ADMs anisotropic correction factors and mixed clear scene types: a sensitivity study

Cédric Bertrand (RMIB)

CONCERN

CERES-TRMM BB ADMs scene types:

- major advance over previous ADMs → ADM scene types → angular resolution

- no mixed-scene models

Difficulty: changes in the physical and optical properties of a scene have a strong influence on the anisotropy of the radiation at TOA

Question: ignoring modifications in the anisotropy of surface-leaving radiances leads to systematic error in the retrieved TOA reflected SW flux over footprints containing a mixture of scene types ?

“GERB-LIKE” SW FLUXES

- RGP-SEVIRI processing but applied to MS-7 data
- Calibration:

cross-calibration: MS-7 visible channel/CERES SW channel

- NB-to-BB Conversion

$$L_{SW} = D_0(\theta_s) + D_1(\theta_s) L_{VIS} + D_2(\theta_s) L_{VIS}^2 + D_3(\theta_s) L_{VIS}^3$$

- Radiance-to-flux conversion

$$F(\theta_s) = \frac{\pi L(\theta_s, \theta_v, \phi)}{R(\theta_s, \theta_v, \phi)}$$

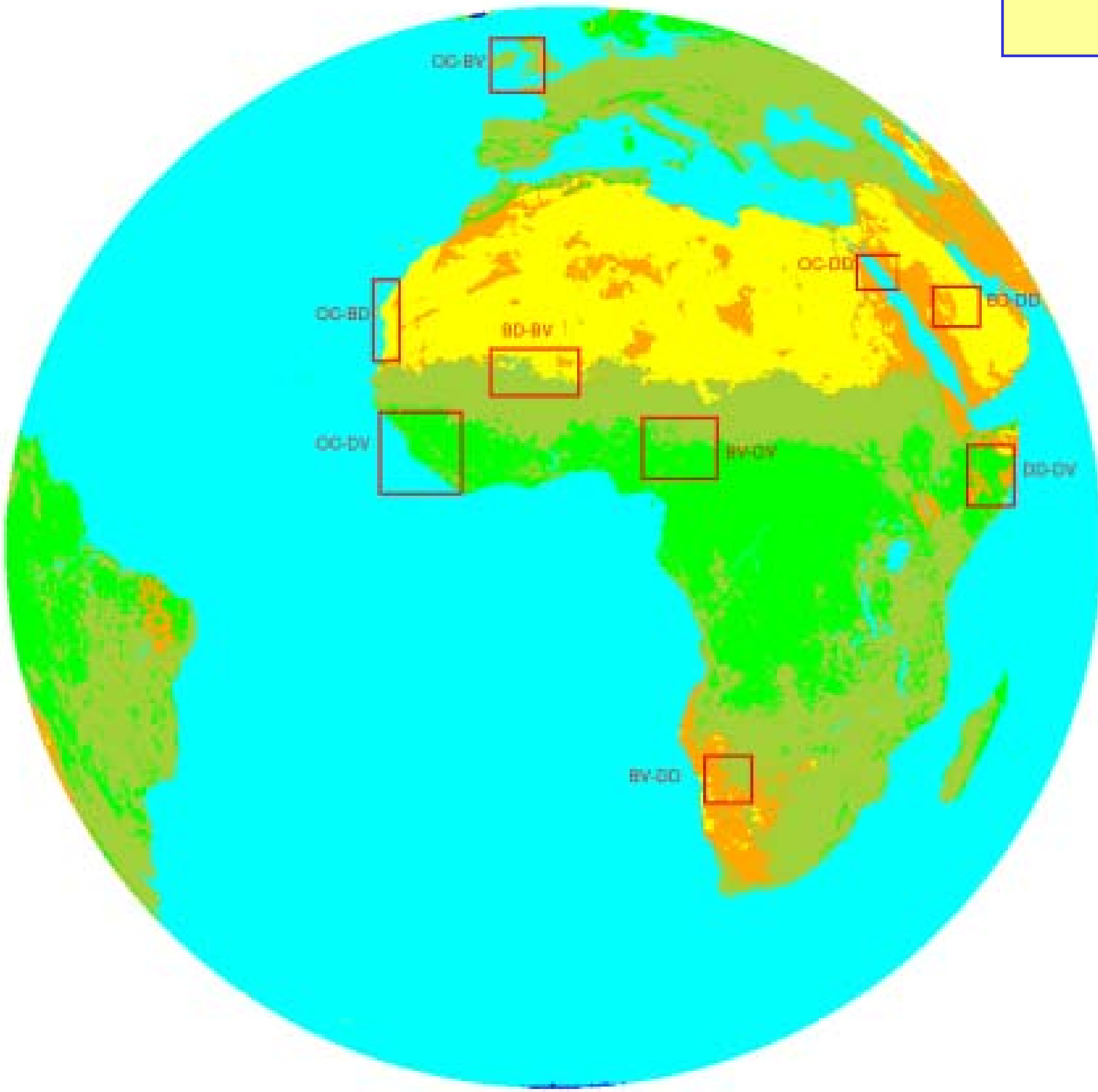
➡ CERES TRMM BB SW ADMs

➡ Scene id.: MS-7 pixels registration according to the CERES-TRMM classes (invariant in time)

