La fisica dell’atmosfera e del clima : modelli , osservazioni, big data con HPCF tools (Anemoi)

Giornata di orientamento alla scelta delle tesi in FISICA
28 marzo 2025

Paolina Bongioannini Cerlini
Lorenzo Silvestri e Miriam Saraceni
Luca Gammaitoni
Francesco Cottone

ARGOMENTI di RICERCA

Modelli fluidodinamici 3D: teoria e applicazioni

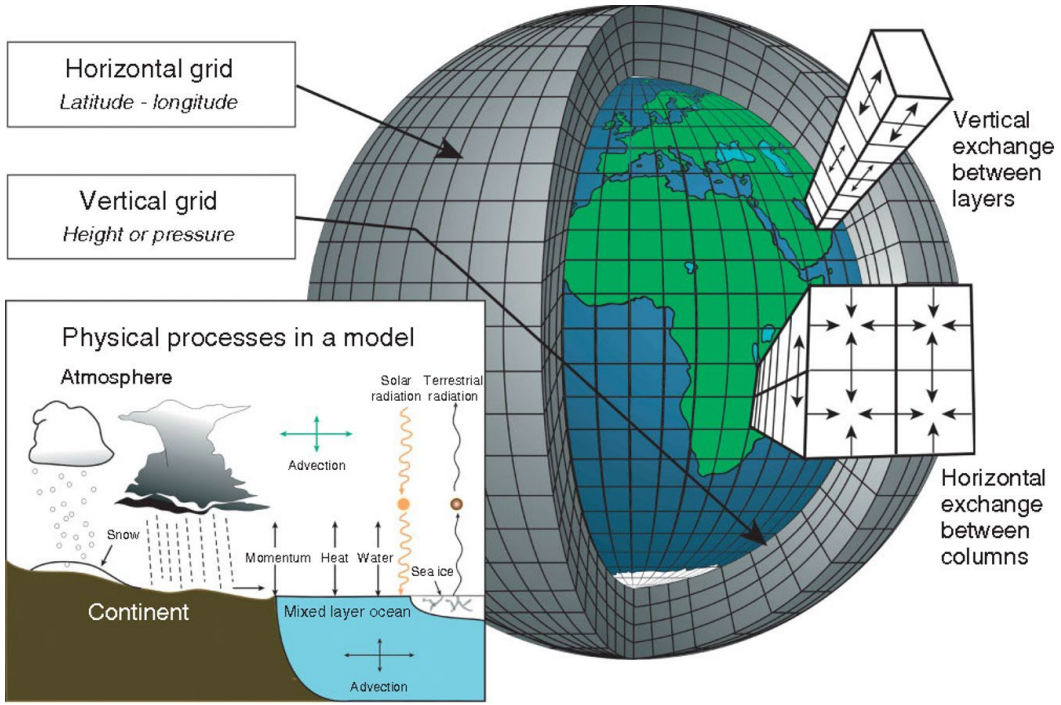
Rilevazione del cambiamento climatico usando le rianalisi ERA5 e strumenti di statistica correlati, ensemble, parametrizzazioni stocastiche come forzanti non lineari (Sistema di Lorenz)

La fisica dei cicloni tropicali mediterranei (Medicanes) e gli ensemble meteorologici per la mappatura degli eventi estremi di pioggia (Special Project @ECMWF finanziato)

Radiative-convective equilibrium e self-aggregation aggregazione spontanea dei fenomeni convettivi

Feedback delle nuvole in un clima in riscaldamento: modellazione con L'Integrated Forecasting System (*European* Centre for Medium-Range Weather Forecasts, Reading U.K., Bonn, Germany,Bologna Italy) e con Anemoi, a framework for creating machine learning (ML) weather forecasting system

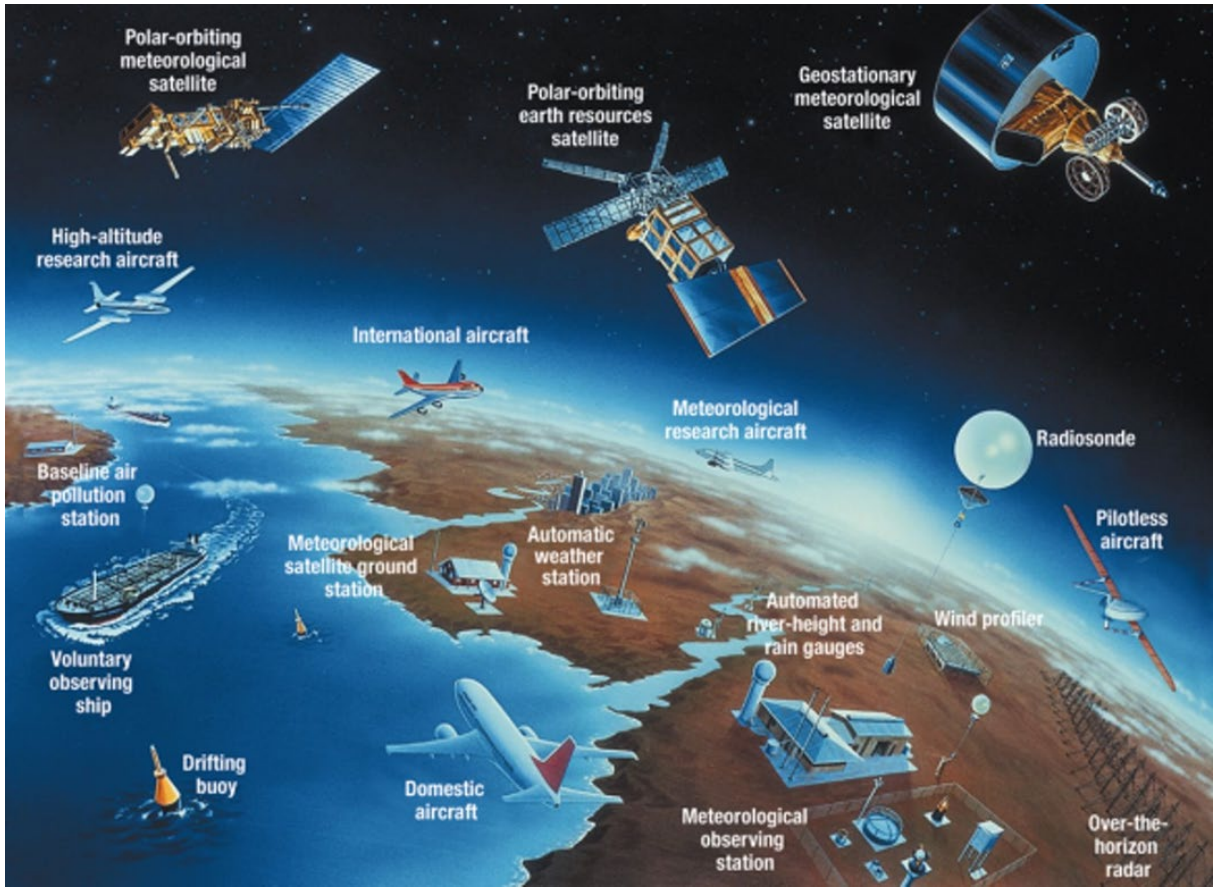
Modelli numerici



Source: PNAS journal

Fluidodinamica teorica ed applicata allo studio dell'atmosfera

Osservazioni



Dati assimilati dai modelli globali e ad area limitata

WMO WIGOS, Sistema integrato globale delle osservazioni

Source: https://public.wmo.int/en/about-us/vision-and-mission/wmo-integrated-global-

Modelli e strumenti

Integrated Forecasting System ECMWF

Weather Research & Forecasting Model (WRF) U.S. NSF **National Center for Atmospheric Research**

System For Atmospheric Modeling

Python; C++ etc

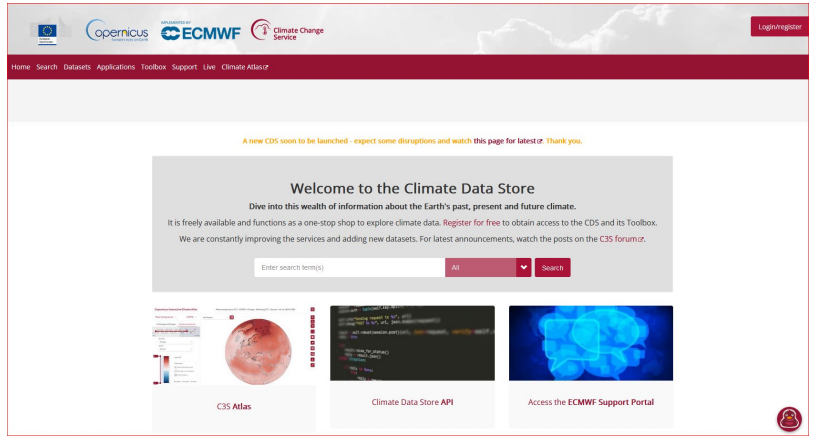
Python Jupyter Notebooks

NCL http://www.ncar.ucar.edu;

METVIEW …..

