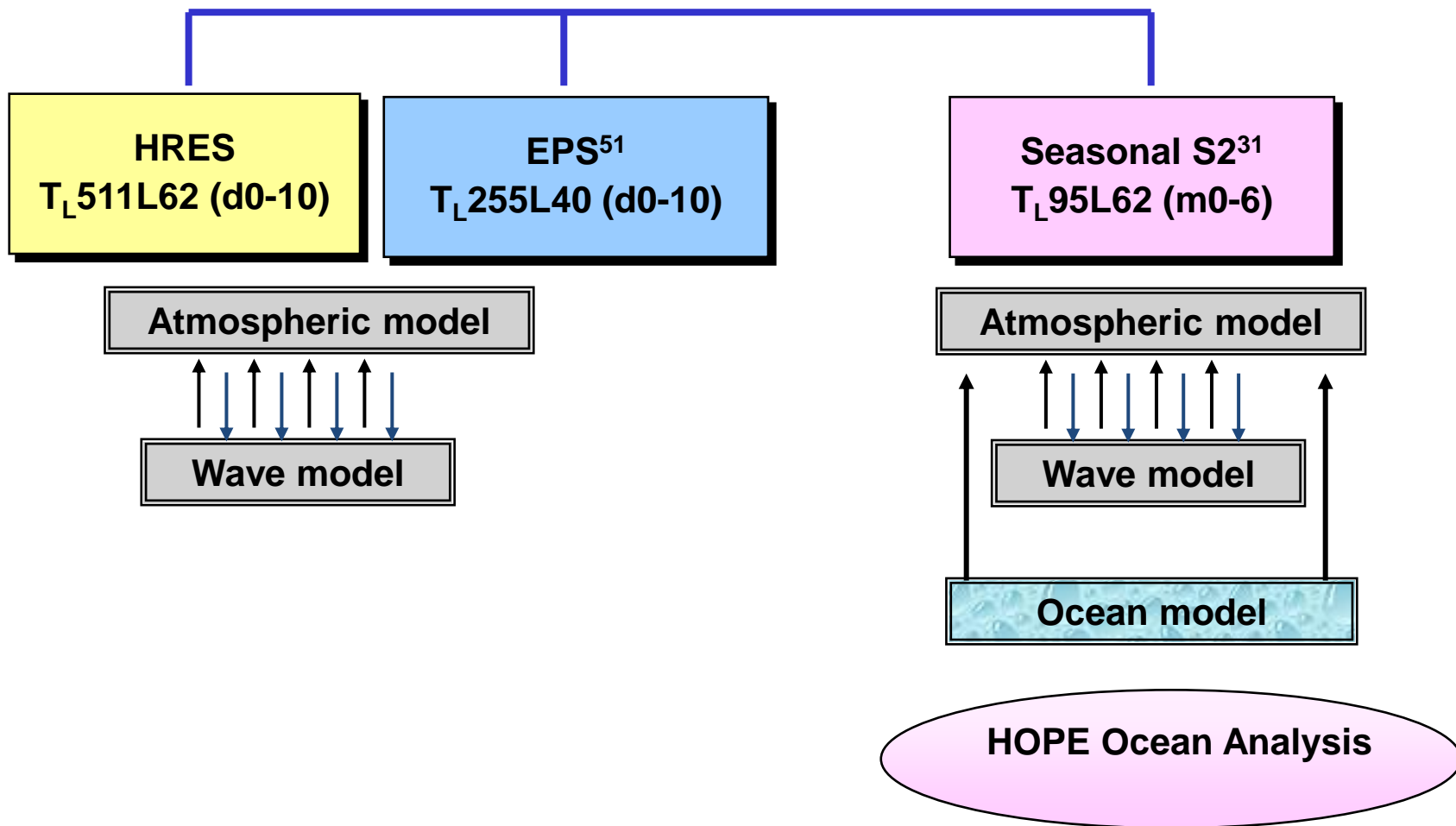# A decade of HEPEX: what have we achieved? An 'atmospheric' perspective