➡ **SW fluxes at TOA at the same temporal rate than MS-7 with a spatial resolution 3 times coarser**

CERES-TRMM ADMs surface geotypes as seen by MS-7 imager

9 zones selected: junction area between 2 CERES-TRMM scene types



Size and location:

- **progressive transition from a 100% cov. of type 1 to a 100% cov. of type 2**
- **relative homogeneity in the 2 scene types**
- **limited variation in the footprints acquisition geometry**

Temporal sampling:

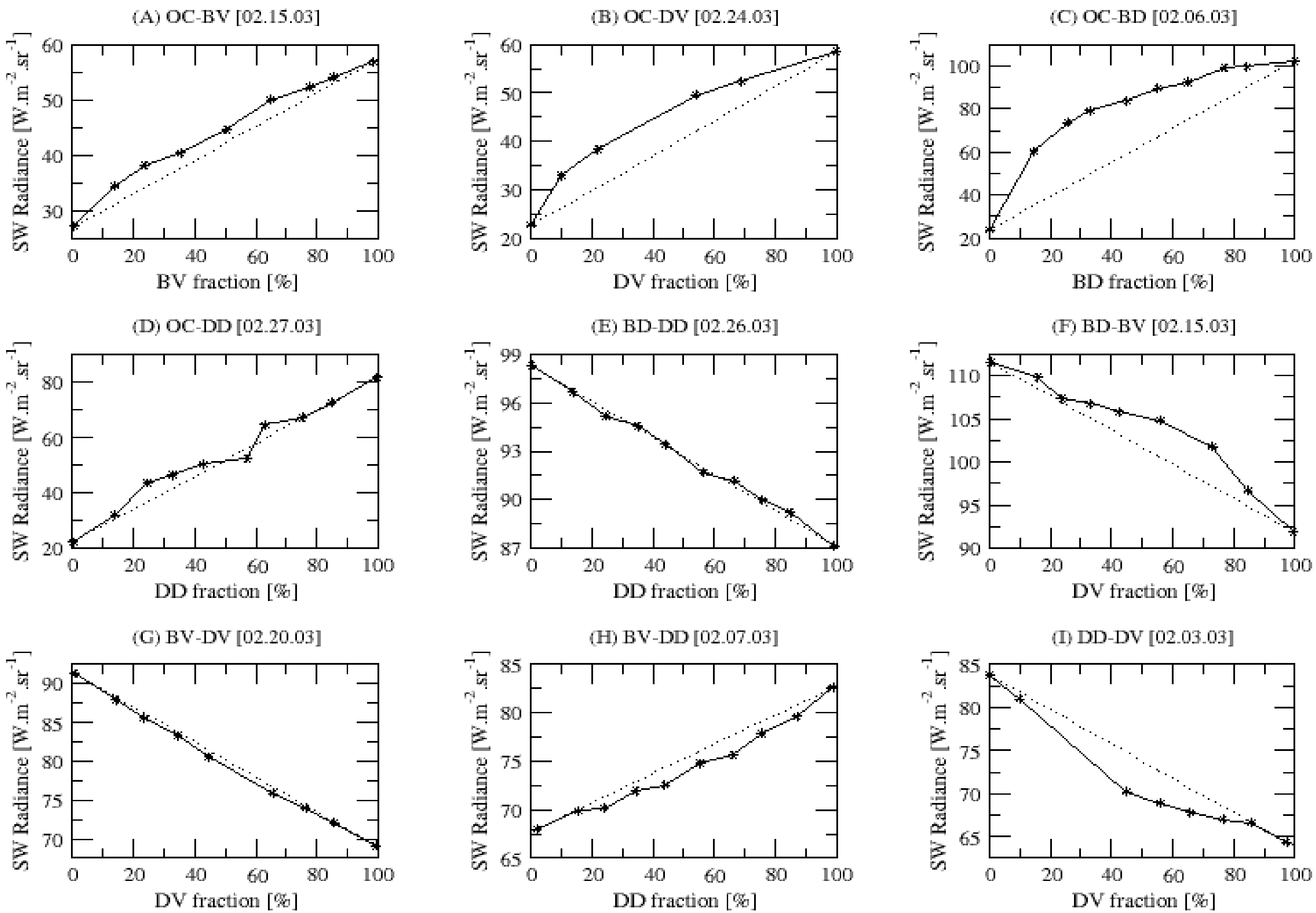
- **12:00 UTC MS-7 time slot**
- **day with the largest clear sky footprints (February 2003)**

CERES-TRMM ADMs surface geotypes

- Ocean = OC (all wind speeds, no aerosols)
- Mod-to-high Tree/Shrub coverage = DV
- Low-to-mod Tree/Shrub coverage = BV
- Dark desert = DD
- Bright desert = BD
- Snow or ice

