

Future Cities

Offer and use cases of the Copernicus Climate Change Service (C3S) and Copernicus Atmosphere Monitoring Service (CAMS)

Juan Garcés de Marcilla ECMWF Brussels, 9 Nov 2018





www.copernicus.eu

Space



Atmosphere Monitoring

The Copernicus Atmosphere **Monitoring Service**













atmosphere.copernicus.eu





CAMS: big data for local applications

Atmosphere Monitoring



CAMS provides big data with the corresponding technical and scientific expertise to support expert users.

CAMS outputs are reaching now audiences of over 10 million Europeans (TV, web and apps). The number of direct users is in excess of 7000 with about 2000 using information routinely.





airTEXT



airTEXT is now available in London and Riga



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CERC			Si vietne izmanto siktatus	

CERC



Free air pollution, UV, pollen and temperature forecasts for Greater London and the South East.

Local forecast models need information on how much pollution flows into and out of the domain to provide an accurate service. This is provided by CAMS European air quality forecasts.



MON TOIT SOLAIRE – SOLAR ENERGY



Mon Toit Solaire provides a web-based decision support system for the development of rooftop photovoltaic solar panels.

CAMS provides the satellite-based time series of available solar radiation for the specific location, taking into account the amount of clouds and aerosols.









Atmosphere Monitoring



2015 - jaargemiddelde NO_2 (µg/m³)

		Pollution s	election
Background Concentrations		Receptor g	rid
Meteorology		Time series	locations
Emission factors Fleet composition	FASTRACE traffic emission model	FDM persion todel	naps
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VITO developed a web application for the Flemish Environmental Agency to calculate road traffic emission scenarios in support of regional air quality management.

Using CAMS European air quality reanalysis data, they can much easier implement their service in other parts of Europe.







PASYFO - ALLERGIES

Atmosphere Monitoring



PASYFO was distinguished at the Congress of the European Academy of Allergy and Clinical Immunology (EAACI), with comment that such an application effectively paves the way to the future of "personalised medicine".





The aim of PASYFO is to provide a highresolution regional system for predicting the personal allergy symptoms of pollensensitive people using personalised sensitivity information.

CAMS European pollen forecasts are used to provide the up-to-date information on pollen for the European domain.



PM apportionment service





The operational service uses the regional LOTOS-EUROS model forced by TNO emission information and CAMS data products to track the contributions to PM10 and PM2.5 levels of predefined source categories. The prototype service is a demonstrator and will be developed further to meet user requirements.



Breezometer

Atmosphere Monitoring

 \mathcal{A}

How does it work?



Case study |



Provides real-time air quality levels, comparing outdoors and indoors









DEDICATED SCHEME FOR NATIONAL UPTAKE

Atmosphere Monitoring There's a deadlock between:

- the agreed "boundary" between CAMS and downstream air quality applications in Europe (don't go higher resolution than 8-10km);
- the strongly expressed requirement by several national environment agencies to be able to use CAMS very directly (higher resolution please!).
- Vision: the national official air quality forecast information in "all" EU MS is based on CAMS products and benefits from support/coordination from CAMS

Proposed solution:

- A "turn-key" downscaling development that can be customized to each EU country or city (could run in one of the DIAS)
- Work together with each Member State's agency in charge of Air Quality management to define appropriate downscaling chain (depends strongly on local context/expertise –no one-for-all solution). Scientific & technical support provided by CAMS.





The Copernicus Climate Change Service

Climate Change





What C3S offers to its users

- Access to climate data (generated • by C3S or made accessible)
- Tools needed to use the data ٠
- Information on sectoral impacts
- Quality assurance ٠
- User support and training ٠

