Progressive coding of satellite images with regions of interest

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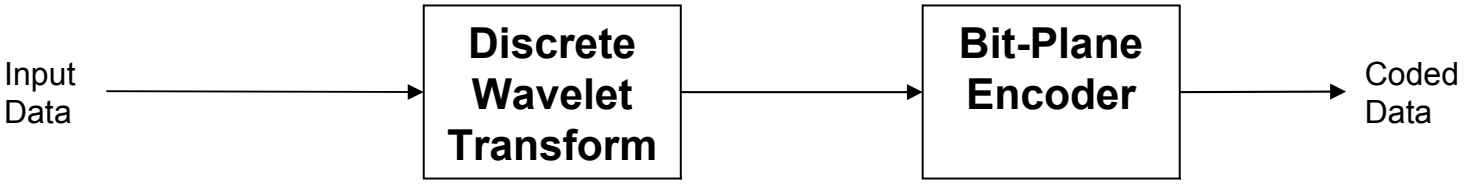
Outline

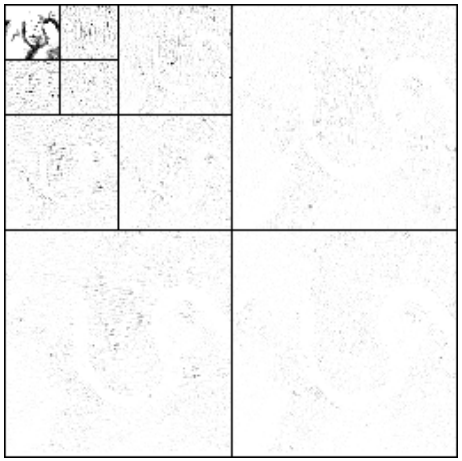
- Context
- Region of interest coding methods selection
- Region of interest coding with the CCSDS-IDC
- Performance evaluation

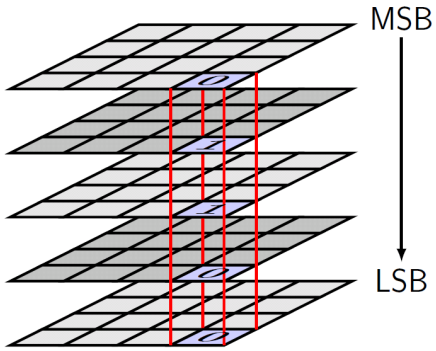
Context

- Satellite images often contain clouds
  - ✓ 80% of SPOT 5 satellite images
- The study of clouds is not the goal of VHR Earth observation satellites
  - ✓ Clouds are considered as noise in these images
- Data transmission is expansive
  - ✓ We need efficient on-board image compression algorithms
- Use selective compression !
  - ✓ On-board detection of cloud cover [Thiebaut et al. OBPDC 2008]
  - ✓ Region Of Interest (ROI) coding

- The CCSDS-IDC standard





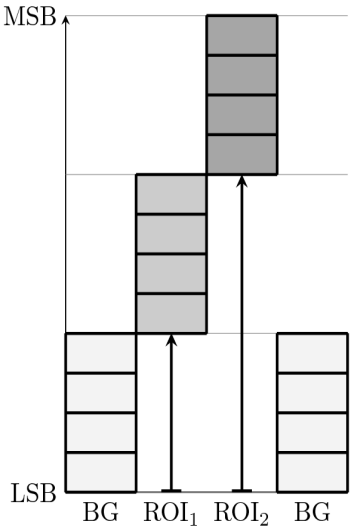


Region of interest coding methods

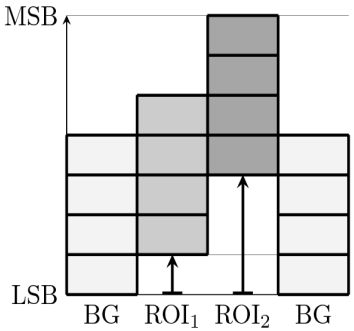
- Criteria for the selection of ROI coding methods:
  - ✓ Fine delineation of the ROI regions
  - ✓ Multiple ROI levels
  - ✓ Compliance with a progressive transmission
  - ✓ Possibility to adapt the on-board compression algorithm
  - ✓ Standard ROI coding methods

Region of interest coding methods

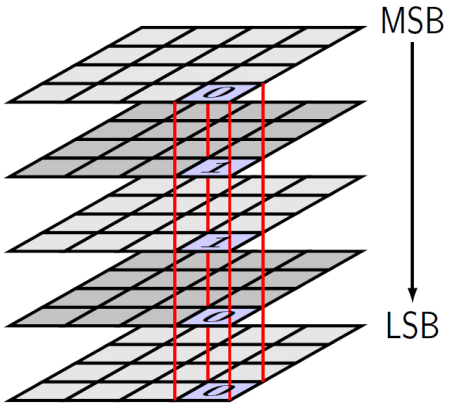
- Selected methods:
  - ✓ **Maxshift**
  - ✓ **Scaling**
- Principle of these methods:
  - ✓ Bit shifts of the wavelet coefficients in the ROI
  - ✓ Progressive coding from the MSB to the LSB