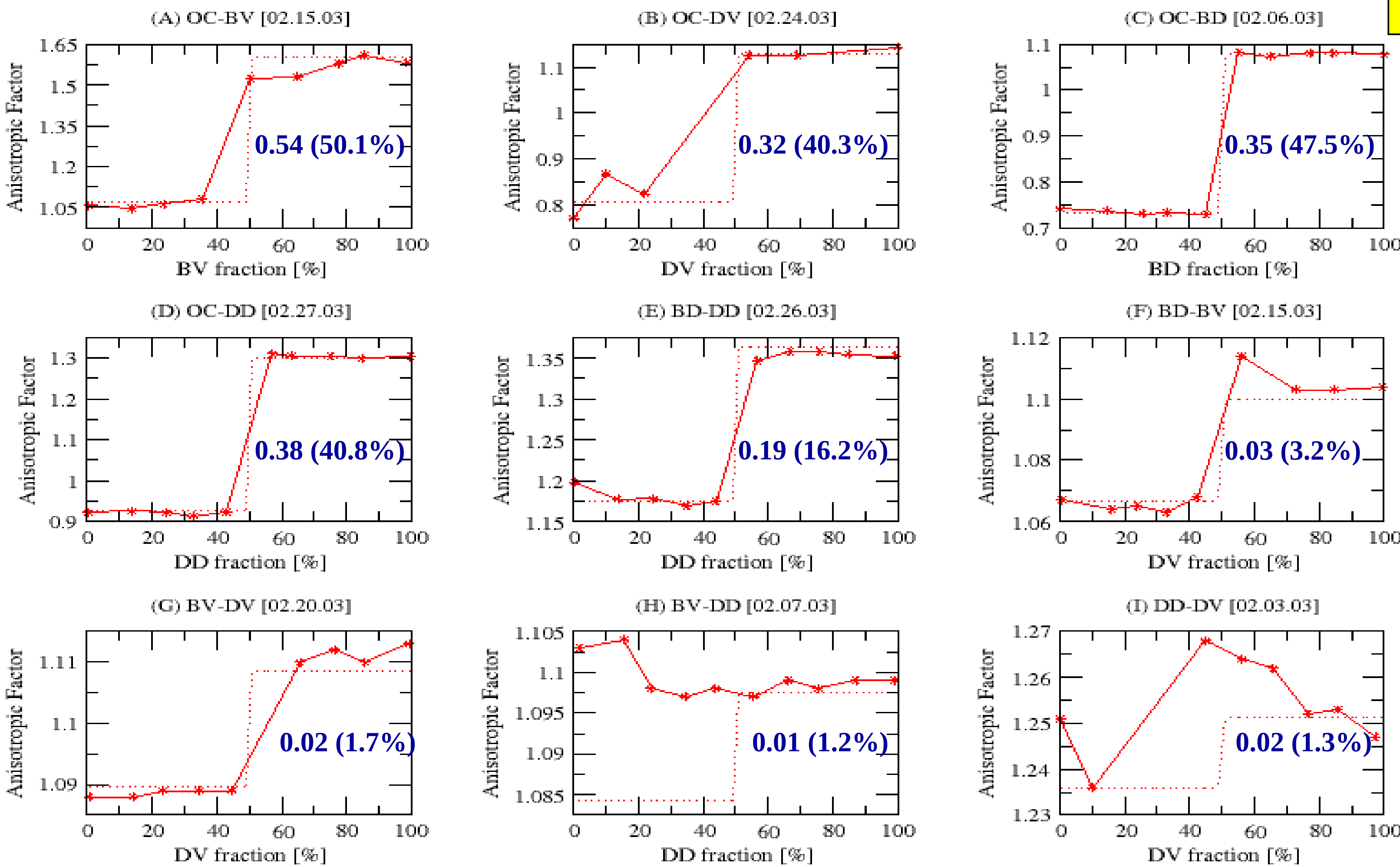
Bin-Averaged and Idealized SW radiances

- Clear sky footprints gathered by discrete bins of 10% in surface types coverage
- Idealized = simple linear interpolation