A one-stop Climate Data Store

























Hor

Catalogue of climate datasets

	Captoregoer CECMWF C times Change Service This is a new service your feedback will help us to improve it B B T A
Home Search Datasets Toolbox Help & suppo	at the second
Search results	
Search dataset Q Sort by Relevancy	Datasets Choises elevation and more change data from 1904 to 2014 from the Electuation of Clarines Database
Title	Glacker's elevation and mass change data from 1694 to 2014 from the Fluctuation of Glacker's Database Aglacier's defined as a perennial mass of ice, and possibly firm and snow, originating on the land surface from the recrystalization of snow or other forms of solid precipitation and showing eviden
Product type Climate projections (4) Reanalysis (2)	Glaciers extent data from 1995 to 2015 from the Randolph Glacier Inventory A gazer is defined as a perennial mass of ice, and possibly firm and snow, originating on the land surface from the recrystallization of snow or other forms of solid precipitation and showing eviden
Satellite observations (11) Seasonal forecasts (6) Sectoral climate indices (2)	Methane data from 2002 to present derived from satellite sensors Methane (CH4) is the second most significant greenhouse gases that has increased in concentration in the atmosphere directly due to human activities, from the viewpoint of the radiative forcing of cl
Variable domain Atmosphere (composition) (3) Atmosphere (surface) (4)	Sea surface temperature daily gridded data from 1991 to 2010 produced by ESA-CCI This dataset provides daily values for sea surface temperature and sea to: fraction over a regular grid with no missing values in space or in time. The initial satellite data from the Along Track Scan
Atmosphere (upper air) (4) Land (biosphere) (1) Land (cryosphere) (2)	Water quality indicators for European rivers This detate contains modeled data for photphorous and nitrogen concentrations and loads. The data comes from the Swedish Meteorological and Hydrological Institute E-HYPE model at catchment level f
Land (rlydrology) (2) Ocean (physics) (5) Spatial coverage	Water quantity indicators for Europe This detaset contains modeled data for water runoff and vectores, river flow, snow water equivalent, soil water content and other water related quantities for the European region. These variables wer
> Temporal coverage	CMIPS daily data on pressure levels This catalogue entry provides daily climate projections on pressure levels from a large number models, members and time periods computed in the framework of fifth phase of the Coupled Model Intercomp
	CMIP5 daily data on single levels This catalogue entry provides daily dimate projections on single levels from a large number of experiments, models, members and time periods computed in the framework of fifth phase of the Coupled
	CMIPS monthly data on pressure levels This catalogue entry provides monthly dimate projections on pressure levels from a large number of experiments, models, members and time periods computed in the framework of fifth phase of the Cou
	Seasonal forecast monthly statistics on single levels from 2017 to present Seasonal forecasts provide a long-range outlook of thanges in the Earth system over pariods of a few weeks or months, as a result of predictable changes in some of the slow-varying components of the s
	Seasonal forecast monthly statistics on pressure levels from 2017 to present Seasonal forecasts provide a long-range outlook of changes in the Earth system over periods of a few weeks or month, as a result of predictable changes in some of the slow-varying components of the s
	Seasonal forecast daily data on pressure levels from 2017 to present Seasonal forecasts provide a long-range outlook of changes in the Earth system over particles of a few weeks or months, as a result of predictable changes in some of the slow-varying components of the s
	ERA5 hourly data on pressure levels from 2000 to present ERA5 is the fifth generation CCMW atmospheric reanalysis of the global climate. Reanalysis combines model data with observations from across the world into a globality complete and consistent dataset
	Seasonal forecast daily data on single levels from 2017 to present

Seasonal forecasts provide a long-range outlook of changes in the Earth system over periods of a few weeks or months, as a result of predictable changes in some of the slow-varying components of the s...



European Commission



C3S: EO based Essential Climate Variables

Climate



OCEANIC

Surface temperature Sea-surface salinity Sea surface salinity Sea state Sea ice Surface current Occan colour Carbon dioxide partial pressure Occan acidity Phytoplanitkon

Sub-surface (8) Temperature Salinity Current Nutrients Carbon dioxide partial pressure Ocean acidity Ocean acidity

For more information, please go to: http://gcos.wmo.int

Biological/Ecological/Other (7) · Land Cover

Leaf area index
 Above ground biomass

Fire disturbance

River discharge

Water use

Ground water

Lakes Soil moisture

Snow cover

Permafrost

Glacies and ice caps

Soil carbon

Albedo

TERRESTRIAL

Hydrological (5)

Cryosheric (4)

Wind speed and direction Water Vapour Pressure Precipitation Surface radiation budget Uppenair (5)

ATMOSPHERIC

Surface (6)

Air temperature

Temperature
 Wind speed and direction
 WaterVapour
 Cloud properties
 Earth radiation budget (incl. solar irradiance)

Composition (5) • Carbon dioxide • Methane • Other Iong-lived greenhouse gases • Ozone, supported by their precursors • Aerosol, supported by their precursors

ICCSU has defined a lit of Essential Climate Variables (ECV) that are both technically and economically feasible for systematic observation and global implementation, and whose observations meet important requirements of the VECCC and the VECC. It is these vaniables for which international exchange is required for both current and historical abservations.

