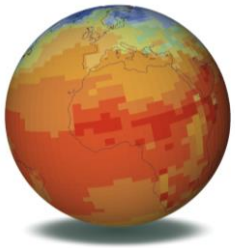


CPDN

ECMWF OpenIFS

Introducing OpenIFS@Home

Department of Engineering Science

David Wallom · Sarah Sparrow · Andy Bowery

ECMWF

Glenn Carver · Marcus Köhler · Gabriella Szépszó

Antje Weisheimer · Florian Pappenberger

Atmospheric Physics Department

Antje Weisheimer

Public Volunteers

Everywhere!

ECMWF

Oxford Physics

Department of Engineering Science

University of Oxford

Oxford e-Research Centre

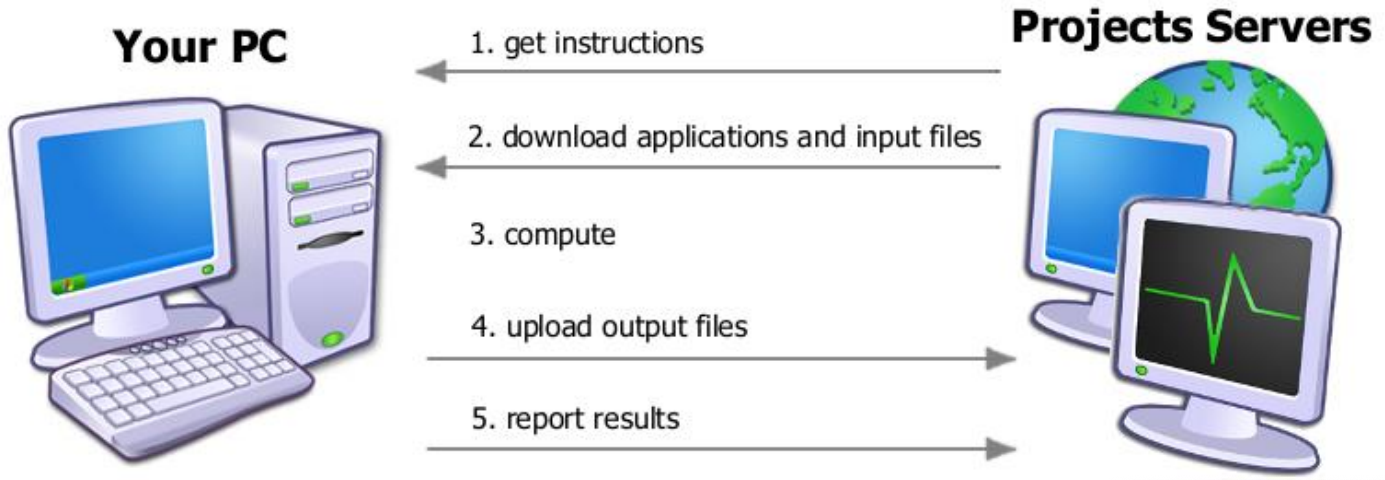
Computational challenge of weather and climate science

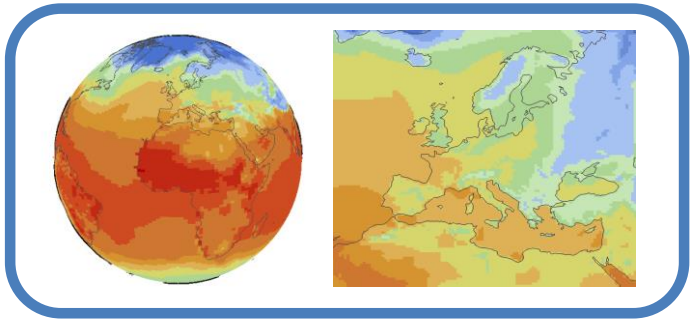
Climate modelling with public distributed computing

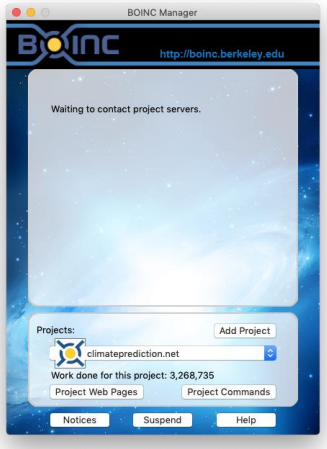
- Disadvantages:
  - Limited diagnostics & resolution.
  - You make all your mistakes in public.
- Advantages:
  - Effectively unlimited ensemble size.
  - Free computation, only pay for infrastructure
  - You make all your mistakes in public.

