A view of Atlantic Climate from the CCI Inventories

Paolo Cipollini, Pascal Lecomte, the ESA Climate Office and the CCI Project Teams

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CCI
Climate Change Initiative

ESA’s 165-MEuro R&D Programme (2010-2024) to exploit the full potential of Earth Observation in support of Climate Research and Assessment

Produces long time series of Essential Climate Variables (ECVs)
Mature and New ECVs in the CCI

- Aerosol
- GHG
- Ozone
- Sea ice
- Ice sheets
- Sea level
- Sea state
- Ocean colour
- Salinity
- Sea surface temperature
- Water vapour Cloud
- Soil moisture
- Land surface temperature
- HR Land cover
- Biomass
- Land cover
- Fire
- Glaciers
- Snow
- Permafrost
- Lakes
CCI achievements to date

- **178** Institutions
- **22** ECVs
- **13** ECVs transferred to Copernicus
- **450** European scientists
- **610** Peer-reviewed articles
- **122** terabytes
- **100+** datasets
- **2.6** million files
- **IPCC AR5**
  - 28 Contributing authors
  - 15 Papers, cited 60 times
Generating an ECV
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Some Examples
**Fig. 1:** ESA Cloud_cci AVHRR-PM v3.0 decadal low-level Cloud Fractional Cover (CFC\textsubscript{low}) trends. Monthly mean Level-3C data on a regular 0.5° x 0.5° grid used. The temporal range is 1995-2016. Unit is % CFC per decade. Dotted areas contain insignificant trends (p > 0.05).

**Fig. 2:** ESA Cloud_cci AVHRR-PM v3.0 decadal total (net) surface Cloud Radiative Forcing (CRF) trends. Net CRF calculated as SWCRF + LWCRF. Monthly mean Level-3C data on a regular 0.5° x 0.5° grid used. The temporal range is 1995-2016. Unit is Wm\textsuperscript{-2} per decade. Dotted areas contain insignificant trends (p > 0.05).

- **Low-level clouds** are increasing between 40°W and 30°W, and 20°N and 40°N, however only in the center of that region the trend exceed 95% significance level.

*Source: Cloud CCI, DWD*
Cloud Radiative Forcing components

**Fig. 4:** ESA Cloud_cci AVHRR-PM v3.0 decadal surface LW Cloud Radiative Forcing (CRF) trends. Monthly mean Level-3C data on a regular 0.5° x 0.5° grid used. The temporal range is 1995-2016. Unit is Wm⁻² per decade. Dotted areas contain insignificant trends (p > 0.05). Negative trends: Weakening heating effect (cooling).

**Fig. 5:** ESA Cloud_cci AVHRR-PM v3.0 decadal surface SW Cloud Radiative Forcing (CRF) trends. Monthly mean Level-3C data on a regular 0.5° x 0.5° grid used. The temporal range is 1995-2016. Unit is Wm⁻² per decade. Dotted areas contain insignificant trends (p > 0.05). Positive trends: Weakening cooling effect (heating).

*Source: Cloud CCI, DWD*
Air-sea CO$_2$ fluxes

Figure 2: June mean air-sea CO$_2$ flux (mol C m$^2$ yr$^{-1}$) in the North Atlantic from a) climatology of Takahashi et al. (2009), b) FOAM-HadOCC control, c) reanalysis assimilating GlobColour data, d) reanalysis assimilating OC-CCI data. Positive values represent a flux into the ocean. The reduction in spurious outgassing in the centre of the domain in c) and d) compared with b) is due to the assimilation reducing the chlorophyll bias in this area. An alternative version of this figure, not including OC-CCI data but mentioning the CCI project, has been published in Gehlen et al. (2015).

Source: CCI Climate Monitoring User Group
Trends in phytoplankton chl-a

Ocean Colour CCI: SeaWiFS+MERIS+MODIS-A+VIIRS

[10/1997-09/2015] (18 years)

only significant ($p<0.05$) trends are shown

Mélin et al., Remote Sens. Environ., 2017

Source: OC CCI, PML
Computation of Primary Production

CCI monthly 05/2011 $\log_{10}[\text{Chl}]$

ESA PAR Product

Source: OC CCI, PML
Improvement in feature resolution with SST CCI

OSTIA Re-analysis (Roberts-Jones et al., 2012).

SST CCI (Merchant et al., 2014)

Magnitude of horizontal SST gradients, mK/km

Source: Univ Reading
Sea Level Budget Closure CCI

Source: SLBC CCI, LEGOS
Coastal sea level trends along western Africa from retracked altimetry

J1+J2 SLA trends
Track 020
July 2002 - June 2016

Closest distance to coast: 700 m

Source: SL CCI, LEGOS
A multivariate view:

Recent multivariate changes in the North Atlantic climate system, with a focus on 2005–2016

Robson et al., Int J Clim, 2018

Uses Sea Level and SST CCI alongside MetOffice EN4 Heat Content

Source: Univ Reading
Large scale climate variability:
Interannual surface salinity on Northwest Atlantic shelf

Grodsky et al., JGR, 2017


- SSS increased by ~2 between 2011 & 2015 in a large region on Northwest Atlantic shelf, north of the Gulf Stream
- Source is a change in the wind & Ekman Transport which limited freshwater inputs from North by Southwestward flowing currents along the coasts

Source: Salinity CCI, IFREMER
SSS modes in Tropical Atlantic

1st PC SSTA-vent

Signature of meridional mode in SSS-SMOS

Awo et al, 2018 JGR

Salinity CCI aims at extending this kind of Investigations as well as anomalies such as the “Big Fresh Blob”

Source: Salinity CCI, LOCEAN
Sea State CCI

Example of satellite-derived climatology (1992-2013) From GlobWave Project

Sea State CCI is at work to derive climate-quality time-series of SWH and other sea state-related parameters – v.1 up to 2018 coming later this year

Source: GlobWave, SatOC
The CCI is a major contributor to the WGClimate/CEOS ECV inventory (climatemonitoring.info)

Mature CCI ECVs are operationalized and transferred to the Copernicus Climate Change Services (C3S)
Accessing and visualizing CCI data

Open Data Portal & CCI Dashboard
cci.esa.int/data

Toolbox
climatetoolbox.io

Climate from Space App
Satellite data for all aspects of Earth System Climate Research

cci.esa.int

ESA Climate Office, ECSAT, Harwell Campus

- Pascal Lecomte (head) – Oceans/Ice
- Stephen Plummer – Land/Ice
- Simon Pinnock – Atmosphere
- Michael Eisinger – Atmosphere
- Anna Maria Trofaier – Cryosphere
- Paolo Cipollini – Oceans
- Ed Pechorro – Data and Toolboxes
- Paul Fisher – Climate Comms
- Romy Schlögel & Nele Reyniers – Natural hazards and change detection

Recommendation: provide the climate perspective to your application by exploiting the CCI data inventories!