CMUG Perspective: ECVs in climate modelling and climate community feedback

March 2018

This presentation

1. CMUG mandate / who we are
2. Confronting models with observations
3. Some CMUG Phase 2 results
    a. Quality Assessment of the 13 CCI ECVs
    b. CMUG MIP experiments
    c. ESMValTool
4. CMUG in CCI+
5. Community engagement
6. CMUG Integration meetings

CMUG origins and mandate

- Before the CCI there was no co-ordinated programme to make satellite climate observation data available.
- ESA established CMUG to ensure a climate perspective at the centre of its CCI programme, and to provide a forum through which the Earth observation data community and climate modelling community can work closely together.

1. Assess the global satellite climate data records produced by CCI ECV projects
2. Examine the consistency between ECVs, from a user perspective
3. Refine the scientific requirements of the climate data based on the needs of GCOS, climate modellers and other users
4. Provide technical feedback to the ECV projects
5. Provide reanalysis data to the ECV projects
6. Promote the use of ECV datasets to climate modellers and other users
7. Coordinate the CSWG

CMUG partners in CCI+

Met Office Hadley Centre

METEO FRANCE

Max-Planck-Institut für Meteorologie

ECMWF

Sciences de l'environnement Institut Pierre Simon Laplace

SMHI

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

DLR

VUB VRIJE UNIVERSITEIT BRUSSEL

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

ULB UNIVERSITÉ LIBRE DE BRUXELLES

ISAC Consiglio Nazionale delle Ricerche

Maynooth University National University of Ireland Maynooth

What do climate modellers do with observation data?

In CCI Phases 1 and 2 satellite records were assessed, verified, gridded, converted from L1 to climate variables and made accessible to the climate community by the ECV teams.

This data have high temporal and spatial resolution and can be used for many purposes in climate models, including:

1. Setting initial conditions in global models
2. Boundary conditions for regional models
3. Reanalysis
4. Data assimilation
5. Model validation
6. Climate monitoring and attribution
7. Q/C of in situ data
8. Analysis of climate processes

Examples from CMUG Phase 2

	Application for climate modellers						
	Model Initialisation	Prescribe boundary conditions	Re-analysis	Data assimilation	Model development and validation	Climate monitoring and attribution	Q/C in situ data
Atmospheric							
Cloud					R		
Ozone							
GHG							
Aerosol							
Terrestrial							
Glaciers							
Land cover							
Fire							
Ice sheets							
Soil moisture		R					
Marine							
SST	R						
Sea level							
Sea ice		R					
Ocean colour							
Specified applications in climate modelling							
	6	6	2	6	22	2	1

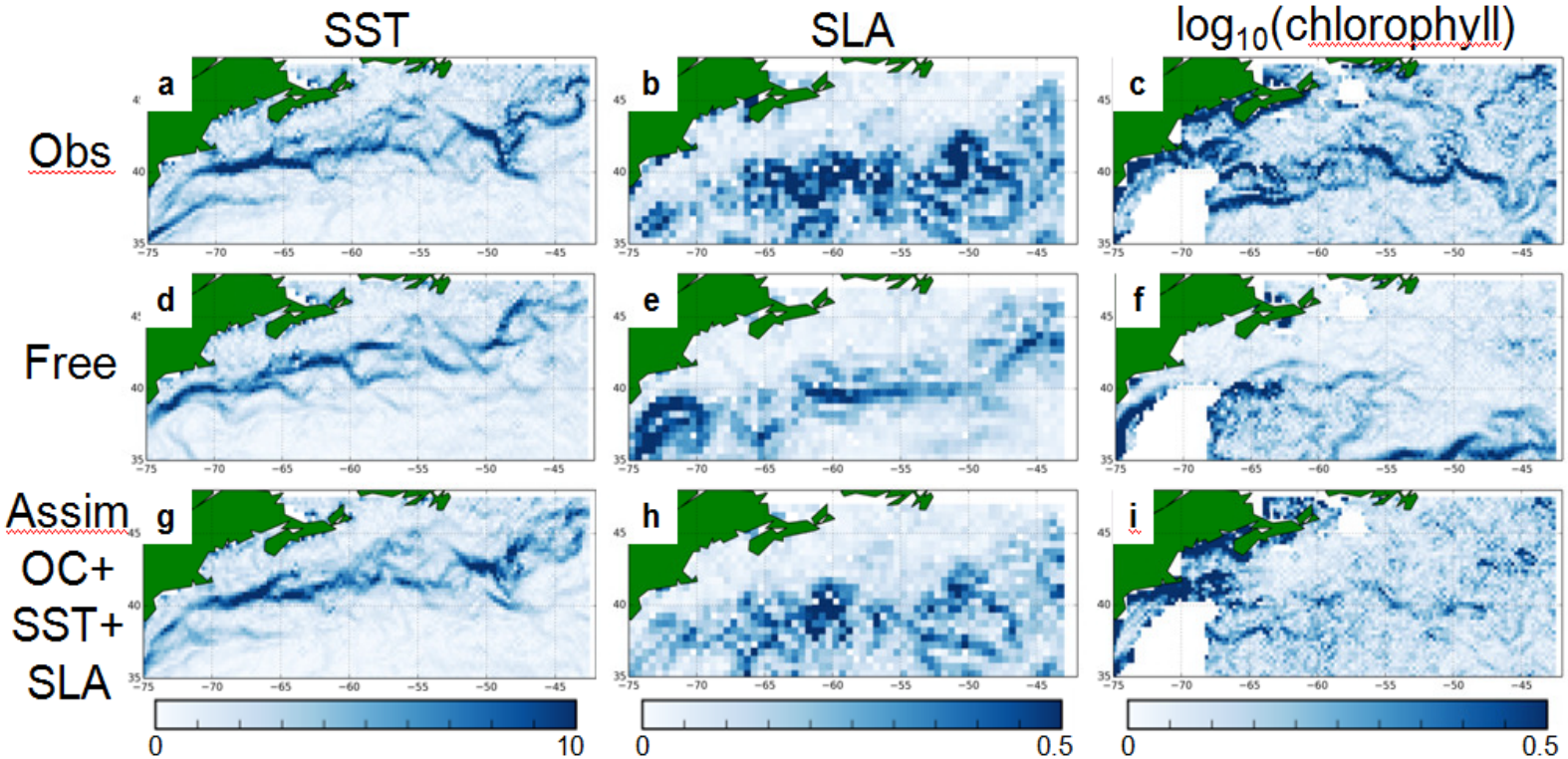
Key:

	Data set identified as useful to climate modelling
R	Interest in data set by a research project

CMUG Phase 2 model experiments

		SST	SSH	Sea ice	OC	Cloud	Ozone	Aerosol	GHG	LC	SM	Fire	Glacier	
WP	**Model**	**Ocean**				**Atmosphere**				**Land**				**Experiment Type**
Task 3 Assessing consistency and quality of CCI products														
3.1	FOAM	X	X	X	X									Assimilation
O3.1	NEMOVAR, ORA	X	X	X	X									Assimilation and Detection
3.2	ERA-Clim						X							Assimilation
3.3	MACC-II						X	X	X					Assimilation
3.4	JSBACH, TM3								X	X	X	X		Assimilation
O3.4	EC-Earth/CMIP5	X				X	X	X	X		X			Assessment, evaluation
3.5	LMDz, ORCHIDEE								X	X	X	X		Boundary Condition
3.6	MPI-OM, MPI-ESM	X		X	X	X								Assimilation (Polar Regions)
3.7	EMAC-MADE					X		X						Comparison
3.8	RCA HARMONIE	X				X					X			Comparison/Eval (CORDEX Africa)
3.9	Arctic HYPE		X							X			X	Assessment
3.10	CNRM-RCM	X	X			X		X			X			Comparison (Med CORDEX)
Task 4 Exploiting CCI products in MIP experiments														
4.1	CNRM-CM, Arpege	X		X				X		X	X	X		Boundary Cond
4.2	IPSL-ESM	X		X										Boundary Cond
O4.2	EC-EARTH	X		X										Boundary Condition
Task 5 Adaption of climate evaluation tools for CCI needs														
5.1	ESMVal	X		X				X		X	X	X		Tech ESMVal CMPI6 + metrics
O5.1	ESMValTool	X	X		X		X	X	X		X			ESMValTool + metrics
5.2	CMF	X	X	X	X	X	X	X	X					Web interface CMF
O5.2	Benchmarking	X		X	X	X	X	X	X	X	X	X		ESMValTool + metrics

