In situ based ECV products

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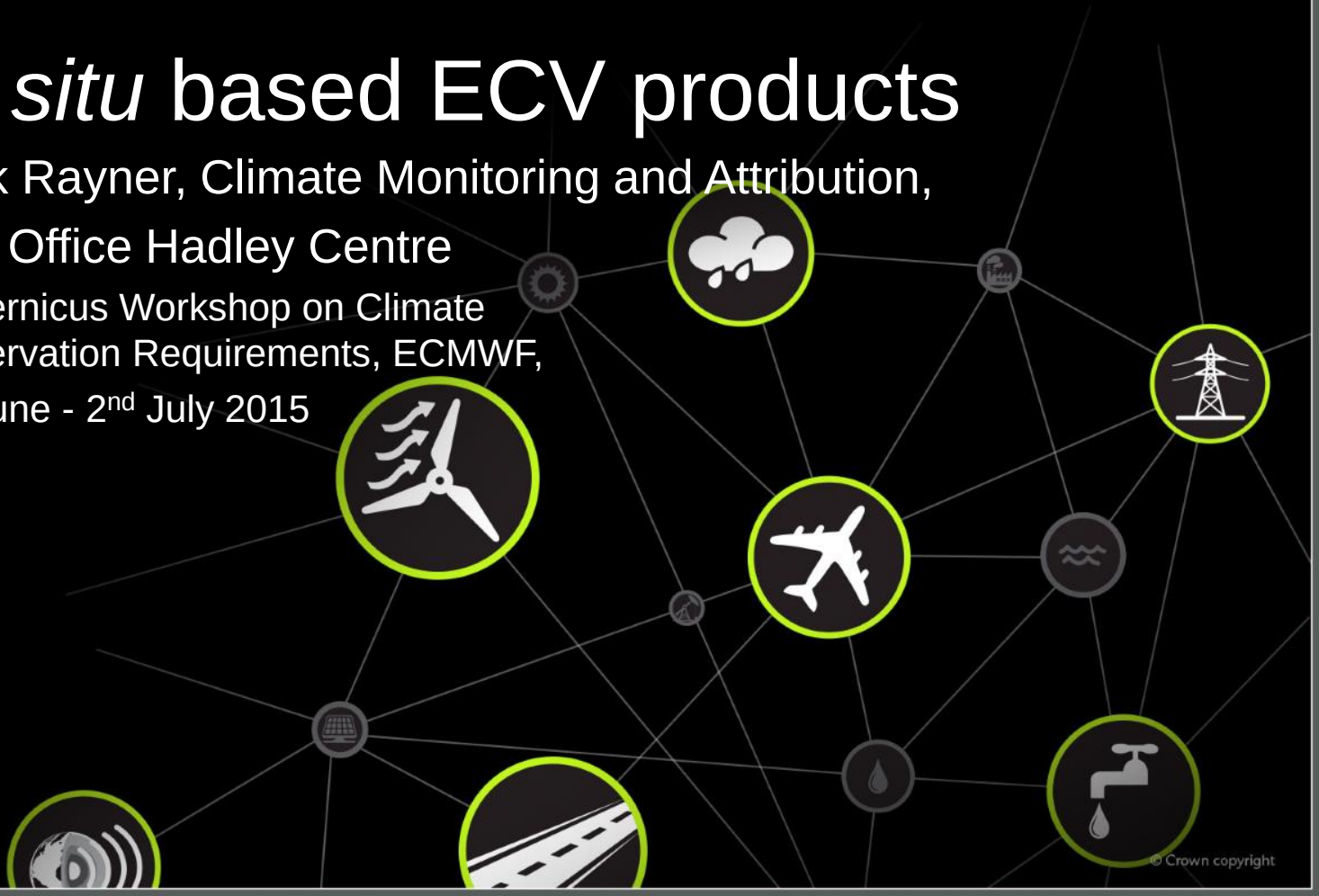
Met Office Hadley Centre

Copernicus Workshop on Climate Observation Requirements, ECMWF,

29 June - 2nd July 2015



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In situ based ECV products

Overview

- Why do we use *in situ* measurements for creating ECV products? What kinds of products are available?
- What are generic statements of need that apply to the development of all *in situ* based ECV products?
- How are these products used in Climate Services and what does this mean for how they need to be produced?
- How could they be used? Why aren't they currently?
- How can we be more creative to enable wider use?
- Which further developments are needed and could be facilitated by Copernicus?

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Air temperature (surface)	Wind speed and direction (surface)	Water vapour (surface)	Pressure	Precipitation	Surface radiation budget	Temperature (upper air)	Wind speed and direction (upper air)	Water vapour (upper air)	Cloud properties
Earth radiation budget (including solar irradiance)	Carbon dioxide	Methane	Other long-lived greenhouse gases (e.g. N_2O, CFCs, HCFCs, HFCs, SF_6 and PFCs)	Ozone	Aerosol	Sea-surface temperature	Sea-surface salinity	Sea level	Sea state
Sea ice	Surface current	Ocean colour	Carbon dioxide partial pressure (surface)	Ocean acidity (surface)	Phyto-plankton	Sub-surface temperature	Sub-surface salinity	Sub-surface current	Nutrients
Carbon dioxide partial pressure (sub-surface)	Ocean acidity (sub-surface)	Ocean oxygen	Ocean tracers	River discharge	Water use	Ground-water	Lakes	Snow cover	Glaciers and ice caps
Ice sheets	Perma-frost	Terrestrial albedo	Land cover (including vegetation type)	Fraction absorbed photo-synthetically active radiation (FAPAR)	Leaf area index (LAI)	Above-ground biomass	Soil carbon	Fire disturbance	Soil moisture

Why do we use *in situ* measurements for creating ECV products?

- Observations of many Essential Climate Variables have been made continuously for at least a century
- In many cases, they are sparse relative to comparable recent estimates from satellites, but allow the evaluation of decadal or multi-decadal variability, which is essential for many climate service applications
- For some variables, *in situ* measurements provide the only means to determine how they vary, e.g. sub-surface ocean temperature and salinity
- Observation-only analyses provide a complementary view to dynamic reanalyses
- Independent *in situ*-only analyses provide a complementary view to satellite-based analyses

