Remote sensing reflectance from SOOP in the Skagerrak and Norwegian coastal waters

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Outline

- Radiometric sensor systems
- Data handling, processing and quality control
- SOOP vs R/V observations
- Validation of satellite ocean colour data

Radiometric parameters

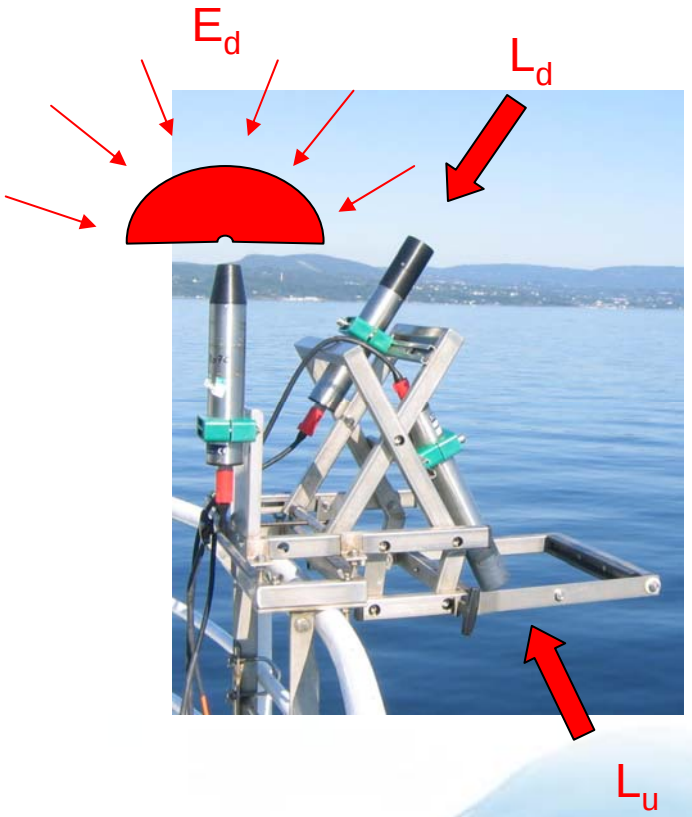
- Ed, Downwelling irradiance (180° FOV)
- Ld, Downwelling radiance (7° FOV)
- Lu, Upwelling radiance (7° FOV)

Wavelength range: 350-900nm

Band interval: 3-4nm

Primary focus on satellite validation

- Caclulate $\rho_{w,}$ Remote sensing (Water-leaving) reflectance
- Validation of Envisat/MERIS reflectance



Calculating MERIS reflectance from RAMSES measurements of Lu, Ld, and Ed

MERIS reflectance $$\rho_w'(\vartheta,\varphi,\lambda) = \pi \frac{L_u(\vartheta,\varphi,\lambda)}{E_d(\lambda)}$$ (Eq. 1)

RAMSES Lu sensor measures: $L_u + L_u^{refl}$

L_u: From beneath surface (to be used in Eq. 1)

L_u^{refl}: Reflected from surface

RAMSES Ld sensor Used to find L_u^{refl}

$$L_u^{refl}(\vartheta,\varphi,\lambda) = r_L L_d(\pi - \vartheta,\varphi,\lambda)$$

We calculate the reflectance as:

$$\rho_w = \pi\,(L_u - r_L L_d)/E_d$$

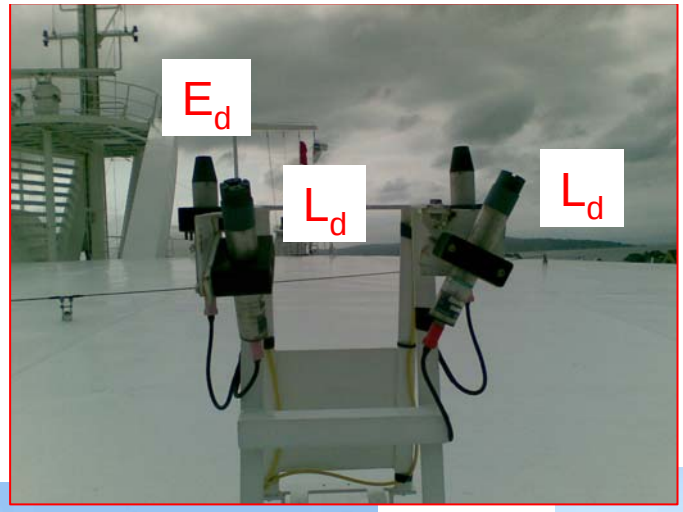
where r_L = 2% for flat surface and 2.8% for rough surface.

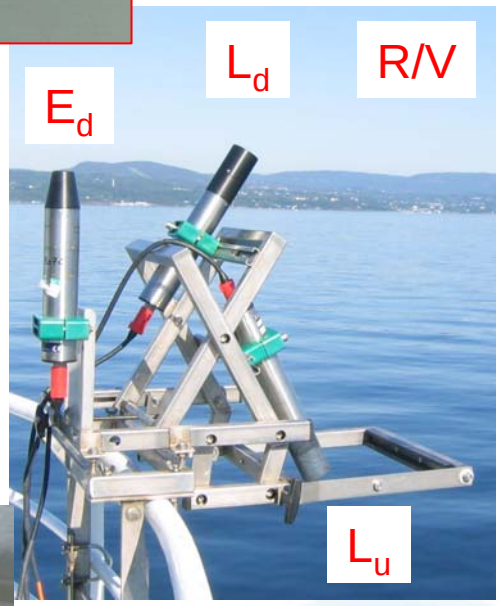
Sensor setup on SOOP vs Research Vessel

Sensor configuration

Two sets of TriOS RAMSES sensors (Lu, Ld, Ed)

