- 4th RSMSP, 14 -16 March 2016, Grenoble, France -

A snow BRDF atlas for RTTOV: comparison with in situ measurements

J. Vidot[1], E. Borbas[2], M. Dumont[3], C. Carmagnola[4] and P. Brunel[1]

[1]CMS, Météo-France

[2]SSEC/CIMSS, University of Wisconsin

[3]CEN, Météo-France

[4]DIANEIGE, Meylan, France

NWP SAF

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Outline

- Motivation
- Methodology: RTTOV Snow-free land surface BRDF model
- Extension to snow-covered land surface
- Comparison with *in situ* snow spectral albedo measurements
- Conclusions and perspectives

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Motivation

- RTTOV simulates clear-sky/simple cloud VIS/NIR TOA radiances (0.4 - 2.5 µm) since version 11 (2013)

⇨ 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 (2013)

⇨ Snow-covered conditions: RTTOV version 11.3 (2015)

- Validations:

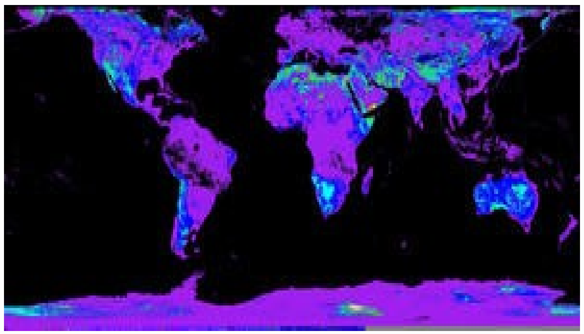
⇨ Snow-free conditions: Comparison with Land SAF SEVIRI albedo map (Vidot and Borbas, QJRMS, 2014)

⇨ Snow-covered conditions: Comparison with *in situ* snow spectral albedo measurements (this work)

Snow-free land surface BRDF model
(Vidot and Borbas, 2014)

- Methodology adapted from IR emissivity (UWIREMIS model)

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



3 linear parameters semiempirical 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 (f_{iso}) · Volumetric scattering (f_{vol}) · Geometric scattering (f_{geo})

λ	wavelength	θ_V	Viewing zenith angle
θ_S	Solar zenith angle	$\Delta\varphi$	Azimuth angles difference

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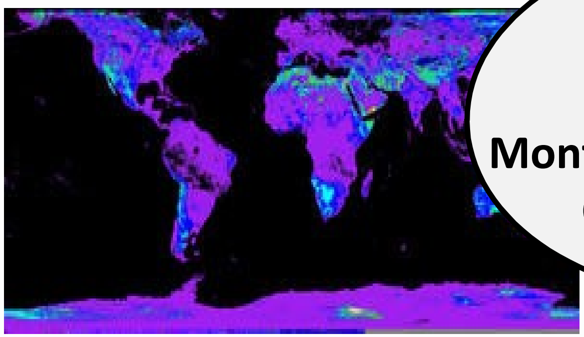

Resampling

Monthly means at 0.1°
Quality Flags

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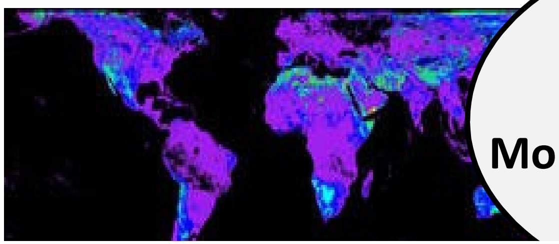

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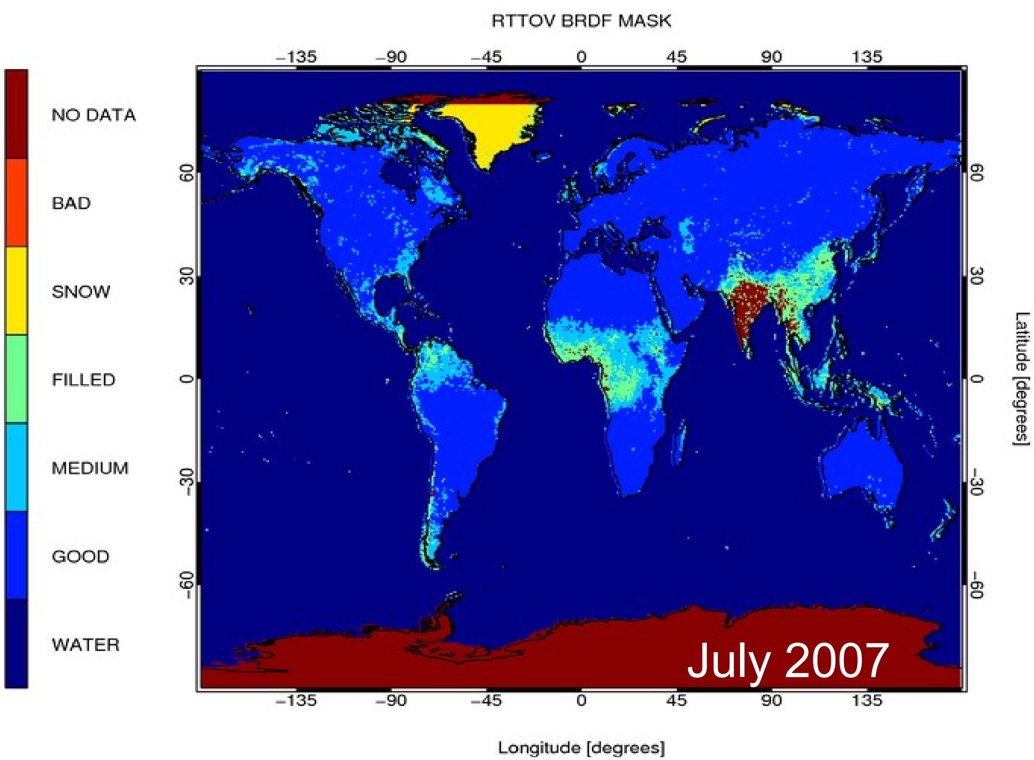

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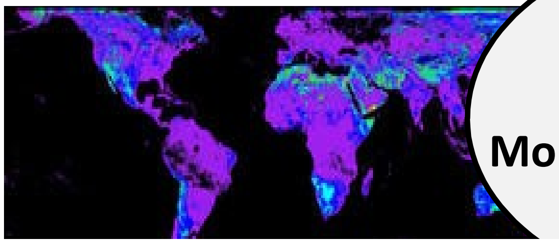

