Project co-financed by the European Union
European Regional Development Fund

MARINE INTELLIGENCE
THE VALUE OF DATA FOR SEA-BASED APPLICATION

HALF-DAY SEMINAR ORGANIZED BY THE PHYSICAL OCEANOGRAPHY RESEARCH GROUP
DEPT. OF GEOSCIENCES, UNIV. OF MALTA
Db San Antonio Hotel – Qawra St. Paul's Bay, 18° April 2018

Data filling and short-term forecasting of HF sea currents by means of ARMA models

Capodici F., PhD
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research group: Capodici F., Ciraolo G. Maltese A., La Loggia G.

Università degli Studi di Palermo
Dipartimento di Ingegneria Civile, Ambientale, Aerospaziale, dei Materiali - DICAM

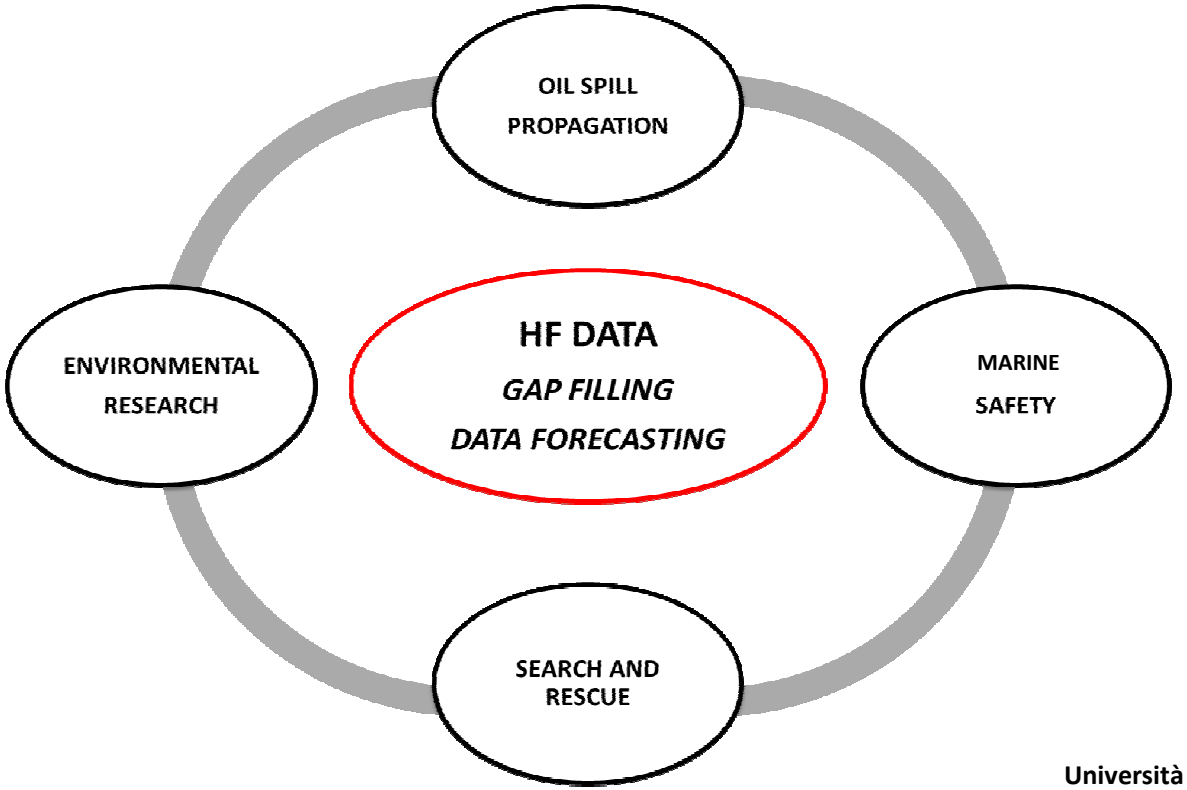
Summary

-Deriving Sea surface currents from HF radars network (as CALYPSO)

-improving the operational use of HF currents data by providing:

- data gap filling;

-data short term forecasting



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Deriving sea currents from HF radar

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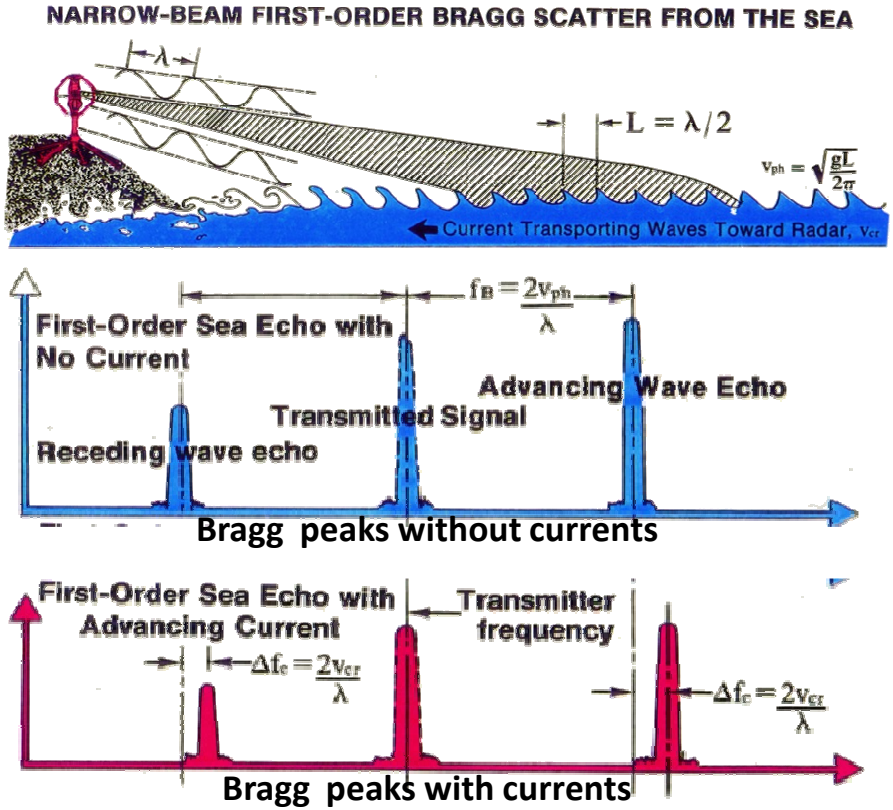
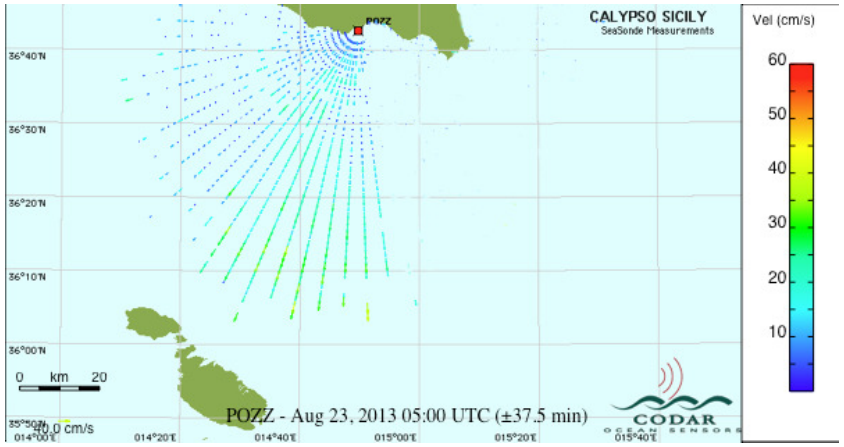
Interreg Italia-Malta Calypso South

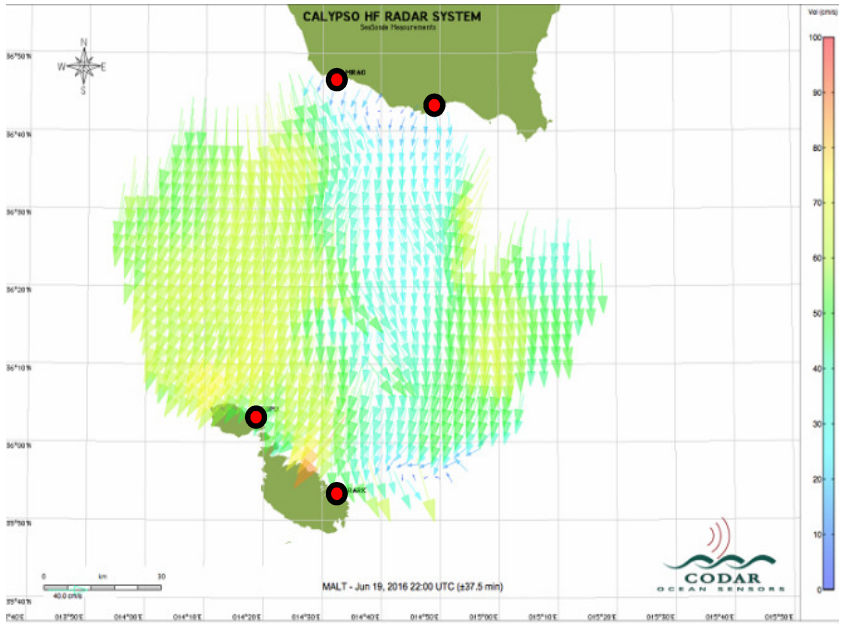
1. The dopler spectra at each HF site is derived and analyzed



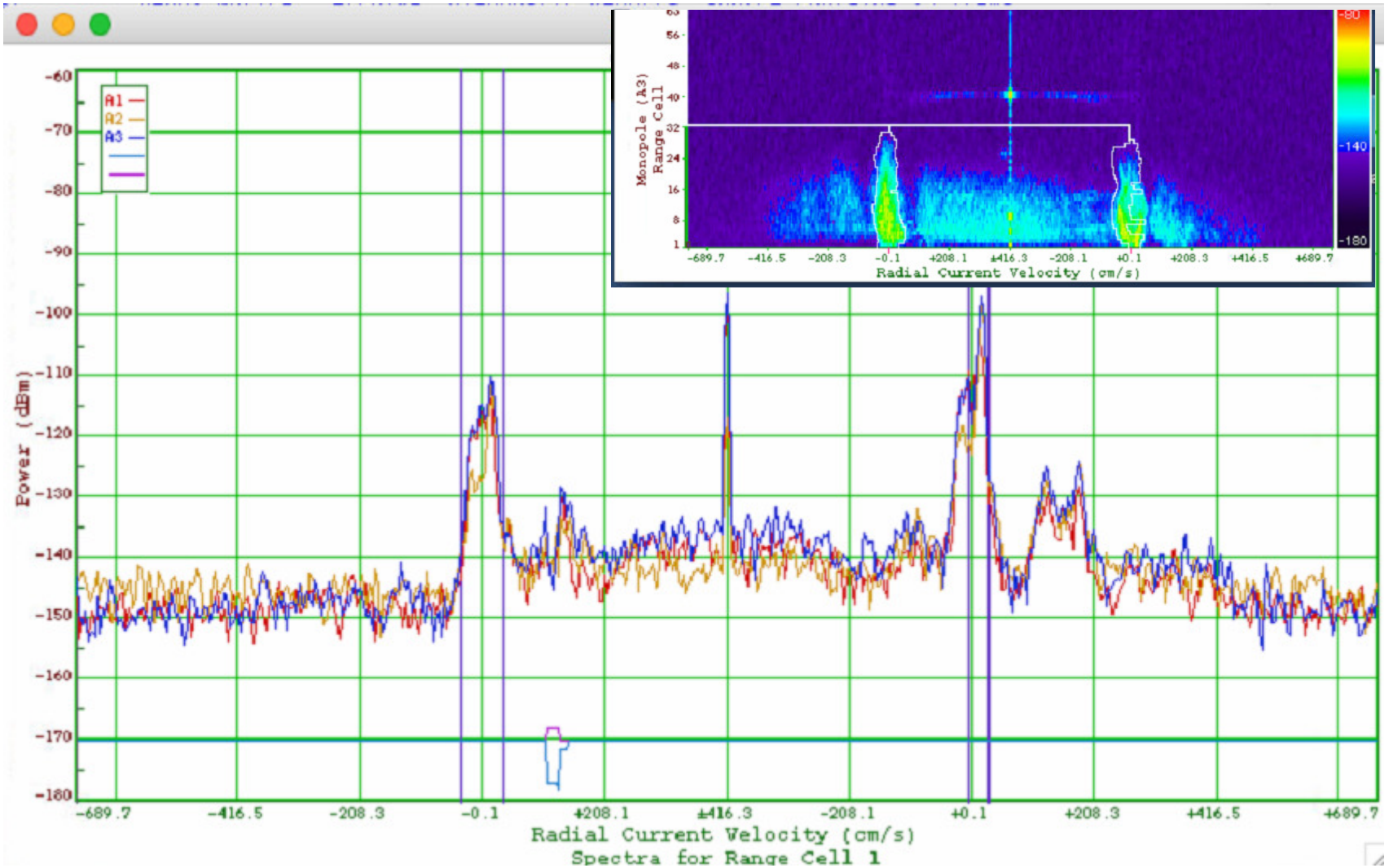
2. A radial map is computed at each HF site



3. The 2D current map is derived by send all available radial maps to a combine server



Why data gap filling is required?



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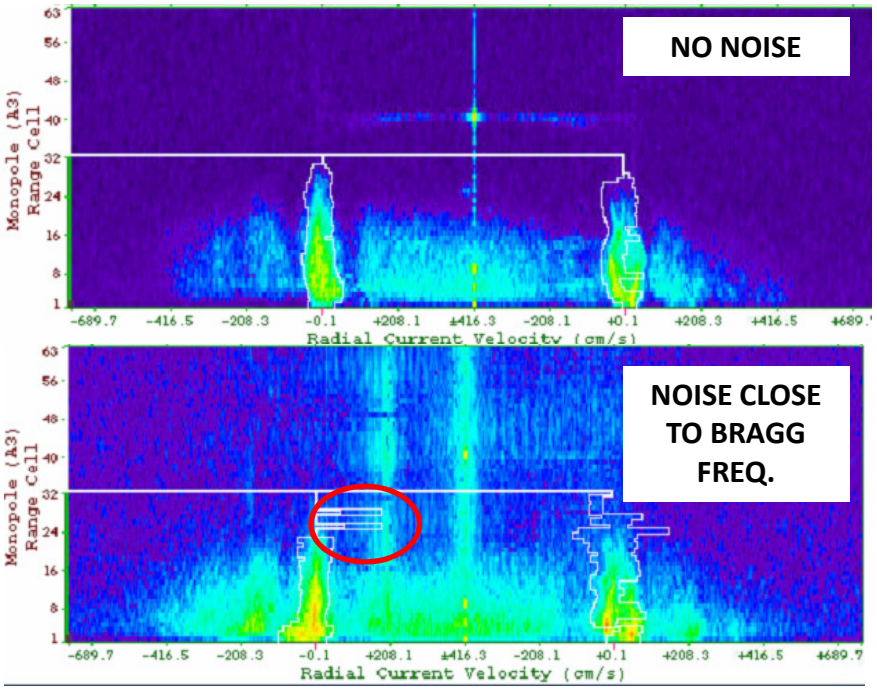
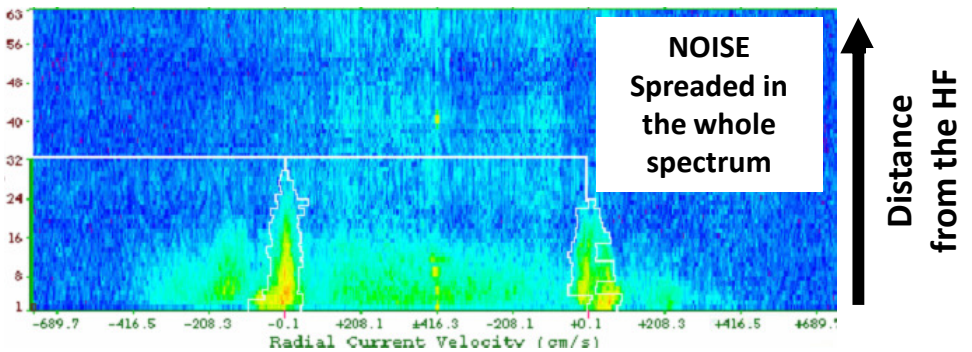
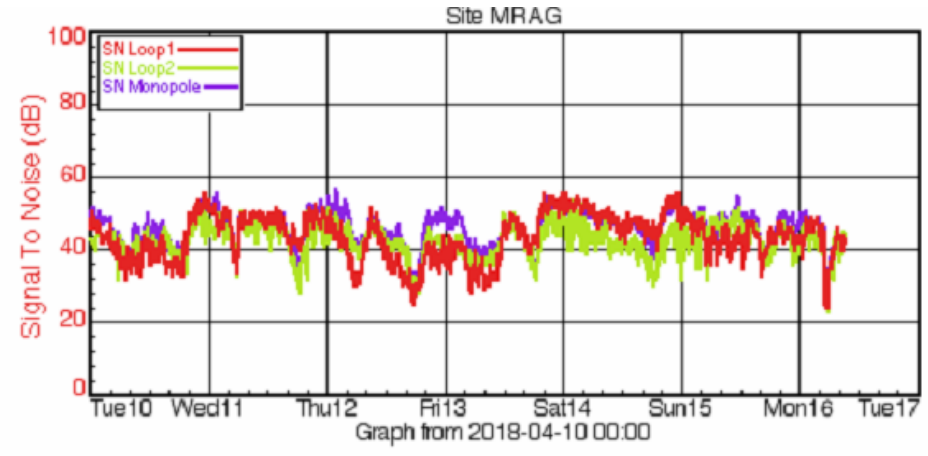
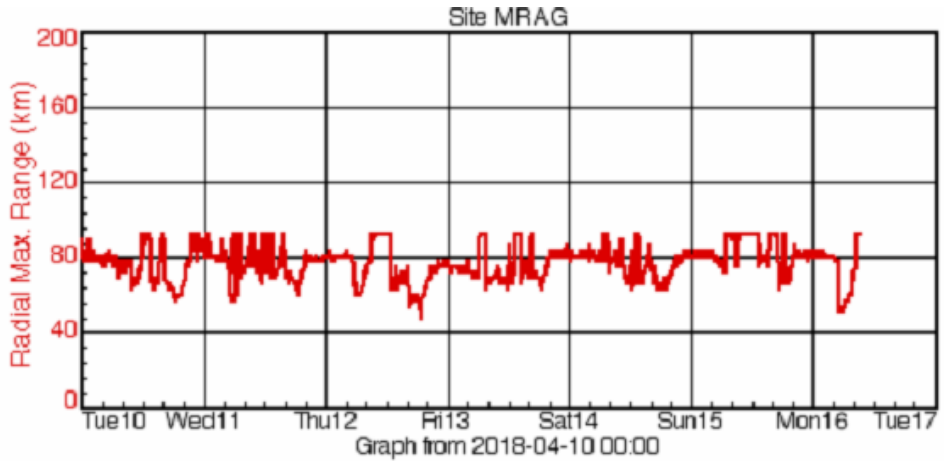


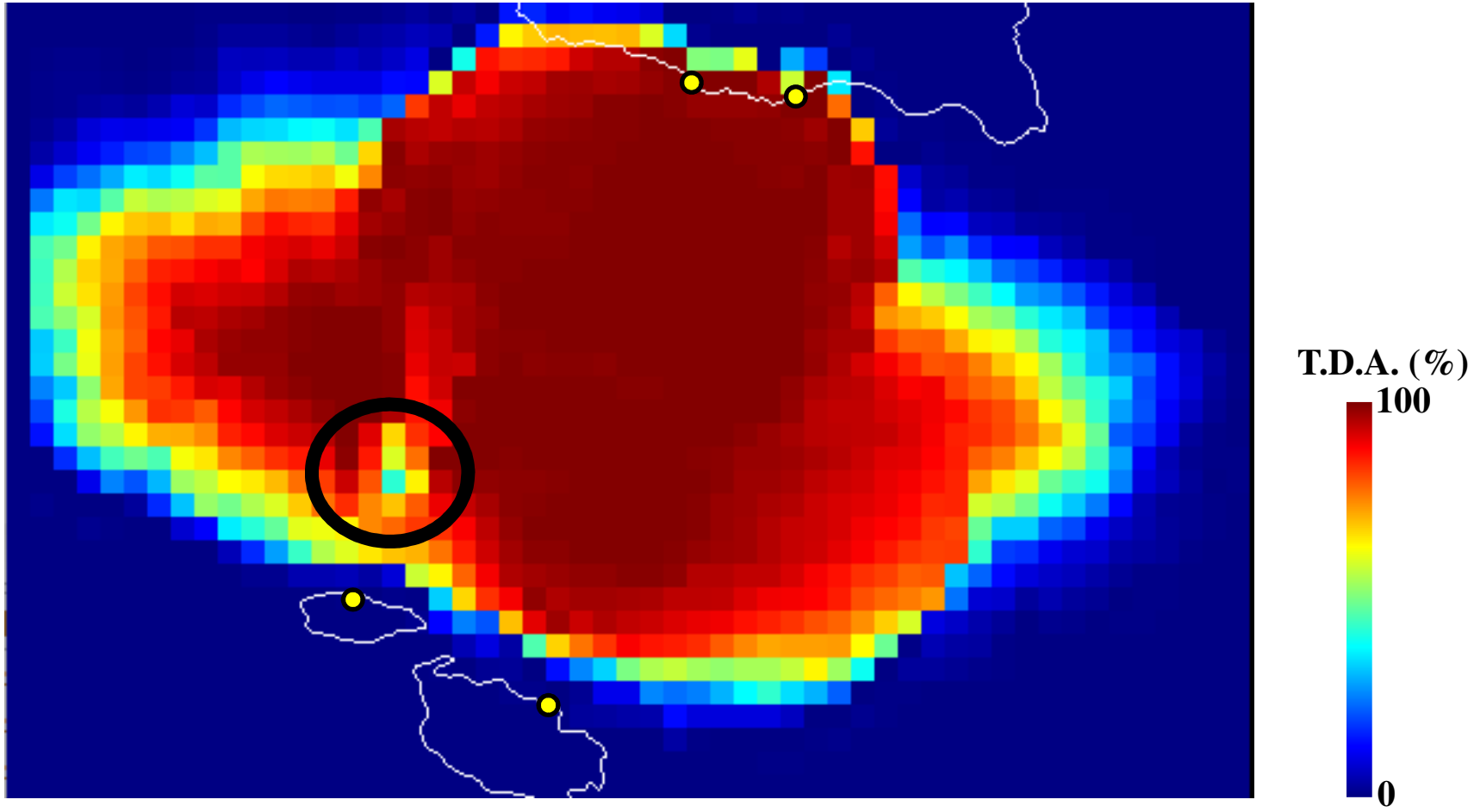






Why data gap filling is required?

