Signal To Noise Ratio Applied to I-COADS Ship-Measured Variables

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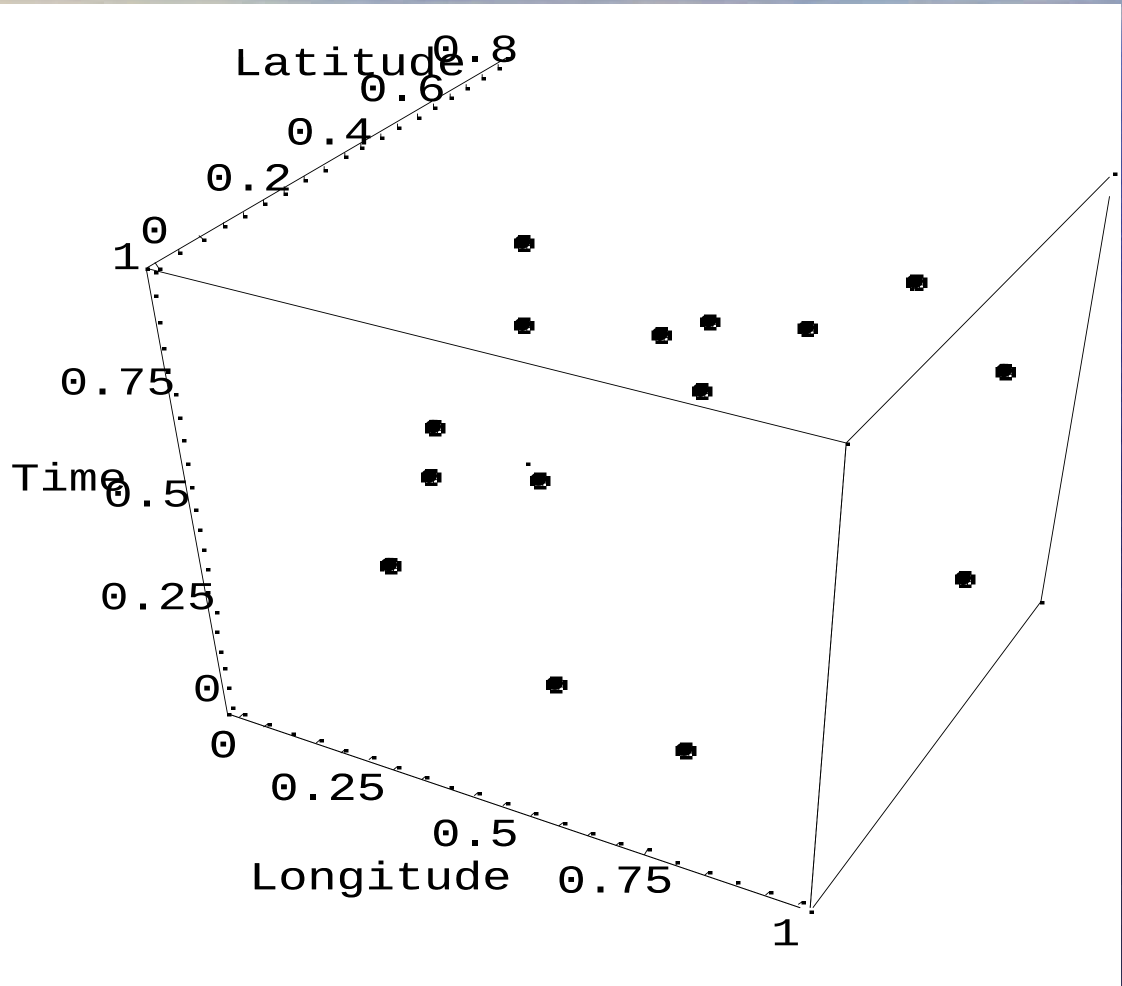
Objective

- Develop a method to use the sampling error of monthly box averaged ship data in a meaningful way
- Should be a function of ship location in time and space
- Method should be flexible enough to accept simple averages or OI
- Must be practical in application

