Building blocks of the ECMWF forecast systems

Sarah Keeley

- How do we create our forecasts?
- What's in our models?
- What are we doing this week?

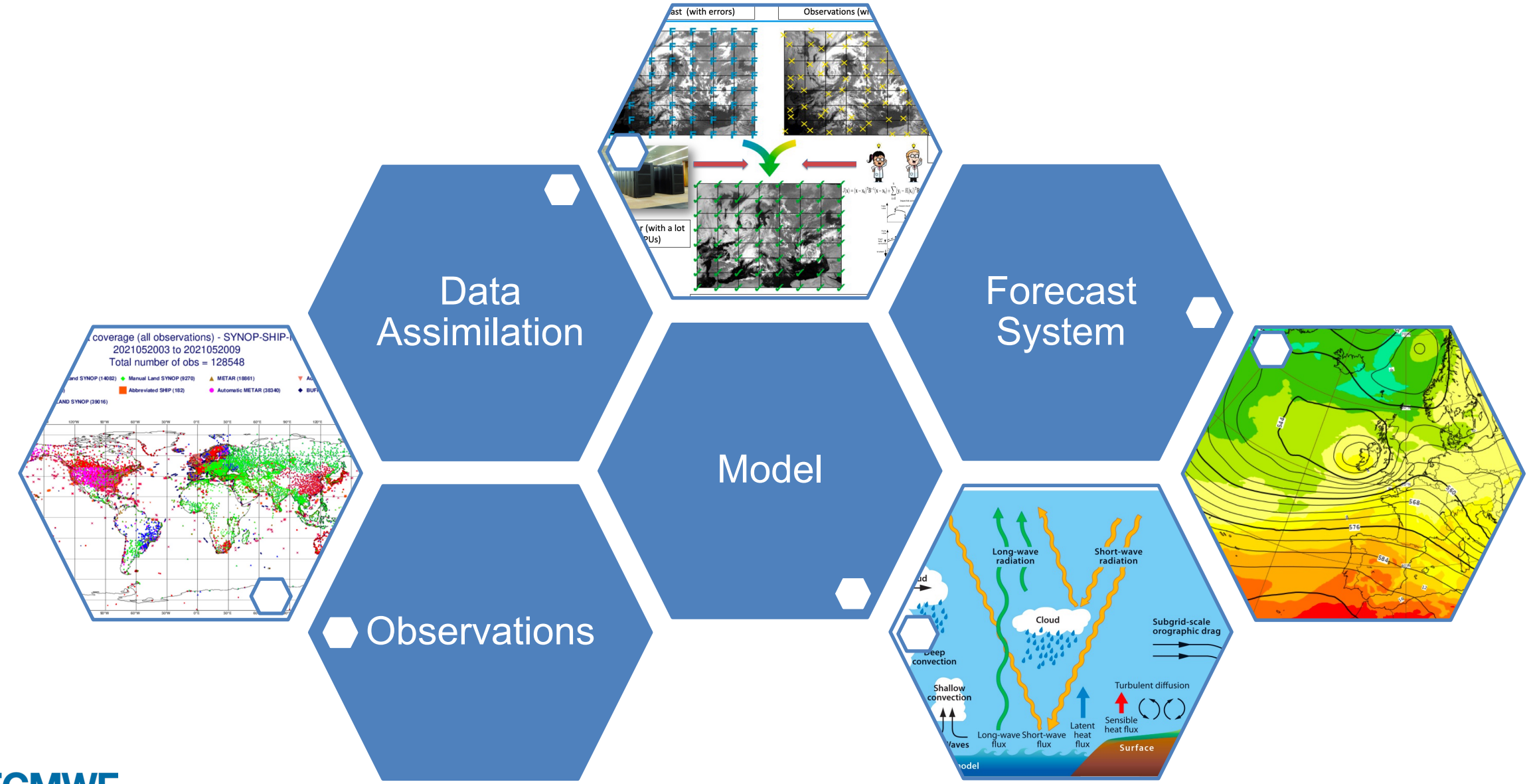
IFS → IFS

OpenIFS

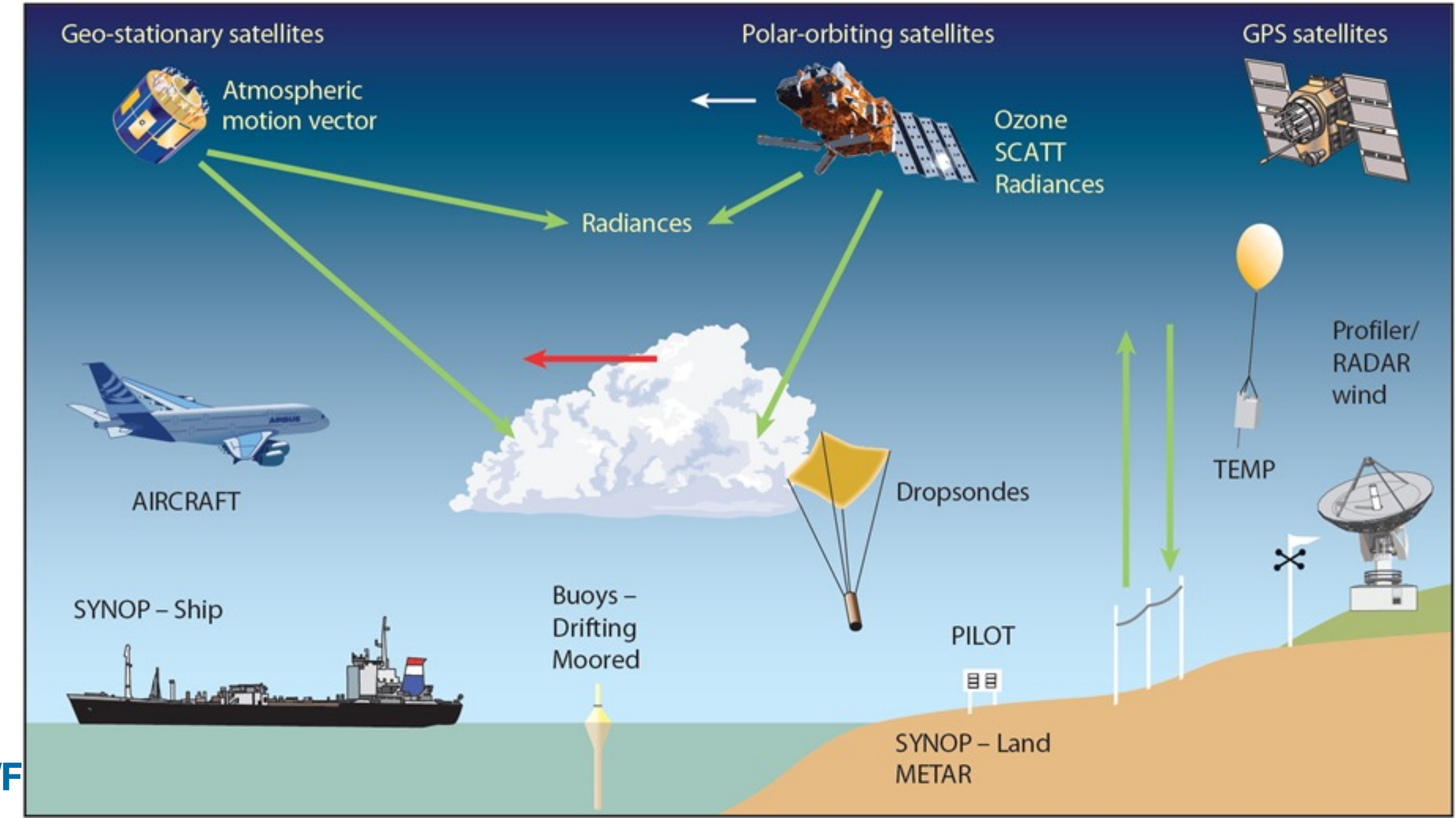
ECMWF Open IFS

A portable version of IFS for research and education and an outreach activity at ECMWF

