UNIWERSYTET PRZYRODNICZY WE WROCŁAWIU

GNSS tomography: technique resolving vertical structure of severe weather

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Severe Weather (1)

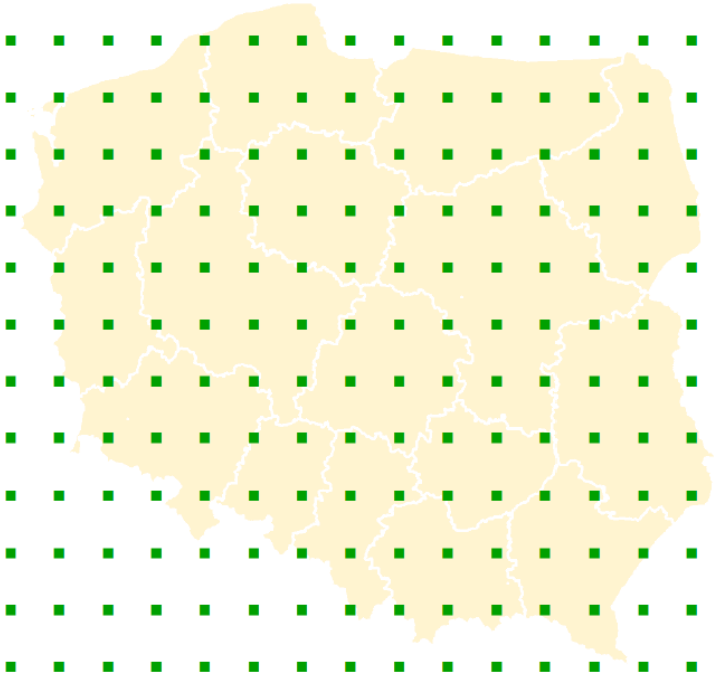
Two types of severe weather:

- Excessive rainfall due to cyclogenesis – example of *general severe weather* taking place at a larger area (Intense precipitation events (IPE))
- Intense convective storms – core type of severe weather (*localized severe weather, example: Mesoscale Convective System*)

What do they have in common?

- Rainfall totals are often many-fold larger than atmospheric PW prior to and during a precipitation event.
- Reason for that is the atmospheric convergence: synoptic scale or local respectively

Troposphere data (WRF model)



Model configuration:

- Two nested domains: 12 and 4km
- Initial and boundary conditions: GFS
- Convection explicitly resolved for d02
- Convection parameterized for d01
- Other options consisted between the domains
- Forecast updated every 6h

Troposphere data: GNSS observations

TOTAL NEUTRAL ATMOSPHERE DELAY

$$L_{atm}(\varepsilon,\alpha) = STD = 10^{-6}\int N\ ds$$

$$N = \underbrace{k_1\frac{P}{T_v}}_{N_{hydrostatic}} + \underbrace{k_2'\frac{e}{T} + k_3\frac{e}{T^2}}_{N_{wet}}$$

P : *pressure*

e : *partial pressure of water vapour*

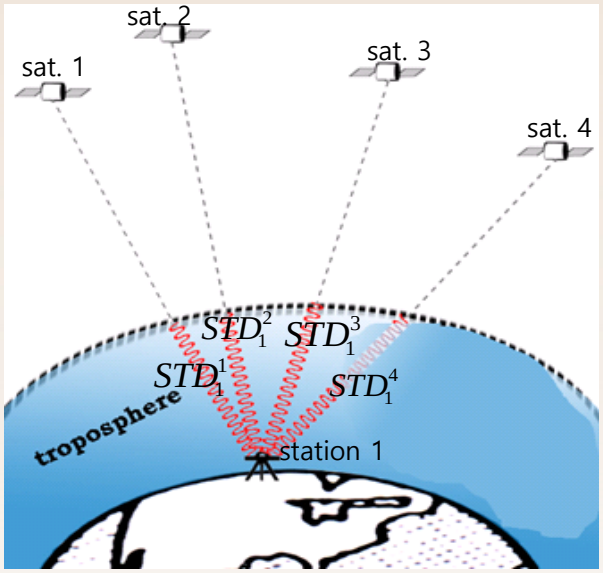
T_v : *virtual temperatur e*

$k_1 \approx 0.776 \quad K/Pa$

$k_2' \approx 0.221 \quad K/Pa$

$k_1 \approx 3739 \quad K^2/Pa$

$$T_v = \frac{T}{1-\frac{r}{P}(1-r)} \qquad r = \frac{R_d}{R_w} = \frac{M_w}{M_d} \approx 0.622$$

