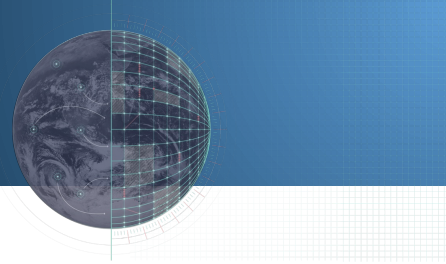
DESTINATION EARTH

HOW WOULD AN APPLICATION DEVELOPER OR THE GENERAL PUBLIC USE DESTINE DATA

Nils Wedi

Funded by the European Union
Destination Earth
implemented by ECMWF esa EUMETSAT

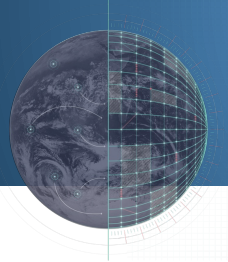


DIGITAL TWIN TECHNOLOGY

New type of **weather extremes and climate information** system used **to assess impacts of climate change and different adaptation strategies** at local and regional levels over multiple decades.

Key features:

- **"User-driven"** approach focused on **user (or broker) interactivity**
- **Global multi-decadal climate simulations** at unprecedented km-scale horizontal **resolution**
- **Directly linking digital twin output to impact models and services**
- **Building an AI-supported ecosystem for condensing information**
- **Extreme weather events** at local (dekametre) and regional levels (sub-km); complementing **detection and triggering framework** leveraged by memberstate weather services
- **Quality assessment and uncertainty quantification** based on observations



TECHNICAL CHALLENGES

- 20+ PB of digital twin data, ”how do I get the bytes I need” ?
  - ➢ Efficiency of Infrastructure use: HPC or cloud ? Near data or near service, serverside or client side processing, workflow parallelism ? **Server-side:** ☁️🗄️ **Client-side:** 💻🌐 **HPC:** ⬛⬛⬛
- Lack of knowledge on the interfaces and services
  - ➢ How to adapt, how does it fit with what I have or want to achieve ?
- Data broker needs and expert knowledge vs general public user appeal
  - ➢ Accomodating different levels of expertise
  - ➢ Ensuring clear + concise messaging to the range of users in an evolving ecosystem
  - ➢ Avoiding over-simplification (scientist ambition)

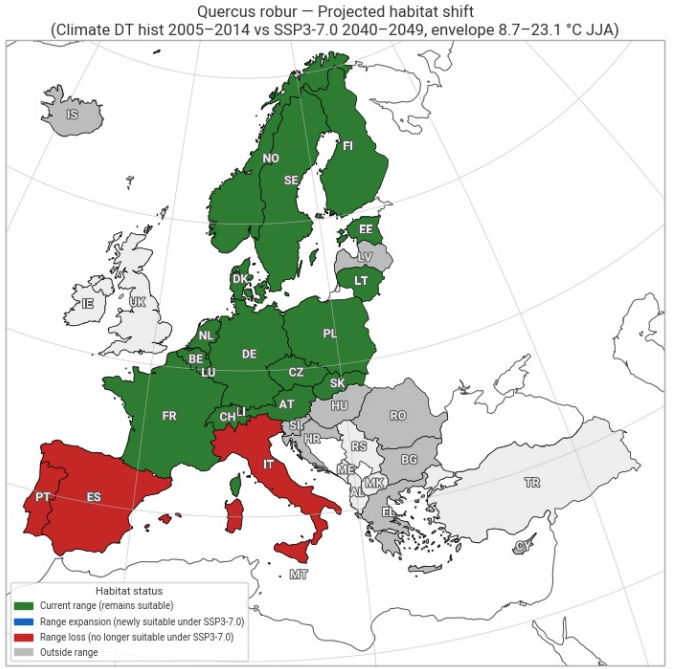
UNCERTAINTY CONSIDERATIONS[1] ON CLIMATE DT

[1] inspired by J. P. van der Sluijs, University of Utrecht

- **Building trust** and addressing uncertainty on climate change and adaptation
  - **Statistical uncertainty**: improving quality of predictions, apply different methods of validation, framing within consensus knowledge, availability of quality assessments, labelling of data
  - **Scenario uncertainty** (CMIP6 or CMIP7, European scenario, …): supporting robustness of decision taking, considering new or bespoke scenarios, reduce time to data bytes
  - **Ignorance, surprises**: define impact resilience thresholds and map to weather in a changing climate, increase flexibility on what-if scenarios, consider risk-based approaches
  - AI for condensing information and interpolation between scenario outcomes

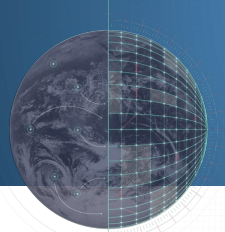
EXAMPLE 1 – USE POLYTOPE TO FUSE EUROSTAT OR GBIF BIODIVERSITY DATA WITH CLIMATE DT OUTPUT

- Requires familiarity with:
  - Python, jupyter notebooks (or LLM AI use)
  - Basic knowledge on databases, content and location
  - Basic domain knowledge on interpreting uncertainty and results
- Targeted users:
  - Information brokers
  - Advanced general public use for illustrations, training, or personal use



