JECAM/GEOGLAM Science Meeting
16-17 November, 2015 - Brussels, Belgium

JECAM SAR cross sites experiments

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Agriculture and Agri-food Canada *UCLouvain-Geomatics, Belgium*

and the JECAM SAR researchers and/or site managers

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Preliminary roadmap (1st JECAM Meeting)

SAR cross sites experiments on JECAM sites:

- ✓Multi-user data license created !
- ✓Common acquisition plan and preprocessing level
- ✓AAFCanada to share his expertise in SAR ag. Application

A. Crop type identification (incl. multi-frequency)

B. LAI monitoring at parcel level

Future SAR experiment plans (2016-2017)

2015 RADARSAT-2 2015 time series over 7 sites

thanks to CSA through CEOS based on 2014 JECAM meeting decision

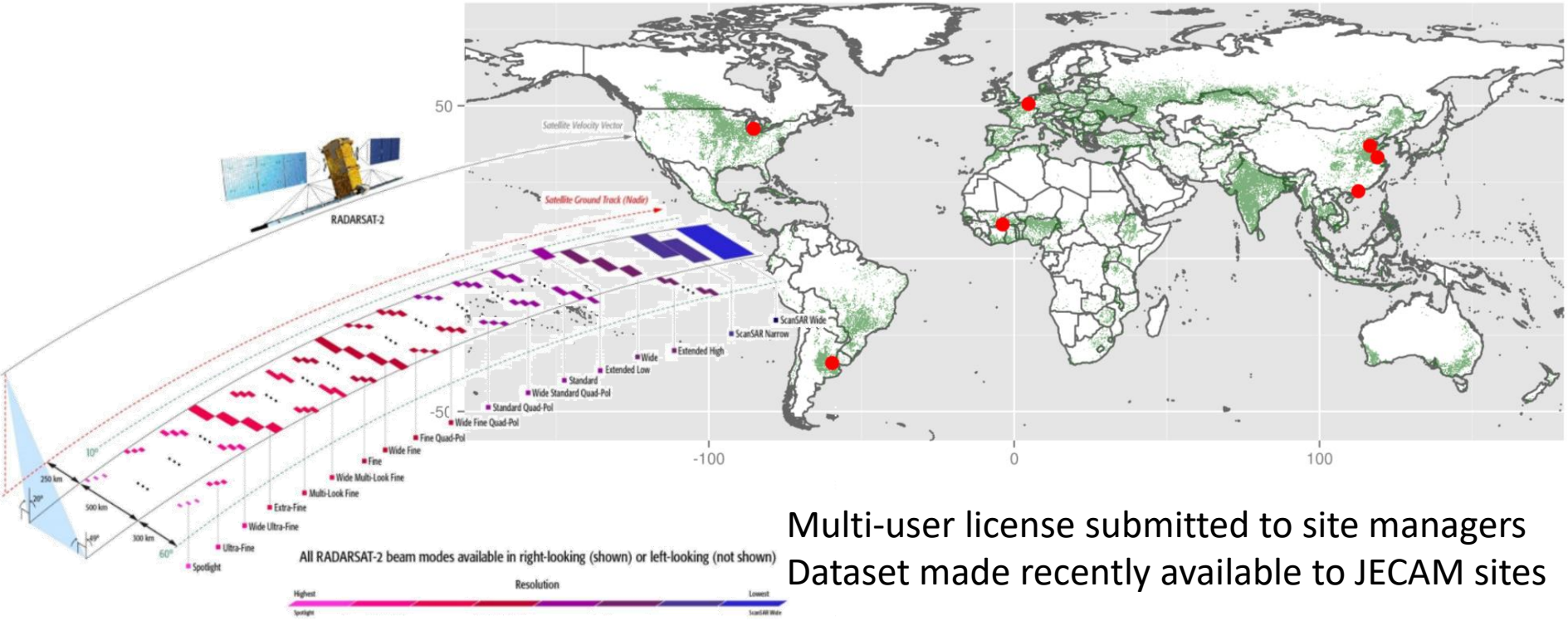

Figure 1-1 RADARSAT-2 SAR Beam Modes

Multi-user license submitted to site managers
Dataset made recently available to JECAM sites

