High-resolution operational NWP for forecasting meteotsunamis

Martina Tudor[1],

MESSI: Jadranka Šepić[2], Principal investigator

ADAM Adria: Ivica Janeković[3,4]

1 Croatian Meteorological and Hydrological Service, Zagreb, Croatia

2 Insititute for Oceanography and Fisheries, Split, Croatia

3 Ruđer Bošković Institute, Zagreb, Croatia

4 The University of Western Australia, School of Civil, Environmental and Mining Engineering & UWA Oceans Institute, Crawley, WA 6009, Australia

http://jadran.izor.hr/~sepic/MESSI/

HIRLAM ALADIN WS, Helsinki, Finland, 3-6 Apr 2017

Outline

- What are meteorological tsunamis?
- Can we forecast meteorological conditions that cause them?
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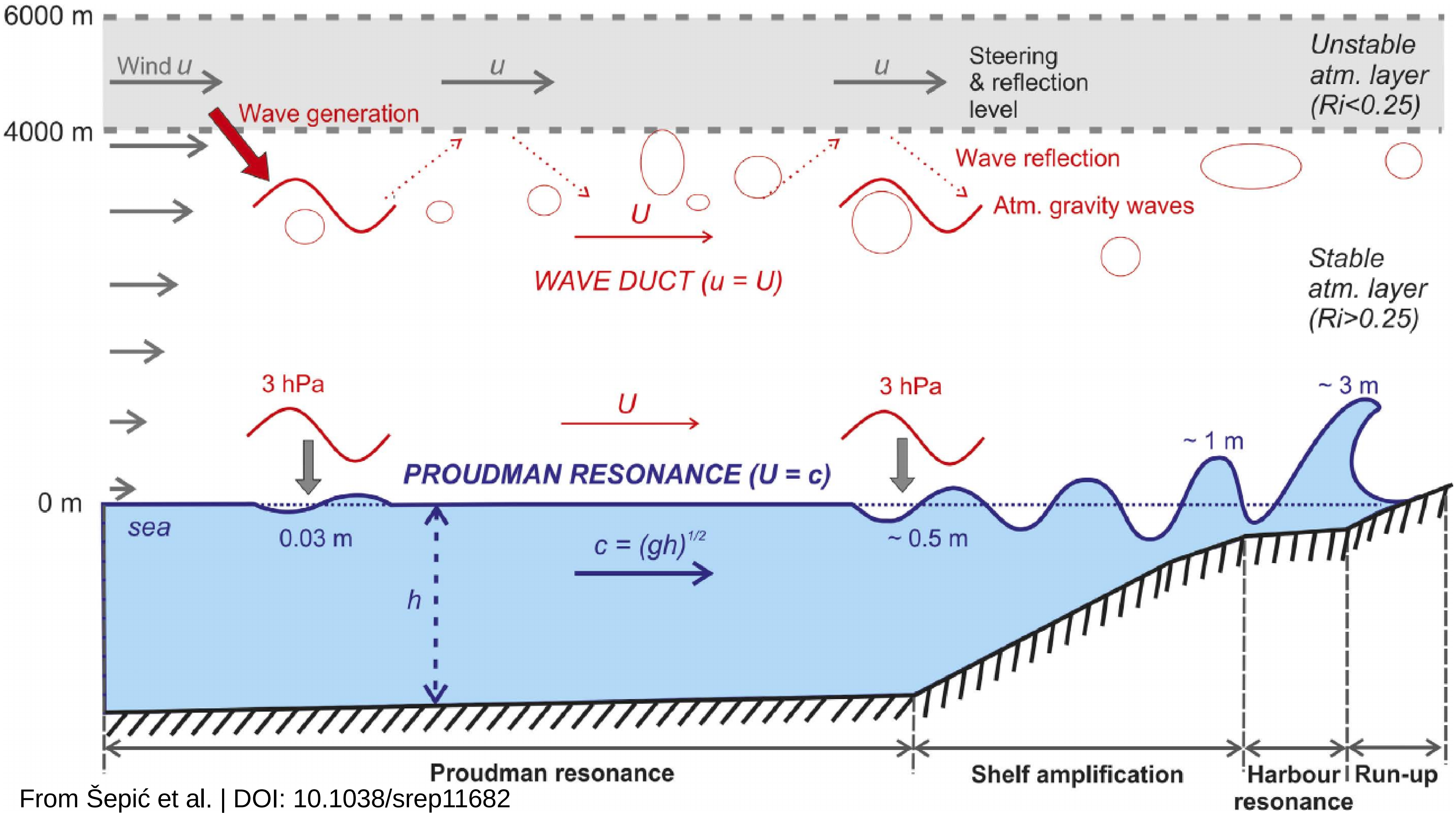
-
- “Meteotsunamis, destructive long ocean waves in the tsunami frequency band: from observations and simulations towards a warning system” (MESSI)

Definition

- **A meteotsunami or meteorological tsunami is a tsunami-like wave of meteorological origin.**
- 10% of tsunamis worldwide have unknown origin
- 3% already assigned to meteorological conditions
- atmospheric gravity waves, pressure jumps, frontal passages, squalls ...
- local names: rissaga (Catalan), ressaca (Portuguese), milghuba (Maltese), marrobbio (Italian), abiki (Japanese), šćiga (Croatian)

