Sampling considerations for baseline monitoring and disaster response

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How often and how many locations should be sampled ?

Depends on the need (requirement):

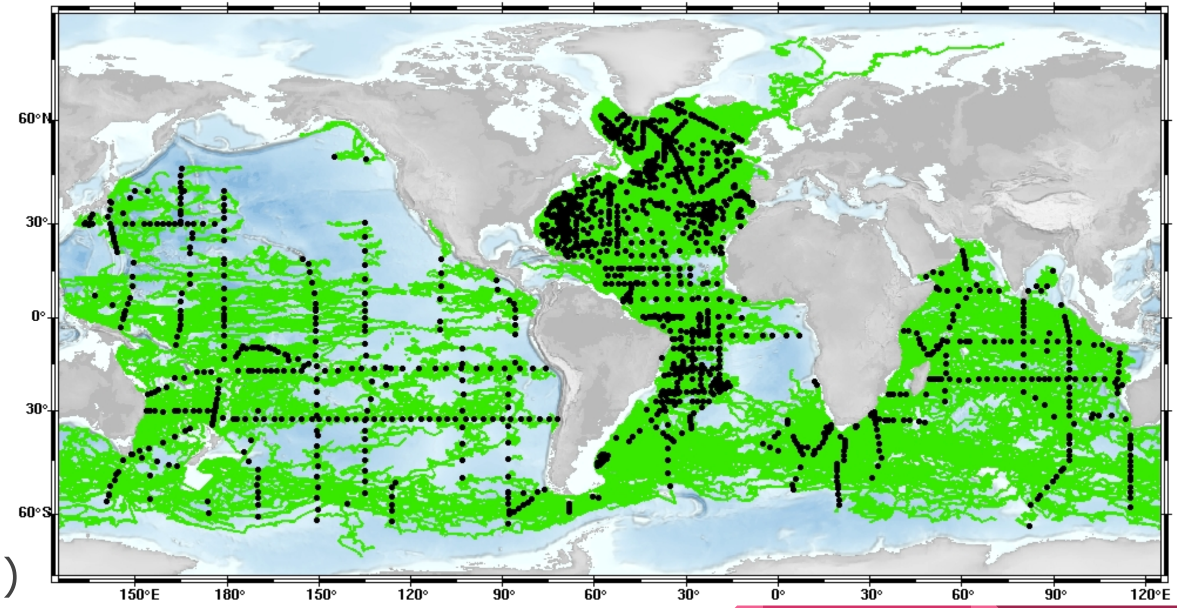
- Typical value at a single location (mean) ?
- Mean over a larger area ?
- Typical variability (variance) ?
- Time scales of variability (spectrum) ?
- Extreme values ?
- To what accuracy are these needed ?

Example: stable mean of deep circulation

Uncertainty of the mean =

$= 6 / N^{1/2}$

(6 standard deviation)



- expected standard deviation of deep flow fluctuations
- estimate of integral timescale (this gives number of independent data)
- desired accuracy of mean

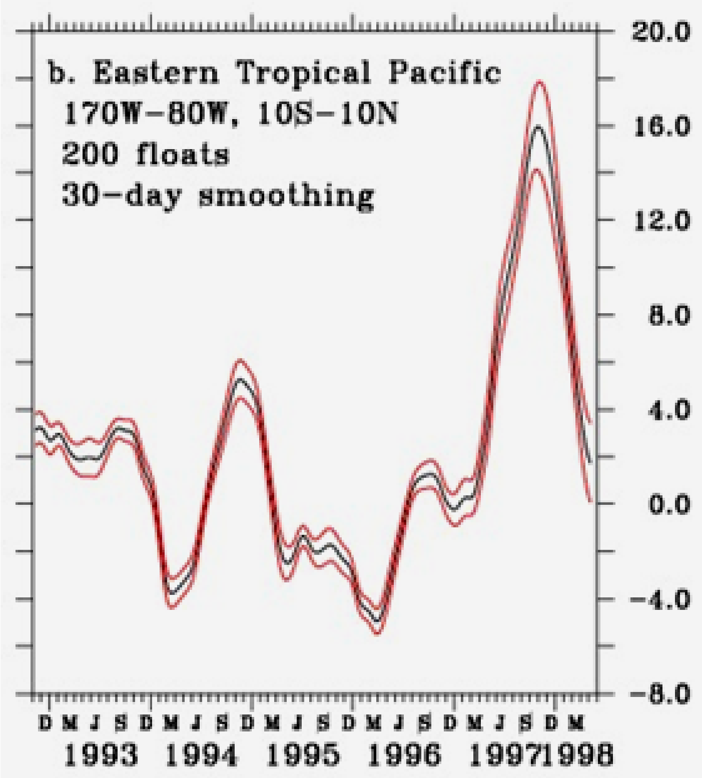
⇒ approx. 5 years data needed in each box

