



# Progress and plans in MF's ARPEGE and AROME suites, with a focus on horizontal resolution increase and new model outputs

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*3 October 2019*

*41st EWGLAM and 26th SRNWP Meeting, Sofia, Bulgaria*



# A few general words about landmark changes

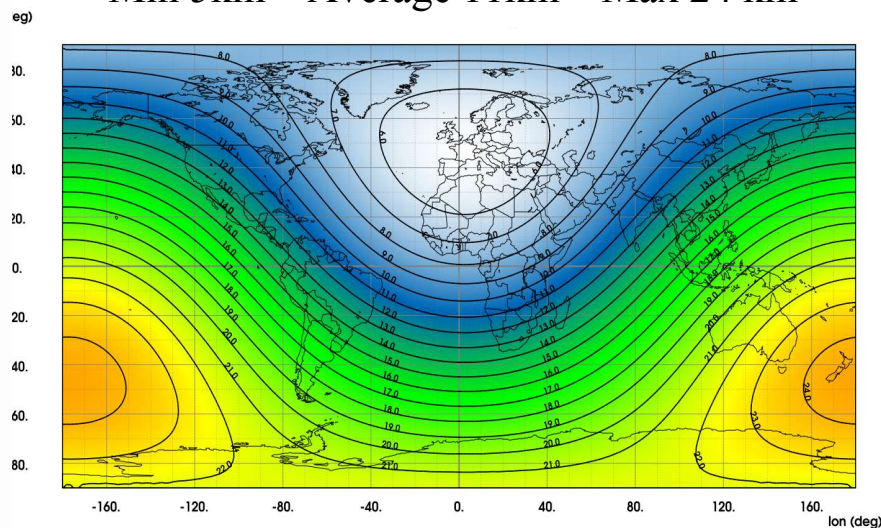
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- Operational since 2 July 2019
- All NWP systems are concerned : Arpège (incl very short cutoff and FABEC), Arpège EDA (AEARP), Arpège EPS (PEARP), Arome-France, Arome-PI (NWC), Arome-IFS, AEARO, PEARO, Arome-OM (Overseas), Arome-assistances, Arome-commerciaux, ALADIN partners coupling file production
- Based on **CY43T2** (RTTOV11 & Surfex v8.0)
- **Higher horizontal resolution for deterministic Arpege, the global EDA (AEARP), the global EPS (PEARP)**
- Increased number of members in AEARP, PEARO
- VORTEX-based scripting now operational for Arpege/AEARP and Arome-France
- Migration to GRIB2 (for all post-processing output files, as well as for global historical files)
- Many new outputs : new BDAP domains, **needs of aviation/forecasting/automated products**, rationalisation, ...

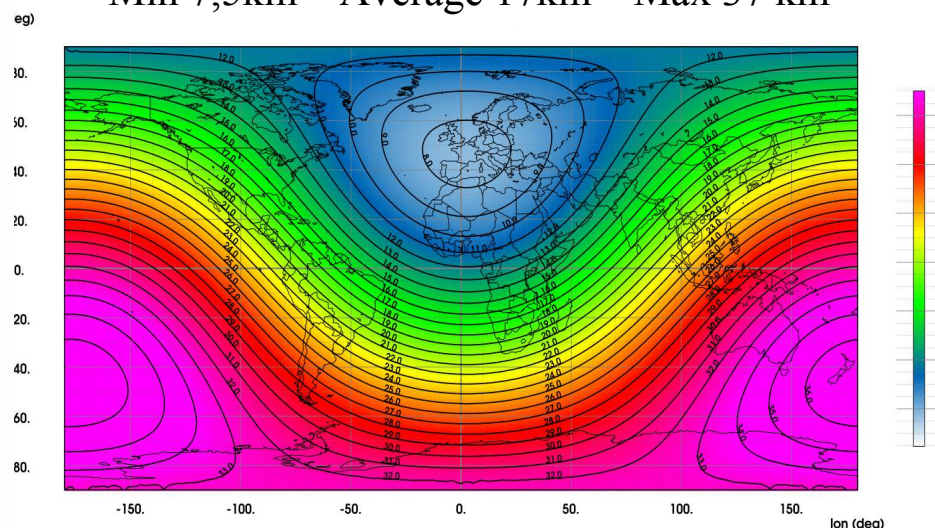
# New versions of Arpege, AEARP, PEARP

|                                | Former operational                                                                                                               | New CY43T2                                                                                                                       |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Arpege<br><i>deterministic</i> | <b>TI1198c2.2 L105 (7.5km over France)</b><br>4DVar (6h cycle): <b>TI149c1L105 &amp; TI399c1L105</b>                             | <b>TI1798c2.2 L105 (5km over France)</b><br>4DVar (6h cycle): <b>TI224c1L105 &amp; TI499c1L105</b>                               |
| AEARP<br><i>(Arpege EDA)</i>   | <b>TI479c1 L105 ; 25 members</b><br>4D-Var (6h cycle): <b>TI149c1 L105</b><br>Forecast error covariances <b>sampled over 36h</b> | <b>TI499c1 L105 ; 50 members</b><br>4D-Var (6h cycle): <b>TI224c1 L105</b><br>Forecast error covariances <b>sampled over 12h</b> |
| PEARP<br><i>(Arpege EPS)</i>   | <b>TI798c2.4 L90 (10km over France)</b><br>Initialisation from <b>25 members of AEARP</b>                                        | <b>TI1198c2.2 L90 (7.5km over France)</b><br>Initialisation from <b>35 members of AEARP</b>                                      |

