Discharge modelling experiments with the TIGGE archive

Ervin Zsótér

Ervin.Zsoter@ecmwf.int

ECMWF

Application Group
Evaluation Section

GEOWOW project

- **GEOWOW:** "GEOSS interoperability for Weather, Ocean and Water" a 3-year EU-funded FP7 project finished in August 2014
- **GEOWOW's main (weather) objectives:** to improve access to TIGGE ensemble forecast archive, document TIGGE quality, develop and demonstrate (multi-disciplinary) forecast products using TIGGE data in collaboration with users in developing countries
- **Multi-disciplinary use case:** Modelling of river discharge using TIGGE weather forecasts and GRDC observations, and demonstrating interoperable use with WaterML/SOS/GEO-DAB in GEOSS

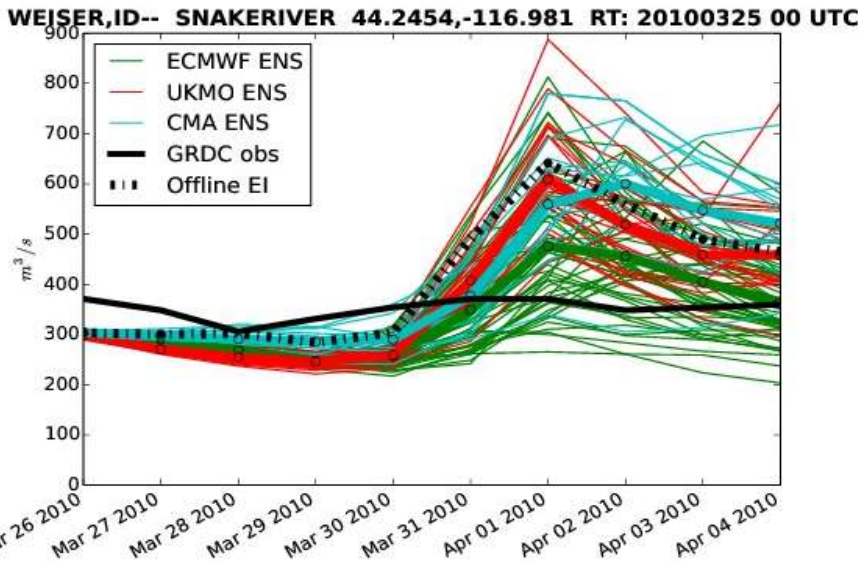
TIGGE archive

- TIGGE is a major component of THORPEX: a WMO World Weather Research Programme to accelerate the improvements in the accuracy of high-impact weather forecasts up to 2-weeks ahead
- Since October 2006, the TIGGE archive has been accumulating regular ensemble weather forecasts from 10 (currently) leading global Numerical Weather Prediction (NWP) centres
- Data is archived in three data centres in common format and made available for research after a 48-hour delay
- The TIGGE data set is a major resource for various scientific research and also development for probabilistic weather forecasting. Over 100 research papers using TIGGE

