Use of MODIS spectral information for CERES fresh snow ADMS

CERES Fall STM

Scripps Institute of Oceanography, October 2013

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Fresh Snow ADMs

- "Fresh" Snow – actually refers to seasonal snow (not necessarily anything fresh about this snow)
- Anisotropy affected by age of snow, snow temperature (grain size), snow fraction, snow depth, underlying surface type (e.g. forest vs tundra vs grasslands)

Fresh Snow ADMs

- Existing ADMs are separated by snow fraction, cloud fraction and for 100% snow cover scenes and overcast scenes the surface brightness and cloud optical thickness.
- Surface brightness determined from MODIS 0.645 mu band over the period 2000-2005, for each region.
- Pros: simple, easy to apply, shouldn't have any biases.
- Cons: too simple? Possibly not accounting for all the variation in anisotropy, have to use CERES radiance to select ADM

Can we use MODIS spectral information to get anisotropy?

- Larger number of spectral bands in SSF product now.
- Potentially these contain information about the anisotropy of the reflected SW radiation.
- We are using two sources in the ed4 ADMs:
  - A modified NDSI
  - The 11mu radiance

Normalized Snow Difference Index

- NDSI = (rho_055 – rho_124)/(rho_055+rho_124)
- (slightly different to other definitions but follows same formula vis-nir/vis+nir)
- NDSI -> 1.0: vis>nir – likely to be older snow (?)
- NDSI -> -1.0: vis<nir – likely to be vegetation dominated.
- NDSI -> 0.0: nir and vis are comparable – for snow this could be bright, fresh snow which has a flat spectral shape, or dirty snow which would be lower in the vis but still high in the NIR.

Normalized Snow Difference Index

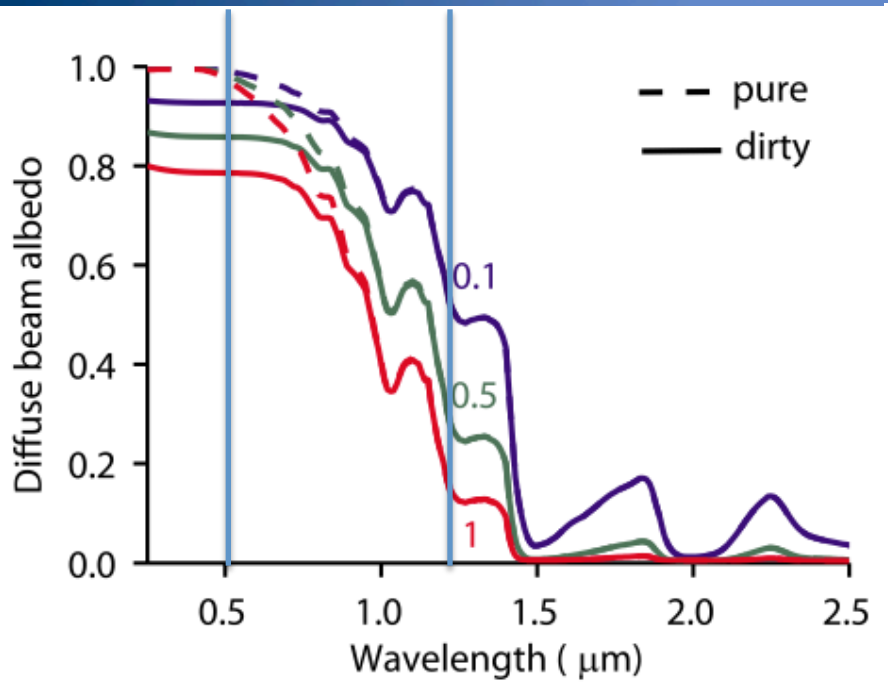


Figure 3. Semi-infinite diffuse beam albedo of pure (dashed) and dirty (solid) snow for three effective grain radii r_e (mm). The dirty snow contains 0.3 ppmw of light-absorbing carbon.

