

SUSPENDED MATTER MEASURED BY AIRBORNE REMOTE SENSING AND SATELLITE IMAGES IN THE EAST FRISIAN WADDEN SEA, GERMANY

INTRODUCTION

Satellite image analysis is a common method for detecting suspended particulate matter (SPM) in coastal waters. The geometric resolution of these optical images is often not appropriate to identify complex hydrodynamic features often occurring in tidal flat regions. This limitation can be overcome with airborne digital imagery, where a pixel size of less than 20 cm can be easily achieved. Moreover, airborne suspended matter detection can be coordinated to the tides while satellite imagery follows strict time schedules.

We explore airborne digital imagery for suspended matter detection. Four digital consumer cameras with different optical filters attached to an airplane are used to take images of the East Frisian Wadden Sea. The camera pictures are compared with satellite measurements from ENVISAT's sensor MERIS.

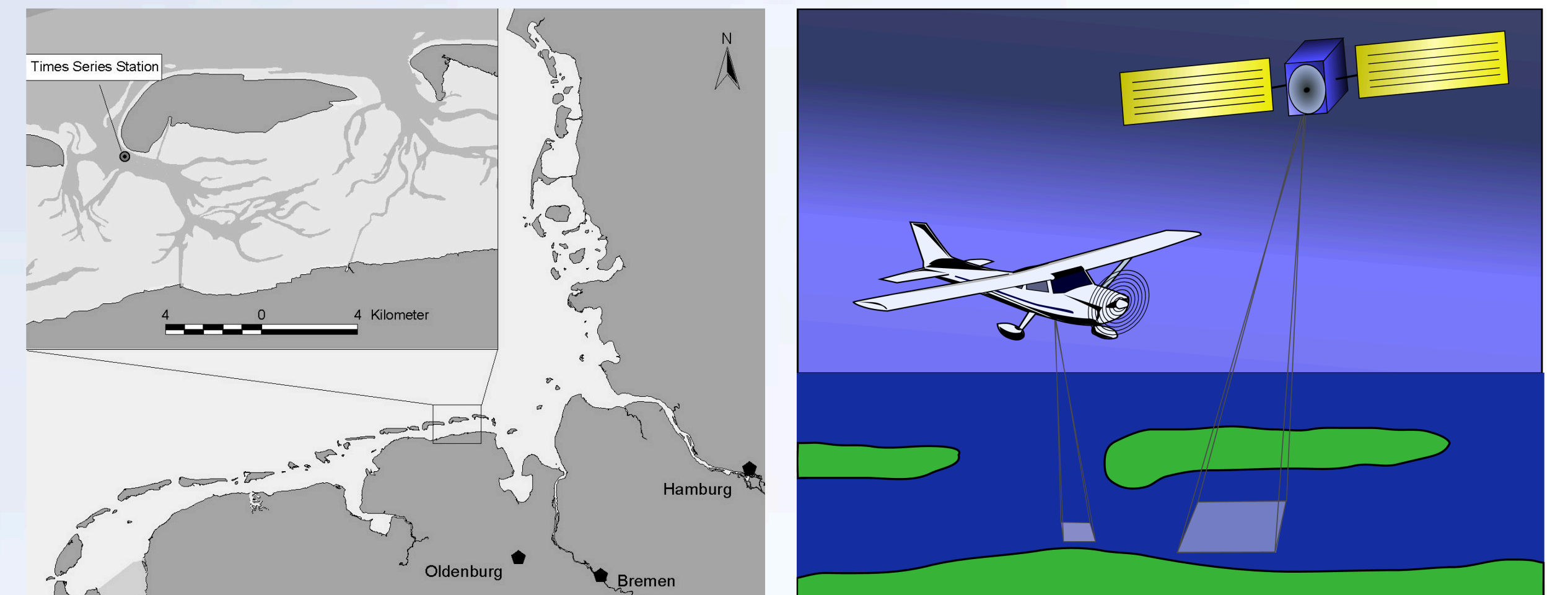


Fig. 1: Left: East Frisian Wadden Sea, and Backbarrier Wadden Sea of Spiekeroog Island, German Bight. Right: Airborne digital camera remote sensing.

