

# Operational NIR-red Algorithms for Estimating Chlorophyll-*a* Concentration in Coastal Waters – The Azov Sea Case Study



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## Introduction

The goal was to test the operational potential of MERIS-based NIR-red algorithms for estimating chlorophyll-*a* (chl-*a*) concentration in coastal waters.

In this study, we applied NIR-red algorithms calibrated previously using a limited set of satellite data from the Azov Sea and the Taganrog Bay (Moses et al. 2009), and also advanced versions of NIR-red algorithms developed using synthetically generated data (Gilerson et al. 2010), to an extensive dataset collected from the Azov Sea and Taganrog Bay over a period of three years. The results from the MERIS-based NIR-red algorithms were compared with those from the standard MERIS Chl-*a* product and data from the spaceborne hyperspectral sensor HICO.

We also present results from HICO for data collected after the demise of MERIS.

## Study Area



The Azov Sea is a shallow inland sea adjoined by Ukraine on the west and Russia on the east. The Taganrog Bay is on the northeastern part of the Azov Sea.

## Data

*In situ* data were collected on the Azov Sea and the Taganrog Bay during 18 campaigns between March and October for three years, from 2008 to 2010, and 4 campaigns between July and Sep in 2012.

2008-2010 Chl-*a* Data (113 stations):

Units	Min	Max	Median	Mean
mg m <sup>-3</sup>	1.09	107.82	22.39	31.74

2012 Chl-*a* Data (31 stations):

Units	Min	Max	Median	Mean
mg m <sup>-3</sup>	29.71	172.77	97.35	94.75

MERIS (for the 2008-2010) and HICO (1 image in 2010 and 4 images in 2012) images acquired mostly on the same date as the *in situ* data and in some cases up to 2 days before/after *in situ* data collection were used.

## NIR-red Algorithms

MERIS-based NIR-red algorithms that were previously calibrated using a limited dataset from the Azov Sea and Taganrog Bay (Moses et al. 2009) were,

**Two-band MERIS NIR-red algorithm:**  

$$\text{Chl-}a = 61.324 [R_{665}^{-1} \times R_{708}^{-1}] - 37.94 \quad (1)$$

**Three-band MERIS NIR-red algorithm:**  

$$\text{Chl-}a = 232.29 [(R_{665}^{-1} - R_{708}^{-1}) \times R_{753}^{-1}] + 23.174 \quad (2)$$

Using a large set of reflectances simulated through Hydrolight, Gilerson et al. (2010) developed advanced versions of the two-band and three-band NIR-red models.

