Climate Change

A Copernicus Climate Change Operational Windstorm Service for the Insurance Sector

7th European Windstorm Workshop, Karlsruhe Institute of Technology
October 2018

Alan Whitelaw - CGI

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C o n t e n t s

Background

- Overview / status of C3S service in Copernicus context
- Climate Data Store (CDS), Toolbox and Sectoral Information
- Overview of WISC products and CDS portal integration

The Operational Windstorm Service

- ERA5 based storm tracks
- ERA5 storm footprints via statistical downscaling
  - Presentation and discussion of method
- Updated loss and risk estimates

Future Developments

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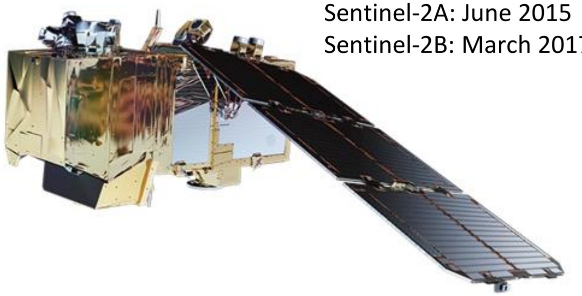
Copernicus: Sentinel Missions

Sentinel 1: Imaging Radar

Sentinel-1A: April 2014
Sentinel-1B: April 2016

Sentinel 2: HR Optical Imager

Sentinel-2A: June 2015
Sentinel-2B: March 2017

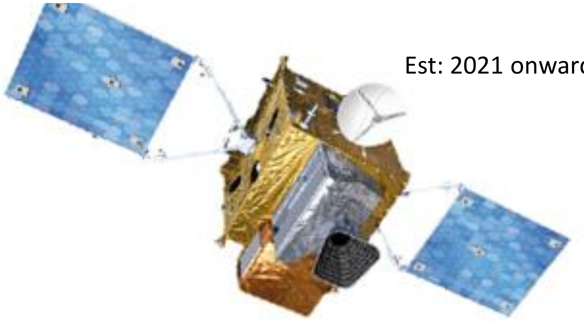


Sentinel 3: SST / Ocean Colour / RA

Sentinel-3A: February 2016
Sentinel-3B: April 2018

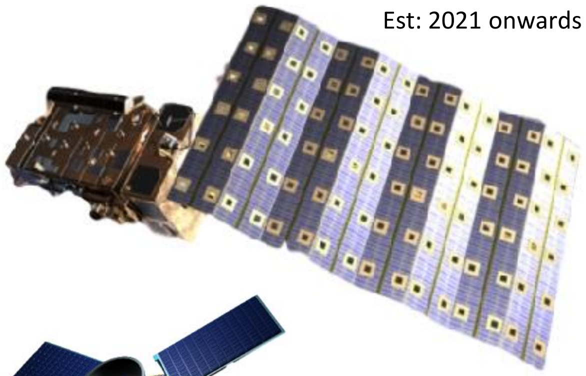
Sentinel 4: MTG Geo Atm Chem

Est: 2021 onwards



Sentinel 5: Metop SG Polar Atm Chem

Est: 2021 onwards



Sentinel 5P: Dedicated – OMI – O_3

5P: October 2017

Sentinel 6: Radar Altimetry

S6: Planned for launch in 2020

Sentinel 7….: CO_2 monitoring etc

DIAS – Data & Info Access Services

+ Copernicus Services:

- Atmosphere (CAMS)
- Marine Environment (CMEMS)
- Land (CLMS)
- Climate Change (C3S)
- Emergency Management (EMS)
- Security

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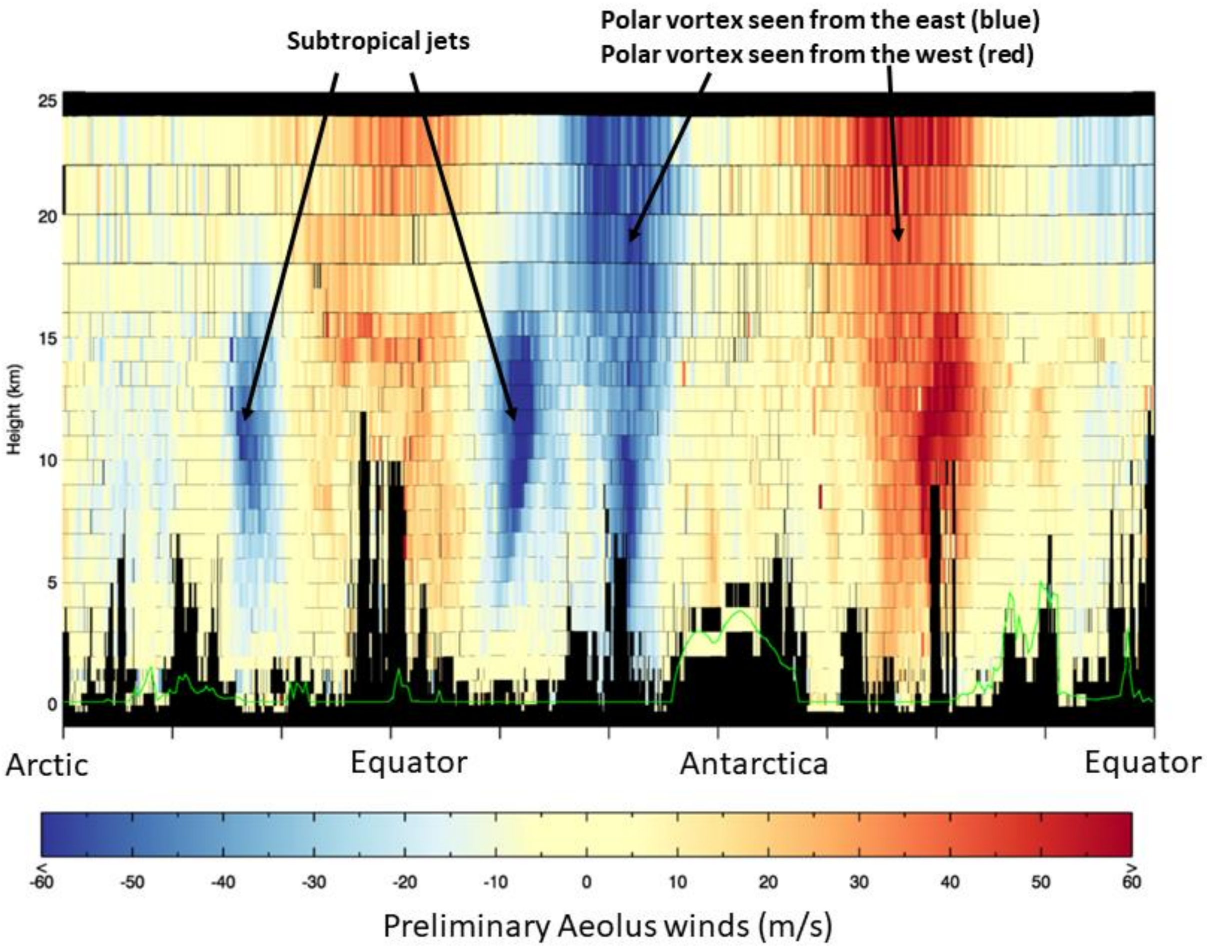
ADM Aeolus - ESA Earth Explorer mission

- Launched 22 August 2018
- Aeolus is the first satellite mission to acquire profiles of Earth's wind on a global scale.
- First wind data from ESA's Aeolus satellite from three quarters of one orbit around Earth.
- The image shows large-scale easterly and westerly winds between Earth's surface and the lower stratosphere, including jet streams.



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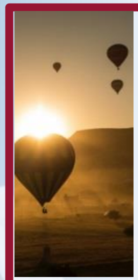
Copernicus Climate Change Service (C3S)



Observations

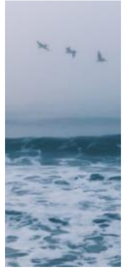
Observations are key to understanding the climate system. C3S users can access a vast variety of instrumental data records, ranging from historic weather observations to the latest measurements from space.

Climate reanalyses

Climate reanalyses combine past observations with models to generate consistent time series for a large set of climate variables. Reanalyses are among the most-used datasets in the geophysical sciences.

Seasonal forecasts

C3S seasonal forecasts combine outputs from several state-of-the-art seasonal prediction systems from providers in Europe and elsewhere. The latest data and products are published monthly on the Climate Data Store.



Climate projections

Projections of future climate change are available for different scenarios for concentrations of greenhouse gases and aerosols, based on outputs from multiple global and regional climate models.

Climate Data Store

Sectoral Information Services

Users / Stakeholders

Evaluation and Quality Control

- ***An authoritative source of climate information for Europe***
- ***Build upon massive European investments in science and technology***
- ***Enable the market for climate services***

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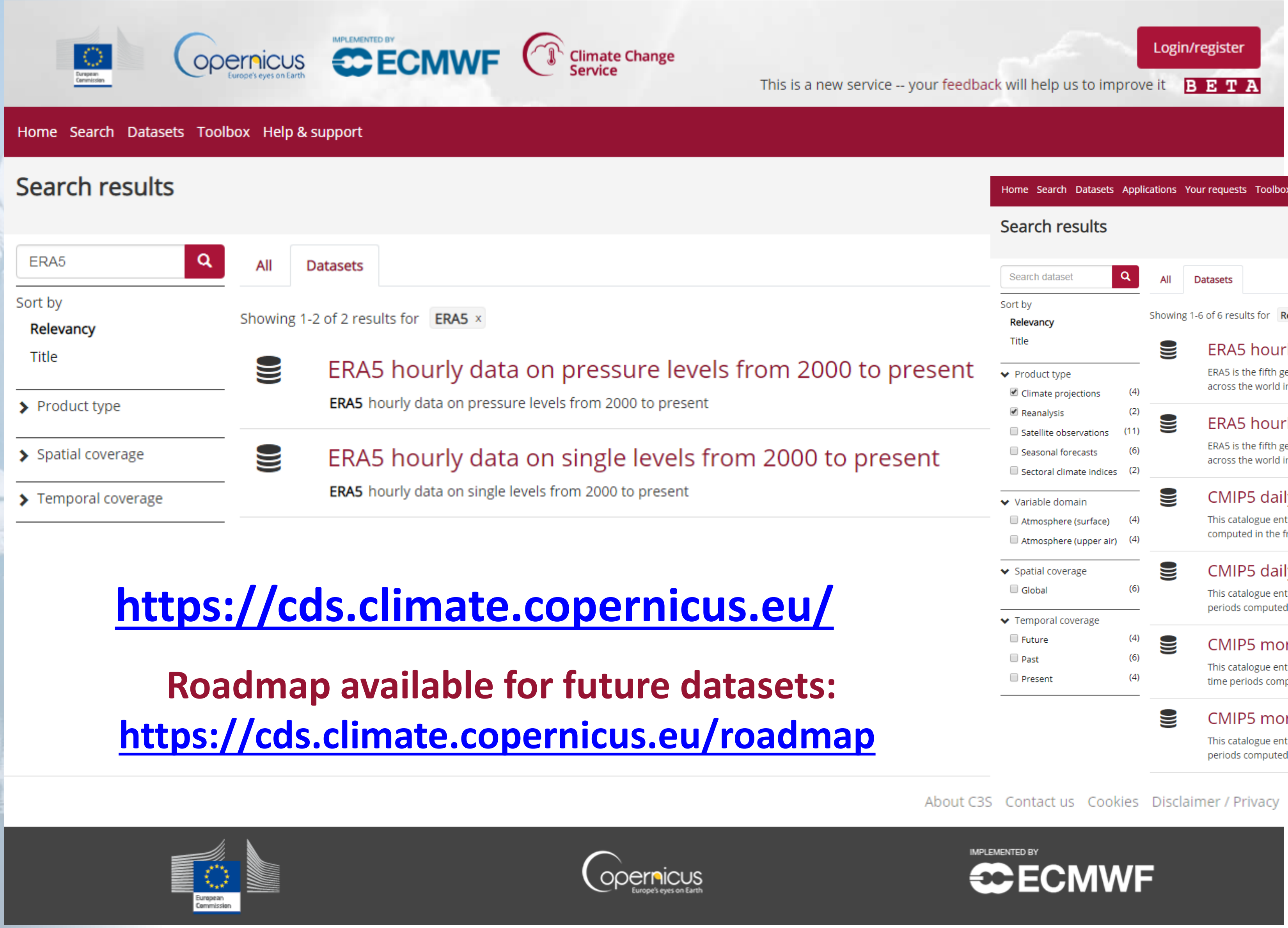
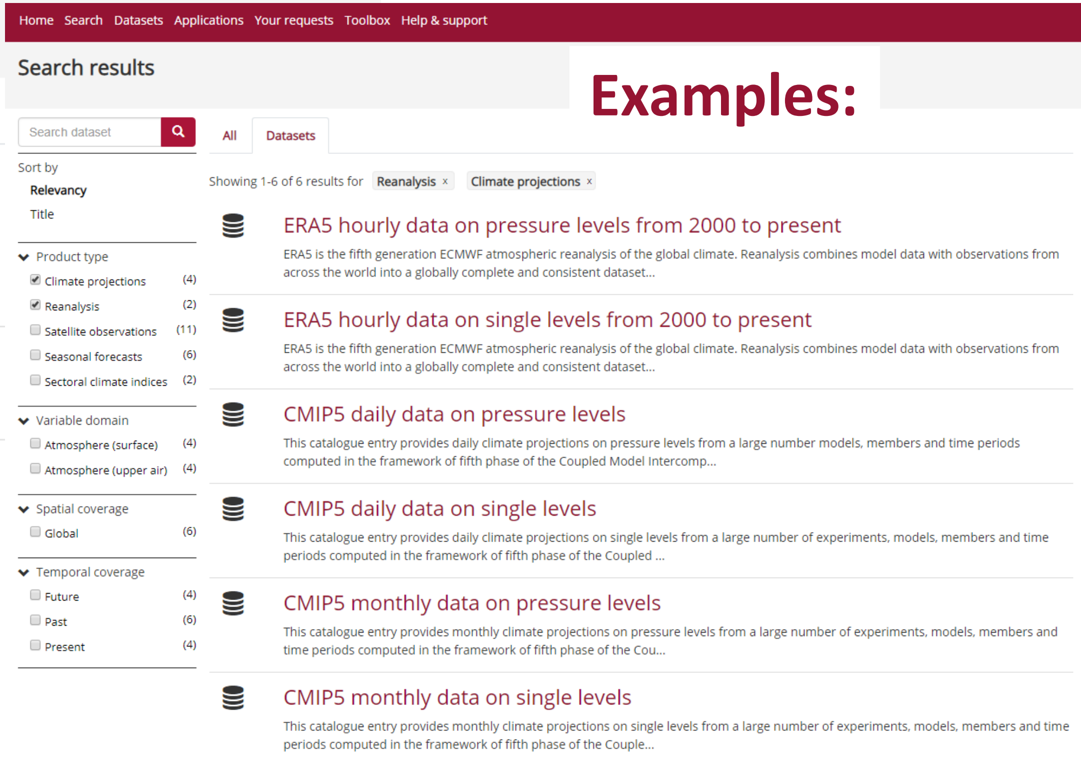
Climate Data Store (CDS) Example – ERA5





