Comparison of fractional snow detection algorithms for VIIRS retrievals

Kat J. Bormann[1]
Thomas H. Painter[1]

[1]Jet Propulsion Laboratory, California Institute of Technology

Background

- MODIS-derived products have become the workhorse for snow cover monitoring
- MODIS instruments on Terra/Aqua have surpassed their expected life span

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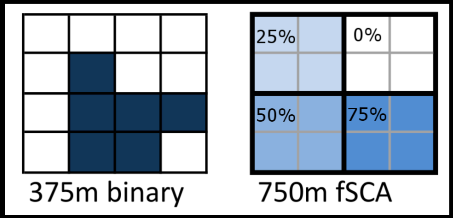
- MODIS instruments on Terra/Aqua have surpassed their expected life span
- VIIRS instrument on Suomi NPP (⇧2011) provides data continuity with MODIS
- The continuation of long-term snow cover records relies on compatible data from the MODIS and VIIRS instruments

Background

- VIIRS binary SCA product (375m) employs the MODIS heritage NDSI algorithm
- VIIRS fSCA product (750m) converts binary to fractional using 2x2 averaging



fSCA is limited to 25% fSCA increments

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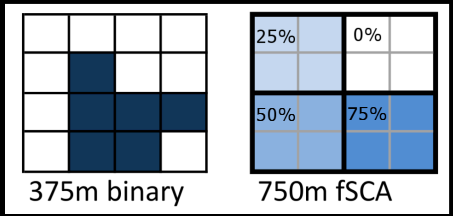

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- Existing algorithm cannot meet product per-pixel requirement of < 10% uncertainty
- Mixed pixel methods have been suggested (Appel, 2011)

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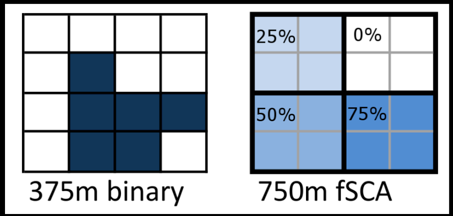

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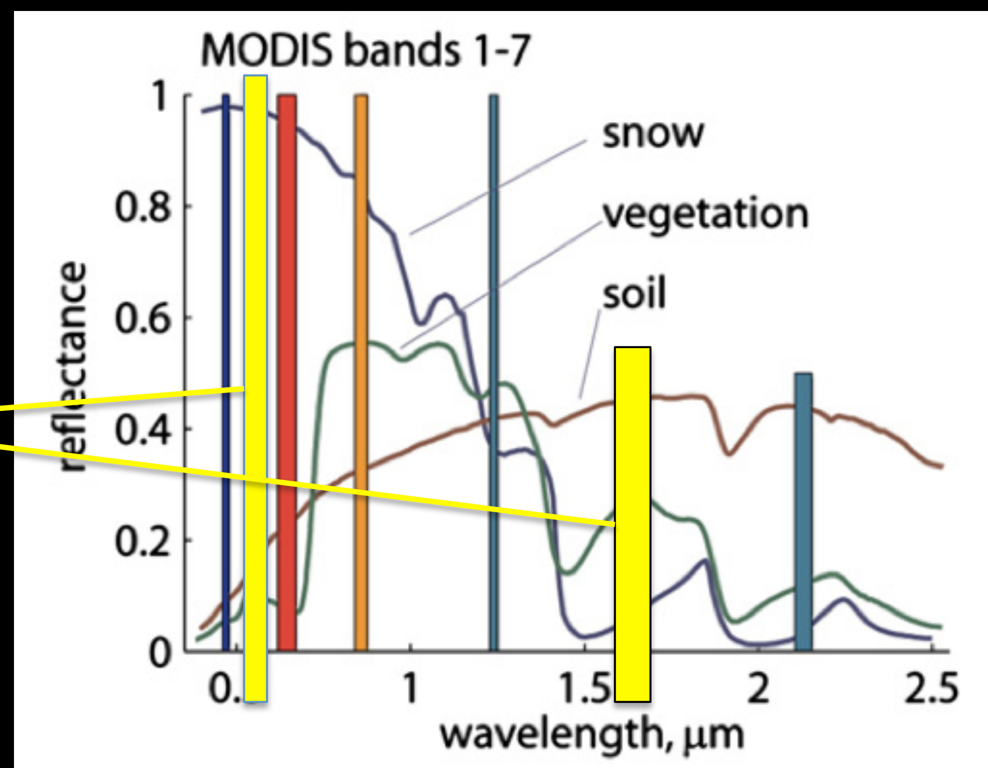
Snow detection algorithms

Normalised Difference Snow Index (NDSI, Salomonson & Appel, 2004)

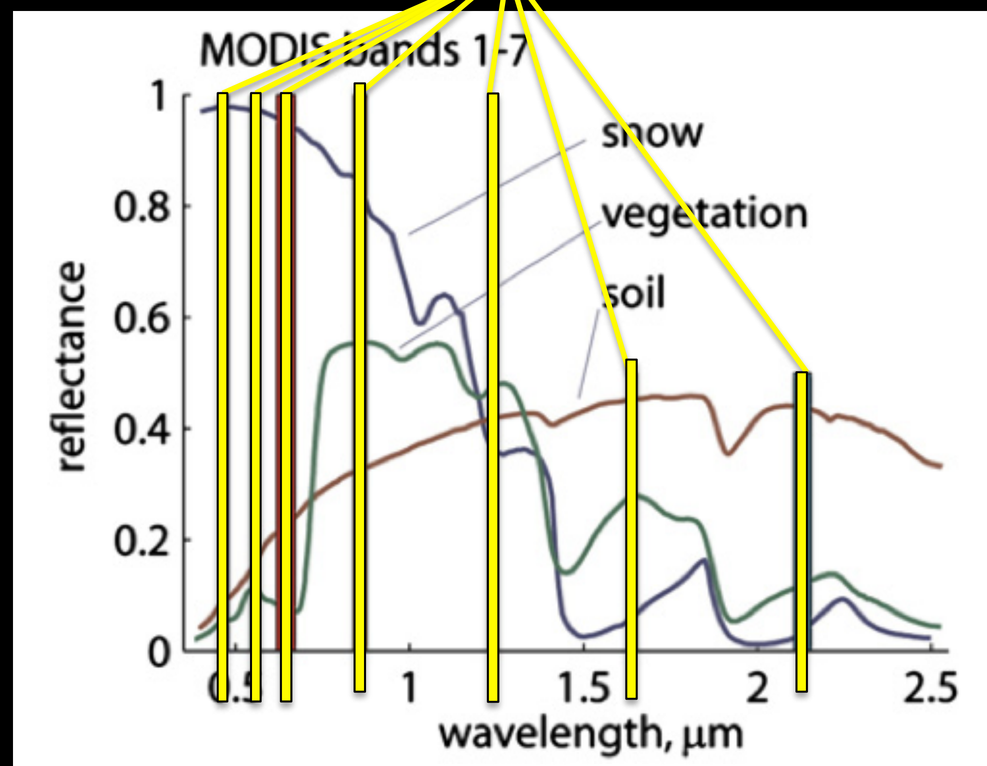
$$NDSI = \frac{R_{VIS} - R_{SWIR}}{R_{VIS} + R_{SWIR}}$$



