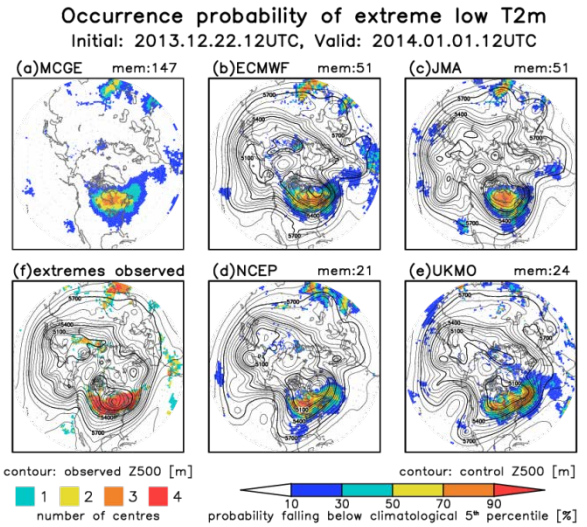
The TIGGE archive

and its applications



Ervin Zsótér

ECMWF, Evaluation Section

with thanks to Richard Swinbank, David Richardson, Florian Pappenberger, Richard Mladek and many others

TIGGE

THORPEX Interactive Grand Global Ensemble

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

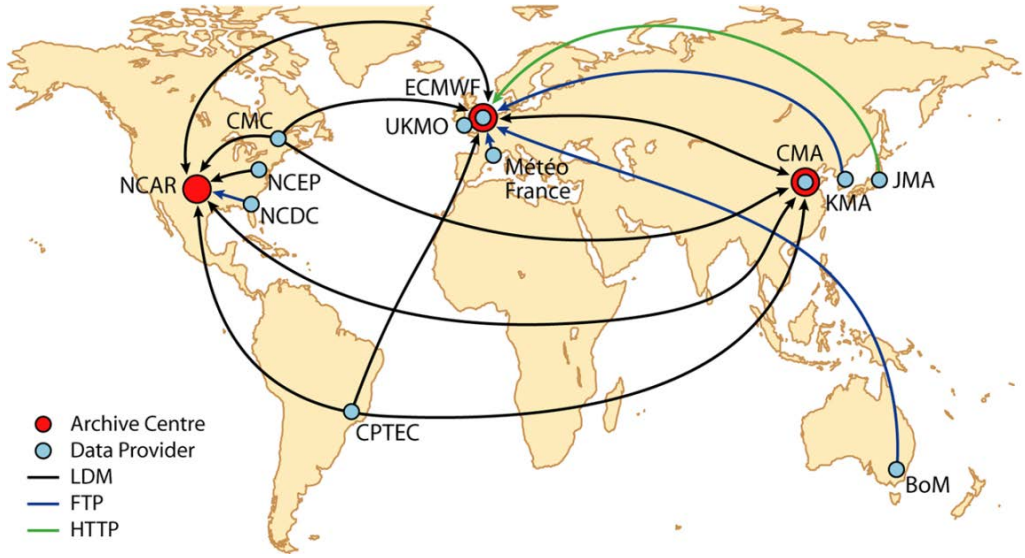
TIGGE objectives:

- Enhance collaboration on ensemble prediction, both internationally and between operational centres & universities.
- Facilitate research on ensemble prediction methods, especially methods to combine ensembles and to correct systematic errors
- Enable evolution towards a prototype operational system, the “Global Interactive Forecast System (GIFS)”

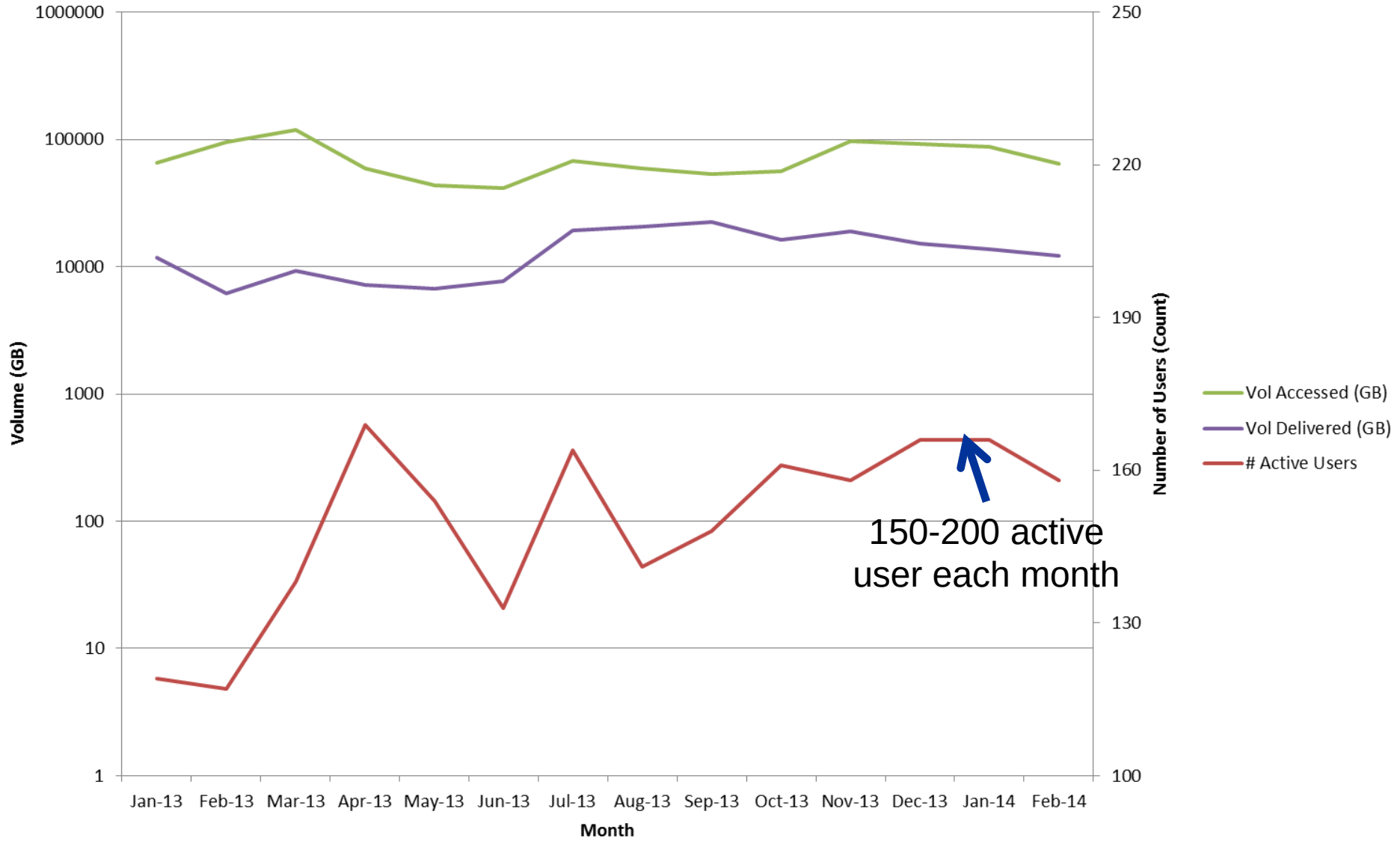
http://tigge.ecmwf.int

TIGGE numbers

- 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
- **<u>TIGGE after 7 years</u>:**
  - ✓ Over 1 Petabyte of data
  - ✓ About 2500 registered users
  - ✓ Over 100 articles related to TIGGE published in the scientific literature



