Spatial scales of SSS subfootprint variability in the SPURS regions

Frederick Bingham

University of North Carolina Wilmington

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Luca Centurioni/Verena Hormann, Tom Farrar

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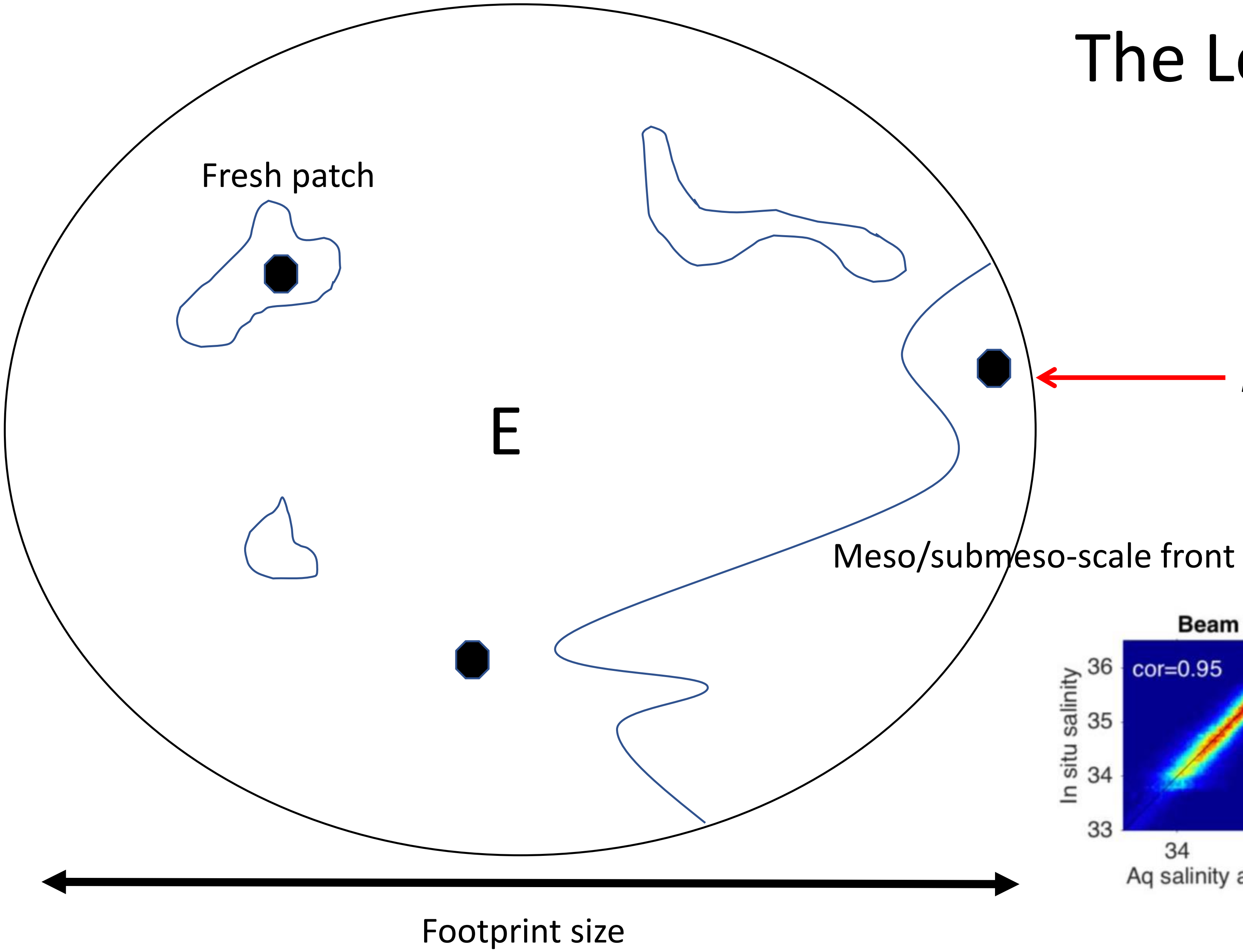
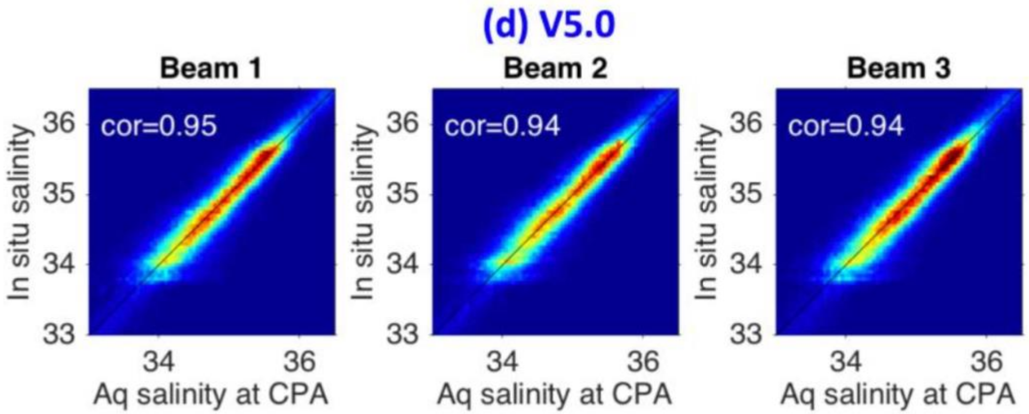
Subfootprint Variability (SFV)

