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EXERCISE (PWV RETRIEVAL): CASE STUDIES (THUNDERSTORMS: NAPLES, 23 & 26 SEPTEMBER, 2019)

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INGV

Exercise (PWV retrieval): Case Studies (Thunderstorms: Naples, 23rd & 26th September, 2019)

Introduction

This exercise will lead us to the calculation of the precipitable water vapor from the zenithal total delay (ZTD) estimated at the TRYAT GNSS TAI1. This antenna is located on the roof of the Leonardo da Vinci school building. The ZTD values, reported in an Excel file, have been estimated with Gamit-Globk software (release 10.7). Data have been collected on the occasion of heavy rain episodes.

Two storms with heavy and sudden rains have stroke Napoli on 23rd & 26th September, 2019 (Figs. 1, 2 and 3).

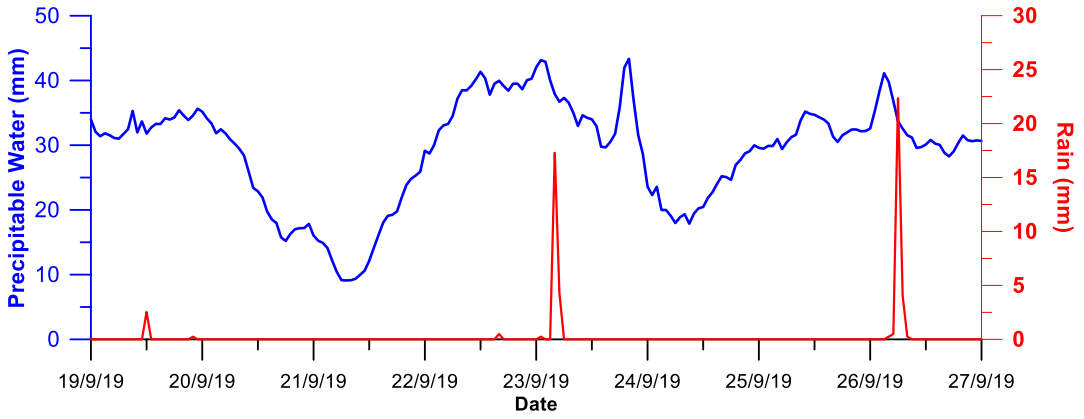
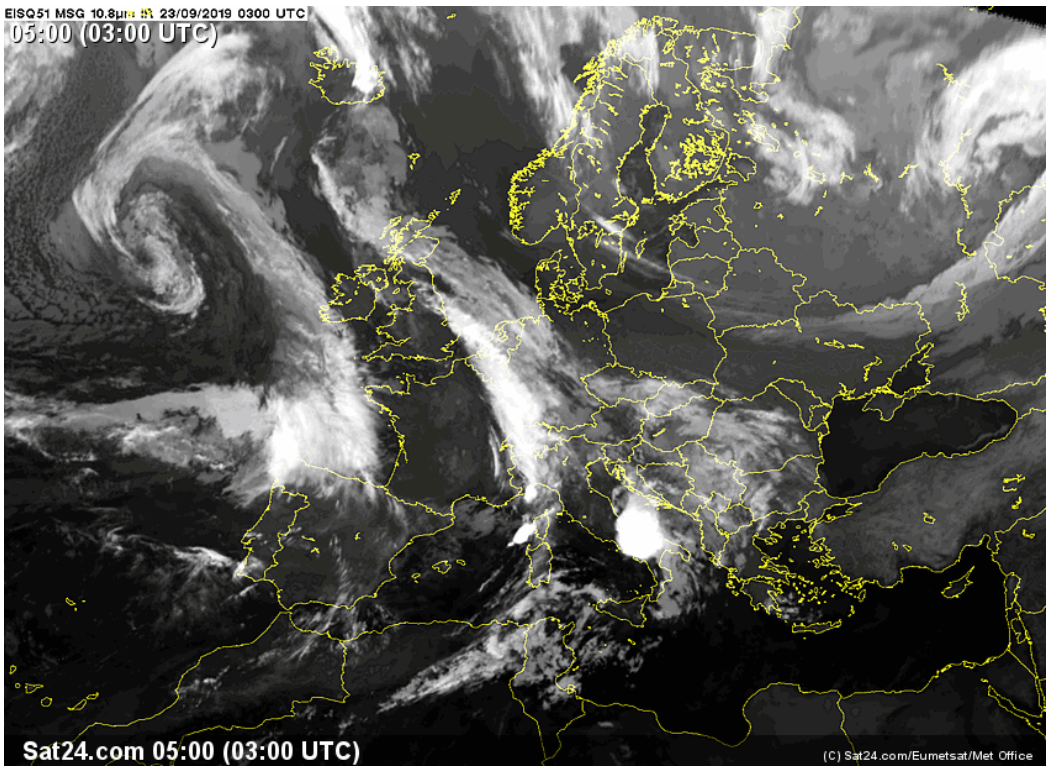


Figure 1: Time Evolution of Precipitable Water computed from GNSS data at TAI1 station and Rain hourly values collected on MAFE Meteorological station @ UNINA.