Example: ARGO float array design

Uncertainty of mean heat content for an ocean basin depends on “noise” which needs to be averaged out.

Limiting is not the accuracy of the individual T measurement (0.003°C) but here the biggest noise is natural variability from mesoscale eddies, several 0.1°C.

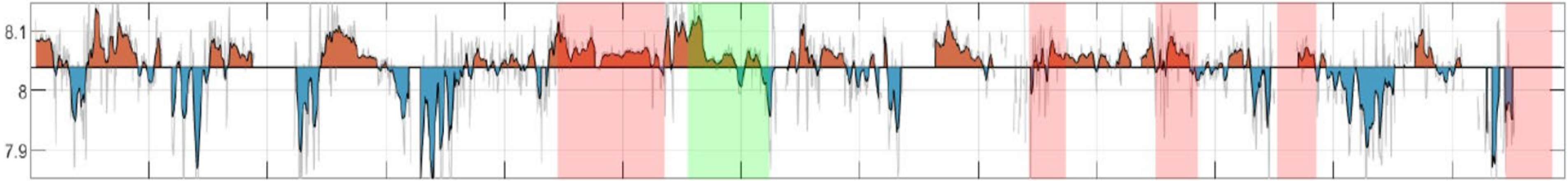
Simulations with one float every 300km gives the uncertainty shown here, compared to the variability of interest.



Lessons:

- Required accuracy usually comes from the size of the “signal” we want to detect or study
- In many cases, this is the full range of natural variability (but can also be a specific process, like day-night variability, climate trends, etc).
- Accuracy comes from all “noise” sources together, i.e. instrument error, calibration error, small-scale or high-frequency natural variability, etc.

Example: pH variability off California



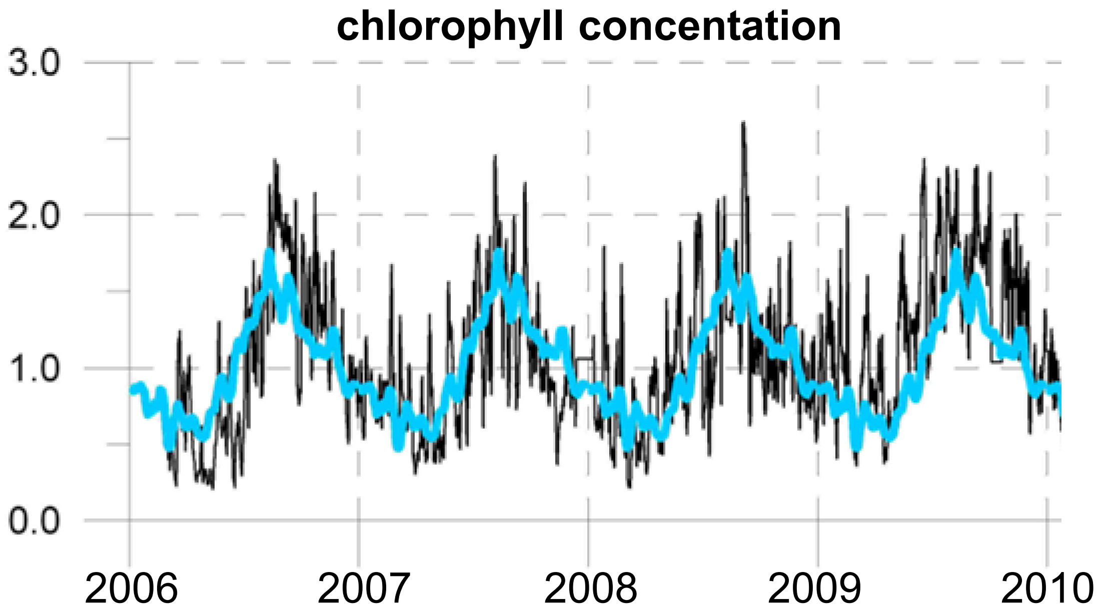
The range is from 7.9 to 8.1, i.e. roughly +/-0.1 in pH units.