TIGGE Data Usage (all portals)



ECMWF

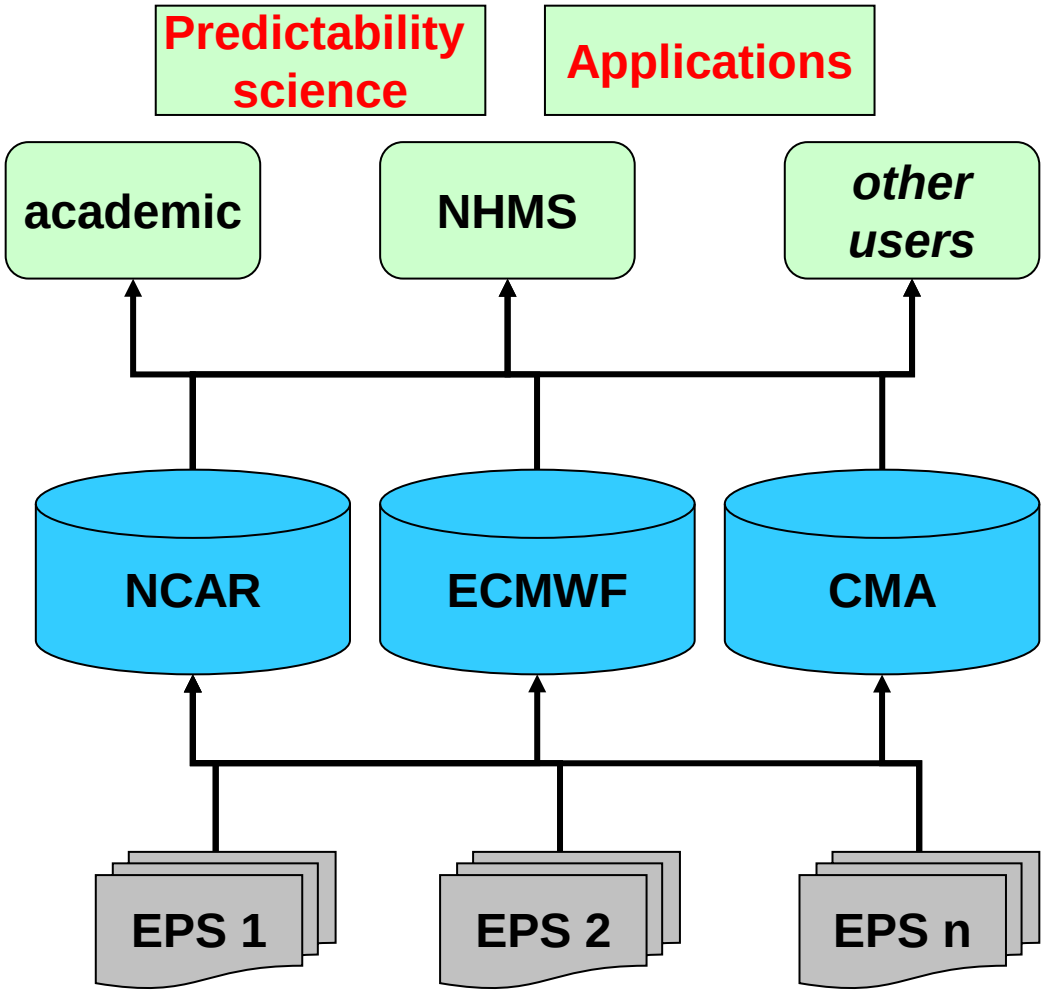
Some technical details of TIGGE

Centre	Ensemble members	Output data resolution	Forecast length	Forecasts per day	Fields (out of 73)	Start date
BoM* (AU)	33	TL119 (1.5°; 210km)	10 day	2	55	10 Mar 07
CMA (CHI)	15	T213 (0.56°; 70km)	10 day	2	60	15 May 07
CMC (CAN)	21	600x300 (0.6°; 75km)	16 day	2	56	10 Mar 07
CPTEC (BR)	15	T126 (0.94°; 120km)	15 day	2	55	1 Feb 08
ECMWF (EU)	51	TL639 (0.28°; 35km) TL319 (0.56°; 70km)	15 day	2	70	1 Oct 06
JMA (JAP)	51	TL479 (0.38°; 40km)	9 day	2	61	1 Oct 06
KMA (KOR)	24	N320 (0.56°; 70km)	10 day	2	46	28 Dec 07
Météo-France	35	TL358 (stretched 2.4)	4.5 day	2	62	25 Oct 07
NCEP (USA)	21	T254 (0.70°; 90km) T190 (0.95°; 110km)	16 day	4	69	5 Mar 07
UKMO (UK)	24	N216 (0.70°; 90km)	15 day	2	72	1 Oct 06

* Delivery of BoM data currently suspended

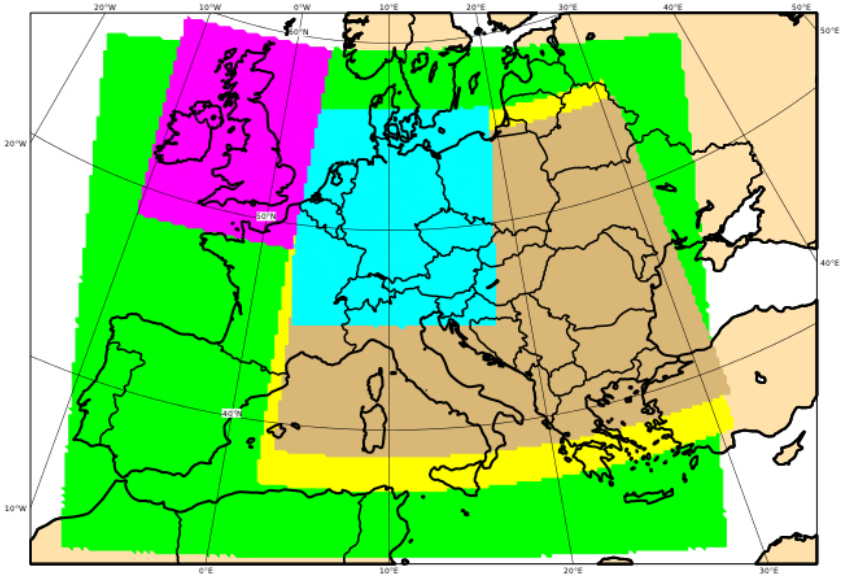
TIGGE features

- All data are archived at native resolution (on native grid when possible)
- Data may be interpolated on any limited-area lat-lon grid defined by the user just before download
- Field names, definitions, units, accumulation times, (etc.) are fully standardized
- Data gaps are continuously monitored and every effort is made to repair them quickly
- All data provided in GRIB2 (WMO standard data format)



