

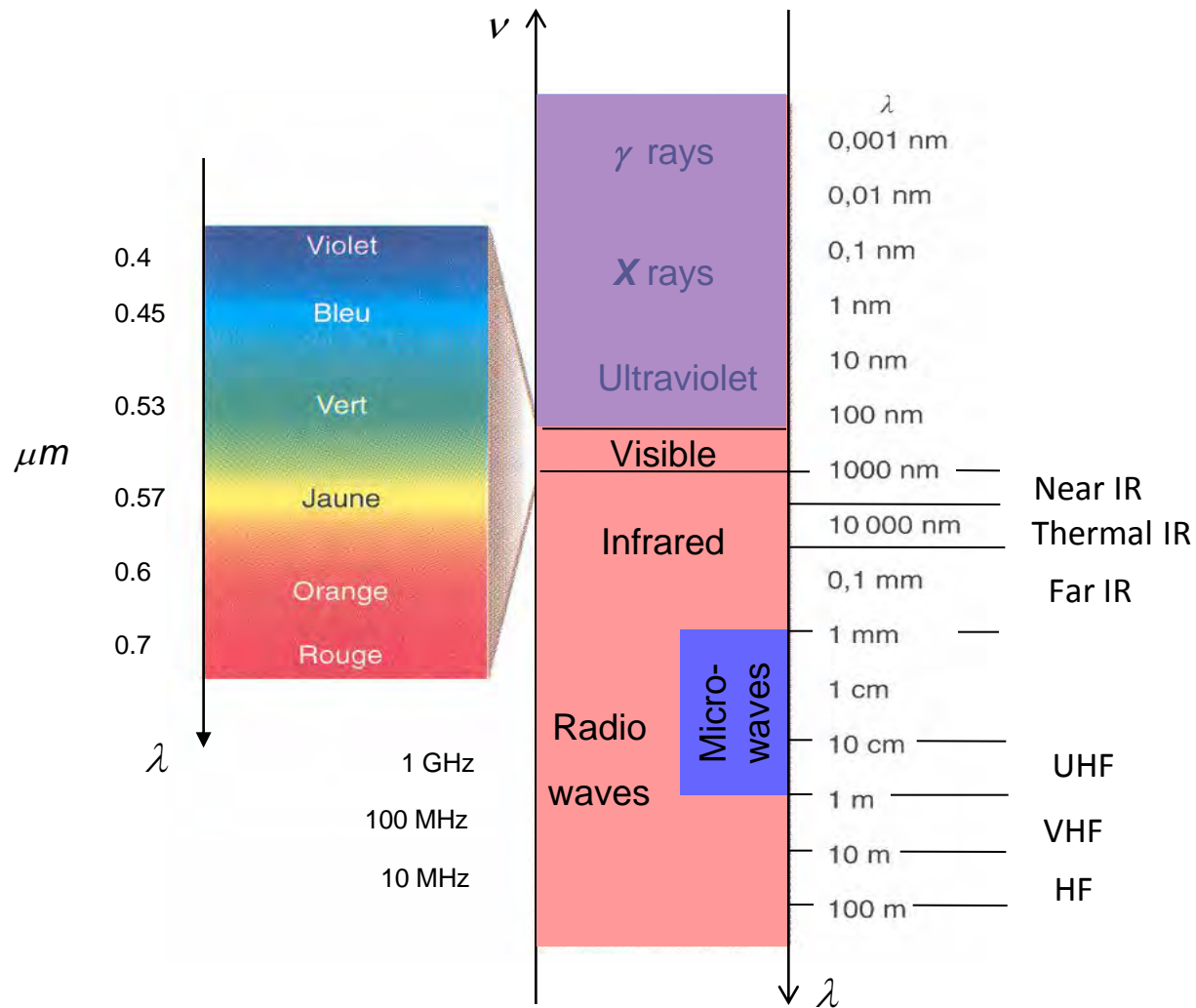


# SAR basics for land

*Pierre-Louis Frison*

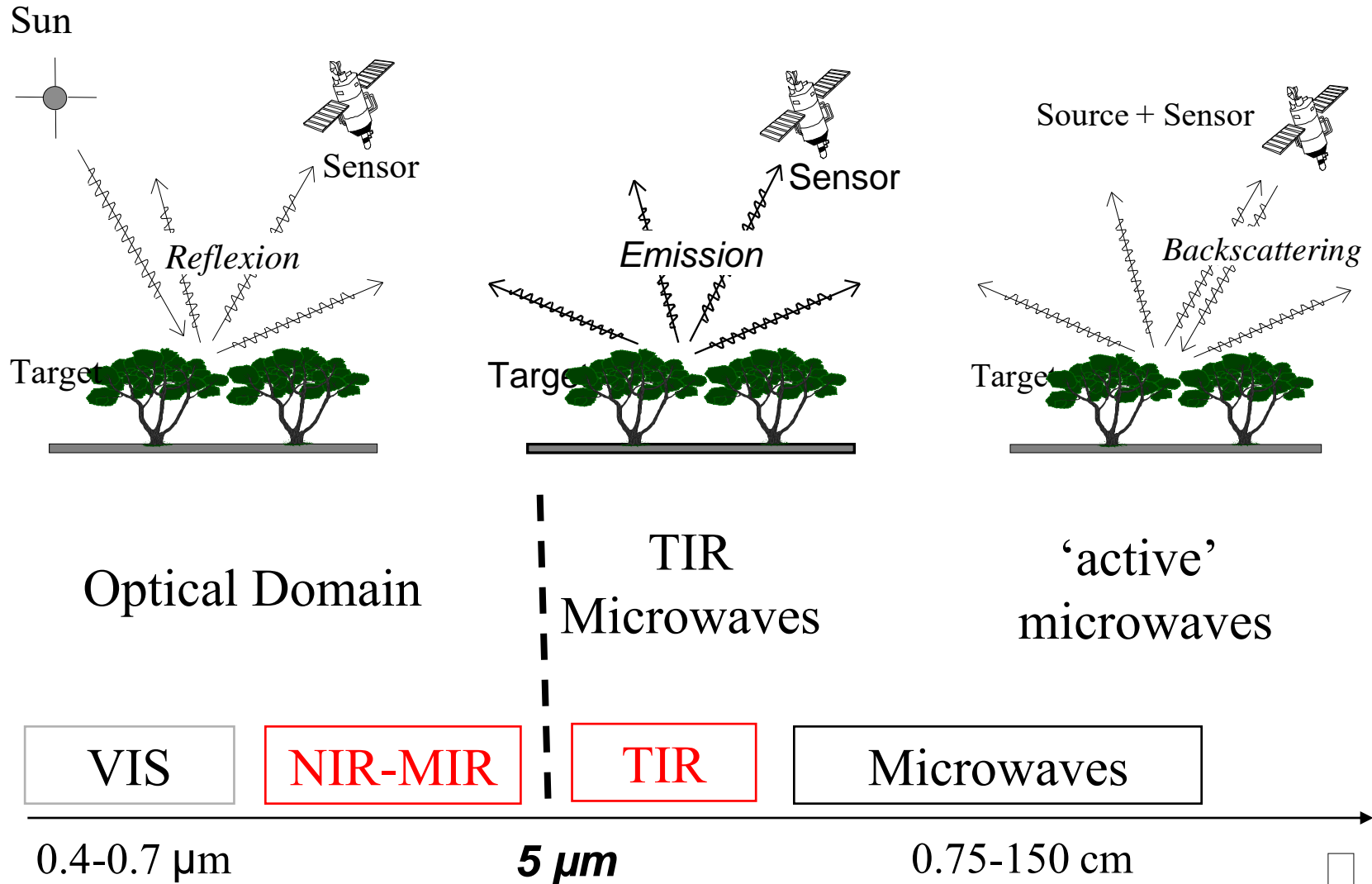
[pierre-louis.frison@univ-eiffel.fr](mailto:pierre-louis.frison@univ-eiffel.fr)

# Electromagnetic spectrum



From Seguin & Villeneuve,  
Astronomie et Astrophysique

# Observation modes



# Radar Fundamentals

## **RADAR:** **R**adio **D**etection **A**nd **R**anging

*Emission* of emw  
*Reception* backscattered echoes



Road RADAR

(© US police)



US Army



Imaging RADAR PALSAR

(© NASDA)

