Cold Regions Hydrology High-Resolution Observatory - Earth Explorer 7 Core Mission Candidate

Overview of mission, activities and system design

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Need for snow and ice observations

Global climate system

Snow and ice – two essential climate elements not well represented in climate models. In particular, snow mass is poorly known

Hydrological and surface/atmosphere exchange processes

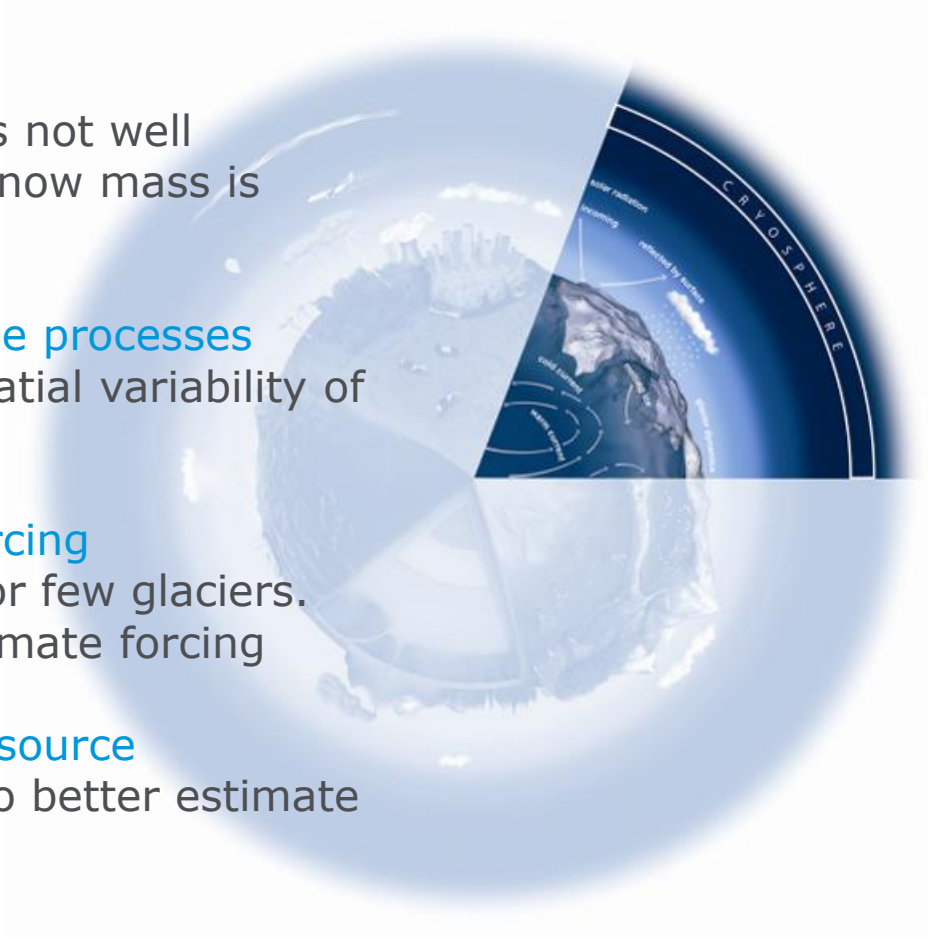
High-resolution data needed to account for spatial variability of snow

Glacier mass balance – link to atmospheric forcing

An essential climate variable measured only for few glaciers. Global data needed to quantify response to climate forcing

Snowmelt and glacier runoff – a vital water resource

Spatially detailed snow observations needed to better estimate the climate impact on water supply



Shortcomings in current snow observations

Ground measurements

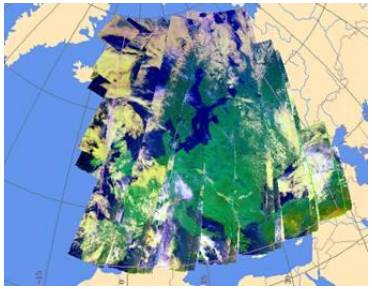
SWE and snow depth measurements based on insitu measurements carried out at fixed points, special station networks or snow courses

Satellite measurements

Optical sensors provide information about area extent of snow cover (SE) but no information on SWE

