CCDs for Earth Observation

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Introduction

- What is this talk all about?
  - e2v sensors in spectrometers
  - CCD and CMOS imagers
- What is this talk really all about?
  - MERIS (CCD25-20)
  - OMI (CCD55-20)
  - TropOMI (CCD275)
  - CMOS hyperspectral imager
- Identifying the trend in the evolution of detectors

MERIS on ENVISAT

- Medium Resolution Imaging Spectrometer (MERIS)
- Launched on Envisat 2002
- One of 10 instruments
- 15 spectral bands, 390 - 1040 nm
- Ground resolution of ~300m
- 1150km wide swath covered by 5 identical cameras
- Global coverage every three days

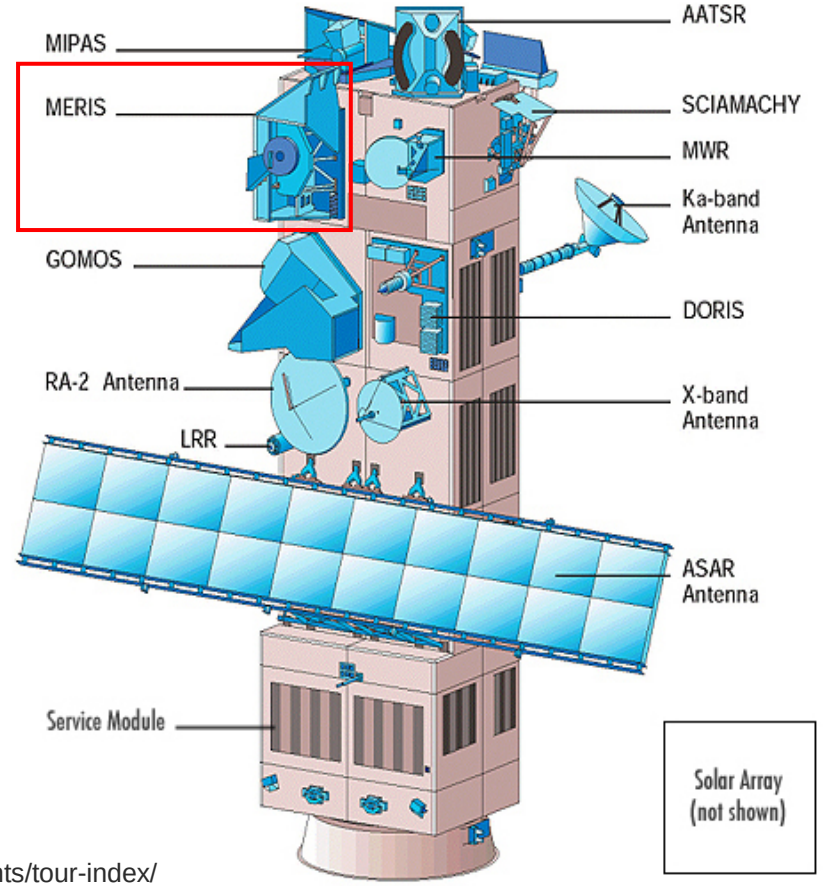
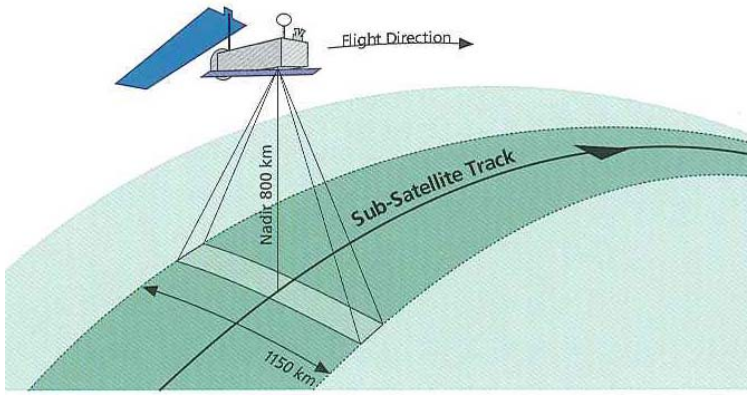


