Sea surface temperature in operational forecast (example of Adriatic Sea)

Martina Tudor, Stjepan Ivatek-Šahdan, Antonio Stanešić

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Sea surface temperature in operational forecast

- The operational LAM forecast uses SST provided in the coupling files
  - There are two sets of coupling files available operationally from the global models ARPEGE (see next slide) and IFS (assumed to be OSTIA).
- Initial values do not change during the forecast (72 hours) but do from one analysis to the next one.
- Some alternatives for SST tested:
  - OSTIA (Operational Sea Surface Temperature and Sea Ice Analysis)
  - MUR (The Multiscale Ultrahigh Resolution) analysis
  - ROMS (Regional Ocean Modelling System) model output (Janeković et al 2014)

ARPEGE SST

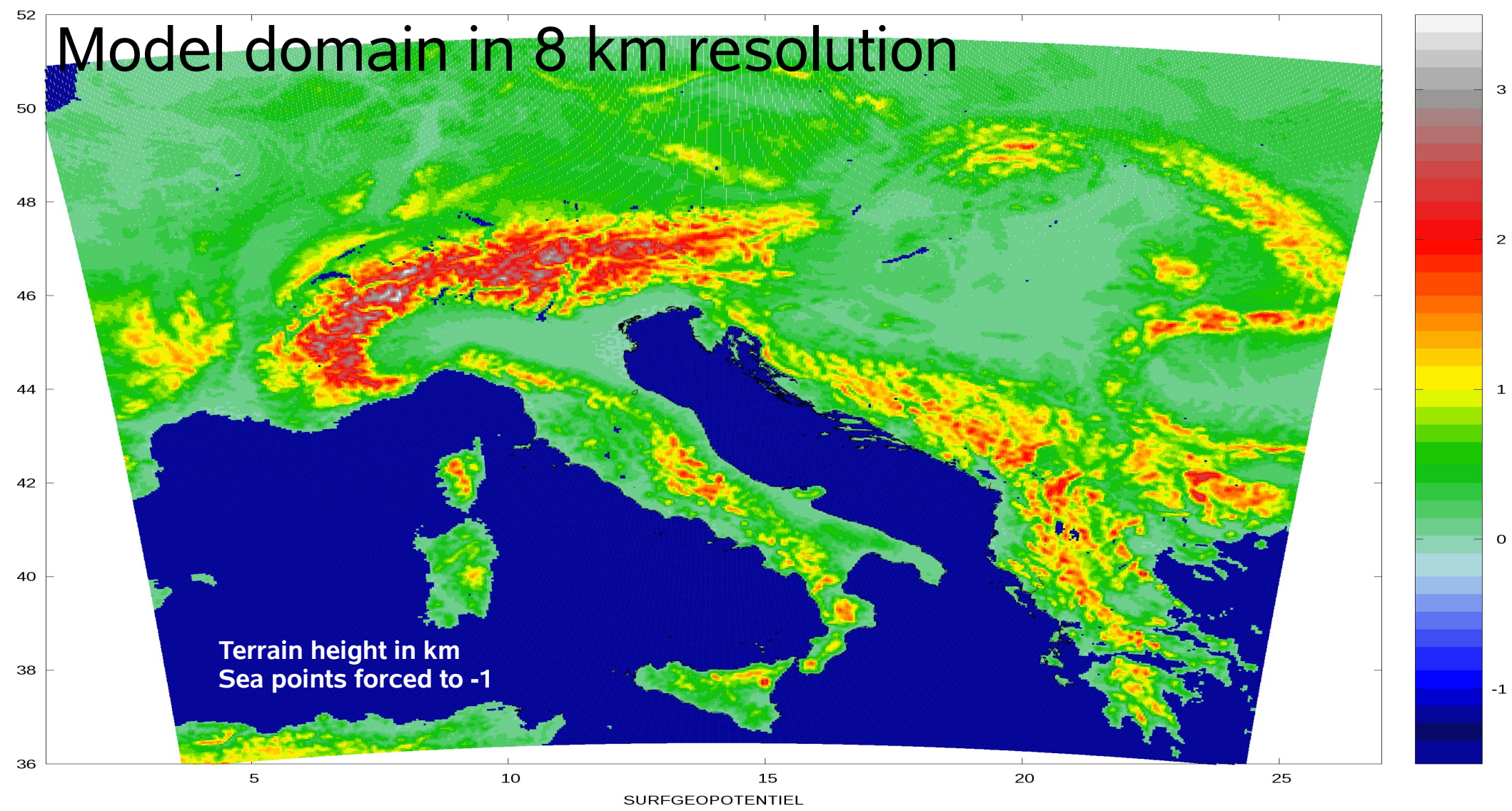
- MERCATOR?
- 2012 WMO report: Sea surface temperature is analysed using SST reports and NCEP SST analysis.

Personally, I did not feel smarter after reading this →

3.2. SST Data

[16] The initial SST fields used for the MESO-NH simulations are usually provided by the IFS or ARPEGE SST analysis. The ARPEGE SST analysis is obtained through an optimal interpolation which combines in situ data collected by ships and buoys with a first-guess analysis that is usually the previous 6-hour analysis but could also be the Reynolds global climatology at a $1^\circ \times 1^\circ$ resolution or the ECMWF SST analysis, when the former misses. The ARPEGE SST analysis error is estimated to about 1°C on average and can reach 2°C locally.

