# Assimilation of information on positions of surface drifters in an operational system

Srdjan Dobricic[(1)], Jenny Nilsson[(2)], Nadia Pinardi[(2)], Pierre-Marie Poulain[(3)] and Daniele Pettenuzzo[(2)]

(1) CMCC, Bologna, Italy
(2) INGV, Bologna, Italy
(3) OGS, Trieste, Italy

# Outline

- Mediterranean Forecasting System (MFS)
- OceanVar Data assimilation scheme
- Trajectory model acting as an observational operator
- Experiemnts with surface drifters and Argo floats
- Future development

# OceanVar data assimilation scheme

OceanVar minimizes a 3DVAR.A cost function, linearized around the background state:

$$J = \frac{1}{2}\delta\mathbf{x}^T\mathbf{B}^{-1}\delta\mathbf{x} + \frac{1}{2}\left[\mathbf{H}(\delta\mathbf{x}) - \mathbf{d})\right]^T\mathbf{R}^{-1}\left[\mathbf{H}(\delta\mathbf{x}) - \mathbf{d})\right]$$

$$\delta\mathbf{x} = \mathbf{x} - \mathbf{x}_b \qquad \mathbf{d} = \left[H(\mathbf{x}_b) - \mathbf{y}\right]$$

Preconditioning is done using a control vector v defined by:

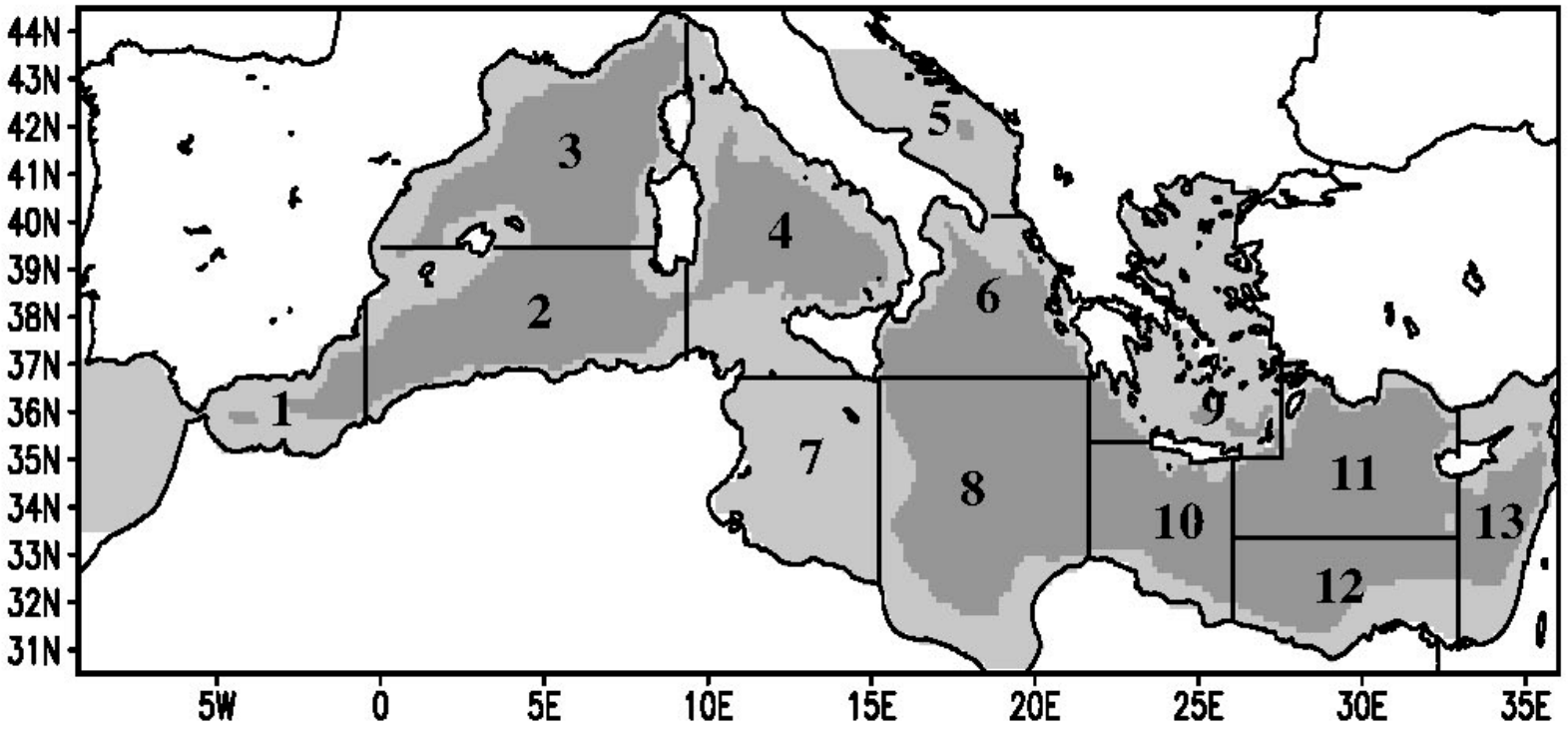
$$\mathbf{v} = \mathbf{V}^+\boldsymbol{\delta}\mathbf{x} \qquad \mathbf{B} = \mathbf{V}\mathbf{V}^T$$