Therefore uncertainty in measurements should not be more than 0.02.

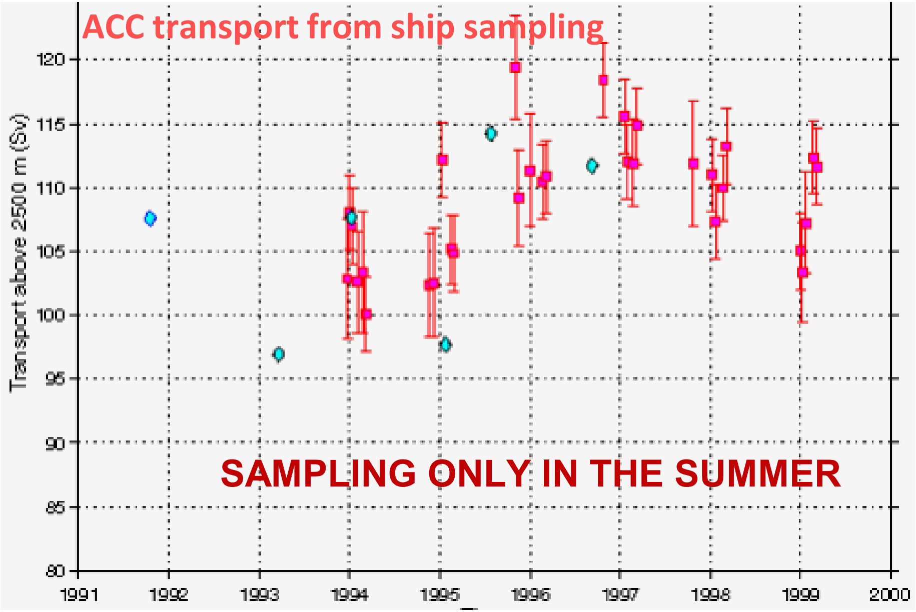
Problem: annual cycle

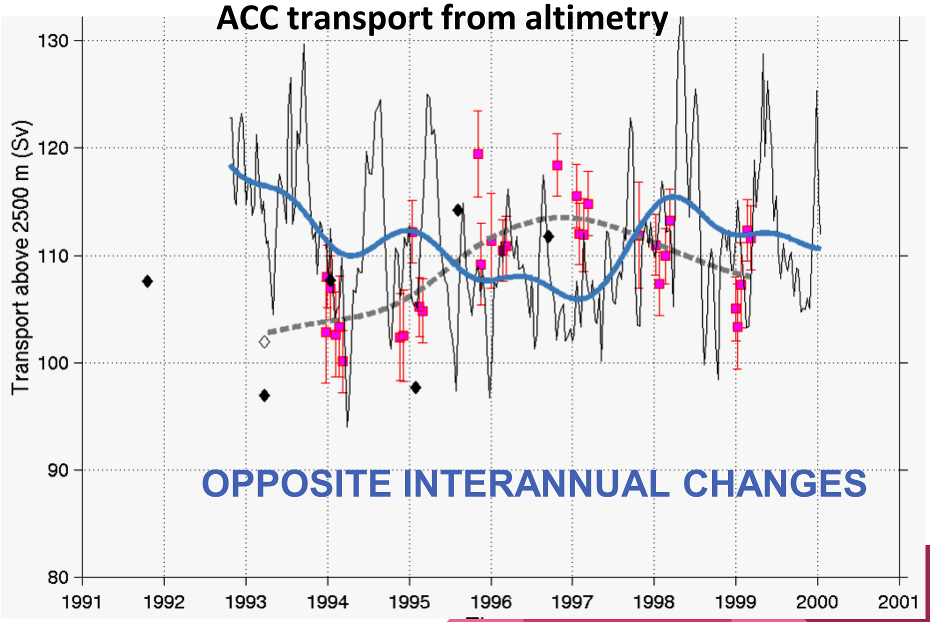
Getting a good annual average, or even sampling the full range, can be tricky.

Around Sri Lanka, monsoon seasons make year-round sampling challenging. But it is crucial !



