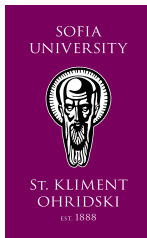


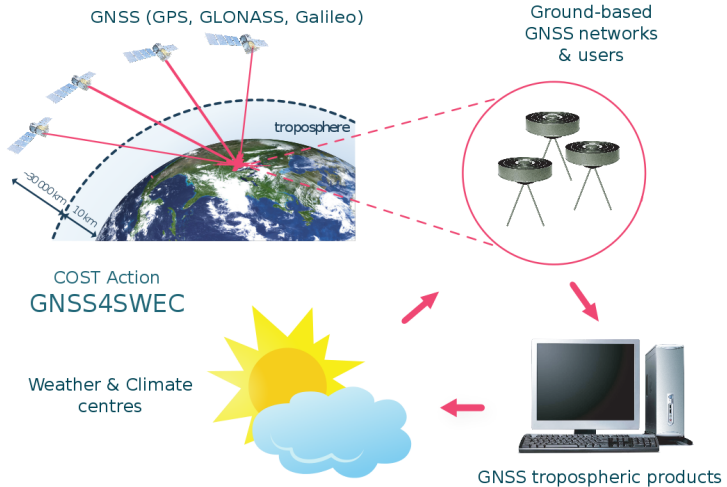
13 Years GNSS Meteorology in Bulgaria and Southeast Europe

Guergana Guerova

Department of Meteorology and Geophysics
Physics Faculty, Sofia University "St. Kliment Ohridski"

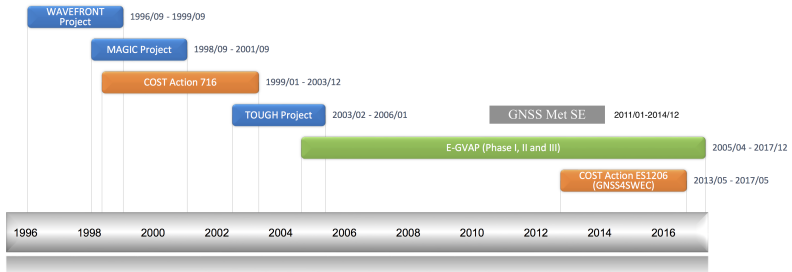


5th Seminar "Physics and chemistry of Earth System",
25-27 September 2023 Bania Bulgaria



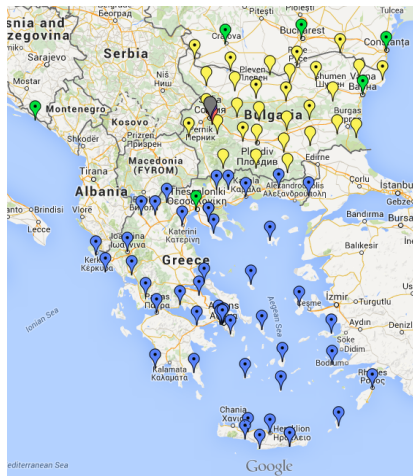
¹<https://www.youtube.com/watch?v=t1inZaRdWY4>

- 1999-2004 COST Action 716 - 15 countries - 1 hourly updated ZTD products
- 2006-2021 Eumetnet GNSS water vapour programme E-GVAP; 24 GNSS Analysis Centers; 3500 GNSS sites
- 2013-2017 GNSS4SWEC - 32 countries - sub-hourly ZTD products, very dense networks



²Guerova et al., 2016. Review of the state-of-the-art and future prospects of the ground-based GNSS meteorology in Europe. Atmos. Meas. Tech., 9, 5385-5406.

