

# Sampling Requirements for VOS Surface Fluxes

Motivation:

Observing systems are being reassessed as NWP users are relying more heavily on satellites and drifting buoys. If we don't tell operators soon what our requirements are (in terms of number of observations, quality and variables), they won't be taken into account in the new observing system designs.



**Southampton  
Oceanography Centre**

UNIVERSITY OF SOUTHAMPTON AND  
NATURAL ENVIRONMENT RESEARCH COUNCIL

# Questions

- What flux accuracy do we want?
  - Use OOSDP criteria (Surface conditions and air sea fluxes, Weller and Taylor 1993)
  - monthly mean flux to  $15 \text{ Wm}^{-2}$
  - $5^\circ \times 5^\circ$  grid ( $5^\circ \times 2^\circ$  in Tropics)
- How many observations do we need?
  - Depends on:
    - VOS sampling
    - spatial and temporal characteristics of the fluxes
    - VOS measurement errors.
  - Try to estimate these using NCEP Reanalysis and ICOADS.



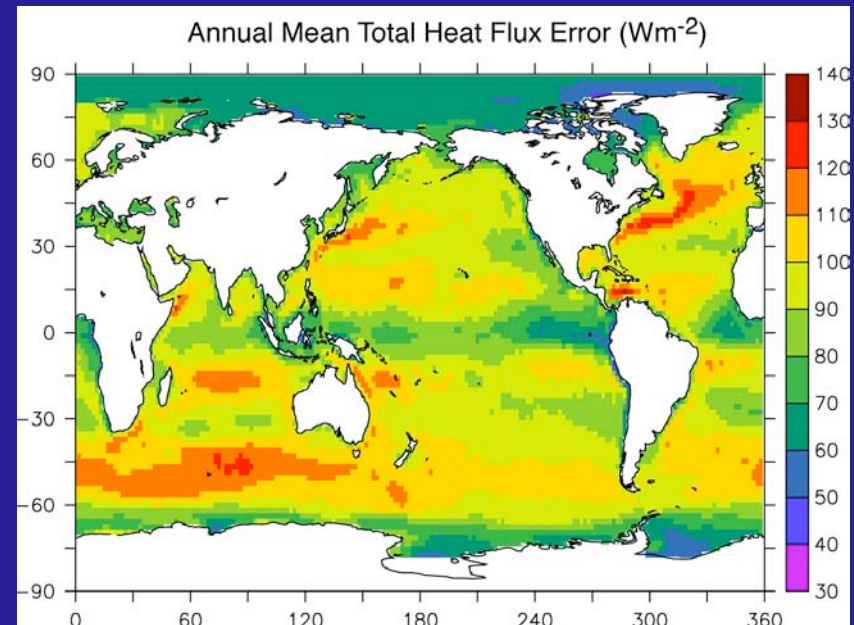
# Measurement Errors

- Due to random errors in the basic variables.
  - Can be estimated (e.g. SST error  $\sim 1.0-1.5^{\circ}\text{C}$ )
  - Reduce as  $1/\sqrt{N}$
  - Need to know them better (is error in wind speed  $\sim 2\text{ms}^{-1}$  or a fraction of mean wind?)
- Use NCEP Reanalysis 6-hour basic variables for 2002 to calculate fluxes and estimate errors.
- Use ensemble of Monte Carlo realisations with varying random errors to estimate measurement error.



# Measurement Errors

- Plot shows annual mean measurement error in a single observation of total flux (mostly due to latent heat)
- Errors reduce as  $1/\sqrt{N}$  - if errors really are random
- 25 reports in every box per month reduces mean measurement uncertainty  $\ll 20 \text{ Wm}^{-2}$ .