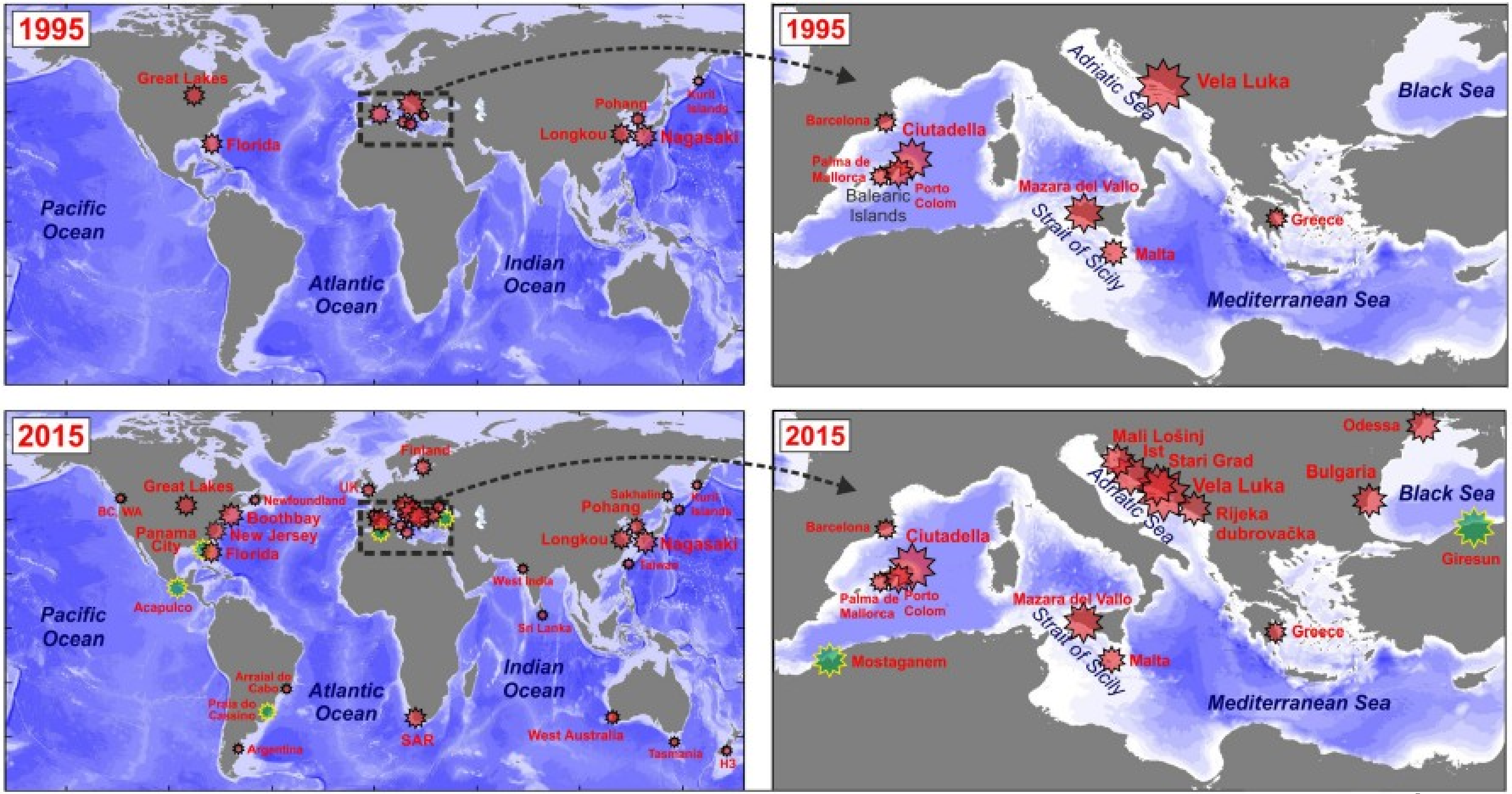


From Šepić et al. | DOI: 10.1038/srep11682

Motivation

- Events: Vela Luka (1978, 6m), Chichago (1954,3m), Nagasaki (1979,5m), Ciutadella (2006,4m), Daytona Beach (1992,3.5m) … Australia, New Zealand, UK, France, Finland
- High waves destroy coastlines, strong currents endanger marine traffic (reduced sea depth during low tide).
- Dangeorus!!! especially in areas where the tide amplitude is low (Adriatic ~ 0.5m)
- https://www.youtube.com/watch?v=y-QlJO0ChwA
- https://www.youtube.com/watch?v=lzA5DTk_vIg

Global and Mediterranean meteotsunamis



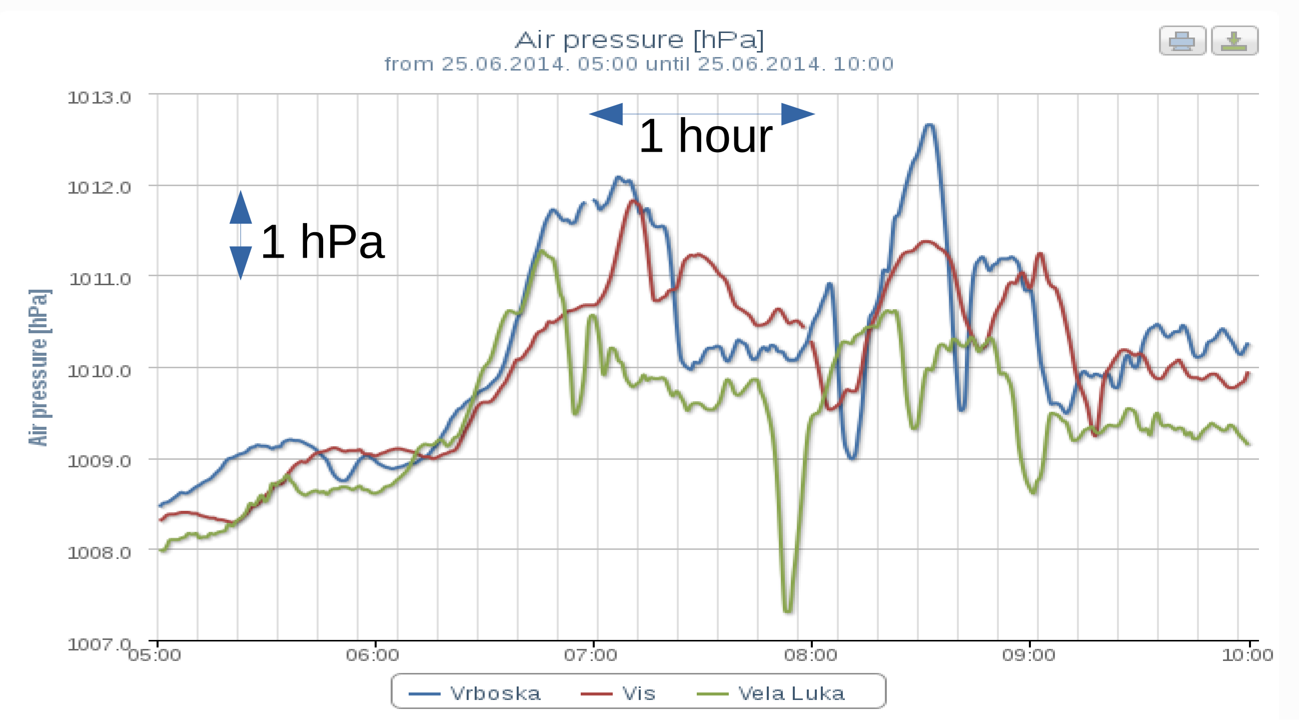
(Vilibić et al. 2016)

Forecasting meteotsunamis requires

- **Synoptic setting**:
  - Inflow of warm air from Africa ~850 hPa
  - SW jet > 20 m/s at ~500 hPa
  - Unstable layer (Ri<0.25) 400-600 hPa
- High resolution: Forecasting a pressure change of more than 1hPa/1min
- Model output every minute
- Pressure disturbance moving
  - in the right direction (direction of SW jet)
  - at the right speed (speed of SW jet)
  - (at the right time)

Can these pressure disturbances be forecast by an operational NWP model?