		C3S_	312a			
				C35_	312b	
	GCOS	2017	2018	2019	2020	2021
Atmospheric physics						
Precipitation	4.3.5					
Surface Radiation Budget	4.3.6					
Water Vapour	4.5.3			Lo	t 1	
Cloud Properties	4.5.4					
Earth Radiation Budget	4.5.5					
Atmospheric composition						
Carbon Dioxide	4.7.1	Lot 6				
Methane	4.7.2	Lot 6		Lo.	* 7	
Ozone	4.7.4	Lot 4			. 2	
Aerosol	4.7.5	Lot 5				
Ocean						
Sea Surface Temperature	5.3.1	Lot 3				
Sea Level	5.3.3	Lot 2		Lo.	• 2	
Sea ice	5.3.5	Lot 1		20		
Ocean Colour	5.3.7					
Land hydrology & cryosphere						
Lakes	6.3.4					
Glaciers	6.3.6	Lot 8		Lo.	* 4	
Ice sheets and ice shelves	6.3.7			20		
Soil moisture	6.3.16	Lot 7				
Land biosphere						
Albedo	6.3.9	Lot 9				
Land Cover	6.3.10					
Fraction of Absorbed Photosynth	eti 6.3.11	Lot 9		Lo	t 5	
Leaf Area Index	6.3.12	Lot 9				
Fire	6.3.15					
		2017	2018	2019	2020	2021









Climate reanalysis

Change

ERA5 hourly data on pressure levels from 2000 to present

	Overview Download data Documentation	ERA5 hourly data on pressure levels from 2000) to present
This is a Home Search Datasets Applications Your requests Toolbox Help & support Search results	ERAS is the fifth generation ECMWF atmospheric reanalysis of the global climate. Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset tuing the laws of physics. This complete the data with newly available observations in an optimal way hours (12 hours at ECMWF) a previous forecast is combined with newly available observations in an optimal way to produce a new best estimate of the state of the state of the state of the analysis works in the same way, but at reduced resolution to allow for the provis a dataset spanning back several decades. Reanalysis does not have the constraint of issuing timely forecasts, so is more time to collect observations, and when going further back in time, to allow for the ingestion of imp.	Overview Download data Documentation Variable • At least one selection must be made • Obvergence • Obvergence • Operational vorticity • Specific cloud is water • Obvergence • O	Geopotential Geop
Sort by Relevancy Title • ERA5 data 1979 • Coming soon: • Product type • Climate projections • Reanalysis • Satellite observations	9 – present, updated daily, with soure levels from 2000 to present d: Global land surface at 9 km	nin 2-5 days resolution	 3 hPa 10 hPa 50 hPa 22 hPa 20 hPa 30 hPa 30 hPa 50 hPa 50 hPa 50 hPa 50 hPa 50 hPa 50 hPa 57 hPa Stelet all
Seasonal forecasts Sectoral dimate indice Spatial coverage Global Temporal coverage Past	eanalysis data for Europe (UER s back to 1950	RA) and the	Ensemble mean Select al Clear al
		2000 2001 2003 2004 2007	2002 2005
		ECMWF (opernicus	European Commiss

Commission



Multi-system seasonal forecasts

Seasonal forecast monthly statistics on single levels from 2017 to present



Home Search Datasets Applications Your requests Toolbox Help & support

Searc	h resu	ts

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Sort by			
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Title			Seasonal forecast
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Climate projections	(4)		Seasonal forecasts provide a lo
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Global	(6)		Seasonal forecast
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Future	(6)		
Dest	(6)		or months, as a result of predict
U Past	(6)		
			Seasonal forecast

Overview Download data Documentation

Seasonal forecasts provide a long-range outlook of changes in the Earth system over periods of a few weeks or months, as a result of predictable changes in some of the slow-varying components of the system. For example, ocean temperatures typically vary slowly, on timescales of weeks or months; as the ocean has an impact on the overlaying atmosphere, the variability of its properties (e.g. temperature) can modify both local and remote atmospheric conditions. Such modifications of the 'usual' atmospheric conditions are the essence of all long-range (e.g. seasonal) forecasts. This is different from a weather forecast, which gives a lot more precise detail - both

in time and space - of the evolution of the state of the atmosphere over a few days into the future. Beyond a the chaotic nature of the atmosphere limits the possibility to predict precise changes at local scales. This is c reasons long-range forecasts of atmospheric conditions have large uncertainties. To quantify such uncertain range forecasts use ensembles, and meaningful forecast products reflect a distributions of outcomes.