ARPEGE horizontal resolution  
Min 5km – Average 11km – Max 24 km



PEARP horizontal resolution  
Min 7,5km – Average 17km – Max 37 km



# Evaluation Arpège

## Test du bootstrap sur les REQM ARPEGE Double PAD par rapport à ARPEGE Opér. PA

### Domaine EUROPE (entre 154 et 155 cas)

|                      | Réf.    | Radiosondages          | Analyses CEP            | SYNOPS                    |
|----------------------|---------|------------------------|-------------------------|---------------------------|
|                      | Grille  | GLOB025                | GLOB05                  | EURAT01                   |
|                      | Éch.    | 0H à 96H<br>pas de 12H | 0H à 102H<br>pas de 6H  | 0H à 102H<br>pas de 6H    |
| Géopotentiel         | 100hPa  | ▲ = ▼ ▼ ▼ ▼ ▼ = = =    | ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼ = = = = |                           |
|                      | 500hPa  | = = ▲ = = = =          | ▼ ▼ ▼ = = ▲             |                           |
|                      | 850hPa  | ▲ ▲ = = = =            | ▼ ▼ ▲ ▲ = ▲ = =         |                           |
|                      | 1000hPa | = ▲ = ▲ = =            | ▼ ▼ ▲ ▲ ▲ = ▲ =         |                           |
| Pression             | Mer     |                        |                         | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲           |
| Température          | 100hPa  | ▼ ▼ ▼ ▼ ▼ ▼            | ▲ ▲ ▼ = ▼ ▼ = ▼ = =     |                           |
|                      | 500hPa  | = = ▲ = = =            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |                           |
|                      | 850hPa  | ▲ ▲ ▲ ▲ ▲ ▲            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |                           |
|                      | 1000hPa | = = ▲ = ▲ = ▲          | ▲ ▲ = = = = = =         |                           |
| Température corrigée | 2m      |                        |                         | = ▲ = ▲ ▲ = ▲ ▲ = ▲ ▲     |
| Vent                 | 250hPa  | = = ▲ ▲ = ▲            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |                           |
|                      | 500hPa  | = ▲ ▲ ▲ ▲              | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |                           |
|                      | 850hPa  | ▲ ▲ ▲ ▲ ▲              | ▲ ▲ ▲ ▲ ▲ ▲ = =         |                           |
| FF                   | 10m     |                        |                         | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲           |
| Humidité             | 400hPa  | ▲ = = ▲ = = =          | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |                           |
|                      | 700hPa  | = ▲ ▲ ▲ ▲ ▲            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |                           |
|                      | 850hPa  | = ▲ ▲ ▲ ▲ ▲            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |                           |
|                      | 2m      |                        |                         | ▲ ▲ ▼ ▲ ▲ ▼ = ▲ ▼ = ▲ ▼ = |

### Domaine NORD20 (155 cas)

|              | Réf.    | Radiosondages          | Analyses CEP           |
|--------------|---------|------------------------|------------------------|
|              | Grille  | GLOB025                | GLOB05                 |
|              | Éch.    | 0H à 96H<br>pas de 12H | 0H à 102H<br>pas de 6H |
| Géopotentiel | 100hPa  | ▲ ▲ ▲ = = ▲ = ▲        | ▲ = = = = = = = =      |
|              | 500hPa  | ▲ ▲ ▲ ▲ ▲ ▲ ▲          | ▼ = ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲    |
|              | 850hPa  | ▲ = = ▲ ▲ ▲ ▲          | ▲ = = ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲  |
|              | 1000hPa | ▲ = = ▲ ▲ ▲ ▲          | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
| Température  | 100hPa  | = ▼ ▼ ▼ ▼ ▼ ▼ ▼        | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|              | 500hPa  | ▲ ▲ ▲ ▲ ▲ ▲ ▲          | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|              | 850hPa  | ▲ ▲ ▲ ▲ ▲ ▲ ▲          | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|              | 1000hPa | ▲ = = = = = =          | ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼    |
| Vent         | 250hPa  | ▲ ▲ ▲ ▲ ▲ ▲            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|              | 500hPa  | ▲ ▲ ▲ ▲ ▲ ▲            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|              | 850hPa  | ▲ ▲ ▲ ▲ ▲ ▲            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
| Humidité     | 400hPa  | = ▲ = ▲ ▲ = =          | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|              | 700hPa  | = ▲ ▲ ▲ ▲ ▲            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|              | 850hPa  | ▲ ▲ ▲ ▲ ▲ ▲            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |

### Période de validité du 20190124 au 20190702

La signification des symboles utilisés dans les tableaux ci-après est :

- ▲ : le double est significativement meilleur que l'opérationnel avec 99,5% de confiance;
- : significatif à 95%;
- = : pas de signal significatif au seuil 95% ;
- ▼ : le double est significativement moins bon que l'opérationnel au seuil 95% ;
- ▼ : significatif à 99,5% ;
- : donnée manquante