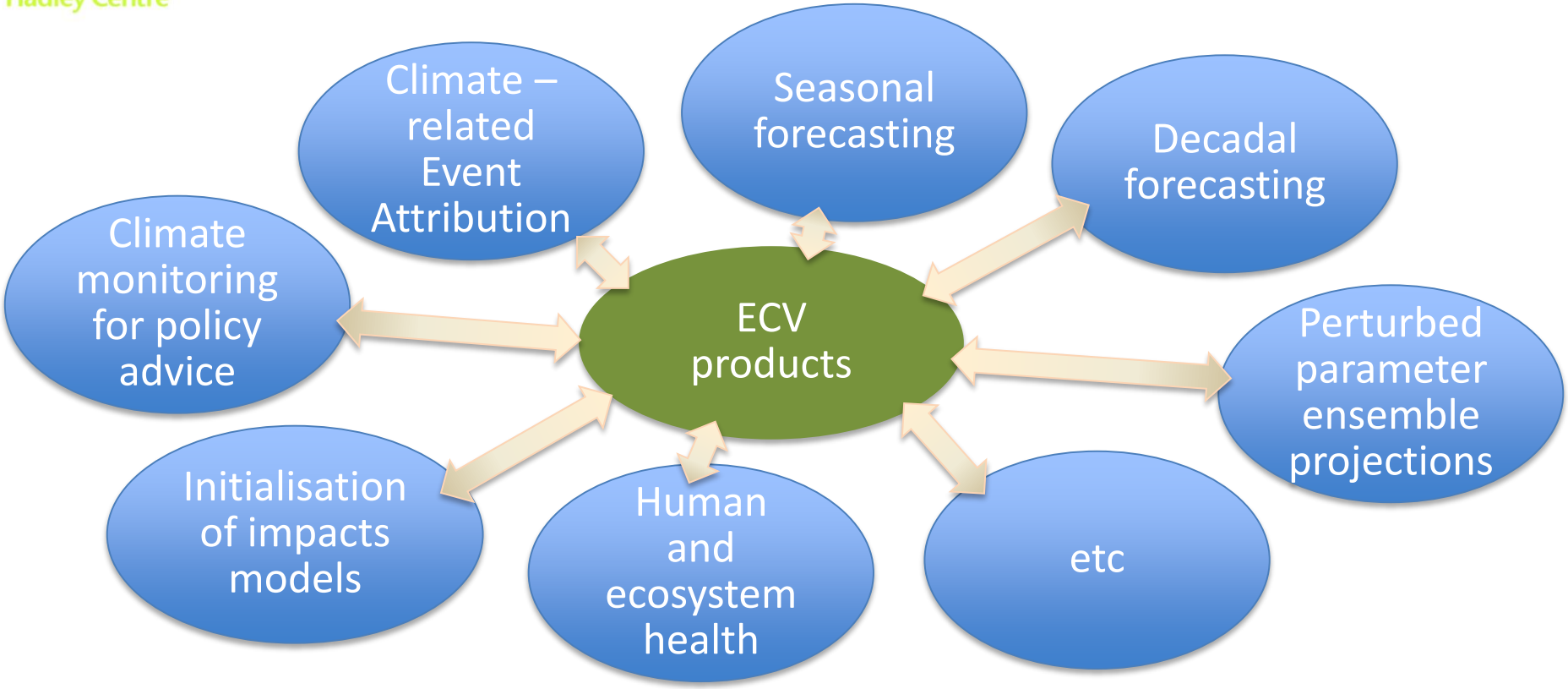
Generic statements of needs

For the development of in situ-based ECV products

- More data
  - more and ongoing measurements in sparsely observed regions
  - unlock the potential of past measurements (digitisation and data sharing)
- More research into creating consistent records
  - understanding how data from different measurement platforms can be knitted together to create an homogeneous record
- More research into quantifying uncertainty components and their covariance structures
- Better statistical modelling techniques
  - use new methods which use this information and allow better representation of full distribution

More subtle requirements

Driven by the needs of different applications



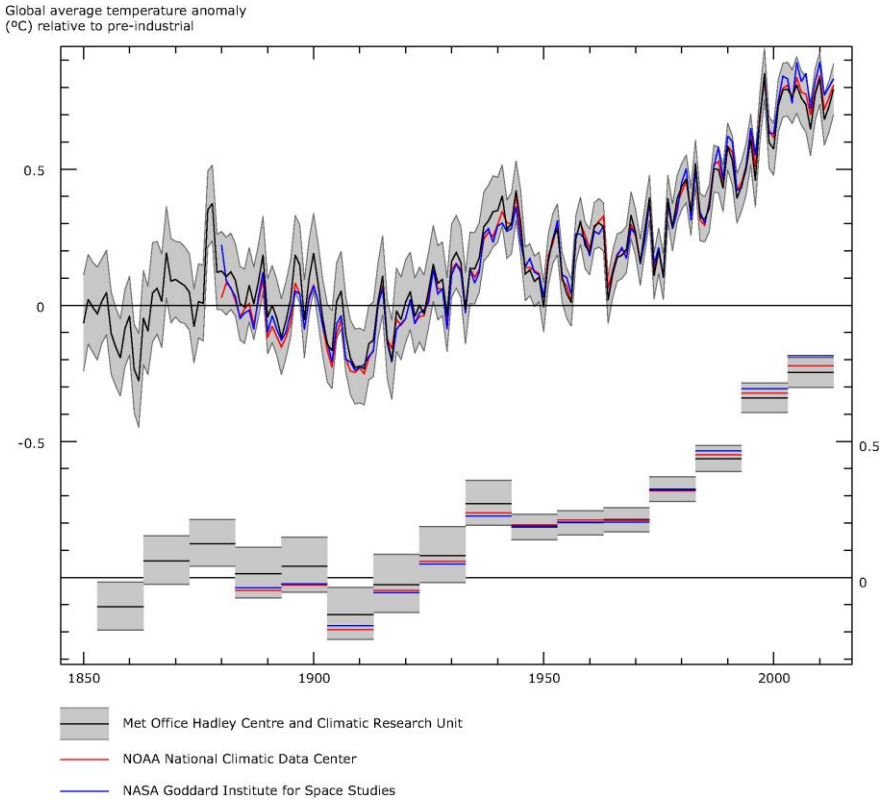
1. Climate monitoring for policy advice

Surface air temperature

Part of EEA global and European temperature change indicator aimed at providing advice relevant to the questions:

- Will the global average temperature increase stay within the UNFCCC policy target of 2.0 degC above pre-industrial levels?

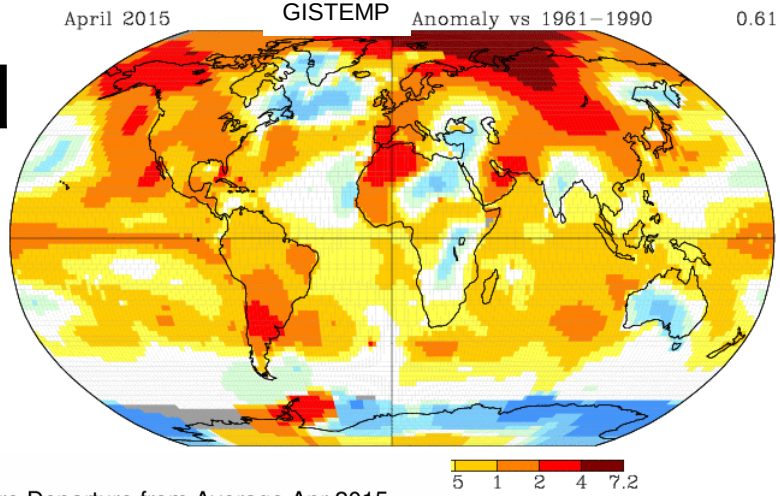
- Will the rate of global average temperature increase stay below the indicative proposed target of 0.2 degC increase per decade?