$\mathbf{V}$ is modelled as a sequence of linear operators: $\mathbf{V} = \mathbf{V}_D\mathbf{V}_{uv}\mathbf{V}_\eta\mathbf{V}_H\mathbf{V}_V$.

- $\mathbf{V}_V$ - Vertical EOFs.
- $\mathbf{V}_H$ - Horizontal covariances.
- $\mathbf{V}_\eta$ - Barotropic model for eta
- $\mathbf{V}_{uv}$ - Diagnose u and v.
- $\mathbf{V}_D$ -Divergence damping filter.

# Regional representation of $\mathbf{V}_v$

- Seasonal climatological matrix for the vertical part of the operator, varying in 13 regions
- Composed of 20 EOF computed from model output standard deviations



# Barotropic model simulates covariances between temperature/salinity and sea level

It finds stationary solution of free-surface equations forced by constant perturbations of salinity and temperature. It is a 4DVAR for the barotropic mode.

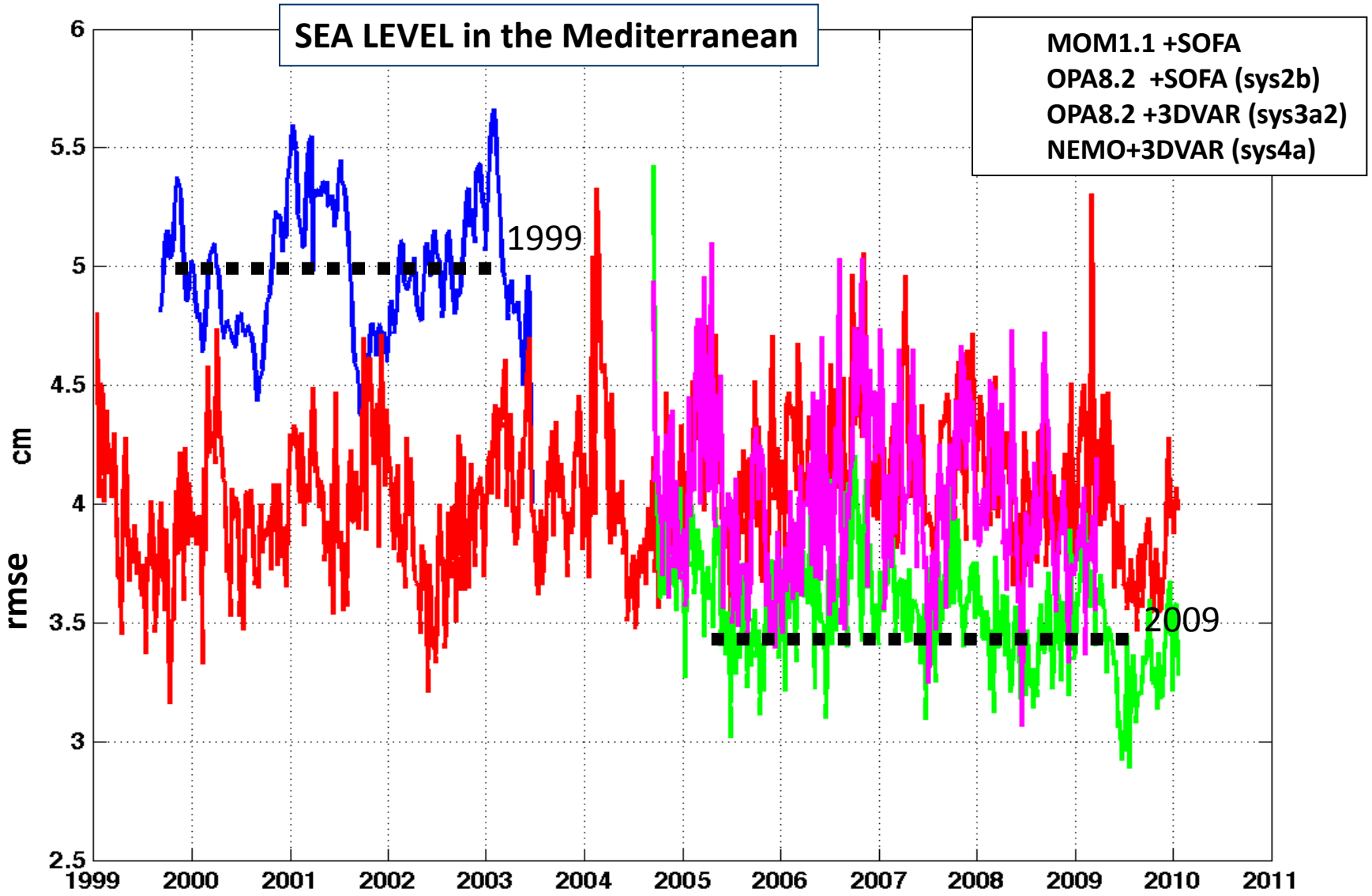
$$\frac{U^{n+1}-U^{n-1}}{\Delta t} - fV^{n} = -gH\frac{\partial \eta^{*}}{\partial x} - \int_{-H}^{0}\left[\int_{-z}^{0}\frac{\partial(\delta b)}{\partial x}dz'\right]dz + \gamma\nabla^{2}U^{n-1}$$