Roberto Buizza

European Centre for Medium-range Weather Forecasts
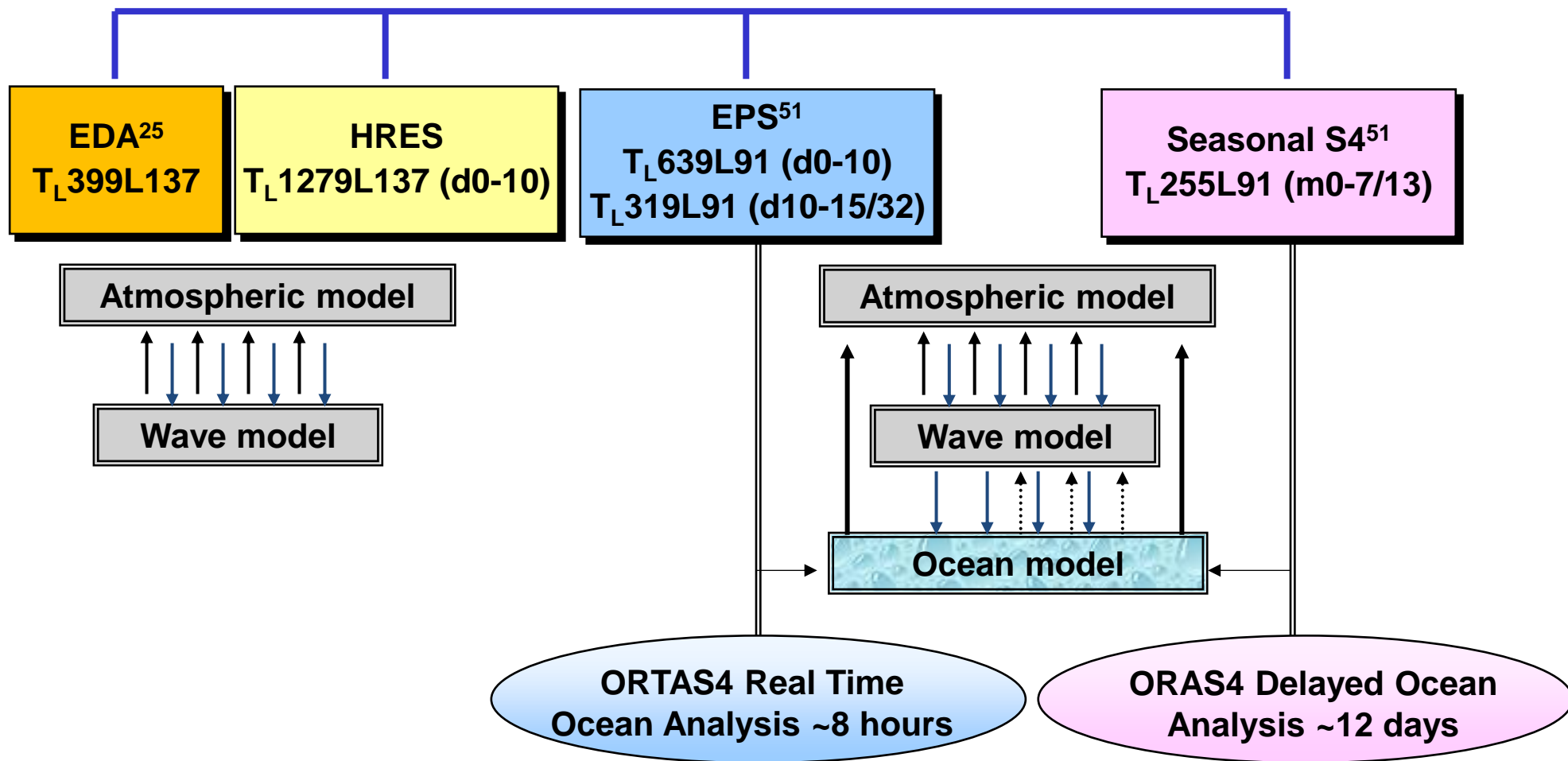
ECMWF operational suite in 2004

HRES
$T_L 511 L62$ (d0-10)

EPS[51]
$T_L 255 L40$ (d0-10)

Seasonal S2[31]
$T_L 95 L62$ (m0-6)

Atmospheric model

Wave model

Atmospheric model

Wave model

Ocean model

HOPE Ocean Analysis

# ECMWF operational suite in 2014

Major changes

- **Model**:
  - Higher resolution (50>16km; 100>32km)
  - Better physics (eg convection, land, stochastic schemes, ..)
  - Coupling to ocean from d0
- **Data assimilation methods**:
  - Use of hybrid (EDA+4DVAR) to take flow dependency into account
  - Use of ensembles for ocean and atmosphere to estimate initial unc.
- **Forecast length**:
  - ENS extended to 32d
  - S4 extended to 7m (13m every quarter
- **Products**:
  - Re-forecast suites to estimate model climate and generate better products
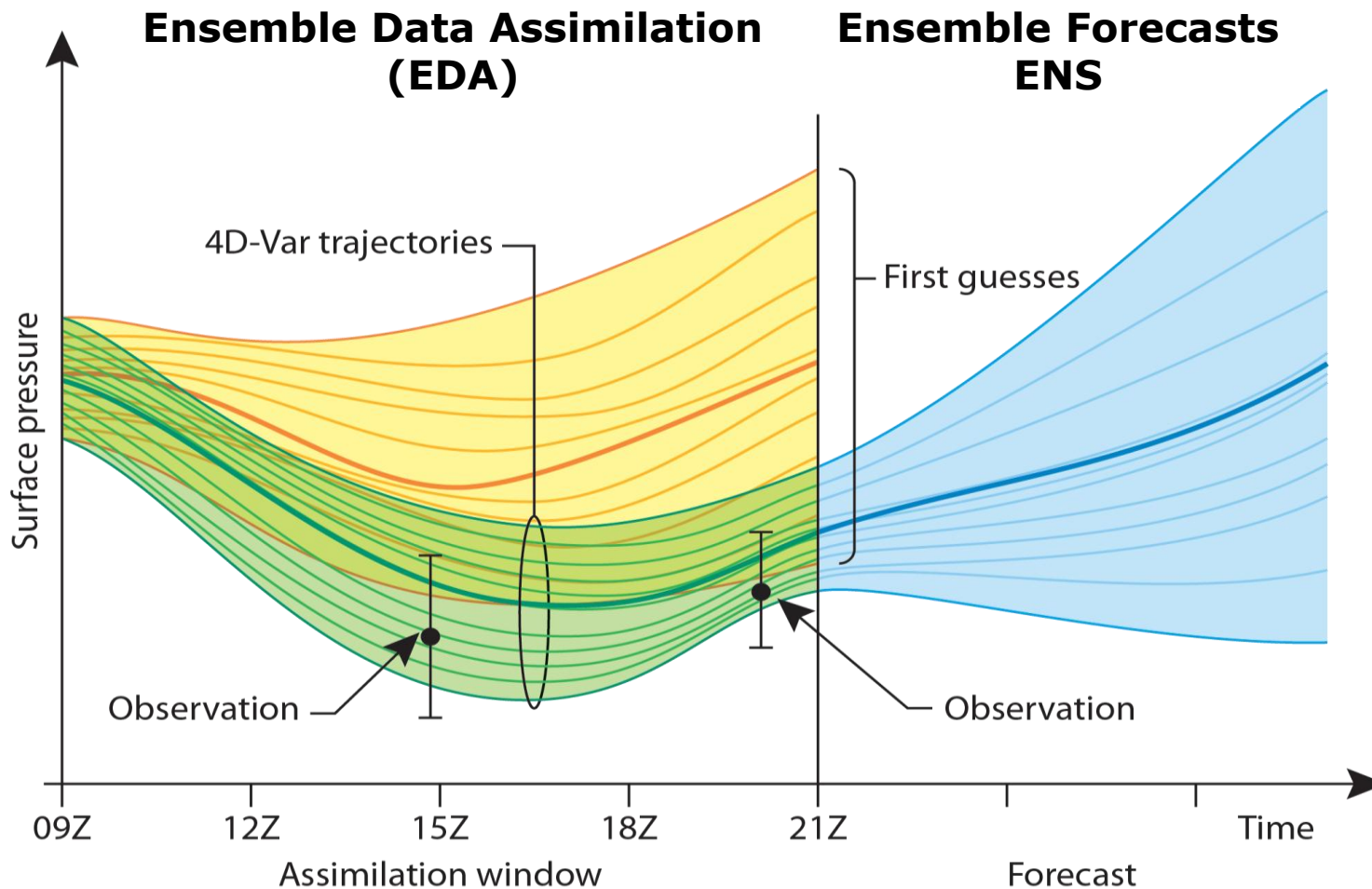

