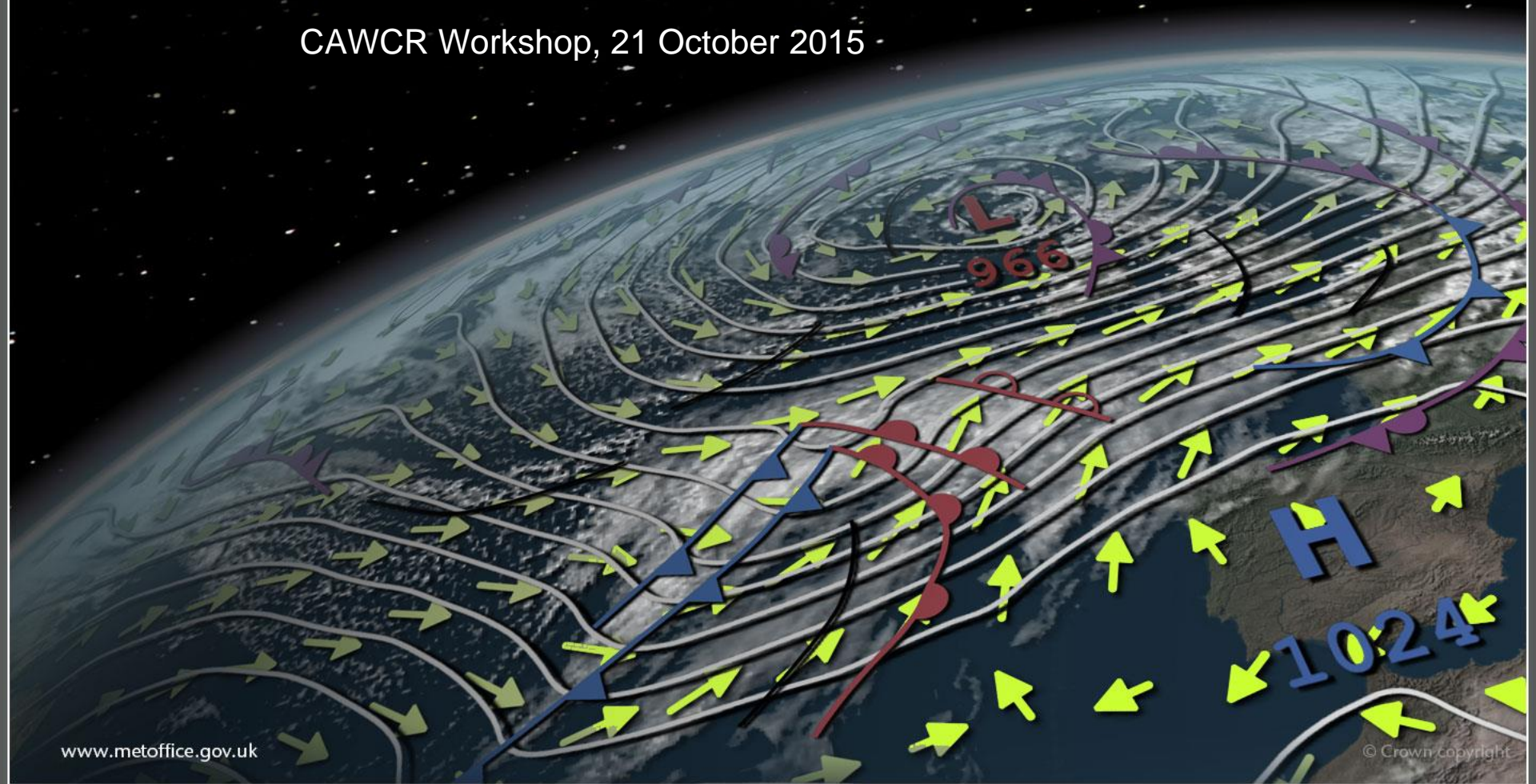




Towards A UM-Based Regional Reanalysis For Europe

Dale Barker, Richard Renshaw, Peter Jerney

CAWCR Workshop, 21 October 2015





Outline

1. Motivation – Why Regional Reanalysis?
2. EURO4M Project (2010 – 2014): Summary
3. UERRA Project (2014 – 2018): Initial Results
4. Summary

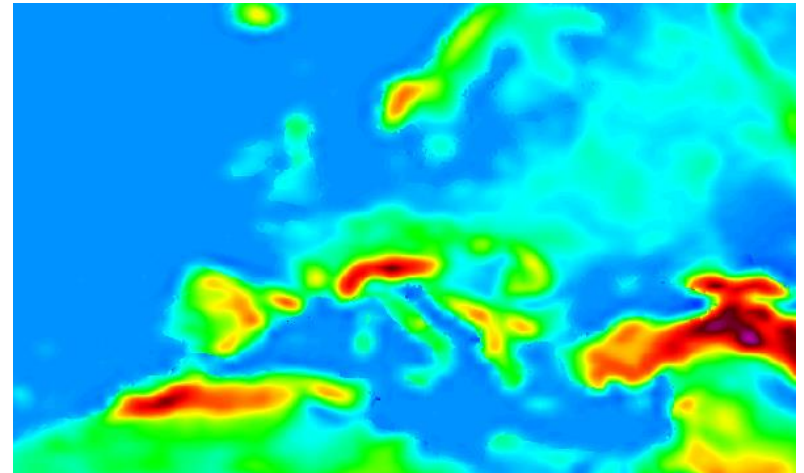


Motivation – Why Regional Reanalysis?

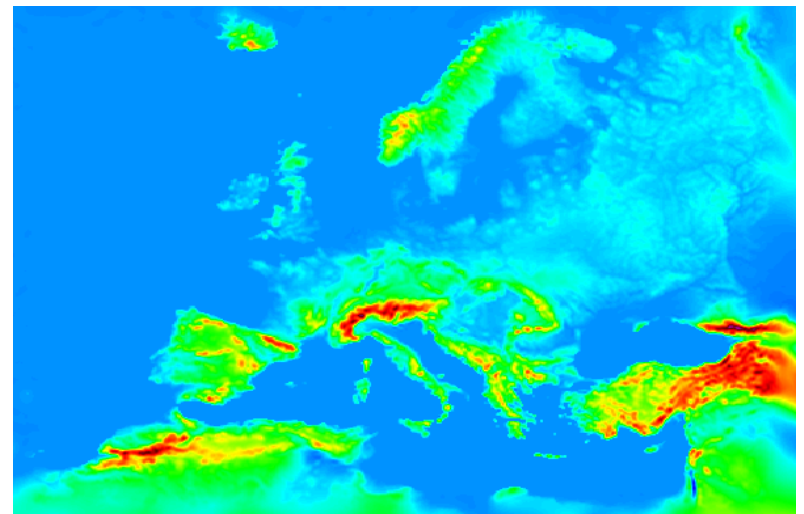
- 1. User Products:** Multivariate, gridded 4D climate datasets for users (DA combines model and observations in consistent manner).
- 2. Improve on global reanalysis (e.g. ERA):** High-resolution model (resolved orography, high-impact weather), and DA (e.g. extra obs).
- 3. Model evaluation:** Provides a testbed for extended period (multi-decadal) evaluation of regional Weather/Climate Model.
- 4. New Science:** Framework for developing/testing new scientific capabilities (e.g. precipitation accumulation assimilation).