Snow detection algorithms

Spectral unmixing (SCAG, Painter et al, 2009)

– MODSCAG



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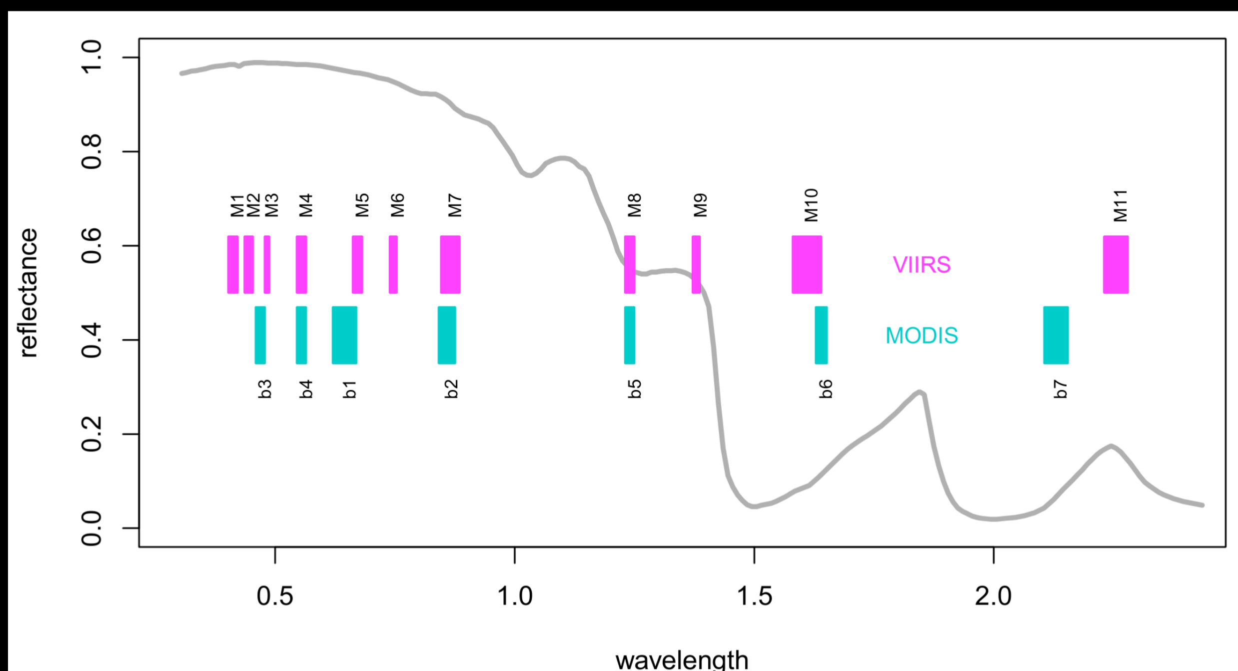
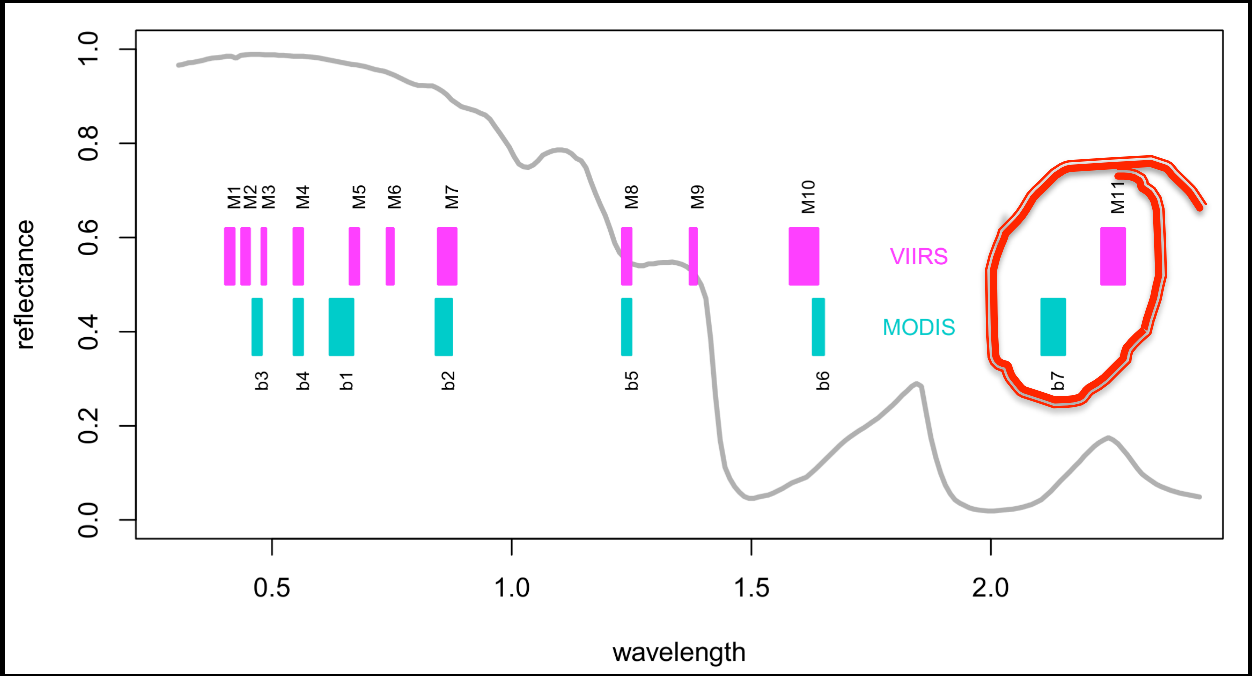
Sensors