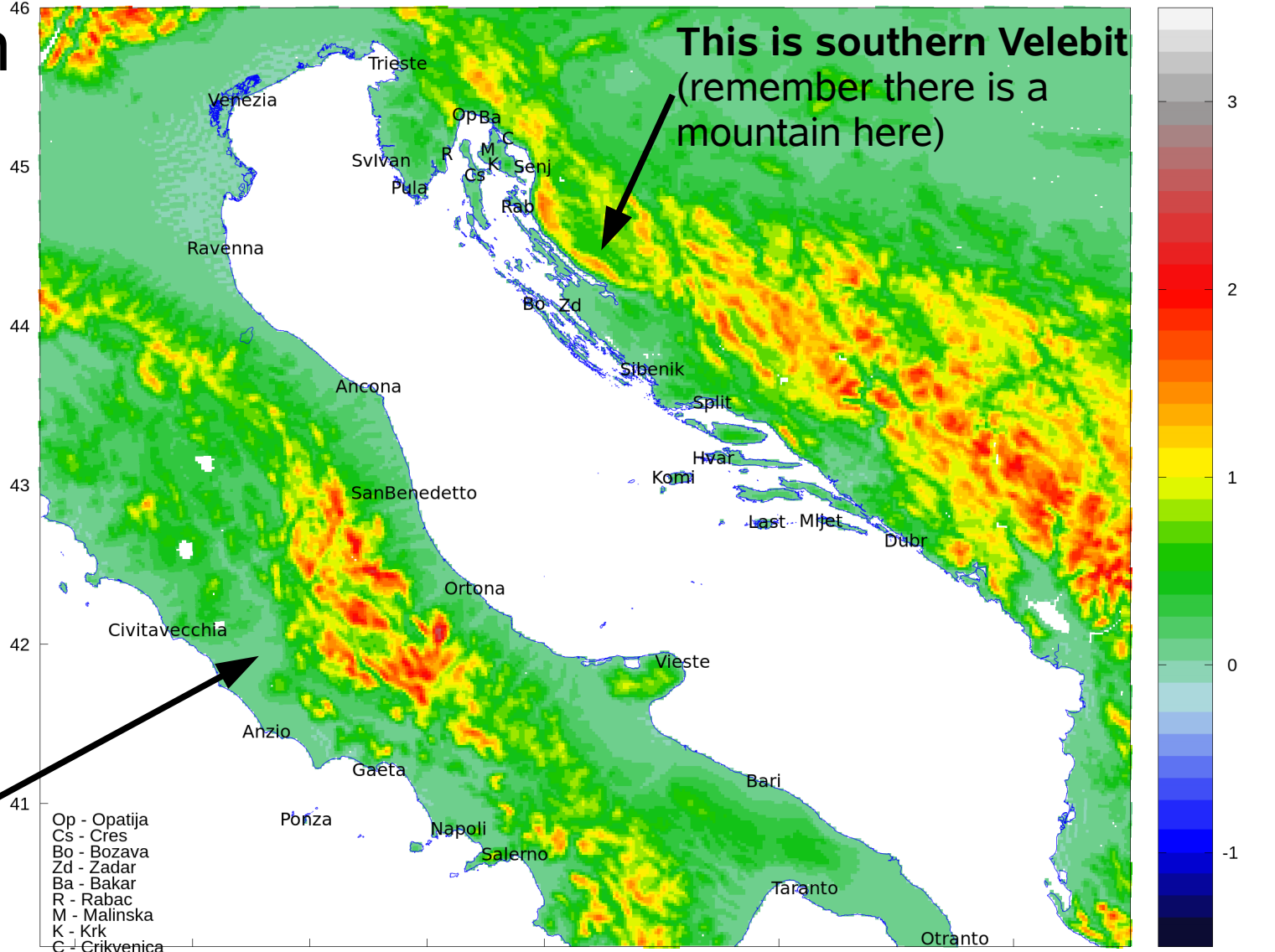
Model domain in 8 km resolution



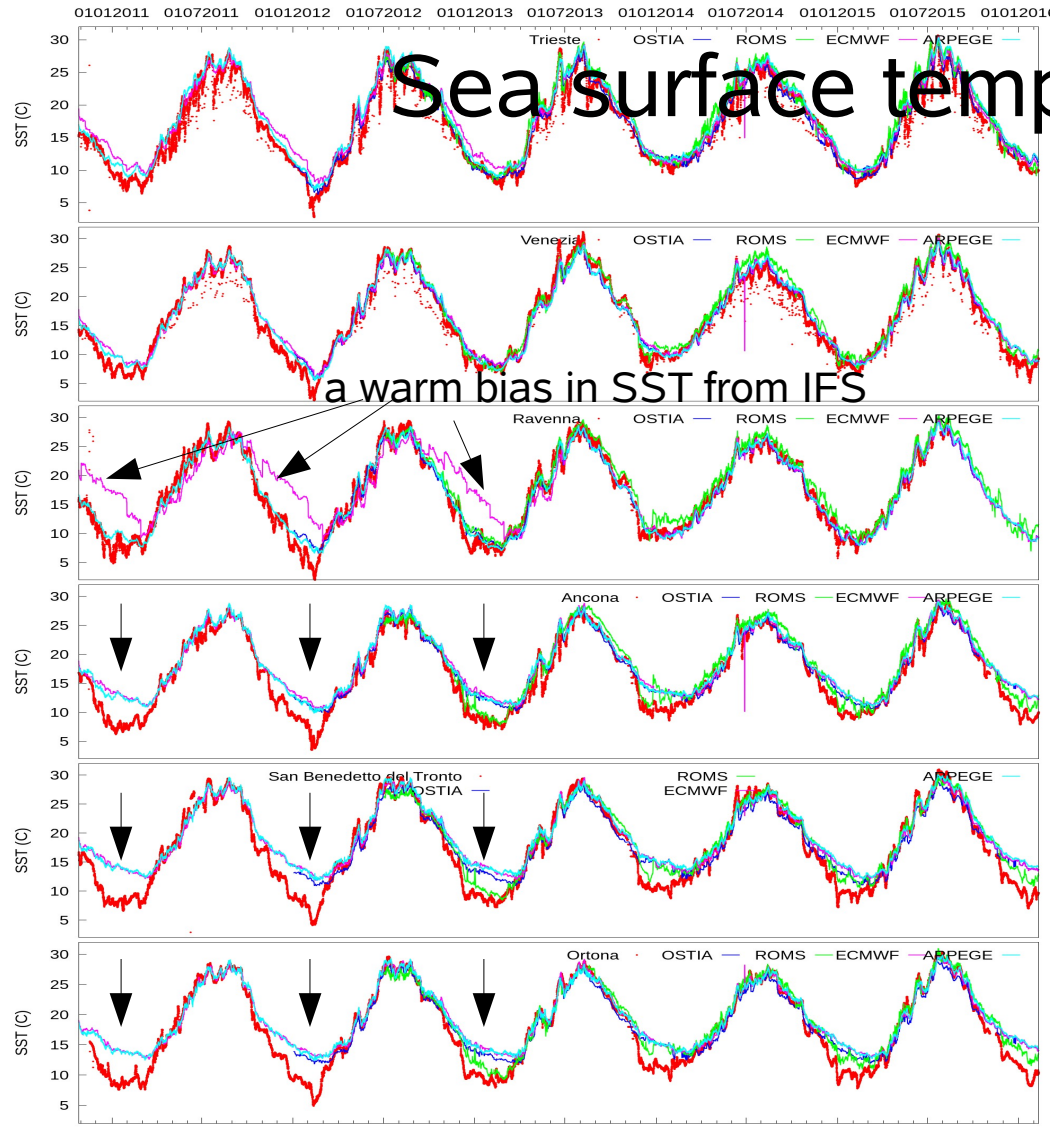
Model domain in 2 km res

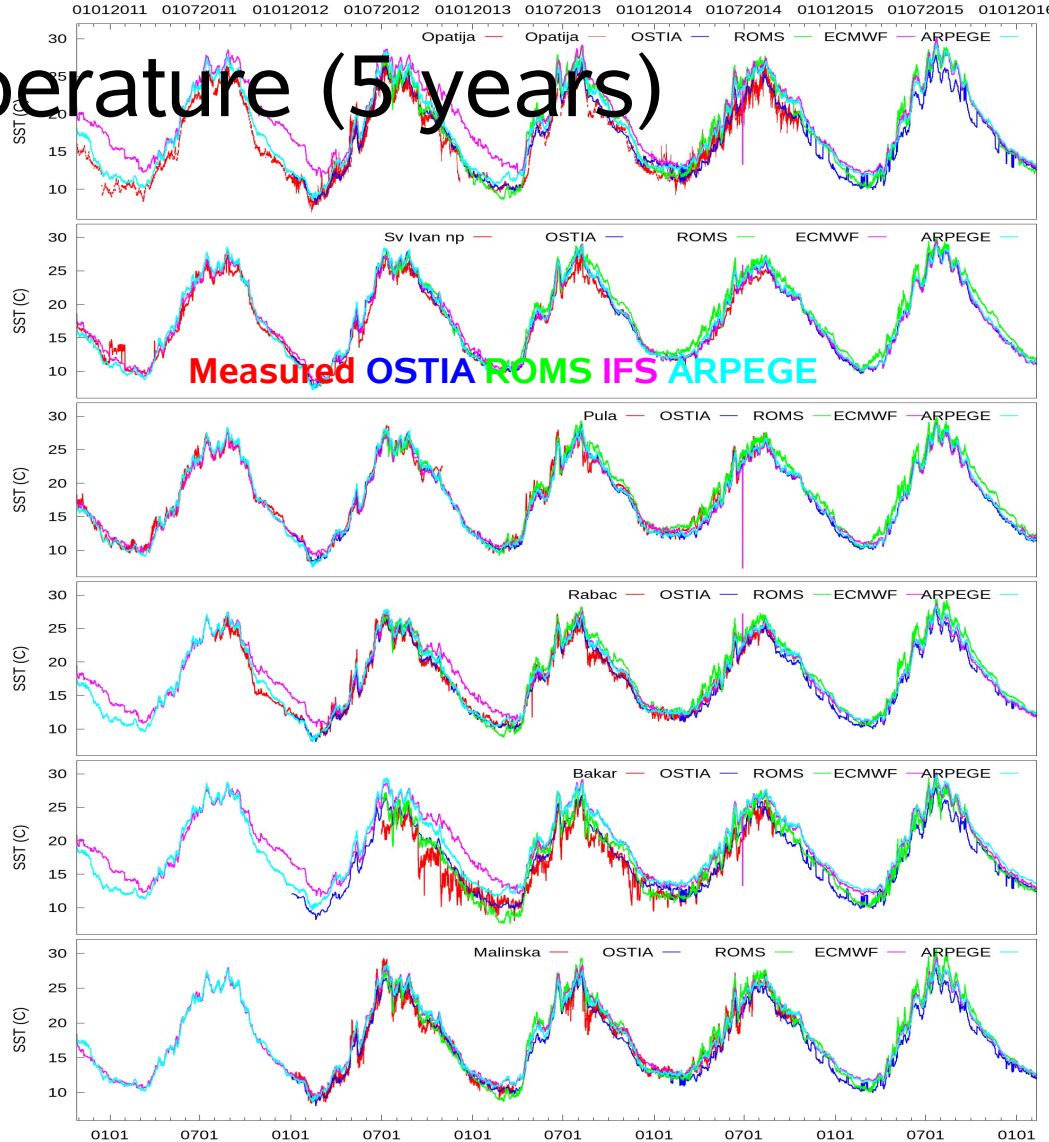
There are operational SST measurements for a number of stations in Italy from ISPRA web page www.mareografico.it.
Sea below Velebit mountain is the Velebit channel.
Western Adriatic Current (WAC) flows along the west Adriatic shore.

Our current position



Sea surface temperature (5 years)

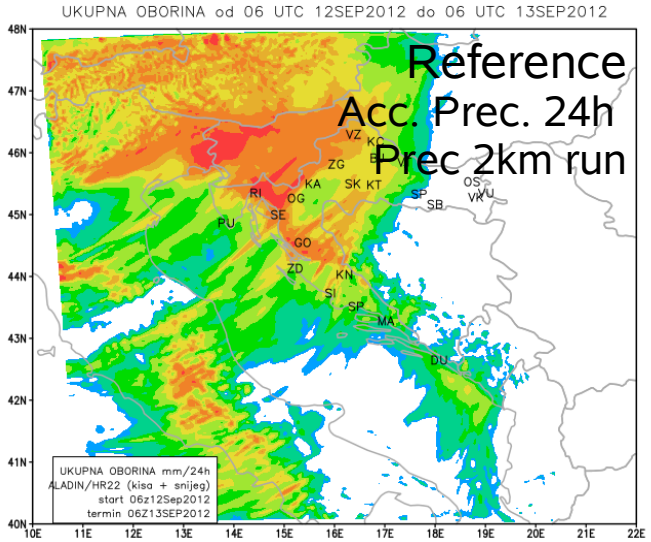


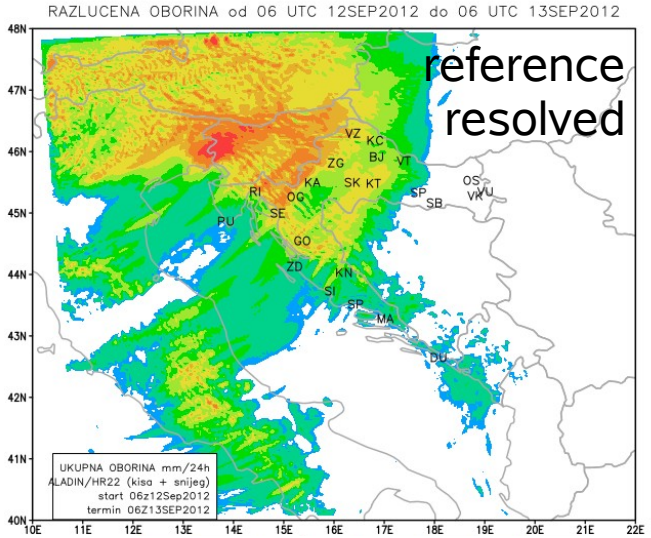


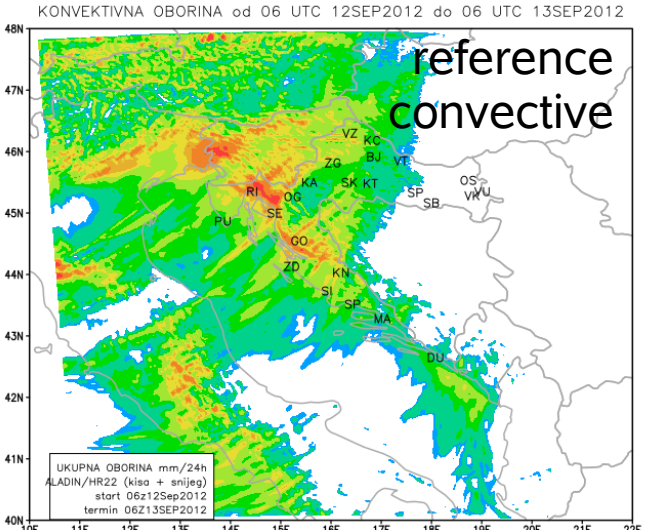
Complete report http://radar.dhz.hr/~tudor/sst/sst_coupl_files2.pdf

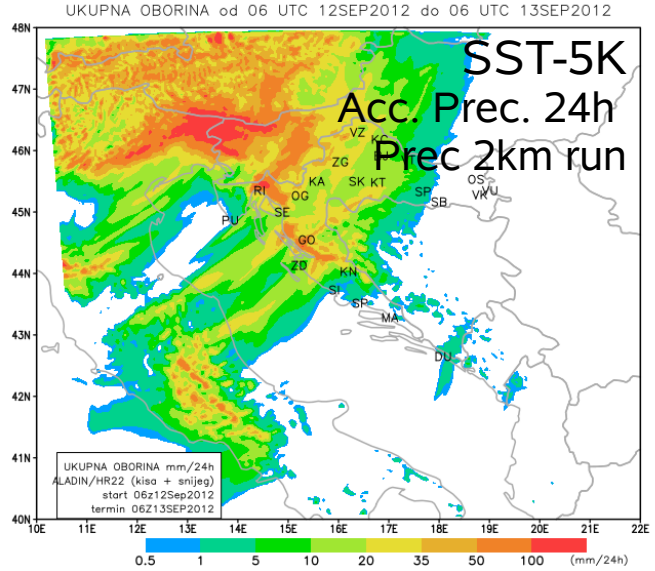
SST experiments

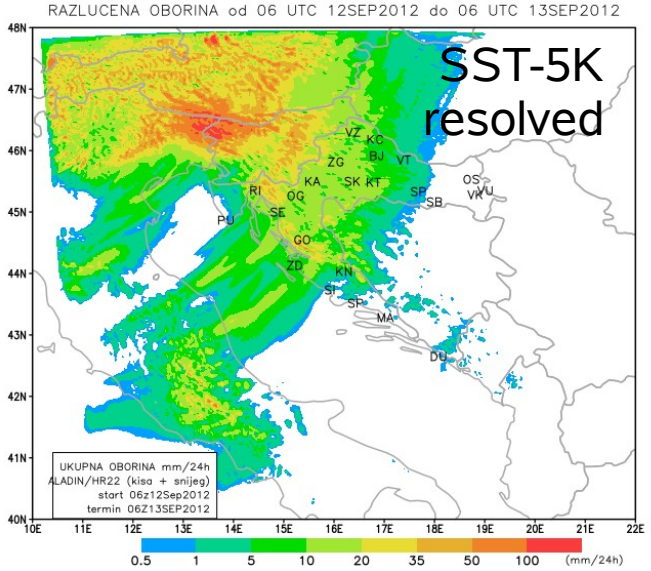
- Changing SST for all sea points by a fixed number (-10K, -5K, -2K, +2K, +5K)
- Insert SST from available analysis (can be from yesterday or few days ago) or from ocean model using available tools
  - For NetCDF files of OSTIA or MUR one can use EPYGRAM (good NetCDF format)
  - For ROMS (old NetCDF) a procedure written that assigns value from the closest ROMS grid-point (limit how far it can affect)
- All experiments presented here used the second tool.

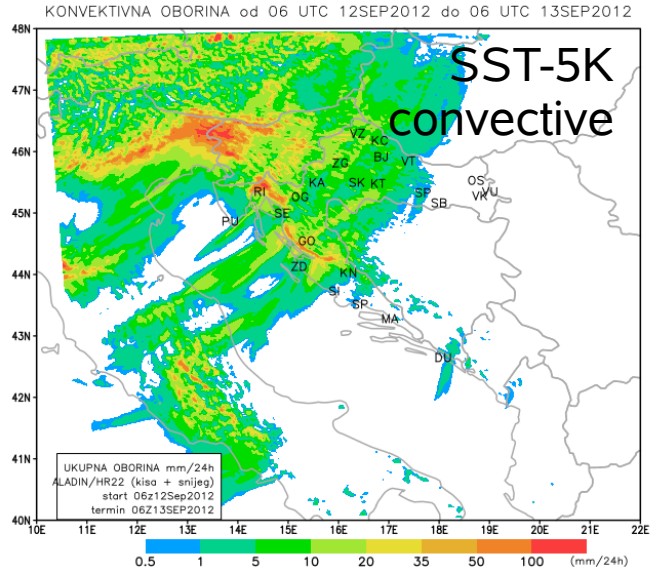

UKUPNA OBORINA od 06 UTC 12SEP2012 do 06 UTC 13SEP2012
Reference
Acc. Prec. 24h
Prec 2km run
UKUPNA OBORINA mm/24h
ALADIN/HR22 (kisa + snijeg)
start 06z12Sep2012
termin 06Z13SEP2012

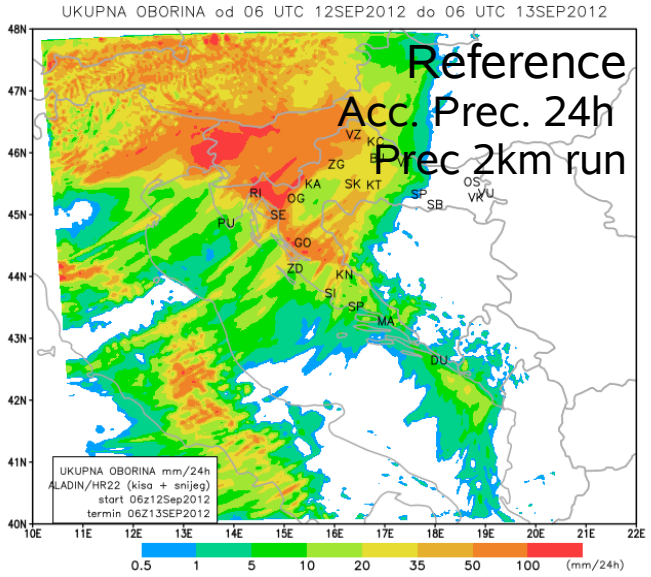

RAZLUCENA OBORINA od 06 UTC 12SEP2012 do 06 UTC 13SEP2012
reference
resolved
UKUPNA OBORINA mm/24h
ALADIN/HR22 (kisa + snijeg)
start 06z12Sep2012
termin 06Z13SEP2012

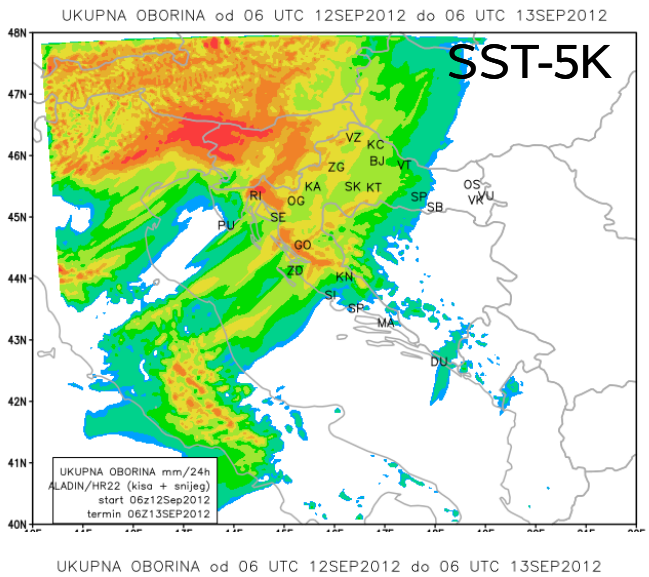

KONVEKTIVNA OBORINA od 06 UTC 12SEP2012 do 06 UTC 13SEP2012
reference
convective
UKUPNA OBORINA mm/24h
ALADIN/HR22 (kisa + snijeg)
start 06z12Sep2012
termin 06Z13SEP2012