ENS orography in 2004
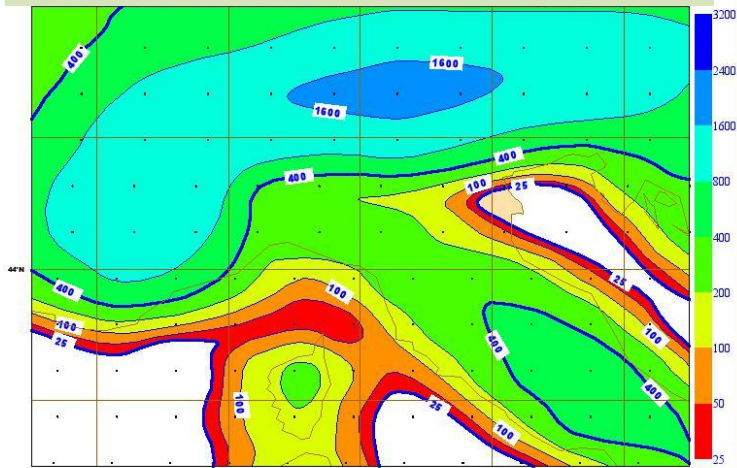
ENS orography in 2014
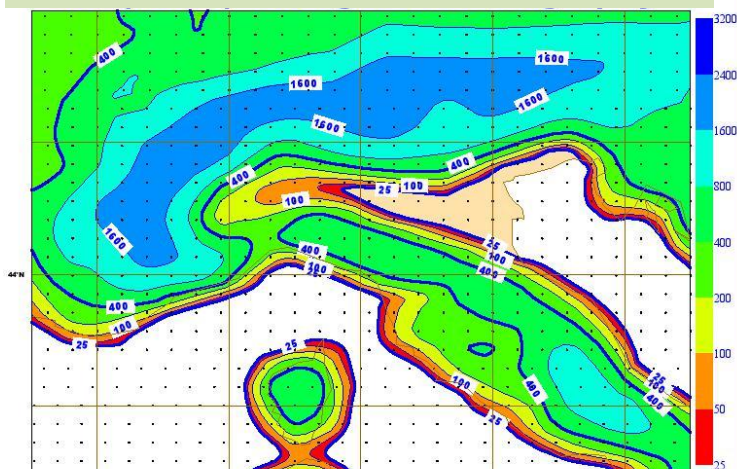
One the major changes: ensembles at initial and fc times

Ensembles are a practical tool to compute the most likely scenario and its uncertainty, expressed in the form of a PDF or probabilities of occurrence of different states, both at initial and forecast times.

Following *Thomas Hamill* work, a re-fc suite is part of all ECMWF ensemble systems. Each day, the M-climate is estimated using **500 EPS re-forecasts**:

- 20 years (1994 – 2013)
- 5 ICs (-14d,-7d,0,+7d, +14d)
- 5 members

Some of the ENS products (e.g. the Extreme Forecast Indices) are bias corrected and/or calibrated using the model climate.
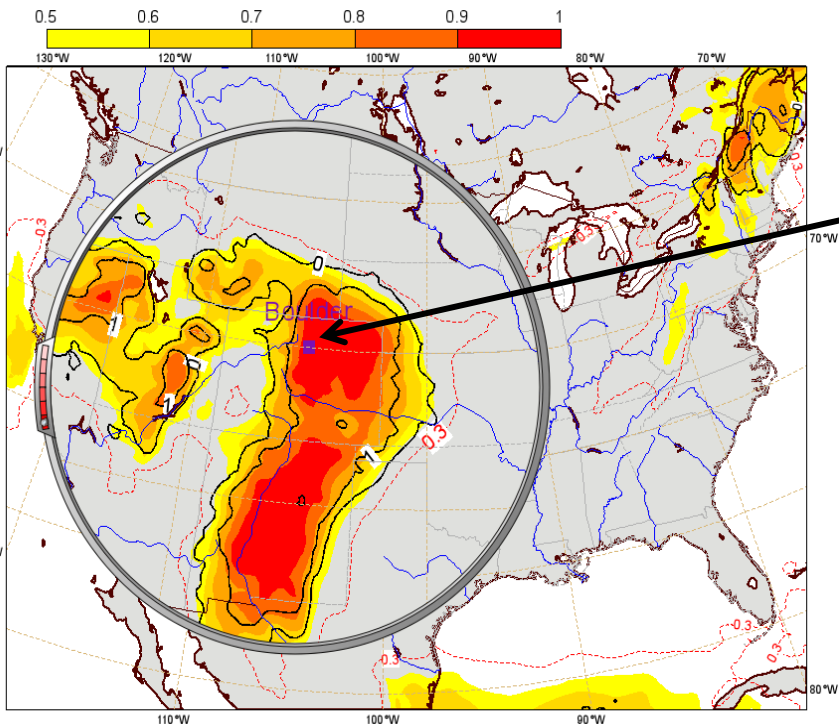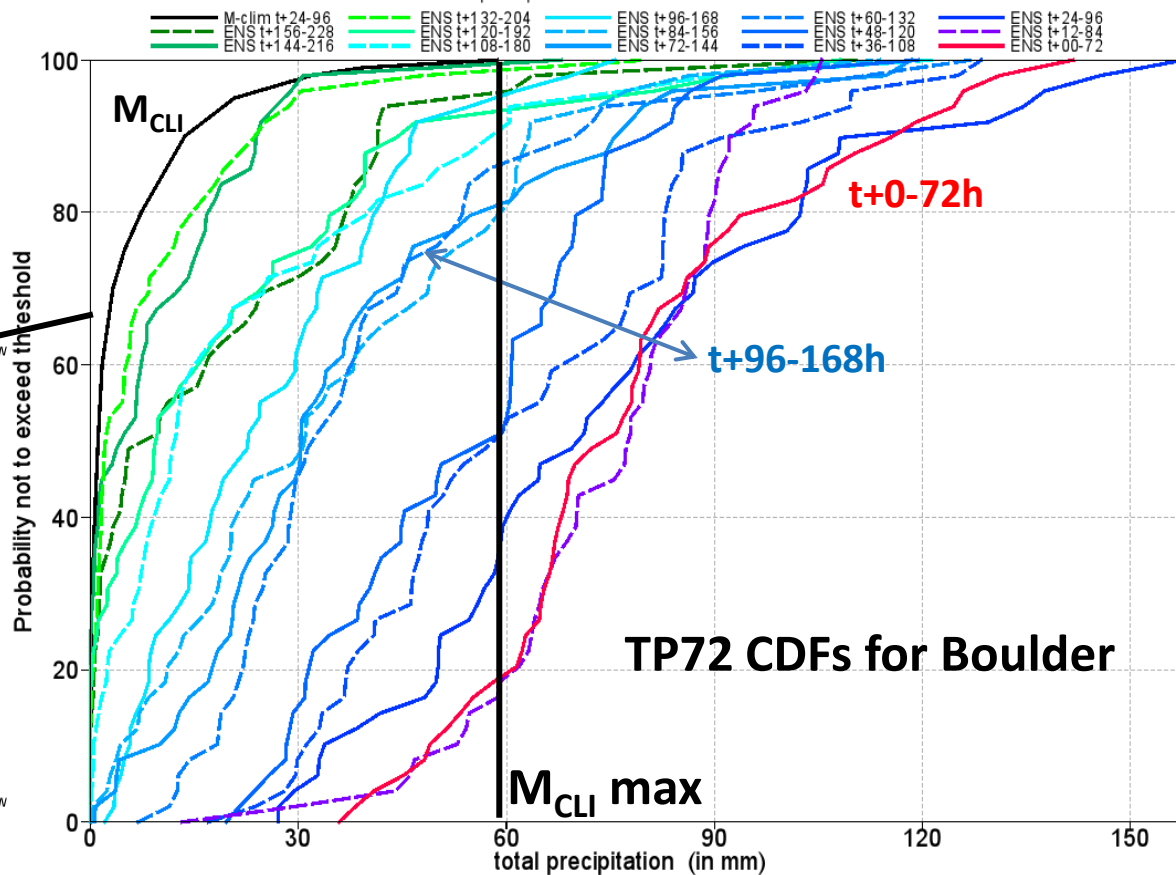

...28   6   13   20   27 March ...

2014 — 51 T639 L91 / 51 T319 L91

2013

20y

2012

2011

.....