$$\frac{V^{n+1}-V^{n-1}}{\Delta t} + fU^{n} = -gH\frac{\partial \eta^{*}}{\partial y} - \int_{-H}^{0}\left[\int_{-z}^{0}\frac{\partial(\delta b)}{\partial y}dz'\right]dz + \gamma\nabla^{2}V^{n-1}$$

$$\frac{\eta^{n+1}-\eta^{n-1}}{\Delta t} + \left(\frac{\partial U^{*}}{\partial x} + \frac{\partial V^{*}}{\partial y}\right) = 0$$

$$\delta b = g(\delta\rho/\rho_{0}) \qquad \delta\rho = \alpha\delta T + \beta\delta S$$

# RMSE SLA misfits 1999 - 2009



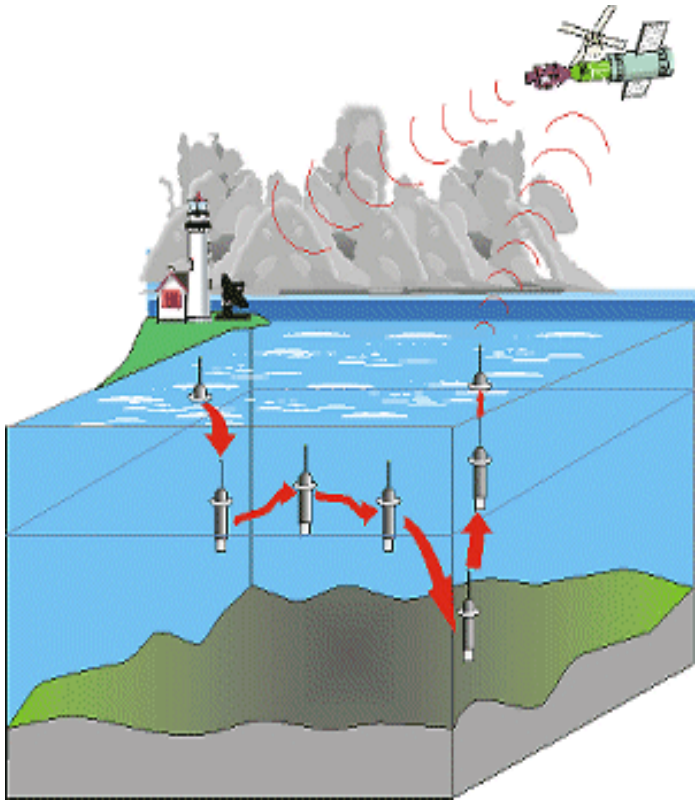
# Assimilation of float position observations