- SFV is a source of “error” for satellite measurement of SSS
- Even if there were no other sources of error, satellite SSS and in situ SSS would differ due to variability within the footprint of the satellite
- SFV is not really an error at all, but a mismatch of scale between satellite and in situ measurement - a source of discrepancy in the validation process

The Level 2 problem



Bingham, 2019



Kao et al., 2018

Sources of SFV

1. Surface flux, mainly precipitation
2. Mesoscale/submesoscale internal ocean variability
3. Large scale fronts (e.g. Gulf Stream, Brazil-Malvinas Confluence, Antarctic Circumpolar Current front, etc.)
4. Mean gradients

These sources are separated by scale

How does SFV vary as a function of footprint size?

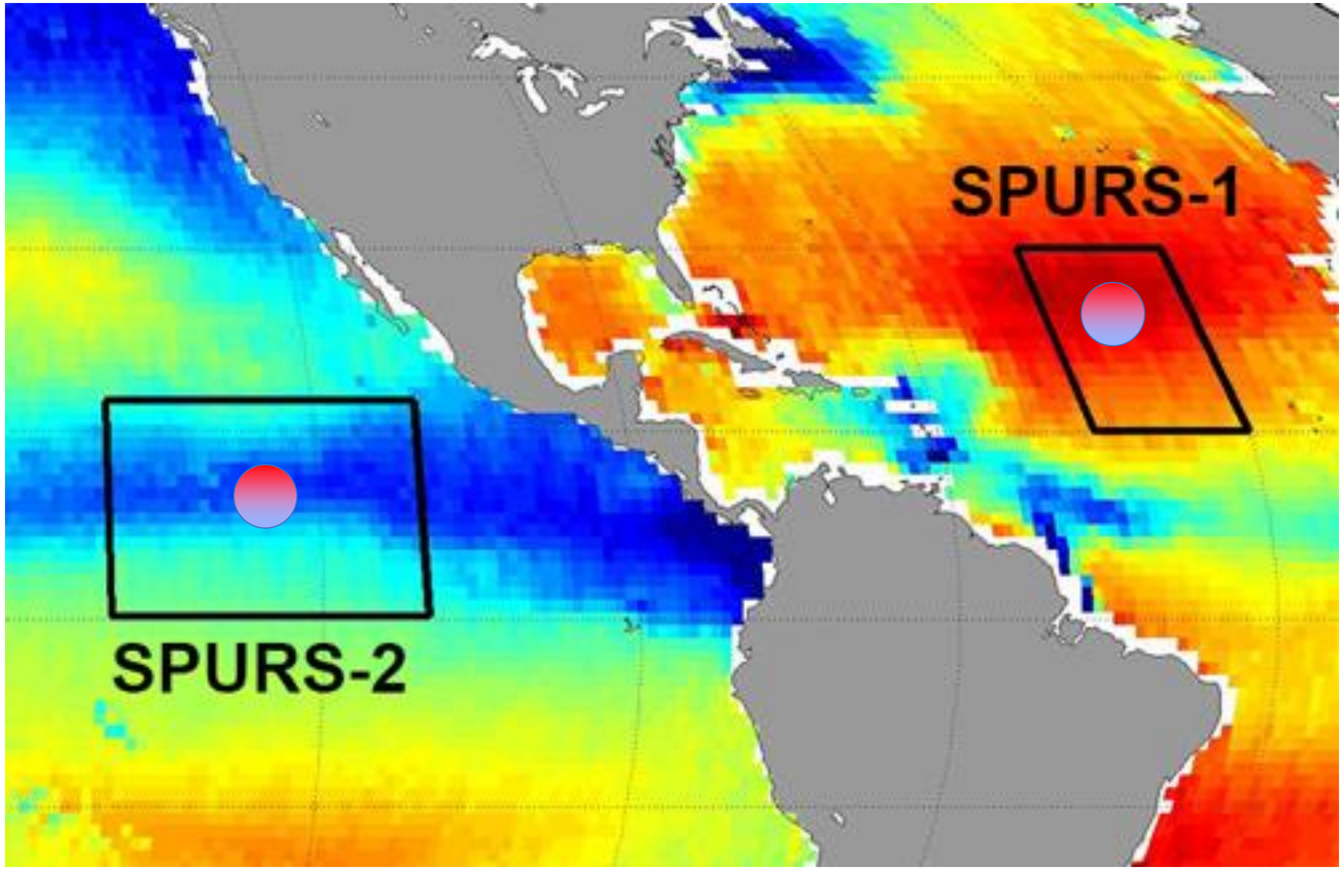
The SPURS field campaigns

SPURS-1 took place in a high SSS evaporation-dominated region of the subtropical North Atlantic in 2012-2013

SPURS-2 took place in a low SSS rainfall-dominated region of the tropical North Pacific in 2016-2017