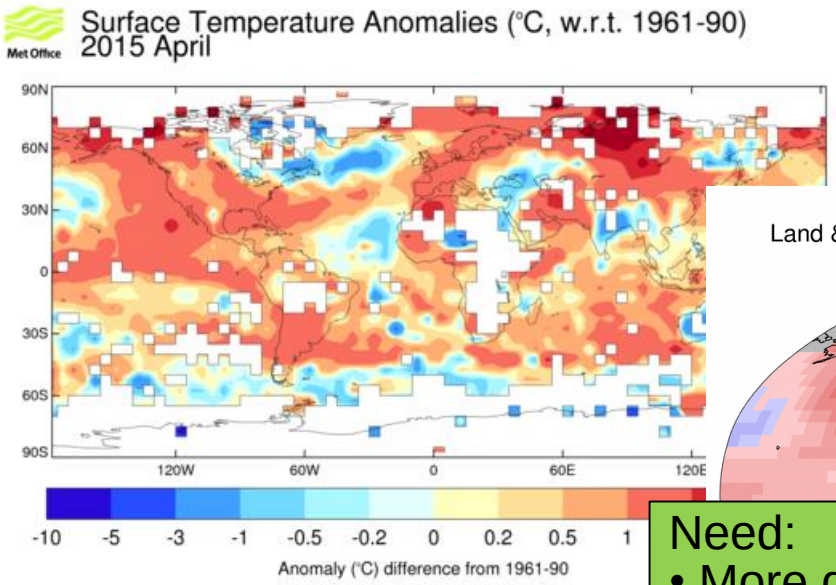


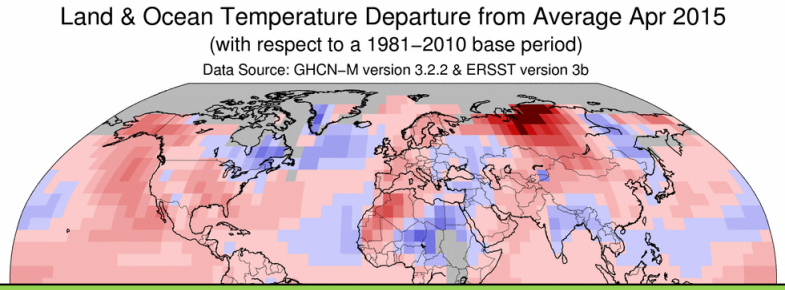
http://www.eea.europa.eu/data-and-maps/indicators/global-and-european-temperature/global-and-european-temperature-assessment-8

ECV products used

For EEA indicator







Need:

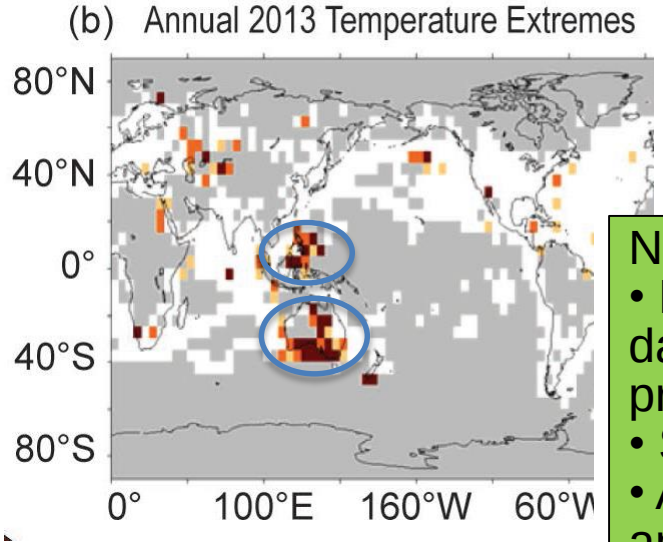
- More data
- Continued research into creating consistent records
- Better quantification of uncertainty components
- Research into new ways of statistical modelling

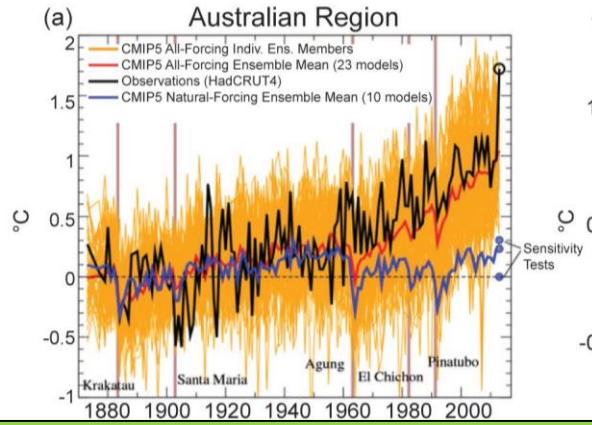
Other *in situ*-based surface air temperature products

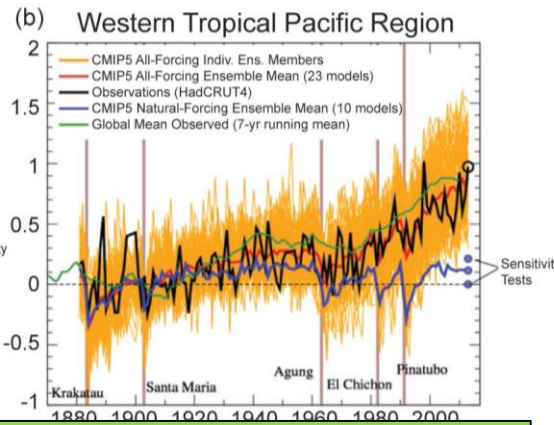
Name	Type	Region / time period	Daily?	Publicly available?	Spatially complete?
Berkley	Gridded, uses statistics	Land only / from C19th	Yes	Yes	Yes
HadCRUT4, MLOST, GISTEMP, Berkley, etc	Gridded, uses statistics	Global / from C19th (uses SST)	No	Yes	Sometimes
E-OBS, etc	Gridded, uses statistics	Regional land only / from 1950	Yes	Yes	Yes
ISTI, GHCN, ECA&D, etc	Station, obs only	Regional land only / various	Some-times	Yes	No

2. Climate-related event attribution

Surface air temperature







Need:

- Development of short-delay updates to monitoring data sets (particularly surface air temperature and precipitation), consistent with the long-term record
- See EUCLEIA analysis of needs (June 2015)
- Also development of short-delay updates to SST and sea ice data for boundary forcing of atmospheric models

