UV Ground-based imaging camera: EnviCam

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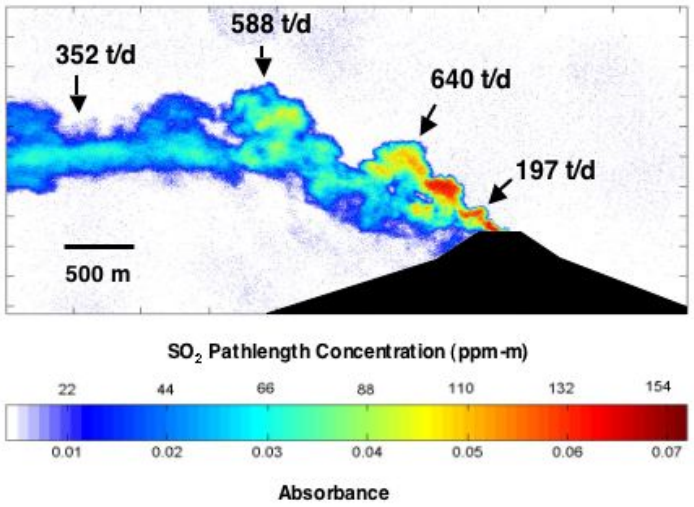
UV Camera systems



Development of an Ultra-Violet Digital Camera for Volcanic SO_2 Imaging

Bluth, G.J.S.*[1], J.M Shannon[2], I.M. Watson[3], A.J. Prata[4] and V.J. Realmuto[5]

500 td ~ 5800 g/s

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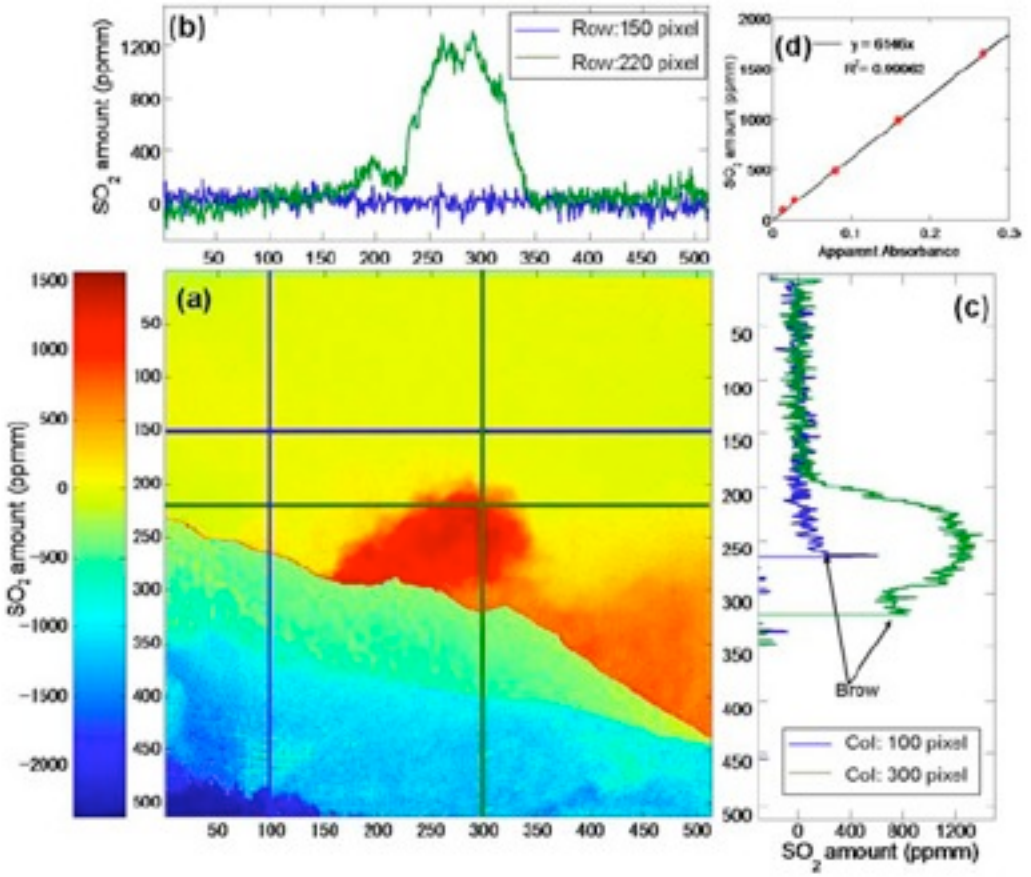
UV Camera for volcanic SO_2



Toshiya Mori and Mike Burton
The SO_2 camera: A simple, fast and cheap method for ground-based imaging of SO_2 in volcanic plumes

GRL, VOL. 33, L24804, doi:10.1029/2006GL027916, 2006

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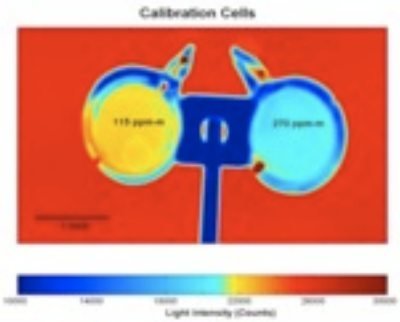
The NILU UVCam

Wavelength range	200–600 nm
Pixels	1344 x 1024
UV lens	50 mm f/3.5
UV filter	307±5 nm
Quantum efficiency	25% @ 250 nm
Digitisation	10 bits

A portable UV imaging camera for industrial and anthropogenic gas emission monitoring and assessment



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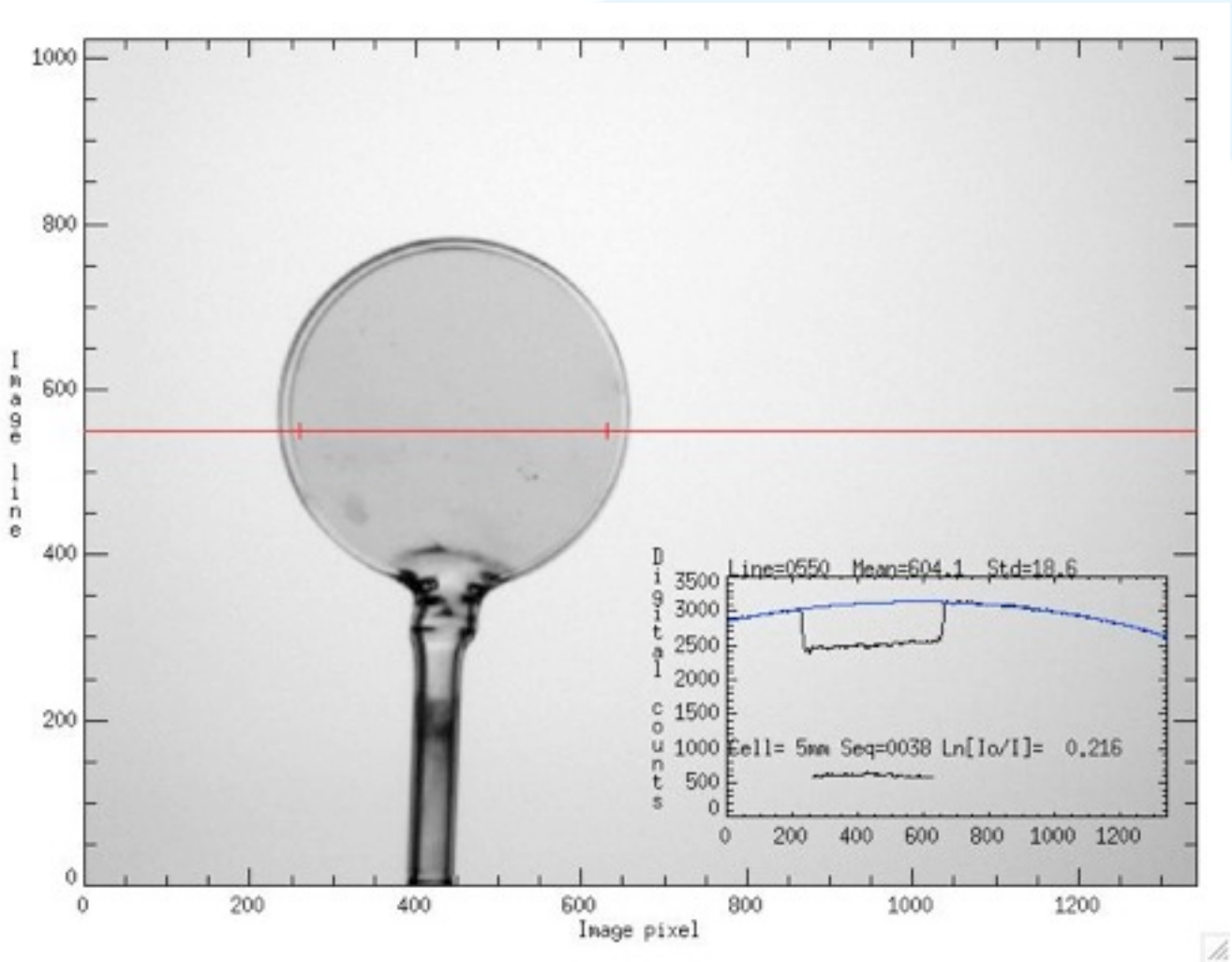
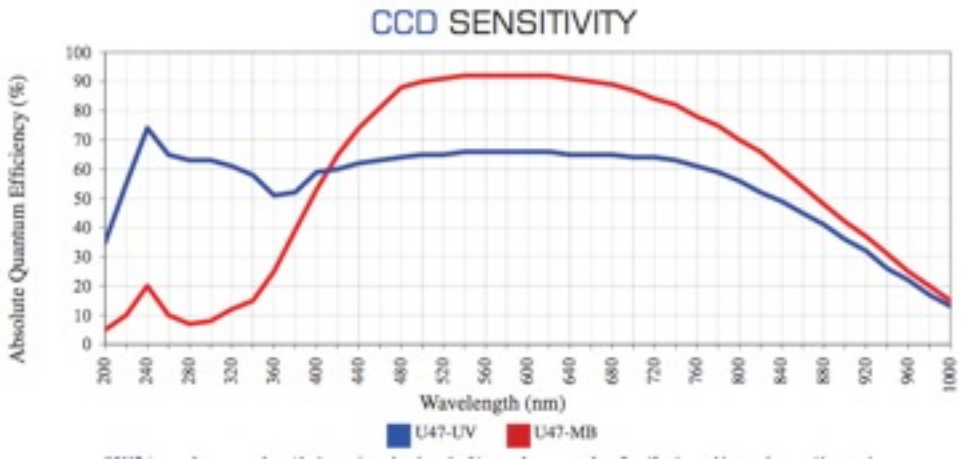
Calibration Cells