Marine ECV assimilation in the FOAM model

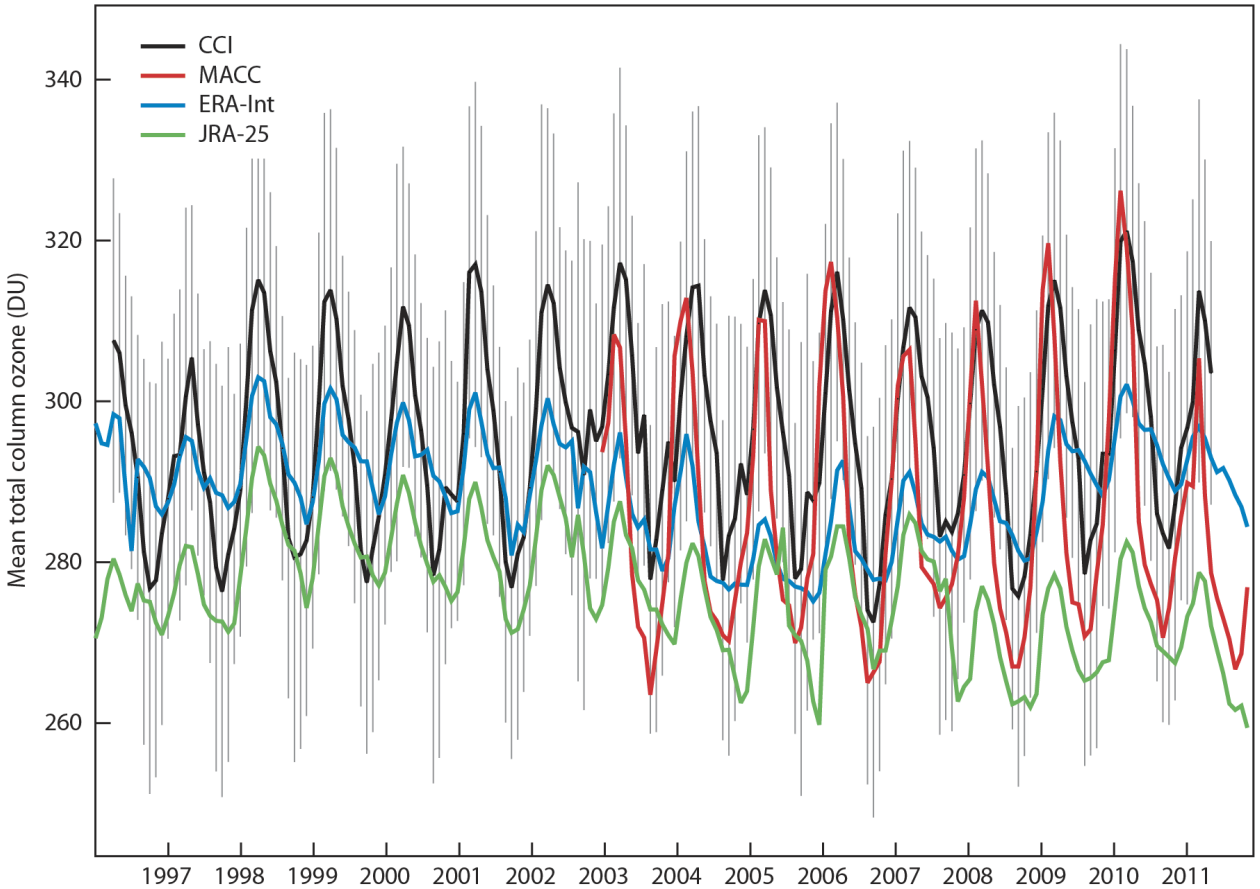


Spatial gradients of SST, SLA and $\log_{10}$(chlorophyll) in the Gulf Stream region of the North Atlantic, for June 2009, from a-c) CCI data, d-f) 1/4° free run, and g-i) 1/4° run assimilating ECVs.

Assimilation of several L2 ozone products in the ERA-Clim system

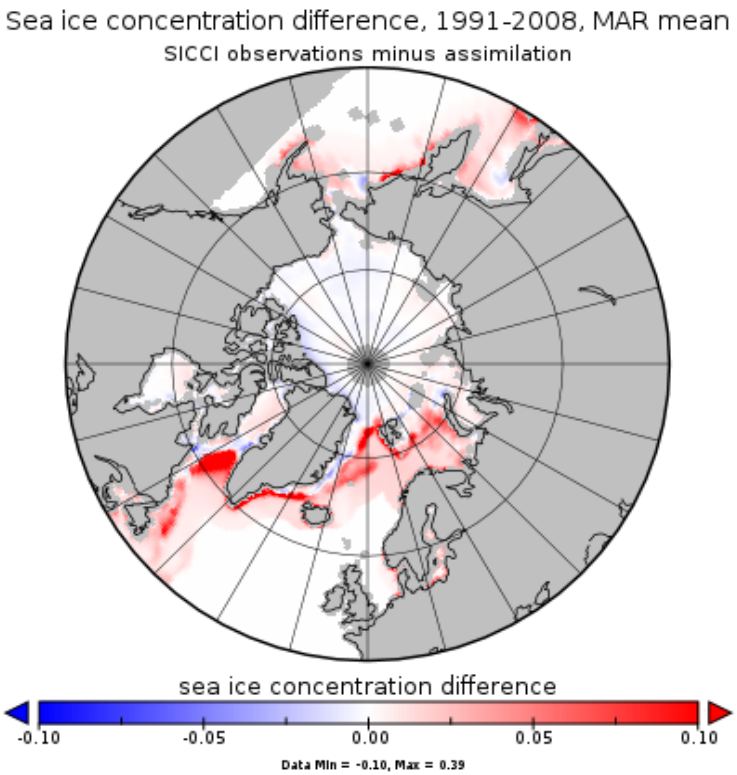
1. The structure of observation uncertainties generally compare well with estimates obtained using the Desroziers method (Desroziers et al., 2005). The differences between estimated and provided uncertainties show up to 60% overestimation in the tropical mid stratosphere for GOME-2 NPO3 (this accounts for less than 4% of the observation values) and up to 100% underestimation in the tropics for the total columns (this difference is about 8% of the global mean total column ozone value).
2. All the products exhibit negligible to very small biases.
3. All assessed O3-CCI datasets lead to improved ozone analyses.
4. Regarding the RR assimilation exercises, with the exception of OMI TCO3, the O3-CCI retrievals seem to better constrain the ozone analyses than retrievals obtained from the same radiances using alternative algorithms.
5. The assimilation of the GOME-2 NPO3 show a clear improvement in the internal consistency of the data assimilation system in terms of better fit to the AIRS ozone-sensitive IR channels that in turn leads to statistically significant reduction (i.e. improvement) in the RMS of the geopotential forecast errors in the tropics.
6. Assimilation User Requirements to Space Agencies and retrieval teams:
   - The comparison of the impact generated by the GOME-2 TCO3 and that of the GOME-2 NPO3 shows that the latter dataset can lead to a greater positive impact on the ozone analyses than the former.
   - The comparison of the impact generated by ……..

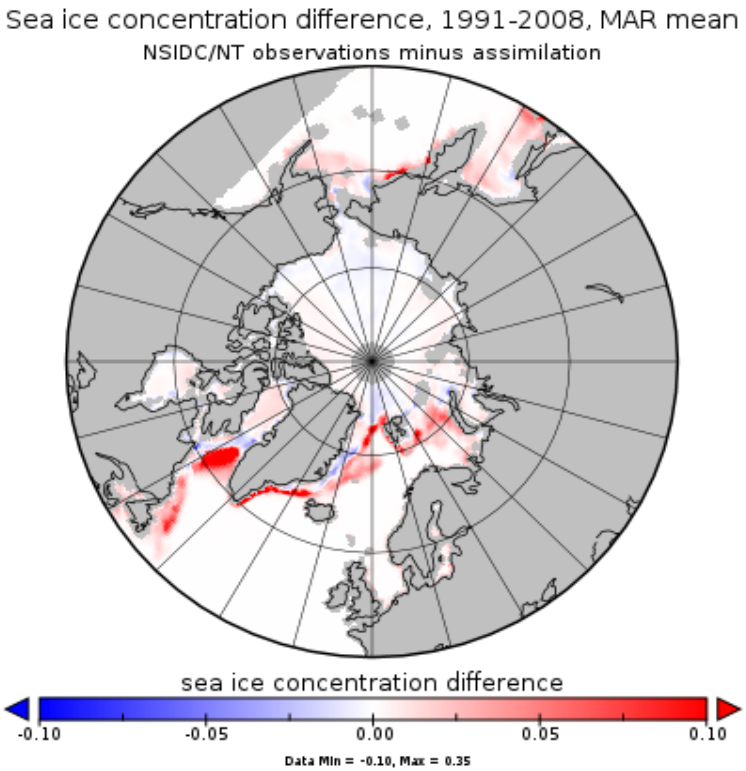
Assimilation of several L2 ozone products in the ERA-Clim system