### Domaine SUD20 (155 cas)

|              | Réf.    | Radiosondages          | Analyses CEP            |
|--------------|---------|------------------------|-------------------------|
|              | Grille  | GLOB025                | GLOB05                  |
|              | Éch.    | 0H à 96H<br>pas de 12H | 0H à 102H<br>pas de 6H  |
| Géopotentiel | 100hPa  | ▼ ▲ = ▲ ▲ ▲ ▲ ▲        | ▲ ▲ = = = ▲ ▲ ▲ ▲ ▲ ▲   |
|              | 500hPa  | ▼ ▲ = ▲ ▲ ▲ ▲ ▲        | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |
|              | 850hPa  | ▼ ▲ = = = ▲ ▲ ▲        | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |
|              | 1000hPa | ▼ = = = ▲ ▲ ▲          | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |
| Température  | 100hPa  | ▲ = = = = = =          | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |
|              | 500hPa  | = ▲ ▲ ▲ = = =          | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |
|              | 850hPa  | = ▲ ▲ ▲ = ▲ =          | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |
|              | 1000hPa | ▲ ▲ ▲ ▲ ▲ ▲            | = = = = = = = =         |
| Vent         | 250hPa  | ▼ ▲ ▲ ▲ ▲ =            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |
|              | 500hPa  | ▼ ▲ ▲ ▲ ▲ =            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |
|              | 850hPa  | = = ▲ = ▲ ▲            | ▲ ▲ = ▲ ▲ ▲ ▲ ▲         |
| Humidité     | 400hPa  | = = = = = =            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |
|              | 700hPa  | ▼ ▲ = ▲ = = =          | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲         |
|              | 850hPa  | ■ = ▲ = = =            | ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼ = = = = |

### Domaine TROPIQ (155 cas)

|             | Réf.    | Radiosondages          | Analyses CEP           |
|-------------|---------|------------------------|------------------------|
|             | Grille  | GLOB025                | GLOB05                 |
|             | Éch.    | 0H à 96H<br>pas de 12H | 0H à 102H<br>pas de 6H |
| Température | 100hPa  | = = = = = =            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|             | 500hPa  | = = = = = ▲            | ▲ ▲ = = = = = =        |
|             | 850hPa  | ▲ = = = = =            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|             | 1000hPa | ■ = = = ▲ =            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
| Vent        | 250hPa  | ▲ = = ▲ ▲ ▲            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|             | 500hPa  | ▲ ▲ ▲ ▲ ▲              | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|             | 850hPa  | ▲ ▲ ▲ ▲ ▲              | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
| Humidité    | 400hPa  | ▲ ▲ ▲ ▲ ▲              | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|             | 700hPa  | = ▲ ▲ = = =            | ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲        |
|             | 850hPa  | ■ = = = = =            | = = = = ▼ = = = = =    |

# Evaluation Arome-France

Test du bootstrap sur les REQM  
AROME Double par rapport à AROME Opér.

Période de validité du 20190124 au 20190701

La signification des symboles utilisés dans les tableaux ci-après est :

- ▲ : le double est significativement meilleur que l'opérationnel avec 99,5% de confiance;
- : significatif à 95%;
- = : pas de signal significatif au seuil 95% ;
- ▼ : le double est significativement moins bon que l'opérationnel au seuil 95% ;
- ▼ : significatif à 99.5% ;
- : donnée manquante

## Domaine FRANGP (entre 152 et 156 cas)

|                      | Réf.    | Radiosondages          | Propres analyses      | Analyses CEP          | SYNOPS                |
|----------------------|---------|------------------------|-----------------------|-----------------------|-----------------------|
|                      | Grille  | EURW1S40               | EURW1S40              | FRANGP05              | EURW1S40              |
|                      | Éch.    | 0H à 48H<br>pas de 12H | 0H à 48H<br>pas de 6H | 0H à 48H<br>pas de 6H | 0H à 48H<br>pas de 6H |
| Géopotentiel         | 100hPa  | = ■ ▼ ■ ■              | ▲▲▲▲▲▲▲▲              | ▼▼▼▼▼▼▼ =             |                       |
|                      | 500hPa  | = = = ▲ ■              | ▲▲▲▲▲▲▲▲              | ▼▼▼▼▼▼▼ = =           |                       |
|                      | 850hPa  | ▲ ▲ ▲ ▲ ▲              | ▲▲▲▲▲▲▲▲              | ▼▼ = = = ▼ ■ =        |                       |
|                      | 1000hPa | = ▲ ▲ ▲ ▲ ▲            | ▲▲▲▲▲▲▲▲              | ▼▼ = = = ▼ ■ =        |                       |
| Pression             | Mer     |                        |                       |                       | ■▲▲▲▲▲▲▲▲             |
| Température          | 100hPa  | = = = ■ ▼              | ▲▲▲▲▲▲▲▲              | =▲▲ = = ▼ = ▼▼        |                       |
|                      | 500hPa  | = ▲ ▲ ▲ ▲              | ▲▲▲▲▲▲▲▲              | =▲▲▲▲▲▲▲▲             |                       |
|                      | 850hPa  | = = = = ■              | ▲▲▲▲▲▲▲▲              | = = ■ ▼ = = = =       |                       |
|                      | 1000hPa | = = = = =              | ▲▲▲▲▲▲▲▲              | = ▼ = = = = ■ =       |                       |
| Température corrigée | 2m      |                        |                       |                       | ▲▲▲▲▲▲▲▲▲             |
| Vent                 | 250hPa  | = ■ ▲ ▲ ▲              | ▲▲▲▲▲▲▲▲              | ■▲▲▲▲▲▲▲▲             |                       |
|                      | 500hPa  | = ▲ ▲ ▲ ▲              | ▲▲▲▲▲▲▲▲              | ▲▲▲▲▲▲▲▲▲             |                       |
|                      | 850hPa  | = ■ = = ▲              | ▲▲▲▲▲▲▲▲              | = ■ ■ ▲▲▲▲▲           |                       |
| FF                   | 10m     |                        |                       |                       | ▼▼▲ = = = ■ =         |
| Humidité             | 400hPa  | ▲ = ▲ ■ ■              | ▲▲▲▲▲▲▲▲              | ▲▲▲▲▲▲▲▲▲             |                       |
|                      | 700hPa  | ▲ = ■ ▲ ■              | ▲▲▲▲▲▲▲▲              | ▲▲▲▲▲▲▲▲▲             |                       |
|                      | 850hPa  | = ■ = ■ ▲              | ▲▲▲▲▲▲▲▲              | ▲▲▲▲▲▲▲▲▲             |                       |
|                      | 2m      |                        |                       |                       | ▲▲▲▲▲▲▲▲▲             |