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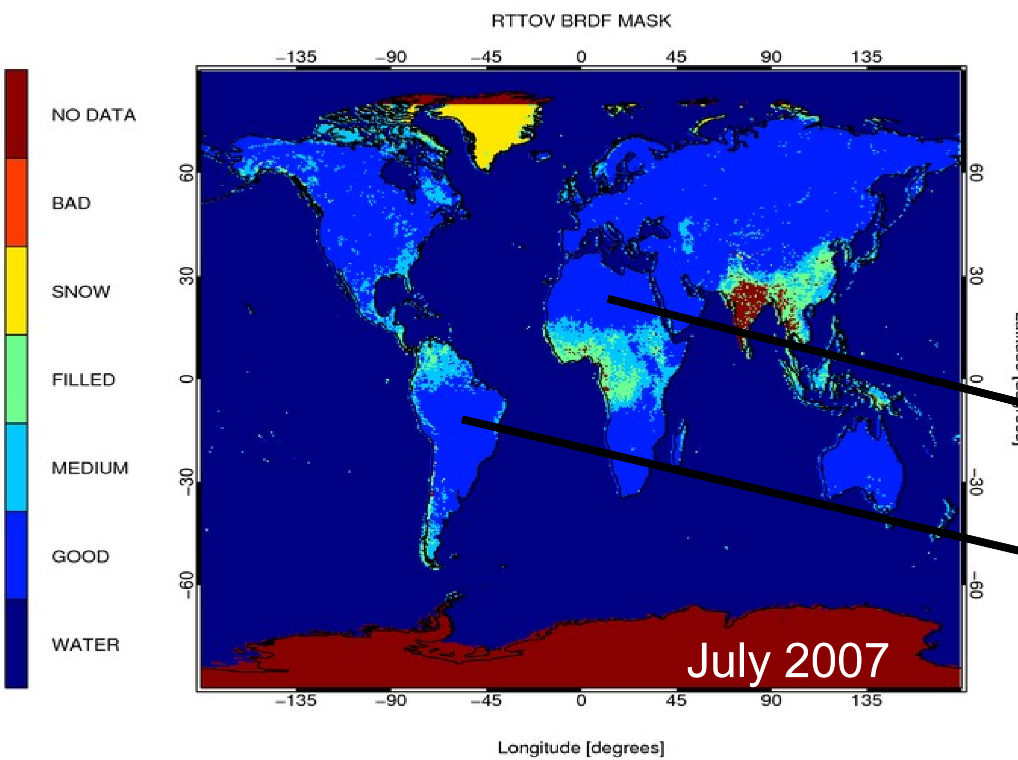

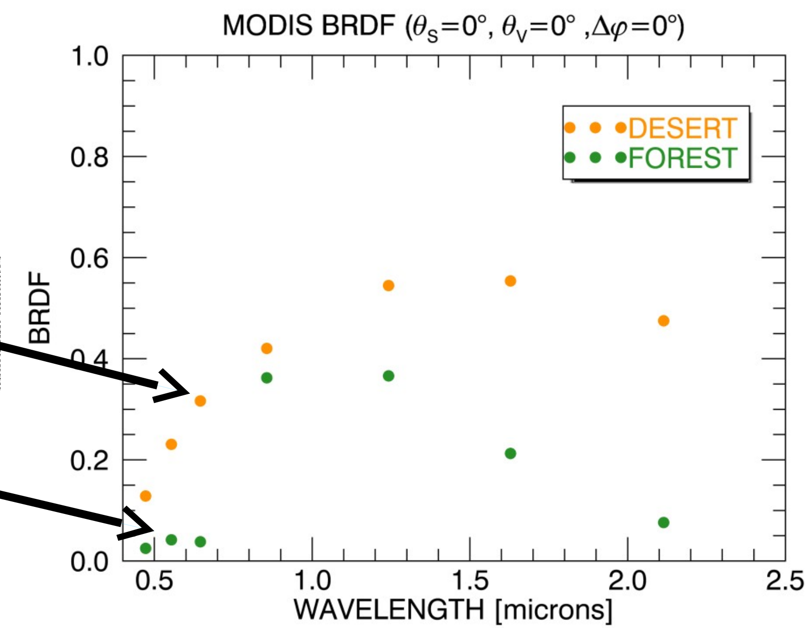

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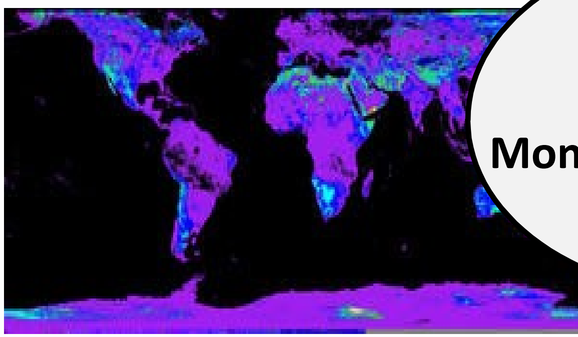

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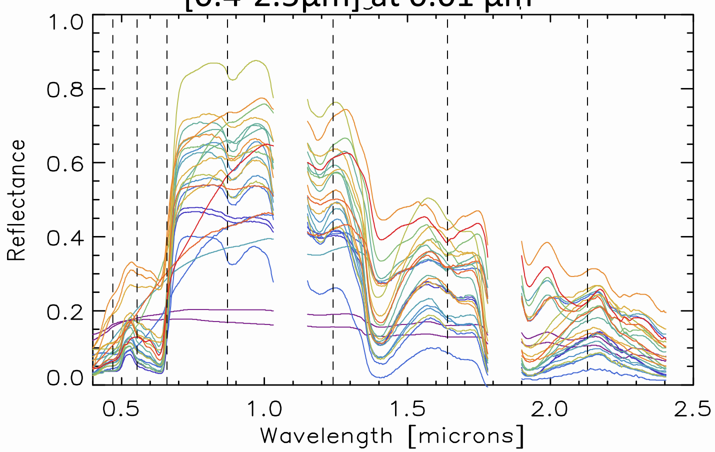
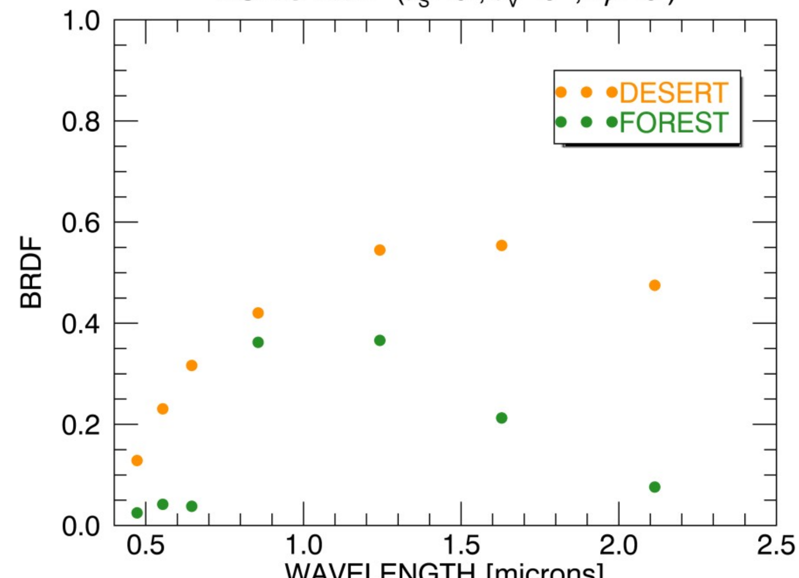
USGS 126 soil and vegetation spectra
[0.4-2.5μm] at 0.01 μm





