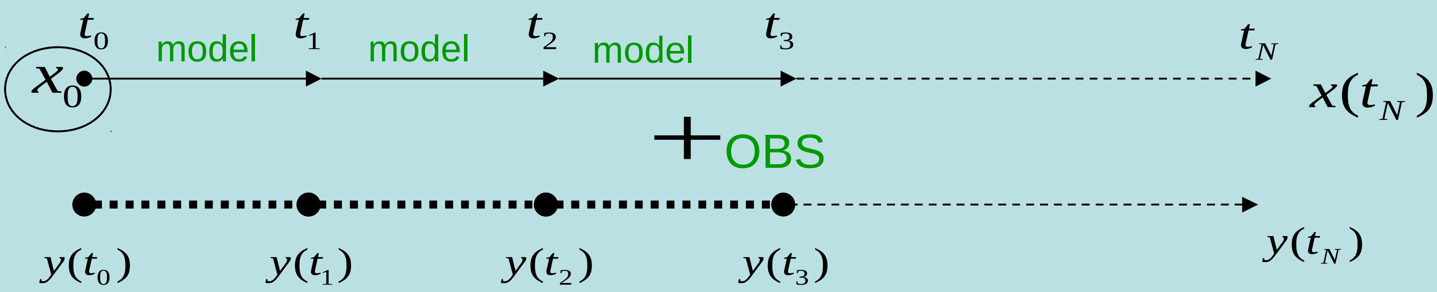
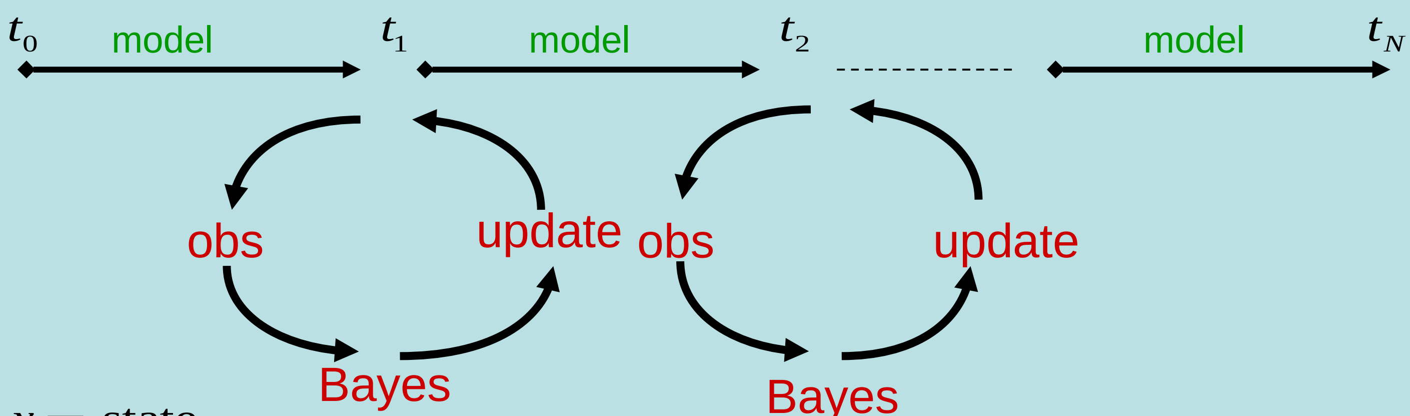
Data Assimilation