Osservazioni

COPERNICUS CDS



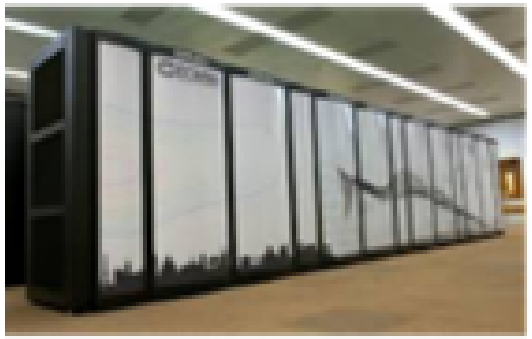
E-OBS gridded dataset

ESA Cloud Climate Change Initiative (CCI) Dataset Collection

The CEDA Archive

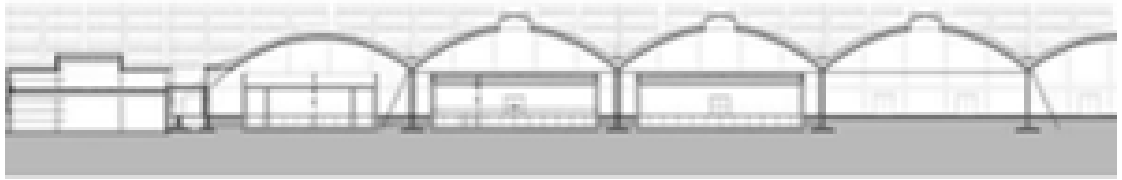
Etc.etc.

ECMWF

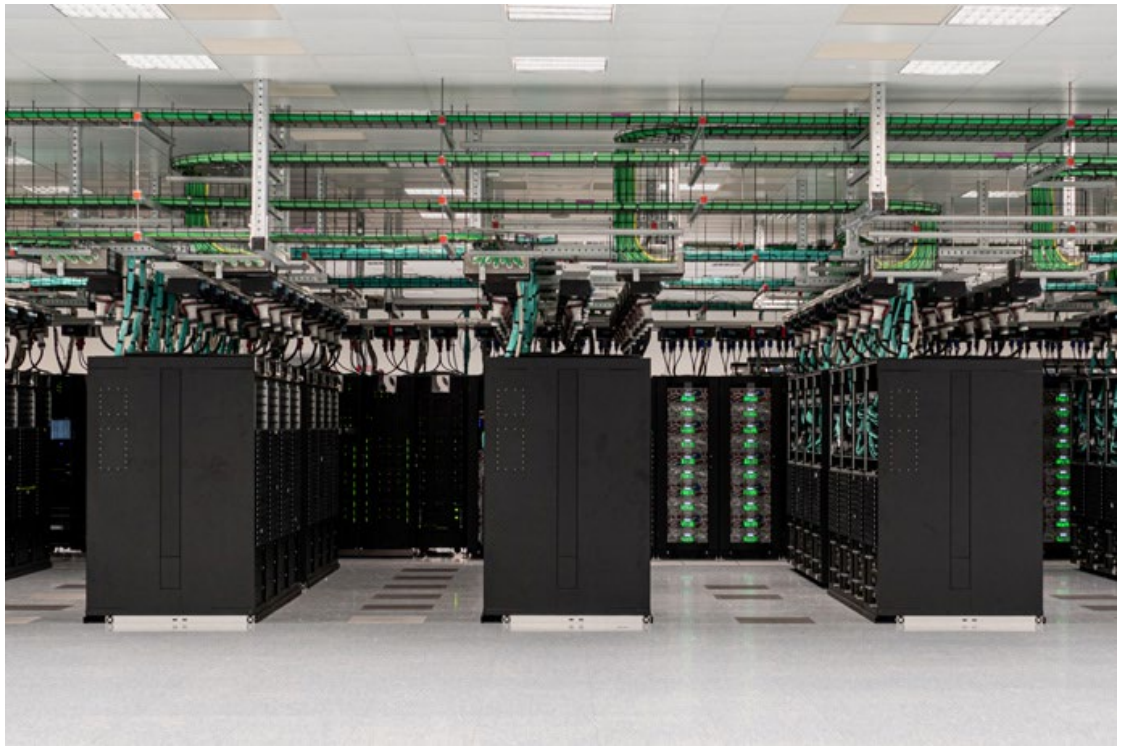


opernicus
Europe's eyes on Earth

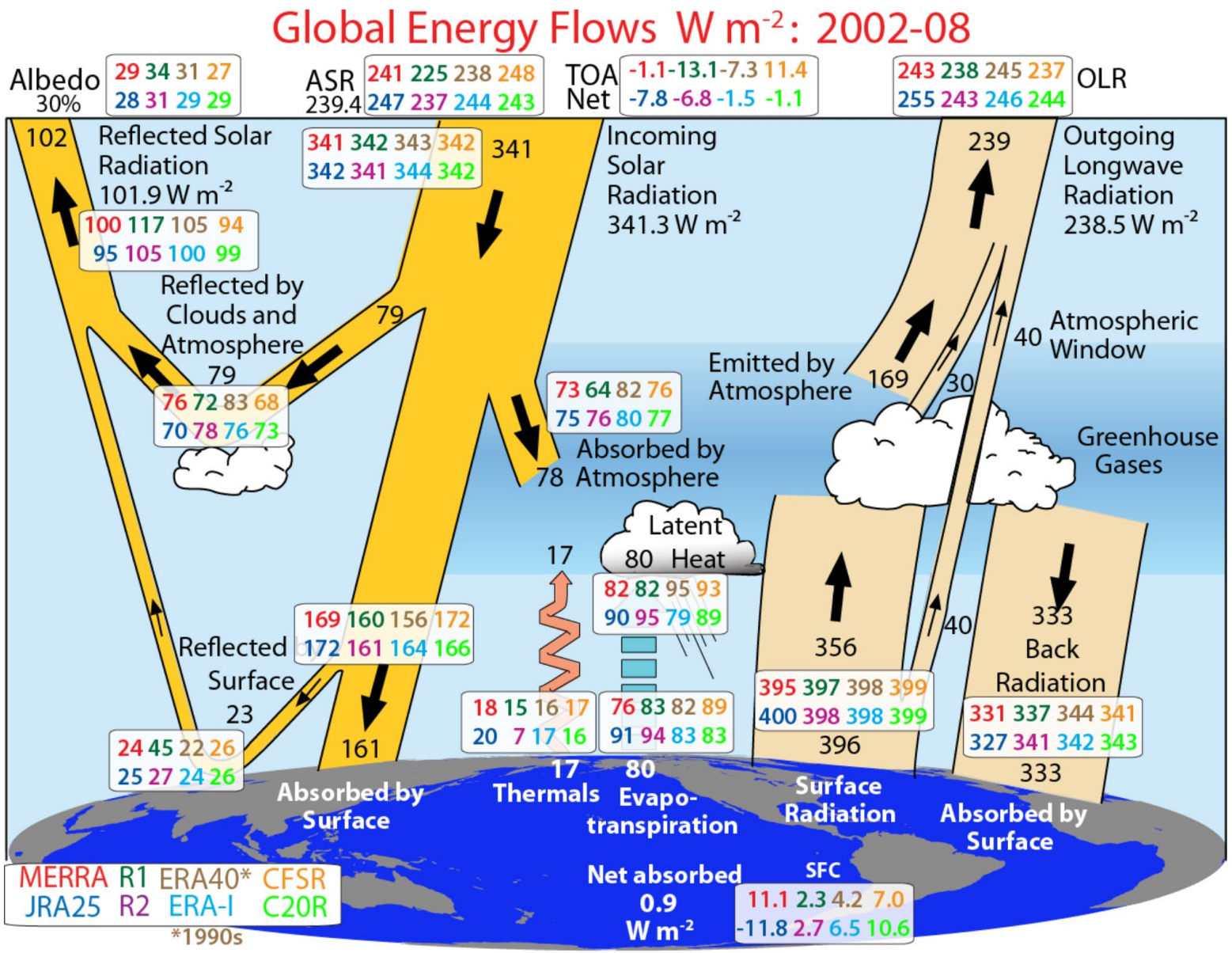
HPFC: High Performance Computer Facility



