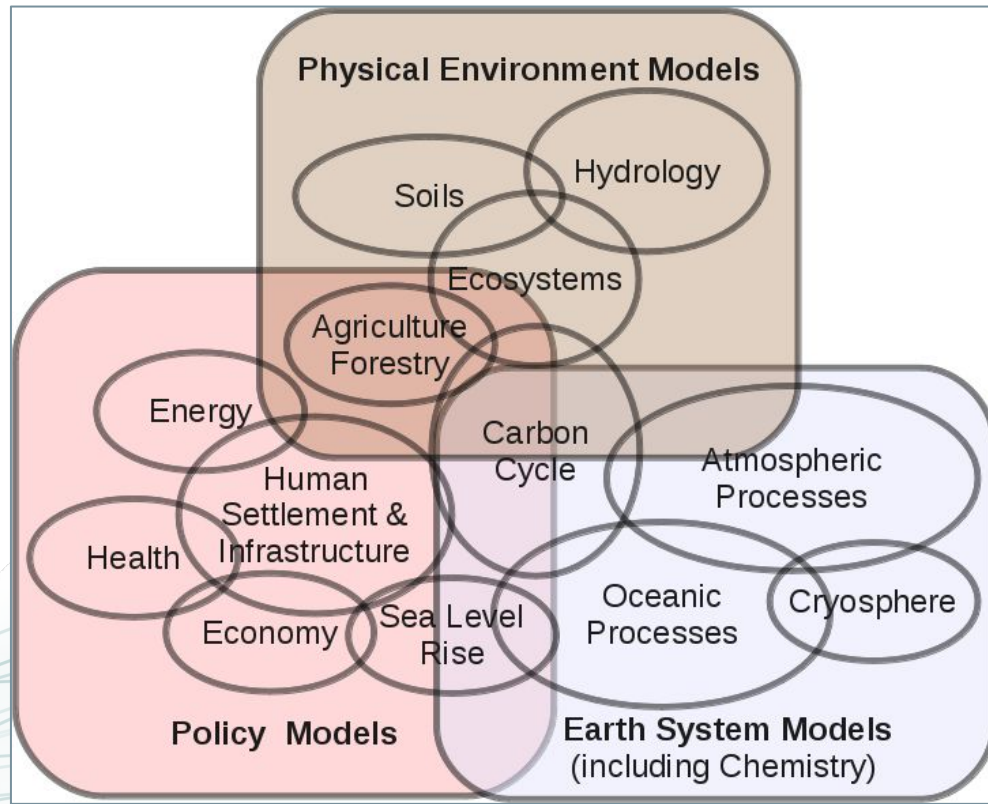


Standards-centric software and support

Sadie Bartholomew, NCAS-CMS@Reading

Why standards?



Community **standards are fundamental to work in NCAS and beyond**. The simpler it is for researchers to determine, access, use, store and share the precise data they need, the more efficient, accurate and insightful the research can be. But we have:

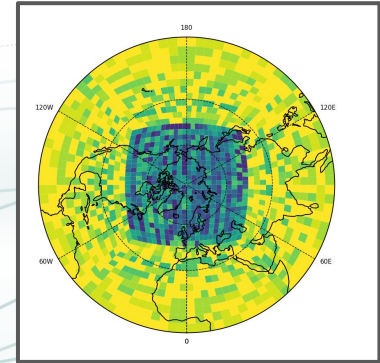
- interacting communities: producers and consumers, with potentially different:
 - computing environments,
 - software tools,
 - observational platforms;
- long interaction timescales: data may be used for decades after it was produced (and for observations, centuries after it was taken).

Need to share and persist **information**, not just “files” or “databases”, can only do this with standard vocabularies and formats.

I. The CF Conventions and our suite of dedicated data tools

‘CF-netCDF’ = netCDF files + CF Metadata Conventions:

- CF: covers **C**limate & **F**orecast data (model, satellite, observational, etc.) for atmosphere, surface & ocean: aligns with scope of work across NCAS
 - Utterly fundamental to CMIP (and hence IPCC)!
- Provides a definitive description of NetCDF data so that it is clear:
 - What the data in each variable represents,
 - How to establish the spatial & temporal properties of that data.
- Community-driven: the CF Conventions are updated by an established community consensus process
 - NCAS leadership from the beginning (Jonathan Gregory, then much later, roles for Bryan Lawrence and David Hassell)



cf development has been supported by the ERC through Seachange and Couplet; by the EC Horizon 2020 programme through IS-ENES3; by NERC through UKFAFMIP; and by NCAS.

