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RESEARCH GROUPS PHOTOGRAMMETRY & REMOTE SENSING

Impact of different resampling methods on soil moisture and preparations for the SCA instrument

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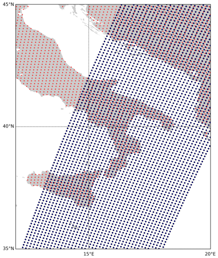
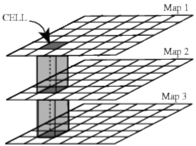
3rd H-SAF Workshop, 3-6 November 2014, Reading (UK)

Resampling of remote sensing data

- Orbit format
  - Irregular grid
  - Irregular/different acquisition times
  - Overlap of ascending and descending orbits



- Image format
  - Regular fixed Earth grid
  - Regular/clear timestamps
  - Typically no overlap



Resampling methods

- Nearest neighbour
- Linear methods
  - $\hat{g}(x) = \sum_{n=1}^{N} g_n w_n(x) \,/\, \sum_{n=1}^{N} w_n(x)$
- Kernel estimators
  - $w(x) = K(x/h)/h$
- Optimal interpolation
  - $\epsilon^2 = \sum_{n=1}^{N} E\left[\left|g(x_n) - \hat{g}_n(x_n)\right|^2\right]$
- Other methods: Smoothing splines, local polynomial fitting, radial basis functions, spherical wavelet basis

Typical resampling approach

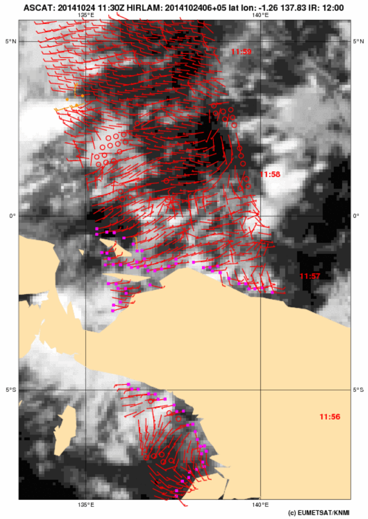
1. Get to know your dataset
   - Spatial and temporal sampling characteristics
   - Spatial/radiometric/spectral/temporal resolution
   - Measurement accuracy, uncertainty
   - Data format, NaN values, important flags
   - Release/version, consistency, calibration
2. Selection of target grid (e.g. $0.1^\circ \times 0.1^\circ$ grid)
   - i.e. spatial sampling, geodetic datum, coordinate system, map projection, . . .
3. Selection of resampling method and parameters
   - Methods: Nearest neighbour, linear methods, kernel estimators, . . .
   - Parameters: Weighting function, kernel, search radius, . . .
4. Filter rules
   - e.g. NaN values, RFI flag, land/water/sea ice flag, quality flags, uncertainty/error fields, . . .

Important things to consider (or typical pitfalls)

- Overlap of orbits
  - A time mixing may occur and measurements from the next overpass are used in the process of resampling
  - However, sometimes this effect is accepted or desired (e.g. resolution enhancements, temporal averages)
- Units
  - E.g. dB should be transformed into linear domain before resampling
- Resampling of categorial fields
  - E.g. weighting of flags often does not make sense (114 = 01110010)
- Restrictions imposed by target grid and/or resampling method
  - Over- and undersampling
  - Smoothing, aliasing
  - Spatial/radiometric resolution and accuracy
- Correct determination of uncertainty after resampling
  - E.g. considering cross-correlations between neighbouring measurements

OSI SAF ASCAT-A Coastal product

- The Scatterometer team (SCAT team) of the Koninklijk Nederlands Meteorologisch Instituut (KNMI) have explored the added value of different backscatter resampling techniques to obtain winds closer to the coast
- Large width of the Hamming window does not allow a successful retrieval of winds close to the coast
- KNMI SCAT team tested a circular Boxcar window based on the full resolution product (SZF)



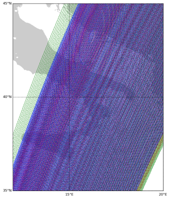
Federated Activity - EUMETSAT/KNMI/TU Wien

Effects on Level 2 Soil Moisture using Level 1b backscatter resampled with a circular Boxcar window and exploration of the Level 1b full-resolution (SZF) product