Projected oak tree occurrence in Europe with climate change

-> Adam Warde



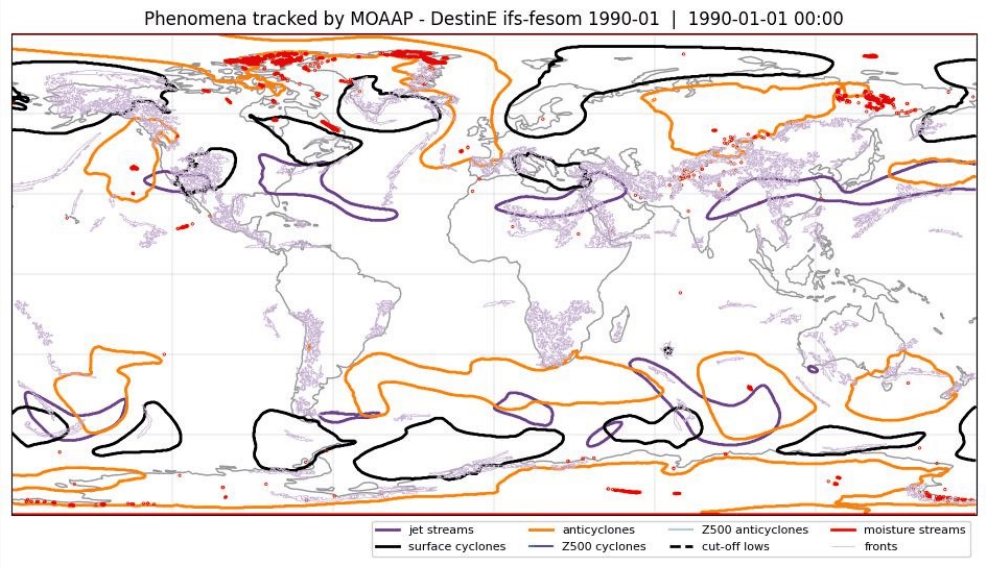
EXAMPLE 2 – USE EDGE SERVICES FOR ANALYSING NEAR THE DT DATA HOLDINGS

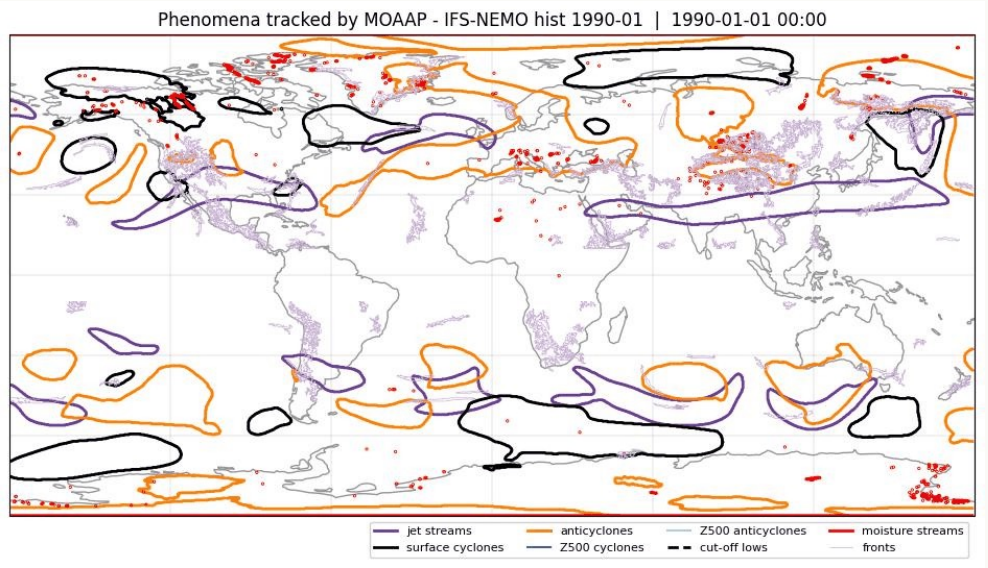
- Requires familiarity with:
  - Setting up and basic knowledge on openstack cloud services, separate account
  - System administration for the chosen desktop environment incl installing all software required, optionally docker containers, python, etc.
  - Domain knowledge required, understanding data and interpreting uncertainty and results
- Targeted users:
  - Information brokers
  - Diagnostics/dataset creators/owners
  - Scientists

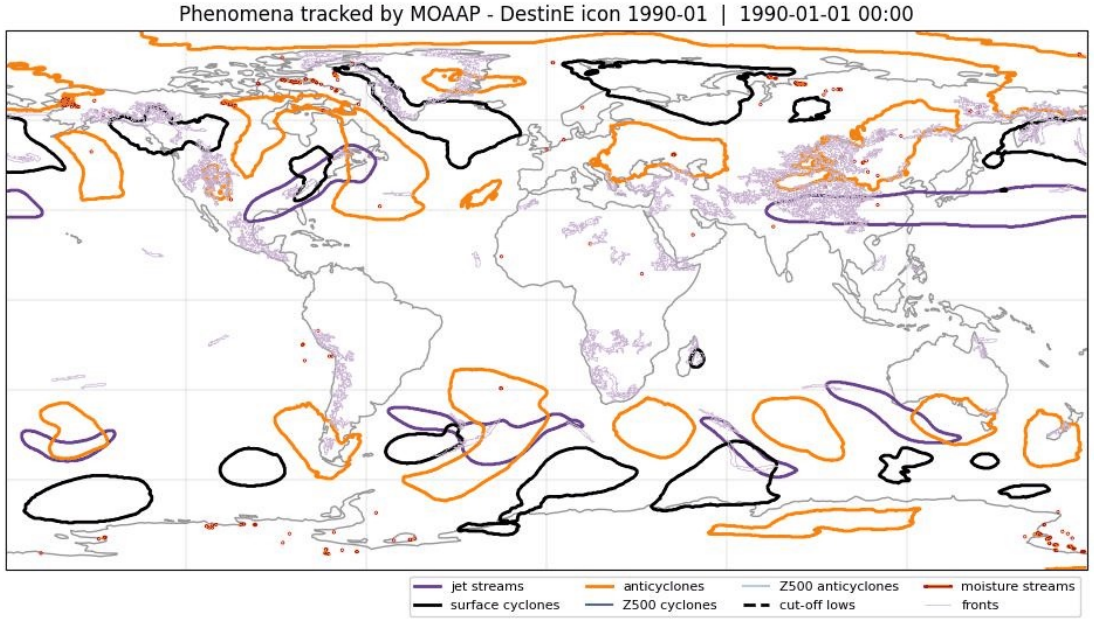
Server-side: ☁️ 🗄️ , configure via 🌐 and command-line shell access

