The Sea Surface Temperature in operational NWP model ALADIN

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ABSTRACT

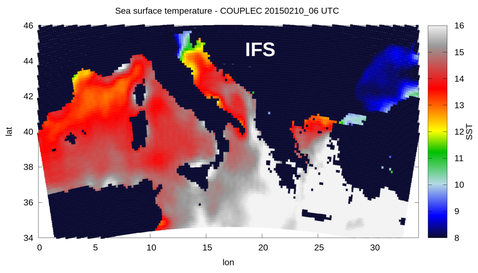
Sea surface temperature (SST) influences the model forecast. For example it is important for the correct modelling of land/sea breeze and influences the intensity of precipitation downstream. In operational forecast using numerical weather prediction (NWP) model ALADIN, SST is taken from initial file and remains constant during the model forecast (up to 72 hours). There are two sets of SST fields provided in the coupling files from operational forecasts of IFS and ARPEGE, provided by ECMWF and Meteo-France respectively. In this study we used SST measured in situ on a number of stations in Croatia and Italy.

The ARPEGE operational SST analysis combines AVHRR satellite data and in situ measurements in the operational oceanographic model Mercator. The SST from IFS forecast is derived from the Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) analysis. SST from the Regional Ocean Modelling System (ROMS) was used over the Adriatic Sea with OSTIA analysis over the rest of the Mediterranean.

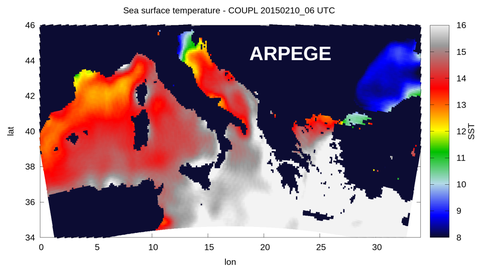
The impact of SST on the intensity and location of intensive rainfall is investigated by using alternative SST fields in the initial conditions, first from ARPEGE and IFS. In the first set of experiments, SST effects on forecast precipitation are analysed by modifying the SST field in the initial file by shifting the SST field uniformly. For each model forecast, the SST field obtained from ARPEGE is modified by increasing or decreasing SST values by 2K and 5K and finally decreasing by 10K for all sea points in the model domain. These values have been chosen on the basis of evaluation of model and analysed SST against in situ data.

In the further set of experiments, SST in the model was replaced using OSTIA and MUR analyses as well as ROMS model output. In one experiment we also nudged the SST field towards the measurements in order to test if precipitation forecast can be improved when SST is based on measurements.

Here we briefly analyse the SST fields from the coupling files and find that errors in SST over Adriatic can exceed 10K. In reality, Kvarner Bay and Velebit Channel are often much colder than the rest of the Adriatic. In winter, western Adriatic current (WAC) is much colder too. The sea surface is too warm in the model and, consequently, the evaporation is much stronger yielding excess precipitation on the coastal mountains. Turbulent fluxes of heat are also too strong above the sea surface. Colder SST in coastal areas reduces the precipitation on the mountain.

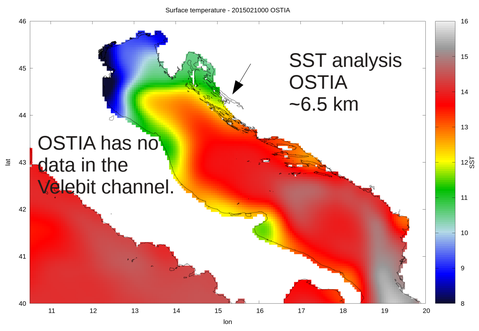


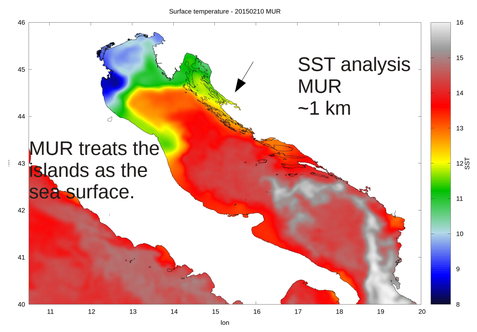
Example of operational SST from IFS.

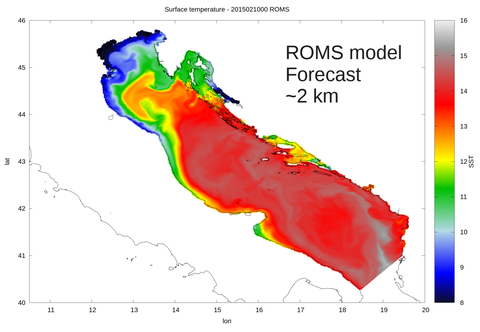


Example of operational SST from ARPEGE.