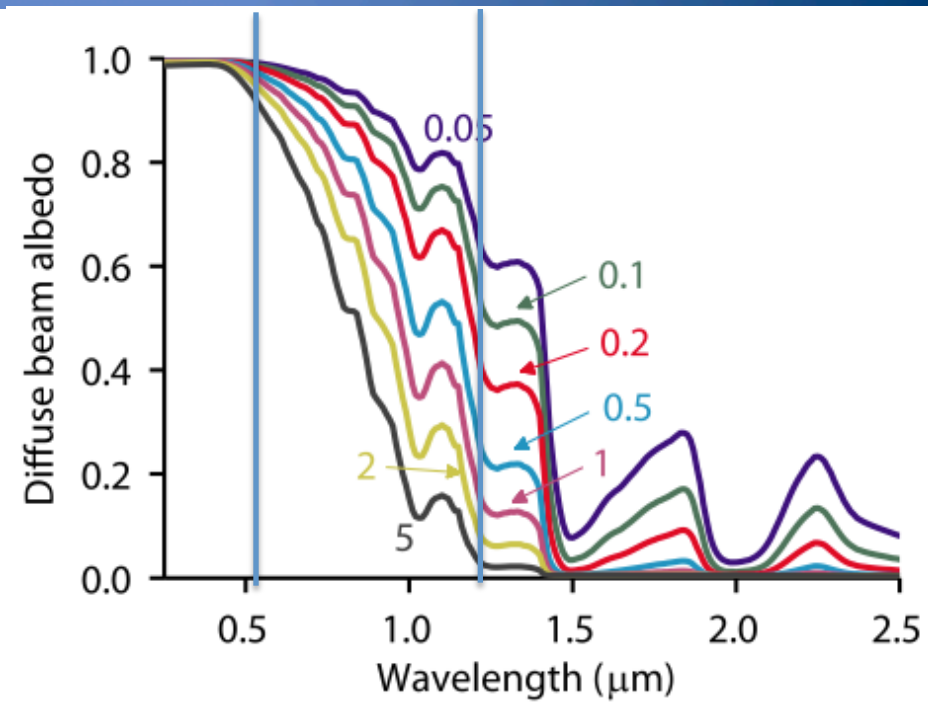


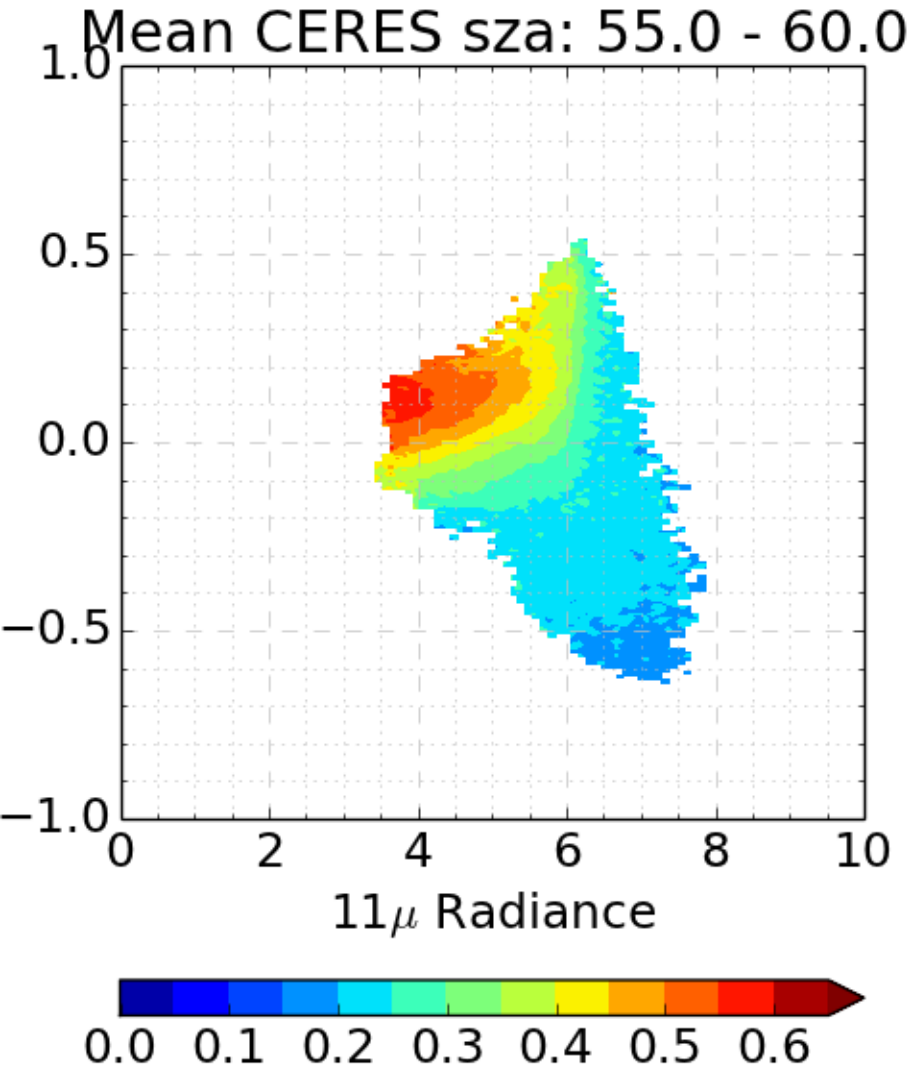
Figure 2. Semi-infinite diffuse beam pure snow albedo as a function of the effective grain radius r_e (mm).

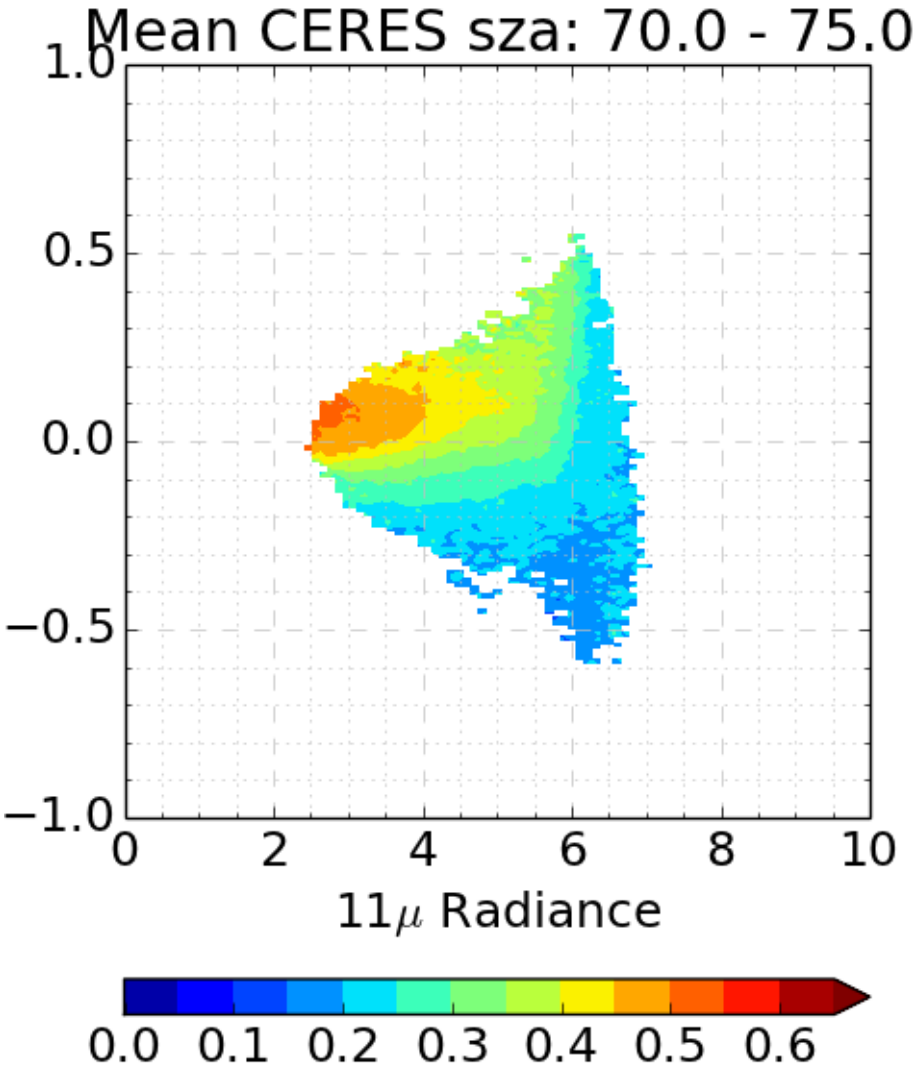