Atos Sequana XH2000 system configuration



Il sistema climatico

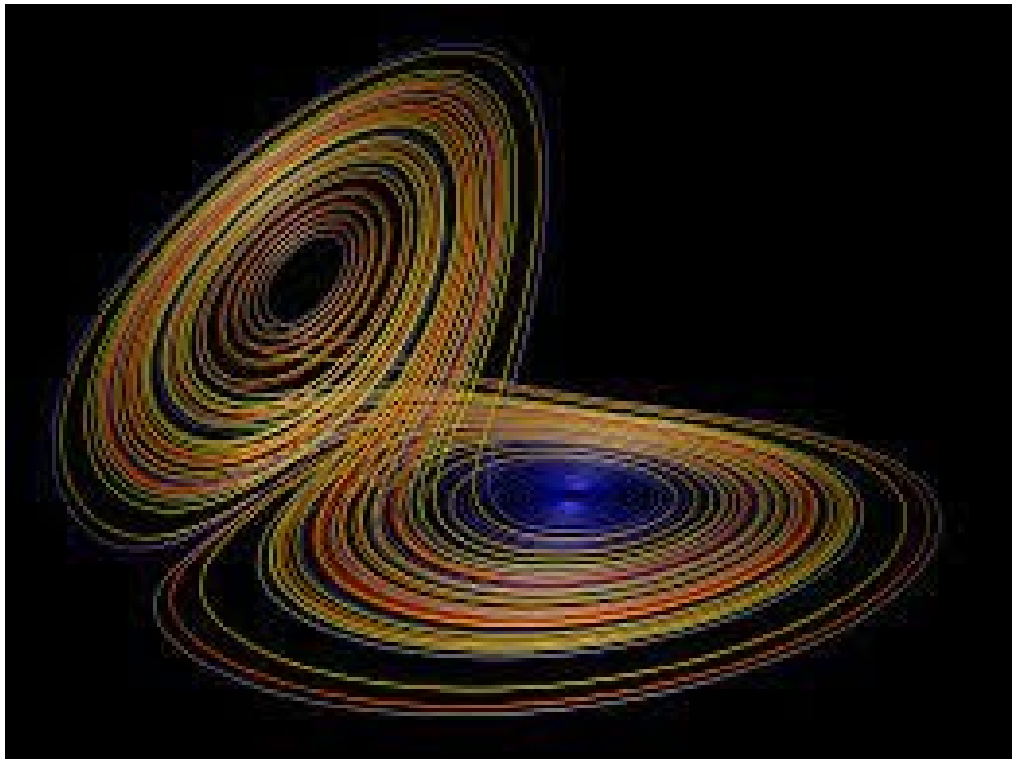


Deterministic Chaos

$$\dot{X} = -\sigma X + \sigma Y$$

$$\dot{Y} = -XZ + rX - Y$$

$$\dot{Z} = XY - bZ$$



Edward N. Lorenz (1963). "Deterministic Nonperiodic Flow",
Journal of Atmospheric Science

Deterministic Chaos

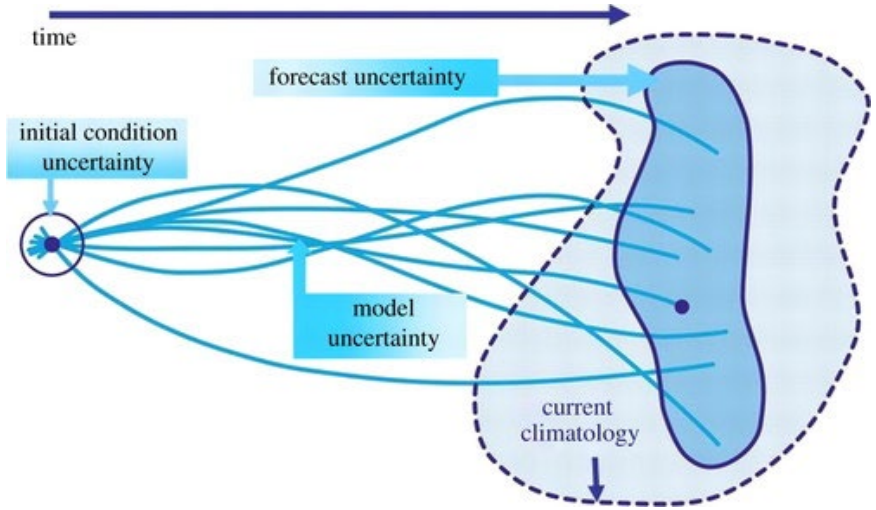
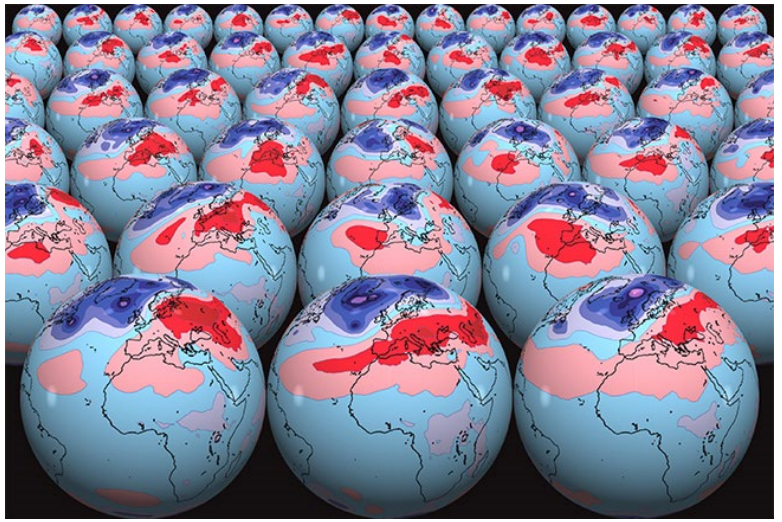
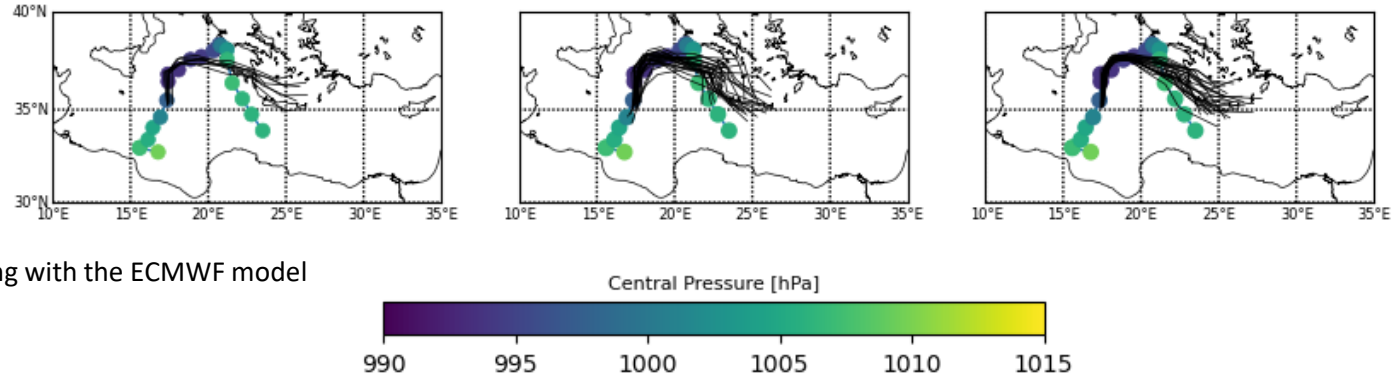


Figure 2 of Slingo, J., & Palmer, T. (2011). Uncertainty in weather and climate prediction.