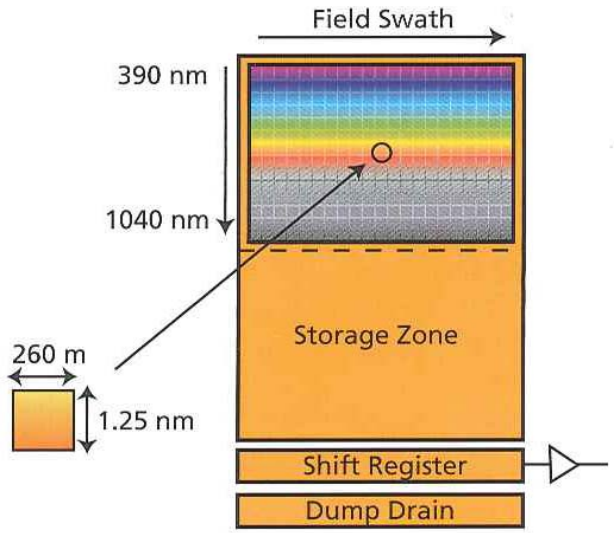
Image courtesy of ESA
http://envisat.esa.int/instruments/tour-index/

MERIS
Medium Resolution Imaging Spectrometer

- Images the Earth in a push broom mode
- 2D array is used to acquire spectral & spatial information
- Each line samples the swath for a different band
- Frame transfer device enabling simultaneous readout and integration

Medium Resolution Imaging Spectrometer (MERIS)





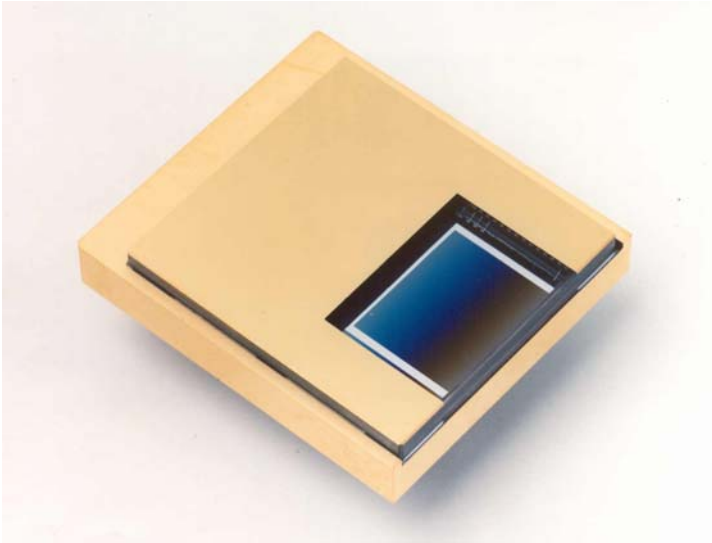
CCD-array schematic

- 44ms frame period (~23Hz)
- Fast frame transfer after integration
- 4x4 binning is used
- Lines outside the 15 spectral bands are dumped

Images courtesy of ESA http://envisat.esa.int/instruments/meris/

MERIS
CCD25-20 highlights

- Gold plated window and package for low emissivity
- Graded AR coating to match the wavelength dispersion of the spectrometer
- Thick window to maintain flatness
- Non Inverted Mode Operation
- 22.5 μm x 22.5 μm pixels
- 780 x 576 image area



The Aura Mission - OMI

- NASA's Aura mission
  - Launched 2004
  - Similar period to Envisat
  - 4 instruments
  - OMI – Ozone Monitoring Instrument
    - Similar to MERIS
    - Push broom imaging frame by frame
    - Spatial information along a row
    - Spectral information in different rows
    - Two channels, UV1 and UV2
    - UV-1, 270 to 314 nm, UV-2 306 to 380 nm