- Port
- Starboard



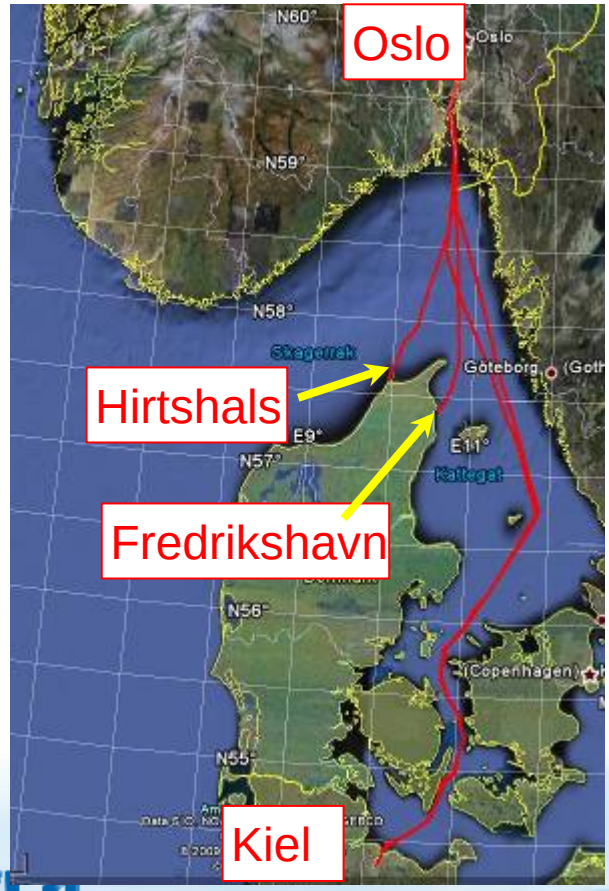


Radiance sensor angles

- Avoid sun glint
- Avoid shadow from ship
- Avoid reflection from ship
- Minimum surface reflection of sky radiance

Ships and routes with radiometric sensors

- M/S Trollfjord (Bergen-Kirkenes) 2004→
- M/S Color Festival (Oslo-Denmark) 2005-2008
- M/S Color Fantasy (Oslo-Kiel) 2008→



Data collection/handling

- System status check and operation of the sensors are done remotely (or onboard).
- Data stored in MSDA database onboard
- Large amount of data collected every day (100-200MB)
- Data transferred from ship by USB stick
- Internet bandwidth limits automatic data transfer to NIVA server
- Presently no requirements for near real-time processing, but we are working towards a fully automated system for data transfer to NIVA server and subsequent processing and quality control.

Data Processing

- Extraction from MSDA database
- Split by days
- Bug corrections *time, position, …*
- Sensors synchronizations (t, λ)
- Merge sensor data for each ship side
- Merge GPS positions from Ferrybox, if necessary
- Add sun and view angles (zenith and azimuth)
- Elementary flagging

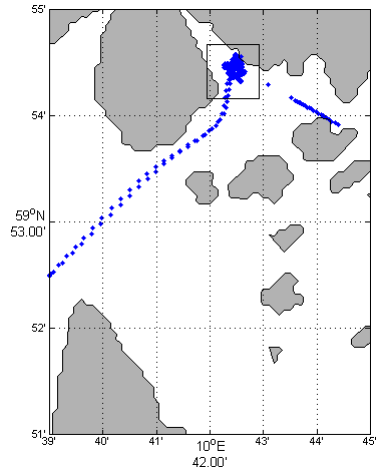
Data File Format

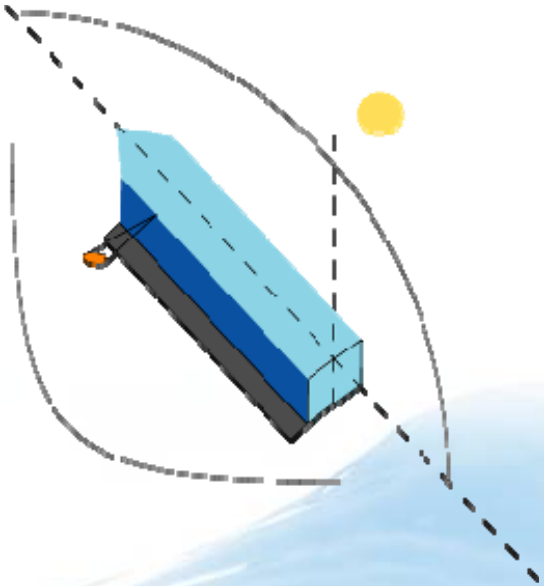
Data	year	month	day	time	lat	lon	Spd	Crs	SZA	SAA	VZA	VAA	VS
Format	I4	I2	I2	F7.4	F6.3	F7.3	F4.1	F5.1	F5.2	F5.1	F5.2	F5.1	F4.1
Unit	none	none	none	UT decimal	Deg.	Deg.	m/s	Deg.	Deg.	Deg.	Deg.	Deg.	m/s.
	2007	3	21	8.936	57.632	10.719	10.1	189.0	64.55	138.1	15.00	139.0	194