Knutson et al., 2014, in Special Supplement to the *Bulletin of the American Meteorological Society,* 95, 9, 2014

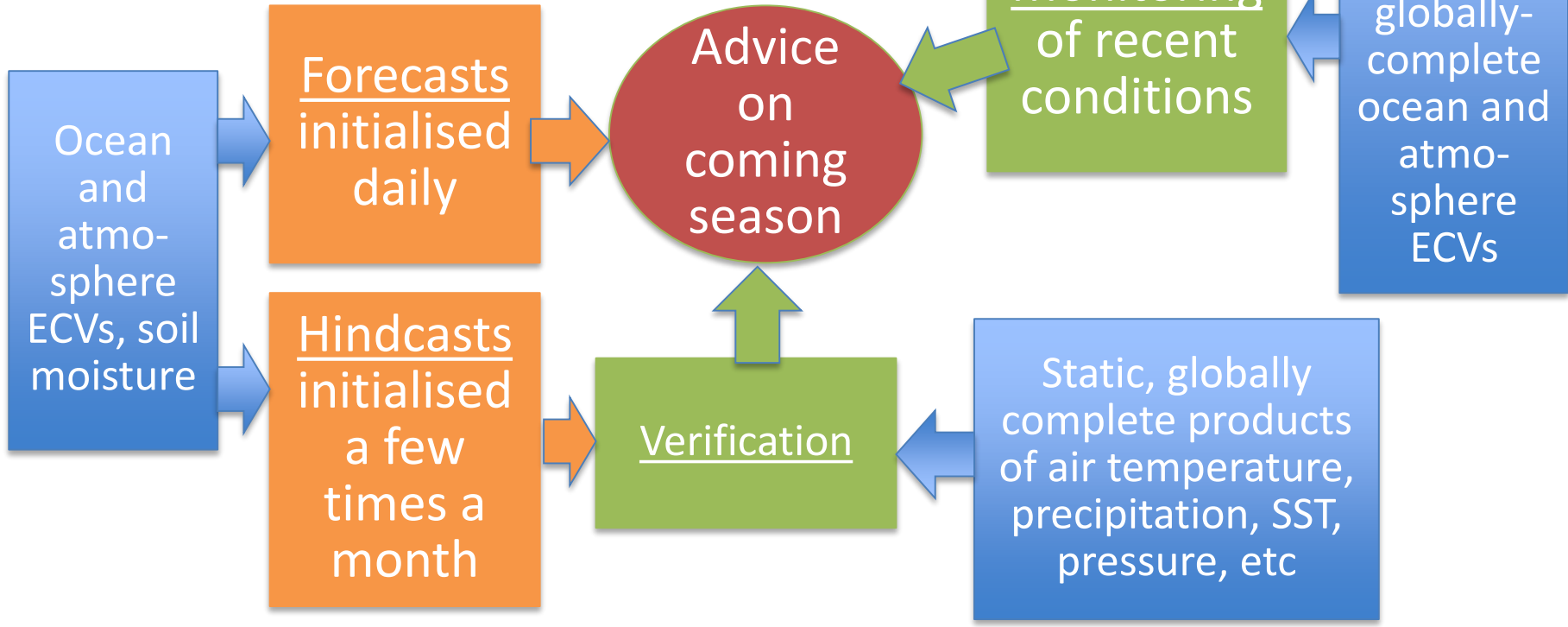
Globally-complete sea surface temperature products

Need:
- Support of short-delay updates to *in situ* (ICOADS) and satellite input data sets consistent with the long-term record
- Support of robust analysis systems to create ECV products

Name	Type			
ERSST, COBE, NOC, etc	Gridded,			
HadISST.2.2.0.0	Gridded, *in situ* and satellite (SST CCI)	Global / from C19th	Can be	yes
“Reynolds”, OSTIA, etc	Gridded, *in situ* and satellite (various)	Global / from 1980s	yes	yes
SST CCI	Gridded, satellite only (SST CCI)	Global / from 1991 currently (1980s in 2016)	yes	yes

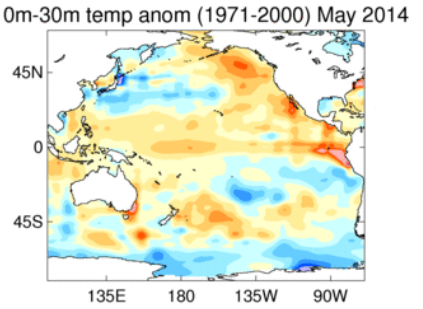
3. Seasonal forecasting

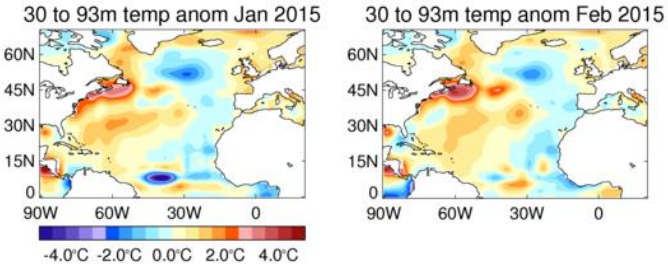
Need:
• Near-real time, short-delay and static ECV products to be more consistent