Examples:

https://cds.climate.copernicus.eu/

Roadmap available for future datasets:

https://cds.climate.copernicus.eu/roadmap

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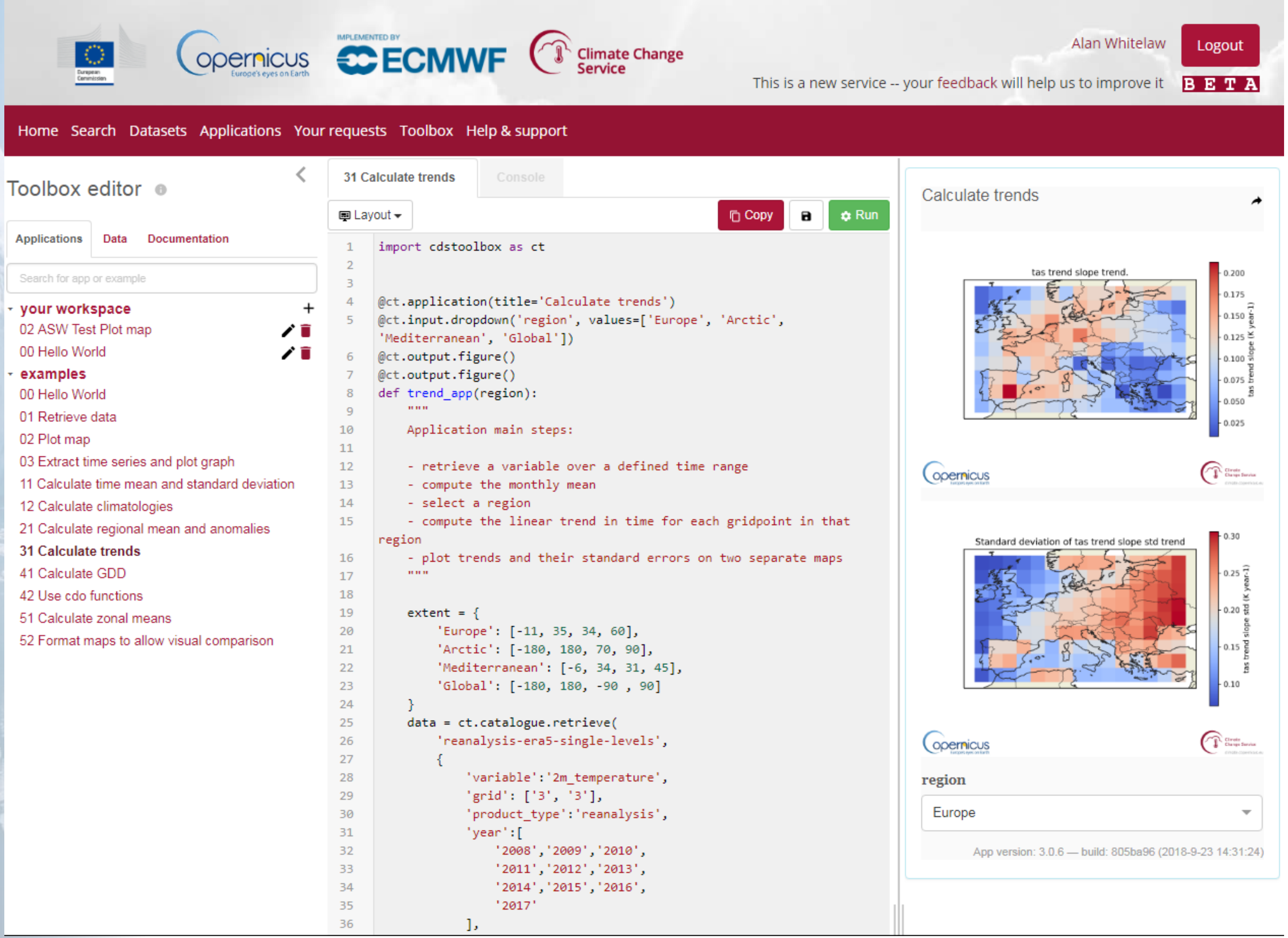
CDS Analysis - Toolbox



- Toolbox used by developers to create web-based applications that draw on CDS datasets
- Users control applications by interacting with web form elements – eg selection of a range of dates or geographical area of interest, which is then used to parameterise the application
- All computations executed within CDS infrastructure
- Data used by the applications do not leave the CDS, only results made available to users
- Results are typically tables, maps and graphs on the CDS data portal which can be downloaded.

https://cds.climate.copernicus.eu/user/login?destination=/toolbox-user

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C3S Sectoral Information Services (SIS)

Water management

We provide our users with the data and tools they need to prepare for climate variability and change in the water sector. For example our data services provide information on changes in river discharge, droughts and floods.

Agriculture and forestry

We use climate data to help the agricultural sector predict the climate-dependent variations in annual crop yield at the regional to global level. Our data have been used to assess how long-term variations in the climate may affect investment decisions for woody crops and forests.

Insurance

We support the insurance sector with data that identifies the historical occurrence of some specific extreme weather events, such as windstorms.

- SIS aim to develop and support user uptake in specific sectors.
- WISC was one of seven initial ‘Proof of Concept’ SIS projects covering insurance, water, energy, agriculture and urban sectors

Energy

We support the energy sector, which is increasingly relying on renewable energy production, by providing climate-related information, such as forecasts of air-temperature, atmospheric transparency, wind strength, and projections of wave size and frequency.

Infrastructure

We provide climate indicators that can be used to help build resilient cities able to mitigate the challenges that climate change pose to infrastructure.

Health

We provide access to high-resolution maps of temperature and heat-wave frequency for major urban centres across Europe. We also provide forecasts of the distributions of pollen and vector-borne diseases.

Coastal areas

Fisheries are an important part of the European economy. We provide information on the future distribution of key ocean variables and their impacts on the aquatic ecosystem, including species distribution and possible changes in fish stocks.

Transport

We use seasonal predictions and climate projections to inform shipping companies of new opportunities and hazards using up-to-date climatologies and future trends in key climate variables such as winds, waves and sea-ice.

Tourism

The warming climate has the potential to significantly affect the appeal of tourist destinations. Working with experts we provide indicators able to inform personal and business decisions on seasonal and multi-decadal time-scales.

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Insurance Service Status in CDS context

WISC Status

- Tracks, footprints, event set complete
- Tier 1 and Tier 3 indicators complete
- Case studies completed
- Portal – remains live

Operational updates:

- Regular periodic updates
  - Tracks
  - Footprints
- Revised Tier 3 data

ECVs / Sectoral Information Services
Stage 0/I - Proof of Concept/Pre-Operational
Stage II - Operational ~20 ECVs, ~5-6 Sectors
Stage III - Operational ~30 ECVs, ~10 Sectors

WISC Product Development

Operational

WISC Portal

Integration or transition to CDS

WISC and Operational ERA5 Products via CDS

CDS Operations

2014 2015 2016 2017 2018 2019 2020 2021

1st. Year

2nd. Year

Data Integration

C3S / CDS Progress

Stage 0/I

Stage II

Stage III

CDS Operational

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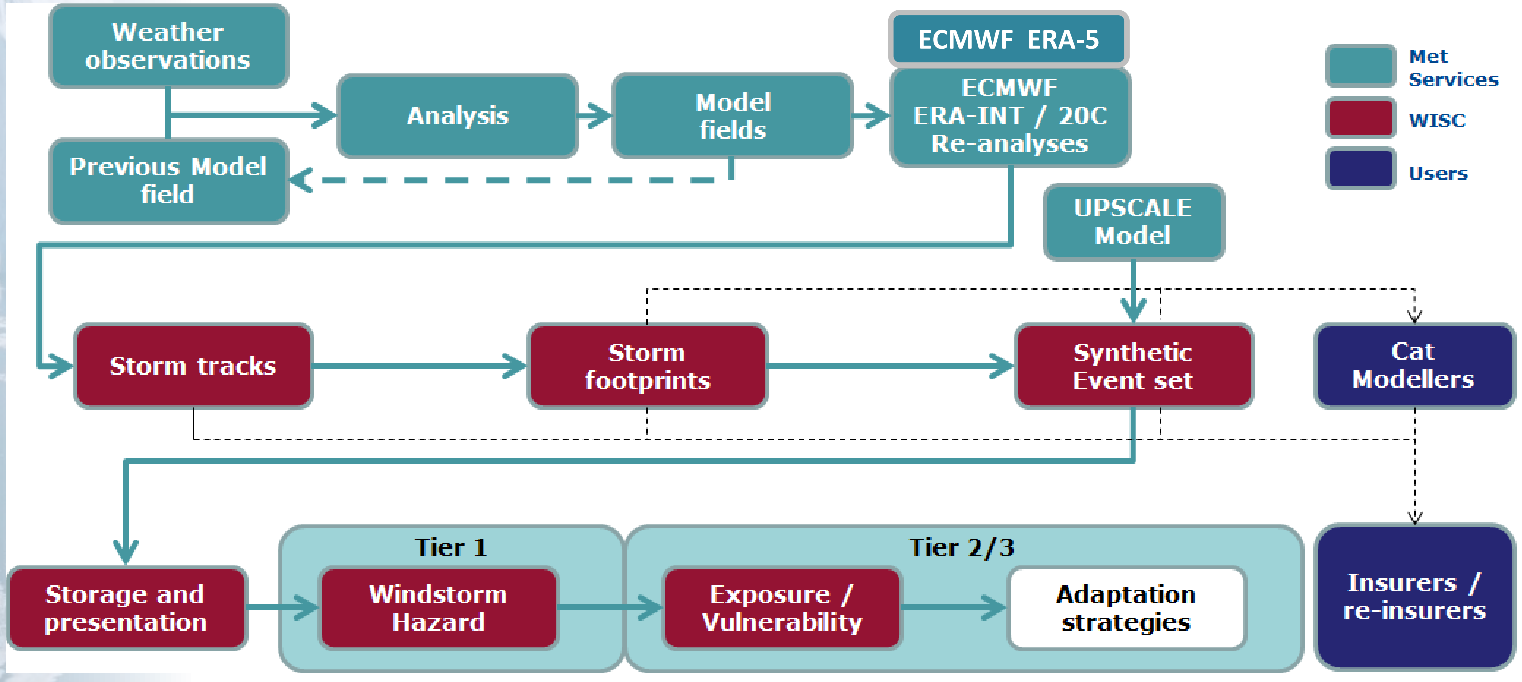
W I S C 2 0 1 6 t o 2 0 1 7

- The operational service will build on the existing WISC Proof of Concept (PoC) data which remain available from the C3S Climate Data Store
- The WISC logic and data are summarised below:

Approach and outputs:



Team:

CGI Experience the commitment®
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OASIS
University of Reading
Swiss Re
ETH zürich
Koninklijk Nederlands Meteorologisch Instituut Ministerie van Infrastructuur en Milieu
VU University Amsterdam
Met Office

Products	Temporal coverage
Historical Storm Tracks	1900 to 1979 (ERA-20C) 1979 to 2016 (ERA-INT) 2010 to 2016 (ERA-5)
Historical Storm Footprints	53 ERA-Int and 95 ERA-20C: 1940 to 2016 (ERA-20C / ERA-INT) 2010 to 2016 (ERA-5 sample)
Synthetic Event Set	22,800 significant storm events
Historic Indicators (Tier 1)	Number of Windstorms 1940 to 2015
	Ave Max Wind Speed 1940 to 2015
	Average Storm Severity 1940 to 2015
	Decadal variability 1940 to 2015
Historic Indicators (Tier 3)	Total Sectoral Insured Losses; 1990 to 2015
	Total Windstorm Risk per Sector; 1990 to 2015

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WISC: Storm Track and Footprint Summary