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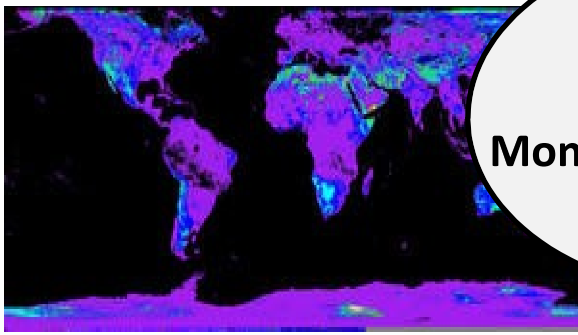

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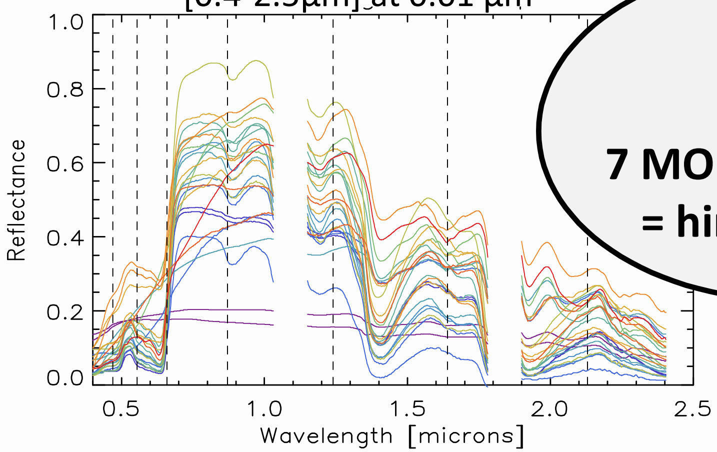
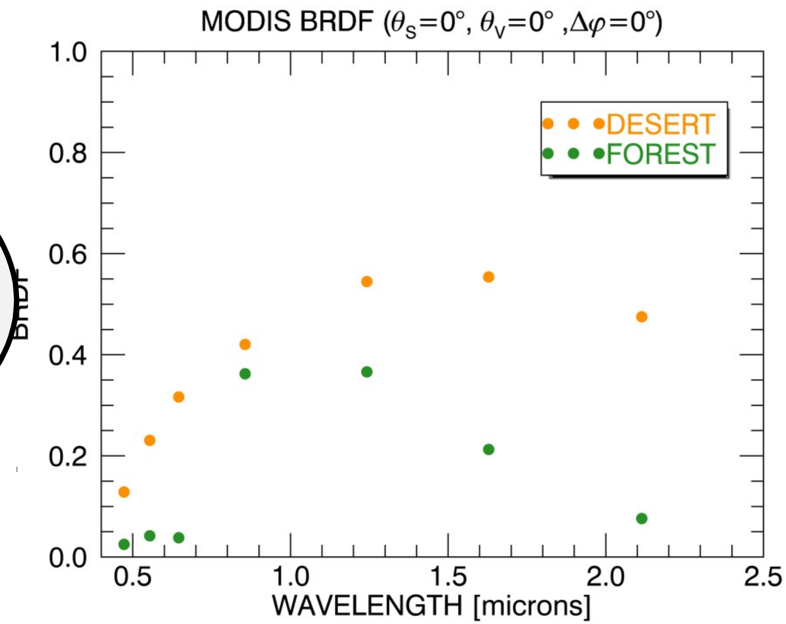


PCA

7 MODIS channels
= hinge points



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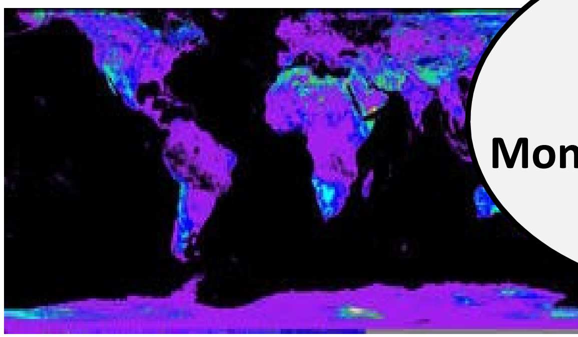

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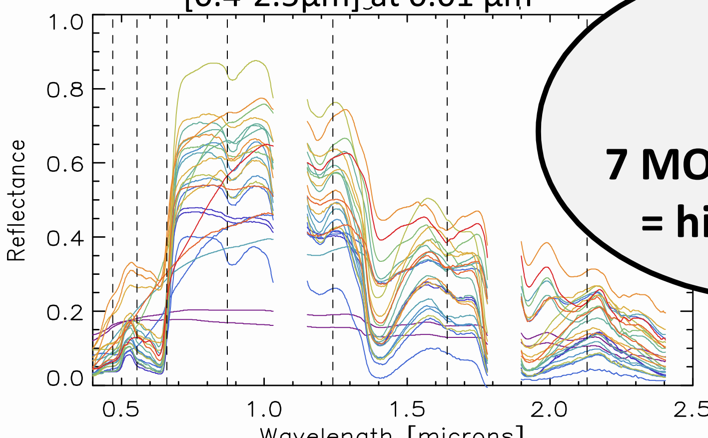

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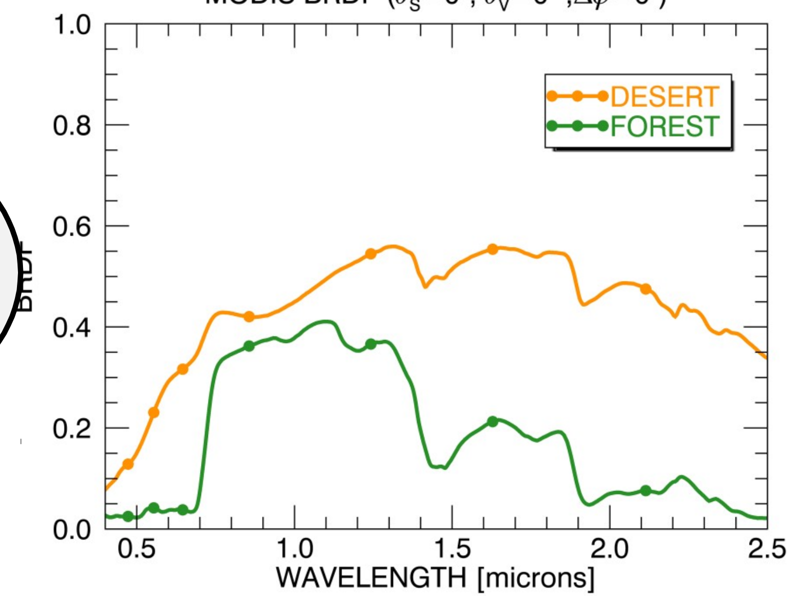

