Simulation of pyrocumulus during a megafire event in Portugal using a coupled atmosphere-fire spread modeling framework

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Framework Outline

I. Introduction – Meteorological Background and Objectives

II. Data and Methods

III. Results

- Fire Progression
- Surface
- Vertical Instability

IV. Final Remarks

I. Introduction – Meteorologica Background and Objectives

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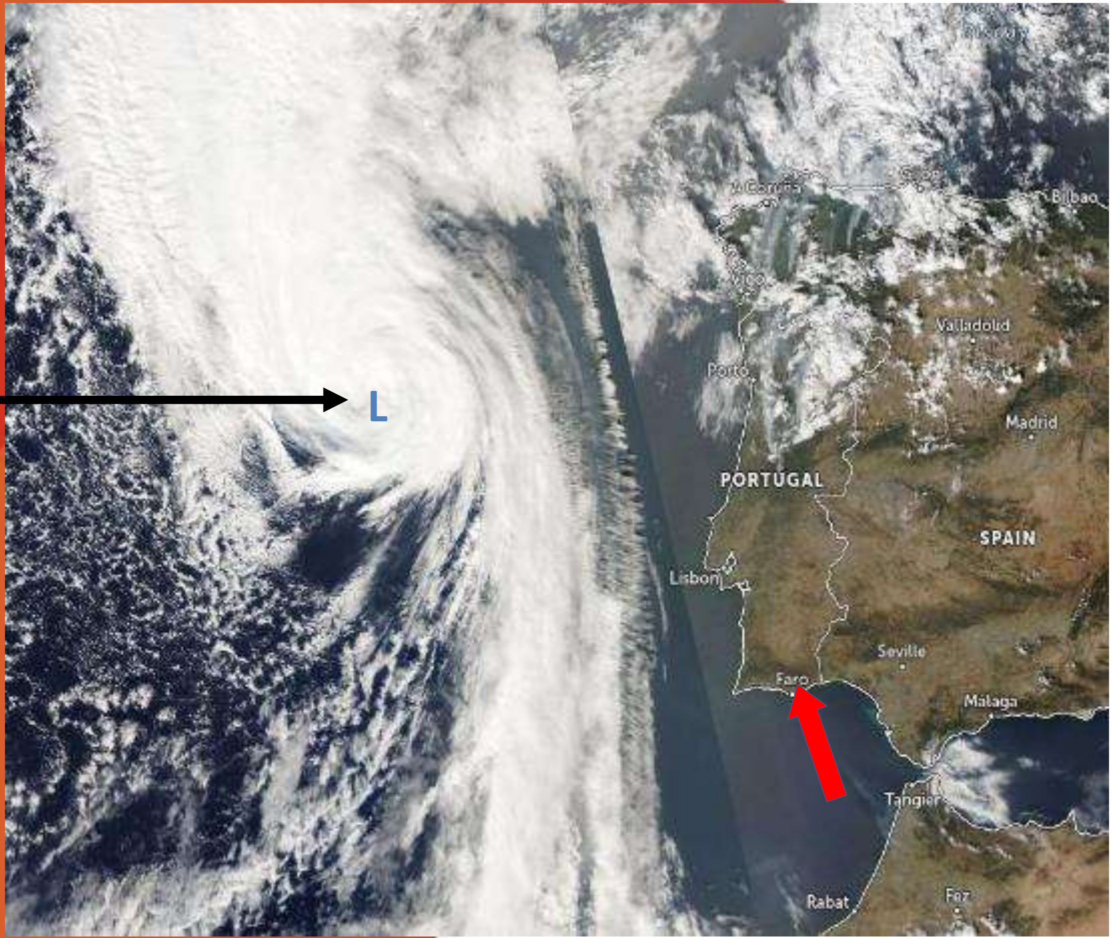
- October 15, 2017 - **large mega-fire event** (~200 kha) **central Portugal**;

- 150 M € in insurance losses, 51 human fatalities.

- **Hurricane Ophelia**, advected dry and hot air from North Africa.

- Low of surface fuel moisture (FMC) and Relative Humidity (RH) 10% - 20% . Temperatures (T) 34ºC - 36ºC.

- Wind shifted in the late afternoon, from SE to SW, decreasing Temperature, increasing RH, and providing moisture to generate **pyro-**



I. Introduction – Meteorological Background and Objectives

Investigating Quiaios Fire Complex using the atmosphere-fire coupled model WRF-SFIRE:

- Atmospheric surface parameters.
- Fuel moisture and Fire progression.
- Vertical stabiliy.
- Fire spread and energy release from the firefront
- Formation of Pyro-cumulus