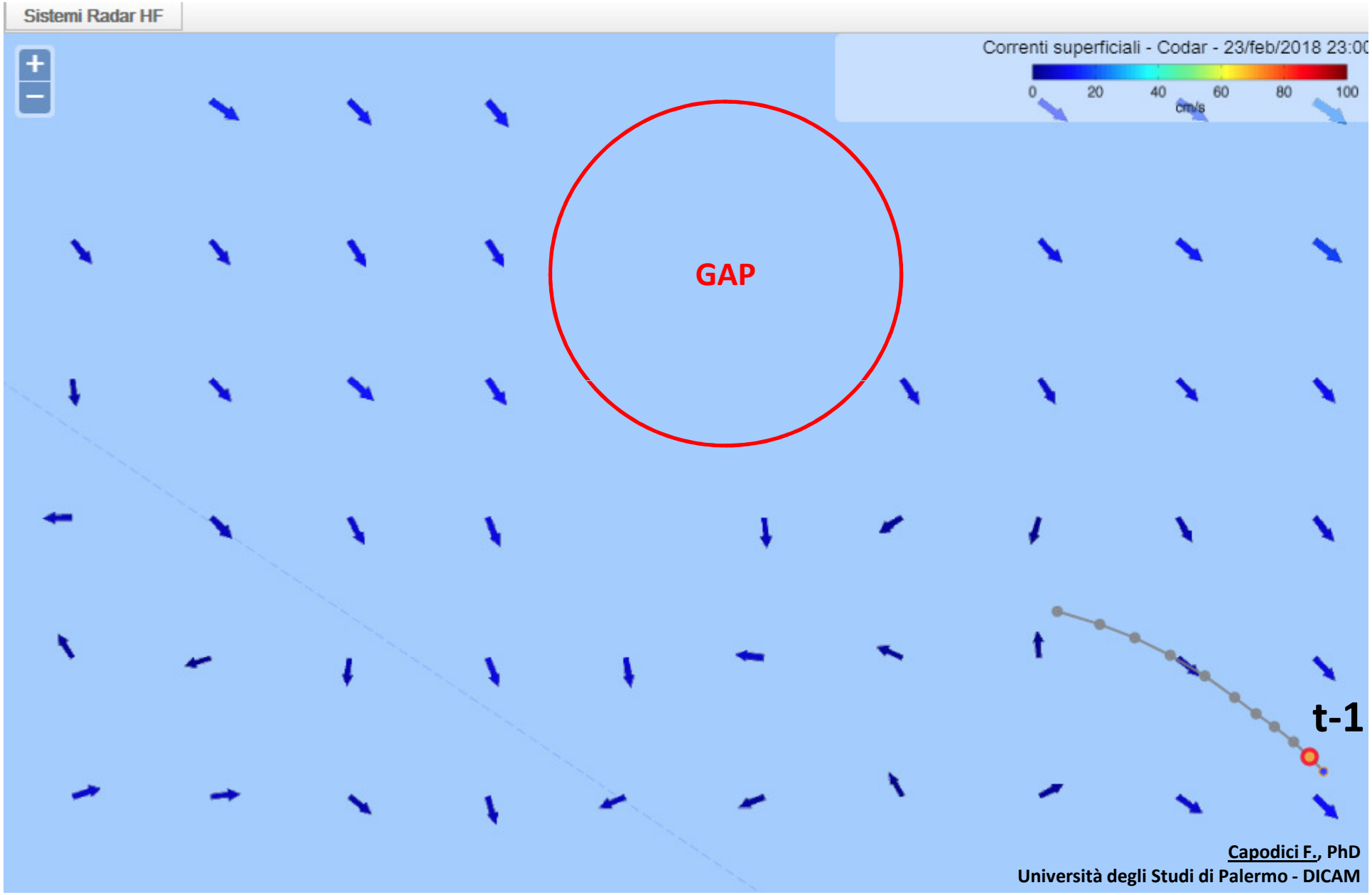
Even if CALYPSO coverage increased thanks to the installation of new HFs stations gaps are observed due to external RFI, sea conditions and other sources



T.D.A. = temporal data availability

Why data gap filling is required?

Trying a 24h backtracking simulation



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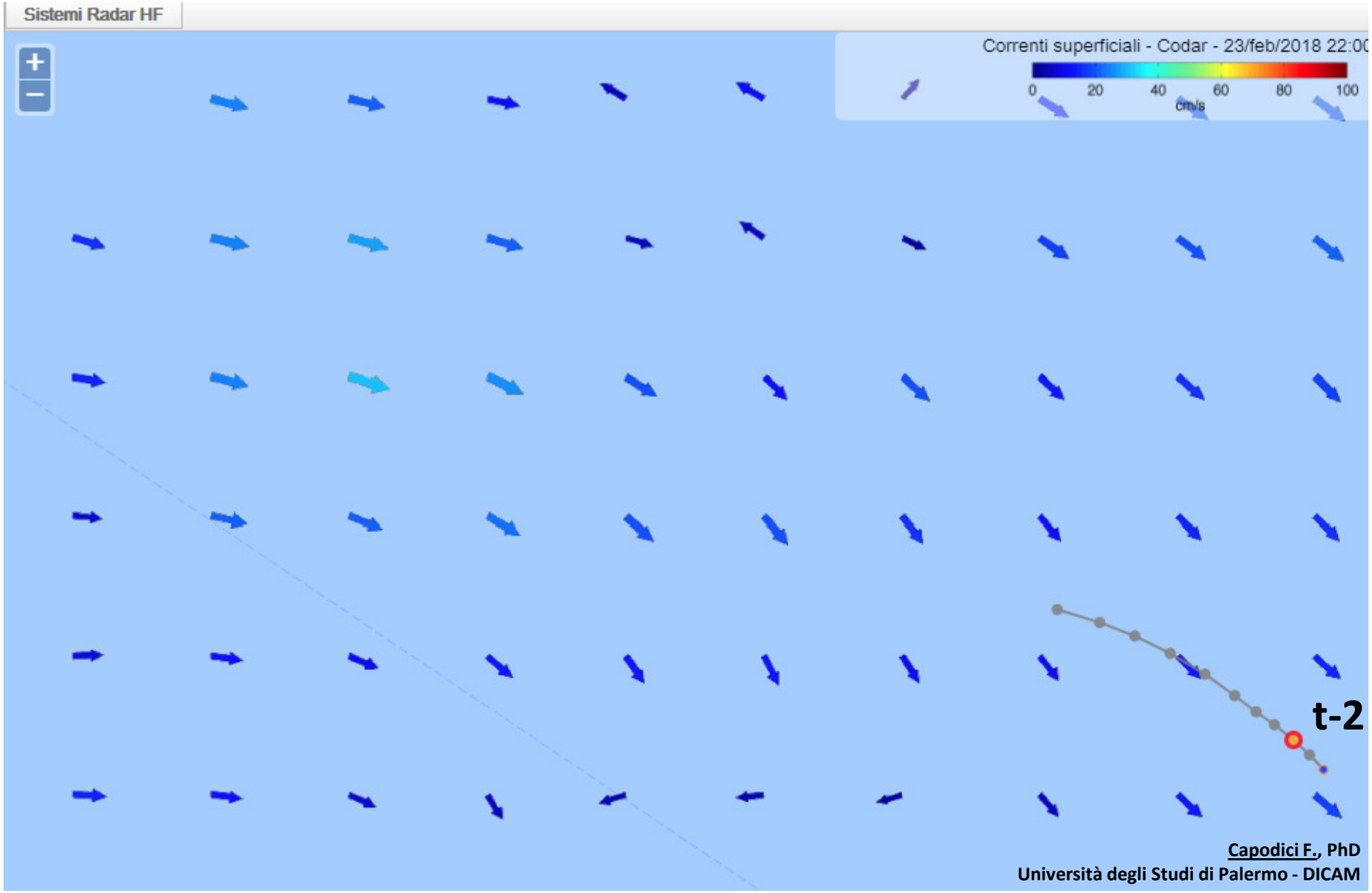

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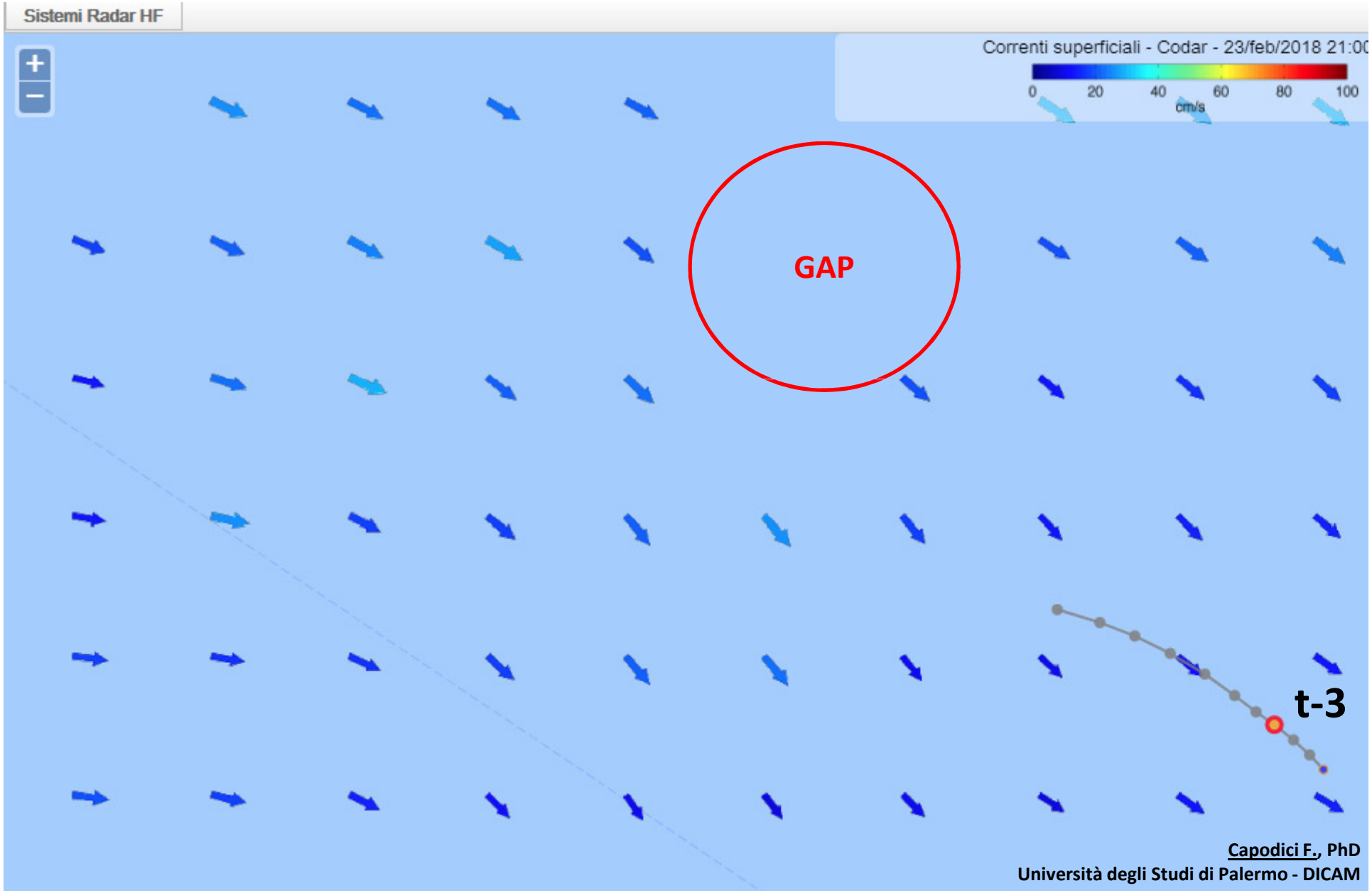

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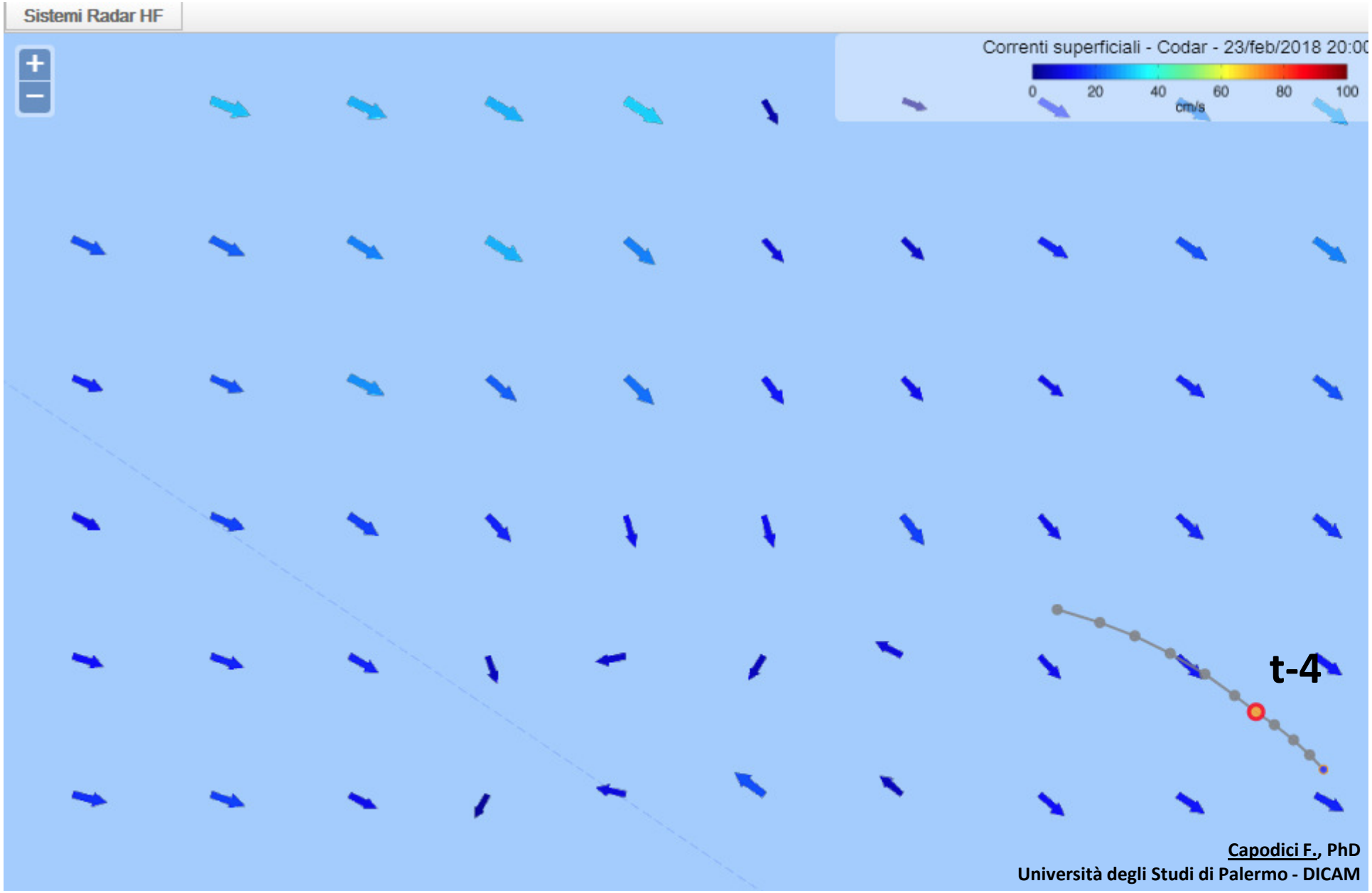