Gardner and Sharp 2010

11mu radiance

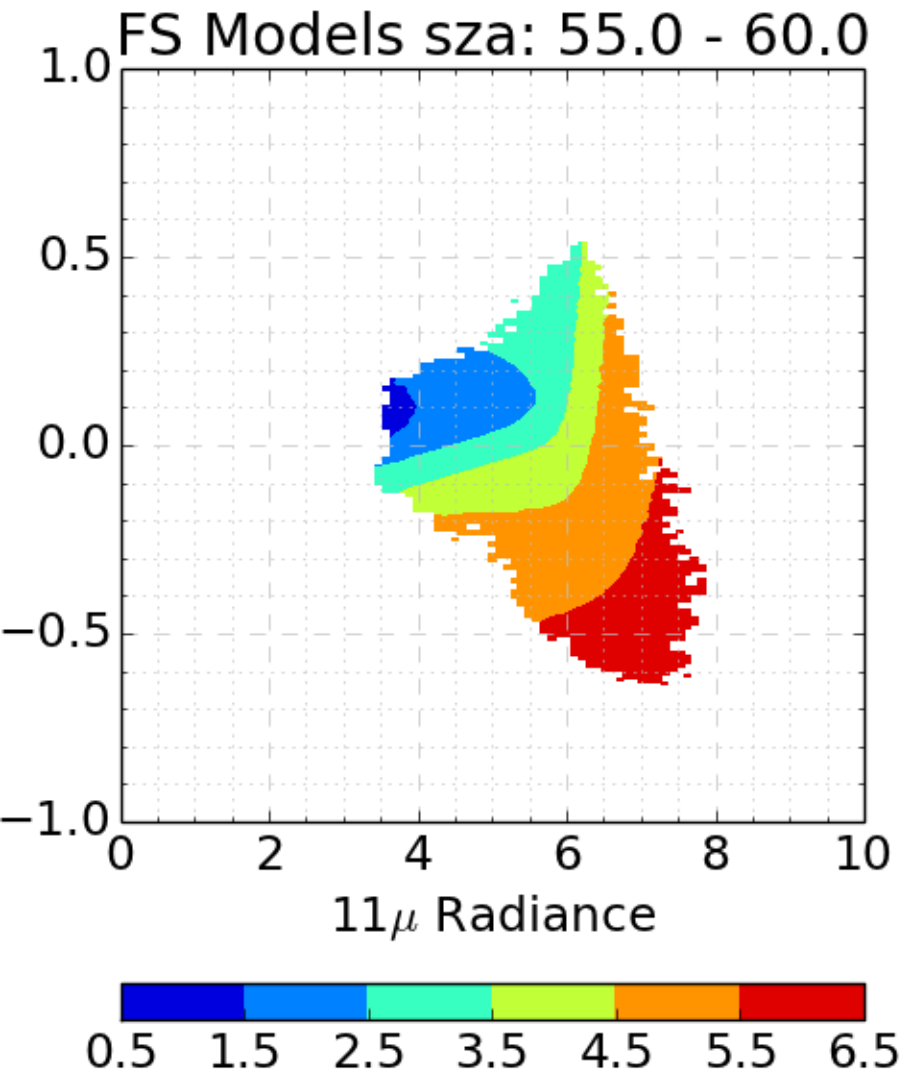
- Related to the temperature of the footprint
- Colder snow is more likely to be fresher and have undergone less grain size changes – brighter