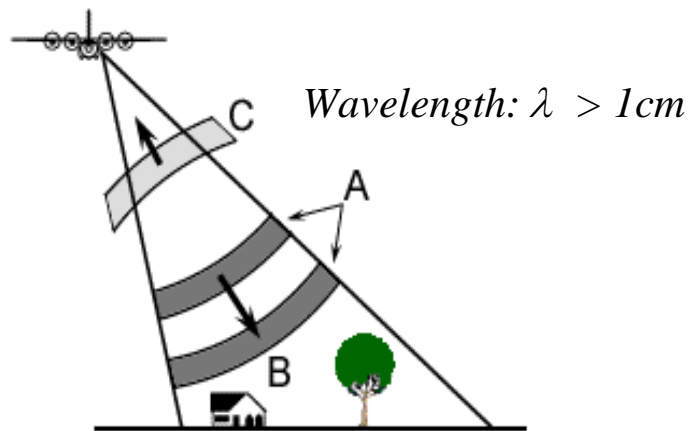


# Vegetation classification with SAR data

## Spaceborne Remote Sensing

Optical since 70's

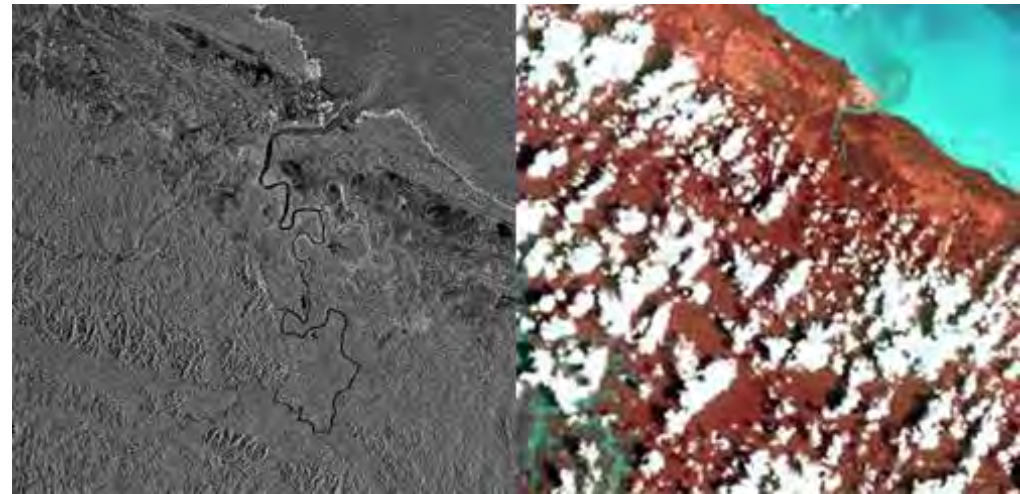
Radar since 1991



Source: Centre canadien de télédétection

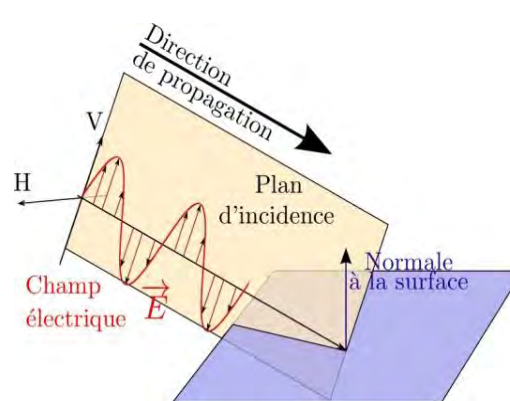
Radar, ERS

Optical, SPOT

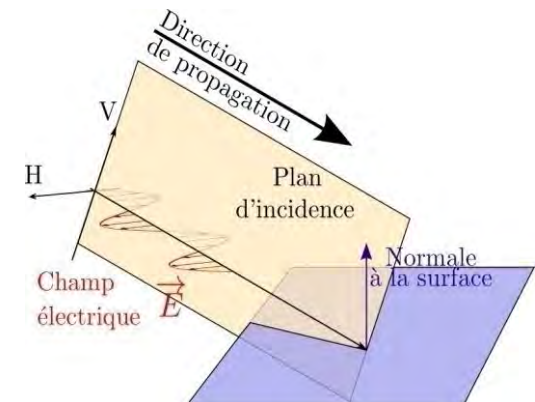


**Insensitive to clouds and atmosphere**  
**+**  
**day / night acquisitions**

*Different polarizations*



**V Polarisation**



**H Polarisation**

# Radar particularly suitable for heavily cloudy areas

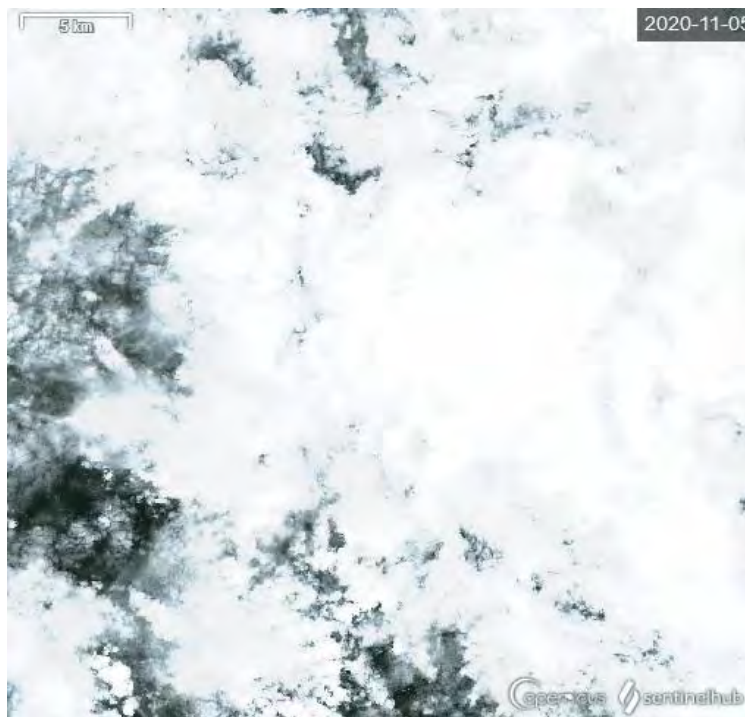
□ *Not sensitive to cloud cover ( $\lambda > 2\text{ cm}$ )*