© Crown Copyright. Source: Met Office

ERA-Interim: Model/DA 80/125km



EURO4M: Model/DA: 12/24km



EURO4M Regional Reanalysis

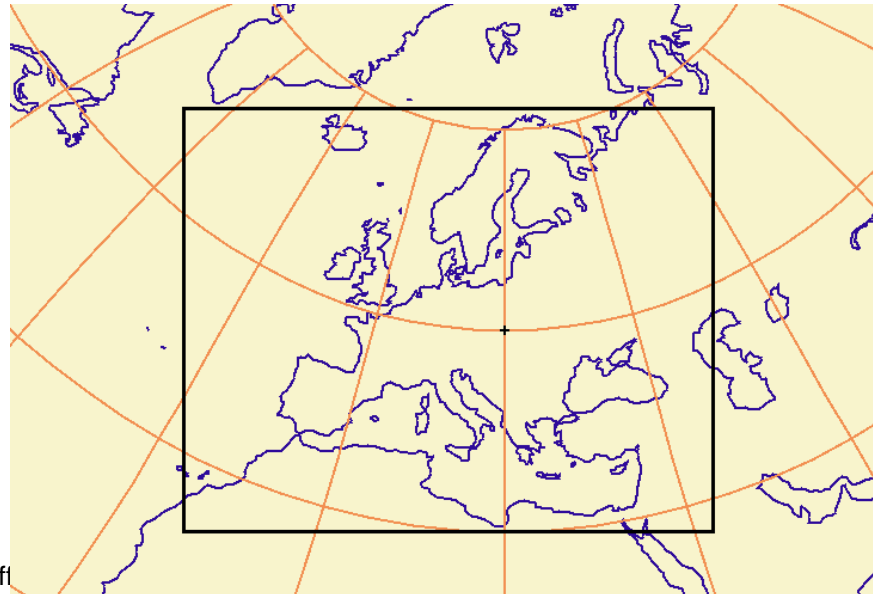


<http://www.euro4m.eu>



- EURO4M Participants: KNMI, UEA, URV, NMA-RO, **MetO**, SMHI, MF, MS, DWD.
- EURO4M leads: WP1 (Obs - UEA), WP2 (DA - **MetO**), WP3 (Products - DWD), WP4 (Project Management - KNMI). **Strong partnership with ECMWF.**
- Project duration April 2010 – March 2014.
- Develop capability and run prototype two-year (2008-2009) initial reanalysis.

EURO4M/MetO Domain





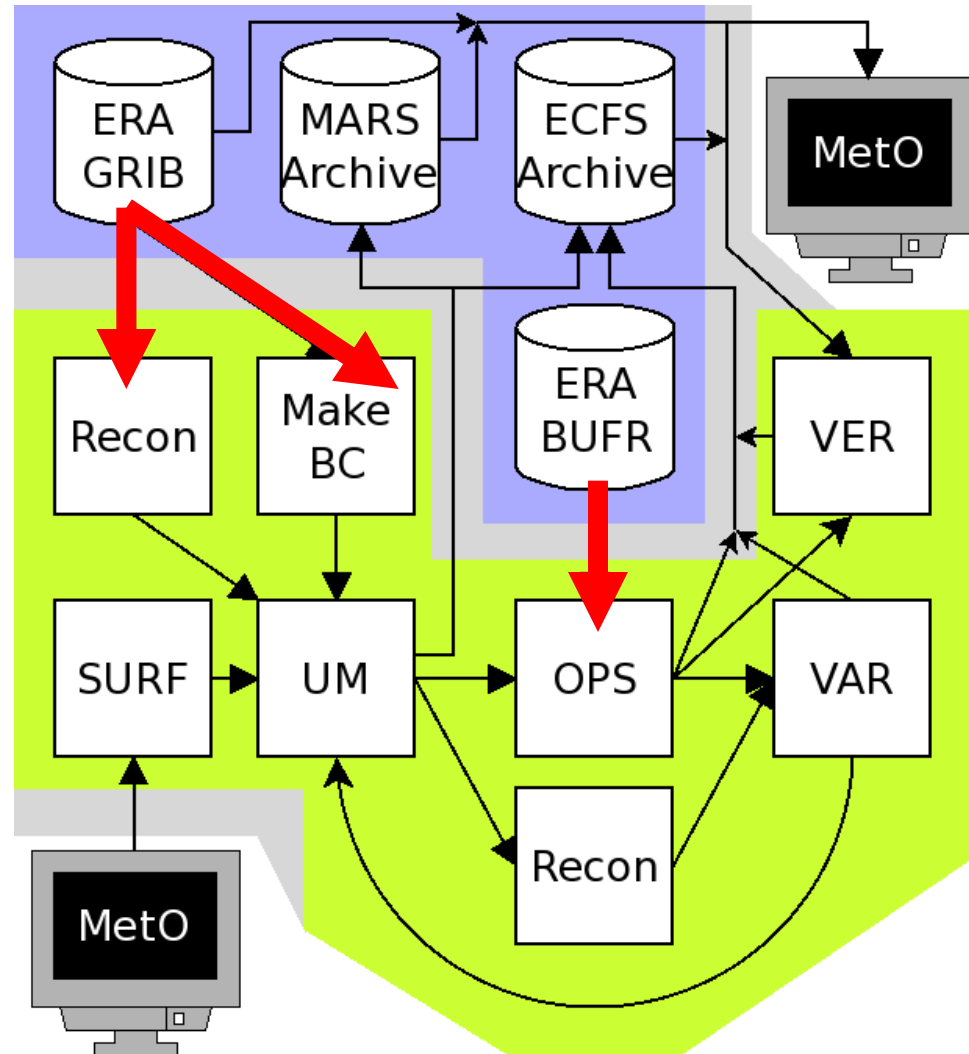
EURO4M Regional Reanalysis: What can we add to ERA-Interim?

- Resolution: 12km UM vs 80km ECMWF model
- Observations: Standard ERA/MO global obs, included radiances assimilated, **plus**:
 - Additional high-resolution surface, sat. data:
 - Precipitation (raingauge accumulations, radar)
 - Cloud fraction, Visibility
- Statistical post-processing of surface fields:
 - Introduces local effects of orography.
 - Inclusion of additional surface mesonet obs.
 - Correct model bias through e.g. Kalman Filter.
- Raw data for tailored European climate information bulletins (WP3 users).



UM Regional Reanalysis: Technical Configuration

- UM ported to ECMWF HPC.
- Use UK share of ECMWF HPC.
- Observations from ERA BUFR, LBCs from ERA GRIB.
- Archive output fields to MARS.
- ECMWF ODB used for observation monitoring.
- 4 six-month streams (2008-2009 pilot reanalysis)

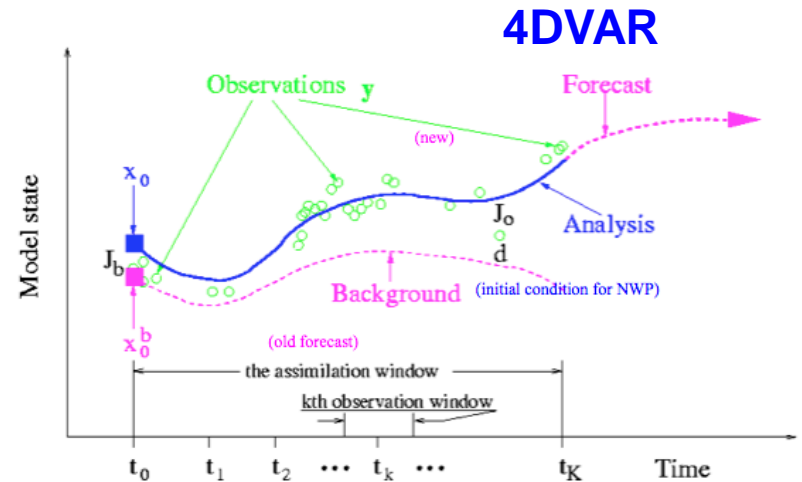




UM Regional Reanalysis: Scientific Configuration

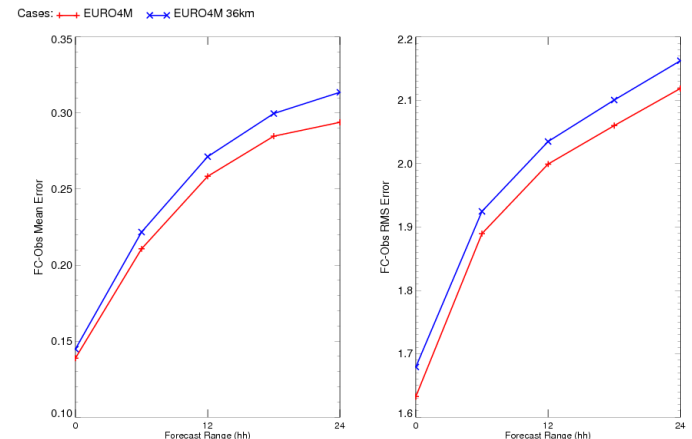


- **Model:** 12km UM
- **Data Assimilation:** 24km 4DVAR
- **Surface fields:**
 - SST and sea-ice from OSTIA
 - UM soil moisture and snow
- **Lateral boundary conditions:**
 - 6-hourly ERA-Interim global analyses
- **Observations:** Surface (SYNOP, buoy, etc), Upper air (sonde, pilot, wind profiler), Aircraft, AMV ('satwinds'), GPS-RO and ground-based GPS, Scatt. winds, Radiances (ATOVS, AIRS, IASI, MSG clear sky)