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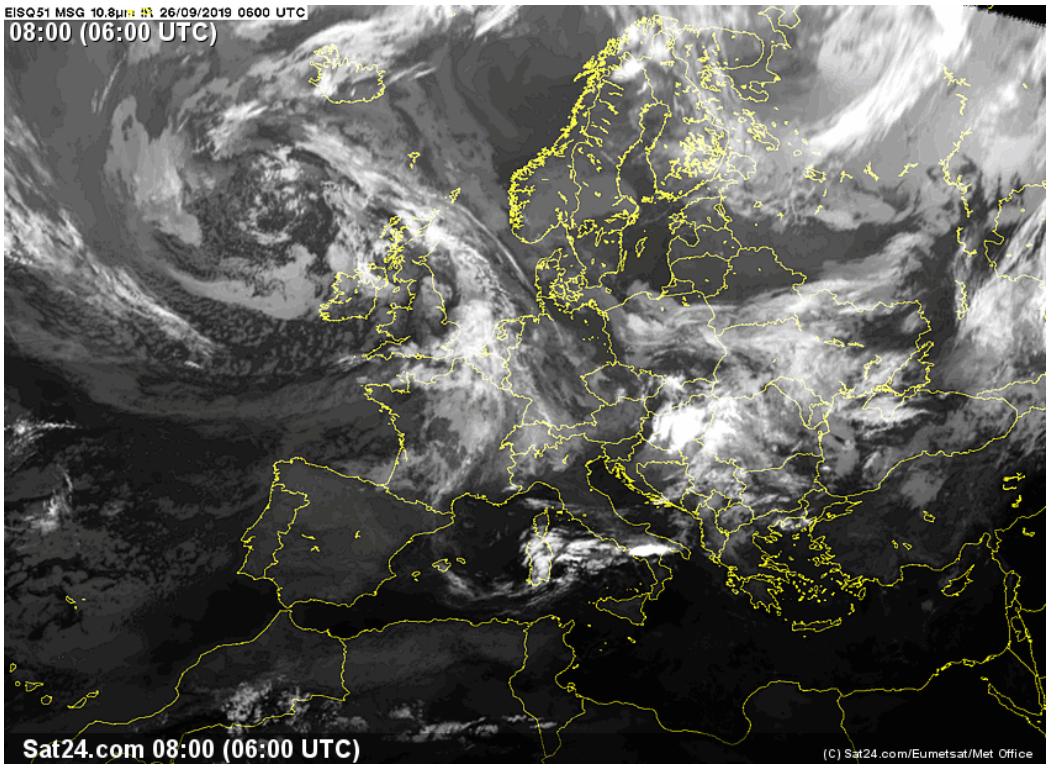

Figure 2 & 3: Infrared Satellite Images showing Cloud Cover on Europe during the two thunderstorms

Reminder on the Basic Formulas used in Meteorological GNSS Analysis:

2 Components contribute to the Zenithal Total Tropospheric Delay (*ZTD*)

$$ZTD = ZHD + ZWD$$

ZHD=Zenithal Hydrostatic Delay; ZWD=Zenithal Wet Delay

ZHD can be computed according to *Saastamoinen's formula*, where $\boldsymbol{p_0}$ = Air Pressure at the Meteo station; $\boldsymbol{\varphi}$, $\boldsymbol{h}$ Station Latitude & height a.s.l

$$ZHD = \left[(2.22768)\frac{mm}{hPa}\right]\frac{p_0}{f(\varphi, h)}$$

$$f(\varphi, h) = 1 - 0.00265cos(2\varphi) - 0.000285h$$

Saastamoinen's Formula

$$PWV = \Pi * ZWD \qquad \text{(where, } \Pi \approx 0.152\text{)}$$

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Exercise

The Excel file consists of two sheets: "*met_tai1_2019_262_269*" with values of tropospheric delays and "*Rain_hou*" containing hourly values of rain collected at MAFE station (DiSTAR University "Federico II" of Naples)

The file collects 7 days of data from TAI1 GNSS station spanning 19-26 September 2019 (Day of the Year: 262-269) to be used for the exercise.

In that time interval two thunderstorms occur. The file can be split in two Sections highlighted with different colours (light gray, Columns from A to S: output of GAMIT-GLOBK Software + Air Pressure values collected at MAFE station at UNINA; peachy, Columns from T to W: Computations according to the Basic Formulas and Air Pressure values at MAFE.

Data in the sheet titled "Rain_hou" (hourly values of rain collected at MAFE), can be used to produce a plot as in **Figure 1**.

In the following a description of the content of each columns of the Excel File.

A) Yr [Year]
B) Doy [Day of the Year]
C) DoY_Dec [decimal DoY, suitable for plotting]
D) Hr [Hour]
E) Mn [Minutes]
F) Sec [Seconds]
G) Total Zen (mm) [ZTD]
H) Wet Zen (mm) [ZWD]
I) Sig Zen (mm) [std on_ZTD]
J) PW (mm) [Precipitable Water]
K) Sig PW (mm) [std on_PW]
L) Press (hPa) [Air Pressure from model GPT2]
M) Temp (K) [Air Temperature from model GPT2]
N) ZHD (mm) [ZHD= Zenith Hydrostatic Delay]
O) Grad NS (mm/km) [Gradient of Zenith Delay along NS Direction]
P) Sig NS (mm/km) [std on_Grad NS]
Q) Grad EW (mm/km) [Gradient of Zenith Delay along EW Direction]
R) Sig EW (mm) [std on_Grad EW]
S) Pres_Mafe (hPa) [Air Pressure from MAFE Meteo Station @ UNINA]

T) ZHD_Obs (mm)) [To calculate by Saastamoinen's Formula]
U) f_Saasta* [To calculate with Function [$f(\varphi, h)$] in Saastamoinen's Formula]
V) ZWD_Obs (mm) [To calculate as ZHD= G-T]
W) PW_Obs (mm) [To calculate as PW=Π*ZWD=0.165*

Students' work (Exercise) consists in computing values in the columns from T to W using the recalled formulae.

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