Po River plume and Northern Adriatic Dense Water: a modeling and statistical approach

***Francesco M. Falcieri*[1], *Alvise Benetazzo*[1], *Mauro Sclavo*[1], *Sandro Carniel*[1], *Andrea Bergamasco*[1], *Davide Bonaldo*[1], *Francesco Barbariol*[1] *and Aniello Russo*[2]**

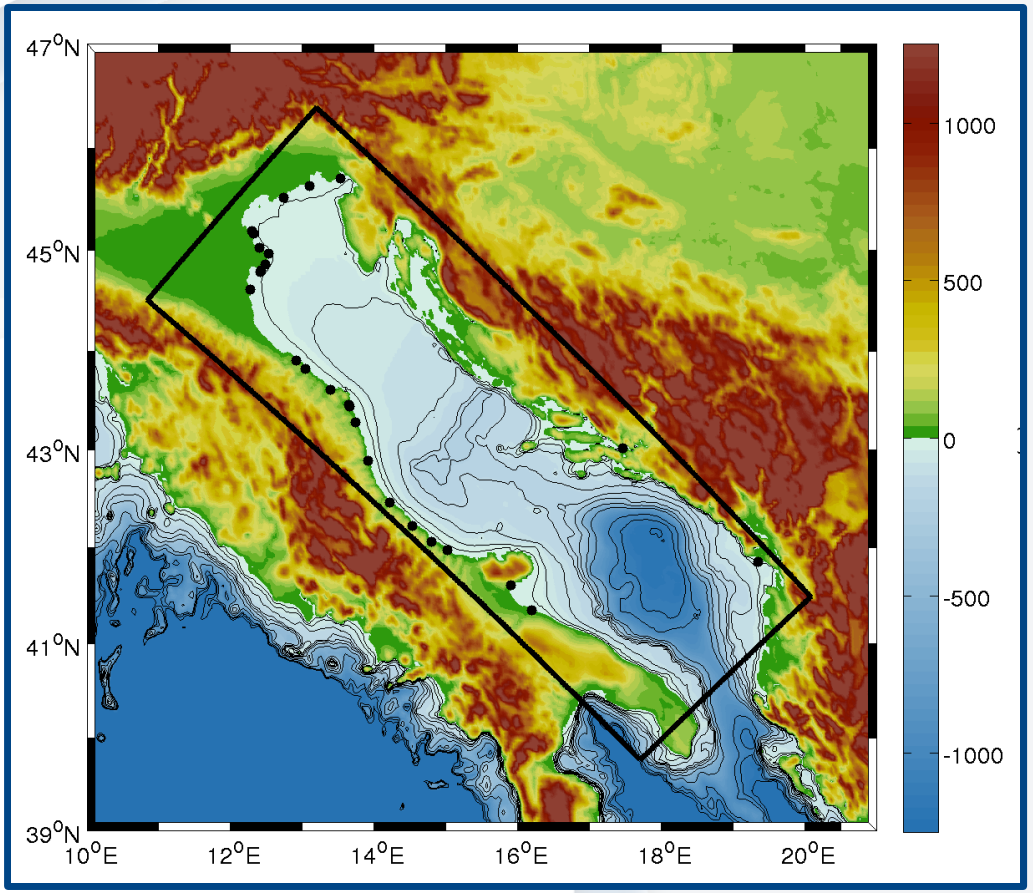
[1] *CNR-ISMAR (Venezia, Italy);*

[2] *Università Politecnica delle Marche (Ancona, Italy)*

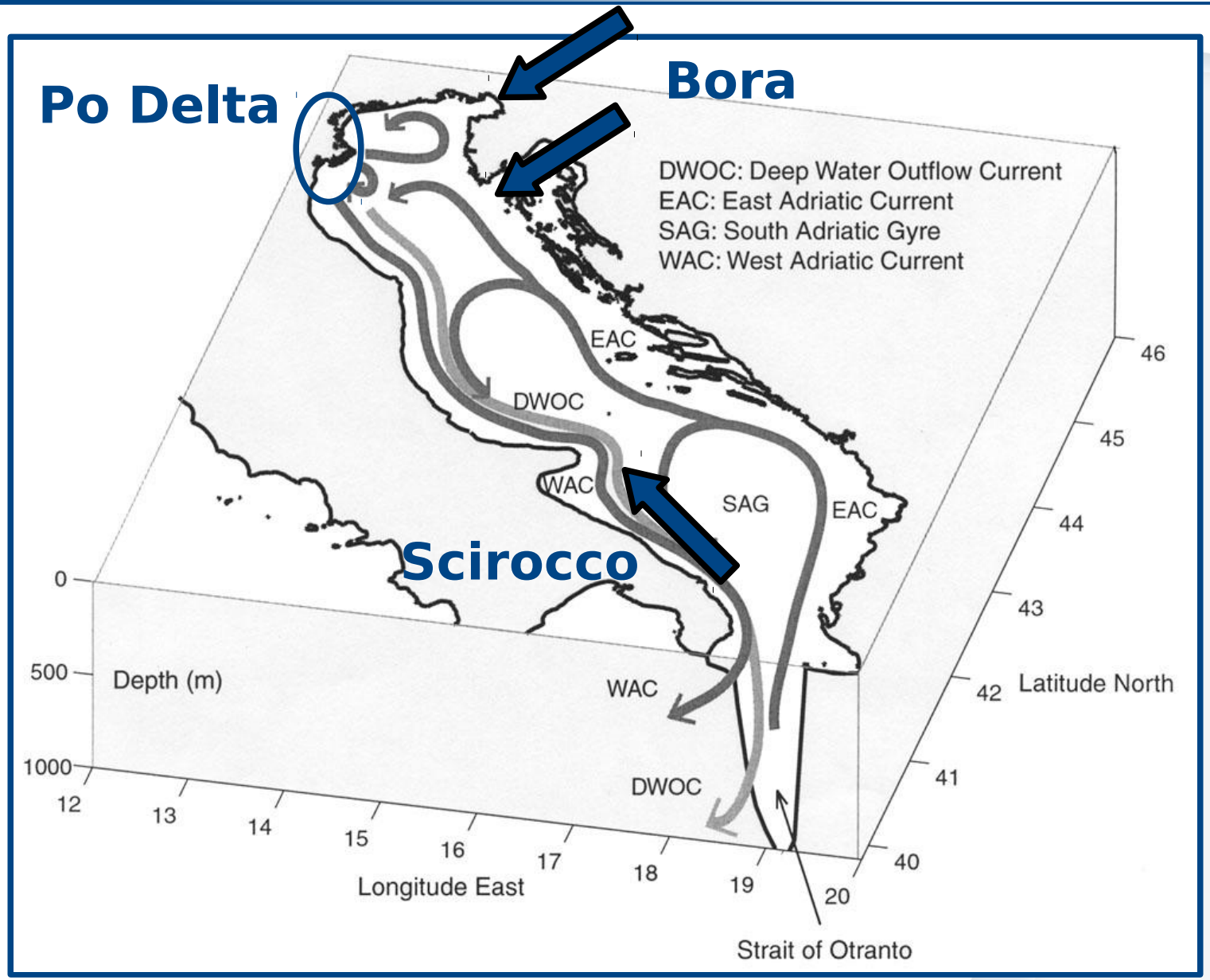
francesco.falcieri@ve.ismar.cnr.it

The Adriatic Sea

- Northernmost Mediterranean epicontinental sub-basin
- Circulation defined by winds and buoyancy gradients
- Site of NAdDW formation
- High socio-economical and ecological value

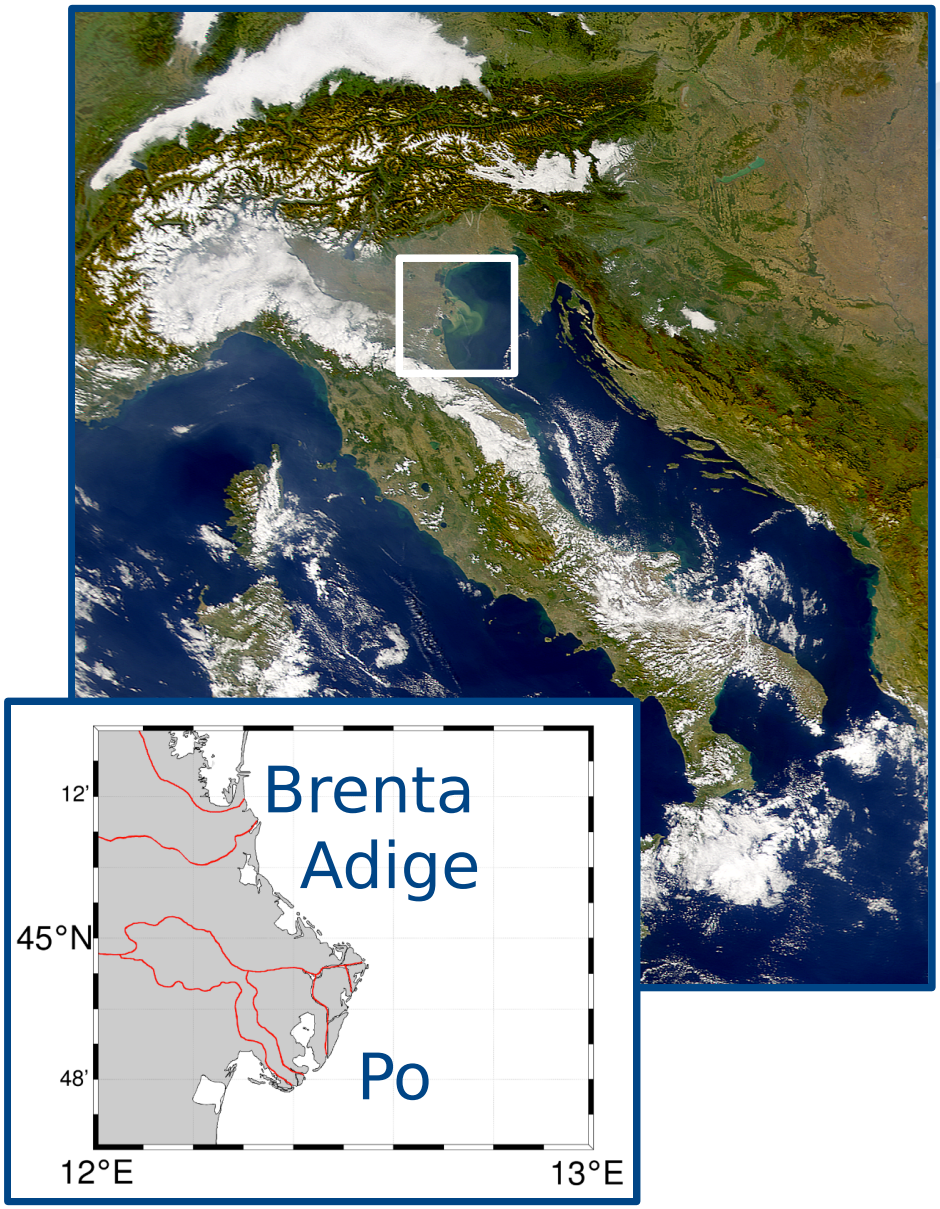


The Po Plume



(from Cushman-Roisin et al, 2002)

