Analysis of H SAF precipitation products for the Mediterranean cyclone Apollo

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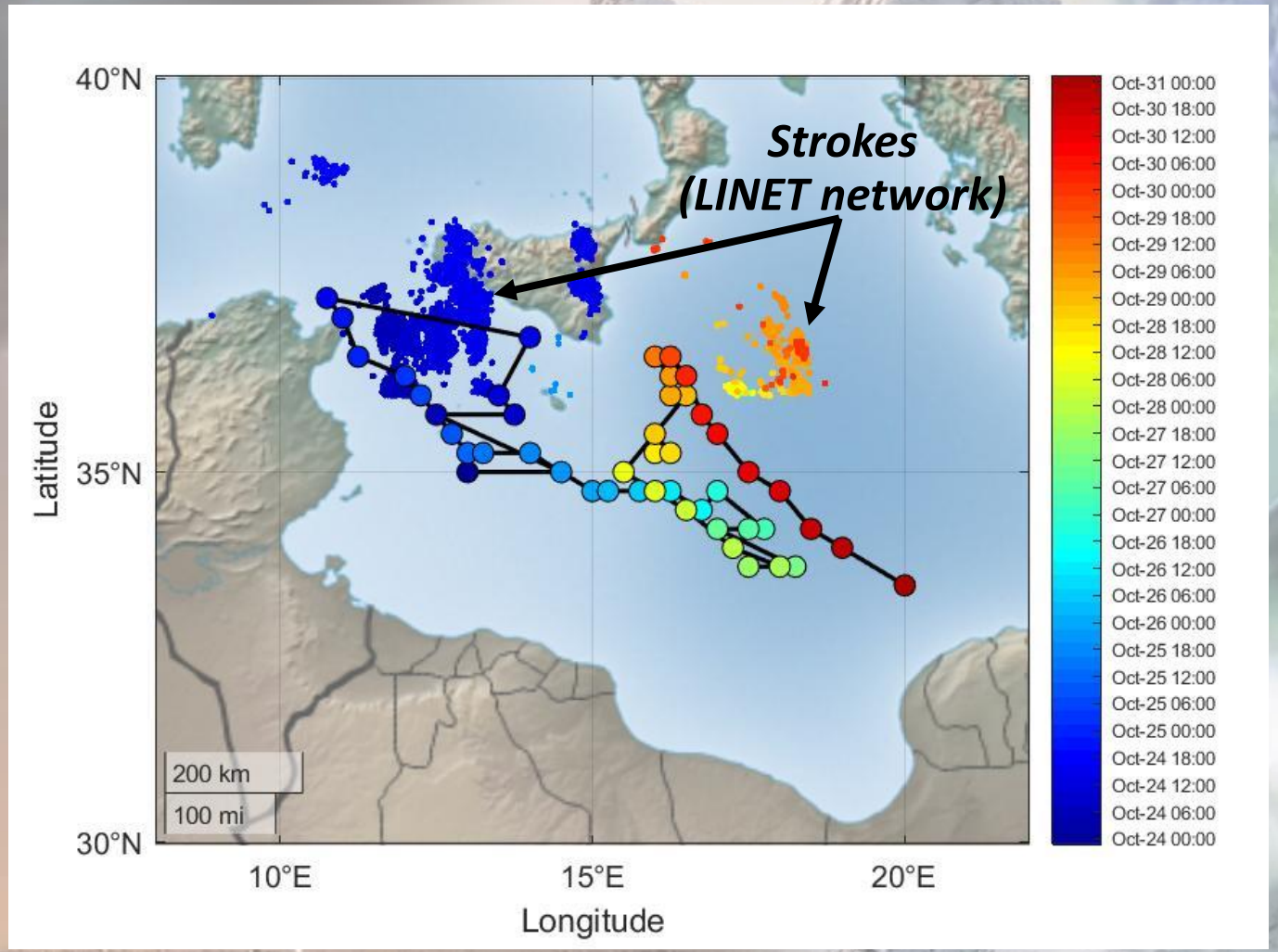
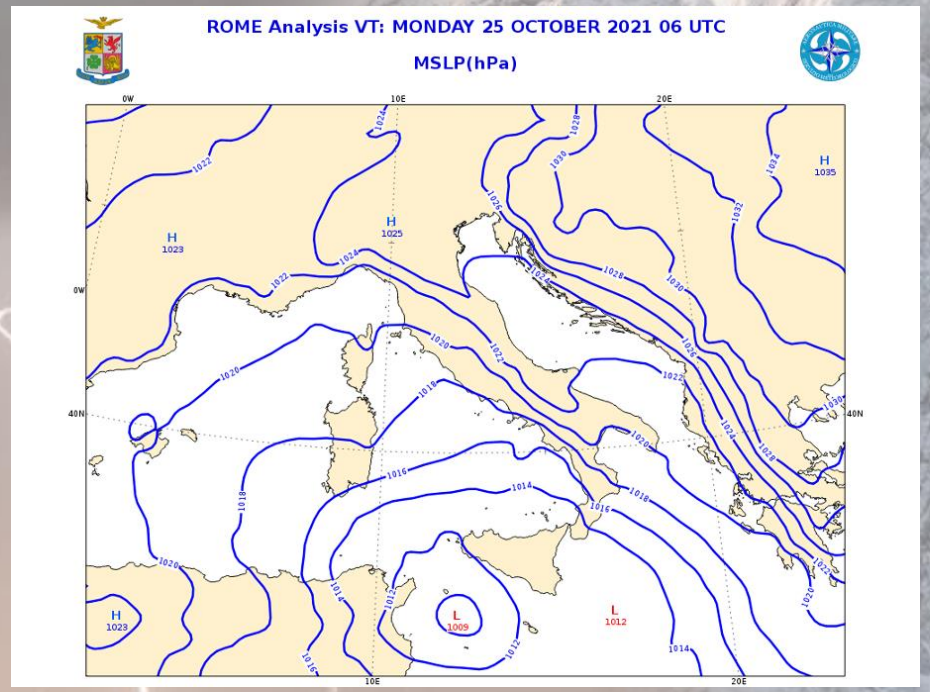
Mediterranean Cyclone Apollo



- Period: 24-30 October 2021
- Cyclone Apollo track from MSLP data from ERA5 reanalysis
- It originated between Tunisia and Sicily and then moved South-East before approaching the South-Eastern coast of Sicily and moving again to the South-East and then dissipate
- Lightning activity has been registered only at initial (western and eastern Sicily) and at maximum strength (over sea, between ending of 28 October and beginning of 29 October) stages