ECMWF

TIGGE/HTESSEL discharge modelling

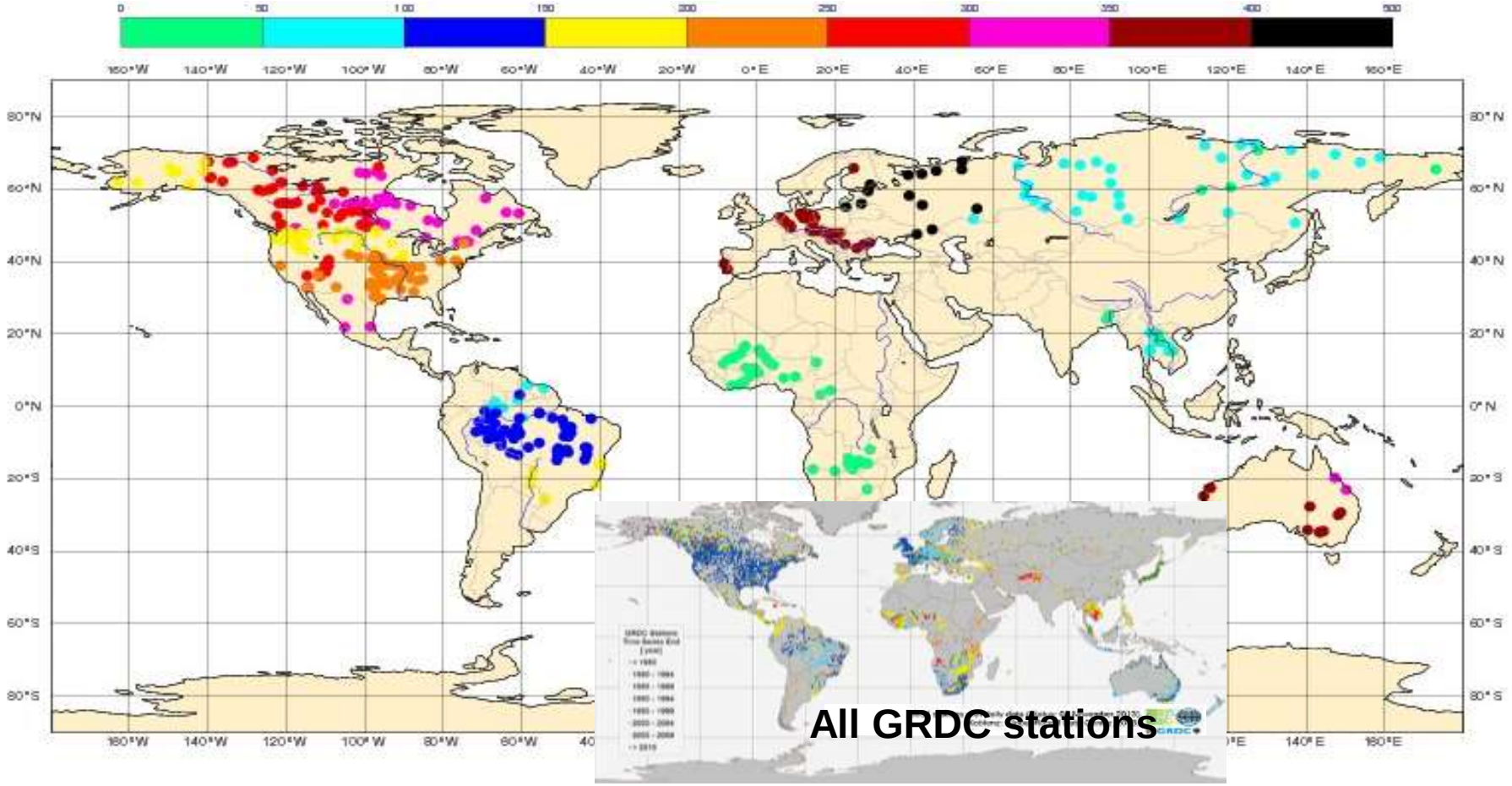
- River runoff ensemble forecasts are produced with the HTESSEL land-surface model (operational at ECMWF)
- CaMa-Flood river routing is coupled to integrate runoff over global river catchments. For detailed description of CaMa-Flood go to: http://hydro.iis.u-tokyo.ac.jp/~yamadai/cama-flood/
- Discharge forecasts for ECMWF(50), UKMO(23), NCEP(20) and CMA(14)
- Two multi-model combinations also produced, an equal weight combination (MMA) and the Bayesian Model Averaging (BMA)
- Forecasts for 2008-2013 at 00 UTC runs for up to 240h
- The discharge forecasts are validated and verified with GRDC (Global Runoff Data Centre) stations



ECMWF

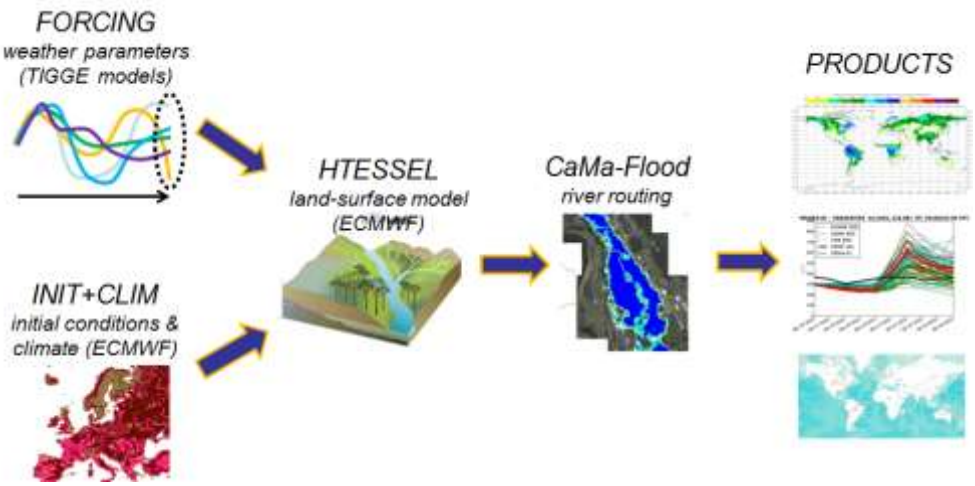
GRDC stations in CaMa-Flood

- Some blank areas globally
- About 400 stations used



TIGGE/HTESSEL discharge modelling

- Offline surface model is further developed for forecasts including ensembles
- Initial conditions and climate for land-surface runs come from ECMWF operations and reanalysis