Apogee UV camera



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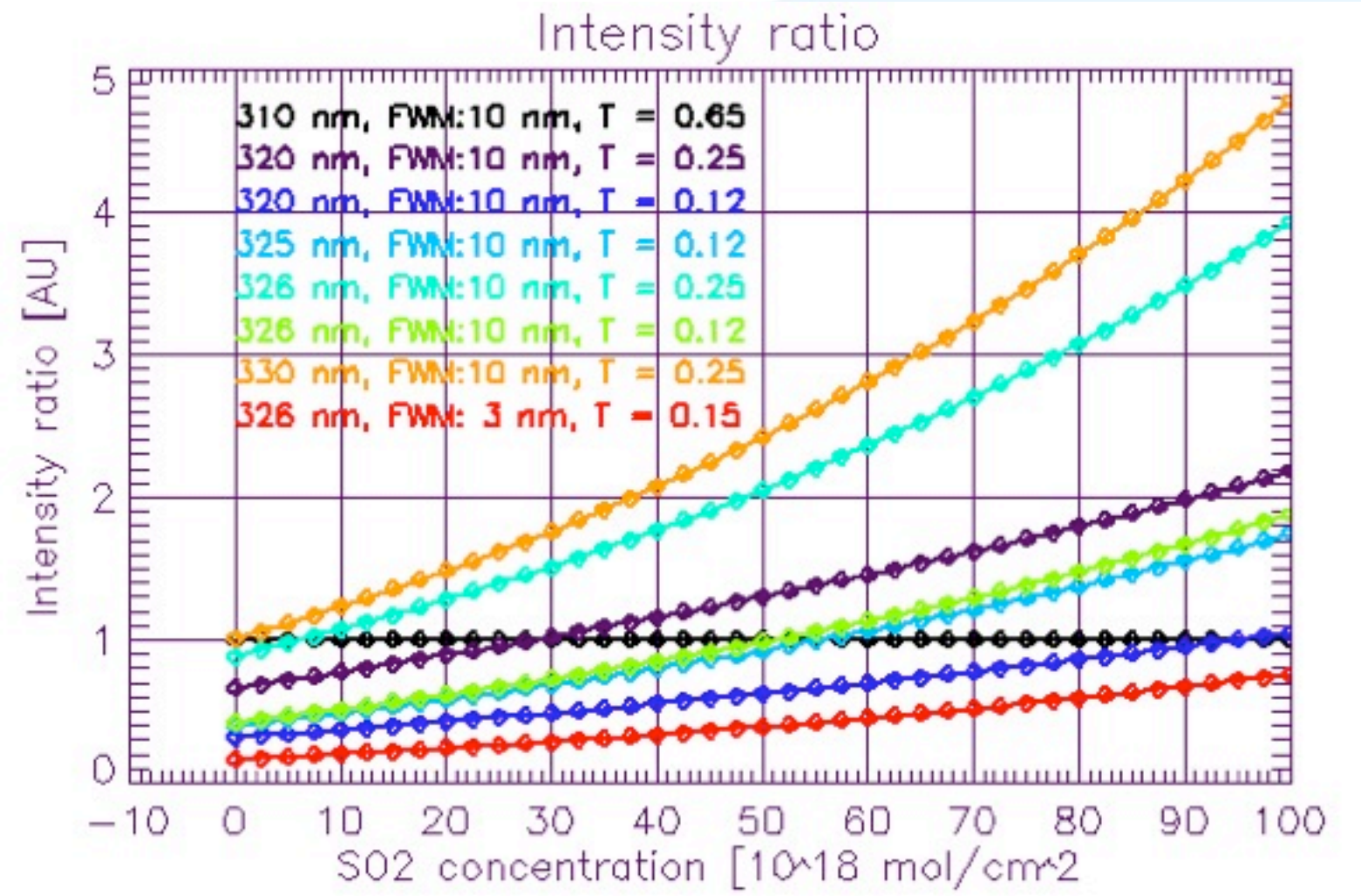
Filter wheel and lenses

Selecting the bands



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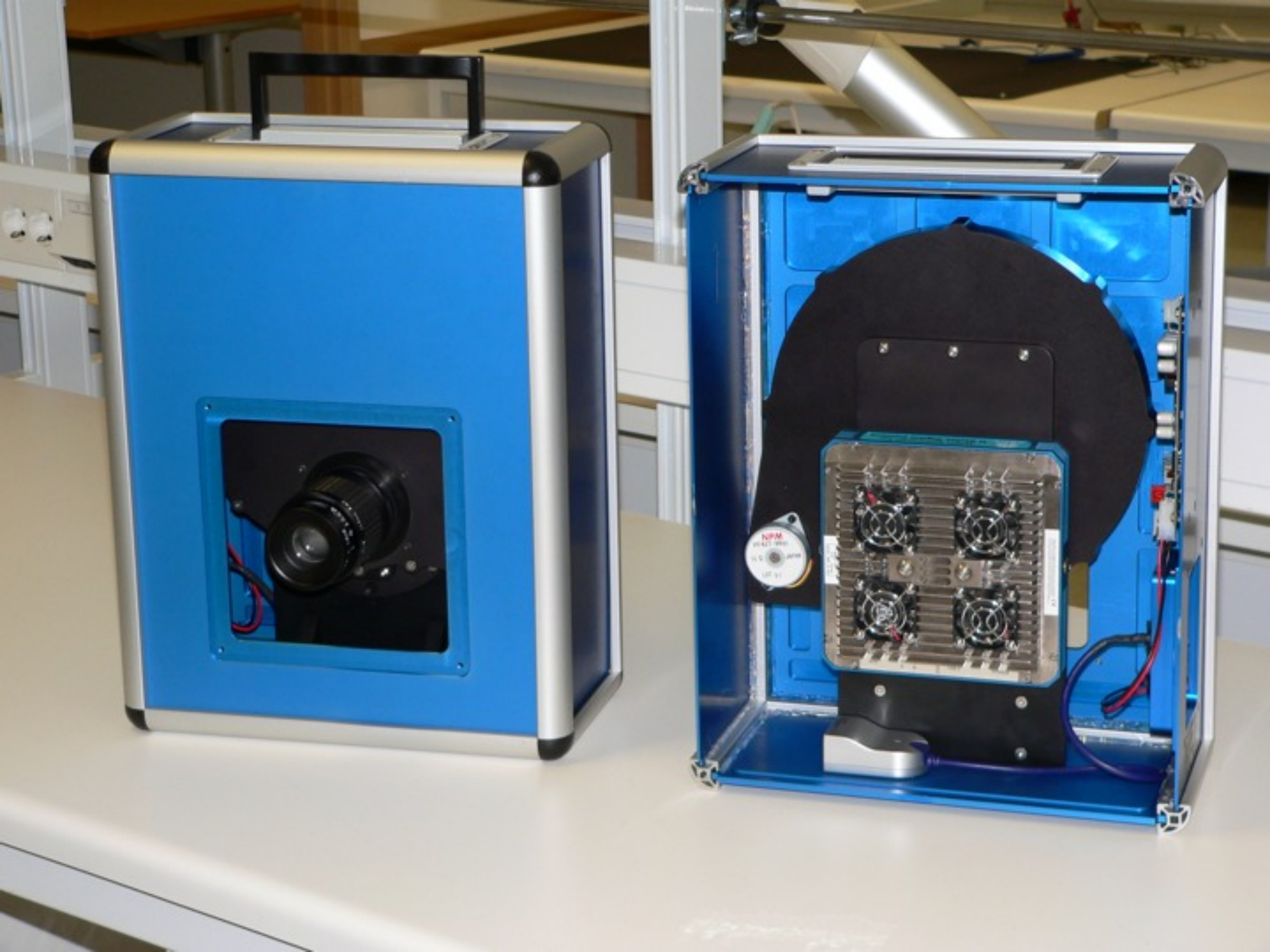
EnviCam 1



Users

Mike Burton (INGV)

Fred Prata (NILU)

INOE – Romania (5 cameras – industrial pollution)

Nick Varley (U of Colima)

Simon Carn (MTU)

Matt Watson (Bristol U.)

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Users - Envicam 2

SERNAGEOMIN - VHP/Chile

- 3 cameras - volcanoes

Matthias Hort -

- 1 camera - volcanoes

JRC/European Commisison

- 1 camera - ship emissions

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- 2 camers - volcanoes/ship emissions

South Africa

- 1 camera - industrial emissions

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SUVEX: Svalbard UV EXperiment

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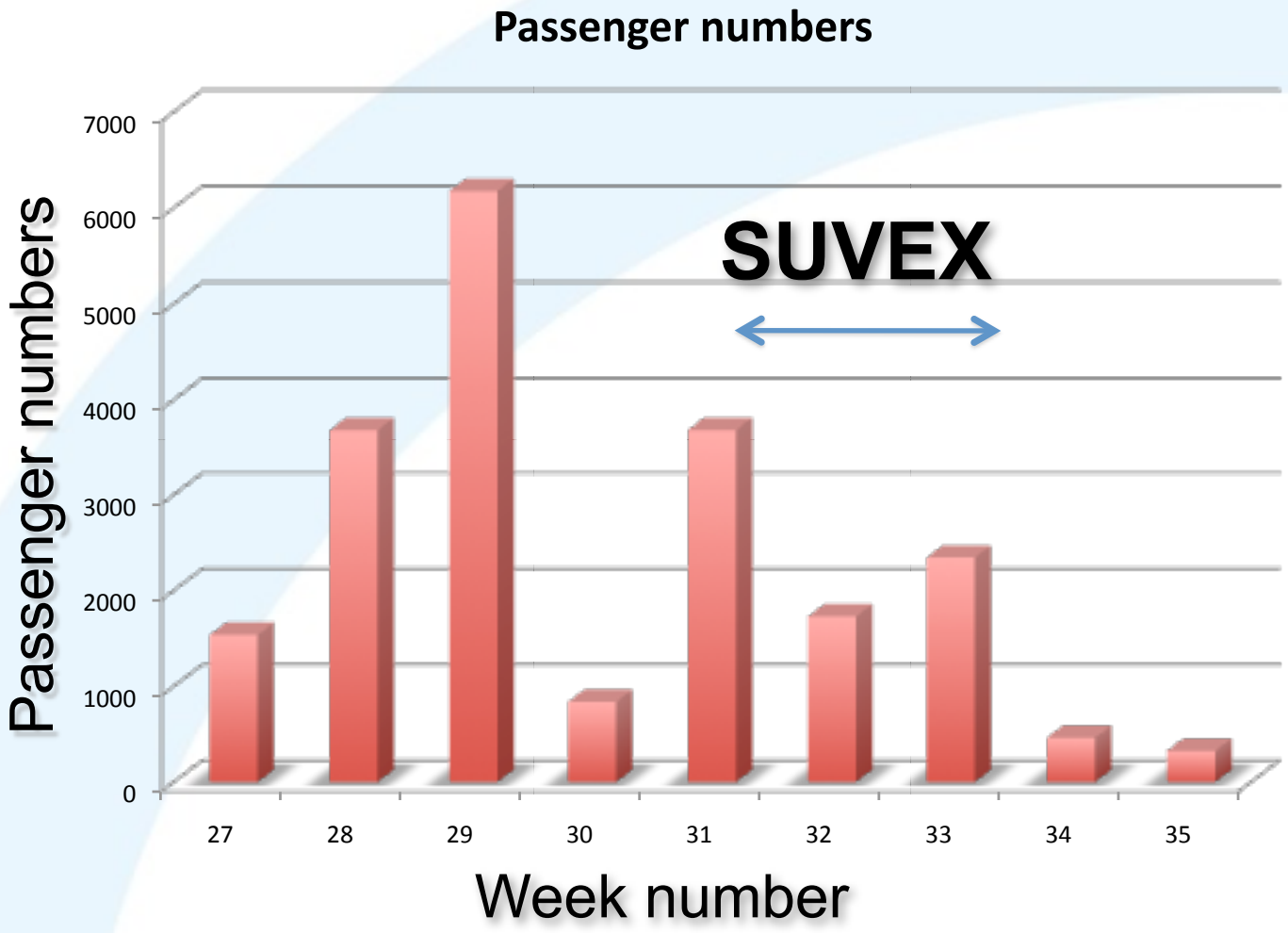
Ny Ålesund, Svalbard
27 July – 6 August, 2009