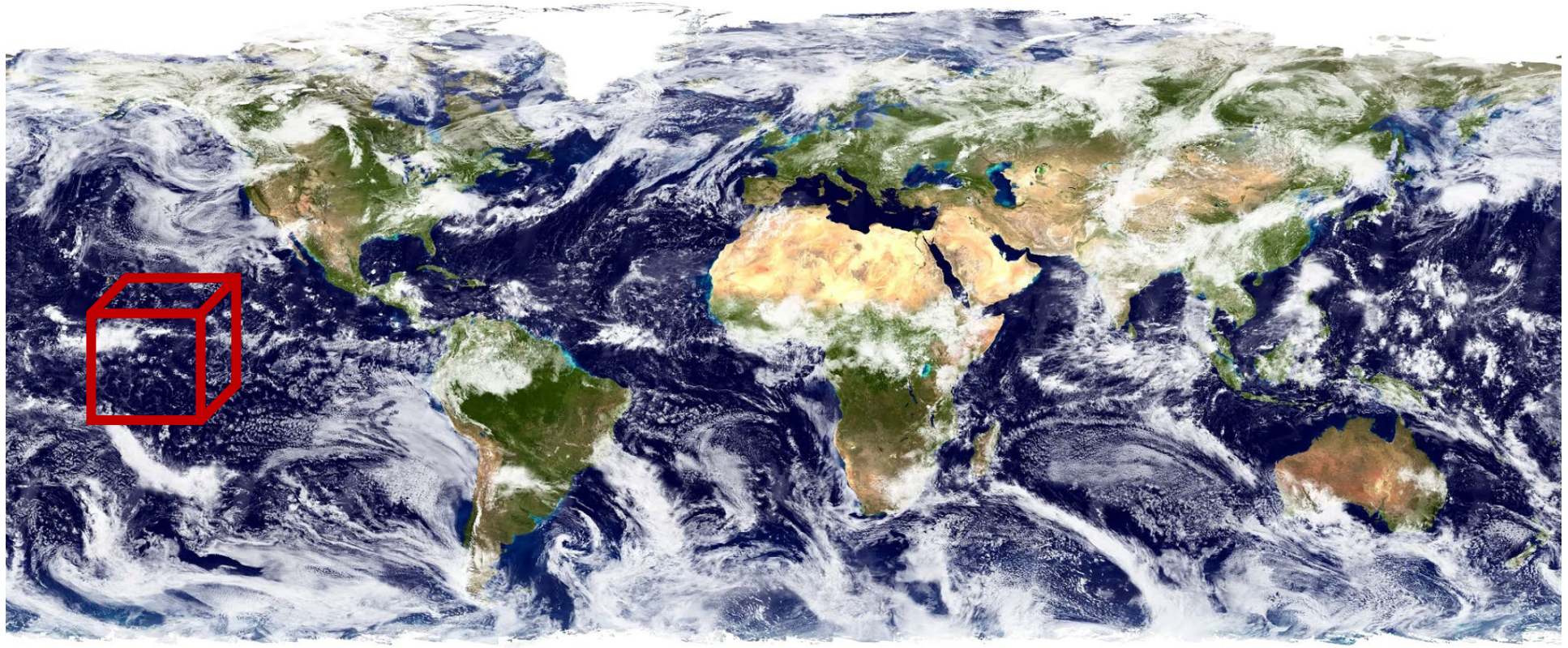


Ensemble weather forecasting at ECMWF



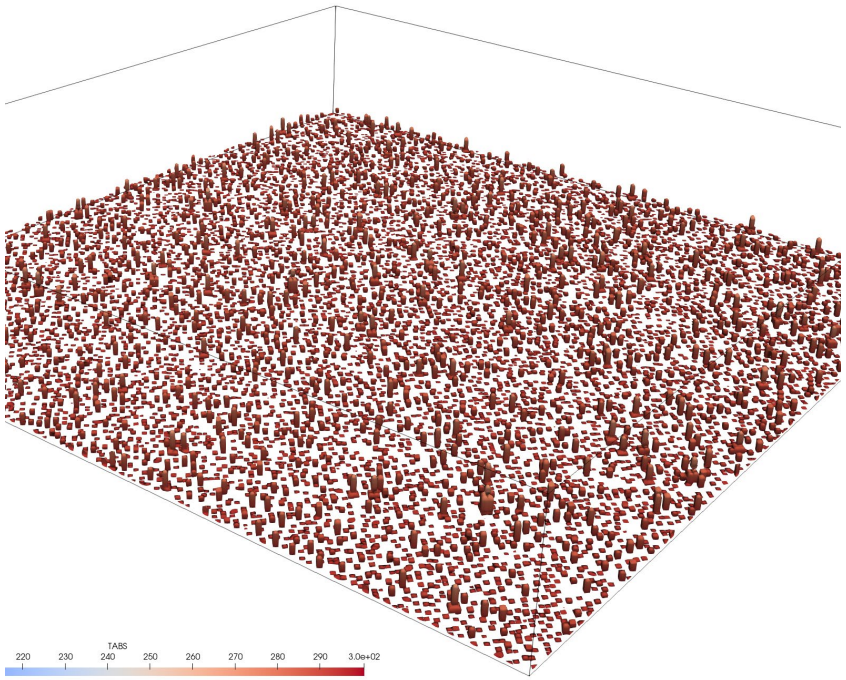
Cyclone Tracking with the ECMWF model

Explicit Simulation of Radiative- Convective Equilibrium

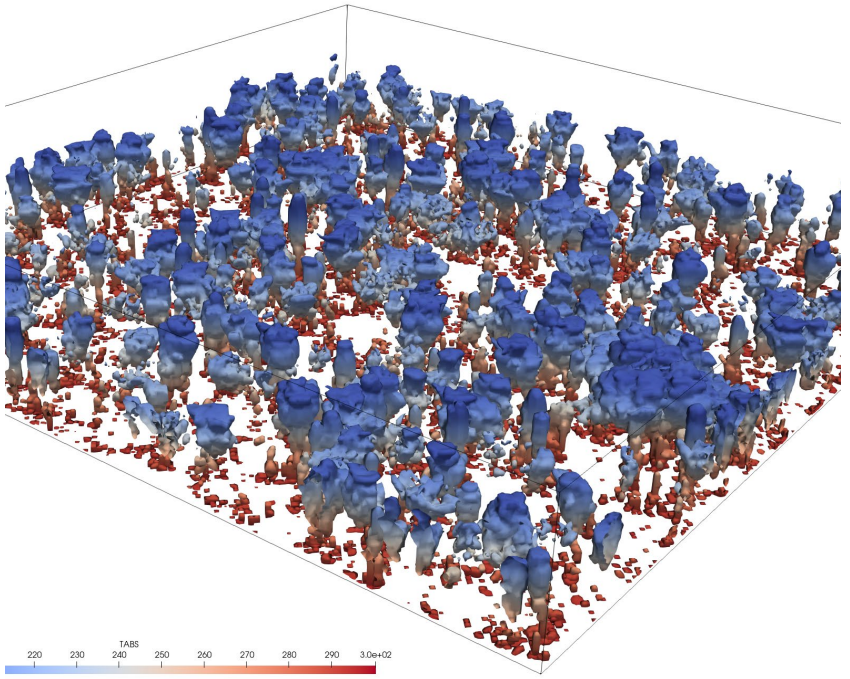


Global cloud patterns (NASA Goddard Space Flight Center)