Ingredients of a Forecasting System

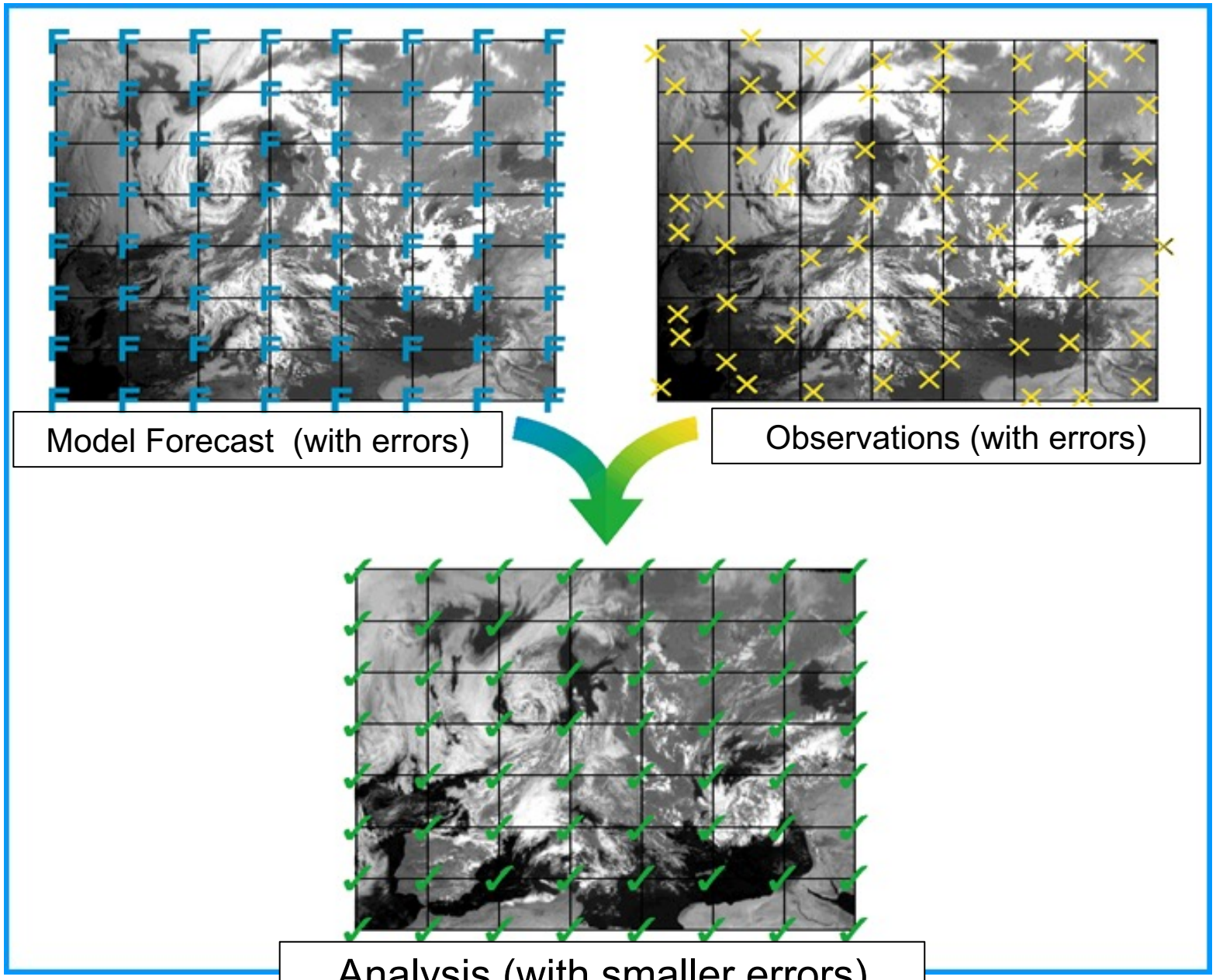


Observations: Make use of as many as possible



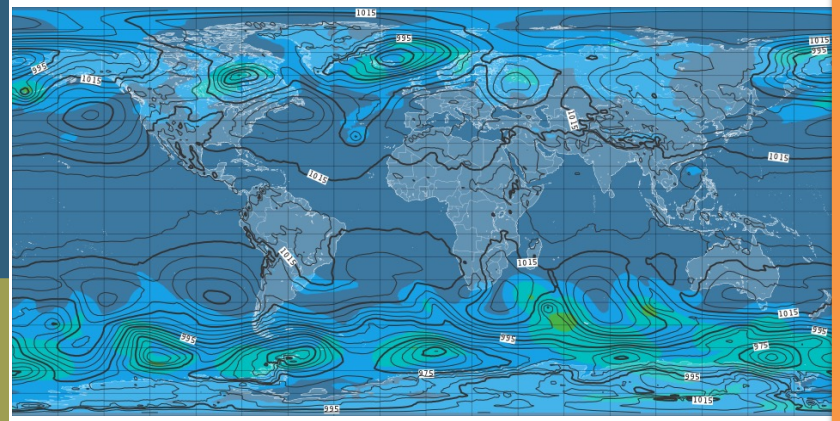
ECMWF

Data Assimilation



Global coupled NWP at all ranges

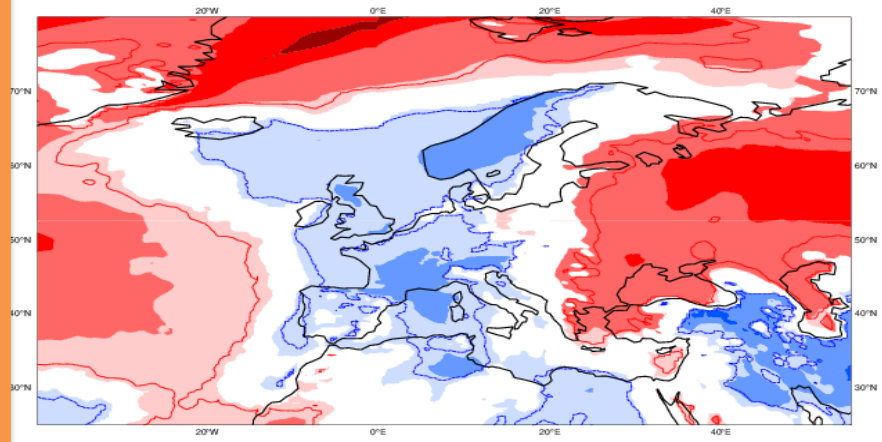
Medium-range prediction



WMO: 3-10 days

ECMWF forecasts: 0-10/15 days

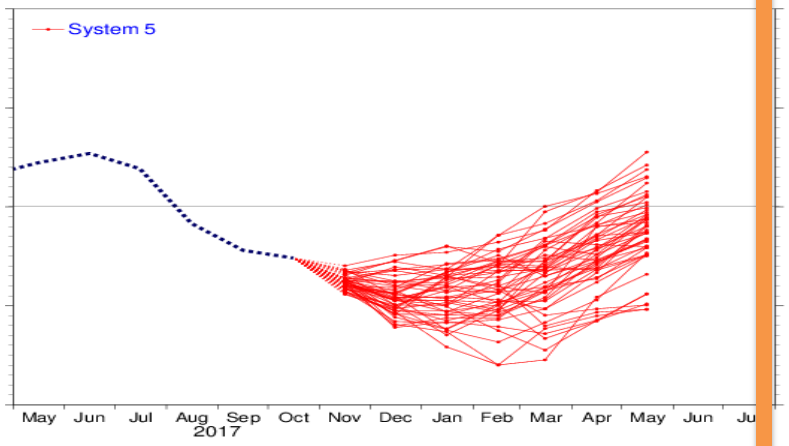
Extended range prediction



10 days – 2 months

0-46 days

Long-range prediction



2 months – 2 years

0-7 months

(out to 13 months once per season)