Alternative SST-s

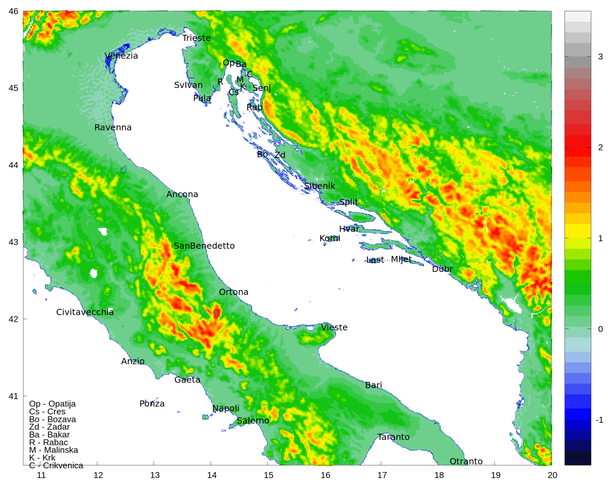




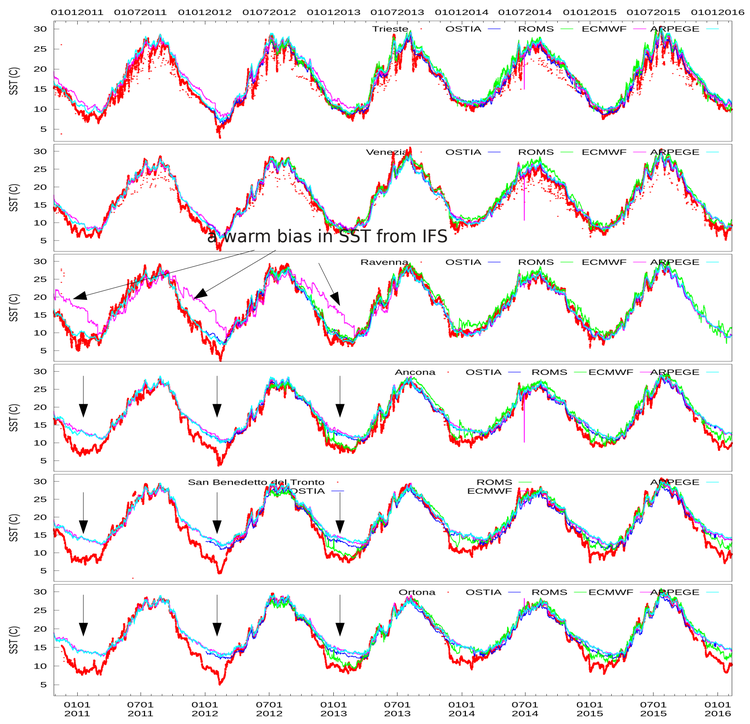


ROMS characteristics
- 2km resolution, 20 S levels
- covers only Adriatic so something else needed on the rest of the sea surface and smooth transition at Otranto
- details in Janeković et al. JGR-Oceans 2014

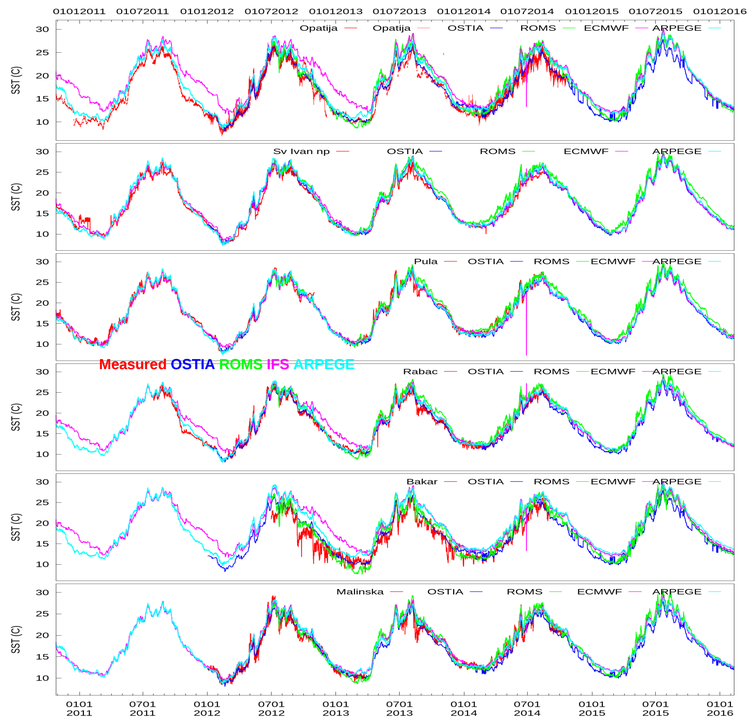
SST is colder along coastlines but warmer in the open sea. Higher spatial variability than higher resolution analysis.