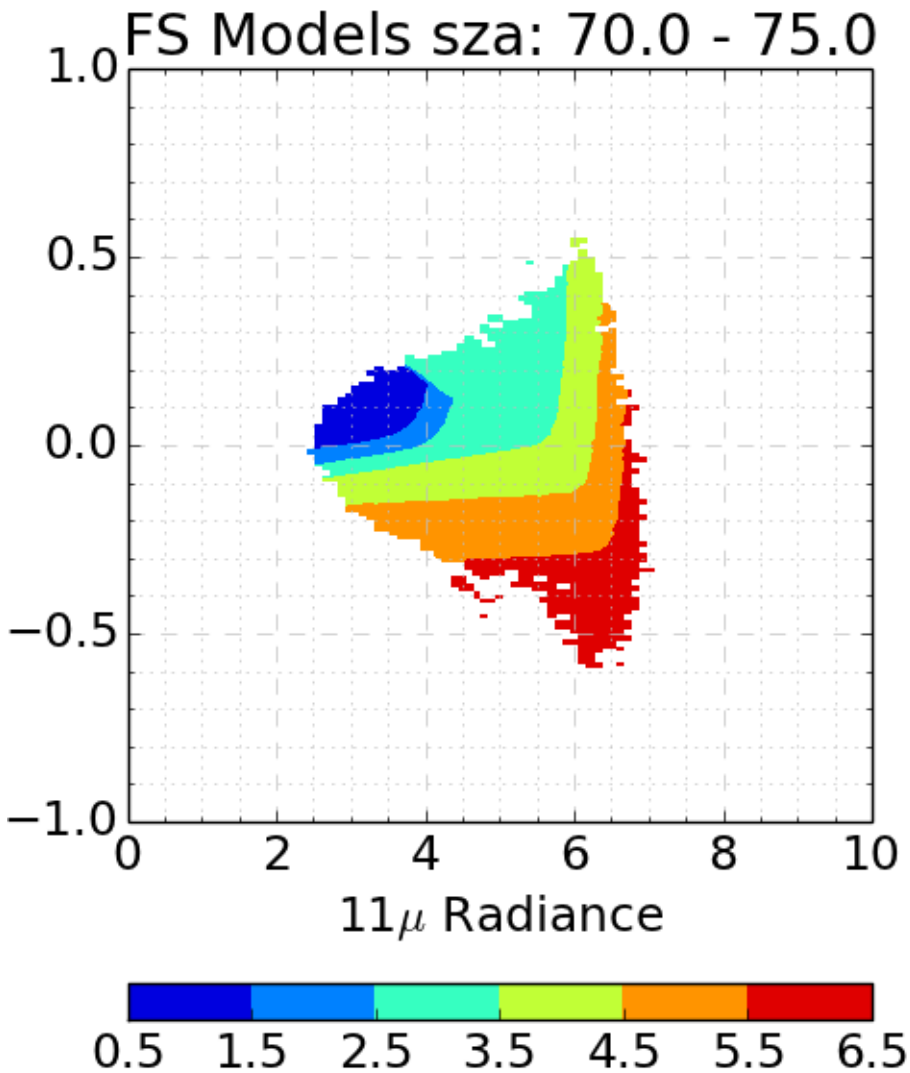
CERES ref, NDSI & 11mu rad





FS Models, NDSI & 11mu rad

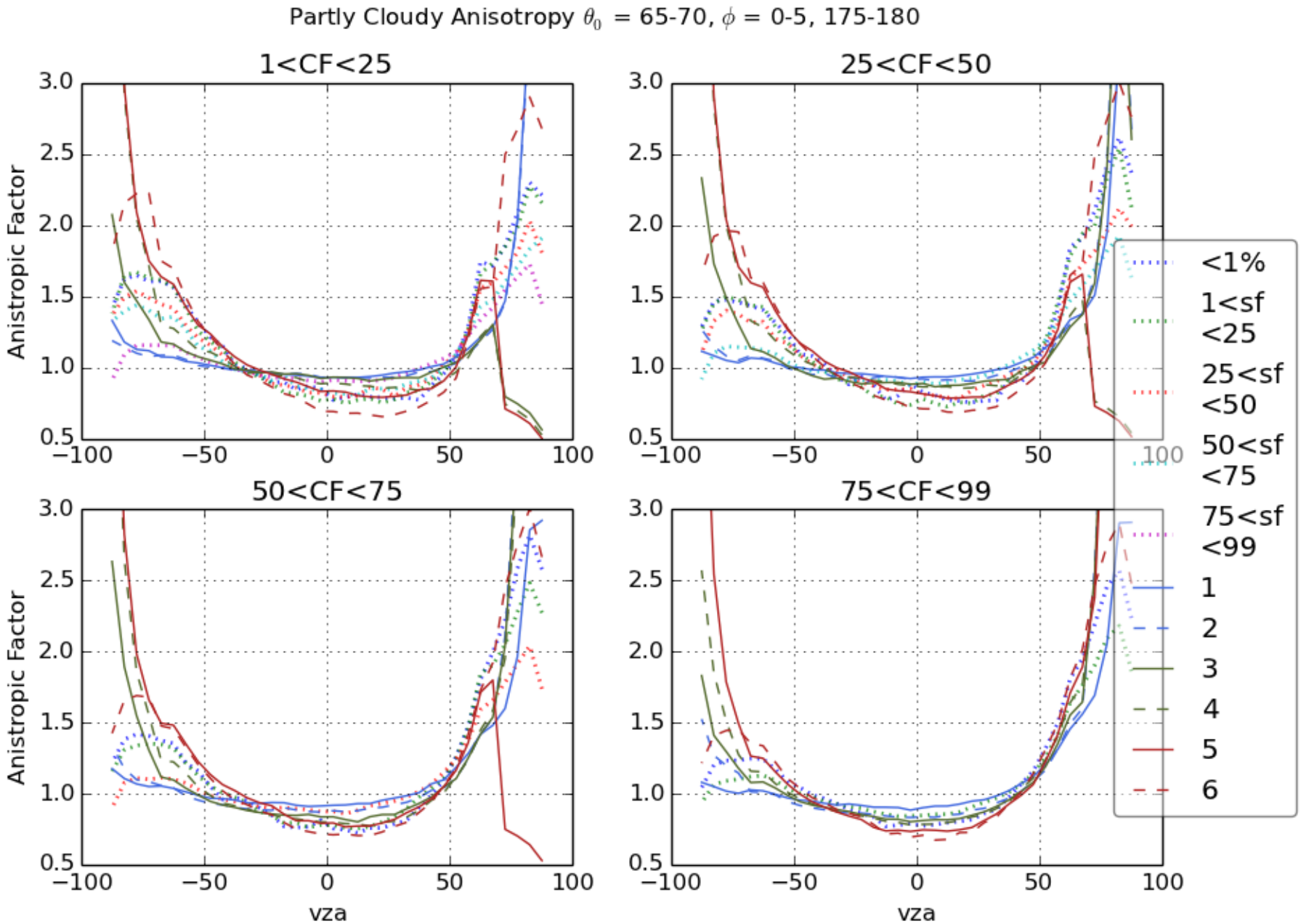




Partly Cloudy Scenes

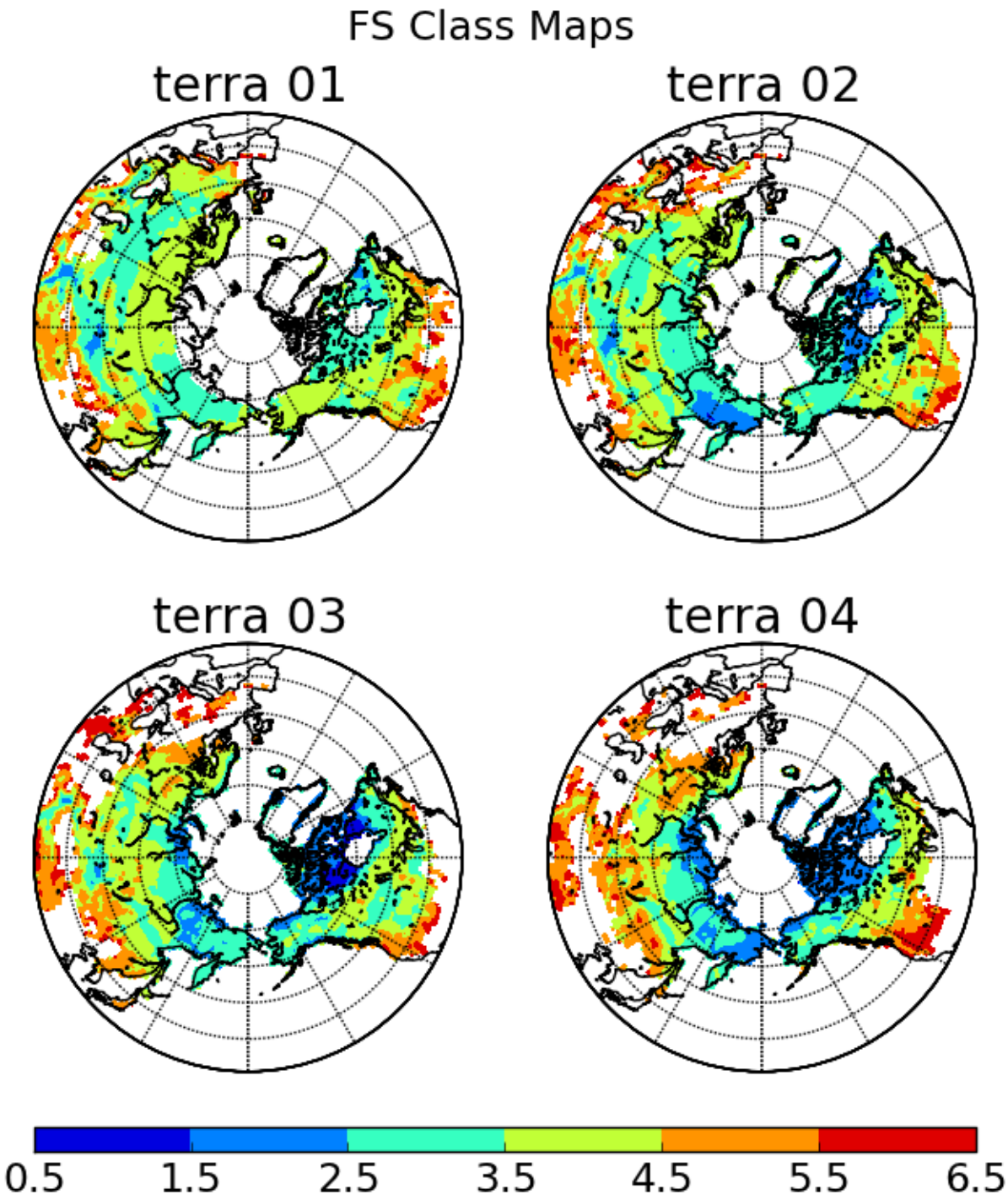
- 6 Fresh Snow Class models
- 4 Cloud fraction bins – each 25%