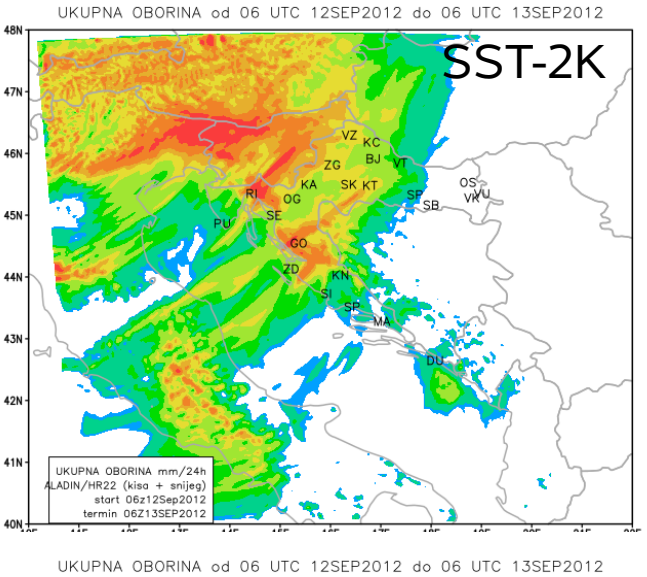

UKUPNA OBORINA od 06 UTC 12SEP2012 do 06 UTC 13SEP2012
SST-5K
Acc. Prec. 24h
Prec 2km run
UKUPNA OBORINA mm/24h
ALADIN/HR22 (kisa + snijeg)
start 06z12Sep2012
termin 06Z13SEP2012
0.5 1 5 10 20 35 50 100 (mm/24h)


RAZLUCENA OBORINA od 06 UTC 12SEP2012 do 06 UTC 13SEP2012
SST-5K
resolved
UKUPNA OBORINA mm/24h
ALADIN/HR22 (kisa + snijeg)
start 06z12Sep2012
termin 06Z13SEP2012
0.5 1 5 10 20 35 50 100 (mm/24h)

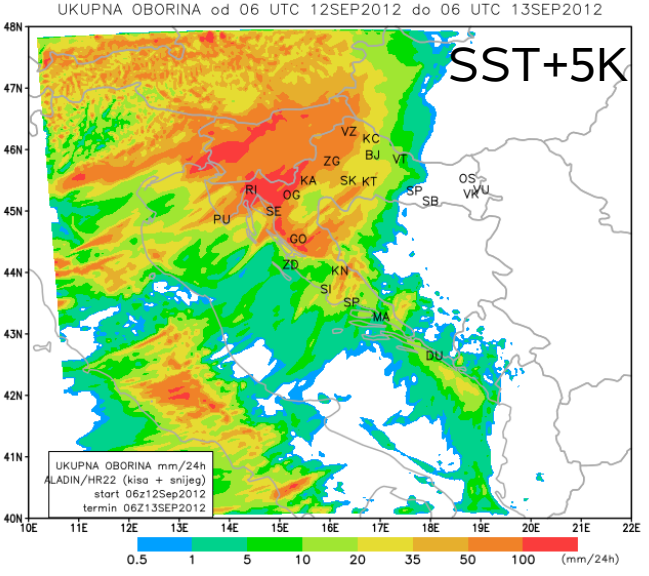

KONVEKTIVNA OBORINA od 06 UTC 12SEP2012 do 06 UTC 13SEP2012
SST-5K
convective
UKUPNA OBORINA mm/24h
ALADIN/HR22 (kisa + snijeg)
start 06z12Sep2012
termin 06Z13SEP2012
0.5 1 5 10 20 35 50 100 (mm/24h)

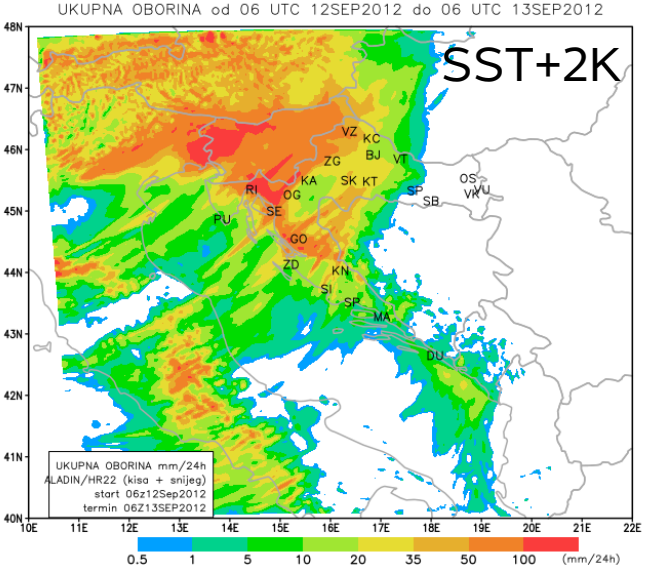


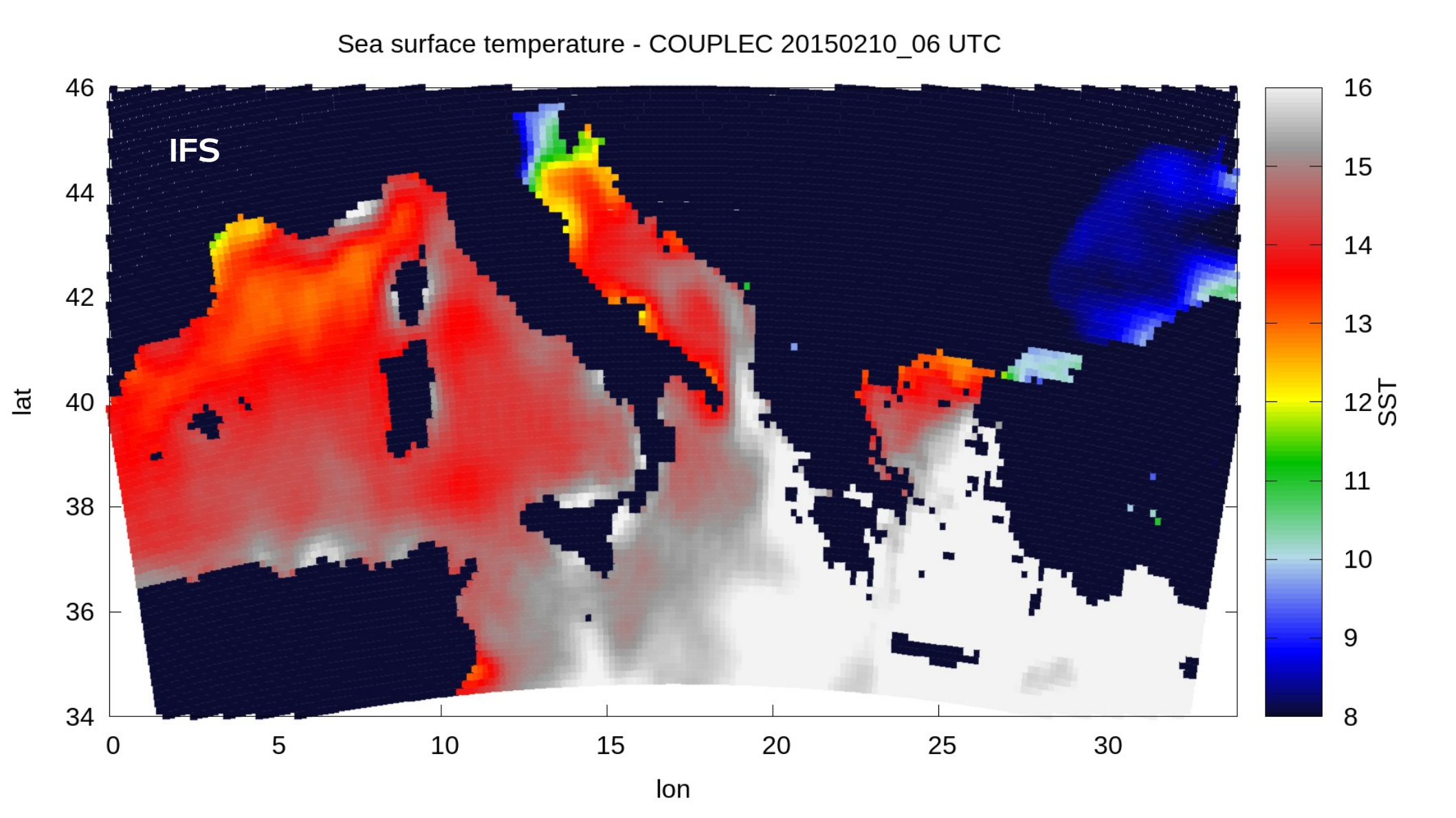




Warmer SST –
more precipitation






Sea surface temperature - COUPLEC 20150210_06 UTC
IFS
lat
lon
SST
46
44
42
40
38
36
34
0
5
10
15
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25
30
16
15
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13
12
11
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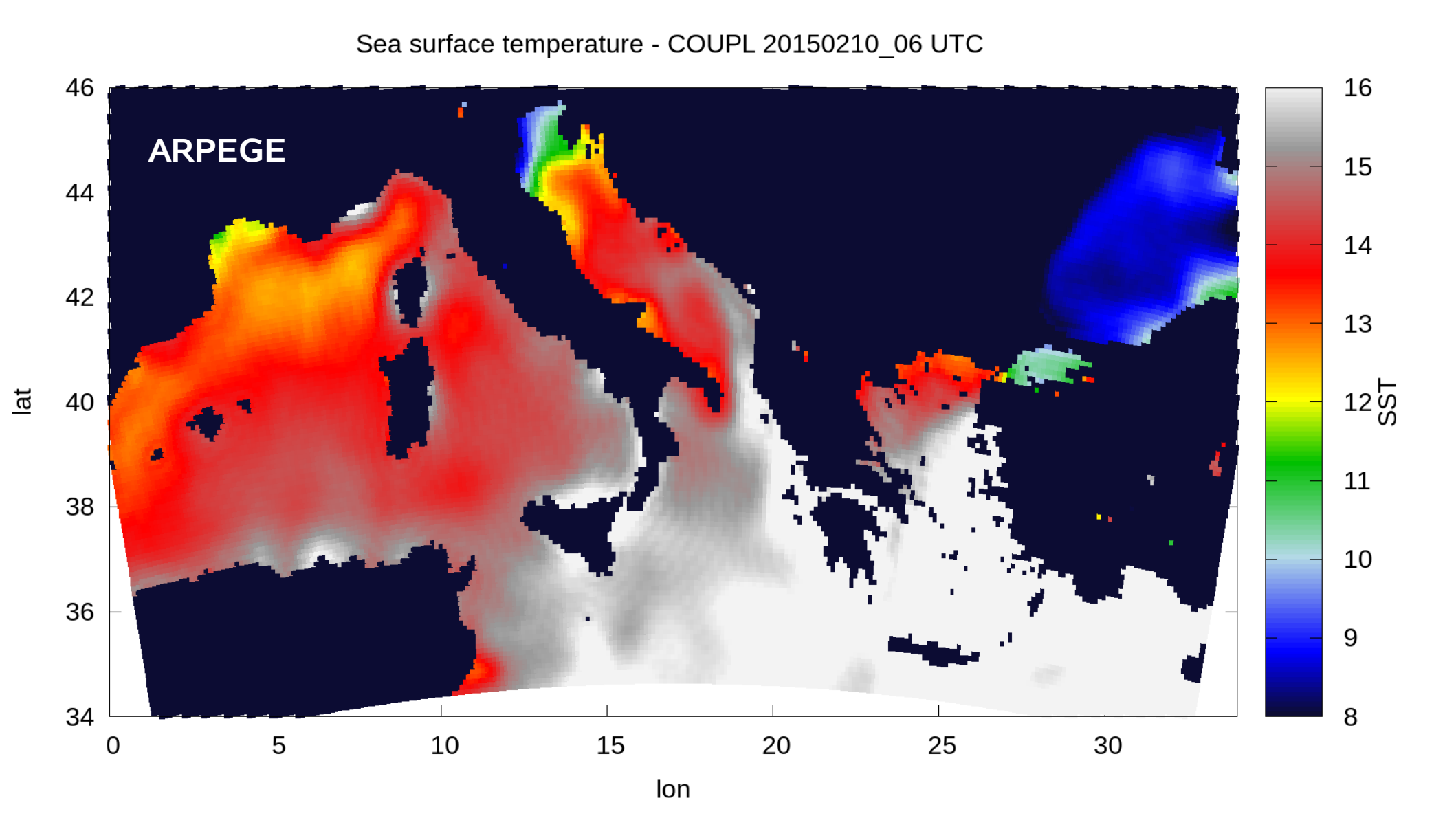
9
8