$\mathbf{y}$ - Observation of Argo position (**r**)

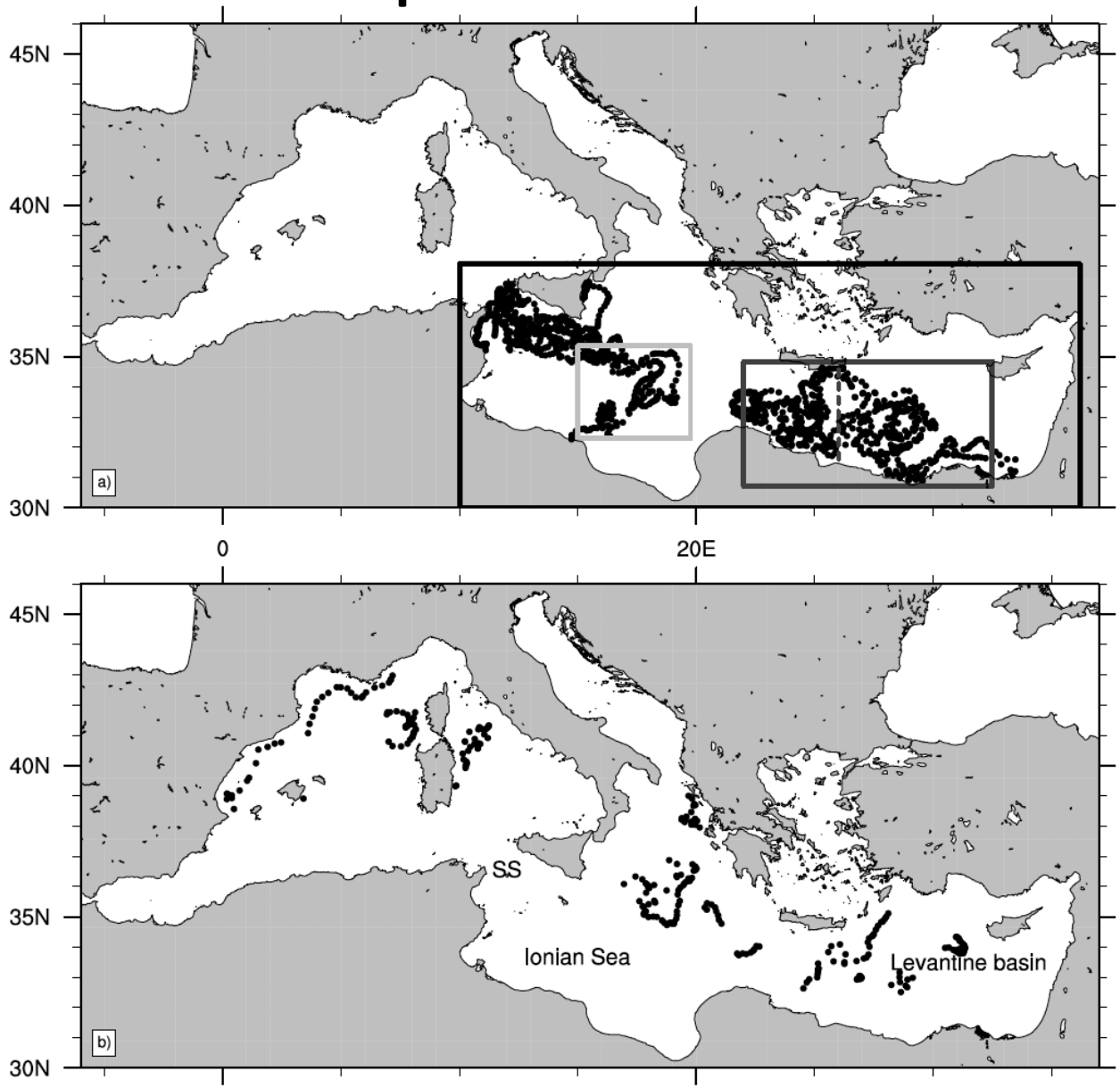
$H(\mathbf{x})$ - Non-linear Lagrangean model of the trajectory

