Vicarious “Calibration” WS, 2-3/12/2013
ESRIN

IR Vicarious Interband Relative Adjustment for MERIS

Jean-Paul Huot, ESA-ESTEC

Constant Mazeran*, ACRI-ST

*now at SOLVO

The Way which is really the Way is not a constant way

The names (of things) which are really the names are not constant names

Lao-Tseu

IR Vicarious Interband Relative Adjustment

Principle

Radiometric signal must be consistent with the physical assumptions made about what it should look like:

If $\rho_{toa} = \rho_R + \rho_{res}$,

where ρ_{res} is simply the difference between ρ_{toa} and ρ_R

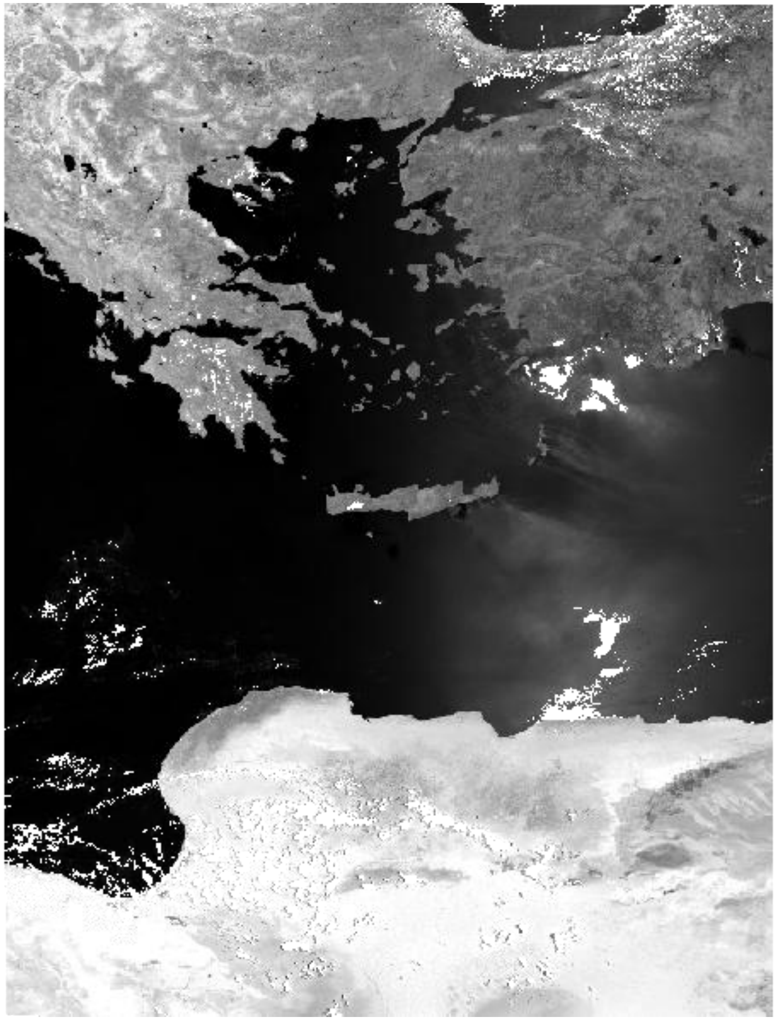
once ρ_R has been tabulated, ρ_{toa} must satisfy the assumptions made about the specral dependence of ρ_{res}.

There will be as many VC as they are Rayleigh tables

There will be as many VC as there are hypotheses about the spectral dependence of ρ_{res}

IR Vicarious Interband Relative Adjustment

ρ_{toa} (865)
22-06-2013



IR Vicarious Interband Relative Adjustment

Outside the glint, residual is mostly aerosol signal

$$\rho_{res}(\lambda) = \rho_0 (\lambda/\lambda_0)^{\alpha} = \rho_0 (1+\eta)^{\alpha}, \quad \text{with } \eta = (\lambda-\lambda_0)/\lambda_0$$

