

An Assessment of the Observing System for the California Current

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Two Questions Posed by West Coast COMT Group

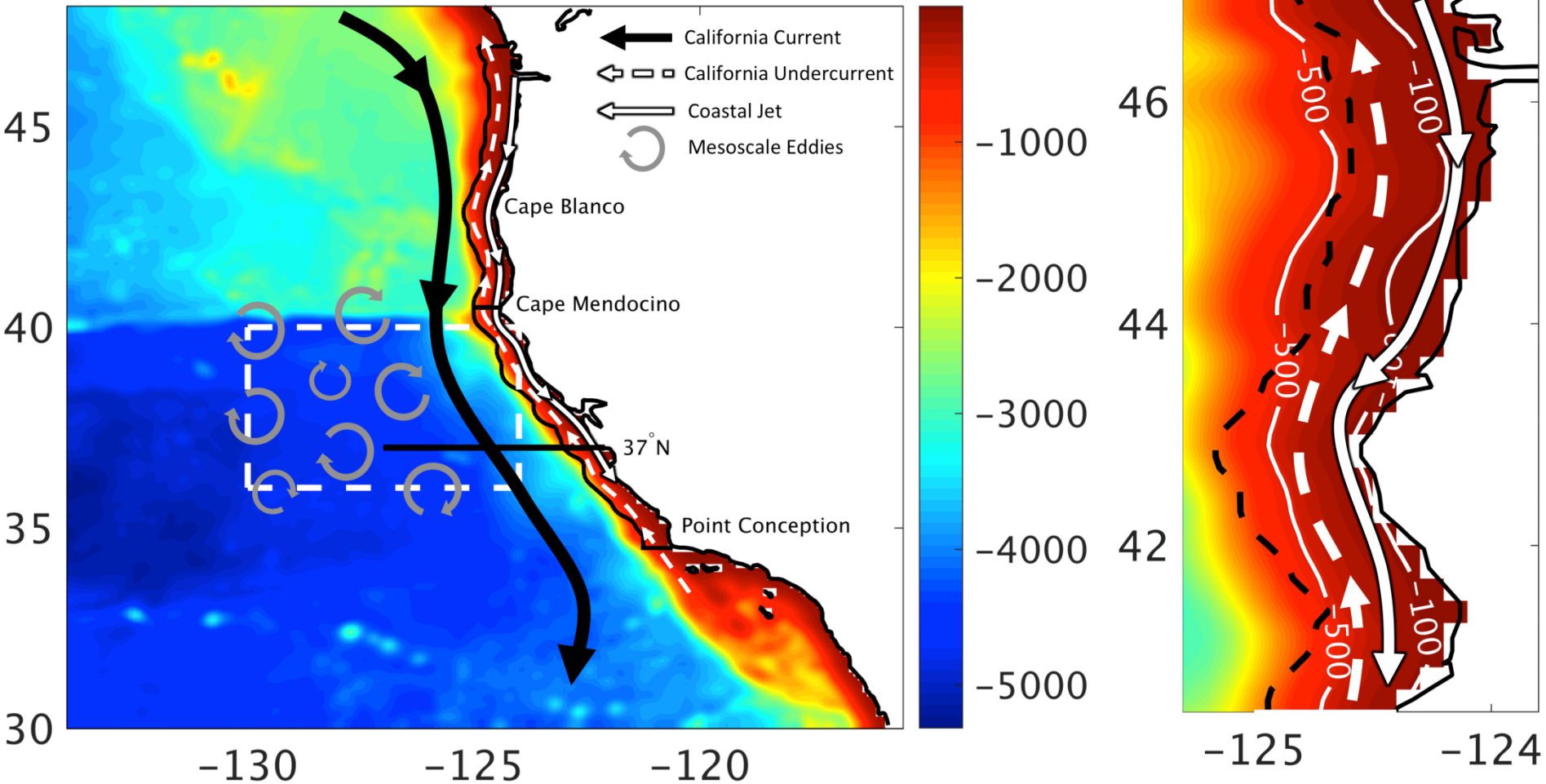
- What is the impact of the current observing system on the CCS circulation?

- Observation impact studies (presented previously)
- Metrics: **upwelling transport**
undercurrent transport
CCS transport along specific section
eddy kinetic energy
thermocline depth
climate variability (NEW)

- How well do existing assets “observe” the CCS?