The Po Plume



- Composed of the 5 Po river's mouths and of Adige and Brenta rivers
- High seasonal horizontal and vertical variability
- Dynamics driven by:
  - Total freshwater discharges
  - Sub-basin wind regime
  - Local circulation
  - Coastline and bottom topography

The Po Plume

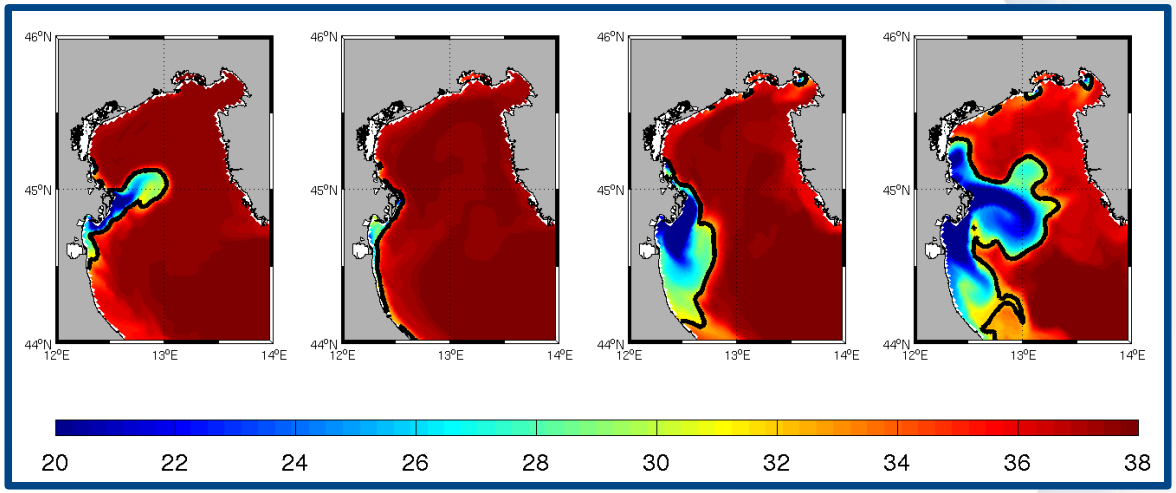
Mean daily discharge: 1500 m^3/s (max of 11550 m^3/s)

Physics:

- Gradients that contribute to general circulation
- Effects on buoyancy
- Freshening of coastal waters;
- Northern Adriatic Dense Water (NAdDW)

Biology:

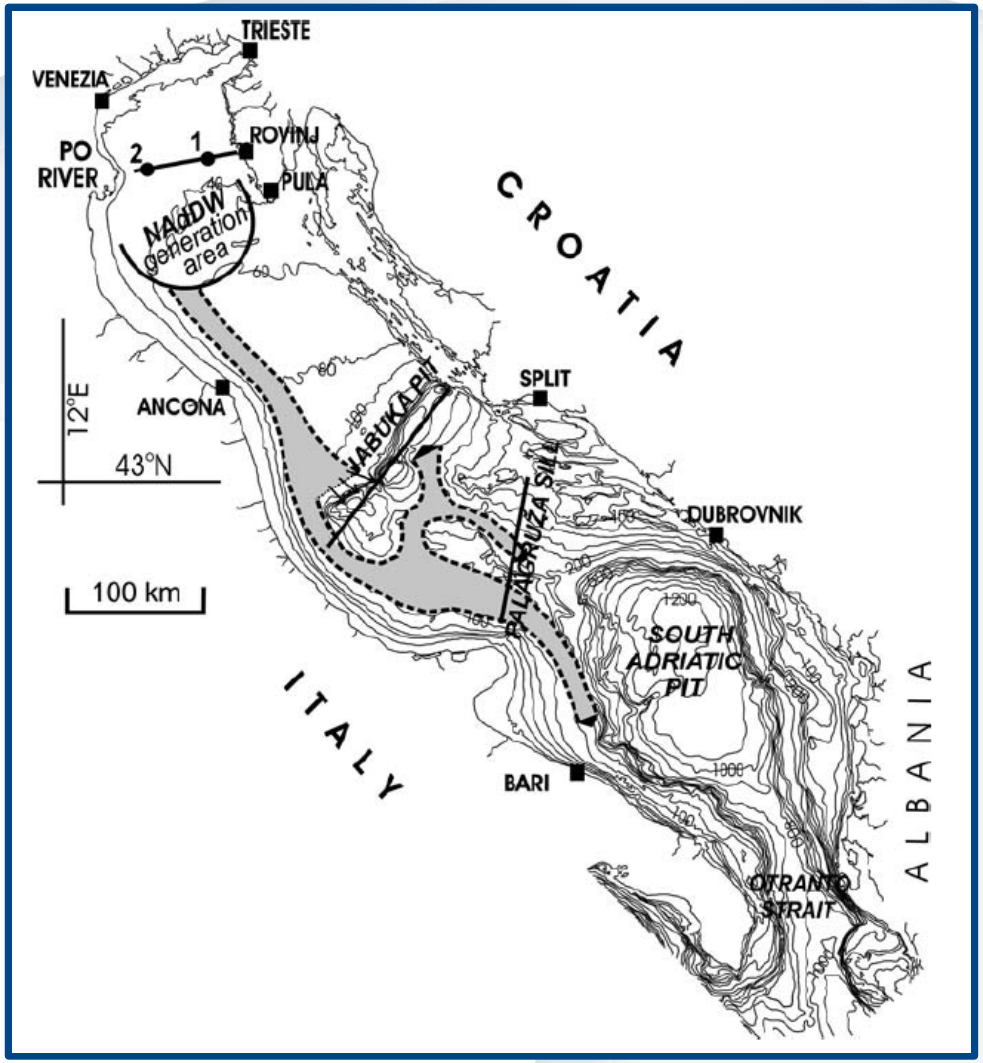
- Sustain primary production
- Enhance secondary production;
- Bring large amounts of nutrients (eutrophication)
- Algal blooms.



Northern Adriatic Dense Waters

"Why do we care about Physics?
Because of Biology!"
(Moninya Roughan)

- Export of sediments, nutrients and oxygen to the Southern Adriatic Pit
- Sustain deep water environments
- Renewal of NA waters



(from: Vilibic and Supic, Ocean Dynamics 2005)

Northern Adriatic Dense Waters

Heat fluxes

Heat losses during winter months mostly due to cold Bora outbreaks

Water Fluxes

Preconditioning phase with low river discharges 2 and up to 8 months prior of formation

LIW

Advection of more saline Levantine Intermediate Waters (LIW) in the NA

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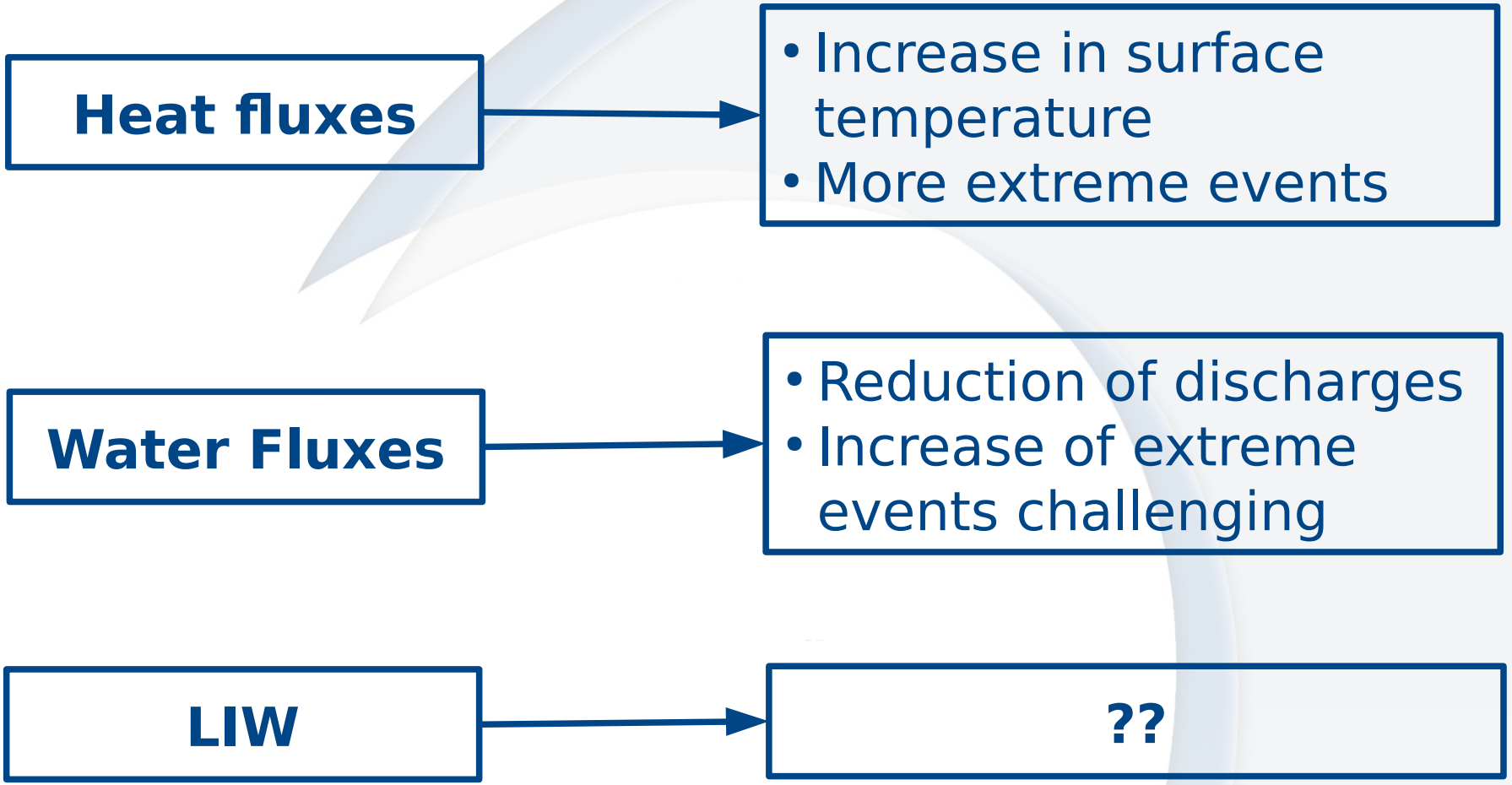
ISMAR Istituto di Scienze Marine

