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

B. Smith, S. Sun-Mack, C. Yost, Q. Trepte, P.Minnis

Background

- No 6.7 and 13 um channel on VIIRS
  - MODIS 6.7 and 13 μm used to improve polar nighttime cloud detection
  - MODIS 13 um 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 μm

1. Remove MODIS dependencies on 6.7 & 13 μm in Ed5
2. Use CrIS to construct 6.7, 13 μm 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 μm 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?

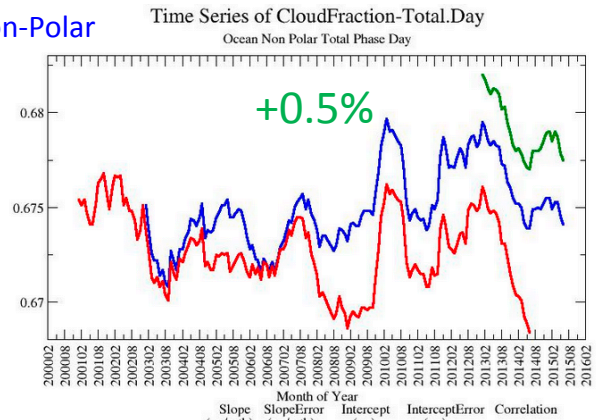
Assessing 6.7 & 13 μm channel impacts on cloud fraction

Consistency of
MODIS Ed4 and VIIRS Ed1

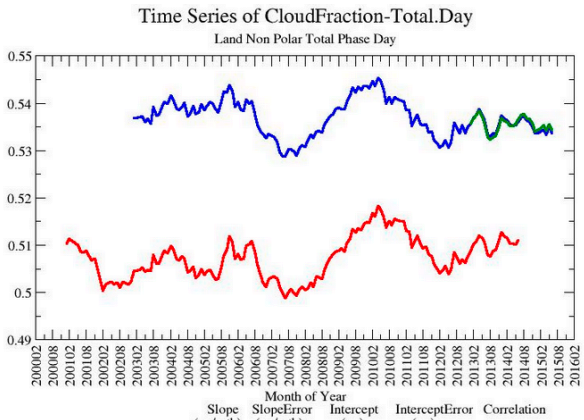
Day Time, Cloud Fraction, 2000 02 – 20160 2

Ocean | Land | Ocean+Land

Non-Polar



	Slope (nu/mth)	SlopeError (nu/mth)	Intercept (nu)	InterceptError (nu)	Correlation
AquaEd4	0.000029	0.000003	0.672809	0.000274	0.594651
TerraEd4	-0.000010	0.000003	0.673523	0.000313	-0.235955
SNPPEd1A	-0.000128	0.000021	0.680927	0.000361	-0.747971



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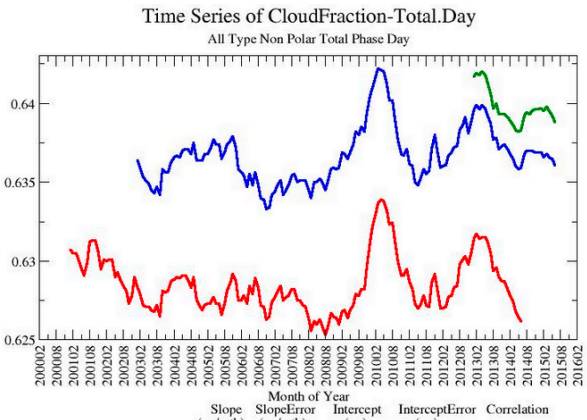
AquaEd4	-0.000022	0.000007	0.538511	0.000600	-0.248596
TerraEd4	0.000038	0.000007	0.504310	0.000629	0.407172
SNPPEd1A	-0.000025	0.000033	0.535899	0.000557	-0.140619



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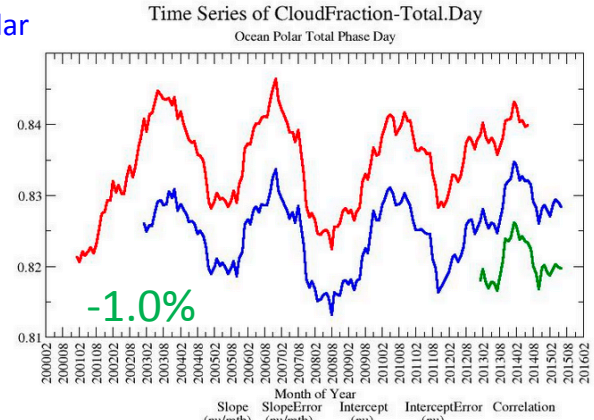
AquaEd4	0.000015	0.000003	0.635576	0.000274	0.363012
TerraEd4	0.000002	0.000003	0.628334	0.000278	0.055135
SNPPEd1A	-0.000083	0.000018	0.640983	0.000310	-0.651803

Polar



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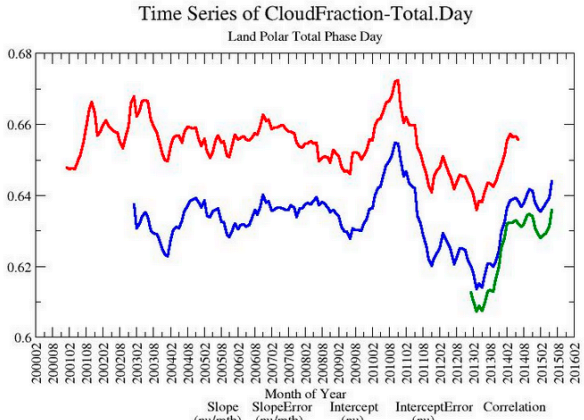
AquaEd4	0.000019	0.000009	0.823618	0.000797	0.164315
TerraEd4	0.000033	0.000010	0.831960	0.000952	0.246206
SNPPEd1A	0.000033	0.000060	0.820105	0.001006	0.104814



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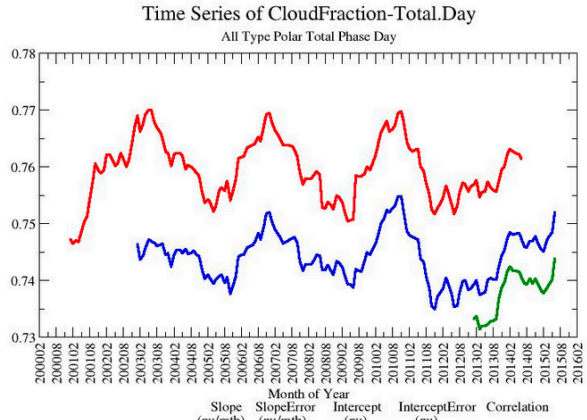
AquaEd4	-0.000013	0.000014	0.634490	0.001241	-0.076105
TerraEd4	-0.000064	0.000011	0.659669	0.000986	-0.432946
SNPPEd1A	0.000959	0.000113	0.610334	0.001906	0.848940