All data at once: *4DVAR, MCMC sampling*

Model runs + observations ⟶ state estimate



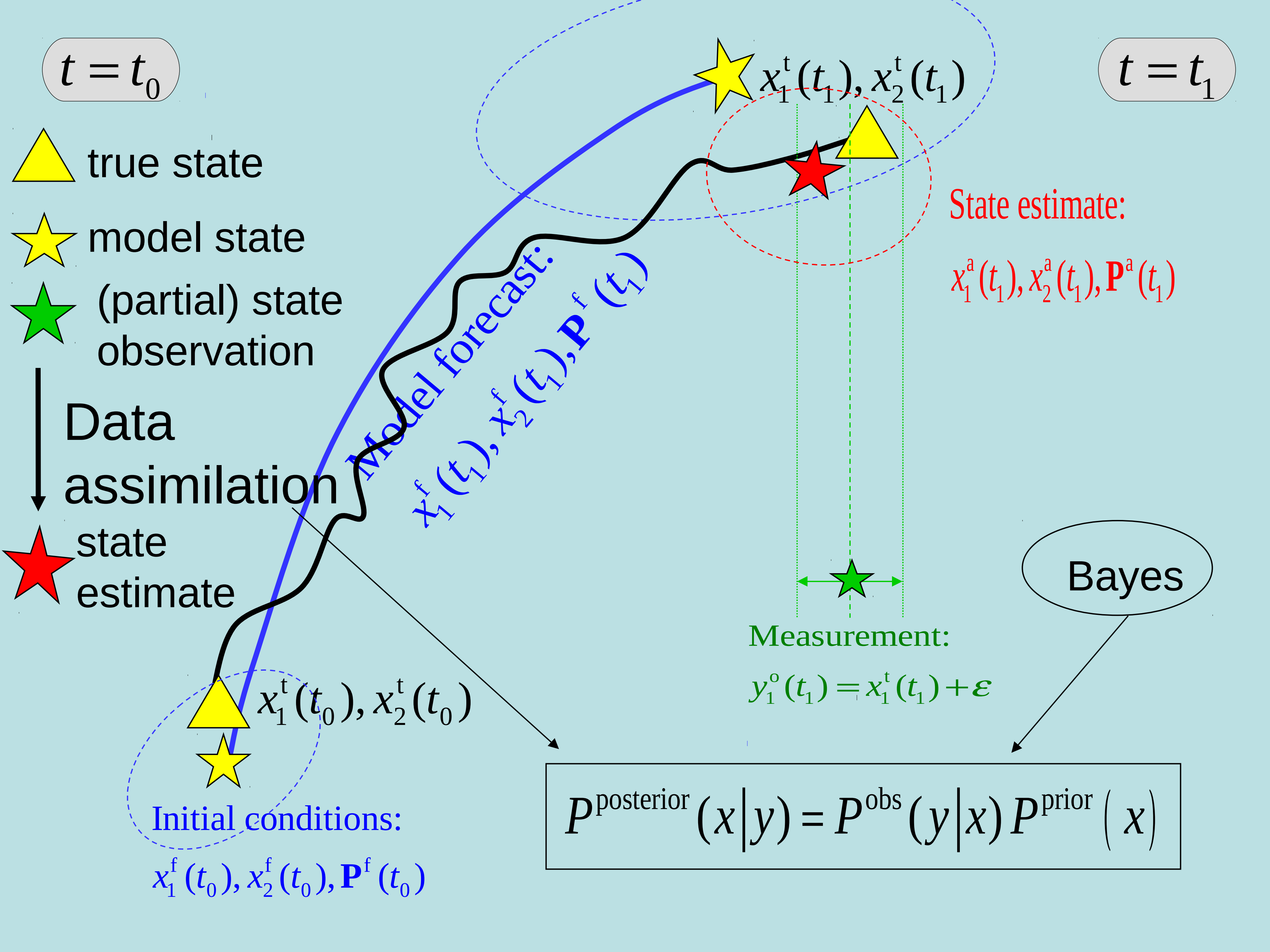
Sequential DA: *Kalman family, particle filters*