- VIIRS was designed with spectral continuity for MODIS in mind



Sensors

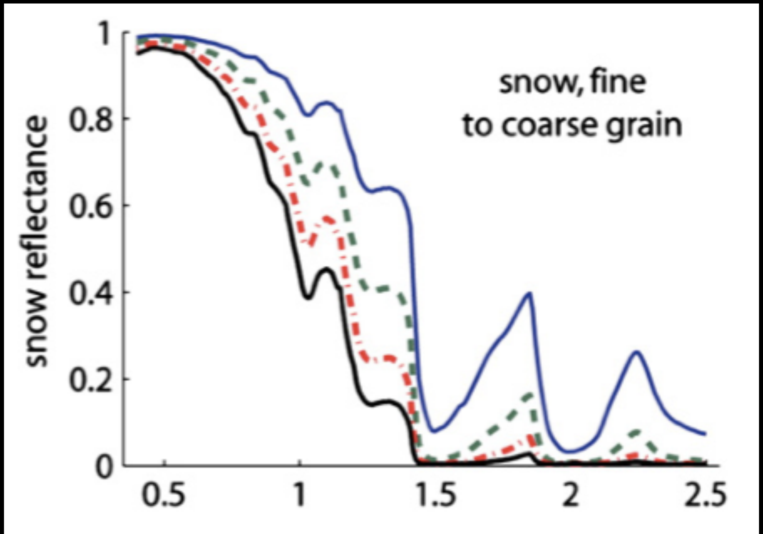
- VIIRS was designed with spectral continuity for MODIS in mind
- Similar, but not the same

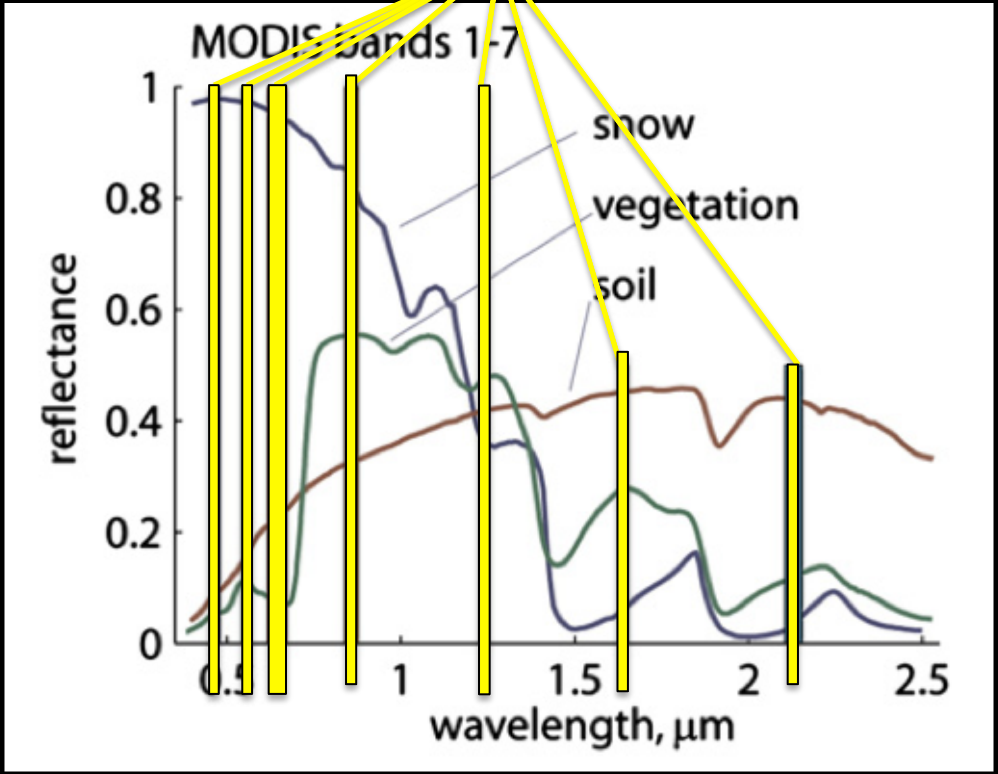


Snow detection algorithms

Spectral unmixing (SCAG, Painter et al, 2009)

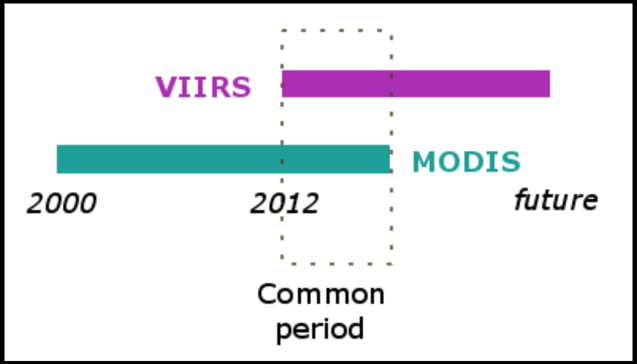
– MODSCAG





Objectives

1. Reconcile snow cover information between MODIS and VIIRS - during common period for data continuation



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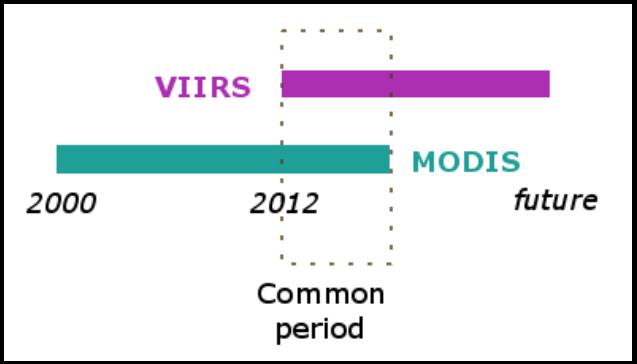