CERES-TRMM clear SW BB ADMs anisotropic correction factors

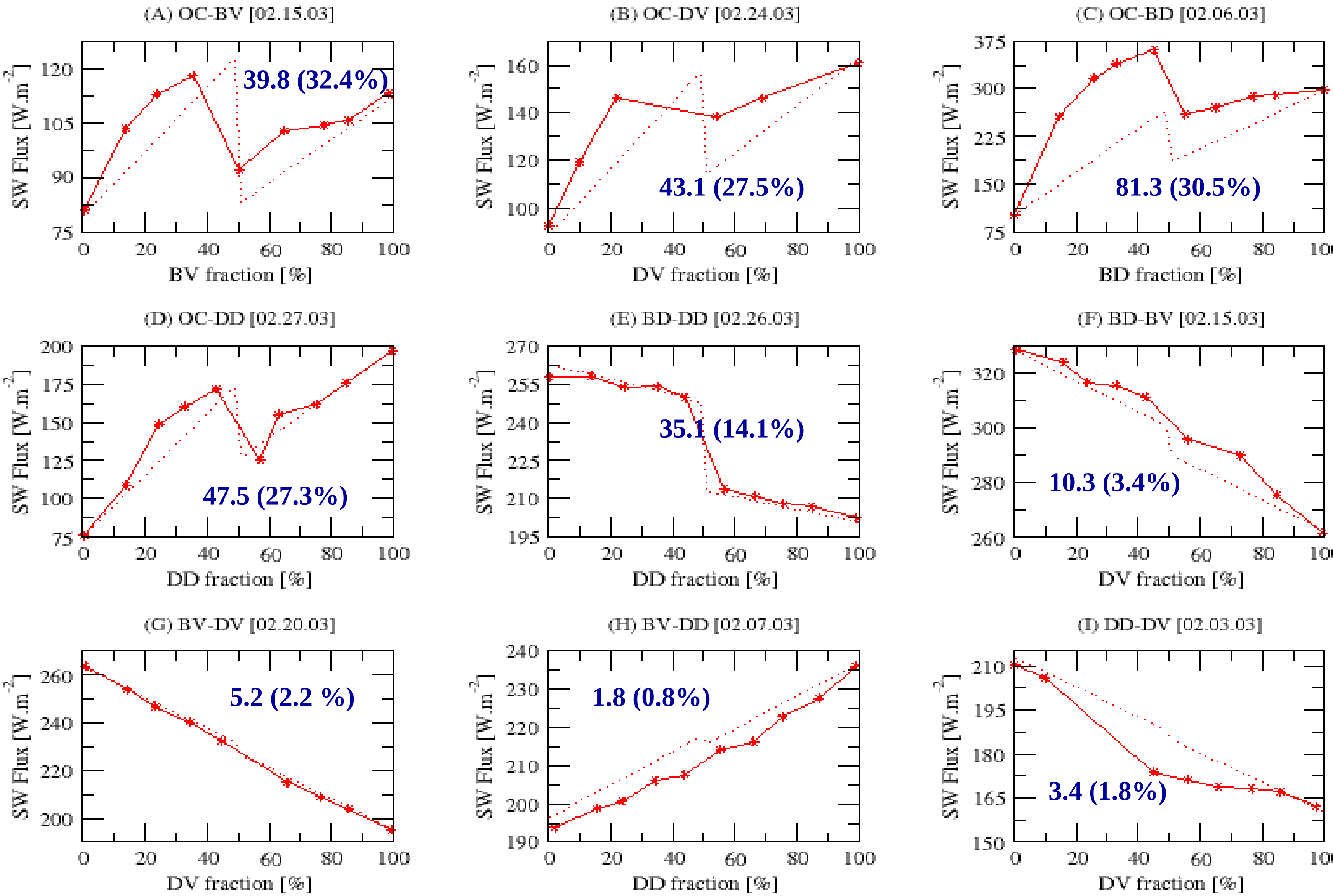
ΔR (r.e %)



- Largest surface anisotropy variations occur along the coastline of continents
- (H) and (I): variations in R due to angular change in the footprints acquisitions angles are larger than the anisotropy difference between the 2 scene types in presence

Retrieved instantaneous SW fluxes at TOA

ΔF (r.e %)



Flux discontinuity at the shifting point between the 2 ADMs scene types

Mixed scene types correction factors formulation

Considering a mixture of 2 components, the BB SW radiance, L^{MIX}, can be write as being:

$$L^{MIX} = f_1 L_1 + f_2 L_2$$

which converterd in term of flux gives:

$$F^{MIX} = f_1 F_1 + f_2 F_2$$

The anisotropic factor for the mixed scene, R^{MIX}, can then be write as follow:

$$R^{MIX} = \pi \frac{f_1 L_1 + f_2 L_2}{f_1 F_1 + f_2 F_2} = \frac{f_1 R_1 + f_2 R_2 \cdot (F_2 / F_1)}{f_1 + f_2 \cdot (F_2 / F_1)}$$

Problem: $F_2 / F_1 = UNKNOWN$

Approximating the unknown ratio by the ratio of :

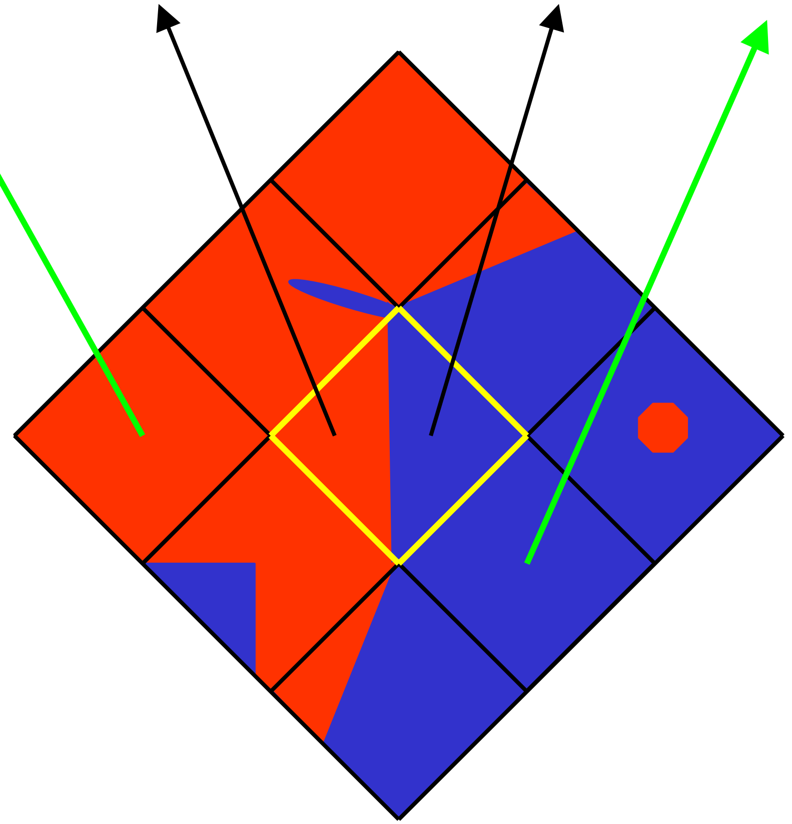
- the corresponding **CERES-TRMM BB SW ADMs climatological SW fluxes** (or equivalently to the ADMs TOA albedos)

