

# State-of-the-art Atmospheric Reanalysis at ECMWF



Climate Change

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European Centre for Medium-Range Weather Forecasts





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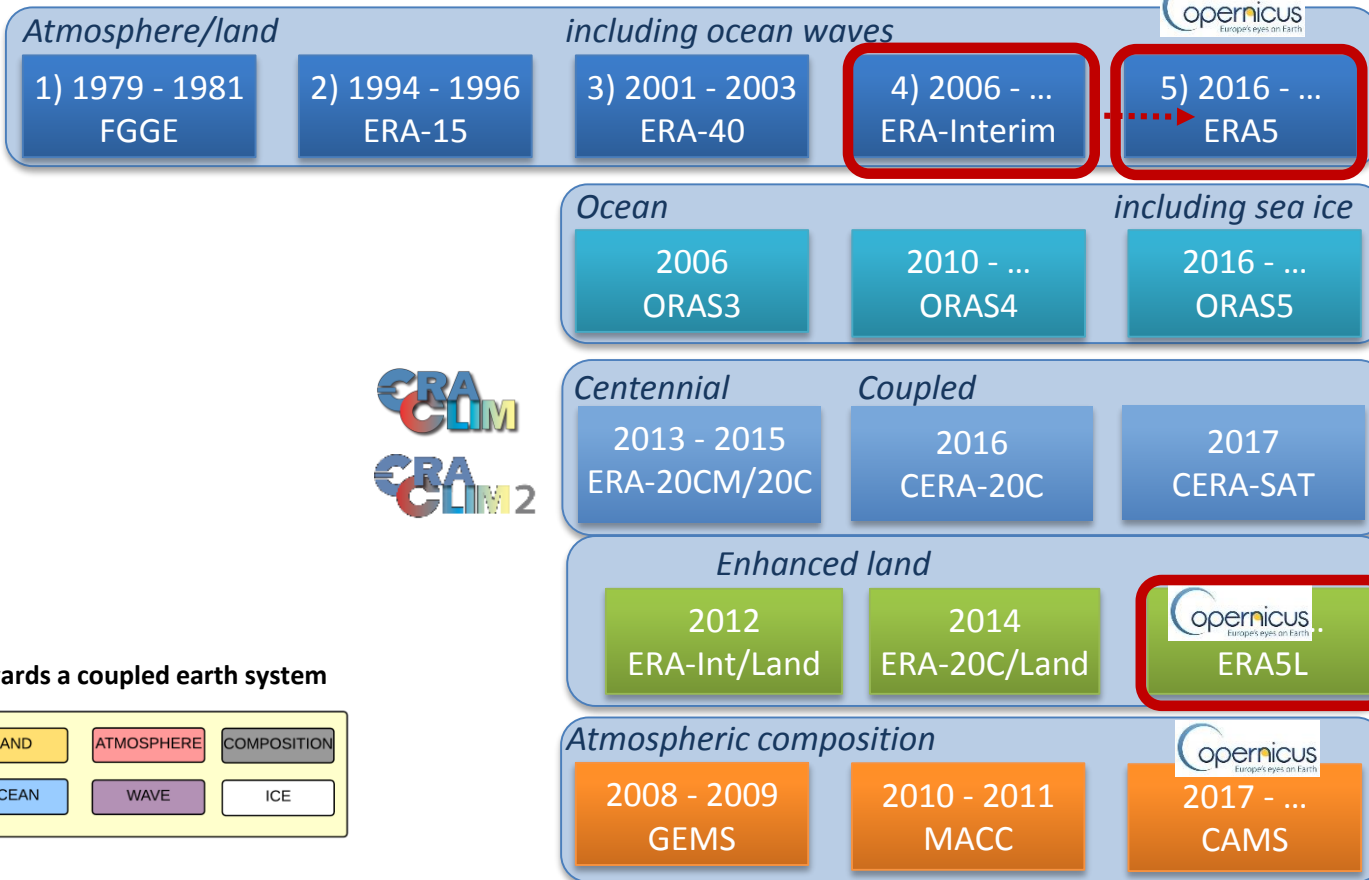
## Overview

- **Overview of Reanalysis products at ECMWF**
- **ERA5, the follow up of ERA-Interim**
- **ERA5 performance**
- **Concluding remarks**