**Southampton  
Oceanography Centre**

UNIVERSITY OF SOUTHAMPTON AND  
NATURAL ENVIRONMENT RESEARCH COUNCIL

# Sampling Errors

- In regions with large variability we cannot get a good estimate of the mean fluxes from a few observations due to sampling errors.
- Measurements close in space or time are correlated with each other.
  - We need 'widely spaced' observations to get the best representation of the monthly box mean.
  - We can represent the time-variation of fluxes as an order 1 autoregressive process (neglecting some 'energy' at diurnal cycles, order 4 for 6 hourly data).
  - AR(1) processes can be modelled simply as they are self-similar at different timescales.



**Southampton  
Oceanography Centre**

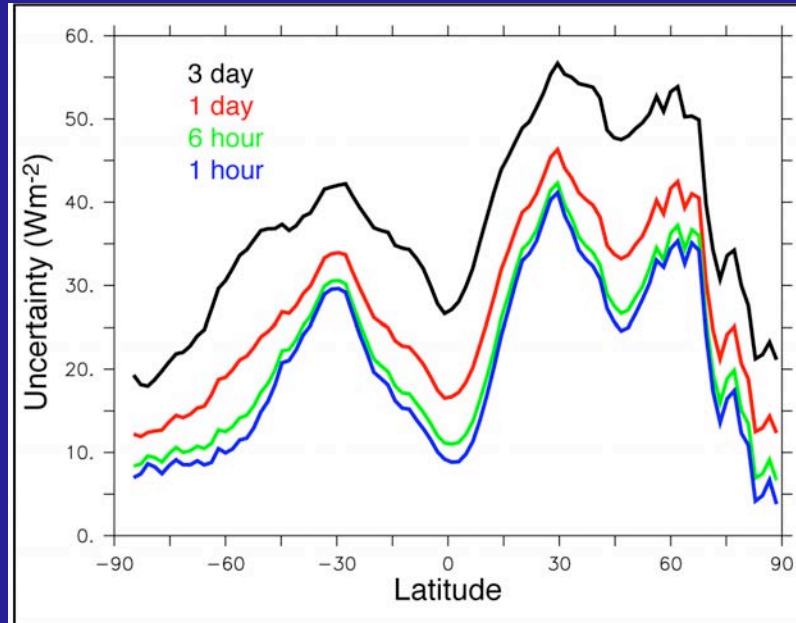
UNIVERSITY OF SOUTHAMPTON AND  
NATURAL ENVIRONMENT RESEARCH COUNCIL

# Sampling Errors (cont ..)

- For AR(1) process:  $x_{t+1} = \alpha x_t + \varepsilon_{t+1}$
- Typical mid-latitude figures ( $\alpha = 0.8$ ):  
weight of second observation in same  
place after a gap of:
  - 6 hours            ~ 0.1
  - 12 hours          ~ 0.2
  - 1 day              ~ 0.4
  - 2 days             ~ 0.7
  - 3 days             ~ 0.9