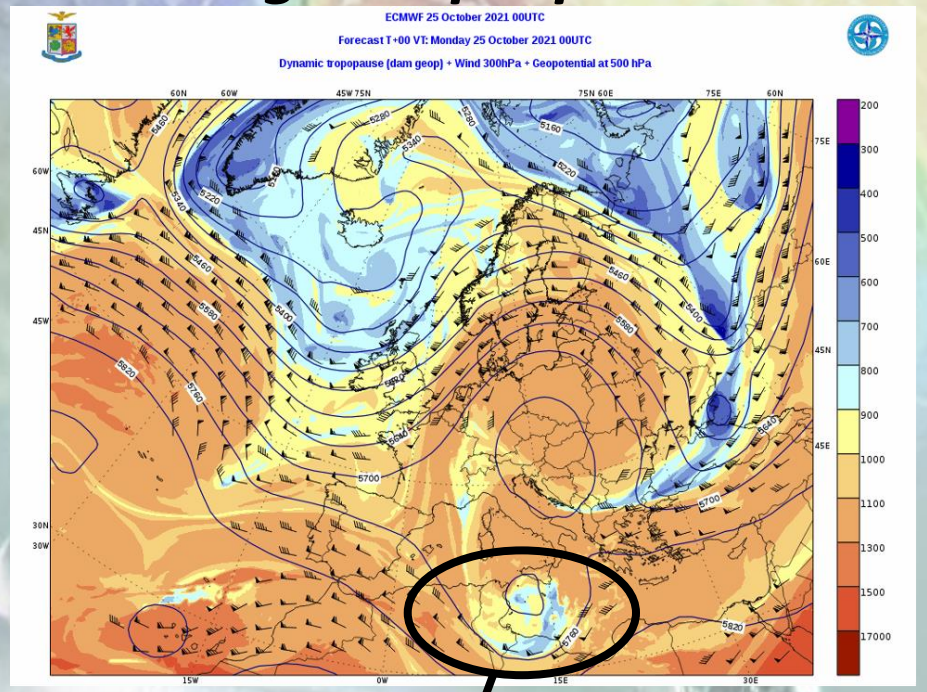
Synoptic situation

Mean Sea Level Pressure



- Split of polar jet forces
- Cyclone between North Africa and Sicily

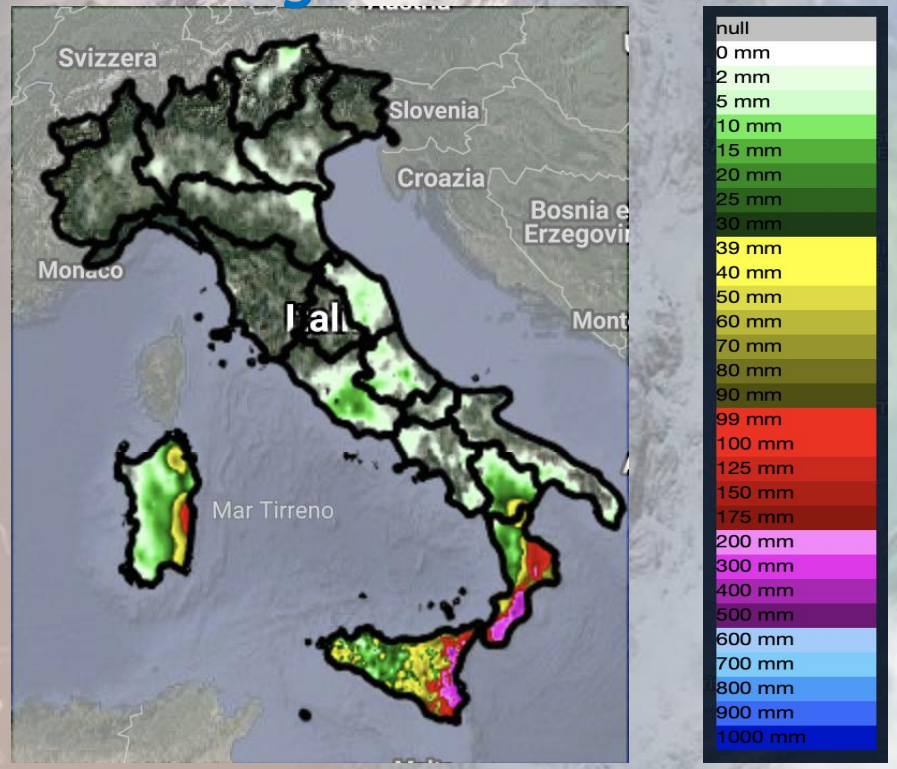
High Troposphere



- stratospheric air intrusion over the Libyan Sea

Ground Data

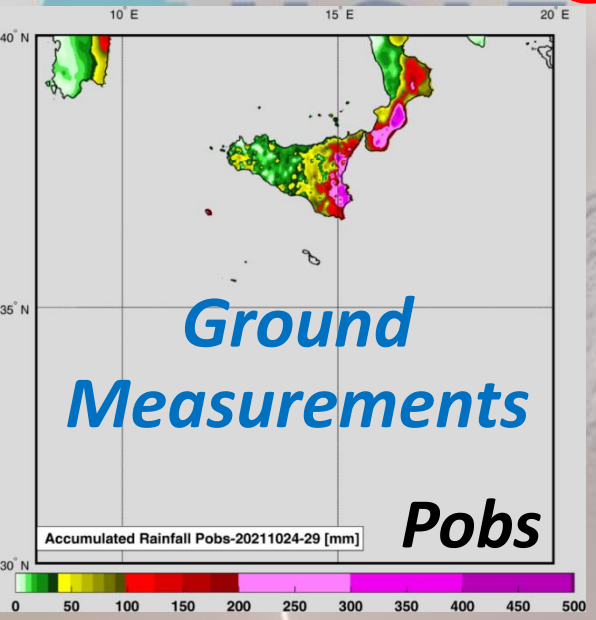
Rain Gauge Network

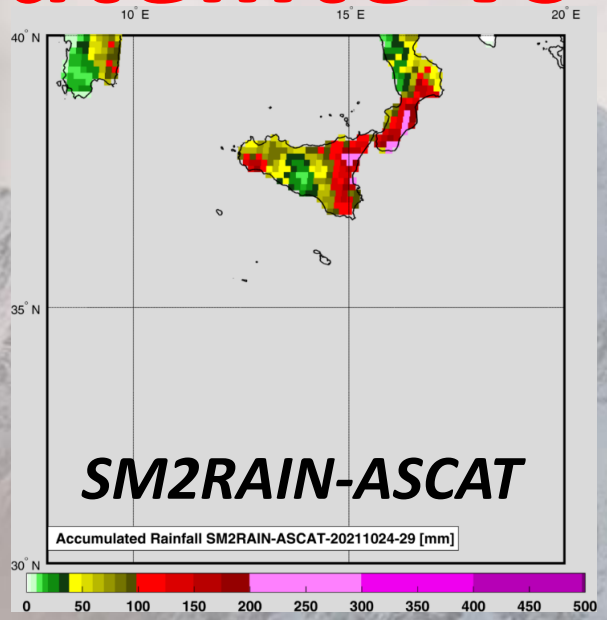


Merging Radar+Gauges

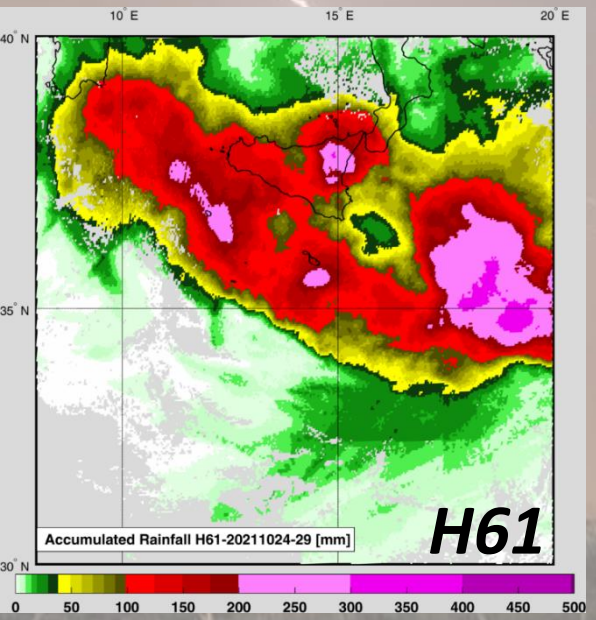
- Period: 24-29 October 2021
- Large amount of precipitation (up to 500+ mm) accumulated on the East coasts of Sicily and Calabria
- Large amount of precipitation over sea (radar coverage)