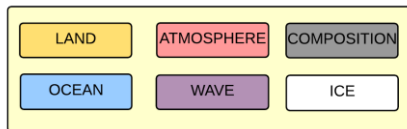


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# Reanalyses Produced at ECMWF



Towards a coupled earth system





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UNITING FOR CLIMATE ACTION  
FURTHER, FASTER, TOGETHER  
6-17 NOVEMBER

C3S at COP23  
03 Nov 2017

**MONTHLY MAPS & CHARTS**

2015-16

Monthly maps and charts of essential climate variables

**NEWS**

03 Nov 2017  
Copernicus services help tackle global climate change issues

27 Oct 2017  
Meeting the world's science journalists at WCSJ2017

26 Oct 2017  
ECMWF Copernicus Services at GEO Week 2017

### Monthly updates:

- based on Reanalysis (ERA-Interim)
- to be replaced by ERA5

ERA5 will provide many ECVs in the **C3S climate data store**

#### EVENTS

13 Nov 2017  
5th International Conference on Reanalysis

06 Nov 2017  
C3S at COP23

#### TENDERS

C3S\_426 Operational Sectoral Information System for the Energy and Wind Storm Insurance Sectors  
Deadline 06 Dec 2017

C3S\_424 Operational Sectoral Information

#### PROJECTS

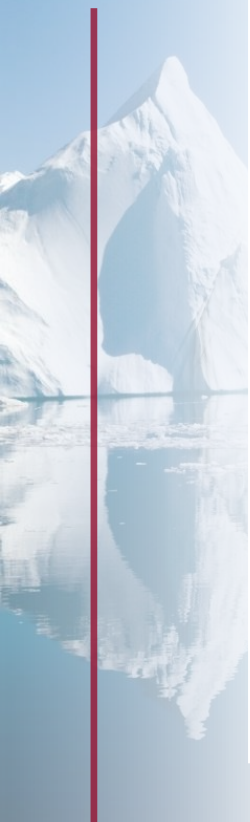
SWICCA - Service for Water Indicators in Climate Change Adaptation

EdgE - End-to-end Demonstrator for improved decision making in the water sector in Europe





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# What is new in ERA5?

	ERA-Interim	ERA5
Period	1979 – present	Initially 1979 – present, later addition 1950-1978
Streams	1979-1989, 1989-present	Parallel streams, one/two per decade
Assimilation system	2006, 4D-Var	2016 ECMWF model cycle (41r2), 4D-Var
<b>Model input</b> (radiation and surface)	As in operations, ( <i>inconsistent sea surface temperature</i> )	<b>Appropriate for climate</b> , e.g., evolution greenhouse gases, volcanic eruptions, sea surface temperature and sea ice
<b>Spatial resolution</b>	79 km globally 60 levels to 10 Pa	<b>31 km globally</b> 137 levels to 1 Pa
<b>Uncertainty estimate</b>		Based on a 10-member <b>4D-Var ensemble</b> at 62 km
<b>Land Component</b>	79km	ERA5L, 9km (separate, forced by ERA5)
<b>Output frequency</b>	6-hourly Analysis fields	<b>Hourly</b> (three-hourly for the ensemble), <b>Extended list of parameters</b> <b>~ 9 Peta Byte (1950 - timely updates)</b>
<b>Extra Observations</b>	Mostly ERA-40, GTS	Various <b>reprocessed CDRs, latest instruments</b>
<b>Variational Bias correction</b>	Satellite radiances	Also ozone, aircraft, surface pressure