Sea surface temperature - COUPL 20150210_06 UTC
ARPEGE
lat
lon
SST
46
44
42
40
38
36
34
0
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10
15
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30
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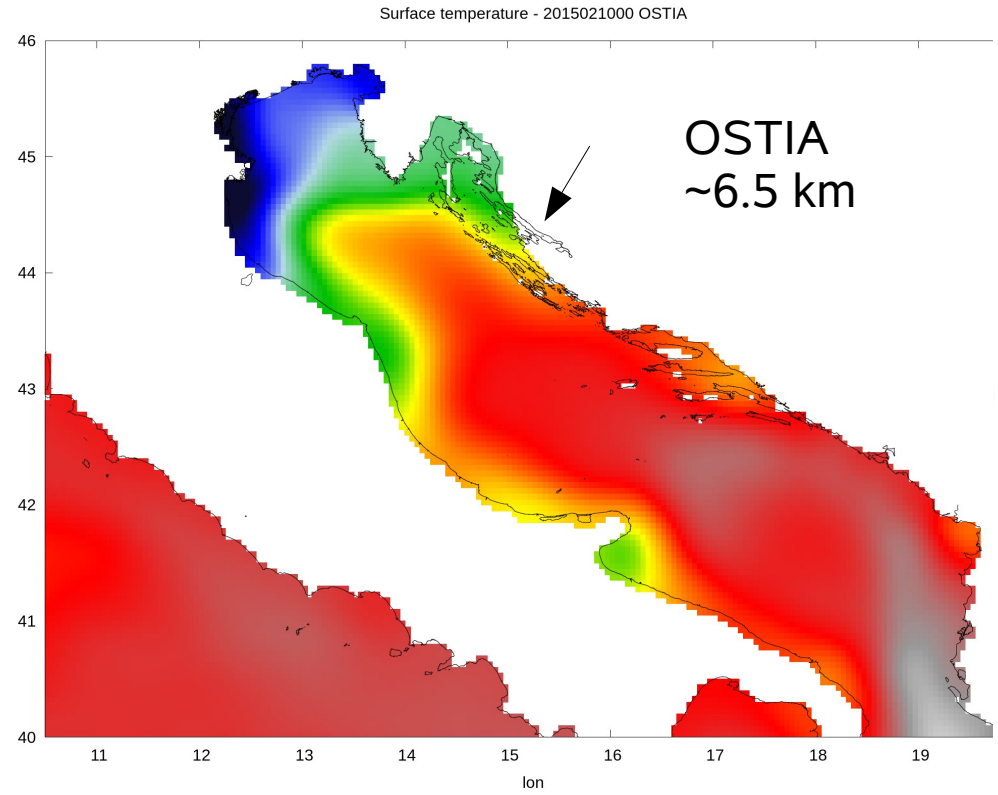
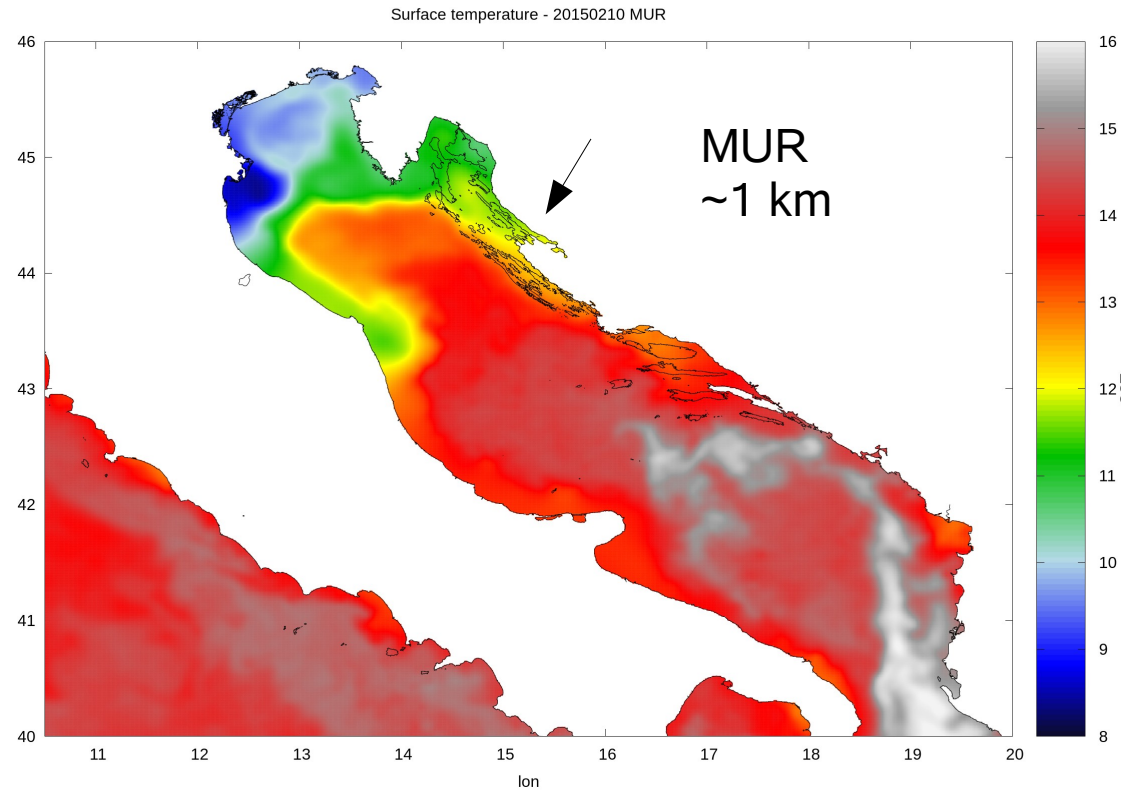
8

SST from SST analyses

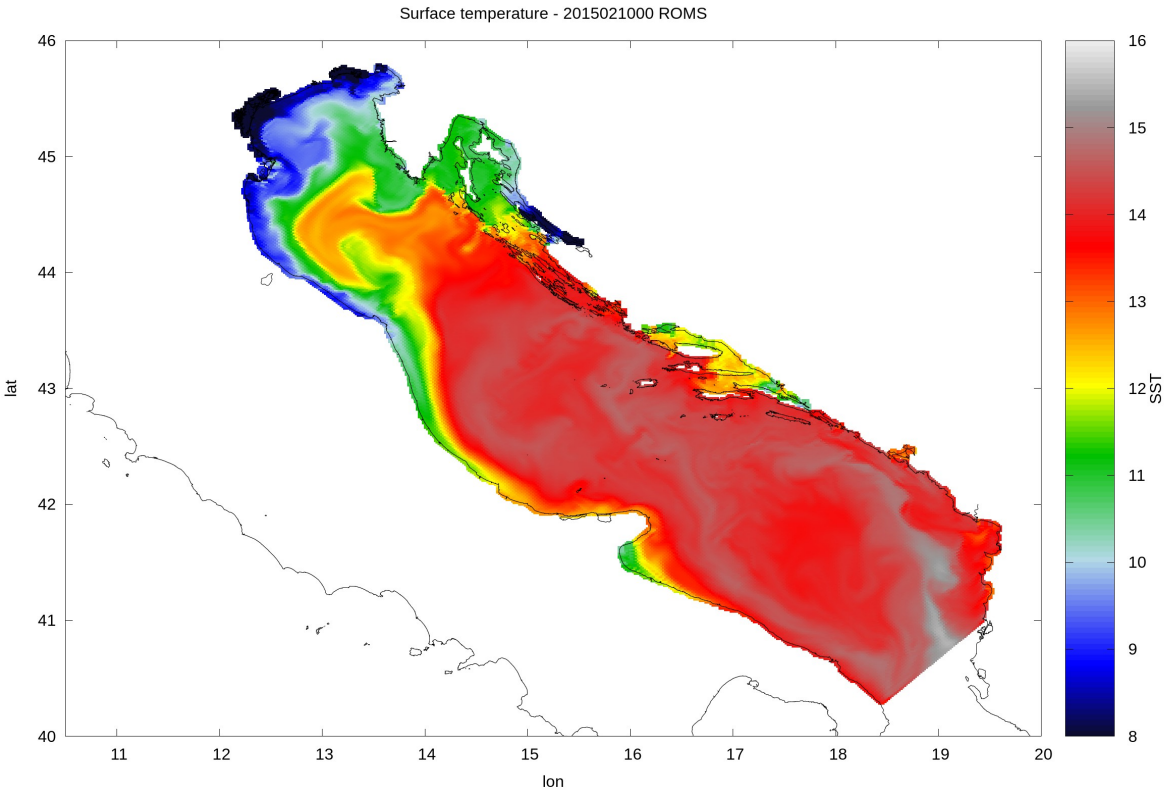




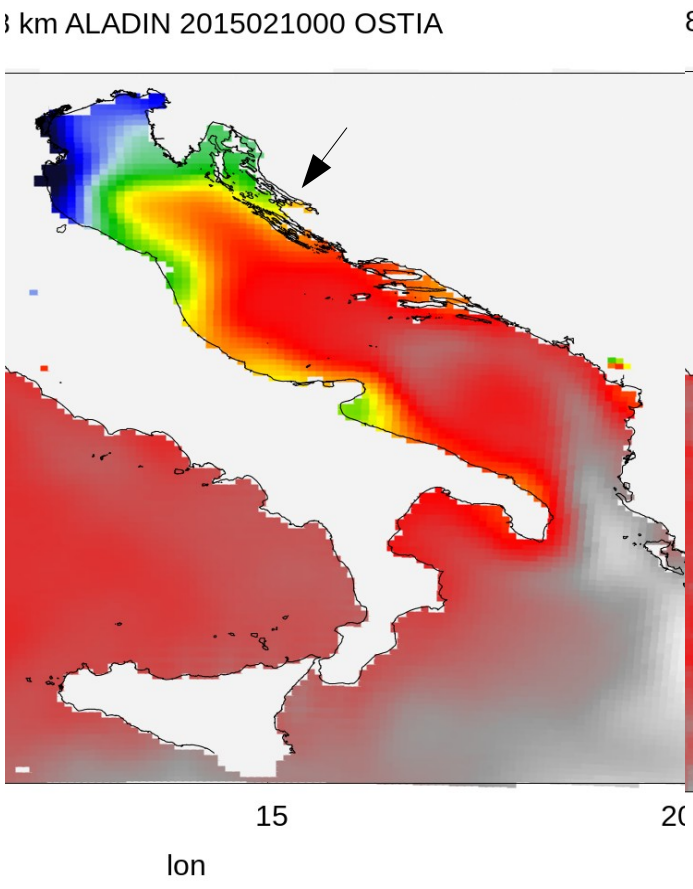
OSTIA has no data in the Velebit channel. MUR treats the islands as the sea surface.

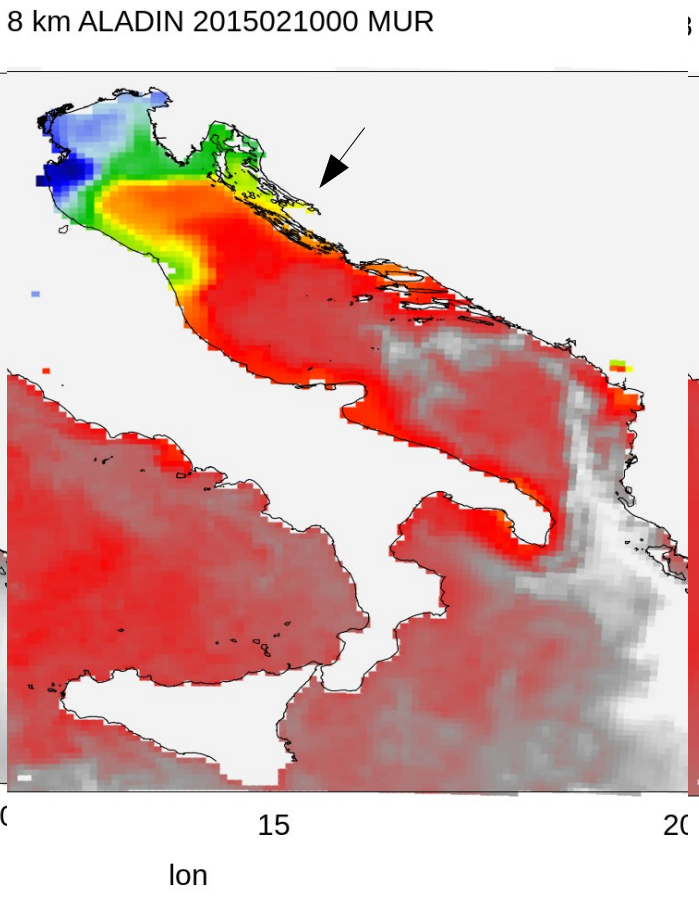
SST from ROMS

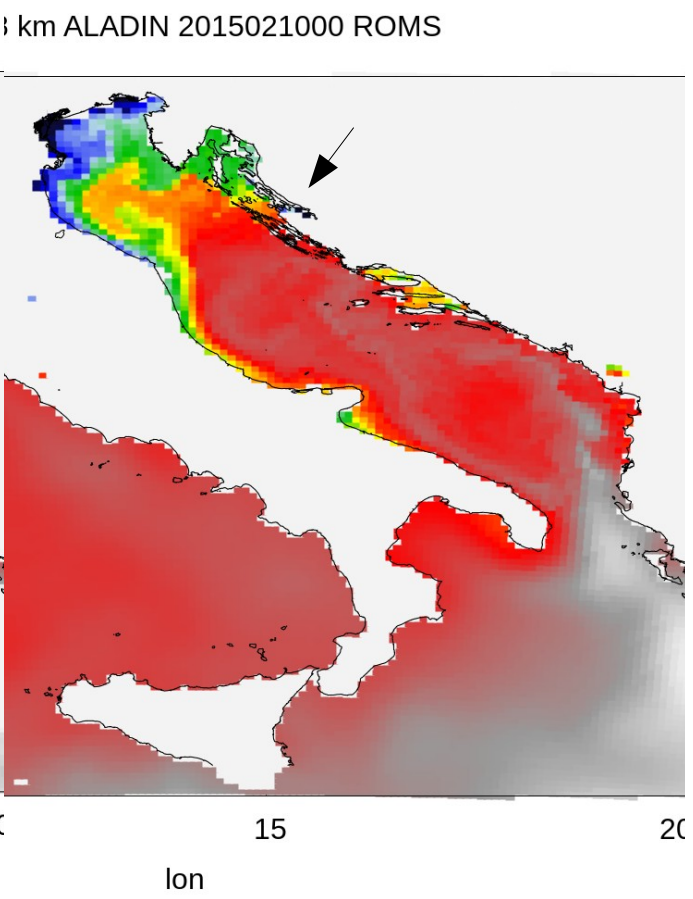
- 2km resolution, 20 S levels
- covers only Adriatic so something else needed on the rest of the sea surface and smooth transition at Otranto
- details in Janeković et al. JGR-Oceans 2014