Not sampling the annual cycle can give very wrong results



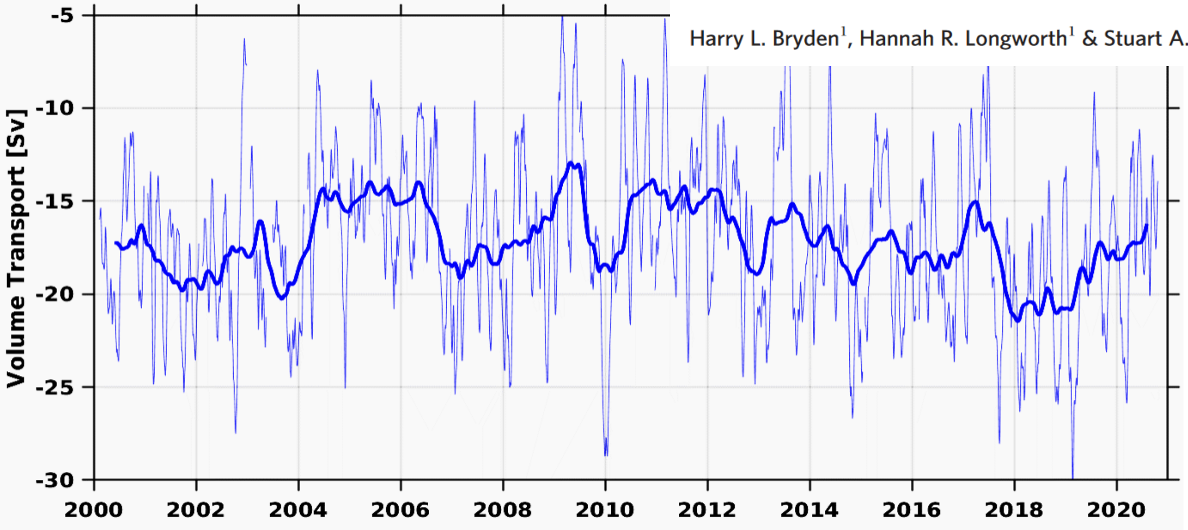


Infrequent sampling can create fake variability

nature LETTERS

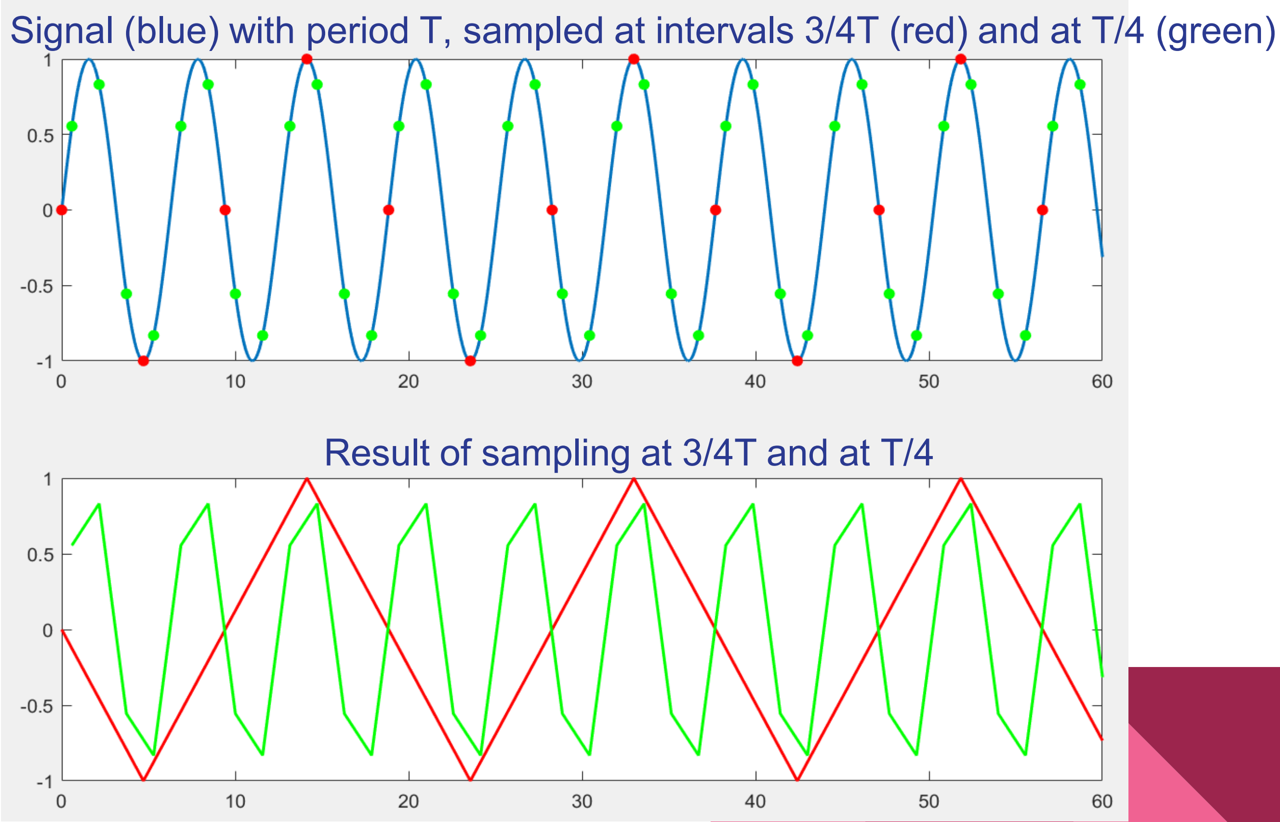
Slowing of the Atlantic meridional overturning circulation at 25° N