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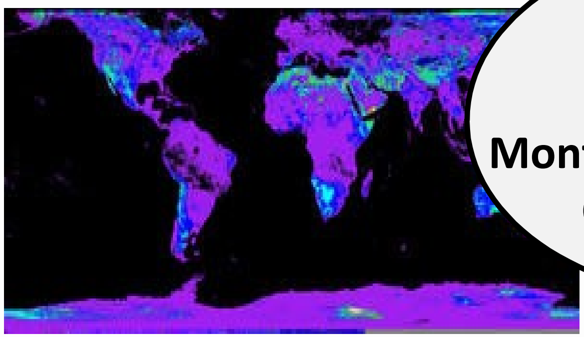

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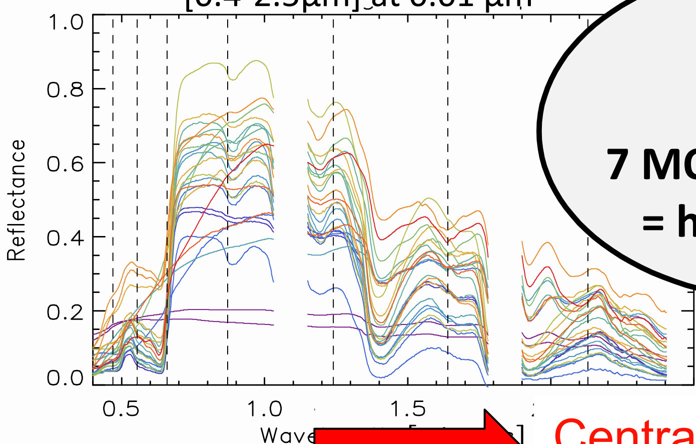

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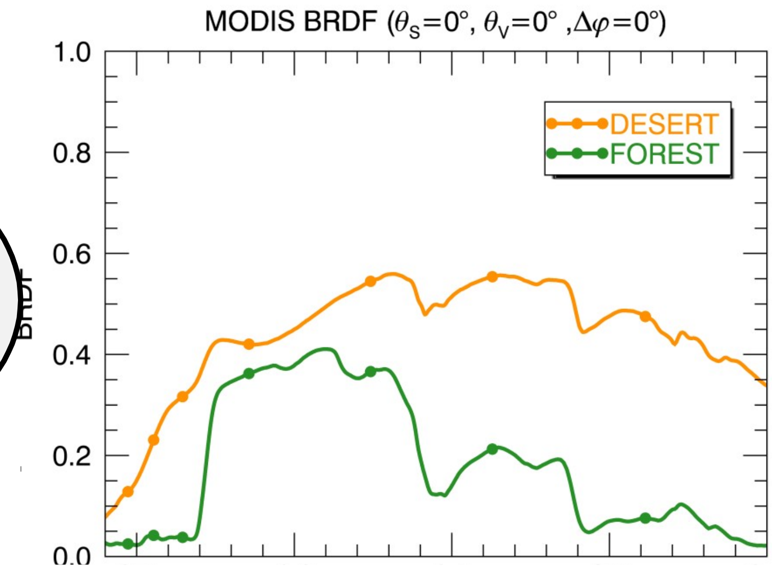
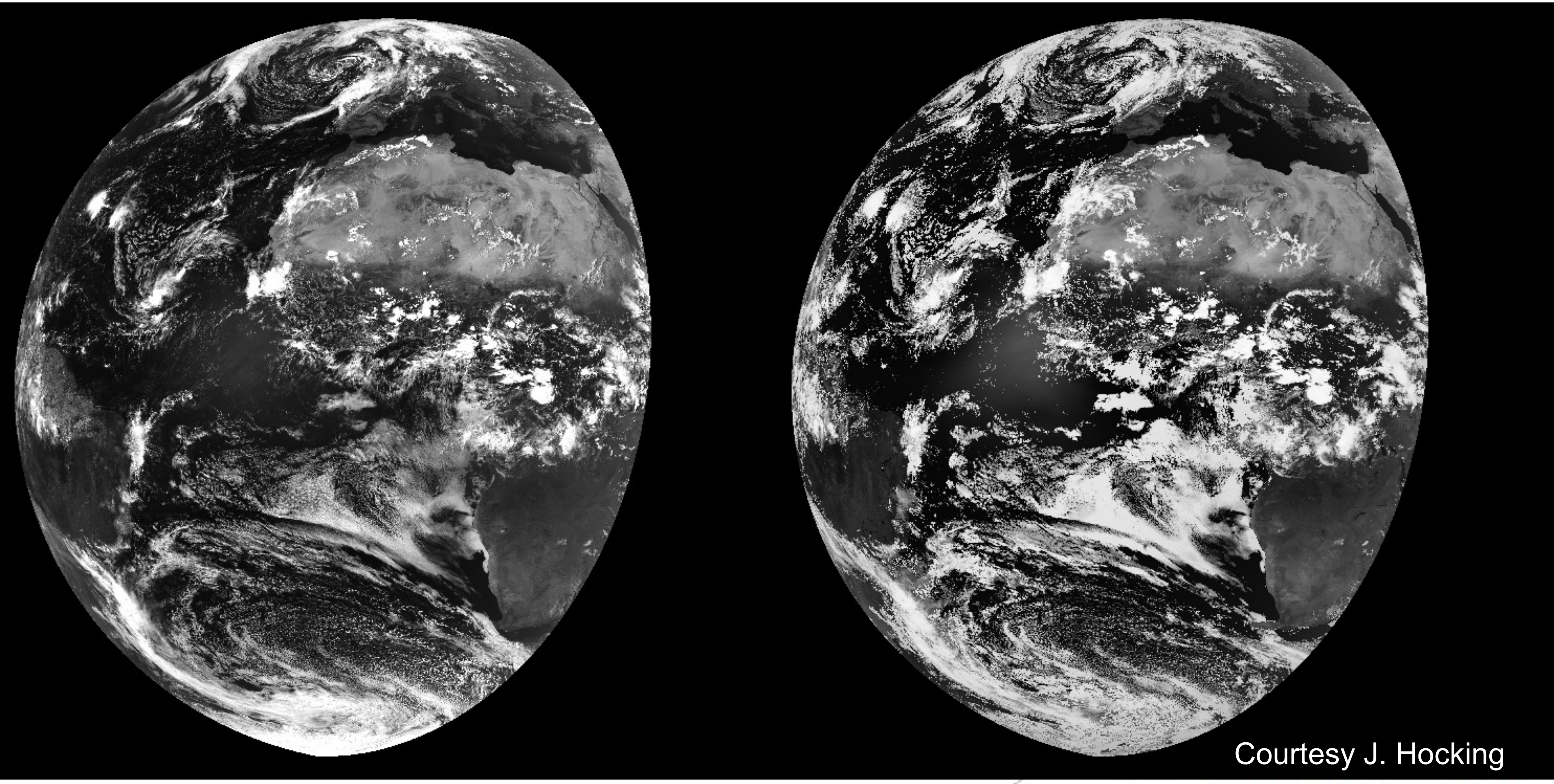


