Dual View Clear-Sky Top-of-Atmosphere Albedo From Meteosat Second Generation Satellites

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Flux and albedo: observer-independent physical quantities

satellite
Observed radiance ($W.m^{-2}.sr^{-1}$) —unfiltering→ —inversion (angular conversion)→ Irradiance, Flux ($W.m^{-2}$)
indep. of observer

Remaining observer-dependent trends in flux/albedo data = unphysical artefacts
→ introduce errors, *e.g.* in the Earth's Radiation Budget determination

Geostationary: good temporal sampling but quite sensitive to angular-dependent errors

Opportunity to cross-check the retrieved products

2 MSG satellites with overlapping scenes since 2016:

- MSG3 @ 0° longitude (then MSG4, since 2018/02/20)
- MSG1 @ 41.5°E longitude ('Indian Ocean')

⇒ Aim: compare, quantify discrepancies, address them

Throughout: focus on the *albedo* ≡ 'clear-sky top-of-atmosphere albedo'

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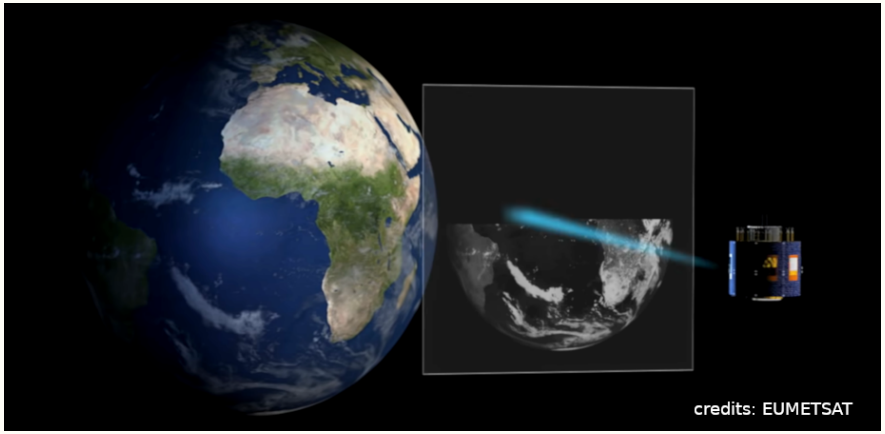

'GERB-like' products [*Dewitte et al.* (2008)]

- every 15 minutes;
- 3x3 SEVIRI pixels grid: (9 km x 9 km @ nadir);
- pure SEVIRI (NB → BB);
- rely on CERES TRMM ADMs [*Loeb et al.* (2013)]

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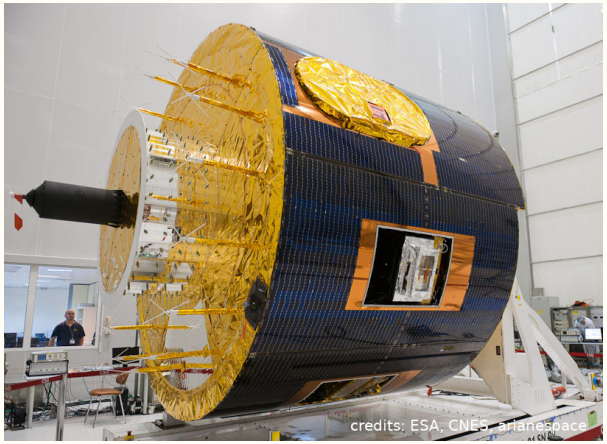

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MSG3–MSG1 comparison method, one month at a time

Same treatment applied independently to SEV3 (MSG3) & SEV1 (MSG1) images

One month at a time: do, for each HHMM among the 96 timeslots

- $\forall$ day @ HHMM: derive the instantaneous clear-sky TOA albedo image
- calculate the monthly "representative" albedo image (mean/median) @ HHMM
- in a common lat/lon grid, calculate pixel-per-pixel difference for that timeslot:

$$x = \text{SEV3} - \text{SEV1} \longleftarrow \text{would be 0 } \forall \text{ pixels if perfect}$$

Statistics over { 'SEV3 − SEV1' images } using all timeslots (RMSD $= \sqrt{\sigma^2 + \text{bias}^2}$, σ, bias)

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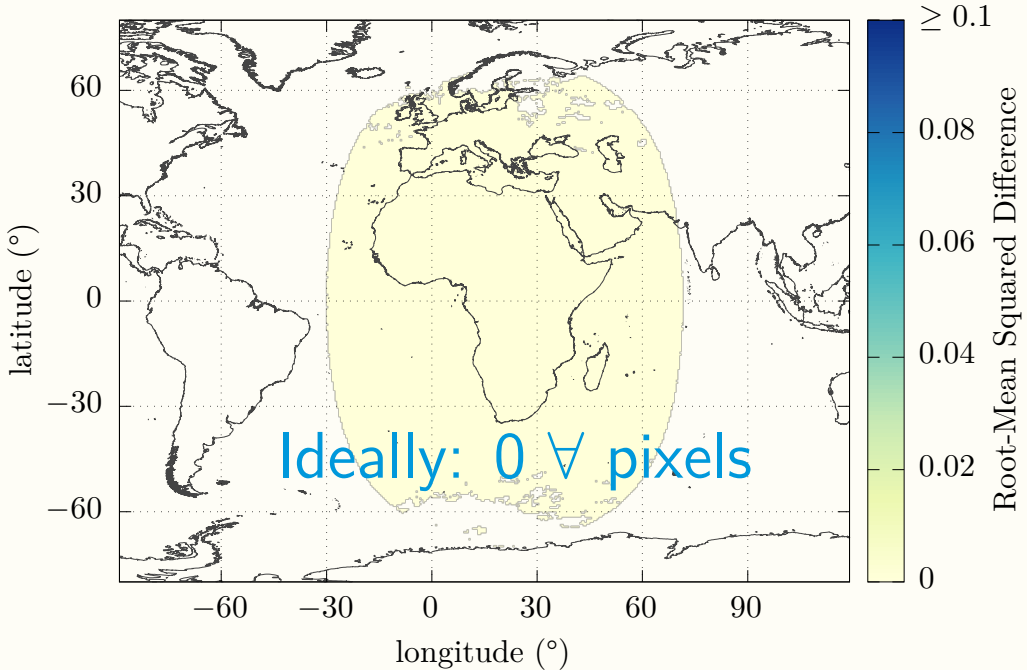

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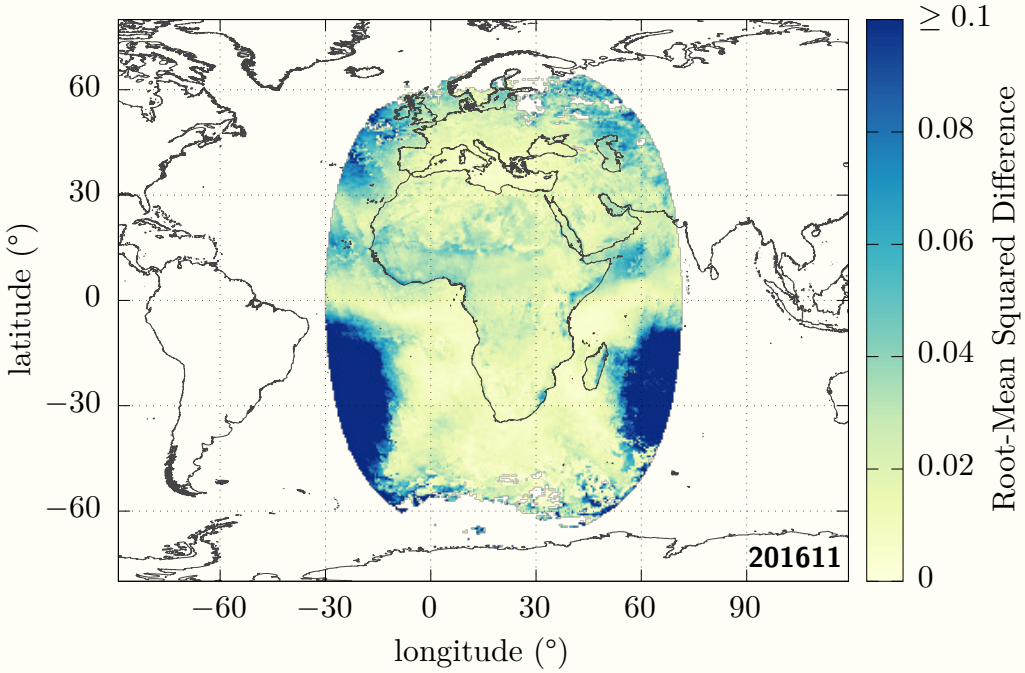

NB:
absolute difference in albedo units

- unidentified clouds (θ_{sz}, θ_{vz})
- sunglint regions close to limbs
  $\rightarrow$ discrepancies > 0.1
- aerosol areas over ocean
  $\rightarrow$ discrepancies ~ 0.05
- further discrepancies over land

Using the fluxes given in the GERB-like products

In particular:

- a SW flux is provided over sunglint region
- 'aerosol over ocean', treated as 'clear-sky ocean'

idem CERES TRMM ADMs

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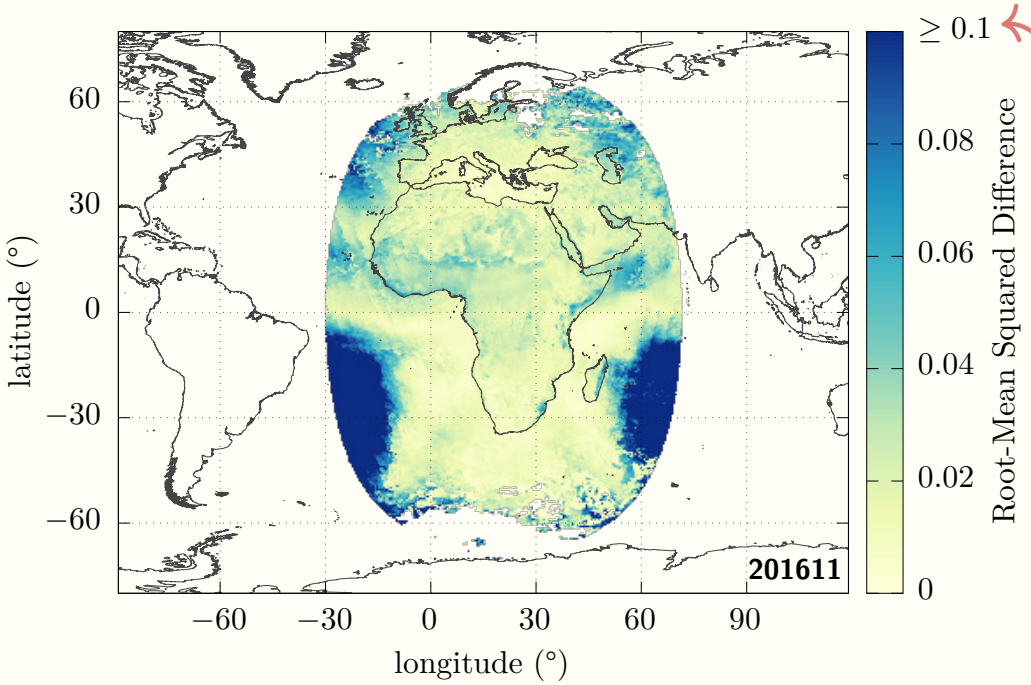

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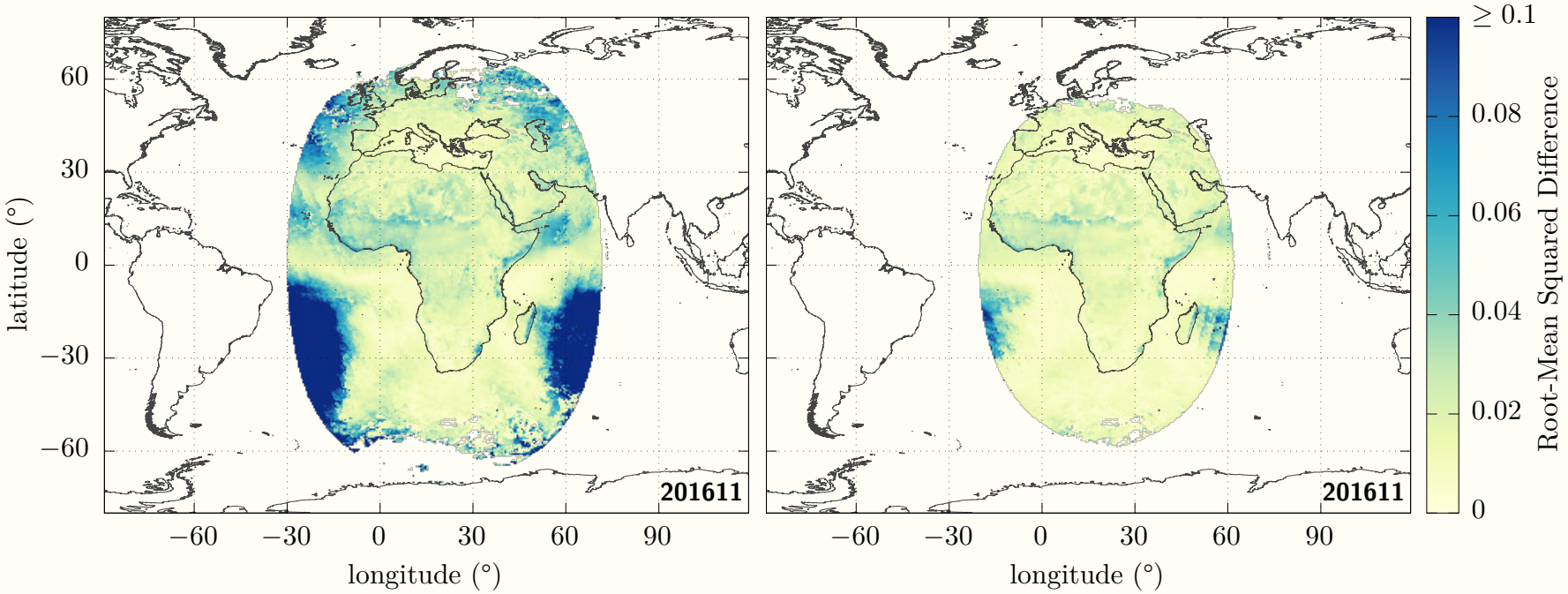

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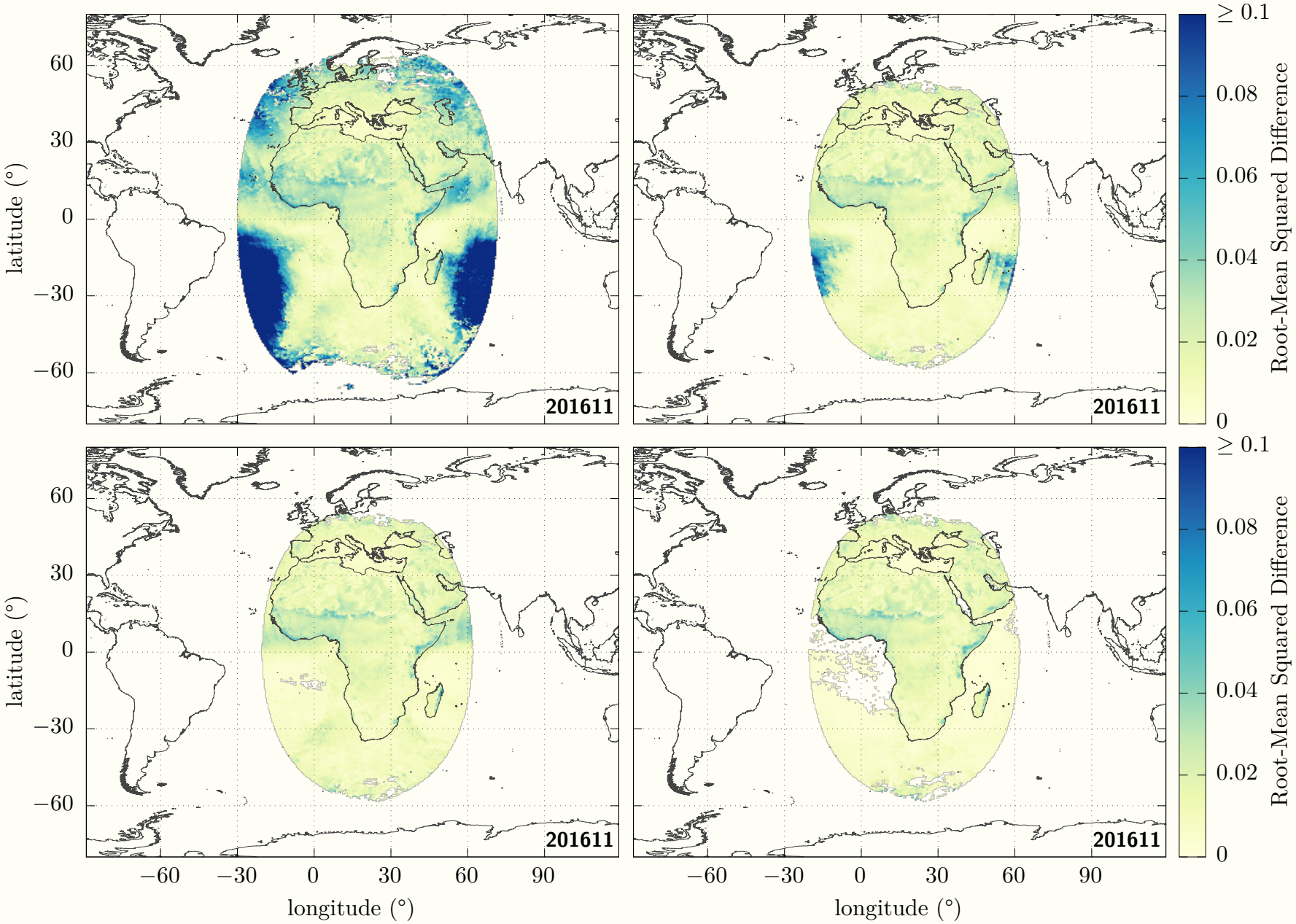

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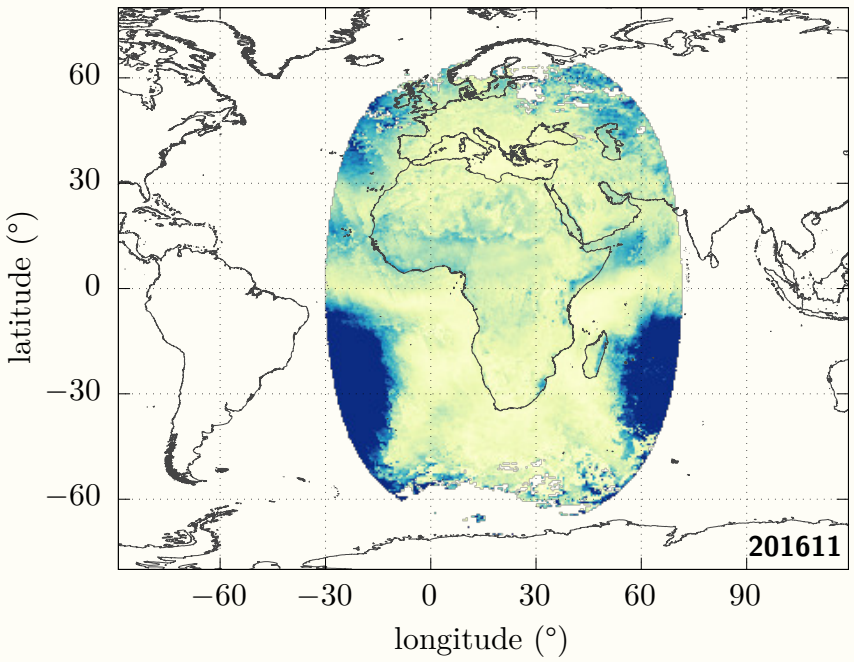
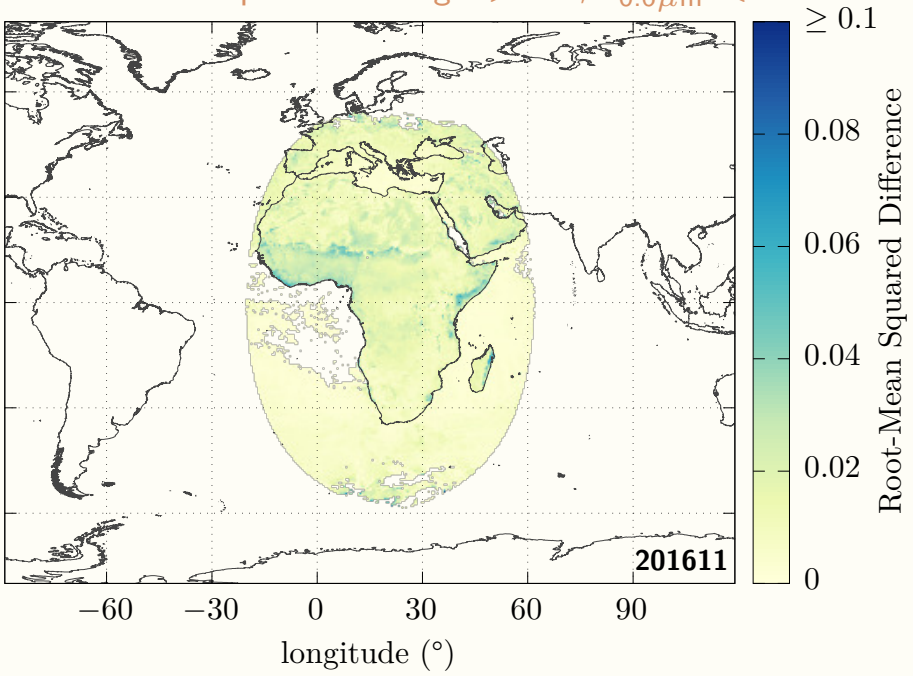