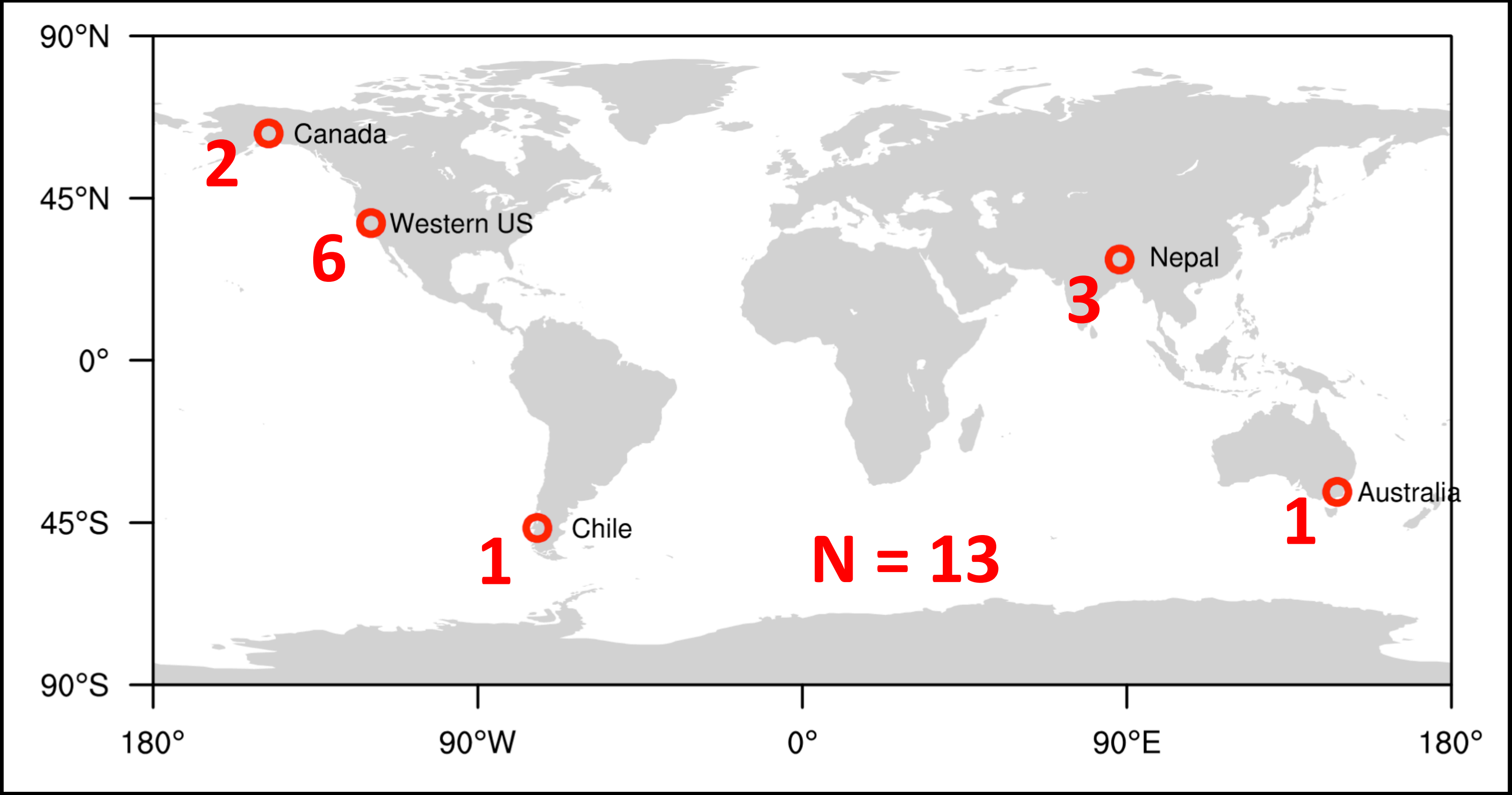
2. Apply demonstrated physically-based linear spectral unmixing technique (Snow Cover and Grain size, SCAG, Painter et al., 2009) to VIIRS surface Refl. for finer fSCA retrieval

In this study

- Compare
  - VIIRS Fractional Snow Cover Product (DSCD1KD)
      - » VIIRS fSCA PRODUCT
  - SCAG mixed pixel algorithm applied to VIIRS DSRF1KD
      - » VIIRSCAG
- To demonstrated MODIS application of SCAG
      - » MODSCAG 500m (coarsened to 1km)
- This preliminary comparison will be conducted at 1km res.

Evaluation scenes

- Clear-sky scenes
- 2013 or 2014 (⇧NPP VIIRS)

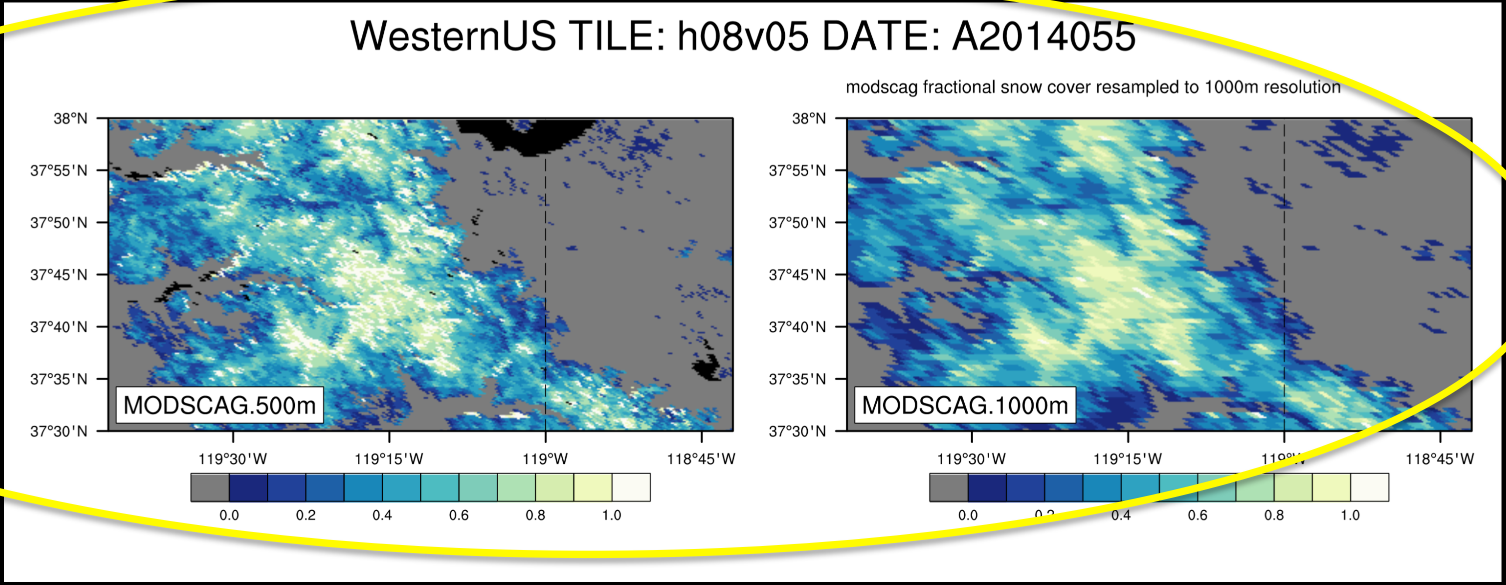


Results – Snow cover

MODSCAG RMSE = 0.10 (Rittger et al., 2012)