I-COADS Time-Space Box



Divide Box into 'm' sub-boxes

Each sub-box has at most 1 ship observation

'n' total number of ships per box

Signal To Noise Ratio

S/N = Month-to-Month Variance/Error Variance

Sampling Error or Error Variance:

$s_e^2 =$

s_p^2

m

-

i=1 j=1

m n

i=1 j=i+1

n²

Assume σ^2_p = E[(R(t) – μ)²] unbiased

ρ = time-space correlation function of vector distance ‘d’

Morrissey and Greene, 1995, WRR; Kagan, Gandin and Smith, 1997, Kluwer Pub.

Month-to-Month Box Variance Estimated from Sample Observations (i.e. the 'Signal')

1. **Find expression for** $\sigma^2_T(n) = E[\,(\bar{R}_t(n) - \mu)^2]$

   - **where** $\bar{R}_t(n)$ **is the sample ave**
   - μ **is the long-term mean**

2. **Let** $n = \infty$

3. **Then compute** $S/N = \sigma^2_T(\infty) / \sigma^2_e(n)$

Equation for $\sigma^2_T(n)$

$$s_T^2$$

$$= s_p^2$$

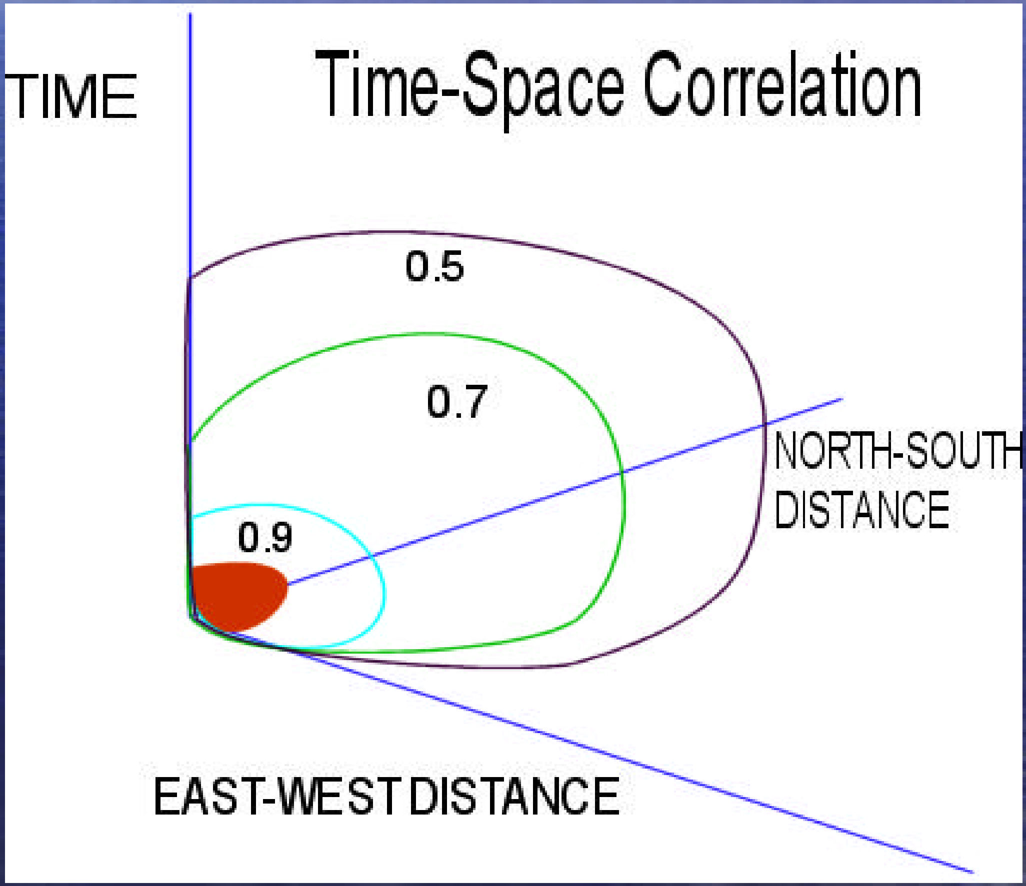
$$s_T^2 = s_p^2 VR$$

1. E[ρ]?

2. VR?

What is ρ and E[ρ]?

