Developments on ensemble calibration at the Hungarian Meteorological Service

István Ihász
ihasz.i@met.hu

Thanks to: Amarilla Mátrai, Máté Mile, Csilla Németh & Zoltán Üveges

12 February 2015, ECMWF

Outline

- General overview on ECMWF related activities
- Developments on ensemble calibration
  - Calibration for stations
  - Gridded calibration
  - Calibration for river basins
  - Verification
  - Products
  - Comparison of the reforecast model climates
- Further plans

Outline

- **General overview on ECMWF related activities**

- Developments on ensemble calibration
  - Calibration for stations
  - Gridded calibration
  - Calibration for river basins
  - Verification
  - Products
  - Comparison of the reforecast model climates

- Further plans

General overview on ECMWF related activities

more details on page 23-30

- **Hungarian Meteorological Service: established 1870**

  ~ 200 employees,

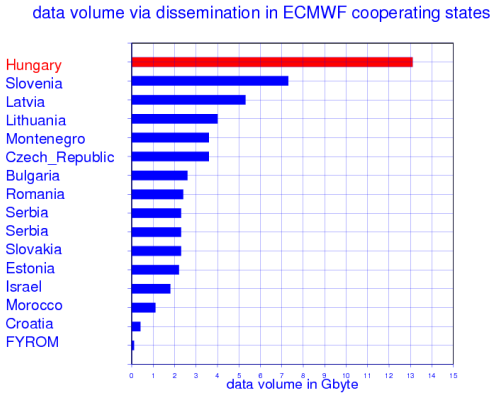
  NWP division: 1 person for ECMWF related activities

- **Relationship between Hungary and ECMWF**

  1994: Cooperating agreement between Hungary and ECMWF

  3 ACCS meetings, 9 liaison visits, 3 User Support's visits

  aim: to be Member State **(res. of gov: 2011)**



- **Disseminated daily operational data transfer:**

  ~13 Gbytes/model run

  ensemble is widely used

- **Short summary of the ECMWF related activities in NWP Div.**

  2003-2015: 8 different topics, including ensemble calibration

  10 students involved: 4 BSc and 9 MSc thesises

  3 students' topic: ensemble calibration

Outline

- General overview on ECMWF related activities

- **Developments on ensemble calibration**
  - **Calibration for stations**
  - **Gridded calibration**
  - **Calibration for river basins**
  - **Verification**
  - **Products**
  - **Comparison of the reforecast model climates**

- Further plans

Motivation and main steps

2000: 3 months stay on EFI at Met Ops, ECMWF, (I. Ihász), head: F. Lalaurette

2004-2006: project founded by National Scientific Foundation of Hungary
subproject: CDF based ensemble calibration
using **static model climate**

2008-2009: station based ensemble calibration
using ensemble reforecasts (time range: +24 - +120 h timestep)
for 2m temperature, 10m windspeed and precipitation (M. Mile, Z. Üveges)
Including ensemble verification (BS, ROC, Talagrand, etc)
- ECMWF's ENS reforecast: operational since 13 March 2008

2010: gridded ensemble calibration for 2m temperature
including ensemble verification (Cs. Németh)

2010: *article in Időjárás, Quart. J. of the Hungarian Meteorological Service*

2013, May-June: heavy flood on river Danube, ENS is a bit underestimated

2014-2015: ensemble calibration for 24 h precipitation
including verification for 21 river basins (A. Mátrai)

Calibration for stations (made: 2008-2009)

CDF based calibration

Meteorological variables:

1. 2m temperature + min & max. temp.
2. 24 precipitation
3. 10m wind speed

Time range: +24 - +360 h

ENS hor. res: 0.5*0.5 degrees

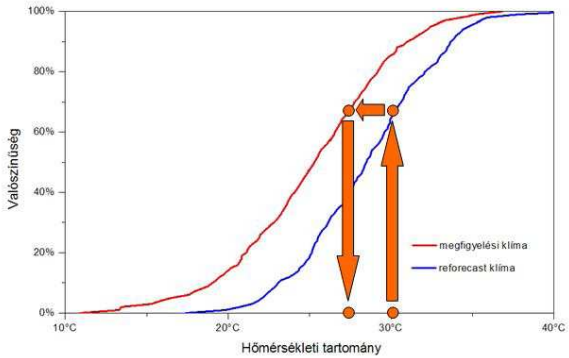
Model climate:

1. 1997-1999 ENS model climate
2. 18 year ensemble reforecast

Observed climate:

1. 1971-2000 , 2.: last 18 years

10 selected stations



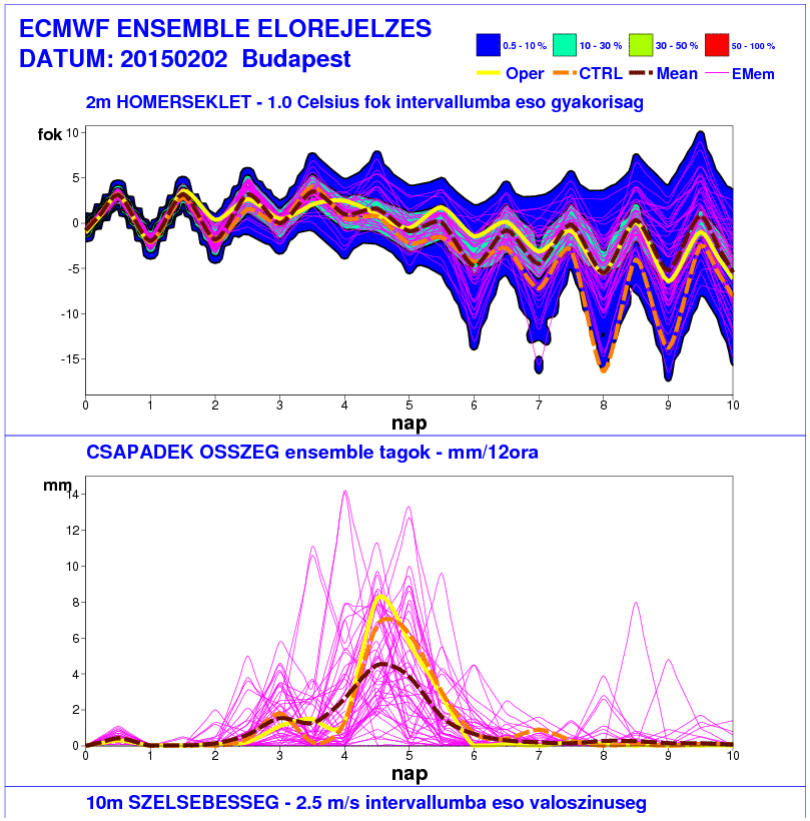
schematic flow

ENS verification:

based on 2 years: March 2006 – March 2008

BS, BSS, ROC, Talagrand, Talagrand outliers, etc

Calibration for stations (2)