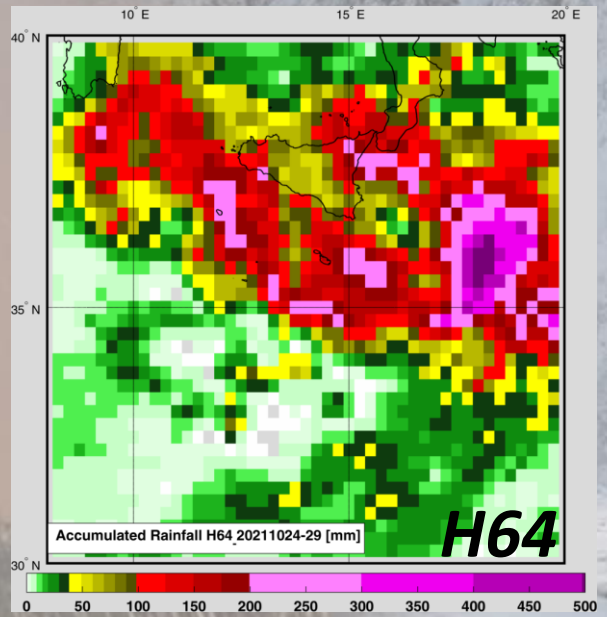
Satellite vs Ground

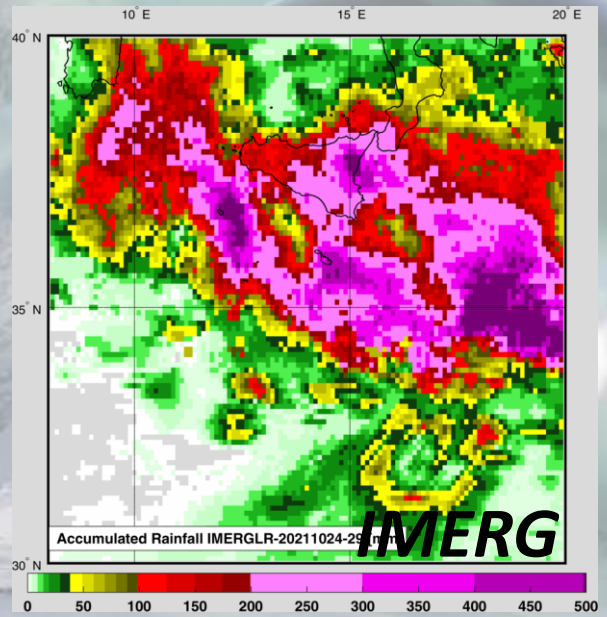




- Period: 24-29 October 2021
- Good agreement between ground and satellite estimation, except in western Sicily (lack of NRT ground measurements)
- Underestimation of all satellite-based product over Calabria
- Good agreement between satellites product even if different spatial resolution







Satellite Measurements

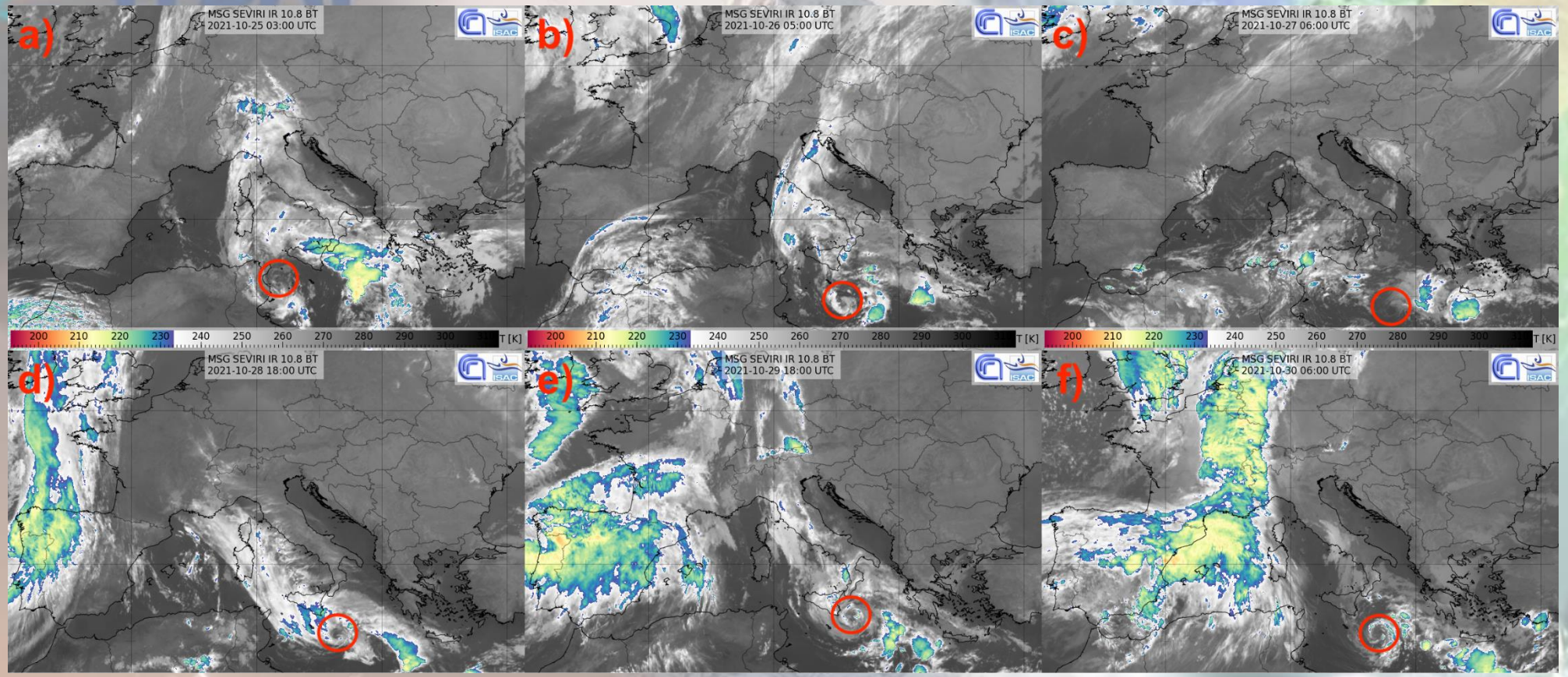
H SAF

- **H61**:IR+PMW
- **H64**: PMW-based (PMW+SM2RAIN)