CPDN

Berkley Open Infrastructure for Network Computing (BOINC)







CPDN

Volunteer and Collaborator Network

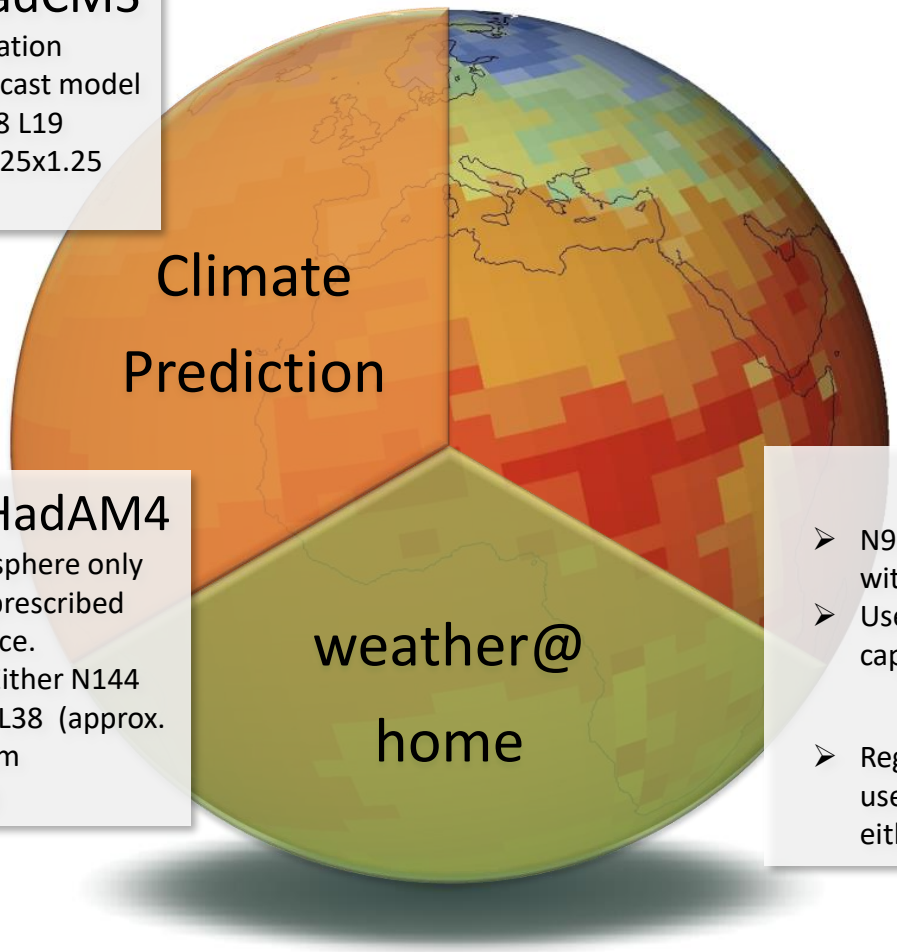
15 years, >30 sub projects, >650,000 volunteers, >200M model-years

CPDN

Models

HadCM3

- Previous generation MetOffice Forecast model
- Resolution: N48 L19 atmosphere, 1.25x1.25 L20 ocean.



HadAM4

- Global atmosphere only model with prescribed SST and sea ice.
- Resolution: Either N144 L38 or N216 L38 (approx. 90km or 60km respectively)

HadAM3P

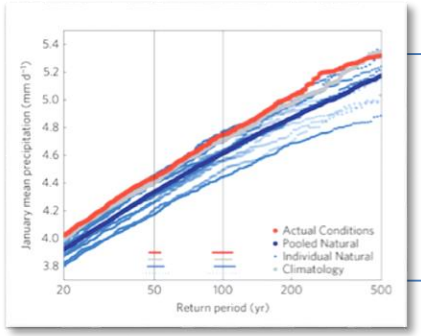
- N96 Global Atmosphere only model with prescribed SST and sea ice.
- Used as driver of regional model but capable of individual operation

HadRM3P

- Regional Climate Model with flexible user defined region of interest run at either 25 km or 50 km.

CPDN

Current CPDN Experiment Types

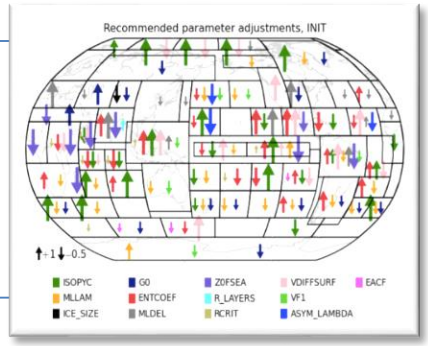


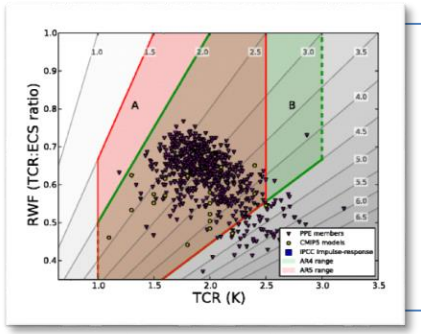
Extreme event attribution:

Quantitative risk assessments of the potential impacts due to extreme weather events under past, current and projected future climate conditions.

Bias reduction methods:

Improved skill for initialised climate model forecasts, through bias reduction from global and regional process adjustment in perturbed parameter sensitivity studies.