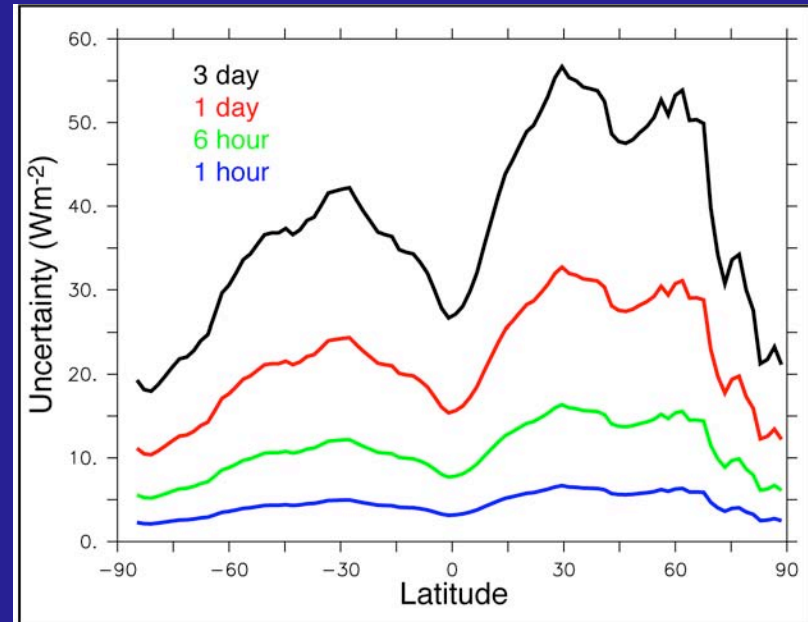
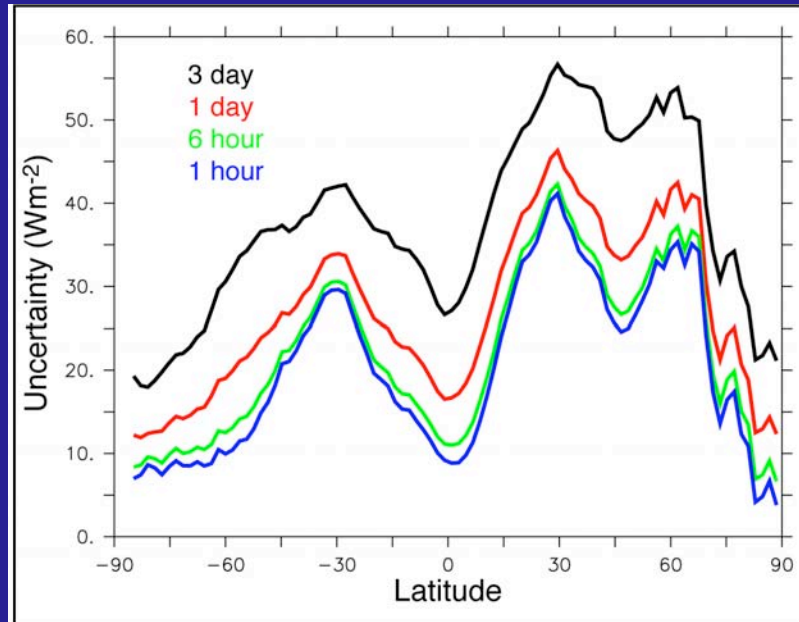


# Measurement plus Sampling Errors



- Left plot assumes total heat flux variability is of sufficiently large spatial scale that only one independent observation can be taken in the grid box at any one time.