$$R^{MIX} = \frac{f_1 R_1 A_1 + f_2 R_2 A_2}{f_1 A_1 + f_2 A_2}$$

- the **neighboring fluxes**

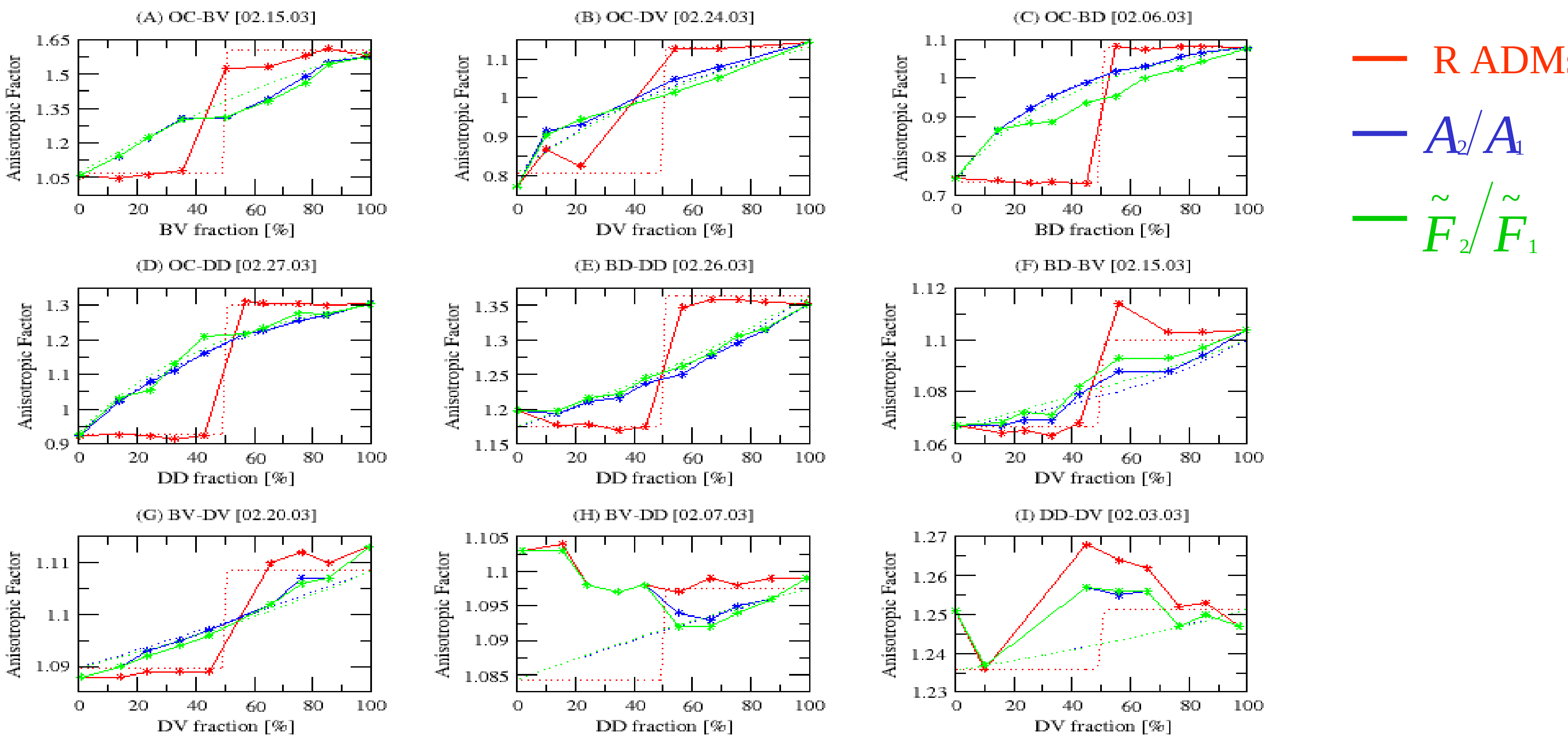
Neighboring flux ratio approach

$$\tilde{F}_2 \approx F_2 \qquad F_1 \approx \tilde{F}_1$$



- We assume that F_1 and F_2 are similar to the SW fluxes $\tilde{F}_1$ and $\tilde{F}_2$ retrieved over the geographically closest footprint of pure CERES-TRMM scene of type 1 and 2, respectively.