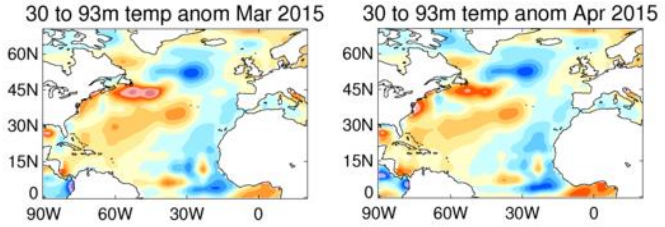


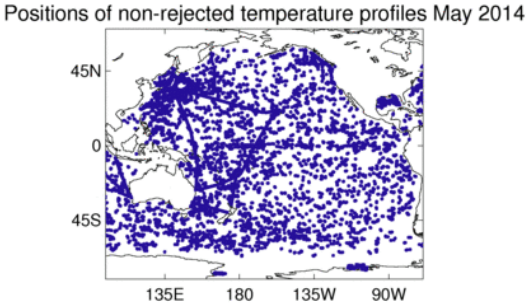
Ocean monitoring

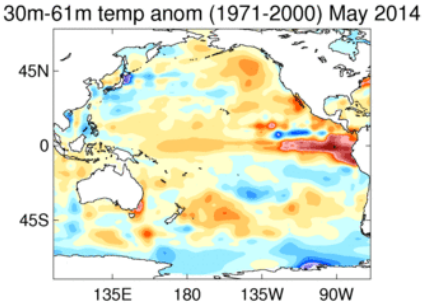
Sub-surface temperature

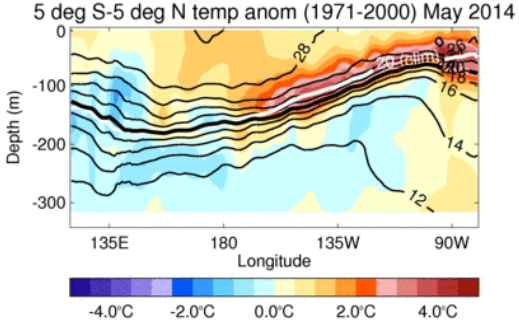


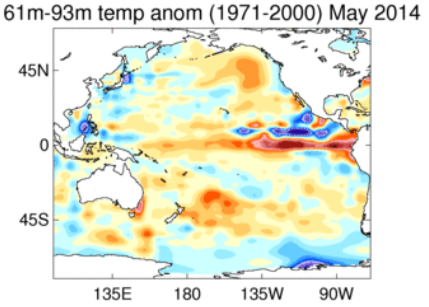












Data from EN4, Good et al., 2013

Sub-surface ocean temperature and salinity products

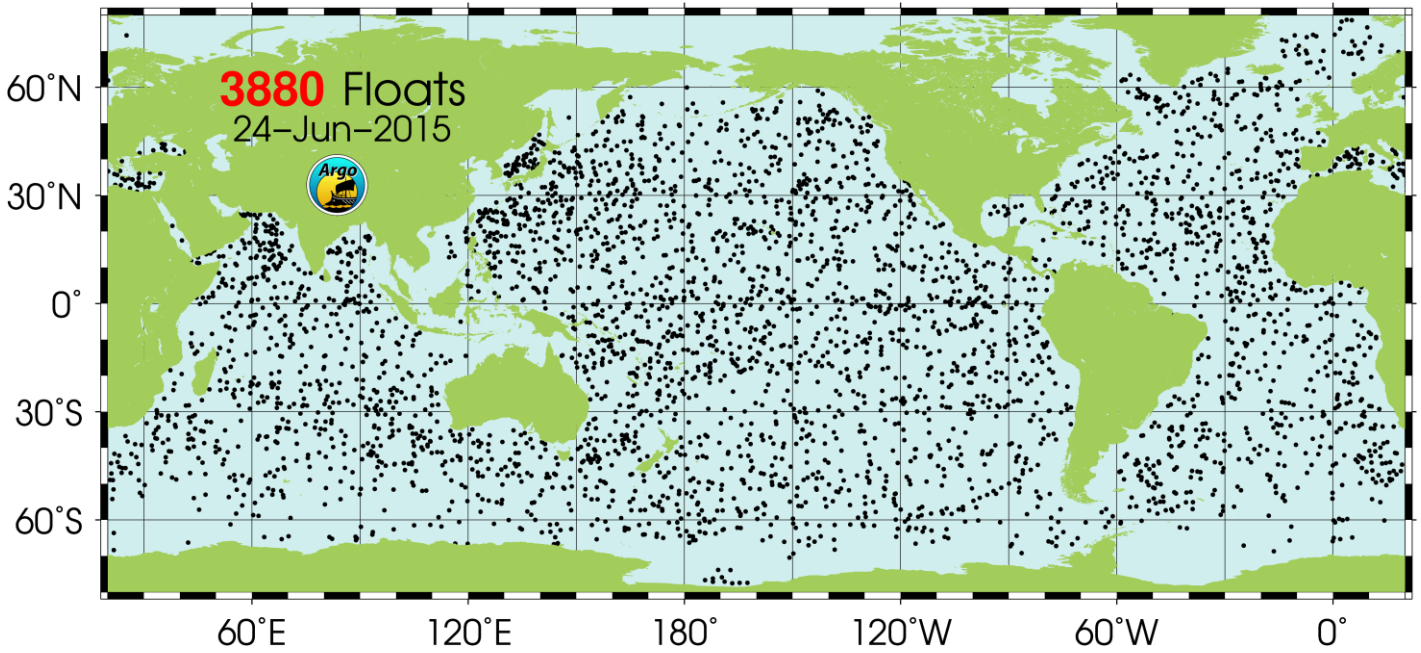
Name	Type	Region / time period	Daily?	Spatially complete?
WOD, EN4	Profile data base	Global / from C18th, 1900	Yes	No
CORA				
Argo				
WOD, EN4, etc	Gridded, in-filled	Global / from 1955, 1900	No	Yes

Need:
- More data – incl. continued support and enhancement of Argo
- Continued research into creating consistent records
- Better quantification of uncertainty components
- Research into new ways of statistical modelling
- Facilitation of IQuOD (http://www.iquod.org)

Argo array

Ocean sub-surface temperature and salinity

Argo is an essential, very high quality component of ECV products of sub-surface ocean temperature and salinity and provides a reference data source for SST analyses.

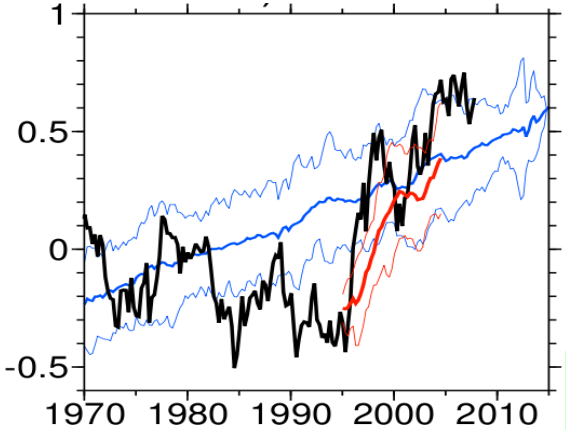


http://argo.ucsd.edu

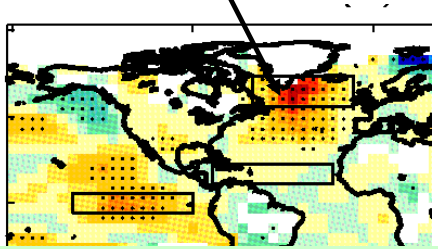
4. Decadal forecasting

Sub-surface ocean temperature and salinity for initialisation

Initialisation with observed ocean temperature and salinity leads to better Atlantic ocean forecasts, e.g. 1990s sub-polar gyre warming, and hence realistic representation of rainfall and hurricane numbers