Central wavelength of any ISRF is finally interpolated

Simulated SEVIRI observations at 0.6 microns

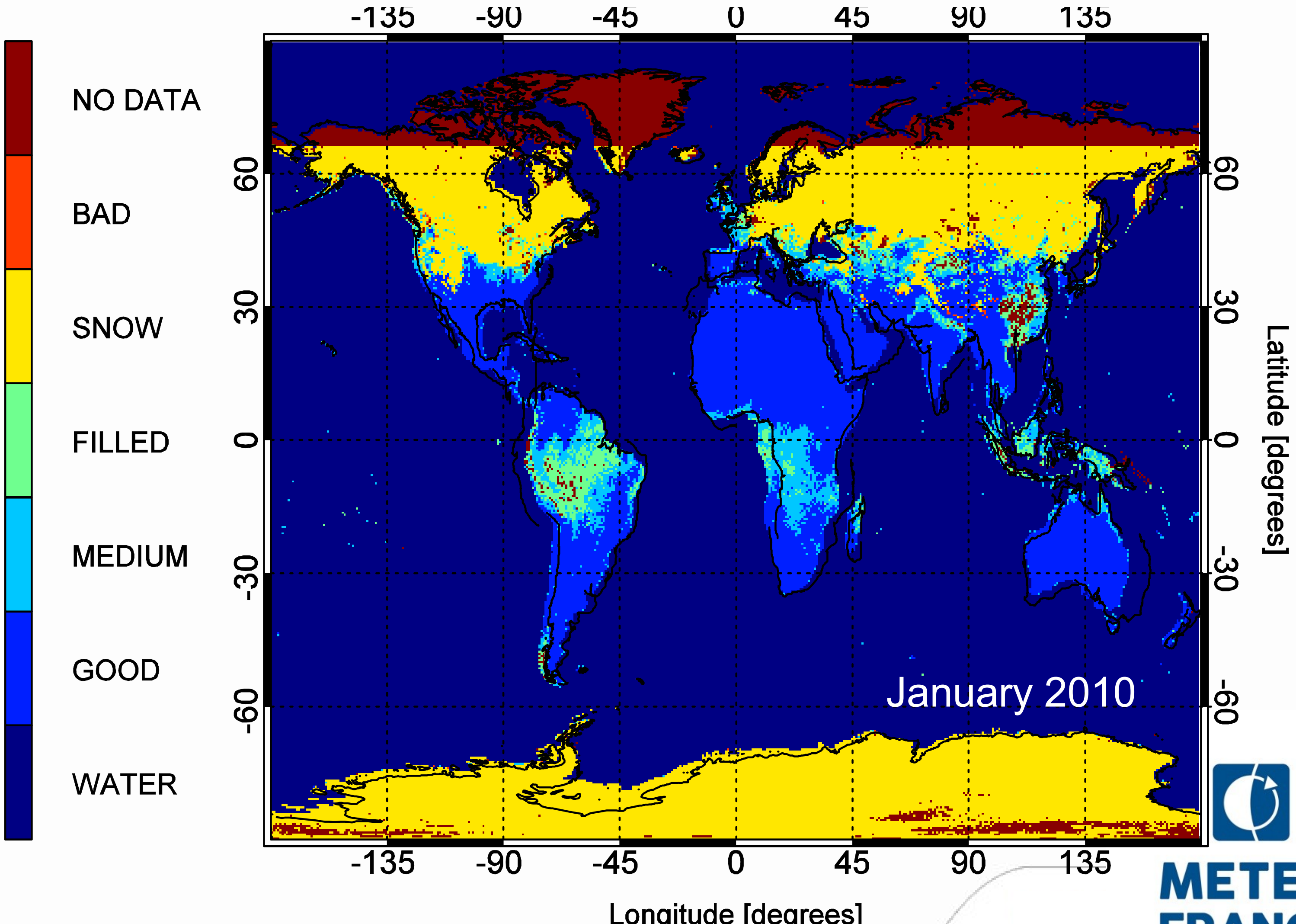
- RTTOV11 + UK MetOffice NWP atmospheric fields

Observations Simulations



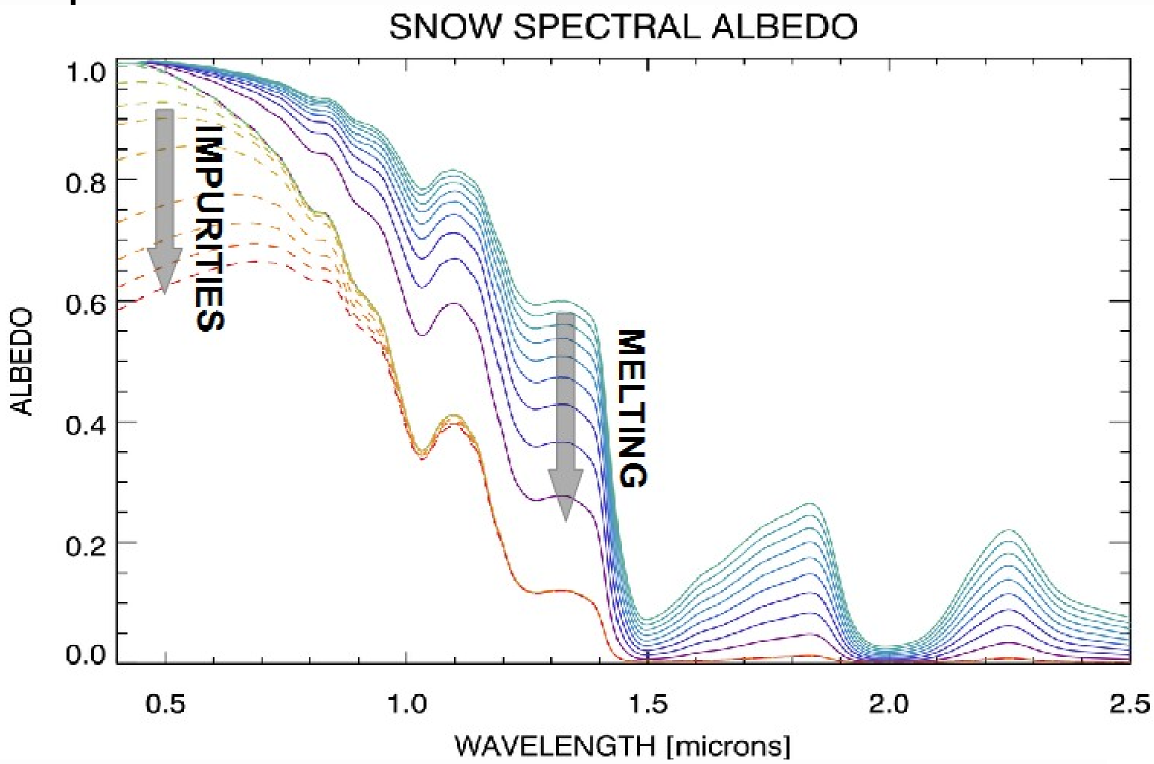
The rationale for snow-covered land surface