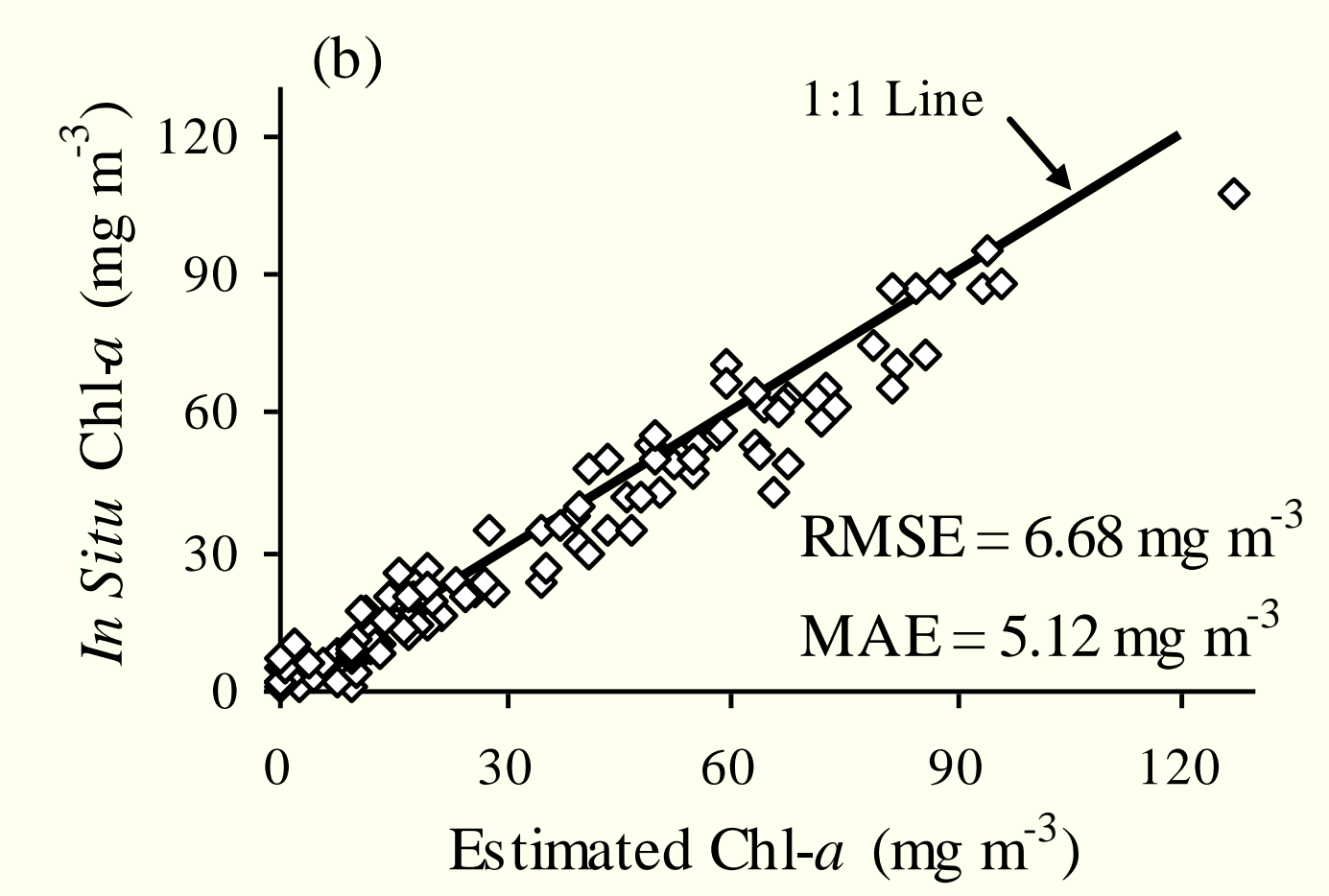
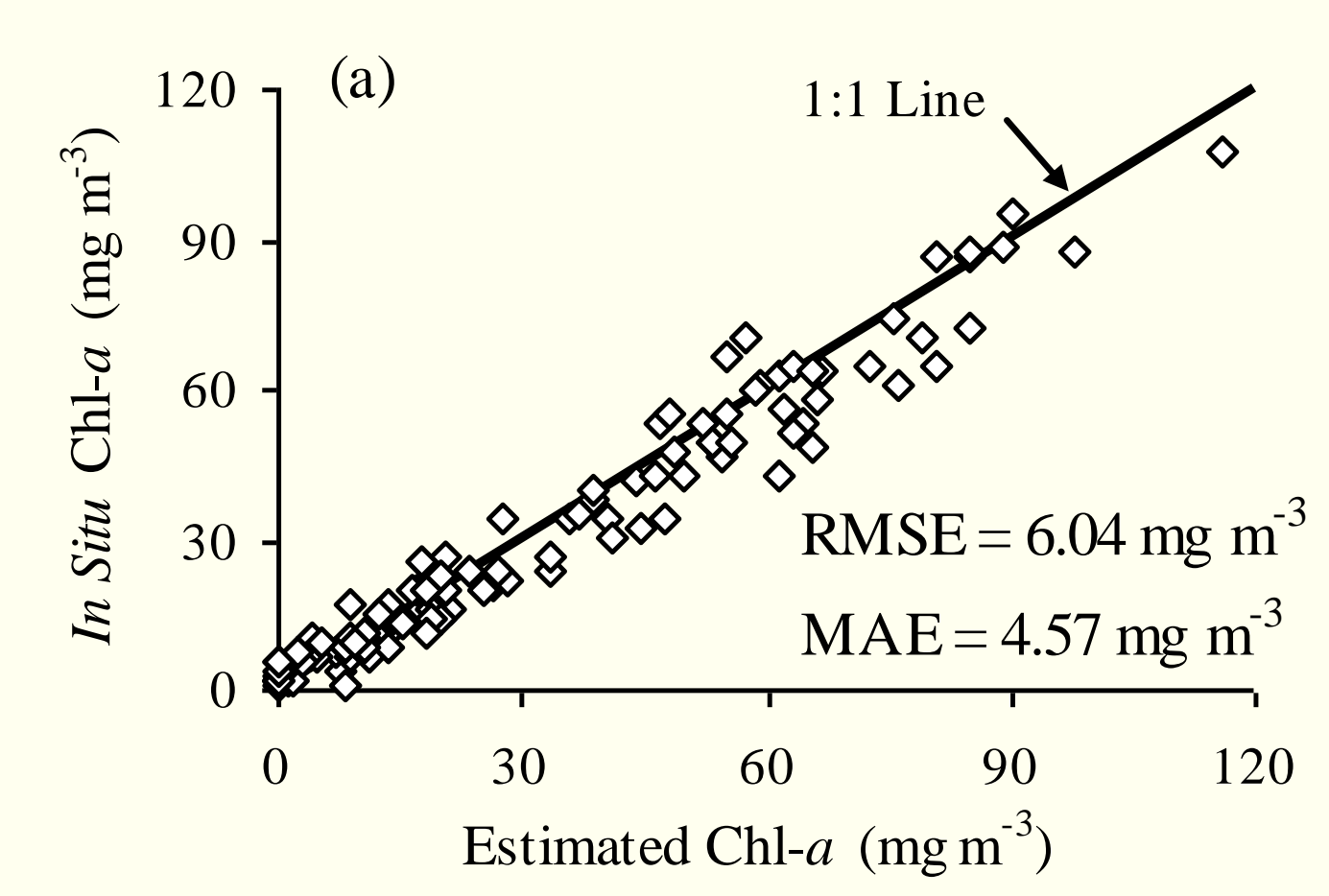
**Advanced Two-band MERIS NIR-red algorithm:**  

$$\text{Chl-}a = [35.75 \times (R_{665}^{-1} \times R_{708}^{-1}) - 19.3]^{1.124} \quad (3)$$

