A new dataset of hourly sea surface temperatures from NOAA's Global Drifter Program

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Data Buoy Cooperation Panel S&T Workshop
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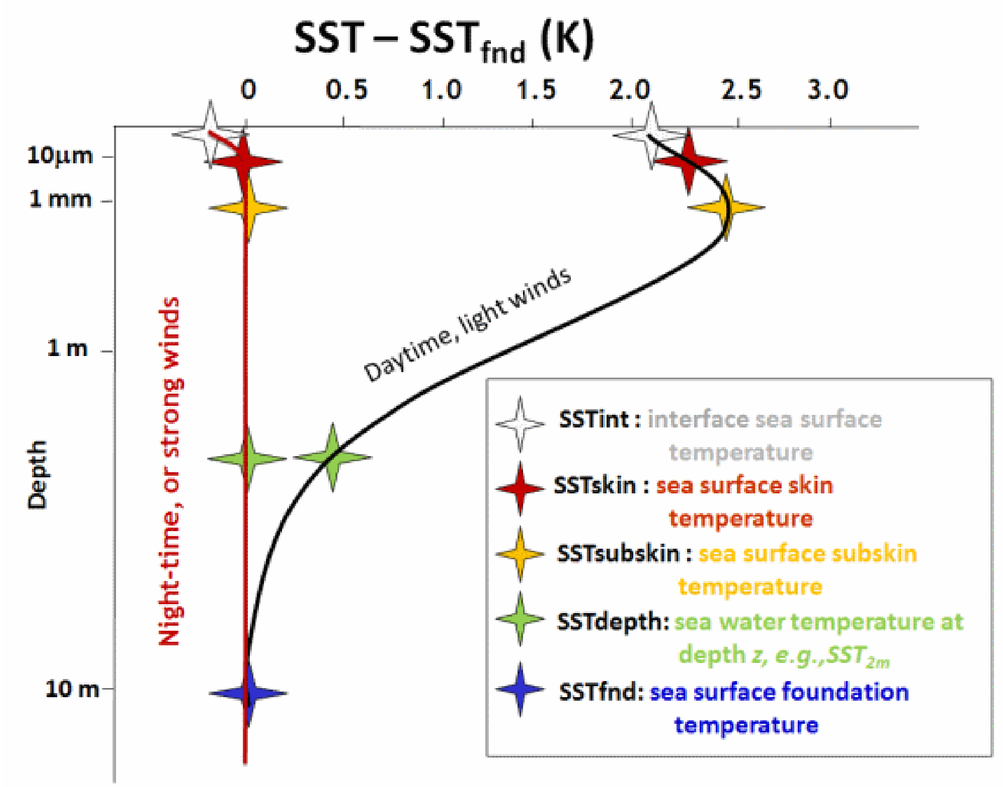
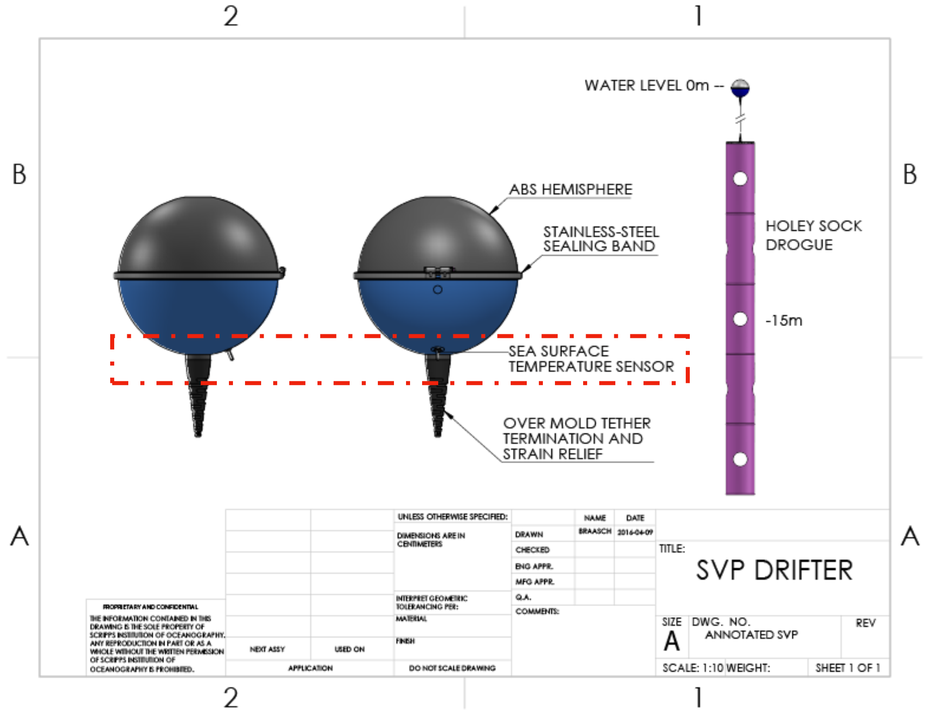
A GDP drifter is measuring **sea water temperature at** ~18 cm depth (hereafter “SST”)



from Group for High Resolution SST (GHRSST)
https://www.ghrsst.org/



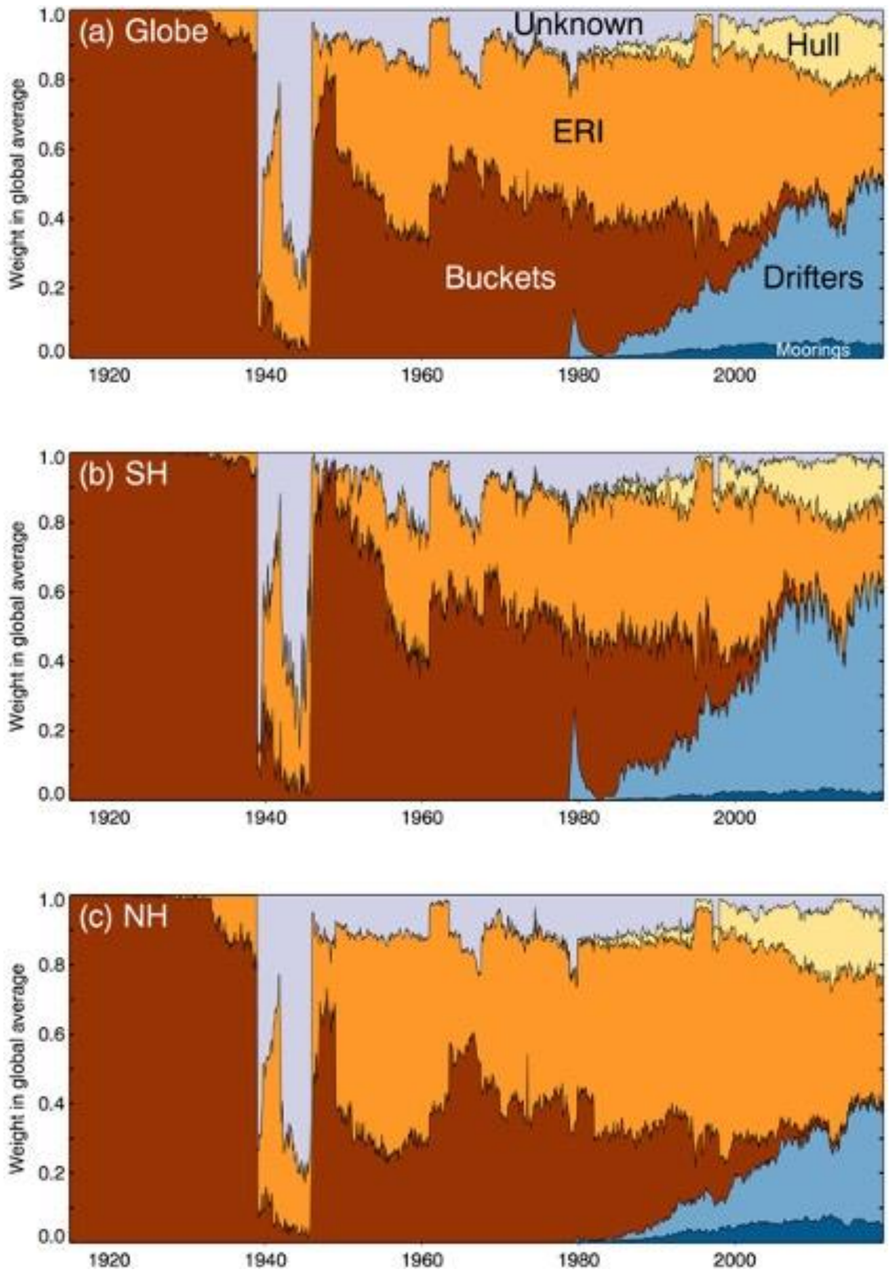
Source: Scripps Lagrangian Drifter Laboratory
http://gdp.ucsd.edu/ldl_drifter/instruments/svp.html

Drifter SST data

- Centurioni et al. (2019): *Global in situ Observations of Essential Climate and Ocean Variables at the Air–Sea Interface* (OceanObs19 collection):

  “Today, SVP drifters provide more **SST observations** than any other source of **in situ data**, including ships (factor of about 4), coastal moorings (factor of about 4), tropical moorings (factor of about 50), or Argo floats (factor of about 100) (Xu and Ignatov, 2014).”