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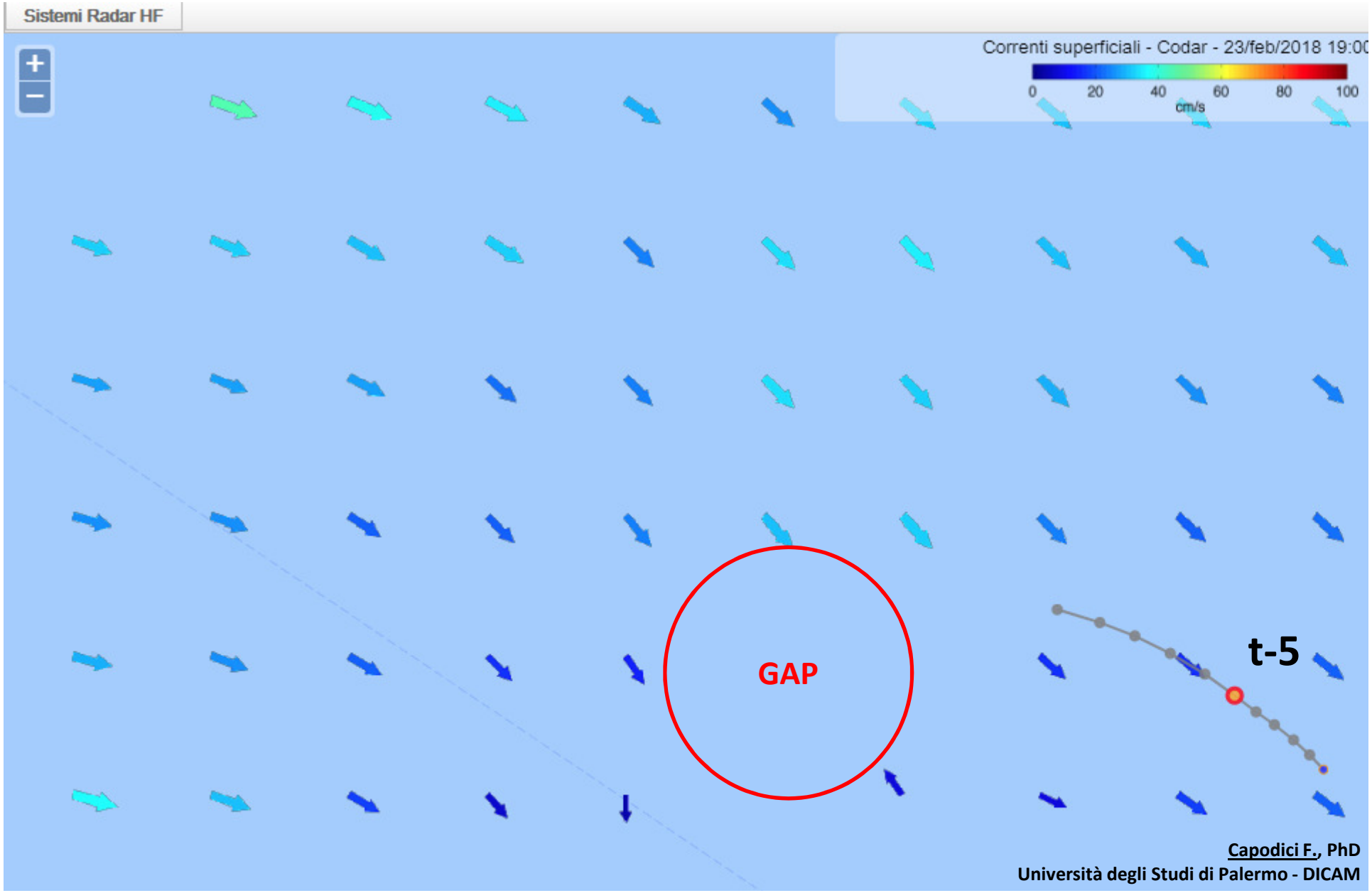

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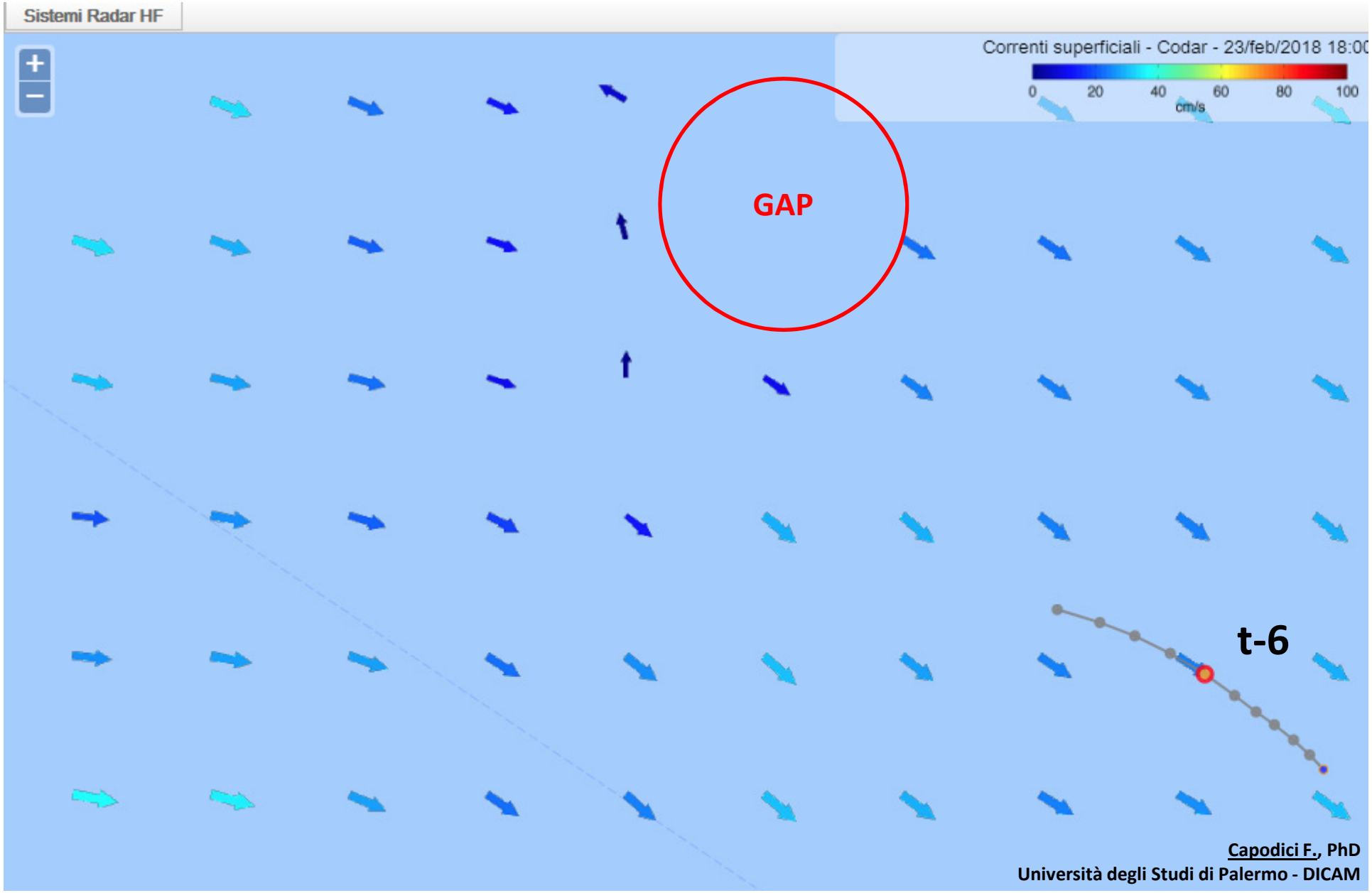

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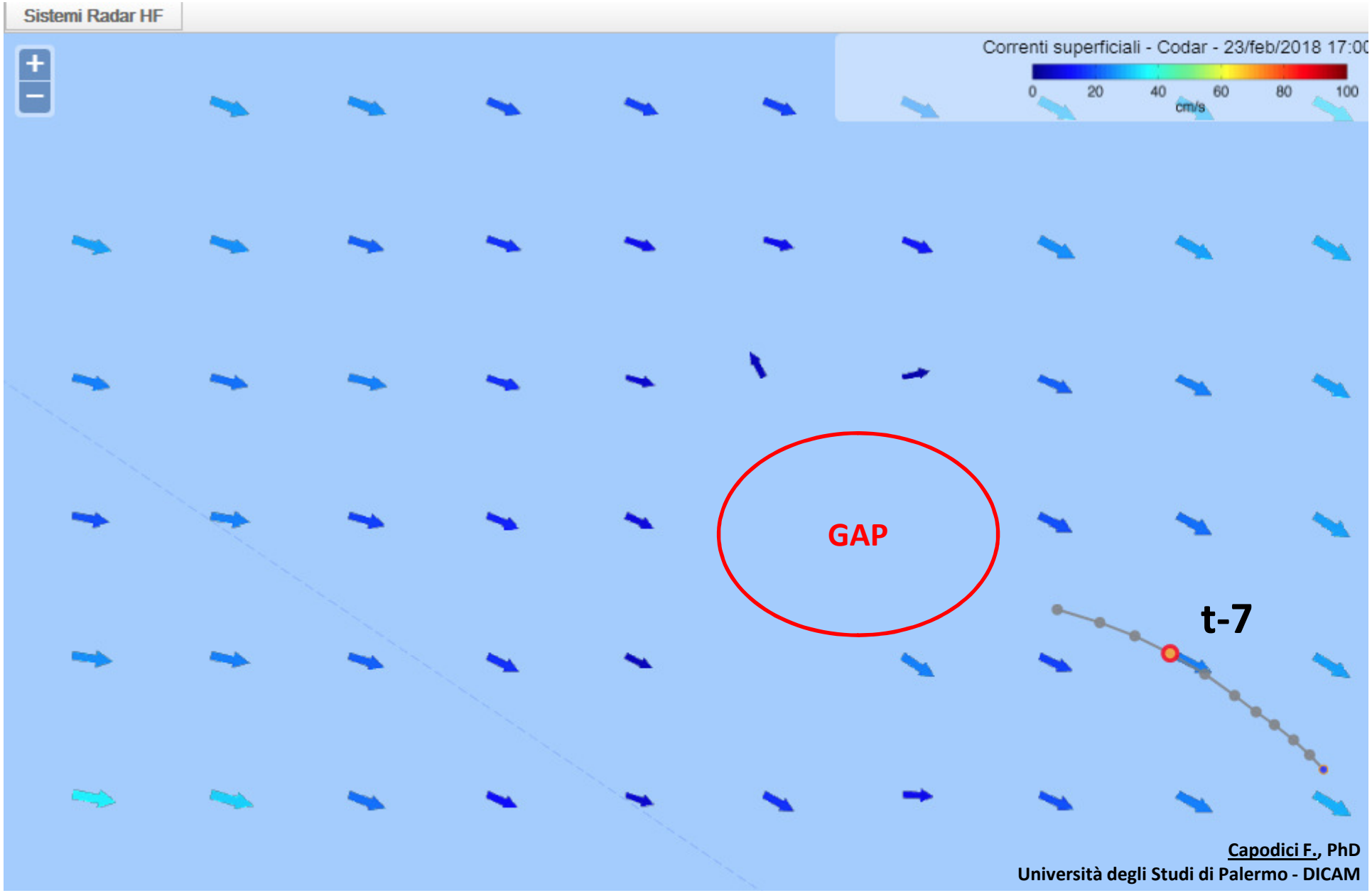

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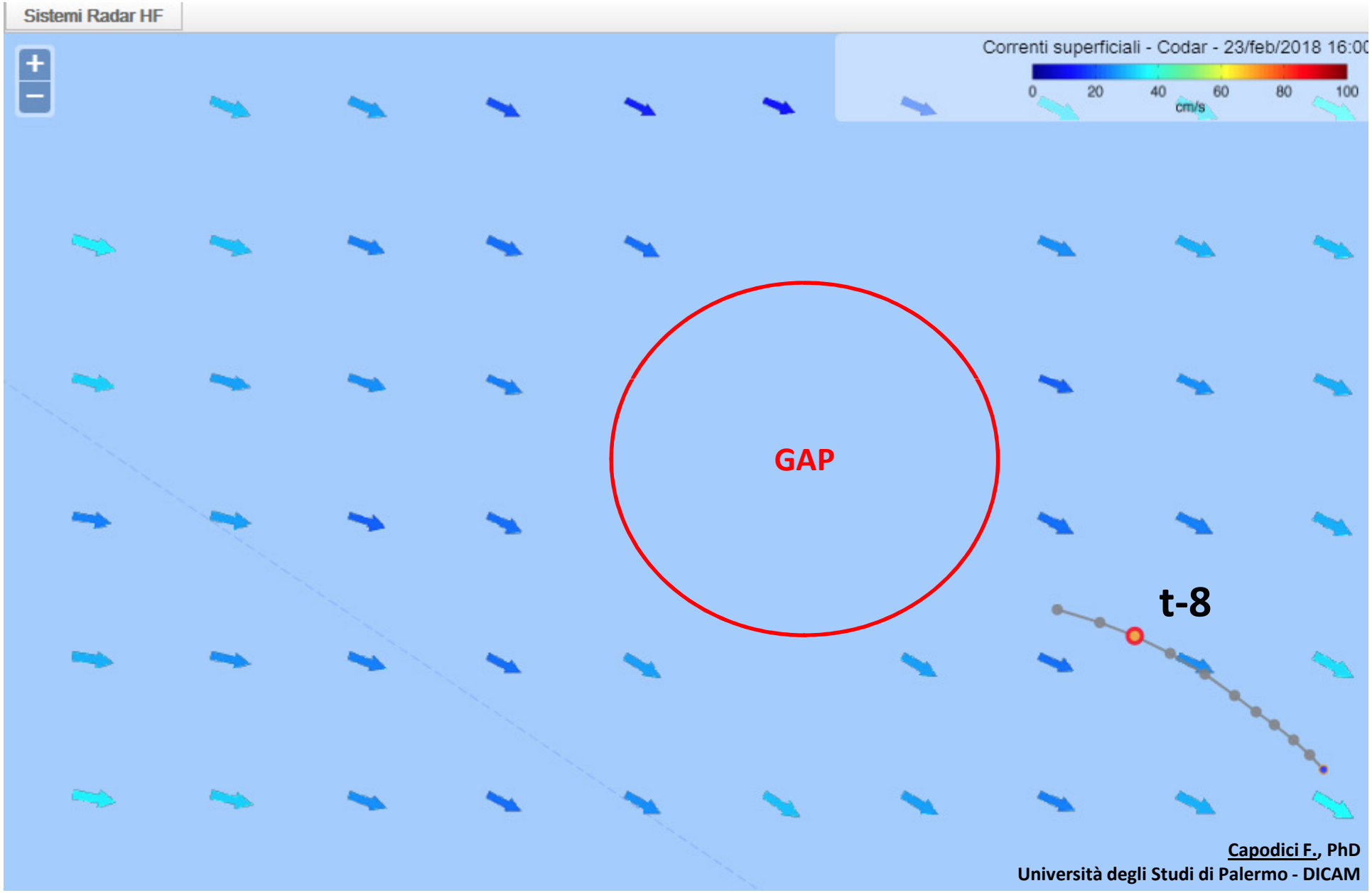

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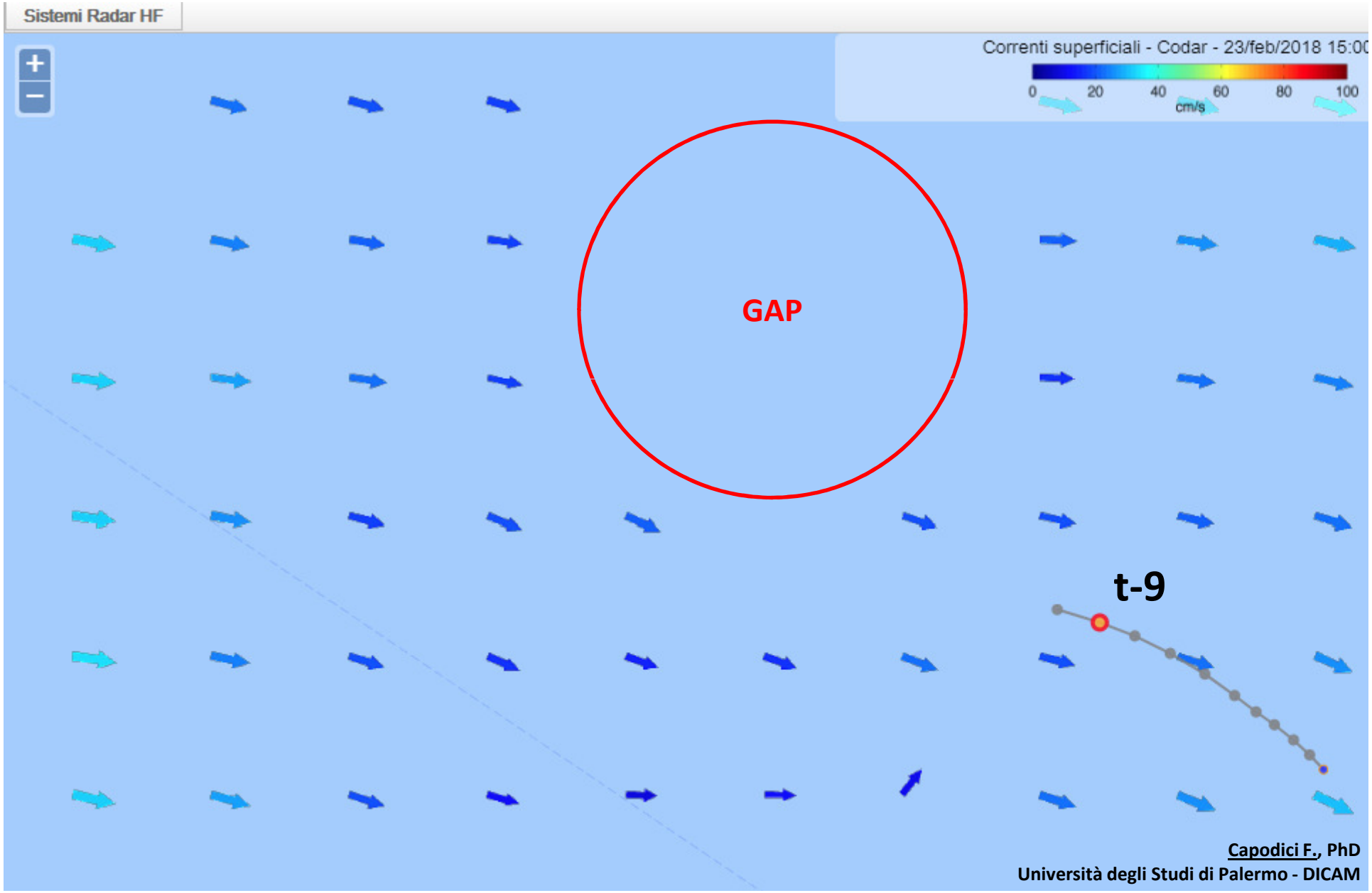

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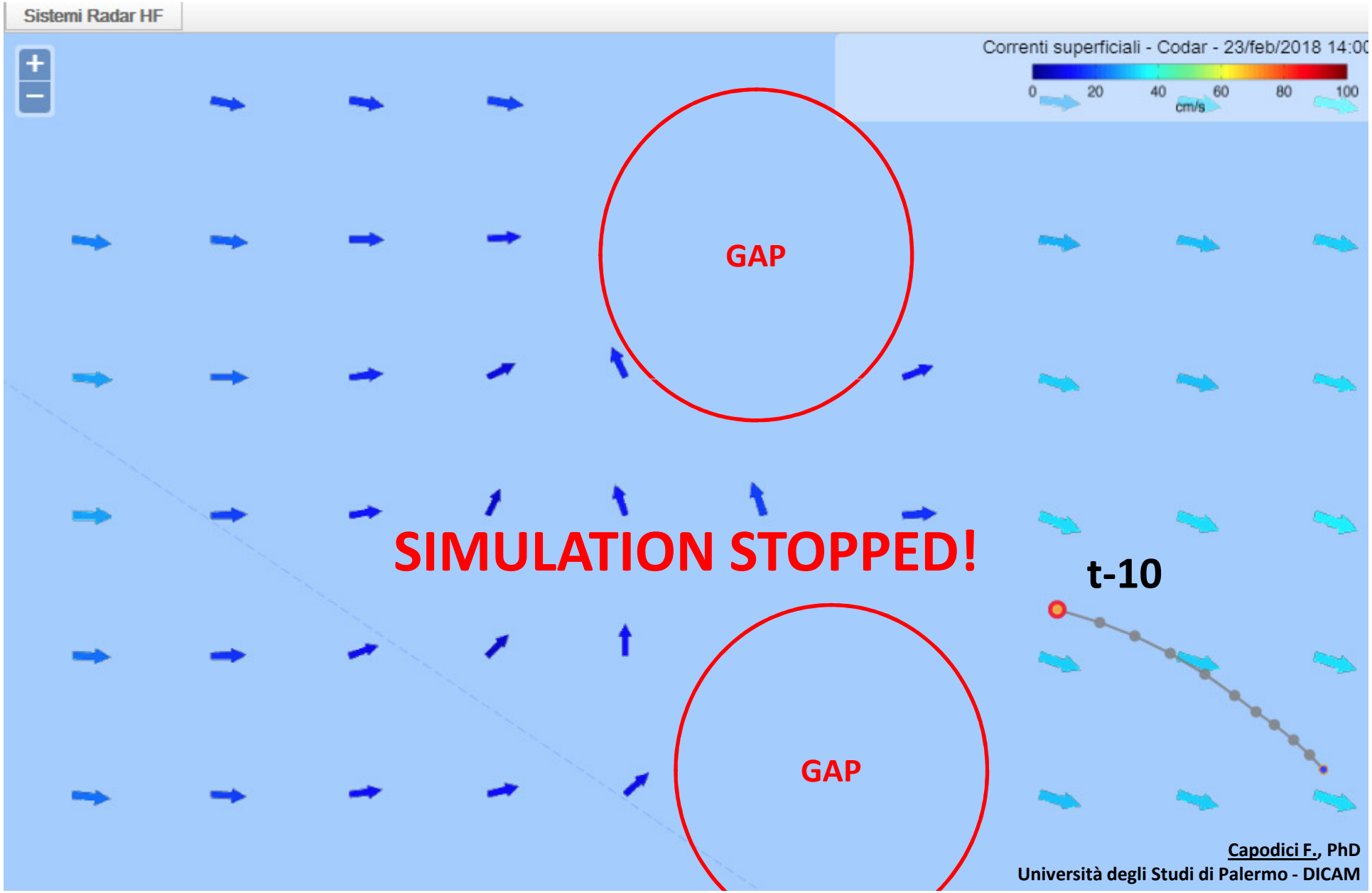

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Why data gap filling is required?