## CY43T2 other contributions

- Model tunings: tuning of convection scheme in ARPEGE; improved version of AROME microphysics scheme etc.
- Assimilation: VarBC for GNSS observations; assimilation of more IASI channels over land; inter-channels observation error correlation for IASI and CRIS; new channels assimilated for geostationary CSR
- Monitoring of new observations :
  - *GPSRO : GNOS/FY3-C, ROSA/MEGHA-T*
  - *Microwave : AMSR2/GCOM-W1, MWRI/FY3-C, ATOVS, ATMS, MWHS-2 Flux DbNet, AMSUA et MHS on METOP-C, ATMS on NOAA20*
  - *Scatterometer : OSCAT sur ScatSat-1*
  - *AMV wind : Goes-16, Goes-17, Metop-C*
  - *Doppler winds and radar reflectivities (European radars)*
- **News diagnostics: visibility, type of precipitations, ...**

# New model outputs

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*3 October 2019*

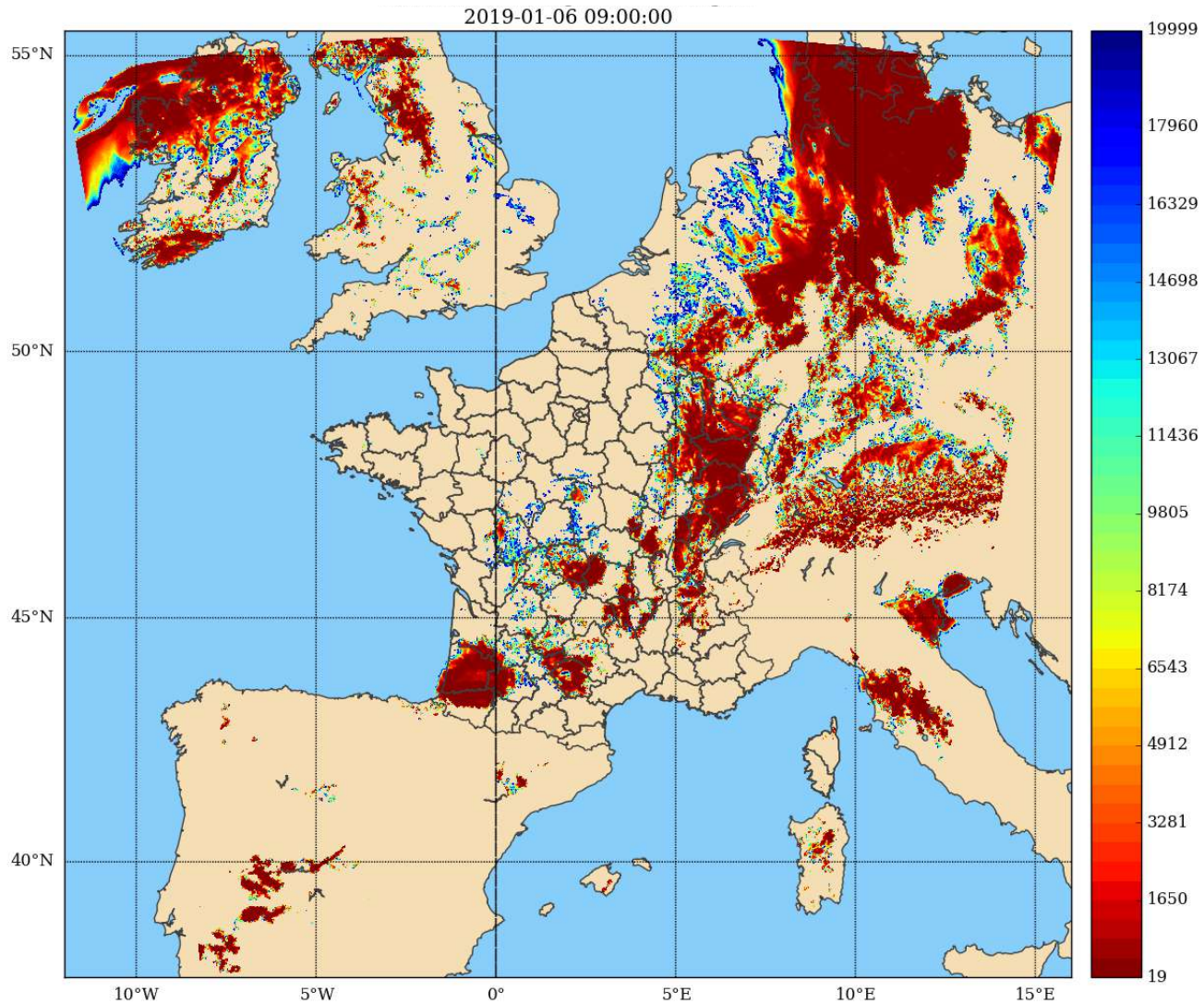
*41st EWGLAM and 26th SRNWP Meeting, Sofia, Bulgaria*