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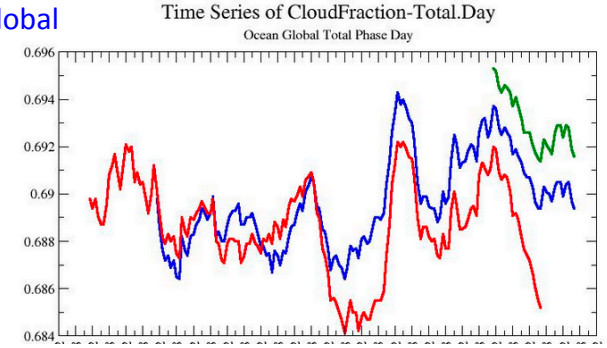
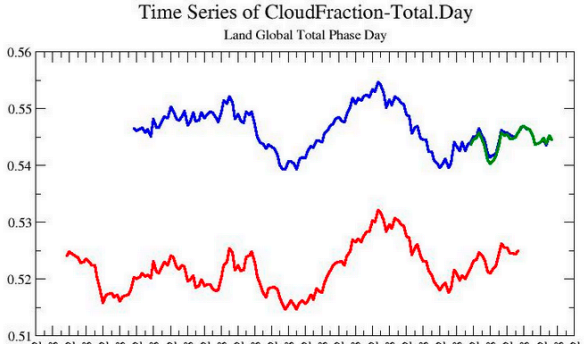
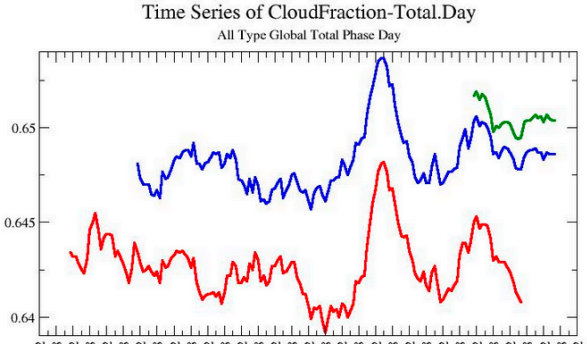
AquaEd4	-0.000005	0.000008	0.744622	0.000687	-0.052704
TerraEd4	-0.000008	0.000009	0.760175	0.000847	-0.065080
SNPPEd1A	0.000312	0.000055	0.733330	0.000927	0.731487

Global



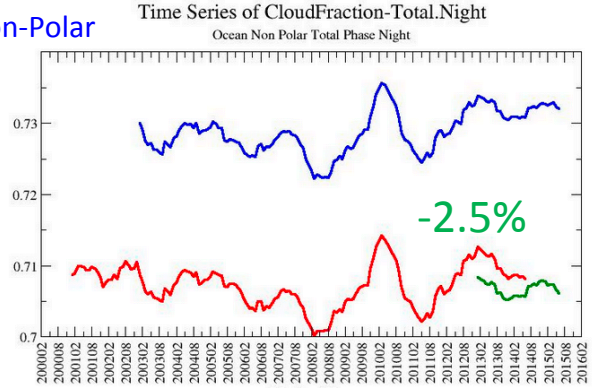




Night Time, Cloud Fraction, 2000 02 – 20160 2

Ocean

Non-Polar



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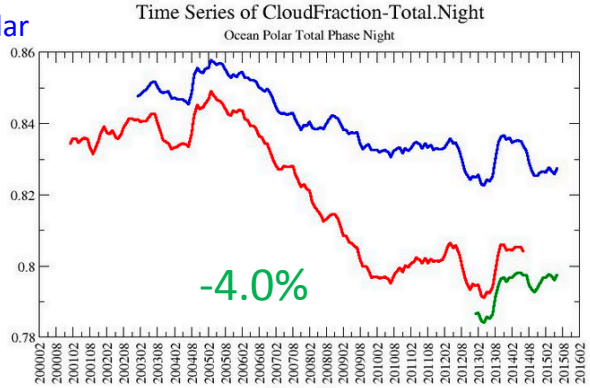
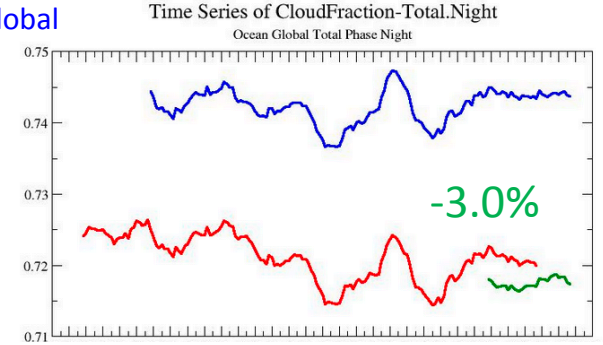
AquaEd4	0.000034	0.000005	0.726243	0.000435	0.488880
TerraEd4	0.000002	0.000005	0.707141	0.000465	0.025213
SNPPEd1A	-0.000005	0.000021	0.706892	0.000356	-0.046873

Polar

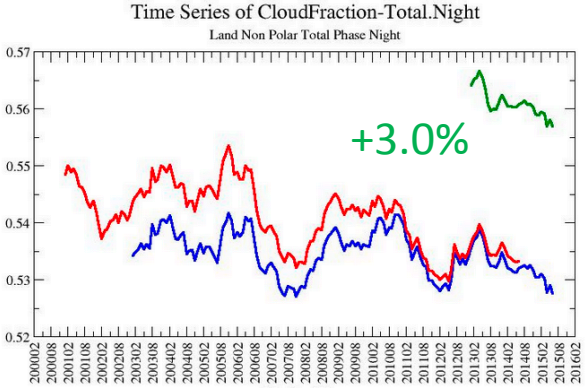


	Slope (nu/mth)	SlopeError (nu/mth)	Intercept (nu)	InterceptError (nu)	Correlation
AquaEd4	-0.000197	0.000008	0.854190	0.000716	-0.889413
TerraEd4	-0.000344	0.000015	0.848454	0.001373	-0.879068
SNPPEd1A	0.000395	0.000070	0.787876	0.001180	0.730140

Global



Land



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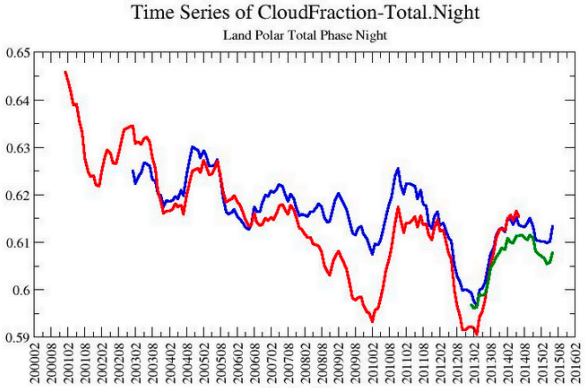
AquaEd4	-0.000033	0.000007	0.537177	0.000572	-0.379829
TerraEd4	-0.000078	0.000007	0.547326	0.000675	-0.650079
SNPPEd1A	-0.000226	0.000030	0.564344	0.000502	-0.821552