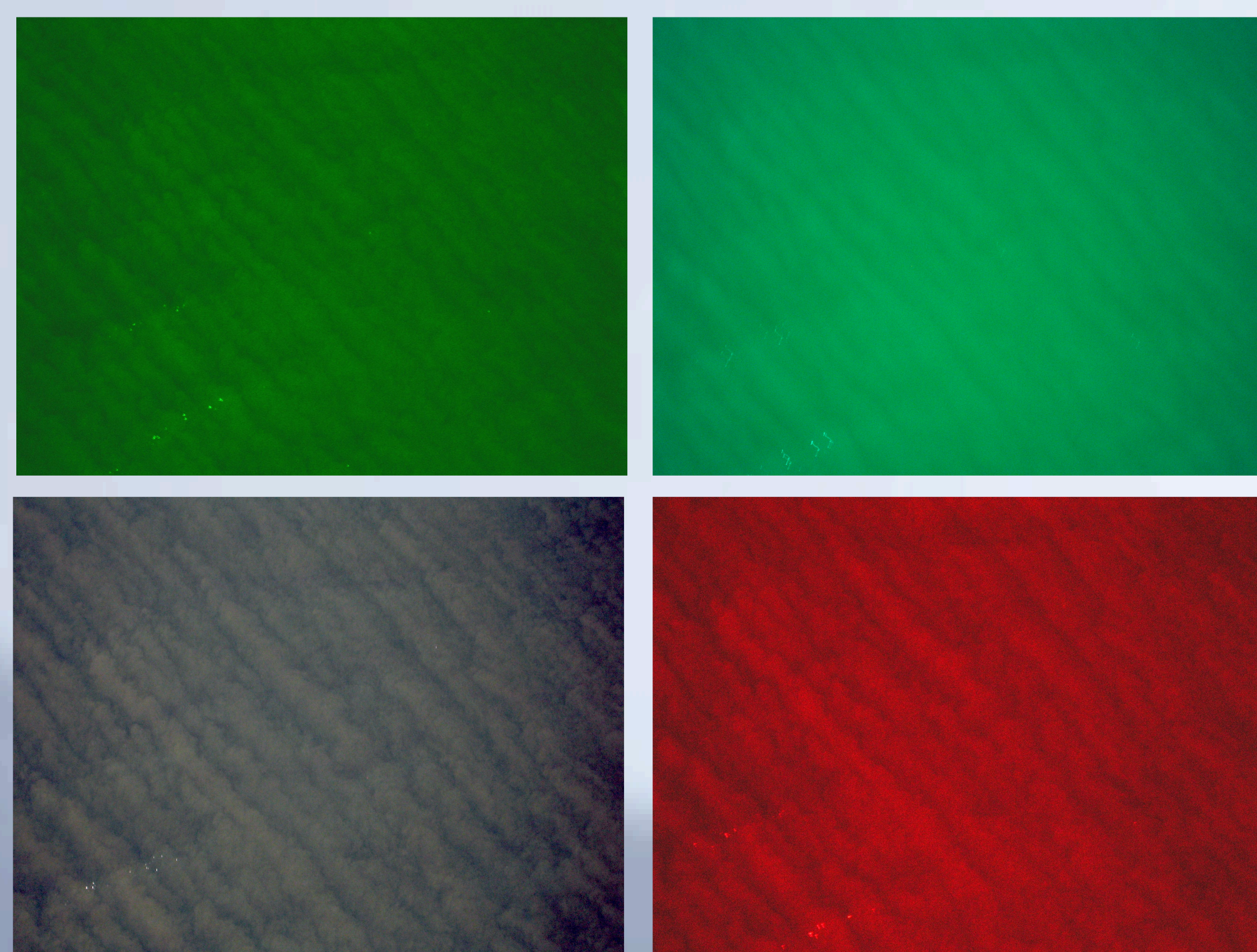


Fig. 3: The digital images taken with the cameras. From left: Camera 1 (filter 560 nm), camera 2 (filter 511 nm), camera 3 (without filter), camera 4 (filter 621 nm). Sediment clouds are visible.

Table 1: Correlation numbers and differences (average square distance) of medians and averages of one flight (12/07/2006). Larger absolute values of "Cor" indicate stronger linear relations. Smaller difference values "Diff" indicate more similarity between the digital camera channel and the MERIS SPM data than higher difference values.

		Camera 1			Camera 2			Camera 3			Camera 4		
		R	G	B	R	G	B	R	G	B	R	G	B
Cor	Avg	-0.022	0.438	-0.128	-0.081	0.256	0.245	0.696	0.426	0.315	0.612	-0.286	0.062
	Med	-	0.278	-0.109	-	0.103	0.199	0.702	0.388	0.285	0.601	-0.094	0.037
Diff	Avg	15.516	8.53	17.129	16.421	11.305	11.459	4.62	8.72	10.407	5.897	19.539	14.244
	Med	-	10.973	16.848	-	13.648	12.163	4.529	9.302	10.859	6.065	16.622	14.631

RESULTS

- Airborne camera values show strong linear correlation to MERIS SPM data.
- Calibration parameters are significantly influenced by small variations in weather conditions.
- Medians of a color channel perform better than averages in most cases.
- Correlations are strongest between the satellite SPM values and the red channel from camera 3 (without filter) and the red channel of camera 4 (filter 621 nm) (see Figure 5 and Table 1).