Explicit Simulation of Radiative- Convective Equilibrium: CLOUDS

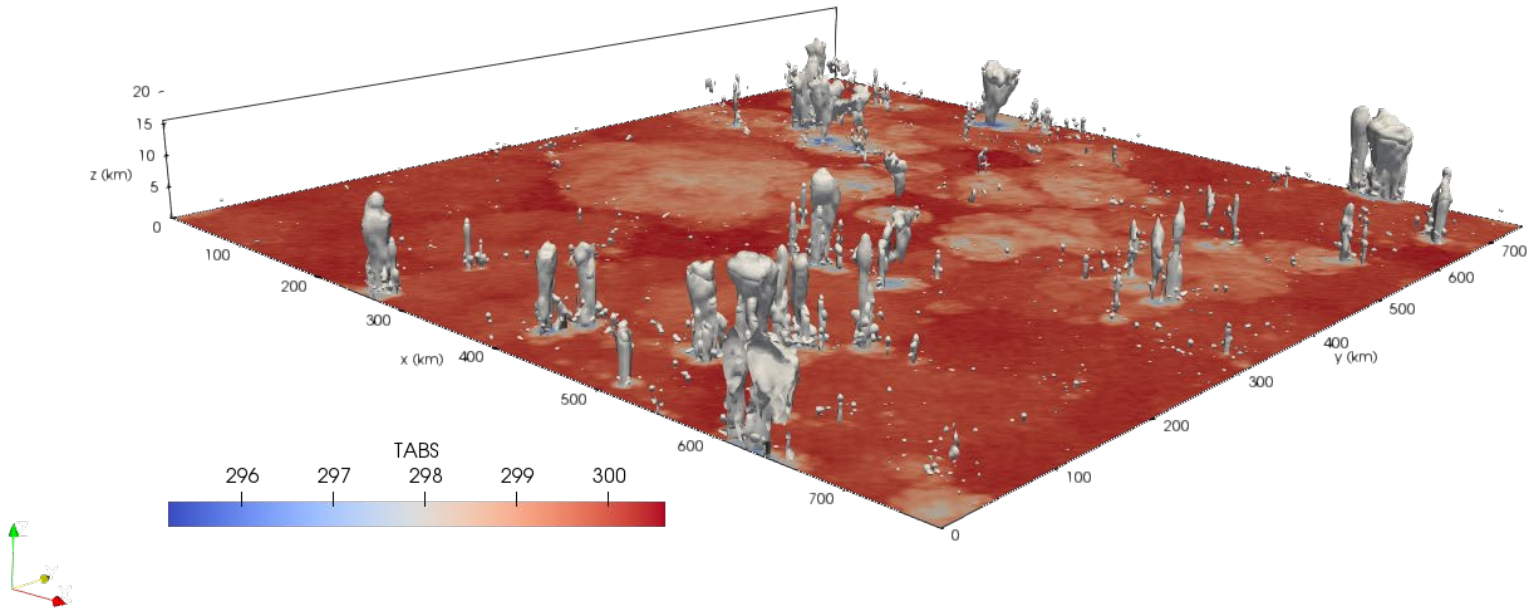


After 2 hours



After 6 hours

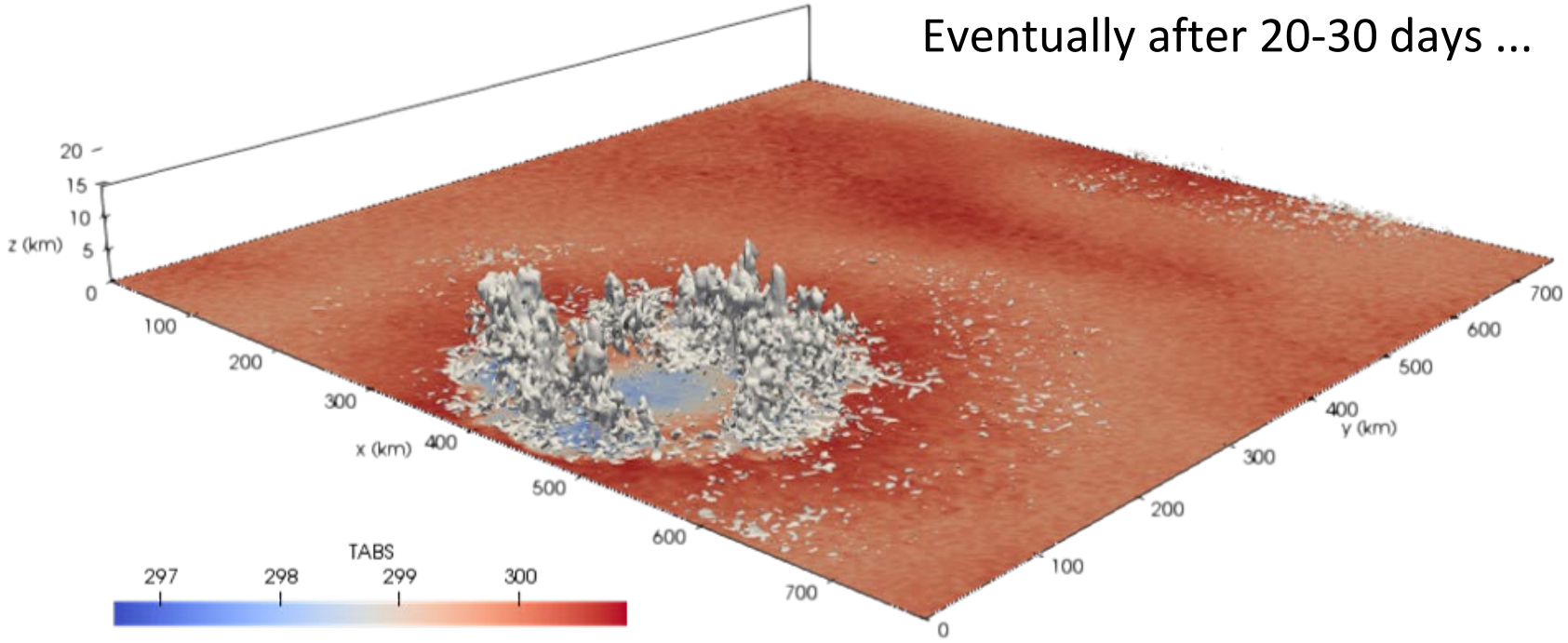
Convection in RCE



In SAM after convection develops uniformly for about 20/30 : here Tsfc and cloud water plus cloud ice and rain and snow.

Explicit Simulation of Radiative- Convective Equilibrium: Self-Aggregation of clouds

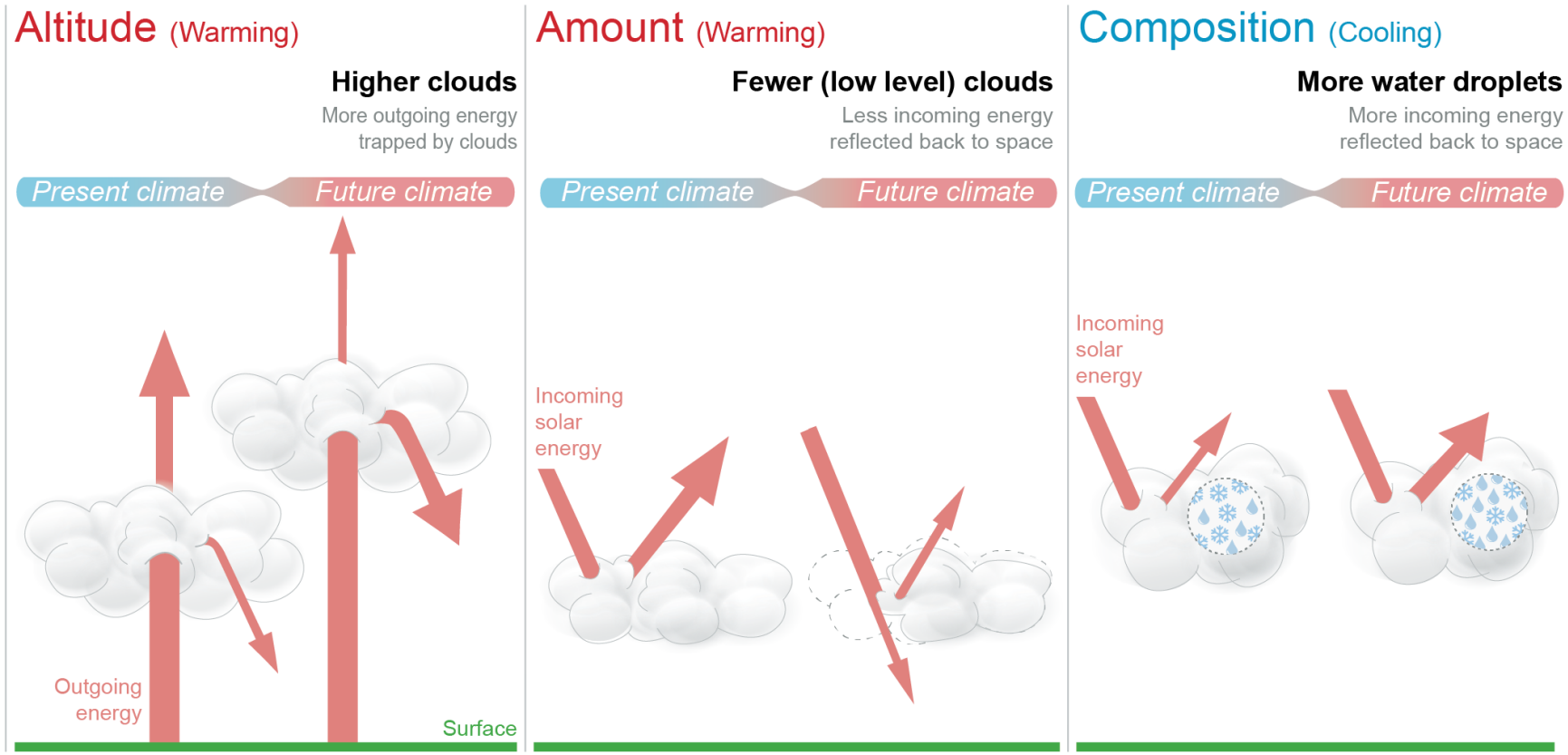
Eventually after 20-30 days ...



This phenomenon is found to occur across a wide variety of models (different equations formulation and parametrizations) and its strength increases with SST.

The importance of clouds in a changing climate

FAQ 7.2: **What is the role of clouds in a warming climate?**
Clouds affect and are affected by climate change. Overall, scientists expect clouds to **amplify future warming**.