- Quality index based on MODIS MCD43C1 retrievals



Snow spectral albedo simulations

- Based on DISORT for 18 solar zenith angles (0°-85°), 20 values of the snow specific surface area (5-100 $m^2.kg^{-1}$) and 22 values of the black carbon content (0-2000 ppm) = ~8000 spectra
- Some examples:



➡ Melting reduces albedo at near infrared wavelengths

➡ Impurities reduces albedo at visible wavelengths

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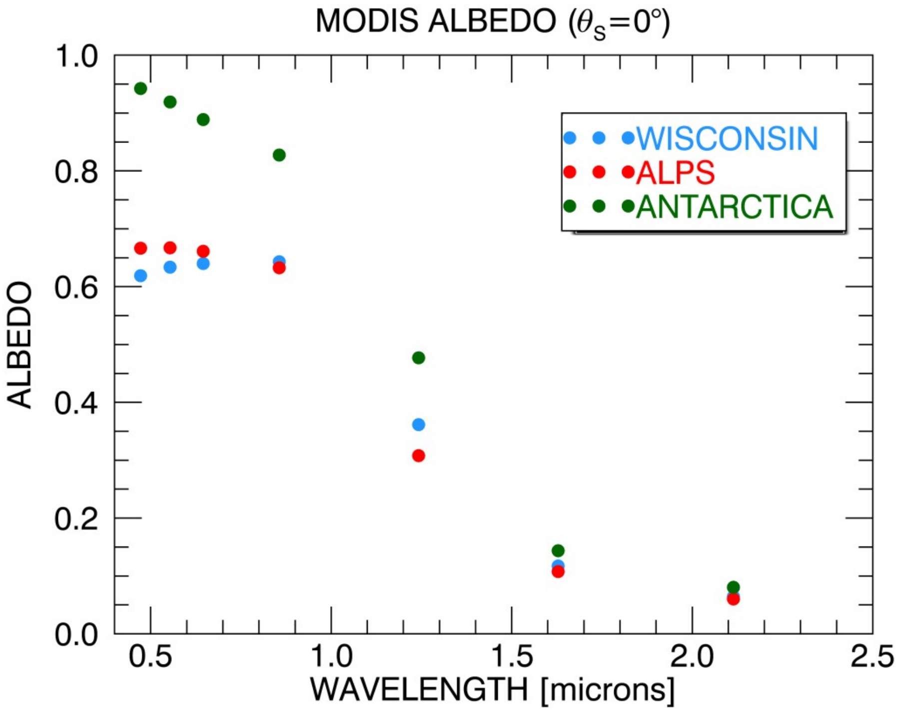
RTTOV Snow spectral albedo

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

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



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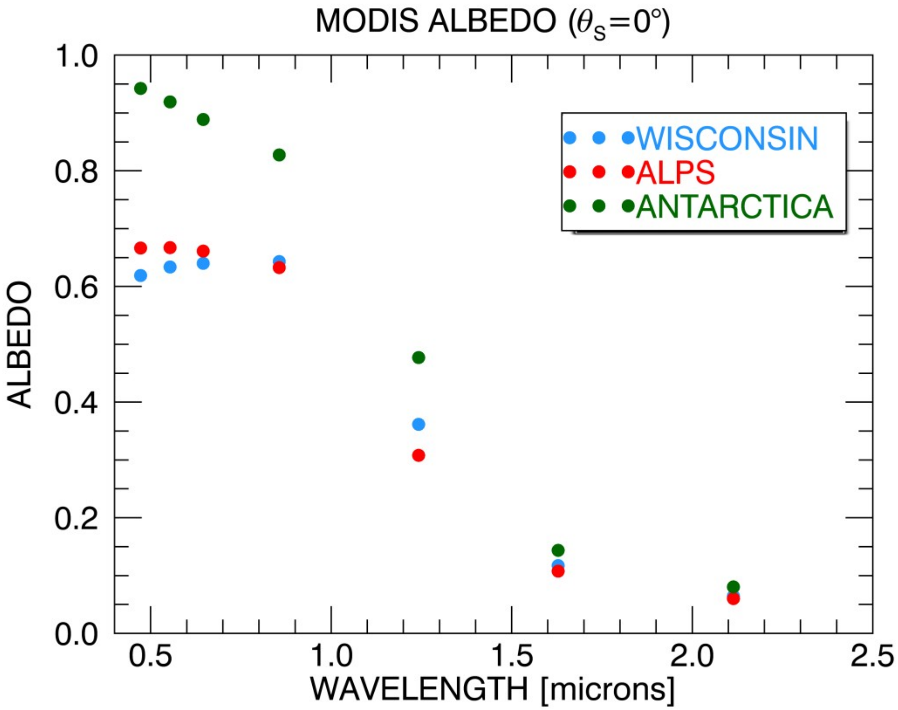