- Kennedy et al. (2019): The UK Met Office Hadley Centre HadSST.4.0.0.0 Data Set: monthly global SST on a 5° latitude by 5° longitude grid from 1850 to present. **Figures: fractional contribution of different SST observation methods, 1915–2018**



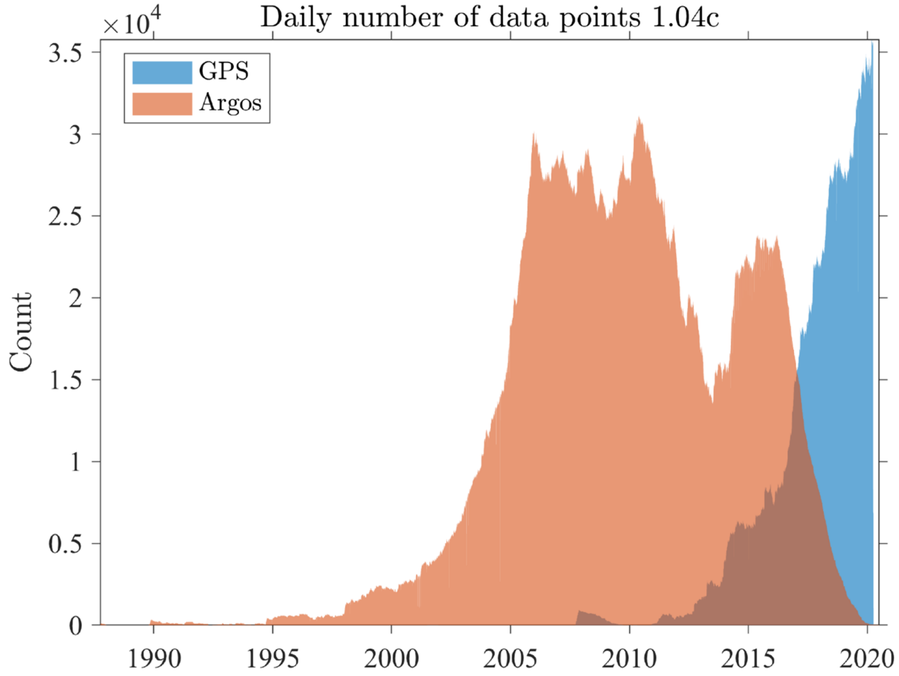
GDP data products

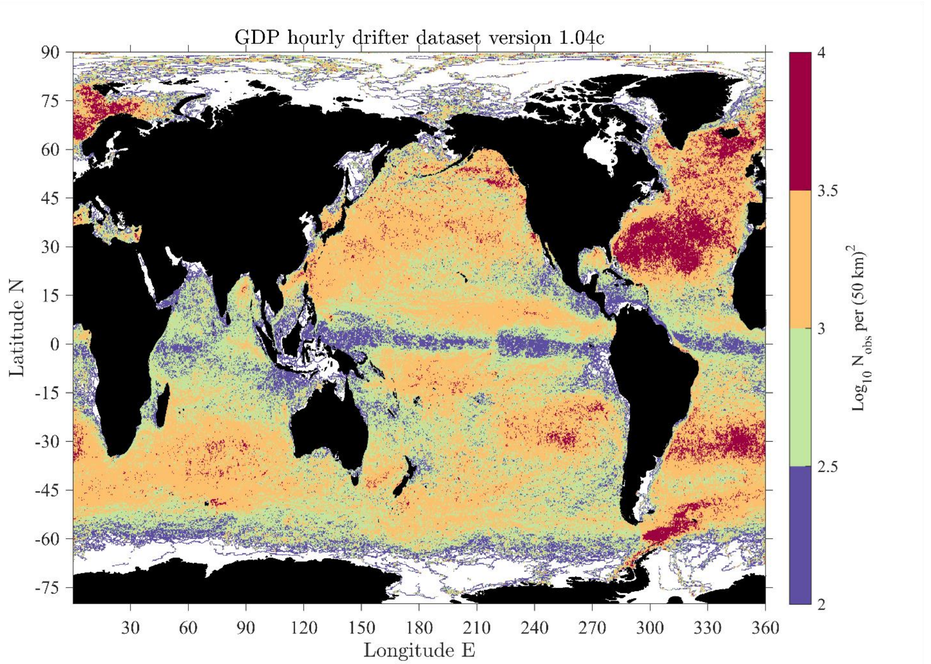
- The GDP releases QC'd data products through the Data Assembly Center (DAC) at NOAA AOML; see https://www.aoml.noaa.gov/phod/gdp

	Position (X,Y) and velocity (U,V)	SST
6-hourly	X*,Y*,U*,V* Hansen and Poulain (1996)	SST* Hansen and Poulain (1996)
1-hourly	X*,Y*,U*,V* Elipot et al. (2016)	SST* Elipot et al. (2022)

- Elipot et al. (2016): *A global surface drifter data set at hourly resolution, JGR: Oceans,* doi: 10.1002/2016JC011716
- Elipot et al. (2022): *A Dataset of Hourly Sea Surface Temperature From Drifting Buoys*, published in *Scientific Data*

Goal: adding SST to dataset of hourly position and velocity



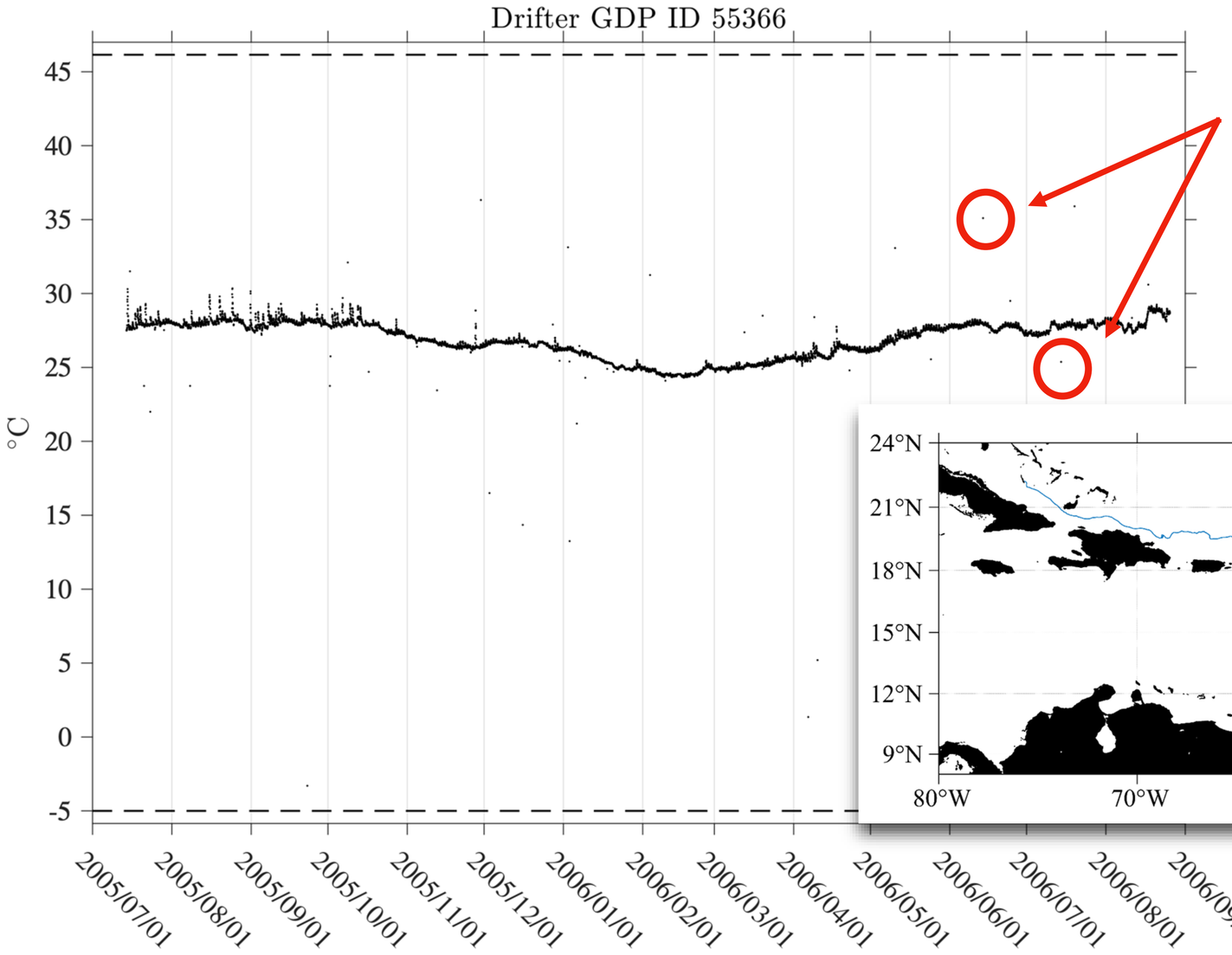


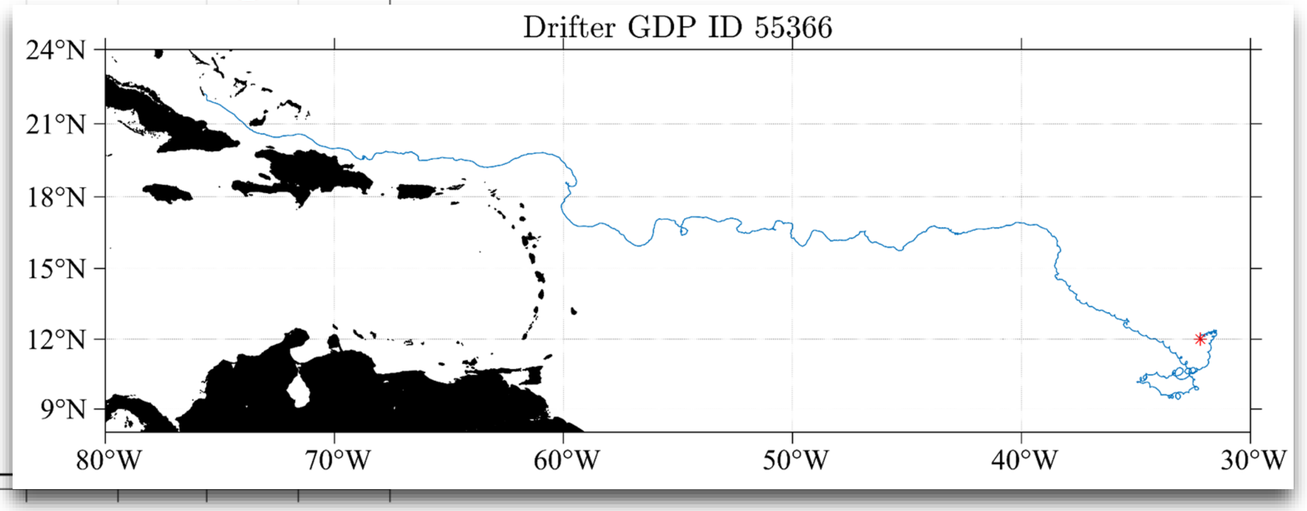
Version 1.04: 17,324 trajectories, 166 million estimates of hourly position and velocity from 03-Oct-1987 to 30-Jun-2020 (a subset of the entire GDP dataset).