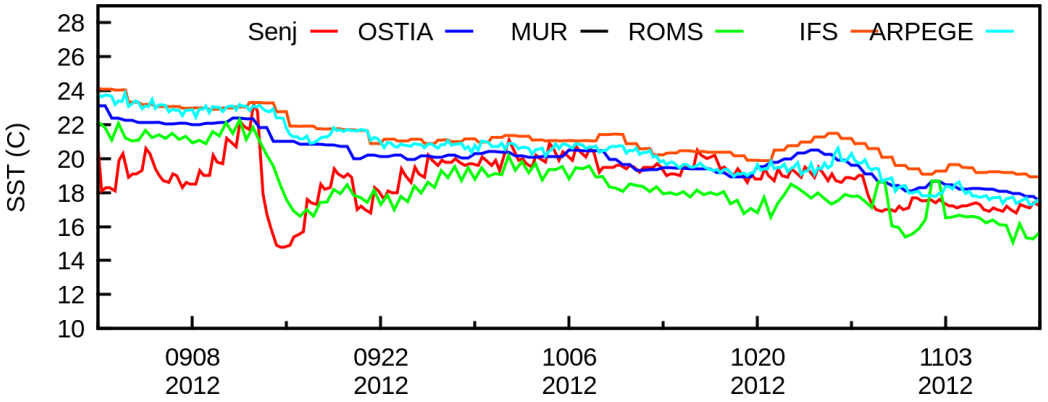
When inserted into 8 km



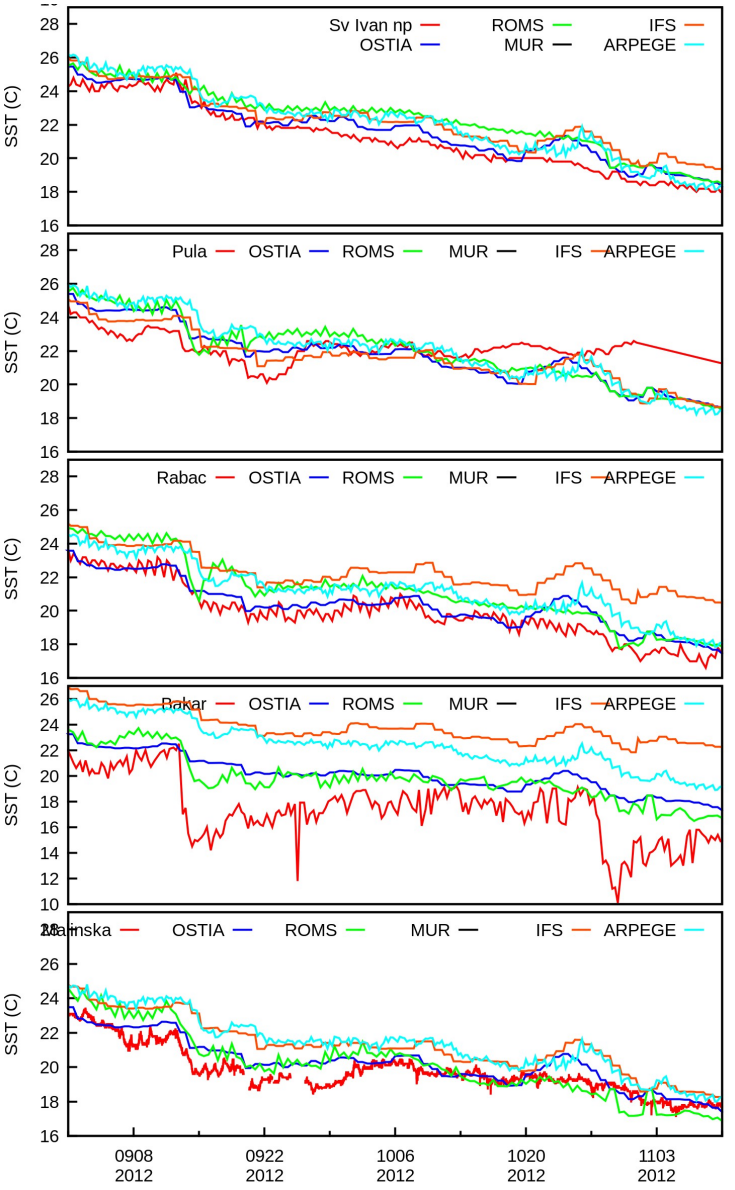


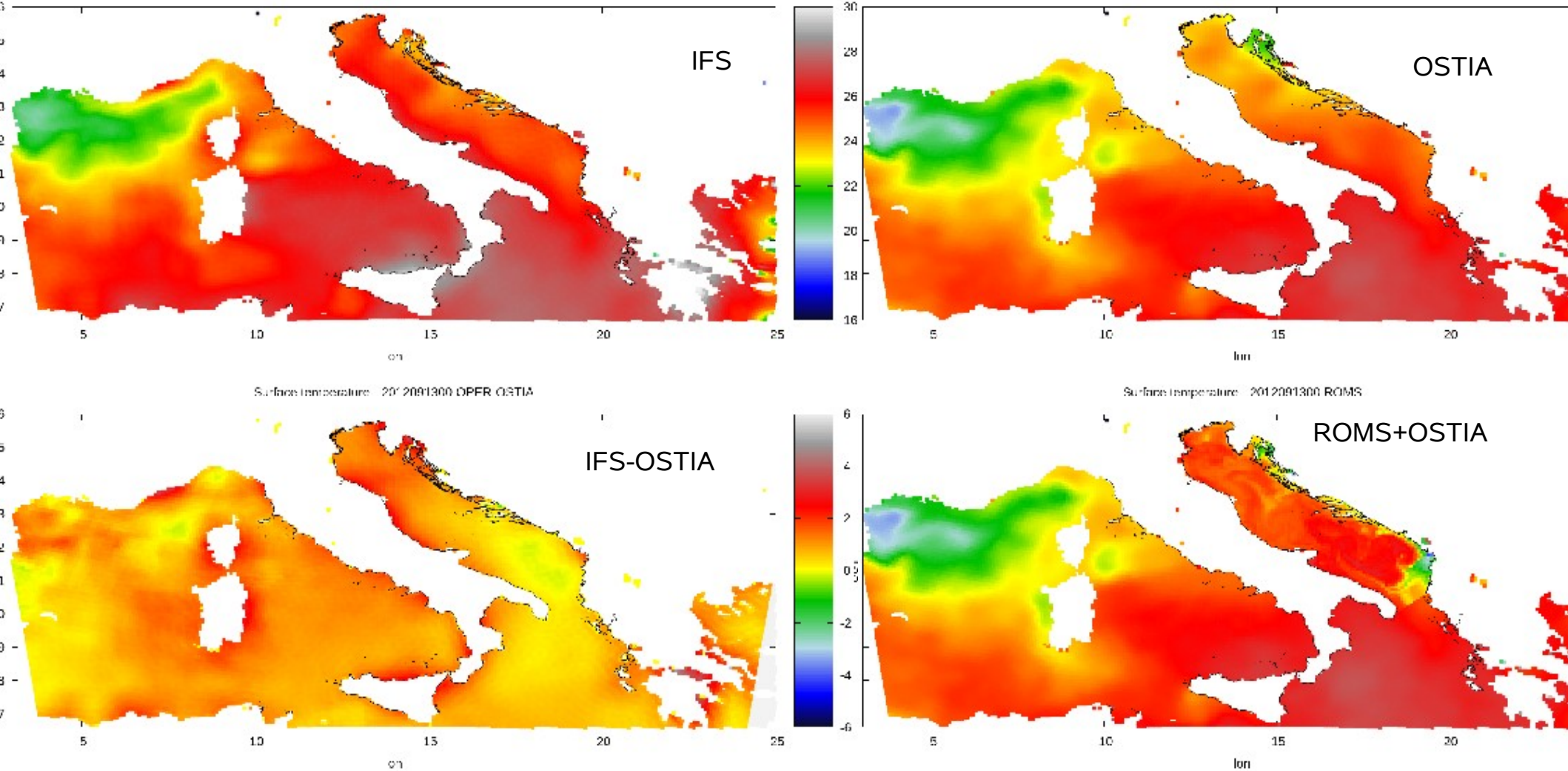


SST from different sources during 2 months



Sea surface temperature: measured (red), from the nearest sea point in OSTIA (blue), MUR 1 km resolution analysis from NASA (black), ROMS ocean model (green), IFS (orange) and ARPEGE (cyan). These stations are in Kvarner bay (Rabac, Bakar), Velebit channel (Senj) and western Istria (sv Ivan).
Both global models have much warmer SST that it is in real life, analyses not always better.

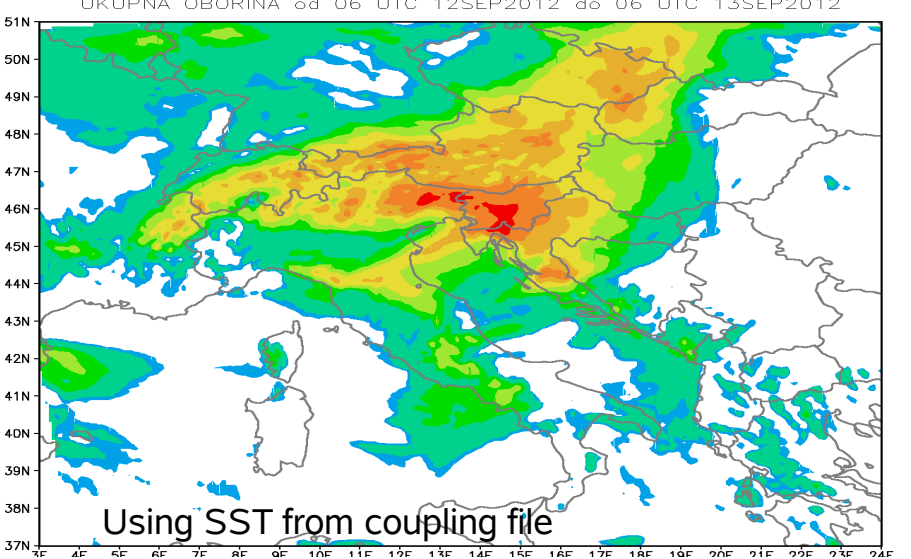


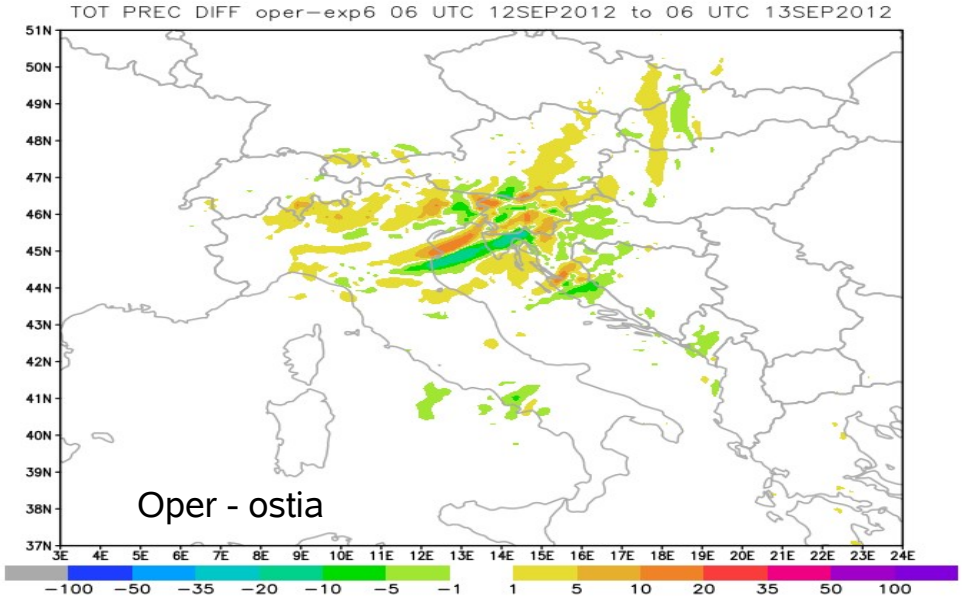


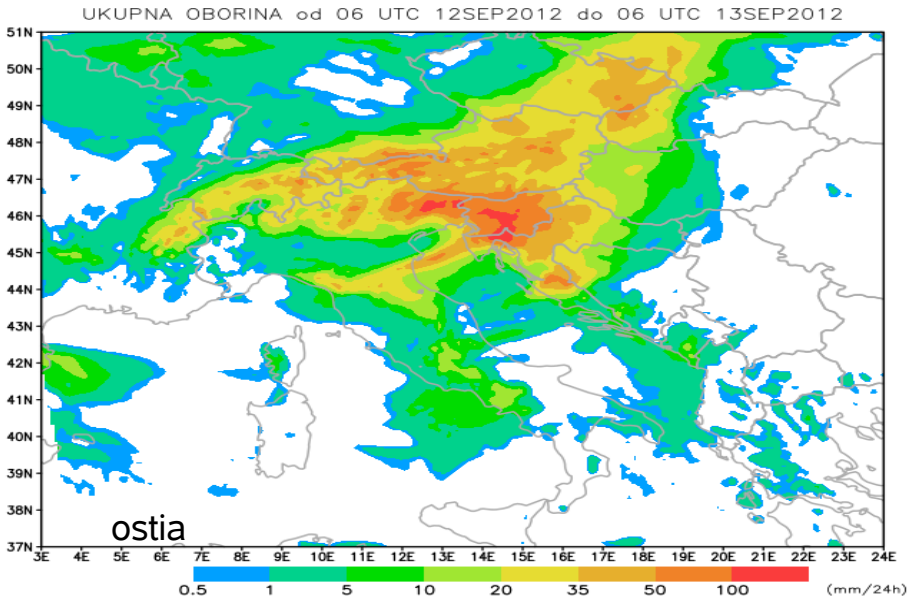
SST from the initial conditions remains fixed during the 72 hour forecast. The above figures are for 13 September 2012. SST used operationally is too warm.

Impact on precipitation forecast

Accumulated 24 hourly precipitation from 06 UTC 12 September 2012, and their difference (54-30 hour forecast starting from 00 UTC 11 Sep 2012).

