Satellite multispectral unmixing by drone data for wet grassland habitats classification

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**Introduction:**

**Habitat mapping**

- **Field**
  - Plant community 1
  - Plant community 2
  - Plant community 3

- **Satellite**
  - Mixed pixel
  - Spectral similarities
  - Expert knowledge

- **Temporal variability**

![Graph showing NDVI values over months](image)
Assumption:

UAV data provides pure pixel

Spatial resolution of remotely sensed data (pixel size)

Potential mixture
Pure signal
Missing signal

Plot area

1) Sentinel-2
2) Pleiades
3) UAV
4) Vegetation cover
Evaluating the supply of UAV data to unmix satellite data for habitat mapping
Study area
The Sougeal marsh
Water periods
Floristic survey

Sentinel-2

Pleiades

UAV

Data

Resolutions | S-2 | Pleiades | UAV
---|---|---|---
Spectral bands | 10 | 4 | 4
Spatial (m) | 10 to 20 | 2.4 | 0.2

Floods

2017 May

2018

2018 Apr

2018 May
Methodology:

General workflow

Step 1. Plant communities

- Floristic data
- Ordination and unsupervised classification
- Plant community classes
- Training data
- Validation data
Methodology:
General workflow

Step 1: Floristic data → Ordination and unsupervised classification → Plant community classes

Step 2: UAV data → Reference map

Training data → Validation data

Supervised classification → Reference abundances
Methodology:

General workflow

Step 1: Plant communities
- Floristic data
- Ordination and unsupervised classification
- Plant community classes
- Training data
- Validation data

Step 2: Reference map
- UAV data
- Supervised classification
- Reference abundances

Step 3: Spectral unmixing
- Satellite data
- Spectral unmixing
- Estimated abundances

Endmembers A)

Endmembers B)
Methodology:

General workflow

Step 1: Plant communities
- Floristic data
- Ordination and unsupervised classification
- Plant community classes
- Training data
- Validation data

Step 2: Reference map
- UAV data
- Supervised classification
- Reference abundances
- Fuzzy confusion matrix

Step 3: Spectral unmixing
- Satellite data
- Spectral unmixing
- Estimated abundances
- Endmembers

Step 4: Fuzzy accuracy assessment
- Endmembers

ALICE
Methodology:

Experiments

- Influence of the sensor features
- Influence of the acquisition date
- Influence of endmember extracted from UAV vs Satellite
Results Step 1:

Plant communities

A) Vegetal species

B) Plots

Hygrophilic (H)

Meso-hygrophilic 2 (MH)

Meso-hygrophilic 1

Mesophilic (H)

Hygrophilic (H)
Results Step 2: Reference map

OA = 0.90 (+/- 0.08)
Kappa = 0.85 (+/- 0.12)
Results Step 3&4: Influence of the sensor features

Reference map

Sentinel-2 May

Pleiades May

OA_F = 0.60
KIA_F = 0.43

OA_F = 0.68
KIA_F = 0.53

Pleiades > Sentinel-2
Results Step 3&4:

Influence of the acquisition date

Reference map

Pleiades November

Sentinel-2 April

April > May > November
Results Step 3&4:
Influence of endmember extracted from UAV vs Satellite

**Reference map**

**Sentinel-2 May Satellite**

**Sentinel-2 May UAV**

\[
\text{OA}_F = 0.60 \\
\text{KIA}_F = 0.43
\]

\[
\text{OA}_F = 0.65 \\
\text{KIA}_F = 0.51
\]

UAV > Satellite, for Sentinel-2 in May
Results Step 3&4:

Influence of endmember extracted from UAV vs Satellite

UAV endmembers always improve the estimation of MH habitats
Discussion & Conclusion:

**Wet grassland mapping**

- **Unmixing approach provides sub-pixel information on habitats and identify relevant features**
  - Fine patterns
  - Ecotones

- **Key resolutions identified**
  - Spectral (-)
  - Spatial (+)
  - Temporal (++)

- **UAV supply**
  - More suitable endmembers for May period
  - More accurate discrimination of Meso-hygrophilic habitat

Thank you

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Assumption:

Non-linear mixture

Linear mixture

Non-linear mixture

Endmember: spectra assimilated as pure

Abundances: classes proportions in pixels

Bioucas-Dias et al. (2012)
Discussion & Conclusion:

UAV and Satellite data synergies

- **Sensor intercalibration (Not shown)**
  - Spectral mismatches between satellite and UAV data
  - Usefulness of domain adaptation

- **UAV complementarity**
  - Validation
  - Explicitation (Further works: spatio-temporal fusion)
Results Step 3 & 4:

Abundances estimation

Influence of radiometric intercalibration

<table>
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<th></th>
<th>Δ OA_f</th>
<th>Δ KIA_f</th>
<th>Δ RMSE (PIR)</th>
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<td>+0.09</td>
<td>+0.16</td>
<td>-0.116</td>
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<td>Pléiades (2018-05-18)</td>
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<td>+0.01</td>
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<td>Sentinel-2 (2018-04-20)</td>
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<td>Sentinel-2 (2018-05-18)</td>
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</tr>
</tbody>
</table>
Methodology:

**Fuzzy accuracy**

- Fuzzy set theory as framework, introducing vagueness
- Capture semantic flexibility inherent in complex categories
- Preserves error localization
- Generalization of traditional matrix
- More precise

Binaghi et al. (1999)