Version 2.00: with added SST variables; to provide a data set for climate research and accompany the on-going hourly position and velocity dataset.

Time series of SST observations from drifter ID 55366

[Argos-tracked drifter, SVP type, built by Pacific Gyre]

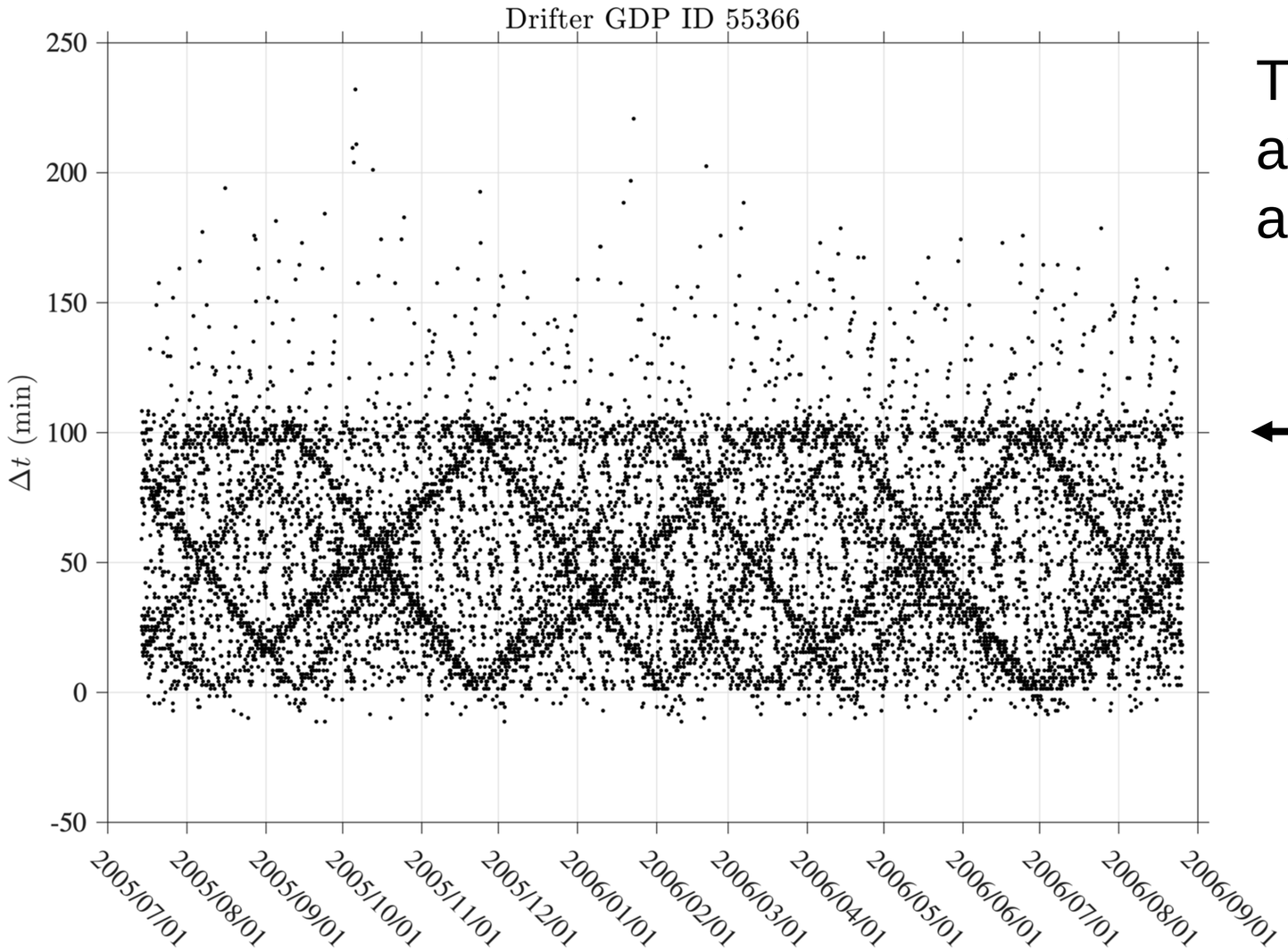




Presence of outliers

10,605 SST observations over 408 days

Time series of temporal intervals (Δt) between consecutive observations:



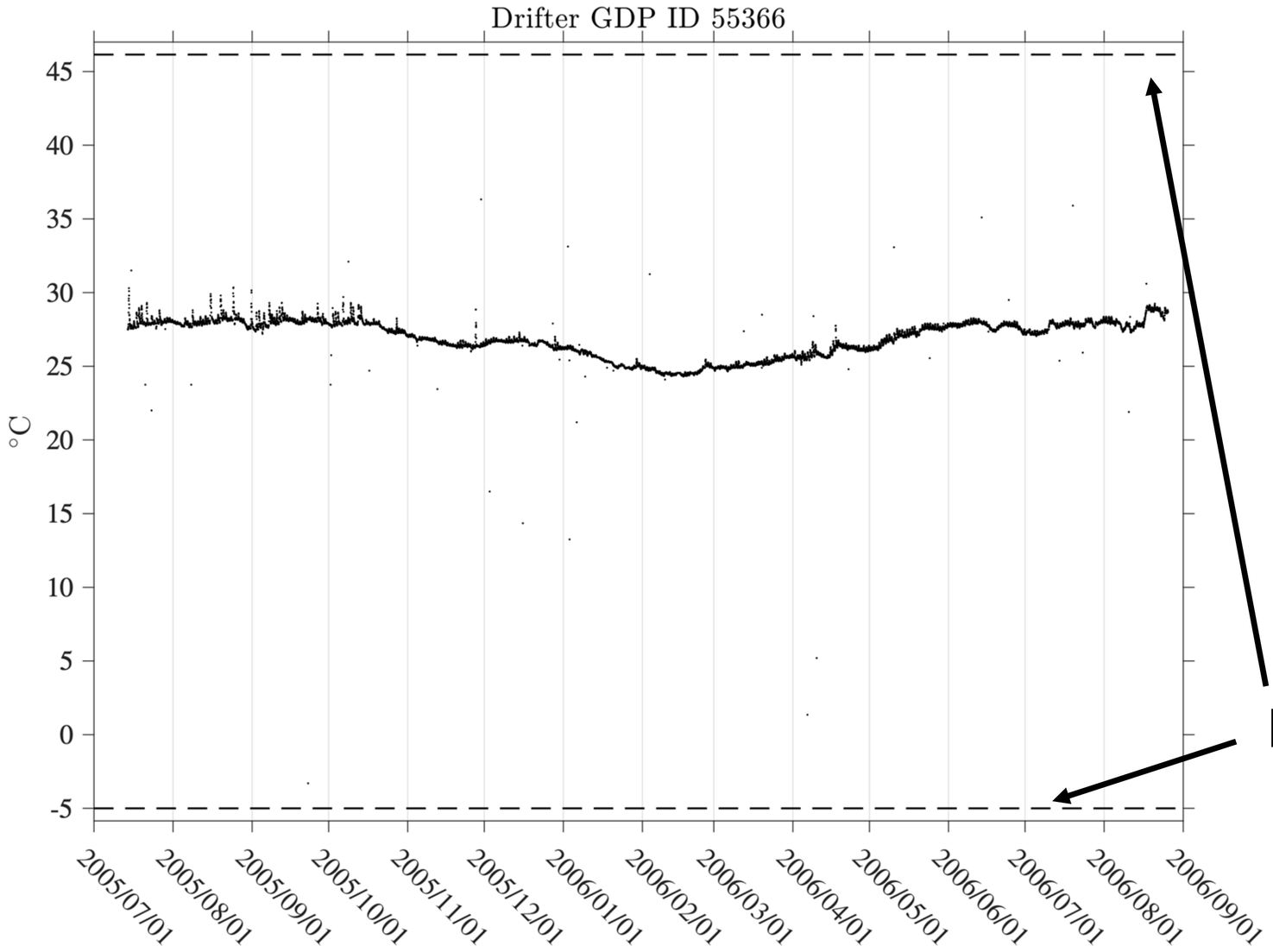
This drifter sampled every 60 s, averaged every 15 samples, and transmitted every 90 s.

← Argos satellite orbital period (101.47 min)

Uneven sampling

Time series of SST observations from drifter ID 55366

For 85% of drifters, observations are derived from an SST equation:



$$SST = an + b$$

a is the *resolution*

n is a binary bit count

Here $a = 0.05$

$b = -5$

n is coded over 10 bits

Range of possible values:

$$0.05 \times [0, (2^{10} - 1)] - 5$$

$$= [-5, 46.15]$$

Methodology

The goal is to estimate SST at time $t = t_k$

model: $$s_i = s_m(t_i; t_k) + \sigma_k \varepsilon_k$$

observations at times t_i = sst model + noise

The noise ε_k is assumed to be zero-mean, with unit variance, locally scaled by σ_k where σ^2_k is the error variance of the observations around time t_k.