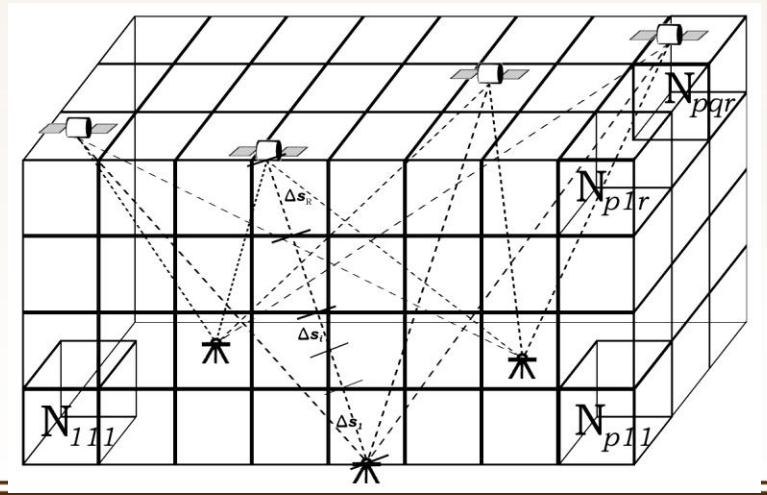


DELAY / WET REFRACTIVITY

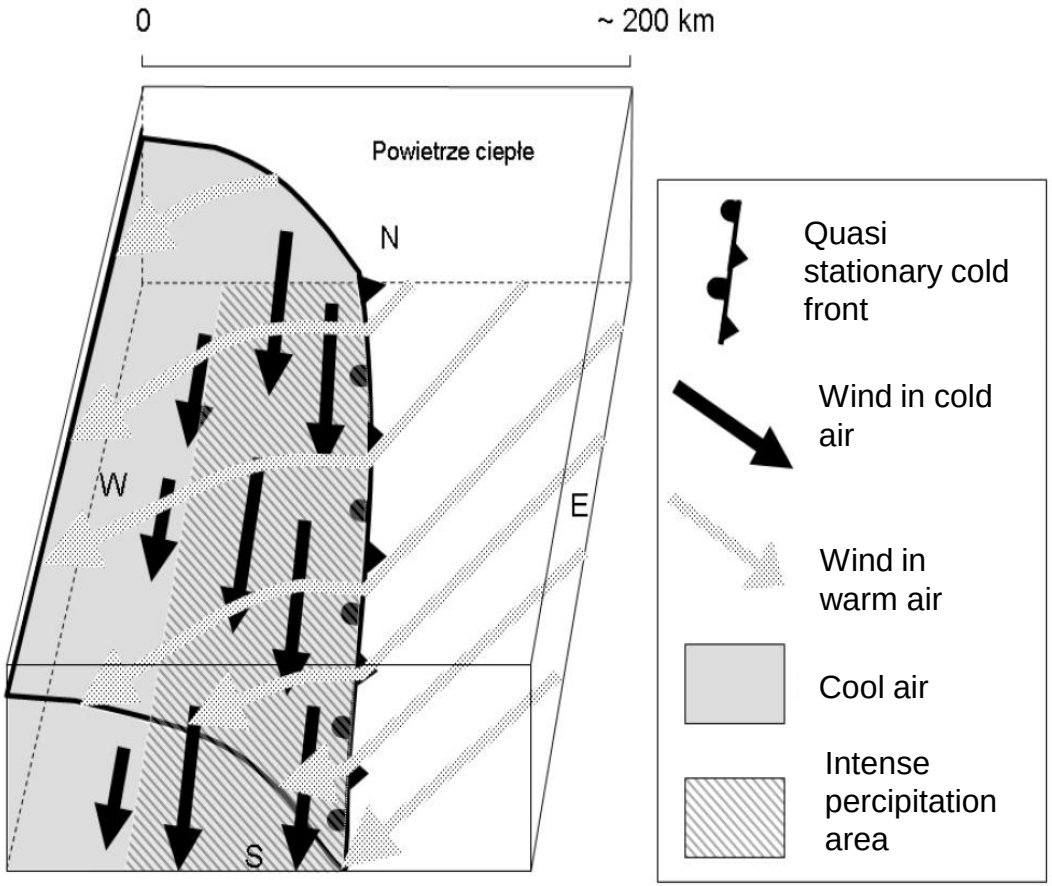
$$SWD = 10^{-6}\int N_{wet}\ ds = 10^{-6}\sum N_{wet}\ \Delta s$$

WATER VAPOUR CONTENT / DENSITY

$$SIWV = 10^{-6}\int \rho_{wv}\ ds = 10^{-6}\sum \rho_{wv}\ \Delta s$$

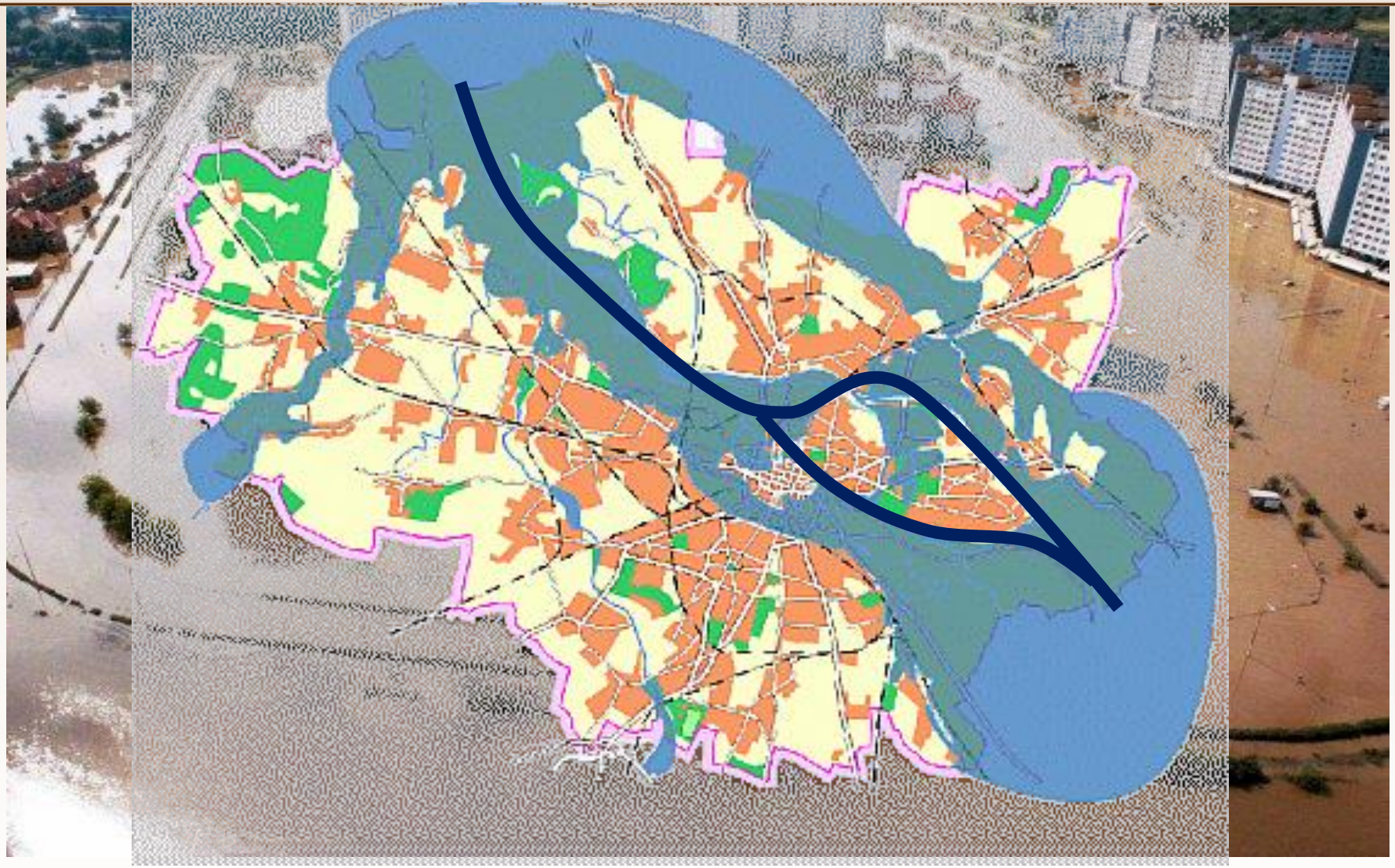


Intense precipitation events (IPE) (1)



- streamlines convergence – ascending motion of warm and humid air;
- slow motion or stagnation of the steering low pressure system;
- intensification of precipitation where low level airflow meets mountains

Intense precipitation events (IPE) (2)