Weather statistics

ECMWF ENSEMBLE PREDICTION

Initial conditions

Ensemble members illustrating the possible scenarios

Distribution of ensemble members

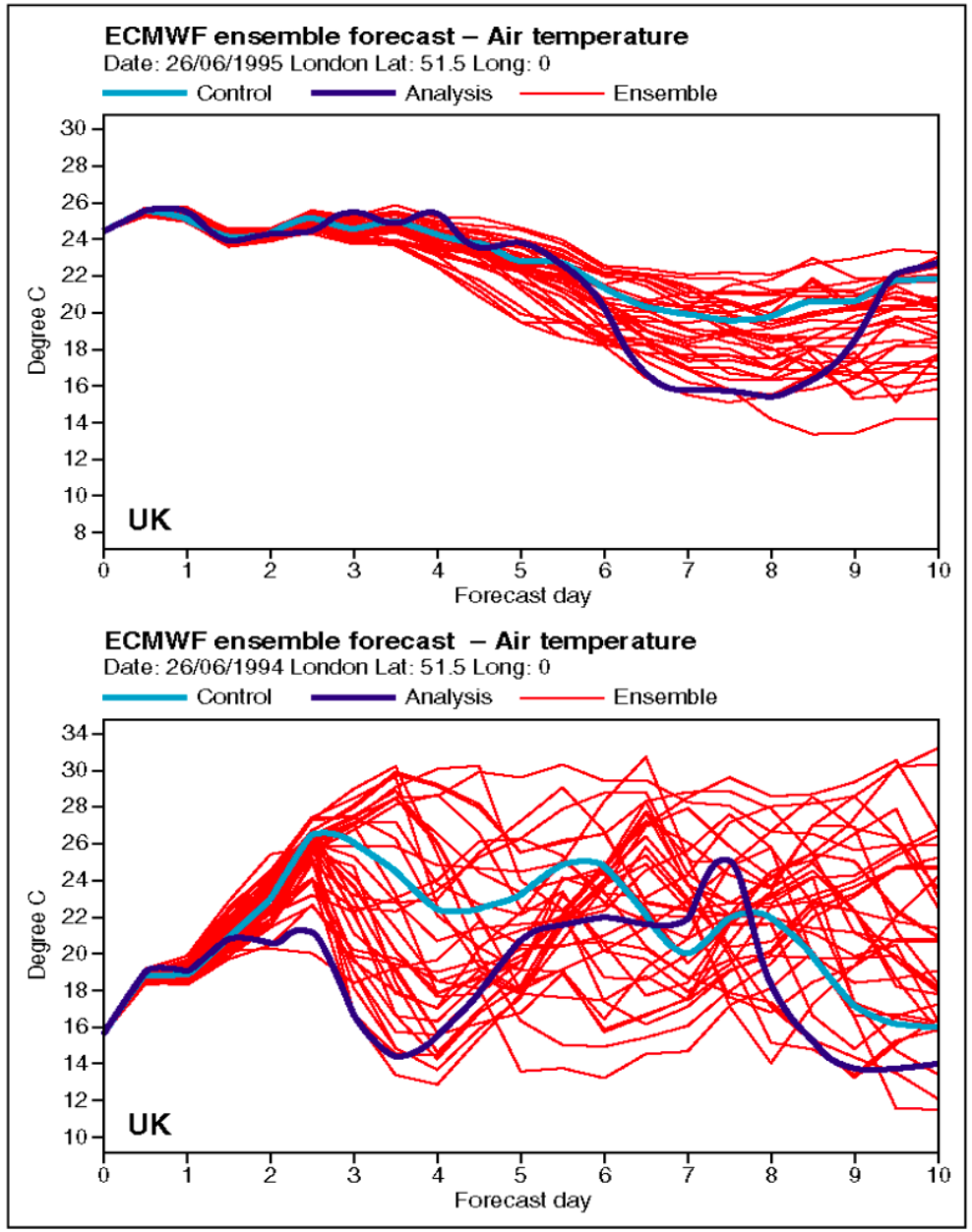
Confidence level of predicted forecasts

Low High

Probabilistic Prediction – how predictable is a situation?

The atmosphere is a chaotic system

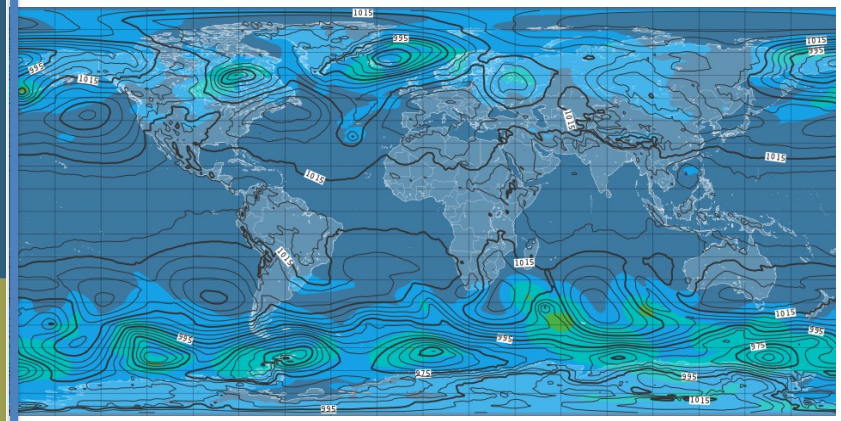
- Small errors can grow to have a major impact
- This limits detailed weather prediction to a week or so ahead
- Slowly evolving components of the Earth system can give predictability at longer timescales



ECMWF

Forecast systems for global coupled NWP

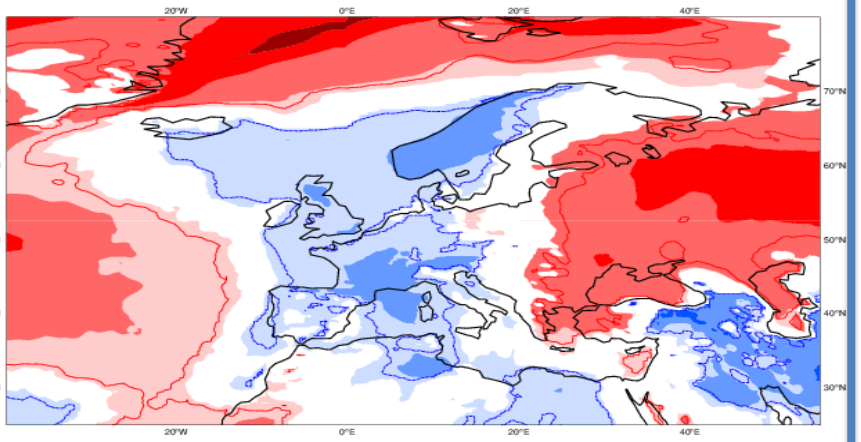
Medium-range prediction



0-15 days

52 members (Twice a day)
9km, 137 levels, 14km wave
1x HRES **and** 1x CTRL
50x Perturbed
(11 member reforecasts run twice a week)