From IPCC 5 Assessment Report WPI: “The scientific base:



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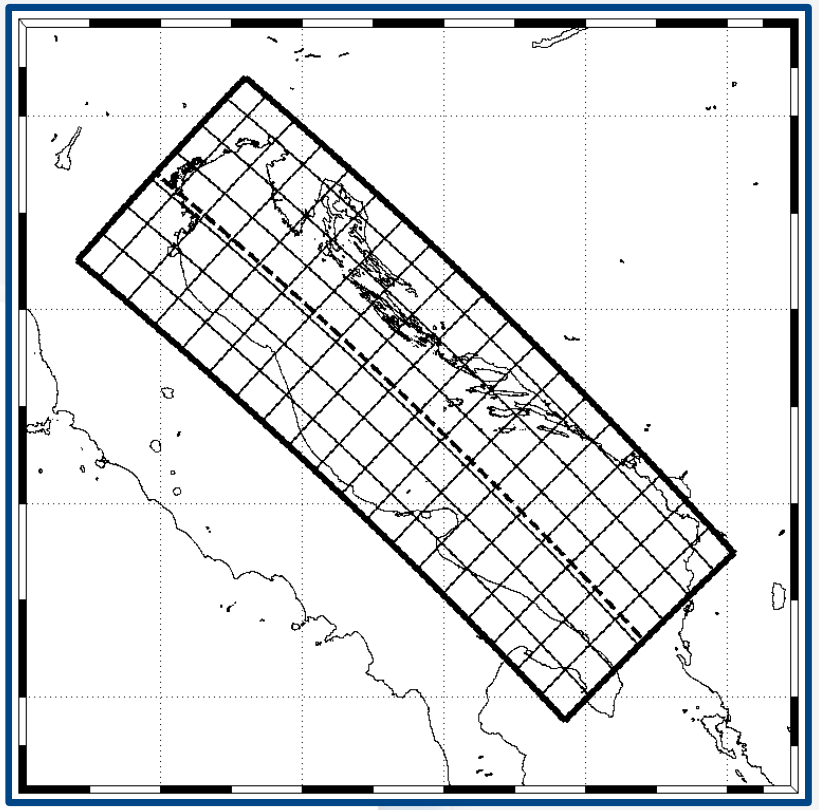
Model implementation

2km horizontal resolution
20 vertical levels
Sigma coordinates

Generic Length Scale mixing scheme

Kantha-Clayson stability function

Initial condition set on September 2002 from objective analysis of observation



Model implementation

44 rivers and underwater springs

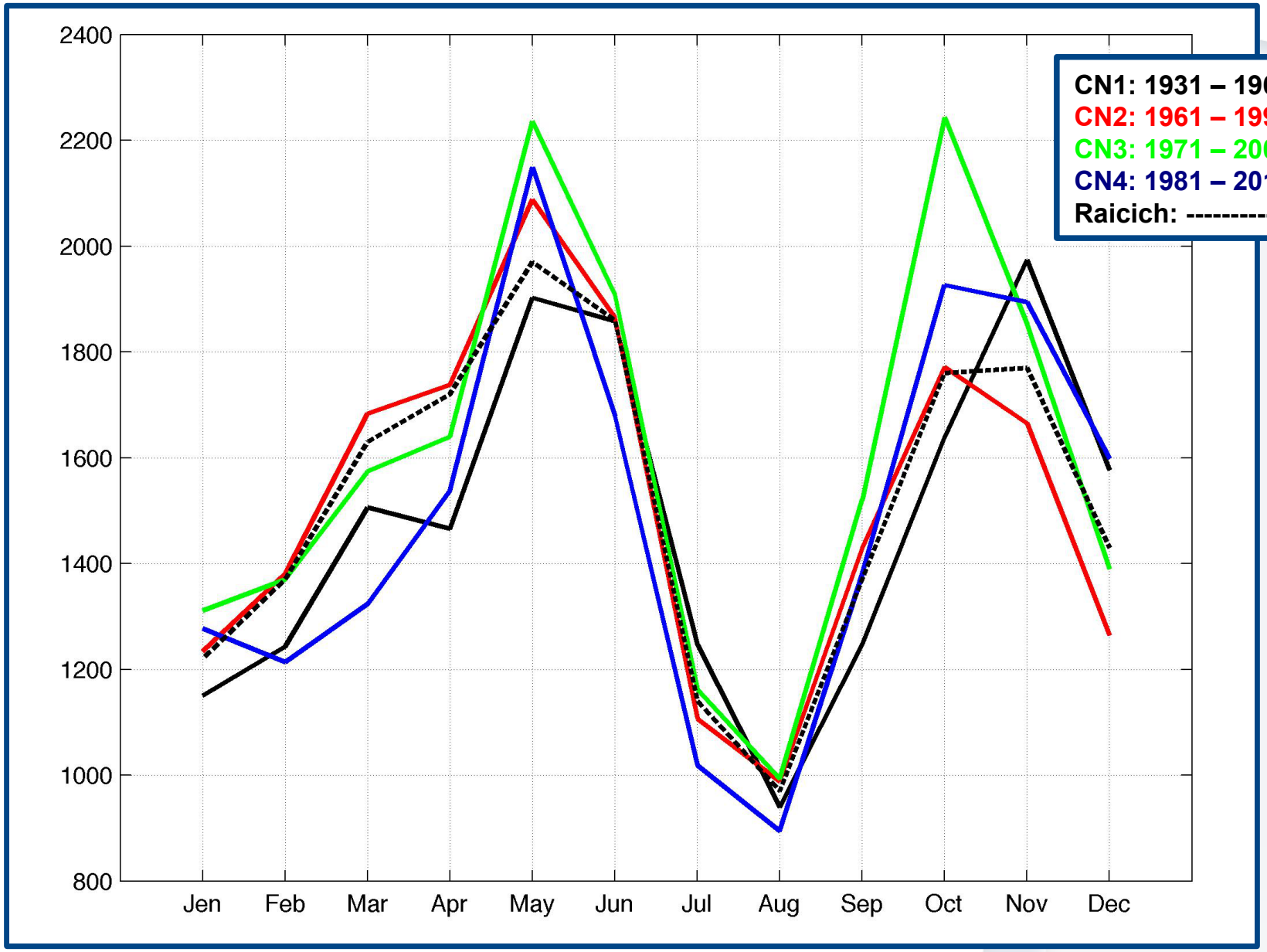
- Measured (Po, Adige, Pescara)
- Raichic 1994
- New climatologies from available data

Tides harmonics from the Oregon State University Tidal Model
(M2, S2, N2, K2, K1, O1, P1 and Q1)