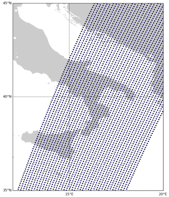
1. Providing evidence on what are the effects (if any) on the Level 2 quality and characteristics, of applying the alternative backscatter resampling approach currently available for 12.5 km coastal wind products by KNMI (circular Boxcar averaging window)
2. Exploring and demonstrating the value of the information content in the currently available ASCAT full resolution product (SZF) to retrieve higher resolution soil moisture data, as well as to remove artefacts that can be identified at the backscatter resampling stage (e.g. corner reflectors)

Overview of Metop ASCAT Level 1b products

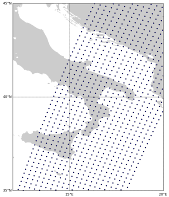
- Full-resolution product (SZF)
  - Resolution: 10 x 20 km
  - Grid spacing: no regular grid
  - 192 values per beam footprint



- Research product (SZR)
  - Resolution: 25-34 x 25-34 km
  - Grid spacing: 12.5 x 12.5 km
  - 41 nodes per swath

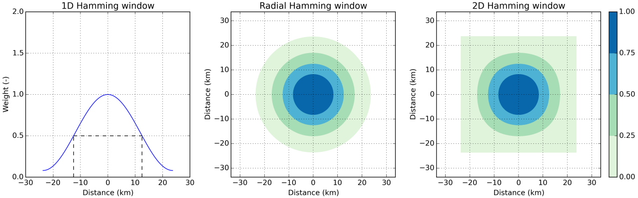


- Operational product (SZO)
  - Resolution: 50 x 50 km
  - Grid spacing: 25 x 25 km
  - 21 nodes per swath

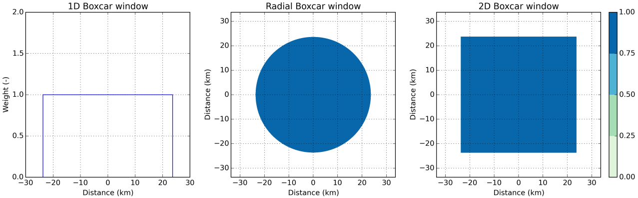


Hamming and Boxcar window

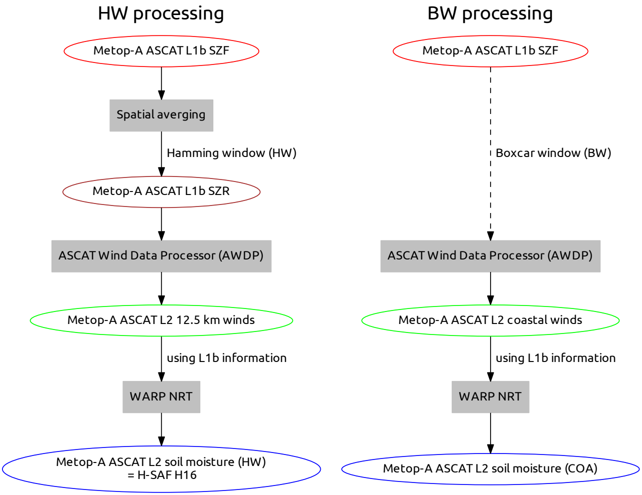
- Hamming window: $w\left(n\right) = 0.54 - 0.46 \cdot \cos\left(\frac{2\pi n}{N-1}\right)$



- Boxcar window: $w\left(n\right) = 1$



Objective 1 - Datasets and Processing



Spectral analysis

1. Selection of samples
   - Along the satellite track
   - 128 consecutive valid backscatter (i.e. 12.5 km * 128 = 1600 km)
2. Detrending methods to remove jumps between end points
   - Linear, least square, first differencing, windowing
3. Fast Fourier Transform (FFT)
   - Final spectrum by averaging the spectra from each sample

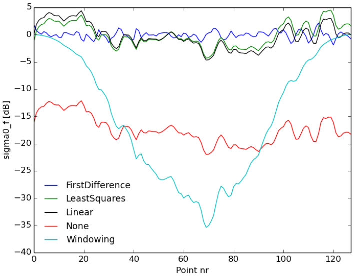


Figure : Detrending example.