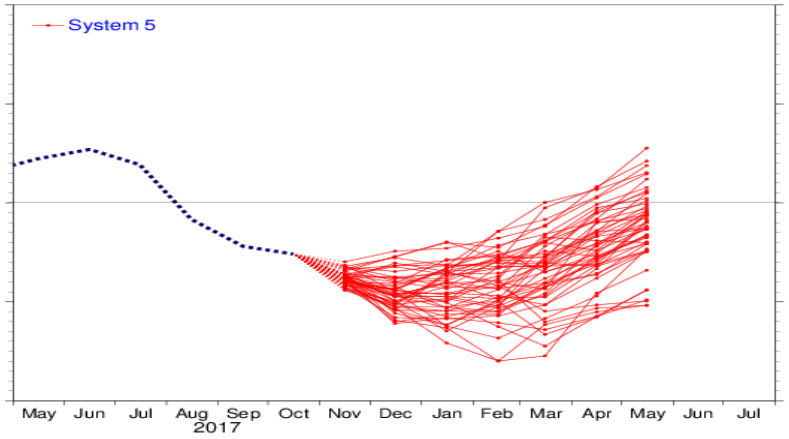
Extended range prediction



15-46 days

101 members (every day)
36km, 137 levels, 55km wave
1x CTRL
100x Perturbed
(11 member reforecasts run twice a week)

Long-range prediction



0-7 months
(out to 13 months once per season)

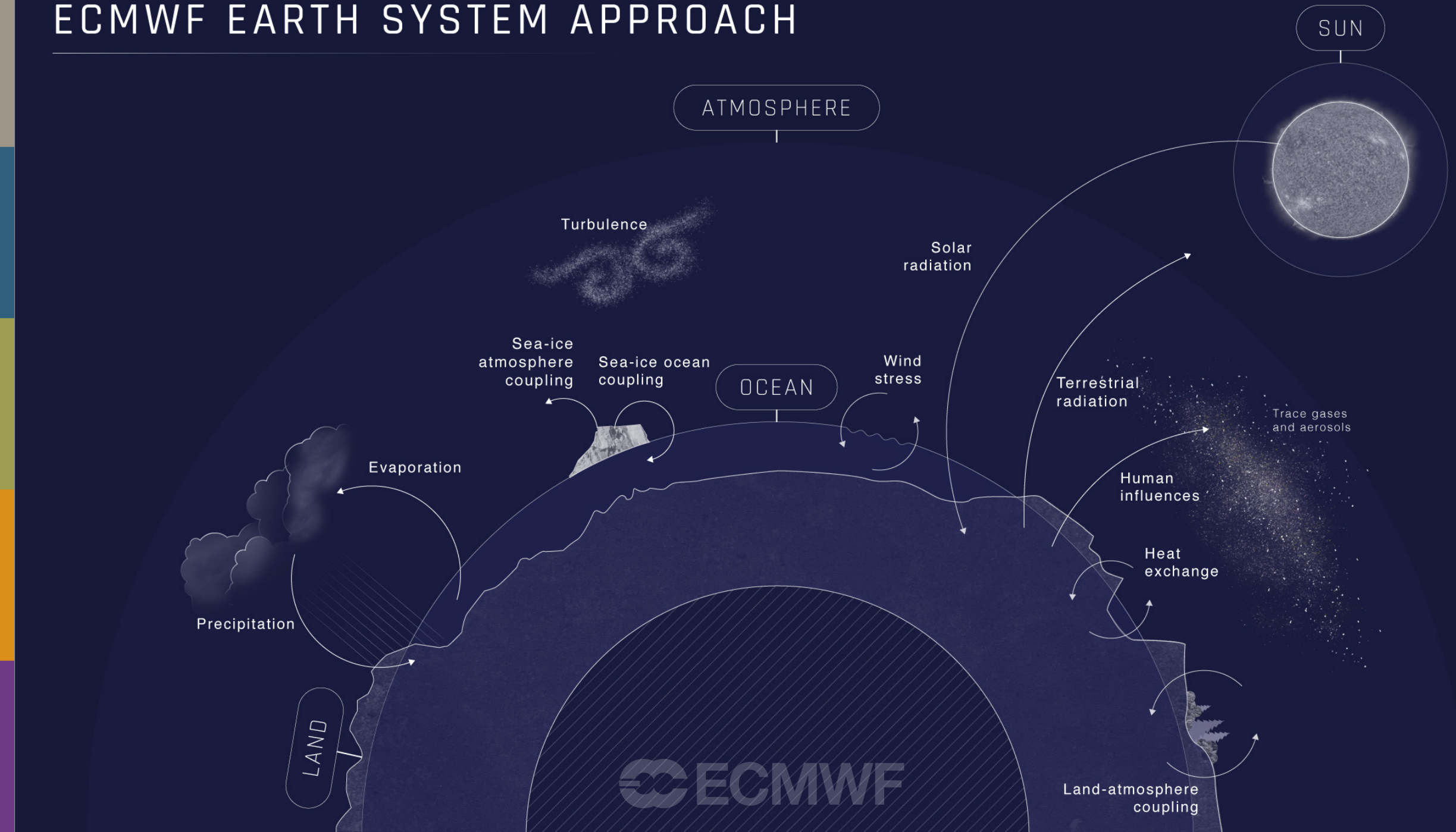
51 members (Once a month)
1x CTRL – 36km, 91 levels, 55km wave
50x Perturbed runs

0.25 deg ocean and sea ice model used for all forecast systems with hourly coupling

Uses latest model cycle (48r1)