In situ SSS data:

- SPURS-1: drifters, wavegliders, shipboard TSG
- SPURS-2: wavegliders
- Data grouped into 7-day bins



Color indicates mean SSS from the Aquarius satellite

salinity.oceansciences.org

Sources of SFV

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Guess: For SPURS-1, SFV is dominated by 2. For SPURS-2, SFV dominated by 1 (during the rainy season), with some possible addition of 3.

$$\sigma^2 \approx \frac{\sum_{2d_0} w_i (S_i - \bar{S})^2}{\sum_{2d_0} w_i}$$

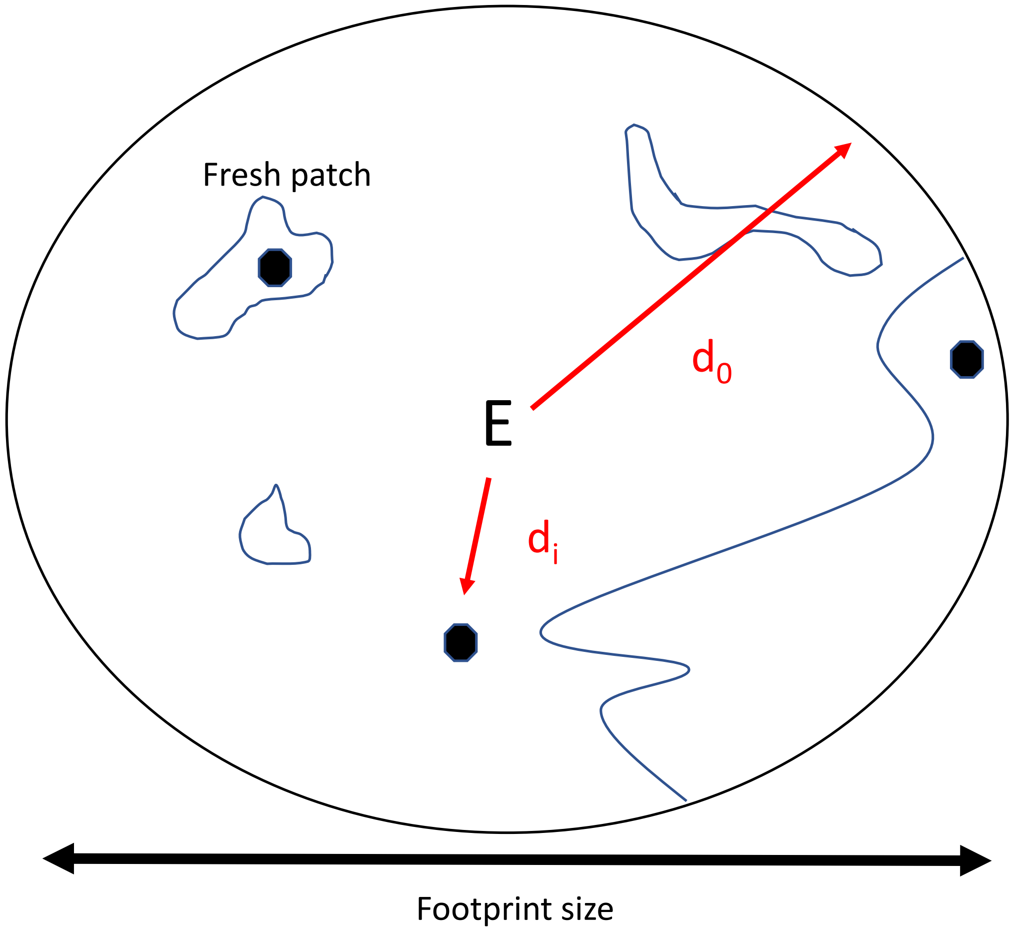
SFV for in situ data

$$w_i = e^{-\log(2)(\frac{d_i}{d_0})^2}$$

$$\sigma^2 = \frac{\iint \quad wS'^2}{\iint \quad w}$$

SFV for satellite data

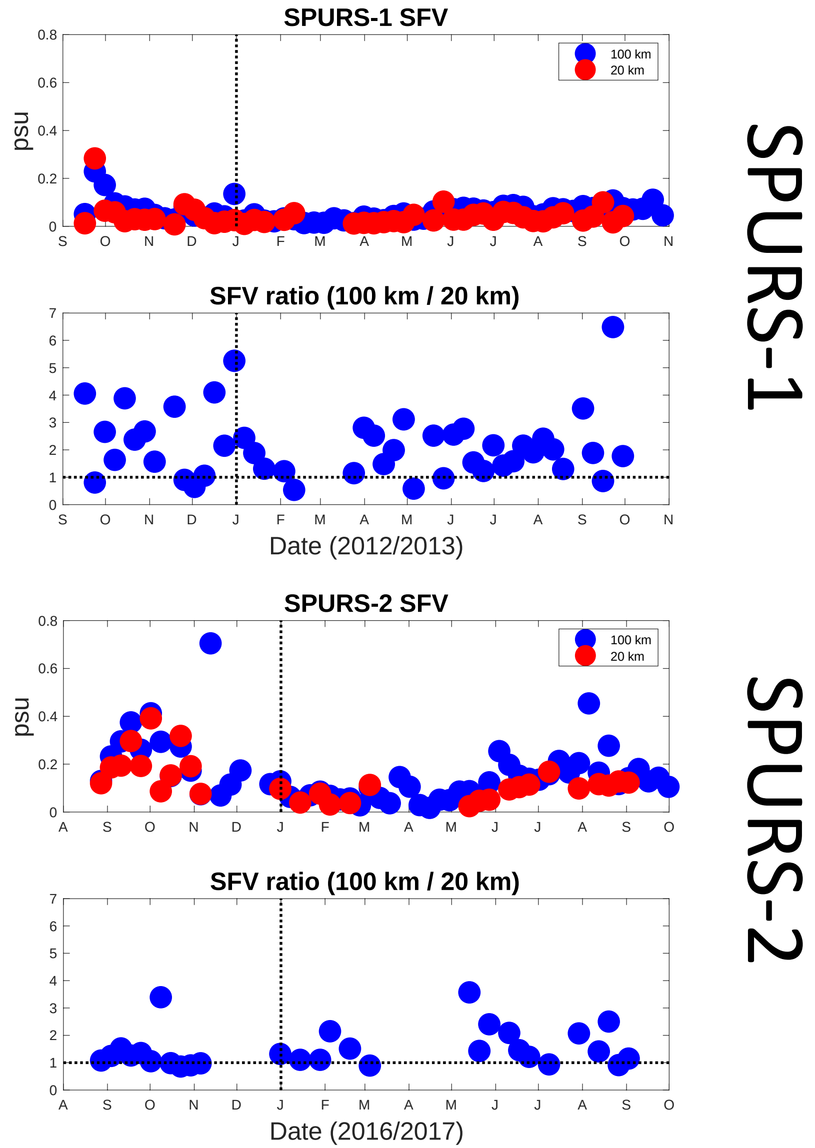