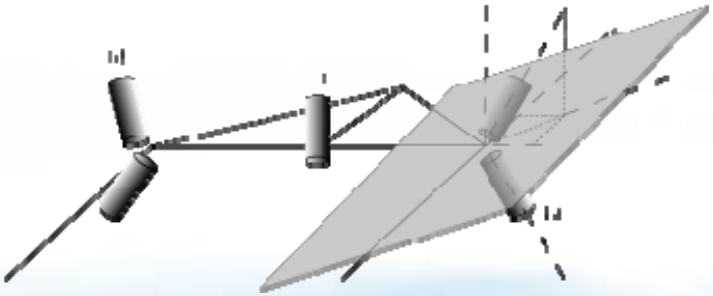
N	L_up	L_down	E_down
I2	E9.3	E9.3	E9.3
non	*W/m²/µm/sr*	*W/m²/µm/sr*	*W/m²/µm*
255	1.167E+00	4.217E+01	7.939E+01

Flagging

- Speed > 5 knots
- Sun Zenith Angle < 75
- Shadow from ship (sensor angle relative to sun)
- Glint (sky and water)
- Atmosphere Optical Thickness
  - AOT > 2
  - AOT > 0.8



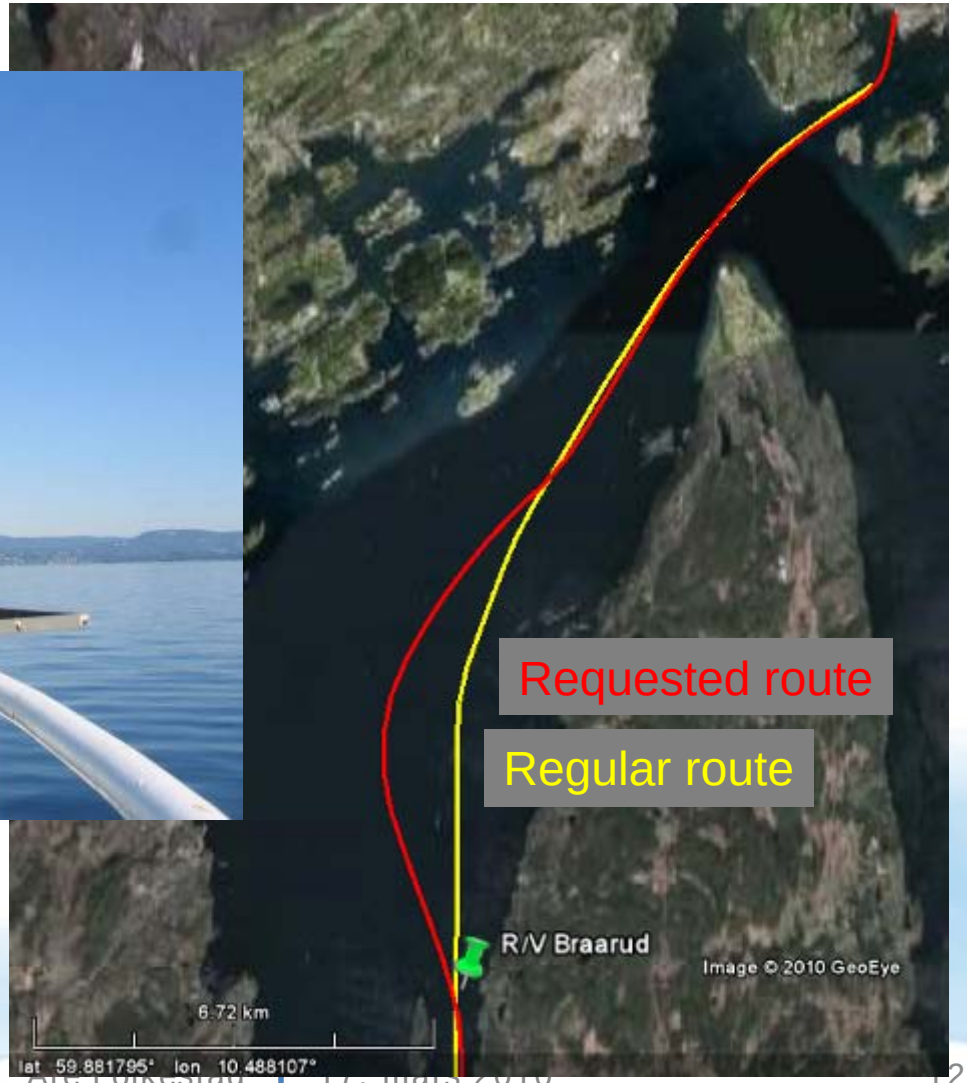


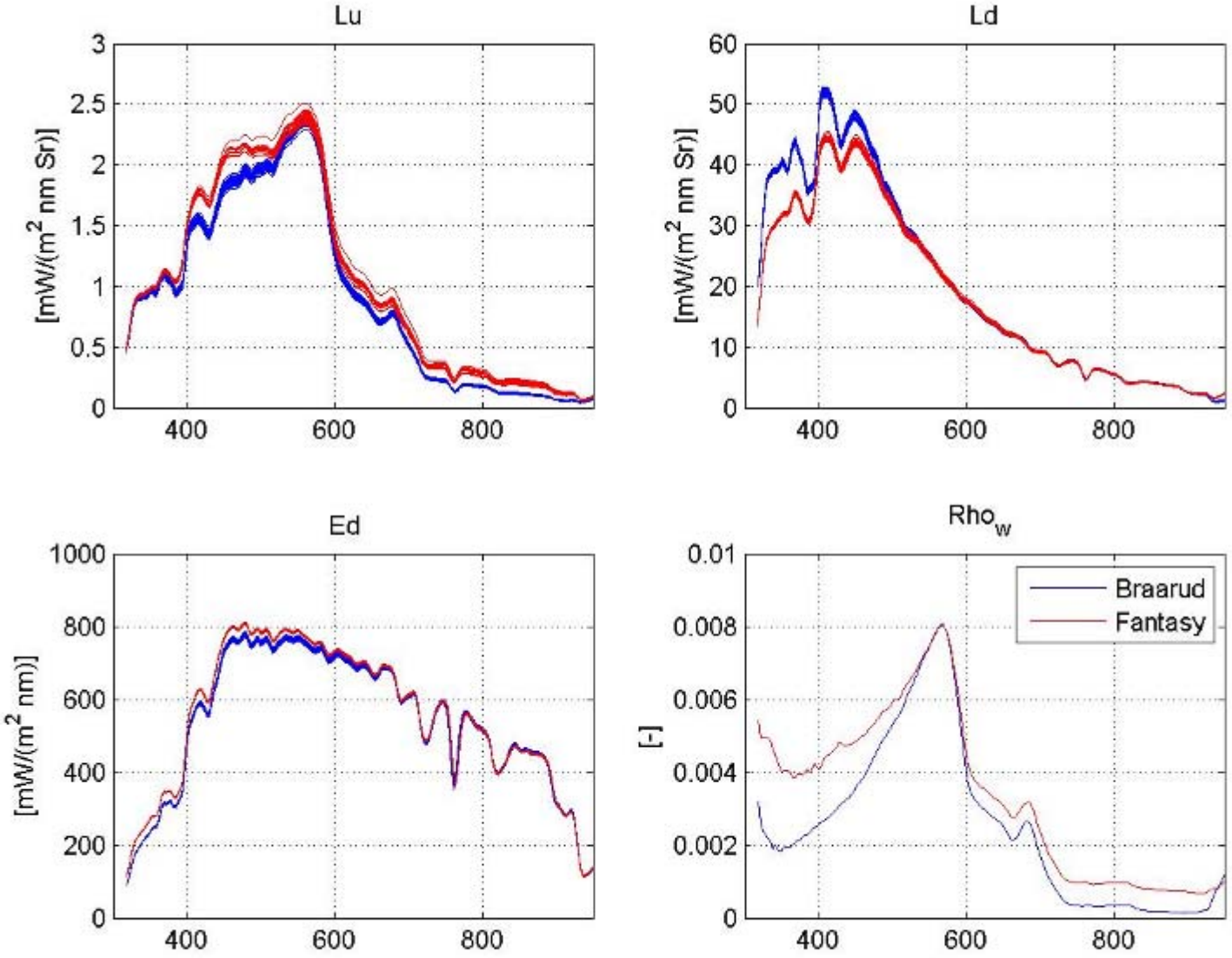


SOOP and R/V data inter-comparison

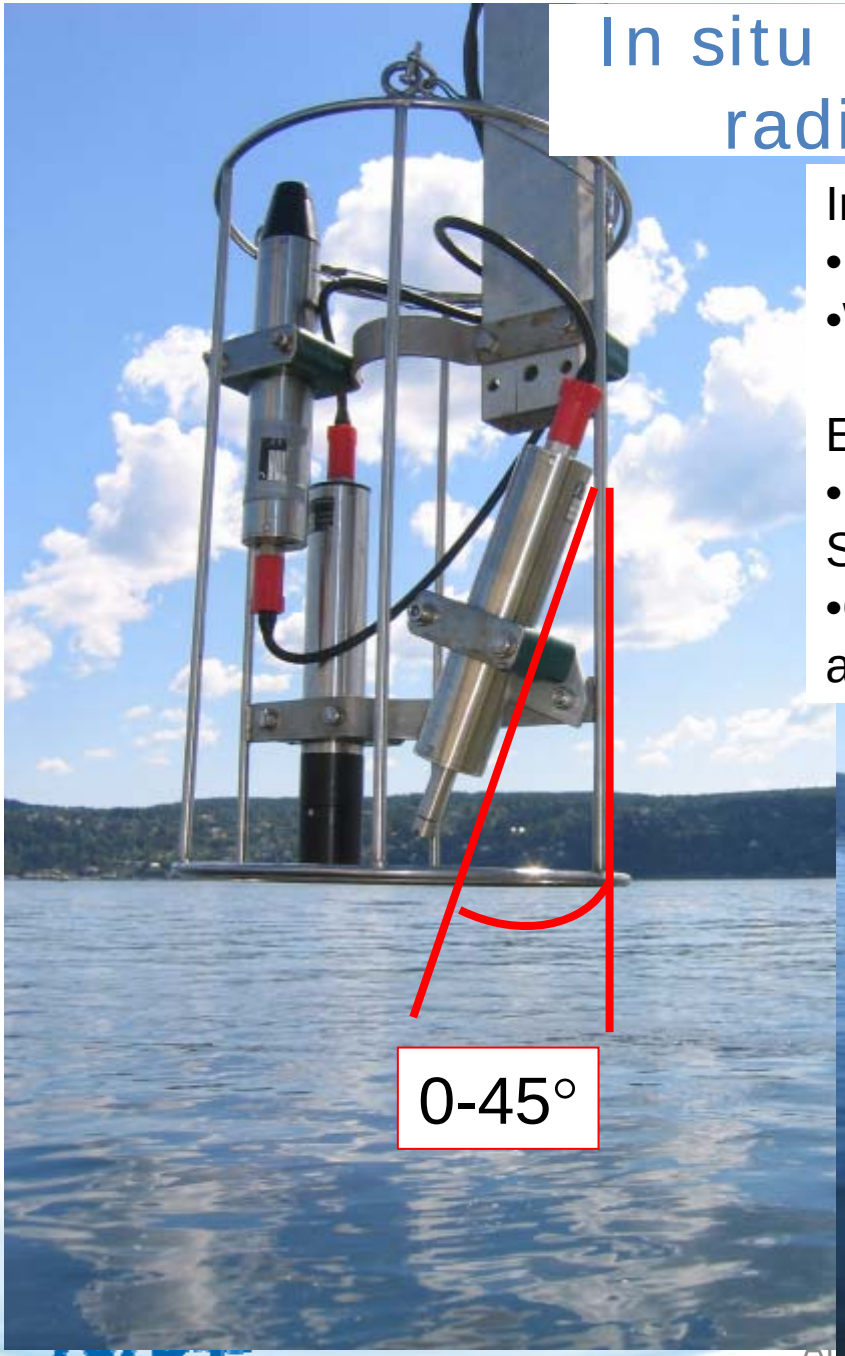
Inner Oslofjord 25 June & 26 August 2009