Maxshift



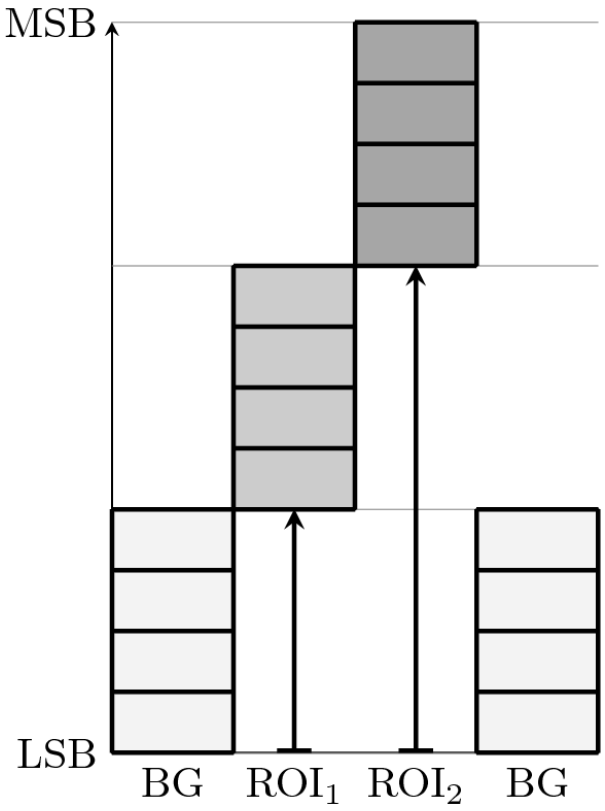
Scaling



Region of interest coding methods

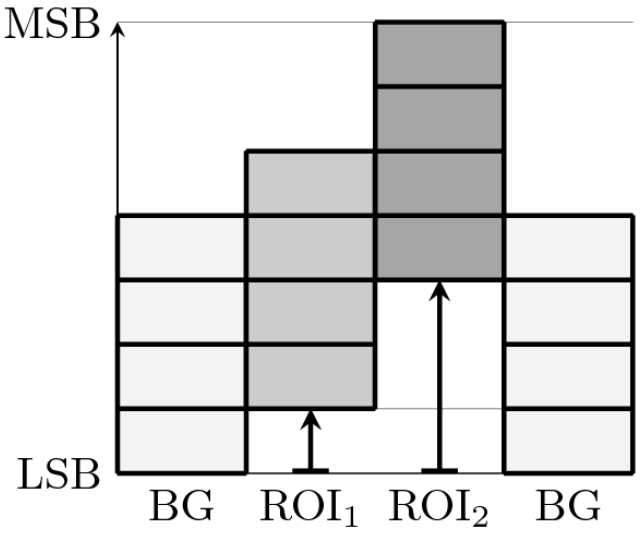
- The maxshift method

  - ✓ Main advantage:
    - ➢ No need to send the ROI mask (implicit coding of the mask)
  - ✓ Main drawbacks:
    - ➢ No quality management between regions (all or nothing method)
    - ➢ Requires high dynamics in the coder