# Visibility diagnostic

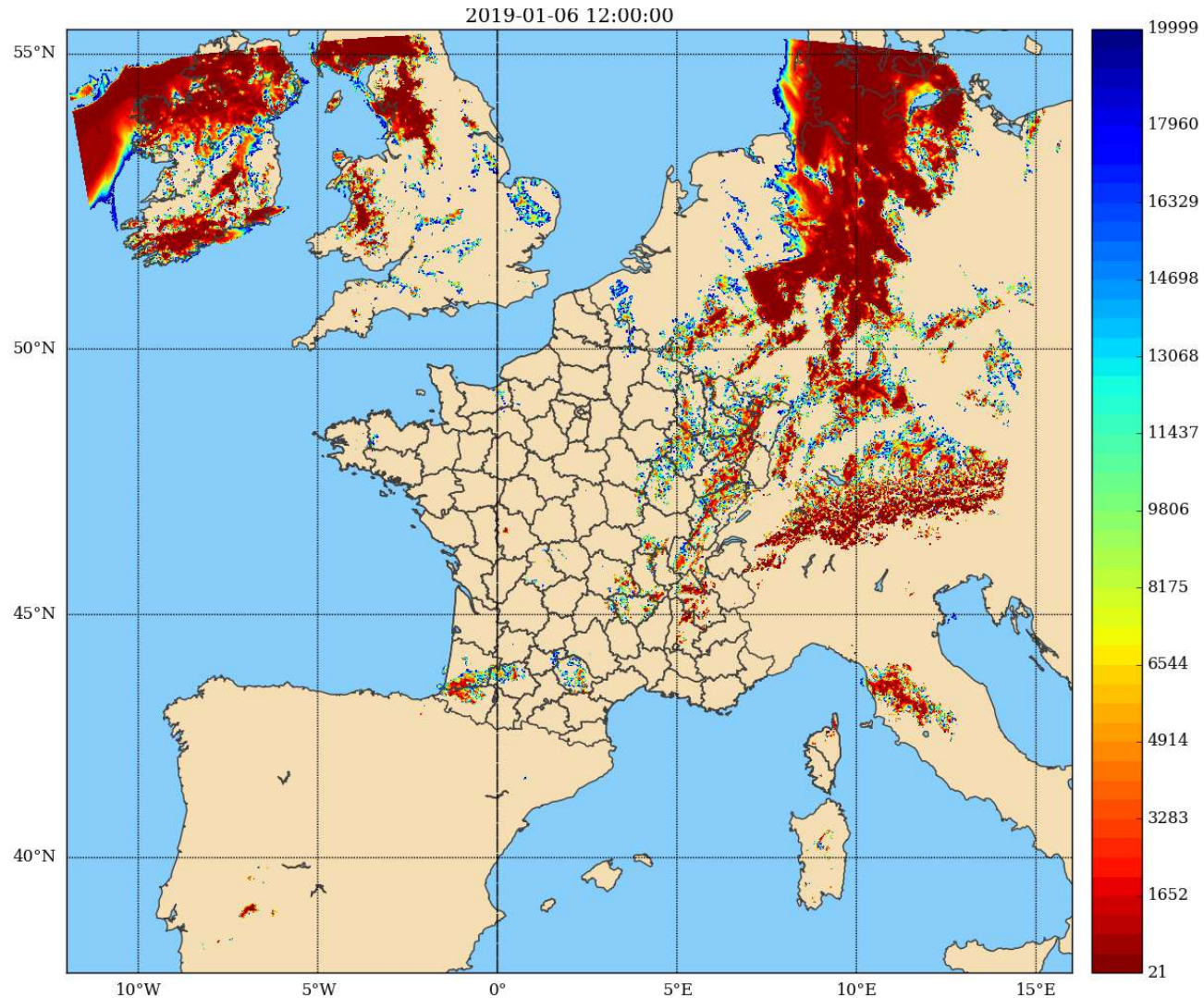
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- **Visibility** =  $-\ln \varepsilon / \beta$  (Koschmieder, 1924)  
where  $\varepsilon$  is the contrast threshold (0.05 OMM, OACI and CIE),  $\beta$  extinction coefficient
- **Visi<sub>Cld</sub>** =  $-\ln(0.05) / (\beta_{cld} + \beta_{ice})$   
 $\beta_{cld} = a \cdot C^b \cdot \exp(c \cdot (\log C)^2) \cdot \exp(d \cdot (\log C)^3)$  ( $C$  = cloud liquid water content [g m<sup>-3</sup>])  
(Olivier Mestre, Ingrid Etchevers)  
 $\beta_{ice} = 163.9 C^{(1.0)}$  ( $C$  = cloud ice water content [g m<sup>-3</sup>]) after (Stoelinga, 1999)
- **Visi<sub>Hydro</sub>** =  $-\ln(0.05) / (\beta_{rain} + \beta_{snow} + \beta_{graupel})$   
 $\beta_{rain} = 2.5 C^{(0.75)}$  ( $C$  = rain water content [g m<sup>-3</sup>])  
after (Niemelä, 2014), FMI  
 $\beta_{snow} = 10.4 C^{(0.78)}$  ( $C$  = snow content [g m<sup>-3</sup>])  
after (Stoelinga, 1999)  
 $\beta_{graupel} = 2.4 C^{(0.78)}$  ( $C$  = graupel content [g m<sup>-3</sup>])  
after (Niemelä, 2014), FMI
- No aerosol in the above formulas, because climatological aerosols in ARPEGE / AROME. Ongoing effort towards prognostic aerosols (Mohamed Mokhtari, AROME dust)
- Minimum 1h (**Visi<sub>Cld</sub>**) et Minimum 1h (**Visi<sub>Hydro</sub>**)