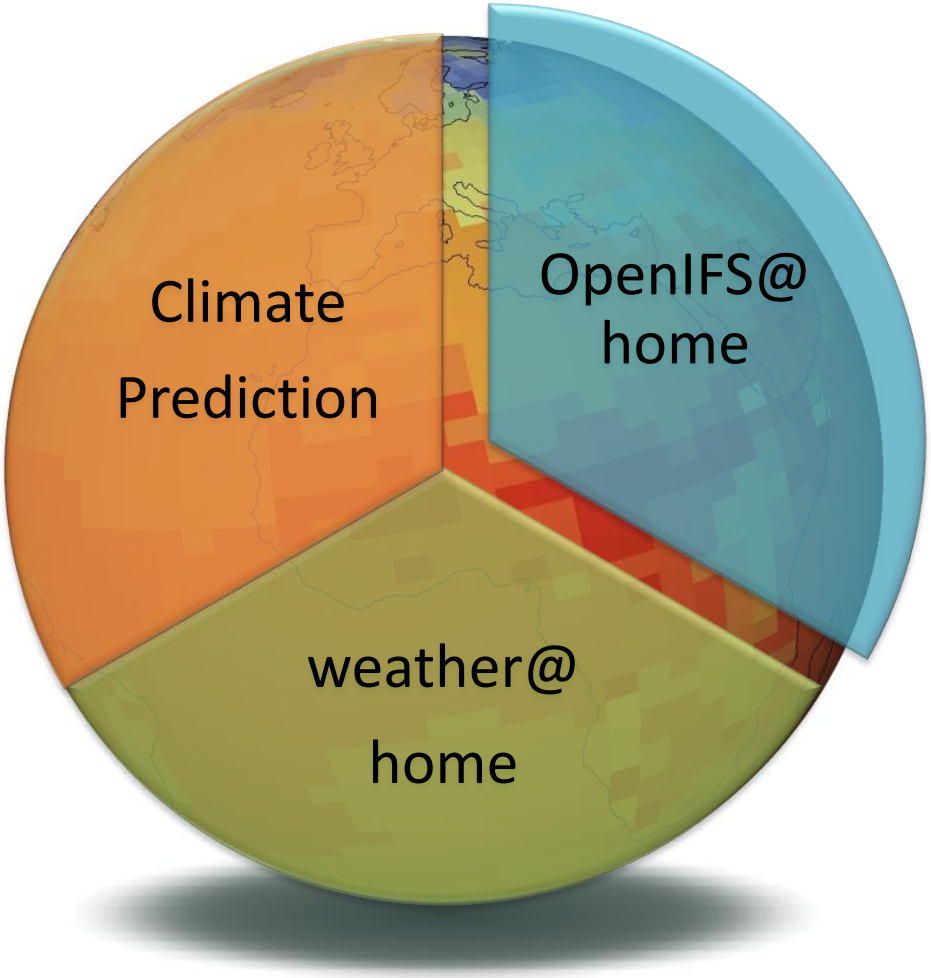


Climate sensitivity studies:

Mapping plausible ranges of climate sensitivity through large perturbed parameter ensembles.

CPDN

Models



CPDN

OpenIFS@Home

- Provides a novel and new platform for scientific experiments with OpenIFS.

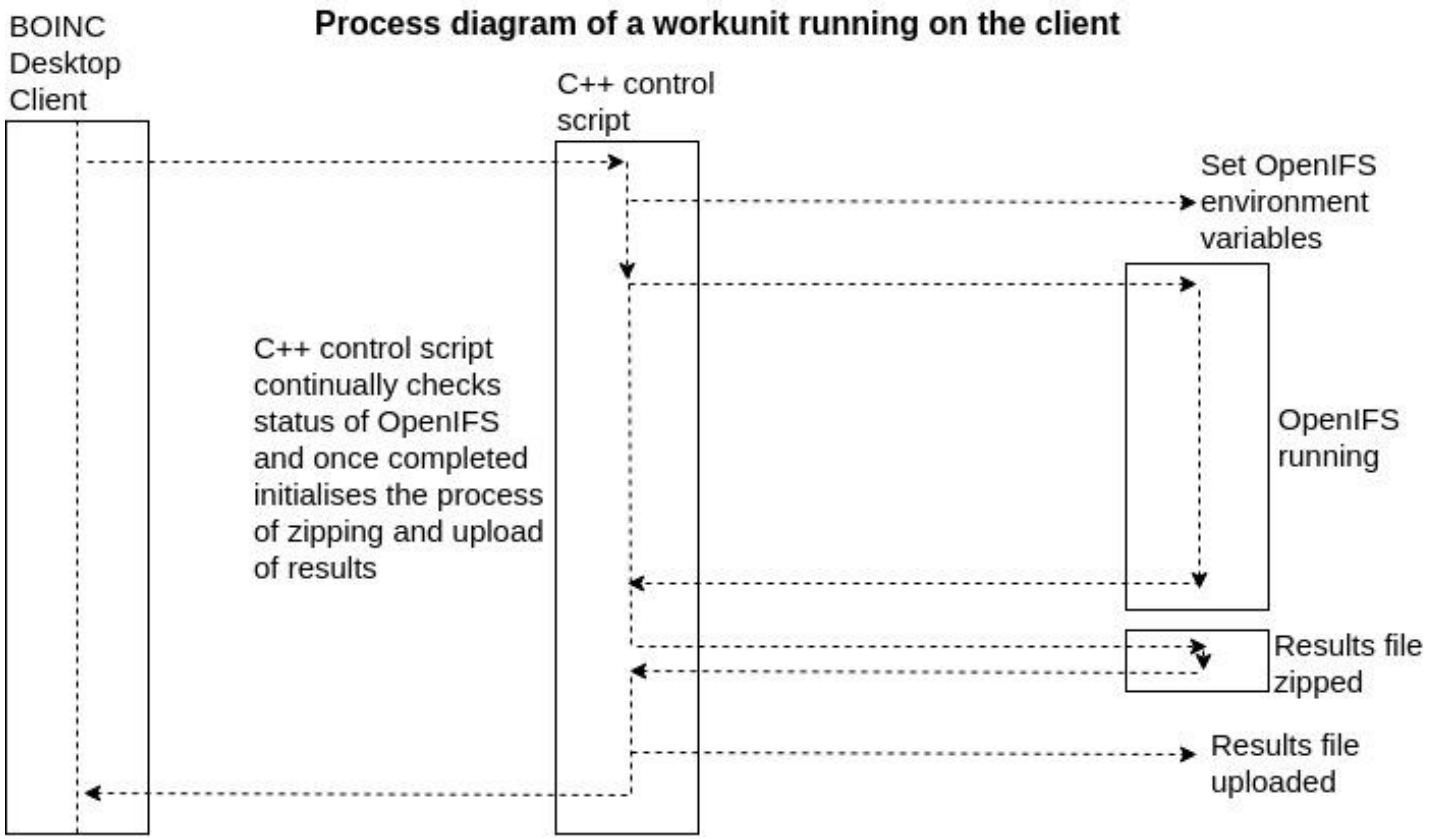
- Current model configuration
  - Spectral T159 (N80; 125km) with 60 or 91 levels.
  - Developed using IFS CY40r1

