From COP 21 to COP 22, new challenges for space agencies on climate: greenhouse gases and water resources measurements from space

CNES
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Objectives of EO: Advanced Earth Sciences

Atmosphere and Climate Monitoring

Land areas

+ Interfaces, Carbon cycles, Water cycles...

Oceanography
Cryosphere

Solid Earth Geomagnetism
Objectives of EO: Inform decision (societal benefit)
Success stories

Some examples…
Numerical weather prediction
IASI and IASI-NG
(Infrared Atmospheric Sounding Interferometer)

Breakthroughs for meteorology and determining the composition of the atmosphere

A CNES/EUMETSAT programme

- An essential instrument in the payload of the 3 European polar-orbiting meteorological satellites, MetOp (A & B) and MetOp-SG, due to its Fourier transform interferometer.

- Has resulted in improved 6-day weather forecasts. Provides air-pollution alerts 1 or 2 days in advance.


- The three IASI-NG models are under development.

Launch of the third IASI model in 2018 and of the first IASI-NG model in 2021
Seasonal variations El Niño/La Niña using altimetry data

Monthly averages maps (in cm) on Novembers each year since 1993, over the Equatorial Pacific from the El Niño Bulletin. The time series of the standardized Sea Level Anomalies is also displayed and updated on the Indicator page. Credits CLS/CNES
Following on from operational meteorology, Jason 2 was able to demonstrate operational oceanography.

The programme is being continued with Jason 3, which shares many of Jason 2’s characteristics.

The follow-up to Jason 3 is already planned. This will be Jason CS (for "Continuity of Service"), the sixth Sentinel satellite of the Copernicus programme.
New challenges: climate
1) Greenhouse Gases observation from Space
<table>
<thead>
<tr>
<th>Domain</th>
<th>Essential Climate Variables</th>
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</table>
| **Atmospheric** (over land, sea and ice) | Surface: Air temperature, **Wind speed and direction**, Water vapour, Pressure, Precipitation, Surface radiation budget  
Upper-air: Temperature, **Wind speed and direction**, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance)  
Composition: **Carbon dioxide**, Methane, and other long-lived greenhouse gases, Ozone and Aerosol, supported by their precursors |
| **Oceanic**                | Surface: Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton  
Sub-surface: Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers |
| **Terrestrial**           | River discharge, Water use, Groundwater, **Lakes**, **Snow cover**, **Glaciers and ice caps**, Ice sheets, Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture |

The ECVs – satellite observations make a major contribution to the ECVs shown in bold
MICROCARB & MERLIN

MICROCARB: CO2 Passive measurement
- Accuracy < 1 ppm Bias < 0.1 ppm
- XCO2 spatial gradients are small (< 10 ppm)
- Error on measurement (regional bias) implies wrong flux computation
- To be launched in 2020

MERLIN: CH4 Active measurement
- Accuracy < 27 ppb Bias < 3.7 ppb
- DIAL Lidar at 1.67 µm
- Horizontal sampling accumulation: 50 km
- To be launched in 2021
Growing interest in CO$_2$ and CH$_4$ Observations from space

Japan:
- GOSAT (JAXA/NIES/MoE), launched in 2009.
- GOSAT-2 (JAXA/NIES/MoE), planned for 2018.

USA:
- OCO-2 (NASA), launched in 2014.
- OCO-3 (NASA), planned in or after 2018.
- GEOCARB (NASA), planned for ?
- ASCENDS (NASA), under study (2023+).

China:
- TanSat (CAS, MOST, CMA) launched in 2016.

Europe:
- MERLIN (CNES-DLR), planned for 2021.
- MICROCARB (CNES), planned for 2020.
- Sentinel 7 (ESA/UE), TBC, for 2025
2) Water cycle and fresh water resources from Space
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SWOT (Surface Water Ocean Topography Mission)

Monitoring the level of oceans and inland waters

- A joint CNES/NASA/UKSA/CSA/ project to map variations in the levels of inland and ocean waters.

- CNES is providing the platform and co-operating with NASA on the instruments, in particular the highly-innovative KaRIn wide-swath altimeter.

- CNES is also in charge of the satellite’s ground control segment and is developing (jointly with NASA) a mission ground segment for data processing. The French contribution is partly financed by the French future investments programme (PIA).

Launch scheduled for 2021
Going from large scale to smaller scale monitoring
New generation of altimetry measurements for oceanography

Example: Ocean dynamics in the Gulf of Mexico
- The colored map depicts the ocean circulation as it is monitored by current satellite altimetry
- Yellow lines shows the actual trajectory or surface drifters

From nadir to wide swath altimetry
SWOT Coverage Leap - *from local altimetry to topography*

SWOT mission will address challenges and shortcomings of conventional altimetry (e.g., spatial coverage and resolution) in both oceanographic and hydrologic applications and will enable a wide range of research opportunities in oceanography and land hydrology.
International cooperation

From COP 21 to COP 22

Marrakech Declaration – Water cycle and fresh water resources
Thank you for your attention!