# ESA and Snow

## European Satellite Snow Monitoring Perspectives

## Joint EUMETSAT-ESA Workshop, EUMETSAT, 4-5 Dec 2012

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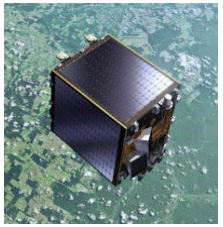
# ESA Satellites for Snow

- ERS-1, ERS-2, Envisat (1991-2012)

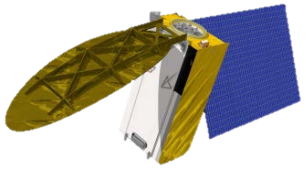


- ProbaV (2013)

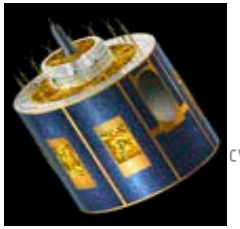


- Sentinels-1, 2, 3 (2013+)
  - developed by ESA for EC-GMES

- Candidate Earth Explorer - CoReH$_2$O (2019?)



- Meteosat and MetOp
  – developed by ESA for Eumetsat



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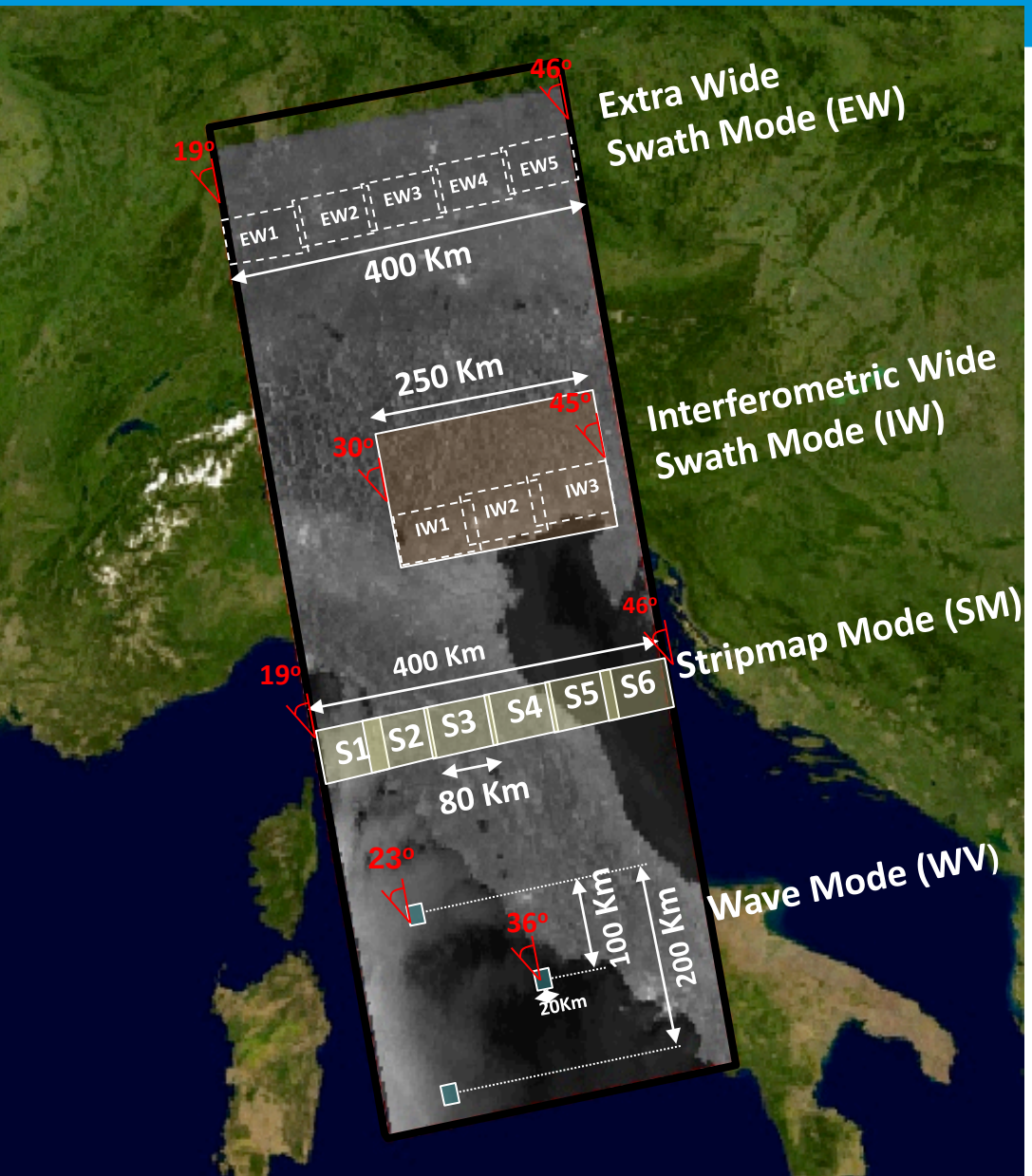
# GMES Sentinel-1

- Launch: Oct 2013, ....
- Constellation of two satellites
- C-Band Synthetic Aperture Radar
- Nominal lifetime in orbit of 7 years (max. 12 yrs)
- Sees through cloud cover!