Feb 24, 2014

Adopt as 'truth'



Results – Snow cover

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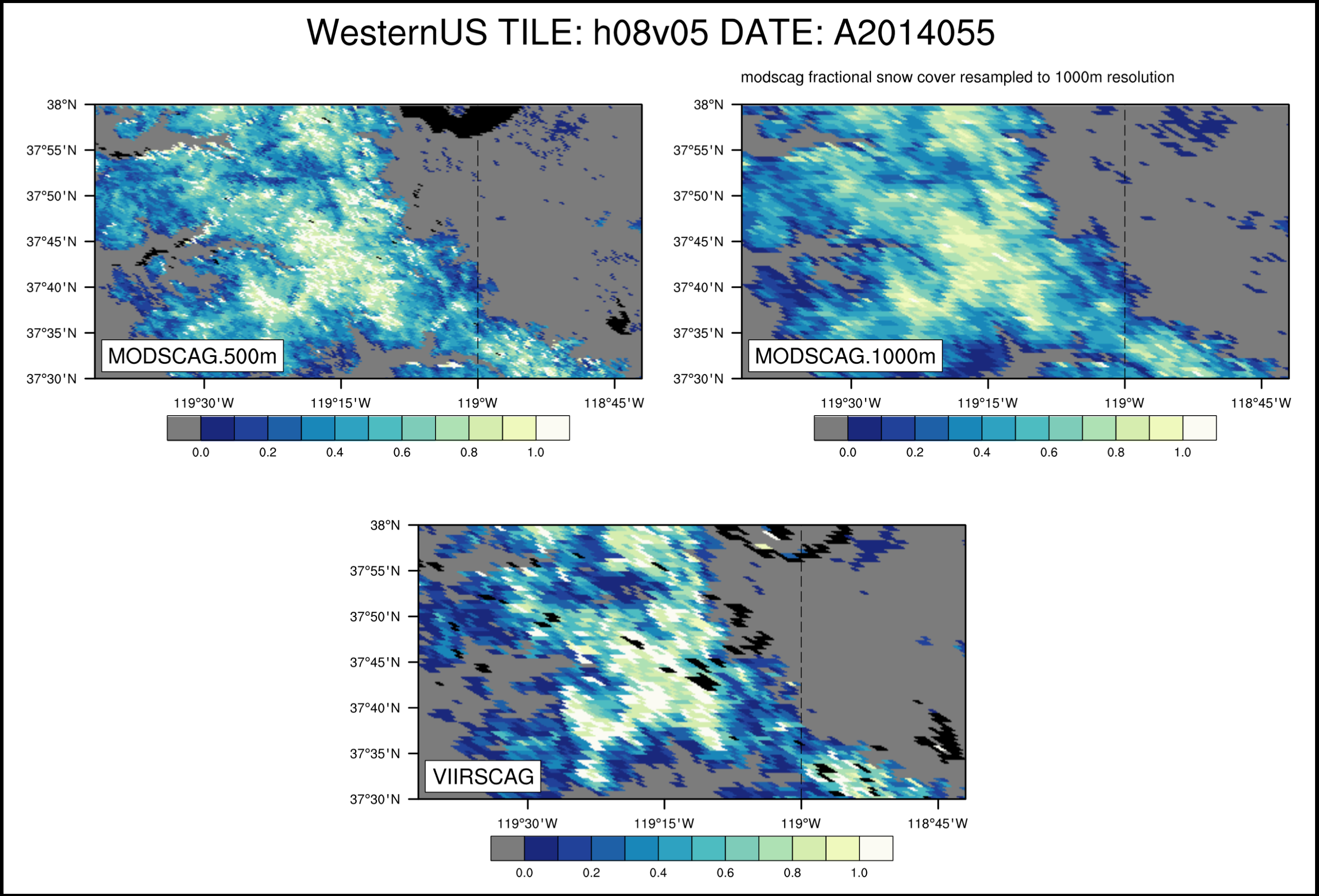
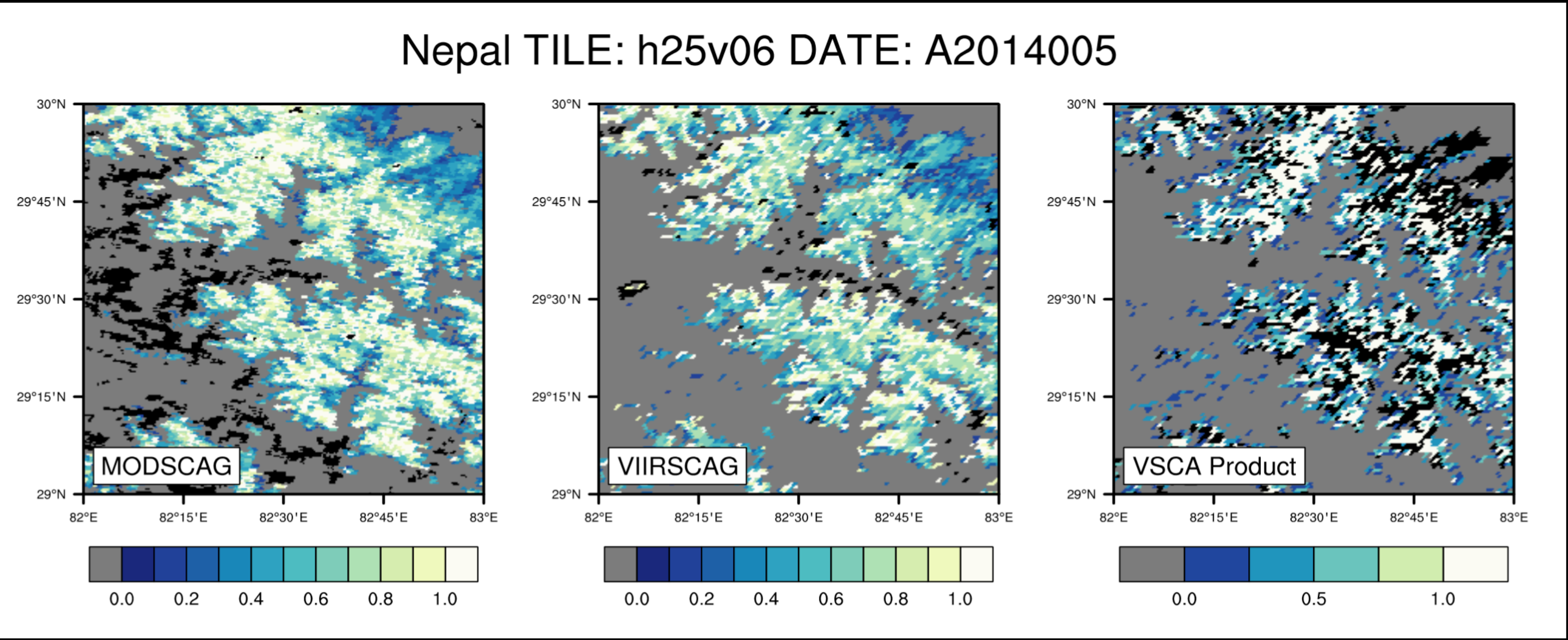