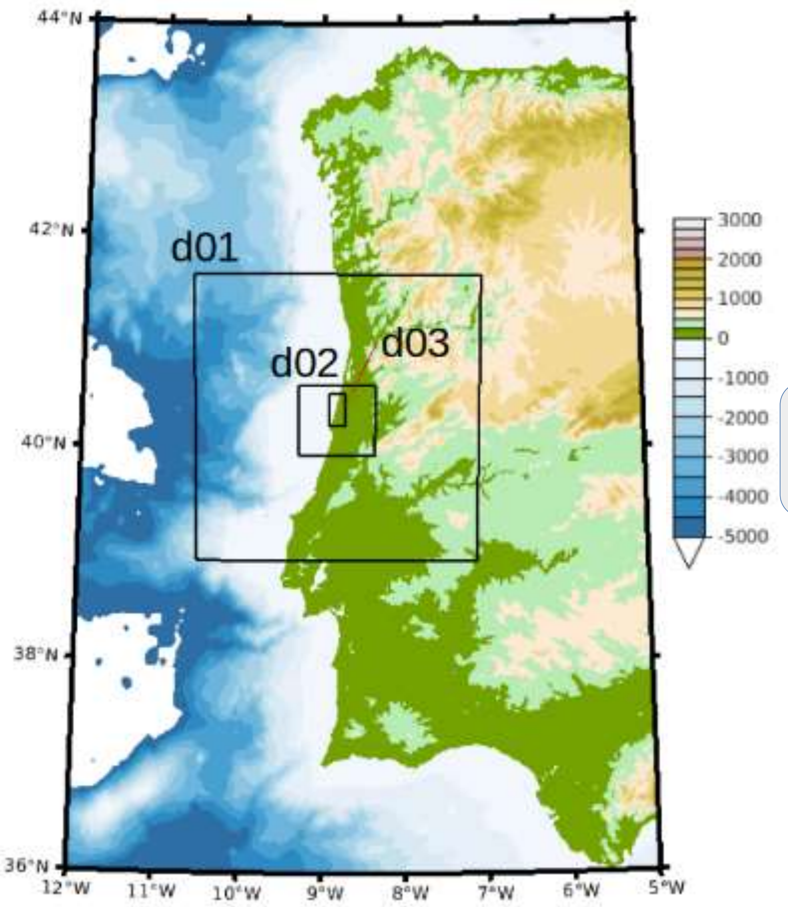
II. Data and Methods

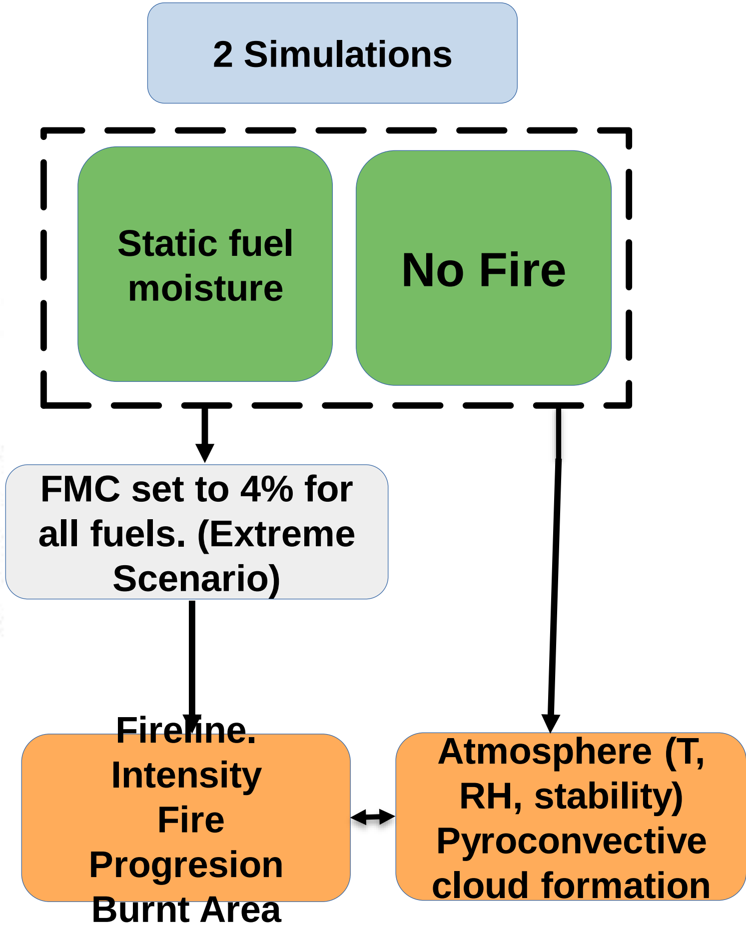
WRF:

- Lateral Boundariy and initial conditions from ERA-5 Realysis.
- 3 domains: 7500 m, 1500 m, 300 m horizontal resolution.
- Landuse: Corine Land Cover => USGS 24 (100 m)
- Topography: SRTM, (~90 m)

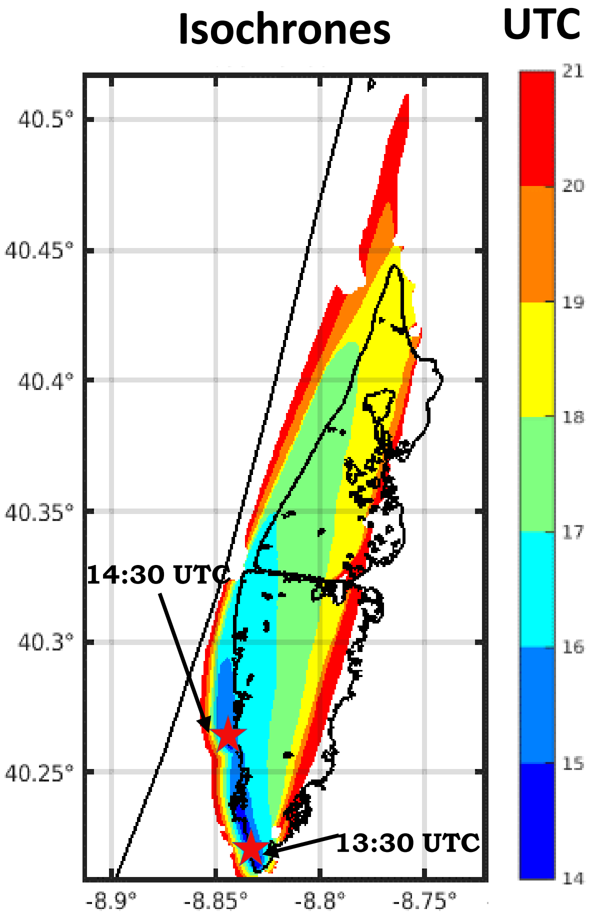
SFIRE:

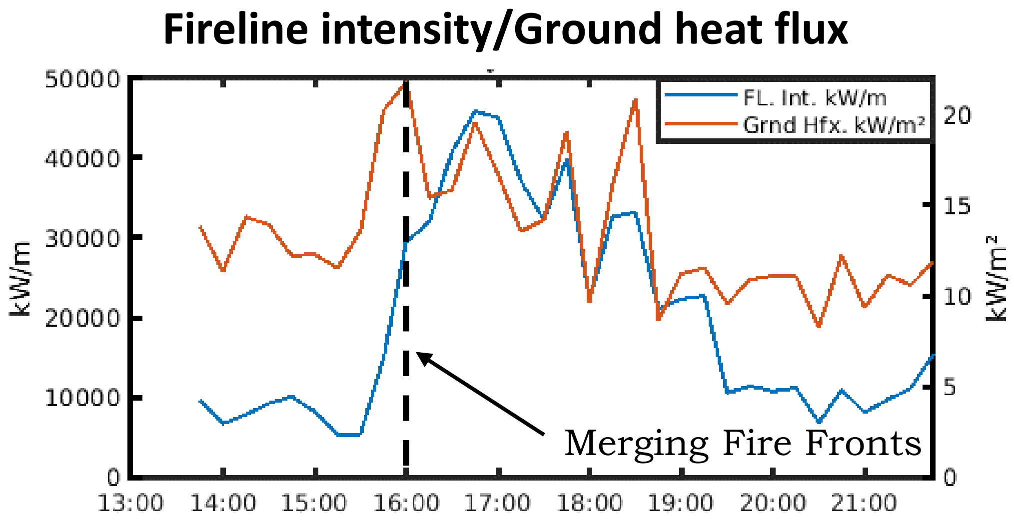
- Subgrid: 30m horizontal resolution.
- National Fuel Model converted to NFFL 13 (100 m).
- EU-DEM Topography (25 m)