- Modified code for encoding in GRIB to enable ensemble sizes beyond 256 members.

- The launch of **OpenIFS@home** will enable large ensemble initialised probabilistic *weather forecasts* to be run by CPDN public volunteers.

CPDN

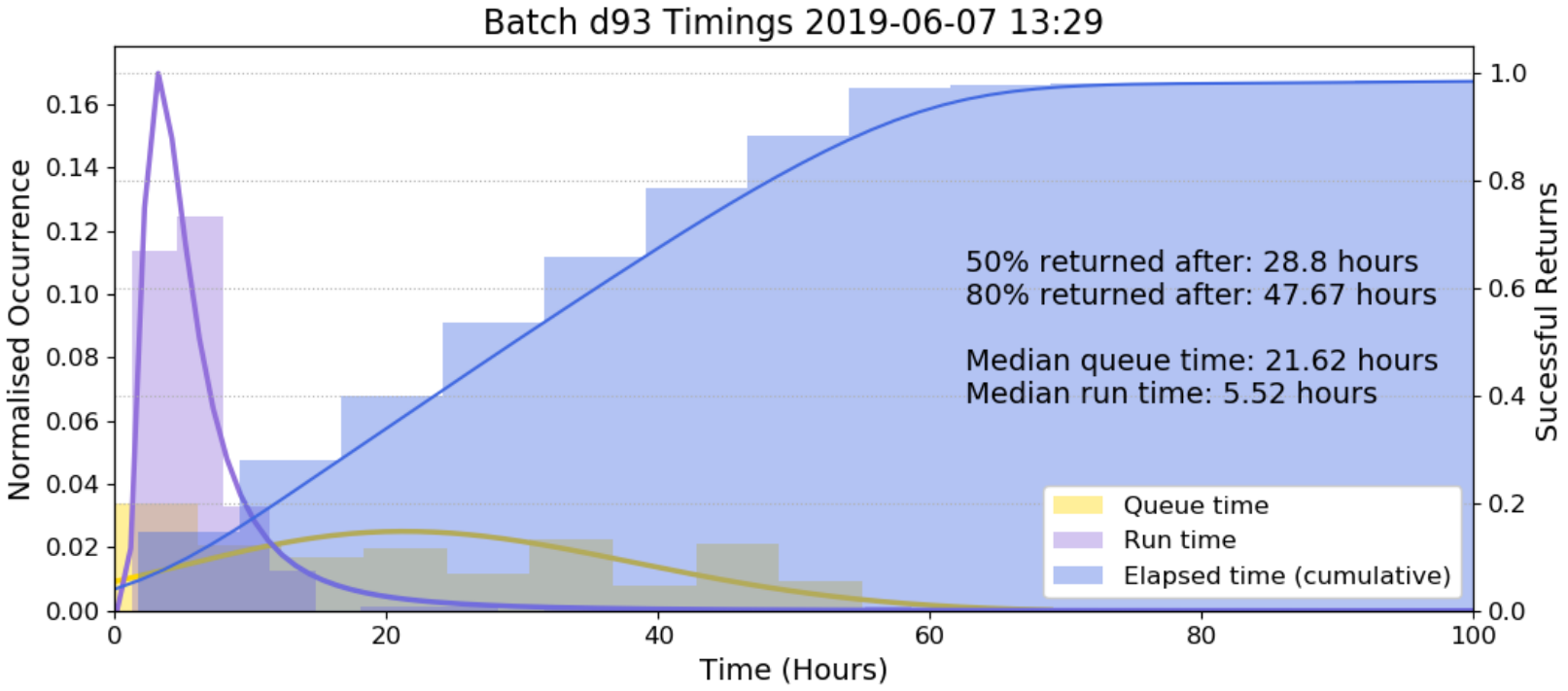
Porting OpenIFS to BOINC



CPDN

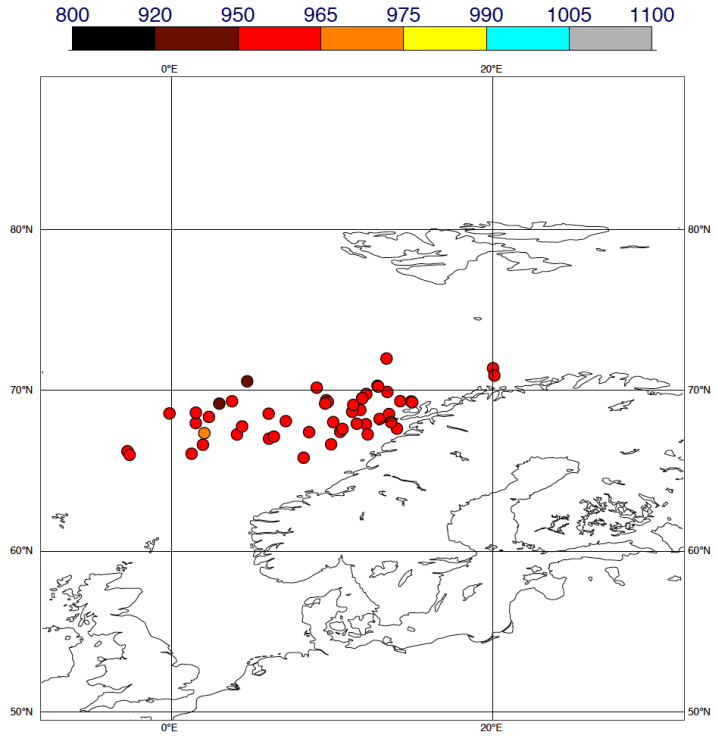