"GMES Sentinel-1 Mission", R. Torres *et al.*, RSE, 120 (2012) 9-24
doi:10.1016/j.rse.2011.05.028

# Sentinel-1 acquisition modes



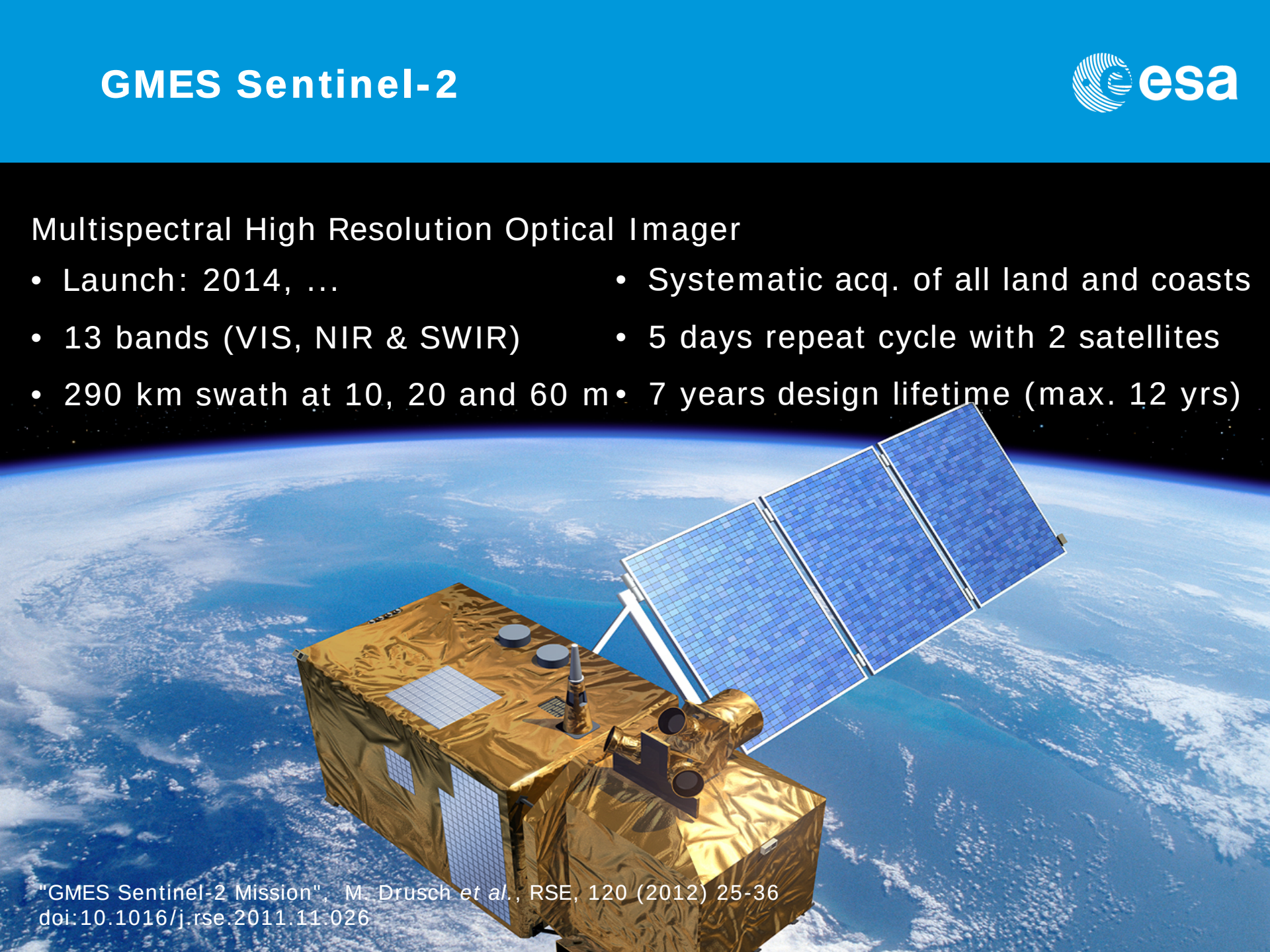

1. S-1 can be operated in 4 exclusive acquisition modes
2. High Bit Rate Modes:
    a. Stripmap (SM)
    b. Interferometric Wide Swath (IW)
    c. Extra Wide Swath (EW)

    *IW and EW are operated under the TOPS acquisition mode*
3. Low bit Rate Mode
    a. Wave Mode (WV)
4. HBR are single or dual polarisation, LBR is single polarisation only