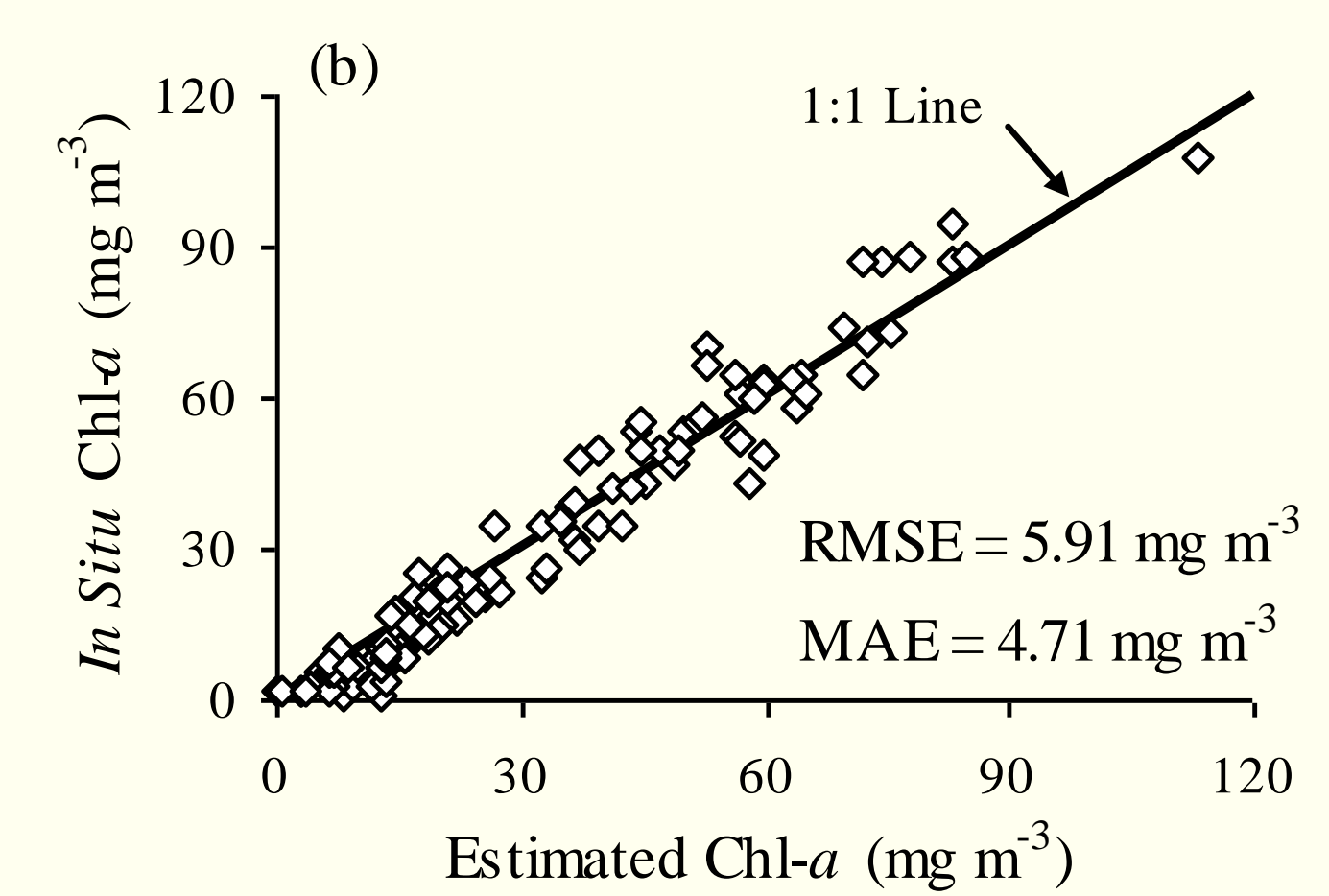
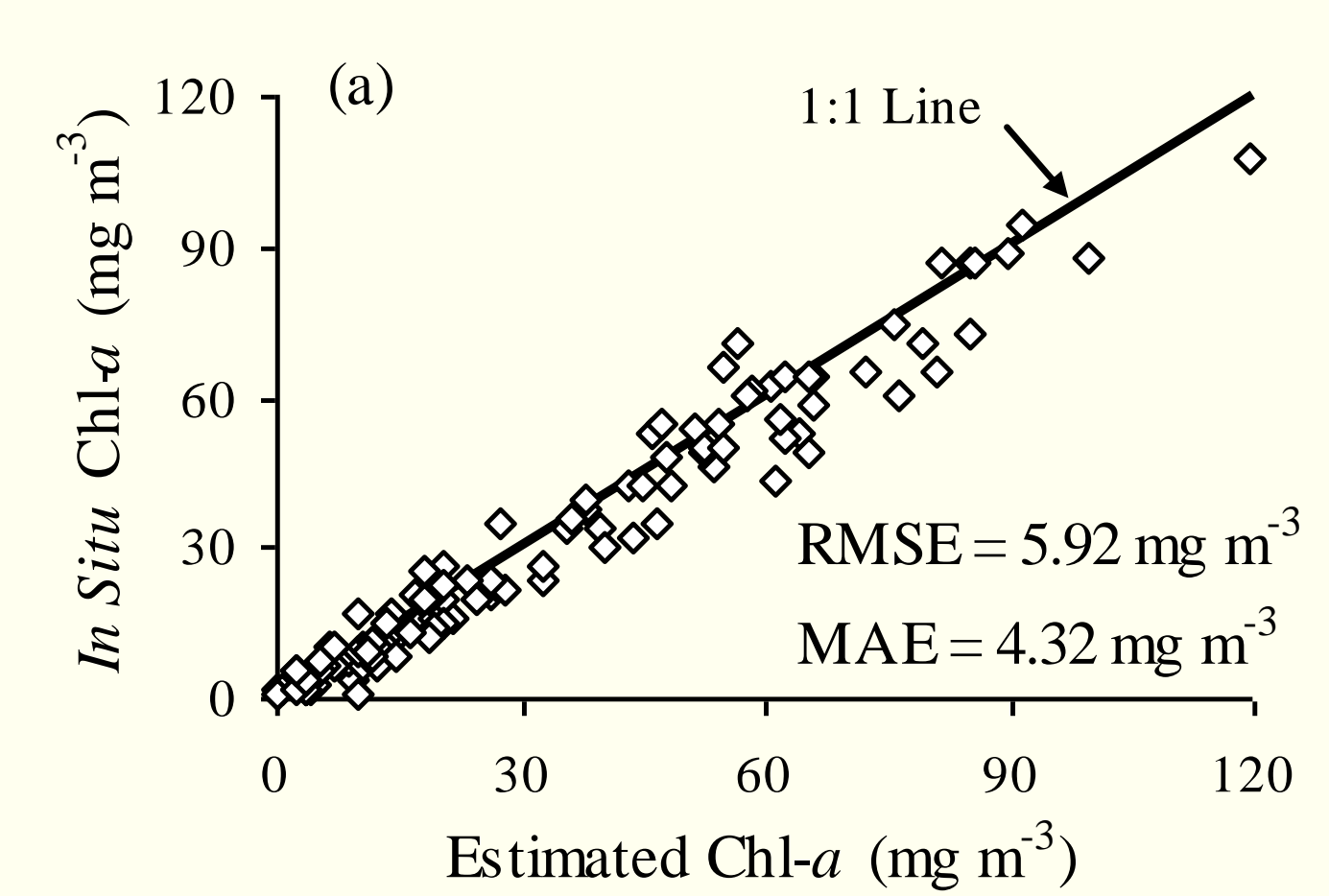
**Advanced Three-band MERIS NIR-red algorithm:**  