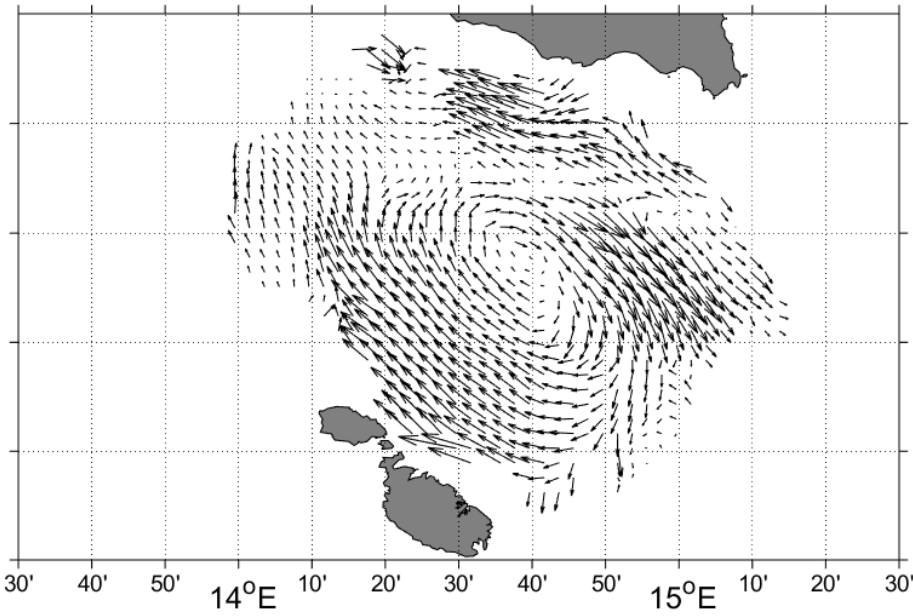
REASONS OF DATA GAP:

- **RADIO FREQUENCY INTERFERENCES (RFI);**
- **NOT FAVOURABLE SEA STATE;**
- **HF SITE FAILURES;**
- **HF SITE INTERNET CONNECTION FAILURES;**

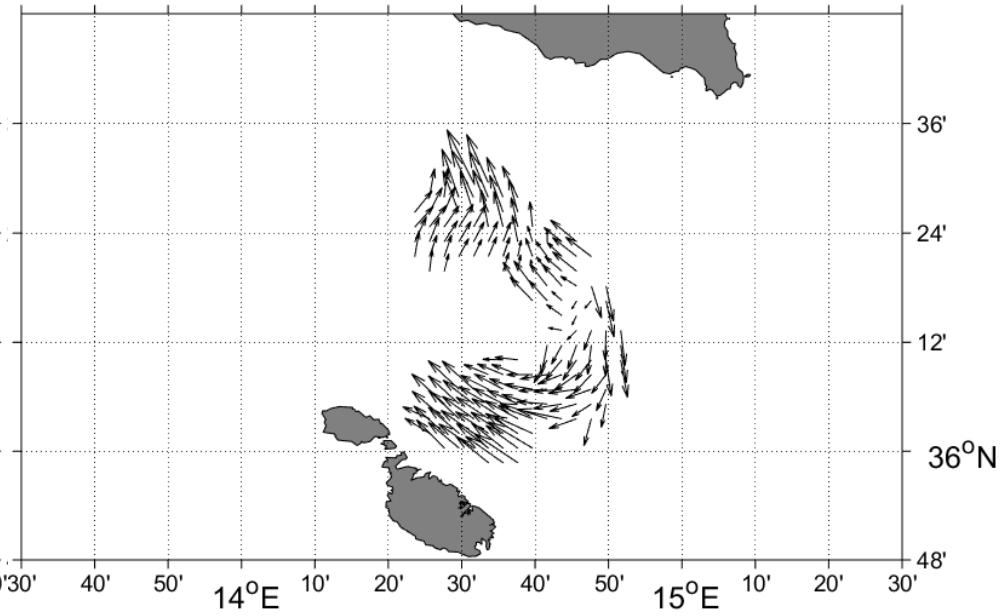
GAP FILLING IS REQUIRED:

- **TO ALLOW BACKTRACKING SIMULATIONS (e.g. oil spill source detection);**
- **FOR SCIENTIFIC PURPOSES (e.g. comparison with other data);**

No missing data



Poor coverage



Why data forecast is required?

- **HF SEA CURRENT MAP COULD BE NOT IN REAL TIME AVAILABLE**
  - **Computing time at the combine server**
  - **Internet failures at some of the HF sites or at the Combine Server**

- **RESPONSIBLE OF THE OPERATIONS COULD EMPLOY SOME TIME TO REACH THE WARNING LOCATION (e.g. the remotely detected oil spill position through satellite radar by EMSA);**

FOR OPERATIONAL PURPOSES
SHORT-TERM FORECASTED MAPS
ARE REQUIRED

FEW HOURS ARE ENOUGH
NEW ACTUAL MAPS COULD BE INCLUDED IN REAL TIME

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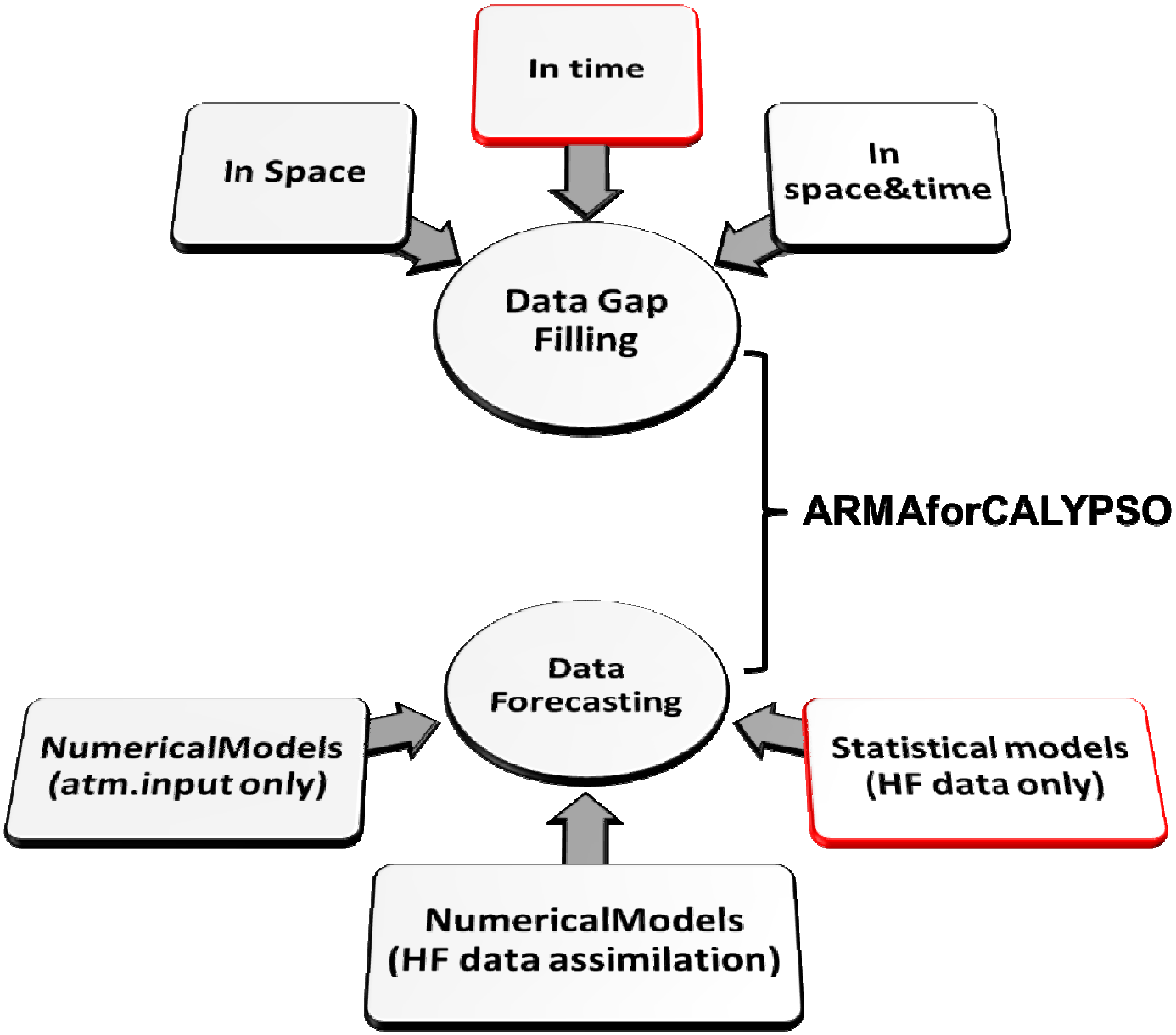
Work rationale



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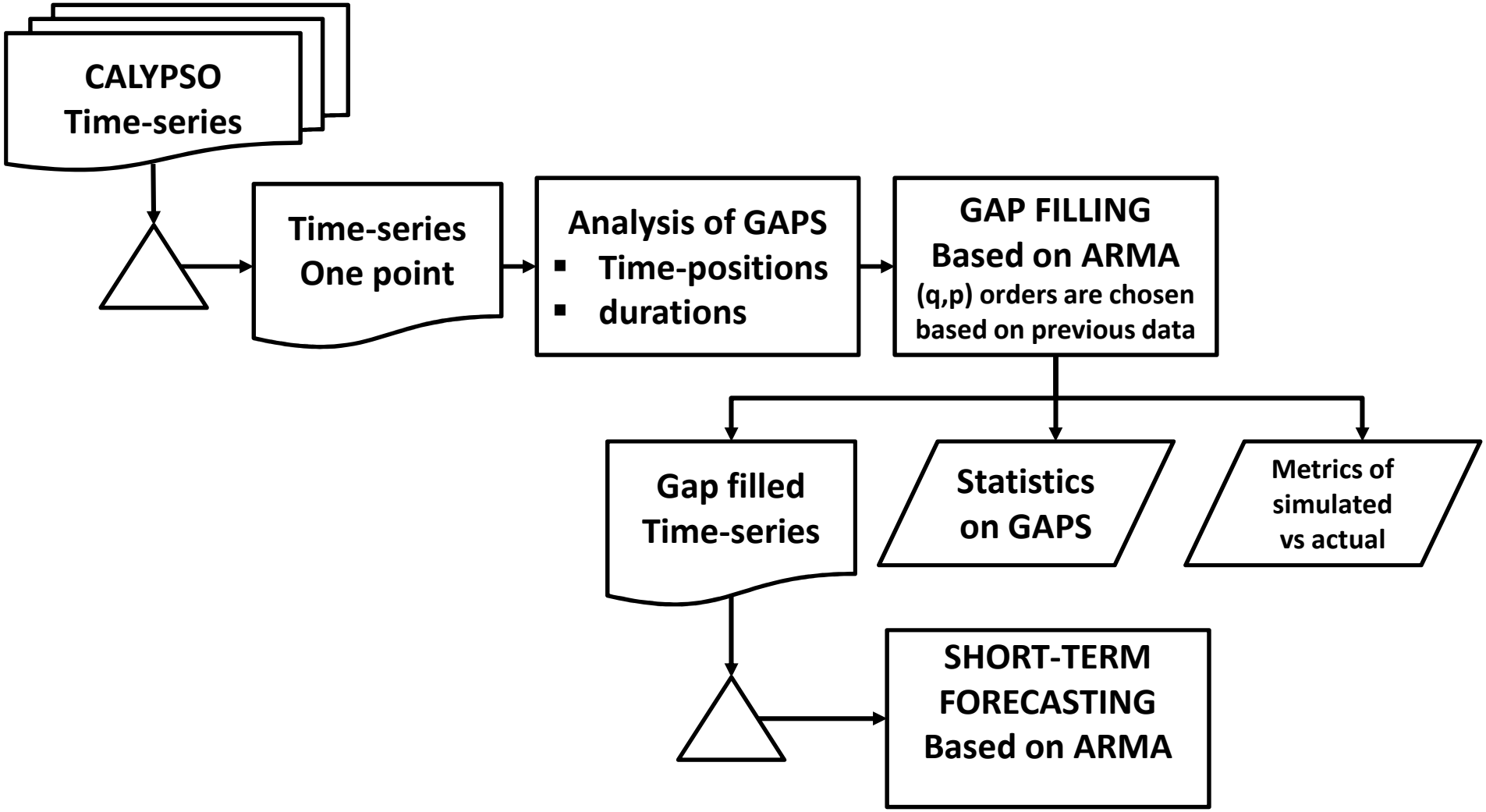
ARMAforCALYPSO

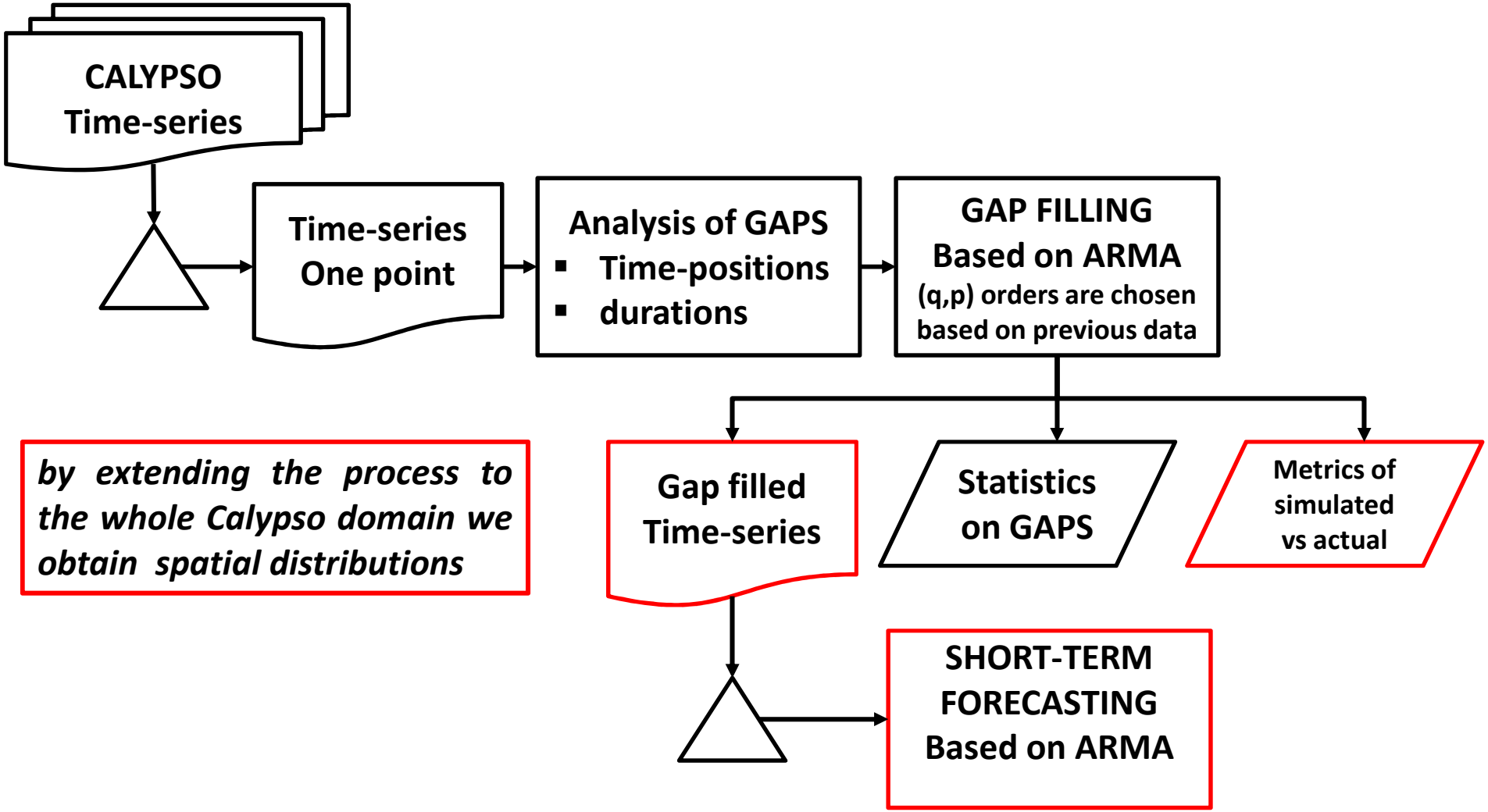


ARMAforCALYPSO is based on ARMA (AutoRegressive Moving Average)

$x_t = \emptyset_1 x_{t-1} + \emptyset_2 x_{t-2} + \ldots . \emptyset_p \, x_{t-p} + \ldots \varepsilon_t$ **AR(p) model - AutoRegressive of 'p' order**

$x_t = \varepsilon_t + \varphi_1 \varepsilon_{t-1} + \ldots . \varphi_q \varepsilon_{t-q}$ **MA(q) model - MovingAverage of 'q' order**