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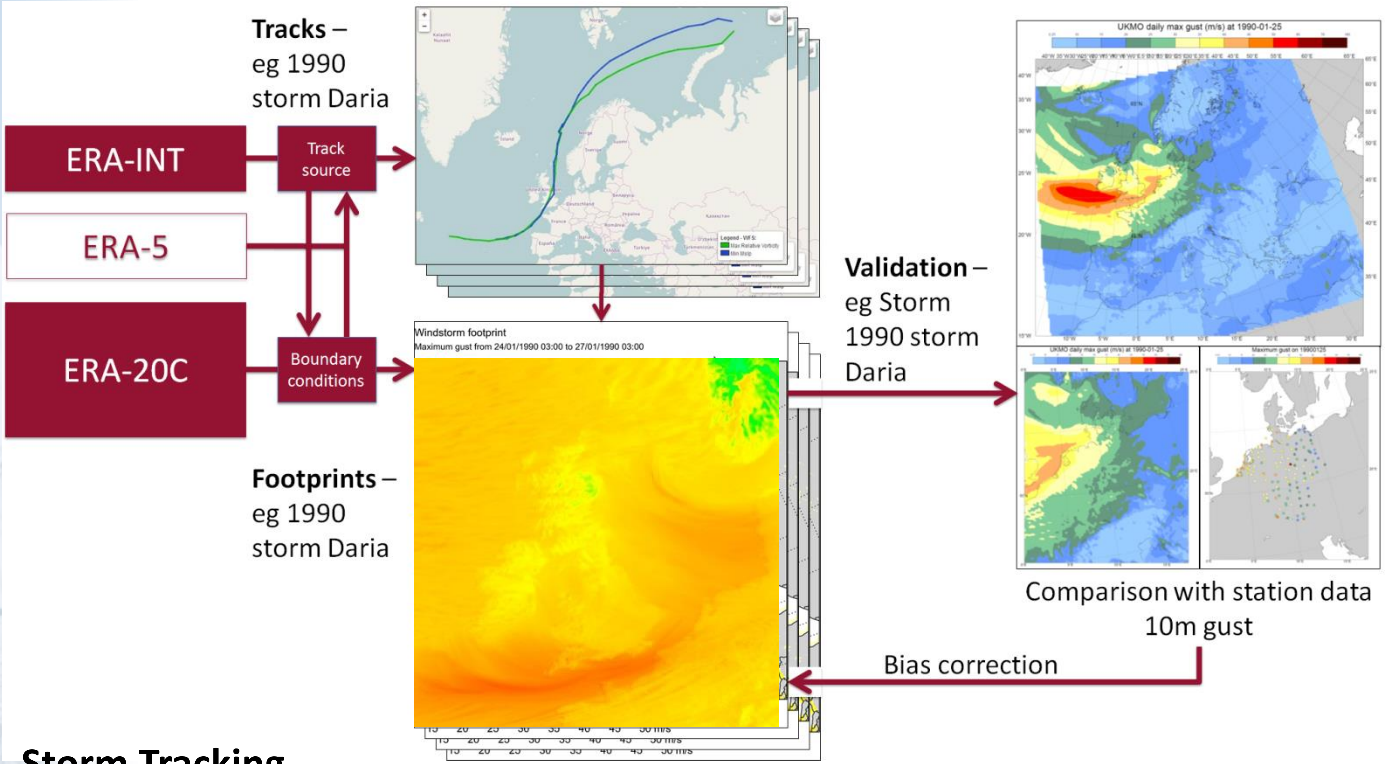

Storm Tracking

Hodges (1994,1995) tracking algorithm

- Based on 850hPa relative vorticity at T42 resolution
- Vorticity centres used to calculate trajectory of individual extra-tropical cyclones (cyclones north of 30N)

Extra fields referenced back to vorticity fields at full resolution at each timestep

- Minimum MSLP within 6 degrees of vorticity centre
- Maximum wind within 6 degrees of vorticity centre
- Maximum land-wind within 3 degrees of vorticity centre (XWS ranking metric)

Storm Footprint Downscaling

ERA-INT: 53 storms, ERA-20C: 95 storms

Event identification

- Extract data for +/- 36 hours from maximum wind value on track
- Select nearest 00:00 (12:00) as start time (ST)
- Where no track available, use user-specified start/peak date/time

Boundary conditions for UKMO Unified Model from ERA-INT / 20C between ST-6 and ST+30h

Remove ‘spin-up’ period (ST-6 to ST+0)

Repeat 3 or 4 times

Concatenate into 72-hour footprint

Output as appropriate (geo-referenced and NetCDF)

Sample ERA5 tracks & footprints

- Three storms from initial 2010 to 2016 ERA5 set
- Examination of ensemble spreads

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W I S C T i e r 1 I n d i c a t o r s - E x a m p l e s

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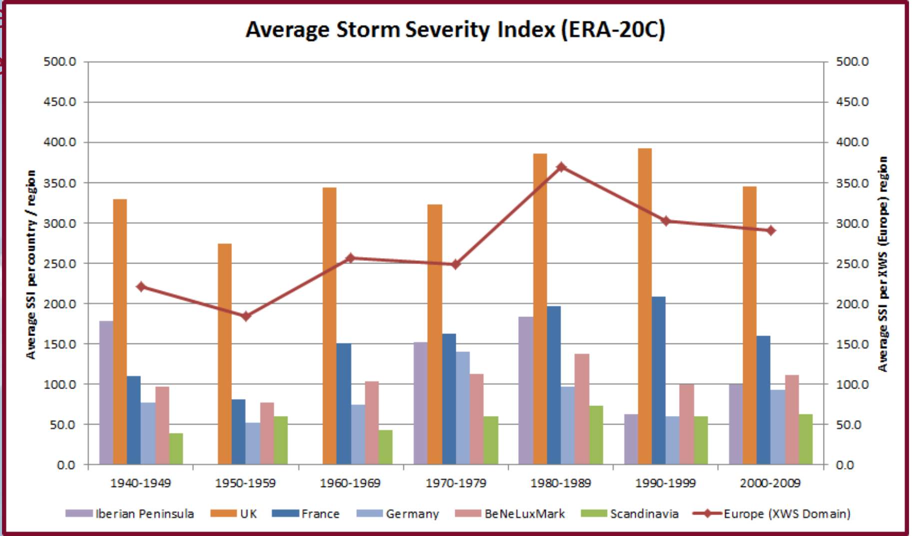
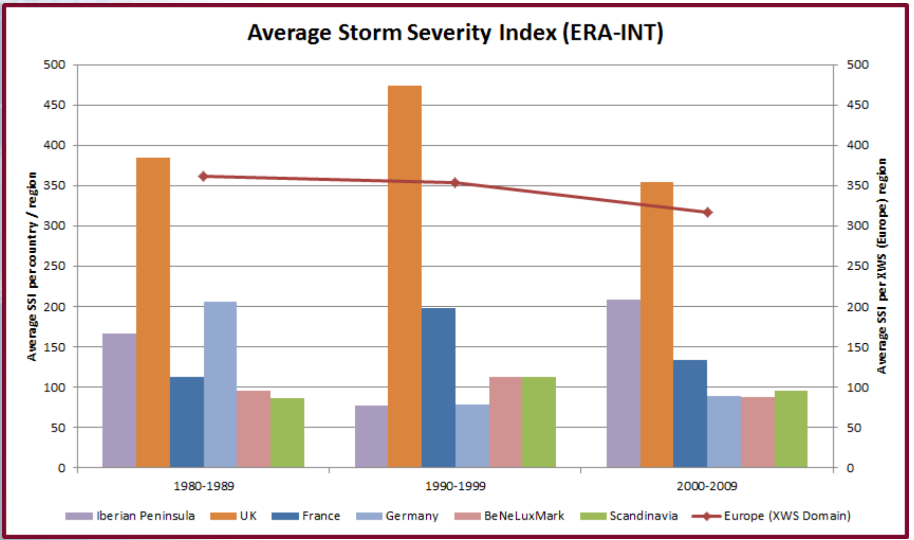
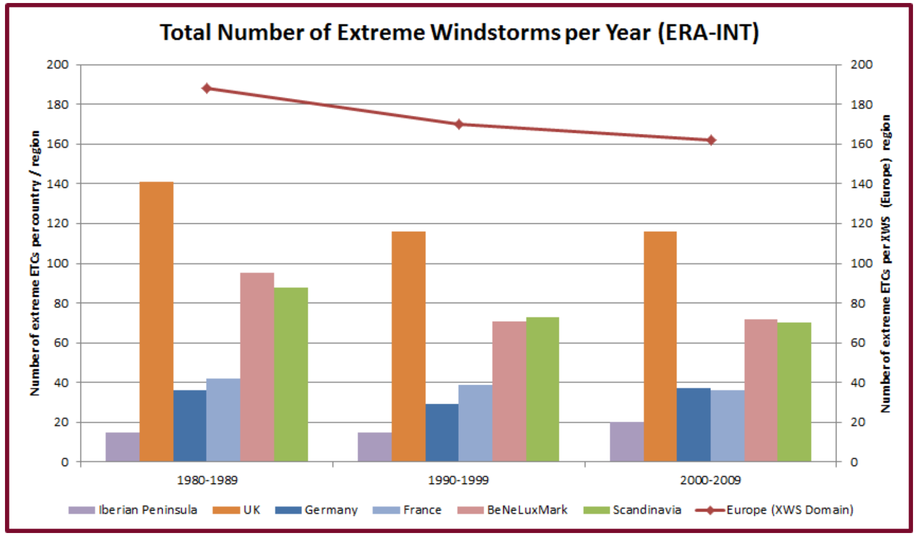
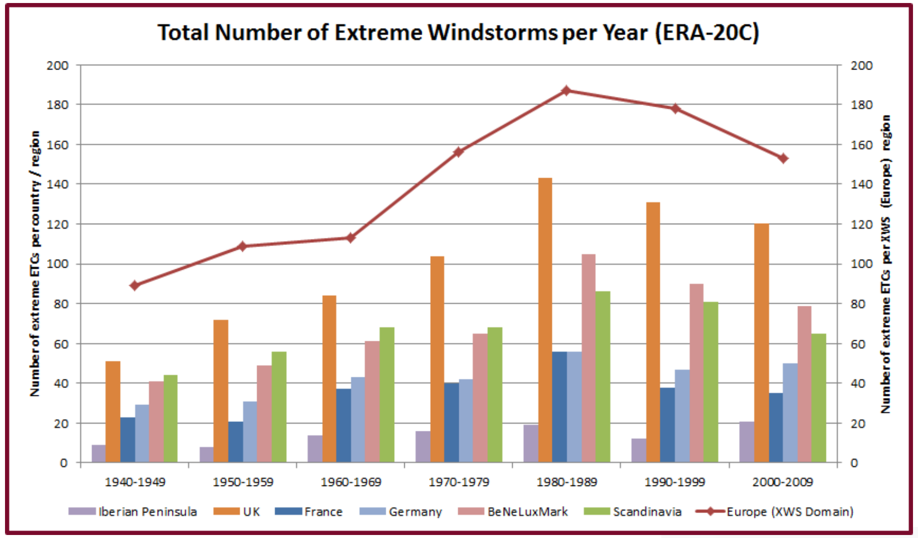


The SSI is defined as: $SSI = A \ast [mean(u10m > threshold)]3$
A: area over land in km2; $u10m$ is 10m wind speed from re-analysis
Cf Dawkins et al., (2016), with threshold of 10m wind speed used.







Vorticity threshold was $1x10^{-5}s^{-1}$ and tracks required to exist for at least 2 days & travelled at least 1,000km.

Track must also have associated 3-hourly land only 10m wind speed over region greater than an ‘extreme’ threshold, here equivalent to 10m wind of 25m/s - ie 13.4m/s for ERA20C & 15.6m/s for ERA-Interim.