Harry L. Bryden[1], Hannah R. Longworth[1] & Stuart A. Cunningham[1]



Aliasing

Not resolving the fastest process can create artificial lower frequency variability.
(Need to sample at least every T/2).



Problems often are:

- **day/night (diurnal) period**
- **Tidal periods**
- **Annual cycle**

Summary:

Not resolving an important periodicity can

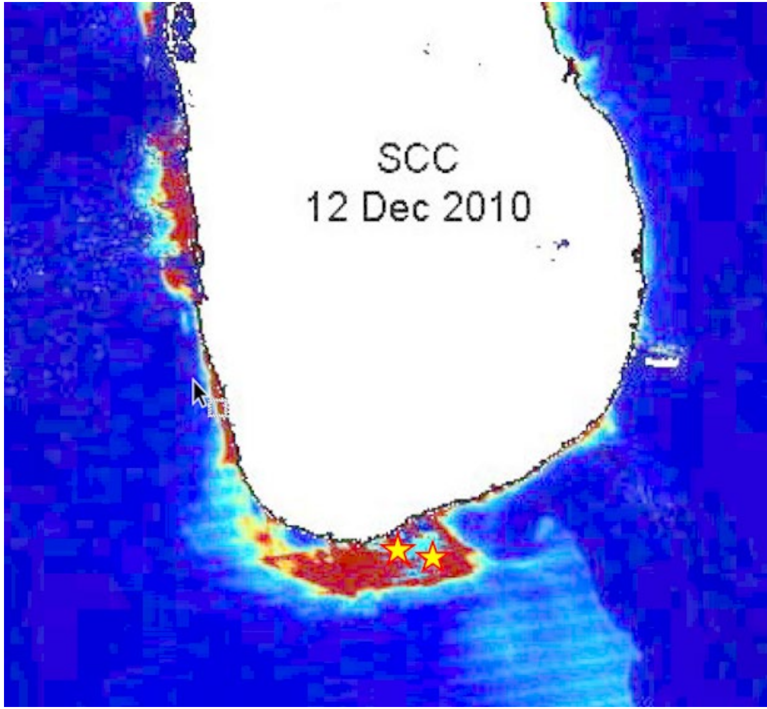
a) Give wrong means (e.g. sampling temperature or chlorophyll only during daytime, or only during summer)
b) Give fake periodicities (non-existing frequencies)
c) Miss full range of values or extremes

This is a problem if a disaster occurs, since extreme values found could also be normal ones that have not been sampled before

Climatology is useful

Good to know typical conditions (for physical, chemical, biological parameters) for each month of the year.

E.g. if the currents are mostly offshore in a certain month (upwelling ?),
then a disaster spill will most likely be advected away from the coast.