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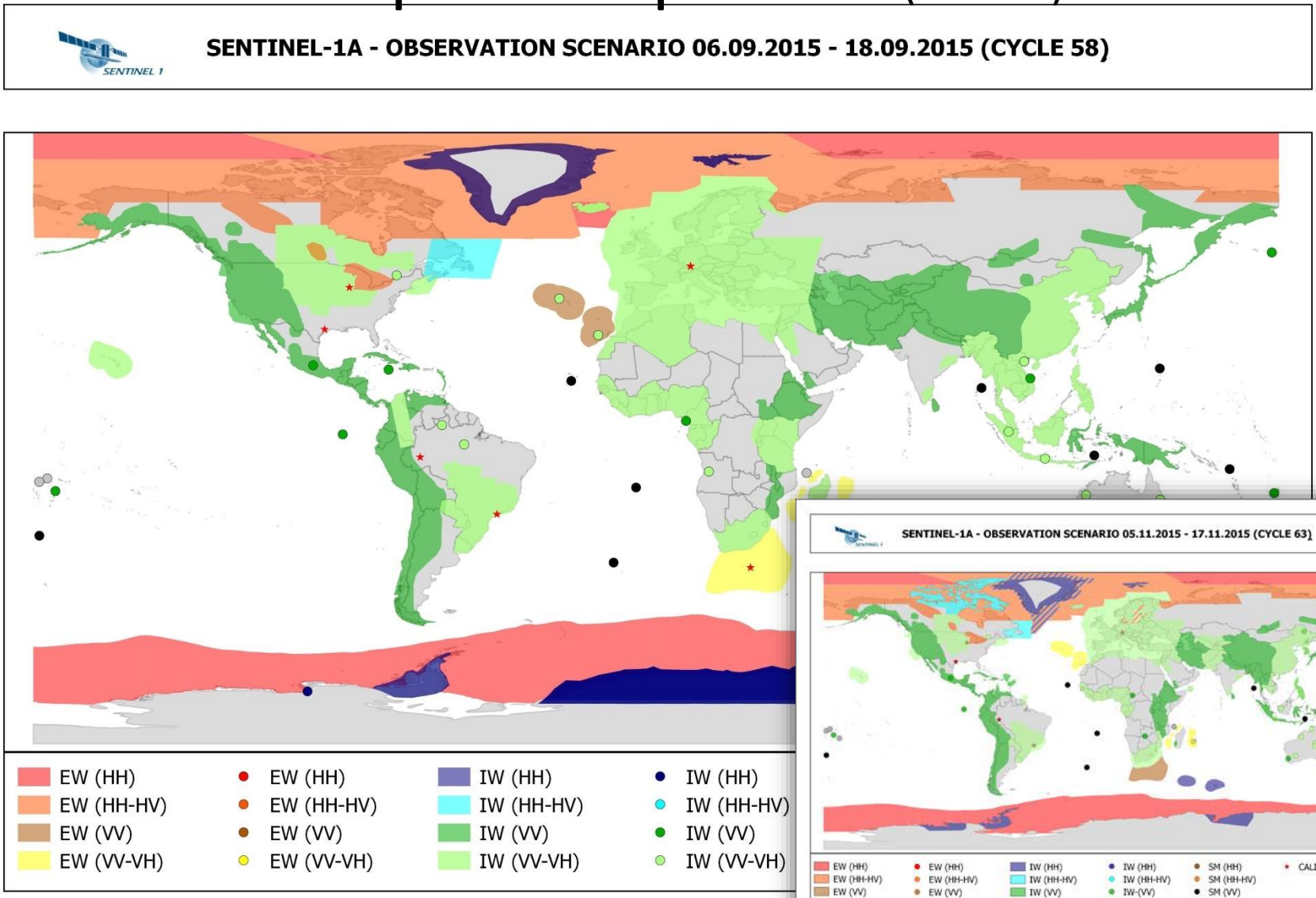
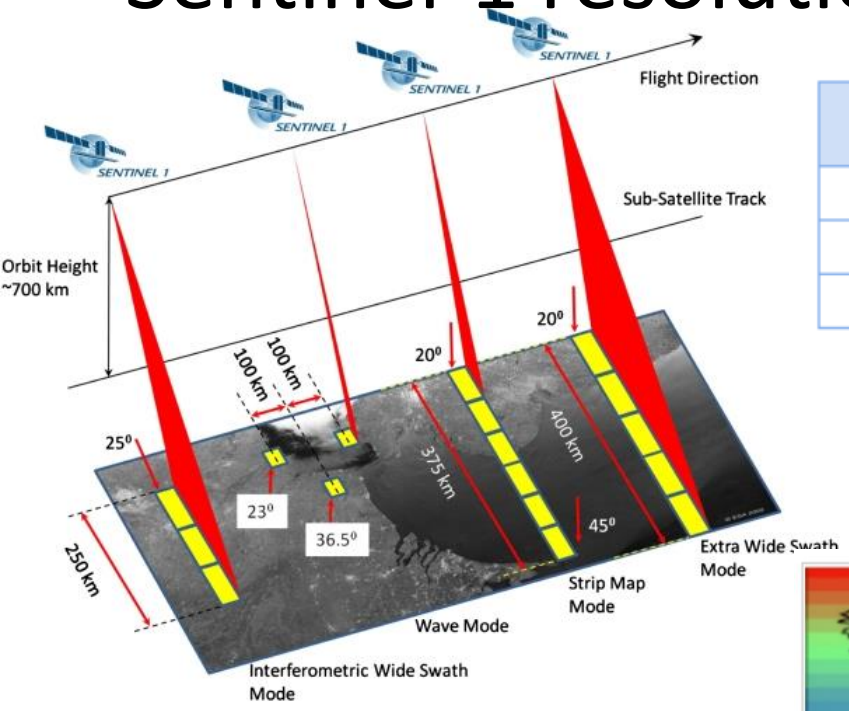
Sentinel-1 acquisition plan : IW (VV-VH) over several sites



https://sentinel.esa.int/web/sentinel/missions/sentinel-1/observation-scenario

Sentinel-1 resolution for IW (VV-VH) in many sites



Mode	Resolution rg x az	Pixel spacing rg x az	Number of looks	ENL
SM	23x23 m	10x10 m	6x6	34.4
IW	20x22 m	10x10 m	5x1	4.9
EW	50x50 m	25x25 m	3x1	2.9