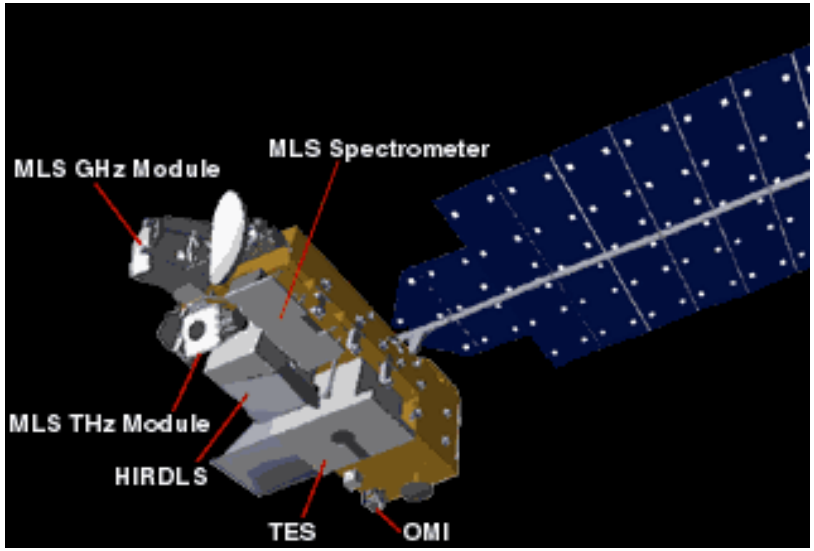


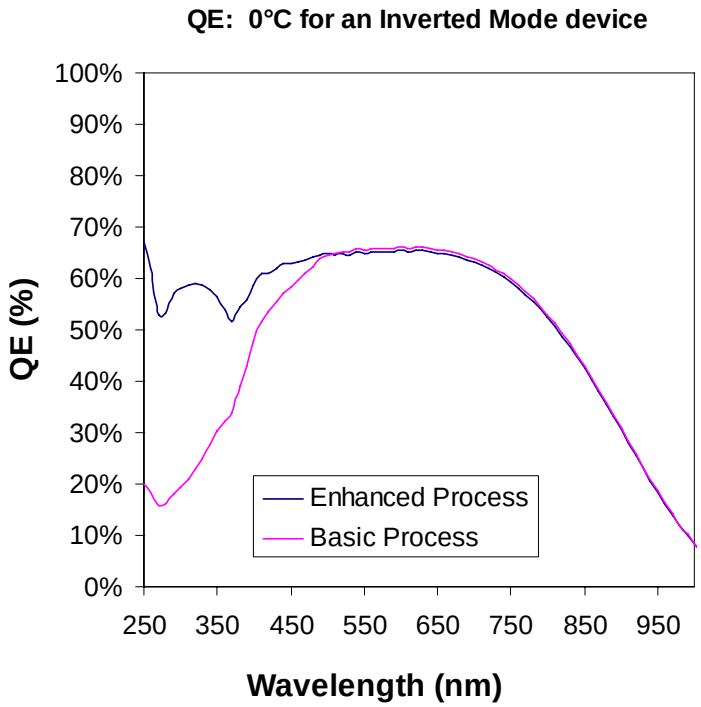
Image courtesy of
http://aura.gsfc.nasa.gov/instruments/omi.html

NASA Aura Ozone Monitoring Instrument CCD55-20

- CCD55
  - CCD25 re-masked
- New manufacturing masks
  - Photolithography
- New features
  - Advance Inverted Mode Operation
- Advantages
  - Lower dark signal (x100)
- Disadvantages
  - Lower Full Well Capacity
  - Slower line transfer
  - Larger Point Spread Function
  - Random telegraph Signal visible after radiation (flickering pixels – bi/tri-stable white defects)