# GMES Sentinel-2

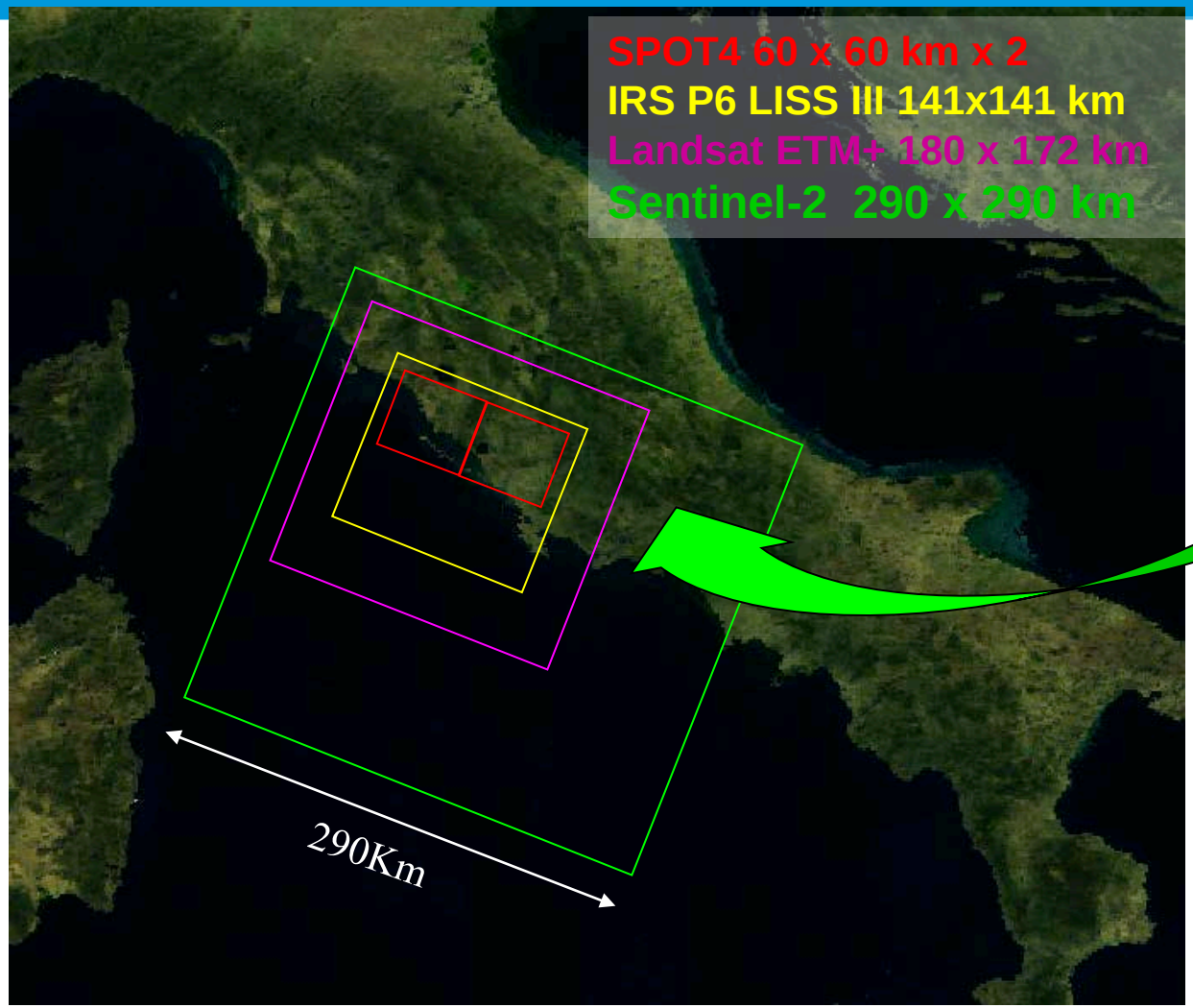
Multispectral High Resolution Optical Imager

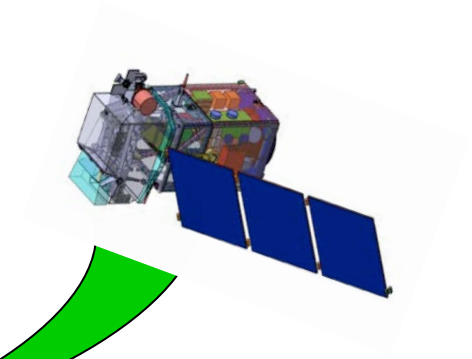
- Launch: 2014, ...
- 13 bands (VIS, NIR & SWIR)
- 290 km swath at 10, 20 and 60 m
- Systematic acq. of all land and coasts
- 5 days repeat cycle with 2 satellites
- 7 years design lifetime (max. 12 yrs)



"GMES Sentinel-2 Mission", M. Drusch *et al.*, RSE, 120 (2012) 25-36
doi:10.1016/j.rse.2011.11.026