Results – Snow cover

Jan 5, 2014

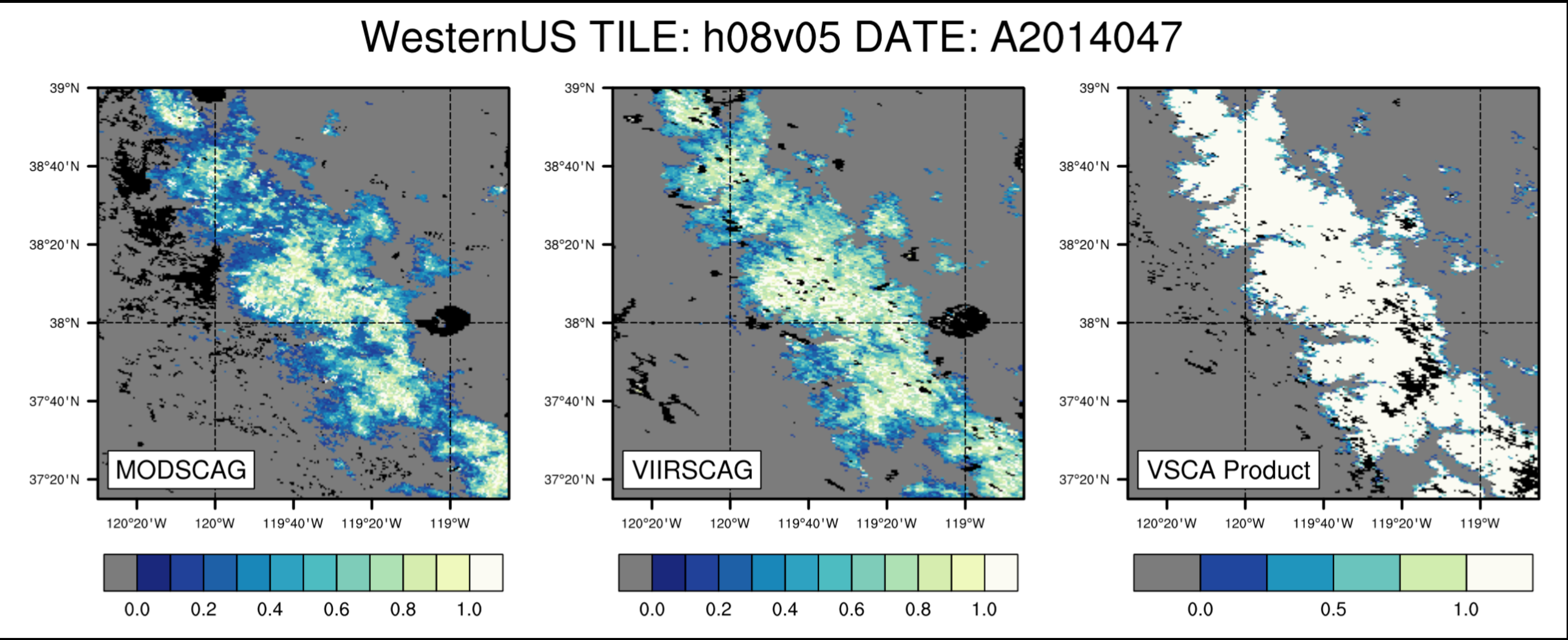


25% 20% 14%

Total scene % snow cover area

Results – Snow cover

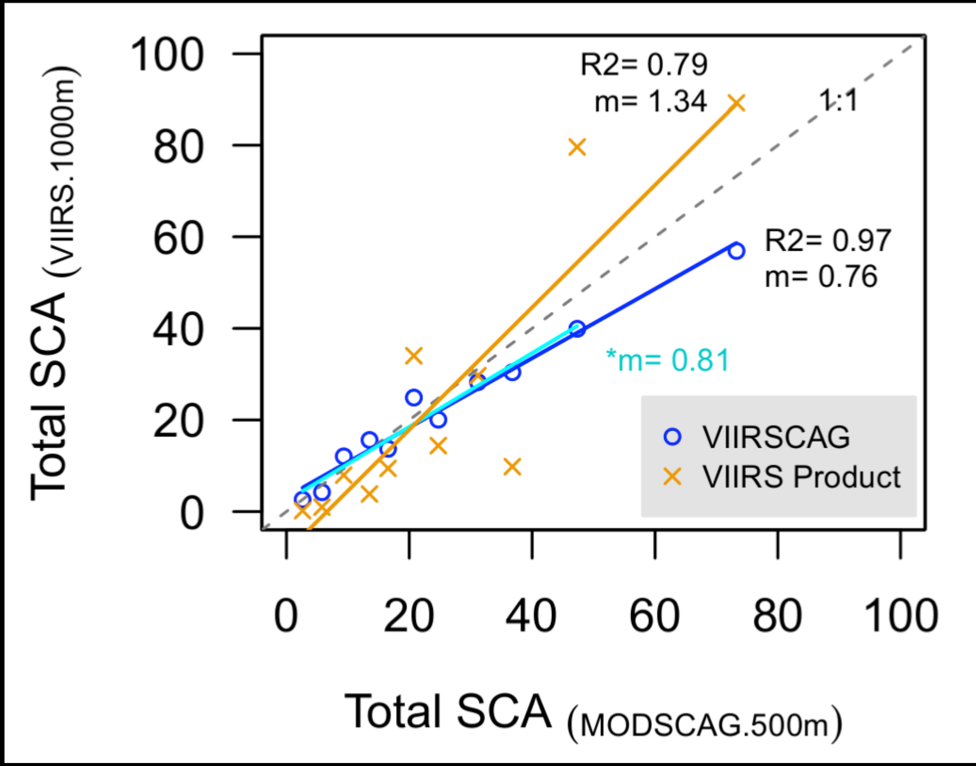
Feb 16, 2014



21% 25% 34%

Total scene % snow cover area

Results – Snow cover area



- Larger variance between MODSCAG & VIIRS Product for snow cover retrieval
- VIIRSSCAG performs better than VIIRS Product, especially when snow is 'fractional'

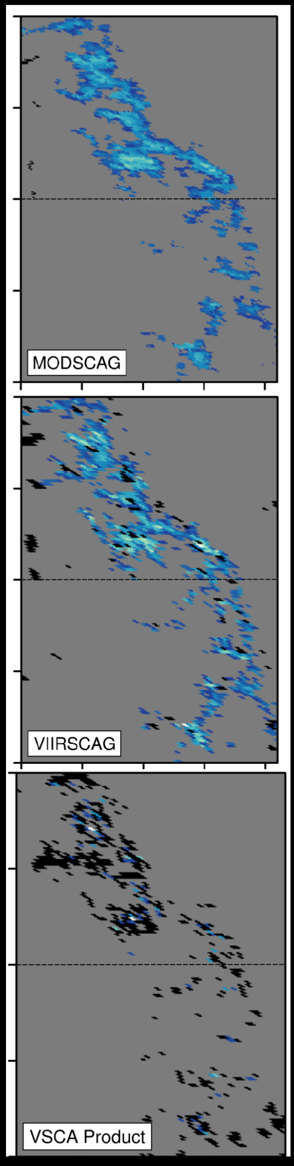
Results – Spatial agreement

- Mean "binary" statistics – TP, TN, FP, FN
- N = 13
- Filter fSCA < 0.15

Results – Spatial agreement

- VIIRSCAG recalls more of the snow pixels
- VIIRS Product hindered by
  - Use of empirical binary mapping (< 50%)
  - Cloud masking issues (well known)
  - < 25% fSCA

	Recall	**Accuracy**	**F-score**	**fSCA RMSE**	**fSCA MAE**
VIIRS fSCA Product	**0.659**	0.924	0.720	0.53	0.46
VIIRSCAG	**0.834**	0.916	0.844	0.24	0.19



Results – Spatial agreement

- Mean accuracies are similar (Probability that a pixel is correctly classified - ↓ 0.78 @ marginal)
- VIIRSCAG reports improved F-score, which balances FP and FN