ARMAforCALYPSO



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ARMAforCALYPSO

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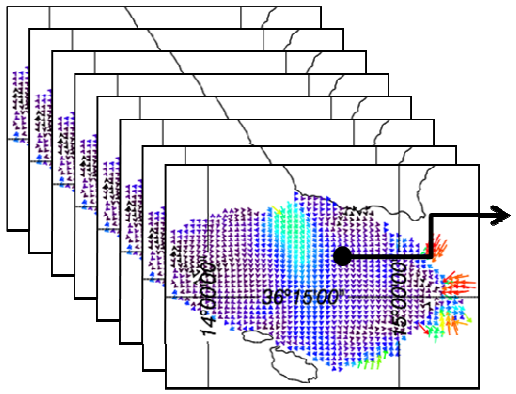
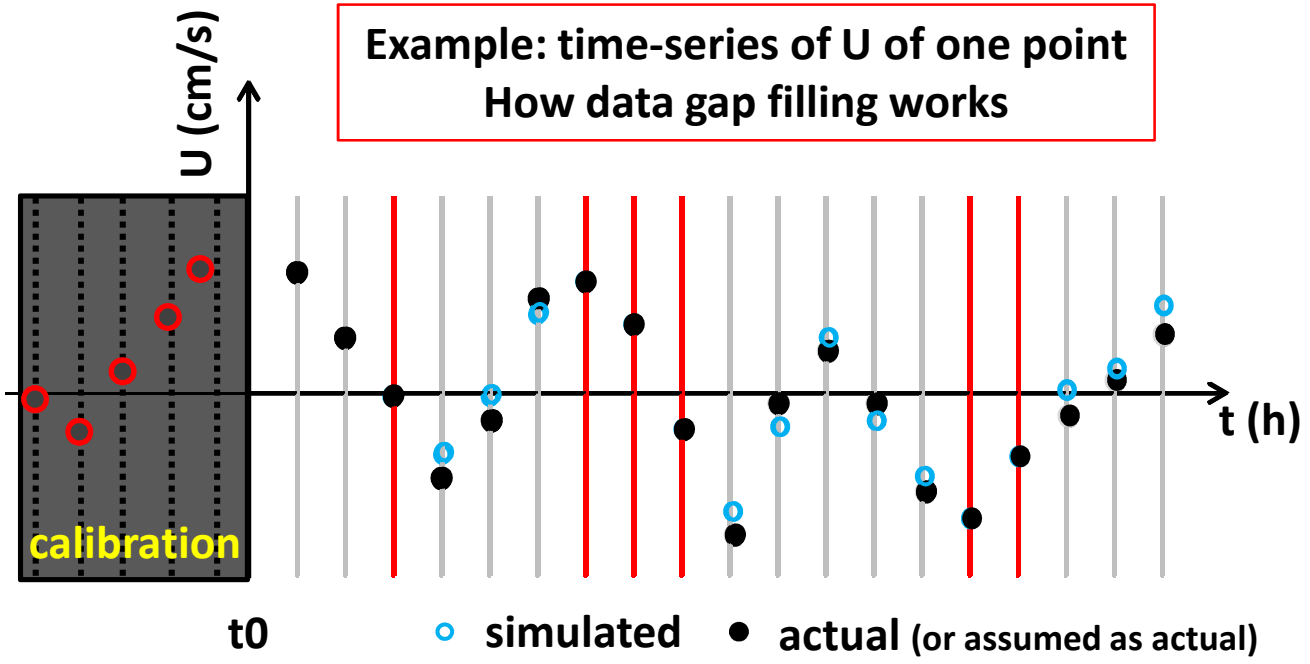
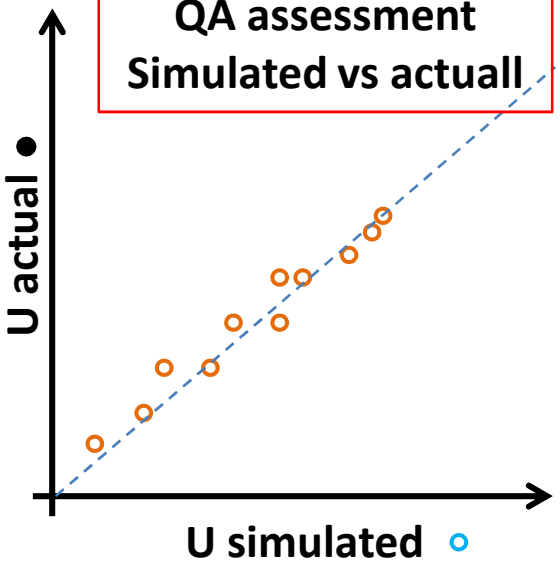
CALYPSO time-series



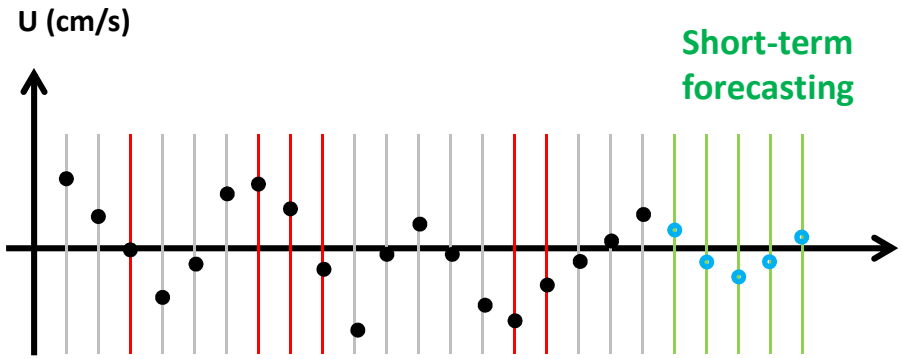
Example: time-series of U of one point
How data gap filling works



QA assessment
Simulated vs actuall



How Forecasting works



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Italia-Malta
Calypso South

Results
(gap filling)

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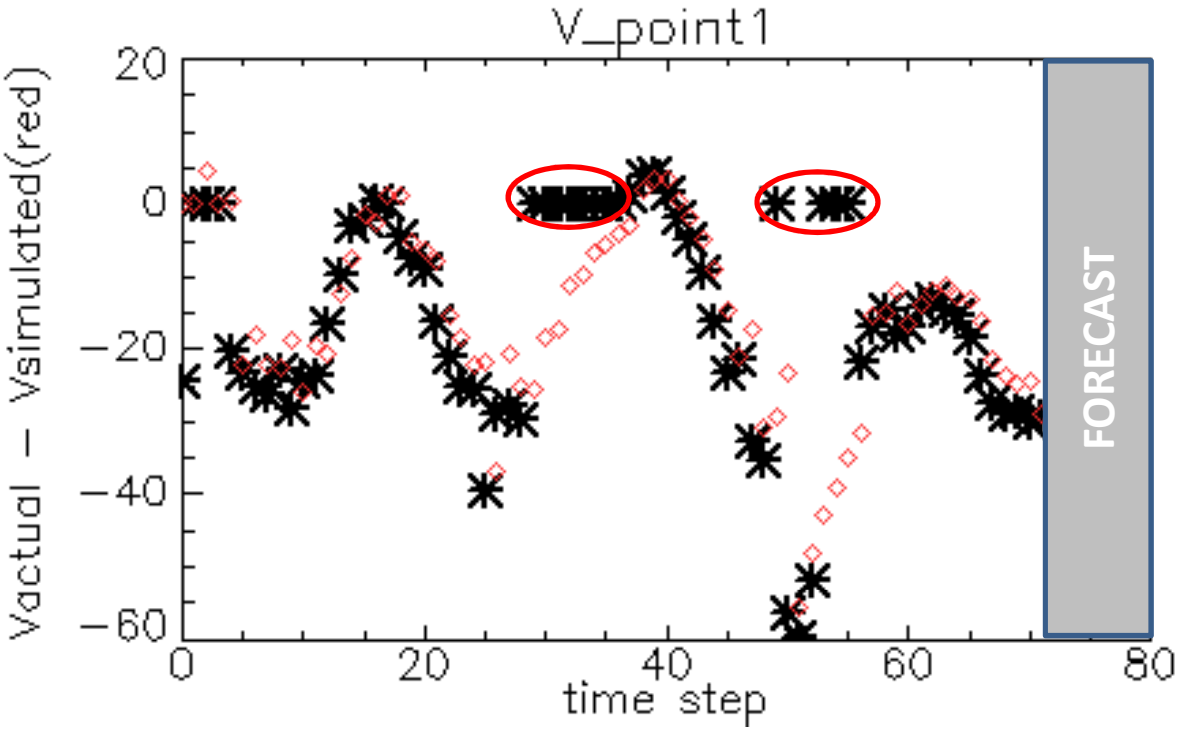
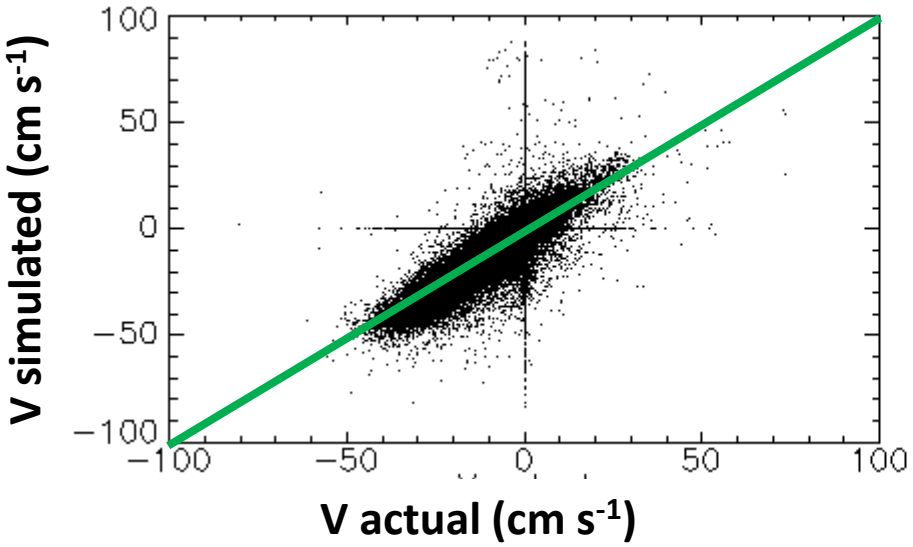
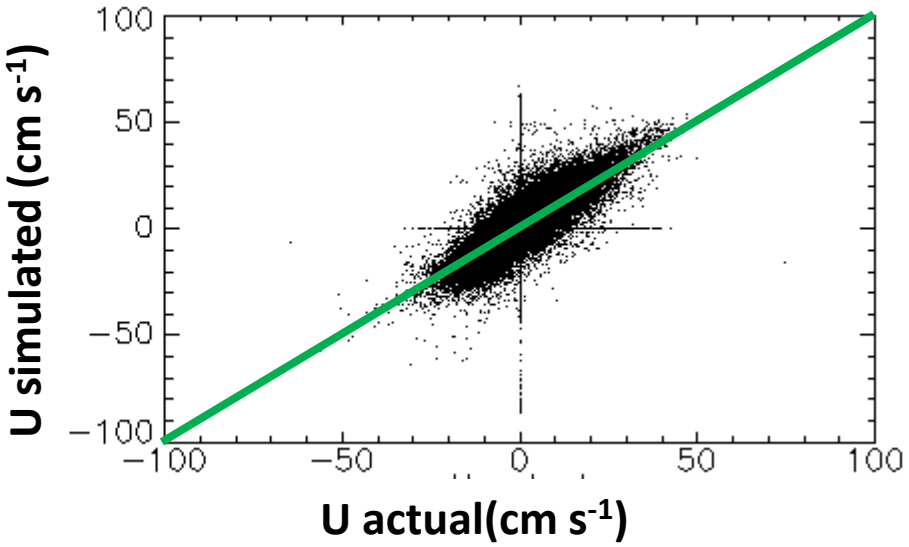
ARMAforCALYPSO: GAP FILLING

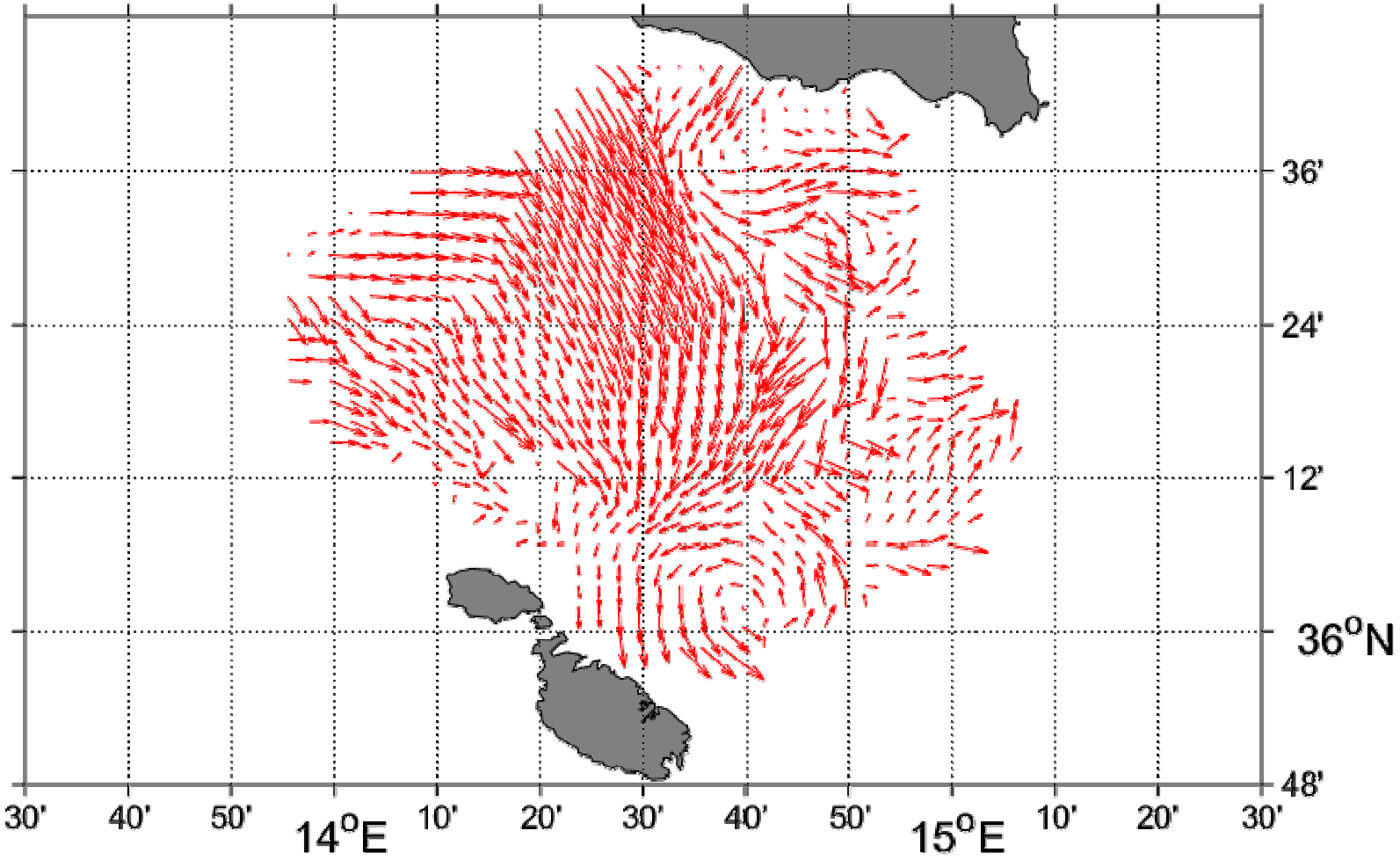


optimum





ARMAforCALYPSO: GAP FILLING



actual vector

simulated vector

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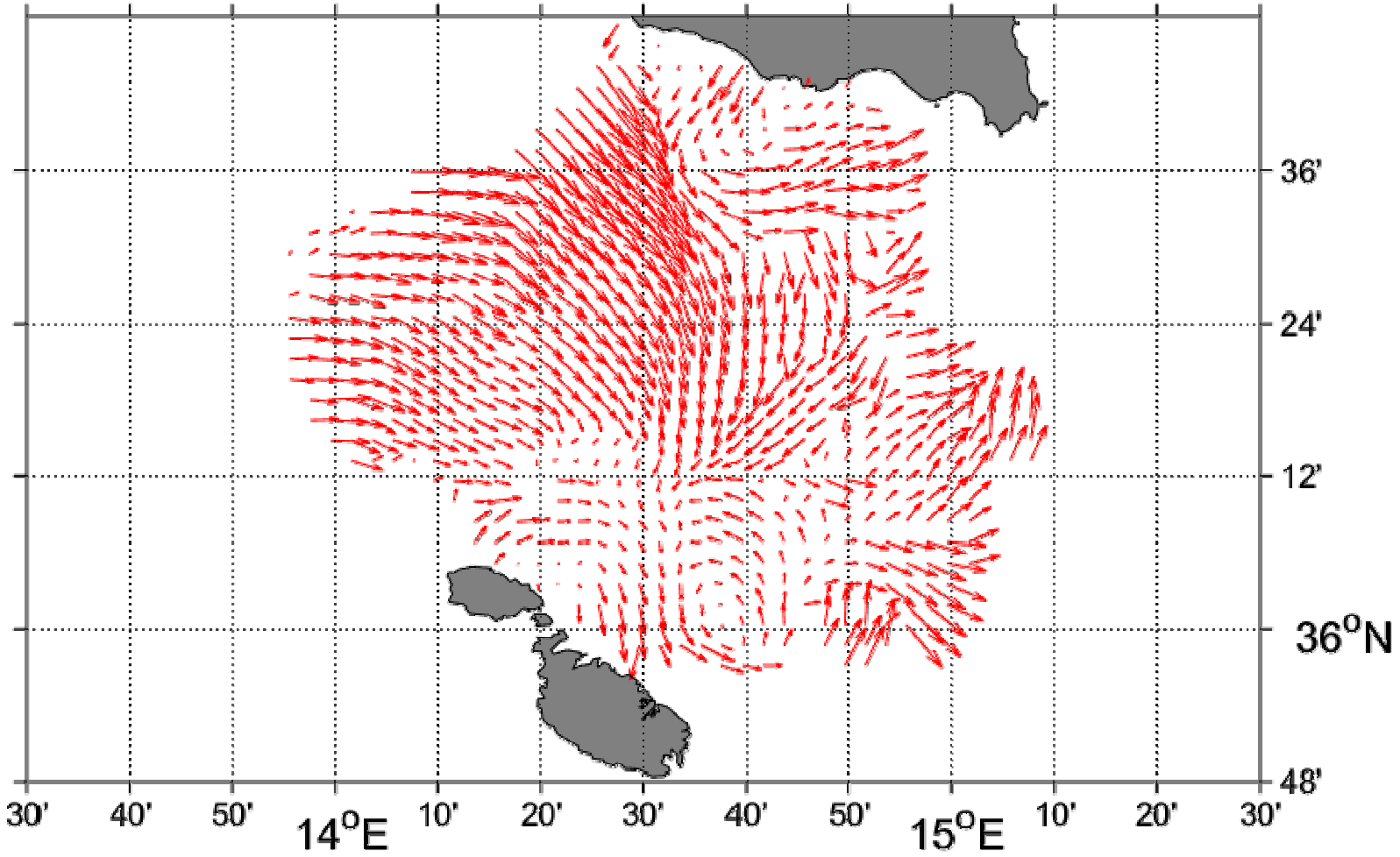

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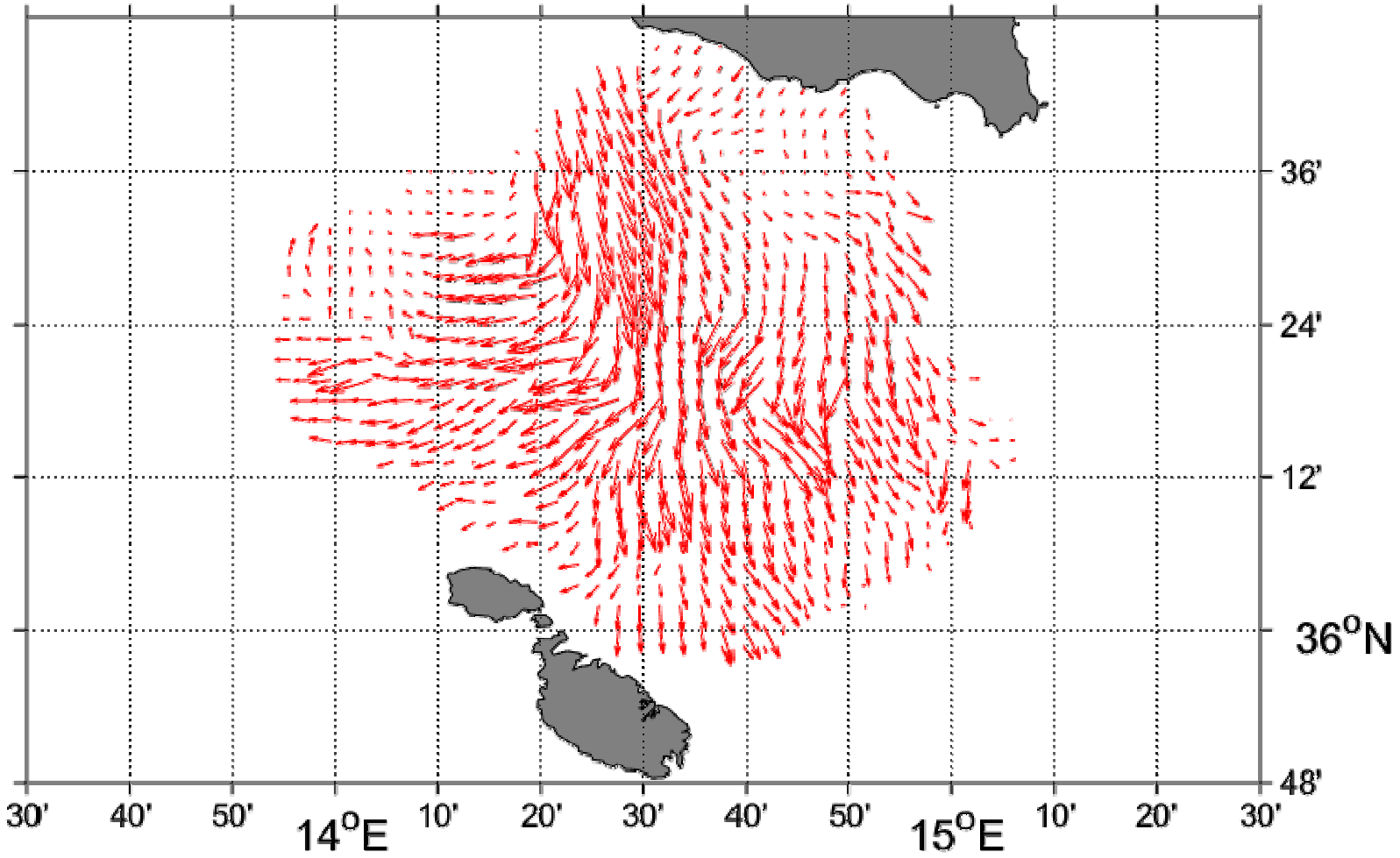