Table 2: High resolution Level-1 GRD

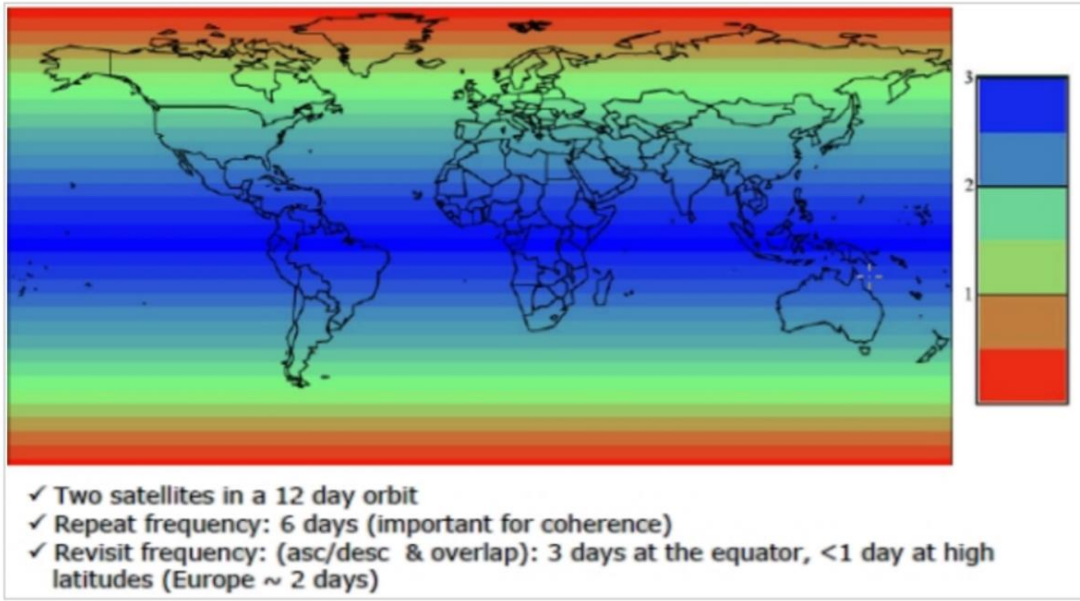


Figure 1: Revisit Frequency for S-1A and S-1B in Days per Revisit

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SAR C-band data availability for 2015 growing season

	Satellites with SAR C-band		
JECAM Sites	RADARSAT-2	Sentinel-1A	Total
Argentina	6	4	10
Belgium	6	60	66
Burkina-Faso	15	14	29
China-Taishan	15	19	34
China-Yangzhou	6	12	18
China-Yucheng	11	22	33
United States	42	40	82
Total	101	171	272

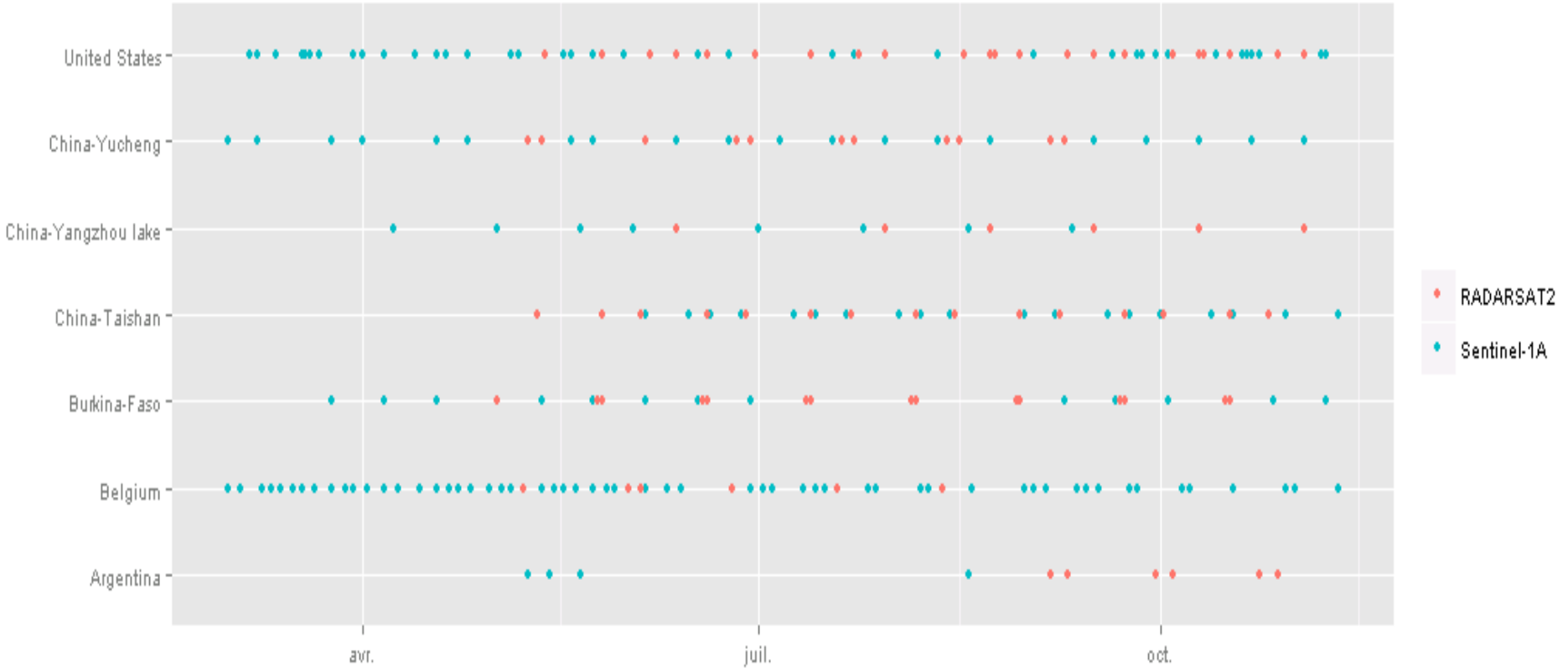
Opportunity for 2016

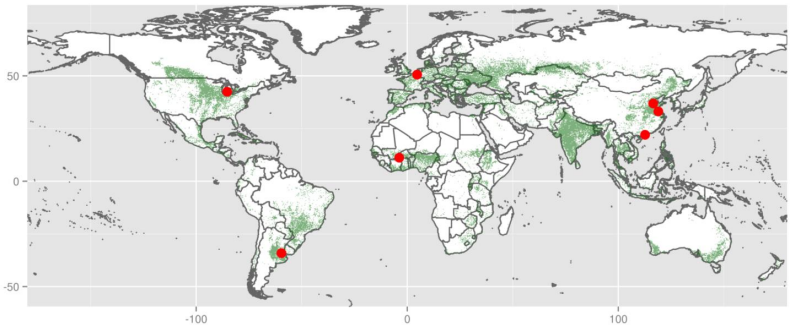
ALOS-2 PALSAR acquisition (L-band) and S1 time series : Taiwan site
possibly Argentina site
+ Vietnam AsiaRice sites

and later

Sentinel-1 A plan could maybe be expanded on ad hoc requests
Sentinel-1 B to be launched in late 2016 (tbc)