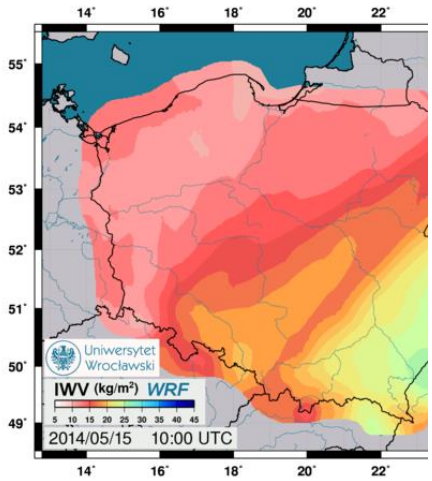


Precipitable water content in the troposphere (06 VII 1997)

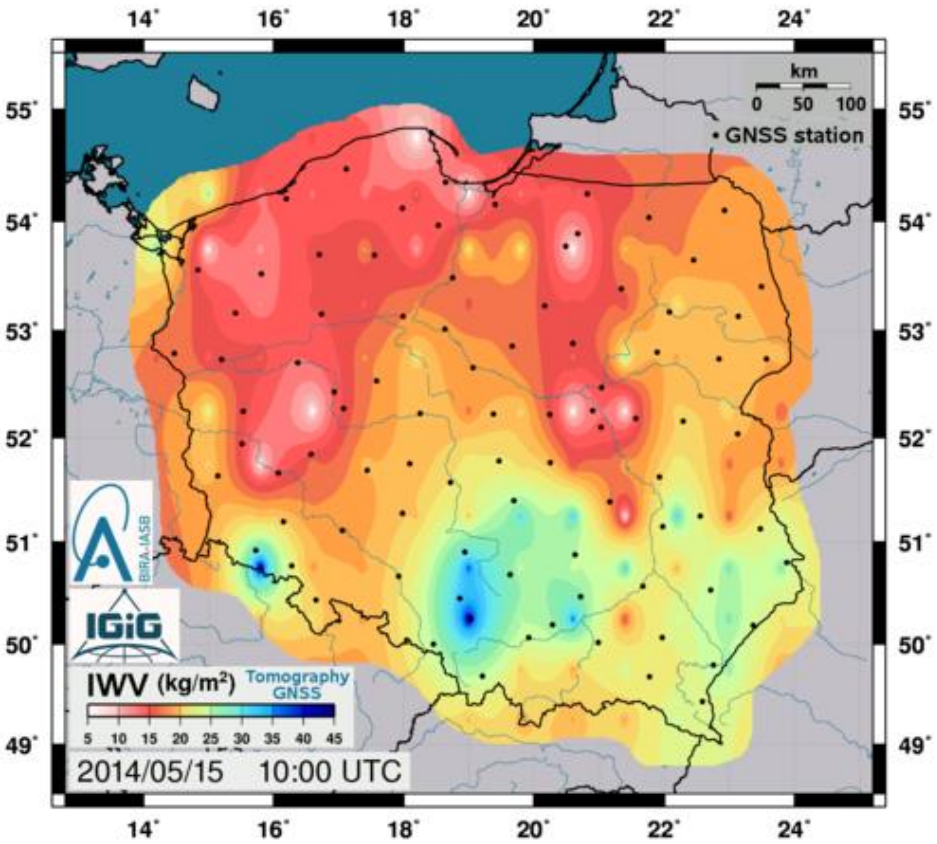
Source: wyborcza.pl; wroclawzwyboru.blox.pl

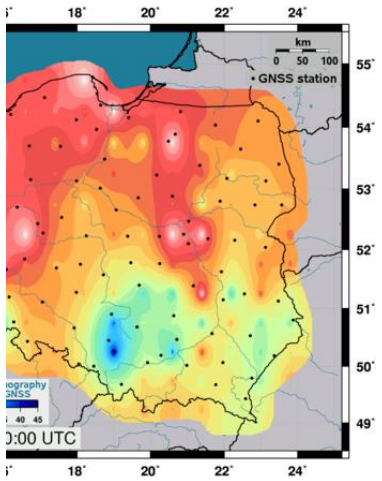
Intense precipitation events (IPE) (3)

