Climate Change

The development and implementation of diagnostics for ERA5 and ERA6

Alison Cobb
and reanalysis team

11 September 2024

Workshop on Diagnostics for Global Weather Prediction

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ERA5 top 980 paper titles

(80 most common words)

Climate Change

All time scales

weather

↓

climate

All spatial scales

global

↓

small-scale processes

Excluding:
era5-land
era5
ecmwf
reanalysis
reanalyses
(and other common words)

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Diagnostics workshop talks

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Predictability:
Synoptic-scale processes, medium to extended range prediction
Diabatic heating from weather to intra-seasonal time scales
Forecast busts
Practical to intrinsic predictability

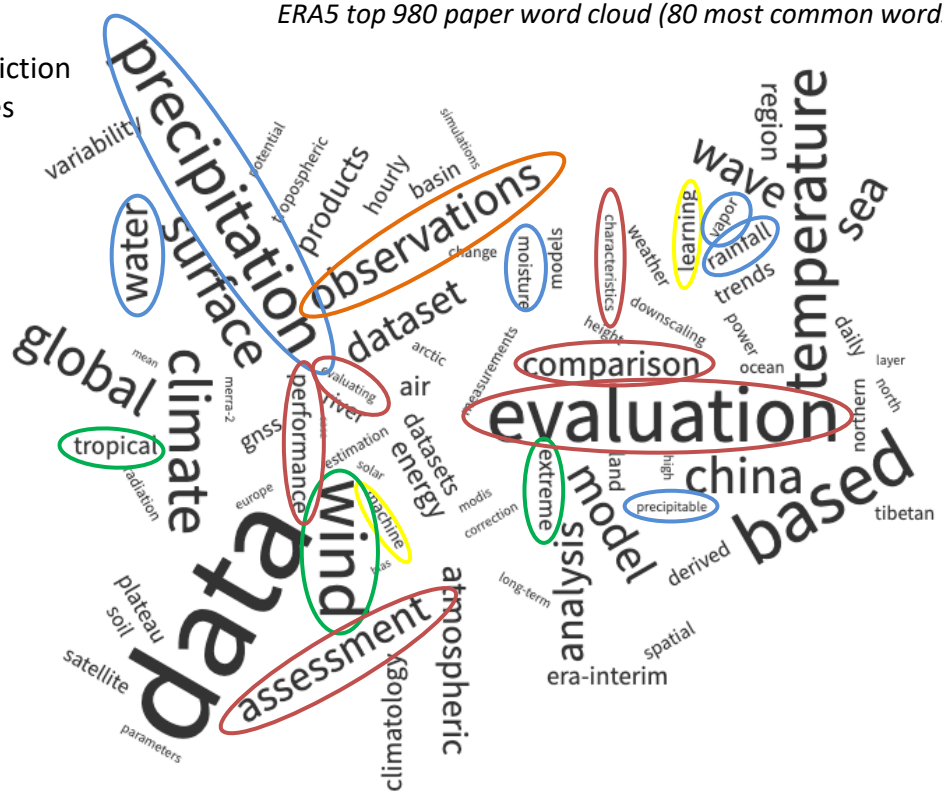
Processes:
Mesoscale convective systems
Severe rainstorm, rainfall
Eddy momentum flux and shallow convection
Model uncertainty
Sea-ice forecasts
Atmosphere budget analysis
Impact of new observations
Error traceability
Tropical waves
Maritime continent barrier and MJO
Tropical cyclones – S2S to mesoscale

Machine Learning

Scale-dependent evaluation, ensemble systems

Resolution and scale interactions

ERA5 top 980 paper word cloud (80 most common words)



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Diagnostics in reanalysis

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Diagnostics → characterise process

Climate means and anomalies

Verification vs. independent data

Ensemble spread

Monitor

Observation counts

Analysis increments

Observation departures

Differences vs. oper

Detect issue

Diagnose ‘an’ (understand problem)

Identify cause

Document

Implement solution

*Bruce Ingleby poster: Two assimilation/observation problems found via SD(O-A) maps