- Array modes (**NEW**)

The California Current System (CCS)



ROMS CCS 30 Yr Analysis

CCMP+ERA
(1980-2010)

$f_b(t), B_f$

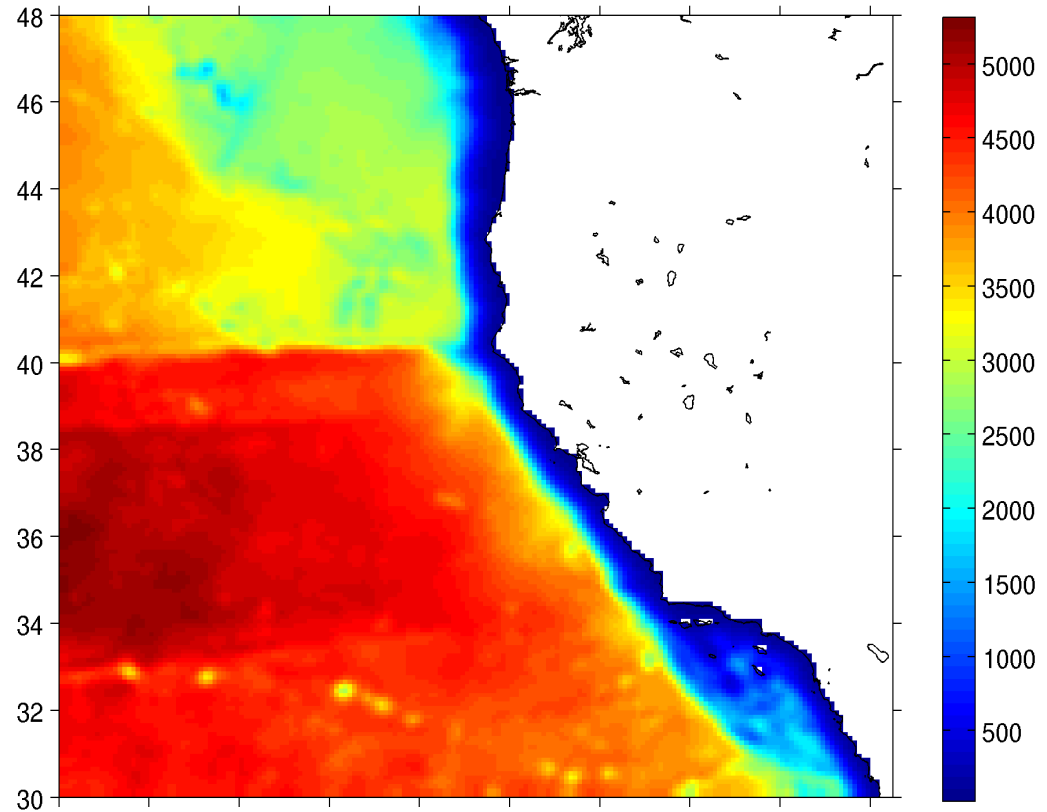
SODA open
boundary
conditions

$b_b(t), B_b$

$x_b(0), B_x$



Previous
assimilation cycle
(8 day overlapping cycles)