13-15 May 2014 intensive rains driven by moist air from South-East, East



WRF





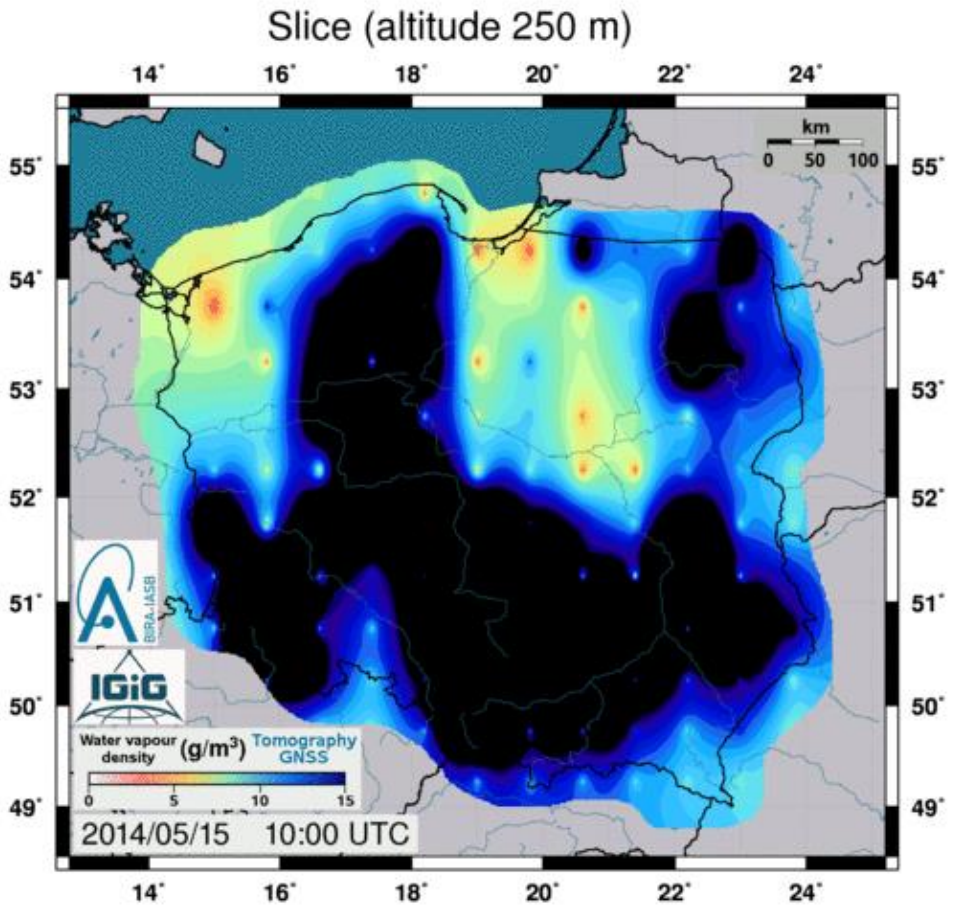
ISS TOMOGRAPHY

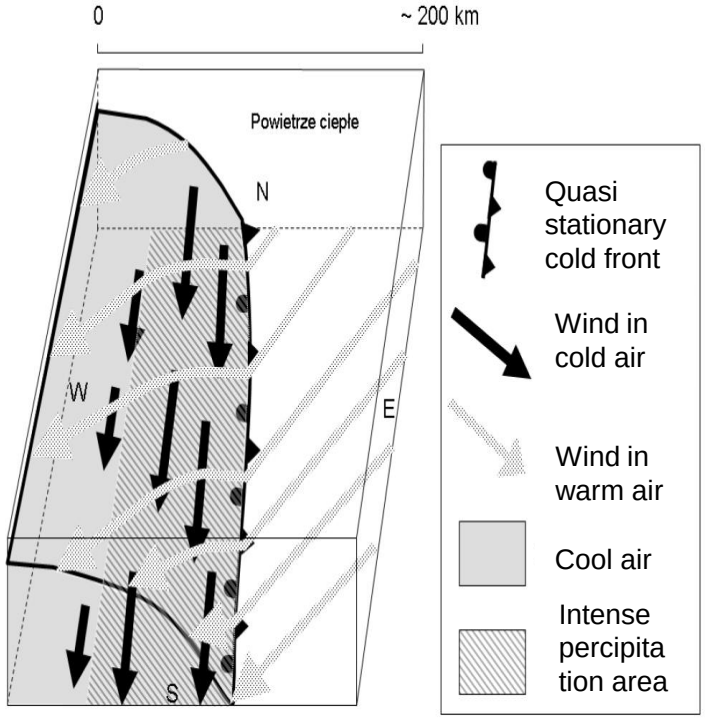
Also in our inventory:

- 11-13 July 2014 – intensive rain in South East Poland

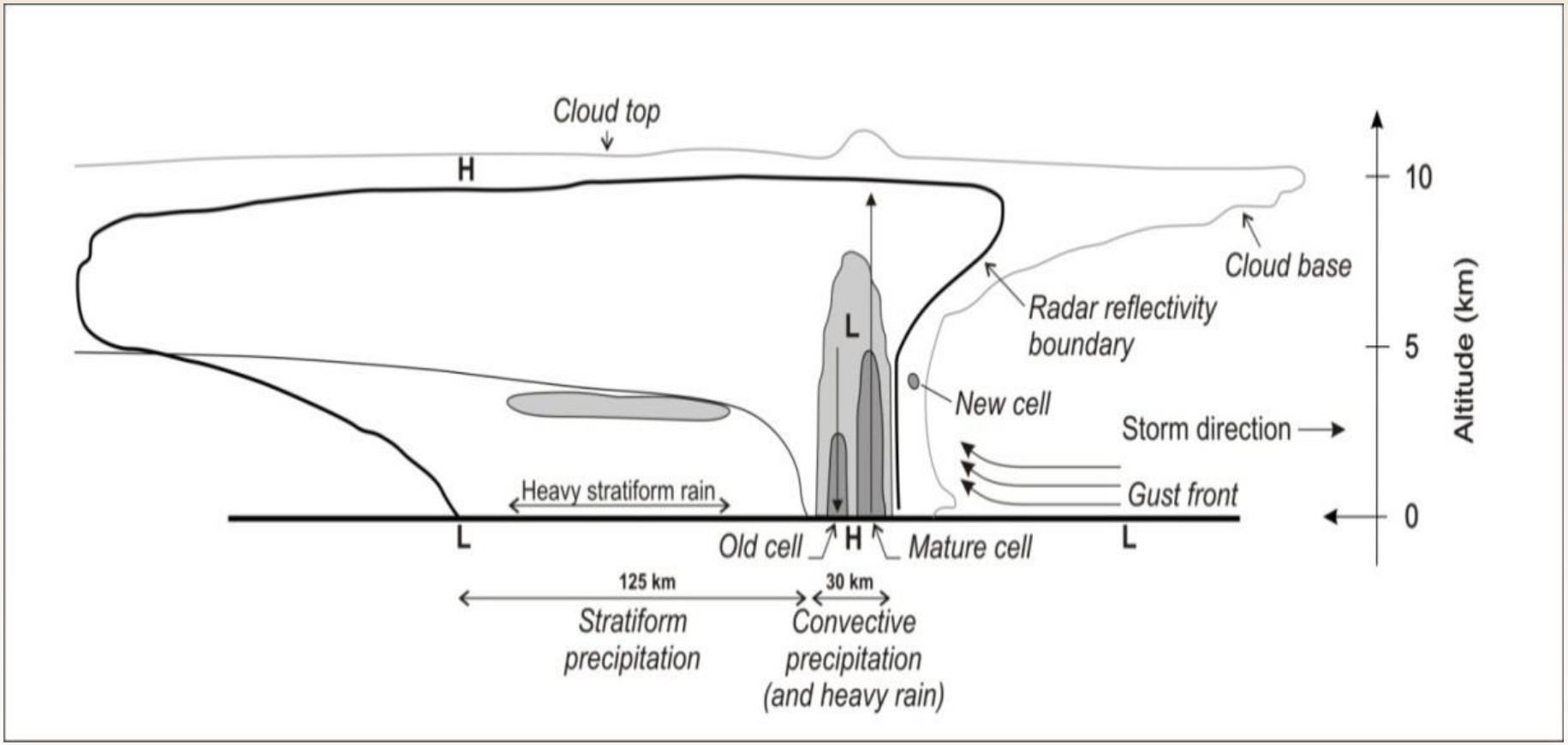
Vertical structure (IPE) (4)