$$\text{Chl-}a = [113.36 \times ((R_{665}^{-1} - R_{708}^{-1}) \times R_{753}^{-1}) + 16.45]^{1.124} \quad (4)$$

## Results - for 2008-2010 from MERIS Data



*In situ* chl-*a* concentrations vs. estimates from (a) the two-band (Eq. 1) and (b) the three-band (Eq. 2) NIR-red algorithms for the 2008-10 dataset.

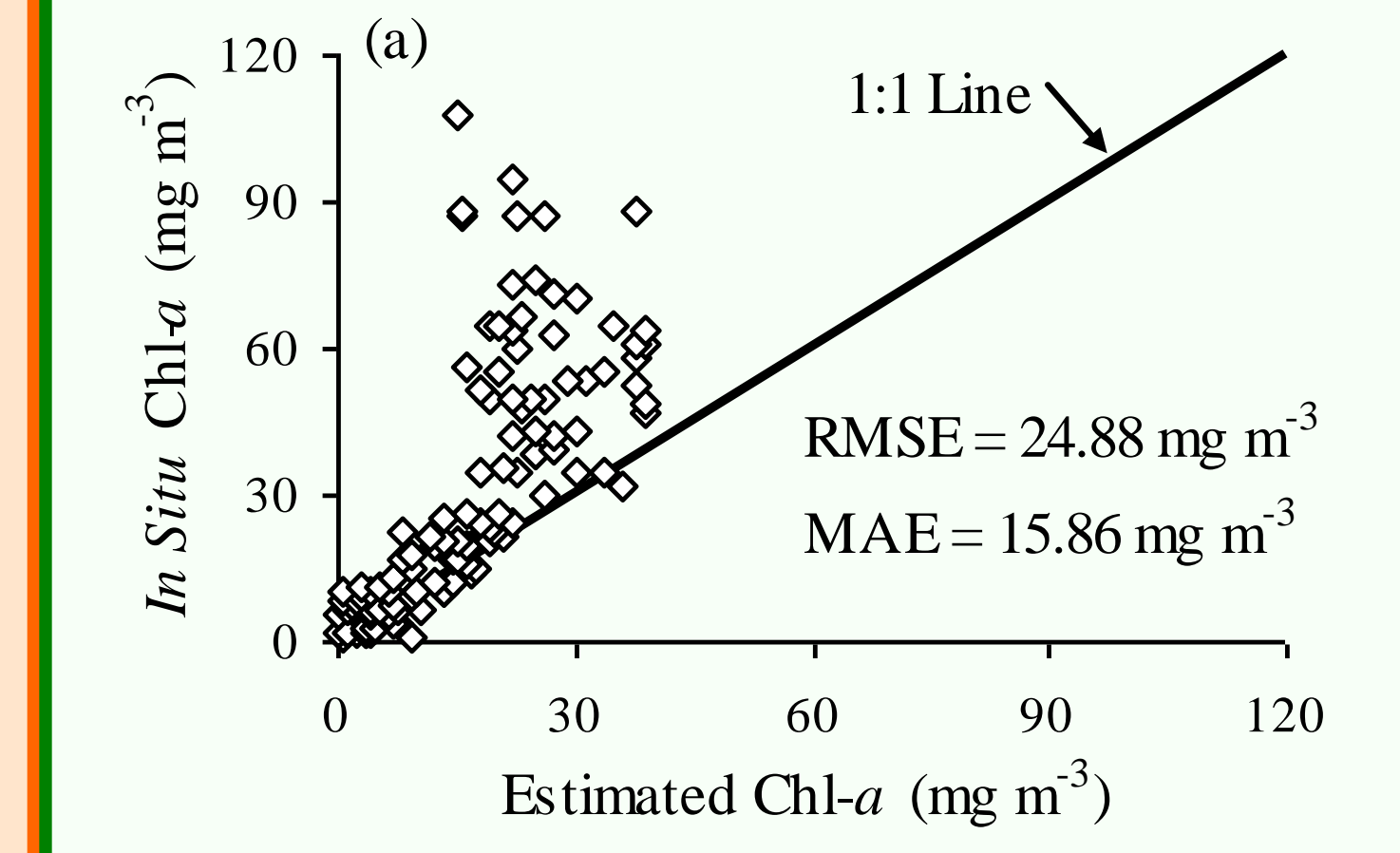


*In situ* chl-*a* concentrations vs. estimates from the advanced (a) two-band (Eq. 3) and (b) three-band (Eq. 2) NIR-red algorithms for the 2008-10 dataset.