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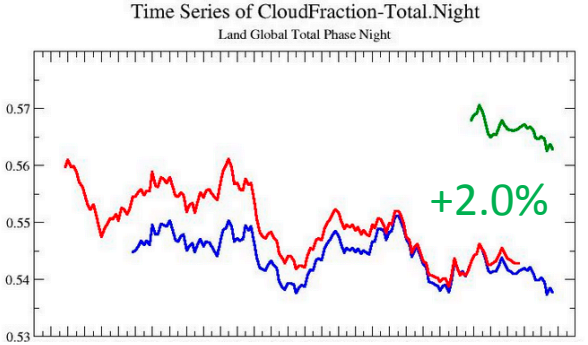
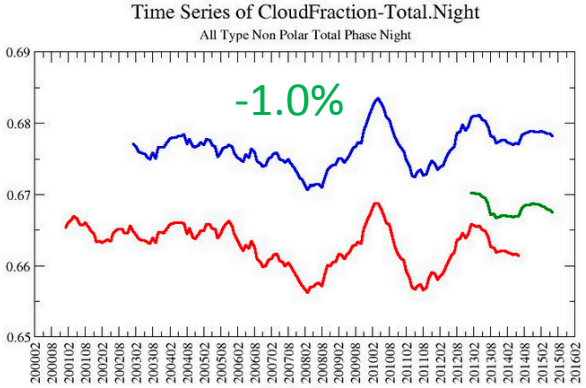
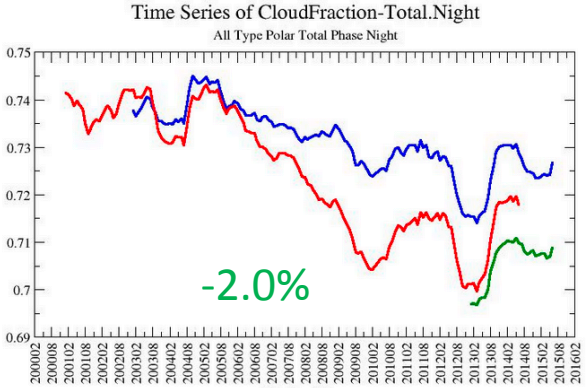
AquaEd4	-0.000108	0.000010	0.624168	0.000841	-0.671789
TerraEd4	-0.000197	0.000012	0.630905	0.001154	-0.782209
SNPPEd1A	0.000378	0.000079	0.600797	0.001334	0.670509



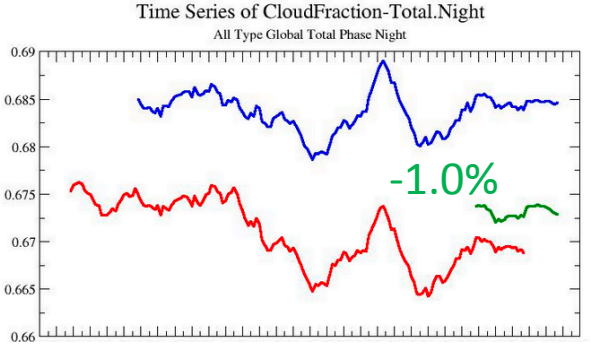
Ocean+Land



	Slope (nu/mth)	SlopeError (nu/mth)	Intercept (nu)	InterceptError (nu)	Correlation
AquaEd4	0.000017	0.000005	0.675227	0.000413	0.280975
TerraEd4	-0.000024	0.000005	0.664722	0.000428	-0.381721
SNPPEd1A	-0.000044	0.000023	0.668799	0.000382	-0.345123



	Slope (nu/mth)	SlopeError (nu/mth)	Intercept (nu)	InterceptError (nu)	Correlation
AquaEd4	-0.000131	0.000008	0.741078	0.000672	-0.810204
TerraEd4	-0.000241	0.000011	0.744076	0.001014	-0.868553
SNPPEd1A	0.000366	0.000073	0.700577	0.001233	0.688026



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

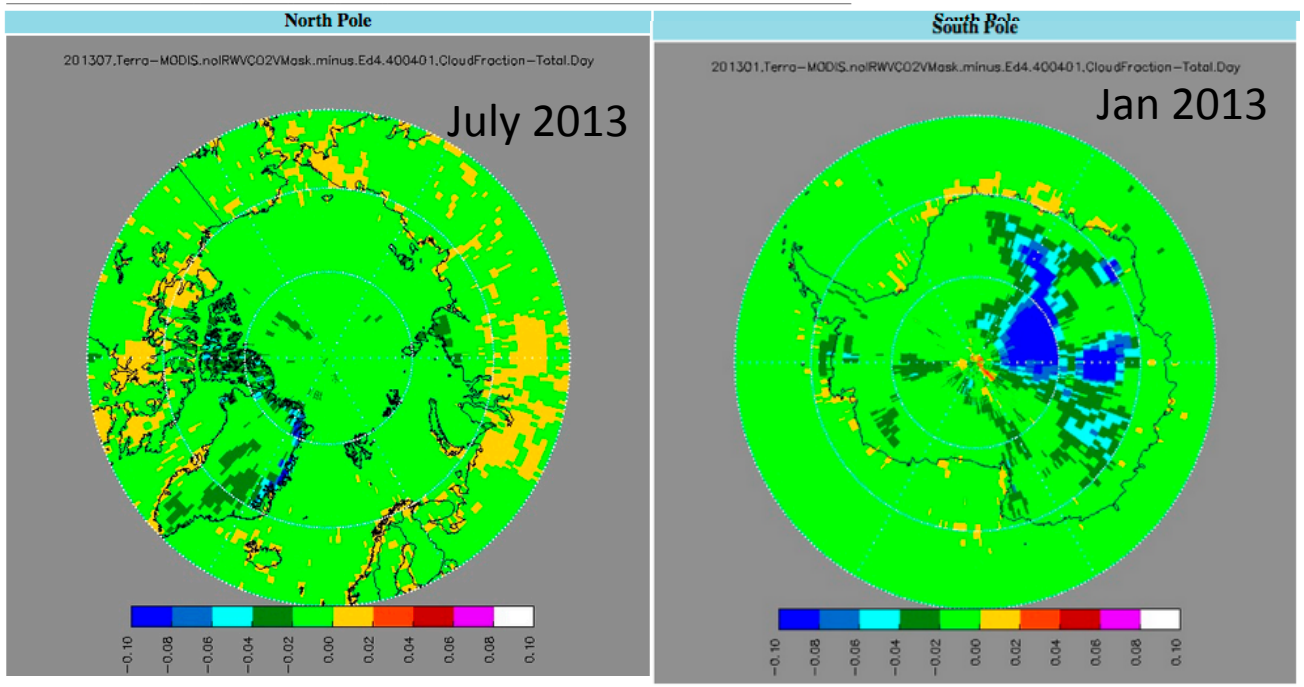
One day used to assess VIIRS+ CrIS: Sept 19, 2015

