Should CrIS Be Used to Supplement VIIRS in CERES SNPP Cloud Processing

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Background

• No 6.7 and 13 μm channel on VIIRS
  – MODIS 6.7 and 13 μm used to improve polar nighttime cloud detection
  – MODIS 13 μm used to improve cirrus detection & high CTH retrievals
  – VIIRS cloud mask excludes 6.7, 13 μm tests but utilizes other channels to help compensate

• 1.6 μm band used for VIIRS and MODIS on Terra (but not AQUA)
  – confuses daytime VIIRS/AQUA-MODIS comparisons over snow/ice/desert (instead, compare TERRA MODIS to VIIRS)

• Calibration, spatial resolution differences could also cause inconsistencies
How to achieve consistent MODIS and VIIRS cloud properties for CERES

Options to deal with loss of 6.7, 13 \( \mu \text{m} \)

1. Remove MODIS dependencies on 6.7 & 13 \( \mu \text{m} \) in Ed5
2. Use CrIS to construct 6.7, 13 \( \mu \text{m} \) radiances and map to VIIRS
3. Do what we are doing now and accept channel combination differences between MODIS and VIIRS but work to improve consistency to the extent possible for MODIS Ed5/VIIRS Ed3

Need to assess:

- Current Ed4 MODIS consistency with Ed1 VIIRS
- Impact of removing MODIS 6.7 and 13 \( \mu \text{m} \) on consistency w/VIIRS
- Level of consistency expected by adding CrIS to VIIRS
- When/where these channels have significant impact? Is adding CrIS worth it?
Consistency of MODIS Ed4 and VIIRS Ed1

Assessing 6.7 & 13 µm channel impacts on cloud fraction
Night Time, Cloud Fraction, 2000 02 – 20160 2

Ocean
Non-Polar
Time Series of CloudFraction-Total.Night

Land
Non-Polar Total Phase Night

Ocean+Land
Non-Polar Total Phase Night

Ocean
Polar
Time Series of CloudFraction-Total.Night

Land
Polar Total Phase Night

Ocean+Land
Polar Total Phase Night

Global
Time Series of CloudFraction-Total.Night

Land
Global Total Phase Night

Ocean+Land
Global Total Phase Night

Ocean
Non-Polar
Time Series of CloudFraction-Total.Night

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Polar Total Phase Night

Global
Time Series of CloudFraction-Total.Night

Land
Global Total Phase Night

Ocean+Land
Global Total Phase Night
Assessing 6.7 & 13 µm channel impacts on cloud fraction

Level of consistency and impact of removing MODIS 6.7 and 13 µm channels

Compare different versions for two months:
- Ed4 MODIS (has WV, CO2)
- Ed1 VIIRS (no WV, CO2)
- V1 MODIS (no WV, CO2) - uses VIIRS mask
- NPP-with-CrIS (VIIRS data and MODIS mask)

Test Months: January 2013 and July 2013
One day used to assess VIIRS+ CrIS: Sept 19, 2015
Focus on Polar night (minor impacts found elsewhere)
Cloud Fraction Differences

Terra, Day, Polar Regions

Terra V1 – Terra Ed4
No WV/CO2 vs with WV/CO2

July 2013
Jan 2013

Minor impact polar daytime except cold Antarctic plateau
Cloud Fraction Differences
Terra, Night, Polar Regions
Terra V1 – Terra Ed4
No WV/CO2 vs with WV/CO2

Big impact polar night over Land, some sea-ice regions
Assessing 6.7 & 13 μm channel impacts on cloud fraction

Consistency of
MODIS Ed4 and VIIRS Ed1+ CrIS
Cloud Fraction Differences
Terra, Night, S. Polar Regions

Adding CrIS WV/CO2 information to VIIRS

NPP-with-Cris minus Aqua-Ed4

NPP V1 minus Aqua-Ed4

Large difference for NPP with and without WV/CO2 compared to AQUA Ed4
- temporal mismatches possible tho
Cloud Fraction Differences
Terra, Night, S. Polar Regions

Adding CrIS WV/CO2 information to VIIRS

NPP-with-CrIS minus Aqua-Ed4

NPP Ed1 minus Aqua-Ed4

Time matched data compare better with CrIS but still some significant differences
- Aqua 3.9 um calibration problem for cold scenes could also be in play
Cloud Fraction Differences
Terra, Night, N. Polar Regions

Adding CrIS WV/CO2 information to VIIRS

NPP-with-CrIS minus Aqua-Ed4
NPP Ed1 minus Aqua-Ed4

Similar story for north pole; CrIS does not appear to add much value for this case
Assessing 6.7 & 13 μm channel impacts on cloud fraction

What does CALIPSO say?

Do MODIS clouds compare significantly better to CALIPSO with WV/CO2 than without

Compare AQUA Ed4 and V1 (no CO2/WV) To CALIPSO
Cloud Detection Statistics vs CALIOP

Jan 2013 Night (mostly north polar)

<table>
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<th>Version</th>
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<th>HR</th>
<th>FAR</th>
<th>HSS</th>
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Snow/ice free

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Snow/ice covered

July 2013 Night (mostly south polar)

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Snow/ice free

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<td>0.74</td>
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<td>0.138</td>
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</table>

Snow/ice covered

Excellent and similar agreement with CALIOP for Ed4 and V1 (no snow/ice)

Poorer agreement with CALIOP and slightly better for Ed4 vs V1 (over snow/ice)
Summary

• WV/CO2 channels have mostly minor impact everywhere except polar night over snow/ice surfaces
• Is this problem worth fixing by bringing in CrIS?
• Only one day of CrIS differences analyzed but problems remain!
• Validation with CALIPSO also indicates very modest improvements with WV/CO2 channels at polar night where skill is already relatively poor
• For cloud fraction, probably could live without CO2/WV
• BUT, WV channel critical for new nighttime algorithm, helping in neural net multilayer algorithm and improved cloud thickness parameterizations

WHAT SHOULD WE DO?
Backups
Ed4/Ed1 comparison affected by diurnal cycle

Minor non-polar WV, CO2 channel impacts except tropics, Saudi.

Arctic land affected more than ocean by co2/wv removal
Non-polar ocean Ed4/Ed1 diffs larger for Aqua than Terra (6.7 problem, diurnal cycle dampen Terra diffs?)

Minor non-polar WV, CO2 channel impacts except tropics, Saudi

Polar impact large over land.
Due to 1.6 issue in Aqua, can only do night time Aqua snow-free.