- 2011-2012: SUADA development, publication of the data in May 2012
- 2012-2014: SUADA data population
- 5 different GNSS processing; 107 GNSS station; temporal resolution 5 to 60 min



³<http://http://suada.phys.uni-sofia.bg/>

COST Action "Advanced Global Navigation Satellite Systems tropospheric products for monitoring severe weather events and climate (GNSS4SWEC)"⁴

- objective: develop the next generation of GNSS tropospheric products with improved temporal, spatial resolution and multi constellation processing
- 190+ participants from 60+ institutions



⁴GNSS4SWEC web page <http://gnss4swec.knmi.nl>

Working Group 1: Advanced Processing Techniques

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G. Guerova

GNSS

MET

EU

SUADA

GNSS4

SWEC

WG1

WG2

WG3

BeRTISS

Team

BG

SUCAC

GNSS-BG

Trop-NET

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BINCA

Storm

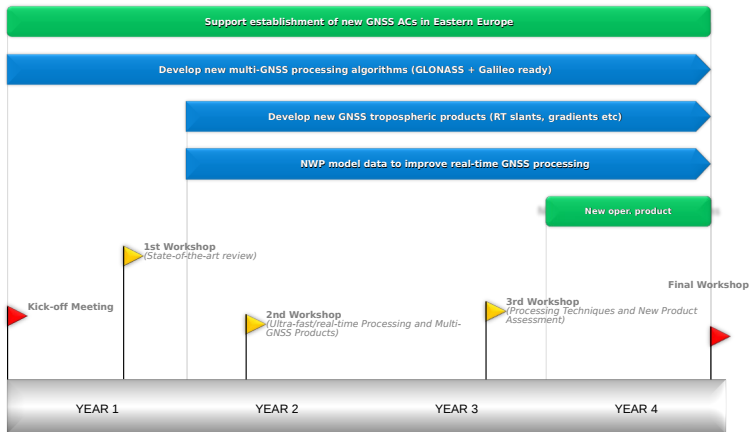
Demo

Design

Web portal

Books

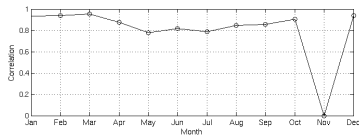
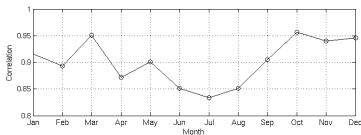
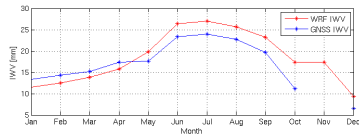
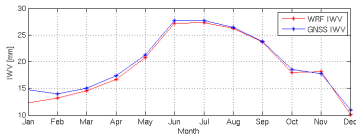
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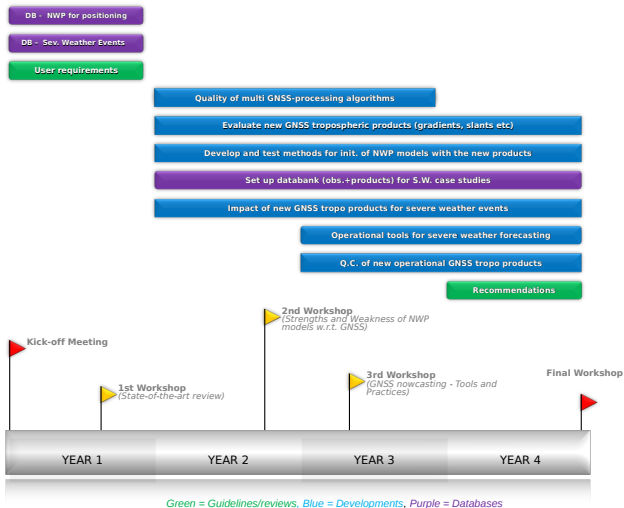
Green = Guidelines/reviews, Blue = Developments, Purple = Databases

WG1: WRF model evaluation with GNSS I WV for Bulgaria

- established Sofia University GNSS Analysis Centre (SUGAC)
- first SUGAC processing campaign: 7 GNSS stations for 1 year with temporal resolution 5 min
- WRF NWP model simulations, 3x3 km horizontal, 44 vertical levels



Working Group 2: Use of GNSS tropospheric products for high resolution NWP and severe weather forecasting