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

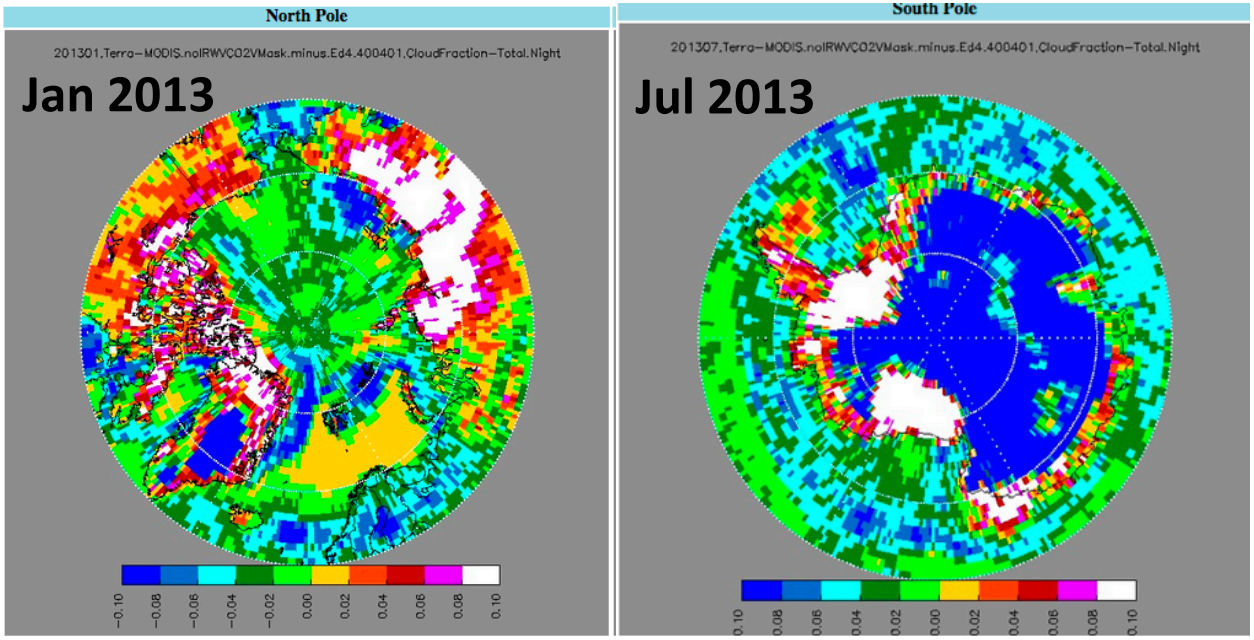


Minor impact polar daytime except cold Antarctic plateau

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

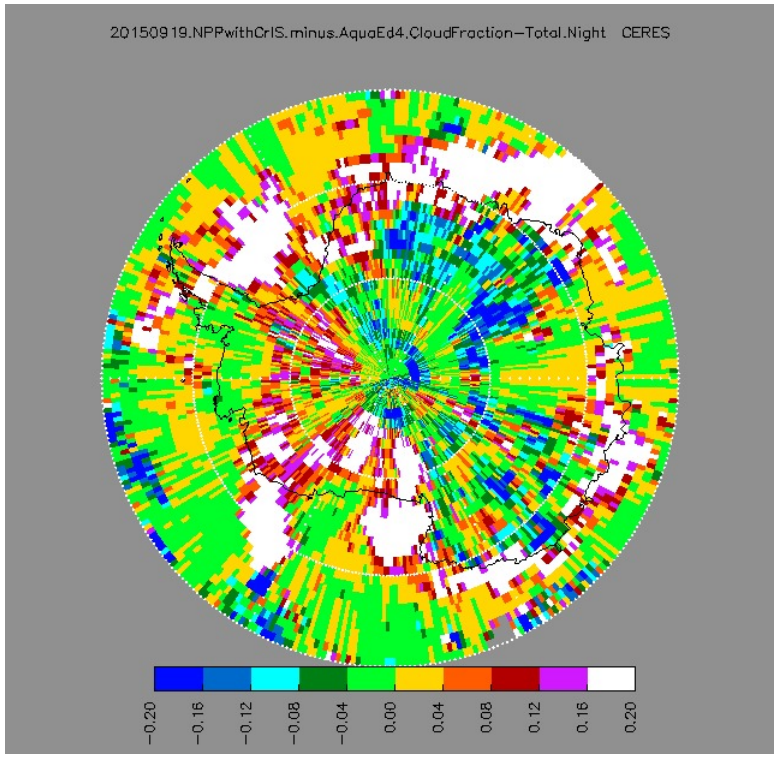
Consistency of
MODIS Ed4 and VIIRS Ed1+ CrIS