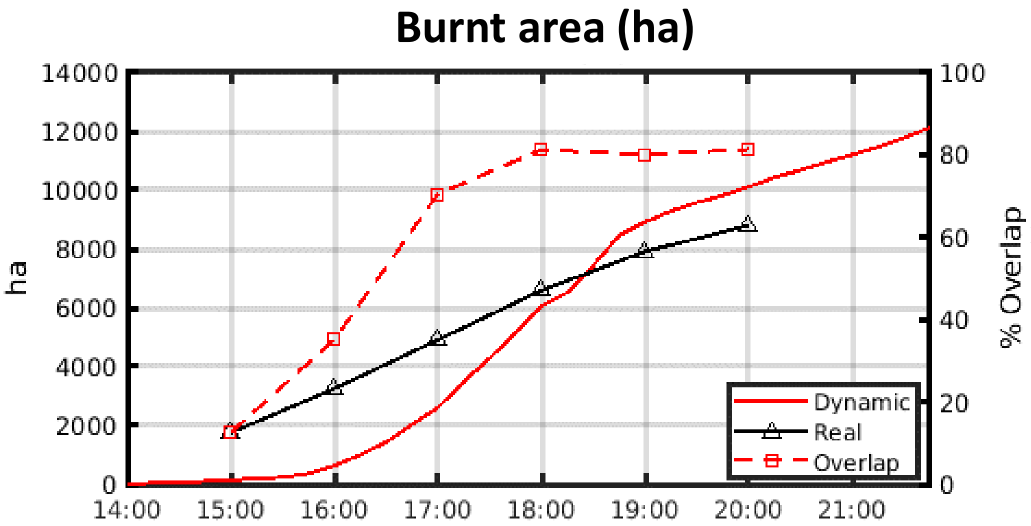




III. Results – Fire Progression



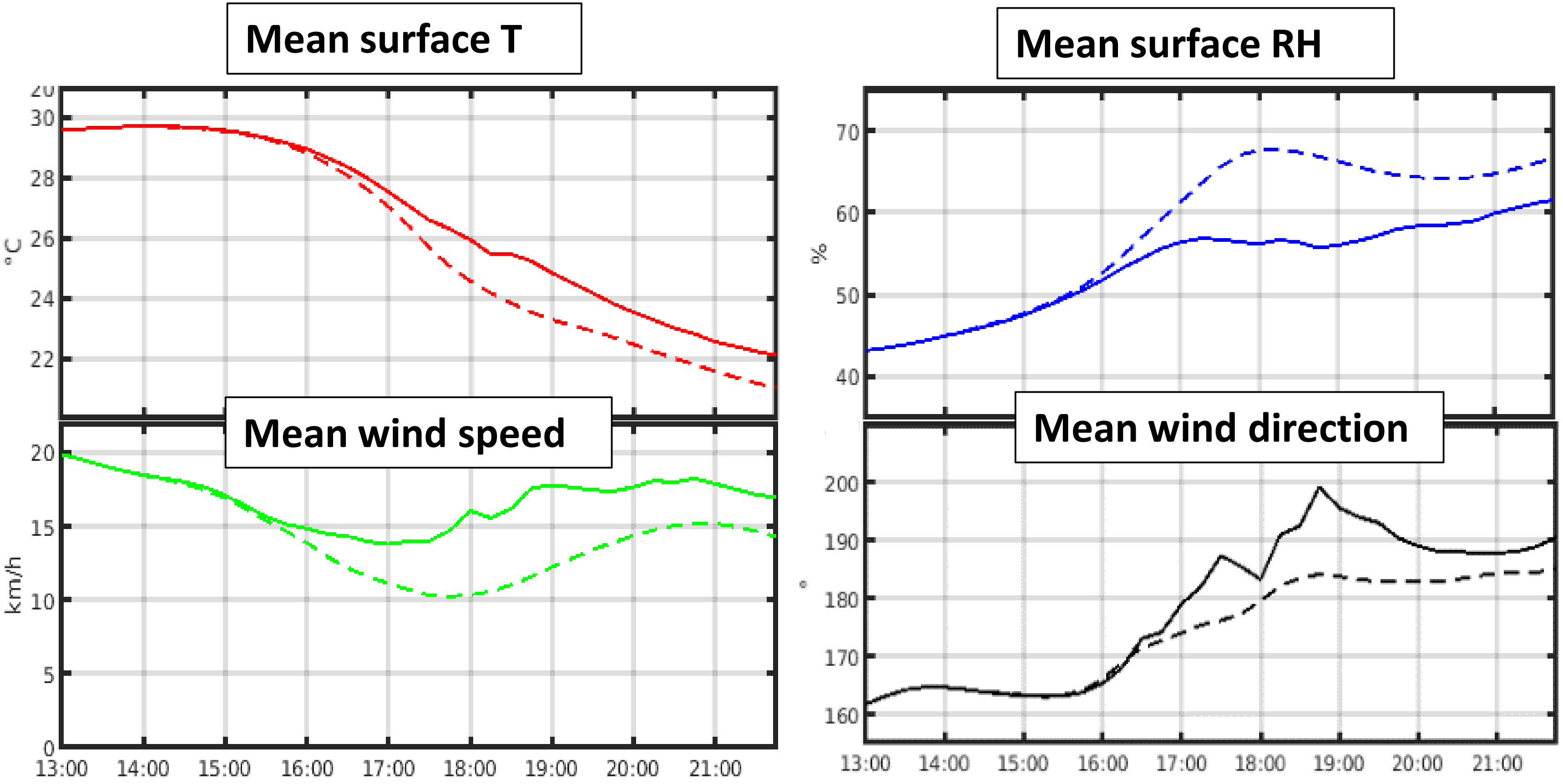




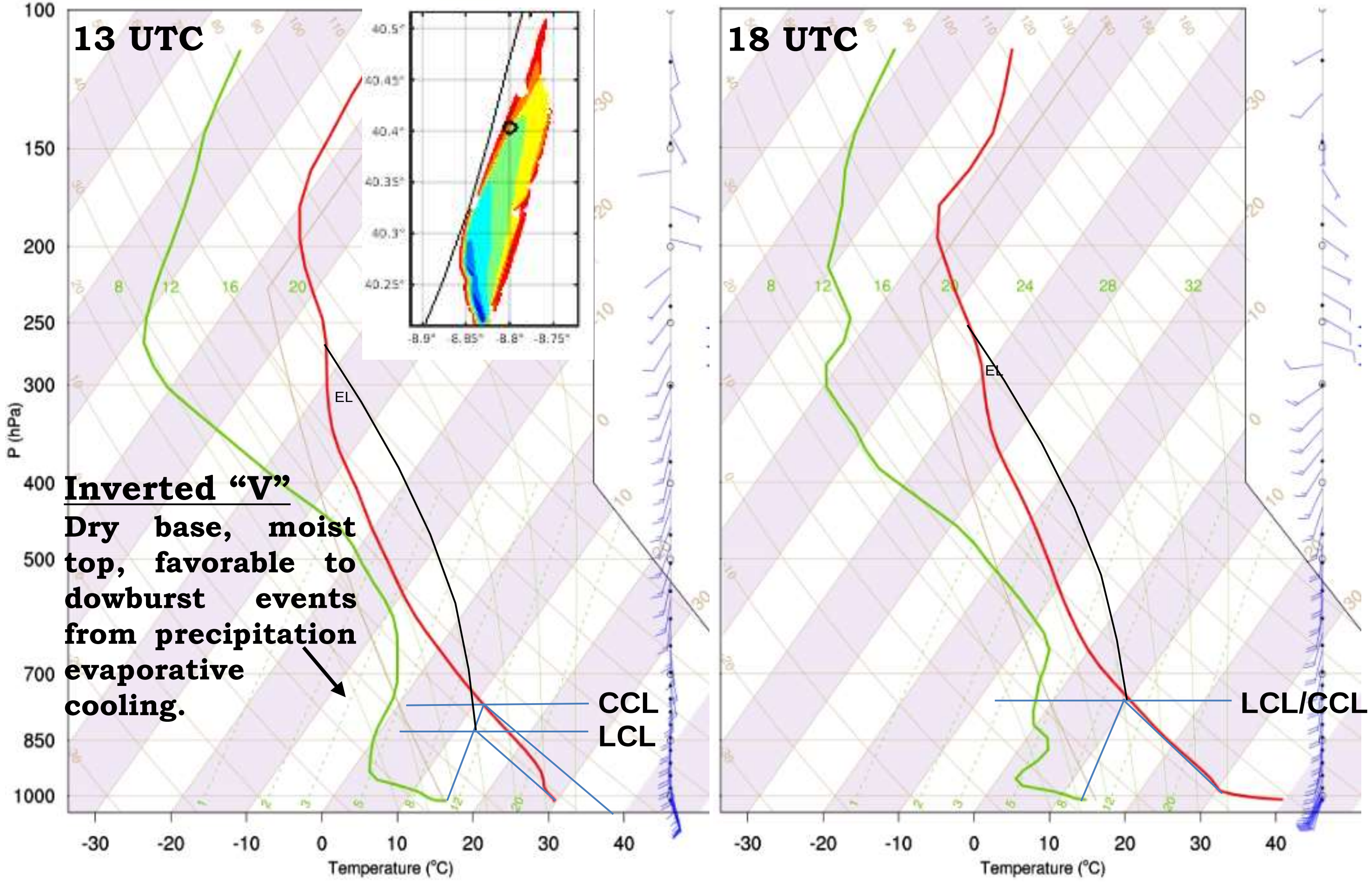
- Fireline Intensities, and spread rates show a large increase after the merger of the fire fronts of the two ignitions.
- The fire simulation greatly underestimate fire spread between 14 to 17 UTC.
- Common Burnt Area beteween reality and simulations (% Overlap), show an >70% agreement after 17 UTC

III. Results – Surface

- T ↑ ~ + 1° C
- WS↑ up to + 5 km/h
- RH ↓ up to – 10%
- Wind direction shifted earlier from SE to SSW.
- Temperatures were ~4ºC Lower and RH > 30% higher than weather station observations.