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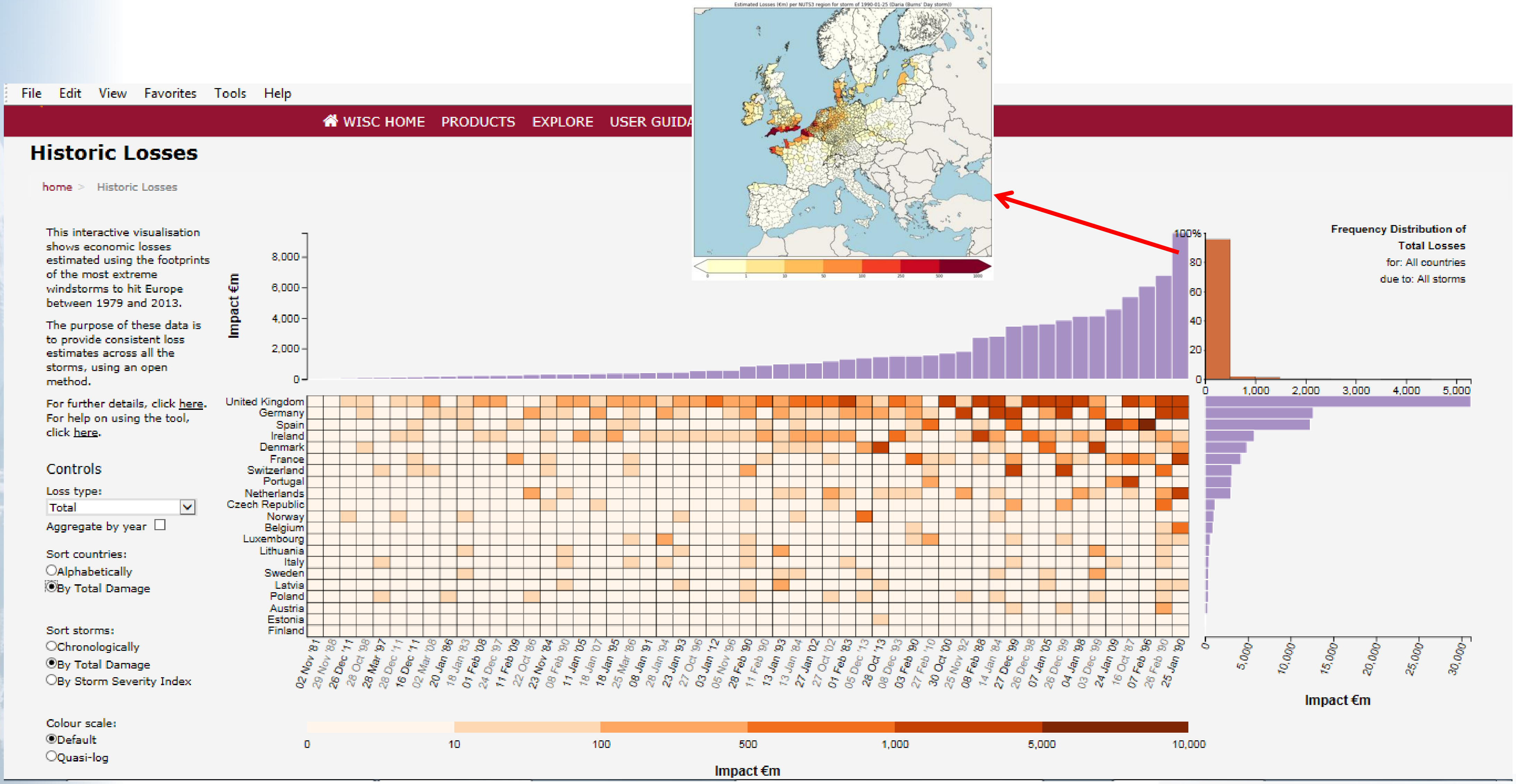
WISC Tier 3 – Risk and Loss overview



Will be updated with new ERA5 footprint data; Basic 'building block' data still available

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W I S C - E x t e n d e d E v e n t S e t

- The model contributing the event set is taken from the UPSCALE project which gives an ensemble of weather-resolving simulations from the **Met Office HadGEM3 Global Atmosphere 3 (GA3)**
- Simulations cover the period from **1985 to 2011** over a grid equivalent to 25 km at 50°N covering the lower 85 km of the Earth's atmosphere.
- Each ensemble member is initialized from one of five consecutive days, starting in February 1985, following a five year model spin-up.
- **In total, the model provides roughly 130 years of data.**
- **Original WISC synthetic event set** considered too small (7,660 storms) following trials / use by Insurers as well as OASIS
- Event set reanalysed to identify how the methodology used might be limiting the representation of extreme events
- **Combined new synthetic set of 22,980 storms** with improved extremes
- Two new elements of the event set were developed in addition to the original (synthetic set 1) as follows:
  - **Synthetic set 1:** downscaled against the cumulative distribution function (CDF) of named events Xynthia, Kyrill, Daria and 87J
  - **Synthetic set 2:** A storm severity index combining maximum wind gust speed and land area above a threshold of 25 m/s was used to select strongest six events from the Met Office historical events database.
  - **Synthetic set 3:** Downscaling based on station observations from the four named storms used for set 1.
- This event set remains available on the CDS portal
- This new set was also ingested into OASIS and provided on request to existing users

WISC Products – Existing Data Access

PROOF OF CONCEPT

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WISC products

home > Products

The WISC project has generated a range of windstorm products tailored for the insurance sector. This page describes the nature of these products, including methodology, format and provides access. The WISC products include:

- Storm Tracks
- Storm Footprints
- Synthetic Event Set
- Tier 1 Indicators
- Tier 3 Indicators
- Case Studies

Extreme Windstorms

As with the predecessor project (Extreme Windstorms Catalogue [XWS]), WISC focuses on monitoring windstorms that have hit Europe. Most of the damaging windstorms in Europe are Extra Tropical Cyclones (ETC): synoptic-scale (~1000 km) low pressure systems, which grow from unstable frontal waves (Eady 1949, Shapiro & Keyser 1990). In order for these systems to grow, a strong north-south temperature gradient is needed, and a strongly baroclinic atmosphere. During the months October to March the North Atlantic Ocean satisfies these conditions, allowing extra-tropical cyclones to form (cyclogenesis) which travel eastwards towards Europe.

The path that these storms follow (storm track) tends to curve northwards (Hoskins & Hodges 2002), and so Iceland and northern European countries (e.g. the Faroe Islands, Ireland, the UK, and Scandinavia) are frequently hit. However, occasionally the storms can travel further southwards, for example when the jet stream is in a more southerly position (e.g. Liberato et al., 2013), affecting countries such as France, Germany, Portugal, and Spain.

High winds in Europe can also be a result of convective storms and cyclones formed in the Mediterranean basin (medicanes). However, these types of windstorm tend to be on a smaller scale and are not well captured by re-analysis data, so are not considered in this version of the catalogue.

https://wisc.climate.copernicus.eu/wisc/#/help/products

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Example for Event Set

Data Access

The full event set is approximately 45GB, which is considered too large for regular download as a single file. It is therefore provided as a collection of smaller files, which can be downloaded from the links below. The summary csv files provide maximum gust, mean gust and storm severity index (SSI) for each footprint. the .zip files contain the individual netCDF footprints for the three sub-datasets as described in the revised Event Set Description Document.

Summary files

Containing maximum gust, mean gust and storm severity index (SSI) for each synthetic event:

- eventset_v1.2_summary.csv
- eventset_v2_summary.csv
- eventset_v3_summary.csv

Original WISC synthetic Event Set

- calibrated_v1_0001_to_1600.zip
- calibrated_v1_1601_to_3200.zip
- calibrated_v1_3201_to_4800.zip
- calibrated_v1_4801_to_6400.zip
- calibrated_v1_6401_to_7660.zip

WISC Synthetic Event Set 2

- calibrated_v2_0001_to_1600.zip
- calibrated_v2_1601_to_3200.zip
- calibrated_v2_3201_to_4800.zip
- calibrated_v2_4801_to_6400.zip
- calibrated_v2_6401_to_7660.zip

WISC Synthetic Event Set 3

- calibrated_v3_0001_to_1600.zip
- calibrated_v3_1601_to_3200.zip
- calibrated_v3_3201_to_4800.zip
- calibrated_v3_4801_to_6400.zip
- calibrated_v3_6401_to_7660.zip

https://wisc.climate.copernicus.eu/wisc/#/help/products

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Evolution of the Operational Service

- **A Copernicus Climate Change Service (C3S) Sectoral Information Service (SIS) for Insurance**
  - **Proof of Concept** – 'WISC' – December 2015 to April 2018 CGI Lead
  - **Operational Service** – May 2018 onwards KNMI Lead

Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Milieu

- **Operational Service**
  - **Storm tracks and footprints from ERA5**:
    - New storm tracks and footprints to add to and complement those produced in WISC
    - Produced backwards in time as ERA5 is released, eventually to 1950
    - Produced forward in time for new storms as these are included in ERA5 updates
    - Tracking as used in the WISC Proof of Concept (Hodges 1995 method)
    - Statistical downscaling of storm footprints (compared to dynamic downscaling in WISC)
  - **Additional 'Tier 3' indicators** – risk and loss estimates
    - Updating with new storms and additional historical storms as provided in ERA5
  - **Integration of the WISC portal and data into the Climate Data Store (CDS)**
    - CDS now the main access point for WISC and Operational Storm and related Tier 3 data
    - Ease of access and integration with CDS analysis tools
  - **User engagement and on-going technical support**
  - **Consideration of expansion options for the insurance portfolio** (ie to hazards other than wind)

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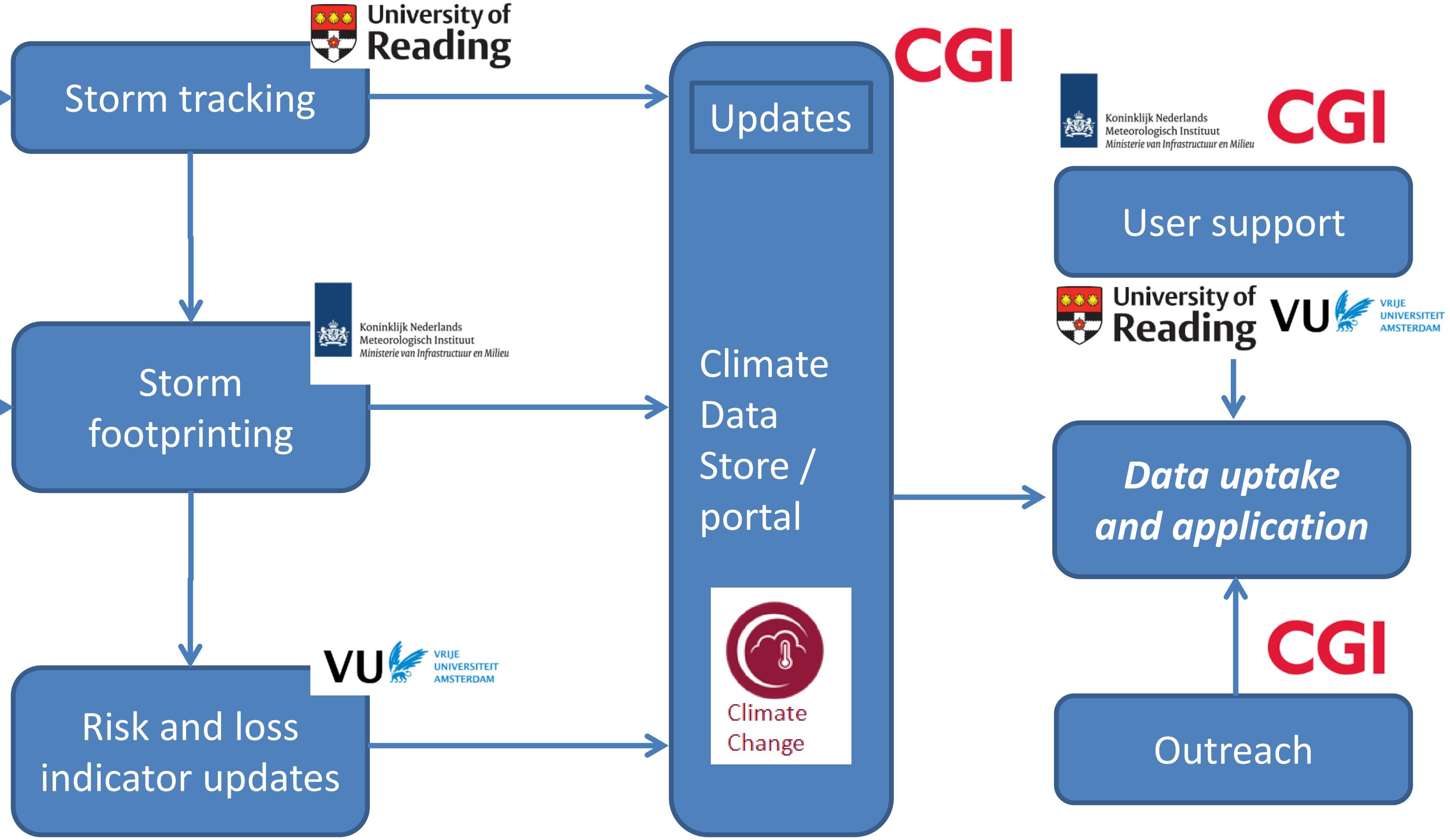
Operational Service Production and Access