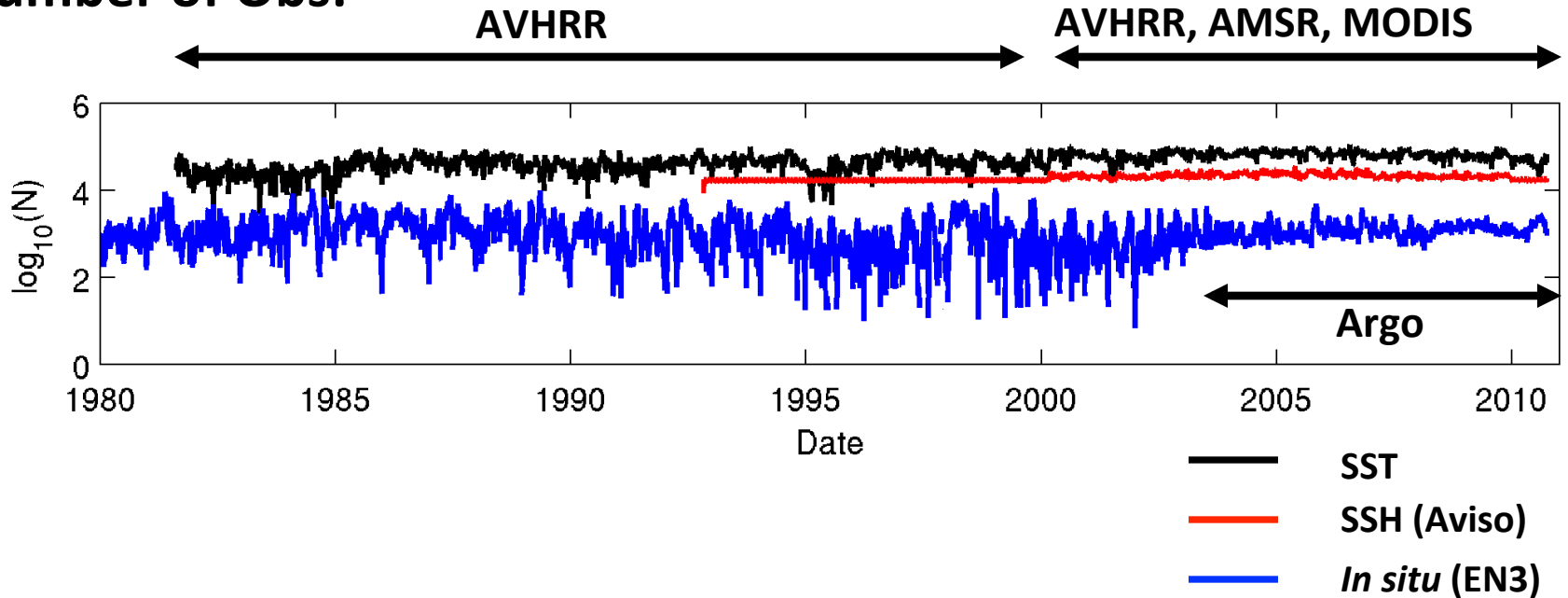


1/10° horizontal resolution, 42 levels

Veneziani et al (2009)
Broquet et al (2009)
Moore et al (2010)

Observation Summary

Number of Obs:



DA Summary

- ROMS dual-space 4D-Var
- 8 day overlapping cycles
- Control vector: x , f , b .
- 1 outer-loop
- 15 inner-loops
- Strong constraint
(Neveu et al., 2015)

- What is the impact of the current observing system on the CCS circulation?