TIGGE-LAM archive

- Extension of TIGGE archive with limited area ensemble forecasts (in Europe)
- The first operationally stored dataset was COSMO-LEPS (from 01.01.2013)
- 10 (confirmed) data providers, 5 already operational: MOGREPS, COSMO-LEPS, ALADIN-LAEF, DMI–HIRLAM, GLAMEPS, COSMO-DE-EPS, PEARP, AEMET-SREPS, SRNWP-PEPS, HUNEPS
- GRIB2 format, high priority parameters (MSLP, T2, Wgust, Precip, etc.)



COSMO-LEPS by ARPA-SIMC (on behalf of COSMO)	**GREEN**
ALADIN-LAEF by ZAMG	**BEIGE**
COSMO-DE-EPS by DWD	**CYAN**
MOGREPS by UK Met Office	**PURPLE**
HUNEPS by Hungarian Met Office	**YELLOW**

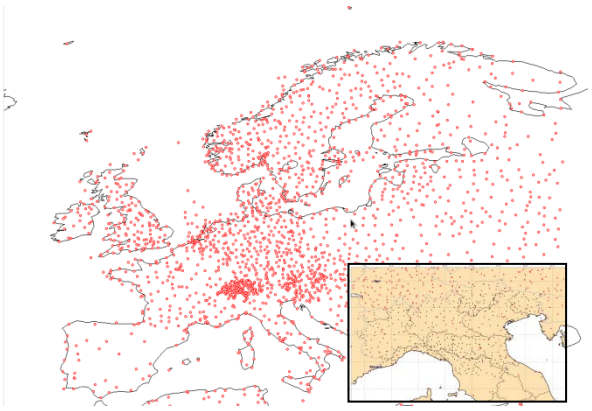
https://software.ecmwf.int/wiki/display/TIGGE/TIGGE-LAM

http://apps.ecmwf.int/datasets/data/tigge_lam/

https://software.ecmwf.int/wiki/display/TIGGE/TIGGE+EPS+time-series+archive

TIGGE and GEOWOW

- **TIGGE-LAM** was originally proposed in 2007 (and supported by the TIGGE-LAM panel) but only recently came to fruition thanks to GEOWOW
- **GEOWOW** (GEOSS interoperability for Weather, Ocean and Water) is a 3-year EU-funded FP7 project ending August 2014
- **GEOWOW's main (weather) objectives:** To improve access to TIGGE weather forecast data and develop and demonstrate products using TIGGE data in collaboration with users in developing countries
  - ✓ TIGGE-LAM
  - ✓ Improve accessibility of key TIGGE data for a wide user community (TIGGE in GEO common Infrastructure and the development of time series archive)
  - ✓ TIGGE data quality (bias, calibration, combination)
  - ✓ Develop and demonstrate (multi-disciplinary) forecast products for high-impact weather in collaboration with WMO Severe Weather Forecast Demonstration Project