Spectral analysis results - Sampling

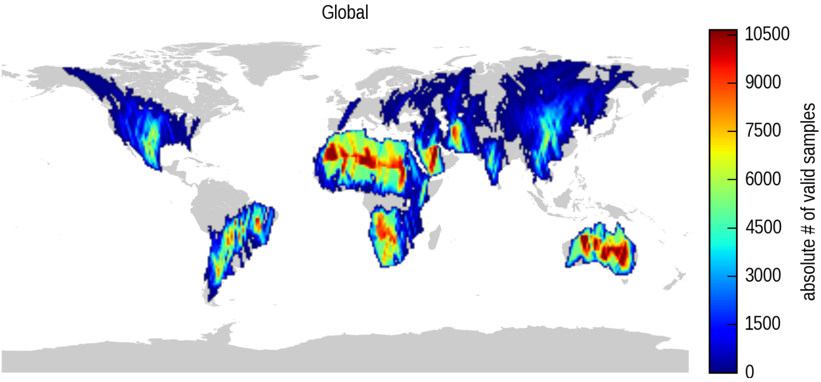
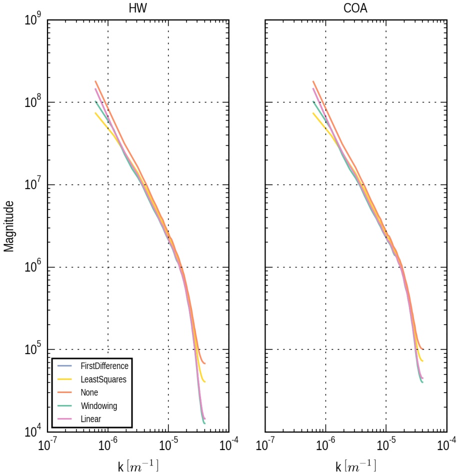


Figure : Number of valid samples within a $1^\circ \times 1^\circ$ cell.

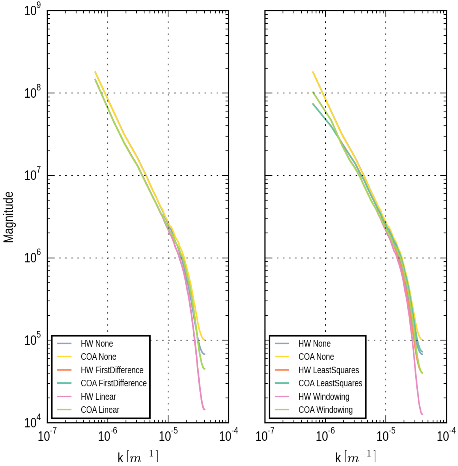
Spectral analysis results - Detrending

- Windowing, first difference and linear are effective
- Magnitude of high frequencies lower for HW
- No flattening of the tail, indicating no presence of noise



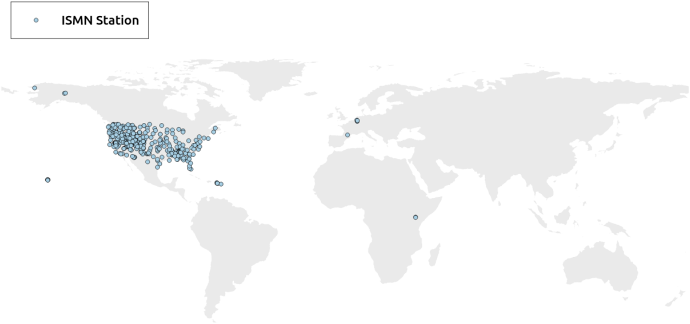
Spectral analysis results - HW vs. COA

- Deviation around $k = 10^{-5}\,\mathrm{m}^{-1}$, which corresponds to $100\,\mathrm{km}$