ECMWF

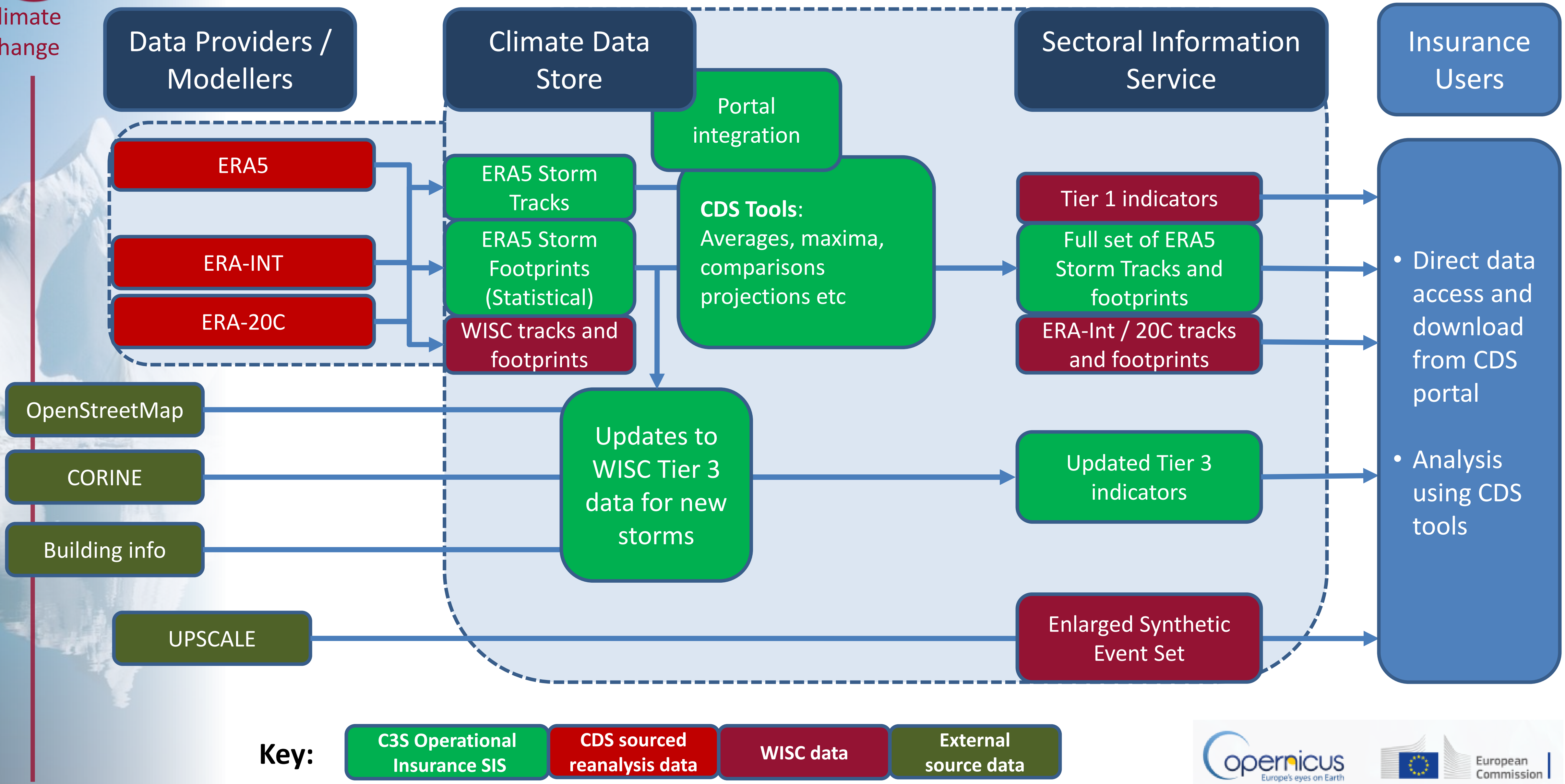
ERA5 input data

July 2017: **2010-2016**
Mar 2018: **2008-2009**
July 2018: **2000-2007**
End 2018: **1979-2000**
2019: **1950-1978**

Monthly updates provided with a delay of 2-3 months behind real time from Dec 2017 onwards



New Operational Service Elements



Operational vs WISC Source Comparison

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Proof of Concept (WISC): ERA-20C / Interim

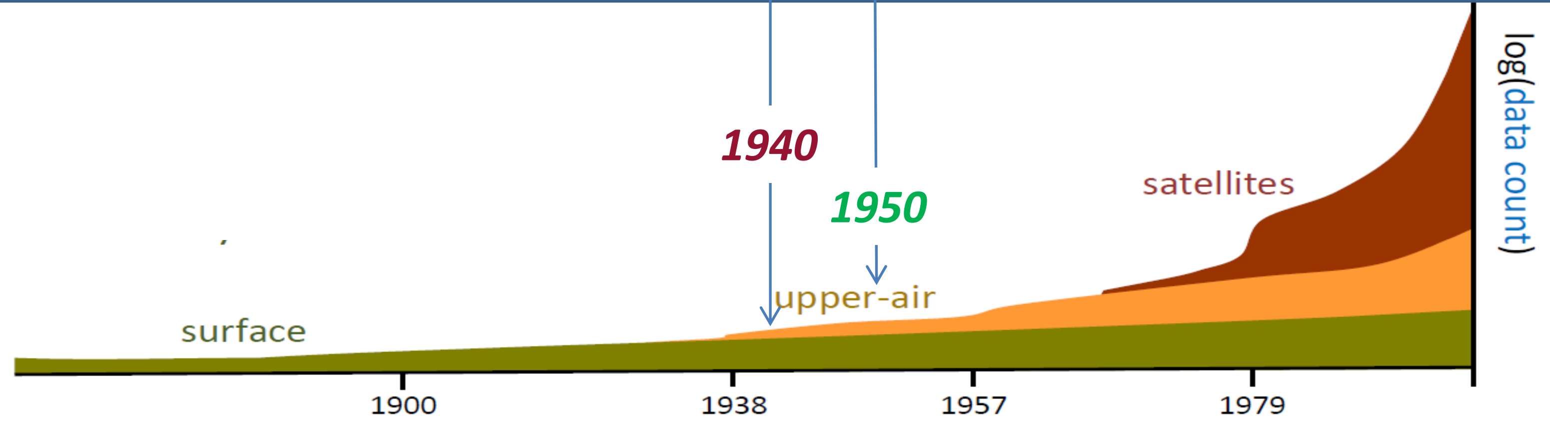
ERA5 - 3 storms

Operational Service: ERA5

Tracks (all storms); Footprints (key storms)

Comparisons for validation

Tracks & Footprints (All storms)



Timelines for the reanalysis datasets:

ERA-Int

ERA5 (when complete)

ERA-20C

PoC (WISC) Storm footprints:

- ERA-INT: 53 storms
- ERA-20C: 95 storms
- ERA5: 3 storms (incl ensembles)

Operational

- ERA5 full set (1950 onwards + new storms)

Native resolutions:

- ERA-20C: 125km / T159
- ERA-Interim: 80km / T255
- ERA5: 31km / T639

ERA5(Operational) vs ERA-Interim

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	ERA-Interim	ERA5
Period covered	**1979 - present**	**1950 - present**
Assimilation system	IFS Cycle 31r2 4D-Var	IFS Cycle 41r2 4D-Var
Spatial resolution	79 km globally, 60 levels to 0.1 hPa	**31 km globally**, 62km for the Ensemble of Data Assimilations (EDA), 137 levels to 0.01 hPa
Output frequency (temporal resolution)	6-hourly analysis fields Forecast fields on surface and pressure levels 3-hourly up to 24 hours, with reduced frequency up to 10 days	**Hourly analysis fields**, 3-hourly for the Ensembles Hourly forecast fields, 3-hourly for the Ensembles, up to 18 hours, with reduced frequency up to 10 days (not in initial release)
Uncertainty estimates	None	**10-member Ensemble of Data Assimilations (EDA)** at 63 km resolution
Model input	As in operations (inconsistent SST)	Appropriate for climate (e.g. CMIP5 greenhouse gases, volcanic eruptions, SST and sea-ice cover)
Input observations	As in ERA-40 and from Global Telecommunication System	Includes newly reprocessed datasets and recent instruments that not ingested in ERA-Interim
Variational bias scheme	Satellite radiances	Also ozone, aircraft and surface pressure data
Satellite data	RTTOV-7, clear-sky, 1D-VAR rainy radiances	RTTOV-11, all-sky for various components
New parameters	ERA-Interim contains ~100 parameters on surface and single level alone, plus parameters on other level types.	ERA5 contains over 240 parameters on surface and single level alone, + parameters on other level types.
Additional innovations		Long-term evolution of CO2 in RTTOV, cell-pressure correction SSU, improved bias correction for radiosondes, EDA perturbations for sea-ice cover

ERA-Interim was used as the main input to the WISC products while the Operational Service uses ERA5 as its main input.

Sources:

Hans Hersbach, Dick Dee, ***ERA5 reanalysis is in production***, ECMWF Newsletter No. 147, Spring 2016
Updated in https://confluence.ecmwf.int/pages/viewpage.action?pageId=74764925

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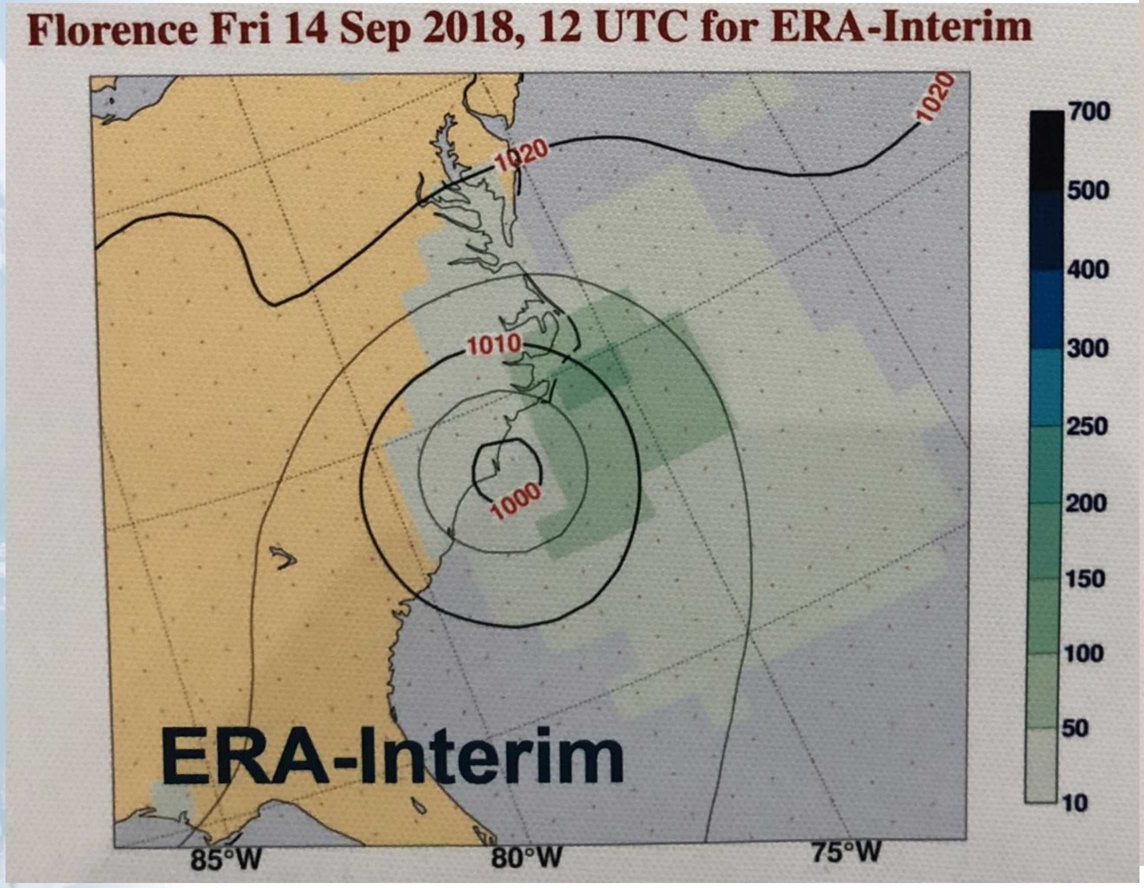
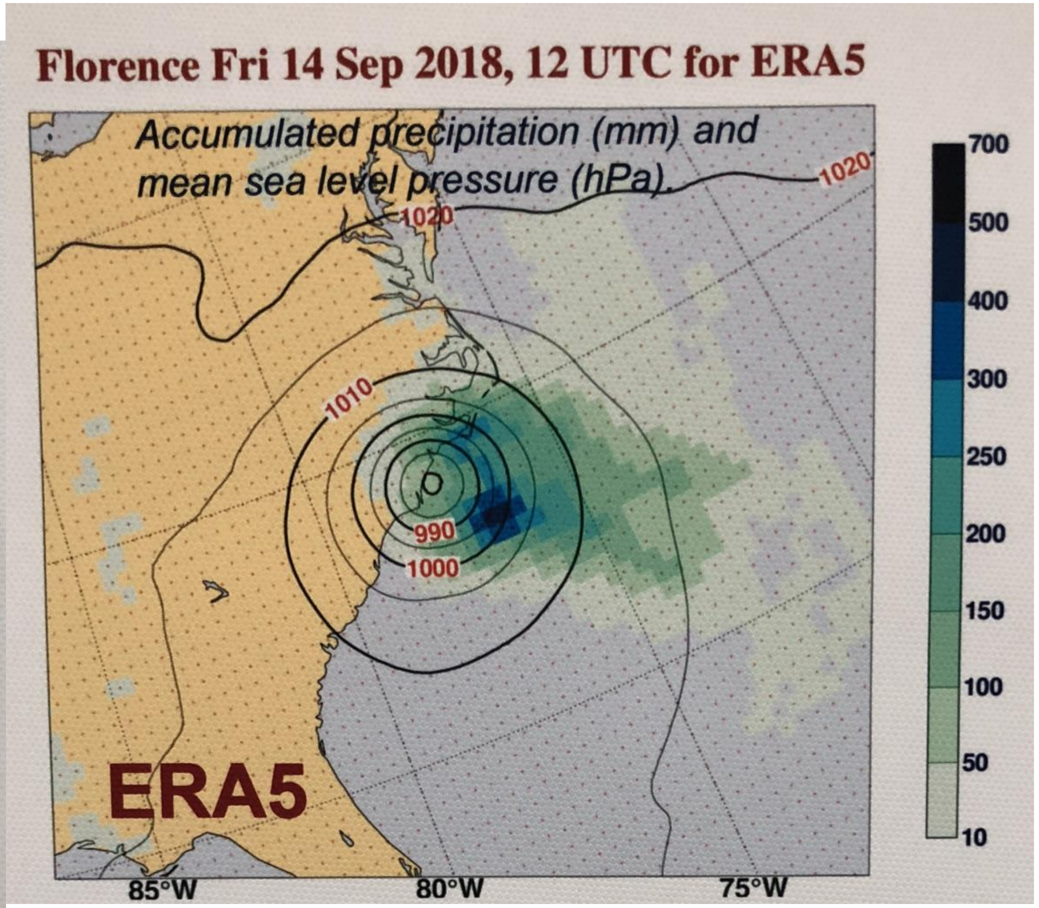
ERA5 vs ERA-Interim for Hurricane Florence