Average statistics over all defined pixels

RMSD $= \sqrt{\sigma^2 + \text{bias}^2}$	0.055
σ	0.052
$\lvert\text{bias}\rvert$	0.012

$\forall$ pixels: clear sky, θ_{sz} & $\theta_{vz} < 70°$

over ocean pixels: tilt angle $> 40°$, $\tau_{0.6\mu m} < 0.1$



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Much improved consistency

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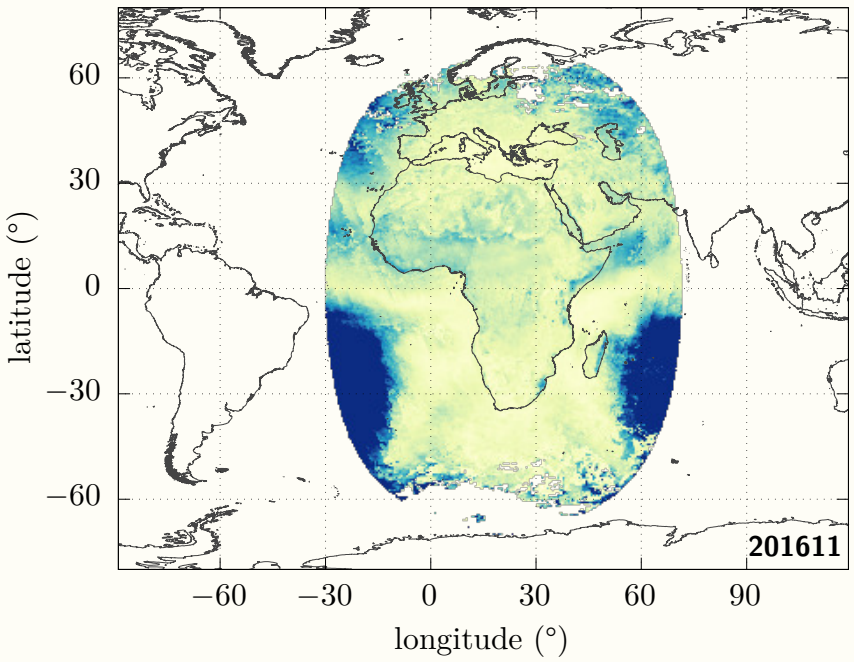

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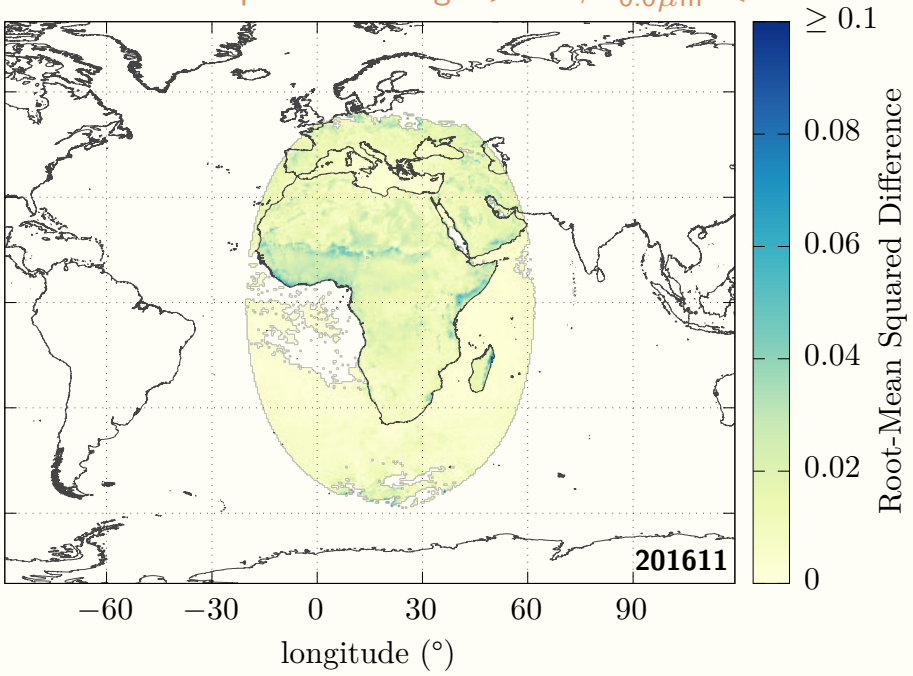

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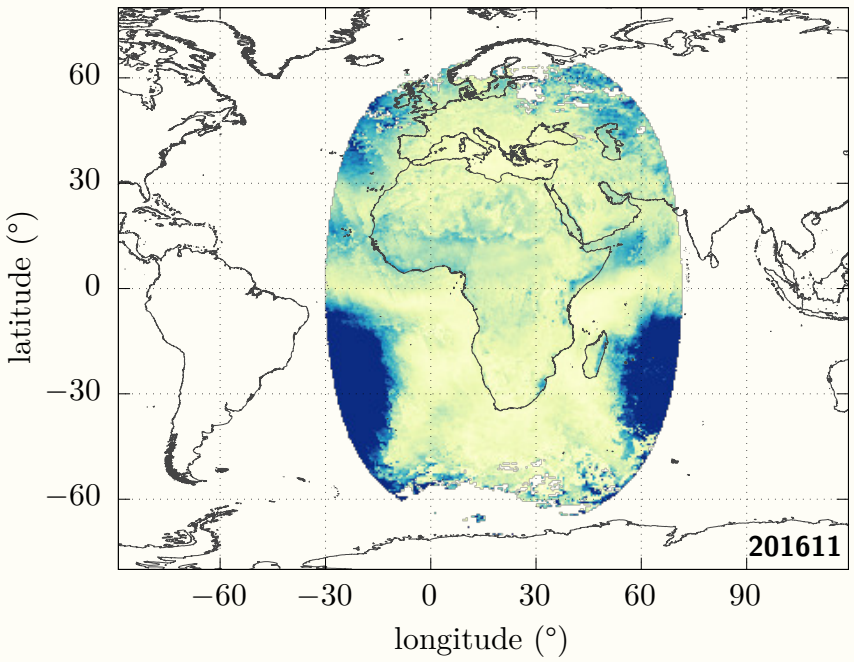

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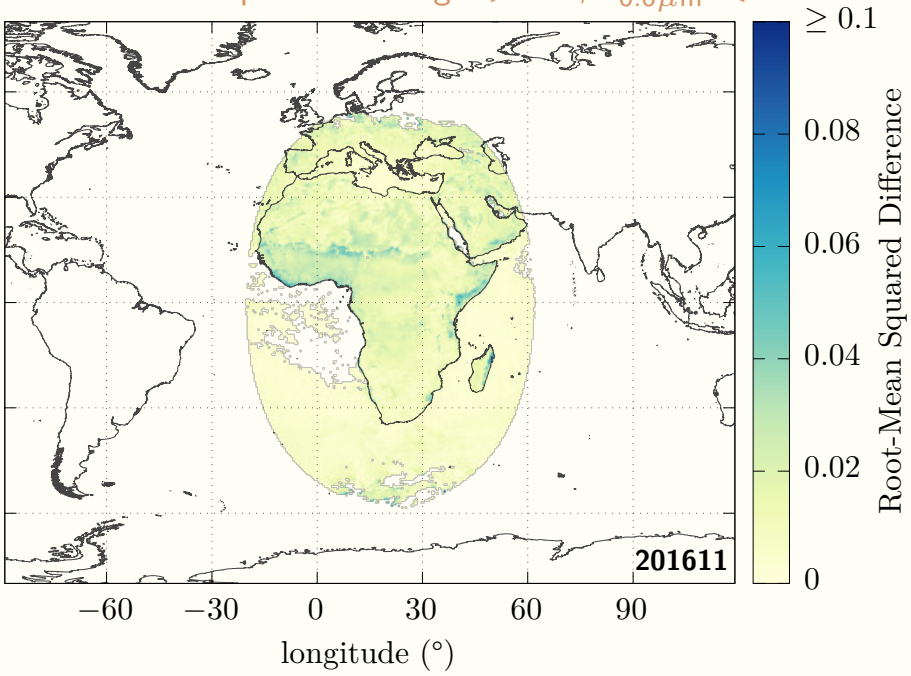

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Clear-sky TOA albedo, function of the solar zenith angle

In the majority of cases, no asymmetry expected between morning & afternoon

i.e. at least if surface properties do not change over time (e.g. dew)

