International Ocean Colour Science Meeting 2013

CNES OCEAN PROGRAMS

Juliette Lambin and Bertrand Fougnie

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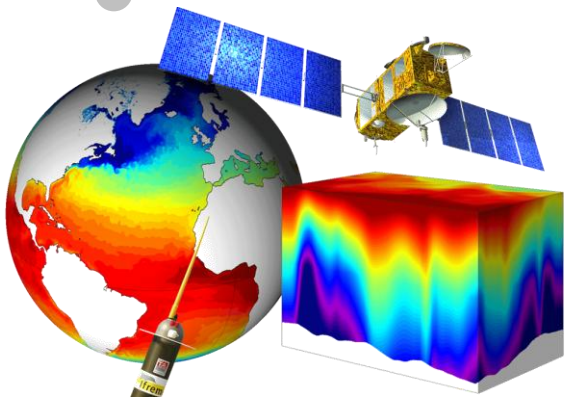
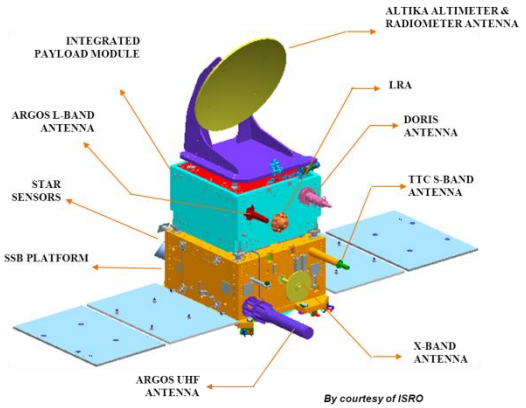
Darmstatd, Germany

OUTLINE

- CNES OCEAN PROGRAMS OUTLOOK
- OCEAN COLOR MISSIONS
- OCEAN COLOR DEVELOPMENTS

CNES INVOLVEMENT IN OCEAN OBSERVATION





Ocean sciences are one of the major interests of CNES Earth observation programs

Supporting (and supported by) a strong scientific community through dedicated research funding

Supporting several larger scope projects and initiatives (e.g. Mercator-Ocean, CORIOLIS and bioArgo, Boussole, GIS COOC…)

Strong support to R&D (Instrument, mission concepts, data processing…)

In terms of satellites missions, the heavy weight is still on physical ocean observation