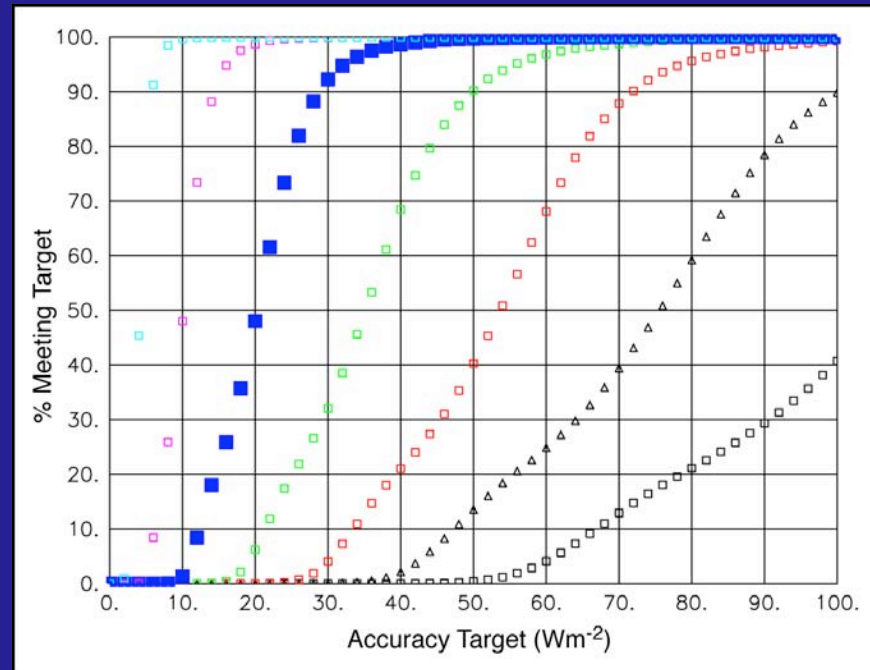
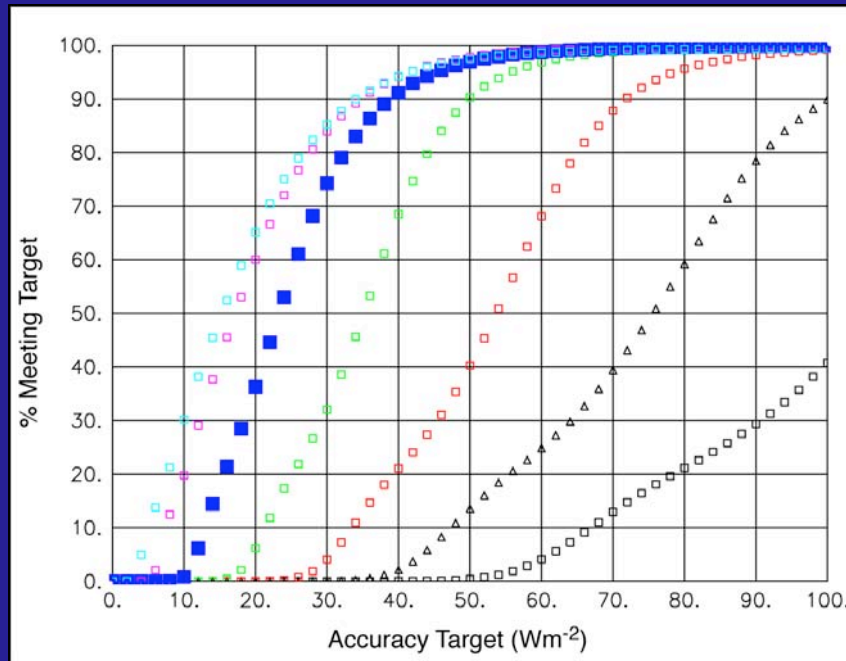
# Measurement plus Sampling Errors



- Left plot assumes total heat flux variability is of sufficiently large spatial scale that only one independent observation can be taken in the grid box at any one time.
- Right plot assumes total heat flux variability is of sufficiently small spatial scale that all observations in the grid box can be assumed to be made up of a number of time series sampled every 3 days.



# Target Accuracy



% of ocean 'boxes' (y-axis) meeting target accuracy for total heat flux (x-axis). Blue squares: daily sampling.