Inside the glint, the residual is mostly glint

$$\rho_{res}(\lambda) = \rho_G\, t_R(\lambda) t_a(\lambda) \quad \text{, with}$$

$$t_R(\lambda) = \exp[-(p_{ecmwf}/1013)\, \tau_R(\lambda)],$$

$$t_a(\lambda) = \exp[-M\, \tau_a(\lambda)]$$

IR Vicarious Interband Relative Adjustment

Outside the glint, linearizing around λ_0, i.e. making the assumption $\eta << 1$,

$$\rho_0 (1+\eta)^\alpha \approx \rho_0 [1+ \alpha \eta + (1/2)\alpha(\alpha-1)\eta^2]$$
$$\approx \rho_0 [1+ \alpha(\eta - \eta^2)]$$

Then, for any two wavelengths i, j

$$[1+ \alpha(\eta_i - \eta_i^2)]/[1+ \alpha(\eta_j - \eta_j^2)] = \rho_{res} (\lambda_i) / \rho_{res} (\lambda_j)$$, and

$$\alpha = [\rho_{res} (\lambda_i) - \rho_{res} (\lambda_j)]/[\rho_{res} (\lambda_j) (\eta_i - \eta_i^2) - \rho_{res} (\lambda_i) (\eta_j - \eta_j^2)]$$

Supposing, **for instance,** that the residual slope between bands i, j is correct, then for any band k, the residual at band k should satisfy

$$\rho^*_{res} (\lambda_k) = \rho_{res} (\lambda_n)[1+ \alpha(\eta_k - \eta_k^2)]/)(1+ \alpha(\eta_n - \eta_n^2)]$$, with n =i or j.

IR Vicarious Interband Relative Adjustment

The vicarious adjustment gain for band k ≠ i or j is then

$$G_{vk} = [\rho^*_{res}(\lambda_k) + \rho_R(\lambda_k)] / \rho_{toa}(\lambda_k)$$

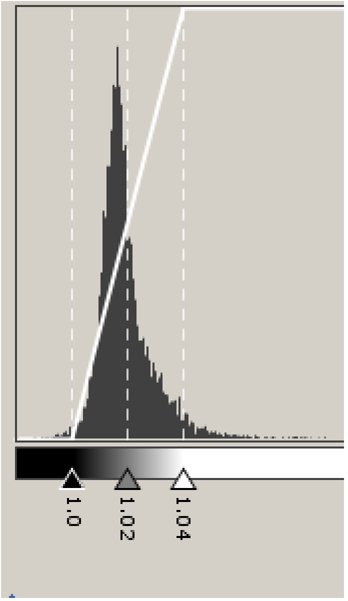
Examples for the NIR.