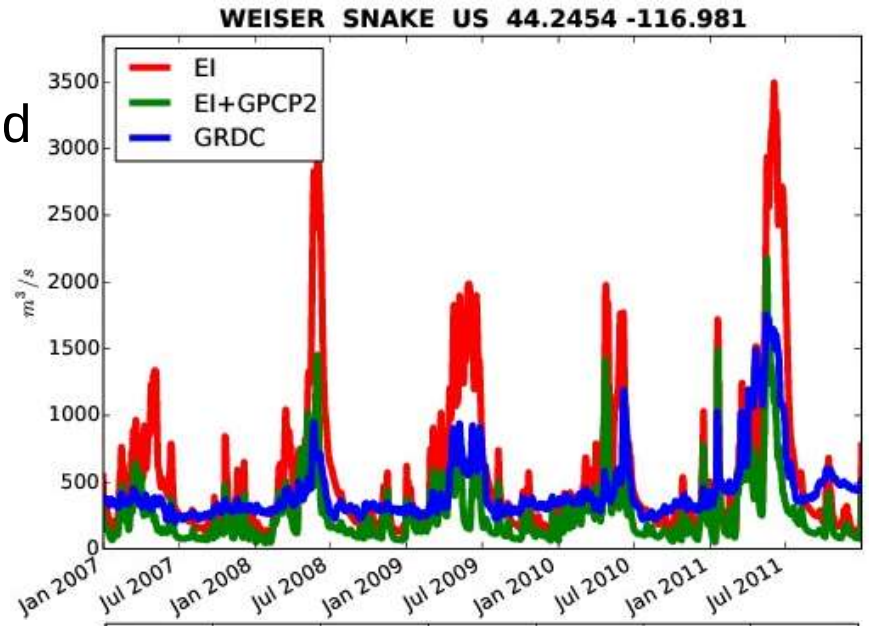


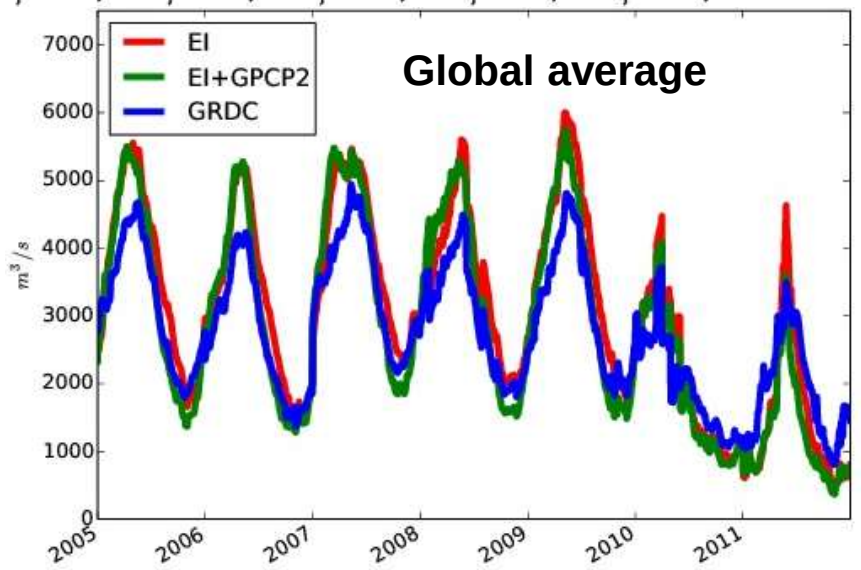
- Surface (2m/10m) TIGGE model forcing is used instead of the default lowest model level (no model levels in TIGGE)
- Some parameters for HTESSEL are missing in TIGGE (global radiations)
- Available TIGGE parameters were used and radiation was replaced (e.g. ERA Interim or ECMWF ensemble mean)
- The impact of the different replacement options is generally limited

ECMWF

ERA Interim discharge

- ERA Interim offline run is used to provide initialisation to the CaMa-Flood routing for each TIGGE forecast
- Two versions:
  - ERA Interim (EI)
  - ERA Interim improved (EI+GPCP2) with GPCP2 corrected precipitation
- Generally good simulation of the variability and overall pattern
- However, large deviations from the actual GRDC observations
- EI+GPCP2 is noticeably better