Cloud Fraction Differences

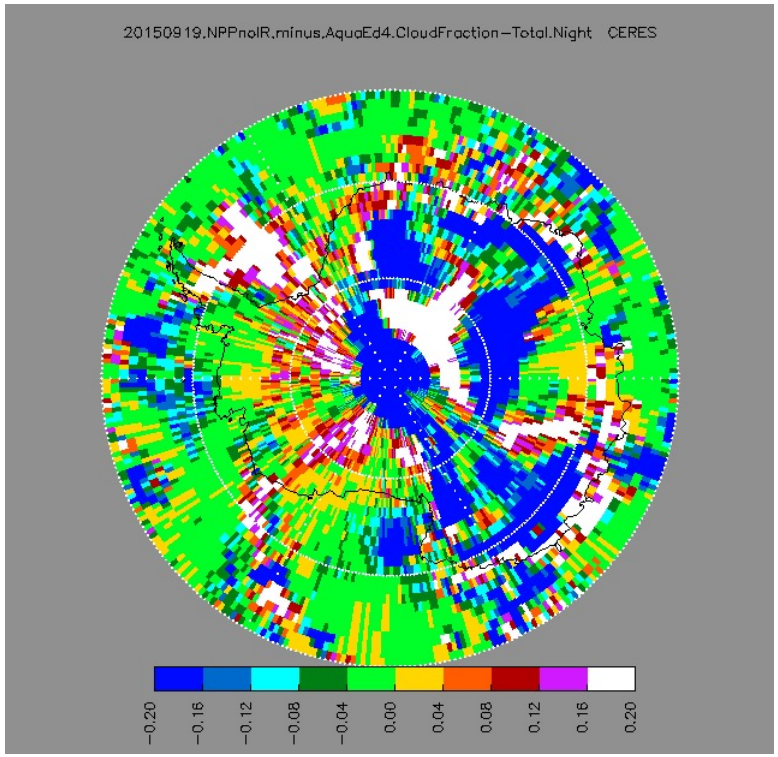
Terra, Night, S. Polar Regions

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

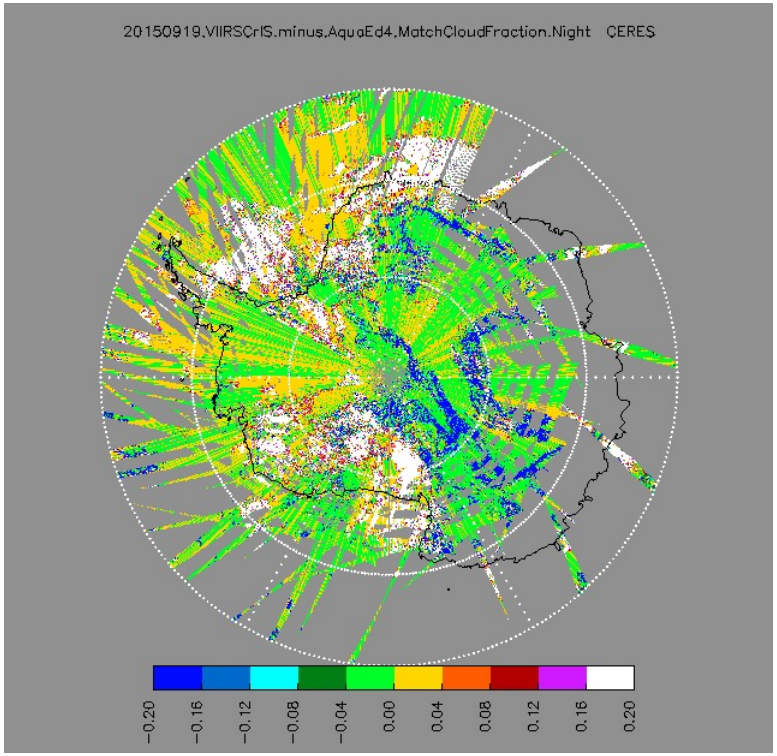
- temporal mismatches possible tho

Cloud Fraction Differences

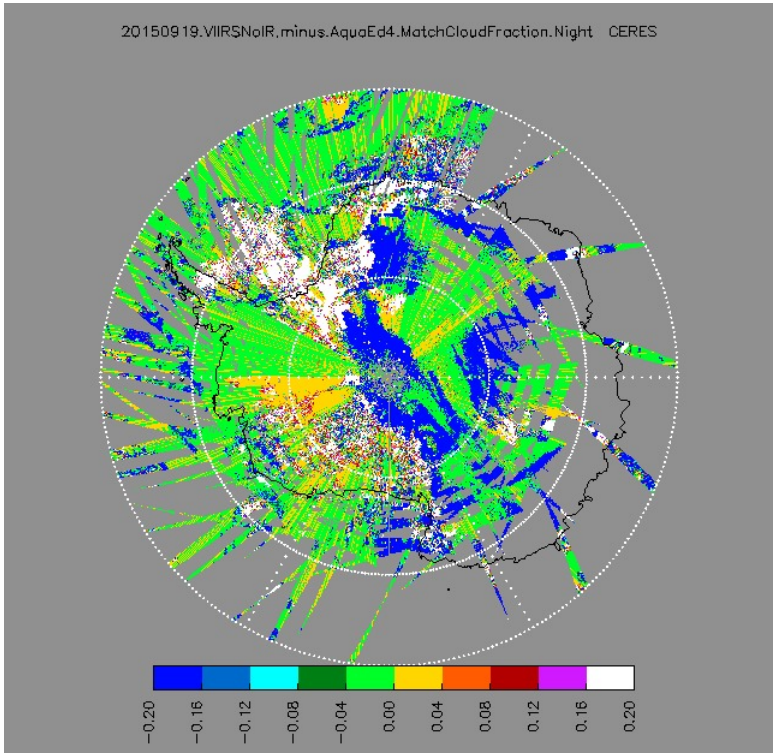
Terra, Night, S. Polar Regions

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

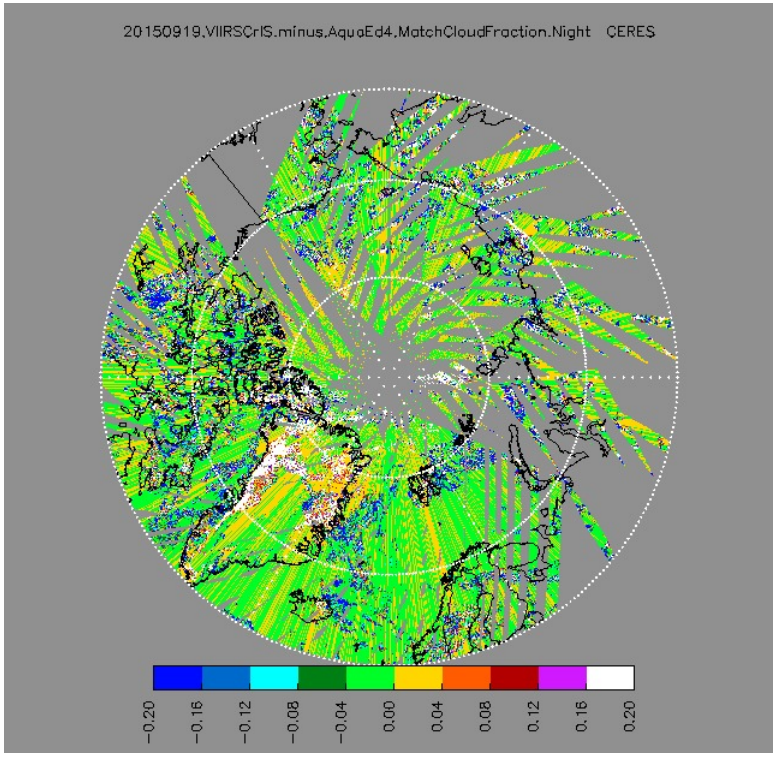
- Aqua 3.9 um calibration problem for cold scenes could also be in play

Cloud Fraction Differences

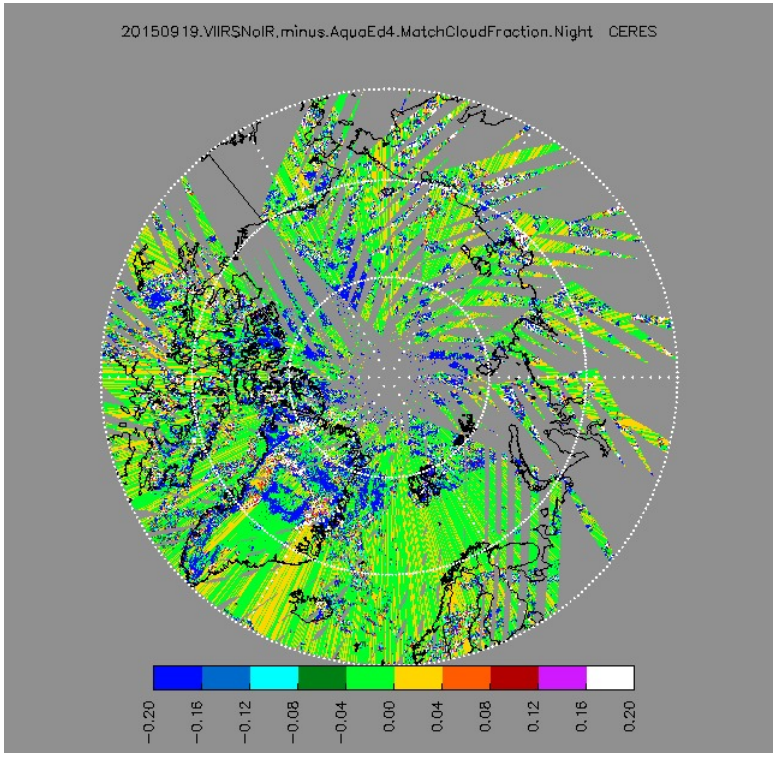
Terra, Night, N. Polar Regions

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)

Snow/ice free

Version	FC	HR	FAR	HSS
Ed4	0.93	0.94	0.011	0.53
V1	0.92	0.93	0.012	0.49

Snow/ice covered

Version	FC	HR	FAR	HSS
Ed4	0.78	0.73	0.016	0.56
V1	0.75	0.67	0.018	0.50

July 2013 Night (mostly south polar)