2015 dense SAR time series for 7 sites





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JECAM SAR roadmap (2015 data sets)

SAR cross sites experiments on JECAM sites:

- ✓ Multi-user data license created !
- ✓ Common acquisition plan and preprocessing level
- ✓ AAFCanada to share his expertise in SAR ag. applications

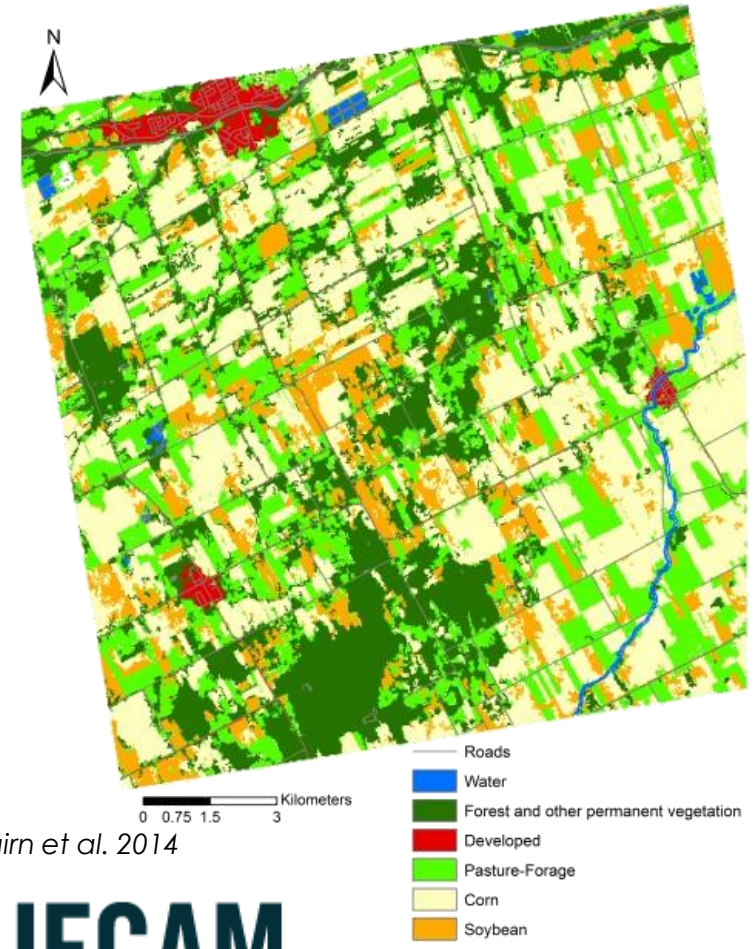
A. Crop type identification (incl. multi-frequency):

- definition of a experimental protocol (methods,
- In situ training set for 2015
- validation data set for 2015
- Ancillary data : meteo data, DEM, parcel delineation layer

- **What is the current status of 2015 in situ and anc. data ?**
- **Who are the partners interested by a SAR collaborative research on crop type mapping over the 7 JECAM sites ?**

AAFCanada JECAM SAR research results (McNairn et al., 2009, 2014) :

JECAM South Nation site (2013) : 8 TerraSAR-X dual-polarization strip mode and 15 RapidEye frames obtained through JECAM-CEOS agreement



McNairn et al. 2014

End of season TerraSAR-X crop classification: Ottawa 2012
Overall accuracy: **97.2**%

Early season: Corn can be identified at V6 or 6th leaf collar stage (about 6 weeks after planting)

McNairn, H., Kross, A., Lapen, D., Caves, R., and Shang J. 2014. Early season monitoring of corn and soybeans with TerraSAR-X and RADARSAT-2, International Journal of Applied Earth Observation and Geoinformation 28 (2014) 252–259.