4DVAR resolution: 24 vs 36 km

Temperature (Kelvin) at Station Height: Surface Obs
Unknown rotated lat / long area
Equalized and Meaned from 1/2/2009 00Z to 28/2/2009 18Z

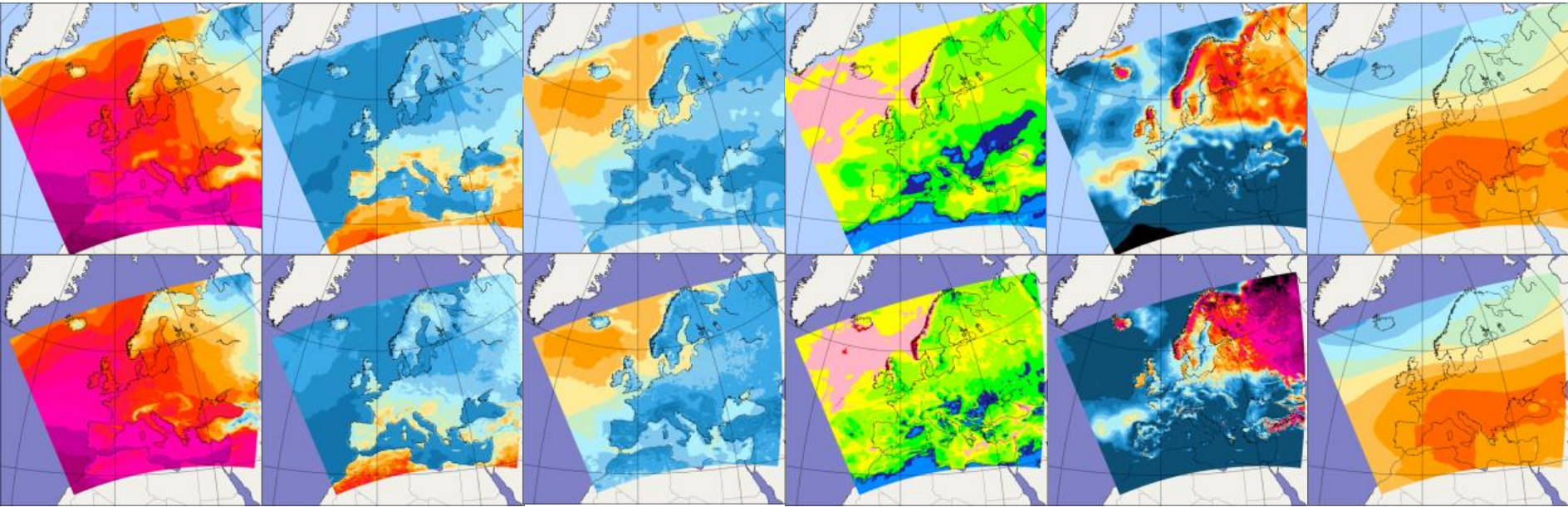




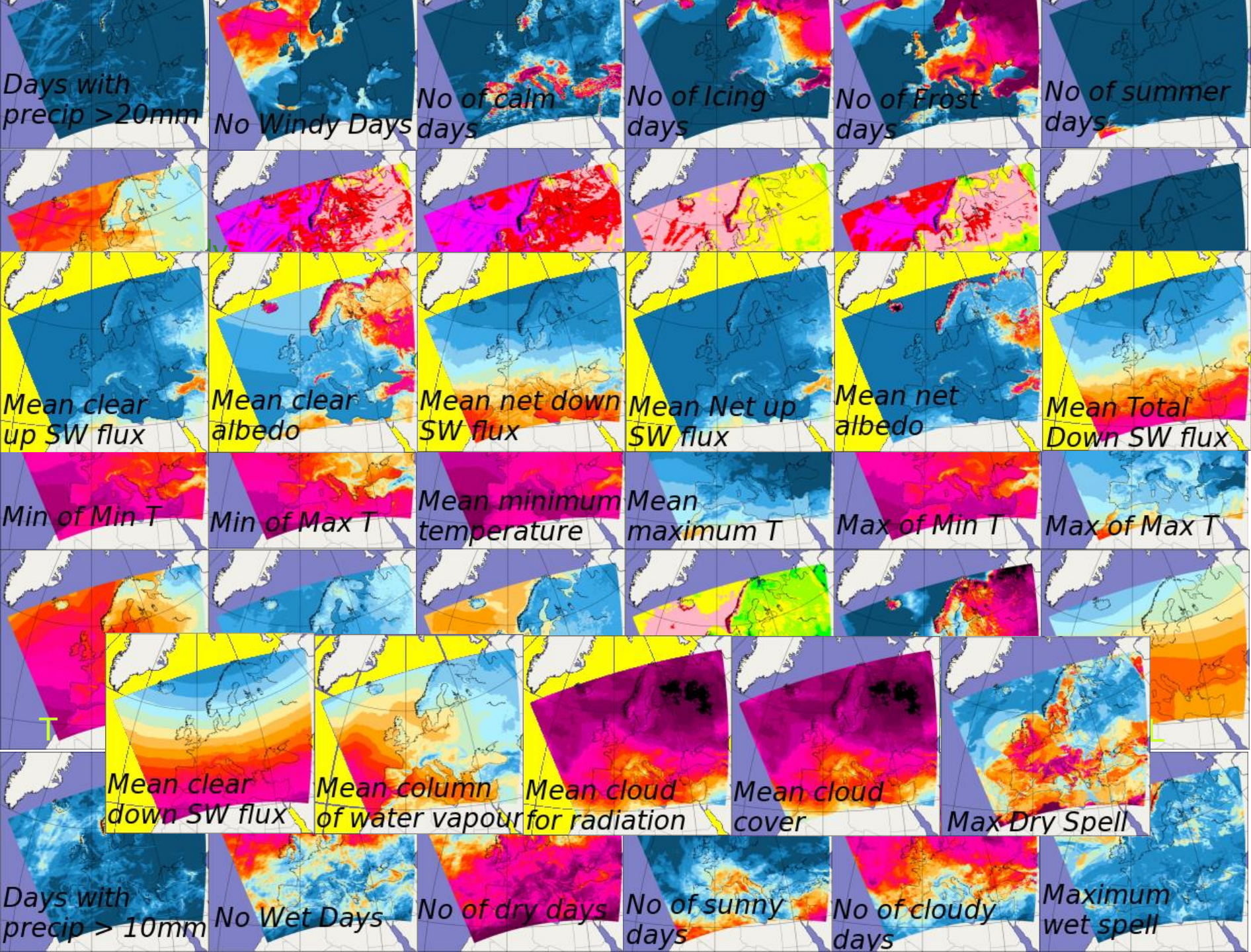
Evaluation of 2008-2009 pilot reanalysis: Climate Statistics