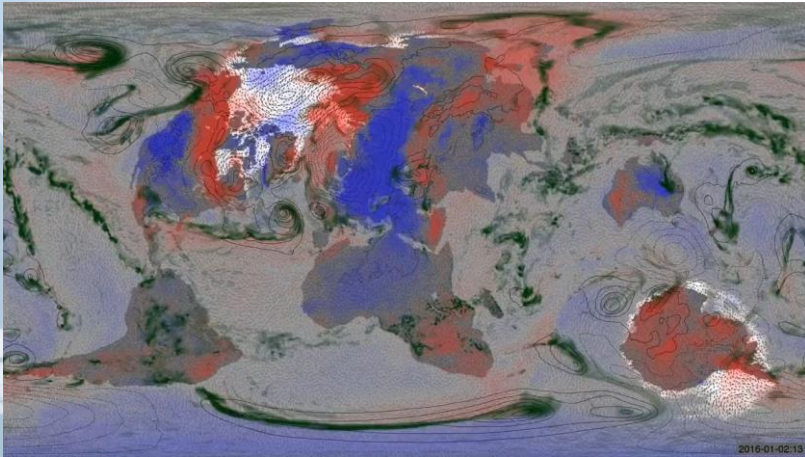




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# Innovations in ERA5 w.r.t. ERA-Interim

## Hourly data and more parameters

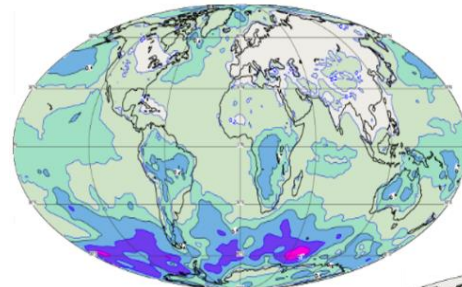


Courtesy: Philip Brohan

## Uncertainty estimate

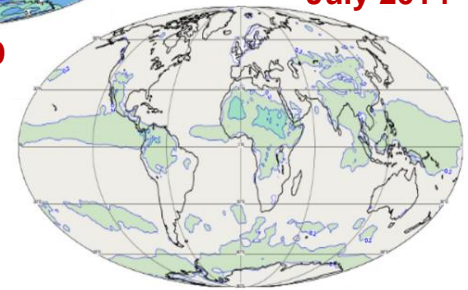
Spread in Surface Pressure (hPa)

0-0.1 0.1-0.2 0.2-0.3 0.3-0.4 0.4-0.6 0.6-0.8 0.8-1



January 1979

July 2014



Reflects variations in:

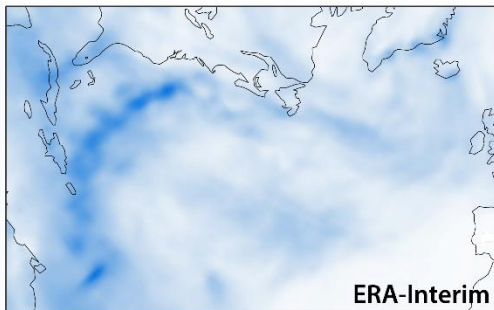
- ingested observing system
- flow-dependent sensitivity



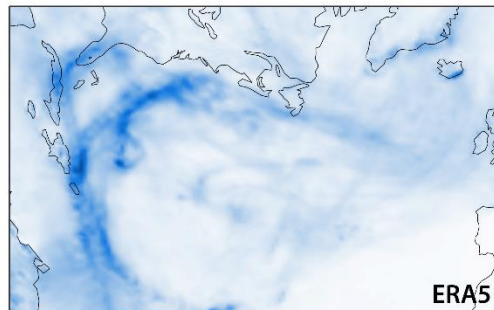
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# Horizontal resolution and depiction of tropical cyclones

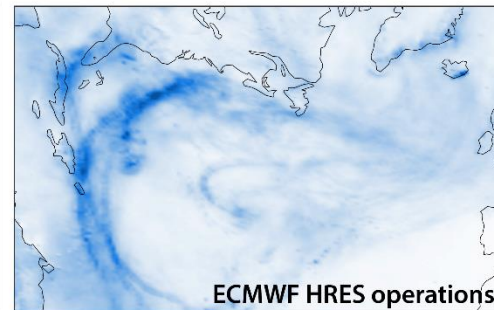
Mean precipitation rate (mm/day) for September 2017