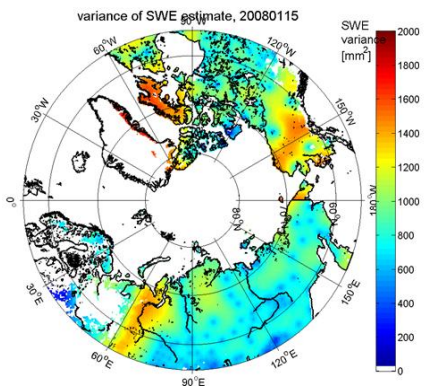
Passive microwave data map snow extent and snow water equivalent but at coarse resolution (~20-25 km). Suitable for large regions with homogeneous snowpack; less suitable in hilly and mountainous regions

Current SAR data (C-band, e.g. ASAR) can be applied to melting snow mapping but is not sensitive to SWE and dry snow (transparent)



Snow extent with ENVISAT AATSR data

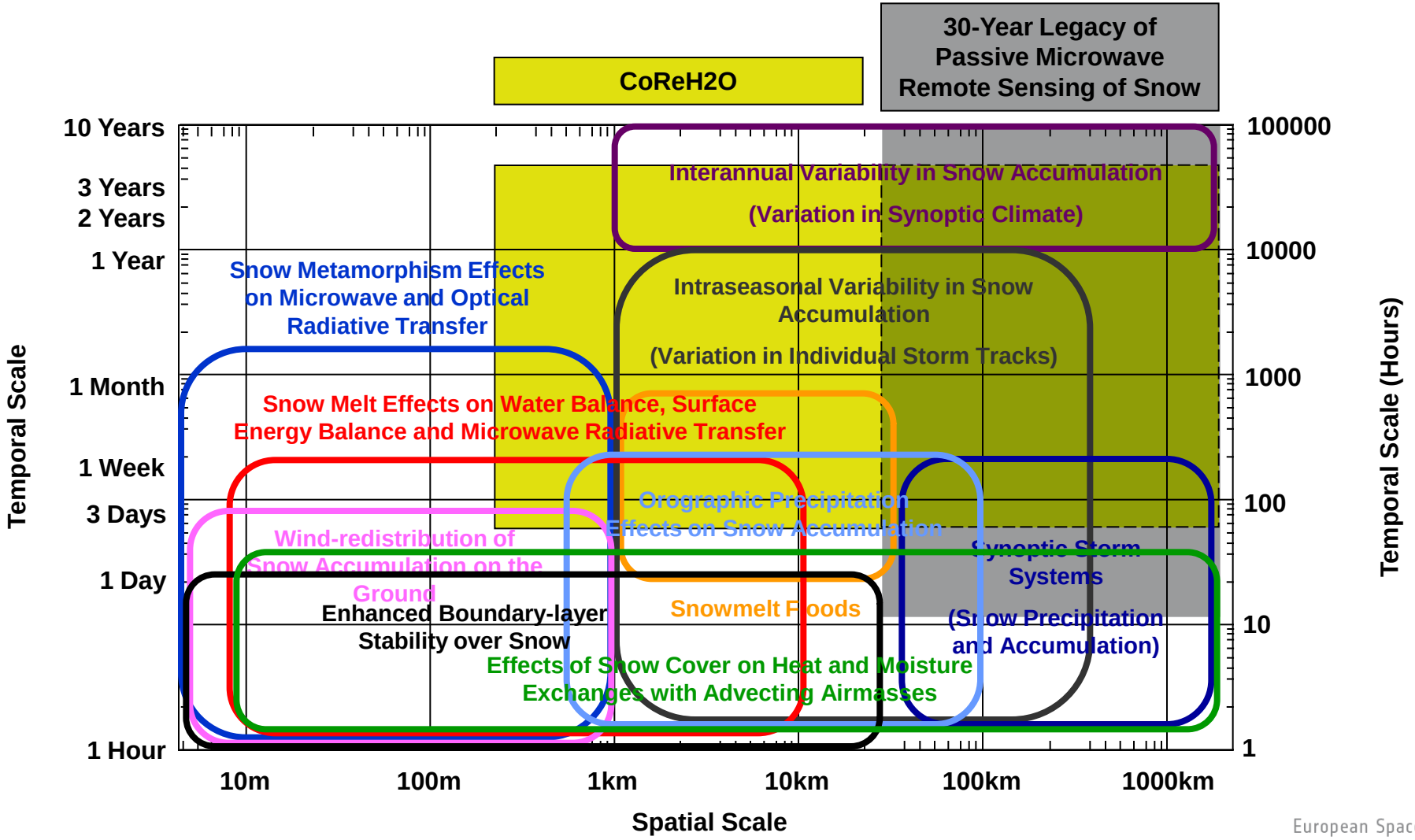
spatial resolution: 1 km
thematic accuracy: <5% error (binary)
temporal frequency: <1 week