WG2: Study fog in Danubian plain 2012⁵

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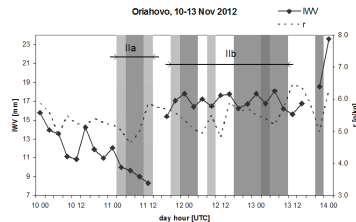
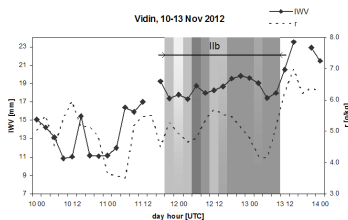
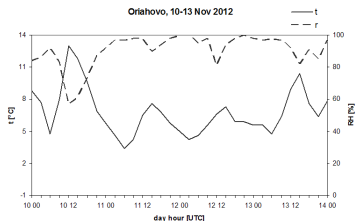
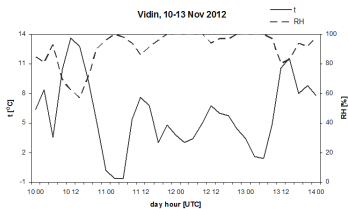
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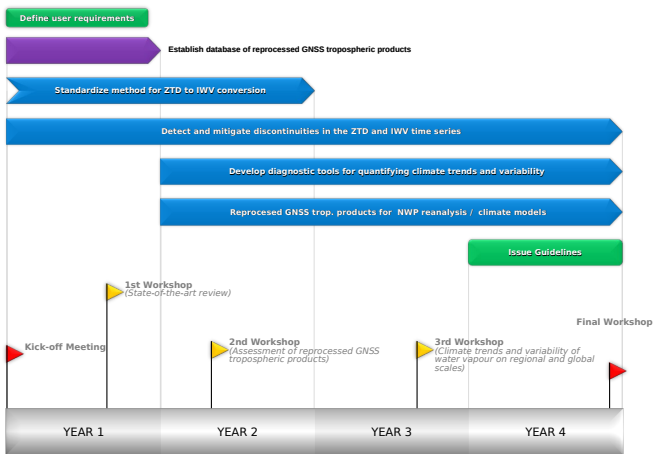
Books

End



⁵ Stoycheva and Guerova, 2015. Study of fog in Bulgaria by using the GNSS tropospheric products and large scale dynamic analysis. J. Atmosph. Solar-Terr. Physics, 133, 87-97.

Working Group 3: Use of GNSS tropospheric products for climate monitoring



Green = Guidelines/reviews, Blue = Developments, Purple = Databases

WG3: Case study 2007 heat wave in Bulgaria⁶

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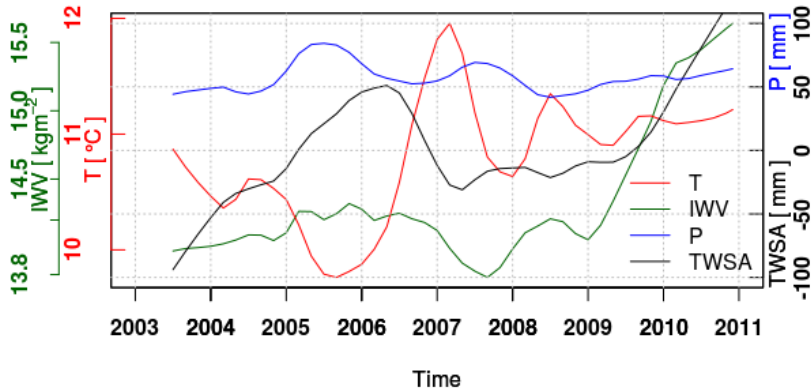
Demo

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Books

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⁶Mircheva et al., 2017. Anomalies of hydrological cycle components during the 2007 heat wave in Bulgaria, J. Atmosph. Solar-Terr. Physics 165-166, 1-9.