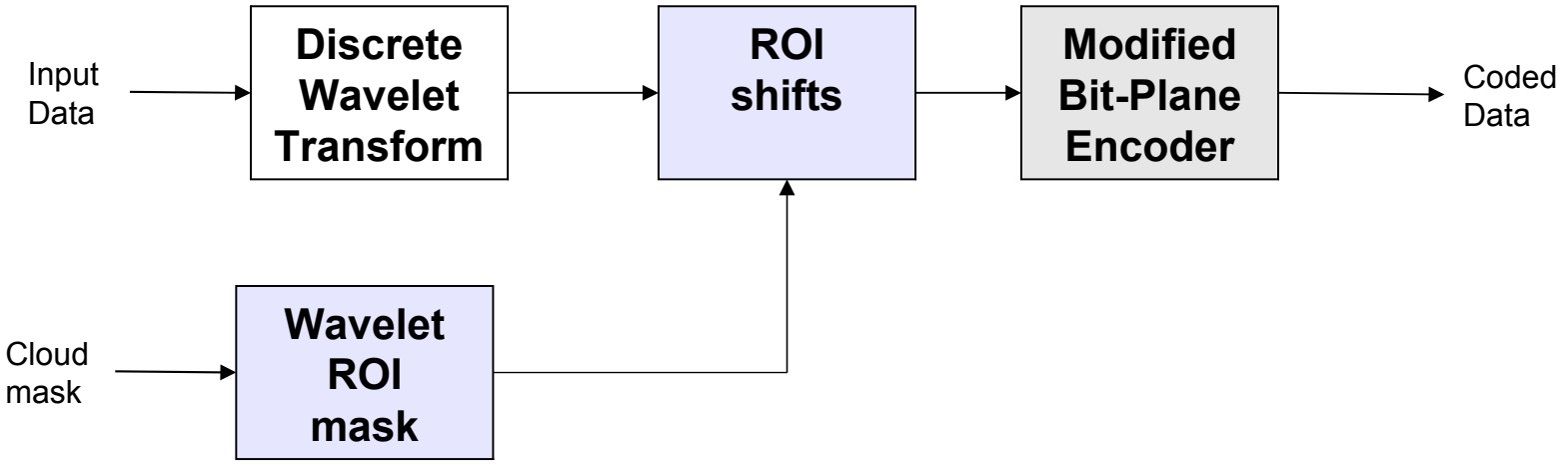
Region of interest coding methods

- The scaling method
  - ✓ Main advantage:
    - ➢ Quality management between regions (user parameter)
  - ✓ Main drawback:
    - ➢ Need to send the ROI mask (explicit transmission as a header)



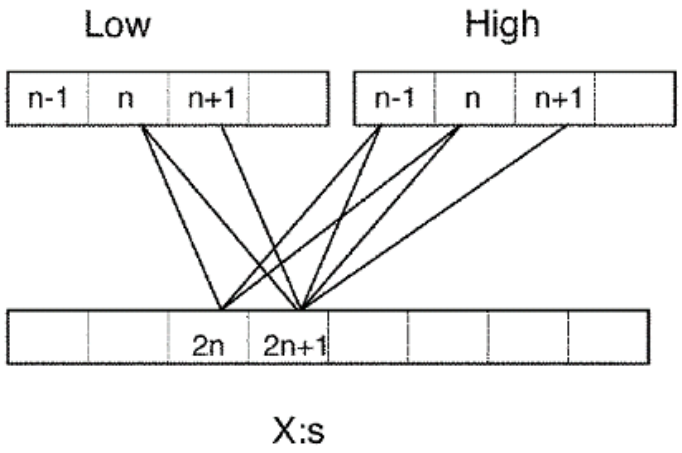
ROI coding with the CCSDS-IDC

- New compression scheme

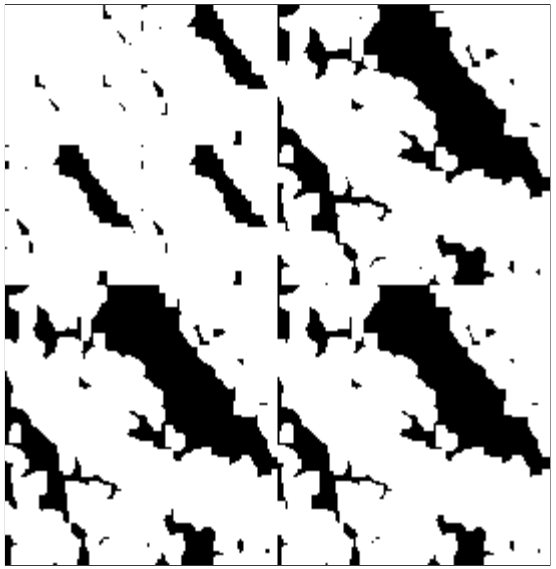


ROI coding with the CCSDS-IDC

- ROI mask in the wavelet domain
  - ✓ Which wavelet coefficients do I need to decode the ROI ?
  - ✓ Follow the steps of the inverse wavelet transform in the inverse order
  - ✓ LL_3 subband all included in the ROI