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Results – Spatial agreement

- An artifact of the VIIRS Product fractional calculation process is a high mean fSCA error
- MODSCAG fSCA and VIIRSCAG fSCA are generally well correlated – matching sensor zenith angles

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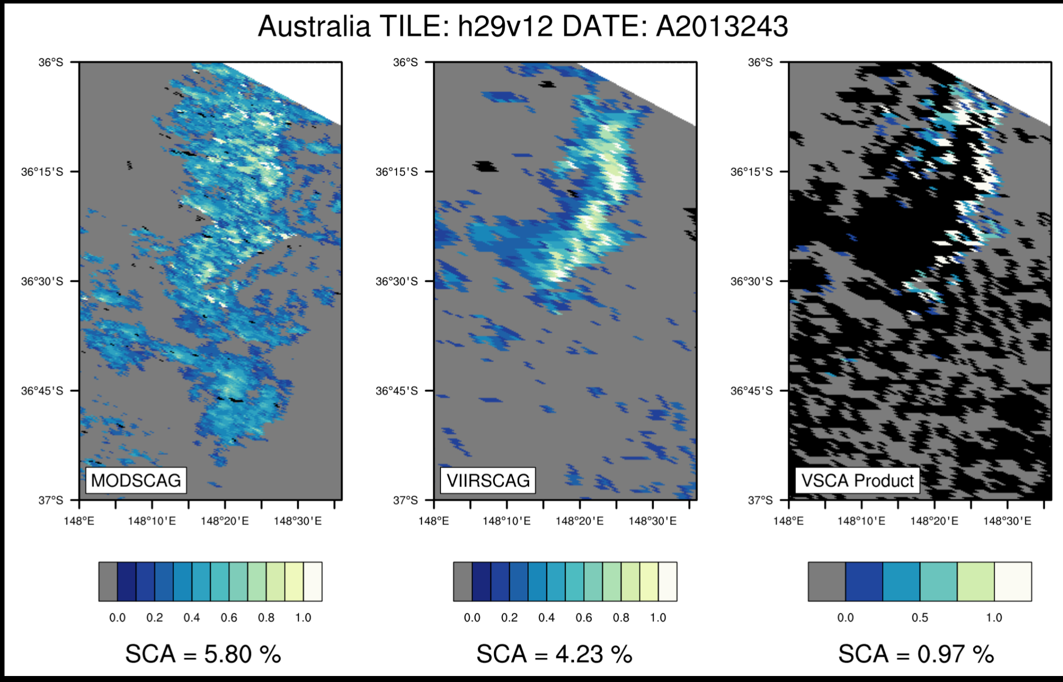
is non-trivial

Discussion

- VIIRS Snow Product performs just as well as SCAG over large fully snow covered areas (100% pixels)
- Value of SCAG is greatest for
  - mixed pixels
  - melting snow (patchy snow with weaker signal)
  - mountain snow areas (smaller areas with snow signal)

Discussion

- But, like MODIS-based products (Bormann et al., 2012), VIIRS Product performance in small, regional snowfields (such as Australia) is poor
  - Largely a cloud masking issue
  - Cloud masking in regions with different snow properties?
  - Also some spectral issues



Conclusions

- Main issues with the VIIRS Product issues are not unexpected
  - Cloud masking
  - Large proportion of mixed pixels
  - Mountainous areas, with large mixed pixel perimeters