BalkanMed real time severe weather service BeRTISS⁷: team

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G. Guerova

GNSS

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⁷funded by Transnational Cooperation Programme Interreg V-B "Balkan-Mediterranean 2014-2020" co-financed by European Union European Regional Development Fund and National Funds of the participating countries

BalkanMed real time severe weather service BeRTISS: Bulgaria

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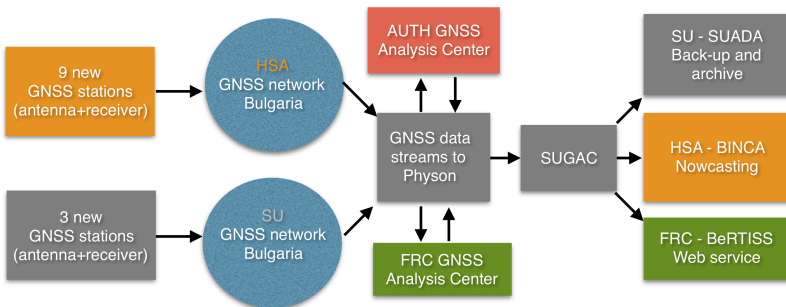
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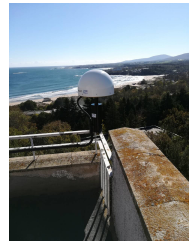
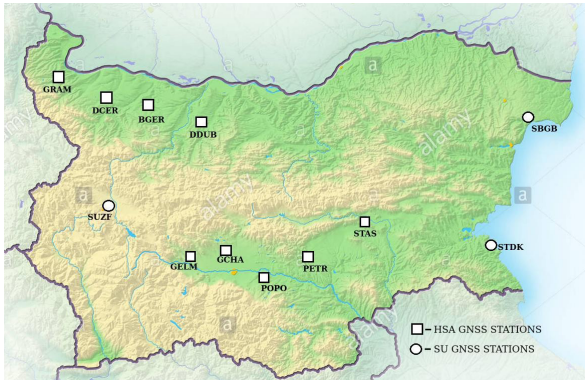
Books

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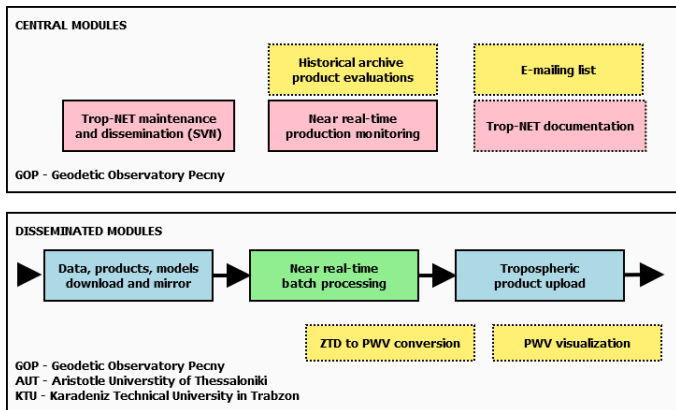
- Sofia University "St Kliment Ohridski" (SU) - GNSS tropospheric products
- Hail Suppression Agency (HSA) - product user



- SU GNSS stations - 3 Hitarget
- HSA GNSS stations - 9 Trimble

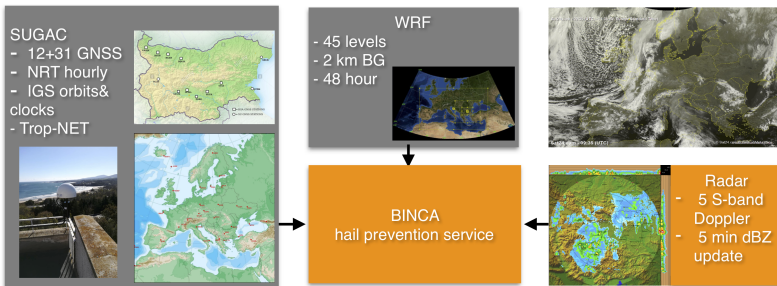


- SUGAC NRT processing - Trop-NET software⁸
- SUGAC post processing - Bernese 5.2