- ρ is the time-space correlation function
- E[ρ] is the expected value of the correlation ρ(x,y,t)
- Difficult to find the ρ(x, y, t) function easily



Practical Way to Compute the ρ Function

- Assume $\rho(t)$ is independent of $\rho(x, y)$
- Thus, $\rho(x, y, t) = \rho(x, y)\,\rho(t)$
- The correlation function is separable in time and space?

(Rodriguez-Iturbe and Mejia, 1974, WWR)

$$E[\rho] = \int \rho(x, y, t)\, f(L)\, dL$$

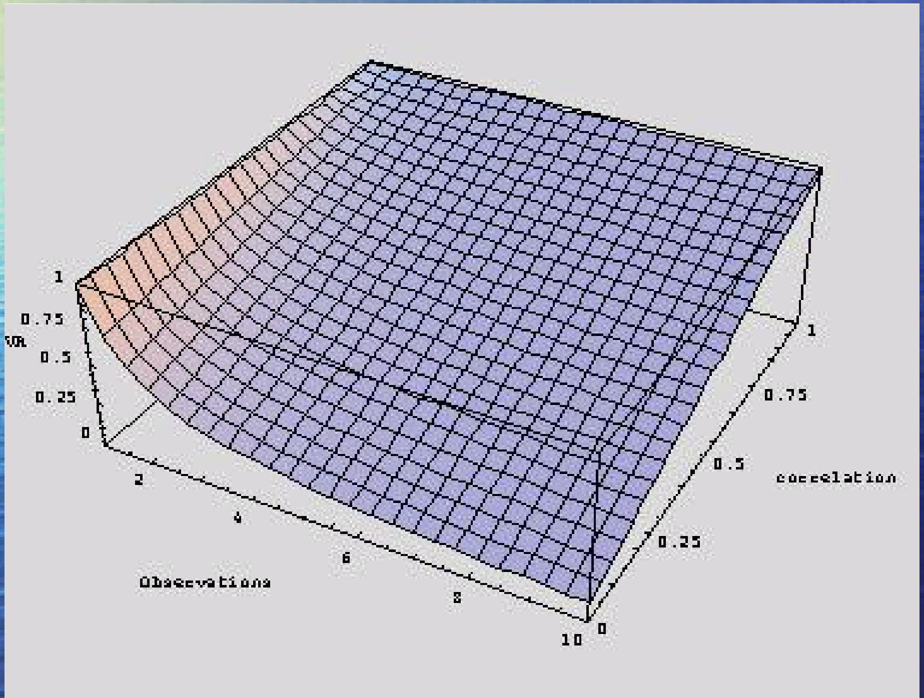
Ave Domain

L = Vector time-space distance between two ship locations

f(L) = pdf of vector time-space distances between two ship randomly located locations

Variance Reduction Factor VR

As VR decreases with increasing observations, the monthly variance estimated from n observations approaches the true monthly variance



$$\sigma^2_T = \sigma^2_p(1/n + (n-1)E[\rho]/n)$$

$$= \sigma^2_p \, VR$$

"n = number of ships"

Take Limit $n \rightarrow \infty$, $VR \rightarrow E[\rho]$

Thus, $\sigma^2_T(\infty) = \sigma^2_p \, E[\rho]$

True Monthly Variance σ_T^2

Thus, by setting the number of Observations = infinity We obtain the true monthly variance σ^2_T for a given monthly box