NASA Aura Ozone Monitoring Instrument CCD55-20

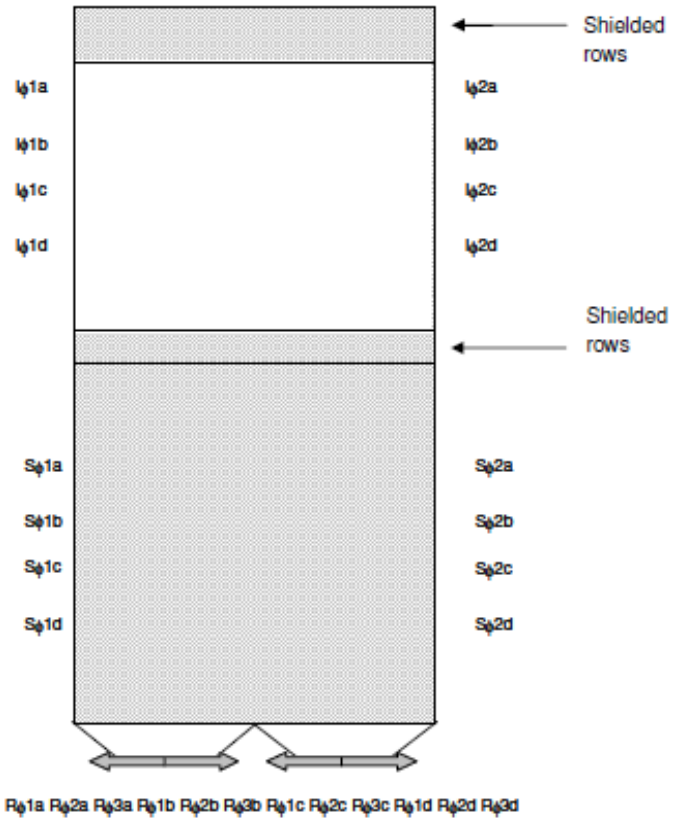
- Enhanced back thinning process
- Improved QE at short wavelengths (< 450 nm)
- OMI – UV
  - No window to maximise UV sensitivity
  - Enhanced BT process
  - UV optimised AR coating
  - AIMO to improve dynamic range



TropOMI – Sentinel 5 precursor

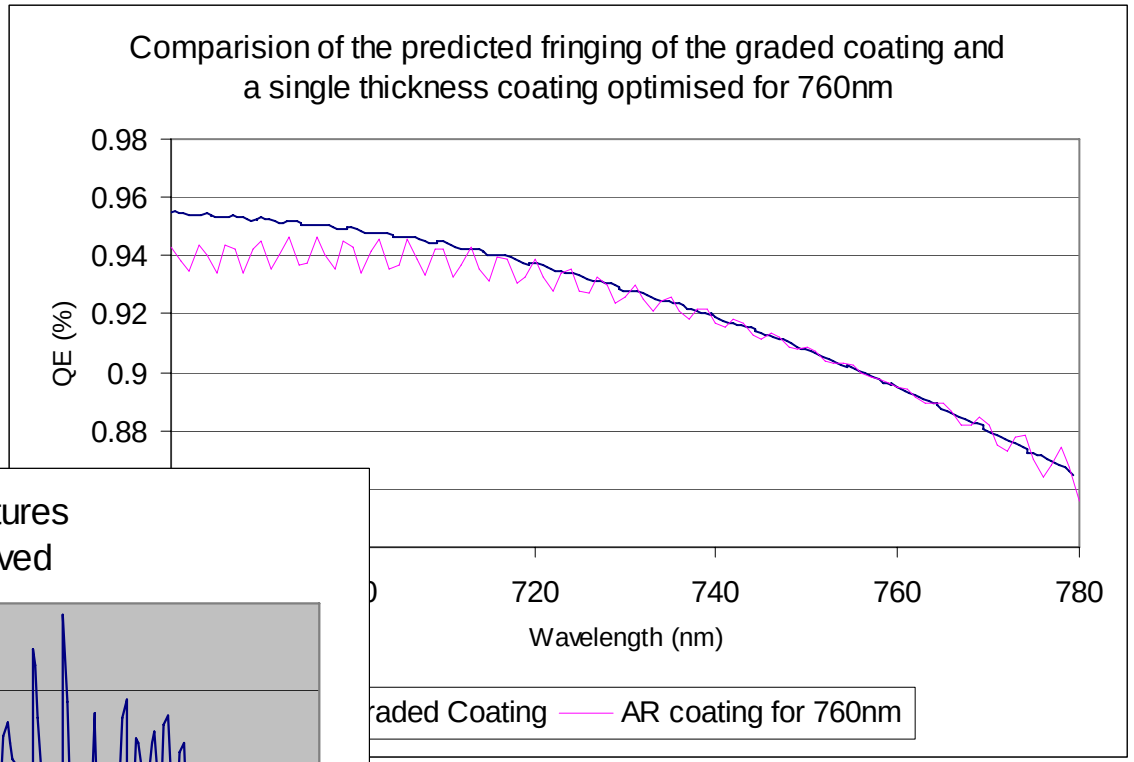
- TropOMI – Tropsheric Ozone Monitoring Instrument
- Aim to bridge the gap between Envisat / Aura and Sentinel 5 (2020)