Calibrated ensemble plume for Budapest

Forecast based time: 00 UTC February 2015

HRES, ENS members, ENS CF, ENS mean

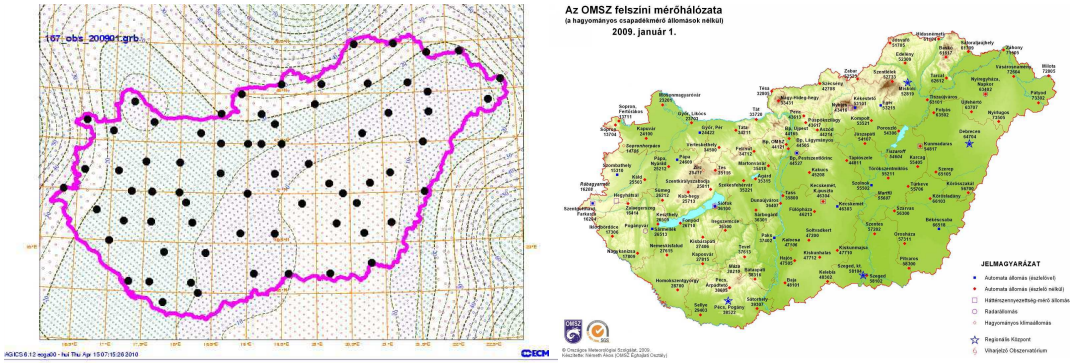
upper: 2m temperature, lower: 12h precipitation

Gridded calibration (made: 2009-2010)

Ensemble model: T399L62
(0,5*0,5 degrees)

Model climate distributions:
18 years ensemble reforecasts

Monthly observed climate distributions
18 years: 70 stations



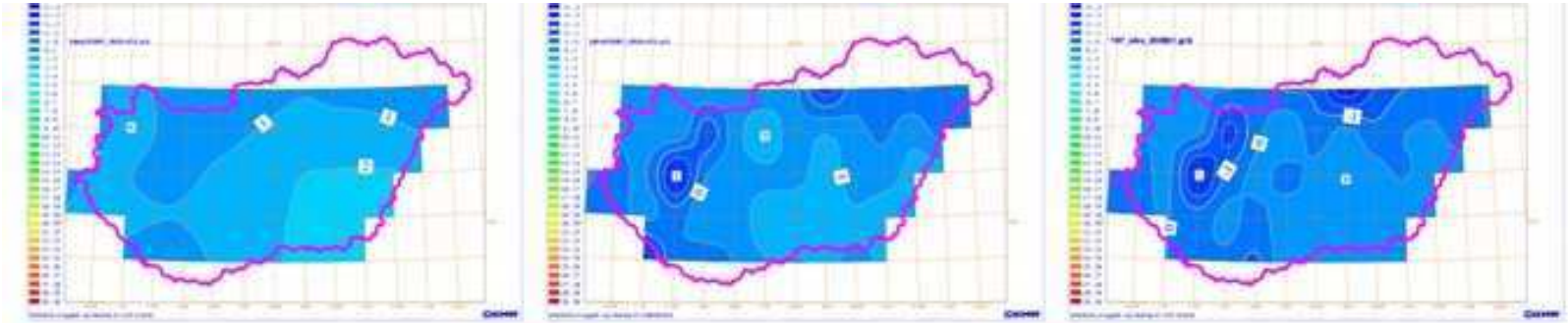
model orography, model grid and stations

Meteorological variable:
2m temperature

Input: ENS GRIB file –> output: calibrated ENS GRIB file

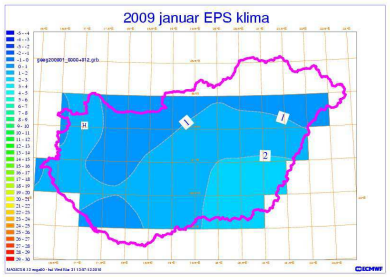
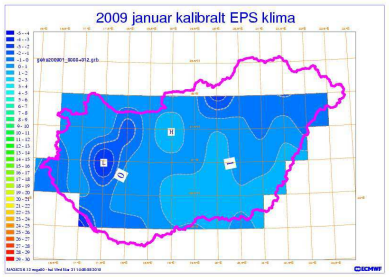
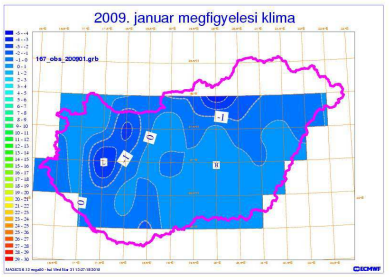
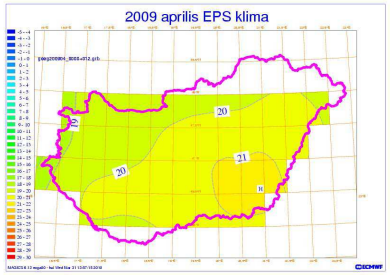
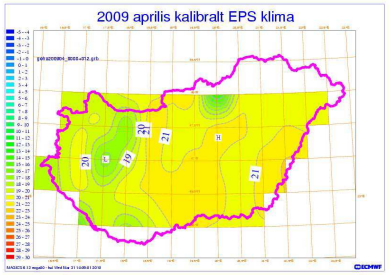
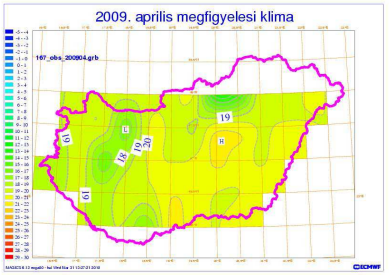
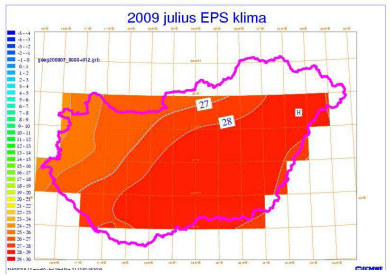
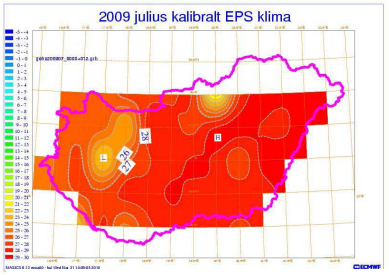
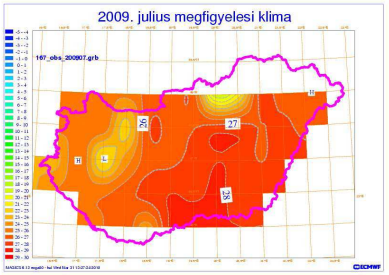
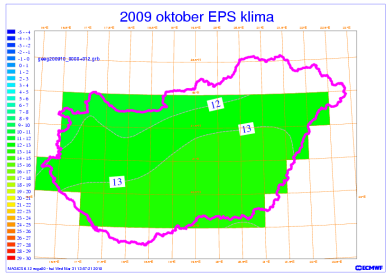
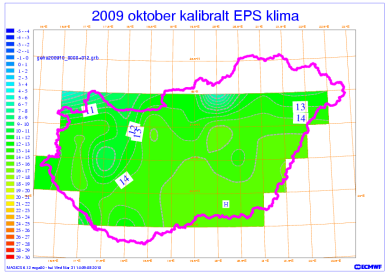
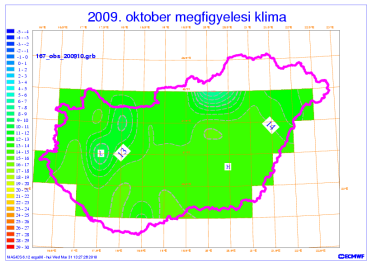
example: monthly mean for January