Figure: Air pressure measured on stations Vrboska (blue, Hvar island), Vis (red) and Vela Luka (green) with one second data interval during a widespread meteotsunami event on 25-26 June 2014, maintained by IOF .



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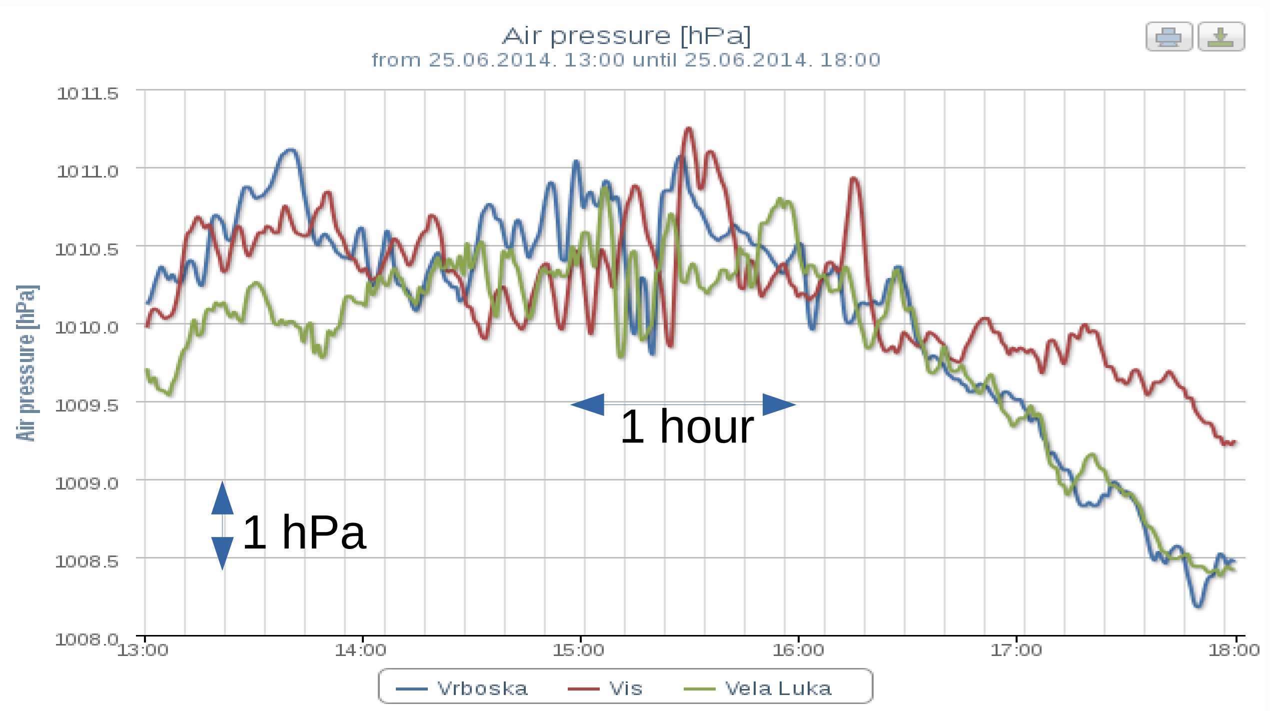