Right plot: large scale variability, left plot: small scale variability

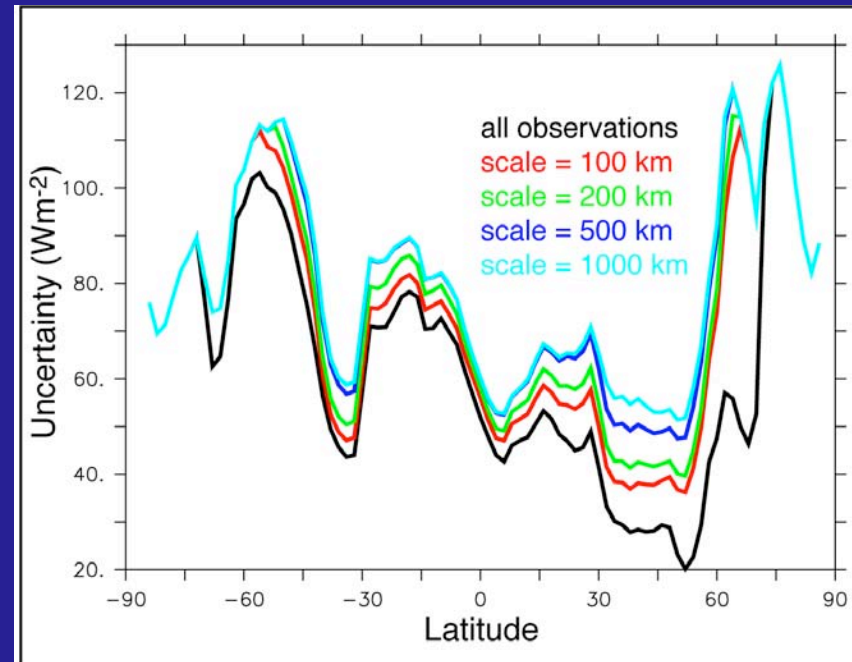
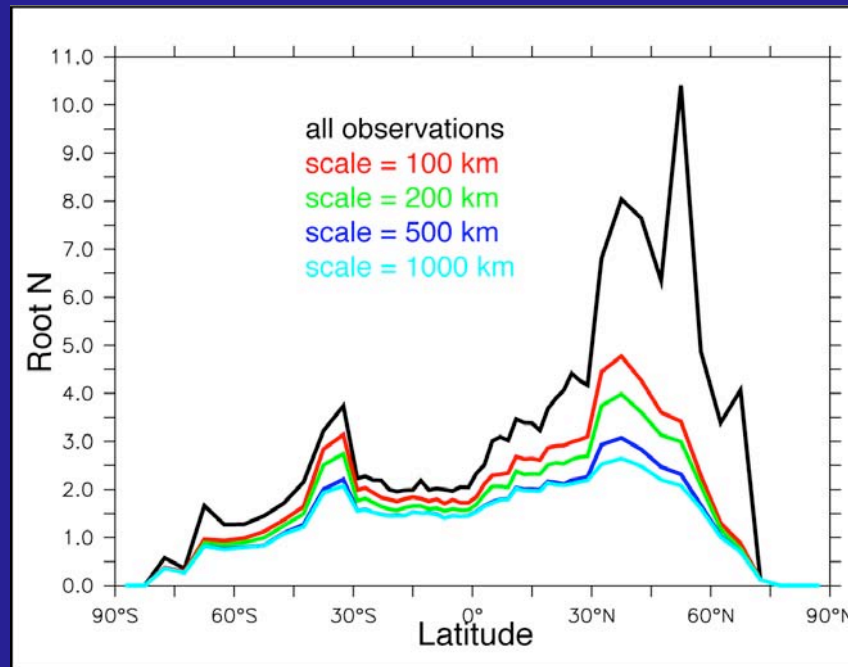


**Southampton  
Oceanography Centre**

UNIVERSITY OF SOUTHAMPTON AND  
NATURAL ENVIRONMENT RESEARCH COUNCIL

# How to weight observations?

- Left plot shows the effective  $\sqrt{N}$  from ICOADS for different assumptions about the spatial scales of total flux variability in January 2002
- Right plot shows the resulting range of total heat flux uncertainty



Southampton  
Oceanography Centre

UNIVERSITY OF SOUTHAMPTON AND  
NATURAL ENVIRONMENT RESEARCH COUNCIL

# Conclusions

- Measurement and sampling errors are of similar size (per observation)
- Sampling errors are more of a problem as the 'effective number' of observations is smaller than the true number
- Need to know spatial scales in order to properly weight the observations
- Diminishing return for higher-frequency observations at a single location, one sample every 3 days probably represents the best 'value for money'
  - But diurnal cycle will be unknown
  - Resulting uncertainty may not be small enough
- However redundancy such as nearly co-located reports is also good
  - 'Buddy' checks
  - Assessment of measurement errors
  - Calculate spatial scales .... etc.
- Need to consider a range of applications - what do we really need and what should we recommend?