Methodology: models

process model: $s_i = s_m(t_i; t_k) + \sigma_k \varepsilon_k$

$$s_m(t_i;t_k) = s_P(t_i;t_k) + s_D(t_i;t_k)$$

model of SST temporal evolution

$$= \sum_{p=0}^{P} s_{p,k}(t_i - t_k)^p + \sum_{n=1}^{N} A_{n,k} \cos[n\omega(t_i - t_k) + \phi_{n,k}]$$

$$= \sum_{p=0}^{P} s_{p,k}(t_i - t_k)^p + \sum_{n=1}^{N} \left[\alpha_{n,k} \cos n\omega(t_i - t_k) + \beta_{n,k} \sin n\omega(t_i - t_k)\right],$$

P+1+2N parameters to estimate

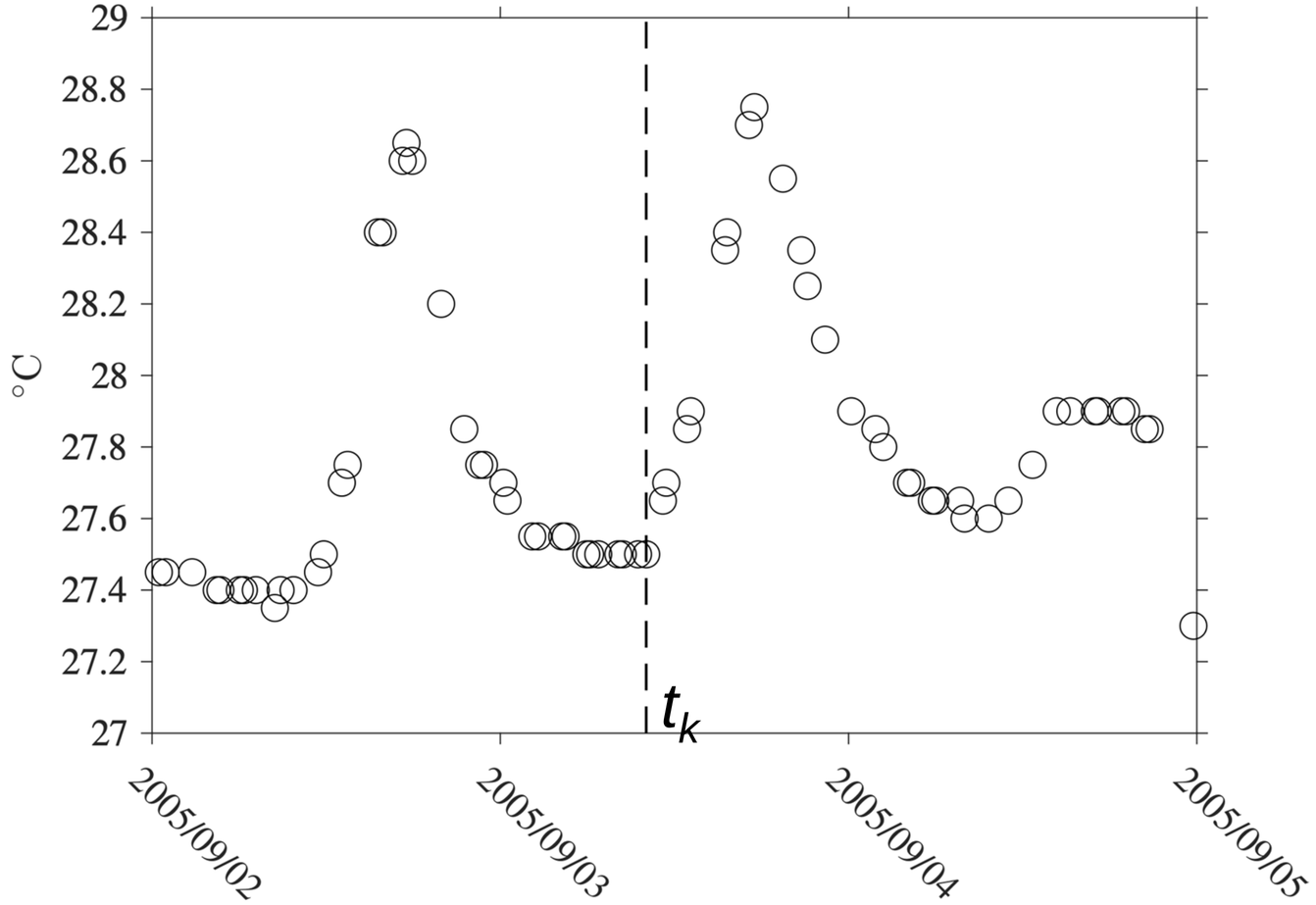
low-frequency

diurnal evolution, ω = 1 cpd
e.g. *Gentemann (2003)*

Estimate at $t_i = t_k$: $\widehat{s}_{m,k} \equiv s_m(t_k;t_k) = s_{0,k} + \sum_{n=1}^{N} \alpha_{n,k}$