GPM

- **IMERG**:IR+MW+Ground

Satellite NRT monitoring



10.8 µm SEVIRI channel

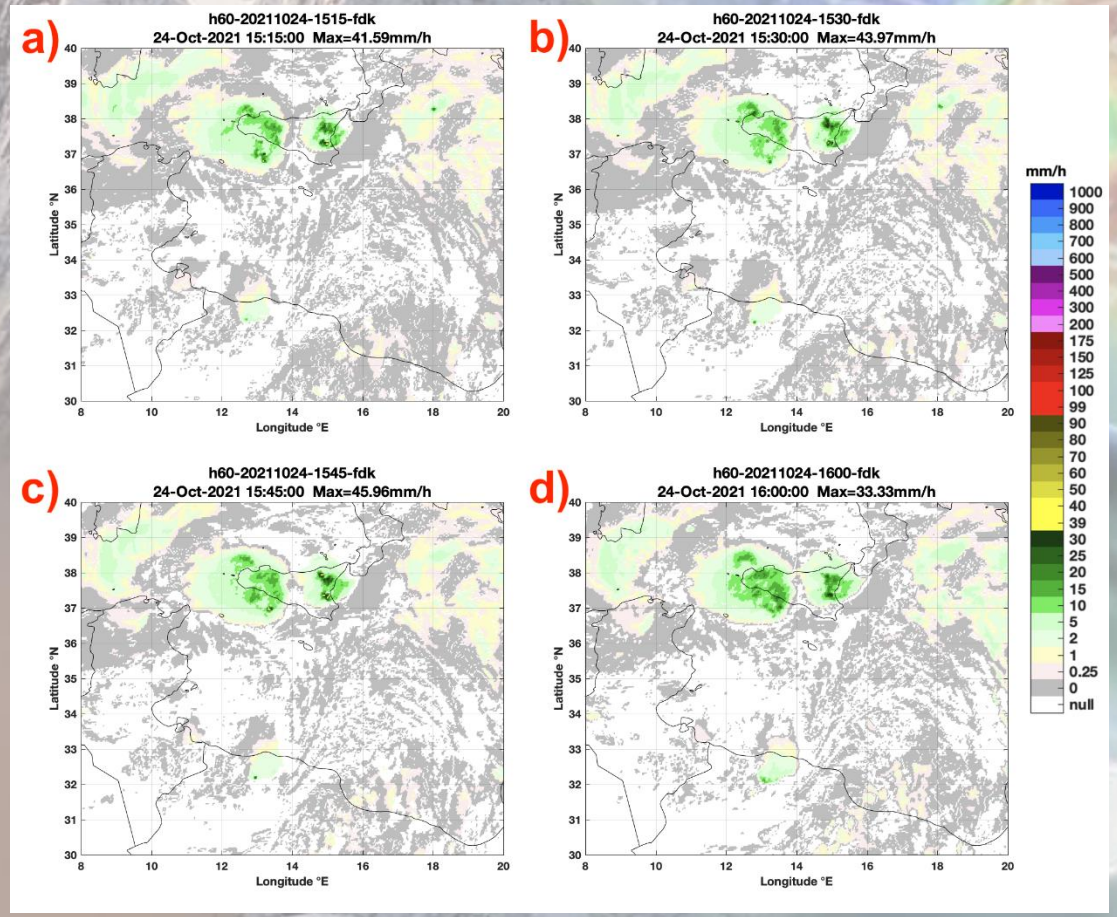
- Period: 25-30 October 2021
- Possibility to monitor the evolution of Apollo every 15 minutes
- Different phases of the Apollo: from not organized cyclone (Panels a-c) with related convective clouds to well organized stage (panels d-e) with more limited convective activity close to the cyclone centre

Satellite NRT monitoring
H SAF MW/IR precip products

P-IN-SEVIRI-PMW (H60): *instantaneous precip rate from blending technique combining passive MW data from LEO satellites and IR data from GEO satellite.*

Spatial resolution 4-5 km

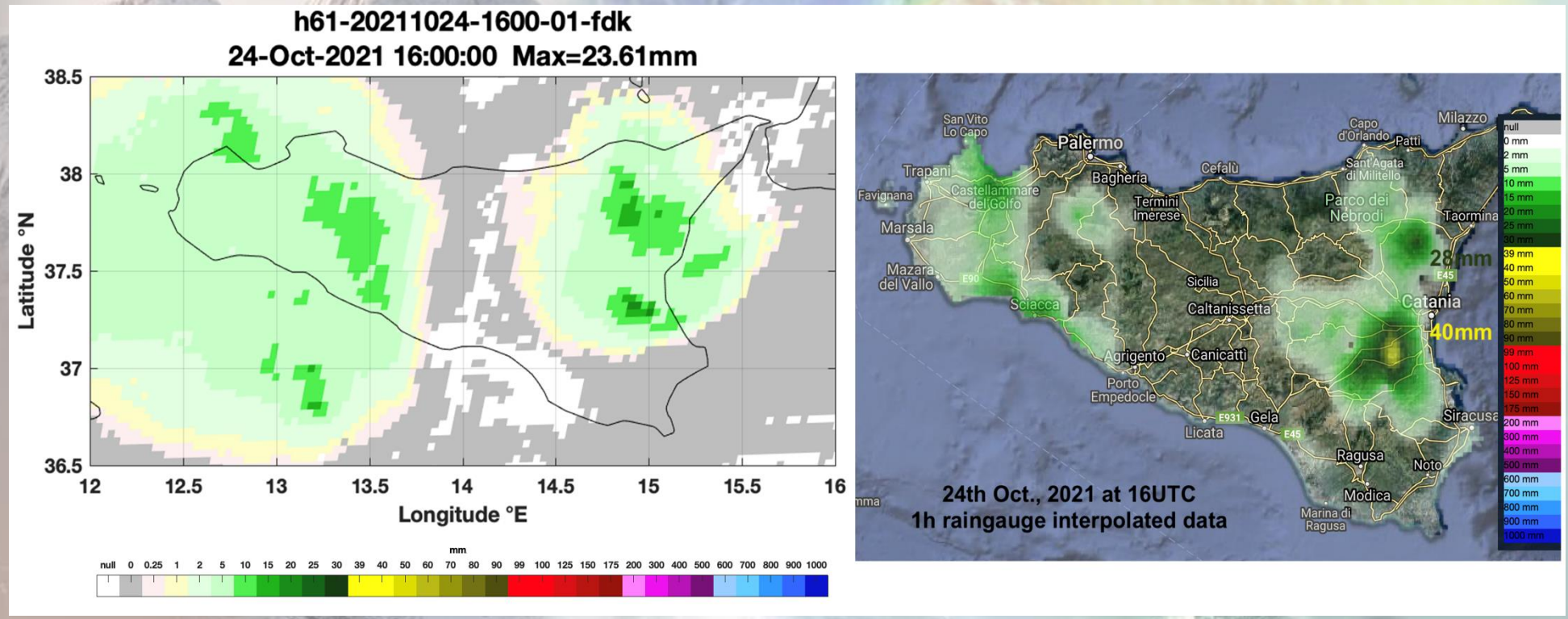
Temporal resolution 15 min



- 4 rainrate maps on 24 October 2021 from 15:15 to 16:00 UTC
- Precipitation affected both Western and Eastern part of Sicily
- High precip intensity with peaks up to more than 40 mm/h