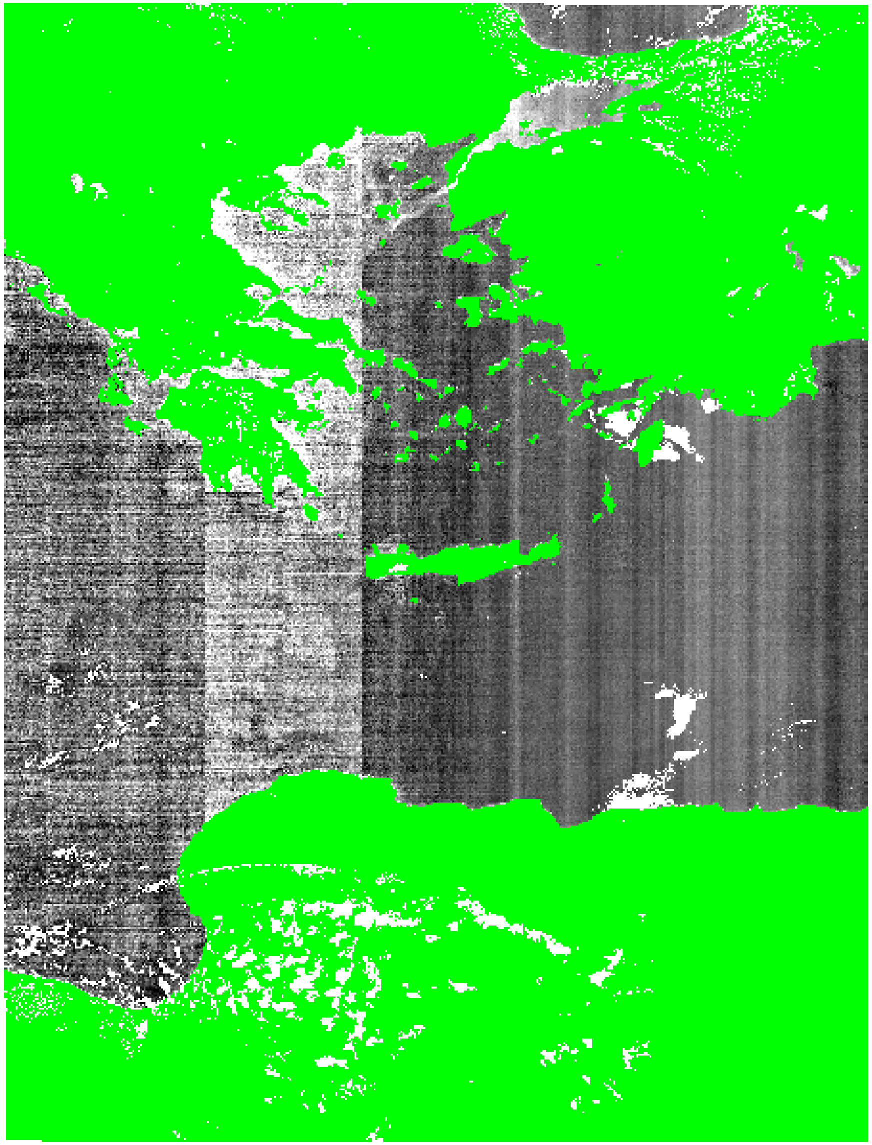
Assume numbering of MERIS bands, i. e., $\lambda_9 = 708.75$ nm $\lambda_{10} = 753.75$ nm, $\lambda_{12} = 778.75$ nm, $\lambda_{13} = 865$ nm, $\lambda_{14} = 885$ nm, take bands 10 and 12 as reference*, compute G_{v13}

*why? 1) it infuriates some of my collegues, 2) it makes things look more dramatic, 3) it is difficult to do least square fitting in BEAM, 4) it is as arbitrary as other choices