SWE with AMSR-E data

spatial resolution: 25 km
thematic accuracy: 40-200mm
temporal frequency: daily

Observation gaps to be filled....



Modified from Cline (2005)

CoReH2O observation requirements

Primary parameters	Spatial scale Regional/Global	Sampling (days)	Accuracy (rms)
Snow water equivalent	200 m / 500 m	3-15	3 cm for SWE ≤ 30 cm, 10% for SWE > 30 cm
Snow extent	100 m / 500 m	3-15	5% area at hillslope scale
Snow accumulation on glaciers	200 m / 500 m	≤ 15	10% of maximum

Secondary parameters

Snow

Melting snow area, snow depth

Glaciers

Diagenetic facies types, glacial lakes

Lake and river ice

Ice area; freeze up and melt onset

Sea ice

Snow on ice (SWE, melt onset and area); type and thickness of thin ice

Measurement principle: radar backscatter

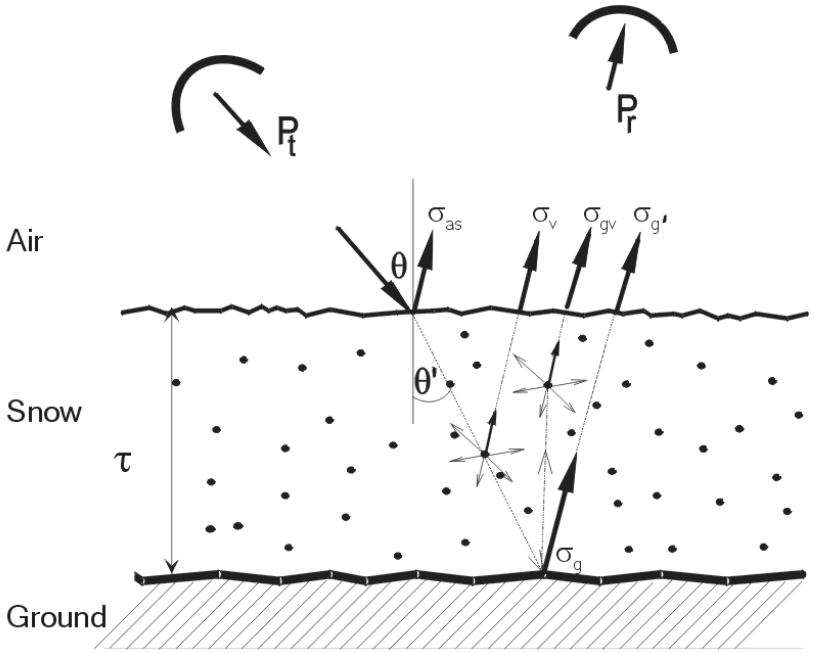
Main parameters relevant for snow backscatter:

Snow water equivalent

Grain size

Soil background signal

Liquid water content (if melting)



Backscatter contributions:

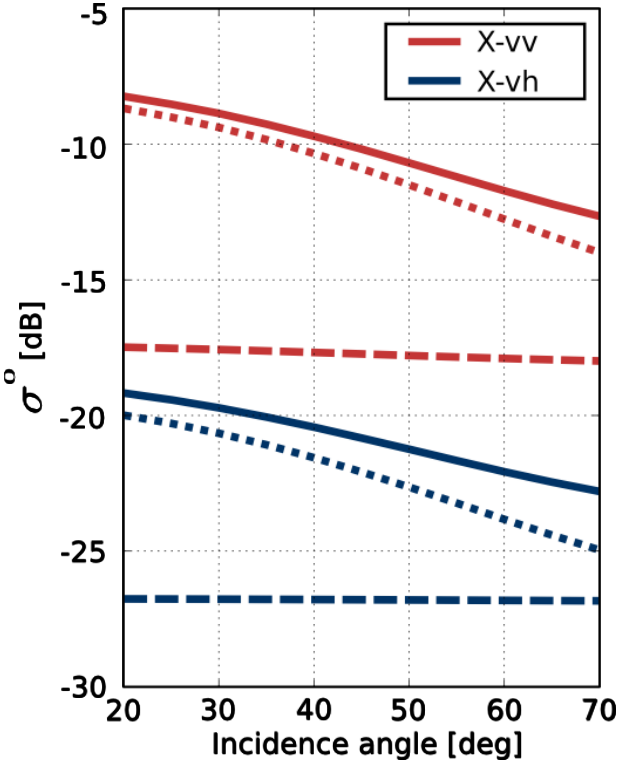
Volume, surface, and interaction terms

$$\sigma^0 = \sigma^{as} + \sigma^{v} + \sigma^{gv} + \sigma^{g'}$$

Dual-frequency, dual-polarisation backscatter

To separate **snow volume and soil signals**, in order to retrieve SWE over a wide range of snow depths

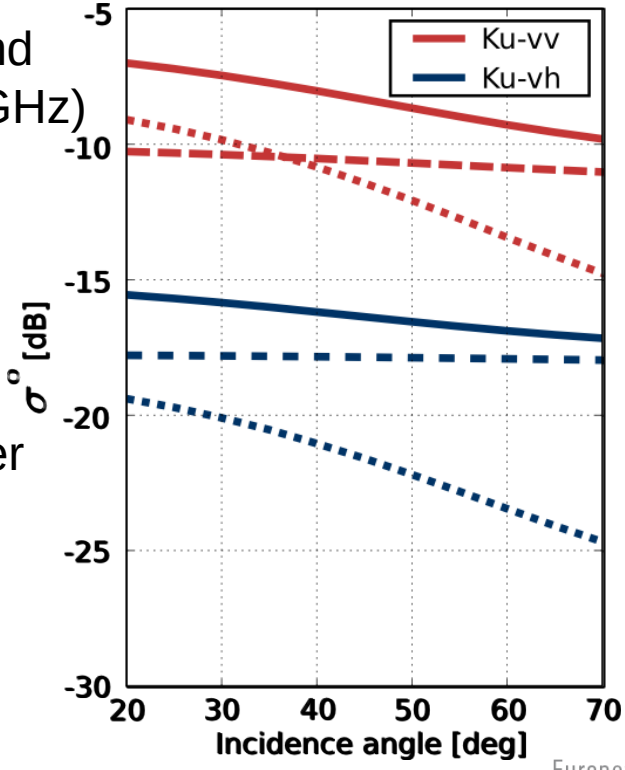
To compensate for **grain size effects**



X-band
(9.6 GHz)

total backscatter
snow volume
soil surface

Ku-band
(17.2 GHz)



Model calculations for
SWE = 150 mm

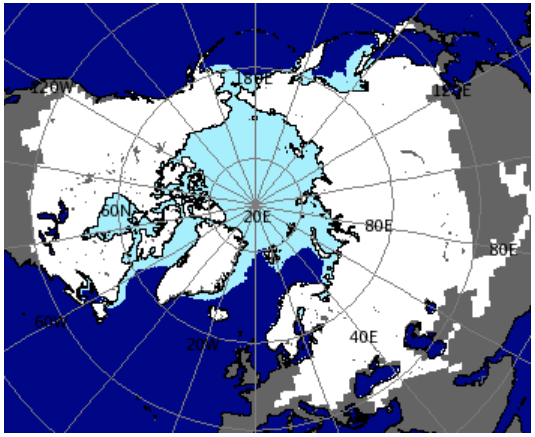
2 Mission phases

Phase 1 (year 1 and 2): 3-day revisit

To advance the parameterization of snow and ice processes in mesoscale atmospheric models, hydrological models, and land surface process models
To support the validation of data products and testing of process models at selected study sites

Phase 2 (year 3+): 15-day revisit

To support development and validation of snow cover parameterizations in global circulation models, and continental scale hydrological models
To improve downscaling of the cryosphere components in climate models