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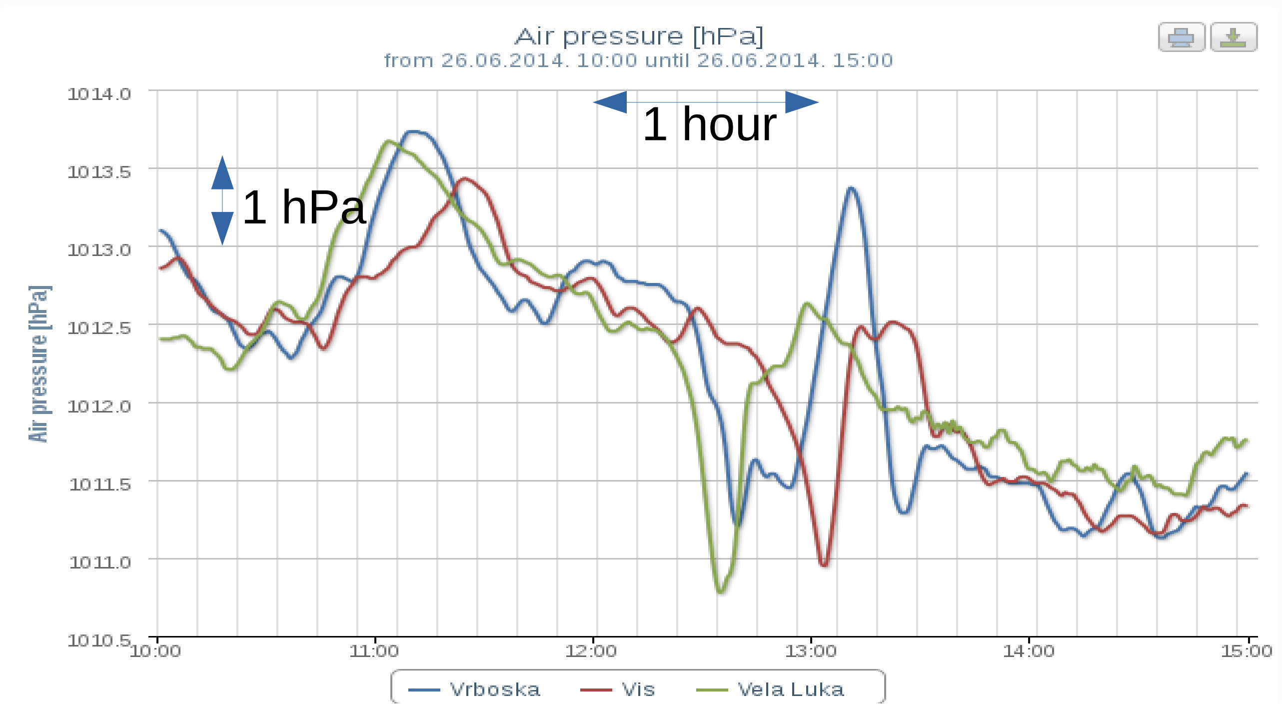
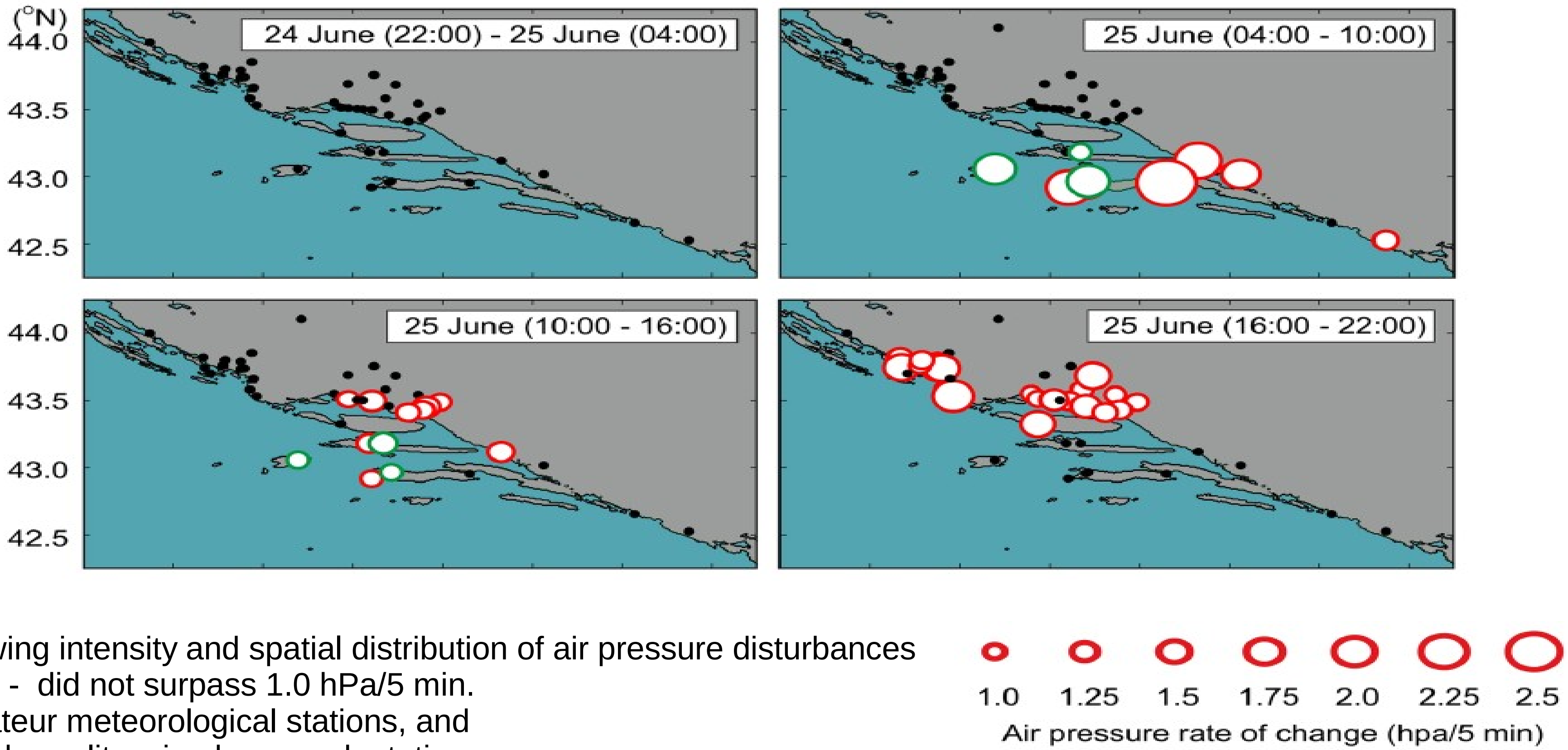


Maximum pressure change in 5 min



Plots showing intensity and spatial distribution of air pressure disturbances
Black dots - did not surpass 1.0 hPa/5 min.
Red - amateur meteorological stations, and
green - high-quality microbarograph stations

(Šepić et al., PAG, 2016)

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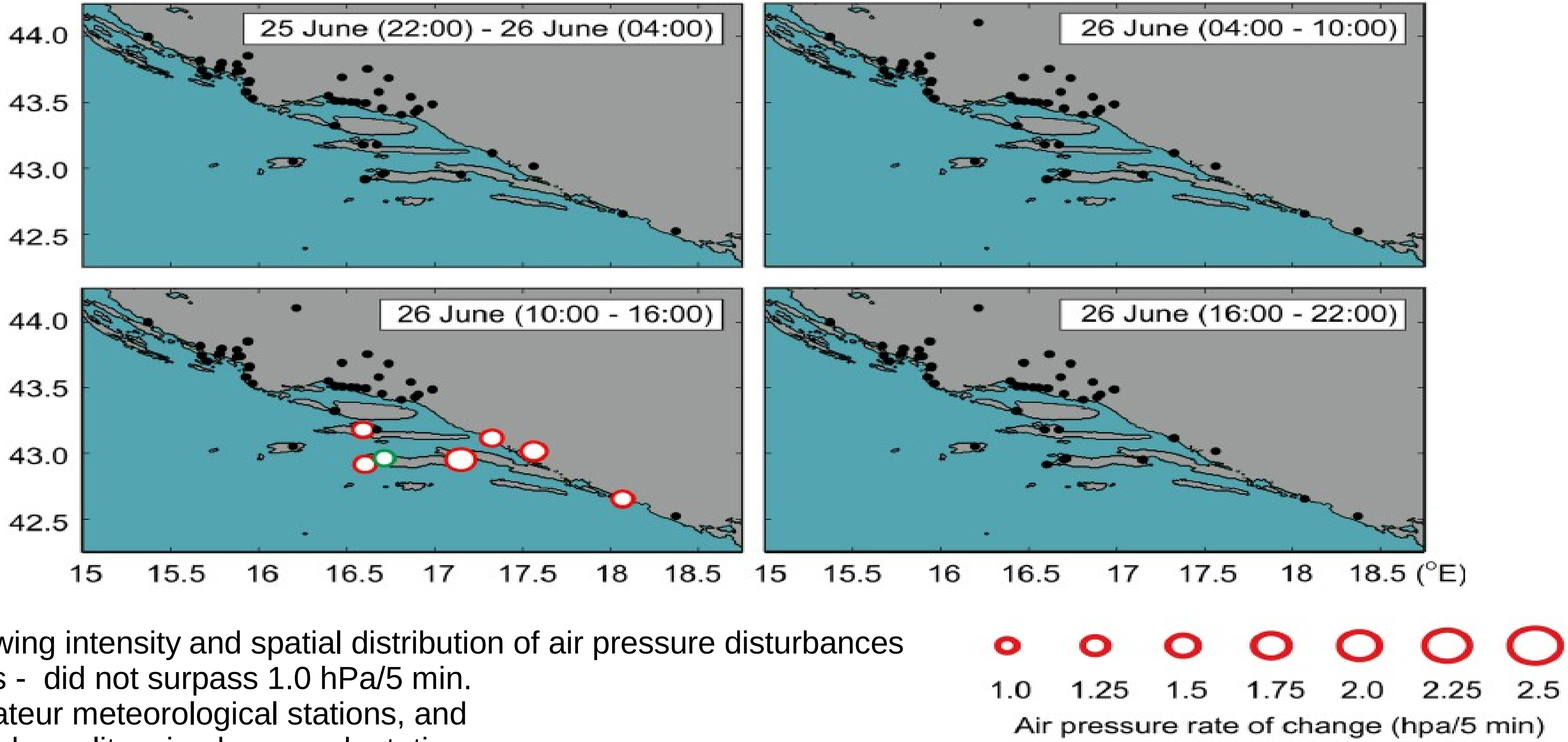