Time series of the global mean monthly mean TCO_3 from Ozone-CCI (black), ERA-Interim (blue), MACC (red) and JRA-25 (green). The vertical bars over-plotted to the CCI data are the standard deviations in a grid square. Data are in Dobson Units.

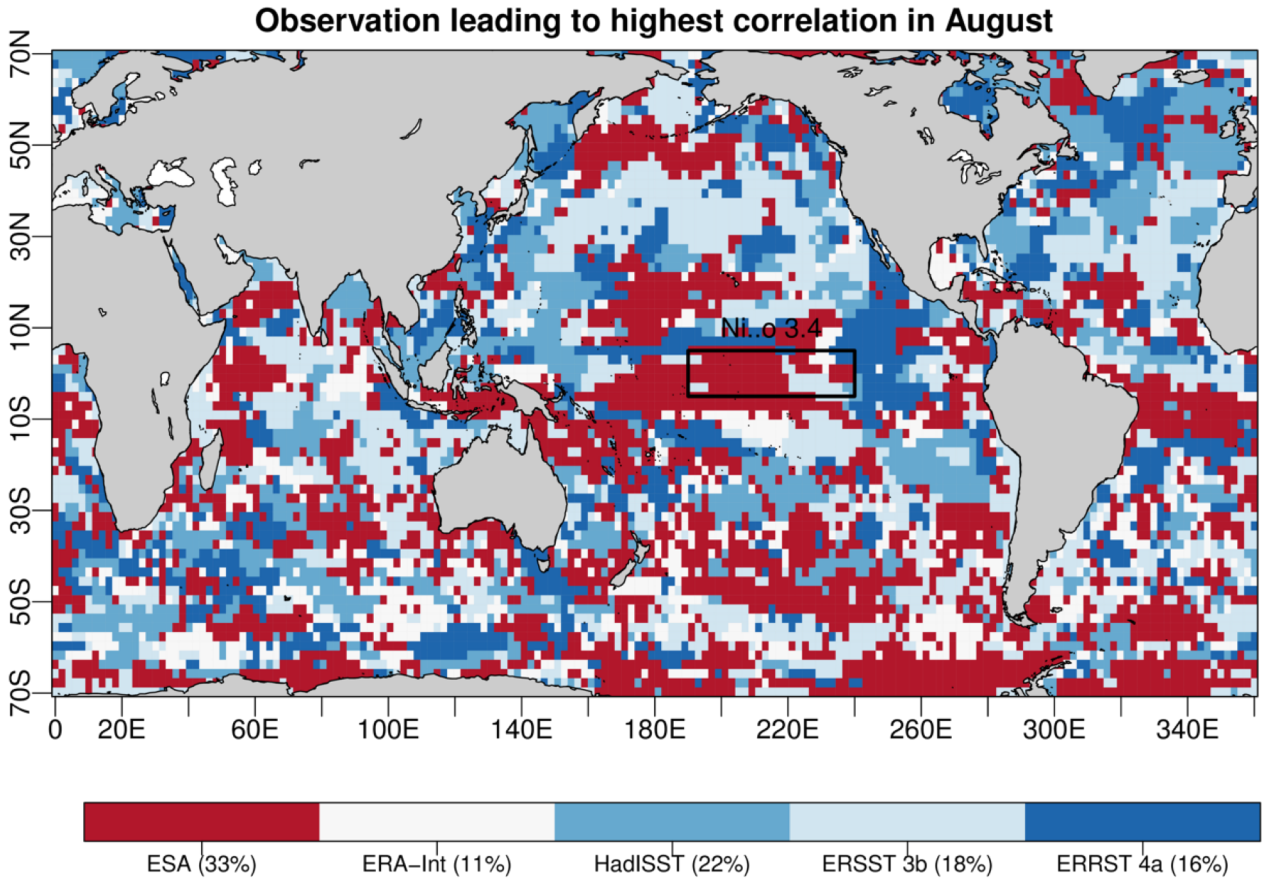
SI concentration





Comparison between different SI concentration datasets assimilated into the MPI-M model. Left is CCI right is NSIDC. From CMUG D3.1 QAR.