Monthly
Means

ERA T TRange Wind Precip RH2 PMSL



MO



Days with precip > 20mm

No Windy Days

No of calm days

No of Icing days

No of Frost days

No of summer days

Mean clear up SW flux

Mean clear albedo

Mean net down SW flux

Mean Net up SW flux

Mean net albedo

Mean Total Down SW flux

Min of Min T

Min of Max T

Mean minimum temperature

Mean maximum T

Max of Min T

Max of Max T

Mean clear down SW flux

Mean column of water vapour for radiation

Mean cloud cover

Mean cloud cover

Max Dry Spell

Days with precip > 10mm

No Wet Days

No of dry days

No of sunny days

No of cloudy days

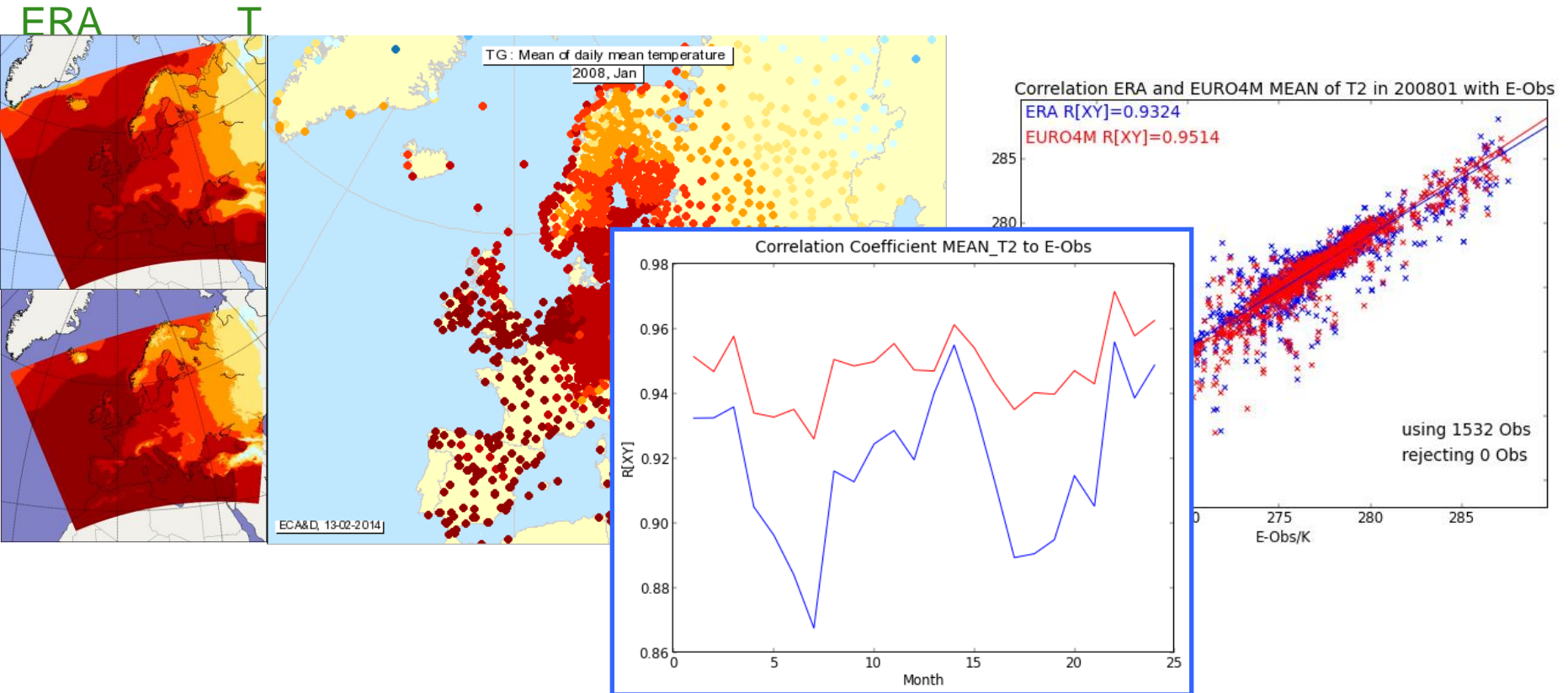
Maximum wet spell



Evaluation of 2008-2009 pilot reanalysis: Climate Statistics

Monthly Means

Compare with ECA&D statistics from obs stations



MO



Evaluation of 2008-2009 pilot reanalysis: Climate Statistics

EURO4M

Compare with ECA&D statistics from obs stations

Mean Temp	Max of Min Temp	Dry Days	
Mean of Min	Mean Precip	Wet Days	
Mean Max Temp	Icing Days	Frost Days	MO better in...
Mean Wind Speed	Total Wet Precip		24/24 months
Max of Min Temp	Mean Temp		23/24 months
Max of Max Temp	Tropical Nights		22/24 or 21/24
Min of Min Temp	Mean Wet Precip		20/24 or 19/24
Max Precip 5Days	Mean Cloud		10/24 months
Summer Days	Mean Rel Hum		
Calm Days	Maximum Gust		
DaysPrecip>10m	Max Daily Precip		
DaysPrecip>20m	Wind Days	Mean PMSL	

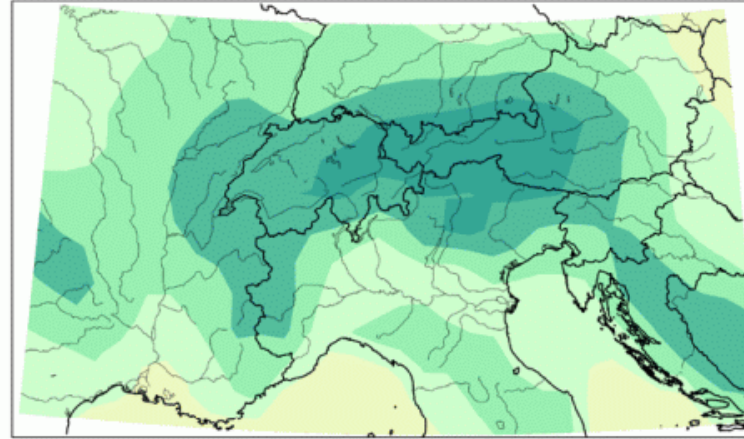
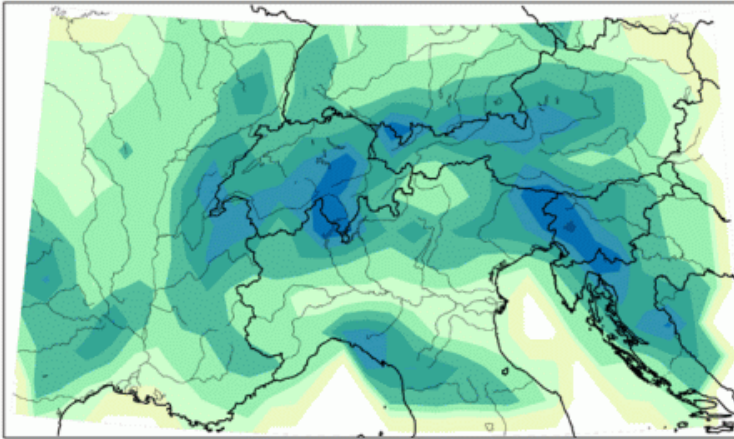


Mean annual precipitation 1989-1996



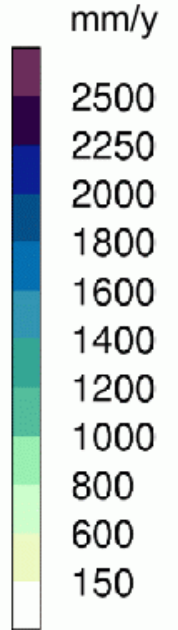
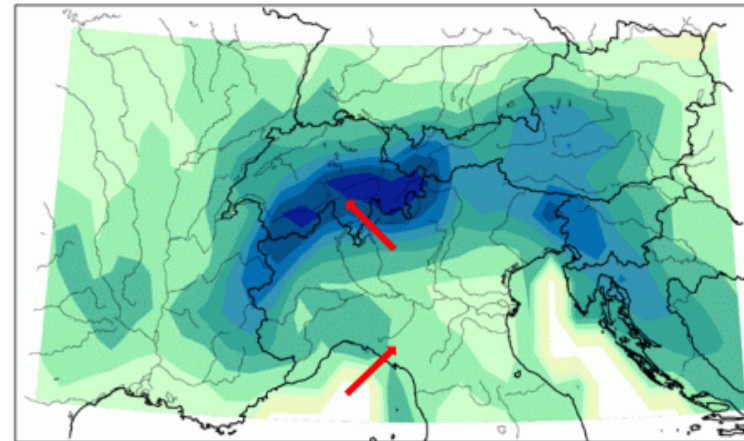
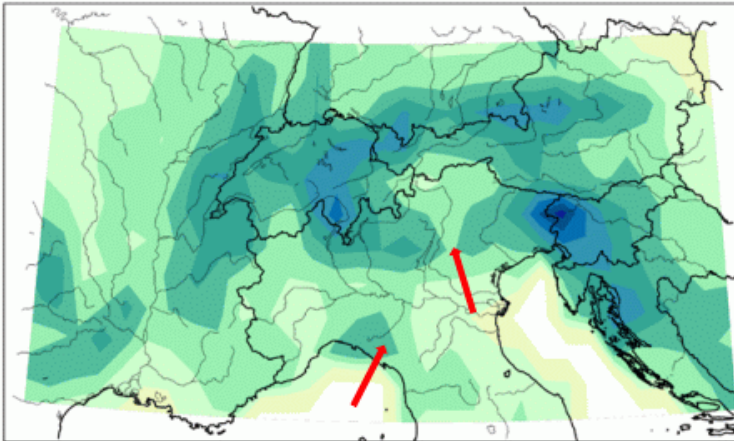
APGD (upscaled 55km)

