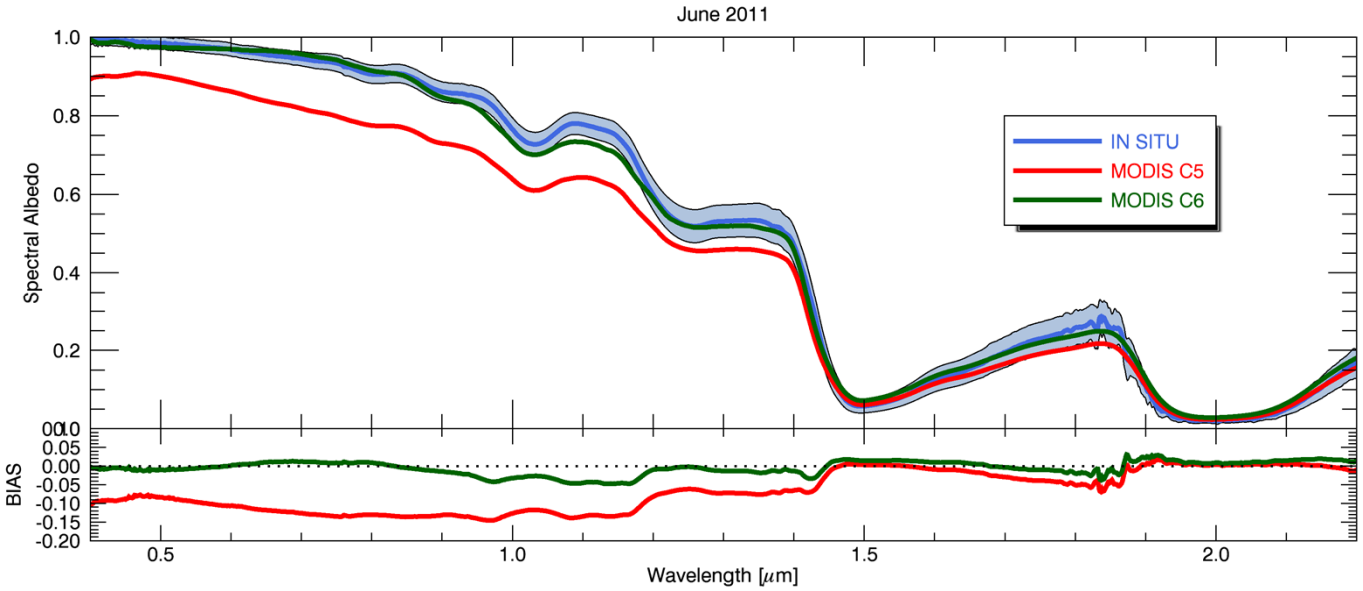


Improvement all over the spectra

Better improvement in the visible part with almost no bias



Summary

- The RTTOV BRDF atlas has been tested with the new collection 6 of MODIS product
- The quality of the BRDF atlas has been improved in cloud/aerosol residual areas (mostly in the Tropics)
- The percentage of snow pixels has been reduced
- To simulate SEVIRI, the collection 6 is better for channel 1 and 3 but not for channel 2. More investigations is needed.
- For snow spectral albedo, collection 6 is better than collection 5 and especially in the visible part of the spectrum (Wright et al., 2014)

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Thank you for your attention

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NWP SAF
Numerical Weather Prediction

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