Anisotropy Comparison

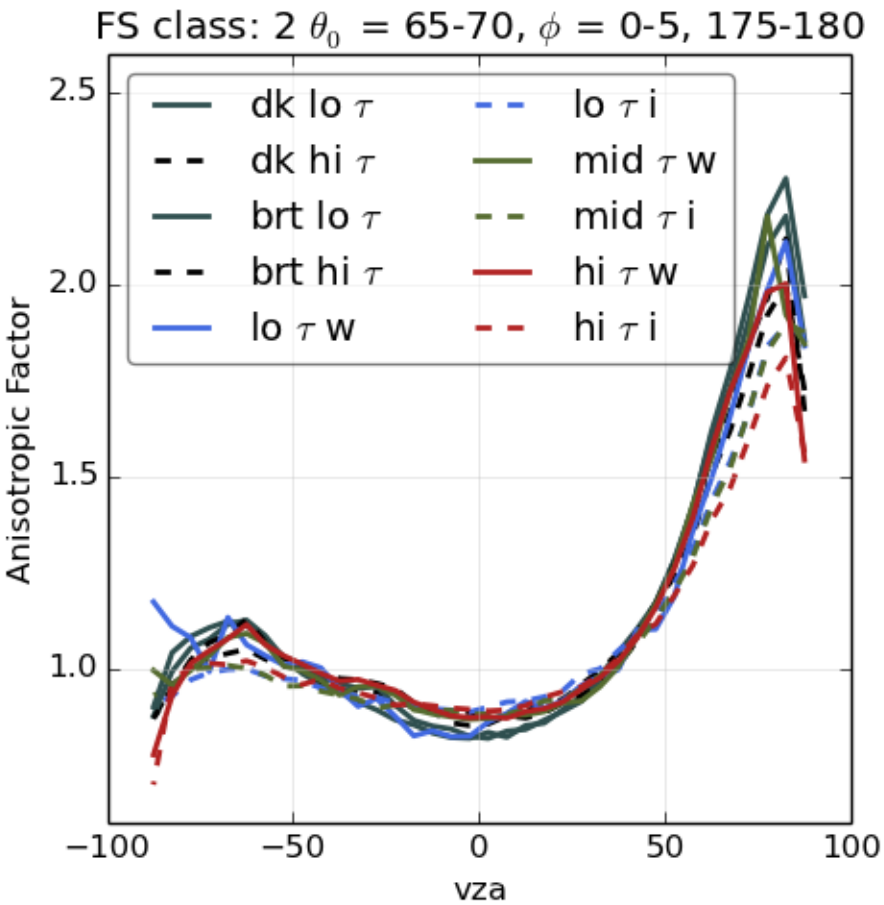


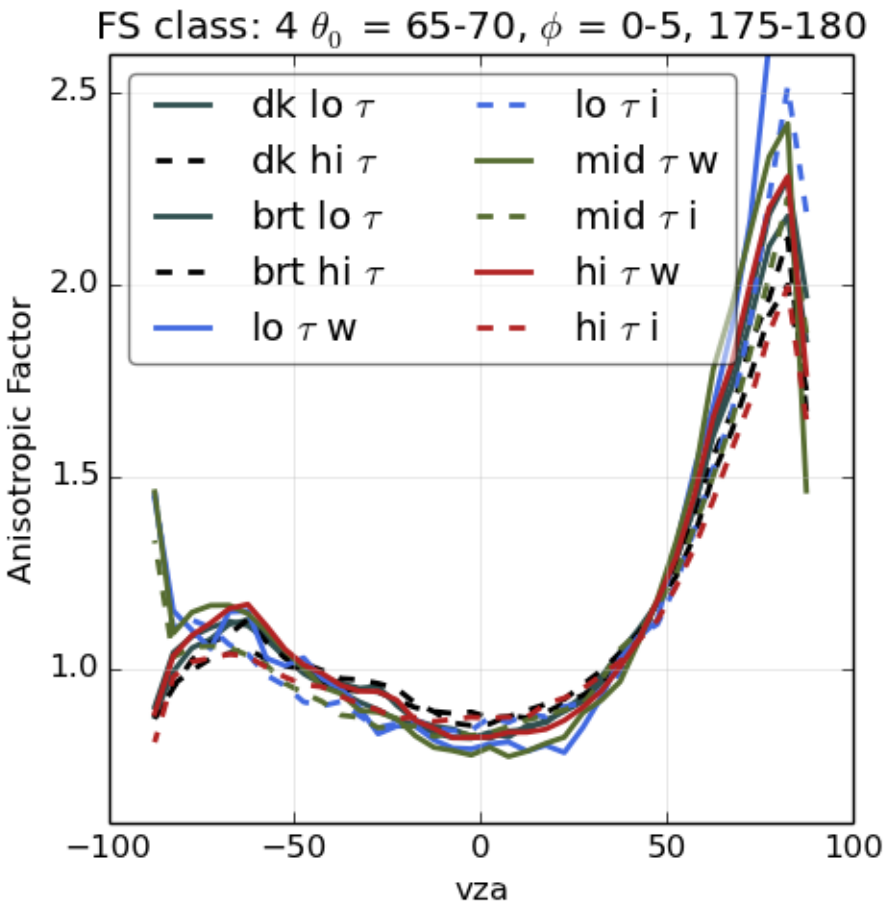
Overcast Scenes

- 6 Fresh Snow Class models, with value determined from monthly maps.
- 2 Cloud phase bins (<1.5, >1.5)
- 3 log tau bins – 33 percentiles, defined for each viewing zenith angle.