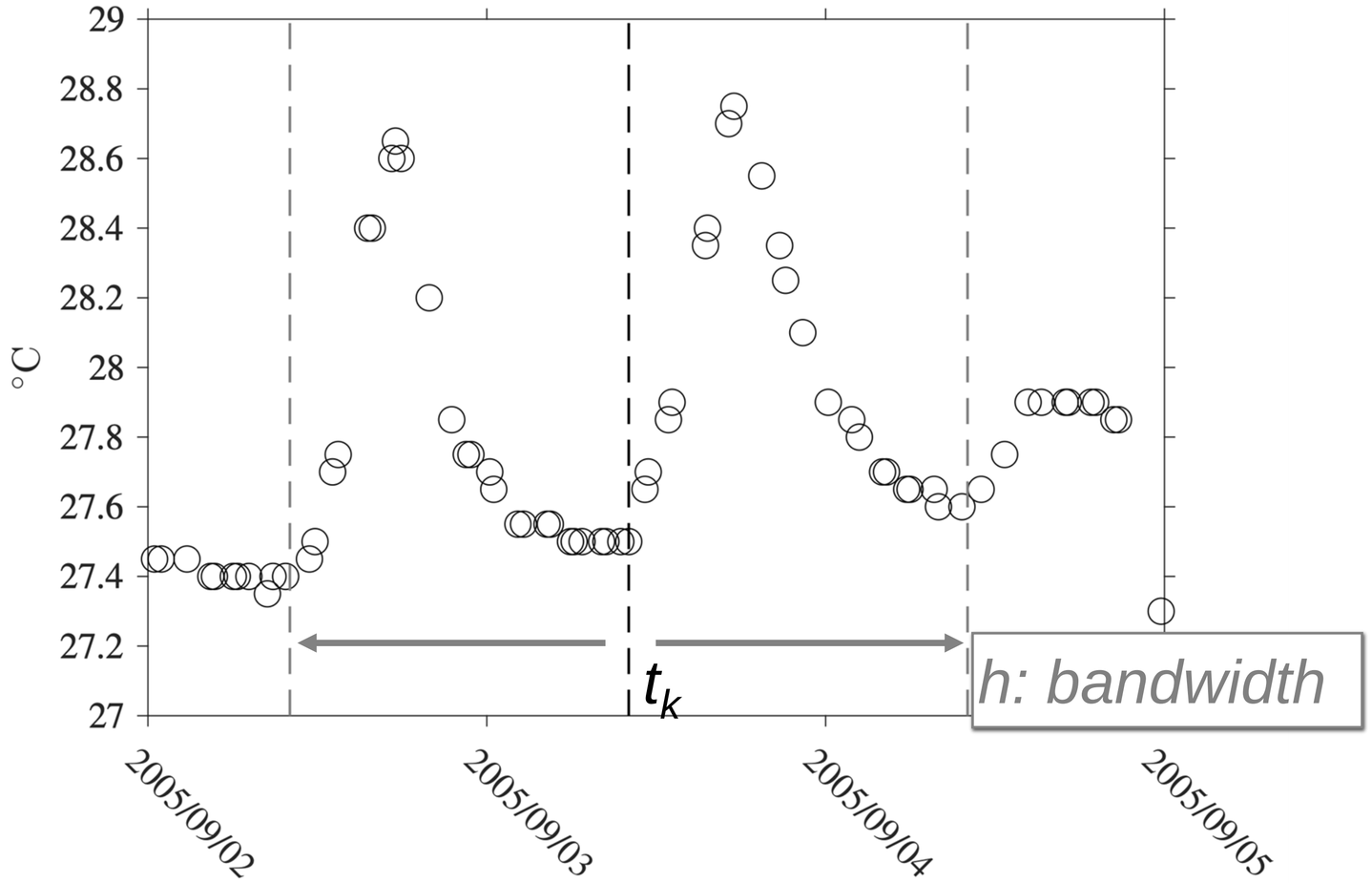
Methodology: models

$$s_i = s_m(t_i; t_k) + \sigma_k \varepsilon_k$$



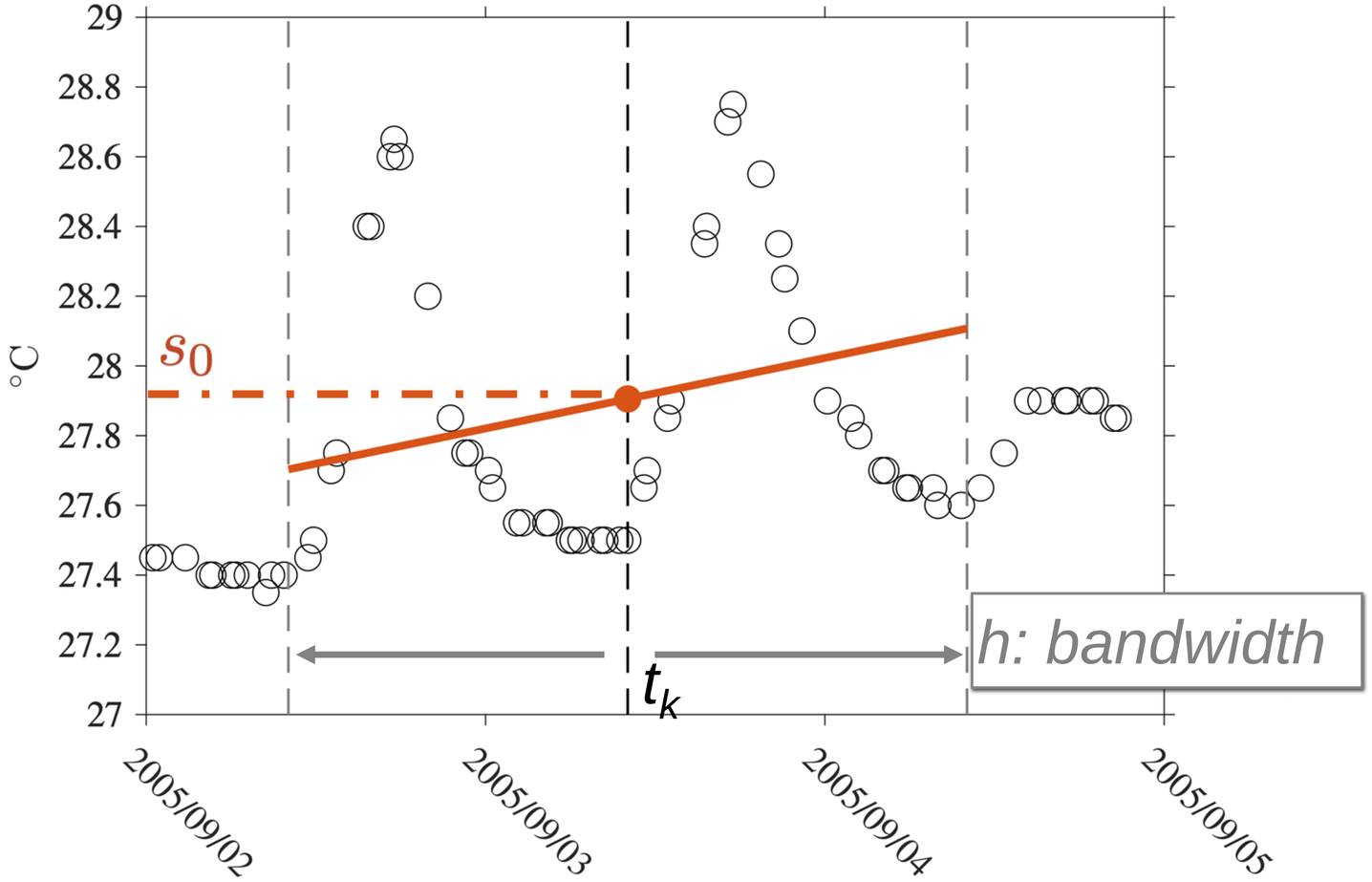
Methodology: models

$$s_i = s_m(t_i; t_k) + \sigma_k \varepsilon_k$$



Methodology: models

$$s_m(t_i; t_k) = s_0 + s_1(t_i - t_k)$$

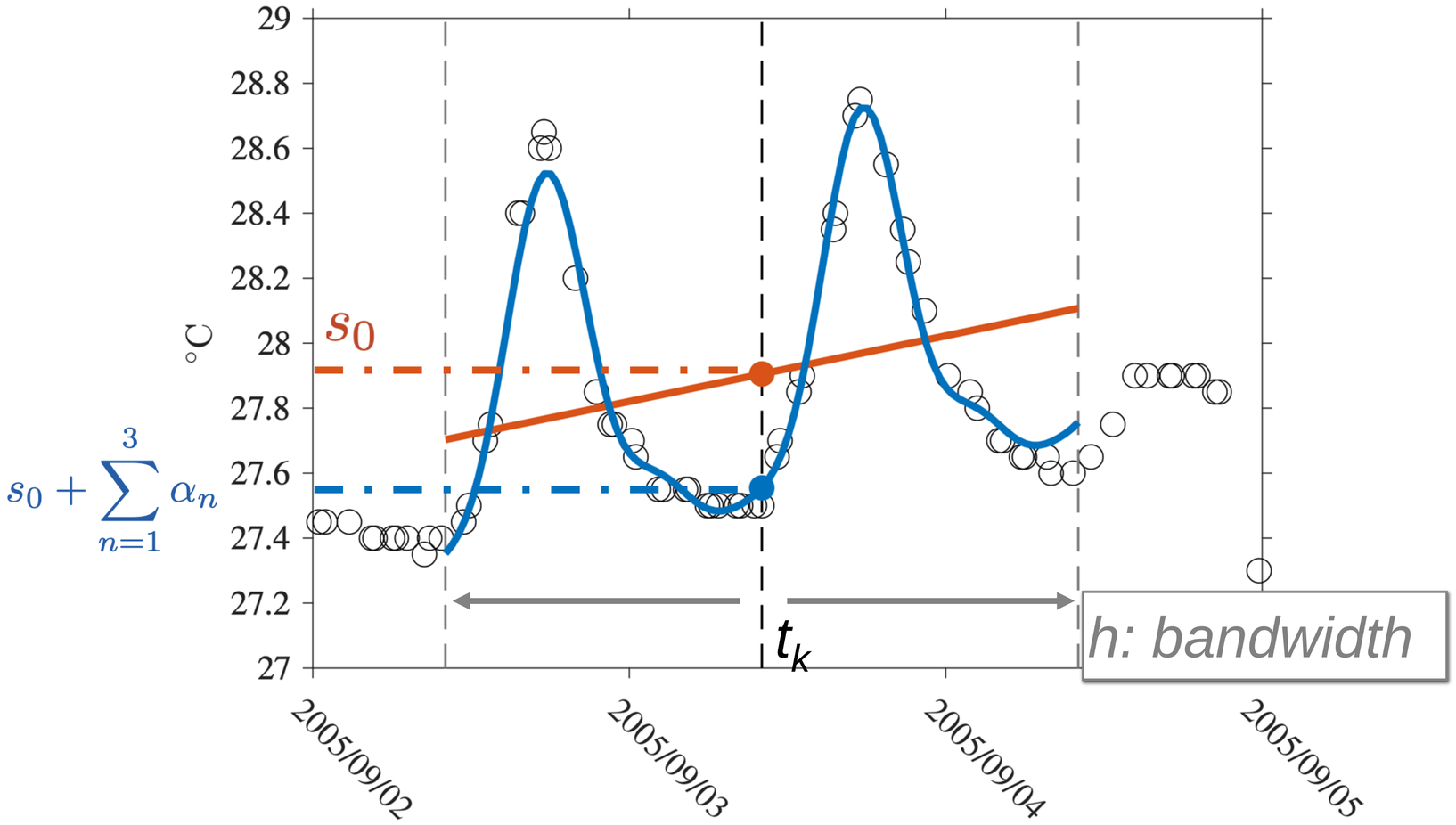


P = 1
N = 0

$$s_m(t_k; t_k) = s_0$$

Methodology: models

$$s_m(t_i;t_k) = s_0 + s_1(t_i - t_k) + \sum_{n=1}^{3} A_{n,k}\cos n\omega(t_i - t_k)$$