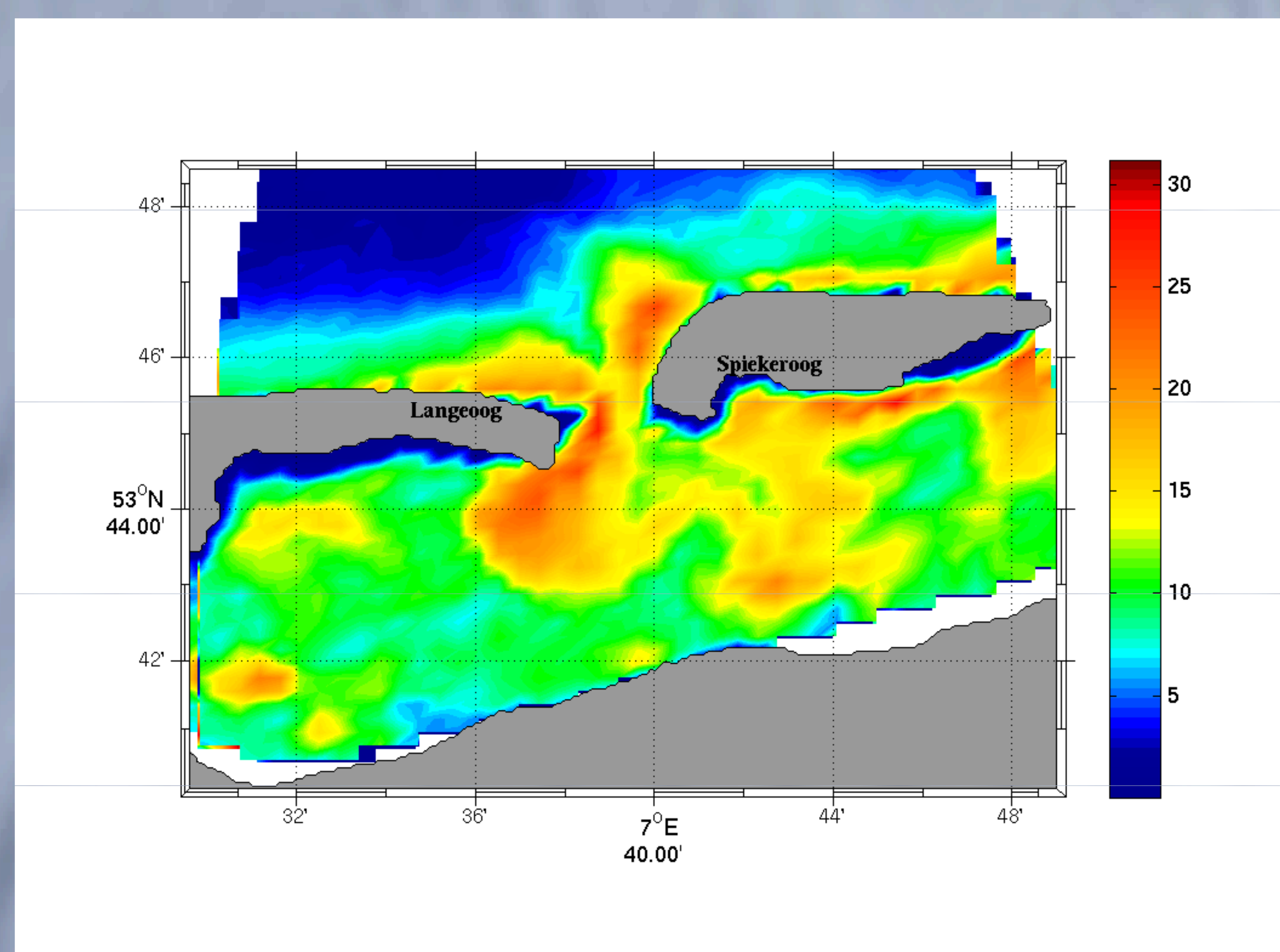


Fig. 4: Interpolated MERIS suspended matter (SPM/mg/l) data in the Spiekeroog tidal flat area on 12 July 2006.



Fig. 2: Left: The airplane. Right: The four cameras mounted to the bottom hatch of the airplane, three having interference filters.