Phenomena tracked by MOAAP

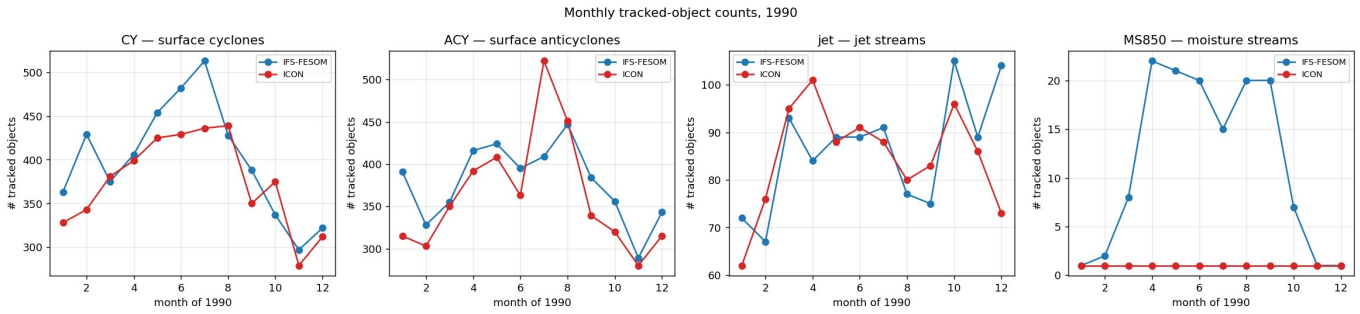
we exclude tropical waves for now

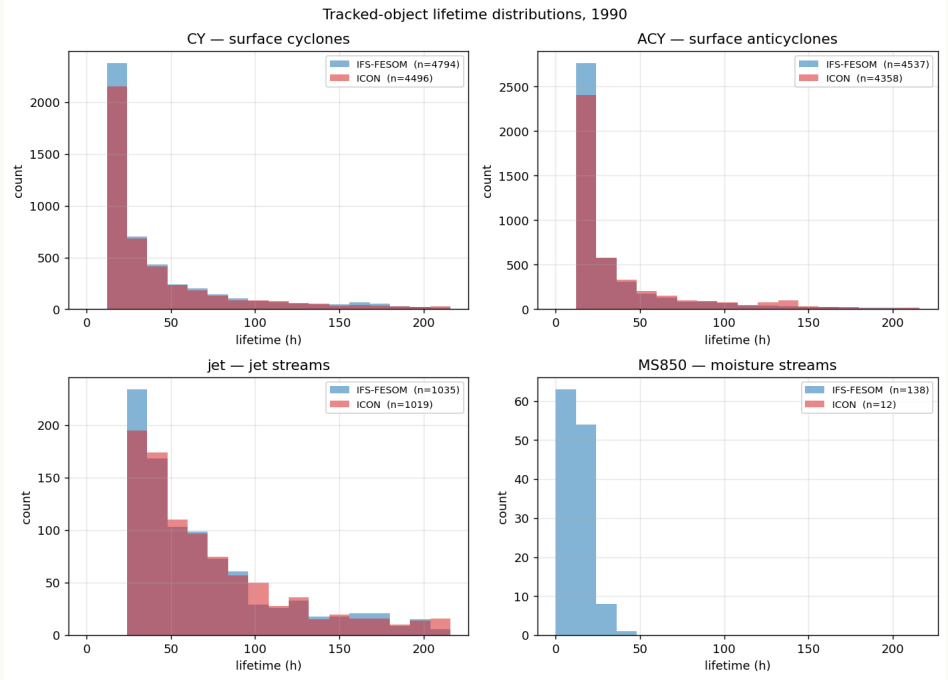


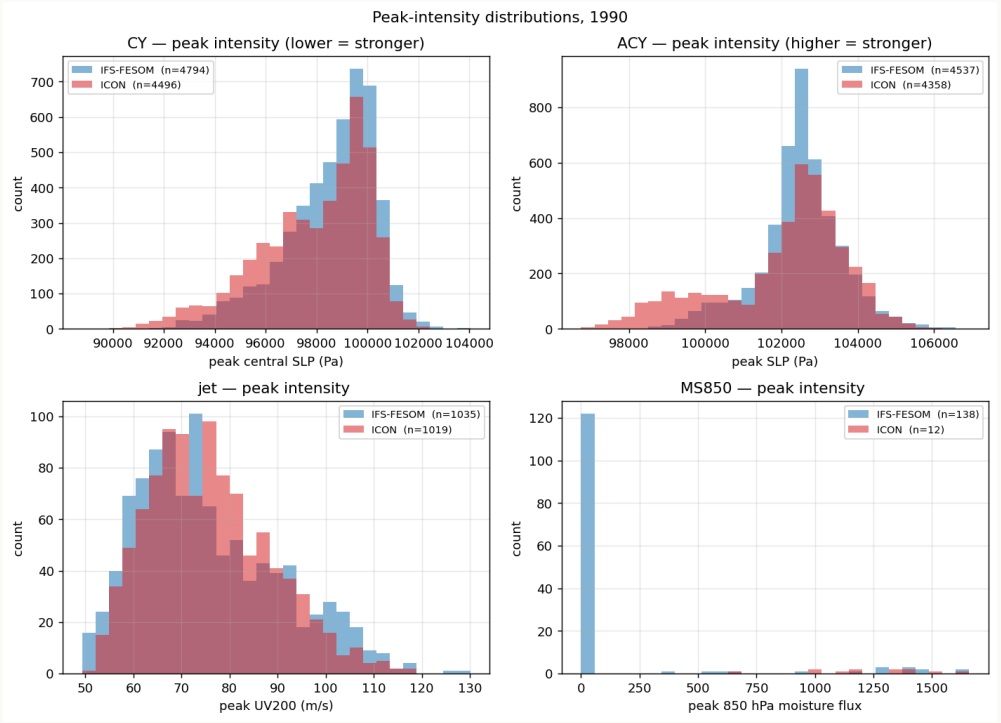




Courtesy Nikolay Koldunov

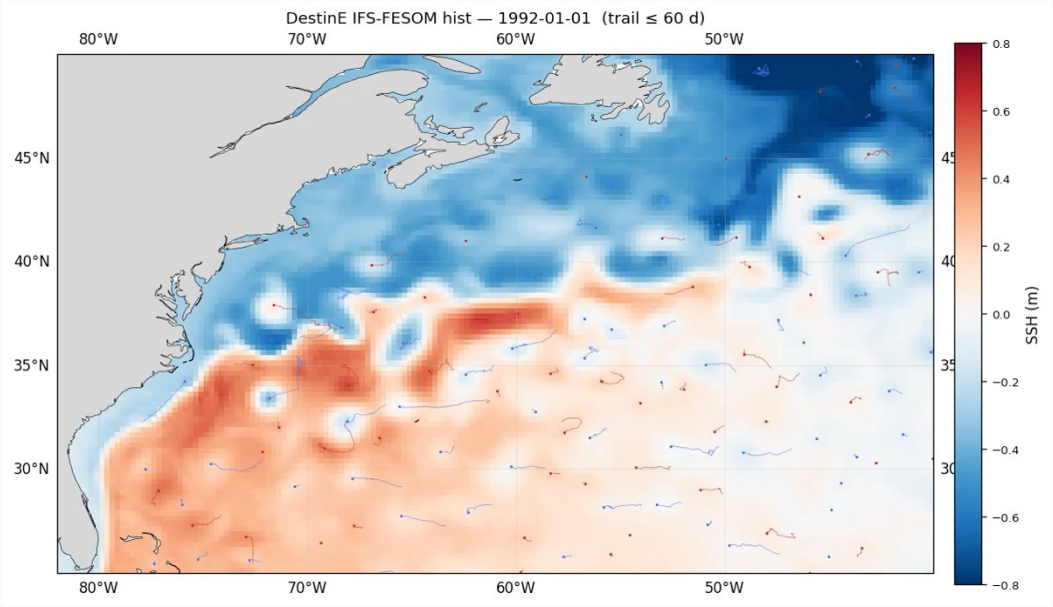