Fred Prata and Are Backlund
NILU, Kjeller, Norway
Email: fred.prata@nilu.no

Cruise ship visits to Ny Ålesund

Summer 2009



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The Costa Majica at anchor in Kongsfjorden, 03.08.2009
(approx. 3,500 passengers)

Expedition leaving Ny Alesund 29.07.2009 Start time:18:45:12 UTC

SO_2 emission rate (g s^{-1})

10
8
6
4
2
0

45.0
45.5
46.0
46.5
47.0
Minutes

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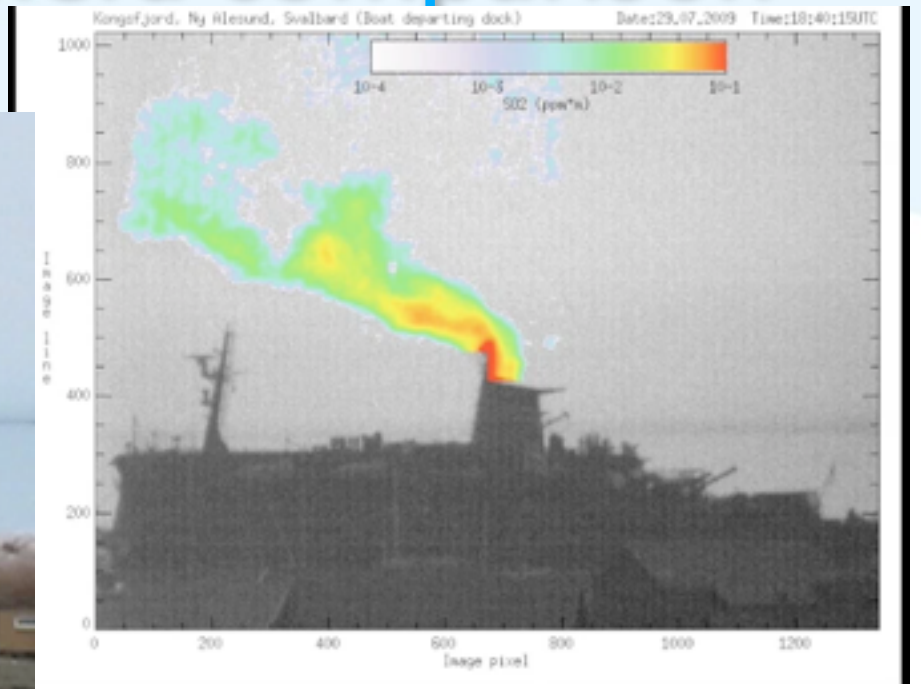
Visible and UV camera comparison



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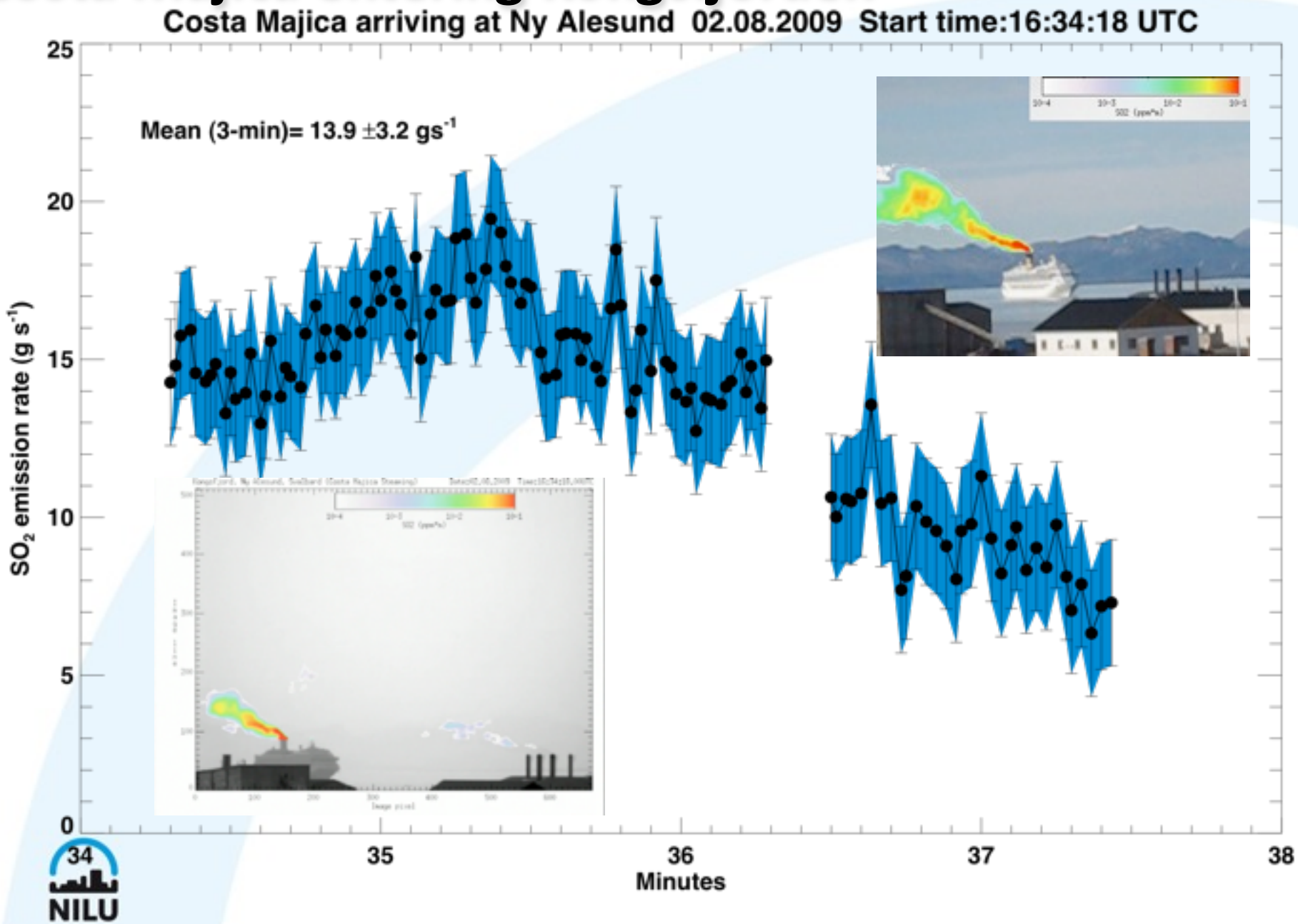
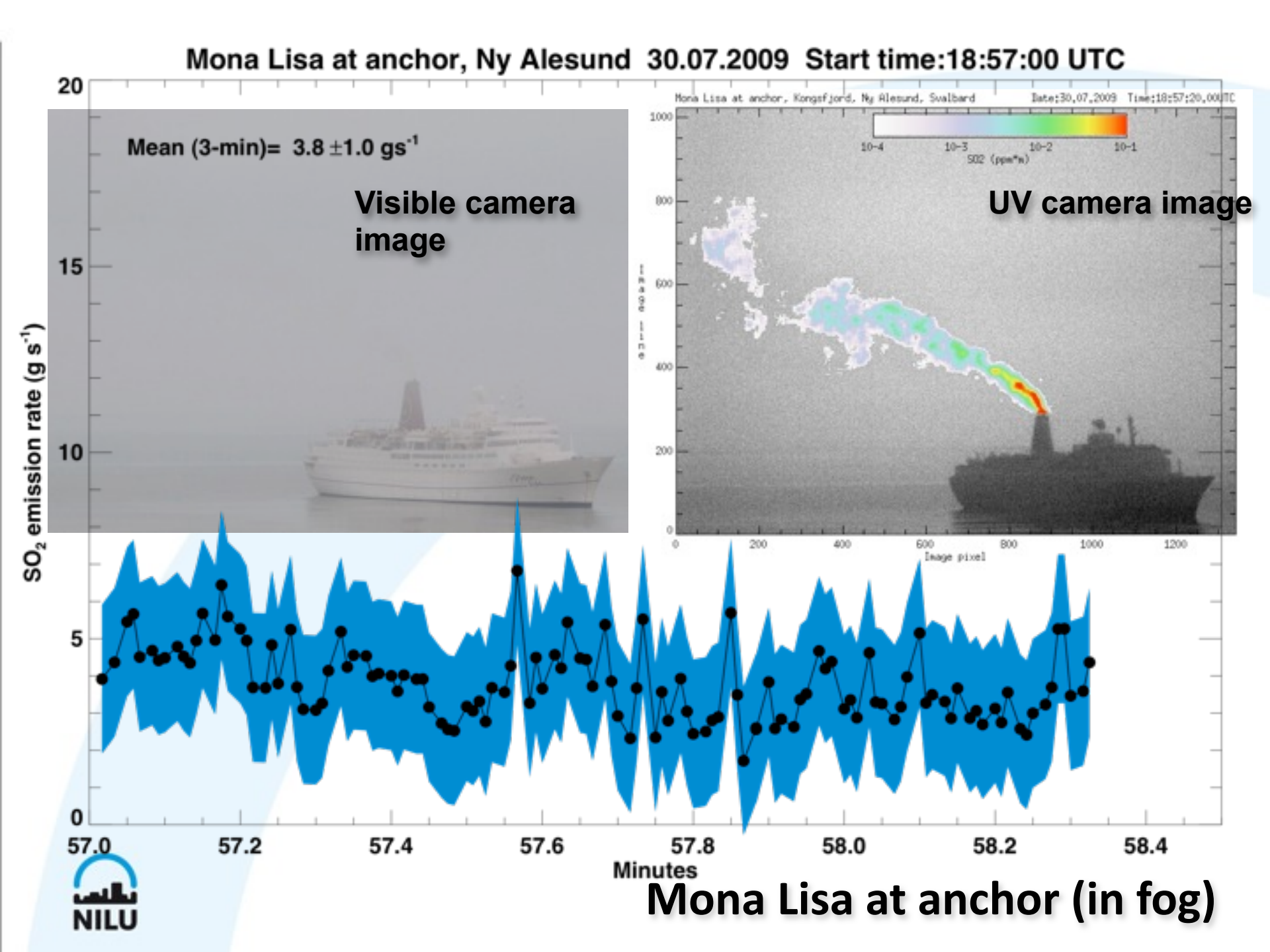
Costa Majica entering Kongsfjorden