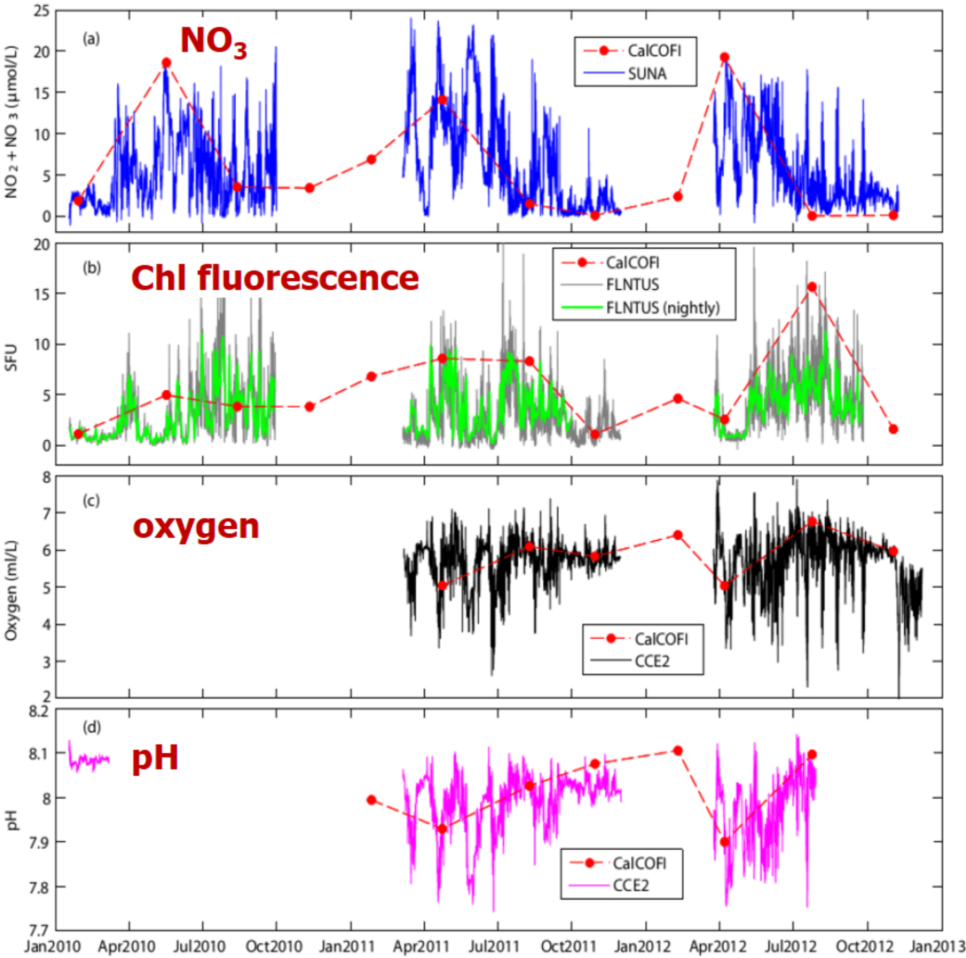


These climatological conditions also include the spatial patterns: need to see if a pattern after a disaster is anomalous.

Natural variability is messy:

Frequent measurements are important

- For the **baseline monitoring**, in order to assess what disaster-related condition are really anomalous
- For the **post-disaster monitoring**, since disaster-related extremes may be missed



For discussion later today:

- What does NARA know already about the time variability of physical, chemical, ecosystem parameters in relevant areas:
  - regions near shipping lanes
  - sensitive shallow habitats (wetlands, lagoons, mangroves)
  - sensitive fish and mammal and turtle habitats
  - coral reef habitats

- What does NARA know about spatial variability/patterns around the island ?

- To what accuracy need the parameters be measured in the different regimes ?

Data accuracy versus precision

Accuracy:
Absolute "correctness" relative to a universal/global reference standard.
For non-physical parameters this requires some chemical standards which are prepared according to accepted international procedures, or even "standard samples" which are shipped around the world.

Precision:
Repeatability of a measurement. Does not include systematic or calibration offsets. Only captures quality of instrument or procedure, not of its calibration.

Resolution:
Smallest difference between 2 samples that can still be recognized as different.

Instrument drift, long -term stability

In the short term, measurements may have high accuracy or precision.

Long-term drift or sudden jumps do occur. Very difficult to track and correct.
If we have a post-calibration, we can at least check whether there WAS a drift and put bounds on its size.

- It really means that precision depends on time-scale.
- Some manufacturers quote precision and stability separately.