# Sentinel-2: Image Size

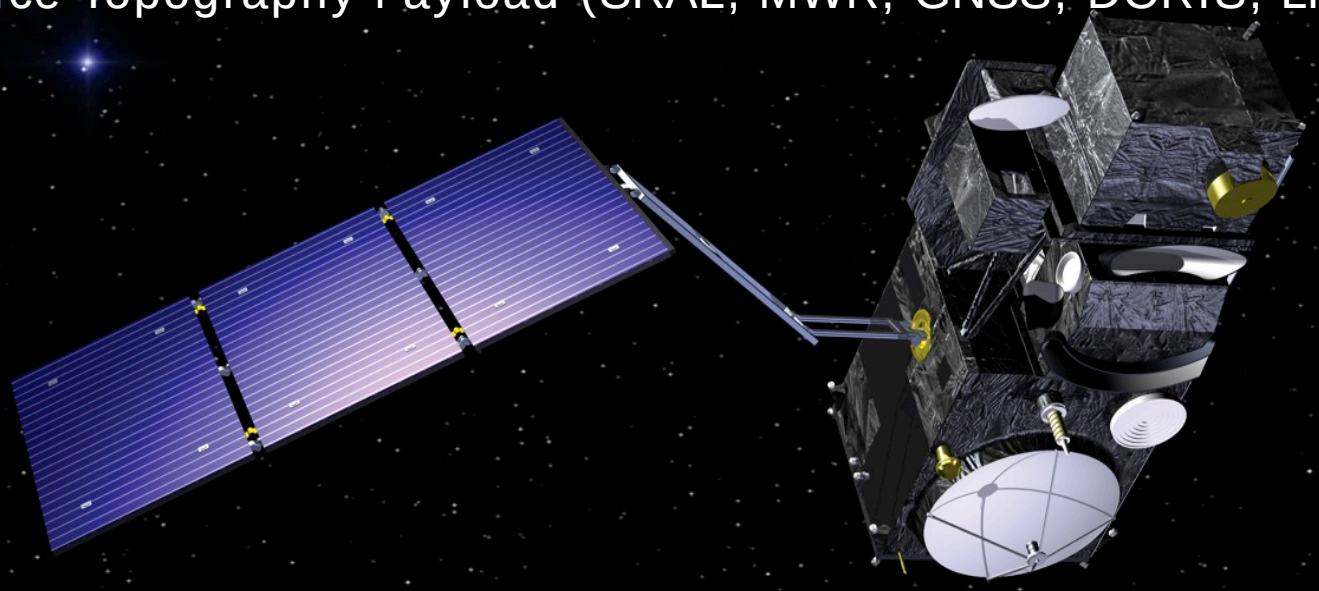


High revisit time → assured by twin satellite observations performed over a very large swath

# GMES Sentinel-3

1. Ocean and Land Colour Instrument (OLCI) – an improved MERIS
2. Sea and Land Surface Temperature Radiometer (SLSTR) – an improved ATSR
3. Sea & Ice Topography Payload (SRAL, MWR, GNSS, DORIS, LRR)