III. Results – Vertical Instability



- Lower level heating induced by the fire, destabilizes the atmosphere near the firefront.
- Lifting Condensation Level (LCL) rises to the Convetive Connsensation Level (CCL) as surface heating from the fire reaches the Convective Temperature (CT), and the atmosphere lapse rate equals the dry adiabatic lapse rate.
- **None of the generated preciptiation reached the ground**, remaining as virga.
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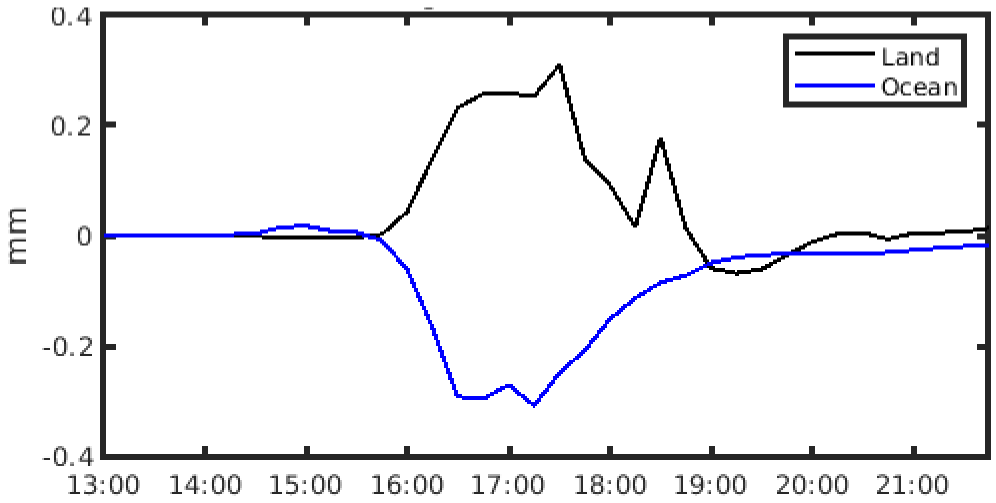
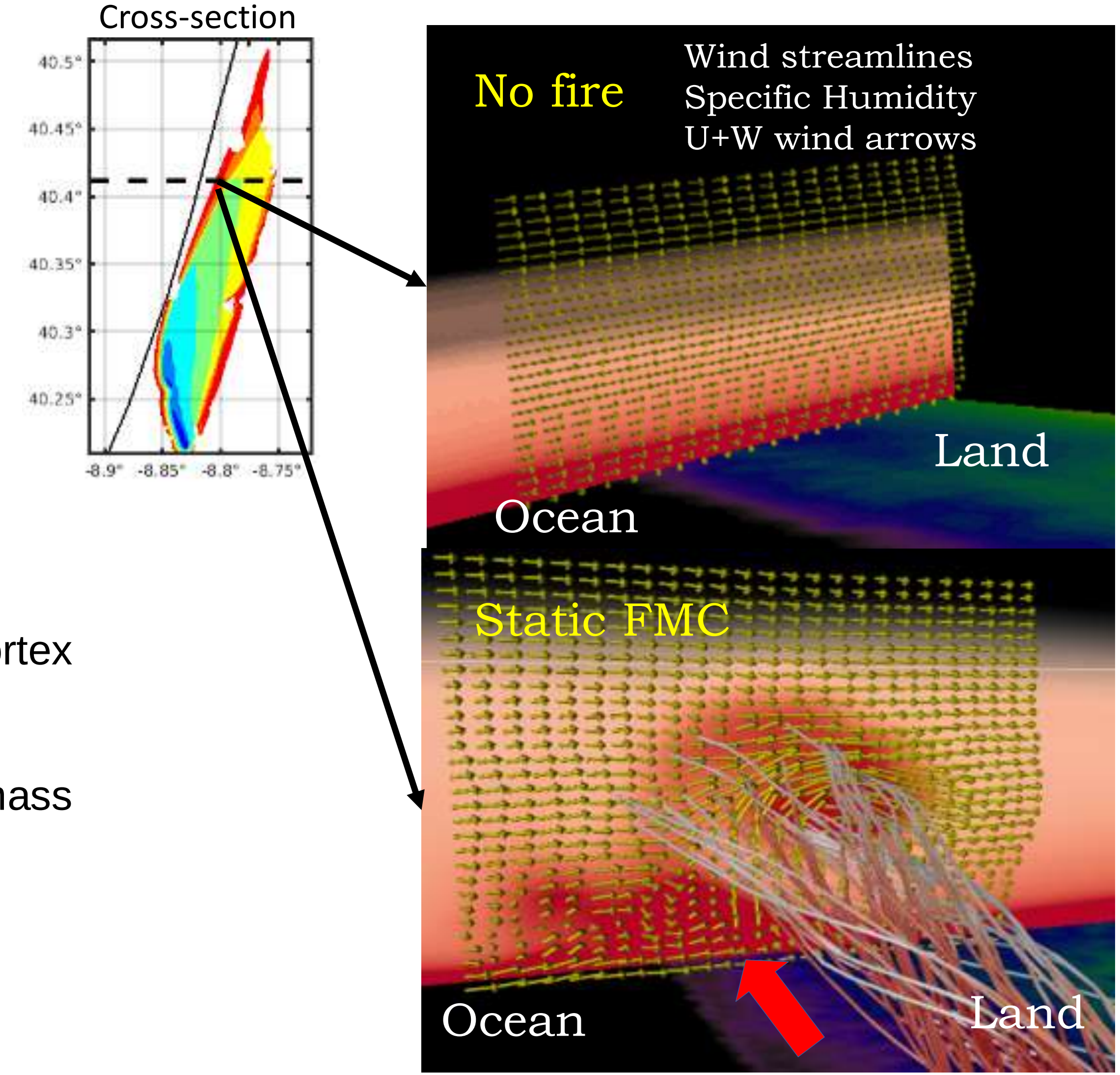
III. Results – Vertical Instability