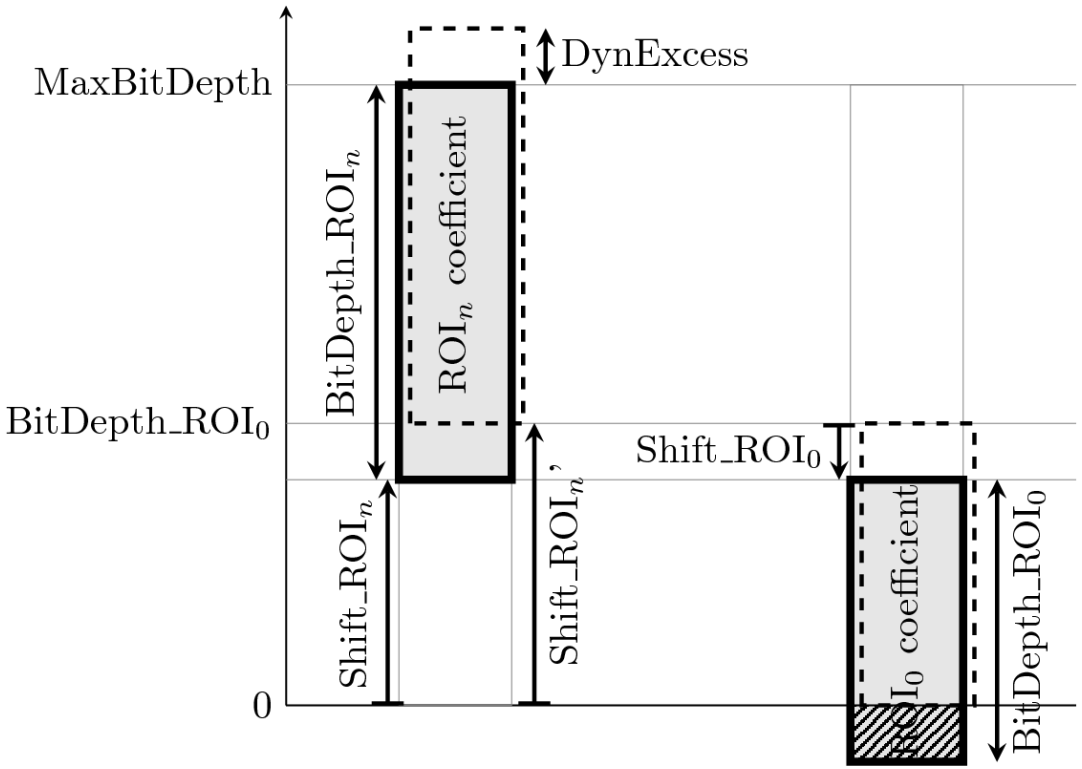
ROI mask



ROI mask in the wavelet domain

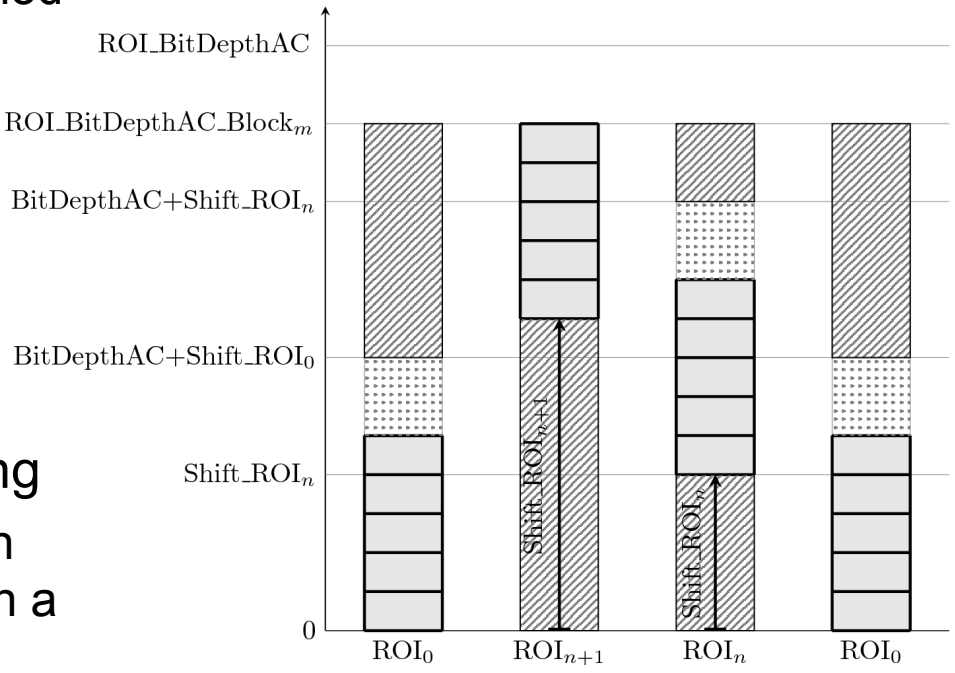
ROI coding with the CCSDS-IDC

- Dynamic excess management
  - ✓ Dynamic limited to 31 bits in the BPE
  - ✓ Down shift of the background wavelet coefficients

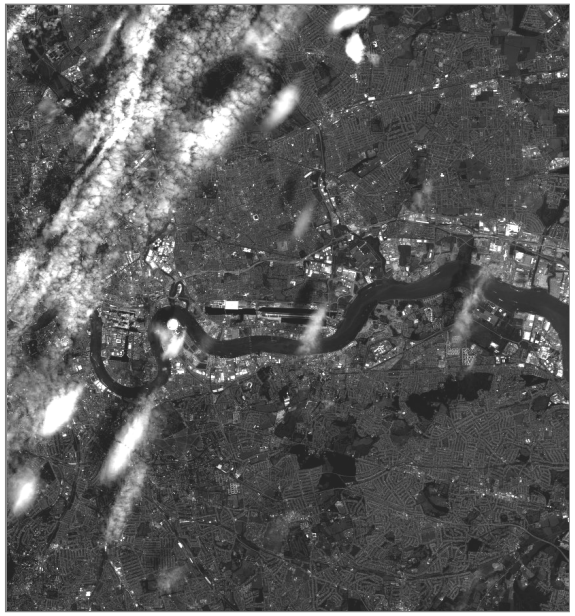


ROI coding with the CCSDS-IDC

- Modification of the BPE
  - ✓ New header (part 5)
    - ROI parameters: presence of ROI in the segment, ROI method applied, number of bit shifts
  - ✓ Modification of DC coefficients coding
    - New quantization parameter
  - ✓ Modification of bit planes coding
    - Coding mode now depends on the wavelet coefficient being in a ROI or not