$$w \quad = e^{-\log(2)(\frac{d}{d_0})^2}$$



σ_{50} is the median value of σ at a given location over time

SFV as a function of time

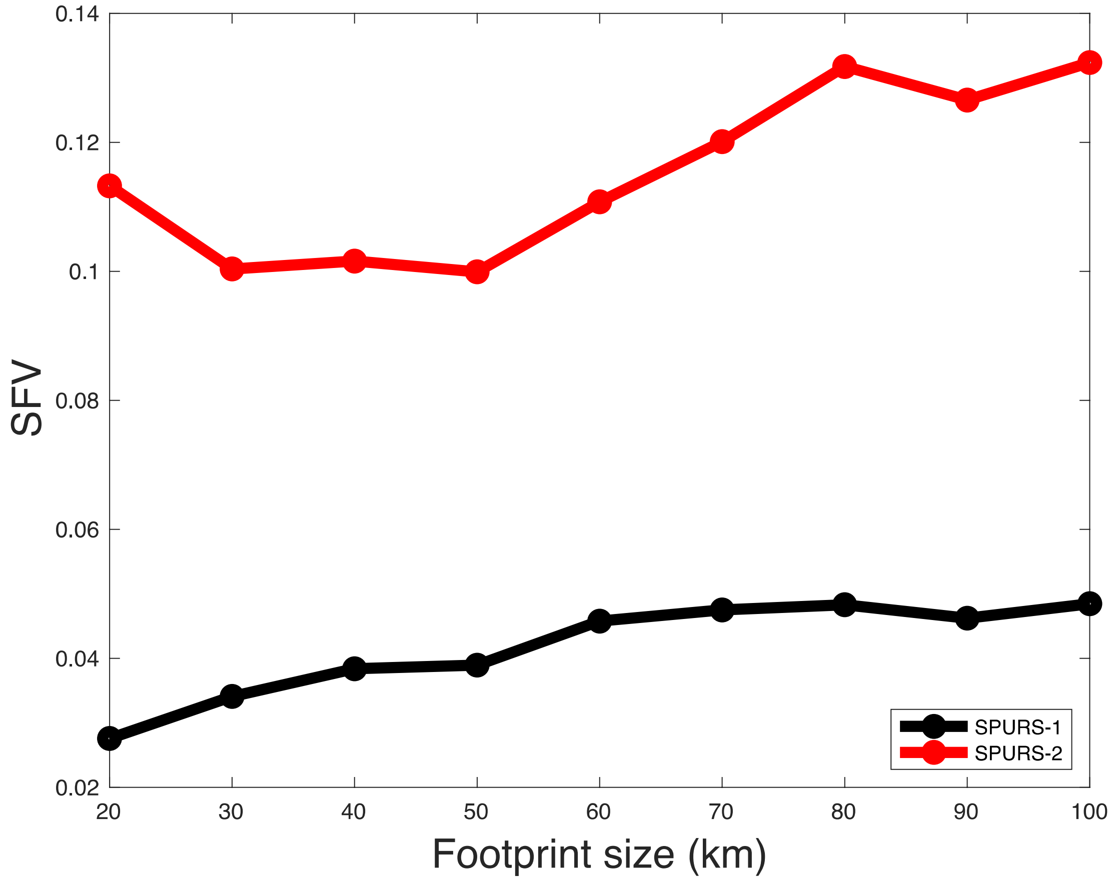
- SFV is much larger in the SPURS-2 region than in SPURS-1
- SFV is seasonal in both locations. Largest in summer/fall and smallest in winter/spring.
- Differences between locations are minimal during low-variance seasons
- In some instances SFV is larger at small scales than it is at large scales (ratio<1)
- Much larger distinction as a function of scale for SPURS-1 than for SPURS-2
- For SPURS-1, SFV increases strongly as a function of scale
- For SPURS-2, SFV increases only a little as a function of scale – in all seasons