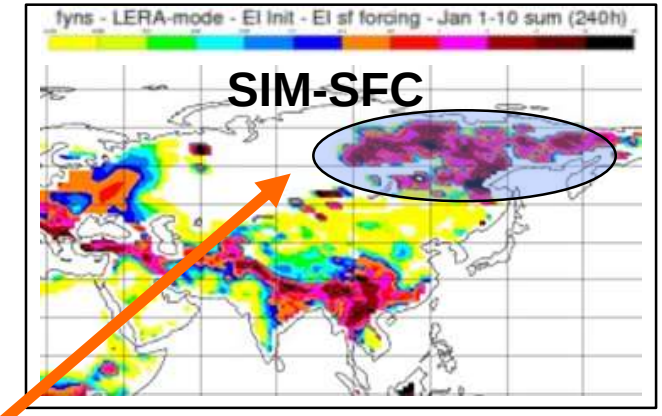


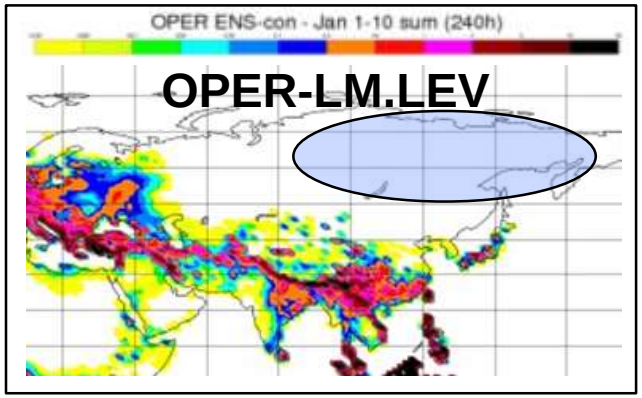
Errors for 2009 (m^3/s)

EI	**1507**
EI+GPCP2	1417

HTESSEL sensitivity to forcing

- HTESSEL input forcing parameters replaced with ERA Interim to analyse sensitivity
- Forcing parameter groups of wind, radiation, temp/hum/pressure and precipitation
- Temperature and humidity kept together due to the very sensitive balance
  - Different model/interpolation provide an imbalanced state which can result in artificial due deposition (mostly in Northern Hemispheric winter season)



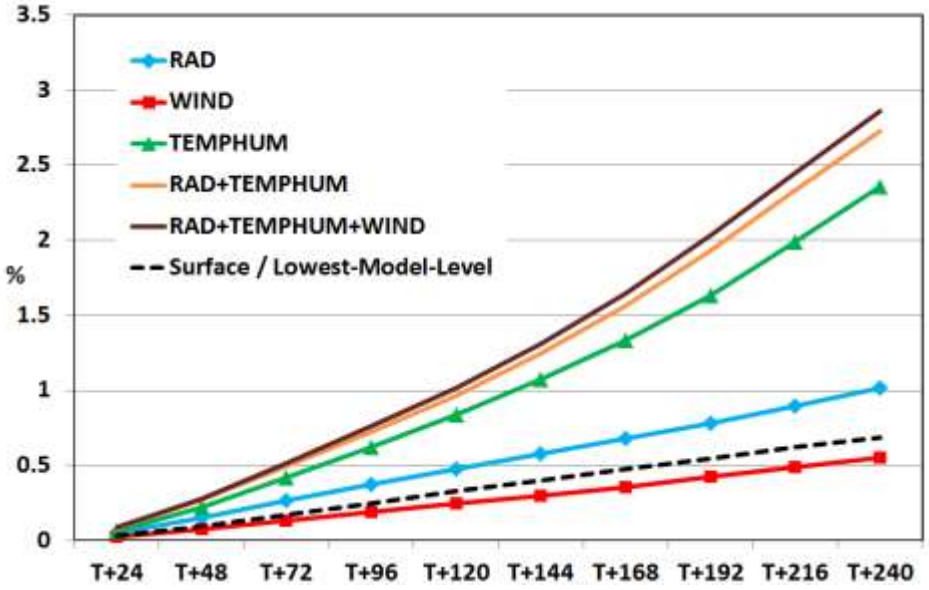


- T+240h ensemble control forecast runs
- Once a week in 2008-2012 (5 years, about 260 runs)
- On the global CaMa-Flood river network (with around 400 stations)
- Statistics as average of the absolute discharge increments (differences divided by original value) over the 5-year period