Albedo over land essentially evolves as a function of the solar zenith angle θ_{sz}

$$a(\theta_{\mathrm{sz}}) = a_{60}\frac{1+d}{1+2d\cos\theta_{\mathrm{sz}}},$$ with parameters a_{60} and d [*Briegleb et al.* (1985)]

A well-known issue

Due to fixed viewing geometry from GEO

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systematic diurnal asymmetry in GEO SW

e.g. [*Bertrand et al.* (2006)], [*Loeb et al.* (2018)]

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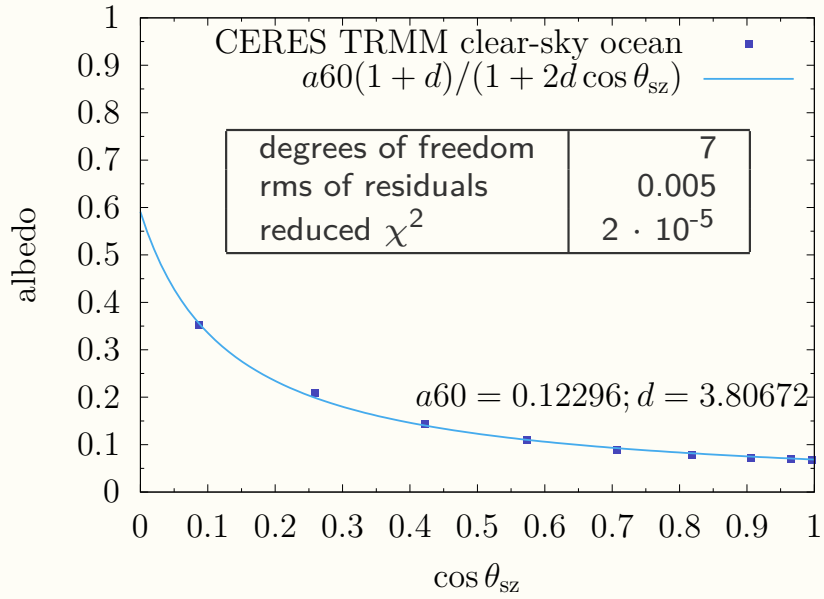
Note, same functional form over ocean pixels:



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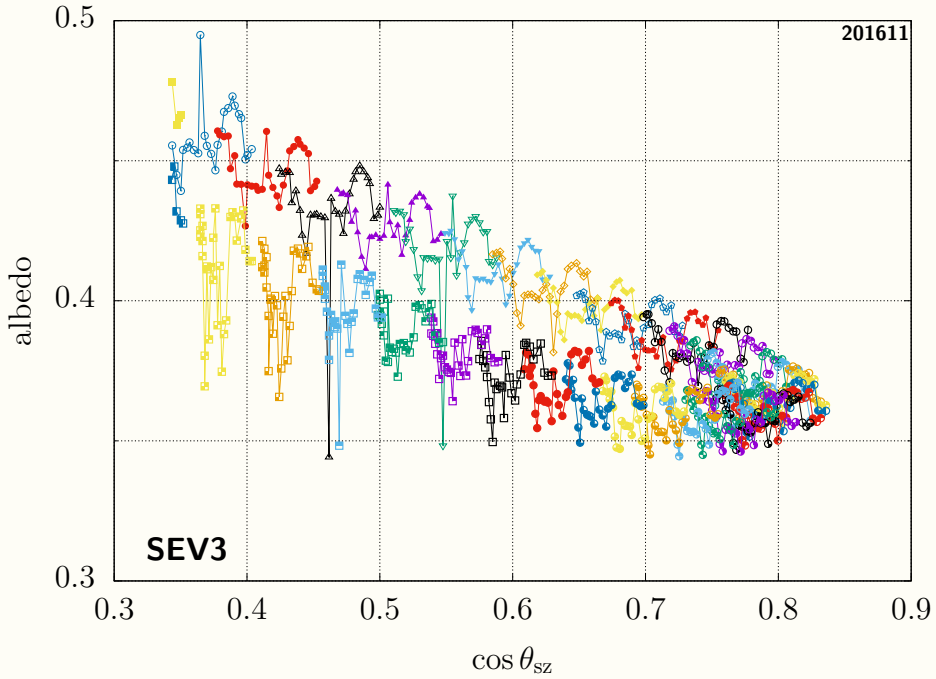
A rarely cloudy sample pixel, seen from SEV3



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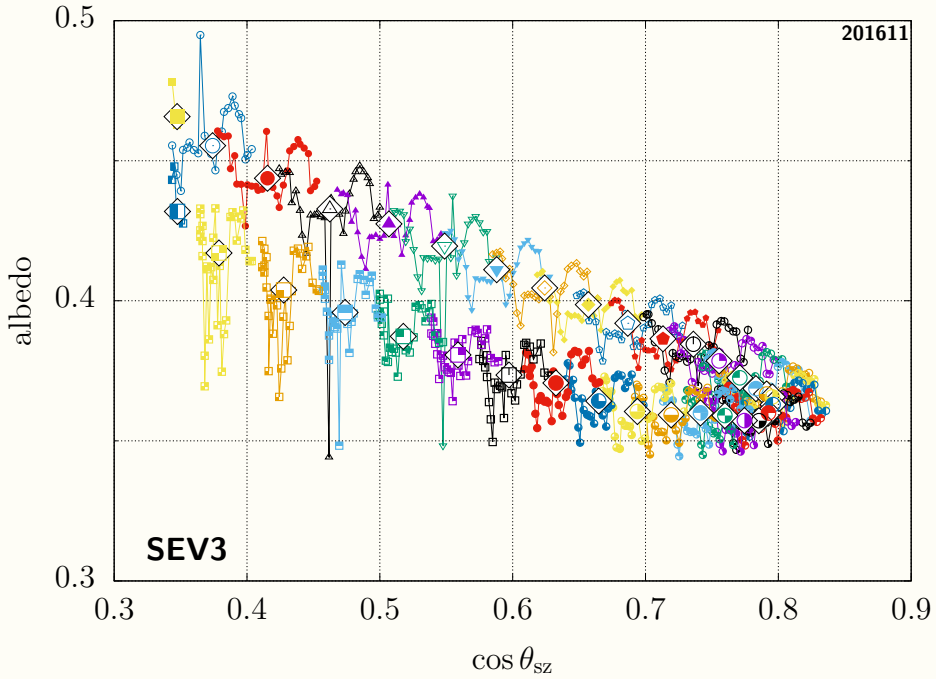

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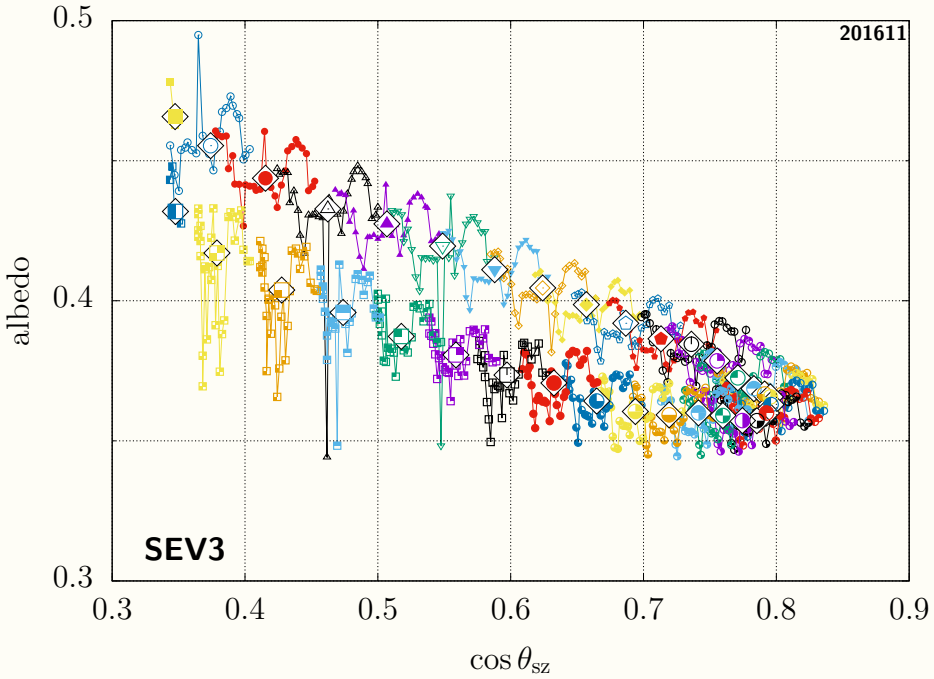