## Acknowledgments

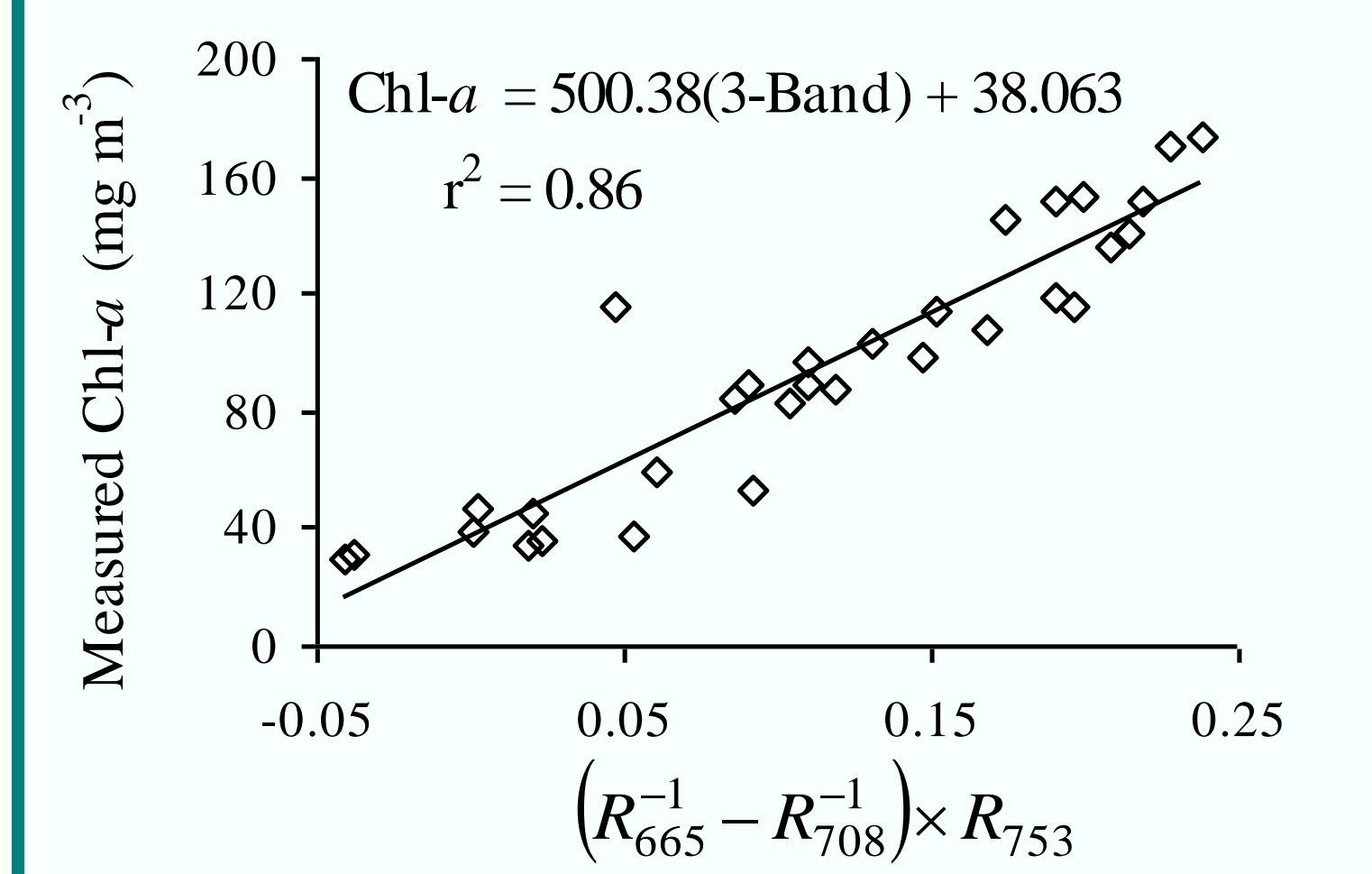
This research was supported by the Office of Naval Research and by the National Research Council Associateship awarded to W. J. Moses via the Naval Research Laboratory and in part by funding from the NASA Land Cover Land Use Program to A. A. Gitelson. MERIS images were obtained from the European Space Agency and HICO images from the Naval Research Laboratory.