# Visibility (min 1h), AROME 2019-01-06 00UTC + 09h

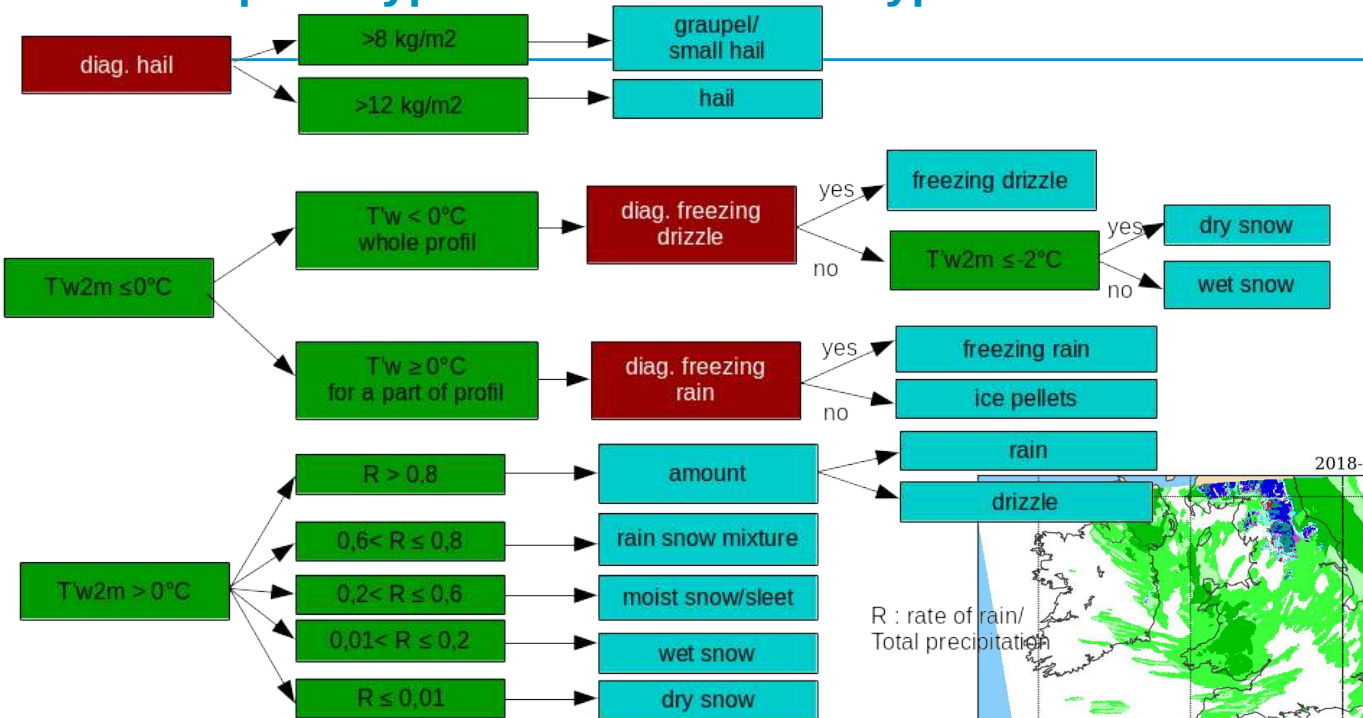


# Visibility (min 1h), AROME 2019-01-06 00UTC + 12h

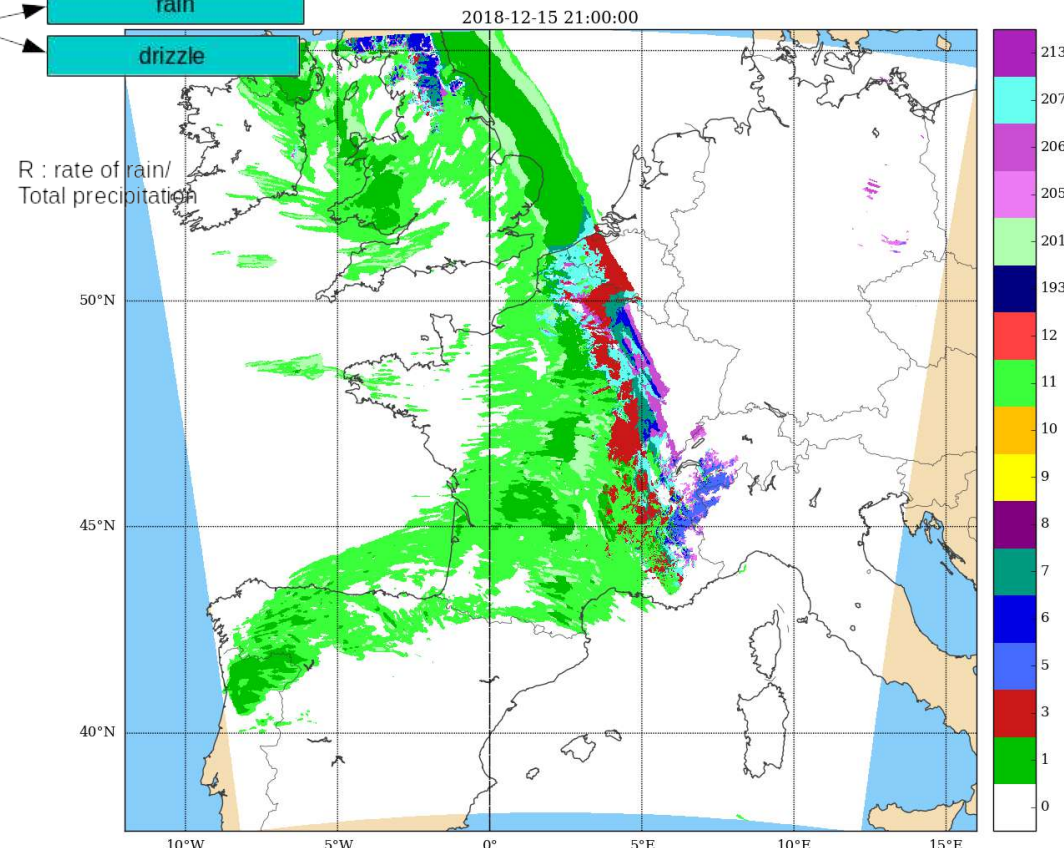


# Precipitation Type

Most frequent type and most severe type defined with forecasters.



|                                |     |  |
|--------------------------------|-----|--|
| Rain                           | 1   |  |
| Freezing rain                  | 3   |  |
| Dry snow                       | 5   |  |
| Wet snow                       | 6   |  |
| Rain snow mixture              | 7   |  |
| Ice pellets                    | 8   |  |
| Graupel/small hail             | 9   |  |
| Hail                           | 10  |  |
| Drizzle                        | 11  |  |
| Freezing drizzle               | 12  |  |
| Moist snow/sleet               | 193 |  |
| Intermittent rain              | 201 |  |
| Intermittent dry snow          | 205 |  |
| Intermittent wet snow          | 206 |  |
| Intermittent rain snow mixture | 207 |  |
| Intermittent moist snow/sleet  | 213 |  |