Radar



Sentinel-1

Optical



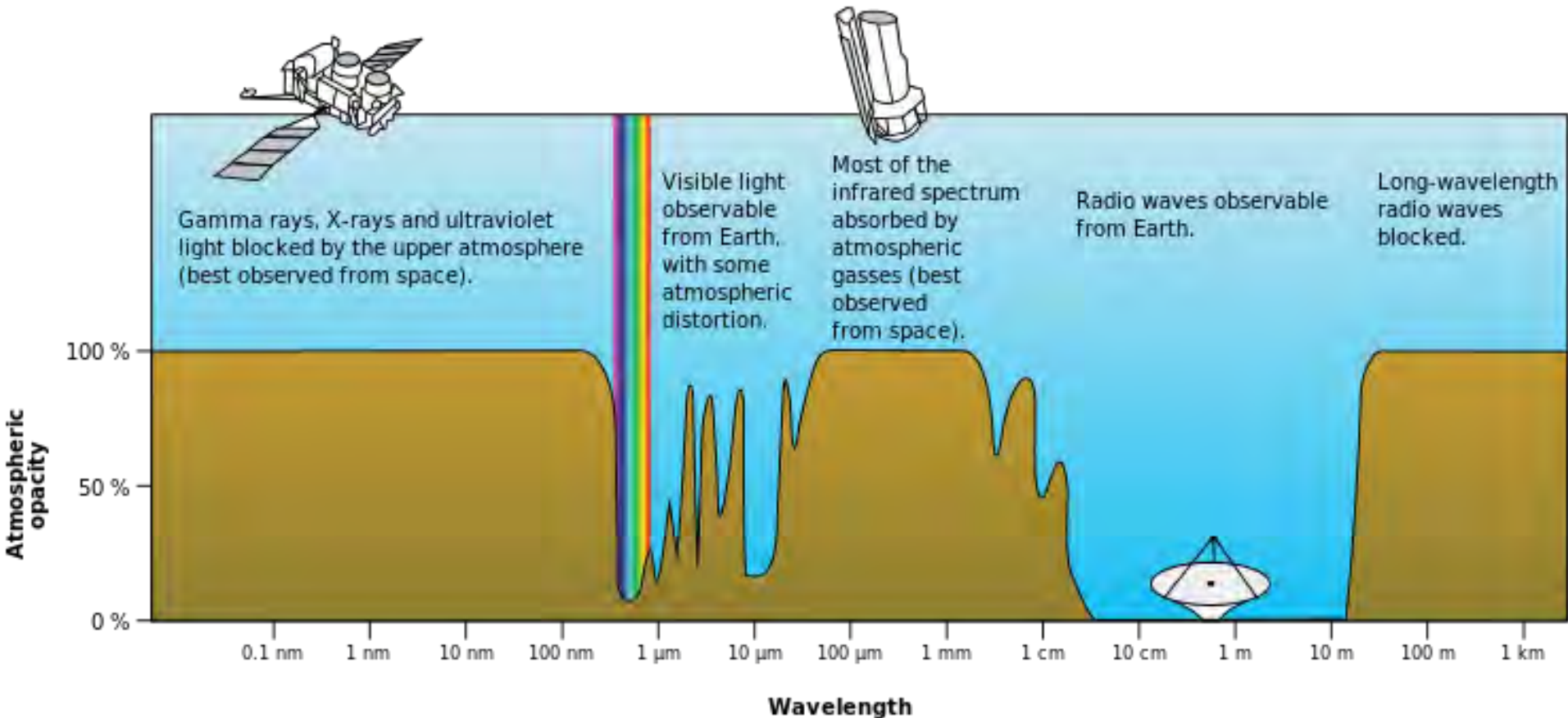
Sentinel-2





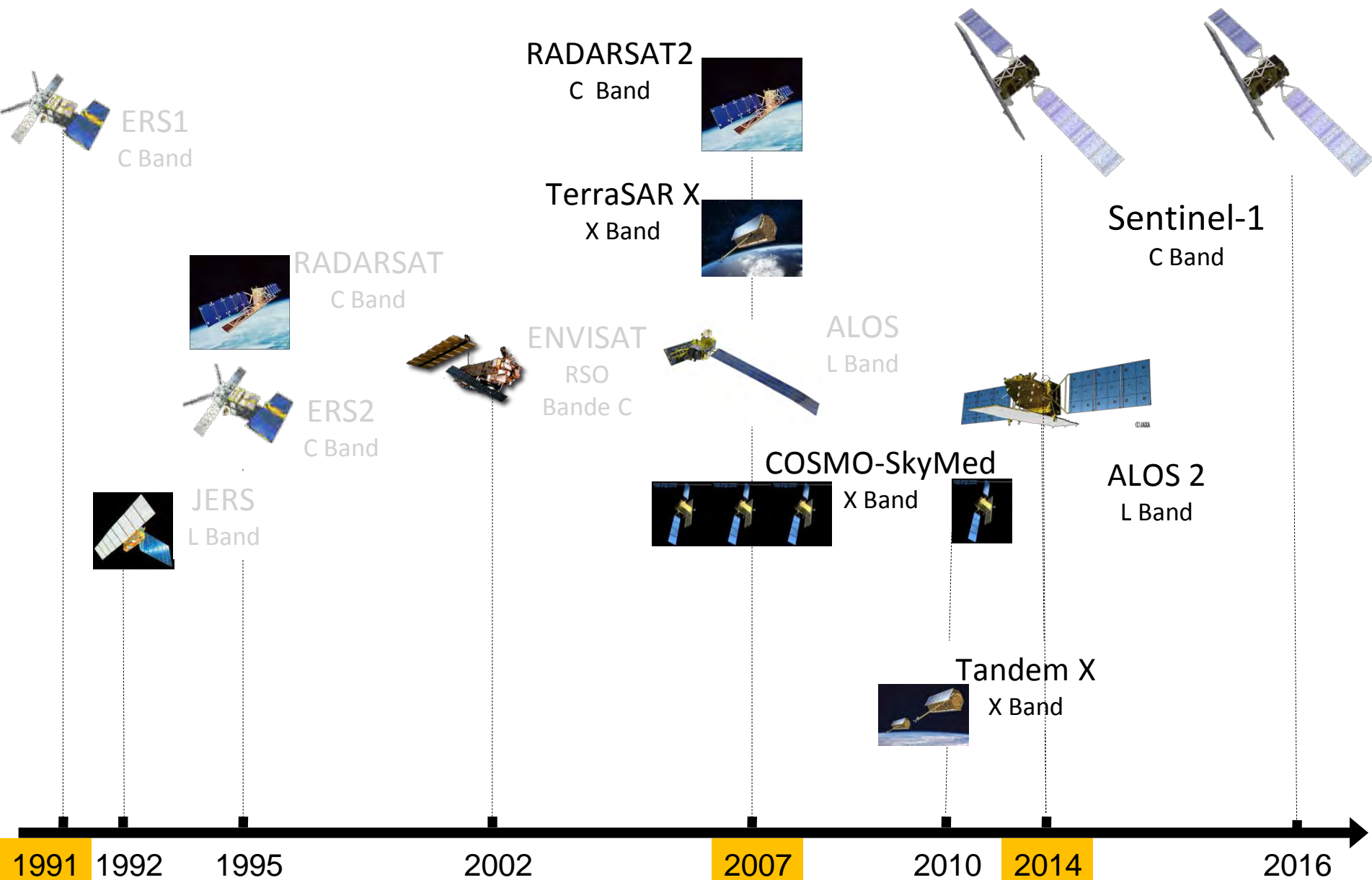
# Frequency - wavelength

## *Radar: all weather