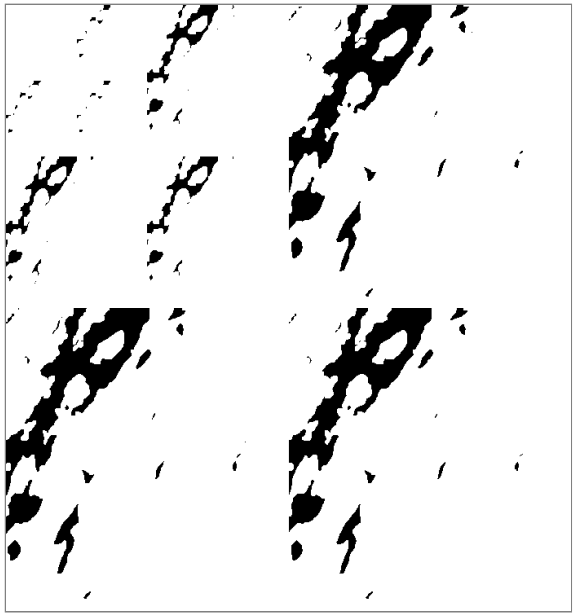


Performance evaluation



Image

ROI mask
14% of clouds



Wavelet ROI mask
9.1% of background coefficients

		PSNR (dB)		
Method	Bit rate (bpp)	Background	ROI	Entire image
CCSDS-IDC	2.29	50.8	50.0	50.1
Maxshift	2.16	39.7	50.0	46.3
Scaling of 4 bits	2.16	41.1	50.0	47.1

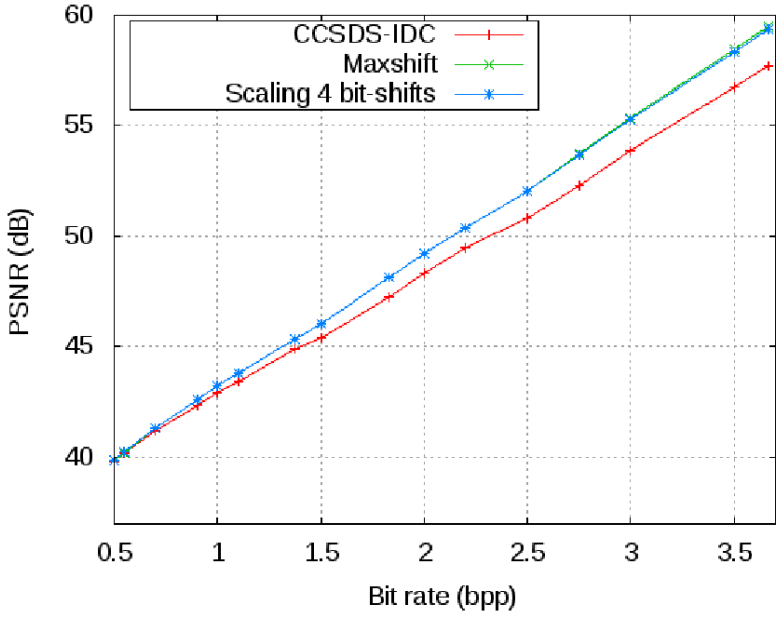
Saving:
0.13bpp
or 5.8% of the total bit rate

Performance evaluation

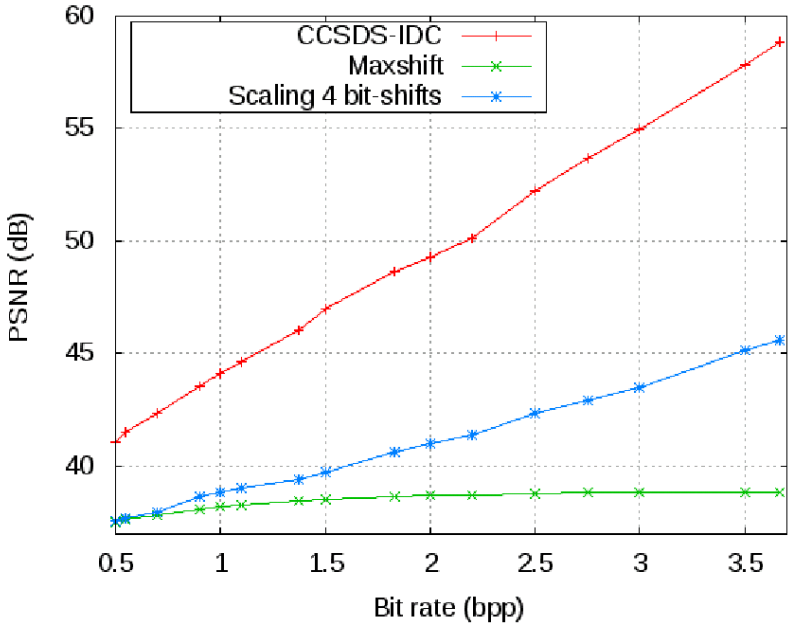
Method	Bit rate (bpp)	PSNR (dB) Background	ROI	Entire image
CCSDS-IDC	2.2	50.18	49.55	49.63
Maxshift	2.2	39.74	50.21	46.34