$\mathbf{x}$ - Eulerian model fileds of velocity

$$\frac{d\mathbf{r}}{dt} = \mathbf{u}(\mathbf{r})$$



# Floats in the Mediterranean during September-December 2009



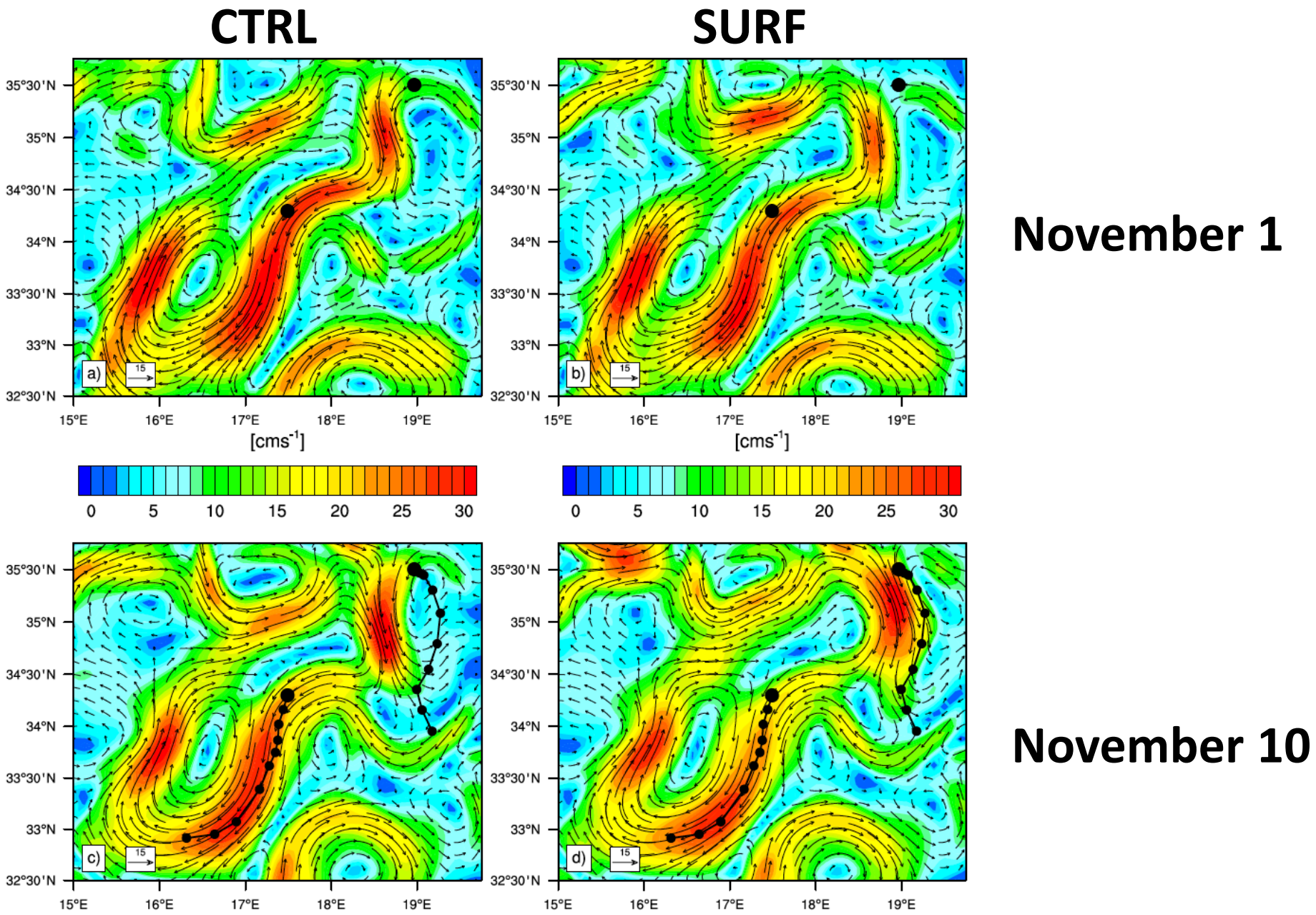

**Surface drifters**

**Argo floats**

# List of data assimilation experiments

| | Assimilated observations | | | | |
|---|---|---|---|---|---|
| **Exp** | **SLA** | **Tem** | **Sal** | **Drifter** | **Argo** |
| CTRL | X | X | X | | |
| SURF | X | X | X | X | |
| SURF2 | X | X | X | X | X |
| ARGO | X | X | X | | X |