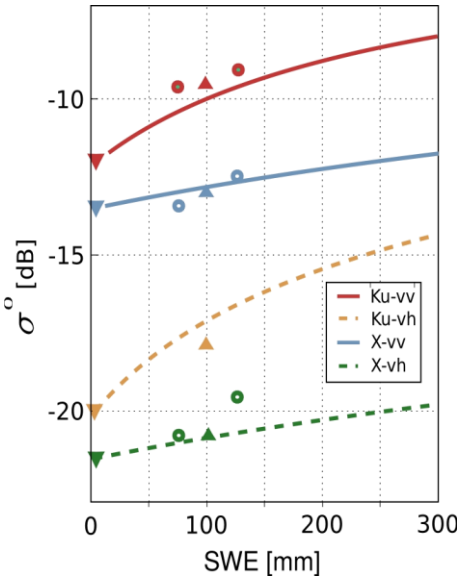
Mission requirements

Mission duration	4 years minimum, target 5 years
Orbit	dawn/dusk, near polar
Sensor	SAR, Ku-band and X-band, VV and VH polarization
Incidence angle and swath	30 – 45 deg (range) with swath ≥ 100 km
Noise equivalent sigma0	X-Band: ≤ -23 dB for VV; ≤ -28 dB for VH Ku-Band: ≤ -20 dB for VV; ≤ -25 dB for VH
Total ambiguity ratio	≤ -20 dB
Spatial resolution	≤ 50 m x 50 m (≥ 5 looks)
Radiometric stability	≤ 0.5 dB
Absolute radiometric bias	≤ 1.0 dB