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- Main issues with the VIIRS Product issues are not unexpected
  - Cloud masking
  - Large proportion of mixed pixels
  - Mountainous areas, with large mixed pixel perimeters
- Main benefits of spectral unmixing (SCAG)
  - Finer resolution of fractional cover, ‘fringes’ (→ 10%)
  - Performance in spring when snow is receding
  - Vast spectral library provides some resilience to regional differences in snow properties

Future work

- Work with smaller/consistent sensor zenith angles (<20°)
- Evaluate VIIRSCAG with high-resolution snow cover Landsat imagery
- Expand this preliminary evaluation to increase number of scenes
- Reconcile snow cover records with MODIS over common period (2012-present)
- Evaluate other SCAG outputs i.e. vegetation cover and snow grain size

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kathryn.j.bormann@jpl.nasa.gov

Research is currently supported by the NASA Postdoctoral Program

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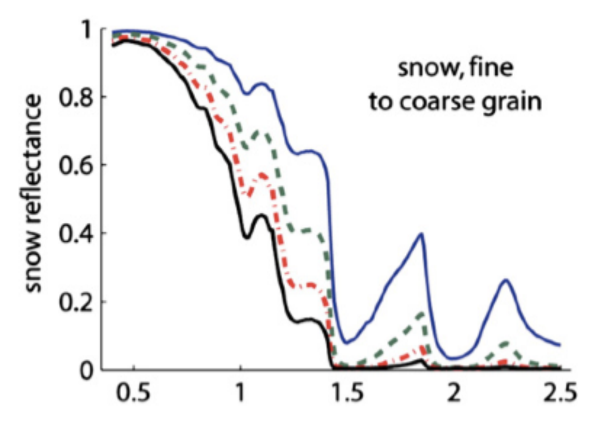
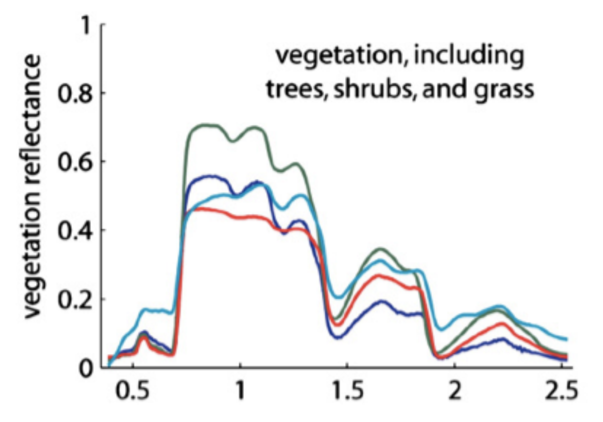
Snow detection algorithms

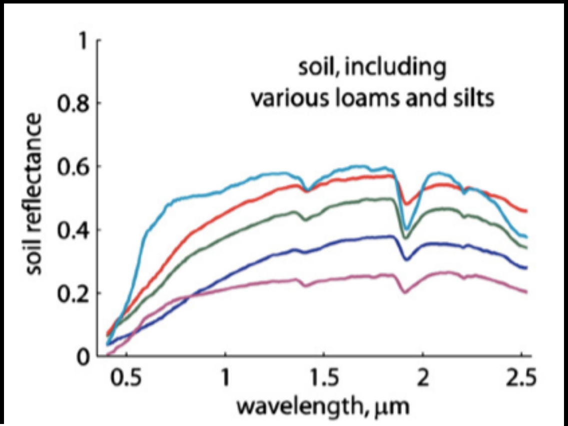
- Snow Cover and Grain size (SCAG)
  - Spectral unmixing algorithm (Painter et al., 2009)



snow

vegetation

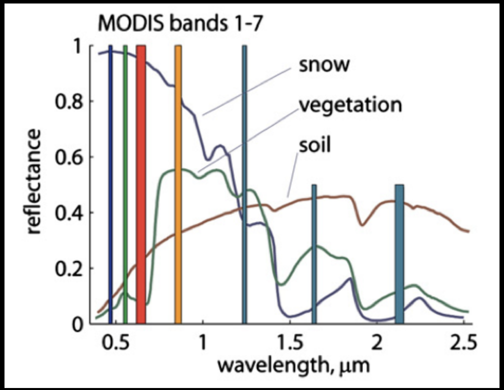




soil

Snow detection algorithms

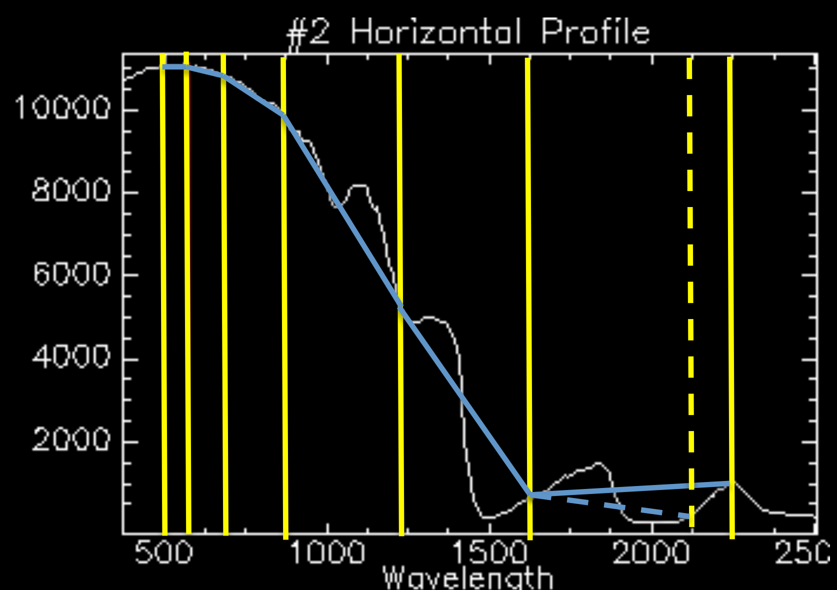
- Snow Cover and Grain size (SCAG)
  - 7-band spectral unmixing algorithm (Painter et al., 2009)



  - MODSCAG evaluated with 172 high resolution Landsat ETM+ scenes average RMSE = 0.10 (Rittger et al., 2012)

Resampling spectral libraries

- High-resolution spectral libraries used for MODSCAG were resampled to VIIRS bandwidths



Evaluation scenes

- Range of viewing angles
  - Affects spectral libraries in SCAG