IR Vicarious Interband Relative Adjustment

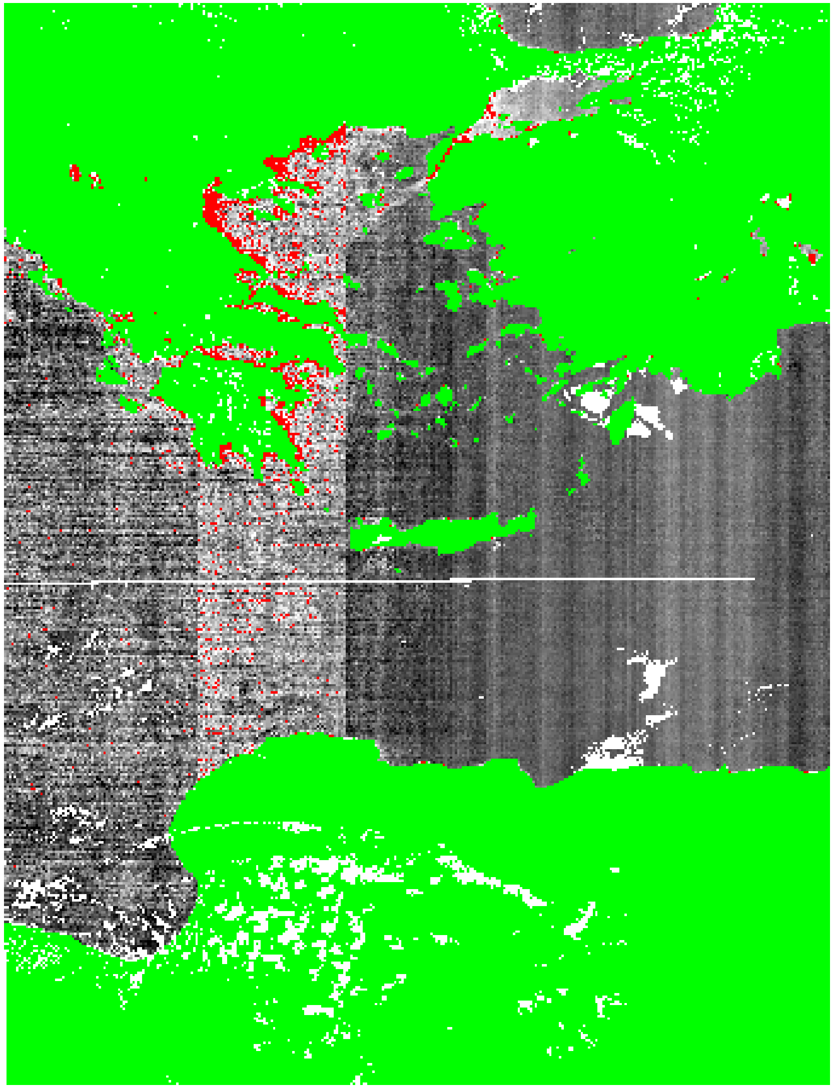
Gv13





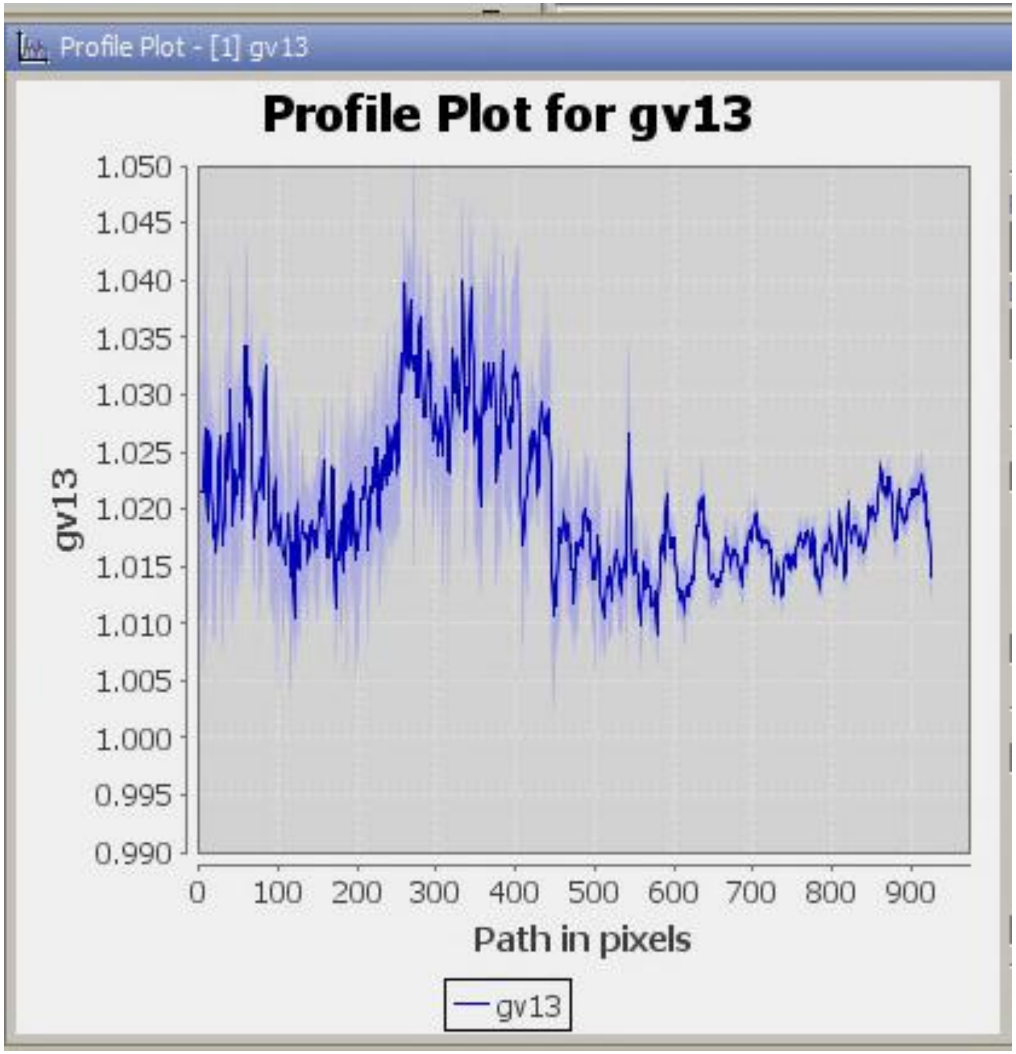
IR Vicarious Interband Relative Adjustment

In red, areas where Gv13 > 1.05



IR Vicarious Interband Relative Adjustment

Transect plot across the swath, south of Crete.