FAQ 7.2 Figure 1 in IPCC, 2021: Chapter 7. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In Climate Change 2021*

Argomenti di ricerca

E di tesi magistrali e compilative

4) Cloud feedback in a warming climate

5) The spontaneous Aggregation of Convective Storms

The uncertainty in tropical anvil high-cloud feedback and the IRIS effect

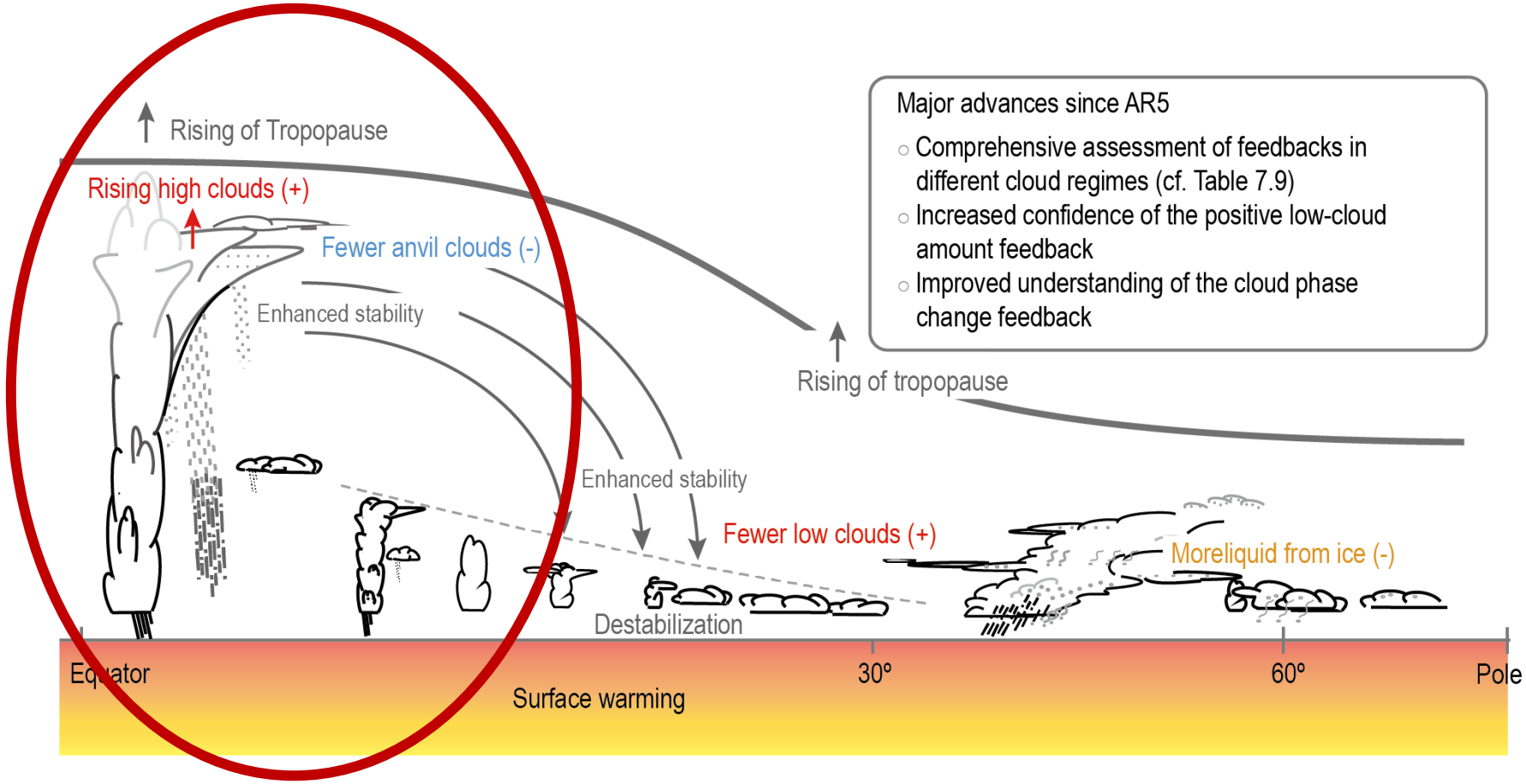


Figure 7.9 in IPCC, 2021: Chapter 7. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, D.J. Lunt, T. Mauritsen, M.D. Palmer, M. Watanabe, M. Wild, and H. Zhang, 2021: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity.*

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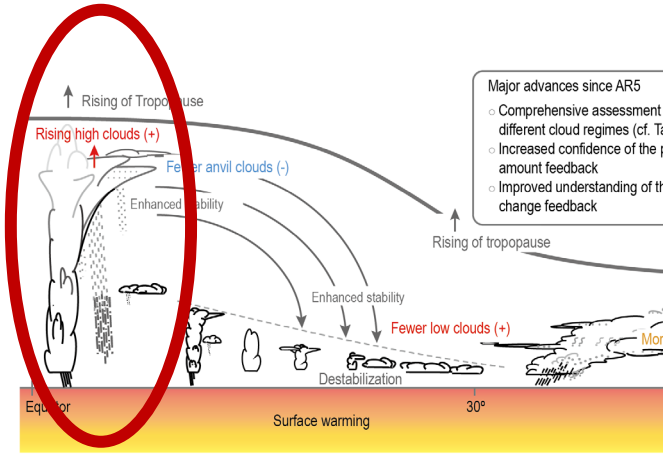
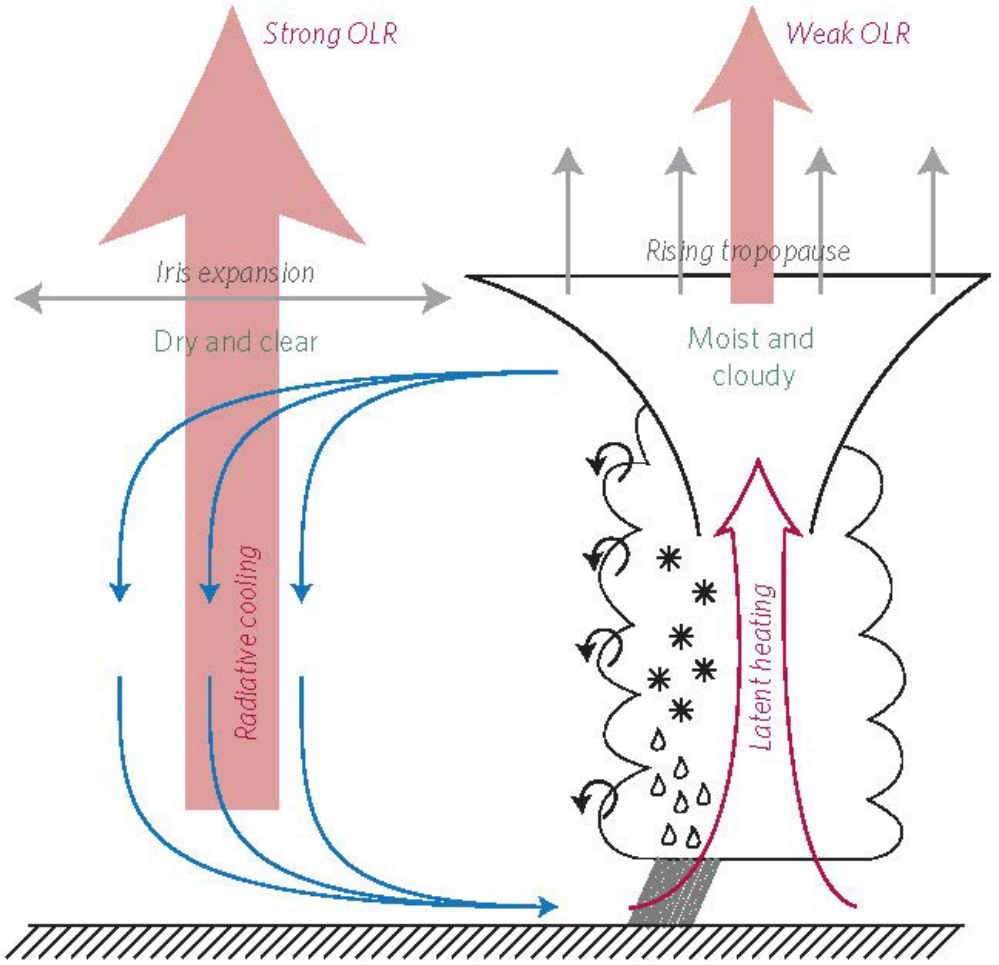


Processes that may change the balance in favour of dry and clear regions in warmer climates have been proposed to constitute **a possible negative feedback not represented by climate models**. This potential feedback has been termed the iris effect, in analogy to the enlargement of the eye's iris as its pupil contracts under the influence of more light.