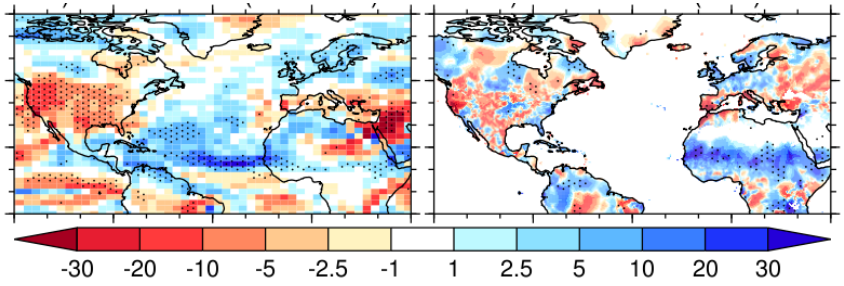
Sub-polar gyre



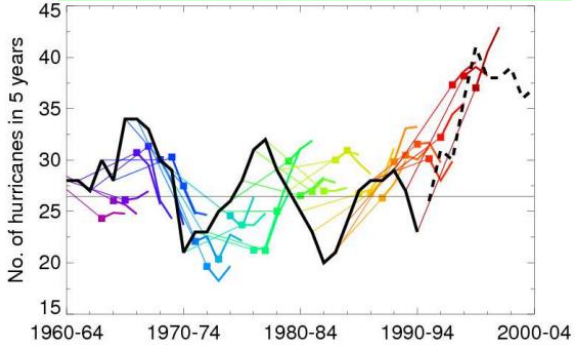
Increase in hurricane numbers well captured

Model

Observations



Rainfall: decade after warming – decade before warming

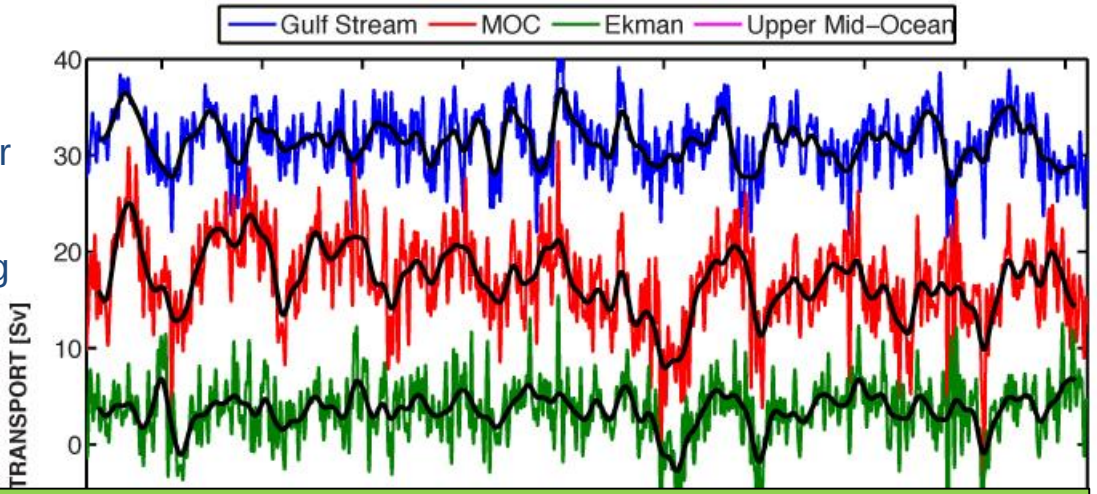


(Robson et al. 2012, 2013, Smith et al 2013)

Sub-surface currents

RAPID and OSNAP for decadal forecast evaluation

Florida Straits transport (blue), Ekman transport (black), upper mid-ocean transport (magenta), and overturning transport (red) for the period 2nd April 2004 to mid- March 2014. The upper mid-ocean transport is based on the RAPID time series. Overturning transport is the sum of the Florida Straits, Ekman, and upper mid-ocean transports. Positive transports correspond to northward flow



Need:
- Continued support of the Argo array
- ECV products need continued research into creating consistent historical records to support multi-decadal hindcasts
- Continued support of the RAPID array

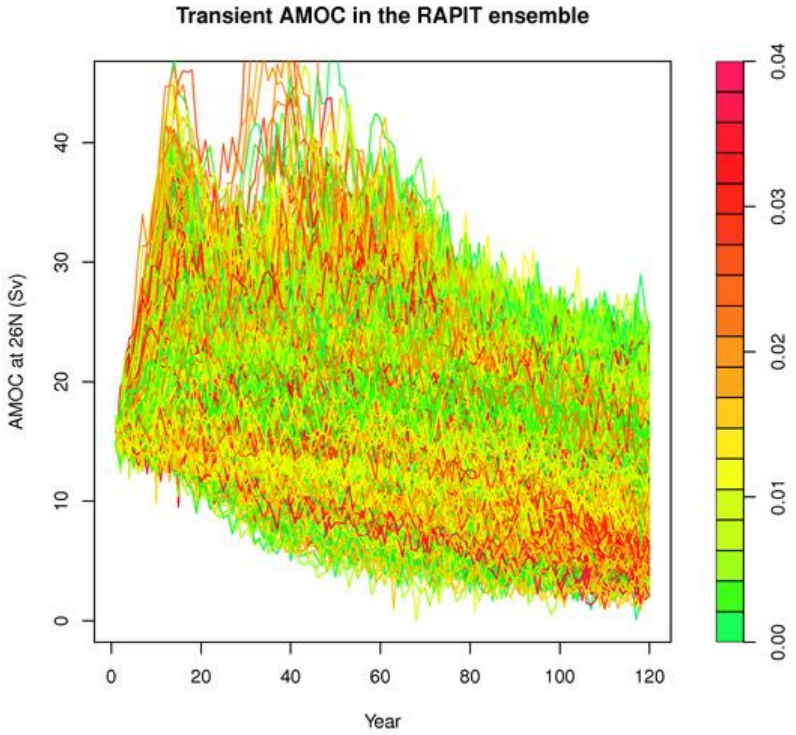
http://rapid.ac.uk

5. Ensemble climate projection

Range of ECV products needed to select plausible models

- Different variants of the climate model can be as good, if not better than, the standard tuned version
- Their response can be different to that of the standard version
- Explore parameter space with a view to finding pockets of good quality and see what that implies for uncertainty
- Need to use observations to find these regions of plausible model variants

Example is Atlantic Meridional Overturning Circulation from the NERC RAPID project, but principle is used in UKCP09