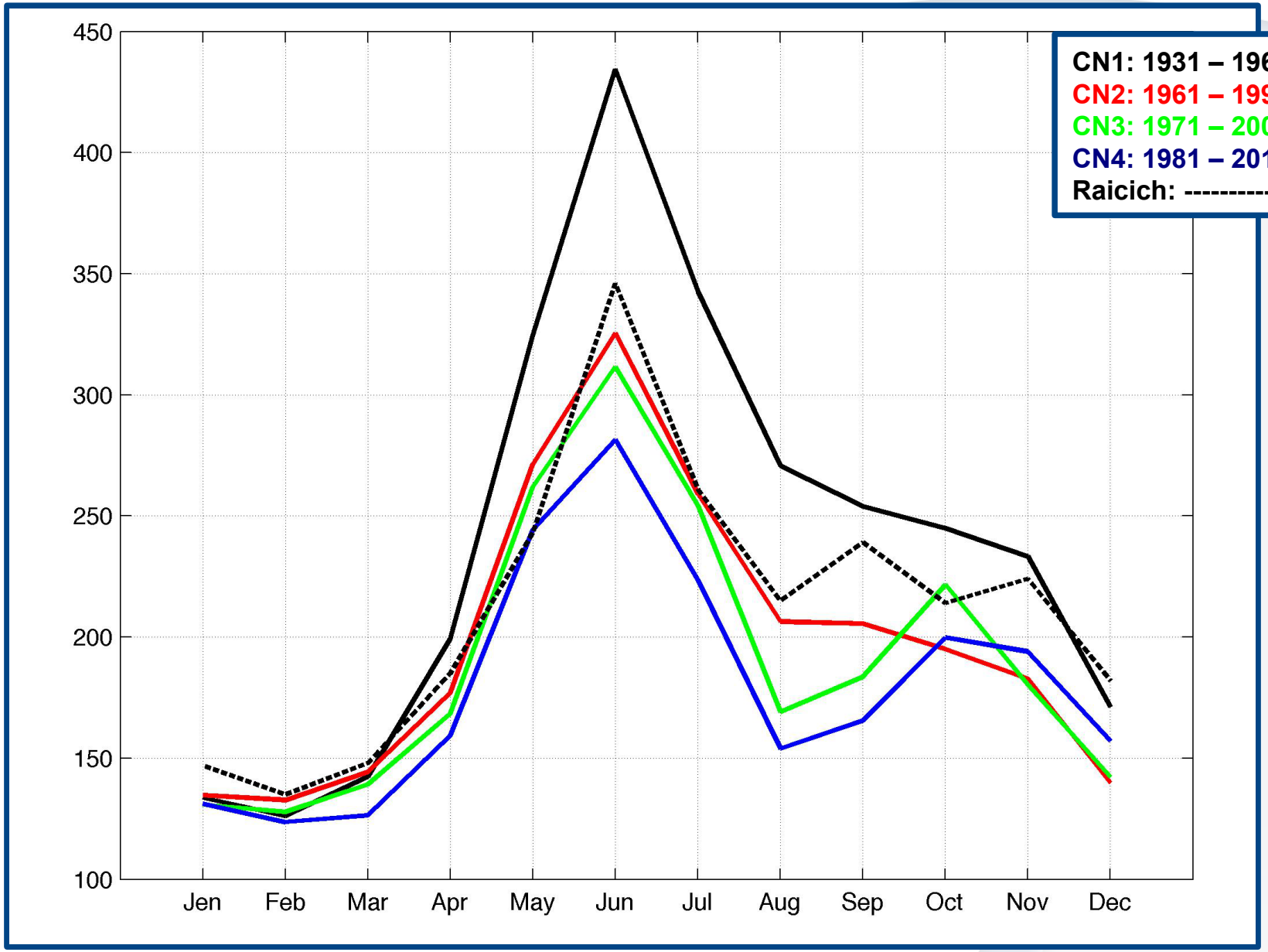
Boundary conditions MFS-GCM

Start up: September → December 2002
Run: January 2003 → December 2010

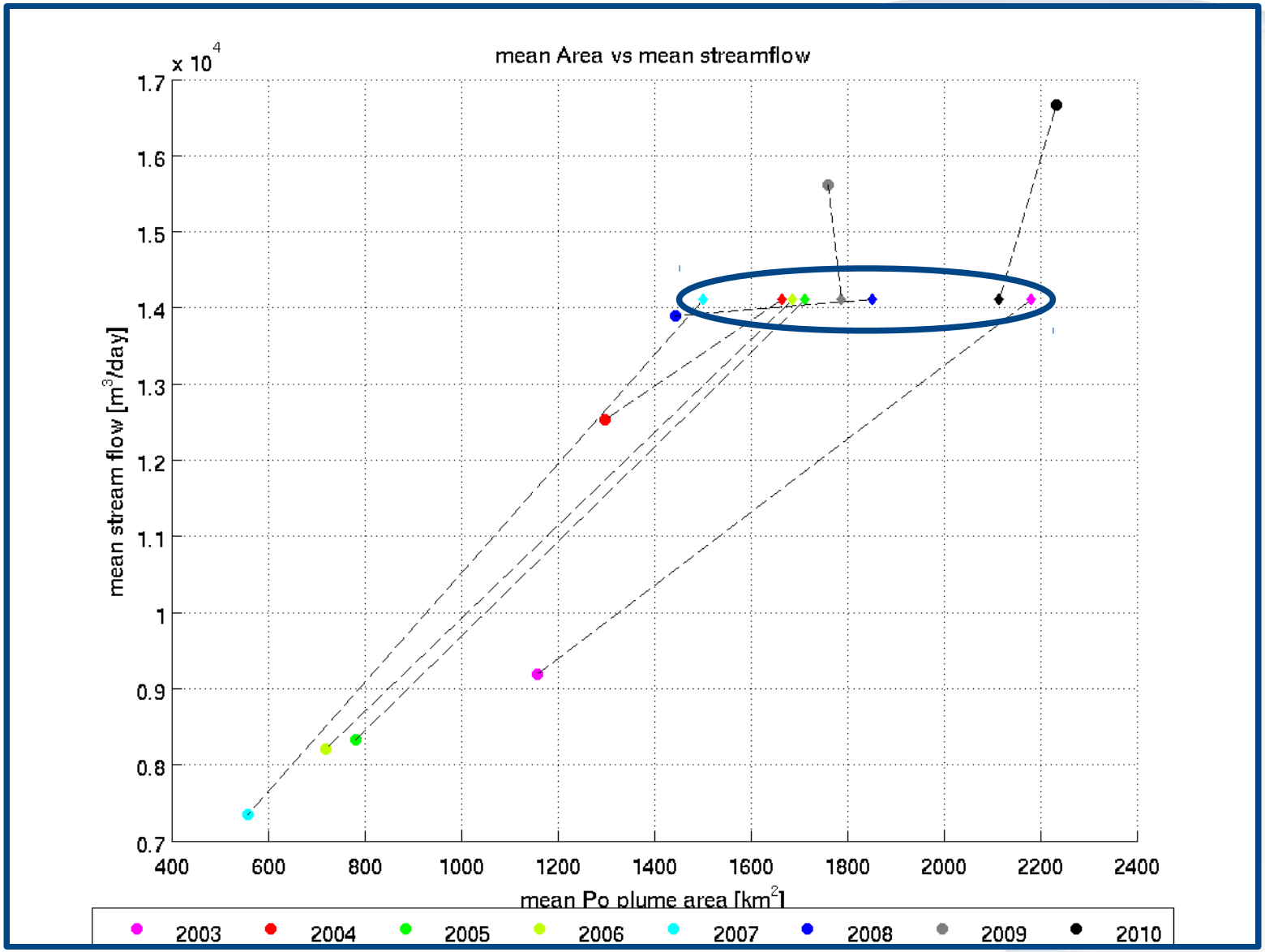
Challenging Raicich? - Po



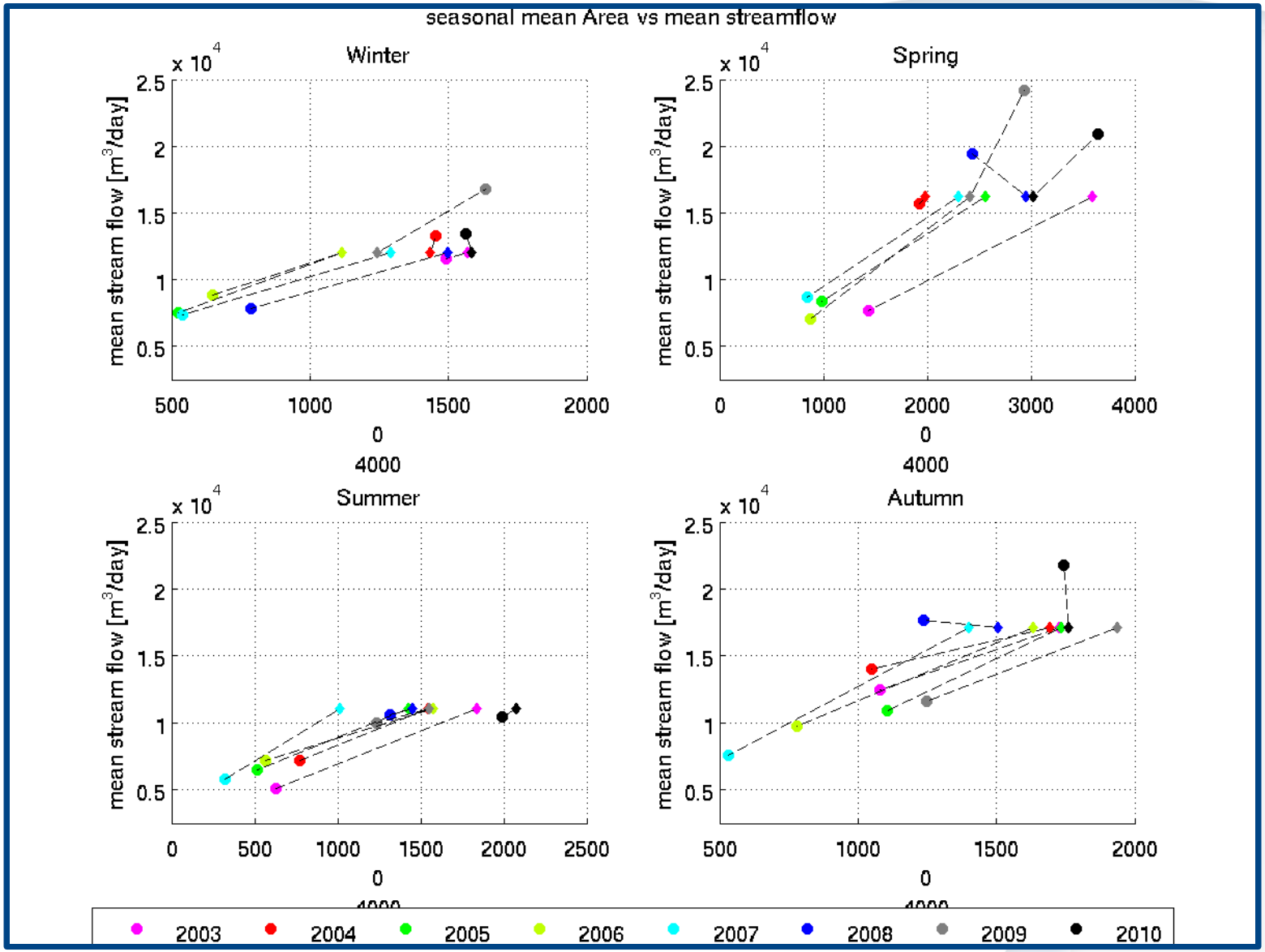
Challenging Raicich? - Adige



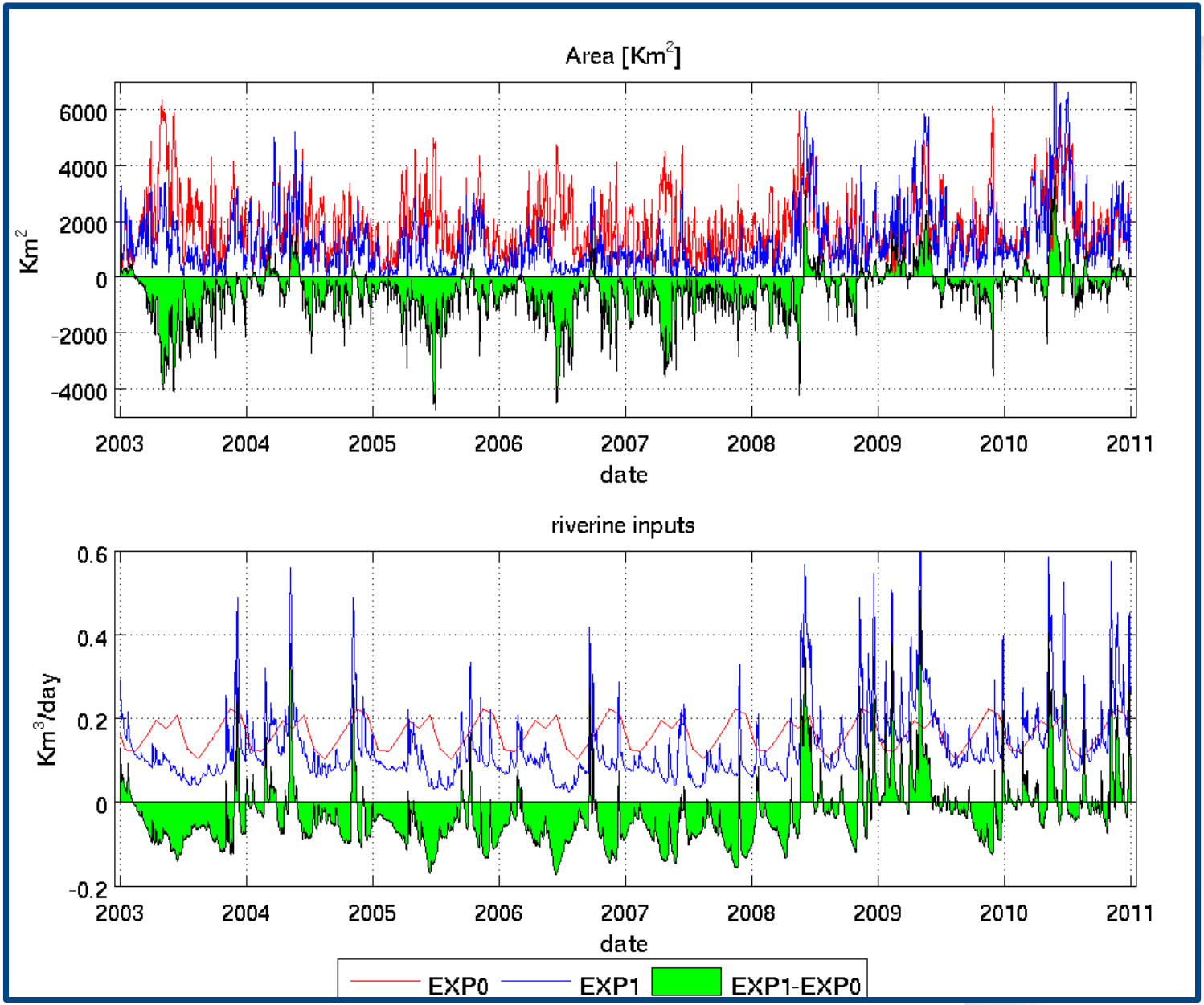
Po Plume Area - Yearly



Po Plume Area - Seasonal