ECMWF

HTESSEL sensitivity to forcing

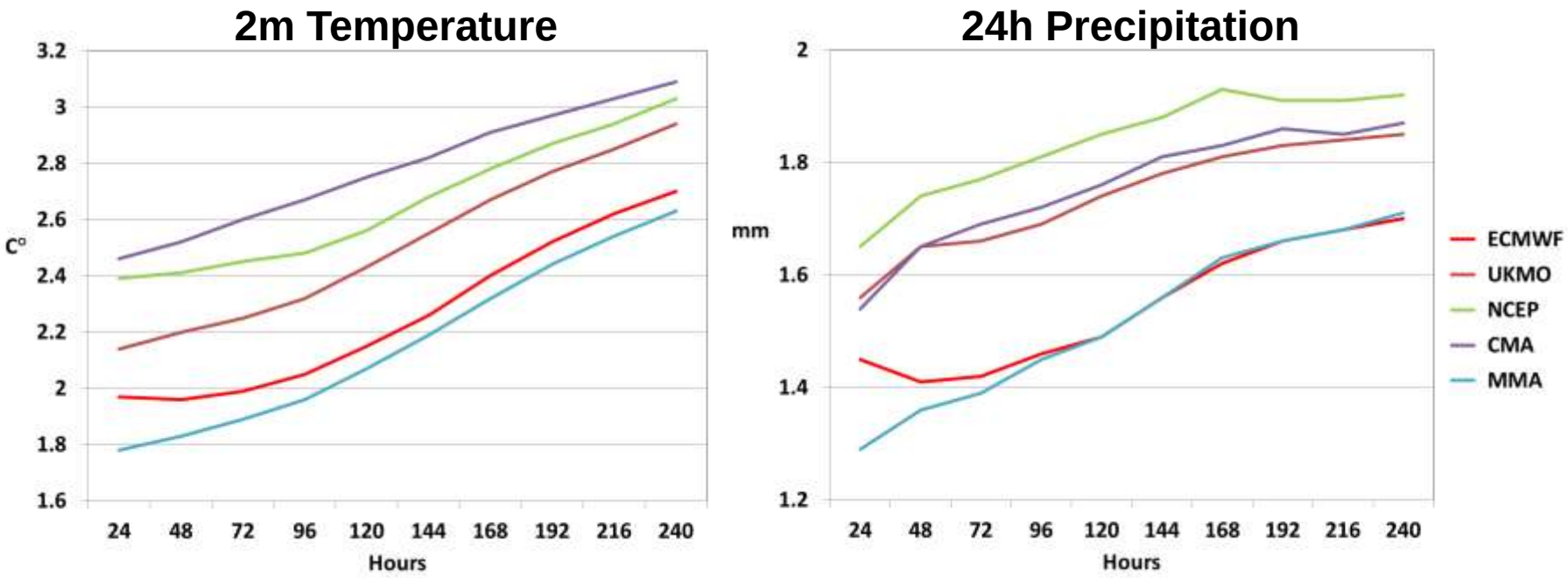
- Precipitation the largest (10-15% by T+240h)
- The other forcing parameters integrated impact remains low (below ~3%)
- Temperature and humidity have much bigger influence than wind or radiation
- Impact of Surface (2m/10m) vrs. Lowest model level is very small
- In NH summer precipitation is very dominant (0.9% vrs. 13%)
- In NH winter relative impact of other parameters is lot bigger (snow melting, etc.)



Average difference (%)	Rad	Wind	TempHum	Rad+Wind + TempHum	All
Global	1	0.6	2.4	2.9	15.6
NH.ET JJA	0.5	0.2	0.6	0.9	13
NH.ET DJF	1.1	0.7	2.9	3.6	9.5
Tropics JJA	0.9	0.4	0.9	1.5	15
Tropics DJF	1.2	0.6	1.3	2.1	18.7