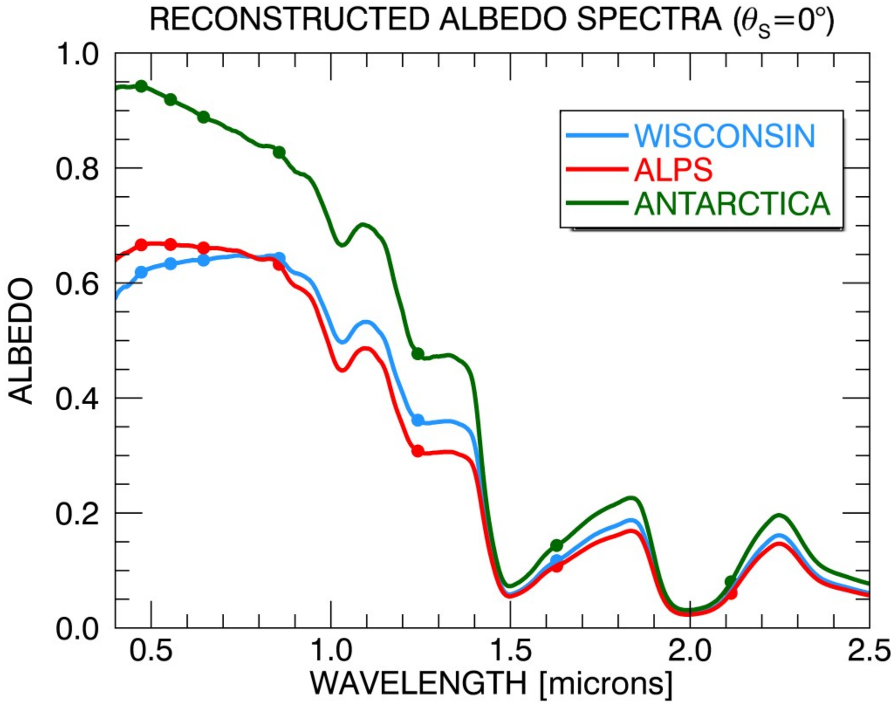

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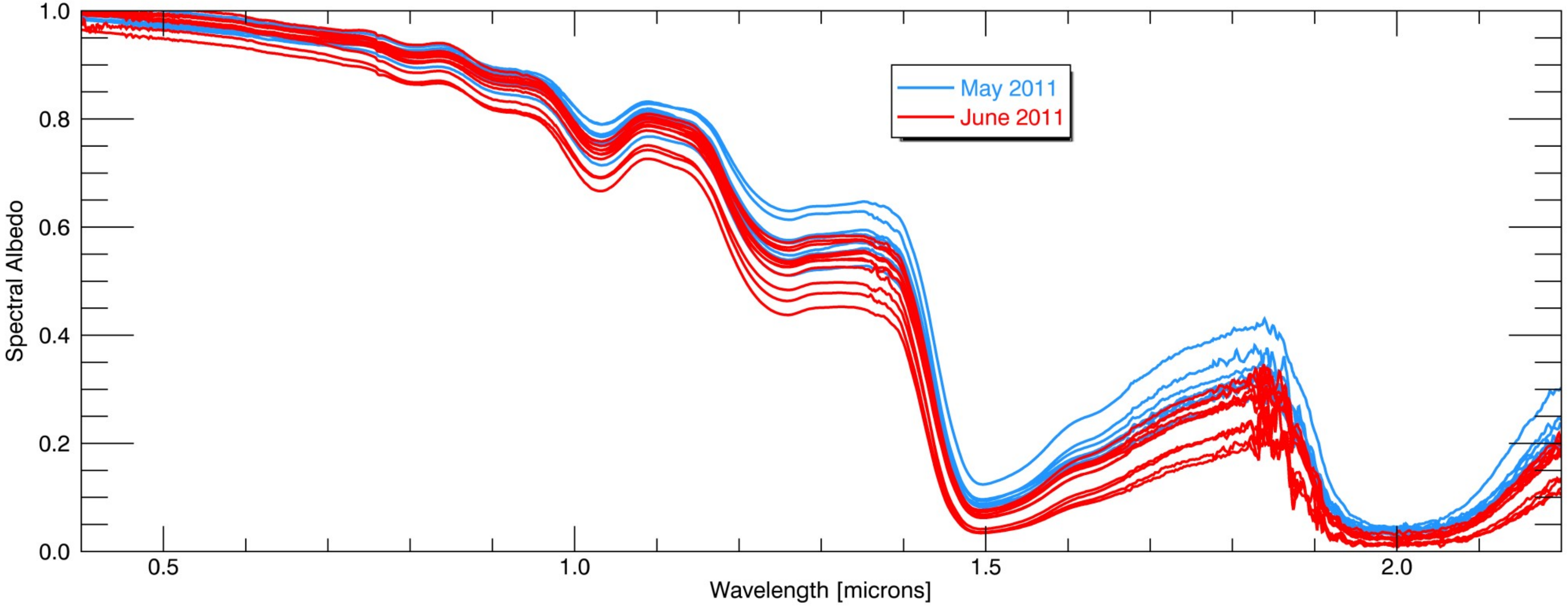
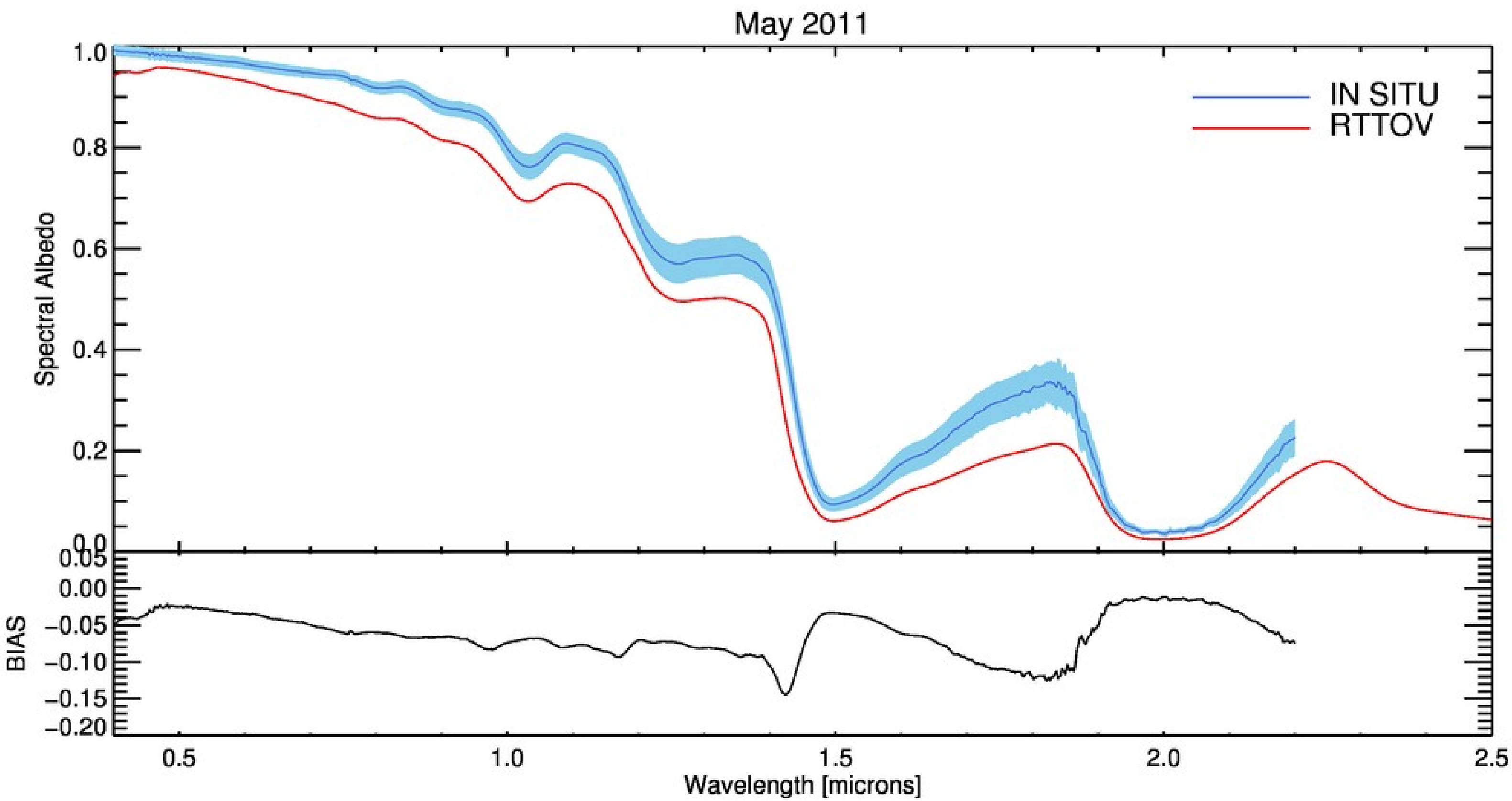
Snow spectral albedo *in situ* measurements