ERA-INTERIM



GPCC

CRU



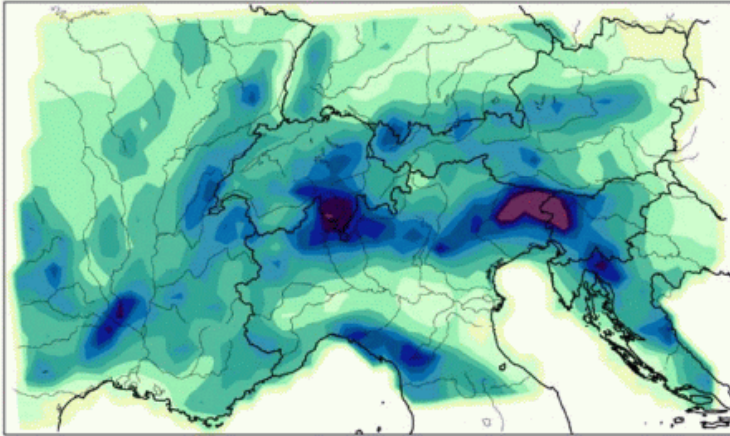
APGD, GPCC, CRU and E-Obs are Observation-Based Climatologies [Francesco Isotta](#)



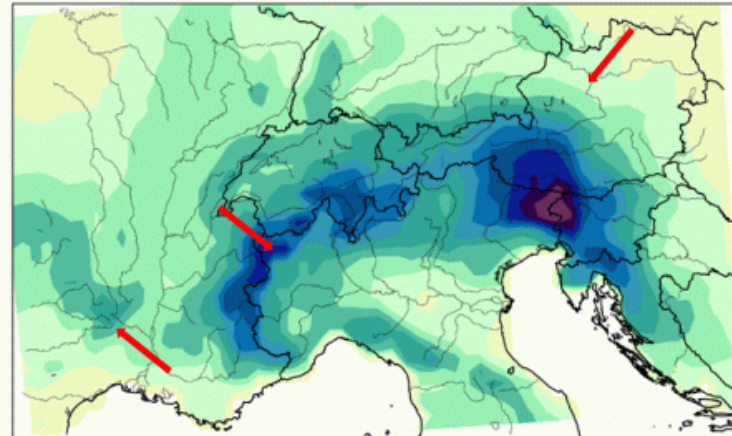
Mean annual precipitation 2008



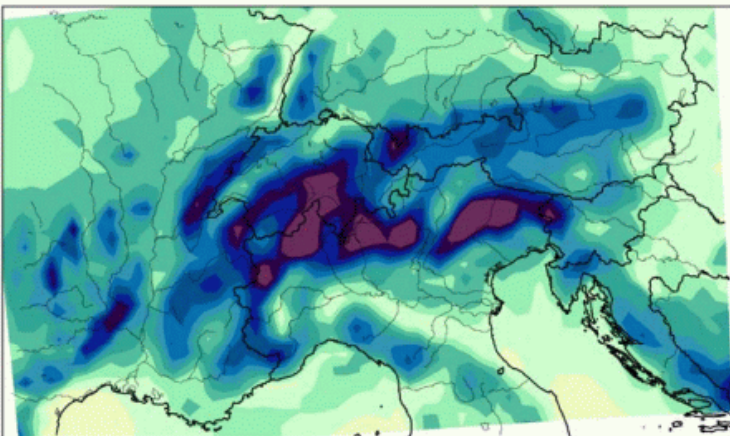
APGD (upscaled ~22 km)



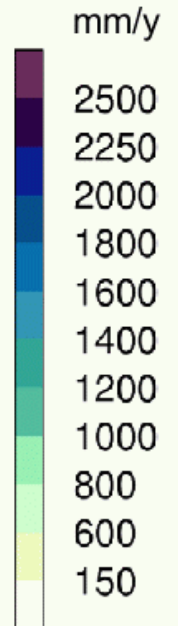
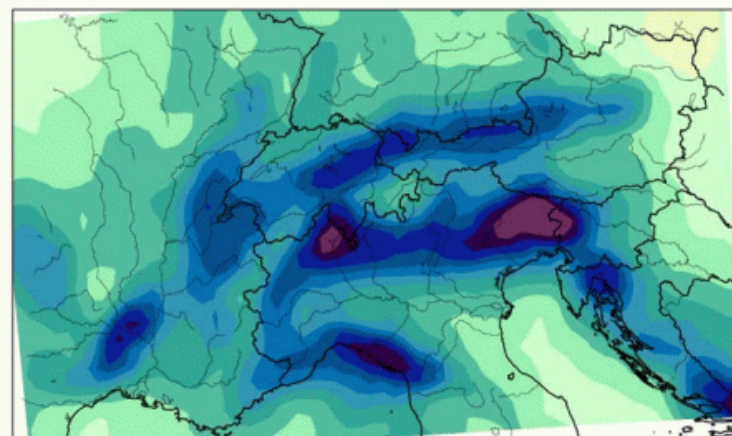
E-OBS



HIRLAM



UK Met Office (upscaled ~22 km)



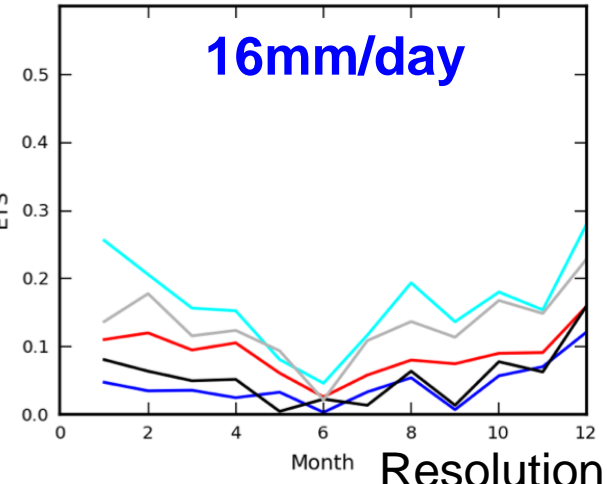
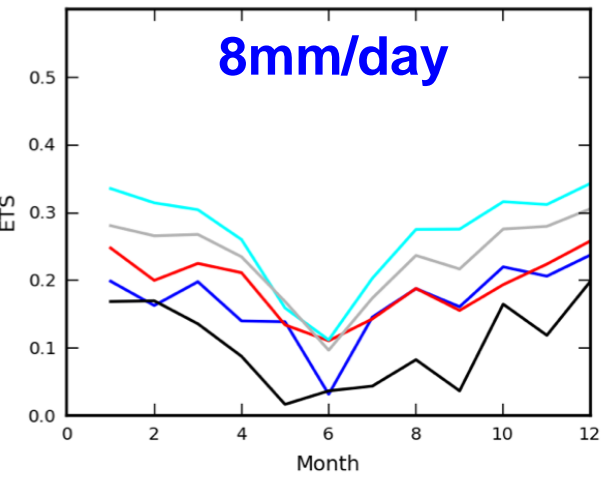
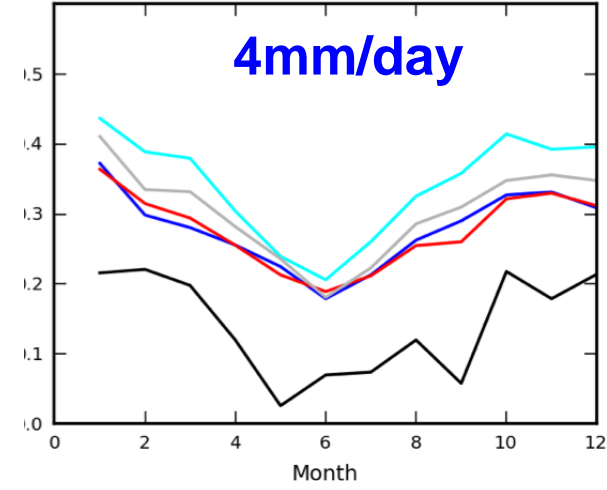
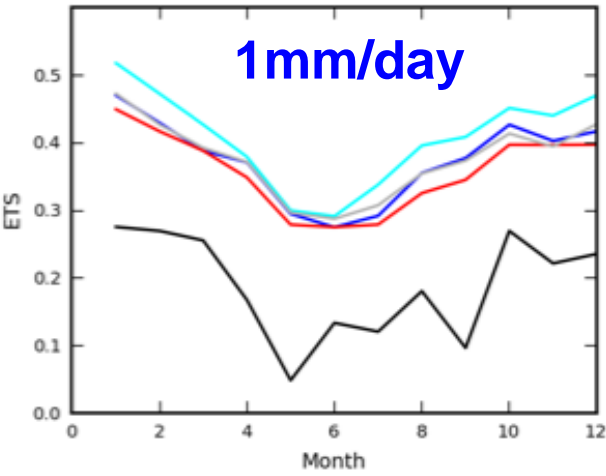
Above: APGD, E-Obs Observation-Based Climatologies
Below: Regional Reanalysis Climatologies (no precip assimilation)