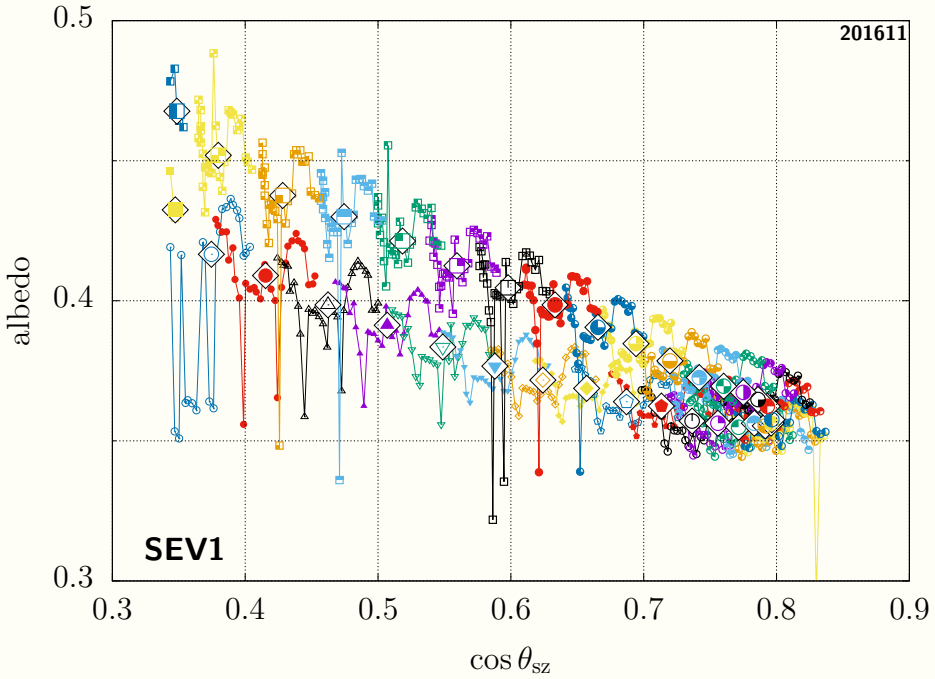

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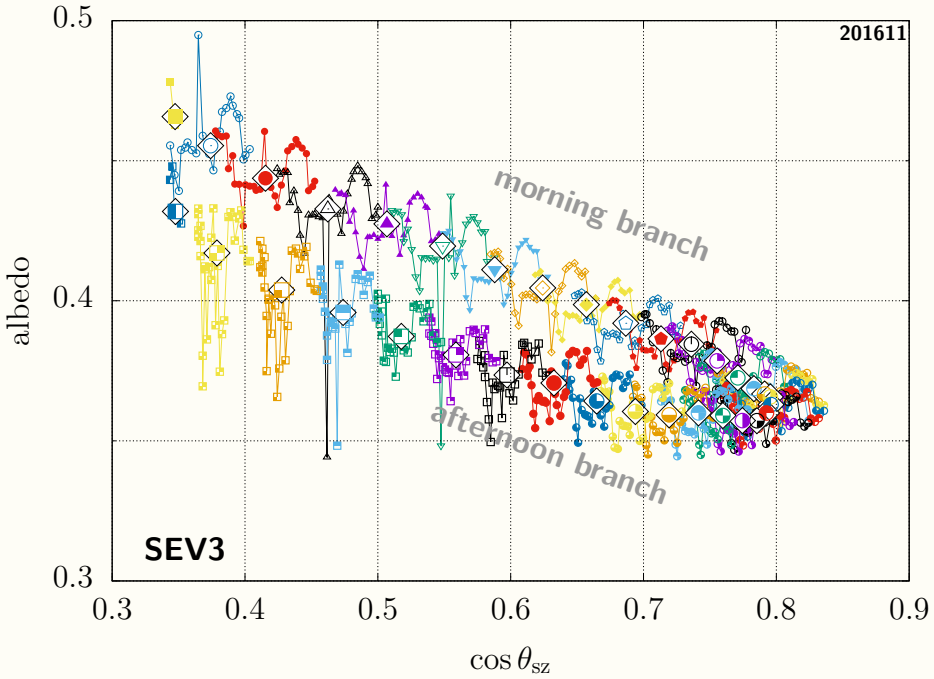

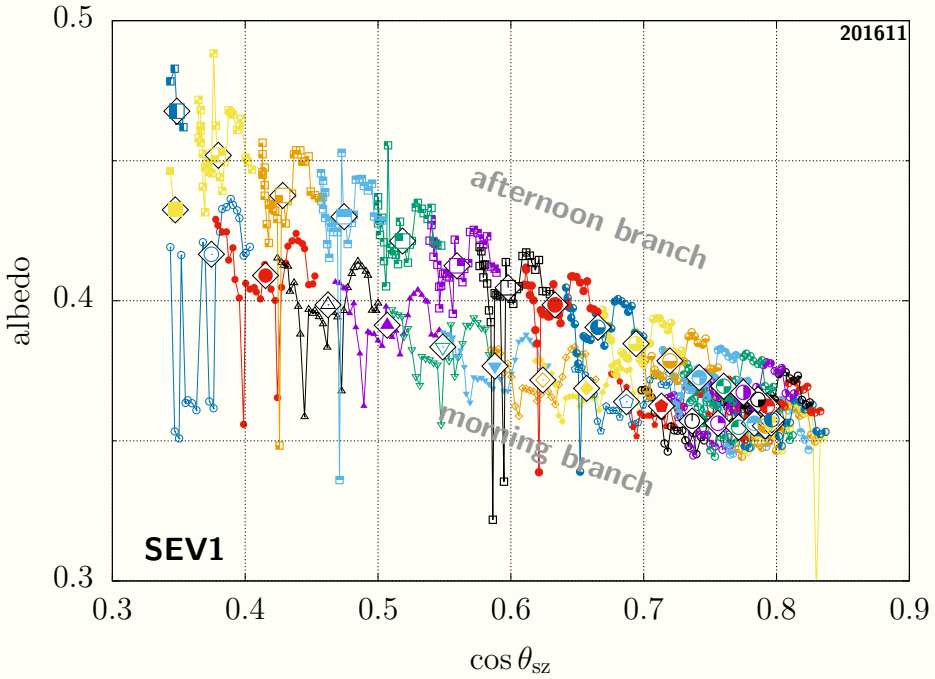

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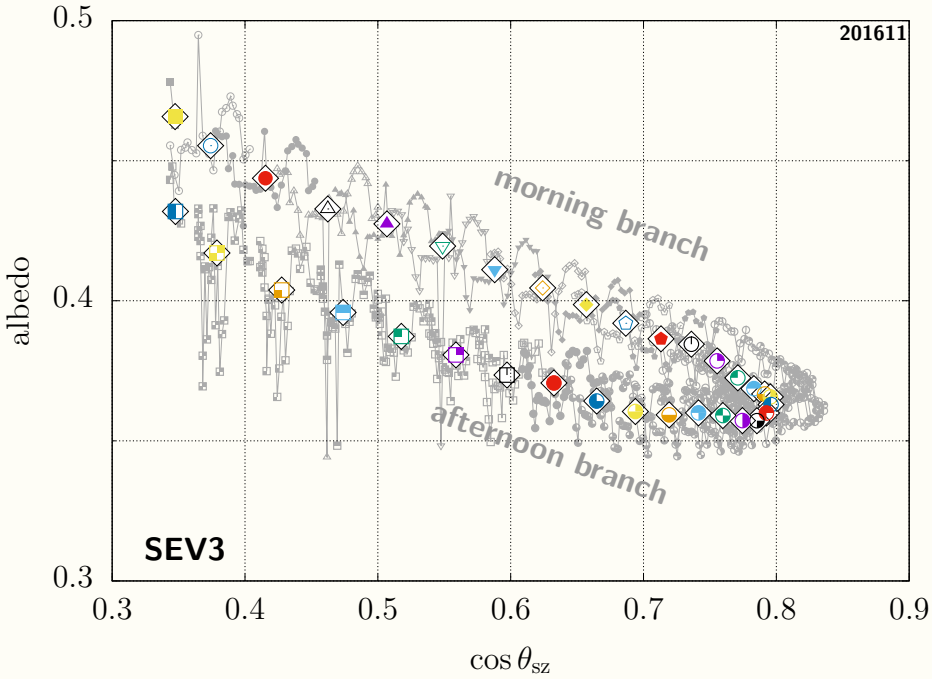