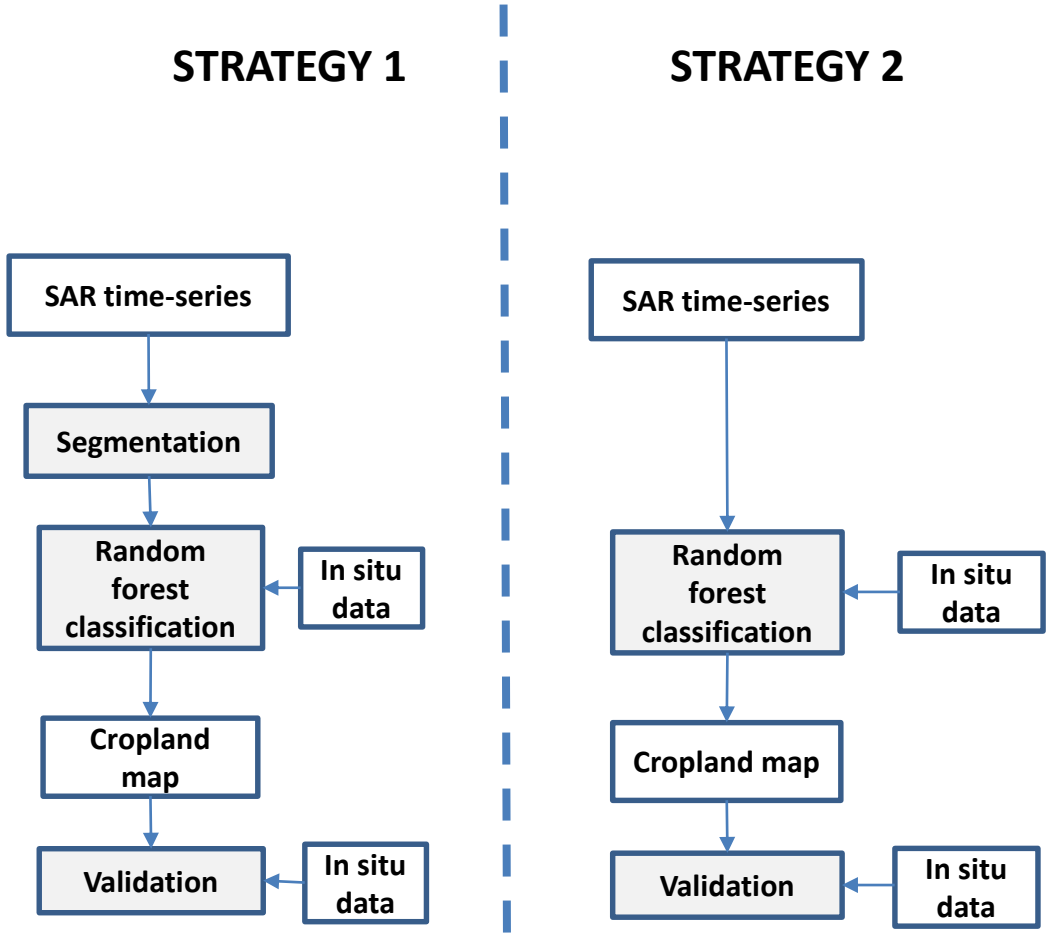
AAFC research and operations results (McNairn et al., 2009, Fisette et al., 2013) : 3 SAR obs. to optical obs. increase crop type accuracies (up to 16%)

***Canadian Approach**: Agriculture and Agri-Food Canada integrates C-Band RADARSAT-2 data with optical data, to deliver their annual crop inventory. The steps include:*

1. *Swath planning using the RADARSAT-2 Acquisition Planning Tool (APT). The tool can be requested from MDA Geospatial Services (clientservices@mdacorporation.com). Periodically, new configuration files are released and thus APT users must ensure that they have the most recent orbit files.*
2. *AAFC plans three RADARSAT-2 acquisitions per growing season; one in each of the early season, mid season and late season. ACP files are generated by the APT and are submitted to the appropriate order desk for de-confliction and upload to the satellite.*
3. *Dual-polarizations (VV, VH) are selected. Incident angles are not considered, and the beam mode which provides the best spatial coverage is selected.*
4. *The beam mode is region-specific and is selected to optimize the trade-offs in swath coverage and spatial resolution. In western Canada where fields are large in size, AAFC selects the ScanSAR Narrow beam mode (300 km swath; 50 m resolution in range and azimuth). In parts of the country were fields are smaller in size, Wide mode is programmed (150 km swath; 25 m (range) x 28 m (azimuth) resolution).*
5. *If possible, AAFC will program ascending (PM) orbits to avoid dew effects. If acquisition conflicts prevent this selection, then descending (AM) orbits are planned.*

JECAM SAR experiment fo crop type identification :

initial proposition of 2 to 4 classification strategies to be discussed



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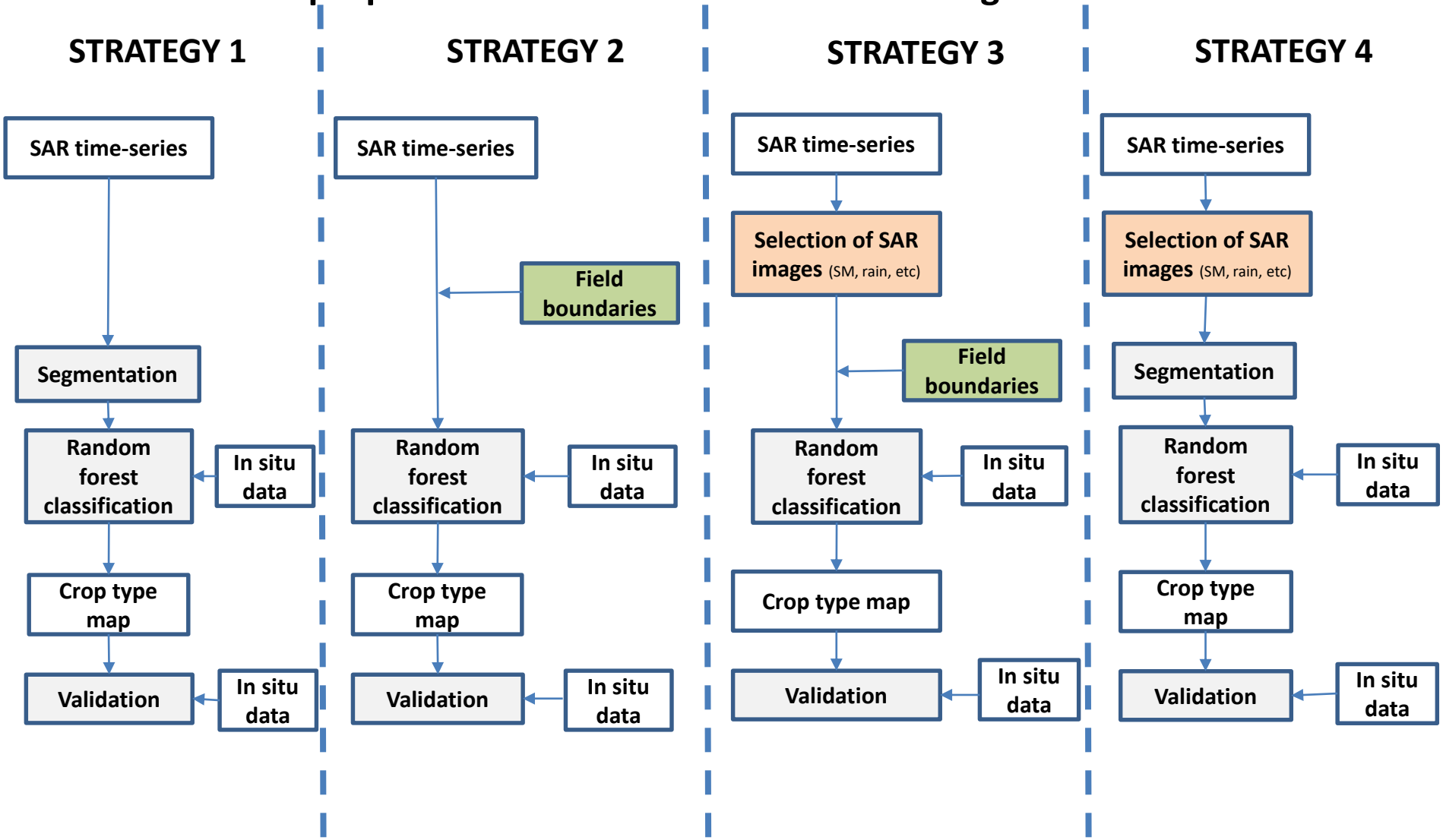
Initial proposition of 2 to 4 classification strategies to be discussed