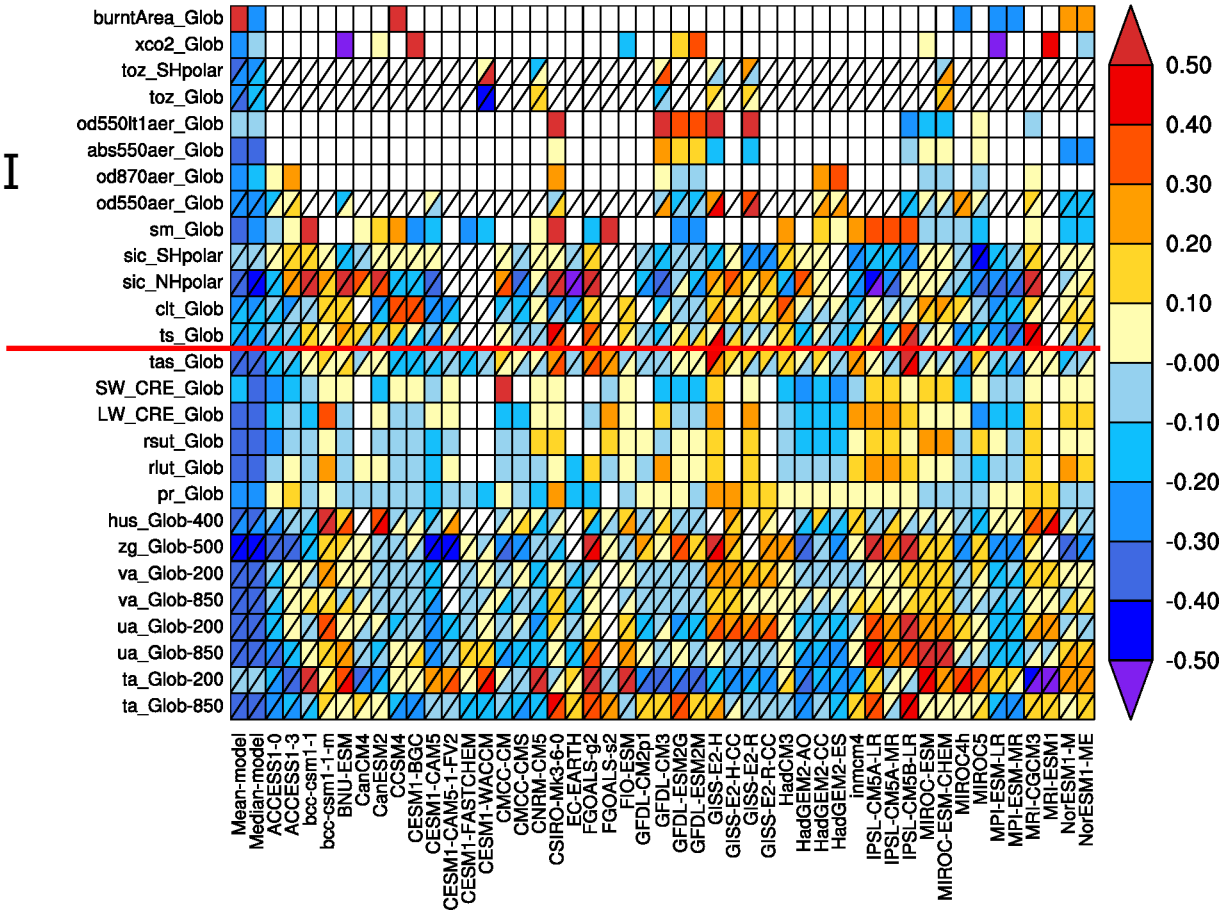
Exploiting CCI products in CMIP like experiments



Spatial distribution of observational reference quality. For each grid point, only the observational reference that correlates best with the hindcast is shown. Data is only shown in grid points where at least one hindcast achieves a significant correlation with one observational reference The black box is the Niño3.4 region. Regions above 70°N or below 70°S are not considered, as these regions are usually ice-covered. The percentages below the colour bar indicate the fraction of the oceans covered by each colour. Figure 5.4 from CMUG D4.1 v3.