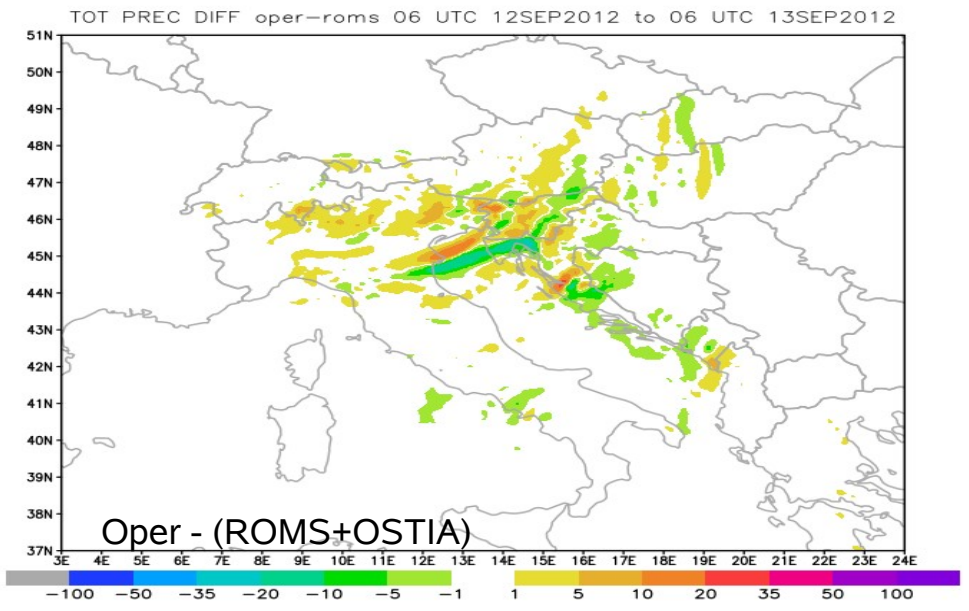


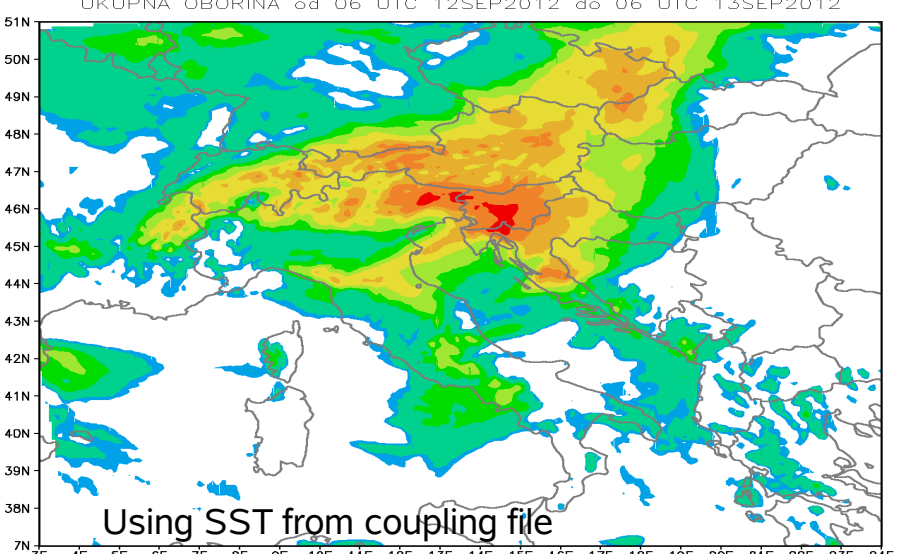


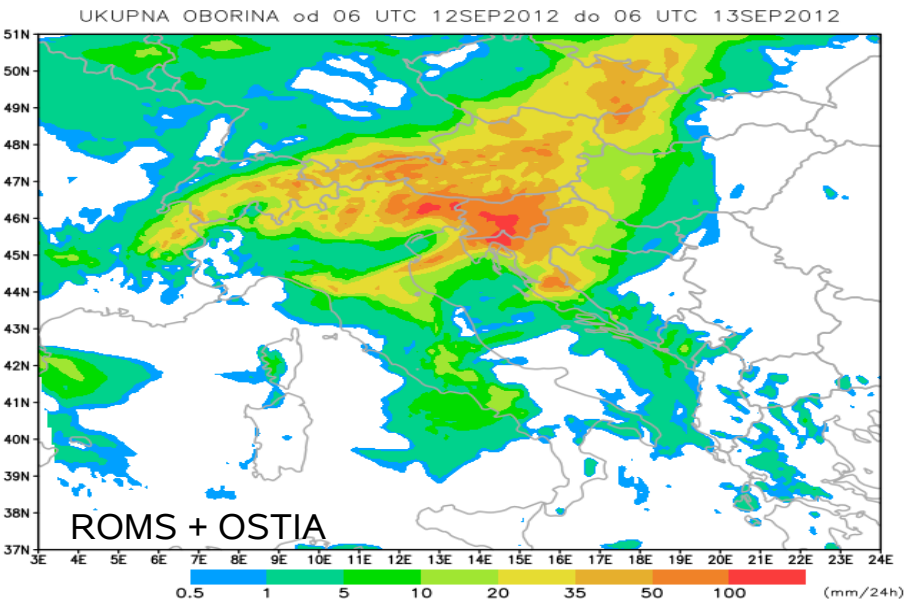


Impact on precipitation forecast

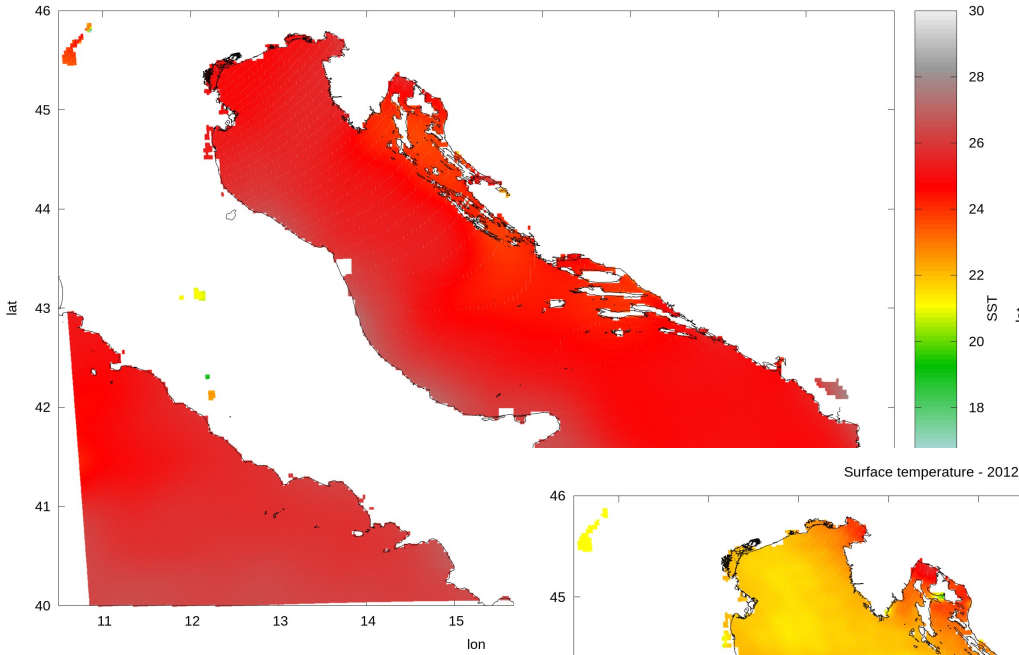
Accumulated 24 hourly precipitation from 06 UTC 12 September 2012, and their difference (54-30 hour forecast starting from 00 UTC 11 Sep 2012).



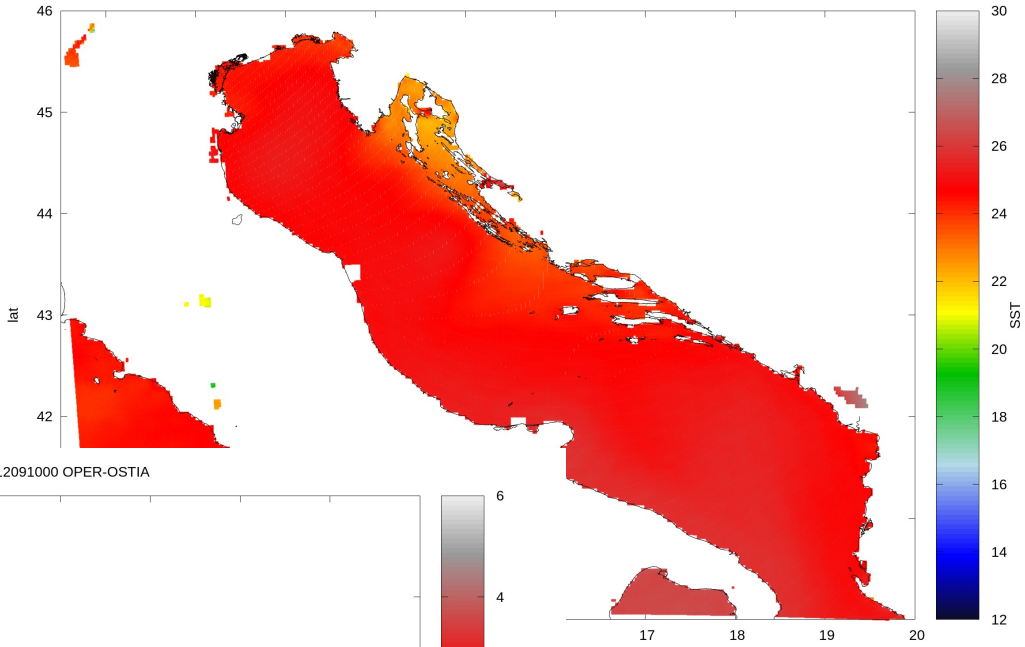




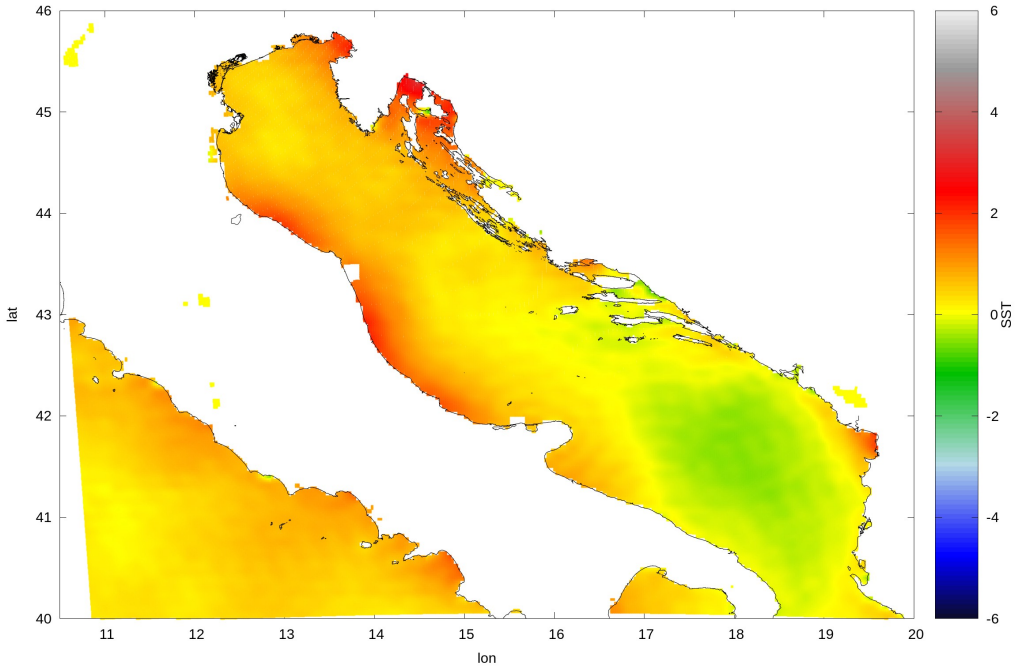
Surface temperature - 2012091000 OPER



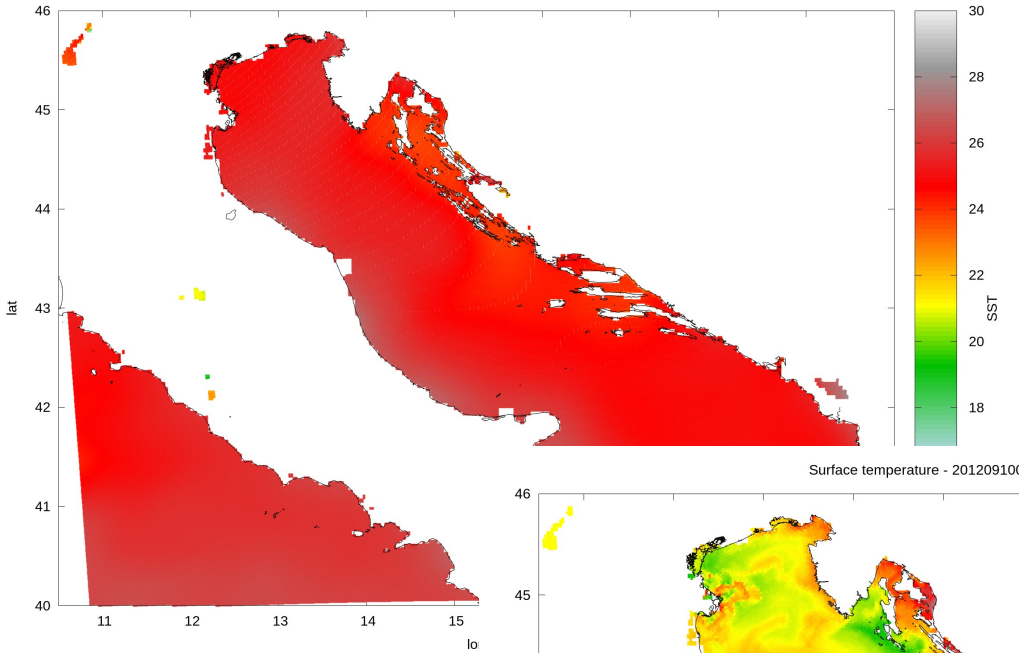
Surface temperature - 2012091000 OSTIA



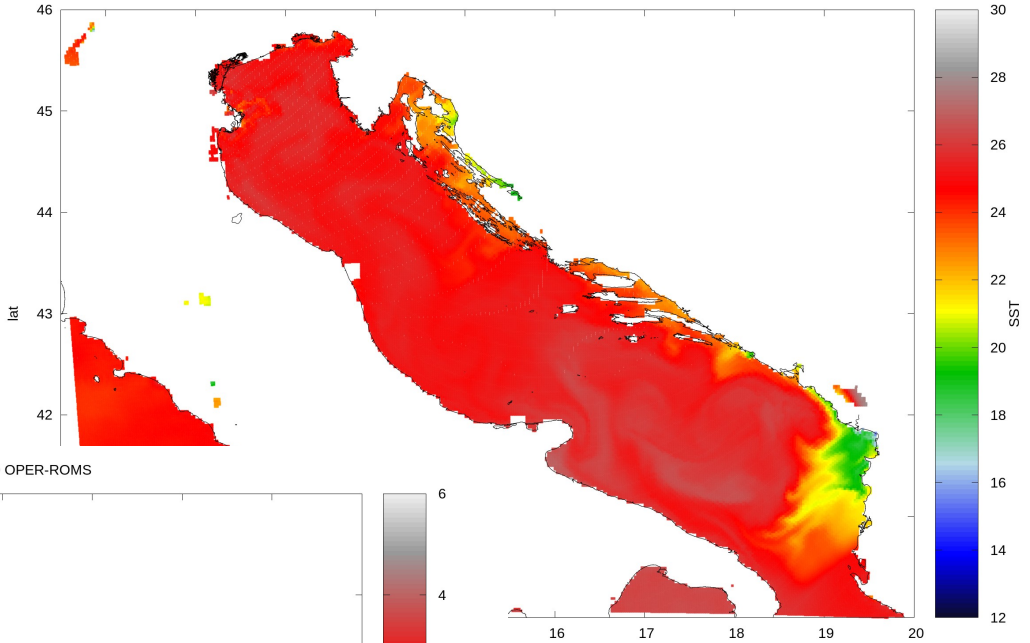
Surface temperature - 2012091000 OPER-OSTIA