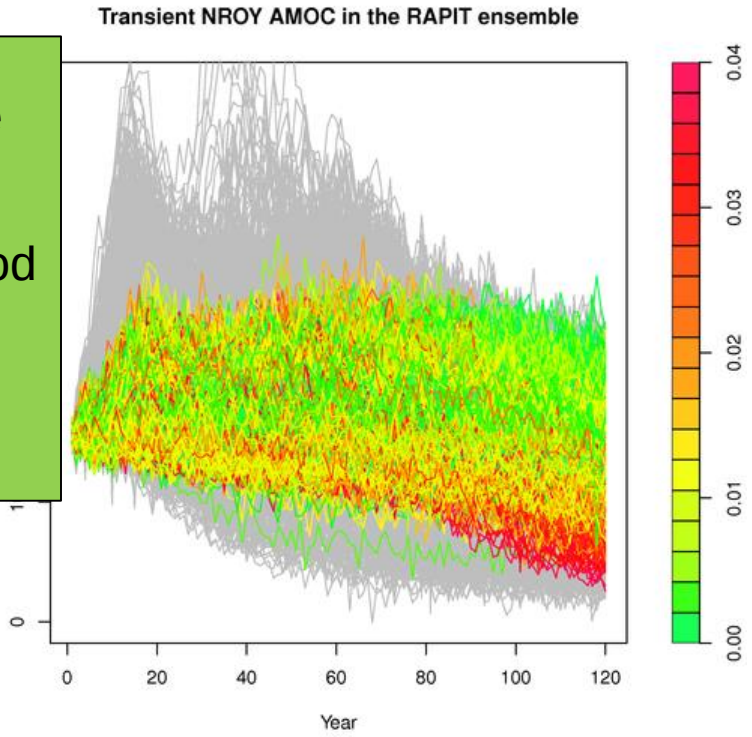
5. Ensemble climate projection

Range of ECV products needed to select plausible models

Need:
- *in situ*-based products used for assessing surface temperature, pressure and precipitation
- ECV products need to be developed with consistent coverage through time (in-filled) and good uncertainty estimates
- Obs4MIPS format (and CF-standards) need to be extended to allow use of full description of these uncertainties

- Need to use observations to find these regions of plausible model variants

Example is Atlantic Meridional Overturning Circulation from the NERC RAPID project, but principle is used in UKCP09



Aerosols

Observations to understand their indirect effect

- Satellite retrievals help to understand the direct effect of aerosols on climate, but don’t help with the indirect effect

- More *in situ* data are needed from the ground or aircraft campaigns on the indirect effect of aerosol on changing cloud properties, e.g. targeted to volcanic eruptions, or impacts in specific meteorological regimes where the results can be generalised to these regimes globally
    - This uncertainty is probably one of the most significant current questions. Answers have implications for regional and global changes and both how we understand decadal and longer term changes

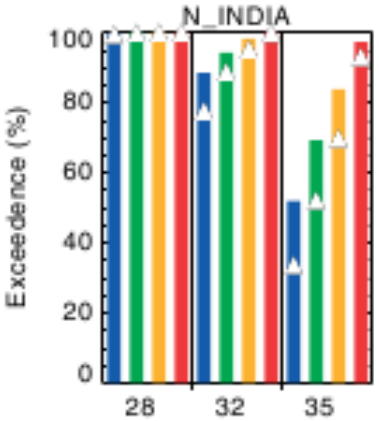
6. Heat stress advice

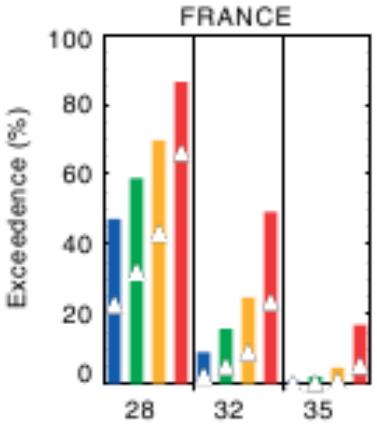
Water vapour

Changes in levels of heat stress driven by changes in both temperature and humidity.

Figure shows likely JJA exceedence (%age of pentads) of thresholds for the wet bulb globe temperature (ISO standard for thermal comfort) under different levels of warming.

Increases in projections of mean regional temperature relative to today of 1 (blue), 2 (green), 3 (yellow) and 5 (red) degrees.





Wet Bulb Globe Temperature Thresholds: 28 high, 32 very high, 35 extreme risk to health of fit adults undertaking physical activity

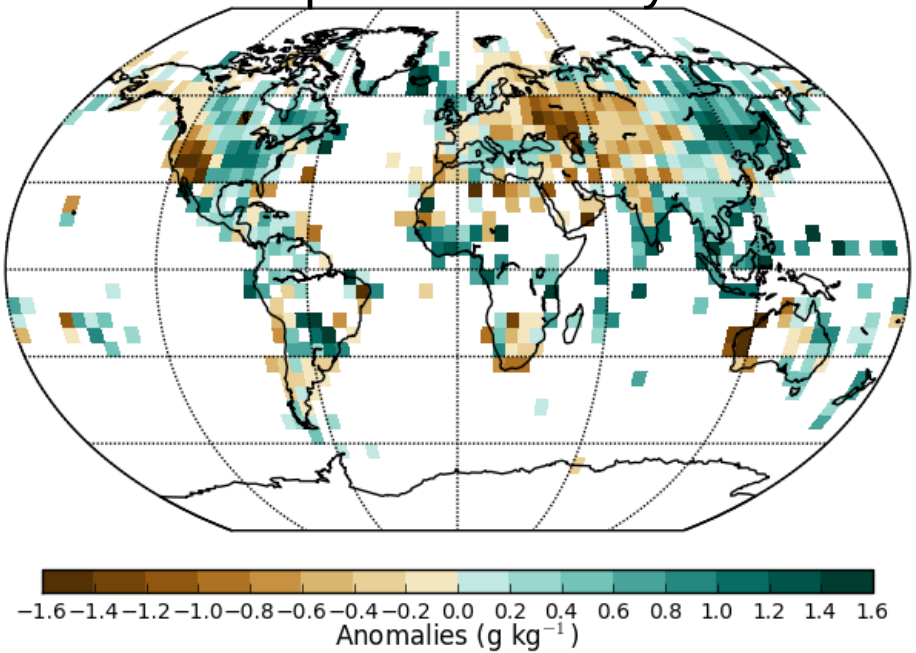
Willett and Sherwood, Int. J Clim., 2010