ECMWF

ECMWF EARTH SYSTEM APPROACH



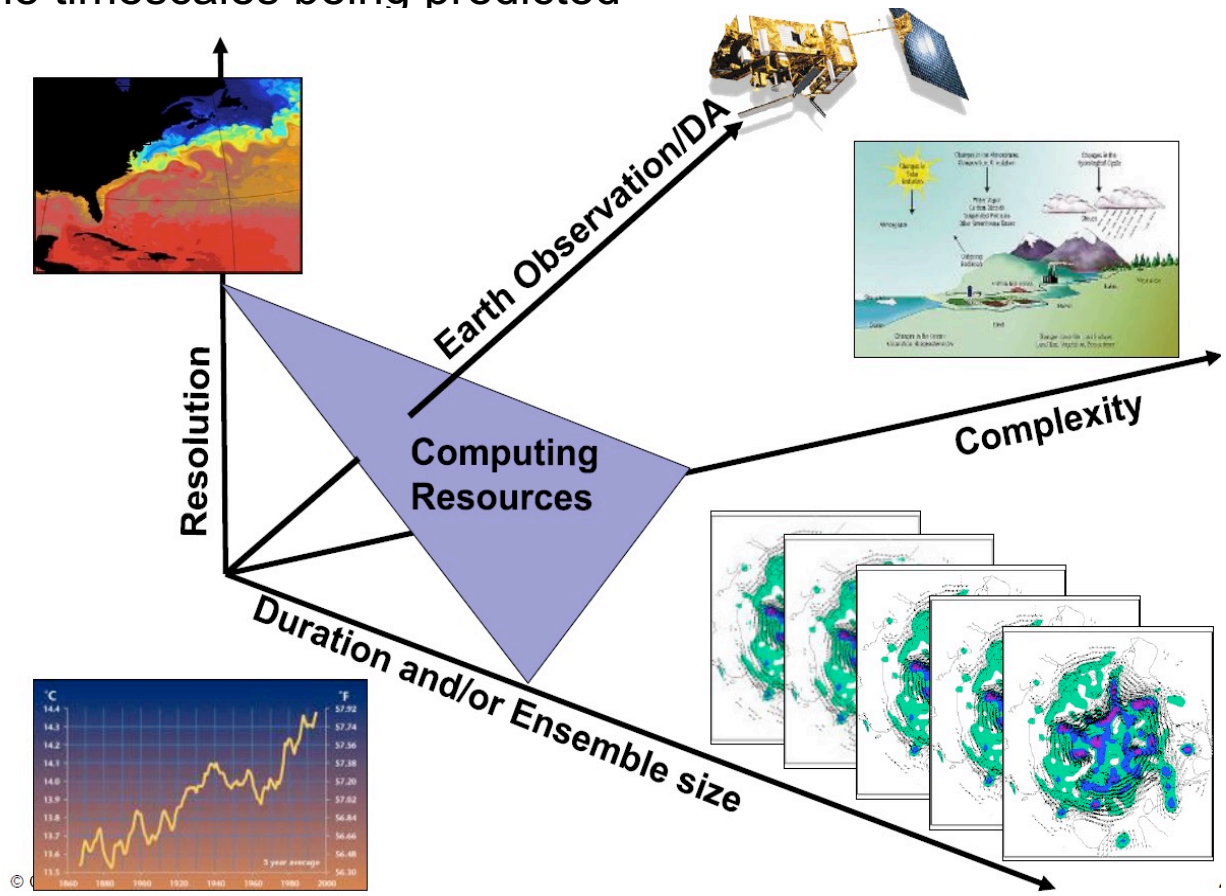
Elements of the forecast system

- Needs to run quickly
  - Medium range forecast needs to run in ~1hour

Iain M

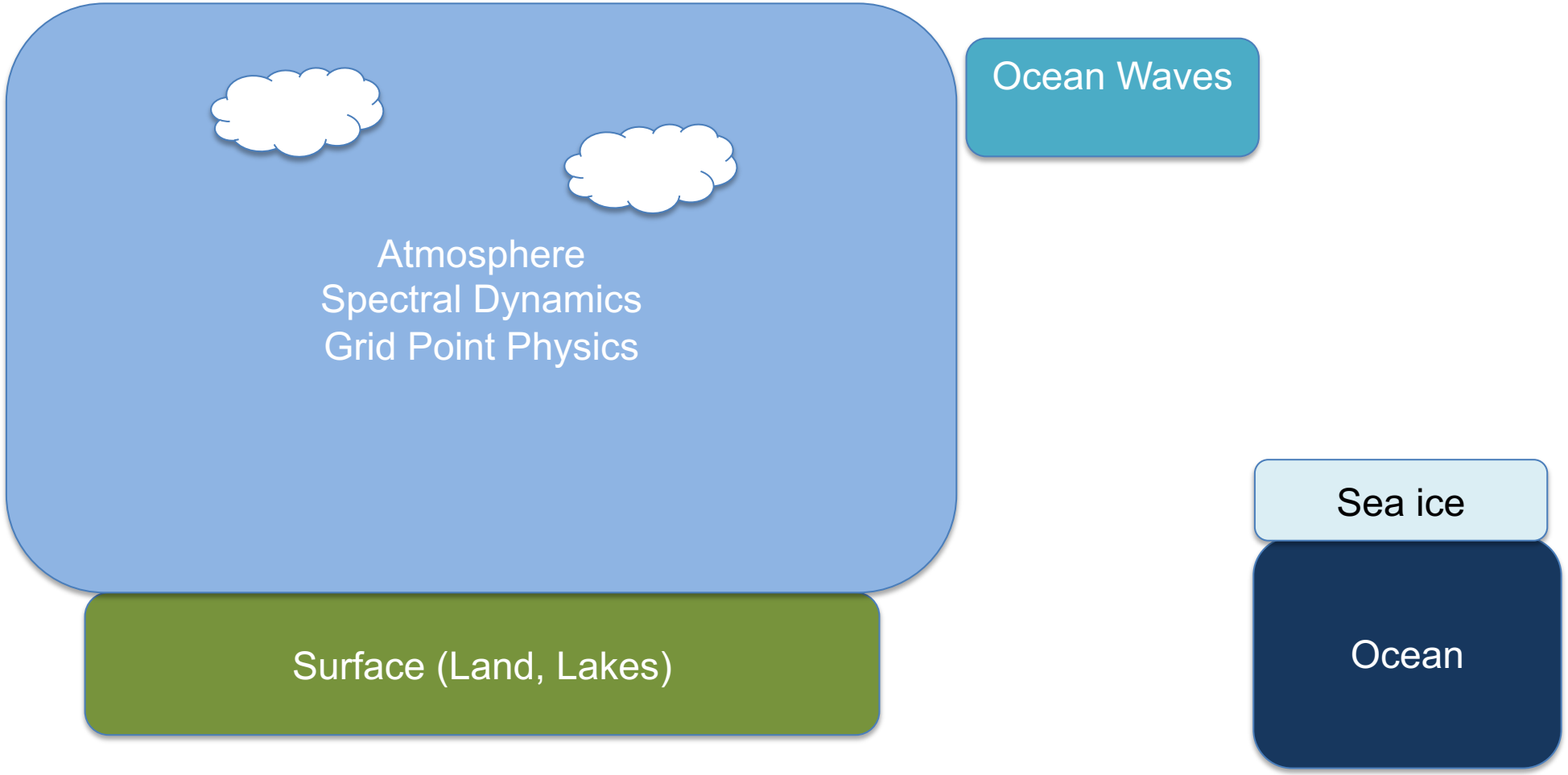
- Needs to capture the processes pertinent for the timescales being predicted
- Needs to support user requirements
  - Calibration
  - Products
  - Using the Data