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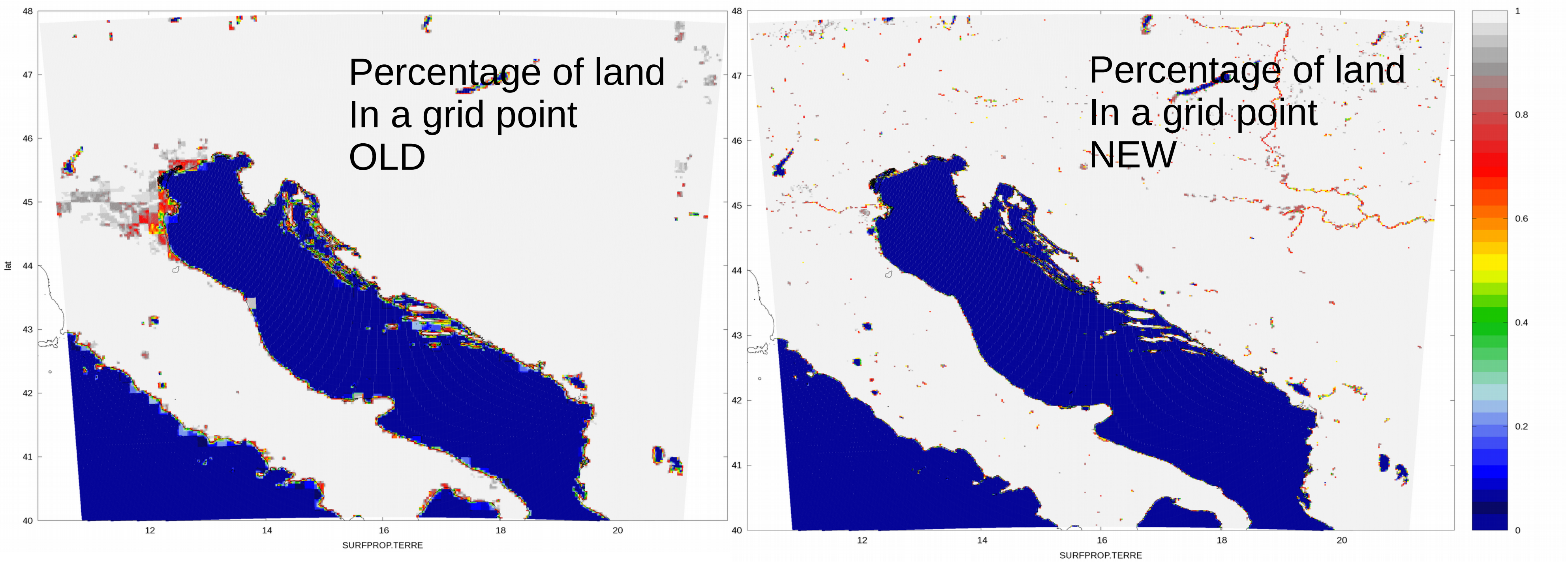
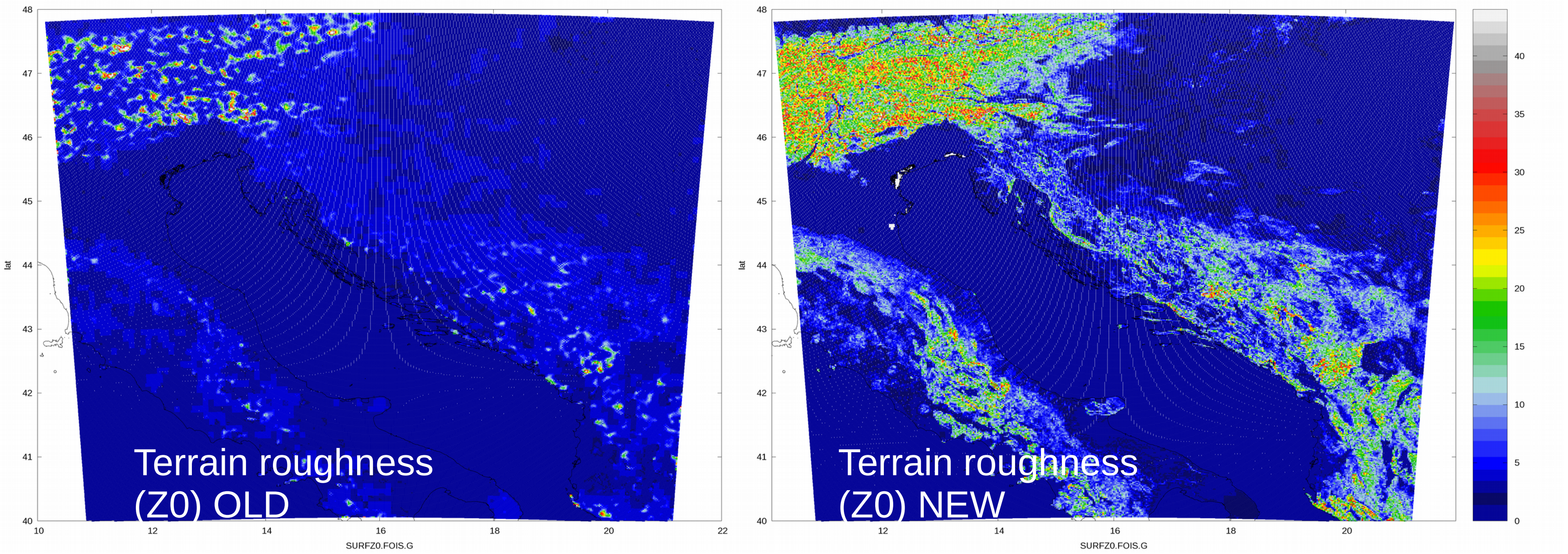
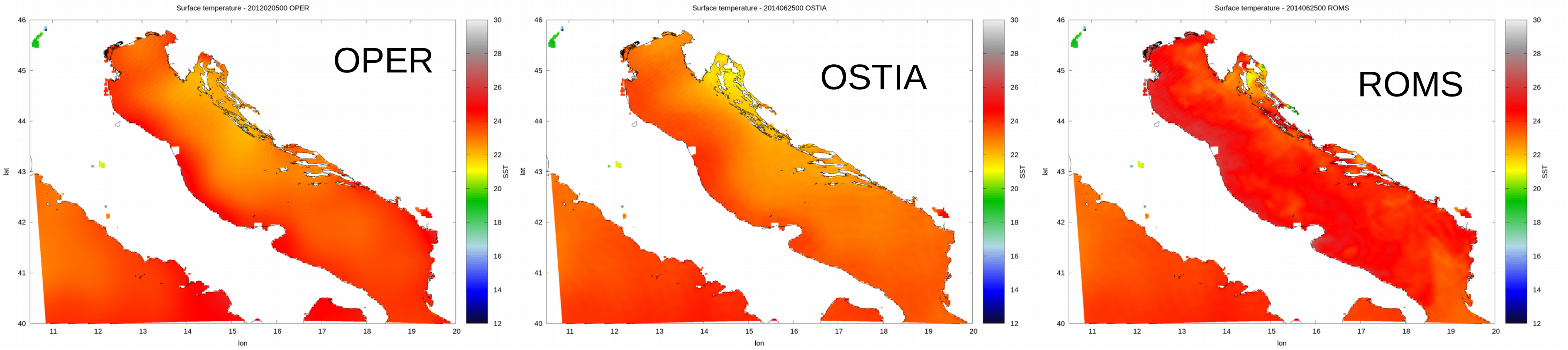
Percentage of land in a grid point (2 km res)