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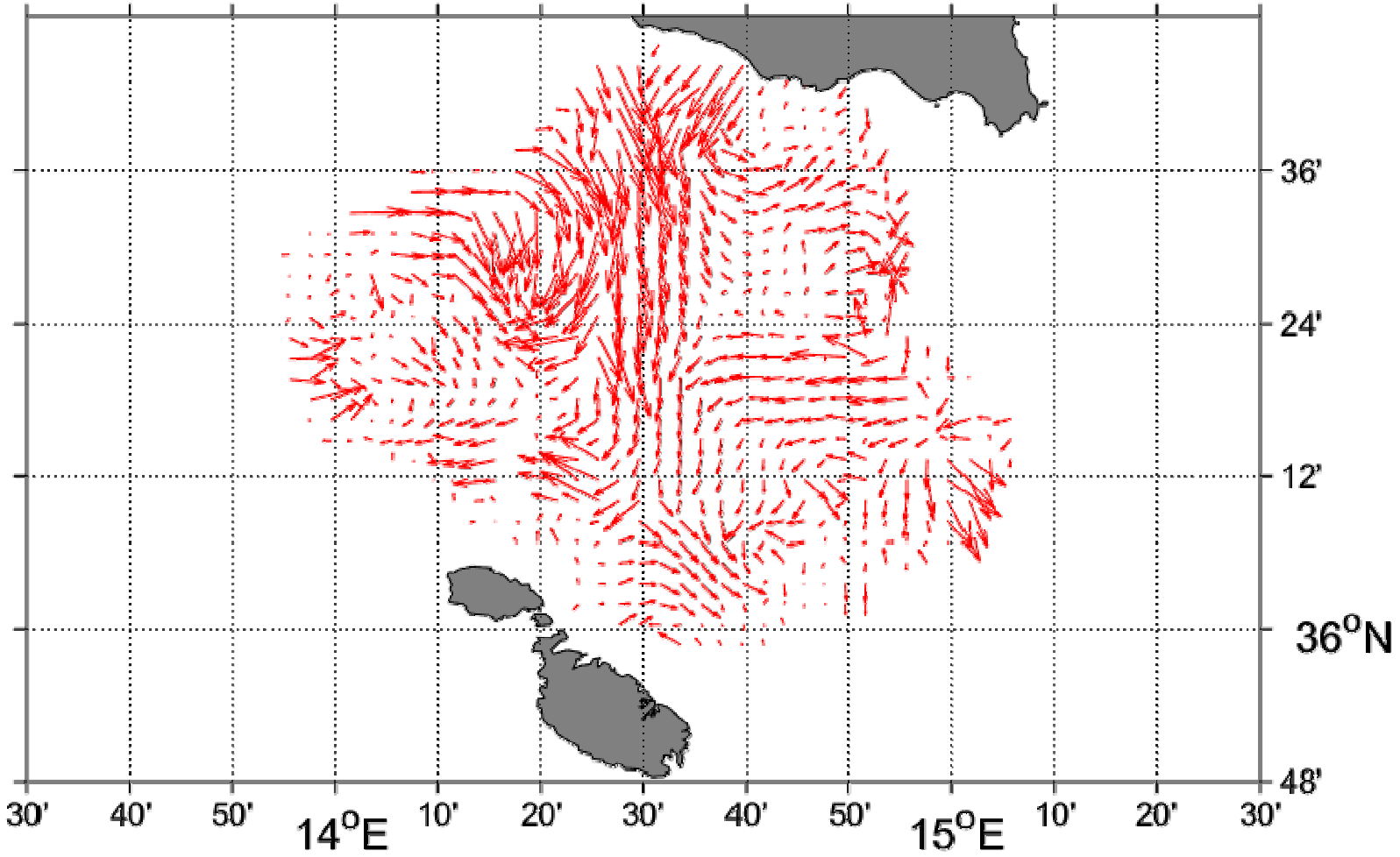

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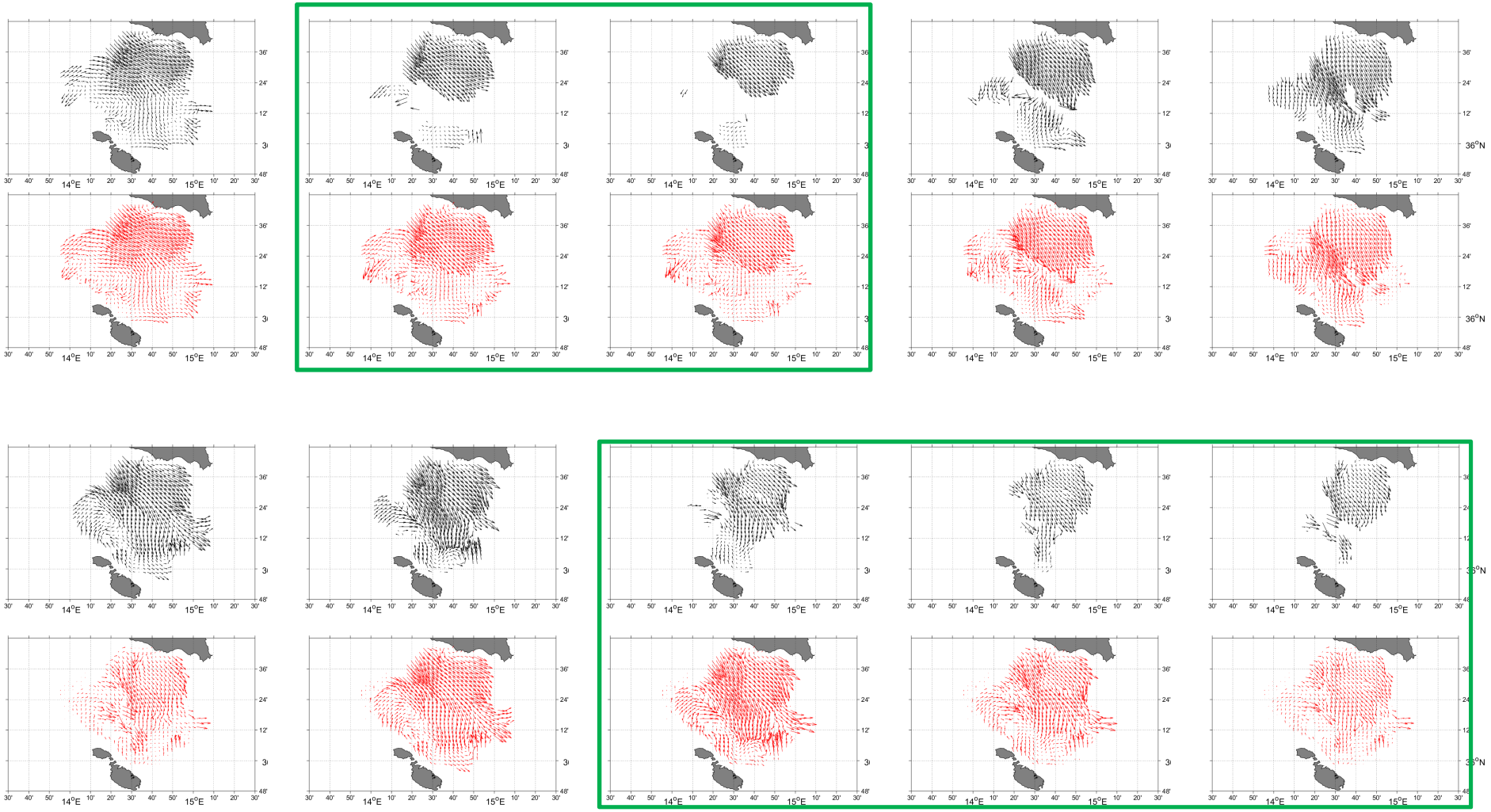

→ actual vector

→ simulated vector

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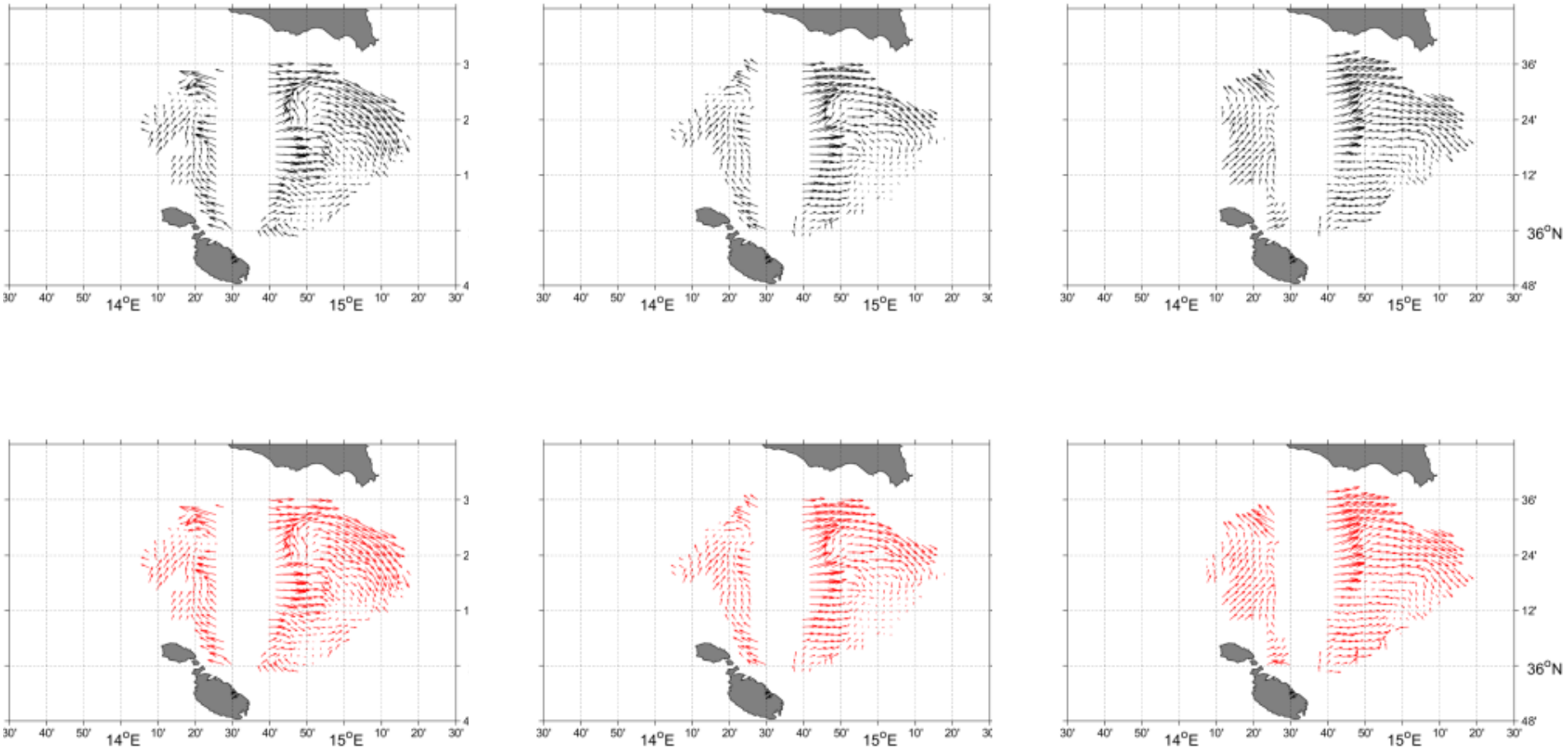
ARMAforCALYPSO: GAP FILLING

Problems in filling areas characterized by countinous gaps



actual vector

simulated vector

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Results (forecasting)

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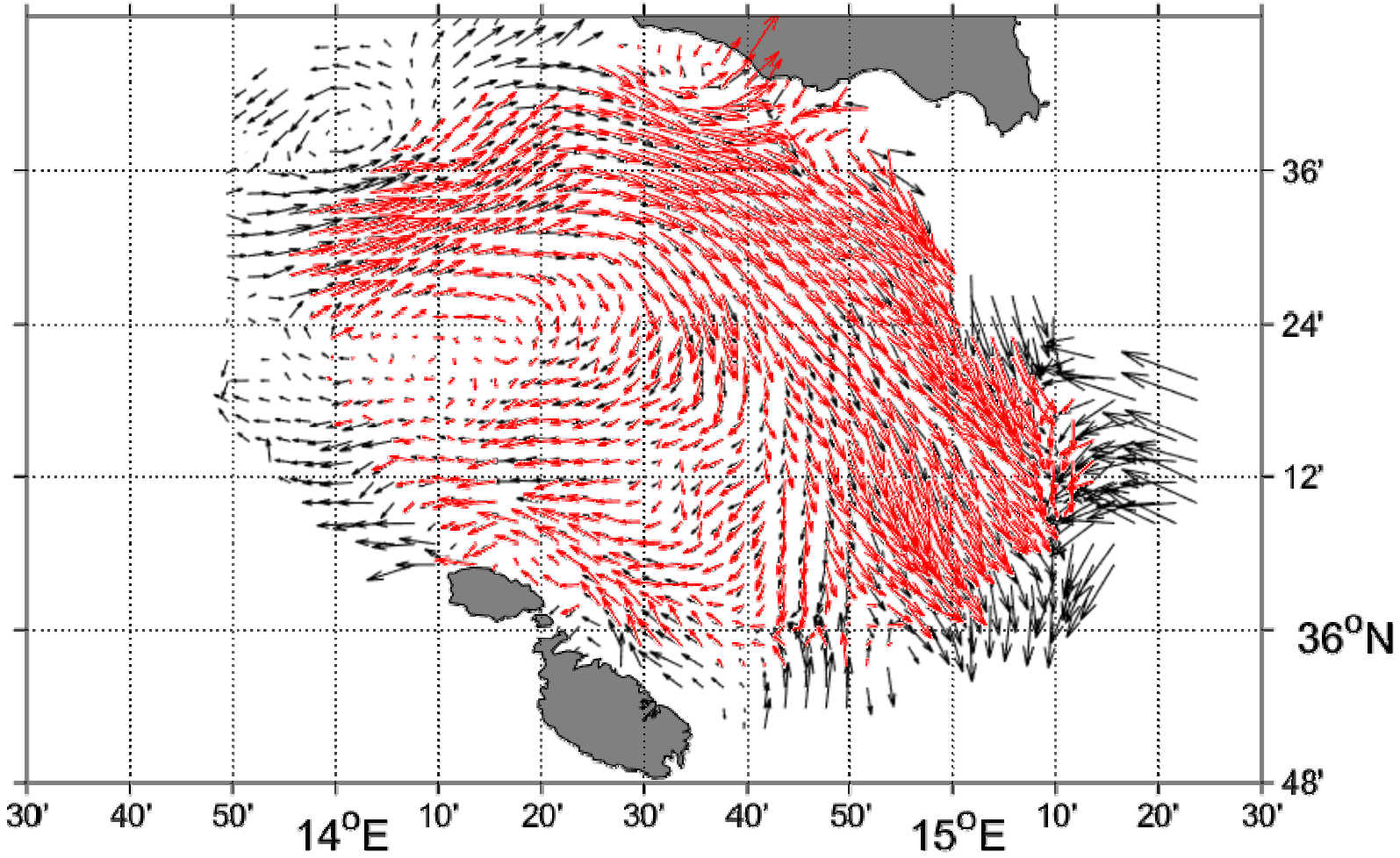
ARMAforCALYPSO: FORECASTING



actual vector

simulated vector

t=t+1

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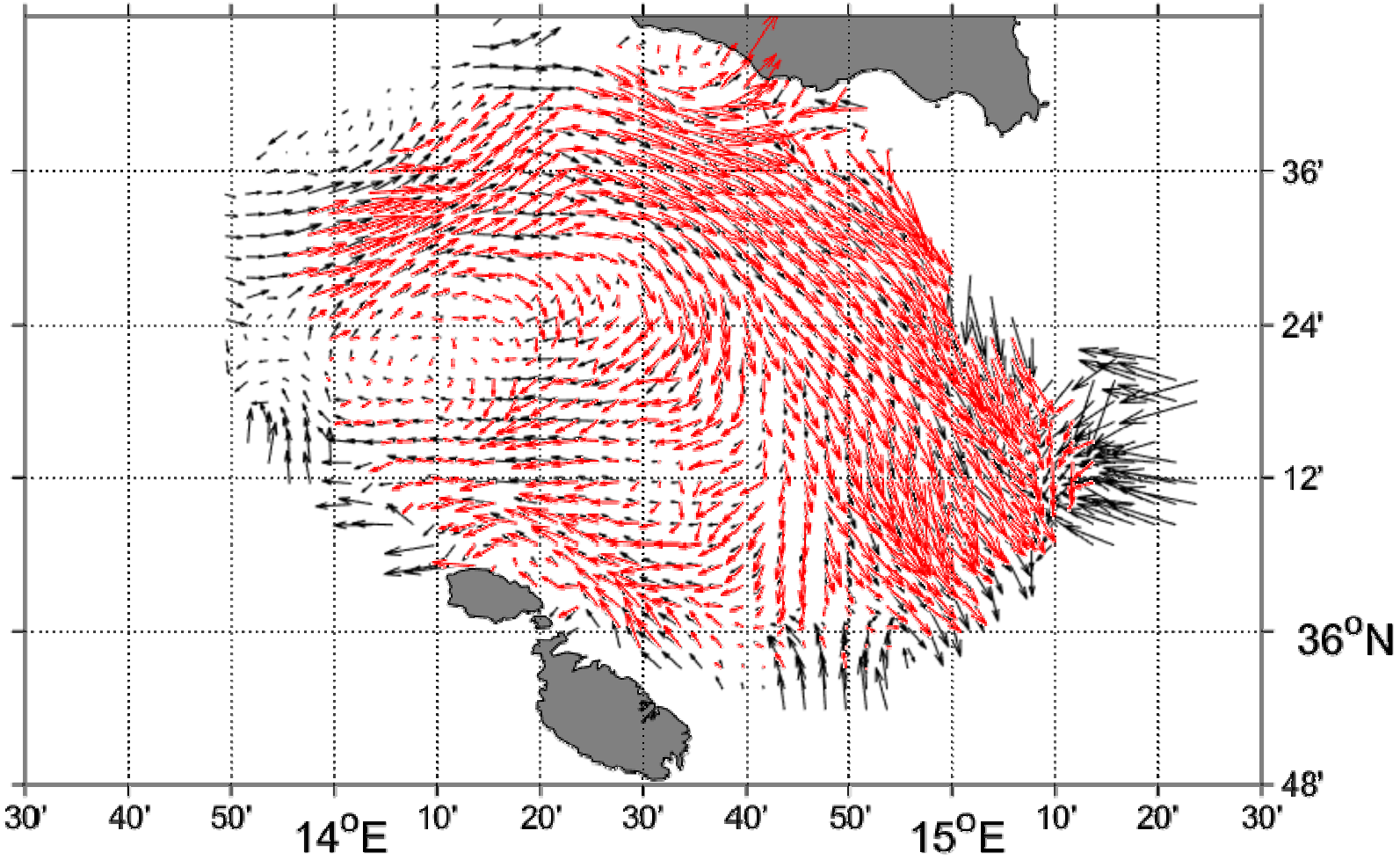
ARMAforCALYPSO: FORECASTING