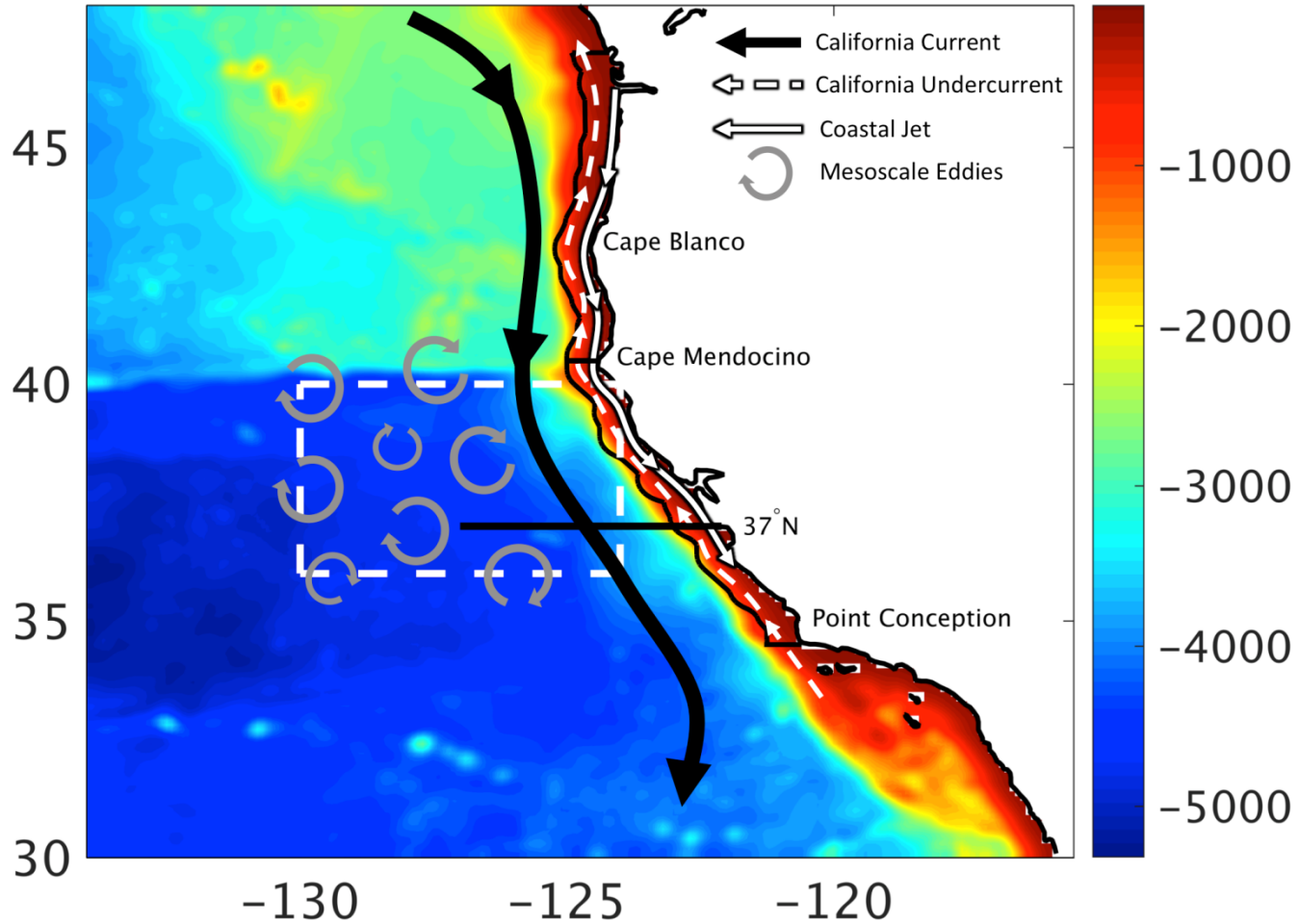
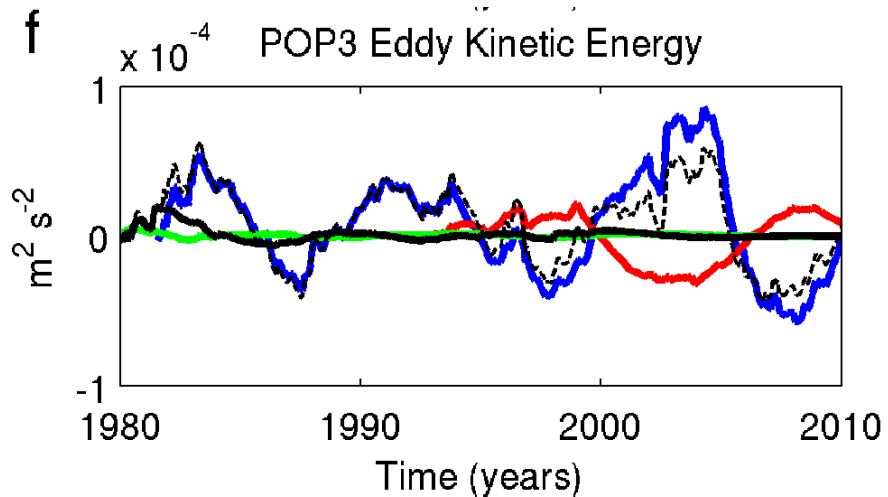
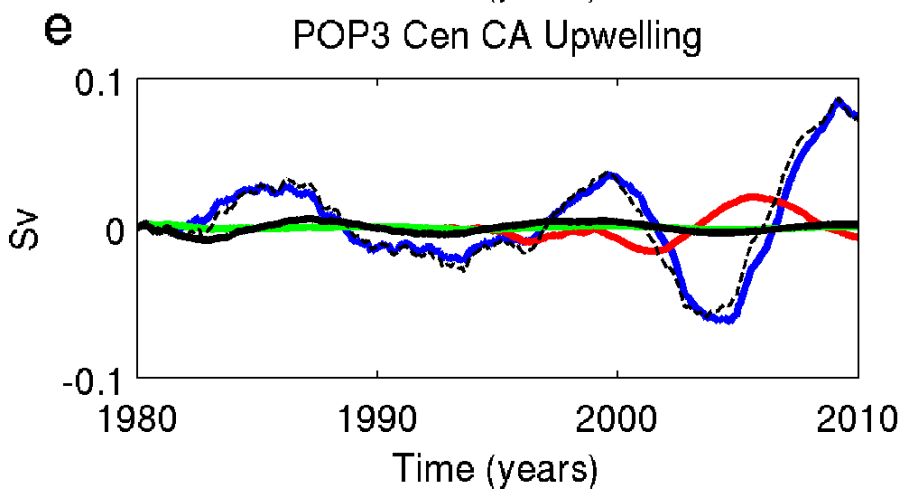
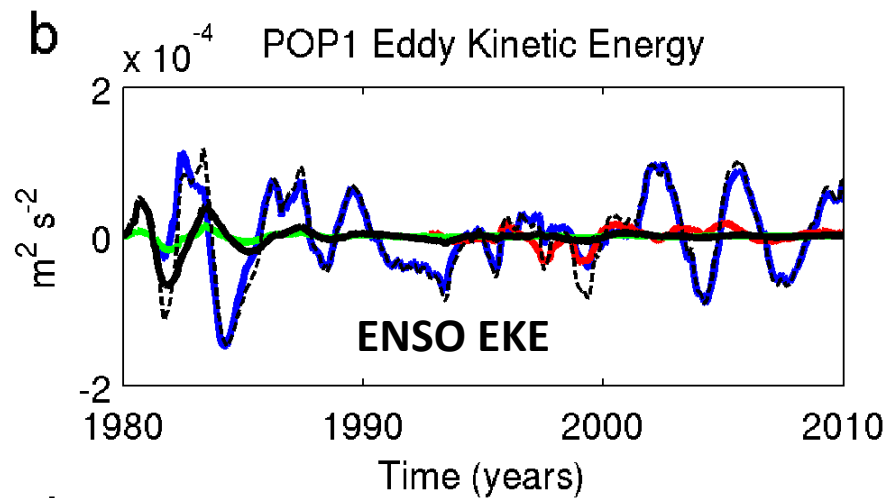
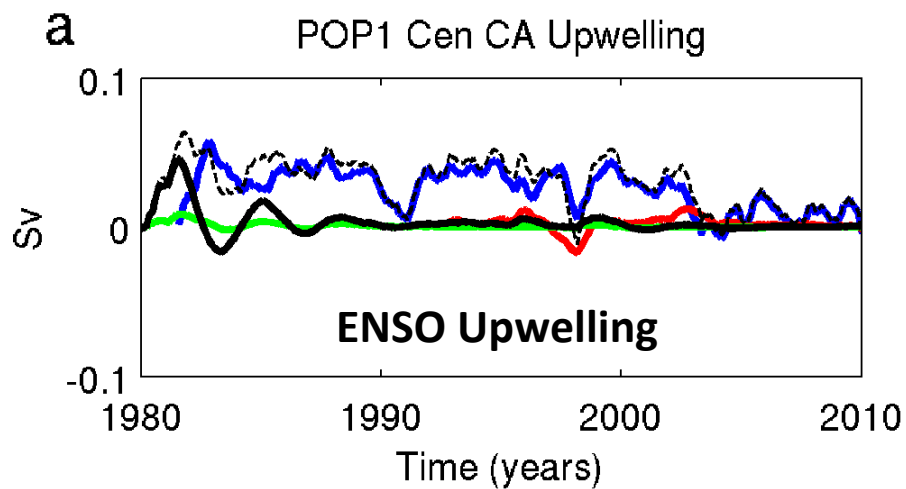