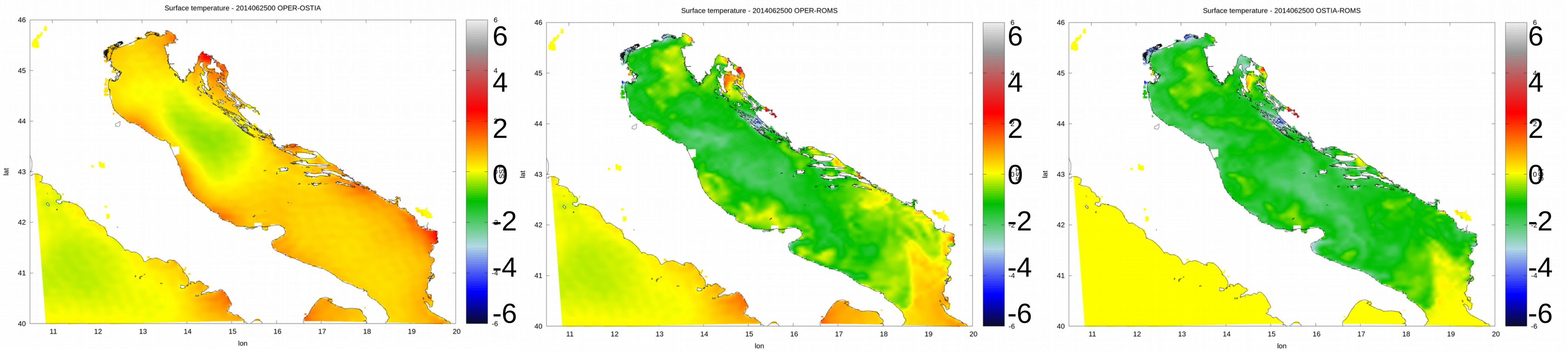
Terrain roughness



Rather smooth terrain over mountains when roughness computed from the old database



The SST in the operational forecast (left), when using SST from OSTIA (middle) and ROMS (right).



SST differences: in the OPER-OSTIA (left), OPER-ROMS (middle) and OSTIA -ROMS (right).