uncalibrated ENS climate observed climate calibrated ENS climate



Ihász I., Üveges Z., Mile M. and Németh Cs., 2010: Ensemble calibration of ECMWF's medium-range forecasts *Időjárás,* 114, 275-286

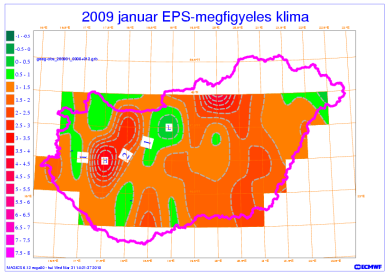
Gridded calibration (2)
(made: 2009-2010)

	raw ENS	observed	calibrated ENS
January			
April			
July			
October			

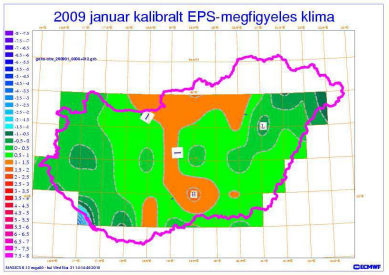
2m temp. monthly mean

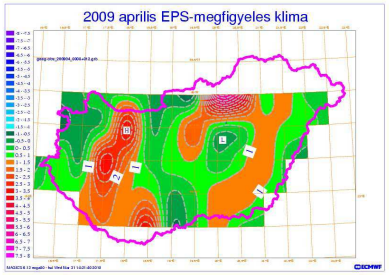
Gridded calibration (3)
(made: 2009-2010)

Difference between raw ENS - observation Difference between cal. ENS - observation

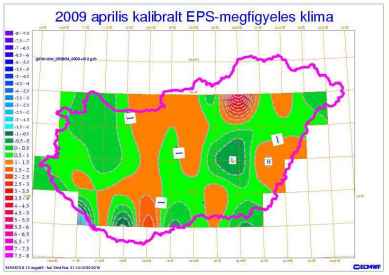


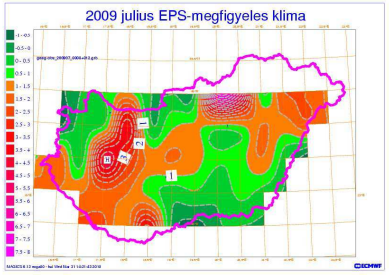
January



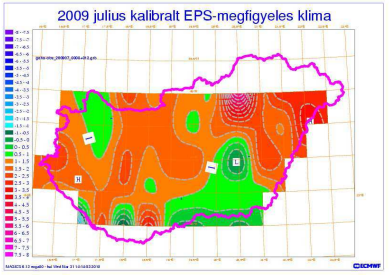


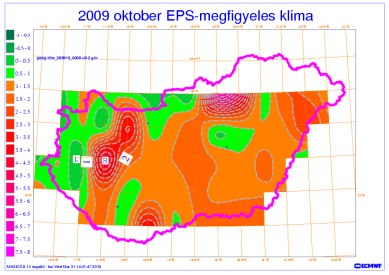
April



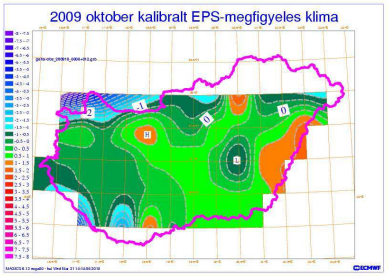


July





October



Gridded calibration (4) (made: 2009-2010)