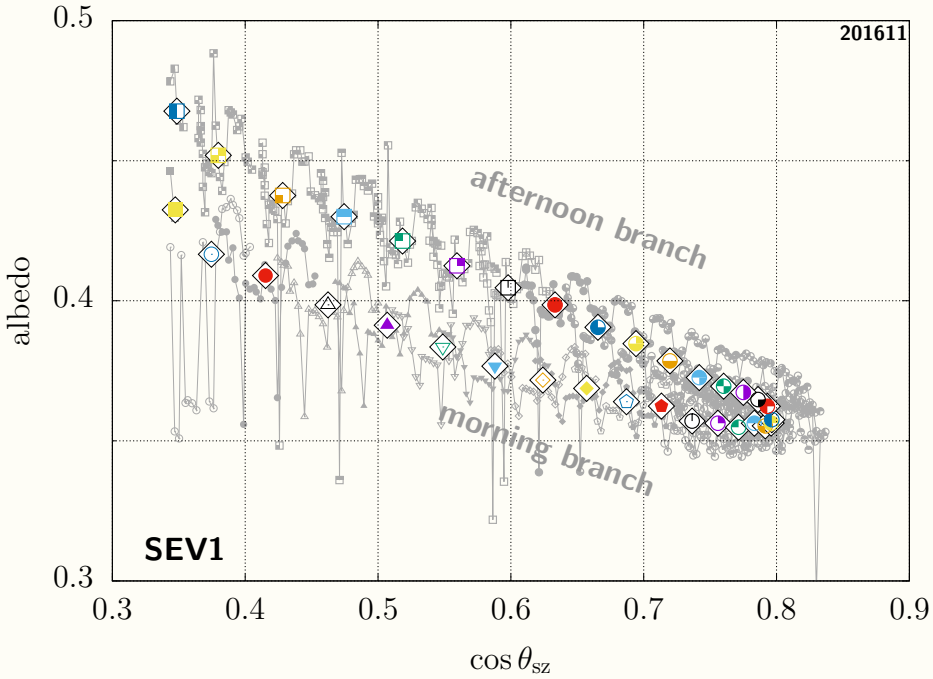

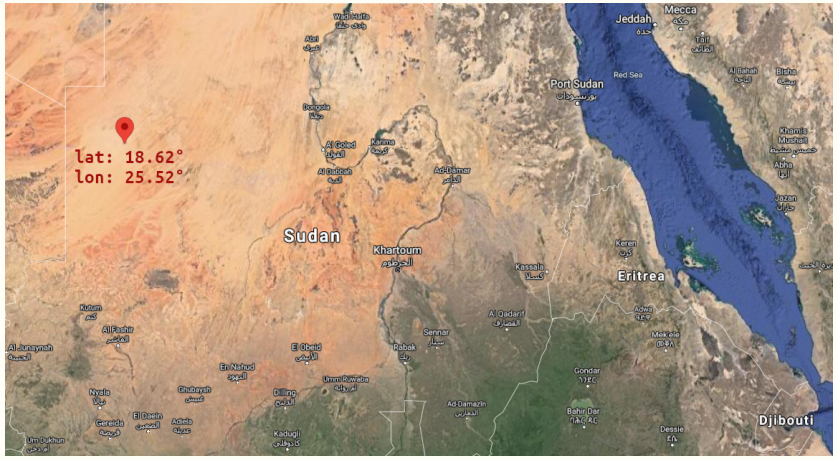

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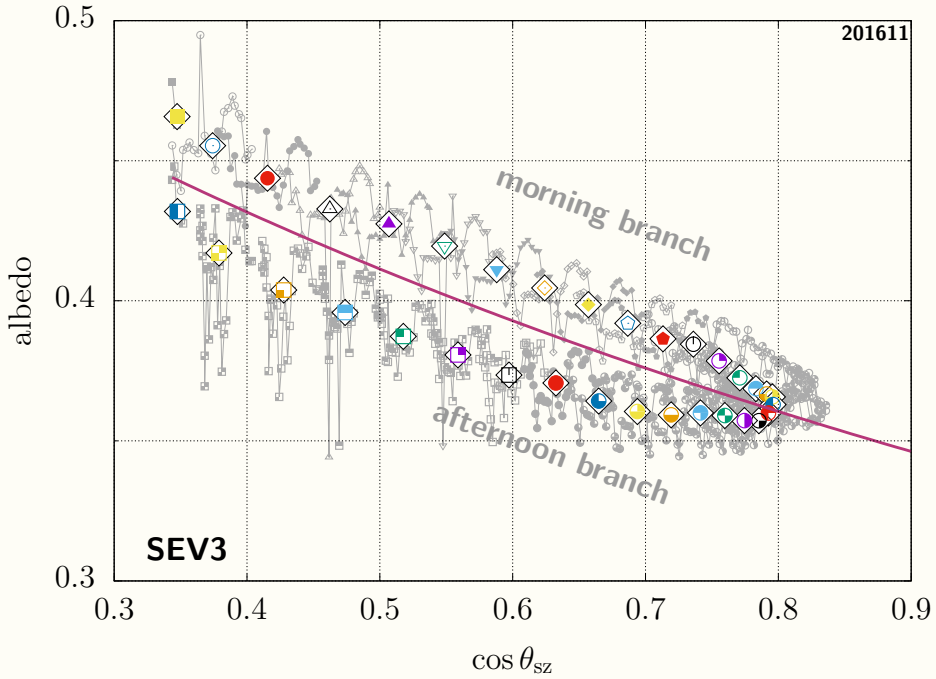
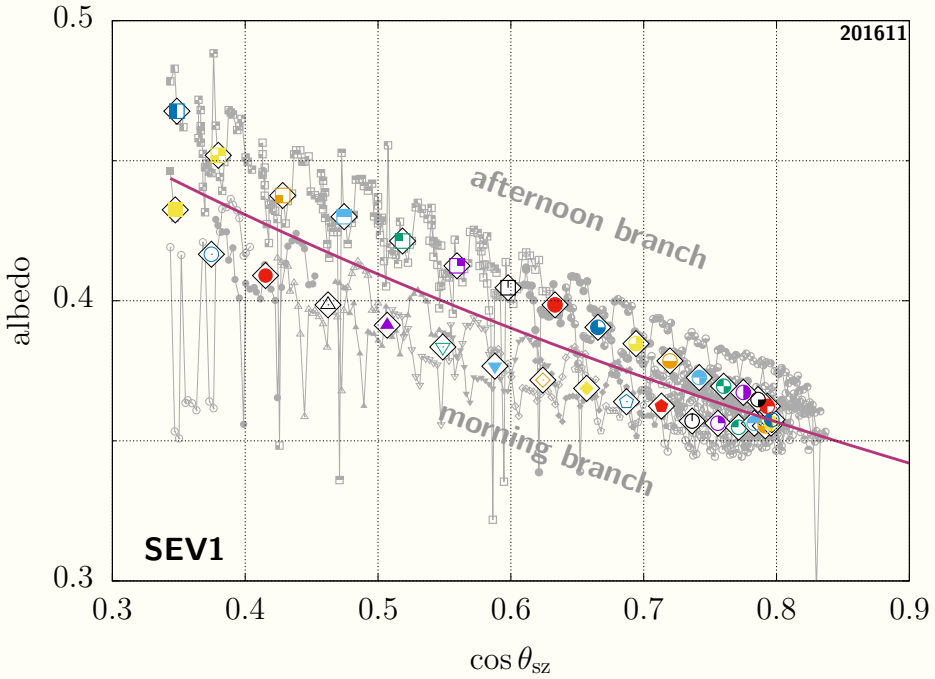
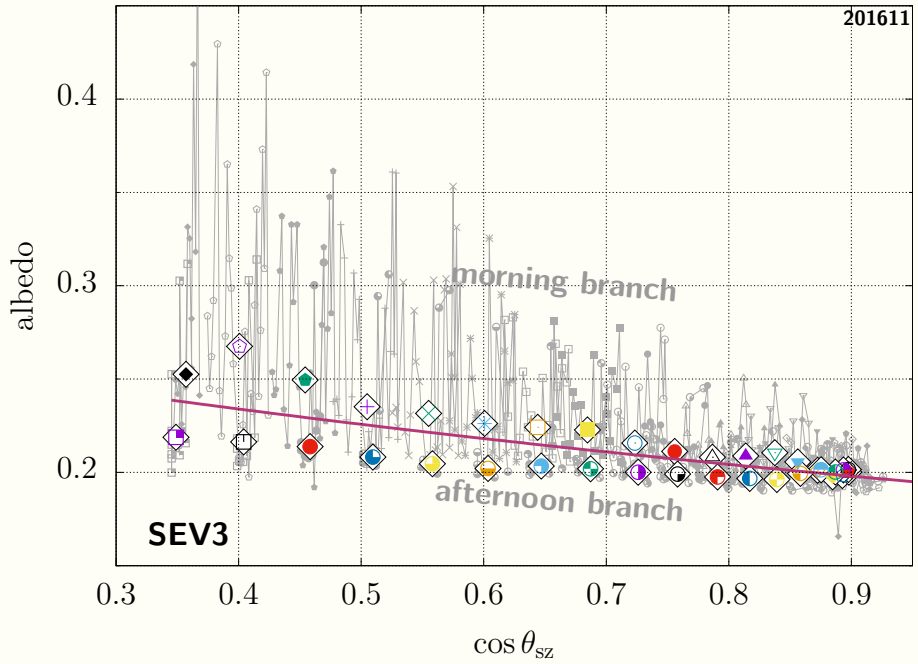
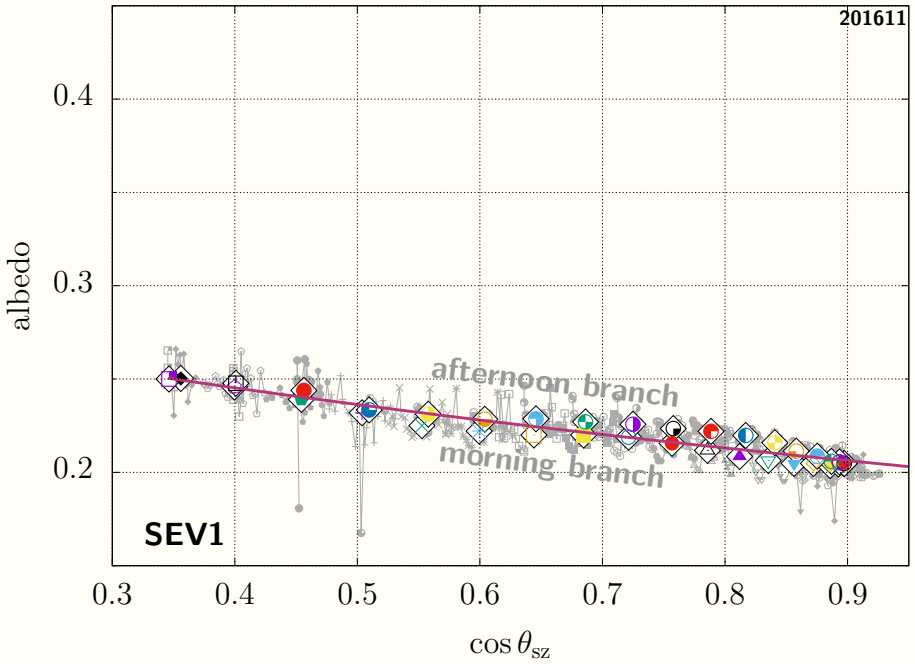




Sample pixel with remaining clouds, from SEV1 and SEV3





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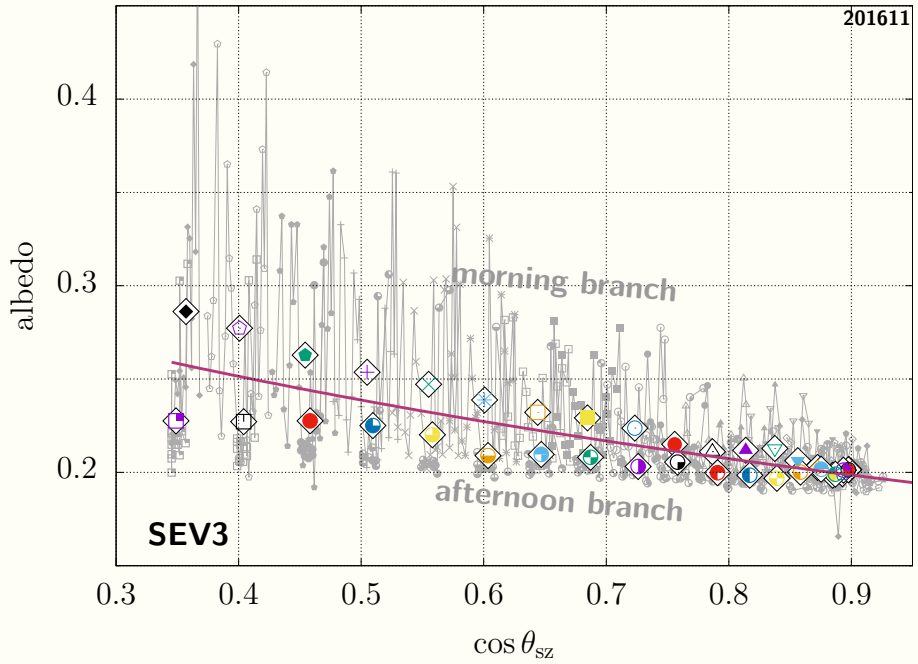