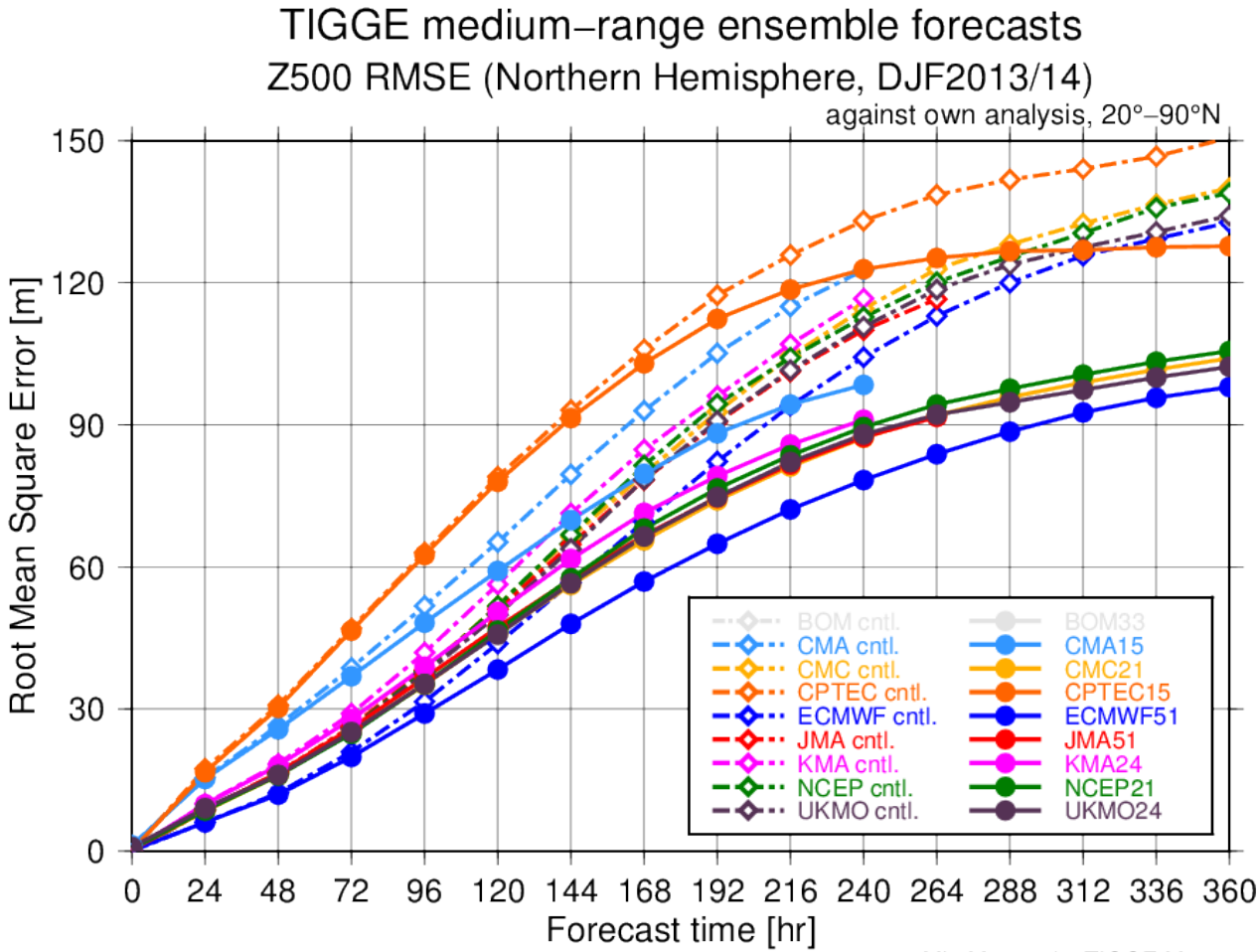


http://www.geowow.eu

TIGGE – focus on research

- 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 data. Topics include:
  - ✓ **Verification of ensemble forecasts** (comparing and documenting performance of the ensembles)
  - ✓ **Calibration of ensemble forecasts** (adaptive and reforecast based methods)
  - ✓ **Combination of ensemble models** (studies on the improved skill, nature of improvements)
  - ✓ **Extratropical cyclones and stormtracks** (representation of cyclones)
  - ✓ **Jetstream variability**, large-scale flow regimes and blocking (understanding and predictability issues)
  - ✓ **Tropical cyclones** (better understanding and prediction of TCs)
  - ✓ **Extratropical transition of tropical cyclones** (impact of transitioning TCs on predictability in downstream regions)
  - ✓ **Madden-Julian Oscillation** (skill, mechanisms, variability)

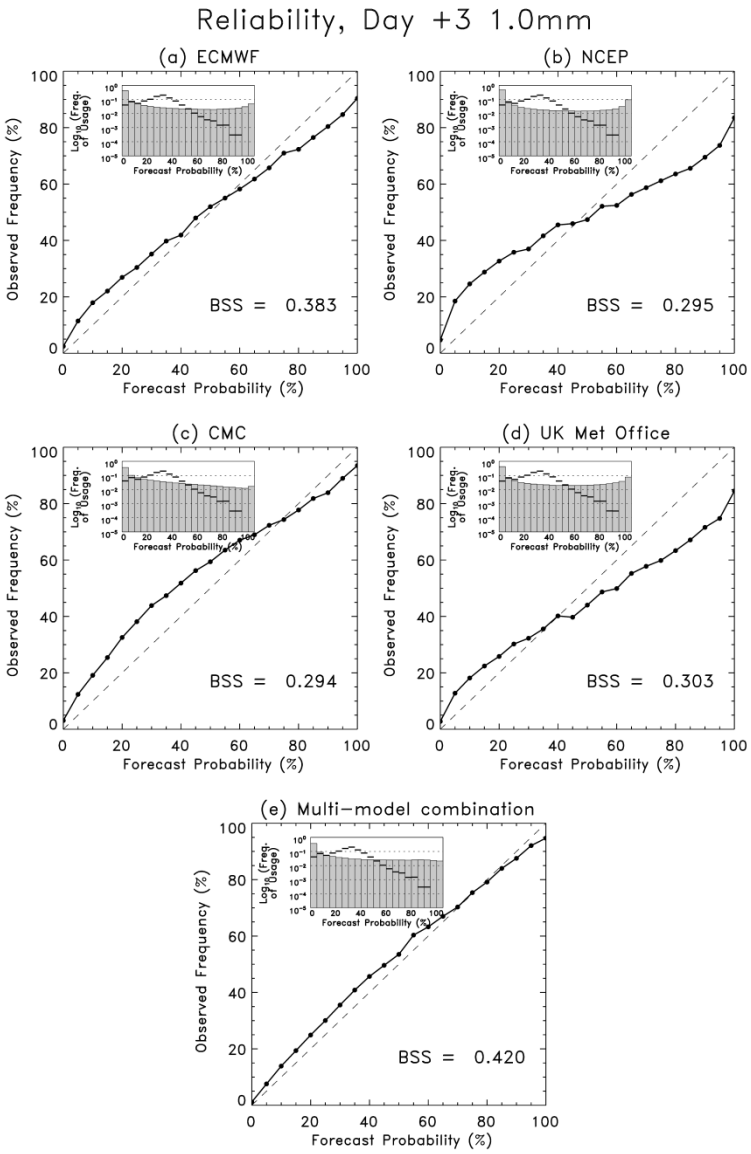
Research examples - verification

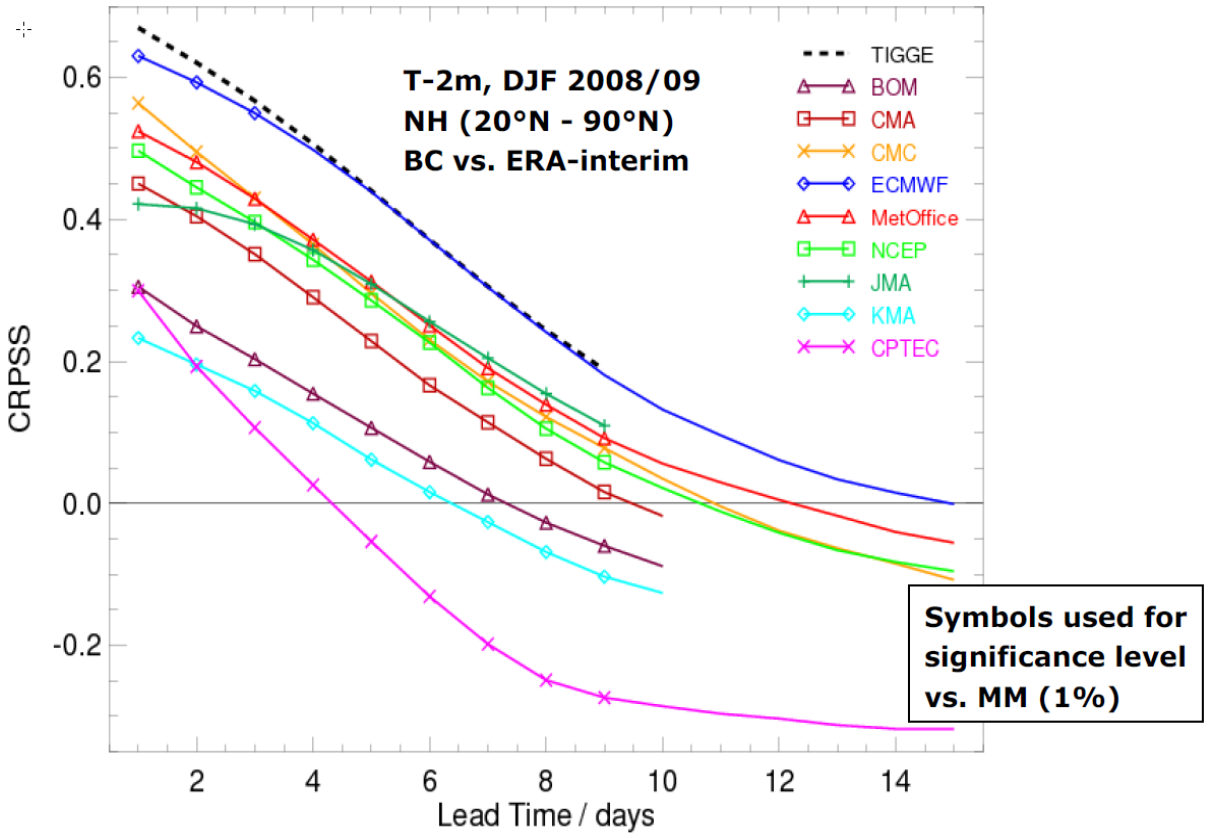


http://tparc.mri-jma.go.jp/TIGGE/

TIGGE skill (RMSE) comparison of 500 hPa in the Northern Hemisphere.
Solid lines: ensemble mean; dashed lines: ensemble control