Mona Lisa at anchor, Ny Alesund 30.07.2009 Start time:18:57:00 UTC
Mean (3-min)= 3.8 ±1.0 gs-1
Visible camera image
UV camera image
Mona Lisa at anchor, Kongsfjord, Ny Alesund, Svalbard
SO2 (ppm*m)
Image line
Image pixel
SO2 emission rate (g s-1)
Minutes
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Mona Lisa at anchor (in fog)

Summary

Ship	GRT§	SO_2 Emission rate (gs^{-1})
MS Expedition	6,336	11–14 (7.8*)
Sergei Vavilov	6,450	8.5
Mona Lisa	26,678	3.8*
Costa Majica	102,587	10–18

Ny Ålesund power plant $<0.5\ gs^{-1}$

*At anchor

§Gross Registered Tonnage

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Rotterdam Ship Emissions Campaign 14–29 September, 2009

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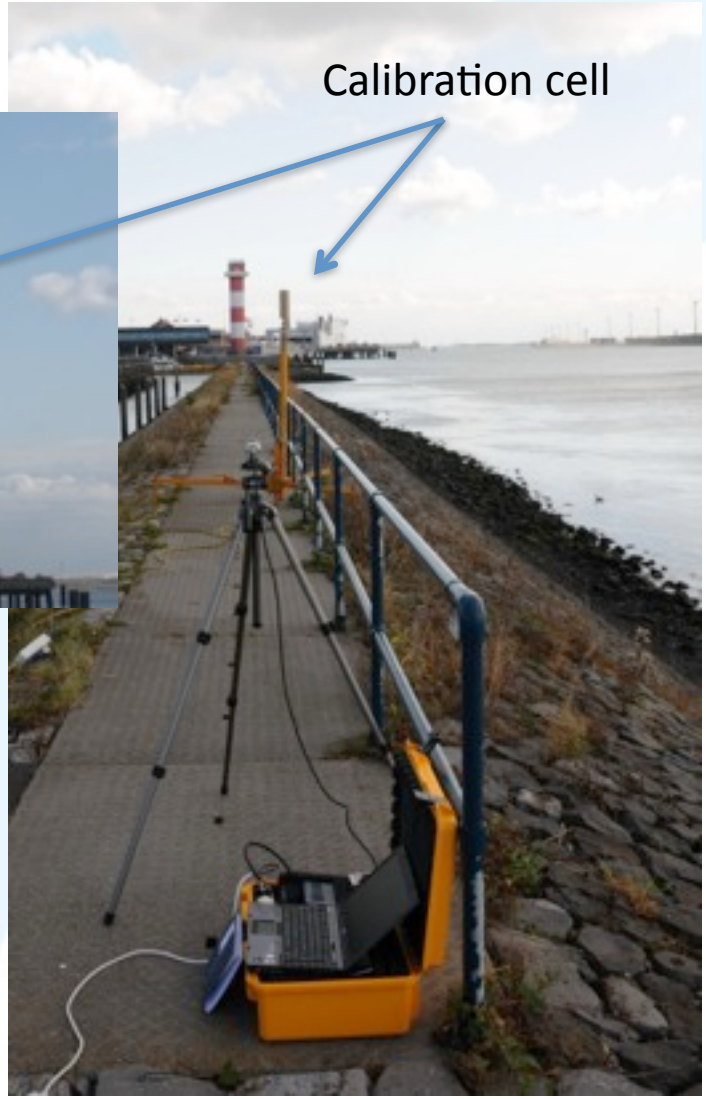
UV Camera at Hoek van Holland



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UV Camera on Stena Ferry

Camera pointing at one funnel

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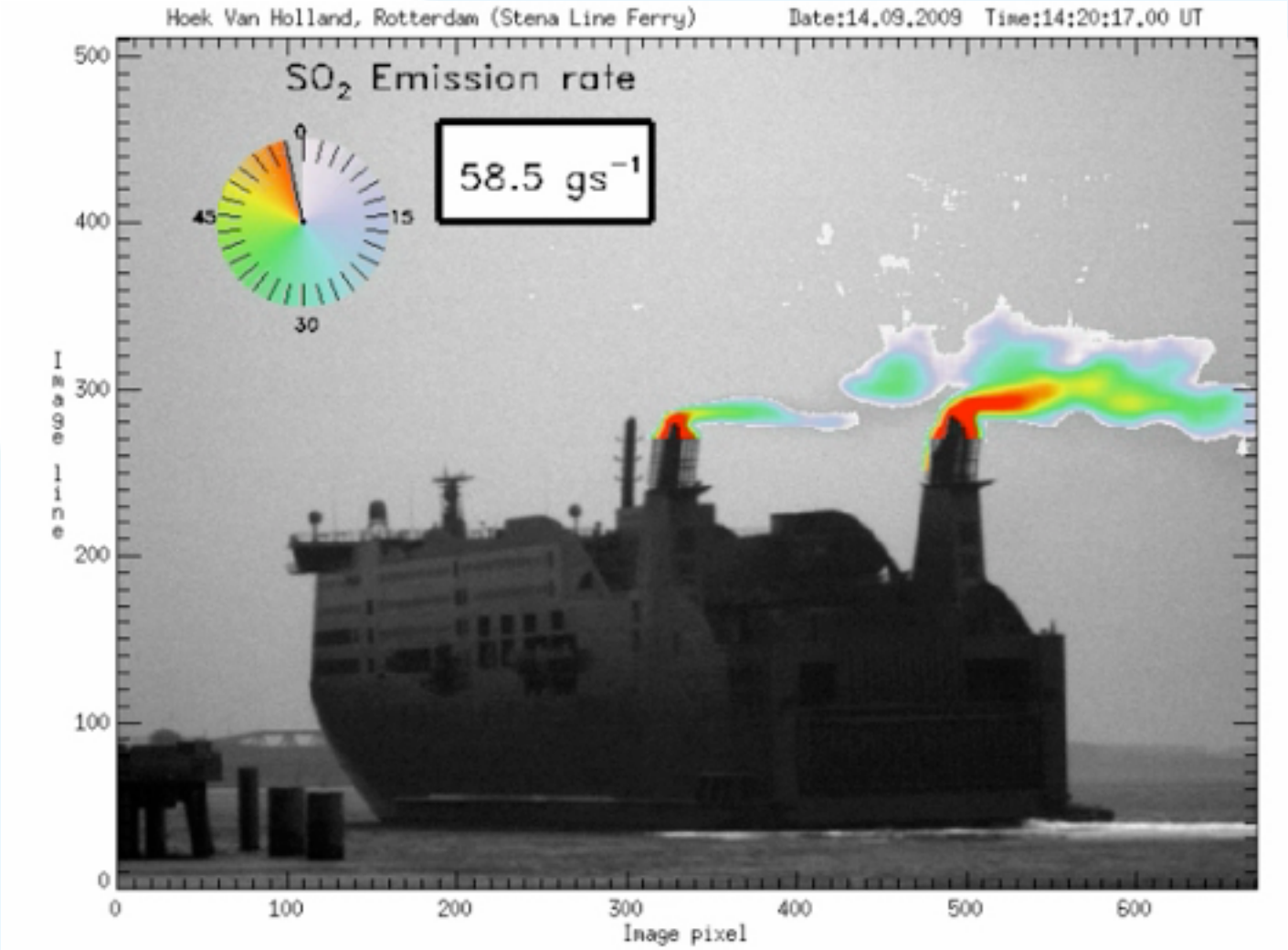
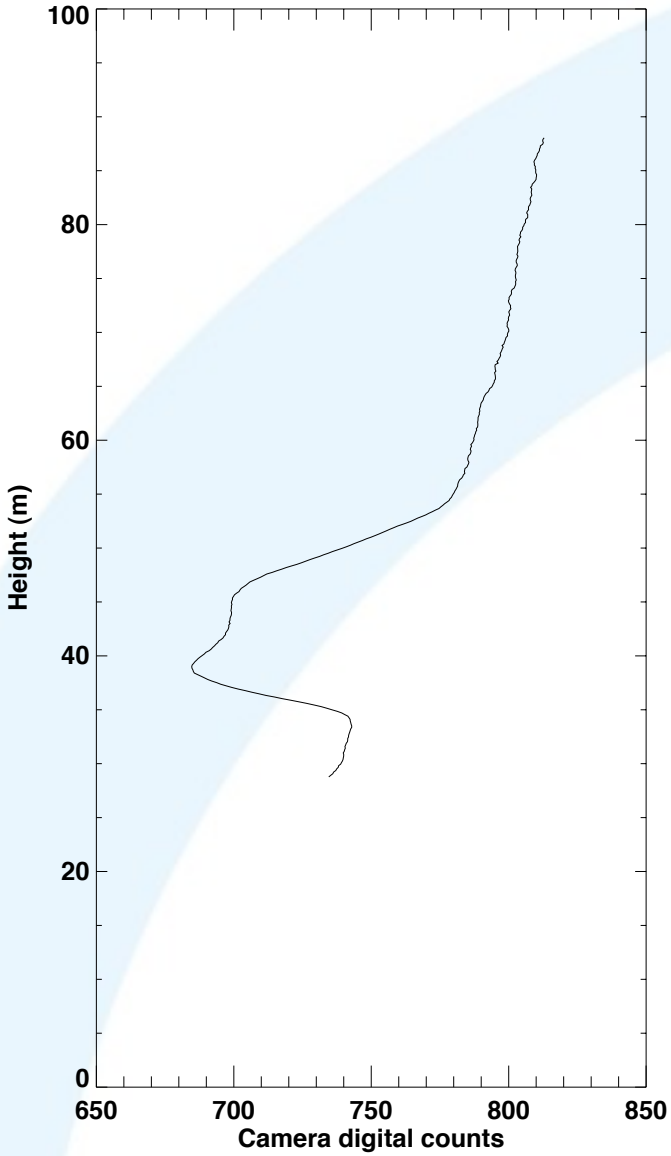
UV Camera at Hoek van Holland