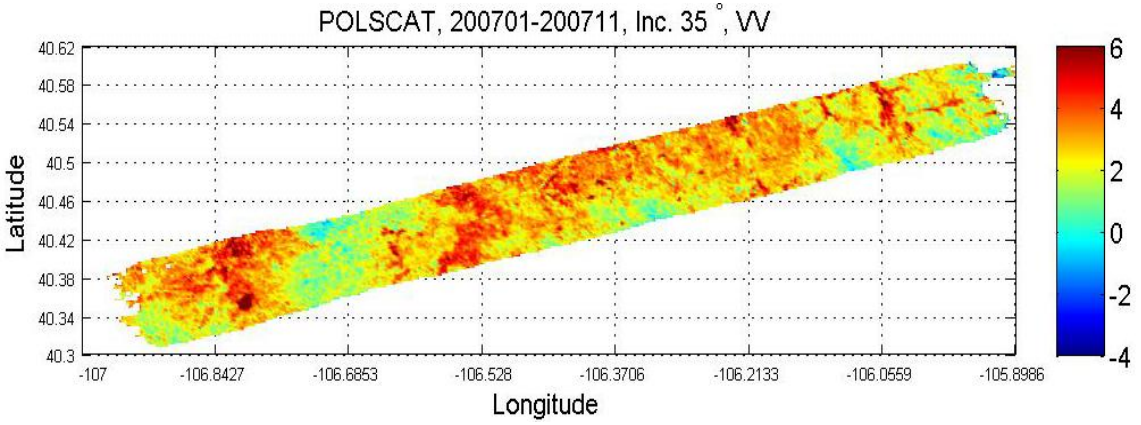
Recent campaign results

Backscatter sensitivity to SWE for different snow conditions demonstrated

HeliSnow ▲ SARAlps

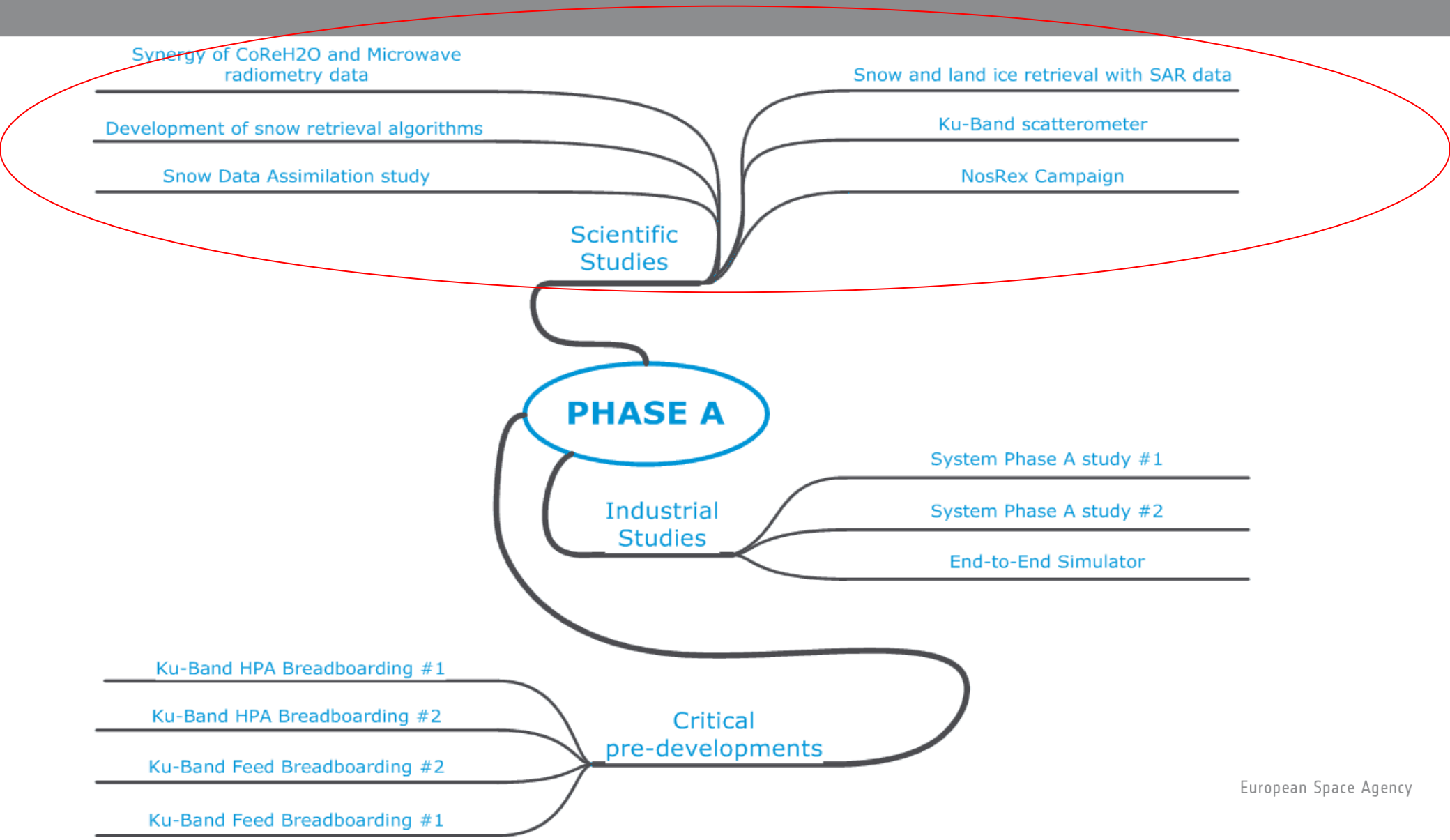


Campaign data are the basis for validation of theoretical backscatter models and development of retrieval algorithms



POLSCAT/CLPX-II Colorado and Alaska

PHASE A ACTIVITIES



Ongoing scientific activities and campaigns

Development of snow retrieval algorithms for CoReH2O

To develop a consolidated and tested processing line for the retrieval of the primary geophysical parameters from the CoReH2O mission, from Level 1b products up to Level 2 products

Synergy of CoReH2O SAR and microwave radiometry data to retrieve snow and ice parameters

To analyse potential synergy of CoReH2O SAR and microwave radiometry data to retrieve snow and ice parameters and to derive methods and strategies to combine the data and improve the retrieval

CoReH2O snow data assimilation study (COSDAS)

To build a modular sequential SWE analysis system that operates in single column mode
To quantify the impact of remotely sensed SWE estimates on the accuracy of the analysis and the subsequent model forecast.

NOSREX campaign

To collect, process and analyse scatterometer data at X- and Ku-bands and together with ground measurements co-incident in time and space to the scatterometer acquisitions