Mixed scene types anisotropic factors

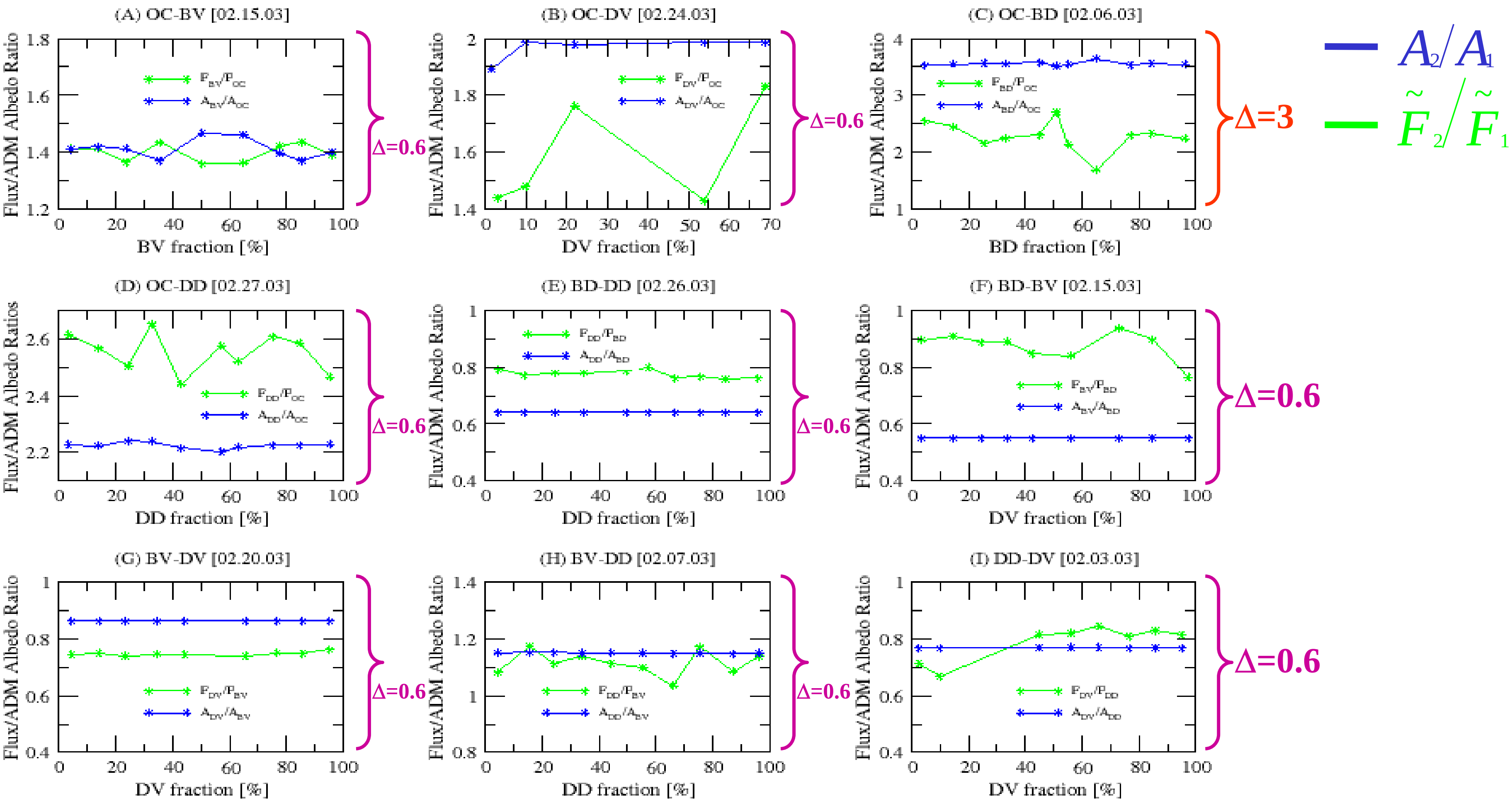


➡ Smoother transition between 2 ADMs scene types

Idealized: F_2/F_1 ratios are known and while A_2/A_1 can differ of about 2% (OC-BV) to about 31% (BD-BV) from the corresponding F_2/F_1, ΔR^{MIX}_{MAX} is less than 1.9 % (OC-BD)

Bin-averaged: ΔR^{MIX}_{MAX}= larger → possible intra/inter-bin(s) heterogeneity in the vege cover