Satellite NRT monitoring
H SAF precip products

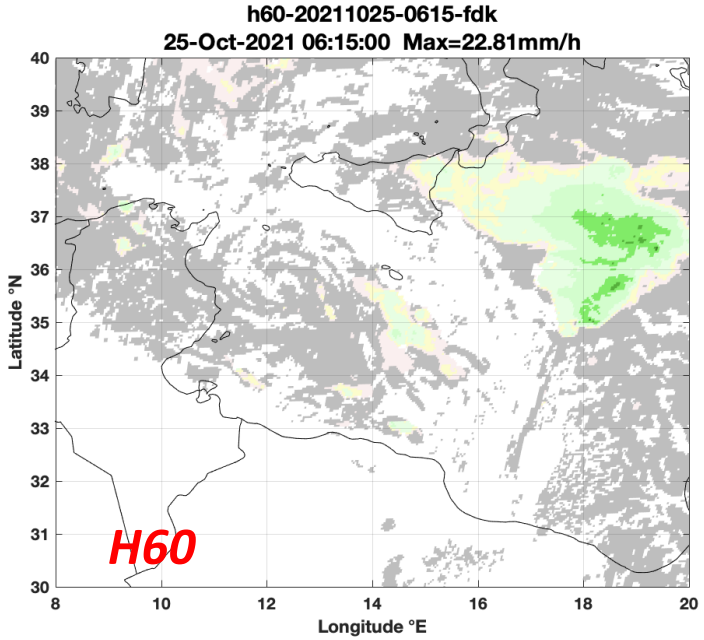
P-AC-SEVIRI-PMW (H61): *accumulated precipitation over 1 hour (or 24 hours) from blending technique combining MW data from LEO satellites and IR data from GEO satellite.*



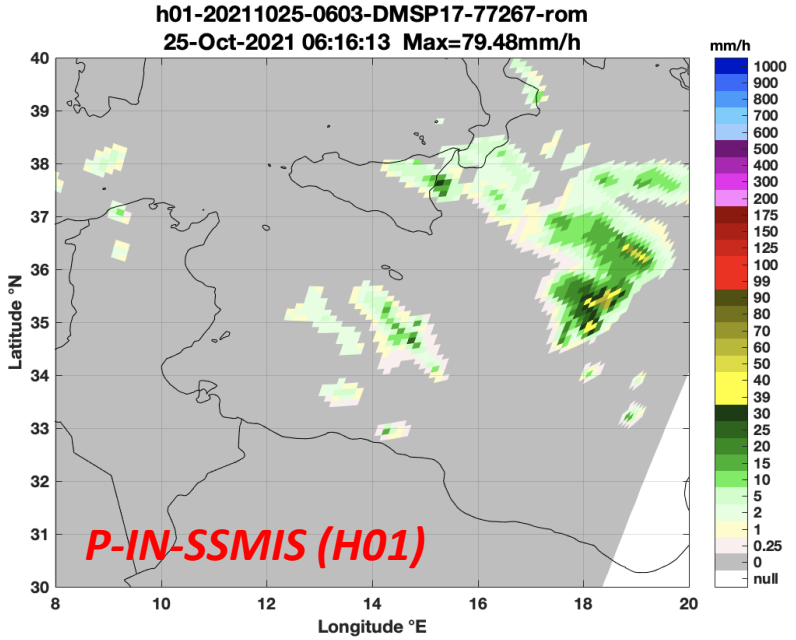
- Period: 24 October 2021 15:00-16:00 UTC
- Comparison between H61 and interpolated rain gauge data
- Very good agreement in the precip pattern
- Underestimation of maximum accumulated precip over Eastern Sicily (23.6 vs 40 mm)

Satellite NRT monitoring
H SAF precip products

MW/IR Product



PMW Product

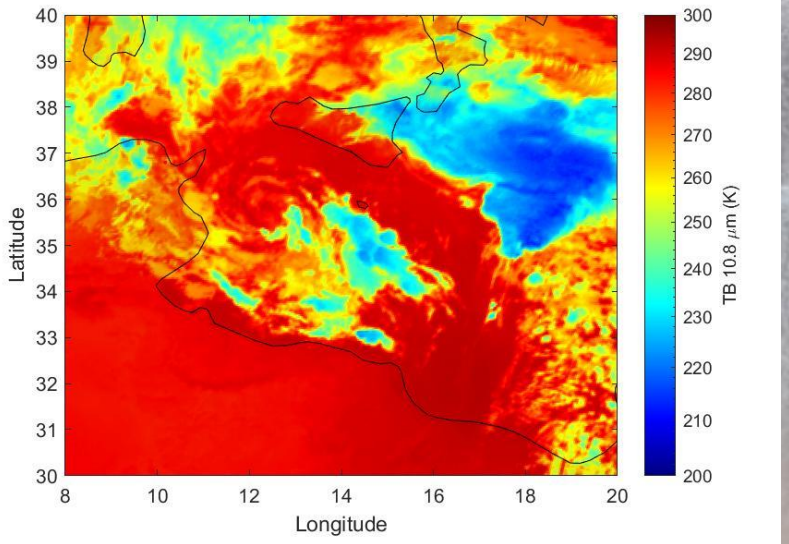


P-IN-SSMIS (H01 new rel.): Precipitation rate at ground by PMW conical scanners.

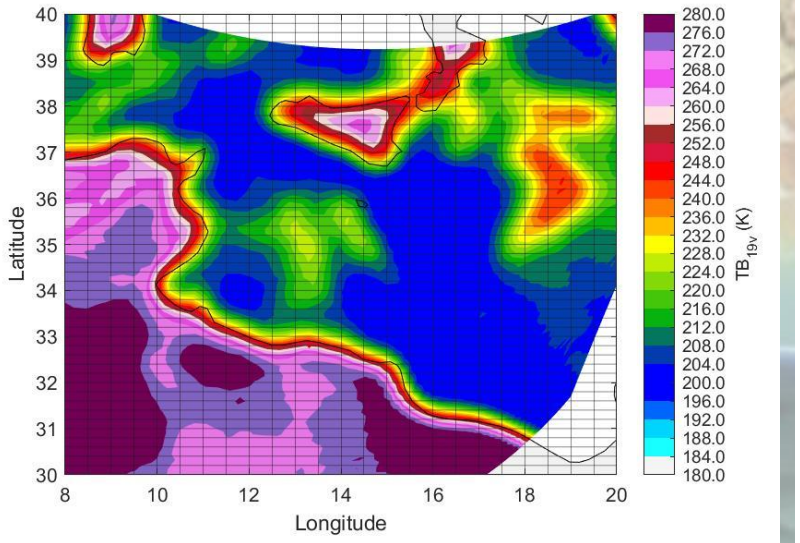
- Period: 25 October 2021 06:15 UTC
- The two products recognize the same precipitation pattern
- Marked difference in precip rate estimation between H60 and H01 both over Ionian Sea and over East coast of Sicily
- *What are the reasons of different estimations?*