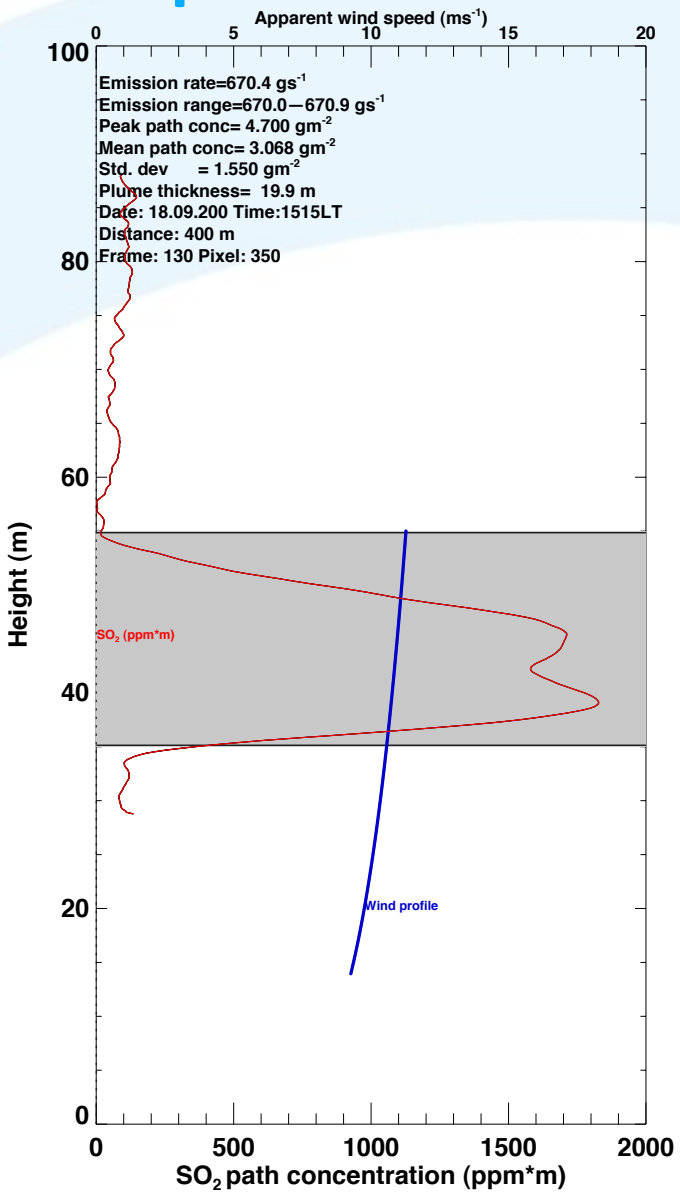
Emissions from power plant potentially cause much higher background levels

NILU UV camera in operation Port of Rotterdam

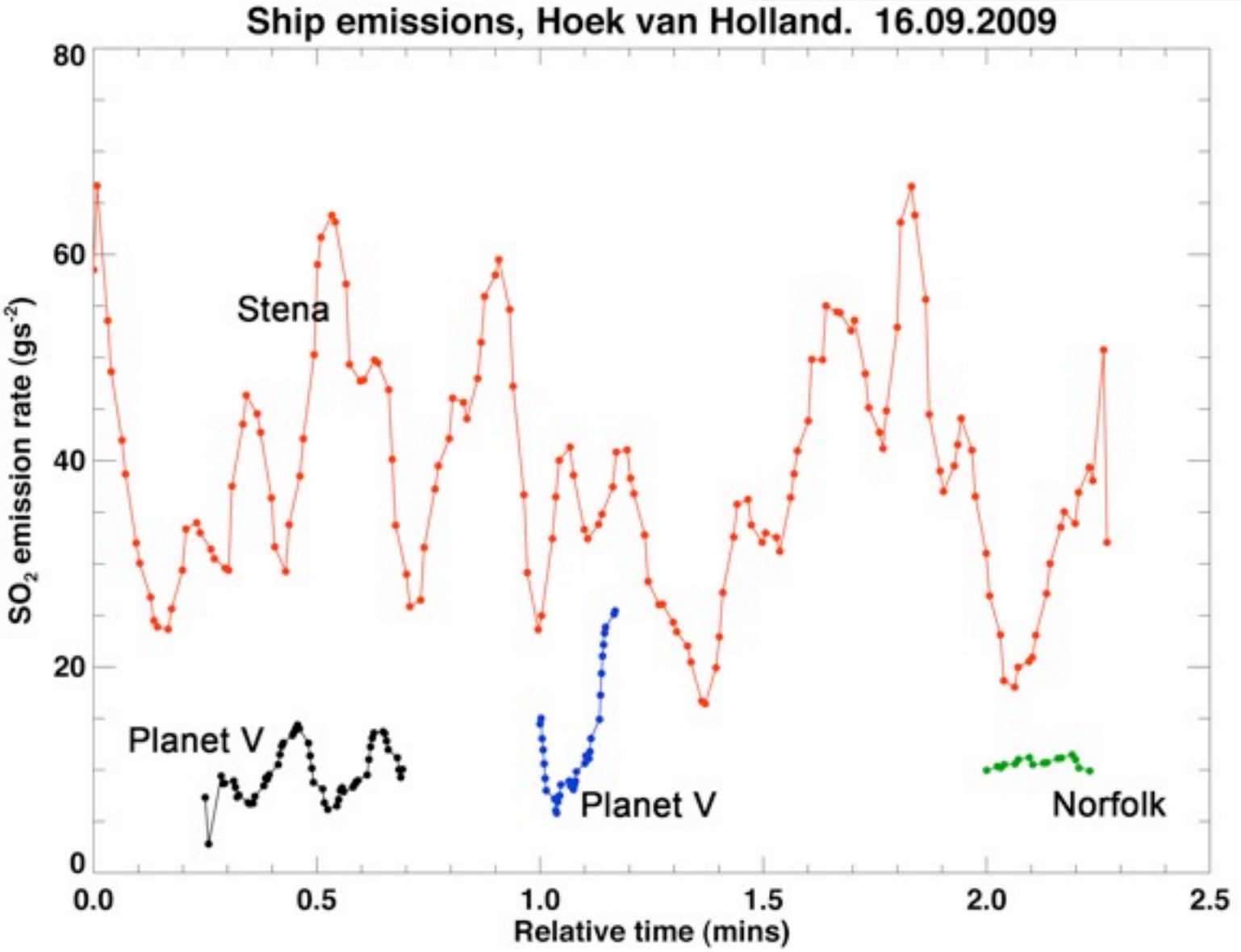


Emissions from power plant





Summary of some measurements



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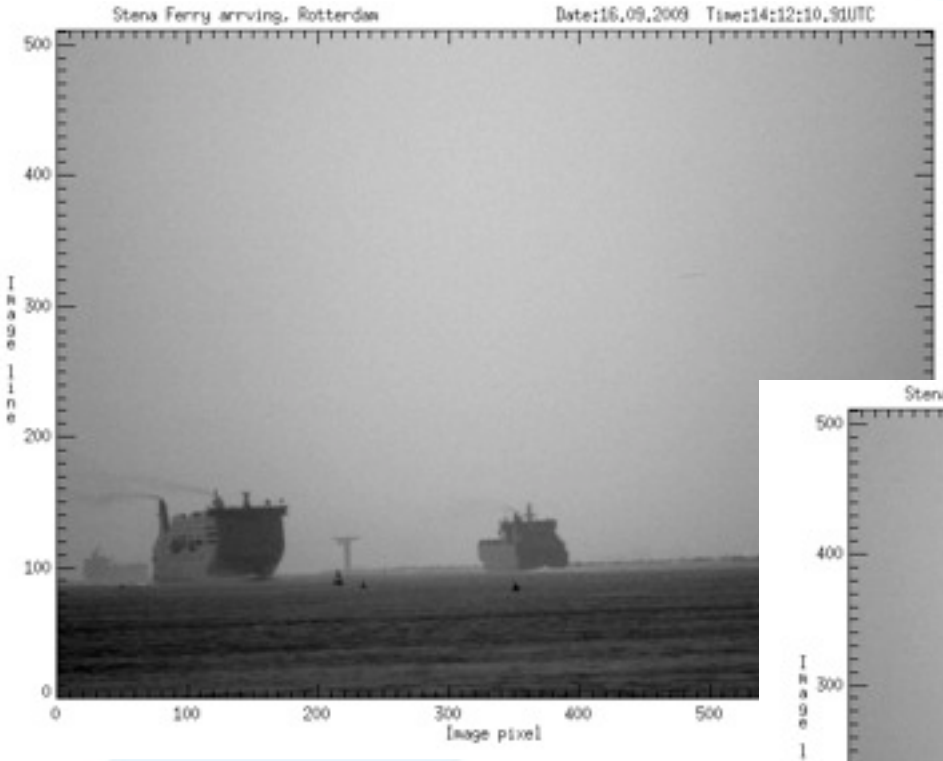
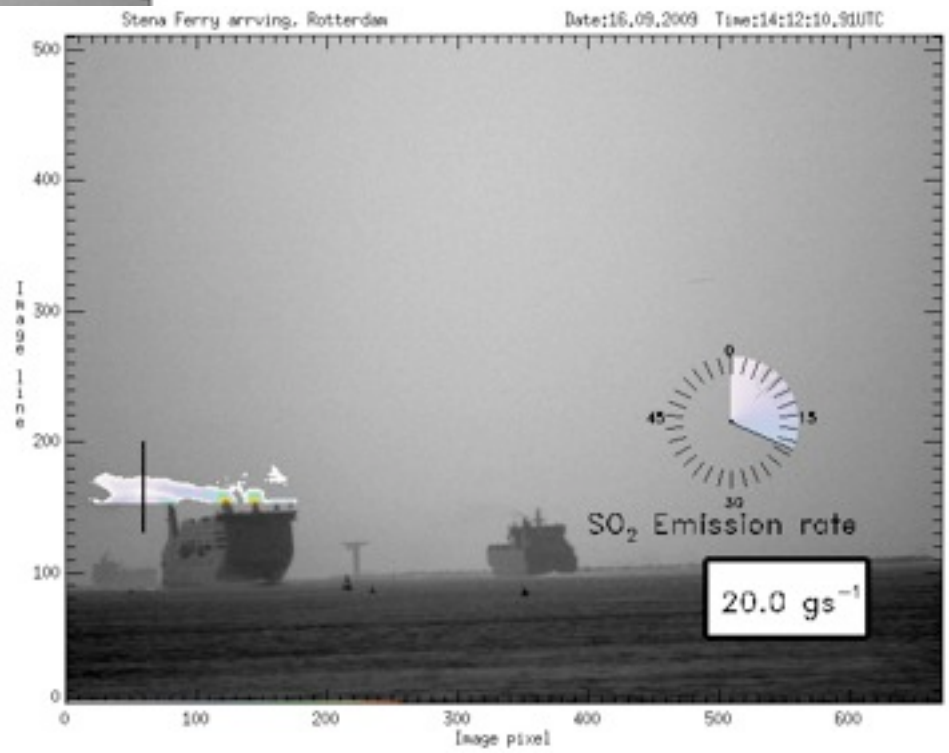
Some ships …