ECMWF

EPS comparison - CRPS - 2009

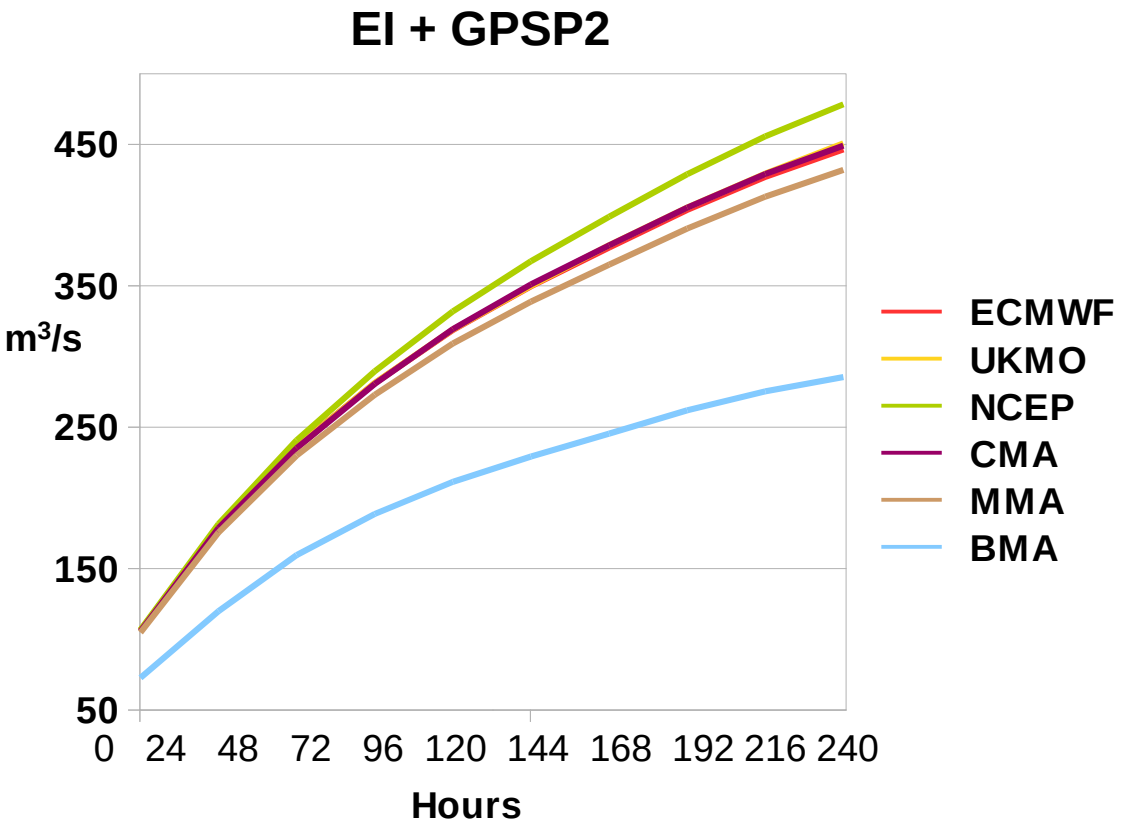


- Skill of the forcing TIGGE models including the equal weight multi-model combination is compared for 2009 (00 UTC runs)
- 2m temperature (00 UTC) and 24-hour (00-00 UTC) precipitation
- Verified by SYNOPs which were near the CaMa-Flood GRDC stations
- ECMWF stands out with further benefits of MMA (multi-model) especially at short range

ECMWF

Discharge comparison - CRPS - 2009

- ECMWF, UKMO, NCEP and JMA compared with an equal weight combination (MMA) and Bayesian Model Averaging (BMA)
- Global (about 400 GRDC stations) with 00 UTC forecast runs up to 240h for 2009
- Lot smaller differences between TIGGE models (then in EPS performance)
- MMA already improves but BMA shows the real potential for post processing

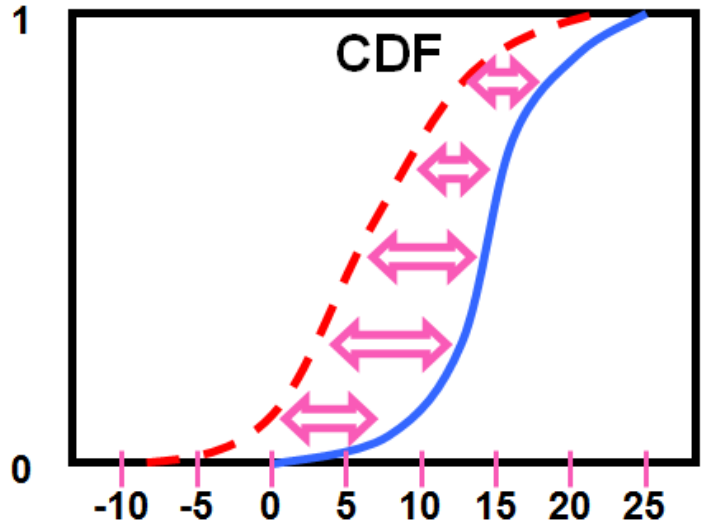


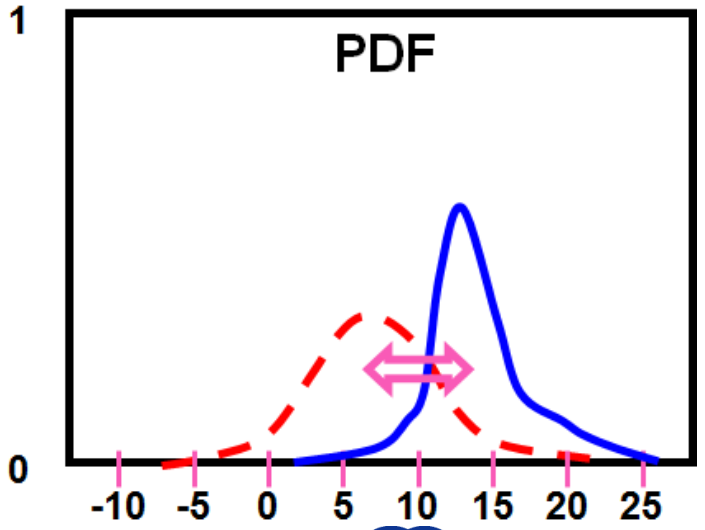
EI+GPCP2 impact on the CRPS

Diff (%)	T+24	T+48	T+72	T+96	T+120	T+144	T+168	T+192	T+216	T+240
ECMWF	0.6	-0.5	-1.4	-2.2	-2.9	-3.6	-4.2	-4.6	-5.0	-5.5

Extreme Forecast Index (EFI)