$x =$ state

$y =$ obs

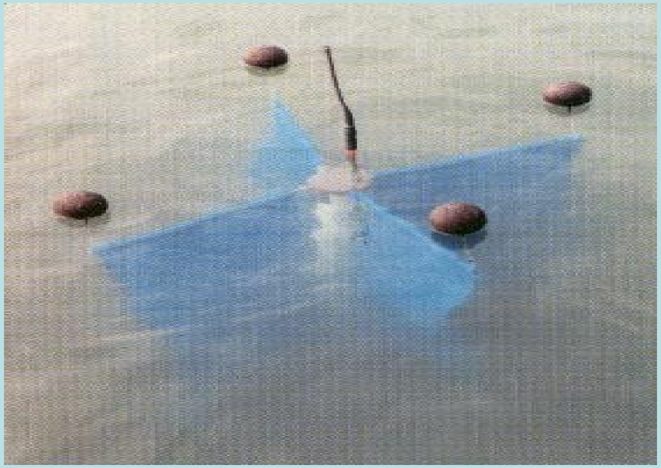
$$P^{\text{posterior}}(x|y) = P^{\text{obs}}(y|x)\,P^{\text{prior}}(x)$$

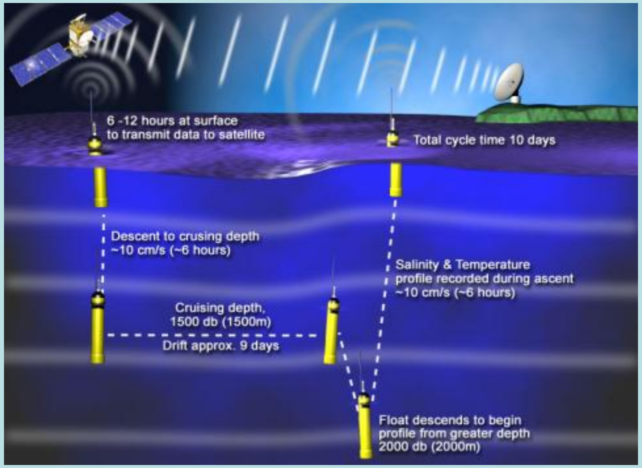


$t = t_0$
$t = t_1$
true state
model state
(partial) state observation
Data assimilation
state estimate
$x_1^t(t_1), x_2^t(t_1)$
State estimate:
$x_1^a(t_1), x_2^a(t_1), \mathbf{P}^a(t_1)$
Model forecast:
$x_1^f(t_1), x_2^f(t_1), \mathbf{P}^f(t_1)$
Bayes
Measurement:
$y_1^o(t_1) = x_1^t(t_1) + \varepsilon$
$x_1^t(t_0), x_2^t(t_0)$
Initial conditions:
$x_1^f(t_0), x_2^f(t_0), \mathbf{P}^f(t_0)$
$P^{posterior}(x|y) = P^{obs}(y|x)\,P^{prior}(x)$

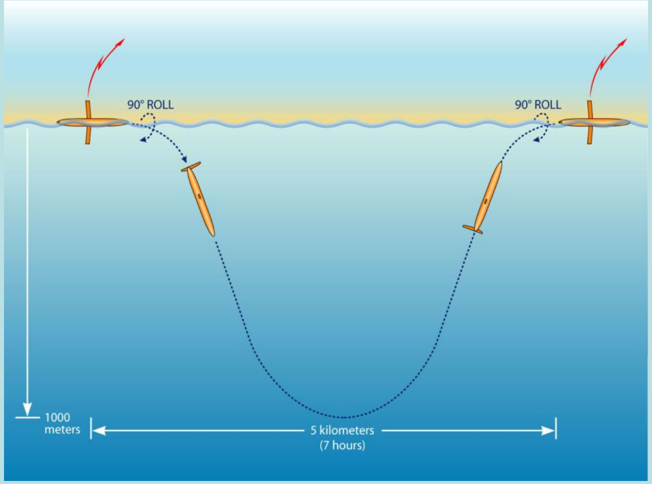
Lagrangian Ocean Data

Argo floats
(Lagrangian at depth)