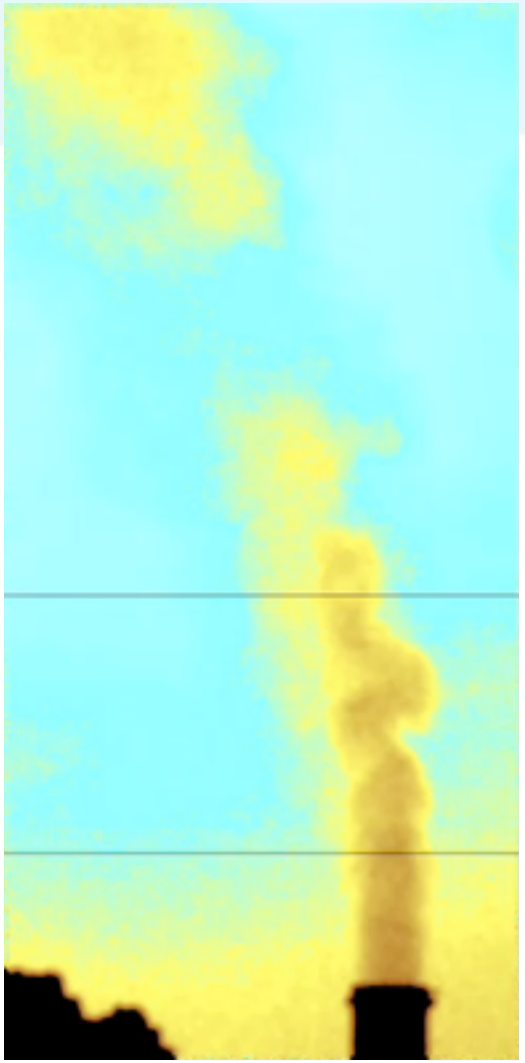

Stena Ferry arrving, Rotterdam
Date:16.09.2009 Time:14:12:10.9UTC
Image line
Image pixel


Stena Ferry arrving, Rotterdam
Date:16.09.2009 Time:14:12:10.9UTC
Image line
Image pixel
SO2 Emission rate
20.0 gs-1

Power plant in Australia

Instrument set-up

SO_2 emissions



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The Genova Ship Emissions Campaign

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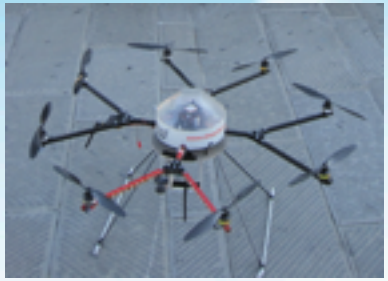

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Motivation

Ship emissions considered an important contributor to climate change and environmental pollution (SO_2 ~7% of global emissions; -0.11 Wm^{-2} forcing)

Virtually no incentive for ships to reduce emissions

Current estimates of ship emissions are based on global bunker fuel sales

New EU regulations (July 2010, Annex VI MARPOL) need enforcement (traditional estimates based on inventories)

JRC are leading a project to investigate possible technologies for measuring ship emissions (SO_2, NOx, CO_2)

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Logistics

Particpants:

- JRC (Lead)
- NILU (Fred Prata)
- OctoCopter pilot (Wolfgang)

Where:

Genova harbour area

Platform:

Guardia Costea vessel

3 days hire; 6 hr per day

Measurements:

Gas sniffers (NOx, SO_2, CO_2)

UV imager (SO_2/particles)

OctoCopter (SO_2)

Ship speed, position, direction.

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EnviCam (nearly 2)

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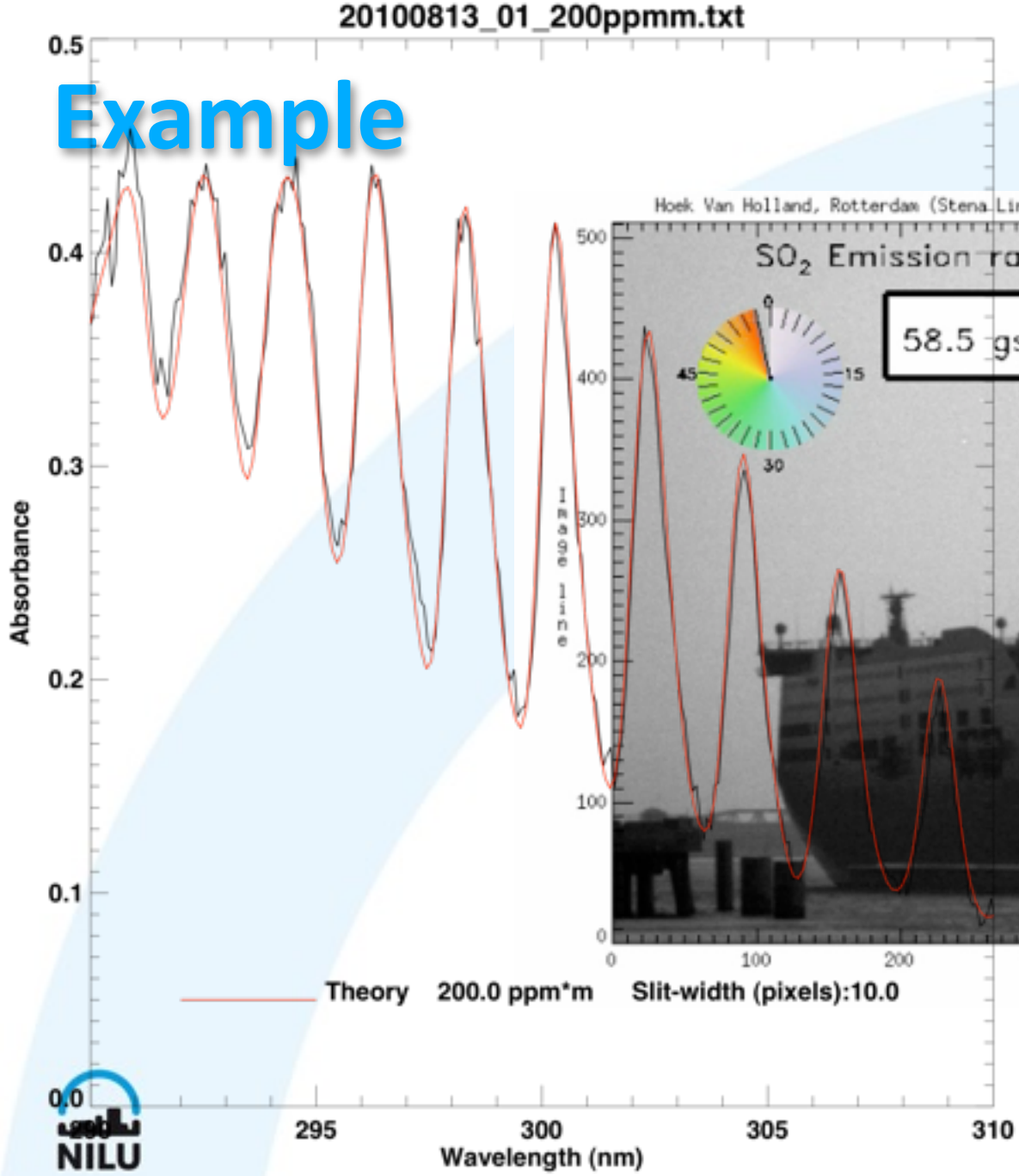
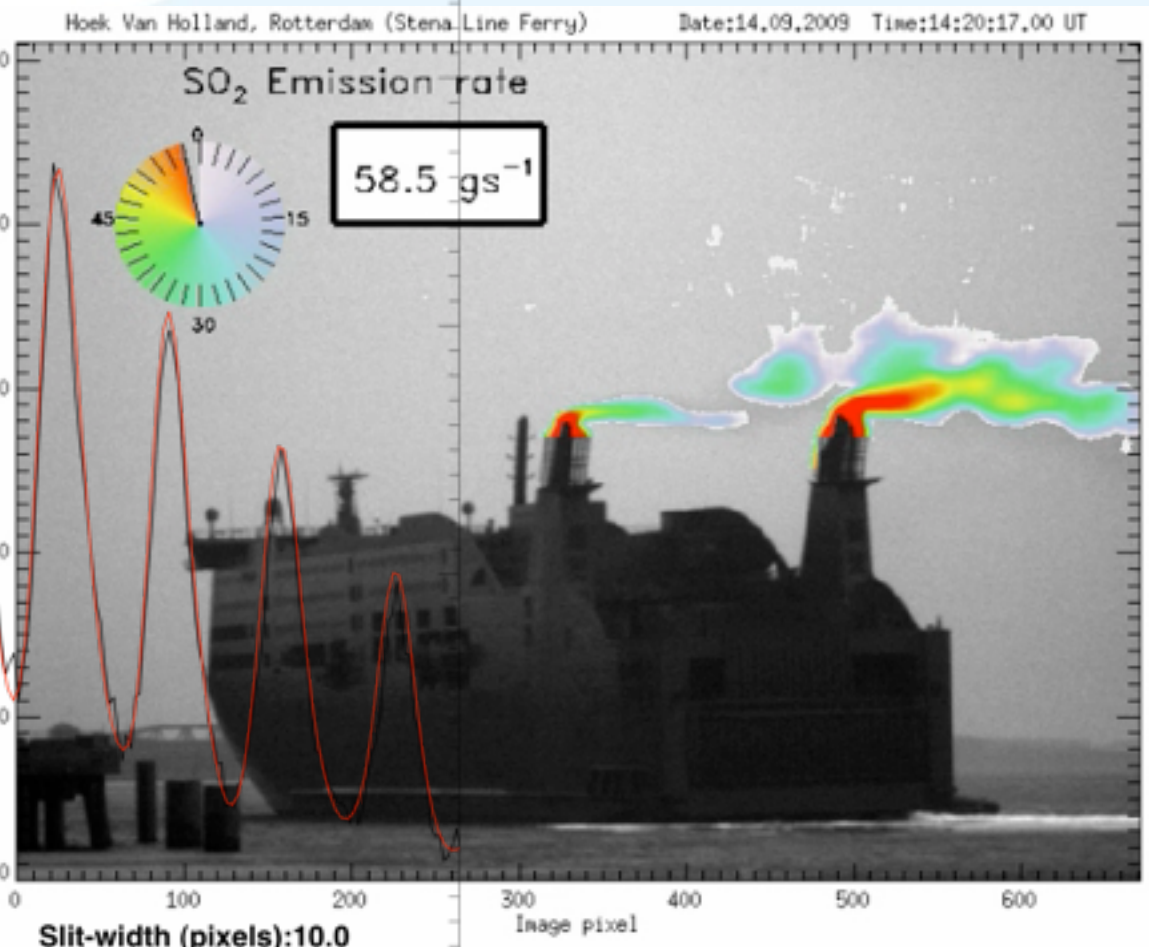
Example