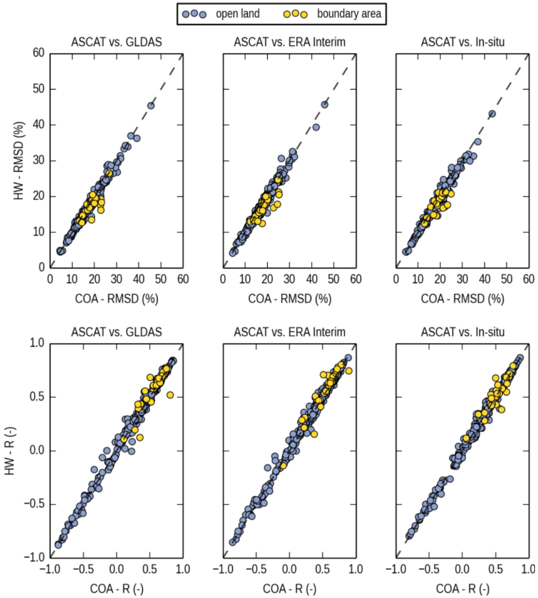


Validation against in-situ stations

- Reference: International Soil Moisture Network - ISMN
- All stations selected between Jan-Jun 2013 (approx. 700)
- Orbit to timeseries conversion: selection of nearest valid soil moisture value (i.e. surface temperature > 0°C and no snow cover)



In-situ validation results - Metrics



Noah GLDAS validation results

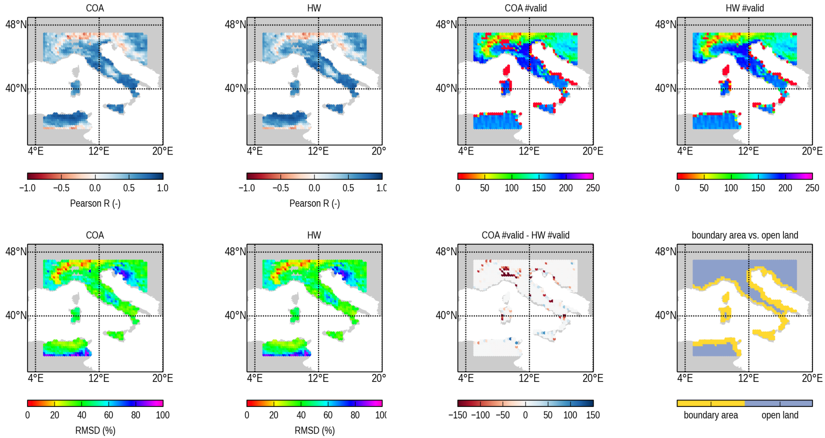
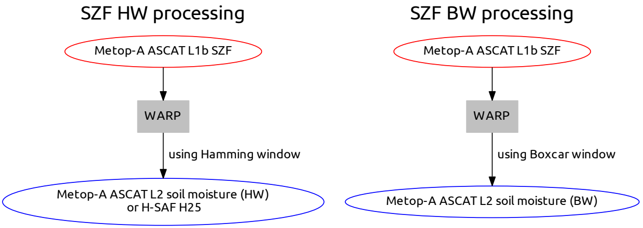


Figure : Study area Italy.

Objective 2 - Datasets and Processing



- SZF analysis
  - Spectral analysis of resampled backscatter
  - Impact of filter on edges
  - Identification and removal of artefacts
  - Experimental high resolution soil moisture