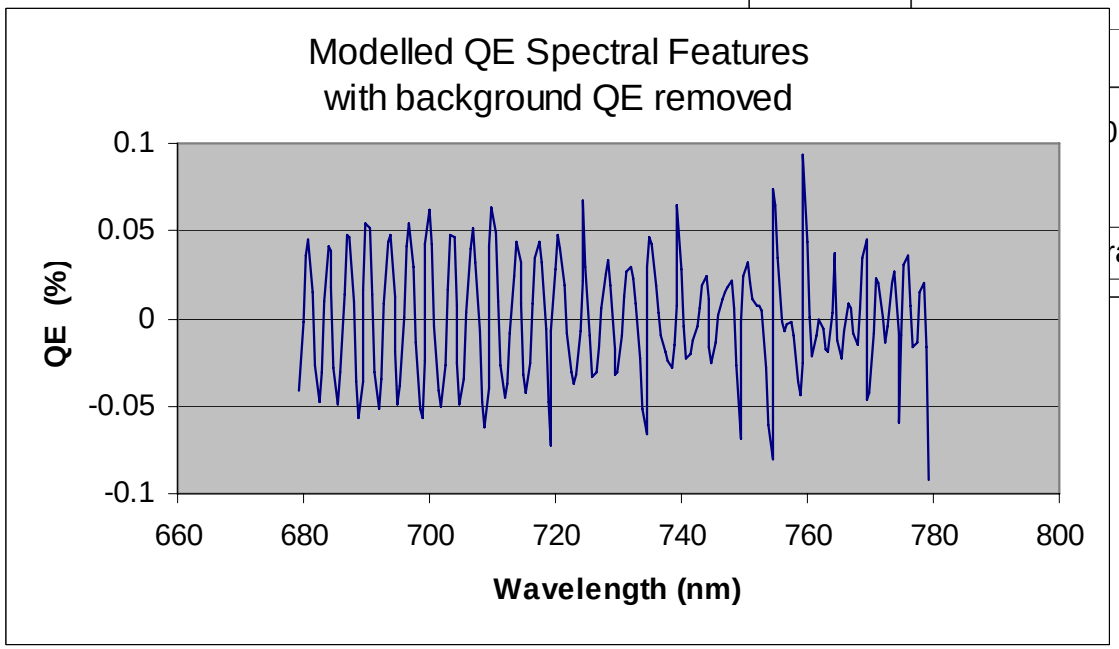
- UV, VIS and NIR imagers from e2v
- CCD275
- 1024 x 1024 image area with 26 μm square pixels
  - More than double the image area of a MERIS or OMI device
- 2 phase image and store pixels with metalisation for fast line transfer
- 0.75μs per line