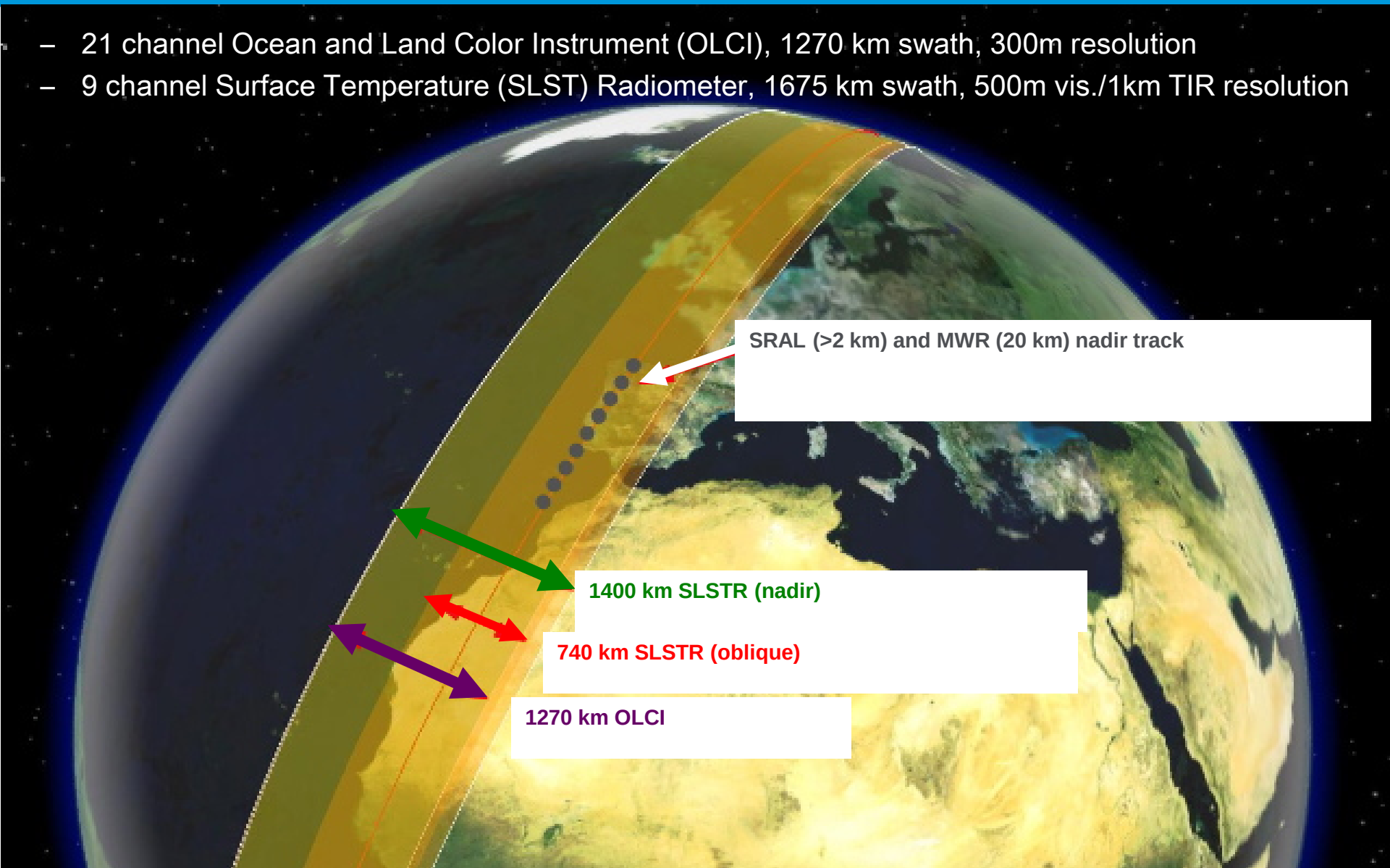


- Launch: 2014, ...
- Revisit at equator = 2 days (or daily with 2 satellites)
- 7 year lifetime (max. 12 yrs)

"GMES Sentinel-3 Mission", C. Donlon *et al.*, RSE, 120 (2012) 37-57, doi:10.1016/j.rse.2011.07.024

# GMES Sentinel-3

- 21 channel Ocean and Land Color Instrument (OLCI), 1270 km swath, 300m resolution
- 9 channel Surface Temperature (SLST) Radiometer, 1675 km swath, 500m vis./1km TIR resolution



# Proba V

proba VEGETATION

Continuation of SPOT-VEGETATION

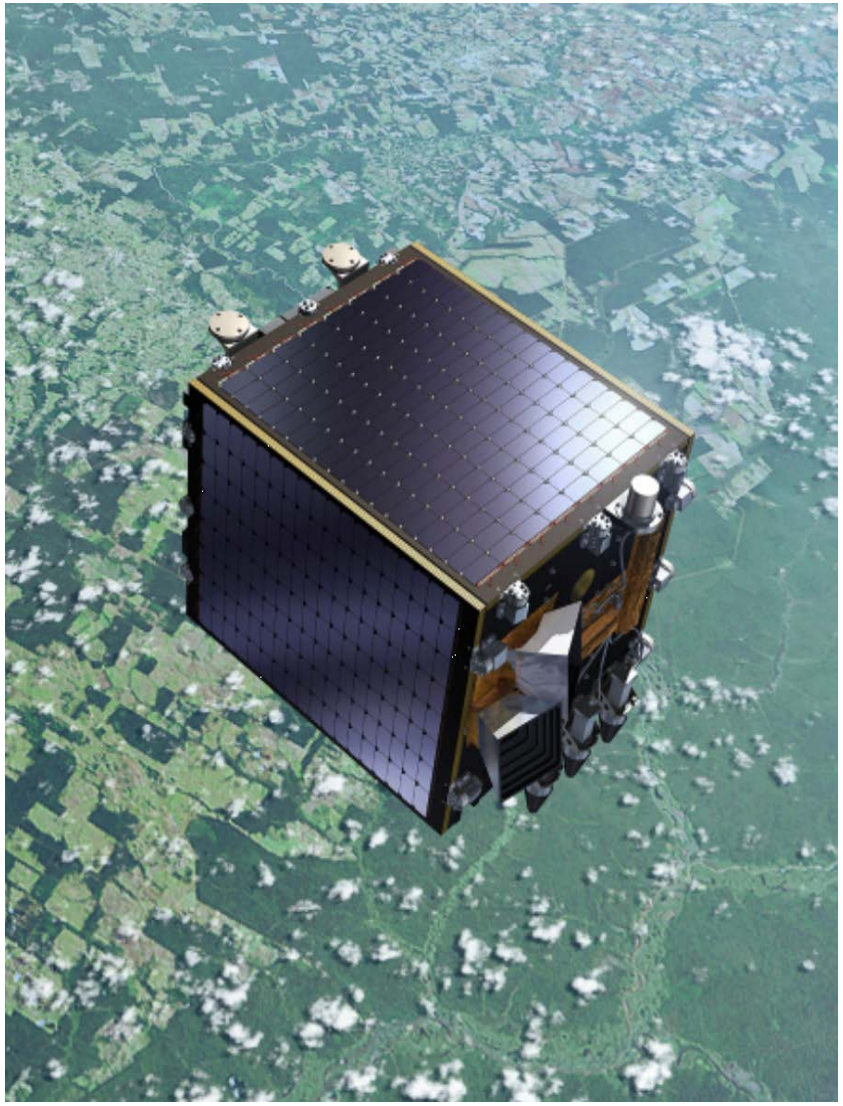
Same visible, NIR, SWIR bands

Global daily coverage (almost)