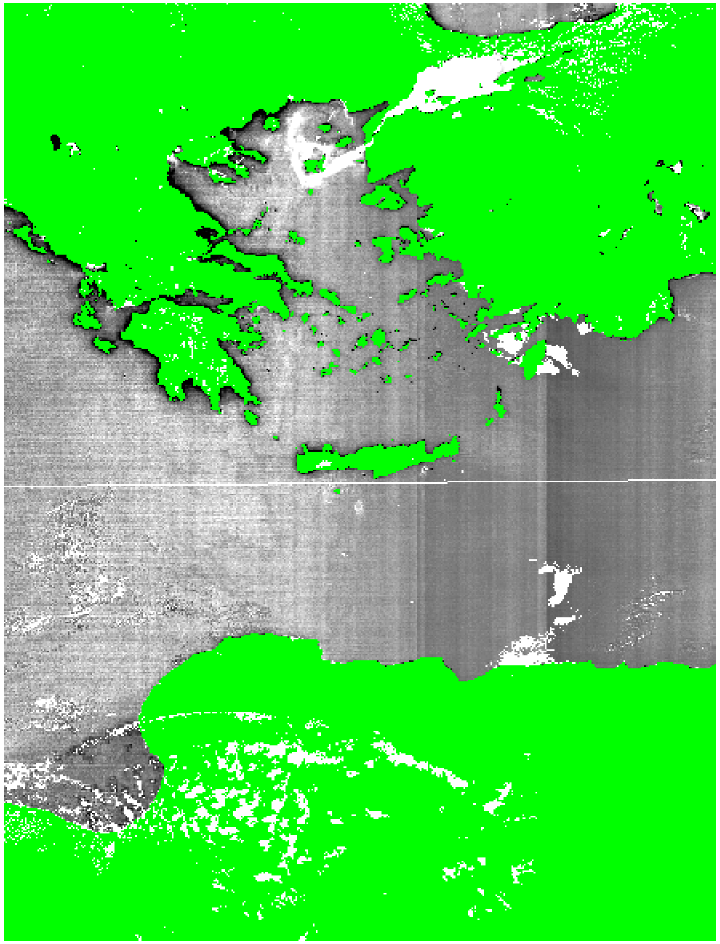
IR Vicarious Interband Relative Adjustment

Different results can be obtained by taking bands 13 and 9 as baseline.

The following images show the vicarious gainnecessary to align bands 10 to the new baseline.