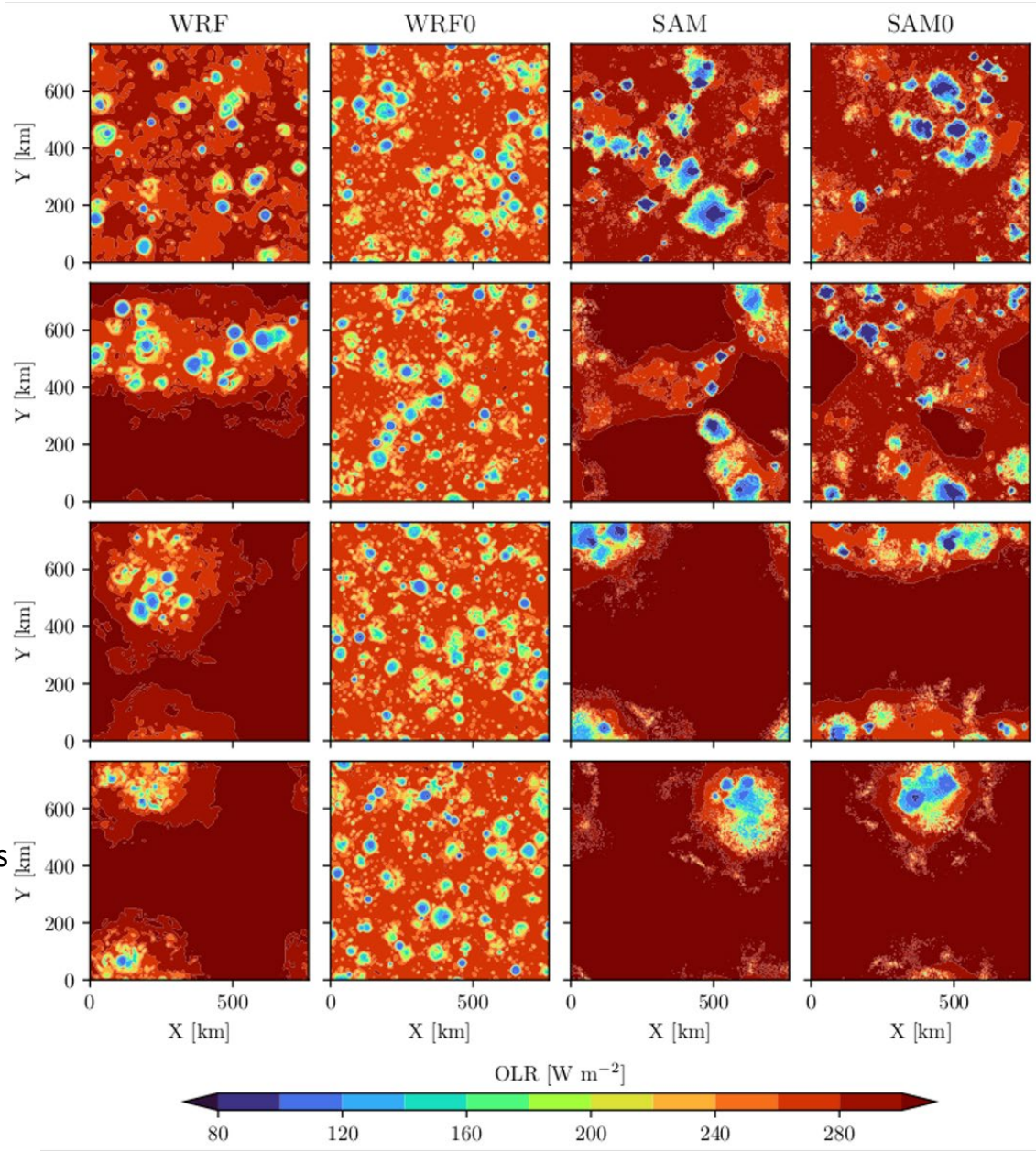
Mauritsen, T., Stevens, B. Nature Geosci 8, 346–351 (2015).

Argomenti di ricerca

6) IRIS Effect in global models

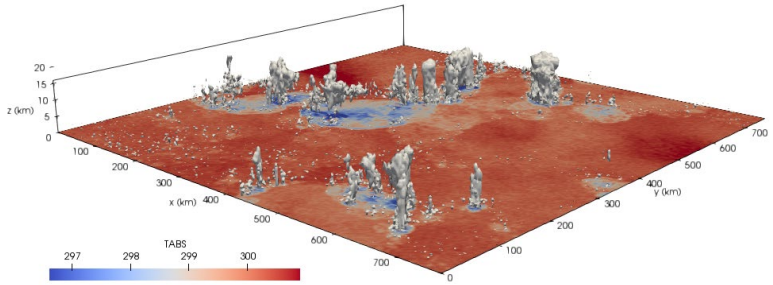
Sensitivity of Self-Aggregation: turbulence

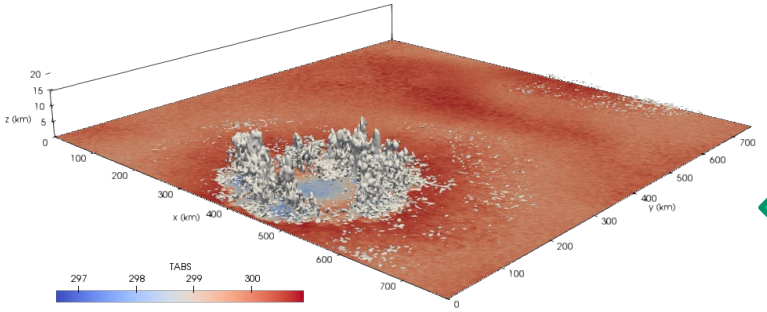
Different models with **different turbulence parametrizations** can lead to different final equilibrium states.