$$A=-Ln(I/I_o)=\alpha\rho L$$





EnviCam Measurements

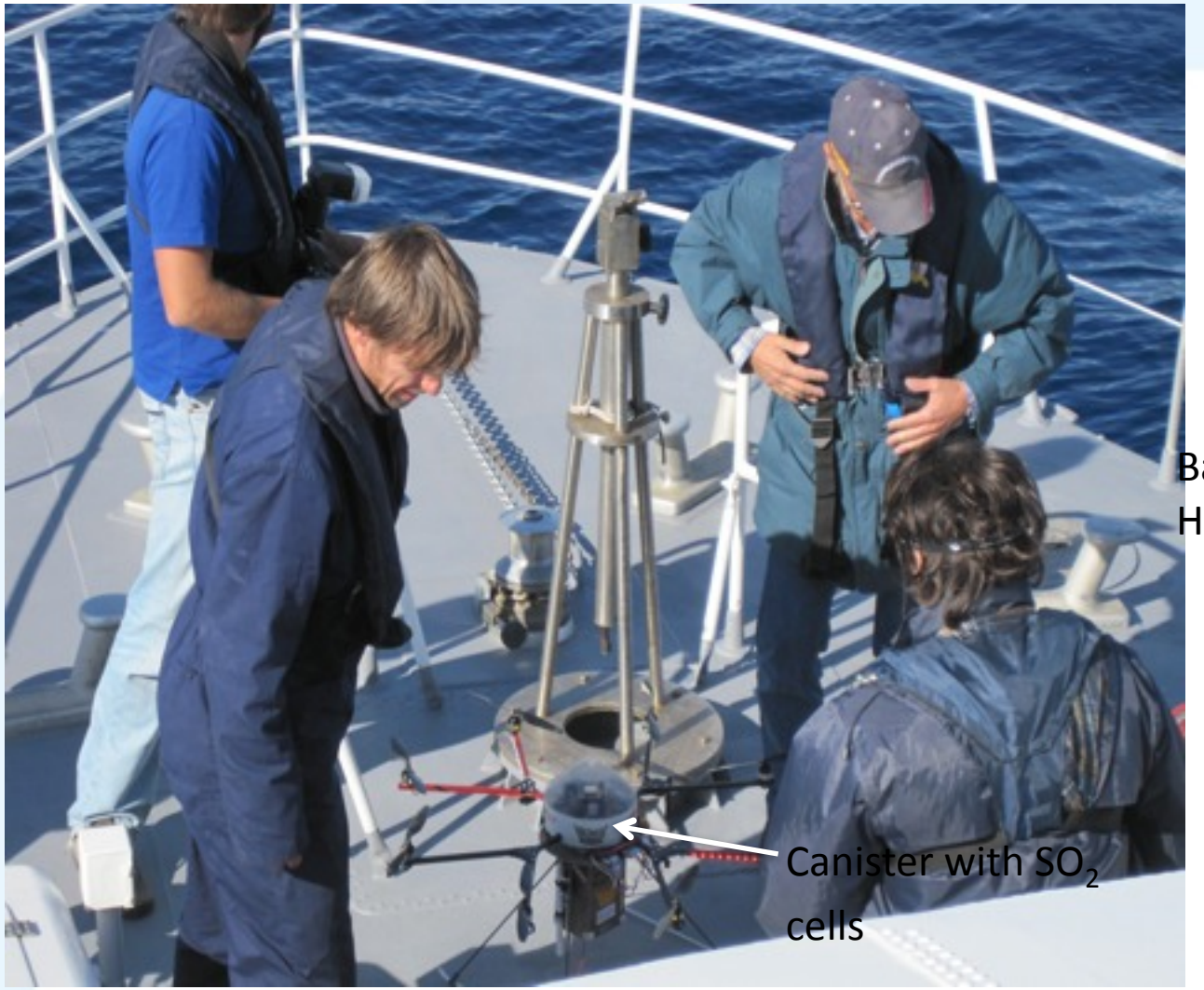
OctoCopter

UAV
8 propellers
Battery powered
Maximum load 1 kg
Endurance (under load) ~7 minutes

OctoCopter SO_2 canister

Jacob (JRC-?)

Wolfgang (?-Austrian)



Fritz (JRC-Austrian)

Balint (JRC-Hungarian)

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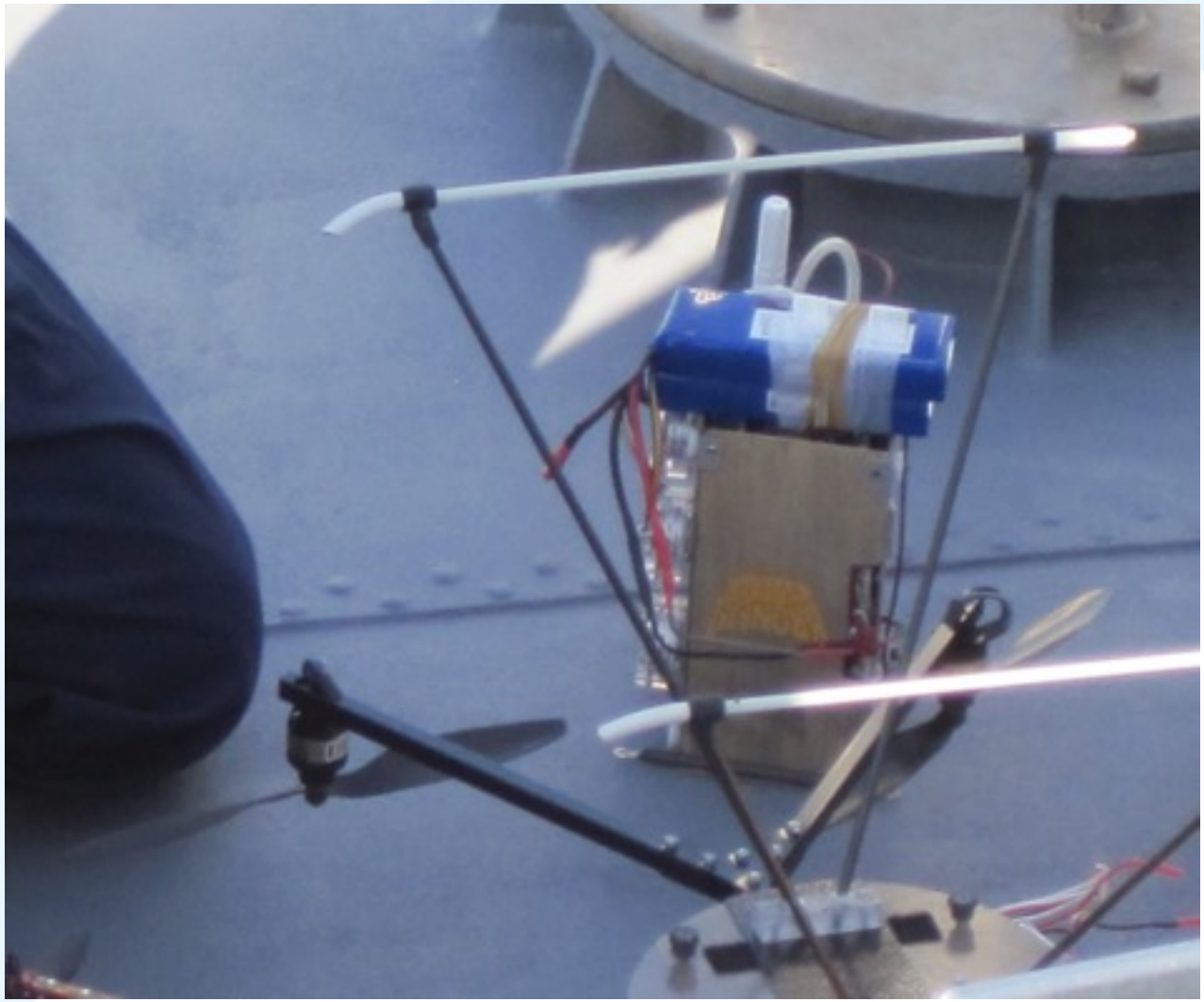
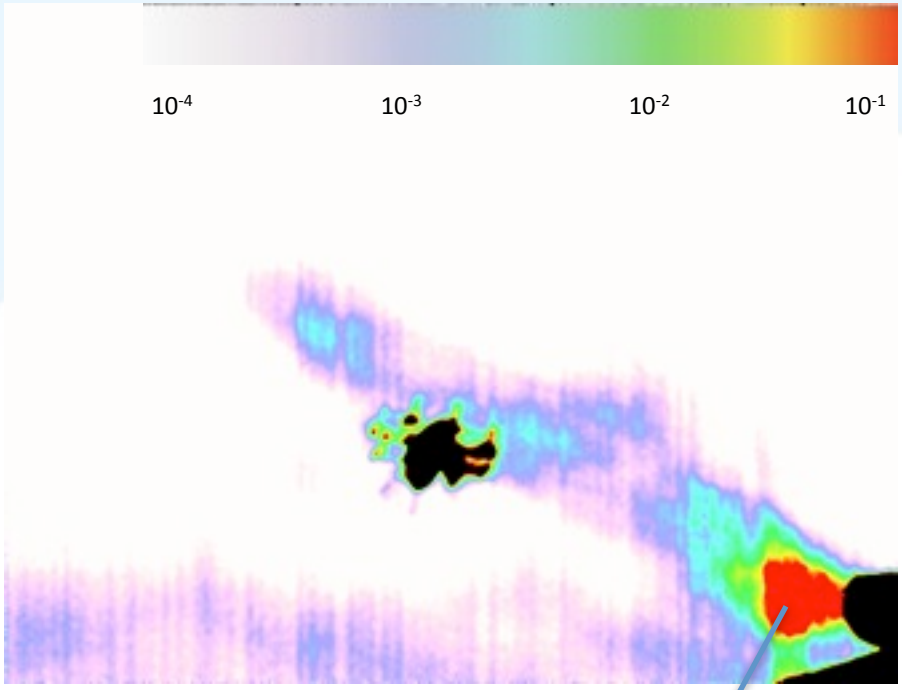
Canister