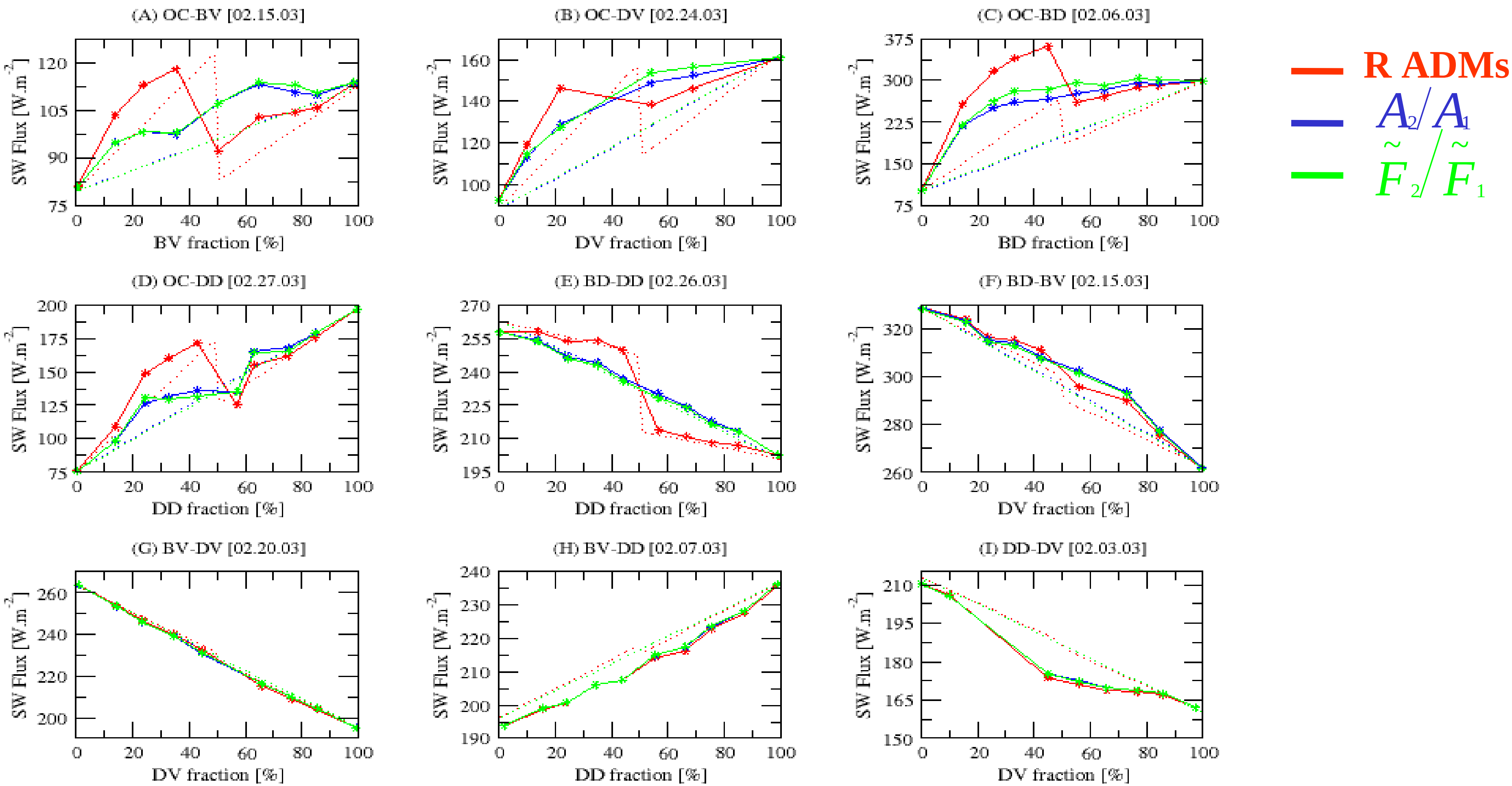
Bin-averaged $\tilde{F}_2/\tilde{F}_1$ vs. A_2/A_1 ratios



- $\tilde{F}_2/\tilde{F}_1$ Not necessarily constant throughout all our discrete coverage bins
- A_2/A_1 Invariant (in the absence of coverage bins dependent angular variations in the footprints acquisition geometry)

  → Gap between the 2 ratio time series -> climatological vs. time dependant values

Retrieved Instantaneous SW Fluxes at TOA



Idealized: magnitude of ΔF between the 2 approaches are negligible (ΔF 0.006 to 1.9 %)

Bin-averaged: ΔF is a function of both: - difference between $\tilde{F}_2/\tilde{F}_1$ and A_2/A_1

- difference between R_1 and R_2

Conclusions (I)

- **Do not account for modifications in factors affecting the anisotropy of surface-leaving radiances in case of footprints containing a mixture of scene types cause TOA flux errors:**

→ **Flux discontinuity when shifting from one CERES-TRMM scene types to another.**

→ **Magnitude of the flux difference depends on the surface anisotropy difference between the 2 scene types in presence**

→ **Largest fluxes discontinuities occur in coastal zone**

OC-BV: 32% vs. BV-DD: 0.8%

Conclusions (II)

- **In the absence of available ADMs for mixed-scene types: possible to combine the existing CERES-TRMM BB SW ADMs to derive reliable mixed CERES-TRMM scene types anisotropic factors:**

ADMs flux approximation approach

The score of the method has a temporal component and depends on :

- the magnitude of the differences existing between the physical and optical properties of each surface within the footprint and the associated CERES_TRMM scene types
- the magnitude of the anisotropy difference between the scene types in presence.