13-15 May 2014 intensive rains driven by moist air from South-East, East



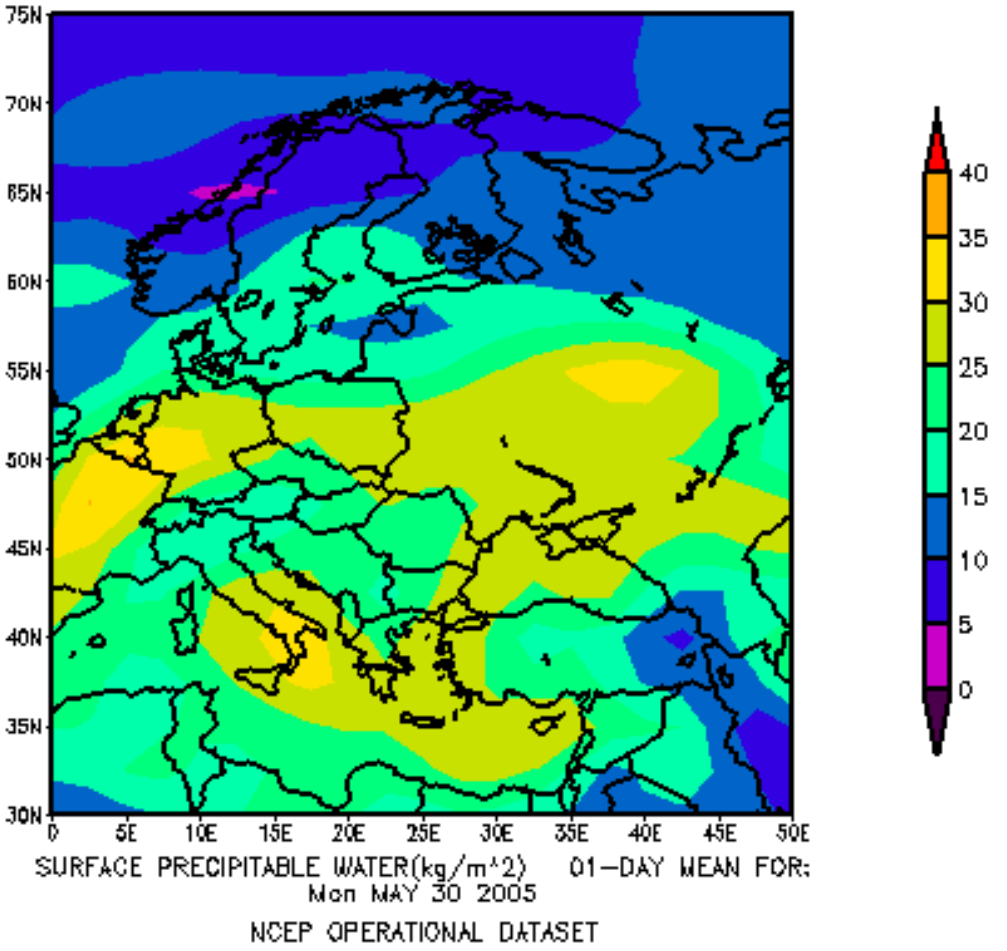


Intense convective storms (1)



Source: after Houze 2004

Intense convective storms (2)

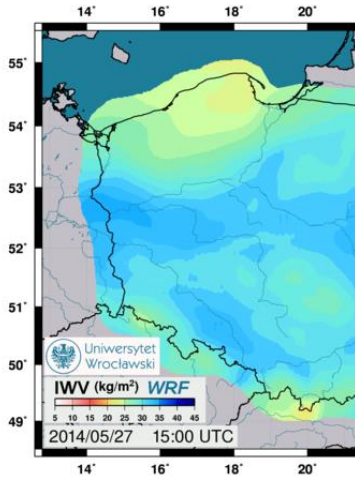


Mesoscale convective system in PL, 30 of May 2005:

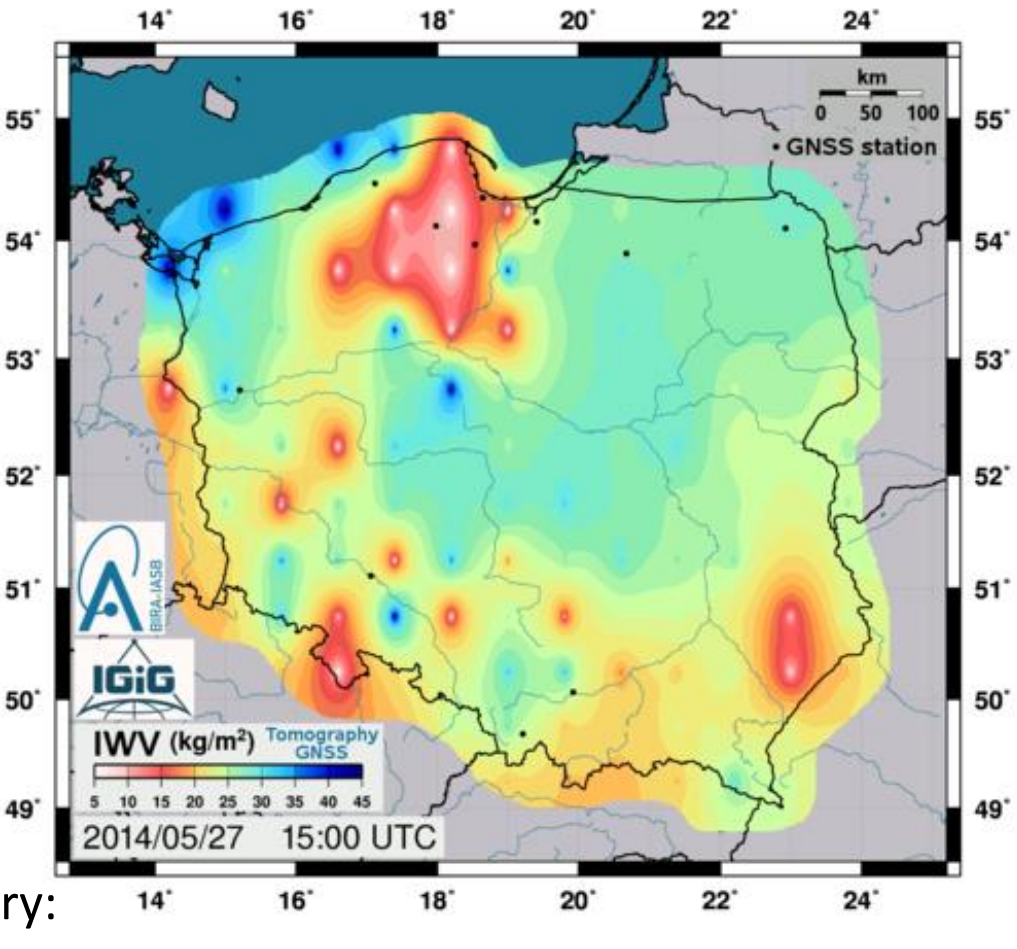
- The highest precipitation totals at the Sudetes Forefield or in the Sudetes;
- Weak horizontal pressure gradient;
- Typically cold front slow motion from W to E;
- Lack of clear dependence on altitude;
- Inhibition layer present.