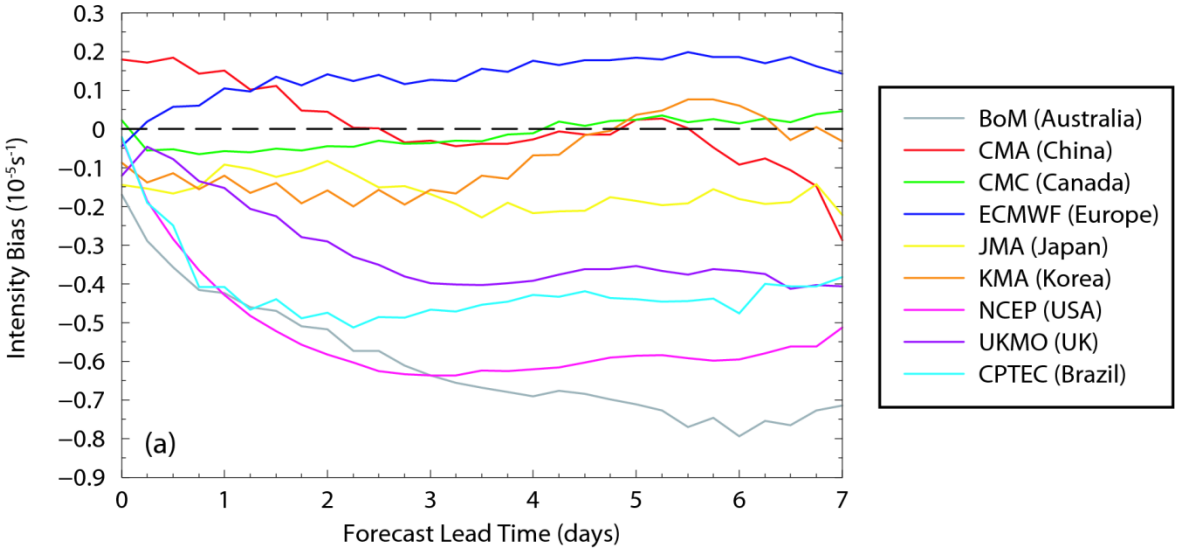
Research examples - combination/calibration

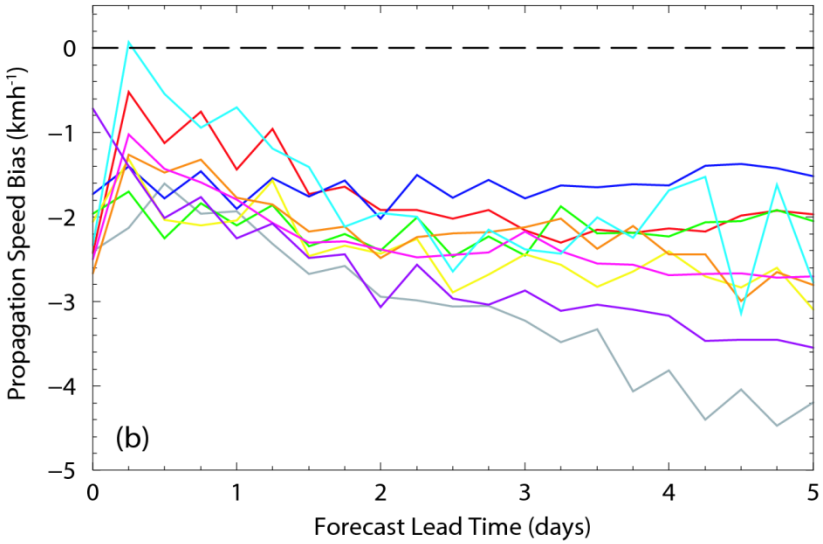




Symbols used for significance level vs. MM (1%)

Research examples - tropical cyclones



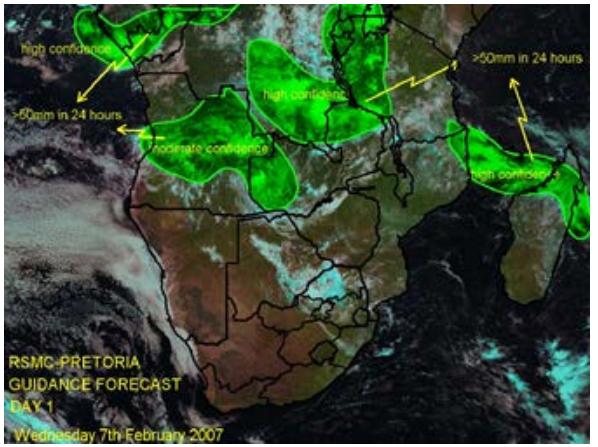


Bias in intensity and propagation speed of cyclones tracked in forecasts from the different TIGGE models as a function of lead time

TIGGE – forecast applications I.