FS Class Maps
terra 01
terra 02
terra 03
terra 04
0.5
1.5
2.5
3.5
4.5
5.5
6.5

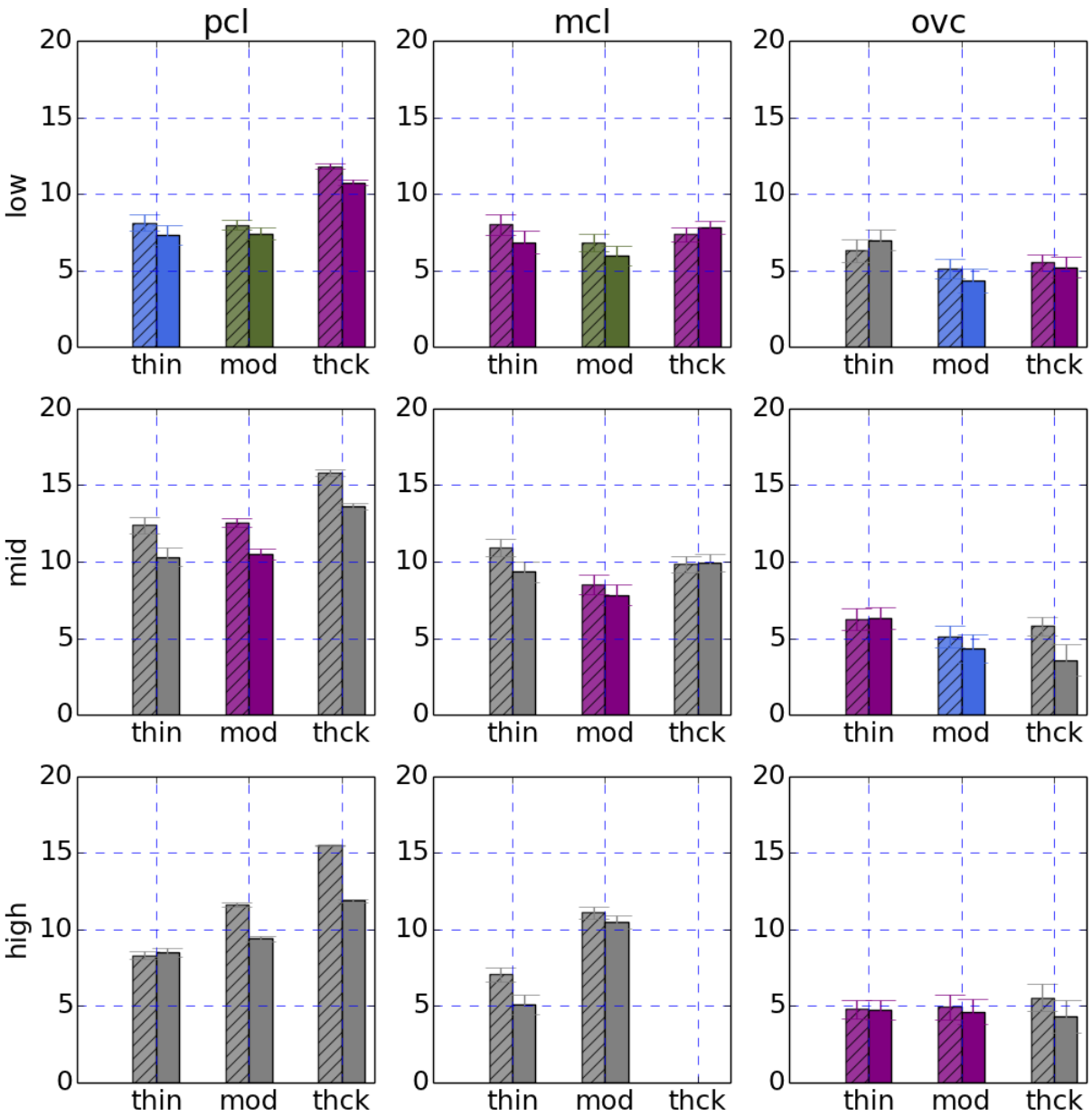
Anisotropy Comparison



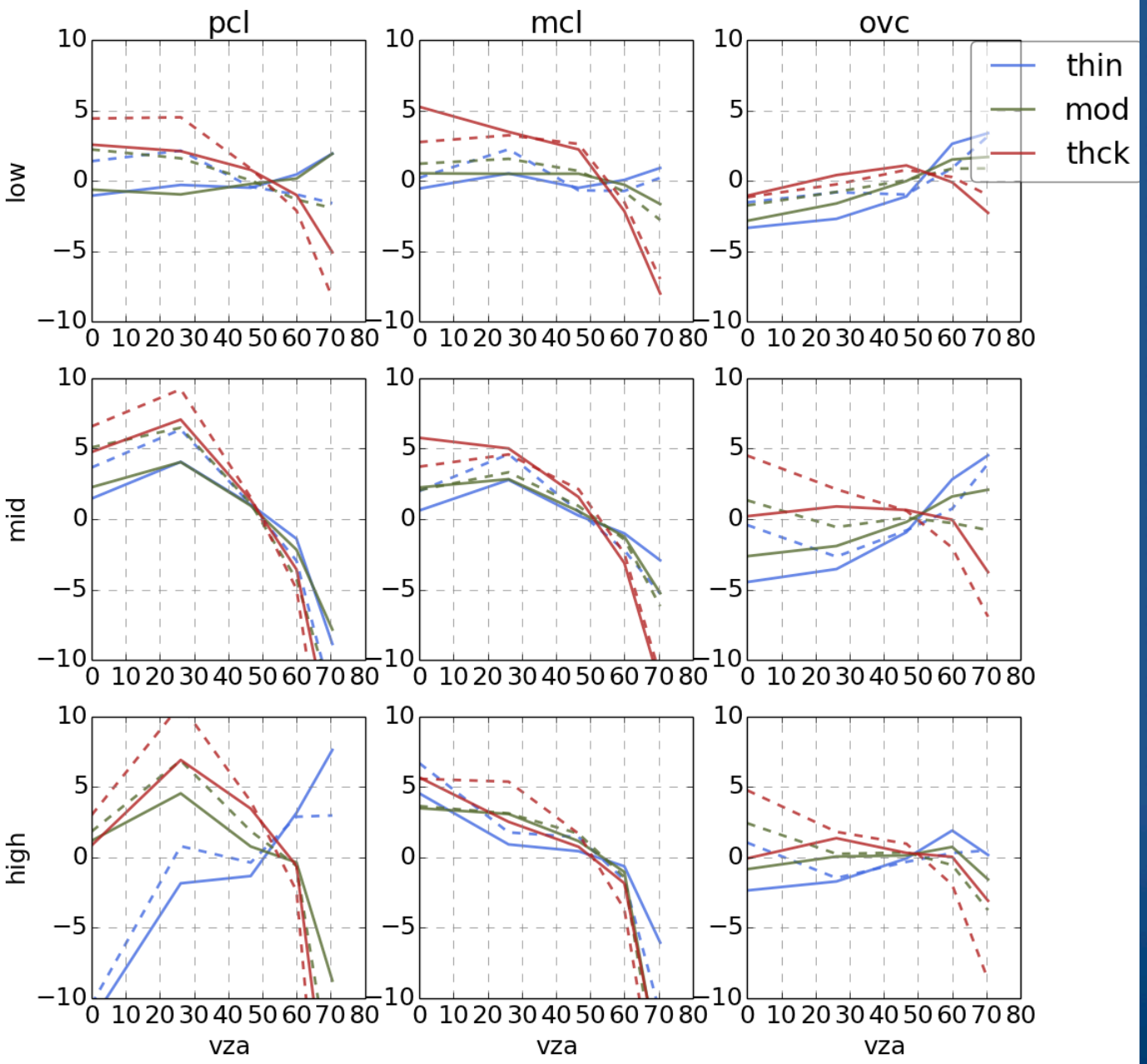


Comparison of anisotropic factors between Edition 2 and new Edition 4 ADMs
Dk -> dark surface, brt -> bright surface
I -> ice clouds, w -> water clouds

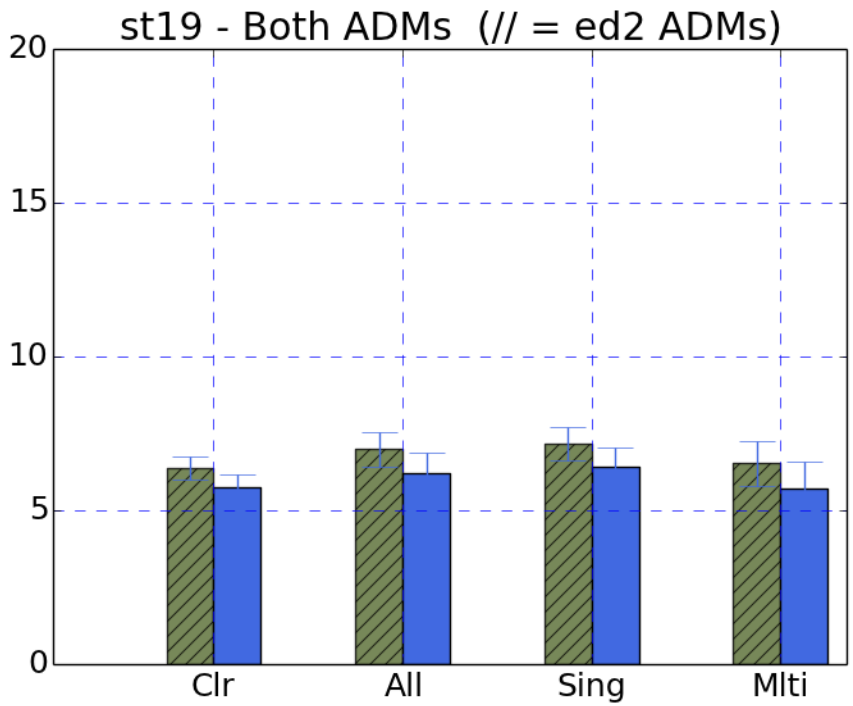
Single Layer Clouds: st19 - Both ADMs (// = ed2 ADMs)