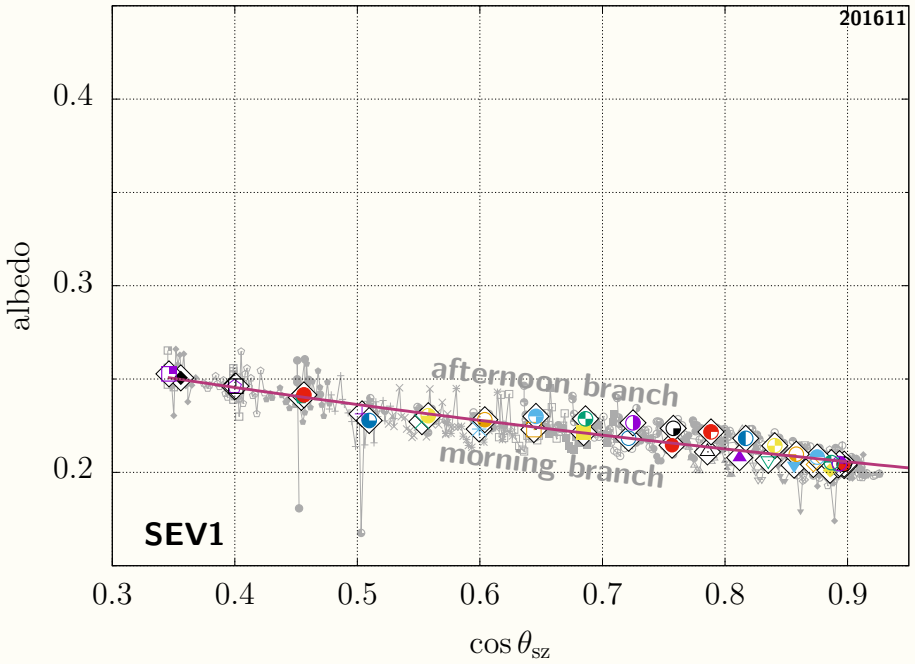

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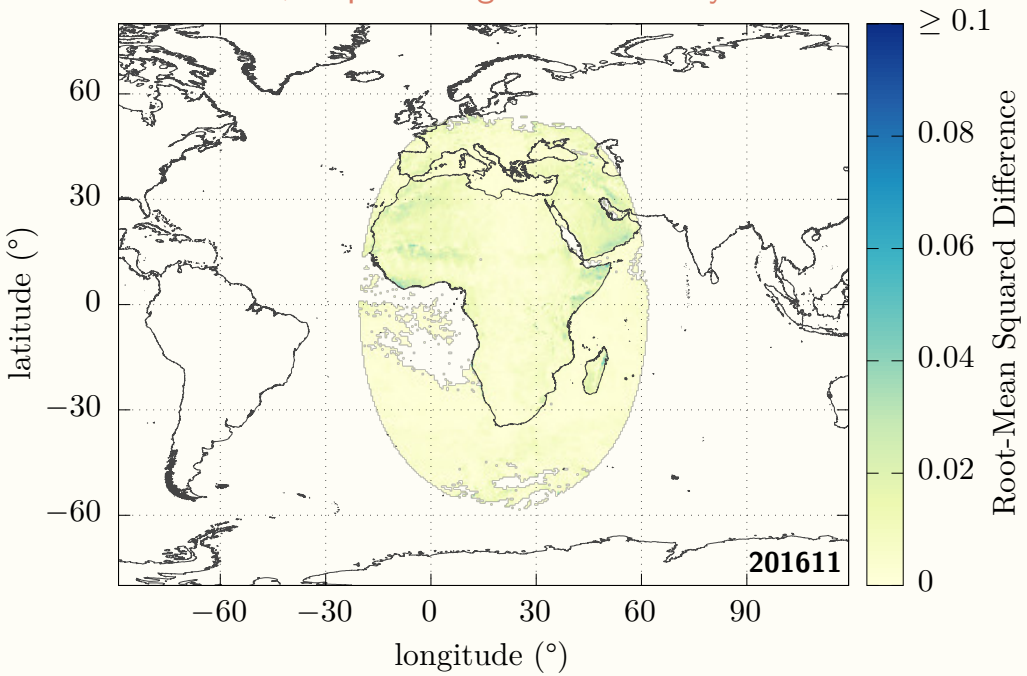
+ imposed angular consistency



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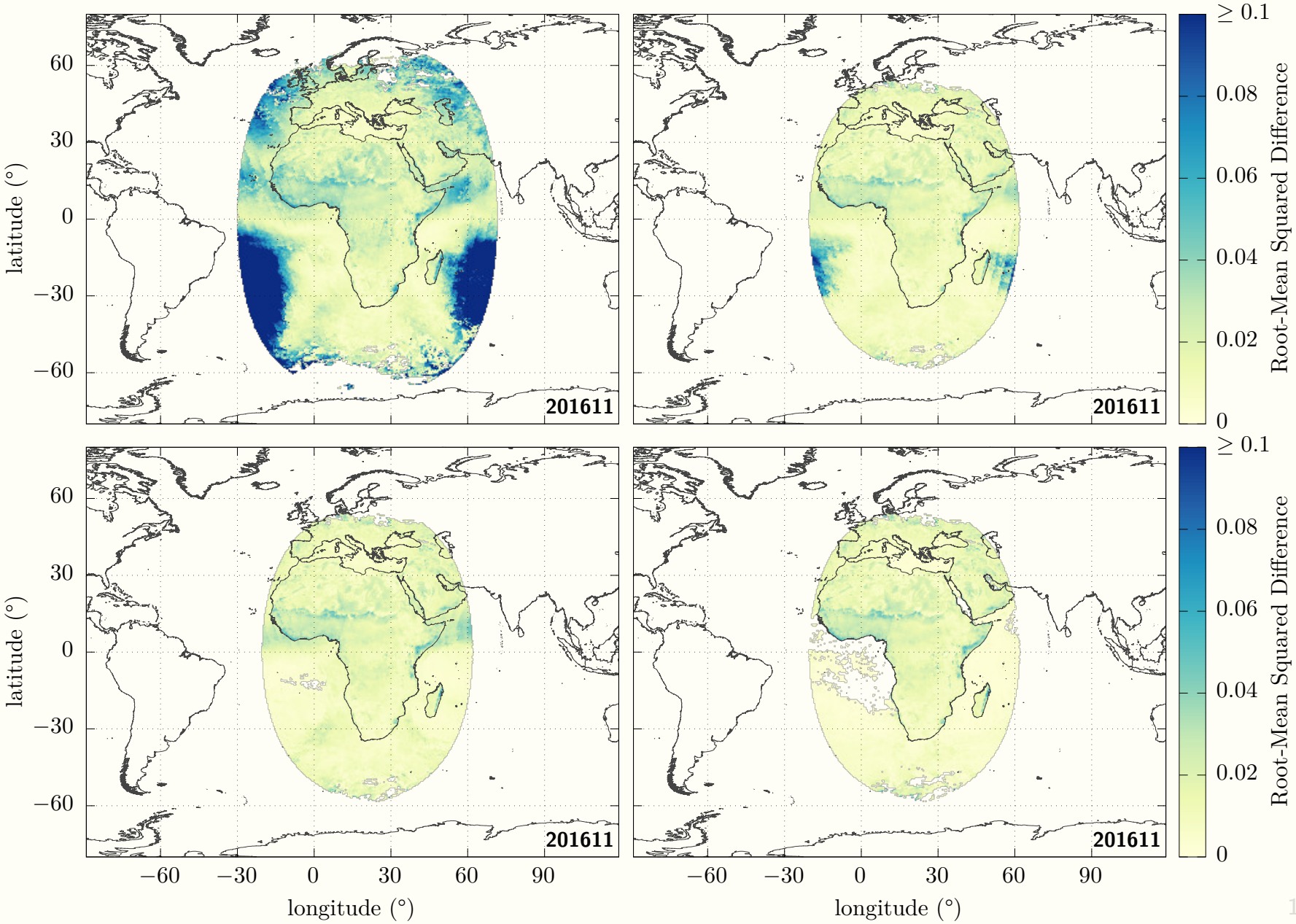