1994
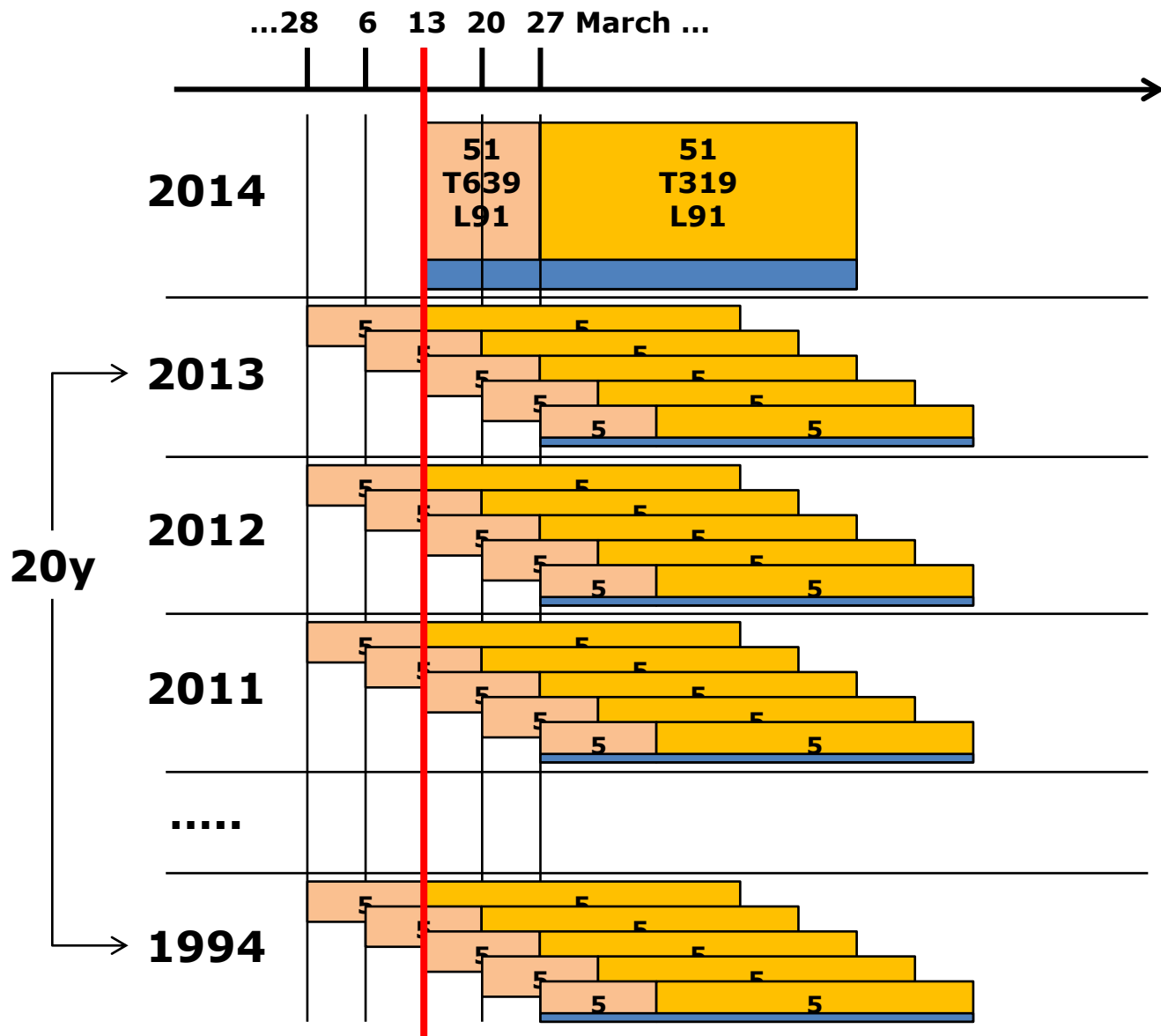
© ECMWF

ENS t+0-72h Extreme Forecast Index

Wed 11 Sep 2013 00UTC @ECMWF VT: Wed 11 Sep 2013 00UTC - Sat 14 Sep 2013 00UTC 0-72h
Extreme forecast index and Shift of Tails (black contours 0,1,5,10,15) for: total precipitation

Cumulative Distribution Functions for total precipitation at 40.02°/-105.29° VT: 11/09/2013 00UTC - 14/09/2013 00UTC

— M-clim t+24-96	— — ENS t+132-204	— — ENS t+96-168	— — ENS t+60-132	— — ENS t+24-96
— — ENS t+156-228	— — ENS t+120-192	— — ENS t+84-156	— — ENS t+48-120	— — ENS t+12-84
— — ENS t+144-216	— — ENS t+108-180	— — ENS t+72-144	— — ENS t+36-108	— ENS t+00-72

M_{CLI}

t+0-72h

t+96-168h

TP72 CDFs for Boulder

M_{CLI} max

The EFI reached high values (approaching 1) in the last few forecasts preceding the onset of the event, with ~10% of the ENS members predicting rainfall beyond the climate extreme (99th percentile of the model climate).

(From Ivan Tsonevski)

Synoptic scales: scores' trends (Z500 NH)

Results indicate predictability gains of 1.5-2.0 days per decade.

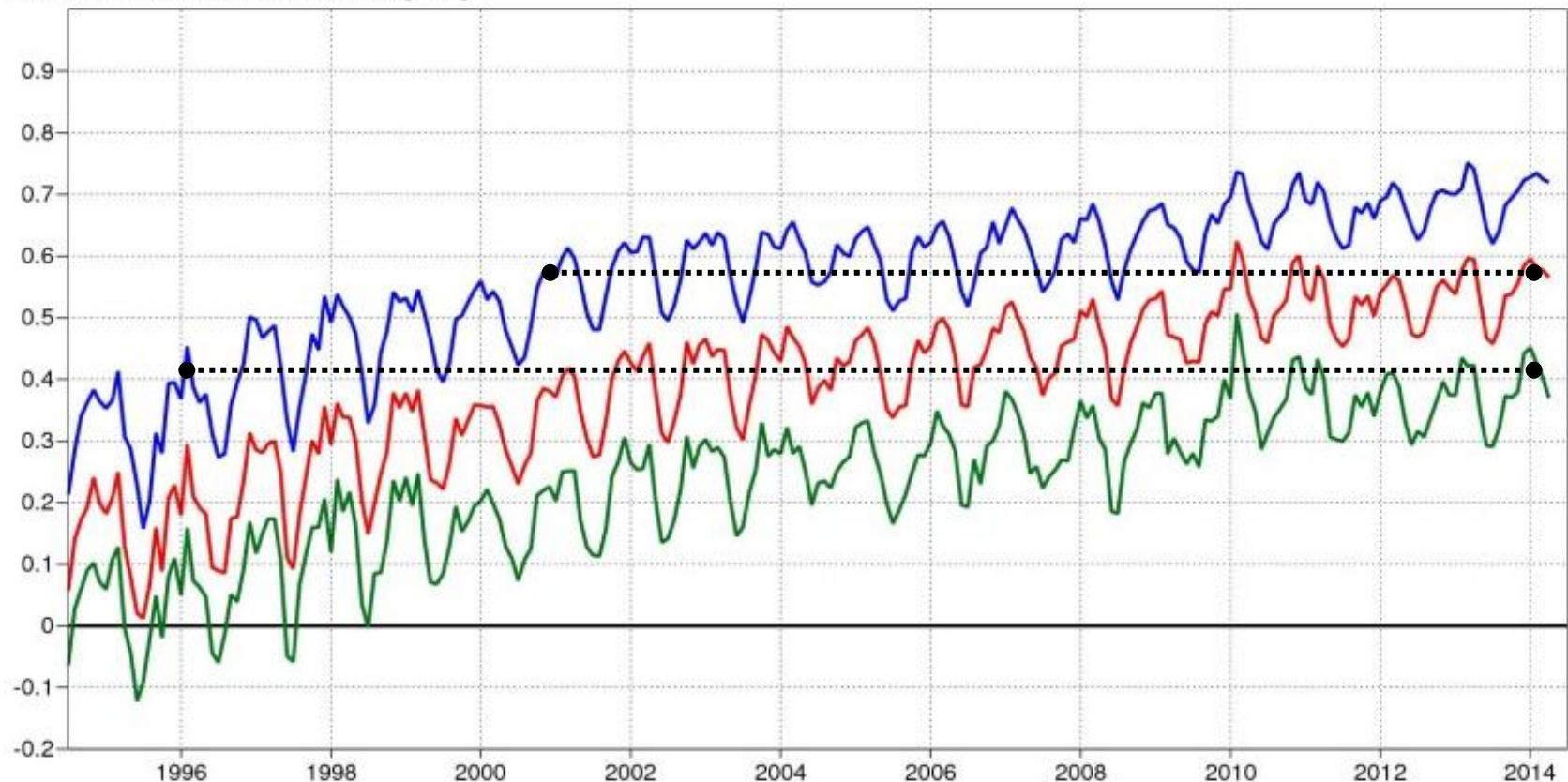850hPa temperature
Continuous ranked probability skill score
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)