Figure shows target regions of interest

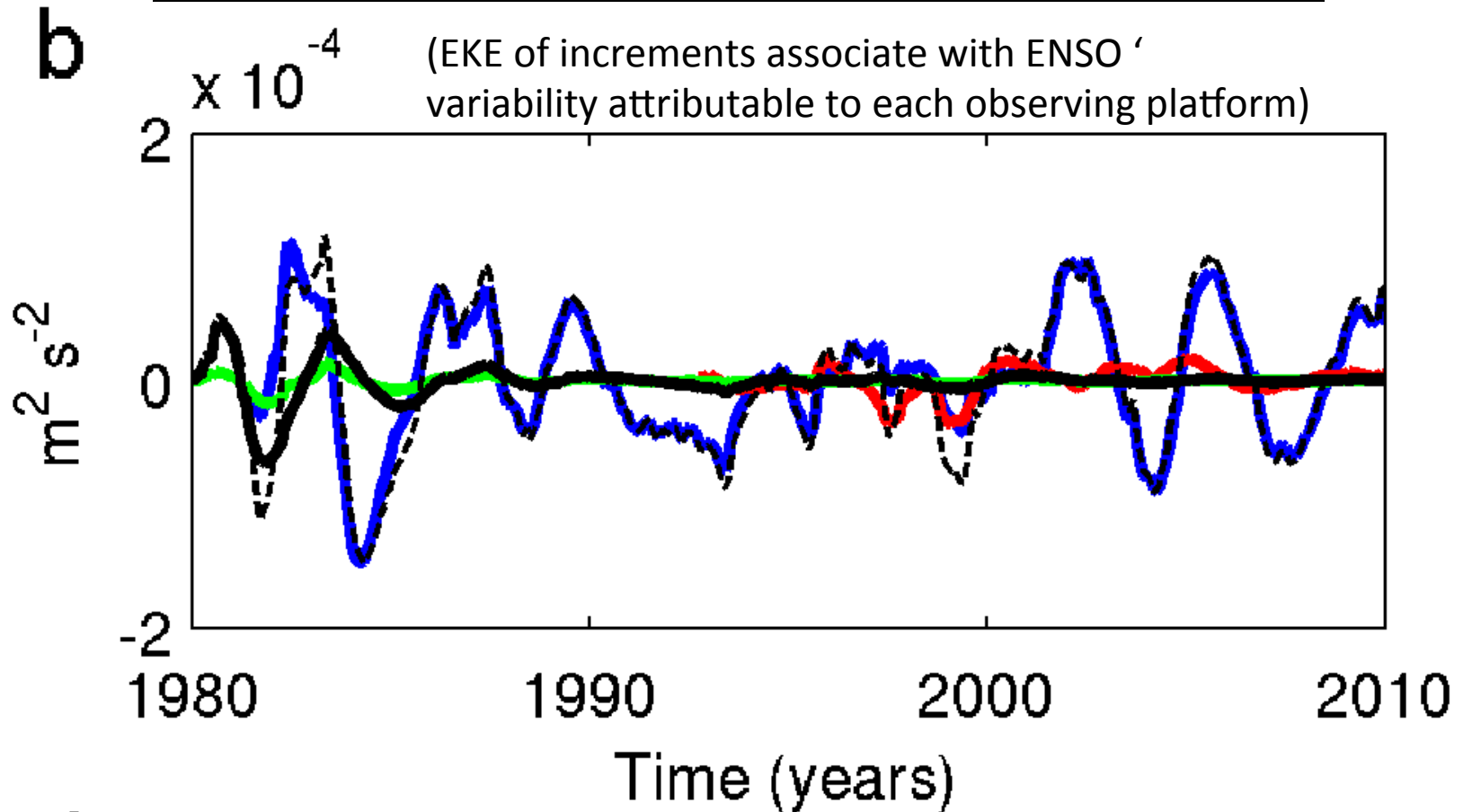
The principal oscillation pattern (POP) analysis is a multivariate technique used to simultaneously infer the characteristic patterns and times cales of a vector time series. The POPs may be seen as the normal modes of a linearized system whose system matrix is estimated from data.