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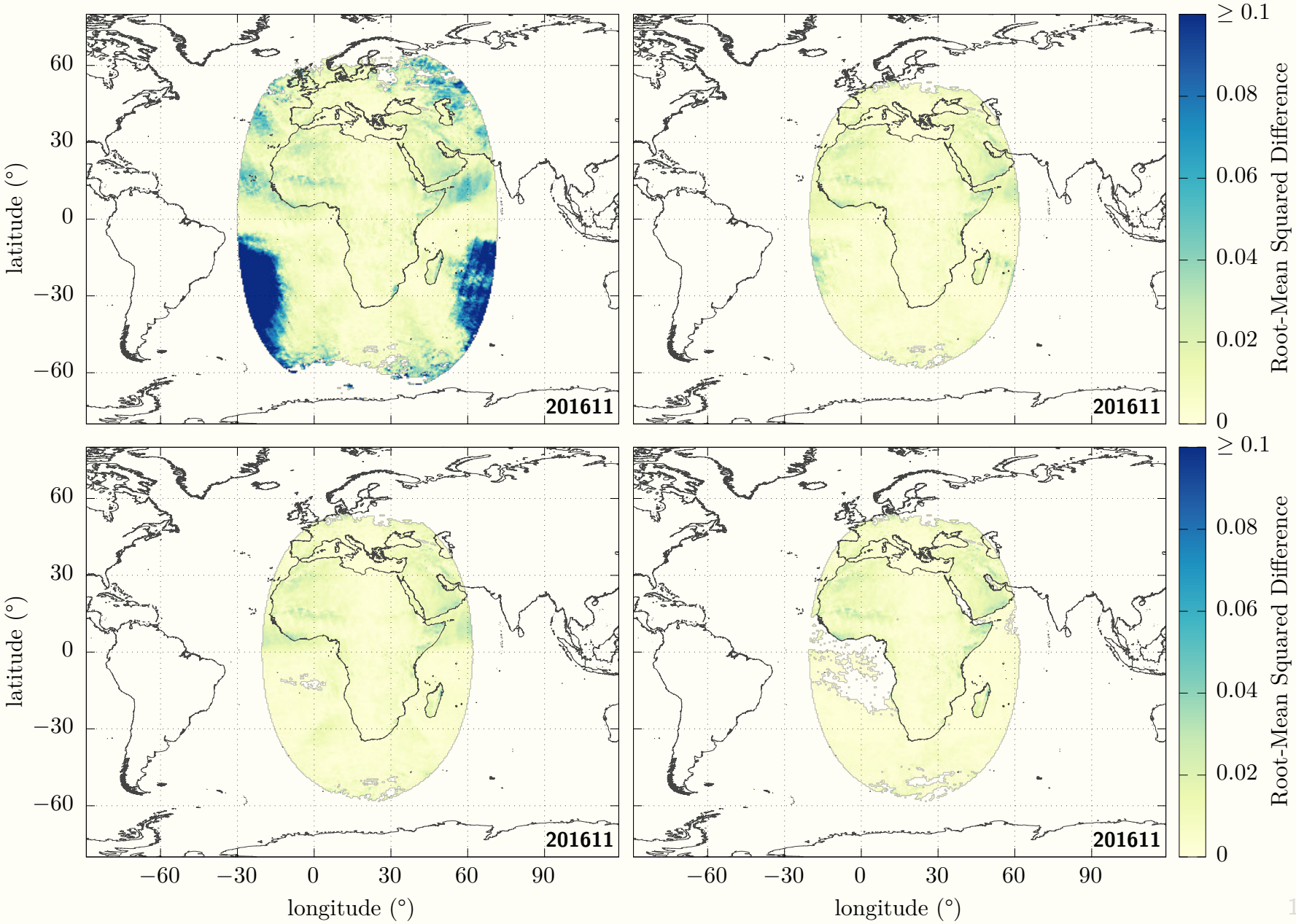
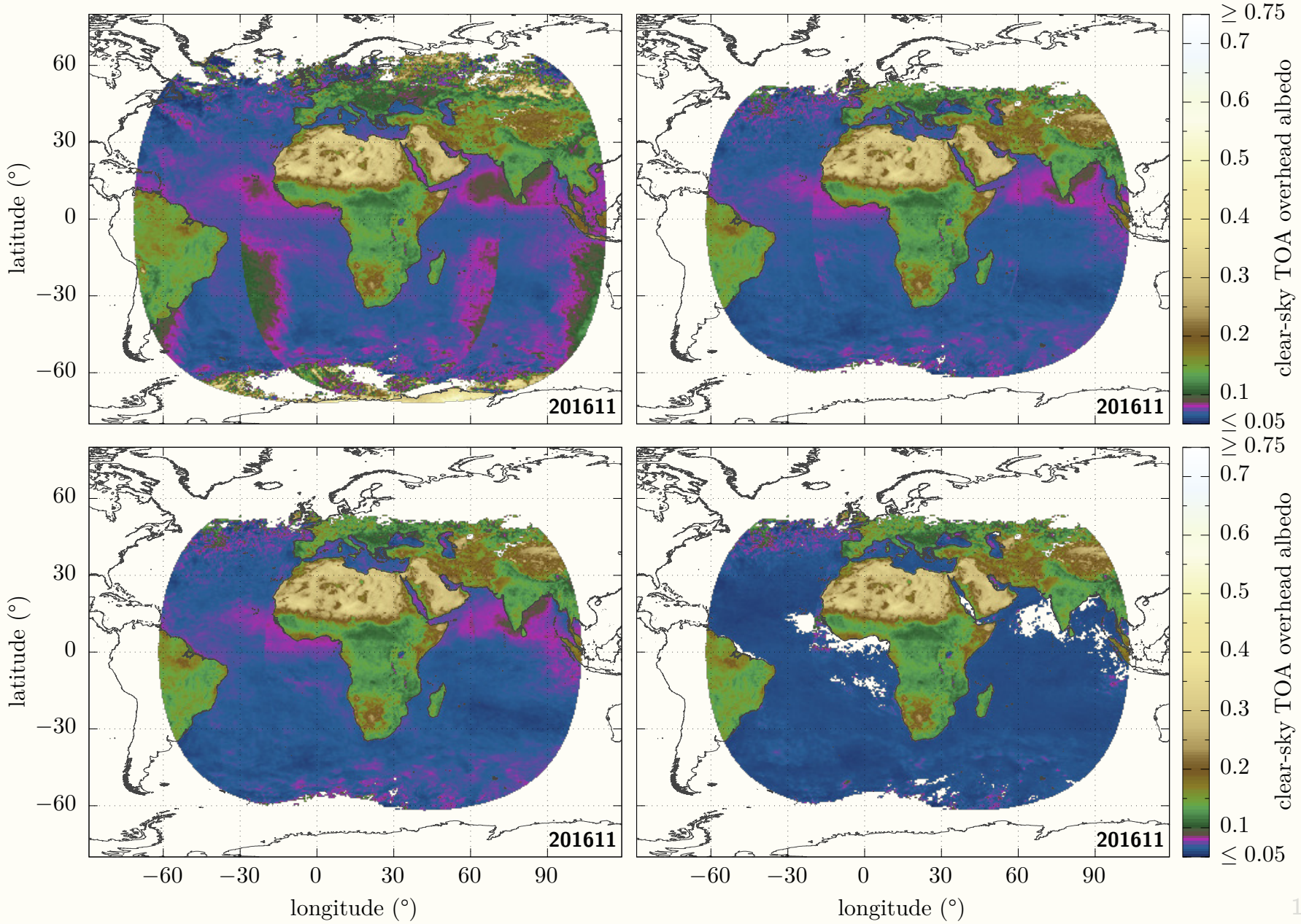


Merged overhead albedo, using GERB-like layers



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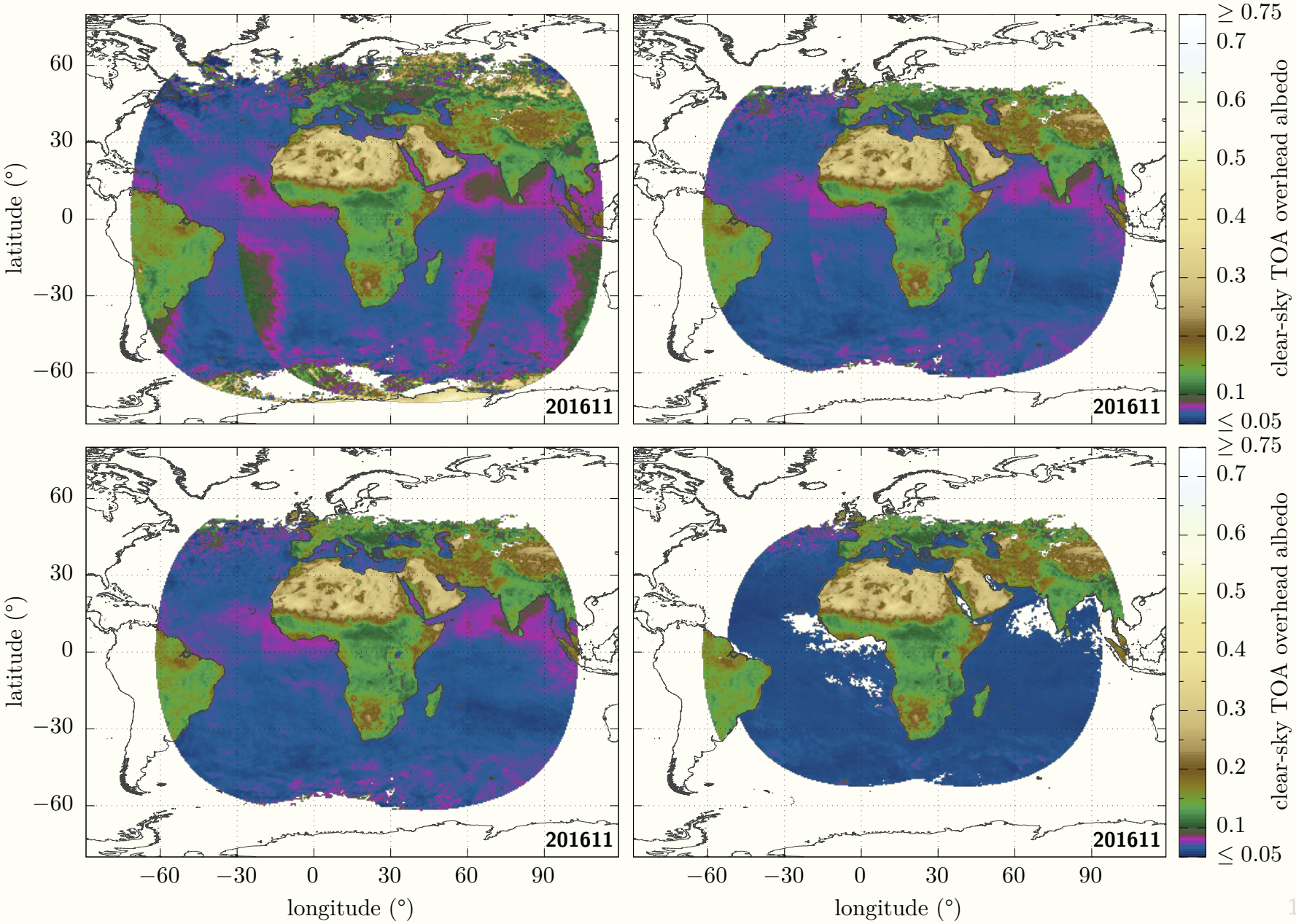

Summary

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The MSG dual view enables comparisons of clear-sky TOA albedo

- Flux retrieved for sunglint regions over ocean pixels: discrepancies > 0.10
- Aerosol over ocean pixels: discrepancies ~ 0.05

  $\rightarrow$ dedicated 'aerosol over ocean' ADMs are direly needed $\leftarrow$

  Having correct fluxes for the case of aerosol over ocean is a high priority
- Issue of unphysical morning/afternoon branches in GEO SW

further issues: unidentified clouds, difficult aerosol retrieval @ unfavourable viewing geometries

Improve consistency

- first with masks only, highlighting sources of problems
- then further imposing angular consistency at the level of one month

  $\Rightarrow$ the average SEV3–SEV1 albedo RMSD then goes from 0.055 to 0.008

Outlooks

- Improved GERB-like product
- Long term: towards an advanced georing product