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JECAM SAR roadmap (2015 data sets)

SAR cross sites experiments on JECAM sites:

- ✓ Multi-user data license created !
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A. Crop type identification (incl. multi-frequency):

B. LAI monitoring at parcel level (lead : H. McNairn):

- definition of experimental protocols (What crops ? What stages ?)
- similar in situ LAI definition and measurements
- appropriate sampling over space and time

- **What is the current status of 2015 in situ and anc. data ?**
- **Who are the partners interested by a SAR collaborative research on LAI retrieval over different JECAM sites ?**

Leaf Area Index Monitoring with SAR

- LAI is an important indicator of crop productivity and is directly linked with yield modeling
- Retrievals using optical data have been successful, but cloud cover is an impediment especially given the importance of temporally dense observations for crop production monitoring
- SAR scattering is intrinsically related to the structure of the target, and thus SAR responses (backscatter and polarimetric responses) are quite sensitive to both crop LAI and biomass

JECAM SAR LAI experiment proposition :

- Evaluate 2-3 methods for LAI retrieval over JECAM sites, incl. these options
  - Methods using parameterization of the Water Cloud Model under development at AAFC and UCLouvain
  - Empirical modeling
  - Other modeling approaches proposed by collaborators
- Consider adaptation of methods to biomass retrieval

McNairn et al. AAFC

Leaf Area Index from RADARSAT-2

SAR modelling with Water Cloud Model

$$\sigma^0 = AL^E \cos\theta(1-\exp(-2BL/\cos\theta)) + \sigma^0_{soi} \exp(-2BL/\cos\theta)$$

Total backscattered by the whole canopy (σ^o) at incidence angle (θ)

