Atmosphere-Ocean Coupling on Synoptic scales

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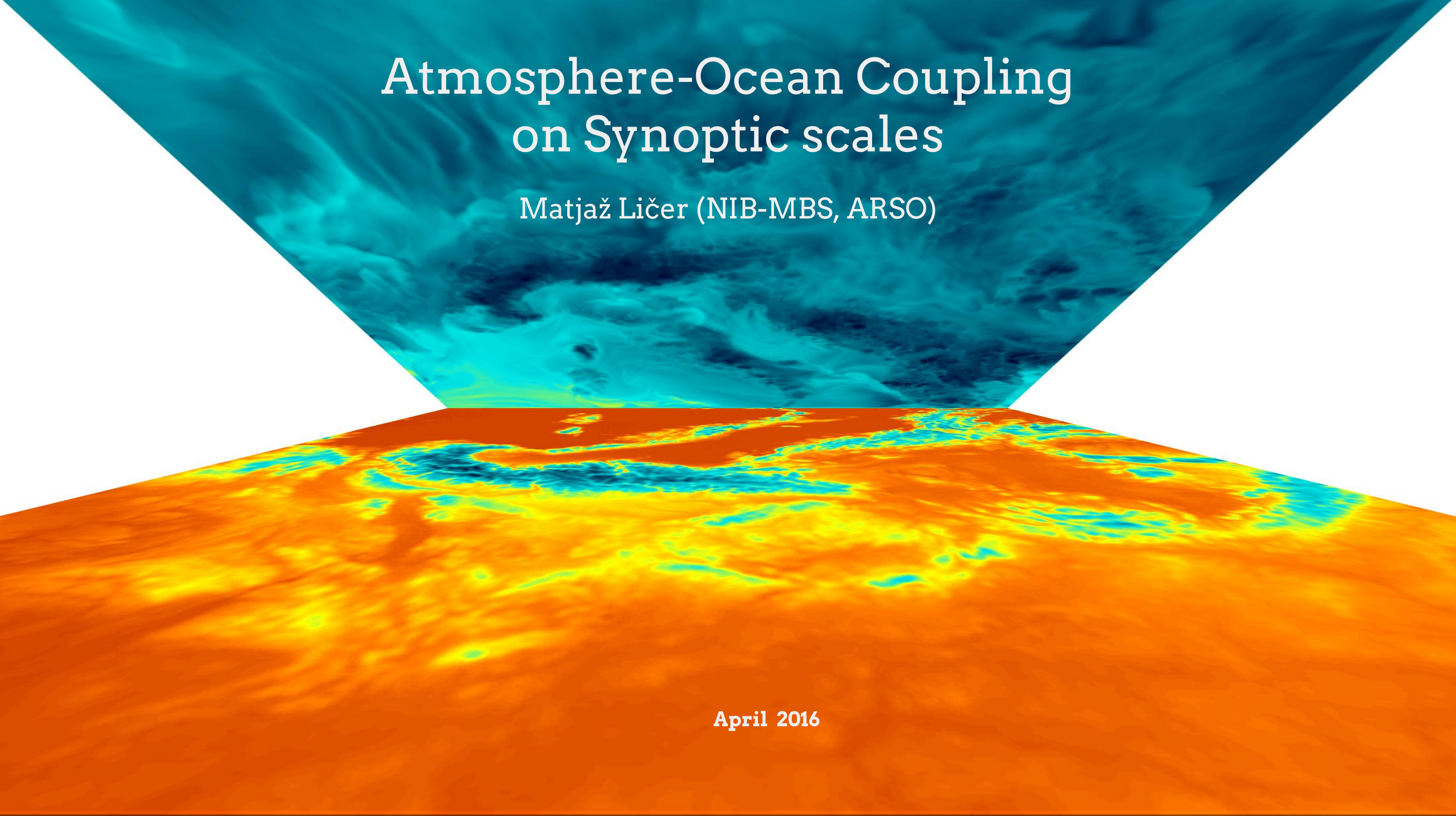
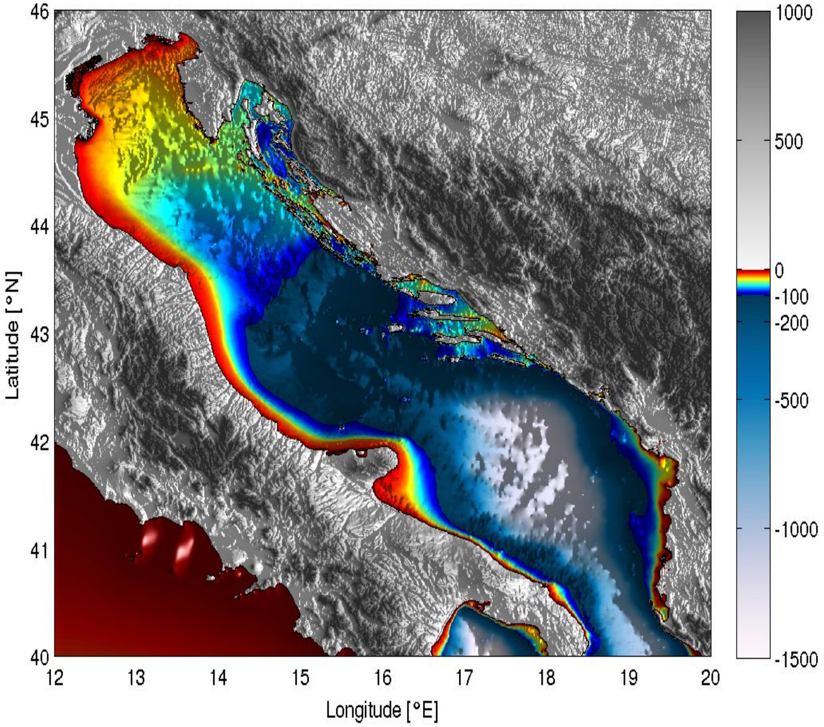