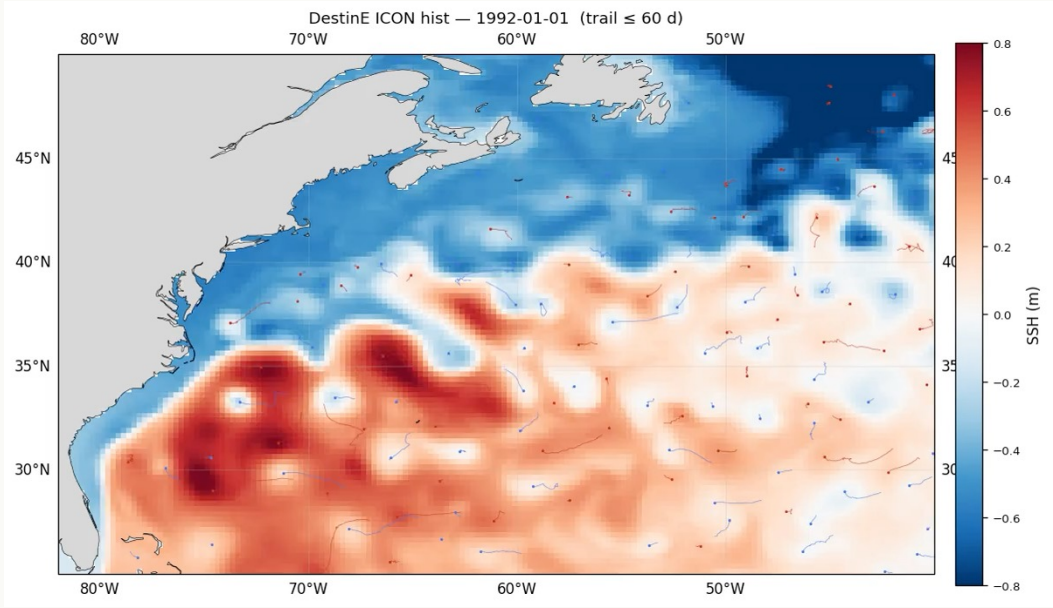


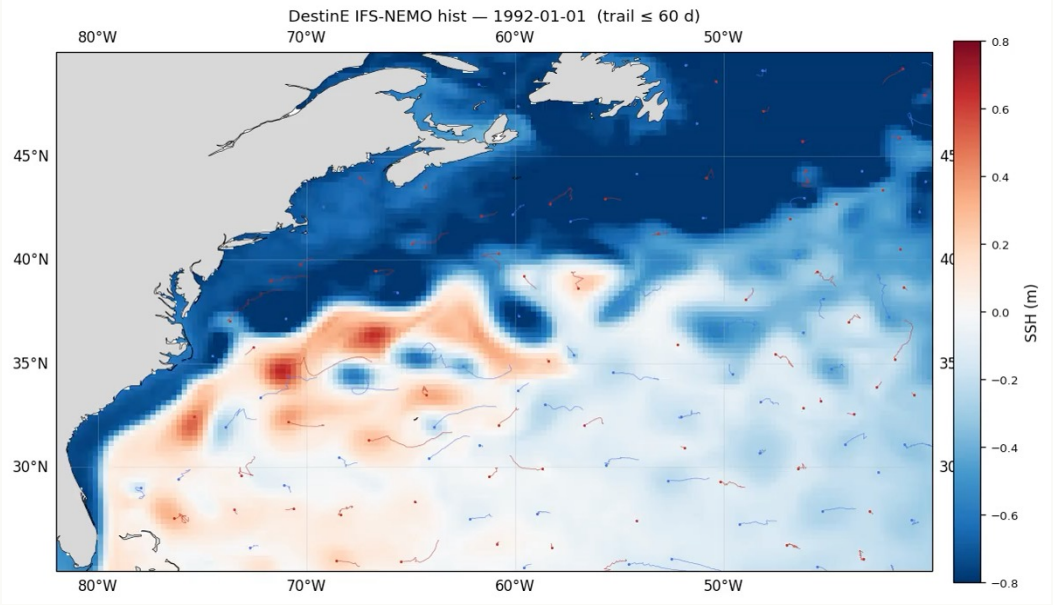


Courtesy Nikolay Koldunov

EDDY TRACKING · PY-EDDY-TRACKER







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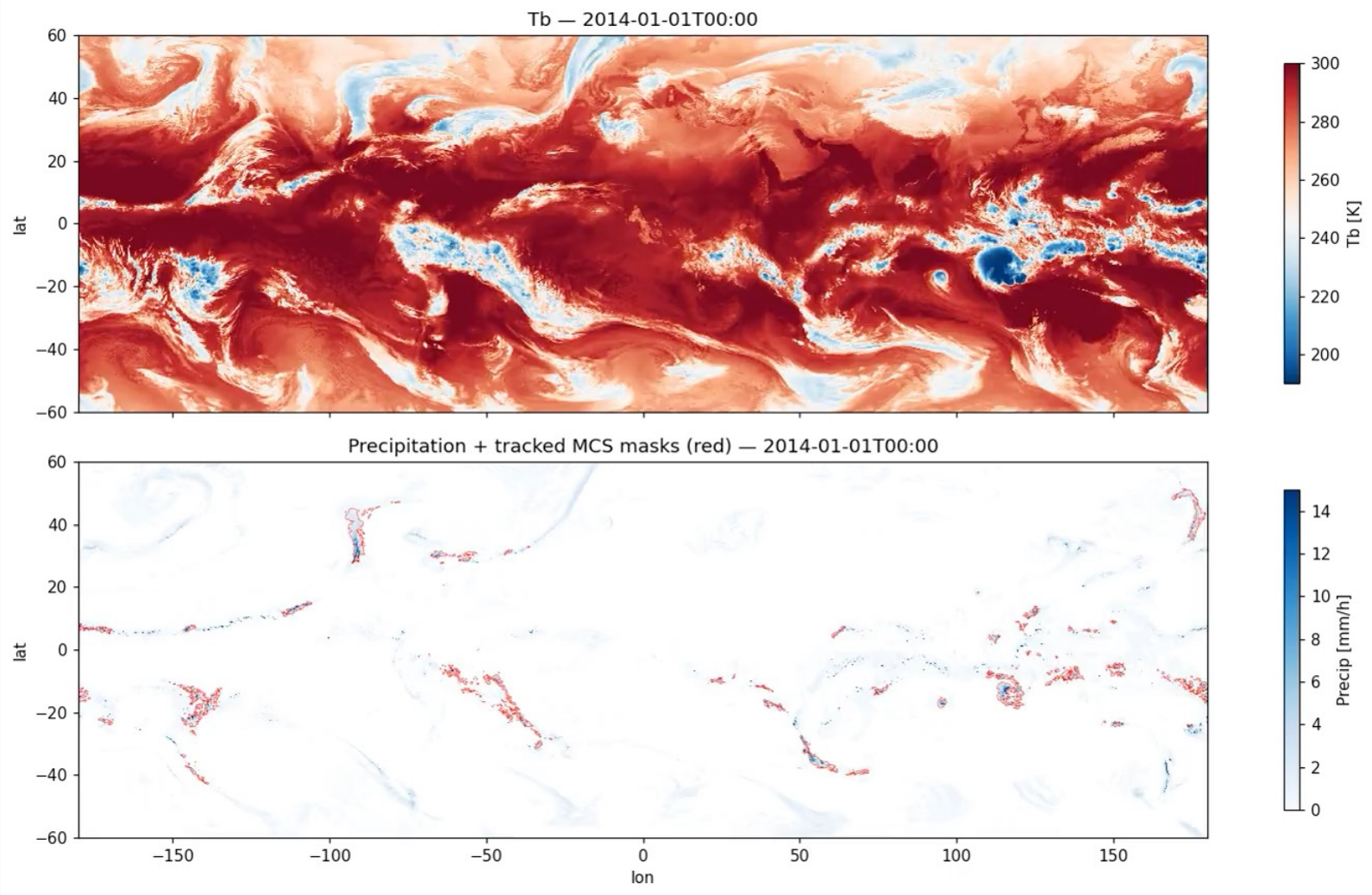