Francesco Isotta



Impact of Resolution and DA on Precipitation Analysis Skill

Monthly skill (ETS) during 2008

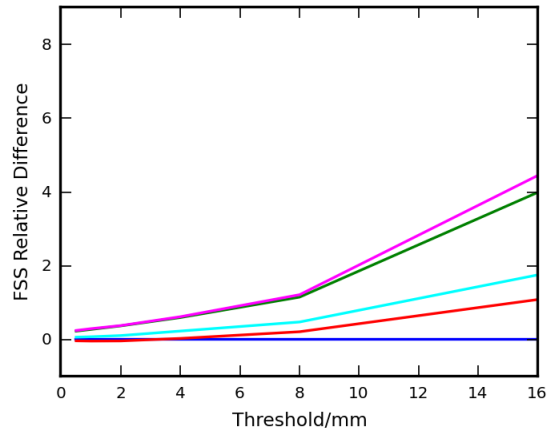


- EURO4M UM reanalysis
- UM downscaler (ECMWF ICs)
- EURO4M HIRLAM reanalysis
- ERA-INTERIM
- UM Climate Run (No analysis)

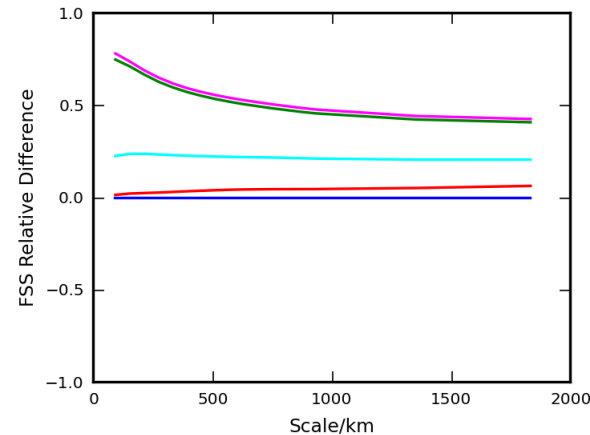
	1mm	4mm	8mm	16mm
Resolution	1%	9%	50%	300
Assimilation	8%	13%	14%	30%

Fractional Skill Score

Mean Rel Diff FSS to UK-ERA by Threshold at Scale 330.0km in France



Mean Rel Diff FSS to UK-ERA by Scale at Threshold 4mm in France



ERA-Interim HIRLAM MO MESAN MESCAN

Truth is gridded 24hr rain gauge observations (ECMWF)

$\text{Rel Diff}(\text{Model}, \text{ERA-Interim}) = (\text{Model} - \text{ERA-Interim}) / \text{ERA-Interim}$

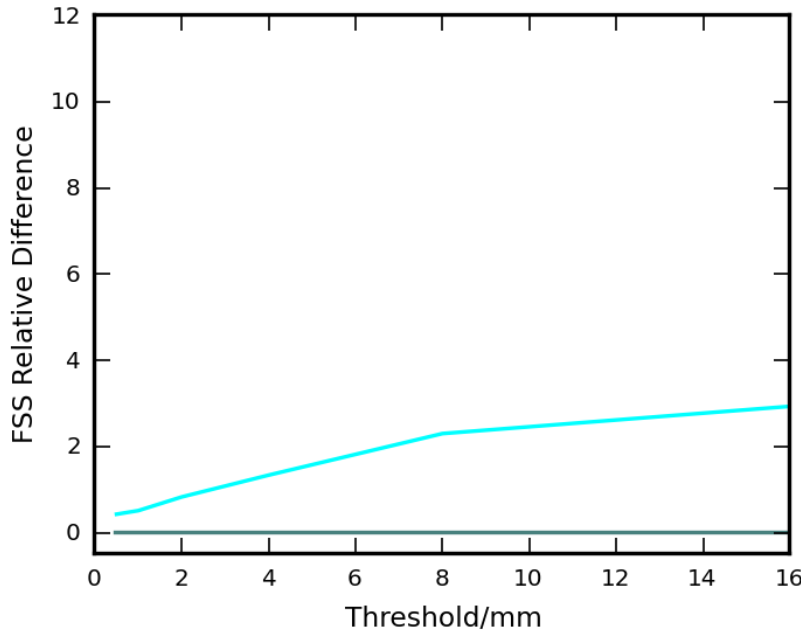


Impact Of Data Assimilation Technique On Precipitation Analysis Quality

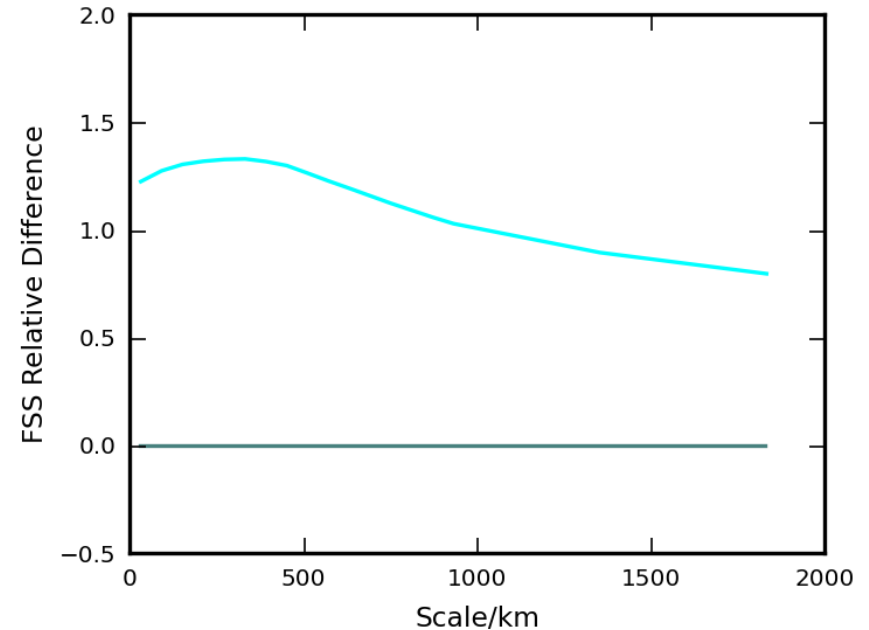


Relative Improvement Of 4DVar Vs 3DVar

Mean Rel Diff FSS to UK-3D by Threshold at Scale 330.0km in France



Mean Rel Diff FSS to UK-3D by Scale at Threshold 4mm in France



- Verify against independent (unassimilated) raingauge observations in France
- Fractional Skill Score (FSS) averaged over three months



European Reanalysis at the Met Office

2010-2014



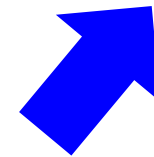
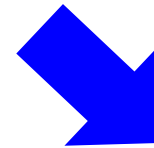
- 12km Deterministic UM Configuration
- 2008-2009 Pilot Reanalysis