acquisition*



Source: Wikipedia

# SPACEBORNE SAR SENSORS



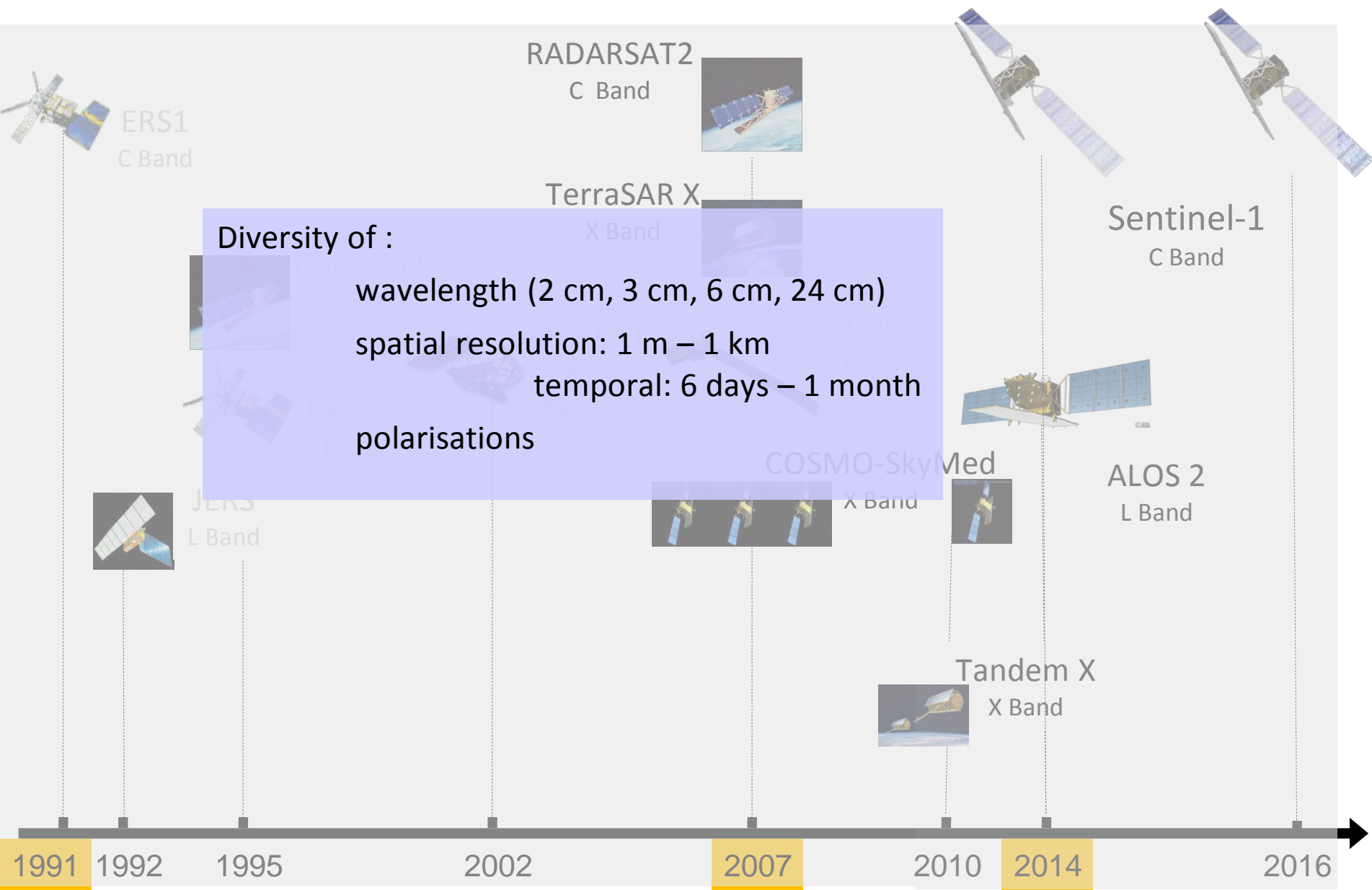


# Frequency – Wavelength

$$f = \frac{c}{\lambda}$$