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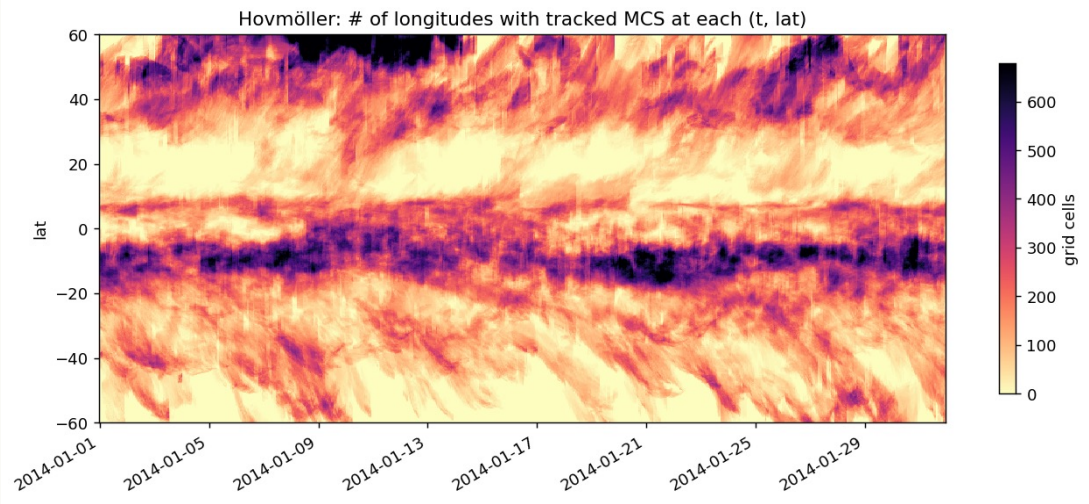
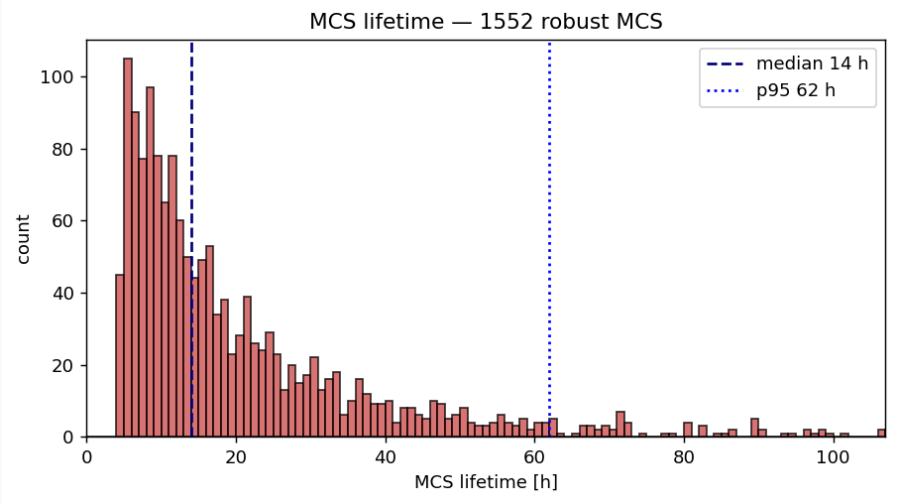
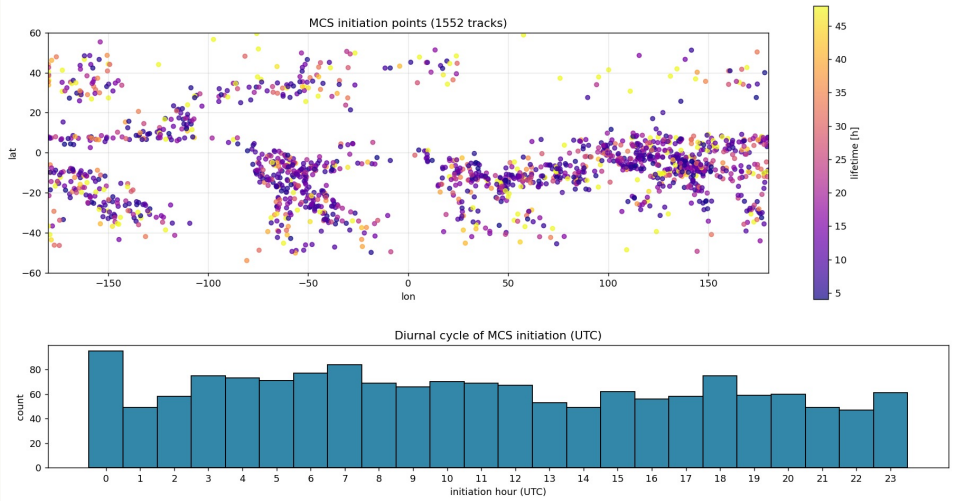
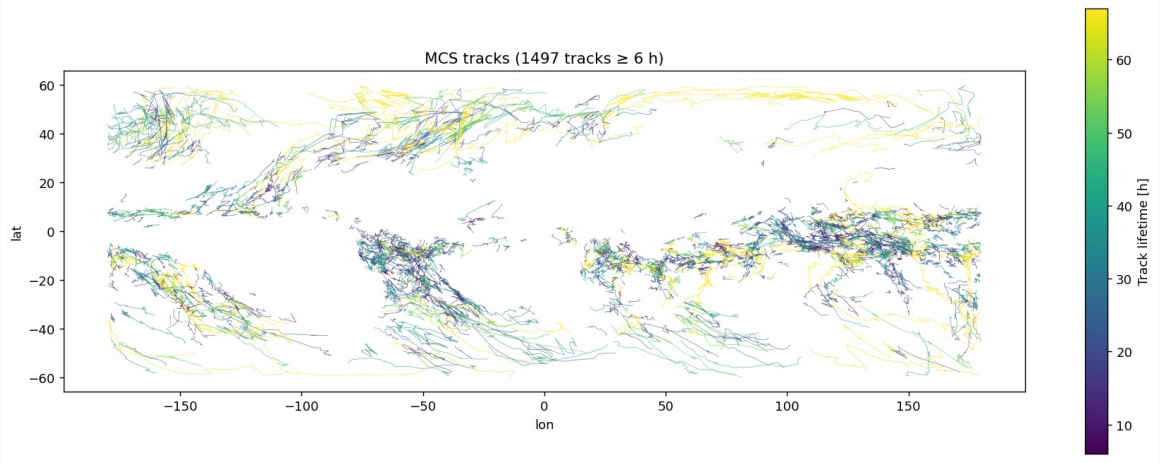






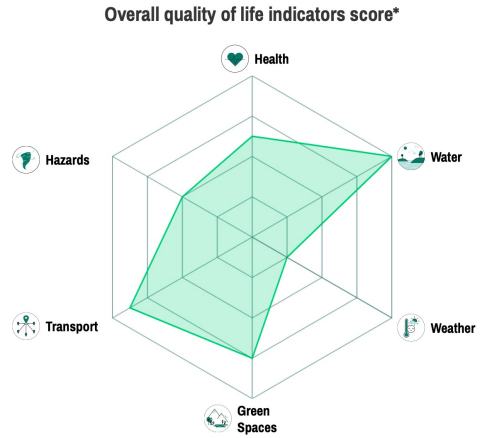


Courtesy Nikolay Koldunov

EXAMPLE 3 – USE DESP SERVICE: CALIFE QUALITY OF LIFE REPORT

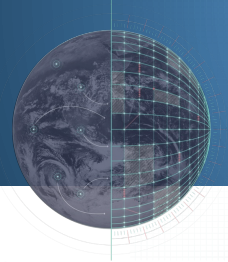
- Requires familiarity with:
  - Technically none
  - Basic domain knowledge on interpreting uncertainty and results
- Targeted users:
  - General public

Only based on one IFS-Nemo scenario…



Data fusion from a range of sources

Server-side: , configure via



EXAMPLE 4 – USE DESP SERVICE: DRE RENEWABLE ENERGY FORECASTS (BASED ON COPERNICUS ATMOSPHERIC MONITORING DATASET)