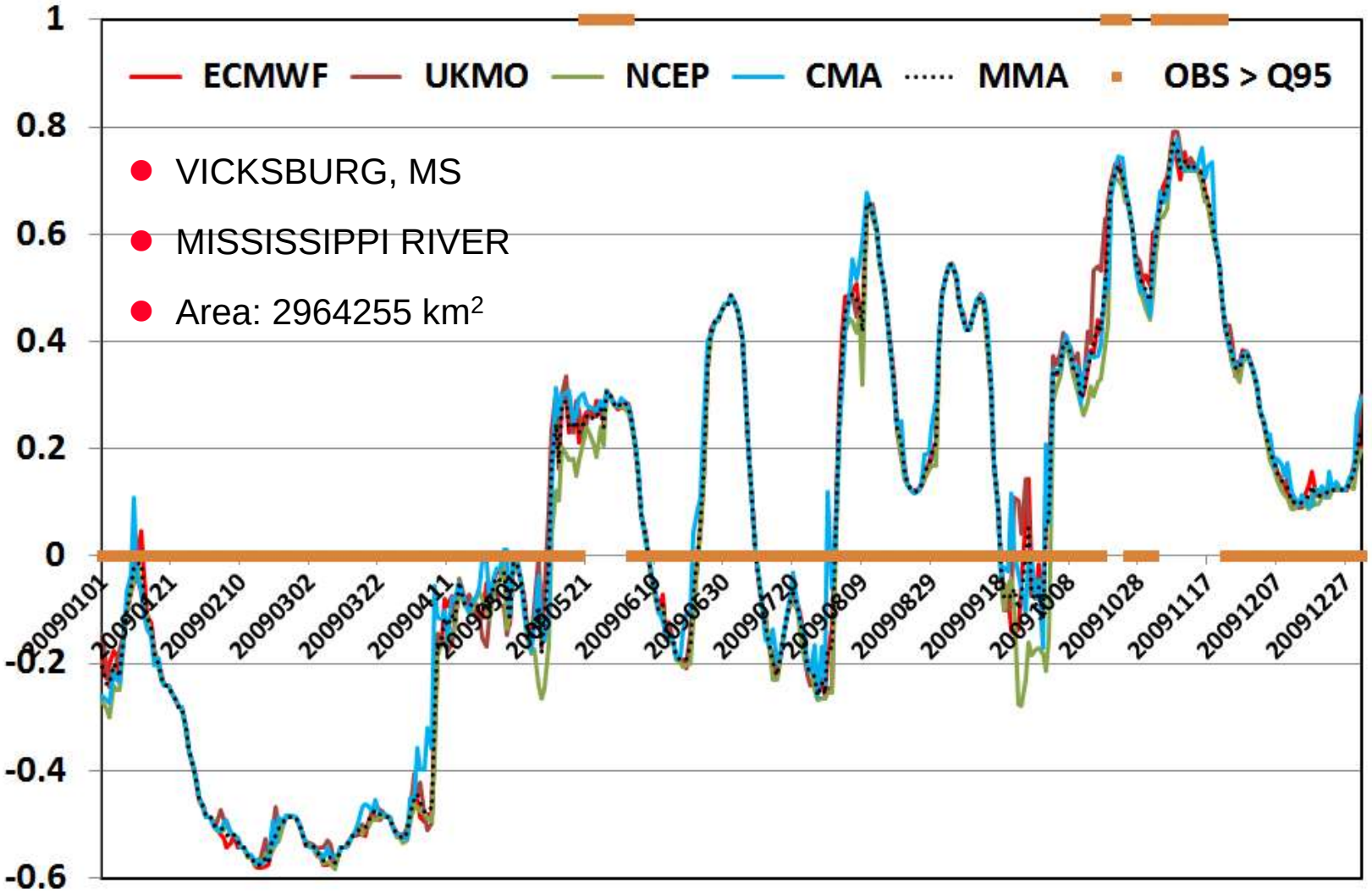
- The EPS system provides HUGE amount of information. The EFI helps to highlight potentially extreme situations in the EPS (EFI range -1 to +1)
- It is defined as an integral (area) between forecast and climate CDFs
- As the definition of extreme weather is strongly climate dependent, the EFI actually provides a way of calibration as it connects the model world to the observed by giving a generic “alarm bell” for extreme situations
- For more details please see: Zsoter, 2006: Recent developments in extreme weather forecasting. ECMWF Newsletter, 107, 8-17.