Talagrand outliers for 2009

Raw ENS

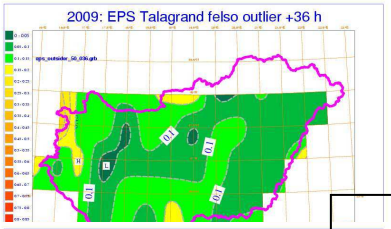
Calibrated ENS

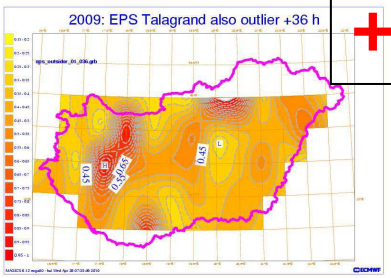
Upper outlier

Upper outlier

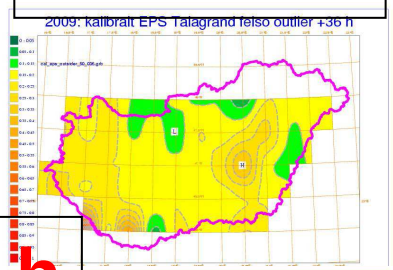
Lower outlier

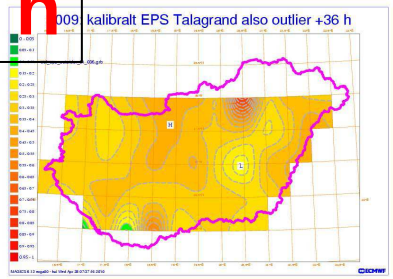
Lower outlier

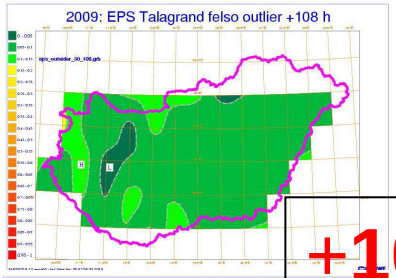


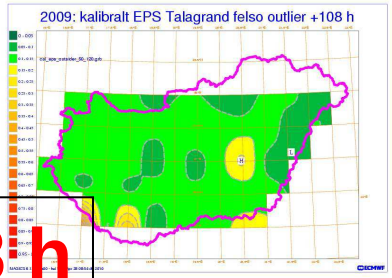


+36 h

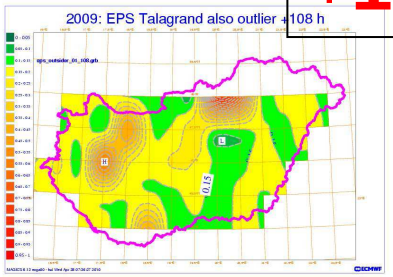


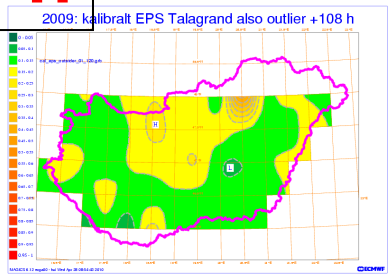


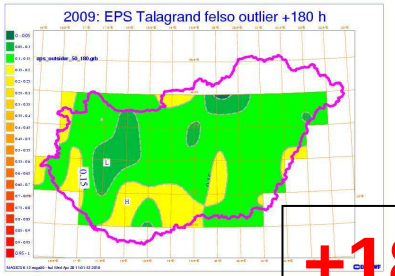


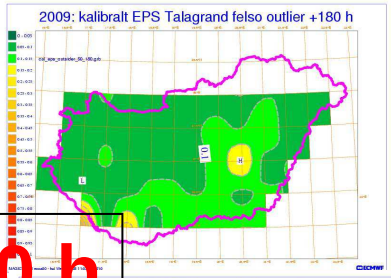


+108 h

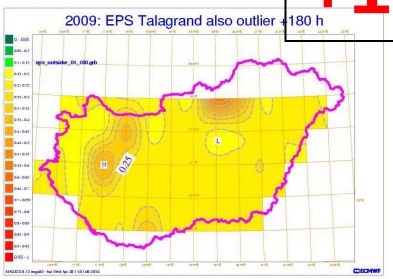


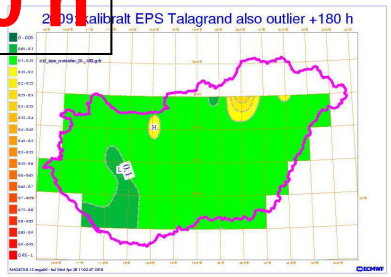






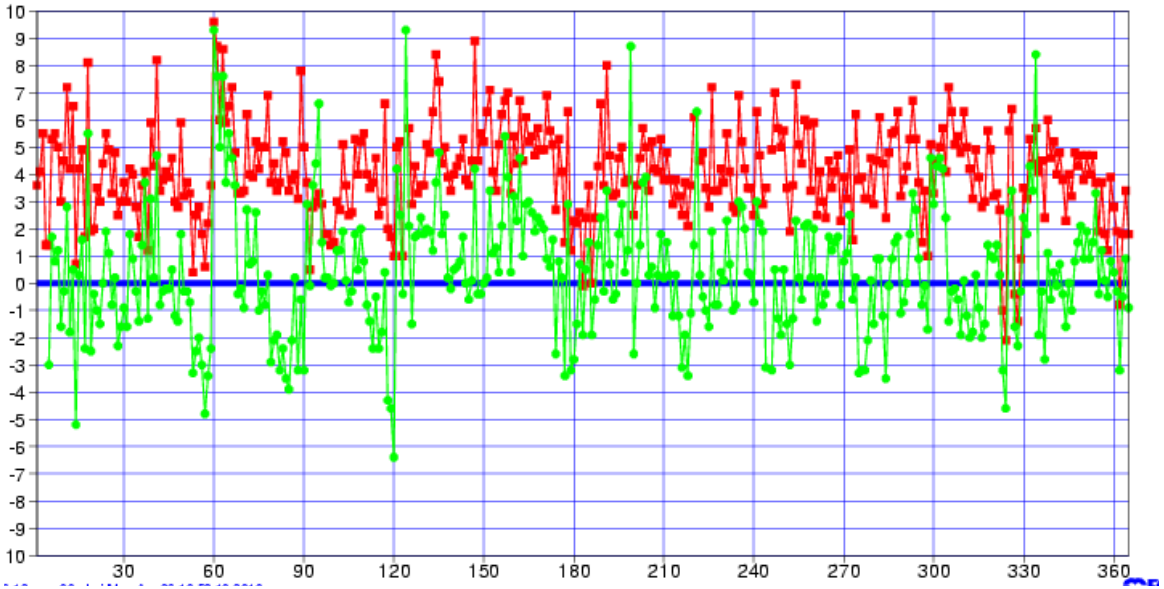
+180 h





Gridded calibration (5)
(made: 2009-2010)

Daily errors of the uncalibrated and calibrated ensemble forecasts
grid point: 47.0 N, 17.5 E