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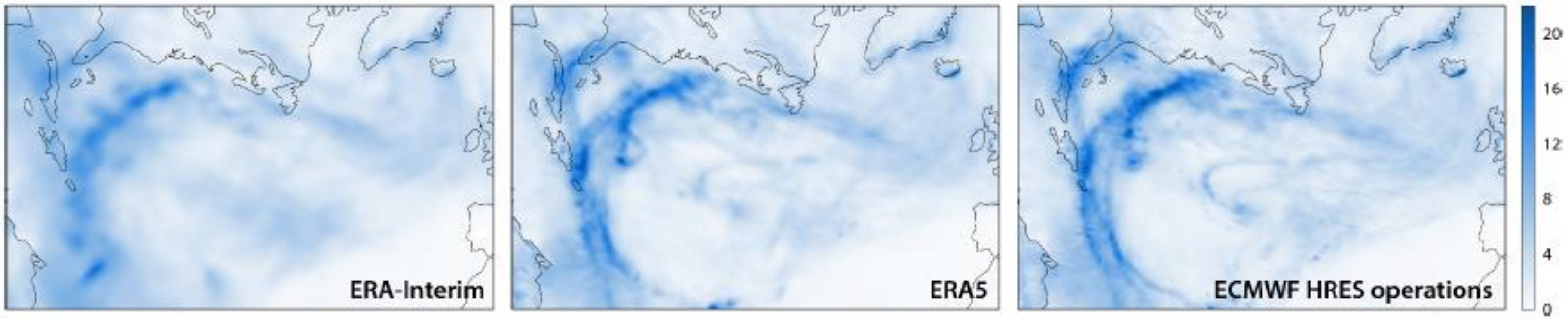
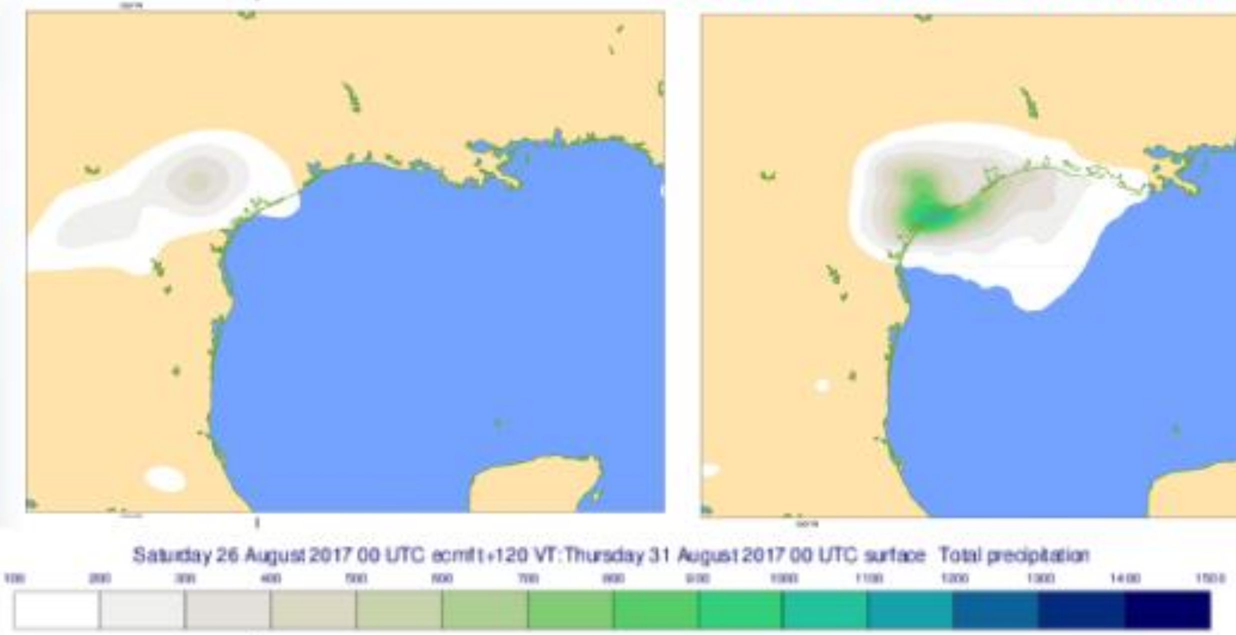
Horizontal resolution and depiction of tropical cyclones

Mean precipitation rate (mm/day) for September 2017



Horizontal resolutions: ~80km ~30km ~10km

5-day precipitation for Harvey



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Operational Approach – Tracks & Footprints

- **Storm tracks**
  - Uses same tracking method as PoC / WISC, ie Hodges (1994,1995)
  - Applied to ERA5 on release - ultimately 1950 forward + new
- **Storm Footprints**
  - Statistical downscaling, compared to dynamic for WISC (UKMO UM)
  - ERA5 native resolution is 31km with native 1 hour source
  - ERA-20C / Interim was:
    - Spatial: 125 / 80km to 4.4km
    - Temporal: 3 hour interpolated from 6 hour
  - Effects are averaged so emphasis on balancing minimising bias and errors while increasing the horizontal resolution
  - Method runs quickly so ERA5 data will be processed on release and updated as new storms are added to the ERA5 catalogue

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Statistical Downscaling – Overall Logic

- It can be shown that the maximum 3-sec gust in 10 minutes at 10m height (i.e., the WMO standard) during severe gales equals the average wind at ~150m
- This provides a straightforward application to estimate the gusts from model data, as the model supplies the wind at multiple vertical levels
- Advantages:
  - Over dynamical downscaling - no time-consuming reruns have to be done, data from ERA5 can be used directly
  - The local roughness length (which is often considerably uncertain) is not explicitly incorporated in the derivation
  - Uncertainty ranges can easily be calculated
- Special attention has to be paid to the following (ie heights & orography):
  - The height of 150m is valid for 10minute-data; this value changes for hourly data to 260m (assuming stationarity in the average wind speed)
  - The fact that the wind is gridbox-averaged has also influence on the height that represents the gust; This influence has to investigated
  - Orographic effects may cause a mismatch between the real surface height and the modelled height; need to investigate how this effect can be incorporated

Statistical Downscaling – Height & Orography

Height -> Average wind speed -> gust speed relationships

- Max gust at height z is the average wind speed at **height determined by**: the ratio of friction velocity to the standard deviation of the wind in period, median normalised gust speed and Von Karman constant
- The vertical profile of the wind gust is thus proportional to the average wind speed
- If changes in wind speed with height are known, the corresponding gust speed can be calculated
- Consideration of options shown in next slide

Orography and height selection:

- Combine vertical relationship with orographic effects using a high-resolution (1km) orographic map
- Shows how the ERA5 surface height (on 31km grid) differs from the 'real' height (on the 1km grid)
- Correct for discrepancies by considering the gust not at 10m but at an adjusted height:
  - Eg: if 31km ERA5 says that the station location is at 50m and the 1km map says 80m:
  - Correct by using the gust at 40m above the surface (ie 30m above the normal 10m wind height)
- Spatially interpolate from ERA5 grid points to sub-grid using above relationships
  - Approach being finalised at present. Trade off is:
    - Minimising bias and errors rather than overly increasing horizontal resolution
    - Identifying small-scale gusts which could be higher than average

Optimization of Gust Representation

The options include:

1) ERA5 gust - directly from ERA5 forecasts
2) based on ERA5 10-m wind and wind shear
3) + orography at 1-km resolution
4) combined option (3) and (2) through linear regression

Considerations (see next slide)

- Left graph shows the results for low stations (< 100m), the right one for the high stations
- The most left box plot shows if the wind speed at 100m is used as direct proxy for the gust.
- Direct (LogShear_4.1, 6th from left) is the originally proposed method
  - for low stations (< 100m, left graph) this method meet the requirements of a RMSE < 5 m/s.
- Linear regression with ERA5_100m_wind as a predictor (or Multiple Linear Regression with ERA5_100m_wind + either 10m wind or climatology) improves the RMSE even further.
- The three right boxplots are perhaps the best – they use a combination of ERA5_100m_wind and LogShear_4.1, but the differences are very small

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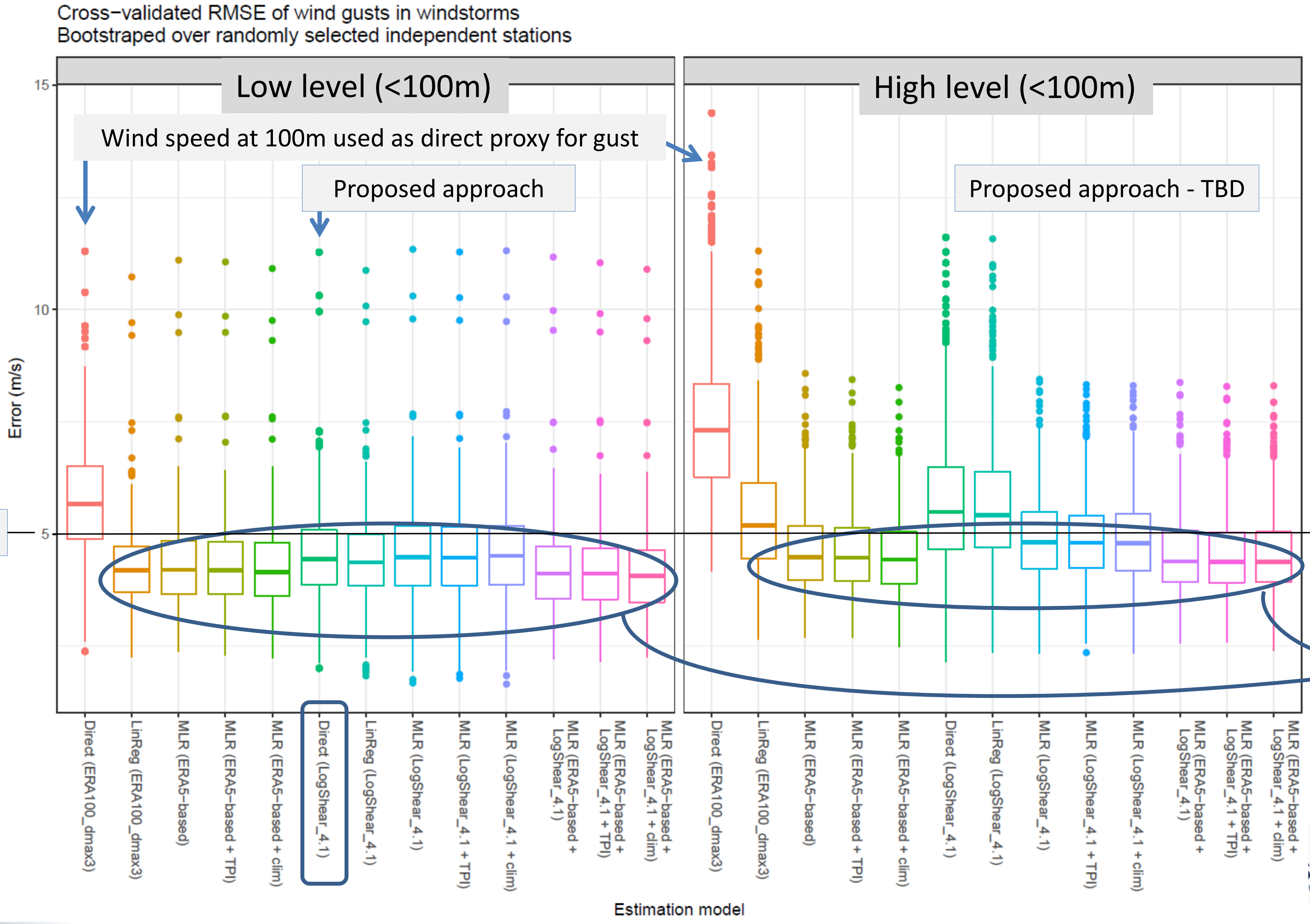
Optimization of Gust Representation



RMSE <5m/s

RMSE <5m/s

- **ERA100** – ERA5 100m wind
- **LINReg** – Linear Regression
- **MLR** – Multiple Linear Regression
- **TPI** – not used

BUT – low RMSE could also preclude extreme coverage – need to trade off

Range of possible approaches below the 5m/s threshold for consideration

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Statistical downscaling - Summary

Summary of method below (cf also poster)

- Cross check against dynamic downscale for Storm Christian also shown (see slide below)
- Validation vs observed gusts also shown below with maximum 3s gust in period from dynamic downscaling

Statistical downscaling

Wind gust calculation from standard turbulence theory:

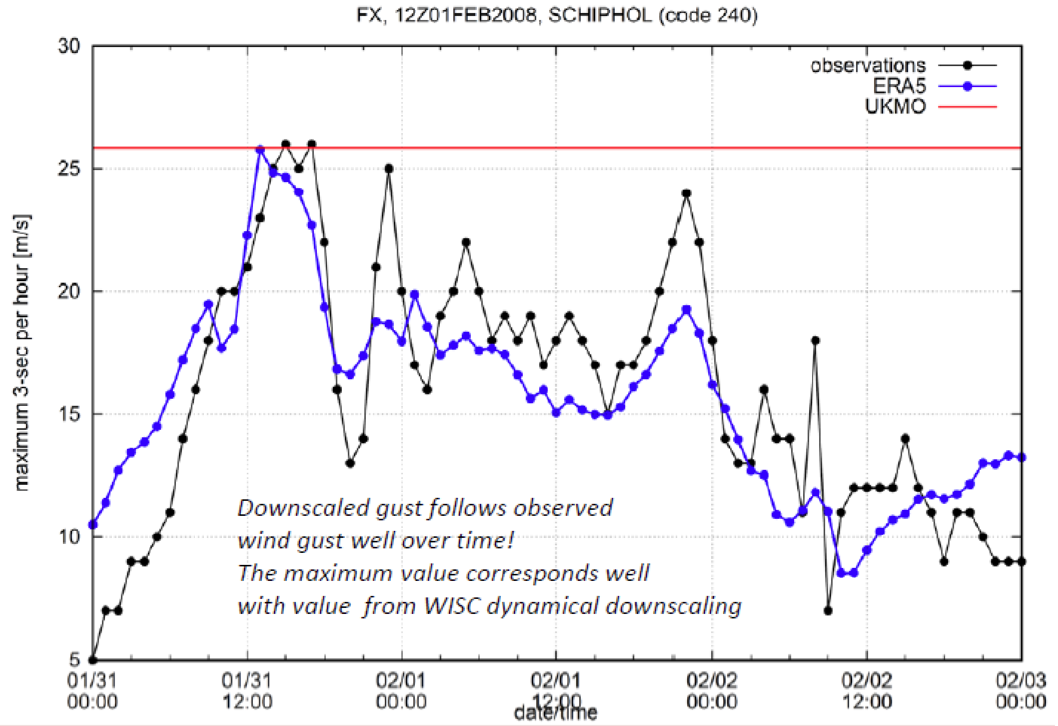
$$\langle U(z)_{max} \rangle = \overline{U(z)} + \alpha \frac{\overline{U(z_2)} - \overline{U(z_1)}}{\ln(z_2) - \ln(z_1)}$$

$\langle U_{max} \rangle$: the maximum 3s gust

$\overline{U(z)}$: the average wind at height z

α : derived physical quantity

making use of orography at 1 km grid plus a linear regression technique using ERA5 gust



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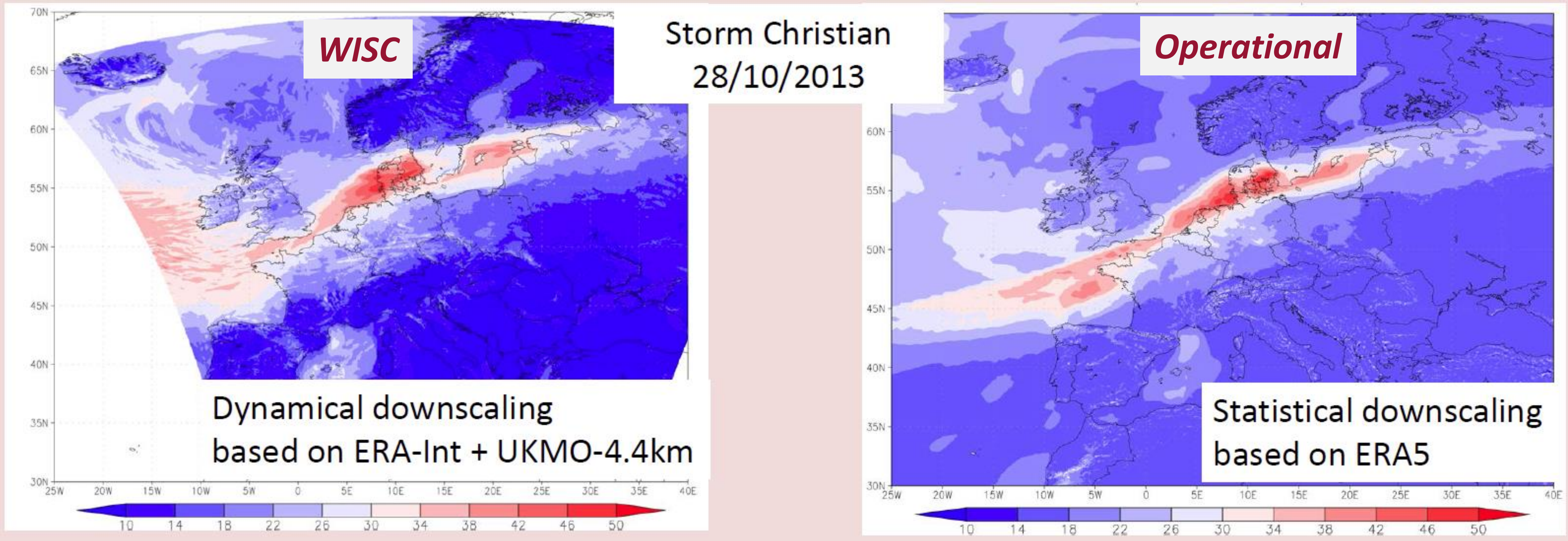
Footprint comparison for Storm Christian

- Concern to ensure lower maximum wind gusts from statistical downscaling are as compared to dynamical downscaling. Approach developed to avoid underestimating the extremes - see comparison below
  - Approach yields stronger gusts in the area of interest, closer to dynamic extremes with orographic effects more pronounced cf Norway.
  - Approach better represents extreme gusts and hence better input for damage calculations, but possibly at the expense of worse overall statistics.



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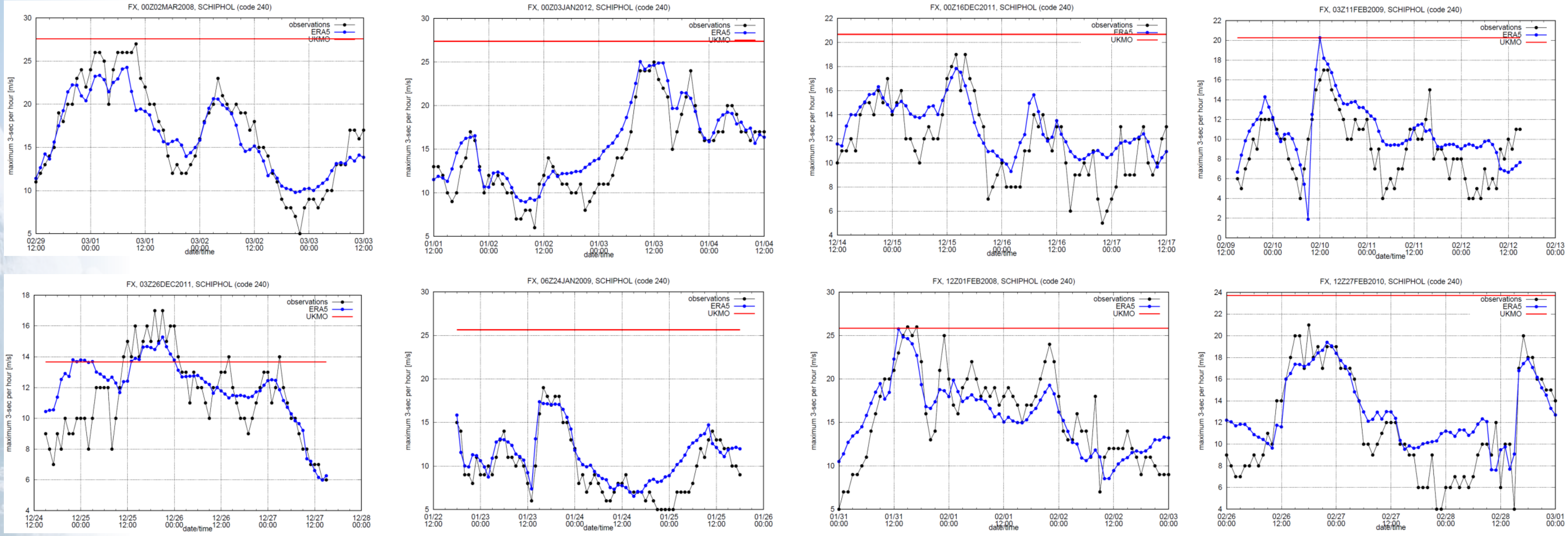
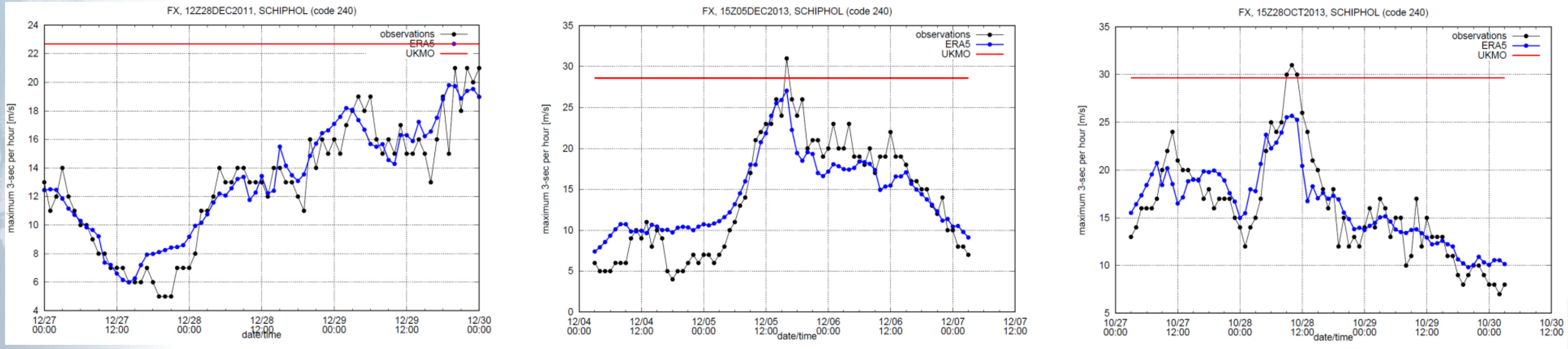
Max Gust Validation – Schiphol (2008-13)





- Gust time series shown to be quite accurate
- Red line is maximum gust in WISC dynamic 72 hour footprint

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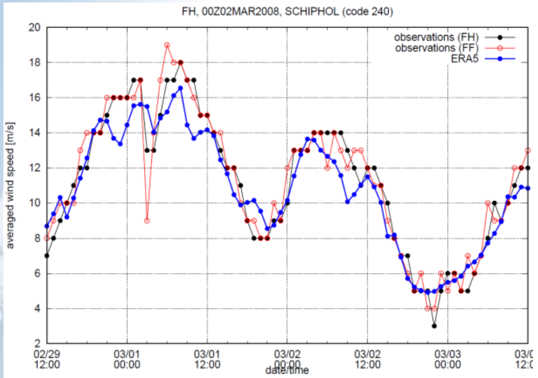
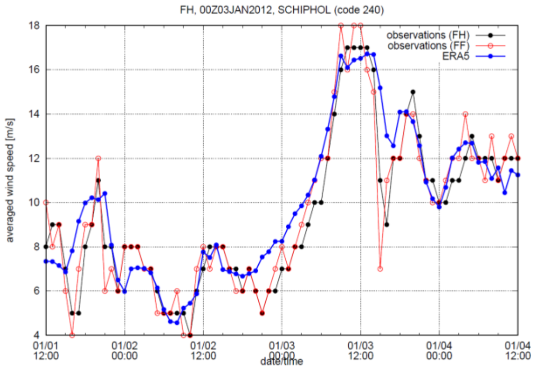
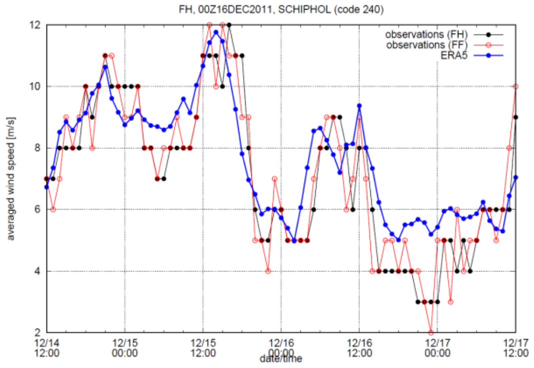
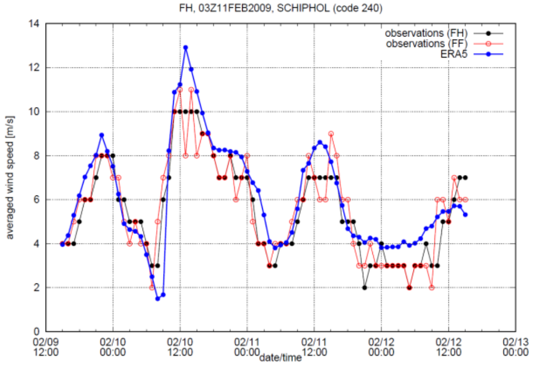
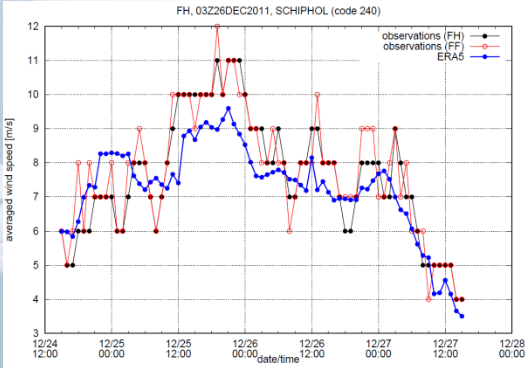
Hourly Wind Validation - Schiphol (2008-13)