Given the complex, non-linear interactions between the individual components of the Earth system, the best long-range forecasting are climate models which include as many of the key components of the system and typically, such models include representations of the atmosphere, ocean and land surface. These models are with data describing the state of the system at the starting point of the forecast, and used to predict the evi this state in time. While uncertainties coming from imperfect knowledge of the initial conditions of the comp the Earth system can be described with the use of ensembles, uncertainty arising from approximations ma models are very much dependent on the choice of model. A convenient way to quantify the effect approximations is to combine outputs from several models, independently developed, initialised and operate

To this effect, the C3S provides a multi-system seasonal forecast service, where data produced by stateseasonal forecast systems developed, implemented and operated at forecast centres in several European co alications. The composition of the C2S seaso

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ast daily data on pressure levels from 2017 to

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Seasonal forecast daily data on single levels from 2017 to present

Seasonal forecasts provide a long-range outlook of changes in the Earth system over periods of a few weeks or months, as a result of predictable changes in some of the slow-varying components of the s...



Seasonal forecast monthly statistics on single levels from 2017 to present

Originating centre		
At least one selection must be made		
ECMWF	UK Met Office	Météo France Select all
Variable 🔞		
At least one selection must be made		
10m u-component of wind	10m v-component of wind	10m wind gust since previous post-processing
10m wind speed	2m dewpoint temperature	2m temperature
East-west surface stress rate of accumulation	Evaporation	Maximum 2m temperature in the last 24 hours
Mean sea level pressure	Minimum 2m temperature in the last 24 hours	North-south surface stress rate of accumulation
Runoff	Sea surface temperature	Sea-ice cover
Snow density	Snow depth	Snowfall
Soil temperature level 1	Surface latent heat flux	Surface sensible heat flux
Surface solar radiation	 Surface solar radiation downwards 	 Surface thermal radiation Surface thermal radiation downwards
Top solar radiation	Top thermal radiation	Total cloud cover
Total precipitation		
		Select all

At least one selection must be made

▼ Ensemble





Climate projections from CMIP5

-							
nat	te			CMIP5 daily data on pressure levels			
ng I	ge			Overview Download data Documentation			
/	110			This catalogue entry provides daily climate projections on pressure levels from a large number models, members and time periods computed in the framework of fifth phase of the Coupled Model Intercomparison Project (CMIP5) for the historical experiment. Information on how to access the complete CMIP5 dataset can be found in the Documentation			
	195 A			The term "pressure levels" is used to express that the	CMIP5 daily data on press	sure levels	
L	1	Home Search Datasets Applicatio	This is a new service your feedbac tions. Your requests. Toolbox. Help & support.	variables were computed at multiple vertical levels, which may differ in number and location among the different models. The term "experiments" refers to the four main categories of CMIPS simulations:	Overview Download data Docur	mentation	
1/		Search results		 Pre-industrial control experiments (Pi-control) with prescribed, non-evolving concentrations of and aerosols as they are supposed to be before the industrial period; 	Variable 💿		
		Scarchiresaids		Historical experiments which cover the period where climate observations do exist;	At least one selection must be made		
		Search dataset	Q All Datasets	 Ensemble of experiments from the Atmospheric Model Intercomparison Project (AMIP), which oceanic variables for all models and during the all period of the experiment. This configuration complexity of ocean-atmosphere feedbacks in the climate system: 	Temperature	U-component of wind	Geopotential height Select a
L.		Sort by		Ensemble of climatic projection experiments following the Representative Concentration Pathy			
		Relevancy	Showing 1-4 of 4 results for Climate projections ×	6.0 and 8.5.	Model 🕐		
16		Title		Typically, the same experiment was done using different models. In addition, for each model, t	At least one selection must be made		
R.			CMIP5 daily data on pressure levels	related. Each member of that ensemble is named after a triad of integers associated to the letters	inmcm4 (INM, Russia)	ACCESS1-0 (BoM-CSIRO,	bcc-csm1-1 (BCC, China)
15		 Product type 	This catalogue entry provides daily climate projections on pressure lev members and time periods computed in the framework of fifth phase	vels from a large number models,	CMCC-CM (CMCC, Italy)	CMCC-CMS (CMCC. Italy)	CNRM-CM5 (CNRM-CERFAC
D		 Climate projections Reanalysis 	(4)		GFDL-CM3 (NOAA, USA)	GFDL-ESM2G (NOAA, USA) HadGEM2-ES (UK Met Office,	France) GFDL-ESM2M (NOAA, USA) FISL-CM5A-LR (IPSL, France)
H		Satellite observations	(11) Civin 5 daily data on single levels	from a large number of experiments	IPSL-CM5B-LR (IPSL, France)	MPI-ESM-LR (MPI, Germany)	IPSL-CM5A-MR (IPSL, France MPI-ESM-MR (MPI, Germany
		Seasonal forecasts Sectoral climate indices	 (6) This catalogue end y provides daily climate projections on single levels models, members and time periods computed in the framework of fift (2) 	th phase of the Coupled	NorESM1-M (NCC, Norway)		Select a
L		✓ Variable domain	CMIP5 monthly data on pressure levels		Ensemble member (2)		
L		Atmosphere (surface)	(4) This catalogue entry provides monthly climate projections on pressure	e levels from a large number of			
L		Atmosphere (upper air)	(4) experiments, models, members and time periods computed in the fra	mework of fifth phase of the Cou	✓ r1i1p1	🔲 r2i1p1	🔲 r3i1p1
		✓ Spatial coverage	CMIP5 monthly data on single levels		🔲 r4i1p1		F6i1p1 Select all Clear a
1	-	Global	(4) This catalogue entry provides monthly climate projections on single le	vels from a large number of			
		 Temporal coverage 	experiments, models, members and time periods computed in the fra	mework of fifth phase of the Couple	Period (?)		
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		Present	(4)		-		
							11.