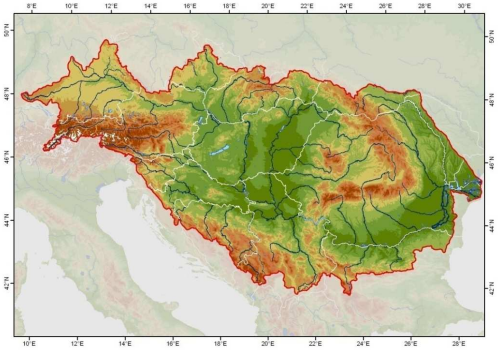


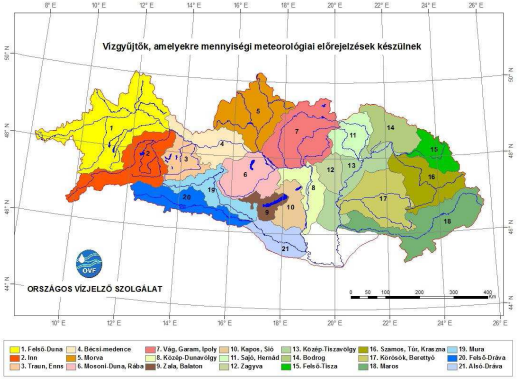
Calibration for area mean 24 h precipitation for river basin (made: 2014-2015)

ENS CF

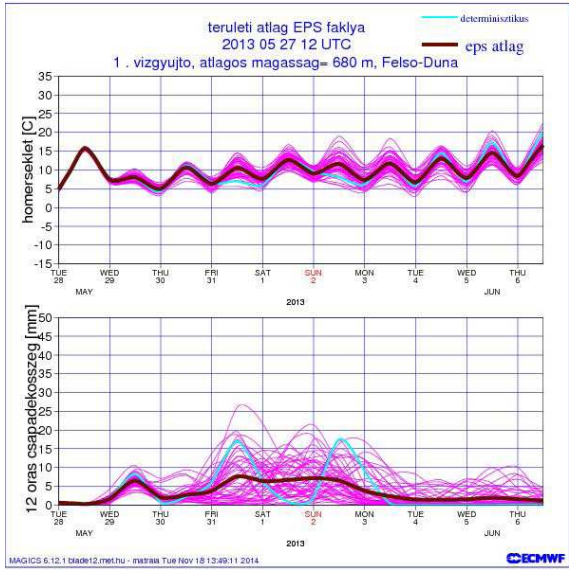
ENS MEAN

- Need: area mean ensemble forecasts and plumes ENS members





21 river basins



2m T

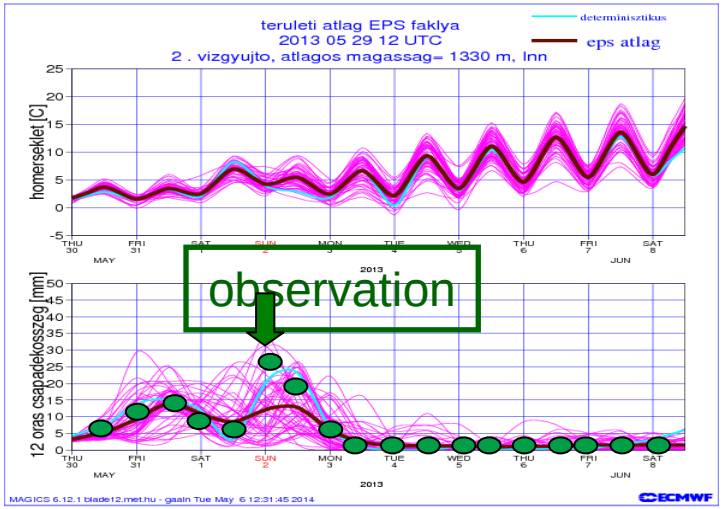
prec.

- Two datasets:
  - Observed 24 h precipitation dataset on daily based for 21 areas (**from Hydrological Authority**)
  - Ensemble reforecasts (**from MARS**)

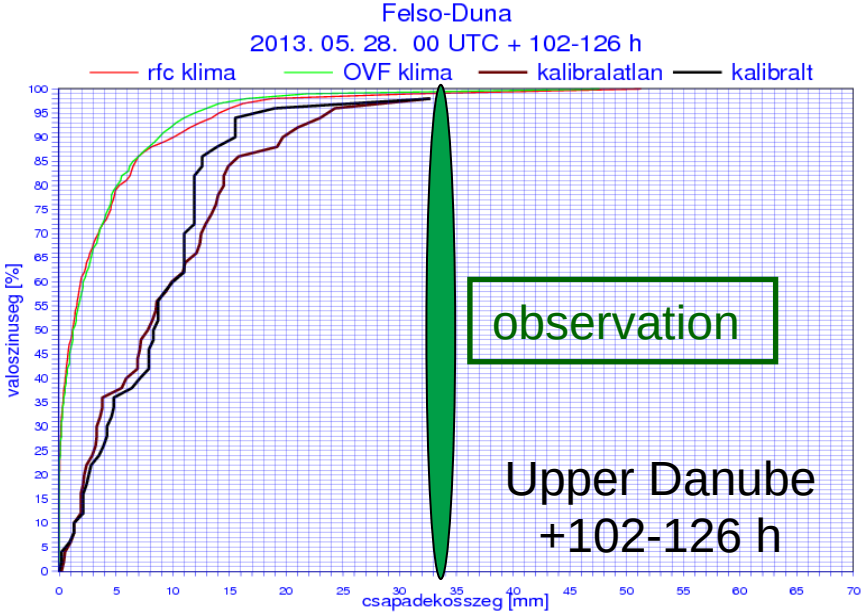
- Method: CDF based calibration

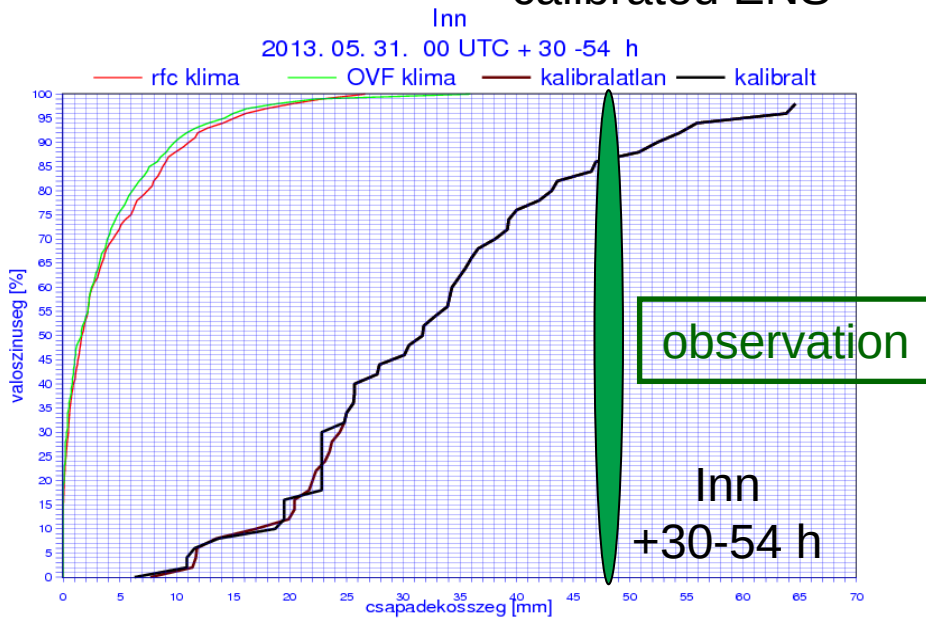
Calibration for area mean 24 h precipitation for river basin (2) (made: 2014-2015)