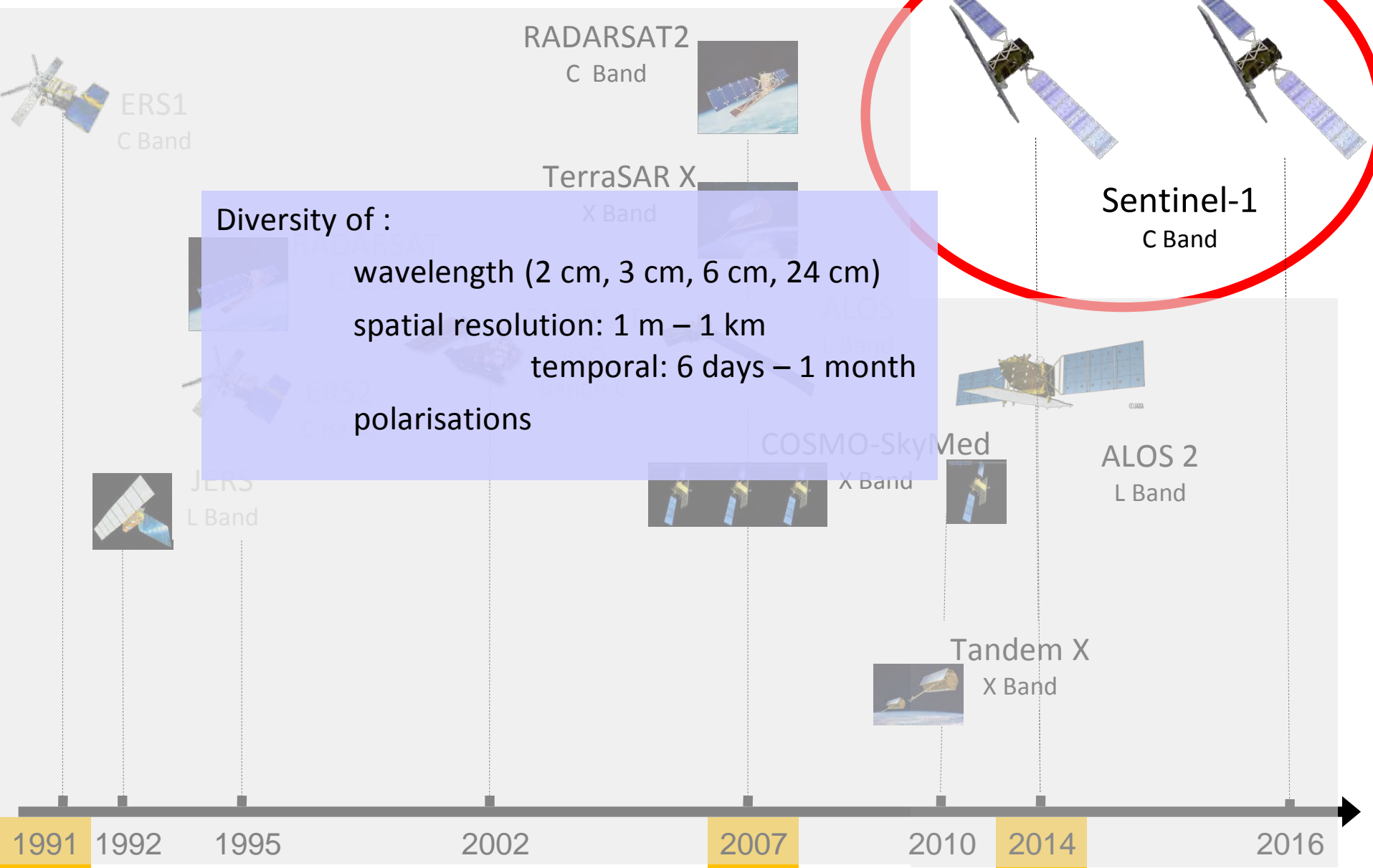
Band	Wavelength $\lambda$ (cm)	Frequency $f$
<i>X</i>	~ 3 cm	~ 10 GHz
<i>C</i>	~ 6 cm	~ 5 GHz
<i>L</i>	~ 25 cm	~ 1,2 GHz
<i>P</i>	~ 70 cm	~ 400 MHz