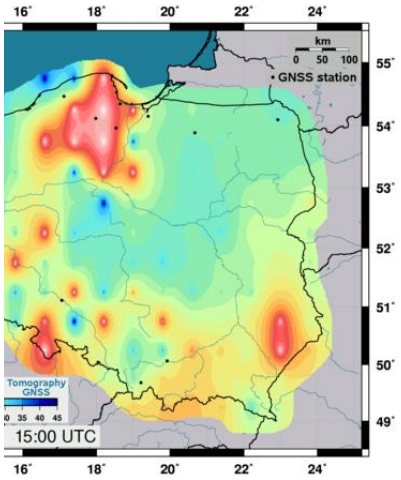
Intense convective storms (2)

27th of May 2014 intensive storm over South-West Poland



WRF





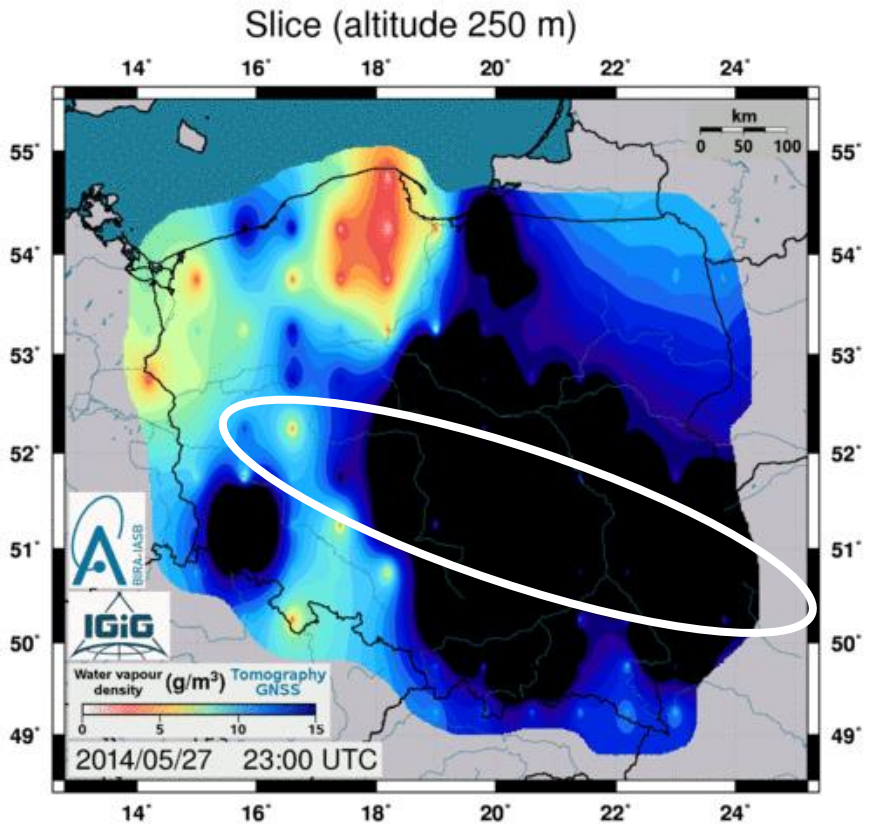
NSS TOMOGRAPHY

Also in our inventory:

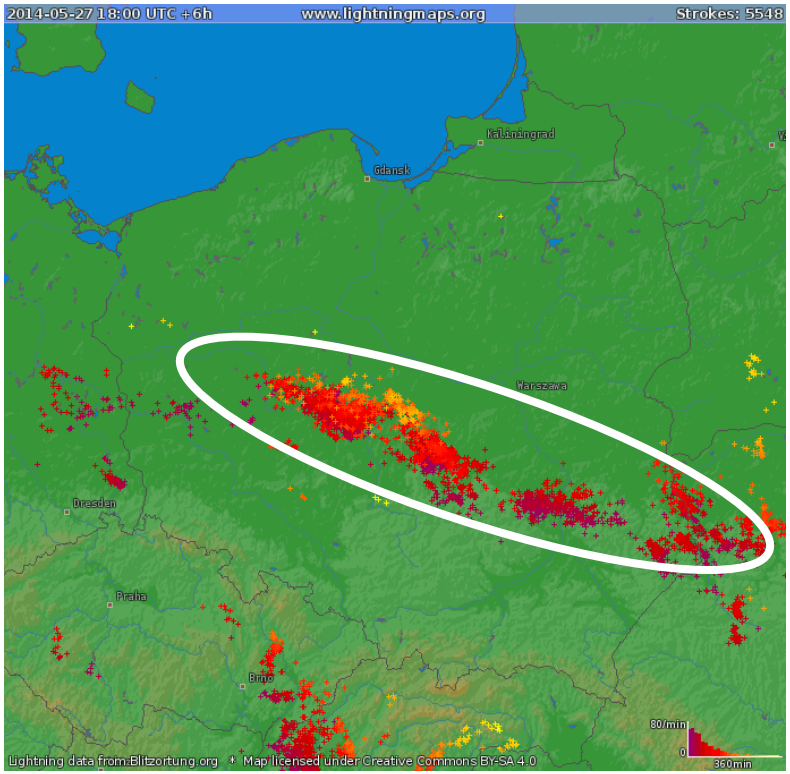
- 3rd of August 2014 – intensive storms

Intense convective storms (3)