OpenIFS@Home

- 500 member ensemble - Storm Desmond
- Initialised using ERA5
- Identical initial conditions other than ensemble member number
- 494 returned (99%)

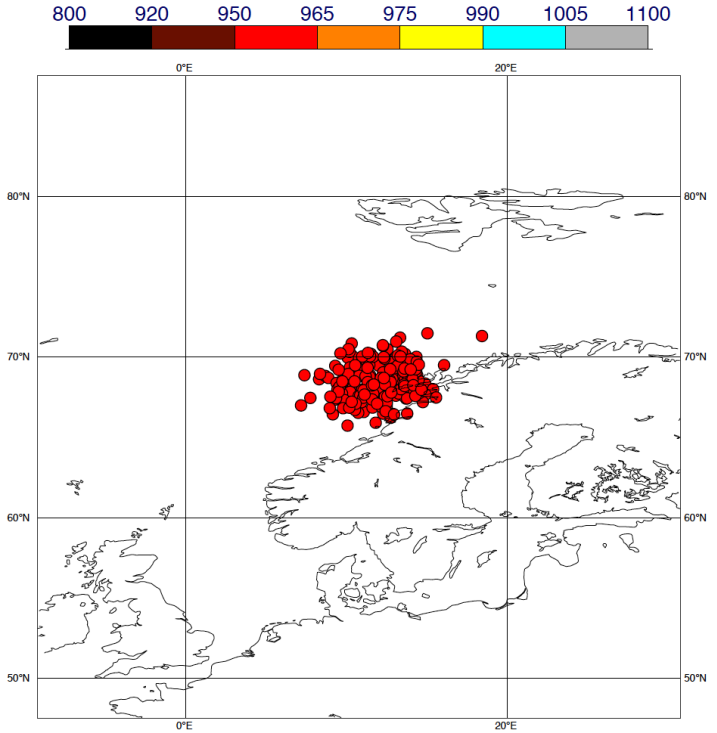


CPDN

Results from OpenIFS@Home test batches



Storm centres from ECMWF operational forecast (50 members)