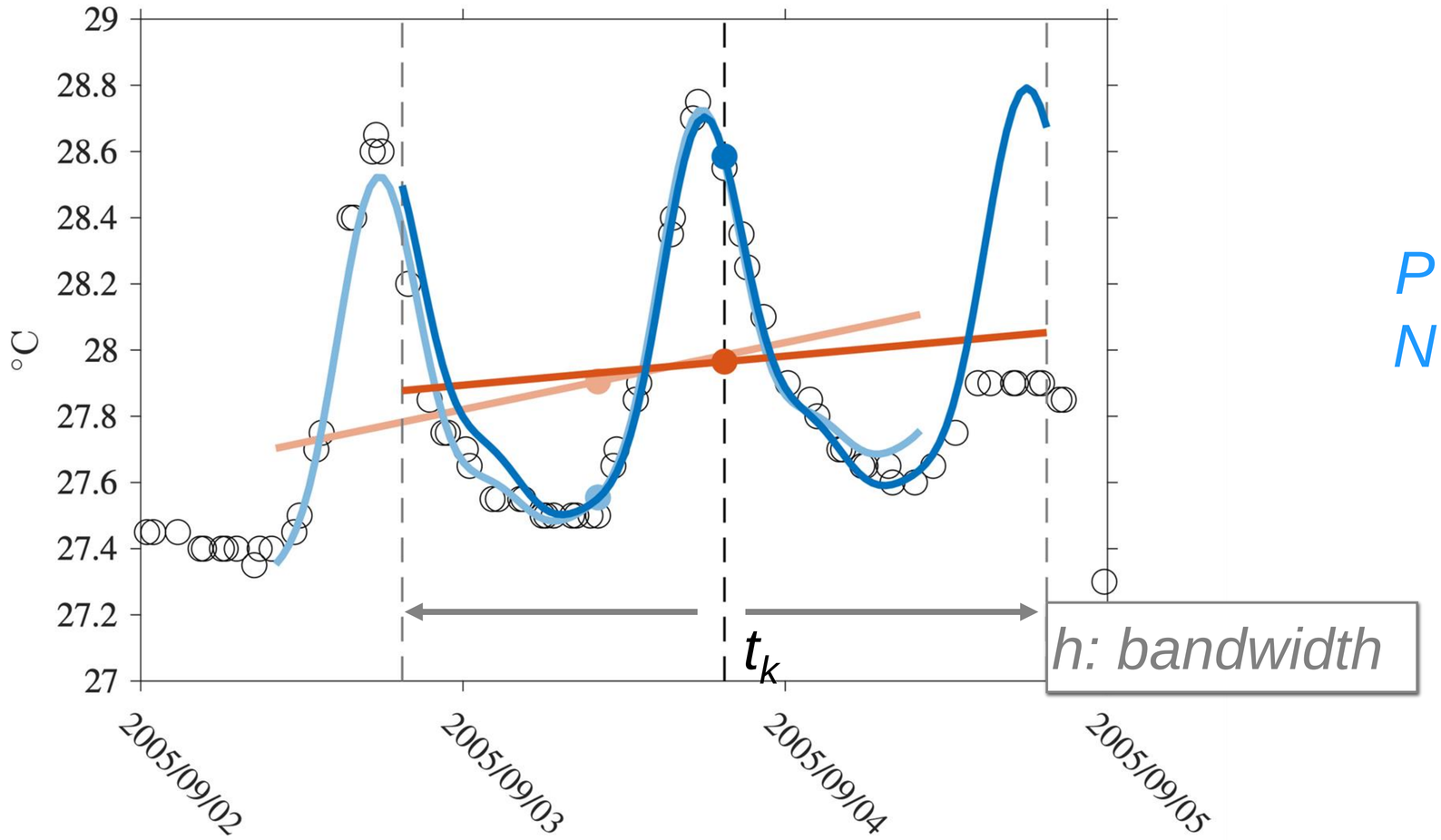


$$s_m(t_k;t_k) = s_0 + \sum_{n=1}^{3} \alpha_n$$

P = 1
N = 3

Methodology: models

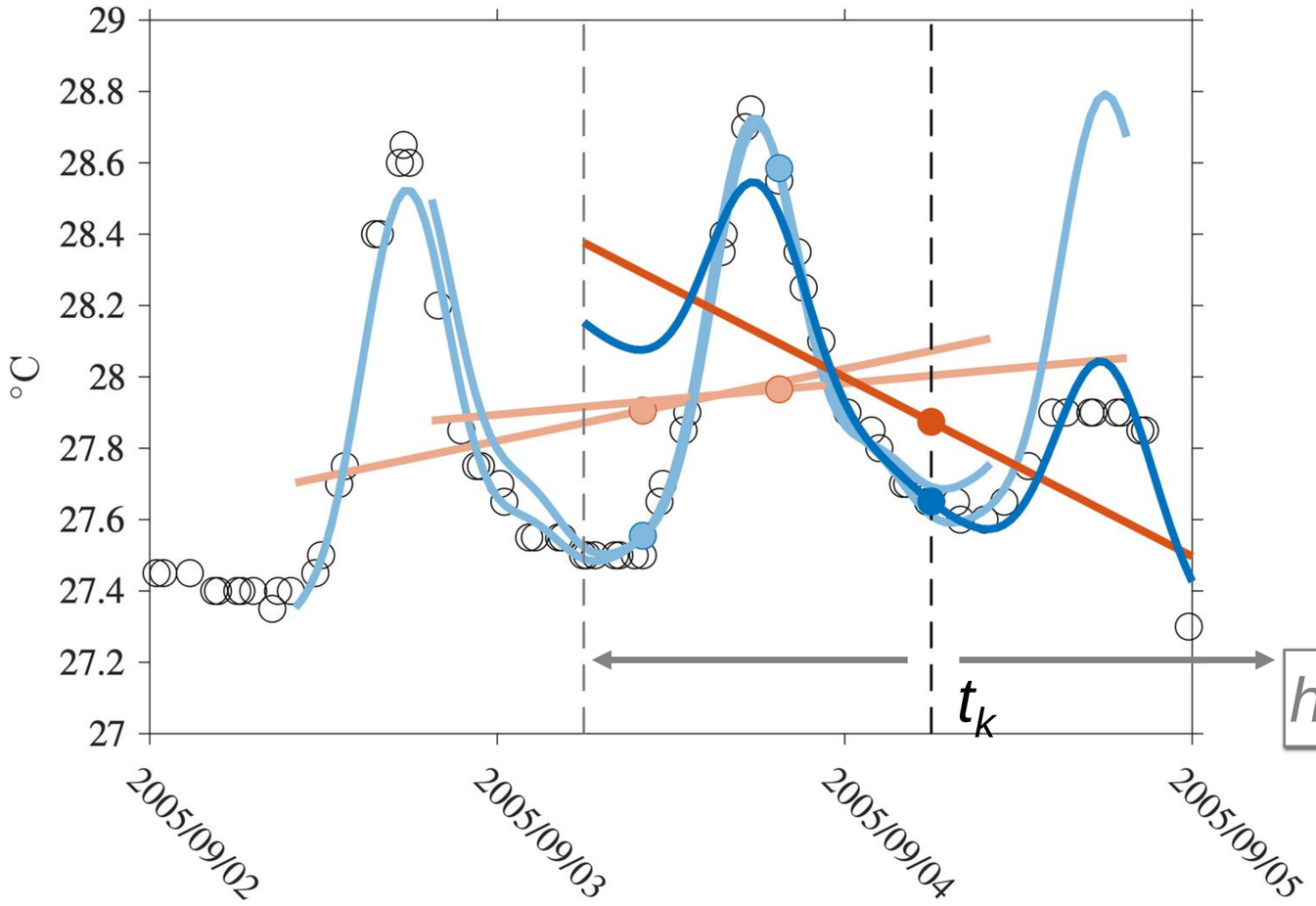
$$s_m(t_i;t_k) = s_0 + s_1(t_i - t_k) + \sum_{n=1}^{3} A_{n,k} \cos n\omega(t_i - t_k)$$



P = 1
N = 3

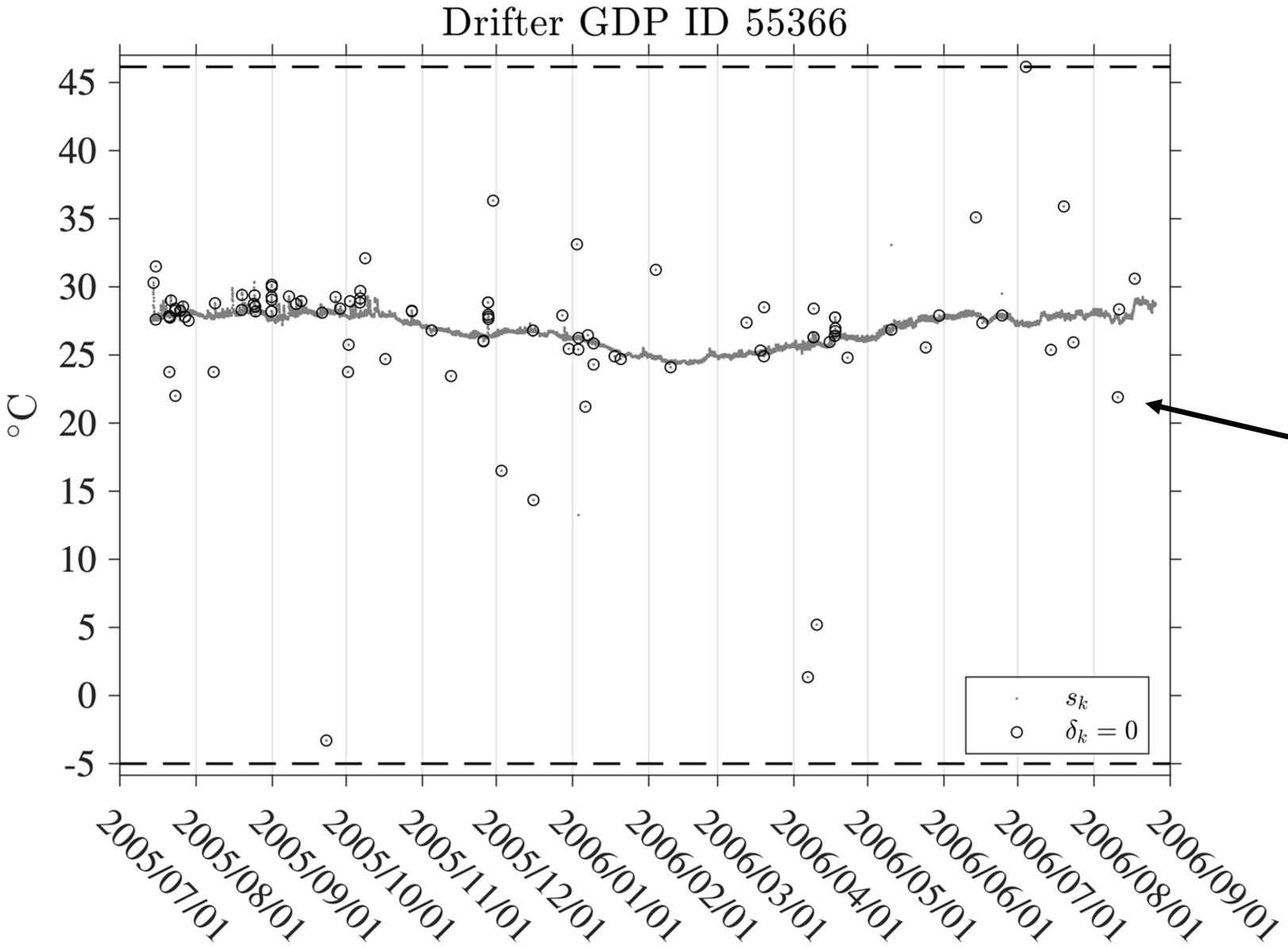
Methodology: models

$$s_m(t_i;t_k) = s_0 + s_1(t_i - t_k) + \sum_{n=1}^{3} A_{n,k} \cos n\omega(t_i - t_k)$$