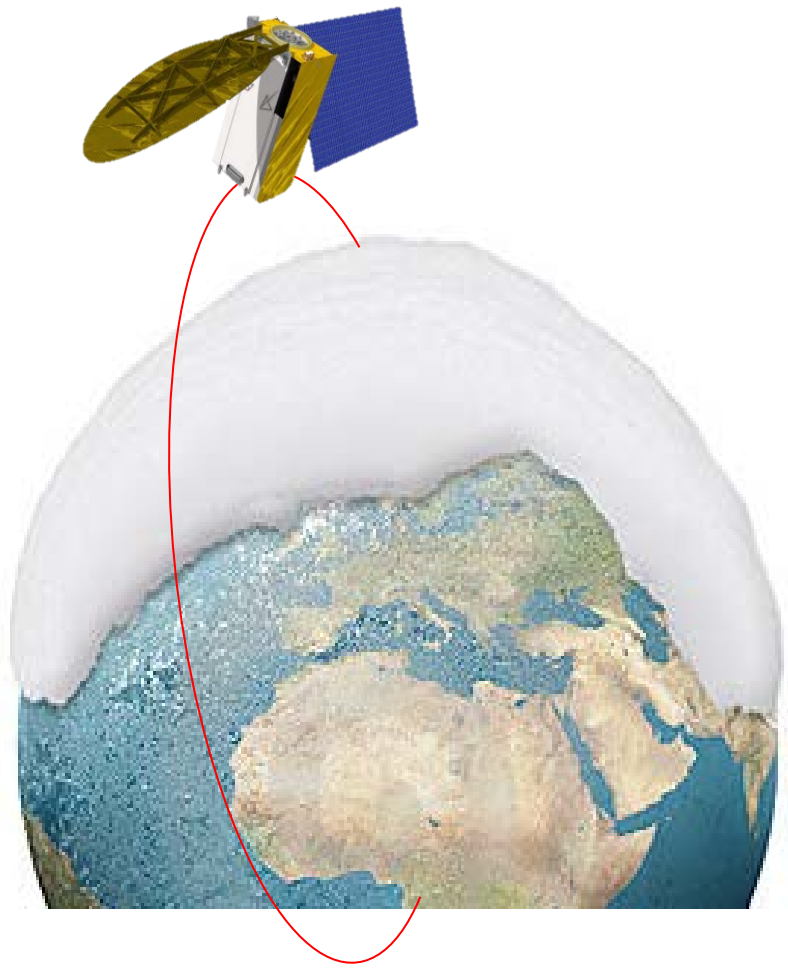
1km and 333 m resolution

Launch: March 2013

Operator: Vito (B)



# Earth Explorer Candidate - CoReH$_2$O



Measures water volume stored in snowpacks at high spatial and temporal resolutions – Main retrieved parameters are:
SWE and grain size.

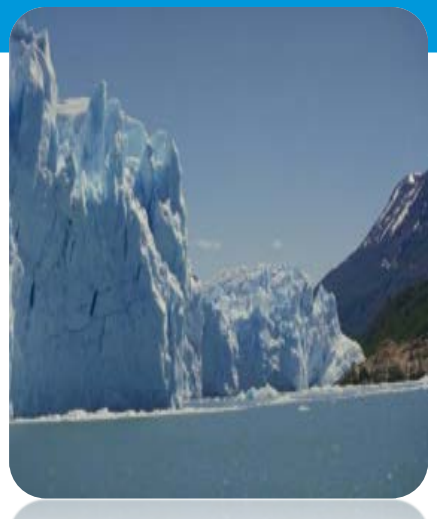
Applications in climate research and hydrology

Dual-polarisation (VV, VH), dual-frequency (X-band, Ku-band) Synthetic Aperture Radar

Mission selection against two other candidates will follow Earth Explorer User Consultation, 5-6 March 2013, Graz, Austria

These slides from Michael Kern (CoReH$_2$O ESA Mission Scientist)