actual vector

simulated vector

t=t+2

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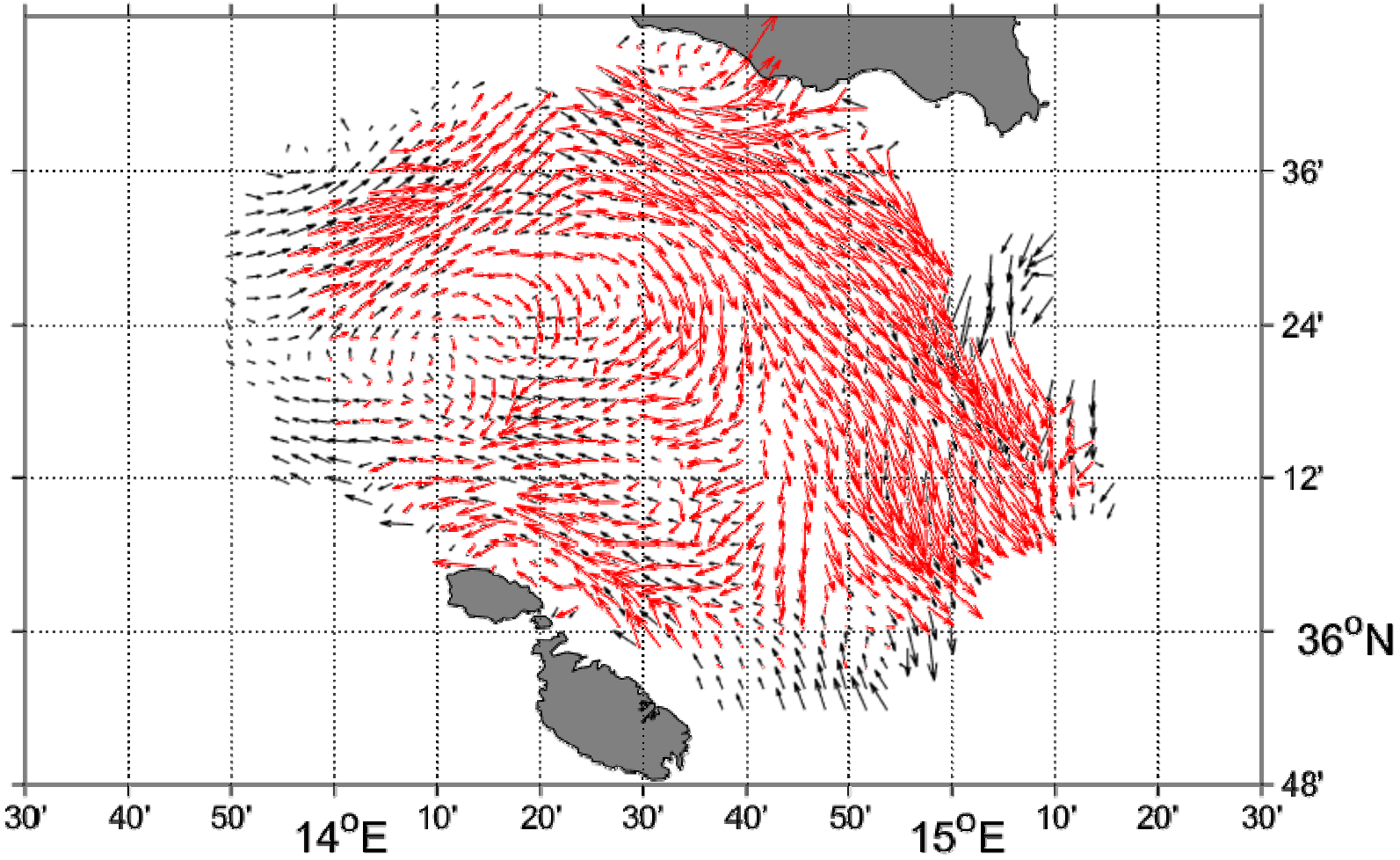
ARMAforCALYPSO: FORECASTING



actual vector

simulated vector

t=t+3

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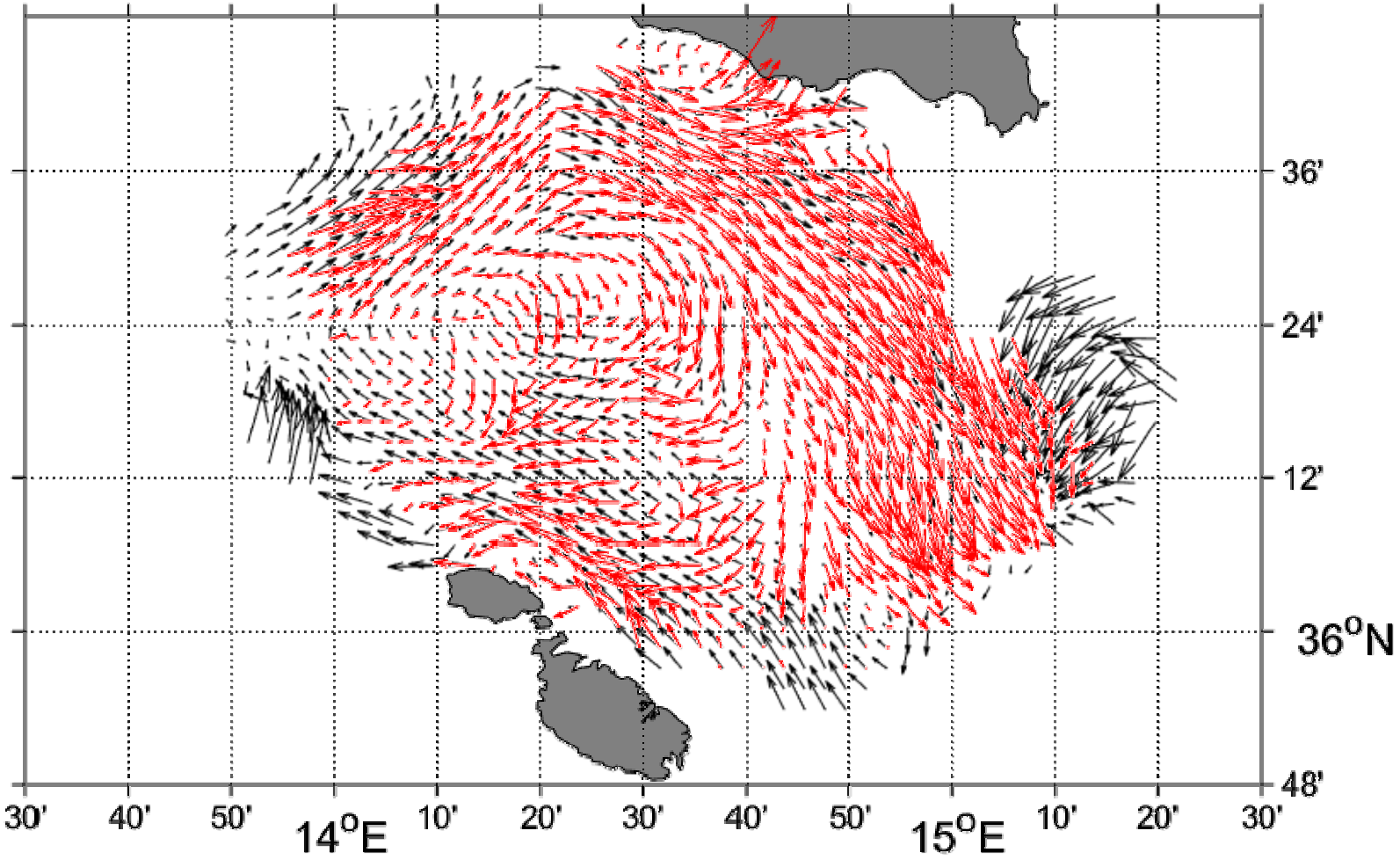
ARMAforCALYPSO: FORECASTING



actual vector

simulated vector

t=t+4

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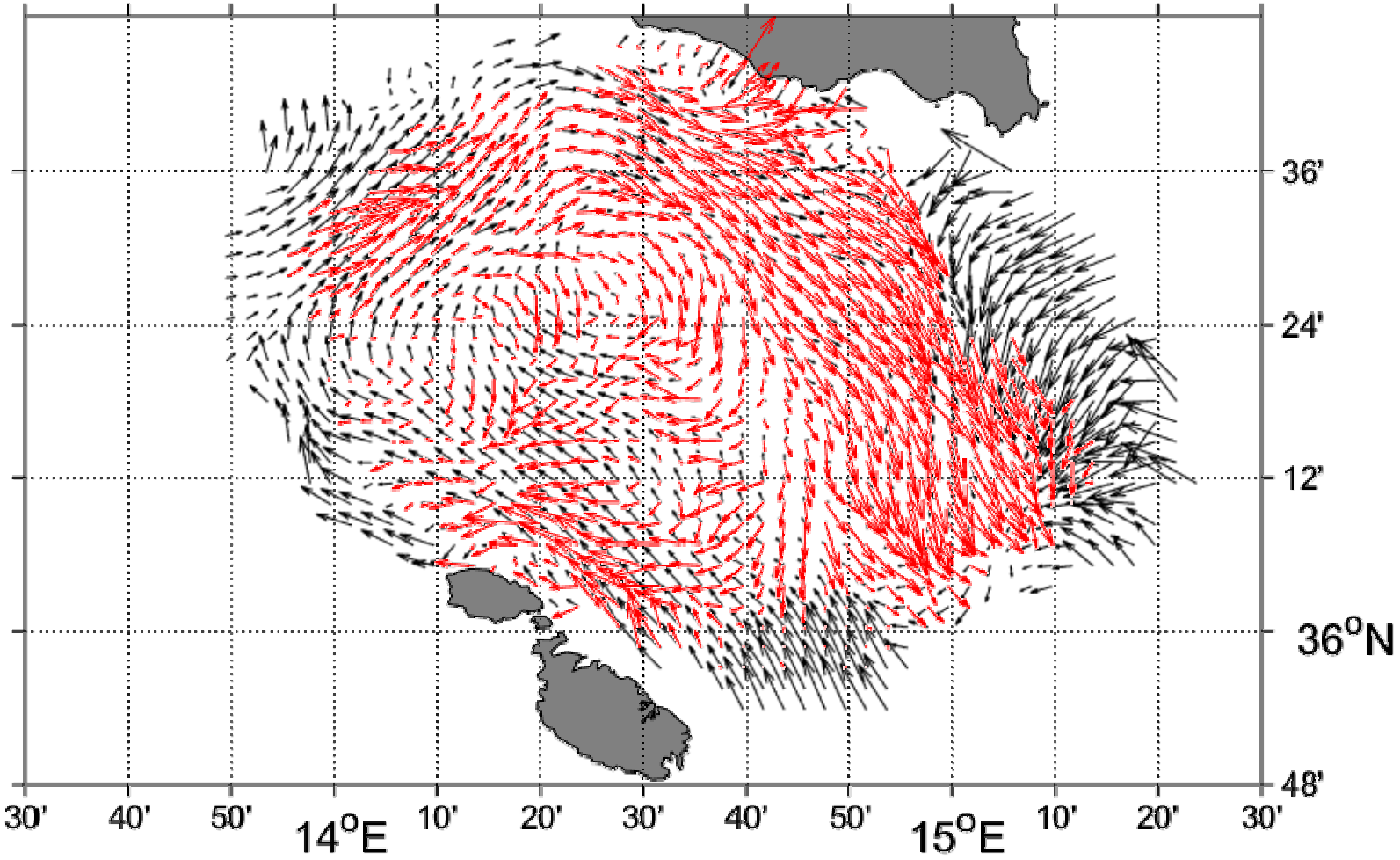
ARMAforCALYPSO: FORECASTING



actual vector

simulated vector

t=t+5

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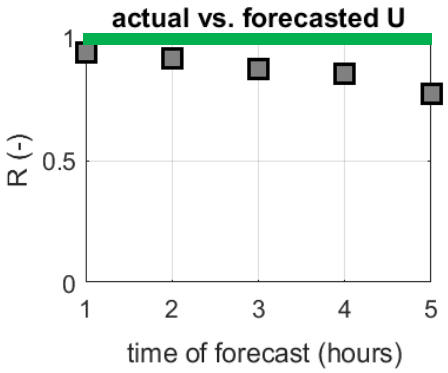
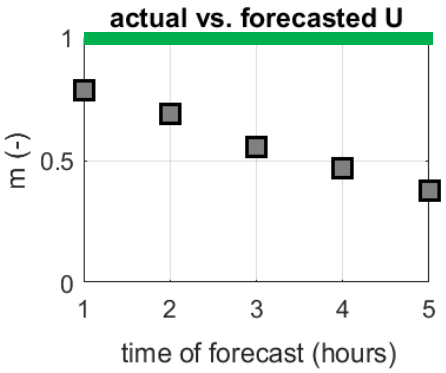
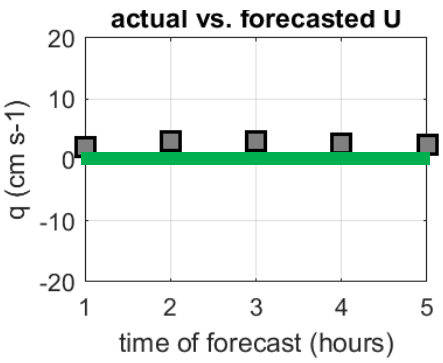
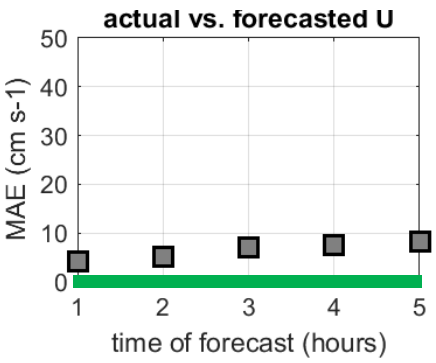
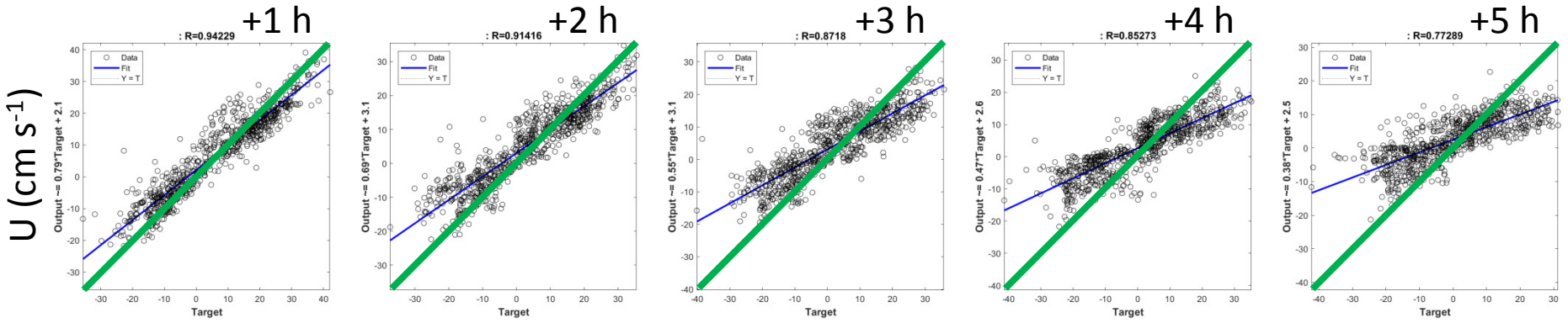
ARMAforCALYPSO: FORECASTING











optimum

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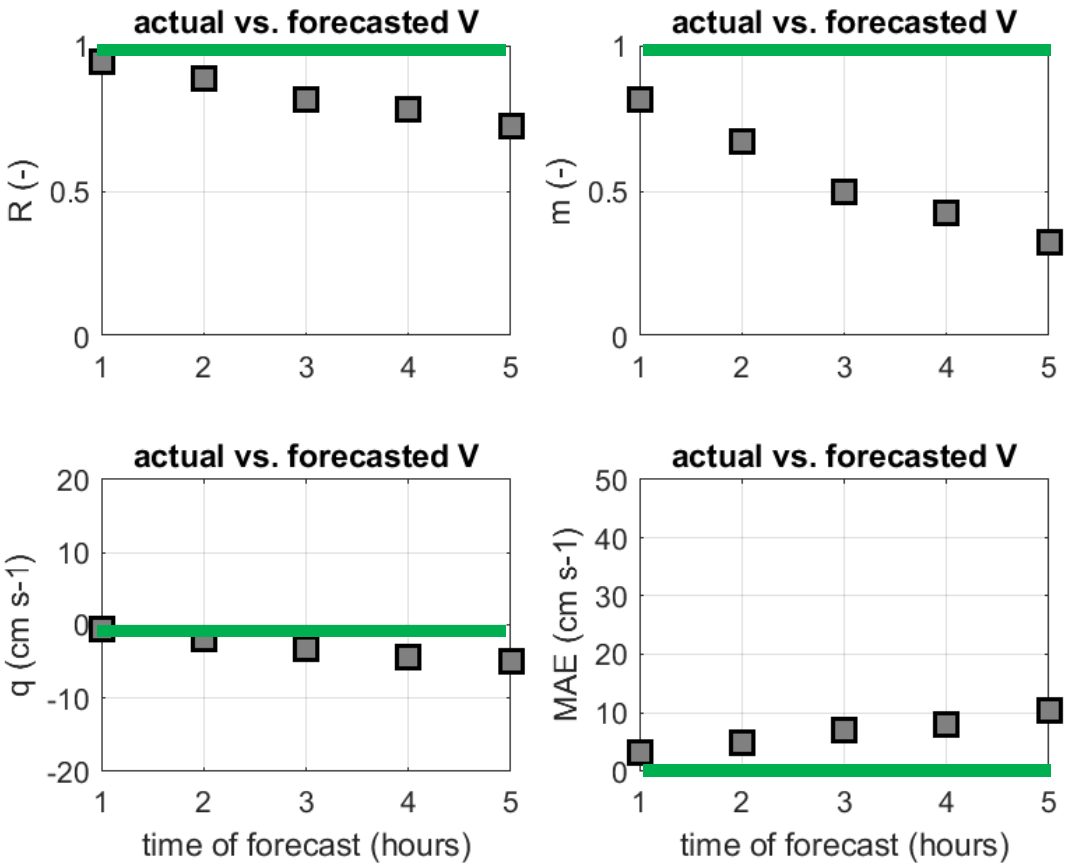
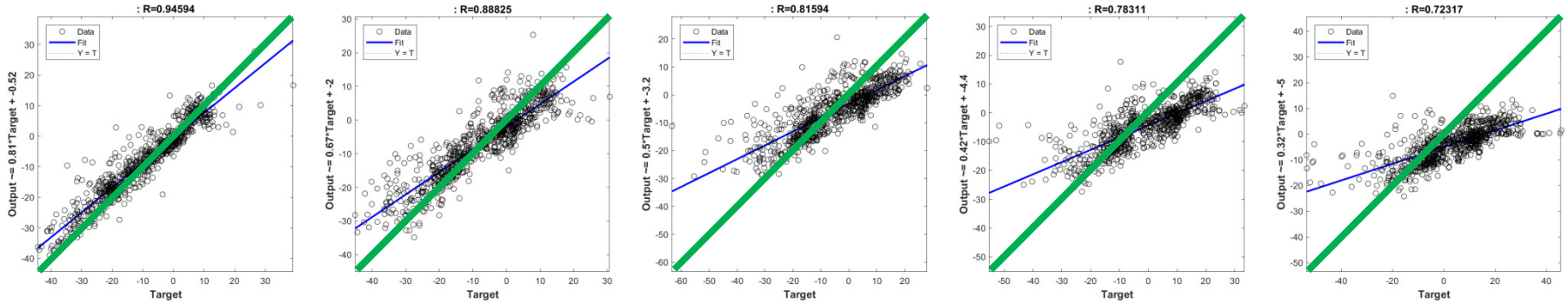