$$\sigma^0_{veg} = AL^E \cos\theta(1-\tau^2)$$

$$\tau^2 = \exp(-2BL/\cos\theta)$$

Vegetation component

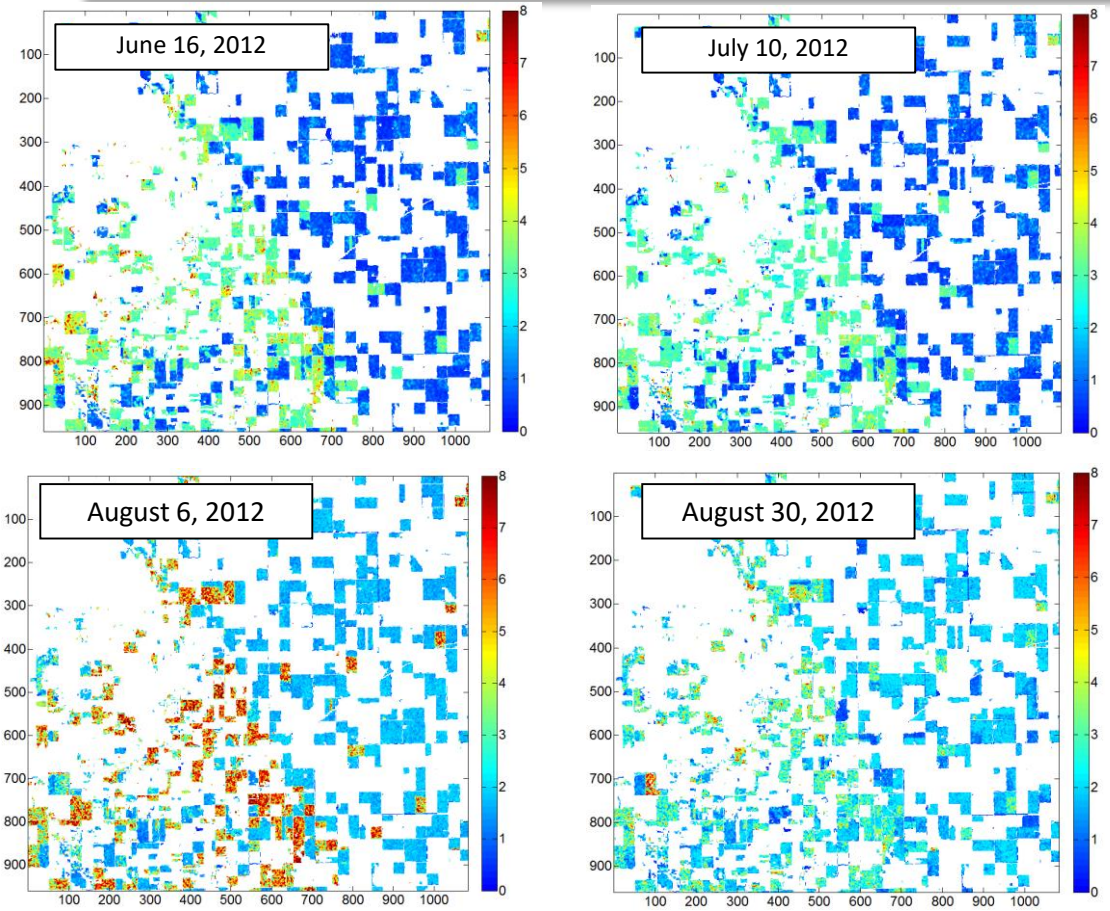
$$\sigma^0_{soil} = C + DM_s$$

Soil component

τ^2 is the two-way attenuation through the canopy layer
L is the LAI, expressed in (m2m-2)
A,B,C,D and E are model coefficients defined by experimental data (A,B, E depend on canopy type)

- Approach by AAFC uses two or three SAR polarizations to simultaneously retrieve LAI and soil moisture (no ancillary data needed) but soil moisture errors still high.
  LAI retrieval for corn and soybeans has been successful (both L- and C-band)
- Approach by UCL combining SAR polarizations to estimate LAI and SWAP model for soil moisture

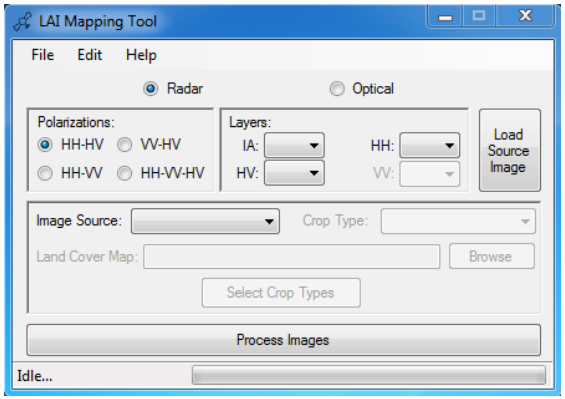
LAI from RSAT-2



Manitoba, 2012

LAI estimates for corn and soybeans using WCM

Accuracies with C- and L-band similar (or better than) than accuracies using optical data



	RMSE ($m^2 m^{-2}$)	MAE ($m^2 m^{-2}$)	R
Corn HH-HV	0.84	0.65	0.83
Corn VV-HV	0.75	0.62	0.81
Soybeans HH-HV	0.64	0.44	0.80
SoybeansVV-HV	0.63	0.44	0.80

Hosseini, M., McNairn, H., Merzouki, A., and Pacheco, A., "Estimation of Leaf Area Index (LAI) in corn and soybeans using multi-polarization C- and L-band radar data", Remote Sensing of Environment, vo. 170, pp. 77-89, 1 December 2015.

SAR LAI Monitoring – Next Steps

- **What is the current status of 2015 in situ and anc. data ?**
- **Who are the partners interested by a SAR collaborative research on crop type mapping over the 7 JECAM sites ?**

=> series of conference calls to develop a short work plan, and a plan of action

- Initiative could be led by AAFC; AAFC could host visiting scientist/post-doc/graduate students funded by JECAM participants, to work on data analysis at their Ottawa lab

- Interest from AAFC
  - Integrate additional data to create a more robust model
  - Extend corn/soybean model to other crops, in particular wheat
  - Adapt current model to estimate above ground biomass
  - Improve simultaneous retrieval of soil moisture under crop canopy

Future JECAM SAR experiment plans

SAR obs. requirements for 2016-2017 (RST-2, S1a&b, PALSAR, TerraSarX) ?

- Is there other SAR research objectives to be investigated ?
- Who is interested by a SAR collaborative research as participant / as leader ?
- Who is interested by a SAR-optical collaborative research as participant / as leader ?

! In 2016, Canada will again play host to a SMAPVEX cal/val campaign; excellent opportunity for international participation. SMAPVEX12 was highly successful involving 75 scientists from U.S. and Canada, and has been supporting many graduate theses.

SMAPVEX12 included extensive collection of LAI, biomass and soil moisture data; collection of airborne and satellite SAR data

Some JECAM partners references

- Hosseini, M., McNairn, H., Merzouki, A., and Pacheco, A. (2015). “Estimation of Leaf Area Index (LAI) in corn and soybeans using multi-polarization C- and L-band radar data”, Remote Sensing of Environment, 170, pp. 77-89.
- Wiseman, G., McNairn, H., Homayouni, S., and Shang, J. (2014). "RADARSAT-2 Polarimetric SAR response to crop biomass for agricultural production monitoring", IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 7(11), pp. 4461-4471.
- Bériaux, Emilie ; Lucau-Danila, Cozmin ; Auquiere, Eric ; Defourny, Pierre. Multiyear independent validation of the water cloud model for retrieving maize leaf area index from SAR time series. In: International Journal of Remote Sensing, Vol. 34, no. 12, p. 4156-4181 (2013). http://hdl.handle.net/2078/126107
- Bériaux, Emilie ; Lambot, Sébastien; Defourny, Pierre, 2011. Estimating surface-soil moisture for retrieving maize leaf-area index from SAR data. In: Canadian Journal of Remote Sensing, Vol. 37, no. 1, p. 136-150 (February 2011). doi:10.5589/m11-021. http://hdl.handle.net/2078.1/95099
- Jiao, X., McNairn, H., Shang, J., Pattey, E., Liu, J., and Champagne, C. (2011). “The sensitivity of RADARSAT-2 polarimetric SAR data to corn and soybean Leaf Area Index”, Canadian Journal of Remote Sensing, 37(1), pp. 69-81.
- Blaes X., Vanhalle L., Defourny P., 2005. Efficiency of crop identification based on optical and SAR time series, Remote Sensing of Environment, 96, 352-365.