Identical sensor viewing angles




Lu
[mW/(m2 nm Sr)]
Ld
[mW/(m2 nm Sr)]
Ed
[mW/(m2 nm)]
Rhow
[-]
Braarud
Fantasy
400
600
800

In situ measurements with varying radiance sensor nadir angle

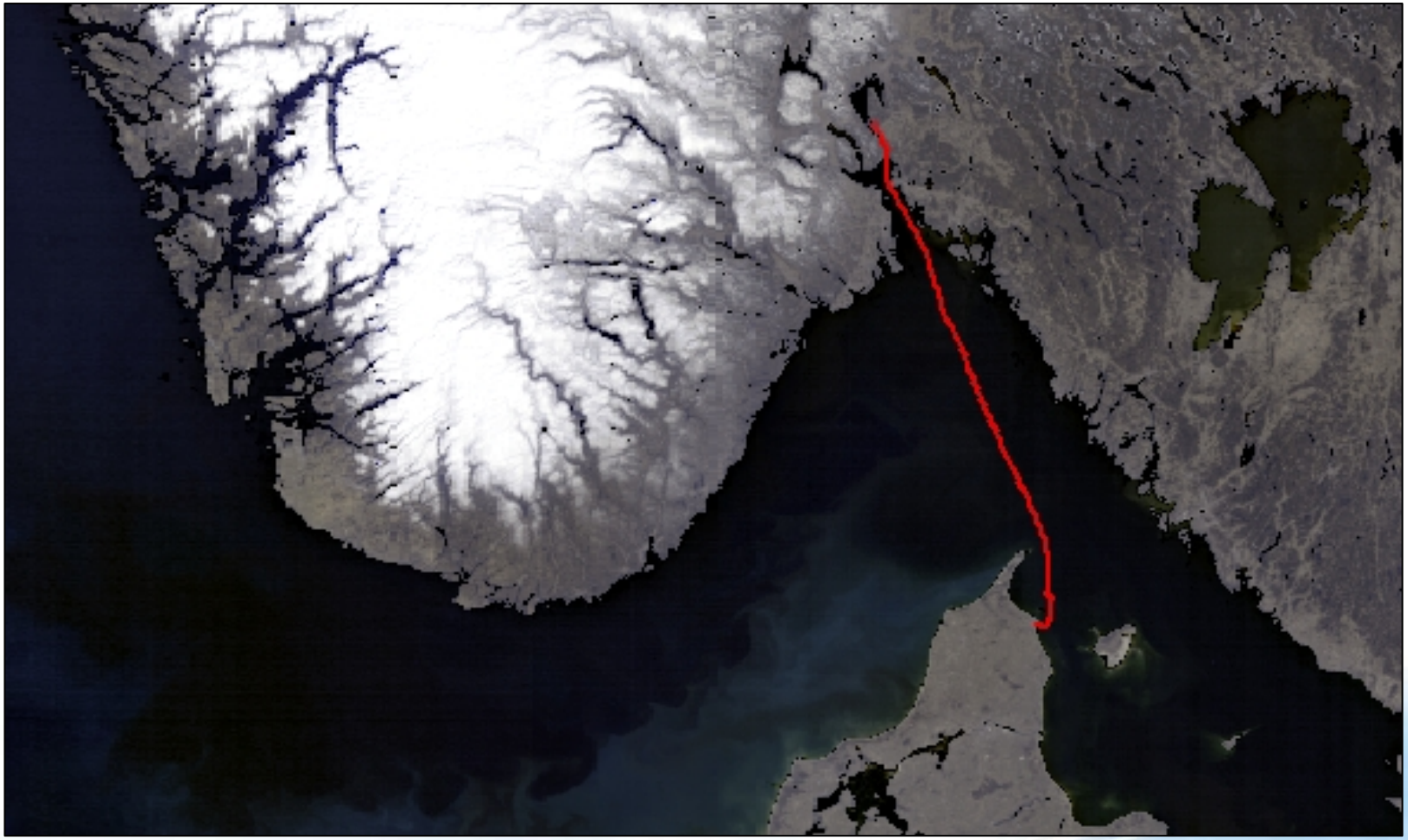


Invsetigate influence on
- Diffuse attenuation coefficient
- Water-leaving reflectance

Extrapolate information to
- Evaluate influence of varying sensor angles on SOOP data
- Optimize future selection of sensor viewing angles