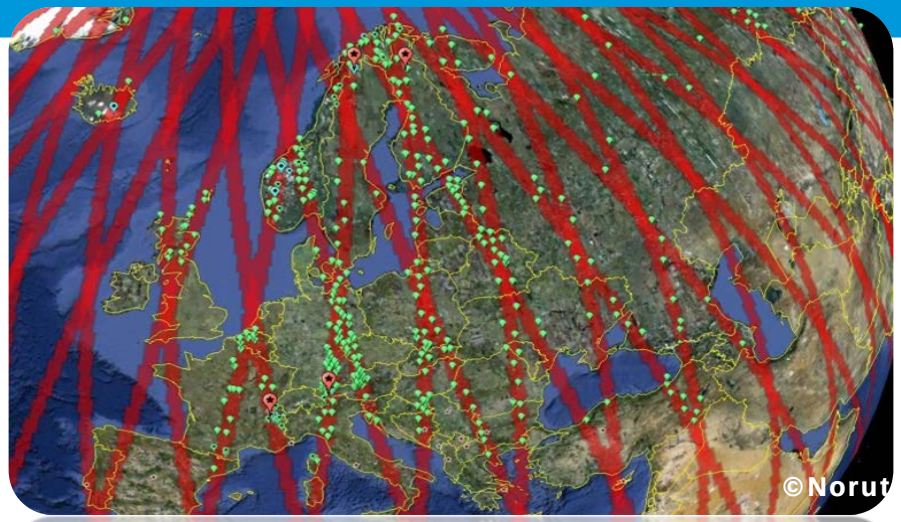
# CoReH$_2$O

| | Snow water equivalent | Snow extent | Snow accumulation over glaciers |
|---|---|---|---|
| sampling | 200m/500m | 200m/500m | 200m/500m |
| accuracy (RMS) | 3 cm for SWE $\leq$ 30 cm<br>10% for SWE > 30 cm | 5% of area | 10% of maximum |

... and many more parameters including key sea ice, lake ice and river ice parameters

# CoReH$_2$O

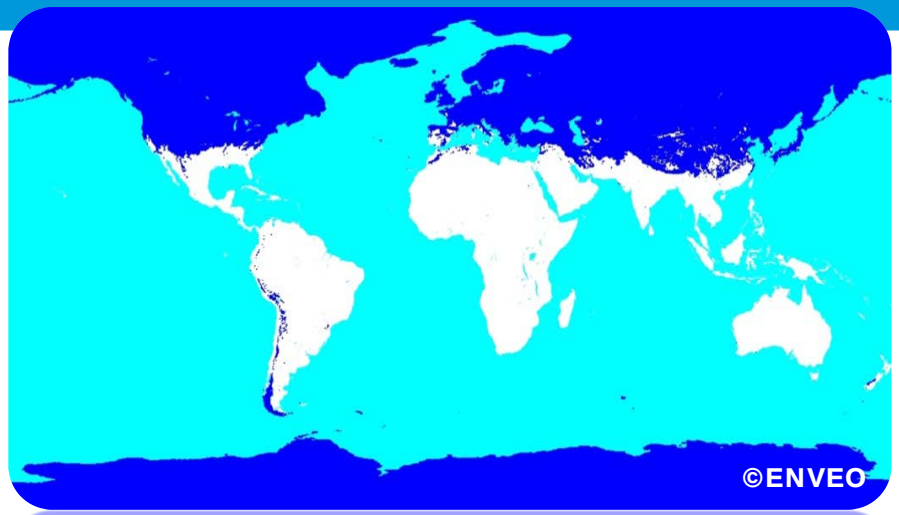



## Phase 1

3 day revisit in year 1 and 2

Advance parameterization in models

Testing at selected study sites




## Phase 2

15 day revisit in year 3+

Almost global coverage of snow and ice areas

Development and validation of snow cover parameterizations in global circulation models and hydrological models

Downscaling of cryosphere components in climate models

# CoReH$_2$O - Science Activities

1. Science support studies

   a. Development of snow retrieval algorithms for CoReH2O

   b. Synergy of CoReH2O SAR and microwave radiometry data to retrieval snow and ice parameters

   c. Algorithms for snow and land ice retrieval using SAR data (X, Ku & S1 C-band)

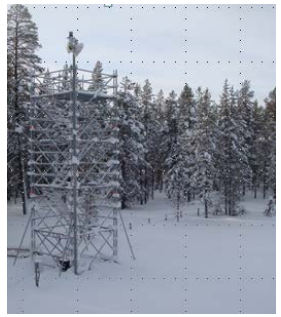
   d. Development of sea ice and lake and river retrieval algorithms for CoReH2O (SILIRIS)

2. Campaigns

   a. NoSREx-III (winters 2011/2012)

   b. NoSREX-IV campaign (winter 2012/2013)

   c. AlpSAR and Trail Valley Creek (TVC) SAR measurements (winter 2012/2013)



3. Mission Advisory Group

   a. 18 meetings held since Phase 0

   b. Report for selection published.

   c. Mission requirement document released in Nov 2010

# ESA Applications Development for Snow

- Support to Science Element (EOEP)
- Scientific Exploitation of Operational Missions (EOEP)
- Data User Element (EOEP)
- GMES Services Element (EarthWatch programme)
- Climate Change Initiative (EarthWatch programme)





snow radiance
support to science element

# STSE SnowRadiance

## SnowRadiance Study objectives:

Investigate the potential for snow parameter retrievals from current and future ESA passive imaging instruments operating in the UV and TIR spectral range, namely Envisat, Sentinel-2 and Sentinel-3.