Paul, Iain R & Sandor



Model Components

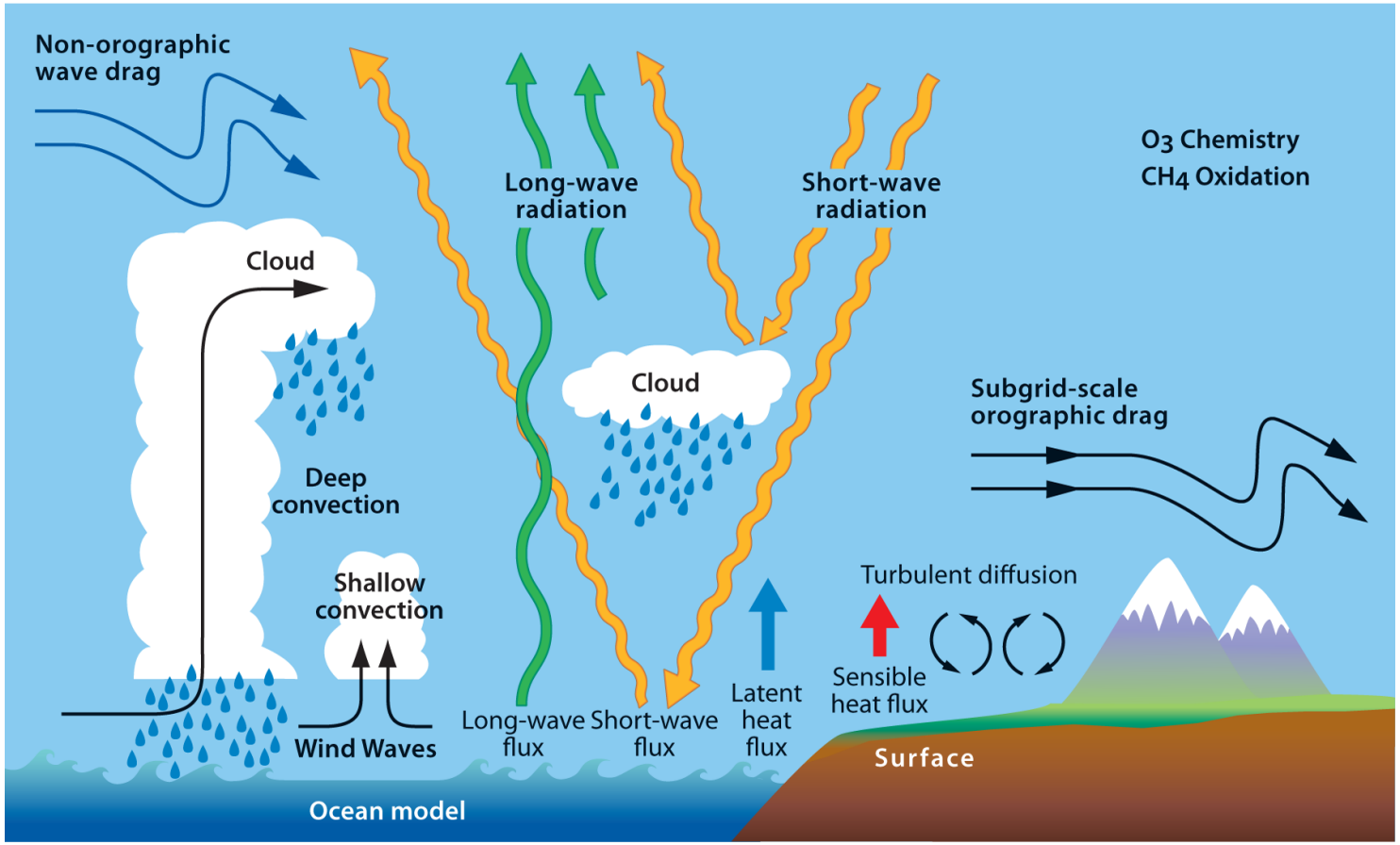
- Coupled modelling in all our forecast systems
- Different grids, time steps and coupling



Model Details

- The model is updated on an annual basis (approximately)
- Each version of the forecast model is named as a cycle
  - IFS cycle 48r1 was implemented on 27th June 2023
  - OpenIFS cycle 43r3 (and 48r1)

Robin, Richard



Model Details

- The model is updated on an annual basis (approximately)
- Each version of the forecast model is named as a cycle
  - IFS cycle 47r3 was implemented on 12th October 2021
  - IFS cycle 48r1 was implemented on 27th June 2023
  - OpenIFS cycle 43r3/48r1
- Each forecast system has an associated horizontal resolution which is determined by the spectral truncation, how many points you use to represent a wave and the underlying grid
  - T_{CO} NNNN

Andreas, Michail

- Each forecast system has an associated vertical resolution
  - L137 (137 Levels)

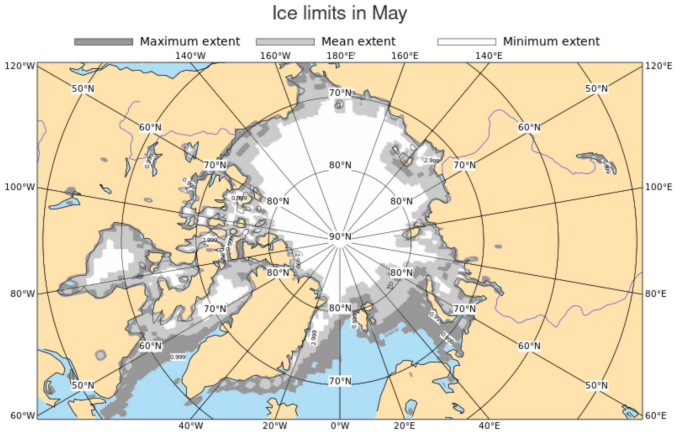
T = spectral truncation
NNNN = truncation of wave number
(T1279 = represents up to wave number 1279)

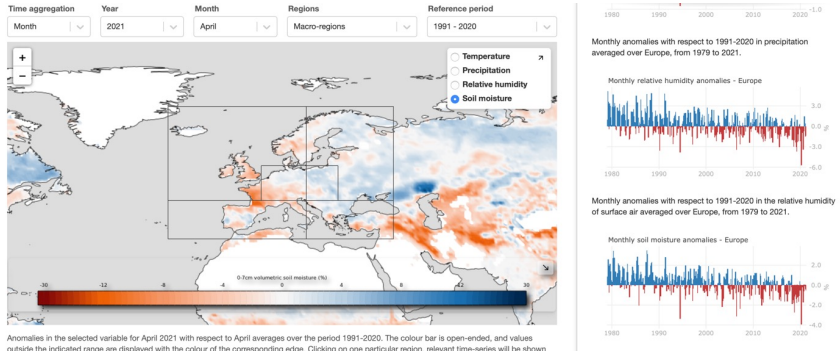
C, L = number of points to represent a wave:
(C cubic=4, L linear=2)

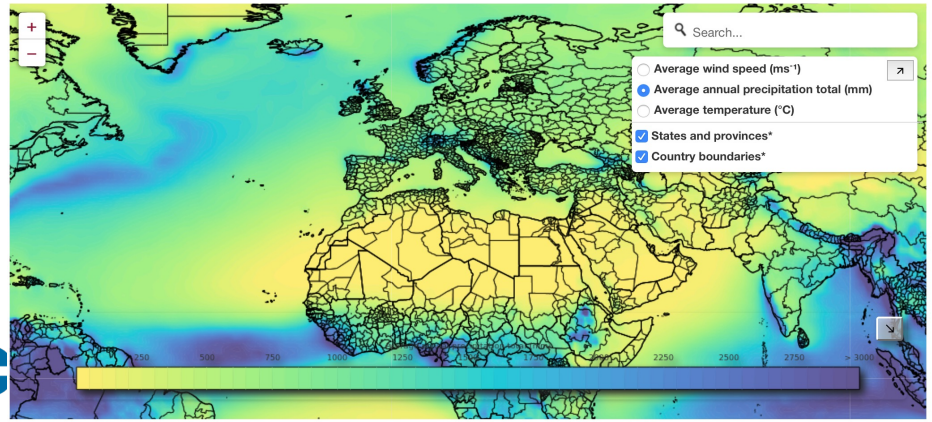
O = Octahedral reduced gaussian grid
(previously the IFS used a reduced gaussian grid)

Reanalysis

- Longer forecasts need to be calibrated – we do this through a set of hindcasts or reforecasts – how the current model would simulate the weather in the past.
- This requires initial conditions for the reforecasts – a reanalysis.
- Reanalyses are also a really useful tool for understanding the climate system!







Hans, Eddy

Browse reanalysis datasets

ECMWF uses its forecast models and data assimilation systems to 'reanalyse' archived observations, creating global data sets describing the recent history of the atmosphere, land surface, and oceans.