Map of Adriatic and Italian area with the locations of stations. The names of stations in Croatia are truncated due to large spatial density. The names are explained in the lower left corner in the figure. The background is terrain height from 2km resolution ALADIN file, white means that land-sea mask is zero (sea or lake point in the model).



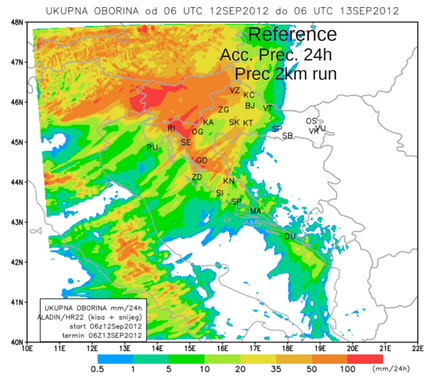
SST from the closest sea point from the initial coupling files of ARPEGE (cyan), IFS (pink), when interpolated to the model grid from the closest sea point of OSTIA (blue) and ROMS (green) and measured in-situ (red) for several stations along the western Adriatic coastline during the period from 27th October 2010 to 6 February 2016.

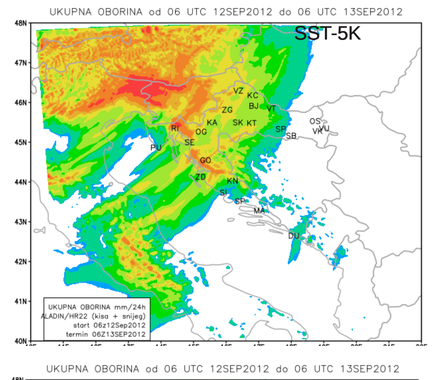


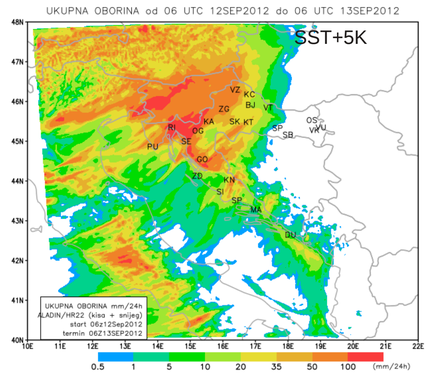
Complete report http://radar.dhz.hr/~tudor/sst/sst_coupl_files2.pdf

SST shift

In the first set of experiments, the SST field in the initial file by shifting the SST field uniformly. For each model forecast, the operational SST field is modified by increasing or decreasing SST values by 2K and 5K. These values have been chosen on the basis of evaluation of model and analyzed SST against in situ data. The effect is not uniform, but it also affects precipitation above land, relatively far from the coastline.



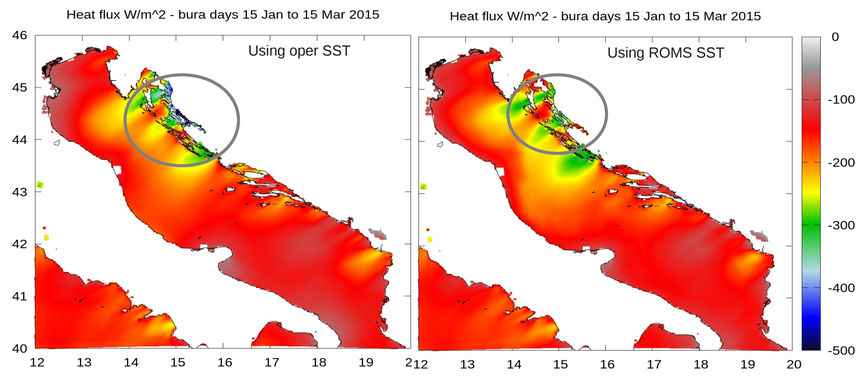




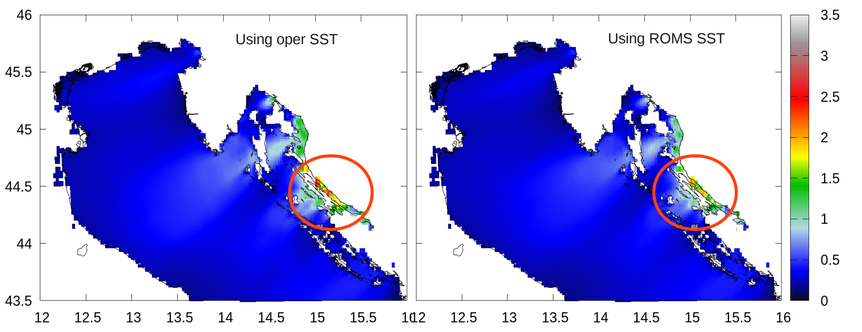
Warmer SST yields more precipitation
Accumulated 24 hourly prec. until 06 UTC 13 September 2012 for reference run (top), when SST is reduced by 5K (top right) and increased by 5K (right) for 2km resolution forecast initialized at 06 UTC 12 September 2012.