Experimental high resolution soil moisture

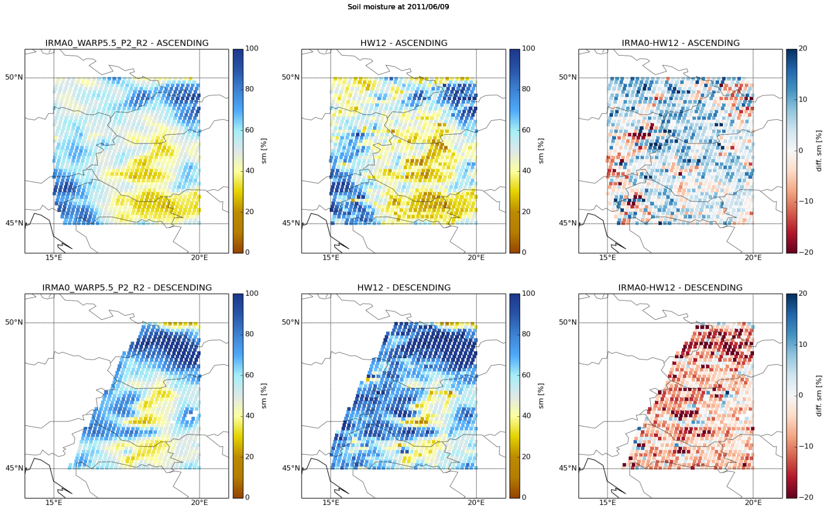


Figure : Soil moisture - 2011-06-09 - H25 vs Hamming window 24 km width

Experimental high resolution soil moisture

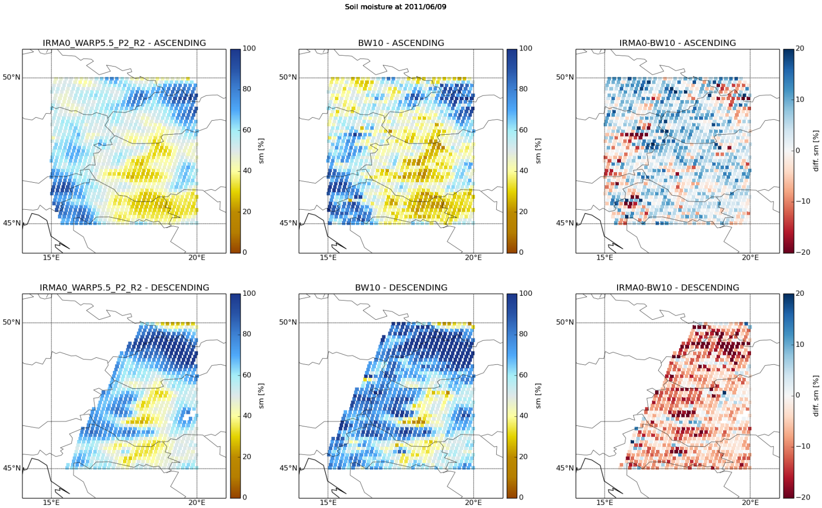


Figure : Soil moisture - 2011-06-09 - H25 vs Boxcar window 20 km width

Resampling - Summary and Conclusion

- Evaluation of the effect of two different resampling filters on soil moisture
  - No significant performance differences detected
- First processing of experimental high resolution soil moisture
  - Results look promising, but a better error characterisation is needed
  - SZF product gives more control during resampling (e.g. removal of unwanted backscatter sources)
- In the future it is planned to conduct more research on the SZF product

Big thank you goes to EUMETSAT and KNMI for their great support!

Metop-SG - Introduction

- Metop-Second Generation is a follow-on system to first generation series of Metop satellites
  - Metop-A launched 19 October 2006
  - Metop-B launched 17 September 2012
  - Metop-C launch planned in 2018
- Metop-SG is a collaborative programme between ESA and EUMETSAT
  - Consists of two series of satellites: SAT-A and SAT-B
- Metop-SG objectives
  - provide operational observations and measurements from polar orbit for numerical weather prediction and climate monitoring in the 2020 to mid-2040's timeframe

Metop-SG - SCA instrument properties

Parameter	ASCAT	MetOp-SG SCA
Frequency	5.3 GHz	
Polarisation	VV for all beams	VV for all beams (+ VH for Mid-beams) [G]
Azimuth views	45°, 90° and 135° w.r.t. satellite track	
Min. incidence	25°	20° [G]
Spatial resolution	Nom: $(50\ \mathrm{km})^2$	Nom: $(25\ \mathrm{km})^2$ [G]
Spatial sampling	Nom: $(25\ \mathrm{km})^2$ High res.: $(12.5\ \mathrm{km})^2$	Nom: $(12.5\ \mathrm{km})^2$ [G] High res.: $(6.25\ \mathrm{km})^2$
Radiometric resolution	≤ 3 % for $\theta_i \leq 25°$ at 25 m/s up-wind (VV) $\leq (0.175\times\theta_i - 1.375)$ % for $\theta_i > 25°$ at 4 m/s cross-wind (VV)	
Coverage	97 % in 48 hrs.	99 % in 48 hrs. [G]

Improvements w.r.t. ASCAT in red

Courtesy of ESA/EUMETSAT

SCA Soil Moisture Retrieval Algorithms

- Thanks to the similarity of ASCAT and SCA, the ASCAT retrieval algorithm can be directly transferred to SCA
- Algorithms may be improved by using the new VH mid beam measurements by
  - either directly improve the soil moisture retrieval
  - or indirectly by, e.g. improving the vegetation characterisation
- Currently on-going EUMETSAT study with TU Wien, IFAC and EURAC