PW Differences

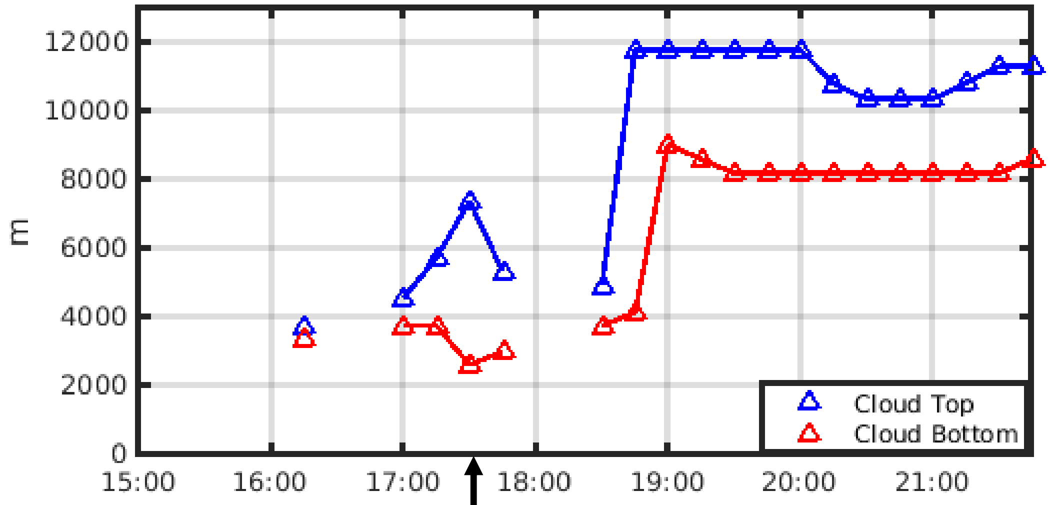


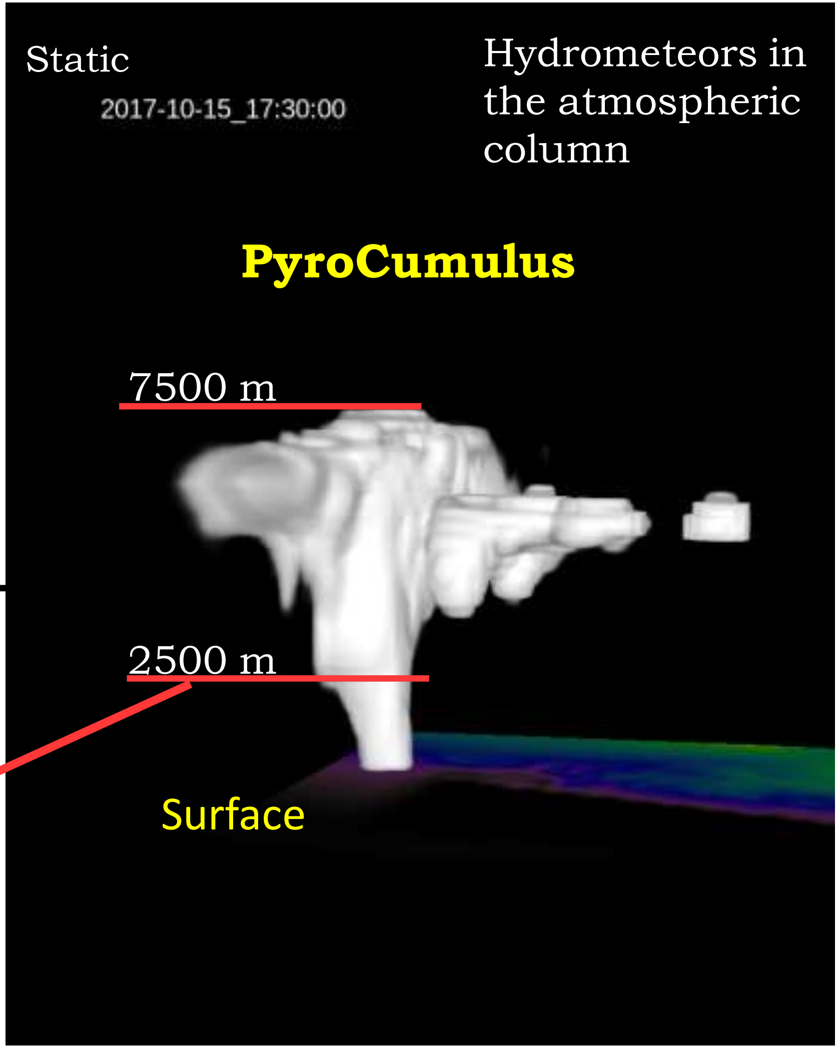


- Moist and cooler air advection from ocean through a vortex generated by the fire.
- Integrated precipitable water (PW) shows mass transportation between the Land and Oean
- **This effect is only observed in the Fire simulation.**