- 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 [θ_S = 50-60°]



Comparison for May 2011

- The 8 spectra of May 2011 were averaged



⇨ Spectral variation is correctly reproduced by RTTOV

⇨ Underestimation of the albedo by 0.05-0.1

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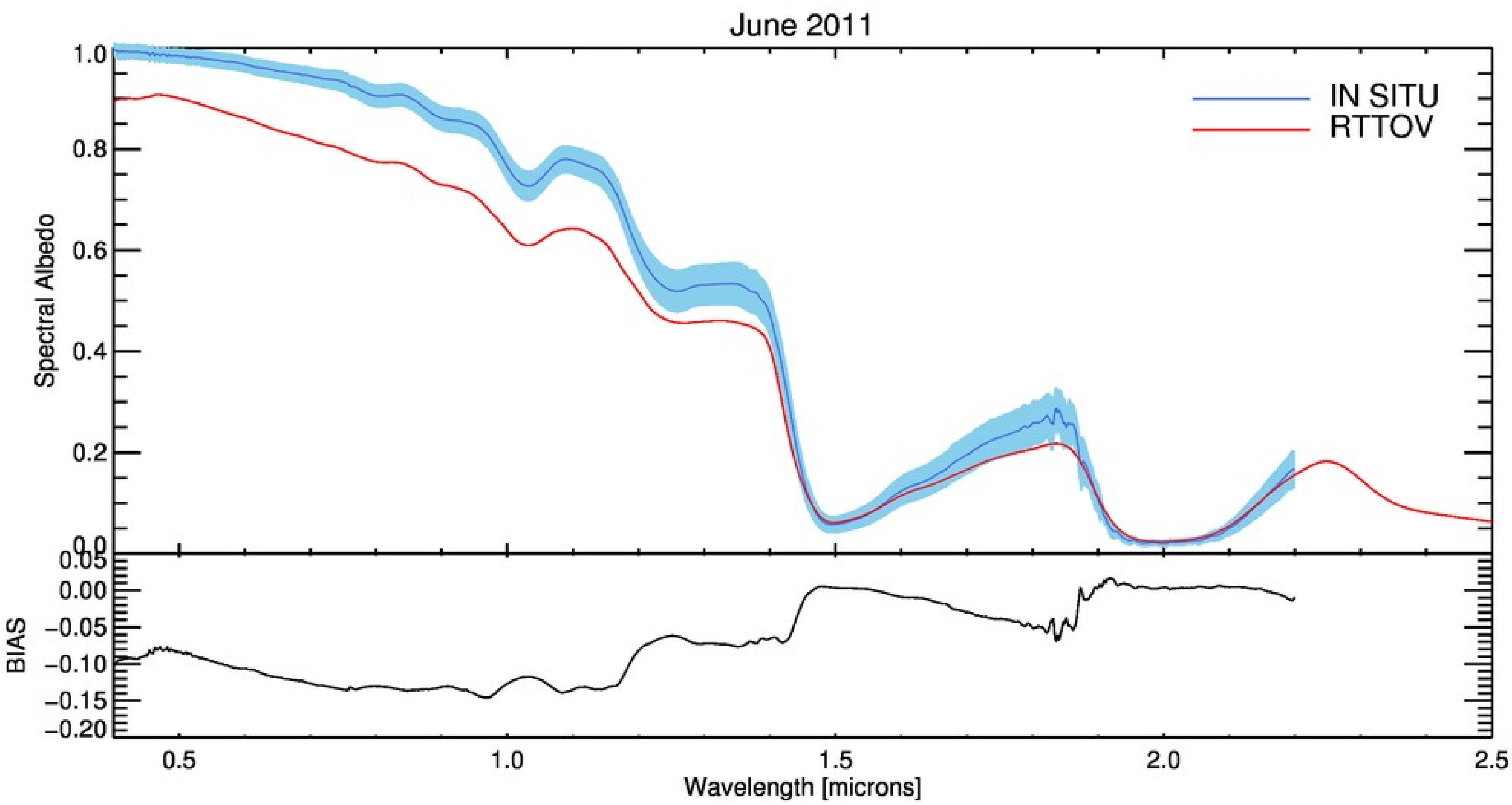
Comparison for June 2011

- The 11 spectra of June 2011 were averaged



⇨ RTTOV better in June when λ > 1.5 microns

⇨ Underestimation of the albedo up to 0.15

Conclusions & perspectives

- Conclusions:

⇨ A Monthly BRDF model land surfaces based on MODIS have been implemented in RTTOV v11 (only for 2007)

⇨ The BRDF model has been extended to snow-covered surfaces

⇨ Comparison with in situ measurements have shown a good description of the spectral variation of the snow albedo

⇨ RTTOV underestimates the albedo by 0.05 to 0.15

- Perspectives:

⇨ RTTOV BRDF atlas is based on MODIS collection 5. The new collection 6 seems to be promising (Wright et al., 2014)

⇨ Snow spectral albedo for PCA training may be improved

⇨ The RTTOV BRDF model for other years would be provided

⇨ VIIRS BRDF and Albedo product are expected for future

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Thank you for your attention