## Standard MERIS Chl-*a* Estimates



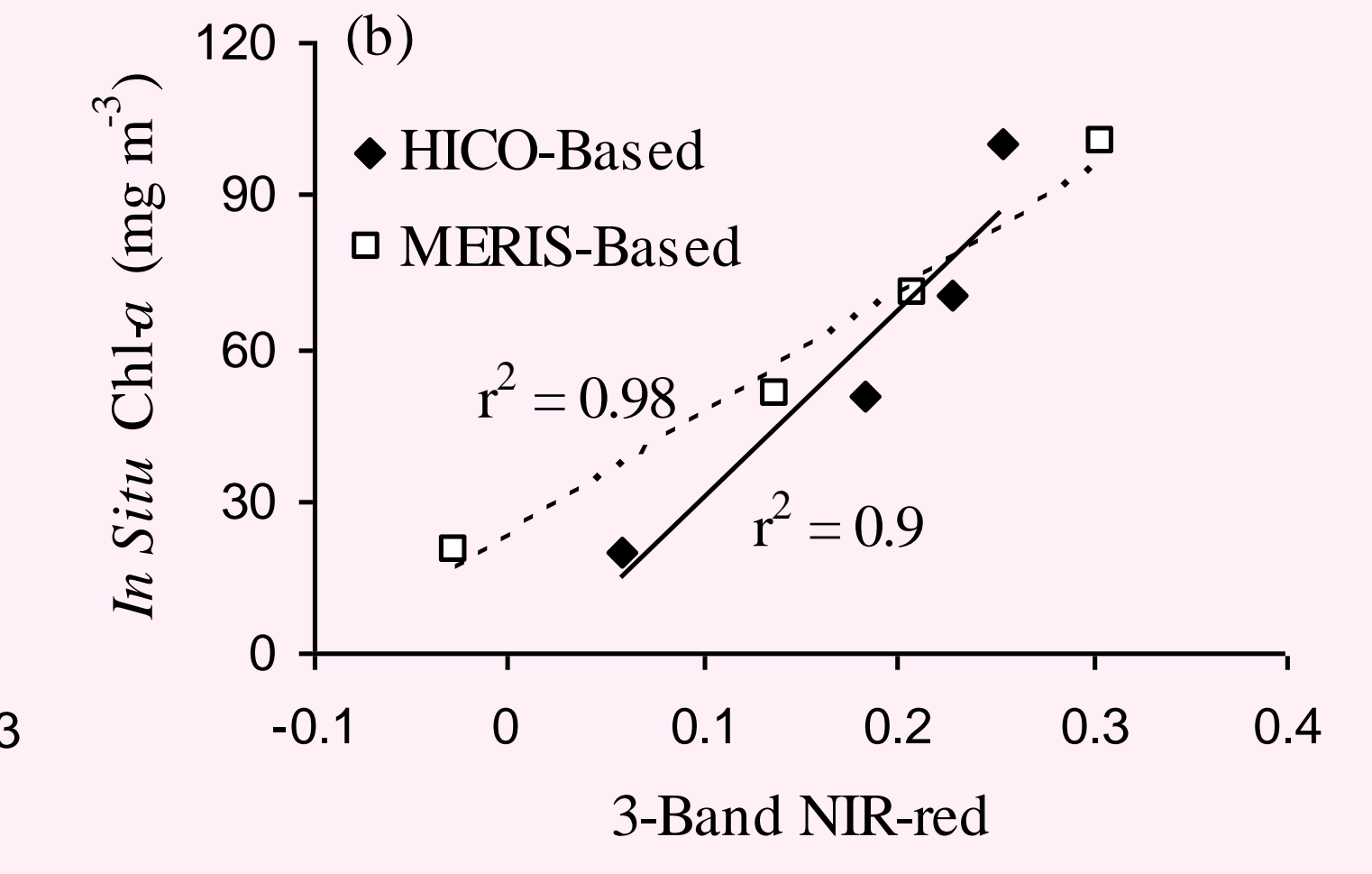
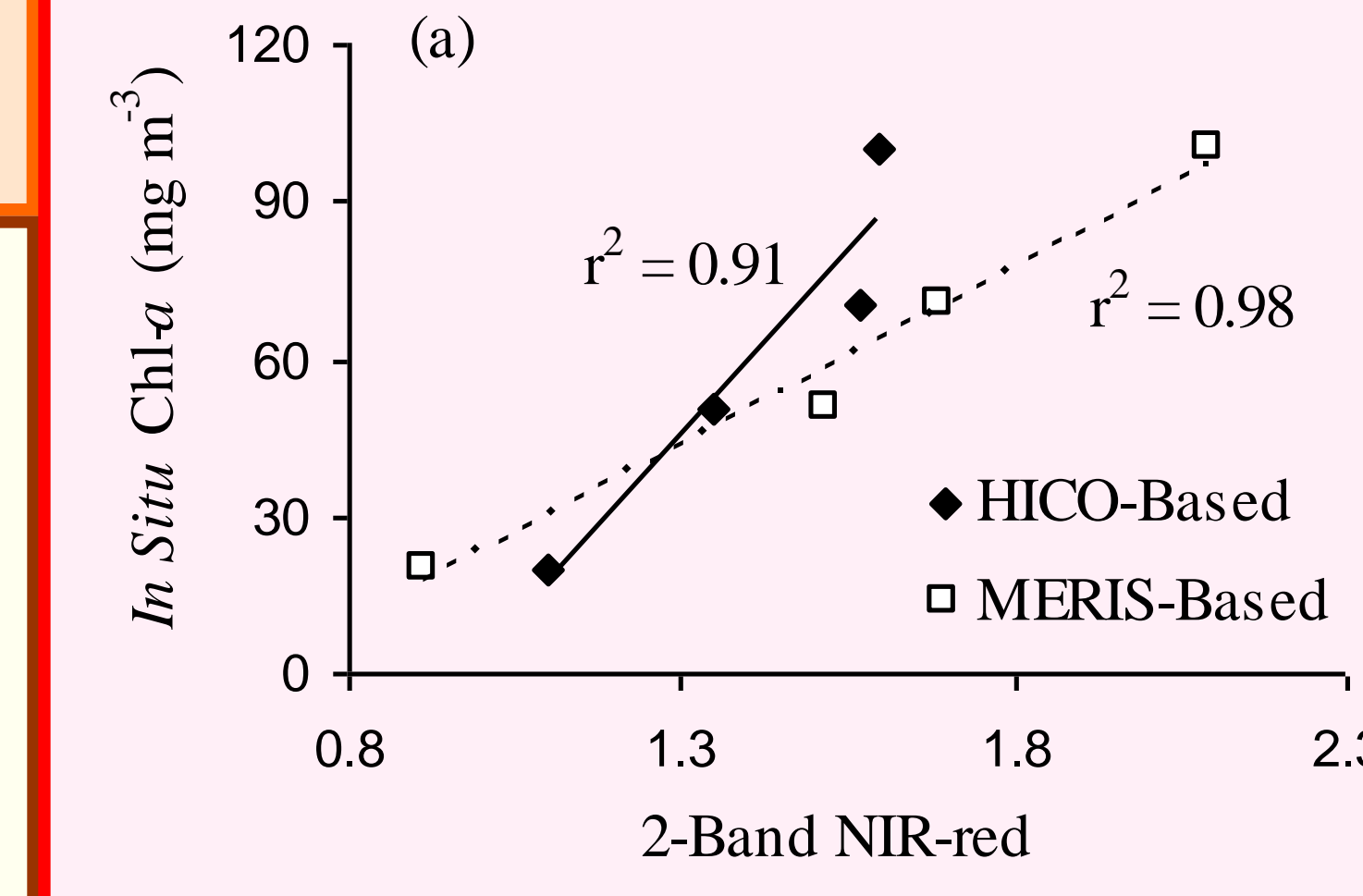
*In situ* chl-*a* concentrations vs. estimates from the default MERIS chl-*a* algorithm (algal\_2), which underestimated the chl-*a* concentrations.