Gain:
0.66dB on the ROI

ROI



Clouds

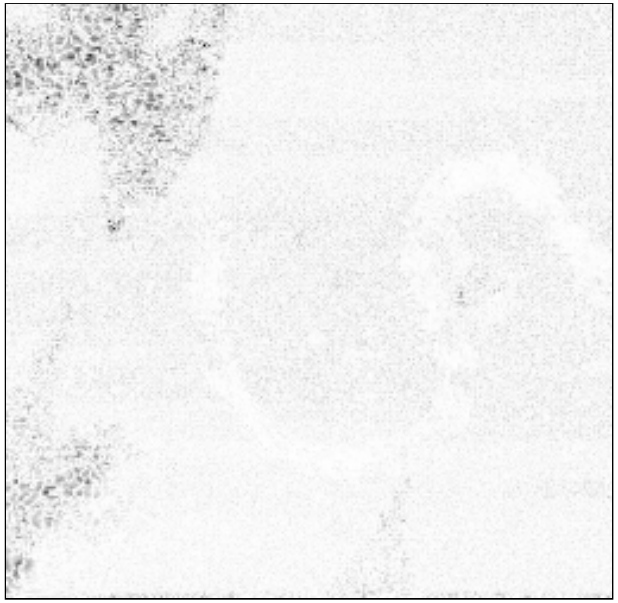


Performance evaluation

Original image

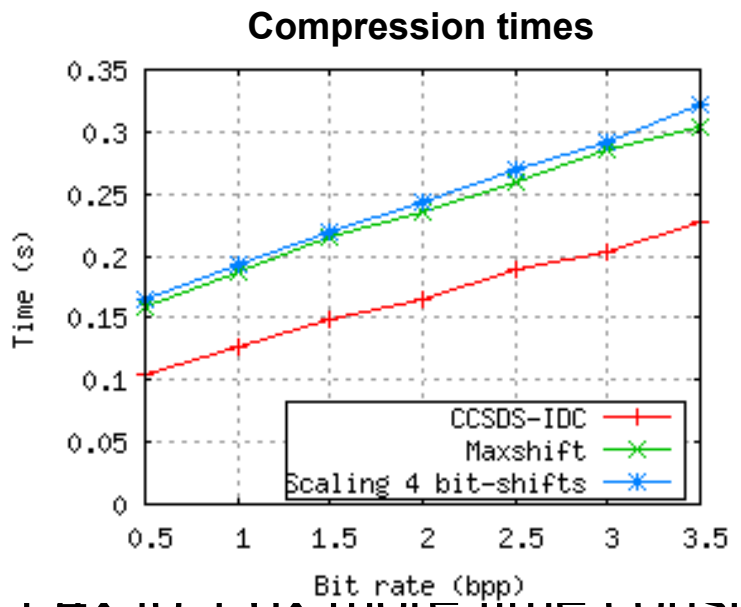
Maxshift method at 2.4bpp
on each component