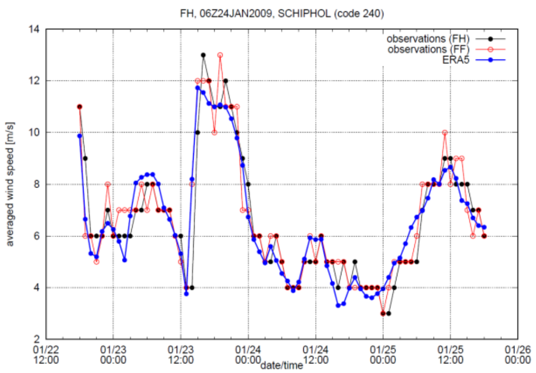


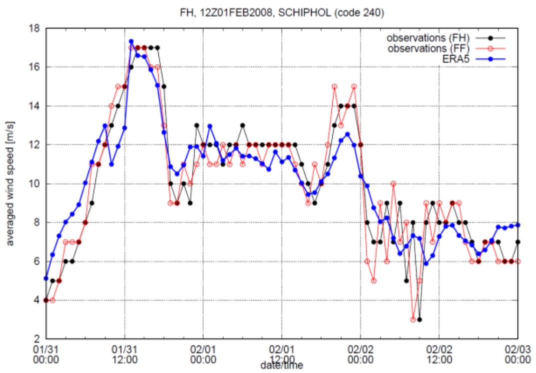


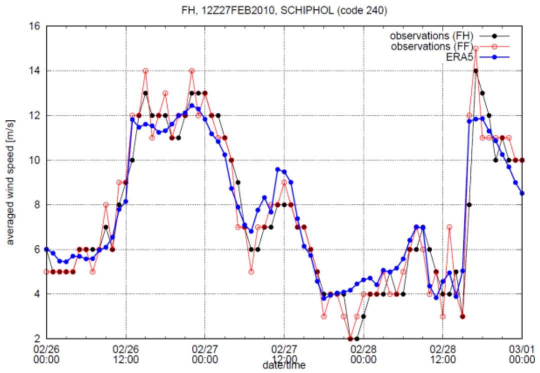


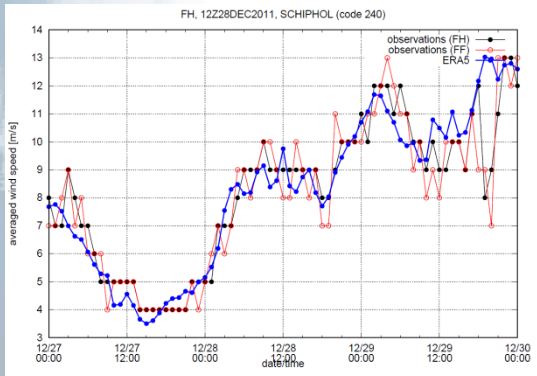


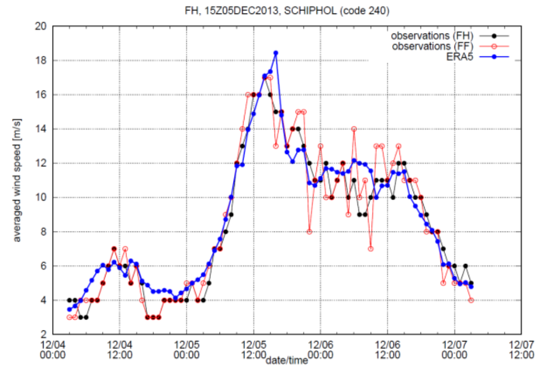


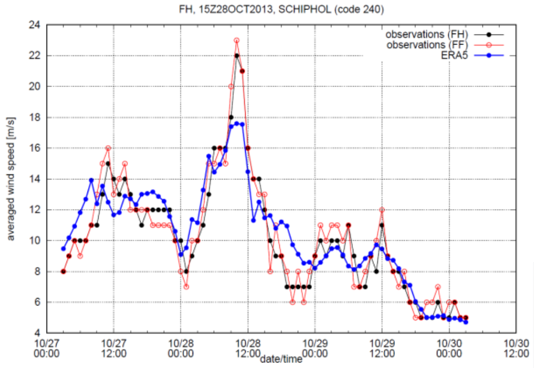












- FH: Hourly wind speed
- FF: Latest 10min wind speed in the hour
- Low gust (e.g. last image) can be attributed to the too low 10m wind speed in ERA5

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Operational Vulnerability and Loss Data

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Operational ERA5 based storm footprints

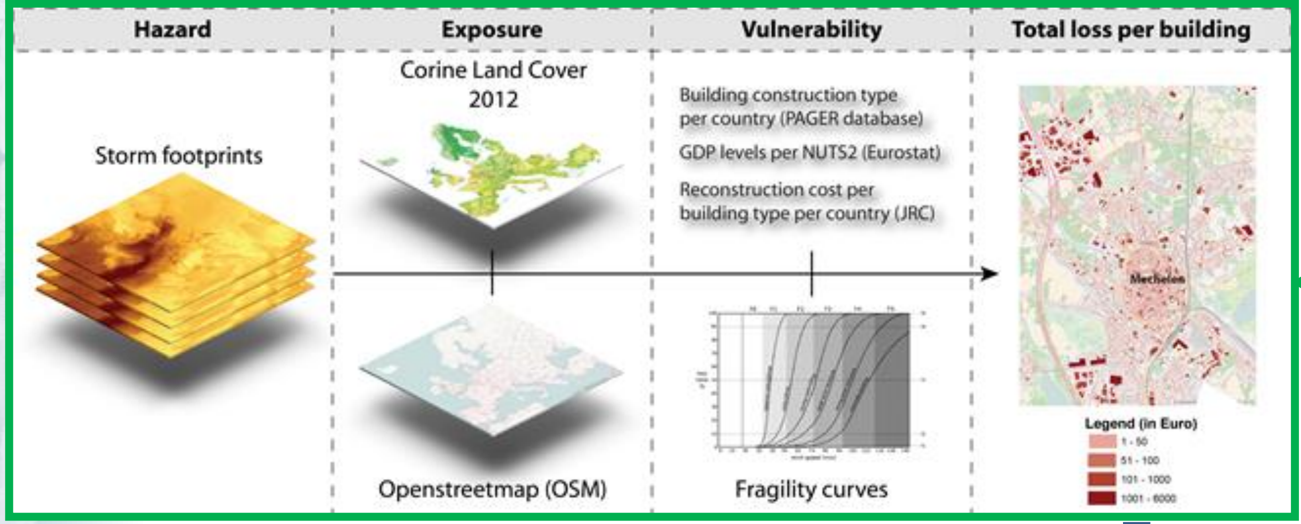
- ***Approach similar to WISC***
- ***Updated and maintained with new ERA5 storm footprints***

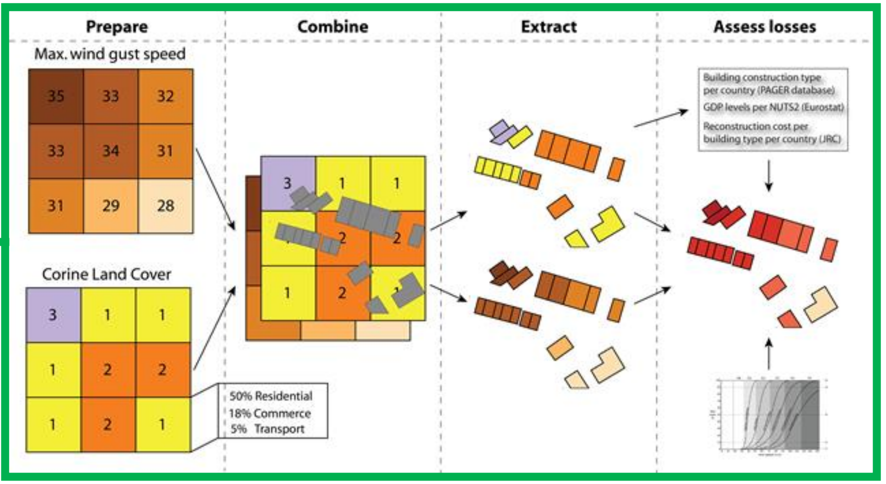
Exposure / Vulnerability

- CORINE – 45 land classes
- PAGER – 106 construction types – aggregated to 6 types
- Fragility curves applied for these 6 types
- Fragility to vulnerability curves via reconstruction costs
- GDP per NUTS3 region applied

Process for Loss Assessment

- Datasets clipped to NUTS3 regions before loss calculations applied
- Loss per hazard (max gust speed) from fragility curves
- Loss ratio multiplied by reconstruction cost per building type
- Losses adjusted by GDP per region
- Validate losses vs actuals





Revised risk and loss estimates

opernicus
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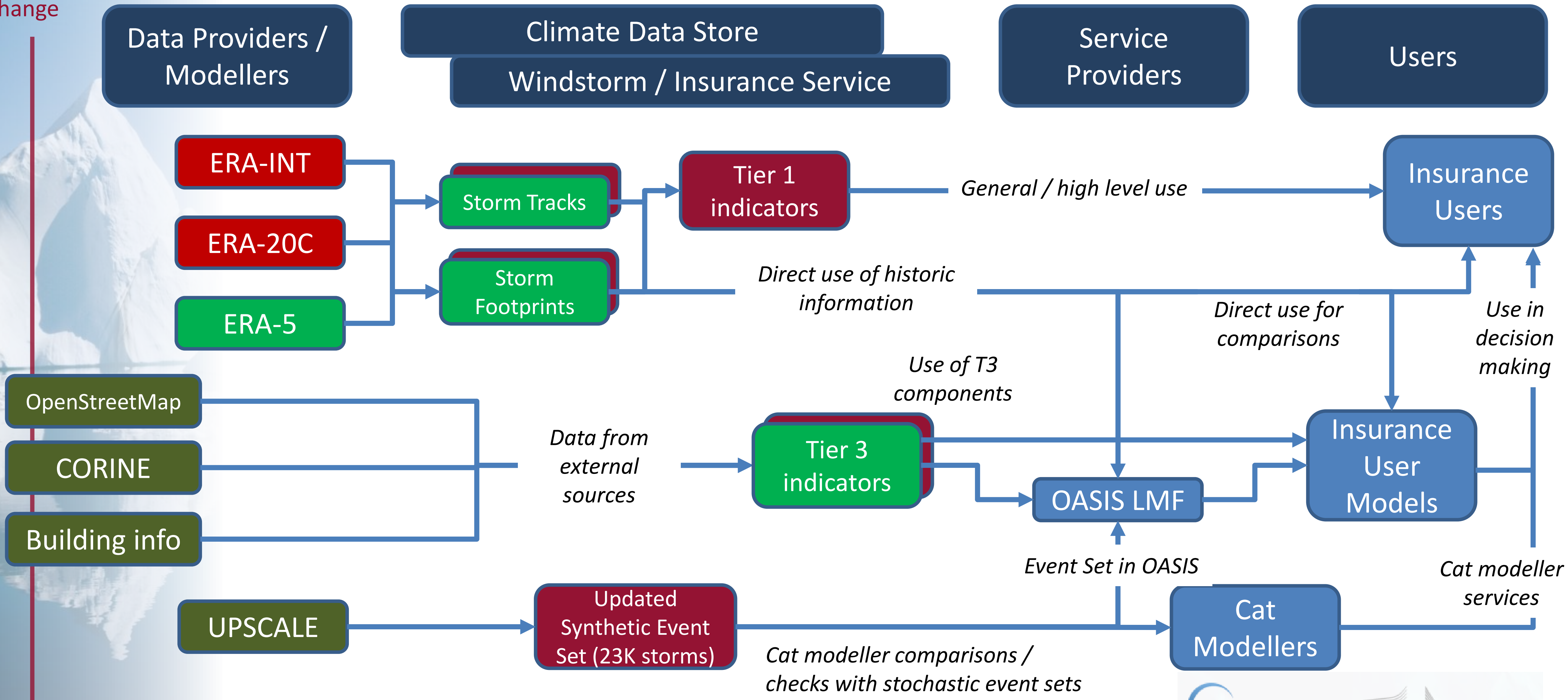
Summary of Operational User Interfaces



Operational Project – Summary of Value Add

Historical data

- Longer high resolution time series (eventually back to 1950 using ERA5)
- Comprehensive coverage of ERA5 for tracks and footprints
- Efficient statistical downscaling can also be applied to the 10 ensemble sets if needed
- Complements existing WISC dataset and overlaps used for cross checks / comparisons.

Probability and extreme values

- Synthetic event set still available to provide cross checks with commercial cat models
- Upgraded by UKMO at the end of WISC to 22,900 storms

Vulnerability and loss

- European-wide exposure and vulnerability assessment with losses
- Being updated with new storms and new historical storms as available in ERA5
- Outputs and building blocks available to help support in-house simulation platforms

Updated portal to make data available and visualise as part of the CDS

- https://wisc.climate.copernicus.eu – new CDS access expected soon, to be confirmed.

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Future Developments

- Storm tracking for ERA5
- Finalise the statistical downscaling approach
- Process the existing ERA5 datasets for tracked storms
- Upload data onto the Climate Data Store (CDS)
- **London workshop proposed for 2019 (WISC and Operational Data)**
- Add new storms as these happen and are included in ERA5 revisions
- Upload new data periodically
- Assess potential for new insurance related services
- **Comments / questions / feedback to the team welcome:**

For more information, please contact: **alan.whitelaw@cgi.com**
For documents and data downloads (currently): **https://wisc.climate.copernicus.eu**

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