CE Merapi
Seattle Bridge
Alessandro F
San Francisco Express

Results (very preliminary)



0.1 ppm*m, 2 m thick plume
gives concentration ~50 ppb

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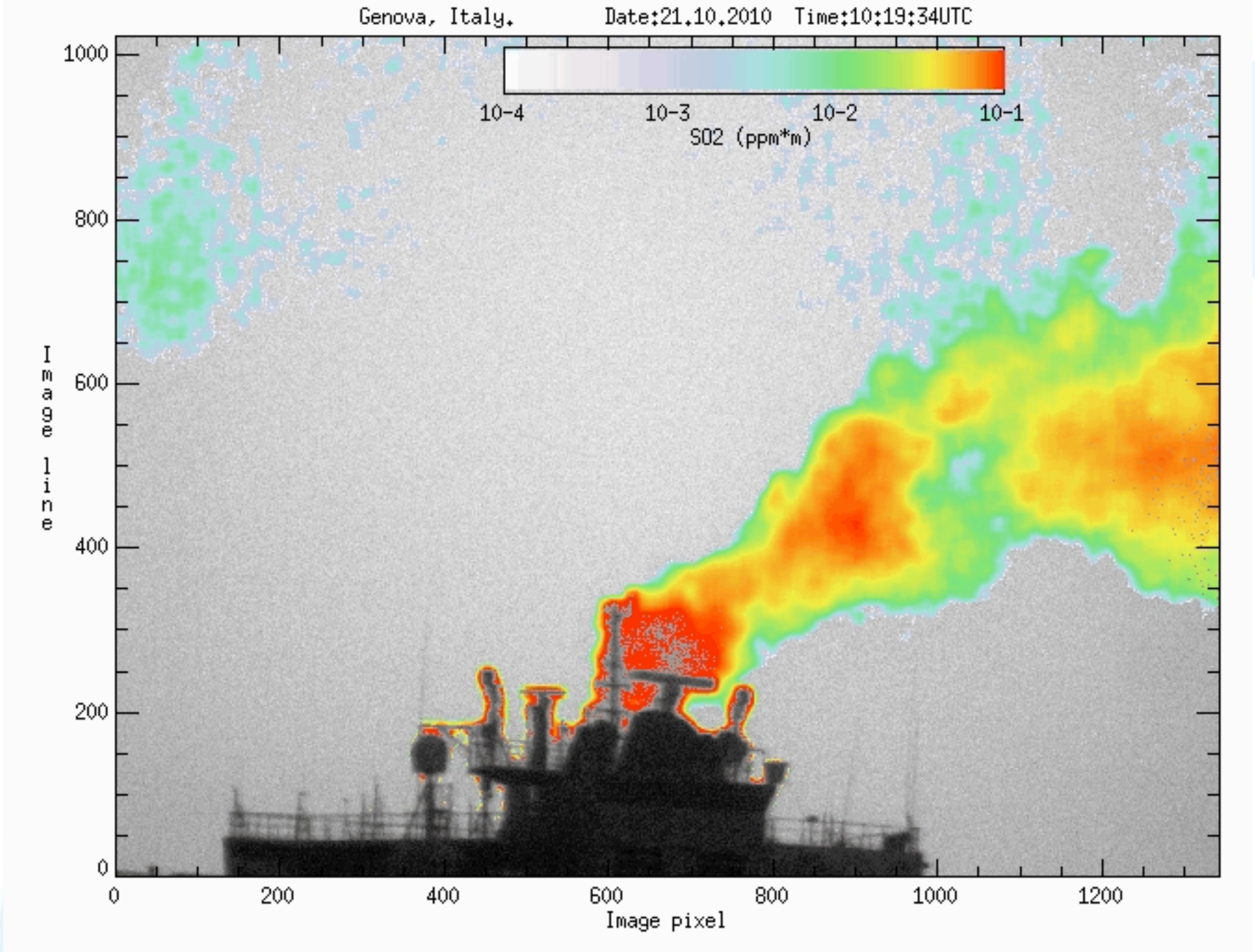
Genova, Italy.
Date:21.10.2010 Time:10:19:34UTC
10-4
10-3
10-2
10-1
SO2 (ppm*m)
1000
800
600
400
200
0
Image line
0
200
400
600
800
1000
1200
Image pixel

… how not to fly an OctoCopter

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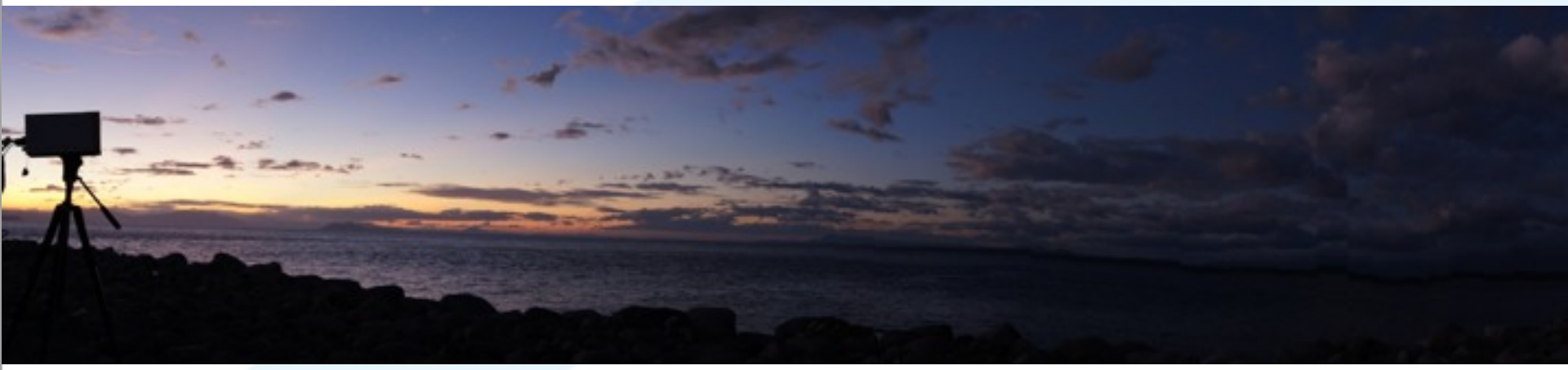
Ferry measurements at Punta Arenas - 13 January, 2011



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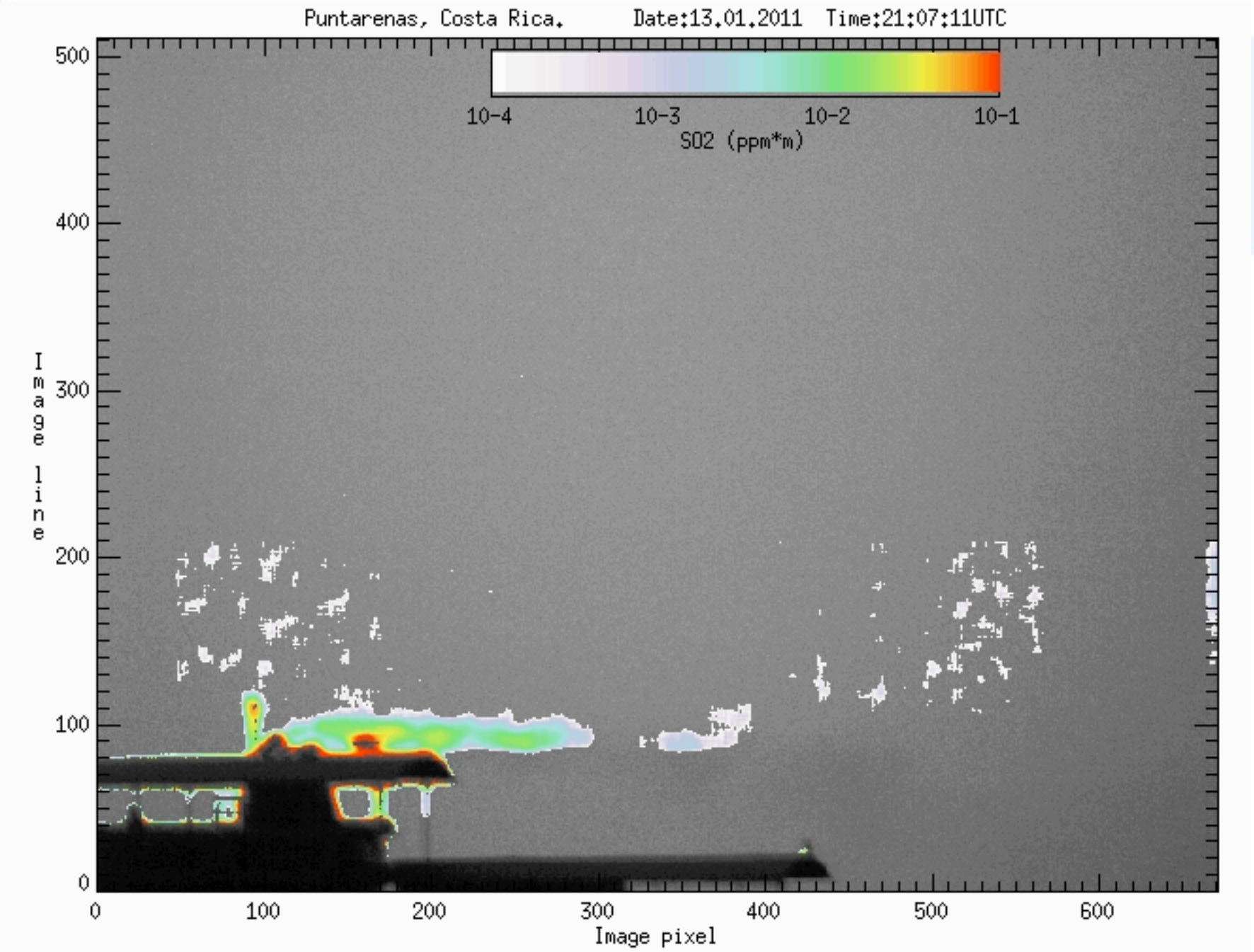
Puntarenas, Costa Rica.
Date:13.01.2011 Time:21:07:11UTC
10-4
10-3
10-2
10-1
SO2 (ppm*m)
Image line
Image pixel
0
100
200
300
400
500
600