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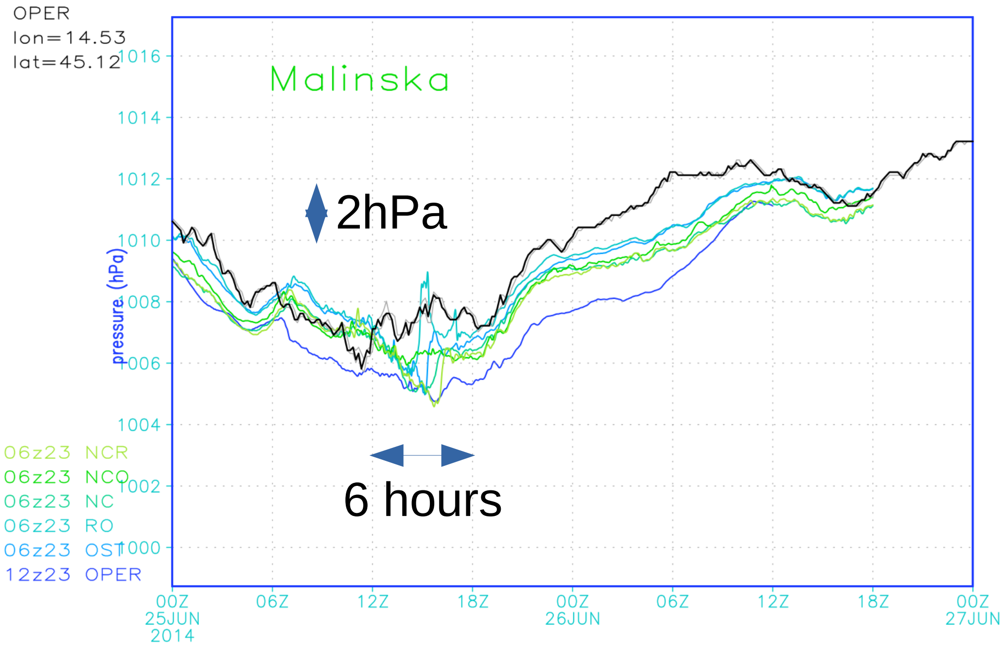
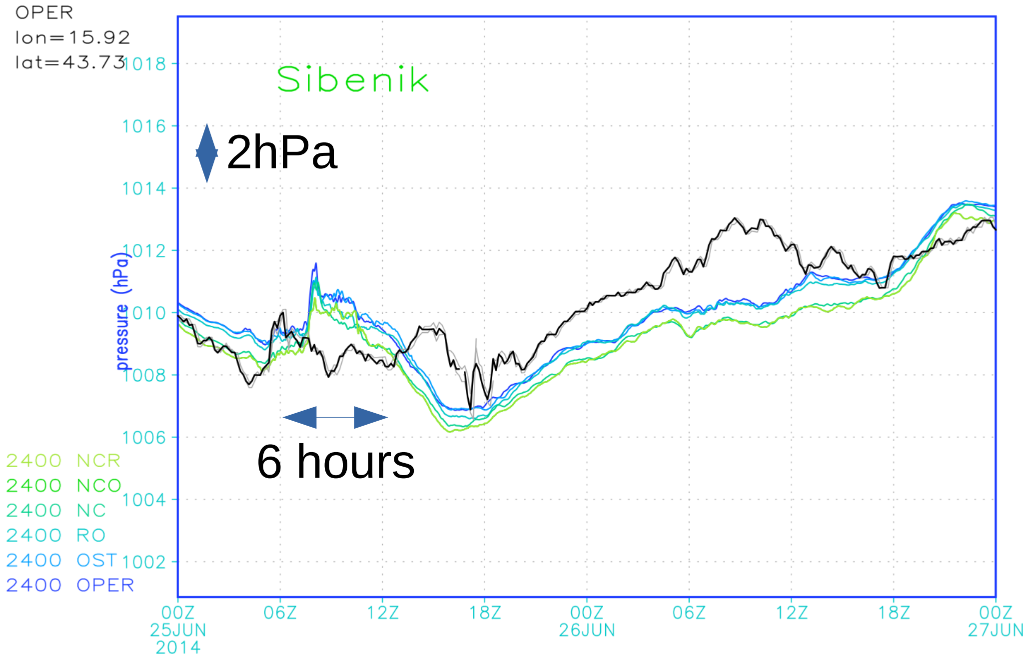
Different SSTs and topography representations





OPER – old topography and z0 IFS SST, OST – using OSTIA SST, RO – using ROMS SST, NC – new topography and z0, NCO – new topo + OSTIA SST, NCR – new topo + ROMS SST.

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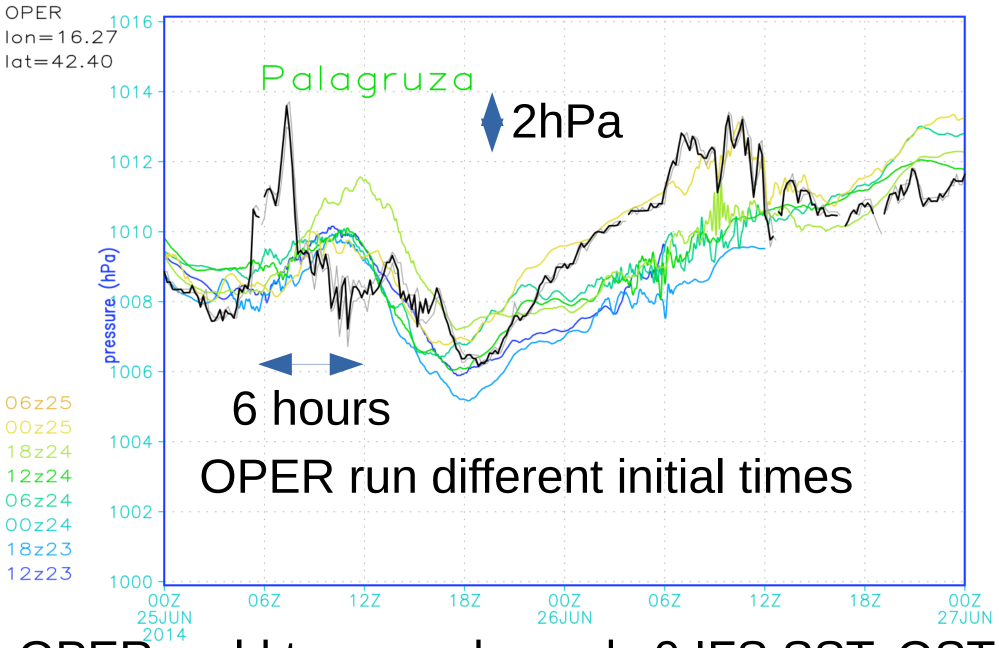