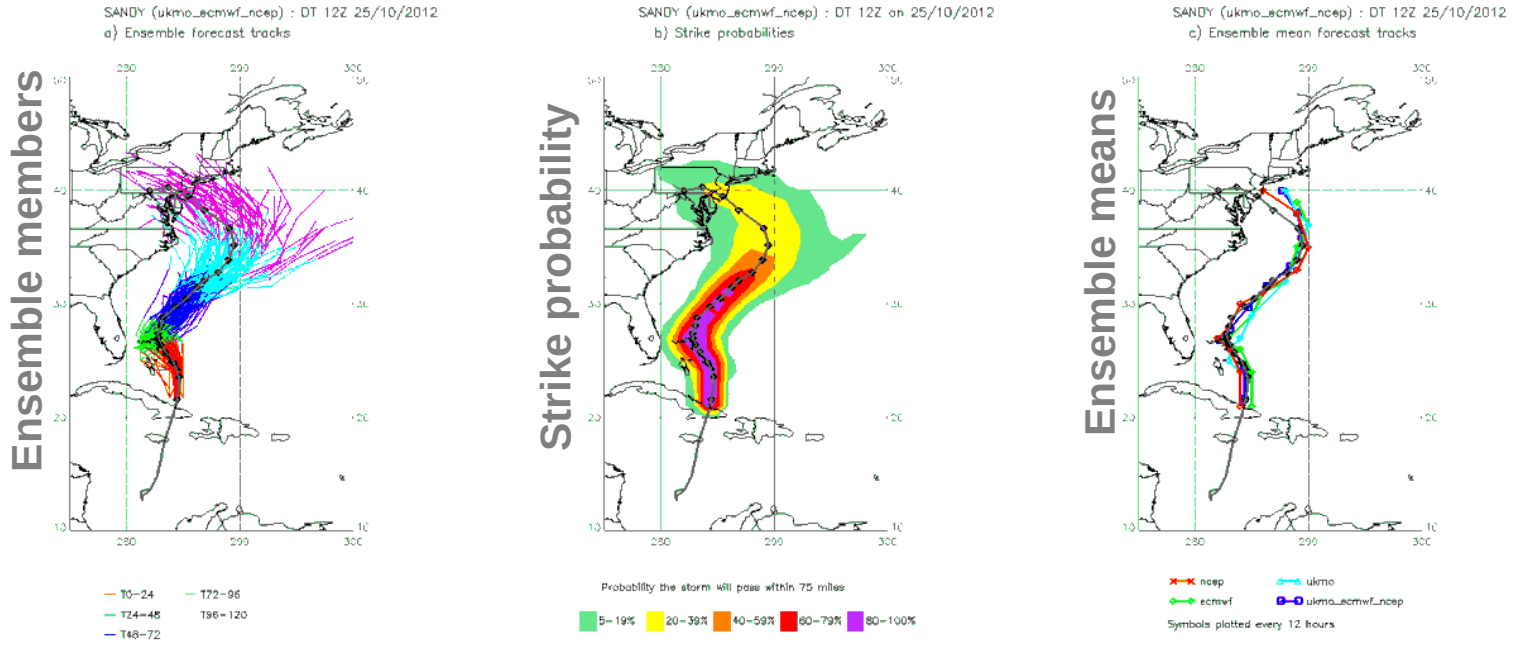
High impact weather forecast products

- TIGGE is not designed for real-time use, but it still has enabled the development and evaluation of many probabilistic products/systems to support forecasts and warnings of high-impact weather. The products are focused mainly on:
  - ✓ Tropical cyclones, Heavy precipitation, Strong winds
- There is also close collaboration with the WMO Severe Weather Forecast Demonstration Project (**SWFDP**) and other projects
  - ✓ To ensure that products address needs of operational forecasters and end users
  - ✓ To provide an environment for the evaluation of prototype products



TIGGE - Tropical Weather Forecasting

- One of the first success stories was the set up of the exchange of real-time tropical cyclone predictions using “Cyclone XML” format (T-PARC, NWP-TCEFP)
- New multi-model TC products provide forecasters with additional information on the forecast uncertainty and increase the level of confidence in the forecasts
- Several types of products to support TC forecasting have been developed
- Example of combined TC track forecasts (ECMWF, UKMO, NCEP) for Hurricane Sandy



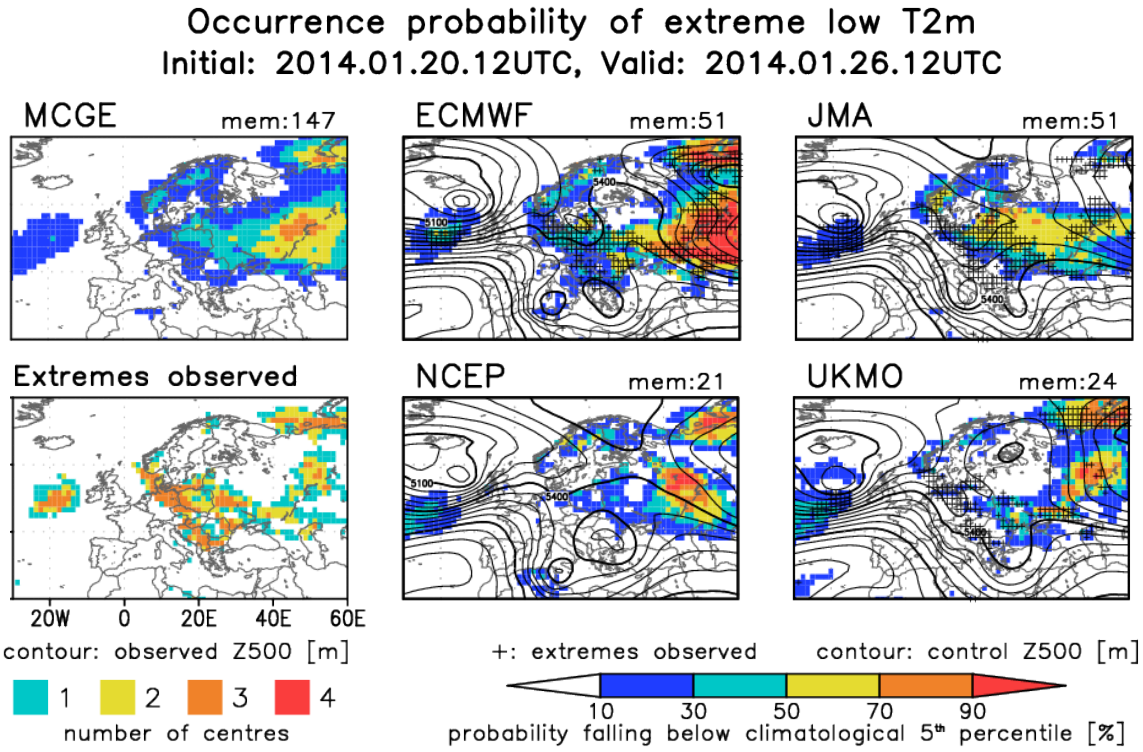
TIGGE – Severe Weather Warning Products

- More recently, prototype severe weather products have been developed based on gridded forecast data (Matsueda and Nakazawa)

- These early warning products for both single-model (ECMWF, JMA, NCEP, and Met Office) and multi-model grand ensembles highlight risk of heavy rainfall, strong winds and severe high/low temperatures

- The products are available with a 2 day delay at http://tparc.mri-jma.go.jp/TIGGE/tigge_extreme_prob.html, as part of the "**TIGGE Museum**"