III. Results – Vertical Instability

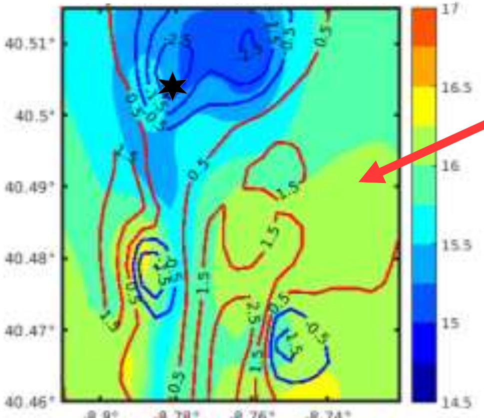
Cloud top/Bottom height





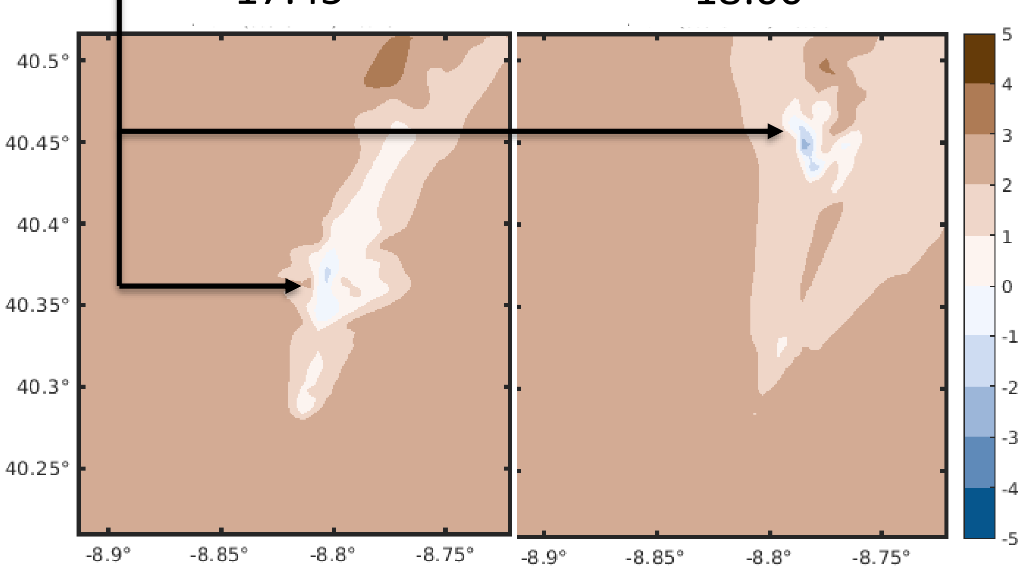
- Evaporating precipitation creates a ~ **2,5 m/s downdraft** (1500 m height) , forming a small “bubble” of cooler air underneath the cloud base (Star) as it evaporates.

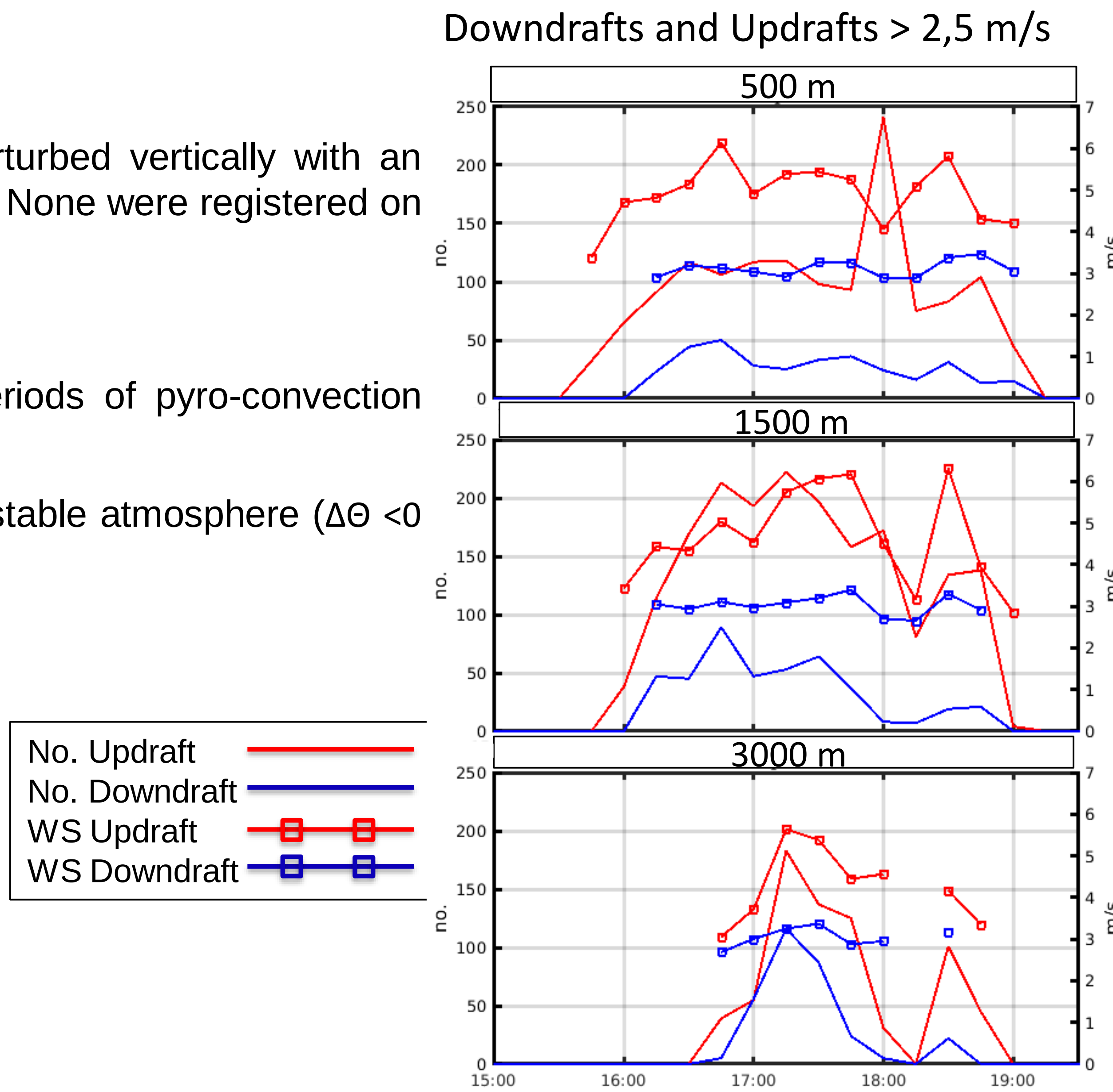
T and W at 1500 m 17:30



III. Results – Vertical Instability

- Between 16-19 UTC, the atmosphere becomes perturbed vertically with an increase in number of updrafts > 2.5 m/s per gridcell. None were registered on the no fire simulation.
- Updrafts stronger than downdrafts at all levels.
- Updrafts/Downdrafts at 3000 m associated with periods of pyro-convection and cloud formation.
- Lower theta advection creates zones of vertically unstable atmosphere (ΔΘ <0 °C) .