## Results for 2012 from HICO

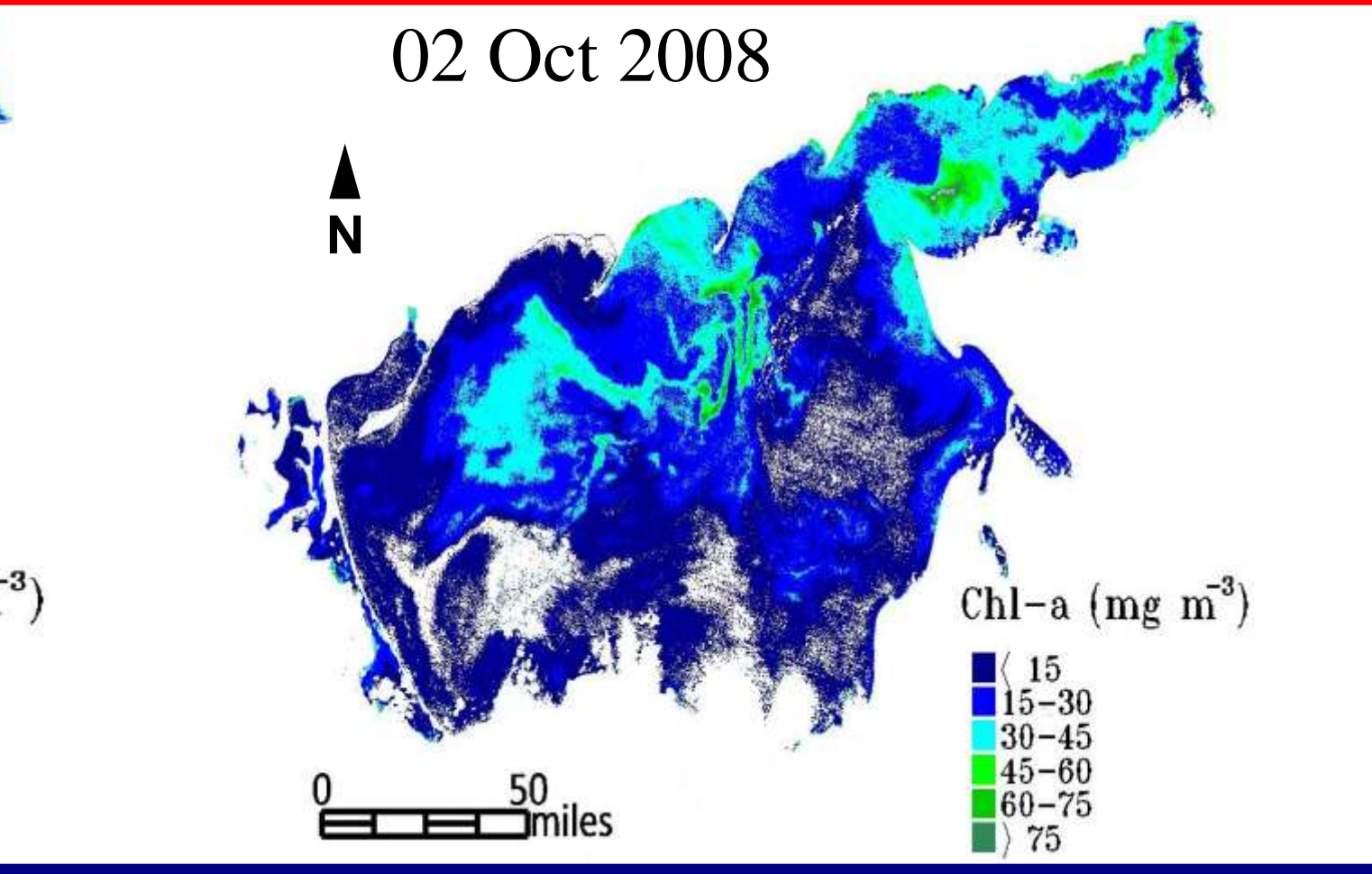
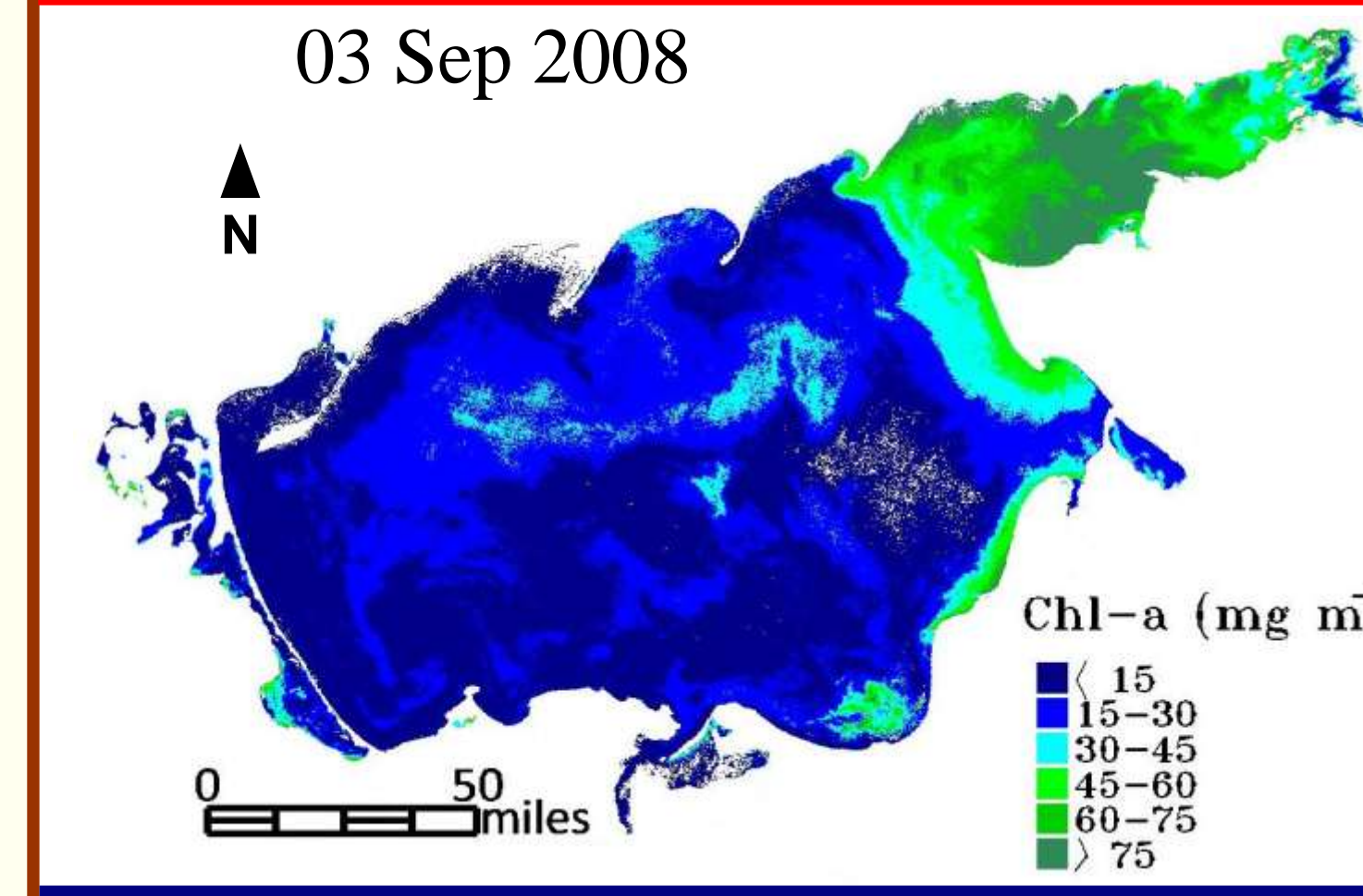