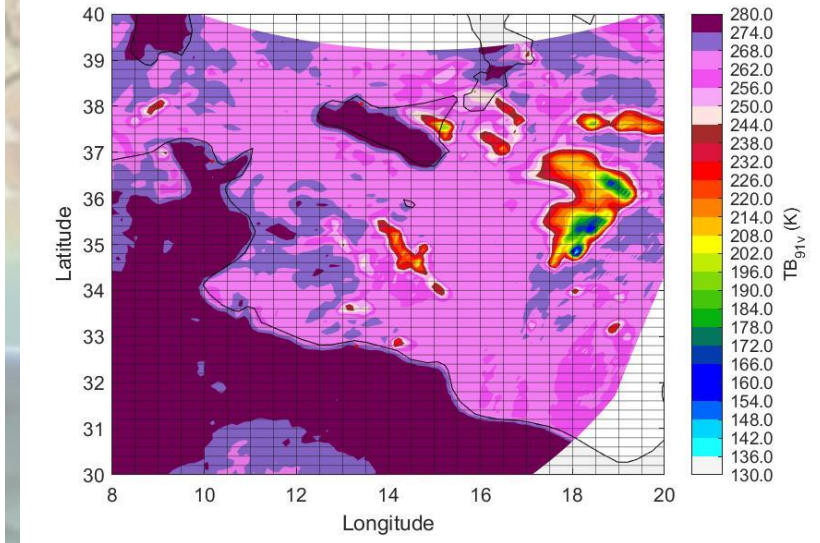
MW vs IR capabilities

SEVIRI



SSMIS

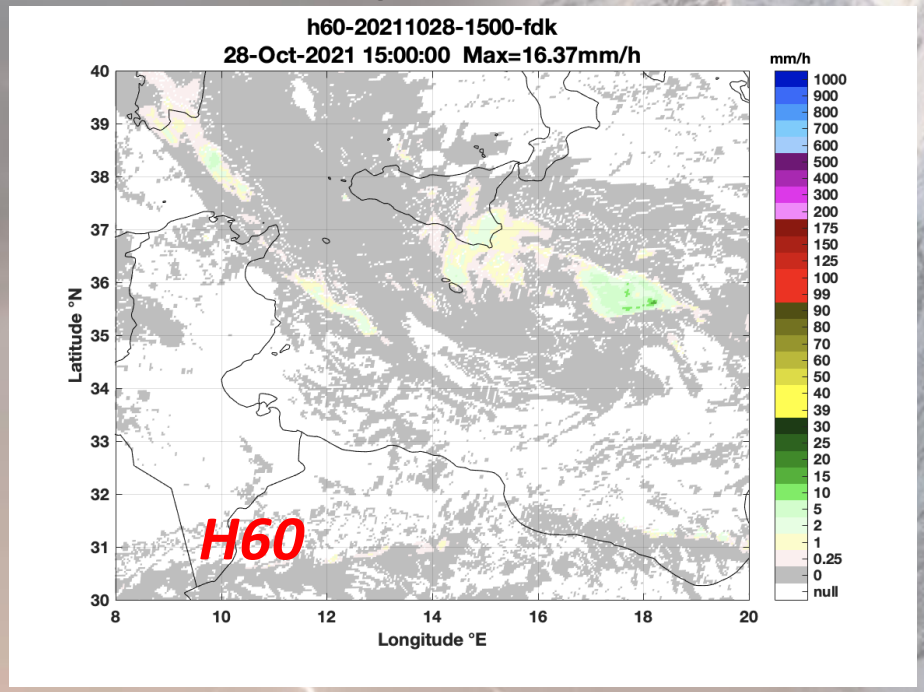




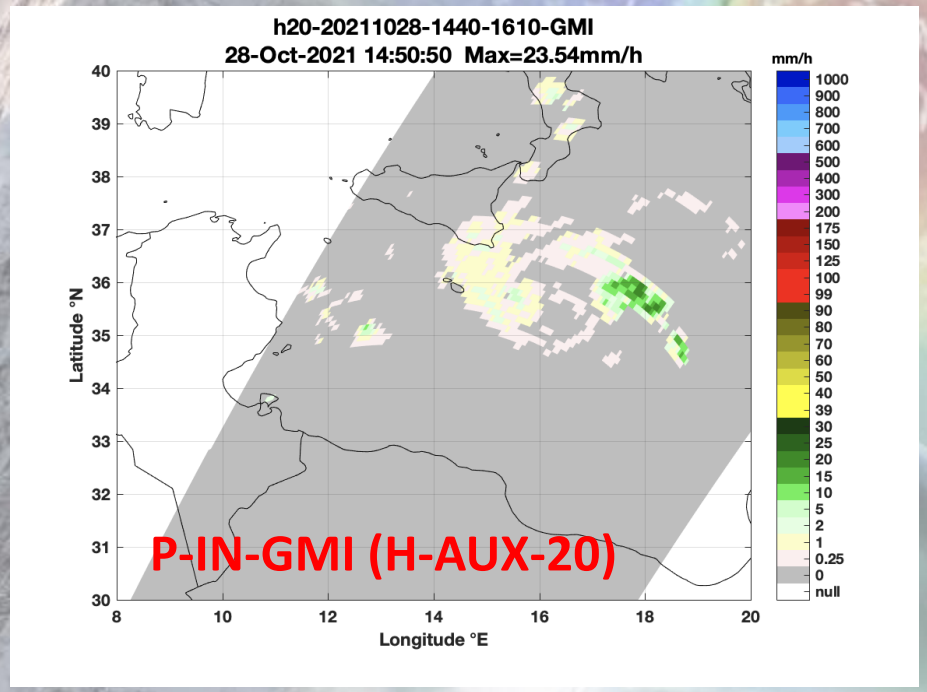
- Period: 25 October 2021 06:15 UTC
- The IR signal at 10.8 µm shows not significantly low TB values
- The SSMIS 19 GHz channel is useful to identify the precipitation area (over sea) indicated by a warm area with respect to the background (low spatial resolution) produced by raindrops emission
- The TB depression at 91 GHz channel show minimum values as low as 140 K due to the ice scattering in presence of deep convection.
- This evidences the absence of heavy ice particles