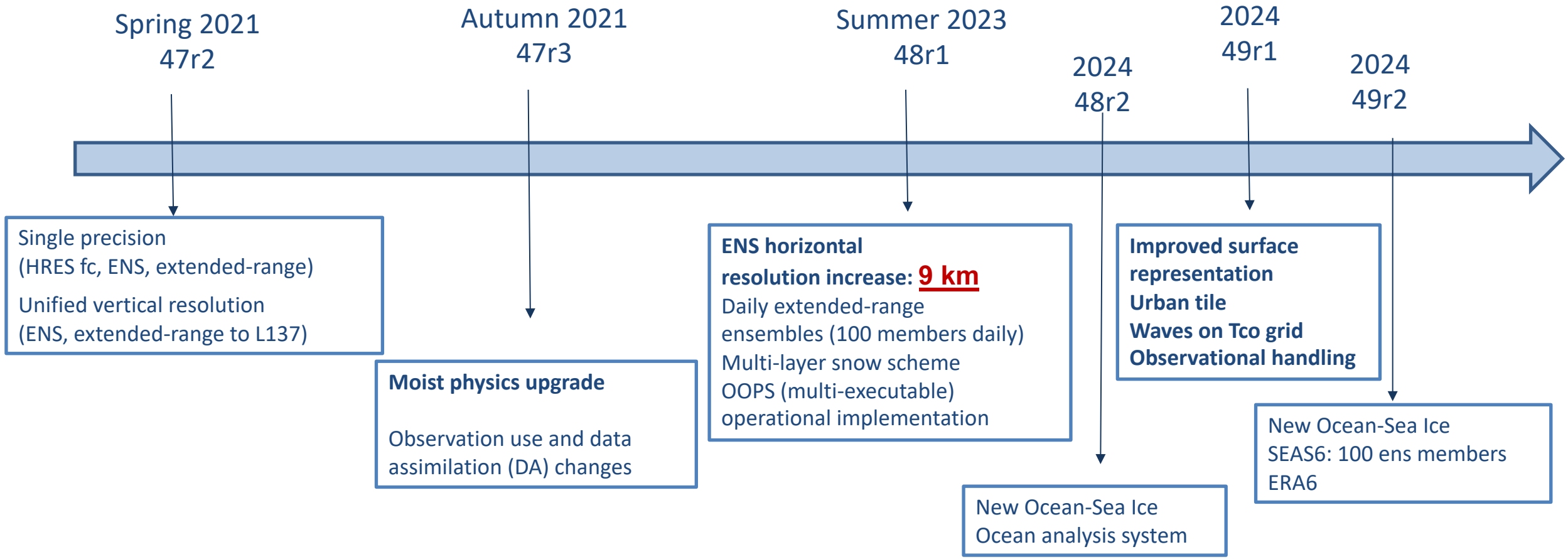
Reanalysis datasets

- ERA5
- ERA-Interim
- ERA-Interim/Land
- CERA-SAT
- CERA-20C
- ERA-20CM
- ERA-20C

Real-time datasets

Dataset	Time period	Atmosphere	Atmospheric composition	Ocean waves	Ocean sub-surface	Land surface	Sea Ice	Observation Feedback Archive	Download using MARS web interface (unless stated otherwise
ERA5	1979-present	✓		✓		✓			Get ERA5 from the Climate Data Store
	1950-1978 preliminary	✓		✓		✓			Get ERA5 preliminary from the Climate Data

Integrated Forecasting System (IFS) cycle upgrades



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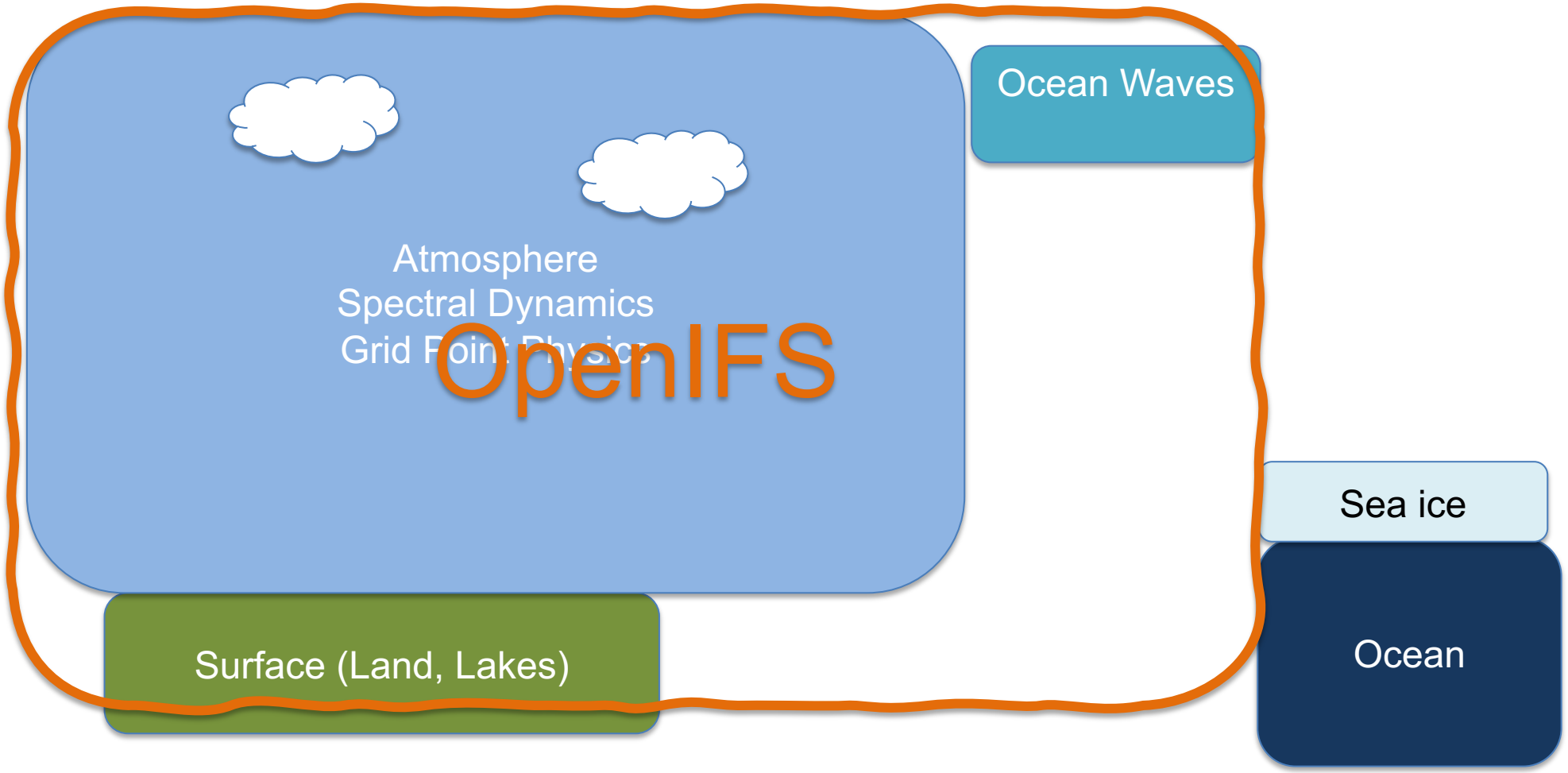
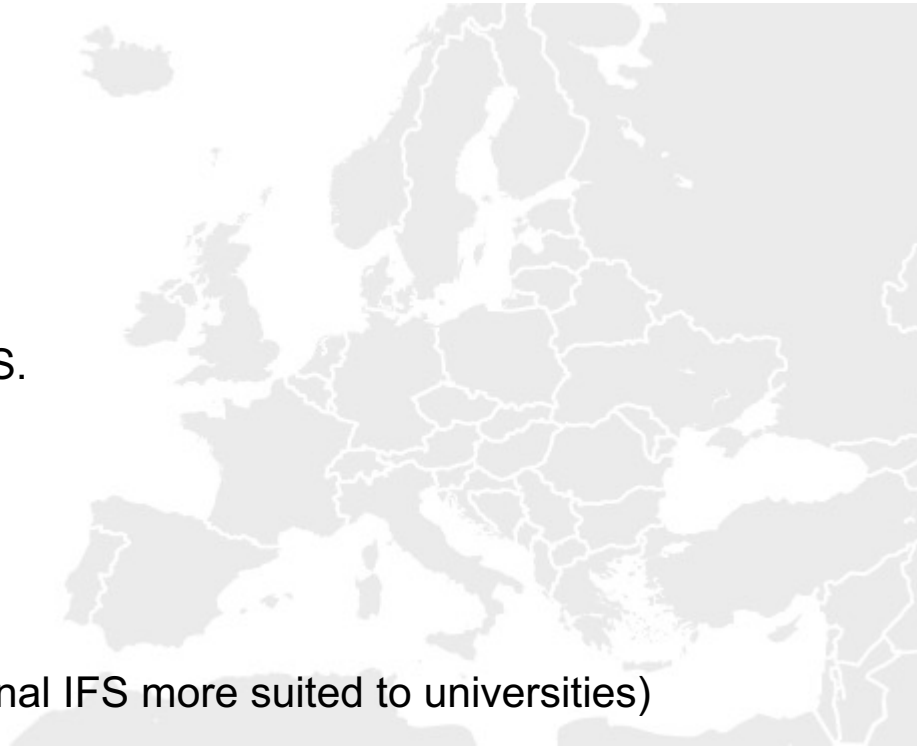