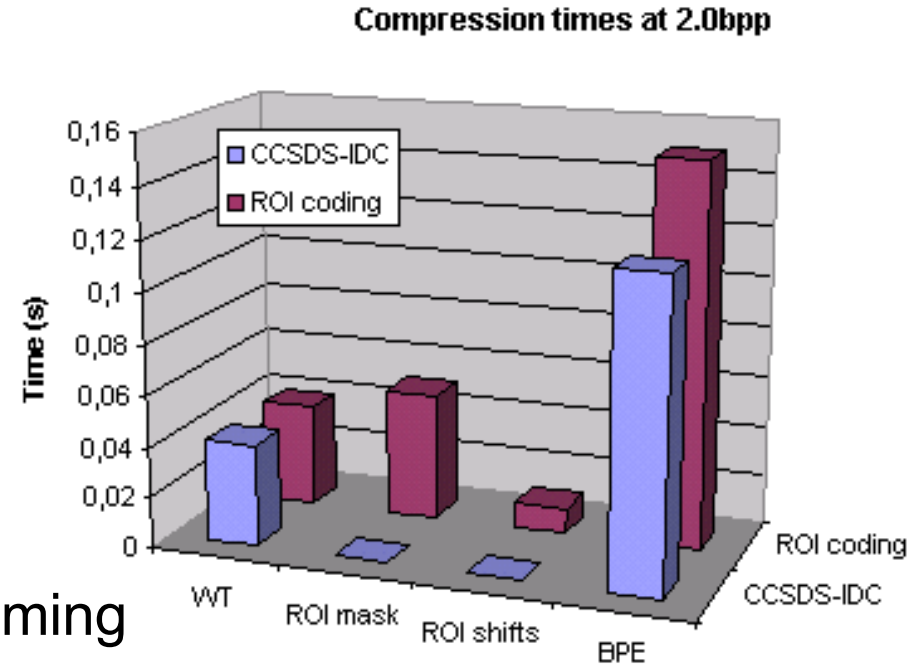
Error map



Performance evaluation

- Compression times
  - ✓ Mean times on 50 iterations at each bit rate (image of size 860x920, CPU Intel Xeon 2GHz)

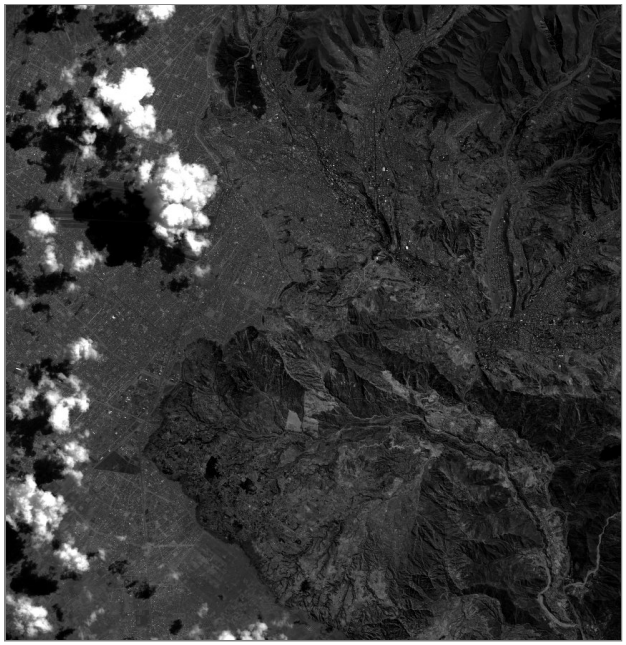
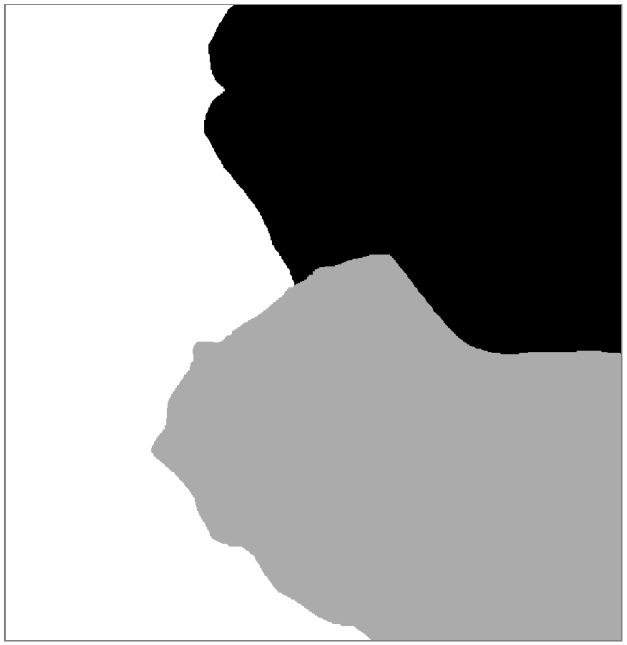
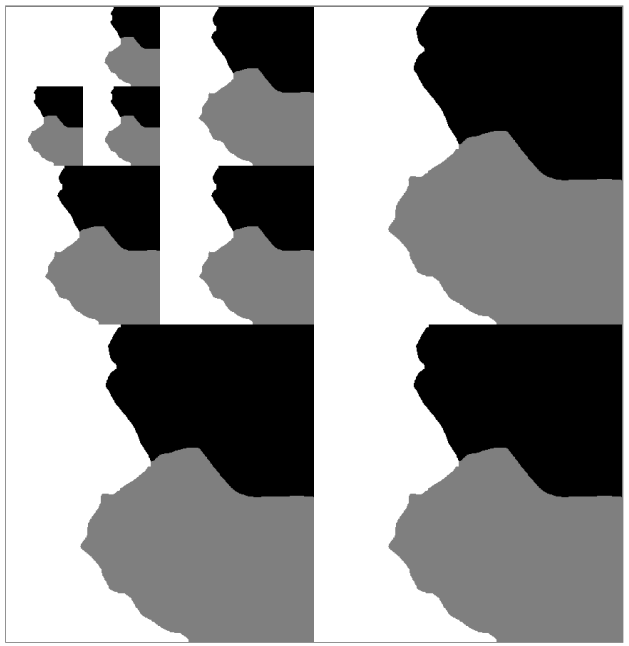