Snow/ice free

Version	FC	HR	FAR	HSS
Ed4	0.89	0.91	0.058	0.69
V1	0.89	0.91	0.058	0.68

Snow/ice covered

Version	FC	HR	FAR	HSS
Ed4	0.78	0.77	0.134	0.55
V1	0.74	0.69	0.138	0.47

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

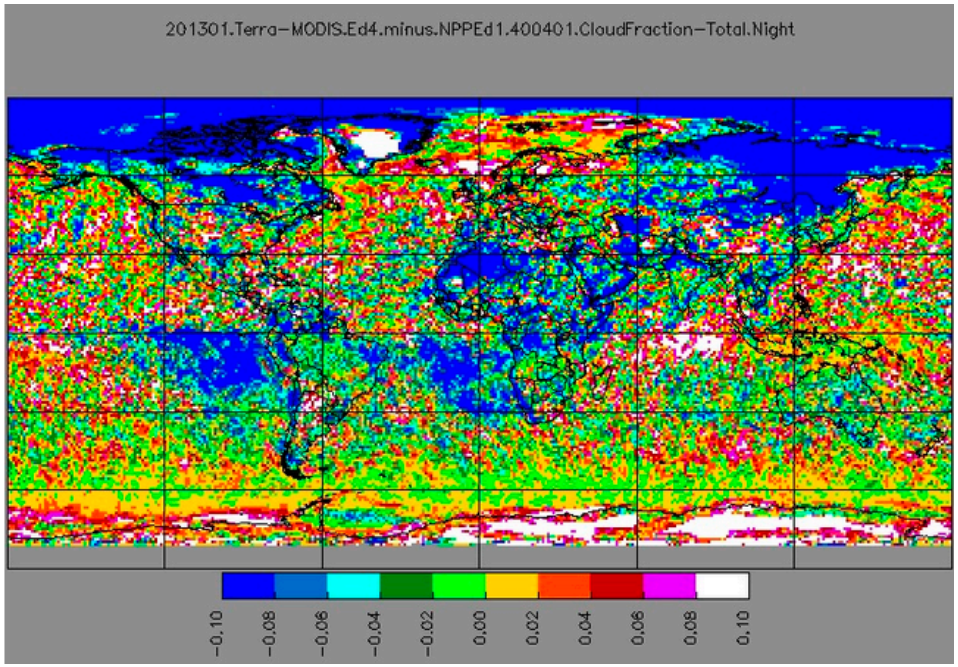
WHAT SHOULD WE DO?