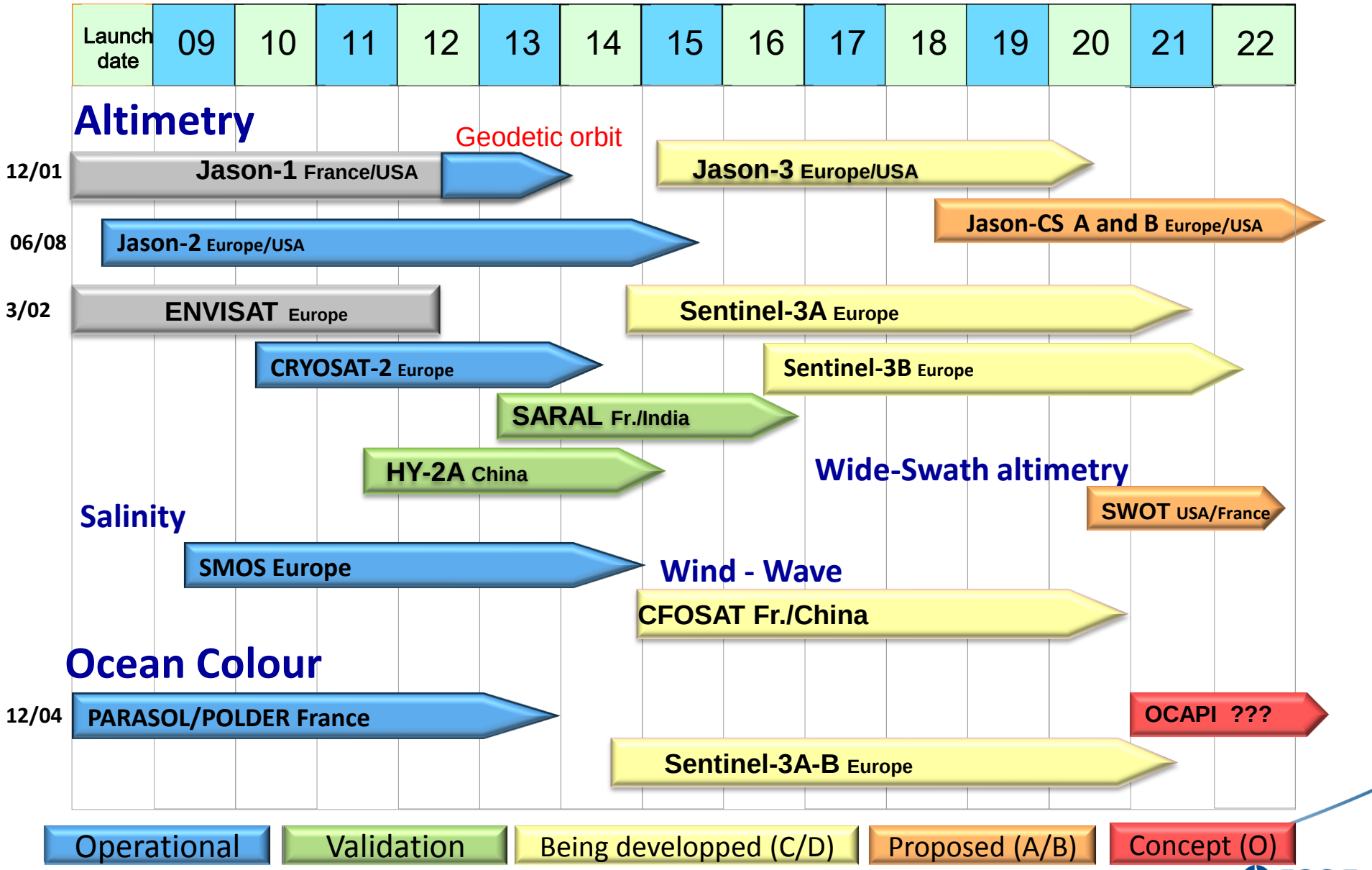
altimetry (Jason-1/2/3/CS, SARAL/AltiKa, SWOT, Sentinel-3, Hy-2A,)

salinity (SMOS)

wind/waves (CFOSAT),

ocean color: PARASOL, Sentinel-3, “GEOCAPI”

Ocean missions @ CNES (various levels of contributions)