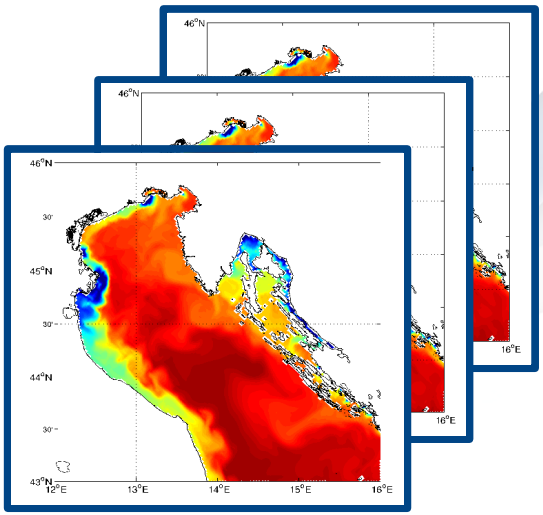


Po Plume Area - Daily



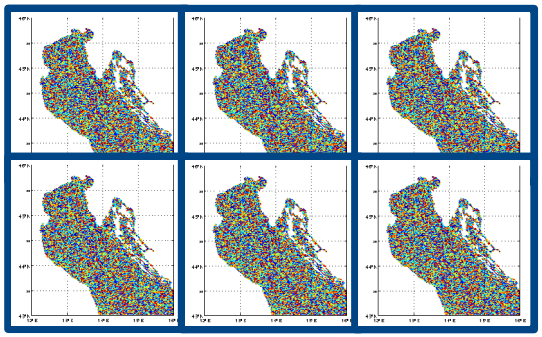
2003-2010 modeled Sea surface salinity analyzed with Self-Organizing Maps

Model SSS



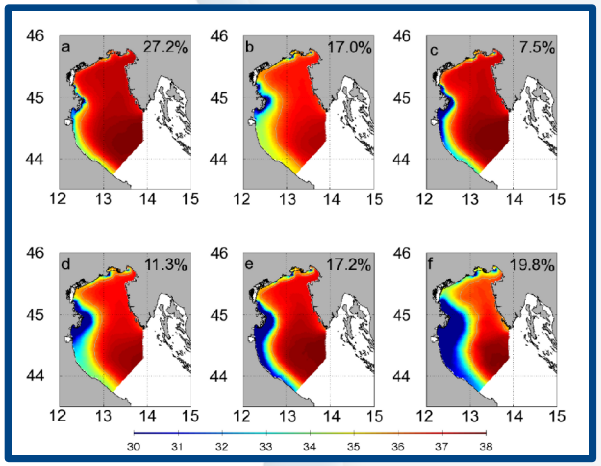
- From multidimensional data to lower dimension
- Preserves topological features and units
- Keep less frequent features
- Clusters inputs into BMUs