April 2016

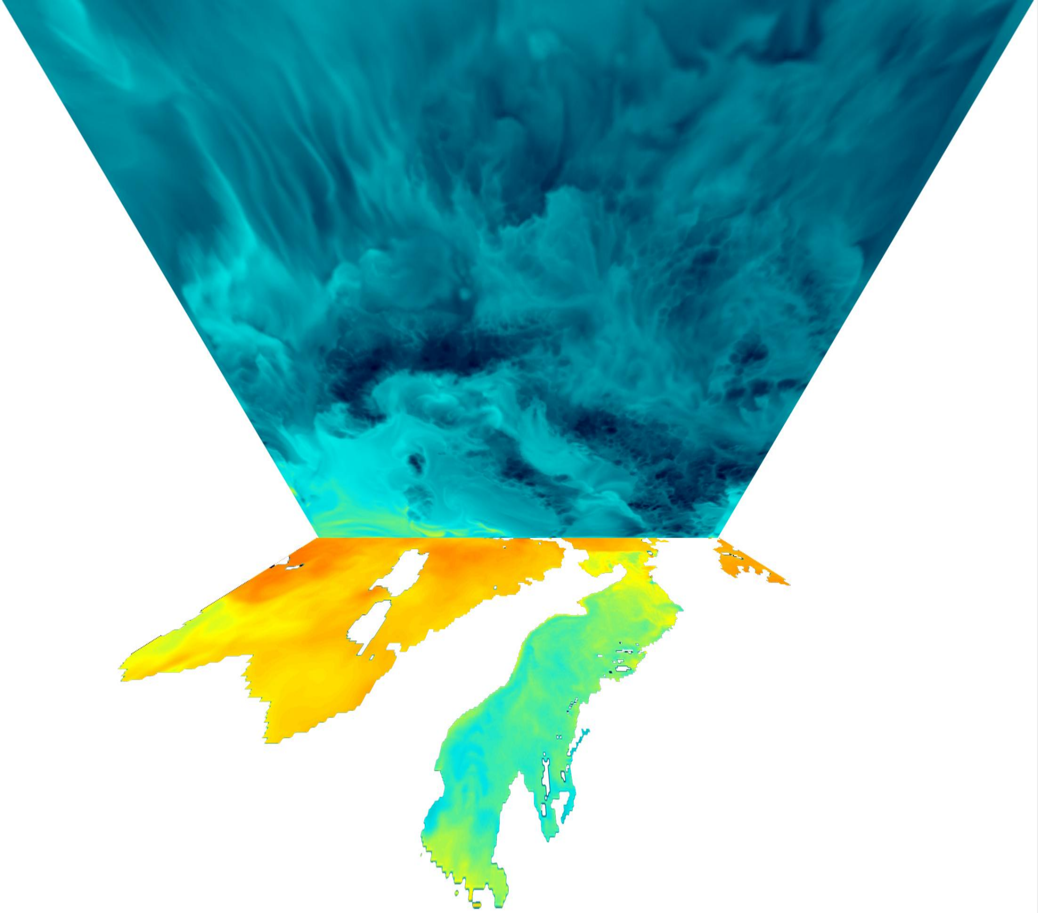


Ocean model: ADRIPOM

Ocean circulation model (1°/30 x 1°/30), solving RANS in the Adriatic basin

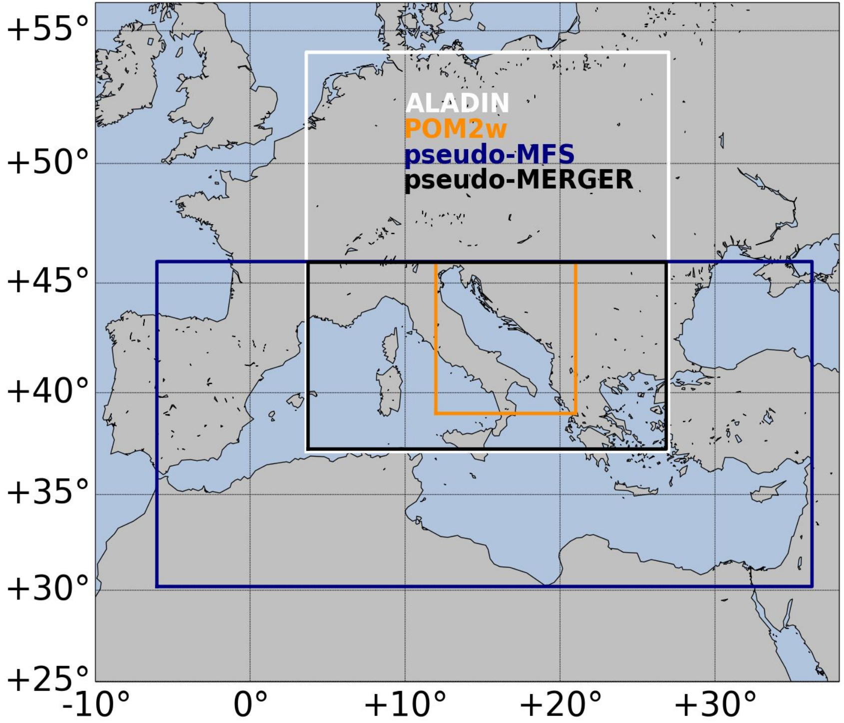
a. IC: MFS
b. atmos BC: ALADIN SI
c. hydro BC:
    i. Adriatic rivers (clim)
    ii. Po (observations)
    iii. Soča (HFS / ARSO)
d. Tidal component: OTPS