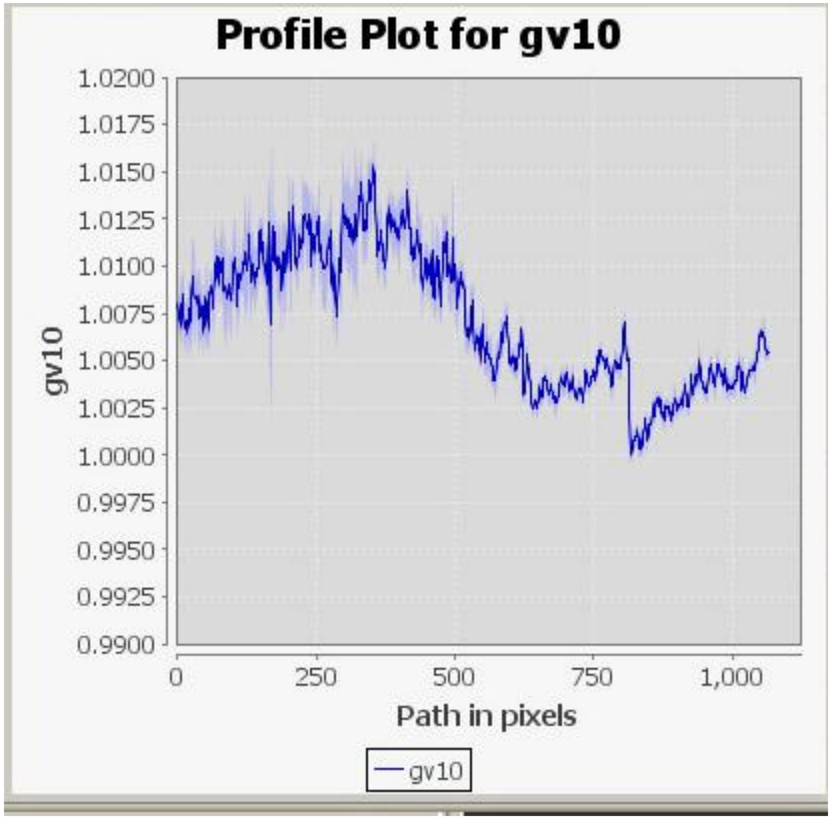
IR Vicarious Interband Relative Adjustment

Gv10 with bands 9
 and 13
as baseline



IR Vicarious Interband Relative Adjustment

Transect plot across the swath, south of Crete.



IR Vicarious Interband Relative Adjustment

Inside the glint

$$\rho_G\, t_R(\lambda i)t_a(\lambda i)= \rho_G\, t_R(\lambda_i) \exp[-M\tau_{a0}(\lambda_i/\lambda_0)^{\alpha}] ,$$

$$\approx \rho_G\, t_R(\lambda_i) \exp[-M\tau_{a0}(1+\alpha\eta_i(1-\eta_i)] ,$$

$$= \rho_G\, t_R(\lambda_i) \exp(-M\tau_{a0})\exp([-M\tau_{a0}\alpha\eta_i(1-\eta_i)] ,$$

$$\approx\rho_G\, t_R(\lambda_i) \exp(-M\tau_{a0}) [1-M\tau_{a0}\alpha\eta_i(1-\eta_i)] ,$$

$$= \rho_G\, t_R(\lambda_i) \exp(-M\tau_{a0}) [1-y(\eta_i(1-\eta_i)] ,$$

with

$$y=M\tau_{a0}\alpha .$$

Then for any two wavelengths

$$[1- y(\eta_i -\eta_i^2)]/[1- y(\eta_j -\eta_j^2)] = [\rho_{res} (\lambda_i) / t_R(\lambda_i)]/ [\rho_{res} (\lambda_j) / t_R(\lambda_j)],$$

and

$$y= [\rho_{res} (\lambda_i)/ t_R(\lambda_i) - \rho_{res} (\lambda_j)/ t_R(\lambda_j)]/ [\rho_{res} (\lambda_j) (\eta_i -\eta_i^2)- \rho_{res} (\lambda_i) (\eta_j -\eta_j^2)]$$

IR Vicarious Interband Relative Adjustment

$\rho^*_{resg}(\lambda_k) = \rho_{res}(\lambda_n)[1- y(\eta_k - \eta_k^2)]/[1- y(\eta_n - \eta_n^2)]\ t_R(\lambda_k)/\ t_R(\lambda_n)$
with n =i or j.

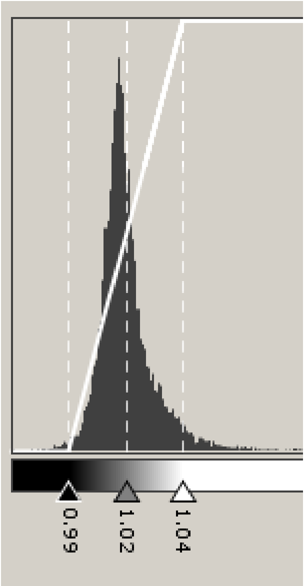
The vicarious adjustment gain for band $k \neq i$ or j is then