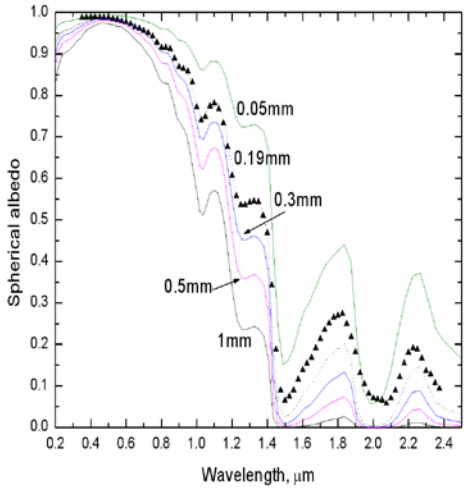
Develop the algorithm theoretical basis for retrievals.

Provide a toolbox for the scientific user community.

## Conclusions

- The most sensitive channels for the soot retrieval: 412-443nm of MERIS.
- The most sensitive channels for the grain size retrieval 865-1240nm,
- depending on the grain size

- The soot concentration can be retrieved from space only for rather high levels of pollution (above 300ng/g or so) and also only for a clear atmosphere case (from the measurements in the blue spectral region, where soot leads to the considerable snow darkening).




Acknowlegdement: IFE, U. Bremen

# Data User Element - GlobSeries

# DUE GlobSnow-2

www.globsnow.info

**Budget:** 750 k€ (STRIN)

**Duration:** 24 months

**KO:** May 2012

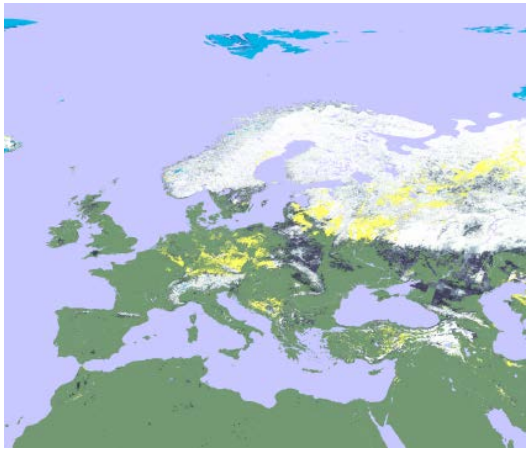
**Objectives:**

1. Provide global long term records of satellite-retrieved snow information for climate research.
2. Fully qualify the near-real time component for operational conditions in cooperation with EUMETSAT Hydrology-SAF
3. Upgrade the GlobSnow system to be ready for operational exploitation of Sentinel-3 data in 2013.

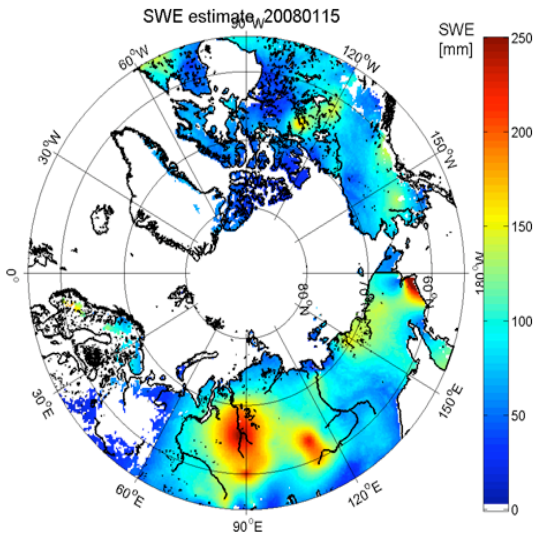
**GlobSnow-2 Consortium:**

FMI (FI), ENVEO (A), ZAMG (A), NR (N), GAMMA (CH), SYKE (FI), MeteoSwiss (CH), U. Bern (CH)
[+ GISAT (CZ)]

Snow Extent



Snow Water Equivalent





Polar View

A unique view of the environment, the economy, and safety

- GMES Service Element (GSE) 2005 - 2012
- offers integrated monitoring and forecasting services in the Polar Regions and parts of the mid-latitudes with significant snow and ice cover using satellite Earth Observation data.
- Services address operational users and science needs

## Services of Polar View

Sea Ice Monitoring

Iceberg Monitoring

Ice Edge Monitoring

Glacier Monitoring

River Ice Monitoring

Lake Ice Monitoring

## Snow Cover Monitoring

- Polar View's snow services provide the latest information on snow cover and the amount of water stored as snow.
- Service providers supply daily information to involved users working in the fields of early warning detection, climate change analysis, consulting and renewable resources.

esa

Vista

SYKE

KONGSBERG

# ESA & Snow

## Summary

- ESA develops, launches and operates satellite missions that support users' requirements for snow monitoring, since 1991.
- Future missions currently in development include instruments to continue and improve on snow monitoring capabilities of ERS/Envisat (i.e. Sentinels), as well as a candidate dedicated snow EarthExplorer mission (i.e. CoReH2O)
- Snow monitoring applications are developed under several ESA programmes focussed on basic EO science, transfer of research to user driven applications, and operational GMES service development. Future plans include a small new programme focussed on the scientific exploitation of operational mission data (SEOM).
- ADVERT:
  ESA Living Planet Symposium,
  Edinburgh, Scotland, 9-13 Sep 2013.