ECV products

water vapour

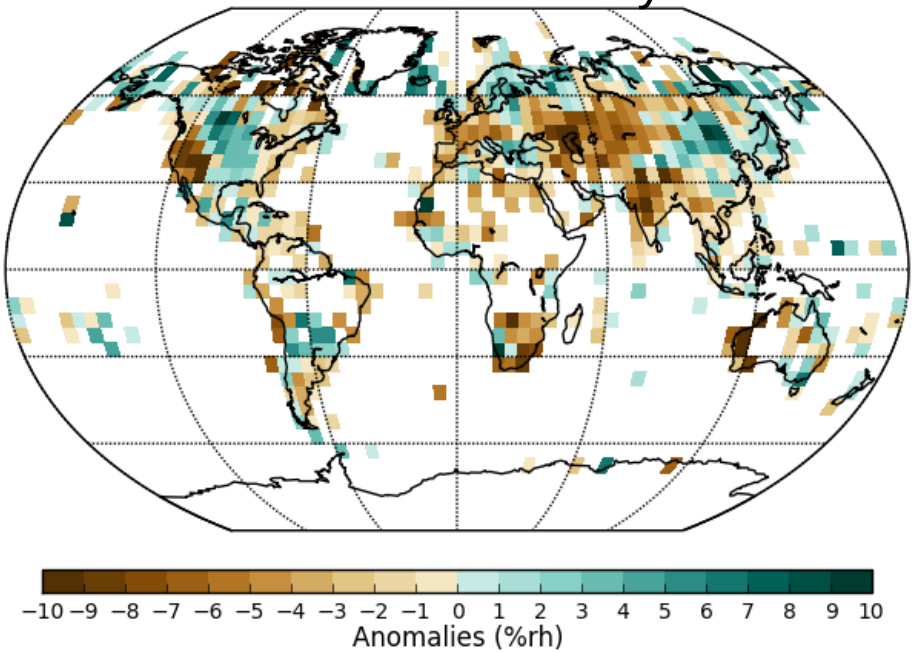
HadISDH.landq.2.0.1.2014p June 2014

Specific humidity



HadISDH.landRH.2.0.1.2014p June 2014

Relative humidity



http://www.metoffice.gov.uk/hadobs

Humidity products

Name	Type	Region / time period	Daily?	Spatially complete?
HadCRUH	Gridded and station, global	Global /1973-2003	No	No
HadISDH	Gridded and station, land	Global / 1973 onwards	No	No
Dai et al	Gridded, global	Global /1973-2004	No	No

Need:
- to be updated more frequently
- development of homogenisation of daily data to allow daily products to be developed

EUSTACE has received funding from the European Union Horizon 2020 Research and Innovation programme, under Grant Agreement number 640171

Met Office Hadley Centre

DMI

Science & Technology Facilities Council

UNIVERSITY OF BATH

EUSTACE

EUSTACE will give publicly available daily estimates of surface air temperature since 1850 across the globe for the first time by combining surface and satellite data using novel statistical techniques

Need:
- more data
- support for short-delay updates (including to underpinning *in situ* and satellite data)
- continued development of consistent long-term ECV products from *in situ* and satellite

Generic statements of needs

For the development of *in situ*-based ECV products needed for climate services

- More data
  - work with other agencies to ensure maintenance of existing observing arrays
  - more and ongoing measurements in sparsely observed regions
  - unlock the potential of past measurements (digitisation and data sharing)
- More research into creating consistent records
  - understanding how data from different measurement platforms can be knitted together to create an homogeneous record
- More research into quantifying uncertainty components and their covariance structures
- Better statistical modelling techniques to create analyses
  - use new methods which allow better representation of full distribution

Suggested ways Copernicus can help

Provision of *in situ*-based ECV products for climate services

- Work with others to facilitate progress in the four generic areas
- Provision of short-delay (after a few days) updates to long-term ECV products, especially for key variables such as sea surface temperature, surface air temperature, precipitation, humidity and sub-surface ocean temperature and salinity
    - this means systems to update input data (both satellite and *in situ*) as well as systems to update the analyses themselves
- Facilitation of the combination of *in situ* and satellite data to enable the development of higher resolution, long term analyses

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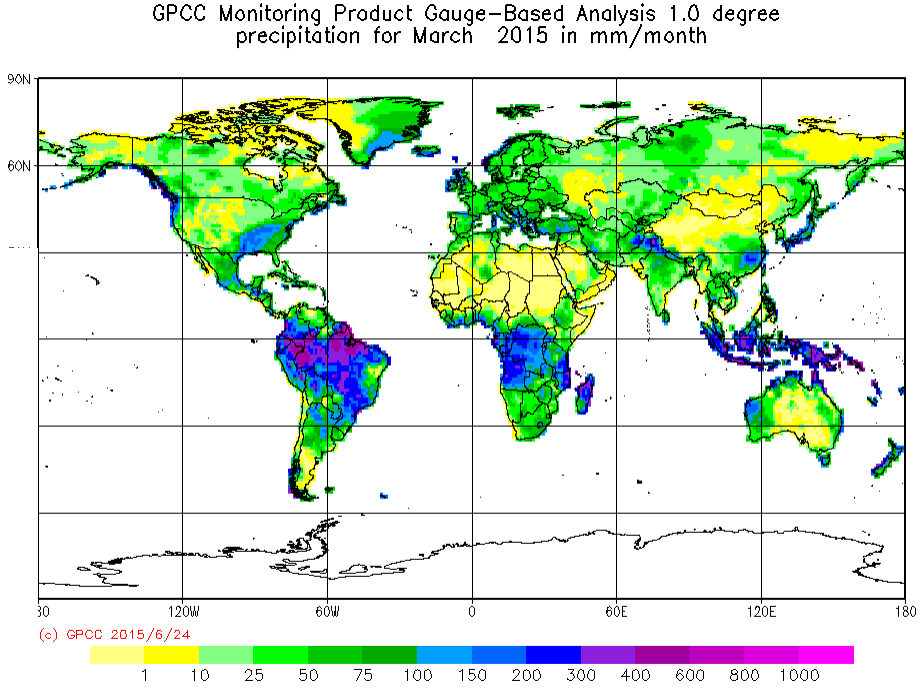
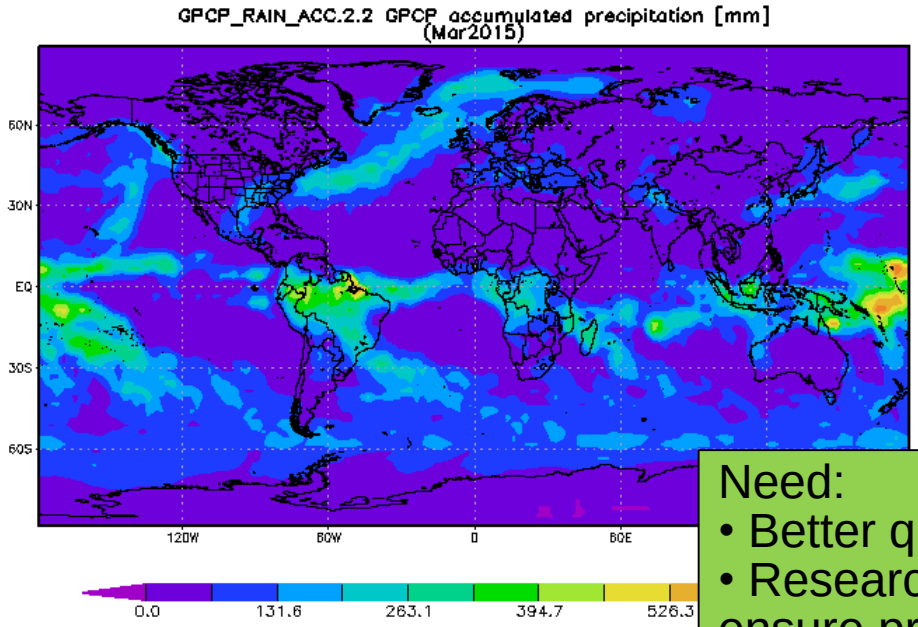
Extra slides

Monitoring

precipitation





Need:

- Better quantification of uncertainty components
- Research into new ways of statistical modelling to ensure preservation of extremes