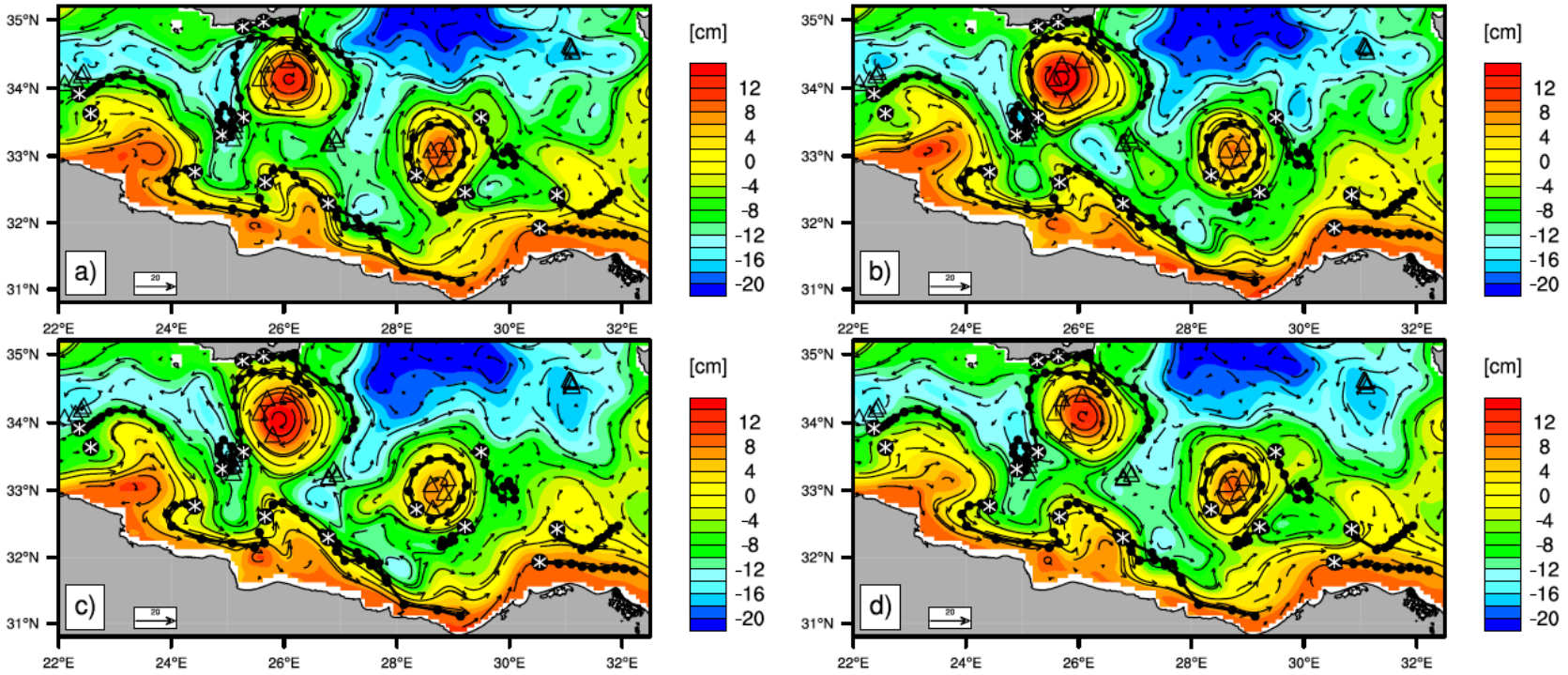
# Velocity at 15 m (m/s)