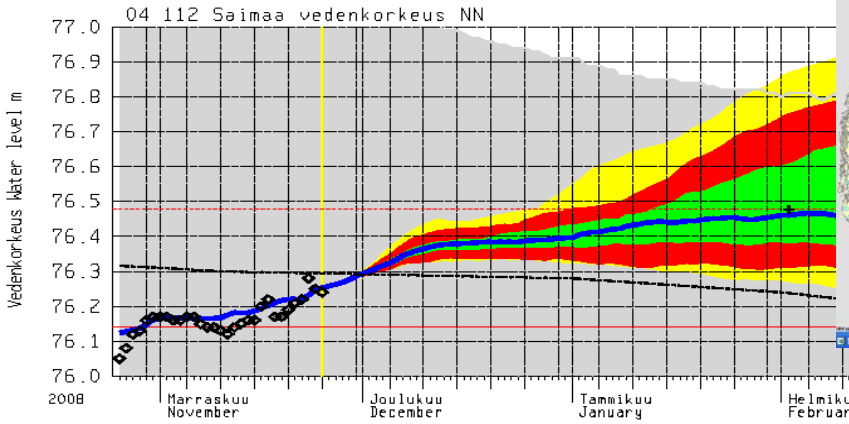
- **GEOWOW** supports trial, evaluation and provision of these products (including also the TC products) to the WMO SWFDP in real time

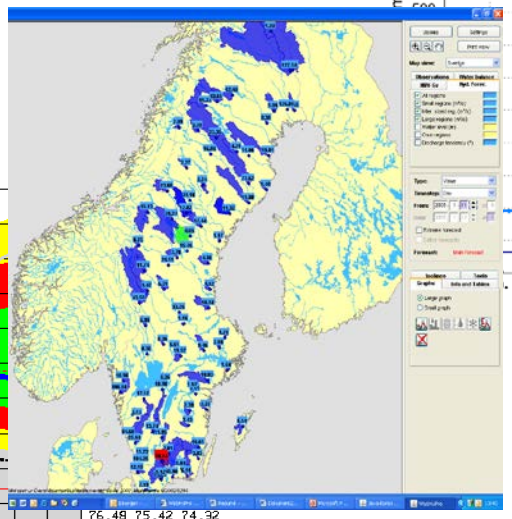


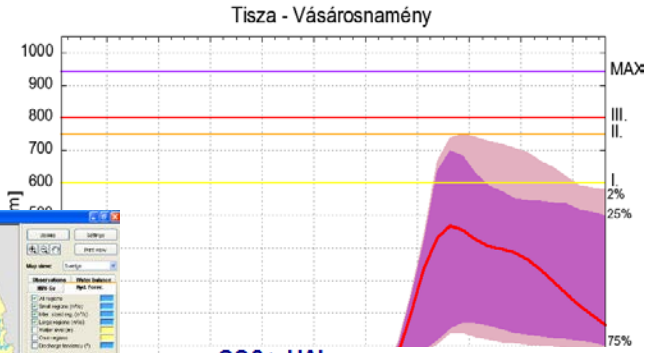
TIGGE – forecast applications II.

Hydrological forecasting

- The multi-model approach and the use of ensembles is well established and quite popular in hydrological forecasting and modelling (see e.g. HEPEX)
- TIGGE models have been used extensively by hydrological forecasters in flood forecasting
- More than 10 publications using TIGGE data
- Systems like EFAS / GloFAS, etc.
- Number is growing fast







COS > HAL

Forecast Day	23	24	25	26	27	28	29	30
2009012312		7	16	16	16			
2009012412		1	16	16	16	16		
2009012512			5	14	16	16	16	
2009012612					15	15	14	11

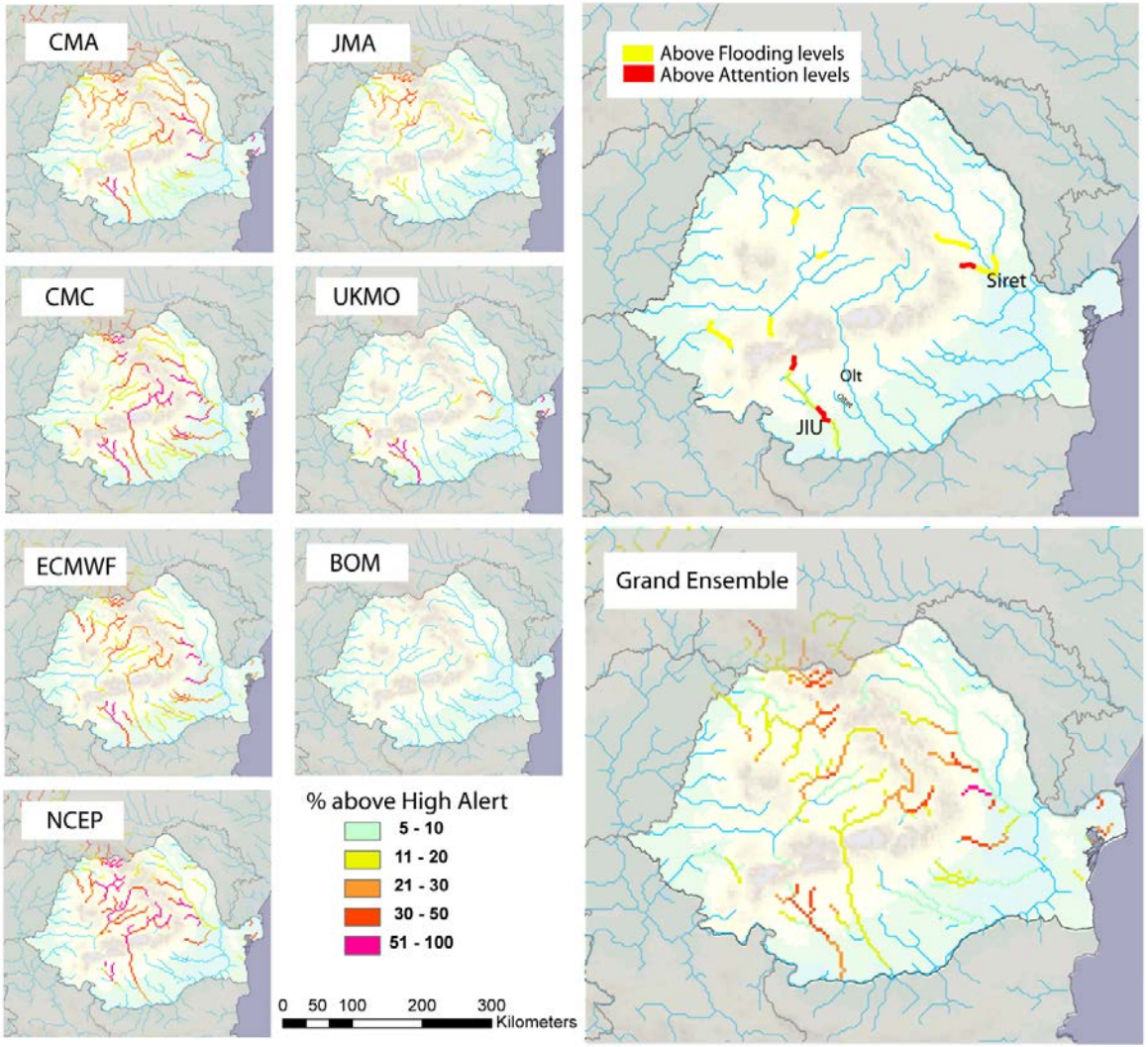
COS > SAL

Forecast Day	23	24	25	26	27	28	29	30
2009012312			10	16	16			
2009012412			4	10	16	16		
2009012512					14	14	11	
2009012612					1	1	1	1