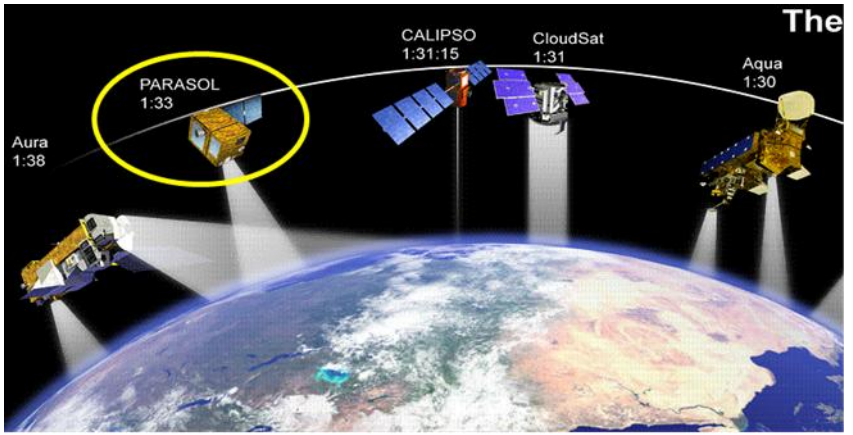


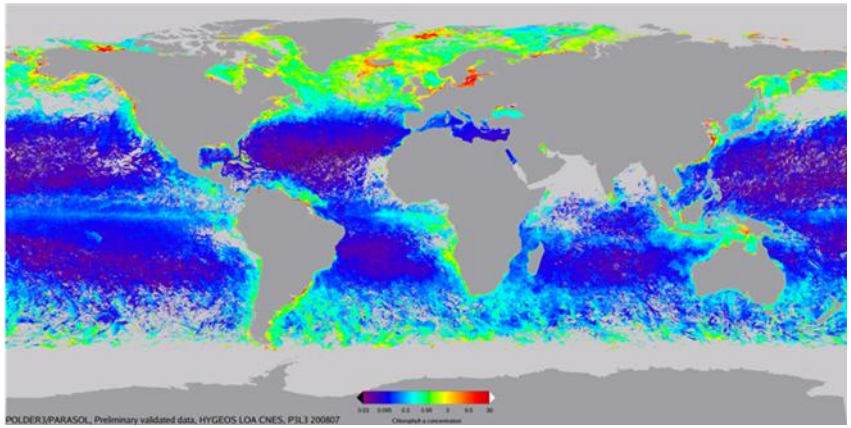
PARASOL STATUS

Main objective is to monitor clouds and aerosols… with an ocean color observing capability (and polarimetry)

- in the A-Train from Dec 04 to Dec 09, then moved to a lower orbit (collision risks avoidance)
- « mission extension review » held successfully in 2011 => mission extended up to 2013
- Level 1b through ICARE thematic center (atmosphere)

- Some OC level-2 products are generated by CNES, but distribution is on request: any request to have them more widely available is welcome!





CNES ACTIVITIES IN THE FRAME OF SENTINEL-3

There is some strong French involvement in GMES Ocean component at all levels

On Space component

- Cooperation with ESA on Sentinel-3 development: system support for the altimetry mission payoad and ground system
- CNES in-kind contribution: DORIS, orbitography processing, part of ground segment prototyping

On Core Services

- Support to Mercator-Ocean (leader of MyOcean/MyOcean-2)
- In-kind contributions and upstream R&D support

On “Collaborative Ground Segment”

- Structuration of a Marine Collaborative Ground Segment => institutional and private funding of prototyping activities
- Balance between ocean color, altimetry, and sea state

Science support (TOSCA program, S3VT)

STATUS ON GEO-OCAPI PHASE 0 STUDY

⇒ OCAPI « Ocean Color Advanced Permanent Imager »

Recommended by the science prospective seminar (Biarritz 2009)

⇒ Decision to start a “phase 0” study at CNES PASO

Quite long « phase 0 » study at CNES (~2 years), but we are getting close to the end

« Key point 2 » end of Feb’13: concludes the phase 0 study (assesment of the different scenarii)

Mission Definition Review planned for April: prepare transition to phase A (selection of the baseline scenario)

Phase A not funded yet, but 1st on the waiting list: could start in 2014

A new round of « science prospective » exercice on-going at CNES, and OCAPI is still a high priority for ocean community: keep pushing for it…

International cooperation needed: CNES is unlikely to do it alone

GEO-OCAPI : MISSION REQUIREMENTS (1/3)

Band	λ (nm)	△λ (nm)	L_{min}	L_{ref}	L_{max}	$L_{max,\ ocean}$	SNR at 250 m[1] & L_{ref}	Use
			W m^{-2} sr^{-1} μm^{-1}					
1	395	10	12	65	580	180	400	Chl-CDOM separation
2	412	20	12	70	550	190	400	CDOM, possibly atmospheric correction above "black waters"
3	442	20	12	65	650	185	400	Chlorophyll, TSM, CDOM
4	470	20	11	60	650	175	400	Specific anomalies of the reflectance spectrum
5	490	20	10	50	665	165	400	Chlorophyll, TSM, CDOM, diffuse attenuation coefficient, Secchi transparency
6	510	20	8	45	620	155	400	Chlorophyll, TSM, CDOM, detection of blue-absorbing dust-like aerosols
7	560	20	6	30	580	132	300	Chlorophyll, TSM, turbidity index, Secchi transparency
8	590	20	5	25	550	120	300	Spectral slope b_{bp}, maximum R in Case-2 waters
9	620	20	4	20	550	95	300	Chlorophyll, TSM
10	660	20	3	15	500	86	300	Chlorophyll, TSM, Chl fluorescence (baseline)
11	681	7.5	3	15	500	82	200	Chl fluorescence (peak)
12	709	10	3	13	450	75	200	Chlorophyll, TSM, Secchi transparency, Chl fluorescence (baseline)
13	750	15	3	11	450	65	150	Atmospheric corrections
14	754	7.5	2	10	400	65	150	Reference for O_2 A-band
15	761	2.5	2	6	400	63	30	O_2 A-Band (aerosol scale height, clouds)
16	779	15	2	9	380	60	150	Atmospheric corrections
17	865	35	1	6	300	45	150	Atmospheric corrections
18	1020	40	1	4	220	45	150	Atmospheric corrections (turbid waters), cirrus clouds

-From 395 to 740 nm thematic needs

-From 750 to1040 nm atmospheric corrections

⇒16 spectral bands minimum.