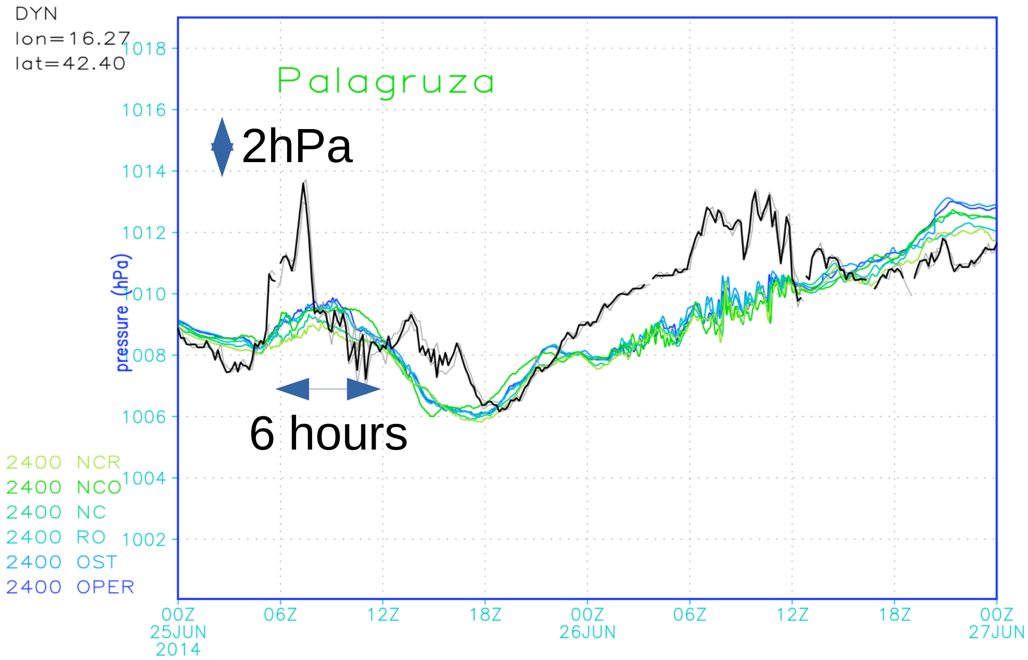

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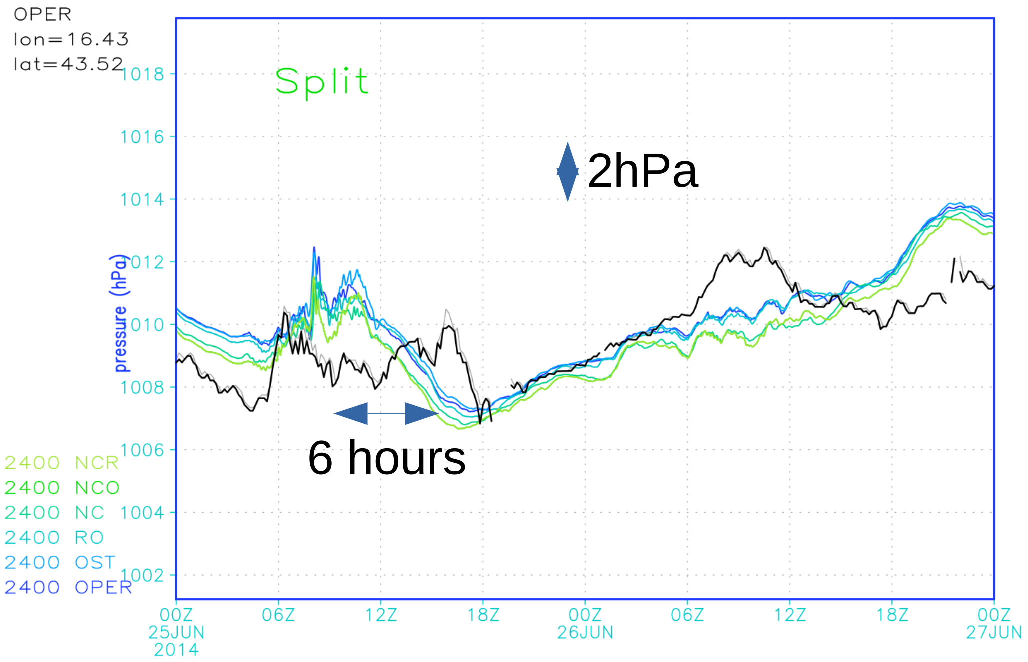

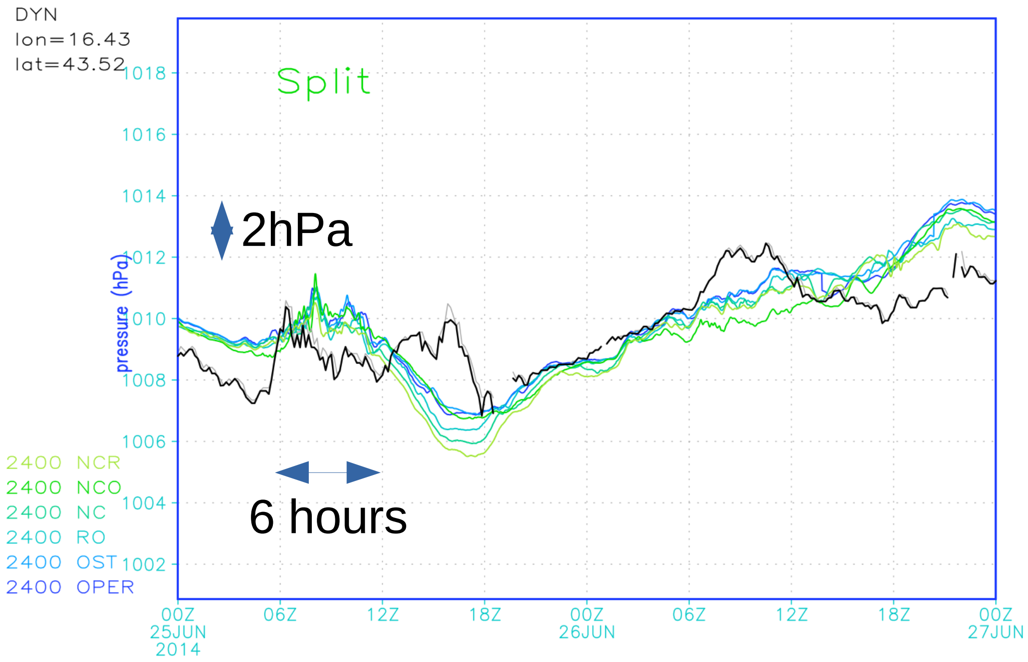

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Summary

- **Definition: A meteotsunami or meteorological tsunami is a tsunami-like wave of meteorological origin.**
- Causes: atmospheric gravity waves, pressure jumps, frontal passages, squalls …
- Sensitive to LBC and dynamics setting (physics not excluded)
- Can be sensitive to SST and topography representation
- **If large scale forecast is correct – forecasting meteorological conditions that lead to meteotsunamis using high resolution LAM is not science fiction.**

Publications

- Vilibić, I., Šepić, J., 2017. Global mapping of nonseismic sea level oscillations at tsunami timescales. Scientific Reports, 40818, doi:10.1038/srep40818
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- Vilibić, I., Šepić, J., Rabinovich, A. B., Monserrat, S., 2016. Modern Approaches in Meteotsunami Research and Early Warning. Frontiers in Marine Sciences, http://dx.doi.org/10.3389/fmars.2016.00057
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- Šepić, J., Vilibić, I., Monserrat, S., 2016. Quantifying the probability of meteotsunami occurrence from synoptic atmospheric patterns. Geophysical Research Letters, doi: 10.1002/2016GL070754
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- Šepić, J., Međugorac, I., Janeković, I., Dunić, N., Vilibić, I., 2016. Multi-meteotsunami event in the Adriatic Sea generated by atmospheric disturbances of 25-26 June 2014. Pure and Applied Geophysics, doi: 10.1007/s00024-016-1249-4