Von Storch (1995)

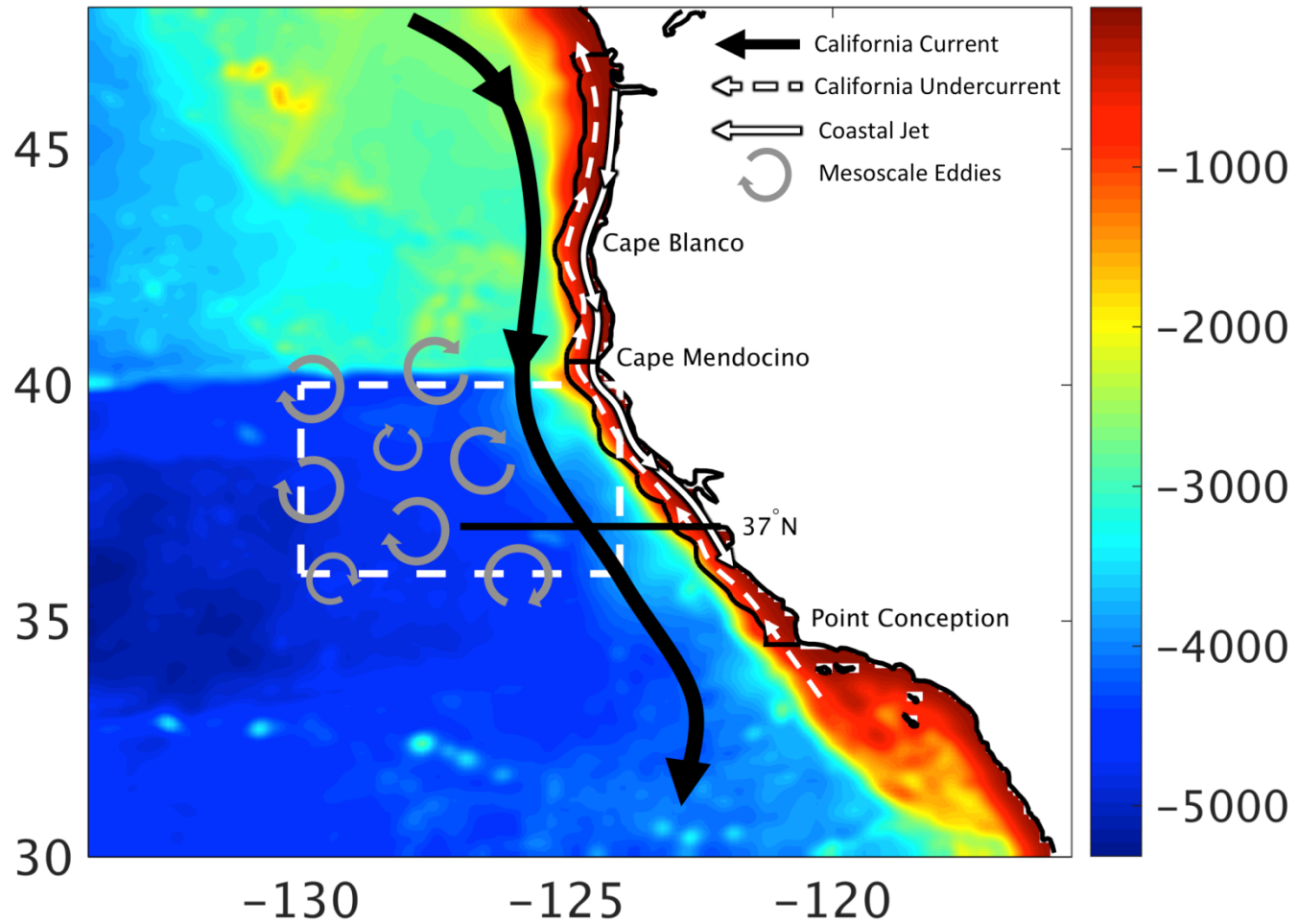
Principal Oscillation Patterns (POPs)



Observation Impacts on ENSO-related EKE



- How well do existing assets “observe” the CCS?