⇒SNR (*) < 400

⇒ Spectral resolution from 10 to 40 nm *(depending of the spectral domain and uses)*

(*) SNR = Signal-to-Noise Ratio

GEO-OCAPI : MISSION REQUIREMENTS (2/3)

Ground Spatial Resolution (GSR) - 3 classes of needs are identified for the VNIR domain (0.4 – 1.1 μm) :

- Threshold: 500 meters and larger for Open Ocean (Case-1 waters)
- Goal: 100 meter for Coast and inland observation (Case-2 waters)
- Breakthrought: 250 meters as well Case-1 than Case -2 waters

Coverage :

- Global disk
- Coastal area should be the goal at the better resolution

Satellite's revisit frequency is the main design driver

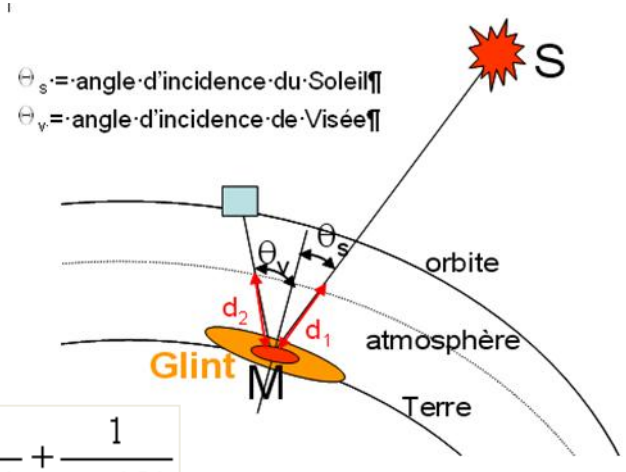
- from ½ to 1 hour (diurnal)
- A daily mosaïc is required after clouds and glitter correction

GEO-OCAPI : MISSION REQUIREMENTS (3/3)

Two main challenges:

IMAGE QUALITY, an image is considered exploitable if:

- Solar zenithal angle (θs) < 80 deg
- Incidence angle (θv) < 60 deg
- Glint < 0.0005 (assuming a wind speed of 7 m/s)
- Air mass fraction (*f*) < 4



$$f = \frac{d_1 + d_2}{d_{atmos}} = \frac{1}{\cos(\theta_s)} + \frac{1}{\cos(\theta_v)}$$

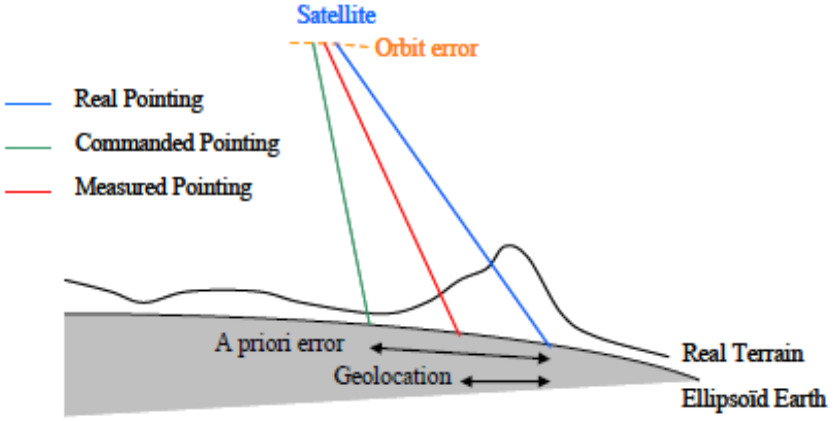


Illustration of geolocation and a priori pointing criteria

RADIOMETRY AND GEOMETRY QUALITY, depends also on platform stabilty

- The a priori pointing error < 5% of the field of view
- The geolocation error -> ½ pixel