2x3 rectangular lattice



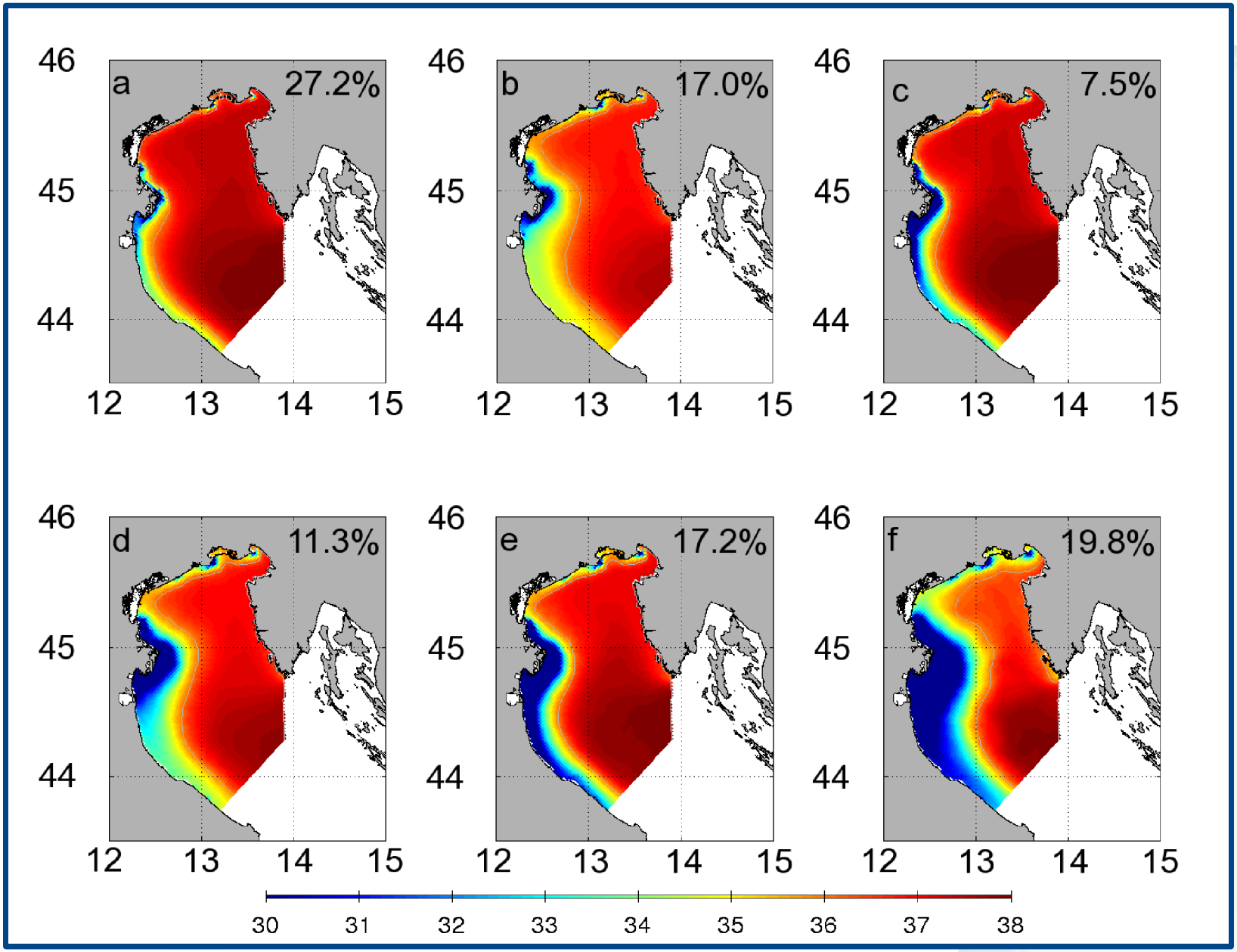
Unsupervised training

6 Best Matching Units (BMUs)

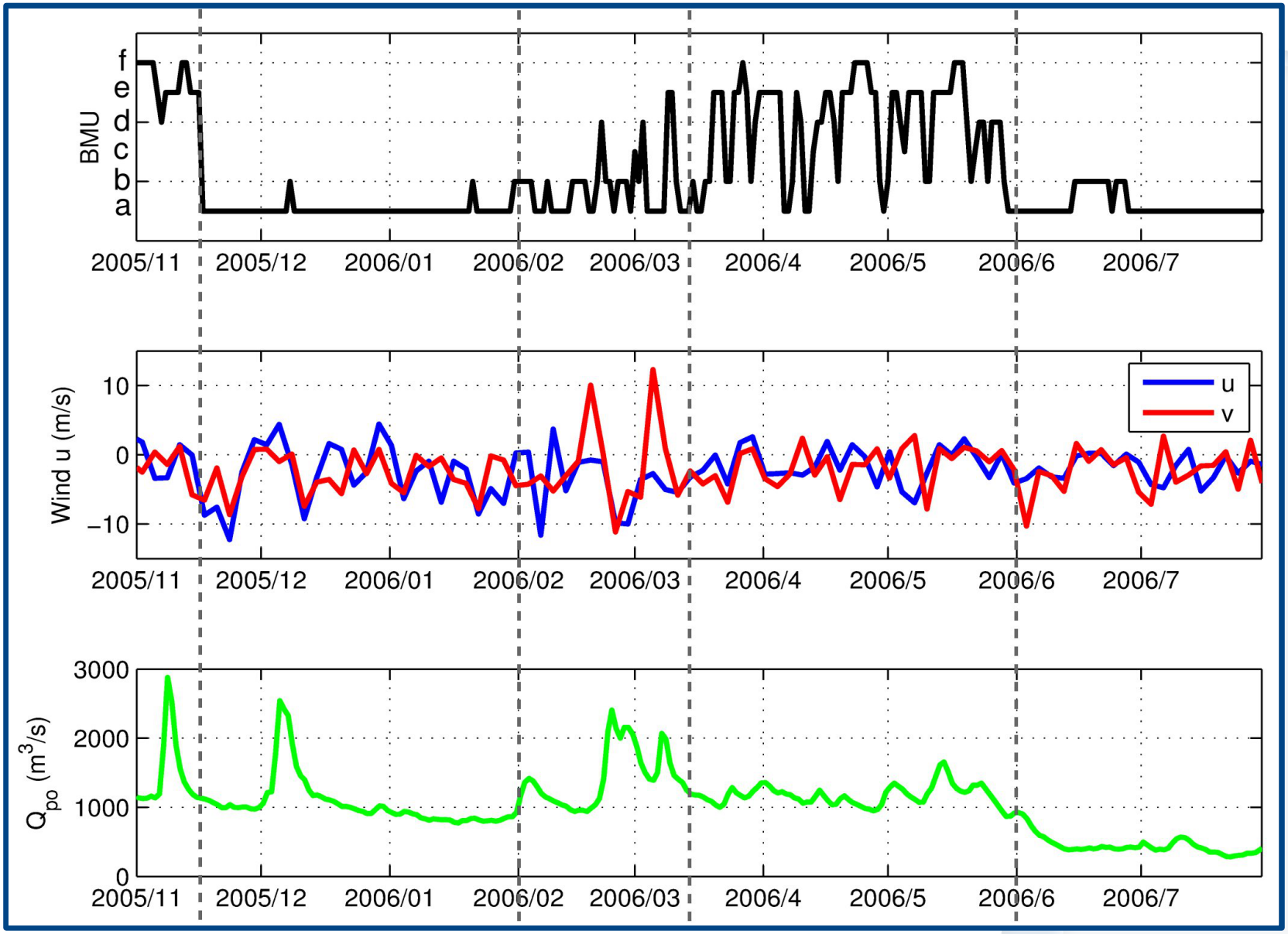


(Falcieri et al., 2014, CSR)

Results – Po Plume - SOMs

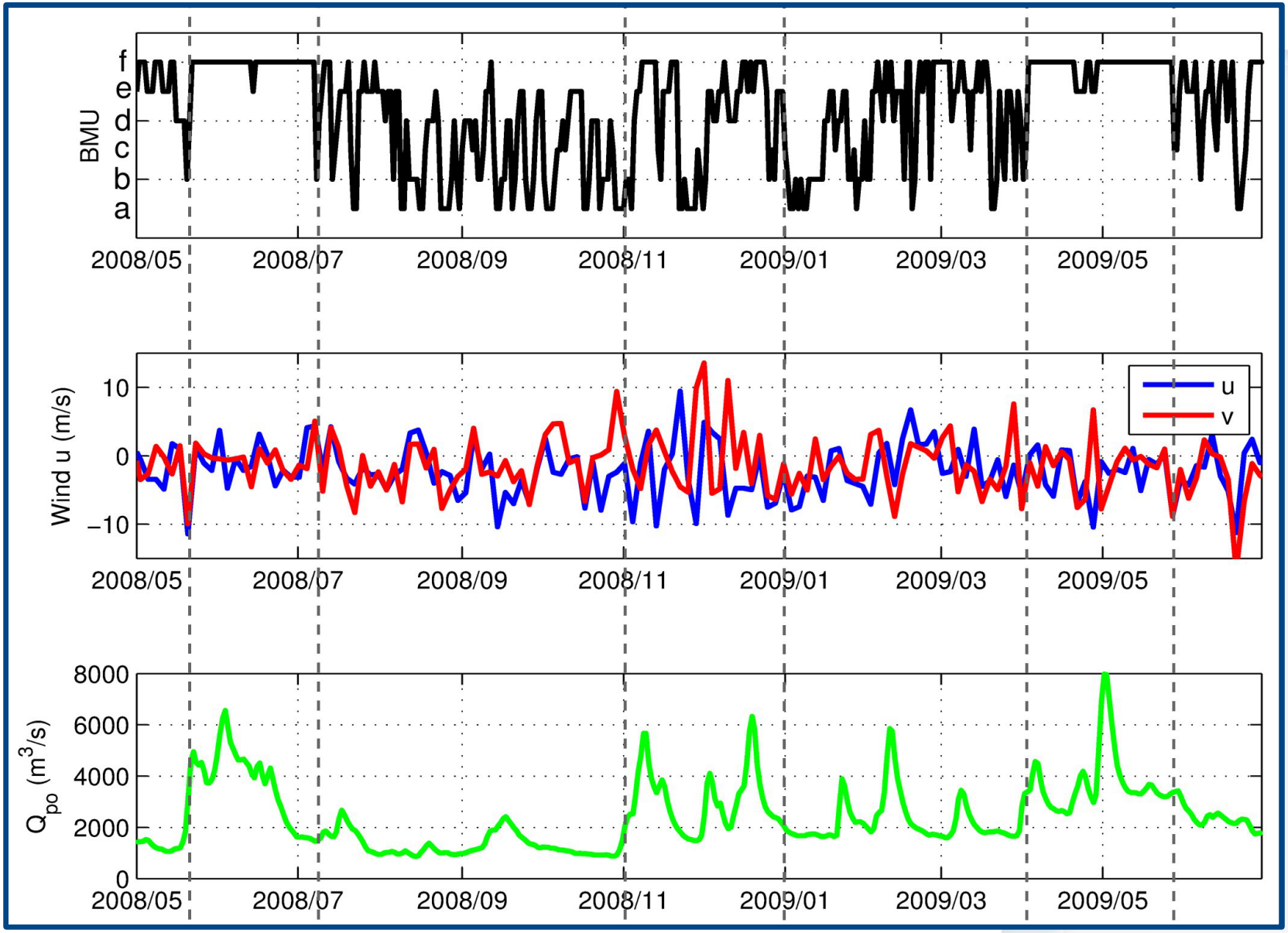


Results – Po Plume – SOMs - BMUs



(Falcieri et al., 2014, CSR)

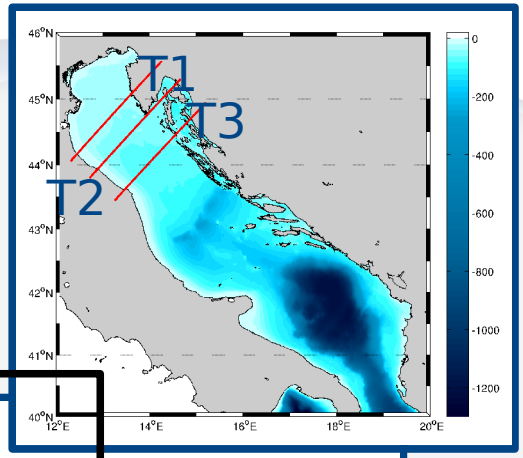
Results – Po Plume – SOMs - BMUs

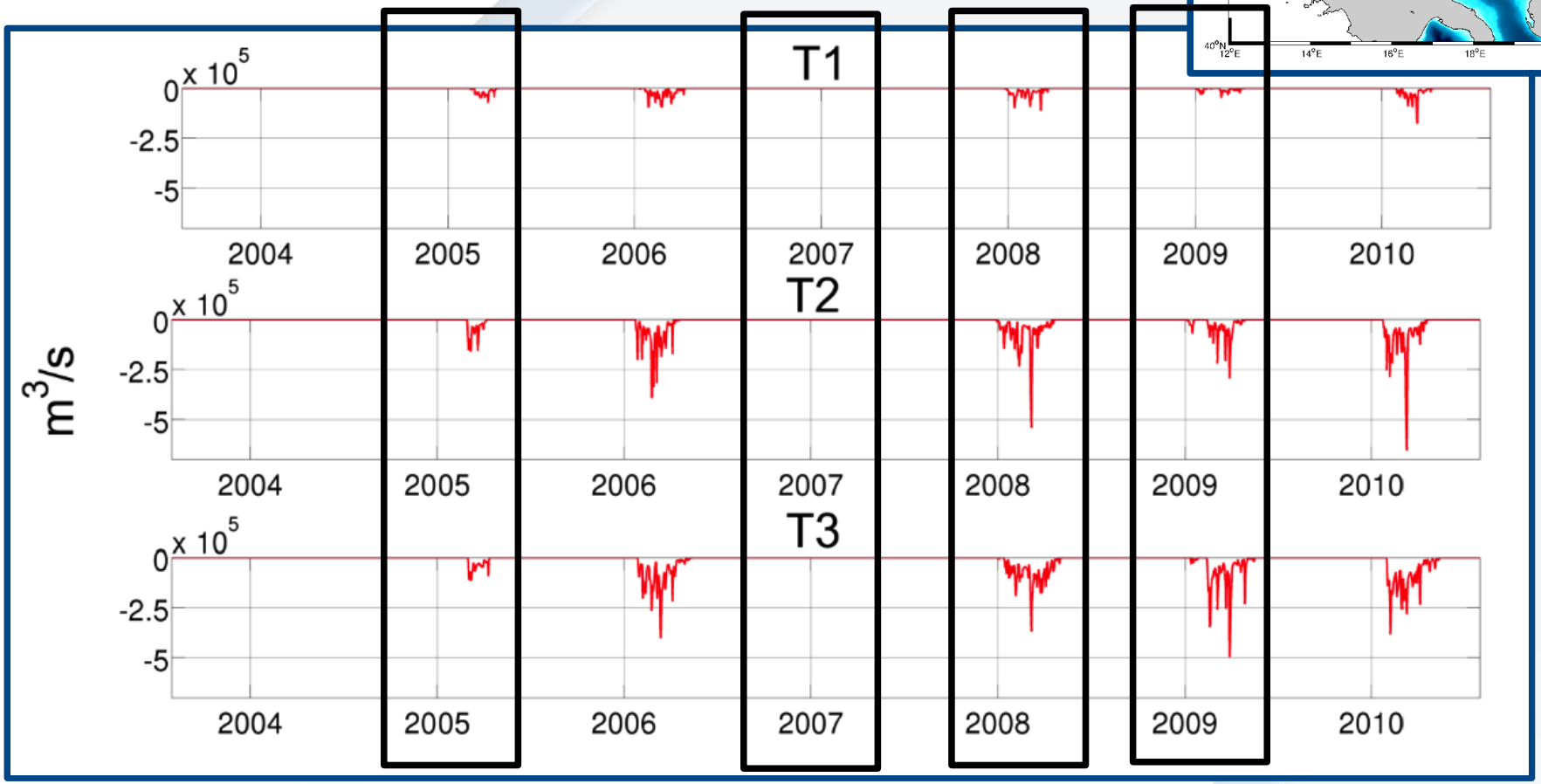


(Falcieri et al., 2014, CSR)