Another SOOP (Trollfjord) and R/V Inter-comparison excercise planned in April 2010

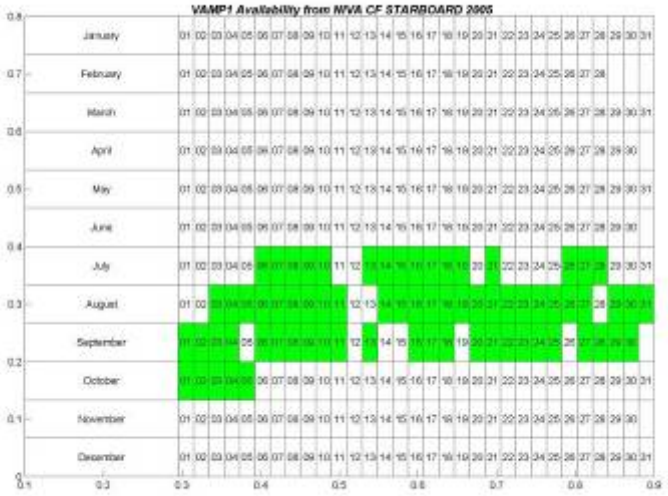
MERIS validation in the Skagerrak



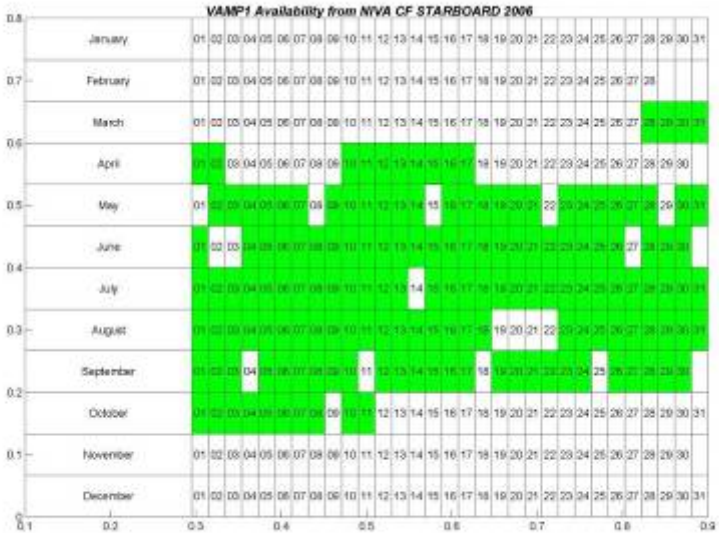
Large amount of in situ data available as potential satellite matchups

2005: 74 days
2006: 160 days
2007: 174 days

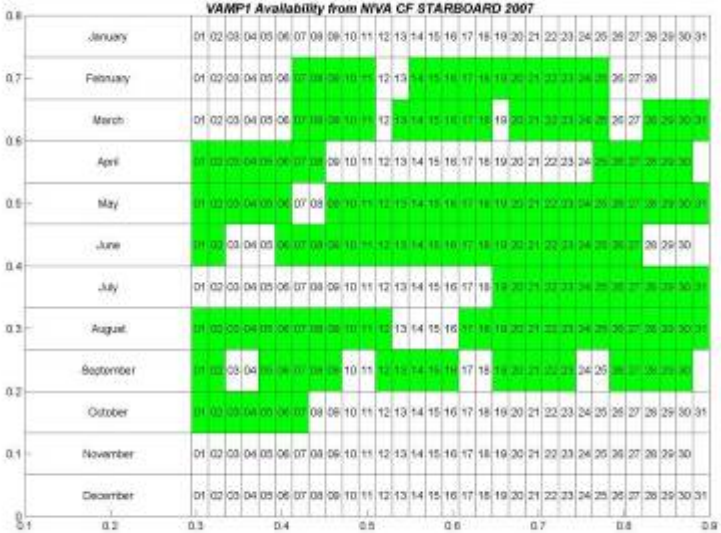
2005



2006



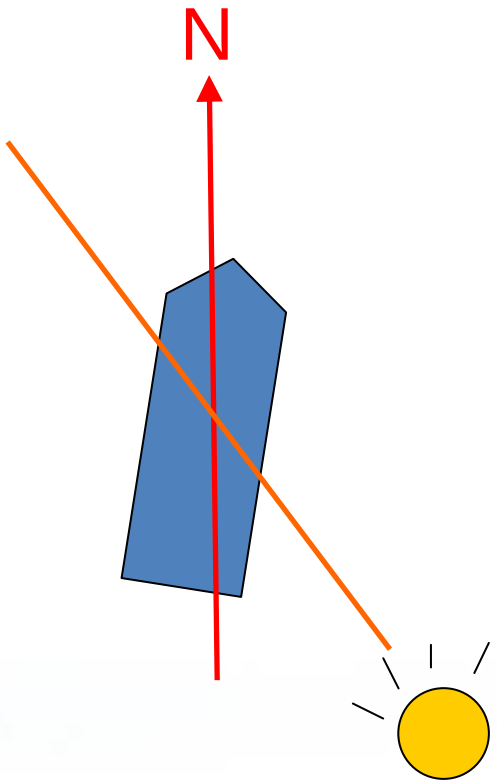
2007



Identification of matchups

- Color Festival in open waters at MERIS overpass
- Matchup searched for in situ measurements within 3min time window from MERIS overpass time (i.e. ship moved appr. 1.8km)
- MERIS flags (Uncertain normalized surface reflectance) used to identify good MERIS quality