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ERA5 monitoring

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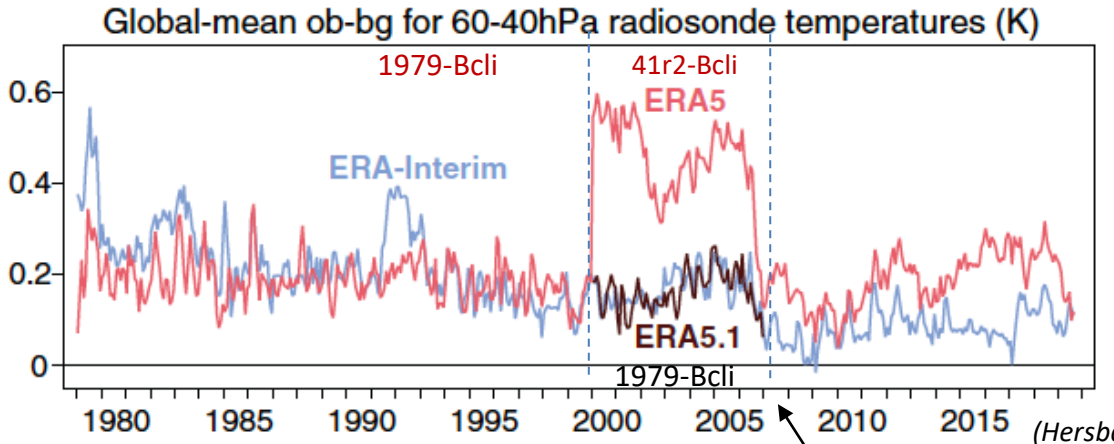

(Hersbach et al. 2019)

41r2-Bcli is less able to correct the model lower-stratospheric cold bias. The resulting (cold) model background leads to more positive observation minus background departures

GNSS-RO data are assimilated

Simmons, A., Soci, C., Nicolas, J., Bell, B., Berrisford, P., Dragani, R., Flemming, J., Haimberger, L., Healy, S., Hersbach, H. and Horányi, A., 2020. Global stratospheric temperature bias and other stratospheric aspects of ERA5 and ERA5. 1.

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ERA5 monitoring

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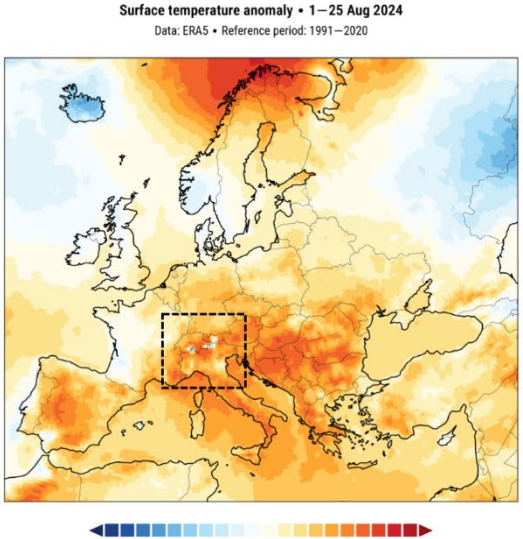
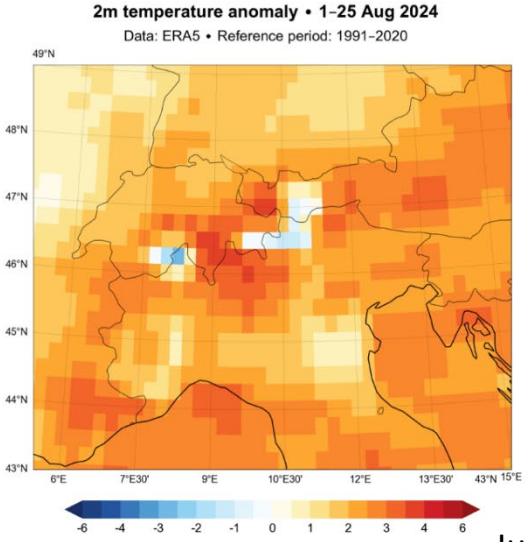
Temperature anomalies

https://pulse.climate.copernicus.eu/





Julien Nicolas

Erroneous station data reporting snow

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ERA6

Configuration:

- Higher horizontal resolution of **14km** (TCo799) for all components (ERA5 31km for atmosphere, 40km for waves)
- Uncertainty estimate at 28km (TCo399) from 11-member ensemble (63km for ERA5)

Science:

- One-way coupled with the ocean, providing a **consistent representation of ocean-atmosphere processes**
- Improved realism, such as introduction of an **urban tile**
- Improved treatment of **systematic model errors** with benefit on the quality of **climate trends**
- **Resolve** several ERA5 **known issues**, such as inconsistencies in snow cover
- ***8 years of additional R&D at ECMWF & improved compute capacity compared to ERA5***