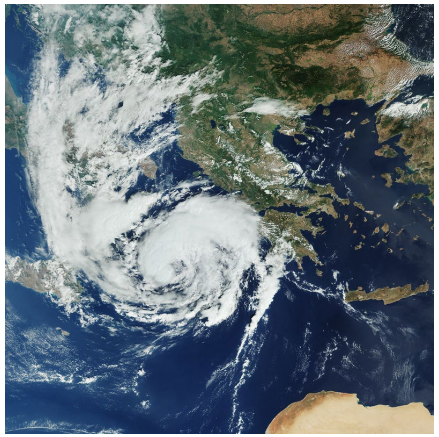
different clouds feedback on climate

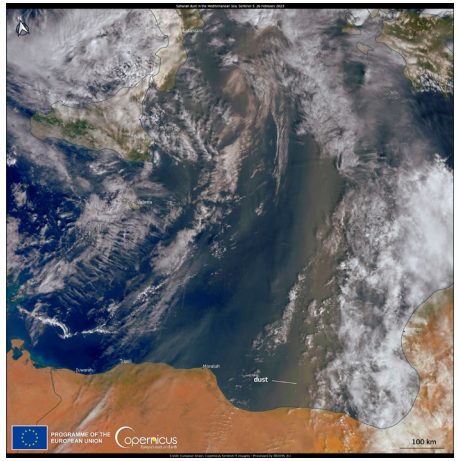
La ricerca di UNIPG

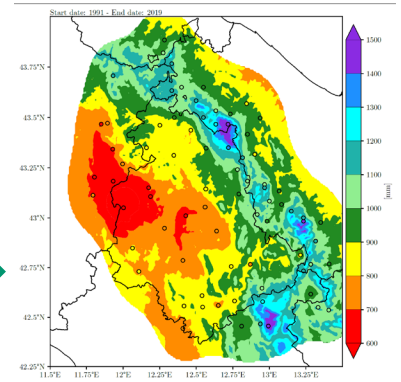


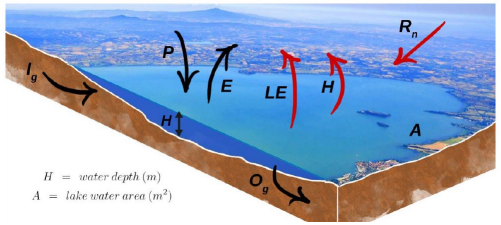


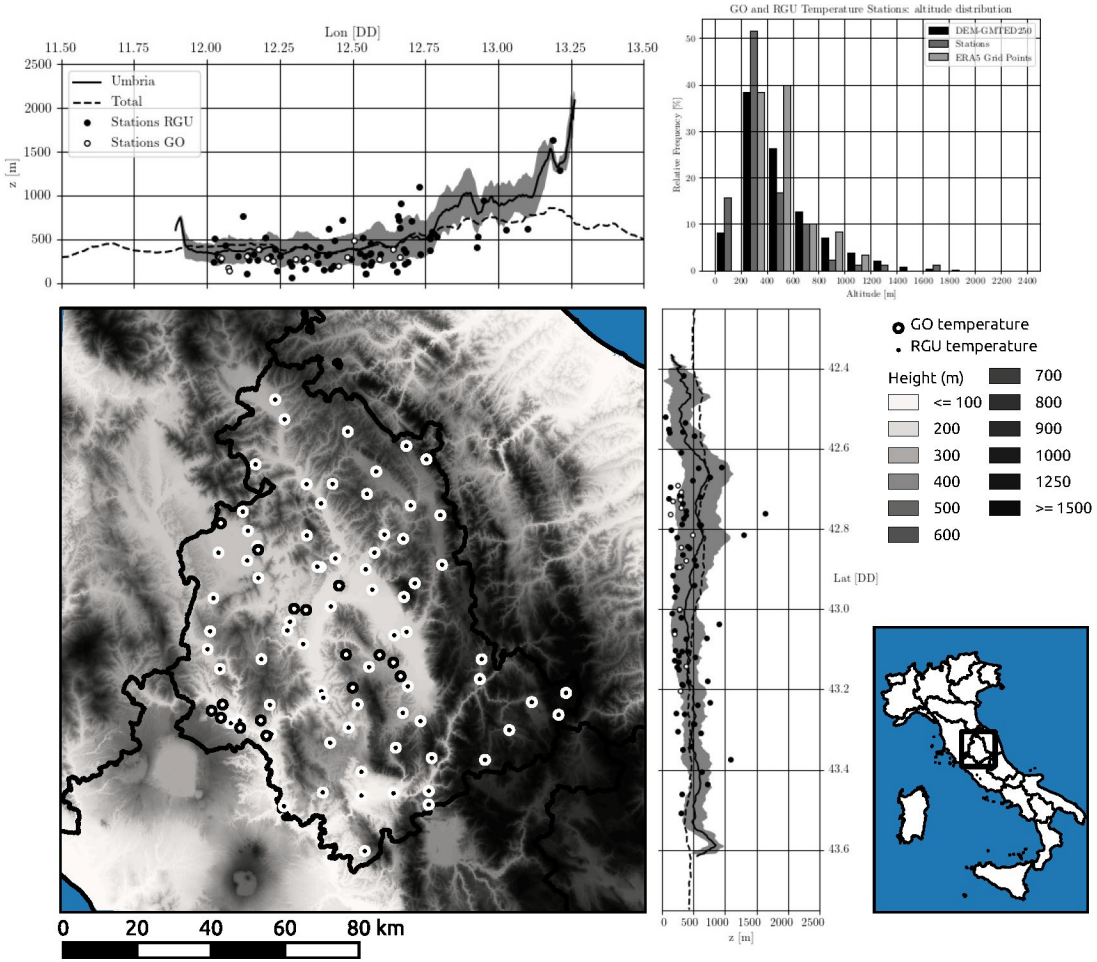
Il clima:
interazioni complesse di fenomeni a tutte le scale










Lon [DD]
11.50
11.75
12.00
12.25
12.50
12.75
13.00
13.25
13.50
z [m]
2500
2000
1500
1000
500
0
Umbria
Total
Stations RGU
Stations GO
GO and RGU Temperature Stations: altitude distribution
DEM-GMTED250
Stations
ERA5 Grid Points
Relative Frequency [%]
Altitude [m]
GO temperature
RGU temperature
Height (m)
<= 100
200
300
400
500
600
700
800
900
1000
1250
>= 1500
Lat [DD]
42.4
42.6
42.8
43.0
43.2
43.4
43.6
z [m]
0 20 40 60 80 km

ARGOMENTI di RICERCA

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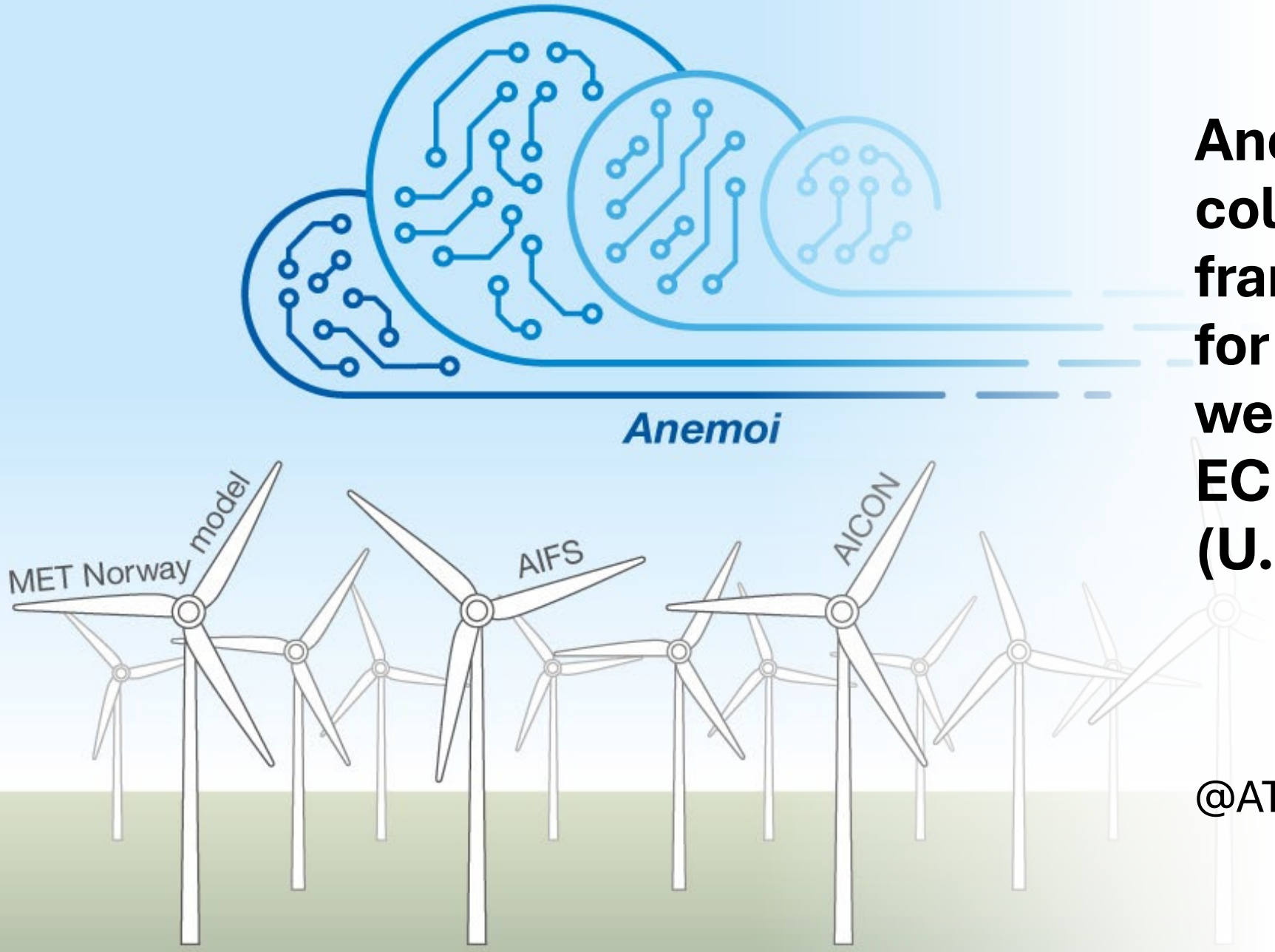

Anemoi: a new collaborative framework for ML weather forecasting ECMWF (U.K., Germany, Italy)

@ATOS HPCF in Bologna

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luca.gammaitoni@unipg.it
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idealized simulation equilibrium framework.

Lunedì 31 marzo 2025 - Ore 15.30

Aula B - Dipartimento di Fisica

Adrian Mark Tompkins

ICTP - The Abdus Salam International Centre for Theoretical Physics

Dr. Adrian Tompkins is a research scientist in the Earth System Physics section of ICTP. His work focuses on cloud and convection dynamics, their representation in weather and climate models, and the role of tropical convection organization in climate sensitivity. He is particularly dedicated to improving weather prediction and climate model applications in developing countries. Over the past 13 years, Dr. Tompkins has taught at more than 35 schools, workshops, and training events across Africa, Asia, and Central/South America, organizing over 25 of these in 12+ African countries. His recent efforts emphasize training in open-access climate tools and datasets, particularly within the Copernicus climate services framework, hosted by ECMWF where he previously worked.

His research has expanded to climate-health applications in Africa, where he leads the development of an open-source regional