Data on sectoral impacts

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All Datasets

Search results

Sort by Relevancy Title

Product type

Reanalysis
 Satellite observation

Climate projections

Seasonal forecasts
Sectoral climate indi
Variable domain

Land (hydrology)
 Spatial coverage

Temporal coverage
 Future

Europe

Water quality indicators for European rivers

Overview Download data Documentation

This dataset contains modelled data for phosphorous and nitrogen concentrations and loads. The data comes from the Swedish Meteorological and Hydrological Institute E-HYPE model at catchment level for Europe. These water quality indicators were computed as a part of a proof of concept contract designed to speed up the workflow in impact assessments and to simplify climate change adaptation of water management practices across Europe.

These indicators are provided as averages over 30 year periods, either for each calendar month or for the whole period. For the reference period (1971-2000) the absolute

values are given, whereas for the future periods the relative changes are provided. In addition to to organic and inorganic parts are provided for nitrogen. For phosphorous, in addition to the total amoun and soluble parts are provided. Values of the temperature of the water is provided for the same periods.

More details about the product are given in the Documentation section.

Horizontal resolution | Irregular catchment polygons, median catchmentsize 215 km²

Horizontal coverage Pan European domain



Water quality indicators for European rivers

Overview Download data Documentation

Variable 🕐

At least one selection must be made

Inorganic nitrogen concentrations	Organic nitrogen concentrations	Particulate phosphorous concentrations
Soluble phosphorous concentrations	Total nitrogen concentrations	Total phosphorous concentrations
Inorganic nitrogen loads	Organic nitrogen loads	Particulate phosphorous loads
Soluble phosphorous loads	Total nitrogen loads	Total phosphorous loads

Water temperature

Emissions scenario (2)

- Indicator datasets to support industry sectors: water,
- energy, insurance

This is a new service -

- More sectors underway: agriculture, tourism, health,
 - shipping, fisheries, coastal

DATA DESCRIPTION



Select all

Select all

Select all

RCP 8.5

2041-2070



CDS toolbox, workflows and applications



DATA SUPPLIERS DEVELOPE INTEROPERABILITY Climate Data Store Infrastructure DATA Petabytes Service chain INFORMATION

Quality assured information and tools for users: scientists, consultants, decision makers.



Enabler for downstream exploitation

॑॑

Climate

Change





C3S data provides:

Climate Change

- POC SIS activity provided case studies to demonstrate the value of C3S to enable the downscaling of regional climate models at city level to:
 - Urban runoff for future climate scenarios through using a local hydraulic modelling, case studies in Bologna (bottom figure) & Stockholm City Centre (see top figure)
 - Simulate the temporal evolution of the meteorological variables inside an urban area for climate scenarios.
 - Indicators could include heat wave duration, number of tropical nights & health indices
 - Coming soon: Copernicus Climate Change Health sector service

CDS data and tools provide an Insight into the future.....





ITTs to stimulate innovative ideas New

Change

C3S 428 C3S Use Cases

- based on market analysis
- develop and demonstrate end-to-end **Applications**
- based on C3S products and the tools provided by the CDS infrastructure.

AIM: stimulate innovative ideas and support the development of



Rolling Invitations to Tender

downstream applications Evaluated on a quarterly basis, with closing dates every three months: 14 September 2018*, 14 December 2018, 14 March 2019, 14 June 2019

*: First batch of proposals under review.



C3S 429 C3S Demo Cases

develop and demonstrate

applications including data

visualisation, scientific

communication and arts

and/or the tools provided

by the CDS infrastructure

AIM: *stimulate innovative*

ideas to show-case the

potential of the CDS

based on C3S products