ERA-Interim



ERA5



ECMWF HRES operations

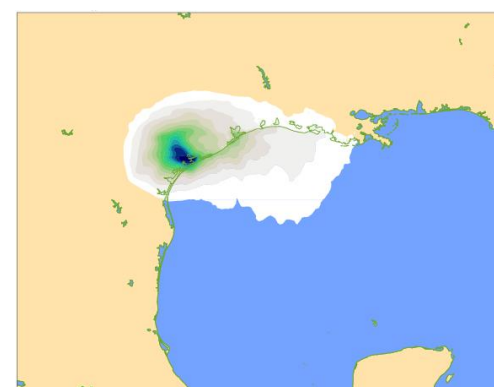
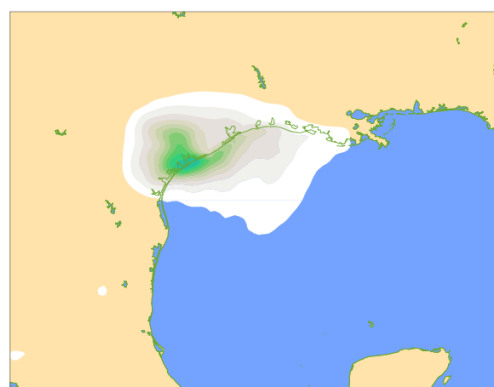
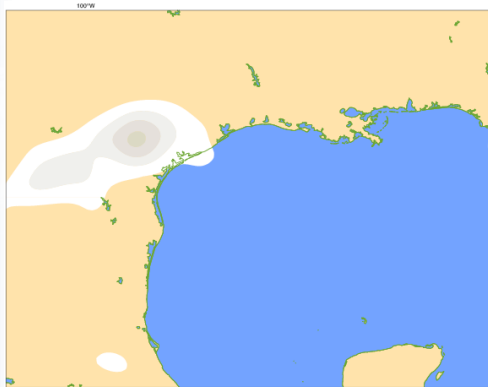


Horizontal resolutions: ~80km

~30km

~10km

## 5-day precipitation for Harvey

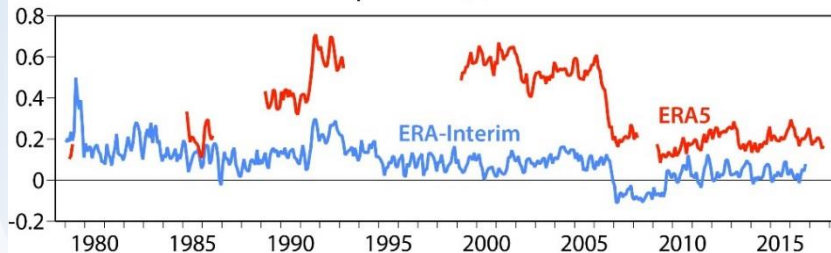




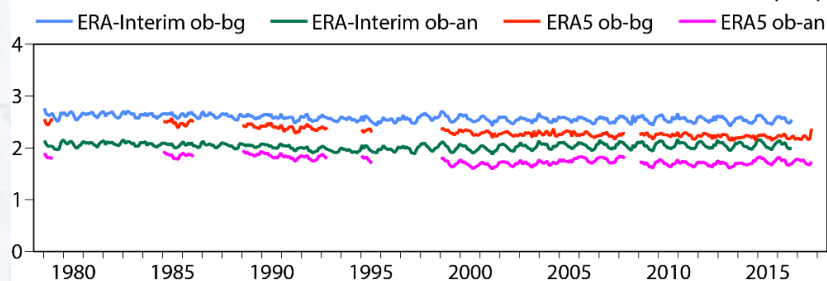
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# ERA5 performance over time compared to ERA-Interim

Global-mean of (observation - background) differences for radiosonde temperatures (K) between 60 and 85hPa



Global standard deviation of fits to 850hPa radiosonde meridional winds (m/s)



Significant wave height scatter index (%) against all available in-situ data



## Stratosphere

- Radiosondes anchor less than GPS-RO
- ERA5 background has shorter correlation lengths
- ERA5 free model appears more biased

## Troposphere

Standard deviations of (observation-background) and (observation-analysis) are generally smaller for ERA5 particularly at 850hPa