*In situ* chl-*a* concentrations vs. three-band NIR-red model values derived from the HICO images for the 2012 dataset.

## Comparison between MERIS and HICO Results



*In situ* chl-*a* concentrations vs. (a) two-band and (b) three-band NIR-red model values derived from MERIS and HICO data.



## Conclusions

- ❖ The results indicate a strong operational potential of the NIR-red algorithms for estimating chl-*a* concentration in coastal waters.
- ❖ The NIR-red algorithms hold great promise for accurate retrieval of chl-*a* concentration from the future Ocean Land Colour Instrument (OLCI) onboard Sentinel-3, expected to be launched in 2014, and for continued monitoring of chl-*a* concentration using HICO in the meantime.

## References

➤ Gilerson, A., Gitelson, A., Zhou, J., Gurin, D., Moses, W., Ioannou, I., and Ahmed, S. (2010), "Algorithms for remote estimation of chlorophyll-*a* in coastal and inland waters using red and near infrared bands", *Optics Express*, 18(23): 24109-24125.  
 ➤ Moses, W., Gitelson, A., Berdnikov, S. and Povazhnyi, V. (2009), "Satellite estimation of chlorophyll-*a* concentration using the red and NIR bands of MERIS - the Azov Sea case study", *IEEE Geoscience and Remote Sensing Letters*, 4(6): 845-849.  
 ➤ Moses, W. J., Gitelson, A. A., Berdnikov, S., Saprygin, V., and Povazhnyi, V. (2012), "Operational MERIS-based NIR-red Algorithms for Estimating Chlorophyll-*a* Concentrations in Coastal Waters - The Azov Sea Case Study", *Remote Sensing of Environment*, 121: 118-124.