Products: based on user requirements

- Hourly, for extended list of (new) parameters, e.g., Rh2m, clear-air turbulence (CAT)
- **Height levels** for the lowest part of the atmosphere (15/30/50/75/100/150/150/200/250/300/400/500m)
- Daily in addition to monthly precalculated statistics

Ingest the best observations:

- Satellite+ in-situ reprocessing and data rescue

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ERA6: ocean coupling

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ERA5 (Hersbach et al. 2019)

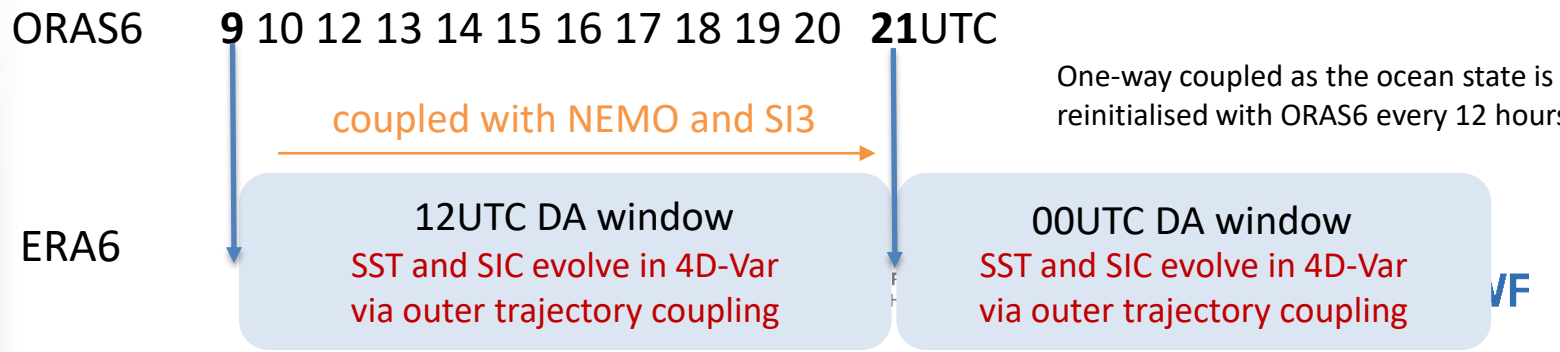
Time period	Sea Surface Temperature	Sea Ice Concentration	Grid (deg)
January 1949–December 1960	HadISST2.1.0.0 (monthly)	HadISST2.0.0.0	0.25 x 0.25
January 1961–December 1978	HadISST2.1.1.0 (pentad)	HadISST2.0.0.0	0.25 x 0.25
January 1979–August 2007	HadISST2.1.1.0 (pentad)	OSI SAF (409a)	0.25 x 0.25
September 2007 onwards	OSTIA	OSI SAF oper	0.05 x 0.05

ORAS6: a new ocean reanalysis (Zuo et al.)

- **Input:** daily SST / SIC, @1, 0.25 , or 0.05 degrees (+ altimeter and in-situ observations)

ERA6 takes ORAS6 at 09 and 21UTC as initial ocean condition into its 12 and 00UTC DA windows