## Ocean Waves

Buoy-comparison improved for ERA5





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# ERA5 Release Plan

## Q2 2017: public release 2010 – 2016

**Access:** initially similar to ERA-Interim (Web-API)  
later (Feb 2018) via the **C3S Climate Data Store**

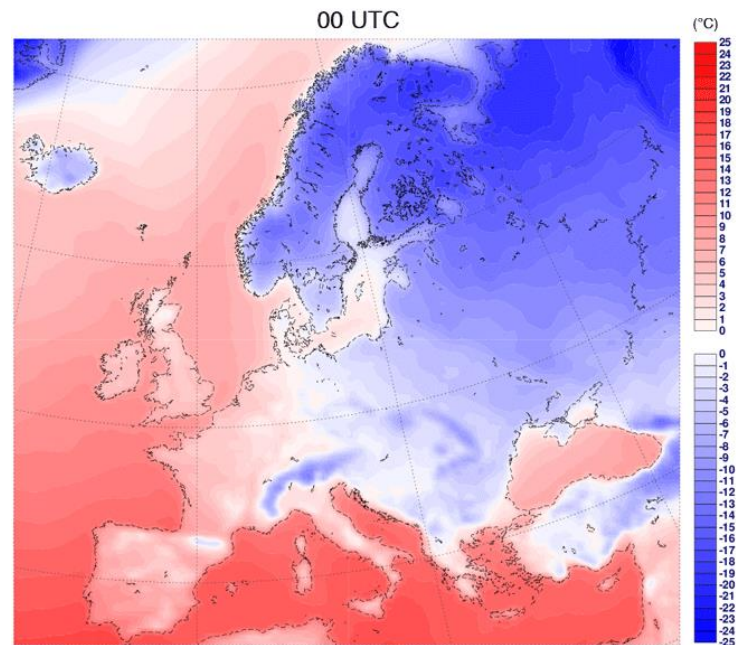
## Q4 2017/ Q1 2018: 2017 – timely updates

- ERA5: Updates with about 2-months delay (final product)
- ERA5T: Updates with short delay (<1 week, preliminary product)

## Q1-3 2018: Release 1979 – 2009:

- Continue ERA5 timely updates
- Continue ERA-Interim for another 6 months after this release

2018: integration of ERA5 segment from 1950





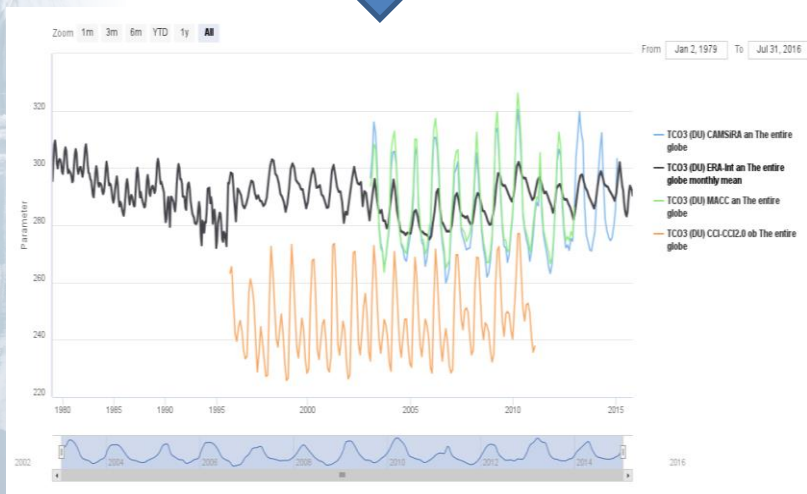
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# Climate Reanalysis Data Access Tool

**Observation Feedback Archive:** Explore, select, plot and download observations used in ERA5



**Climate Monitoring Facility:** Explore, compare, plot ECV estimates from multiple sources





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# Summary

## ERA-Interim is 10 years old and needs replacement

### As part of C3S, the production of ERA5 is well underway:

- Higher resolution, hourly output, uncertainty estimate.
- Produced in parallel streams
- Public Release 2010-2016 end June 2017
- Release other stream to be done in stages within CDS from 2018.

### The performance of ERA5 is very promising in the troposphere.

- improved global hydrological and mass balance
- reduced biases in precipitation,
- refinement of the variability and trends of surface air temperature.

### There are some imperfections, though

- Biases upper stratosphere
- Tropical jet mesosphere too intense
- Initially there were quality issues over the southern hemisphere in the 1980s (delay in production stream)

### At ECMWF activities are focused towards a coupled Earth system

- Benefit to reanalysis (ERA6)

Range (days) when 365-day mean 500hPa height AC (%) falls below threshold