10 June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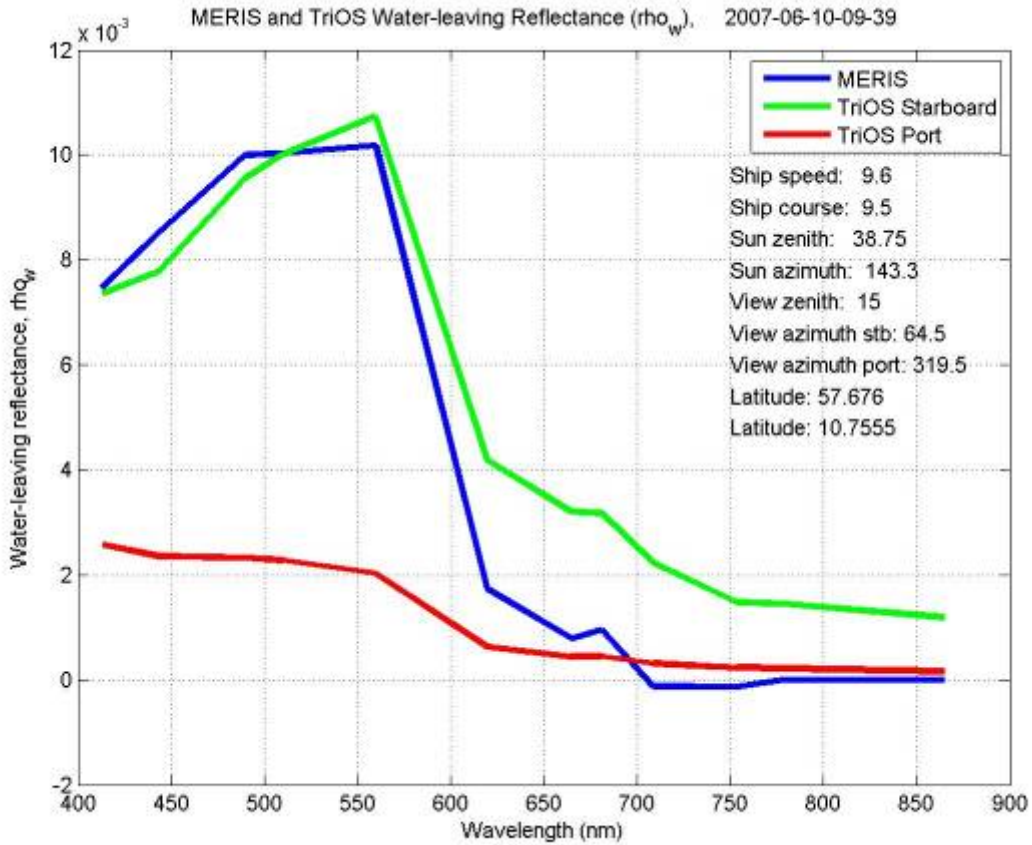
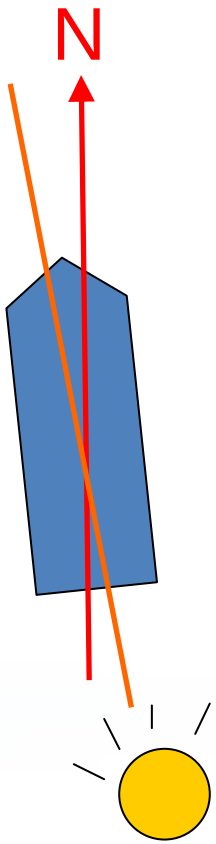

MERIS and TriOS Water-leaving Reflectance (rho$_w$), 2007-06-10-09-39
x 10^{-3}
Water-leaving reflectance, rho$_w$
Wavelength (nm)
MERIS
TriOS Starboard
TriOS Port
Ship speed: 9.6
Ship course: 9.5
Sun zenith: 38.75
Sun azimuth: 143.3
View zenith: 15
View azimuth stb: 64.5
View azimuth port: 319.5
Latitude: 57.676
Latitude: 10.7555