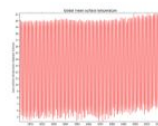


- NCAS-CMS have pioneered a data model for CF-netCDF, now integrated into the CF Conventions defining document...
- ...and with CF and the data model at the centre, have developed and provided continuous support for a small suite of complementary libraries, all open-source:
 - **cfdm**: a reference implementation of the CF data model;
 - **cf-python**: a data analysis library extending cfmd to provide advanced functionality for researchers;
 - **cf-plot**: plotting and visualisation;
 - **cf-view**: quick look tool for data files;
 - **cf-checker**: compliance checking.

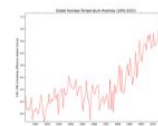
Recipes using cf

Version 3.15.0 for version 1.10 of the CF conventions.

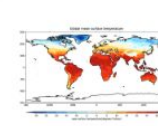
Click on the keywords below to filter the recipes according to their function:



Calculating global mean temperature timeseries



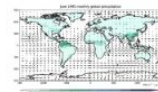
Calculating and plotting the global average temperature anomalies



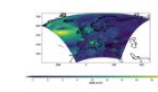
Plotting global mean temperatures spatially



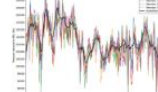
Comparing two datasets with different resolutions using regridding



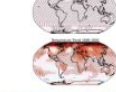
Plotting wind vectors overlaid on precipitation data



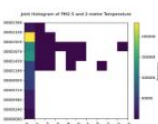
Converting from rotated latitude-longitude to regular latitude-longitude



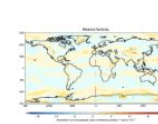
Plotting members of a model ensemble



Plotting statistically significant temperature trends with stippling



Plotting a joint histogram



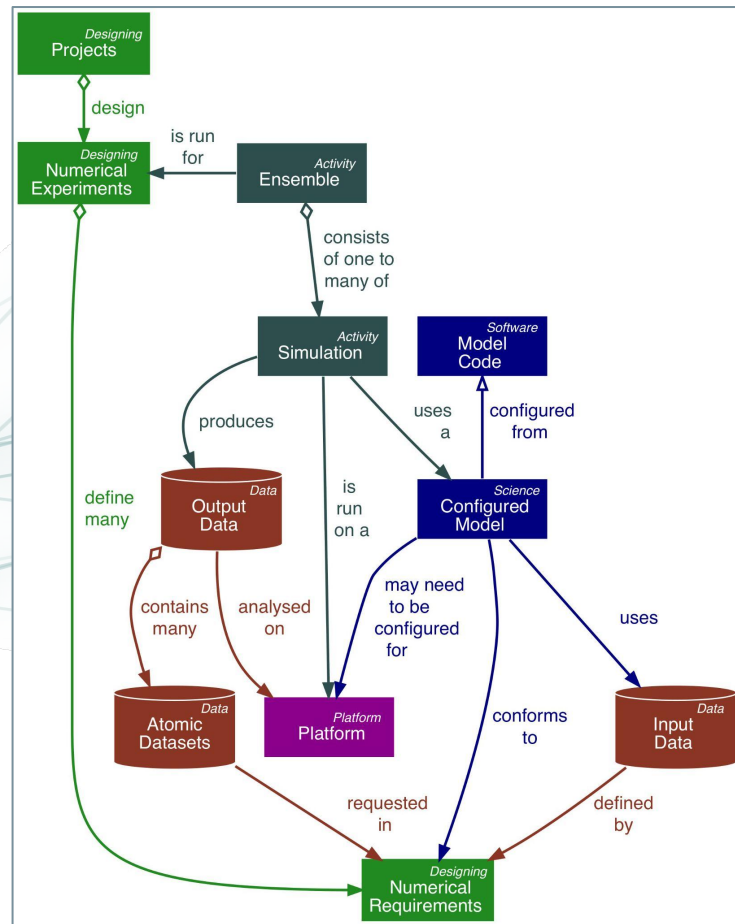
Calculating and plotting the relative vorticity