σ_{50} vs. footprint size

σ_{50} = median SFV over the entire year at each location

SFV at SPURS-2 is several times that at SPURS-1

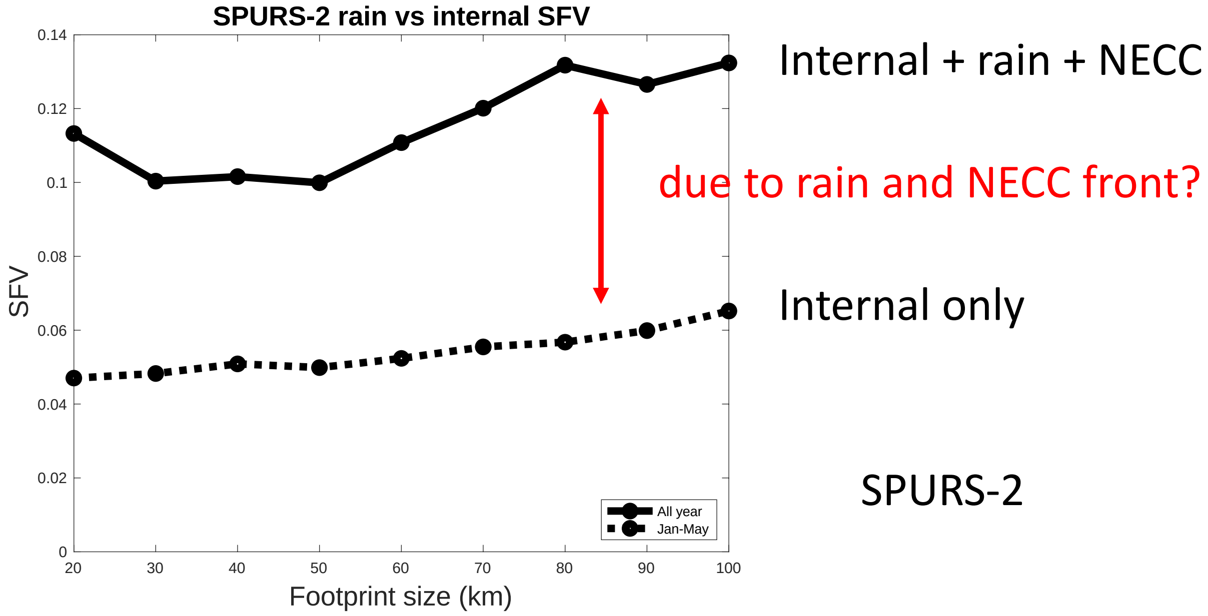


SFV during the dry season vs the whole year

In both SPURS regions, little rain falls between January and May

SFV due to internal variability has a weak dependence on scale

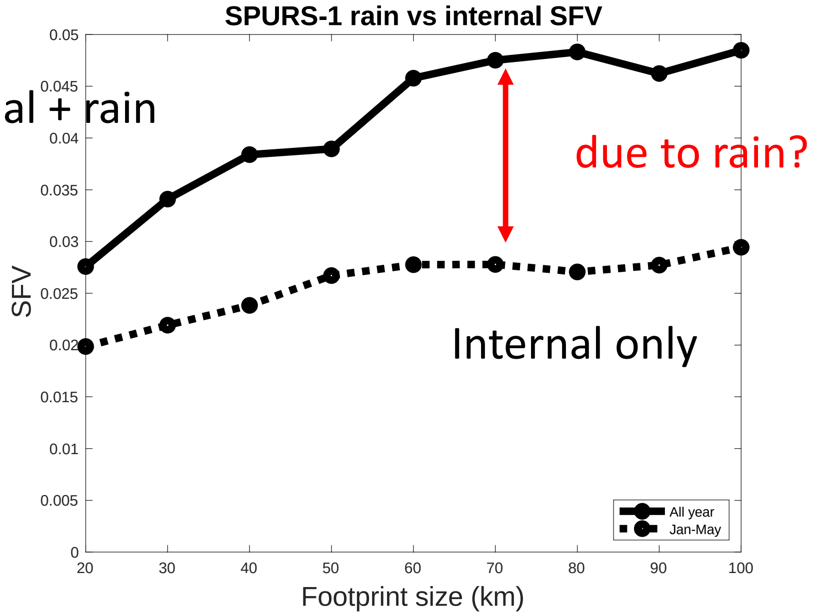
Internal variability still much larger at SPURS-2