The Importance of the Background Error Covariance Matrix

$$\mathbf{x}_a = \mathbf{x}_b + \mathbf{B}\mathbf{G}^T \left(\mathbf{G}\mathbf{B}\mathbf{G}^T + \mathbf{R} \right)^{-1} \left(\mathbf{y} - H(\mathbf{x}_b) \right)$$

The diagram illustrates the Kalman filter analysis increment equation. The equation is enclosed in a red rectangular box. The terms are color-coded and labeled with arrows pointing to their respective parts:

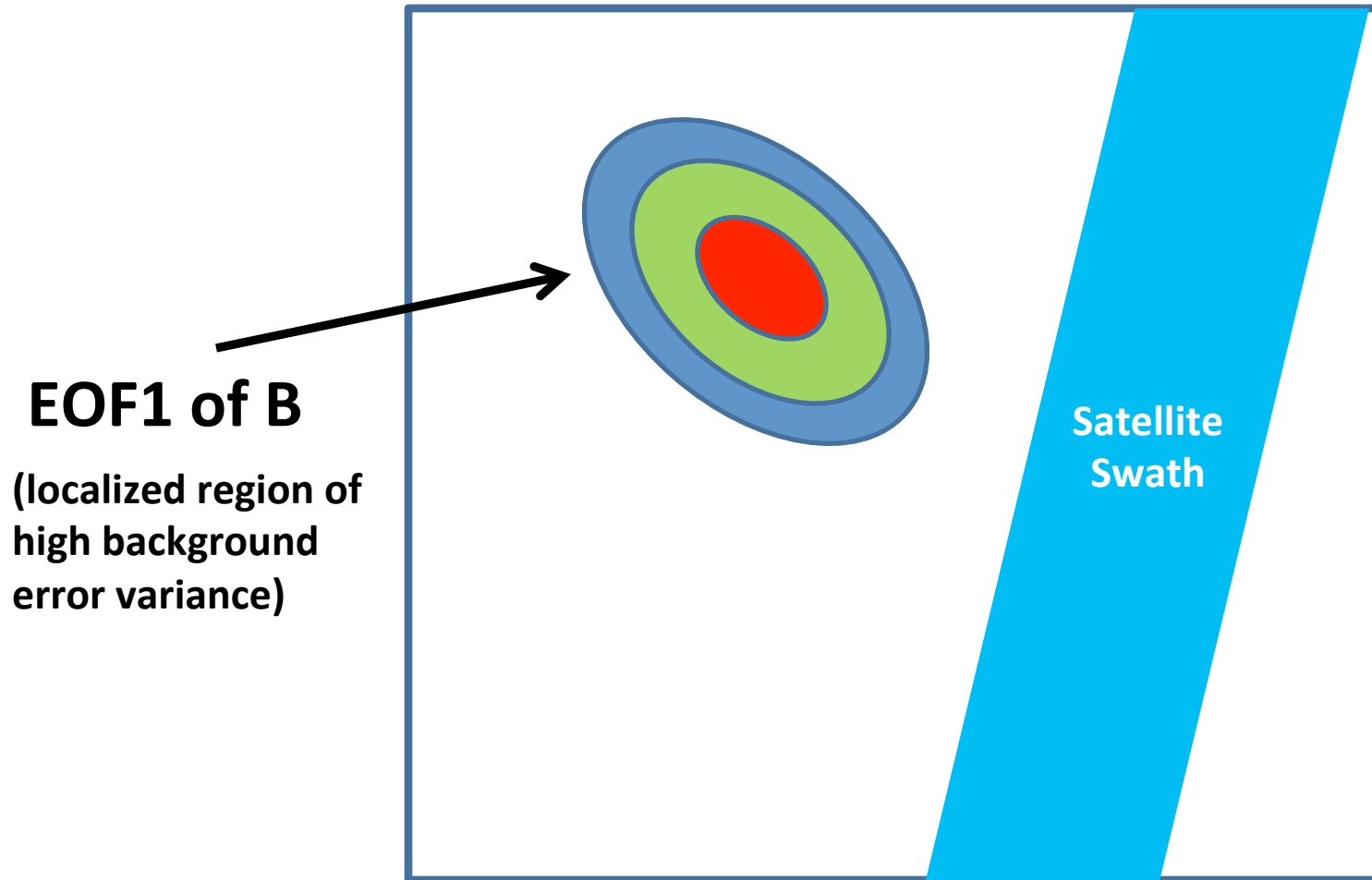
- \mathbf{x}_a : analysis (black text, arrow from 'analysis' below)
- \mathbf{x}_b : background (black text, arrow from 'background' below)
- \mathbf{B} : adjoint obs operator (blue text, arrow from 'adjoint obs operator' below)
- \mathbf{G} : background error cov matrix (blue text, arrow from 'background error cov matrix' below)
- \mathbf{G}^T : background error cov matrix (blue text, arrow from 'background error cov matrix' below)
- \mathbf{R} : obs error cov matrix (magenta text, arrow from 'obs error cov matrix' below)
- \mathbf{y} : obs (green text, arrow from 'obs' below)
- H : obs operator (black text, arrow from 'obs operator' below)

Analysis increment

The analysis increment “lives” in the space spanned by B !!!