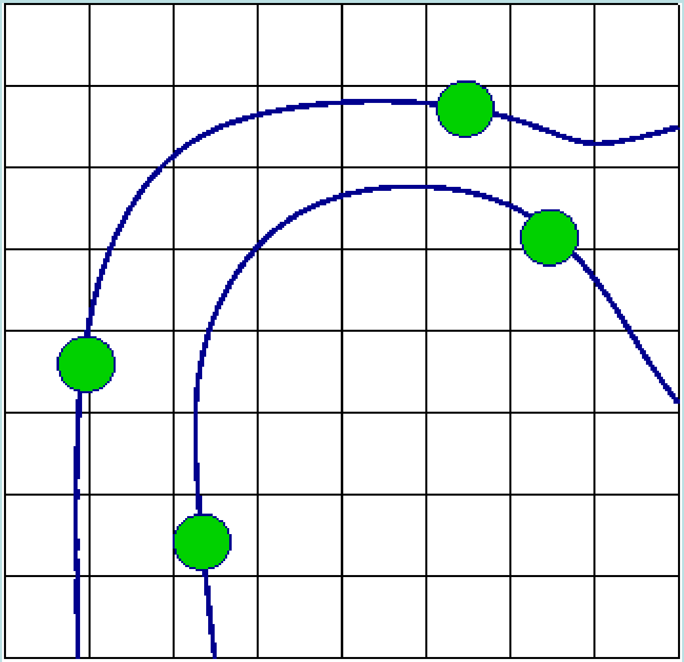




Ocean Gliders
(semi-Lagrangian)



Lagrangian Data Assimilation



Lagrangian observations from drifters, gliders, and floats do not give the data in terms of model variables.

Solution: Include drifter coordinates into the model

$$\mathbf{x} = \begin{pmatrix} \mathbf{x}_F \\ \mathbf{x}_D \end{pmatrix}$$ -- augmented state vector

$$\frac{d\mathbf{x}_F^{\mathrm{f}}}{dt} = M_F(\mathbf{x}_F^{\mathrm{f}}, t)$$ -- flow equations

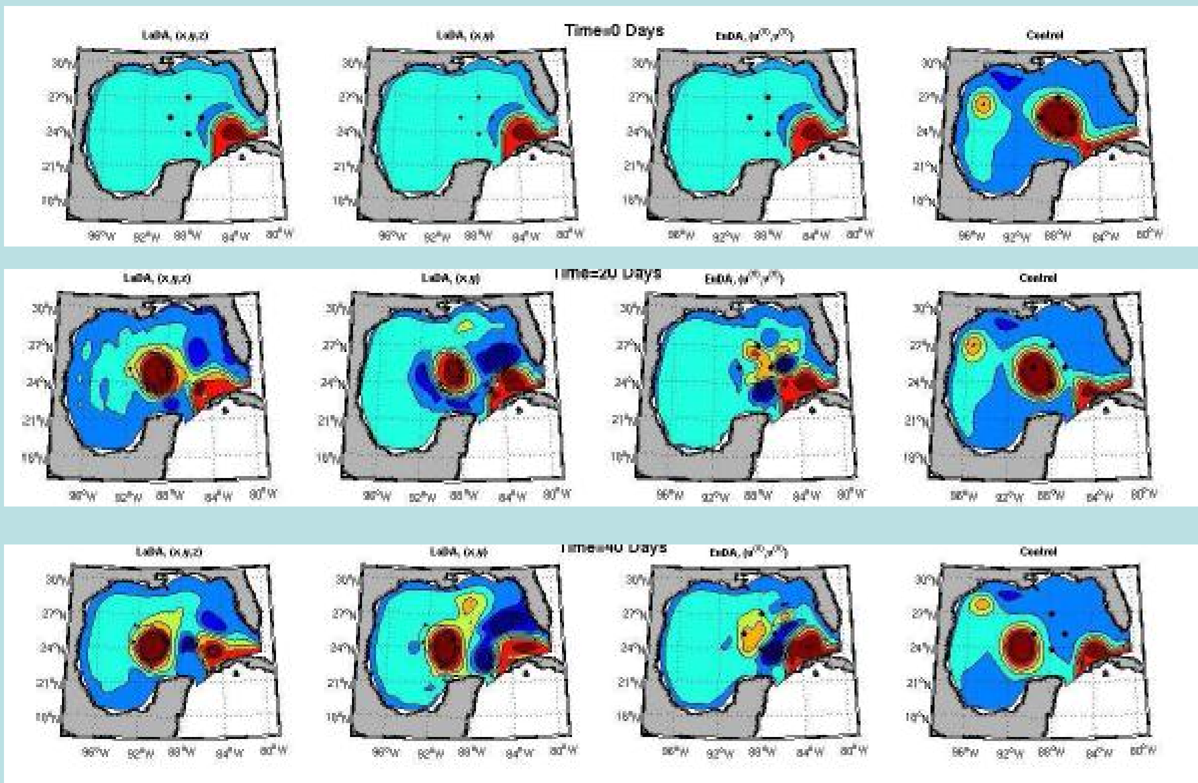
$$\frac{d\mathbf{x}_D^{\mathrm{f}}}{dt} = M_D(\mathbf{x}_D^{\mathrm{f}}, \mathbf{x}_F^{\mathrm{f}}, t)$$ -- tracer advection equations