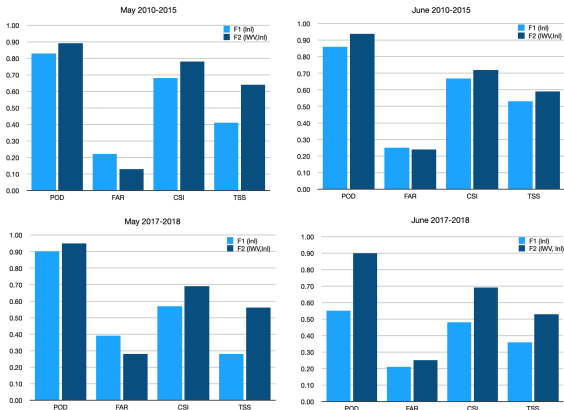
⁸collaboration with dr. Jan Dousa, GOP, Czech Republic

- GNSS tropospheric product (IWV and gradients) time series and maps integration with radar refractivity
- Requested 5 minute product up-date rate
- Weather Research and Forecasting (WRF) model 48 hour forecast
- Other products: e.g. cloud images MSG satellite

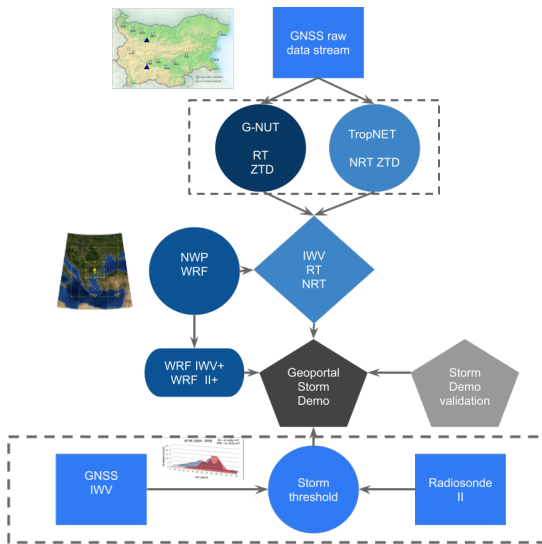


IWV and Instability Indices: May-June 2010-2015 vs 2017-2018¹⁰

- August F1 (InI) = $1.43 \cdot \text{SHI} - 0.34 \cdot \text{LI} + 0.03 \cdot \text{SWEAT} - 0.01 \cdot \text{K} + 0.77 \cdot \text{TT} - 40.92$
- August F2 (IWV,InI) = $0.28 \cdot \text{IWV} + 0.99 \cdot \text{TT} + 1.72 \cdot \text{SHI} + 0.03 \cdot \text{SWEAT} - 59.33$



GNSS storm nowcasting demonstrator (Storm Demo)¹¹



¹¹ funded by ESA AO/1-10327/2020/NL/CBi Invitation to Tender for the Sixth Call for Outline Proposals under the Plan for European Cooperating States (PECS) in Bulgaria

- hosted by Sofia University Atmospheric Data Archive
- public access with real-time and near-real time IWW update for operational use



- IWW below the storm threshold

- IWW above the storm threshold

- 22 BSc/MSc theses, 6 completed and 2 ongoing PhD theses,
- 20+ publications, 2 books, 100+ presentations

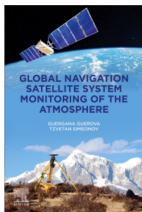


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Advanced GNSS Tropospheric Products for Monitoring Severe Weather Events and Climate

COST Action ES1206 Final Action Dissemination Report

Editors: **Jones, J., Guerova, G., Douša, J., Dick, G., de Haan, S., Pottiaux, E., Bock, O., Pacione, R., van Malderen, R.** (Eds.)



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1st Edition

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Thank you!



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