TropOMI – Sentinel 5 precursor

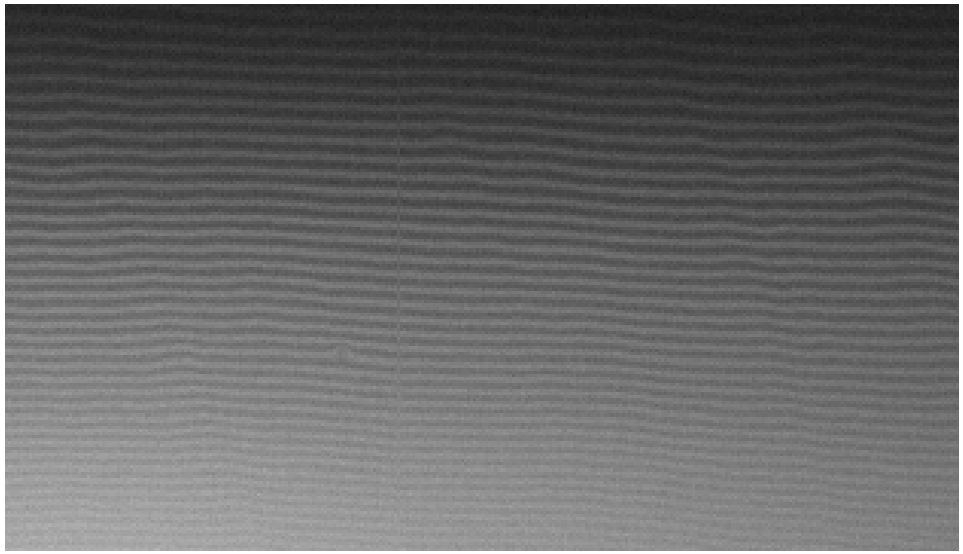
- Graded AR coating for the NIR channel





TropOMI – Sentinel 5 precursor

- Fringe Suppression for the NIR channel



- Switch-able gain
  - Switched in capacitance to alter the device responsivity
  - Higher responsivity for lower signal spectral bands
  - Lower responsivity for higher signal spectral bands

Summary of CCDs for Ozone Monitoring Instruments

- MERIS
  - CCD25-20, NIMO, graded AR coating, UV-VIS-NIR on each device
  - 5 cameras to achieve a wide swath
- OMI
  - CCD55-20, AIMO, UV enhanced process
- TropOMI
  - CCD275, 2-phase imager with metalisation for fast frame transfer / reduced smear / optical cross talk
  - Split readout register to achieve higher data rate
  - Graded AR coating and fringe suppression structure
  - Selectable gain (responsivity)
- What is next?

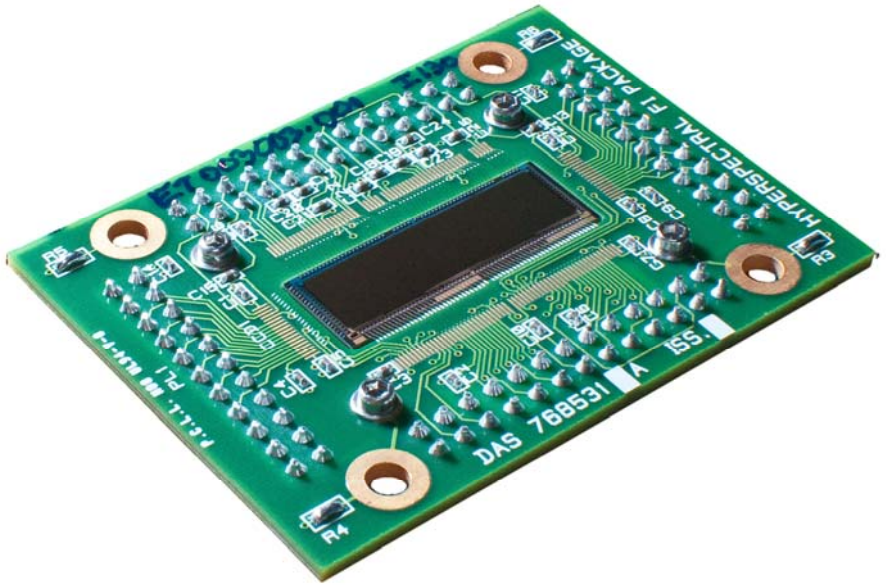
CMOS hyper spectral sensor

- e2v have designed (in collaboration) and characterised a hyper spectral CMOS sensor
- Manufactured at a foundry

Resolution	1024 x 256
Pixel pitch	24 µm square
Readout speed	250 frames per second
ROI, windowing	**Random access in Y-direction (spectral direction) only**
Full Well charge for 1% linearity	100 ke- and 300 ke- (programmable)
Line-by-line programmable charge conversion factor	**12 fF or 13 µV/e^-** **36 fF or 4 µV/e^-**
Total noise	<50 e^-_{RMS} in basic mode without CDS <20 e^-_{RMS} with CDS
QE	>90% in VIS

CMOS hyper spectral sensor

- Characterisation of the front illuminated device has been successful
- Characterisation of the back illuminated device has revealed some drawbacks in noise, responsivity and dark signal
- 2012 will see a 2nd iteration of the device for future Earth observation instrumentation



Thank you for your attention