ESMValTool

CCI

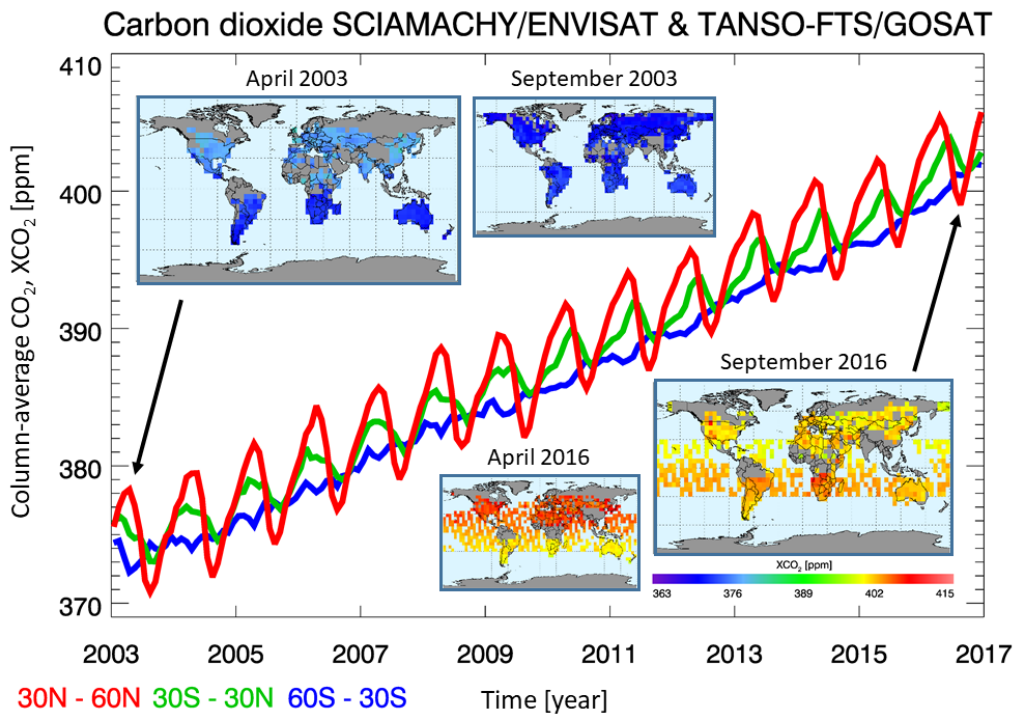


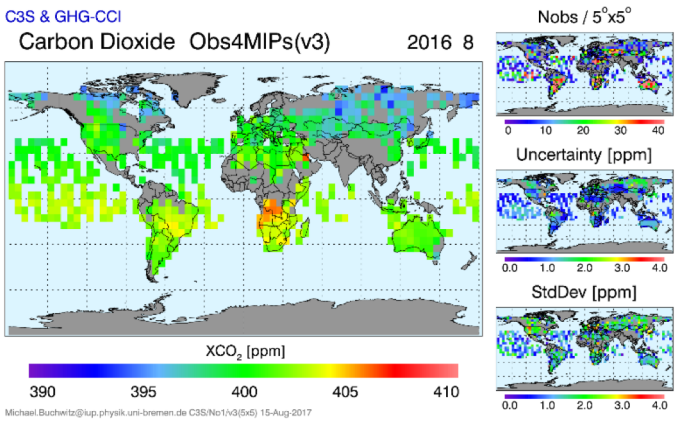
RMSD calculated from the climatological seasonal cycle of the CMIP5 simulations. A relative performance is displayed, with blue shading indicating better and red shading indicating worse performance than the median of all model results. A diagonal split of a grid square shows the relative error with respect to the reference dataset (lower right triangle) and the alternate dataset (upper left triangle). ESA CCI datasets have been used as reference data (lower right triangle) for the following variables: burned area (burntArea), column-averaged CO_2 concentration (xco2), total ozone column (toz), aerosol optical depth (AOD) at 550 nm from particles smaller than 1 µm (od550lt1aer), absorption AOD at 550 nm (abs550aer), AOD at 870 nm (od870aer), AOD at 550 nm (od550aer), soil moisture (sm), sea ice concentration (sic), total cloud amount (clt), and sea surface temperature (ts).

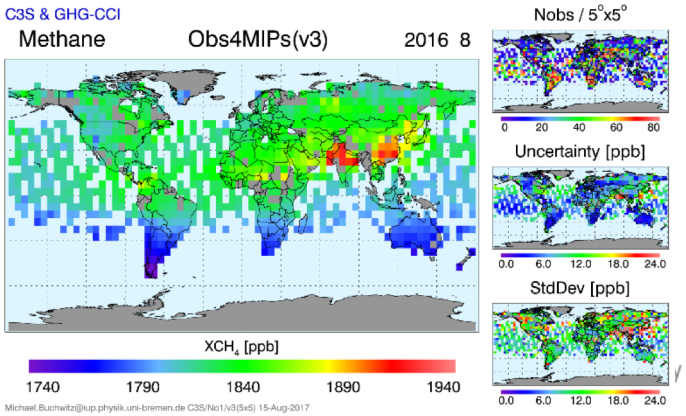
GHG-CCI: Obs4MIPs

GHG-CCI:

- **Core products:** Column-average CO_2 & CH_4: XCO_2 & XCH_4
- **Obs4MIPs:** Core product Obs4MIPs format files generated for easy comparison with output from Climate Models. So far 3 versions (and one peer-rev. publication: Lauer et al., 2017):
  - v1 (GHG-CCI CRDP#3, 2003-2014)
  - v2 (GHG-CCI CRDP#4, 2003-2015)
  - v3 (C3S, 2003-2016)







CMUG work across the CCI

In addition to the climate modelling studies and analysis tools:

1. Uncertainty characterisation
2. The “Golden” year
3. Terminology between specialisms
4. CSWG
5. DEWG
6. Integration meetings