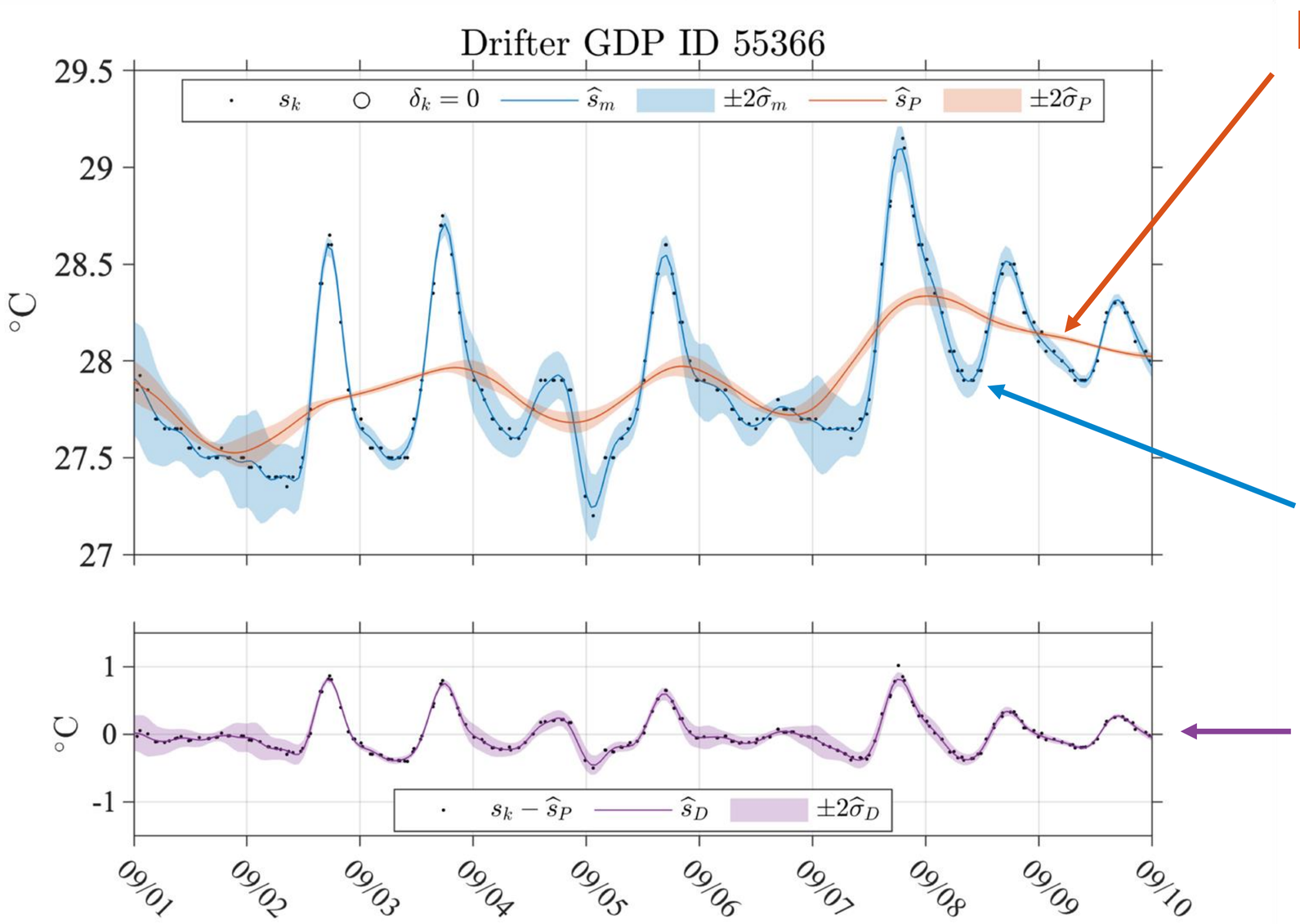
P = 1
N = 3

Results: identification of outliers



outliers

Results: estimation at regular hourly times

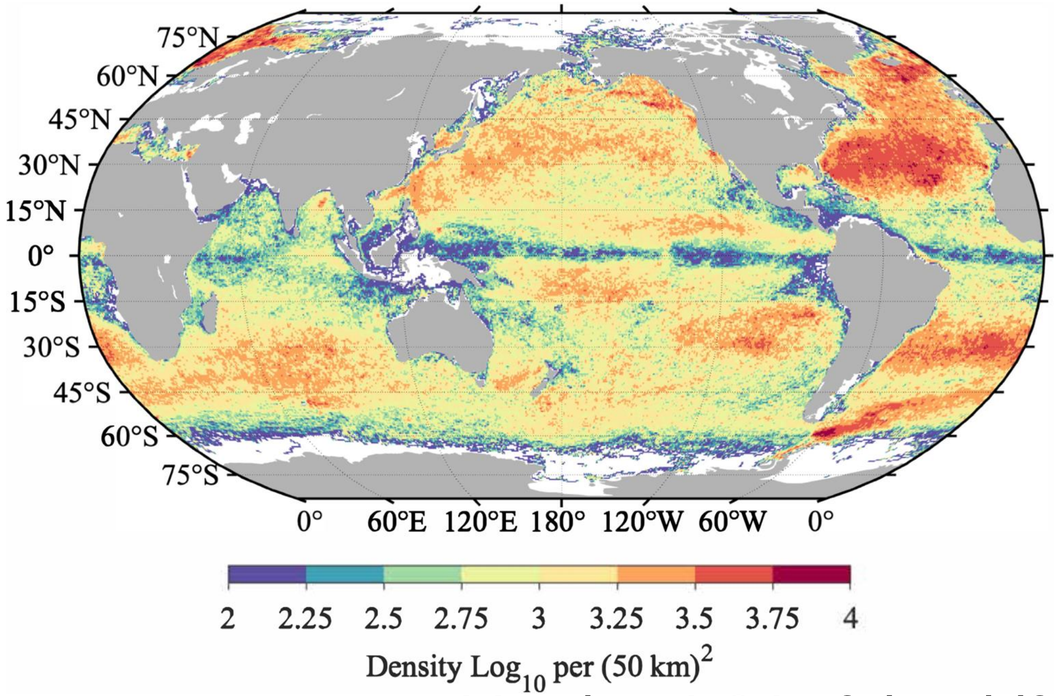


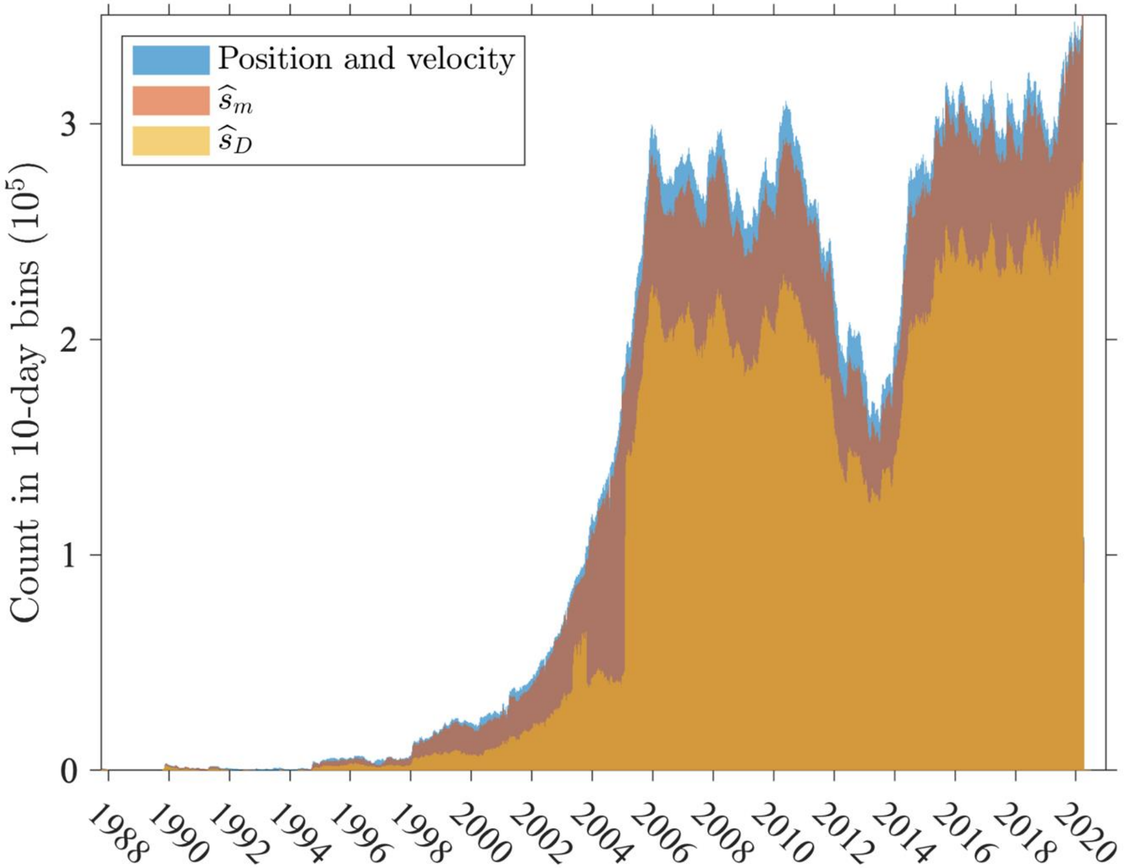
low-frequency component

total SST

diurnal component

Results
version 1.04





Version 1.04 of the drifter dataset of **position** and **velocity**
is from 03-Oct-1987 to 30-Jun-2020
17,324 trajectories
165,754,333 estimates of lon,lat,U,V

For 95.6% of these points, we were able to calculate high quality SST estimates
(158,436,770)