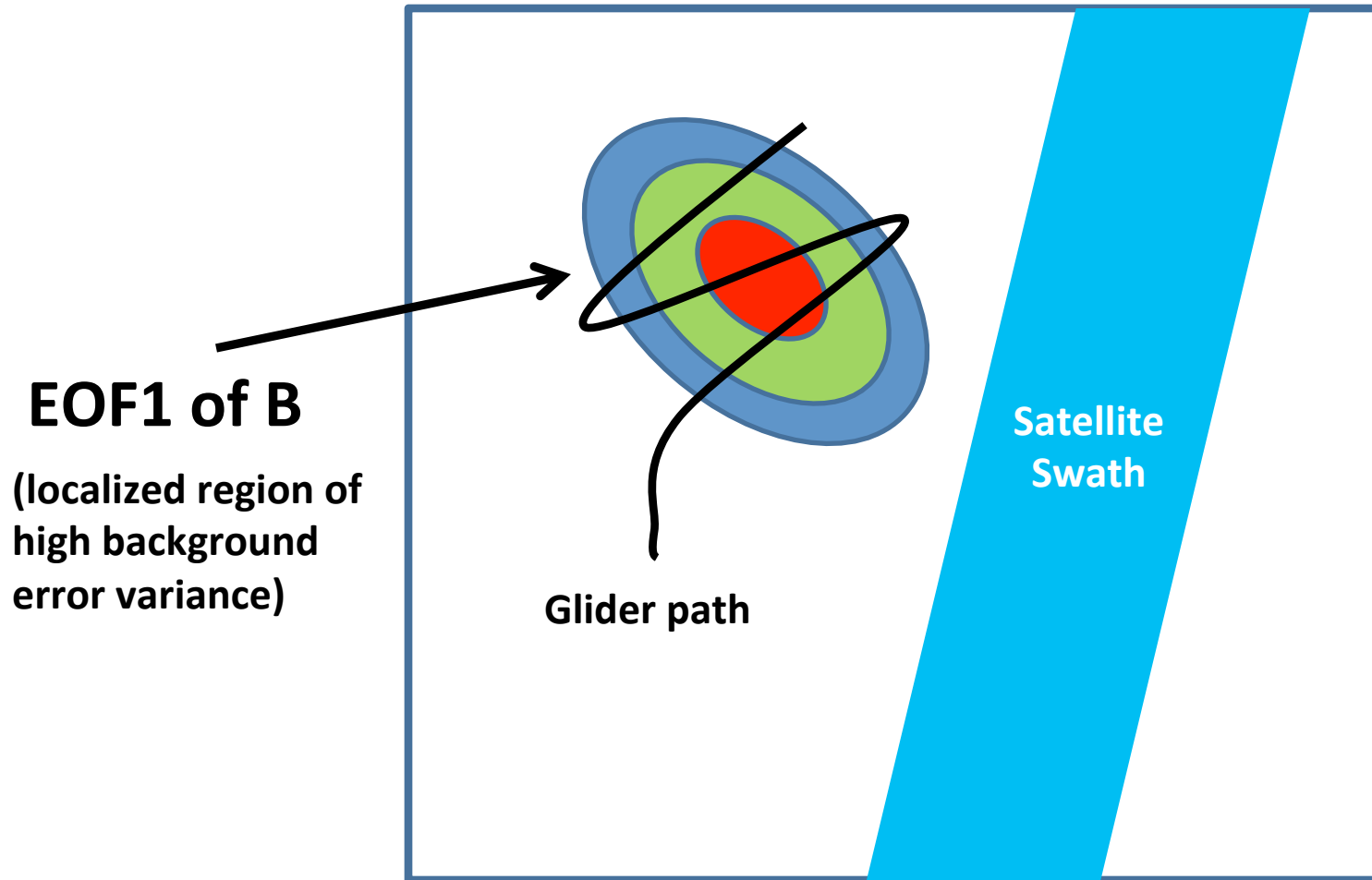
Therefore, to reduce errors in \mathbf{x}_b , the observing system must effectively observe (directly via \mathbf{G} or indirectly via \mathbf{G}^T) the dominant EOFs of \mathbf{B} .

An Illustrative Example



The satellite swath **does not** directly (G) or indirectly (G^T) observe the region of elevated background error variance associated with EOF1 of B, so errors in this regions **will not** be corrected during data assimilation by the satellite.

An Illustrative Examples



The glider path **does** directly observe the region of high error background error variance associated with EOF1 of B, so errors in this regions **will** be corrected during data assimilation by the glider.

Array Modes

- The degree to which the EOFs of B are captured by the observing systems is described by the “**array modes.**”
- The **array modes** depend *ONLY* on the observation locations, not the observation values.

$$\mathbf{X}_a = \mathbf{X}_b + \sum_{i=1}^N \alpha_i \Phi_i$$

analysis background

Bennett (1985)

Weights
(depend on obs values)

Array modes

Summary and Conclusions

- We have used observation impact calculations to quantify the influence of the existing observing system on the CCS circulation and climate variability (Moore et al., 2016).
- Analysis of the array modes is currently underway.
- Preliminary results suggest that the current observing system observed rather well the dominant EOFs of the background error covariance matrix.
- Caveat: the analysis will only ever be as good as **B**