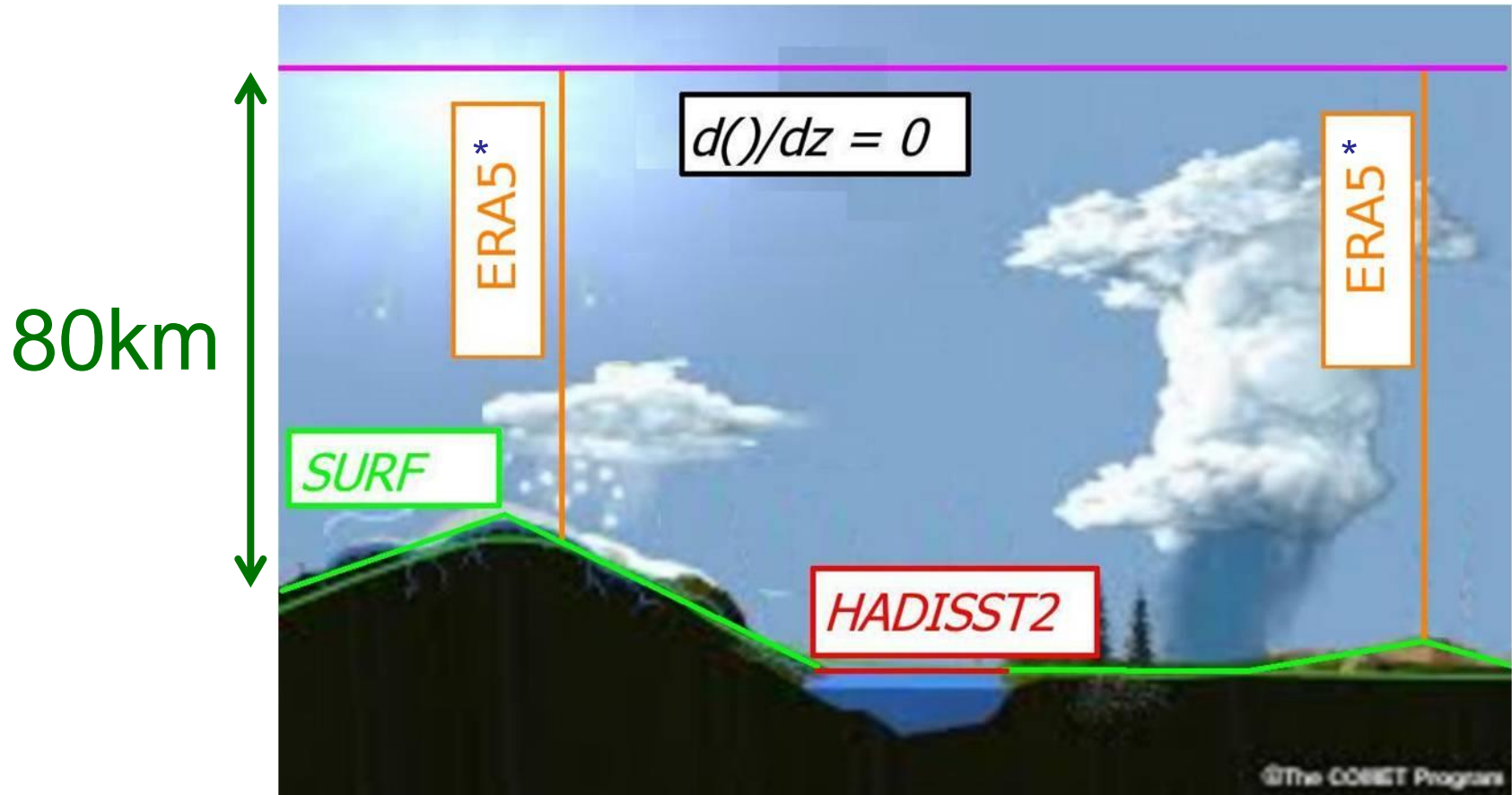
2014-2018



- 12km Deterministic UM Configuration
- 20 member Ensemble UM Configuration
- 40 year (1978-2017) Production Reanalysis



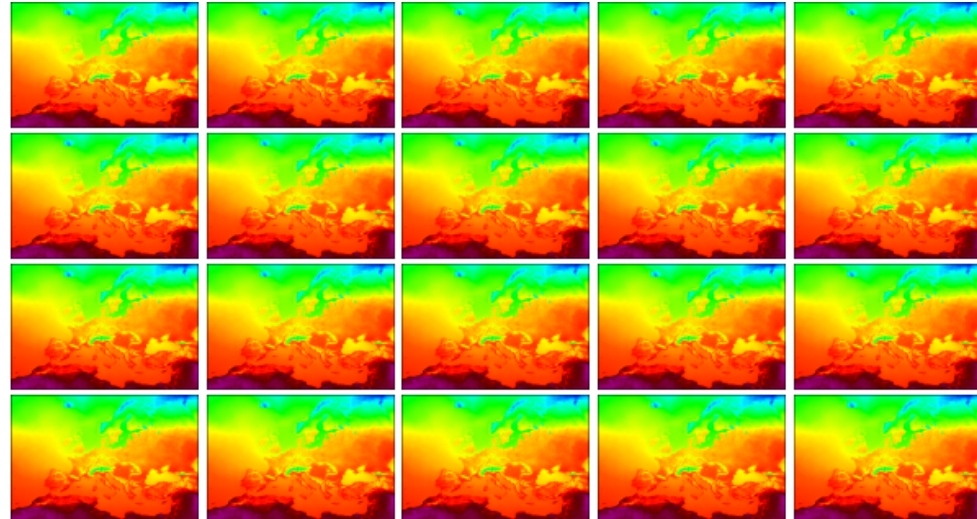
Boundary Conditions



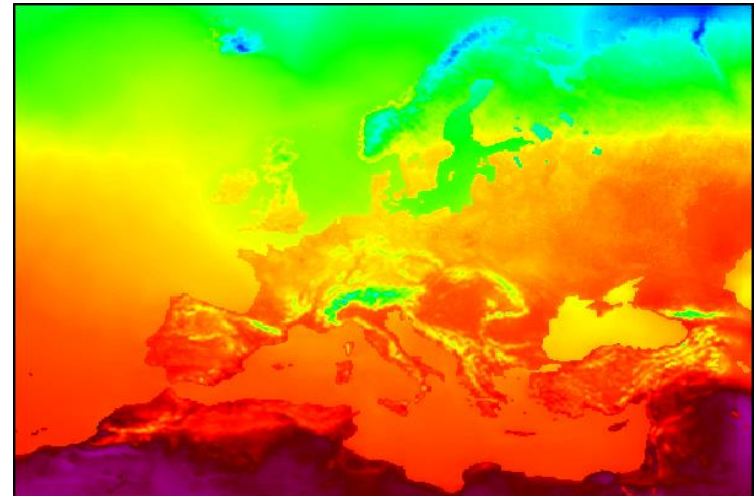
*planned

Uncertainties in Ensembles of Regional ReAnalyses (UERRA)

- **Ensemble using static 4DVAR**
- Provides lower resolution fields with uncertainty estimation
- i.e. mean and spread at 24km
- **Production start: Dec 2015**

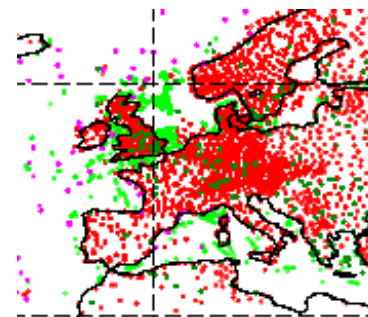


- **Deterministic reanalysis using hybrid 4DVAR**
- Uses ensemble reanalysis uncertainty to improve assimilation (B)
- Provides higher resolution deterministic fields at 12km
- **Production start: late 2016**

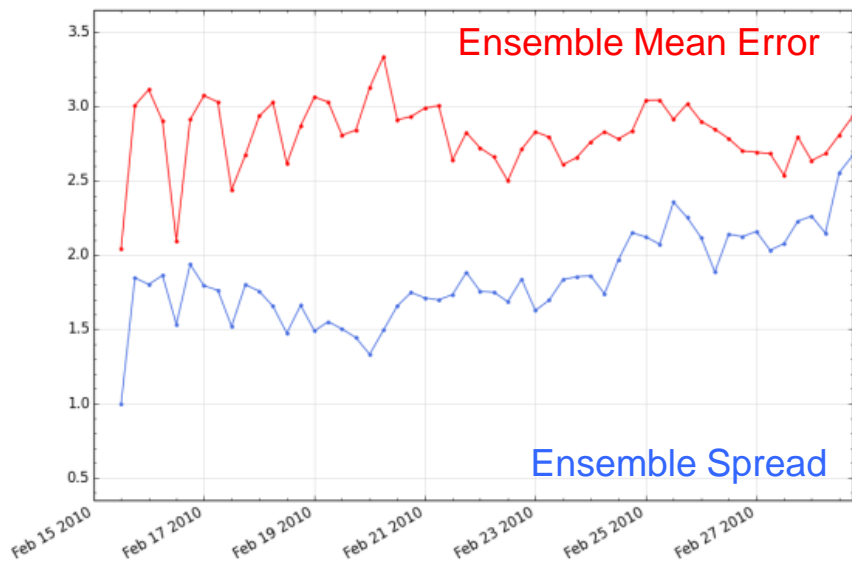


UERRA Ensemble (of 4DVars) Initial Results (10 members)