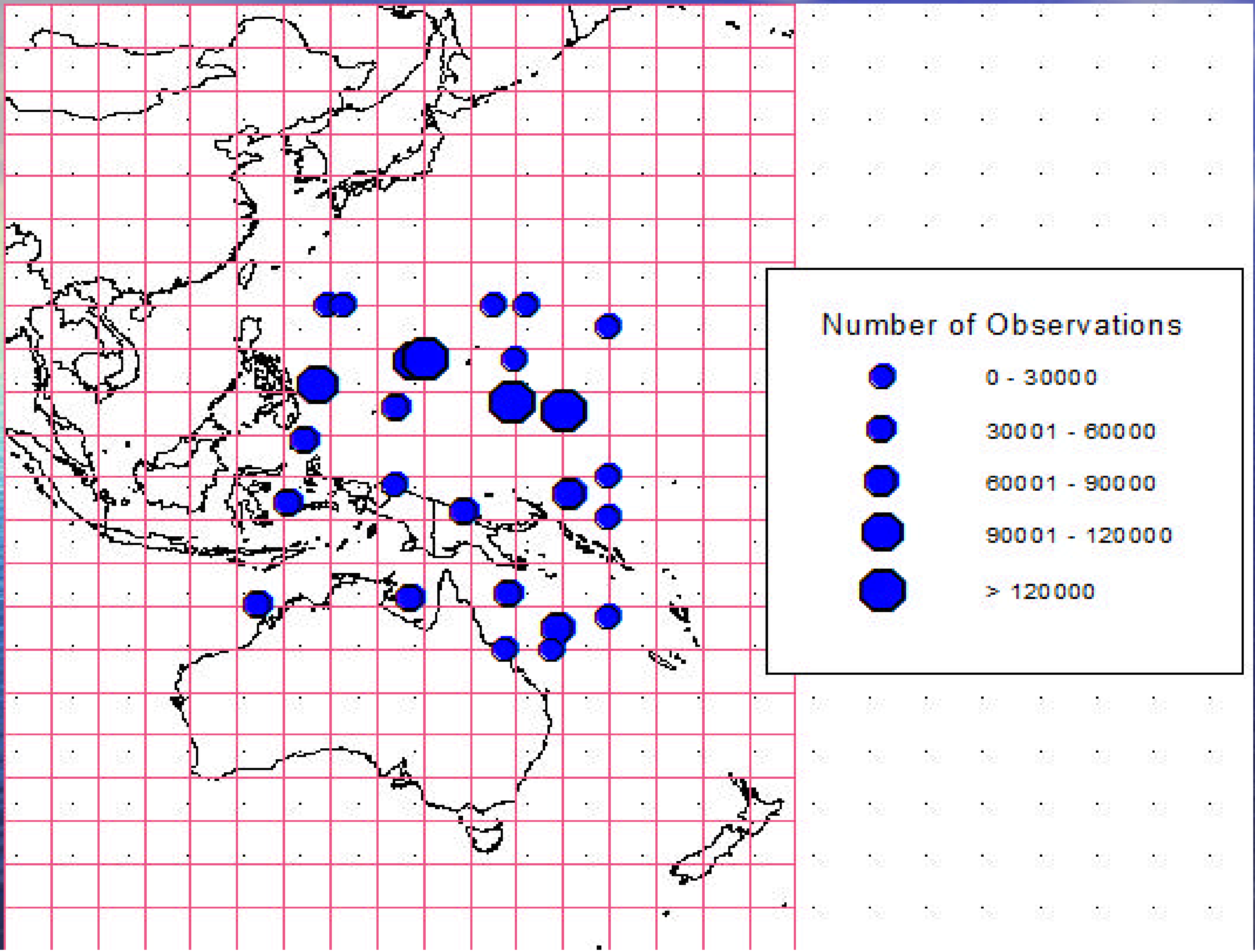
Signal to Noise Ratio:

$$= \frac{\sigma^2_T(\infty)}{\sigma^2_e(n)}$$

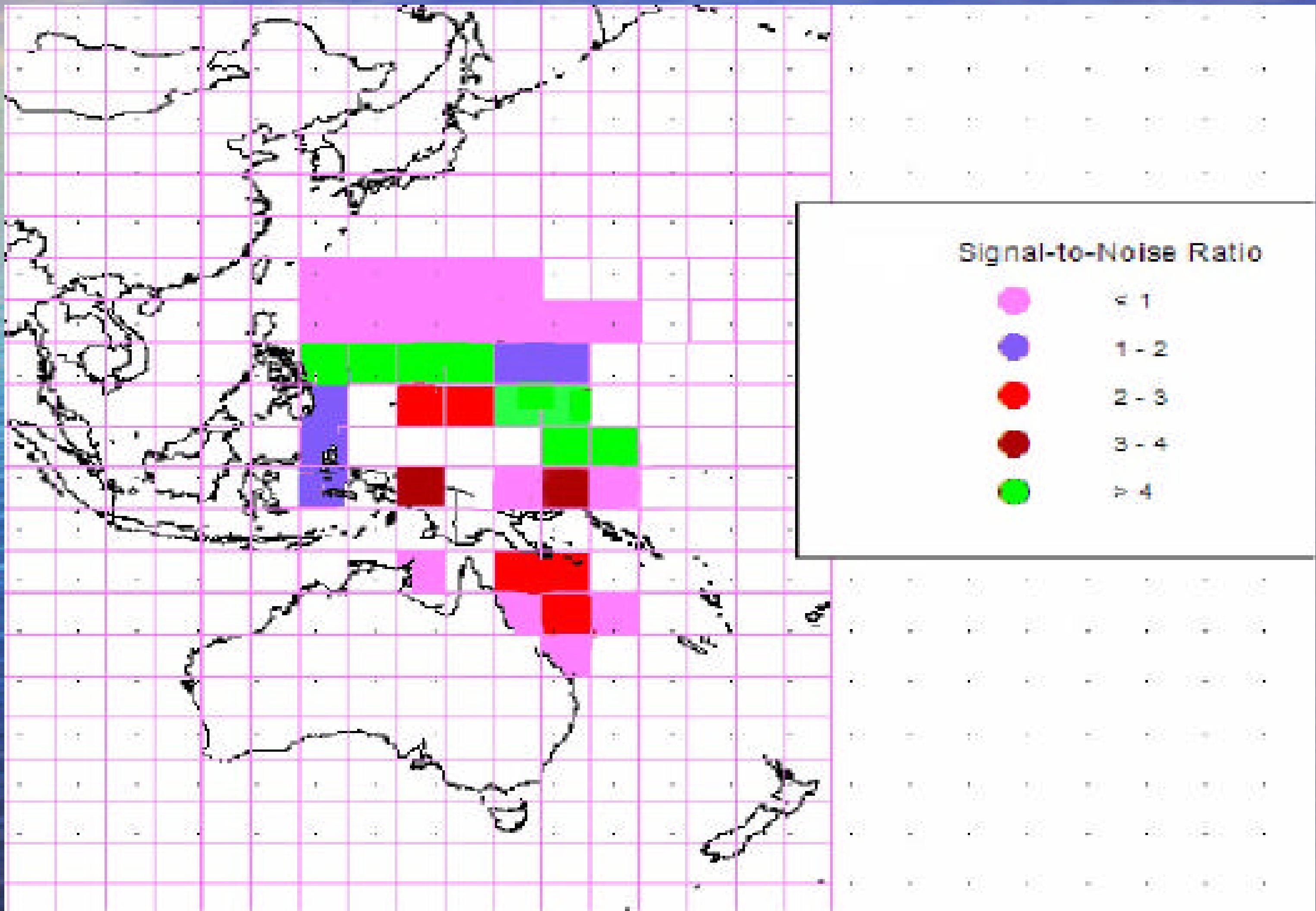
I-COADS Analysis

- Ship Air Temperature observations from sample month
- Location limits: 120E to 160E and 20S to 20N
- Only those boxes with sufficient observations included in analysis

Study Locations (and # of obs 1950-1997)



Signal To Noise Ratio (sample month)



Conclusions

- Method allows a S/N ratio value to be placed on every I-COADS monthly box
- Accounts for month-to-month ship location variation in time and space
- May be applied to OI schemes
- More work needed on the validity of statistical assumptions