27th of May 2014 intensive storm over South Poland



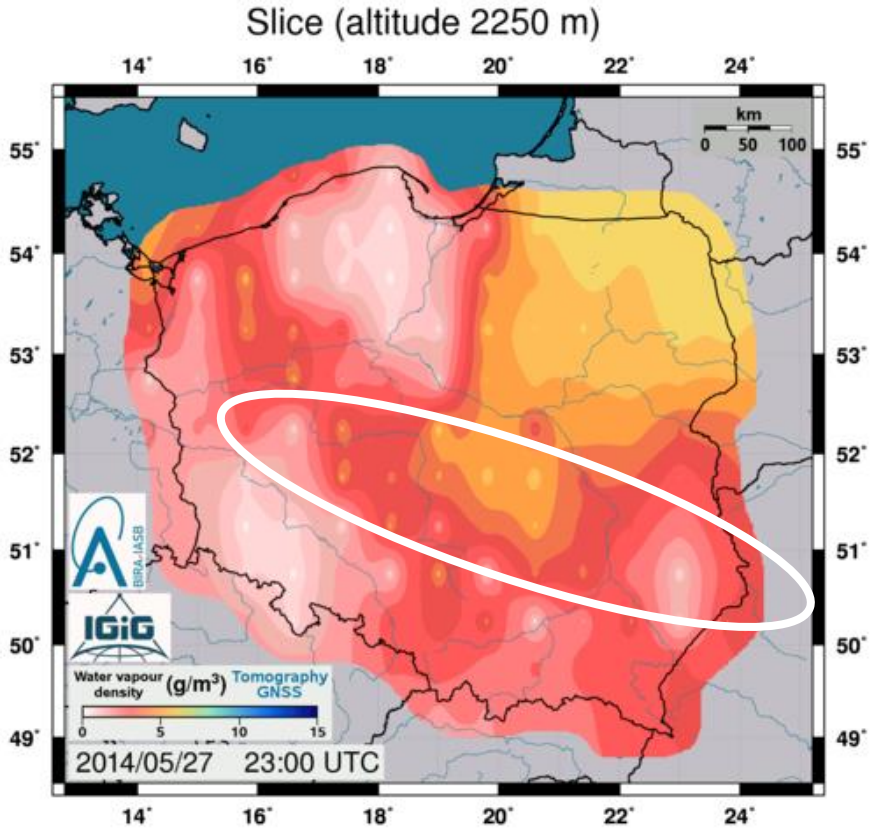
TOMOGRAPHY



LIGHTNING STRIKES

Intense convective storms (3)

27th of May 2014 intensive storm over South Poland



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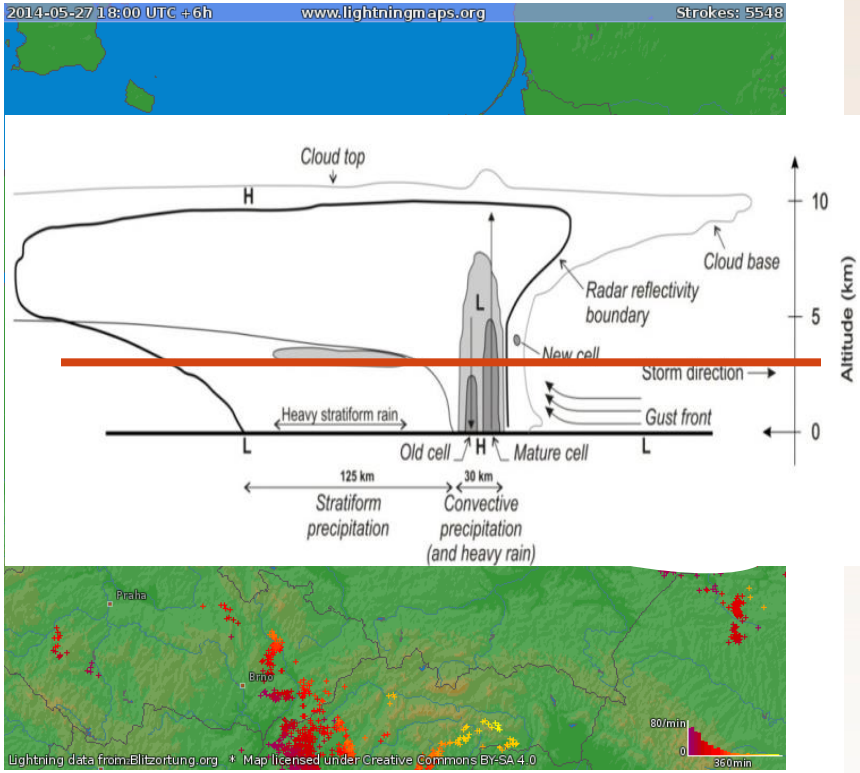
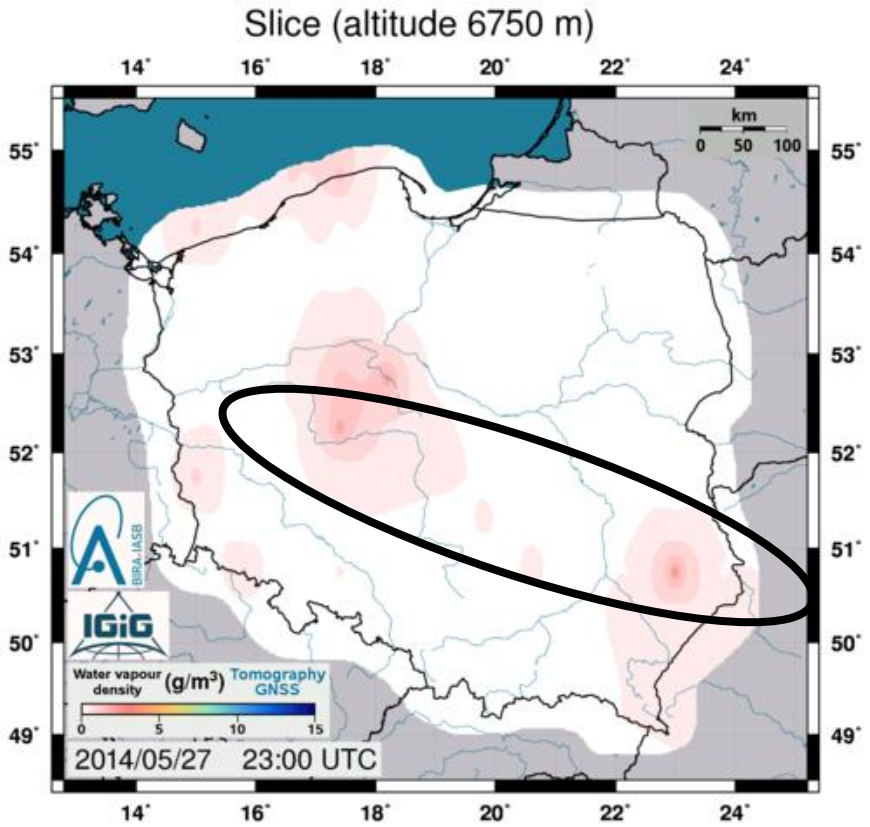


LIGHTNING STRIKES

Intense convective storms (3)