Backups

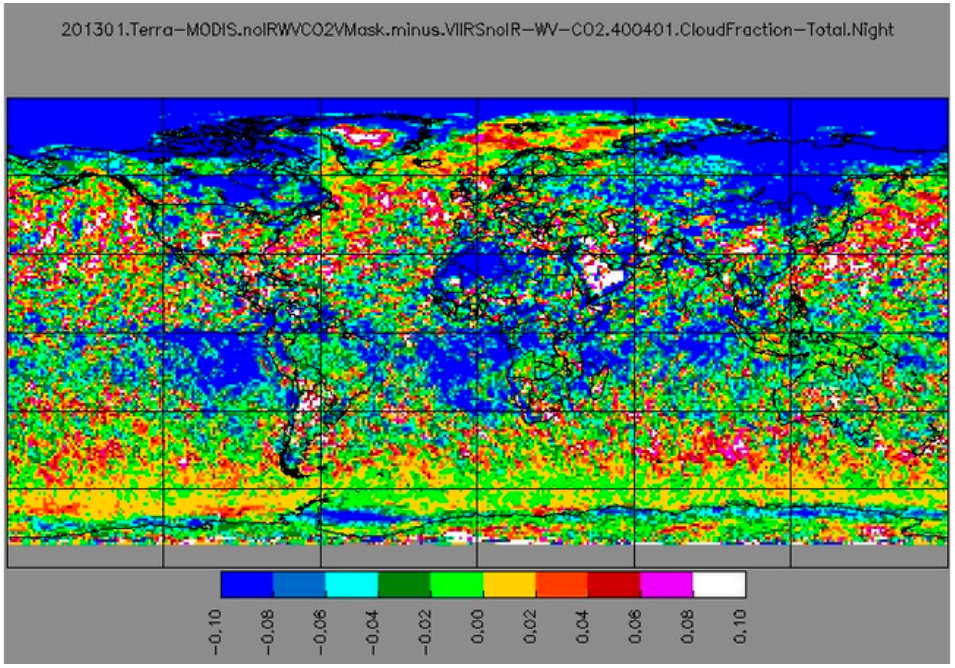
Terra, Night

CF, **Night**, January 2013

Terra Ed4 - NPP Ed1



Terra V1 – NPP Ed1

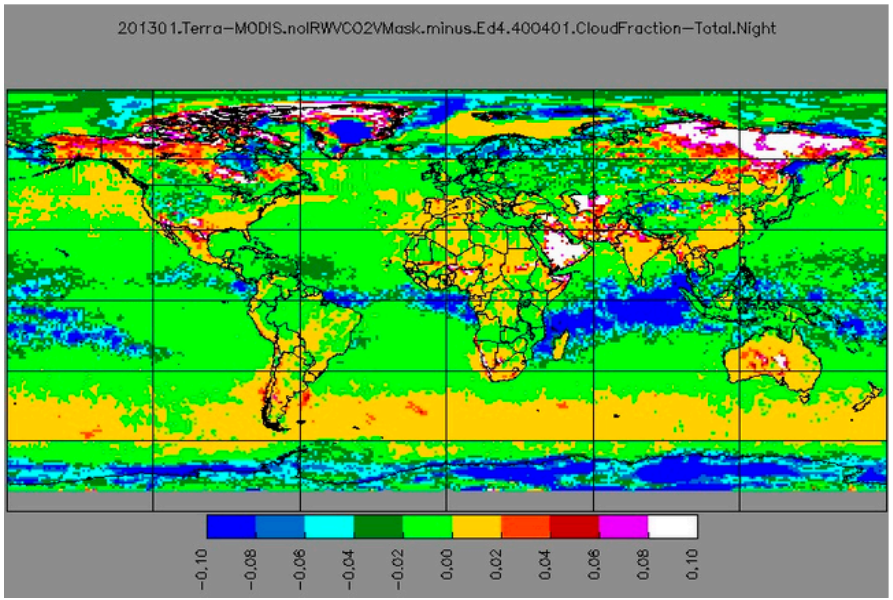


Ed4/Ed1 comparison affected by diurnal cycle

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

Arctic land affected more than ocean by co2/wv removal

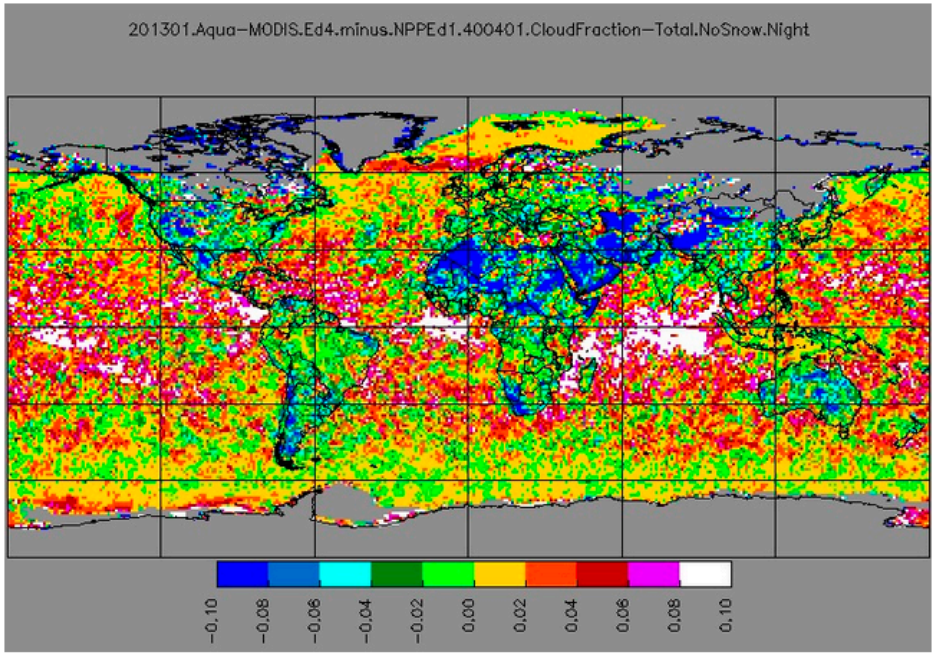
Terra V1 – Terra Ed4



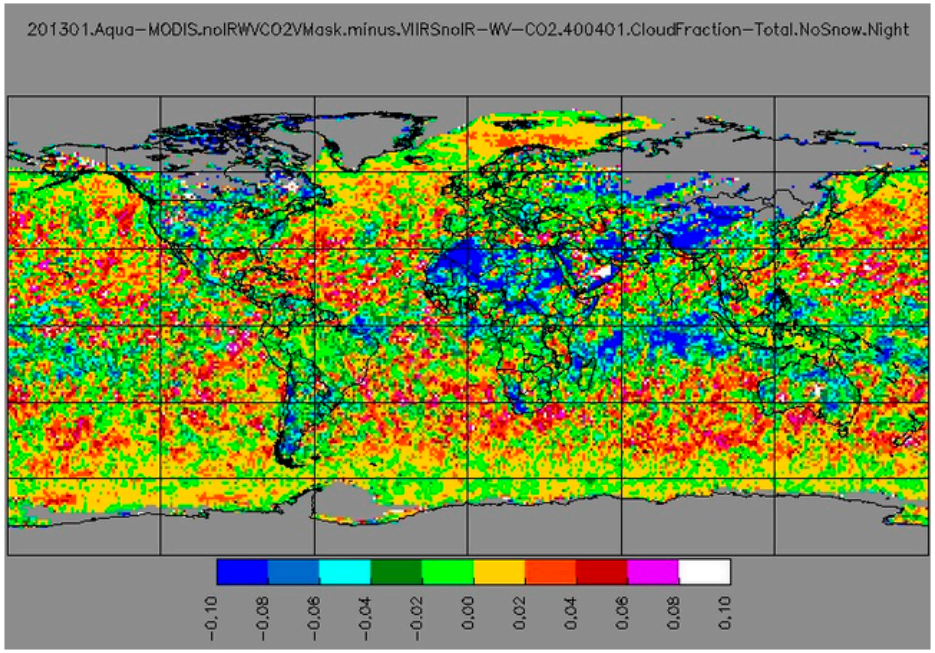
Aqua, Night

CF, **Night**, January 2013

Aqua Ed4 – NPP Ed1



Aqua V1 – NPP Ed1

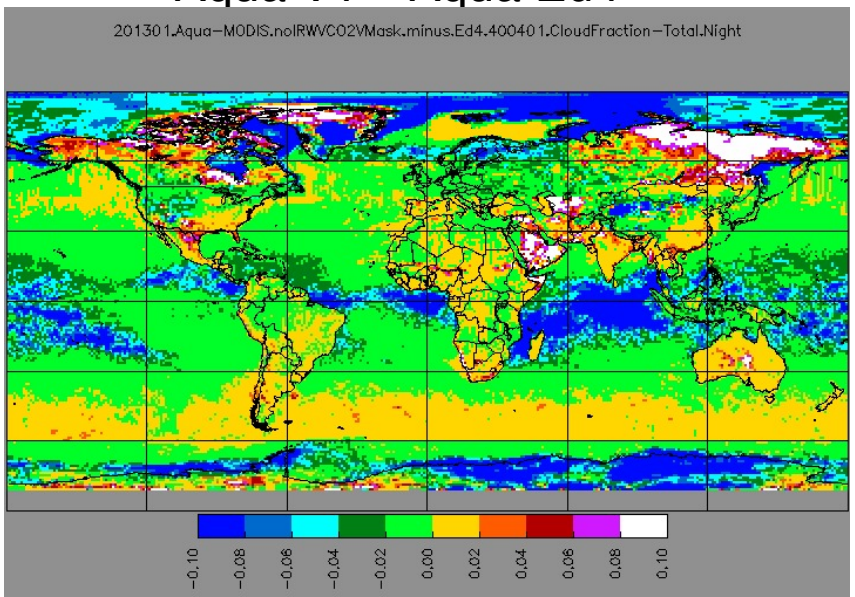


Non-polar ocean Ed4/Ed1 diffs larger for Aqua than Terra (6.7 problem, diurnal cycle dampen Terra diffs?)

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

Polar impact large over land.