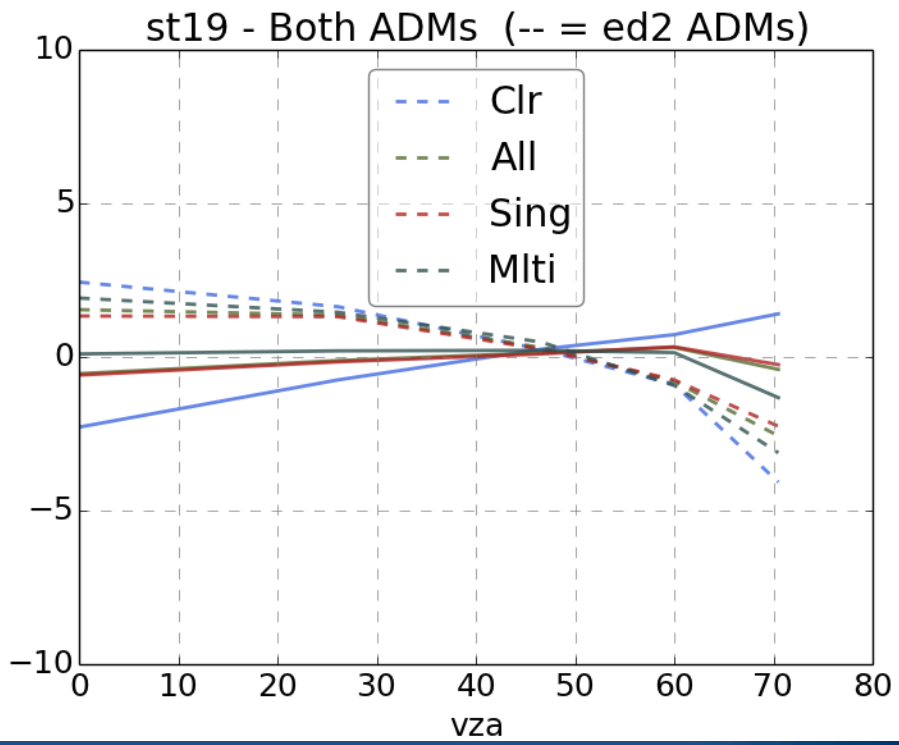


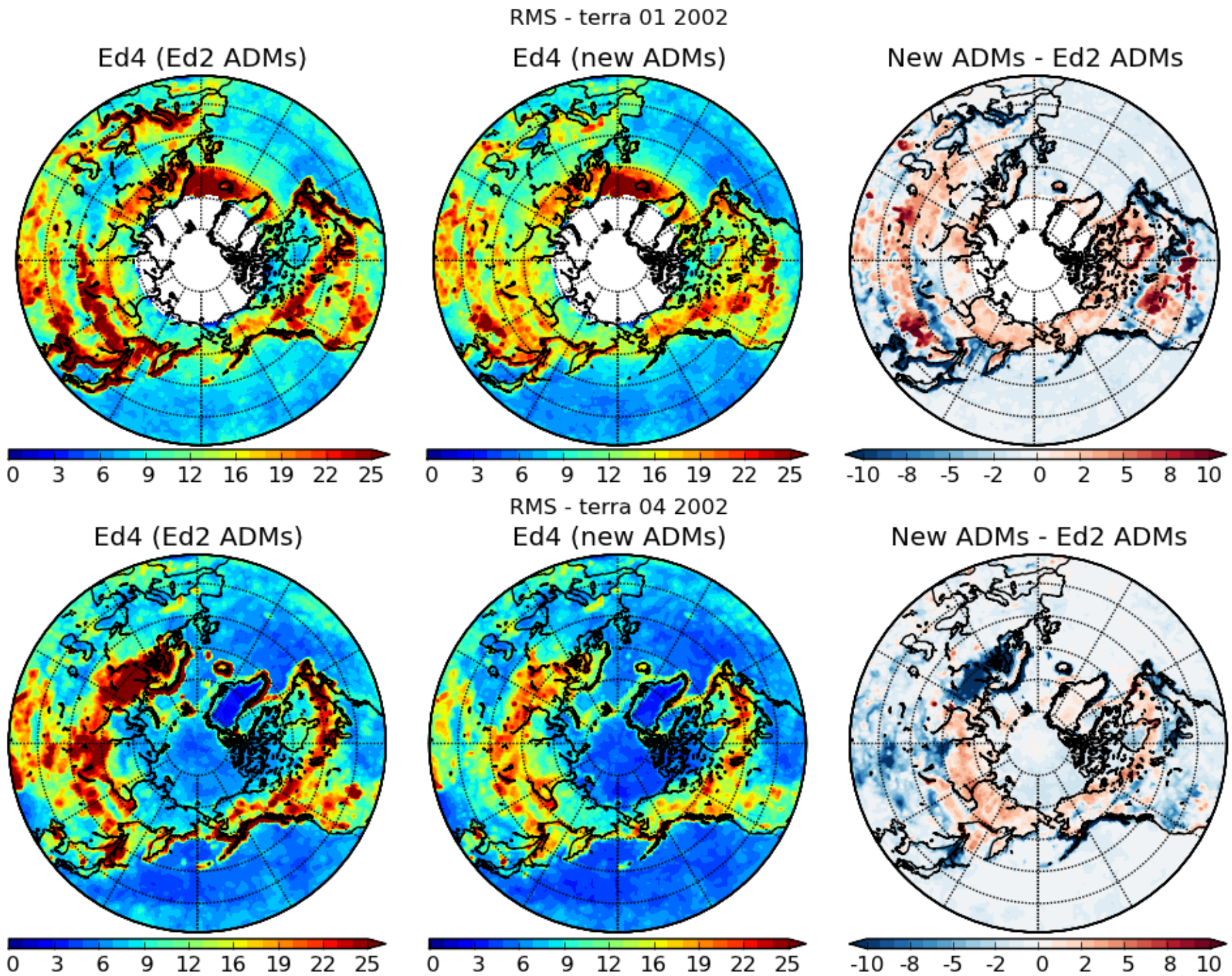
Single Layer Clouds: st19 - Both ADMs (-- = ed2 ADMs)