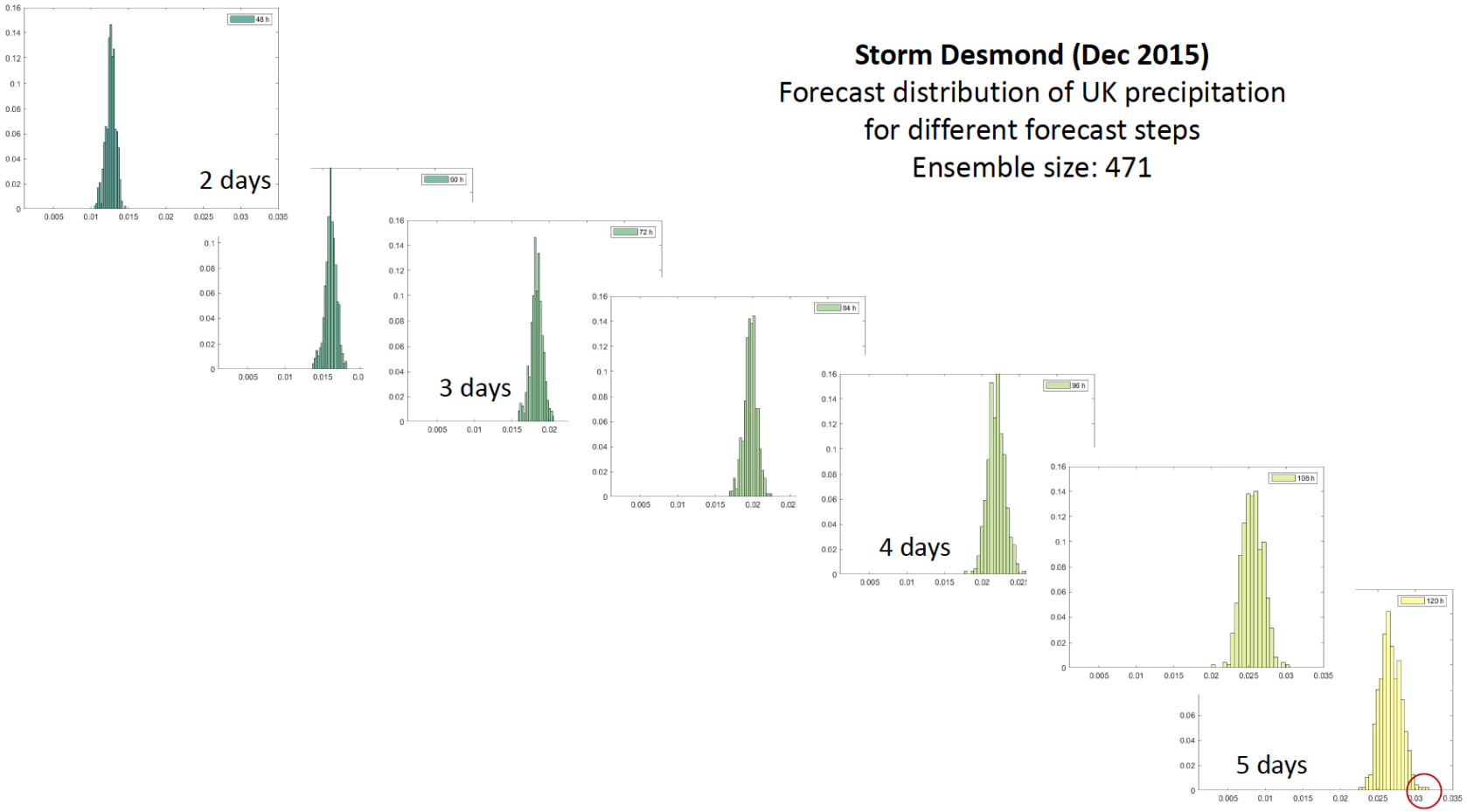


Storm centres from openifs@home forecasts (192 members)

Glenn Carver

CPDN

Results from OpenIFS@Home test batches



Storm Desmond (Dec 2015)
Forecast distribution of UK precipitation
for different forecast steps
Ensemble size: 471

Antje Weisheimer

CPDN

New experiment types enabled

Large ensembles will be used to study the predictability of weather forecasts especially for high impact extreme weather.

Interesting past weather and climate events will be explored by testing sensitivities to physical parameter choices in the model.

Large ensemble simulations will help study probabilistic forecasts in a chaotic atmospheric flow and reduce uncertainties due to nonlinear interactions.

Current experiments performed with OpenIFS should be possible to run in OpenIFS@home provided certain resource constraints are met.

CPDN

How to use OpenIFS@Home

Contact CPDN Team

- Register for account.
- Discuss overall experimental idea with team in Oxford
- Understand cost implications including generated data final destination.

Detailed Experimental Design

- Ancillaries – either reuse existing or work with ECMWF OpenIFS team to create new.
- Check data volumes returned of successful simulations.