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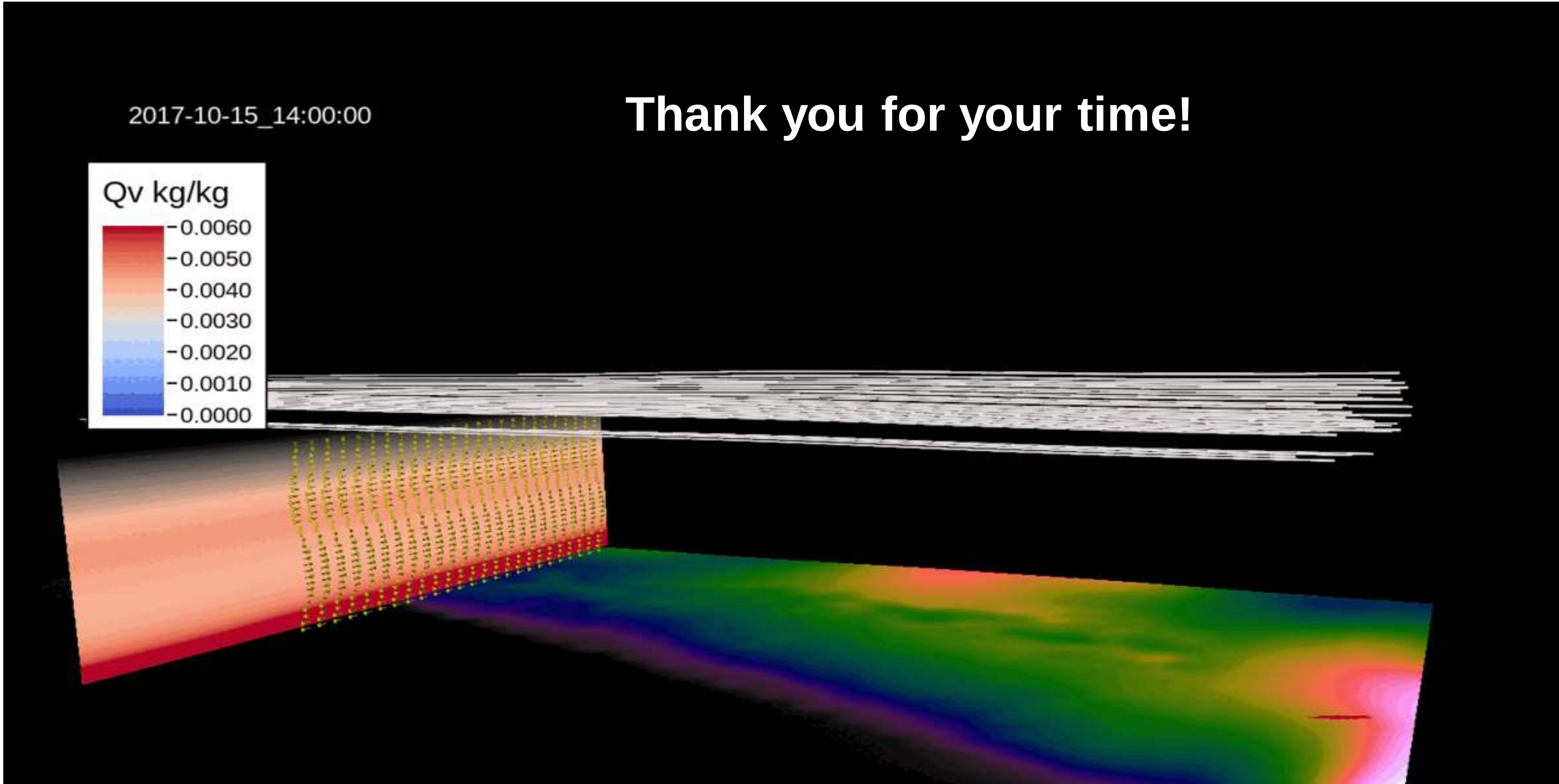
IV. Final Remarks

Despite differences between surface observations and simulations of Temperature and RH, the following was found:

- Moist air advection from a fire induced Vortex.
- **Formation of pyrocumulus in the fire simulations**, whilst in the no fire nothing formed.
- Merging of fire fronts from both ignitions induced a “burst” of Fire intensity and spread.
- More testing is required to improve surface wind speed, direction, temperature, relative humidity, and heat/mass exchanges between fire and atmosphere.

Thank you for your time!



Acknowledgements:

The authors acknowledge the R&D project CLING with the reference PTDC/EME-REN/34690/2021 funded by FCT, the EEA Grants R&D project FoRES - Development of Forests RESilience to fires in a climate change scenario, with the reference 04_Call#5_FoRES_Uaveiro, and the FCT/MCTES for the financial support to CESAM (UIDP/50017/2020 + UIDB/50017/2020), through national funds.

Ricardo Vaz acknowledges the FCT/MCTES for the financial support for his PhD fellowship under the R&D project CLING with the reference PTDC/EME-REN/34690/2021.

Rui Silva acknowledges the Portuguese Foundation for Science and Technology (FCT) for his PhD Grant (SFRH/BD/139020/2018).

Susana Cardoso Pereira acknowledges the EEA Grants for her researcher contract (FoRES - Development of Forests RESilience to fires in a climate change scenario, 04_Call#5_FoRES_UAveiro). Susana Cardoso Pereira is a working member of COST Action CA 18135 – FireLINKS (WG Member CA18135 - Fire dynamics and prevention).

David Carvalho acknowledges the Portuguese Foundation for Science and Technology (FCT) for his researcher contract (CEECIND/00563/2020).