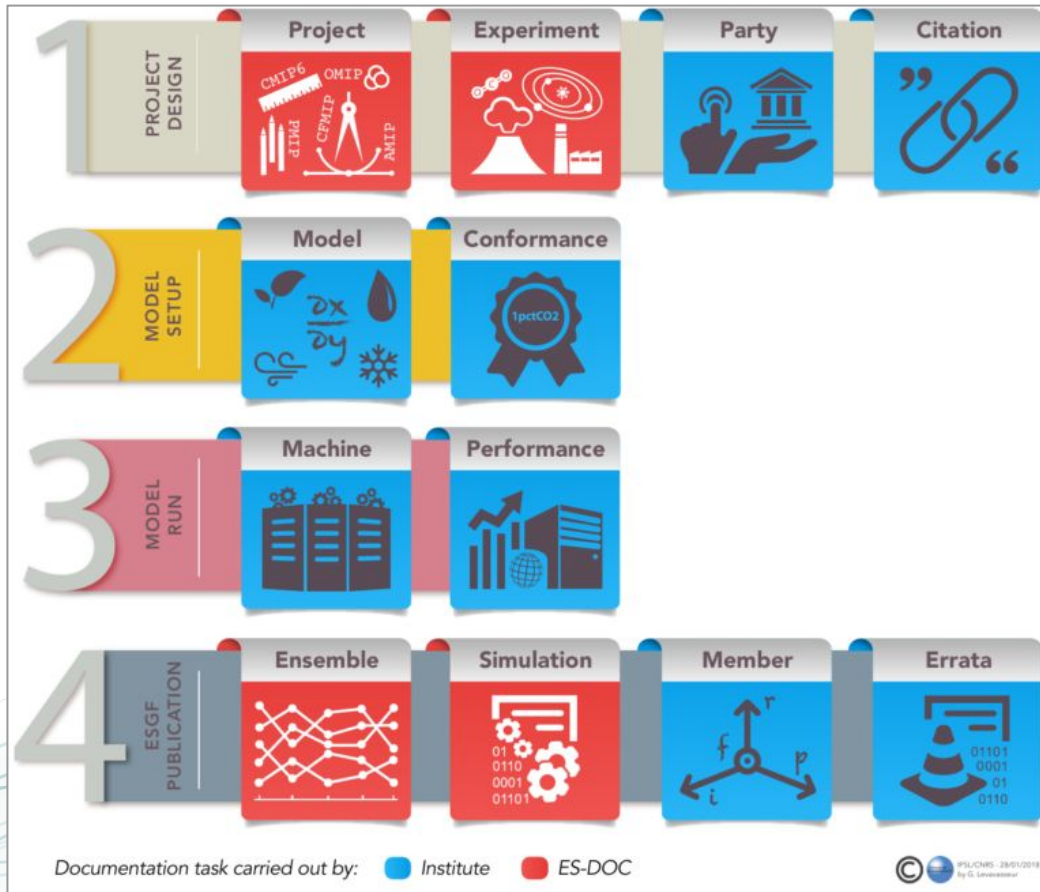


Plotting the Warming Stripes

2. Earth System Documentation (ES-DOC) and beyond

- The workflow for a given simulation that produces data products involves numerous components, as summarised in the schematic.
- **All of these components must be documented robustly to ensure reproducibility and repeatability.**
- Standards involved in encapsulating this, as underlying pillars of the ES-DOC project, are:
 - the **Common Information Model (CIM)** to define the *ontology* (components/objects, their properties and inter-relationships)
 - a set of **controlled vocabularies**;
 - a set of *specialisations* for specific projects.





- An ecosystem of tools and services to enable the community to better understand and utilise Earth system model data
 - **CMIP support is priority**, but is designed as a generic tool and has also been used to support e.g. CORDEX and obs4MIPs
 - Documentation published is made available via open website and archives
- **David Hassell** and **Sadie Bartholomew** are part of the international team developing and maintaining the tools and services and providing modelling group support, as well as (with **Bryan Lawrence**) planning aligned efforts for CMIP7.

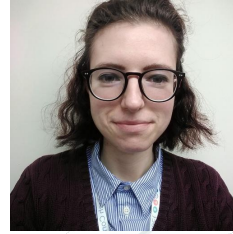
Specific contributions by NCAS-CMS in these areas



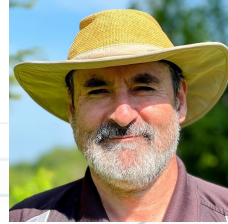
Rosalyn Hatcher (RH)



David Hassell (DH)



Sadie Bartholomew (SB)



Bryan Lawrence (BL)



Andy Heaps (AH)



Ankit Bhandekar (AB)



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Atmospheric Science
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