Model initialized with no eddy present.

Eddy is “discovered” and tracked with incorporation of drifter path data via
Lagrangian data assimilation

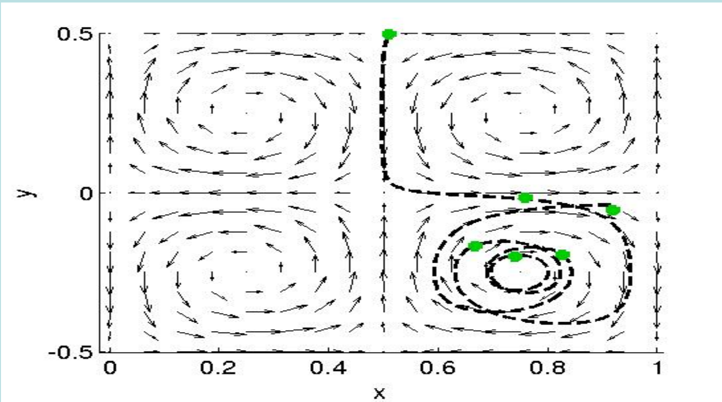
Most success with multilayer model and data from isopycnal floats

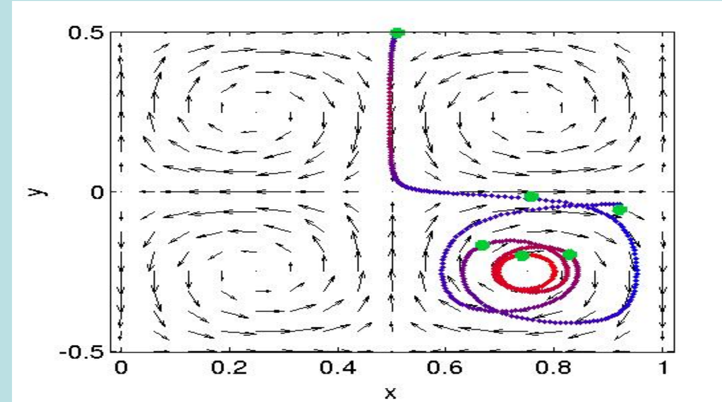
Below: analysis snapshots of eddy shedding (*Vernieres, Jones, Ide* Phys. D, 240, 2011)



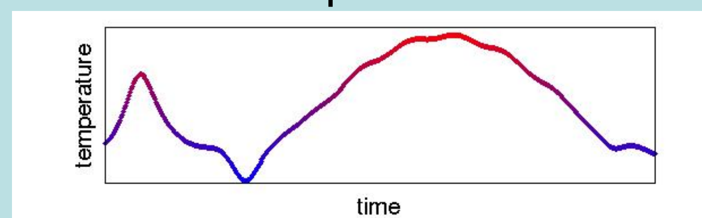
Cellular flow field: Lagrangian and En route obs DA

Drifter obs – green dots





Temperate recorded by drifter on unknown path between *



DA

Posterior (shaded) and Prior for u-v paramters

DA

With en route temp obs