# Sea surface height and velocity on December 22

**CTRL**

**SURF**



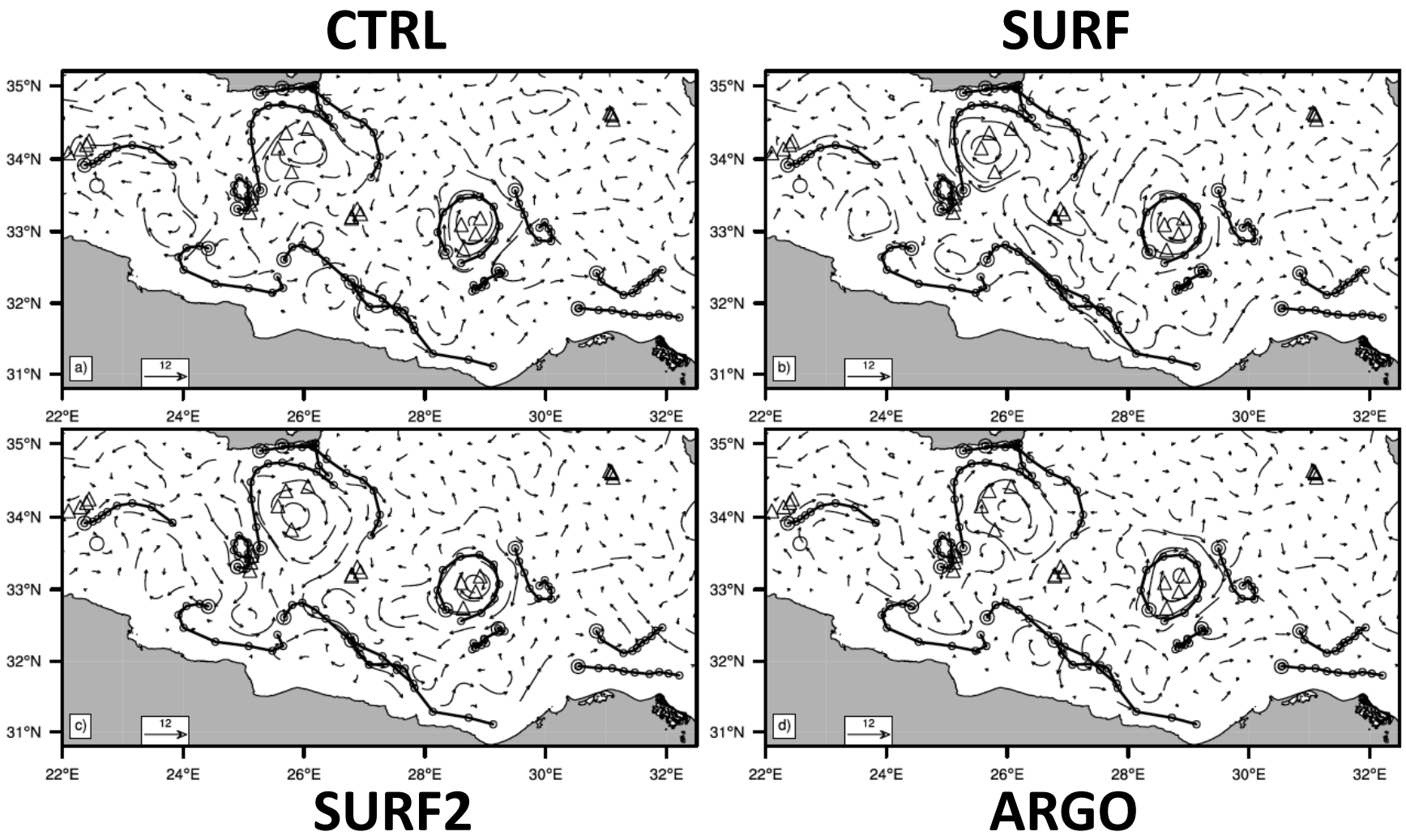

**SURF2**

**ARGO**

**Dots – surface drifters**

**Triangles – Argo floats during December 13-23**

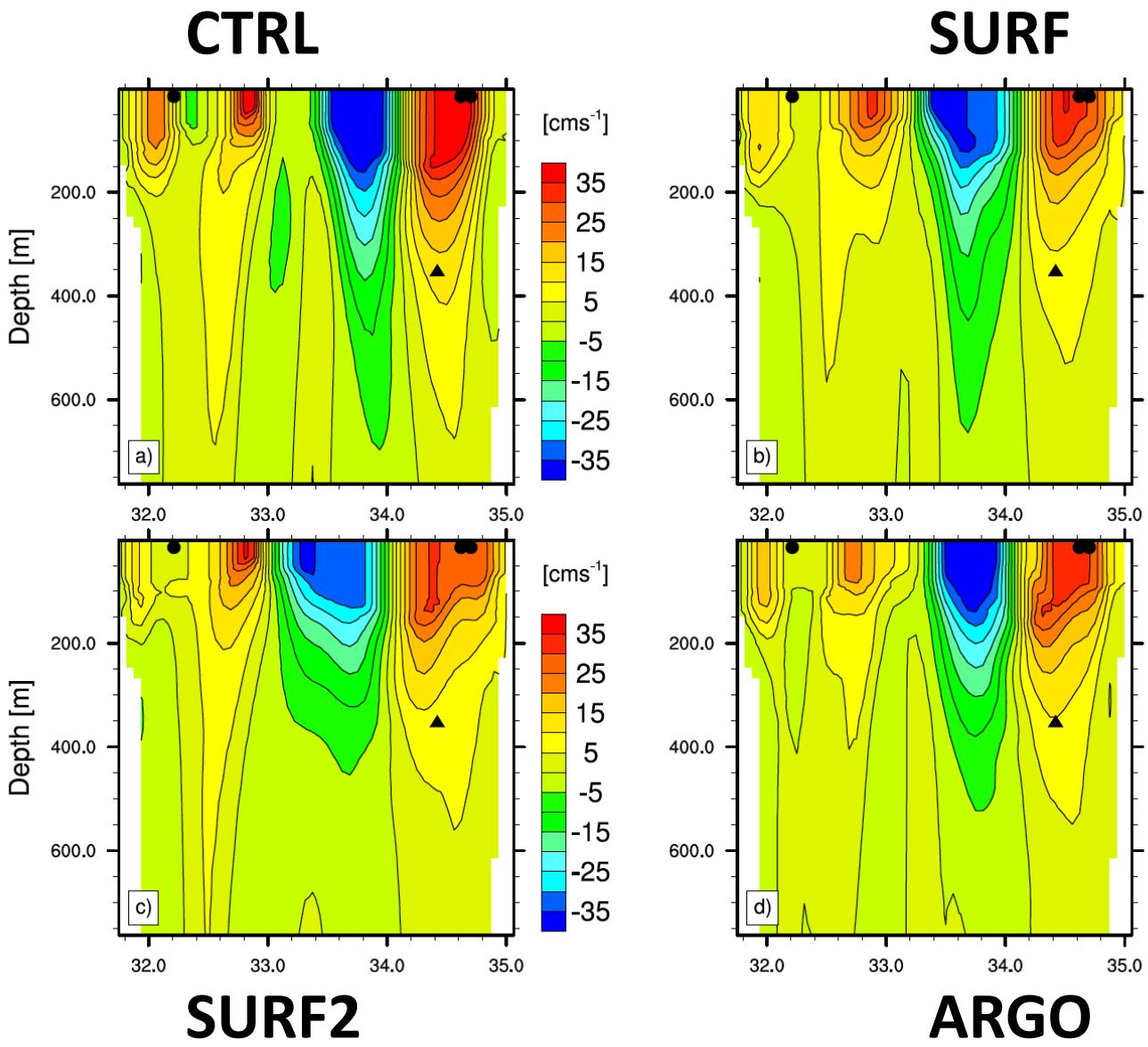
# Velocity at 300 m on December 22




**Dots – surface drifters**

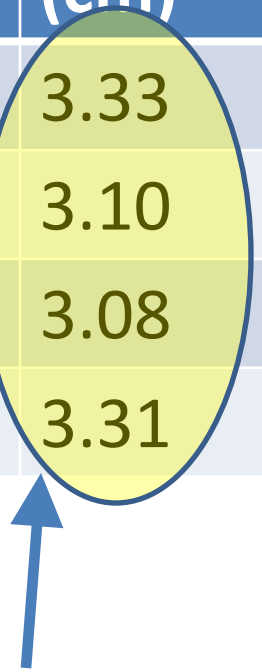
**Triangles – Argo floats during December 13-23**

# Zonal velocity at Creten Passage on December 22



# RMS of residuals

| Exp | SLA (cm) | Tem (0C) | Sal | Drifter (km) | Argo (km) |
|---|---|---|---|---|---|
| CTRL | 3.33 | 0.77 | 0.22 | 17.5 | 25.2 |
| SURF | 3.10 | 0.79 | 0.22 | 15.2 | 25.0 |
| SURF2 | 3.08 | 0.78 | 0.22 | 15.3 | 20.5 |
| ARGO | 3.31 | 0.77 | 0.22 | 17.7 | 21.0 |



**Improved SLA forecast when surface drifter position is assimilated**

# Future development

- During MyOcean2 it is planned to include the drifter position assimilation in the MFS operational chain
- The assimilation of surface drifters may become very important in emergency situations