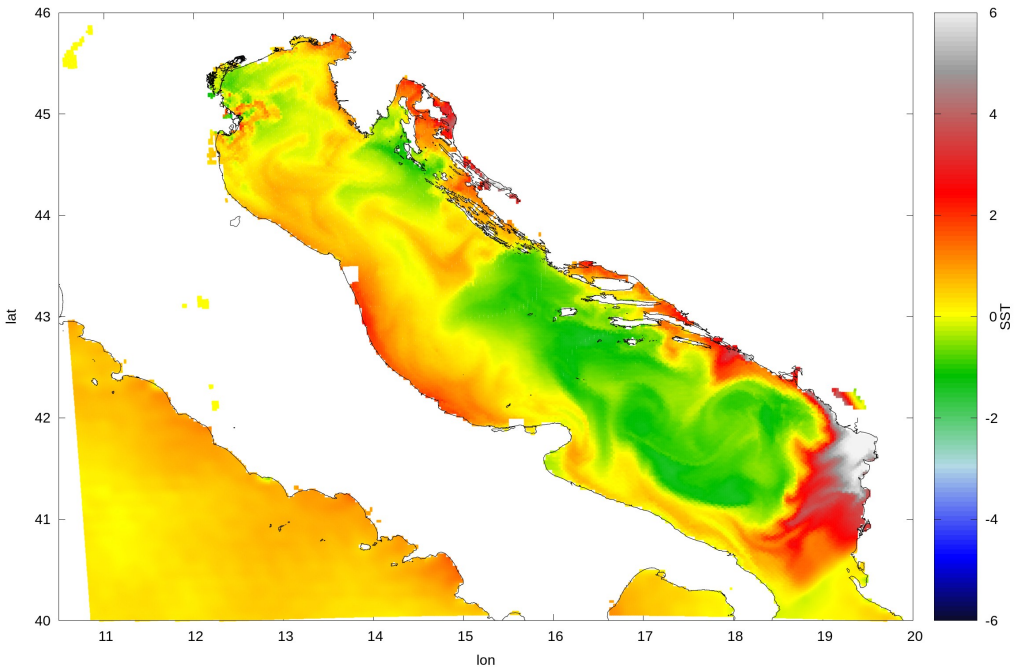
Surface temperature - 2012091000 OPER



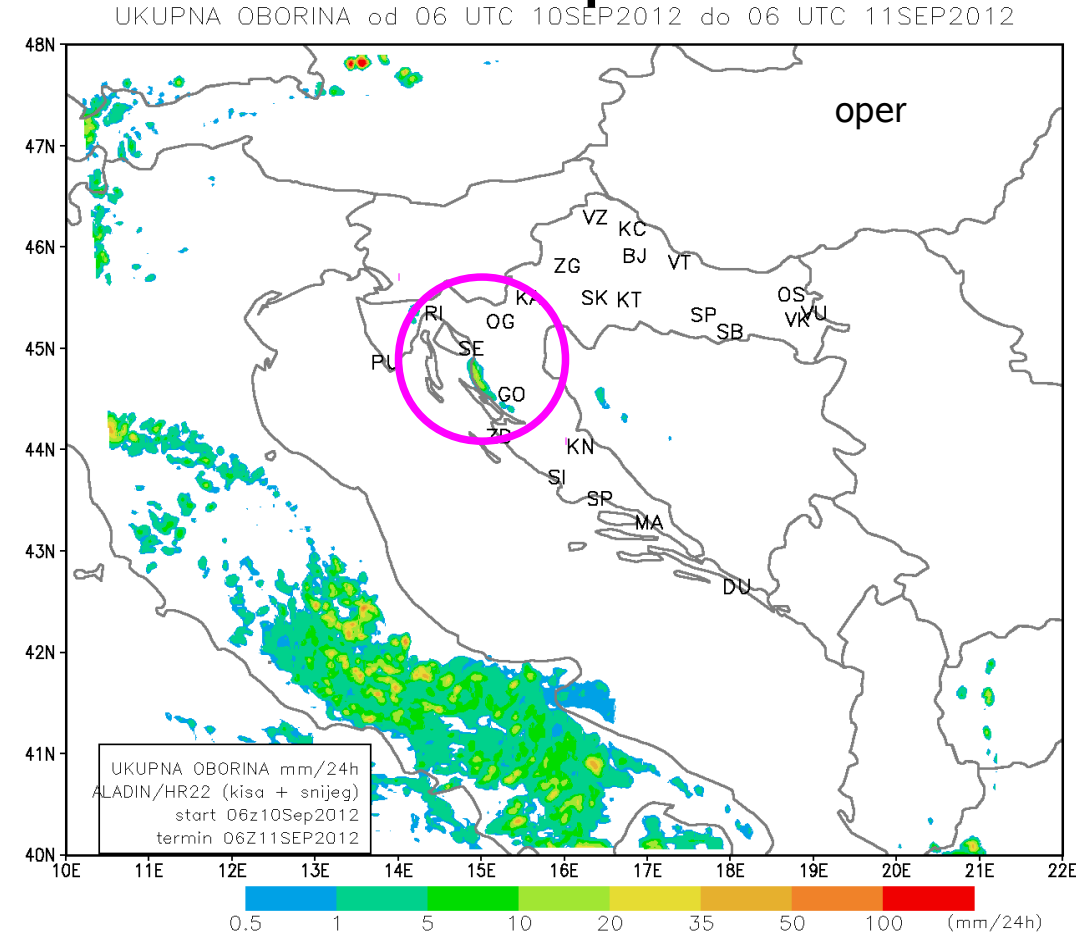
Surface temperature - 2012091000 ROMS

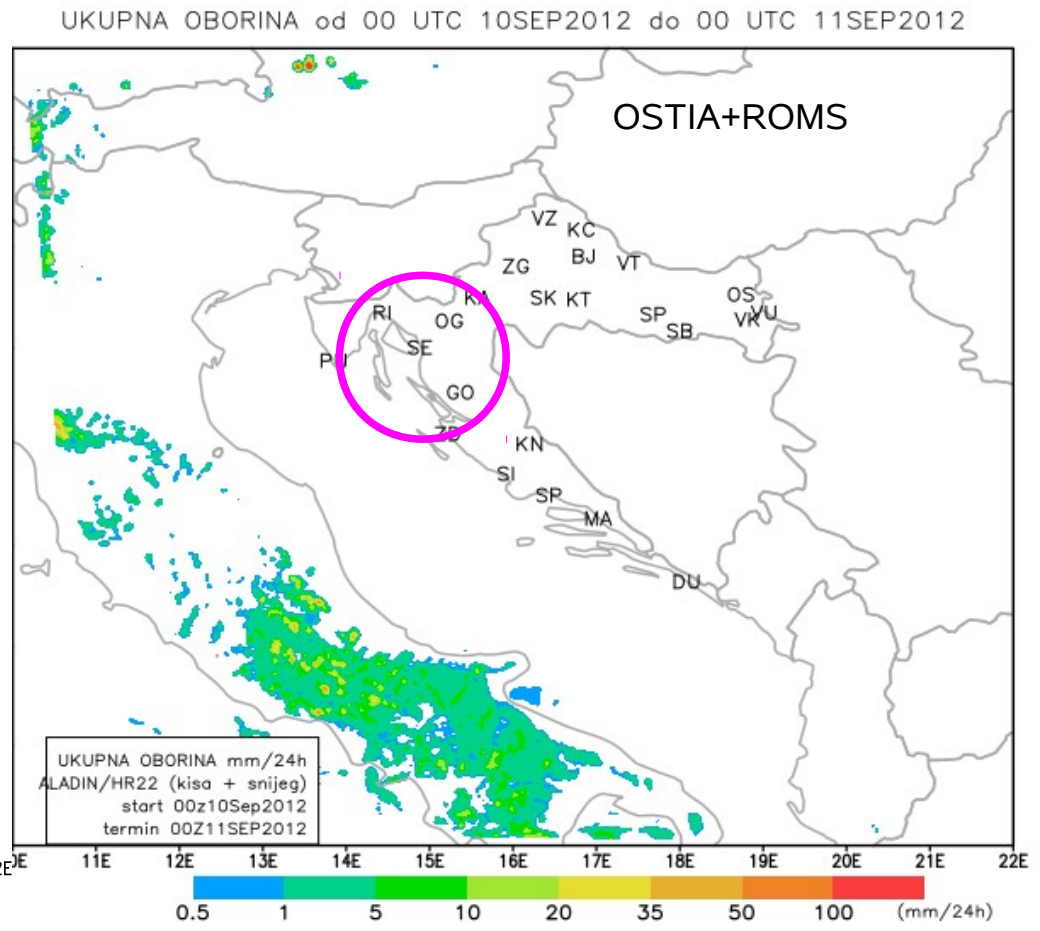


Surface temperature - 2012091000 OPER-ROMS



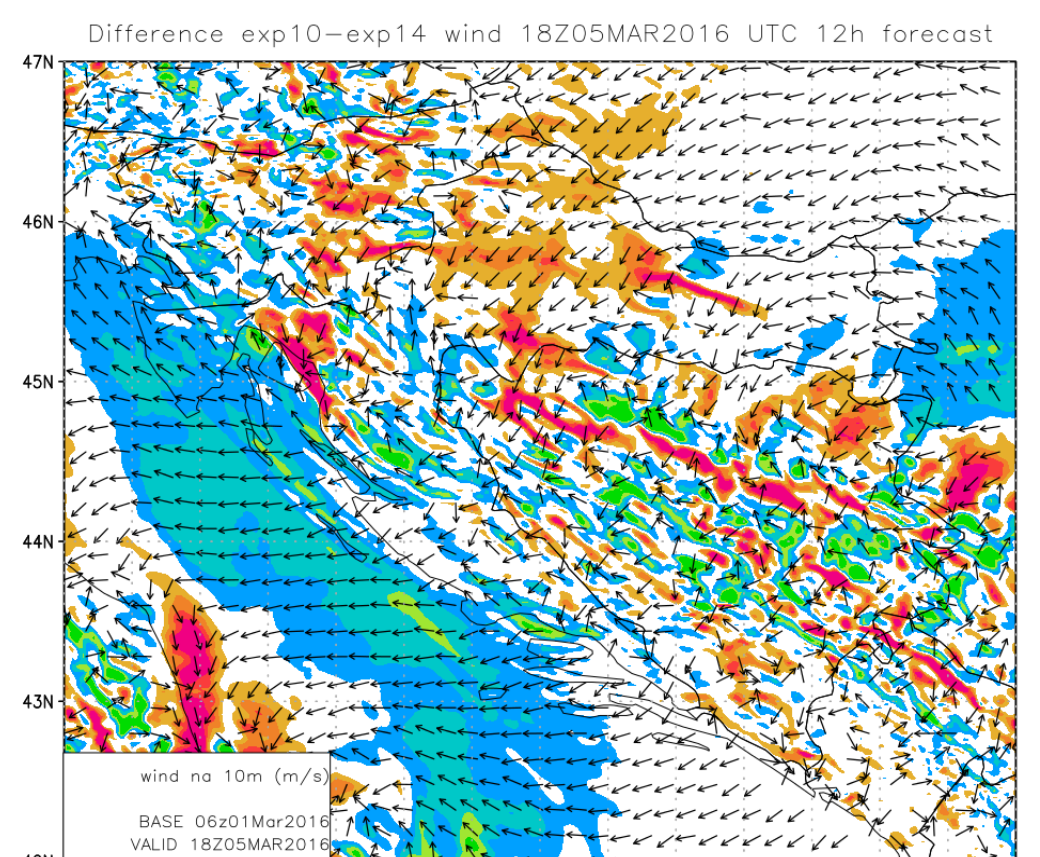
Precipitation over Velebit mountain

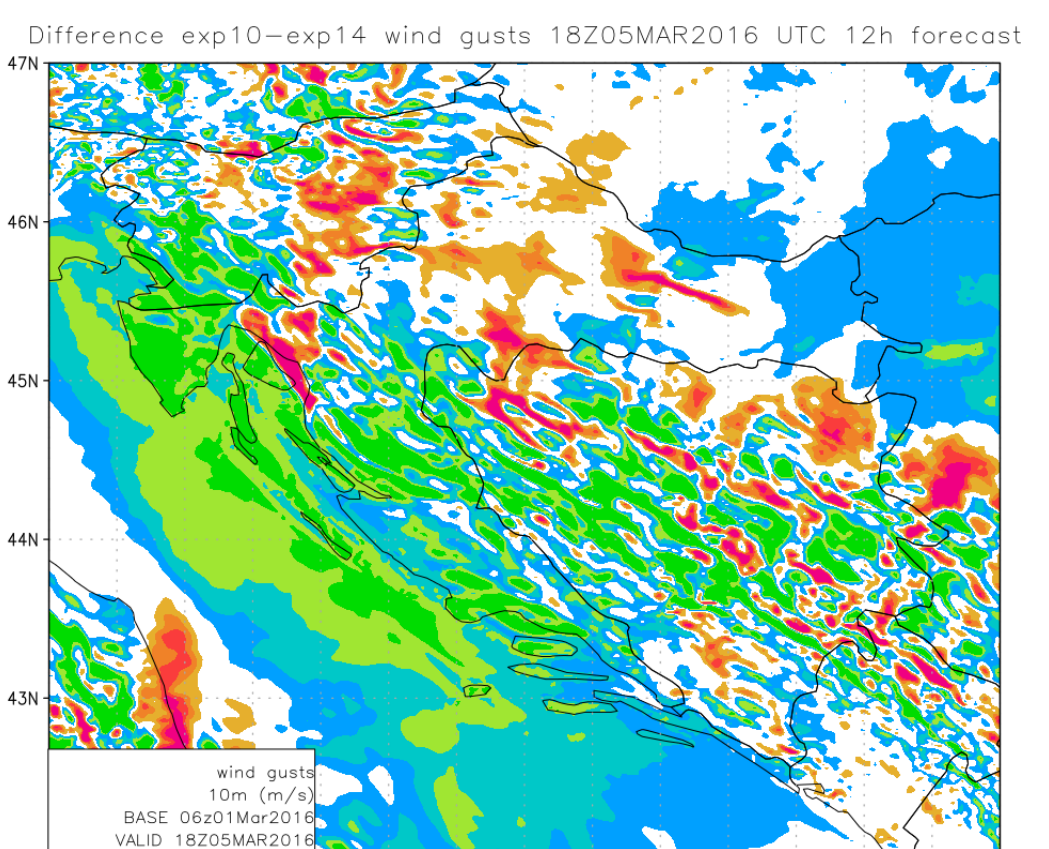




Accumulated 24 hourly precipitation forecast from 06 UTC 10 September 2012
Using operational SST (left) and a combination OSTIA and ROMS (right)
Warm SST in Veelbit channel was the cause of wrong precipitation forecast over Velebit!

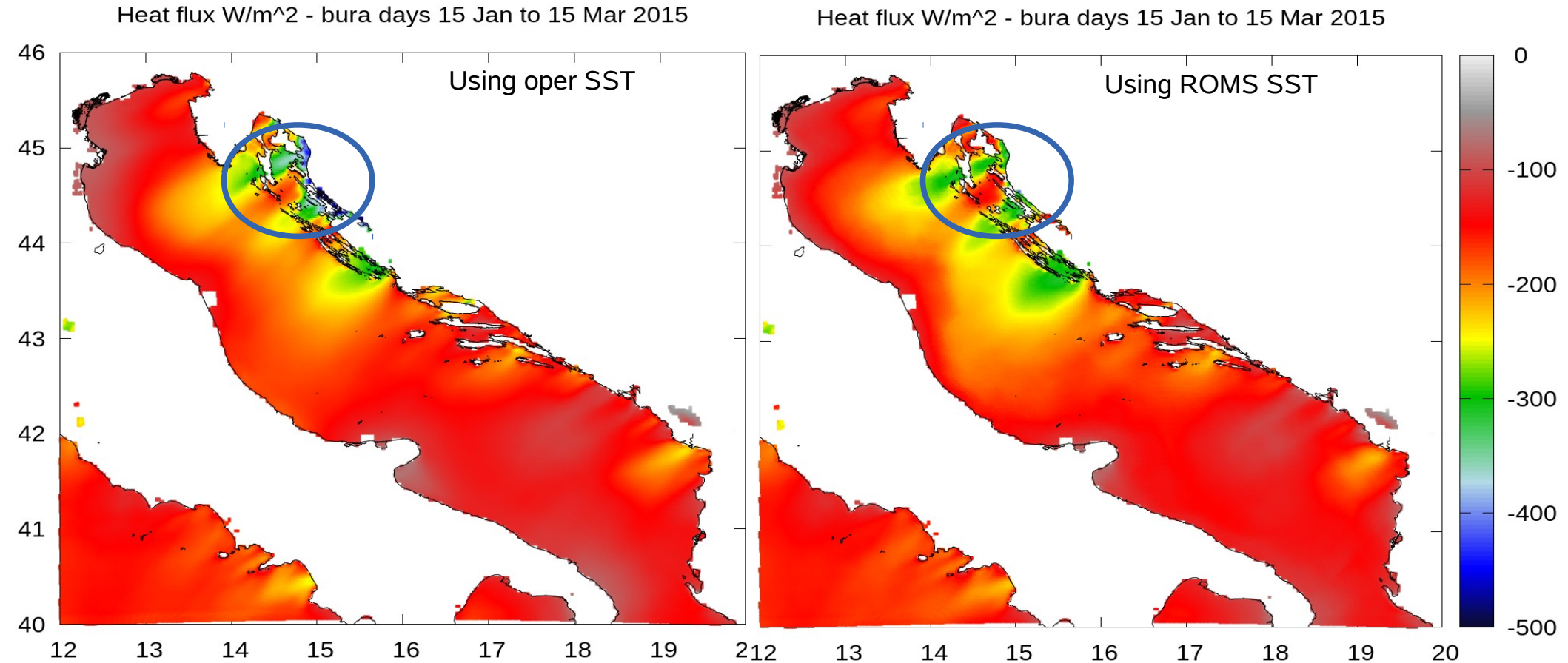
Impact on wind speed and gusts





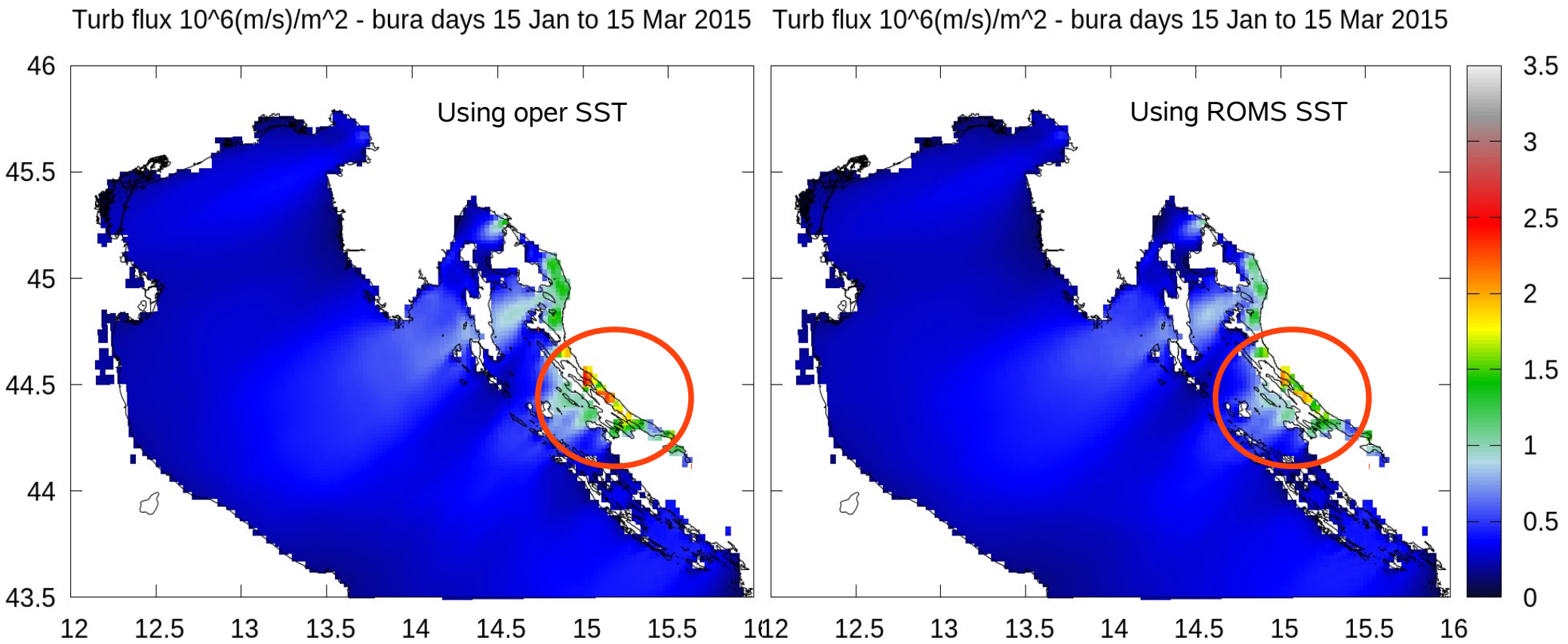
Heat fluxes in bura (strong dry wind)

Heat fluxes too strong over too warm sea surface since there is more evaporation.
Using improved SST from ROMS model (2 km resolution ocean model with data assimilation over Adriatic) yields more reasonable fluxes in Velebit chanel.

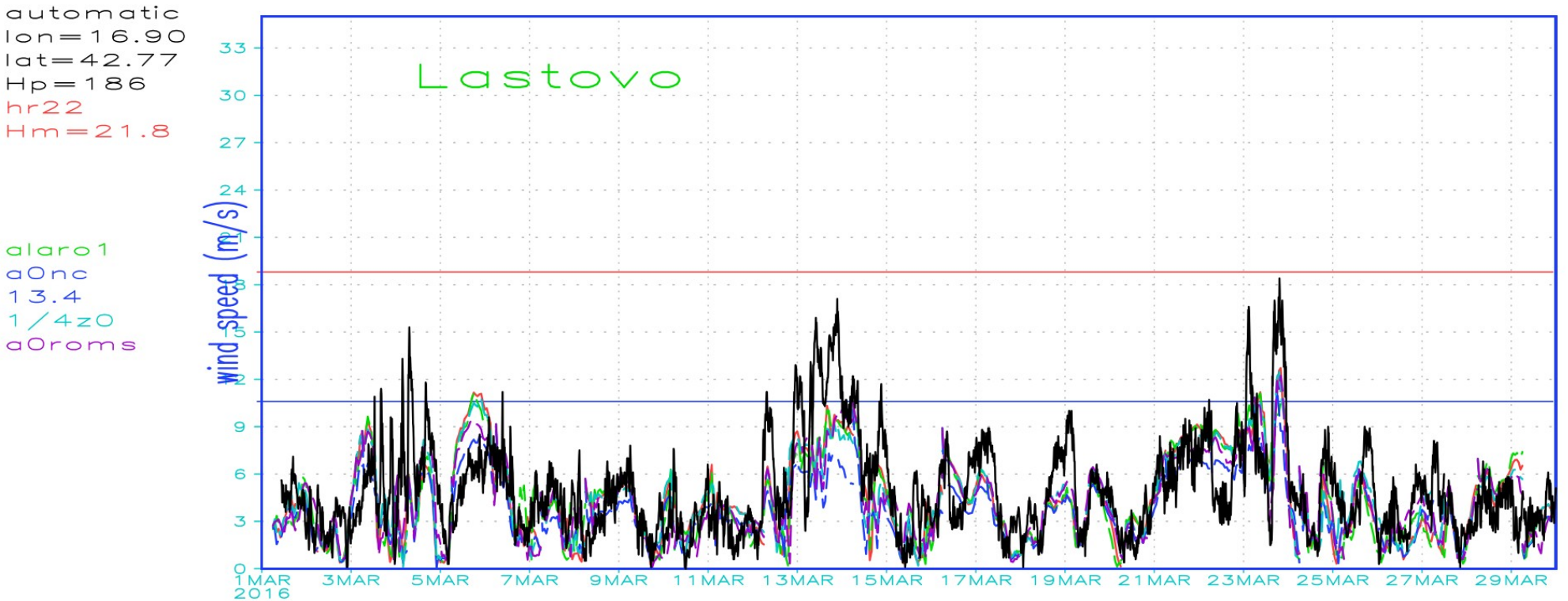


Turbulent fluxes in bura

Turbulent fluxes too strong over too warm sea surface since the atmosphere is less stable there.
Using improved SST from ROMS model (2 km resolution ocean model with data assimilation over Adriatic) yields more reasonable fluxes in Velebit chanel.



Month of 2km 24 hourly forecasts