# SPACEBORNE SAR SENSORS



# SPACEBORNE SAR SENSORS

COPERNICUS

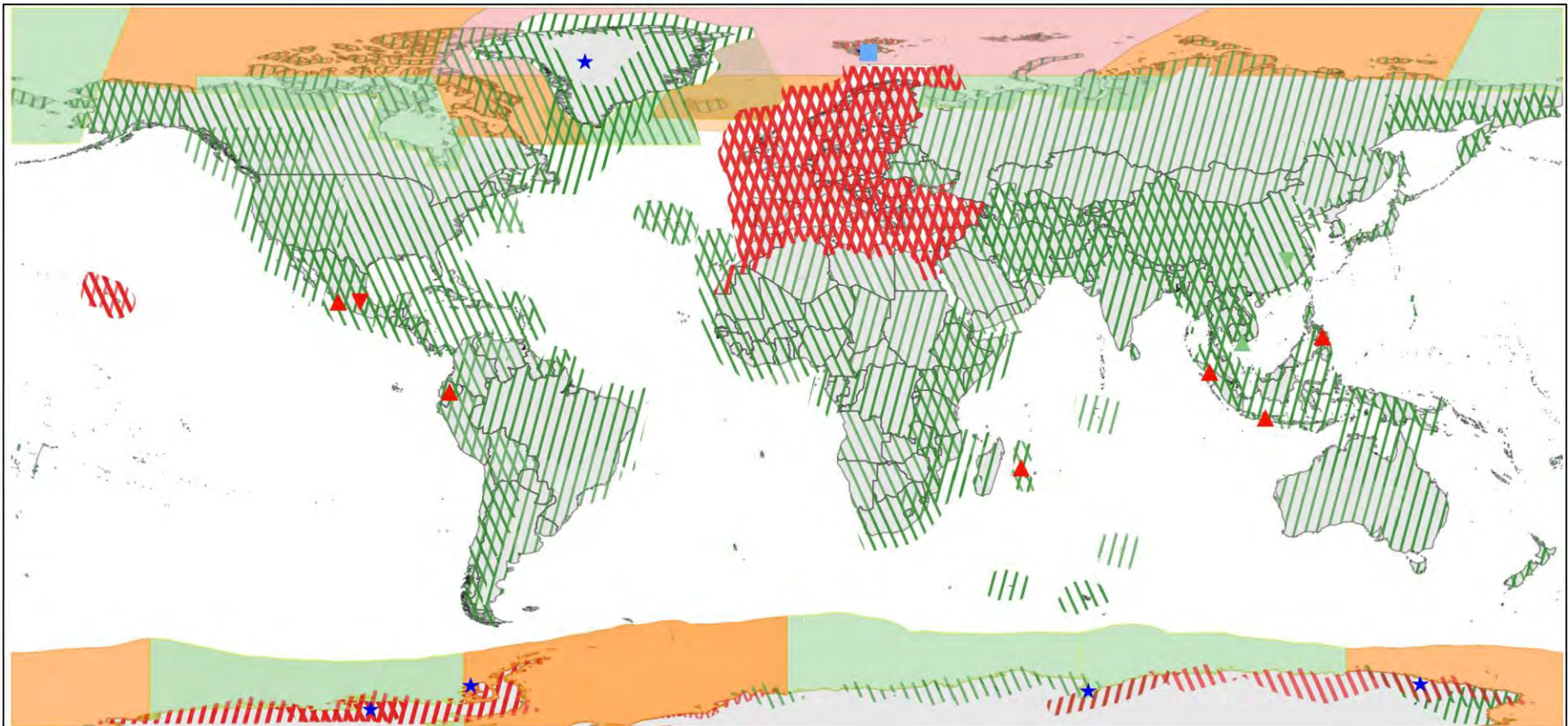


# SPACEBORNE SAR SENSORS

## Sentinel-1 Constellation Observation Scenario: Revisit & Coverage Frequency



validity start: 02/2018



PASS	REVISIT	FREQUENCY *	COVERAGE	FREQUENCY **	REFERENCE DATA SITES (6d repeat)
<div style="display: inline-block; width: 15px; height: 10px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); border: 1px solid black;"></div> ASCENDING	<div style="display: inline-block; width: 15px; height: 10px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); border: 1px solid black;"></div> 6 days	<div style="display: inline-block; width: 15px; height: 10px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); border: 1px solid black;"></div> 12 days	<div style="display: inline-block; width: 15px; height: 10px; background-color: #ffcccc; border: 1px solid black;"></div> 1 days		<div style="display: inline-block; width: 0; height: 0; border-left: 5px solid transparent; border-right: 5px solid transparent; border-bottom: 8px solid red;"></div> Highly active volcanism
<div style="display: inline-block; width: 15px; height: 10px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); border: 1px solid black;"></div> DESCENDING	<div style="display: inline-block; width: 15px; height: 10px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); border: 1px solid black;"></div> 6 days	<div style="display: inline-block; width: 15px; height: 10px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); border: 1px solid black;"></div> 12 days	<div style="display: inline-block; width: 15px; height: 10px; background-color: #ffcc99; border: 1px solid black;"></div> 1-3 days		<div style="display: inline-block; width: 0; height: 0; border-left: 5px solid transparent; border-right: 5px solid transparent; border-bottom: 8px solid orange;"></div> Fast subsidence