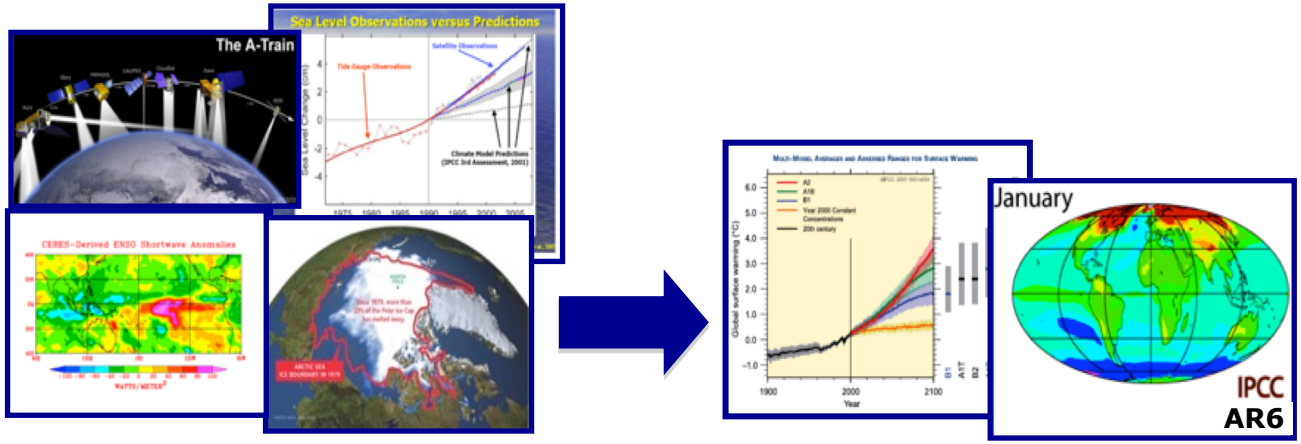
CMUG CCI+ Objectives

- Update **USER REQUIREMENTS** for climate modelling applications, reanalyses, and Climate Services, and compare with CCI ECV specifications
- Assess the **QUALITY AND CONSISTENCY** of multiple CCI datasets in combination using state of the art climate models and provide **FEEDBACK** on this to the CCI teams
- **EXPLOIT CCI DATASETS** through MIP experiments
- Adapt climate **EVALUATION TOOLS for CCI NEEDS** – the Climate Monitoring Facility at ECMWF and the ESMVal tool will be further developed for use on CCI data
- Provide the CCI teams with an **INTEGRATED PERSPECTIVE** on research issues (uncertainty, data, Obs4MIPs)
- Actively **PROMOTE CCI DATASETS** to the climate modelling and climate research communities through scientific engagement with programmes and initiatives (e.g. engaging with Horizon 2020 climate research projects, the CMUG Data Forum)
- **ENGAGEMENT at an INTERNATIONAL LEVEL** to ensure CCI datasets reach researchers around the world (e.g. through IPCC reports, GCOS, and other international and regional initiatives)
- **COORDINATE CLIMATE RESEARCH** activities through the CSWG of the CCI

Meeting the evolving needs of the climate community

User Requirements – conducted a requirements gathering exercise across the climate modelling, climate research, and climate impacts and adaptation communities. It included GCOS requirements, plus those of other international and regional organisations.

Earth Observation Foresight Report – produced a "Foresight Report" for use of EO data for climate applications (monitoring, model validation, reanalysis).

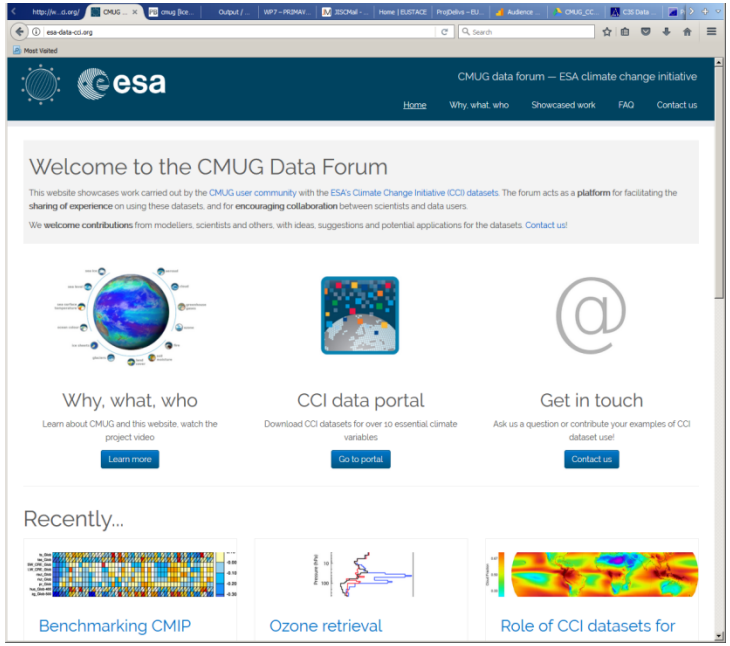


Providing an integrated view of CCI, and feedback to ESA and the CCI teams

Scientific Impact Report – documents the scientific impact of the CCI on the climate research community.

Climate Data Forum – climate data forum web pages, a one-stop shop for information on satellite climate datasets.

Technical Note on Product Assessment – Provide feedback to ESA and CCI teams on their plans for product assessments.



Assessing consistency and quality of CCI products across ECVs

	title	experiment type	CCI ECVs	other ECVs
WP 3	**Quality Assessment**			
3.1	Consistency between CCI LST, SM product and LAI products	Reanalysis, benchmarking	LST, SM	C3S LAI
3.2	Consistency between CCI Snow, SM product and LAI products	Reanalysis, benchmarking	Snow, SM	C3S LAI
3.3	Assess the added value of HRLC in the SM and LAI representation and	Reanalysis, benchmarking	HRLC, SM	C3S LAI
3.4	Propagation of CCI(+) observational uncertainties to climate models	Statistical analysis	SM, Fire, LST	
3.5	Document SM-atmosphere feedbacks in transition regions (temperature and ppts)	Process analysis	SM,LST	turbulent fluxes, radiation, air temp. Precipitations
3.6	Better constrain evapotranspiration at the scale of climate model	Process analysis	SM, Snow, LST, HRLC	LAI , flux, radiation, air temp
3.7	Production and evaluation of a high-resolution sea-ice reanalysis	Reanalysis	SI conc, SI thick, Salinity, SST	
3.8	Evaluation of the impact on skill of HiRES-SIR on seasonal prediction	Hindcast	SI conc, SI thick, Salinity, SST	
3.9	Biophysical feedbacks in the global ocean	Assim, reanalyses, process	OC, SST, SI, Sea level, Salinity	Temp, salinity, carbon dioxide, ocean heat content
3.1	CCI/CCI+ data to constrain mineral dust simulations	Assimilation, stat. analysis	Aerosol dust, HRLC	
3.11	Dust reanalysis at the regional scale	Assimilation, stat. analysis	Aerosol dust, HRLC	
3.12	17-year long Global Aerosol Reanalysis	Reanalysis	Aerosol	