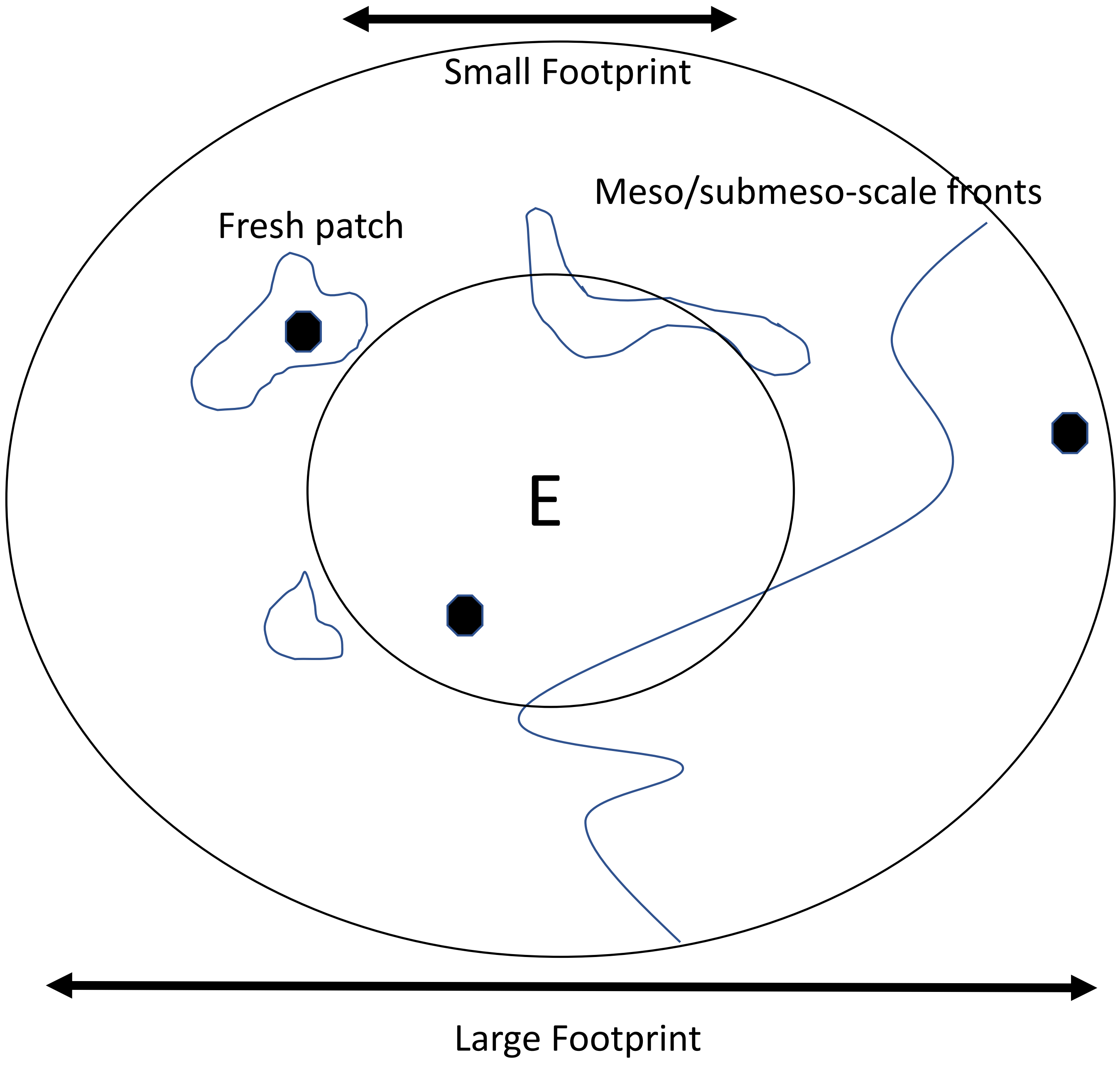
Internal + rain + NECC front

Internal only

SPURS-2

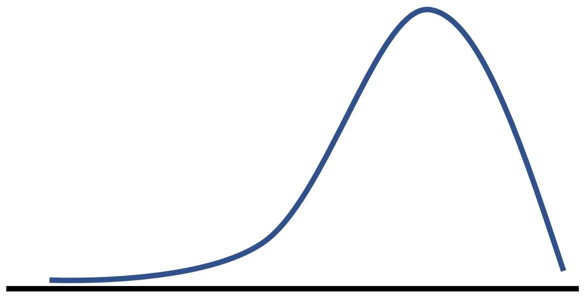


SPURS-1



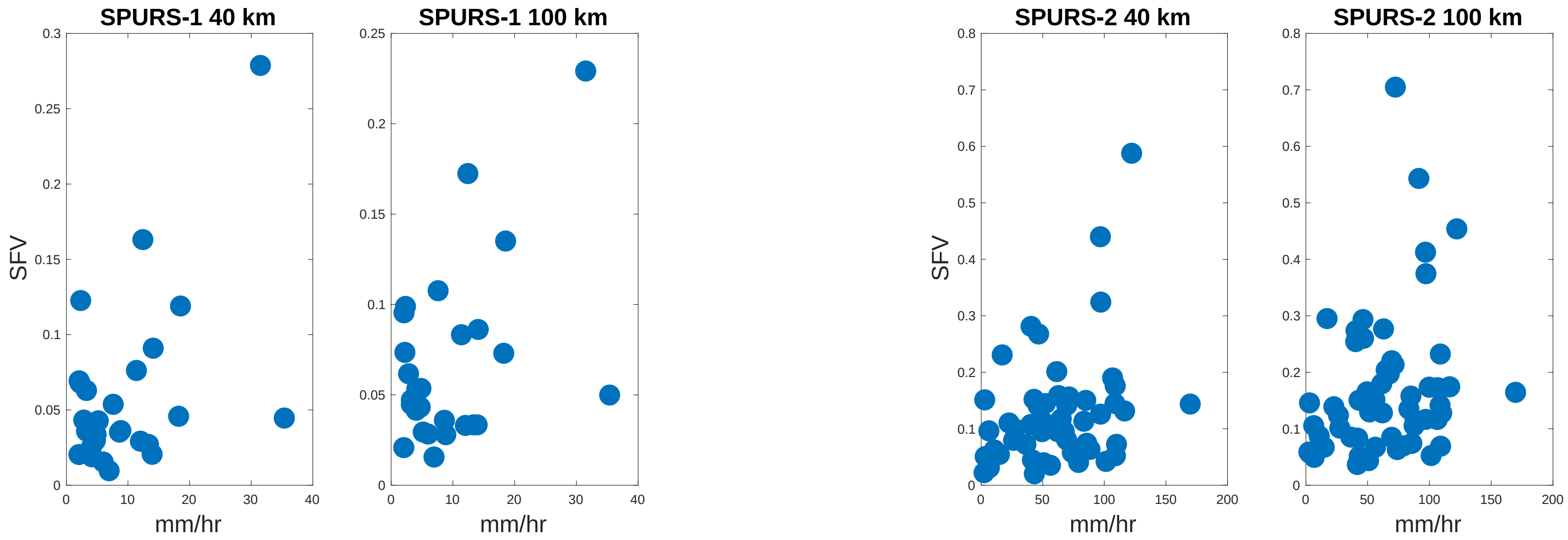
My definition of SFV depends strongly low probability on outlier values