ENS CF
ENS MEAN
ENS members



CDF:
RFC climate
observed climate
raw ENS
calibrated ENS



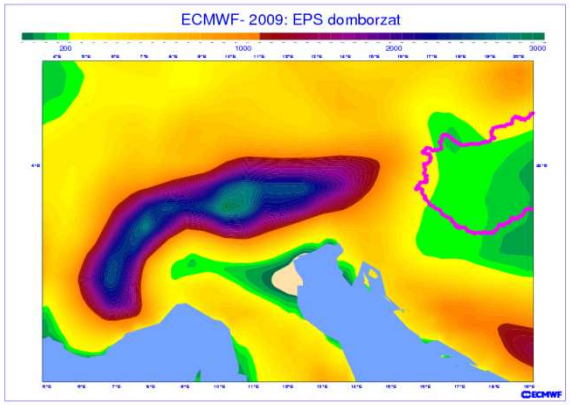


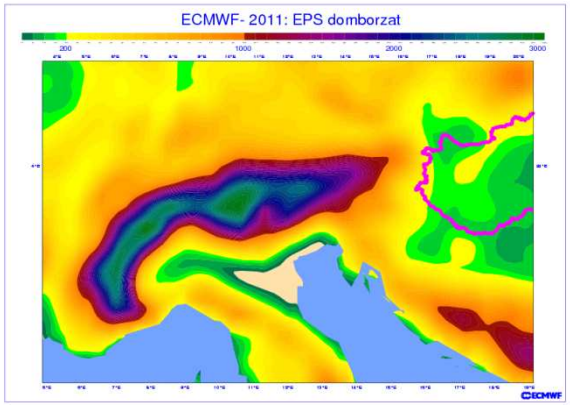
Selected case studies: May-June 2013

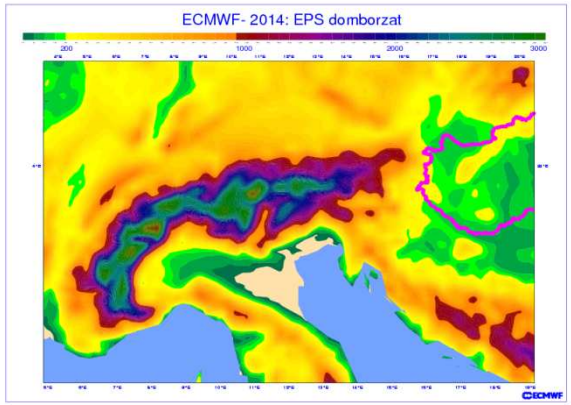
Comparison of the reforecast model climates
Is it necessary or straightforward to do calibration?

Horizontal and vertical resolution of the ensemble model:

2006-2010,	2011-2013,	2014-2015,	2016 -
50 km	32 km	32 km	16 km
L62	L62	L91	L91







How did cdf of the model climate change in time?

Kolmogorov – Smirnov test

52 samples/year: 2008, 2011, 2014

Comparison of the reforecast model climates (2)

example: period: last week of May

CDF +54-78h:

RFC 2008

RFC 2011

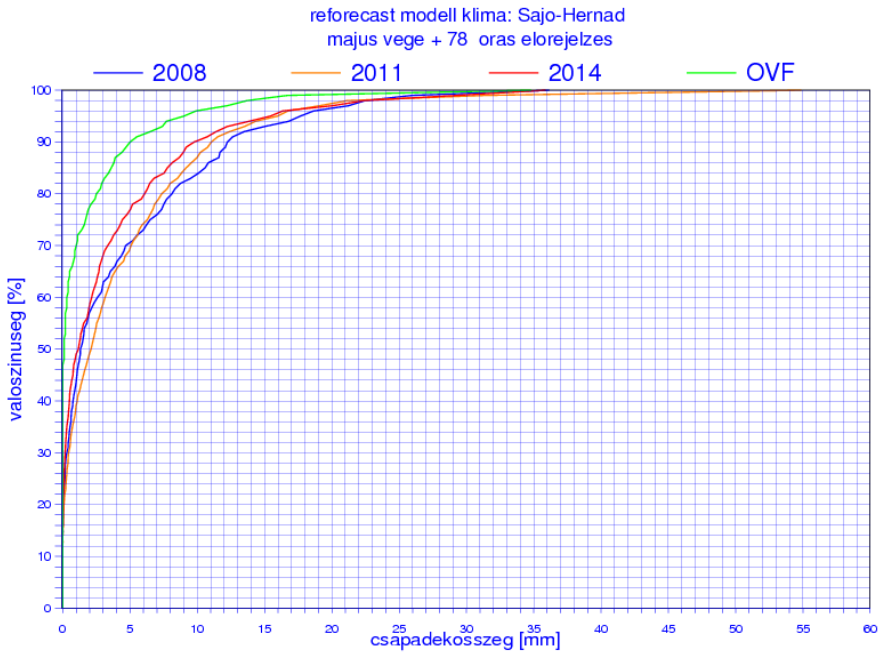
RFC 2014

observed climate

river: Sajó Hernád

Hungary

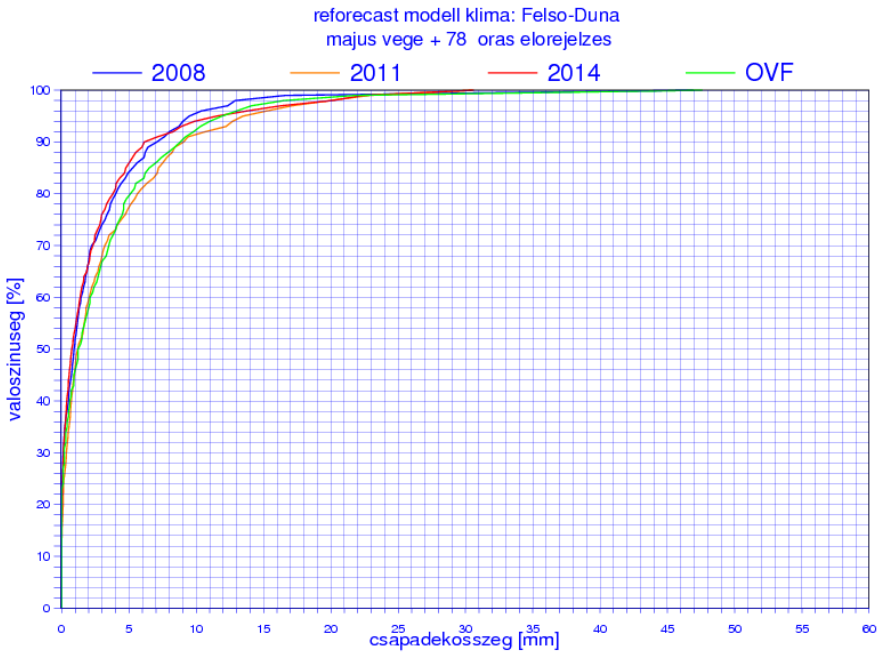
RFCs - too wet



river: Upper Danube

Germany

RFCs - quite good



Comparison of the reforecast model climates (3)

Results of Kolmogorov Smirnov tests:

Rate of differences between reforecast-2014 and observed climate for subdomains of river Danube (spring, summer, autumn, winter)

Year	71	69	100	85	75	48	73	100	100	100	100	100
Spring	50	75	100	100	92	100	75	100	100	100	100	100
Sum.	67	58	100	75	67	75	50	83	100	100	100	100
Aut.	100	100	100	92	83	17	33	83	100	100	100	100
Winter	67	58	100	67	58	75	42	25	100	100	100	100

Rate of differences between reforecast-2014 and reforecast-2008 for subdomains of river Danube (spring, summer, autumn, winter)

Year	13	15	13	15	13	17	15	15	12	13	19	19
Spring	25	33	25	33	25	25	25	25	17	25	17	33
Sum.	25	33	33	25	33	25	25	25	17	25	17	33
Aut.	17	17	8	17	0	17	17	17	8	8	25	17
Winter	8	8	8	17	0	8	0	0	17	0	25	17

Comparison of the reforecast model climates (4)

Summary of the results of Kolmogorov Smirnov tests: all subdomains

(spring, summer, autumn, winter)

rfc-2014 & observed climate

Year	79
Spring	92
Summer	79
Autumn	77
Winter	72

rfc-2014 & rfc-2008

Year	15
Spring	13
Summer	27
Autumn	15
Winter	8

Conclusions:

1. wide range of the changes from river to river and from season to season

2. differences: rfc2014 & observed climate: max: spring, min: winter

3. differences: rfc2014 & rfc2008: max: summer, min: winter

4. improvements in ensemble model in time

5. ensemble calibration is needed

Outline

- General overview on ECMWF related activities
- Developments on ensemble calibration
  - Calibration for stations
  - Gridded calibration
  - Calibration for river basins
  - Verification
  - Products
  - Comparison of the reforecast model climates
- **Further plans**

Further plans:

- **Ensemble calibration for river basins**
  - Calibration for 100 extreme events between 2008 and 2013
  - Ensemble verification for these events
  - **H1 2015: Operational introduction of the uncalibrated and calibrated ensemble forecasts for river basins.**
  - Article submitted to ECMWF Newsletter
  - **Using enhanced method for calibration**

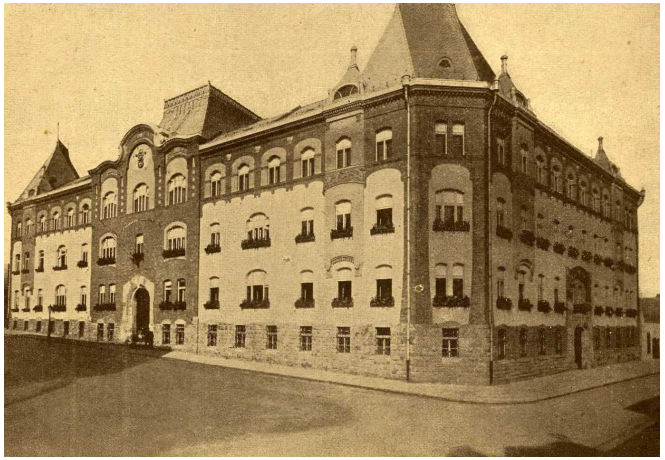
Thank you for your attention

http://www.met.hu/activity/ECMWF

Overview on ECMWF related activities

- more details -

Hungarian Meteorological Service



meteorological service established: 1870, headquarter built: 1912

http://www.met.hu

employees: ~ 200

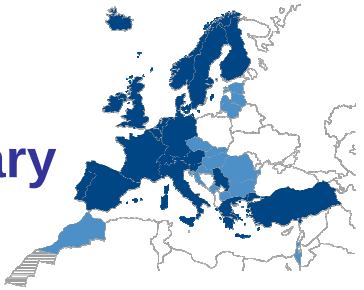
NWP division: Methodology Development Division:
15 people, 1 person for ECMWF related activities

http://www.met.hu/activity/

http://www.met.hu/activity/ECMWF

Hungary: 93.000 square km, 10.000.000 people

Relationship between Hungary and ECMWF



- **June 1994:**
  Cooperating agreement between ECMWF and Hungary
  http://www.ecmwf.int/en/about/who-we-are/member-states

- October 1999:
  5th meeting of Advisory Committee of Co-operating States (ACCS), held in Budapest: opening the floor for discussion of the full membership

Iván Mersich
president: 1991-2005

- April 2005:
  At its 62nd session the ECMWF Council unanimously adopted amendments to the Convention in form of an Amending Protocol.

- June 2010:
  The amendments to the Convention entered in force.