ECMWF

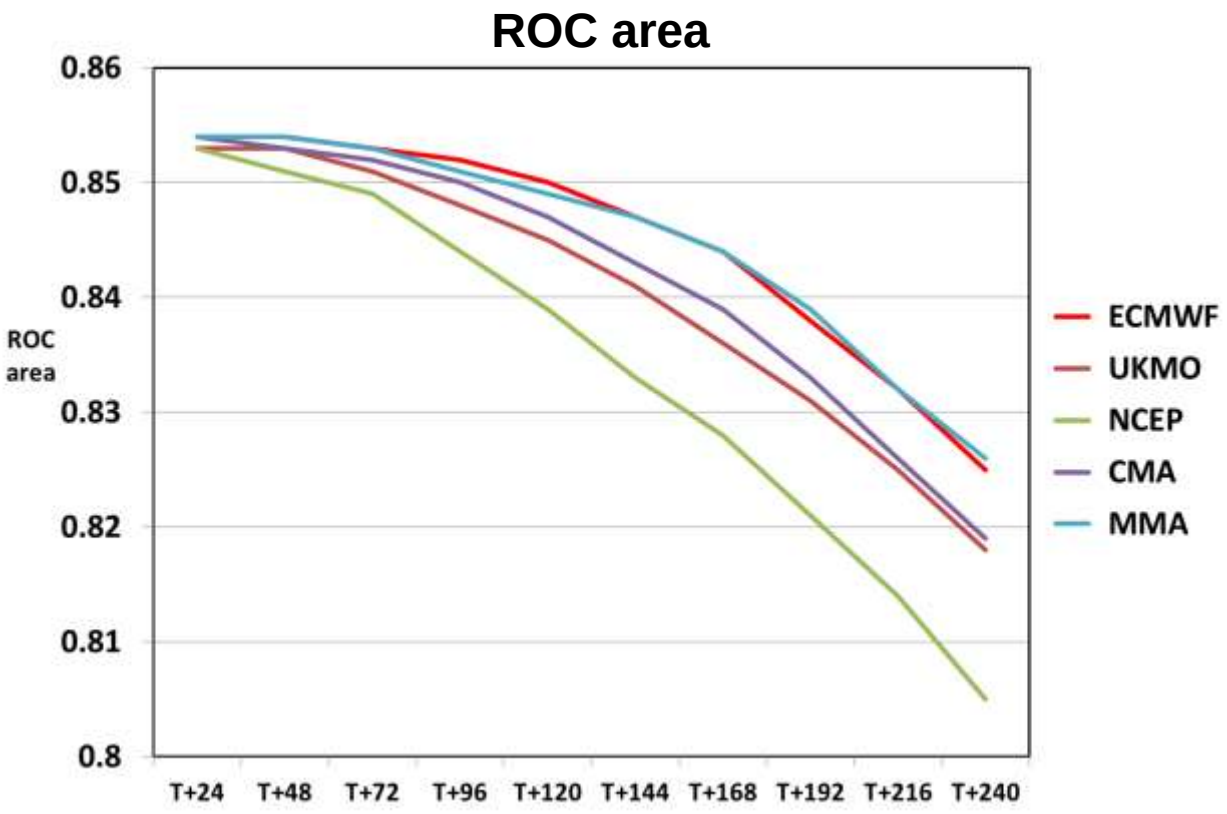
EFI time series example
T+240h - 2009



ECMWF

EFI model comparison 2008-2011

- ROC area of the forcing TIGGE models and the equal weight combination compared
- EFI for discharge is verified
- 00 UTC runs
- Observed event is 95 percentile of the observed discharge climate



- ECMWF/MMA are the best
- Here quite large differences between models

ECMWF

Summary

- Discharge forecasts were produced for TIGGE models in the GEOWOW project
- HTESSEL land-surface model and CaMa-Flood routing were used
- Demonstrating interoperability by providing discharge forecasts and observations through WaterML/SOS/GEO-DAB into GEOSS
- Comparison of four TIGGE models with two multi-model combinations highlighting the potential benefit of model combinations and post processing
- The interoperability and discharge modelling work done in GEOWOW continues in the future at ECMWF in different hydrological applications

ECMWF

Thanks for your attention!

Any questions?

ECMWF