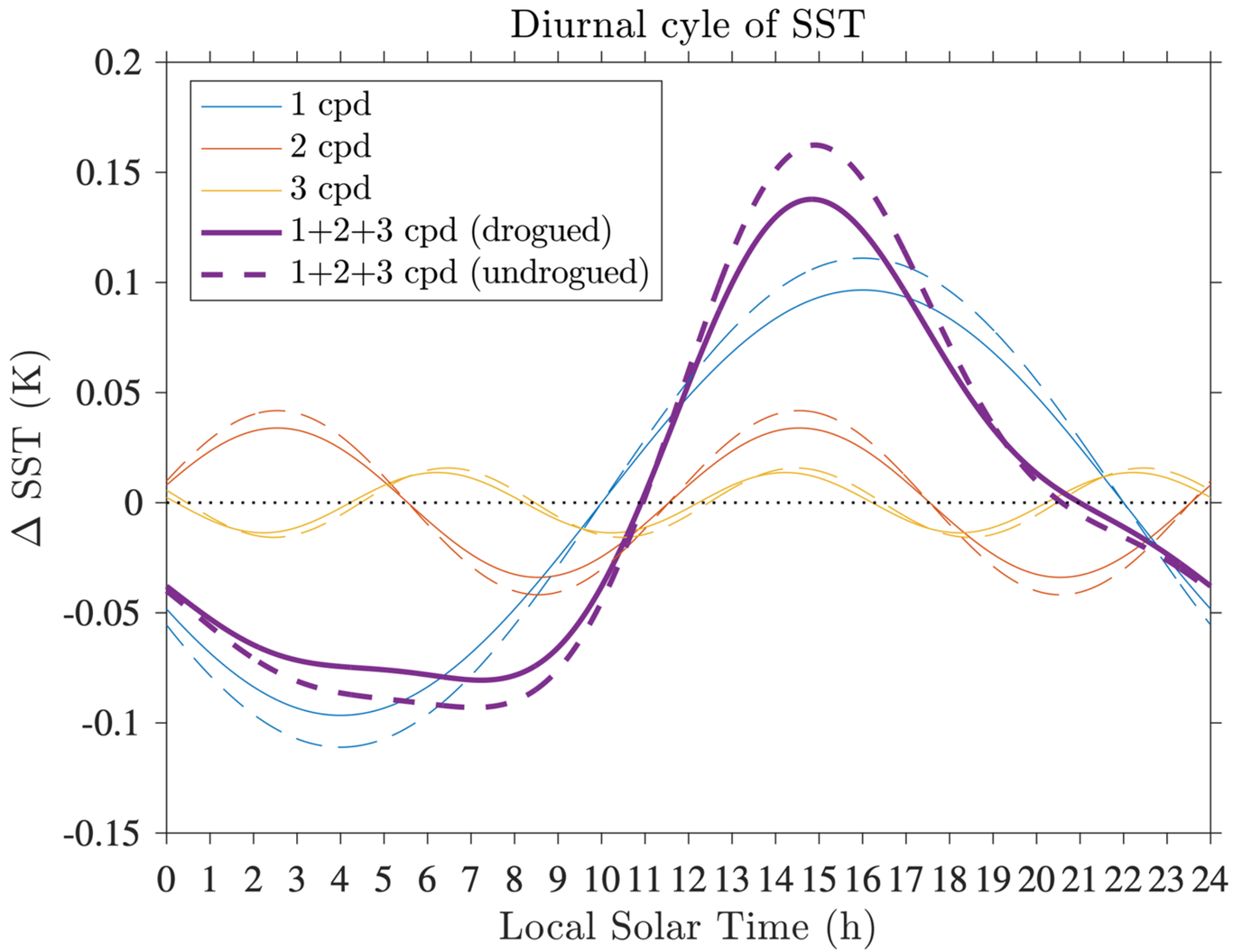
Results
version 2.00

New hourly dataset version 2.0 now include 9 new variables:

- fitted **sea water temperature** (3 decimal places, last digit rounded towards the nearest 0.001)
- fitted **non-diurnal sea water temperature**
- fitted **diurnal sea water temperature anomaly**
- **standard uncertainty** of fitted **sea water temperature** (1-σ, 3 decimal places, last digit rounded “up” to the nearest 0.001)
- **standard uncertainty** of fitted **non-diurnal sea water temperature** (1-σ)
- **standard uncertainty** of fitted **diurnal sea water temperature anomaly** (1-σ)
- fitted **sea water temperature quality flag** (0 to 5, 5 being highest quality)
- fitted **non-diurnal sea water temperature quality flag** (0 to 5)
- fitted **diurnal sea water temperature anomaly quality flag** (0 to 5)

Results

Averaged diurnal cycle



Thank you!

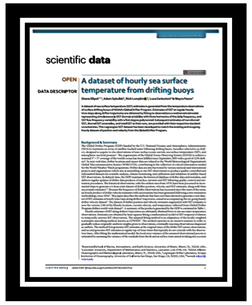
Questions?

Additional Resources

Scientific Manuscript

(Elipot et al. 2022)

https://www.nature.com/articles/s41597-022-01670-2



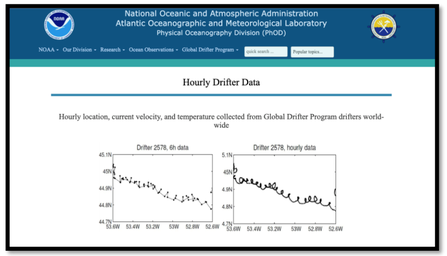
Full Length Presentation

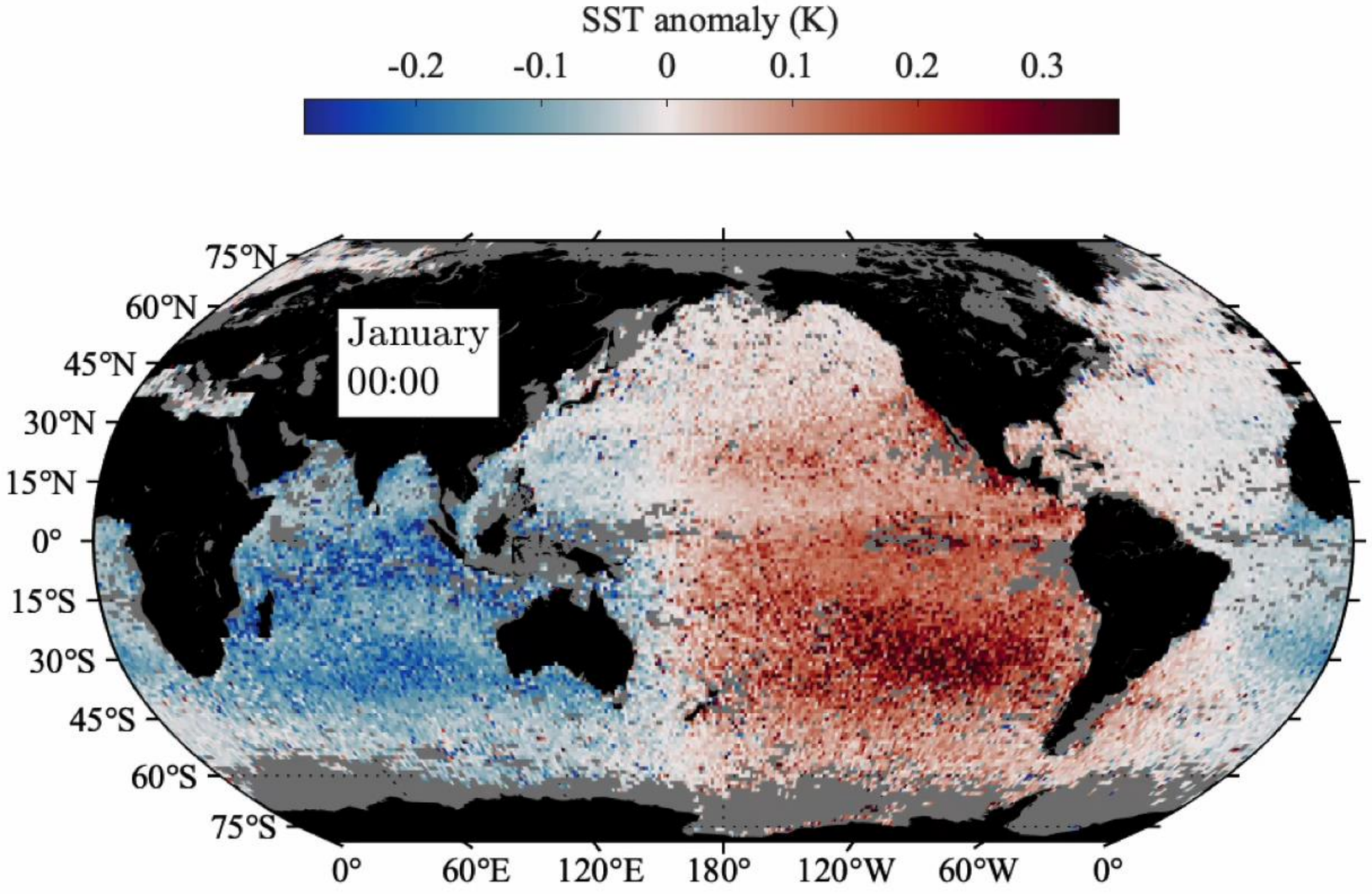
By: Shane Elipot

https://www.youtube.com/watch?v=J9SXVDwHuFo&t=1s

Links, Code, Tutorials, etc.

https://www.aoml.noaa.gov/phod/gdp/hourly_data.php




SST anomaly (K)
-0.2
-0.1
0
0.1
0.2
0.3
January
00:00
75°N
60°N
45°N
30°N
15°N
0°
15°S
30°S
45°S
60°S
75°S
0°
60°E
120°E
180°
120°W
60°W
0°

Available datasets & references

Not readily available **Readily available** X: observation X*: estimate (or “interpolated value”) X,Y: geo. position U,V: velocity		*Argos* *(positioning and transmission)*		*GPS (positioning) & Iridium (transmission)*	
		Position	**SST**	**Position**	**SST**
Level-0 *(observation times)*		X,Y	SST	X,Y	SST
Level-1 *(observation times)*		-	SST* Elipot et al. (2022)	X*,Y*,U*,V* Elipot et al. (2016)	SST* Elipot et al. (2022)
Level-2 *(regular, non-observation times)*	*6-hourly*	**X*,Y*,U*,V*** Hansen and Poulain (1996)	**SST*** Hansen and Poulain (1996)	**X*,Y*,U*,V*** Hansen and Poulain (1996)	**SST*** Hansen and Poulain (1996)
	1-hourly	**X*,Y*,U*,V*** Elipot et al. (2016)	**SST*** Elipot et al. (2022)	**X*,Y*,U*,V*** Elipot et al. (2016)	**SST*** Elipot et al. (2022)

For data links, please see https://www.aoml.noaa.gov/phod/gdp/index.php