- **Output**: hourly evolving SST and SIC product



One-way coupled as the ocean state is reinitialised with ORAS6 every 12 hours

ERA6 projected production timeline

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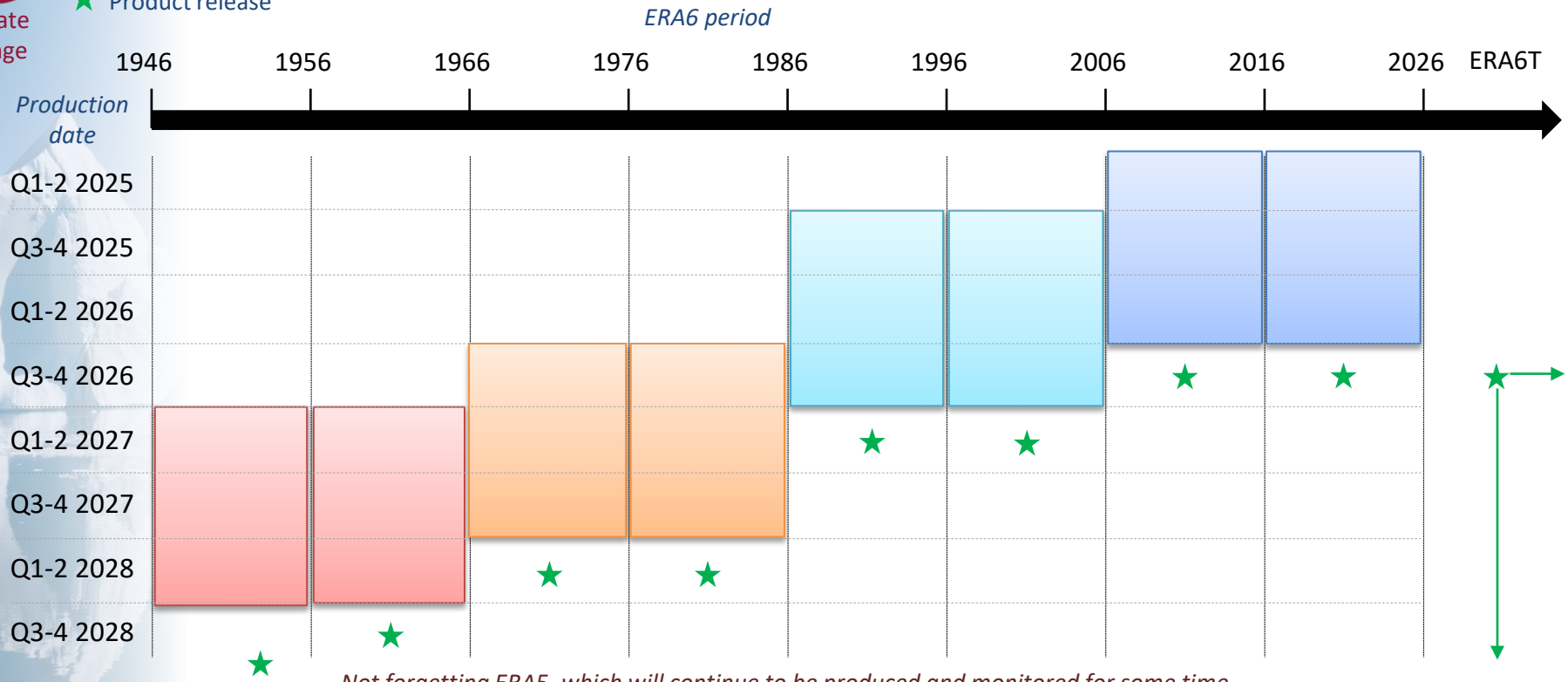
★ Product release



Not forgetting ERA5, which will continue to be produced and monitored for some time

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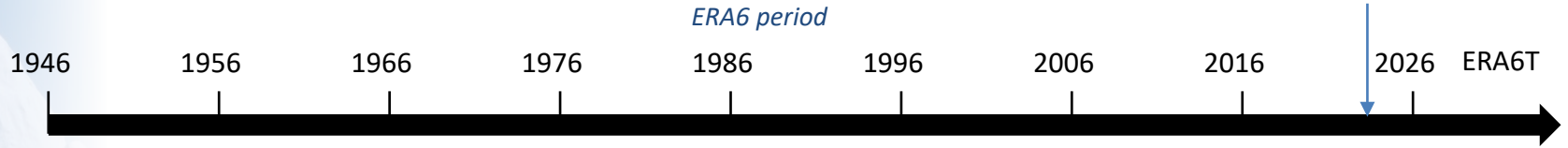
ERA6 prototype experiments

Necessary to test different periods



pre-satellite ERA, before 1973

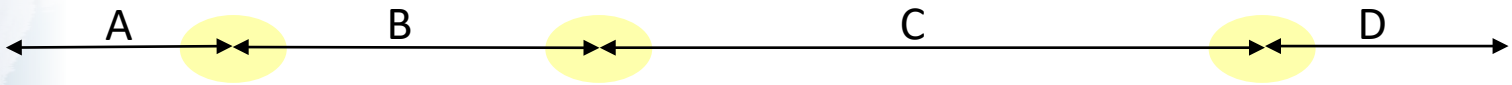
1973-1978: early pre-sat

1982 El Nino / El Chichón

2006
2022
3 months, summer and winter

pre-, post- GNSS-RO

TOVS -> ATOVS (mainly SSU -> AMSU-A)