Prepare to submit

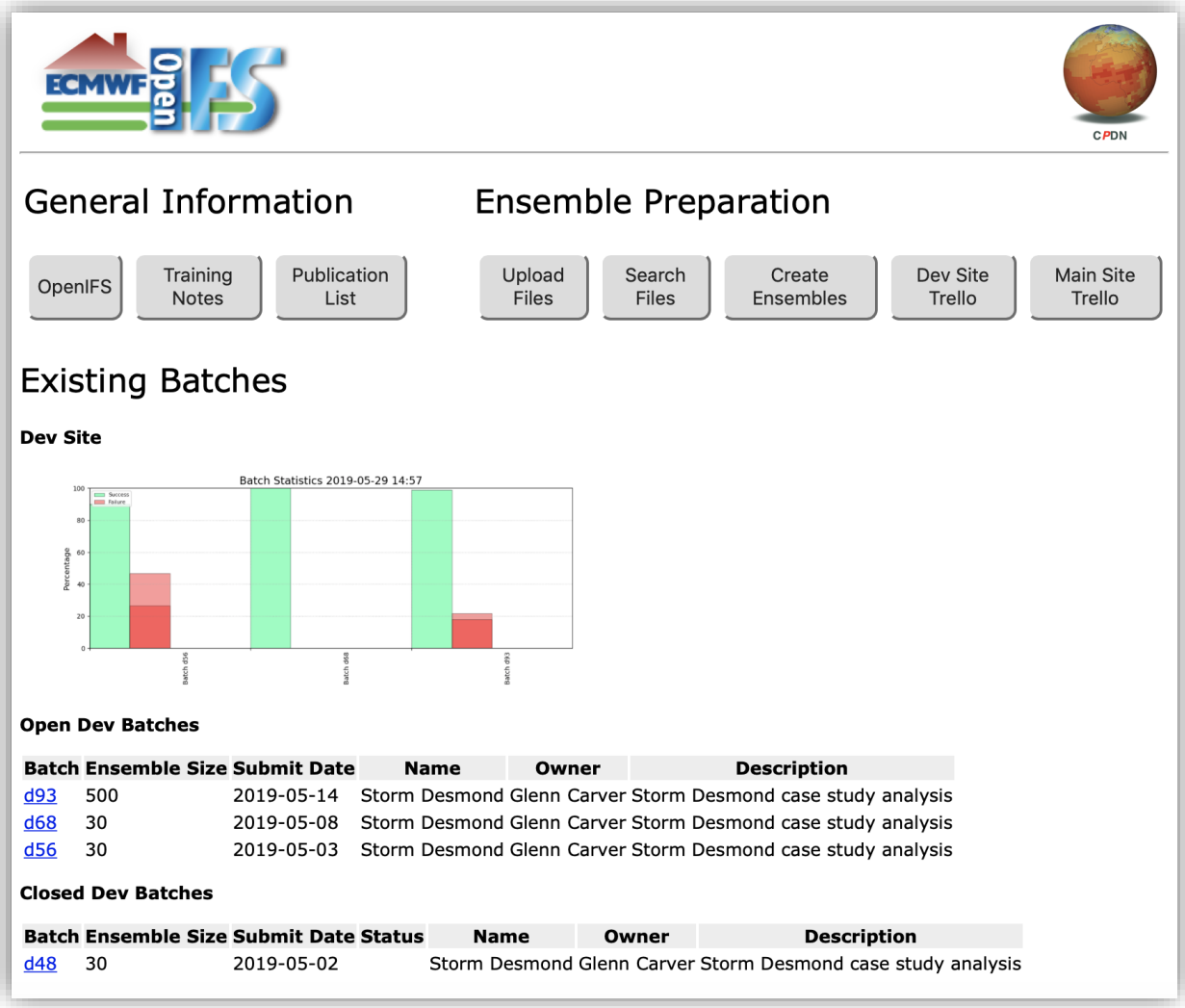
- Create experiment definition.
- Upload to CPDN team repository
- Final submission by CPDN Team
- Wait for workunits to return successful simulations

CPDN

OpenIFS Dashboard

The OpenIFS@home dashboard is a single entry point for scientists to:

- **upload** new files to the repository.
- **search** existing files held in the repository.
- **create** ensembles.
- **notify** CPDN team that ensembles are ready for submission.
- **monitor** batch progress (drill down on batch numbers for more detail).
- **view and record** publications.
- **access** OpenIFS documentation and training notes.



https://dev.cpdn.org/oifs_dashboard.php

CPDN

Live Launch

Key Points:

- Ensemble initial conditions created using ECMWF's operational system that creates a number of starting analyses.
- First a combination of the 'ensemble data assimilation' system creates alternate starting analyses.
- Further perturbations to these are created by computing and applying 'singular vectors' which represent a measure of the fastest growing modes in the atmospheric state.
- A linear combination of these singular vectors is then applied with to create as many initial states as we care to.
- In this experiment we created 250 initial states with a combination of the ensemble data assimilation and singular vectors.
- To each of these runs we then apply the model's stochastic physics perturbations whilst the model is running.
- Allows us to explore the forecast uncertainty.

CPDN

File Name: Case Study/Description: Type: Select... Sub type: Select... Start Date: ECMWF exptid: Search