———— T+168
———— T+120
———— T+72
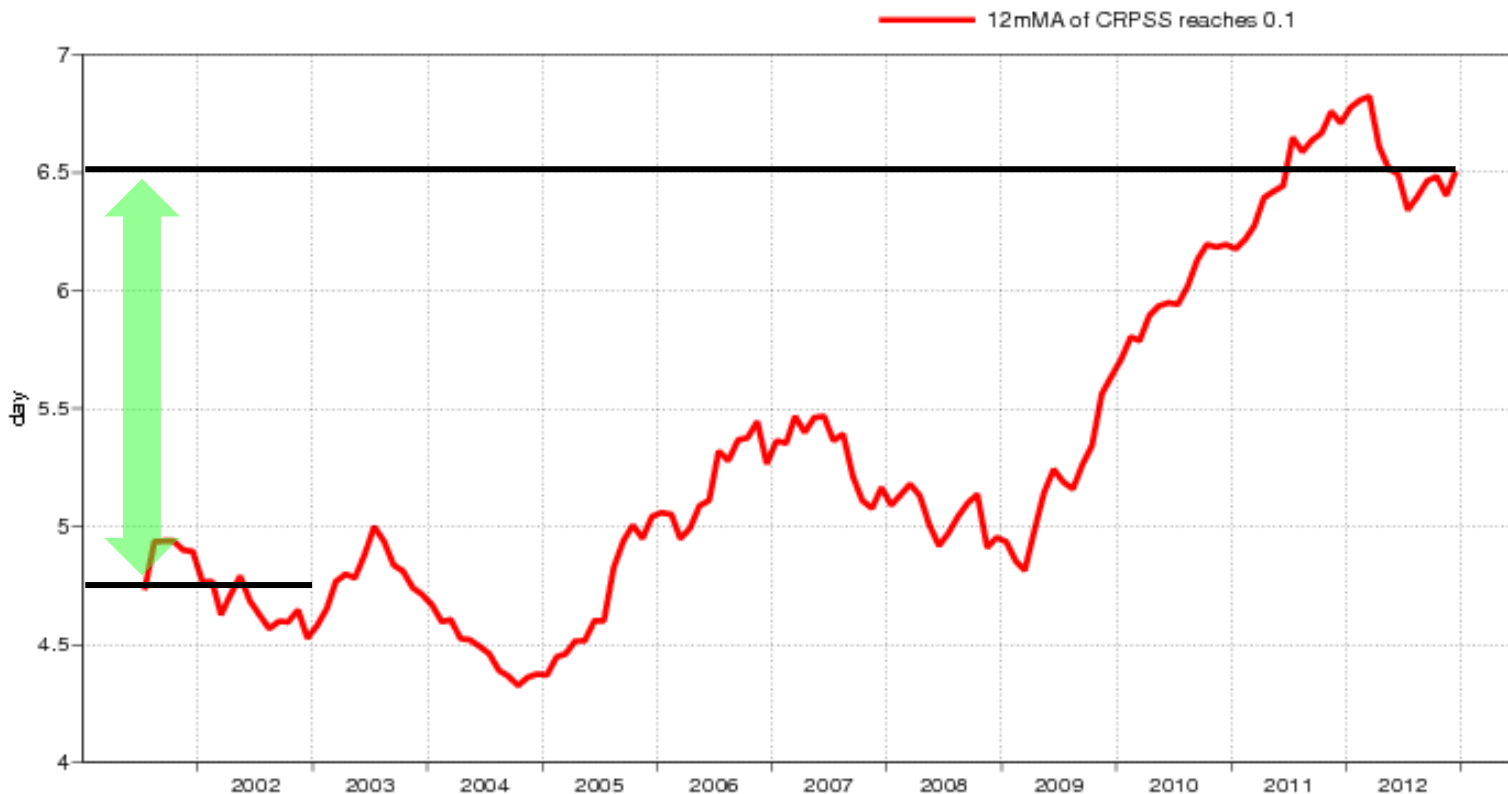
oper_an od enfo 0001 | 00UTC,12UTC,beginning

Precipitation forecasts: scores evolution

Similar, although smaller in size, improvements can be seen by looking at 24h total precipitation, with skill gains of about 1.75 days between 2001 and 2012.