Periods with different ORAS6 input datasets and where they overlap

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ERA6 assessment

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Groups

Atmospheric variability

EDA reliability and sharpness

Global budgets

Assessment of ERA6 prototype experiments

Surface and coupling

AIFS training and performance

Atmospheric composition

ECMWF in-house experts

External collaborators

Tools

Methods

Observation counts

Analysis increments

Observation departures

Differences

ERA6 real-time monitoring

Ensemble spread

Verification vs. independent data

Climate means and anomalies

vs. ERA5

vs. Operations

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ERA6 prototype results

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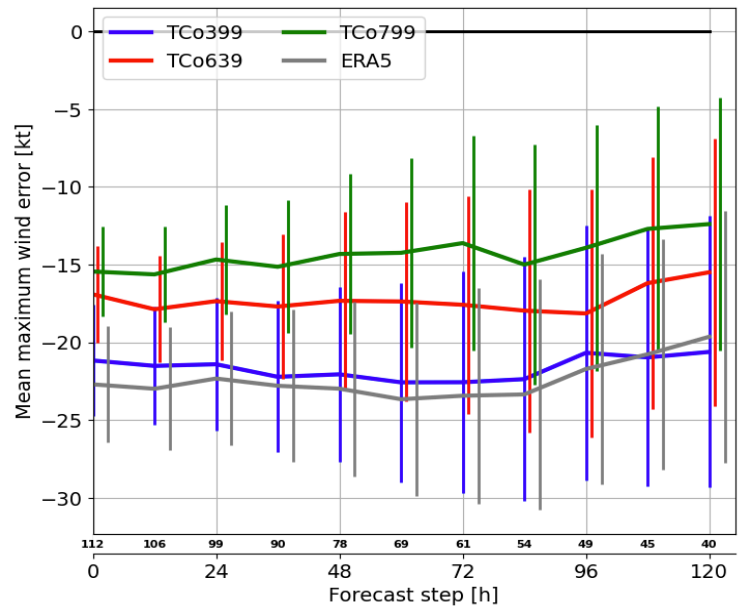
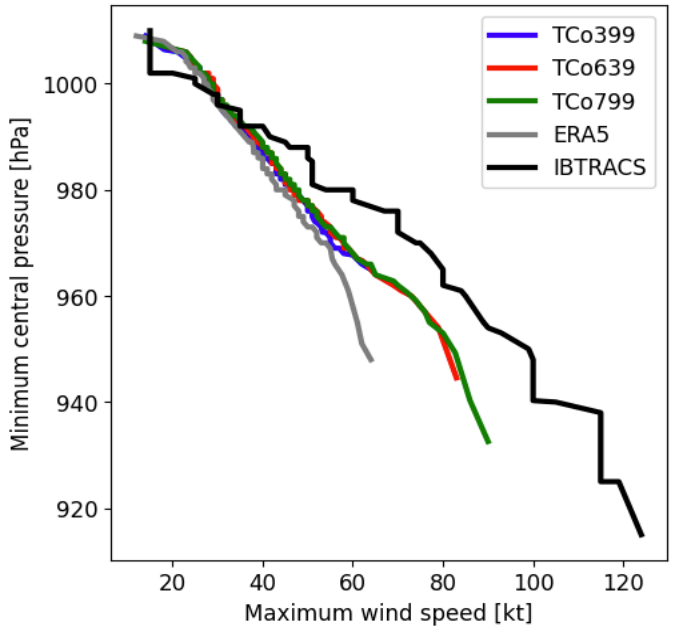
Tropical cyclones:

- Mean maximum wind error
- Minimum ventral pressure vs. max wind speed relationship





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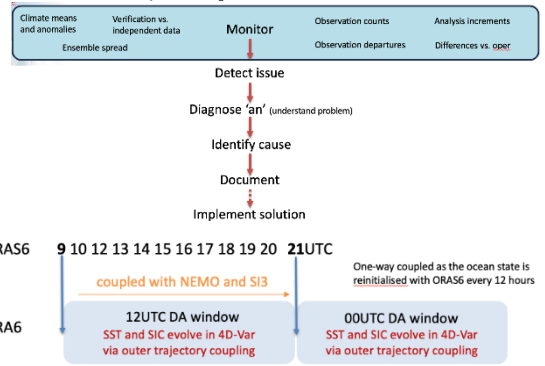
Summary

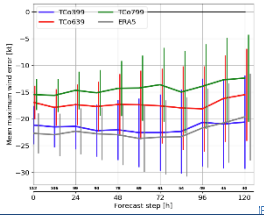
Reanalysis datasets are widely used for diagnostics
- Multi-scale
- Global to regional, to small-scale

Monitoring tools
- Detect issues
- Diagnosing ERA5 reanalysis
- Identify errors with model and observations

ERA6 characteristics and production
- 14 km, one-way ocean-atmosphere coupled
- Variety of test periods
- Prototype assessment leading to tool development for monitoring and diagnostics for ERA6

ERA6 protype showing positive results





Diagnostics play a pivotal role in understanding ERA5, and will play in important role in evaluating ERA6

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Questions?

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