Prognostic fields: u, v, T, S, ϱ, η



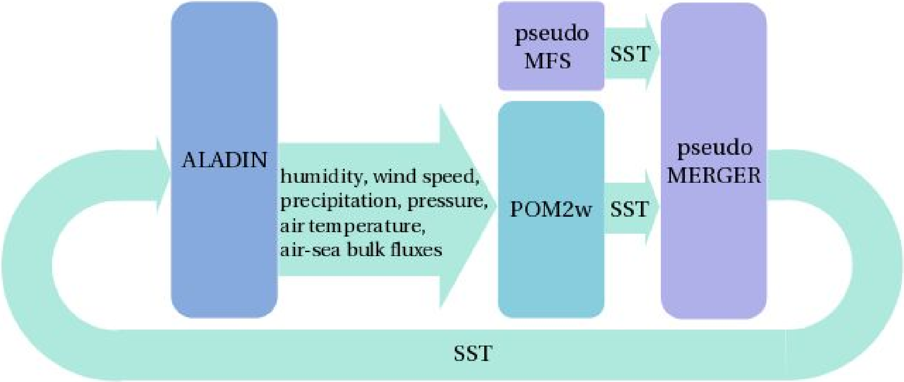
Motivation for atmosphere-ocean coupling on synoptic scale

1. New dynamics should lead to a better description of transient processes in the planetary boundary layer
2. Better forecasts of precipitation over mainland Slovenia, leading to increased flood safety
3. Better BC for the ocean models
4. Energy consistent modeling of atmosphere and ocean on synoptic scales



Execution of the atmosphere-ocean coupling

1. Environment: OASIS3-MCT (MPI compliant = > coupled simulations are faster than uncoupled since models do not communicate via file IO)
2. Atmosferic component: ALADIN
3. Ocean components:
   a. ADRIPOM + pMFS
   b. OTPS
   c. WAM
4. Atmosphere-ocean interactions: pMERGER

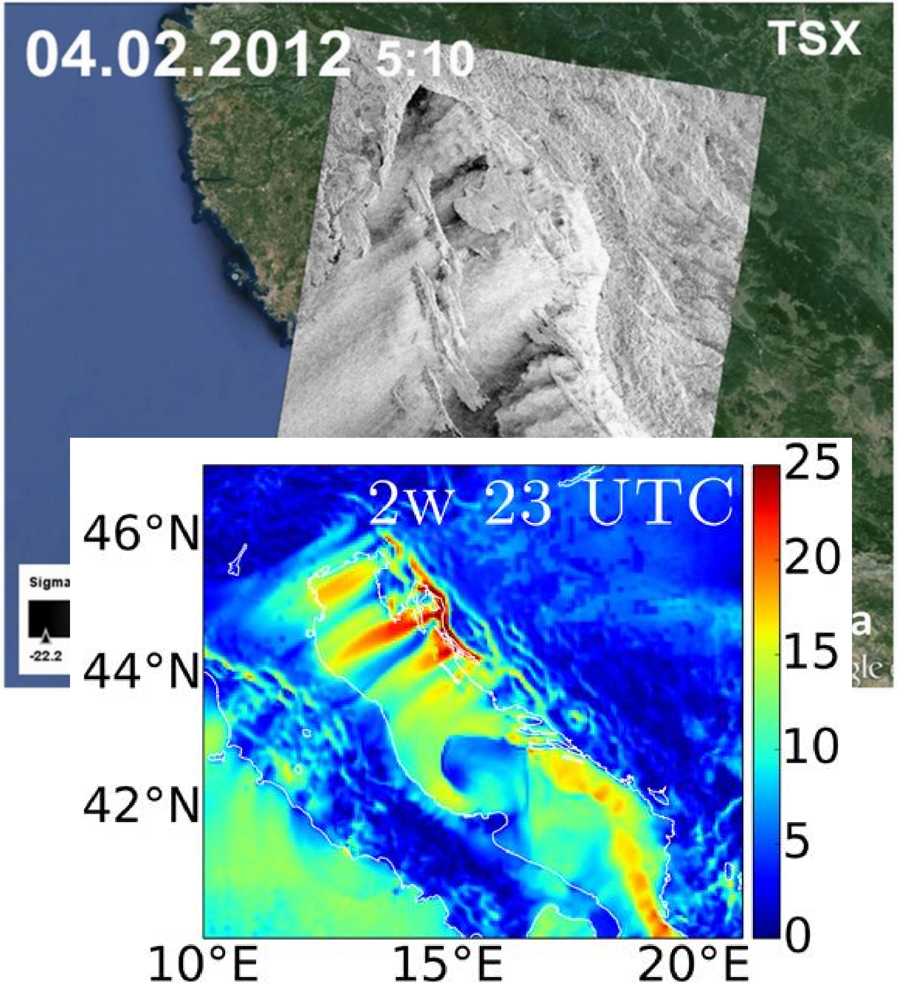


Atmosphere ocean field exchange during one runtime step:

1. ALADIN sends (T, PP, fluxes, ...)
2. POM receives (T, PP, fluxes, ...)
3. POM + pMFS send (SST)
4. pMERGER receives (SST)
5. pMERGER sends (SST)
6. ALADIN receives (SST)

Temporal synchronisation and spatial interpolations are done by OASIS.

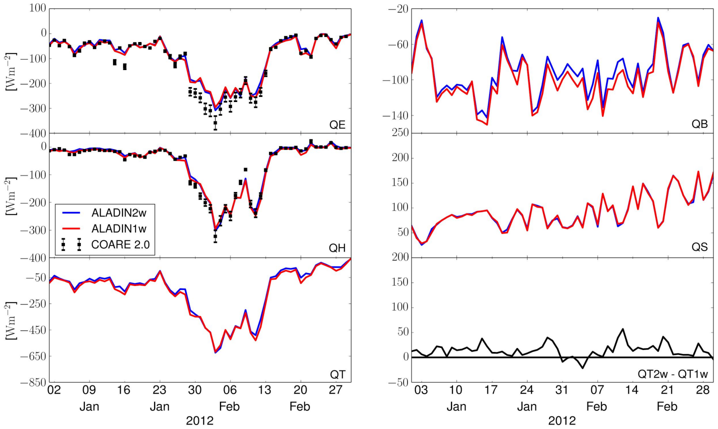
(Kuzmić et al. 2013)



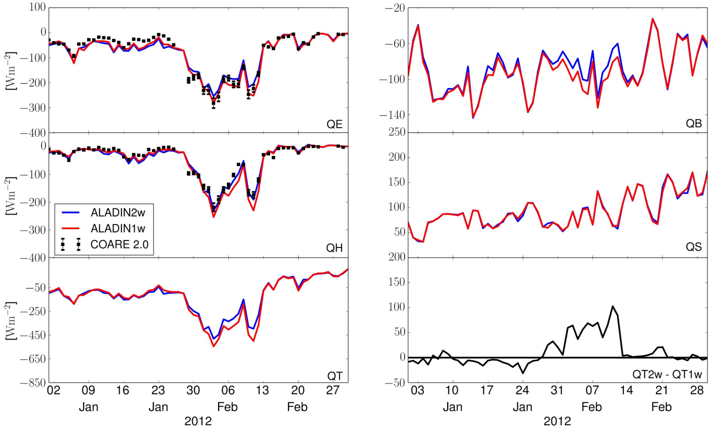
Case study: hurricane bora in february 2012

1. 14 days > 10 m/s
2. Record ocean cooling (below 4° C in the northern Adriatic!)
3. Record seawater density anomalies (σ > 30.5 kg /m^3)
4. Intense atmosphere-ocean interactions

Fluxes at VIDA buoy location (Piran):



Fluxes at Acqua Alta location (Venice Gulf):



Results: atmosphere-ocean fluxes

- Sensible heat flux:

$$Q_H = \rho_a c_{pa} C_H |\mathbf{V}| (T_{air} - T_{sea})$$

- Latent heat flux:

$$Q_E = \rho_a L C_E |\mathbf{V}| (q_{air} - q_{sea})$$

- Net radiation at sea surface:

$$R_n = j_{SW} + \epsilon (R_{atm\downarrow} - \sigma T_{sea}^4)$$

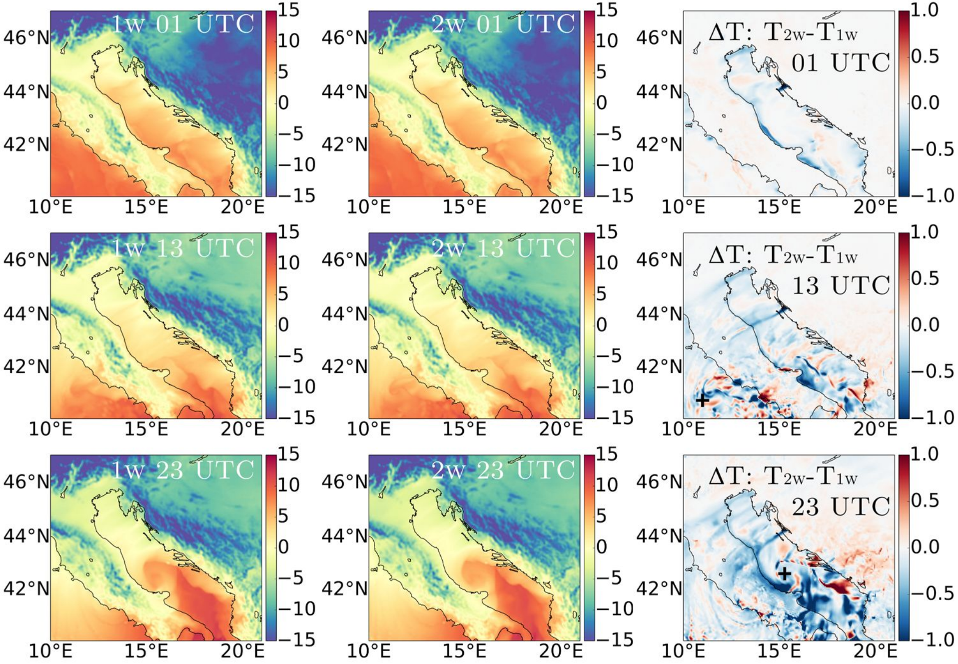
- Total flux:

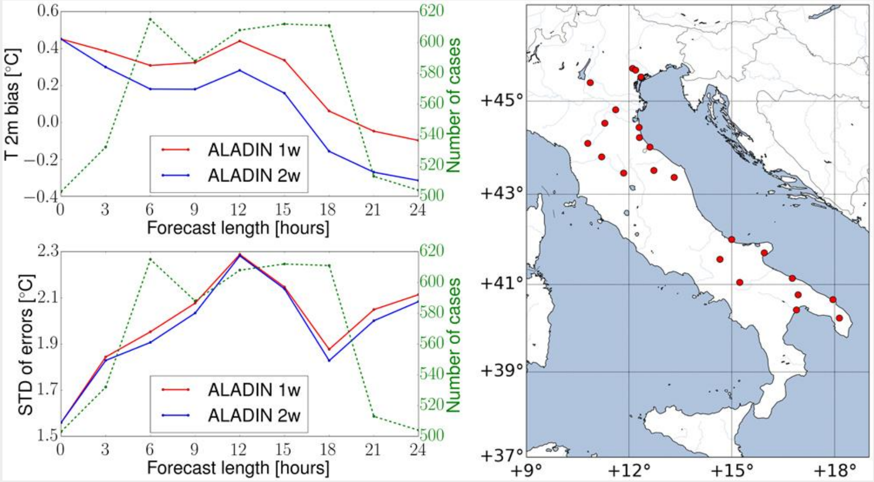
$$Q_T = Q_E + Q_H + R_n$$

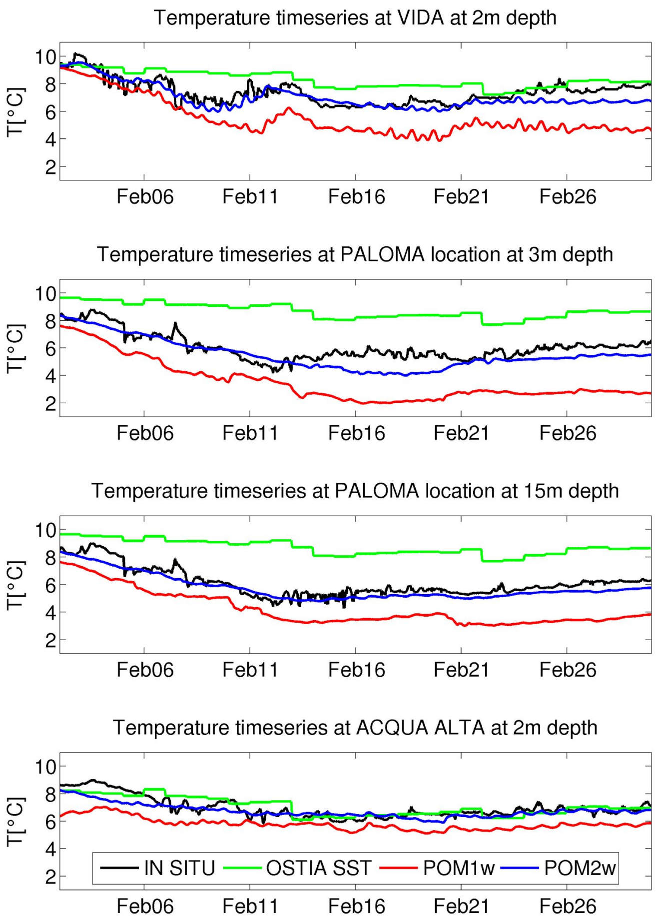
(Details: Ličer et al., Ocean Science 2016)