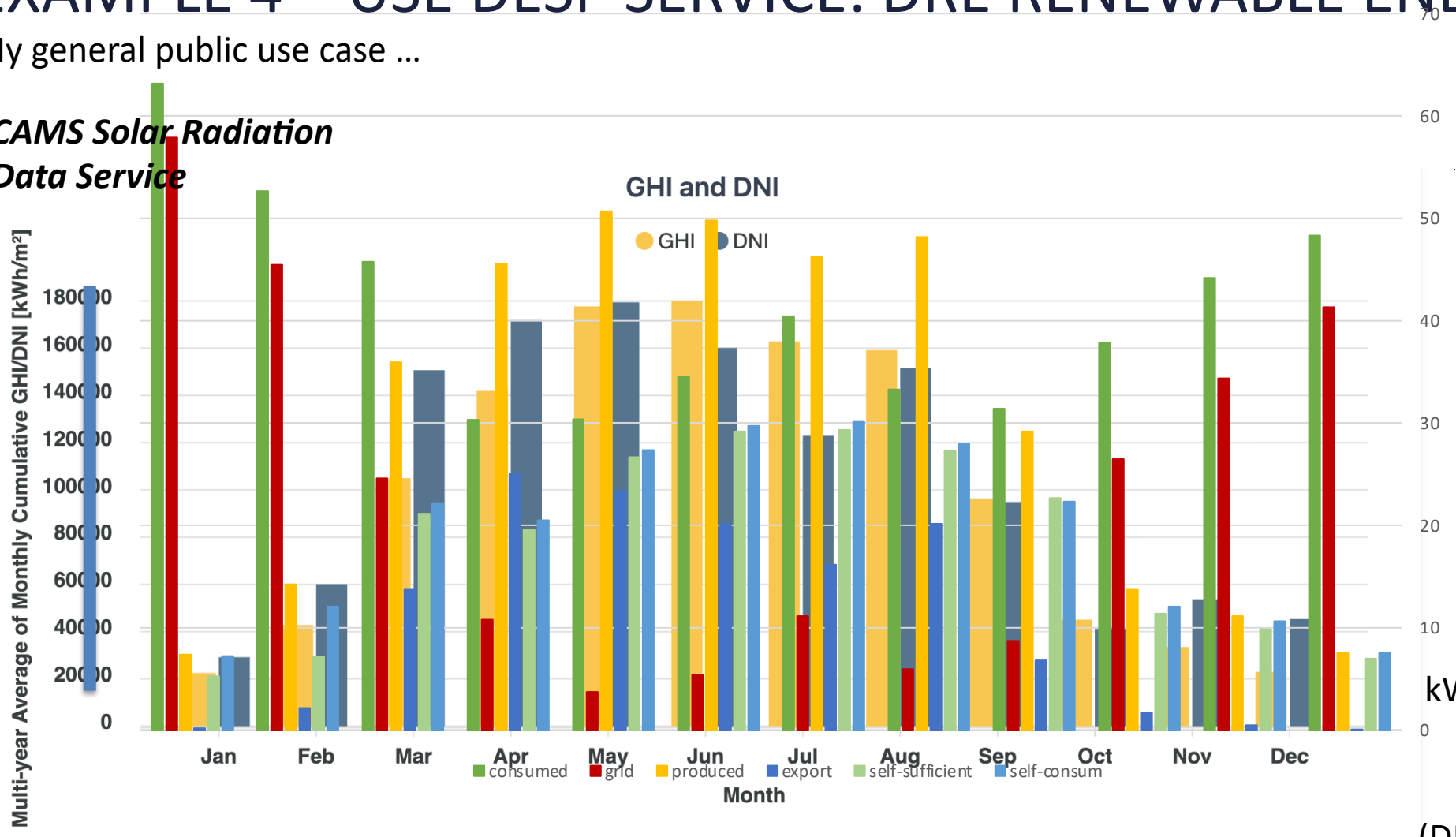
- Requires familiarity with:
  - Technically none
  - Basic domain knowledge on interpreting uncertainty and results
- Targeted users:
  - General public
  - Advanced users / data brokers

Server-side: ☁️ 🗄️ and **Client-side:** 💻 🌐

EXAMPLE 4 – USE DESP SERVICE: DRE RENEWABLE ENERGY FORECASTS

My general public use case …

CAMS Solar Radiation Data Service



Service explains, downloads or visualises the data.

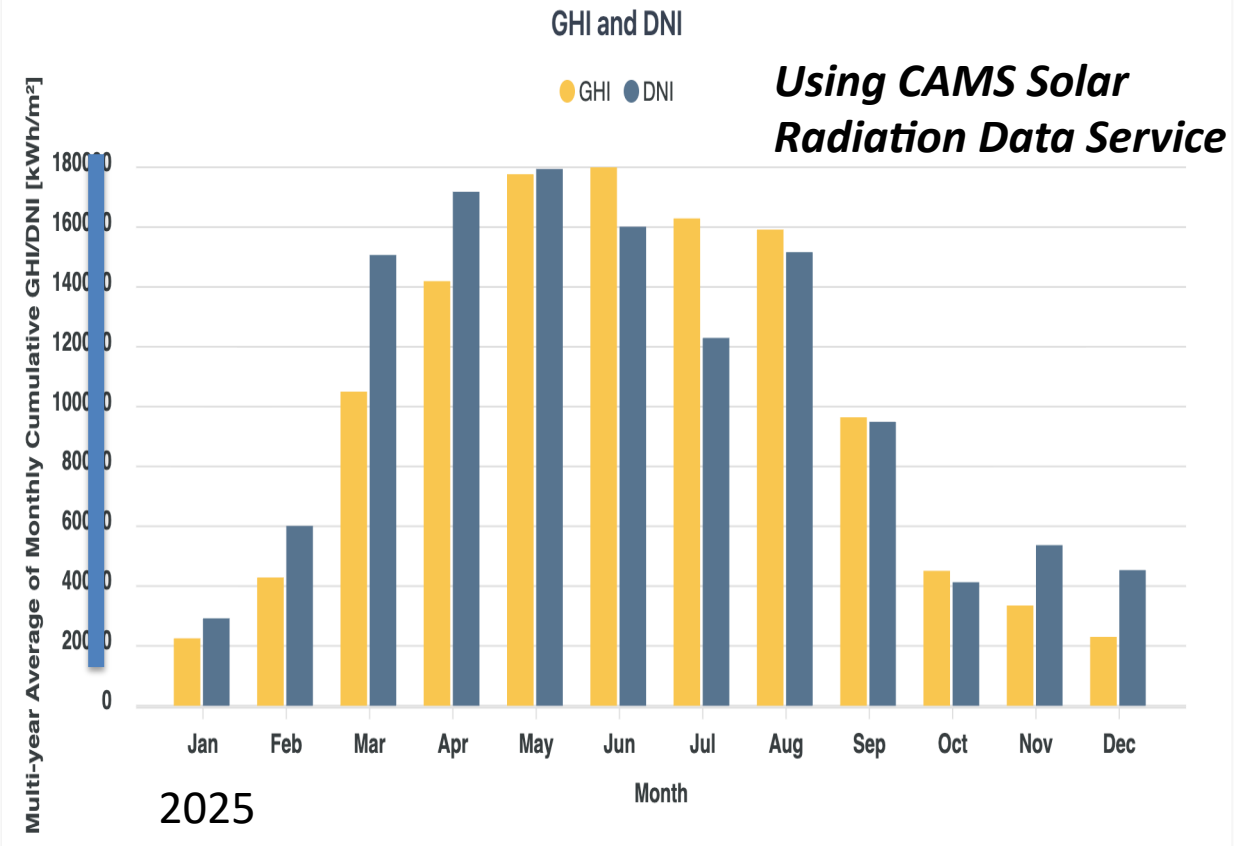
2025 Average of Monthly Cumulative (GHI) and Direct Normal solar Irradiation (DNI)

kWh/solar panel of my home

(DESP note: attention to units ☺)

Expectation == kWh/solar panel = 0,380 kWh x 0,8 (==20% losses) x GHI, about 30% of GHI