11 June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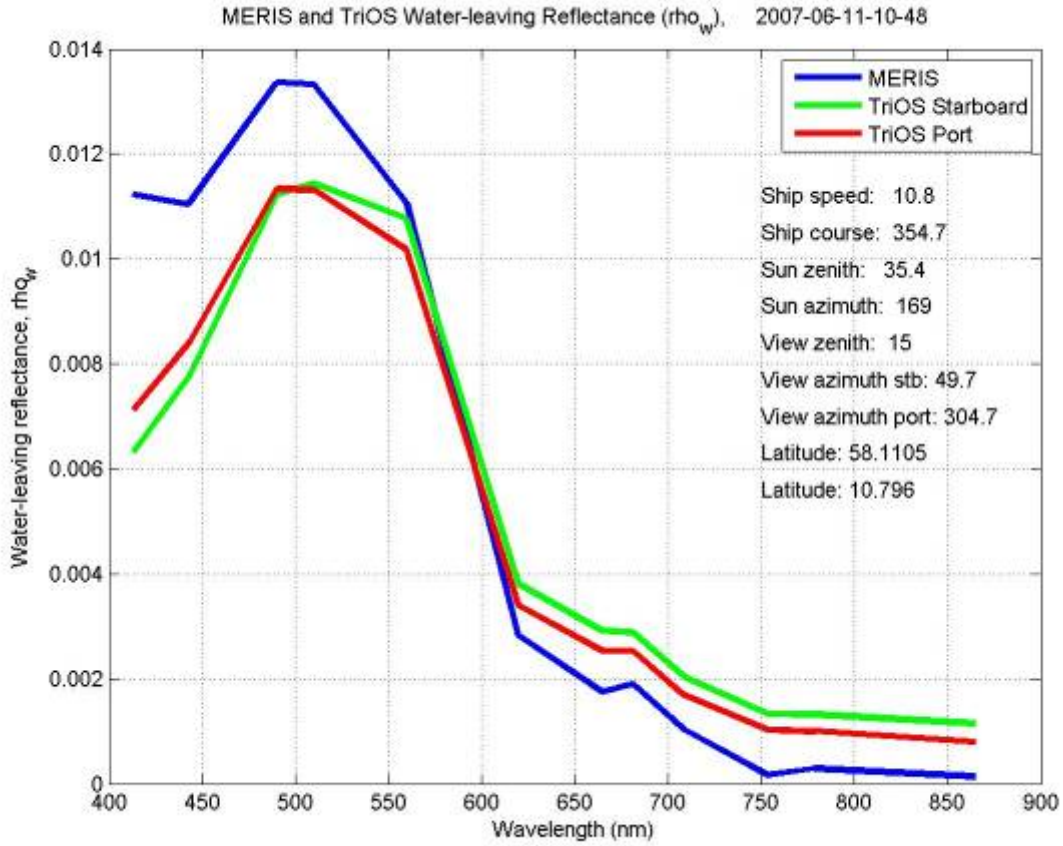
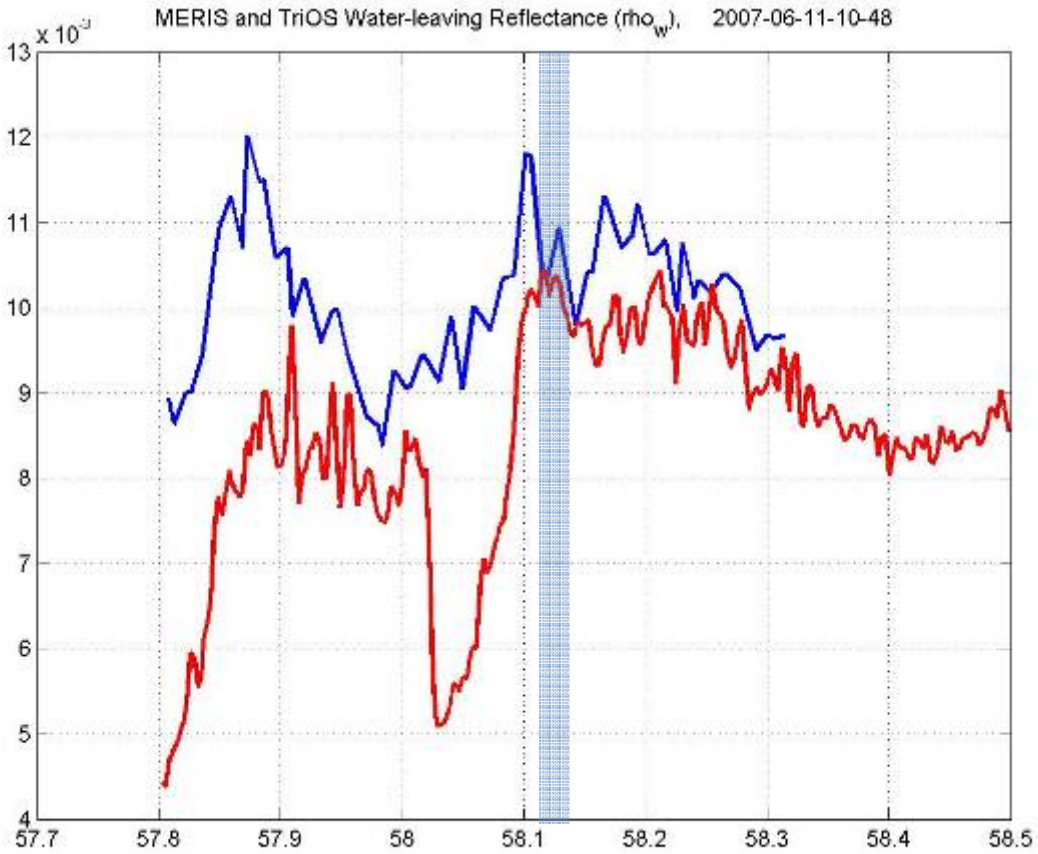

MERIS and TriOS Water-leaving Reflectance (rho$_w$), 2007-06-11-10-48
MERIS
TriOS Starboard
TriOS Port
Ship speed: 10.8
Ship course: 354.7
Sun zenith: 35.4
Sun azimuth: 169
View zenith: 15
View azimuth stb: 49.7
View azimuth port: 304.7
Latitude: 58.1105
Latitude: 10.796
Water-leaving reflectance, rho$_w$
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
400
450
500
550
600
650
700
750
800
850
900
Wavelength (nm)

Reflectance compared along transect



MERIS
Trios

Band 5
560nm

Future work on radiometric measurements

- Further development and implementation of SOOP data flagging
- Automize data transfer to enable near real-time data processing
- Automize procedures for
  - MERIS data extraction along ship transect
  - MERIS matchup identification
- Validation of SOOP data by research vessel data, investigate discrepancies
- Installation on new lines (e.g. Tromsø-Svalbard)?
- Hydro-optical modelling from simultaneous radiometric and water sensor/sample data