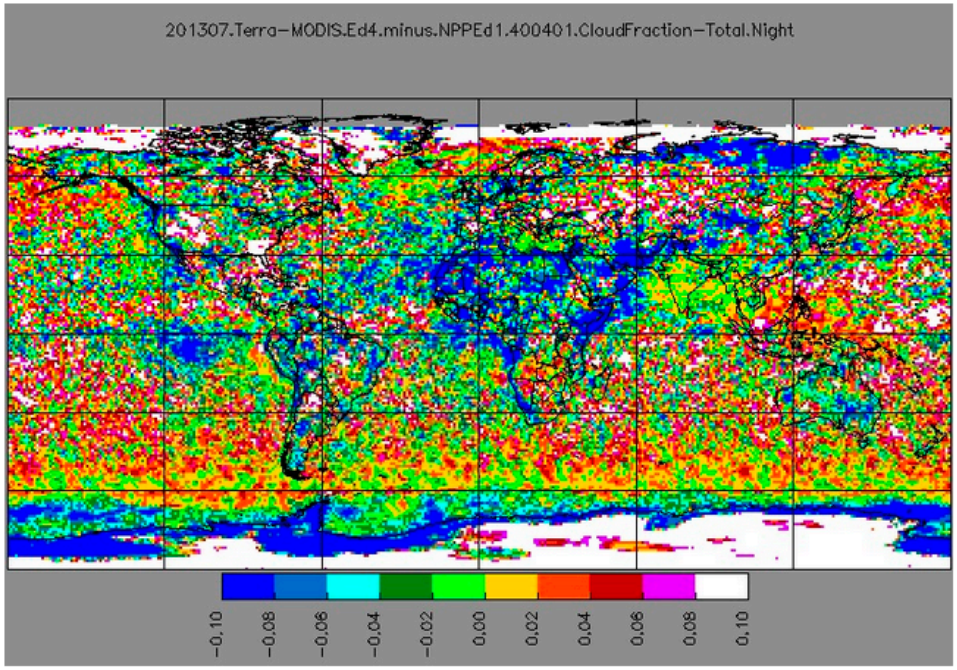
Aqua V1 – Aqua Ed4



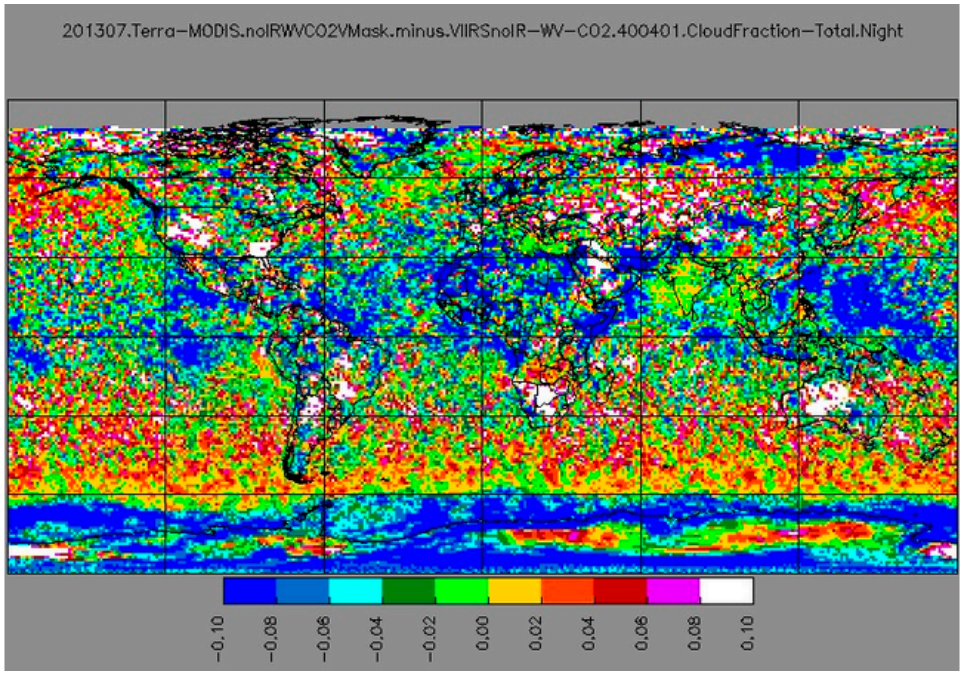
Terra, Night

CF, **Night**, July 2013

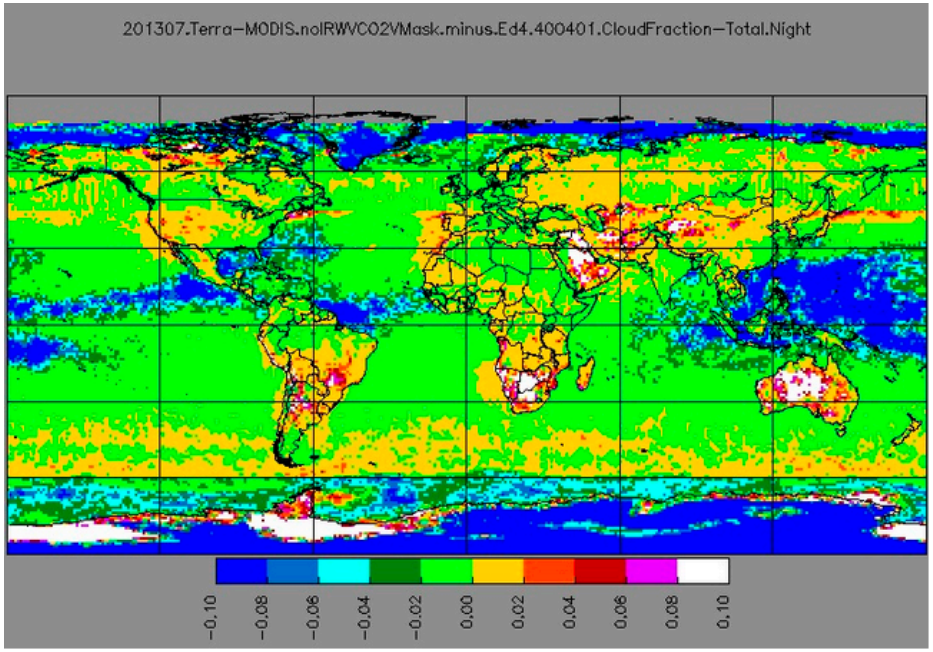
Terra Ed4 – NPP Ed1



Terra V1 – NPP Ed1



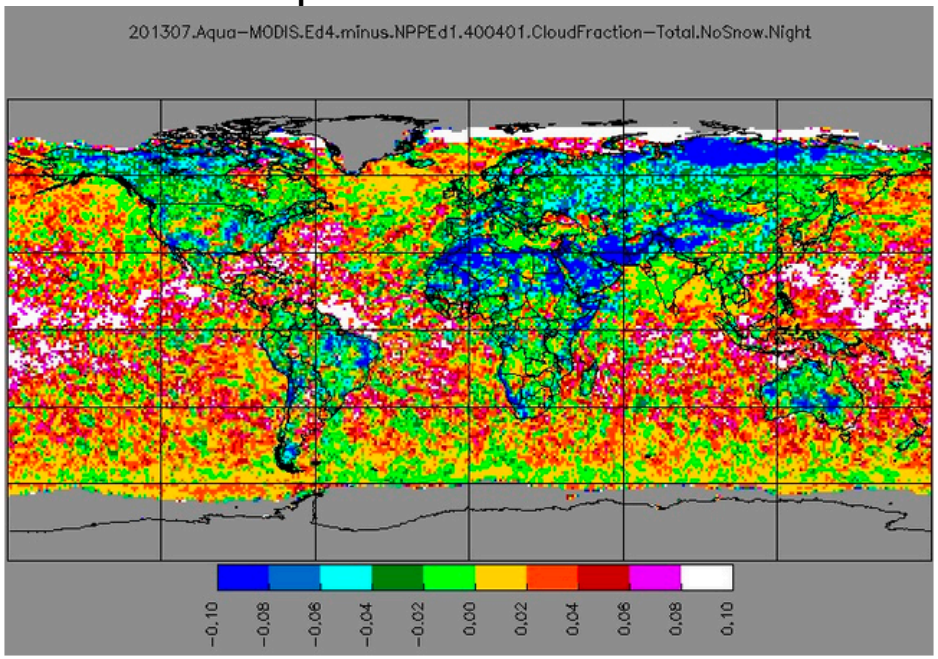
Terra V1 – Terra Ed4



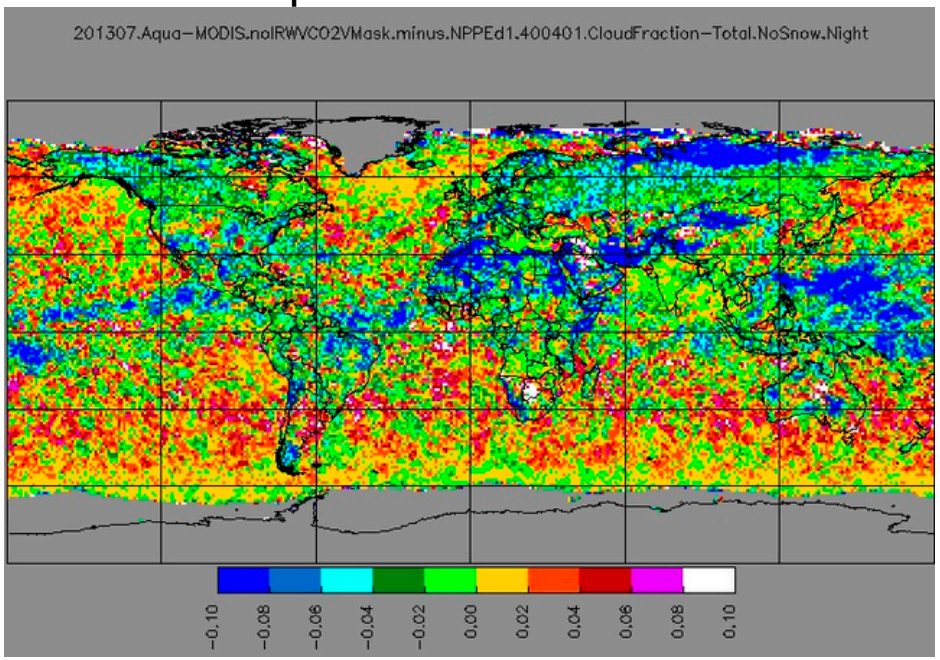
Aqua, Night, Snow-free

CF, **Night**, July 2013

Aqua Ed4 – NPP Ed1



Aqua V1 – NPP Ed1



Aqua V1 – Aqua Ed4

Due to 1.6 issue in Aqua, can only do night time Aqua snow-free.