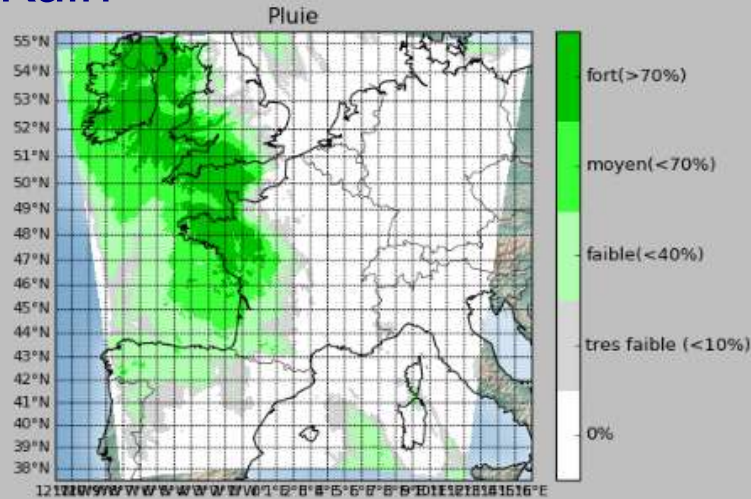


# Precipitation types : prob. EPS (AROME)

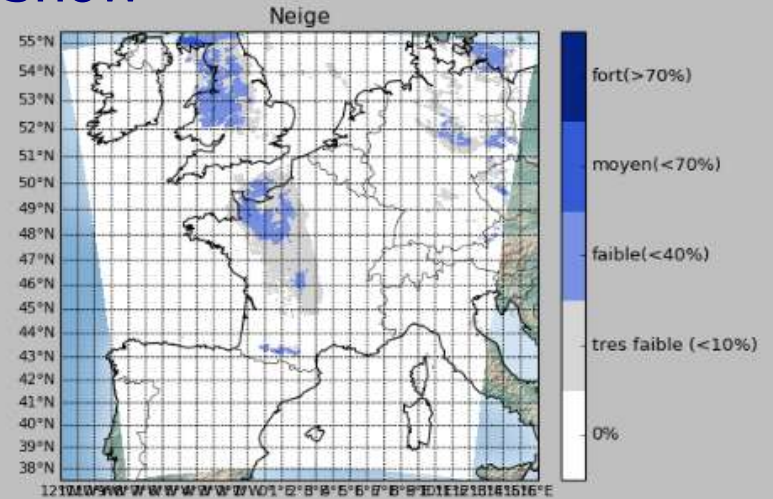
14-12-2018, run : 21h, echeance : +13h

Cartes de risques

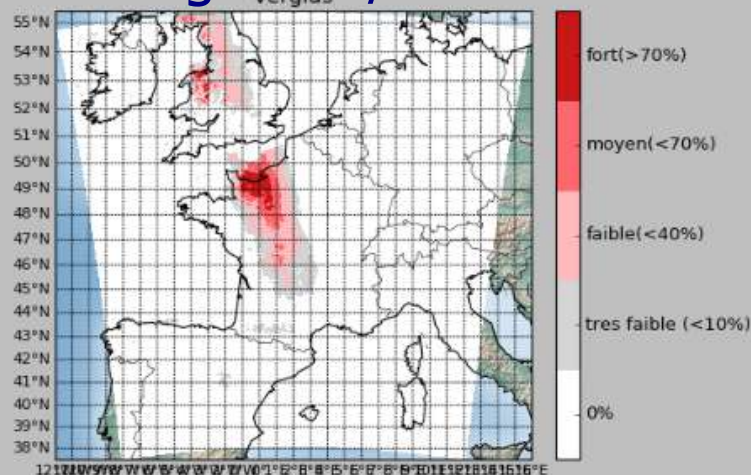
## Rain



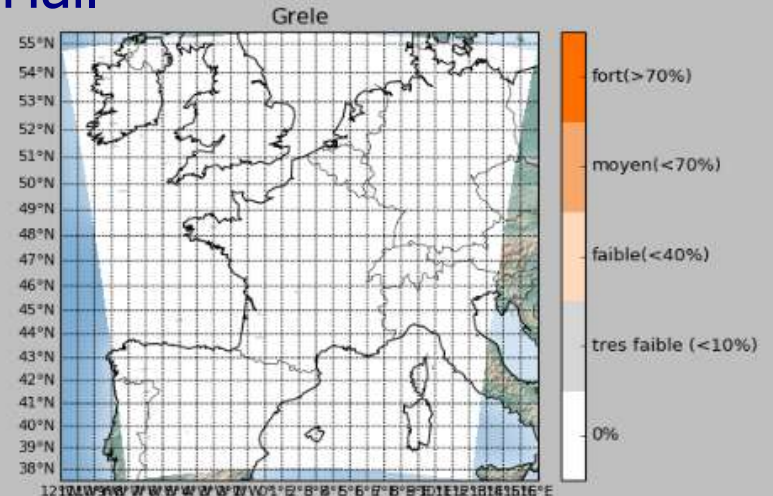
## Snow



## Freezing rain / drizzle



## Hail



02/10/19

Ingrid Etchevers, Yann Sely



MÉTÉO FRANCE

# 2019 plans and what will shift to 2020

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- 2019 last changes :
  - Snow analysis in Arome
  - New satellites : GOES, NOAA-20, METOP-C, chinois, AEOLUS winds ...
  - Assimilation of OPERA radar data in AROME
- Winter/spring 2020 : **migration to new HPC**
- 2020 scientific changes **after HPC migration** :
  - CY46T1 or CY47T1 into Operations
  - Monitoring of Mode-S
  - Snow analysis in Arpège and Arome (if not in last e-suite of 2019)
  - Tuning of observation error stdev
  - Model output : CAT index, ice crystals index (for aviation purpose) (if not in last e-suite of 2019)
  - *Note : work on IFS convection and radiation schemes will be continued, as well as on the IFS/GWD scheme + revisited orography based on GMTED2010 (Tiedtke-Bechtold, ECRAD, GWD)*
  - Arome aspects :
    - Revisited choices for diffusion (SLHD)
  - EPS :
    - PEARP (global) : revisited multi-physics choices, research work on SPP
    - PEARO : research work on SPP, stochastic objects and post-processing

## 2020-2024 plans (after migration)

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- With respect to operational implementation steps :
  - 2021 : Arome (PEARO) and Arpège (PEARP) EPS change of resolution to the deterministic ones (will probably require single-precision) => first & important step towards a probabilistic production system
  - 2022 : OOPS ported to operations, perhaps in association with implementing 3D-EnVar for Arome
  - 2022+ : Renewed surface assimilation ?
  - 2022+ : 4D-EnVar or hybrid 4DVAR/4D-EnVar in Arpège (perhaps only for the EDA part?)
  - 2023 : Instances of Arome-500m become operational
  - 2023 : 4D-EnVar in Arome ?

# това е краят на моята презентация

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- благодаря за вниманието

# tova e krayat na moyata prezentacija

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- blagodarya za vnimanieto