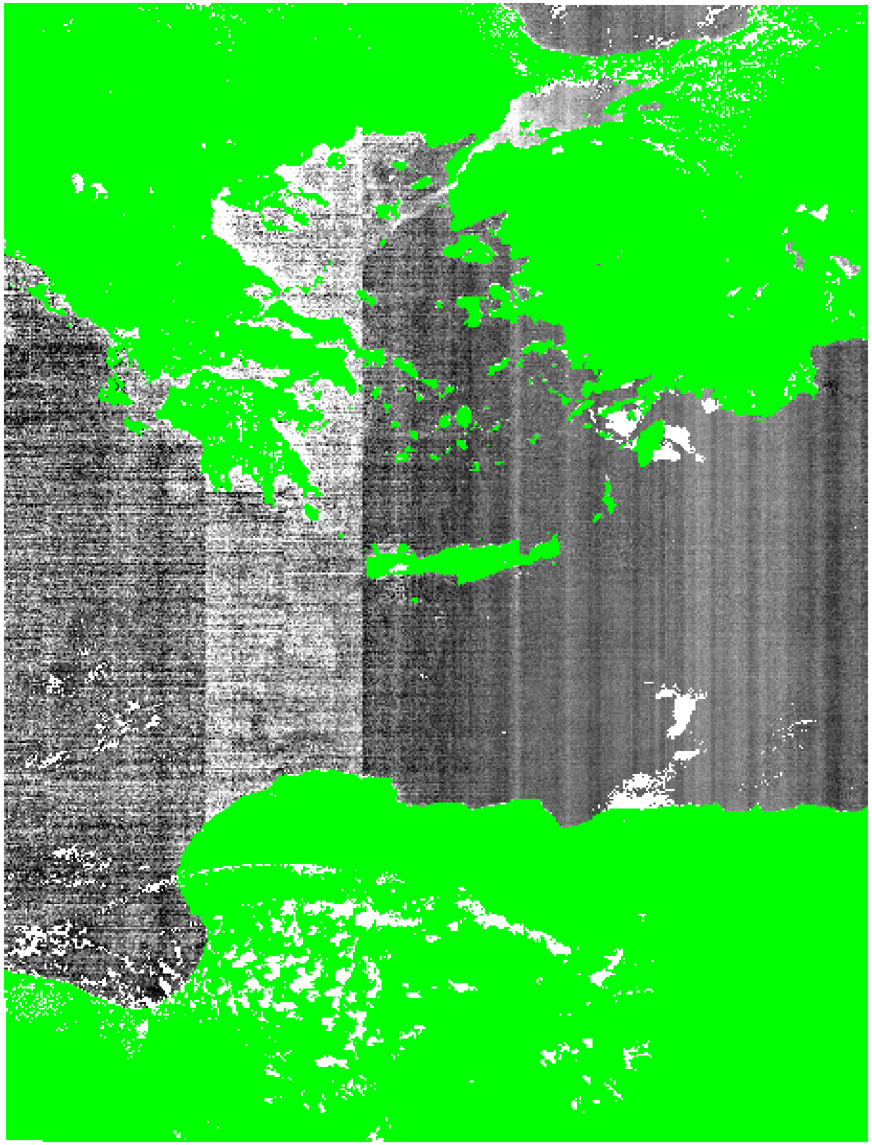
$$G_{vkg} = [\rho^*_{resg}(\lambda_k) + \rho_R(\lambda_k)]/\ \rho_{toa}(\lambda_k)$$

,

IR Vicarious Interband Relative Adjustment

Gv13g





IR Vicarious Interband Relative Adjustment

The vicarious gains are virtually identical (relative difference 0.5% maximum)

=>It seems to confirm that the aerosol signal cannot be discriminated from the glint signal in the NIR.

=>Non linearity correction seems to be effective for MERIS, in the NIR, because the spectral misalignment is independent of signal level

=>There is a strong across-track pattern in the vicarious gains, that looks detector dependent.

IR Vicarious Interband Relative Adjustment

Conclusions

Interband relative adjustment should be performed on a detector per detector basis. (the same idea is behind pixel equalization)

Non-linearity correction seems to be effective in the NIR

The ultimate assumptions about the way to compute the vicarious gains should take into account vicarious information from all types of targets: Clouds, Land, Sea.