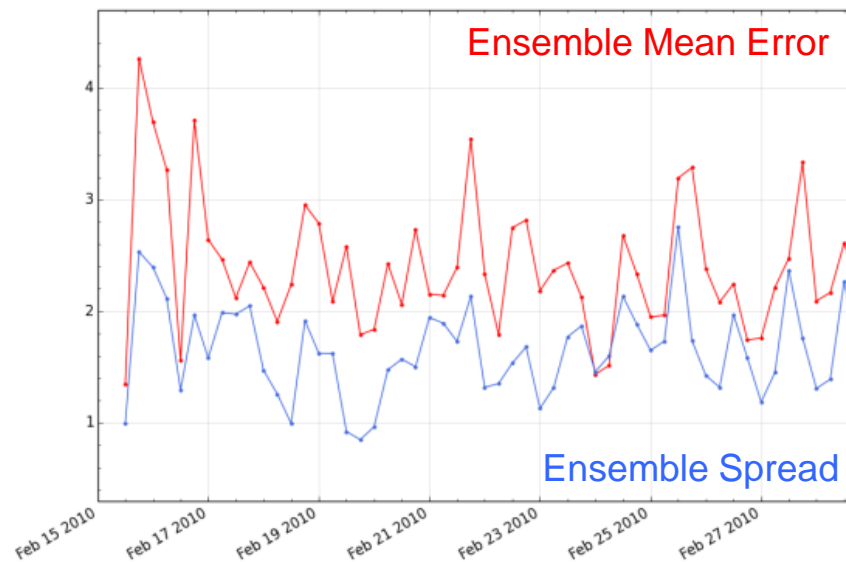
Temperature 1.5m



Europe

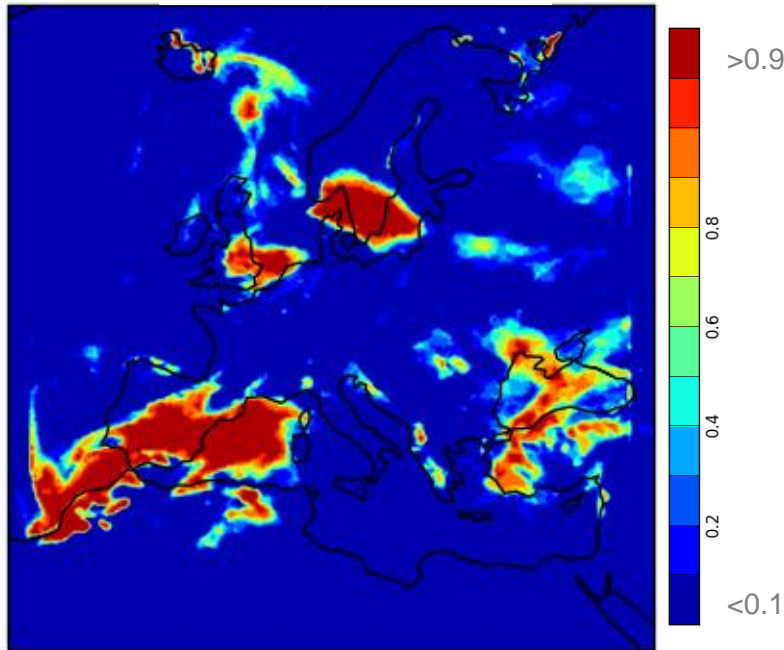


Germany



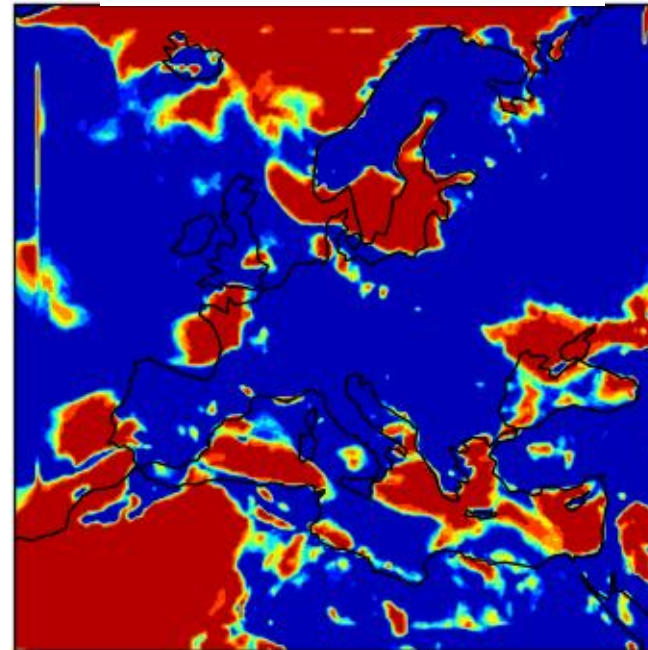
UERRA Sample Probability Maps

Precipitation



Probability of 1mm/6h
12Z to 18Z 18/02/10

Surface Wind

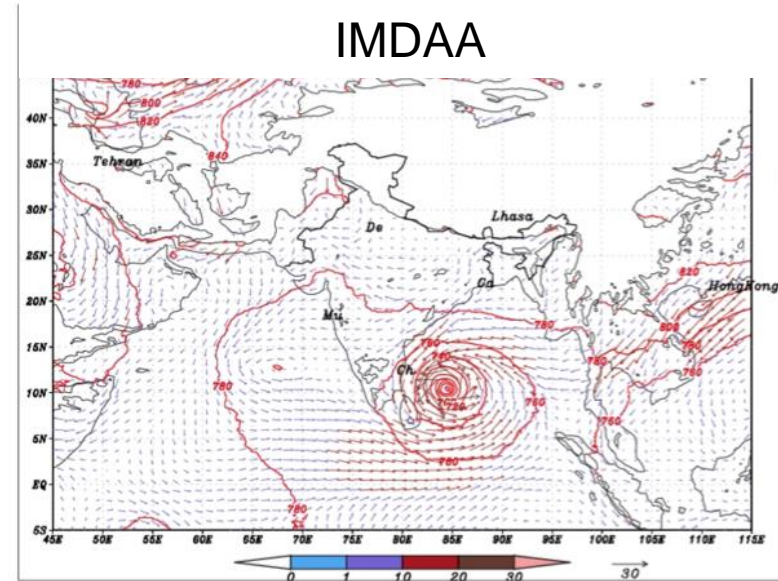


Probability 50m wind
 $3\text{ms}^{-1} < \text{speed} < 15\text{ms}^{-1}$
18Z on 18/02/10

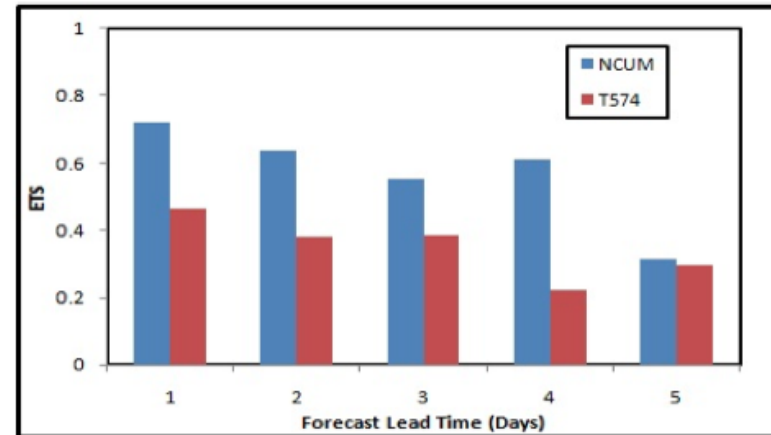


Indian Monsoon Data Assimilation and Analysis (IMDAA) Project: 2014-2018

- Goal: Improved understanding and modelling of the Indian monsoon.
- Funding from Indian Ministry of Earth Sciences. Collaboration with NCMRWF (modelling/DA) and IMD (data recovery).
- Developed in parallel with, and contribute to, NCMRWF's regional UM NWP application.
- Leverage UM regional reanalyses efforts performed in the 'sister' UERRA European regional reanalysis.
- IMDAA includes a >35yr deterministic reanalysis (1978-present).



June 2013 Uttarakhand Rainfall Skill





Summary

1. Motivations for regional reanalysis similar to those for regional NWP.
2. Very promising early results from EURO4M pilot 2008-2009 study.
3. Impact of 4DVAR regional reanalysis largest for HIW e.g. intense rainfall.
4. Current efforts in Met Office regional reanalysis
 - a. UERRA: 'Production' European regional reanalyses (1978-present).
 - b. Indian Monsoon UM regional reanalysis project to begin in 2014.
 - c. RR for other areas being considered (e.g. E. Asia, Maritime Continent).



Thanks.

Any Questions?