	<div style="display: inline-block; width: 15px; height: 10px; background: repeating-linear-gradient(-45deg, transparent, transparent 2px, black 2px, black 4px); border: 1px solid black;"></div> 6 days	<div style="display: inline-block; width: 15px; height: 10px; background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); border: 1px solid black;"></div> 12 days	<div style="display: inline-block; width: 15px; height: 10px; background-color: #ccffcc; border: 1px solid black;"></div> 2-4 days		<div style="display: inline-block; width: 0; height: 0; border-left: 5px solid transparent; border-right: 5px solid transparent; border-bottom: 8px solid green;"></div> Short growth cycle, intensive agriculture
					<div style="display: inline-block; width: 0; height: 0; border-left: 5px solid transparent; border-right: 5px solid transparent; border-bottom: 8px solid blue;"></div> Fast changing wetlands
					<div style="display: inline-block; width: 0; height: 0; border-left: 5px solid transparent; border-right: 5px solid transparent; border-bottom: 8px solid lightblue;"></div> Fast moving outlet glaciers
					<div style="display: inline-block; width: 0; height: 0; border-left: 5px solid transparent; border-right: 5px solid transparent; border-bottom: 8px solid lightblue;"></div> Permafrost & glaciers

\* coverage ensured from same, repetitive relative orbits  
 \*\* coverage not considering repetitiveness of relative orbits



# SAR data: summary

<i>Name</i>	<i>Acquisition period</i>	<i>Band Frequency</i>	<i>Polarization mode</i>	<i>Spatial resolution (m)</i>	<i>Revisit time (days)</i>	<i>Scene cover (km)</i>
<b>ERS-1 / 2</b>	91 - 11	C	VV	20	35	185x185
<b>JERS</b>	92 - 98	L	HH	20	44	75 x 75
<b>Radarsat</b>	95 – 13	C	HH	10-100	24	35 x 500
<b>ASAR</b>	01-13	C	1 or 2 pol. HH/HV/VV	30-1000	few -35	100x500
<b>PALSAR</b>	07-11	L	Polarimetric HH/HV/VV	10-100	few-24	100-500
<b>Radarsat-2</b>	2007 -	C	Polarimetric HH/HV/VV	1-15	5 to 10	NA
<b>TerraSAR-X</b>	2007 -	X	1 or 2 pol. HH/HV/VV	1-20	few-11	5-100
<b>Cosmo-Skymed</b>	2007 -	X	1 or 2 pol HH/HV/VV	1-100	12 h	10-200
<b>SAOCOM</b>	2015	L	Polarimetric HH/HV/VV	7-100	few-16	60-320
<b>Sentinel 1</b>	2015	C	1 or 2 pol HH/HV/VV	5 - 100m	few-12	80-400
<b>ALOS-2</b>	2015	L	Polarimetric HH/HV/VV	3-100	few-14	25-350

# OUTLINE

- I. Radar imaging - Spatial resolution**
- II. Polarization - Polarimetry**
- III. Radar response sensitivity**
- IV. Relief effects**
- V. Speckle and Filtering**