Exploiting CCI products in MIP experiments

WP4	Exploiting CCI products in MIP experiments			
4.1	Evaluation of modeled system memory	Statistical analysis	Salinity, Snow, LST, SST, SI	
4.2	Evaluation of model results considering observational uncertainty	Statistical analysis	Salinity, Snow, LST, SST, SI	
4.3	Evaluation of model results considering the abstraction level of	Statistical analysis	Salinity, Snow, LST, SST, SI	
4.4	Optimal spatial and temporal scales for model evaluation	Statistical analysis	Salinity, Snow, LST, SST, SI	
4.5	Evaluation of model results considering internal variability	Statistical analysis	Salinity, Snow, LST, SST, SI	
4.6	Evaluation of model results considering a combination of sources of uncertainties	Statistical analysis	Salinity, Snow, LST, SST, SI	
4.7	Skill assessment of the DCPP decadal predictions	Skill analysis	Sea Level, SST, Clouds	
4.8	Thresholds in LST to vegetation type, productivity and moisture stress	MIP process analysis	AGBiomass, LST, SM, LC	Temperature, Precipitation, FAPAR, LAI
4.9	Use CCI+ LST to evaluate model LST versus near surface temperature relationships	MIP process analysis	LST, AGBiomass, HRLC	Temperature
4.10	Comparison of CCI data in vegetation study with other satellite data and LS models	MIP process analysis	AGBiomass, LST, SM, LC	Temperature, Precipitation, FAPAR, LAI
4.11	Land-surface interaction related biases in AMIP	MIP process analysis	LST , Snow, SM	Air temp, turb. fluxes (Jung, Gleam,)

Adaptation of community climate evaluation tools for CCI needs

WP 5.1 Coordination of CMUG ESMValTool activities

WP 5.2O Enhancement of ESMValTool with baseline diagnostics for CCI ECVs

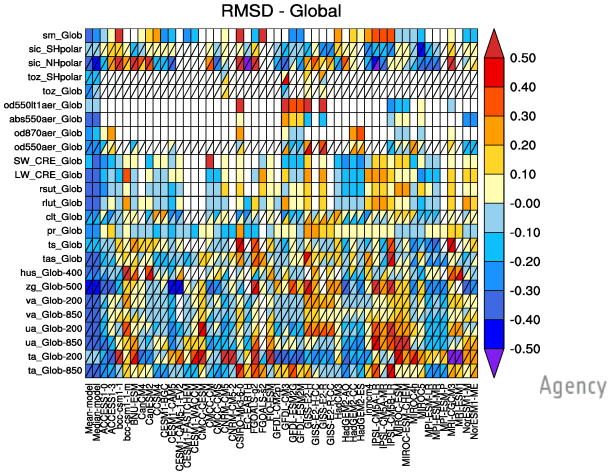
WP 5.3 Implementation of CCI products in to the ESMValTool

WP 5.3O Implementation of further CCI products in to the ESMValTool

WP 5.4 Evaluating the CMIP6 ensemble with CCI data using the ESMValTool

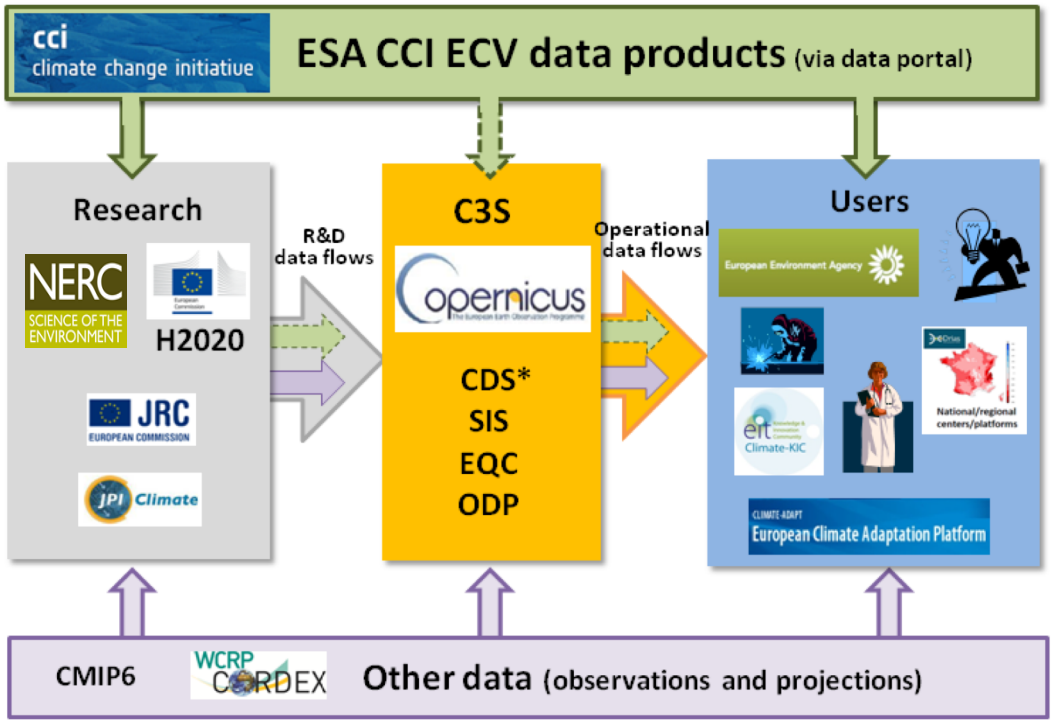
WP 5.4O Evaluating the CMIP6 ensemble with CCI data using the ESMValTool

WP 5.5 Enhancement of the ESMValTool for regional model evaluation



Interface to European climate services

Interface to European climate services – describes the utility of CCI ECV datasets for use in climate services



* CDS = Climate Data Store, SIS = Sectoral Information System
EQC = Evaluation and Quality Control platform, ODP = Outreach and Dissemination platform

Outreach and engagement

Scientific exploitation report – describes the uptake and use by the climate research community of CCI data via CMUG

Promotion package – websites, newsletters, presentations, posters, social media, etc.

European Space Agency

CCI+ CMUG Integration Meeting 8

Tuesday 30 October to Thursday 1 November 2018, Met Office, Exeter, UK