- **December 2011:**
  Hungarian government gave greenlight to join the ECMWF

ECMWF visitors

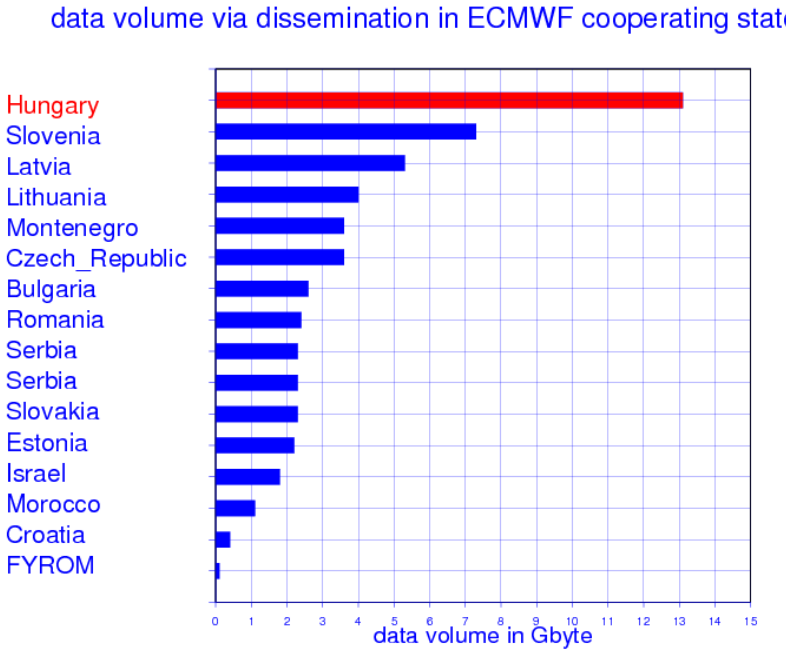
- July 1994 – co-operating agreement between ECMWF and Hungary
- First visit: April 1995 – visit of David Burridge, director of ECMWF

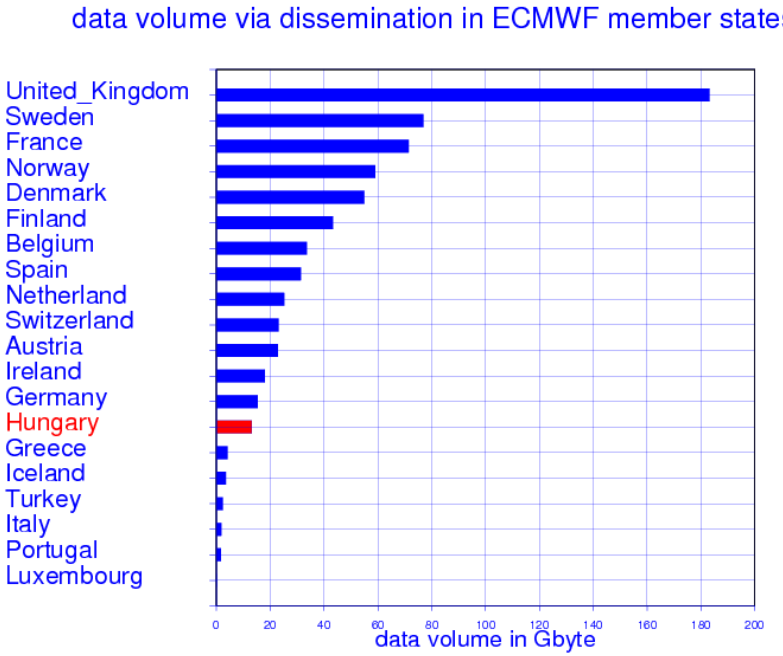
- 3 ACCS meetings, 9 liaison visits, 3 User Supports' visit

- Last visit: October 2014 – visit of Alan Thorpe and Florence Rabbier

Relationship between Hungary and ECMWF

Disseminated daily operational data transfer from ECMWF via RMDCN and internet: 2012





Short summary of the ECMWF related activities in Methodology Dev. Division

- 1. Verification of the deterministic and ensemble forecasts /since 1995/ http://old.ecmwf.int/products/greenbook/index.html
- 2. Graphical products for forecasters, public web and intraweb /since 2000/
- 3. Clustering of the ensemble forecasts for Central Europe /since 2003/
- 4. Downscaling ensemble forecasts by LAMs /2005-2006/
- 5. Ensemble calibration /since 2008/
- 6. Ensemble vertical profile /since 2011/ {ECMWF Newsletter article}
- 7. Study of the dispersion and trajectory models driven by ENS mod. /2012/
- 8. Study of the cold drops using ECMWF reanalysis and ENS /2012-2014/ {ECMWF Newsletter article}

Students involved in ECMWF related R&D in Methodology Dev. Division

/supervisor István Ihász/

- 1. Extreme Forecast Index /EFI/

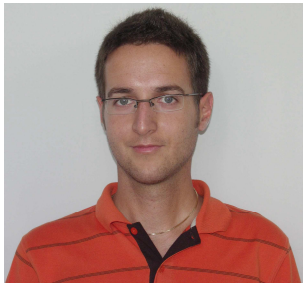
Edit Hágel
2003
MSc

- 2. Downscalling ensemble forecasts by LAMs

Balázs Szintai
2006
- MSc

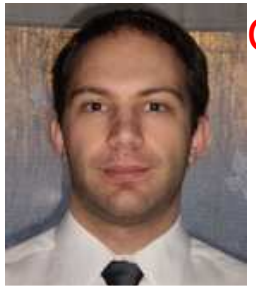
- 3. Ensemble calibration

Máté Mile
2008
- MSc



Zoltán Üveges
2009
MSc

- 4. Verification of the calibrated and monthly ensemble forecasts



Dávid Tajti
2009
BSc

Csilla Németh
2010
BSc

Dóra Lázár
2011
BSc

Students involved in ECMWF related R&D in Methodology Dev. Division

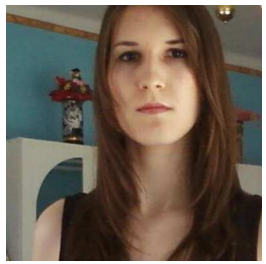
/supervisor István Ihász/

- 5. Ensemble vertical profile
  Dávid Tajti
  2011 MSc

- 6. Study of dispersion models and trajectory models driven by ENS model
  Judit Sábitz
  2012 MSc

- 7. Using ENS in severe convective events in summer
  Dóra Lázár
  2013 MSc

- 8. Study of the cold drops based on reanalysis and ENS model
  Nikolett Gaál
  2012 BSc, 2014, MSc



- 9. Ensemble calibration of 24 h precipitation for river basins
  Amarilla Mátrai
  2015 MSc