MAIN TRADE OFF FOR GEOOCAPI : RESOLUTION VS REVISIT

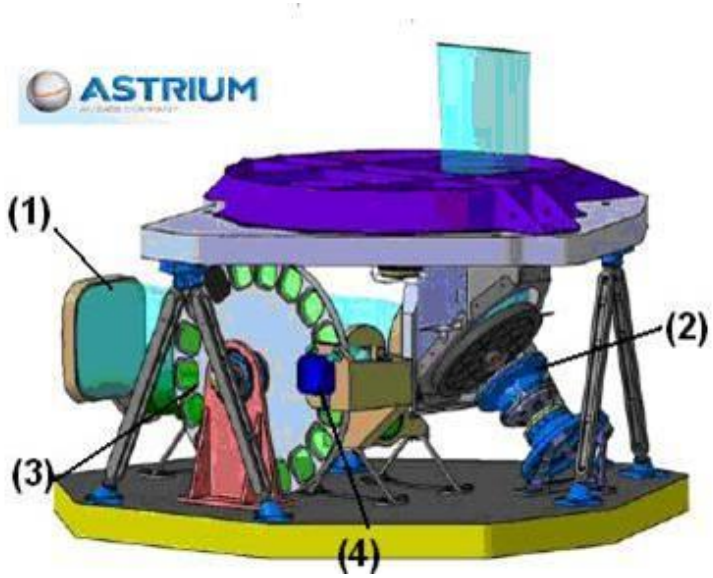
- "Breakthrought" scenario: GeoOCAPI 250
  - The main challenge for this mission was to design a satellite able to cover all the disk, every hours, at 250m of resolution with 16 narrow bands on a mini satellite (500 kg -> 1 ton class)
  - Preliminary studies lead by CNES with industrial support show that this challenge can be taken to space before 2021.

- "Goal" scenario: GeoOCAPI 100
  - The challenge for this mission is to design a very high-resolution (100 m class) superspectral (16 bands) system, able to cover all the Atlantic + Mediterranean coasts every ½ or 1 hour.
  - Specifications are more difficult to reach and may require additional analysis to definitively demonstrate the feasibility of the concept

⇒ Feasibility and Cost studies favour the GeoOCAPI 250 design

cnes

GEOOCAPI: STRONG HERITAGE FROM GOCI BUT > 2 TIMES MORE PERFORMANT



(1) TMA telescope (Three-Mirror Anastigmat)
(2) 2-axes pointing mecanism (pointing mirror)
(3) Filter Wheel (16 filters+1 black)
(4) Focal plane: 2D CMOS new detector

- Pupil diameter: 160 mm
- Dimensions : 1,2m*1m*1m
- Mass: 140kg
- Power: 300W
- Data rate ~100 Mbps per day

(<25 Mbps after compression)

- Ka band strongly recommended
- *(Operational congestion of X Band)*

Commits with all the performance requirements

	GeoOCAPI 250
Altitude	36000 km
Payload	TMA telescope Φ160 mm Detector VNIR CMOS 4000 x 356 pixels (to be developped)
Resolution/Swath	250 m / 1000*750 km
Spectral bandwidth	350 – 1050 nm / 10 to 40 nm
Nb of bands	16 2 (in option)
Heure locale	6H-18H
Payload budget	Mass 140 kg/Power 300 W (imaging),
Satellite budget	700 kg (dry ass) – 1100 kg (at launch)/ 1500W
Geolocalisation/ Co-registration	130m/ 2 pixels en 36s
Revisit period	1 Hour
Imaging capacity	~ 750 000km2 per image / 1200 images by day
Data rate	100 Mbps (25 Mbp after compression)
Link to Ground	Ka-band (with ground stations)
Launcher compatib.	Soyuz direct GEO
Expected lifetime	10 years (incl. end-of-life operations)

CONCLUSIONS

GeoOCAPI introduces the next Ocean Color generation with :

- high spatial resolution of 250 m, 16 spectral channel, a swath of 1000 km2 compatible with LEO data (MODIS, SENTINEL 3, …);
- thanks to his GEO position, the disk is revisit 1 time by hour and Near Real Time observation (NRT) is possible
- technological miniaturization which allows an innovative mini-satellite less than 700kg (dry, marged)
- lifetime is 10 years

The GeoOCAPI phase A should take place in CNES in 2014. Phases B/C/D/E1 (for 7 years) should be decided for a launch in 2020/2021.

This program is strongly depending on the development of critical technologies (like specific detectors) and international cooperation interest.