  - ✓ 1.4x to 1.6x more time consuming
  - ✓ Mainly because of the wavelet ROI mask generation

Performance evaluation

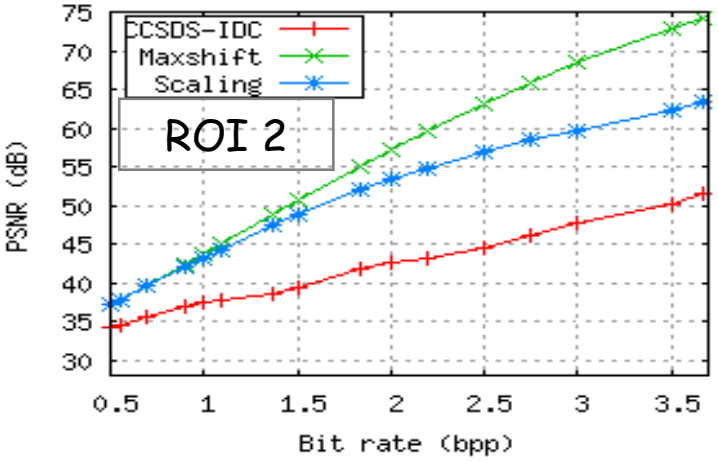
- Multiple regions, toy ROI mask

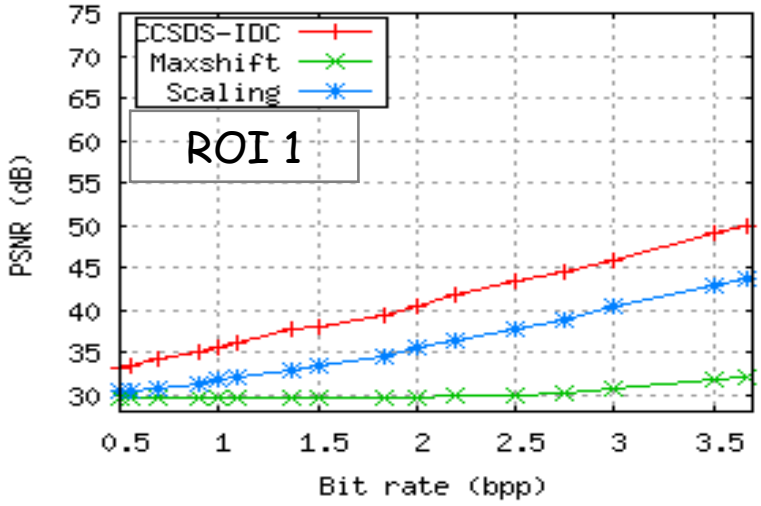




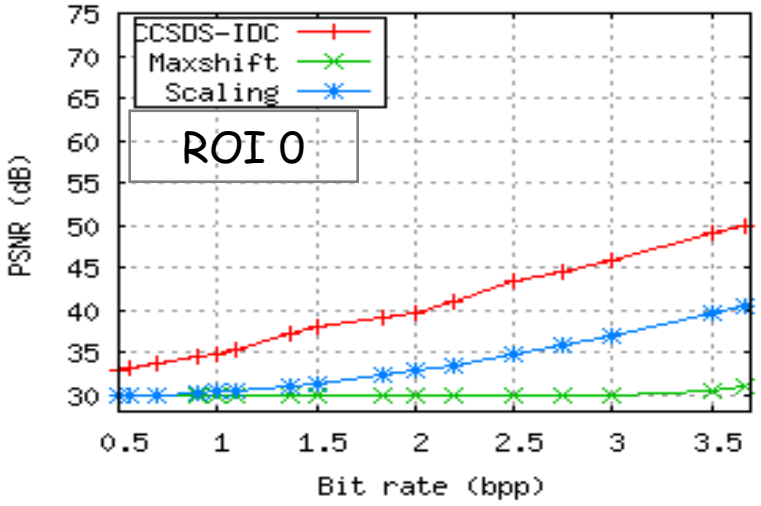
- ✓ **Pixels : ROI 0 : 30,1% - ROI 1: 33,7% - ROI 2 : 36,2%**
- ✓ **Wavelet coefficients : ROI 0 : 28,9% - ROI 1: 32,9% - ROI 2 : 38,2%**

Performance evaluation

- PSNR of 50dB on the ROI2
  - ✓ Bit rate reduced between 44% and 58% compared to the CCSDS-IDC







Conclusions

- ROI coding features successfully integrated to the CCSDS-IDC coder
- Compression performance increased on the ROI
- For a given quality on the ROI, the bit rate saving depends on
  - ✓ The ROI size
  - ✓ The scattering of the ROI
- Need for an efficient ROI mask coder for the scaling method to be competitive