Impact on surface fluxes

Warmer sea means warmer surface and less stable atmospheric layer above. The turbulent fluxes depend on atmospheric stability. Less stable atmosphere allows for stronger fluxes. With too warm SST, the fluxes of heat and momentum were too strong. Using more realistic (and in this case colder) SST improved the model fluxes (that were too strong to begin with).



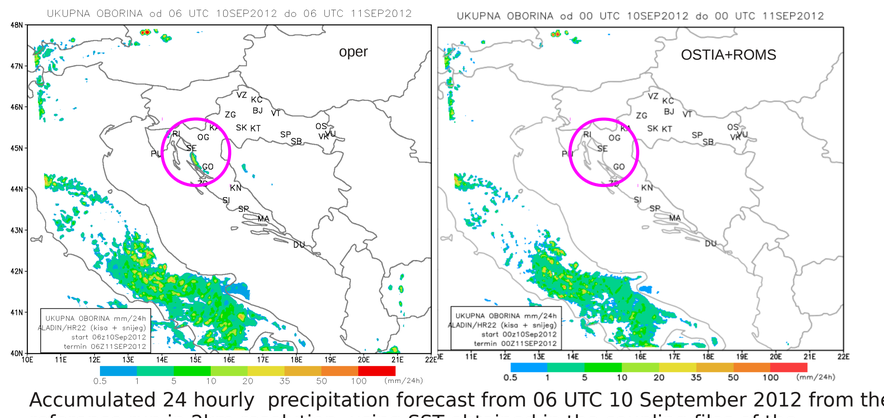
Accumulated heat fluxes from the reference run in 2km resolution, using SST obtained in the coupling files of the operational IFS (left) and from the run using ROMS model SST and OSTIA analysis (right).



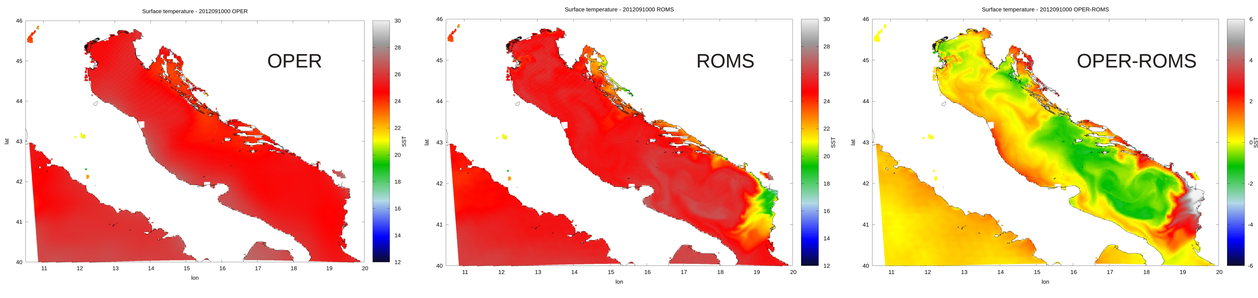
Accumulated turbulent fluxes from the reference run in 2km resolution, using SST obtained in the coupling files of the operational IFS (left) and from the run using ROMS model SST and OSTIA analysis (right).

Impact on precipitation

The operational forecast in 2km resolution often produced bogus rainfall over Velebit mountain. A blob of weak to moderate rainfall would be there (in 24 hourly accumulated precipitation) for days and sometimes weeks. Using more realistic SST from OSTIA analysis and ROMS ocean model removed this precipitation.



Accumulated 24 hourly precipitation forecast from 06 UTC 10 September 2012 from the reference run in 2km resolution, using SST obtained in the coupling files of the operational IFS (left) and from the run using ROMS model SST and OSTIA analysis (right). Warm SST in Velebit channel was the cause of wrong precipitation forecast over Velebit!



SST at 10th September 2012 from the operational run in 2 km resolution (left) and when SST from ROMS was used over Adriatic (centre) and their difference (OPER-ROMS, right). The SST in the Velebit channel is considerably colder in ROMS.