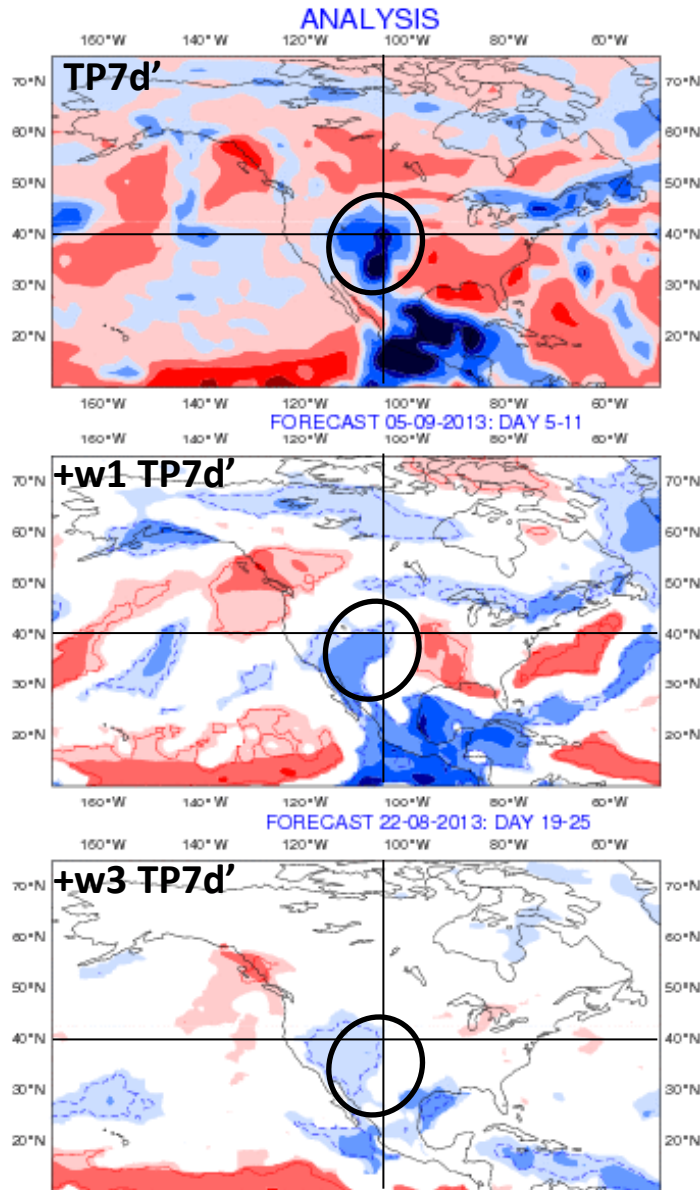The plot shows the forecast lead time when CRPSS crosses a 10% value.

ECMWF EPS 12UTC forecast skill
total precipitation
Continuous ranked probability skill score
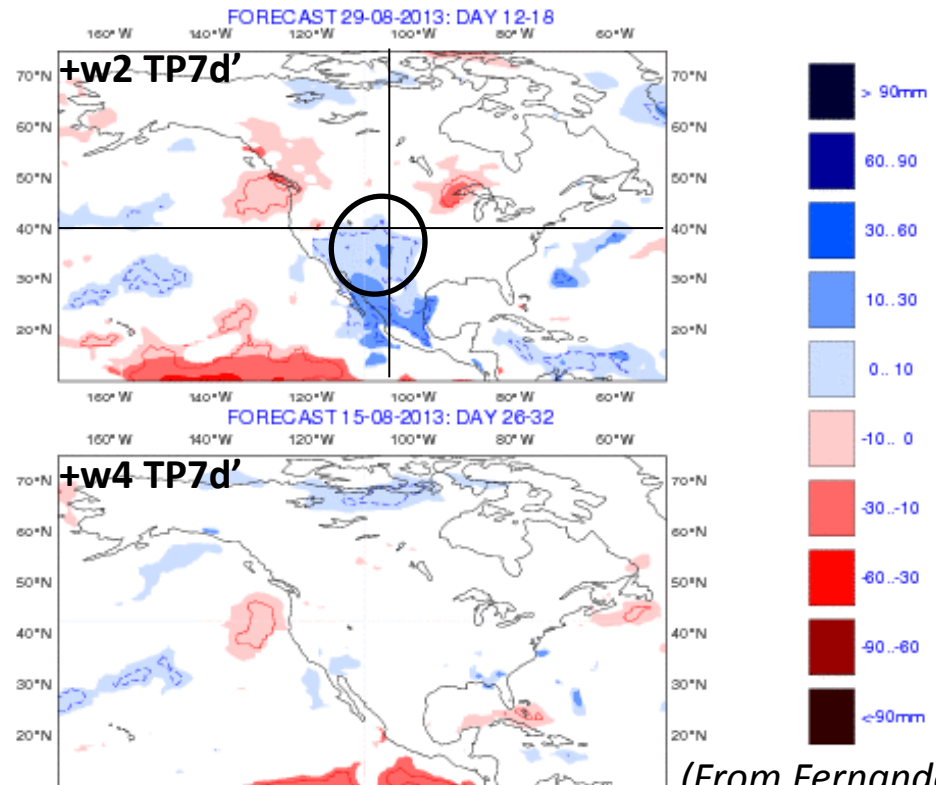Europe (lat 35.0 to 75.0, lon -12.5 to 42.5)

12mMA of CRPSS reaches 0.1

In some cases weekly anomalies are forecast weeks ahead

(From Fernando Prates)