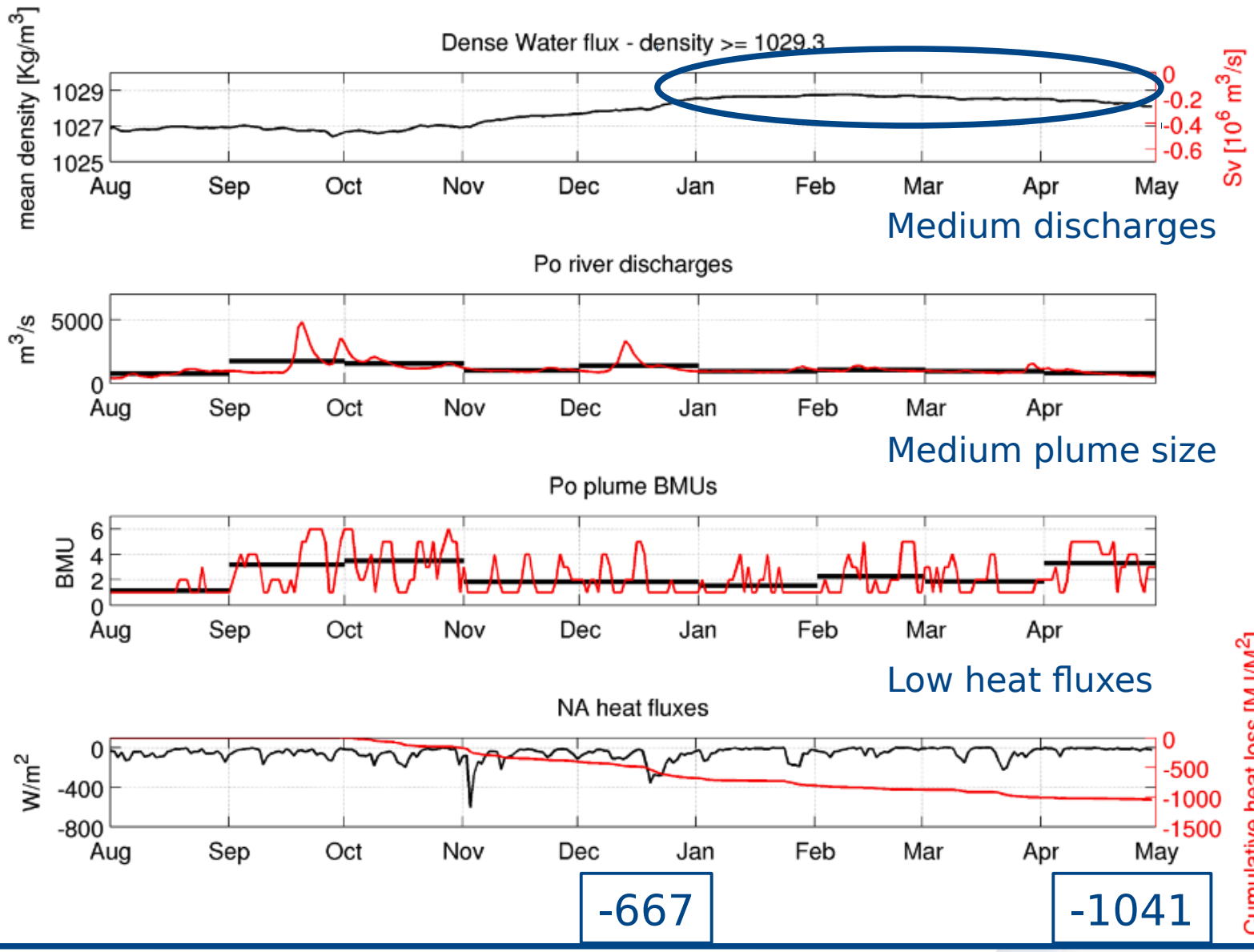
Results – NAdDW

Dense water transport across 3 sections, reference density >= 1029.3 Kg/m^3

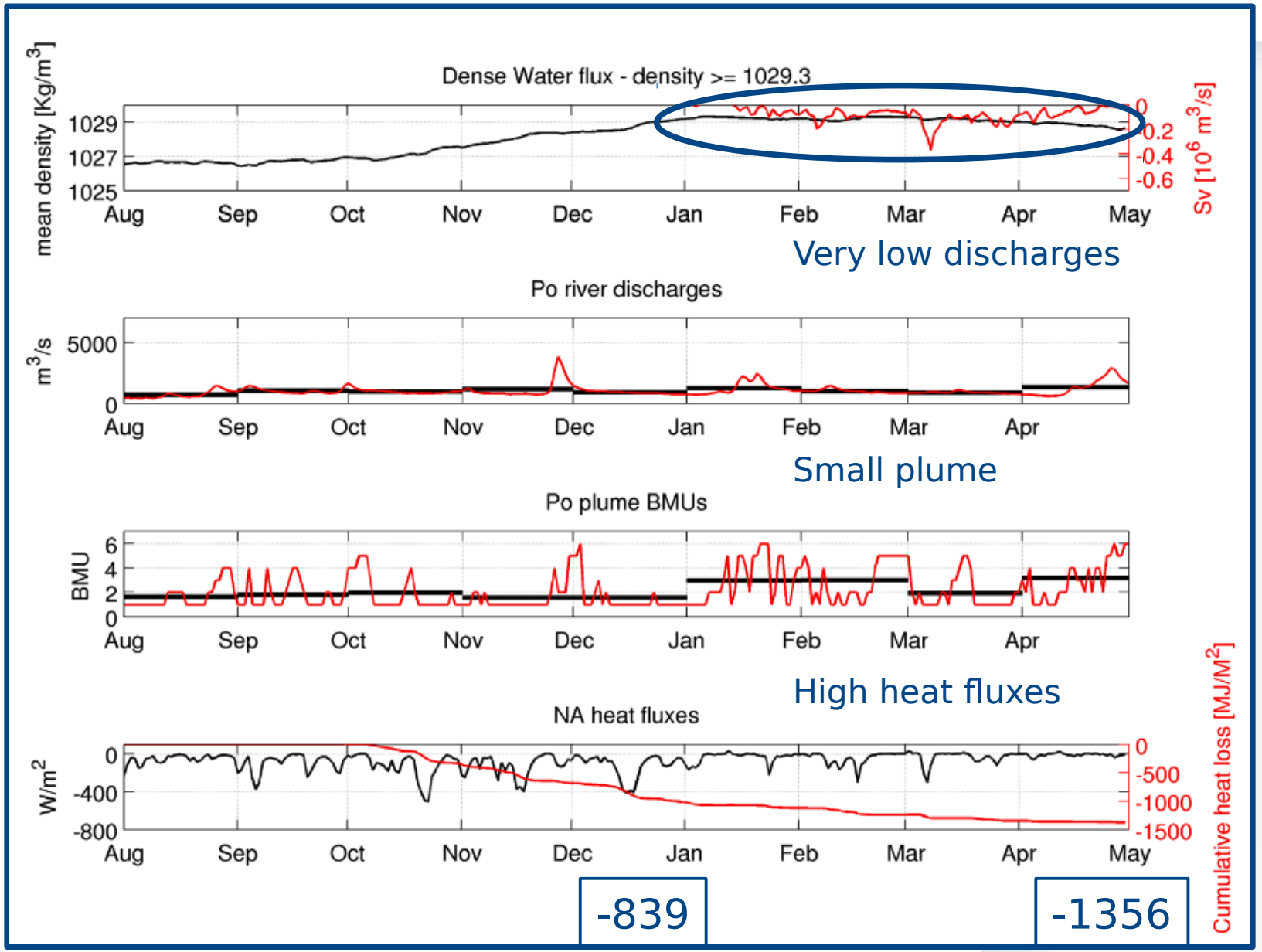




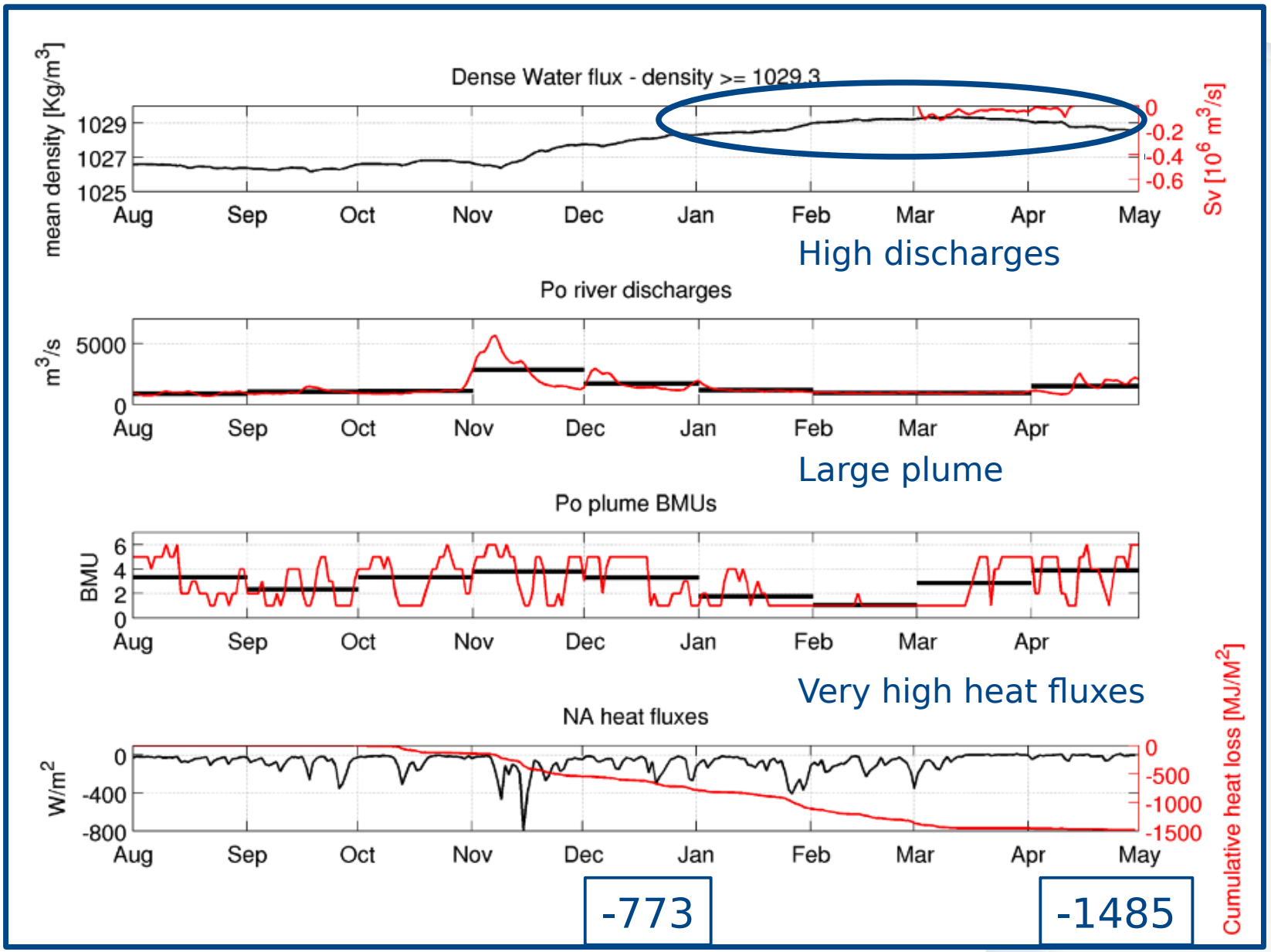
Results – NAdDW - 2007



Results – NAdDW - 2008

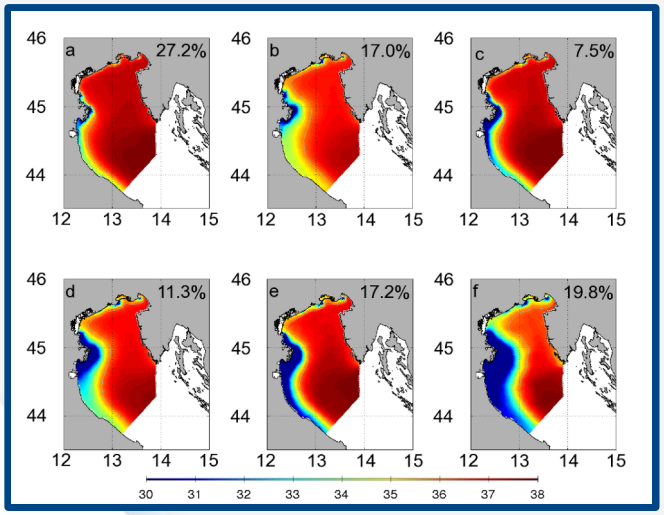


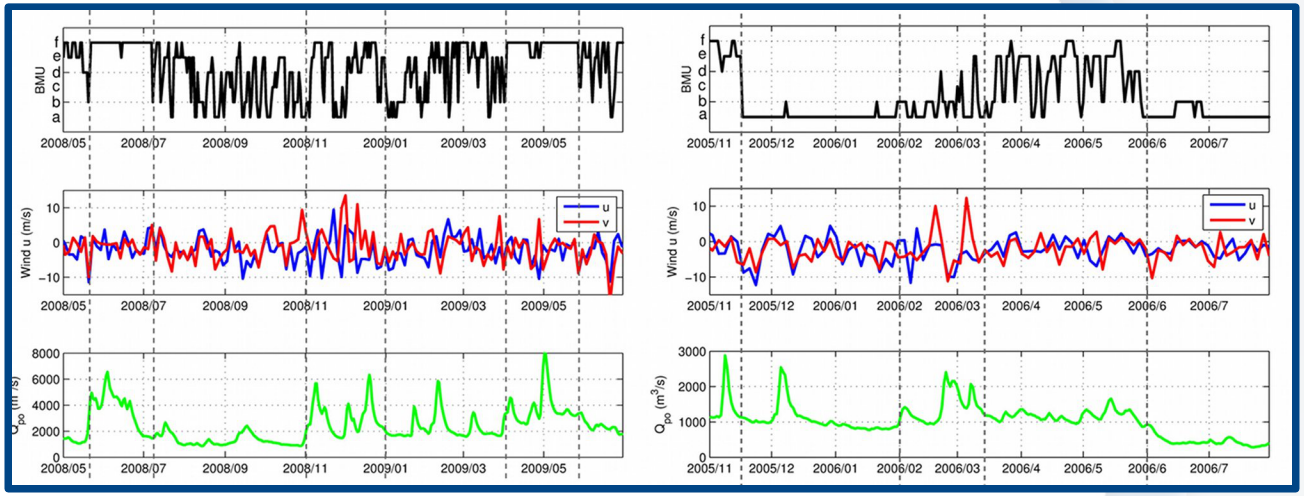
Results – NAdDW - 2005



Po Plume

- Importance of daily discharges
- Po plume characterization through SOMs BMUs
- Insights on plume dispersion under different forcing:
  - Small and narrow plume: low discharges and short Bora events
  - Wide plume: high discharges and Scirocco or long Bora



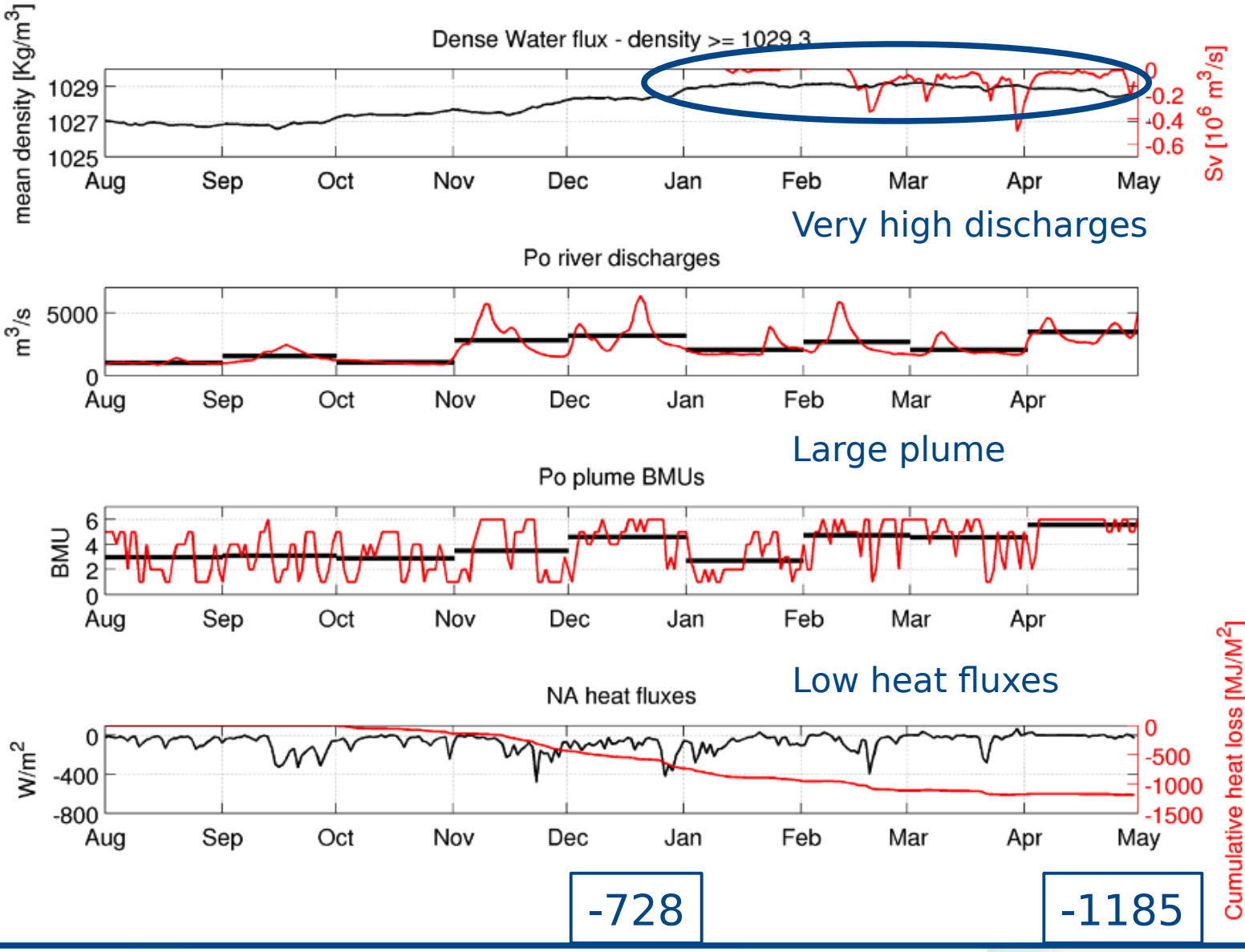


NAdDW

- Quantification of NAdDW production between 2004 and 2010
- General model for forcing relation in formation processes which relates Po plume dynamics to NAdDW formation process

	NAdDW	Riverine discharges	BMUs	Heat fluxes
2007	No	High	Wide	Low
2008	Yes	Low	Small	High
2005	Yes	High	Wide	Very high

Results – NAdDW - 2009



Summary / 2.2

	NAdDW	Riverine discharges	BMUs	Heat fluxes
2007	No	High	Wide	Low
2008	Yes	Low	Small	High
2005	Yes	High	Wide	Very high
2009	Yes	Very high	Wide	Very low

Why?

- 12 months preconditioning?
- LIW intrusions
- Local vs sub-basin processes?
- ...

Now what? (i.e. my wish list)

- New long runs (2000/2002 → 2014)
- Higher horizontal resolution =<1 Km (eddy permitting / eddy resolving?)
- Vertical resolution
- Coupling ROMS – SWAN
- LIW contribution
- Local vs whole sub-basin process
- heat fluxes computed over formation sites
- Initial conditions and Salinity bias
- ...