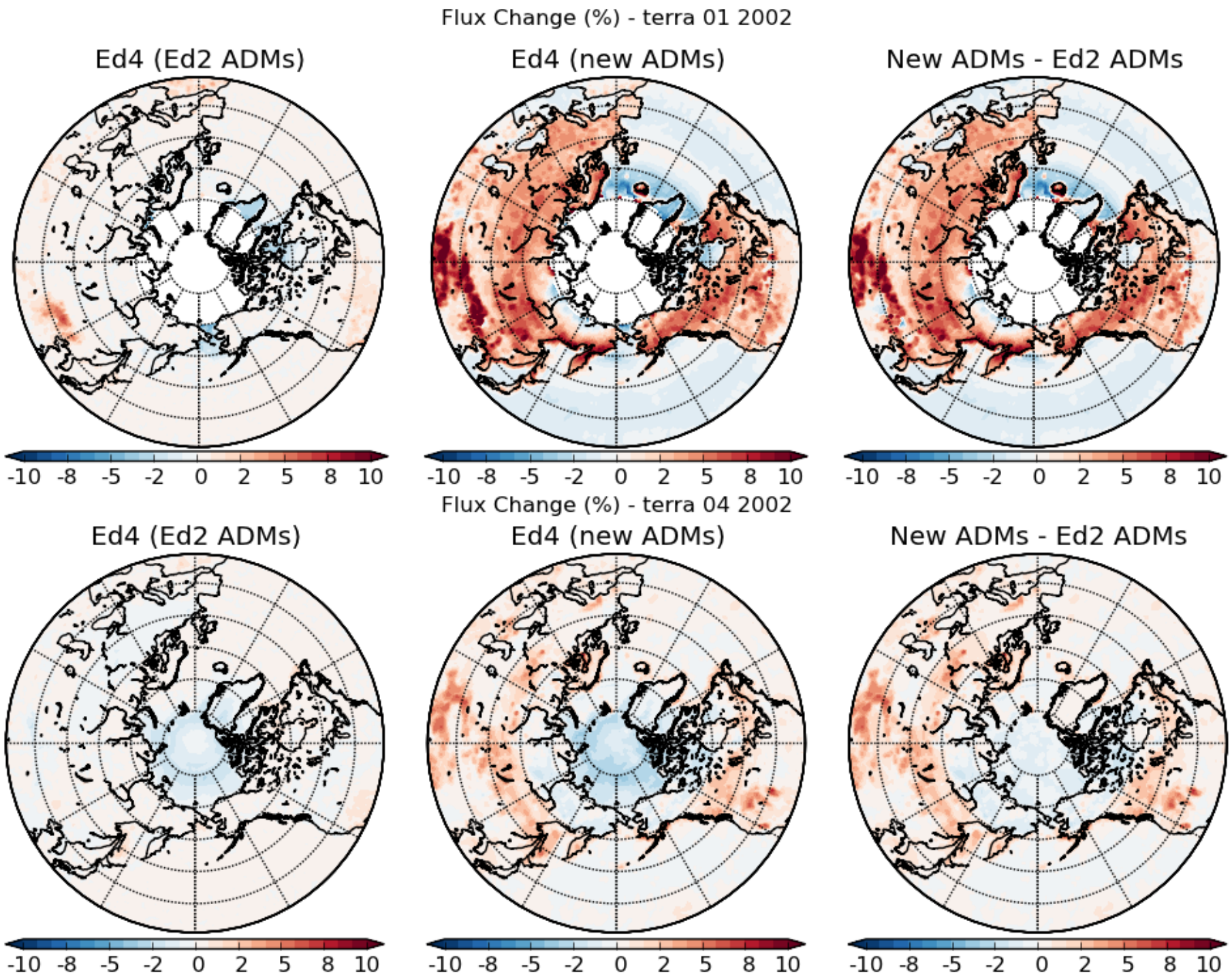


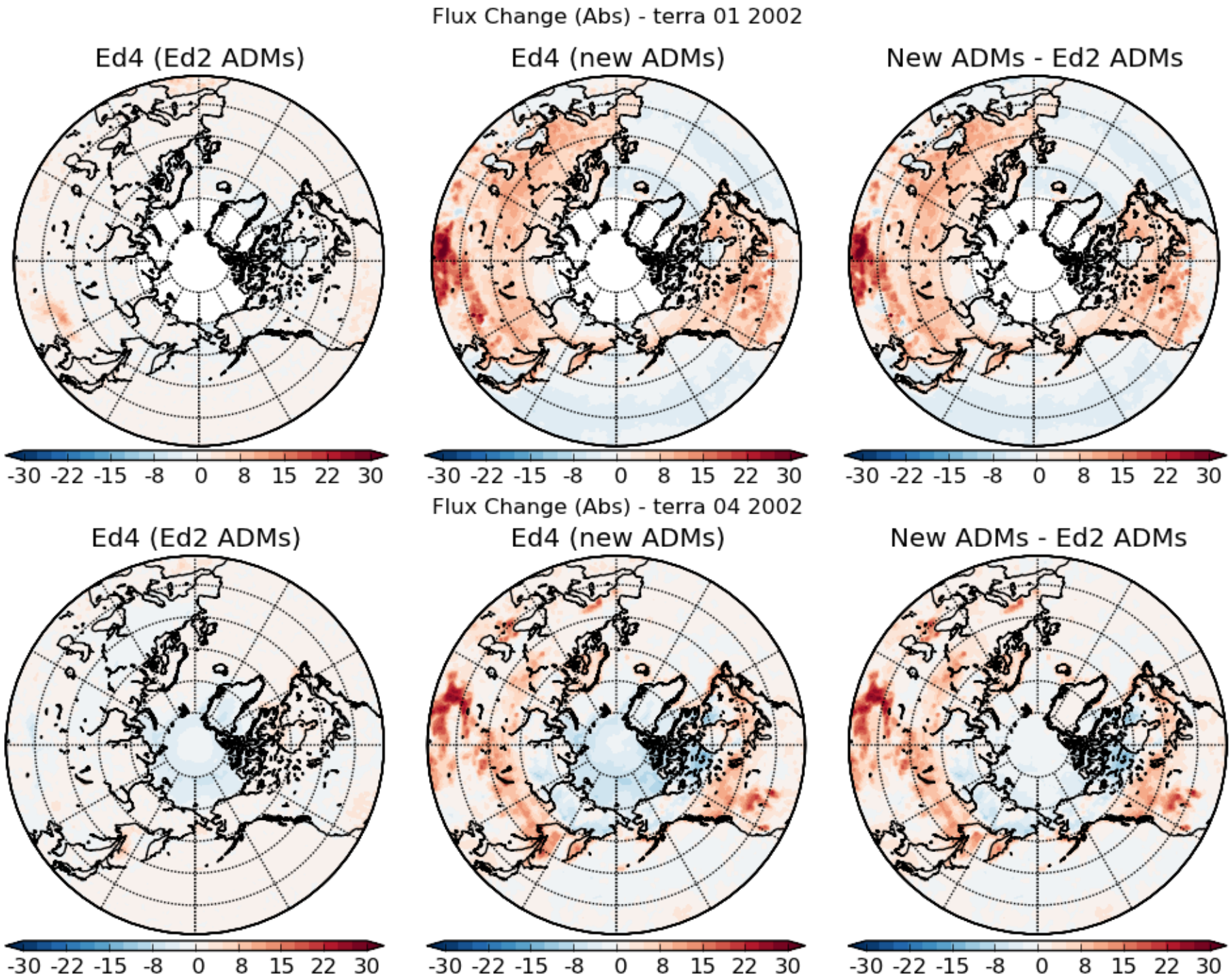
SSFM Flux Consistency






RMS - terra 01 2002
Ed4 (Ed2 ADMs)
Ed4 (new ADMs)
New ADMs - Ed2 ADMs
0 3 6 9 12 16 19 22 25
0 3 6 9 12 16 19 22 25
-10 -8 -5 -2 0 2 5 8 10
RMS - terra 04 2002
Ed4 (Ed2 ADMs)
Ed4 (new ADMs)
New ADMs - Ed2 ADMs
0 3 6 9 12 16 19 22 25
0 3 6 9 12 16 19 22 25
-10 -8 -5 -2 0 2 5 8 10


Flux Change (%) - terra 01 2002
Ed4 (Ed2 ADMs)
Ed4 (new ADMs)
New ADMs - Ed2 ADMs
-10 -8 -5 -2 0 2 5 8 10
-10 -8 -5 -2 0 2 5 8 10
-10 -8 -5 -2 0 2 5 8 10
Flux Change (%) - terra 04 2002
Ed4 (Ed2 ADMs)
Ed4 (new ADMs)
New ADMs - Ed2 ADMs
-10 -8 -5 -2 0 2 5 8 10
-10 -8 -5 -2 0 2 5 8 10
-10 -8 -5 -2 0 2 5 8 10


Flux Change (Abs) - terra 01 2002
Ed4 (Ed2 ADMs)
Ed4 (new ADMs)
New ADMs - Ed2 ADMs
-30 -22 -15 -8 0 8 15 22 30
-30 -22 -15 -8 0 8 15 22 30
-30 -22 -15 -8 0 8 15 22 30
Flux Change (Abs) - terra 04 2002
Ed4 (Ed2 ADMs)
Ed4 (new ADMs)
New ADMs - Ed2 ADMs
-30 -22 -15 -8 0 8 15 22 30
-30 -22 -15 -8 0 8 15 22 30
-30 -22 -15 -8 0 8 15 22 30

Summary

- Use of MODIS information shows some ability to classify anisotropy.
- Using MODIS to classify anisotropy generally results in improved or as good as the snow fraction classification method.
- Improved VZA consistency
- Some areas of improved radiance RMS differences.
- Mostly positive flux changes.