The larger the footprint the more likely it is to encompass a fresh patch, and the the larger the SFV



Probability distribution of SSS

When it’s raining



SPURS-1

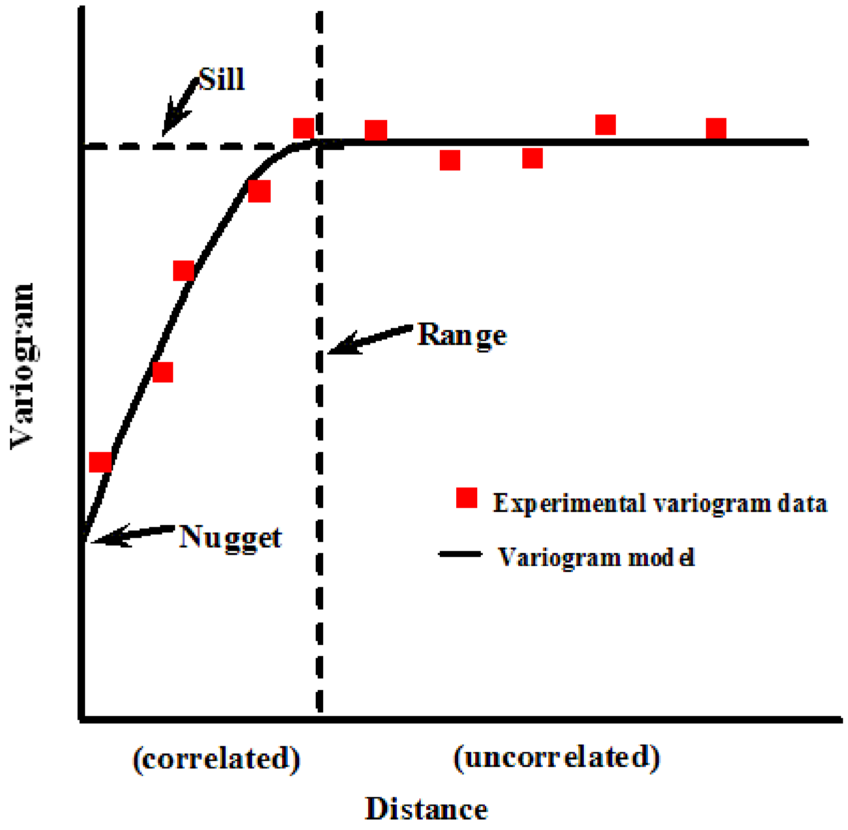
SPURS-2

SFV vs. maximum rain rate at the central mooring for 7-day periods where maximum RR>2 mm/hr.