Wind at 10 m at Knin station during March 2016: measured 10 minute average (black), operationalforecasts in 2 km resolution using **Alaro0** (red), Alaro1 (green), alaro0 with new z0 (blue), scaled new z0 (cyan) and using OSTIA+ROMS SST (purple).

Month of 2km 24 hourly forecasts

Wind gusts at 10 m at Knin station during March 2016: measured 10 minute average (black), operationalforecasts in 2 km resolution using **Alaro0** (red), Alaro1 (green), alaro0 with new z0 (blue), scaled new z0 (cyan) and using OSTIA+ROMS SST (purple).

Final thoughts

- Initial values of SST are very important for the forecast.
- Correcting SST after initialization means the lower layers of the atmosphere adapt to the new surface during the forecast.
- The errors in the forecast of precipitation in high-resolution were linked to too warm SST.
- These experiments are a starting point for the coupled atmosphere-ocean model runs (using the same SST).

Hot spots

Unfortunately there were some features in SST that could not be physically explained. The most striking examples were stations where measured and model SSTs agree well for the period from 1st April until 1st November each year, but then SST in coupling files from ECMWF suddenly increases for several degrees. This warm bias in SST of up to 5°C (depends on station) remains, or changes suddenly on the 1st day of a calendar month. On 1st April, the bias disappears. Other stations nearby do not exhibit this strange feature.