Regular *in situ* data collection

Every year once :

Crop type

Row orientation

Plant density

4 to 7 times over a season:

Leaf Area Index (LAI)

Development stage

On ad hoc basis:

Yield

Fresh and dry biomass

Soil moisture incl. GPR

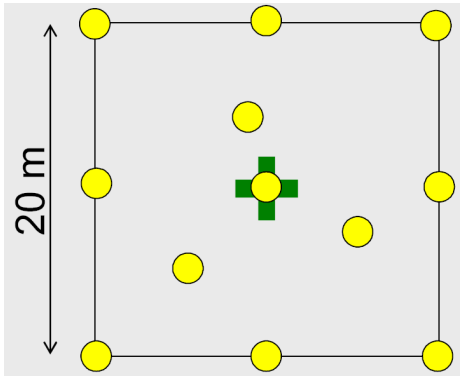
Synchroneous field campaign: LAI measurements

Leaf Area Index (LAI): the one-sided green leaf area per unit of ground surface area (m^2/m^2) estimate from hemispherical photo using CAN-EYE

→ 15 winter wheat fields visited in 2013

→ 7 dates of hemispherical photographs/ field

Fish-Eye lens



Spatial sampling example

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UCL Université catholique de Louvain

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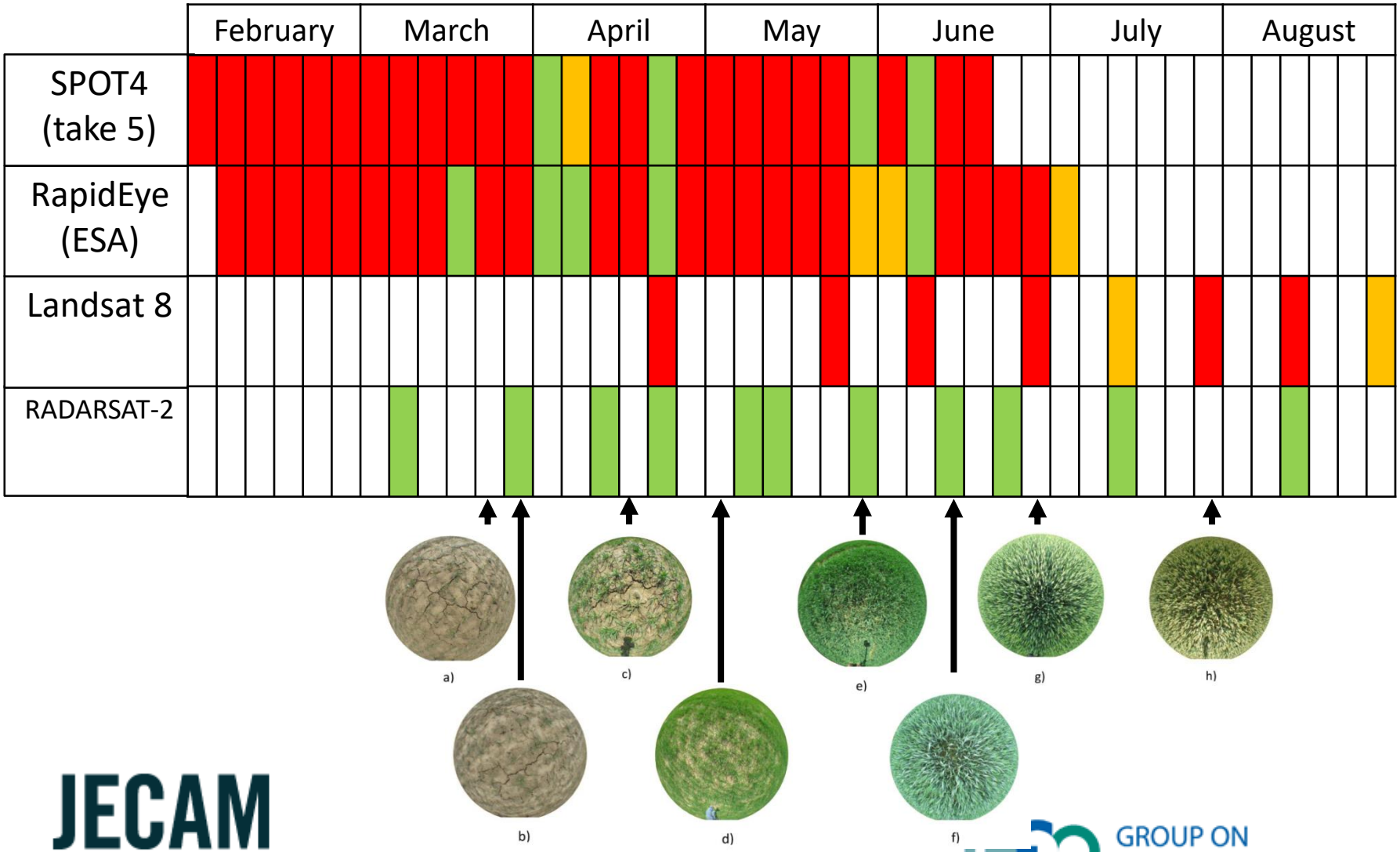
LAI measurements along 2013 intensive EO acquisition campaign



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