© ECMWF

In some cases weekly anomalies are forecast weeks ahead

ANALYSIS

TP7d'

FORECAST 29-08-2013: DAY 12-18

+w2 TP7d'

FORECAST 22-08-2013: DAY 19-25

+w3 TP7d'
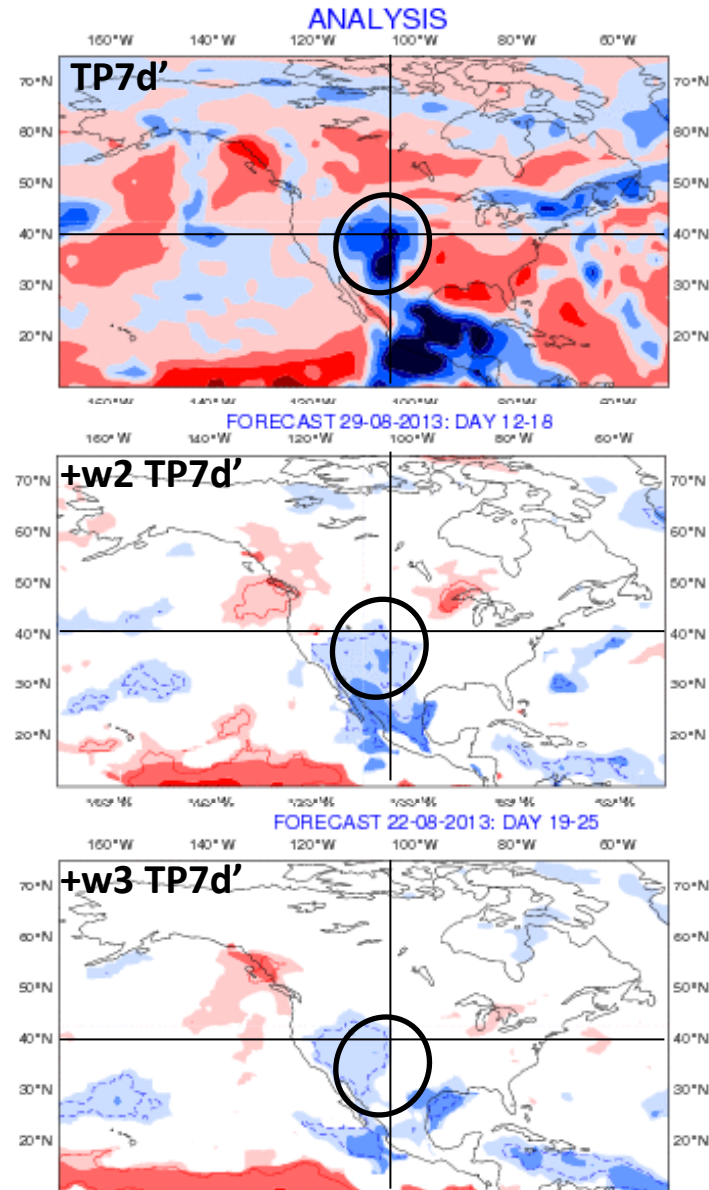
A probabilistic perspective is essential: Forecasts are issued in terms of anomalies wrt M-climate estimated using re-forecasts. The whole fc PDF is used.

| < 10% | 10.. 20 | 20.. 40 | 40.. 50 | 50.. 60 | 60.. 70 | > 70% |

+w2 PR(TP7d'>66th)

+w3 PR(TP7d'>66th)
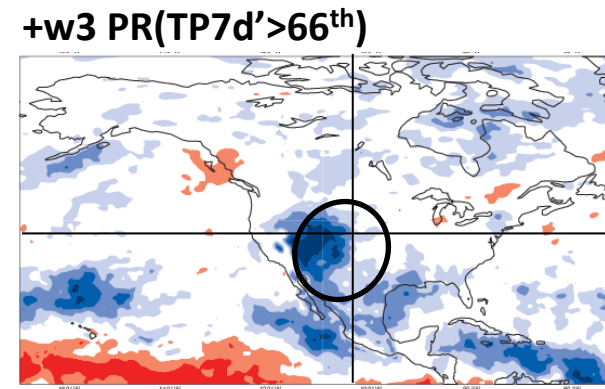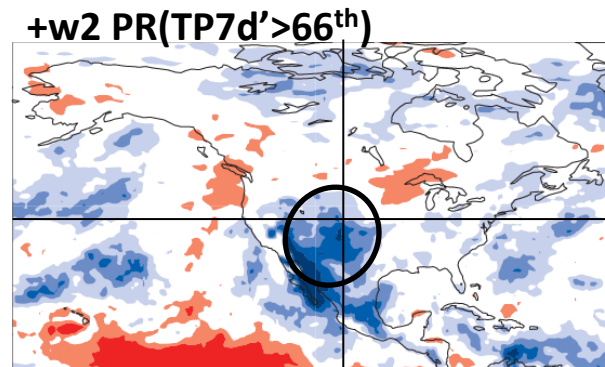
(From Fernando Prates)

ECMWF

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Conclusions

➢ Ensemble methods are now used in analysis and forecast mode, and ECMWF issues probabilistic forecasts up to 13-month, and ensemble-based analysis error estimates.

➢ The future will see ECMWF providing more accurate estimates of the most likely scenario and its uncertainty at analysis and forecast time for all variables (atmospheric, land, ocean, chemical and composition, ...).

➢ This will help further developments of applications (hydrology, e.g. EFAS>GloFAS, health, agriculture,..)

➢ **Two key open questions that we still have to address are:**

    ➢ **How can we help users take decisions with forecasts issued in probabilistic terms?**

    ➢ **Can we (forecast producers and users), together, design methodologies and procedures so that probabilistic forecasts can be used earlier and better in the decision making process?**

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