SFV appears correlated with maximum RR at both 40 and 100 km footprint sizes

Variograms

- A description of the spatial variability of a dataset



$$\gamma(h \pm \delta) = \frac{1}{2N(h)} \sum_{i,j \in N(h \pm \delta)} (S_i \ - S_j \ )^2$$

Nugget – "instrumental error"

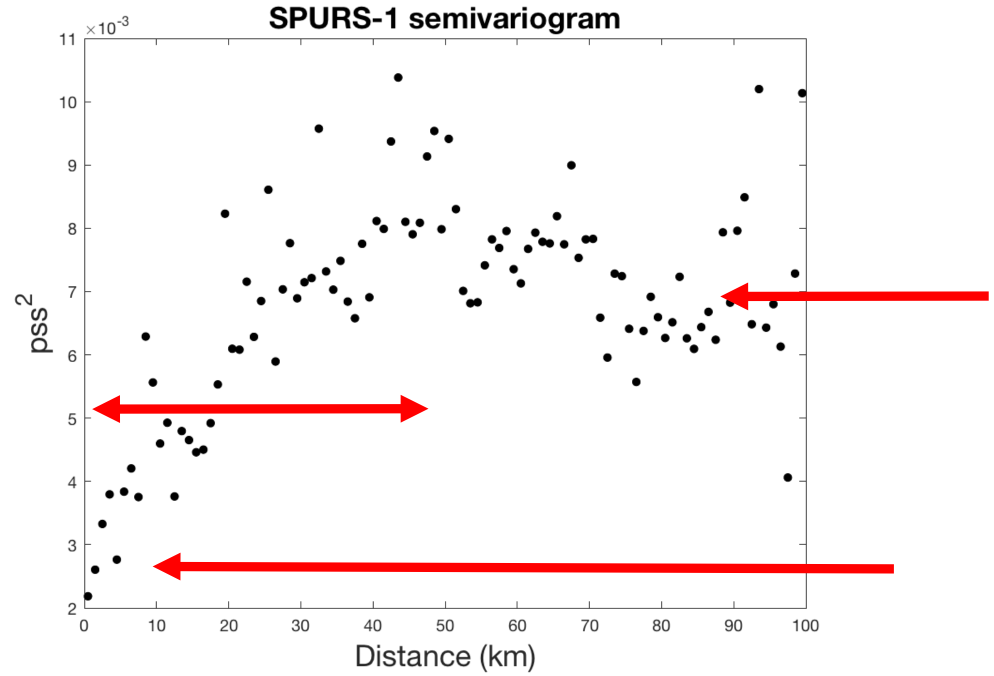
Sill – Inherent variability

Range – decorrelation scale

Kind of like the autocovariance, but turned upside down

"semivariogram" = variogram / 2

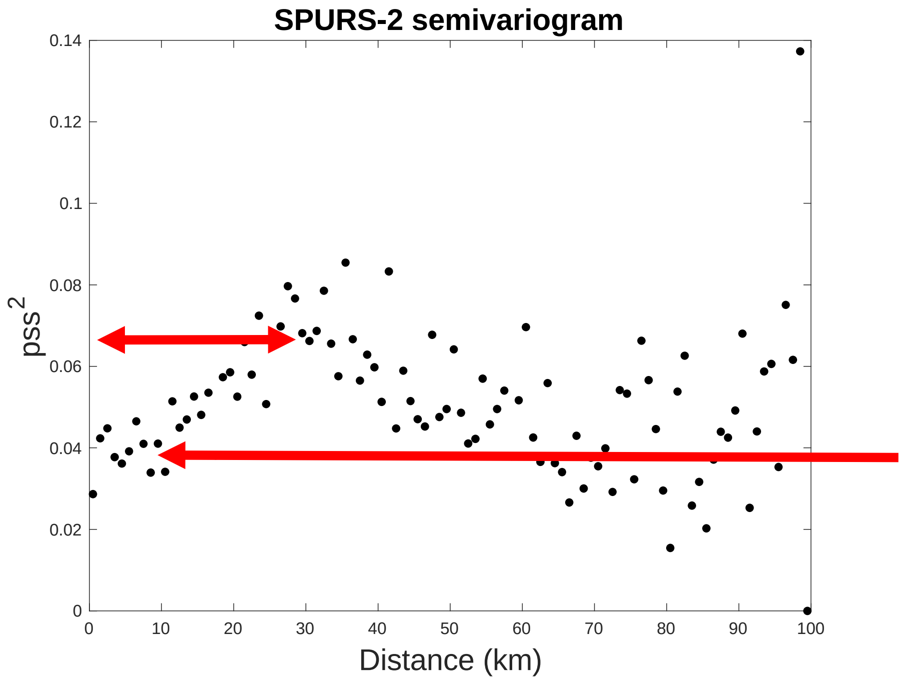
Semivariograms



Sill ≅ 0.08 pss

Range ≅ 50 km

Nugget ≅ 0.05 pss



Range ≅ 30 km

Nugget ≅ 0.2 pss

Conclusions

- SFV does depend on rain rate – for all scales
- SFV due to internal ocean variability depends only weakly on scale
- For SPURS-1, SFV increases as a function of footprint size to a size of ~50 km
- For SPURS-2, dependence of SFV on scale is more complicated
- From separation by rainy/dry season, about ½ of SFV is due to rainfall at both sites