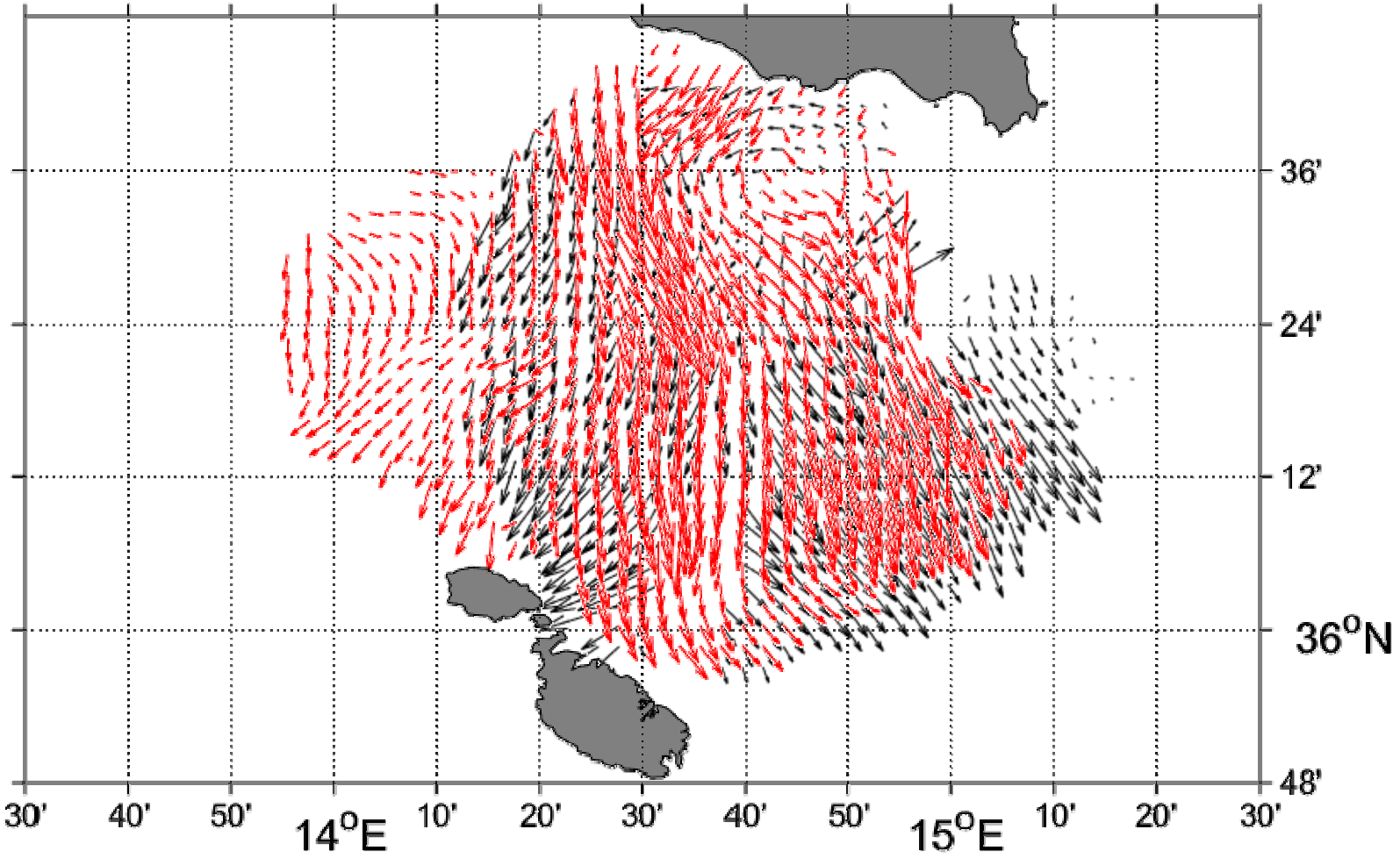
optimum

V (cm s^{-1})



ARMAforCALYPSO: FORECASTING

Problems in forecasting highly variable currents



actual vector

simulated vector

t=t+1

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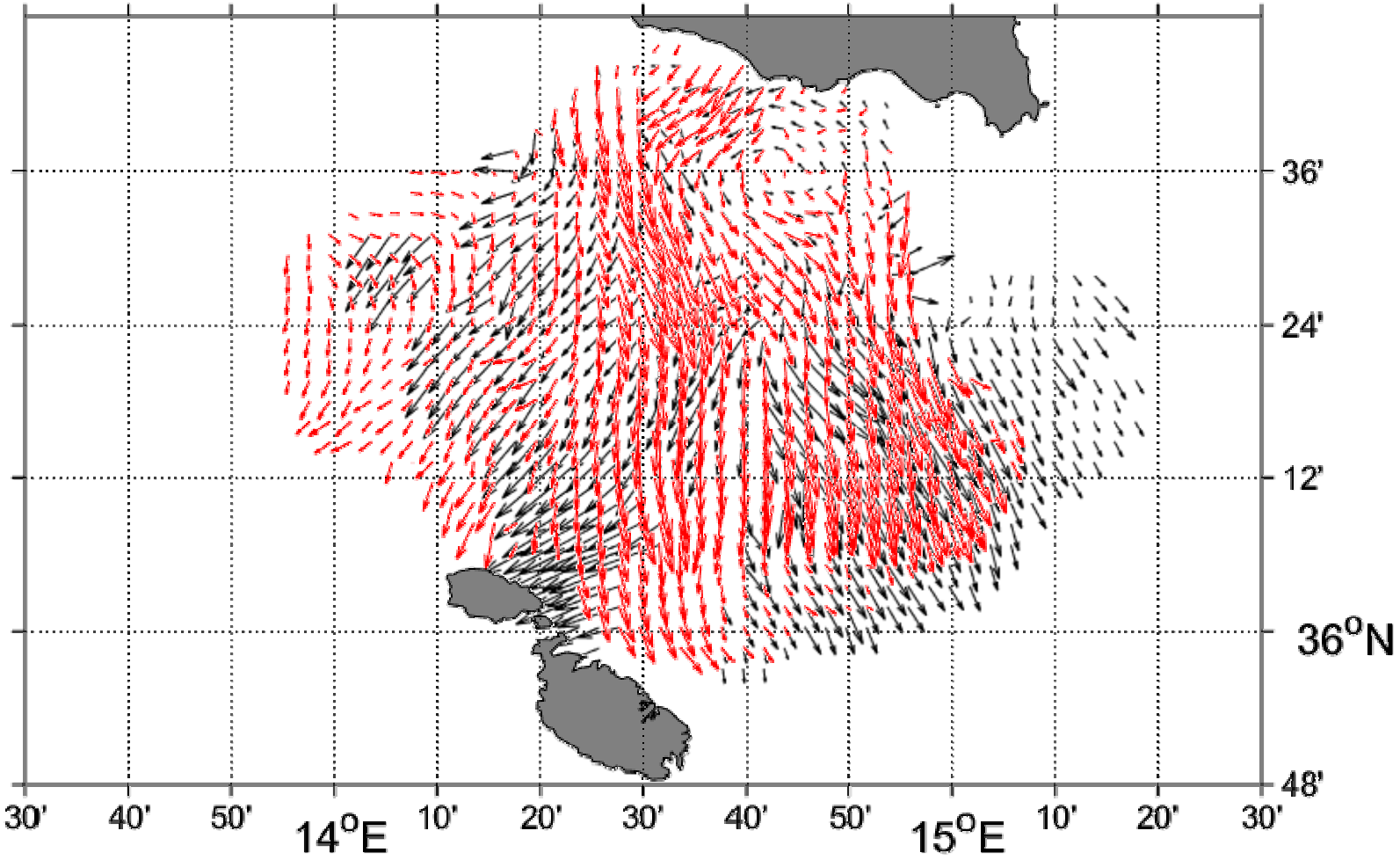
ARMAforCALYPSO: FORECASTING

Problems in forecasting highly variable currents



actual vector

simulated vector

t=t+2

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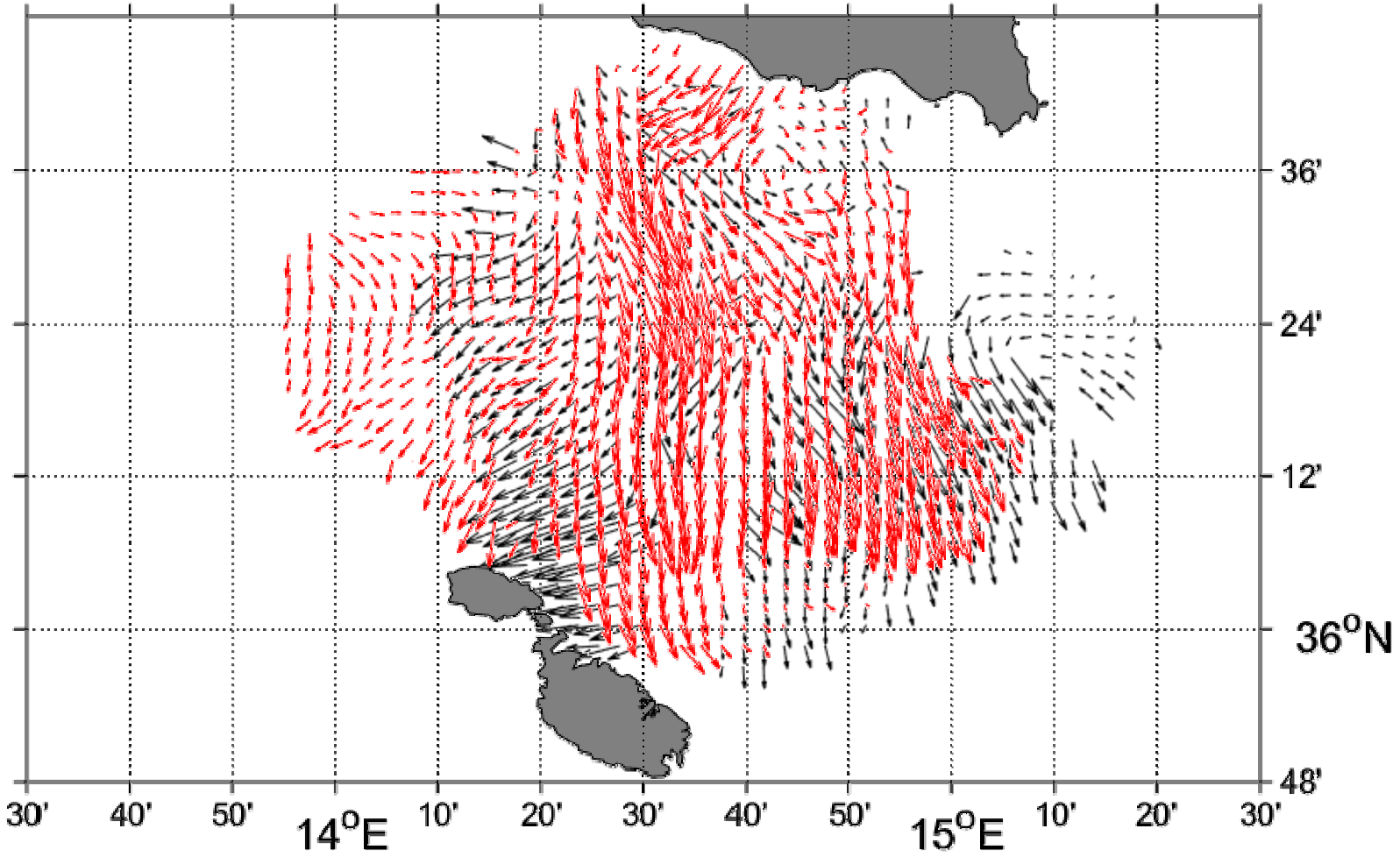
ARMAforCALYPSO: FORECASTING

Problems in forecasting highly variable currents



actual vector

simulated vector

t=t+3

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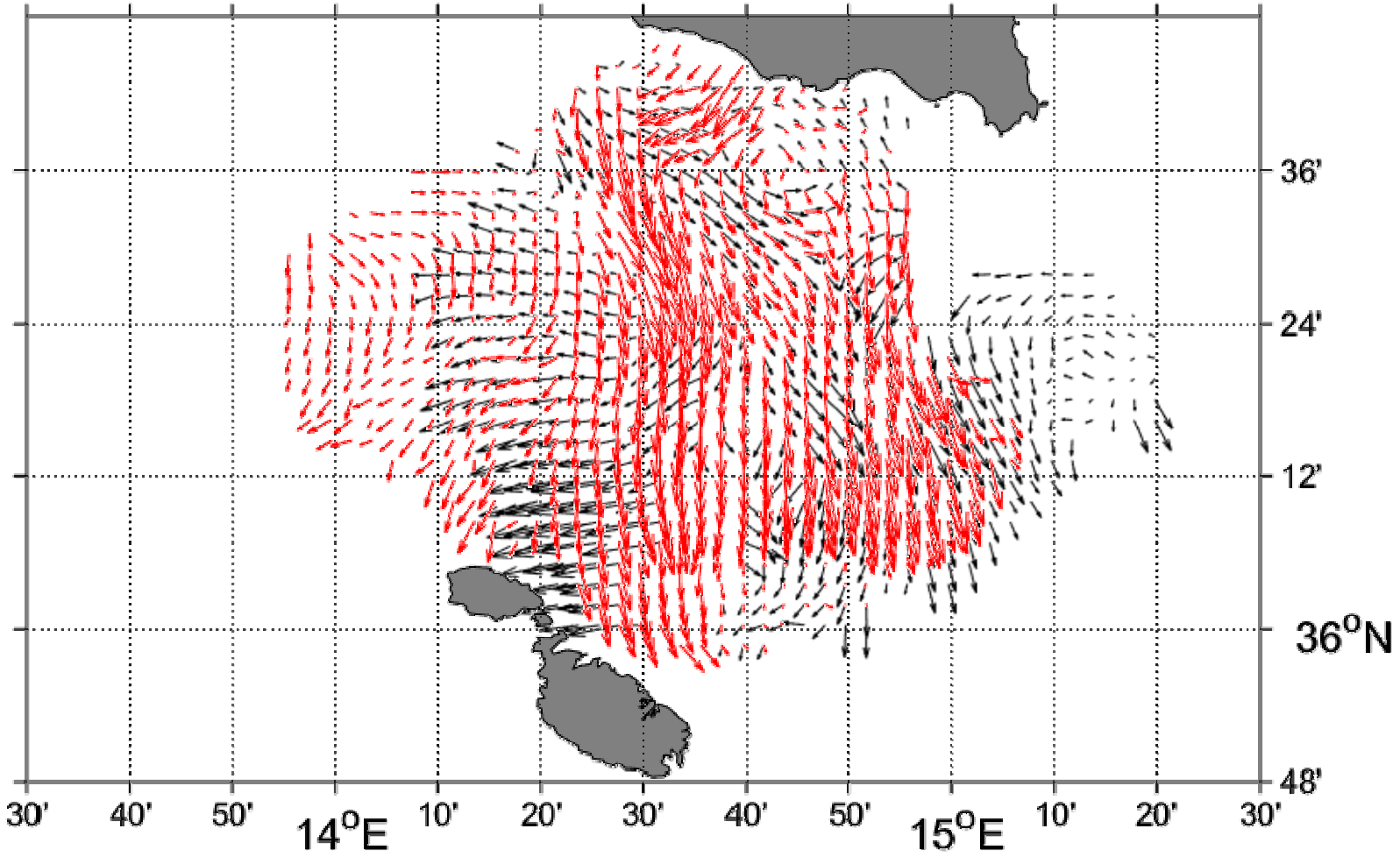
ARMAforCALYPSO: FORECASTING

Problems in forecasting highly variable currents



actual vector

simulated vector

t=t+4

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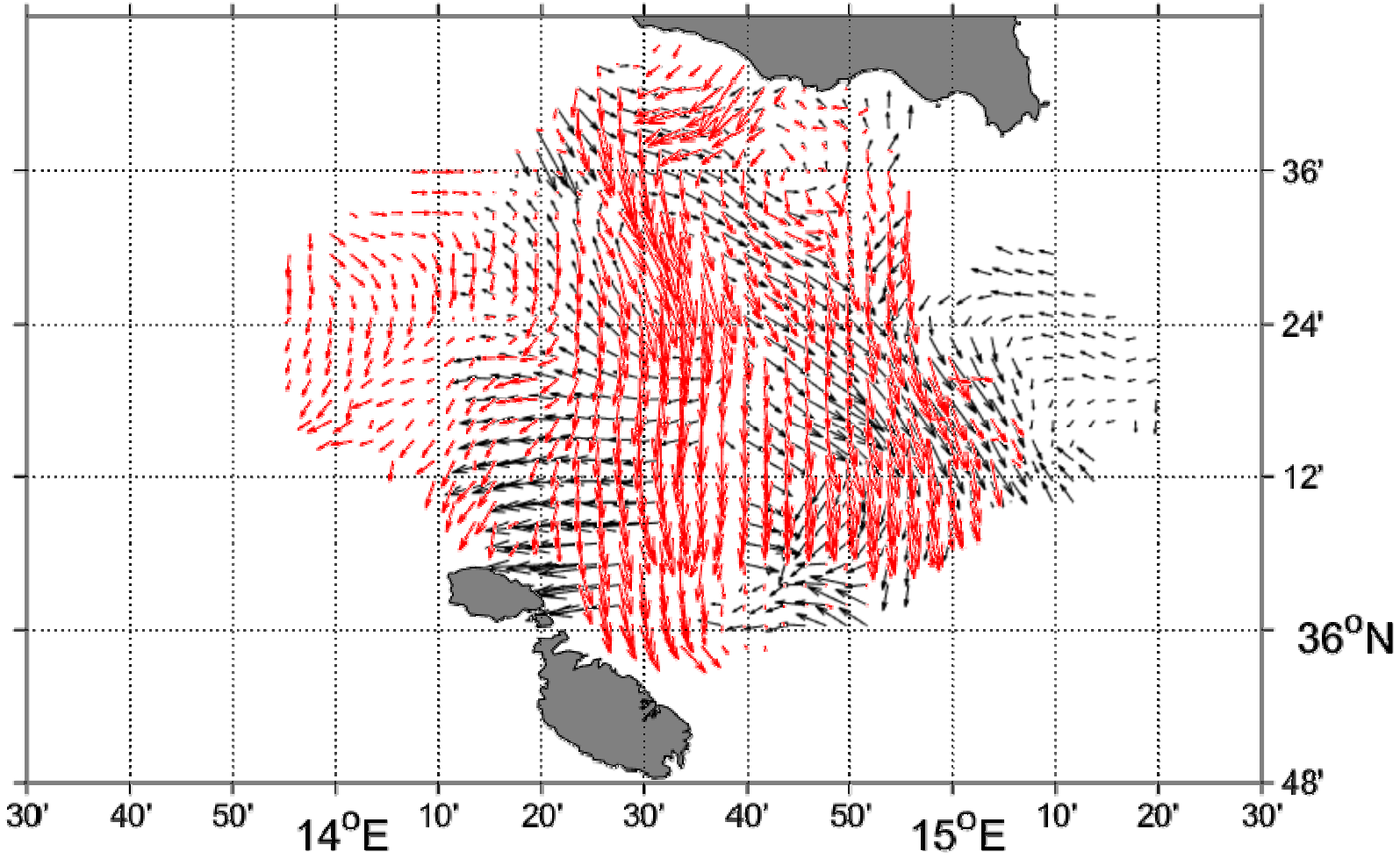
ARMAforCALYPSO: FORECASTING

Problems in forecasting highly variable currents



actual vector

simulated vector

t=t+5

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FUTURE DEVELOPMENTS

- Including spatial gap filling techniques
  - Mixing gap filling?
- Understanding because of ARMA sometimes fails;
- Compare ARMA with other gap filling and data forecasting models;

QUESTIONS?

For further information please contact

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