METHODS

- Four nadir-looking digital cameras (Canon PowerShot S70) mounted to a bottom hatch of an airplane.
- Three of them with interference filters (511 nm, 560 nm, 621 nm).
- Photos taken every four seconds.
- Upwelling radiance measured by the camera.
- Downwelling irradiance spectra measured with upward looking spectrometer (RAMSES UV/VIS).
- Manual outlier removal (e.g., images showing sun glint)
- Averages and medians of RGB-channels are scaled and compared to suspended matter values from MERIS.

GENERAL FLIGHT PRECONDITIONS

- No clouds
- Satellite overflight at same time
- Wind speed < 4 Beaufort
- Within 2 hours prior or after high tide
- Flight height approximately 500 m

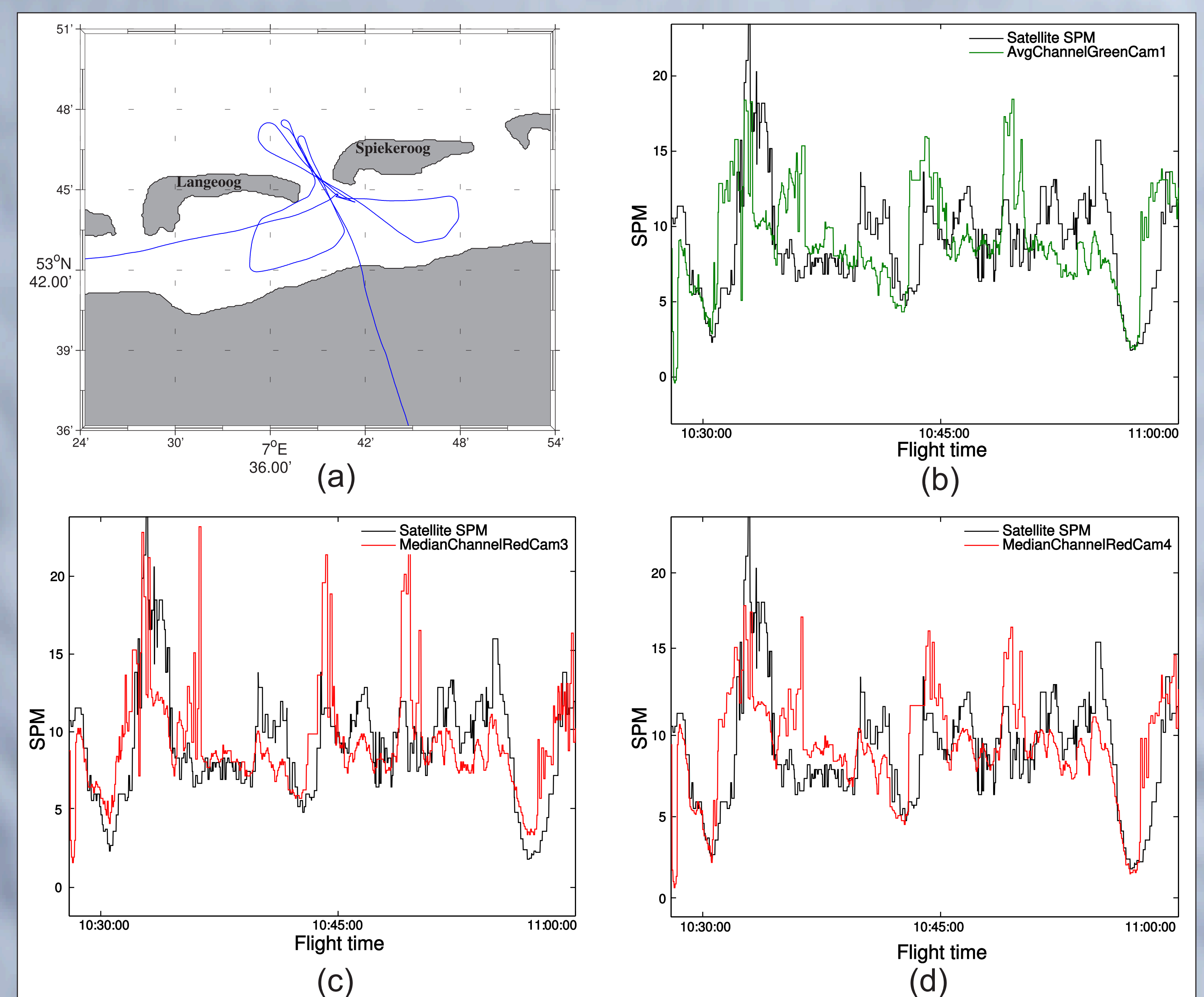


Fig. 5: (a) Flight route on 12 July 2006, (b-d) comparison between the scaled pixel values and the SPM-values: (b) average green channel of camera 1 (560nm filter), (c) median red channel of camera 3 (without filter), (d) median red channel of camera 4 (621 nm filter).