TIGGE - Hydrological forecasting

Case study in Romania:

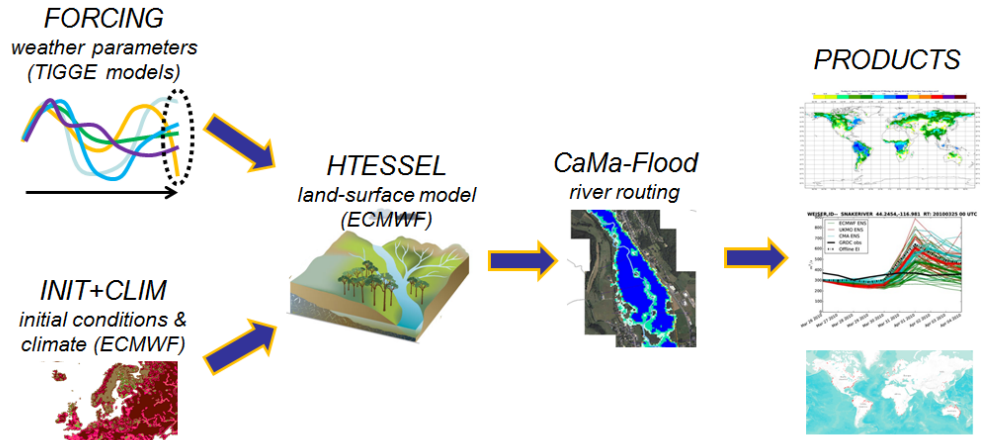
- The first published example using TIGGE in hydro-meteorological forecasting environment was by Pappenberger et al. (2008, GRL)
- TIGGE models where used within the setting of the European Flood Awareness System (EFAS) for a case study in Romania (October 2007)
- Warning maps: Some individual centres clearly over predict others significantly under predict

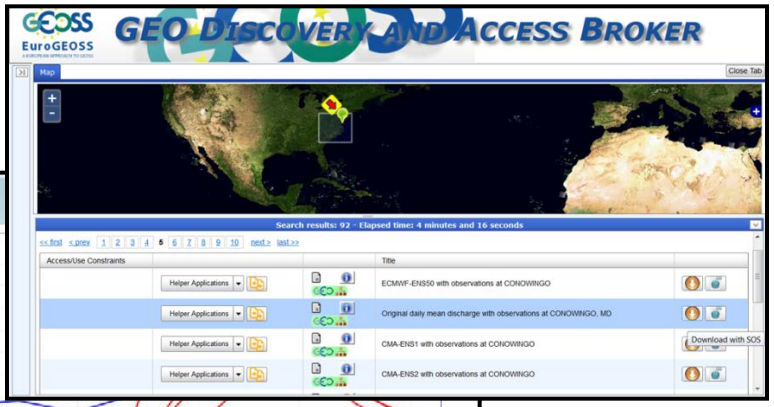


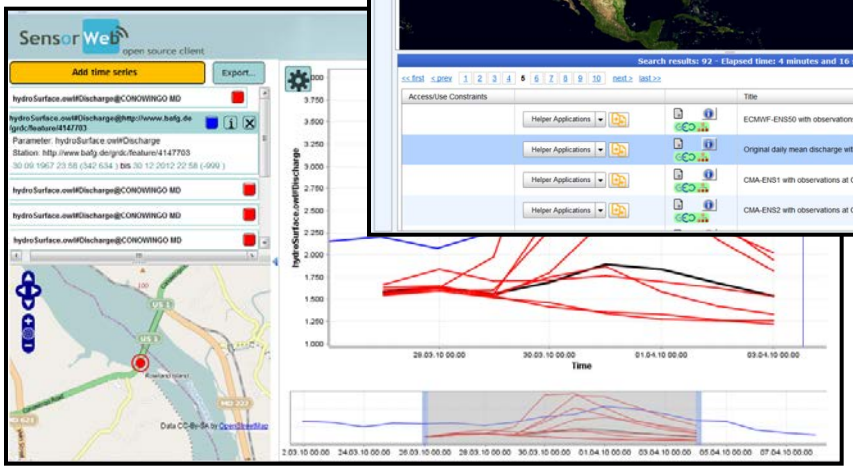
TIGGE - Hydrological forecasting

Discharge modelling in GEOWOW:

- River runoff ensemble forecasts are produced with the HTESSEL land-surface model (operationally used at ECMWF)
- CaMa-Flood river routing is coupled to integrate runoff over river catchments
- The discharge forecasts are validated and verified with GRDC (Global Runoff Database) stations
- This multidisciplinary work in GEOWOW provides an interactive platform for the investigation of river discharge data
- It is integrated into the GEOSS Common Infrastructure (GCI) with the SOS/WaterML and the GEO-DAB







http://www.geoportal.org/web/guest/geo_home

TIGGE - Summary and Future

- The TIGGE project is a major component of the THORPEX research program
- Since October 2006, the TIGGE archive has been accumulating regular ensemble forecasts from leading global NWP centres
- TIGGE is currently being extended with limited area ensembles (TIGGE-LAM) which will provide an invaluable platform to improve high resolution prediction of high-impact weather at short range
- TIGGE has provided an invaluable dataset for research on ensemble techniques, predictability and dynamics of weather systems
- Over 100 research papers using TIGGE data, more than 2500 registered users
- TIGGE facilitated development of probabilistic products for forecasting tropical cyclones and other severe weather events (single- and multi-model grand ensembles)
- TIGGE contributed a lot in helping probabilistic forecasting with ensembles becoming a standard part of the operational weather forecasting of high impact events
- The TIGGE archive has been of incredible value for research in hydro-meteorological forecasting, the combination of ensemble and high-resolution deterministic forecasts has been demonstrated to lead to significantly improved skill for flood forecasting

TIGGE - Summary and Future

- TIGGE will continue after the end of THORPEX (ends 2014)
- New Polar Prediction Project (PPP) to Promote cooperative international research enabling development of improved weather and environmental prediction services for the polar regions, on time scales from hours to seasonal
- New High-Impact Weather (HIW) project to continue some of THORPEX R&D, with more of a focus on short-range convective-scale resolution
- Subseasonal to Seasonal Prediction Project (S2S) will extend TIGGE concept to sub-seasonal range (include forecasts and reforecasts)