What is OpenIFS?

The **OpenIFS programme** provides a **supported, portable** version of the ECMWF IFS **operational model** to academic and research institutions, for **research and education**.

OpenIFS is a **long term**, **supported core activity** to provide IFS to member and co-operating states

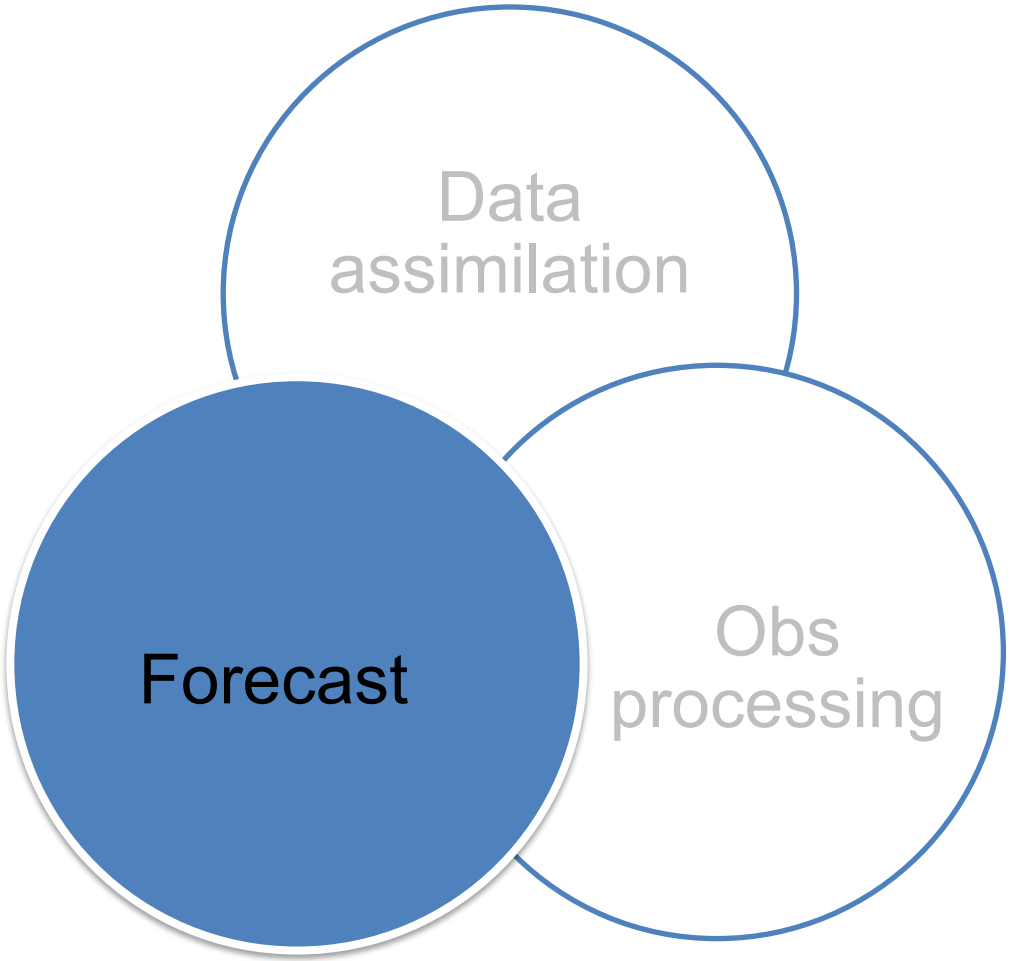


- **Objectives**
  - Increase scientific **research** using IFS.
  - Increase **collaborations** with ECMWF on topics of interest.
  - Improve **training**, focusing on NWP and researchers trained on IFS.

- **History of OpenIFS**
  - Began in 2011.
  - Release new version every 2-3 yrs (slower upgrades than operational IFS more suited to universities)

ECMWF OpenIFS

The **OpenIFS model** has the exactly the same forecast capability as IFS but no data assimilation or observation handling capability.



OpenIFS:

2.5 million lines of code.

Runs on laptops, desktops, clusters and HPC.

Supports all IFS resolutions.

Supports ensemble forecasts.

Released every 2-3 years.

What is OpenIFS being used for?

Education / training

- Masters level and above
- OpenIFS workshops and training

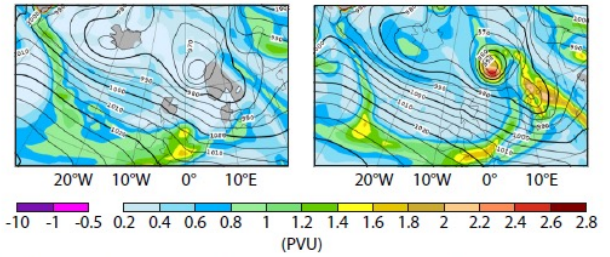
Research: many topics

- Diagnostic studies combined with reanalyses
- Seasonal studies
- Coupled to other models (EC-Earth)

OpenIFS used by University of Reading students

ROBERT PLANT, SUZANNE GRAY (both University of Reading)

The OpenIFS programme has allowed the Integrated Forecasting System (IFS) to be made available to external institutes for both research and teaching purposes. At the University of Reading we have been experimenting with its use as a teaching tool for Masters-level students and have been encouraged by the enthusiasm of and benefits for students. It has worked particularly well for intensive small-team projects. We intend to



Storm Nina simulations. Mean sea-level pressure (contours) and 700-hPa potential vorticity (shading) for simulations of storm Nina with 10% of the default latent heating (left) and double the default latent heating (right). Both plots are at the time of the peak intensity of the storm.

Dynamic meteorology

Factors affecting atmospheric vertical motions as analyzed with a generalized omega equation and the OpenIFS model

Oleg Stepanyuk, Jouni Räisänen, Victoria A. Sinclair & Heikki Järvinen

Article: 1271563 | Received 02 Jun 2016, Accepted 03 Dec 2016, Published online: 18 Jan 2017

Download citation Check for updates

So what's coming?

- Tour round the main components of the model included in OpenIFS
- Getting to play with one of the best NWP models in the world.
  - Hands on sessions to help you be a confident user of models using a real case study
  - Space to go deeper if you are already familiar
  - Learn how to visualise the model output using python based tools
- Time to chat with others and with the experts at ECMWF to help get you started.
  - Build a network of other model users.