27th of May 2014 intensive storm over South Poland



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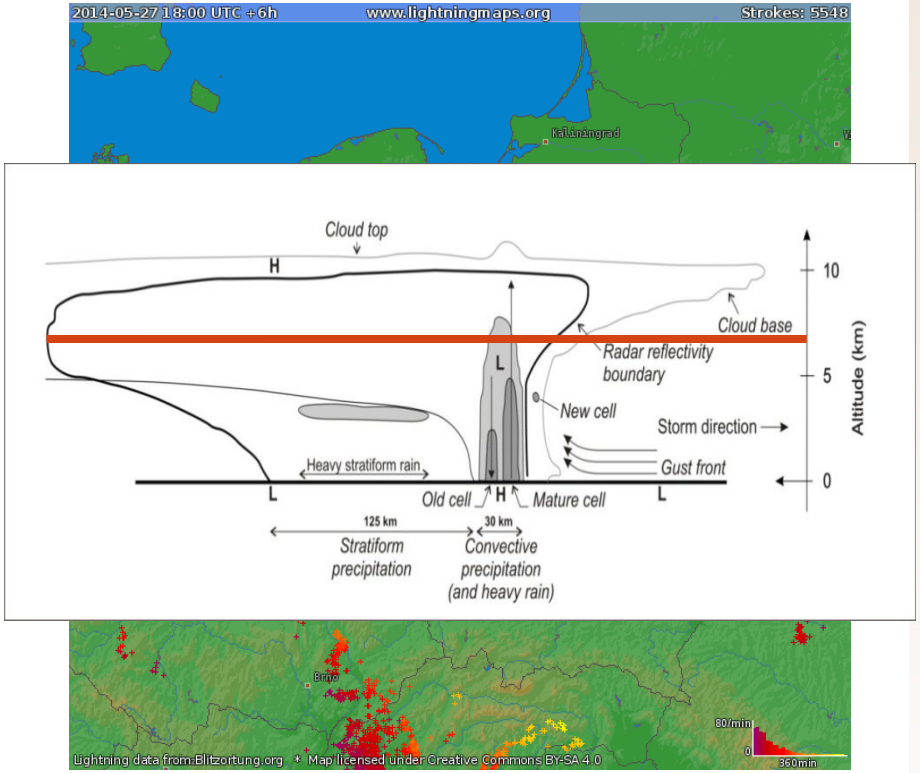
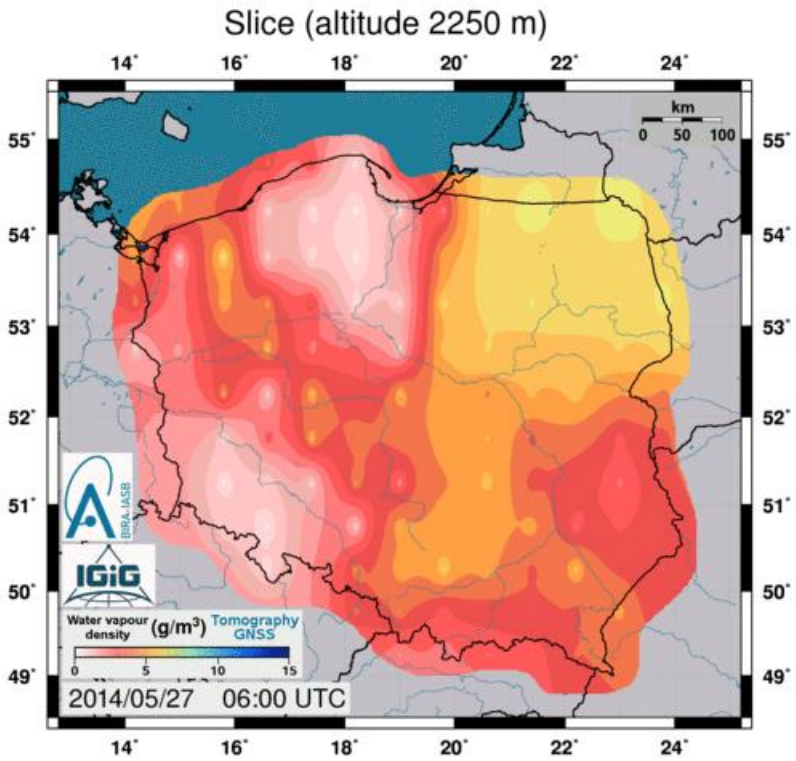


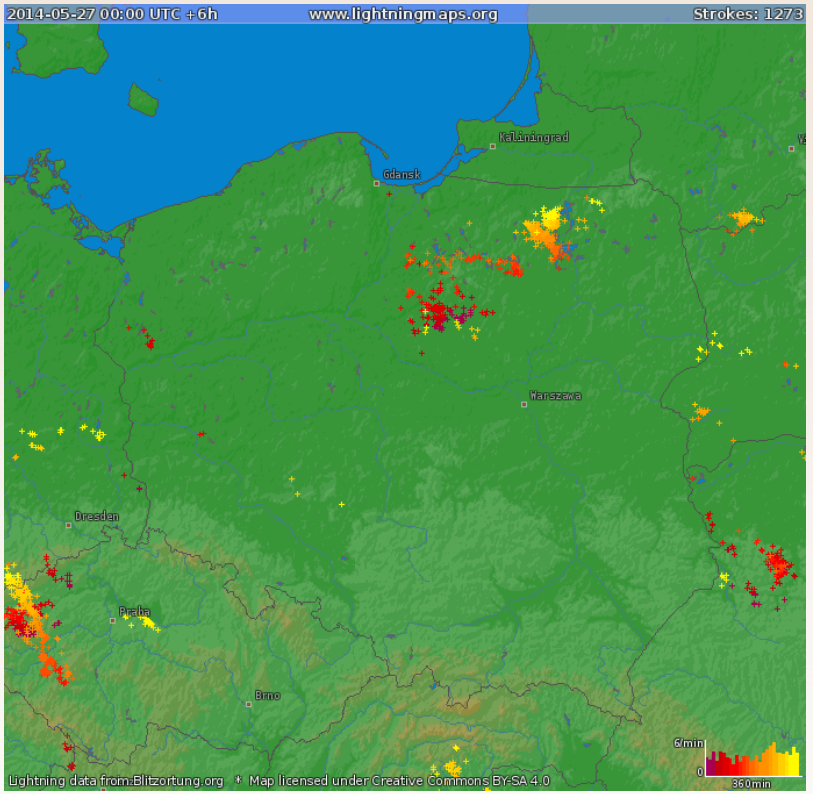
LIGHTNING STRIKES

Water vapour field evolution (4)

TOMOGRAPHY WV FIELD



LIGHTNING STRIKES



Tomography repository

Nowcasting
Collection of 5 case studies selected by meteorologists (3 intesive storms, 2 intensive rains), ZTDs, SWDs, SIWVs, NWPs, RSs, retrievals TOMOlab: -> apriori -> data -> image -> radiosonde -> retrievals host: geo2.igig.up.wroc.pl user: IAGtomographyWG Password: waiting for your e-mail

GNSS tomography

- Data in agreement with general atmospheric circulation
- PW or IWV of interest as the wet refractivites might not be so obvious for interpretation
- „Integrated” tomography image is appealing
- Eventhough the absolute value of IWV/PW might not be correct the variability of this parameter should provide important information of the severe weather onset

Thank you!

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http://www.igig.up.wroc.pl/igg/

TOMO2