Idealized cases: maximum fluxes differences range from 0.01 to 1.75 %

Bin-averaged cases: larger but negligible in regards to the ones introduced without R^{MIX}

Neighboring flux approach

v

Requires additional computing time

Benefit depending on the cloud cover

Clear sky averaged acquisition angles + Idealized ΔR and ΔF

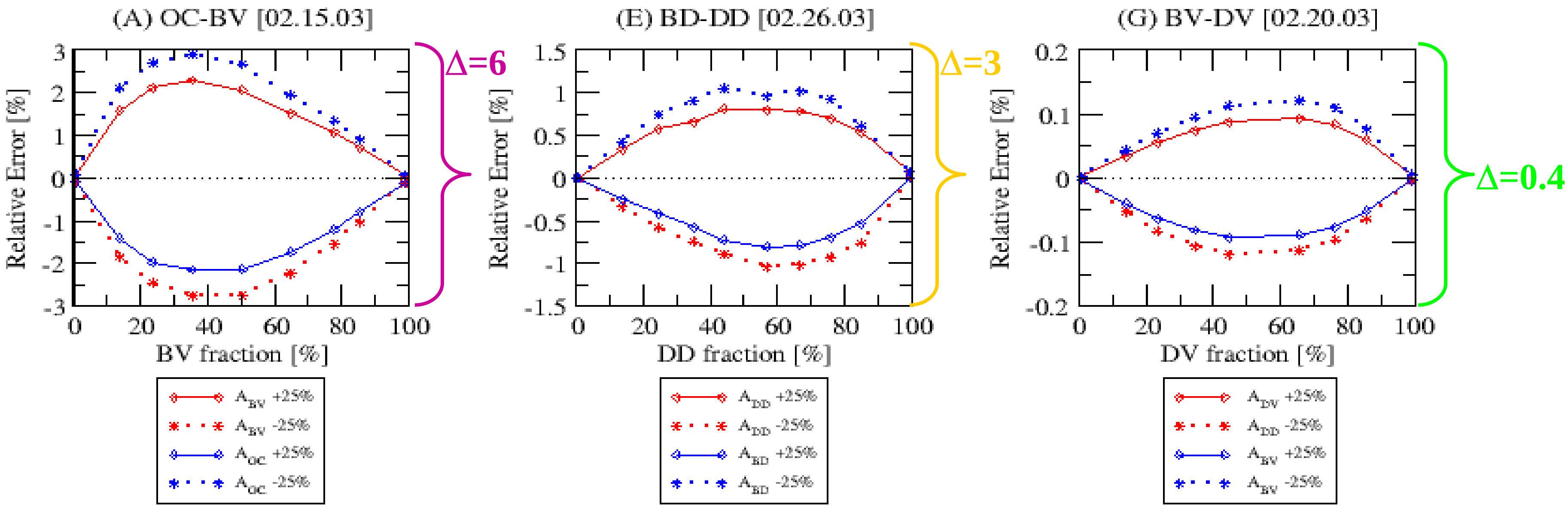
Mixed surface types	θ_s (degree)	θ_v (degree)	ϕ (degree)	ΔR (r.e. %)	ΔF (r.e. %)
OC-BV	66.70	61.14	175.21	0.54 (50.09%)	39.84 (32.41%)
OC-DV	23.87	14.36	168.95	0.32 (40.30%)	43.12 (27.45%)
OC-BD	42.84	30.69	173.97	0.35 (47.45%)	81.26 (30.47%)
OC-DD	44.89	49.82	165.26	0.38 (40.08%)	47.49 (27.26%)
BD-DD	48.62	55.65	165.54	0.19 (16.16%)	35.06 (14.12%)
BD-BV	29.53	18.68	167.99	0.03 (03.16%)	10.34 (03.44%)
BV-DV	21.22	16.44	142.59	0.02 (01.72%)	05.19 (02.24%)
BV-DD	08.51	30.39	166.71	0.01 (01.22%)	01.75 (00.80%)
DD-DV	43.00	52.00	154.00	0.02 (01.26%)	03.35 (01.78%)

Idealised fluxes ratios

	F_2/F_1	A_2/A_1	ΔR_{max}	ΔF_{max}
OC-BV	1.42	1.39 (2.05 %)	2.8E-03 (0.21 %)	0.19 (0.21 %)
OC-DV	1.84	1.97 (6.79 %)	5.3E-03 (0.55 %)	0.63 (0.53 %)
OC-BD	2.93	3.56 (21.57 %)	1.7E-02 (1.87 %)	2.81 (1.75 %)
OC-DD	2.64	2.23 (15.59 %)	1.6E-02 (1.41 %)	1.63 (1.38 %)
BD-DD	0.72	0.64 (15.88 %)	8.2E-03 (0.64 %)	1.48 (0.65 %)
BD-BV	0.80	0.55 (31.12 %)	3.1E-03 (0.29 %)	0.84 (0.29 %)
BV-DV	0.74	0.87 (16.89 %)	7.3E-04 (0.07 %)	0.15 (0.07 %)
BV-DD	1.21	1.15 (4.72 %)	1.6E-04 (0.01 %)	0.03 (0.01 %)
DD-DV	0.75	0.77 (2.03 %)	8.0E-05 (6E-3 %)	0.01 (6E-3 %)

CERES-TRMM SW ADMs TOA Albedo
Variation of ± 25 %

1. ANISOTROPIC CORRECTION FACTOR



2. REFLECTED SW FLUX (TOA)