EXAMPLE 4 – USE DESP SERVICE: DRE RENEWABLE ENERGY FORECASTS

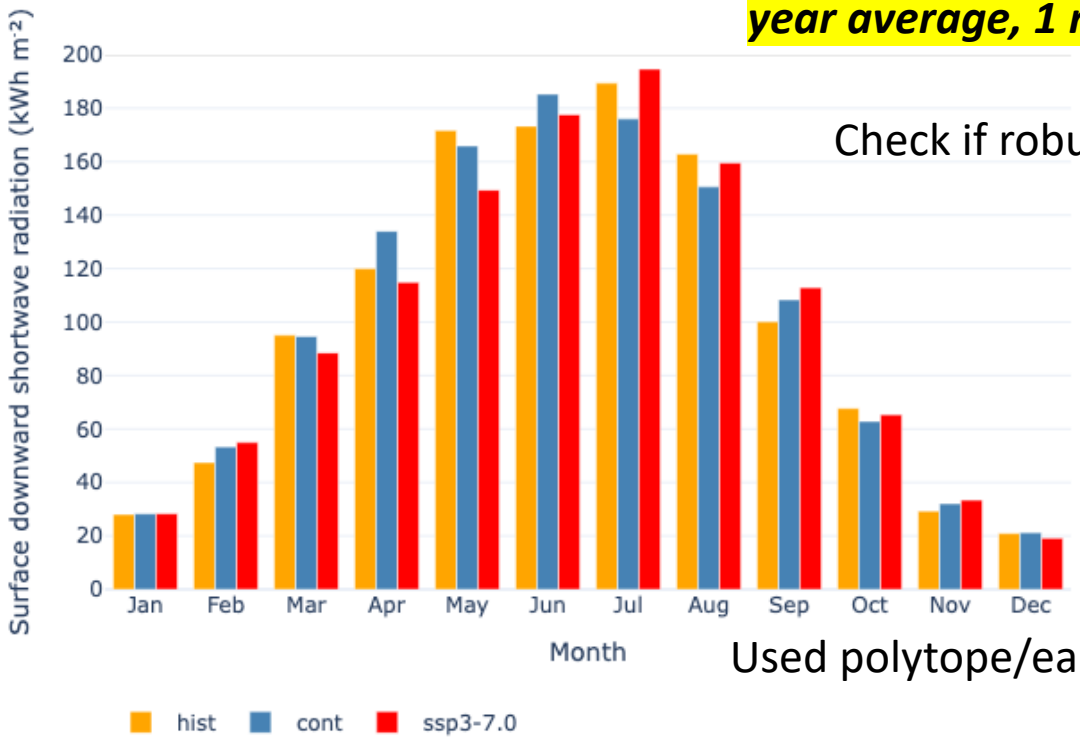


Using CAMS Solar Radiation Data Service

2025

How about climate DT …

DestinE climate DT generation 2 data, 4 year average, 1 model



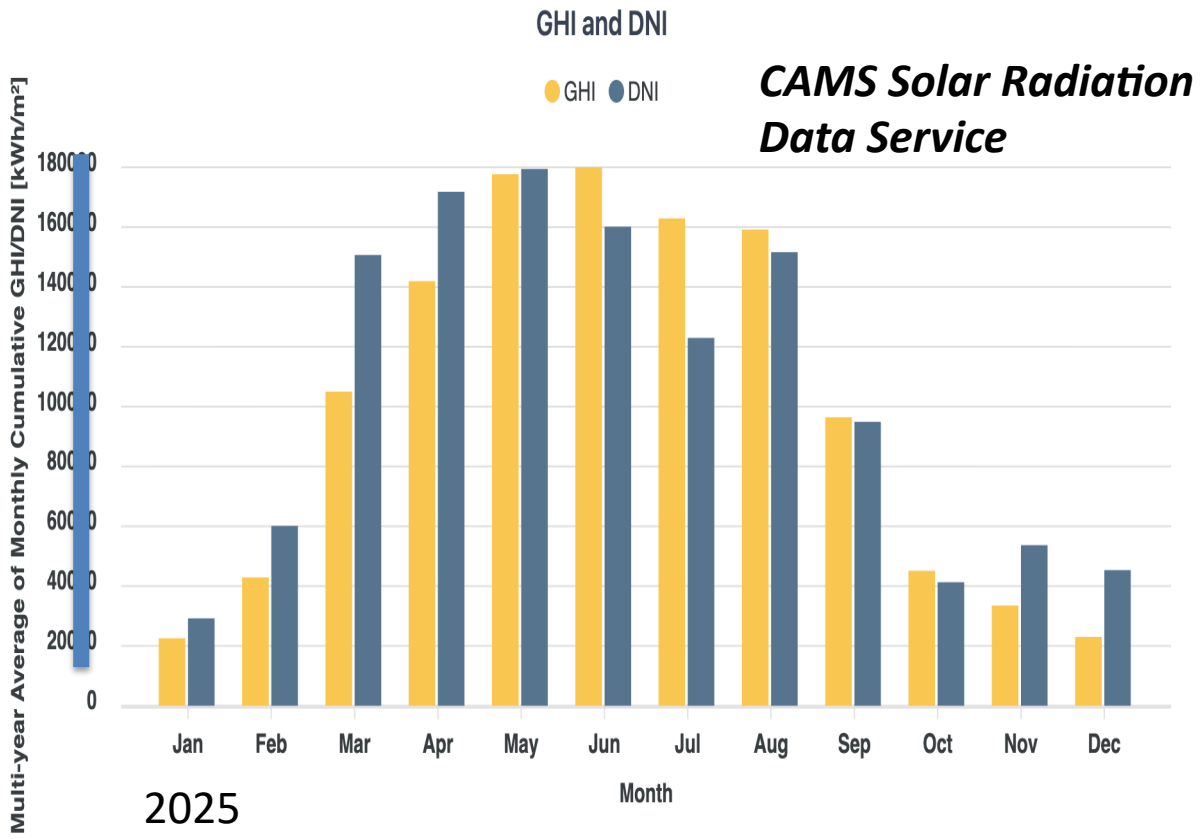
Check if robust…

Used polytope/earthkit

Shift to higher values Jul-Sep

Copernicus Atmosphere Monitoring Service (2020): CAMS solar radiation time-series. Copernicus Atmosphere Monitoring Service (CAMS) Atmosphere Data Store, DOI: 10.24381/5cab0912 (Accessed on 01-06-2026)