File name	Creation date	Created by	Description	Type	Sub type	Model version	Exptid	Starting analysis	Analysis number	Start date	End date	Horizontal resolution	Vertical resolution
CFC.zip	2019-05-29	Sarah Sparrow	Standard greenhouse gas files to use with release 40r1	ifsdata	CFC_files	40r1							
climate_data.zip	2019-05-29	Sarah Sparrow	Standard ozone climate data files to use with 40r1	climate_data		40r1							
h6sp.nml	2019-05-14	Marcus Koehler	NAWDEX TC Karl for OpenIFS Workshop 2019	fullpos_namelist		40r1							
h6uc_namfpc.nml	2019-05-13	Glenn	Storm Desmond case study T159L50 ERA5 starting analyses Experiment id: h6uc Text file.	fullpos_namelist		40r1							
ic_h6sp_2016092500_000.zip	2019-05-14	Marcus Koehler	NAWDEX TC Karl for OpenIFS Workshop 2019	ic_ancil		40r1	h6sp	ERA5	000	2016092500	2016100512	T159N80	L60
ic_h6uc_2015120312_000.zip	2019-05-13	Glenn	Storm Desmond case study T159L50 ERA5 starting analyses Experiment id: h6uc Prepared on ECMWF system. No starting ensemble (single member) Inventory: h6uc/ h6uc/2015120312/ h6uc/2015120312/ICMCLh6ucINIT h6uc/2015120312/wam_grid_tables h6uc/2015120312/sfcwindin h6uc/2015120312/wam_subgrid_0 h6uc/2015120312/cdwavein h6uc/2015120312/ICMSHh6ucINIT h6uc/2015120312/wam_subgrid_2 h6uc/2015120312/specwavein h6uc/2015120312/uwavein h6uc/2015120312/ICMGGh6ucINIUA h6uc/2015120312/ICMGGh6ucINIT h6uc/2015120312/wam_subgrid_1 md5sum: 730805805292d571793d132634daedb8 h6uc.tgz	ic_ancil		40r1	h6uc	ERA5	000	2015120312	2015120912	T159N80	L60
ic_h76y_2016092500_000.zip	2019-06-17	Glenn Carver	OpenIFS workshop tropical cyclone Karl case study. 2016092500 start. 250 members. IMPORTANTtail -200 oifs_upload_handler.php ! These initial data files require a non-standard fort.4 model namelist. There are a number of sqitches that need changing. Disabling the wave model is one, but there	ic_ancil		40r1	h76y	Operational	000	2016092500	2016111500	T159N80	L60

To generate a submission xml enter the following information about your experiment file(s).

Sarah Sparrow is logged in

Use comma separated lists to enter mutliple values of fields (e.g. start date and batch owner) if required.

Batch Information

Batch Project:	OpenIFS@HOME
Batch Name:	Tropical Cyclone Karl Workshop
Batch Description:	Tropical Cyclone Karl OpenIFS@home launch experiment
Batch Owner(s) as Name (e-mail):	Glenn Carver (Glenn.Carver@ecmwf.int), Sarah Sparrow (sarah.sparrow@oerc.ox.ac.uk)
Batch Technical Information:	TC Karl with 250 analysis members and 8 ensemble member numbers using Prikka's initial conditions.

Model Configuration Details

Model Class:	openifs
Model Configuration File:	40r1_T159_TC_Karl.xml

Ensemble Setup

Start date(s) as YYYYMMDDHH:	2016092500
Starting UMID:	k000
Number of analyses (per start date):	250
Number of ensemble members (per analysis):	8
Starting ensemble member number:	1
Upload Location:	Dev

Ensemble Configuration

ECMWF Experiment ID:	h76y
Forecast Length:	6 Days
FullPos Namelist File:	namfpc-oifs-workshop2019-tc-karl.nml

IFS data

SO4 File:	SO4.zip
Radiation File:	radiation.zip
CFC File:	CFC.zip

Climate Data

Climate Data File:	climate_data.zip

Create

CPDN

Sarah Sparrow is logged in
Form was submitted, here are the form values:

```
Array
(
    [BatchProj] => OpenIFS@HOME
    [BatchName] => Tropical Cyclone Karl Workshop
    [BatchDesc] => Tropical Cyclone Karl OpenIFS@home launch experiment
    [BatchOwner] => Glenn Carver (Glenn.Carver@ecmwf.int), Sarah Sparrow (sarah.sparrow@oerc.ox.ac.uk)
    [BatchTechInfo] => TC Karl with 250 analysis members and 8 ensemble member numbers using Prikka's initial conditions.
    [model_class] => openifs
    [model_config] => 40r1_T159_TC_Karl.xml
    [start_dates] => 2016092500
    [start_umid] => k000
    [n_analysis] => 250
    [n_ens] => 8
    [s_ens] => 1
    [upload_loc] => dev
    [exptid] => h76y
    [fclen] => 6
    [fclen_units] => days
    [fullpos_namelist] => namfpc-oifs-workshop2019-tc-karl.nml
    [SO4_file] => SO4.zip
    [Rad_file] => radiation.zip
    [CFC_file] => CFC.zip
    [climate_data_file] => climate_data.zip
    [submit] => Create
)

Creating experiments...
Writing to: wu_oifs_TropicalCycloneKarlWorkshop_k000_k1jj_20190618-104826.xml ...
Number of workunits:  2000
Done!
```

CPDN

Future development of OpenIFS@home

- Adapting OpenIFS to run attribution experiments including climate science relevant length workunits
- OpenIFS on Windows
- Include slab ocean*
- Possible incorporation of HTESSEL *

CPDN

Future Large Ensemble Multi-Model Studies

Adding OpenIFS to CPDN will enable very large ensembles of different models to run under a single framework.

Multi-model large ensembles of extreme weather events occurring around the globe will be available for subsequent impact studies.

Not only will large initial conditions ensembles be possible, but also large multi-model perturbed parameter experiments. Comparing results across multiple models could provide valuable insight into fundamental model processes and guide future model development.

CPDN

Conclusion

- New capability for researchers using OpenIFS, successfully porting cycle 40r1 into CPDN,
- Produced large test ensemble beyond normal OpenIFS scales studying Storm Desmond for validation,
- Planing for future development to introduce enhancements and updates.

CPDN

Speak to the team about how you could make use of OpenIFS@Home!

In person today

or via

https://www.cpdn.org/cpdnboinc/oifs_contact.php

CPDN