Satellite NRT monitoring
H SAF precip products

MW/IR Product



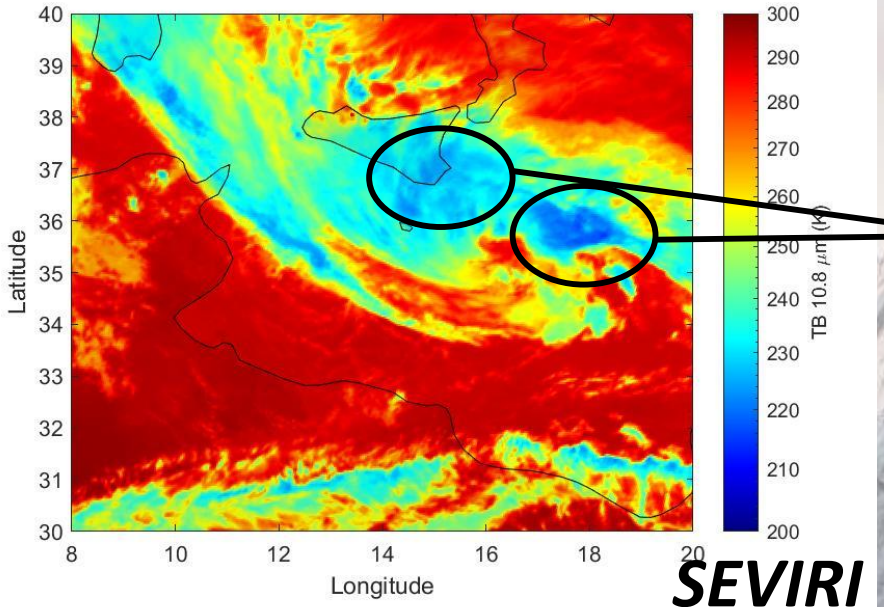
PMW Product



P-IN-GMI (H-AUX-20): Precipitation rate at ground by PMW conical scanners.

- Period: 28 October 2021 15:00 UTC
- The two products recognize the same precipitation pattern
- Good agreement in precip rate estimation between Sicily and Malta
- Slight difference in precip rate estimation over the Ionian Sea
- ***What are the reasons of different estimations?***

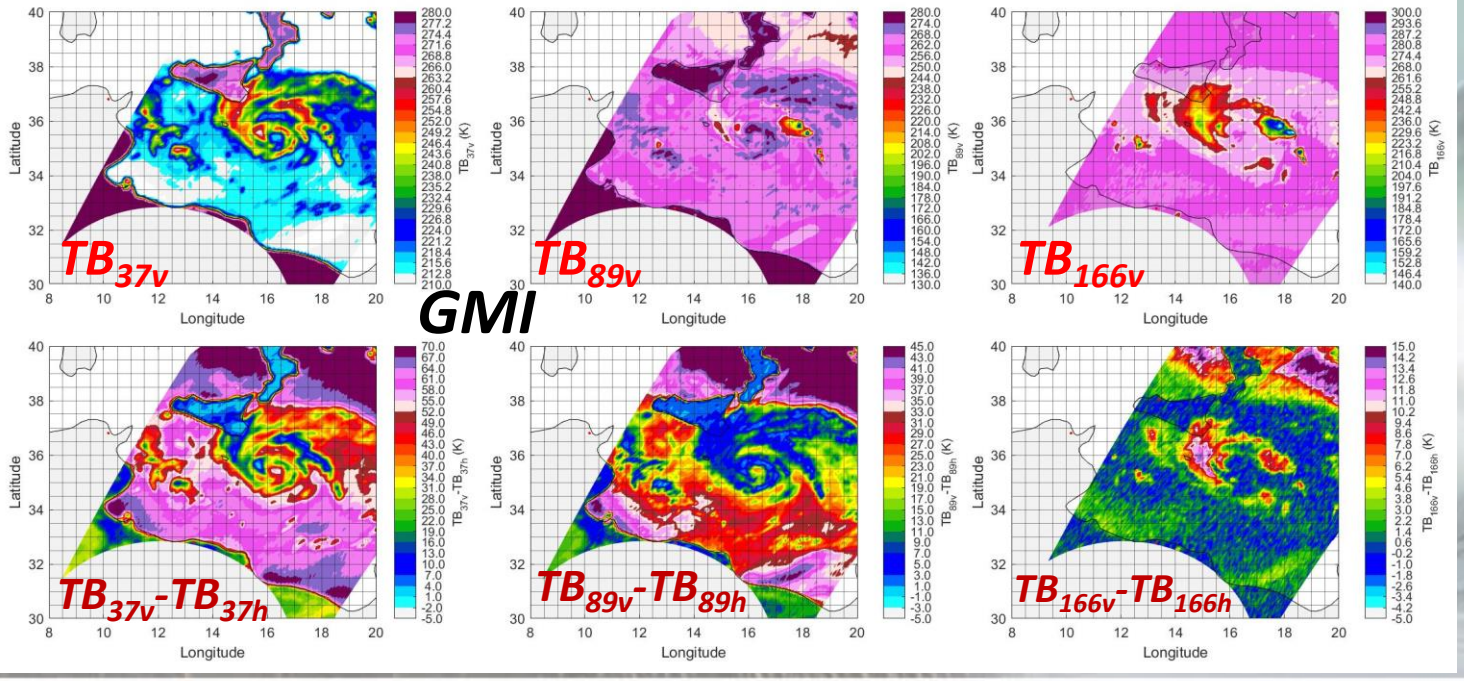
MW vs IR



SEVIRI

- Relatively high IR TB (above 220 K)
- Signature of absence of deep convection

Did Apollo reach Tropical-like cyclone phase?



GMI

- $\Delta TB_{37GHz}(TB_{37v}-TB_{37h})$ approaching 0 K indicates the presence of rain
- Limited TB depression at 89GHz, as well as TB increase (with respect to the background) at 37 GHz indicate the absence of heavy ice (i.e. hail, graupel) and the presence of precipitation, respectively
- Agreement with TB SEVIRI about the absence of deep convection
- TB depression (not marked) at 166 GHz evidences the presence of snowflake sand small aggregates in the upper levels
- **These features are typical of a Mediterranean cyclone with tropical-like characteristics during its mature phase (Marra et al., 2019; D'Adderio et al., 2022 – see slide 18)**