EXAMPLE 4 – USE DESP SERVICE: DRE RENEWABLE ENERGY FORECASTS

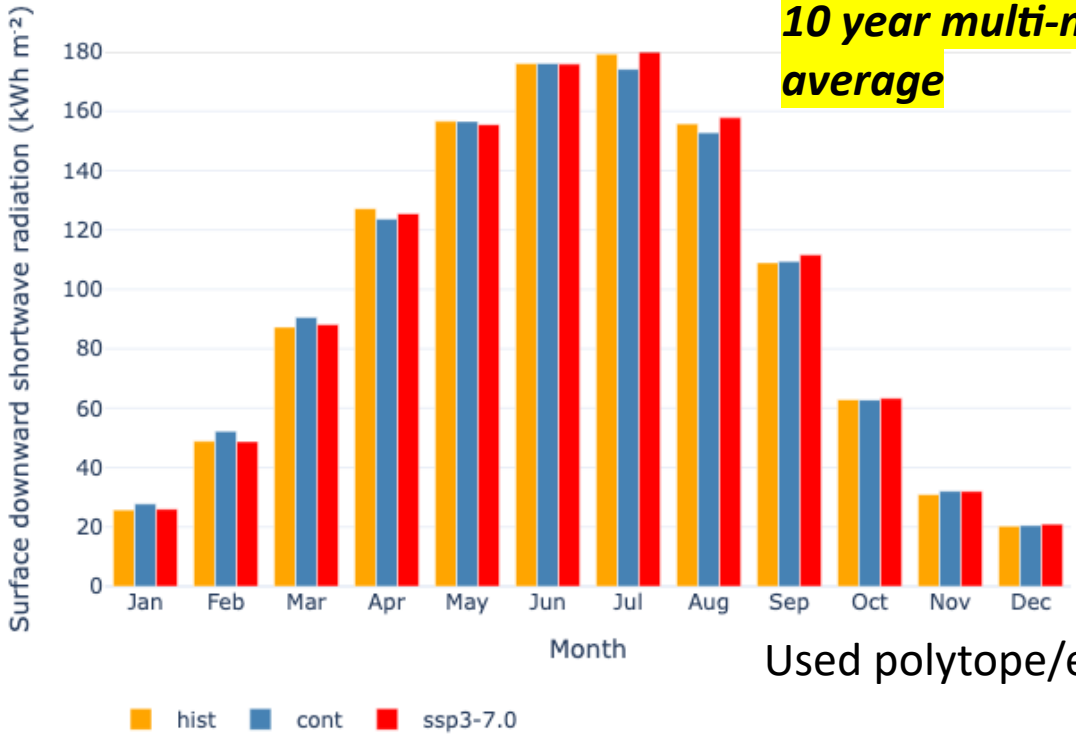


CAMS Solar Radiation Data Service

2025

How about climate DT …

DestinE climate DT generation 2 data, 10 year multi-model average



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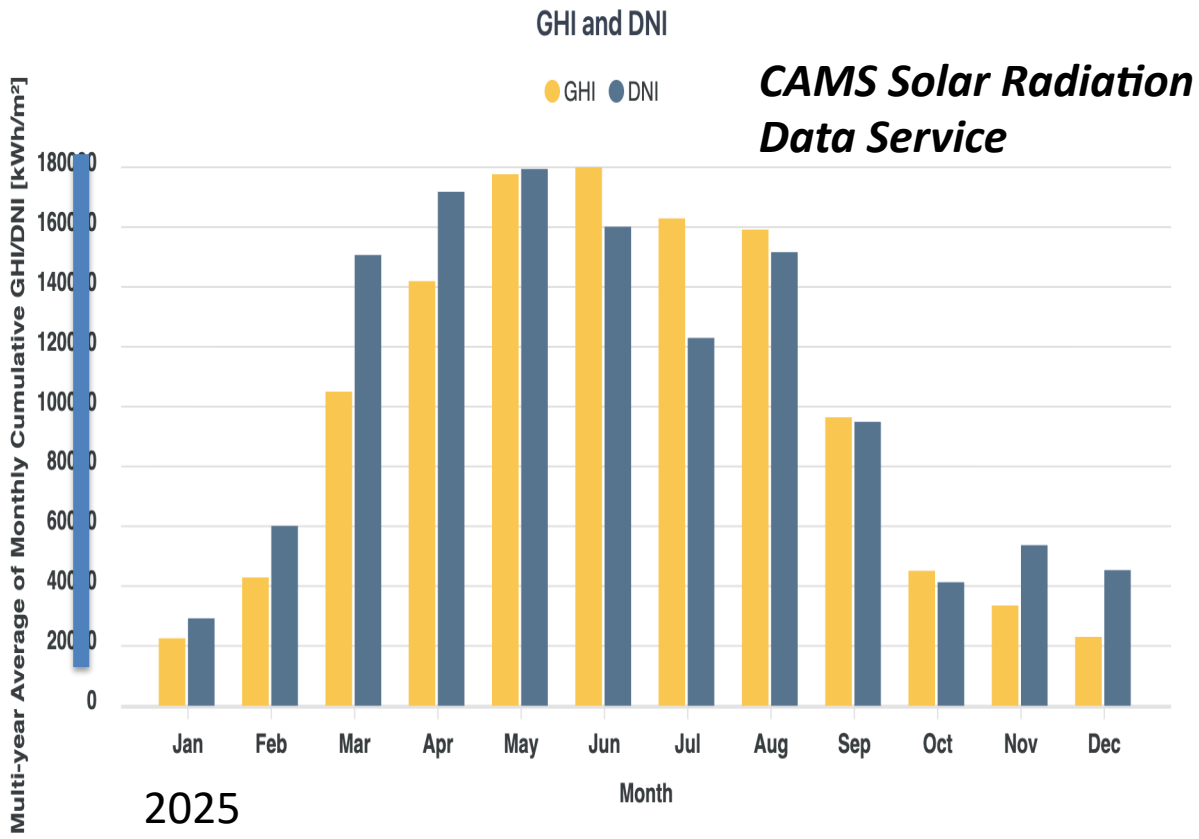
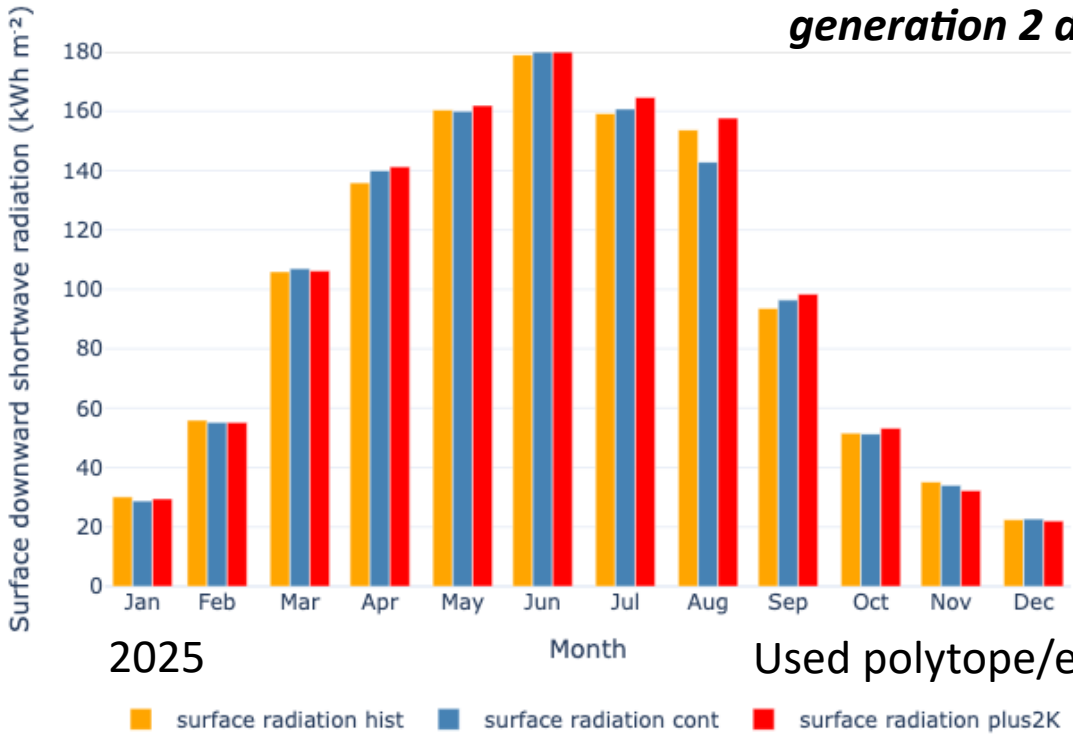


CAMS Solar Radiation Data Service

2025

How about storylines …

DestinE storylines generation 2 data



2025

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