Results: Air temperatures at the surface

Uncoupled coupled difference



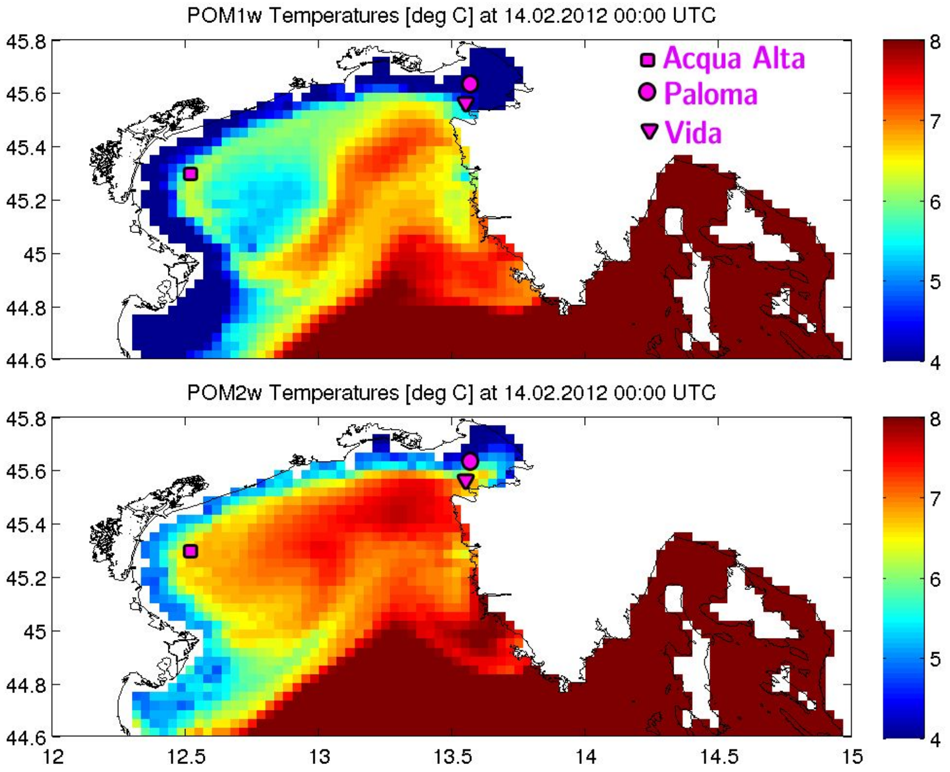




Results: ocean temperatures in northern Adriatic

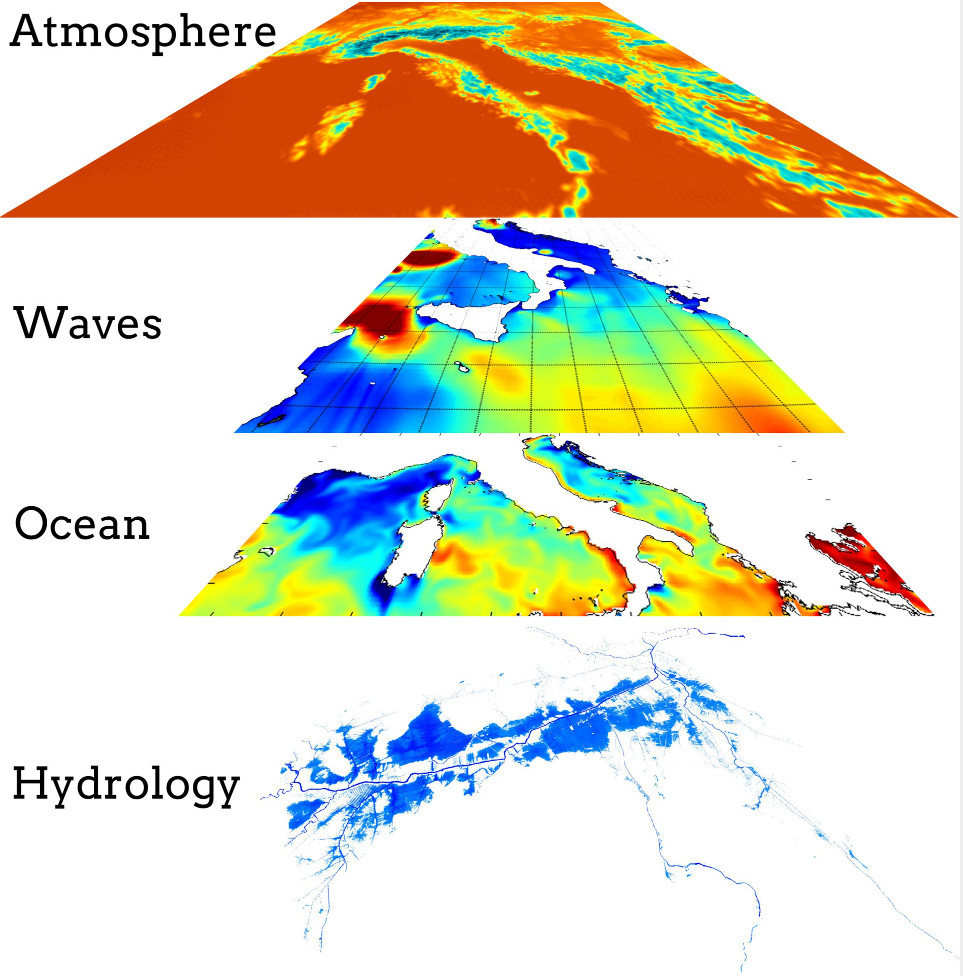
Coupled system exibits **4x lower RMSE** of the ocean temperature at all stations!.

Station (sensor depth):	Vida (2 m)	Paloma (3 m)	Paloma (15 m)	Acqua Alta (2 m)
T BIAS 1w [° C]	-1.88	-2.53	-1.90	-1.16
T BIAS 2w [° C]	-0.33	-0.53	-0.35	-0.22
T RMSE 1w [° C]	2.06	2.68	1.99	1.24
T RMSE 2w [° C]	0.59	0.79	0.48	0.46



Results: ocean temperatures in northern Adriatic

1. Uncoupled system exhibits excessive cooling. Cause: ALADIN SST BC from OSTIA is overestimated, causing enhanced heat fluxes
2. Ocean temperatures in the gulf of Trieste are very dependent on recirculated water and not only on local cooling due to local heat losses..



Conclusion

1. Coupling does improve model results:
   a. During the Bora the interactions are significant for the ocean
   b. Summer situations might be more significant for the atmosphere
2. To-do list::
   a. Operational implementation
   b. Summer and SW, SE situations
   c. Analysis of the PP impact on hydrology