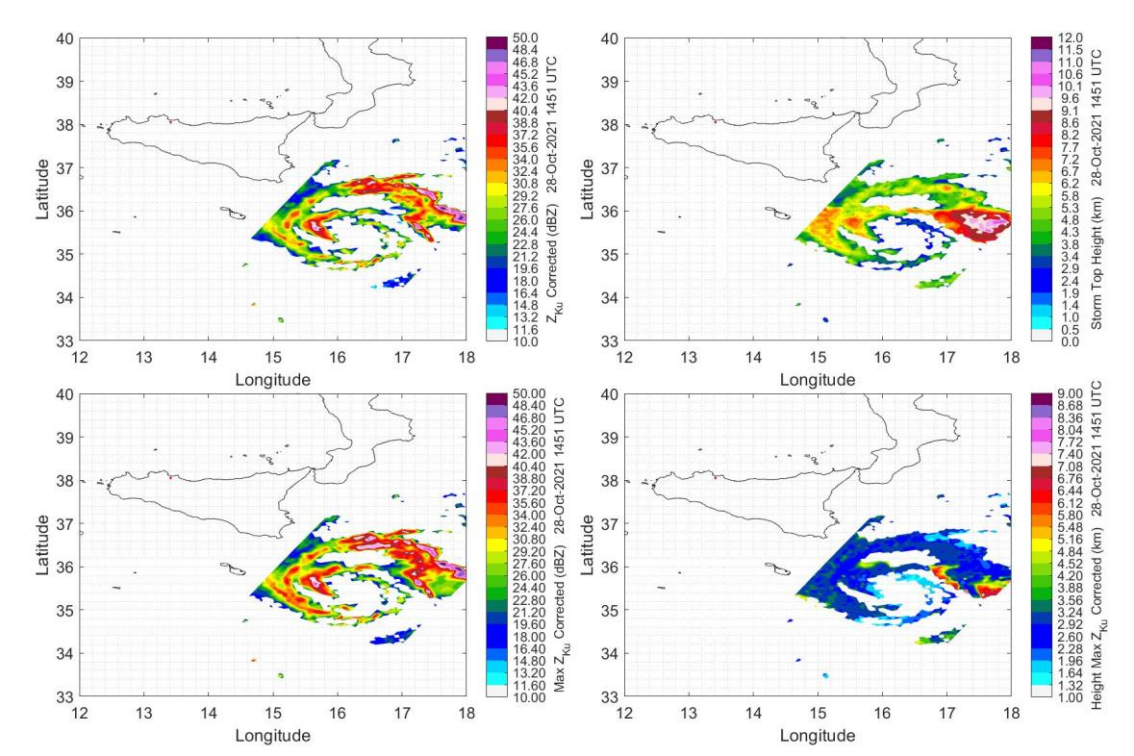
Satellite monitoring GPM DPR products

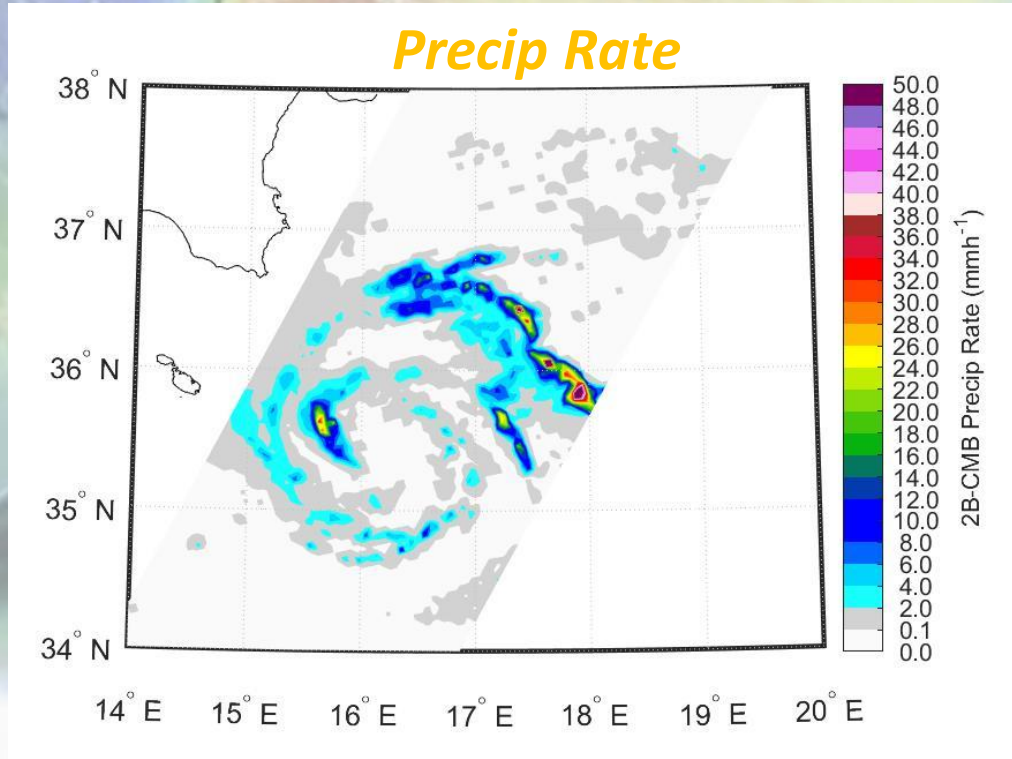
- ***DPR: Dual-frequency Precipitation Radar***
- Two radars on board of Global Precipitation Measurement (GPM) mission: Ku-band (13.6 GHz) & Ka-band (35.5 GHz)
- Three different scans: *Normal Scan* (**NS**), *Matched Scan* (**MS**) e *High Sensitivity* (**HS**)
- Inner swath: 25 Instantaneous Field of View (IFOV)
  - Dual-frequency based products (2ADPR-MS/NS)
  - Single-frequency based products (2AKa-MS & 2AKu-NS)
- Three different rain classification: ***Convective, Stratiform, Other***

  +

  - Land/Sea classification
- Parameters provided:
  - Corrected radar reflectivity (Z_{ka}, Z_{ku})
  - Mass-Weighted Mean Diameter (D_m)
  - Normalized intercept parameter (N_w)
  - Rainfall rate (R)

Satellite monitoring GPM DPR products





- Period: 28 October 2021 15:00 UTC
- The Ku-band reflectivity measured by DPR shows not high values (generally lower than 40 dBZ)
- The storm top height product highlights the limited vertical extension of the clouds
- The precip rate estimated by combined DPR-GMI product is closer to H-AUX-20 than H60 (additional confirmation that in presence of shallow precipitation the MW signal is more useful than IR signal)
- **DPR seems to confirm the tropical-like characteristics observed from GMI**

Conclusions

- The Mediterranean storm Apollo occurred between 24 and 29 October 2021 in a region between Tunisia, Sicily and Ionian Sea
- A huge amount of rain (up to 500+ mm) occurred in the affected area, and especially on the Eastern coast of Sicily as registered by both rain gauge and ground radar networks
- The H SAF satellite-based precipitation products, even if working at different spatial resolution, show a good agreement with ground-based data
- The H SAF precipitation products, being based on different working principles, allowed to highlight different characteristics of the storm
- The MW/IR-based products (i.e. H60) allows a high spatial-temporal resolution NRT monitoring of the Apollo
- The PMW-based products (i.e. H01, H-AUX-20) had better performance in precipitation rate estimation because most of the precipitation is shallow or stratiform.
- The additional information provided by spaceborne radar (GPM DPR) are particularly useful to better characterize Apollo and confirms tropical-like characteristics observed during the mature phase

Thank you for your attention!

For more questions and information

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References

- Marra, A.C.; Federico, S.; Montopoli, M.; Avolio, E.; Baldini, L.; Casella, D.; D'Adderio, L.P.; Dietrich, S.; Sanò, P.; Torcasio, R.C.; Panegrossi, G. The Precipitation Structure of the Mediterranean Tropical-Like Cyclone Numa: Analysis of GPM Observations and Numerical Weather Prediction Model Simulations. *Remote Sens.* **2019**, *11*, 1690. https://doi.org/10.3390/rs11141690

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